

Preparation of 1,3-Diarylpropenes by Phosphine-Free Palladium(0)-Catalyzed Suzuki-Type Coupling of Allyl Bromides with Arylboronic Acids

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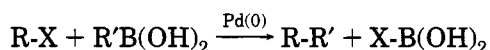
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1,3-Diarylpropenes **3** featuring different substituents at the aryl rings are obtained in high yields by a modified Suzuki coupling between cinnamyl bromides and arylboronic acids using the phosphine-free Pd(dba)_n (*n* = 1.5–2) as catalyst, in benzene and in the presence of suspended potassium carbonate.

Introduction

Palladium-catalyzed cross-coupling is a versatile synthetic method for making C–C bonds between a formal electrophile C–X (X mainly Br, I, OTf) and an organometallic C–M (M mainly Mg, Zn, Sn, and B).¹ The boron variant (Suzuki coupling) has met with a certain degree of popularity since it tolerates the presence of electrophilic functional groups, many boron compounds are stable (e.g. several arylboronic acids became recently commercially available), the inorganic product of the reaction can be easily eliminated, and the reaction conditions tolerate aqueous media, which renders elimination of the inorganic part even more easy.² Although the Suzuki method was initially used for C(sp²)–C(sp²) couplings,³ recently it was extended to accommodate carbon atoms in other hybridizations such as sp³.⁴ A recent major improvement of the Suzuki coupling is the introduction of phosphine-free catalytic systems.⁵ The report of one such system^{5b} prompts us to report our results in this field.



Results and Discussion

In the course of a research project we required 1,3-diarylpropenes of general formula **3** (See Scheme 1) with different substituents at the benzene rings. Different methods have been used to prepare this type of compounds as indicated in the references of Table 1. In particular, compounds **3a,b** have been prepared by a nickel-catalyzed cross-coupling of allyl alcohols with Grignard reagents requiring 2 equiv of the Grignard

Scheme 1

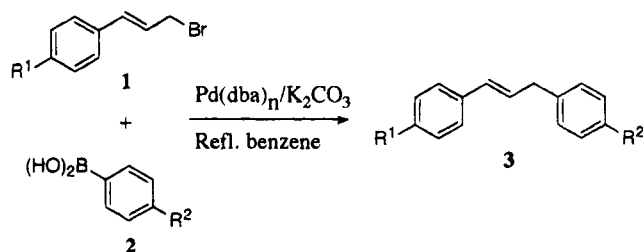


Table 1. Data for Compounds **3**

3	R ¹	R ²	yield(%) ^a	mp (°C)	lit.
3a	H	H	72	oil	ref 6
3b	H	OMe	58	oil	ref 6
3c	H	Cl	78	oil	ref 7
3d	Cl	H	77	oil	ref 7
3e	H	Br	87	oil	ref 8 ^b
3f	Br	H	91	oil	ref 8 ^b
3g	Cl	Cl	78	56–58	ref 9 ^c
3h	Cl	Br	73	59–62	<i>d</i>
3i	Cl	OMe	83	oil	<i>e</i>

^a Isolated yields. ^b Reference 8 reports the preparation of **3e** and **3f** as a mixture. ^c Mp 60 °C. ^d Required for C₁₅H₁₂BrCl: C, 58.57; H, 3.90. Found: C, 58.45 and 58.52; H, 3.89 and 3.98. ^e Required for C₁₆H₁₅ClO: C, 74.29; H, 5.80. Found: C, 74.41 and 74.14; H, 5.67 and 5.60.

reagents.⁶ Also a mixture of products **3e** and **3f** was formed in a nonregioselective Pd(0)-catalyzed reduction of one regioisomeric allylic acetate.⁸ Looking for a more convenient method to prepare compounds **3** we directed our attention to the Suzuki coupling and therefore to the stable and commercially available arylboronic acids **2**.

We found that the coupling products **3** in Scheme 1 can be easily obtained in high yields by a modified Suzuki cross-coupling operating in benzene with Pd(dba)_n (*n* = 1.5–2) as phosphine-free catalyst and in the presence of suspended potassium carbonate. The working up is extremely easy and involves filtration and evaporation. An additional treatment with hydrogen peroxide is aimed at eliminating traces of the arylboronic acids introduced in excess. All compounds, and in particular those of the pairs **3c,d** and **3e,f** were obtained free from their corresponding regioisomers.

To our surprise, blank experiments in the absence of palladium led to the formation of minor amounts of

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(1) (a) Billington, D. C. *Coupling Reactions Between sp³ Carbon Centers*; Vol 3, Chapter 2.1. (b) Tamao, K. *Coupling Reactions Between sp³ and sp² Carbon Centers*; Vol 3, Chapter 2.2. (c) Knight, D. W. *Coupling Reactions Between sp² Carbon Centers*; Vol 3, Chapter 2.3. (d) Sonogashira, K. *Coupling Reactions Between sp² and sp Carbon Centers*; Vol 3, Chapter 2.4. In *Comprehensive Organic Synthesis*; Trost, B. M., Fleming, I., Ed.; Pergamon Press: New York, 1991.

(2) For recent reviews see (a) Suzuki, A. *Pure Appl. Chem.* **1991**, 63, 419. (b) Martin, A. R.; Yang, Y. *Acta Chem. Scand.* **1993**, 47, 221.

(3) Miyaura, N.; Yanagi, T.; Suzuki, A. *Synth. Commun.* **1981**, 11, 513.

(4) See for instance (a) Miyaura, N.; Sugimoto, H.; Suzuki, A. *Tetrahedron Lett.* **1984**, 25, 761. (b) Ishiyama, T.; Abe, S.; Miyaura, N.; Suzuki, A. *Chem. Lett.* **1992**, 691. (c) Oh-e, T.; Miyaura, N.; Suzuki, A. *J. Org. Chem.* **1993**, 58, 2201. (d) Moriya, T.; Furuuchi, T.; Miyaura, N.; Suzuki, A. *Tetrahedron* **1994**, 50, 7961.

(5) (a) Marck, G.; Villiger, A.; Buchecker, R. *Tetrahedron Lett.* **1994**, 35, 3277. (b) Wallow, T. I.; Novak, B. M. *J. Org. Chem.* **1994**, 59, 5034. For a discussion on the benefits of using phosphine-free Pd catalysts see ref 5b.

(6) Wenkert, E.; Fernandes, J. B.; Michelotti, E. L.; Swindell, C. S. *Synthesis* **1983**, 701.

(7) Rondestvedt, C. S., Jr. *J. Am. Chem. Soc.* **1951**, 73, 4509.

(8) Keinan, E.; Greenspoon, N. *J. Org. Chem.* **1983**, 48, 3545.

compounds **3** under the same conditions, but only after considerably longer reaction times (GC monitoring). These observations could not be converted into a non-catalytic synthetic method.

Experimental Section

Allyl Bromides 1 ($R^1 = \text{Cl, Br}$). They were prepared by the method previously described for **1** ($R^1 = \text{Br}$).¹⁰ Compound **1** ($R^1 = \text{Br}$): mp 75–79 °C (lit.¹⁰ mp 72–76 °C). Compound **1** ($R^1 = \text{Cl}$): mp 56–57 °C (lit.¹¹ mp 60–62 °C).

1,3-Diphenylpropene (3a) (General Procedure). A mixture of cinnamyl bromide (**1**) ($R^1 = \text{H}$; 0.240 g, 1.218 mmol), potassium carbonate (1.5 g, 10.8 mmol), $\text{Pd}(\text{dba})_n$ ($n = 1.5\text{--}2$) (0.042 g, 0.073–0.092 mmol of palladium),¹² phenylboronic acid (0.320 g, 2.62 mmol), and anhydrous benzene (35 mL) was refluxed under argon for 15 h. 30% Hydrogen peroxide (25 mL) was added, the heterogeneous mixture was stirred at room

temperature for 1 h, and the benzene layer was separated. The aqueous solution was extracted with diethyl ether (4 × 15 mL). The combined benzene and diethyl ether layers were washed with saturated aqueous sodium chloride, dried with sodium sulfate, and evaporated to afford **3a** as an oil that was purified by passing through a silica gel column with hexanes–ethyl acetate (8:1) as eluent. Product **3a** (0.171 g, 72%) was isolated as an oil: IR (film) 963, 738, 695 cm^{-1} ; ^1H NMR (CDCl_3) δ 3.49 (d, $J = 6.2$ Hz, 2H), 6.24–6.44 (m, 2H), 7.1–7.4 (m, 10H), this spectrum is coincident with the reported one;⁶ ^{13}C NMR (CDCl_3) δ 39.25, 126.04, 126.10, 127.02, 128.32, 128.42, 128.58, 129.13, 130.98, 137.38, 140.07; MS (m/z) 194 (M^+ , 72), 178 (30), 115 (100), 103 (24), 91 (50), 77 (21), 65 (25), 51 (23).

Compounds **3** presented signals for the CH_2 group in ^1H NMR (CDCl_3) at δ 3.40–3.49 (d, 2H) and in ^{13}C NMR (CDCl_3) at δ 38.3–39.5. Physical constants, literature references, and analyses are summarized in Table 1.

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Supplementary Material Available: Copies of ^1H and ^{13}C NMR spectra of **3a–i** (18 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

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(9) Chauhan, P. M. S.; Iyer, R. N.; Bhakuni, D. S. *Indian J. Chem.* **1988**, *27B*, 144.

(10) Hammond, M. L.; Zambias, R. A.; Chang, M. N.; Jensen, N. P.; McDonald, J.; Thompson, K.; Boulton, D. A.; Kopka, I. E.; Hand, K. M.; Opas, E. E.; Luell, S.; Bach, T.; Davies, P.; MacIntyre, D. E.; Bonney, R. J.; Humes, J. L. *J. Med. Chem.* **1990**, *33*, 908.

(11) White, W. N.; Fife, W. K. *J. Am. Chem. Soc.* **1961**, *83*, 3846.

(12) We prepare $\text{Pd}(\text{dba})_2$ by the method of Takahashi et al.¹³ Sometimes our catalyst shows mp ca. 135 °C as described in ref 13, but sometimes the mp is ca. 150 °C. Some chemical catalogues offer $\text{Pd}_2(\text{dba})_3$, mp 152–5 °C. It has been suggested that $\text{Pd}(\text{dba})_2$ is really a dimer $\text{Pd}_2(\text{dba})_3(\text{dba})$.¹⁴ We have observed no differences in behavior when catalysts of either mp were used.

(13) Takahashi, Y.; Ito, Ts.; Sakai, S.; Ishii, Y. *J. Chem. Soc., Chem. Commun.* **1970**, 1065.

(14) Ukai, T.; Kawazura, H.; Ishii, Y.; Bonnet, J. J.; Ibers, J. A. *J. Organomet. Chem.* **1974**, *65*, 253.