A Double Suzuki Approach for Synthesis of Substituted Diarylmethylidenefluorenes

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Abstract: A convenient synthesis of substituted diarylmethylidenefluorene derivatives, using a double Suzuki reaction, is reported.

Key words: diarylmethylidenefluorene, dibromomethylidenefluorene, Suzuki reaction, arylboronic acids, Pd-mediated coupling

There is great current interest in the chemistry of fluorenes and their polymers as electroluminescent compositions,¹ and the alkylidene fluorene liquid crystalline semi-conducting polymers² as organic field effect transistor devices. Diarylmethylidenefluorenes in general, and the dications³ or radical anions⁴ derived from them in particular, are subjects of extensive physical studies. The studies are related to anti-aromaticity or electron-spin distribution/conformation, and are evaluated by means of either magnetic criteria focusing on the consequences of the existence of a ring current, or ESR and ENDOR spectra. While there appears to be a great deal of discussion about the derived transient intermediates by theoretical and experimental calculations, little has focused on the synthesis of these diarylmethylidenefluorene derivatives.

Substituted diarylmethylidenefluorene derivatives are generally synthesized by addition of fluorenylidene anions to benzophenone and subsequent dehydration^{4,5} and very recently using Peterson olefination.^{3a} There are a few reports in which the addition of diazofluorene to a thioketone,⁶ Wittig olefination,⁷ [2+2] addition of fluorenylidene stannene⁸ to a benzophenone and subsequent [2+2] decomposition have been described. In many of these approaches, the use of strong bases to generate the requisite benzylic anion and strong acids to dehydrate the intermediate alcohol limits the variation of the substituents on aromatic rings, especially the lack of a protocol compatible with base-sensitive groups. Herein we wish to report a facile synthesis of diarylmethylidenefluorenes by means of Suzuki coupling of dibromomethylidenefluorene (2) with arylboronic acids 3 (Figure 1).

The Suzuki reaction, consisting of a palladium-mediated cross-coupling of organoboronic acids with alkenyl or aryl halides, is a great tool in synthetic organic chemistry.⁹ The Suzuki reaction of 1,1-dibromo-1-alkenes with alkenyl or arylboronic acids is well known and well used in the synthesis of tri- and tetrasubstituted olefins and also for



Figure 1 Double Suzuki approach to substituted diarylmethylidenefluorenes

the stereoselective formation of (*Z*)-1-aryl- or (*Z*)-alkenyl-1-bromo-1-alkenes.¹⁰ Because a variety of organoboronic acid derivatives are now readily available, we examined the feasibility of a double Suzuki reaction with the known dibromomethylidenefluorene (2)¹¹ to synthesize symmetric diarylmethylidenefluorene derivatives.

Our initial attempts to optimize the reaction conditions were carried out with simple phenylboronic acid (**3a**). After a careful examination of various reaction conditions, such as reaction temperature, reaction time, base, solvent, and amount of phenylboronic acid, we concluded that the best results for the intended double Suzuki reaction were achieved by using a suspension of benzene–ethanol–water as a solvent, sodium carbonate as a base, conducting the reaction at 70–80 °C and addition of the catalyst Pd(PPh₃)₂Cl₂ (7.5 mol%) and phenylboronic acid (1.5 equiv) twice to the reaction mixture with a ten-hour interval.

Thus, the reaction of **2** with differently substituted aryl boronic acids **3b–i** following the above conditions led to the previously known and a couple of unknown diarylmethylidenefluorene derivatives **1b–i** (Scheme 1). In general, the reactions with electron-deficient boronic acids were facile and good yields were obtained. For the boronic acids with an electron-donating group, the reactions were sluggish and resulted in low yields. The physical data of all the known compounds are in agreement with those of the reported data. All the new compounds were characterized by their spectral and analytical data and a single-crystal X-ray structure for compound **1h**.¹²

In conclusion, a simple method for the synthesis of symmetric and substituted diarylmethylidenefluorenes has been reported using a double Suzuki reaction. Work in the direction of stepwise coupling of different boronic acids to address the synthesis of unsymmetric derivatives is in progress.

SYNLETT 2007, No. 1, pp 0127–0128 Advanced online publication: 20.12.2006 DOI: 10.1055/s-2006-958407; Art ID: G29506ST © Georg Thieme Verlag Stuttgart · New York



Scheme 1 Double Suzuki coupling reaction with dibromomethylidenefluorene (2)

Acknowledgment

C.N.R. thanks UGC (New Delhi) for the financial support in the form of a research fellowship.

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- (12) Selected Experimental Procedure: Under an argon atmosphere, a solution of dibromide 2 (200 mg, 0.6 mmol) in benzene (15 mL) was treated with solid Na₂CO₃ (154 mg, 1.5 mmol), Pd(PPh₃)₂Cl₂ (40 mg, 0.06 mmol) and boronic acid 3h (145 mg, 0.9 mmol) and the contents were degassed for 5 min. To this, EtOH (0.5 mL) and H₂O (0.5 mL) were added and the reaction mixture was heated at 80 $^{\circ}\mathrm{C}$ for 10 h. The reaction mixture was cooled, the catalyst (40 mg, 0.06 mmol) and boronic acid 3h (145 mg, 0.9 mmol) were introduced and the heating at 80 $^{\circ}\mathrm{C}$ was continued for an additional 10 h. In general, the reactions are light-sensitive and covering the reaction vessel with aluminum foil is recommended. The reaction mixture was concentrated under reduced pressure and diluted with EtOAc (30 mL) and washed with H2O. The organic layer was separated, dried (Na₂SO₄), concentrated and purified by silica gel column chromatography (10% EtOAc-PE). Recrystallization from toluene gave 1h (217 mg, 88%) as yellow colored crystals suitable for single-crystal X-ray diffraction studies.¹² Spectral Data of Compound 1h: mp 231–233 °C (toluene). IR (CHCl₃): 3019, 1682, 1601, 1446, 1403, 1360, 1266, 1215, 1075, 958, 849 cm⁻¹. ¹H NMR (200 MHz, CDCl₃): $\delta = 2.65$ (s, 6 H), 6.61 (br dt, J = 0.83, 8.0 Hz, 2 H), 6.92 (dt, J = 1.2, 7.4, 8.0 Hz, 2 H), 7.26 (dt, J = 1.0, 7.4 Hz, 2 H), 7.48 (br dt, J = 1.6, 8.1 Hz, 4 H), 7.65–7.74 (m, 2 H), 8.64 (br dt, J = 1.8, 8.1 Hz, 4 H). ¹³C NMR (50 MHz, CDCl₃): $\delta = 26.6$ (q), 119.4 (d), 124.8 (d), 126.6 (d), 128.4 (d), 128.9 (d), 129.9 (d), 135.7 (s), 136.6 (s), 137.8 (s), 140.7 (s), 141.9 (s), 146.9 (s), 197.5 (s). Anal. Calcd for C₃₀H₂₂O₂: C, 86.93; H, 5.35. Found: C, 86.97; H, 5.59.
- (13) The crystallographic data for 1h has been deposited with the Cambridge Crystallographic Data Centre with deposition no. CCDC 625077. Copies of the data can be obtained free of charge on application to the CCDC, 12 Union Road, Cambridge CB2 1EZ, UK [fax: +44(1223)336033; e-mail: deposit@ccdc.cam.ac.uk].

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