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AN EFFICIENT ROUTE TO HETEROARENE-SUBSTITUTED VINYL- AND ALLYL-SILANES VIA PALLADIUM-PHOSPHINE COMPLEX CATALYZED CROSS-COUPLING

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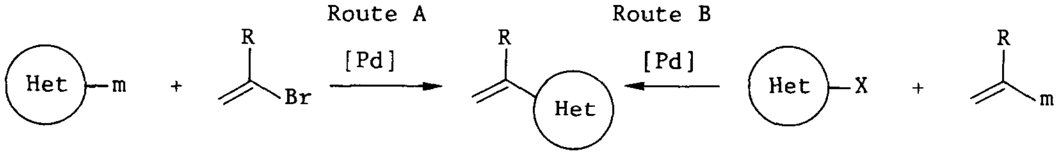
Summary: Heteroarene-substituted vinyl- and allyl-silanes were obtained in good yields by the cross-coupling reaction of either heteroaryl Grignard reagents with halovinyl- and haloallyl-silanes or, alternatively, silyl- and silylmethyl-substituted vinylmetallic reagents with heteroaryl halides in the presence of $PdCl_2$(dppb) as a catalyst.

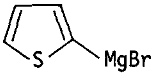
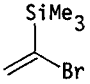
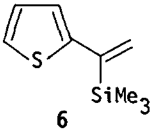
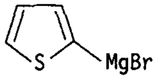
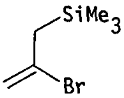
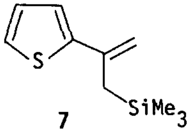
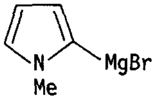
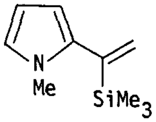
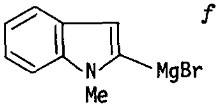
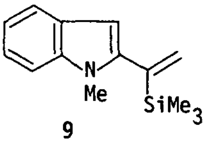
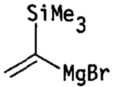
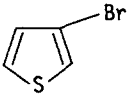
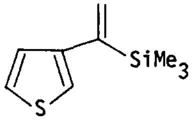
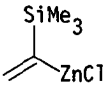
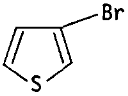
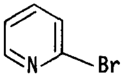
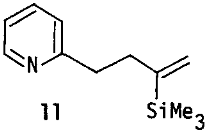
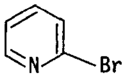
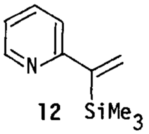
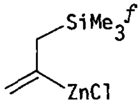
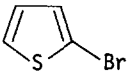
Although the importance of vinylsilanes and allylsilanes as versatile precursors in organic synthesis has been well recongnized in recent years,[1] little is known about the heteroarene-substituted vinyl- and allyl-silanes for lack of general synthetic methods. As part of our study on the transition metal complex catalyzed selective introduction of organic groups onto heteroarene nuclei,[2] we report here a general and practical method for the preparation of such a sort of compounds via palladium-phosphine complex catalyzed cross-coupling reaction of either heteroaryl-metallic reagents with halovinyl- and haloallyl-silanes (route A) or silyl- and silylmethyl-substituted vinylmetallic reagents with heterocyclic halides (route B) (see Scheme 1).

Scheme 1



R = Me_3Si- or Me_3SiCH_2-
m = MgBr or ZnCl

Table 1. Palladium-Complex Catalyzed Synthesis of Heteroarene Substituted Vinyl- and Allyl-silanes[a]

entry	organometallics	halide	conditions[b]	product	yield (%)[c]
1		 **1**	ether, 2 h	 **6**	81[d]
2		 **2**	ether, 1 h	 **7**	78[e]
3	 [f]	**1**	THF, 1 h	 **8**	74
4	 [f]	**1**	THF, 1 h	 **9**	87
5	 **3**		THF, 19 h	 **10**	60[g]
6	 [f] **4**		THF, 17 h	**10**	72
7	**3**[h]		THF, 2 h[i]	 **11**	77
8	**4**		THF, 2 h	 **12**	70
9	 [f] **5**		THF, 2 h	**7**	66

(continued)

Table 1 (continued).

[a] Molar ratio: organometallics / halide / $PdCl_2$(dppb) = 1.2-1.8 / 1 / 0.005-0.01. dppb = $Ph_2P(CH_2)_4PPh_2$. [b] All reactions were carried out under solvent reflux conditions. [c] Yields were determined by GLC, unless otherwise stated. [d] Isolated yield. [e] Double bond isomers, 2-thienyl-$C(CH_3)=CHSiMe_3$, were formed in up to 9% yield. [f] Prepared by treatment of the lithium reagent with $MgBr_2$ or $ZnCl_2$. [g] 3,3'-Bithienyl was also formed in 14% yield. [h] Used in fourfold excess. [i] At r.t. for 1 h and then reflux for 1 h.

The representative results are listed in Table 1. Via route A, α-bromovinyltrimethylsilane 1[3] was allowed to react with 2-thienyl, 1-methyl-2-pyrrolyl,[4] and 1-methyl-2-indolyl[4] Grignard reagents in the presence of a catalytic amount of $PdCl_2$(dppb), dppb = $Ph_2P(CH_2)_4PPh_2$, to afford the corresponding silyl-substituted vinylheterocycles 6, 8, and 9, respectively, in good yields (entries 1, 3, and 4). Similarly, 2-bromo-3-(trimethylsilyl)propene 2[5] reacted with 2-thienylmagnesium bromide to give the coupling product 7, along with a small amount of double bond isomer (entry 2).

In the alternative route B, 3-bromothiophene was coupled with α-silylvinylmagnesium bromide 3[3] or -zinc chloride 4.[6] The zinc reagent afforded more satisfactory results with respect to the selectivity and product yield (entry 6) than the Grignard reagent 3, with which a considerable amount of 3,3'-bithienyl, homocoupling product of 3, was formed as a by-product (entry 5). Also, in the coupling with 2-bromopyridine, the vinylic zinc reagent 4 gave the corresponding silyl-substituted vinylpyridine 12 effectively (entry 8), whereas the vinylic Grignard reagent 3 afforded an unexpected result: the use of about fourfold excess of 3 gave rise to the exclusive formation of 2-(3-trimethylsilyl-3-butenyl)pyridine **11**, which probably arose from conjugate addition of 3 to the initially formed coupling product 12 followed by cleavage of the silyl group α to the pyridine ring[7] during work-up.[8] Coupling of the homologous vinylzinc reagent 5 with 2-bromothiophene afforded 7 very cleanly (entry 9), not contaminated with the double bond isomer (cf., entry 2).

Although route B gave slightly lower yields of the coupling products than route A, it still seems to have more synthetically useful features: it can introduce (1) silylfunctionalyzed vinyl groups regioselectively even onto heteroarenes whose metallic reagents are relatively unstable[9] (entry 6), and (2) allylsilane moieties onto heteroarenes with no contamination of isomerization product (entry 9).

We have presented here the first, efficient method for the preparation of otherwise hardly accessible heteroarene substituted vinyl- and allylsilanes.

A typical procedure is as follows. To a mixture of 1 (533 mg; 3.0 mmol), $PdCl_2$(dppb) (10 mg; 0.016 mmol), and dry ether (15 ml) was added an ethereal solution of 2-thienylmagnesium bromide (2.8 ml; 3.8 mmol) at 0°C under an argon atmosphere. The mixture was refluxed for 2 h, hydrolyzed, and extracted with ether three times. After drying over $MgSO_4$, the solvent was removed. Bulb-to-bulb distillation of the residue gave 441 mg (81% yield) of **6** (97% purity by GLC): b.p. 110-120°C/3 mmHg (bath temperature); n_D^{20} 1.5342; ^1H NMR (CCl_4, cyclohexane) δ 0.24 (s, 9H), 5.41 (d, J = 2 Hz, 1H), 5.94 (d, J = 2 Hz, 1H), 6.81-6.97 (m, 2H), 6.97-7.17 (m, 1H). Anal Calcd for $C_9H_{14}SSi$: C, 59.28; H, 7.74. Found: C, 58.99; H, 7.71%.[10]

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REFERENCES AND NOTES

(1) (a) T. H. Chan and I. Fleming, *Synthesis*, 761 (1979). (b) E. W. Colvin, "Silicon in Organic Synthesis", Butterworths, London (1981). (c) W. P. Weber, "Silicon Reagents for Organic Synthesis", Springer-Verlag, Berlin, Heidelberg (1983).

(2) (a) A. Minato, K. Tamao, T. Hayashi, K. Suzuki, and M. Kumada, *Tetrahedron Lett.*, 21, 845 (1980). (b) A. Minato, K. Tamao, K. Suzuki, and M. Kumada, *ibid.*, **21**, 4017 (1980). (c) A. Minato, K. Tamao, T. Hayashi, K. Suzuki, and M. Kumada, *ibid.*, 22, 5319 (1981). (d) K. Tamao, S. Kodama, I. Nakajima, M. Kumada, A. Minato, and K. Suzuki, *Tetrahedron*, 38, 3347 (1982).

(3) (a) T. H. Chan, W. Mychajlowskij, B. S. Ong, and D. N. Harpp, *J. Org. Chem.*, 43, 1526 (1978). (b) R. K. Boeckman, Jr. and K. J. Bruza, *ibid.*, 44, 4781 (1979). (c) C. Huynh and G. Linstrumelle, *Tetrahedron Lett.*, 1073 (1979).

(4) These Grignard reagents were prepared by treatment of the lithio derivatives with magnesium bromide (ref. 2c).

(5) H. Nishiyama, H. Yokoyama, S. Narimatsu, and K. Itoh, *Tetrahedron Lett.*, 23, 1267 (1982). We thank these authors for the experimental details of the preparation of bromide **2**.

(6) Palladium complex catalyzed cross-coupling reaction of organozinc reagents: E. Negishi, *Acc. Chem. Res.*, **15**, 340 (1982) and references cited therein. See also refs. 2a-2c.

(7) T. Kondo, K. Yamamoto, and M. Kumada, *J. Organomet. Chem.*, **35**, C30 (1972).

(8) The use of one equivalent of Grignard reagent **3** gave a mixture of **12**, unchanged halide, and unknown unstable product, together with a trace amount of **11**.

(9) (a) T. Frejd, J. O. Karlsson, and S. Gronowitz, *J. Org. Chem.*, **46**, 3132 (1981). (b) S. Gronowitz and T. Frejd, *Acta Chem. Scand.*, Ser. B30, 485 (1976).

(10) All products have been fully characterized.

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