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Preparation of novel β,β-diphenyl α-(trifluoromethyl)vinylstannane and its cross-coupling reactions with aryl iodides

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Abstract

β,β-Diphenyl-α-(trifluoromethyl)vinylstannane **6** was prepared in good yield via several steps from 2,3,3,3-tetrafluoro-1-phenyl-1-phenylthiopropene. The cross-coupling reactions of **6** with aryl iodides in the presence of a catalytic amount of $Pd(PPh_3)_4$ and CuI provided trifluoromethylated triphenylethene derivatives **7** in high yields. © 2000 Elsevier Science Ltd. All rights reserved.

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The introduction of a trifluoromethyl (CF_3) functionality into organic molecules is an important subject in organofluorine chemistry because some of the resultant compounds exhibit unique properties in the areas of agrochemicals, pharmaceuticals and material science.[1] Although direct trifluoromethylation[2] and halogen-exchange reaction[3] have been widely utilized to construct trifluoromethylated compounds, a promise alternative approach is to use trifluoromethylated building blocks.[4] Of particular interests in this conjunction is β,β-diphenyl α-(trifluoromethyl)vinylstannane, which is a quite useful building block for the synthesis of trifluoromethylated triphenylethene derivatives. It has been well known that triphenylethene unit[5] is the important framework of many nonsteroidal antiestrogens which exhibit mammary tumor inhibiting properties via binding to the estrogen receptor. In particular, trifluoromethyl-analogs have received much attention in recent years because of enhancement of biological property.[6] Although α-(trifluoromethyl)vinylmetal reagents bearing proton, fluorine or ethoxy groups at β-position have been synthesized via previous methods, however, methodology for the preparation of α-(trifluoromethyl)vinylmetal reagents bearing two phenyl groups at β-position has not been exploited previously. Generally, α-(trifluoromethyl)vinyllithium reagents[7] are quite

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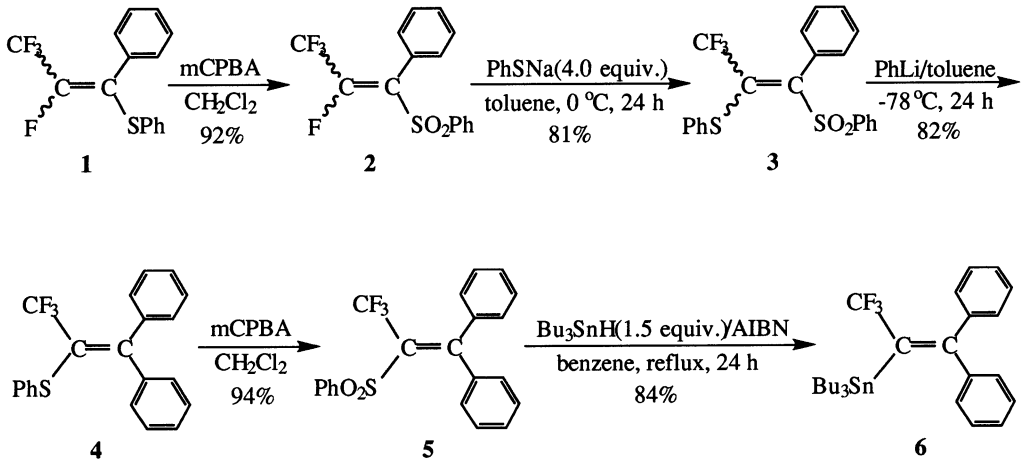
unstable even at low temperature, in which difluoroallene was formed via defluorination of α-(trifluoromethyl)vinyllithium. However, β,β-difluoro-α-(trifluoromethyl)vinyllithium[8] can be prepared from the reaction of 2-hydropentafluoropropene with LDA or *t*-BuLi at −78°C. Jiang prepared a stable α-(trifluoromethyl)vinylzinc reagent[9] from the reaction of 2-bromotrifluoropropene with Zn(Ag) in the presence of TMEDA. The coupling reactions of α-(trifluoromethyl)-vinylzinc reagent with aryl and vinyl halides have been quite successful,[9,10] but α-(trifluoromethyl)vinylzinc reagent failed to react with acyl chlorides in the presence of palladium catalyst.[9] α-(Trifluoromethyl)vinylzinc reagents bearing fluorine[11] or ethoxy group[12] at β-position were also prepared in a similar manner and their coupling reactions with aryl halides afforded the corresponding α-trifluoromethylated compounds. Recently, α-(trifluoromethyl)vinylstannane reagents bearing only hydrogens at β-position have been prepared from the reaction of 2-bromotrifluoroisopropene with lithium tributylstannate in the presence of CuI and utilized for the cross-coupling with acyl halides to give α-(trifluoromethyl)vinyl ketones.[13] However, there is no report on the coupling reaction of α-(trifluoromethyl)vinylstannane with aryl halides. Thus, we wish to describe a new and efficient method for the preparation of novel β,β-diphenyl-α-(trifluoromethyl)vinylstannane reagent and cross coupling reactions with aryl iodides to give trifluoromethylated triphenylethene derivatives in this communication.

A novel starting material, β,β-diphenyl-α-(trifluoromethyl)vinylstannane reagent, was prepared via several steps from 2,3,3,3-tetrafluoro-1-phenyl-1-phenylthiopropene (**1**).[14] Oxidation of **1** with mCPBA (2.5 equiv.) in CH_2Cl_2 at reflux temperature for 24 hours afforded 2,3,3,3-tetrafluoro-1-phenyl-1-phenylsulfonylpropene (**2**)[15] in 92% yield. Treatment of **2** with sodium thiophenoxide (4 equiv.) in toluene at 0°C for 24 hours resulted in the formation of 3,3,3-trifluoro-1-phenyl-1-phenylsulfonyl-2-phenylthiopropene (**3**)[15] in 81% yield. The choice of solvent and reaction temperature are quite important to give **3** in this reaction. The use of solvents, such as THF, CH_3CN or DMF, or elevated reaction temperature caused the formation of a significant amount of 1,2-bis(phenylthio)-3,3,3-trifluoro-1-phenylpropene. When **3** was reacted with phenyllithium (1.5 equiv.) in toluene at −78°C for 24 hours, 3,3,3-trifluoro-1,1-diphenyl-2-phenylthiopropene (**4**)[15] was obtained in 82% yield. Oxidation of **4** with mCPBA (2.5 equiv.) in CH_2Cl_2 at reflux temperature for 24 hours provided 3,3,3-trifluoro-1,1-diphenyl-2-phenylsulfonylpropene (**5**)[15] in 94% yield. Finally, β,β-diphenyl-α-(trifluoromethyl)vinylstannane (**6**)[15] reagent can be obtained in 84% yield by treatment of **5** with Bu_3SnH (1.5 equiv.)/AIBN (10 mol%) in benzene at reflux temperature for 24 hours. The reducing product, 3,3,3-trifluoro-1,1-diphenylpropene, was obtained in less than 5% yield (Scheme 1).

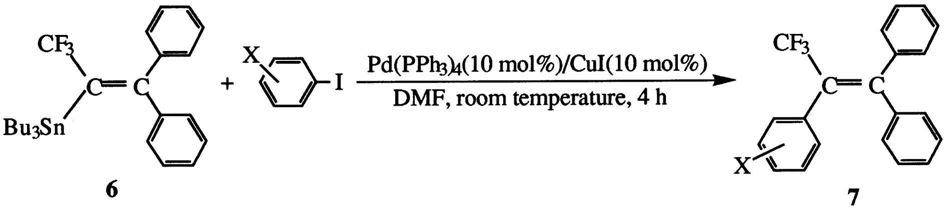
Since the vinylstannane group is an excellent functionality for carbon–carbon bond formation with electrophiles in the presence of palladium catalyst,[16] we examined the reaction of **6** with aryl iodides bearing a substituent on benzene ring in the presence of several palladium catalysts. The use of a Pd catalyst such as $Pd(PPh_3)_4$ or $Pd(PPh_3)_2Cl_2$ in THF, DMF, toluene or HMPA did not provide any cross-coupling product. However, the cross-coupling reaction was well proceeded by using a mixture of 10 mol% $Pd(PPh_3)_4$ and 10 mol% CuI in DMF. The reaction was completed in 4 hours at room temperature. Aryl bromides did not provide a cross-coupling adduct even at 80°C. Therefore, aryl iodides bearing a bromo, methoxy, methyl, nitro or trifluoromethyl on *para*- or *meta*-position of benzene ring underwent the cross-coupling reaction with **6** in the presence of 10 mol% $Pd(PPh_3)_4$ and 10 mol% CuI in DMF at room temperature for 4 hours, and the corresponding coupling products were obtained in high yields. Unfortunately, the coupling product, formed from the reaction of **6** with aryl iodides bearing a methoxy



Scheme 1.

or methyl on *ortho*-position of benzene ring, was obtained in less than 5% yield under the same reaction conditions, whereas a reducing product and dimerization product (butadiene) were formed as major products. The heating of the reaction mixture at 80°C resulted in the formation of a messy reaction mixture. The experimental results are summarized in Table 1.

Table 1
The cross-coupling reactions of **6** with aryl iodides



Compound no.	X	Yield (%)[a]
7a	H	93
7b	p-Br	86
7c	p-OCH$_3$	89
7d	p-CH$_3$	88
7e	p-NO$_2$	93
7f	p-CF$_3$	90
7g	m-Br	88
7h	m-OCH$_3$	80
7i	m-CH$_3$	81
7j	m-NO$_2$	82
7k	m-CF$_3$	85
7l	o-CH$_3$	<5
7m	o-OCH$_3$	<5

[a] Isolated yields.

A typical reaction procedure for the preparation of **7c** is as follows. To a DMF (5 ml) solution of *p*-iodoanisole (0.066 g, 0.28 mmol) and β,β-diphenyl-α-(trifluoromethyl)vinylstannane (0.118 g, 0.22 mmol) was added $Pd(PPh_3)_4$ (10 mol%) and CuI (10 mol%), and the reaction mixture was stirred at room temperature for 4 hours under an argon atmosphere. After the reaction mixture was quenched with water and then washed with 5% KF solution and brine, the solution was extracted with ether twice. The ether solution was dried and chromatographed on a SiO_2 column. Elution with a mixture of hexane and ethyl acetate (20:1) provided 0.069 g of 3,3,3-trifluoro-2-(4′-methoxy)phenyl-1,1-diphenylpropene **7c** in 89% yield. Compound **7c**: mp 67–68°C; ^{1}H NMR ($CDCl_3$) δ 7.84–6.69 (m, 14H), 3.75 (s, 3H); ^{19}F NMR ($CDCl_3$) δ −56.47 (s, 3F); MS, *m/z* (relative intensity) 354 (M^+, 100), 285(7), 270(11), 241(8), 165(5), 126(3), 120(3), 51(3); IR (KBr) 3058, 2926, 2853, 1733, 1661, 1608, 1511, 1445, 1328, 1250, 1226, 1170, 1111, 1033, 983, 824, 757, 701, 640 cm^{-1}.

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References

1. (a) Welch. J. T.; Eswarakrishnan, S. In *Fluorine in Bioorganic Chemistry*; John Wiley & Sons: New York, 1991. (b) *Organofluorine Chemistry—Principle and Commercial Applications*; Bank, R. E.; Smart, B. E.; Tatlow, J. C., Eds.; Plenum: New York, 1994.
2. (a) McClinton, M. A.; McClinton, D. A. *Tetrahedron* **1992**, *48*, 6555–6666. (b) Prakash, G. K. S.; Yudin, A. K. *Chem. Rev.* **1997**, *97*, 757–786. (c) Singh, R. P.; Kirchmeier, R. L.; Shreeve, J. M. *J. Org. Chem.* **1999**, *64*, 2579–2581.
3. (a) Bloodworth, A. J.; Bowyer, K. J.; Mitchell, J. C. *Tetrahedron Lett.* **1987**, *28*, 5347–5350. (b) Riera, J.; Castaner, J.; Carilla, J.; Robert, A. *Tetrahedron Lett.* **1989**, *30*, 3825–3828. (c) Castaner, J.; Riera, J.; Carilla, J.; Robert, A.; Molins, E.; Miravitlles, C. *J. Org. Chem.* **1991**, *56*, 103–110.
4. (a) Derstine, C. W.; Smith, D. N.; Katzenellenbogen, J. A. *J. Am. Chem. Soc.* **1996**, *118*, 8485–8486. (b) Qing, F. L.; Zhang, Y. *Tetrahedron Lett.* **1997**, *38*, 6729–6732. (c) Komatsu, Y.; Sakamoto, T.; Kitazume, T. *J. Org. Chem.* **1999**, *64*, 8369–8374.
5. Desombre, E. R.; Mease, R. C.; Sanghavi, J.; Singh, T.; Seevers, R. H.; Hughes, A. *J. Steroid Biochem.* **1988**, *29*, 583–590.
6. Nemeth, G.; Dezsofi, R. K.; Lax, G.; Simig, G. *Tetrahedron* **1996**, *52*, 12821–12830.
7. Drakesmith, F. G.; Stewart, O. J.; Tarrant, P. *J. Org. Chem.* **1967**, *33*, 280–285.
8. Morken, P. A.; Lu, H.; Nakamura, A.; Burton, D. J. *Tetrahedron Lett.* **1991**, *32*, 4271–4274.
9. Jiang, B.; Xu, Y. *J. Org. Chem.* **1991**, *56*, 7336–7340.
10. Jiang, B.; Xu, Y. *Tetrahedron Lett.* **1992**, *33*, 511–514.
11. Morken, P. A.; Burton, D. J. *J. Org. Chem.* **1993**, *58*, 1167–1172.
12. Shi, G.-Q.; Huang, X.-H.; Hong, F. *J. Org. Chem.* **1996**, *61*, 3200–3204.
13. (a) Xu, Y.; Jin, F.; Huang, W. *J. Org. Chem.* **1994**, *59*, 2633–2641. (b) Ichikawa, J.; Fujiwara, M.; Okauchi, T.; Minami, T. *Synlett* **1999**, 927–929.
14. Jeong, I. H.; Min, Y. K.; Kim, Y. S.; Kim, B. T.; Cho, K. Y. *Tetrahedron Lett.* **1994**, *35*, 7783–7784.
15. Compound **2**: mp 104–106°C; ^{1}H NMR ($CDCl_3$) δ 7.65–7.01 (m, 10H); ^{19}F NMR ($CDCl_3$) δ −62.49 (d, $J=4.2$ Hz, 3F, one isomer), −66.25 (d, $J=4.2$ Hz, 3F, other isomer), −102.16 (q, $J=4.2$ Hz, 1F, one isomer), −108.77 (q, $J=4.2$ Hz, 1F, other isomer); MS, *m/z* (relative intensity) 330 (M+, 48), 266(5), 189(53), 169(100), 125(52), 77(47), 51(33); IR (KBr) 3065, 1652, 1447, 1347, 1306, 1196, 1156, 1118, 1088, 761, 696, 605 cm^{-1}. Compound **3**: mp 94–96°C; ^{1}H NMR ($CDCl_3$) δ 7.90–6.85 (m, 15H); ^{19}F NMR ($CDCl_3$) δ −53.58 (s, 3F, one isomer), −54.50

(s, 3F, other isomer); MS, *m*/*z* (relative intensity) 420 (M^+, 17), 239(100), 210(78), 186(67), 109(77), 77(72), 65(42), 51(38); IR (KBr) 3061, 2962, 2924, 1726, 1581, 1476, 1445, 1326, 1260, 1146, 1084, 1024, 811, 753, 727, 689, 575 cm^{-1}. Compound **4**: mp 68–70°C; ^1H NMR ($CDCl_3$) δ 7.37–7.02 (m, 15H); ^{19}F NMR ($CDCl_3$) δ −56.22 (s, 3F); MS, *m*/*z* (relative intensity) 356 (M+, 100), 287(52), 254(19), 239(25), 227(25), 210(27), 178(30), 165(34), 152(10), 109(8), 77(23); IR (KBr) 3059, 2926, 2854, 1582, 1491, 1443, 1293, 1253, 1184, 1147, 1122, 1033, 991, 742, 699, 637 cm^{-1}. Compound **5**: mp 111–113°C; ^1H NMR ($CDCl_3$) δ 7.60–6.97 (m, 15H); ^{19}F NMR ($CDCl_3$) δ −52.14 (s, 3F); MS, *m*/*z* (relative intensity) 388 (M^+, 10), 246(100), 227(48), 178(25), 165(10), 125(17), 77(57), 51(34); IR (KBr) 3062, 3030, 1583, 1449, 1323, 1294, 1247, 1192, 1154, 1083, 998, 759, 735, 687, 580 cm^{-1}. Compound **6**: oil; ^1H NMR ($CDCl_3$) δ 7.34–7.12 (m, 10H), 1.53–0.59 (m, 27H); ^{19}F NMR ($CDCl_3$) δ −49.47 (s, 3F); MS, *m*/*z* (relative intensity) 481 (M^+−56, 4), 210(16), 209(100), 207(12), 189(11), 183(9), 177(5), 139(3), 57(6); IR (KBr) 3058, 3025, 2957, 2924, 2854, 2362, 2342, 1491, 1445, 1243, 1170, 1126, 1074, 764, 699 cm^{-1}.

16. Stille, J. K. *Pure Appl. Chem.* **1985**, *57*, 1771–1780.