

LETTERS
TO THE EDITOR

A Simple Synthesis of 1,3-Diphenylpropene

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Abstract—A simple approach to the synthesis of 1,3-diphenylpropene isomers was developed based on Fe(acac)₃-catalyzed cross-coupling of (*E*)- and (*Z*)-1,3-dichloropropenes with phenylmagnesium bromide.

Keywords: 1,3-diphenylpropene, cross-coupling, Fe-catalyzed cross-coupling, Fe(acac)₃

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1,3-Diphenylpropene isomers are used in organic synthesis as the starting substrates and model compounds [1–4]. The specific reactivity of 1,3-diphenylpropene is due to the presence of methylene group, being simultaneously in the allyl and benzyl positions. (*E*)-1,3-Diphenylpropene is usually obtained by treating a not easily accessible phenylacetaldehyde with a KOH alcohol solution [5, 6], while the synthesis of less thermodynamically stable (*Z*)-isomer with an acceptable stereochemical purity is very problematic [7, 8].

We investigated the possibility of obtaining 1,3-diphenylpropene **2** by Fe(acac)₃-catalyzed cross-coupling of 1,3-dichloropropene **1** with phenylmagnesium bromide. It is known that available iron(III) salts are effective catalysts in cross-coupling reactions of Grignard reagents with vinyl [9–12] and allyl halides [13, 14]. Fe(acac)₃ the most commonly used in the synthesis of natural compounds [15, 16] and drugs [17–20] is advantageously characterized by low hygroscopicity, good solubility, and ease of handling [21].

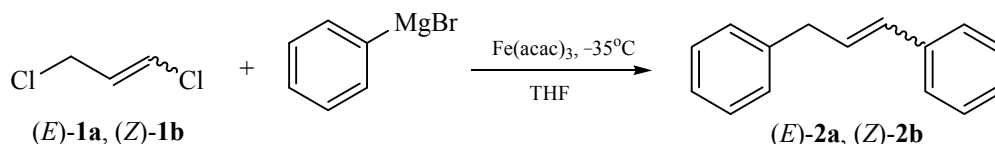
The reaction of (*E*)-1,3-dichloropropene **1a** with 3 equiv of PhMgBr in tetrahydrofuran in the presence of 3 mol % of Fe(acac)₃ afforded a mixture of (*E*)- and (*Z*)-isomers of 1,3-diphenylpropene **2a** and **2b** (*E* : *Z* =

92 : 8) in a 52% yield. The introduction of the most frequently used ligands like *N,N,N,N*-tetramethylethylenediamine (TMEDA) [22] or *N*-methylpyrrolidone (NMP) [10], the replacement of THF by diethyl ether and the use of FeCl₃ as the catalyst did not substantially increase the yield of the reaction product. However, a decrease in the reaction temperature to –35°C results in an increase in the yield of 1,3-diphenylpropene to 80% with the same isomeric composition.

The cross-coupling with (*Z*)-1,3-dichloropropene under similar conditions resulted in an isomeric mixture of 1,3-diphenylpropene (*E* : *Z* = 55 : 45) with 72% yield, while at room temperature the reaction direction shifted toward the formation of (*E*)-isomer (*E* : *Z* = 76 : 24). (*E*)- and (*Z*)-isomers of 1,3-diphenylpropene and diphenyl formed by homocoupling reaction were separated by column chromatography (Scheme 1).

Structure and purity of the obtained compounds was confirmed by high-performance GLC analysis, NMR spectroscopy and chromato-mass spectrometry. A reliable evidence of the stereochemical configuration of isomers **2a** and **2b** was the values of spin-spin coupling constant of vinyl hydrogen atoms (*J* = 15.6 and 11.3 Hz), characteristic of the *E*- and *Z*-configurations, respectively. In addition, the signal of the

Scheme 1.



allylic carbon atom of *trans*-isomer **2a** was shifted downfield by ~5 ppm compared with the *cis*-analog **2b**.

Cross-coupling of (*E*)-1,3-dichloropropene with PhMgBr. To a solution of 0.1 g (0.9 mmol) of (*E*)-1,3-dichloropropene **1a**, 9.5 mg (0.027 mmol) of Fe(acac)₃ in 1 mL of THF in an argon atmosphere at -35°C was slowly added 2.7 mL of a 1 M solution of PhMgBr in THF. The reaction mixture was stirred at -35°C for 1.5 h, and then treated with a 10% HCl solution and 3 mL of hexane. The organic layer was separated, and the aqueous layer was extracted with hexane (3 × 3 mL). The combined organic phases were washed with a saturated NaHCO₃ solution, dried with MgSO₄, and concentrated. The reaction products were isolated by column chromatography (SiO₂, hexane). Yield 0.129 (**2a**) and 0.011 g (**2b**).

The cross-coupling of (*Z*)-1,3-dichloropropene with PhMgBr was carried out analogously. Yield 0.057 (**2b**) and 0.069 g (**2a**).

(*E*)-1,3-Diphenylpropene (2a). ¹H NMR spectrum, δ, ppm: 3.55 d (2H, CH₂, *J* = 6.7 Hz), 6.36 d.t (1H, CH=, *J* = 15.6, 6.7 Hz), 6.46 d (1H, CH=, *J* = 15.6 Hz), 7.18–7.38 m (10H, CH_{Ar}). ¹³C NMR spectrum, δ_C, ppm: 39.33 (CH₂), 126.10 (CH), 126.16 (CH), 127.08 (CH), 128.48 (CH), 128.65 (CH), 129.20 (CH), 131.05 (CH), 137.44 (C), 140.14 (C). Mass spectrum, *m/z* (*I*_{rel}, %): 194 (83) [*M*]⁺, 193 (45), 179 (38), 178 (32), 117 (25), 116 (59), 115 (100), 103 (24), 91 (44), 65 (22).

(*Z*)-1,3-Diphenylpropene (2b). ¹H NMR spectrum, δ, ppm: 3.68 d (2H, CH₂, *J* = 7.4 Hz), 5.86 d.t (1H, CH=, *J* = 11.3, 7.4 Hz), 6.59 d (1H, CH=, *J* = 11.3 Hz), 7.17–7.36 m (10H, CH_{Ar}). ¹³C NMR spectrum, δ_C, ppm: 34.63 (CH₂), 126.05 (CH), 126.81 (CH), 128.24 (CH), 128.34 (CH), 128.47 (CH), 128.68 (CH), 129.97 (CH), 130.66 (CH), 137.22 (C), 140.76 (C). Mass spectrum, *m/z* (*I*_{rel}, %): 194 (71) [*M*]⁺, 193 (41), 179 (34), 178 (29), 117 (24), 116 (55), 115 (100), 103 (23), 91 (45), 65 (24).

¹H and ¹³C NMR spectra of solutions in CDCl₃ were recorded on an AV-500 spectrometer [500 (¹H) and 125 MHz (¹³C)]. Chromato-mass spectral analysis was performed on a GCMS-QP2010S Shimadzu instrument [electronic ionization, 70 eV, a detectable mass range 33–350 Da, HP-1MS capillary column (30 m × 0.25 mm × 0.25 μm), evaporator temperature 280°C, the ionization chamber temperature 200°C, the

temperature programming mode from 50 to 300°C at a rate of 10 deg/min, carrier gas helium (1.1 mL/min)].

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