

Transition Metal Complexes in Organic Synthesis – 44.¹

Iron-Mediated Synthesis of Indolo[2,3-*b*]carbazole

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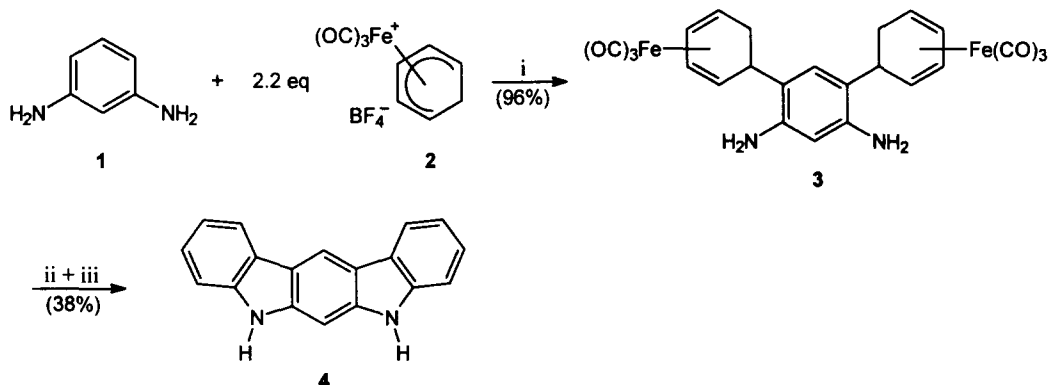
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Abstract: A straightforward two-step synthesis of indolo[2,3-*b*]carbazole using a double iron-mediated arylamine cyclization as the key-step is described.

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The chemistry of 9*H*-carbazole alkaloids has been extensively investigated and several novel procedures for their synthesis have been developed because of their biological activities and physical properties.² All of the five possible isomeric indolocarbazoles were prepared.^{3–5} We described a direct synthesis of 9*H*-carbazole derivatives by a consecutive iron-mediated C–C and C–N bond formation, which was applied to the synthesis of many biologically active carbazoles.⁶ The crucial steps of this procedure are an *ortho*-selective electrophilic substitution of an arylamine by a tricarbonyliron-complexed cyclohexadienyl cation followed by oxidative cyclization of the resulting substituted tricarbonyl(η^4 -cyclohexa-1,3-diene)iron complex with concomitant aromatization to the 9*H*-carbazole (iron-mediated arylamine cyclization).⁷ In the present paper we report the first example of an extension of this methodology to a double electrophilic substitution and subsequent double iron-mediated arylamine cyclization. Thus, indolo[2,3-*b*]carbazole, previously obtained by two different syntheses,^{3,4} is easily prepared starting from *m*-phenylenediamine (1) and the iron complex salt 2 (Scheme).



Scheme. *Reagents and conditions:* i) MeCN, 25°C, 16 h; ii) 3 eq. iodine, pyridine, 25°C, 1 h; iii) 3 eq. iodine, pyridine, 25°C, 18 h and 55°C, 6 h.

Reaction of *m*-phenylenediamine (1) with 2.2 equivalents of the iron complex salt 2 provides the dinuclear iron complex 3 as a 1:1 mixture of two diastereoisomers (m.p. 156–158°C). This optimized procedure for double electrophilic substitution at 1 proceeds almost quantitatively without any trace of monosubstitution product.⁸

The arylamine cyclization with concomitant aromatization and demetalation of the intermediate tricarbonyliron-complexed 4a,9a-dihydro-9*H*-carbazole represents a direct access to the 9*H*-carbazoles and was in most cases achieved by oxidation with very active manganese dioxide^{6,7} or with ferricenium hexafluorophosphate/sodium carbonate.⁹ However, in case of the double iron-mediated arylamine cyclization required for the transformation of complex **3** into indolo[2,3-*b*]carbazole (**4**) these reagents led exclusively to decomposition. An alternative reagent for this oxidative cyclization is iodine in pyridine.^{8,10} We developed a protocol for the conversion of complex **3** into **4** by two consecutive oxidations. Treatment of the dinuclear complex **3** with 3 equivalents of iodine in pyridine for 1 h at room temperature followed by filtration over silica gel (hexane/ether, 2:1) and further oxidation with additional 3 equivalents of iodine in pyridine first for 18 h at room temperature and then for 6 h at 55°C afforded indolo[2,3-*b*]carbazole (**4**) in 38% yield.¹¹

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11. **Indolo[2,3-*b*]carbazole**: colorless solid, m.p. 348–350°C; UV (EtOH): λ = 209, 238, 265, 274, 303, 343, 351, 360 nm; ¹H NMR (500 MHz, DMSO-*d*₆): δ = 7.13 (t, *J* = 7.6, 2 H), 7.31 (t, *J* = 7.6, 2 H), 7.37 (s, 1 H), 7.42 (d, *J* = 7.6, 2 H), 8.13 (d, *J* = 7.6, 2 H), 8.78 (s, 1 H), 11.04 (s, 2 H); ¹³C NMR and DEPT (125 MHz, DMSO-*d*₆): δ = 90.66 (CH), 110.21 (2 CH), 111.15 (CH), 117.19 (2 C), 118.18 (2 CH), 119.26 (2 CH), 123.22 (2 C), 124.36 (2 CH), 140.18 (2 C), 140.30 (2 C); MS (170°C): *m/z* (%) = 256 (M⁺, 100), 255 (46), 128 (31); HRMS: calcd. for C₁₈H₁₂N₂ (M⁺): 256.1000, found: 256.0991.