SUPPORTING INFORMATION

Selectivity control during the synthesis of 1,2-disubstituted benzimidazoles and mechanistic insight to rationalize selectivity

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**Effect of reaction medium on the selectivity control**

*Table 1.* The selectivity in the formation of 3a and 4a during the HClO₄-SiO₂ catalysed reaction of 1a with 2a in various solvents.\[a\]

![Chemical structure image]

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<tr>
<th>Entry</th>
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<th>4a</th>
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<td>15</td>
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\[a\] 1a (2.5 mmol) was treated with 2a (5 mmol, 2 equiv) in various solvents (5 mL) in the presence of HClO₄-SiO₂ (0.5 mol%) at rt (~ 35-40 °C) for 1 h. \[b\] The isolated yield of 3a and 4a after column chromatographic purification. \[c\] The products were characterised by NMR (¹H & ¹³C) and MS (APCI).

**Selectivity control using protic acid alone**

*Table 2.* Selectivity in the formation of 3b and 4b during the reaction of 1a with 2b under the catalytic influence of various protic acids without any solid support.\[a\]

![Chemical structure image]

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<th>Entry</th>
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<td>1</td>
<td>HClO₄ (aq 70 %)</td>
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<tr>
<td>2</td>
<td>TfOH</td>
<td>22</td>
<td>12</td>
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<td></td>
<td></td>
<td>Amount of HClO₄-SiO₂</td>
<td>Yield (%)&lt;sup&gt;[c][d]&lt;/sup&gt;</td>
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Recovery and reuse of HClO₄-SiO₂

Table 3. The recyclability of HClO₄-SiO₂ during the reaction of 1a with 2b.<sup>[a]</sup>

Representative experimental procedure for recovery and reuse of HClO₄-SiO₂ during the synthesis of 1,2-disubstituted benzimidazole: The mixture of 1a (5.4 g, 50 mmol), 2a (14.91 g, 100 mmol, 2 equiv), and HClO₄-SiO₂ (0.5 g, 0.25 mmol, 0.5 mol %) in EtOH (100 mL) was stirred magnetically at rt (~25-30 ºC). After completion of the reaction (1 h, TLC, 3:1 n-hexane-EtOAc), the reaction mixture was diluted with EtOH (50 mL), filtered through a plug of cotton (to separate the catalyst), and the cotton plug was washed with EtOH (2 × 10 mL). The combined filtrates were evaporated and the crude product was purified by crystallization using 10 % aq EtOH to afford 3a (16.67 g, 90 %) as white solid.<sup>[1]</sup> The cotton plug retaining the recovered catalyst was placed in a rb flask (50 mL) and dried by rotary vacuum evaporation when the catalyst separated out from the cotton (0.48 g, 96%). The catalyst was activated on heating under reduced pressure (10 mm Hg) at 80 ºC for 24 h. The reaction was repeated with 1 and 2a at 40 mmol, 30 mmol, 20 mmol and 10 mmol scales in the presence of the recovered HClO₄-SiO₂ (0.4 g, 0.3 g, 0.2 g and 0.1 g, respectively) to afforded 3a in 13.34g (90 %), 9.67 g (87 %), 6.30 g (85 %) and 3.14 g (85 %) yields respectively.

<sup>[a]</sup>1a (1 mmol) was treated with 2b (2 mmol, 2 equiv) in the presence of the catalyst (10 mol %) in EtOH (3 mL) at rt (~35 - 40 ºC) for 1.5 h. <sup>[b]</sup> Isolated yield of 3b and 4b after column chromatographic purification. 

Large scale synthesis (100 mmol) of 1,2-disubstituted benzimidazole

Representative experimental procedure for large scale synthesis (100 mmol) of 1,2-disubstituted benzimidazole using HClO₄-SiO₂: The mixture of 1a (10.8 g, 100 mmol), 2a (29.82 g, 200 mmol, 2 equiv), and HClO₄-SiO₂ (1 g, 0.50 mmol, 0.5 mol %) in EtOH (250 mL) was stirred magnetically at rt (~25-30 ºC). After completion of the reaction (1.5 h, TLC, 3:1 n-hexane-EtOAc), the reaction mixture was diluted with EtOH (100 mL), filtered through a plug of cotton (to separate the catalyst), and the cotton plug was washed with EtOH (2 × 20 mL). The combined filtrates were evaporated and the crude product was purified by crystallization (10% aq EtOH) to afford 3a (34.83 g, 94%) as white solid.[2] The cotton plug retaining the recovered catalyst was placed in a rb flask (50 mL) and dried by rotary vacuum evaporation when the catalyst separated out from the cotton (0.95 g, 95%). The remaining reactions were carried out following these general procedures. The purification was carried out by crystallization in aq EtOH or passing through a column of silica-gel and eluting with 10% EtOAc in hexane, wherever required. In each occasion, the spectral data (IR, NMR, and MS) of known compounds were found to be identical with those reported in the literature.

Spectral data

1-Phenylmethyl-2-phenyl-1H-benzimidazole (Entry 1, Table 3): white solid; mp = 131-133 ºC; IR (KBr) νmax = 3392, 1602, 1508, 1460, 1388, 1264, 1161, 1129, 1073 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ = 7.88 (d, J = 8.1 Hz, 1H), 7.68 (m, 2H ), 7.47 (m, 3H), 7.22-7.34 (m, 6H), 7.11 (d, J = 7.4 Hz, 2H), 5.46 (s, 2H); MS (APCI) m/z: 285 (M+H)⁺.

1-(4-Methylphenylmethyl)-2-(4-methylphenyl)-1H-benzimidazole (Entry 2, Table 3): White Solid; mp = 128-130 ºC; IR (KBr) νmax = 3545, 1683, 1610, 1441, 1248, 1183, 1119, 983 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ = 7.45 (d, J = 7.9 Hz, 1 H), 7.58 (d, J = 8.1 Hz, 2 H), 7.28-7.31 (m, 2 H), 7.13 (d, J = 7.9 Hz, 2 H), 6.99 (d, J = 8.0 Hz, 2 H), 5.41 (s, 2 H), 2.40 (s, 3 H), 2.33 (s, 3 H); MS (APCI) m/z: 313 (M+H)⁺.

1-(4-Methoxyphenylmethyl)-2-(4-methoxyphenyl)-1H-benzimidazole (Entry 3, Table 3): White Solid; mp = 129-130 ºC; IR (KBr) νmax = 3529, 1608, 1586, 1228, 1291, 1284, 1291, 1244, 1170, 1107, 1082, 1011, cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ = 8.42 (d, J =

8.0 Hz, 1 H), 7.60 (t, J = 8.3 Hz, 3 H), 7.21-7.29 (m, 3 H), 6.84-7.04 (m, 6 H), 5.38 (s, 2 H), 3.83 (s, 3 H), 3.75 (s, 3 H); MS (APCI) m/z: 345 (M+H)^+. 

1-(4-Chlorophenylmethyl)-2-(4-chlorophenyl)-1H-benzimidazole (Entry 5, Table 3): White Solid; mp = 136 °C; IR (KBr) v_max = 3447, 1601, 1493, 1384, 1291, 1249, 1160, 765, cm^{-1}; ^1H NMR (300 MHz, CDCl_3): δ = 7.87 (d, J = 6.6 Hz, 1 H), 7.59 (d, J = 6.7 Hz, 2 H), 7.43 (d, J = 6.8 Hz, 2 H), 7.30-7.36 (m, 3 H), 7.19 (t, J = 7.8 Hz, 2 H), 7.02 (d, J = 7.0 Hz, 2 H), 5.36 (s, 2 H); MS (APCI) m/z: 354 (M+H)^+. 

1-(4-Bromophenylmethyl)-2-(4-bromophenyl)-1H-benzimidazole (Entry 6, Table 3): White Solid; mp = 140-141 °C; IR (KBr) v_max = 3035, 2890, 1618, 1592, 1052 cm^{-1}; 1H NMR (400 MHz, CDCl_3): δ = 7.88 (d, J = 7.92 Hz, 1 H), 7.60 (d, J = 7.52 Hz, 2 H), 7.53 (d, J = 8.36 Hz, 2 H), 7.48-7.46 (m, 2 H), 7.34 (t, J = 7.24 Hz, 1 H), 7.27 (t, J = 8.36 Hz, 1 H), 7.20 (d, J = 7.96 Hz, 2 H), 6.96 (d, J = 7.88 Hz, 2 H), 5.38 (s, 2 H); MS (APCI) m/z: 440 (M+H)^+. 

1-(4-Trifluoromethylphenylmethyl)-2-(4-(trifluoromethyl)phenyl)-1H-benzimidazole (Entry 7, Table 3): White Solid; mp = 145-147 °C; IR (KBr) v_max = 3025, 1609, 1589, 1108, 1058 cm^{-1}; ^1H NMR (400 MHz, CDCl_3): δ = 7.88 (d, J = 7.96 Hz, 1 H), 7.59 (d, J = 7.52 Hz, 2 H), 7.53 (d, J = 8.36 Hz, 2 H), 7.48-7.46 (m, 2 H), 7.34 (t, J = 7.24 Hz, 1 H), 7.27 (t, J = 8.36 Hz, 1 H), 7.20 (d, J = 7.96 Hz, 2 H), 6.97 (d, J = 8.32 Hz, 2 H), 5.38 (s, 2 H); 13C NMR (100 MHz, CDCl_3): 152.4, 143.1, 140.0, 135.9, 131.9, 130.5, 129.5, 127.8, 126.2, 126.1, 125.9, 125.1, 125.0, 123.9, 123.3, 122.4, 119.7, 119.6, 110.3, 48.0; MS (APCI) m/z: 421.2 (M+H)^+; Anal.Calcd. For C_{22}H_{14}F_{6}N_{2}: C, 62.86; H, 3.36; N, 6.66 % Found: C, 62.88; H, 3.38; N, 6.67 %. 

1-(4-Phenylmethyloxyphenylmethyl)-2-(4-benzyloxy-phenyl)-1H-benzimidazole (Entry 8, Table 3): White Solid; mp = 127 °C; IR (KBr) v_max = 3434, 1610, 1511, 1455, 1384, 1246, 1175, 1024 cm^{-1}; ^1H NMR (300 MHz, CDCl_3): δ = 7.83 (d, J = 7.5 Hz, 1 H), 7.77 (d, J = 7.3 Hz, 1 H), 7.63 (t, J = 7.3 Hz, 1 H), 7.57 (t, J = 7.3 Hz, 1 H), 7.42 (d, J = 7.3 Hz, 1 H), 7.37 (t, J = 7.3 Hz, 1 H), 7.25 (d, J = 7.3 Hz, 1 H), 7.06 (d, J = 7.3 Hz, 1 H), 6.92 (d, J = 7.3 Hz, 1 H), 5.38 (s, 2 H), 5.11 (s, 2 H), 5.03 (s, 2 H); 13C NMR (75 MHz, CDCl_3): 160.64, 158.90, 137.04, 136.59, 131.28, 129.20, 128.04, 127.80, 123.32, 123.11, 120.26, 115.90, 115.66, 110.98, 70.63, 48.44; MS (APCI) m/z: 497.5 (M+H)^+; Anal. Calcd. For C_{34}H_{28}N_{2}O_{2}: C, 82.23; H, 5.68; N, 5.64 % Found: C, 82.25; H, 5.67; N, 5.66 %. 

(4-Nitro-phenyl)-1H-benzimidazole (Entry 10, Table 3): Yellow Solid; mp = 327 °C; IR (KBr) v_max = 3442, 1612, 1525, 1460, 1385, 1232, 1140, 1030 cm^{-1}; ^1H NMR (300 MHz, CDCl_3): δ = 8.54 (s, 1 H), 8.30 (d, J = 6.4 Hz, 2 H), 8.06 (m, 3 H), 7.26 (m, 1 H), 7.13 (m, 1 H); MS (APCI) m/z: 240.3 (M+H)^+. 

Electronic Supplementary Material (ESI) for RSC Advances
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2-Benzodio[1,3]dioxol-5-yl-1-benzo[1,3]dioxol-5-ylmethyl-1H-benzimidazole (Entry 11, Table 3): White solid; mp = 162 °C; IR (KBr) \( \nu_{\text{max}} = 3344, 1608, 1501, 1487, 1388, 1325, 1243, 1190, 1115, 1076, 1038 \text{ cm}^{-1}; ^1\text{H NMR (300 MHz, CDCl}_3): \delta = 7.83 (d, J = 8.0 \text{ Hz, 1 H}), 7.53 (s, 2 H), 7.17 (m, 2 H), 6.88 (t, J = 8.7 \text{ Hz, 1 H}), 6.75 (d, J = 8.3 \text{ Hz, 1 H}), 6.56 (s, 2 H), 6.04 (s, 2 H), 5.95 (s, 2 H), 5.35 (s, 2 H); MS (APCI) m/z: 373 (M+H)^+.

2-Naphthalen-2-yl-1-naphthalen-2-ylmethyl-1H-benzimidazole (Entry 12, Table 3): White Solid; mp = 125-126 °C; IR (KBr) max = 3056, 1600, 1439, 1378, 1325, 1253, 1143 \text{ cm}^{-1}; 1H NMR (300 MHz, CDCl_3): \delta = 8.21 (s, 1 H), 7.85-7.95 (m, 6 H), 7.74 (t, J = 7.3 Hz, 2 H), 7.48-7.57 (m, 5 H), 7.28-7.35 (m, 4 H), 5.36 (s, 2 H); MS (APCI) m/z: 385 (M+H)^+.

2-Furan-2-yl-1-furan-2-ylmethyl-1H-benzimidazole (Entry 13, Table 3): White solid; mp = 94 °C; IR (KBr) \( \nu_{\text{max}} = 3393, 1608, 1511, 1456, 1378, 1108, 921 \text{ cm}^{-1}; 1H NMR (300 MHz, CDCl_3): \delta = 7.79 (s, 1 H), 7.50 (s, 2 H), 7.22 (m, 4 H), 6.62 (s, 1 H), 6.27 (d, J = 12.39 Hz, 2 H), 5.65 (s, 2 H); MS (APCI) m/z: 265.2 (M+H)^+.

2-Thiophen-2-yl-1-thiophen-2-ylmethyl-1H-benzimidazole (Entry 14, Table 3): White solid; mp =145-147 °C; IR (KBr) \( \nu_{\text{max}} = 3064, 1610, 1556, 1443, 1422, 1369, 1283, 1160, 1087, 1004 \text{ cm}^{-1}; 1H NMR (300 MHz, CDCl_3): \delta = 7.83 (d, J = 7.9 \text{ Hz, 1 H}), 7.50 (d, J = 13 Hz, 1 H), 7.37 (d, J = 6.3 \text{ Hz, 2 H}), 7.23-7.49 (m, 4 H), 7.14 (t, J = 4.9 \text{ Hz, 1 H}), 6.90 (t, J = 4.8 \text{ Hz, 2 H}), 5.70 (s, 2 H); MS (APCI) m/z: 297.5 (M+H)^+.

2-Pyridin-2-yl-1-pyridin-2-ylmethyl-1H-benzimidazole (Entry 15, Table 3): White Solid; mp =128-130 °C; IR (KBr) \( \nu_{\text{max}} = 3401, 1633, 1592, 1462, 1444, 1388, 1331, 1046 \text{ cm}^{-1}; 1H NMR (300 MHz, CDCl_3): \delta = 8.58 (s, 1 H), 8.47 (d, J = 7.76 Hz, 1 H), 7.49 (t, J = 16.4 Hz, 1 H), 7.29-7.38 (m, 4 H), 7.14 (s, 1 H), 6.90 (d, J =7.5 Hz, 1 H), 6.29 (s, 2 H); MS (APCI) m/z: 287.2 (M+H)^+.

1-((1H-Indol-3-yl)methyl)-2-(1H-indol-3-yl)-1H-benzimidazole (Entry 16, Table 3): Brown Solid; mp = 253-255 °C; IR (KBr) \( \nu_{\text{max}} = 3035, 1615, 1598, 1258, 1108, 1058 \text{ cm}^{-1}; 1H NMR (400 MHz, CDCl_3): \delta = 8.31 (d, J = 7.76 Hz, 1 H), 7.86 (d, J = 2.56 Hz, 1 H), 7.67 (d, J = 7.48 Hz, 1 H), 7.55 (d, J = 7.4 Hz, 1 H), 7.49 (d, J = 7.92 Hz, 1 H), 7.31 (d, J = 8.16 Hz, 1 H), 7.25-7.23 (m, 2 H), 7.20-7.12 (m, 3 H), 7.04-7.01 (m, 2 H), 6.83 (t, J =7.56 Hz, 1 H), 5.82 (s, 2 H); MS (APCI) m/z: 363 (M+H)^+.

2-Cyclohexyl-1-cyclohexylmethyl-1H-benzimidazole (Entry 17, Table 3): White Solid; mp = 90-91 °C IR (KBr) \( \nu_{\text{max}} = 3369, 1613, 1457, 1347, 1273 \text{ cm}^{-1}; 1H NMR (300 MHz, CDCl_3): \delta = 7.74 (m, J = 2.7 Hz, 1 H), 7.28 (t, J = 3.4 Hz, 1 H), 7.17-7.21 (m, 2 H), 3.93 (t, J = 5.7 Hz, 2 H), 2.82 (d, J = 2.8 Hz, 1 H), 1.60-1.90 (m, 14 H), 1.40 (m, 2 H), 1.01-1.17 (m, 3 H), 0.87-0.94 (m, 2 H); MS (APCI) m/z: 297 (M+H)^+.
1-Isobutyl-2-isopropyl-1H-benzimidazole (Entry 18, Table 3): Viscous liquid; IR (neat) ν_{\text{max}} = 3400, 1614, 1508, 1461, 1416, 1282, 1086 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)): δ = 7.72-7.78 (m, 1 H), 7.18-7.30 (m, 3 H), 3.92 (d, J = 7.5 Hz, 1 H), 3.14-3.24 (m, 1 H), 2.17-2.27 (m, 1 H), 1.44 (d, J = 6.7 Hz, 6 H), 0.95 (d, J = 6.73 Hz, 6 H); \(^1^3\)C NMR (300 MHz, CDCl\(_3\)): δ = 160.71, 143.07, 135.64, 122.34, 122.20, 119.77, 110.21, 51.35, 29.81, 26.91, 20.76, 19.65; MS (APCI) m/z: 217.4 (M+H)+; Anal. Calcd. For C\(_{14}\)H\(_{20}\)N\(_2\): C, 77.73; H, 9.32; N, 12.95 %. Found: C, 77.74; H, 9.30; N, 12.94 %.

1-(3,3-Dimethylbutyl)-2-neopentyl-1H-benzimidazole (Entry 19, Table 3): Viscous liquid; IR (neat) ν_{\text{max}} = 3343, 1605, 1444, 1378, 1354, 1366, 1074 cm\(^{-1}\); \(^1\)H NMR (300 MHz, CDCl\(_3\)): δ = 7.73-7.76 (m, 1 H), 7.21-7.27 (m, 3 H), 4.13-4.19 (m, 2 H), 2.77 (s, 2 H), 1.60-1.66 (m, 2 H), 1.09 (s, 9 H), 1.06 (s, 9 H); \(^1^3\)C NMR (300 MHz, CDCl\(_3\)): δ = 151.94, 141.87, 133.48, 127.76, 120.67, 118.40, 108.00, 46.00, 41.52, 39.46, 33.62, 30.30, 28.95; MS (APCI) m/z: 273.4 (M+H)+; Anal. Calcd. For C\(_{\text{18}}\)H\(_{28}\)N\(_2\): C, 79.36; H, 10.36; N, 10.28 %. Found: C, 79.34; H, 10.34; N, 10.30 %.

2-tert-Butyl-1H-benzimidazole (Entry 20, Table 3): White solid; mp = 321-323 °C; IR (KBr) ν_{\text{max}} = 3342, 1610, 1440, 1375, 1392, 1081 cm\(^{-1}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)): δ = 12.07 (bd, J = 6.64 Hz, 1 H), 7.52 (d, J = 6.64 Hz, 1 H), 7.40 (d, J = 7.2 Hz, 1 H), 7.06-7.14 (m, 2 H), 1.39 (s, 9 H); MS (APCI) m/z: 175.2 (M+H)+.

6-Nitro-2-phenyl-1H-benzimidazole 4c: Yellow solid; mp = 202-203 °C; IR (KBr) ν_{\text{max}} = 3245, 1470, 1630, 1621, 734 cm\(^{-1}\); \(^1\)H NMR (400 MHz, DMSO): δ = 8.49 (s, 1 H), 8.21 (d, J = 5.3 Hz, 2 H), 8.15 (d, J = 8.8 Hz, 1 H), 7.78 (d, J = 8.5 Hz, 1 H), 7.61(d, J = 6.4 Hz, 3 H); MS (APCI) m/z: 240.3 (M+H)+.

6-Nitro-2-(4-nitrophenyl)-1H-benzimidazole 4e: Yellow solid; 270 °C (decomp); IR (KBr) ν_{\text{max}} = 3142, 1465, 1640, 1625, 730 cm\(^{-1}\); \(^1\)H NMR (400 MHz, DMSO): δ = 8.36 (m, 4 H), 8.15 (d, J = 2.8 Hz, 2 H), 7.95-7.98 (m, 2 H), 6.93 (bd, s, 1 H), 8.15 (d, J = 9.8 Hz, 1 H); MS (APCI) m/z: 285.2 (M+H)+.

6-Nitro-2-(4-methoxyphenyl)-1H-benzimidazole 4f: White solid; mp = 235-236 °C; IR (KBr) ν_{\text{max}} = 3242, 1470, 1645, 11598, 825, 715 cm\(^{-1}\); \(^1\)H NMR (400 MHz, DMSO): δ = 8.10-8.12 (m, 2 H), 7.90 (s, 1 H), 7.89-7.91(m, 2 H), 7.08(m, 2 H); MS (APCI) m/z: 270.3 (M+H)+.
Scanned NMR spectra

Entry 1, Table 3, $^1$H NMR
Entry 2, Table 3, $^1$H NMR
Entry 3, Table 3, $^1$H NMR
Entry 4, Table 4, $^1$H NMR
Entry 5, Table 3, $^1$H NMR
Entry 6, Table 3, $^1$H NMR
Entry 7, Table 3, $^1$H NMR
Entry 7, Table 3, $^{13}$C NMR
Entry 8, Table 3, $^1$H NMR
Entry 8, Table 3, $^{13}$C NMR
Entry 9, Table 3, $^1$H NMR
Entry 9, Table 3, $^{13}$C NMR
Entry 10, Table 3, $^1$H NMR
Entry 11, Table 3, $^1$H NMR
Entry 12, Table 3, $^1$H NMR
Entry 13, Table 3, $^1$H NMR
Entry 14, Table 3, $^1$H NMR
Entry 15, Table 3, $^1$H NMR
Entry 16, Table 3, $^1$H NMR
Entry 17, Table 3, $^1$H NMR
Entry 18, Table 3, $^1$H NMR
Entry 18, Table 3, $^{13}$C NMR
Entry 19, Table 3, $^1$H NMR
Entry 19, Table 3, $^{13}$C NMR
Entry 20, Table 3, $^1$H NMR
Mass spectra (APCI) of N-(4-methylbenzylidene) aniline (Reaction b/w aniline & 4-methylbenzaldehyde; 1:1)
Mass spectra (APCI) of bis(4-methylbenzylidene)benzene-1,3-diamine (Reaction b/w \textit{m}-phenylelediamine \& 4-methylbenzaldehyde; 1:2)
Mass spectra (APCI) of aliquot sample of reaction mixture (b/w o-phenylelediamine & 4-methylbenzaldehyde; 1:2 in EtOH)

T: + c APCI corona Full ms [50.00-500.00]
GCMS spectra at different time interval for the reaction b/w o-phenylelediamine and 4-methylbenzaldehyde (1:2) in EtOH

@ 10 min
Low Mass (m/z): 50.00
High Mass (m/z): 600.00
RT: 3.00 - 38.78  SM: 7G

RT  | Area % | Peak Area | Peak Height
---  | ------ | --------- | ----------
29.06 | 9.00   | 726716    | 89972     
33.72 | 1.40   | 112734    | 19834     
34.38 | 89.60  | 7231889   | 837018    

RT: 34.32  AV: 1  NL: 1.19E5
T: + c Full ms [50.00-600.00]  105.14
### @ 20 min

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<td>SM: 7G</td>
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**Graph:**

- **Relative Abundance**
- **Time (min):** 0 to 35

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### @ 30 min

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**Graph:**

- **Relative Abundance**
- **Time (min):** 0 to 35

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High Mass (m/z): 600.00
RT: 0.00 - 38.78 SM: 7G

@ 50 min
Low Mass (m/z): 50.00
High Mass (m/z): 600.00
RT: 0.00 - 38.78 SM: 7G
Mass spectra (APCI) of 1-(4-Methylphenylmethyl)-2-(4-methylphenyl)-1H-benzimidazole
$MS^2$ of mass peak 313

T: + c APCI corona Full ms2 313.00@20.00 [ 85.00-500.00]
Mass spectra (APCI) of aliquot sample of reaction mixture \((o\text{-phenylelediamine} \& 4\text{-methylbenzaldehyde}; 1:2)\) subjected after 10 min

\[\text{MS}^2\text{ of mass peak 313}\]
$^1$H NMR spectra of 2-Phenyl-1-$\alpha$-$d_2$-phenylmethyl-$1H$-benzimidazole (Scheme 5)
$^1$H NMR spectra of $N^1, N^2$-dibenzylbenzene-1,2-diamine (Scheme 4)
Mass spectra (APCI) of NaBH₄ treated aliquot sample of reaction mixture involving o-phenylenediamine & 2,4,6-trimethylbenzaldehyde (1:2) in HClO₄-SiO₂/EtOH (Scheme 6)
NMR spectra of 2-(2,4,6-trimethylphenyl)-1H-benzimidazole (Scheme 6)

$^1$H NMR spectra

$^{13}$C NMR spectra
$^1$H NMR spectra of N$^1$-benzyl-5-nitrobenezene-1,2-diamine (Scheme 7)
$^{13}$C NMR spectra of $N^i$-benzyl-5-nitrobenzene-1,2-diamine (Scheme 7)
$^1$H NMR spectra of $N$-benzyl-4-nitroaniline & $N$-benzyl-3-nitroaniline (Scheme 7)

$^1$H NMR spectra of $N$-benzyl-4-nitroaniline

$^1$H NMR spectra of $N$-benzyl-3-nitroaniline
Structural elucidation of the reductive alkylation product for the reaction of 1b with 2c (following scheme).

The reductive alkylation of 1b with 2c would form either 7 or 7a due to the competitive imine formation by both amino groups. Due to the higher nucleophilicity of the amino group meta to nitro, it may be anticipated that the final (reductive amination) product would be 7. In the absence of authentic sample of 7a, the ChemNMR estimation (ChemBioDraw Ultra 11.0) was chosen as diagnostic tool to predict/assign the structure of the isolated product as 7 or 7a on the basis of chemical shift of the benzylic proton/carbon. However, in both case (7 and 7a) the chemical shift of benzylic proton (δ = 4.35) and benzylic carbon (δ = 48) exhibit similar value making it as an inappropriate tool for determination/establishment of the structure of the final (reductive amination) product. Therefore, the 2D NMR analysis of 7 was carried out to determine the structure.

Chem NMR of 7

\[ \begin{align*}
\text{Chem NMR of 7} \\
\text{\textsuperscript{1}H NMR} \\
\text{\textsuperscript{13}C NMR}
\end{align*} \]
2D NMR Analysis

Work out Plan for 2D NMR analysis:

To establish the structure of the isolated reductive amination product 7 as 4-nitro-2-methylphenylamino aniline, the 2D NMR experiments of 7 were carried out and analyzed. The sequence of analysis are given below:

Identification of H\textsuperscript{1} proton: Assignment of H\textsuperscript{1} proton was essential as it is required for NOESY experiment (correlation between H\textsuperscript{1} and benzylic protons). Out of eight aromatic protons, the five aromatic protons of ring B comes as complex multiplets with the chemical shift ranges from 7.24-7.40. The remaining three protons of ring A appear as dd (\(\delta = 7.46-7.49\)) with coupling constant \(J = 8.7\) Hz (ortho coupling) and \(J = 2.5\) Hz (meta coupling), d (\(\delta = 7.11\)) with coupling
constant $J = 8.7$ Hz (ortho coupling), and $d$ ($\delta = 6.58$) with coupling constant $J = 2.4$ Hz (meta coupling). Out of these three protons, the ortho and meta coupling ($J = 8.7, J = 2.4$ Hz) is only possible with $H^2$ proton, the ortho coupling ($J = 8.7$ Hz) is only possible with $H^3$ proton and meta coupling ($J = 2.4$ Hz) is only possible with $H^1$ proton. Thus the splitting pattern and coupling constant were the key point to assign $H^1$ proton.

Next the DEPT-135 was carried out which eliminated the four quaternary aromatic carbons ($\delta = 144.29, 139.56, 137.48$, and $134.35$) and clearly differentiate the benzylic carbon ($\delta = 47.19$). Further the three carbons of ring B were differentiated on the basis of peak intensity ($\delta = 128.88, 127.74$, and $127.39$). Now we left with three aromatic carbons ($\delta = 116.29, 111.50$, and $104.61$) belonging to the aromatic ring A and this could be any of $H^1$, $H^2$, and $H^3$. 

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**Electronic Supplementary Material (ESI) for RSC Advances**

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Further validation of H\textsuperscript{1} proton was carried out using HSQC experiment which clearly correlated the H\textsuperscript{1} (δ = 7.11), H\textsuperscript{2} (δ = 7.48), and H\textsuperscript{3} (δ = 6.58) with respective carbon C1(δ = 104.61), C3(δ = 116.29), and C4 (δ = 111.50).
**NOESY Experiment:** Finally NOESY experiment was carried out and correlation between H1 proton and benzylic proton were established confirming the structure of 7 as 4-nitro-2-methylphenylamino aniline and not as 2-methylphenylamino-5-nitro aniline.