

# The Stille Reaction

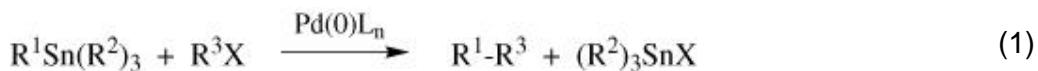
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## 1. Introduction

Examples of the palladium-catalyzed coupling of organotin compounds with carbon electrophiles were first reported in 1977 by Kosugi, Shimizu, and Migita.  
[\(1-3\)](#) The first study by Stille appeared in 1978.  
[\(4\)](#) The early work of Beletskaya, using “ligandless” catalysts in cross-coupling reactions, also often employed organostannanes.  
[\(5\)](#) In recognition of Stille’s comprehensive synthetic and mechanistic studies, this coupling is now referred to as the Stille reaction.  
[\(6\)](#) The Stille reaction is schematically defined in Eq. 1.



In Eq. 1,  $R^1$  is typically an unsaturated moiety (e.g., vinyl, aryl, heteroaryl, alkynyl, allyl) or less often an alkyl group, and  $R^2$ , the nontransferable ligand, is almost always butyl or methyl. Electrophiles participating in the coupling include halides (almost always bromides or iodides) and sulfonates (most often used are the triflates). Other leaving groups have been used in special cases.

The Stille reaction belongs to the larger family of palladium- and nickel-catalyzed cross-coupling reactions which features, e.g., organomagnesium,  
[\(7\)](#) organozinc,  
[\(8\)](#) organoboron,  
[\(9\)](#) and organosilicon reagents.  
[\(10\)](#)

Organotin reagents are air- and moisture-stable organometallics, and can be conveniently purified and stored. Since they do not react with most common functional groups, the use of protecting groups is almost always unnecessary in conjunction with the Stille reaction. This is a very unusual and attractive feature for an organometallic process. Also, the reaction is often neither air nor moisture sensitive. In some cases, water and oxygen have actually been shown to promote the coupling. Although the reaction as initially described by Stille is often carried out under rather drastic conditions (temperatures of  $^{\circ}100$  are not uncommon), newly developed ligands  
[\(11\)](#) and the addition of copper(I) salts  
[\(12\)](#) have solved some of the problems associated with low reactivity.

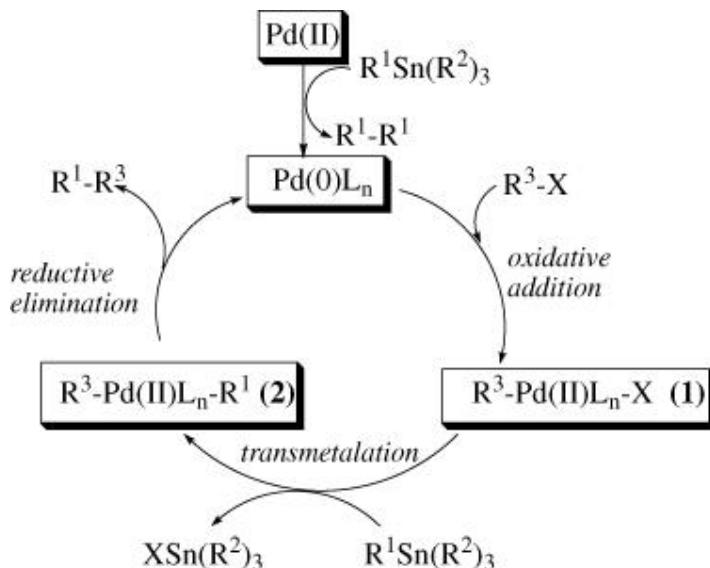
The utility and mildness of the Stille reaction are demonstrated by its frequent use in the final stages of complex natural product syntheses.

This review attempts a critical and comprehensive coverage of the reaction scope. Our mechanistic description of the reaction is rather brief, and we refer the reader to the pertinent literature for a more detailed analysis. All of the relevant literature is covered up to the end of 1994. The reaction was reviewed by Stille in 1986, (6) and by Mitchell in 1992; (13) a rather comprehensive account by Farina and Roth has appeared more recently. (14) Developments that occurred in 1995, as this work was in progress, and that were deemed important were incorporated as much as possible in this review.

## 2. Mechanistic Considerations, Regiochemistry, and Stereochemistry

The three-step catalytic cycle proposed for the Stille reaction follows the general principles of transition metal-mediated cross-coupling reactions and is shown in Scheme 1. (6)

Scheme 1. Catalytic cycle of the Stille reaction.

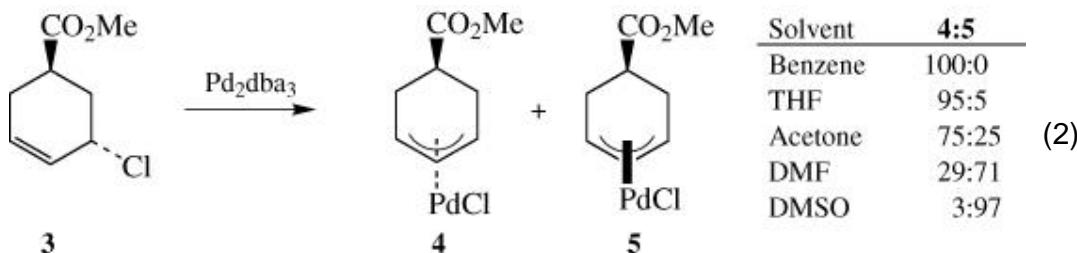


When the catalyst is introduced as Pd(II), fast reduction by the stannane to a Pd(0) complex ensues, and the resulting Pd(0) species enters the cycle. Alternatively, the catalyst can be introduced directly as Pd(0). The rate or yield differences sometimes observed between Pd(II) and Pd(0) catalysts are not likely to be due to the initial difference in oxidation state, but rather to the stoichiometric ratio of palladium to ligand or other factors. (11)

The first step of the cycle is termed *oxidative addition* and is a quite general process for low-valent transition metal complexes. (15) The reaction is represented as a simple process in Scheme 1, but is likely to be a rather complex one. There is substantial evidence that a coordinatively unsaturated Pd(0) species, for example Pd(PPh<sub>3</sub>)<sub>2</sub>, is responsible for the oxidative process. (16) When the substrate is an aryl iodide, the reaction is accelerated by electron-withdrawing substituents on the ring ( $\rho = +2$ ). (17) Oxidative additions are also accelerated by electron-rich phosphorus ligands on the palladium center. (18) In the coupling of aryl bromides with tetramethylstannane, the overall rate is strongly enhanced by electron-withdrawing groups on the aryl moiety ( $\rho = +3.38$ ), suggesting that in this case the oxidative addition is rate limiting. (19)

At least with alkenyl halides, the oxidative addition may be a reversible process. Such a reaction generally proceeds with retention of olefin geometry. (20) Benzylic bromides undergo oxidative addition with partial or total racemization; (21) this has been explained by invoking a one-electron transfer process for this oxidative addition, (22) and CIDNP studies have supported the suggestion. (23) In these cases, the oxidative addition may be accelerated by the presence of oxygen in solution. (19) Intermediate **1** (Scheme 1) is generally formed as a *trans* square-planar complex, i.e., the two phosphine moieties are *trans* to each other, although the intermediacy of the less stable *cis* complex is assumed. (6)

In allylic systems, i.e., allylic chlorides, the oxidative addition was initially shown to proceed with complete inversion of configuration, through the intermediacy of  $\eta^3$ -complexes, (24) but subsequent studies have revealed a more complex situation (Eq. 2). (25)



Specifically, it was shown that, in the absence of strong coordinating ligands, the stereochemistry depends on the solvent, nonpolar solvents favoring retention and polar ones leading to inversion. Furthermore, olefin ligands promote *syn* oxidative addition, and phosphines favor the *anti* pathway. (26)

Although it is known that the transmetalation is very often the rate-determining step of the Stille reaction, much less is known mechanistically about this metathesis reaction.

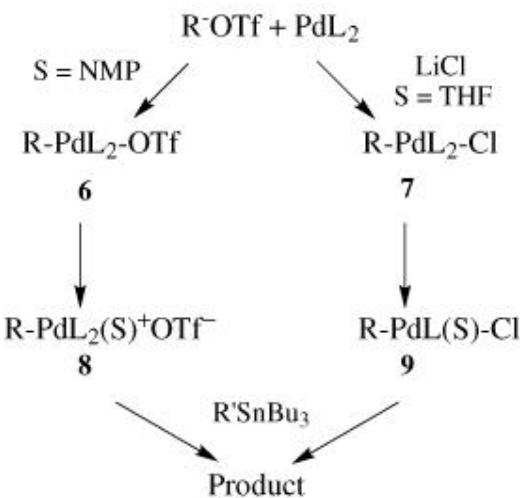
In early studies, Stille et al. showed that, in the coupling of benzylic stannanes with acid chlorides, electron-releasing substituents slightly increased the transmetalation rate ( $\rho = +1.2$ ), suggesting that carbon-tin bond breaking precedes palladium-carbon bond formation. The stereochemical outcome with benzylic stannanes is predominantly inversion at the tin-bearing carbon, suggesting an “open” S<sub>E</sub>2 mechanism. (27)

More recently, it has been shown that the transmetalation of **1** to **2** proceeds via prior ligand dissociation and that ligands with lower donicity toward Pd(II)

than  $\text{PPh}_3$  [i.e., tri(2-furyl)phosphine and triphenylarsine] can lead to major (up to 1,000-fold) rate enhancements in the transmetallation. (11) With these ligands, many Stille couplings previously requiring vigorous conditions can be performed at room temperature.

In studies of the synthetically important coupling of organic triflates, (28, 29)  $\text{LiCl}$  is necessary to induce coupling of organic triflates in THF as solvent. This has been rationalized by postulating that the initial oxidative addition product (**6**, Scheme 2), which was isolated in one case, is catalytically incompetent, whereas ligand substitution with chloride ion leads to the reactive species **7**. (28)

**Scheme 2.** Two possible pathways in the Stille coupling with organic triflates.



More recently, it has been found that addition of  $\text{LiCl}$  is often not necessary when operating in highly polar solvents like NMP, and in many cases  $\text{LiCl}$  is actually an inhibitor of the coupling. This was explained by invoking two pathways in the transmetallation, i.e., a faster one proceeding via cationic species **8** and a slower one (with  $\text{L} = \text{PPh}_3$ ) proceeding via ligand dissociation (through **9**). Hammett studies confirmed that there are two pathways with opposite electronic demands. Thus, in the absence of chloride the reaction is faster when the arylstannane contains electron-releasing groups ( $r = -0.89$ ), whereas in the presence of  $\text{LiCl}$ , electron-withdrawing substituents also enhance the rate. The transmetallation is affected in a complex way by the combination of  $\text{LiCl}$ , ligands, and solvent, and the highest rates are obtained with  $\text{AsPh}_3$  as ligand. With this superior ligand, the effect of halide additives on the rate of the transmetallation is minimal. (30)

Intramolecular couplings of triflates with stannanes do not require  $\text{LiCl}$  even in THF. (31) The recently reported ability of  $\text{Ag(I)}$  salts to improve some Stille couplings may also be explained by a switch of the transmetallation pathway via **8** and away from **9** (Scheme 2). (32)

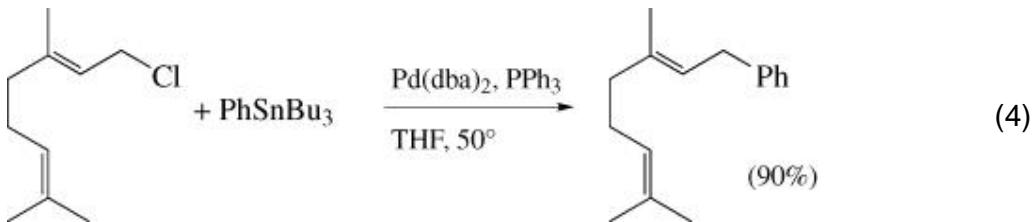
The cocatalytic effect of Cu(I) in the Stille coupling was first reported by Liebeskind and Fengl. (12) Later studies have shown that Cu(I) performs a dual role: In ethereal solvents (THF, dioxane) and in conjunction with highly coordinating ligands ( $\text{PPh}_3$ ), Cu(I) acts as a ligand scavenger to facilitate formation of the coordinatively unsaturated Pd(II) intermediate (9 in Scheme 2) needed to effect transmetallation, whereas in highly dipolar solvents (NMP) in the presence of “soft” ligands ( $\text{AsPh}_3$ ) formation of an organocopper species is likely. (33) Thus, it seems simply that in the presence of inorganic Cu(I) salts, an organostannane may be in equilibrium with an organocopper species (Eq. 3). Another important role of Cu(I), enhancing the selectivity of group transfer in the Stille reaction, is discussed in a later section.

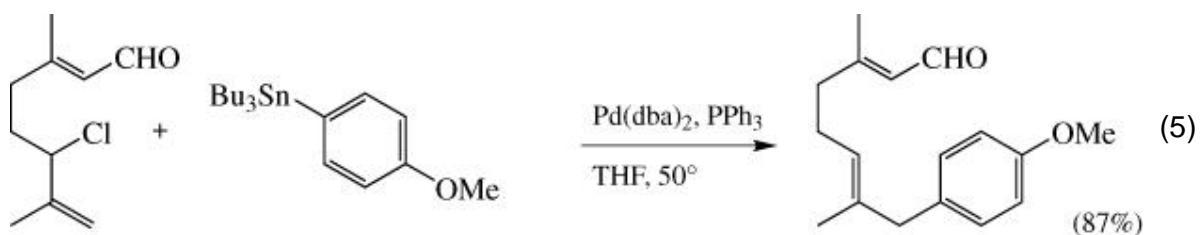


Similar transmetallations have been postulated in order to explain the beneficial effect of stoichiometric Zn(II) salts on certain Stille couplings, but no experimental evidence is available. (28)

From the standpoint of the stereochemistry at Pd(II), the transmetallation usually proceeds with retention of configuration and is probably followed by *cis-trans* isomerization. The reductive elimination that follows probably proceeds through a T-shaped intermediate via prior ligand dissociation at Pd(II). (15) Pd(IV) species have been implicated as intermediates in the reductive elimination, (34) but factors that influence this step are not discussed further since reductive elimination is not rate determining in the Stille coupling. In the coupling of allylic electrophiles, however, reductive elimination will determine the regiochemistry of coupling, and in this case detailed understanding of this step is very important.

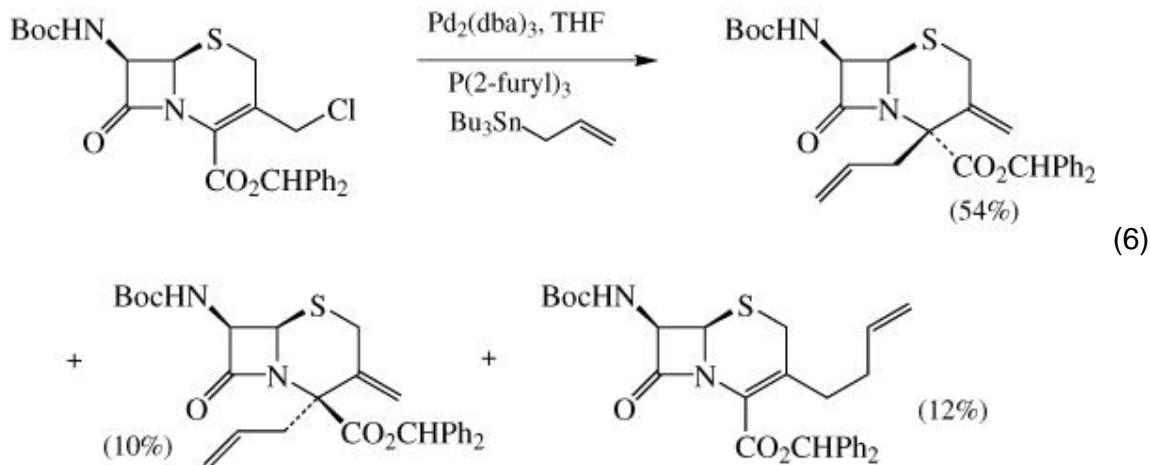
Allylic halides, typically chlorides, couple smoothly with organostannanes under normal conditions, and the regiochemistry of the coupling is usually the one resulting from attack of the organostannane at the less hindered terminus of the allylic moiety (Eqs. 4 and 5). (24)



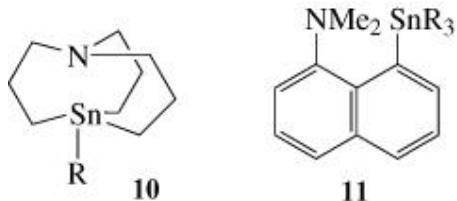


When the organostannane is also allylic, the situation is more complicated. Apparently, the coupling is somewhat regiospecific, and the C-C bond is formed between the more substituted end of the allylic stannane and the less substituted one in the allylic halide. (35, 36) To explain the predominant allylic transposition of the stannane, both Stille and Trost postulated a direct attack of the stannane at the carbon terminus of an intermediate  $\pi$ -allyl complex, but there is no proof for such a mechanism. Indeed, indicator substrates for nucleophilic attack at  $\pi$ -allyl complexes classify allylstannanes as reacting directly at Pd(II) and not at carbon. (37) This mechanistic issue is still unresolved, even though a simple stereochemical probe could resolve the issue. On the other hand, in the presence of maleic anhydride the coupling takes place in a preferred head-to-head mode, and the stereochemistry indicates attack of the stannane at the Pd center of the  $\pi$ -allyl complex, followed by reductive elimination with retention of configuration. (38, 39)

Exceptions to these regiochemical trends, however, can be found in the literature. One is shown in Eq. 6 and is mechanistically difficult to explain. One must also note that the two regiochemistries are interconvertible by Cope rearrangement. (40)



An important mechanistic issue that has recently begun to be addressed by several investigators concerns the effect of nucleophilic assistance at tin(IV) during the transmetallation. Two studies (41, 42) have independently shown that a nucleophilic moiety placed within the stannane considerably enhances transmetallation rates, whereas other studies in related systems have failed to detect such enhancements. (30) The increased reactivity of stannanes **10** has been explained by invoking internal N-Sn coordination in the transition state, (41) and a similar rationalization has been applied to the increased reactivity of systems such as **11**. (42)



These stannanes are able to effect transfers of alkyl moieties, which occur sometimes with difficulty or not at all using traditional Stille chemistry. The mechanistic and synthetic significance of these intriguing observations should be further explored.

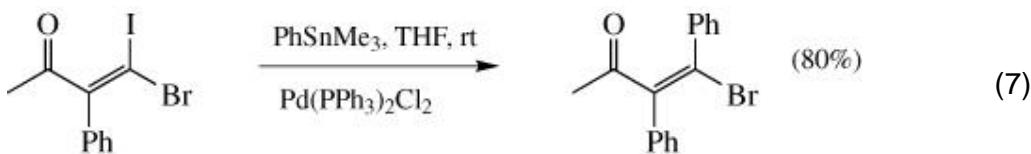
### 3. Scope and Limitations: The Electrophile

In this section, the range of electrophiles used in the Stille coupling is surveyed. Details of experimental conditions and side reactions are more fully described in separate sections. The examples discussed are a select few. A complete survey is found in the tables. Limitations are discussed whenever carefully documented in the literature. Occasionally, low yields are reported in a number of isolated Stille couplings. These may be due to incomplete optimization of the reaction. Therefore, these examples are considered a real limitation only if the authors reported a thorough study exploring a comprehensive list of catalysts and conditions.

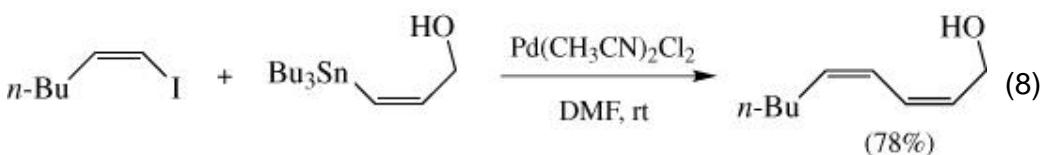
#### 3.1. Alkenyl Halides

Alkenyl chlorides have been used very little in Stille couplings, presumably because of their lack of reactivity in the oxidative addition with Pd(0). Scattered examples of successful coupling exist, but appear limited to activated systems. (43, 44)

Alkenyl bromides and iodides are generally useful partners. Their coupling is often stereospecific. Since bromides undergo oxidative addition only at elevated temperatures, *E/Z* isomerizations are sometimes observed. More consistently stereospecific is the coupling with vinyl iodides, which takes place at room temperature or slightly above. The higher reactivity of the iodides vs. the bromides is nicely illustrated in Eq. 7, where under the mild conditions employed the bromide moiety is left unreacted. (45)

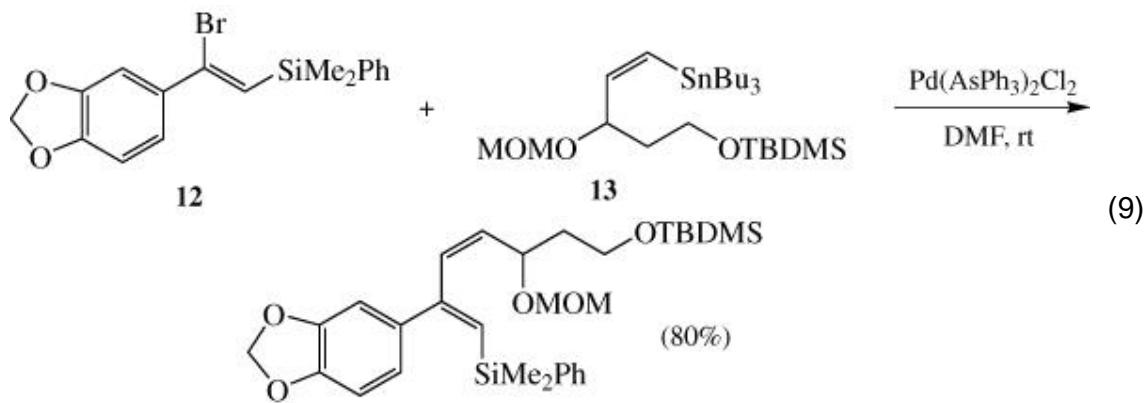


Two general studies on the cross-coupling between simple alkenyl iodides with both alkenyl (46) and alkynyl (47) stannanes are reported. Bromides also couple, but in lower yield. In each case, the preferred catalyst is the "ligandless" species Pd(CH<sub>3</sub>CN)<sub>2</sub>Cl<sub>2</sub>. The reaction proceeds in DMF or THF at room temperature, and *E/Z* isomerization is negligible (Eq. 8).



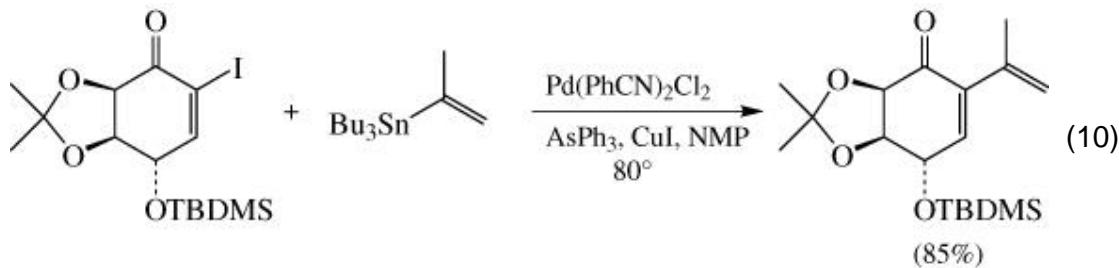
The palladium-catalyzed reduction of vinyl iodides with tributyltin hydride or other hydride reagents can be loosely classified as a Stille coupling. The reaction is highly stereospecific, in contrast with the radical-induced reduction, which leads to geometrical isomerization. (48)

Very few limitations of this coupling reaction have been clearly documented. Even tetrasubstituted vinyl iodides couple in good yields. (49, 50) However,  $\beta$ -silyl vinyl bromide **12** couples with stannane **13** to yield only a completely isomerized product even under the mildest conditions. (51) This lack of stereospecificity is attributed to the bulky silyl group (Eq. 9).



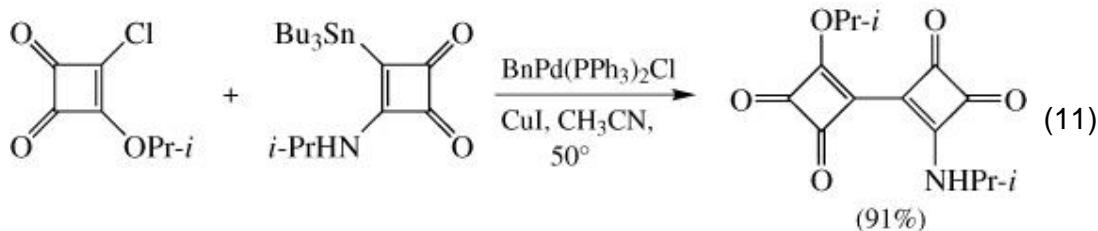
Special classes of alkenyl halides that have been made the objects of specific studies include  $\beta$ -halo-  $\alpha$ ,  $\beta$ -unsaturated ketones and esters, which couple smoothly with a variety of stannanes, (52-54) quinone halides, which also couple well (preferentially using CuBr as cocatalyst), (55-58) and  $\beta$ -halo-  $\alpha$ ,  $\beta$ -unsaturated sulfoxides, which couple with alkenyl- (59) and alkynylstannanes (60) without *E/Z* isomerization and without epimerization at the chiral sulfur center.

Certain systems, on the other hand, appear difficult to couple and require carefully optimized conditions. For example,  $\alpha$ -iodo-  $\alpha$ ,  $\beta$ -unsaturated ketones must be coupled using the “soft” ligand AsPh<sub>3</sub> and cocatalytic Cu(I). Even under these conditions, high temperatures are required, but the reaction is general and gives very good yields (Eq. 10). (61)



On the other hand,  $\alpha$ -bromo-  $\alpha,\beta$ -unsaturated ketones can be coupled with aryl stannanes using  $P(o\text{-Tol})_3$  as ligand in the absence of  $Cu(I)$  additives. (62)

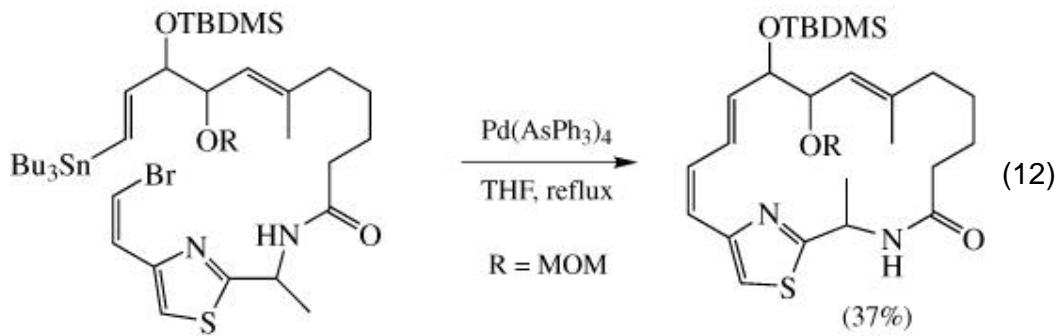
Halocyclobutenediones couple with stannanes, and  $CuI$  cocatalyst is necessary to obtain good yields (Eq. 11). (63, 64)



Cyclooctatetraenyl bromide couples with stannanes at room temperature, and  $P(2\text{-furyl})_3$  or  $AsPh_3$  are the ligands of choice. (65, 66)

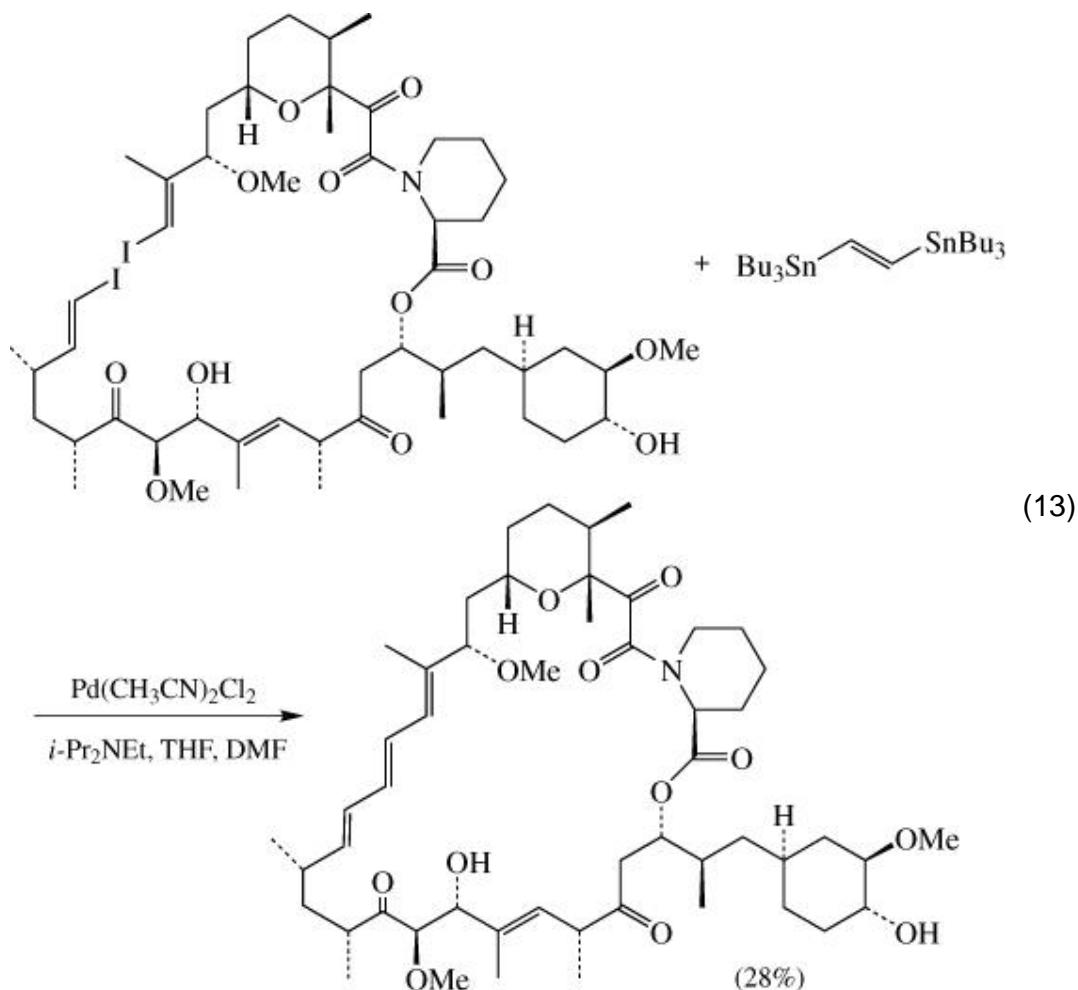
Bromotropolones can be coupled with a variety of arylstannanes, to yield analogs of the antimitotic agent colchicine. (67)

Intramolecular versions of this coupling reaction yield a variety of ring sizes, from four (68) and five (69) to medium-size rings, (70-74) and even macrocycles. (75) Equation 12 illustrates the key step in the total synthesis of leinamycin. (76) The



mildness and generality of this method is demonstrated by its frequent application to the late stages of complex natural product syntheses. Thus, the alkenyl halide/organostannane coupling has been applied in recent years to the total syntheses of neooxazolomycin, (77) onnamide A, (78) 22,23-dihydroavermectin, (79) calyculin A, (80-82) lankacidin C, (83) lepidicidin A, (84) and rapamycin. (85)

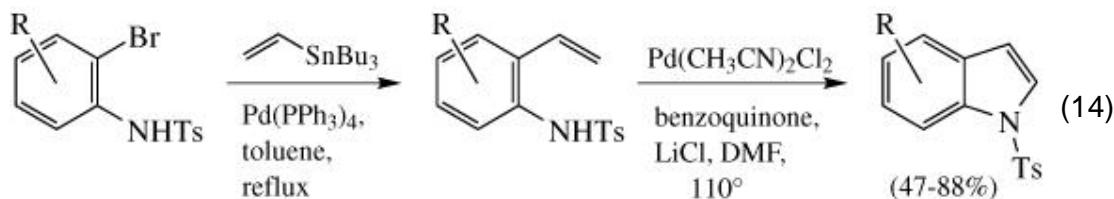
Probably the most spectacular application of this reaction is represented by the final step of Nicolaou's total synthesis of rapamycin, in which a tandem Stille coupling is carried out on the fully functionalized skeleton. (86) The yield is modest, but an intermediate iodostannane could be isolated and resubjected to the reaction conditions, affording more cyclized product and thereby increasing the overall yield to 46% (Eq. 13).



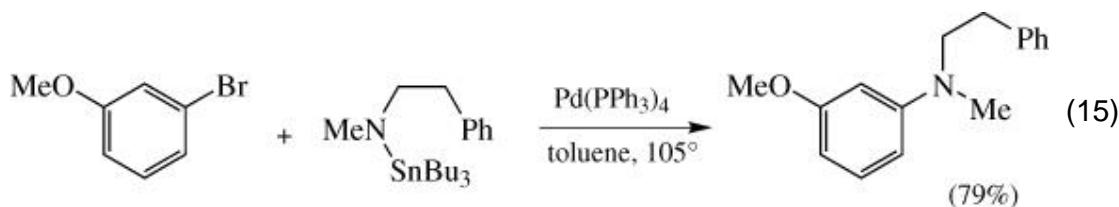
### 3.2. Aryl and Heterocyclic Halides

An early study reports that in the coupling of aryl halides with organostannanes, aryl bromides are the optimal electrophiles in the coupling reaction with allyltributylstannane. Aryl chlorides react only if strongly activated toward oxidative addition (e.g., *p*-nitrochlorobenzene), whereas aryl iodides couple only in low yields. (3)

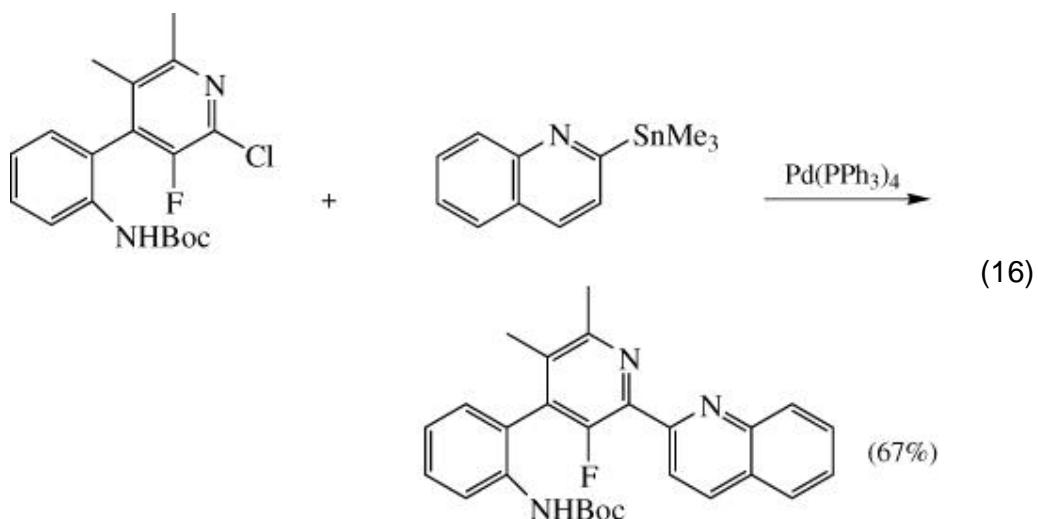
In independent studies of the scope and utility of the reaction, it was found that both aryl bromides and iodides couple with a number of stannanes in high yield. (19, 87) The coupling of aryl bromides requires more vigorous conditions and is facilitated by electron-withdrawing substituents in the *para* position of the halide derivative, indicating that oxidative addition is the rate-determining step. A specific study deals with the preparation of styrene derivatives. (88) The method was applied to the synthesis of indole derivatives (Eq. 14). (89)



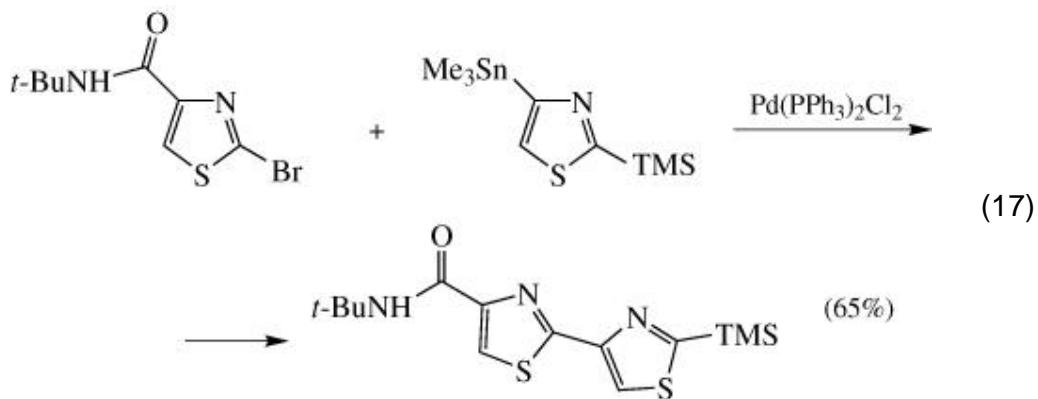
A synthetically useful variant of the Stille reaction is the coupling of aryl halides with aminostannanes. (90-92) The reaction so far is limited to aryl bromides. Secondary amines can generally be coupled, whereas among primary amines, only anilines have been reported to couple. The aminostannanes can be conveniently generated *in situ* from the corresponding amines and (diethylamino)tributylstannane. This is obviously a reaction with much potential, and it is likely that its scope will grow after further scrutiny. An example is shown in Eq. 15. (91) Other carbon-heteroatom bonds can be made through the intermediacy of organostannanes, as detailed later in the section describing the scope and limitation with respect to the types of stannanes that can be used.

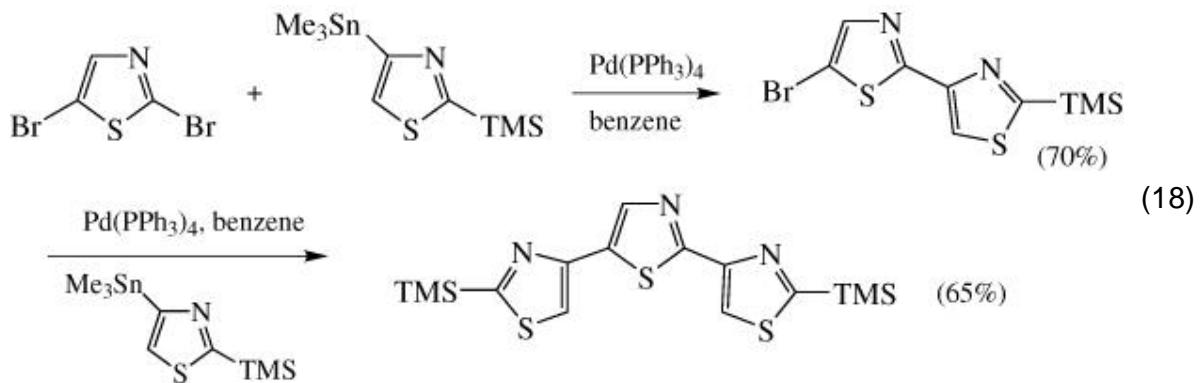


Heteroaryl halides also couple with organostannanes. Although the scope of these reactions has generally not been studied in detail, many examples in the literature exist to support some generalizations. For example, 2-, 3-, or 4-bromopyridines couple well with aryl and heteroaryl stannanes, (93-95) whereas 3-iodopyridines couple in only fair yields. (96) 2-Chloro-3-fluoropyridine derivatives couple specifically at the 2 position with a variety of alkenyl stannanes. (97) Even 4-chloropyridine can be coupled. 3-Bromoquinolines also couple with stannanes. (93, 98) Equation 16 illustrates the key step in the synthesis of a lavendamycin analog. (99)

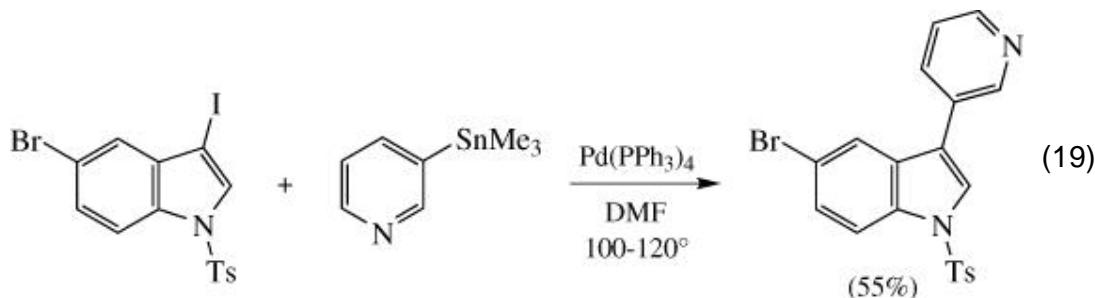


2- and 3-Furyl (**100**) and thienyl (**96**, **101–106**) halides are easily coupled with stannanes. 2-Halothiazoles couple smoothly, as illustrated by a key step in a recent synthesis of micrococcinic acid (Eq. **17**). (**107**) 2,5-Dibromothiazole couples first at the 2 position, then at C-5 (Eq. **18**). (**108**)





Both 2- ([109](#)) and 3-indolyl ([110](#)) halides have been coupled with stannanes. Interestingly, 5-bromo-3-iodotosylindole couples specifically at C-3 (Eq. [19](#)). ([110](#))



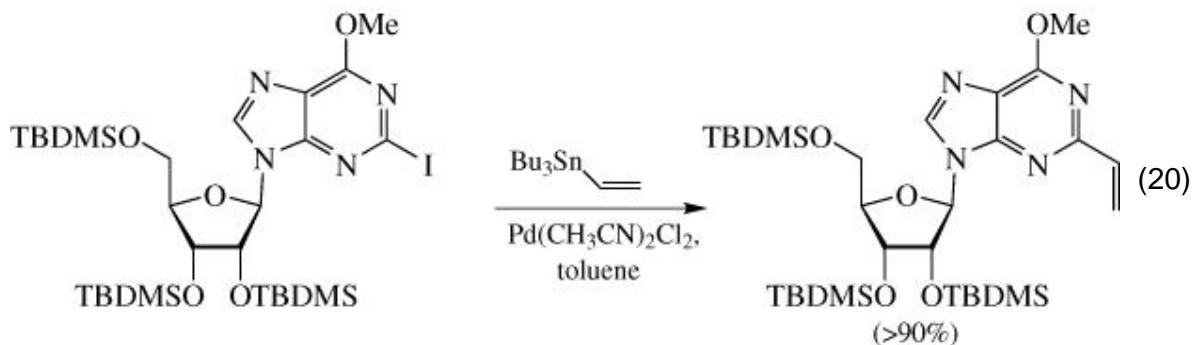
2-Imidazolyl bromides couple with phenyltrimethylstannane, and 2,4-imidazolyl dibromides couple selectively at the 2 position with aryl stannanes, contrary to the corresponding arylboronates, which couple at both positions without selectivity. ([111](#))

4(5)-Imidazolyl iodides, however, can be successfully coupled. ([112](#), [113](#))

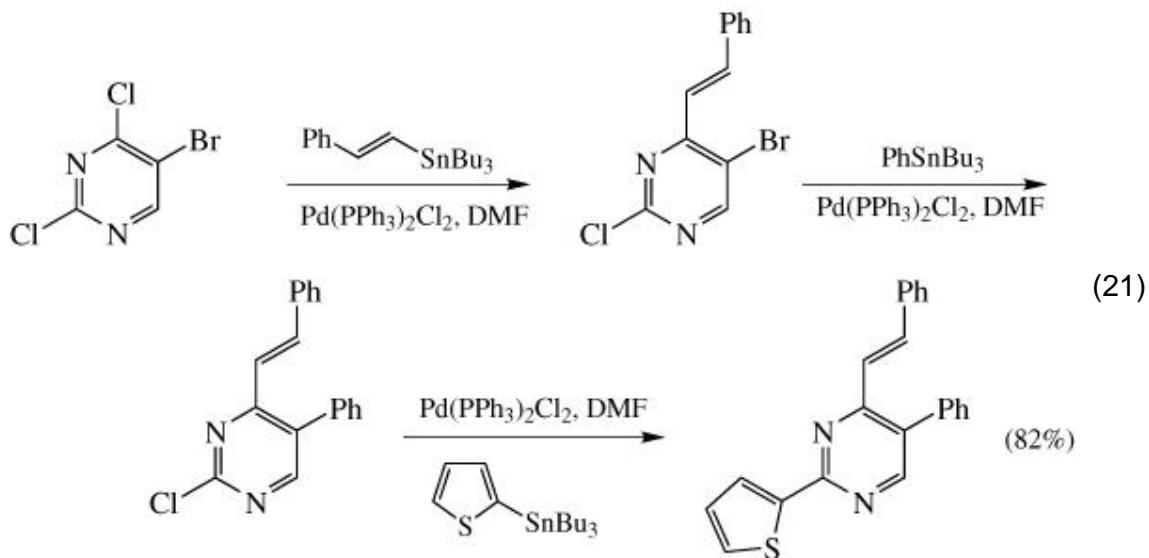
4-Iodoisoxazoles can be coupled with a large number of stannanes. ([114](#))

2,5-Dibromosiloles couple with alkynylstannanes, ([115](#)) and 2-bromo- and 2,4,6-tribromophosphinines couple with stannanes in an interesting selectivity pattern. ([116](#))

Many applications of the Stille reaction to nucleoside chemistry have been made since the first application of the reaction to 2-iodopurines (Eq. [20](#)). ([117-120](#))



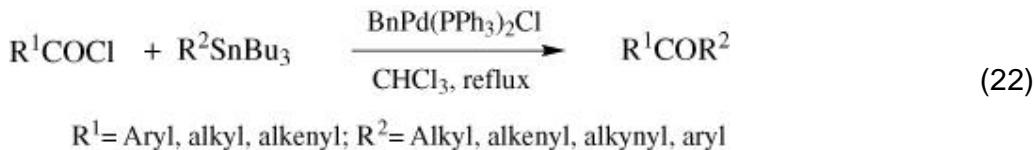
Similar chemistry has been reported for 5-iodouridines, (121-125) and 5-bromo- or 5-iodouracil (126-128) derivatives. 5-Arylcytosines have been prepared from the corresponding 5-iodo derivatives by Stille coupling. (129) Stannane coupling in purine chemistry has been extended to 8-bromoadenosines, (130) 8-iodoadenosines, (131) 6-iodouridines, (132) and 6-chloropurines. (133, 134) A number of 4- and 5-halopyrimidines (halo = Cl, Br, I) have been coupled with stannanes. (135-140) In polyhalogenated pyrimidines the order of reactivity in the coupling is C-4 > C-5 > C-2, regardless of the halide (Eq. 21). (141)



2-Chloropyrazines can be coupled with stannanes, (142) and even bromo-substituted porphyrins have been subjected to the Stille coupling. (143, 144) Finally, aryl iodides attached to a polymer have been subjected to Stille couplings in relation to the building of combinatorial libraries. (145)

### 3.3. Acyl Chlorides

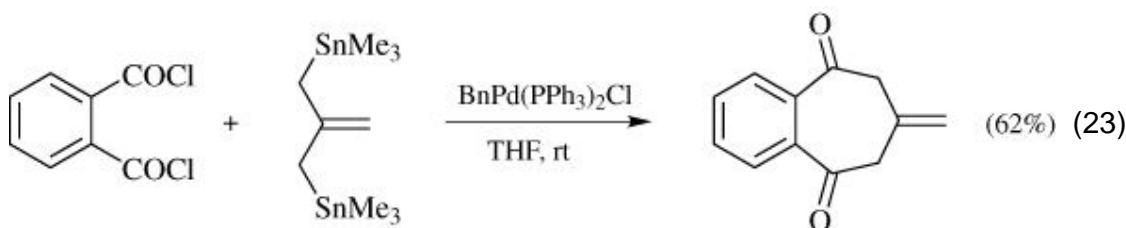
It was reported in 1977 that stannanes can be coupled with acyl chlorides under palladium (1) or rhodium catalysis. (2) Stille subsequently explored the scope of the reaction and showed that it is general for a wide variety of acyl chlorides (Eq. 22). (146)



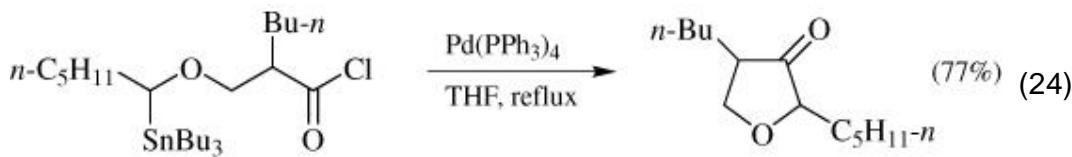
Few limitations are encountered in this reaction. Allylstannanes may react further with the ketone products in a nonpalladium catalyzed nucleophilic carbonyl addition. Decarbonylation is seen in some cases, but can be avoided by running the reaction under a CO atmosphere. Product isomerization is a complication when allyl- and alkenylstannanes are employed. This reaction can be run under milder conditions (room temperature) by using tri(2-furyl)phosphine or AsPh<sub>3</sub> as ligands. (11) Use of the former often prevents the unwanted geometric isomerization. Oxalyl chloride is not a good substrate for this reaction. (147) Coupling with  $\beta$ -stannyln enones yields butene-1,4-diones, which are directly reduced to 1,4-diketones under the reaction conditions. (148)

The coupling of acyl chlorides and alkynylstannanes is quite general and affords good yields of  $\alpha, \beta$ -acetylenic ketones. (149)

Examples of this reaction in the absence of palladium are well known, (150) and, although the uncatalyzed reaction is outside the scope of this chapter, in some cases it is claimed to be higher yielding than its palladium-promoted counterpart. (151) Acyl chlorides from dicarboxylic acids also participate in the coupling. If a distannane is used, an annulation reaction results (Eq. 23). (152)

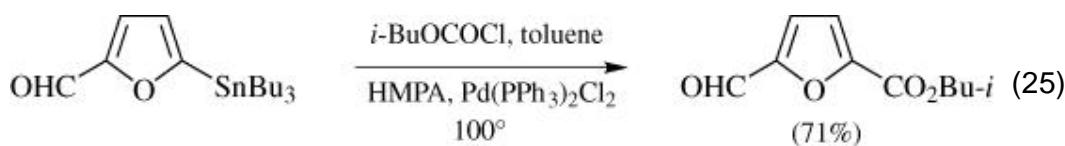


Intramolecular couplings are also quite useful synthetically. (153, 154) An example is shown in Eq. 24. (155)



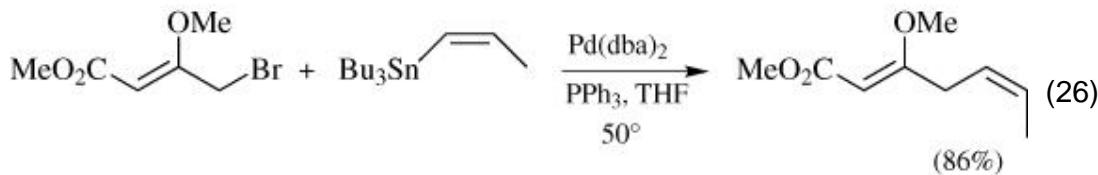
When the stannane used is tributyltin hydride, a general synthesis of aldehydes results. (156)

Chloroformates and carbamoyl chlorides also couple with stannanes (157) to yield esters and amides, respectively, in good yields (Eq. 25). (158) Intramolecular examples have been reported. (159)



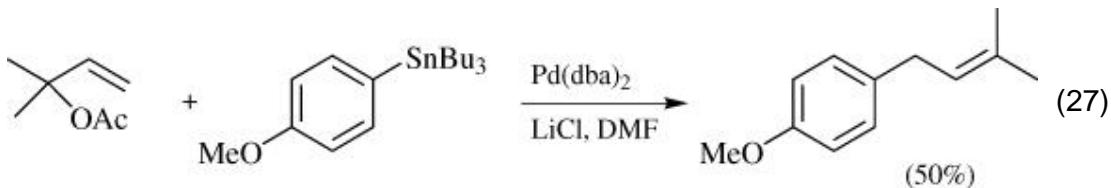
### 3.4. Allylic, Benzylic, and Propargylic Electrophiles

The coupling of allylic electrophiles with organostannanes is a reaction of general utility. Stille studied the scope of the reaction of allylic chlorides and bromides with organostannanes. With allylic electrophiles, a regiochemical issue exists: Since these couplings probably proceed via  $\eta^3$ -allylpalladium intermediates, coupling at either the  $\alpha$  or the  $\gamma$  position is possible. Stille reports that coupling generally occurs at the less substituted terminus of the allyl moiety. An example is shown in Eq. 26. (24)



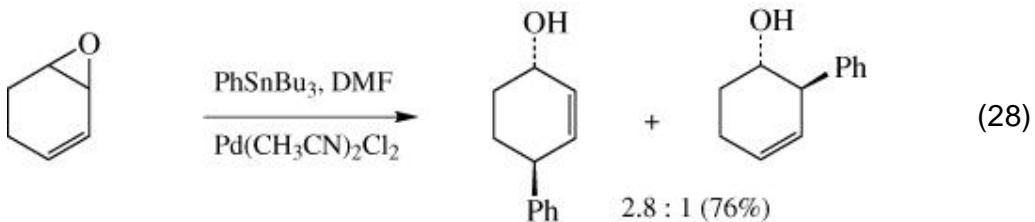
Aryl- and alkenylstannanes couple in good yields. Allylic stannanes react to yield mixtures in which coupling at the more substituted terminus of the stannane is favored. (36, 37) Among the applications to compounds of biological interest, the coupling of chloromethylcephems with stannanes constitutes a versatile approach to novel semisynthetic cephalosporins. (41)

Allylic acetates (36,160,161) and allylic phosphates (162) also couple with stannanes under special conditions. A study on the cross-coupling of allylic acetates showed that the reaction is quite general and is best carried out in the absence of phosphine but in the presence of LiCl. Again, coupling takes place at the less substituted allyl terminus, and both alkenyl- and arylstannanes couple in high yields. An example is given in Eq. 27. (163)

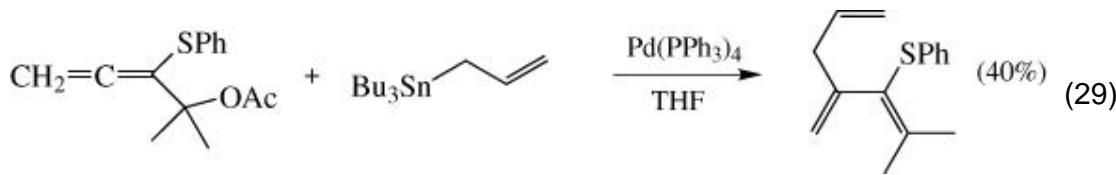


Alkenyl epoxides can be considered allylic electrophiles. They also undergo coupling with aryl- and alkenyl- (but not allyl-, benzyl-, alkyl-, and alkynyl-) stannanes to yield mixtures of 1,2 and 1,4 coupling products.

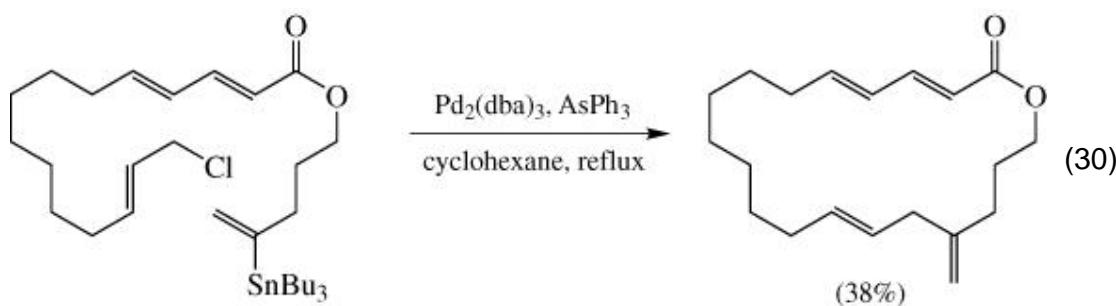
As with allylic acetates, the less substituted terminus is the more reactive. Added water increases the yield and the regioselectivity, but further work aimed at better control of the regiochemistry is necessary to make this reaction synthetically useful. Equation 28 shows a typical example. (164)



Propargylic acetates do not couple with organostannanes, (165) and alkynylstannanes may undergo anomalous coupling with allyl halides. (41) Allenyl acetates have been coupled with stannanes to yield polysubstituted 1,3-dienes (Eq. 29). (166)

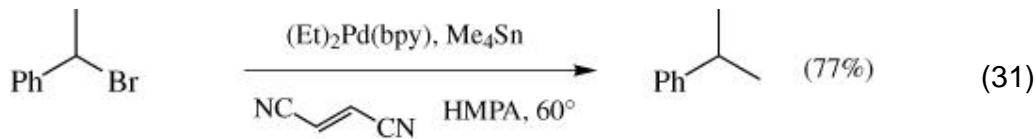


Intramolecular examples of the coupling of organostannanes with allylic electrophiles have also been reported. Under optimized conditions, large rings can be constructed in fair yields (Eq. 30). (167)

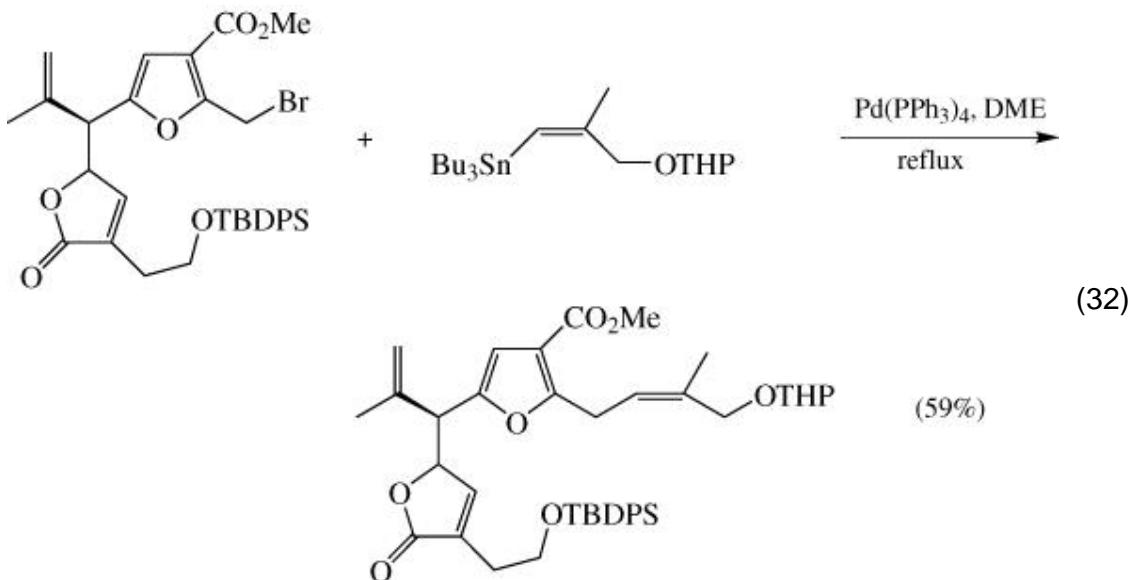


Allyl esters and carbamates are important in the protection of carboxy and amine functional groups. Deprotection conditions sometimes involve use of Pd(0) catalysts in conjunction with tributyltin hydride. (168) Specific examples are not discussed, since they are outside the scope of this review.

Few studies on the coupling of benzyl halides with stannanes have appeared. Benzyl bromide itself couples with tetramethylstannane, vinyltributylstannane, and tetraphenylstannane in good yields under the catalysis of  $BnPd(PPh_3)_2Cl$  in HMPA. (19) Reaction with hexaalkyldistannanes yields benzylic stannanes in fair to good yields. (169) Propargyl halides have not generally been used as substrates in the Stille reaction. Propargyl bromide couples to some stannanes to yield allene derivatives. (170) The coupling of benzylic bromides containing  $\beta$  hydrogens takes place smoothly, without substantial  $\beta$  elimination, in the presence of the catalyst (2,2'-bipyridine) fumaronitrile palladium(0) (Eq. 31) (171). Further applications of

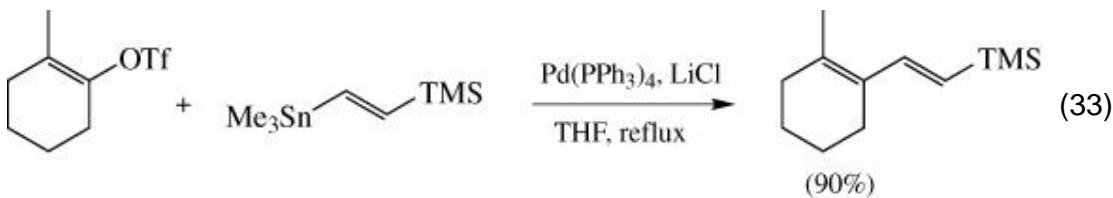


this interesting catalyst to other cross-coupling chemistry have not been reported. Finally, a nice application of this coupling to natural product synthesis is found in an approach to furanocembranolides (Eq. 32). (172)

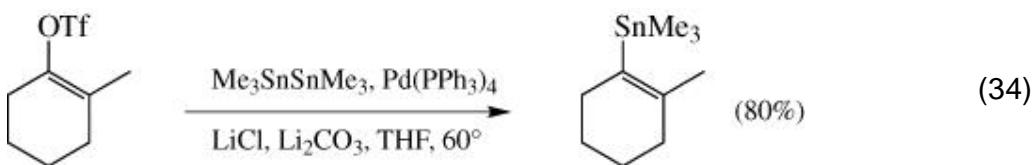


### 3.5. Alkenyl Sulfonates and Other Electrophiles

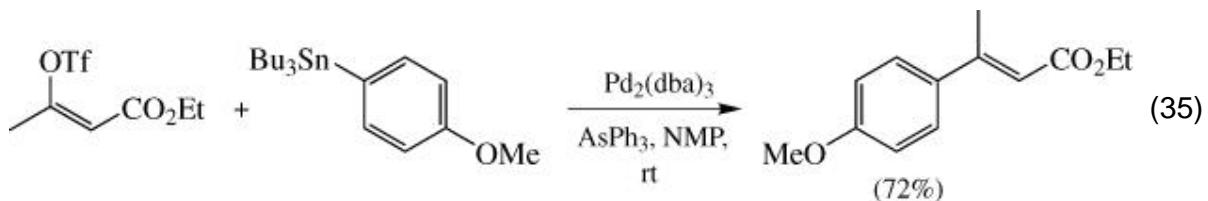
The coupling of vinyl sulfonates is, in general, limited to triflates. In a few special cases where extra activation is present, mesylates (173) and tosylates (174) can be used, but these substrates have limited utility and are not discussed further. The coupling of vinyl triflates with organostannanes is a truly general reaction of paramount importance in organic synthesis, owing in part to the ready availability of isomerically pure alkenyl triflates. (175) An initial study shows that the coupling takes place in high yield in THF with alkenyl-, alkynyl-, and allylstannanes, but arylstannanes do not react. (28) The reaction requires addition of excess LiCl (Eq. 33).



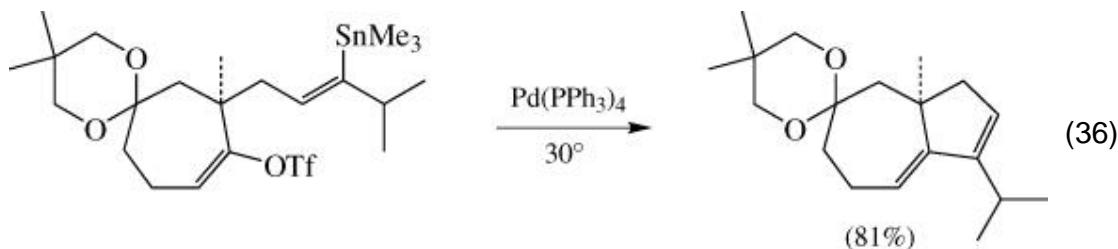
The reaction of alkenyl triflates with hexamethyldistannane constitutes an important approach to alkenylstannanes (Eq. 34). (176)



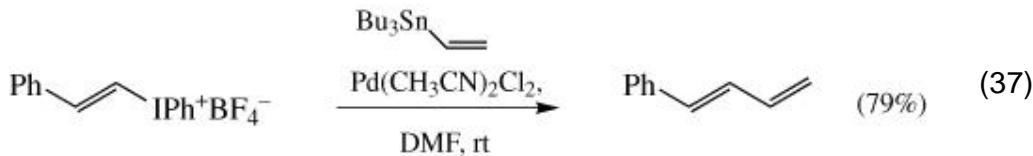
A more recent study has shown that even arylstannanes couple smoothly under optimized conditions, using the “soft” ligand  $\text{AsPh}_3$  and highly polar solvents such as NMP. (30) A careful reexamination of the  $\text{LiCl}$  effect has shown that this additive is often unnecessary for the reaction to proceed if one operates in NMP as solvent.  $\text{LiCl}$  is generally an inhibitor of the reaction in NMP when strong ligands ( $\text{PPh}_3$ ) are used, but has little effect on the rate when “soft” ligands ( $\text{AsPh}_3$ ) are employed. For a discussion of this complex behavior, the reader is referred to the mechanistic section. *E/Z* isomerization of the product can be a problem with these couplings (Eq. 35). (30) Use of  $\text{CuI}$  as a cocatalyst often reduces such isomerization. (177)



The intramolecular version of this reaction has been developed. The cyclization precursors were assembled using an array of tin-containing bifunctional synthons developed for this purpose. A variety of small- and medium-size rings was assembled, and applications to the total synthesis of terpenoids were reported. (31,69,178–183) Once again,  $\text{LiCl}$  behaved as an inhibitor of the coupling. An example of this powerful methodology is shown in Eq. 36. (184) An extension to macrocyclizations is reported. (185, 186)

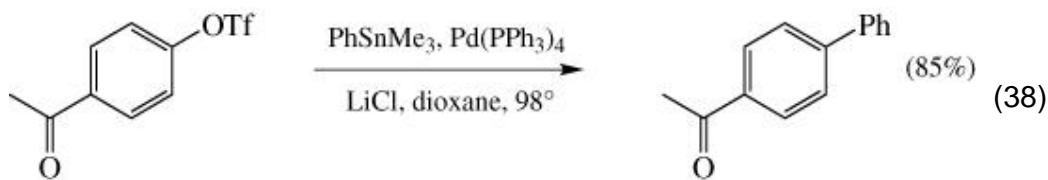


Alkenyl phenyliodonium salts also couple with alkenylstannanes under mild conditions, as shown in Eq. 37. (187, 188)

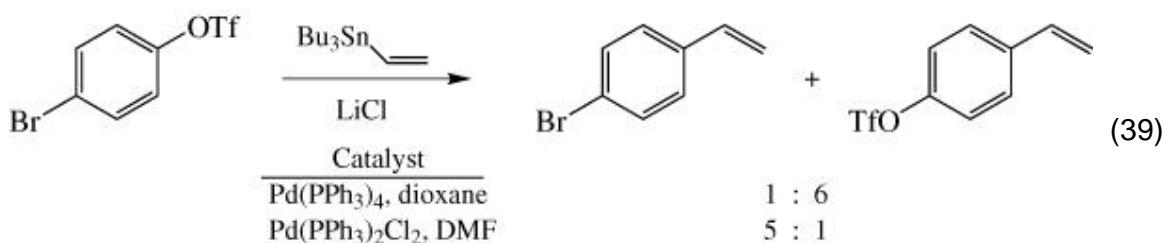


### 3.6. Aryl and Heterocyclic Sulfonates and Other Derivatives

The Stille coupling of aryl triflates has been extensively studied. In the presence of LiCl, these substrates couple with alkyl-, alkenyl-, allyl-, alkynyl-, and arylstannanes in high yields under relatively harsh conditions (ca. 100°). Dioxane and DMF are the solvents of choice. Equation 38 shows a typical example. (189)



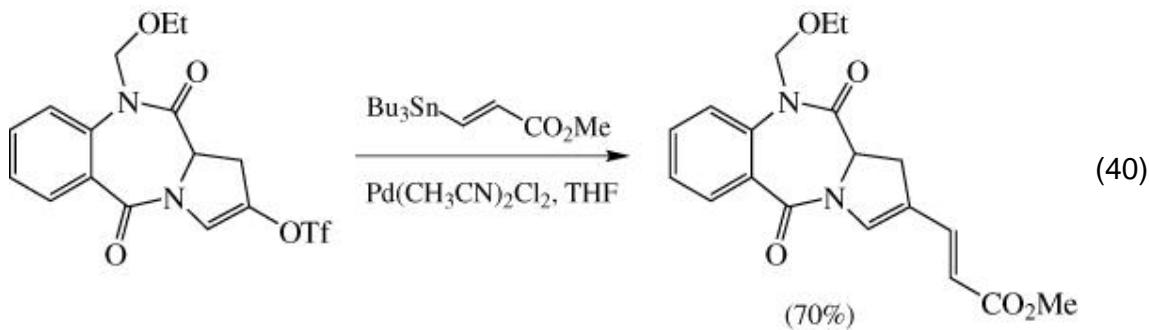
Aryl triflates are less reactive than aryl iodides, but their reactivity is comparable to that of aryl bromides. A direct competition experiment showed that product distribution depends strongly on the coordinative level of the catalyst used (Eq. 39). Unfortunately, no firm conclusions can be drawn about the mechanistic



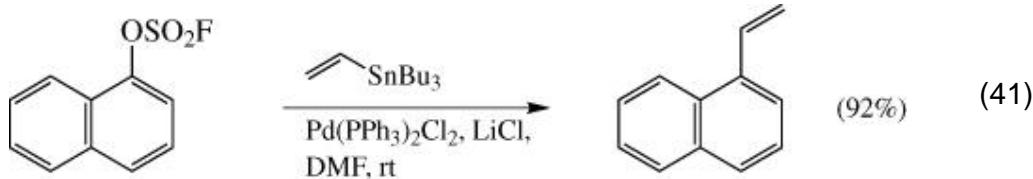
basis for this dichotomy, since the two catalysts were used in different solvents, and it is likely that the solvent is also a key factor in the ease of oxidative

addition. (30) Ether, nitro, amido, and carbonyl groups (even aldehydes) are tolerated on the aryl triflate. Because of the harsh conditions employed, double bond migrations and isomerizations are recurring problems. As for vinyl triflates, a reexamination of the reaction showed that the coupling of aryl triflates is best carried out in NMP with  $\text{AsPh}_3$  as ligand. In this solvent,  $\text{LiCl}$  reduces the coupling rate, but is sometimes beneficial to catalyst stability. An *ortho* methyl group on the aryl triflate slows the coupling by a factor of 3. (30)

Separate studies have shown that electron-rich aryl triflates also couple in good yields, especially with  $\text{Cu(I)}$  cocatalysts. (190, 191) Both 1- and 2-naphthyl triflates couple as expected, (192) as do indolyl, (193) quinolyl, and isoquinolyl triflates. (194, 195) Pyrimidyl triflates couple with organostannanes in good yields. (196) Among the derivatives of medicinal interest as targets, one must note the utility of the coupling of cephem, (40) carbacephem, (197) and carbapenem (198) triflates with stannanes for the synthesis of antibacterial  $\beta$ -lactams, the coupling of uridine triflates with stannanes, (199) and an application to the synthesis of anthramycin (Eq. 40). (200)

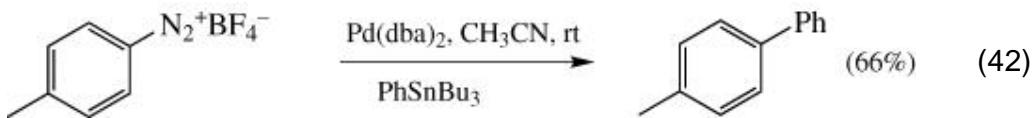


In addition to triflates, other sulfonates can be used, including long-chain polyfluorinated sulfonates, (29, 201) *p*-fluorophenyl sulfonates, (202) and fluorosulfonates. (203) The last appears to be of practical utility, considering the low cost of fluorosulfonic acid vs. the expense of triflic acid (Eq. 41).



Among the aryl electrophiles, diazonium salts participate in the Stille coupling

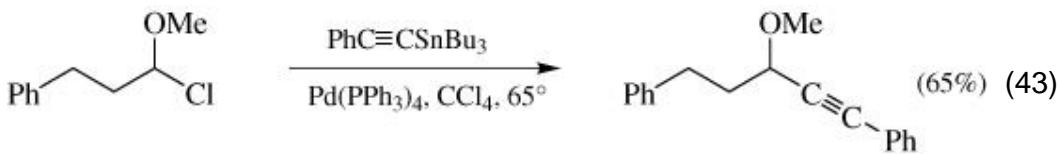
with alkenyl-, alkyl-, and arylstannanes, and an example is shown in Eq. 42. (204) Given their ready availability, the under-utilization of these substrates is hard to understand.



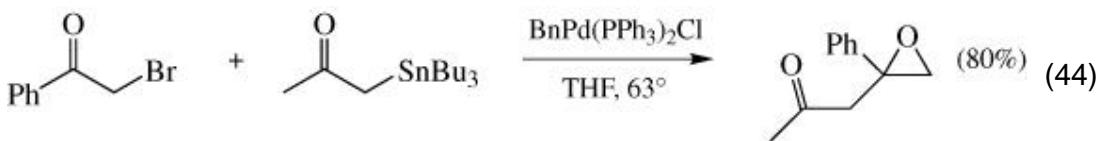
Even some ether derivatives, notably some *pseudo-saccharyl* O-ethers, couple with stannanes in low to fair yield, especially under Ni(0) catalysis, but this reaction is restricted to tetramethylstannane so far, and therefore its scope is still to be fully explored. (205) Diaryliodonium salts also participate in the Stille reaction. (206)

### 3.7. Miscellaneous Electrophiles

Alkyl halides do not normally cross-couple with organostannanes, but some  $\alpha$ -activated substrates do undergo the Stille coupling. Among them, the  $\alpha$ -halo ethers and  $\alpha$ -halo thioethers couple smoothly, even if  $\beta$  hydrogens are present (Eq. 43), (207) whereas  $\alpha$ -halolactones couple with allylic and acetonyl stannanes. (208)

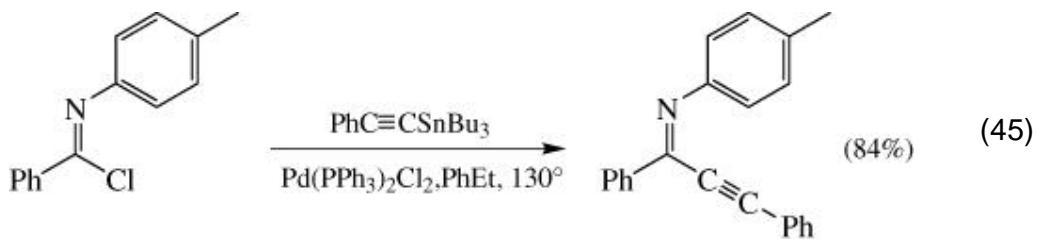


$\alpha$ -Halocarbonyl compounds react with allyl and acetonyl stannanes in an anomalous fashion, i.e., by attack at the carbonyl followed by oxirane formation (Eq. 44). (209)

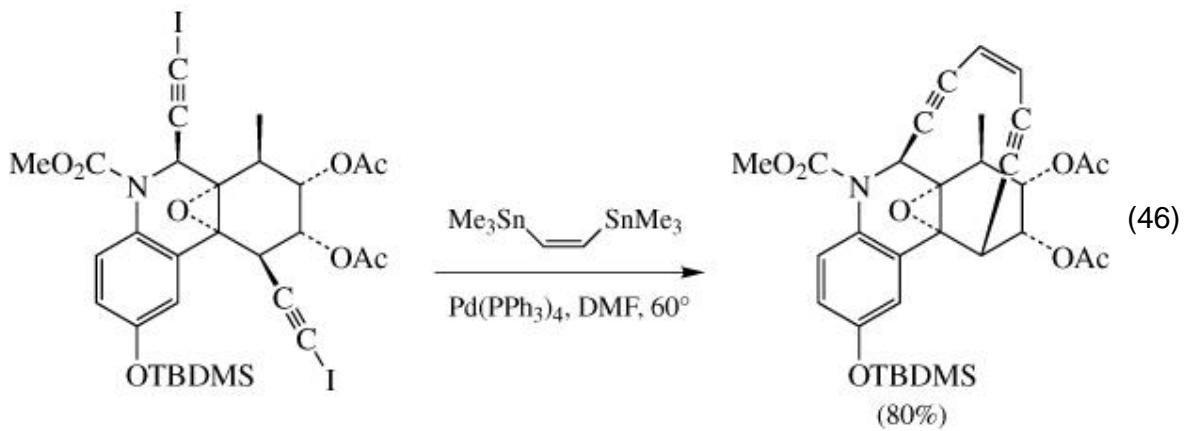


Perfluorinated alkyl iodides, in which  $\beta$ -hydride elimination after oxidative addition is impossible, couple with stannanes in good yields, although the reaction is proposed to be radical mediated. (210) Imidoyl chlorides couple with stannanes in low to fair yields, thus providing a route to imines from

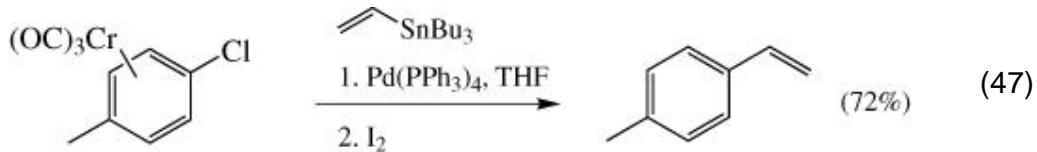
amides. An example is shown in Eq. 45. (211) Alkynylstannanes react in particularly good yields. (212)



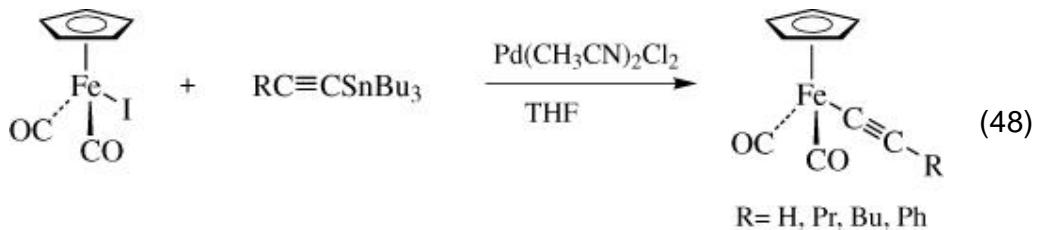
Although no general study has appeared on the use of alkynyl halides in the Stille reaction, sporadic but useful applications of these electrophiles have been recorded. (213-215) A remarkable result is reported in a dynemicin total synthesis (Eq. 46). (216)



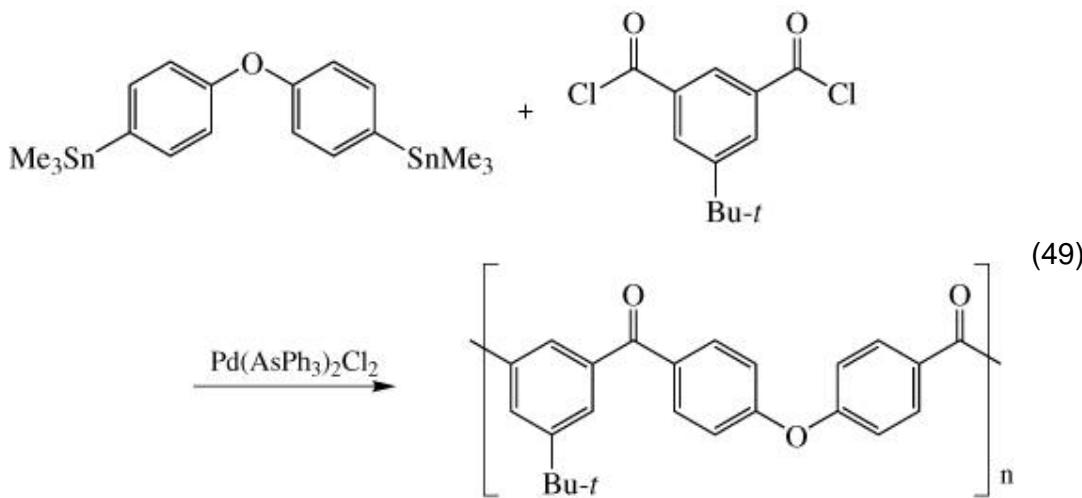
Many examples of arene or polyene metallocarbonyls in the Stille cross-coupling have been reported. (217-226) The purpose of the metallocarbonyl moiety is often to activate the aryl electrophile toward oxidative addition, as in Eq. 47. (227)



Several heteroatom-halogen bonds can be activated toward coupling by Pd(0) catalysts, including P-Cl, (228) S-Cl, (229) and Fe-I bonds. (230) The last appears to be the first example of the formation of a transition metal-carbon bond under the catalysis of a Pd(0) complex. An example is shown in Eq. 48. (231)



Bifunctional electrophiles and stannanes, when coupled, usually give rise to polymeric materials. Many examples of this strategy have been reported, as is evident from Table XXXI. A typical example is shown in Eq. 49. (232)



## 4. Scope and Limitations: The Stannane

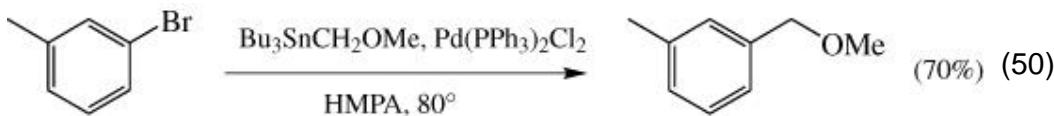
Unfortunately, most studies on the Stille reaction emphasize a specific type of electrophile, and very few studies examine a particular class of stannanes. General studies of stannane reactivity are therefore lacking. It is impossible to discuss all examples in which a particular type of stannane has been used. In this section we attempt to focus on a limited number of more general papers in an effort to delineate the current scope and limitations in the use of stannanes for the Stille reaction.

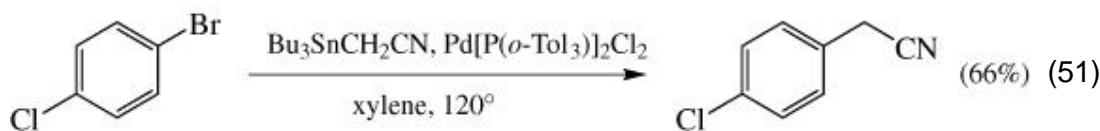
### 4.1. Alkylstannanes

It is generally accepted that transfer of alkyl groups from tin is much slower than that of unsaturated substituents.<sup>(6)</sup> Indeed, it is this property that makes the methyl and especially the butyl group such excellent “dummy,” i.e., “nontransferable,” ligands. Nevertheless, in many cases coupling of tetraalkylstannanes occurs in high yields at elevated temperatures. Among the tetraalkylstannanes, tetramethylstannane and tetrabutylstannane are most often used, the former being more reactive. The coupling of these stannanes with aryl and benzyl halides is carried out in HMPA and proceeds in good yields.<sup>(19)</sup> Use of triphenylarsine as ligand facilitates the coupling of these sluggish nucleophiles with aryl triflates.<sup>(30)</sup>

One of the problems associated with the coupling of symmetrical tetraalkylstannanes is that only the first alkyl group is transferred at a sufficient rate to be of synthetic utility,<sup>(6)</sup> successive transfer becoming more and more difficult with increasing halogen substitution at tin. The need therefore arises for the use of “dummy” ligands; selectivity in the transfer of alkyl groups, however, is quite poor. In special cases, when the alkyl group is activated by particular substituents, some selectivity may be observed. Thus, benzyl trialkylstannanes selectively transfer the benzyl group<sup>(27)</sup> with inversion of configuration at carbon. The reaction is facilitated by electron-withdrawing substituents on the aryl ring of the stannane.

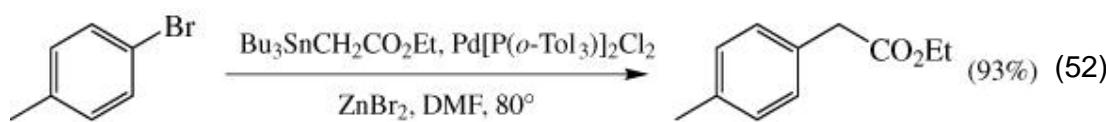
Other activated stannanes have been coupled successfully, including transfer of hydroxymethyl,<sup>(233)</sup> methoxymethyl,<sup>(234)</sup> and cyanomethyl<sup>(235)</sup> groups onto a number of aryl bromides (Eqs. 50 and 51).



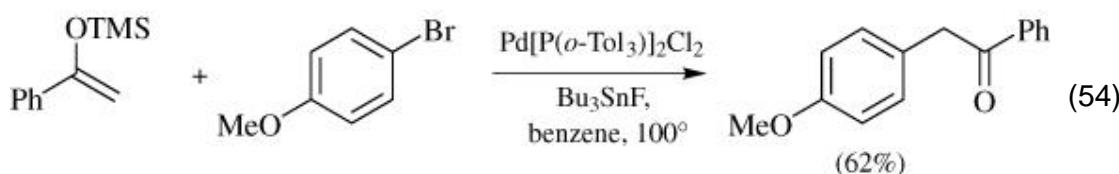
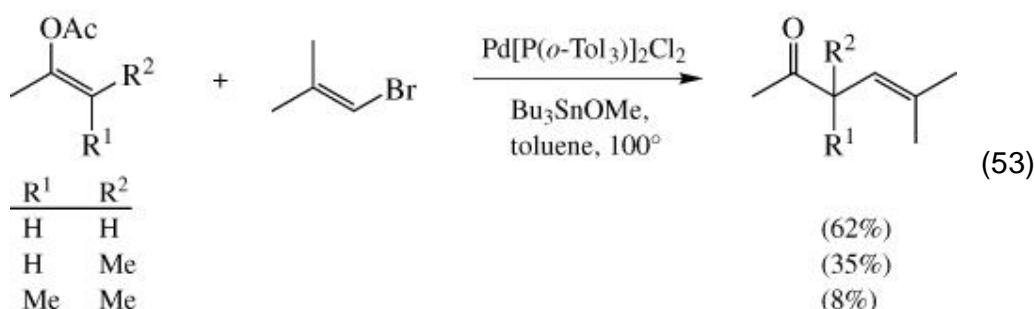


The successful coupling of ethyl  $\alpha$ -(tributylstannyl)acetate is reported; the addition of Zn(II) salts is needed for optimum results (Eq. 52). (236)

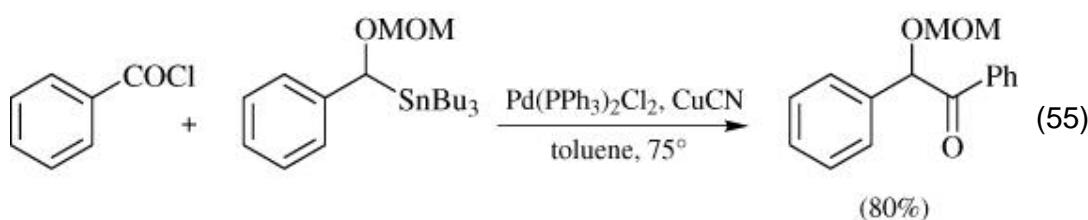
Unfortunately, in none of these studies was a quantitative assessment carried out regarding the transfer selectivity of the activated alkyl vs. the “dummy” butyl group.



Acetylation is also possible using acetyltributylstannane, (237) but in general these  $\alpha$ -stanny ketones are unstable, and their coupling is best carried out by generating them in situ from enol acetates (238-240) or enol silanes. (241) This reaction amounts to a net  $\alpha$ -arylation (or alkenylation) of enolates, a rather difficult operation. The above methodology, however, is limited: Only methylene enolates are arylated in good yields, whereas more substituted derivatives couple poorly (Eqs. 53 (240) and 54 (241)). Further synthetic studies in this important area are warranted.



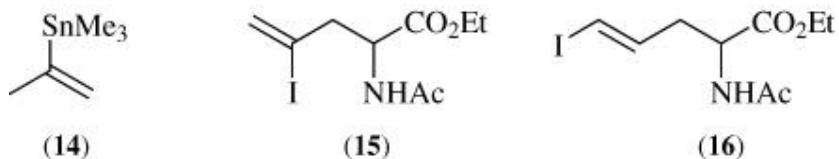
Cyclopropyltributylstannane transfers the cyclopropyl group in low yield. (126) The coupling of  $\alpha$ -amino- and  $\alpha$ -alkoxystannanes (242) with acyl chlorides takes place in good yields and with retention of configuration at the  $sp^3$  carbon of the stannane, provided Cu(I) salts are added as cocatalysts (Eq. 55). (243) The intermediacy of an organocupper species has been implicated. 4-(Tributylstannylyl)-2-azetidinones also couple with acid chlorides. (244)



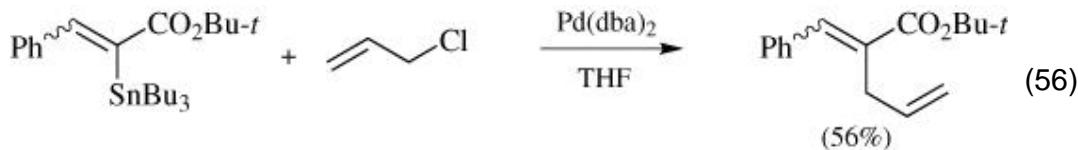
An important advance in the selective transfer of alkyl groups from tin has been reported. (41) Using alkylstannanes **10**, selective transfer of alkyl groups, including sec-butyl and  $\alpha$ -trimethylsilylmethyl, is achieved under rather mild conditions. Further research is needed to expand the synthetic utility of systems containing a substituent capable of triggering pentacoordination at tin.

## 4.2. Alkenylstannanes

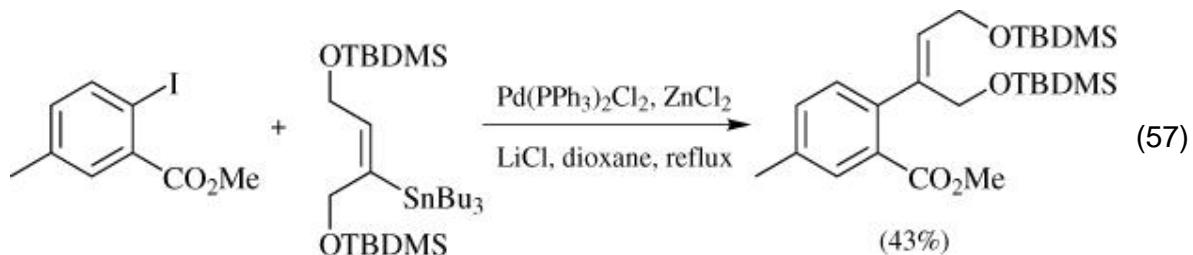
The coupling of alkenylstannanes with a variety of electrophiles is a quite general reaction, and it is difficult to find specific limitations in the literature. Some failures, however, have been reported. Most studies on the cross-coupling of alkenylstannanes are limited to readily accessible 1,2-disubstituted substrates. These couple efficiently and often with good stereospecificity. (47) More heavily substituted or more complex stannanes couple sometimes with difficulty or not at all. In particular, alkenylstannanes that bear another substituent *a* to tin appear difficult to couple. For example, stannane **14** does not couple with internal alkenyl iodide **15**, but couples normally with its terminal isomer **16**. (244a) This difference is most likely due to steric hindrance.



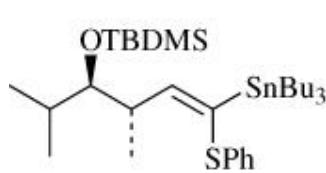
Methyl  $\alpha$ -(tributylstannyly)acrylates couple abnormally with iodobenzene, owing to their tendency to yield cine-substitution products (vide infra). (245) Normal *ipso* reactivity is restored by the addition of Cu(I) salts. (246)  $\beta$ -Substituted  $\alpha$ -(tributylstannyly)acrylates, however, couple normally with both acyl chlorides (247) and allylic halides (Eq. 56). (248) Evidently, the  $\beta$  substitution dramatically slows the cine-substitution process.



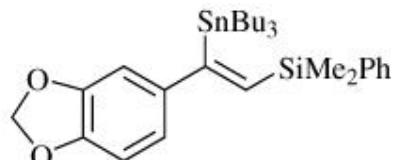
$\alpha$ -Styrylstannanes yield cine substitution when coupled with aryl diazonium compounds (vide infra), (249) but can be coupled with acyl chlorides without side reactions. (250) Again,  $\beta$  substitution restores normal Stille reactivity, although in poor yield. (251) In general, densely substituted stannanes react poorly, and their coupling must be carefully optimized. An example from the total synthesis of lacrimin A is shown in Eq. 57. (252)



Examples where every attempt to induce coupling fails include stannanes 17 (253) and 18. (51) Other stannanes with seemingly comparable steric hindrance, however,

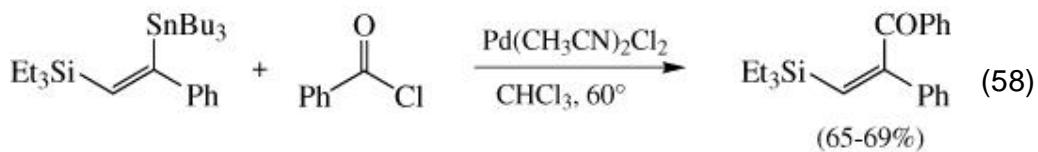


(17)

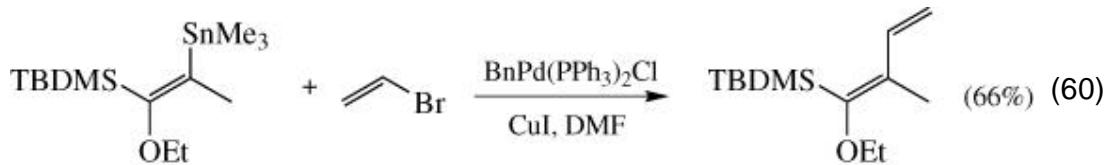
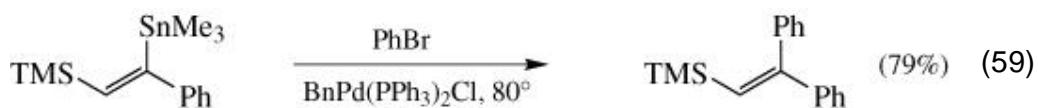


(18)

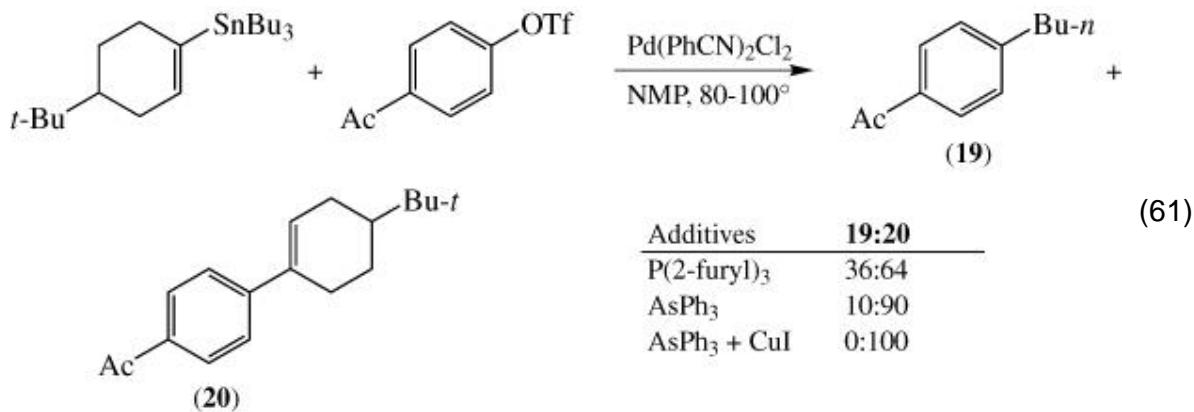
couple under standard conditions. For example,  $\alpha$ -trialkylsilyl substitution in alkenyltrimethylstannanes prevents Stille coupling with allyl halides because the methyl groups on tin transfer more rapidly. (254) However, 1-triethylsilyl-2-trialkylstannylyl-1-alkenes similar to **18** can be coupled with acyl halides (Eq. 58). (255)



$\alpha$ -Phenyl and  $\alpha$ -methyl substitution of olefinic stannanes does not seem to hinder Stille coupling in some cases (Eqs. 59 (49) and 60 (256)). The latter coupling, however, is successful only in the presence of cocatalytic copper. This may represent a general solution to the problem of coupling hindered alkenylstannanes.

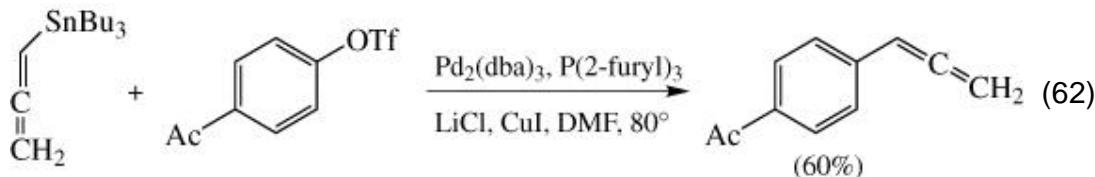


Another example of this trend is shown by the difficult coupling of cyclohexenylstannanes with aryl triflates. Butyl transfer is an important side reaction here, unless one employs cocatalytic copper (Eq. 61). (33)



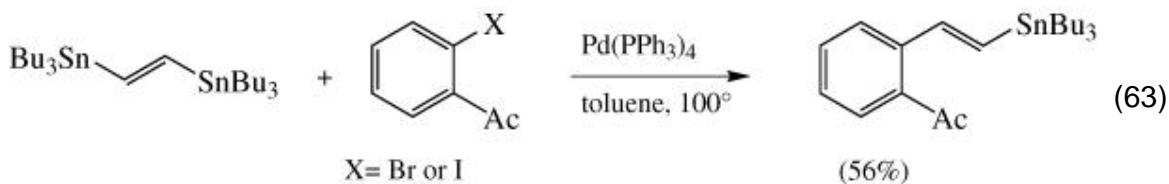
In general, 1-tributylstannylic cycloalkenes couple very sluggishly under Stille conditions, (257, 258) and the reason must be attributed to some type of steric hindrance.  $\beta$ -Stannyl enones, (259)  $\beta$ -sulfonyl alkenylstannanes, (260) and 3-(or 4-) tributylstannyl-2-(5H)-furanones (261) have been made the objects of special investigations. In each case coupling with electrophiles is successful. Other types of alkenylstannanes that have been separately investigated include a variety of fluorinated alkenyl stannanes, (262-266) cyclobutenedione, (267) and cyclobutenedione (12, 64, 268) stannanes.

$\alpha$ -Alkoxy-substituted alkenylstannanes seem to be especially reactive partners in the Stille reaction. (269-271)  $\beta$ -Alkoxyalkenylstannanes have also been coupled successfully. (272-274) Polyunsaturated alkenylstannanes have been studied in a few sporadic cases. Thus, allenylstannanes couple with aryl iodides (275) and triflates in modest yields (Eq. 62). (276) With allylic electrophiles, these stannanes



yield propargylic derivatives, the result of allylic inversion. (165) A variety of dienyl- (277) and ynenyl- (278) stannanes have also been coupled with a number of electrophiles. 1,1-Distannylalkenes have been coupled with allylic halides, double substitution being the result. (254) With 1,2-bis(stannyl)ethylenes, on the other hand, monocoupling can be controlled to produce substituted alkenylstannanes. A large excess of the bis(stannane) is not necessary, because the first cross-coupling is faster than the second

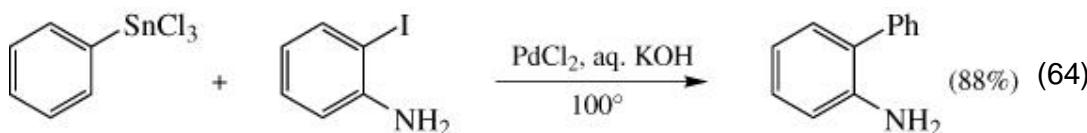
one. The second coupling can be carried out under more forcing conditions (Eqs. 13 and 63 (279)).



### 4.3. Aryl and Heterocyclic Stannanes

Arylstannanes couple readily with a variety of electrophiles. Both electron-withdrawing and electron-releasing substituents on the aryl ring can accelerate coupling, an indication of a dual mechanism for the transmetallation (see mechanistic section). (30) In general, however, electronic effects in the transmetallation are minor. On the other hand, steric effects can be important. An alkyl group *ortho* to the tin residue can slow the coupling by a factor of ca. 20. An *ortho* methoxy group, which is sterically much smaller, leads to only a 2-fold rate reduction. (30) In general, therefore, coupling with *ortho*-substituted arylstannanes can be difficult, and substantial transfer of the dummy ligand can take place (see section on side reactions). This problem has been tackled successfully by using Cu(I) salts. Under these conditions aryl group transfer is exclusive. (30, 280)

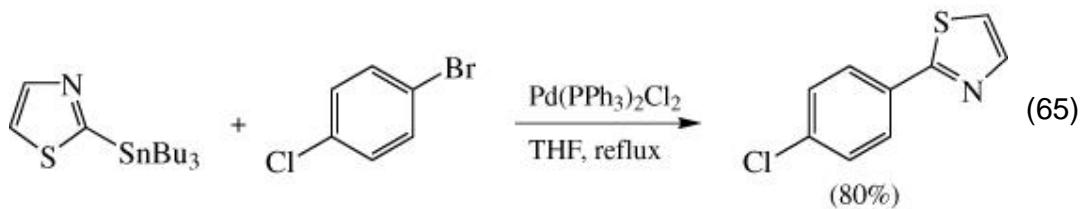
Aryl trichlorostannanes have been used as coupling partners in aqueous media employing vigorous conditions, (281) under which the tin-chlorine bond is probably hydrolyzed to a tin-hydroxy species, because coupling does not take place in organic media (Eq. 64). (282) This protocol obviates the use of organic solvents, but



appears limited to water-soluble electrophiles. In a similar vein, tetrabutylammonium difluorotriphenylstannate can be used to transfer a phenyl group onto vinyl triflates. (283)

Pyridyl-, quinolyl-, and isoquinolylstannanes have been the objects of separate studies. They couple smoothly with acyl chlorides. (284, 285) Electron-rich heterocyclic stannanes, such as the 2-furyl-, 2-thienyl-, 2-pyrrolyl-, and

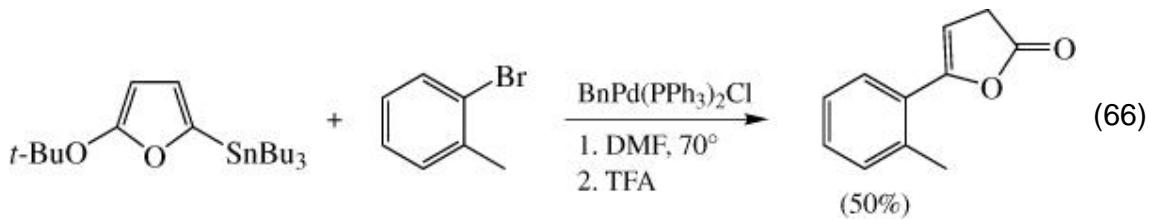
2-thiazolylstannanes, couple with aryl halides under rather mild conditions. An example is shown in Eq. 65. (286)



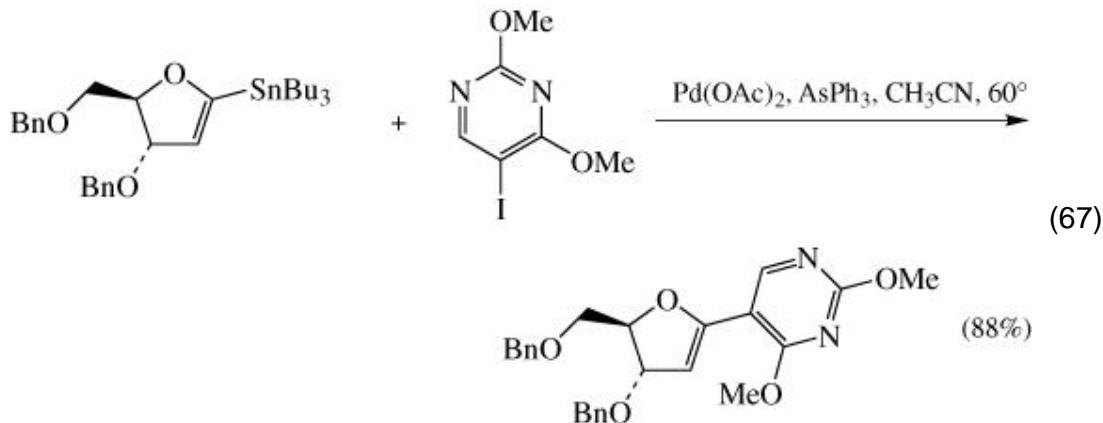
3,4-Distannylfurans have been studied in great detail as bifunctional reagents, (287) and 3-stannylfurans have been used as substrates with acyl chlorides. (288) 2-Stannyl- (289, 290) and 3-stannylindoles (291) have also been coupled with a variety of electrophiles. 5-Isoxazolylstannanes have been coupled with aryl iodides. (292, 293)

2-Tributylstannylfuran couples with a number of  $\alpha$ -chlorocyclobutenones in low yields, and it is postulated that this is due to further attack of the electrophile on the 5 position of the heterocycle, which is very electron-rich. These electrophilic palladations of electron-rich heteroaromatics are indeed precedented. (294) However, 5-trimethylsilyl-substituted stannylfurans couple in excellent yields. (295)

Equation 66 shows the application of the Stille reaction to the synthesis of 5-substituted furanones. (296)

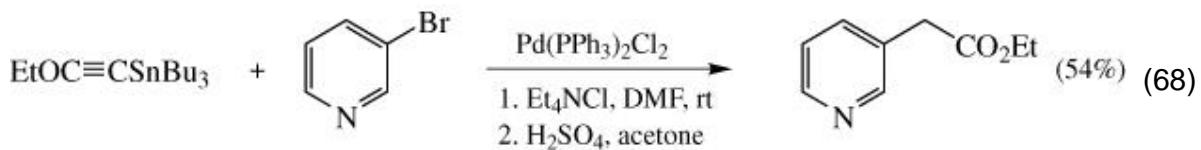


Couplings of nonaromatic, heterocyclic stannanes are often found in the literature. A popular target has been  $\alpha$ -substituted glycals. (297-300) One example is shown in Eq. 67. (301)



#### 4.4. Alkynylstannanes

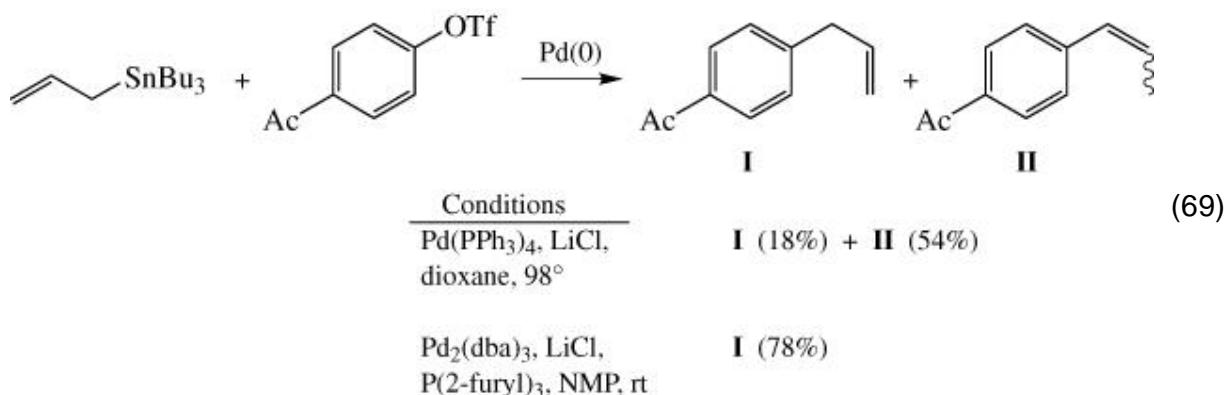
Alkynylstannanes couple smoothly with a variety of electrophiles, including alkenyl halides. (47) This class of stannanes is the most reactive of all, according to Stille, (6) and few limitations exist. Alkoxy-substituted alkynylstannanes have been used in an interesting approach to  $\alpha$ -aryl and heteroaryl acetates (Eq. 68). (302)



In general, although these stannanes are quite reactive, their use in cross-coupling chemistry is often unnecessary, since terminal alkynes couple directly with organic electrophiles using a palladium catalyst, cocatalytic copper, and amines as bases (Sonogashira coupling). (303)

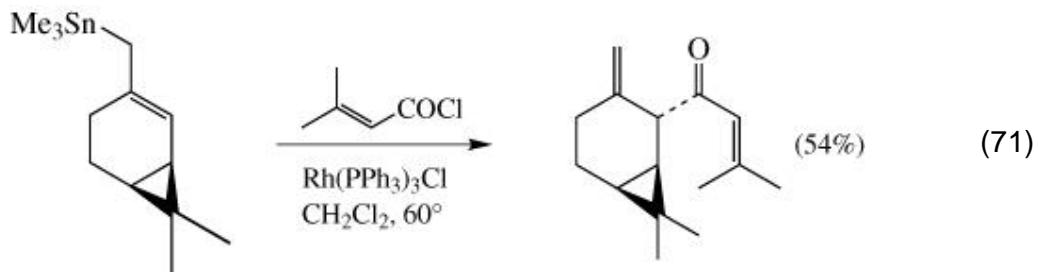
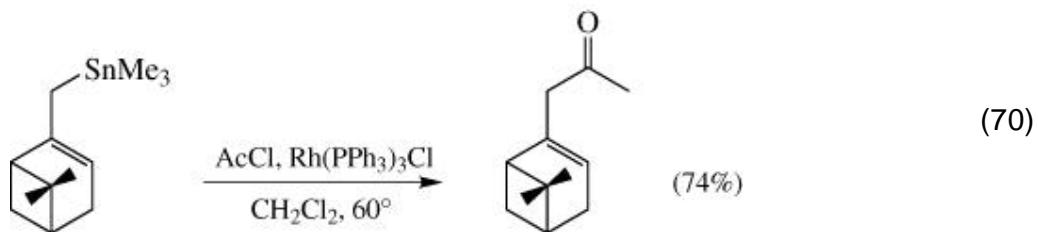
#### 4.5. Allylstannanes

Allylstannanes have been underutilized in the Stille coupling, presumably because of the difficulties with the synthesis of regiochemically defined substrates and their tendency to undergo allylic isomerization, thus making it hard to predict the regiochemistry of the coupling. Simple allylic stannanes couple more slowly than alkynylstannanes, (6) but at acceptable rates in most cases. One problem that has been documented with allylstannanes is the tendency of the double bond to move into conjugation after coupling, especially in reactions with acyl halides (146) and aryl triflates. (189) This can sometimes be prevented by operating at lower temperatures using tri(2-furyl)phosphine as the palladium ligand (Eq. 69). (11)



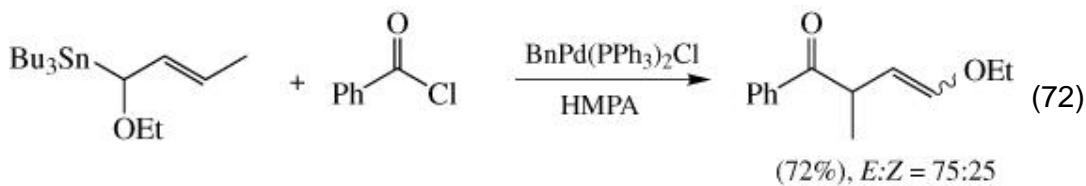
$\gamma$  position, and not enough data are presented in the literature to draw firm conclusions. (2) Thus, crotyltrimethylstannane couples with acyl chlorides to yield a 1:1 mixture of  $\alpha$  and  $\gamma$  products, but the product resulting from  $\gamma$  attack predominates at lower temperatures. (146)

Terpenic allylstannanes undergo regioselective Rh-catalyzed acylation at the  $\alpha$  or  $\gamma$  position, depending on the structure of the substrate (Eqs. 70 and 71). (150, 304)



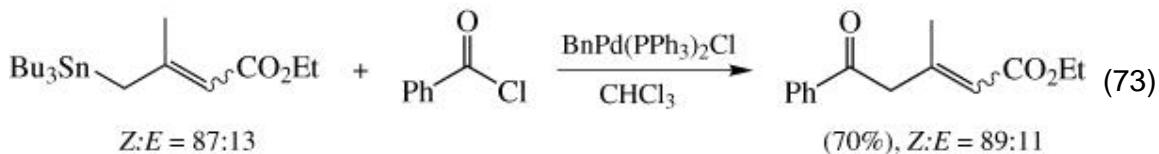
A few special classes of allylstannanes have been described as substrates for

the Stille reaction. An interesting one is shown in Eq. 72. (305) Thus,  $\alpha$ -alkoxyallylstannanes



couple with acyl chlorides to yield the allylically inverted  $\beta$ ,  $\gamma$ -unsaturated ketones, which can be further converted to 1,4-dicarbonyl compounds by acid hydrolysis.

On the other hand,  $\gamma$ -carbalkoxy-substituted allylstannanes undergo selective coupling at the  $\alpha$  position with alkenyl, aryl, and acyl halides (Eq. 73), but only at



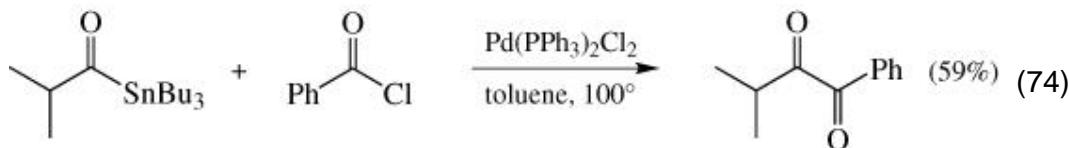
the  $\gamma$  position with allylic electrophiles. (306) This confirms early results, in which allylstannanes were coupled with allylic electrophiles with predominant allylic inversion. (35, 36) Further aspects of this reaction are discussed in the mechanistic section.

The use of an allylic bis(stannane) as an annulation reagent has already been discussed (Eq. 23).

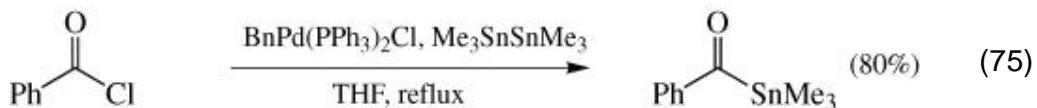
In conclusion, although allylstannanes are useful partners in the Stille reaction, they have been used infrequently, probably because the regiochemistry of the coupling is still unpredictable. This area certainly deserves further in-depth research.

#### 4.6. Other Stannanes

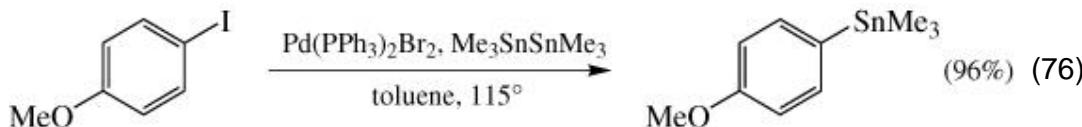
Acylstannanes have been coupled in a few cases with acyl chlorides to provide unsymmetrical  $\alpha$ -diketones (Eq. 74). (307) A CO atmosphere may help to prevent decarbonylation.



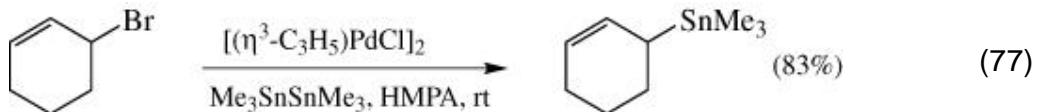
Distannane derivatives are useful reagents in conjunction with a variety of electrophiles. Upon reaction with acyl halides, they yield mixtures of symmetrical ketones and  $\alpha$ -diketones. Diketones predominate under a CO atmosphere. (308) Under suitable conditions, the reaction stops at the acylstannane stage, and this is preparatively useful (Eq. 75). (309)



The couplings of hexamethyl- and hexabutyldistannanes with aryl bromides and iodides, and also with benzylic bromides, are high yielding, homocoupling of the electrophile being the only detectable side reaction (Eq. 76). Most substituents on the aryl ring are tolerated except *p*-amino and *p*-nitro. Under these conditions, allyl and alkenyl halides give the corresponding stannanes in low yields. (169)

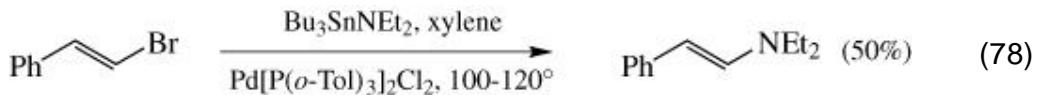


The coupling of distannanes with aryl halides has been studied independently, (310, 311) and another investigator found that some of the above limitations can be overcome by using “ligandless” conditions. (312, 313) A problem with this protocol is, however, disproportionation of the distannane, and an excess of the reagent must be used. A typical example of this protocol as it applies to allylic acetates, bromides, and chlorides is shown in Eq. 77. (314) Nickel catalysis has also been used in this reaction. (315)

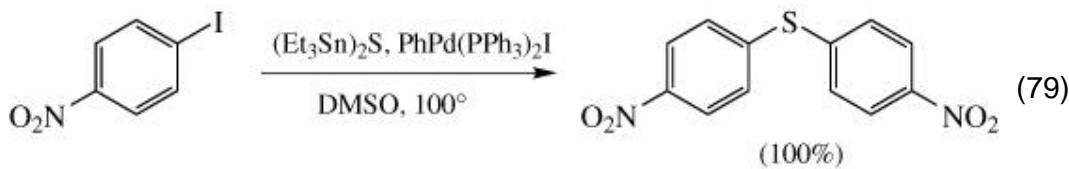


The reaction of distannanes with vinyl triflates is an important route to regiochemically and geometrically defined vinylstannanes, as previously shown (Eq. 34). (176) Even some activated vinylic chlorides couple with hexamethyldistannane. (260)

Aminostannanes react with electrophiles, such as aryl and alkenyl bromides, in variable yields (Eq. 78). (90, 316) This process was recently reinvestigated and improved, (91, 92) as already illustrated (Eq. 15).



The formation of C-S bonds via organotin sulfides is also well preceded. Alkenyl, (317) aryl, (318) and heteroaryl halides (319) participate. An example is shown in Eq. 79. (320)



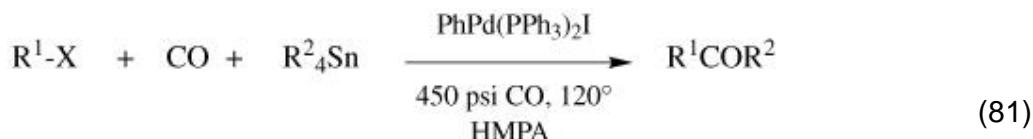
Among related reactions that have received only scant attention, (trimethylstannyly)diphenylphosphine couples with iodoaromatics to provide substituted triarylphosphines, (321) and tin alkoxides have been coupled with allylic electrophiles. (322) These methods have not been further applied to organic synthesis.

## 5. Carbonylative Couplings

When a Stille coupling is carried out under a CO atmosphere, carbonyl incorporation under catalytic conditions is possible. The reaction is general for alkenyl, aryl, heteroaryl, and allyl electrophiles (Eq. 80).



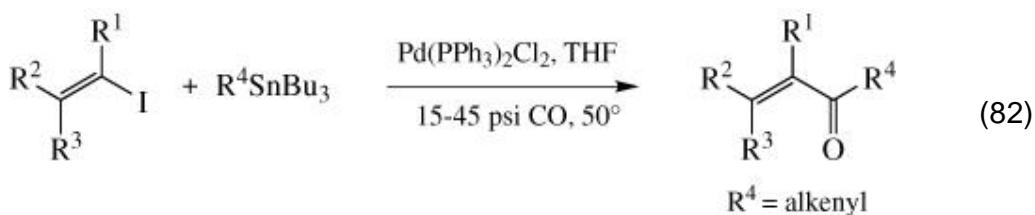
The earliest report of a successful carbonylative coupling between a stannane and an organic halide showed that several simple aryl, alkenyl, and benzyl halides could be coupled with simple stannanes under rather vigorous conditions (Eq. 81). (323) A considerable body of research has been reported as this procedure has been refined and its scope defined.



$R^1 = \text{Ph, PhCH}_2, \text{PhCH=CH, EtO}_2\text{CCH}_2$ ;  $R^2 = \text{Me, Bu, Ph}$ ;  $X = \text{Cl, Br, I}$

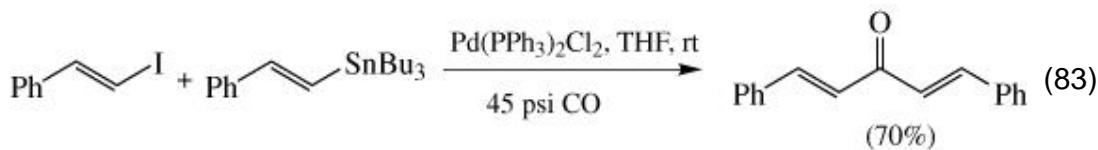
### 5.1. Alkenyl Halides

The palladium-catalyzed carbonylative coupling of alkenyl iodides with alkenylstannanes affords the corresponding dialkenyl ketones in good yield (Eq. 82). (324) The reaction takes place under neutral, mild conditions ( $40\text{--}50^\circ$ ,



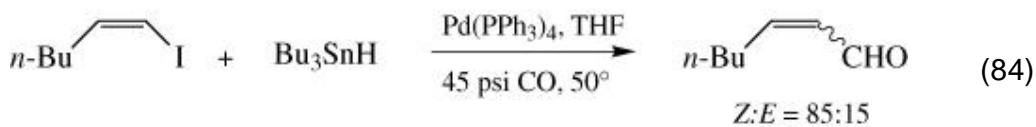
THF) and low CO pressure (1–3 atm). One may assume that all of the functional groups compatible with the standard, noncarbonylative cross-coupling reactions are also compatible with the carbonylative conditions, although no comprehensive study has been reported.

The outcome of the reaction can be sensitive to CO pressure, and slightly elevated pressures (45 psi) typically eliminate the competing direct coupling. An example can be seen in Eq. 83.  $\beta$ -Iodostyrene requires 45 psi CO for exclusive



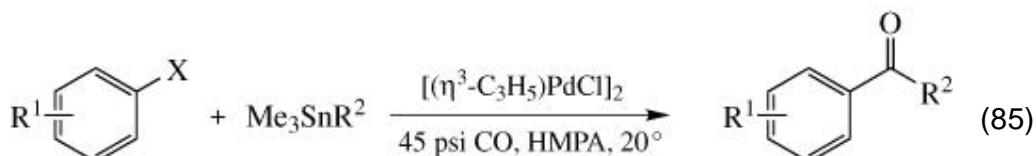
carbonylative coupling, because under 15 psi CO a 1:1 mixture of direct and carbonylative coupling products is formed. (324) Double bond isomerization can be a problem. Alkenes with *Z* geometry have a propensity to isomerize, especially under harsh reaction conditions.

Alkenyl iodides can also be transformed into the corresponding  $\alpha, \beta$ -unsaturated aldehydes through carbonylative cross-coupling using tributyltin hydride as a partner. As with ketone formation, partial *Z/E* isomerization is a problem (Eq. 84). (325)



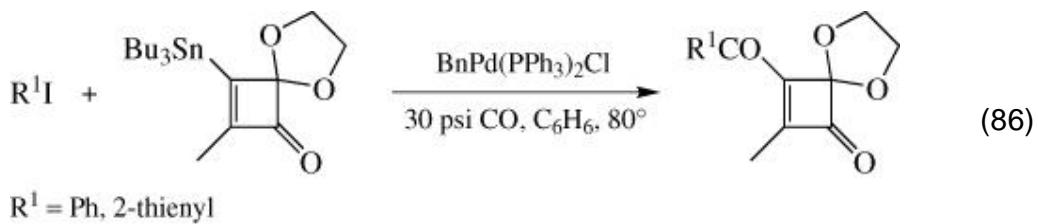
## 5.2. Aryl and Heterocyclic Halides

Aryl iodides and bromides, but not chlorides, can be carbonylatively coupled with organostannanes to furnish ketones. The number of examples in the literature for aryl iodides and bromides is limited, and although bromides couple, the yields are low. The moderate interest in aryl halides is due to the extensive versatility of aryl triflates in this coupling strategy. The protocol using “ligandless” conditions is illustrated in Eq. 85. (326, 327)

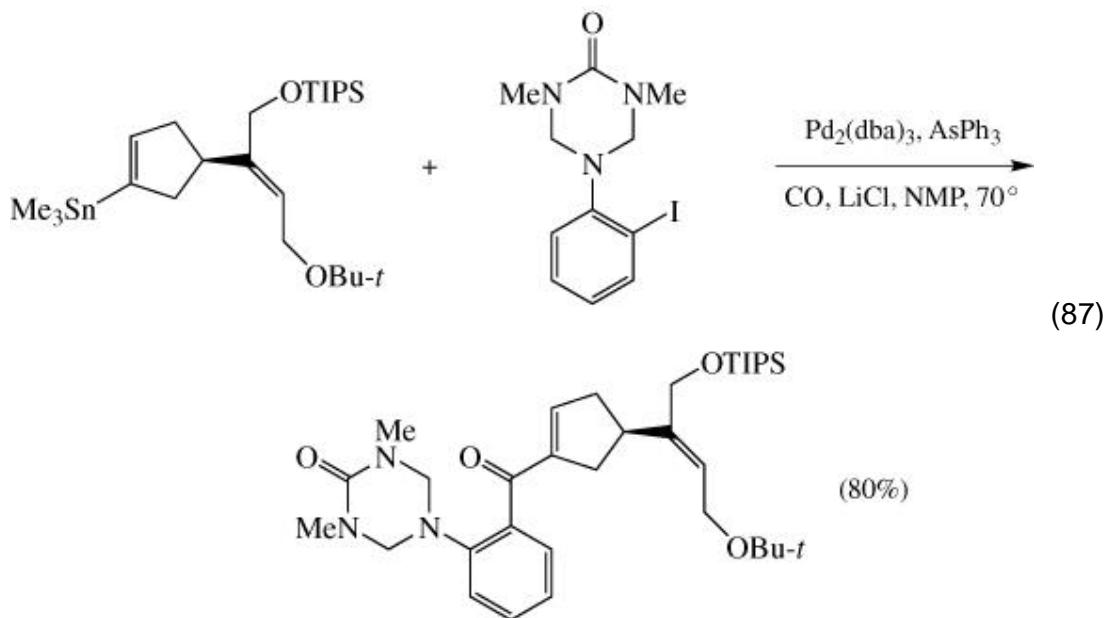


X = I, Br

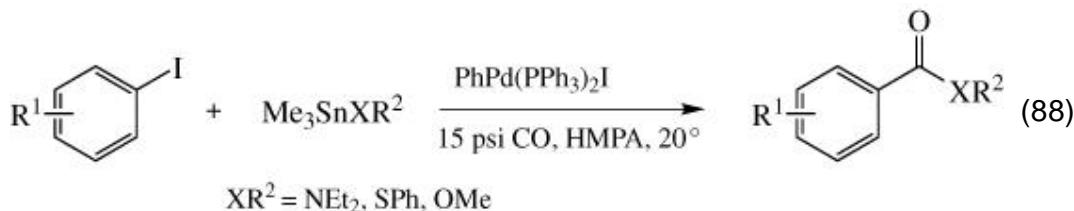
A recent example, which uses more vigorous conditions but employs a nonpolar solvent, is shown in the coupling of aryl and heteroaryl iodides with cyclobutenedionestannanes (Eq. 86). (268)



The role of additives, as well as potential ligand effects, has not been experimentally determined for the carbonylation reaction. There is a report on the beneficial effect of  $\text{AsPh}_3$  in the context of a key step in a total synthesis of strychnine (Eq. 87). (328)



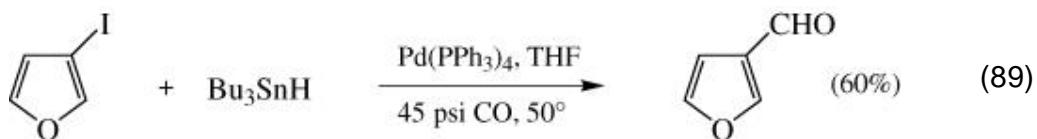
A variety of heterostannanes ( $R_3\text{Sn-OR}',-\text{SR}',-\text{NR}'_2$ ) can also be used as nucleophilic partners in the carbonylative Stille reaction (Eq. 88). (329, 330)  
Esters and



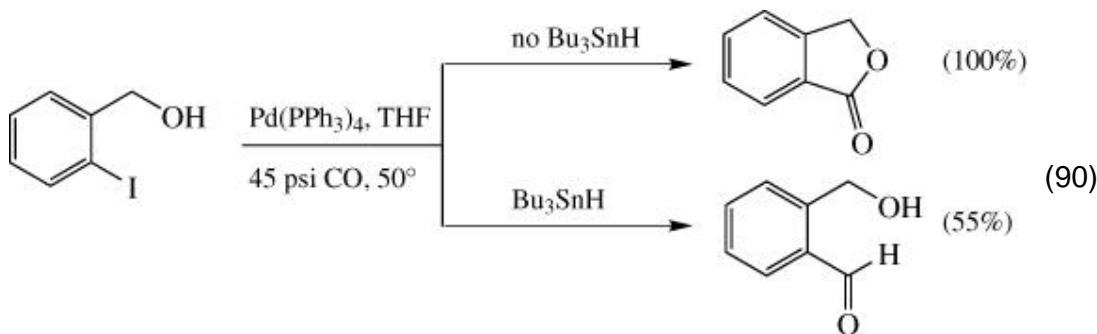
amides are formed under mild conditions using HMPA as solvent.

Electron-withdrawing groups on the aromatic ring appear to slow down CO insertion, and when such functional groups are present, there is competing direct coupling between the aryl moiety and the heterostannane.

The formylation of aryl iodides appears to be a general process. Aryl bromides furnish the desired aldehydes in moderate to low yield. A competing side reaction is direct reduction of the halide. Aryl iodides containing electron-releasing groups are formylated under 15 psi CO, whereas those containing electron-withdrawing groups need at least 45 psi CO to minimize reduction. Slow addition of tributyltin hydride to the reaction mixture under CO pressure is necessary in order to optimize the ratio of aldehyde to reduced product. A single example using 3-iodofuran demonstrates that heterocycles can also be formylated in this manner (Eq. 89). (325, 331)

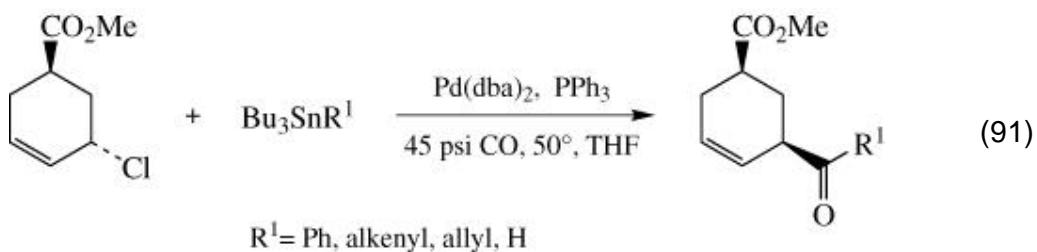


*Ortho* substituents adversely affect the yield, and those containing a heteroatom also present a unique problem: the potential for competitive alkoxycarbonylation or amidation (Eq. 90). (332)



### 5.3. Allylic and Benzylic Halides

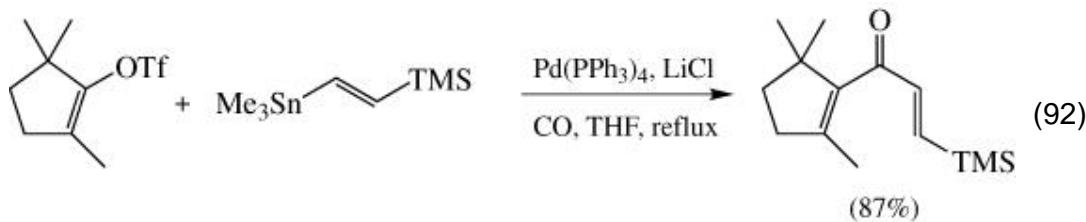
Allyl and benzyl chlorides insert CO when reacted with stannanes, forming the corresponding ketones. (24) Diallylic ketones have been prepared under very mild conditions. (333) Higher pressures of CO favor ketone formation over direct coupling. The major side reaction is the carbonylative homocoupling of the organostannane. Carbonylative couplings occur with inversion of stereochemistry at the halide-bearing carbon, at least under the conditions specified in Eq. 91. (24)



Allyl and benzyl chlorides are also formylated readily. Double bond migration to the  $\alpha, \beta$ -unsaturated aldehyde is a common problem with allylic chlorides, as is competing reduction. (331)

### 5.4. Alkenyl Sulfonates

Alkenyl triflates are popular substrates for carbonylative coupling, which leads to  $\alpha, \beta$ -unsaturated ketones and aldehydes. Many coupling examples can be found in the literature, and the scope of the reaction is broad. This strategy has been used in the total synthesis of natural products such as  $\Delta^{9(12)}$ -capnellene (Eq. 92) (334) and jatrophone. (335)

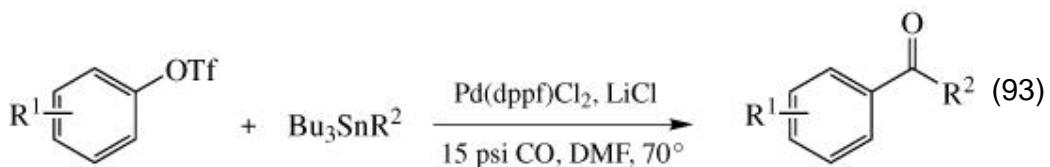


Aryl-, alkynyl-, and alkenylstannanes all couple well, but double bond migration is a problem with allylstannanes. It has been reported that lithium chloride is a required additive for successful reaction. In several examples, the addition of

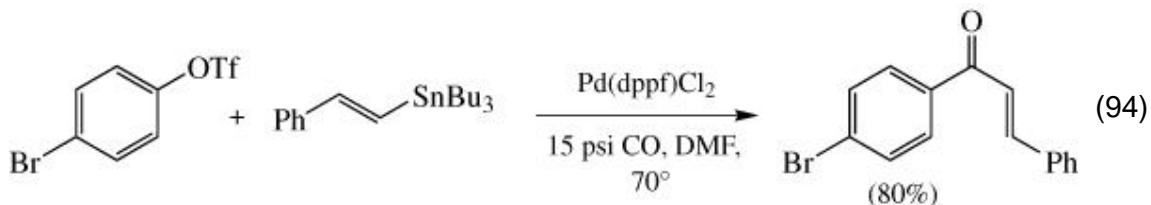
zinc chloride improves the yields. (335) Macrocycles can be effectively prepared through intramolecular carbonylative ketone formation using a polymer-supported palladium catalyst. (186)

### 5.5. Aryl and Heterocyclic Sulfonates

The palladium-catalyzed carbonylative coupling of aryl triflates to give aryl ketones takes place under mild conditions. (336) Alkenyl-, alkynyl-, and arylstannanes all work well as coupling partners, but the presence of electron-withdrawing groups (e.g.,  $\text{NO}_2$ ) in these stannanes adversely affects the reaction because the aryl triflate is cleaved at the oxygen-sulfur bond. Allylstannanes are ineffective, resulting in high proportions of directly coupled products. As with alkenyl triflates, the presence of lithium chloride is required, but here the catalyst dichloro[1,1'-bis(diphenylphosphino)ferrocene]palladium gives superior yields (Eq. 93). If a competitive coupling site such as bromide is present on the

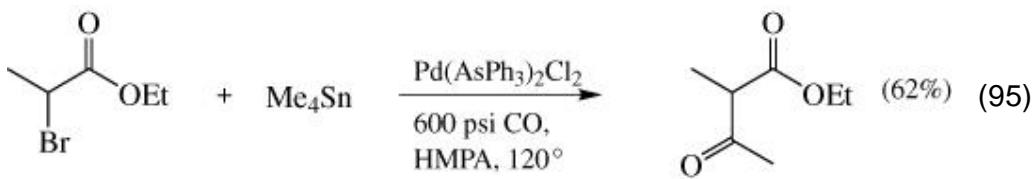


aryl triflate, carbonylative cross-coupling takes place selectively at the triflate moiety even in the absence of lithium chloride (Eq. 94).



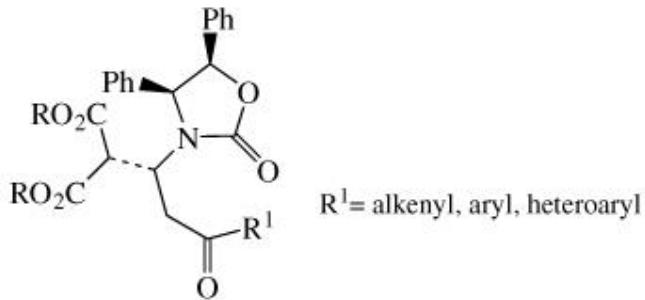
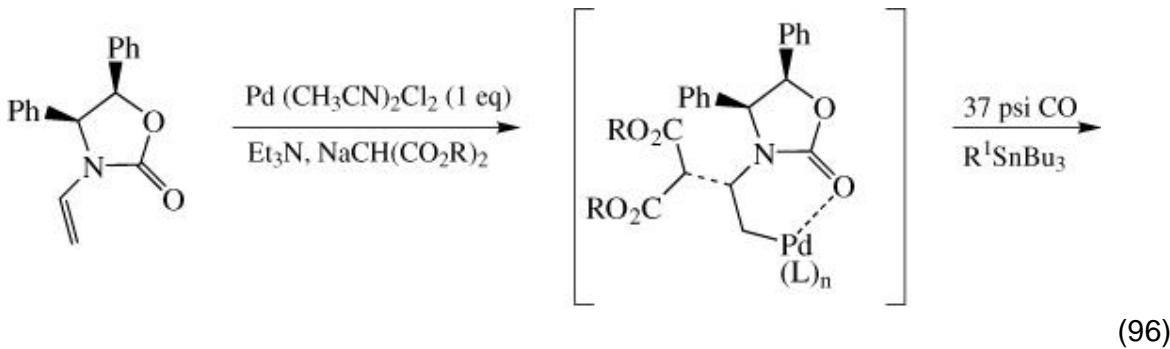
### 5.6. Miscellaneous Substrates

Some activated organic halides containing  $\beta$  hydrogens can be carbonylatively cross-coupled under high CO pressures, and the ligand of choice for this reaction is triphenylarsine (Eq. 95). (337) The reported scope of this reaction is limited to the



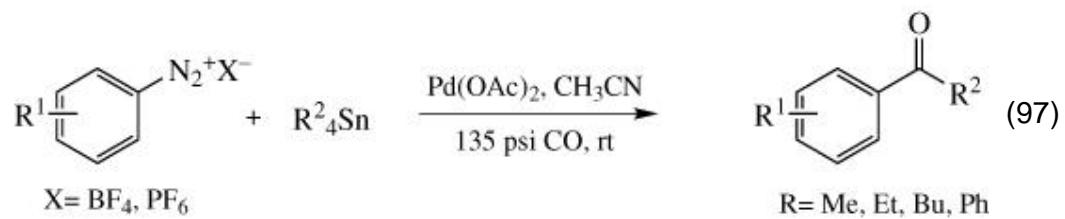
use of  $\alpha$ -phenethyl bromide, ethyl  $\alpha$ -bromopropionate, and  $\alpha$ -phenylpropyl bromide as substrates for the formation of methyl ketones, and the major side product is the result of elimination to the corresponding alkene. In a single example tetraphenylstannane has also been coupled. (323)

An interesting example of carbonylation has been applied to the synthesis of (+)-negamycin and (-)-5-*epi*-negamycin (Eq. 96). (338) The intermediate from the



palladium-assisted alkylation of an optically active enecarbamate is effectively carbonylated in the presence of an alkenylstannane to furnish the desired optically active ketone. Although this transformation requires a stoichiometric amount of palladium, it appears to be quite general and works well with a variety of alkenyl, aryl, and heteroarylstannanes. (339)

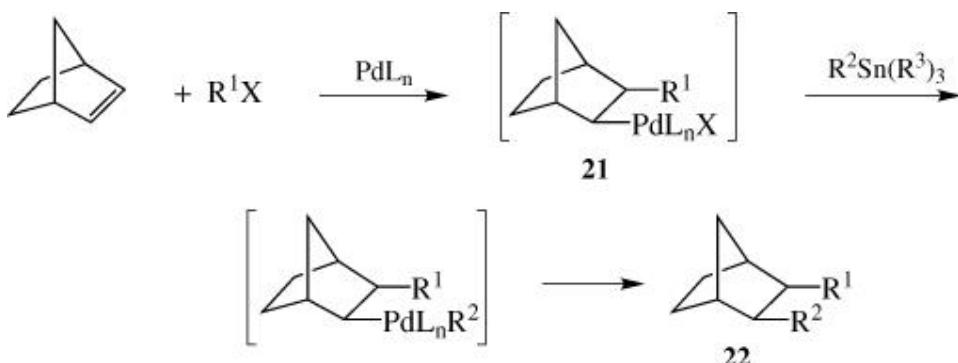
Aryl diazonium salts are also effective substrates for ketone formation (Eq. 97). (340) Diaryl and arylalkyl ketones can be prepared under very mild conditions. The presence of electron-withdrawing and electron-releasing groups on the ring is tolerated, and products from direct coupling are not observed.



## 6. Complex Synthetic Sequences Involving Tin-to-Palladium(II) Metathesis Steps

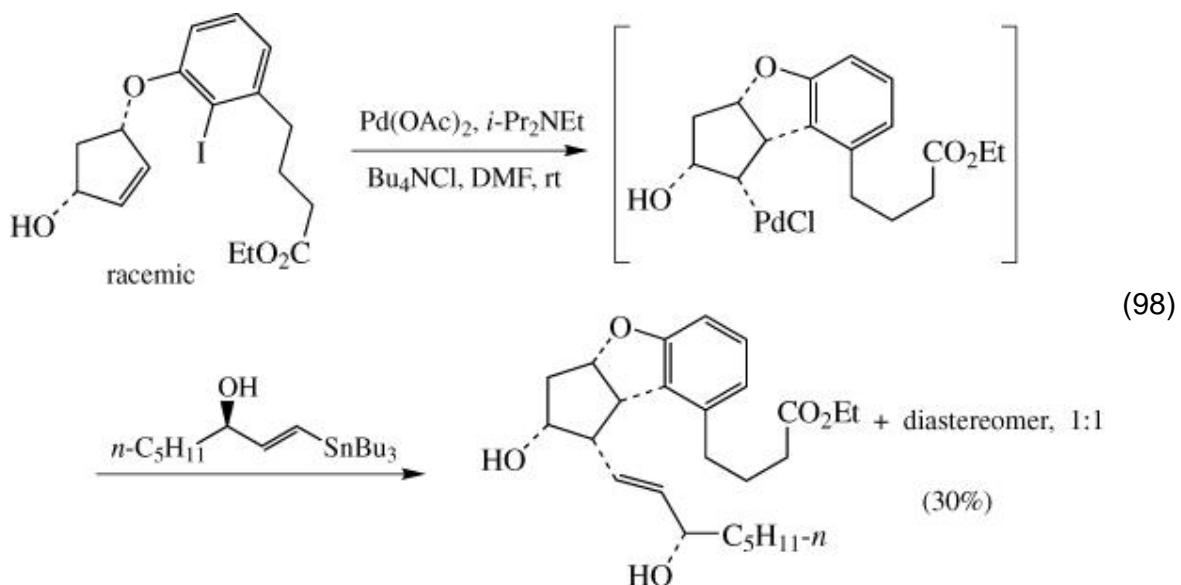
A strategy that is receiving considerable attention in palladium chemistry is the tandem Heck-Stille sequence. Under suitable conditions, the organopalladium(II) intermediate resulting from a Heck insertion can be trapped by an organostannane, resulting in the formation of two C-C bonds at once. This strategy works best when the Heck adduct cannot undergo palladium hydride  $\beta$  elimination. The norbornyl system is used often in this sequence because the initially formed adduct **21** (Scheme 3) has no easily accessible *syn*  $\beta$  hydrogens, which are needed for a stereocontrolled elimination, and it is stable enough to be intercepted by the stannane to yield **22**.

**Scheme 3.** The Tandem Heck/Stille Strategy.

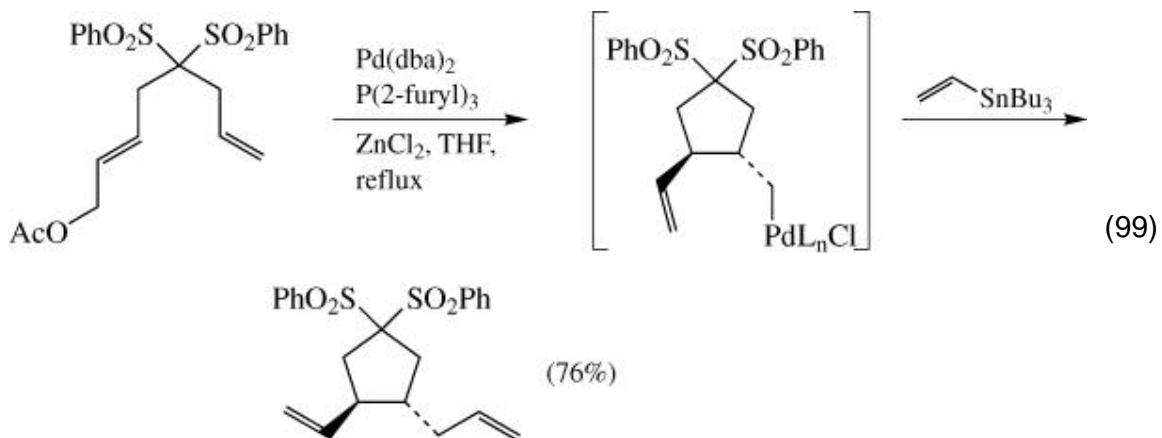


This strategy can be used in conjunction with  $Pd(PPh_3)_4$  as catalyst, alkenyl or aryl bromides as electrophiles, and alkenyl-, alkynyl-, aryl- or allylstannanes as traps. The yields are low to fair, and direct coupling is the major side process. (341) Allyl, benzyl, and acyl halides do not participate in this reaction. Among the stannanes that do not participate are the activated alkylstannanes, aminostannanes, alkoxytannanes, and thioalkoxytannanes. (342) For the analogous reaction with norbornadiene as substrate, the best ligand is (*o*-tolyl)diphenylphosphine. The additive tetraethylammonium chloride is needed for best results. (343)

More generally useful is the analogous sequence in which the initial Heck insertion is intramolecular. An elegant application to the synthesis of benzoprostacyclins is shown in Eq. 98. (344)

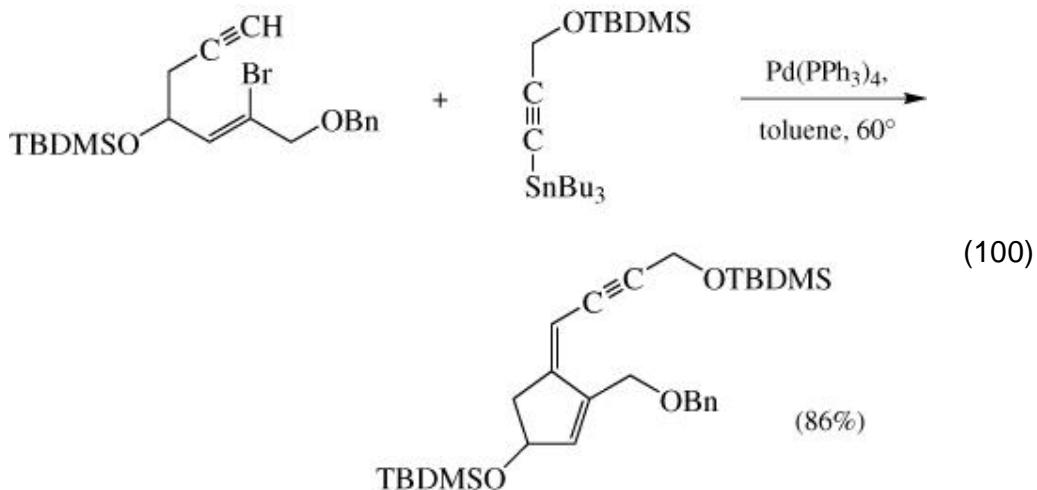


This method can be extended to situations in which the initially formed organopalladium(II) intermediate is, in principle, capable of undergoing ready  $\beta$ -hydride elimination. Nevertheless, fine-tuning of the process with the help of tri(2-furyl)phosphine to accelerate the metathesis, in conjunction with zinc chloride, affords the Heck-Stille coupling product in high yield. The generality of these observations remains to be verified (Eq. 99). (345)

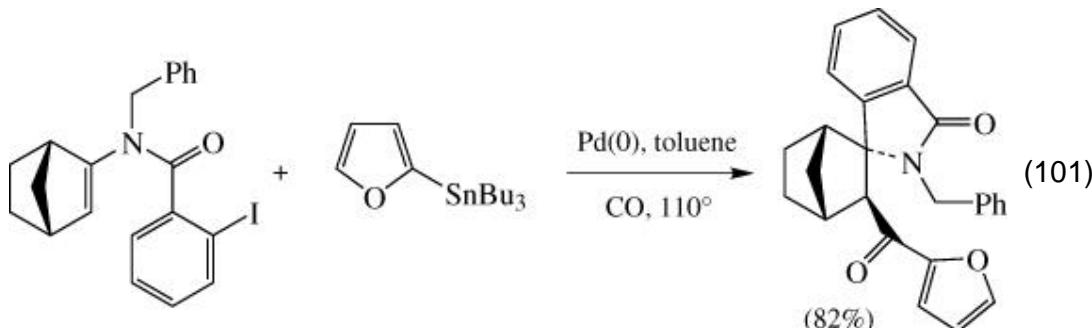


When C-C triple bonds are used as intramolecular traps in this strategy, competing  $\beta$  elimination is not possible, and the tandem process is often successful, the only competition originating from the direct coupling (intermolecular) process. The initial 5-exo and 6-exo cyclizations are faster than direct coupling, and the tandem process succeeds, even though Al, Zr,

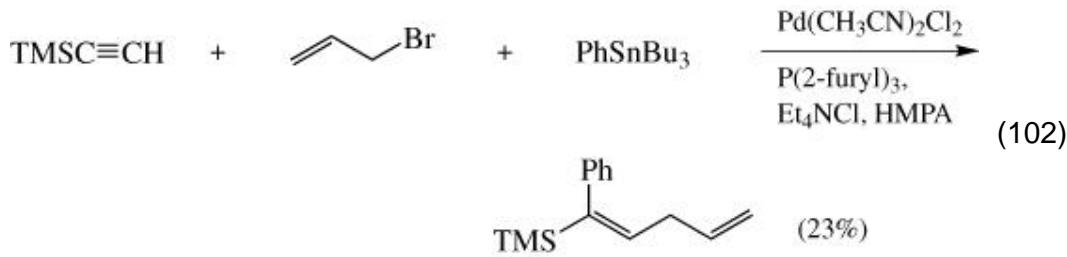
and Zn derivatives often yield better results. (346-350) An application of this strategy to a neocarzinostatin synthesis is shown in Eq. 100. (351-353)



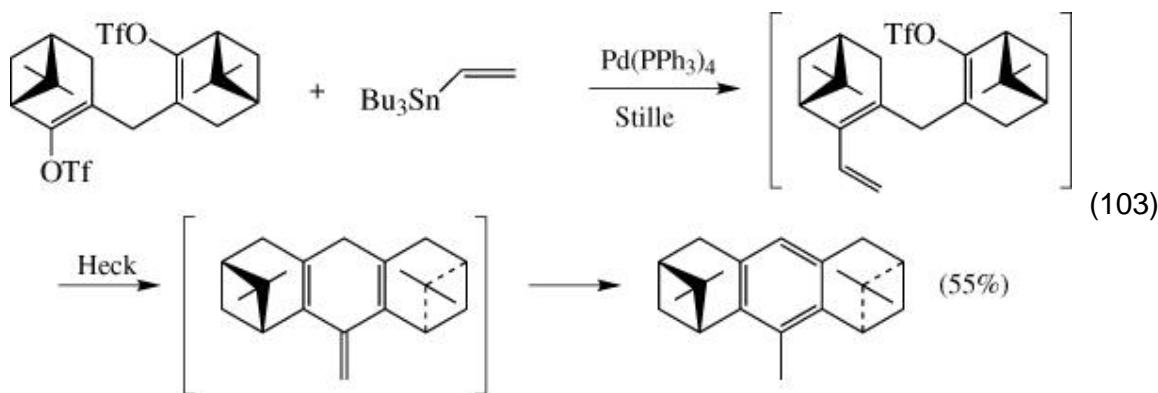
Similar applications to the synthesis of vitamin D are reported. (354) Carbon monoxide insertion can be included in this sequence. An example of this interesting intramolecular Heck-CO insertion-transmetallation strategy is shown in Eq. 101. (355)



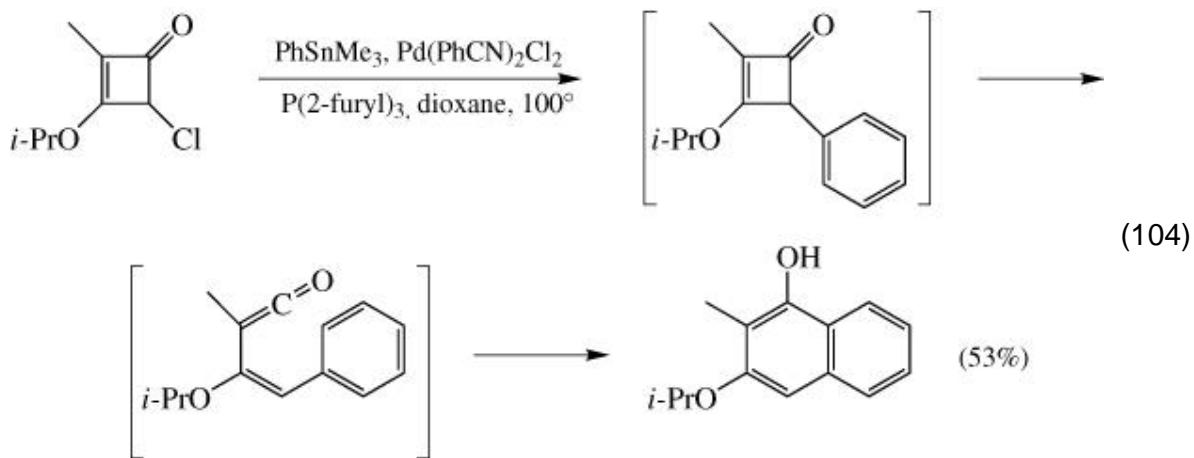
In special cases, even the intermolecular insertion of alkynes can be carried out. When the electrophile is an allylic halide, apparently the direct coupling with stannanes is slow enough that the alkyne is first to react with the intermediate allylpalladium complex. Aryl-, alkenyl-, and alkynylstannanes can be used as traps. The yields, however, are quite modest (10–53%). An example is shown in Eq. 102. (356) A Ni(0)-catalyzed version of this reaction proceeds in higher yields, at least with alkynylstannanes as traps. (357)



An interesting variant of the tandem Heck-Stille protocol is the reverse strategy. A bis(electrophile) can undergo monocoupling with an alkenylstannane, and this is followed by a fast intramolecular Heck reaction (Eq. 103). (358) This interesting



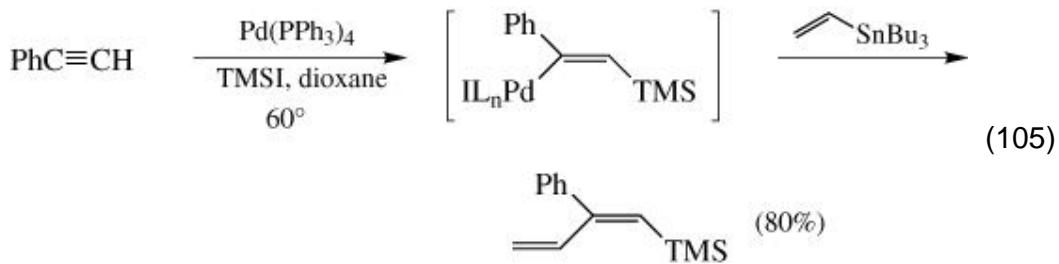
strategy deserves further investigation. There are a number of interesting strategies for the construction of aromatic rings based on the ring opening of complex cyclobutenones, which on thermolysis rearrange to arenes via dienylketenes, as exemplified in Eq. 104. (359) Both alkenyl- and arylstannanes can be



used in this coupling, leading to benzene and naphthalene derivatives, respectively, after electrocyclic ring opening/reclosure.

Variants of this technique are the synthesis of benzofurans and benzothiophenes, (295) an approach to naphthoquinones and anthraquinones, (360) and new routes to benzocyclobutenedione derivatives, (361) azaheteroaromatics, (362) and 2-pyrone, the last involving a carbonylative step. (363)

Finally, the oxidative addition of Pd(0) onto silicon halides can be incorporated in a three-component condensation involving 1-alkynes, TMSI, and alkenyl-, alkynyl-, or allylstannanes. An example of this powerful protocol is shown in Eq. 105. (364)



The use of complex strategies centered on, or terminated by, cross-coupling chemistry is an important and expanding synthetic tool that allows the formation of two or more C-C bonds, usually in a regioselective and stereoselective manner.

## 7. Side Reactions

### 7.1. Homocoupling Reactions

Homocoupling of stannanes is apparently the most common side reaction observed when attempting Stille couplings. (30, 106, 204, 286, 297, 299, 365) The reaction may even be synthetically useful when symmetrical dienes (366) or biaryls (30) are desired. An obvious source of small amounts of homocoupled product is the reaction of the stannane with the Pd(II) precatalyst when this is employed. Each molar equivalent of Pd(II) reacts with two equivalents of the stannane to afford a symmetrical product. In many cases, however, larger amounts of homocoupling products are observed than can be accounted for in this way, and homocoupling takes place even when employing preformed Pd(0) catalysts. The reaction involves a catalytic cycle that has a radical component and requires atmospheric oxygen. Insertion of Pd(0) in the carbon-tin bond of the stannane is postulated as the first step of the cycle. (30)

Homocoupling of the electrophile is often observed in transition metal-catalyzed cross-coupling reactions, (367) and there is evidence for a mechanism involving the exchange of organic groups between palladium and tin. (368) These authors used bidentate nitrogen-based ligands, and it is not clear whether this exchange occurs in reactions that use phosphorus-based ligands. A similar phenomenon with  $\text{PPh}_3$  as ligand, on the other hand, has been documented. (34)

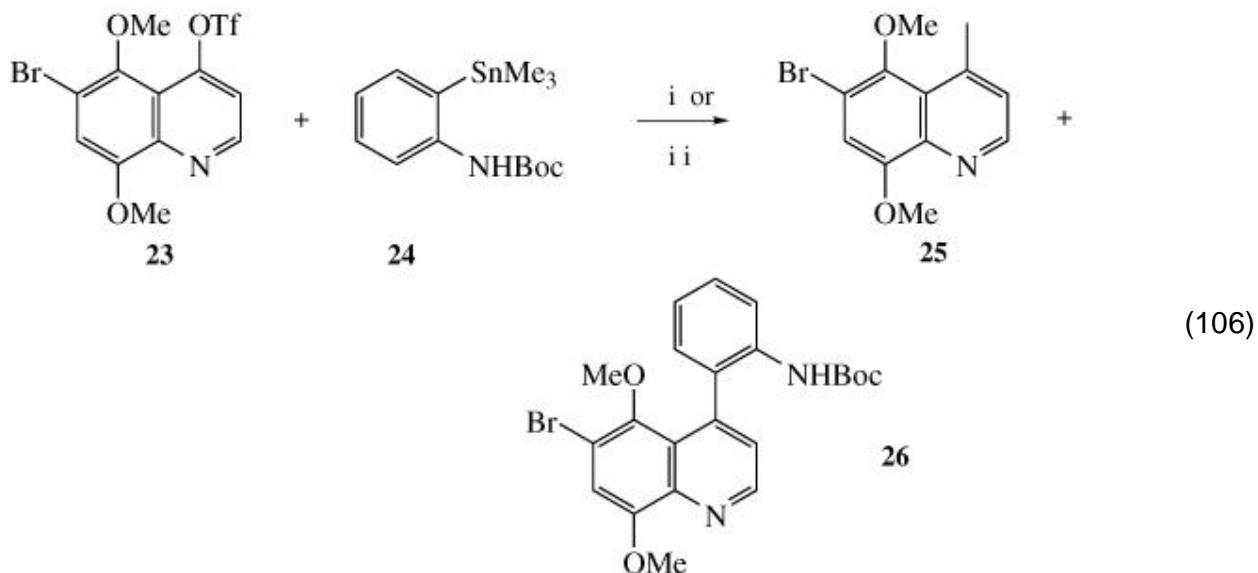
### 7.2. Transfer of “Nontransferable” Ligands

The Stille reaction usually employs three groups on tin that are not meant to be transferred in the coupling. Overwhelmingly, trialkyl derivatives are used because alkyl groups transfer slowly. Typically, trimethyl- or tributylstannane derivatives are used because of the ready availability of the corresponding trialkyltin halides. Selectivity is not, however, always complete.

For example, phenyltrimethylstannane couples with aryl triflates to yield products resulting from both aryl and methyl group transfer. (189) The selectivity is solvent dependent, dioxane yielding more aryl transfer than DMF or NMP. The phenyl group transfers 37 times more readily than *n*-butyl in NMP, using an aryl triflate as the electrophile. This ratio shows little dependence on the type of ligand. The ratio of the transfer rates of phenyl vs. methyl, on the other hand, is only 5. (30) These data strongly suggest that *n*-butyl groups are preferable to methyl groups as nontransferable moieties. The use of Cu(I) salts as cocatalysts improves this selectivity to >50:1, (33) and this may represent a potentially general solution to the selectivity problem (see also Eq. 61).

An interesting selectivity switch occurs in a hindered Stille coupling using

stannane **24**. Whereas exclusive methyl transfer is observed under traditional conditions, use of Cu(I) salts leads to the aryl transfer product **26** in moderate yields (Eq. 106). (280)



Conditions: (i)  $\text{PdCl}_2(\text{dppf})$ , DMF, **25** (80%); (ii)  $\text{Pd}(\text{PPh}_3)_4$ , LiCl, dioxane, CuBr,  $90^\circ$ , **26** (60-64%).

Other reports of alkyl group transfer in competition with the intended transfer of an aryl group are rather widespread, (55, 191, 369, 370) and alkyl group transfer can sometimes be competitive even with alkynyl (219) and alkenyl coupling. (40, 259) Once again, use of Cu(I) has resulted in substantial selectivity improvement in a butyl vs. alkenyl transfer competition. (33)

Further studies aimed at more careful quantification of alkyl group transfer as a side process and at discovering new tools to increase selectivity are definitely warranted.

### 7.3. Destannylation

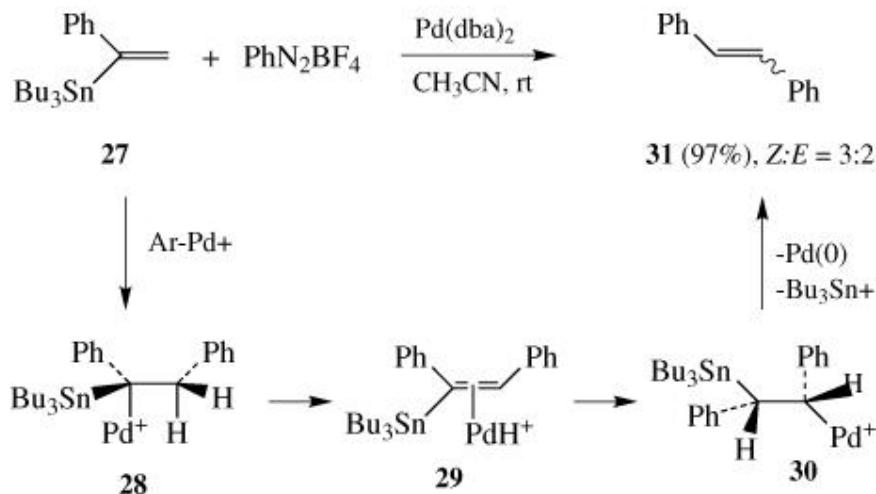
Hydrolytic destannylation, probably brought about by traces of water and/or acids in the reaction medium, has been reported in very few cases, perhaps only because such a process in structurally simple stannanes yields volatile products that are difficult to detect. Organostannanes are quite stable hydrolytically, but when electron-rich aryl- or heteroarylstannanes are employed, destannylation may be a serious side reaction. (371, 372)

### 7.4. Cine Substitution

Cine substitution can be a side process in a cross-coupling reaction, and

Scheme 4 illustrates an example, together with a proposed mechanism. (204)

**Scheme 4.** Mechanistic interpretation of cine-substitution.



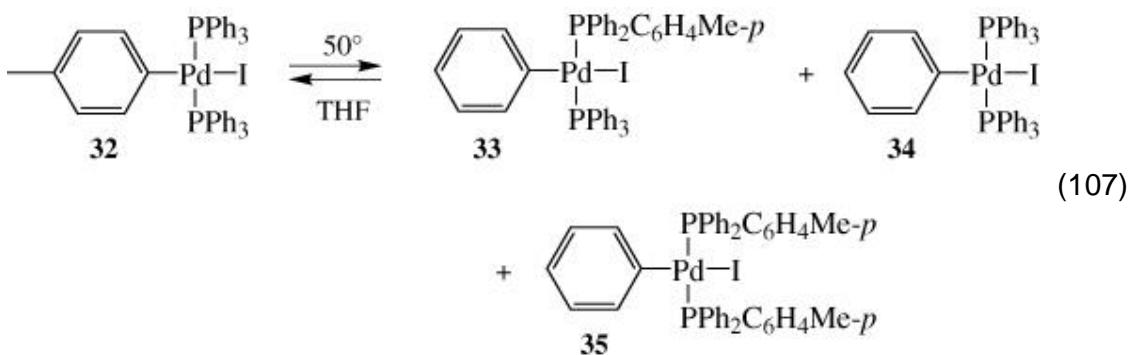
The first step is obviously an insertion of the arylpalladium intermediate across the double bond of the olefin. Evidently, a direct transmetalation is hindered by the  $\alpha$ -phenyl substituent on the stannane. The following steps of  $\beta$  elimination and protodestannylation are reasonable and precedented. Another example of cine substitution requires an *anti* $\beta$  elimination of palladium and hydrogen, which is a stereoelectronically disfavored pathway. (373)

It has been proposed that species like **28** may be able to undergo an unprecedented  $\alpha$  elimination of Bu<sub>3</sub>SnX to yield a Pd(0)-carbene species. A study of cine substitution with  $\alpha$ -(tributylstannyl)acrylate showed that nonpolar solvents favor cine substitution, whereas ligands of different donicity have remarkably little effect on the product distribution. (245) Other authors have independently observed similar cine substitutions, (374-376) and high-yielding Stille coupling can be restored, once again, by using cocatalytic Cu(I). (246)

Cine substitution is a rare event in the coupling of organostannanes and is so far limited to 1-substituted 1-stannylethylenes, but it is a mechanistically intriguing process. From the mechanistic point of view, use of Cu(I) salts presumably yields intermediate organocopper species, (33) which undergo transmetalation with the “correct” regiochemistry. Silver carbonate has been used in one reaction to avoid cine substitution. (375) The generality of these observations remains to be verified.

### 7.5. Phosphorus-to-Palladium Aryl Migration

Arylpalladium(II) complexes like **32** (Eq. 107) undergo exchange of substituents between phosphorus and palladium at temperatures as low as 50° to yield **33–35**. (377) Thus, it is remarkable that this scrambling has not been detected



in most of the classical Stille couplings. Recently, however, some examples of side products originating from aryl transfer by the phosphine were reported. (375, 378) Triphenylarsine and tri(2-furyl)phosphine also lead to this side reaction. An obvious way to limit this unwanted process is to run the coupling at as low a temperature as possible.

### 7.6. Electrophile Reduction

Electrophile reduction is often a side reaction in Stille couplings, especially at high temperatures. It has been observed in the coupling of aryl triflates, (189, 379) heteroaryl iodides, (126, 128) alkenyl halides, (380) and allylic electrophiles. (163) The origin of this side process is uncertain. Alkyl transfer with  $\beta$  elimination prior to reductive elimination may be involved, although a radical mechanism is also possible.

### 7.7. Product Isomerization

In the coupling of acyl chlorides with alkenylstannanes, *E/Z* isomerization is observed under the coupling conditions. (146) Allylic stannanes, on the other hand, may yield mixtures of  $\alpha$ ,  $\beta$  - and  $\beta$ ,  $\gamma$  -unsaturated ketones. (146) Geometric isomerization of olefins has often been reported as a side reaction. (46, 51, 153, 157, 269, 289, 381, 382) Double bond migration has also been observed quite frequently. (56, 135, 383) It is likely that isomerization occurs at the product stage, but it is not clear whether it is catalyzed by palladium. Mild thermal conditions are believed to prevent or reduce isomerization. In addition, tri(2-furyl)phosphine-based catalysts prevent *E/Z* isomerization in the coupling of acyl chlorides and (*Z*)-alkenylstannanes. (11) The generality of this observation must be verified.

### 7.8. Miscellaneous Side Reactions

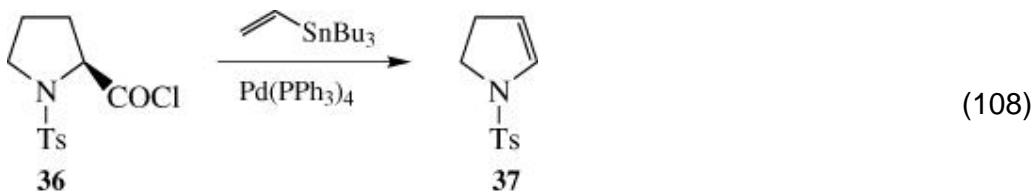
When using aryl triflates, hydrolytic cleavage to the corresponding phenols is a side reaction, especially at high temperatures. (55) Replacement of triflate with chloride owing to the presence of LiCl is a rare event, but it must be kept in mind as a possibility, especially for activated substrates. (40, 173, 195)

When carrying out Stille reactions on substrates containing isolated double bonds, the intermediate organopalladium species may undergo insertion

across the double bond (Heck reaction), as discussed in the section on complex strategies. (336)

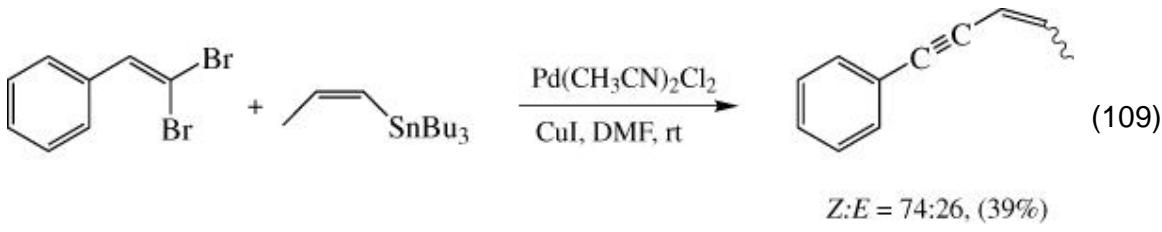
Reduction of enones has also been observed. The reducing agent is the tri-butyltin halide produced in the coupling. (148)

In one example, attempted coupling of an acyl chloride with vinyltributylstannane has led to dehydrodecarbonylation. Thus, proline derivative **36** gives **37** in unreported yield (Eq. 108). Use of the catalyst  $\text{Pd}(\text{dpdf})\text{Cl}_2$  obviates the problem. (381)



In reactions where the electrophile contains a quinone system, reduction to a dihydroquinone is a serious side reaction. (58, 384)

1,1-Dibromoolefins couple with stannanes only once, whereas the second bromine moiety is eliminated (Eq. 109). (385) This side reaction may not be palladium catalyzed.



The large variety of side reactions described for the Stille coupling does not reflect serious weaknesses in this cross-coupling method, but rather the careful scrutiny given to this important synthetic method in recent years. The side reactions can often be minimized or eliminated by using simple modifications of the traditional conditions, such as the use of appropriate ligands, solvents, additives, and temperatures, as described in this section.

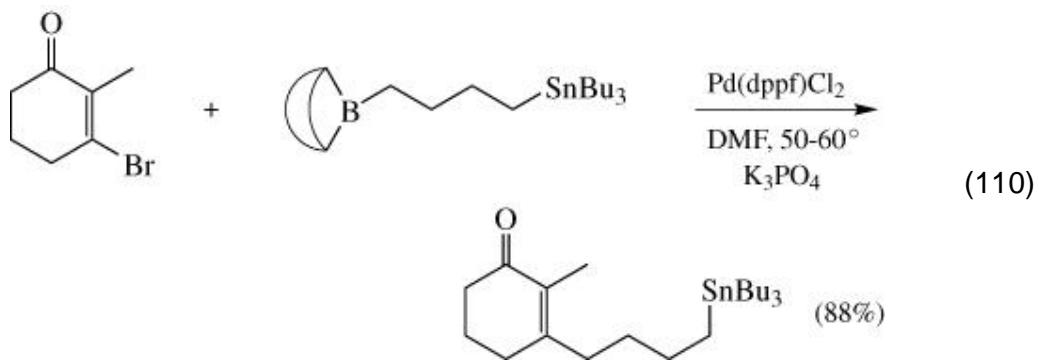
## 8. Comparison with Other Methods

A direct comparison between the Stille reaction and other cross-coupling protocols has been made in only a few cases, and these studies must be regarded with skepticism, since often each particular coupling was not separately optimized, as it should for the comparison to be legitimate. Thus, in a study of several alkenyl-alkenyl couplings in an approach to vitamin A, (386) it was concluded that the Stille coupling was unsatisfactory because of extensive homocoupling and that the reaction of alkenyl iodides with organozinc reagents gave better results. However, a limited set of conditions was explored.

Similarly, it has been concluded that zinc acetylides are better partners than alkynylstannanes in the coupling with certain alkenyl iodides. (387) In the coupling of an iodoglucal with arylmetals, the yields using arylzinc and arylboron compounds were quite superior to the ones obtained with the corresponding stannanes, but only under one set of conditions. (388) Similar conclusions were reached in a related system. (389) The synthesis of polyphenylenes by the Suzuki coupling appears to be superior to the corresponding Stille approach. (390)

Conversely, in other reactions, the Stille protocol outperforms the competition. In the 2-arylation of benzofuran derivatives, the use of organostannanes gives better results than the corresponding zinc derivatives. (391, 392) In the synthesis of tamoxifen analogs, coupling of an alkenyl bromide with organotin, organozinc, and organoboron derivatives gives excellent results in each case. (50) Coupling of tetraalkylstannanes is reported to be superior to alkylaluminum and alkylzinc derivatives. (43) The Stille coupling is also the preferred route to substituted nucleosides. (132, 374) A commonly given reason for preferring the use of organozinc and organoboron reagents over organostannanes is the toxicity of the latter. Conversely, the stannanes are often preferred because of the unusually mild and absolutely neutral conditions their coupling involves.

Bifunctional derivatives bearing a 9-BBN moiety and a tributylstannane residue couple selectively at the boron end under basic conditions (Eq. 110). (393)



In general, the Stille reaction will continue to be a favorite method for carbon-carbon bond formation, owing to the lack of cross-reactivity displayed by the organostannanes with most functional groups. Its general utility is demonstrated by the many diverse applications reported in the tables.

## 9. Experimental Conditions

### 9.1. The Stannane: Preparation and Handling

**Caution!** Many organotin compounds are toxic, especially the lower alkyl derivatives. Their acute toxicity decreases dramatically with increasing alkyl group length. (394, 395) As a precaution, the preparation and use of all stannanes should only be carried out in a well-ventilated hood. After use, all glassware should be thoroughly washed, preferably after soaking in a KOH/alcohol bath to remove surface-bound tin alkoxides and/or halides.

Organostannanes are typically synthesized by reaction of organolithium or organomagnesium derivatives with trialkyltin halides. Another important method is the radical-induced or Pd-promoted addition of tin hydrides to unsaturated systems (e.g., alkynes, alkenes). Very important also is the transition metal-catalyzed cross-coupling of hexaalkylstannanes with organic electrophiles, as discussed in the section on scope and limitations. Tin acetylides are best formed by the reaction of trialkyltin diethylamide with an alkyne. (396) A thorough treatment of the synthesis of organostannanes is outside the scope of this review, and the reader is referred to reviews on organostannanes. (6, 395)

Most organostannanes are stable to air and moisture and can therefore be distilled and/or chromatographed. Stannanes are often too nonpolar to be efficiently purified on silica gel, but C-18 flash chromatography appears to be useful. (397) Given their ease of purification, for best results stannanes should not be used as crude preparations in Stille couplings.

### 9.2. Alkenyl and Aryl Triflates

Alkenyl triflates are typically synthesized by the reaction of triflic anhydride with a ketone or aldehyde in the presence of a hindered base, such as 2,6-di-*tert*-butylpyridine. (398, 399) Enolates can be trapped with *N*-aryltriflimides, such as *N*-phenyltriflimide. (400, 401) Vinyl triflates are also available from the addition of triflic acid to alkynes, though regio- and stereochemical considerations may be a problem. (402, 403)

Aryl triflates are readily prepared by the reaction of triflic anhydride with a phenol in the presence of a base such as triethylamine or pyridine. (189) *N*-Phenyltriflimide can also be used for this transformation. (404) A thorough treatment of the synthesis of vinyl and aryl triflates is beyond the scope of this review, and the reader is referred to reviews on the formation and reactions of triflates. (405, 406)

### 9.3. Choice of Nontransferable Ligands

Using nontransferable ligands is an area of the Stille reaction that needs further improvement. As discussed above, tributylstannane derivatives are usually preferred because of the low cost and low toxicity of tributyltin chloride, as well as the fact that competitive transfer of the butyl groups is a rare event. On the other hand, removal of traces of tributylstannane derivatives from the product can be problematic. Trimethylstannane derivatives have the disadvantage that methyl group transfer can often compete with the desired transfer of the unsaturated group, but the trimethylstannane derivatives produced in the coupling can usually be removed from the product by simple aqueous wash. Nontransferable ligands that speed up the transmetallation have been described in recent years, but have not yet found general acceptance. (41) Trichlorostannates have recently been used and can be employed to carry out Stille reactions in aqueous systems. (282, 283)

#### **9.4. Choice of Catalyst and Ligands**

As discussed earlier, both Pd(0) and Pd(II) catalysts may be used to promote the cross-coupling reaction. Pd(II) catalysts have the advantage of being air stable, but must be reduced before entering the catalytic cycle. Typically, reduction is achieved in situ through the homocoupling of two equivalents of stannane, or with some reductant such as carbon monoxide. In rare instances, Pd(II) catalysts are pre-reduced by the addition of a Grignard or hydride reagent (often L-Selectride or DIBAL). (43) Pd(0) catalysts can enter the catalytic cycle directly, but can suffer from air and/or light stability problems.

Most catalysts are commercially available. Some of the most commonly used are: tetrakis(triphenylphosphine)palladium(0), (407) bis(dibenzylideneacetone)-palladium(0), (408) bis(acetonitrile)palladium(II) dichloride, (409) bis(triphenylphosphine)palladium(II) chloride, (410, 411) benzyl[bis(triphenylphosphine)]palladium(II) chloride, (21, 412) 1,1¢-bis(diphenylphosphino)ferrocenepalladium(II) dichloride, (413) and allylpalladium(II) chloride dimer. (414) Catalysts that do not incorporate strong ligands are often used in conjunction with added phosphines. Particularly useful among them are the Pd-dibenzylideneacetone complexes, which are commercially available and air stable. They can be used in conjunction with a variety of ligands. In addition to the traditional triphenylphosphine, ligands of reduced donicity, such as tri(2-furyl)phosphine and triphenylarsine, or increased steric bulk, such as tri(o-tolyl)phosphine, usually lead to much faster coupling. (11) These ligands are all commercially available. Nitrogen-based ligands have been used in a few cases, but their scope and utility have not been well established. (169, 171, 415) In some instances, it is advantageous to completely omit the ligand from the Stille reaction. (5) Ligandless catalysts usually afford high coupling rates but also premature interruption of the catalytic cycle.

#### **9.5. Choice of Solvent**

Solvents used include benzene, toluene, xylene, mesitylene, chloroform, 1,2-dichloroethane, THF, DME, dioxane, DMF, DMA, NMP, DMSO, HMPA, and water. Given the stable nature of the stannane organometallic species, it is fair to say that almost any conceivable solvent is likely to be compatible with the Stille protocol. Most couplings are carried out either in an ethereal solvent like THF or dioxane, or in highly dipolar solvents, such as DMF or NMP. Any of these four solvents represents a reasonable first choice when studying a new Stille coupling. The solvents are typically of anhydrous quality, but there does not seem to be a compelling reason to avoid traces of moisture. In many cases the literature specifically mentions that moisture accelerates the reaction. The same can be said about air: Whereas many Pd(0) complexes are air sensitive, during the Stille coupling the active catalyst is normally in the air-stable Pd(II) oxidation state (owing to rapid oxidative addition), and oxygen has no deleterious effect on the reaction. Many Stille reactions have been run in the presence of oxygen: Under these conditions a black precipitate of Pd metal signals the end of the reaction, where air-sensitive Pd(0) species accumulate. However, atmospheric oxygen can sometimes induce efficient homocoupling of the stannane (as discussed in the section on side reactions). In this event, careful deoxygenation by multiple freeze-thaw cycles is recommended.

### 9.6. Additives

The use of copper salts to facilitate the Stille cross-coupling is one the more significant recent developments in this area; the “copper effect” was discussed in the mechanistic section. The use of silver salts was also mentioned. Zinc chloride has often been used as additive. Yields are often better in the presence of stoichiometric amounts of Zn(II) salts, although the origin and the generality of the effect are not understood. The use of a stabilizing halide source, such as LiCl, and its complex effect on reaction rates in conjunction with the coupling of triflates have been discussed in the mechanistic section. When coupling triflates in ethereal solvents, LiCl appears to be necessary to induce coupling; in DMF or NMP (and presumably other dipolar solvents), LiCl is often unnecessary when coupling alkenyl triflates, whereas it sometimes appears to be necessary when coupling the less reactive aryl triflates. The experimentalist is urged to try the reaction both with and without LiCl. Bases such as triethylamine, (54, 416) diisopropylethylamine, (80) lithium carbonate, (417) sodium carbonate, (298, 418) pyridine, (419) and 2,6-di-*tert*-butyl-4-methylpyridine, (417) have also been employed as additives, presumably to minimize degradation of stannanes by adventitious acid.

Antioxidants, such as BHT, di-*tert*-butylphenol, or *tert*-butylcatechol are sometimes added to minimize side product formation via radical pathways.

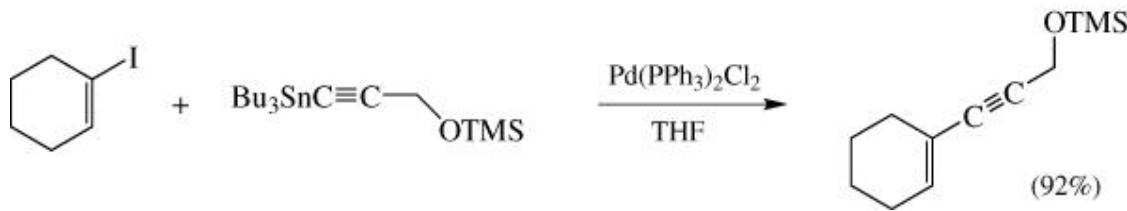
Some reactions proceed more rapidly or in higher yield when run under dry air. (19) Palladium compounds catalyze the oxidation of triphenylphosphine to triphenylphosphine oxide by atmospheric oxygen. The rate enhancement

found when running reactions under air may simply be due to the depletion of excess phosphine (see the “Mechanistic Considerations” section).

### 9.7. Workup: Removal of Tin Halides

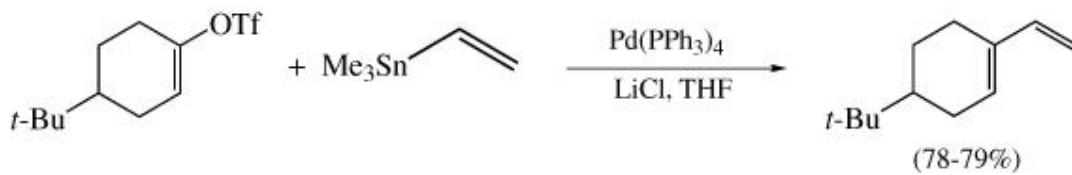
A major consideration in working up reaction mixtures from the Stille cross-coupling is the removal of tin byproducts. Trimethyltin chloride is water soluble and rather volatile and is therefore readily removed on normal aqueous workup. Tributyltin chloride has low volatility (bp 171–173° at 25 mm Hg) and is soluble in most common organic solvents. Separation by chromatography on silica gel is made difficult by the tendency for tributyltin chloride to elute under relatively nonpolar conditions and to streak. A variety of methods have been devised to remove bulk tributyltin chloride prior to final purification. Aqueous KF solutions react with tributyltin halides under biphasic conditions to form polymeric tributyltin fluoride, which may be removed by filtration. Ammonia complexes with tributyltin halides, making them somewhat water soluble. Thus, washing of organic solutions with dilute ammonium hydroxide can remove the stannane. (88) Tributyltin chloride is insoluble in acetonitrile. Thus, dissolving crude or partially purified reaction mixtures in acetonitrile followed by washing with hexanes (in which tributyltin chloride is soluble) will remove most of the tin. (420) DBU in wet diethyl ether, followed by filtration through silica, has also been used to remove tributyltin residues. (420a) Scott and Stille proposed that CsF as a coupling additive might cause the formation of tributyltin fluoride *in situ*, thus facilitating workup. (28)

## 10. Experimental Procedures



### 10.1.1. Trimethyl[3-(cyclohexen-1-yl)-2-propynyl]oxy)silane [Cross-Coupling of a Vinyl Halide with an Alkynylstannane Using $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ ] (47)

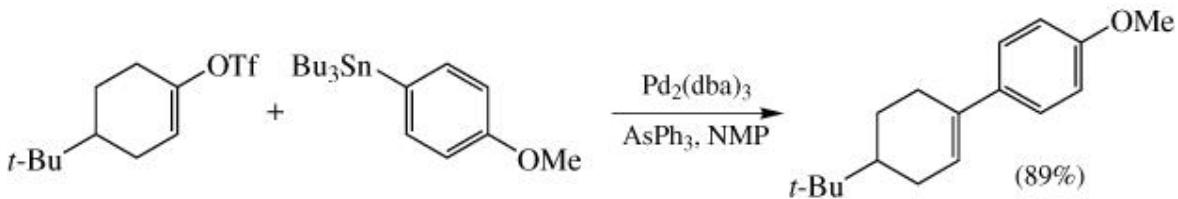
To a solution of 1-iodocyclohexene (0.424 g, 2.04 mmol), and trimethyl[3-(trimethylstannylyl)-2-propynyl]oxy]silane (0.592 g, 2.04 mmol) in dry THF (25 mL) was added  $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$  (0.0215 g, 0.031 mmol). The resulting mixture was stirred at 22–25° for 2 hours. The progress of the reaction was followed by TLC. The reaction mixture was diluted with  $\text{CH}_2\text{Cl}_2$ , coated onto alumina (10 g), and eluted with pentane. The resulting pentane solution was washed with water ( $3 \times 25$  mL) and a saturated  $\text{NaCl}$  solution (25 mL), dried ( $\text{K}_2\text{CO}_3$ ), and concentrated under reduced pressure to give a pale yellow liquid (0.388 g, 92%):  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  0.14 (s, 9 H), 1.48–1.68 (m, 4 H), 2.00–2.15 (m, 4 H), 4.36 (s, 2 H), 6.04–6.12 (m, 1 H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  -0.3, 21.5, 22.3., 25.6, 29.1, 51.5, 84.9, 86.8, 120.5, 134.5; IR (neat) 3040, 2218, 1442, 1322, 1258  $\text{cm}^{-1}$ ; Anal. Calcd for  $\text{C}_{12}\text{H}_{20}\text{OSi}$ : C, 69.17; H, 9.67. Found: C, 68.93; H, 9.70.



### 10.1.2. 4-tert-Butyl-1-vinylcyclohexene [Cross-Coupling of a Vinyl Triflate with a Vinylstannane Using $\text{Pd}(\text{PPh}_3)_4$ and $\text{LiCl}$ ] (421)

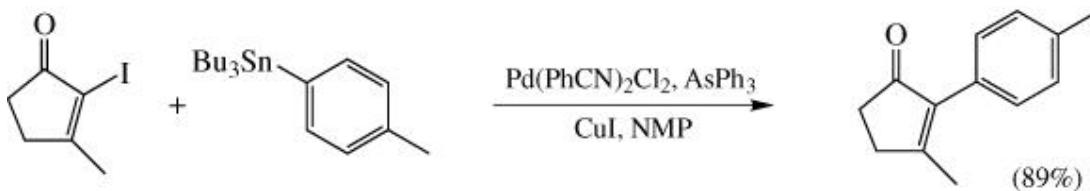
A slurry of  $\text{Pd}(\text{PPh}_3)_4$  (1.18 g, 1.02 mmol) and  $\text{LiCl}$  (12.9 g, 0.305 mol) in dry THF (500 mL) was stirred for 15 minutes under a static Ar atmosphere, then a solution of 4-tert-butylcyclohexenyl triflate (28.0 g, 0.0979 mol) and trimethylvinylstannane (19.0 g, 0.0997 mol) in dry THF (250 mL) was added,

followed by an additional 250 mL of THF. The resulting solution was heated under gentle reflux for 48 hours, then was cooled to room temperature and partitioned between water (500 mL) and pentane (250 mL). The aqueous layer was back-extracted with pentane ( $2 \times 250$  mL), and the combined organics were washed with a saturated  $\text{NaHCO}_3$  solution ( $2 \times 250$  mL), water ( $2 \times 250$  mL), and a saturated  $\text{NaCl}$  solution ( $2 \times 250$  mL). The organic extracts were dried ( $\text{MgSO}_4$ ), filtered through a pad of silica gel (4 cm  $\times$  4 cm), and concentrated by distillation using a 10-cm Vigreux column. Bulb-to-bulb distillation (Kugelrohr; oven temperature 65–68° at 0.55 mm Hg) gave the desired product (12.6–12.8 g, 78–79%): bp 45° (0.1 mm Hg);  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  0.87 (s, 9 H), 1.08–1.34 (m, 3 H), 1.84–2.36 (m, 4 H), 4.88 (d,  $J = 10.7$  Hz, 1 H), 5.04 (d,  $J = 17.5$  Hz, 1 H), 5.73–5.75 (m, 1 H), 6.35 (dd,  $J = 17.5, 10.7$  Hz, 1 H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  23.8, 25.3, 27.2 (3 C), 27.4, 32.2, 44.4, 109.7, 129.8, 136.0, 139.7; IR (neat) 3100, 3020, 1650, 1610, 1395, 1365, 985, 890  $\text{cm}^{-1}$ .



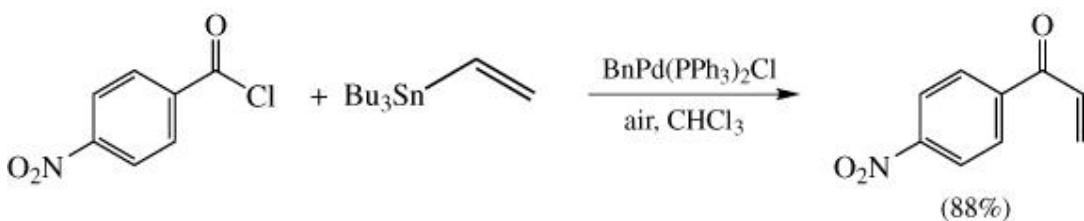
### **10.1.3. 1-(4-Methoxyphenyl)-4-tert-butylcyclohexene [Cross-Coupling of a Vinyl Triflate with an Arylstannane Using $\text{Pd}_2(\text{dba})_3$ and $\text{AsPh}_3$ ] (30)**

A solution of  $\text{Pd}_2(\text{dba})_3$  (0.0083 g, 0.0184 mmol),  $\text{AsPh}_3$  (0.023 g, 0.0734 mmol), and 4-tert-butylcyclohexenyl triflate (0.263 g, 0.918 mmol) in anhydrous degassed NMP (5 mL) was allowed to stand until the purple color was discharged (5 minutes), and (4-methoxyphenyl)tributylstannane (0.430 g, 1.083 mmol) in dry NMP (2 mL) was added. The resulting solution was stirred at room temperature for 16 hours, then stirred with a 1 M aqueous KF solution (1 mL) for 30 minutes, diluted with EtOAc, and filtered. The filtrate was washed extensively with water, dried, and concentrated to give a crude oil. The oil was purified by reverse phase flash chromatography (C-18, 10%  $\text{CH}_2\text{Cl}_2$ , 90%  $\text{CH}_3\text{CN}$ ) to give a white solid which was recrystallized (MeOH), (0.201 g, 89%): mp 78–79°;  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  0.91 (s, 9 H), 1.22–1.39 (m, 2 H), 1.89–2.02 (m, 2 H), 2.19–2.54 (m, 3 H), 3.80 (s, 3 H), 6.04 (m, 1 H), 6.84 (d,  $J = 9.0$  Hz, 2 H), 7.32 (d,  $J = 9.0$  Hz, 2 H); Anal. Calcd. for  $\text{C}_{17}\text{H}_{24}\text{O}$ : C, 83.55; H, 9.90. Found: C, 83.58; H, 9.85.



**10.1.4. 3-Methyl-2-(4-tolyl)-2-cyclopentenone [Cross-Coupling of an Unreactive Alkenyl Halide Under “Modified” Conditions Using  $Pd(PhCN)_2Cl_2$ ,  $AsPh_3$ , and  $CuI$  as Cocatalyst] (61)**

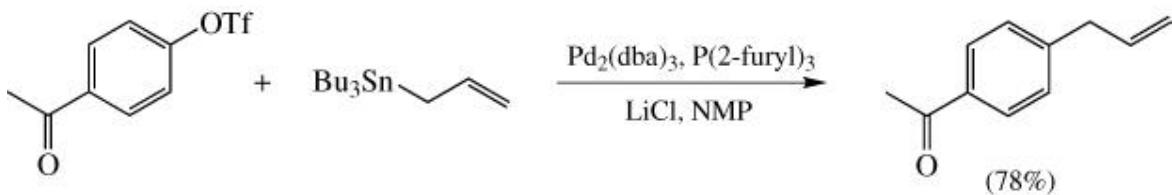
A solution of 2-iodo-3-methyl-2-cyclopentenone (0.222 g, 1.00 mmol),  $CuI$  (0.019 g, 0.10 mmol),  $AsPh_3$  (0.031 g, 0.10 mmol), and  $Pd(PhCN)_2Cl_2$  (0.019 g, 0.05 mmol) in NMP (1 mL) was treated under Ar with *p*-tolyltributylstannane (0.37 mL, 1.20 mmol), and the mixture was heated in an oil bath at 100° for 30 minutes. After cooling, the solution was diluted with EtOAc (100 mL) and washed with aqueous KF (0.67 satd., 3 × 30 mL) and water (2 × 20 mL). The combined aqueous layers were back-extracted with EtOAc (60 mL). The combined organics were dried ( $MgSO_4$ ) filtered, and evaporated to dryness. The resulting oil was purified by silica gel chromatography (gradient 2–10% EtOAc in pet. ether) to yield a white solid (0.165 g, 89%): mp 102–103° (EtOAc/pet. ether);  $^1H$  NMR ( $CDCl_3$ )  $\delta$  7.20 (m, 4 H), 2.61 (m, 2 H), 2.51 (m, 2 H), 2.35 (s, 3 H), 2.15 (s, 3 H);  $^{13}C$  NMR ( $CDCl_3$ )  $\delta$  207.6, 171.2, 140.1, 137.2, 128.9, 34.7, 31.7, 21.2, 18.2. IR ( $CHCl_3$ ) 1685  $cm^{-1}$ ; Anal. Calcd for  $C_{13}H_{14}O$ : C, 83.87; H, 7.54. Found: C, 84.06; H, 7.42.



**10.1.5. 1-(4-Nitrophenyl)-2-propenone [Cross-Coupling of an Acid Chloride with an Arylstannane] (146)**

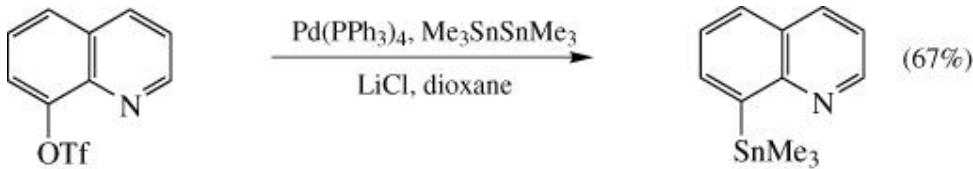
To a solution of 4-nitrobenzoyl chloride (5.00 mmol) and  $BnPd(PPh_3)_2Cl$  (0.015–0.020 g, 0.020–0.026 mmol) in chloroform (1 mL) was added a solution of tributylvinylstannane (5.20 mmol) in chloroform (4 mL). The resulting yellow solution was heated at 65° under dry air until palladium metal precipitated (20 minutes). The reaction mixture was diluted with  $Et_2O$  (30 mL) and washed with water (30 mL). The organic phase was shaken with an aqueous KF solution (15 mL of saturated KF solution/15 mL of water) and allowed to stand for

15–30 minutes. The resulting white precipitate (  $\text{Bu}_3\text{SnF}$  ) was removed by filtration. The organic layer was separated and again treated with an aqueous KF solution. After decantation from the resulting white precipitate, the organic phase was washed with concentrated  $\text{NaCl}$  solution, dried (  $\text{MgSO}_4$  ), and concentrated under reduced pressure. Treatment of the residue with  $\text{EtOAc}$  afforded an additional crop of white precipitate, which was removed by filtration through a Celite pad. Following concentration under reduced pressure, recrystallization from chloroform/hexanes gave the product as a yellow solid (0.780 g 88%): mp 87–89°;  $^1\text{H}$  NMR(  $\text{CDCl}_3$  )  $\delta$  6.0 (dd,  $J = 10.2$  Hz, 1 H), 6.4 (dd,  $J = 18.2$  Hz, 1 H), 7.1 (dd,  $J = 18.1$  Hz, 1 H), 8.0 (d,  $J = 9$  Hz, 2 H), 8.3 (d,  $J = 9$  Hz, 2 H); IR (KBr) 1670  $\text{cm}^{-1}$ ; Anal. Calcd. for  $\text{C}_9\text{H}_7\text{NO}_3$ : C, 61.02; H, 3.93. Found: C, 61.23; H, 4.11.



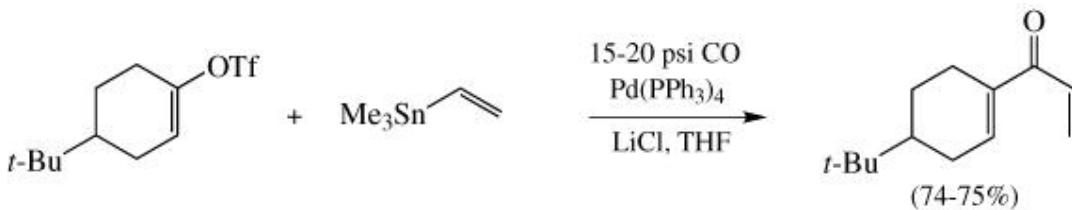
#### **10.1.6. 4-Allylacetophenone[Cross-Coupling of an Aryl Triflate under Mild Conditions Using Tri(2-furyl)phosphine as Ligand] (11)**

A solution of 4-(triflyloxy)acetophenone (0.566 g, 2.11 mmol) in NMP (3 mL) was treated with anhydrous LiCl (0.268 g, 6.30 mmol), tri(2-furyl)phosphine (0.0392 g, 0.168 mmol), and  $\text{Pd}_2(\text{dba})_3$  (0.0193 g, 0.042 mmol Pd). After 10 minutes at room temperature, the solution was treated with allyltributylstannane (0.72 mL, 2.464 mmol) and the mixture was stirred at room temperature for 24 hours. The solution was stirred with a saturated aqueous KF solution, diluted with  $\text{EtOAc}$ , and filtered. Washing the organics with water, drying (anhydrous  $\text{Na}_2\text{SO}_4$ ), and evaporation of the solvent gave a crude oil which was purified by flash chromatography (silica gel, 5%  $\text{EtOAc}$  in hexanes) to yield a colorless liquid (0.264 g, 78.5%); bp (Kugelrohr) 90–95° (0.2 mmHg);  $^1\text{H}$  NMR(  $\text{CDCl}_3$  )  $\delta$  7.89 (d,  $J = 8.3$  Hz, 2 H), 7.27 (d,  $J = 8.2$  Hz, 2 H), 5.94 (m, 1 H), 5.13–5.06 (m, 2 H), 3.43 (d,  $J = 6.7$  Hz, 2 H), 2.57 (s, 3 H); Anal. Calcd for  $\text{C}_{11}\text{H}_{12}\text{O}$  : C, 82.46; H, 7.55. Found: C, 82.11; H, 7.56.



**10.1.7. 8-(Trimethylstanny)quinoline (Preparation of an Arylstannane by Cross-Coupling of an Aryl Triflate with Hexamethyldistannane) (189)**

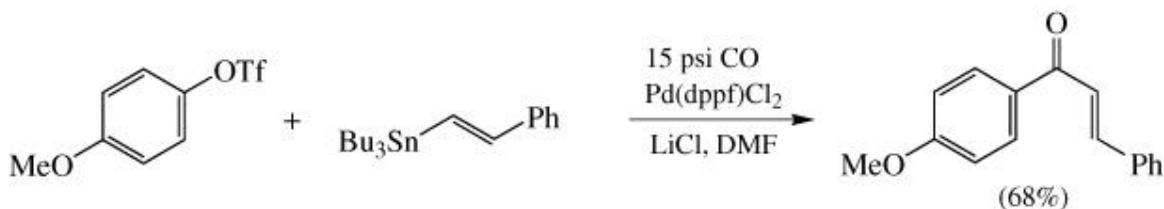
To a solution of 8-(triflyloxy)quinoline (1.98 mmol) in dioxane (9 mL) were added hexamethyldistannane (2.05 mmol), LiCl (0.252 g, 5.94 mmol)  $\text{Pd}(\text{PPh}_3)_4$  (0.046 g, 0.040 mmol), and a few crystals of BHT. The mixture was heated to reflux for 75 hours, cooled, and treated with pyridine (1 mL) and pyridinium fluoride (1.4 M in THF, 2 mL) for 16 hours at room temperature. The mixture was diluted with  $\text{Et}_2\text{O}$ , filtered through Celite, and washed with water, 10% HCl, water, and brine. Drying ( $\text{MgSO}_4$ ) and concentration afforded an oil. Silica gel chromatography and bulb-to-bulb distillation (bp: 103–104° at 0.4 mm Hg) gave a colorless oil in 67% yield;  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  8.86 (dd,  $J = 4.2, 1.7$  Hz, 1 H), 8.07 (dd,  $J = 8.2, 1.8$  Hz, 1 H), 7.88 (d,  $J = 6.5, 1.3$  Hz, 1 H), 7.75 (dd,  $J = 8.1, 1.3$  Hz, 1 H), 7.49 (dd,  $J = 8.1, 6.6$  Hz, 1 H), 7.31 (dd,  $J = 8.2, 4.2$  Hz, 1 H), 0.30 (s, 9 H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  153.17, 153.06, 149.35, 147.56, 136.94, 127.97, 126.21, 125.83, -8.32; IR (neat) 3050, 2970, 2905, 1485, 810, 785  $\text{cm}^{-1}$ ; Anal. Calcd. for  $\text{C}_{12}\text{H}_{15}\text{NSn}$  : C, 49.37; H, 5.18. Found: C, 49.50; H, 5.25.



**10.1.8. 4-(tert-Butyl-1-vinylcyclohexen-1-yl)-2-propenone [Carbonylative Cross-coupling of an Alkenyl Triflate with an Alkenylstannane Using  $\text{Pd}(\text{PPh}_3)_4$  and LiCl] (421)**

A slurry of  $\text{Pd}(\text{PPh}_3)_4$  (1.12 g, 0.968 mmol) and LiCl (13.2 g, 0.312 mol) in dry THF (500 mL) was stirred for 15 minutes under a static Ar atmosphere, then a solution of 4-*tert*-butylcyclohexenyl triflate (28.6 g, 0.100 mol) and trimethylvinylstannane (19.1 g, 0.100 mol) in dry THF (250 mL) was added, followed by an additional 250 mL of THF. The reaction mixture was flushed with carbon monoxide and maintained under a carbon monoxide atmosphere (15–20 psi) while heating to 55°. After 40 hours the reaction mixture darkened and was cooled to room temperature. The resulting solution was diluted with pentane (500 mL), washed with water (2 × 200 mL), saturated  $\text{NaHCO}_3$  solution (2 × 200 mL), and brine (2 × 200 mL), then was dried ( $\text{MgSO}_4$ ), filtered through a 4-cm × 4-cm pad of silica gel, and concentrated under reduced pressure. Bulb-to-bulb distillation (Kugelrohr) at 85–95° (0.35 mm Hg) gave the desired product (14.3–14.5 g, 74–75%): bp 75° (0.1 mm Hg);  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  0.81 (s, 9 H), 1.21–2.65 (m, 7 H), 5.58 (d,  $J = 9.0$  Hz, 1 H),

6.14 (d,  $J = 17.2$  Hz, 1 H), 6.75–7.00 (m, 2 H);  $^{13}\text{C}$  NMR ( $\text{CDCl}_3$ )  $\delta$  23.3, 24.6, 26.9 (3 C), 27.8, 32.0, 43.4, 127.1, 131.5, 141.1, 190.8; IR (neat) 1665, 1645, 1612  $\text{cm}^{-1}$ .



**10.1.9. (E)-1-(4-Methoxyphenyl)-3-phenyl-2-propenone [Carbonylative Cross-Coupling of an Aryl Triflate with an Alkenylstannane Using  $\text{Pd(dppf)Cl}_2$  and  $\text{LiCl}$ ] (336)**

To a solution of 4-methoxyphenyl triflate (0.390 g, 1.52 mmol) in DMF (7 mL) was added (E)-(  $\beta$  -tributylstannyl)styrene (0.645 g, 1.64 mmol), LiCl (0.200 g, 4.72 mmol),  $\text{Pd(dppf)Cl}_2$  (0.045 g, 0.060 mmol), a few crystals of BHT, and 4 Å molecular sieves (0.10 g). The resulting mixture was heated at 70° under 15 psi of CO. After 23 hours the reaction was cooled to room temperature, diluted with  $\text{Et}_2\text{O}$ , and filtered. The filtrate was washed with water (3 times) and saturated NaCl solution, dried ( $\text{MgSO}_4$ ), and concentrated. The resulting material was purified by chromatography (silica gel, 10:1 hexanes/EtOAc) to give the product as a white solid (0.250 g, 68%), which was recrystallized from 20:1 hexanes/EtOAc: mp 105–106°.  $^1\text{H}$  NMR ( $\text{CDCl}_3$ )  $\delta$  3.82 (s, 3 H); 6.94, (d,  $J = 8.8$  Hz, 2 H), 7.36–7.39 (m, 3 H), 7.53 (d,  $J = 15.7$  Hz, 1 H), 7.59–7.63 (m, 2 H), 7.79 (d,  $J = 15.7$  Hz, 1 H), 8.03 (d,  $J = 8.9$  Hz, 1 H).

## 11. Tabular Survey

The literature was searched to the end of 1994 by Chemical Abstracts, extensive citation searches and browsing. A few of the papers which describe Stille couplings but are missing a vital piece of information (i.e., clear structure of substrates and/or products) were not abstracted. No attempts were made to cover the patent literature. A dash indicates lack of reported yield. When only GLC, NMR, or HPLC yields were reported, these were simply incorporated in the tables without specific notation. When both isolated and "estimated" yields were given, the isolated yields are shown in the tables. If experimental conditions were not given, the appropriate column usually contains the generic statement "Pd(0)". Reactions that appear well documented but afford none of the anticipated product are still reported, and 0% yield is shown next to the structure of the expected product. We think failed reactions may stimulate further research and new thinking. In some papers, the attempt to optimize a reaction led to many experiments done on the same substrate under slightly different catalytic conditions. In most cases, for the sake of simplicity, we report only the highest yielding of all these experiments. However, in some cases the comparison of two or more sets of conditions on the same substrate proves a point which, in our opinion, was important enough to warrant a separate entry.

Some of the 1995 papers were incorporated in the tables as they appeared in the literature, but only those which, in our opinion, reported new catalytic systems or new classes of substrates.

The substrates are broken down into specific classes according to electrophile type, to reflect the classification made in the "Scope and Limitations" section. Some classes (heterocyclic or acyl electrophiles) are further broken down into subclasses to facilitate target finding. The electrophiles are listed in order of increasing carbon count for the moiety that is being transferred (the leaving group is not included in the carbon or heteroatom count). Within a given C count, they are listed in order of increasing numbers of heteroatoms, the priority being assigned alphabetically except for H, which has *the lowest* priority. For example  $C_6H_5ClO$  has priority over  $C_6H_5O$  and/or  $C_6H_6ClO$ . This ranking was the simplest and visually the most pleasing of a number of alternatives that we examined.

Electrophiles where the halide moiety is attached to a heterocyclic system or an aryl ring fused to a heterocyclic system (be it aromatic or partially saturated) are considered heterocyclic electrophiles. If the heterocyclic portion is *isolated* from the electrophilic moiety, then it is not considered.

The stannanes are similarly arranged according to the moiety that is being transferred. Tin hydrides are listed first, then all the C-based nucleophiles in the order explained above (in addition, trimethylstannanes have priority over tributylstannanes and bis[stannanes] are listed after all the monostannanes within a given electrophile), then the heterostannanes are listed (priority is assigned based on the alphabetical rank of the atom whose bond to tin is being broken). Intramolecular Stille couplings are listed in separate tables. A special case is the coupling of bis(stannanes) with bis(electrophiles), ultimately yielding a cyclic product. These reactions are listed twice: once in the appropriate table for the Stille coupling which our mechanistic knowledge tells us is taking place first, the second time in the intramolecular table. We realize this is cumbersome and causes duplication, but it seems the only logical way of dealing with the problem in an informative way. Other, more complex strategies in which the Stille reaction is coupled to other reactions are listed separately in Tables XXXII (no CO involved) and XXXIII (CO involved). The structures of stannanes that were formed in situ are enclosed in brackets.

The following abbreviations are used in the tables:

BINAP	2,2¢-bis(diphenylphosphino)-1,1¢-binaphthyl
Bn	benzyl
Boc	<i>tert</i> -butoxycarbonyl
BOM	benzyloxymethyl
Bz	benzoyl
Cbz	benzyloxycarbonyl
d	day(s)
dba	dibenzylideneacetonyl
DIOP	2,3-O-isopropylidene-2,3-dihydroxy-1,4-bis-(diphenylphosphino)butane
DME	1,2-dimethoxyethane, glyme
DMF	dimethylformamide
DMSO	dimethyl sulfoxide
dppb	1,3-bis(diphenylphosphino)butane
dppf	1,1'-bis(diphenylphosphino)ferrocene
dppp	1,3-bis(diphenylphosphino)propane
EE	(1-ethoxy)ethyl
FMOC	fluorenylmethyloxycarbonyl
HMPA	hexamethylphosphoric triamide
MEM	methoxyethoxymethyl
MOP	2-diphenylphosphino)-2'-methoxy-1,1-binaphthyl
MOM	methoxymethyl

Ms	methanesulfonyl
NMP	<i>N</i> -methylpyrrolidinone
Ph-BIAN	bis(phenylimino)acenaphthene
PMB	<i>p</i> -methoxybenzyl
PNB	<i>p</i> -nitrobenzyl
rt	room temperature
SEM	(2-trimethylsilylethoxy)methyl
TBDMS	<i>tert</i> -butyldimethylsilyl
TBDPS	<i>tert</i> -butyldiphenylsilyl
Tf	trifluoromethanesulfonyl
Thexyl	1-(1,1,2-trimethyl)propyl
TIPS	tri(isopropyl)silyl
THF	tetrahydrofuran
THP	tetrahydropyranyl
TMS	trimethylsilyl
<i>p</i> -Tol	<i>p</i> -tolyl
Ts	<i>p</i> -toluenesulfonyl

**Table I. Direct Cross-Coupling of Alkenyl Electrophiles**

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**Table II. Intramolecular Cross-Coupling of Alkenyl Electrophiles**

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**Table III. Direct Cross-Coupling of Aryl Electrophiles**

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**Table IV. Intramolecular Cross-Coupling of Aryl Electrophiles**

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**Table V. Direct Cross-Coupling of Furan and Benzofuran Electrophiles**

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**Table VI. Direct Cross-Coupling of Pyrrole and Indole Electrophiles**

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**Table VII. Direct Cross-Coupling of Thiophene and Benzothiophene Electrophiles**

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**Table VIII. Direct Cross-Coupling of Pyran and Benzopyran Electrophiles**

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**Table IX. Direct Cross-Coupling of Pyridine Electrophiles**

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**Table X. Direct Cross-Coupling of Pyrimidine Electrophiles**

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**Table XI. Direct Cross-Coupling of Quinoline and Isoquinoline Electrophiles**

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**Table XII. Direct Cross-Coupling of Miscellaneous Heterocyclic Electrophiles**

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**Table XIII. Direct Cross-Coupling of Acyl Chlorides: Alkyl Systems**

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**Table XIV. Direct Cross-Coupling of Acyl Chlorides: Aryl Systems**

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**Table XV. Direct Cross-Coupling of Acyl Chlorides: Benzyl Systems**

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**Table XVI. Direct Cross-Coupling of Acyl Chlorides: Alkenyl Systems**

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**Table XVII. Direct Cross-Coupling of Acyl Chlorides: Heterocyclic Systems**

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**Table XVIII. Direct Cross-Coupling of Chloroformates and Carbamoyl Chlorides**

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**Table XIX. Intramolecular Cross-Coupling of Acyl Chlorides and Chloroformates**

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**Table XX. Direct Cross-Coupling of Allyl and Propargyl Electrophiles**

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**Table XXI. Direct Cross-Coupling of Benzyl Electrophiles**

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**Table XXII. Intramolecular Cross-Coupling of Allyl and Benzyl Electrophiles**

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**Table XXIII. Direct Cross-Coupling of Organometallic Electrophiles**

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**Table XXIV. Direct Cross-Coupling of Miscellaneous Electrophiles**

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**Table XXV. Carbonylative Cross-Coupling of Alkenyl Electrophiles**

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**Table XXVI. Carbonylative Cross-Coupling of Aryl Electrophiles**

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**Table XXVII. Carbonylative Cross-Coupling of Heterocyclic Electrophiles**

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**Table XXVIII. Carbonylative Cross-Coupling of Allyl and Benzyl Electrophiles**

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**Table XXIX. Carbonylative Cross-Coupling of Miscellaneous Electrophiles**

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**Table XXX. Intramolecular Carbonylative Cross-Coupling Reactions**

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**Table XXXI. Cross-Coupling Reactions that Form Polymers**

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**Table XXXII. Multi-Step Transformations Involving Direct Cross-Coupling Reactions**

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**Table XXXIII. Multi-Step Transformations Involving Carbonylative Cross-Coupling**

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TABLE I. DIRECT CROSS-COUPING OF ALKENYL ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>2</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, neat, 80°, 12 h		270
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 66°		422
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), CuI, DMF, 50°		49
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 90°, 1 h		74
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (20%), DMF, 80°, 100 min		170
			Pd(0)		423, 424
C <sub>3</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 66°		422
	Cl-CH=CH-Cl		Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF		44
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF		44
C <sub>3</sub>			Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°		239, 240
			Pd[PPh <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux, 20 h		425
			Pd[PPh <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux, 20 h		425
			Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe or xylene, 100-120°		316
	HO <sub>2</sub> C-CH=CH-BR	PhSnCl <sub>3</sub>	PdCl <sub>2</sub> , KOH, 90°		281
		PhSnCl <sub>3</sub>	PdCl <sub>2</sub> , KOH, 90°, PhP(m-C <sub>6</sub> H <sub>4</sub> SO <sub>3</sub> Na) <sub>2</sub>		281
C <sub>4</sub>	HO <sub>2</sub> C-CH=CH-I		Pd(0)		54
	Et-CH=CH-I	Me <sub>3</sub> SnC≡C(CH <sub>2</sub> ) <sub>10</sub> OAc	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 25°		47
			Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°		239, 240
			Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°		239, 240
			Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°		239, 240

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

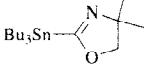
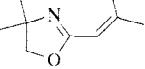
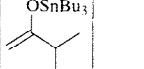
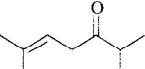
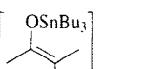
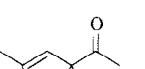
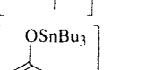
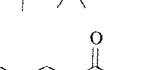
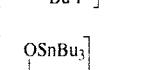
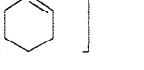
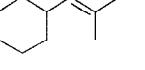
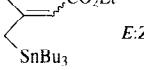
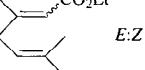
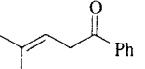
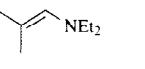
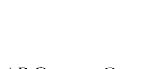
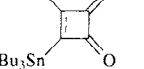
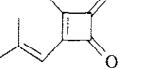
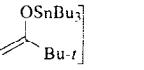
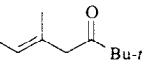
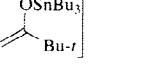
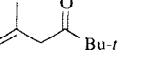
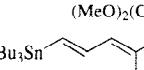
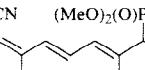
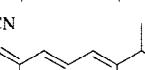
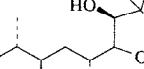
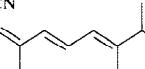
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
64		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%)	 (51)	426
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°	 (74)	239, 240
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°	 (8)	239, 240
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°	 (81)	239, 240
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°	 (32)	239, 240
		E:Z = 1:7 Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 21 h	 E:Z = 1:3 (20)	306, 427
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°	 (74)	239, 240
	Bu <sub>3</sub> SnNEt <sub>2</sub>	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100-120°	 (50)	316
	(Bu <sub>3</sub> Sn) <sub>2</sub> S	Pd(PPh <sub>3</sub> ) <sub>4</sub> , (1%), PhMe, 120°	 (25)	426
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (8%), DMF, rt, 30 min	 (70)	188
65		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°	 (76)	239, 240
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°	 (90)	239, 240
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF	 (73)	80
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF	 (>59)	80
	 OTBDMS TBDMSO OMe	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , NMP, rt	 (64)	80
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, 60°	 (55)	81
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 20°, 2 h	 (51)	428

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
Bu <sub>3</sub> SnC≡CTMS		Pd(PPh <sub>3</sub> ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 20°, 2 h	 (30)	428
Bu <sub>3</sub> SnC≡CPh		Pd(PPh <sub>3</sub> ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 20°, 2 h	 (70)	428
Bu <sub>3</sub> SnC≡C—C≡CPh		Pd(PPh <sub>3</sub> ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 20°, 6 h	 (11)	428
<sup>99</sup> MeO <sub>2</sub> C—CH=Br Z:E = 7:1	MOMO-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (20%), DMF, 80°, 10 min	 (81) Z:E = 3:1	170
	"	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (10%), DMF, rt, 1 h	 (68) Z:E = 1.5:1	289
MeO <sub>2</sub> C—CH=I	"	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 90°, 2 h	" (87)	289
	Bu <sub>3</sub> Sn-	Pd(OAc) <sub>2</sub> , P( <i>o</i> -Tol) <sub>3</sub> , NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 2 h	 (64)	429
<sup>100</sup> HO <sub>2</sub> C—CH=I	Bu <sub>3</sub> Sn-	Pd(OAc) <sub>2</sub> , P( <i>o</i> -Tol) <sub>3</sub> , NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 2 h	 (60) Z:E = 4:1	429
	Bu <sub>3</sub> Sn—CH=	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 45°, 12 h	 (60)	430
	Bu <sub>3</sub> Sn—CH=CH-OEt	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 45°, 12 h	 (50)	430
	Bu <sub>3</sub> Sn—CH=CH-Ph	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 45°, 12 h	 (82)	430
C <sub>5</sub>  <i>n</i> -Pr—CH=I	Ph <sub>3</sub> SnF <sub>2</sub> <sup>-</sup> Bu <sub>4</sub> N <sup>+</sup>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, reflux, 30 min	 (81)	283
	Me <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°	 (—)	431
	<i>n</i> -Pr—CH=I	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 25°	 (83)	47
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%)	 (65)	426
<sup>101</sup>  <i>t</i> -Bu <sub>3</sub> Sn- [O-SnBu <sub>3</sub> ] <i>t</i> -Bu-I		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100°	 (86)	239, 240
	Bu <sub>3</sub> SnNEt <sub>2</sub>	Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100–120°	 (0)	316
	(Bu <sub>3</sub> Sn) <sub>2</sub> S	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°	 (0)	318

TABLE I. DIRECT CROSS-COUPING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnC≡CPh	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (8%), DMF, rt, 30 min	(64)	188
	Bu <sub>3</sub> SnC≡CPh	"	(66)	188
	Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°, 6 h	(92)	289
	TsHN-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°, 3 h	(78)	74
89 	Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), DMF, 70°, 6 h	(70)	287
	"	"	(77)	287
	Bu <sub>3</sub> Sn-	[{η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> }PdCl] <sub>2</sub> , DMF, rt, 24 h	(66)	287, 432
	Bu <sub>3</sub> Sn-	[{η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> }PdCl] <sub>2</sub> , DMF, 70°, 1 h	(79)	287
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (20%), DMF, 80°, 1 h	(70)	170
	Bu <sub>3</sub> Sn-	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 13 h	(73)	63
69 	Bu <sub>3</sub> SnC≡CTMS	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 20 h	(57)	63
	Bu <sub>3</sub> SnPh	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 6 h	(85)	63
	Bu <sub>3</sub> Sn-	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 15 h	(81)	63
	Bu <sub>3</sub> SnC≡CBu- <i>n</i>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 20 h	(55)	63
	Bu <sub>3</sub> Sn-	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 10 h	(83)	63

TABLE I. DIRECT CROSS-CO尤LING OF ALKENYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnSPh	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 3 h	 (88)	63
	Bu <sub>3</sub> Sn(OEt) <sub>2</sub>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 10 h	 (62)	63
	Bu <sub>3</sub> Sn-Substituted Thiophene	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 15 h	 (65)	63
	Bu <sub>3</sub> SnC≡CTMS	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 20 h	 (56)	63
	Bu <sub>3</sub> SnPh	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 20 h	 (70)	63
	Bu <sub>3</sub> SnC≡CBu- <i>n</i>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 20 h	 (50)	63
	Bu <sub>3</sub> Sn-Substituted Phenyl	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 20 h	 (81)	63
	Bu <sub>3</sub> Sn-Substituted THP	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 20 h	 (61)	63
	Bu <sub>3</sub> SnSPh	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 8 h	 (80)	63
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°, 30 min	 (55)	289
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (20%), DMF, 80°, 75 min	 (56)	170
	EtO <sub>2</sub> C-Substituted Br	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), <i>m</i> -xylene, 120°, 20 h	 (40)	433
	Me <sub>3</sub> Sn-Substituted SEM	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), THF, reflux	 (74)	434
	EtO <sub>2</sub> C-Substituted I	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (75%), DMF, rt, 7 h	 (66)	435
	Bu <sub>3</sub> Sn-Substituted EtO <sub>2</sub> C	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	 (53) Z:E = 87:13 +  (17) Z,E:E,E = 72:28	375

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	(84)	375	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°	(—)	431	
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 55°, 30 min	(56)	436	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), C <sub>6</sub> H <sub>6</sub> , 80°, 40 h	I (67) + II (21)	317	
TMS- Br E:Z = 87:13	Me <sub>3</sub> SnSPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3-4%), C <sub>6</sub> H <sub>6</sub> , 40°, 2 h	(91)	317	
72	E:Z = 9:1	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°, 1 h	(93)	289	
	E:Z = 100:0	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 90°, 1.5 h	(98)	74	
C <sub>6</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.45%), LiCl, THF, 60°, 4 h	(72)	176	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, Li <sub>2</sub> CO <sub>3</sub> , THF, 60°, 96 h	(80)	176	
73		Me <sub>3</sub> SnC≡CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 22-25°, 24 h	(90)	47
		"	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 8 h	(61)	46
		"	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.5-2%), DMF, 25°, 23 h	" (80)	46
		"	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.5-2%), DMF, 25°, 23 h	" (90)	46
	Me <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 22-25°, 3 h	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 50°	(96)	47
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	" (—)		431
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 65°	" (48)		437
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 65°	" (53)		437
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 80°, 68 h	(68)		376
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 25°, 23.5 h	(69)		46

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (1-2%), DMF, 25°, 12 h	(59)	46
		Pd(PPh3)4 (5%), THF, rt, 24 h	(33)	438
		Pd(PPh3)4, THF, 22-25°, 3 h	(76)	47
	"	Pd(PPh3)2Cl2, THF, 22-25°, 2 h	" (92)	47
74		Pd(PPh3)4 (5%), PhMe, reflux	(58)	437
		Pd(PPh3)4 (5%), PhMe, 111°	" (63)	437
		Pd(PPh3)2Cl2, THF, 22-25°, 10 h	(90)	47
		Pd(PPh3)2Cl2, THF, 22-25°, 50 h	" (92)	47
		Pd(PPh3)4, PhMe, 55°, 50 h	" (51)	376
		Pd(PPh3)2Cl2, THF, 22-25°, 18 h	(91)	47
75		Pd(PPh3)4 (5%), Et3N, MeCN, 100°, 8 h	(58)	290
		Pd(PPh3)4 (5%), LiCl, THF, 60°, 16 h	(82)	270
		Pd(PPh3)4, THF, reflux, 30 min	(83)	283
		Pd2(dba)3 (5%), AsPh3 (40%), THF, 65°	(47)	375
		"	(79)	375
		Pd2(dba)3 (2%), LiCl, DMF, rt	(53)	439
		Pd(PPh3)4 (1.8%), LiCl, THF, 60°, 3 h	(81)	176
		Pd(PPh3)4 (1%), LiCl, THF, 60°, 12 h	(22)	176
		Pd(CH3CN)2Cl2 (5%), DMF, rt, 15 min	(63)	187
		Pd(CH3CN)2Cl2 (5%), DMF, rt, 1 h	" (63)	187

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Me <sub>3</sub> SnC≡CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , Et <sub>2</sub> O, 22-25°, 22 h	(50)	47
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 8.5 h	(74)	46
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 70°, 5 h	(41)	440
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 4 h	(83) E,E,Z,E = 94:6	46
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 4 h	(78)	46
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), Et <sub>3</sub> N, CuI, CH <sub>3</sub> CN, 100°, 8 h	(71)	290
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2-5%), DMF, 50°, 70 h	(10) +  (13)	441
"		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2-5%), HMPA, 80°, 20 h	(30) (5)	441
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 24 h	(41)	438
Me <sub>3</sub> SnC≡CTMS		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 50°, 24 h	(78)	47
"		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , THF, 22-25°, 3 h	" (89)	47
Me <sub>3</sub> SnC≡CTMS		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 4 h	(68) +  (57)	46
Me <sub>3</sub> SnC≡CBu-n		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, -50°, 3 min	(88)	47
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI(7-10%), DMF, rt	(36)	12
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI(7-10%), DMF, rt	(66)	12
Me <sub>3</sub> SnC≡C(CH <sub>2</sub> ) <sub>4</sub> OAc		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, -50°, <2 min	(97)	47
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DIBAL, THF, rt	(88)	442
Me <sub>3</sub> SnC≡C(CH <sub>2</sub> ) <sub>4</sub> OTHP		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 25°	(91)	47
	Me <sub>3</sub> SnC≡CH	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 9 h	(78)	46
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 4 h	(65)	46
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 122 h	(62)	46

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.		
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 24 h		(40)	438	
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), n-BuLi, DMF, 25°, 6 h		(25) +	(53)	46
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 22-25°, 1 h		(91)	47	
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> or Pd(0)/P(2-furyl) <sub>3</sub> , DMF		(64)	443	
	"	"		(42)	443	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°		(—)	431	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 17 h		(90)	28, 444	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 60°, 48 h		(94)	270	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, dioxane, reflux, 16 h		(76)	445	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°, 4 h		(87)	289	
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80-85°, 40 h		(46)	446	
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, rt, 18 h		(60)	61	
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 40 min		(75)	61	
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 4 h		(86)	61	
		Pd(dba) <sub>2</sub> (4%), P(2-furyl) <sub>3</sub> (8%), THF, 25°, 48 h		(84)	447	
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), NMP, rt		(77)	30, 448	
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), LiCl, NMP, rt		(83)	30, 448	
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 55°, 1 h		(60)	436	

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

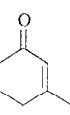
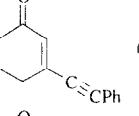
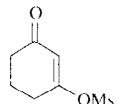
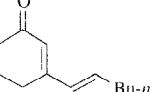
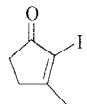
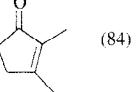
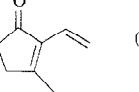
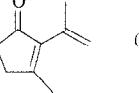
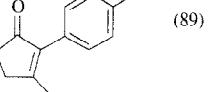
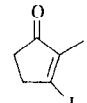
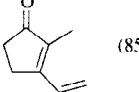
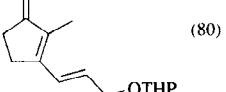
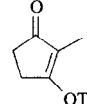
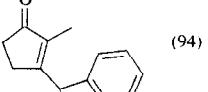
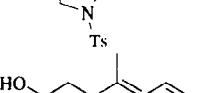
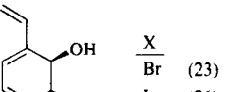
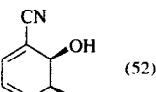
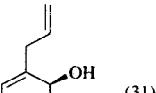
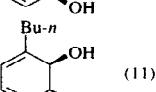
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
	<chem>Bu3SnC=C</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF	 +  (—)	173	
	<chem>Bu3SnC#CPh</chem>	Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 55°, 40 min	 (91)	436	
		<chem>Bu3SnC=CBu-n</chem>	 (50) E:Z = 91:9	173	
	<chem>HO(CH2)4C=CI</chem>	<chem>Me3SnC=CBu-n</chem>	 (CH <sub>2</sub> ) <sub>4</sub> OH (73)	46	
80		<chem>Me4Sn</chem>	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80–85°	 (84)	446
		<chem>Bu3SnC=C</chem>	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 90°, 20 min	 (81)	61
		<chem>Bu3SnC=C</chem>	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 100°, 30 min	 (93)	61
		<chem>Bu3SnC6H5</chem>	"	 (89)	61
		<chem>Bu3SnC=C</chem>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (3%), THF, 55°	 (85)	52
		<chem>Bu3SnC=COTHP</chem>	"	 (80)	52
		<chem>Bu3SnC=CNTs</chem>	Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), DMF, 60°, 1 h	 (94)	291
	<chem>HOCCCCC=CI</chem>	<chem>Bu3SnC=C</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, rt, 12 h	 (76)	449
81	<chem>Oc1ccc(O)c(O)c1X</chem>	<chem>Bu3SnC=C</chem>	Pd(OAc) <sub>2</sub> , PPh <sub>3</sub> , THF	 X: Br (23), I (26)	450
	<chem>Oc1ccc(I)c(O)c1O</chem>	<chem>Bu3SnC#C</chem>	Pd(OAc) <sub>2</sub> , PPh <sub>3</sub> , THF, 50°, 4 h	 (52)	450
		<chem>Bu3SnC=C</chem>	Pd(OAc) <sub>2</sub> , PPh <sub>3</sub> , THF	 (31)	450
		<chem>Bu3SnOMe</chem>	Pd(OAc) <sub>2</sub> , PPh <sub>3</sub> , THF	 (11)	450

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
			Pd <sub>2</sub> (dba) <sub>3</sub> (1%), AsPh <sub>3</sub> (8%), NMP, rt	(72) E:Z = 95:5	30, 448
			Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (6%), NMP, 35-40°	(92)	278
	E:Z = 68:32	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3-4%), PhMe, 60°, 3 h	(85) E:Z = 98:2	317
C <sub>7</sub>		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, reflux, 3.5 h	(71)	451
82		Bu <sub>3</sub> SnAllyl	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, reflux, 12 h	(97)	452
		Bu <sub>3</sub> SnAllyl	Pd(OAc) <sub>2</sub> (10%), CH <sub>2</sub> Cl <sub>2</sub> , rt, 30 min	(>90)	453
		Me <sub>3</sub> SnAllylTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 6 h	(100)	28, 444
		Ph <sub>3</sub> SnF <sub>2</sub> <sup>-</sup> Bu <sub>4</sub> N <sup>+</sup>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, reflux, 30 min	(85)	283
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.8%), LiCl, THF, 60°, 9 h	(84)	176
83		Me <sub>3</sub> SnAllylTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux 100 h	(90)	28, 444
		Ph <sub>3</sub> SnF <sub>2</sub> <sup>-</sup> Bu <sub>4</sub> N <sup>+</sup>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, reflux, 30 min	(84)	283
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, Li <sub>2</sub> CO <sub>3</sub> , THF, 60°, 168 h	(80)	176
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.8%), LiCl, THF, 60°, 0.75 h	(73)	176
	+	Bu <sub>3</sub> SnAllylOH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF	(47) +  (11)	454
	Z:Z:E = 4:1				
		Me <sub>3</sub> SnC <sub>2</sub> H <sub>4</sub> OCH <sub>2</sub> OTBDMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, rt, 20 h	(58) +  (34)	455
			[{η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> }PdCl] <sub>2</sub> , CH <sub>3</sub> CN, THF, rt, 5 min	(85)	41

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
84		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, rt, 3 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(81)	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), CuI (8%), DMF, 60°, 24 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(71)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 24 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(34)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	I (79)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, 111°	I (67)	437	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	I (46) + <i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(24)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 24 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(36)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	I (64)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 65°	I (43)	437	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	I (52) + <i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(19)	
85		Bu <sub>3</sub> SnSPh		437	
		[( <i>i</i> -Pr <sup>3</sup> -C <sub>2</sub> H <sub>5</sub> )PdCl] <sub>2</sub> , CH <sub>3</sub> CN, THF, rt, 5 min	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(71)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3-4%), PhMe, 65°, 6 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(70)	
		[( <i>i</i> -Pr <sup>3</sup> -C <sub>2</sub> H <sub>5</sub> )PdCl] <sub>2</sub> , CH <sub>3</sub> CN, THF, rt, 5 min	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(85)	
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, rt, 3 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(85)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 24 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(32)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 24 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(39)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 110°, 4.5 h	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(77) + <i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(22)
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(91)	
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	<i>n</i> -C <sub>5</sub> H <sub>11</sub> -	(58)	

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
98			Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, dioxane, reflux, 16 h 	(80) 445
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 30 min 	(95) 61	
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 110°, 5 h 	(83) 61	
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 110°, 7 h 	(89) 61	
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 65° 	(68) 259	
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 65° 	(10) + (86) 259	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux, 80 min 	(≥54) 67, 456	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux, 16 h 	(≥80) 456	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux 	(≥36) + (≥24) 67	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), dioxane, reflux, 48 h 	(≥80) 67, 456	
97		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux, 16 h 	(≥98) 67, 456	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux 	(≥31) 67	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux 	(≥39) 67	

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.		
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux		67		
	$\begin{array}{cccc} \text{R}^1 & \text{R}^2 & \text{R}^3 & \text{R}^4 \\ \hline \text{H} & \text{H} & \text{OMe} & \text{H} \\ \text{H} & & \text{OCH}_2\text{O} & \text{H} \\ \text{OMe} & \text{OMe} & \text{H} & \text{H} \\ \text{H} & \text{OMe} & \text{OMe} & \text{H} \\ \text{H} & \text{OMe} & \text{H} & \text{OMe} \\ \text{OMe} & \text{H} & \text{OMe} & \text{H} \\ \text{OMe} & \text{H} & \text{H} & \text{OMe} \\ \text{H} & \text{OMe} & \text{OMe} & \text{OMe} \\ \text{H} & \text{OMe} & \text{OTBDMS} & \text{OMe} \end{array}$		(≥53) (≥60) (≥80) (≥57) (≥80) (≥61) (≥79) (≥59) (≥55)			
88		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), P(2-furyl) <sub>3</sub> (2%), NMP, 80°, 24 h		(99)	356
	Bu <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), P(2-furyl) <sub>3</sub> (2%), HMPA, 80°, 24 h		(65)	356	
	Bu <sub>3</sub> SnC≡CPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), P(2-furyl) <sub>3</sub> (2%), PhMe, 80°, 24 h		(88)	356	
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiBr, THF, reflux, 3 h		(>82)	173
		Bu <sub>3</sub> SnPh	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 70°, 20 h		(87)	63
	Bu <sub>3</sub> SnC≡CBu-n	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 70°, 10 h		(58)	63	
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 70°, 20 h		(76)	63	
89		Bu <sub>3</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 50°		(50) (47) (64) (91) (60)	64
	$\begin{array}{cc} \text{R}^1 & \text{R}^2 \\ \hline \text{H} & \text{H} \\ \text{H} & \text{Me} \\ \text{H} & n\text{-Pr} \\ \text{H} & i\text{-Pr} \\ (\text{CH}_2)_5 & \end{array}$	Time (h)				
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 50°, 4 h		(84)	64	
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 70°, 20 h		(70)	63	

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 70°, 20 h		(49) (57)	63 63
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 70°, 10 h			
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 70°, 24 h		(68)	63
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN, 70°, 3 h		(87)	63
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, rt, 12 h		(80)	61
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 1 h		(76)	61
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 50°, 18 h		(66)	61
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), THF, rt		R = TMS (63) R = Ph (64)	65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), PPh <sub>3</sub> (10%), THF, rt, 24 h		(45)	65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), THF, rt, 3 h	" (55)		65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), THF, rt, 1 h	" (45)		65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), PPh <sub>3</sub> (10%), THF, rt, 24 h		(45)	65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), THF, rt, 5 h	" (60)		65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), THF, rt, 2 h	" (40)		65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), PPh <sub>3</sub> (10%), THF, rt, 48 h		(0)	65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), THF, rt, 48 h	" (23)		65, 66
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), THF, rt, 24 h	" (30)		65, 66

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
Ph <sup>≡</sup> CBr	Bu <sub>3</sub> SnCH <sub>2</sub> OTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub>	Ph <sup>≡</sup> CH(OTMS) (53)	457
	Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> N <sub>2</sub> Py	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, 80°	Ph <sup>≡</sup> CHC <sub>6</sub> H <sub>4</sub> N <sub>2</sub> Py (58)	458
	Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> OMe	Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), CuI (10%), DMF, 60°, 3 h	Ph <sup>≡</sup> CHC <sub>6</sub> H <sub>4</sub> OMe (62)	291
	Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> N(Bn)C=O	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 12 h	Ph <sup>≡</sup> CHC <sub>6</sub> H <sub>4</sub> N(Bn)C=O (81)	459
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (1.3%), PhMe, 115°, 15 h	Ph <sup>≡</sup> CHSnBu <sub>3</sub> (21)	460
92	Ph <sup>≡</sup> CBr E:Z = 93:7	Me <sub>2</sub> SnCH <sub>2</sub> TMS	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, rt, 23 h (56) E,E:E,Z = 95:5 (34)	46
	Ph <sup>≡</sup> CBr E:Z = 89:11	Bu <sub>3</sub> SnSPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3-4%), PhMe, 110°, 2 h Ph <sup>≡</sup> CHSPh (91) E:Z = 98.5:1.5	317
	Ph <sup>≡</sup> CBr E:Z = 85:15	Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> N(Boc)	Pd/C (0.5%), AsPh <sub>3</sub> (20%), CuI (10%), NMP, 80°, 12 h Ph <sup>≡</sup> CHC <sub>6</sub> H <sub>4</sub> N(Boc) (85) E:Z = 75:25	461
	Ph <sup>≡</sup> CBr E:Z = 81:19	Bu <sub>3</sub> SnCH <sub>2</sub> Z:E = 86:14	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CuI, DMF, 100° (30) E,Z:E,E = 85:15	385
	Ph <sup>≡</sup> CBr	Bu <sub>3</sub> SnCH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux (51)	462
93		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> O	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), HMPA, 60°, 23 h Ph <sup>≡</sup> CHC <sub>6</sub> H <sub>4</sub> O (80)	287
		Bu <sub>3</sub> SnCH <sub>2</sub> OEt	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 80°, 20 h 2. 5% HCl Ph <sup>≡</sup> CHCO (63)	269
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> O	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%) Ph <sup>≡</sup> CHC <sub>6</sub> H <sub>4</sub> O (77)	426
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> O	Pd(OAc) <sub>2</sub> (5%), P(o-Tol) <sub>3</sub> (10%), NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 2 h Ph <sup>≡</sup> CHC <sub>6</sub> H <sub>4</sub> O (>27)	429
		Me <sub>2</sub> SnPh	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), Bu <sub>4</sub> NCl, HMPA, 70°, 3.5 h Ph <sup>≡</sup> CHPh (60) + Ph-Ph (34)	463
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> N(Cyclohexyl)	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux Ph <sup>≡</sup> CHC <sub>6</sub> H <sub>4</sub> N(Cyclohexyl) (49)	437
		Bu <sub>3</sub> SnCH <sub>2</sub> CH <sub>2</sub> N(TMS) <sub>2</sub>	1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux 2. HCl Ph <sup>≡</sup> CHCH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub> Cl (75)	464
		Bu <sub>3</sub> SnCH <sub>2</sub> CH <sub>2</sub> CO <sub>2</sub> Et	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65° Ph <sup>≡</sup> CHCH <sub>2</sub> CH <sub>2</sub> CO <sub>2</sub> Et (75)	375
		Bu <sub>3</sub> SnCH <sub>2</sub> CH <sub>2</sub> CO <sub>2</sub> Et	" Ph <sup>≡</sup> CHCH <sub>2</sub> CH <sub>2</sub> CO <sub>2</sub> Et I (5) + II (7) + Ph <sup>≡</sup> CHCH <sub>2</sub> CH <sub>2</sub> CO <sub>2</sub> Et (54)	375
		Bu <sub>3</sub> SnCH <sub>2</sub> CH <sub>2</sub> CO <sub>2</sub> Et	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), Ag <sub>2</sub> CO <sub>3</sub> , I (33) + II (14) THF, 65°	375

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 65°	(91)	375
		[( $\eta^3$ -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> , HMPA, 60°, 6 h	(82)	287, 432
		[( $\eta^3$ -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> , HMPA, DMF, rt, 24 h	(76)	287, 432
		[( $\eta^3$ -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> , HMPA, rt, 1 h	(69)	287, 432
94	Bu <sub>3</sub> SnNEt <sub>2</sub>	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100-120°	(50)	316
	(Et <sub>3</sub> Sn) <sub>2</sub> S	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (5%), DMSO, 100°	(99)	320
	(Bu <sub>3</sub> Sn) <sub>2</sub> S	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°	" (77)	318
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 80°, 20 h 2. HCl (5%)	(73)	269
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%)	(95) Z:E = 1:1	426
	Bu <sub>3</sub> SnNEt <sub>2</sub>	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (0.66%), PhMe, 100-120°	(43)	316
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 6 min	(85)	46
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), DMF, 60°, 1 h	(71)	287
	Bu <sub>3</sub> Sn-CH=CH-NHBoc	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, rt	(89)	465
	Bu <sub>3</sub> Sn-CH=CH-CH=CH-NHFMOC	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 20°, 24 h	(65)	466
	Me <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°	(—)	431
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	(82)	437
95		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	R = Bu (77) +  (17) R = Ph (71) +  (17)	437
	Me <sub>3</sub> Sn-CH=CH-Ph E:Z = 93:7	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1-2%), DMF, 25°, 6 min	(71) E,E:E,Z = 6:1+ (14)	46, 187
	Bu <sub>3</sub> Sn-CH=CH-Ph	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, rt, 10 min	(69)	187, 46
	Bu <sub>3</sub> Sn-CH=CH-C(=O)-SiPh <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CH <sub>2</sub> Cl <sub>2</sub> , rt	(60)	467
	Bu <sub>3</sub> Sn-CH=CH-Ph	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, rt, 5 min	(79)	187
	Bu <sub>3</sub> Sn-CH=CH-Ph	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, rt, 5 h	(72)	187
		Pd(OAc) <sub>2</sub> (5%), P(o-Tol) <sub>3</sub> (10%), NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 2 h	(>38)	429

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(OAc) <sub>2</sub> (5%), P(o-Tol) <sub>3</sub> (10%), NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 2 h	(>46)	429
		Pd <sub>2</sub> (dba) <sub>3</sub> (2%), NMP, 24°	(72)	30
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 133 h	(80)	28.443
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 60°, 48 h	(94)	270
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 36 h	(100)	28, 444
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, Li <sub>2</sub> CO <sub>3</sub> , THF, 60°, 120 h	(62)	176
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, Li <sub>2</sub> CO <sub>3</sub> , THF, 60°, 120 h	(67)	176
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux	(75)	28, 444
		E:Z = 89:11 Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 20°, 24 h	E:Z = 90:10	466
		E:Z = 64:36 Pd(PPh <sub>3</sub> ) <sub>4</sub> (3.4%), PhMe, 50°, 7.5 h	(84) E:Z = 96:4	317
		E:Z = 64:36 Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°	(→)	431
		E:Z = 64:36 Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°	(→)	431
		E:Z = 64:36 Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.8%), LiCl, THF, 60°, 5 h	(74)	176
		E:Z = 64:36 BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (8%), DMF, rt, 30 min	(60)	188
		E:Z = 64:36 " "	(67)	188
		E:Z = 64:36 " "	(76)	188
		Z:E = 86:14 Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CuI, DMF, rt	(39) Z:E = 76:24	385
		Z:E = 86:14 Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CH <sub>2</sub> Cl <sub>2</sub> , rt, 12 h	(88)	445
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, dioxane, reflux, 16 h	(86)	467
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CH <sub>2</sub> Cl <sub>2</sub> , rt, 12 h	(86)	467

TABLE I. DIRECT CROSS-COUPLED OF ALKENYL ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), PPh <sub>3</sub> (8%), NMP, rt, 40 min	Me <sub>3</sub> Sn- (72)	260
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), PPh <sub>3</sub> (8%), NMP, rt, 85 min	Me <sub>3</sub> Sn- (47)	260
		Bu <sub>3</sub> Sn-	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), P(2-furyl) <sub>3</sub> , PhMe, 80°	(8)	356
86		Bu <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), Et <sub>4</sub> NCl, HMPA, 80°	(55)	356
		Bu <sub>3</sub> Sn--C≡CTMS	Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (6%), NMP, 35–40°	(80) E:Z = 80:20	278
		Bu <sub>3</sub> Sn--C≡SEM	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°, 1 h	(42)	289
		Me <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiBr, THF, reflux, 36 h	(73)	173
		Bu <sub>3</sub> Sn-	"	" (69)	173
		Bu <sub>3</sub> Sn-	"	I (24) E:Z = 93:7	173
		Bu <sub>3</sub> Sn-	"	I (69) +  (3) +  (28)	173
		Bu <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub>	(—)	173
		Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiBr, THF, reflux, 36 h	(33)	173
68		Bu <sub>3</sub> Sn-R	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiBr, THF, reflux, 36 h	R = Bu-n (79) R = Ph (57)	173
		Bu <sub>3</sub> Sn-CO <sub>2</sub> Et	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.25%), CsF, THF, reflux, 6 h	(58)	468, 469
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), PPh <sub>3</sub> (8%), NMP, rt, 4 h	Me <sub>3</sub> Sn- (78)	260
		Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF	X = Br (<5) X = I (80)	452
		Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), LiCl, THF	" X = OTf (85)	452
		Bu <sub>3</sub> Sn-	Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 55°, 6 h	(61)	436

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 55°, 12 h	(56)	436
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 65°	(59)	259
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 55°, 20 min	(0)	436
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 55°	(83)	436
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	(91)	375
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	(93)	375
		Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (6%), NMP, 35-40°	(90)	278
		Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (6%), NMP, 35-40°	(79)	278
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 65°	(75)	259
		Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (6%), NMP, 35-40°	(91)	278
		Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (6%), NMP, 35-40°	(94)	278
		Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (6%), NMP, 35-40°	(85)	278
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), PPh <sub>3</sub> (8%), NMP, rt, 90 min	(60)	260
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2-3%), CuI (6-10%), LiCl, THF, 67°	(65-70)	174
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux	(>89)	67, 456
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, reflux	(59)	67

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Bu <sub>3</sub> Sn <sup>≡</sup>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), LiCl, THF, reflux, 6 h	 (86)	470
		Bu <sub>3</sub> Sn <sup>≡</sup>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (5%), dioxane, 101°	 (55)	471
	"		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), dioxane, 101°	 (80)	471
102		Bu <sub>3</sub> Sn <sup>≡</sup>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), P(2-furyl) <sub>3</sub> (2%), PhMe, 80°, 24 h	 (40)	356
		Bu <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), Et <sub>4</sub> NCl, HMPA, 80°, 24 h	 (52)	356
		Bu <sub>3</sub> SnC≡CPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 24 h	 (26)	356
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> Cl-p	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), NMP, 24°	 (68)	30
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.8%), LiCl, Li <sub>2</sub> CO <sub>3</sub> , THF, 60°, 4 h	 (80)	176
		Bu <sub>3</sub> Sn <sup>≡</sup>	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), NMP, 24°	 (60)	30, 448
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (8%), LiCl, Li <sub>2</sub> CO <sub>3</sub> , THF, 60°, 240 h	 (39)	176
103		Bu <sub>3</sub> Sn <sup>≡</sup>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), P(2-furyl) <sub>3</sub> (2%), HMPA, 80°, 24 h	 (35)	356
		Bu <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), Et <sub>4</sub> NCl, HMPA, 80°, 24 h	 (52)	356
		Bu <sub>3</sub> SnC≡CPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 24 h	 (0)	356
		Ph <sub>3</sub> SnF <sub>7</sub> <sup>-</sup> Bu <sub>4</sub> N <sup>+</sup>	Pd(PPh <sub>3</sub> ) <sub>4</sub> . THF, reflux, 30 min	 (83)	283
		HSnBu <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub>	 (—)	472
		Me <sub>3</sub> Sn <sup>≡</sup>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , or Pd(AsPh <sub>3</sub> ) <sub>4</sub> , DMF	 (0)	473
		Bu <sub>3</sub> Sn <sup>≡</sup>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 90°, 2 h	 (23)	473
		Bu <sub>3</sub> Sn <sup>≡</sup> TMS	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 90°, 1 h	 (86)	473

TABLE I. DIRECT CROSS-COUPING OF ALKENYL ELECTROPHILES (Continued)

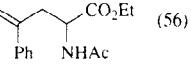
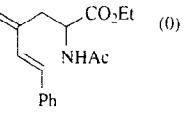
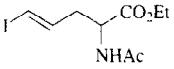
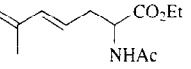
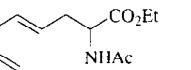
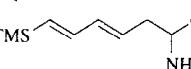
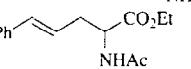
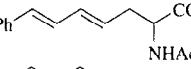
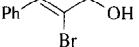
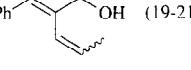
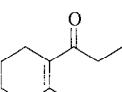
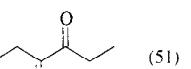
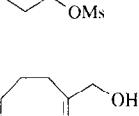
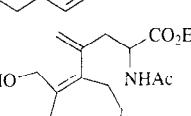
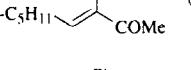
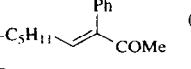
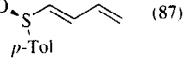
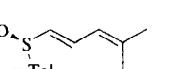
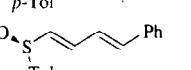
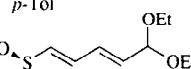
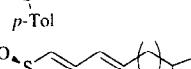
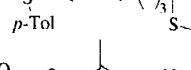
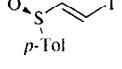
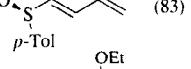
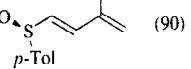
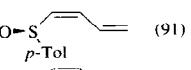
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 90°, 1 h	 (56)	473
	Me <sub>3</sub> SnPh-CH=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 80°, 1 h	 (0)	473
	Me <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 40°, 18 h	 (65)	473
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 80°, 4 h	 (41)	473
	Bu <sub>3</sub> Sn-CH=CH-TMS	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 80°, 4 h	 (23)	473
	Bu <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 15°, 15 h	 (31)	473
	Me <sub>3</sub> Sn-CH=CH-Ph	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF 40°, 17 h	 (21)	473
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CuI, DMF or PhMe, 100° to reflux	 (19-21)	385
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiBr, THF, reflux, 48 h	 (51)	474
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	 (44)	375
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 45°, 19 h	 (57)	446
	Me <sub>3</sub> SnPh	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 55°, 4.5 h	 (84)	446
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (2%), PPh <sub>3</sub> (8%), THF, reflux, 30 min	 (87)	59
	Bu <sub>3</sub> Sn-CH=CH-CH <sub>2</sub> -CH <sub>3</sub>	"	 (80)	59
	Bu <sub>3</sub> Sn-CH=CH-Ph	"	 (87)	59
	Bu <sub>3</sub> Sn-CH=CH-OEt	"	 (85)	59
	Bu <sub>3</sub> Sn-CH=CH-CH <sub>2</sub> -C(CH <sub>3</sub> ) <sub>2</sub> -S	"	 (83)	59
	Bu <sub>3</sub> Sn-CH=CH-CH <sub>2</sub> -C(CH <sub>3</sub> ) <sub>2</sub> -S	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, rt	 (83)	59
	Bu <sub>3</sub> Sn-CH=CH-OEt	"	 (90)	59
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	"	 (91)	59
	Bu <sub>3</sub> Sn-CH=CH-CH <sub>2</sub> -C(CH <sub>3</sub> ) <sub>2</sub> -S	"	 (80)	59
	Bu <sub>3</sub> Sn-CH=CH-CH <sub>2</sub> -C(CH <sub>3</sub> ) <sub>2</sub> -S	"	 (81)	59

TABLE I. DIRECT CROSS-COUPING OF ALKENYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		"	(83)	59
		Pd(CH3CN)2Cl2 (2%), DMF/THF, rt	(77)	60
		Pd(CH3CN)2Cl2 (2%), DMF, rt	(82)	60
		"	(76)	59
		"	(87)	60
		"	(75)	60
		Pd(CH3CN)2Cl2 (2%), DMF/THF, rt	(74)	60
100		Pd(OAc)2 (7%), PPh3 (14%), THF, 55°, 4 h	(81)	436
		Pd(OAc)2 (7%), PPh3 (14%), THF, 55°, 6 h	(66)	436
		Pd(OAc)2 (7%), PPh3 (14%), THF, 55°	(0)	436
		Pd(PPh3)4 (7%), THF, 55°	(89)	436
101				
		Pd(OAc)2 (7%), PPh3 (14%), THF, 65°	(72)	259
		Pd(PhCN)2Cl2 (5%), AsPh3 (10%), CuI (10%), DMF, 80°, 24 h	(38)	435
		Pd(PhCN)2Cl2 (5%), AsPh3 (10%), CuI (10%), DMF, 20°, 3 h	(69)	435
		Pd(PhCN)2Cl2 (5%), AsPh3 (10%), CuI (10%), DMF, 20°, 64.5 h	(40)	435
		Pd(PhCN)2Cl2 (5%), AsPh3 (10%), CuI (10%), DMF, 20°, 2.5 h	(83)	435
		Pd(PhCN)2Cl2 (5%), AsPh3 (10%), CuI (10%), DMF, 20-40°	(47)	435
102		Pd(PhCN)2Cl2 (5%), AsPh3 (10%), CuI (10%), DMF, 20°, 23 h	(80)	435
		Pd(PPh3)4 (2%), LiCl, THF, reflux, 22 h	(74)	433
		Pd2(dba)3 (1%), PPh3 (8%), NMP, rt, 4 h	(84)	260
		"	(81)	260

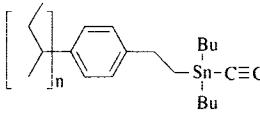
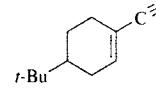
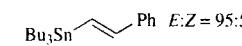
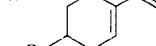
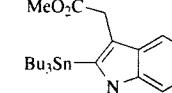
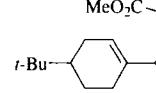
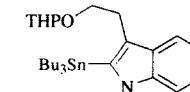
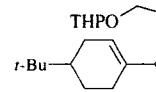
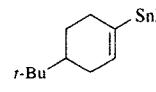
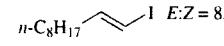
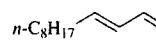
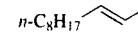
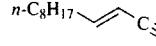
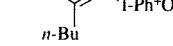
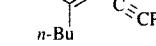
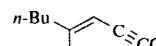
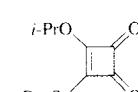
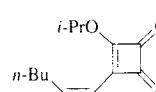
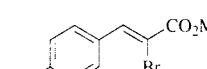
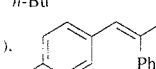
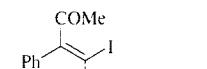
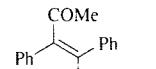
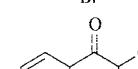
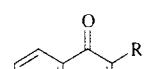
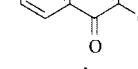
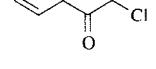
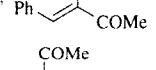
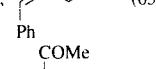
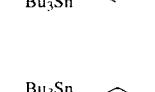
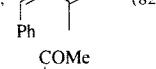
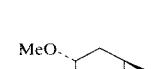
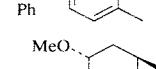
TABLE I. DIRECT CROSS-CO尤LING OF ALKENYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu3SnC≡CH	Pd(PPh3)4, C6H6, reflux, 30 min	 (74)	475
	Bu3SnC≡C	Pd(PPh3)4, C6H6, reflux, 30 min	 (52)	475
	Bu3SnSnBu3	Pd(PPh3)4, C6H6, reflux, 15 min	 (34)	475
TsO-CH=CH-I-Ph+BF4-	Bu3Sn-CH=CH	Pd(CH3CN)2Cl2 (5%), DMF, rt, 5 h	TsO-CH=CH-CH=CH (72)	187
	Bu3SnC≡CH	Pd(PPh3)4, LiCl, THF, reflux	 (84-95)	452, 476
	Bu3SnC≡C	Pd(PPh3)4, LiCl, THF, reflux	 (84-95)	452, 476
THPO-CH=CH-CH=CH-I	Bu3SnC≡CH	Pd(CH3CN)2Cl2, DMF, 25°	THPO-CH=CH-CH=CH-C≡CH (91)	47
	Bu3Sn-CH(R)-C(=O)-Ph	Pd2(dba)3•CHCl3 (1.5%), P(o-Tol)3 (12%), NMP, 70°, 2 h	 R = H (78) R = OTBDMS (69)	62
	Bu3SnH	Pd(PPh3)4 (2%), C6H6, rt, 1 h	 (82)	48
	Ph3SnF2-Bu4N+	Pd(PPh3)4, THF, reflux, 30 min	 (85)	283
		Pd2(dba)3 (5%), AsPh3 (40%), THF, 65°	 (98)	375
		"	 (53)	375
	Me3Sn-CH=CH-Bu-t	Pd(CH3CN)2Cl2, DMF	 (82)	443
	Me3Sn-CH=CH-SnMe3	"	 (39)	443
	Bu3Sn-CH=CH-OH	"	 (—)	477
	Me3SnC≡C	Pd(PPh3)4 (5%), LiCl, THF, reflux, 1 h	 (94)	478, 479
	Me3SnSnMe3	Pd(PPh3)4, LiCl, THF, reflux	 (81)	373

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (40%), CuI (10%) DMF, 60°, 1 h	(74)	291
	Me <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1-2%), DMF, 25°, 6.5 h	(80)	46
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 0.5 h	(78)	444
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 17 h	(91)	28, 444
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> , (8%), NMP, 35°	" (>95)	11
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), LiCl, AsPh <sub>3</sub> (8%), NMP, 35°	" (>95)	11
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 31 h	(96)	28, 444
	Bu <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 41 h	(80)	28, 444
	Me <sub>3</sub> SnC(=O)OEt	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 60°, 18 h	(93)	270
	"	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, reflux, 15 h	" (97)	480
	Me <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, reflux, 15 h	C≡CTMS (90)	28, 444
	Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 24 h	Ph (tr)	28
	Me <sub>3</sub> SnCH <sub>2</sub> Ph	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 24 h	Ph (tr)	28
	Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), AsPh <sub>3</sub> (8%), ZnCl <sub>2</sub> , NMP, rt	CF <sub>3</sub> (89)	30, 448
	"	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), AsPh <sub>3</sub> (8%), LiCl, NMP, 60°	" (87)	30, 448
	"	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), AsPh <sub>3</sub> (8%), NMP, 60°	" (83)	30, 448
	"	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), PPh <sub>3</sub> (8%), LiCl, NMP, 60°	" (54)	30, 448
	"	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), LiCl, NMP, 60°	" (69)	30, 448
	Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), AsPh <sub>3</sub> (8%), NMP, rt	OMe (89)	30, 448
	i-PrO-C(=O)-C(=O)-SnBu <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), ZnCl <sub>2</sub> , P(2-furyl) <sub>3</sub> (10%), 65°, 45 min	i-PrO-C(=O)-C(=O)-O (83)	12

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.	
112		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 62°, 20 h	 (53)	376	
	 E:Z = 95:5	Pd/C (0.5%), AsPh <sub>3</sub> (20%), CuI (10%), NMP, 80°, 16 h	 (80)	461	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , NEt <sub>3</sub> , CH <sub>3</sub> CN, 100°, 7 h	 (64)	290	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , NEt <sub>3</sub> , LiCl CH <sub>3</sub> CN, DMF, 100°, 7 h	 (49)	290	
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.6%), LiCl, THF, reflux, 12 h	 (73)	28	
	 E:Z = 83:17	Bu <sub>3</sub> SnCH=CH-NHFMOC	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 20°, 24 h	 (61) E:Z = 85:15	466
		Me <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°	 (—)	431
		Bu <sub>3</sub> SnC≡CPh	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (8%), DMF, rt, 30 min	 (77)	188
	Bu <sub>3</sub> SnC≡CCOBu-t	"	 (66)	188	
113		"	 (65)	188	
		Me <sub>3</sub> SnPh	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), DMF, 50°, 3.5 h	 (66)	435
		Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, rt	 (80)	45
		R <sub>4</sub> Sn	Pd(dppp)Cl <sub>2</sub> , i-Bu <sub>2</sub> AlH, dioxane, reflux	 R Me (88) n-Bu (91) n-C <sub>12</sub> H <sub>25</sub> (25)	43
		Me <sub>4</sub> Sn	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (5%), NMP, 80°, 4 h	 (94)	446
	Bu <sub>3</sub> SnCH=CH		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (5%), NMP, 35°, 43 h	 (65)	61, 446
	Bu <sub>3</sub> SnCH=CH		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (5%), NMP, 70°, 16 h	 (82)	61
			Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (5%), NMP, 85°, 16 h	 (87)	61
	MeO- 	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.75%), LiCl, THF, 60°, 18 h	 (80-92)	481-483

		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, rt, 8 h		52, 53
	Me <sub>4</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (3%), HMPA, 55°		52
	Me <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CuBr (5%), dioxane, reflux, 15 h, HMPA, 55°		55, 57
	Bu <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CuBr (5%), dioxane, reflux, 30 h		55
	Me <sub>3</sub> SnC≡CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 22-25°, 24 h		47
	Me <sub>3</sub> SnC≡CTMS	"		47
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%),		55, 57
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, reflux, CuI (5%), CH <sub>3</sub> CN, 50°, 2 h, Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, reflux		484
	Bu <sub>3</sub> SnCH <sub>2</sub> O	"		452, 476
	Bu <sub>3</sub> Sn	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 100-105°, CuBr (5%), dioxane, reflux, 12 h		385
	R <sup>1</sup> R <sup>2</sup> N=O	Pd(dba) <sub>2</sub> /DDE, LiCl / SDA		64
	-	-		-
	-	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (5%), CH <sub>3</sub> CN		64
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> , PPh <sub>3</sub> , NMP, rt, 16 h		260

TABLE I. DIRECT CROSS-COUPLING OF ALKENYI ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.
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		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (3%),		52
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, 55°, 72 h		53
	Bu <sub>4</sub> Sn	Pd(dppf)Cl <sub>2</sub> (5%), DMF, 100°, 8.5 h		55, 57

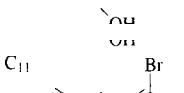
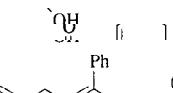
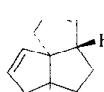
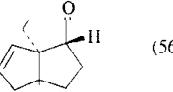
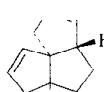
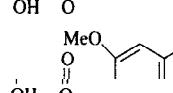
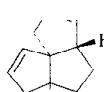
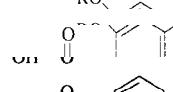
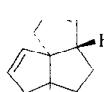
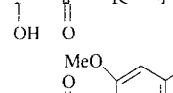
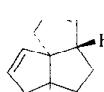
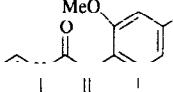
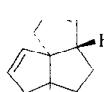
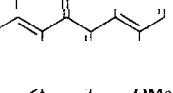
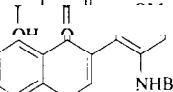
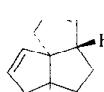
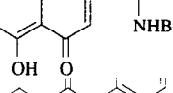
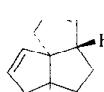
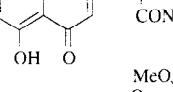
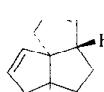
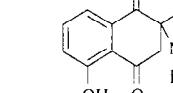
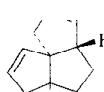
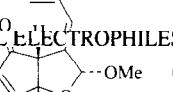
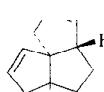
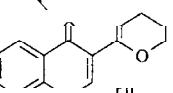
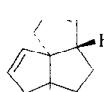
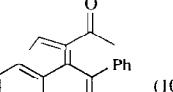
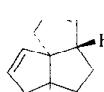
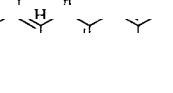
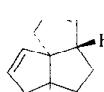
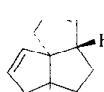
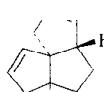
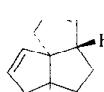
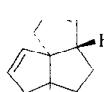
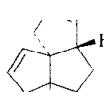
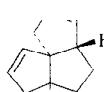
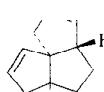
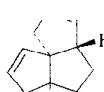
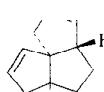
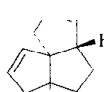
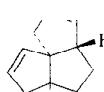
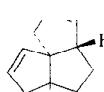
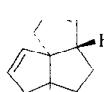
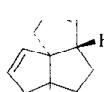
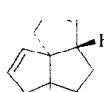
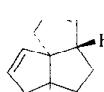
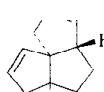
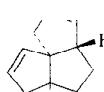
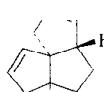
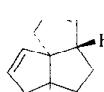
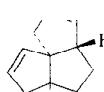
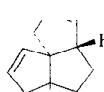
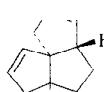
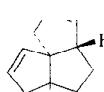
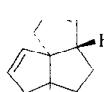
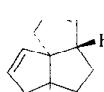
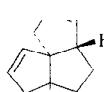
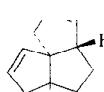
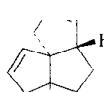
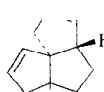
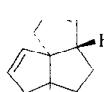
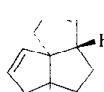
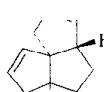
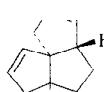
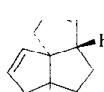
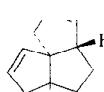
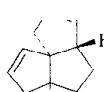
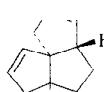
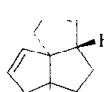
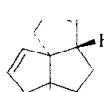
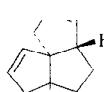
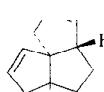
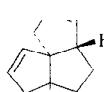
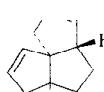
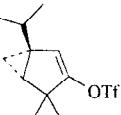
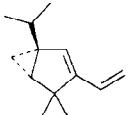
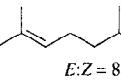
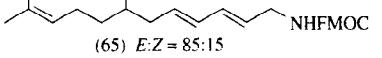
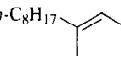
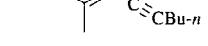
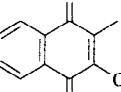
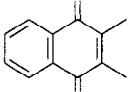
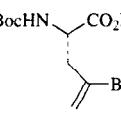
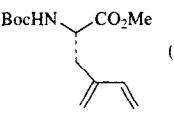
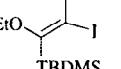
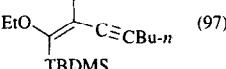
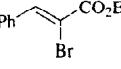
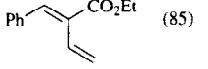
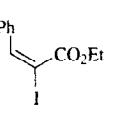
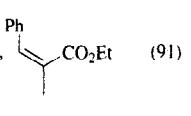
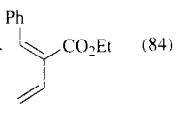
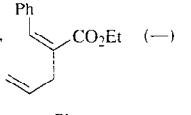
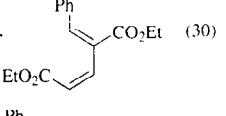
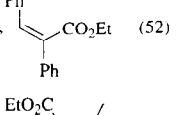
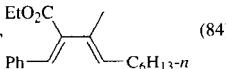
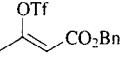
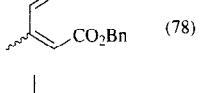
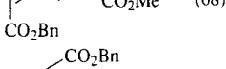
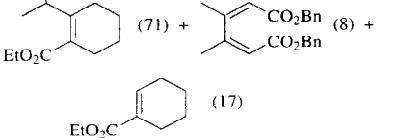
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.			
	Bu3SnPh Bu3SnO	Pd(CH3CN)2Cl2 (1%), dioxane, reflux, 1 h	 (55)	356			
	Me3Sn(OEt)	1. Pd(PPh3)4, LiCl, THF, 70°, 10 h reflux, 5-30 h	 (56)	487			
	OMe	reflux, 15 h	 (57)	487			
	Ro-NH OR	reflux, 3 h	 (58)	487			
	t-BuHNOC		 (59)	487			
	Et3NOC		 (60)	487			
	Me3Sn MeO	Pd(PPh3)4 (5%), CuBr (8%), dioxane, reflux, 1 h	 (61)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (62)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (63)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 1 h	 (64)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (65)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (66)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (67)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (68)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (69)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (70)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (71)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (72)	485, 486			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (73)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (74)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (75)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (76)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (77)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (78)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (79)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (80)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (81)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (82)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (83)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (84)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (85)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (86)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (87)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (88)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (89)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (90)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (91)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (92)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (93)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (94)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (95)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (96)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (97)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (98)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (99)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (100)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (101)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (102)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (103)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (104)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (105)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (106)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (107)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (108)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (109)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (110)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (111)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (112)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (113)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (114)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (115)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h	 (116)	55, 57			
	Me3Sn OMe	Pd(PPh3)4 (5%), CuBr (5%), dioxane, reflux, 20 h	 (117)	55, 57			
	Me3Sn OMe	dioxane, reflux, 1 h		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF	 (69)	488
	Bu <sub>3</sub> SnCH=CHCH=CH-NHFMOC	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 20°, 24 h	 (65) E:Z = 85:15	466			
	Bu <sub>3</sub> SnC≡CBu-n	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DIBAL, THF, rt	 (88)	442			
	Me <sub>4</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, dioxane, reflux	 (82)	43			
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe	 (63)	489, 490			
	Bu <sub>3</sub> SnC≡CBu-n	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, 50°	 (97)	49			
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 20°, 29.5–46 h	 (85)	435			
	Me <sub>4</sub> Sn	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 16 h	 (91)	435			
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 20°, 2.5 h	 (84)	435			
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 168 h	 (—)	435			
	Me <sub>3</sub> SnCH=CHCO <sub>2</sub> Et	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 20°, 48 h	 (30)	435			
	Bu <sub>3</sub> SnPh	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 50°, 14 h	 (52)	435			
	Bu <sub>3</sub> SnCH=CHC <sub>6</sub> H <sub>13</sub> -n	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 20°, 23 h	 (84)	435			
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 55°, 4.5 h	 (78)	436			
	Bu <sub>3</sub> SnCH=CHCO <sub>2</sub> Me	Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 65°, 1.5 h	 (68)	259			
	"	"	 (71) + (8) + (17)	259			

TABLE I. DIRECT CROSS COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{SnC}\equiv\text{CH}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, 22–25°, <2 min	(68)	47
	$\text{Bu}_3\text{SnC}\equiv\text{C}-\text{S}-\text{C}_6\text{H}_4-\text{S}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, 25°	(≥93)	47
	$\text{Bu}_3\text{SnC}\equiv\text{CH}$	$\text{Pd}(\text{PPh}_3)_4$ (10%), LiCl, THF, reflux	(69)	491
120	$\text{Bu}_3\text{SnCH}_2=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_4$ (5%), LiCl, THF, reflux	(91)	491
	$\text{Me}_3\text{SnC}\equiv\text{CBu}-n$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, 25°	n-BuC≡C— $\text{CH}_2=\text{CH}_2-(\text{CH}_2)_4\text{OTHP}$ (95)	47
	$\text{Bu}_3\text{SnCH}_2=\text{CH}-\text{C}_5\text{H}_{11-n}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ , DMF, 60°, 4 d	MeO2C(CH2)7— $\text{CH}_2=\text{CH}-\text{C}_5\text{H}_{11-n}$ OTBDMS (60)	492
	$\text{Bu}_3\text{SnPh}$	$\text{Pd}(\text{PPh}_3)_4$	Ph— $\text{C}_6\text{H}_4-\text{CH}(\text{Br})-\text{CH}_2-\text{CO}_2\text{Me}$ (69)	493
56		$\text{Pd}(\text{PPh}_3)_4$ (5%), CuBr (5%), dioxane, reflux, 3 h	OMe— $\text{C}_6\text{H}_3(\text{OMe})_2-\text{C}(=\text{O})-\text{C}_6\text{H}_3(\text{OMe})_2-\text{C}(=\text{O})-\text{NHBoc}$ (65)	56
121		"	OMe— $\text{C}_6\text{H}_3(\text{OMe})_2-\text{C}(=\text{O})-\text{C}_6\text{H}_3(\text{OMe})_2-\text{C}(=\text{O})-\text{NHBoc}$ (100)	56
		$\text{Pd}(\text{dppt})\text{Cl}_2$ (5%), DMF, 100°, 18 h	OMe— $\text{C}_6\text{H}_3(\text{OMe})_2-\text{C}(=\text{O})-\text{CH}_2-\text{CH}(\text{OH})-\text{C}_6\text{H}_3(\text{OMe})_2-\text{C}(=\text{O})-\text{Bu}-n$ (74)	55
	$\text{Bu}_4\text{Sn}$	$\text{Pd}(\text{PPh}_3)_4$ (5%), CuBr (5%), dioxane, reflux, 15 h	OMe— $\text{C}_6\text{H}_3(\text{OMe})_2-\text{C}(=\text{O})-\text{CH}_2-\text{CH}(\text{OH})-\text{C}_6\text{H}_3(\text{OMe})_2-\text{C}(=\text{O})-\text{Ph}$ (100)	55
	$\text{Bu}_3\text{SnPh}$	$\text{Pd}(\text{PPh}_3)_4$ (5%), CuBr (5%), dioxane, reflux, 15 h	SEMO— $\text{C}_6\text{H}_3(\text{SEMO})_2-\text{C}(=\text{O})-\text{CH}_2-\text{CH}(\text{OPMB})-\text{C}_6\text{H}_3(\text{OPMB})_2-\text{C}(=\text{O})-\text{CO}_2\text{Me}$ (70)	494
		$\text{Pd}(\text{PhCN})_2\text{Cl}_2$ (5%), AsPh <sub>3</sub> (10%), CuI (10%), rt	OAc— $\text{C}_6\text{H}_3(\text{OAc})_2-\text{C}(=\text{O})-\text{CH}_2-\text{CH}(\text{OPMB})-\text{C}_6\text{H}_3(\text{OPMB})_2-\text{C}(=\text{O})-\text{OAc}$ (100)	495

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

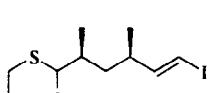
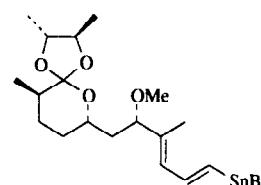
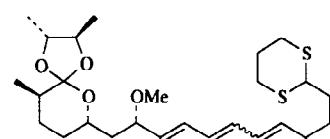
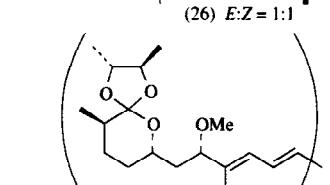
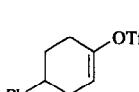
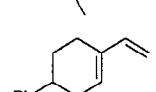
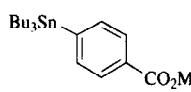
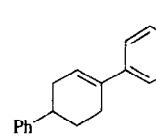
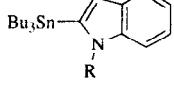
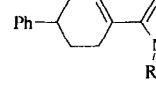
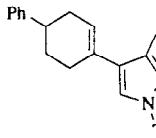
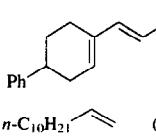
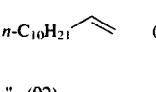
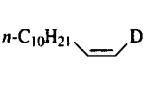
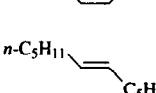
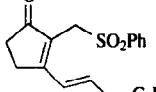
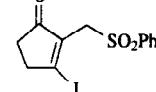
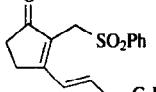
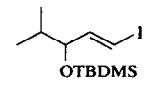
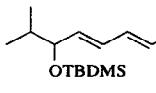
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, rt	 	85
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(OAc) <sub>2</sub> (10%), CH <sub>2</sub> Cl <sub>2</sub> , rt		453
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), PPh <sub>3</sub> or AsPh <sub>3</sub> or P(2-furyl) <sub>3</sub> , NMP, (LiCl), 35°	" (>90)	11
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF		496
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux		425
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), DMF, 60°, 1.5 h		291
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), LiCl, ZnCl <sub>2</sub> , NMP, rt, 2 h		260
n-C <sub>10</sub> H <sub>21</sub> -CH=CHBr	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 75°, 3 h		48
n-C <sub>10</sub> H <sub>21</sub> -CH=CHI	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 25°, 3 h	" (92)	48
n-C <sub>10</sub> H <sub>21</sub> -CH=CH-I	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 25°, 5 h	" (82)	48
n-C <sub>10</sub> H <sub>21</sub> -CH=CH-D	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 25°, 2 h		48
n-C <sub>5</sub> H <sub>11</sub> -CH=CH-I	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 25°, 1 h		48
n-C <sub>5</sub> H <sub>11</sub> -CH=CH-I	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 75°, 5 h		48
	Bu <sub>3</sub> SnCH=CH-C <sub>3</sub> H <sub>11</sub> -OH	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 25°, 2 h		497
	Bu <sub>3</sub> SnCH=CH-CH=CH-NHFMOC	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 20°, 24 h		466

TABLE I. DIRECT CROSS-COUPING OF ALKENYL ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
124		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 75°, 5 h		48
		Bu <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Bu <sub>4</sub> NBr, Li <sub>2</sub> CO <sub>3</sub> , PhMe, 110°		417
		Me <sub>3</sub> SnOEt	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF		498
		Bu <sub>3</sub> SnCH=CHPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, rt		59
		Bu <sub>3</sub> SnCH=CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 80°, 12 h		58
		Bu <sub>3</sub> SnC≡CBu-n	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 90°, 12 h		58
		Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 80°, 30 h		58
		Bu <sub>3</sub> SnCH=CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, reflux, 5 h		486
		Bu <sub>3</sub> SnNHC(S(=O)(=O)c6ccccc6)Bu-n	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, reflux, 22 h		433
		Bu <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, Bu <sub>4</sub> NBr, 2,6-di- <i>t</i> -butyl-4-methylpyridine, 110°, 1.5 h		417
125		Bu <sub>3</sub> SnCH(OH)CH <sub>2</sub> C <sub>5</sub> H <sub>11</sub> -n	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 25°, 3 h		497
		Bu <sub>3</sub> SnCH=CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 23°, 72 h		496
		Me <sub>3</sub> SnC≡CBu-n	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%)		387
		Bu <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Bu <sub>4</sub> NBr, Li <sub>2</sub> CO <sub>3</sub> , PhMe, 110°, 2 h		417

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100°		(54) 500
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, reflux, 20 h		(82) 501
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 19 h		(70) 446
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 45°, 20 h		(79) 446
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 68 h		(63) 446
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, rt, 48 h		(>53) 502
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, reflux, 18 h		(88) 476
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, reflux		(89) 452
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, reflux		(98) 503
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, THF, 55-60°		(70-73) 53, 52
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, 60°, 48 h		(60) 53
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), DMF, 20°, 3 h		(82) 435
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 23-24°, 18 h		(71-78) 486
		Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 65°		(68) 259

TABLE I. DIRECT CROSS-CO尤LING OF ALKENYL ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>15</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (3.6%), CsF, LiCl, THF, 25°, 60 h	(31)	504
		Bu <sub>3</sub> SnC≡CR	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 0°, 1 h	R-TMS (80) n-Bu (87) t-Bu (70)	505
		Bu <sub>3</sub> SnCH=CH-NH-FMOC	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 23°, 0.5 h Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 2.5 h Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 55°, 2 h	(84)	77
128		Me <sub>3</sub> Sn	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 2.5 h Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 55°, 2 h	I (94)	446
		Me <sub>3</sub> SnPh	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 21 h	I (43) + (50)	446
		Me <sub>3</sub> Sn	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 21 h	(97) E:Z = 45:55	446
		Bu <sub>3</sub> SnCH=CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), LiCl, THF, reflux	(100)	503
		Me <sub>3</sub> Sn OTBDMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiCl, THF, reflux	(100)	503
		Bu <sub>3</sub> SnCH=CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, reflux	(81)	484
129		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 25°, 3 h	n-C <sub>10</sub> H <sub>21</sub> -CH=CH-TMS (67) Z:E = 95:5	48
		Bu <sub>3</sub> SnCH=CH Bu-n	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2-5%), DMF, 20°, 20 h	(66)	441
		Bu <sub>3</sub> SnCH=CH CO <sub>2</sub> Et	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2-5%), DMF, 20°, 20 h	(62)	441
		Bu <sub>3</sub> SnCH=CH OTHP	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2-5%), DMF, 20°, 20 h	(57)	441
		Bu <sub>3</sub> SnCH=CH OPMB	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2-5%), HMPA, 60°, 8 h	I (13) + II (47)	441

TABLE I. DIRECT CROSS-CO尤LING OF ALKENYL ELECTROPHILES (Continued)

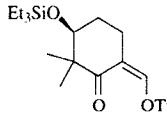
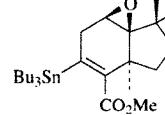
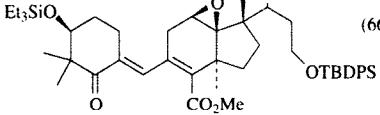
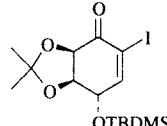
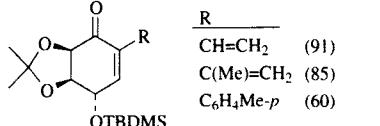
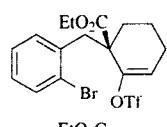
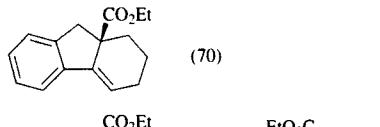
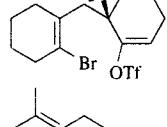
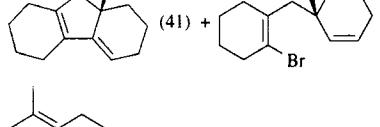
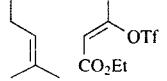
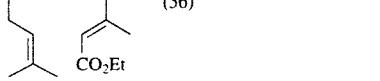
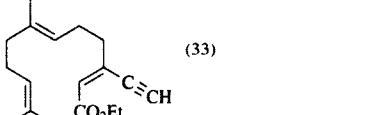
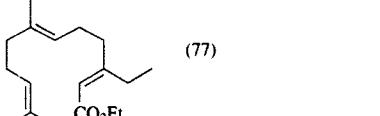
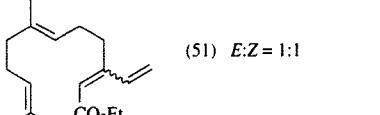
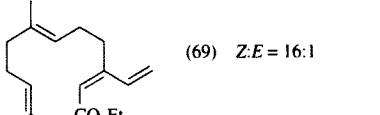
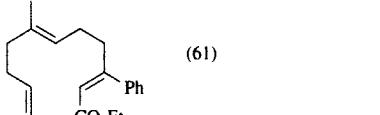
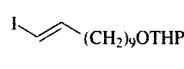
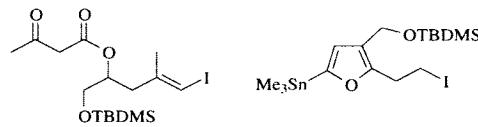
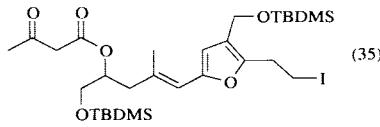
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Bu <sub>3</sub> SnCH <sub>2</sub> OPMB	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2-5%), HMPA, 60°, 8 h	I (34) + II (40)	441	
		Bu <sub>3</sub> SnCH <sub>2</sub> OPMB	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2-5%), HMPA, 20°, 72 h	I (67) + II (15)	441	
			Pd(OAc) <sub>2</sub> (7%), PPh <sub>3</sub> (14%), THF, 70°		(66) 506	
130	C <sub>16</sub>		Bu <sub>3</sub> SnR	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, rt, 16 h		(91) (85) (60) 61
			Bu <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Bu <sub>4</sub> NBr, Li <sub>2</sub> CO <sub>3</sub> , PhMe, 110°, 1.5 h		(70) 417
			Bu <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Bu <sub>4</sub> NBr, Li <sub>2</sub> CO <sub>3</sub> , PhMe, 110°, sieves, 8 h		(41) (13) 417
			Me <sub>3</sub> Sn	Pd(AsPh <sub>3</sub> ) <sub>4</sub> , CuI, NMP, 100°		(56) 177
		Bu <sub>3</sub> SnC≡CH	Pd(AsPh <sub>3</sub> ) <sub>4</sub> , CuI, NMP, rt		(33) 177	
131		Et <sub>4</sub> Sn	Pd(AsPh <sub>3</sub> ) <sub>4</sub> , CuI, NMP, 100°		(77) 177	
		Bu <sub>3</sub> SnCH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, reflux		(51) E:Z = 1:1 177	
		Bu <sub>3</sub> SnCH <sub>2</sub>	Pd(AsPh <sub>3</sub> ) <sub>4</sub> , CuI, NMP, rt		(69) Z:E = 16:1 177	
		Bu <sub>3</sub> SnPh	Pd(AsPh <sub>3</sub> ) <sub>4</sub> , CuI, NMP, 100°		(61) 177	
			Me <sub>3</sub> SnC≡CPr- <i>n</i>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 25°		(86) 47
				Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, rt, 16 h		(35) 455

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (Continued)

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

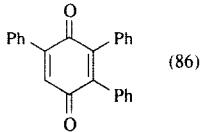
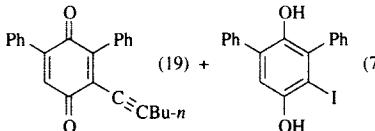
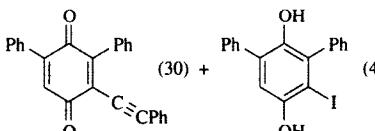
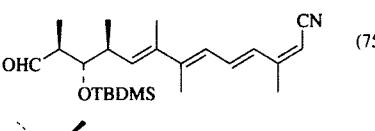
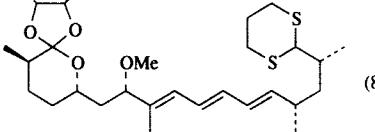
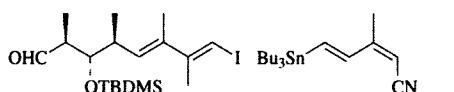
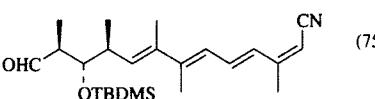
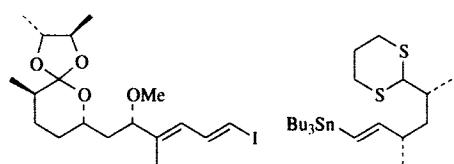
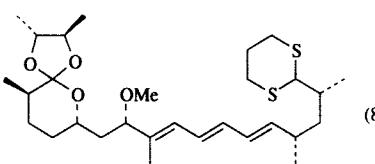
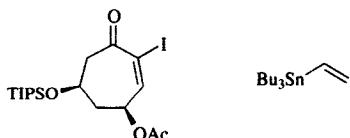
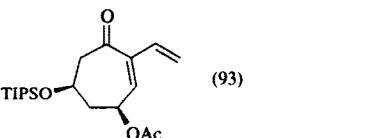
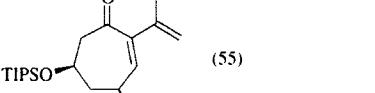
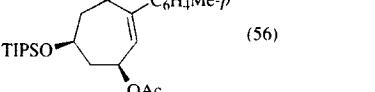
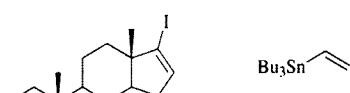
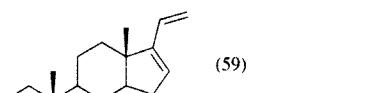
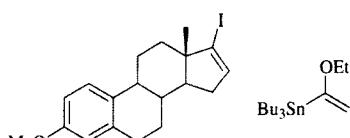
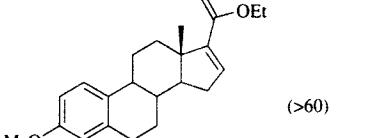
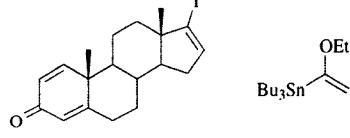
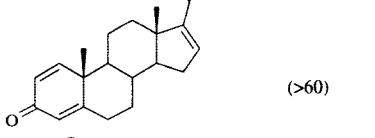
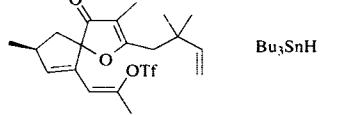
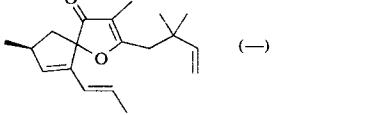
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 80°, 24 h	 (86)	58
	Bu <sub>3</sub> SnC≡CBu- <i>n</i>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 70°, 16 h	 (19) +  (70)	58
	Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 80°, 17 h	 (30) +  (40)	58
134		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, 60°	 (75)	81
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, rt	 (84)	85
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, rt, 4 h	 (93)	61
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 2 h	 (55)	61
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 18 h	 (56)	61
C <sub>19</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, <i>t</i> -Bu-catechol, 110°, 4 h	 (59)	512
135		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> , HMPA, 60°	 (>60)	513
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> , HMPA, 60°	 (>60)	513
		Pd(PPh <sub>3</sub> ) <sub>4</sub>	 (—)	335

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Bu3SnCH=CH2	Pd(PPh3)2Cl2 (1%), LiCl, THF, reflux, 3.5 h		514
C20		Bu3SnTMS	Pd(PPh3)2Cl2 (3%), Bu4NBr, Li2CO3, PhMe, 110°, 1.5 h		417
136		Bu3SnCH=CH2	1. Pd(PPh3)4, DMF, rt; 2. I2, CH2Cl2, rt		78
		Me3SnSnMe3	Pd(PPh3)4, LiCl, Li2CO3, THF, 60°, 12 h		515
			Pd(PPh3)4, PhMe, 90°, 2 h		516
		Bu3SnH	Pd(PPh3)4 (2%), C6H6, 75°, 5 h		48
C21			Pd(OAc)2 (5%), PPh3 (10%), LiCl, DMF, 60°, 4.5 h		517
137		Bu3SnCH=CH2	Pd(CH3CN)2Cl2 (10%), DMF, rt, 1 h		518
		Bu3SnCH=CH2	Pd(CH3CN)2Cl2 (10%), DMF, rt, 1 h		518
		Bu3SnCH=CH2	Pd(CH3CN)2Cl2 (10%), DMF, rt, 1 h		518
		Me3SnC≡CTMS	Pd(CH3CN)2Cl2 (10%), DMF, rt, 9 h		518
		Bu3SnCH=CH2	Pd(CH3CN)2Cl2 (10%), DMF, rt, 12 h		518, 467

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

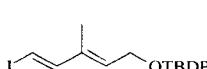
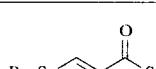
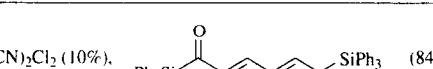
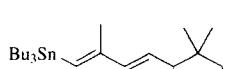
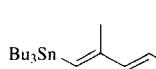
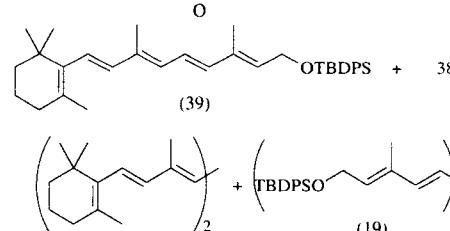
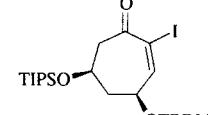
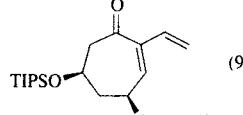
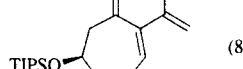
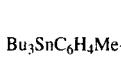
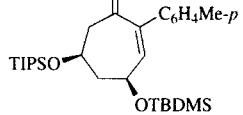
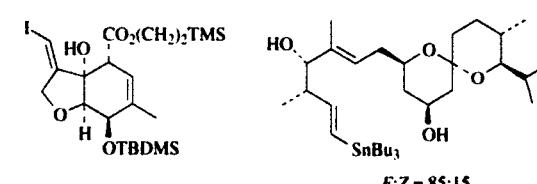
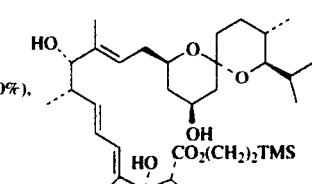
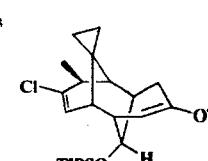
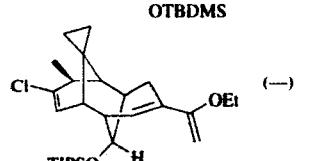
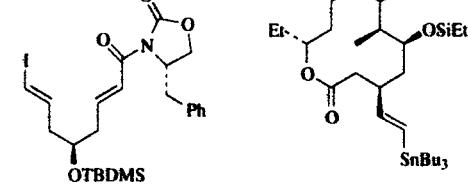
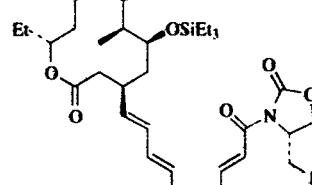
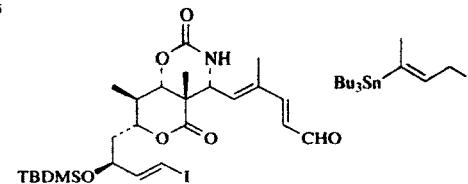
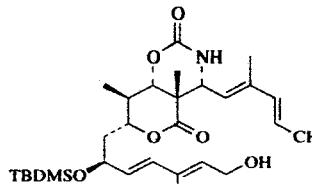
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.
C <sub>22</sub> 138			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (10%), DMF, rt, 8 h	 (84)	518
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , HMPA, 65°, 3 h	 (39) (18) + (19) (18) (19)	386
C <sub>23</sub> 139			Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, rt, 4 h	 (95)	61
			Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 80°, 2 h	 (80)	61
			Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), NMP, 60°, 24 h	 (95)	61
C <sub>24</sub> 139			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (20%), DMF	 (40)	79
			Pd <sub>2</sub> (dba) <sub>3</sub> , P(2-furyl) <sub>3</sub> , ZnCl <sub>2</sub>	 (498)	498
C <sub>25</sub>			Pd <sub>2</sub> (dba) <sub>3</sub> , CdCl <sub>2</sub> , (i-Pr) <sub>2</sub> NEt, NMP, 40°	 (65-69)	84, 519
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, rt	 (90)	83

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>26</sub>		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, DMF or dioxane, 110°	 (90-100)	520
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, 60°	 (82)	521
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(OAc) <sub>2</sub> , NMP	 (79)	522
C <sub>27</sub>		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(dba) <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), ZnCl <sub>2</sub> , NMP, 65°	 (95)	12
		Pd(PPh <sub>3</sub> ) <sub>4</sub>		 (65-80)	512, 520
C <sub>14</sub>		Bu <sub>3</sub> SnC6H <sub>4</sub> Ts	Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), DMF, 60°, 2 h	 (85)	291
		Bu <sub>3</sub> SnC6H <sub>4</sub> Ts	Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), DMF, 60°, 1 h	 (93)	291
		Bu <sub>3</sub> SnC6H <sub>4</sub> OMe	Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), DMF, 60°, 1.5 h	 (84)	291
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), THF, 65°, 12 h	 (87)	506

TABLE I. DIRECT CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
C <sub>28</sub>		Bu <sub>3</sub> SnAllyl	Pd(OAc) <sub>2</sub> , NMP, rt	 (72)	522	
142		Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 140°, 8 h	 (~)	523	
		Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 140°, 8 h	 (93)	523	
		Bu <sub>3</sub> SnAllyl	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 140°, 4 h	 (84)	523	
		Bu <sub>3</sub> SnAllyl-C <sub>6</sub> H <sub>13-n</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, rt	 E,Z,Z:E,Z,E = 1:1:1 (63)	524	
C <sub>29</sub>		Bu <sub>3</sub> SnAllyl-C <sub>5</sub> H <sub>11-n</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, rt	 (>48)	524	
C <sub>49</sub>		Bu <sub>3</sub> SnAllyl-SnBu <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , (iPr) <sub>2</sub> NEt, DMF, THF, rt	 (28)	86	
143	C <sub>55</sub>		Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiCl, THF, 80°, 14 h	 (62)	525
	C <sub>75</sub>		Bu <sub>3</sub> SnAllyl-C≡CN	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF	 (67)	82

TABLE II. INTRAMOLECULAR CROSS-COUPING OF ALKENYL ELECTROPHILES

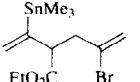
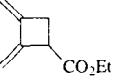
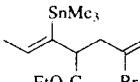
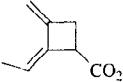
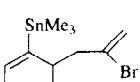
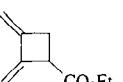
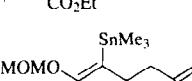
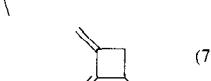
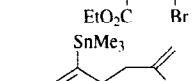
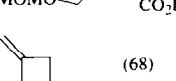
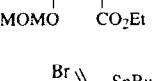
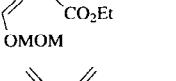
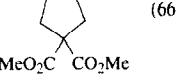
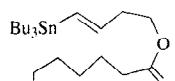
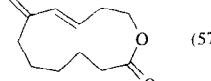
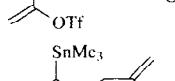
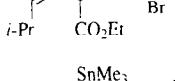
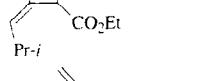
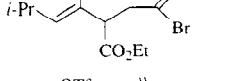
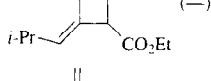
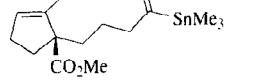
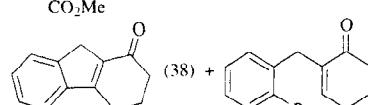
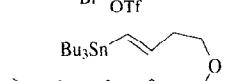
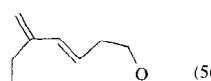
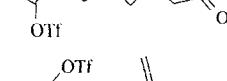
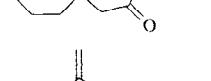
	Substrate	Conditions	Product(s) and Yield(s) (%)	Ref.s.
C <sub>9</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h	 (70-95)	68
C <sub>10</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h	 (70-95)	68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h	 (70-95)	68
C <sub>11</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, Et <sub>3</sub> N, 80°	 (71)	68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, Et <sub>3</sub> N, 80°	 (68)	68
14		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, rt, 20 h	 (66)	526
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF	 (55)	181
15		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, reflux	 (57)	185
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF	 (—)	524
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF	 (—)	524
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF or CH <sub>3</sub> CN, reflux, 11 h	 (82-85)	31, 181
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Bu <sub>4</sub> NBr, Li <sub>2</sub> CO <sub>3</sub> , PhMe, 110°	 (38) + (43)	417
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, reflux	 (56)	185
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux, 9 h	 (82-85)	31, 181

TABLE II. INTRAMOLECULAR CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

	Substrate	Conditions	Product(s) and Yield(s) (%)	Refs.
14		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CH <sub>3</sub> CN, reflux		182, 184
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux, 23 h		181
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux, 3 h		31, 181
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
14		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
14		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
14		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
14		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
14		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
14		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
14		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 1 h		68
14</td				

TABLE II. INTRAMOLECULAR CROSS-COUPLING OF ALKENYL ELECTROPHILES (Continued)

	Substrate	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4, DMF		527
		Pd(OAc)2 (5%), PPh3 (10%), Et3N, CH3CN, reflux, 2.5-4 h		69
148		Pd(PPh3)4 (5%), CH3CN, reflux		182, 184
C <sub>16</sub>		Pd(PPh3)4 (5%), THF, rt, 15 min		31, 181
		Pd(PPh3)2Cl2 (3%), Bu4NBr, Li2CO3, PhMe, 110°, 1.5 h		417
		Pd(PPh3)2Cl2 (3%), Bu4NBr, Li2CO3, PhMe, 110°, sieves, 8 h		417
		Pd(PPh3)4 (5%), THF, rt, 15 min		31, 181
149		Pd(PPh3)4 (5%), THF, rt, 15 min		31, 181
		Pd(OAc)2 (5%), PPh3 (10%), Et3N, CH3CN, reflux, 2.5-4 h		69
C <sub>17</sub>		Pd(PPh3)2Cl2 (3%), Bu4NBr, Li2CO3, PhMe, 100°, 3.5 h		417
		Pd(PPh3)4 (5%), THF, reflux, 15 min		31, 181
C <sub>18</sub>		Pd(PPh3)4 (5%), DMF, 80°, 1 h		68
		Pd(PPh3)4 (5%), DMF, 80°, 1 h		68
C <sub>19</sub>		Pd(PPh3)4, 30°, 5 min		182, 184

TABLE II. INTRAMOLECULAR CROSS-CO尤LING OF ALKENYL ELECTROPHILES (Continued)

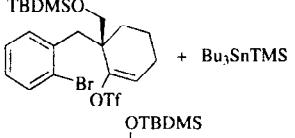
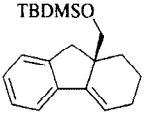
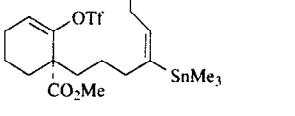
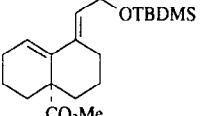
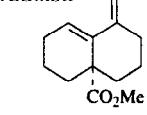
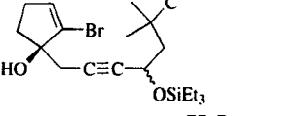
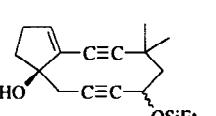
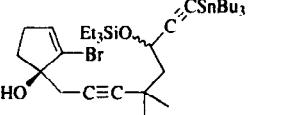
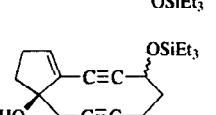
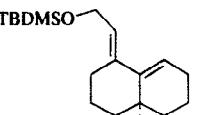
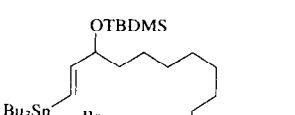
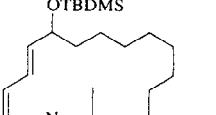
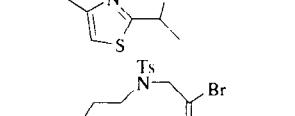
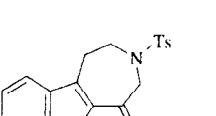
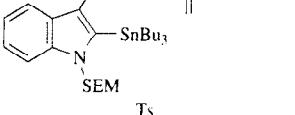
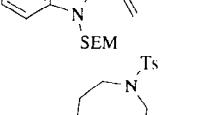
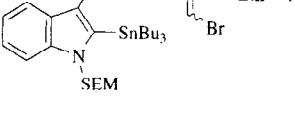
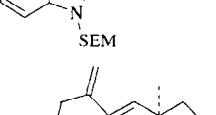
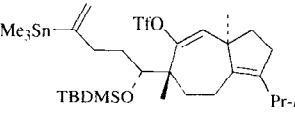
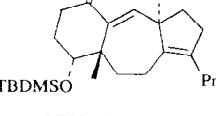
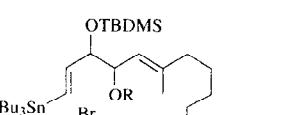
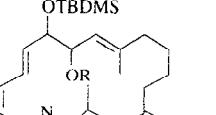
	Substrate	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>20</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> Cl <sub>2</sub> (3%), Bu <sub>4</sub> NBr, Li <sub>2</sub> CO <sub>3</sub> , PhMe, 110°, 1.5 h	 (61)	417
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), THF, reflux	 (61)	179
C <sub>21</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), THF, reflux	 (65)	179
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°, 86 h	 (72)	71
C <sub>22</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 50°	 (32)	70
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), THF, reflux	 (>86)	180, 528
C <sub>24</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), PhMe, reflux, 6 h	 (65)	76
		Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (9%), THF, reflux	 (85)	74
C <sub>26</sub>		Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (9%), THF, reflux	 (93)	74
		Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (9%), THF, reflux	 (74-75)	178, 182
C <sub>27</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 30 min	 (37)	76
		Pd(AsPh <sub>3</sub> ) <sub>4</sub> , THF, reflux	 (37)	76

TABLE II. INTRAMOLECULAR CROSS-COUPING OF ALKENYL ELECTROPHILES (*Continued*)

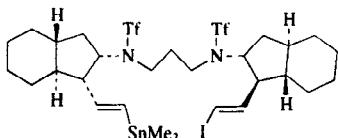
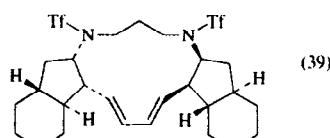
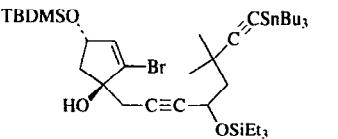
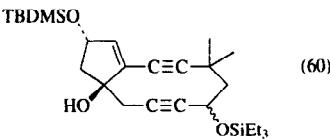
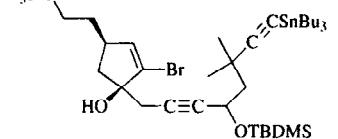
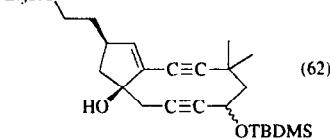
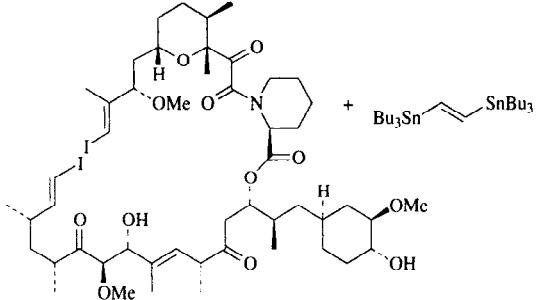
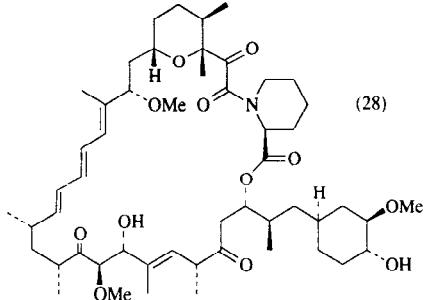
	Substrate	Conditions	Product(s) and Yield(s) (%)	Ref.s.
		Pd(AsPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100°	 (39)	75
C <sub>29</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, 60°	 (60)	72
152		Pd(PPh <sub>3</sub> ) <sub>4</sub> , 60°	 (62)	73
C <sub>49</sub>		+ Bu <sub>3</sub> SnCH=CH-SnBu <sub>3</sub> Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , (i-Pr) <sub>2</sub> NEt, DMF, THF, rt	 (28)	86

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>6</sub> 153	PhBr	Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), air, HMPA, 65°	PhMe (89)	19
	Bu <sub>3</sub> SnCH <sub>2</sub> OH		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 80°	PhCH <sub>2</sub> OH (60)	233
	Bu <sub>3</sub> SnCH <sub>2</sub> CN		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), <i>m</i> -xylene, 120°, 3 h	PhCH <sub>2</sub> CN (72)	235
	Bu <sub>3</sub> SnCH <sub>2</sub> OMe		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 20 h	PhCH <sub>2</sub> OMe (76)	234
	Bu <sub>3</sub> SnCH <sub>2</sub> C≡C		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	PhCH <sub>2</sub> C≡C (96)	3, 29
	Bu <sub>3</sub> SnCH <sub>2</sub> CO		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	PhCH <sub>2</sub> CO (19) + PhSnBu <sub>3</sub> (15)	529
	[OSnBu <sub>3</sub> ] CH=CH <sub>2</sub>		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	PhCH <sub>2</sub> CO (78)	237, 238, 240
	Bu <sub>3</sub> SnCF <sub>3</sub>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), dioxane, reflux, 25 h	PhCF <sub>3</sub> (72)	292, 530
	Bu <sub>3</sub> Snimidazole		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), xylene, 120°, 20 h	Phimidazole (89)	531
	Bu <sub>3</sub> Snfuran		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), DMF, 70°, 1.5 h	Phfuran (67)	287
	[OSnBu <sub>3</sub> ] CH=CH <sub>2</sub>		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	PhCH <sub>2</sub> CO (67)	238, 240

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	(60)	238, 240
	Bu <sub>3</sub> Sn OMe	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	(81)	305, 532
	Bu <sub>3</sub> Sn OEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°, 48 h	(71)	270
	Bu <sub>3</sub> Sn OEt	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 20 h 2. H <sup>+</sup>	(80)	269
	Bu <sub>3</sub> Sn OEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), Et <sub>4</sub> NCl, DMF, 80°, 2 h	(78)	272, 273
	Bu <sub>3</sub> Sn CO <sub>2</sub> Et	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h	(71)	236
154	Bu <sub>3</sub> Sn	{(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )Pd(OAc)} <sub>2</sub> (5%), DIOP (10%), TIOAc, THF, reflux, 20 h	(72) (S) 40% ee	533
	Bu <sub>3</sub> Sn	{(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )Pd(OAc)} <sub>2</sub> (5%), BPPM (10%), TIOAc, THF, 40°, 6 h	(36) (R) 42% ee	533
		Pd(dppb)Cl <sub>2</sub> , CuO, DMF, 100°, 80-90 min	(82)	96
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%)	(70)	426
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 110°, 15 h	(83) E:Z = 95:5	534
155		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (3%), C <sub>6</sub> H <sub>6</sub> , reflux, 7 h	(0)	241
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	(87)	238, 240
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	(33)	238, 240
	Me <sub>3</sub> Sn OTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100°	(74)	457
	Bu <sub>3</sub> SnPh	D <sub>717</sub> -Pd(0) (polymer-supported), Me <sub>2</sub> CO, reflux, 25 h	(43)	535
	Ph <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), air, HMPA, 65°	(78)	19
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 65°, 4 h	(33)	437
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	(54)	238, 240, 241
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 110°, 15 h	(69)	534
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (3%), C <sub>6</sub> H <sub>6</sub> , reflux, 3 h	(56)	241

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd[P(o-Tol)3]2Cl2 (1%), PhMe, 100°, 5 h	 (86)	238, 240, 241
		Pd[P(o-Tol)3]2Cl2 (3%), C6H6, reflux, 10 h	 (47)	241
		Pd(PPh3)4, PhMe, reflux, 5 h	 (59)	536
		BnPd(PPh3)2Cl (1-2%), CHCl3, 65°, 1 d	 (68)	537
		Pd(PPh3)4 (1%), C6H6, 120°, 20 h	 R = o-Me (tr) R = m-Me (75) R = p-Me (73)	538
15		Pd(PPh3)2Cl2 (1%), xylene, 120°, 20 h	 X = O (75) X = S (56)	531
		Pd(PPh3)4 (1%), C6H6, 110°, 15 h	 (72) E:Z = 85:15	534
		Pd[P(o-Tol)3]2Cl2 (3%), C6H6, reflux, 3 h	 (84)	241
		Pd(PPh3)4, C6H6, 110°	 (76)	305, 529
		Pd(PPh3)4 (5%), C6H6, reflux, 21 h	 (55) E:Z = 1:4	306, 427
		Pd[P(o-Tol)3]2Cl2 (1%), PhMe, 100°, 5 h	 (90)	238, 240, 241
		Pd(PPh3)4 (2%), C6H6, 80°, 20 h	 E:Z = 85:15 (75)	539
		Pd(PPh3)4 (5%), THF, 66°, 24 h	 (63)	422
		Pd(PPh3)2Cl2 (1%), xylene, 120°, 20 h	 (0)	531
		Pd[P(o-Tol)3]2Cl2 (3%), C6H6, reflux, 4 h	 (65)	241
		1. Pd(PPh3)4 (2%), PhMe, reflux, 72 h 2. H3O+	 (72)	462, 464, 540
157		Pd[P(o-Tol)3]2Cl2, PhMe, 100°, 4 h	 (61) + (2)	541
		Pd(PPh3)4, THF, reflux, 4 h	 (0)	542
		Pd(PPh3)4, NEt3, CH3CN, 100°, 5 h	 (≥82)	290
		Pd(PPh3)4, THF	 (65)	543

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (2%), PhMe, reflux, 1 h	 (90)	371
		Pd(PPh3)4 (2%), PhMe, reflux, 18 h	 (51)	371
		BnPd(PPh3)2Cl (1%), 200 h	 (79)	256
		Pd(PPh3)2Cl2 (1%), xylene, 120°, 20 h	 (0)	531
158		Pd(PPh3)4, NEt3, CH3CN, 100°, 5 h	 (≥65)	290
		Pd(PPh3)4, NEt3, CH3CN, 100°, 7 h	 (≥63)	290
		Pd(PPh3)4	 (84)	544
		Pd(PPh3)2Cl2 (5%), Et4NCl, DMF, 80°	 (26)	545
159		Pd[P(o-Tol)3]2Cl2, PhMe, 100°, 22 h	 (49) + (3)	541
		Pd(PPh3)4, THF, reflux	 (6)	299, 300
		Pd(PPh3)4 (1%), PhMe, 100°, 3 h	 (88)	423
		Pd(PPh3)4 (5%), HMPA, 65°, 10 h	 (54)	287, 546
		Pd(PPh3)2Cl2 (1%), xylene, 120°, 20 h	 (0)	531
		Pd[P(o-Tol)2]2Cl2 (1%), PhMe, 100°, 3 h	 (3)	316
		"	 (12)	90, 316
		"	 (19)	90, 316
		"	 (81)	90, 316
		"	 (61)	316

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
109		Pd[P(o-Tol) <sub>2</sub> ]Cl <sub>2</sub> (1%), PhMe, 100°, 3 h	(0)	316
		"	(37)	316
	Bu <sub>3</sub> SnNPh	"	Ph <sub>2</sub> NH (64)	316
	Bu <sub>3</sub> SnN(Pr-i) <sub>2</sub>	"	PhN(Pr-i) <sub>2</sub> (0)	316
	Bu <sub>3</sub> SnN(TMS) <sub>2</sub>	"	PhN(TMS) <sub>2</sub> (0)	316
		"	Et (43)	316
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), xylene, 120°, 20 h	NEt <sub>2</sub> (0)	531
	Bu <sub>3</sub> Sn—N=C=N—SnBu <sub>3</sub>	"	Ph—N=C=N—Ph (0)	531
	Bu <sub>3</sub> SnSBu-n	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	PhSBu-n (86)	318
	Bu <sub>3</sub> SnSPh	"	PhSPh (83)	318
110	Bu <sub>3</sub> SnSSnBu <sub>3</sub>	"	PhSPh (75)	318
	Me <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (1.3%), PhMe, 115°, 15 h	PhTMS (—)	547
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 115°, 15 h	PhSnBu <sub>3</sub> (79)	547, 548
	PhCl		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h  (0)	3
		Pd(dppb)Cl <sub>2</sub> , CuO, DMF, 100°, 24 h	(tr)	96
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 66°, 24 h	TMS (0)	422
	Me <sub>3</sub> SnCN	Pd(PPh <sub>3</sub> ) <sub>4</sub>	PhCN (—)	549
	Bu <sub>3</sub> SnC≡CH	Pd <sub>2</sub> (dba) <sub>3</sub> (4%), AsPh <sub>3</sub> (16%), Cul (8%), DMF, 60°, 6 h	PhC≡CH (58)	33
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), PPh <sub>3</sub> (10%), Cul (10%), dioxane, 50°, 72 h	(>95)	33
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (8%), THF, 50°, 72 h	(>95)	11
111		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), AsPh <sub>3</sub> (8%), THF, 50°, 72 h	(>95)	11
		Pd(BH-BIAN) (dimethyl fumarate) (2%), DMF, 50°, 16 h	(49)	415
	Me <sub>3</sub> SnCF=CF <sub>2</sub>	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I, HMPA or DMF, 50-70°, 3 h	PhCF=CF <sub>2</sub> (85-87)	265, 266
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 80°	(32)	3
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiCl, DMF, 90°, 30 h	(88)	29

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> (4%), AsPh <sub>3</sub> (16%), CuI (8%), DMF, 60°, 6 h	PhCH=CH <sub>2</sub> (61)	33
		Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (3%), PPh <sub>3</sub> (24%), LiCl, DMF, rt	PhC≡CCH <sub>2</sub> (45)	275
		Pd <sub>2</sub> (dba) <sub>3</sub> (4%), AsPh <sub>3</sub> (16%), CuI (8%), DMF, 60°, 6 h	PhBu-n (34)	33
162		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, 7 h	Ph-furan (80)	292
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 24 h	Ph-pyrazole (80)	550
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 7 h	Ph-furan (82)	292, 530
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, overnight	Ph-pyridine (43)	458
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.5%), CuI, CH <sub>3</sub> CN, rt, 1 h	Ph-cyclobutene (59)	267
		Pd <sub>2</sub> (dba) <sub>3</sub> (4%), AsPh <sub>3</sub> (16%), CuI (8%), DMF, 60°, 6 h	Ph-furan (58)	33
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), DMF, 70°, 2 h	Ph-furan (75)	287
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, DMF, rt, 1 h	PhC≡COEt (60)	302
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), dioxane, 95°, 96 h	Ph-alkene (92)	270
		Pd <sub>2</sub> (dba) <sub>3</sub> (4%), AsPh <sub>3</sub> (16%), CuI (8%), DMF, 60°, 6 h	Ph-alkene (71)	33
163		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1-2%), PhMe, reflux	Ph-furan (65)	261
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1-2%), PhMe, reflux	Ph-furan (45)	261
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI, DMF, rt, 48 h	Ph-alkene (87)	246
		Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (12%), THF, 50°, 18 h	Ph-alkene + Ph-alkene (70) 1:254	245
		Pd <sub>2</sub> (dba) <sub>3</sub> (3%), AsPh <sub>3</sub> (12%), THF, 50°, 18 h	Ph-alkene (70)	245
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h	Ph-alkene (31)	236
		Pd(dppb)Cl <sub>2</sub> , CuO, DMF, 100°, 70-80 min	Ph-pyridine (64)	96, 33
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), THF, reflux, 20 h	Ph-pyrrole (54)	286

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 12 h	Ph- (100)	550, 551
Bu <sub>3</sub> SnC≡CCO <sub>2</sub> Et		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), Et <sub>3</sub> NCl, ZnCl <sub>2</sub> , DMF, 50°, 2 h	PhC≡CCO <sub>2</sub> Et (94)	552
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux, 6 h	Ph- (58)	437
Me <sub>3</sub> SnPh		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 8 h	Ph-Ph (86)	553
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux, 40-80 min	Ph- (72)	437
Me <sub>3</sub> Sn-		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 3 h	Ph- (67)	536
Me <sub>3</sub> Sn-		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 70°, 1 h	Ph- (90)	553
Me <sub>3</sub> Sn-		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux, 40-80 min	Ph- (78)	437
Bu <sub>3</sub> Sn-		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (7-10%), DMF, rt	Ph- (77)	12
Bu <sub>3</sub> Sn-		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (7-10%), DMF, rt	Ph- (99)	12
	Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 66°, 24 h	Ph- (98)	422
Bu <sub>3</sub> Sn-		Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (3%), PPh <sub>3</sub> (24%), DMF, rt	Ph- (45)	275
Bu <sub>3</sub> Sn-		Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), DMF, 100°, 6 h	Ph-	473
Bu <sub>3</sub> Sn-		Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (4%), AsPh <sub>3</sub> (30%), THF, reflux, 6 h	I (42) + II (10) E:Z = 1:1	473
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 20 h	Ph- (59)	302
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 24 h	Ph- (49)	302
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 24 h	Ph- (0)	302
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), air, CuI (50%), DMF, 60°, 0.5-1 h	Ph- (84)	554
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI, DMF, rt, 24 h	Ph- (87)	555

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	BnPd(PPh3)2Cl, CuI, DMF, rt		(77)	49
	Pd(PPh3)4, NEt3, CH3CN, 190°, 8 h		(≥68)	290
	BnPd(PPh3)2Cl, CuI, DMF, rt		(68)	49
	Pd(OAc)2 (10%), PPh3 (30%), DMF, rt, 72 h		(75)	555
	Pd(PPh3)2Cl2 (4.8%), CH2Cl2, 80°, 12 h		(61)	459
	Pd(dba)2 (5%), PhMe, reflux, 12 h		(78)	556
	Pd(PPh3)4 (0.7%), DMF, 110°, 5 h		(98)	289
	Pd2(dba)3 (2%), DMF, rt, 6 h		(50)	439
	Pd(dba)2 (5%), Bu4NI, DMF, 80°, 16 h		(60)	382
	Pd(PPh3)2Cl2, PPh3, LiCl, DMF, heat		(35)	251
	Pd(PPh3)4 (10%), Cul (20%), DMF, 80°, 15 min		(88)	170
	Pd2(dba)3 (2%), DMF, rt, 6 h		(89)	439
	Pd(PPh3)4 (10%), DMF, 90°, 3 h		(93)	74
	Pd(PPh3)2Cl2 (5%), Et4NCl, DMF, 80°, 30 h		(39)	545
	Pd(PPh3)4, PhMe, reflux		R = Me or Bu (25-30)	556

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		$[(\eta^3\text{-C}_5\text{H}_5)\text{PdCl}]_2$ (1%), DMF, 65°, 2 h	(65)	287, 546	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 60°, 16 h	(28)	422	
		Pd(0)	(low)	390	
	Et <sub>3</sub> SnSPh	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (1%), DMSO, 100°, 1 h	Ph <sub>2</sub> S (94)	320	
	Et <sub>3</sub> SnSSnEt <sub>3</sub>	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (5%), DMSO, 100°, 4 h	Ph <sub>2</sub> S (96)	320	
	Me <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (1.3%), PhMe, 115°, 15 h	Ph-Ph (—)	547	
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (1.3%), PhMe, 115°, 15 h	PhSnMe <sub>3</sub> (96)	547, 557	
	Et <sub>3</sub> SnSnEt <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 20°, 2 h	PhSnEt <sub>3</sub> (99)	313	
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 115°, 15 h	PhSnBu <sub>3</sub> (96)	547, 313	
198	PhN <sub>2</sub> <sup>+</sup> BF <sub>4</sub> <sup>-</sup>	Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> (10%), CH <sub>3</sub> CN, rt, 2 h	PhMe (55)	204
		Bu <sub>3</sub> Sn	Pd(dba) <sub>2</sub> (10%), CH <sub>3</sub> CN, rt, 5 min	Ph (80)	204
			Pd(dba) <sub>2</sub> (5%), CH <sub>3</sub> CN, Et <sub>2</sub> O, rt	Ph (97) E:Z = 40:60	249
			Pd(dba) <sub>2</sub> (5%), CH <sub>3</sub> CN, Et <sub>2</sub> O, rt, 20 min	Ph (90) E:Z = 18:82	249
	PhOSO <sub>2</sub> F	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiCl, DMF, 25°, 6-18 h	Ph (76)	203
			"	Ph (70)	203
	PhOTf	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7.5%), LiCl, DMF, 90°, 30 h	Ph (69)	29, 201
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, dioxane, 95°, 18 h	Ph (100)	270
199			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, THF, 66°, 24 h	(37)	422
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiCl, THF, reflux	(73)	475
	PhOSO <sub>2</sub> CF <sub>2</sub> CF <sub>2</sub> H	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7.5%), LiCl, DMF, 90°, 30 h	Ph (51-65)	29, 201
	PhTl(O <sub>2</sub> CCF <sub>3</sub> ) <sub>2</sub>	Ph <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> , DMF, reflux	Ph-Ph (84)	558
		Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	(13) +  (57)	538
		Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> (10%), CH <sub>3</sub> CN, 25°, 2 h	(41)	559

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux		423
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), BHT, PhMe, reflux, 1 h		88
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), BHT, PhMe, reflux, 1 h		88
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), Et <sub>3</sub> NCl, DMF, 80°, 1.5 h		272, 273
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux		560, 561
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 3 h		90, 316
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (75%), DMF, rt, 24 h		246
		Pd(OAc) <sub>2</sub> (10%), CH <sub>3</sub> CN, rt, 2 h		204
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiCl, DMF, 25°, 6-18 h		203
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), BHT, dioxane, 98°, 2.5 h		189
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, 98°, 7 h		189
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, BHT, DMF, 70°, 3 h		189
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (10%), LiCl, CuBr, BHT, dioxane, reflux		191
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), PPh <sub>3</sub> (10%), CuBr, BHT, dioxane, reflux		191
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (20%), LiCl, CuBr (20%), BHT, dioxane, reflux		191
		"		191
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 23 h		562

†70

†71

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), $\text{Et}_3\text{NCl}$ , $\text{CH}_3\text{CN}$ , reflux, 4 h 2. $\text{H}^+$ , reflux, 3 h	 (96)	553
		$\text{Pd}(\text{PPh}_3)_4$ (5%), dioxane, 80°	 (71)	233
		$\text{Pd}[\text{P}(o\text{-Tol})_3]_2\text{Cl}_2$ (1%), <i>m</i> -xylene, 120°, 24 h	 (66)	235
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), HMPA, 80°, 20 h	 (61)	234
172		$\text{Pd}[\text{P}(o\text{-Tol})_3]_2\text{Cl}_2$ (1%), PhMe, 100°, 5 h	 (80)	240
		$\text{Pd}[\text{P}(o\text{-Tol})_3]_2\text{Cl}_2$ (1%), $\text{ZnBr}_2$ , DMF, 80°, 5 h	 (66)	236
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), DMF, 90°, 25 h	 (76)	564
		$\text{Pd}(\text{PPh}_3)_4$ (1%), PhMe, 120°, 20 h	 (73)	318
		$\text{Me}_4\text{Sn}$	 (64)	204
			 (70)	29, 201
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), DMF, 90°, 25 h	 (80)	564
		$\text{Pd}(\text{PPh}_3)_4$ (1%), PhMe, 120°, 20 h	 (60)	318
		$\text{Pd}(\text{PPh}_3)_4$ (1.3%), PhMe, 115°, 15 h	 (73)	547
173		$\text{Me}_4\text{Sn}$	 (89)	204
			 (73)	233
		$\text{Pd}[\text{P}(o\text{-Tol})_3]_2\text{Cl}_2$ (1%), <i>m</i> -xylene, 120°, 24 h	 (66)	235
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), HMPA, 80°, 20 h	 (70)	234
		$\text{Pd}(\text{PPh}_3)_4$ (1%), $\text{C}_6\text{H}_6$ , 100°, 20 h	 (100)	3
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (0.5%), THF, reflux, 20 h	 (80)	286
		$\text{Pd}[\text{P}(o\text{-Tol})_3]_2\text{Cl}_2$ (1%), PhMe, 100°, 5 h	 (73)	237, 240

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		BnPd(PPh3)2Cl, C6H6, 100°, 20 h	(79)	305
		1. Pd(PPh3)2Cl2 (1%), PhMe, 100°, 20 h 2. H+	(73)	269
		Pd[P(o-Tol)3]2Cl2 (1%), ZnBr2, DMF, 80°, 5 h	(89)	236
		Pd(PPh3)4 (1%), C6H6, 110°, 15 h	(76) E:Z = 65:35	534
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h	(66)	538
		Pd(PPh3)4, C6H6, 110°	(72)	305, 532
		BnPd(PPh3)2Cl, DMF, 70°, 16 h	(94)	296
		Pd(PPh3)4 (2%), PhMe, reflux, 1 h	(88)	371
		Pd(PPh3)4 (17%), dioxane, reflux, 40 h	(89)	565
		Pd(PPh3)2Cl2, PhMe	(49)	299, 300
174				
		Pd[P(o-Tol)3]2Cl2 (1%), PhMe, 100°, 3 h	(55)	90, 316
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h	(74)	318
175				
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h	(86)	318
		Pd(PPh3)4 (1.3%), PhMe, 115°, 15 h	(34)	547
		Pd(PPh3)4 (1.3%), PhMe, 115°, 15 h	(59)	547
		Bu3SnCH=CH2	(4)	3
		Me3SnCH=CH2	(94)	553

TABLE III. DIRECT CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
<chem>Clc1ccc(cc1)C(=O)OCC(C)C</chem>	<chem>Bu3SnCH=CH2</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	<chem>Clc1ccc(cc1)C=C</chem> (29)	3
<chem>Me3SnC#C#C6H5</chem>		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 25 min	<chem>Clc1ccc(cc1)C#C#C6H5</chem> (90)	553
<chem>CC1=CC=C(OBu-t)C=C1[Sn](Bu3)C6H4Cl</chem>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, DMF, 70°, 16 h	<chem>Clc1ccc(cc1)C=C(OBu-t)[Sn](Bu3)C6H4Cl</chem> (94)	296
<chem>Me3SnSnMe3</chem>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 115°, 15 h	<chem>Clc1ccc(cc1)SnMe3</chem> (74)	547
<chem>Bu3SnSnBu3</chem>		NiBr <sub>2</sub> (10%), HMPA, 135°, 17 h	<chem>Clc1ccc(cc1)SnBu3</chem> (92)	566, 313
<chem>Clc1ccc(cc1)OSO2(CF2)2O(CF2)2H</chem>	<chem>Bu3SnCH=CH2</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7.5%), LiCl, DMF, 90°, 30 h	<chem>Clc1ccc(cc1)C=C</chem> (77)	29, 201
<chem>Clc1ccc(cc1)N2+BF4-</chem>	<chem>Me4Sn</chem>	Pd(OAc) <sub>2</sub> (10%), CH <sub>3</sub> CN, rt, 2 h	<chem>Clc1ccc(cc1)C=C</chem> (88)	204
<chem>FC(F)c1ccccc1Br</chem>	<chem>Me4Sn</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), air, HMPA, 65°	<chem>FC(F)c1ccccc1C=C</chem> (89)	19
<chem>CC1=CC=C([Sn](Bu3)OC(C)C)C=C1</chem>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 24 h	<chem>FC(F)c1ccccc1C=C1ON(C)C=C1</chem> (100)	550, 551
<chem>CC1=CC=C([Sn](Bu3)OC(C)C)C=C1OEt</chem>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 110°, 15 h	<chem>FC(F)c1ccccc1C=C1COEt=C1</chem> (78) E:Z = 60:40	534
<chem>CC1=CC=C([Sn](Bu3)OC(C)CO2Et)C=C1OEt</chem> E:Z = 85:15		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	<chem>FC(F)c1ccccc1C=C1COEt=C1CO2Et</chem> (60) E:Z = 85:15	539
<chem>FC(F)c1cc(F)c(Br)c(F)c1</chem>	<chem>CC1=CC=C([Sn](Bu3)C6N)C=C1</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (7%), HMPA, dioxane, reflux, 24 h	<chem>FC(F)c1cc(F)c(Br)c(F)c1C=C1CN=C1</chem> (47)	567
<chem>FC(F)c1cc(F)c(I)c(F)c1</chem>	<chem>Bu3SnCH=CC(CO2Et)NHC(=O)C</chem>	Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (4%), P(2-furyl) <sub>3</sub> (30%), THF, reflux, 6 h	<chem>FC(F)c1cc(F)c(I)c(F)c1C=CCC(CO2Et)NHC(=O)C</chem> (56)	473
<chem>Ic1cc(F)c(I)c(F)c1</chem>	<chem>Bu3SnC6F5</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, 100°, 16 h	<chem>Ic1cc(F)c(I)c(F)c1C=C6F5</chem> (—)	568
<chem>Ic1ccc(cc1)I</chem>	<chem>Bu3SnC6S2=C=S2</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux	<chem>Ic1ccc(cc1)I-C6S2=C=S2</chem> (61)	536
<chem>Ic1ccc(cc1)I</chem>	<chem>Bu3SnC=CC6H5</chem>	Pd(dba) <sub>2</sub> (5%), CH <sub>3</sub> CN, Et <sub>2</sub> O, rt, 2 h	<chem>Ic1ccc(cc1)I-C=C6H5</chem> (86) E:Z = 8:92	249

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (2%), LiCl, BHT, dioxane, 98°, 16 h	(73)	189
		Pd2(dba)3 (5%), AsPh3 (40%), dioxane, 50°, 48 h	(61)	569
		Pd(PPh3)2Cl2 (20%), dppf (80%), LiCl, DMF, reflux	(100)	191
		Pd(PPh3)2Cl2 (1%), Et4NCl, DMF, 100°, 1.5 h	(—)	273
		PdCl2 (0.8%), PPh2(C6H4SO3Na-m) (3.2%), KOH, H2O, 100°, 4 h	(57)	282
		PdCl2 (0.8%), PPh2(C6H4SO3Na-m) (1.6%), KOH, H2O, 100°, 3 h	(88)	282
		Pd(PPh3)2Cl2 (1%), Et4NCl, DMF, 80°, 18 h	(0)	272, 273
		Pd[P(o-Tol)3]2Cl2 (1%), PhMe, 100°, 3 h	(0)	316
		Pd2(dba)3 (4.8%), AsPh3, CuI, DMF, 60°, 3-4 h	(59)	554
		Pd(PPh3)2Cl2 (1%), dioxane, reflux, 20 h	(90)	530
		Pd(PPh3)2Cl2 (1%), dioxane, reflux, 20 h	(57)	530
		Pd(PPh3)4 (3%), DMF, 100°, 24 h	(62)	570
		Pd(PPh3)4 (3%), DMF, 100°, 24 h	(52)	570, 571
		1. Pd(PPh3)4 (2%), PhMe, reflux, 63 h 2. H3O+	(88)	461, 540
		Pd(PPh3)2Cl2, DMF, 80°, 12 h	(78)	572

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 80°	(59)	310
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (20%), CuI (50%), DMF, 60°, 3-4 h	(82)	554
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), DMF, 110°, 6 h	(97)	289
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 5 min	(100)	312, 573
	Me <sub>3</sub> SnSnMe <sub>3</sub>	[η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ]PdCl <sub>2</sub> , CH <sub>2</sub> Cl <sub>2</sub> , 20°	" (75)	557
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 80°, 72 h	(98)	311
	Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> (10%), CH <sub>3</sub> CN, rt, 2 h	(94)	204
		Pd(dppf)Cl <sub>2</sub> , PhMe, 105°, 2 h	(93)	41
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 105°, 3 h	(80)	41
		Pd(dppf)Cl <sub>2</sub> , PhMe, 105°, 12 h	(86)	41
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 105°, 20 h	(85)	41
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 80°, 1 h	(41)	547
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (20%), CuI (50%), DMF, 60°, 3-4 h	(80)	554
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), air, CuI (50%), DMF, 60°, 0.5-1 h	(88)	554
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 10 min	(98)	312, 573
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 60°, 72 h	" (65)	310, 311
	Me <sub>3</sub> SnSnMe <sub>3</sub>	[η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ]PdCl <sub>2</sub> , CH <sub>2</sub> Cl <sub>2</sub> , 20°	" (55)	557
	Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> (2%), DMF, 60-70°, 2.5 h	(77)	206
		Pd(OAc) <sub>2</sub> (2%), DMF, 60-70°, 2.5 h	(83)	206
	Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> (10%), CH <sub>3</sub> CN, rt, 2 h	(62)	204

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(dba) <sub>2</sub> (5%), CH <sub>3</sub> CN, Et <sub>2</sub> O, rt, 2 h	 (54) <i>E/Z</i> = 8:92	249
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 80°	 (0)	233
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), BHT, PhMe, reflux, 4 h	 (80)	88
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ]Cl <sub>2</sub> (1%), <i>m</i> -xylene, 120°, 3 h	 (tr)	235
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 20 h	 (65)	234
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	 (72)	3
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (10%), PhMe, 100°, 5 h	 (0)	240
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , 70°	 (99)	574
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	 (75)	305
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°, 48 h	 (82)	270
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 20 h 2. H <sup>+</sup>	 (91)	269
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), Et <sub>4</sub> NCl, DMF, 80°, 2 h	 (86)	272, 273
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h	 (34)	236
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , 70°	 (93)	574
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , 70°	 (77)	574
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100°	 (63)	457
		D <sub>717</sub> -Pd(0)-polymer, Me <sub>2</sub> CO, reflux, 25 h	 (57)	535
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	 (68)	538
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , C <sub>6</sub> H <sub>6</sub> , 110°	 (58)	305

TABLE III. DIRECT CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		BnPd(PPh3)2Cl, DMF, 70°, 16 h		(98) 296
		1. Pd(PPh3)4, PhMe, reflux, 63 h 2. H3O+		(59) 461
		Pd(PPh3)4 (5%), CuI (8%), NMP, 70°, 48 h		(45) 575
		Pd(PPh3)4 (5%), HMPA, 80°, 23 h		(81) 287, 546
		Pd(PPh3)4 (10%), dioxane, reflux, 24 h		(77) 565
		Pd(PPh3)2Cl2, PhMe		(78) 299, 300
		Pd(PPh3)4 (5%), HMPA, 80°, 24 h		(85) 287, 546
184		Pd[P(o-Tol)3]2Cl2 (1%), PhMe, 100°, 3 h		(24) 90, 316
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h		(52) 318
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h		(44) 318
		Pd(PPh3)4 (5%), PhMe, 120°, 40 h		(58) 548
		Pd(PPh3)4 (5%), PhMe, 80-120°, 1-15 h		(37) 547
185		Pd(CH3CN)2Cl2 (1%), HMPA, 20°, 1 h		(48) 313
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h	" (38)	310
		Pd(PPh3)4 (1.3%), PhMe, 115°, 15 h		(26) 547, 548
		Pd(PPh3)4 (1%), C6H6, 120°, 20 h		(59) 3
		Pd(PPh3)2Br2 (1.3%), PhMe, 115°, 15 h		(0) 547
		PhPd(PPh3)2I (2%), HMPA, 70°, 30 min		(87) 463
		Pd(CH3CN)2Cl2 (2%), DMF, 20°, <1 min		(98) 553, 463

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

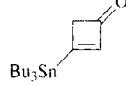
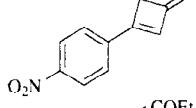
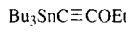
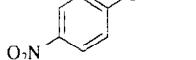
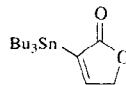
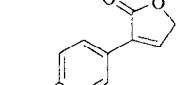
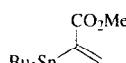
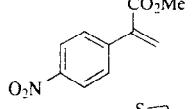
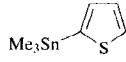
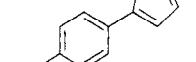
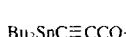
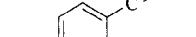
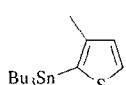
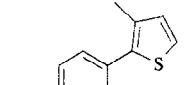
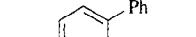
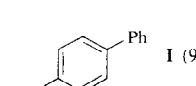
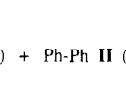
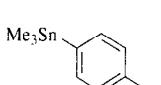
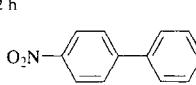
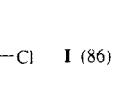
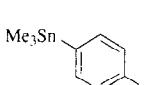
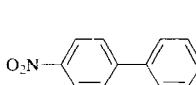
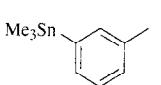
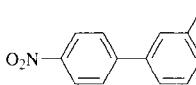
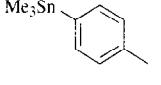
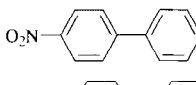
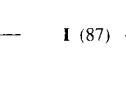
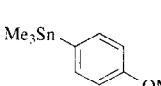
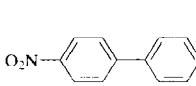
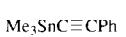
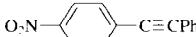
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
		BnPd(PPh3)2Cl (1.5%), THF, 78°, 2 h	 (50)	267
		Pd(PPh3)2Cl2 (5%), Et4NCl, DMF, rt, 1 h	 (52)	302
		Pd(PPh3)2Cl2 (1-2%), PhMe, reflux	 (0)	261
		Pd(PPh3)4 (10%), CuI, DMF, rt, 12 h	 (76)	246
		Pd(CH3CN)2Cl2 (2%), DMF, 20°, 5 min	 (96)	553
		Pd(PPh3)2Cl2 (1%), Et4NCl, ZnCl2, C6H6, 50°, 1 h	 (47)	552
		Pd/C (5%), CuI (10%), AsPh3 (20%), NMP, 80°, 24 h	 (85)	458
		Pd(CH3CN)2Cl2 (2%), DMF, 20°, 3 h	 (100)	553
		PhPd(PPh3)2I (2%), HMPA, 20°, 20 min	 I (92) +  II (8)	463, 576
		( <i>p</i> -O2NC6H4)Pd(PPh3)2I (2%), Cl(CH2)2Cl, 120-130°, 2 h	I (83) + II (17)	87
		PhPd(PPh3)2I (2%), HMPA, 20°, 20 min	 I (86) +  (8)	463
"		Pd(CH3CN)2Cl2 (2%), DMF, 20°, 5 h	I (94)	553
		PhPd(PPh3)2I (2%), HMPA, 20°, 5 h	 (97)	463
		PhPd(PPh3)2I (2%), Cl(CH2)2Cl, 120°, 2 h	 (76)	87
		PhPd(PPh3)2I (2%), HMPA, 20°, 20 min	 I (87) +  (12)	463
"		Pd(CH3CN)2Cl2 (2%), DMF, 20°, 3 h	I (96)	553
		Pd(CH3CN)2Cl2 (2%), DMF, 20°, 3 h	 (93)	463, 553
		PhPd(PPh3)2I (2%), HMPA, 20°, 10 h	 I (57)	463

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
<chem>Me3SnC≡CPH</chem>		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 5 min	<b>I</b> (93)	553
<chem>Me3SnC≡CPH</chem>		PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 120°, 2 h	<b>I</b> (94)	87
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), air, CuI (50%), DMF, 60°, 0.5-1 h	O <sub>2</sub> N-phenyl-C(=O)-C(=O)-phenyl-O <sub>2</sub> N (85)	554
		"	O <sub>2</sub> N-phenyl-C(=O)-C(=O)-phenyl-TMS (76)	554
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 90°, 3 h	O <sub>2</sub> N-phenyl-indole-2-yl-CH <sub>2</sub> -SEM (86)	74
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 90°	O <sub>2</sub> N-phenyl (66) + O <sub>2</sub> N-phenyl-C(=O)-phenyl-N=N-NO <sub>2</sub> (—)	577
			IMe <sub>2</sub> Sn-decalin (—)	
<chem>Et3SnSSnEt3</chem>		PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (5%), DMSO, 100°, 4 h	O <sub>2</sub> N-phenyl-C(=S)-phenyl-NO <sub>2</sub> (100)	320
<chem>Me3SnSnMe3</chem>		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 5 min	O <sub>2</sub> N-phenyl-SnMe <sub>3</sub> (100)	312
<chem>Me3SnSnMe3</chem>		[( $\eta^3$ -C <sub>5</sub> H <sub>5</sub> PdCl)] <sub>2</sub> (1%), CH <sub>2</sub> Cl <sub>2</sub> , 20°	" (75)	557
<chem>Et3SnSnEt3</chem>		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 20°, 5 min	O <sub>2</sub> N-phenyl-SnEt <sub>3</sub> (81)	313
<chem>Bu3SnSnBu3</chem>		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 20°, 5 min	O <sub>2</sub> N-phenyl-SnBu <sub>3</sub> (94)	313
<chem>Bu3SnSnBu3</chem>		NiBr <sub>2</sub> (10%), HMPA, 135°, 3 h	" (72)	315
<chem>Bu3SnSnBu3</chem>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (1.3%), PhMe, 115°, 15 h	" (0)	547
<chem>Bu3SnSnBu3</chem>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 60°, 72 h	" (63)	311
	Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> (10%), CH <sub>3</sub> CN, rt, 2 h	O <sub>2</sub> N-phenyl-SnMe <sub>3</sub> (95)	204
	<chem>Bu3Sn=Ph</chem>	Pd(dba) <sub>2</sub> (5%), Et <sub>2</sub> O, CH <sub>3</sub> CN, rt, 1 h	O <sub>2</sub> N-phenyl-C=C-Ph (60) E:Z = 16:84	249
	<chem>Bu3Sn=CH2</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiCl, DMF, 25°, 6-18 h	O <sub>2</sub> N-phenyl-CH=CH (60)	203
		"	O <sub>2</sub> N-phenyl-C(=O)-OMe (50)	203

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	(TMSCH <sub>2</sub> ) <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, BHT, dioxane, 98°, 9 h	(25)	189
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, 98°, 36 h	(74)	189, 420
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, BHT, DMF, 100°, 5 h	(47) <i>E/Z</i> = 1:2	189
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, 98°, 9 h	(82)	189
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux, 48 h	(91)	89
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , DMF	(96)	578
	Me <sub>3</sub> SnPh	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 120-130°, 2 h	(93)	87
	Me <sub>3</sub> SnPh	[( <i>n</i> <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), Me <sub>2</sub> CO, 20°, 24 h	" (99)	553, 557
	Me <sub>3</sub> SnPh	( <i>p</i> -O <sub>2</sub> N <sub>2</sub> C <sub>6</sub> H <sub>3</sub> )Pd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 120-130°, 2 h	" (94)	87
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 5 min	(93)	312, 573
	Me <sub>3</sub> SnSnMe <sub>3</sub>	[( <i>n</i> <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), CH <sub>2</sub> Cl <sub>2</sub> , 20°	" (70)	573
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 20°, 1 h	(79)	313
	Me <sub>3</sub> SnPh	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I, Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 120-130°, 1.5 h	R = Cl (95), R = I (96)	87, 576 87
	Me <sub>3</sub> SnC≡CPh	"	R = I (85)	87
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (20%), dioxane, 50°	(95)	471, 579
		"		
		PdCl <sub>2</sub> (0.5-3%), PPh <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> Na- <i>m</i> ) <sub>2</sub> , KOH, H <sub>2</sub> O, 90°	(81)	471
	Cl <sub>3</sub> SnPh	PdCl <sub>2</sub> (0.5-3%), PPh <sub>3</sub> (C <sub>6</sub> H <sub>5</sub> SO <sub>3</sub> Na- <i>m</i> ) <sub>2</sub> , KOH, H <sub>2</sub> O, 90°	(89)	281, 282
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , Et <sub>4</sub> NCl, DMF, 80°, 12 h	(0)	272, 273

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Cl}_3\text{SnPh}$	$\text{PdCl}_2$ (0.5–3%), $\text{PPh}(\text{C}_6\text{H}_4\text{SO}_3\text{Na}-m)_2$ , KOH, $\text{H}_2\text{O}$ , 90°	 (<5)	281
	$\text{Bu}_3\text{SnNEt}_2$	$\text{Pd}[\text{P}(o\text{-Tol})_3]_2\text{Cl}_2$ (1%), $\text{PhMe}$ , 100°, 3 h	 (0)	316
	$\text{Cl}_3\text{SnCH}_2\text{CH}_2\text{CO}_2\text{H}$	$\text{PPh}_2(\text{C}_6\text{H}_4\text{SO}_3\text{Na}-m)$ (6.4%), $\text{PdCl}_2$ (1.6%), KOH, $\text{H}_2\text{O}$ , 100°, 3 h	 (<10)	282
	$\text{Cl}_3\text{SnPh}$	$\text{PdCl}_2$ (0.8%), KOH, $\text{H}_2\text{O}$ , 100°, 3 h	 (87)	282
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_3(\text{O}^-)(\text{N}=\text{O})\text{Ph}$	$\text{Pd}_2(\text{dba})_3$ (2.5%), $\text{AsPh}_3$ (20%), dioxane, 50°,	 (62)	569
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_3(\text{O}^-)(\text{N}=\text{O})\text{Ph}$	"	 (78)	471
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_3(\text{O}^-)(\text{N}=\text{O})\text{C}_6\text{H}_3(\text{OMe})_2$	"	 (67)	471
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_3(\text{O}^-)(\text{N}=\text{O})\text{Ph}$	$\text{PdCl}_2$ (5%), dioxane, 101°	 (42)	471
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_3(\text{O}^-)(\text{N}=\text{O})\text{Ph}$	$\text{PdCl}_2$ (5%), dioxane, 105°	 (35)	471, 579
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_3(\text{O}^-)(\text{N}=\text{O})\text{C}_6\text{H}_3(\text{OMe})_2$	$\text{PdCl}_2$ (5%), dioxane, 105°	 (43)	471
	$\text{Bu}_3\text{SnCH}_2\text{OH}$	$\text{Pd}(\text{PPh}_3)_4$ (5%), dioxane, 80°	 (80)	233
	$\text{Bu}_3\text{SnCH}_2\text{CN}$	$\text{Pd}[\text{P}(o\text{-Tol})_3]_2\text{Cl}_2$ (1%), <i>m</i> -xylene, 120°, 3 h	 (74)	235
	$\text{Bu}_3\text{SnCH}_2\text{OMe}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (1%), $\text{HMPA}$ , 80°, 70 h	 (80)	234
		$\text{Pd}[\text{P}(o\text{-Tol})_3]_2\text{Cl}_2$ (1%), $\text{PhMe}$ , 100°, 5 h	 (91)	237, 240
	$\text{Bu}_3\text{Sn}-\text{C}(=\text{O})-\text{CH}_2\text{Br}$	1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (1%), $\text{PhMe}$ , 100°, 20 h 2. $\text{H}^+$	 (78)	269

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

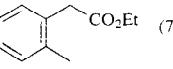
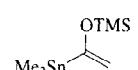
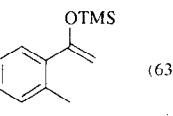
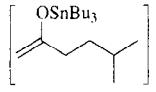
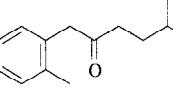
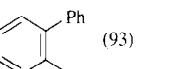
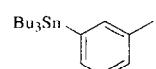
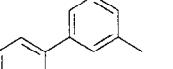
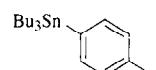
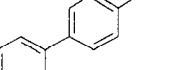
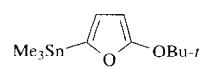
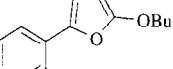
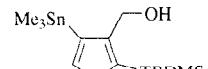
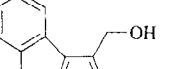
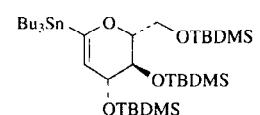
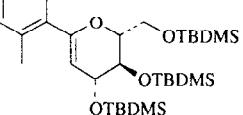
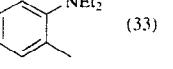
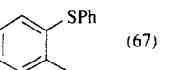
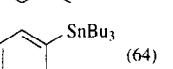
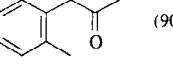
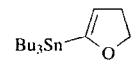
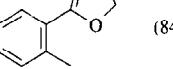
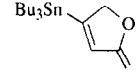
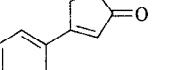
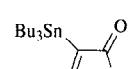
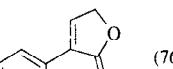
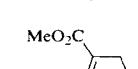
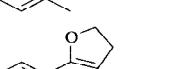
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnCH <sub>2</sub> CO <sub>2</sub> Et	Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h	 (71)	236
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100°	 (63)	457
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (3%), C <sub>6</sub> H <sub>6</sub> , reflux, 3 h	 (59)	241
194	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	 (93)	538
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	 (97)	538
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	 (87)	538
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, DMF, 70°, 16 h	 (64)	296
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 4 h	 (80)	371
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, reflux	 (49)	299, 300
195	Bu <sub>3</sub> SnNEt <sub>2</sub>	Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 3 h	 (33)	90, 316
	Bu <sub>3</sub> SnSPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	 (67)	238
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 115°, 15 h	 (64)	547
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	 (90)	240
		Pd(OAc) <sub>2</sub> (5%), P( <i>o</i> -Tol) <sub>3</sub> , NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 2 h	 (84)	429
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1-2%), PhMe, reflux	 (36)	261
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1-2%), PhMe, reflux	 (76)	261
		Pd(OAc) <sub>2</sub> (15%), P( <i>o</i> -Tol) <sub>3</sub> , NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 3 h	 (82)	580

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> Sn—CH=CH—CO <sub>2</sub> Me	Pd(OAc) <sub>2</sub> (15%), P(o-Tol) <sub>3</sub> , NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux, 3 h	 (62)	580
	Bu <sub>3</sub> Sn—C <sub>6</sub> H <sub>4</sub> —N(S <i>i</i> -SEM)C <sub>6</sub> H <sub>5</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), DMF, 110°, 2 h	 (93)	289
	Et <sub>3</sub> SnSSnEt <sub>3</sub>	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (5%), DMSO, 100°, 4 h	 (82)	320
	Bu <sub>3</sub> Sn—CH <sub>2</sub> —OH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 80°	 (62)	233
	Bu <sub>3</sub> Sn—CH=CH—CN	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), <i>m</i> -xylene, 120°, 3 h	 (74)	235
	Bu <sub>3</sub> Sn—CH=CH—OMe	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 20 h	 (72)	234
	[OSnBu <sub>3</sub> —CH=CH—]	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	 (88)	237, 240
	Bu <sub>3</sub> Sn—CH=CH—CO <sub>2</sub> Et	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h	 (60)	236
	Bu <sub>3</sub> Sn—CH=CH—OEt	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 20 h 2. H <sup>+</sup>	 (70)	269
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	 (80)	538
	Bu <sub>3</sub> Sn—C <sub>6</sub> H <sub>4</sub> —Ph	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	 (82)	538
	Bu <sub>3</sub> Sn—C <sub>6</sub> H <sub>4</sub> —Ph	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	 (72)	538
	Me <sub>3</sub> Sn—C <sub>6</sub> H <sub>4</sub> —CH(OH)—TBDSMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux, 18 h	 (55)	371
	Bu <sub>3</sub> SnNEt <sub>2</sub>	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 3 h	 (61)	90, 316
	[Bu <sub>3</sub> SnNHPh]	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°	 (66)	91
	[Bu <sub>3</sub> Sn—N—C <sub>6</sub> H <sub>4</sub> —OMe]	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°	 (64)	91
	[Bu <sub>3</sub> Sn—N—C <sub>18</sub> H <sub>37-n</sub> ]	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°	 (79)	91
	Bu <sub>3</sub> SnSSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	 (50)	238

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Et <sub>3</sub> SnSSnEt <sub>3</sub>	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (5%), DMSO, 100°, 4 h	(70)	320
	Bu <sub>3</sub> SnPh	Pd(OAc) <sub>2</sub> (5%), Ph <sub>2</sub> PM <sub>e</sub> (11%), LiCl, DMF, 110°, 76 h	(41)	202
	Bu <sub>3</sub> SnPh	Pd(OAc) <sub>2</sub> (5%), dppp (5.5%), LiCl, DMF, 110°, 72 h		(70) 202
	Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), air, HMPA, 65°	(84)	19
	Bu <sub>3</sub> SnCH <sub>2</sub> OH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 80°		(52) 233
	Bu <sub>3</sub> SnCH <sub>2</sub> CN	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), <i>m</i> -xylene, 120°, 3 h		(78) 235
	Bu <sub>3</sub> SnCH <sub>2</sub> OMe	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 20 h		(67) 234
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h		(80) 237, 240
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 20 h 2. H <sup>+</sup>		(67) 269
	Bu <sub>3</sub> SnCH <sub>2</sub> CO <sub>2</sub> Et	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h		(93) 236
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 12 h		(70) 550
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 110°, 15 h		(71) <i>E:Z</i> = 75:25 534
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 110°, 15 h		(74) <i>E:Z</i> = 80:20 534
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h 2. H <sup>+</sup>		(71) 581
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100° 2. H <sup>+</sup>		(66) 457
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h		(61) 538
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100° 2. H <sup>+</sup>		(35) 457
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h		(77) 538
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h		(64) 538

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (3%), C <sub>6</sub> H <sub>6</sub> , reflux, 3 h	(62)	241
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100° 2. H <sup>+</sup>	(31)	457
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , C <sub>6</sub> H <sub>6</sub> , 100° 2. Bu <sub>4</sub> NF, THF	(87)	532
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, reflux, 2 h	R = Me (82) R = SEM (66)	425
200		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> , PhMe, 100°, 20 h	(38)	541
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 105°	(36) + (22)	378
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (16%), dioxane, reflux, 40 h	(69)	565
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 3 h	(79)	90, 316
201		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105-100°	(73)	91
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°	(55)	91
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	(76)	318
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	(60)	312
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 115°, 15 h	(60)	547
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 115°, 15 h	(75)	547
		Pd(Ph-BtAN) (dimethyl fumarate) (1%), DMF, 50°, 18 h	(41)	415
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), CuI, DMF, rt, 2 h	(72)	287, 546
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, DMF, rt, 15 h	(45)	302

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

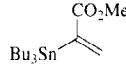
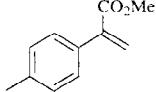
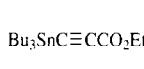
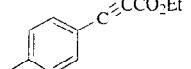
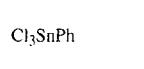
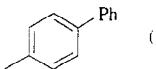
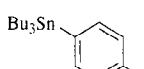
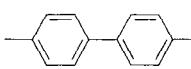
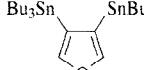
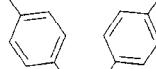
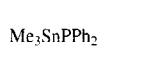
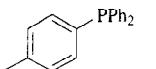
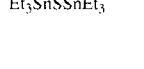
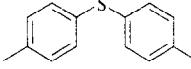
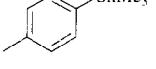
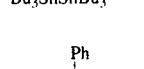
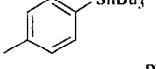
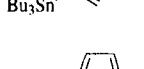
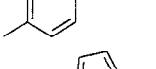
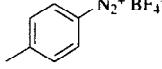
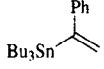
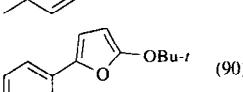
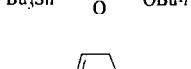
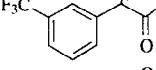
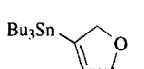
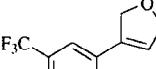
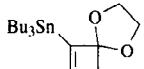
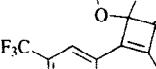
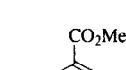
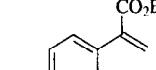
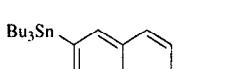
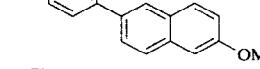
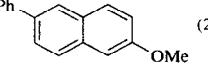
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), CuI, DMF, rt, 48 h	 (71)	246
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), Et <sub>3</sub> NCl, ZnCl <sub>2</sub> , DMF, rt, 40 h	 (23)	552
		PdCl <sub>2</sub> (0.8%), PPh <sub>3</sub> (C <sub>6</sub> H <sub>4</sub> SO <sub>3</sub> Na- <i>m</i> ) (1.6%), KOH, H <sub>2</sub> O, 100°, 3 h	 (86)	282
		Pd(Ph-BIAN) (dimethyl fumarate) (1%), DMF, 50°, 18 h	 (35)	415
202				
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (7%), DMF, 65°, 10 h	 (45)	287, 546
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2.5%), C <sub>6</sub> H <sub>6</sub> , 60°, 36 h	 (74)	321
		PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (5%), DMSO, 100°, 4 h	 (88)	320
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (1.3%), PhMe, 115°, 15 h	 (86)	547
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (1.3%), PhMe, 115°, 15 h	 (81)	547
		Pd(dba) <sub>2</sub> (5%), CH <sub>3</sub> CN, Et <sub>2</sub> O, rt, 15 min	 (97) E:Z = 7:93	249
203				
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, DMF, 70°, 16 h	 (90)	296
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1-2%), PhMe, reflux	 (61)	261
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1-2%), PhMe, reflux	 (23)	261
		Pd/C (0.5%), AsPh <sub>3</sub> (20%), CuI (10%), NMP, 80°, 24 h	 (67)	461
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (75%), DMF, rt, 24 h	 (72)	246
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 105°	 (49) +  (2)	378

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , CuI	(>61)	582
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	(98)	550
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , dioxane, 105°	(—)	583
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , dioxane, 105°	(—)	583
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux	(65)	584
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , dioxane, 105°	(—)	584
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , CuI, THF, reflux, 48 h	(67)	585
		Pd(PPh <sub>3</sub> ) <sub>4</sub> Cl <sub>2</sub> , DMF, 100°, 12 h	(83)	572
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 80°	(42)	310
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , CuI, THF, reflux, 48 h	(67)	585
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux, 72 h 2. H <sup>+</sup>	(72)	464
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 80°	(31)	310
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 80°	(0)	233
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), m-xylene, 120°, 20 h	(tr)	235
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 20 h	(57)	234

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	(0)	237	
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	(73)	305	
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h	(67)	236	
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 20 h 2. H <sup>+</sup>	(81)	269	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	(72)	318	
206		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100°	(67)	457	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 3 h		R = Me (98) R = Bu (95)	536
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100° 2. H <sup>+</sup>	(47)	457	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	(92)	538	
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100° 2. H <sup>+</sup>	(43)	457	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , C <sub>6</sub> H <sub>6</sub> , 110°	(65)	305	
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , C <sub>6</sub> H <sub>6</sub> , 110° 2. Bu <sub>4</sub> NF, THF	(77)	532	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, reflux, 2 h		R = Me (91) R = Boc (66)	425
207		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux, 24 h 2. H <sup>+</sup>	(79)	464, 540	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (15%), dioxane, reflux, 38 h	(81)	565	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, 20 min	(81)	299, 300	
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 3 h	(25)	90, 316	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	(57)	318	

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

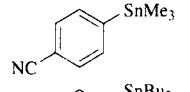
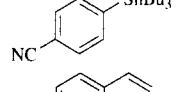
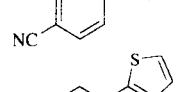
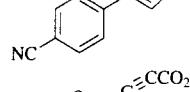
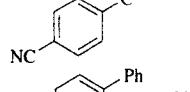
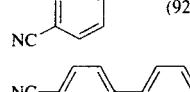
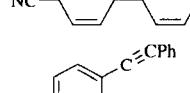
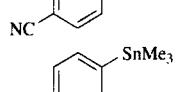
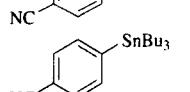
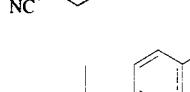
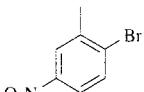
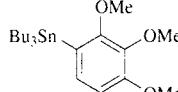
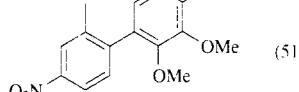
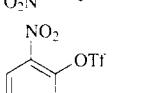
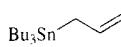
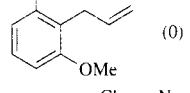
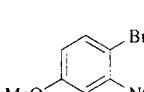
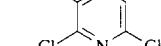
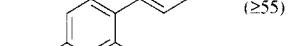
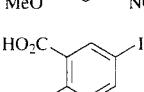
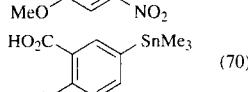
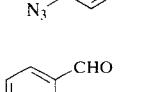
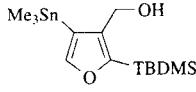
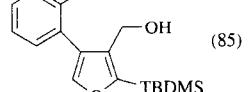
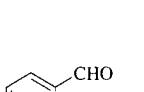
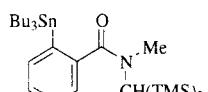
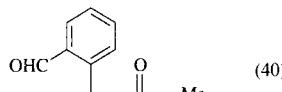
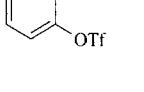
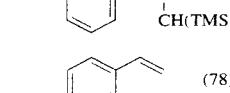
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
208	<chem>Me3SnSnMe3</chem>	Pd( <i>PPh</i> <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 115°, 15 h	 (64)	547
	<chem>Bu3SnSnBu3</chem>	Pd( <i>PPh</i> <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (1.3%), PhMe, 110°, 15 h	 (57)	547, 310
	<chem>Me3SnC=C</chem>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 5 min	 (99)	553
	<chem>Me3SnC=C</chem>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 10 min	 (91)	553
	<chem>Bu3SnC#CCO2Et</chem>	Pd( <i>PPh</i> <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), Et <sub>4</sub> NCl, ZnCl <sub>2</sub> , DMF, rt, 72 h	 (8)	552
	<chem>Me3SnPh</chem>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 4 h	 (92)	553
	<chem>Me3SnC=C</chem>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 4 h	 (94)	553
	<chem>Me3SnC#CPh</chem>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 10 min	 (95)	553
	<chem>Me3SnSnMe3</chem>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 20°, 10 min	 (98)	312
	<chem>Bu3SnSnBu3</chem>	Pd( <i>PPh</i> <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 60°, 72 h	 (85)	311
209			 (51)	575
			 (0)	190
			 (>55)	582
		<chem>Me3SnSnMe3</chem>	 (70)	586
			 (85)	371
			 (40)	587
			 (78)	88

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	N≡C—C <sub>6</sub> H <sub>4</sub> —C <sub>6</sub> H <sub>4</sub> —Cl (75)	538
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 110°, 15 h	OHC—C <sub>6</sub> H <sub>4</sub> —CH=CH—OEt (80) <i>E:Z</i> = 75:25	534, 588
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100°	OHC—C <sub>6</sub> H <sub>4</sub> —CH=CH—OTMS (71)	457
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1-2%), CHCl <sub>3</sub> , 65°, 1 d	OHC—C <sub>6</sub> H <sub>4</sub> —CH=CH—TMS (40)	537
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, DMF, 70°, 16 h	OHC—C <sub>6</sub> H <sub>4</sub> —C <sub>6</sub> H <sub>2</sub> (OBu-t) (96)	296
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	OHC—C <sub>6</sub> H <sub>4</sub> —CH=CH—CH(OEt) <sub>2</sub> (85) <i>E:Z</i> = 85:15	539
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux	OHC—C <sub>6</sub> H <sub>4</sub> —C <sub>6</sub> H <sub>2</sub> (N(Boc)) (62)	425
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (16%), dioxane, reflux, 38 h	OHC—C <sub>6</sub> H <sub>4</sub> —C <sub>6</sub> H <sub>2</sub> (N(TIPS)) (85)	565
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, reflux, 24 h	OHC—C <sub>6</sub> H <sub>4</sub> —SnMe <sub>3</sub> (92)	445
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, 98°, 3 h	OHC—C <sub>6</sub> H <sub>4</sub> —CH=CH (90)	189
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 80°	OHC—C <sub>6</sub> H <sub>3</sub> (OMe)—CH <sub>2</sub> OH (83)	233
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), <i>m</i> -xylene, 120°, 3 h	OHC—C <sub>6</sub> H <sub>3</sub> (OMe)—CN (70)	235
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), HMPA, 80°, 70 h	OHC—C <sub>6</sub> H <sub>3</sub> (OMe)—CH <sub>2</sub> OMe (tr)	234
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h	OHC—C <sub>6</sub> H <sub>3</sub> (OMe)—CO <sub>2</sub> Et (82)	236
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	OHC—C <sub>6</sub> H <sub>4</sub> —SPh (66)	318
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> , PhMe, 100°, 25 h	OHC—C <sub>6</sub> H <sub>4</sub> —C <sub>6</sub> H <sub>2</sub> (OMe)—C(=O)C <sub>6</sub> H <sub>4</sub> —C(=O)C <sub>6</sub> H <sub>2</sub> (OMe) (33) + OHC—C <sub>6</sub> H <sub>4</sub> —C <sub>6</sub> H <sub>2</sub> (OMe)—C(=O)C <sub>6</sub> H <sub>4</sub> —C(=O)C <sub>6</sub> H <sub>2</sub> (OMe) (8)	541
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, 110°, 18 h	OHC—C <sub>6</sub> H <sub>4</sub> —CH=CH—CH <sub>2</sub> —C <sub>6</sub> H <sub>2</sub> (OMe) (0)	371

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (20%), air, CuI (50%), DMF, 60°, 3-4 h	(67)	554
	Bu <sub>3</sub> SnC≡CSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiCl, BHT, dioxane, reflux, 5 h	(85)	589
212		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°	(79)	91
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°	(84)	91
212		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (20%), air, CuI (50%), DMF, 60°, 3-4 h	(67)	554
	Bu <sub>3</sub> SnC≡CSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiCl, BHT, dioxane, reflux, 5 h	(70)	589
	Bu <sub>3</sub> SnCH=C=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), P(2-furyl) <sub>3</sub> (8%), LiCl, CuI (10%), DMF, 80°, 2 h	(70)	276
213	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7.5%), LiCl, DMF, 90°, 30 h	I (81)	29, 201
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7.5%), i <sub>2</sub> Cl, THF, 90°, 30 h	I (11) +  (71)	29
213	Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), air, HMPA, 65°	(85)	19
		Pd(dppf)Cl <sub>2</sub> , PhMe, 75°, 2 h	" (94)	41
	Bu <sub>3</sub> SnCH <sub>2</sub> OH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 80°	(53)	233
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, BHT, reflux, 24 h	(76)	88
	Bu <sub>3</sub> SnCH <sub>2</sub> CN	Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), <i>m</i> -xylene, 120°, 3 h	(77)	235
	Bu <sub>3</sub> SnCH <sub>2</sub> OMe	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 20 h	(68)	234
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	(96)	3
	[OSnBu <sub>3</sub> ]	Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	(51)	237, 240
	MOMO-Sn(piperidin-4-yl)methyl	Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 105°, 3 h	(61)	41

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(dppf)Cl2, PhMe, 105°, 48 h	Bu-n-C6H4OMe (64)	41
		BnPd(PPh3)2Cl, C6H6, 100°, 20 h	Bu3SnCH=CHCO2Et (82)	305
		Pd[P(o-Tol)3]2Cl2 (1%), ZnBr2, DMF, 80°, 5 h	Bu3SnCH2CO2Et (47)	236
214		1. Pd(PPh3)2Cl2 (1%), PhMe, 100°, 20 h 2. H+	Bu3SnCH2CO2Et (54)	269
		Pd(PPh3)2Cl2, Et4NCl, DMF, 80°, 1 h	Bu3SnCH2CO2Et (67)	272, 273
		Pd(PPh3)4 (5%), C6H6, reflux, 12 h	Bu3SnC6H4N (85)	550, 551
		Pd(PPh3)4 (1%), C6H6, 110°, 15 h	Bu3SnCH2CH=CHCO2Et (63) E:Z = 50:50	534
		1. Pd(PPh3)4, PhMe, 100° 2. H+	Bu3SnCH2CH=CHCO2Et (75)	457
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h	Bu3SnC6H4CF3 (61)	538
215		Pd[P(o-Tol)3]2Cl2 (3%), C6H6, reflux, 3 h	Bu3SnC6H4CH2CH2CH(C2H5)2 (86)	241
		1. Pd(PPh3)4, PhMe, 100° 2. H+	Bu3SnCH2CH=CHCO2Et (18)	457
		Pd(PPh3)4, C6H6, 110°	Bu3SnCH2CH=CHCO2Et (75)	305
		1. Pd(PPh3)4, C6H6, 110° 2. Bu4NF, THF	Bu3SnCH2CH=CHCO2Et (56)	532
		Pd(OAc)2 (5%), PPh3 (20%), C6H6, reflux, 1 d	Bu3SnCH2CH=CHCO2Et (60) E:Z = 1:3	306, 427
		Pd(PPh3)4 (2%), C6H6, 80°, 20 h	Bu3SnCH2CH=CHCH(OEt)2 (55) E:Z = 85:15	539
		Pd[P(o-Tol)3]2Cl2 (3%), C6H6, reflux, 3 h	Bu3SnC6H4CH2C7H15-n (62)	241
		1. Pd(PPh3)4 (2%), PhMe, reflux, 48 h 2. H+	Bu3SnCH2CH=CHN(TMS)2 (78)	462, 464, 540
		Pd[P(o-Tol)3]2Cl2, PhMe, 100°, 20 h	Bu3SnC6H4CH2C7H15-n (26) + p-MeOC6H4CO2C6H4CH2C7H15-n (10)	541

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

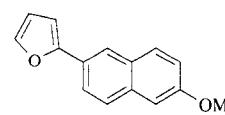
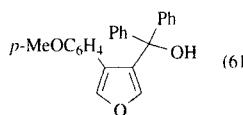
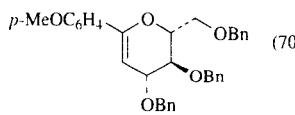
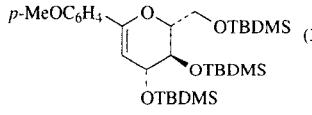
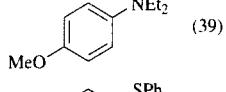
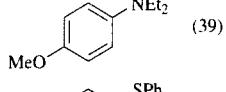
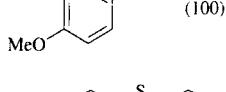
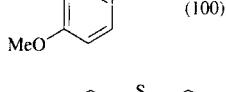
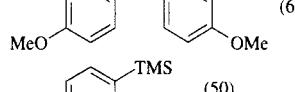
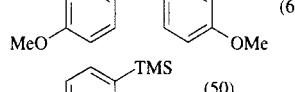
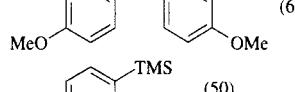
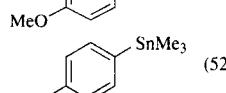
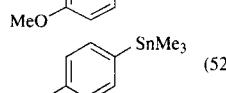
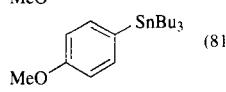
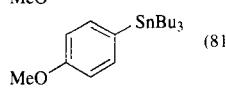
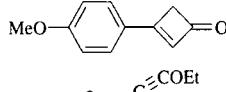
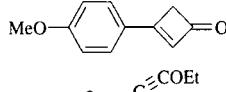
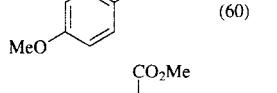
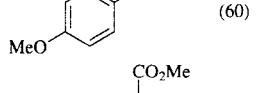
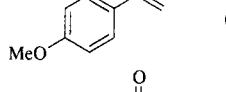
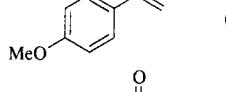
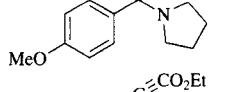
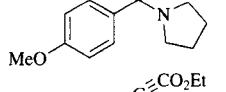
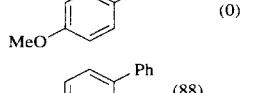
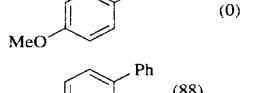
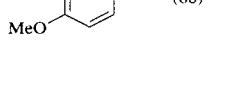
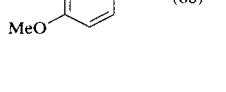
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 105°	 I (22) + II (55)	378
	"	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), AsPh <sub>3</sub> , DMF, 105°	I (25) + II (49)	378
	"	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> , DMF, 105°	I (6) +  III (60)	378
216		Pd(PPh <sub>3</sub> ) <sub>4</sub> (6%), DMF/HMPA (10:1), 70°, 24 h	 p-MeOC <sub>6</sub> H <sub>4</sub> Ph OH (61)	287
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux 3 h	 p-MeOC <sub>6</sub> H <sub>4</sub> O - CH(OBn) - CH(OBn) - (70)	423, 424
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, 2 h	 p-MeOC <sub>6</sub> H <sub>4</sub> O - CH(O-TBDMS) - CH(O-TBDMS) - OTBDMS (30)	299, 300
	Bu <sub>3</sub> SnNEt <sub>2</sub>	Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 3 h	 MeO -  NEt <sub>2</sub> (39)	90, 316
	Bu <sub>3</sub> SnSPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	 MeO -  SPh (100)	238
	Bu <sub>3</sub> SnSSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	 MeO -  S -  OMe (62)	316
	Me <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3%), PhMe, 115°, 15 h	 MeO -  TMS (50)	547
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, 120°, 40 h	 MeO -  SnMe <sub>3</sub> (52)	548
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1.3-5%), PhMe, 115°, 15 h	 MeO -  SnBu <sub>3</sub> (81)	547, 548
217		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.5%), CH <sub>3</sub> CN, rt, 5.75 h	 MeO -  C=COEt (52)	267
	Bu <sub>3</sub> SnC≡COEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, DMF, rt, 1.5 h	 MeO -  C≡COEt (60)	552
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (75%), DMF, rt, 48 h	 MeO -  C=C CO <sub>2</sub> Me (42)	246
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	 MeO -  C=O N (62)	437
	Bu <sub>3</sub> SnC≡CO <sub>2</sub> Et	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, ZnCl <sub>2</sub> , DMF, rt, 1.5 h	 MeO -  C≡CO <sub>2</sub> Et (0)	552
	Me <sub>3</sub> SnPh	Pd/C (0.5%), AsPh <sub>3</sub> (20%), CuI (10%), NMP, 100°, 21 min	 MeO -  Ph (88)	461, 33, 590

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (5%), PhMe, reflux	(72)	437
		Pd(PPh3)4 (5%), PhMe, reflux, 40-80 min	(83)	437
		Pd(PPh3)4 (5%), PhMe, reflux, 5 h	(33)	536
218		BnPd(PPh3)2Cl (5%), CuI (7-10%), DMF, rt	(72)	12
		BnPd(PPh3)2Cl (5%), CuI (7-10%), DMF, rt	(80)	12
		Pd/C (0.5%), AsPh3 (20%), CuI (10%), NMP, 80°, 12 h	(82)	461
		Pd2(dba)3 (2.5%), AsPh3 (20%), CuI (50%), DMF, 60°, 3-4 h	(30)	392
		Pd(PPh3)4 (0.7%), DMF, 110°, 3 h	(91)	554
219		Pd(PPh3)4, DMF, 110°, 3 h	(56)	289
		Pd(PPh3)4 (10%), DMF, 90°, 1.5 h	(75)	74
		Pd(PPh3)4 (4%)	(40)	392
		Pd2(dba)3 (5%), AsPh3 (10%), CuI (10%), DMF, 60°, 4 h	(63)	291
		Pd(OAc)2 (10%), AsPh3 (20%), CH3CN/THF (2:1), 40°, 8 h	(59)	301
		Pd(PPh3)4 (10%), LiCl, BHT, dioxane, reflux, 5 h	(71)	589
		Pd(PPh3)4 (1.3%), PhMe, 115°, 15 h	R = Me (96) R = Bu (53)	547, 312
		Pd(PPh3)2Cl2 (5%), LiCl, DMF, 25°, 6-18 h	(70)	203
		Pd(PPh3)2Cl2 (5%), LiCl, DMF, 25°, 6-18 h	(84)	189

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{Sn}\text{CH}_2=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), LiCl, BHT, dioxane, 98°, 6.5 h	(74)	189
	$\text{Bu}_3\text{Sn}\text{CH}_2=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_4$ (7.5%), LiCl, DMF, 90°, 30 h	(58)	29, 201
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_3-\text{N}$	$\text{Pd}(\text{OAc})_2$ , DMF, reflux	(40)	558
	$\text{Ph}_4\text{Sn}$	$\text{Pd}(\text{OAc})_2$ , DMF, reflux	(49)	558
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{O}$	$\text{Pd}(\text{OAc})_2$ (10%), $\text{P}(o\text{-Tol})_3$ (20%), $\text{NEt}_3$ , $\text{CH}_3\text{CN}$ , reflux	(35) + (12)	54
		$\text{Pd}(\text{PPh}_3)_4$ (10%), PhMe, reflux	(75)	423
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{O}$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (5%), CuI (7-10%), DMF, rt	(57)	12
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (5%), CuI (7-10%), DMF, rt	(57)	12
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{O}$	$\text{Pd}(\text{dba})_2$ , $\text{Bu}_4\text{NI}$ , DMF, 80°, 16 h	(55)	382
	$\text{Bu}_3\text{SnC}\equiv\text{CH}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), LiCl, BHT, dioxane, 98°, 4 h	(73)	189
	$\text{Bu}_3\text{SnCH}=\text{C}=\text{CH}_2$	$\text{Pd}_2(\text{dba})_3$ (2%), $\text{P}(2\text{-furyl})_3$ (8%), LiCl, CuI (10%), DMF, 80°, 2 h	(24)	276
	$\text{Me}_3\text{SnSnMe}_3$	$\text{Pd}(\text{PPh}_3)_4$ (2%), LiCl, BHT, dioxane, 98°, 4 h	(61) + (23)	189
	$\text{Me}_3\text{Sn}-\text{C}_6\text{H}_4-\text{O}$	$\text{PdCl}_2$ (5%), dioxane, 105°	(44)	471
	$\text{Cl}_3\text{SnPh}$	$\text{PdCl}_2$ (0.8%), KOH, $\text{H}_2\text{O}$ , 100°, 3 h	(88)	282
	$\text{Br}_3\text{SnMe}$	$\text{PdCl}_2$ (0.8%), KOH, $\text{H}_2\text{O}$ , 100°, 6 h $\text{PdCl}_2$ (1.6%), $\text{PPh}_2(\text{C}_6\text{H}_4\text{SO}_3\text{Na}-m)$ (6.4%), KOH, $\text{H}_2\text{O}$ , 100°, 3 h	(98)	282
	$\text{Cl}_3\text{Sn}-\text{CH}_2-\text{CO}_2\text{H}$		(71)	282
	$\text{Cl}_3\text{SnPh}$	$\text{PdCl}_2$ (0.8%), KOH, $\text{H}_2\text{O}$ , 25°, 2 h	(83)	282

TABLE III. DIRECT CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Cl <sub>3</sub> SnMe	PdCl <sub>2</sub> (0.5-3%), KOH, H <sub>2</sub> O, 90°	(82)	281
	Cl <sub>3</sub> Sn vinyl	PdCl <sub>2</sub> (0.5-3%), PPh(C <sub>6</sub> H <sub>4</sub> SO <sub>3</sub> Na- <i>m</i> ) <sub>2</sub> , KOH, H <sub>2</sub> O, 90°	(97)	281
	Cl <sub>3</sub> SnPr- <i>i</i>	PdCl <sub>2</sub> (0.5-3%), KOH, H <sub>2</sub> O, 90°	(<5)	281
	Cl <sub>3</sub> SnCH=CHCO <sub>2</sub> H	PdCl <sub>2</sub> (0.5-3%), PPh(C <sub>6</sub> H <sub>4</sub> SO <sub>3</sub> Na- <i>m</i> ) <sub>2</sub> , KOH, H <sub>2</sub> O, 90°	(76)	281
	Cl <sub>3</sub> SnBu- <i>n</i>	"	(78)	281
	Cl <sub>3</sub> SnPh	"	(95)	281
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CuI (8%), NMP, 70°, 48 h	(17)	575
	Me <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 15 h	(100)	550, 551
	Me <sub>3</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, DMF, 70°, 16 h	(23)	296
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-20%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	(62)	190, 201
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-20%), CuBr (20%), LiCl, DMF, reflux	(94)	191, 190
	Bu <sub>3</sub> SnC≡CR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 1.5-3.5 h	R = Pr- <i>n</i> (81) R = Pr- <i>i</i> (76) R = Bu- <i>n</i> (81) R = Ph (77)	591
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 90°, 25 h	(56)	591
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> , CuI	(32)	582
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, BHT, dioxane, reflux, 12 h	(80)	568
	Me-Sn	Pd(dppf)Cl <sub>2</sub> , PhMe, 105°, 30 h	(56)	41
	[OSnBu <sub>3</sub> ]	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	(71)	237, 240

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (Continued)

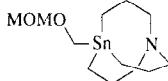
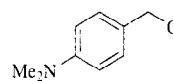
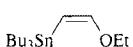
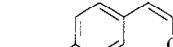
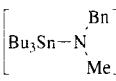
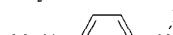
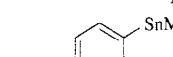
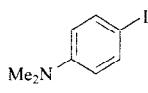
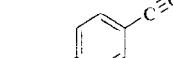
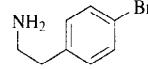
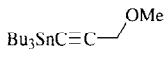
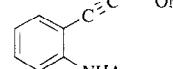
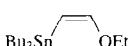
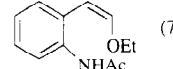
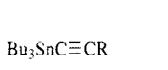
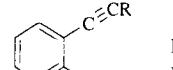
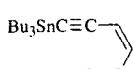
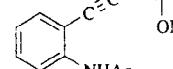
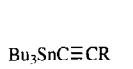
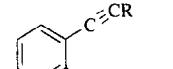
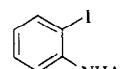
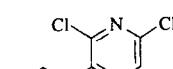
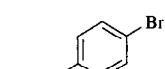
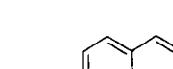
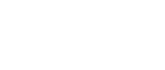
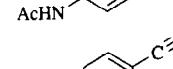
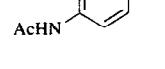
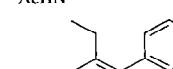
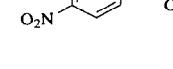
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.
		Pd(PPh3)4, PhMe, 105°, 3 h	 (80)	41
		Pd(PPh3)2Cl2, Et4NCl, DMF, 80°, 18 h	 (22)	272, 273
		Pd[P(o-Tol)3]2Cl2 (1%), PhMe, 100°, 3 h	 (36)	90, 316
		Pd[P(o-Tol)3]2Cl2 (2%), PhMe, 105°	 (81)	91
	Me3SnSnMe3	Pd(PPh3)4 (1.3%), PhMe, 115°, 15 h	 (0)	547
224		Pd(PPh3)2Cl2 (5%), Et4NCl, DMF, 50°, 12 h	 (0)	302
		Pd(PPh3)4 (1%), PhMe, 95°, 48 h	 (78)	592
		Pd(PPh3)4 (3%), PhMe, 100°, 3.5 h	 (60)	591
		Pd(PPh3)2Cl2 (1%), dioxane, 100°, 4 h	 (72)	273
		Pd(PPh3)4 (3%), PhMe, 100°, 2.5 h	 R = Pr-n (77) R = Pr-i (68)	591
		Pd(PPh3)4 (3%), PhMe, 100°, 4.5 h	 (51)	591
		Pd(PPh3)4 (3%), PhMe, 100°, 1.8-6 h	 R ————— TMS (88) Bu-n (84) Ph (94) CH2OTHP (76) (CH2)2OTBDMS (53)	591
225		Bu3SnC≡CR	 (81)	582
		Bu3SnC≡CR	 (73)	305, 532
		Bu3SnC≡COEt	 (71)	272, 273
		Bu3SnC≡COEt	 (0)	302
		Pd(PPh3)4 (5%), Et4NCl, DMF, 50°, 2 h	 (77)	575

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , CuI, dioxane, reflux	(81)	582
		Pd <sub>2</sub> (dba) <sub>3</sub> (2%), P(2-furyl) <sub>3</sub> (4%), LiCl, NMP, rt, 2 h	(90)	40
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 80°	(25)	310
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), air, HMPA, 65°	(95)	19
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 80°	(0)	233
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), BHT, PhMe, reflux, 4 h	(82)	88
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), <i>m</i> -xylene, 120°, 20 h	(tr)	235
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 80°, 20 h	(64)	234
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	(98)	3
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	(64)	240
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 12 h	(100)	550
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), ZnBr <sub>2</sub> , DMF, 80°, 5 h	(22)	236
227		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 20 h 2. H <sup>+</sup>	(89)	269
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 12 h	(90-93)	550, 551
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	(89)	538

TABLE III. DIRECT CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h	(98)	538
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h	(90)	538
		Pd(PPh3)4 (1%), C6H6, 115°, 15 h	(55) E:Z = 63:37	534
228		Pd[P(o-Tol)3]2Cl2 (3%), C6H6, reflux, 3 h	(70)	241
		Pd(PPh3)4 (5%), C6H6, reflux, 21 h	(60) E:Z = 1:3	306
		Pd(PPh3)4 (2%), C6H6, 80°, 20 h	(78)	539
		1. Pd(PPh3)4 (2%) PhMe, reflux, 48 h 2. H+	(30)	540
		Pd(PPh3)4, NEt3, CH3CN, 100°, 12 h	(≥81)	290
		Pd(PPh3)4 (0.7%), DMF, 90°, 24 h	(97)	289
		Pd(PPh3)4, 75°, 2 h	(61)	432
229		1. Pd(PPh3)4, PhMe, 100° 2. Br2, CCl4	(69)	279
		Pd(PPh3)4 (5%), HMPA, 80°, 20 h	(45)	287, 546
		Pd[P(o-Tol)3]2Cl2 (1%), PhMe, 100°, 3 h	(16)	90, 316
		Pd(PPh3)4 (1%), PhMe, 120°, 20 h	(67)	318

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
	$\text{Bu}_3\text{SnSSnBu}_3$	$\text{Pd}(\text{PPh}_3)_4$ (1%), $\text{PhMe}$ , $120^\circ$ , 20 h	(52)	318	
	$\text{R}_3\text{SnSnR}_3$	$\text{Pd}(\text{PPh}_3)_4$ (1.3%), $\text{PhMe}$ , $115^\circ$ , 15 h	R = Me (56) R = Bu (57)	547, 310	
230		$\text{Me}_3\text{Sn}\text{CH}_2=\text{CH}_2$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (2%), $\text{DMF}$ , $70^\circ$ , 10 min	(96)	553, 461
		$\text{Bu}_3\text{Sn}\text{CH}_2=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_4$ , $\text{THF}$ , $65^\circ$ , 1 h	(66)	264
		$\text{Bu}_3\text{Sn}\text{CH}_2=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_4$ (10%), $\text{CuI}$ (75%), $\text{DMF}$ , rt, 12 h	(78)	246
	$\text{Cl}_3\text{SnPh}$	$\text{PdCl}_2$ (0.8%), $\text{KOH}$ , $\text{PPh}_2(\text{C}_6\text{H}_4\text{SO}_3\text{Na}-m)$ (1.6%), $\text{H}_2\text{O}$ , $100^\circ$ , 3 h	I (80)	282	
	$\text{Me}_3\text{SnPh}$	$\text{PhPd}(\text{PPh}_3)_2\text{I}$ (2%), $\text{HMPA}$ , $70^\circ$ , 30 min	I (76) + Ph-Ph (24)	463	
231			$\text{Pd/C}$ (5%), $\text{CuI}$ (10%), $\text{AsPh}_3$ (20%), $\text{NMP}$ , $80^\circ$ , 24 h	(60)	461
	$\text{Me}_3\text{SnSnMe}_3$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (2%), $\text{DMF}$ , $20^\circ$ , 15 min	(95)	312	
	$\text{Bu}_3\text{SnSnBu}_3$	$\text{Pd}(\text{PPh}_3)_4$ (1%), $\text{PhMe}$ , $60^\circ$ , 72 h	(83)	311	
		$\text{Bu}_3\text{Sn}\text{CH}_2=\text{CH}_2$	$\text{Pd}(\text{dba})_2$ (5%), $\text{CH}_3\text{CN}$ , $\text{Et}_2\text{O}$ , rt, 1 h	(80) E:Z = 17:83	249
		$\text{Bu}_3\text{Sn}\text{CH}_2=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), $\text{LiCl}$ , $\text{DMF}$ , $25^\circ$ , 6-18 h	(70)	203
	$\text{Me}_4\text{Sn}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), $\text{LiCl}$ , $\text{BHT}$ , dioxane, $100^\circ$ , 16 h	(75)	189	
	$\text{Me}_4\text{Sn}$	$\text{Pd}_2(\text{dba})_3$ (1%), $\text{LiCl}$ , $\text{AsPh}_3$ (8%), $\text{NMP}$ , $60^\circ$	" (>95)	11	
		$\text{Bu}_3\text{Sn}\text{CH}_2=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_4$ (2%), $\text{BHT}$ , $\text{LiCl}$ , dioxane, $98^\circ$ , 4 h	I (95)	189
	"	$\text{Pd}_2(\text{dba})_3$ (1%), $\text{LiCl}$ , $\text{L}$ (8%), $\text{NMP}$ , $35^\circ$		11	
	"	$\text{L} = \text{PPh}_3$	I (>95)	11, 40	
	"	$\text{L} = \text{P}(2\text{-furyl})_3$	I (95)	11	
	"	$\text{L} = \text{AsPh}_3$	I (>95)	11	

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4, LiCl, THF, 65°, 1 h	(65)	264
		Pd2(dba)3 (2%), P(2-furyl)3 (8%), LiCl, CuI (8%), DMF, 80°, 1 h	(60)	276
		Pd(PPh3)4 (2%), LiCl, BHT, dioxane, 98°, 43 h	I (72) 1:3	189
232		Pd2(dba)3 (1%), P(2-furyl)3 (4%), LiCl, NMP, rt, 2 h	I (78)	11
		Pd(PPh3)4 (2%), LiCl, BHT, dioxane, 98°, 31 h	I + II + III (11) I:II:III = 65:20:15 II E:Z = 4:1 III IV (29)	189
		Pd2(dba)3 (1%), AsPh3 (12%), LiCl, NMP, 80°	I (>98)	30, 189
		Pd(PPh3)4 (2%), LiCl, BHT, dioxane, 98°, 65 h	I (83)	189
		Pd(PPh3)4 (2%), LiCl, BHT, dioxane, 98°, 23 h	I (85)	189
		Pd(PPh3)4 (2%), LiCl, BHT, DMF, 90°, 1 h	I (54) + II (16)	189
		Pd2(dba)3 (1%), LiCl, AsPh3 (8%), NMP, 80°	I (54) + II (21)	30
		Pd2(dba)3 (1%), LiCl, PPh3 (8%), dioxane, 65°, 40 h	I (81) + III (2)	189
233		Pd2(dba)3 (1%), AsPh3 (8%), NMP, 65°, 40 h	I (81) + III (1)	30
		Pd2(dba)3 (1%), LiCl, AsPh3 (8%), NMP, 65°, 40 h	I (92) + III (6)	30
		Pd2(dba)3 (1%), LiCl, AsPh3 (8%), NMP, 80°	I + II	30
			I (89) + II (9) I (72) + II (4) I (88) + II (10) I (92) + II (7) I (50) + II (24) I (76) + II (6) I (46) + II (27)	

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.
		Pd2(dba)3 (1%), LiCl, AsPh3 (8%), NMP, 65°	 (45) + (6)	30
		Pd(PhCN)2Cl2 (2%), AsPh3 (8%), CuI (5%), LiCl, NMP, 80°, 6 h	 (84)	33
		Pd(PPh3)4, NEt3, CH3CN/DMF (9:1), 100°, 3 h	 (≥75)	290
		Pd2(dba)3 (1%), LiCl, AsPh3 (8%), NMP, 65°	 (0) + (39)	30
		Pd2(dba)3·CHCl3 (4%), AsPh3 (30%), LiCl, THF, reflux, 6 h	 (66) + (3)	473
		Pd(PPh3)4 (2%), LiCl, BH-T, dioxane, 98°, 24 h	 (94)	189
		Pd(OAc)2 (5%), dppp (5.5%), LiCl, DMF, 90°, 24 h	 (90)	202
		"	 (86)	202
		Pd(OAc)2 (5%), dppp (5.5%), LiCl, DMF, 100°, 26 h	 (52) + (28)	202
		Pd(OAc)2 (5%), Ph2PMe (11%), LiCl, DMF, 120°, 48 h	 (67)	202
		Pd(OAc)2 (5%), dppp (5.5%), LiCl, DMF, 110°, 24 h	 (85)	202
		Pd(OAc)2 (5%), dppp (5.5%), LiCl, DMF, 100°, 20 h	 (69)	202
235		Pd(OAc)2 (5%), dppp (5.5%), LiCl, DMF, 90°, 24 h	 R / C6H4NO2-p (78)	202
		Pd(OAc)2 (5%), Ph2PMe (5.5%), LiCl, DMF, 110°, 88 h	 C6H2Me3-2,4,6 (53)	202
		Pd(OAc)2 (5%), dppp (5.5%), LiCl, DMF, 110°, 96 h	 EtO / OSO2C6H4(NMe2)-p (I) (34)	202
			 EtO / OSO2C6H4(NMe2)-p (I) (12) + (II) (13)	202

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(OAc) <sub>2</sub> , NEt <sub>3</sub> , CH <sub>3</sub> CN	(71)	54
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, 15 h	(48)	300
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.5%), THF, 65°, 2 h	(50)	267
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1-2%), PhMe, reflux	(72)	261
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1-2%), PhMe, reflux	(65)	261
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), THF, reflux, 20 h	(81)	286
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (7-10%), DMF, rt	(70)	12
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (7-10%), DMF, rt	(68)	12
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI (7-10%), DMF, rt	(68)	12
	Me <sub>3</sub> SnSnMe <sub>3</sub>	[( <i>n</i> <sup>3</sup> -C <sub>5</sub> H <sub>5</sub> )PdCl] <sub>2</sub> , CH <sub>2</sub> Cl <sub>2</sub> , 20°	(62)	557, 573
	Bu <sub>3</sub> SnCH=C=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), LiCl, P(2-furyl) <sub>3</sub> (8%), CuI (7%), DMF, 80°, 1.5 h	(71)	276
	Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> , DMF, reflux	(38)	558
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, reflux, 15 h	(89)	593
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h	(98)	538
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100° 2. H <sup>+</sup>	(42)	457
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100° 2. H <sup>+</sup>	(40)	457
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , C <sub>6</sub> H <sub>6</sub> , 110°	(71)	305

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		1. $\text{Pd}(\text{PPh}_3)_4$ , $\text{C}_6\text{H}_6$ , $110^\circ$ 2. $\text{Bu}_4\text{NF}$ , THF	(82)	532
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ , $\text{PhMe}$ , 15 h	(56)	299, 300
238			$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (0.5%), THF, reflux, 20 h (73)	286
		$\text{Pd}(\text{PPh}_3)_4$ (10%), $\text{CuI}$ (75%), DMF, rt, 12 h	(78)	246
		$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (2%), DMF, $70^\circ$ , 20 min	(98)	553
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (0.5%), THF, reflux, 20 h	(95)	286
	$\text{Bu}_3\text{SnC}\equiv\text{CCO}_2\text{Et}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (1%), $\text{Et}_4\text{NCl}$ , $\text{ZnCl}_2$ , $\text{C}_6\text{H}_6$ , rt, 48 h	(6)	552
	$\text{Me}_3\text{SnPh}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (2%), DMF, $20^\circ$ , 5 h	<b>I</b> (97)	553
	$\text{Me}_3\text{SnPh}$	$\text{PhPd}(\text{PPh}_3)_2\text{I}$ (2%), HMPA, $70^\circ$ , 30 min	<b>I</b> (74) + $\text{Ph-Ph}$ (21)	463
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ , DMF, heat	(56) (X = O) (61) (X = S)	584
	$\text{Me}_3\text{SnSnMe}_3$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (2%), DMF, $20^\circ$ , 15 min	(97)	312
	$\text{Bu}_3\text{SnSnBu}_3$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), PhMe, reflux, 55 min	<b>I</b> (75)	594
239	$\text{Bu}_3\text{SnSnBu}_3$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (2%), HMPA, $20^\circ$ , 10 min	<b>I</b> (92)	313
	$\text{Bu}_3\text{SnSnBu}_3$	$\text{NiBr}_2$ (10%), HMPA, $135^\circ$ , 7 h	<b>I</b> (72)	566
		$\text{Pd}_2(\text{dba})_3$ (5%), $\text{AsPh}_3$ (10%), DMF, $60^\circ$ , 4 h	(80)	291
		$\text{Pd}(\text{PPh}_3)_4$ (2%), LiCl, BHT, dioxane, $100^\circ$ , 3.5 h	(60)	433
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ , PhMe, 2 h	(40)	299, 300

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), BHT, PhMe, reflux, 8 h	 (62)	88
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), THF, reflux	 (65)	286
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (0) + (34)	190
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), dioxane, reflux, 4 h	 (68)	530
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), dioxane, 100°, 5 h	 (79)	530
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, 100°, 1 h	 (65)	299, 300
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (92)	190, 376
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (85)	190, 376
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (84)	190, 379
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (0) + (86)	190, 379
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (74)	190, 379
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-20%), PPh <sub>3</sub> (15-20%), LiCl, CuBr (20%), DMF, reflux	 (49)	191, 190
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (50)	190, 379
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF	 (55)	595
		PdCl <sub>2</sub> (0.8%), KOH, H <sub>2</sub> O, 100°, 3 h	 (98)	282

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd(OAc) <sub>2</sub> (10%), P(o-Tol) <sub>3</sub> (20%), Et <sub>3</sub> N, DMF, 70°, 50 h		(63) 596	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CuI (8%), NMP, 70°, 48 h		(33) 575	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), dioxane, 101°		(80) 471	
C <sub>9</sub>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, BHT, DMF, 60°, 7 h		(65) 189	
		Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h		(94) 240	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h		(58) 538	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h		(34) 318	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, 110°, 6 h		(55) 371	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 120°, 20 h		(3) 318	
243			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , BHT, DMF, 120°, 48 h		(40) 597
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , BHT, DMF, 90°, 15-19 h		R = cyclopentyl (8) R = cyclohexyl (34) 597	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 3.5 h		(65) 591	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , CuI		(21) 582	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 2 h		R = Bu-n (81) R = Ph (89) R = (CH <sub>2</sub> ) <sub>2</sub> OTBDMS (43) 591	

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 1.5 h	(71)	591
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 1.5 h	(52)	591
	Bu <sub>3</sub> SnC≡CR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 3 h	R = Bu- <i>n</i> (36) R = Ph (67)	591
	Bu <sub>3</sub> SnC≡CR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 2 h	R = Pr- <i>i</i> (80) R = Bu- <i>n</i> (84)	591
	Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 3 h	(96)	591
	Bu <sub>3</sub> SnCH=CH-OEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, Et <sub>4</sub> NCl, 80°, 18 h	(65)	272, 273
	Bu <sub>3</sub> SnC≡CR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°		591
	R	Time (h)		
	Pr- <i>n</i>	6	(60)	
	Pr- <i>i</i>	3.5	(57)	
	Bu- <i>n</i>	6	(62)	
	Ph	5	(76)	
	Bu <sub>3</sub> SnC≡COEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, DMF, 50°, 3 h	(62)	302
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 105°	(—)	583
	Bu <sub>3</sub> SnCH=CH-OEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), Et <sub>4</sub> NCl, DMF, 80°	(80)	273
	Bu <sub>3</sub> SnCH=CH-N(TMS) <sub>2</sub>	1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 72 h 2. H <sup>+</sup>	(66)	464, 540
	Bu <sub>3</sub> SnCH=CH-OEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , Et <sub>4</sub> NCl, DMF, 80°, 1 h	(73)	272, 273
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°	R = Ph (83) R = Bn (88)	91
	Bu <sub>3</sub> SnC≡CPh	Pd(dba) <sub>2</sub> (5%), CH <sub>3</sub> CN, Et <sub>2</sub> O, rt, 1 h	(97) E:Z = 7:93	249
	Bu <sub>3</sub> SnC≡COEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, DMF, rt, 5 h	(59)	302
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), P(2-furyl) <sub>3</sub> (8%), THF, rt, 2 d	(89)	425

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(dba) <sub>2</sub> (4%), P(2-furyl) <sub>3</sub> (8%), THF, 25°, 2 d		(82) 447
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux		(68) 425
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(43) 252, 598
246		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(46) 299, 300
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(18) 32
		Me <sub>4</sub> Sn		(96) 190, 379
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(90) 190, 379
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(98) 190, 376
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(79) 190, 376
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(93) 191, 190
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(56) 190
247		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		R = Me (26) R = Bu (13) 190
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(97) 190
		Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH(O-TBDMS)-C <sub>8</sub> H <sub>17-n</sub>		(87) 190

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)2Cl2 (10-20%), PPh3 (10-15%), LiCl, CuBr (20%), DMF, reflux	 (30)	191, 190
		Pd(OAc)2 (10%), P(o-Tol)3 (20%), Et3N, DMF, 70°, 50 h	 (65)	596
		Pd(PPh3)2Cl2 (10-15%), PPh3 (40%), LiCl, DMF, reflux	 (78)	190
		Pd(PPh3)2Cl2 (10-20%), P(o-Tol)3 (10-15%), LiCl, CuBr (20%), BHT, DMF, reflux	 (26)	191
		Pd(PPh3)4 (5%), CuI (8%), NMP, 70°, 48 h	 (21-31)	575
		Pd(PPh3)2Cl2 (10-15%), PPh3 (40%), LiCl, DMF, reflux	 (67)	190
		Pd(PPh3)2Cl2 (10-15%), PPh3 (40%), LiCl, DMF, reflux	 (41)	190
C <sub>10</sub>		Pd(PPh3)4 (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h	 (25)	550
		1. Pd(PPh3)4 (2%), PhMe, reflux, 120 h 2. H <sup>+</sup>	 (74)	464, 540
		BnPd(PPh3)2Cl (1%), HMPPA, 65°, 2 d	 (45)	537
		Pd(OAc)2 (5%), PPh3 (20%), C <sub>6</sub> H <sub>6</sub> , reflux, 1 d	 (50) E:Z = 1:10	306, 427
		Pd(PPh3)2Cl <sub>2</sub> , PhMe, 100°, 2 h	 (59)	299, 300

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
	Bu <sub>3</sub> SnNEt <sub>2</sub>	Pd[P(o-Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 3 h	(38)	90	
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 25°, 5 h		(94)	48
	Bu <sub>3</sub> Sn	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (10%), CuI (10%), DMF, 60°, 5 h		(92)	291
	Bu <sub>3</sub> Sn	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), DMF, rt, 6 h		(45)	439
	Et <sub>3</sub> SnSSnEt <sub>3</sub>	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (5%), DMSO, 100°, 4 h		(98)	320
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiCl, DMF, 25°, 6-18 h		(91)	203
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiCl, DMF, 25°, 6-18 h		(69)	203
	Bu <sub>3</sub> SnH	Pd(dba) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), LiCl, THF, 60°, 16 h		(78)	192
	Bu <sub>3</sub> Sn	Pd(dba) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), LiCl, THF, 60°, 16 h		(65)	192
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, BHT, DMF, 60°, 3 h		(82)	189
	Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, BHT, DMF, 60°, 6 h		(62)	189
	Me <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), LiCl, THF, 60°, 16 h		(68)	192
	Bu <sub>3</sub> SnC≡CPh	Pd(dba) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), LiCl, THF, 60°, 16 h		(75)	192
	Bu <sub>3</sub> Sn	Pd(dba) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), LiCl, THF, 60°, 16 h		(61)	192

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(OAc) <sub>2</sub> (5%), dppp (5.5%), LiCl, DMF, 100°, 30 h	(50)	202
		Ni(acac) <sub>2</sub> , PPh <sub>3</sub> , DIBAL, THF, 3.3 h	(80)	205
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 24 h	(92)	550
252		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 12 h	(90-95)	550, 551
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux, 18 h	(46)	371
R H CH=CH <sub>2</sub> 2-thienyl Ph (E)-CH=CHPh C=CPh	Bu <sub>3</sub> SnR	Pd(dba) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), LiCl, THF, 60°, 16 h	(75)	192
			(75)	
			(70)	
			(72)	
			(67)	
			(68)	
253		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, DMF, 100°, 6 h	(60) +  (10)	473
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (10%), DMF, 60°, 1.5 h	R = H (87) R = OMe (91)	291
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(dba) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), LiCl, THF, 60°, 16 h	(69)	192
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, 23 h	(48)	205
		Pd(PPh <sub>3</sub> ) <sub>4</sub> PhMe	(—)	599
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	(74-86)	599

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (74-86)	599
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (75)	599
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (74-86)	599
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (74-86)	599
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (74-86)	599
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (74-86)	599
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (74-86)	599
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (74-86)	599
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, reflux	 (74-86)	599
	Bu <sub>3</sub> Sn(OEt)CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 105°, 48 h	 (82)	270
	Bu <sub>3</sub> SnC≡CR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, dioxane, 100°	 (97)	591
	R	Time (h)		
	TMS	1	(97)	
	Pr- <i>n</i>	3	(73)	
	Pr- <i>i</i>	1.75	(77)	
	Bu- <i>n</i>	3	(88)	
	Ph	2	(84)	
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (92)	190, 379
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (47-67)	190, 379
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (0) +  (34)	190
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (63)	190, 379

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

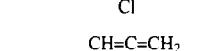
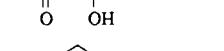
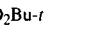
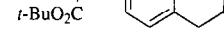
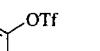
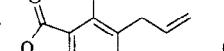
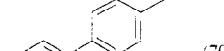
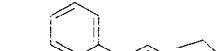
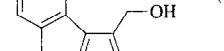
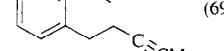
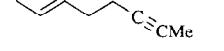
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (28)	190
	Bu <sub>3</sub> SnCH=C=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), P(2-furyl) <sub>3</sub> (8%), LiCl, CuI (10%), DMF, 80°, 1.5 h	 (60)	276
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 105°	 (—)	583
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), BHT, PhMe, reflux, 2 h	 (72)	88
	Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> N <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 100°, 12 h	 (73)	572
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (34)	190
	Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> N <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 90°, 6 h	 (70)	600
	Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> N <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 50°, 12 h	 (28-32)	572
	Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> N <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, 110°, 3 h	 (82)	371
	Me <sub>3</sub> SnCH=CH <sub>2</sub> Bu-n	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, THF, reflux	 (69)	601
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, THF, reflux	 (tr)	601
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 25°, 10 h	 (73)	48
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 25°, 10 h	 (71)	48

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (Continued)

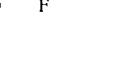
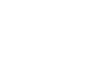
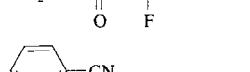
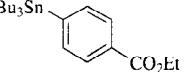
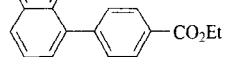
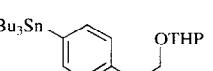
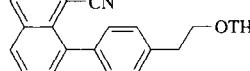
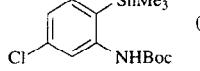
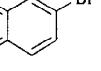
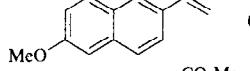
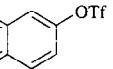
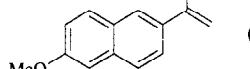
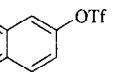
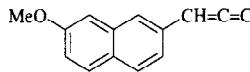
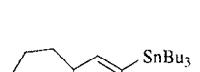
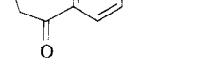
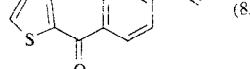
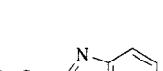
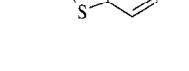
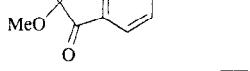
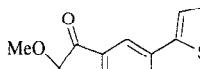
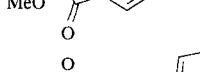
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (7%), dioxane, reflux, 16 h		(84)
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 100°, 18 h		(80)
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 100°, 22 h		(≥76)
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , NaH, NMP, reflux		(57)
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), BHT, PhMe, reflux, 1 h		(83)
	Bu <sub>3</sub> SnCO <sub>2</sub> Me	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (75%), LiCl, DMF, rt, 48 h		(71)
	Bu <sub>3</sub> SnCH=C=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), P(2-furyl) <sub>3</sub> (8%), LiCl, CuI (10%), DMF, 80°, 1.5 h		(67)
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 105°		(—)
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), BHT, PhMe, reflux, 1 h		(85)
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, heat		(81)
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, heat		(73)
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, heat		(91)
	Me <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux		(58)
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, 100°, 8 h		(87)

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>12</sub>	Bu <sub>3</sub> Sn—CH=CH—OTBDMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, 100°, 2 h	(88)	605
260		Me <sub>4</sub> Sn	(65)	206
		Bu <sub>3</sub> SnCH=C=CH <sub>2</sub>	(20)	276
		Bu <sub>3</sub> Sn—C(=O)F—OBu-t	(93)	296
		Me <sub>3</sub> Sn—C(=O)F—OH	(70)	371
	Bu <sub>3</sub> SnCH=C=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), P(2-furyl) <sub>3</sub> (8%), LiCl, CuI (8%), DMF, 80°, 5 h	(31)	276
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 110-120°, 4 h	(90)	606
261		Bu <sub>3</sub> Sn—C(=O)F—SEM	(97)	289
		Bu <sub>3</sub> Sn—C(=O)F—BocNH	(65)	564
		Me <sub>3</sub> Sn—C(=O)F—CO <sub>2</sub> Me	(46)	607
		Bu <sub>3</sub> Sn—C(=O)F	(50)	202
		Bu <sub>3</sub> Sn—C(=O)F—TMS	(74)	263
		Me <sub>4</sub> Sn	(49)	608
		Bu <sub>3</sub> Sn—C(=O)F	(74)	370

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

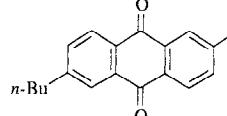
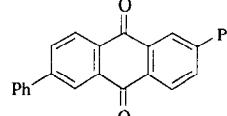
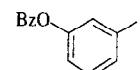
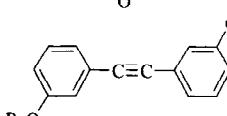
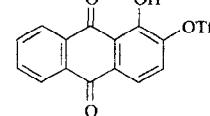
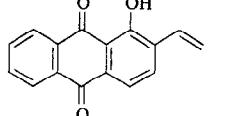
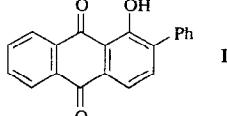
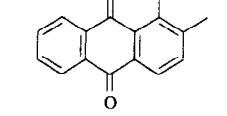
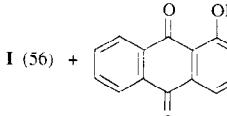
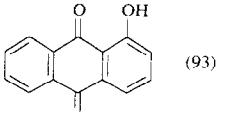
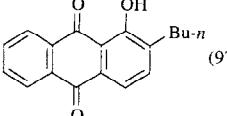
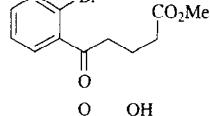
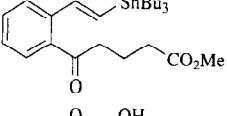
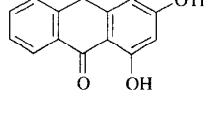
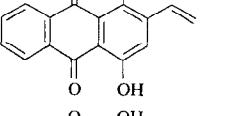
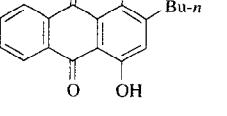
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
Bu <sub>4</sub> Sn		Pd(dppf)Cl <sub>2</sub> , LiCl, DMF, 90-95°, 2.5-4 h	 (63)	370
Me <sub>3</sub> SnPh		Pd(dppf)Cl <sub>2</sub> , LiCl, DMF, 90-95°, 2.5-4 h	 (67)	370
	Bu <sub>3</sub> SnC≡CSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiCl, BHT, dioxane, reflux, 5 h	 (28)	589
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(dppf)Cl <sub>2</sub> , LiCl, DMF, 90-95°, 2 h	 (70)	370
Me <sub>3</sub> SnPh		Pd(dppf)Cl <sub>2</sub> , LiCl, DMF, 90-95°, 2.5 h	 I (56) +  (28)	370
Bu <sub>3</sub> SnPh		Pd(dppf)Cl <sub>2</sub> , LiCl, DMF, 90-95°, 3 h	I (56) +  (14)	370
Bu <sub>3</sub> SnSnBu <sub>3</sub>		Pd(dppf)Cl <sub>2</sub> , LiCl, DMF, 90-95°, 17 h	 (93)	370
Bu <sub>4</sub> Sn		Pd(dppf)Cl <sub>2</sub> , LiCl, DMF, 90-95°, 20 h	 (97)	370
	Bu <sub>3</sub> SnCH=CHSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 100°	 (≥57)	500
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, 90-95°, 1 h	 (70)	370
Bu <sub>4</sub> Sn		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 90-95°, 2.5 h	 (74)	370

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, 90–95°, 8.5 h	 (100)	370
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, 90–95°, 17 h	 (80)	370
	Bu <sub>3</sub> Sn-CH=CH-Ph	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, 90–95°, 2 h	 (100)	370
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10–15%), PPh <sub>3</sub> (30–40%), LiCl, CuBr, DMF, reflux	 (93)	191
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10–15%), PPh <sub>3</sub> (30–40%), LiCl, CuBr, DMF, reflux	 (62)	191
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10–15%), AsPh <sub>3</sub> (30–40%), LiCl, CuBr, DMF, reflux	 (21)	191
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux	 (52)	89
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux	 (50)	89
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux	 (82)	89
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10–15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (0) (40)	190
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, DMF, rt, 4 h	 (78)	189
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, DMF, dioxane, 98°, 11 h	 (81)	189
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, DMF, dioxane, 98°, 12 h E:Z = 7:1	 (72) E:Z = 3:1	189

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (Continued)

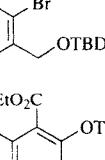
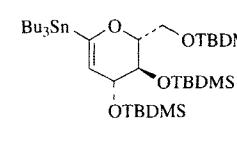
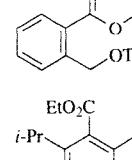
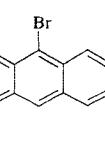
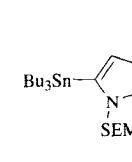
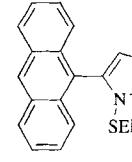
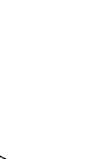
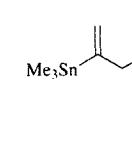
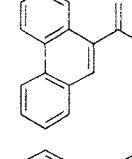
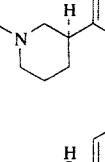
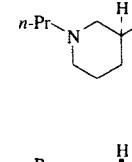
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , NEt <sub>3</sub> , reflux, 12 h	(44)	609
	Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PhMe, reflux, 1 h	 (44)	299, 300
	Bu <sub>3</sub> Sn 	Pd(OAc) <sub>2</sub> (5%), P(o-Tol) <sub>3</sub> , NEt <sub>3</sub> , CH <sub>3</sub> CN, reflux	 (33)	429
	Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 100°	 (>88)	610
	Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10-15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 (68)	190
	Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), DMF, 110°, 6 h	 (95)	289
	Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 80°, 8 h	(35)	287, 432
	Me <sub>3</sub> Sn 	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), HMPA, 65°, 3 d	(35)	537
	Me <sub>3</sub> Sn 	Pd(0), LiCl, DMF	(76)	611
	Bu <sub>3</sub> SnCN	Pd(PPh <sub>3</sub> ) <sub>4</sub> (150%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 80°, 24 h	(56)	612
	Bu <sub>3</sub> SnCN	Pd(PPh <sub>3</sub> ) <sub>4</sub> (150%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 80°, 24 h	(52)	612
	Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux, 36 h	 R = Me (—) R = OMe (73)	89

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		$\text{Me}_3\text{SnSnMe}_3$	$\text{PhPd}(\text{PPh}_3)_2\text{I}$ (1%), DMF, 50°, 2 h	 (52)	613
		$\text{Bu}_3\text{SnTMS}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (3.5%), HMPA, 80°, 5 h	 (36) (20) +	614
268		$\text{Me}_3\text{Sn}-\text{C}_6\text{H}_3(\text{R})-\text{S}-\text{C}_6\text{H}_3(\text{R})-\text{Cl}$ R: H or Me	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), THF, reflux, 4 h Time (h) 4 20	 (73) (82)	615
		$\text{Bu}_3\text{Sn}-\text{CH}_2=\text{CH}-\text{SnBu}_3$	$\text{Pd}(\text{PPh}_3)_4$ (2%), PhMe, reflux, 4 h		616
		$\text{Me}_3\text{SnSnMe}_3$	$\text{Pd}(\text{PPh}_3)_4$ (4.5%), dioxane, reflux, 6.5 h		617
		$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_3(\text{OMe})-\text{S}-\text{C}_6\text{H}_3(\text{OMe})-\text{N}=\text{O}$	$\text{Pd}_2(\text{dba})_3$ (2.5%), AsPh <sub>3</sub> (20%), dioxane, 50°, 24 h		569
269		$\text{Bu}_3\text{Sn}-\text{CH}_2=\text{CH}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), PhMe, reflux, 36 h	 R = CO <sub>2</sub> Me (60) R = OAc (57)	89
		$\text{Bu}_3\text{Sn}-\text{CH}_2=\text{CH}$	$\text{Pd}(\text{dppf})\text{Cl}_2$		370
		$\text{Bu}_4\text{Sn}$	$\text{Pd}(\text{dppf})\text{Cl}_2$		370
		$\text{Bu}_3\text{Sn}-\text{CH}_2=\text{CH}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ , LiCl, DMF, 70°		618

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4, LiCl, dioxane, 100°	 (91)	618
C16		Me4Sn	 (57)	619, 620
		Me4Sn	 (56)	619, 620
		Bu3SnPh	 (83)	619, 620
		Bu3SnPh	 (88)	619, 620
270		Bu3Sn-phenyl-F	 (>88)	610
		Bu3Sn-phenyl-F	 (82)	621
		Bu3Sn-alkene	 (93)	622
			 R = H, (18)  R = Cl, (42)  R = F, (26)	416
C17			 (28)	416
			 (34)	416
			 (23)	416
271				

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (16%), NEt <sub>3</sub> , DMF, 70°		416 (20)
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (16%), NEt <sub>3</sub> , DMF, 70°		416 (13)
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (16%), NEt <sub>3</sub> , DMF, 70°		416 (17)
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, 60°, 24 h		572 (47)
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), LiCl, dioxane, reflux, 4 h		623 (61)
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (10%), LiCl, NMP, 90-100°, 3 h		623 (19)
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), LiCl, NMP, 90-100°, 2 h		623 (44)
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 90°, 0.5 h		624 (85)
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (16%), NEt <sub>3</sub> , DMF, 70°		416 R = Me, (31) R = OMe, (19)
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, BHT, dioxane, 110°, 12 h		521, 625 (62-98)
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (7.5%), LiCl, DMF, 90°, 6 h		201 (89)

TABLE III. DIRECT CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

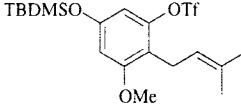
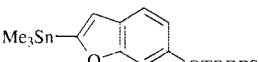
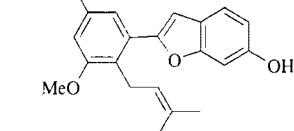
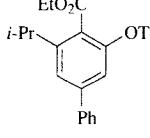
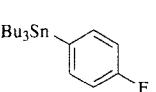
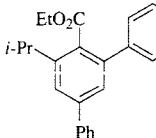
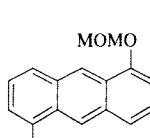
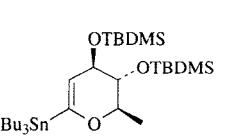
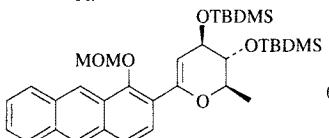
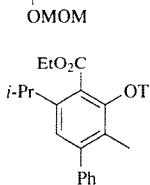
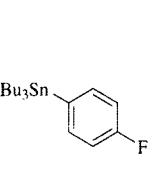
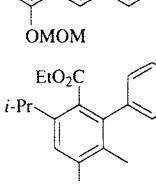
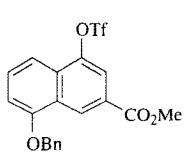
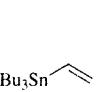
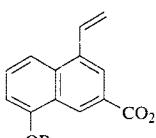
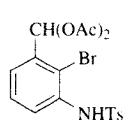
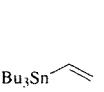
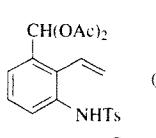
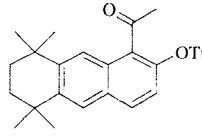
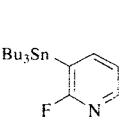
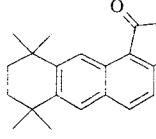
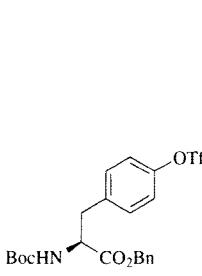
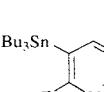
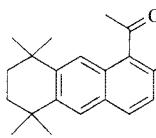
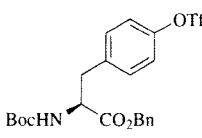
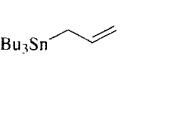
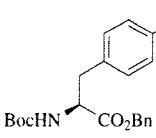
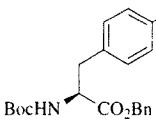
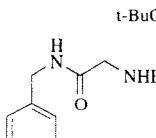
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
			1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), LiCl, dioxane, reflux, overnight 2. Bu <sub>4</sub> NF, THF	 (81)	392
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 100°	 (>88)	610
274			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 80°, 21 h	 (31)	389
C <sub>19</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 100°	 (60)	610
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl	 (80)	626
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, reflux, 36 h	 (86)	89
C <sub>20</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> (OAc) <sub>2</sub> (5%), LiCl, DMF, 90-100°, 3 h	 (27)	627
			Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), LiCl, NMP, 100°, 2 h	 (48)	628
275			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 90°, 0.5 h	 (87-92)	383
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 90°, 1 h	 (65)	383
C <sub>21</sub>				 (50)	629

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		$\text{Et}_4\text{Sn}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2, \text{LiCl}, \text{DMF}, 100^\circ$	 (>88)	610
		$\text{Bu}_3\text{SnCH}_2\text{CH}_3$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2, \text{LiCl}, \text{DMF}, 85^\circ, 1.5 \text{ h}$	 (90)	610
276		$\text{Me}_3\text{SnH}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2, \text{DMF}, 140^\circ$	 (75)	630
		$\text{Me}_3\text{SnSnMe}_3$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2, (3\%), \text{dioxane, reflux, 2 h}$	 (100)	631
		$\text{Bu}_3\text{SnC}_6\text{H}_4\text{OBn}_2$	$\text{Pd}(\text{PPh}_3)_4 (10\%), \text{Na}_2\text{CO}_3, \text{PhMe, reflux, 4 h}$	 (70)	423, 424
		$\text{Bu}_3\text{SnC}_6\text{H}_4\text{OBn}_2$	$\text{Pd}(\text{PPh}_3)_4 (10\%), \text{Na}_2\text{CO}_3, \text{PhMe, reflux, 3 h}$	 (78)	297
		$\text{Bu}_3\text{SnC}_6\text{H}_4\text{OBn}_2$	$\text{Pd}(\text{PPh}_3)_4 (10\%), \text{PhMe, reflux}$	 (73)	423, 424
C <sub>22</sub>		$\text{Bu}_3\text{SnC}_6\text{H}_4\text{O}i\text{-Pr}$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}, \text{CuI, CH}_3\text{CN, }70^\circ$	 (71)	632
277		$\text{Bu}_3\text{SnCH}_2\text{CH}_2\text{CO}_2\text{Et}$	$\text{Pd}(\text{OAc})_2 (10\%), \text{NMP, rt, 40 h}$	 (79)	633
C <sub>23</sub>		$\text{Bu}_3\text{SnC}_6\text{H}_4\text{OBn}_2$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2 (5\%), \text{PhMe, reflux}$	 (85)	299
		$\text{Bu}_3\text{SnC}_6\text{H}_4\text{OBn}_2$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2 (2.5\%), \text{C}_6\text{H}_6, \text{reflux, 15 h}$	 (85)	300
C <sub>24</sub>		$\text{Bu}_3\text{SnCH}_2\text{CH}_3$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2, \text{dioxane}$	 (—)	634

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

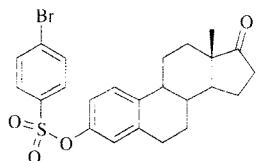
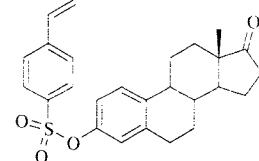
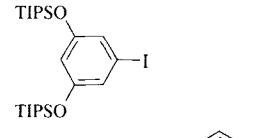
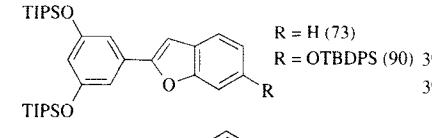
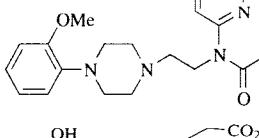
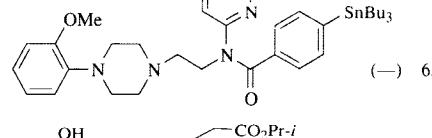
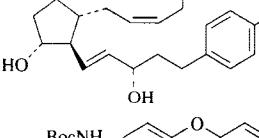
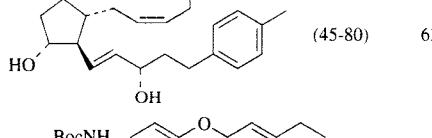
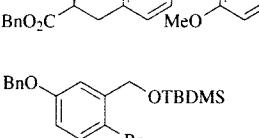
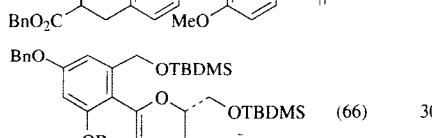
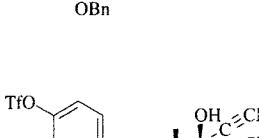
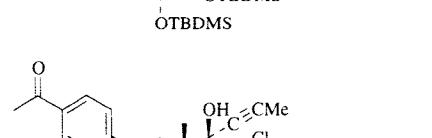
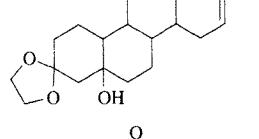
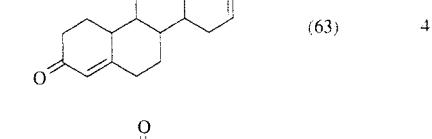
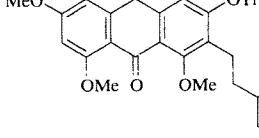
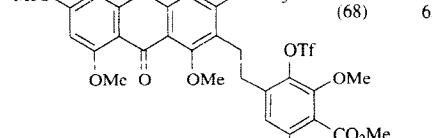
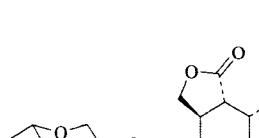
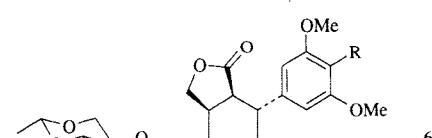
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
		$\text{Bu}_3\text{SnCH=CH}_2$	Pd( $\text{PPh}_3$ ) <sub>4</sub> (10%), LiCl, BHT, dioxane, 110°, 12 h	 (—)	625
		$\text{Me}_3\text{Sn}-\text{C}_6\text{H}_4-\text{O}-\text{C}_6\text{H}_3(\text{R})_2$	Pd( $\text{PPh}_3$ ) <sub>4</sub> (4%), THF, reflux, 16 h		392, 391
278		$\text{Bu}_3\text{SnSnBu}_3$	Pd( $\text{PPh}_3$ ) <sub>4</sub>	 (—)	635
		$\text{Me}_4\text{Sn}$	Pd( $\text{OAc}$ ) <sub>2</sub> , P( <i>o</i> -Tol) <sub>3</sub> , NEt <sub>3</sub> , DMF, 100°, 8 h	 (45-80)	636
		$\text{Bu}_3\text{SnCH=CH}_2$	Pd( $\text{PPh}_3$ ) <sub>4</sub> (2%), LiCl, dioxane, reflux, 12 h	 (80)	637
		$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{O}-\text{C}_6\text{H}_3(\text{OTBDMS})_2$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (2.5%), mesitylene, reflux, 30 min	 (66)	300
279		$\text{Bu}_3\text{SnCH(OEt)}=\text{CH}_2$	1. Pd( $\text{PPh}_3$ ) <sub>4</sub> (5%), LiCl, pyridine, dioxane, reflux, 2 h 2. H <sup>+</sup> , acetone	 (63)	419
		$\text{Me}_3\text{SnSnMe}_3$	Pd( $\text{PPh}_3$ ) <sub>4</sub>	 (68)	638
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (15%), $\text{PPh}_3$ (40%), LiCl, DMF, reflux	 R Me (83) $\text{CH}=\text{CH}_2$ (48) $\text{CH}_2\text{CH}=\text{CH}_2$ (63)	639	

TABLE III. DIRECT CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.																					
C <sub>31-32</sub> 280		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , C <sub>6</sub> H <sub>6</sub>	 n = 3 (20) n = 4 (19)	640																					
C <sub>32</sub>		Bu <sub>3</sub> SnCH=CH <sub>2</sub> Bu <sub>3</sub> SnCH <sub>2</sub> CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (15%), PPh <sub>3</sub> (40%), LiCl, DMF, reflux	 R = CH=CH <sub>2</sub> (49) R = CH <sub>2</sub> CH=CH <sub>2</sub> (70)	639																					
C <sub>37</sub>		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, BHT, dioxane, 90°, 1 h	 (86)	641																					
C <sub>47</sub> 281		Bu <sub>3</sub> SnC≡CR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (14%), LiCl, THF, 90°, 2 d	 <table border="1"><tr><th>OTf</th><th>R</th><th>Yield (%)</th></tr><tr><td>m</td><td>TMS</td><td>(74)</td></tr><tr><td>m</td><td>Bu-n</td><td>(76)</td></tr><tr><td>m</td><td>Ph</td><td>(72)</td></tr><tr><td>p</td><td>TMS</td><td>(76)</td></tr><tr><td>p</td><td>Bu-n</td><td>(76)</td></tr><tr><td>p</td><td>Ph</td><td>(73)</td></tr></table>	OTf	R	Yield (%)	m	TMS	(74)	m	Bu-n	(76)	m	Ph	(72)	p	TMS	(76)	p	Bu-n	(76)	p	Ph	(73)	642
OTf	R	Yield (%)																								
m	TMS	(74)																								
m	Bu-n	(76)																								
m	Ph	(72)																								
p	TMS	(76)																								
p	Bu-n	(76)																								
p	Ph	(73)																								

TABLE III. DIRECT CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
282		$\text{Bu}_3\text{SnC}\equiv\text{CTMS}$	$\text{Pd}(\text{PPh}_3)_4$ (14%), $\text{LiCl}$ , THF, 90°, 2 d	(75)	642
C <sub>53</sub>		$\text{Bu}_3\text{SnCH}_2\text{CH}_2\text{CH}_2\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), dioxane, 90°, 6 h	(85)	643

TABLE IV. INTRAMOLECULAR CROSS-COUPLING OF ARYL ELECTROPHILES

	Substrate	Conditions	Product(s) and Yield(s) (%)	Refs.	
C <sub>11</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (4.9%), THF, reflux, 20 h		(61)	644
C <sub>12</sub>		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), PhMe, 110°, 18 h		(90)	645
283		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), syringe pump, PhMe, 105°, 5.5 h		(65)	646
C <sub>14</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5-20%), dioxane, 100-105°, 24 h		(97) (87)	647
		Pd(PPh <sub>3</sub> ) <sub>4</sub>		I (78)	647
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5-20%), dioxane, 100-105°, 24 h		I (82)	647

TABLE IV. INTRAMOLECULAR CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

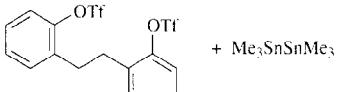
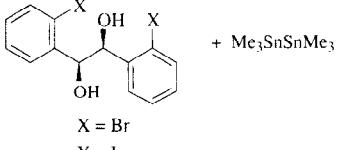
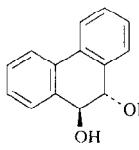
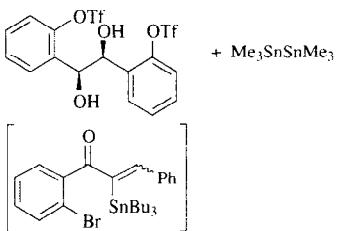
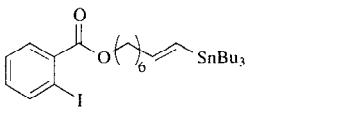
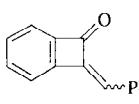
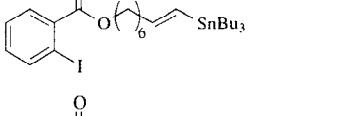
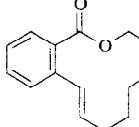
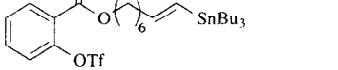
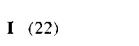
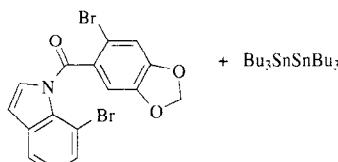
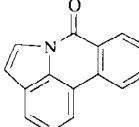
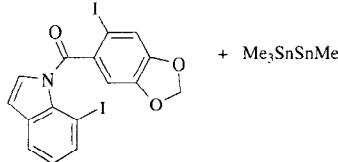
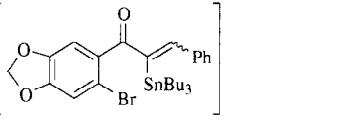
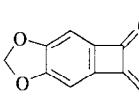
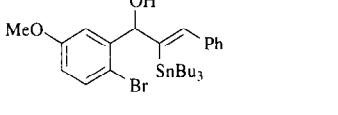
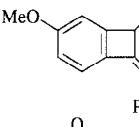
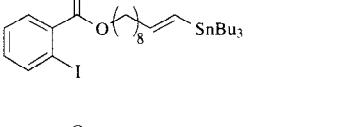
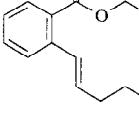
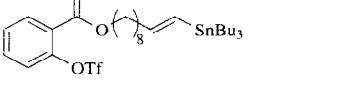
	Substrate	Conditions	Product(s) and Yield(s) (%)	Ref(s.)
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5-20%), dioxane, LiCl, 100-105°, 24 h	<b>I</b> (95)	647
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5-20%), dioxane, 100-105°, 24 h	 <b>I</b> <b>I</b> (80) <b>I</b> (87)	647
284		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5-20%), dioxane, LiCl, 100-105°, 24 h	<b>I</b> (88)	647
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2.2%), PPh <sub>3</sub> (8.8%), PhMe, reflux, 2 h	 (70) E:Z = 1.5:1	648
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), syringe pump, PhMe, 105°, 5.5 h	 <b>I</b> (37)	646
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2-3%), LiCl, DMF, 60°, 69 h	 <b>I</b> (22)	646
C <sub>16</sub>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, Li <sub>2</sub> CO <sub>3</sub> , PhMe, reflux, 12 h	 <b>I</b> (68)	563
		Pd(0), xylene, 140°, 24 h	<b>I</b> (60)	645
285		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2.2%), PPh <sub>3</sub> (8.8%), PhMe, reflux, 2 h	 (58) E:Z=1.1:1	648
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), 2,6-di-tert-butylphenol, PhMe, reflux, 4.5 h	 (45)	648
C <sub>17</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), syringe pump, PhMe, 105°, 5.5 h	 <b>I</b> (67)	646
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2-3%), LiCl, DMF, 70°, 72 h	<b>I</b> (<5)	646

TABLE IV. INTRAMOLECULAR CROSS-CO尤LING OF ARYL ELECTROPHILES (*Continued*)

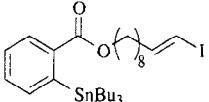
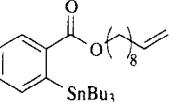
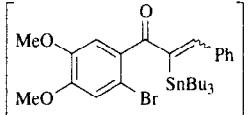
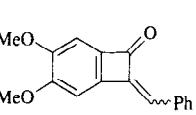
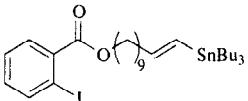
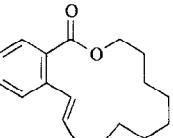
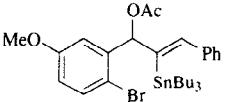
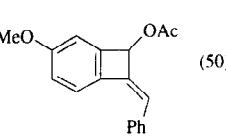
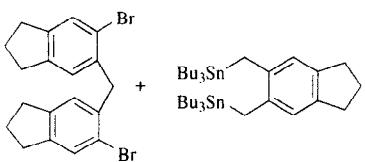
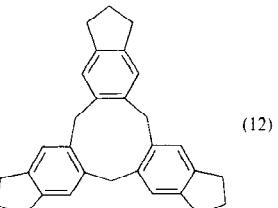
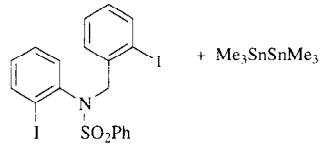
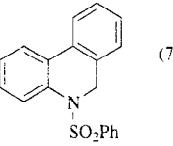
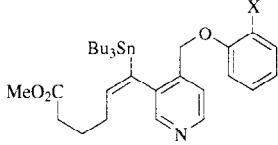
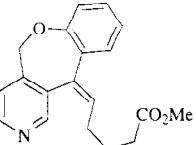
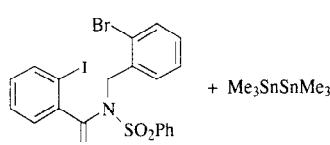
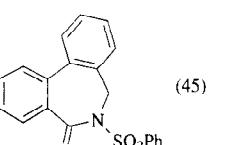
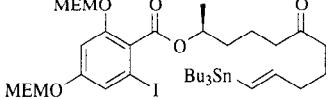
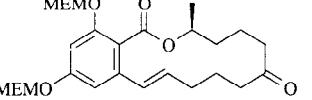
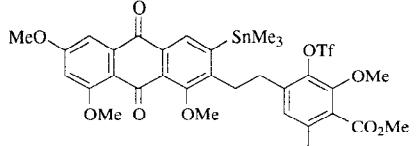
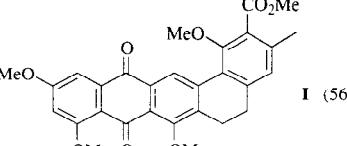
	Substrate	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>18</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 110°	 (87)	646
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2.2%), PPh <sub>3</sub> (8.8%), PhMe, reflux, 2 h	 (49) E:Z=1.5:1	648
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), syringe pump, PhMe, 105°, 5.5 h	 (66)	646
C <sub>19</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), BHT, PhMe, reflux, 4.5 h	 (50)	648
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, air, HMPA, 115°	 (12)	649
C <sub>20</sub>		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), PhMe, 110°, 18 h	 (77)	645
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 24 h Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , LiCl, DMF	 (43)  (53)	650 650
		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), PhOMe, 120°, 18 h	 (45)	645
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , syringe pump, PhMe, 105°, 14 h Polymer complexed Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 105°, 61 h	 I (39)  I (54)	646 646
C <sub>29</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub>	 I (56)	638

TABLE IV. INTRAMOLECULAR CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

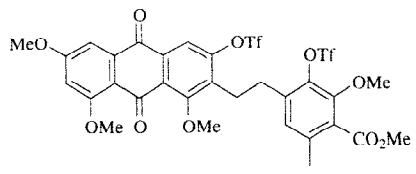
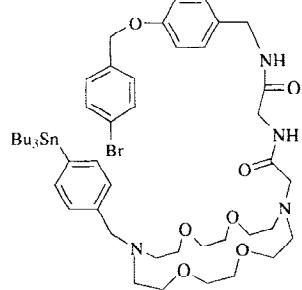
	Substrate	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>37</sub> 288	 <p>+ Me<sub>3</sub>SnSnMe<sub>3</sub></p>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (15%), 100°, 7 d	I (44)	638
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5-10%), K <sub>2</sub> CO <sub>3</sub> , DMF, reflux	(15)	629

TABLE V. DIRECT CROSS-COUPING OF FURAN AND BENZOFURAN ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>4</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 4.5 h	 (89)	651
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	 (84)	437
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , 80°, 18 h	 (80)	550, 551
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 10 h	 (72)	651
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	 (48)	100
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux, 5 h	 (50)	560, 561
C <sub>5</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 80°, 3 h	 (82)	458

TABLE V. DIRECT CROSS-COUPING OF FURAN AND BENZOFURAN ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>7</sub>		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 4.5 h	OHC-furan-2-yl-2-(2-methylthiophenyl) (100)	651
		Cl <sub>3</sub> SnPh	PdCl <sub>2</sub> , PPh(C <sub>6</sub> H <sub>4</sub> SO <sub>3</sub> Na- <i>m</i> ) <sub>2</sub> , aq. KOH, 90°	HO <sub>2</sub> C-furan-2-yl-2-phenyl (96)	281
		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 4 h	AcO-furan-2-yl-2-(2-methylthiophenyl) (82)	651
C <sub>11</sub>		Bu <sub>3</sub> Sn 		n-C <sub>8</sub> H <sub>17</sub> -furan-2-yl-2-(2-methylthiophenyl) (50)	652
		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, 50-60°, 2.5 h	HO <sub>2</sub> C-furan-2-yl-2-(2-methylthiophenyl) (50)	652
290		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, 50-60°, 2.5 h	HO <sub>2</sub> C-furan-2-yl-2-(2-methylthiophenyl) (50)	652
		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, 50-60°, 2.5 h	HO <sub>2</sub> C-furan-2-yl-2-(2-methylthiophenyl) (50)	652
		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, reflux, 3 h	HO <sub>2</sub> C-furan-2-yl-2-(2-methylthiophenyl) (97)	653
C <sub>13</sub>		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, reflux, 3 h	HO <sub>2</sub> C-furan-2-yl-2-(2-methylthiophenyl) (97)	653
		Bu <sub>3</sub> Sn 	Pd(0)	n-C <sub>5</sub> H <sub>11</sub> -furan-2-yl-2-(2-methylthiophenyl) (80)	654
C <sub>22</sub>		Bu <sub>3</sub> Sn 	Pd(0)	n-C <sub>5</sub> H <sub>11</sub> -furan-2-yl-2-(2-methylthiophenyl) (75)	654
		Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(OAc) <sub>2</sub> (10%), NEt <sub>3</sub> , 100°, 2.5 h	SnBu <sub>3</sub> -furan-2-yl-2-(2-methylthiophenyl) (43)	653
C <sub>23</sub>		Bu <sub>3</sub> Sn 	Pd(OAc) <sub>2</sub> (10%), NEt <sub>3</sub> , 100°, 2.5 h	SnBu <sub>3</sub> -furan-2-yl-2-(2-methylthiophenyl) (43)	653
		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiCl, DMF, 105°, 24 h	SnBu <sub>3</sub> -furan-2-yl-2-(2-methylthiophenyl) (65)	655
C <sub>24</sub>		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiCl, DMF, 105°, 24 h	SnBu <sub>3</sub> -furan-2-yl-2-(2-methylthiophenyl) (65)	655
		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.8%), LiCl, DMF, 100°, 2 h	SnBu <sub>3</sub> -furan-2-yl-2-(2-methylthiophenyl) (98)	656
291		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.8%), LiCl, DMF, 100°, 2 h	SnBu <sub>3</sub> -furan-2-yl-2-(2-methylthiophenyl) (98)	656
		Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, 100°, 48 h	TBDPSO-furan-2-yl-2-(2-methylthiophenyl) R-Me (14)	657, 658
		Bu <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), DMF, 60°, 1 h	TBDPSO-furan-2-yl-2-(2-methylthiophenyl) R-CH=CH (37)	657, 658
C <sub>25</sub>		Ph <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, 100°, 24 h	TBDPSO-furan-2-yl-2-(2-methylthiophenyl) R-Ph (39)	657, 658
		Ph <sub>4</sub> Sn			

TABLE V. DIRECT CROSS-COUPLING OF FURAN AND BENZOFURAN ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>26</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), DMF, 70°, 2 h Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 100°, 18 h		658
292			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), DMF, 70°, 2 h Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 100°, 18 h Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, 100°, 24 h		658

TABLE VI. DIRECT CROSS-COUPLING OF PYRROLE AND INDOLE ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
C <sub>8</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.7%), DMF, 70°, 16 h		(60)	296
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°		(65)	289
C <sub>9</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , aq. Na <sub>2</sub> CO <sub>3</sub> , reflux, 2 d		(50)	659
		Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> , Bu <sub>4</sub> NCl		(39)	109
			Pd(OAc) <sub>2</sub> , Bu <sub>4</sub> NCl		(67)	109
			Pd(OAc) <sub>2</sub> , Bu <sub>4</sub> NCl		(5)	109
			Pd(OAc) <sub>2</sub> , Bu <sub>4</sub> NCl		(38)	109
			Pd(OAc) <sub>2</sub> , Bu <sub>4</sub> NCl		(87)	109

TABLE VI. DIRECT CROSS-CO尤LING OF PYRROLE AND INDOLE ELECTROPHILES (Continued)

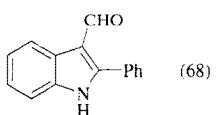
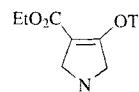
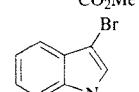
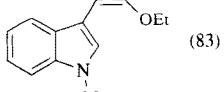
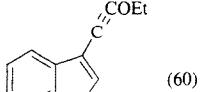
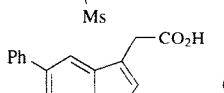
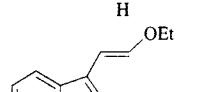
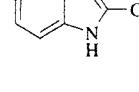
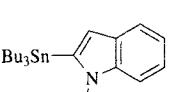
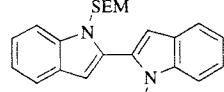
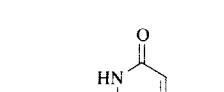
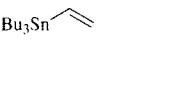
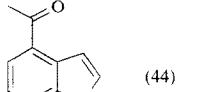
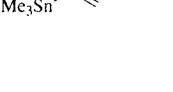
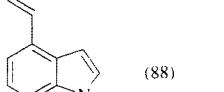
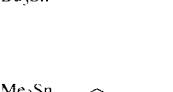
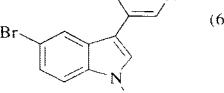
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.		
	Ph <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> , Bu <sub>4</sub> NCl	 (68)	109		
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), THF, reflux, 3 h	 (70)	660		
	Bu <sub>3</sub> SnCH=OEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%) Et <sub>4</sub> NCl, DMF, 80°, 9 h	 (83)	272, 273		
294	C <sub>10</sub>	Bu <sub>3</sub> SnC≡COEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, DMF, 50°, 2 h	 (60)	302	
	C <sub>11</sub>	Cl <sub>3</sub> SnPh	PdCl <sub>2</sub> , KOH, PPh( <i>m</i> -C <sub>6</sub> H <sub>4</sub> SO <sub>3</sub> Na) <sub>2</sub> , 90°	 (79)	281	
	C <sub>14</sub>	Bu <sub>3</sub> SnCH=OEt	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%) Et <sub>4</sub> NCl, DMF, 80°, 18 h	 (65)	273	
	C <sub>15</sub>		Bu <sub>3</sub> Sn- 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°	 (96)	289
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (20%), DMF, 80°, 1 h		170	
295	C <sub>15</sub>		Bu <sub>3</sub> SnCH=	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, reflux, 24 h	 (86)	89
			1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, dioxane, 95°, 18 h 2. H <sub>3</sub> O <sup>+</sup>	 (44)	89, 270	
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, reflux, 24 h	 (88)	89	
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 120°, 24 h	 (62)	110	

TABLE VI. DIRECT CROSS-COUPING OF PYRROLE AND INDOLE ELECTROPHILES (*Continued*)

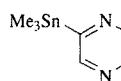
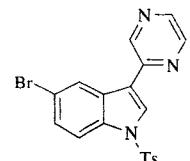
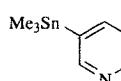
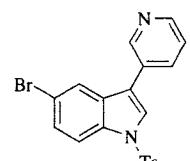
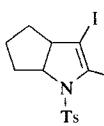
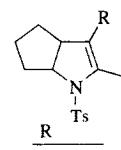
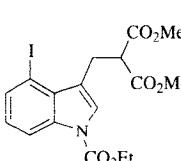
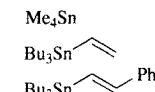
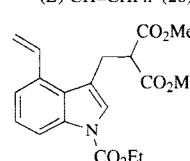
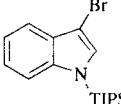
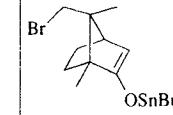
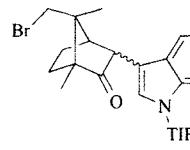
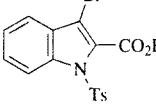
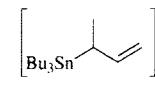
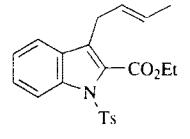
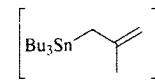
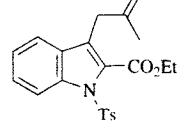
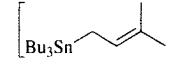
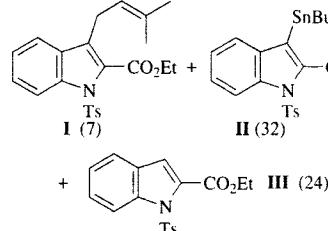
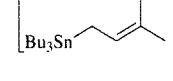
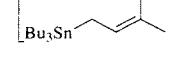
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 120°, 24 h	 (56)	110
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 120°, 24 h	 (55)	110
		Pd(OAc) <sub>2</sub> , P( <i>o</i> -tolyl) <sub>3</sub> , <i>n</i> -Bu <sub>3</sub> N, 100°, 24 h	 R = Me, CH=CH <sub>2</sub> , (E)-CH=CHPh	661 (17) (36) (26)
		Pd(OAc) <sub>2</sub> (0.9%), THF, 85°, 15 h	 (87)	662
		Pd[P( <i>o</i> -Tol) <sub>3</sub> ] <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 5 h	 (51) <i>endo:exo</i> >9:1	663
		Pd(dppf)Cl <sub>2</sub> , DMF, 120°, 90 min	 (59)	664
		Pd(dppf)Cl <sub>2</sub> , DMF, 120°, 80 min	 (93)	664
		Pd(dppf)Cl <sub>2</sub> , DMF, 120°, 150 min	 I (7) + II (32) + III (24)	664
		Pd(dppf)Cl <sub>2</sub> , DMF, 120°, 100 min	I (35) + II (13) + III (15)	664
		Pd(dppf)Cl <sub>2</sub> , NaOAc, DMF, 120°, 30 min	I (54)	664

TABLE VI. DIRECT CROSS-COUPLING OF PYRROLE AND INDOLE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd(dppf)Cl <sub>2</sub> , NaOAc, DMF, 120°, 100 min	(60)	664	
		Pd(dppf)Cl <sub>2</sub> , DMF, 120°, 100 min	I (72)	664	
		Pd(dppf)Cl <sub>2</sub> , DMF, 120°, 110 min	(43)	664	
		Pd(dppf)Cl <sub>2</sub> , DMF, 120°, 35 min	(52) +  (38)	664	
		Pd(dppf)Cl <sub>2</sub> , DMF, 120°, 150 min	(73)	664	
C <sub>19</sub>		Bu <sub>3</sub> SnPh	1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, 94°, 38 h 2. 150°, 6 h	(63)	665
C <sub>23</sub>		Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°	(94)	289
C <sub>25</sub>		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), PhMe, reflux, 7 h	(85)	666
299			Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), C <sub>6</sub> H <sub>6</sub> , aq. Na <sub>2</sub> CO <sub>3</sub> , reflux, 2 d	(—)	659
C <sub>27</sub>	$\frac{n}{3}$			(—)	
C <sub>45</sub>	5			(—)	
C <sub>63</sub>	7			(—)	

TABLE VII. DIRECT CROSS-COUPLING OF THIOPHENE AND BENZOTHIOPHENE ELECTROPHILES

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), PhMe, 110°, 24 h	 (70)	462
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Et <sub>4</sub> NCl, DMF, 80°, 2.5 h	 (68)	272, 273
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , 80°, 12 h	 (70)	550
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, reflux, 10 h	 (71)	651
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux	 (57)	437
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux, 3 h	 (62)	536
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%) PhMe, reflux, 48 h 2. HCl (1 N)	 (82)	461, 540
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°	 (88)	289
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 90°, 4 h	 (89)	74
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), THF, reflux, 20 h	 (6)	667
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 25°	 (84)	47
		Pd <sub>2</sub> (dba) <sub>3</sub> (3%), PPh <sub>3</sub> (24%), DMF, rt, 20 h	 (42)	275
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.5%), CH <sub>3</sub> CN, rt, 2 h	 (52)	267
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, DMF, rt, 5 h	 (47)	302
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, reflux	 (58)	261
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 60°, 16 h	 (80)	103
		PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), HMPA, 70°, 30 min	 <b>I</b> (94)	463
		Pd/C (0.5%), CuI (10%), AsPh <sub>3</sub> (20%), NMP, 80°, 16 h	 <b>I</b> (77)	461

TABLE VII. DIRECT CROSS-CO尤LING OF THIOPHENE AND BENZOTHIOPHENE ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux		437
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI, DMF, rt		12
302		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CuI, DMF, rt		12
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), P(2-furyl) <sub>3</sub> (40%), THF, 65°		375
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°		375
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), CuI, AsPh <sub>3</sub> , DMF, 60°		554
		Pd(OAc) <sub>2</sub> , CuI, PPh <sub>3</sub> , DMF, rt, 23 h		435
		Pd <sub>2</sub> (dba) <sub>3</sub> (2%), DMF, rt		439
		Pd(OAc) <sub>2</sub> , P(2-furyl) <sub>3</sub> , DME, reflux, 5 h		668
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, rt, 80 min		313
303				96, 669
		Pd(dppb)Cl <sub>2</sub> (5%), DMF, 100°, 24 h		96, 669
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , 80°, 12 h		550, 555
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, reflux, 24 h		651
		Pd(dppb)Cl <sub>2</sub> (5%), CuO, DMF, 100°, 1.5 h		96, 669

TABLE VII. DIRECT CROSS-COUPLING OF THIOPHENE AND BENZOTHIOPHENE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), CuI (10%), DMF, 60°, 4 h	(73)	291
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), THF, reflux, 20 h	(52)	667
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux, 5 h	(64)	560, 561
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux, 5 h	(64)	560
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux, 5 h	(55)	560
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (20%), PhMe, reflux, 3 h	(52)	536
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux, 5 h	(30)	560
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 60°, 16 h	(61)	103
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (20%), PhMe, reflux, 12 h 2. NaOMe, MeOH	(47)	670
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux	(>36)	584
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , Ag <sub>2</sub> O, DMF, 100°	(29)	669
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , Ag <sub>2</sub> O, DMF, 100°	(51)	669
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF	(—)	671
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF	(—)	671

TABLE VII. DIRECT CROSS-COUPLING OF THIOPHENE AND BENZOTHIOPHENE ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
C <sub>5</sub>		Bu <sub>3</sub> SnCH=CHSnBu <sub>3</sub>	Pd(OAc) <sub>2</sub> , P(2-furyl) <sub>3</sub> , DME, reflux, 5 h	 (46)	668
		Bu <sub>3</sub> SnC(SMe)=N=C(SMe)N	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, 80°, 4.5 h	 (87)	651
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> N	Pd <sub>2</sub> (dba) <sub>3</sub> (1%) P(2-furyl) <sub>3</sub> (4%), dioxane	 (—)	672
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> S	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 60°, 16 h	 (71)	103
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> S	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 60°, 16 h	 (79)	103
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> N(Me)C <sub>6</sub> H <sub>4</sub> S	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux	 (89)	425
C <sub>6</sub>		Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> S	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, reflux, 24 h	 (9)	104
		Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> S	Pd(PPh <sub>3</sub> ) <sub>4</sub> , Ag <sub>2</sub> O, DMF, 100°	 (25)	669
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> N	Pd <sub>2</sub> (dba) <sub>3</sub> (1%) P(2-furyl) <sub>3</sub> (4%), dioxane	 (—)	672
		Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> N	Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 5 h	 (24)	560
		Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> SnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (31%), PhMe, 70°, 2 d	 (13)	673
	C <sub>7</sub>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 4 h	 (64)	105
				 (66)	
		Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> S	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 60°, 16 h	 (63)	103
C <sub>8</sub>		Me <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> S	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 7 h	 (47) + (15)	104
				 (56)	668

TABLE VII. DIRECT CROSS-CO尤LING OF THIOPHENE AND BENZOTHIOPHENE ELECTROPHILES (Continued)

TABLE VII. DIRECT CROSS-COUPLING OF THIOPHENE AND BENZOTHIOPHENE ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>37</sub>		Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> , NMP, 60°, 16 h	 (65)	670
C <sub>41</sub>	TBDMSO-CH <sub>2</sub> -Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS	TBDMSO-CH <sub>2</sub> -Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS	Pd(PPh <sub>3</sub> ) <sub>4</sub>	TBDMSO-CH <sub>2</sub> -Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS  (75)	677
310	TBDMSO-CH <sub>2</sub> -Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS	Bu <sub>3</sub> Sn-Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS	Pd(PPh <sub>3</sub> ) <sub>4</sub>	TBDMSO-CH <sub>2</sub> -Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS  (58)	677
	TBDMSO-CH <sub>2</sub> -Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS	Bu <sub>3</sub> Sn-Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS	Pd(PPh <sub>3</sub> ) <sub>4</sub>	TBDMSO-CH <sub>2</sub> -Si(Ph <sub>2</sub> )-CH <sub>2</sub> -OTBDMS  (63)	677

TABLE VIII. DIRECT CROSS-COUPING OF PYRAN AND BENZOPYRAN ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>6</sub>		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.7%) LiCl, THF, reflux, 14 h	(71)	678
C <sub>7</sub>		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.7%) LiCl, THF, reflux, 14 h	(78)	678
C <sub>8</sub>		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.7%) LiCl, THF, reflux, 14 h	(75)	678
C <sub>8</sub>		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.7%) LiCl, THF, reflux, 14 h	(70)	678
311		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.7%) LiCl, THF, reflux, 14 h	(69)	678
C <sub>9</sub>		Me <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%) LiCl, dioxane, reflux, 5 h	(89)	679
		Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%) LiCl, dioxane, reflux, 6 h	(76)	679

TABLE VIII. DIRECT CROSS-COUPING OF PYRAN AND BENZOPYRAN ELECTROPHILES (*Continued*)

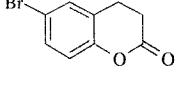
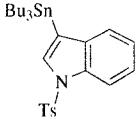
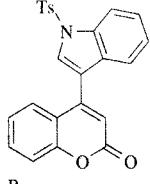
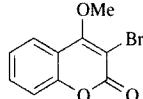
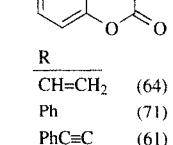
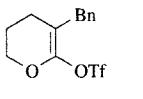
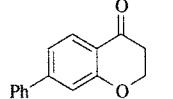
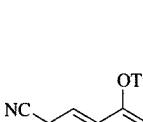
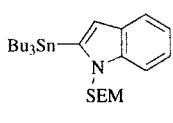
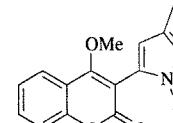
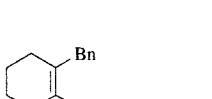
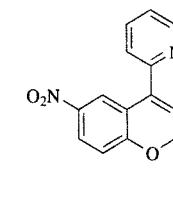
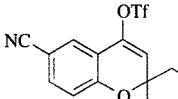
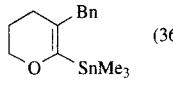
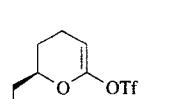
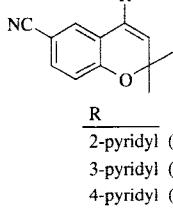
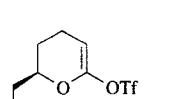
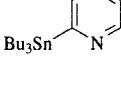
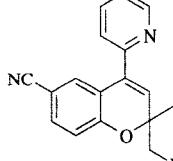
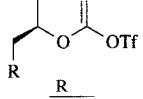
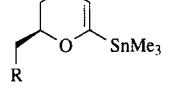
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), DMF, 60°, 2 h	 (93)	291
	Bu <sub>3</sub> SnPh Bu <sub>3</sub> SnC≡CPh	Pd(OAc) <sub>2</sub> , PPh <sub>3</sub> (8%), NEt <sub>3</sub> , 100°, 24 h	 (64) (71) (61)	327
	Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, dioxane, reflux, 18 h	 (87)	680
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°	 (96)	289
		Pd <sub>2</sub> (dba) <sub>3</sub> *CHCl <sub>3</sub> , PPh <sub>3</sub> , LiCl, THF	 (83)	681
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.7%), LiCl, THF, reflux, 14 h	 (36)	678
	Bu <sub>3</sub> Sn-pyridyl-2 Bu <sub>3</sub> Sn-pyridyl-3 Me <sub>3</sub> Sn-pyridyl-4	Pd <sub>2</sub> (dba) <sub>3</sub> *CHCl <sub>3</sub> (5-10%), P(2-furyl) <sub>3</sub> (10-20%), LiCl, THF, reflux, 10 h	 (80) (72) (75)	683, 682 683 683
		Pd <sub>2</sub> (dba) <sub>3</sub> *CHCl <sub>3</sub> (5-10%), P(2-furyl) <sub>3</sub> (10-20%), LiCl, THF, reflux, 10 h	 (—)	681
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.7%), LiCl, THF, reflux, 14 h	 (71) (82)	678

TABLE VIII. DIRECT CROSS-COUPING OF PYRAN AND BENZOPYRAN ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>14</sub>		Bu <sub>3</sub> SnR	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF		684
314		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, reflux, 12 h		685
C <sub>15</sub>		Sn(≡C) <sub>4</sub>	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, DMF, 100° 2. NaOH (2 N)		686
		SnEt <sub>4</sub>	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, DMF, 100° 2. NaOH (2 N)		686
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 80°, 40 h		58
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 77°, 40 h		58
315		Bu <sub>3</sub> SnC≡CR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 80°		58
		R TMS Bu-n Ph	Time (h) 48 43 36		
		Bu <sub>4</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), LiCl, DMF, 100°, 12 h		189
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), LiCl, DMF, 100°, 12 h		189
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, dioxane, 98°, 60 h		189

TABLE VIII. DIRECT CROSS-COUPING OF PYRAN AND BENZOPYRAN ELECTROPHILES (*Continued*)

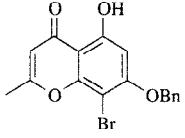
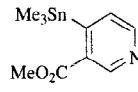
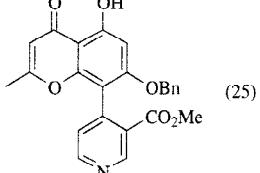
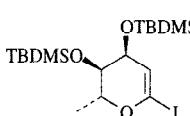
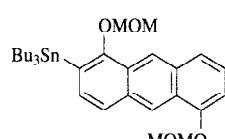
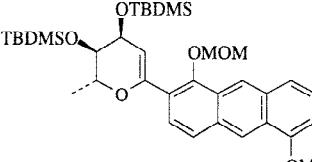
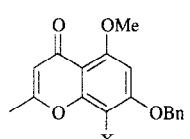
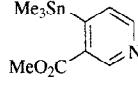
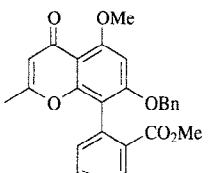
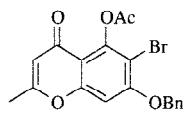
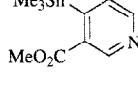
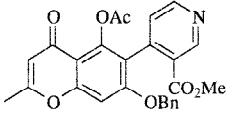
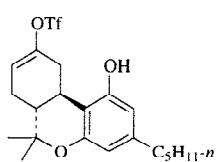
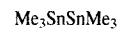
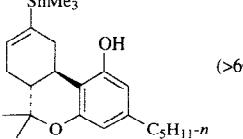
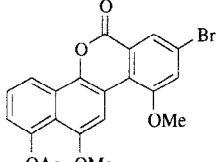
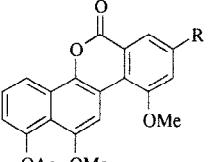
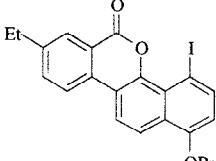
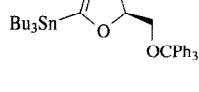
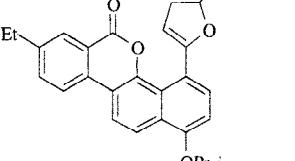
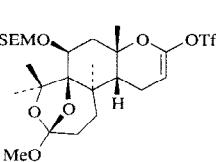
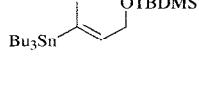
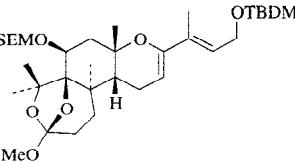
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>17</sub>		Me <sub>3</sub> Sn MeO <sub>2</sub> C 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (15%), PhMe, 115°, 21 h  (25)	687
C <sub>18</sub>		Bu <sub>3</sub> Sn 	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 80° or Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , CHCl <sub>3</sub> , 80°  (0)	688
316		Me <sub>3</sub> Sn MeO <sub>2</sub> C 	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (50%), dioxane, 115°, 3 d Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (14%), PhMe, 115°, 2 d  (18) (20)	687
C <sub>19</sub>		Me <sub>3</sub> Sn MeO <sub>2</sub> C 	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), dioxane, 115°, 4 d  (36)	687
C <sub>20</sub>		Me <sub>3</sub> SnSnMe <sub>3</sub> 	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, Li <sub>2</sub> CO <sub>3</sub> , THF, 60°, 12 h  (>60)	515
C <sub>21</sub>		R <sub>4</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub>  (61) (66) (44) (20)	689
317		OCPh <sub>3</sub> 	Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), CH <sub>3</sub> CN/THF, 40°, 10 h  (78)	301
C <sub>24</sub>		OTBDMS 	Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, THF, reflux, 72 h  (30)	690

TABLE VIII. DIRECT CROSS-COUPLING OF PYRAN AND BENZOPYRAN ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>26</sub>			Pd <sub>2</sub> (dba) <sub>3</sub> , P(2-furyl) <sub>3</sub> , LiCl, THF, 60°	 (81)	691
C <sub>33</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), THF, reflux, 8 h	 (67)	300, 388
		Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), THF, reflux, 24 h	 (20)	300, 388

TABLE IX. DIRECT CROSS-COUPLING OF PYRIDINE ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>5</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), dioxane, reflux, 6 h	(64)	292, 530
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Et <sub>4</sub> NCl, DMF, 80°, 3.5 h	(62)	272, 273
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux, 12 h	(77)	93
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux, 12 h	(59)	93
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%) C <sub>6</sub> H <sub>6</sub> , 80°, 24 h	(85)	550, 551
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), Ag <sub>2</sub> O, DMF, 100°, 5 min	(60)	32
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, 80°, 24 h	(72)	651
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux, 4 h	(82)	536

TABLE IX. DIRECT CROSS-COUPLING OF PYRIDINE ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (2%), C6H6, 80°, 20 h	(88)	539
		Pd(PPh3)4 (1%), xylene, reflux, 12 h	(79)	93
		Pd(PPh3)4 (3%), Ag2O, DMF, 100°, 0.5 h	(58)	32
		Pd(PPh3)4 (10%), PhMe, 110°, 18 h	(0)	371
		Pd(PPh3)4 (10%), DMF, 110°	(80)	289
		Pd2(dba)3 (2.5%), AsPh3, (10%), CuI (10%), DMF, 60°, 6 h	(54)	291
		Pd(PPh3)4 (10%), DMF, 90°, 8 h	(78)	74
		Pd(PPh3)4 (5%), PhMe, 100°, 24 h	(85)	319
		Pd(CH3CN)2Cl2, HMPA, 70°	(80)	692
		Pd(PPh3)2Cl2 (5%), THF, Et4NCl, 50°, 2 h	(19)	552
		Pd2(dba)3 (2.5%), CuI, DMF, 60°	(76)	554
		Pd(PPh3)4 (3%), LiCl, dioxane, reflux, 72 h	(67)	693
		Pd(PPh3)4 (5%), C6H6, 80°, 12 h	(100)	550
		Pd(PPh3)2Cl2 (3%), dioxane, reflux, 4 h	(60)	292, 536
		Pd(PPh3)2Cl2 (3%), DMF, Et4NCl, 80°, 5 h	(72)	272, 273

TABLE IX. DIRECT CROSS-COUPLING OF PYRIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (1%), xylene, reflux, 12 h		I (63) 93
		Pd(dppb)Cl2 (5%), DMF, 100°, 24 h		I (99) 96
		Pd(PPh3)4 (1%), xylene, reflux, 12 h		(68) 93
		Pd(PPh3)4 (1%), xylene, reflux, 12 h		(70) 93
322		Pd(PPh3)4 (5%), C6H6, 80°, 24 h		(82) 550, 551
		Pd(PPh3)2Cl2 (3%), THF, reflux, 24 h		(65) 651
		Pd(PPh3)4 (5%), PhMe, reflux		(63) 437
		BnPd(PPh3)2Cl (1.7%), DMF, 70°, 16 h		(91) 296
323		Pd(PPh3)2Cl2 (2%), THF, reflux, 2 h		(70) 425
		Pd(PPh3)4 (2%), PhMe, reflux, 72 h		(64) 464
		Pd(PPh3)2Cl2 (2%), THF, reflux		(66) 425
		Pd(PPh3)4 (1%), xylene, reflux, 12 h		(48) 93
		Pd(PPh3)4 (5%), PhMe, 100°, 24 h		(87) 319
				(61) 302
		Pd(PPh3)2Cl2 (5%), Et4NCl, DMF, rt, 2 h		(62) 96
		Pd(dppb)Cl2 (5%), CuO, DMF, 100°, 3 h		(29) 552
		Pd(PPh3)2Cl2 (5%), Et4NCl, THF, 50°, 3 h		(65) 539
		Pd(PPh3)4 (2%), C6H6, 80°, 20 h		I (70) 669
		Pd(PPh3)4, Ag2O, DMF, 100°, 70-80 min		

TABLE IX. DIRECT CROSS-COUPLING OF PYRIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (1%), xylene, reflux, 12 h	I (65)	93
		Pd(dppb)Cl2 (5%), CuO, DMF, 100°, 80 min	I (75)	96
		Pd(PPh3)4 (1%), xylene, reflux, 12 h	 (72)	93
		Pd(PPh3)2Cl2 (3%), DMF, 80°, 10 h	 (67)	651
		PPh(m-C6H4SO2Na)2, PdCl2, KOH, 90°	 (81)	281
324			Pd(dppb)Cl2 (5%), CuO, DMF, 100°, 4 h  (44)	96
		PdCl2, HMPA, 70°  (96)	692	
			Pd(PPh3)2Cl2 (10%), THF, reflux, 20 h  (52)	667
			Pd(PPh3)4 (10%), DMF, 110°  (92)	289
			Pd(PPh3)4, CuI, dioxane, reflux  (81)	582
			Pd(PPh3)2Cl2 (3%), Et4NCl, CH3CN, reflux, 1 h  (74) + (14)	95
			Pd(PPh3)4 (5%), CuO, DMF, 100°, 40 min  (69)	694
325			Pd(PPh3)2Cl2 (3%), Et4NCl, CH3CN, reflux, 1.5 h  (96)	95
			Pd(PPh3)2Cl2 (3%), Et4NCl, CH3CN, reflux, 1.5 h  (36) + (47)	95
			Pd(PPh3)2Cl2 (3%), Et4NCl, CH3CN, reflux, 3 h  (78) + (16)	95
			Pd(CH3CN)2Cl2 (1%), DMF, THF, 70°, 10 min  (89)	695
C6			Pd(PPh3)2Cl2 (5%), THF, reflux, 28 h  (58)	696

TABLE IX. DIRECT CROSS-COUPLING OF PYRIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (20%), CuI, DMF, 100°, 18 h	(8)	585
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux, 12 h	(81)	697
		Pd(PPh <sub>3</sub> ) <sub>4</sub>	(—)	698
326				
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux, 12 h	(26)	697
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux, 12 h	(32)	697
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux, 12 h	(17)	697
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux, 12 h	(72)	697
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, 90°, 9 h	(66)	699
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux, 12 h	(7)	697
C <sub>7</sub>				
327				
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, Et <sub>4</sub> NCl, 80°, 12 h	(70)	272
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, Et <sub>4</sub> NCl, reflux, 24 h	(69)	274
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), CH <sub>3</sub> CN, Et <sub>4</sub> NCl, reflux, 2.5 h	(93)	95
C <sub>8</sub>				
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, Et <sub>4</sub> NCl, 100°, 2 h	(76)	273
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, Et <sub>4</sub> NCl, 100°, 4 h	(66)	273

TABLE IX. DIRECT CROSS-COUPLING OF PYRIDINE ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>9</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 20 h	(54)	700
C <sub>12</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux	(94)	94
C <sub>14</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub>	(—)	698
328			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), PhMe, 120°, 15 h	(60)	606
C <sub>15</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, reflux	(75)	701
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, reflux	(95)	701
329			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 2 h	(41)	606
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), LiCl, DMF, 130°	(88)	702, 703
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Et <sub>3</sub> N, DMF, 90°, 4 h	(86)	704
C <sub>16</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, dioxane, reflux, 36 h	(66)	693
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, reflux, 48 h	(89)	556
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, reflux, 48 h	(92)	556

TABLE IX. DIRECT CROSS-COUPLING OF PYRIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (3%), PhMe, reflux, 48 h	(51)	556
		Pd(PPh3)4 (3%), PhMe, reflux, 48 h	(78)	556
<b>C<sub>17</sub></b> 330		Pd(PPh3)2Cl2 (6%), PhMe, 110°, 16 h	(—)	606
		Pd(PPh3)4 (3%), LiCl, dioxane, reflux, 20 h	(65)	693
		1. Pd(PPh3)2Cl2 (5%), PhMe, reflux, 4 h 2. HCl (conc.)	(68)	705
<b>C<sub>18</sub></b>		Pd(PPh3)4 (3%), PhMe, reflux, 60 h	(67)	99
		Pd(PPh3)4 (3%), LiCl, dioxane, reflux, 20 h	(67)	693
<b>C<sub>23</sub></b> 331		Pd(PPh3)4 (3%), LiCl, dioxane, reflux, 15 h	(—)	693
		Pd(PPh3)4, PhMe, reflux	(—)	706

TABLE IX. DIRECT CROSS-COUPLING OF PYRIDINE ELECTROPHILES (*Continued*)

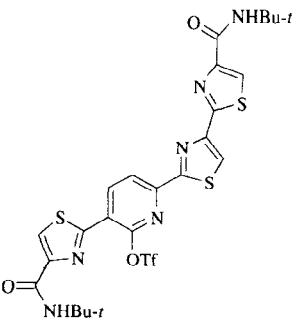
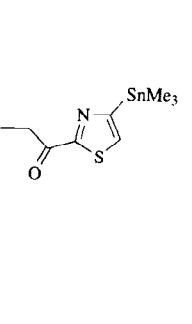
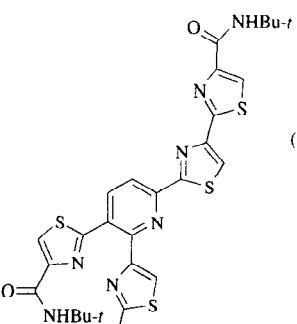
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>24</sub> 332		 Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%)	 (89)	107

TABLE X. DIRECT CROSS-COUPLING OF PYRIMIDINE ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
$C_4$		$Bu_3SnSPh$	$Pd(PPh_3)_4$ (5%), PhMe, 100°, 24 h	(95)	319
		$Bu_3Sn\text{---CH=CH}_2$	$Pd(PPh_3)_4$ (3%), LiCl, dioxane, 80°	(68)	196
		$Bu_3Sn\text{---CH=CH---Ph}$	$Pd(PPh_3)_4$ (3%), LiCl, dioxane, 80°	(57)	196
		$Bu_3Sn\text{---CH}_2\text{---Thiophene}$	$Pd(PPh_3)_4$ (3%), LiCl, dioxane, 80°	(67)	196
333		$Bu_3Sn\text{---CH=CH---OTMS}$	$Pd(PPh_3)_4$ (3%), PhMe, 100°, 24 h	(67)	457
		$Bu_3SnSPh$	$Pd(PPh_3)_4$ (5%), PhMe, 100°, 24 h	(94)	319
			$Pd_2(dba)_3$ (2.5%), CuI, DMF, 60°	(61)	554
			$Pd_2(dba)_3$ (2.5%), CuI, DMF, 60°	(69)	554

TABLE X. DIRECT CROSS-COUPLING OF PYRIMIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), CuI, DMF, 60°	(49)	554
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 80°, 6 h	(61)	137
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 80°, 60 h	(73)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 80°, 6 h	(73)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 70°, 7 h	(77)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 80°, 10 h	(60)	141
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 70°, 24 h	(94)	137
		Pd(0), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 70°, 24 h	(83)	137
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 7 h	(70)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 70°, 6 h	(73)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 70°, 3 h	(69)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 80°, 10 h	(71)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 10 h	(63)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 15 h	(68)	141
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 70°, 48 h	(92)	137
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 90°, 24 h	(56)	140
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 8 h	(60)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 1.3 h	(85)	141
334				
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 7 h	(70)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 70°, 6 h	(73)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 70°, 3 h	(69)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 80°, 10 h	(71)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 10 h	(63)	141
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 15 h	(68)	141
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 70°, 48 h	(92)	137
335				

TABLE X. DIRECT CROSS-COUPLING OF PYRIMIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{Sn}-\text{OR}$ $\text{R} \begin{array}{c}   \\ \text{TBDMS} \end{array}$ $\text{SiMe}_2\text{Thex}$ $\text{TBDPS}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 90°, 24 h	 (53) (32) (64)	140
	$\text{Bu}_3\text{Sn}-\text{Ph}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 50°, 27 h	 (66)	141
	$\text{Bu}_3\text{SnPh}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 100°, 5 h	 (66)	141
	$\text{Bu}_3\text{Sn}-\text{Ph}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 100°, 3.5 h	 (66)	141
	$\text{Me}_3\text{Sn}-\text{N}=\text{C}_6\text{H}_4-\text{SMe}$	$\text{Pd}(\text{PPh}_3)_4$ (0.7%), PhMe, reflux, 20 h	 (38)	140
	$\text{R}_3\text{SnSnR}_3$	$\text{Pd}(\text{PPh}_3)_2(\text{OAc})_2$ (3%), $\text{Bu}_4\text{NCl}$ , THF, rt, 6 h	 R = Me (54) R = Bu (46)	140
	$\text{Bu}_3\text{Sn}-\text{Ph}$	$\text{Pd}[\text{P}(\text{OPr}-i)_3]_4$ , $\text{Cl}(\text{CH}_2)_2\text{Cl}$ , 70°, 24 h	 (64)	137
	$\text{Me}_4\text{Sn}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 70°, 48 h	 (78)	135
	$\text{Bu}_3\text{Sn}-\text{Ph}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), THF, reflux, 4 h	 (71)	135
	$\text{Bu}_3\text{Sn}-\text{Ph}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 100°, 2 h	 (69)	135
	$\text{Bu}_3\text{Sn}-\text{Ph}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), THF, reflux, 17 h	 (90)	135
	$\text{Bu}_4\text{Sn}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 120°, 14 h	 (62)	135
	$\text{Bu}_3\text{Sn}-\text{C}_5\text{H}_4\text{S}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), THF, reflux, 7 h	 (90)	135
	$\text{Bu}_3\text{SnPh}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), THF, reflux, 20 h	 (62)	135
	$\text{Bu}_3\text{SnBn}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 100°, 15 h	 (60)	135
	$\text{Bu}_3\text{Sn}-\text{Ph}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), THF, reflux, 6 h	 (90)	135
	$\text{Bu}_3\text{Sn}-\text{Ph}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), THF, reflux, 33 h	 (66)	135
	$\text{Me}_3\text{Sn}-\text{N}=\text{C}_6\text{H}_4-\text{SMe}$	$\text{Pd}(\text{PPh}_3)_4$ (0.7%), PhMe, reflux, 20 h	 (56)	140

TABLE X. DIRECT CROSS-COUPING OF PYRIMIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd( $\text{PPh}_3$ ) <sub>4</sub> (3%), LiCl, dioxane, 80°	(60)	196
	$\text{Bu}_3\text{SnCH}=\text{CH}-\text{Ph}$	Pd( $\text{PPh}_3$ ) <sub>4</sub> (3%), LiCl, dioxane, 80°	(68)	196
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{SMe}$	Pd( $\text{PPh}_3$ ) <sub>4</sub> (3%), LiCl, dioxane, 80°	(73)	196
	$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd( $\text{PPh}_3$ ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 70°, 2 h	(90)	137
	$\text{Bu}_3\text{SnCH}=\text{CH}-\text{CH}=\text{CH}_2$	Pd( $\text{PPh}_3$ ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 70°, 24 h	(86)	137
	$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd( $\text{PPh}_3$ ) <sub>4</sub> , Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 70°, 48 h	(49)	137
	$\text{Bu}_4\text{Sn}$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 5.5 h	(56)	141
	$\text{Bu}_3\text{SnPh}$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 2.5 h	(65)	141
	$\text{Bu}_3\text{SnCH}=\text{CH}-\text{Ph}$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 100°, 3 h	(65)	141
	$\text{Bu}_3\text{SnCH}=\text{CH}-\text{OEt}$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (3%), Et <sub>4</sub> NCl, THF, reflux, 5 h	(8) +  (72)	274
	$\text{Me}_3\text{SnC}\equiv\text{CTMS}$	Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), Et <sub>3</sub> N, CH <sub>3</sub> CN, rt, 4 h	(92)	136
	$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(45)	138
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{S}$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(88)	138
	$\text{Bu}_3\text{SnCH}=\text{CH}-\text{TMS}$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(73)	138
	$\text{Bu}_3\text{SnPh}$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 3 h	(60)	138
	$\text{Bu}_3\text{SnC}\equiv\text{CCO}_2\text{Et}$	Pd( $\text{PPh}_3$ ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, THF, 50°, 3 h	(21)	552

TABLE X. DIRECT CROSS-COUPLING OF PYRIMIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(52)	138
	Bu <sub>3</sub> SnCH=CH-CH <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(88)	138
	Bu <sub>3</sub> SnCH=CH-TMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(78)	138
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 3 h	(71)	138
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 8 h	(71)	138
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(67)	138
	Bu <sub>3</sub> SnCH=CH-CH <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(95)	138
	Bu <sub>3</sub> SnCH=CH-TMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 2 h	(73)	138
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 4 h	(92)	138
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 4 h	(7) +  (50)	138
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 6 h	(50)	138
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 5 h	(45)	138, 139
	Bu <sub>3</sub> SnCH=CH-CH <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 4 h	(60)	138, 139
	Bu <sub>3</sub> SnCH=CHCO <sub>2</sub> Et	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub>	(—)	139
	Bu <sub>3</sub> SnCH=CH-TMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 5 h	(69)	138, 139
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, K <sub>2</sub> CO <sub>3</sub> , DMF, 110°, 7 h	(73) +  (20)	138, 139

TABLE X. DIRECT CROSS-COUPLING OF PYRIMIDINE ELECTROPHILES (*Continued*)

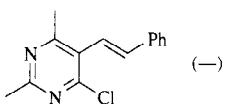
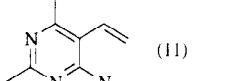
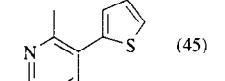
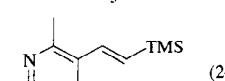
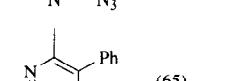
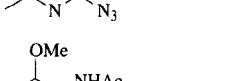
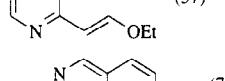
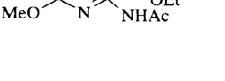
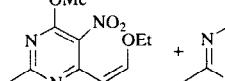
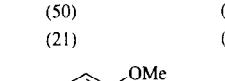
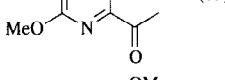
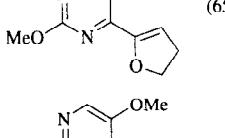
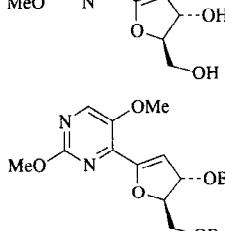
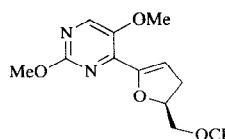
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
342	<chem>Bu3SnC=CPh</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub>	 (—)	139
	<chem>Bu3SnC=C</chem>	PdCl <sub>2</sub> , Et <sub>4</sub> NCl, DMF, 110°, 2 h	 (11)	139
	<chem>Bu3SnC=CSc</chem>	PdCl <sub>2</sub> , Et <sub>4</sub> NCl, DMF, 110°, 2 h	 (45)	139
	<chem>Bu3SnC=C[SiH]3</chem>	PdCl <sub>2</sub> , Et <sub>4</sub> NCl, DMF, 110°, 2 h	 (24)	139
	<chem>Bu3SnPh</chem>	PdCl <sub>2</sub> , Et <sub>4</sub> NCl, DMF, 110°, 3 h	 (65)	139
	<chem>Bu3SnC=C[EtO]</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), Et <sub>4</sub> NCl, CH <sub>3</sub> CN, reflux, 33 h	 (37)	274
	<chem>Bu3SnC=C[EtO]</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Et <sub>4</sub> NCl, CH <sub>3</sub> CN, reflux, 3 h	 (71)	274
	<chem>Bu3SnC=C[EtO]</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, Et <sub>4</sub> NCl, reflux 4 h	 (50) (21)	274
	<chem>Bu3SnC=C[EtO]</chem>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, Et <sub>4</sub> NCl, reflux 24 h	 (44) (73)	274
	<chem>Bu3SnC=C[EtO]</chem>	Pd(OAc) <sub>2</sub> (10%), Bu <sub>4</sub> NCl, NaHCO <sub>3</sub> , NEt <sub>3</sub> , H <sub>2</sub> O/EtOH	 (83)	707
343	<chem>Bu3SnC=CSc</chem>	Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 40°, 8 h	 (65)	301
	<chem>Bu3SnC=C[C1=CC(O)C(O)=C1]</chem>	Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 40°, 14 h	 (54)	301
	<chem>Bu3SnC=C[C1=CC(OBn)C(OBn)=C1]</chem>	Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 60°, 0.5 h	 (88)	301
	<chem>Bu3SnC=C[C1=CC(OC(Ph3))C(OC(Ph3))=C1]</chem>	Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), CH <sub>3</sub> CN, THF, 40°, 10 h	 (66)	301

TABLE X. DIRECT CROSS-COUPLING OF PYRIMIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)2Cl2 (3%), THF, Et4NCl, reflux 2 h 15 h	 (32) (11) (51) (73)	274
		Pd(PPh3)4 (3%), LiCl, dioxane, 80°	 (60)	196
		Pd(PPh3)4 (3%), LiCl, dioxane, 80°	 (88)	196
		Pd(PPh3)2Cl2 (3%), Et4NCl, DMF, 140°, 1 h	 (95)	274
		Pd(PPh3)2Cl2 (4%), Et4NCl, CH3CN, reflux, 31 h	 (75)	274
		Pd(PPh3)2Cl2 (3%), Et4NCl, CH3CN, reflux, 24 h	 (81)	274
		Pd(PPh3)2Cl2 (2%), DMF, 100°, 10 h	 (68)	141
		Pd(PPh3)2Cl2 (3%), Cl(CH2)2Cl, reflux, 1.5 h	 (89)	708
		Pd(PPh3)2Cl2 (3%), Cl(CH2)2Cl, reflux, 14 h	 (85)	708
		1. Pd(PPh3)2Cl2 (5%), THF, reflux, 72 h 2. H2O, 12 h	 (82)	129
		1. Pd(PPh3)2Cl2 (5%), THF, reflux, 72 h 2. H2O, 12 h	 X = O (47) X = S (57)	129
		1. Pd(PPh3)2Cl2 (5%), THF, reflux, 72 h 2. H2O, 12 h	 X = O (57) X = S (77) X = Se (57)	129
		1. Pd(PPh3)2Cl2 (5%), neat, 100°, 72 h 2. THF, H2O, 12 h	 R = 2-pyridyl (60) R = 3-pyridyl (45) R = 4-pyridyl (34)	129

TABLE X. DIRECT CROSS-COUPLING OF PYRIMIDINE ELECTROPHILES (*Continued*)

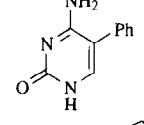
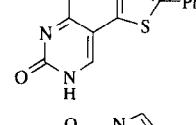
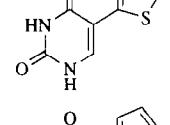
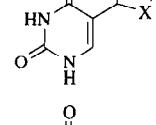
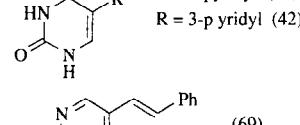
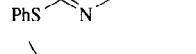
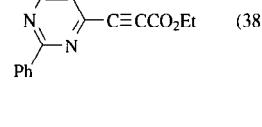
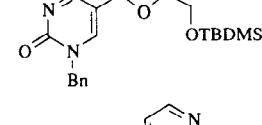
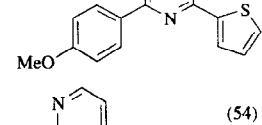
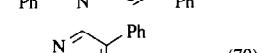
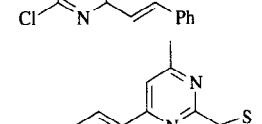
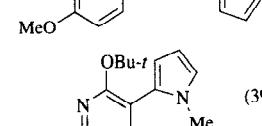
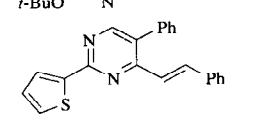
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
	$\text{Bu}_3\text{SnPh}$	1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), THF, reflux, 72 h 2. $\text{H}_2\text{O}$ , 12 h	 (62)	129	
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{S}-\text{Ph}$	1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), THF, reflux, 72 h 2. $\text{H}_2\text{O}$ , 12 h	 (82)	129	
	$\text{OTMS}$ $\text{TMSO}$	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{S}$	1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), THF, reflux 2. $\text{H}_2\text{O}$	 (34)	135
346		$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{X}$	1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), THF, reflux 2. $\text{H}_2\text{O}$	 $X = \text{S}$ (37) $X = \text{Se}$ (39) $X = \text{NMe}$ (44)	135
	$\text{Br}$ $\text{PhS}$	$\text{Bu}_3\text{SnR}$	1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), THF, reflux 2. $\text{H}_2\text{O}$	 $R = 2\text{-pyridyl}$ (28) $R = 3\text{-pyridyl}$ (42)	135
$\text{C}_{11}$	$\text{Br}$ $\text{PhS}$	$\text{Bu}_3\text{Sn}-\text{CH}_2-\text{Ph}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 100°, 8 h	 (69)	141
	$\text{I}$ $\text{Ph}$	$\text{Bu}_3\text{SnC}\equiv\text{CCO}_2\text{Et}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), $\text{Et}_4\text{NCl}$ , THF, 50°, 4 h	 (38)	552
$\text{C}_{12}$	$\text{Br}$ $\text{Bn}$	$\text{R}_3\text{Sn}-\text{C}_6\text{H}_4-\text{O}-\text{CH}_2-\text{OTBDMS}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (3%), THF, reflux, 1 h	 $R = \text{Me}$ (98) $R = \text{Bu}$ (72)	708
	$\left[ \text{MeO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{N}=\text{C}_6\text{H}_4-\text{Cl} \right]$	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{S}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), THF, reflux, 2 h	 (48)	709
347	$\text{Cl}$ $\text{Ph}$	$\text{Bu}_3\text{SnPh}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 130°, 15 h	 (54)	141
	$\text{Cl}$ $\text{Br}$ $\text{Ph}$	$\text{Bu}_3\text{SnPh}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 80°, 50 h	 (70)	141
$\text{C}_{18}$	$\text{MeO}$	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{S}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), THF, reflux, 2 h	 (61)	709
	$t\text{-BuO}$ $t\text{-BuO}$	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{N}(\text{Me})=\text{S}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), THF, reflux	 (39)	135
	$\text{Cl}$ $\text{Ph}$	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{S}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), DMF, 100°, 15 h	 (82)	141

TABLE X. DIRECT CROSS-CO尤LING OF PYRIMIDINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (20%), PhMe, reflux, 24 h	(—)	127
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (20%), PhMe, reflux, 24 h	(—)	127

TABLE XI. DIRECT CROSS-COUPLING OF QUINOLINE AND ISOQUINOLINE ELECTROPHILES

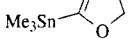
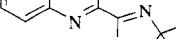
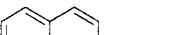
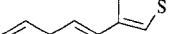
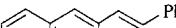
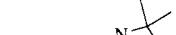
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>9</sub> 		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , 80°, 12 h	 (75)	550, 551
	Me <sub>3</sub> SnR <hr/>  H CH=CH <sub>2</sub> 2-thienyl Ph C≡CPh (E)-CH=CHPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiCl, dioxane, 90°, 24 h	 (89) (74) (71) (88) (65) (69)	194
	Me <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, reflux, 16 h	 (74)	699
	Me <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, reflux, 16 h	 (33)	699
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , 80°, 48 h	 (92)	550, 551
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), xylene, reflux	 (79)	93

TABLE XI. DIRECT CROSS-COUPLING OF QUINOLINE AND ISOQUINOLINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)4 (15%), C6H6, reflux, 2 h	 (74)	284
		Pd(PPh3)4 (5%), LiCl, dioxane, reflux, 16 h	 (75)	699
		Pd(PPh3)4 (5%), LiCl, dioxane, reflux, 16 h	 (92)	699
350		Pd(PPh3)4 (5%), LiCl, dioxane, reflux, 16 h	 (92)	699
		Pd(PPh3)4 (5%), LiCl, dioxane, reflux, 16 h	 (86)	699
	Bu3SnR	Pd(PPh3)4 (5%), LiCl, dioxane	 <b>I</b>	194
	R CH=CH2 C≡CPh (E)-CH=CHPh	90°, 24 h 90°, 24 h 90°, 24 h	(68) (43) (60)	
	Me3SnPh	Pd(PPh3)4 (2%), LiCl, dioxane, 98°, 82 h	<b>I</b> , R = Ph, (61)	189
	Me3SnSnMe3	Pd(PPh3)4 (2%), LiCl, dioxane, 98°, 75 h	 (67)	189
	Bu3Sn<sup>=CH</sup>	Pd(OAc)2 (5%), LiCl, dppp (5%), DMF, 90°	 (50)	202
351		Pd(PPh3)4 (5%), C6H6, 80°, 12 h	 (92)	550
		Pd(PPh3)4 (5%), PhMe, 110°	 (85)	710
		Pd(PPh3)4 (5%), C6H6, 80°, 12 h	 (92)	551
	Bu3SnR	Pd(PPh3)4 (5%), LiCl, dioxane, 90°, 24 h	 <b>I</b>	194
	R CH=CH2 Ph C≡CPh (E)-CH=CHPh	ZnCl2	(62) (58) (70) (69)	

TABLE XI. DIRECT CROSS-COUPLING OF QUINOLINE AND ISOQUINOLINE ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>10</sub> 352			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , LiCl, THF, 65°, 18 h	 (61)	264
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (15%), C <sub>6</sub> H <sub>6</sub> , reflux, 2 h	 (85)	98
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (99)	699
C <sub>11</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (34)	699
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (86)	699
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (80)	699
353			Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (10%), DMF, 60°, 1 h	 (92)	291
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (86)	699
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (82)	699
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (68)	699
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (56)	699
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (86)	699

TABLE XI. DIRECT CROSS-COUPLING OF QUINOLINE AND ISOQUINOLINE ELECTROPHILES (*Continued*)

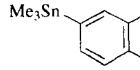
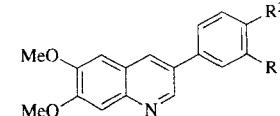
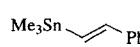
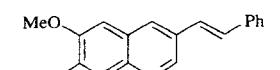
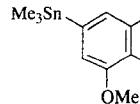
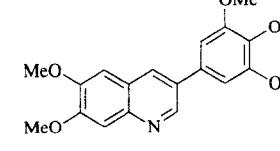
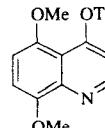
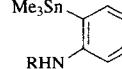
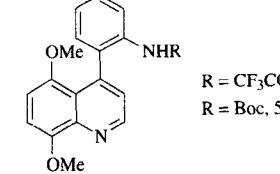
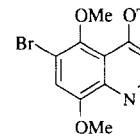
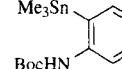
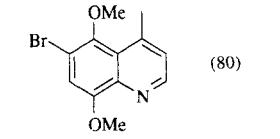
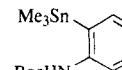
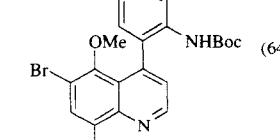
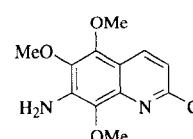
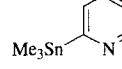
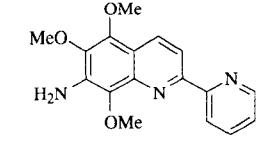
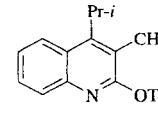
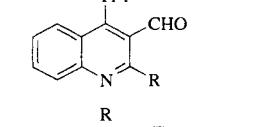
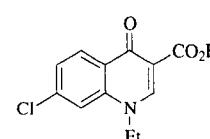
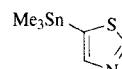
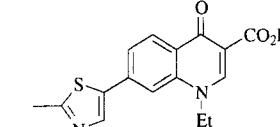
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (83) (90) (97) (91) (74) (99) (93) (62) (66)	699
R <sup>1</sup>	R <sup>2</sup>			
Cl	Cl			
F	F			
H	NO <sub>2</sub>			
OMe	H			
H	OMe			
NO <sub>2</sub>	OMe			
H	CO <sub>2</sub> Et			
CH=CH-CH=CH				
H	Ph			
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (91)	699
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, dioxane, reflux, 16 h	 (51)	699
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, dioxane, 100°	 R = CF <sub>3</sub> CO, 16 h, (71) R = Boc, 5-7 h, (87)	711
		Pd(dppf)Cl <sub>2</sub> , DMF	 (80)	280
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, CuBr (5%), dioxane, 90°, 60 h	 (64)	280
C <sub>12</sub> 		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, reflux, 18 h	 (98)	712
C <sub>13</sub> 		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, BHT, dioxane, 100°	 R CH=CH <sub>2</sub> (91) Et (78) C <sub>6</sub> H <sub>4</sub> F- <i>p</i> (95)	195
C <sub>14</sub> 		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF/HMPA, 150° 2. HCl (1.5 N)	 (57)	713

TABLE XI. DIRECT CROSS-COUPLING OF QUINOLINE AND ISOQUINOLINE ELECTROPHILES (*Continued*)

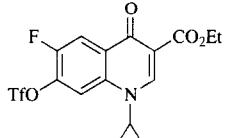
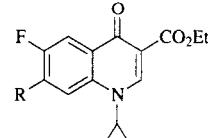
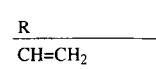
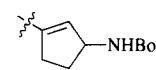
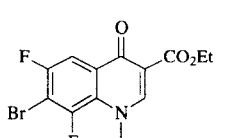
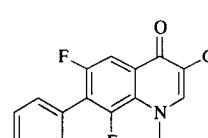
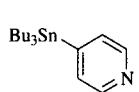
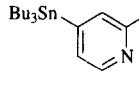
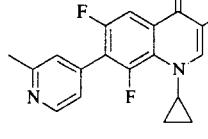
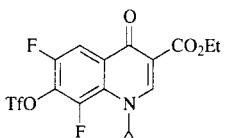
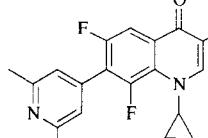
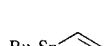
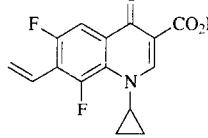
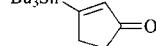
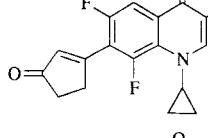
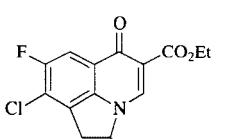
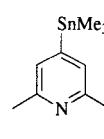
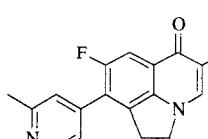
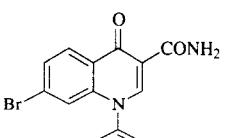
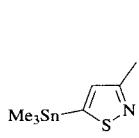
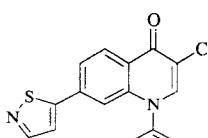
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>15</sub> 356 357		Bu <sub>3</sub> SnR	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, BHT, THF, 65°, 20 h	 (44)	257
					
				(31)	257
		Me <sub>3</sub> Sn-pyridine	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), MeO(CH <sub>2</sub> ) <sub>2</sub> OH, 140°, 20 h	 (25)	567
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3.5%), DMF, 165°, 20 min, 145°, 1 h	 (7)	567
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), MeO(CH <sub>2</sub> ) <sub>2</sub> OH, 140°, 7 h	 (43)	567
		Me <sub>3</sub> Sn-pyridine	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5.5%), MeO(CH <sub>2</sub> ) <sub>2</sub> OH, 140°, 24 h	 (24)	567
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, BHT, THF, 65°, 20 h	 (74)	257
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), LiCl, THF, reflux, 24 h	 (88)	257, 258
C <sub>16</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , EtOH	 (-)	602
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 150°	 (72)	713

TABLE XI. DIRECT CROSS-COUPLING OF QUINOLINE AND ISOQUINOLINE ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu3SnPh	Pd(PPh3)2Cl2, DMF, 150°, 1 h	 (56)	713
		1. Pd(PPh3)2Cl2, DMF, 150° 2. MeSO3H, MeOH	 (80)	713
		Pd(PPh3)2Cl2, DMF, 150°	 (—)	713
	Me3SnPh	Pd(PPh3)4 (10%), LiCl, dioxane, reflux	 (45)	714

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>3</sub> 359			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h	 (83)	108
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h	 (95)	108
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h	 (96)	108
			Pd(dppb)Cl <sub>2</sub> (5%), CuO, DMF, 100°, 0.5h	 (81)	96, 669
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , Ag <sub>2</sub> O, DMF, 100°, 80-100 min	 (25)	669
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , 80°, 24 h	 (85)	550
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 24 h	 (68)	651
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h	 (79)	108
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h	 (72)	108

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h		108	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h		108	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h		108	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h		108	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), THF, reflux, 20 h		667	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), THF, reflux, 20 h		667	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux		108	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 48 h		108	
<b>C<sub>4</sub></b>		Bu <sub>3</sub> Sn-2-methylthiophene	Pd(PPh <sub>3</sub> ) <sub>4</sub> , Ag <sub>2</sub> O, DMF, 100°, 20 h		669
		Bu <sub>3</sub> Sn-allyl	Pd <sub>2</sub> (dba) <sub>3</sub> , AsPh <sub>3</sub> , NMP, 40°		11
		Bu <sub>3</sub> Sn-allyl	Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, 100°, 2 h		264
		Bu <sub>3</sub> Sn-allyl	1. Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), NMP, rt, 16 h 2. 50°, 5 h		128
		Bu <sub>3</sub> Sn-2-methylthiophene	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, reflux		135, 669
		Bu <sub>3</sub> Sn-2-methylselenophene	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, reflux		135
<b>C<sub>5</sub></b>		Bu <sub>3</sub> Sn-2-methylpyridine	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 100°, Ag <sub>2</sub> O		669, 135
		Bu <sub>3</sub> SnR	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), NMP		128

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux, 20 h	(60)	425
		Pd <sub>2</sub> (dba) <sub>3</sub> , P(2-furyl) <sub>3</sub> , NMP, rt, 16 h	(78)	715
		Pd <sub>2</sub> (dba) <sub>3</sub> , P(2-furyl) <sub>3</sub> , NMP, 40°, 2 d	(65)	447
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux	(60)	425
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, 80°, 20 h	(58)	133
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, 90°, 20 h	(81)	133
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, 20 h		133
		100° 130° 80°	(81) (36) (84)	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, 45 h	(76)	133
		90° 100° 80°	(73) (75)	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 90°, 18 h		114
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 90°, 18 h		114
		(84) (58) (61)		
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 90°, 18 h	(61)	114
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.1%), PhMe, reflux, 8 d	(80)	716

TABLE XII. DIRECT CROSS-CO尤LING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
			Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), CuI, DMF, 60°		554
C <sub>6</sub>			Pd(dba) <sub>2</sub> , PPh <sub>3</sub> , PhMe, reflux, 5 h		116
364			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°		289
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 110°, 2 h		74
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (2.5%), PhMe, 110°, 1 h		116
			Pd(dba) <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), THF, 70°, 4 h		116
			Pd(dba) <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), THF, 80°, 8 h		116
C <sub>7</sub>			Pd(dba) <sub>2</sub> , PPh <sub>3</sub> , PhMe, reflux, 10 h		116
365			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), xylene, 120°, 20 h		531
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), xylene, 120°, 20 h		531
			Pd(dba) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), THF, 85°, 3 h		116
C <sub>8</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), K <sub>2</sub> CO <sub>3</sub> , DMF, reflux, 5 h		142
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%)		107
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%)		107

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>9</sub> 	Bu <sub>3</sub> SnR	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 24 h	 (47) (55) (57) (42)	123
366 	<u>R</u> CH=CH <sub>2</sub> CH <sub>2</sub> CH=CH <sub>2</sub> CH=C(Me) <sub>2</sub> Bu	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (7.6%), dioxane		717, 123
	<u>X</u> O S	70°, 2 h 95°, 1 h	 (89) (77)	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 24 h	 (60)	123
367 		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, 60°, 15 h 2. 90°, 1 h	 (83)	718
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, 100°, 4 h	 (28)	263
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 24 h	 (72)	123
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), dioxane, reflux, 3 h	 (52)	670

TABLE XII. DIRECT CROSS-COUPING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)2Cl2 or Pd(PPh3)4		717
		Pd(PPh3)4 (20%), PhMe, reflux, 24 h		127
368				
	Bu3SnR	Pd(PPh3)4, LiCl, THF, 65°		719
C10	Bu3SnR R _____ Bu [C5H11-n] [C6H4Cl-p] [C6H4Me-o] [C6H4Me-m] [C6H4Me-p] [C6H4OMe-p] [C8H17-n]	Pd(PPh3)4 (5%), K2CO3, DMF, reflux, 5 h		142
	[Bu3SnC5H11-n]	Pd(OAc)2 (5%), K2CO3, DMF, reflux, 18 h		142
	[Bu3SnR] R _____ C6H4Cl-p C6H4Me-p C6H4OMe-p	Pd(PPh3)4 (5%), K2CO3, DMF, reflux		142
369	[Bu3SnC8H17-n]	Pd(OAc)2 (5%), K2CO3, DMF, reflux, 18 h		142
	[Bu3SnR] R _____ C6H4Cl-p C6H4Me-p C6H4OMe-p	Pd(PPh3)4 (5%), K2CO3, DMF, reflux		142
	Bu3SnR R _____ CH=CH2 2-thienyl Ph C≡CPh (E)-CH=CHPh I	Pd(PPh3)2Cl2 (5%), Cl(CH2)2Cl, 50°, 20 h		720

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Et <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, reflux, 5 h	 (48)	721
	Et <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, reflux, 5 h	 (45)	721
	Bu <sub>3</sub> Sn-	Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), CH <sub>3</sub> CN, THF, 40°, 16 h		(81) 301
	Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), P(o-Tol) <sub>3</sub> , DMF, 100°, 18 h		(50) 120
	R <sub>4</sub> Sn — Me CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), NMP, 110° 2 h 14 h	 (72) (65)	130, 722
	R <sub>4</sub> Sn — Me CH=CH <sub>2</sub> Et	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), NMP, 110° 2 h 14 h 14 h	 (92) (75) (87)	130, 722
	Bu <sub>3</sub> Sn-	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 90°		(80) 723
	Bu <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (8%), DMF, 95°, 30 h		(82) 723
	R <sub>4</sub> Sn — Me CH=CH <sub>2</sub> Et	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), NMP, 110° 14 h 14 h 15 h	 (74) (70) (80)	130, 722

TABLE XII. DIRECT CROSS-COUPING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>11</sub>		Bu <sub>3</sub> SnR	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF		119
372		Bu <sub>3</sub> SnR R CH=CH <sub>2</sub> C(OEt)=CH <sub>2</sub> 2-pyridyl C≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, 110°, 4 h		724
		Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, 110°, 4 h		724
		Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), PhMe, reflux		111
		Bu <sub>3</sub> Sn<sup>≡</sup>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), BHT, PhMe, reflux, 1.5 h		72
		Bu <sub>3</sub> Sn<sup>C</sup>(OEt)<sub>2</sub>	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), PhMe, reflux, 17 h 2. HCl, rt, 2 h		726
		Bu <sub>3</sub> Sn<sup>≡</sup>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (10%), PhMe, reflux		118, 120
		Bu <sub>3</sub> Sn<sup>C</sup>(OEt)<sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 90°, 6 h		120
373		Bu <sub>3</sub> Sn<sup>≡</sup>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, 105°, 24 h		120
C <sub>12</sub>		Bu <sub>3</sub> SnR R CH=CH <sub>2</sub> 2-furyl Ph CH=CH <sub>2</sub> 2-furyl Ph	Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), CuI (10%), NMP, 100°, 30 min		727

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

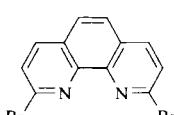
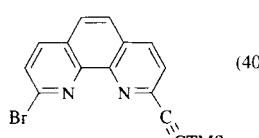
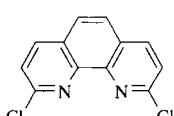
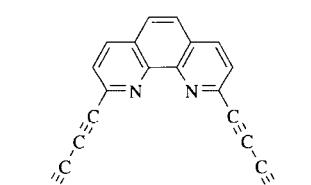
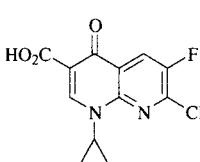
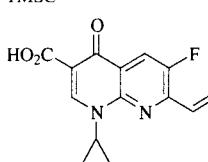
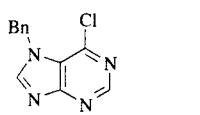
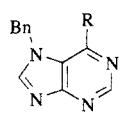
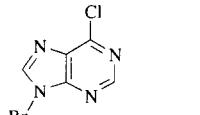
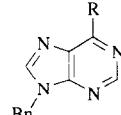
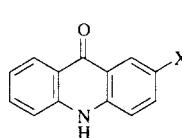
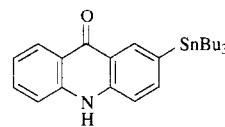
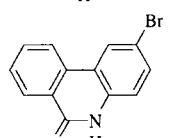
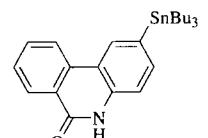
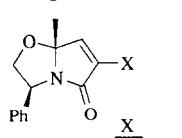
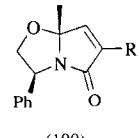
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Bu <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, 80°, 4 h	 (40)	728
		Bu <sub>3</sub> SnC≡C-C≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 50°, 18 h	 (10)	728
374		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), BHT, DMF, 50°, 5.5 h 2. rt, 64 h	 (30)	729
		Bu <sub>3</sub> SnR	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF		134
		R			
		Bu-n	reflux, 3 h	(65)	
		2-thienyl	100°, 16 h	(90)	
		Ph	110°, 4 h	(93)	
		Bn	reflux, 4 h	(62)	
		Bu <sub>3</sub> SnR	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), DMF		134
		R			
		CH=CH <sub>2</sub>	reflux, 3.5 h	(87)	
		Bu-n	reflux, 21 h	(18)	
		C(OEt)=CH <sub>2</sub>	100°, 4.5 h	(81)	
		2-thienyl	100°, 16 h	(87)	
		Ph	110°, 7 h	(75)	
		Bn	reflux, 18 h	(48)	
		(E)-CH=CHPh	100°, 24 h	(76)	
C <sub>13</sub>		Bu <sub>3</sub> SnSnBu <sub>3</sub>	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (1%), Bu <sub>4</sub> NBr, HMPA, 120°, 19 h	 X = Br (56) X = I (30)	613
375		Bu <sub>3</sub> SnSnBu <sub>3</sub>	PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (1%), Bu <sub>4</sub> NBr, HMPA, 110°, 10 h	 (10)	613
		Bu <sub>3</sub> SnR	Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), CuI (10%), NMP, 100°, 30 min	 (100) (70) (75) (95) (55) (72)	727
		R			
		CH=CH <sub>2</sub>			
		2-furyl			
		Ph			
		CH=CH <sub>2</sub>			
		2-furyl			
		Ph			

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

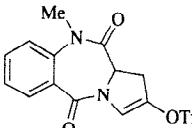
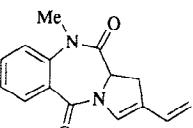
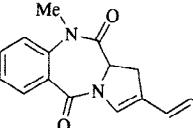
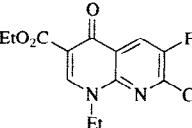
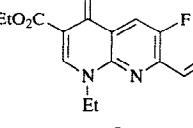
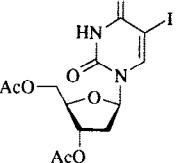
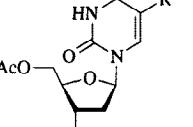
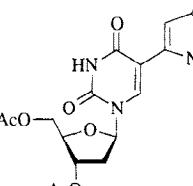
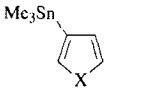
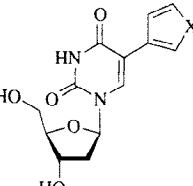
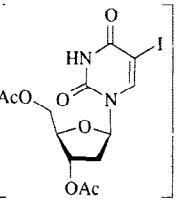
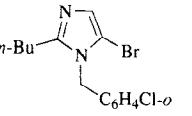
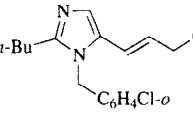
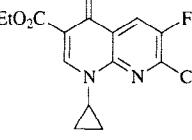
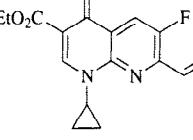
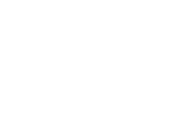
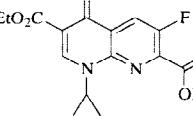
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_4$ (3-4%), LiCl, THF, 65°	 (60)	200, 730
		$\text{Bu}_3\text{SnCH}=\text{CHCO}_2\text{Et}$	$\text{Pd}(\text{PPh}_3)_4$ (3-4%), LiCl, THF, 65°	 (78)	200, 730
376		$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), BHT, THF, reflux, 20 h	 (70)	729
		$\text{Me}_3\text{SnR}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), THF, reflux	 (50)	731
		R		(44) (28) (56) (24)	
		2-thiazolyl 2-thienyl 3-Me-2-thienyl 5-Ph-2-thienyl 3-n-hexyl-2-thienyl	15 h 15 h 15 h 15 h 72 h		
			$\text{Pd}(\text{PPh}_3)_4$ (10%), DMF, 110°	 (89)	289
			1. $\text{Pd}(\text{OAc})_2$ (10%), $\text{PPh}_3$ , $\text{Et}_3\text{N}$ , NMP, 80°, 1 h 2. $\text{NH}_3$ , $\text{CH}_3\text{OH}$	 $X = \text{O}$ (44) $X = \text{S}$ (55)	670
377		$\text{Me}_3\text{SnC}_6\text{H}_4\text{X}$			
		$\text{Bu}_3\text{SnCH}=\text{CHCO}_2\text{Me}$	$\text{Pd}(\text{PPh}_3)_4$ (5%), BHT, PhMe, 110°, 5.5 h	 (81)	433
		$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), BHT, DMF, 50°, 5.5 h	 (97)	729
		$\text{Bu}_3\text{SnOMe}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (1.8%), BHT, THF, 58°, 77 h	 (92)	729

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd(PPh3)2Cl2 (2%), BHT, THF, 65°, 28 h	 (88)	729	
		Pd(PPh3)2Cl2 (9%), BHT, dioxane, reflux, 3 h	 (54)	729	
378		Pd(PPh3)4 (2%), BHT, dioxane, reflux, 40 h	 (48)	729	
		Pd(PPh3)2Cl2 (2%), DMF, reflux, 24 h	 (76)	258, 729	
		Pd(PPh3)2Cl2 (2.2%), BHT, THF, 65°, 26 h	 (67)	729	
379		Bu3SnCH=CONH2	Pd(PPh3)4 (4%), THF, reflux	 (22)	200
			Pd(PPh3)4 (20%), PhMe, reflux, 24 h	 (20)	127
			Pd(PPh3)4 (10%), DMF, 110°	 (96)	289
			Pd(PPh3)4, Ag2O, dioxane, reflux, 4 h	 (31)	582

TABLE XII. DIRECT CROSS-CO尤LING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref(s)
	$\text{Bu}_3\text{SnCH}_2\text{CO}_2\text{Me}$	$\text{Pd}(\text{PPh}_3)_4$ (4%), THF, reflux		(70) 200
	$\text{Bu}_3\text{SnCH}_2$	$\text{Pd}_2(\text{dba})_3$ (1%), $\text{P}(2\text{-furyl})_3$ (4%), NMP, rt, 72 h		(91) 128
	$\text{Bu}_3\text{SnCH}_2\text{OH}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , $\text{CH}_3\text{CN}$ , 100°		(68) 112
	$\text{Bu}_3\text{SnC}\equiv\text{CTMS}$	$\text{Pd}(\text{PhCN})_2\text{Cl}_2$		(77) 113
	$\text{Bu}_3\text{SnC}_6\text{H}_4\text{S}_2$	$\text{Pd}(\text{PPh}_3)_4$ (4%), PhMe, reflux, 22 h		(33) 717
	$\text{Bu}_3\text{SnR}$	$\text{Pd}(\text{PPh}_3)_4$ (5%), LiCl, BHT, dioxane, 100°		199, 374
	<u>R</u>			
	$\text{CH}=\text{CH}_2$	4 h	(87)	
	$\text{C}(\text{Me})=\text{CH}_2$	5 h	(86)	
	$(E)\text{-CH}=\text{CHCO}_2\text{Et}$	1 h	(92)	
	$\text{C}(\text{CO}_2\text{Et})=\text{CH}_2$	15 h	(46)	
	$(E)\text{-CH}=\text{CHTMS}$	4 h	(73)	
	$(E)\text{-CH}=\text{CHPh}$	8 h	(75)	
	$(E)\text{-CH}=\text{CHCH}_2\text{OSiMe}_2\text{Thex}$	5 h	(92)	
$\text{Me}_3\text{SnR}$	<u>R</u>			
	Ph	20 h	(64)	
	$\text{C}_6\text{H}_4\text{F}-4$	8 h	(89)	
	$\text{C}_6\text{H}_3\text{F}_2-3,5$	5 h	(81)	
	$\text{C}_6\text{H}_4\text{CF}_3-4$	3 h	(91)	
	$\text{C}_6\text{H}_4\text{OMe}-4$	28 h	(55)	
	$\text{C}_6\text{H}_3(\text{CF}_3)_2-3,5$	4 h	(85)	

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

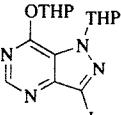
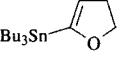
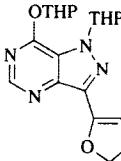
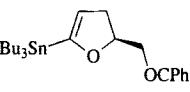
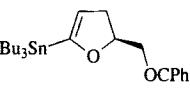
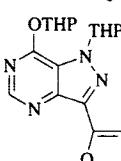
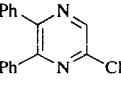
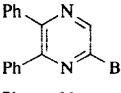
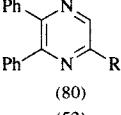
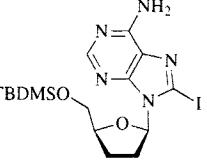
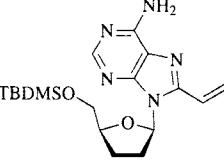
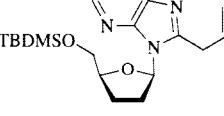
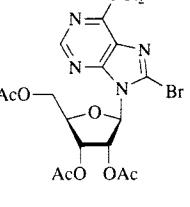
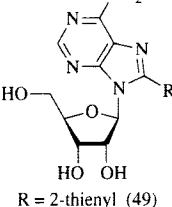
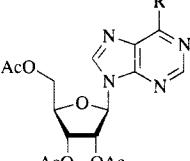
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
			Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 25°, 8 h	 (85)	301
			Pd(OAc) <sub>2</sub> (10%), AsPh <sub>3</sub> (20%), THF, CH <sub>3</sub> CN, 25°, 12 h	 (83)	301
382		Bu <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), K <sub>2</sub> CO <sub>3</sub> , DMF, reflux, 5 h	 (82)	142
	[Bu <sub>3</sub> SnR]	R C <sub>5</sub> H <sub>11</sub> - <i>n</i> C <sub>6</sub> H <sub>4</sub> Cl- <i>p</i> C <sub>6</sub> H <sub>4</sub> Me- <i>o</i> C <sub>6</sub> H <sub>4</sub> Me- <i>m</i> C <sub>6</sub> H <sub>4</sub> Me- <i>p</i> C <sub>6</sub> H <sub>4</sub> OMe- <i>p</i> C <sub>8</sub> H <sub>17</sub> - <i>n</i>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), K <sub>2</sub> CO <sub>3</sub> , DMF, reflux	 (80) (52) (53) (87) (88) (87) (83)	142
		Bu <sub>3</sub> Sn- 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 95°, 45 min	 (90)	131
		Bu <sub>3</sub> Sn- 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 145°, 45 min	 (75)	131
383			1. Pd(OAc) <sub>2</sub> , AsPh <sub>3</sub> , NEt <sub>3</sub> , NMP, 80°, 12 h 2. NH <sub>4</sub> OH, CH <sub>3</sub> OH, dioxane	 R = 2-thienyl (49) R = Ph (33)	732
	Bu <sub>3</sub> Sn-thienyl-2 Ph <sub>4</sub> Sn			 (53) (88)	722
		R Me CH <sub>2</sub> =CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), NMP		
			85°, 20 h 80°, 1 h		

TABLE XII. DIRECT CROSS-CO尤LING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	R <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), NMP	 (80) (95) (60) (45)	722
		R		
		Me	80°, 2 h	
		CH <sub>2</sub> =CH	80°, 4 h	
 384		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), BHT, DMF, reflux, 7 h	 (83)	729
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), BHT, dioxane, reflux, 55 h or Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF	 (42)	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.7%), PhMe, reflux	 (60)	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, DMF, 100°, 18 h	 (88)	
 385		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (12%), PPh <sub>3</sub> (60%), LiCl, BHT, DMF, 120°, 3 h 2. HCl (1 M), THF	 (50)	733 734 733 198
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, DMF, 100°, 16 h	 (77)	
		Pd <sub>2</sub> (dba) <sub>3</sub> (2%), P(2,4,6-trimethoxyphenyl) <sub>3</sub> (8%), ZnCl <sub>2</sub> , NMP, rt	 (69) (41) (73) (70) (73) (67) (64) (82) (77)	

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

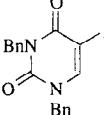
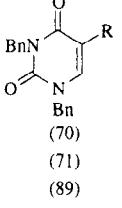
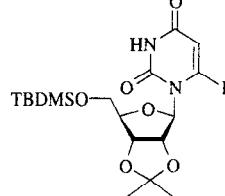
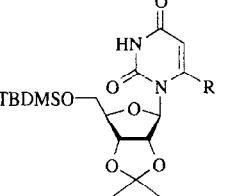
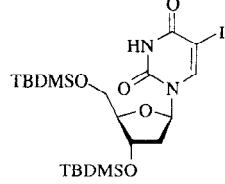
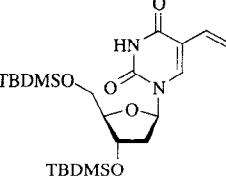
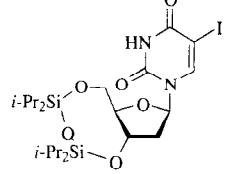
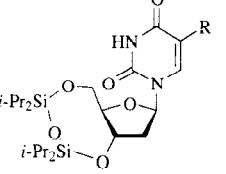
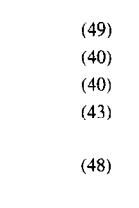
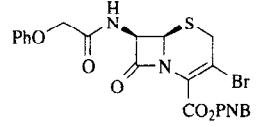
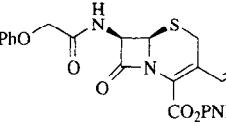
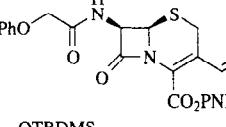
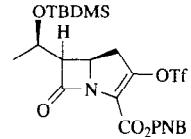
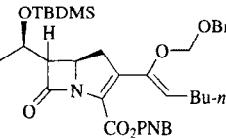
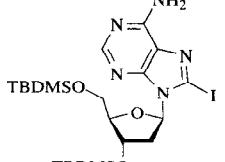
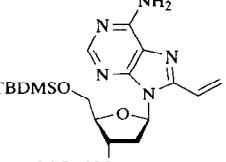
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{SnR}$ $\text{R} \begin{cases} \text{CN} \\ \text{SEt} \\ \text{SPh} \end{cases}$	$\text{Pd}(\text{PPh}_3)_4$ (5%), PhMe, 100°, 24 h	 (70) (71) (89)	319
	$\text{R}_4\text{Sn}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (10%), dioxane, 110°	 R = Me, 3 h, (>95) R = Ph, 12 h, (95)	132
	$\text{Bu}_3\text{Sn}\text{C}\equiv\text{C}$	$\text{Pd}_2(\text{dba})_3$ (1%), $\text{P}(\text{2-furyl})_3$ (4%), NMP, rt, 14 h	 (72)	128
	$\text{Me}_3\text{SnR}$ $\text{R} \begin{cases} \text{C}_6\text{H}_4\text{F}-4 \\ \text{C}_6\text{H}_3\text{F}_2-3.5 \\ \text{C}_6\text{H}_4\text{CF}_3-4 \\ \text{C}_6\text{H}_3(\text{CF}_3)_2-3.5 \end{cases}$	$\text{Pd}(\text{PPh}_3)_4$ (10%), dioxane, 75°, 24 h		122
			 (48)	
	$\text{Bu}_3\text{Sn}\text{C}\equiv\text{C}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , $\text{LiCl}$ , DMF, 25°	 (80)	197
	$\text{Bu}_3\text{Sn}\text{C}\equiv\text{C}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , $\text{LiCl}$ , DMF, 35°	 (64)	197
	$\text{Bu}_3\text{Sn}\text{C}\equiv\text{C}$ $\text{O} \text{---} \text{OBn}$	$\text{Pd}(\text{dba})_2$ (2%), $\text{P}(\text{2,4,6-trimethoxy-phenyl})_3$ (8%), $\text{ZnCl}_2$ , NMP, 50°, 3 h	 (75)	439
	$\text{Bu}_3\text{Sn}\text{C}\equiv\text{C}$	$\text{Pd}(\text{PPh}_3)_4$ (5%), DMF, 95°, 45 min	 (89)	131

TABLE XII. DIRECT CROSS-CO尤LING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
	<chem>Bu3SnCH=CH2</chem>				
	<chem>Bu3SnCN</chem>	Pd(PPh3)4 (5%), HMPA, 145°, 45 min		(89) 131	
388		<chem>Bu3SnCN</chem>	Pd(PPh3)4, DMF, reflux		(91) 723
	<chem>Bu3SnCH=CH2</chem>	Pd(CH3CN)2Cl2 (5%), DMF, 90°, 45 min		(69) 723	
		1. Pd(PPh3)4, DMF, reflux 2. Bu4NF		(87) 723	
	<chem>Bu3SnCH=CH2</chem>	1. Pd(CH3CN)2Cl2 (5%), DMF, 90° 2. Deprotection		(72) 723	
	<chem>Sn(C=CH2)4</chem>	1. Pd(CH3CN)2Cl2 (5%), DMF, 90° 2. Deprotection		(79) 723	
389		<chem>Bu3SnCN</chem>	Pd(PPh3)4, DMF, reflux		(—) 723
		<chem>Me3SnSnMe3</chem>	Pd(PPh3)4, LiCl, dioxane, reflux		(34) 735
		<chem>Bu3SnC1=CC=C(Si(i-Pr)2Br)C1=Br</chem>	Pd(PPh3)2Cl2 (12%), THF, reflux, 2 d		(66) 115

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

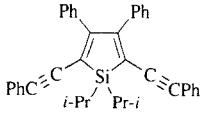
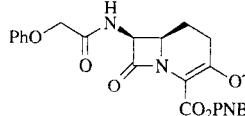
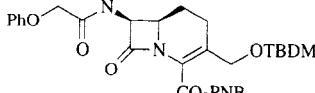
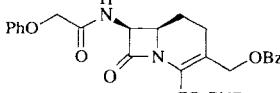
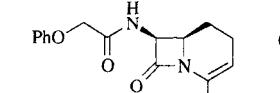
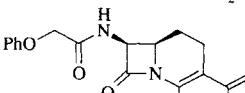
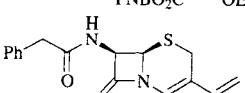
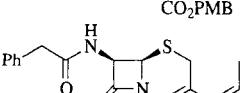
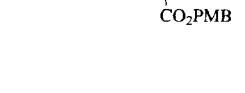
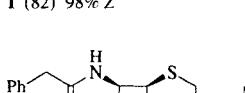
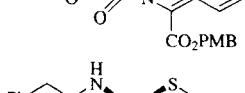
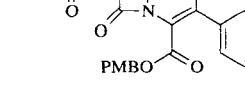
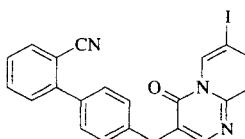
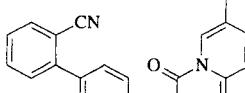
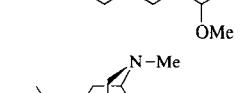
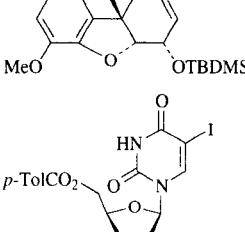
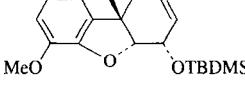
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
					
C <sub>23</sub>		Me <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 12 h	(100)	115
		Bu <sub>3</sub> SnCH <sub>2</sub> OTBDMS	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 65°		(25) 197
		Bu <sub>3</sub> SnCH <sub>2</sub> OBz	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 60°		(28) + 197
		Bu <sub>3</sub> SnCH <sub>2</sub> OBz	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 60°		(17)
360		Bu <sub>3</sub> SnCH <sub>2</sub> OBz	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , LiCl, DMF, 25°		(81) 197
		Bu <sub>3</sub> SnCH <sub>2</sub> CH=CH <sub>2</sub>	Pd(OAc) <sub>2</sub> (10%), NMP or CH <sub>2</sub> Cl <sub>2</sub> , rt, 3 min		(55) 451
		Bu <sub>3</sub> SnCH <sub>2</sub> CH=CH <sub>2</sub>	Pd(OAc) <sub>2</sub> (10%), NMP or CH <sub>2</sub> Cl <sub>2</sub> , rt, 20-180 min		I (>95) 451
		Bu <sub>3</sub> SnCH <sub>2</sub> CH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (8%), ZnCl <sub>2</sub> , NMP, 25°, 20 h		I (82) 98% Z 40
		Bu <sub>3</sub> SnCH <sub>2</sub> CH=CH <sub>2</sub>	Pd(OAc) <sub>2</sub> (10%), NMP, rt, 44 h		(36) 453
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> OMe	Pd(OAc) <sub>2</sub> (10%), NMP, rt, 24 h		(31) 453
391		Bu <sub>3</sub> SnCH <sub>2</sub> CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 80°		(→) 736
C <sub>24</sub>		Bu <sub>3</sub> SnCH <sub>2</sub> CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 80°		(90) 737
		Me <sub>4</sub> Sn	Pd(OAc) <sub>2</sub> (2%), P( <i>o</i> -Tol) <sub>3</sub> (8%), Et <sub>3</sub> N, DMF		(76) 125
C <sub>25</sub>		Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> , HMPA, 60°, 16 h		

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
(CH <sub>2</sub> =CH) <sub>4</sub> Sn		Pd(PPh <sub>3</sub> ) <sub>4</sub> , HMPA, 60°, 16 h	 I (80)	125
Bu <sub>3</sub> Sn <sup>≡</sup>		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (8%), NMP, rt, 72 h	 I (76)	128
Bu <sub>3</sub> Sn <sup>≡</sup>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), CH <sub>3</sub> CN, 20°, 6 h	 I (86)	121
Bu <sub>3</sub> Sn—S—C(=N)C=C		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), dioxane, 90°, 20 h 2. K <sub>2</sub> CO <sub>3</sub> , CH <sub>3</sub> OH	 (81)	718
Me <sub>3</sub> Sn—C=C—O—C <sub>6</sub> H <sub>4</sub> —F		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 7 h	 (95)	717
Me <sub>3</sub> Sn—C=C—S		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, reflux	 (87)	717
Bu <sub>3</sub> Sn—C=C—CO <sub>2</sub> Et		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), CH <sub>3</sub> CN, 50°, 20 h	 (57)	121
Bu <sub>3</sub> Sn—C=C—TMS		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), CH <sub>3</sub> CN, 60°, 16 h	 (82)	121
Ph <sub>4</sub> Sn		Pd(PPh <sub>3</sub> ) <sub>4</sub> , HMPA, 60°, 3 d	 (35)	125
Bu <sub>3</sub> Sn—C=C—Ph		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), CH <sub>3</sub> CN, 50°, 16 h	 (81)	121
Bu <sub>3</sub> Sn—C=C—OTHP		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), CH <sub>3</sub> CN, 60°, 16 h	 (82)	121
Me <sub>3</sub> SnSnMe <sub>3</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), EtOAc, reflux, 24 h	 (72)	670

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

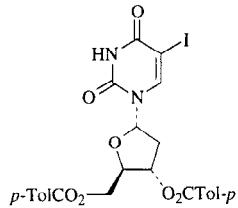
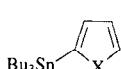
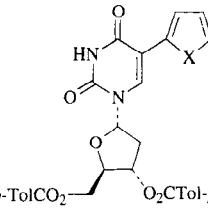
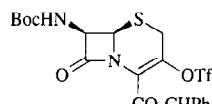
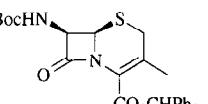
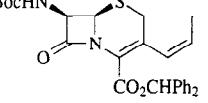
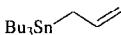
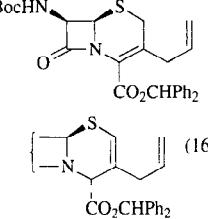
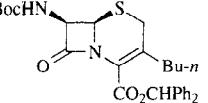
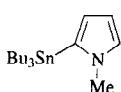
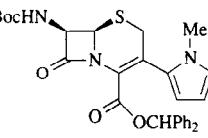
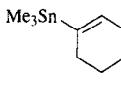
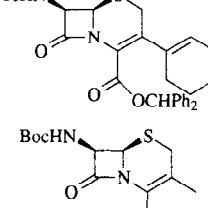
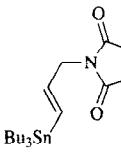
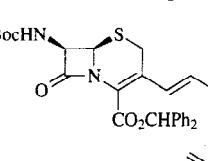
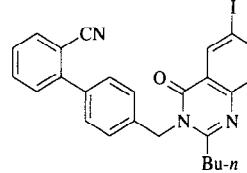
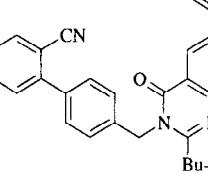
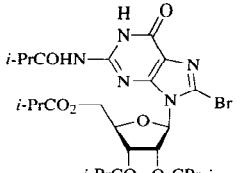
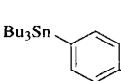
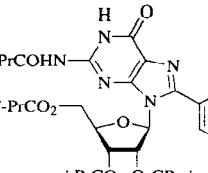
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF		X = O (—) 717 X = S (—)
	Me <sub>4</sub> Sn	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), NMP, 25°, 16 h		(85) 40
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), NMP, ZnCl <sub>2</sub> , 25°, 16 h		(90) 98% Z 40
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), NMP, 50°, 40 h		(48) + (16) + (12) 40
	Bu <sub>4</sub> Sn	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), NMP, 50°, 7 d		(16) 40
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), NMP, 25°, 1 h		(89) 40
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), NMP, 25°, 16 h		(17) + (74) 40
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), ZnCl <sub>2</sub> , NMP, 25°, 20 h		(73) 40
C <sub>26</sub>		Bu <sub>3</sub> Sn—CO <sub>2</sub> Me		(80) 738
		Pd(0), CuI, DMF		
				(67) 739

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
C <sub>27</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> (20%), PhMe, reflux, 24 h		(79)	127
963			Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, 100°, 15 h		(88)	740
C <sub>28</sub>		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	1. Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), P(o-Tol) <sub>3</sub> , PhMe 2. Et <sub>4</sub> NF, CH <sub>3</sub> CN		(63)	120
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (6%), P(o-Tol) <sub>3</sub> , PhMe, reflux, 3 h			(90)	741
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), P(o-Tol) <sub>3</sub> , PhMe, reflux, 36 h			(44)	120
	[OSnBu <sub>3</sub> ]	PdCl <sub>2</sub> (15%), P(o-Tol) <sub>3</sub> , PhMe, reflux, 4 h			(43)	741
	[OSnBu <sub>3</sub> ]	PdCl <sub>2</sub> (15%), P(o-Tol) <sub>3</sub> , PhMe, reflux, 4 h			(60)	741
387		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), DMF, 95°, 45 min		(92)	131
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 145°, 45 min			(81)	131
		[OSnBu <sub>3</sub> ]	1. Pd(OAc) <sub>2</sub> (10%) P(o-Tol) <sub>3</sub> , PhMe, reflux 2. Bu <sub>4</sub> NF, CH <sub>3</sub> CN		(40)	118

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{SnR}$	$\text{Pd}_2(\text{dba})_3$ (1%), $\text{P}(2\text{-furyl})_3$ (4%), $\text{ZnCl}_2$ R H $\text{CH}=\text{CH}_2$ $\text{CF}=\text{CF}_2$ $\text{C}\equiv\text{CMe}$ $\text{CH}=\text{CMe}_2$ $\text{C}(\text{OEt})=\text{CH}_2$ $\text{C}_6\text{H}_4\text{OMe}-p$	 (68) (79) (55) (50) (66) (52) (57)	40, 742
	$\text{Bu}_3\text{SnC}_6\text{H}_4\text{O}_2$	$\text{Pd}_2(\text{dba})_3$ (1%), $\text{P}(2\text{-furyl})_3$ (4%), $\text{ZnCl}_2$ , NMP, rt, 17 h	 (61)	743
	$\text{Bu}_3\text{SnR}$	$\text{Pd}(\text{OAc})_2$ (10%), NMP, rt R $\text{CH}=\text{CH}_2$ $(Z)\text{-CH}=\text{CHMe}$ $\text{CH}=\text{CMe}_2$	 (85) (>98) (47)	744
	$\text{Bu}_3\text{SnCH}_2\text{CO}_2\text{Et}$	1. $\text{Pd}(\text{OAc})_2$ (10%), $\text{P}(2\text{-furyl})_3$ , NMP 2. $\text{H}_3\text{O}^+$	 (58)	744
	$\text{Bu}_3\text{SnC}_6\text{H}_4\text{OMe}$	$\text{Pd}(\text{OAc})_2$ (10%), $\text{P}(2\text{-furyl})_3$ , NMP, rt, 16 h	 (>98)	744
	$\text{Me}_4\text{Sn}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (5%), $\text{LiCl}$ , DMF, 35°	  (28) +  (18)	197
	$\text{Bu}_3\text{SnR}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (5%), $\text{LiCl}$ , DMF	  (91)  (78)  (58) + R = H (5-10)  (66)  (88)  (76)	197
	$\text{Bu}_3\text{SnCH}_2\text{C}_6\text{H}_4\text{CH}_2\text{C}_6\text{H}_4\text{C}_6\text{H}_3\text{CH}_2$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (5%), $\text{LiCl}$ , DMF, 85°	  (28) +  (18)	197

TABLE XII. DIRECT CROSS-CO尤LING OF MISCELLANEOUS HETERO CYCLIC ELECTROPHILES (Continued)

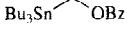
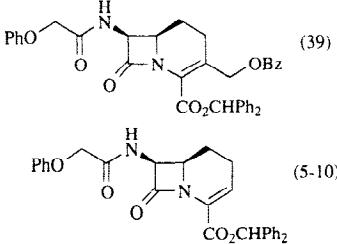
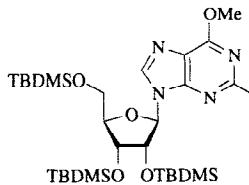
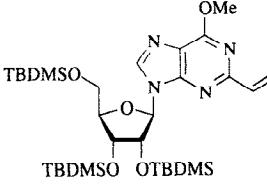
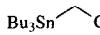
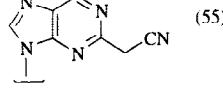
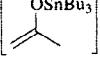
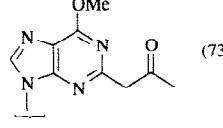
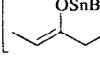
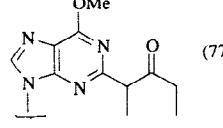
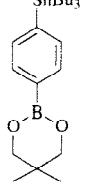
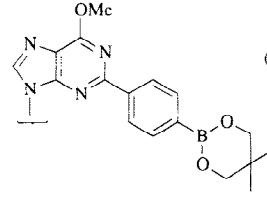
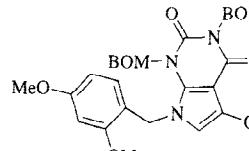
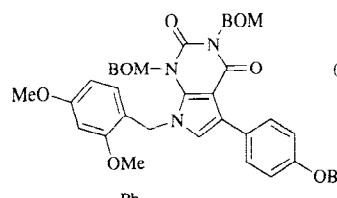
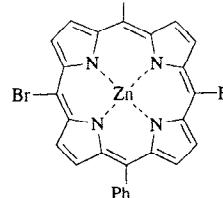
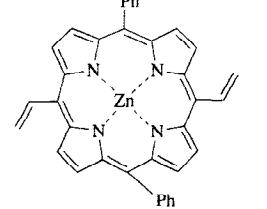
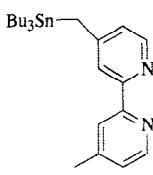
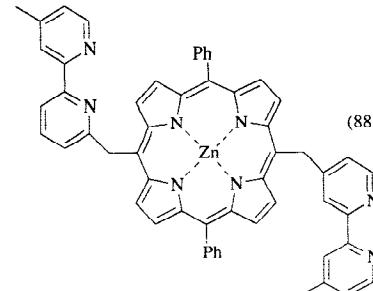
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{Sn}-\text{CH}_2-\text{OBz}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (5%), $\text{LiCl}$ , DMF, 60°		197
	$\text{Bu}_3\text{Sn}-\text{CH}_2-\text{I}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (10%), $\text{PhMe}$ , reflux		117, 118, 120
	$\text{Bu}_3\text{Sn}-\text{CH}_2-\text{CN}$	$\text{Pd}(\text{OAc})_2$ (10%), $\text{P}(o\text{-Tol})_3$ , $\text{PhMe}$ , reflux		117, 118
		$\text{Pd}(\text{OAc})_2$ (10%), $\text{P}(o\text{-Tol})_3$ , $\text{PhMe}$ , reflux, 6 h		117, 118
		$\text{Pd}(\text{OAc})_2$ (10%), $\text{P}(o\text{-Tol})_3$ (20%), $\text{PhMe}$ , reflux, 9 h		117
		$\text{Pd}(\text{PPh}_3)_4$ (20%), $\text{PhMe}$ , reflux, 24 h		127
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{OBn}$	$\text{Pd}_2(\text{dba})_3$ (5%), $\text{P}(2\text{-furyl})_3$ (10%), $\text{ZnCl}_2$ , NMP, 58°, 24 h		740
	$\text{Bu}_3\text{Sn}-\text{CH}_2-\text{I}$	$\text{Pd}(\text{PPh}_3)_4$ , $\text{PhMe}$ , 60°, 48 h		143
		$\text{Pd}(\text{PPh}_3)_4$ , $\text{PhMe}$ , 60°, 48 h		143

TABLE XII. DIRECT CROSS-CO尤LING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_4$ (60%), BHT, PhMe, reflux, 2 h		(85) 745
C <sub>33</sub>		$\text{Me}_4\text{Sn}$	1. $\text{Pd}(\text{PPh}_3)_4$ , HMPA, 60° 2. $\text{NH}_3$		(76) 125
402		$(\text{CH}_2=\text{CH})_4\text{Sn}$	1. $\text{Pd}(\text{PPh}_3)_4$ , HMPA, 60° 2. $\text{NH}_3$		(80) 125
		$(\text{CF}_2=\text{CF})_4\text{Sn}$	1. $\text{Pd}(\text{OAc})_2$ (10%), $\text{PPh}_3$ , $\text{NEt}_3$ , NMP, rt, 2 h 2. $\text{NH}_3$ , 48 h		(21) 746
		$\text{Ph}_4\text{Sn}$	1. $\text{Pd}(\text{PPh}_3)_4$ , HMPA, 60° 2. $\text{NH}_3$		(35) 125
C <sub>34</sub>		$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	$\text{Pd}_2(\text{dba})_3$ (1%), $\text{P}(2\text{-furyl})_3$ (4%), THF, 50°, 40 h		(98) 128
C <sub>37</sub>		$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , LiCl, DMF, 25°		(78) 197
403		$\text{Bu}_3\text{Sn}-\text{OBn}$	$\text{Pd}_2(\text{dba})_3$ (5%), $\text{P}(2\text{-furyl})_3$ (20%), NMP, 55°, 16 h		(71) 193
C <sub>38</sub>		$\text{Me}_3\text{Sn}-\text{C}_6\text{H}_4-\text{S}_\text{Ph}$	1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (10%), THF, 70°, 20 h 2. $\text{K}_2\text{CO}_3$ , $\text{CH}_3\text{OH}$		(31) 718

TABLE XII. DIRECT CROSS-COUPLING OF MISCELLANEOUS HETEROCYCLIC ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>45</sub>			1. Pd (II) 2. H <sub>3</sub> O <sup>+</sup>		747
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF, 90°		748
C <sub>46</sub>			1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), Ag <sub>2</sub> O, DMF, 100°, 48 h 2. NH <sub>4</sub> OH, dioxane, 60°		718

TABLE XIII. DIRECT CROSS-COUPLING OF ACYL CHLORIDES: ALKYL SYSTEMS

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>2</sub>		Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 140°, 5 h	(53)	1
			Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl (2%), CH <sub>2</sub> Cl <sub>2</sub> , 40°, 3 h	(51)	2
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , reflux, 1 h	(44)	749
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , rt, 0.5 h	(70)	749
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, rt, 12 h	(43)	288
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.08%), C <sub>6</sub> H <sub>6</sub> , reflux, 3 h	(82)	271
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (7%), THF, reflux, 2 h	(96)	459
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (14%), THF, reflux, 6 h	R = Me (71) R = Bu (52)	459
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , reflux, 24 h	(42)	749
	Me <sub>3</sub> SnPh		[{η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> }PdCl] <sub>2</sub> (1%), HMPA, 20°, 24 h	I (70)	750, 751, 415
404	Ph <sub>4</sub> Sn		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.05%), HMPA, 65°	I (76)	147, 1
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), HMPA, 0°, 2 h	(38)	752
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 12 h	(81)	537
	Me <sub>3</sub> SnCH <sub>2</sub> Ph		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 12 h	(69)	2
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.8%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 84°, 2 h	(31)	149
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 100°, 30 h	(100)	148, 753
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 60°, 3 h	(93)	148, 753

TABLE XIII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), CO (15 psi), C <sub>6</sub> H <sub>6</sub> , 80°		(68) 268
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.6%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, HMPA, 50°, 24 h		(66) 754
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.8%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 84°, 2 h		(55) 149
		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl (2%), CH <sub>2</sub> Cl <sub>2</sub> , 60°, 10 h		(30) 755
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 8 h		(70) 285
		PdCl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 4 d		(24) 284
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 100°, 30 h		(47) 148, 753
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 60°, 3 h		(86) 148
	Bu <sub>3</sub> SnC≡CCH <sub>2</sub> OTBDMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.8%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 84°, 2 h		(48) 149
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.05%), THF, reflux, 8 h		(68) 756
		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl, CH <sub>2</sub> Cl <sub>2</sub> , 60°, 48 h		(72) 150, 30
		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl, CH <sub>2</sub> Cl <sub>2</sub> , 60°, 48 h		(74) 150, 30
		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl, CH <sub>2</sub> Cl <sub>2</sub> , 60°, 16 h		(62) 150, 30
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, C <sub>6</sub> H <sub>6</sub> , rt, 4 h		(79) 543
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), 80°, 300 h		(62) 256
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), CuCN, PhMe, 75°, 16 h		(<5) 243
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4%), CO (30 psi), C <sub>6</sub> H <sub>6</sub> , 90°, 9 h		(52) 757

TABLE XIII. DIRECT CROSS-COUPLING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

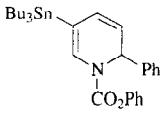
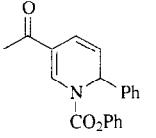
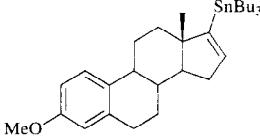
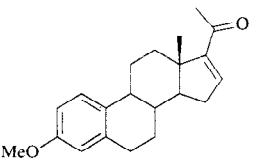
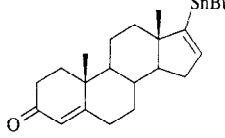
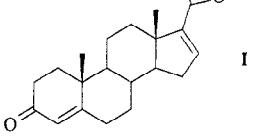
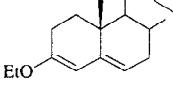
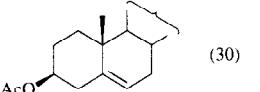
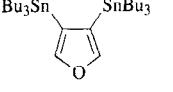
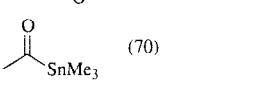
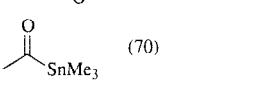
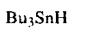
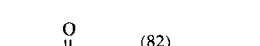
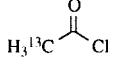
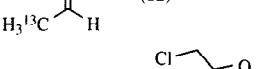
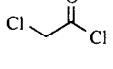
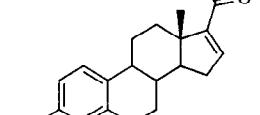
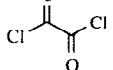
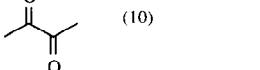
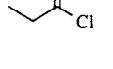
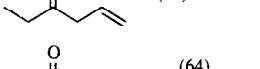
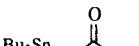
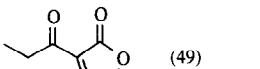
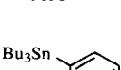
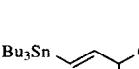
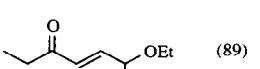
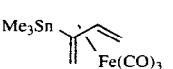
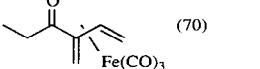
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub>	 (45)	758
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), HMPA, 80°	 (60)	513
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), HMPA, 80°	 <b>I</b> (40)	513
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), HMPA, 80°	 <b>I</b> (10)	513
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), HMPA, 80°	 (30)	513
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 80°, 24 h	 (59)	287, 546
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl or Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux, dark, 12 h	 (70)	309, 759
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, -70°	 (82)	760
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), HMPA, 80°	 (60)	513
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.05%), HMPA, 65°	 (10)	147
		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl (2%), CH <sub>2</sub> Cl <sub>2</sub> , 40°, 5 h	 (70)	2
		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl (2%), C <sub>6</sub> H <sub>6</sub> , 80°, 12 h	 (64)	2
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 60°, 16 h	 (49)	761, 762
		Pd(Ph-BIAN) (dimethyl fumarate) (1%), DMF, 50°, 17 h	 (85)	415
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), DMF, 20°, 2 h	 (89)	763
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.6%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, HMPA, 80°, 2 h	 (70)	754

TABLE XIII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 8 h		(76) 284
		PdCl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 4 d		(55) 284
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, THF, reflux, 9 h		(81) 764
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (6.5%), THF, 70°, 20 h		(70) 287
		Pd <sub>2</sub> (dba) <sub>3</sub> (0.05%), HMPA, 100°, 2.4 h		(30) 247
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (3.7%), CO (30 psi), C <sub>6</sub> H <sub>6</sub> , 90°, 21 h		(67) 757
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), THF, reflux, 18 h		(70) 309, 759
		Pd <sub>2</sub> (dba) <sub>3</sub> (0.05%), CHCl <sub>3</sub> , 100°, 16 h		(22) 247
C <sub>4</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CO (15 psi), BHT, C <sub>6</sub> H <sub>2</sub> Me <sub>4</sub> -1,2,3,4, 100°, 1.5 h		(73) 250
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.05%), THF, reflux, 8 h		(76) 756
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), PhMe, 100°, 16 h		(43) 759
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), Et <sub>2</sub> O, rt		(95) 156
		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl (2%), C <sub>6</sub> H <sub>6</sub> , 80°, 12 h		(37) 2
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.5%), CH <sub>3</sub> CN, rt, 1 h		(55) 267
Bu <sub>3</sub> SnC≡CR R CO <sub>2</sub> Me TMS CH(OEt) <sub>2</sub>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.8%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 84°, 2 h		(67) (71) (70) 149
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), CO (15 psi), C <sub>6</sub> H <sub>6</sub> , 80°		(64) 268

TABLE XIII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		BnPd(PPh3)2Cl (2.6%), Cl(CH2)2Cl, HMPA, 80°, 2 h	R = Me, (58) R = Bu, (48)	754
		Pd(CH3CN)2Cl2 (1%), DMF, 20°, 2 h	(83)	763
		Pd(PPh3)2Cl2 (1.8%), Cl(CH2)2Cl, 84°, 2 h	(77)	149
		Pd(PPh3)2Cl2 (5%), C6H6, reflux, 8 h	(82)	284
		PdCl2 (5%), C6H6, reflux, 4 d	(28)	284
		Pd(PPh3)2Cl2 (1.8%), Cl(CH2)2Cl, 84°, 2 h	(60)	149
		Pd(CH3CN)2Cl2, THF, reflux, 12 h	(40)	765
		BnPd(PPh3)2Cl (0.01%), BHT, THF, 10° to rt, 4 h	R = Me (90) R = Bn (70)	766
		BnPd(PPh3)2Cl (2%), CHCl3, 65°, 24 h	(38)	537
		BnPd(PPh3)2Cl (2.5%), CuI, THF, 50°, 30 min	(41)	268
		BnPd(PPh3)2Cl (10%), THF, rt, 2 h	(65)	152
		Pd(CH3CN)2Cl2 (5%), HMPA, 80°	(35)	513
		Pd(PPh3)4 (1%), C6H6, rt	(71)	156
		Pd(PPh3)2Cl2 (4%), CuCN, PhMe, 75°, 32 h	(68)	243
		Pd(PPh3)2Cl2 (5%), THF, 80°, 24 h	(57)	287, 546
		Pd(PPh3)4 (5%), CO (15 psi), BHT, C6H2Me4-1,2,3,4, 100°, 1.5 h	(44)	250

414

415

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TABLE XIII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub>	(—)	244
	Bu <sub>3</sub> SnH	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.08%), C <sub>6</sub> H <sub>6</sub> , reflux, 3 h	(82)	271
	Bu <sub>3</sub> SnH	PhCOPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), THF, rt	(89)	156
	Me <sub>4</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.05%), HMPA, 65°	(82)	4
	Bu <sub>3</sub> SnH	Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl (2%), C <sub>6</sub> H <sub>6</sub> , 80°, 10 h	(72)	2
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CO (15 psi), BHT, C <sub>6</sub> H <sub>2</sub> Me <sub>4</sub> -1,2,3,4, 100°, 1.5 h	(30)	250
	Me <sub>3</sub> SnH	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , reflux, 4 h	(79)	749
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, 80°, 24 h	(75)	376
	Me <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 8 h	(73)	284
	Bu <sub>3</sub> SnH	PdCl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 4 d	(7)	284
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 100°, 30 h	(87)	148, 753
	Bu <sub>3</sub> SnH	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (30 psi), C <sub>6</sub> H <sub>6</sub> , 90°, 5.5 h	(69)	757
	Bu <sub>3</sub> SnH	Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), THF, rt, 6 h	(96)	447
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), PhMe, 100°, 16 h	(80)	759
	Me <sub>3</sub> SnH	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , reflux, 1 h	(79)	749
	Bu <sub>3</sub> SnH	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 60°, 16 h	(47)	761
	Bu <sub>3</sub> SnH	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, CO, CHCl <sub>3</sub> , 65°, 16 h	(56)	761, 762
	Me <sub>3</sub> SnH	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 48 h	(60)	537

TABLE XIII. DIRECT CROSS-CO尤LING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), CuCN, PhMe, 75°, 64 h		243
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, rt, 12 h		288
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), CHCl <sub>3</sub> , 65°		146
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), THF, rt		146
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.05%), HMPA, 65°		147
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.01%), BHT, THF, 10° to rt, 4 h		766
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.05%), HMPA, 65°		147
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.6%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, HMPA, 80°, 2 h		754
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , rt		156
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.7%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 0.5 h		767
		PdCl <sub>2</sub> (1%), PPh <sub>3</sub> , C <sub>6</sub> H <sub>6</sub> , rt		156
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CO (15 psi), BHT, PhMe, 100°, 2.5 h		250
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , reflux, 1 h		749
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 8 h		284
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 8 h		284
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 8 h		284
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 8 h		284

TABLE XIII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
420		PdCl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 4 d		284
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 10 h		284
		PdCl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 5 d		284
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), THF, 25°, 16 h		447, 768
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CO (30 psi), C <sub>6</sub> H <sub>6</sub> , 100°, 3.5 h		757
		Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), THF, rt, 6 h		447
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , rt		156
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.4%), PhMe, 110°, 24 h		307
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, C <sub>6</sub> H <sub>6</sub> , 100°, 24 h		305
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux		277
421		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.8%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 15 min		767
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, HMPA, 100°, 16 h		305
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, 65° 2. Bu <sub>4</sub> NF, THF		532
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.05%), THF, reflux, 8 h		756
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 70°		574
C <sub>8</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), CHCl <sub>3</sub> , reflux, 24 h		427

TABLE XIII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu3SnH	Pd(PPh3)4 (1%), C6H6, rt, 2 h	(77)	769
	Bu3Sn-	BnPd(PPh3)2Cl (1%), C6H6, reflux, 1 h	(62)	749
	Bu3Sn-	Pd(PPh3)4 (5%), CO (15 psi), BHT, PhMe, 100°, 2 h	(59)	250
	Bu3Sn-	BnPd(PPh3)2Cl (1%), HMPA, 65°, 24 h	(78)	262
	Bu3Sn-	BnPd(PPh3)2Cl (1%), C6H6, reflux, 1 h	(82)	749
	Bu3Sn-	BnPd(PPh3)2Cl (1%), CHCl3, reflux, 24 h <i>E:Z = 1:7</i>	(25) <i>E:Z = 1:5</i>	427
		[ $(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}_2$ ] (1%), P(OEt)3, CO (120 psi), PhMe, 111°, 2 h	(78)	308
	Bu3Sn-	BnPd(PPh3)2Cl (5%), CO (45 psi), PhMe, 100°, 7 h	(38)	770
	Me4Sn	BnPd(PPh3)2Cl (0.05%), HMPA, 65°	(99)	4
	Bu3SnC≡CTMS	Pd(PPh3)2Cl2 (2.2%), Cl(CH2)2Cl, reflux, 5 min	(31)	767
	Bu3Sn-	Pd(PPh3)2Cl2 (3%), THF, rt, 12 h	(86)	288
	Bu3Sn-	Pd(PPh3)4, dioxane, 100°	(45)	771
	Bu3SnH	Pd(PPh3)4 (1%), C6H6, rt	(85)	156
	Bu3Sn-	BnPd(PPh3)2Cl (0.4%), Cl(CH2)2Cl, 60°, 16 h	(49)	761
	Bu3Sn-	BnPd(PPh3)2Cl, THF, 90°	(85)	581
	Bu3Sn-	BnPd(PPh3)2Cl (1%), HMPA, 65°, 22 h	(83)	262
	Me3SnSnMe3	Pd(PPh3)2Cl2 (5%), PhMe, 100°, 20 h	(80)	759

TABLE XIII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

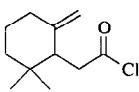
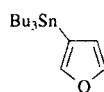
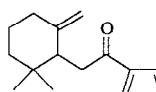
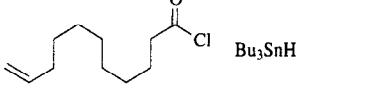
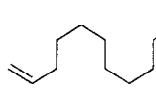
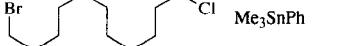
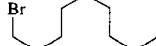
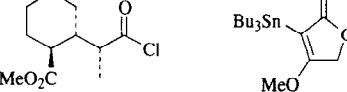
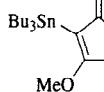
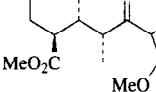
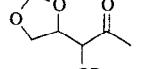
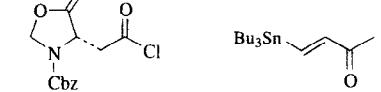
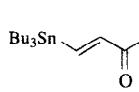
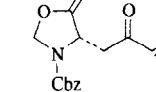
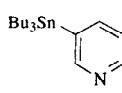
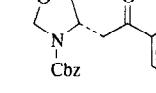
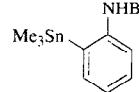
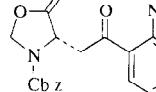
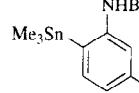
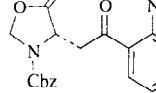
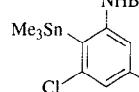
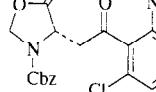
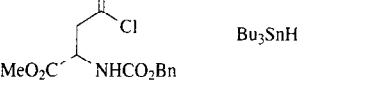
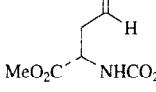
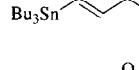
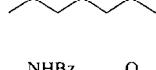
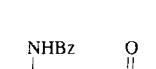
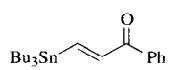
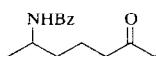
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		BnPd(PPh3)2Cl (0.63%), HMPA, 65°, 22 h	 (95)	772
		Pd(PPh3)4 (1%), C6H6, rt	 (88)	156
		BnPd(PPh3)2Cl (0.4%), CHCl3, 65°, 5 h	 (87)	146
		BnPd(PPh3)2Cl (0.4%), Cl(CH2)2Cl, 60°, 16 h	 (49)	761, 762
		BnPd(PPh3)2Cl, CO (15 psi), HMPA, rt, 4 h	 (87)	773
		Pd(PPh3)4 (5%), dioxane, 100°, 30 h	 (45)	148
		Pd(PPh3)2Cl2 (0.7%), C6H6, reflux, 12 h	 (48)	774
		Pd2(dba)3 (0.5%), PhMe, 70°, 4 h	 (79)	775
		Pd(CH3CN)2Cl2, PhMe, reflux	 (62)	775
		Pd(CH3CN)2Cl2, PhMe, reflux	 (53)	775
		Pd(PPh3)4 (7%), THF, rt	 (>77)	776
		Pd(PPh3)4 (5%), dioxane, 100°, 30 h	 (37)	148
		Pd(PPh3)4 (5%), dioxane, 100°, 30 h	 (38)	148
		Pd(PPh3)4 (5%), dioxane, 60°, 3 h	 (50)	148
		Pd(PPh3)4 (5%), dioxane, 100°, 30 h	 (38)	148

TABLE XIII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKYL SYSTEMS (Continued)

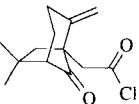
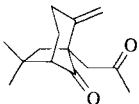
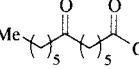
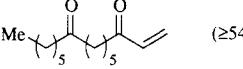
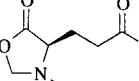
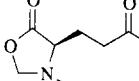
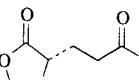
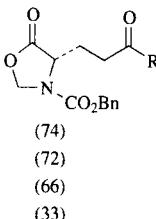
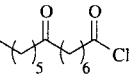
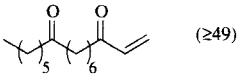
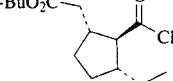
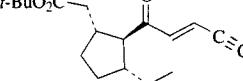
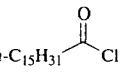
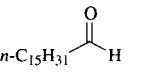
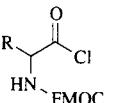
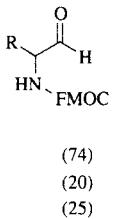
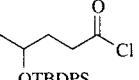
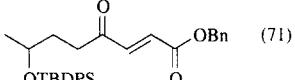
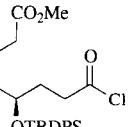
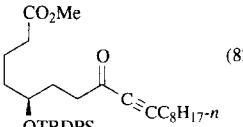
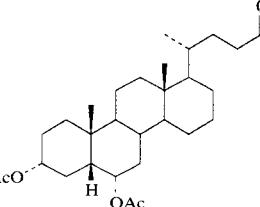
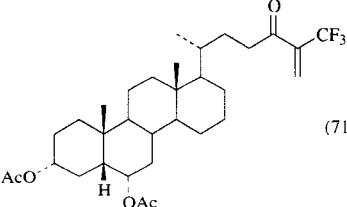
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Me4Sn	BnPd(PPh3)2Cl, HMPA, 65°, 3 d	 (82)	777
C <sub>14</sub>		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	BnPd(PPh3)2Cl, C <sub>6</sub> H <sub>6</sub> , reflux, 3.5 h	 (≥54)	778
426		Me4Sn	BnPd(PPh3)2Cl (0.5%), HMPA, 65°, 4 h	 (58)	779
		R <sub>4</sub> Sn <u>R</u> Me Et Bu Bn	BnPd(PPh3)2Cl (0.5%), HMPA, 65°, 4 h	 (74) (72) (66) (33)	779
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	BnPd(PPh3)2Cl (1%), C <sub>6</sub> H <sub>6</sub> , reflux, 2.5 h	 (≥49)	780
C <sub>16</sub>		Bu <sub>3</sub> SnCH=CHC≡CTMS	BnPd(PPh3)2Cl (5%), THF, 50°	 (76)	781
		Bu <sub>3</sub> SnH	Pd(PPh3)4 (5%), C <sub>6</sub> H <sub>6</sub> , rt, 2 h	 (75)	156, 769
		Bu <sub>3</sub> SnH	Pd(PPh3)4, THF, rt	 (74) (20) (25)	782
427		Bu <sub>3</sub> SnCH=CHCOOBn	BnPd(PPh3)2Cl (2.4%), CO (15 psi), CHCl <sub>3</sub> , 65°, 30 h	 (71)	146, 783
C <sub>25</sub>		Me <sub>3</sub> SnC≡CC <sub>8</sub> H <sub>17-n</sub>	Pd(PPh3)2Cl <sub>2</sub> (2%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 30 min	 (82)	784
C <sub>29</sub>		Bu <sub>3</sub> SnCF <sub>3</sub>	BnPd(PPh3)2Cl (1%), HMPA, 65°, 24 h	 (71)	262

TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>7</sub>	Ph-C(=O)Cl	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PPh <sub>3</sub> , C <sub>6</sub> H <sub>6</sub> , rt	Ph-C(=O)H (95)	156, 769
	Me <sub>4</sub> Sn		Pd(Ph-BIAN) (dimethyl fumarate) (1%), DMF, 50°, 16 h	Ph-C(=O)Ph (98)	415, 147, 4, 750, 1
	Et <sub>3</sub> SnMe		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.45%), HMPA, 65°	Ph-C(=O)Ph + Ph-C(=O)Et (—) 83:17	27
	Bu <sub>3</sub> SnMe		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.45%), HMPA, 65°	Ph-C(=O)Ph + Ph-C(=O)Bu-n (—) 57:43	27
	Me <sub>3</sub> Sn-		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), CHCl <sub>3</sub> , 65°, 18 h	Ph-C(=O)- I (88)	146, 750
	Bu <sub>3</sub> Sn-		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 40°, 5 h	I (87)	1, 785, 146
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, 40°, 47 h	I (95)	376
	Me <sub>3</sub> Sn-OMe		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), CHCl <sub>3</sub> , 65°, 18 h	Ph-C(=O)-OMe (48) + Ph-C(=O)Ph (16)	146
	Bu <sub>3</sub> Sn-OMe		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), CHCl <sub>3</sub> , 65°, 18 h	Ph-C(=O)-OMe (36) + Ph-C(=O)Bu-n (14)	146
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.45%), CHCl <sub>3</sub> , 65°	Ph-C(=O)- I + Ph-C(=O)- II (—) 50:50	27
428			Pd <sub>2</sub> (dba) <sub>3</sub> (1%), L (8%), THF, 24°	I + II (>90), I:II = 70:30 L = PPh <sub>3</sub> L = AsPh <sub>3</sub> L = P(2-furyl) <sub>3</sub>	11
	Bu <sub>3</sub> Sn-		Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl (2%), C <sub>6</sub> H <sub>6</sub> , 80°, 5 h	Ph-C(=O)- (86)	2
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), PhMe, 90°, 65 h	Ph-C(=O)- (53) + Ph-C(=O)- (7) + Ph-C(=O)- (5)	376
	Bu <sub>3</sub> Sn-		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CO (15 psi), BHT, PhMe, 100°, 3 h	Ph-C(=O)- (75)	250
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), HMPA, 65°, 3 h	Ph-C(=O)-CF <sub>3</sub> (90)	262
	Bu <sub>3</sub> Sn-OEt		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), dioxane, 60°, 3 h	Ph-C(=O)-OEt (60)	148
	Me <sub>3</sub> Sn-		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , reflux, 1 h	Ph-C(=O)-OMe (73)	749
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TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)2Cl2 (1%), 100°, 20 h	(43)	529
		Pd(PPh3)4 (5%), PhMe, 40°, 48 h	(74) E:Z = 69:31	376
430	Bu4Sn	BnPd(PPh3)2Cl (0.05%), HMPA, 65°	(91)	4, 146, 1, 27
		BnPd(PPh3)2Cl (0.4%), CHCl3, 65°, 4.5 h	(63) E:Z = 30:70	146, 783
		BnPd(PPh3)2Cl (2.5%), CuI, THF, 50°, 20 min	(84)	268
		Pd(PPh3)2Cl2, dioxane, reflux, 3 h	(80)	292, 530
		BnPd(PPh3)2Cl (1.5%), CH3CN, rt, 2 h	(81)	267
		BnPd(PPh3)2Cl (1.5%), C6H6, 100°	(75)	269
431		Pd(PPh3)4 (5%), dioxane, 100°, 30 h	(70)	148, 753
		BnPd(PPh3)2Cl, CH2Cl2, 65°, 4 h	(71)	305, 532
		BnPd(PPh3)2Cl, C6H6, 100°, 48 h	(85)	305
		Pd2(dba)3 (1%), p-Tol-BIAN, THF, 65°, 3 h	(53)	415
		Pd(PPh3)2Cl2 (3%), THF, rt, 12 h	(91)	288, 287
		Pd(PPh3)2Cl2 (1.4%), PhMe, 110°, 24 h	(59)	307
		BnPd(PPh3)2Cl (0.08%), C6H6, reflux, 3 h	(93)	271
		[( <i>n</i> 3-C3H5)PdCl]2 (1%), HMPA, 20°, 5 min	(87)	750
		BnPd(PPh3)2Cl (0.4%), ClICl3, 65°, 23 h	(70)	146
		Pd(PPh3)4, PhMe, reflux	(82)	277

TABLE XIV. DIRECT CROSS-COUPLING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)2Cl2 (5%), C6H6, reflux, 8 h	(67)	284
		Pd(PPh3)2Cl2 (7%), Cl(CH2)2Cl, reflux	(97)	459
		Pd(PPh3)2Cl2 (14%), THF, reflux		459
432		Pd(PPh3)4 (5%), PhMe, 40°, 44 h	(64)	376
		BnPd(PPh3)2Cl, CO, CHCl3, 65°, 16 h	(47)	762, 761
	Bu3SnC≡CTMS	Pd(PPh3)2Cl2 (1.8%), Cl(CH2)2Cl, 84°, 2 h	(64)	149
		Pd(PPh3)2Cl2, CH2Cl2, 82°	(65)	263
433	Me3SnPh	[ $(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}_2$ ] (1%), Cl(CH2)2Cl, 75°	(>98)	786, 147, 750, 4, 1, 27
		[ $(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}_2$ ] (1%), HMPA, 20°, 10 min	(77)	750, 751
		Pd(PPh3)2Cl2 (5%), C6H6, reflux, 8 h	(60)	284
		[ $(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}_2$ ] (1%), HMPA, 20°, 20 min	(97)	750, 751
		BnPd(PPh3)2Cl (2%), 110-120°, 20 h	(77)	534
		BnPd(PPh3)2Cl (1%), THF, 100°, 16 h	(72)	305
		Pd(PPh3)4 (1%), HMPA, 0°, 3 h	(51)	752
		BnPd(PPh3)2Cl (2%), CHCl3, 65°, 24 h	(73)	537

TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.s.
<chem>Me3SnCH2Ph</chem>	<chem>Me3SnCH2Ph</chem>	BnPd(PPh3)2Cl (0.05%), HMPA, 65°	I (91)	147, 750, 751
<chem>Me3SnCH2Ph</chem>	<chem>Me3SnCH2Ph</chem>	BnPd(PPh3)2Cl (0.45%), CHCl3, 65°	I + II (→) I:II = 17:83	146
<chem>Me3SnCH2Ph</chem>	<chem>Me3SnCH2Ph</chem>	BnPd(PPh3)2Cl (0.45%), HMPA, 65°	I + II (→) I:II = 10:90	146
<chem>Me3SnCH2Ph</chem>	<chem>Me3SnCH2Ph</chem>	BnPd(PPh3)2Cl (4%), HMPA, 65°	I + II (→) I:II = 60:40	146
<chem>Bu3SnCH2Ph</chem>	<chem>Bu3SnCH2Ph</chem>	BnPd(PPh3)2Cl (0.45%), CHCl3, 65°	I (6) + III (34)	146
<chem>Bu3SnCH2Ph</chem>	<chem>Bu3SnCH2Ph</chem>	BnPd(PPh3)2Cl (0.45%), HMPA, 65°	I (9) + III (51)	146
<chem>Bu3SnCH2Ph</chem>	<chem>Bu3SnCH2Ph</chem>	BnPd(PPh3)2Cl (4%), HMPA, 65°	I (78) + III (6)	146
<chem>(Bn)4Sn</chem>	<chem>(Bn)4Sn</chem>	BnPd(PPh3)2Cl (0.05%), HMPA, 65°	I (95)	4
<chem>Bu3Sn(CD)2Ph</chem>	<chem>Bu3Sn(CD)2Ph</chem>	BnPd(PPh3)2Cl (4%), HMPA, 65°, 16 h	I (71)	27
<chem>Bu3Sn(c-C6H4CF3)2</chem>	<chem>Bu3Sn(c-C6H4CF3)2</chem>	BnPd(PPh3)2Cl (0.4%), CHCl3, reflux, 5 h	(64)	146
<chem>Me3Sn(c-C6H4CN)2</chem>	<chem>Me3Sn(c-C6H4CN)2</chem>	$[(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}]_2$ (1%), HMPA, 20°, 5 min	(100)	750
	<chem>Me3Sn-c6N(C)2</chem>	Pd(PPh3)2Cl2 (5%), C6H6, reflux, 8 h	(70)	284
	<chem>Bu3Sn-c6O2Me</chem>	BnPd(PPh3)2Cl (0.4%), CHCl3, reflux, 5 h	(85)	146
	<chem>[Et3SnC(=O)Ph]2</chem>	$[(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}]_2$ (1%), P(OEt)3, CO (120 psi), PhMe, 111°, 2 h	(70)	308, 307
	<chem>Bu3Sn-CH=CH-C(=O)Bu-n</chem>	Pd(PPh3)4 (5%), dioxane, 100°, 30 h	(66)	148
	<chem>Bu3Sn-CH=CH-C(=O)Bu-n</chem>	Pd(PPh3)4 (5%), dioxane, 60°, 3 h	(56)	148
	<chem>Bu3Sn-CH=CH-C(=O)OMe</chem>	1. Pd(PPh3)2Cl2, THF, 65° 2. Bu4NF, THF, 0°	(>56)	532
	<chem>Bu3SnC≡C(OEt)2</chem>	Pd(PPh3)2Cl2 (1.8%), Cl(CH2)2Cl, 84°, 2 h	(68)	149
	<chem>Bu3Sn-CH=CH-C(=O)OEt</chem>	Pd(CH3CN)2Cl2 (1%), DMF, 20°, 2 h	(75)	763
	<chem>Bu3Sn-CH=CH-C(=O)CO2Et</chem>	BnPd(PPh3)2Cl (1%), CHCl3, reflux, 24 h <i>E:Z</i> = 1:7	(70) <i>E:Z</i> = 1:8	427

TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		1. $\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.5%), $\text{CuI}$ , THF, 50° 2. $\text{H}_3\text{O}^+$	(69)	268
		1. $\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.5%), $\text{CuI}$ , THF, 50° 2. Piperidine	(79)	268
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (1%), CO (15 psi), $\text{C}_6\text{H}_6$ , 80°	(78)	268
436		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (4%), $\text{CuCN}$ , $\text{PhMe}$ , 75°, 36 h	(50)	243
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.6%), $\text{Cl}(\text{CH}_2)_2\text{Cl}$ , HMPA, 80°, 2 h		754
	$\text{Bu}_3\text{SnC}\equiv\text{CPh}$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (1.8%), $\text{Cl}(\text{CH}_2)_2\text{Cl}$ , 84°, 2 h	(94)	149, 146
		$\text{Pd}(\text{PPh}_3)_4$ (5%), $\text{PhMe}$ , 40°, 48 h	(96)	376
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (0.4%), $\text{CHCl}_3$ , 65°, 24 h	<b>I</b> (82)	146
	" E:Z = 95:5	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (0.5%), $\text{CHCl}_3$ , 65°	<b>I</b> (—)	27
	" E:Z = 15:85	"	<b>I</b> (—)	27
		$\text{Pd}(\text{PPh}_3)_4$ (5%), CO (15 psi), BHT, $\text{PhMe}$ , 100°, 24 h	(55)	250
437		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.5%), $\text{CuI}$ , THF, 50°, 60 min	(73)	268
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (2%), $\text{CHCl}_3$ , 100°, 40 h	(70)	787
		$\text{Pd}(\text{PPh}_3)_4$ (4%), $\text{CuCN}$ , $\text{PhMe}$ , 75°, 60 h	(57)	243
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2%), $\text{THF}$ , 65°, 17 h	(81) E:Z = 85:15	539
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (1%), $\text{PhMe}$ , reflux	(71)	457
		$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (5%), $\text{C}_6\text{H}_6$ , reflux, 8 h	(71)	284

TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
438		PdCl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 4 d	(47)	284
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 10 h	(69)	284
		PdCl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 5 d	(49)	284
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 3 d	(54)	788
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 3 h	(42)	788
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF, reflux, 3 h	(0)	788
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), CuI, THF, 50°, 15 min	(92)	268
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, rt, 48 h	(80)	375
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	(69)	375
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), CuCN, PhMe, 75°, 15 h	(80)	243
439		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), CuCN, PhMe, 75°, 12 h	(78)	243
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1.8%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 84°, 2 h	(66)	149
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), CHCl <sub>3</sub> , 65°, 24 h	(78)	146
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3.7%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, reflux, 20 h 2. AcOH	R = Me (47) R = Bu (30)	459
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), CHCl <sub>3</sub> , 65°, 20 h	I (55)	146
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.5%), THF, 65°	I +  (—) 62:38	27

TABLE XIV. DIRECT CROSS-CO尤LING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
<chem>Bu3SnC=CCCCOBn</chem>		Pd(PPh3)4 (5%), C6H6, reflux, 4 h	<chem>O=C/C=C\CCCCOBn</chem> (62)	789
<chem>Bu3SnC(C(=O)OC)C7H15-n</chem>		Pd(PPh3)2Cl2 (4%), CuCN, PhMe, 75°, 18 h	<chem>O=C/C=C\CC(C(=O)OC)C7H15-n</chem> (74)	243
<chem>Bu3SnC=C[C@@H](TMS)C6H5</chem>		BnPd(PPh3)2Cl (1%), 80°, 18 h	<chem>O=C/C=C\CC(C(=O)[C@H](TMS)C6H5)C6H5</chem> (75)	256
<chem>Bu3SnC(C(=O)OMOM)C6H5</chem>		Pd(PPh3)2Cl2 (4%), CuCN, PhMe, 75°, 38 h	<chem>O=C/C=C\CC(C(=O)OMOM)C6H5</chem> (30)	243
<chem>Bu3SnC(C(=O)COC(=O)Bu-t)C6H5</chem>		Pd2(dba)3 (0.05%), HMPA, 100°, 1 h	<chem>O=C/C=C\CC(C(=O)COC(=O)Bu-t)C6H5</chem> (78)	247
<chem>Bu3SnC=CCC(C8H17-n)OC(=O)C6H5</chem>		Pd2(dba)3, P(2-furyl)3, THF, 25°, 16 h	<chem>O=C/C=C\CC(C8H17-n)OC(=O)C6H5</chem> (90)	447, 768
<chem>[BnO[C@H]1[C@H](O[C@H]1C(=O)C=C[C@@H](SiEt3)C6H5)C(=O)C6H5]C6H5</chem>		Pd(PPh3)2Cl2 (4%), CuCN, PhMe, 95°, 18 h	<chem>O=C/C=C\CC(C(=O)OC1[C@H](O[C@H]1C(=O)C=C[C@@H](SiEt3)C6H5)C6H5)C6H5</chem> (60)	242
<chem>Bu3SnC=C[C@@H](SiEt3)C6H5</chem>		Pd(CH3CN)2Cl2, CHCl3, 60°, 24 h	<chem>O=C/C=C\CC(C(=O)[C@H](SiEt3)C6H5)C6H5</chem> (65)	255
<chem>Bu3SnC(C(=O)OC6H4NO2-p)C7H15-n</chem>		Pd(PPh3)2Cl2 (4%), CuCN, PhMe, 75°, 36 h	<chem>O=C/C=C\CC(C(=O)OC6H4NO2-p)C7H15-n</chem> (50)	243
<chem>Bu3SnC(C(=O)OBz)C7H15-n</chem>		Pd(PPh3)2Cl2 (4%), CuCN, PhMe, 75°, 18 h	<chem>O=C/C=C\CC(C(=O)OBz)C7H15-n</chem> (70)	243
<chem>Bu3SnC(C(=O)OBz)C7H15-n</chem> 94% ee		Pd(PPh3)2Cl2 (4%), CuCN, PhMe, 75°, 18 h	<chem>O=C/C=C\CC(C(=O)OBz)C7H15-n</chem> (74) 92% ee	243
<chem>Bu3SnC6H4N=NC6H4Ph</chem>		Pd(PPh3)2Cl2 (5%), Et4NCl, C6H6, reflux, 41 h	<chem>O=C/C=C\CC(C(=O)C6H4N=NC6H4Ph)C6H5</chem> (38)	545
<chem>Bu3SnC(C(=O)N1C(=O)c2ccccc2C1=O)C7H15-n</chem>		Pd(PPh3)4 (4%), CuCN, PhMe, 75°, 36 h	<chem>O=C/C=C\CC(C(=O)N1C(=O)c2ccccc2C1=O)C7H15-n</chem> (45) + <chem>O=C/C=C\CC(C(=O)C7H15-n)C6H5</chem> (28)	243
<chem>Bu3SnC(C(=O)N1C(=O)C=C2C1=OCC2)C6H5</chem>		BnPd(PPh3)2Cl (5%), CO (35 psi), C6H6, 110°, 24 h	<chem>O=C/C=C\CC(C(=O)N1C(=O)C=C2C1=OCC2)C6H5</chem> (48)	757
<chem>Bu3SnC=CCC(C8H17-n)OTBDMS</chem>		Pd2(dba)3, P(2-furyl)3, THF, rt, 6 h	<chem>O=C/C=C\CC(C8H17-n)OTBDMS</chem> (83)	447
<chem>Bu3SnC=C[C@@H](CO2Bu-t)C15H31-n</chem>		Pd2(dba)3 (0.05%), HMPA, 100°, 16 h	<chem>O=C/C=C\CC(C(=O)CO2Bu-t)C15H31-n</chem> (65)	247

TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		$[(\eta^3-C_3H_5)PdCl]_2$ (11%), proton sponge, THF, reflux, 7 h	 (67)	666	
442		Pd(PPh3)4 (5%), dioxane, 60°, 2 h	 (27)	148	
		Pd(PPh3)4 (5%), dioxane, 100°, 30 h	 (50)	148, 753	
		Pd(PPh3)4 (5%), dioxane, 60°, 3 h	 (40)	148	
		Pd(PPh3)2Cl2 (5%), THF, 80°, 24 h or THF, 65°, 8 h	 (82)	287, 546	
		Pd(PPh3)2Cl2 (5%), PhMe, 100°, 32 h	 (20)	287	
	Me3SnSnMe3	BnPd(PPh3)2Cl or Pd(PPh3)4 (5%), THF, reflux, 14 h	 (80)	309, 759	
443		Bu3SnH	Pd(PPh3)4 (1%), C6H6, rt	 (81)	156
	Me4Sn		BnPd(PPh3)2Cl (0.4%), CHCl3, reflux, 24 h	 (60)	146
	Me4Sn		BnPd(PPh3)2Cl (0.05%), HMPA, 65°	 (67) + (26)	4
			BnPd(PPh3)2Cl (1%), HMPA, 65°, 5 h	 (89)	262
	Bu3SnPh		BnPd(PPh3)2Cl (0.4%), CHCl3, reflux, 2 h	 (89)	146
			BnPd(PPh3)2Cl (1%), THF, 100°, 16 h	 (69)	305
	Me4Sn		BnPd(PPh3)2Cl (0.05%), HMPA, 65°	 (97)	4
			BnPd(PPh3)2Cl (1%), HMPA, 65°, 4 h	 (93)	262

TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh3)2Cl2 (1.4%), PhMe, 110°, 24 h	(59)	307
		BnPd(PPh3)2Cl, CH2Cl2, 70°, 8 h	(71)	305
		Pd(PPh3)4 (1%), HMPA, rt, 3 h	(37)	752
		BnPd(PPh3)2Cl (2%), CHCl3, 65°, 24 h	(69)	537
444		[(η3-C3H5)PdCl]2 (1%), P(OEt)3, CO (120 psi), PhMe, 111°, 2 h	(63)	308, 307
		Pd2(dba)3 (0.05%), HMPA, 100°, 45 min	(65)	247
		Pd(PPh3)2Cl2 (5%), PhMe, 100°, 15 h	(75)	759
			(86)	750
		[(η3-C3H5)PdCl]2 (1%), HMPA, 20°, 10 min		
		Pd(PPh3)2Cl2 (2%), THF, reflux, 1 h	R = Me (79) / R = Boc (59)	425
		BNPd(PPh3)2Cl (0.05%), HMPA, 65°	(73)	4
445		Pd(PPh3)4 (1%), C6H6, rt	(75)	156
		[(η3-C3H5)PdCl]2 (1%), HMPA, 20°, 10 min	(100)	750, 4, 146
		BnPd(PPh3)2Cl (0.4%), CHCl3, reflux, 20 min	(88)	146, 750
		BnPd(PPh3)2Cl (0.08%), C6H6, reflux, 3 h	(86)	271
		[(η3-C3H5)PdCl]2 (1%), HMPA, 20°, 2 min	(91)	750

TABLE XIV. DIRECT CROSS-COUPLING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

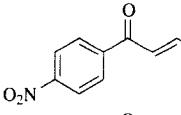
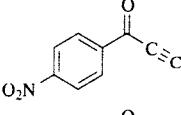
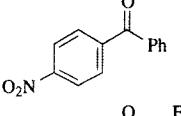
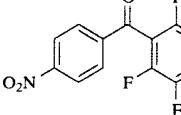
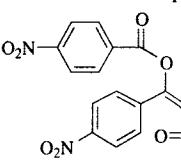
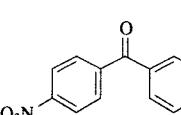
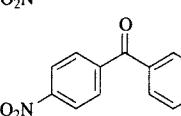
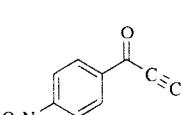
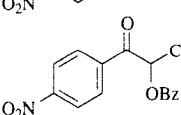
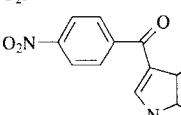
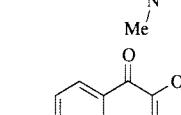
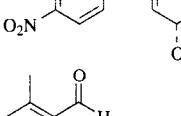
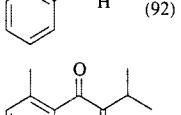
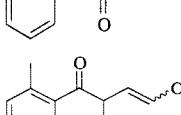
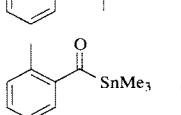
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	<chem>Bu3SnC=CC(=O)OEt</chem>	BnPd(PPh3)2Cl (0.5%), CO (15 psi), CHCl3, 50°, 12 h	 (80)	250
	<chem>Bu3SnC≡CTMS</chem>	Pd(PPh3)2Cl2 (1.8%), Cl(CH2)2Cl, 84°, 2 h	 (51)	149
	<chem>Me3SnPh</chem>	BnPd(PPh3)2Cl (0.4%), CHCl3, reflux, 18 h	 (97)	146, 750, 751
	<chem>Me3SnC(F)(F)c1c(F)c(F)c(F)c(F)c1-</chem>	[ $(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}_2$ ] (1%), HMPA, 20°, 24 h	 (32)	750
	<chem>Me3SnC1=C(O=S(=O)[O-])C=C1</chem>	Pd(PPh3)4 (1%), HMPA, 0°, 0.5 h	 (33)	752
	<chem>Me3SnC6H5</chem>	Pd(CH3CN)2Cl2 (1%), THF, Et2O, 20°, 2 h	 (70)	367, 590, 750
	<chem>Me3SnC6H4OMe</chem>	[ $(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}_2$ ] (1%), HMPA, 20°, 10 min	 (66)	750
	<chem>Bu3SnC≡CPh</chem>	Pd(PPh3)2Cl2 (1.8%), Cl(CH2)2Cl, 84°, 2 h	 (57)	149
	<chem>Bu3SnC(C7H15-n)OBz</chem>	Pd(PPh3)2Cl2 (4%), CuCN, PhMe, 75°, 24 h	 (40)	243
	<chem>Me3SnC1=CC2=C(N1)C=C2</chem>	Pd(PPh3)2Cl2 (2%), THF, reflux, 30 min	 (75)	425
C8	<chem>Bu3SnC1OC(OBn)C(OBn)=C1OBn</chem>	Pd(CH3CN)2Cl2 (5%), Cl(CH2)2Cl, reflux, 15 min	 (71)	423
	<chem>Bu3SnH</chem>	Pd(PPh3)4 (1%), C6H6, rt	 (92)	156
	<chem>Bu3SnC(C(C)C)C(=O)C(C)C</chem>	Pd(PPh3)2Cl2 (1.4%), PhMe, 110°, 24 h	 (54)	307
	<chem>Bu3SnC(C=CC(=O)OEt)C(=O)OEt</chem>	BnPd(PPh3)2Cl (1%), THF, 100°, 16 h	 (52)	305
	<chem>Me3SnSnMe3</chem>	Pd(PPh3)2Cl2 (5%), PhMe, 100°, 16 h	 (75)	759

TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		BnPd(PPh3)2Cl, THF, 65°, 30 min	(85)	264
		Pd(PPh3)2Cl2 (1.4%), PhMe, 110°, 24 h	(63)	307
	[Et3SnC(=O)Ar]	[(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), P(OEt) <sub>3</sub> , CO (120 psi), PhMe, 111°, 2 h	(73)	308, 307
	Me <sub>3</sub> SnSnMe <sub>3</sub>	BnPd(PPh3)2Cl (5%), THF, reflux, 14 h	(64)	309
	Me <sub>4</sub> Sn	BnPd(PPh3)2Cl (0.05%), HMPA, 65°	(99)	4
		BnPd(PPh3)2Cl (1%), HMPA, 65°, 13 h	(81)	262
		BnPd(PPh3)2Cl (1%), THF, 100°, 16 h	(67)	305
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , π	(75)	156
	Me <sub>4</sub> Sn	BnPd(PPh3)2Cl (0.05%), HMPA, 65°, 25 h	(86)	4
		Pd(PPh3)2Cl <sub>2</sub> (1.4%), PhMe, 110°, 24 h	(61)	307
		BnPd(PPh3)2Cl (2.5%), CuI, THF, 50°, 20 min	(98)	268
		Pd(PPh3)2Cl <sub>2</sub> (1.4%), PhMe, 110°, 24 h	(65)	307
		BnPd(PPh3)2Cl, C <sub>6</sub> H <sub>6</sub> , 100°, 36 h	(78)	305
		BnPd(PPh3)2Cl (0.08%), C <sub>6</sub> H <sub>6</sub> , reflux, 3 h	(93)	271
	Ph <sub>4</sub> Sn	BnPd(PPh3)2Cl (0.05%), HMPA, 65°	(84)	4
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), HMPA, rt, 3 h	(36)	752

TABLE XIV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

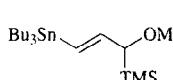
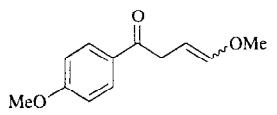
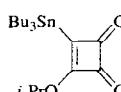
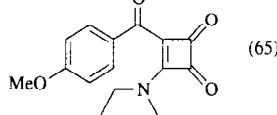
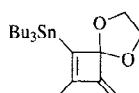
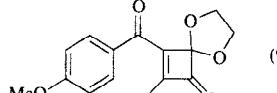
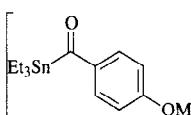
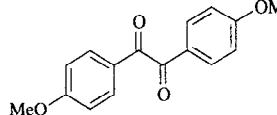
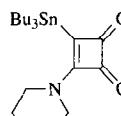
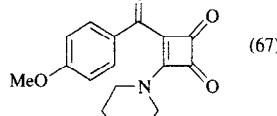
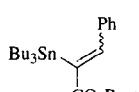
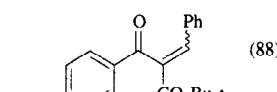
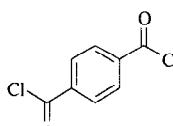
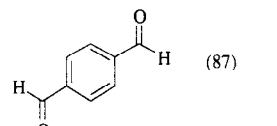
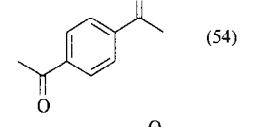
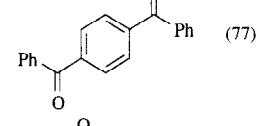
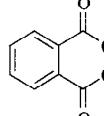
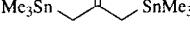
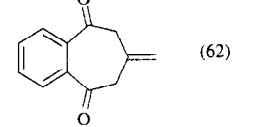
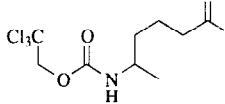
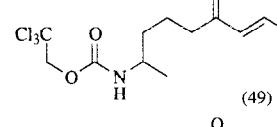
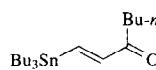
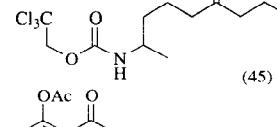
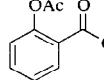
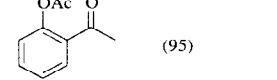
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		1. $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ , THF, 65° 2. $\text{Bu}_4\text{NF}$ , THF, 0°	 (>53)	532
		1. $\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.5%), $\text{CuI}$ , THF, 50° 2. Piperidine	 (65)	268
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (1%), CO (15 psi), $\text{C}_6\text{H}_6$ , 80°	 (92)	268
		$[(\eta^3-\text{C}_3\text{H}_5)\text{PdCl}]_2$ (1%), $\text{POEt}_3$ , CO (120 psi), $\text{PhMe}$ , 111°, 2 h	 (76)	308, 307
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.5%), $\text{CuI}$ , THF, 50°, 45 min	 (67)	268
		$\text{Pd}_2(\text{dba})_3$ (0.05%), HMPA, 100°, 15 min	 (88)	247
		$\text{Pd}(\text{PPh}_3)_4$ (1%), $\text{C}_6\text{H}_6$ , $\pi$	 (87)	156
		$[(\eta^3-\text{C}_3\text{H}_5)\text{PdCl}]_2$ (1%), HMPA, 20°, 15 min	 (54)	750
		$[(\eta^3-\text{C}_3\text{H}_5)\text{PdCl}]_2$ (1%), HMPA, 20°, 1 min	 (77)	750
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (10%), THF, rt, 2 h	 (62)	152
		$\text{Pd}(\text{PPh}_3)_4$ , dioxane, 40°, 4 h	 (49)	771
		$\text{Pd}(\text{PPh}_3)_4$ , dioxane, 100°, 24 h	 (45)	771
		$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (0.05%), HMPA, 65°	 (95)	4

TABLE XIV. DIRECT CROSS-COUPLING OF ACYL CHLORIDES: ARYL SYSTEMS (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
452			BnPd(PPh3)2Cl (2.5%), CuI, BHT, THF, 25°, 2 h	(65)	268
			BnPd(PPh3)2Cl (2.5%), CuI, BHT, THF, 25°, 2 h	(73)	268
			BnPd(PPh3)2Cl (2.5%), CuI, BHT, THF, 25°, 3 h	(88)	268
C <sub>11</sub>			Pd(PPh3)4 (1%), C <sub>6</sub> H <sub>6</sub> , rt, 2 h	(65)	156, 769
			Pd(PPh3)4 (1%), C <sub>6</sub> H <sub>6</sub> , rt, 2 h	(85)	156, 769
			BnPd(PPh3)2Cl (5%), THF, reflux, 45 h	(50)	759
453			BnPd(PPh3)2Cl (2.5%), CuI, BHT, THF, 25°, 3 h	(70)	268
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , THF, rt, 16 h	(>63)	790
C <sub>27</sub>			BnPd(PPh3)2Cl (0.05%), HMPA, 65°	(88)	147

TABLE XV. DIRECT CROSS-COUPING OF ACYL CHLORIDES: BENZYL SYSTEMS

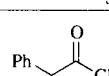
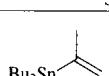
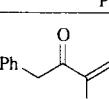
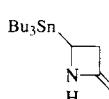
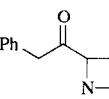
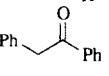
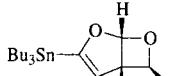
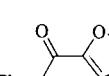
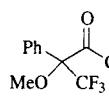
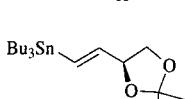
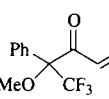
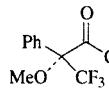
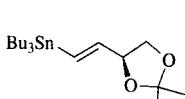
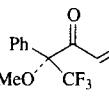
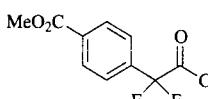
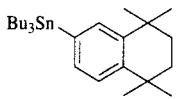
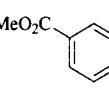
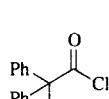
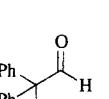
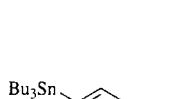
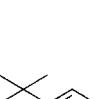
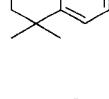
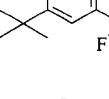
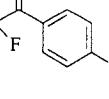
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>8</sub> 454			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CO (15 psi), BHT, PhMe, 100°, 5 h	 (70)	250
			Pd(PPh <sub>3</sub> ) <sub>4</sub>	 (—)	244
		Me <sub>3</sub> SnPh	[(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°, 10 h	 (72)	750
C <sub>10</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, C <sub>6</sub> H <sub>6</sub> , rt, 4 h	 (62)	543
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, CHCl <sub>3</sub> , 65°	 (35)	791
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, CHCl <sub>3</sub> , 65°	 (49)	791
C <sub>14</sub> 455			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, HMPA	 (—)	792
		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , rt	 (75)	156
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , rt	 (—)	792
C <sub>20</sub>		Bu <sub>3</sub> SnH	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), PPh <sub>3</sub> , C <sub>6</sub> H <sub>6</sub> , rt	 (71) +  (19)	156

TABLE XVI. DIRECT CROSS-COUPLING OF ACYL CHLORIDES: ALKENYL SYSTEMS

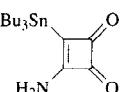
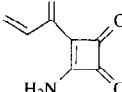
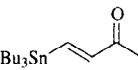
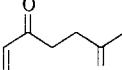
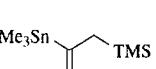
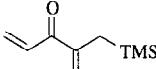
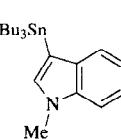
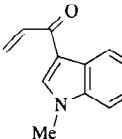
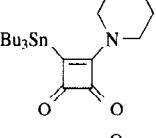
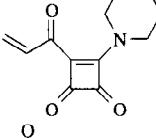
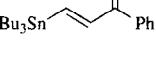
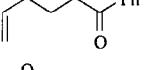
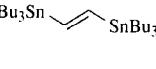
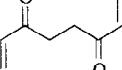
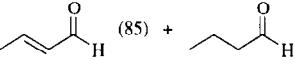
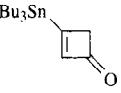
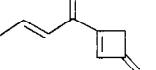
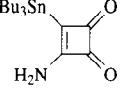
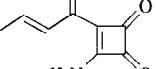
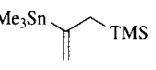
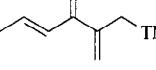
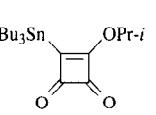
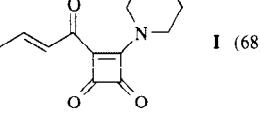
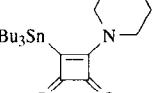
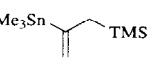
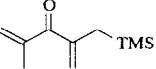
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Me <sub>3</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.05%), HMPA, 65°	 (93)	4
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), CuI, THF, 50°, 15 min	 (53)	268
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h	 (86)	148
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 24 h	 (75)	537
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux, 4 h	 (70)	425
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), CuI, THF, 50°, 1 h	 (64)	268
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h	 (97)	148
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h	 (63)	148
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , rt		156
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.5%), CH <sub>3</sub> CN, rt, 1.5 h	 (53)	267
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), CuI, THF, 50°, 15 min	 (93)	268
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 24 h	 (89)	537
		1. BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), CuI, THF, 50°, 30 min 2. Piperidine	 I (68)	268
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), CuI, THF, 50°, 30 min	 I (83)	268
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 24 h	 (75)	537

TABLE XVI. DIRECT CROSS-COUPING OF ACYL CHLORIDES: ALKENYL SYSTEMS (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>5</sub>		 <i>E:Z = 85:15</i>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 17 h	 (80) <i>E:Z = 85:15</i>	539
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h	 (86)	148, 753
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 24 h	 (74)	537
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h	 (63)	753
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), DMF, 20°, 2 h	 (57)	763
		 <i>E:Z = 85:15</i>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 17 h	 (85) <i>E:Z = 85:15</i>	539
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%)	 (71)	465
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h	 (97)	148, 753
			Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl, CH <sub>2</sub> Cl <sub>2</sub> , 60°, 48 h	 (53)	150, 304
			Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl, CH <sub>2</sub> Cl <sub>2</sub> , 60°, 24 h	 (54)	150, 304
C <sub>6</sub>			Rh(PPh <sub>3</sub> ) <sub>3</sub> Cl, CH <sub>2</sub> Cl <sub>2</sub> , 60°, 16 h	 (47) + (15)	150, 304
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, 80°, 3 h	 (35)	256
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°	 (63)	148, 753
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), DMF, 20°, 2 h	 (85)	763
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CHCl <sub>3</sub> , 60°, 24 h	 (77)	255
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CHCl <sub>3</sub> , 60°, 24 h	 (87)	255
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CHCl <sub>3</sub> , 60°, 24 h	 (58)	255
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CHCl <sub>3</sub> , 60°, 24 h	 (58)	255

TABLE XVI. DIRECT CROSS-COUPLED OF ACYL CHLORIDES: ALKENYL SYSTEMS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>8</sub>	Bu <sub>3</sub> Sn—	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , CHCl <sub>3</sub> , 60°, 24 h	(68)	255
C <sub>9</sub>	Bu <sub>3</sub> Sn—	Pd(AsPh <sub>3</sub> ) <sub>4</sub>		793
	Me <sub>3</sub> SnSnMe <sub>3</sub>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), reflux, 12 h		309
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , rt, 2 h		769
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , rt	I (73) +	156
	Me <sub>4</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.05%), HMPA, 65°		4
	Bu <sub>3</sub> Sn—	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), HMPA, 65°, 4 h		262
	Bu <sub>3</sub> Sn—	Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h		148, 753
	Bu <sub>3</sub> Sn—	Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 60°, 3 h		148
	Bu <sub>3</sub> Sn—	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 70°		574
	Bu <sub>3</sub> Sn—	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, CO, CHCl <sub>3</sub> , 65°, 16 h or BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 60°, 16 h		762, 761
	Me <sub>3</sub> SnPh	[ $(\eta^3\text{-C}_5\text{H}_5)\text{PdCl}]_2$ (1%), HMPA, 20°, 10 min		750, 751
	Me <sub>3</sub> Sn—	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 24 h		537
	Me <sub>3</sub> Sn—	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), 80°, 15 min		256
	Bu <sub>3</sub> Sn—	Pd <sub>2</sub> (dba) <sub>3</sub> (0.05%), hydroquinone, CHCl <sub>3</sub> , 100°, 2.5 h		247
	Bu <sub>3</sub> Sn—	Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h		148
	Me <sub>3</sub> SnSnMe <sub>3</sub>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl or Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux, 12 h		309
C <sub>10</sub>	Bu <sub>3</sub> Sn—	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux, 4 h		425
	Bu <sub>3</sub> Sn—	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 60°, 16 h		761

TABLE XVII. DIRECT CROSS-COUPLING OF ACYL CHLORIDES: HETEROCYCLIC SYSTEMS

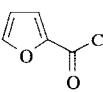
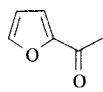
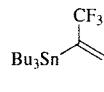
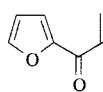
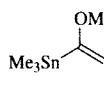
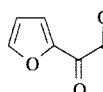
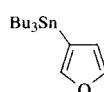
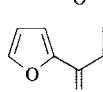
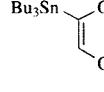
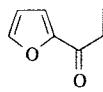
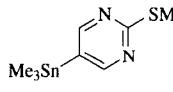
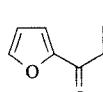
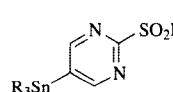
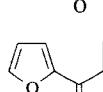
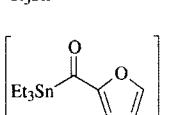
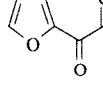
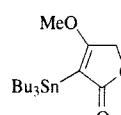
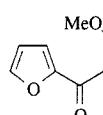
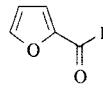
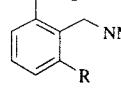
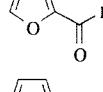
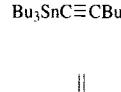
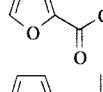
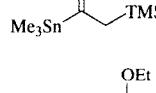
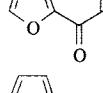
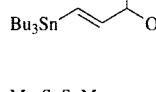
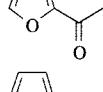
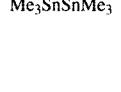
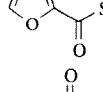
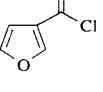
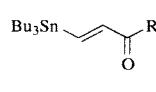
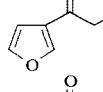
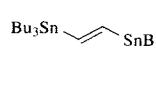
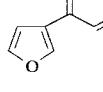
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Me <sub>4</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.05%), HMPA, 65°	 (91)	4
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), HMPA, 65°, 10 h	 (85)	262
	Me <sub>3</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , reflux, 1 h	 (83)	749
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, rt, 12 h	 (95)	288
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.08%), C <sub>6</sub> H <sub>6</sub> , reflux, 3 h	 (95)	271
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (7%), THF, reflux, 3 h	 (71)	459
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (14%), THF, reflux	 R = Me (72) R = Bu (62)	459
		[(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), POEt <sub>3</sub> , CO (120 psi), PhMe, 111°, 2 h	 (41)	308
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.4%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 60°, 16 h or BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, CO, CHCl <sub>3</sub> , 65°, 16 h	 (48)	761, 762
		PhCOPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4%), THF, 40°	 R = H (—) R = TMS (—)	42
		PhCOPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4%), THF, 40°	 R = Me (—) R = Ph (—)	42
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), PPh <sub>3</sub> , CHCl <sub>3</sub> , rt, 6 h	 (52)	794
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 48 h	 (67)	537
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), DMF, 20°, 2 h	 (78)	763
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), THF, reflux, 15 h	 (80)	309
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 100°, 30 h	 R = Me (70) R = Ph (64)	148, 753
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , dioxane, 60°, 3 h	 (35)	148

TABLE XVII. DIRECT CROSS-COUPING OF ACYL CHLORIDES: HETERO CYCLIC SYSTEMS (Continued)

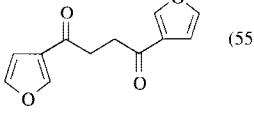
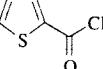
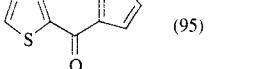
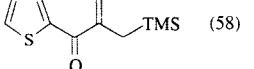
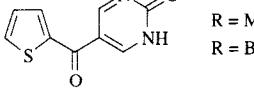
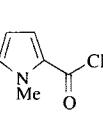
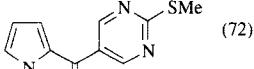
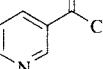
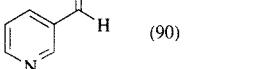
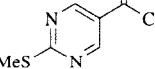
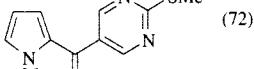
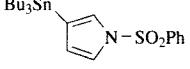
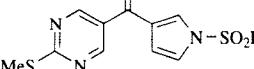
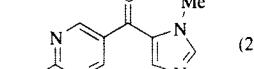
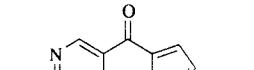
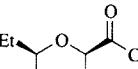
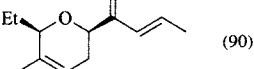
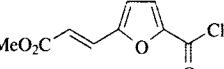
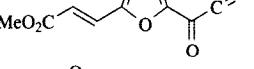
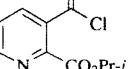
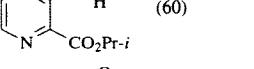
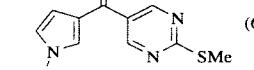
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)4</chem> , dioxane, 100°, 30 h	 (55)	148, 753
		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)2Cl2</chem> (3%), THF, rt, 12 h	 (95)	288
		<chem>Me3SnC=C[Si](C)(C)C</chem>	<chem>BnPd(PPh3)2Cl</chem> (2%), <chem>CHCl3</chem> , 65°, 48 h	 (58)	537
		<chem>R3SnC=C[Sn]Bu3</chem>	1. <chem>Pd(PPh3)2Cl2</chem> (3.7%), <chem>Cl(CH2)2Cl</chem> , reflux, 20 h 2. AcOH		459
 <i>C<sub>6</sub></i>		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)2Cl2</chem> (4%), THF, reflux, 6 h or <chem>Pd2(dba)3</chem> (3.7%), <chem>AsPh3</chem> , THF, rt, 7 h	 (72)	151
		<chem>Bu3SnH</chem>	<chem>Pd(PPh3)4</chem> (1%), <chem>C6H6</chem> , rt	 (90)	156
		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)2Cl2</chem> (3%), THF, reflux	 (72)	151
 <i>C<sub>9</sub></i>		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)2Cl2</chem> (3%), THF, reflux	 (61)	151
		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)2Cl2</chem> (3%), THF, reflux	 (25-31)	151
		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)2Cl2</chem> (7%), THF, reflux, 30 min	 (73)	459
		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)2Cl2</chem> (7%), THF, reflux, 30 min	 (77)	459
 <i>C<sub>10</sub></i>		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>BnPd(PPh3)2Cl</chem> (0.4%), <chem>HMPA</chem> , 70°, 3 h	 (90)	795
		<chem>Bu3SnC≡CBu-n</chem>	<chem>Pd(CH3CN)2Cl2</chem> (5%), <chem>PPh3</chem> , <chem>CH2Cl2</chem> , 20°, 24 h	 (60)	794
 <i>C<sub>11</sub></i>		<chem>Bu3SnH</chem>	<chem>PdCl2</chem> , <chem>PPh3</chem>	 (60)	796
		<chem>Bu3SnC=C[Sn]Bu3</chem>	<chem>Pd(PPh3)2Cl2</chem> (4%), THF, reflux, 6 h	 (61)	151

TABLE XVII. DIRECT CROSS-COUPLING OF ACYL CHLORIDES: HETEROCYCLIC SYSTEMS (Continued)

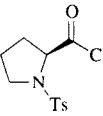
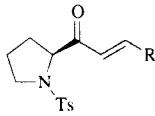
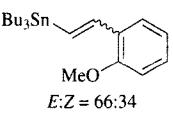
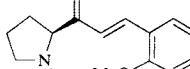
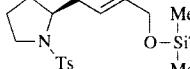
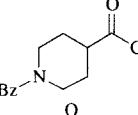
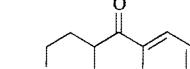
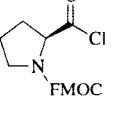
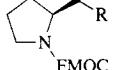
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>12</sub>		$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH}-\text{R}$ $\text{R} \begin{array}{c}   \\ \text{TMS} \end{array}$ $\text{CO}_2\text{Et}$ $\text{Ph}$	Pd(dppf)Cl <sub>2</sub> (5%), CHCl <sub>3</sub> , rt, 2 d	 (53) (51) (54) <b>I</b>	381
		$\text{Me}_3\text{Sn}-\text{CH}=\text{CH}-\text{Ph}$	Pd(dppf)Cl <sub>2</sub> (5%), CHCl <sub>3</sub> , rt, 2 d	<b>I</b> (94)	381
			Pd(dppf)Cl <sub>2</sub> (5%), CHCl <sub>3</sub> , rt, 2 d	 (25)	381
		$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH}-\text{CH}_2-\text{O}-\text{Si}(\text{Hex})_2$ $E:Z = 83:17$	Pd(dppf)Cl <sub>2</sub> (5%), CHCl <sub>3</sub> , rt, 2 d	 (41)	381
C <sub>13</sub>		$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{NO}_2$	$[(\eta^3-\text{C}_3\text{H}_5)\text{PdCl}]_2$ (1%), THF, rt, 5 h	 (43)	797
C <sub>20</sub>		$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH}_2$ $\text{Bu}_3\text{Sn}-\text{CH}=\text{CH}-\text{CO}_2\text{Et}$ $\text{Me}_3\text{Sn}-\text{CH}=\text{CH}-\text{CO}_2\text{Et}$ $\text{Me}_3\text{Sn}-\text{CH}=\text{CH}-\text{Ph}$	Pd(dppf)Cl <sub>2</sub> (5%), CHCl <sub>3</sub> , rt, 2 d	 R = CH=CH <sub>2</sub> (64) R = (E)-CH=CHCO <sub>2</sub> Et (51) R = (E)-CH=CHCO <sub>2</sub> Et (64) R = (E)-CH=CHPh (96)	381

TABLE XVIII. DIRECT CROSS-COUPING OF CHLOROFORMATES AND CARBAMOYL CHLORIDES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>2</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), CHCl <sub>3</sub> , 65°, 48 h	(49)	537
C <sub>3</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4%), PhMe, 100°, 8 h	(71)	157
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4%), PhMe, 100°, 8 h	(72)	157
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), hydroquinone, PhMe, HMPA, 100° 5 h	(71)	157
C <sub>5</sub>			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), quinone, PhMe, HMPA, 100°, 3 h	(70)	158
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), hydroquinone, PhMe, HMPA, 100° 5 h		157
				(66)	
		H		(64)	
		Me		(66)	
		OMe		(88)	
		NMe <sub>2</sub>		(72)	
		CO <sub>2</sub> Me			
C <sub>8</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4%), PhMe, 100°, 8 h	(74)	157

TABLE XVIII. DIRECT CROSS-COUPLING OF CHLOROFORMATES AND CARBAMOYL CHLORIDES (*Continued*)

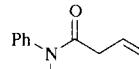
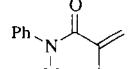
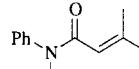
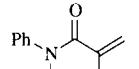
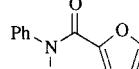
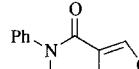
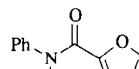
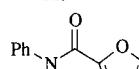
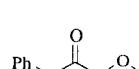
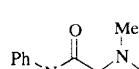
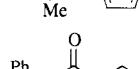
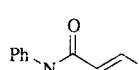
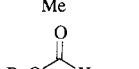
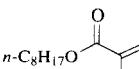
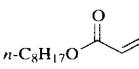
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	<chem>Bu3SnCH=CH2</chem>	BnPd(PPh3)2Cl (4%), PhMe, 100°, 8 h	 (18)	157
	<chem>Bu3SnC(=C)CH3</chem>	BnPd(PPh3)2Cl (4%), PhMe, 100°, 8 h	 (71)	157
	<chem>Bu3SnCH=CHCH3</chem>	BnPd(PPh3)2Cl (4%), PhMe, 100°, 8 h	 (60)	157
	<chem>Bu3SnCOEtCH3</chem>	BnPd(PPh3)2Cl (4%), PhMe, 100°, 8 h	 (65)	157
468	<chem>Bu3SnC1=COC=C1</chem>	BnPd(PPh3)2Cl (4%), PhMe, 100°, 8 h	 (68)	157
	<chem>Bu3SnC1=COC=C1</chem>	BnPd(PPh3)2Cl (4%), PhMe, 100°, 8 h	 (73)	157
	<chem>Bu3SnC1=COC(=O)C=1</chem>	Pd(PPh3)2Cl2 (0.5%), quinone, PhMe, 100°, 1 h	 (90)	158
	<chem>Bu3SnC1=COC(=O)C=1</chem>	Pd(PPh3)2Cl2 (0.5%), quinone, PhMe, 100°, 3 h	 (62)	158
	<chem>Bu3SnC1=COC(=O)C=1</chem>	Pd(PPh3)2Cl2 (0.5%), quinone, PhMe, 100°, 4 h	 (70)	158
	<chem>Bu3SnC1=CN(C)=CC1</chem>	Pd(PPh3)2Cl2 (0.5%), quinone, PhMe, 100°, 3 h	 (65)	158
	<chem>Bu3SnC6H4R</chem>	BnPd(PPh3)2Cl (4%), PhMe, 100°, 8 h		157
	$\begin{array}{c} \text{R} \\ \hline \text{H} \\ \text{Me} \\ \text{OMe} \\ \text{NMe}_2 \end{array}$		(81) (48) (57) (50)	
469	<chem>Bu3SnCH=CHPh</chem> <i>E:Z = 80:20</i>	BnPd(PPh3)2Cl (4%), PhMe, 100°, 8 h	 (67)	157
	<chem>Bu3SnH</chem>	Pd(PPh3)4 (5%), C6H6, rt, 2 h	 (17)	156
	<chem>Bu3SnC(=C)CH3</chem>	BnPd(PPh3)2Cl (5%), hydroquinone, PhMe, HMPA, 100°, 5 h	 (47)	157
	<chem>Bu3SnCH=CHCH3</chem>	BnPd(PPh3)2Cl (5%), hydroquinone, PhMe, HMPA, 100°, 5 h	 (70)	157

TABLE XVIII. DIRECT CROSS-COUPING OF CHLOROFORMATES AND CARBAMOYL CHLORIDES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), hydroquinone, PhMe, HMPA, 100°, 5 h	<i>n</i> -C <sub>8</sub> H <sub>17</sub> O-C(=O)-furan	(70)	157
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), hydroquinone, PhMe, HMPA, 100°, 5 h	<i>n</i> -C <sub>8</sub> H <sub>17</sub> O-C(=O)-furan	(83)	157
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), quinone, PhMe, HMPA, 100°, 3 h	<i>n</i> -C <sub>8</sub> H <sub>17</sub> O-C(=O)-furan-3-carbaldehyde	(71)	158
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), quinone, PhMe, HMPA, 100°, 3 h	<i>n</i> -C <sub>8</sub> H <sub>17</sub> O-C(=O)-furan-3-carbaldehyde	(53)	158
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), quinone, PhMe, HMPA, 100°, 3 h	<i>n</i> -C <sub>8</sub> H <sub>17</sub> O-C(=O)-furan-3-carbaldehyde	(70)	158

TABLE XIX. INTRAMOLECULAR CROSS-COUPLING OF ACYL CHLORIDES AND CHLOROFORMATES

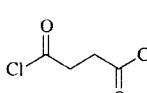
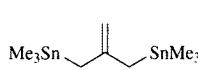
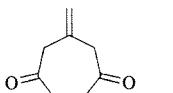
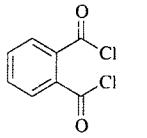
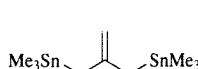
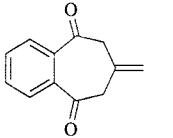
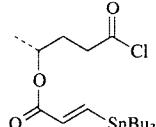
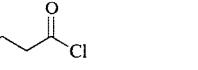
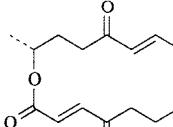
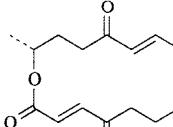
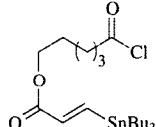
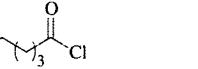
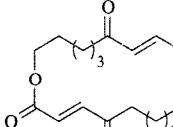
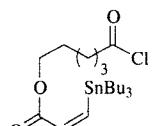
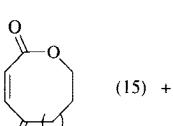
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>4</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (10%), THF, rt, 2 h	 (65)	152
C <sub>8</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (10%), THF, rt, 2 h	 (62)	152
C <sub>7</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 7 h	 (38)	770
				 (38)	770
C <sub>9</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h	 I (58)	153, 154
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h	 (15) + I (38)	154

TABLE XIX. INTRAMOLECULAR CROSS-COUPLING OF ACYL CHLORIDES AND CHLOROFORMATES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>10</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h		(32) + (30) 153, 154
C <sub>11</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h		(41) 153, 154
C <sub>12</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4.5%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 37°, 20 h		(84) 798
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4.5%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, rt, 92 h		(49) 798
C <sub>13</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.4%), THF, reflux		(77) 155
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h		(55) 153, 154
C <sub>14</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (4.5%), Cl(CH <sub>2</sub> ) <sub>2</sub> Cl, 37°, 20 h		(96) 798
C <sub>15</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h		(53) 153, 154
C <sub>16</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h		(70) 153, 154
C <sub>19</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h		(48) 153, 154
C <sub>21</sub>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), CO (45 psi), PhMe, 100°, 14 h		(58) 153, 154

TABLE XX. DIRECT CROSS-COUPLING OF ALLYL AND PROPARGYL ELECTROPHILES

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>3</sub>				
HC≡C—Br		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), CuI, P(2-furyl) <sub>3</sub> (20%), THF, 60°, 2 h	 (47)	170
—Br	Bu <sub>3</sub> Sn—CH=CH <sub>2</sub>	[η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ]PdCl] <sub>2</sub> (1%), HMPA, 20°	 (94)	553
	Bu <sub>3</sub> Sn—CH <sub>2</sub> CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 60°, 20 h	 (44)	529
	Bu <sub>3</sub> Sn—CH=CH—CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , CHCl <sub>3</sub> , 65°	 (80)	24
474	Bu <sub>3</sub> Sn—CH=CH—CH <sub>2</sub>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.3%), CHCl <sub>3</sub> , 65°, 48 h	 (20) + (58)	35
	Me <sub>3</sub> Sn—CH=CH—CH(OH)CH <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, 70°, 1.5 h	 (89)	440
	Me <sub>3</sub> Sn—CH=CH—CH <sub>2</sub> —S—CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 6 h	 (8)	161
	Bu <sub>3</sub> Sn—CH=CH—CH <sub>2</sub> —S—CH <sub>2</sub>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.3%), CHCl <sub>3</sub> , 65°, 48 h	 (3) + (48)	35
	Bu <sub>3</sub> SnPh	[η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ]PdCl] <sub>2</sub> (1%), DMF, 70°	 (95)	553, 535
475				
		[η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ]PdCl] <sub>2</sub> (1%), DMF, 70°	 (94)	553
		Pd(dba) <sub>2</sub> (2%), THF, 55°, 5.5 h	 (89)	440
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), 80°, 240 h	 (40)	256
	Bu <sub>3</sub> Sn—CH <sub>2</sub> Ph	D <sub>717</sub> -Pd(0), Me <sub>2</sub> CO, reflux, 25 h	 (92)	535
		[η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ]PdCl] <sub>2</sub> (1%), HMPA, 20°	 (75)	553
		[η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ]PdCl] <sub>2</sub> (1%), DMF, 70°	 (80)	553
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), 80°, 48 h	 (55)	256
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), 80°, 48 h	 (32) + (8)	256
	Me <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 6 h	 (3)	161
	Bu <sub>3</sub> Sn—CH=CH—CH(OH)C <sub>5</sub> H <sub>11-n</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , HMPA, 20°, 5 h	 (90)	799

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		BnPd(PPh3)2Cl (1%), 80°, 36 h	 (61)	256
		Pd(PPh3)2Cl2 (2%), THF, reflux, 20 h		425
		Pd2(dba)3 (5%), AsPh3 (40%), THF, 65°		375
		Pd (0)		800
476		BnPd(PPh3)2Cl (1%), 80°, 55 h		256
		BnPd(PPh3)2Cl (1%), 80°, 450 h	 (43) +	256
		BnPd(PPh3)2Cl (1.6%), CuI, DMF, 50°, 7 h	 (95)	49
		Pd(PPh3)4 (5%), C6H6, reflux	 (—)	442
		BnPd(PPh3)2Cl (1%), 80°	 R = Me, 170 h (51)  R = Bu, 45 h (75)	256
477		BnPd(PPh3)2Cl		254
		BnPd(PPh3)2Cl (1.6%), CuI, DMF, 50°		49
		Pd (0)		800
		Pd(PPh3)4 (5%), C6H6, reflux, 4 h	 (87)	789
		BnPd(PPh3)2Cl (1%), 80°, 48 h	 (50)	256
		[ $(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}_2$ ] (1%), HMPA, 20°	 (70)	553
		Pd2(dba)3 (5%), P(2-furyl)3 (20%), THF, 60°	 (93)	289, 425
		Pd2(dba)3 (10%), P(2-furyl)3 (20%), THF, 65°, 2.5 h	 (89)	74

TABLE XX. DIRECT CROSS-COUPLING OF ALLYL AND PROPARGYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> , THF, reflux	(71-74)	423, 424
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, 70°, 5 d	I (54)	254
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, THF	I +  (—)	254
	Me <sub>3</sub> SnSnMe <sub>3</sub>	[( <i>n</i> <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (5%), HMPA, 20°, 10 min	(80)	314, 557
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (0.6%), PhMe, 110°, 15 h	(68)	547
478		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 20 h 2. HCl (5% aq.)	(43)	269
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 6 h	(11)	161
		Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h	R = H (71) R = Me (16)	161
	Me <sub>3</sub> SnC≡CPh	"	(12)	161
		Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 19 h	(56)	248
	Me <sub>3</sub> SnSnMe <sub>3</sub>	[( <i>n</i> <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (5%), HMPA, 20°, 10 min	(83)	314
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (0.6%), PhMe, 110°, 15 h	(32)	547
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 70°, 6 h	(40)	161
479		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 6 h	(56)	161
	Me <sub>3</sub> SnSnMe <sub>3</sub>	[( <i>n</i> <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (5%), HMPA, 20°, 10 min	(85)	314
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 5 h	(95)	161
	Et <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 4 h	(72)	161
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 4 h	(68)	161
	Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 6 h	(100)	161
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 20 h	R = Cl, 20 h (82) R = Me, 6 h (100)	161
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 4 h	(76)	161
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 1 h	(90)	160
	Me <sub>3</sub> SnCH=CHPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 2.5 h	(90)	161

TABLE XX. DIRECT CROSS-COUPLING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
			Pd(PPh3)4 (5%), HMPA, 20°, 4 h	(72)	161
			Pd(PPh3)4 (5%), HMPA, 20°, 2.5 h	(77)	161
			Pd(PPh3)4 (5%), HMPA, 20°, 4 h	(97)	161
			Pd(PPh3)4 (5%), HMPA, 20°, 40 min	(92)	314
480		Bu3SnH	Pd(PPh3)4 (6%), THF, rt	(>90) 38:62	801
		Bu3SnH	Pd(PPh3)4 (6%), THF, rt	(>90) 35:65	801
		Bu3SnH	Pd(PPh3)4 (6%), THF, rt	(>90) 36:64	801
C4		Bu3SnH	Pd(PPh3)4 (6%), THF, rt	(>90) 35:65	801
		Bu3SnH	[(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), maleic anhydride (5%), THF, 50°, 12 h	(40)	38, 39
			"	(35)	38, 39
			[(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (5%)		314
			HMPA, 20°, 10 min	I (57) + II (16)	
			Me <sub>2</sub> CO, 20°, 10 min	I (58) + II (14)	
			DMF, 20°, 10 min	I (42) + II (13)	
			Pd(PPh3)4 (10%), C <sub>6</sub> H <sub>6</sub> , 60°, 20 h	(64) + (22)	529
			Pd(PPh3)4 (10%), C <sub>6</sub> H <sub>6</sub> , 60°, 20 h	(84)	529
			Pd(PPh3) <sub>2</sub> Cl <sub>2</sub> (1%)	(47)	426
481			Pd(PPh3)4 (10%), C <sub>6</sub> H <sub>6</sub> , 60°, 20 h	(54) + (18)	529
			[(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (5%)		314
			HMPA, 20°, 10 min	I (41)	
			Me <sub>2</sub> CO, 20°, 10 min	I (44) + II (12)	
			DMF, 20°, 10 min	I (43) + II (11)	
			Pd(PPh3)4, THF, rt	(66)	322
			Pd(PPh3)4, THF, rt	(77)	322

TABLE XX. DIRECT CROSS-COUPLING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Me}_3\text{SnCH}_2\text{CH}=\text{CH}_2$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, $\text{H}_2\text{O}$ , rt	 (67) + (10) $E:Z = 10:1$	164, 802
	$\text{Bu}_3\text{SnCH}_2\text{CH}=\text{CH}_2\text{SiMe}_3$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, $\text{H}_2\text{O}$ , rt	 (82-88) $E:Z = 7:1$ + (18-12)	164, 802
$\text{Me}_3\text{SnPh}$	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, $\text{H}_2\text{O}$ , rt	 (73) + (10) $E:Z = 18:1$	164, 802	
	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, $\text{H}_2\text{O}$ , rt	 (74) + (19)	803	
	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, $\text{H}_2\text{O}$ , rt	 (56) $E:Z = 13:1$ + (9)	164, 802	
	$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ , DMF, $\text{H}_2\text{O}$ , rt	 (56) + (12)	802	
$\text{Cl}_3\text{C}-\text{CH}=\text{CH}_2-\text{Cl}$	$\text{Bu}_3\text{SnH}$	$\text{Pd}(\text{PPh}_3)_4$ (6%), THF, rt	 >90%	804
$\text{Br}-\text{CH}=\text{CH}_2-\text{CN}$	$\text{Bu}_3\text{SnCH}_2\text{CH}=\text{CH}_2$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ , $\text{CHCl}_3$ , $65^\circ$	 (65)	24
$\text{C}_5$ 	$\text{Bu}_3\text{SnCH}_2\text{CH}=\text{CH}_2$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (0.3%), $\text{ZnCl}_2$ , THF, $65^\circ$ , 24 h	 I (43)	35
	$\text{Sn}(\text{CH}_2\text{CH}=\text{CH}_2)_4$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (0.3%), $\text{C}_6\text{H}_6$ , $100^\circ$ , 24 h	 I (70) + (10)	35
	$\text{Sn}(\text{CH}_2\text{CH}=\text{CH}_2)_4$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (0.3%), $\text{ZnCl}_2$ , THF, $65^\circ$ , 48 h	 I (81)	35
	$\text{Bu}_3\text{SnCH}_2\text{CH}_2\text{C}(=\text{O})\text{CH}_2$	$\text{Pd}(\text{PPh}_3)_4$ (10%), $\text{C}_6\text{H}_6$ , $60^\circ$ , 20 h	 (54)	529
	$\text{Me}_3\text{SnCH}_2\text{CH}_2\text{C}(=\text{O})\text{CH}_2\text{OH}$	$\text{Pd}_2(\text{dba})_3$ (2%), THF, $55^\circ$ , 3 h	 (90)	440
$\text{C}_5$ 	$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH}_2-\text{O}-\text{CH}(\text{CH}_3)_2-\text{N}(\text{CH}_3)_2$	$\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (1%)	 (51)	426
		$\text{Pd(0)}$	 (56) (90) (90) (92)	800

TABLE XX. DIRECT CROSS-COUPLING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), CuI (20%), P(2-furyl) <sub>3</sub> (20%), THF, 60°, 30 min	(84)	170
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , CHCl <sub>3</sub> , 65°	(53-81)	24
		[( $\eta^3$ -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (2%), maleic anhydride (5%), THF, 25°, 12 h	(38)	38, 39
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.3%), ZnCl <sub>2</sub> , THF, 65°, 50 h	(16)	35
	Me <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 27 h	I (65)	163
	Me <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 27 h	I (69)	163
	Me <sub>3</sub> Sn-	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 56°, 47 h	(50)	163
	Me <sub>3</sub> SnOPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt	(42) +  (42)	322
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), PPh <sub>3</sub> (10%), THF, 50°, 45 min	(75)	365
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 50°, 40 min	(70) +  (15)	365
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), PPh <sub>3</sub> (10%), THF, 50°, 1 h	(70)	365
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), PPh <sub>3</sub> (10%), THF, 50°, 45 min	(30)	365
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), THF, 50°, 40 min	(60) +  (10)	365
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), PPh <sub>3</sub> (10%), THF, 50°, 24 h	(60)	365
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	(36) +  (31)	164
	Me <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	(40) +  (23)	164

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (Continued)

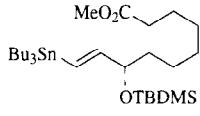
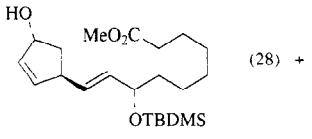
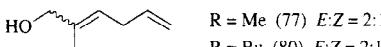
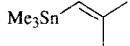
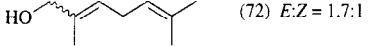
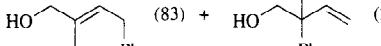
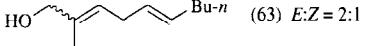
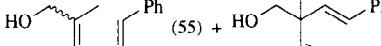
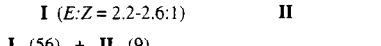
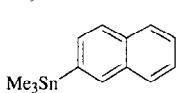
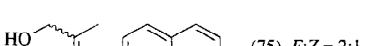
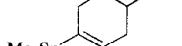
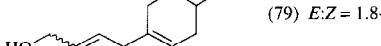
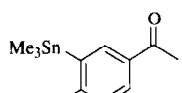
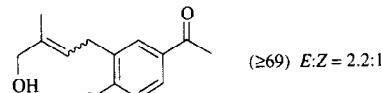
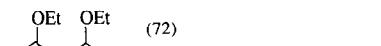
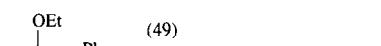
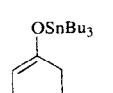
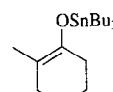
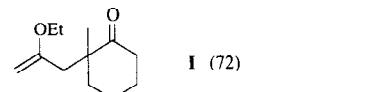
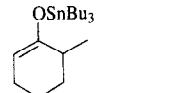
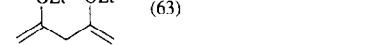
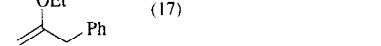
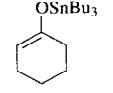
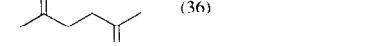
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, -10°	 (28) + (21)	164
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 R = Me (77) E:Z = 2:1 R = Bu (80) E:Z = 2:1	164, 802
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 (72) E:Z = 1.7:1	164, 802
	Me <sub>3</sub> SnPh or Bu <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 (83) + (2)	164, 802
48	Me <sub>3</sub> SnCH=CHBu-n	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 (63) E:Z = 2:1	164, 802
	Me <sub>3</sub> SnCH=CHPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 <b>I</b> (E:Z = 2.2-2.6:1) <b>II</b> (55) + (8)	164, 802
	Bu <sub>3</sub> SnCH=CHPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 <b>I</b> (56) + <b>II</b> (9)	164, 802
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 (75) E:Z = 2:1	164
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 (79) E:Z = 1.8-2:1	164, 802
484				
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	 (≥69) E:Z = 2.2:1	164
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	 (72)	162
	Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), HMPA, 100°, 20 h	 (49)	162
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (70)	162
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 41 h	 <b>I</b> (72)	160
484				
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 41 h	<b>I</b> (—)	160
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	 (63)	162, 805
	Me <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), HMPA, 100°, 20 h	 (17)	162, 805
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (63)	162
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (36)	162

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	 (99)	162, 805	
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub> 2. HCl	 (83)	805	
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub> 2. HCl	 (72)	805	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	 (60)	805	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	 (84)	805	
488		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (49)	162	
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (61)	162	
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (68)	162	
489		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (69)	162	
	Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), HMPA, 100°, 20 h	 (74)	162, 805	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	 (34)	805	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	 (48)	805	
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (83)	162	
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (68)	162	
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF 2. H <sub>3</sub> O <sup>+</sup>	 (71)	162	
	MeO <sub>2</sub> C	Bu <sub>3</sub> Sn	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , CHCl <sub>3</sub> , 65°	 (87-100)	24
		Bu <sub>3</sub> Sn	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, reflux 2. LiOH, H <sub>2</sub> O, reflux	 (86)	806
		Bu <sub>3</sub> Sn	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, reflux 2. LiOH, H <sub>2</sub> O, reflux	 R = H (74) R = Cl (73)	806
		Bu <sub>3</sub> Sn	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, reflux 2. LiOH, H <sub>2</sub> O, reflux	 (91)	806
		Bu <sub>3</sub> Sn	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, reflux 2. LiOH, H <sub>2</sub> O, reflux	 R = H (72) R = F (71)	806
		Bu <sub>3</sub> Sn	1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , THF, reflux 2. LiOH, H <sub>2</sub> O, reflux	 (74)	806

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , CHCl <sub>3</sub> , 65°	(74)	24
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , CHCl <sub>3</sub> , 65°	(94)	24
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	(42)	805
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	(55)	805
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	(79)	805
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	(70)	805
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , C <sub>6</sub> H <sub>6</sub>	(71)	805
		[(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (5%), HMPA, 20°, 15 min	(83)	314, 557
		Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h	(62)	24
		Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h	(72)	24
		[(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (5%), HMPA, 20°, 22 h	(26)	314
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 60°, 20 h	(75) + (22)	529
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	(58) + (20)	164, 802
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	(71) + (4)	164
		Pd <sub>2</sub> (dba) <sub>3</sub> (2%), THF, 55°, 3 h	(79)	440
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 60°, 2 h	(60)	287
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, 70°, 2 h	(67)	287
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , CHCl <sub>3</sub> , 80°, 3 h	(76) E:Z = 1:1	468, 469
		Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h	(69)	24
		Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h	(81)	24, 807
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, CHCl <sub>3</sub> , 65°	(56)	24

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>7</sub>		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h	(86)	24, 807
		Bu <sub>3</sub> SnCH=CHCH <sub>2</sub> OH	Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h	(82)	24, 807
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 42 h	(24)	160
		Me <sub>3</sub> SnOPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt	I +  II	$\frac{R}{Pr-n}$ (66) $\frac{I}{(16)}$ $\frac{II}{(6)}$ 322
C <sub>8</sub>		Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.5%), HMPA, 120°	(58)	805
		[Bu <sub>3</sub> SnCH=CHCH <sub>2</sub> Thieno[2,3-f]thiophene]	PdCl <sub>2</sub> (1.2%), PPh <sub>3</sub> , Et <sub>4</sub> NOTs, DMF, 50°, 1.16 F/mol, 10 mA	(55)	808
		Me <sub>3</sub> SnOPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt	I +  II	$\frac{R}{Bu-n}$ (64) $\frac{I}{(17)}$ $\frac{II}{(8)}$ 322
		Bu <sub>3</sub> SnCH=CHC <sub>5</sub> H <sub>11-n</sub> OH	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 20°, 20 h	(72)	799
492		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, THF, 40°	(70) <i>trans:cis</i> = 29:71	24
		Bu <sub>3</sub> SnPh	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl, THF, 40°	(57) <i>trans:cis</i> = 25:75	24
		Bu <sub>3</sub> SnCH=CHCO <sub>2</sub> Bn	Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h	(87)	24, 807
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	$[(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}]_2$ (5%), L, CD <sub>2</sub> Cl <sub>2</sub> , rt, 24 h	I +  II	
			L: maleic anhydride (20%) dimethyl fumarate (20%) cyclooctadiene (20%) styrene (20%) — maleic anhydride, C <sub>6</sub> H <sub>6</sub> , 48 h	(>95) I:II = 90:10 (>95) I:II = 20:80 (>95) I:II = 4:96 (>95) I:II = 1:99 (>95) I:II = 0:100 (>95) I:II = 92:8	809 809 809 809 809 809
		Bu <sub>3</sub> SnPh	$[(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}]_2$ (5%), maleic anhydride, C <sub>6</sub> H <sub>6</sub> , rt, 48 h	I +  II	(80) I:II = 98:2 25
		Bu <sub>3</sub> SnPh	$[(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}]_2$ (8%), C <sub>6</sub> H <sub>6</sub> , 25°, 24 h	I (48)	809
		Bu <sub>3</sub> SnPh	$[(\eta^3\text{-C}_3\text{H}_5)\text{PdCl}]_2$ (8%), maleic anhydride (32%), C <sub>6</sub> H <sub>6</sub> , rt, 24 h	I (100)	809

TABLE XX. DIRECT CROSS-CO尤LING OF ALLYL AND PROPARGYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Me <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 55°, 19 h	<b>I</b> (47)	163
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 24 h	(85)	160
	Bu <sub>3</sub> SnOPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 30 min	(53) +  (27)	322
	Me <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	(45)	164
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), PhMe, 100°, 24 h	(55)	457
		2. HCl (1 N)	(70)	306
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 24 h	(43) +  (6)	256
		[n <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> ]PdCl <sub>2</sub> (5%), Me <sub>2</sub> CO, 20°, 10 min	(97)	314
	Me <sub>3</sub> SnCH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> , L = AsPh <sub>3</sub> , P(2-furyl) <sub>3</sub> or PPh <sub>3</sub> , NMP, 40°	(>95)	11
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 60°, 20 h	(36) +  (26)	529
		[(n <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), maleic anhydride (5%), THF, 50°, 12 h	(64)	38
		PdCl <sub>2</sub> (1.2%), PPh <sub>3</sub> , Et <sub>4</sub> NOTs, DMF, 50°, 1.14 F/mol, 10 mA	(89)	808
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux	(R = Me) (80) +  (R = Boc) (72)	425
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	(99)	375
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, rt	(96)	375
	Bu <sub>3</sub> SnH 	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF	(100)	810
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt	(37) +  (25)	165
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), LiCl, DMF, 23°, 22 h	(80)	163
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, reflux	(71)	36
		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), LiCl, DMF, 23°, 22 h	(69)	163

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, reflux	Ph-CH=CH-CH=CH <sub>2</sub> (32)	36
	Bu <sub>3</sub> SnCH=CH-CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, reflux	Ph-CH=CH-CH=CH-CH=CH <sub>2</sub> (69)	36
	Bu <sub>3</sub> SnCH=CH-CH <sub>2</sub> OEt	1. Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 20 h 2. HCl (1 N)	Ph-CH=CH-CH <sub>2</sub> CO <sub>2</sub> Et (88)	163
	Bu <sub>3</sub> SnCH=CH-CH=CH-CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, reflux	Ph-CH=CH-CH=CH-CH=CH-CH=CH <sub>2</sub> (4)	36
	Me <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 69 h	Ph-CH=CH-CH=CH-Ph (57)	163, 36
	OSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt	Ph-CH=CH-CH=CH-C(=O)C <sub>6</sub> H <sub>11</sub> (82-89)	160
	OSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt	Ph-CH=CH-CH=CH-C(=O)C <sub>6</sub> H <sub>11</sub> (—)	160
	Bu <sub>3</sub> SnCH=CH-CH=CH-CO <sub>2</sub> Et <i>E:Z</i> = 13:87	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux, 24 h	Ph-CH=CH-CH=CH-CO <sub>2</sub> Et (80)	306
	[Bu <sub>3</sub> SnCH=CH-CH=CH-Ph]	PdCl <sub>2</sub> (1.2%), PPh <sub>3</sub> , Et <sub>4</sub> NOTs, DMF, 50°, 1.4 F/mol, 10 mA	Ph-CH=CH-CH=CH-Ph (82)	808, 36
	Bu <sub>3</sub> SnCH=CH-CH=CH-OTBDMS <i>E:Z</i> = 1:1	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 62 h	Ph-CH=CH-CH=CH-OTBDMS (60) <i>E:Z</i> = 1:1	163
	Bu <sub>3</sub> SnCH=CH-CH=CH-OTBDMS	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 70 h	Ph-CH=CH-CH=CH-OTBDMS (64)	163
	Bu <sub>3</sub> SnCH=CH-CH=CH-C(=O)OBn	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 60°, 72 h	Ph-CH=CH-CH=CH-C(=O)OBn (70)	163
	Bu <sub>3</sub> SnCH=CH-CH=CH-SnBu <sub>3</sub>	1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), THF, rt, 19 h 2. HCl (1 N)	Ph-CH=CH-CH=CH-CH=CH <sub>2</sub> (45)	811
	Me <sub>3</sub> SnOPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, rt	Ph-CH=CH-OPh (92)	322
	Ac <sub>2</sub> O-OSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, rt	Ph-CH=CH-CH=CH-CH=CH-OSnBu <sub>3</sub> (38) $\beta:\alpha = 2:1$	322
	Ac <sub>2</sub> O-OSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, rt	Ph-CH=CH-CH=CH-CH=CH-OSnBu <sub>3</sub> (33) $\beta:\alpha = 1:2$	322
	Sn-Bu <sub>2</sub> -O-CH(OH)-CH(OAc)-CH(OAc)-CH(OAc)-OSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, rt	Ph-CH=CH-CH=CH-CH=CH-OSnBu <sub>3</sub> (47) + Ph-CH=CH-CH=CH-CH=CH-OSnBu <sub>3</sub> (34)	322
	Sn-Bu <sub>2</sub> -O-CH(OH)-CH(OAc)-CH(OAc)-CH(OAc)-OSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, rt	Ph-CH=CH-CH=CH-CH=CH-OSnBu <sub>3</sub> (51) $\beta:\alpha = 1:2$	322
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), HMPA, 20°, 44 h	Ph-CH=CH-SnMe <sub>3</sub> (96)	314
	Me <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 19 h	Ph-CH=CH-Ph (32)	163
	Ph-CH=CH-OAc			

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (Continued)

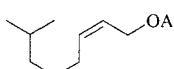
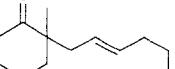
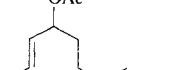
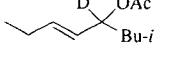
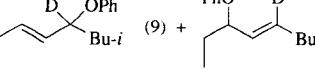
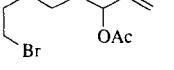
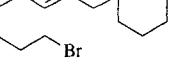
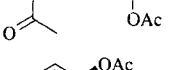
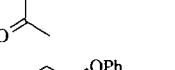
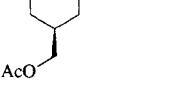
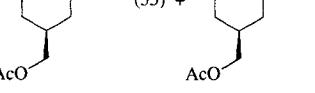
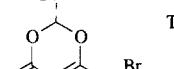
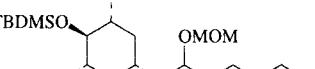
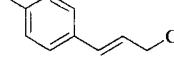
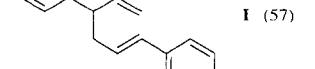
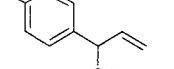
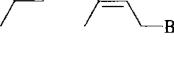
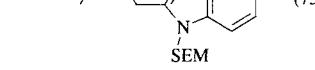
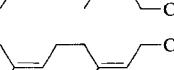
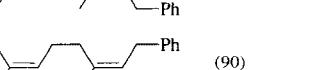
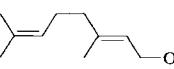
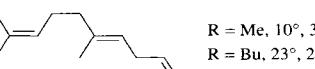
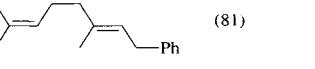
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\left[ \text{Bu}_3\text{SnCH}_2\text{CH=CHPh} \right]$	PdCl <sub>2</sub> (1.2%), PPh <sub>3</sub> , Et <sub>4</sub> NOtS, DMF, 50°, 1.39 F/mol, 10 mA	Ph C=C Ph (79)	808
	$\text{OSnBu}_3$	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 0.5 h	 (96)	160
	Me <sub>3</sub> SnOPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt	 (68) + (20)	322
	Me <sub>3</sub> SnOPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 3 h	 (9) + (70)	322
	$\left[ \text{OSnBu}_3 \right]$	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 19 h	 (89)	160
	$\left[ \text{OSnBu}_3 \right]$	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 3 h	 (91)	160
	Bu <sub>3</sub> SnOPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 20 min	 (55) + (28)	322
	$\left[ \text{OTBDMS} \right]$	Pd <sub>2</sub> (dba) <sub>3</sub> , CHCl <sub>3</sub> , PPh <sub>3</sub> , THF, 70°	 (45-50)	372, 389
	$\left[ \text{Bu}_3\text{SnCH}_2\text{CH=CHPh} \right]$	PdCl <sub>2</sub> (1.2%), PPh <sub>3</sub> , Et <sub>4</sub> NOtS, DMF, 50°, 1.15 F/mol, 10 mA	 <b>I</b> (57)	808
	$\left[ \text{Bu}_3\text{SnCH}_2\text{CH=CHPh} \right]$	PdCl <sub>2</sub> (1.2%), PPh <sub>3</sub> , Et <sub>4</sub> NOtS, DMF, 50°, 1.4 F/mol, 10 mA	 <b>I</b> (82)	808
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{N}(\text{SEM})-\text{C}_6\text{H}_4-\text{SnBu}_3$	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), P(2-furyl) <sub>3</sub> (20%), THF, 60°, 76 h	 (75)	289
	Bu <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°	 (82)	24
	Bu <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°	 (90)	24, 807
	R <sub>3</sub> Sn $\text{CH}_2\text{CH=CH}_2$	Pd(dba) <sub>2</sub> (5%), LiCl, DMF	 R = Me, 10°, 38 h, (68) R = Bu, 23°, 20 h, (68)	163
	Me <sub>3</sub> SnPh	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 47 h	 (81)	163

TABLE XX. DIRECT CROSS-COUPLING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 22 h		163
		Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 60°, 48 h		163
	Bu <sub>3</sub> Sn=CH <sub>2</sub>	Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 44 h		163
		Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 23°, 43 h		163
	Cyclohex-1-enyl SnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 42 h		160
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF		810
	H Bu <sub>3</sub> Sn—C≡C—CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF		165
	Sn(CH <sub>2</sub> =CH <sub>2</sub> ) <sub>4</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF		165
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF	+	(-) 37
	Me <sub>3</sub> SnOR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt		322
			R = Me (55)	
			R = Ph (89)	
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, H <sub>2</sub> O, NH <sub>4</sub> Cl		810
	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, BHT		810
	H Bu <sub>3</sub> Sn—C≡C—CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt		165
	[Bu <sub>3</sub> Sn-CH <sub>2</sub> -CH=CH-Ph-OMe]	PdCl <sub>2</sub> (1.2%), PPh <sub>3</sub> , Et <sub>4</sub> NOtS, DMF, 50°, 1.31 F/mol, 10 mA		808
	Me <sub>3</sub> Sn=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt		164, 802
	Me <sub>3</sub> SnPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt		164, 802
	Me <sub>3</sub> Sn-CH=CH-Ph	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt		164, 802
	Bu <sub>3</sub> Sn=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt		164, 802

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		<chem>Me3SnPh</chem>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF, H <sub>2</sub> O, rt	(54)	164
		<chem>Bu3Sn-c1ccc(OC)cc1</chem>	Pd(dba) <sub>2</sub> (3%), PPh <sub>3</sub> (6%), THF, 50°, 24 h		164, 802
		<chem>Bu3SnPh</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, H <sub>2</sub> O (1%)		810
502		<chem>Bu3Sn-C(H)=C=CH2</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt		165
		<chem>Bu3Sn-C(H)=C=CH2</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt		165
		<chem>Bu3Sn-C(H)=C=CH2</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt		165
		<chem>Bu3Sn-C(H)=C=CH2</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), THF, rt, 2 h		812
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt			165
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), THF, rt, 3 h			812
503			Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), THF, rt, 1 h		812
		<chem>OSnBu3</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt		322
		<chem>OSnBu2</chem>			
		<chem>OSnBu2</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt		322
		<chem>OSnBu3</chem>			
		<chem>OSnBu3</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 22 h		160

TABLE XX. DIRECT CROSS-COUPING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , PPh <sub>3</sub> , DME, reflux	(75)	813
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux, 0.5 h	(40)	166
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, reflux, 0.5 h	(46)	166
54	C <sub>14</sub> 	Me <sub>3</sub> SnOMe	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, rt, 3 h	(16) + (82)	322
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt	(52) + (10) + (6)	165
				(92)	
55	C <sub>15</sub> 	Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , BHT, THF	(42) + (38)	810
				(45) + (36)	165
		Bu <sub>3</sub> SnOR	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt	(45) + (36)	322
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , BHT, THF	(90)	810
				(52) + (41)	165
	C <sub>16</sub> 		Pd(dba) <sub>2</sub> (5%), LiCl, DMF, 100°, 31 h	(71)	163
		Bu <sub>3</sub> SnC≡CH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt	(47) + (47)	165

TABLE XX. DIRECT CROSS-CO尤LING OF ALLYL AND PROPARGYL ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>17</sub>		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> , BHT, THF		810
C <sub>17</sub>		Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (7%), THF, rt, 2 h		812
C <sub>19</sub>		Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt		165
C <sub>19</sub>		Sn(CH=CH <sub>2</sub> ) <sub>4</sub>	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (0.3%), ZnCl <sub>2</sub> , THF, 65°, 50 h		35
C <sub>22</sub>		Bu <sub>3</sub> Sn-O-C6H <sub>4</sub> -TMS	Pd <sub>2</sub> (dba) <sub>3</sub> , PPh <sub>3</sub> , 50°, 12 h		814
506			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (3%), PPh <sub>3</sub> (5%), DME, reflux		815
		Bu <sub>3</sub> SnH	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, 25°, 0.5 h		40
507		Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 3 h		40
			Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 72 h		40
		Bu <sub>3</sub> Sn-CH=CH-CH <sub>2</sub> OH	Pd <sub>2</sub> (dba) <sub>3</sub> , P(2-furyl) <sub>3</sub>		816
C <sub>26</sub>		Bu <sub>3</sub> Sn-CH=CH-CH <sub>2</sub> OH	Pd <sub>2</sub> (dba) <sub>3</sub> , P(2-furyl) <sub>3</sub>		816
		Bu <sub>3</sub> Sn-CH=CH-SnBu <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 16 h		40
		Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 16 h	 BocHN- BocHN- BocHN-	40

TABLE XX. DIRECT CROSS-COUPLING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>27</sub>			Pd(dba) <sub>2</sub> , LiCl, DMF	(92)	817
C <sub>28</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> , BHT, THF	(51)	810
508		Bu <sub>3</sub> SnH		(80)	40
		Bu <sub>3</sub> SnPh	Pd <sub>2</sub> (dba) <sub>3</sub> (2%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 3 h	(88)	743
		Bu <sub>3</sub> SnOMe	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 24 h	(81)	40, 818
509		Bu <sub>3</sub> Sn-phenyl	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), P(2-furyl) <sub>3</sub> (20%), THF, 65°	(95)	289
		TsHN-phenyl	Pd <sub>2</sub> (dba) <sub>3</sub> (10%), P(2-furyl) <sub>3</sub> (20%), THF, 65°, 3 h	(95)	74
		MOMO-SnBu <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), CuI (20%), P(2-furyl) <sub>3</sub> (20%), THF, 60°, 0.5 h	(79)	170
C <sub>34</sub>		Bu <sub>3</sub> SnH	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 40 min	(87)	40
		Bu <sub>3</sub> SnH	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 3 h	(82)	40, 818
		Bu <sub>3</sub> SnCF <sub>2</sub> =CF <sub>2</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 72 h	(65)	40, 818

TABLE XX. DIRECT CROSS-COUPLING OF ALLYL AND PROPARGYL ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	<chem>Bu3SnC=CMe</chem>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 16 h	(78)	40, 818
	<chem>Bu3SnC=CMe</chem>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 16 h	(9) +  (47)	818
	<chem>Bu3SnC≡CMe</chem>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 16 h	(32)	40
	<chem>Bu3SnC=CMe</chem>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 72 h	(60)	40, 818
51	<chem>Bu3SnCOEt</chem>	Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), THF, reflux, 2 h	(71)	40, 818
C <sub>40</sub>	<chem>CCl(CO2PMB)N1C(=O)NC2=C(S1)C(=O)N(C=C(Cl)C(CO2PMB)N3C(=O)C=C4=C(C=C3C=C4)N(O)C=C5=C(C=C(C=C5)N5C(=O)N6=C(C=C(C=C6)S(=O)(=O)C=C7=C(C=C(C=C7)N7C(=O)N8=C(C=C(C=C8)C=C9=C(C=C(C=C9)N9C(=O)N10=C(C=C(C=C10)C=C11=C(C=C(C=C11)N11C(=O)N12=C(C=C(C=C12)C=C13=C(C=C(C=C13)N13C(=O)N14=C(C=C(C=C14)C=C15=C(C=C(C=C15)N15C(=O)N16=C(C=C(C=C16)C=C17=C(C=C(C=C17)N17C(=O)N18=C(C=C(C=C18)C=C19=C(C=C(C=C19)N19C(=O)N20=C(C=C(C=C20)C=C21=C(C=C(C=C21)N21C(=O)N22=C(C=C(C=C22)C=C23=C(C=C(C=C23)N23C(=O)N24=C(C=C(C=C24)C=C25=C(C=C(C=C25)N25C(=O)N26=C(C=C(C=C26)C=C27=C(C=C(C=C27)N27C(=O)N28=C(C=C(C=C28)C=C29=C(C=C(C=C29)N29C(=O)N30=C(C=C(C=C30)C=C31=C(C=C(C=C31)N31C(=O)N32=C(C=C(C=C32)C=C33=C(C=C(C=C33)N33C(=O)N34=C(C=C(C=C34)C=C35=C(C=C(C=C35)N35C(=O)N36=C(C=C(C=C36)C=C37=C(C=C(C=C37)N37C(=O)N38=C(C=C(C=C38)C=C39=C(C=C(C=C39)N39C(=O)N40=C(C=C(C=C40)C=C41=C(C=C(C=C41)N41C(=O)N42=C(C=C(C=C42)C=C43=C(C=C(C=C43)N43C(=O)N44=C(C=C(C=C44)C=C45=C(C=C(C=C45)N45C(=O)N46=C(C=C(C=C46)C=C47=C(C=C(C=C47)N47C(=O)N48=C(C=C(C=C48)C=C49=C(C=C(C=C49)N49C(=O)N50=C(C=C(C=C50)C=C51=C(C=C(C=C51)N51C(=O)N52=C(C=C(C=C52)C=C53=C(C=C(C=C53)N53C(=O)N54=C(C=C(C=C54)C=C55=C(C=C(C=C55)N55C(=O)N56=C(C=C(C=C56)C=C57=C(C=C(C=C57)N57C(=O)N58=C(C=C(C=C58)C=C59=C(C=C(C=C59)N59C(=O)N60=C(C=C(C=C60)C=C61=C(C=C(C=C61)N61C(=O)N62=C(C=C(C=C62)C=C63=C(C=C(C=C63)N63C(=O)N64=C(C=C(C=C64)C=C65=C(C=C(C=C65)N65C(=O)N66=C(C=C(C=C66)C=C67=C(C=C(C=C67)N67C(=O)N68=C(C=C(C=C68)C=C69=C(C=C(C=C69)N69C(=O)N70=C(C=C(C=C70)C=C71=C(C=C(C=C71)N71C(=O)N72=C(C=C(C=C72)C=C73=C(C=C(C=C73)N73C(=O)N74=C(C=C(C=C74)C=C75=C(C=C(C=C75)N75C(=O)N76=C(C=C(C=C76)C=C77=C(C=C(C=C77)N77C(=O)N78=C(C=C(C=C78)C=C79=C(C=C(C=C79)N79C(=O)N80=C(C=C(C=C80)C=C81=C(C=C(C=C81)N81C(=O)N82=C(C=C(C=C82)C=C83=C(C=C(C=C83)N83C(=O)N84=C(C=C(C=C84)C=C85=C(C=C(C=C85)N85C(=O)N86=C(C=C(C=C86)C=C87=C(C=C(C=C87)N87C(=O)N88=C(C=C(C=C88)C=C89=C(C=C(C=C89)N89C(=O)N90=C(C=C(C=C90)C=C91=C(C=C(C=C91)N91C(=O)N92=C(C=C(C=C92)C=C93=C(C=C(C=C93)N93C(=O)N94=C(C=C(C=C94)C=C95=C(C=C(C=C95)N95C(=O)N96=C(C=C(C=C96)C=C97=C(C=C(C=C97)N97C(=O)N98=C(C=C(C=C98)C=C99=C(C=C(C=C99)N99C(=O)N100=C(C=C(C=C100)C=C101=C(C=C(C=C101)N101C(=O)N102=C(C=C(C=C102)C=C103=C(C=C(C=C103)N103C(=O)N104=C(C=C(C=C104)C=C105=C(C=C(C=C105)N105C(=O)N106=C(C=C(C=C106)C=C107=C(C=C(C=C107)N107C(=O)N108=C(C=C(C=C108)C=C109=C(C=C(C=C109)N109C(=O)N110=C(C=C(C=C110)C=C111=C(C=C(C=C111)N111C(=O)N112=C(C=C(C=C112)C=C113=C(C=C(C=C113)N113C(=O)N114=C(C=C(C=C114)C=C115=C(C=C(C=C115)N115C(=O)N116=C(C=C(C=C116)C=C117=C(C=C(C=C117)N117C(=O)N118=C(C=C(C=C118)C=C119=C(C=C(C=C119)N119C(=O)N120=C(C=C(C=C120)C=C121=C(C=C(C=C121)N121C(=O)N122=C(C=C(C=C122)C=C123=C(C=C(C=C123)N123C(=O)N124=C(C=C(C=C124)C=C125=C(C=C(C=C125)N125C(=O)N126=C(C=C(C=C126)C=C127=C(C=C(C=C127)N127C(=O)N128=C(C=C(C=C128)C=C129=C(C=C(C=C129)N129C(=O)N130=C(C=C(C=C130)C=C131=C(C=C(C=C131)N131C(=O)N132=C(C=C(C=C132)C=C133=C(C=C(C=C133)N133C(=O)N134=C(C=C(C=C134)C=C135=C(C=C(C=C135)N135C(=O)N136=C(C=C(C=C136)C=C137=C(C=C(C=C137)N137C(=O)N138=C(C=C(C=C138)C=C139=C(C=C(C=C139)N139C(=O)N140=C(C=C(C=C140)C=C141=C(C=C(C=C141)N141C(=O)N142=C(C=C(C=C142)C=C143=C(C=C(C=C143)N143C(=O)N144=C(C=C(C=C144)C=C145=C(C=C(C=C145)N145C(=O)N146=C(C=C(C=C146)C=C147=C(C=C(C=C147)N147C(=O)N148=C(C=C(C=C148)C=C149=C(C=C(C=C149)N149C(=O)N150=C(C=C(C=C150)C=C151=C(C=C(C=C151)N151C(=O)N152=C(C=C(C=C152)C=C153=C(C=C(C=C153)N153C(=O)N154=C(C=C(C=C154)C=C155=C(C=C(C=C155)N155C(=O)N156=C(C=C(C=C156)C=C157=C(C=C(C=C157)N157C(=O)N158=C(C=C(C=C158)C=C159=C(C=C(C=C159)N159C(=O)N160=C(C=C(C=C160)C=C161=C(C=C(C=C161)N161C(=O)N162=C(C=C(C=C162)C=C163=C(C=C(C=C163)N163C(=O)N164=C(C=C(C=C164)C=C165=C(C=C(C=C165)N165C(=O)N166=C(C=C(C=C166)C=C167=C(C=C(C=C167)N167C(=O)N168=C(C=C(C=C168)C=C169=C(C=C(C=C169)N169C(=O)N170=C(C=C(C=C170)C=C171=C(C=C(C=C171)N171C(=O)N172=C(C=C(C=C172)C=C173=C(C=C(C=C173)N173C(=O)N174=C(C=C(C=C174)C=C175=C(C=C(C=C175)N175C(=O)N176=C(C=C(C=C176)C=C177=C(C=C(C=C177)N177C(=O)N178=C(C=C(C=C178)C=C179=C(C=C(C=C179)N179C(=O)N180=C(C=C(C=C180)C=C181=C(C=C(C=C181)N181C(=O)N182=C(C=C(C=C182)C=C183=C(C=C(C=C183)N183C(=O)N184=C(C=C(C=C184)C=C185=C(C=C(C=C185)N185C(=O)N186=C(C=C(C=C186)C=C187=C(C=C(C=C187)N187C(=O)N188=C(C=C(C=C188)C=C189=C(C=C(C=C189)N189C(=O)N190=C(C=C(C=C190)C=C191=C(C=C(C=C191)N191C(=O)N192=C(C=C(C=C192)C=C193=C(C=C(C=C193)N193C(=O)N194=C(C=C(C=C194)C=C195=C(C=C(C=C195)N195C(=O)N196=C(C=C(C=C196)C=C197=C(C=C(C=C197)N197C(=O)N198=C(C=C(C=C198)C=C199=C(C=C(C=C199)N199C(=O)N200=C(C=C(C=C200)C=C201=C(C=C(C=C201)N201C(=O)N202=C(C=C(C=C202)C=C203=C(C=C(C=C203)N203C(=O)N204=C(C=C(C=C204)C=C205=C(C=C(C=C205)N205C(=O)N206=C(C=C(C=C206)C=C207=C(C=C(C=C207)N207C(=O)N208=C(C=C(C=C208)C=C209=C(C=C(C=C209)N209C(=O)N210=C(C=C(C=C210)C=C211=C(C=C(C=C211)N211C(=O)N212=C(C=C(C=C212)C=C213=C(C=C(C=C213)N213C(=O)N214=C(C=C(C=C214)C=C215=C(C=C(C=C215)N215C(=O)N216=C(C=C(C=C216)C=C217=C(C=C(C=C217)N217C(=O)N218=C(C=C(C=C218)C=C219=C(C=C(C=C219)N219C(=O)N220=C(C=C(C=C220)C=C221=C(C=C(C=C221)N221C(=O)N222=C(C=C(C=C222)C=C223=C(C=C(C=C223)N223C(=O)N224=C(C=C(C=C224)C=C225=C(C=C(C=C225)N225C(=O)N226=C(C=C(C=C226)C=C227=C(C=C(C=C227)N227C(=O)N228=C(C=C(C=C228)C=C229=C(C=C(C=C229)N229C(=O)N230=C(C=C(C=C230)C=C231=C(C=C(C=C231)N231C(=O)N232=C(C=C(C=C232)C=C233=C(C=C(C=C233)N233C(=O)N234=C(C=C(C=C234)C=C235=C(C=C(C=C235)N235C(=O)N236=C(C=C(C=C236)C=C237=C(C=C(C=C237)N237C(=O)N238=C(C=C(C=C238)C=C239=C(C=C(C=C239)N239C(=O)N240=C(C=C(C=C240)C=C241=C(C=C(C=C241)N241C(=O)N242=C(C=C(C=C242)C=C243=C(C=C(C=C243)N243C(=O)N244=C(C=C(C=C244)C=C245=C(C=C(C=C245)N245C(=O)N246=C(C=C(C=C246)C=C247=C(C=C(C=C247)N247C(=O)N248=C(C=C(C=C248)C=C249=C(C=C(C=C249)N249C(=O)N250=C(C=C(C=C250)C=C251=C(C=C(C=C251)N251C(=O)N252=C(C=C(C=C252)C=C253=C(C=C(C=C253)N253C(=O)N254=C(C=C(C=C254)C=C255=C(C=C(C=C255)N255C(=O)N256=C(C=C(C=C256)C=C257=C(C=C(C=C257)N257C(=O)N258=C(C=C(C=C258)C=C259=C(C=C(C=C259)N259C(=O)N260=C(C=C(C=C260)C=C261=C(C=C(C=C261)N261C(=O)N262=C(C=C(C=C262)C=C263=C(C=C(C=C263)N263C(=O)N264=C(C=C(C=C264)C=C265=C(C=C(C=C265)N265C(=O)N266=C(C=C(C=C266)C=C267=C(C=C(C=C267)N267C(=O)N268=C(C=C(C=C268)C=C269=C(C=C(C=C269)N269C(=O)N270=C(C=C(C=C270)C=C271=C(C=C(C=C271)N271C(=O)N272=C(C=C(C=C272)C=C273=C(C=C(C=C273)N273C(=O)N274=C(C=C(C=C274)C=C275=C(C=C(C=C275)N275C(=O)N276=C(C=C(C=C276)C=C277=C(C=C(C=C277)N277C(=O)N278=C(C=C(C=C278)C=C279=C(C=C(C=C279)N279C(=O)N280=C(C=C(C=C280)C=C281=C(C=C(C=C281)N281C(=O)N282=C(C=C(C=C282)C=C283=C(C=C(C=C283)N283C(=O)N284=C(C=C(C=C284)C=C285=C(C=C(C=C285)N285C(=O)N286=C(C=C(C=C286)C=C287=C(C=C(C=C287)N287C(=O)N288=C(C=C(C=C288)C=C289=C(C=C(C=C289)N289C(=O)N290=C(C=C(C=C290)C=C291=C(C=C(C=C291)N291C(=O)N292=C(C=C(C=C292)C=C293=C(C=C(C=C293)N293C(=O)N294=C(C=C(C=C294)C=C295=C(C=C(C=C295)N295C(=O)N296=C(C=C(C=C296)C=C297=C(C=C(C=C297)N297C(=O)N298=C(C=C(C=C298)C=C299=C(C=C(C=C299)N299C(=O)N2910=C(C=C(C=C2910)C=C2911=C(C=C(C=C2911)N2911C(=O)N2912=C(C=C(C=C2912)C=C2913=C(C=C(C=C2913)N2913C(=O)N2914=C(C=C(C=C2914)C=C2915=C(C=C(C=C2915)N2915C(=O)N2916=C(C=C(C=C2916)C=C2917=C(C=C(C=C2917)N2917C(=O)N2918=C(C=C(C=C2918)C=C2919=C(C=C(C=C2919)N2919C(=O)N2920=C(C=C(C=C2920)C=C2921=C(C=C(C=C2921)N2921C(=O)N2922=C(C=C(C=C2922)C=C2923=C(C=C(C=C2923)N2923C(=O)N2924=C(C=C(C=C2924)C=C2925=C(C=C(C=C2925)N2925C(=O)N2926=C(C=C(C=C2926)C=C2927=C(C=C(C=C2927)N2927C(=O)N2928=C(C=C(C=C2928)C=C2929=C(C=C(C=C2929)N2929C(=O)N2930=C(C=C(C=C2930)C=C2931=C(C=C(C=C2931)N2931C(=O)N2932=C(C=C(C=C2932)C=C2933=C(C=C(C=C2933)N2933C(=O)N2934=C(C=C(C=C2934)C=C2935=C(C=C(C=C2935)N2935C(=O)N2936=C(C=C(C=C2936)C=C2937=C(C=C(C=C2937)N2937C(=O)N2938=C(C=C(C=C2938)C=C2939=C(C=C(C=C2939)N2939C(=O)N2940=C(C=C(C=C2940)C=C2941=C(C=C(C=C2941)N2941C(=O)N2942=C(C=C(C=C2942)C=C2943=C(C=C(C=C2943)N2943C(=O)N2944=C(C=C(C=C2944)C=C2945=C(C=C(C=C2945)N2945C(=O)N2946=C(C=C(C=C2946)C=C2947=C(C=C(C=C2947)N2947C(=O)N2948=C(C=C(C=C2948)C=C2949=C(C=C(C=C2949)N2949C(=O)N2950=C(C=C(C=C2950)C=C2951=C(C=C(C=C2951)N2951C(=O)N2952=C(C=C(C=C2952)C=C2953=C(C=C(C=C2953)N2953C(=O)N2954=C(C=C(C=C2954)C=C2955=C(C=C(C=C2955)N2955C(=O)N2956=C(C=C(C=C2956)C=C2957=C(C=C(C=C2957)N2957C(=O)N2958=C(C=C(C=C2958)C=C2959=C(C=C(C=C2959)N2959C(=O)N2960=C(C=C(C=C2960)C=C2961=C(C=C(C=C2961)N2961C(=O)N2962=C(C=C(C=C2962)C=C2963=C(C=C(C=C2963)N2963C(=O)N2964=C(C=C(C=C2964)C=C2965=C(C=C(C=C2965)N2965C(=O)N2966=C(C=C(C=C2966)C=C2967=C(C=C(C=C2967)N2967C(=O)N2968=C(C=C(C=C2968)C=C2969=C(C=C(C=C2969)N2969C(=O)N2970=C(C=C(C=C2970)C=C2971=C(C=C(C=C2971)N2971C(=O)N2972=C(C=C(C=C2972)C=C2973=C(C=C(C=C2973)N2973C(=O)N2974=C(C=C(C=C2974)C=C2975=C(C=C(C=C2975)N2975C(=O)N2976=C(C=C(C=C2976)C=C2977=C(C=C(C=C2977)N2977C(=O)N2978=C(C=C(C=C2978)C=C2979=C(C=C(C=C2979)N2979C(=O)N2980=C(C=C(C=C2980)C=C2981=C(C=C(C=C2981)N2981C(=O)N2982=C(C=C(C=C2982)C=C2983=C(C=C(C=C2983)N2983C(=O)N2984=C(C=C(C=C2984)C=C2985=C(C=C(C=C2985)N2985C(=O)N2986=C(C=C(C=C2986)C=C2987=C(C=C(C=C2987)N2987C(=O)N2988=C(C=C(C=C2988)C=C2989=C(C=C(C=C2989)N2989C(=O)N2990=C(C=C(C=C2990)C=C2991=C(C=C(C=C2991)N2991C(=O)N2992=C(C=C(C=C2992)C=C2993=C(C=C(C=C2993)N2993C(=O)N2994=C(C=C(C=C2994)C=C2995=C(C=C(C=C2995)N2995C(=O)N2996=C(C=C(C=C2996)C=C2997=C(C=C(C=C2997)N2997C(=O)N2998=C(C=C(C=C2998)C=C2999=C(C=C(C=C2999)N2999C(=O)N29100=C(C=C(C=C29100)C=C29101=C(C=C(C=C29101)N29101C(=O)N29102=C(C=C(C=C29102)C=C29103=C(C=C(C=C29103)N29103C(=O)N29104=C(C=C(C=C29104)C=C29105=C(C=C(C=C29105)N29105C(=O)N29106=C(C=C(C=C29106)C=C29107=C(C=C(C=C29107)N29107C(=O)N29108=C(C=C(C=C29108)C=C29109=C(C=C(C=C29109)N29109C(=O)N29110=C(C=C(C=C29110)C=C29111=C(C=C(C=C29111)N29111C(=O)N29112=C(C=C(C=C29112)C=C29113=C(C=C(C=C29113)N29113C(=O)N29114=C(C=C(C=C29114)C=C29115=C(C=C(C=C29115)N29115C(=O)N29116=C(C=C(C=C29116)C=C29117=C(C=C(C=C29117)N29117C(=O)N29118=C(C=C(C=C29118)C=C29119=C(C=C(C=C29119)N29119C(=O)N29120=C(C=C(C=C29120)C=C29121=C(C=C(C=C29121)N29121C(=O)N29122=C(C=C(C=C29122)C=C29123=C(C=C(C=C29123)N29123C(=O)N29124=C(C=C(C=C29124)C=C29125=C(C=C(C=C29125)N29125C(=O)N29126=C(C=C(C=C29126)C=C29127=C(C=C(C=C29127)N29127C(=O)N29128=C(C=C(C=C29128)C=C29129=C(C=C(C=C29129)N29129C(=O)N29130=C(C=C(C=C29130)C=C29131=C(C=C(C=C29131)N29131C(=O)N29132=C(C=C(C=C29132)C=C29133=C(C=C(C=C29133)N29133C(=O)N29134=C(C=C(C=C29134)C=C29135=C(C=C(C=C29135)N29135C(=O)N29136=C(C=C(C=C29136)C=C29137=C(C=C(C=C29137)N29137C(=O)N29138=C(C=C(C=C29138)C=C29139=C(C=C(C=C29139)N29139C(=O)N29140=C(C=C(C=C29140)C=C29141=C(C=C(C=C29141)N29141C(=O)N29142=C(C=C(C=C29142)C=C29143=C(C=C(C=C29143)N29143C(=O)N29144=C(C=C(C=C29144)C=C29145=C(C=C(C=C29145)N29145C(=O)N29146=C(C=C(C=C29146)C=C29147=C(C=C(C=C29147)N29147C(=O)N29148=C(C=C(C=C29148)C=C29149=C(C=C(C=C29149)N29149C(=O)N29150=C(C=C(C=C29150)C=C29151=C(C=C(C=C29151)N29151C(=O)N29152=C(C=C(C=C29152)C=C29153=C(C=C(C=C29153)N29153C(=O)N29154=C(C=C(C=C29154)C=C29155=C(C=C(C=C29155)N29155C(=O)N29156=C(C=C(C=C29156)C=C29157=C(C=C(C=C29157)N29157C(=O)N29158=C(C=C(C=C29158)C=C29159=C(C=C(C=C29159)N29159C(=O)N29160=C(C=C(C=C29160)C=C29161=C(C=C(C=C29161)N29161C(=O)N29162=C(C=C(C=C29162)C=C29163=C(C=C(C=C29163)N29163C(=O)N29164=C(C=C(C=C29164)C=C29165=C(C=C(C=C29165)N29165C(=O)N29166=C(C=C(C=C29166)C=C29167=C(C=C(C=C29167)N29167C(=O)N29168=C(C=C(C=C29168)C=C29169=C(C=C(C=C29169)N29169C(=O)N29170=C(C=C(C=C29170)C=C29171=C(C=C(C=C29171)N29171C(=O)N29172=C(C=C(C=C29172)C=C29173=C(C=C(C=C29173)N29173C(=O)N29174=C(C=C(C=C29174)C=C29175=C(C=C(C=C29175)N29175C(=O)N29176=C(C=C(C=C29176)C=C29177=C(C=C(C=C29177)N29177C(=O)N29178=C(C=C(C=C29178)C=C29179=C(C=C(C=C29179)N29179C(=O)N29180=C(C=C(C=C29180)C=C29181=C(C=C(C=C29181)N29181C(=O)N29182=C(C=C(C=C29182)C=C29183=C(C=C(C=C29183)N29183C(=O)N29184=C(C=C(C=C29184)C=C29185=C(C=C(C=C29185)N29185C(=O)N29186=C(C=C(C=C29186)C=C29187=C(C=C(C=C29187)N29187C(=O)N29188=C(C=C(C=C29188)C=C29189=C(C=C(C=C29189)N29189C(=O)N29190=C(C=C(C=C29190)C=C29191=C(C=C(C=C29191)N29191C(=O)N29192=C(C=C(C=C29192)C=C29193=C(C=C(C=C29193)N29193C(=O)N29194=C(C=C(C=C29194)C=C29195=C(C=C(C=C29195)N29195C(=O)N29196=C(C=C(C=C29196)C=C29197=C(C=C(C=C29197)N29197C(=O)N29198=C(C=C(C=C29198)C=C29199=C(C=C(C=C29199)N29199C(=O)N291100=C(C=C(C=C291100)C=C291101=C(C=C(C=C291101)N291101C(=O)N291102=C(C=C(C=C291102)C=C291103=C(C=C(C=C291103)N291103C(=O)N291104=C(C=C(C=C291104)C=C291105=C(C=C(C=C291105)N291105C(=O)N291106=C(C=C(C=C291106)C=C291107=C(C=C(C=C291107)N291107C(=O)N291108=C(C=C(C=C291108)C=C291109=C(C=C(C=C291109)N291109C(=O)N291110=C(C=C(C=C291110)C=C291111=C(C=C(C=C2</chem>			

TABLE XXI. DIRECT CROSS-COUPING OF BENZYL ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>7</sub>	Ph <chem>C=CBr</chem>	Me <sub>4</sub> Sn	Pd(2, 2'-bipyridine), (fumaronitrile) (1.5%), HMPA, 60°, 15 h	Ph <chem>C=C</chem> (94)	171, 819, 19
	Bu <sub>3</sub> Sn <chem>C=C</chem>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), HMPA, 65°	Ph <chem>C=C</chem> (100)	19
	Bu <sub>4</sub> Sn		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), HMPA, 65°	Ph <chem>C=C</chem> Bu-n (42)	19
	Bu <sub>3</sub> Sn <chem>c1ccoc1</chem> SnBu <sub>3</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, 70°, 10 h	Ph <chem>C=C</chem> Ph (45)	287
	Bu <sub>3</sub> Sn <chem>O=C1CC(C)(C)ON1</chem>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%)	Ph <chem>C=C</chem> (58)	426
	MeSnPh <sub>3</sub>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), HMPA, 65°	Ph <chem>C=C</chem> Ph (95)	19
	Me <sub>3</sub> Sn <chem>C=C</chem> Ph		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), HMPA, 65°	Ph <chem>C=C</chem> Ph (89)	19
	Bu <sub>3</sub> Sn <chem>c1ccc(cc1)C</chem>		Pd(Ph-BIAN) (1%), HMPA, 20°, 20 h or DMF, 50°, 20 h	Ph <chem>C=C</chem> Ph (76)	819
	Bu <sub>3</sub> Sn <chem>c1ccc2c(c1)N(C)c3ccccc23</chem>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux, 1 h	Ph <chem>C=C</chem> Ph (70)	425
	Bu <sub>3</sub> Sn <chem>CC(=O)C(C(=O)OCC)N</chem>		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, 65°	Ph <chem>C=C</chem> CO <sub>2</sub> Et NHAc (100)	375
512	Bu <sub>3</sub> Sn <chem>CC=CC(C(=O)OCC)N</chem>		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (40%), THF, rt	Ph <chem>C=C</chem> CO <sub>2</sub> Et (68)	375
	Bu <sub>3</sub> Sn <chem>CC=C(CO)C[Si](C)(C)C</chem>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.6%), CuI, DMF, 50°, 7 h	Ph <chem>C=C</chem> OEt (88)	49
	Bu <sub>3</sub> Sn <chem>CC=C(C)Cn</chem>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux	Ph <chem>C=C</chem> (—)	442
	Bu <sub>3</sub> Sn <chem>c1ccoc1CC(O)C</chem>		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> , DMF/HMPA (10:1), 60°, 2 h	Ph <chem>C=C</chem> OH (70)	287
	Bu <sub>3</sub> Sn <chem>CC=C(CO)C[Si](C)(C)C</chem>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1.6%), CuI, DMF, 50°	Ph <chem>C=C</chem> OEt (79)	49
	Bu <sub>3</sub> Sn <chem>CC=C(C)C[Si](C)(C)C</chem>		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), 80°	Ph <chem>C=C</chem> TMS (19)	256
	Bu <sub>3</sub> Sn <chem>CC=C(C)COBn</chem>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), C <sub>6</sub> H <sub>6</sub> , reflux	Ph <chem>C=C</chem> OEt OBN (81)	789
	Bu <sub>3</sub> Sn <chem>c1ccc2c(c1)N(C)c3ccccc23</chem>		Pd <sub>2</sub> (dba) <sub>3</sub> (5%), P(2-furyl) <sub>3</sub> (20%), THF, 60°, 3 h	Ph <chem>C=C</chem> SEM (95)	289
	Bu <sub>3</sub> Sn <chem>CC(=O)C1Cc2ccccc2N1</chem>		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CH <sub>3</sub> CN, 100°, 1 h	Ph <chem>C=C</chem> MeO <sub>2</sub> C SEM (71)	290
513					

TABLE XXI. DIRECT CROSS-COUPING OF BENZYL ELECTROPHILES (*Continued*)

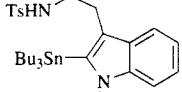
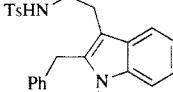
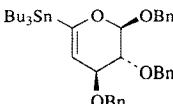
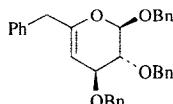
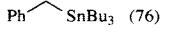
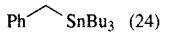
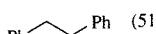
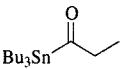
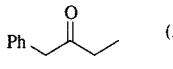
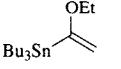
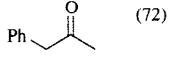
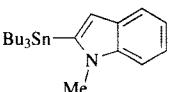
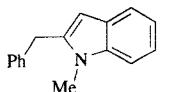
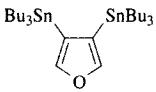
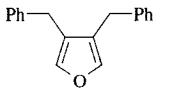
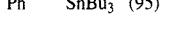
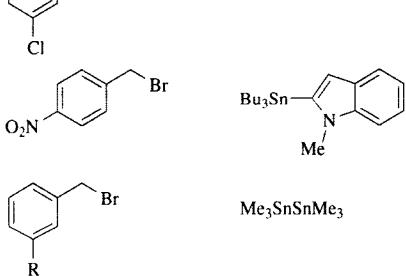
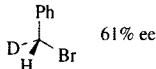
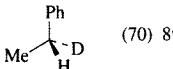
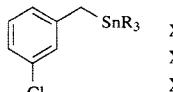
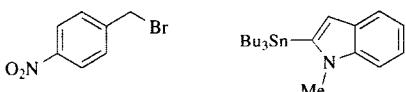
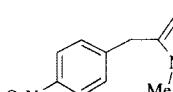
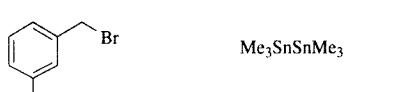
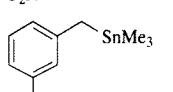
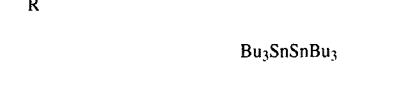
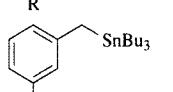
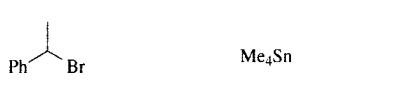
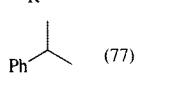
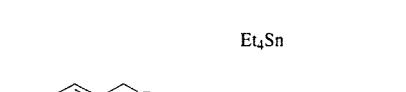
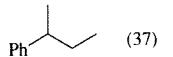
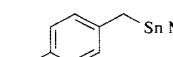
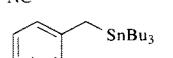
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
 514		Pd <sub>2</sub> (dba) <sub>3</sub> (10%), P(2-furyl) <sub>3</sub> (20%), THF, 65°, 1.5 h	 (93)	74
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), PhMe, reflux, 1 h	 (74)	424
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Br <sub>2</sub> (0.6%), PhMe, 110°, 15 h	 (76)	547
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 25°, 40 min	 (24) +  (51)	313
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), HMPA, 65°	 (61)	19
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h	 (30)	529
		1. Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 20 h 2. HCl (5%)	 (72)	269
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), THF, reflux, 1 h	 (—)	425
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, 100°, 12 h	 (70)	287
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.6%), PhMe, 110°, 15 h	 (95)	547
 515	 61% ee	Me <sub>4</sub> Sn	 (70) 8% ee	19
		R <sub>3</sub> SnSnR <sub>3</sub>	 X = Br, R = Me (65) X = Br, R = Bu (51) X = Cl, R = Bu (58)	547
		Bu <sub>3</sub> Sn-CH2-CH2-N(Me)-C6H4-C6H5	 (79)	425
		Me <sub>3</sub> SnSnMe <sub>3</sub>	 R = NO <sub>2</sub> (68) R = CN (95)	547
		Bu <sub>3</sub> SnSnBu <sub>3</sub>	 R = NO <sub>2</sub> (30) R = CN (56)	547
		Me <sub>4</sub> Sn	 (77)	171
 547	Et <sub>4</sub> Sn	Pd(2,2'-bipyridine) (1.5%), fumaronitrile, HMPA, 60°, 113 h	 (37)	171
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.6%), PhMe, 110°, 15 h	 (96)	547
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.6%), PhMe, 110°, 15 h	 R = m-OMe (87) R = p-OMe (35)	547

TABLE XXI. DIRECT CROSS-COUPING OF BENZYL ELECTROPHILES (*Continued*)

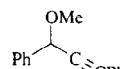
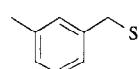
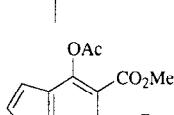
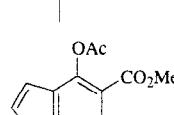
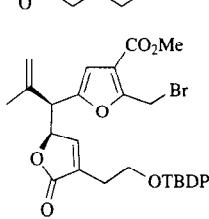
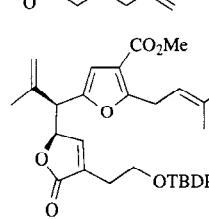
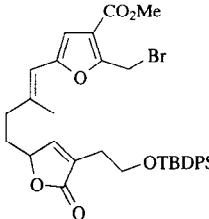
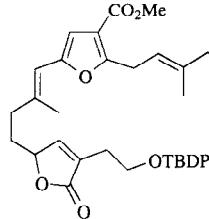
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Bu3SnC≡CPh	Pd(PPh3)4 (4%), CCl4, 80°, 20 h	 (65)	207
C9		Bu3SnSnBu3	Pd(PPh3)2Br2 (0.6%), PhMe, 110°, 15 h	 (56)	547
C13		Bu3SnCH=CH2	BnPd(PPh3)2Cl (0.7%), HMPA, 65°, 6 h	 (92)	820
516		Bu3SnCH=CH-CH2-OTHP	Pd(PPh3)4, C6H6, reflux	 (56-63)	172, 821
C34		Bu3SnCH=CH-CH2-OTHP	Pd(PPh3)4, CHCl3, reflux	 (50-60)	822, 823

TABLE XXII. INTRAMOLECULAR CROSS-COUPLING OF ALLYL AND BENZYL ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
<sup>C<sub>4</sub></sup>			Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt	 (66)	322
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt	 (77)	322
<sup>C<sub>12</sub></sup>		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> , PhMe, 110°, 18h	 (90)	645
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> , 1-hexene, THF, reflux	 (83)	824
<sup>517</sup>			Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt	 (94)	322
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , THF, rt	 (20)	322

TABLE XXII. INTRAMOLECULAR CROSS-CO尤LING OF ALLYL AND BENZYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
C <sub>14</sub>		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> , 1-hexene, THF, reflux		(52)	824
			Pd <sub>2</sub> (dba) <sub>3</sub> , AsPh <sub>3</sub> , cyclohexane, reflux		(26)	167
C <sub>15</sub>			Pd <sub>2</sub> (dba) <sub>3</sub> , AsPh <sub>3</sub> , cyclohexane, reflux		(40)	167
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> , 1-hexene, THF, reflux		(15) + (45)	824
C <sub>16</sub>		Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), Li <sub>2</sub> CO <sub>3</sub> , Et <sub>4</sub> NBr, PhMe, reflux		(68)	563
			Pd <sub>2</sub> (dba) <sub>3</sub> , AsPh <sub>3</sub> , cyclohexane, reflux		(45)	167
C <sub>17</sub>			Pd <sub>2</sub> (dba) <sub>3</sub> , AsPh <sub>3</sub> , cyclohexane, reflux		(55)	167
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> , 1-hexene, THF, reflux		(62) + (12)	167
C <sub>19</sub>			Pd <sub>2</sub> (dba) <sub>3</sub> , AsPh <sub>3</sub> , cyclohexane, reflux		(57)	167
		Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> , PhMe, 110°, 18 h		(60)	645

TABLE XXII. INTRAMOLECULAR CROSS-COUPLING OF ALLYL AND BENZYL ELECTROPHILES (*Continued*)

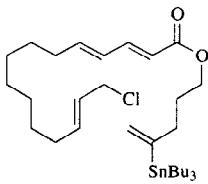
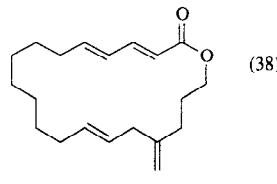
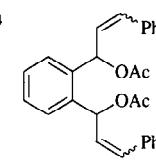
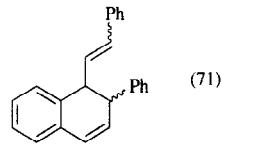
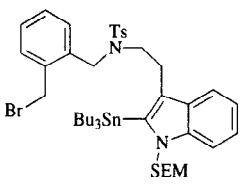
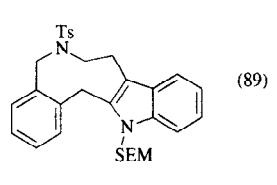
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> , AsPh <sub>3</sub> , cyclohexane, reflux	 (38)	167
	Me <sub>3</sub> SnSnMe <sub>3</sub>	Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> , 1-hexene, THF, reflux	 (71)	824
		Pd <sub>2</sub> (dba) <sub>3</sub> , P(2-furyl) <sub>3</sub> , THF, reflux	 (89)	74

TABLE XXIII. DIRECT CROSS-COUPLING OF ORGANOMETALLIC ELECTROPHILES

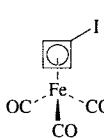
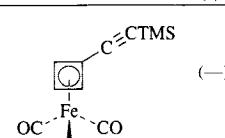
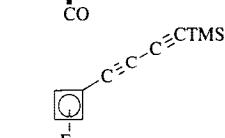
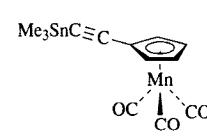
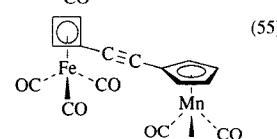
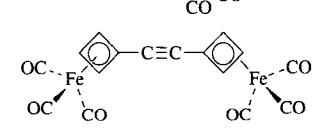
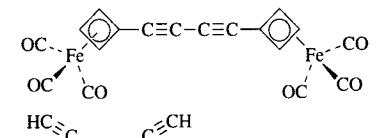
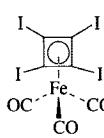
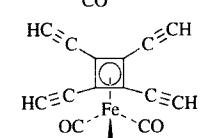
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Me}_3\text{SnC}\equiv\text{CTMS}$	$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	 (—)	223
	$\text{Me}_3\text{SnC}\equiv\text{C}-\text{C}\equiv\text{CTMS}$	$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	 (44)	223
		$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	 (55)	223
	$\text{Me}_3\text{SnC}\equiv\text{CSnMe}_3$	$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	 (65)	223
	$\text{Me}_3\text{SnC}\equiv\text{C}-\text{C}\equiv\text{CSnMe}_3$	$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	 (67)	223
	$\text{Me}_3\text{SnC}\equiv\text{CH}$	$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	 (25)	219

TABLE XXIII. DIRECT CROSS-CO尤LING OF ORGANOMETALLIC ELECTROPHILES (Continued)

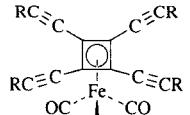
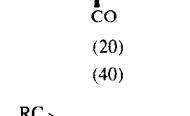
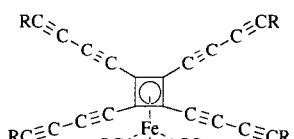
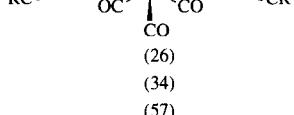
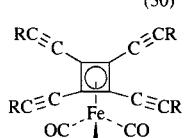
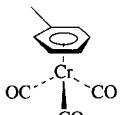
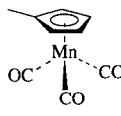
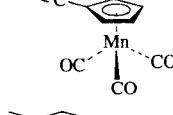
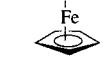
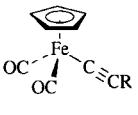
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
$\text{Me}_3\text{SnC}\equiv\text{CR}$		$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	 (20)  (20) (40)	
$\frac{\text{R}}{\text{TMS}}$				219, 220
$\text{Bu}-t$				219
$\text{Me}_3\text{SnC}\equiv\text{C}-\text{C}\equiv\text{CR}$		$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	 (26)  (34) (57) (30)	220
$\frac{\text{R}}{\text{Pr}-i}$				
TMS				
$\text{Bu}-t$				
$\text{C}_5\text{H}_{11}-n$				
$\text{Me}_3\text{SnC}\equiv\text{CR}$			 (18)	220
$\frac{\text{R}}{\text{C}_8\text{H}_{17}-n}$		$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	(83)	219
		$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (30%), DMF, 20°, 48 h	(49)	220
		$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	(69)	220
		$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	(28)	220
		$\text{Pd}_2(\text{dba})_3$ (5.5%), $\text{AsPh}_3$ (22%), DMF, 20°, 18 h	(35)	220
$\text{Bu}_3\text{SnC}\equiv\text{CR}$		$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (5%), THF, rt, overnight	 (67) (51) (71) (74) (74)	231
$\frac{\text{R}}{\text{H}}$				
$\text{C}\equiv\text{CH}$				
$\text{Pr}-n$				
$\text{Bu}-n$				
Ph				
$\text{Bu}_3\text{SnC}\equiv\text{C}-\text{C}\equiv\text{CSnBu}_3$		$\text{Pd}(\text{CH}_3\text{CN})_2\text{Cl}_2$ (5%), THF, rt, overnight	 (43)	231

TABLE XXIII. DIRECT CROSS-CO尤LING OF ORGANOMETALLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnC≡CH	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 (86)	825
	Bu <sub>3</sub> SnC≡C	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), DMF, rt, 2 h	 (91)	826
	Bu <sub>3</sub> SnC≡CSnBu <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 (72)	226
	Bu <sub>3</sub> SnC≡CH	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 (92)	825
	Me <sub>3</sub> SnC≡C-C≡CTMS	Pd <sub>2</sub> (dba) <sub>3</sub> (5.5%), AsPh <sub>3</sub> (22%), DMF, 20°, 18 h	 (79)	220
	Bu <sub>3</sub> SnC≡C	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 (79)	825
	Bu <sub>3</sub> SnC≡C	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 M = Mo (70) M = W (81)	825
	Bu <sub>3</sub> SnC≡CSnBu <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 (90)	226
	Me <sub>3</sub> SnC≡CR			
	R Me	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (4%), DMF, 20°, 40 h	(38)	218
	Pr- <i>i</i>	"	(17)	218
	C≡CPr- <i>i</i>	Pd <sub>2</sub> (dba) <sub>3</sub> (5.5%), AsPh <sub>3</sub> (22%), DMF, 20°, 18 h	(11)	220
	C≡CBu- <i>t</i>	"	(10)	220
	C≡CC <sub>5</sub> H <sub>11</sub> - <i>n</i>	"	(5)	220
	Bu <sub>3</sub> SnC≡CH	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 (94)	825
	Bu <sub>3</sub> SnC≡C	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 (96)	825
	Bu <sub>3</sub> SnC≡C	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	 (73)	825

TABLE XXIII. DIRECT CROSS-COUPLING OF ORGANOMETALLIC ELECTROPHILES (Continued)

TABLE XXXI. DIRECT CROSS COUPLING OF ORGANOMETALLIC ELECTROPHILES (Continued)						
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)		Refs.	
C <sub>9</sub>		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h		M = Mo (68) M = W (85)	825	
	Bu <sub>3</sub> SnC≡CSnBu <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h		(78)	226	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, reflux, 16 h		X = Cl (80) X = I (64)	392	
		[( $\eta^3$ -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (10%), ( <i>R</i> )-BINAP (12%), 40°, 18 h		I + II (80) 75:25 ee = 0%	222, 827	
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	[( $\eta^3$ -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (10%), ( <i>S</i> - <i>R</i> )-PPFA (12%), 40°, 18 h	I (ee = 0%) + II (46) 87:13	222, 827		
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	[( $\eta^3$ -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (10%), ( <i>R</i> )-MeO-MOP (24%), 0°, 18 h	I (ee = 0%) + II (46) 0:100	222, 827		
	Cl-	Me <sub>3</sub> SnC≡CPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), CH <sub>2</sub> Cl <sub>2</sub> , rt, 72 h	PhC≡C-	(84)	828
		Me <sub>3</sub> Sn-	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, reflux		X = Cl (80) X = I (64)	391
		Bu <sub>3</sub> SnC≡CH	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h		(tr)	825
		Bu <sub>3</sub> SnC≡C	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h		(82)	825
526	Bu <sub>3</sub> SnC≡CSnBu <sub>3</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h		(64)	226	
	Bu <sub>3</sub> SnC≡CH	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h		(92)	825	
	Me <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, rt, 24 h		(58)	369	
	Me <sub>3</sub> SnC≡CMe	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, rt, 10 h		(58)	369	
	Me <sub>3</sub> SnCH=CH <sub>2</sub> TMS	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), DMF, rt, 12 h		(56)	369	

TABLE XXIII. DIRECT CROSS-CO尤LING OF ORGANOMETALLIC ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(CH3CN)2Cl2 (2%), DMF, rt, 12 h	(55)	369
		Pd(CH3CN)2Cl2 (2%), DMF, rt, 72 h	(32)	369
		Pd(CH3CN)2Cl2 (2%), DMF, rt, 4 h	(56)	369
		Pd(CH3CN)2Cl2 (2%), DMF, rt, 12 h	(5) (major) + (5) (minor)	369
		Pd(CH3CN)2Cl2 (2%), DMF, rt, 12 h	(29)	369
		Pd(CH3CN)2Cl2 (2%), DMF, rt, 12 h	(85)	825
		Pd(CH3CN)2Cl2 (2%), DMF, rt, 12 h	(76)	825
		Pd(CH3CN)2Cl2 (2%), DMF, rt, 12 h	(77)	226
		1. Pd(PPh3)4 (2%), THF, 70°, 15 h 2. I2	(72)	227
		1. Pd(PPh3)4 (2%), THF, 70°, 15 h 2. I2	(75)	227
		Pd(PPh3)4 (0.7%), THF, 70°, 22 h	(62)	829
		Pd(PPh3)4 (0.7%), THF, 70°, 22 h	(34)	829
		Pd(PPh3)4 (0.7%), THF, 70°, 22 h	(85)	829
		Pd(PPh3)4 (0.7%), THF, 70°, 22 h	(70)	829

TABLE XXIII. DIRECT CROSS-CO尤LING OF ORGANOMETALLIC ELECTROPHILES (Continued)

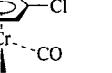
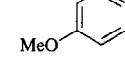
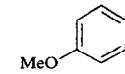
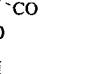
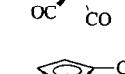
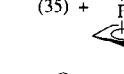
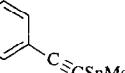
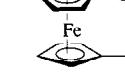
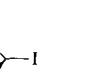
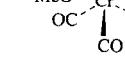
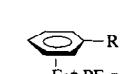
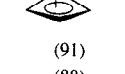
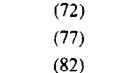
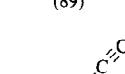
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref(s.)	
	Bu <sub>4</sub> Sn	1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), THF, 70°, 15 h 2. I <sub>2</sub>	 (68)	227	
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), THF, 70°, 15 h 2. I <sub>2</sub>	 (68)	227	
	Bu <sub>4</sub> Sn	1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), THF, 70°, 15 h 2. I <sub>2</sub>	 (82)	227	
	Me <sub>3</sub> SnC≡CSnMe <sub>3</sub>	Pd <sub>2</sub> (dba) <sub>3</sub> (5.5%), AsPh <sub>3</sub> (22%), DMF, 20°, 18 h	 (35)	223	
	Me <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), THF, 75°, 20 h	 (35) +  (51)	830	
	Me <sub>3</sub> SnC≡C 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), THF, 75°, 20 h	 (57)	830	
C <sub>11</sub>		Me <sub>3</sub> Sn 	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, reflux, 16 h	 R = H (46)  R = OTBDPS (54)	391, 392
C <sub>12</sub>		Bu <sub>3</sub> SnR	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5.8%), DMF, 100°		831
	R			(91) (88) (72) (77) (82) (89)	
	CH=CH <sub>2</sub>	10.5 h			
	2-thienyl	3.5 h			
	Ph	20 h			
	Bn	22 h			
	C≡CPh	3.5 h			
	(E)-CH=CHPh	3.5 h			
C <sub>13</sub>		Me <sub>3</sub> SnC≡CR	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (6%), H <sub>2</sub> O, DMF, rt, 36 h		224
	R			(78) (57) (28) (65) (72)	
	TMS				
	Bu-t				
	C≡CBu-t				
	Ph				
	Si(Pr-t) <sub>3</sub>				
C <sub>14</sub>		Me <sub>3</sub> SnC≡CR	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (6%), H <sub>2</sub> O, DMF, rt, 36 h		224
	R			(78) (78)	
	TMS				
	Si(Pr-t) <sub>3</sub>				
	Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 65°, 37 h	 (46)	217	

TABLE XXIII. DIRECT CROSS-CO尤LING OF ORGANOMETALLIC ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
	Bu <sub>3</sub> SnC≡CPh	Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 65°, 16 h	(91)	217	
	Bu <sub>3</sub> SnC≡CTMS	Bu <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 65°, 37 h	(79)	217	
C <sub>15</sub>	 OC CO I	Bu <sub>3</sub> SnC≡CPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (3%), DMF, rt, overnight	(99)	230	
532	C <sub>16</sub>	 MeO Pr-n SMT OC CO OTf	Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 65°, 24 h	(99)	217
C <sub>17</sub>	 MeO Pr-n OC CO OTf	Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 65°, 132 h	(41)	217	
	Bu <sub>3</sub> SnC≡CPh	Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 65°, 15 h	(76)	217	
C <sub>18</sub>	 Me <sub>2</sub> N OC CO OTf	Bu <sub>3</sub> SnC≡CMe	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 65°, 83 h	(50)	217	
533	C <sub>25</sub>	 OC CO I	Me <sub>3</sub> SnC≡CTMS	I. Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 65°, 17 h 2. I <sub>2</sub>	(87)	217
	C <sub>25</sub>	 OC CO I	Me <sub>3</sub> SnC≡CTMS	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (6%), H <sub>2</sub> O, DMF, rt, 36 h	(62)	224
	C <sub>27</sub>	 OC CO PPh <sub>3</sub>	Bu <sub>3</sub> SnC≡CPh	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5.5%), DMF, 25°, 12 h	(—)	825
	C <sub>27</sub>	 i-Pr <sub>3</sub> SiO OC CO	Me <sub>3</sub> SnC <sub>9</sub> H <sub>7</sub> O	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF or C <sub>6</sub> H <sub>6</sub> , reflux	(18)	391, 392

TABLE XXIV. DIRECT CROSS-COUPING OF MISCELLANEOUS ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>1</sub>	MeI		Pd(dba) <sub>2</sub> (0.5%), PPh <sub>3</sub> (2%), C <sub>6</sub> H <sub>6</sub> , 60°, 20 h	(0) + MeSnBu <sub>3</sub> (26)	529
	CF <sub>3</sub> I		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 80°, 3 h	(11)	210
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 80°, 3 h	(11)	210
	O <sub>2</sub> NCH <sub>2</sub> Br	Bu <sub>3</sub> SnSnBu <sub>3</sub> + TMSCl	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), tetralin, 80°, 20 h	O <sub>2</sub> NCH <sub>2</sub> TMS (0)	832
C <sub>2</sub>	MeSO <sub>2</sub> Cl		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), THF, 65-70°, 15 min	(90)	229
	F <sub>3</sub> CCH <sub>2</sub> I		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 80°, 4 h	(38)	210
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 80°, 4 h	(35)	210
C <sub>3</sub>	NCCH <sub>2</sub> Br	Bu <sub>3</sub> SnSnBu <sub>3</sub> + TMSCl	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), tetralin, 80°, 20 h	NCCH <sub>2</sub> TMS (61)	832
		Me <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 80°, 5 h	(67)	833
C <sub>4</sub>	MeO <sub>2</sub> CCH <sub>2</sub> Br		D <sub>717</sub> -Pd(0) on polymer, Me <sub>2</sub> CO, reflux, 25 h	(91)	535
			D <sub>717</sub> -Pd(0) on polymer, Me <sub>2</sub> CO, reflux, 25 h	(90)	535
	n-C <sub>4</sub> F <sub>9</sub> I		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>14</sub> , 70°, 4 h	(52)	210
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>14</sub> , 70°, 4 h	(68)	210
534		(E) or (Z) Bu <sub>3</sub> SnCH=CHPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>14</sub> , 70°, 4 h	(70)	210
		Me <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 80°, 5 h	(72)	833, 832
			Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	(41)	834
		Bu <sub>3</sub> SnSnBu <sub>3</sub> + TMSCl	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), tetralin, 80°, 20 h	(77)	832, 833
	MeO <sub>2</sub> CC≡CBr		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), hydroquinone, DMF, 20°, 2 h	(52)	215
535			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), hydroquinone, DMF, 20°, 15 h	(73)	215
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), THF, 50°, 12 h	X = Br (73) X = I (82)	208
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), THF, 50°, 12 h	(97)	208
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 6 h	(67)	208
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), PhMe, 100°, 9 h	(41)	208

TABLE XXIV. DIRECT CROSS-COUPLING OF MISCELLANEOUS ELECTROPHILES (*Continued*)

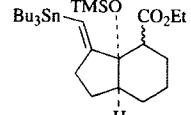
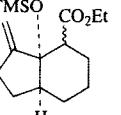
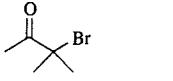
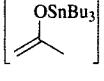
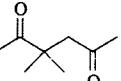
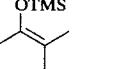
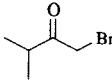
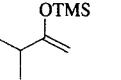
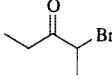
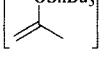
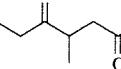
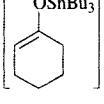
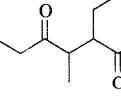
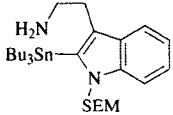
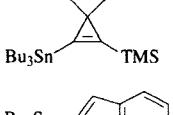
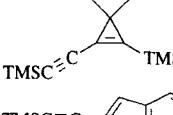
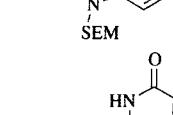
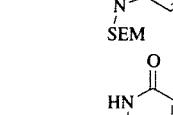
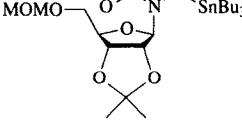
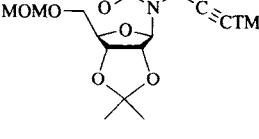
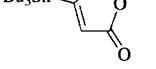
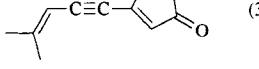
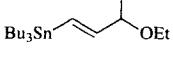
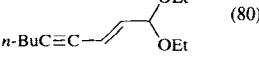
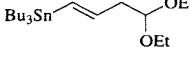
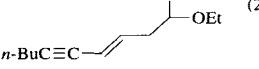
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>5</sub>		Bu <sub>3</sub> SnPh	D <sub>717</sub> -Pd(0) on polymer, Me <sub>2</sub> CO, reflux, 25 h	EtO <sub>2</sub> C—CH <sub>2</sub> —Ph (94)	535
		Bu <sub>3</sub> SnSnBu <sub>3</sub> + TMSCl	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), HMPA, 80°, 20 h	EtO <sub>2</sub> C—CH <sub>2</sub> —TMS (79)	832
	MeO—CH <sub>2</sub> —O—CH <sub>2</sub> —Cl		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2-5%), DMF, 100°, 12 h	 (60)	441
			Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	 (0)	834
		Bu <sub>3</sub> SnSnBu <sub>3</sub> + TMSCl	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), tetralin, 80°, 20 h	 (75)	832, 833
		Me <sub>3</sub> SnTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 80°, 5 h	 (93)	833
			Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	 (70)	834
			Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	 (21)	834
	EtO <sub>2</sub> C—CH <sub>2</sub> —Br	Bu <sub>3</sub> SnSnBu <sub>3</sub> + TMSCl	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), HMPA, 80°, 20 h	EtO <sub>2</sub> C—CH <sub>2</sub> —TMS (49)	832
C <sub>6</sub>	TMSC≡CBr		Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), DMF, 110°, 0.5 h	 (95)	74
	TMSC≡Cl		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 20°, 24 h	 (0)	422
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (0.7%), DMF, 110°, 1 h	 (88)	289
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), CuI (20%), DMF, 80°, 20 min	 (69)	170
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , DMF	 (37)	214
	n-BuC≡CBr		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , hydroquinone, DMF, 20°, 20 h	 (80)	215
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> , hydroquinone, DMF, 20°, 20 h	 (28)	215

TABLE XXIV. DIRECT CROSS-COUPLING OF MISCELLANEOUS ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$Bu_3Sn\text{C}\equiv\text{CPh}$	Pd( $PPh_3$ ) <sub>4</sub> (1%), THF, 65–70°, 15 min		(75)
$n\text{-C}_6\text{F}_{13}\text{I}$	$Bu_3Sn\text{C}\equiv\text{CH}_2$	Pd( $PPh_3$ ) <sub>4</sub> (10%), $C_6\text{H}_{14}$ , rt, 1 h	$n\text{-C}_6\text{F}_{13}\text{CH}_2=\text{CH}_2$	(100)
	$Me_3Sn\text{C}\equiv\text{CPh}$	Pd( $PPh_3$ ) <sub>4</sub> (10%), $C_6\text{H}_{14}$ , 70°, 6 h	$n\text{-C}_6\text{F}_{13}\text{C}\equiv\text{CPh}$	(27)
	$Me_3Sn\text{C}\equiv\text{CC}_6\text{H}_{13-n}$	Pd( $PPh_3$ ) <sub>4</sub> (10%), $C_6\text{H}_{14}$ , 70°, 6 h	$n\text{-C}_6\text{F}_{13}\text{C}\equiv\text{CC}_6\text{H}_{13-n}$	(55)
	$Me_3Sn\text{C}\equiv\text{C}(\text{OTHP})_4$	Pd( $PPh_3$ ) <sub>4</sub> (10%), $C_6\text{H}_{14}$ , 70°, 6 h	$n\text{-C}_6\text{F}_{13}\text{C}\equiv\text{C}(\text{OTHP})_4$	(60)
	$Me_3SnTMS$	Pd( $PPh_3$ ) <sub>4</sub> (10%), $C_6\text{H}_6$ , 80°, 5 h		(52)
	$[OSnBu_3]$	Pd( $PhCN)_2\text{Cl}_2$ (1%), $C_6\text{H}_6$ , 80°, 20 h		(83)
	$[OSnBu_3]$	Pd( $PhCN)_2\text{Cl}_2$ (1%), $C_6\text{H}_6$ , 80°, 20 h		(35)
	$[OSnBu_3]$	Pd( $PhCN)_2\text{Cl}_2$ (1%), $C_6\text{H}_6$ , 80°, 20 h		(95)
	$[OSnBu_3]$	Pd( $PhCN)_2\text{Cl}_2$ (1%), $C_6\text{H}_6$ , 80°, 20 h		(97)
	$Bu_3SnSnBu_3 + TMSCl$	Pd( $PPh_3$ ) <sub>4</sub> (10%), tetralin, 80°, 20 h		(81)
	$Bu_3Sn\text{C}\equiv\text{CPh}$	Pd( $PPh_3$ ) <sub>4</sub> (4%), $CCl_4$ , 80°, 12 h		(61)
	$Bu_3Sn\text{C}\equiv\text{CR}$	Pd( $PPh_3$ ) <sub>2</sub> $\text{Cl}_2$ (1%), $C_6\text{H}_6$ , 70°, 5 h		(60)
	$R$			(31)
	TMS			(70)
	$C\equiv\text{CEt}$			(64)
	$Bu-n$			(65)
	$C(Me)_2\text{OMe}$			(74)
	Ph			
	1-cyclohexenyl			
	$Bu_3Sn\text{C}\equiv\text{C}(\text{CH}_2)_n\text{O}$	Pd( $PPh_3$ ) <sub>2</sub> $\text{Cl}_2$ (5%), $LiClO_4$ , PhMe, 50°		n = 3 (31) n = 4 (42) n = 5 (45) n = 6 (42)
	$Bu_3Sn\text{C}\equiv\text{C}(\text{CH}_2)_n\text{O}$			n = 8 (28) n = 10 (24)
	$Bu_3Sn\text{C}\equiv\text{C}(\text{CH}_2)_n\text{O}$	Pd( $PPh_3$ ) <sub>2</sub> $\text{Cl}_2$ (5%), $LiClO_4$ , PhMe, 50°		n = 2 (52) n = 3 (32)
	$Bu_3Sn\text{C}\equiv\text{C}(\text{CH}_2)_n\text{X}$	Pd( $PPh_3$ ) <sub>2</sub> $\text{Cl}_2$ (5%), $LiClO_4$ , PhMe, 50°		X = CH <sub>2</sub> (34) X = NPr- <i>i</i> (41)

TABLE XXIV. DIRECT CROSS-COUPING OF MISCELLANEOUS ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiClO <sub>4</sub> , PhMe, 50°	 (40)	212
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiClO <sub>4</sub> , PhMe, 50°	 (23)	212
	Bu <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 70°, 5 h	 (35)	835
541				
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiClO <sub>4</sub> , PhMe, 50°	 (17)	212
	Bu <sub>3</sub> SnC≡C(CH <sub>2</sub> ) <sub>5</sub> O	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiClO <sub>4</sub> , PhMe, 50°	 (52)	212
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), LiClO <sub>4</sub> , PhMe, 50°	 (55)	212
541				
	Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), C <sub>6</sub> H <sub>6</sub> , 65°, 12 h	 (61)	207
	[OSnMe <sub>3</sub> ]	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	 (73)	834
	Bu <sub>3</sub> SnC≡C	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), hydroquinone, DMF, 20°, 1 h	 (80)	215
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), hydroquinone, DMF, 0°, 1 h	 (63)	215
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), hydroquinone, neat, 70°, 2 h	 (83)	215
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), hydroquinone, DMF, 20°, 4 h	 (67)	215
	Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), C <sub>6</sub> H <sub>6</sub> , 75°, 8 h	 (67)	207
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (2-5%), DMF, 100°, 12 h	 (40)	441
	Bu <sub>3</sub> SnC≡C	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), THF, 65-70°, 3 h	 (60)	229
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), THF, 65-70°, 30 min	 I (68)	229

TABLE XXIV. DIRECT CROSS-COUPLING OF MISCELLANEOUS ELECTROPHILES (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd(PPh3)4 (1%), THF, 65-70°, 30 min	<b>I</b> (64) 	229	
		Pd(PPh3)4 (1%), THF, 65-70°, 15 min		(77) 229	
		Pd(PPh3)4 (1%), THF, 65-70°, 12 h		(57) 229	
		Pd(PPh3)4 (2%), C6H6, 80°, 20 h		(85) 763	
		Pd(PPh3)4 (2%), C6H6, 80°, 20 h		(85) 539	
542		Bu3SnCH=CHOTHP	Pd(PPh3)4 (1%), THF, 65-70°, 30 min		(90) 229
		Pd(PPh3)4 (1%), THF, 65-70°, 30 min		(87) 229	
C8		Bu3SnCH=CHPh	Pd(PPh3)4 (1%), THF, 65-70°, 15 min		(75) 229
		Bu3SnCH=CHCO2Et	Pd(PPh3)2Cl2 (5%), hydroquinone, DMF, 20°, 20 h		(36) 215
		Pd(CH3CN)2Cl2 (5%), hydroquinone, DMF, 20°, 20 h		(64) 215	
543			Pd(PPh3)4 (5%), THF, 20°, 24 h		(0) 422
		Pd(PPh3)4 (10%), CuI (20%), DMF, 80°, 30 min		(77) 170	
		Bu3SnCH=CH	D717-Pd(0) on polymer, Me2CO, reflux, 25 h		(86) 535
		Pd(PPh3)4 (10%), C6H6, 80°, 5 h		(69) 833, 832	
		Bu3SnC≡CPh	Pd(PPh3)4 (4%), C6H6, 80°, 6 h		(73) 207
		Pd(PPh3)4 (4%), C6H6, 80°, 4 h		(75) 207	
		Bu3SnC≡CPh	Pd(PPh3)4 (4%), CCl4, 80°, 20 h		(71) 207
		[]	Pd(PhCN)2Cl2 (5%), C6H6, 80°, 20 h		(21) 834

TABLE XXIV. DIRECT CROSS-COUPING OF MISCELLANEOUS ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
544		Bu3Sn<sup>≡</sup>C<sub>2</sub>	Pd(CH<sub>3</sub>CN)<sub>2</sub>Cl<sub>2</sub> (5%), hydroquinone, DMF, 0°, 4 h		(78)	215
		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(CH<sub>3</sub>CN)<sub>2</sub>Cl<sub>2</sub> (5%), hydroquinone, DMF, 0°, 9 h		(44)	215
		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(PPh<sub>3</sub>)<sub>2</sub>Cl<sub>2</sub> (5%), hydroquinone, DMF, 20°, 72 h		(57)	215
C<sub>9</sub>		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(CH<sub>3</sub>CN)<sub>2</sub>Cl<sub>2</sub> (5%), hydroquinone, DMF, 20°, 96 h		(58)	215
		Bu3SnPh	D<sub>7</sub>/Pd(0) on polymer, Me<sub>2</sub>CO, reflux, 25 h		(84)	535
		Bu3SnC<sub>2</sub>CPh	Pd(PPh<sub>3</sub>)<sub>2</sub>Cl<sub>2</sub> (4%), PhEt, 70°, 5 h		(69)	211
		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(PPh<sub>3</sub>)<sub>4</sub>, Cl(CH<sub>2</sub>)<sub>2</sub>Cl, 24°		X = Br, 1.5 h (84) X = Cl, 10 h (84)	207
		Bu3SnC<sub>2</sub>CPh	Pd(PPh<sub>3</sub>)<sub>4</sub>, CH<sub>2</sub>Cl<sub>2</sub>, 40°, 8 h		(55)	207
		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(PPh<sub>3</sub>)<sub>4</sub>, C<sub>6</sub>H<sub>6</sub>, 80°, 12 h		(81)	207
C<sub>10</sub>		Bu3SnPh	Pd(PPh<sub>3</sub>)<sub>4</sub>, C<sub>6</sub>H<sub>6</sub>, 80°, 2 h		(86)	207
		Bu3SnC<sub>2</sub>CPh	Pd(PPh<sub>3</sub>)<sub>4</sub>, C<sub>6</sub>H<sub>6</sub>, 80°, 1.5 h		(71)	207
		Bu3SnC<sub>2</sub>CPh	Pd(PPh<sub>3</sub>)<sub>4</sub>, CCl<sub>4</sub>, 65°, 12 h		(65)	207
		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(PPh<sub>3</sub>)<sub>4</sub>, THF, 65-70°, 3 h		(60)	229
		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(PPh<sub>3</sub>)<sub>4</sub>, THF, 65-70°, 30 min		(85)	229
		Bu3SnC<sub>2</sub>CPh	Pd(PPh<sub>3</sub>)<sub>4</sub>, THF, 65-70°, 15 min		(0)	229
C<sub>11</sub>		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(PPh<sub>3</sub>)<sub>4</sub>, THF, 65-70°, 15 min		(70)	229
		Bu3Sn<sub>2</sub>C<sub>2</sub>	Pd(PPh<sub>3</sub>)<sub>4</sub>, THF, 65-70°, 30 min		(70)	229
		Ph<sub>4</sub>Sn	Pd(PPh<sub>3</sub>)<sub>2</sub>Cl<sub>2</sub> (4%), PhEt, 130°, 63 h		(25)	211
		Bu3SnC<sub>2</sub>CPh	Pd(PPh<sub>3</sub>)<sub>4</sub>, C<sub>6</sub>H<sub>6</sub>, 80°, 12 h		(0)	207
		Ph<sub>4</sub>Sn	Pd(PPh<sub>3</sub>)<sub>2</sub>Cl<sub>2</sub> (4%), PhEt, 130°, 15 h		(63)	211

TABLE XXIV. DIRECT CROSS-COUPING OF MISCELLANEOUS ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
C <sub>13</sub>		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), xylene, 120°, 10 h		(67)	531
		Bu <sub>3</sub> SnCH=CHCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), xylene, 120°, 20 h			531
		Bu <sub>3</sub> SnCH=CHCH=CHCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), xylene, 120°, 20 h		I (67)	531
		[OSnBu <sub>3</sub> CH=CH <sub>2</sub> ] <sub>n</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), xylene, 120°, 5 h		(9) + (25)	531
		Bu <sub>3</sub> SnPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), xylene, 120°, 60 h		(78)	531
		[Bu <sub>3</sub> SnO-C <sub>6</sub> H <sub>4</sub> -Ph] <sub>n</sub>	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (10%), xylene, 120°, 5 h		(74)	531
		Bu <sub>3</sub> SnC≡CR	Pd(dppf)Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°		(93) (64) (76) (83) (83)	836
		TMS				
		Bu-n				
		C(Me) <sub>2</sub> OMe				
		Ph				
		CH <sub>2</sub> O(CH <sub>2</sub> ) <sub>3</sub> CH=CH <sub>2</sub>				
C <sub>14</sub>		Bu <sub>3</sub> SnC≡CPh	Pd(dppf)Cl <sub>2</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°		(80)	836
		Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), PhEt, 130°, 15 h		(27)	211
		Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), PhEt, 70°, 12 h		(84)	211
		Bu <sub>3</sub> SnCH=CHPh	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), PhEt, 70°, 7 h		(70)	211
		Ph <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (4%), PhEt, 130°, 15 h		(70)	211
		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 25°, 4 min		(91) E:Z = 2:98	837
		Bu <sub>3</sub> SnC≡CR	Pd(dppf)Cl <sub>2</sub> (2%), PhMe, 80°		(75) (87) (81) (80)	836
		TMS				
		Bu-n				
		C(Me) <sub>2</sub> OMe				
C <sub>19</sub>		Bu <sub>3</sub> SnC≡CBu-n	Pd(dppf)Cl <sub>2</sub> (2%), PhMe, 80°		(82)	836
		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 25°, 4 min		(89) E:Z = 9:91	837
		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 25°, 4 min		(90) E:Z = 7:93	837

TABLE XXIV. DIRECT CROSS-COUPLING OF MISCELLANEOUS ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>23</sub>		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 25°, 4 min		(98) E:Z = 0:100 837
		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 25°, 4 min		(98) E:Z = 4:96 837
C <sub>31</sub>		Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 65°, 12 h		(71) 213
		Bu <sub>3</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 65°, 12 h		(71) 213
548		Me <sub>3</sub> SnCH=SnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 60°, 1 h		(—) 216
		Me <sub>3</sub> SnCH=SnMe <sub>3</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), DMF, 60°, 1 h		(80) 216, 838
C <sub>34</sub>		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 25°, 4 min		(86) Z,E,Z,Z = 2:98 837
		Me <sub>4</sub> Sn	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), THF, 120°, 16 h		(90) 228

TABLE XXV. CARBONYLATIVE CROSS-COUPING OF ALKENYL ELECTROPHILES

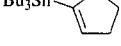
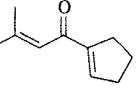
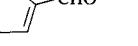
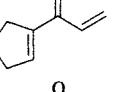
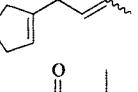
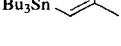
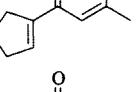
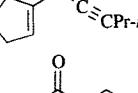
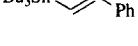
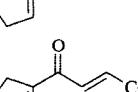
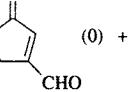
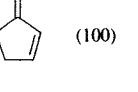
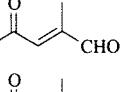
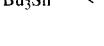
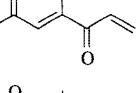
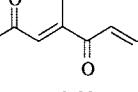
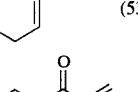
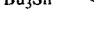
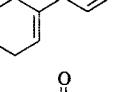
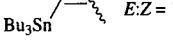
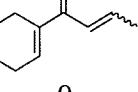
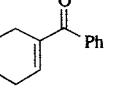
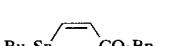
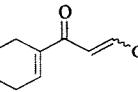
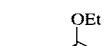
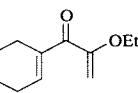
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>4</sub>	Bu <sub>3</sub> Sn- 	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 50°	 (40)	324
C <sub>5</sub>	Me <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5h	 (35)	331
	R <sub>3</sub> Sn- 	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°	 R = Me, 6 h, (86) R = Bu, 18 h, (70)	324
	Bu <sub>3</sub> Sn-  E:Z = 1:6	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 24 h	 (63) E:Z = 2.5:1	324
	Bu <sub>3</sub> Sn- 	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 50°	 (0)	324
	Bu <sub>3</sub> SnC≡CPr-n	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 7 h	 (54)	324
	Bu <sub>3</sub> Sn-  Ph	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 8 h	 (60)	324
	Bu <sub>3</sub> Sn-  CO <sub>2</sub> Bn	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 10 h	 (40)	324
	Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	 (0) +  (100)	331
	Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 (51)	325, 331
	Bu <sub>3</sub> Sn- 	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 2 h	 (50)	324
	Bu <sub>3</sub> Sn-  E:Z = 1:6	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 55 h	 (56) E:Z = 1:0.9	324
C <sub>6</sub>	Bu <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	 (53)	325, 331
	Bu <sub>3</sub> Sn- 	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 24 h	 (93)	324
	Bu <sub>3</sub> Sn-  E:Z = 1:6	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 24 h	 (83) E:Z = 1:0.7	324
	Bu <sub>3</sub> SnPh	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 48 h	 (40)	324
	Bu <sub>3</sub> Sn-  CO <sub>2</sub> Bn	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 80 h	 (45) E:Z = 4:1	324
	Me <sub>3</sub> Sn- 	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 55°, 18 h	 (89)	270

TABLE XXV. CARBOXYLATIVE CROSS-CO尤LING OF ALKENYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Bu <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	 (88)	331
	R <sub>3</sub> Sn-CH=CH <sub>2</sub>	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 35-40°	 R = Me, 5 h, (65) R = Bu, 12 h, (70)	324
	Me <sub>3</sub> Sn-CH=CH <sub>2</sub> E:Z = 1:2	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 44 h	 (70)	324
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub> E:Z = 1:6	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 48 h	 (62)	324
	R <sub>3</sub> Sn-CH=CH-Ph	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°	 R = Me, 18 h, (65) R = Bu, 23 h, (40)	324
552	Me <sub>3</sub> Sn-CH=CH-TMS	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, 55°	 (77)	334
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	 I (20) + II (69)	331
C <sub>7</sub>	Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	I (84) + II (18)	325, 331
		CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 65°, 5 h	 (65)	324
553	Bu <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 I (13) + II (54)	331
		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	I (53) + II (8)	331
	Me <sub>3</sub> Sn-CH=CH <sub>2</sub>	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, 55°	 (77)	334
		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, 50°	 I (53) + II (4)	334
	Bu <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 55°, 1.5 d	 I (78)	331
		CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, 55-60°, 1.5 d	 (52)	287
	Me <sub>4</sub> Sn	CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (0.2%), HMPA, 120°, overnight	 (62)	323
		CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 13 h	 (65)	324
	Bu <sub>3</sub> Sn-CH=CH <sub>2</sub>	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 12 h	 (75)	324
		CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 12 h		

TABLE XXV. CARBONYLATIVE CROSS-COUPING OF ALKENYL ELECTROPHILES (*Continued*)

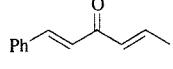
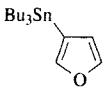
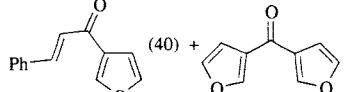
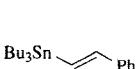
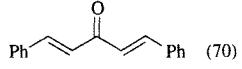
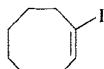
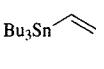
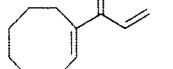
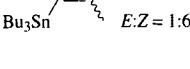
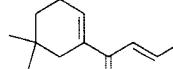
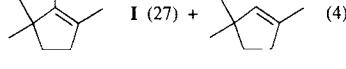
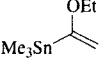
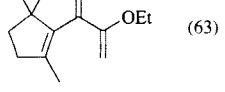
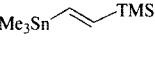
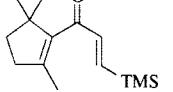
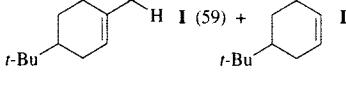
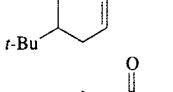
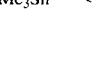
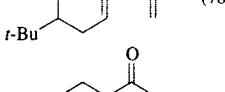
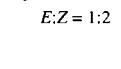
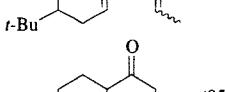
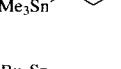
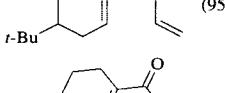
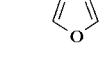
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 22 h	 (40)	324	
		CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), THF, 50°, 1 d		287	
		CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 66 h	 (70)	324	
554			CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 65°, 8 h	 (74)	324
		CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%) <sup>a</sup> , THF, 45-50°, 12 h	 (71)	324	
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), LiCl, PhMe, 50°, 3.5 h		331	
		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), LiCl, PhMe, 50°, 3.5 h	I (1)	331	
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), LiCl, THF, 55°, 16 h	 (63)	270	
C <sub>10</sub>		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, 55°, 36 h	 (87)	334	
555		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), LiCl, THF, 50°, 3.5 h		331	
		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), LiCl, THF, 50°, 3.5 h	I (55) + II (45)	331	
		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, 55°, 36 h	I (67) + II (2)	331	
		CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, ZnCl <sub>2</sub> , THF, 75°	 (76)	334	
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, 55°	 (76)	334, 421	
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, THF, 55°	 (70) E:Z = 1:2	334	
		CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), LiCl, ZnCl <sub>2</sub> , THF, 75°	 (95)	334	
		CO (30 psi), Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (2.5%), THF, 60°, 3 d	 (44)	287	

TABLE XXV. CARBONYLATIVE CROSS-COUPLING OF ALKENYL ELECTROPHILES (*Continued*)

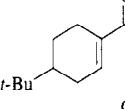
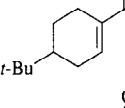
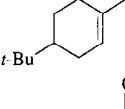
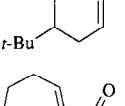
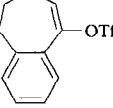
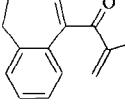
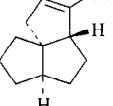
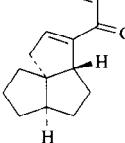
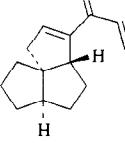
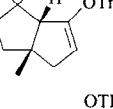
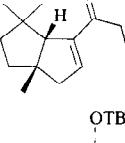
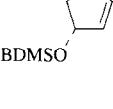
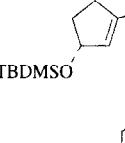
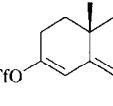
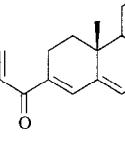
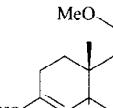
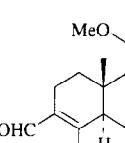
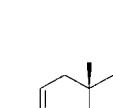
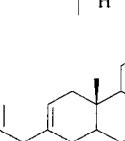
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
	$\text{Me}_3\text{SnC}\equiv\text{CTMS}$	CO (50 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (3%), LiCl, THF, 20°	 (95)	334	
	$\text{Me}_3\text{SnPh}$	CO (50 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (3%), LiCl, $\text{ZnCl}_2$ , THF, 75°	 (93)	334	
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{CF}_3$	CO (50 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (3%), LiCl, $\text{ZnCl}_2$ , THF, 75°	 (76)	334	
	$\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_4-\text{OMe}$	CO (50 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (3%), LiCl, $\text{ZnCl}_2$ , THF, 75°	 (88)	334	
C <sub>11</sub>		$\text{Me}_3\text{Sn}-\text{CH}=\text{OEt}$	CO (15 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (2%), LiCl, THF, 55°, 21 h	 (92)	270
		$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH}_2$	CO (15 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (4%), LiCl, THF, 55°, 48 h	 (50)	487
		$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH-TMS}$	CO (15 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (4%), LiCl, THF, 70°, 48 h	 (80)	487
C <sub>17</sub>		$\text{Me}_3\text{Sn}-\text{CH}=\text{CH-TMS}$	CO (15 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (3%), LiCl, THF, 55°, 24 h	 (86)	334
		$\text{Bu}_3\text{SnH}$	CO (15 psi), Pd( $\text{PPh}_3$ ) <sub>4</sub> (5%), THF	 (>86)	839
C <sub>19</sub>		$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH}_2$	CO, Pd( $\text{PPh}_3$ ) <sub>4</sub> (10%), LiCl, BHT, dioxane, 110°, 12 h	 (98)	521
C <sub>21</sub>		$\text{Bu}_3\text{SnH}$	CO, Pd( $\text{PPh}_3$ ) <sub>4</sub> , LiCl, THF	 (95)	840
C <sub>26</sub>		$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH}_2$	CO, Pd( $\text{PPh}_3$ ) <sub>4</sub> (10%), LiCl, BHT, dioxane, 110°, 16 h	 (>98)	521

TABLE XXV. CARBOXYLATIVE CROSS-CO尤LING OF ALKENYL ELECTROPHILES (Continued)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>27</sub> 598		$\text{Bu}_3\text{SnCH}_2\text{C}_8\text{H}_{17}$	$\text{CO, Pd(PPh}_3)_4$ (10%), LiCl, BHT, dioxane, 110°, 10 h	 (>98)	521

<sup>a</sup> An alternative reagent was  $\text{BnPd(PPh}_3)_2\text{I}$  (2%).

TABLE XXVI. CARBOXYLATIVE CROSS-CO尤LING OF ARYL ELECTROPHILES

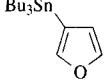
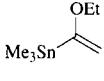
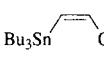
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>6</sub>	PhBr	Bu <sub>3</sub> SnH	CO (450 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (4%), PhMe, 50°, 3.5 h	PhCHO (2) + PhBr (70) + C <sub>6</sub> H <sub>6</sub> (28)	331
PhI	Bu <sub>3</sub> SnH		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	PhCHO (93)	325, 331
	Me <sub>4</sub> Sn		CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (0.2%), HMPA, 120°, overnight	 (85)	323
	Me <sub>4</sub> Sn		CO (15 psi), Ni(PPh <sub>3</sub> ) <sub>2</sub> (CO) <sub>2</sub> (3%), HMPA, 120°, 24 h	 (73)	841
659	Bu <sub>4</sub> Sn		CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (0.2%), HMPA, 120°, overnight	 (73)	841
	Bu <sub>3</sub> Sn 		CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, 55°, 3 d	 (60)	287
			CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), dioxane, 95°, 19.5 h	 (67)	270
			CO (75 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), CHCl <sub>3</sub> , 80°	 (60)	842
	Me <sub>3</sub> SnPh		CO (15 psi), [(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°, 48 h	PhCOPh (42) + Ph-Ph (58)	326, 843

TABLE XXVI. CARBONYLATIVE CROSS-COUPING OF ARYL ELECTROPHILES (*Continued*)

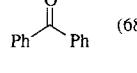
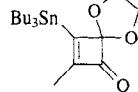
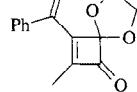
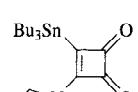
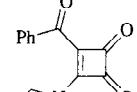
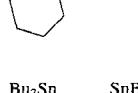
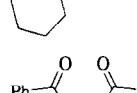
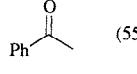
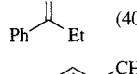
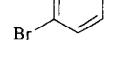
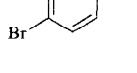
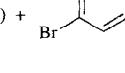
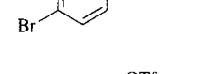
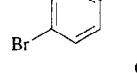
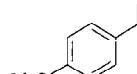
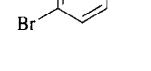
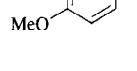
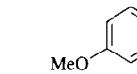
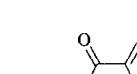
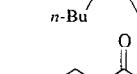
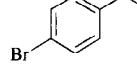
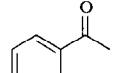
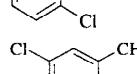
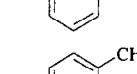
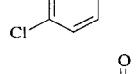
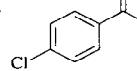
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref(s.)
	Ph <sub>4</sub> Sn	CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (0.2%), HMPA, 120°, overnight	 (68)	323
		CO (32 psi), BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 18 h	 (86)	844
		CO (15 psi), CuI (2%) BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2%), THF, 50°, 40 h	 (65)	844
		CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), THF, 55°, 3 d	 (80)	287
	Me <sub>3</sub> SnNEt <sub>2</sub>	CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), 3 h	PhCONET <sub>2</sub> (90)	329, 330
PhN <sub>2</sub> <sup>+</sup> PF <sub>6</sub> <sup>-</sup>	Me <sub>4</sub> Sn	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux, 1 h	 (55)	845
PhN <sub>2</sub> <sup>+</sup> BF <sub>4</sub> <sup>-</sup>	Et <sub>4</sub> Sn	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux, 6 h	 (40)	845
	Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	 (2) +  (28)	325, 331
	R <sub>4</sub> Sn	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux	 R = Me, 1 h (84)  R = Ph, 6 h (59)	845
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 95°, 27 h	 (45) +               <img alt="Chemical structure of 4-bromo-N,N-diphen	

TABLE XXVI. CARBOXYLATIVE CROSS-COUPING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Me <sub>3</sub> SnPh	CO (15 psi), [(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°, 12 h	 (98)	326
	Me <sub>4</sub> Sn	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux, 1 h	 X = Cl (76) X = I (79)	845
	Me <sub>3</sub> SnPh	CO (15 psi), [(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°, 10 h	 (78)	326
562	Me <sub>4</sub> Sn	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux, 1 h	 (70)	845
	Bu <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	 <b>I</b> + <b>II</b>	331
	Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	<b>I</b> (20) + <b>II</b> (62)	331
	Me <sub>4</sub> Sn	CO (15 psi), [(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°, 30 h	 (95)	326, 843
	Me <sub>3</sub> SnCH=CH <sub>2</sub>	CO (15 psi), [(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°, 1 h	 (31) + (54)	326
	Bu <sub>3</sub> Sn(OEt)CH=CH <sub>2</sub>	1. CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), dioxane, 95°, 25.5 h 2. O <sub>3</sub>	 (23)	270
	Bu <sub>3</sub> Sn(OEt)CH=CH <sub>2</sub>	CO (75 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), CHCl <sub>3</sub> , 80°	 (25) + (40)	842
563	Me <sub>3</sub> Sn-	CO (15 psi), [(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°, 0.7 h	 (36) + (64)	326
	Me <sub>3</sub> SnR	CO (15 psi), [(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°	 (99)	326, 843
	R			
	Ph		4.5 h	
	p-ClC <sub>6</sub> H <sub>4</sub>		3 h	
	p-O <sub>2</sub> NC <sub>6</sub> H <sub>4</sub>		4 h	
	C <sub>6</sub> F <sub>5</sub>		72 h	
	p-MeC <sub>6</sub> H <sub>4</sub>		5 h	
	p-MeOC <sub>6</sub> H <sub>4</sub>		3 h	

TABLE XXVI. CARBONYLATIVE CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Me}_3\text{SnC}\equiv\text{CPh}$	CO (15 psi), [(η <sup>3</sup> -C <sub>3</sub> H <sub>5</sub> )PdCl] <sub>2</sub> (1%), HMPA, 20°, 0.5 h	(64) + (36)	326
	$\text{Me}_3\text{SnNEt}_2$	CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), 0.5 h	(82)	329, 330
	$\text{Et}_3\text{SnOMe}$	CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), 1 h	(100)	329, 330
	$\text{Et}_3\text{SnSPh}$	CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (2%), 1 h	(6) + (90)	329, 330
	$\text{Me}_4\text{Sn}$	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux, 1 h	(85)	845
	$\text{Bu}_3\text{SnC}\equiv\text{CPr}-n$	CO (15 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 100°, 6 h	(0)	336
	$\text{Bu}_3\text{SnH}$	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	(28)	325, 331
	$\text{Me}_4\text{Sn}$	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux, 1 h	(63)	845
	$\text{Me}_4\text{Sn}$	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux, 1 h	(70)	845
	$\text{Bu}_3\text{SnH}$	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	I (62) + (22)	331
	$\text{Bu}_3\text{SnH}$	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	I (99)	325, 331
	$\text{Me}_4\text{Sn}$	CO (15 psi), Ni(PPh <sub>3</sub> ) <sub>2</sub> (CO) <sub>2</sub> (3%), HMPA, 150°, 12 h	(62)	841
	$\text{Bu}_3\text{Sn}-\text{CH}=\text{CH-OEt}$	CO (75 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), CHCl <sub>3</sub> , 80°	(69)	842
	$\text{R}_4\text{Sn}$	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, reflux	(86)	845
	$\text{Me}$	1 h	(74)	
	$\text{Et}$	7 h	(63)	
	$\text{Me}_3\text{SnPh}$	CO (130 psi), Pd(OAc) <sub>2</sub> (2%), CH <sub>3</sub> CN, Et <sub>2</sub> O, rt	(98)	340
	$\text{Bu}_3\text{SnH}$	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	(41) + (5)	331

TABLE XXVI. CARBOXYLATIVE CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Me4Sn	CO (15 psi), Ni(PPh3)2(CO)2 (3%), HMPA, 140°, 24 h	(41)	841
	Me3SnPh	CO (15 psi), [(η3-C3H5)PdCl]2 (1%), HMPA, 20°, 4.5 h	(94)	326
	Bu3Sn-allyl	CO (15 psi), Pd(dppf)Cl2 (4%), LiCl, BHT, DMF, 23°, 19 h	(50)	336
	Bu3Sn-allyl-TMS	CO (15 psi), Pd(dppf)Cl2 (4%), LiCl, BHT, DMF, 23°, 18 h	(84)	336
	Bu3Sn-OMe	CO (15 psi), Pd(dppf)Cl2 (4%), LiCl, BHT, DMF, 70°, 1 h	(29) + (23)	336
	Bu3Sn-OMe	CO (15 psi), Pd(dppf)Cl2 (2%), LiCl, BHT, DMF, 90°, 8 h	(98)	336
	Bu3SnH	CO (15 psi), Pd(PPh3)4 (4%), PhMe, 50°, 3.5 h	(11) + (56)	331
	Me4Sn	CO (15 psi), Ni(PPh3)2(CO)2 (3%), HMPA, 140°, 24 h	(88)	841
	Bu3Sn-allyl-OEt	CO (75 psi), Pd(PPh3)2Cl2 (3%), CHCl3, 80°	(68)	842
	Bu3SnH	CO (15 psi), Pd(PPh3)4 (4%), PhMe, 50°, 3.5 h	(77)	325, 331
	Me3Sn-allyl-OEt	1. CO (15 psi), Pd(PPh3)4 (2%), dioxane, 55°, 21.5 h 2. O3	(62)	270
	Bu3Sn-allyl-2-OEt	CO (32 psi), BnPd(PPh3)2Cl (1%), C6H6, 80°, 18 h	(81)	844
	Bu3Sn-allyl-OH	CO (15 psi), Pd(dppf)Cl2 (4%), LiCl, BHT, DMF, 100°, 2 h	(37) + (20)	336
	Me3SnPh	CO (15 psi), Pd(dppf)Cl2 (4%), LiCl, BHT, DMF, 100°, 21 h	(69)	336

TABLE XXVI. CARBONYLATIVE CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (2%), LiCl, BHT, DMF, 70°, 23 h	 (68)	336
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	 (14) + (41) + PhCH <sub>2</sub> OH (20)	325, 331
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (2%), LiCl, BHT, DMF, 90°, 13 h	 (62)	336
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	 (76) + PhCH <sub>2</sub> OH (12)	325, 331
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 110°, 44 h	 (65)	336
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 70°, 6 h	 (68)	336
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 75°, 5 h	 (96)	336
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 90°, 7 h	 (88)	336
		CO (75 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), CHCl <sub>3</sub> , 80°	 (71)	842
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, 50°	 <b>I</b> + <b>II</b> + <b>I</b> + <b>II</b> (40) <b>I</b> : <b>II</b> = 10:1	846
		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 (21) + PhCO <sub>2</sub> Me (73)	331
		CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (3%), THF, 55°, 3 d	 (85)	287
		CO (50 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 80°, 12 h	 (45) + (~15)	336
		CO (50 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 90°, 21 h	 (64)	336
		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 (68) + PhCO <sub>2</sub> Me (12)	331
		CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 (90) + PhCO <sub>2</sub> Me (8)	331

TABLE XXVI. CARBONYLATIVE CROSS-CO尤LING OF ARYL ELECTROPHILES (Continued)

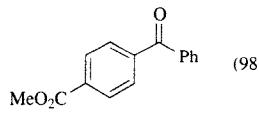
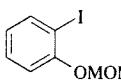
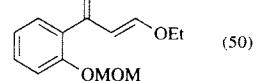
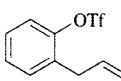
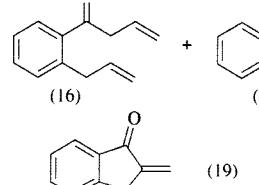
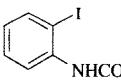
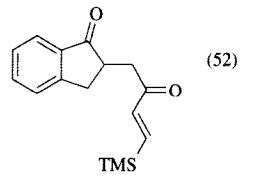
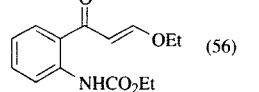
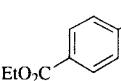
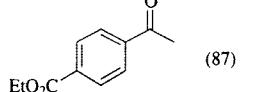
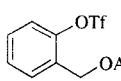
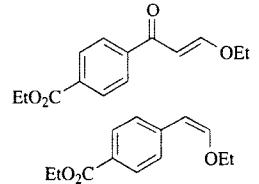
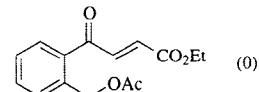
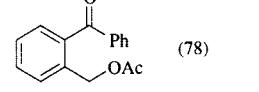
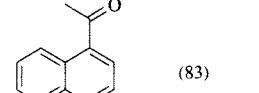
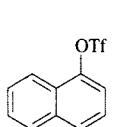
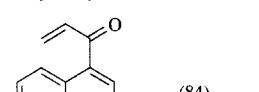
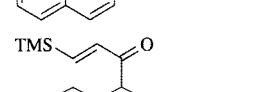
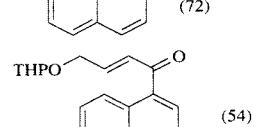
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Me}_3\text{SnPh}$	CO (15 psi), [( $\eta^3\text{-C}_3\text{H}_5$ ) $\text{PdCl}]_2$ (1%), HMPA, 20°, 8 h	 (98)	326
	$\text{Bu}_3\text{SnCH}_2\text{CH(OEt)}$	CO (75 psi), $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (3%), CHCl <sub>3</sub> , 80°	 (50)	842
	$\text{Bu}_3\text{SnCH}_2\text{CH=CH}_2$	CO (50 psi), $\text{Pd}(\text{dpfp})\text{Cl}_2$ (4%), LiCl, BHT, DMF, 70°, 15 h	 (16) (44) (19)	336
	$\text{Bu}_3\text{SnCH}_2\text{CH(OEt)}$	CO (50 psi), $\text{Pd}(\text{dpfp})\text{Cl}_2$ (4%), LiCl, BHT, DMF, 50°, 15 h	 (52)	336
	$\text{Me}_4\text{Sn}$	CO (75 psi), $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (3%), CHCl <sub>3</sub> , 80°	 (56)	842
	$\text{Me}_4\text{Sn}$	CO (15 psi), $\text{Ni}(\text{PPh}_3)_2(\text{CO})_2$ (3%), HMPA, 140°, 24 h	 (87)	841
	$\text{Bu}_3\text{SnCH}_2\text{CH(OEt)}$	CO (75 psi), $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (3%), CHCl <sub>3</sub> , 80°	 (59) + (26)	842
	$\text{Bu}_3\text{SnCH}_2\text{CH(CO}_2\text{Et)}$	CO (15 psi), $\text{Pd}(\text{dpfp})\text{Cl}_2$ (4%), LiCl, BHT, DMF, 90°, 18 h	 (0)	336
	$\text{Bu}_3\text{SnPh}$	CO (15 psi), $\text{Pd}(\text{dpfp})\text{Cl}_2$ (4%), LiCl, BHT, DMF, 100°, 15 h	 (78)	336
	$\text{Me}_4\text{Sn}$	CO (50 psi), $\text{Pd}(\text{dpfp})\text{Cl}_2$ (4%), LiCl, BHT, DMF, 90°, 1.5 h	 (83)	336
	$\text{Bu}_3\text{SnCH}_2\text{CH=CH}_2$	CO (15 psig), $\text{Pd}(\text{dpfp})\text{Cl}_2$ (4%), LiCl, BHT, DMF, 90°, 2 h	 (84)	336
	$\text{Bu}_3\text{SnCH}_2\text{CH(OEt)}$	CO (30 psi), $\text{Pd}(\text{dpfp})\text{Cl}_2$ (4%), LiCl, BHT, DMF, 70°, 4 h	 (72)	336
	$\text{Bu}_3\text{SnCH}_2\text{CH(OETHP)}$	CO (30 psi), $\text{Pd}(\text{dpfp})\text{Cl}_2$ (4%), LiCl, BHT, DMF, 70°, 3 h	 (54)	336

TABLE XXVI. CARBOXYLATIVE CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

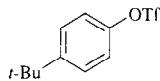
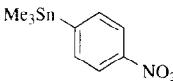
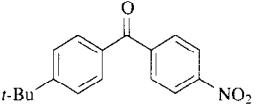
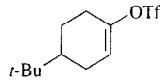
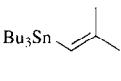
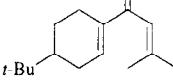
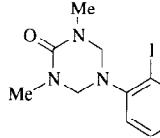
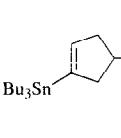
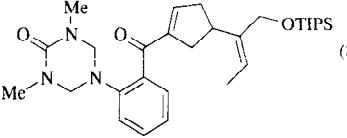
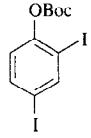
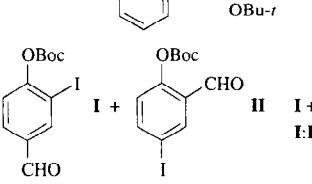
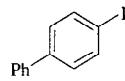
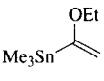
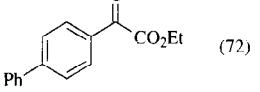
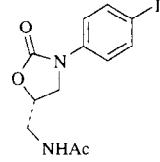
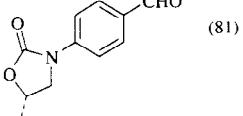
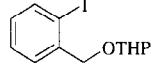
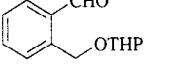
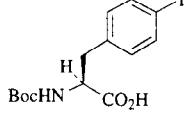
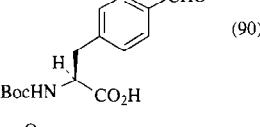
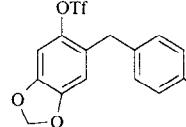
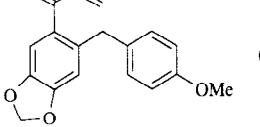
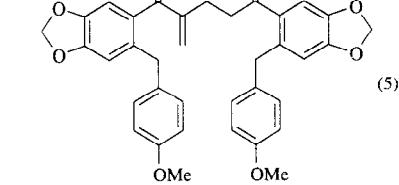
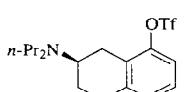
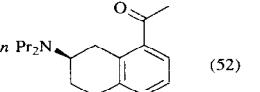
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
			CO (15 psi), Pd(dppf)Cl <sub>2</sub> (4%), LiCl, BHT, DMF, 95°, 11 h	 (0)	336
			CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (5.3%), LiCl, BHT, dioxane, 95°, 18 h	 (58)	173
C <sub>11</sub>			CO (50 psi), Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (22%), LiCl, THF, 70°, 16 h	 (85)	511
572					
			CO (50 psi), Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), AsPh <sub>3</sub> (22%), LiCl, THF, 70°, 16 h	 (80)	328
C <sub>12</sub>					
			1. CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), dioxane, 95°, 24 h 2. O <sub>3</sub>	 (72)	270
			CO, Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), THF, PhMe, 55°	 (81)	847
C <sub>14</sub>			CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 (72)	331
			CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 50°, 2.5 h	 (90)	848
573					
			CO (15 psi), Pd(dppf)Cl <sub>2</sub> (2%), LiCl, BHT, DMF, 75°, 21 h	 (67) +  (5)	336
C <sub>16</sub>			CO (15 psi), Pd(dppf)Cl <sub>2</sub> (5%), LiCl, BHT, DMF, 90°, 14 h	 (52)	619, 620

TABLE XXVI. CARBOXYLATIVE CROSS-COUPLING OF ARYL ELECTROPHILES (*Continued*)

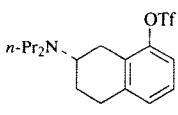
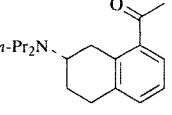
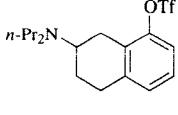
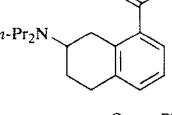
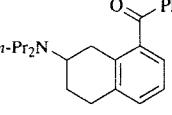
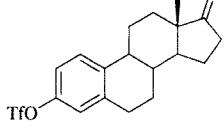
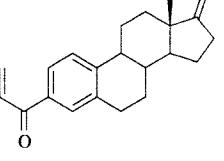
Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	Me <sub>4</sub> Sn	CO (15 psi), Pd(dppf)Cl <sub>2</sub> (5%), LiCl, BHT, DMF, 90°, 14 h	 (44)	619, 620
	Bu <sub>4</sub> Sn	CO (15 psi), Pd(dppf)Cl <sub>2</sub> (5%), LiCl, BHT, DMF, 90°, 14 h	 (71)	620
	Me <sub>3</sub> SnPh	CO (15 psi), Pd(dppf)Cl <sub>2</sub> (5%), LiCl, BHT, DMF, 90°, 14 h	 (52)	620
C <sub>18</sub> 	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	CO, Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, BHT, dioxane, 110°, 14 h	 (0)	521

TABLE XXVII. CARBONYLATIVE CROSS-COUPLING OF HETEROCYCLIC ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
$C_4$		$Bu_3SnH$	CO (45 psi), $Pd(PPh_3)_4$ (4%), THF, 50°, 3.5 h	(60)	331
		$Me_4Sn$	CO (15 psi), $Ni(PPh_3)_2(CO)_2$ (3%), HMPA, 140°, 8.5 h	(48)	841
$C_5$		$Bu_3Sn$	CO (32 psi), $BnPd(PPh_3)_2Cl$ (1%), $C_6H_6$ , 80°, 18 h	(53)	844
			CO (75 psi), $Pd(PPh_3)_2Cl_2$ (3%), $CHCl_3$ , 80°	X = Br (low) X = I (9)	842
$C_9$		$Bu_3Sn$	CO (75 psi), $Pd(PPh_3)_2Cl_2$ (3%), $CHCl_3$ , 80°	(44)	842
		$Me_4Sn$	CO (45 psi), $Pd(OAc)_2$ (2%), $PPh_3$ (8%), THF, 65°, 24 h	(64)	327
		$Bu_3Sn$	CO (45 psi), $Pd(OAc)_2$ (2%), $PPh_3$ (8%), THF, 40-45°, 6 h	(64)	327
		$Bu_4Sn$	CO (45 psi), $Pd(OAc)_2$ (2%), $PPh_3$ (8%), THF, 85°, 6 h	(74)	327

TABLE XXVII. CARBONYLATIVE CROSS-CO尤LING OF HETERO CYCLIC ELECTROPHILES (Continued)

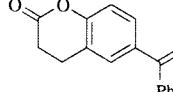
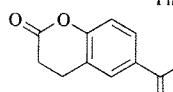
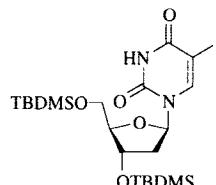
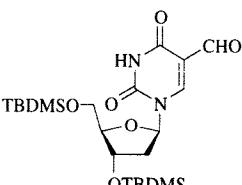
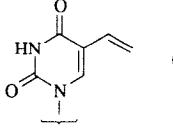
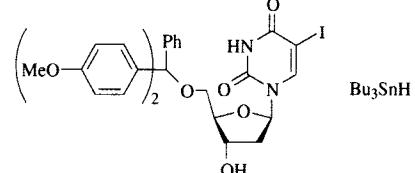
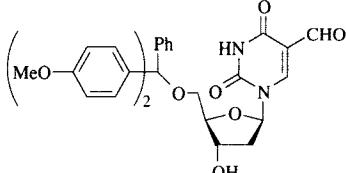
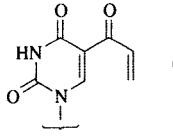
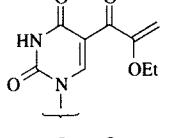
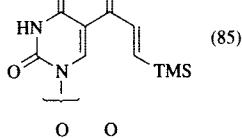
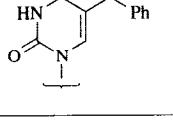
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
		Bu <sub>3</sub> SnPh	CO (45 psi), Pd(OAc) <sub>2</sub> (2%), PPh <sub>3</sub> (8%), THF, 65-70°, 6 h	 (62)	327
		Bu <sub>3</sub> SnC≡CPh	CO (45 psi), Pd(OAc) <sub>2</sub> (2%), PPh <sub>3</sub> (8%), THF, 65-70°, 6 h	 (81)	327
C <sub>21</sub>		Bu <sub>3</sub> SnH	CO, Pd(PPh <sub>3</sub> ) <sub>4</sub>	 (82)	849
576		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	CO (50 psi), Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (30%), CuI (30%), THF, 70°, 5 h	 (82)	849
C <sub>30</sub>		Bu <sub>3</sub> SnH	CO (50 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), THF, 70°, 8 h	 (95)	849
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	CO (50 psi), Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (30%), CuI (30%), THF, 70°, 12 h	 (77)	849
		Bu <sub>3</sub> SnCOEt	CO (50 psi), Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (30%), CuI (30%), THF, 70°, 12 h	 (81)	849
577		Bu <sub>3</sub> SnCH=CH <sub>2</sub> TMS	CO (50 psi), Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (30%), CuI (30%), THF, 70°, 8 h	 (85)	849
		Bu <sub>3</sub> SnPh	CO (50 psi), Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (30%), CuI (30%), THF, 70°, 12 h	 (95)	849

TABLE XXVIII. CARBONYLATIVE CROSS-COUPING OF ALLYL AND BENZYL ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>3</sub> 578			Pd(ClCH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), PPh <sub>3</sub> (0.75%), CHCl <sub>3</sub> , 25°, 48 h CO (15 psi) CO (45 psi) CO (90 psi)	 (7) (62) (70)	333
			CO (90 psi), PPh <sub>3</sub> (0.75%), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), CHCl <sub>3</sub> , 25°, 48 h	 (28)	333
			"	 (47)	333
			"	 (0)	333
			"	 (28)	333
			CO (45 psi), PPh <sub>3</sub> (0.75%), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), CHCl <sub>3</sub> , 25°, 48 h	 (27)	333
C <sub>4</sub>			"	 (20)	333
		Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 (100)	331
			CO (90 psi), PPh <sub>3</sub> (0.75%), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), CHCl <sub>3</sub> , 25°, 48 h	 (16) + (20)	333
			CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), THF, 55°, 1.5 d	 (66)	287
			CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), THF, 55-60°, 3 d	 (80)	287
			Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), PPh <sub>3</sub> (0.75%), CHCl <sub>3</sub> , 25°, 48 h CO (45 psi) CO (90 psi)	 (I) (33)  (II) (48) + (I) (33)	333
C <sub>5</sub> 579			CO (500 psi), PPh <sub>3</sub> (20%), Pd <sub>2</sub> (dba) <sub>3</sub> •CHCl <sub>3</sub> (10%), 3 Å molecular sieves, C <sub>6</sub> H <sub>6</sub> , 60°	 (76)	522
		Bu <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 (65)	331
		Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	 (100)	331
			CO (45 psi), PPh <sub>3</sub> (0.75%), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), CHCl <sub>3</sub> , 25°, 48 h	 (59)	333

TABLE XXVIII. CARBONYLATIVE CROSS-COUPLING OF ALLYL AND BENZYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>6</sub>		Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	I (14)	331
		Bu <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), PhMe, 50°, 3.5 h	I (65) +  II (23)	325, 331
		Me <sub>3</sub> SnCH=CH <sub>2</sub>	CO (90 psi), PPh <sub>3</sub> (0.75%), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), CHCl <sub>3</sub> , 25°, 48 h	(21) + (13) + II (22)	333
580		Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	I +  II +  III + IV	325, 331
				I + II = (49); I:II = 1:1; III + IV = (51); III:IV = 1:1	
		Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	I + II = (41); I:II = 1:1; III + IV = (59); III:IV = 1:1	325, 331
C <sub>7</sub>		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> O	CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), THF, 60°, 1 d	(22) + (28)	287
		Bu <sub>3</sub> SnH	Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	I + PhMe II	325, 331
			CO (15 psi)	I (75) + II (12)	
			CO (45 psi)	I (94) + II (6)	
581		Me <sub>4</sub> Sn	CO (15 psi), Ni(PPh <sub>3</sub> ) <sub>2</sub> (CO) <sub>2</sub> (3%), HMPA, 150°, 0.5 h	(29)	841
		Me <sub>4</sub> Sn	CO (15 psi), Pd(Ph-BIAN) (dimethyl fumarate) (1%), HMPA, 50°, 20 h	(88)	415
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> O	CO (30 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), THF, 50°, 2 d	(82)	287
		Bu <sub>3</sub> SnC <sub>6</sub> H <sub>4</sub> Br	CO (15 psi), Pd(Ph-BIAN) (dimethyl fumarate) (1%), DMF, 50°, 15 h	(79)	415
		Bu <sub>3</sub> SnH	CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	(66) + PhMe (21)	331
		Me <sub>4</sub> Sn	CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (0.2%), HMPA, 120°, overnight	(86)	323
		Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	I +  II	325, 331
			X = Br, I (27) + II (45)		
			X = Cl, I (85) + II (14)		
		Me <sub>3</sub> SnCH=CH <sub>2</sub>	CO (90 psi), PPh <sub>3</sub> (0.75%), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), CHCl <sub>3</sub> , 25°, 48 h	(20) + (29) + (26)	333

TABLE XXVIII. CARBONYLATIVE CROSS-CO尤LING OF ALLYL AND BENZYL ELECTROPHILES (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Ref.
C <sub>8</sub>		Me <sub>4</sub> Sn	CO (300 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.3%), HMPA 120°, 1 h		337
		Ph <sub>4</sub> Sn	CO (300 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.3%), HMPA 120°, 1 h		337
C <sub>9</sub>		Me <sub>4</sub> Sn	CO (90 psi), PPh <sub>3</sub> (0.75%), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), CHCl <sub>3</sub> , 25°, 48 h		333
			CO (300 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (0.6%), HMPA, 120°, 7 h		337
C <sub>10</sub>		Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h		325, 331
		Me <sub>3</sub> SnCH=CH <sub>2</sub>	CO (90 psi), PPh <sub>3</sub> (0.75%), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (1.5%), CHCl <sub>3</sub> , 25°, 48 h		333
C <sub>24</sub>		Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h		331
			CO (45 psi), Pd <sub>2</sub> (dba) <sub>3</sub> (10%), PPh <sub>3</sub> (20%), 50°, 36 h		850

TABLE XXIX. CARBONYLATIVE CROSS-COUPING OF MISCELLANEOUS ELECTROPHILES

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>4</sub>		Ph <sub>4</sub> Sn	CO (15 psi), PhPd(PPh <sub>3</sub> ) <sub>2</sub> I (0.2%), HMPA, 120°, overnight	(67)	323
C <sub>5</sub>		Me <sub>4</sub> Sn	CO (300 psi), Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 120°, 1 h	I (14) +  II (25)	337
		Me <sub>4</sub> Sn	CO (300 psi), Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), HMPA, 120°, 3 h	I (62) + II (25)	337
C <sub>6</sub>	<i>n</i> -BuC≡Cl	Bu <sub>3</sub> SnH	CO (45 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), THF, 50°, 3.5 h	<i>n</i> -BuC≡CCHO (0) +  III (28) + IV (38)	331

TABLE XXX. INTRAMOLECULAR CARBOXYLATIVE CROSS-COUPLING REACTIONS

	Substrate	Conditions	Product(s) and Yield(s) (%)	Refs.
<sup>98g</sup> C <sub>11</sub>		CO (15 psi), Pd(dba) <sub>2</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , THF or DMF, 60°		186
		CO (15 psi), polymer-supported Pd(0)(dppf) (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , dioxane, reflux, 3-4 h		186
<sup>98g</sup> C <sub>12</sub>		CO (15 psi), Pd(dba) <sub>2</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , THF or DMF, 60°		186
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , THF, 65°		186
<sup>98g</sup> C <sub>13</sub>		CO (15 psi), Pd(dba) <sub>2</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , THF or DMF, 60°		186
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , THF, 65°		186
<sup>98g</sup> C <sub>14</sub>		CO (15 psi), Pd(dba) <sub>2</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , THF or DMF, 60°		186
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , dioxane, 90°		186
		CO (15 psi), Pd(dppf)Cl <sub>2</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , THF, 65°		186

TABLE XXX. INTRAMOLECULAR CARBOYLATIVE CROSS-COUPLING REACTIONS (Continued)

	Substrate	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>15</sub>		CO (15 psi), polymer-supported Pd(0)(dpff) (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , dioxane, reflux, 3-4 h	I (76)	186
		CO (15 psi), Pd(dba) <sub>2</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , THF or DMF, 60°	I (34-39)	186
		CO (15 psi), Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , dioxane, 90°	I (60)	186
		CO (15 psi), polymer-supported Pd(0)(dpff) (5%), LiCl, K <sub>2</sub> CO <sub>3</sub> , dioxane, reflux, 3-4 h	I (70)	186
985		CO (50 psi), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (10%), LiCl, DMF, rt, 13 h	(24)	335
		CO (50 psi), Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (10%), LiCl, DMF, rt, 13 h	(53)	335

TABLE XXXI. CROSS-CO尤LING REACTIONS THAT FORM POLYMERS

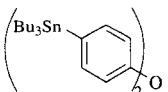
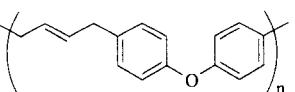
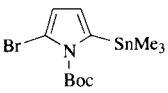
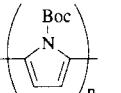
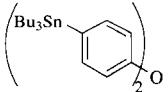
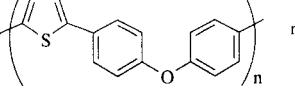
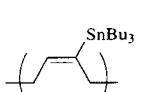
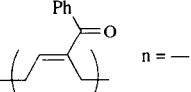
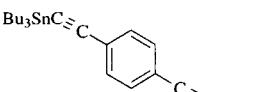
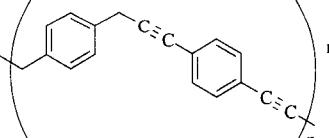
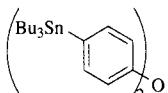
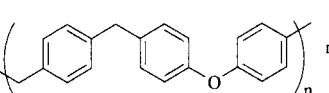
	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
<i>C</i> <sub>4</sub>	BrCH <sub>2</sub> CH=CHCH <sub>2</sub> Br		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 165°, 4 h	 n = 21.8	851, 852
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 165°, 4 h	 n = 4	659
<i>C</i> <sub>7</sub>	Br-C(=S)-C(=S)-Br		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 165°, 4 h	 n = 18.1	851, 852
	PhCOCl		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PhMe, 70°, 12 h	 n = —	225
<i>C</i> <sub>8</sub>	Br-CH <sub>2</sub> -C <sub>6</sub> H <sub>4</sub> -CH <sub>2</sub> -Br		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 120°, 4 h	 n = 24.6	851, 852a
			Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 165°, 4 h	 n = 17.8	851, 852

TABLE XXXI. CROSS-COUPLING REACTIONS THAT FORM POLYMERS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{SnC}\equiv\text{C}-\text{C}_6\text{H}_3-\text{C}\equiv\text{CSnBu}_3$	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 120°, 4 h		n = 5.3 851, 852a
	$\text{Me}_3\text{Sn}-\text{C}_6\text{H}_3-\text{C}(\text{Bu}-t)-\text{SnMe}_3$	Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h		n = 49 232
		Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), THF, reflux		x = 2, 3 n = -- 853
		Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), THF, reflux		x = 2, 3 n = -- 853
	$\text{Me}_3\text{SnC}\equiv\text{C}-\text{C}_6\text{H}_3-\text{C}\equiv\text{CSnMe}_3$	Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), THF, 75°, 20 h		n = -- 830
	$\text{Me}_3\text{Sn}-\text{C}_6\text{H}_3-\text{C}(\text{R})-\text{SnMe}_3$	Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h		R — n OEt 4 232 Bu-t 110 232, 786 OC <sub>6</sub> H <sub>13</sub> -n 3 232 OC <sub>10</sub> H <sub>21</sub> -n 13 232
	$\text{Bu}_3\text{SnC}\equiv\text{C}-\text{C}_6\text{H}_3-\text{C}\equiv\text{CSnBu}_3$	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 165°, 4 h		n = 4 852a
	$(\text{Bu}_3\text{Sn}-\text{C}_6\text{H}_3-\text{C}_6\text{H}_3-\text{O})_2$	Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 165°, 4 h		n = 4.1 852
	$\text{Me}_3\text{Sn}-\text{C}_6\text{H}_3-\text{C}(\text{Bu}-t)-\text{SnMe}_3$	Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h		n = 13 232
	$\text{Me}_3\text{Sn}-\text{C}_6\text{H}_3-\text{C}(=\text{O})-\text{C}_6\text{H}_3-\text{C}(=\text{O})-\text{SnMe}_3$	Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h		n = 1 232

TABLE XXXI. CROSS-CO尤LING REACTIONS THAT FORM POLYMERS (Continued)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
 C <sub>13</sub>		Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h	 n = —	232
		Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h	 n = 109	232
		Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h	 n = 148	232
 C <sub>14</sub>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 160°, 4 h	 n = 21	852
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 160°, 4 h	 n = 5.7	851, 852a
 C <sub>15</sub>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 130-300°, 4 h	 n = 2-15.8	851, 852
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 160°, 4 h	 n = 3.7	851, 852a
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (4%), DMA, 165°, 4 h	 n = 14	851, 852
 C <sub>15-16</sub>		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF	 n = —	854, 855
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (2%), PPh <sub>3</sub> (5%), DMA, 165°, 4 h	 n = —	856
			$R^1, R^2 = CH_2CH_2$ $R^1 = R^2 = OMe$ $R^1, R^2 = CH_2CHCH_3$	

TABLE XXXI. CROSS-COUPLING REACTIONS THAT FORM POLYMERS (*Continued*)

Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd(PPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (5%), THF			
C <sub>16</sub> R: n-C <sub>5</sub> H <sub>11</sub>			n = —	855	
C <sub>18</sub> R: n-C <sub>6</sub> H <sub>13</sub>			n = —	855	
C <sub>20</sub> R: n-C <sub>7</sub> H <sub>15</sub>			n = —	855	
C <sub>22</sub> R: n-C <sub>8</sub> H <sub>17</sub>			n = —	855	
C <sub>24</sub> R: n-C <sub>9</sub> H <sub>19</sub>			n = —	855	
C <sub>30</sub> R: n-C <sub>12</sub> H <sub>25</sub>			n = —	854, 855	
C <sub>38</sub> R: n-C <sub>16</sub> H <sub>33</sub>			n = 22	854, 855	
592					
C <sub>20</sub>			Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h		n = —      232
			Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h		n = —      232
593					
C <sub>29</sub>			Pd(PPh <sub>3</sub> ) <sub>4</sub> , LiCl, dioxane, 90°, 16 h		n = —      x + y = 1      y = 0-0.49      857
C <sub>41</sub>			Pd(0)		n = 11      858

TABLE XXXI. CROSS-COUPLING REACTIONS THAT FORM POLYMERS (*Continued*)

	Substrate	Stannane	Conditions	Product(s) and Yield(s) (%)	Refs.
45	C <sub>42</sub> 	Me <sub>3</sub> Sn-	Pd(AsPh <sub>3</sub> ) <sub>2</sub> Cl <sub>2</sub> (1%), neat, 70°, 24 h		n = 9 232
	>C <sub>50</sub> 	Me <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> Cl <sub>2</sub> (2%), PhMe, 70°, 12 h		n = -- 225
		Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), NMP, 45°, overnight		(≥89) 145
		Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), NMP, 45°, overnight		(≥91) 145
		Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), NMP, 45°, overnight		(≥85) 145
		Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), NMP, 45°, overnight		(≥90) 145
46		Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), NMP, 45°, overnight		(≥89) 145
		Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), NMP, 45°, overnight		(≥92) 145
		Bu <sub>3</sub> Sn-	Pd <sub>2</sub> (dba) <sub>3</sub> (5%), AsPh <sub>3</sub> (20%), NMP, 45°, overnight		(≥88) 145

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-COUPLING REACTIONS

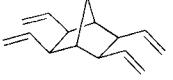
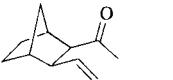
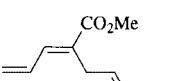
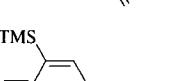
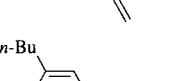
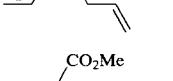
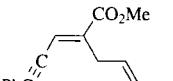
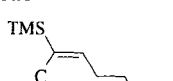
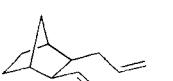
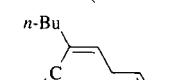
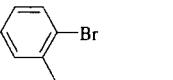
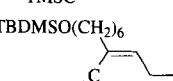
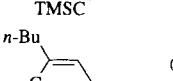
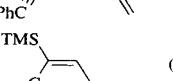
Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
$C_2$	$Bu_3SnCH=CH_2 + \text{C}_2H_5SiPh_3$	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 120°, 20 h	 (64)	342
	$Bu_3SnCH=CH_2 + \text{C}_2H_5SiPh_3$	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 20 h	 (0)	342
$C_3$	$Bu_3SnCH=CH_2 + HC\equiv CO_2Me$	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (2%), NMP, 80°, 24 h	 (16)	356
	$Bu_3SnCH=CH_2 + HC\equiv CTMS$	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (2%), PhMe, 80°, 24 h	 (16)	356
	$Bu_3SnCH=CH_2 + HC\equiv CBu-n$	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (2%), HMPA, 80°, 24 h	 (20)	356
	$Bu_3SnPh + HC\equiv CO_2Me$	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (2%), HMPA, 80°, 24 h	 (36)	356
	$Bu_3SnPh + HC\equiv CR$	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), Et <sub>4</sub> NCl, HMPA, 80°, 24 h	 (21)	356
	R CH <sub>2</sub> OEt		(23)	
	TMS		(24)	
596	Bu-n		(26)	
	Ph			
$C_3$	$Bu_3SnC\equiv CPh + HC\equiv CO_2Me$	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (2%), PhMe, 80°, 24 h	 (16)	356
	$Bu_3SnC\equiv CPh + HC\equiv CTMS$	Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (5%), HMPA, 80°, 24 h	 (10)	356
597	$\text{CH}_2=CHCl$	$Bu_3SnCH=CH_2 + \text{C}_2H_5SiPh_3$	 (0)	342
	$Bu_3SnC\equiv CTMS + HC\equiv CBu-n$	Ni(acac) <sub>2</sub> (10%), DIBAL (10%), THF, reflux, 1 h	 (72)	357
	$Bu_3SnC\equiv CTMS + \text{Br-C}_6H_4-\text{CH}_2-\text{C}_6H_4-\text{Br}$	Ni(acac) <sub>2</sub> (10%), DIBAL (10%), THF, reflux, 1 h	 (83)	357
	$Bu_3SnC\equiv CTMS + HC\equiv C(\text{CH}_2)_6OTBDMS$	Ni(acac) <sub>2</sub> (10%), DIBAL (10%), THF, reflux, 1 h	 (76)	357
	$Bu_3SnC\equiv CPh + HC\equiv CBu-n$	Ni(acac) <sub>2</sub> (10%), DIBAL (10%), THF, reflux, 1 h	 (70)	357
	$Bu_3SnC\equiv CPh + HC\equiv CTMS$	Ni(acac) <sub>2</sub> (10%), DIBAL (10%), THF, reflux, 1 h	 (36)	357

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-COUPLING REACTIONS (Continued)

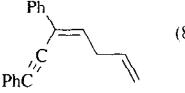
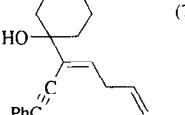
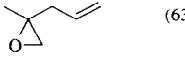
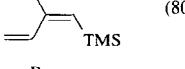
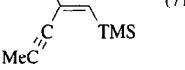
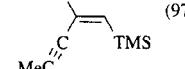
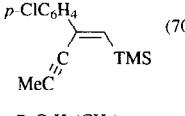
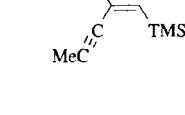
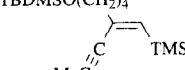
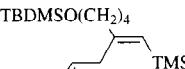
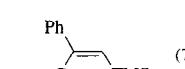
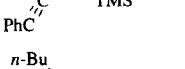
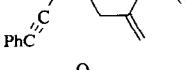
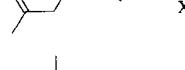
Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.	
	$\text{Bu}_3\text{SnC}\equiv\text{CPh} + \text{HC}\equiv\text{CPh}$	$\text{Ni}(\text{acac})_2$ (10%), DIBAL (10%), THF, reflux, 1 h	 (80)	357	
	$\text{Bu}_3\text{SnC}\equiv\text{CPh} + \text{HC}\equiv\text{C}(\text{OH})\text{C}_6\text{H}_11$	$\text{Ni}(\text{acac})_2$ (10%), DIBAL (10%), THF, reflux, 1 h	 (79)	357	
	$\text{Bu}_3\text{SnC}\equiv\text{CPh} + \text{CH}_2=\text{CHCH}_2\text{SnBu}_3$	$\text{Pd}(\text{PPh}_3)_4$ (1%), $\text{CH}_2\text{Cl}_2$ , 80°, 20 h	 (63)	859	
	TMSI	$\text{Bu}_3\text{SnC}\equiv\text{CPh} + \text{HC}\equiv\text{CPh}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 7 h	 (80)	364
	$\text{Bu}_3\text{SnC}\equiv\text{CMe} + \text{HC}\equiv\text{CBu}-n$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 3 h	 (71)	364	
	$\text{Bu}_3\text{SnC}\equiv\text{CMe} + \text{HC}\equiv\text{CPh}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 2.5 h	 (97)	364	
595	$\text{Bu}_3\text{SnC}\equiv\text{CMe} + \text{HC}\equiv\text{CC}_6\text{H}_4\text{Cl}-p$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 2.5 h	 (70)	364	
	$\text{Bu}_3\text{SnC}\equiv\text{CMe} + \text{HC}\equiv\text{C}(\text{CH}_2)_2\text{C}_6\text{H}_4\text{Br}-o$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 2 h	 (70)	364	
	$\text{Bu}_3\text{SnC}\equiv\text{CMe} + \text{HC}\equiv\text{C}(\text{CH}_2)_4\text{OTBDMS}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 3 h	 (76)	364	
	$\text{Bu}_3\text{SnC}\equiv\text{CMe} + \text{HC}\equiv\text{C}(\text{CH}_2)_4\text{OTBDMS}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 7 h	 (73)	364	
	$\text{Bu}_3\text{SnC}\equiv\text{CTMS} + \text{HC}\equiv\text{CPh}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 3 h	 (79)	364	
	$\text{Bu}_3\text{SnC}\equiv\text{CPh} + \text{HC}\equiv\text{CPh}$	$\text{Pd}(\text{PPh}_3)_4$ (2%), dioxane, 60°, 2 h	 (71)	364	
C <sub>4</sub>	$\text{Bu}_3\text{SnC}\equiv\text{CPh} + \text{HC}\equiv\text{C}(\text{CH}_2)_2\text{C}_6\text{H}_4\text{Br}-n$	$\text{Ni}(\text{acac})_2$ (10%), DIBAL (10%), THF, reflux, 1 h	 (67)	357	
	$\text{OHC}-\text{CH}_2-\text{CH}_2-\text{Br}$	$[\text{OSnBu}_3]$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.5%), THF, 63°, 15 h	 (80)	209
	$(\text{CH}_2=\text{CHCH}_2)_4\text{Sn}$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.5%), THF, 63°, 48 h	 (85)	209	
	$\text{O}-\text{C}(=\text{O})-\text{CH}_2-\text{X}$	$[\text{OSnBu}_3]$	$\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (2.5%), THF, 63°, 5 h	 X = Br (70) X = Cl (65)	209
	$\text{O}-\text{C}(=\text{O})-\text{CH}_2-\text{Cl}$	$\text{Bu}_3\text{SnC}\equiv\text{CPh}$	$\text{Pd}(\text{PPh}_3)_4$ (1%), $\text{CH}_2\text{Cl}_2$ , 80°, 20 h	 (53)	859

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-COUPLING REACTIONS (Continued)

	Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.	
			1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), Ag <sub>2</sub> O, DMF, 100°, 15 min 2. HCl (2 N), 100°, 1 h		(71)	860
			1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), CuO, DMF, 100° 2. HCl (2 N)		(5)	861
		(CH <sub>2</sub> =CHCH <sub>2</sub> ) <sub>4</sub> Sn	BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 48 h		(90)	209
		Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), CH <sub>2</sub> Cl <sub>2</sub> , 80°, 20 h		(30)	859
600	Me <sub>3</sub> SiSiMe <sub>2</sub> I	Bu <sub>3</sub> SnC≡CMe + HC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (2%), dioxane, 60°, 2 h		(72)	364
C <sub>6</sub>	PhBr	Bu <sub>3</sub> SnH + <i>t</i> -BuNC	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 120°		(0)	862
		Bu <sub>3</sub> SnCH=CH <sub>2</sub> + <i>t</i> -BuNC	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 120°		(tr)	862
		Bu <sub>3</sub> SnCH=CH <sub>2</sub> +	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°		(87)	342
		Bu <sub>3</sub> SnCH=CH <sub>2</sub> +	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h		(87)	341, 342
609		Bu <sub>3</sub> SnCH <sub>2</sub> OMe +	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h		(0)	342
		Bu <sub>3</sub> SnCH=CH <sub>2</sub> + <i>t</i> -BuNC	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 120°		(tr)	862
		Bu <sub>3</sub> SnCH=CH <sub>2</sub> +	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 48 h		(49)	341, 342
		+	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h		(0)	342
		Bu <sub>3</sub> SnCH=CH <sub>2</sub> + <i>t</i> -BuNC	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 120°		(30)	862
		Bu <sub>3</sub> SnCH=CH <sub>2</sub> +	1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h 2. H <sup>+</sup>		(73)	342
		Bu <sub>3</sub> SnPh + <i>t</i> -BuNC	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 120°		(0)	862
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h		(60)	341, 342
		Bu <sub>3</sub> SnC≡CPh + <i>t</i> -BuNC	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 120°		(40)	862

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-CO尤PLING REACTIONS (Continued)

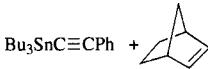
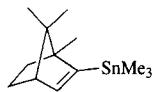
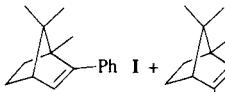
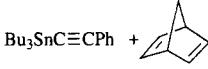
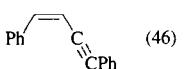
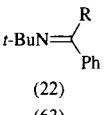
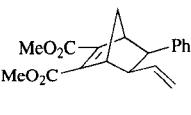
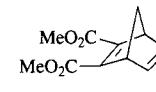
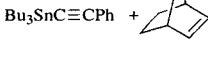
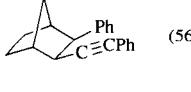
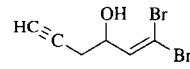
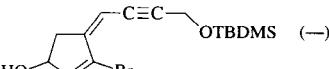
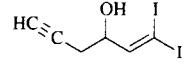
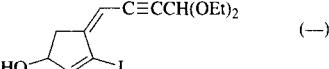
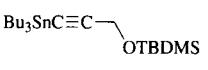
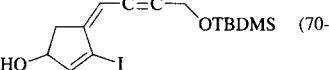
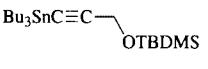
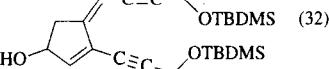
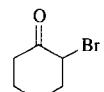
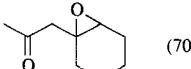
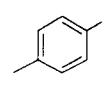
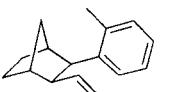
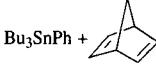
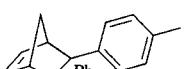
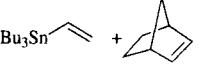
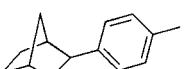
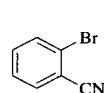
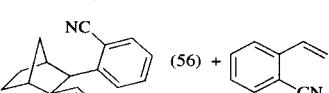
Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 12 h	 (28)	341, 342	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , <i>i</i> -Pr <sub>2</sub> NEt, BHT, PhMe, reflux	 I + II (58) I:II = 9:91	373	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°	 (46)	342	
	Bu <sub>3</sub> SnR + <i>t</i> -BuNC	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), C <sub>6</sub> H <sub>6</sub> , 120°	 R (22)	862	
			(63)		
	OMe		(48)		
	OEt		(10)		
	SPh		(40)		
	CN				
	Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub>	 (49)	342	
					
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h	 (56)	341, 342	
					
		Bu <sub>3</sub> SnC≡COTBDMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), THF, 40-45°	 (—)	352
		Bu <sub>3</sub> SnC≡CCH(OEt) <sub>2</sub>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), THF, 40-45°	 (—)	352
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), THF, 40-45°	 (70-80)	352	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%)	 (32)	352	
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 4 h	 (70)	209
		Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h	 (87)	342
		Pd <sub>2</sub> (dba) <sub>3</sub> (0.5%), P( <i>o</i> -Tol) <sub>2</sub> Ph (2%), Et <sub>4</sub> NCl, THF, 100°, 24 h	 (85)	343	
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h	 (95)	341	
		Bu <sub>3</sub> SnC≡CPh	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h	 (56) + (15)	342

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-CO尤PLING REACTIONS (Continued)

Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 100°, 8 h		860
		1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CuO, DMF, 100° 2. HCl (2 N)		861
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 100°, 8 h		860
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CuO, DMF, 100°		694
	+	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 80°, 12 h		341, 342
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 24 h		462
		BnPh(PPh <sub>3</sub> ) <sub>2</sub> Cl (6.5%), CuI, C <sub>6</sub> H <sub>6</sub> , rt, 20 h		644
		BnPh(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), CuI, THF, reflux, 20 h		644
	+	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h		342
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%)		207
	+	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h		341, 342
	+	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h		341
	+	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 20 h		341
	+	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 12 h		341
	+	Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h		342

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-COUPLING REACTIONS (Continued)

Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Ref.s.
		1. PdCl <sub>2</sub> , LiCl, norbornene, CH <sub>3</sub> CN 2. stannane, PPh <sub>3</sub> , THF	(34)	863
		Pd(dppb)Cl <sub>2</sub> , CuO, DMF, 105–110°, 48 h	(78)	864
		Pd(dppb)Cl <sub>2</sub> , CuO, DMF, 105–110°, 48 h	(80)	864
		Pd(dppb)Cl <sub>2</sub> , CuO, DMF, 105–110°, 48 h	(68)	864
		Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 48 h	(86)	464, 540
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), C <sub>6</sub> H <sub>6</sub> , 100°, 10 h	(96)	341, 342
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 5 h	(75)	209
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 5 h	(80)	209
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 20 h	(87) + (99) + (80)	209
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), CH <sub>2</sub> Cl <sub>2</sub> , 80°, 20 h	(65)	859
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (1%), CH <sub>2</sub> Cl <sub>2</sub> , 80°, 20 h	(39)	859
		1. Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), PhMe, 60°, overnight, 2. reflux, 8 h	(34)	362
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (2%), THF, 40–70°, 3 h	(61)	361
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%) dioxane, 50–100°, 8 h	(X = O (≥71), X = S (≥58))	295
		1. Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), PhMe, 60°, overnight, 2. reflux, 6 h	(34)	362

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-CO尤LING REACTIONS (Continued)

Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.	
	Pd(PhCN)2Cl2 (5%), P(2-furyl)3 (10%) dioxane, 50-100°, 16 h		X = O (≥94) X = S (≥85)	295	
	Pd(PhCN)2Cl2 (5%), P(2-furyl)3 (10%) dioxane, 50-100°, 16 h		(≥92)	295	
	Pd2(dba)3 (1%), P(2-furyl)3 (4%), dioxane, 80-100°		(95)	360	
	Pd(PhCN)2Cl2 (5%), P(2-furyl)3 (10%) dioxane, 50-100°, 16 h		X = O (≥76) X = S (≥78)	295	
	Bu3Sn vinyl stannane	Pd(dba)2 (5%), P(2-furyl)3 (10%), dioxane, 60°, 5 h		(67)	359
	Bu3Sn vinyl stannane	Pd(PhCN)2Cl2 (5%), P(2-furyl)3 (10%) dioxane, 100°, 6 h		(55)	359
	1. Pd2(dba)3 (5%), P(2-furyl)3 (10%), PhMe, 60°, overnight, 2. reflux, 6 h		(62)	362	
	Pd(PhCN)2Cl2 (5%), P(2-furyl)3 (10%) dioxane, 100°, 6 h		(53)	359	
	Pd(dba)2 (1%), P(2-furyl)3 (2%), PhMe, 55-60°, 3 h		(95)	361	
	Pd(PhCN)2Cl2 (5%), P(2-furyl)3 (10%) dioxane, 50-70°, 8 h		(≥78)	295	
	1. Pd2(dba)3 (2.5%), P(2-furyl)3 (10%), PhMe, 60°, overnight, 2. reflux, 6 h		(44)	362	
	Pd(dba)2 (1%), P(2-furyl)3 (4%), dioxane, 80-100°		$\frac{R^1}{TMS} \frac{R^2}{Me}$ (81) $H \quad OPr-i$ (77)	360	
	Pd(PhCN)2Cl2 (5%), P(2-furyl)3 (10%) dioxane, 50-100°, 16 h		X = O (≥84) X = S (≥82)	295	

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-CO尤LING REACTIONS (Continued)

	Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.	
C <sub>9</sub>			Pd(dba) <sub>2</sub> (1%), P(2-furyl) <sub>3</sub> (4%), dioxane, 80-100°		(75)	360
			Pd(dppb)Cl <sub>2</sub> , CuO, DMF, 105-110°, 48 h		R = Me (87) R = OMe (91)	864
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, 100°, 24 h		(59)	101
			1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 100°, 24 h 2. HCl (2 N)		(43)	102
			1. Pd(dppb)Cl <sub>2</sub> (5%), CuO, DMF, 100°, 3 h 2. HCl (2 N) 3. NaOH (2 N)		(57)	96
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, 100°, 24 h		(75)	101
			1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 100°, 24 h 2. HCl (2 N)		(63)	102
G			Pd(PPh <sub>3</sub> ) <sub>4</sub> , DMF, 100°, 24 h		(42)	101
			1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (3%), DMF, 100°, 24 h 2. HCl (2 N)		(27)	102
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 5 h		(55)	209
			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 48 h		(85)	209
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 96 h		(90)	462
			Pd(PPh <sub>3</sub> ) <sub>4</sub> , PhMe, reflux, 24 h		(18)	462
			1. Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), PhMe, 60°, overnight, 2. reflux, 8 h		(31)	362
			Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (2%), THF, 40-70°, 3 h		(71)	361

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-COUPLING REACTIONS (Continued)

	Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>10</sub>			Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (2%), THF, 40–70°, 3 h	 (72)	361
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, DMF, 60°, 8 h	 (43) + (5)	349
612			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, DMF, 60°, 8 h	 (54)	349
			Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), Et <sub>3</sub> N, LiCl, DMF, 60°, 8 h	 (63)	349
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, DMF, 60°, 8 h	 (46) + (39)	349
			Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), Et <sub>3</sub> N, LiCl, DMF, 60°, 8 h	 (45)	349
613			1. Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (83%), malonate, THF, -78°, 1.5 h 2. stannane, DMF, THF, -60° to rt, 15–18 h	 (80)	339
			1. Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (83%), malonate, THF, -78°, 1.5 h 2. stannane, DMF, THF, -60° to rt, 15–18 h	 (50)	339
			1. Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (83%), malonate, THF, -78°, 1.5 h 2. stannane, DMF, THF, -60° to rt, 15–18 h	 (31)	339
			1. Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (83%), malonate, THF, -78°, 1.5 h 2. stannane, DMF, THF, -60° to rt, 15–18 h	 (56)	339
			1. Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), CuO, DMF, 100° 2. HCl (2 N)	 (44)	861
C <sub>11</sub>			BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 48 h	 (90)	209
			Pd(dppf)Cl <sub>2</sub> (5%), LiCl, DMF, 60°, 8 h	 (51)	349
			Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, DMF, 60°, 8 h	 (51)	349

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-CO尤PLING REACTIONS (Continued)

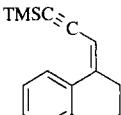
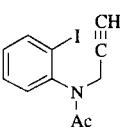
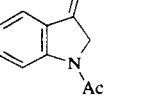
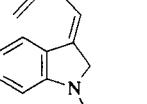
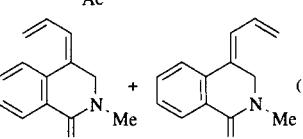
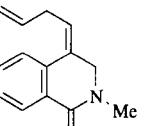
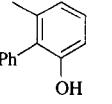
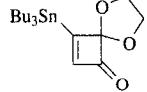
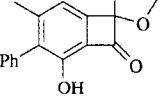
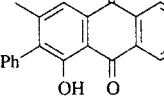
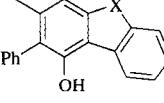
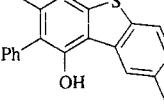
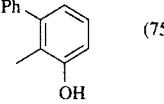
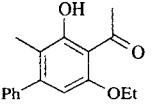
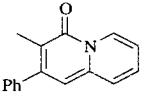
Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Ref.s.	
					
	Bu <sub>3</sub> SnC≡CTMS	Pd(PPh <sub>3</sub> ) <sub>4</sub> (5%), LiCl, DMF, 60°, 8 h	(54)	349	
	Bu <sub>3</sub> SnCH=	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 5-25°, 2-6 h		(40)	347
	Bu <sub>3</sub> SnCH=	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, CH <sub>3</sub> CN, 5-25°, 2-6 h		(54)	347
	Bu <sub>3</sub> SnCH=	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), LiCl, CH <sub>3</sub> CN, 60°, 2 h		(20) 4:1	347
	Bu <sub>3</sub> SnCH=	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, CH <sub>3</sub> CN, 60°, 1.5 h		(50)	347
	Bu <sub>3</sub> SnCH=	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (4%), P(2-furyl) <sub>3</sub> (10%), dioxane, 100°, 3 h		(75)	359
				(75)	361
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (2%), THF, 40-70°, 3 h		(94)	360
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), dioxane, 80-100°		(94)	360
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-100°, 16 h		X = O (≥89) X = S (≥51)	295
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-100°, 16 h		(≥63)	295
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-100°, 3 h		(75)	359
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 100°, 3 h		(50)	359
		1. Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), PhMe, 60°, overnight, 2. reflux, 10 h		(42)	362

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-CO尤LING REACTIONS (Continued)

Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (2%), THF, 40-70°, 3 h	 (56)	361
		1. Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), PhMe, 60°, overnight, 2. reflux, 8 h	 (58)	362
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-100°, 16 h	 X = O (≥75) X = S (≥63)	295
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-100°, 16 h	 (≥60)	295
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), dioxane, 80-100°	 (74)	360
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), dioxane, 80-100°	 (82)	360
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), dioxane, 80-100°	 (81)	360
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-100°, 16 h	 X = O (≥60) X = S (≥62)	295
		BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (2.5%), THF, 63°, 48 h	 (35)	209
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (2%), THF, 40-70°, 3 h	 R = n-Bu (99) R = s-Bu (91) R = t-Bu (69)	361
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), dioxane, 80-100°	 (77)	360
		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 5-25°, 2-6 h	 (60)	347
		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, CH <sub>3</sub> CN, 5-25°, 2-6 h	 (55)	347

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-CO尤PLING REACTIONS (Continued)

Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.	
	$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 100°, 3 h	(74)	359	
	$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 100°, 4 h	(54)	359	
	$\text{Me}_3\text{SnPh}$	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 100°, 53 h	(77)	359	
	$\text{Bu}_3\text{Sn}-\text{C}(\text{O})-\text{CH}_2-\text{CH}_2-\text{TMS}$	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-70°, 8 h	(≥65)	295	
	$\text{Bu}_3\text{Sn}-\text{C}(\text{O})-\text{CH}_2-\text{CH}_2-\text{X}$	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-100°, 16 h	X = O (≥65) X = S (≥61)	295	
	$\text{Bu}_3\text{Sn}-\text{C}(\text{O})-\text{CH}_2-\text{CH}_2-\text{CH}_3$	Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 50-100°, 16 h	(≥58)	295	
	$\text{MeO}_2\text{C}-\text{CH}=\text{CH}-\text{CH}(\text{CO}_2\text{Me})-\text{CH}_2-\text{CH}=\text{CH}_2$	$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 0.5 h	(72)	345
	$\text{Bu}_3\text{SnC}\equiv\text{C}-\text{CH}_2-\text{R}$	Pd(OAc) <sub>2</sub> (5%), PPh <sub>3</sub> (10%), PhMe, 60°, 5 h	R = OTHP (51) R = OTBDMS (28)	353	
		1. Pd <sub>2</sub> (dba) <sub>3</sub> (2.5%), P(2-furyl) <sub>3</sub> (10%), PhMe, 60°, overnight, 2. reflux, 3 h	(10)	362	
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (2%), THF, 40-70°, 3 h	(90)	360	
		Pd <sub>2</sub> (dba) <sub>3</sub> (1%), P(2-furyl) <sub>3</sub> (4%), dioxane, 80-100°	(76)	360	
	$\text{AcO}-\text{CH}=\text{CH}-\text{CH}(\text{Ts})-\text{CH}_2-\text{CH}=\text{CH}_2$	$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 1 h	(83)	345
		$\text{Bu}_3\text{Sn}\text{CH}=\text{CH}_2$	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 5-25°, 2-6 h	(50)	347
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), P(2-furyl) <sub>3</sub> (4%), THF, 70°	(38) + (19)	361	

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-COUPLING REACTIONS (Continued)

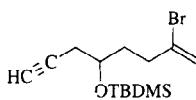
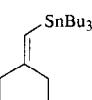
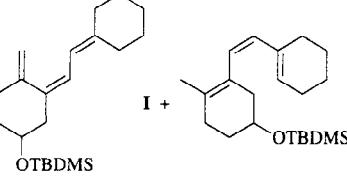
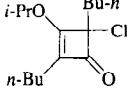
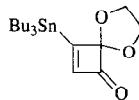
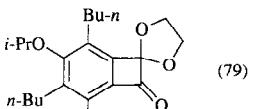
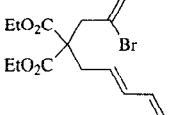
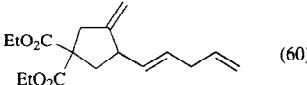
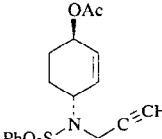
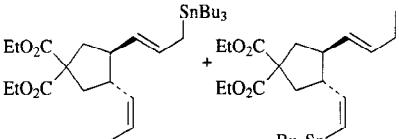
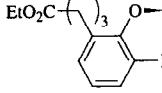
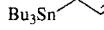
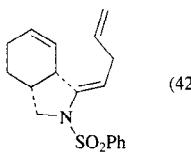
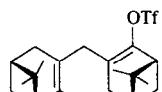
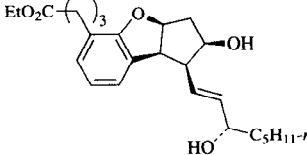
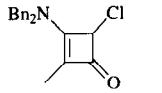
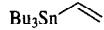
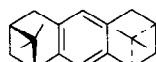
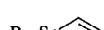
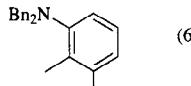
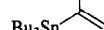
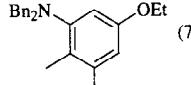
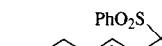
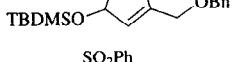
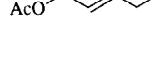
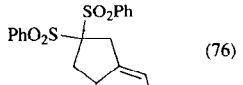
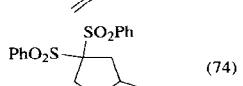
Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), THF, 60°	 I + II (72), I:II = 11:1	354
		Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (2%), P(2-furyl) <sub>3</sub> (4%), THF, 70°	 (79)	361
		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), LiCl, CH <sub>3</sub> CN, 80°, 48 h	 (60)	347
		Pd <sub>2</sub> (dba) <sub>3</sub>	 (96) + Bu <sub>3</sub> Sn	865
		Pd(0) (10%), THF, 60°, 24 h	 (42)	866
		Pd(OAc) <sub>2</sub> (10%), i-Pr <sub>2</sub> NEt, Bu <sub>4</sub> NCl, DMF, 25°, 12 h	 (30)	344
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (4%), NMP, 75°	 (55)	358
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 100°, 6 h	 (62)	359
		Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (5%), P(2-furyl) <sub>3</sub> (10%), dioxane, 100°, 6 h	 (74)	359
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, 70°, 6 h	 (75)	351
		Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 1 h	 (76)	345
		Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 1 h	 (74)	345

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-COUPLING REACTIONS (Continued)

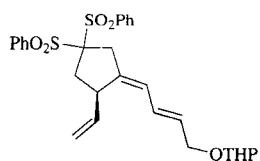
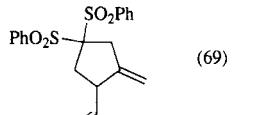
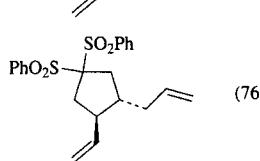
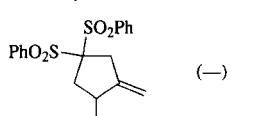
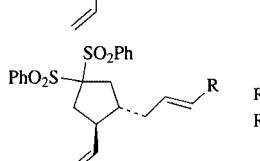
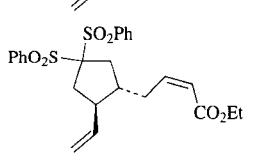
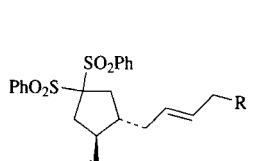
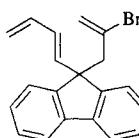
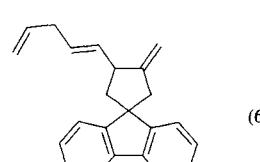
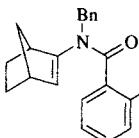
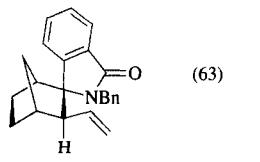
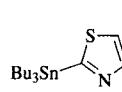
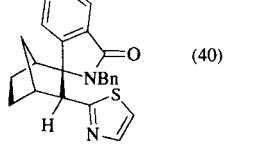
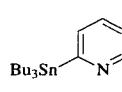
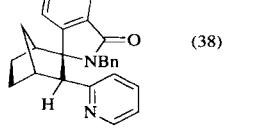
Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.		
<chem>Bu3SnC=C[CH2]O[THP]</chem>	Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 4 h		(61)	345		
<chem>AcO[C]C=C[CH2]C(S(=O)(=O)c1ccccc1)C=C</chem>	<chem>Bu3SnC=C</chem>	Pd(PPh <sub>3</sub> ) <sub>4</sub> (15%), THF, 40°, 6 h		(69)	345	
<chem>AcO[C]C=C[CH2]C(S(=O)(=O)c1ccccc1)C=C</chem>	<chem>Bu3SnC=C</chem>	Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 1 h		(76)	345	
<chem>Bu3SnC=C</chem>	Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 1 h		(—)	345		
<chem>Bu3SnC=C</chem>	Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 2 h		R = CO <sub>2</sub> Et (77) R = TMS (85)	345		
<chem>Bu3SnC=C[CH2]CO2Et</chem>	Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 4 h		(67)	345		
<chem>Bu3SnC=C[CH2]R</chem>	Pd(dba) <sub>2</sub> (10%), P(2-furyl) <sub>3</sub> (30%), ZnCl <sub>2</sub> , THF, reflux, 2 h		R = OTHP (75) R = NHFMOC (65)	345		
<chem>C21</chem>		<chem>Bu3SnC=C</chem>	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), LiCl, CH <sub>3</sub> CN, 80°, 24 h		(60)	347
623		<chem>Bu3SnC=C</chem>	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 80°, 1 h		(63)	347
		<chem>Bu3SnC=C</chem>	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), THF, 60°, 1 h		(40)	347
		<chem>Bu3SnC=C</chem>	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), THF, 60°, 1 h		(38)	347

TABLE XXXII. MULTI-STEP TRANSFORMATIONS INVOLVING DIRECT CROSS-CO尤LING REACTIONS (Continued)

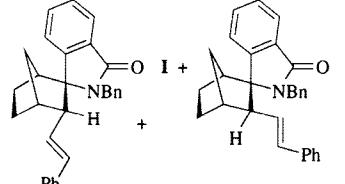
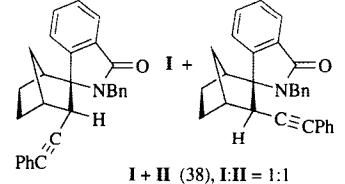
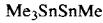
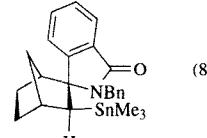
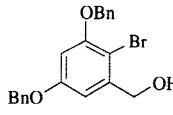
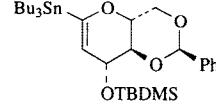
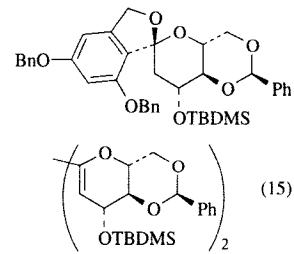
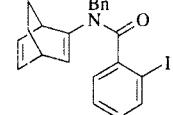
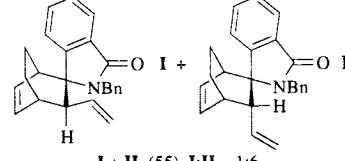
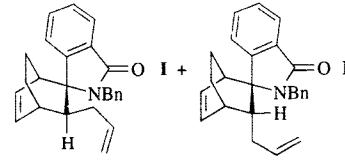
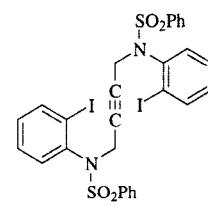
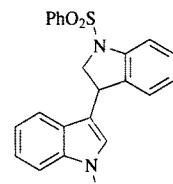
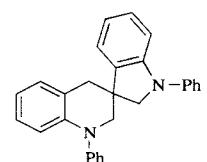
Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), THF, 60°, 1 h	 I + II (46), I:II = 1:8	347
		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), THF, 60°, 1 h	 I + II (38), I:II = 1:1	347
		Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), CH <sub>3</sub> CN, 80°, 1 h	 (80)	347
		Pd(PPh <sub>3</sub> ) <sub>4</sub> (10%), PhMe, reflux, 12 h	 (72) + (15)	297
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, CH <sub>3</sub> CN, 80°, 4.5 h	 I + II (55), I:II = 1:6	347
	Bu <sub>3</sub> SnCH=CH <sub>2</sub>	Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, CH <sub>3</sub> CN, 80°, 4.5 h	 I + II (35), I:II = 1:2	347
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(0), anisole, 100°, 16 h	 (48)	346
	Bu <sub>3</sub> SnSnBu <sub>3</sub>	Pd(0), anisole, 124°, 17 h	 (70)	346

TABLE XXXIII. MULTI-STEP TRANSFORMATIONS INVOLVING CARBONYLATIVE CROSS-COUPLED

Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
C <sub>3</sub> 	Me <sub>3</sub> SnR + Na—	1. Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (83%), THF, rt 2. malonate, Et <sub>3</sub> N, -78° to -60°, 2 h 3. CO (15 psi), -30°, 2 h 4. stannane, -30° to rt, 15-18 h	MeO <sub>2</sub> C—CH(CO <sub>2</sub> Me)—CH(CO <sub>2</sub> Me)—C(=O)R (73) (63) (75) (65)	339
C <sub>8</sub> 	Bu <sub>3</sub> SnR 	CO (45 psi), BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), dioxane, 50-100°, 16 h	Et—C(=O)cyclohex-2-en-1-yl—OR (60) (65) stereochemistry not determined (80) (63) (84) (80)	363
i-PrO—C(=O)cyclobut-1-en-1-one	Bu <sub>3</sub> Sn—	CO (45 psi), BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), dioxane, 50-100°, 16 h	i-PrO—C(=O)cyclohex-2-en-1-yl—OR X = O (89) X = S (74)	363
Bu <sub>3</sub> SnPh		CO (45 psi), BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), dioxane, 50-100°, 16 h	i-PrO—C(=O)cyclohex-2-en-1-yl—Ph (60)	363
Bu <sub>3</sub> Sn—		CO (45 psi), BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), dioxane, 50-100°, 16 h	i-PrO—C(=O)cyclohex-2-en-1-yl—OMe (62)	363
C <sub>10</sub> 	Me <sub>3</sub> SnR + Na—	1. Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (89%), malonate, Et <sub>3</sub> N, THF, -78°, 2 h 2. CO (15 psi), -20°, 2 h 3. stannane, -20° to rt, 15-18 h	MeO <sub>2</sub> C—CH(CO <sub>2</sub> Me)—CH(CO <sub>2</sub> Me)—CH(CO <sub>2</sub> Me)—NHCO <sub>2</sub> Bn—R (79) (69) (74) (59) (62) (77) (59) (95) (93) (72)	339
	Me <sub>3</sub> Sn—	1. Pd(CH <sub>3</sub> CN) <sub>2</sub> Cl <sub>2</sub> (89%), malonate, Et <sub>3</sub> N, THF, -78°, 2 h 2. CO (15 psi), -20°, 2 h 3. stannane, -20° to rt, 15-18 h	MeO <sub>2</sub> C—CH(CO <sub>2</sub> Me)—CH(CO <sub>2</sub> Me)—CH(CO <sub>2</sub> Me)—NHCO <sub>2</sub> Bn—Bu-t (70)	339

TABLE XXXIII. MULTI-STEP TRANSFORMATIONS INVOLVING CARBONYLATIVE CROSS-COUPLING (*Continued*)

Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
	$\text{Bu}_3\text{SnR}$  $\text{R}$ 2-furyl 2-pyridyl (E)-CH=CHPh	CO, $\text{Pd}(\text{OAc})_2$ (10%), $\text{PPh}_3$ (20%), $\text{Et}_4\text{NCl}$ , PhMe, 100°, 15 h	 (88) (83) (61)	355
		CO, $\text{Pd}(\text{OAc})_2$ (10%), $\text{PPh}_3$ (20%), $\text{Et}_4\text{NCl}$ , PhMe, 100°, 15 h		355
	$\text{Me}_3\text{Sn}\text{CH}=\text{CH}_2 + \text{Na}-\text{CO}_2\text{Me}$	1. $\text{Pd}(\text{PhCN})_2\text{Cl}_2$ (71%), rt 2. malonate, $\text{Et}_3\text{N}$ , 2.5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15-18 h		339
	$\text{Me}_3\text{Sn}\text{CH}=\text{CH}_2 + \text{Na}-\text{CO}_2\text{Me}$	1. $\text{Pd}(\text{PhCN})_2\text{Cl}_2$ (71%), rt 2. malonate, $\text{Et}_3\text{N}$ , 2.5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15-18 h		339
	$\text{Me}_3\text{SnCH}=\text{CH}_2 + \text{Na}-\text{CO}_2\text{Me}$	1. $\text{Pd}(\text{PhCN})_2\text{Cl}_2$ (71%), rt 2. malonate, $\text{Et}_3\text{N}$ , 2.5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15-18 h		339
	$\text{Me}_3\text{SnCH}=\text{CH}_2 + \text{Na}-\text{CO}_2\text{Me}$	1. $\text{Pd}(\text{PhCN})_2\text{Cl}_2$ (71%), rt 2. malonate, $\text{Et}_3\text{N}$ , 2.5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15-18 h		339
	$\text{Me}_3\text{SnC}\equiv\text{CPh} + \text{Na}-\text{CO}_2\text{Me}$	1. $\text{Pd}(\text{PhCN})_2\text{Cl}_2$ (71%), rt 2. malonate, $\text{Et}_3\text{N}$ , 2.5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15-18 h		339
	$\text{Me}_3\text{SnC}\equiv\text{CPh} + \text{Na}-\text{CO}_2\text{Me}$	1. $\text{Pd}(\text{PhCN})_2\text{Cl}_2$ (71%), rt 2. malonate, $\text{Et}_3\text{N}$ , 2.5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15-18 h		339
	$\text{Bu}_3\text{SnPh}$	CO (45 psi), $\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (5%), dioxane, 50-100°, 16 h		363
		CO (45 psi), $\text{BnPd}(\text{PPh}_3)_2\text{Cl}$ (5%), dioxane, 50-100°, 16 h		363

TABLE XXXIII. MULTI-STEP TRANSFORMATIONS INVOLVING CARBONYLATIVE CROSS-COUPING (Continued)

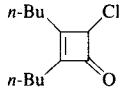
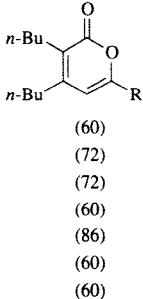
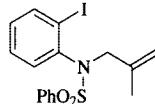
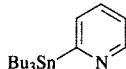
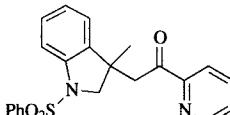
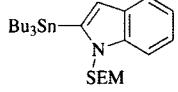
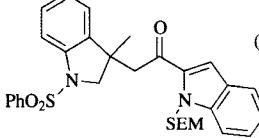
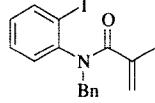
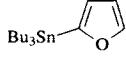
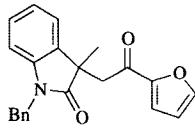
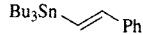
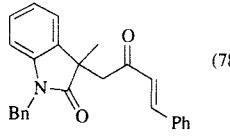
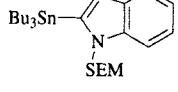
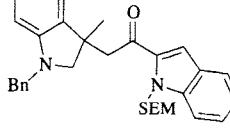
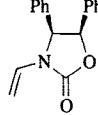
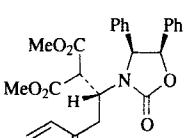
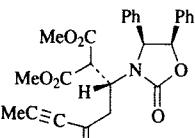
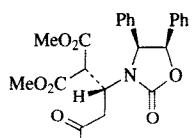
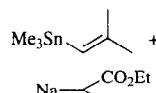
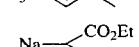
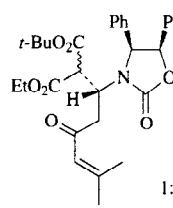
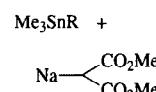
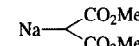
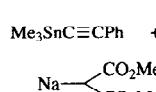
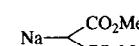
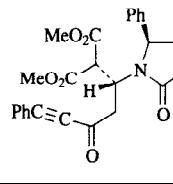
Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.	
C <sub>12</sub>		Bu <sub>3</sub> SnR R C(OEt)=CH <sub>2</sub> 3-furyl 2-thienyl 2-N-methylpyrrolyl Ph C <sub>6</sub> H <sub>4</sub> Cl- <i>p</i> C <sub>6</sub> H <sub>4</sub> OMe- <i>p</i>	CO (45 psi), BnPd(PPh <sub>3</sub> ) <sub>2</sub> Cl (5%), dioxane, 50–100°, 16 h	 (60) (72) (72) (60) (86) (60) (60)	363
C <sub>16</sub>			CO, Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, PhMe, 100°, 15 h	 (71)	355
			CO, Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, PhMe, 100°, 15 h	 (71)	355
C <sub>17</sub>			CO, Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, PhMe, 100°, 15 h	 (87)	355
		CO, Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, PhMe, 100°, 15 h	 (78)	355	
		CO, Pd(OAc) <sub>2</sub> (10%), PPh <sub>3</sub> (20%), Et <sub>4</sub> NCl, PhMe, 100°, 15 h	 (61)	355	
631		Me <sub>3</sub> SnC≡CMe + Na—CO <sub>2</sub> Me	1. Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (71%), rt 2. malonate, Et <sub>3</sub> N, -78°, 5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15–18 h	 (88)	339
	Me <sub>3</sub> SnC≡CMe + Na—CO <sub>2</sub> Me	1. Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (71%), rt 2. malonate, Et <sub>3</sub> N, -78°, 5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15–18 h	 (71)	339	
	Me <sub>3</sub> SnC≡CMe + Na—CO <sub>2</sub> Me	1. Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (71%), rt 2. malonate, Et <sub>3</sub> N, -78°, 5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15–18 h	 (70)	339	

TABLE XXXIII. MULTI-STEP TRANSFORMATIONS INVOLVING CARBONYLATIVE CROSS-COUPLING (*Continued*)

Substrate	Stannane and Other Components	Conditions	Product(s) and Yield(s) (%)	Refs.
				
				
		1. Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (71%), rt 2. malonate, Et <sub>3</sub> N, -78°, 5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15-18 h	 (68-77) 1:1 diastereomers	339
				
				
R				
2-furyl			(65)	
2-thienyl			(68)	
Ph			(37)	
C <sub>6</sub> H <sub>4</sub> Cl- <i>p</i>			(25)	
C <sub>6</sub> H <sub>4</sub> Me- <i>p</i>			(69)	
				
				
		1. Pd(PhCN) <sub>2</sub> Cl <sub>2</sub> (71%), rt 2. malonate, Et <sub>3</sub> N, -78°, 5 h 3. CO (15 psi), -78 to -20° 4. stannane, -20° to rt, 15-18 h	 (90)	339

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