Electronic Supplementary Material (ESI) for Catalysis Science & Technology.

Supporting Information

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I. Characterization results of catalysts

Figure S1. BJH Desorption patterns of prepared catalysts with different kinds of metal chloride.

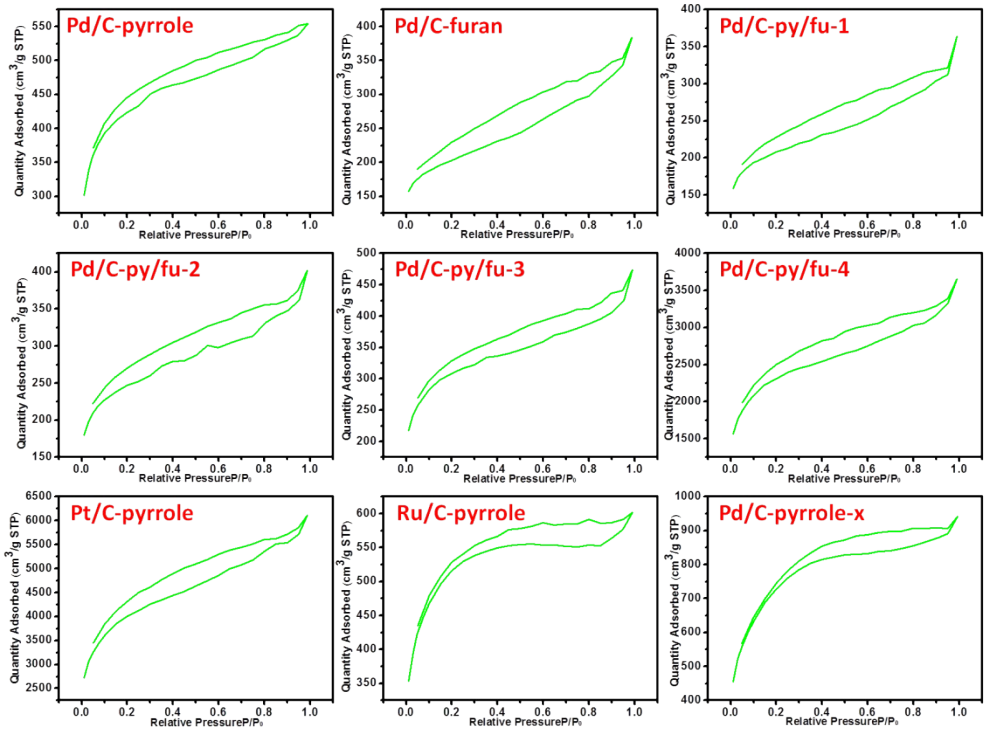


Figure S2. Energy dispersive X-ray spectroscopy (EDX) elemental line scans over different catalysts

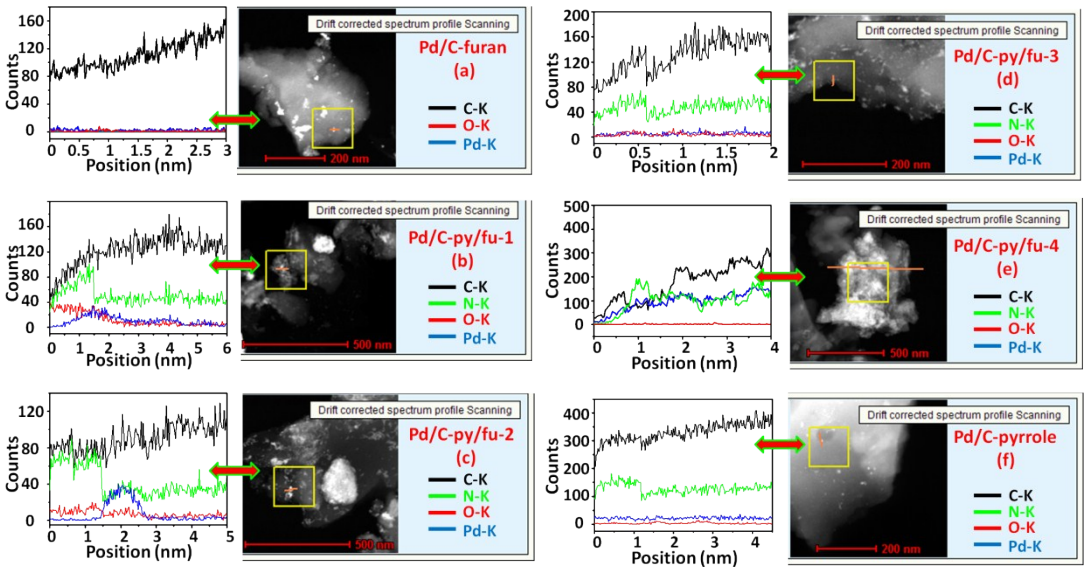


Figure S3. HR-TEM of catalyst samples.

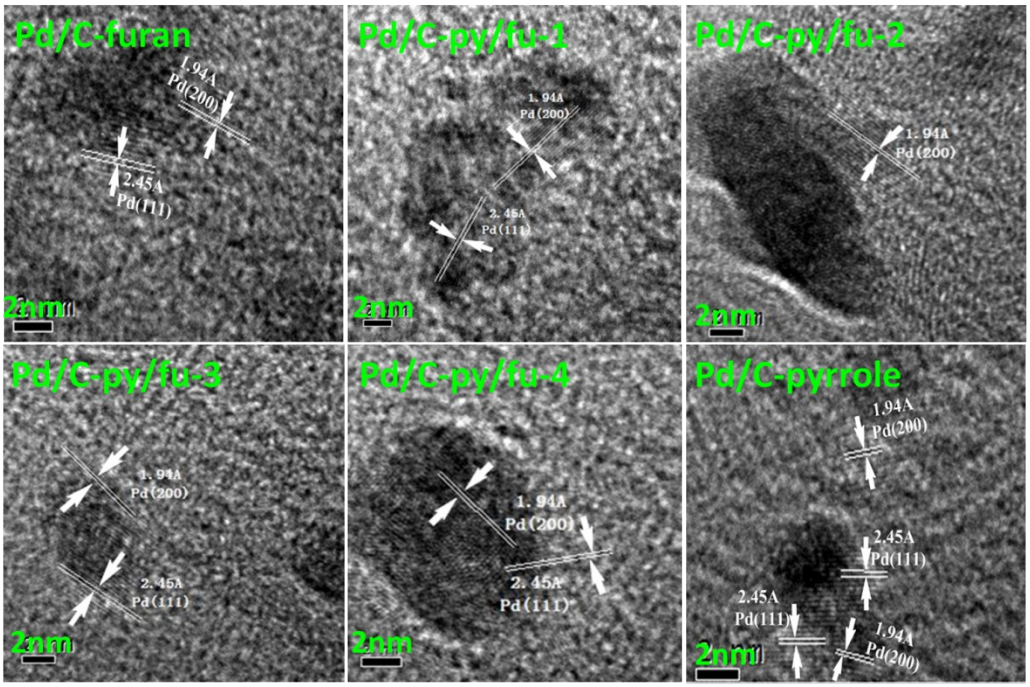


Figure S4. (SAED) patterns of catalyst samples.

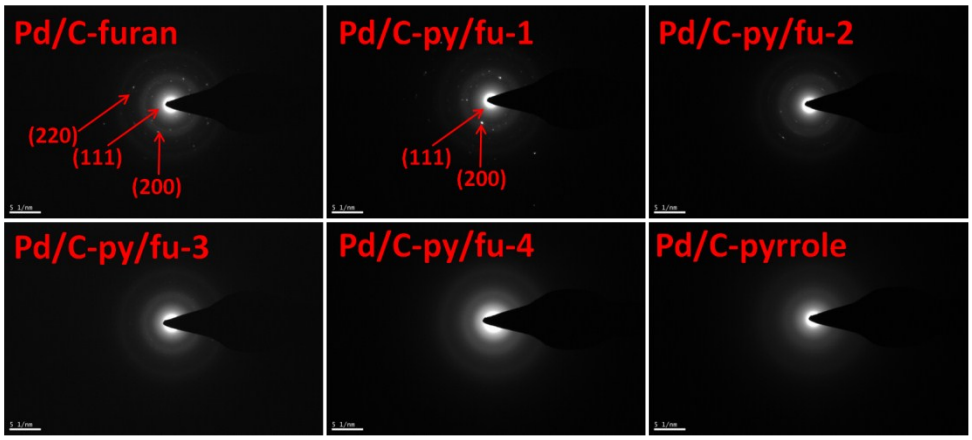


Figure S5. Typical XPS survey scans of catalyst samples.

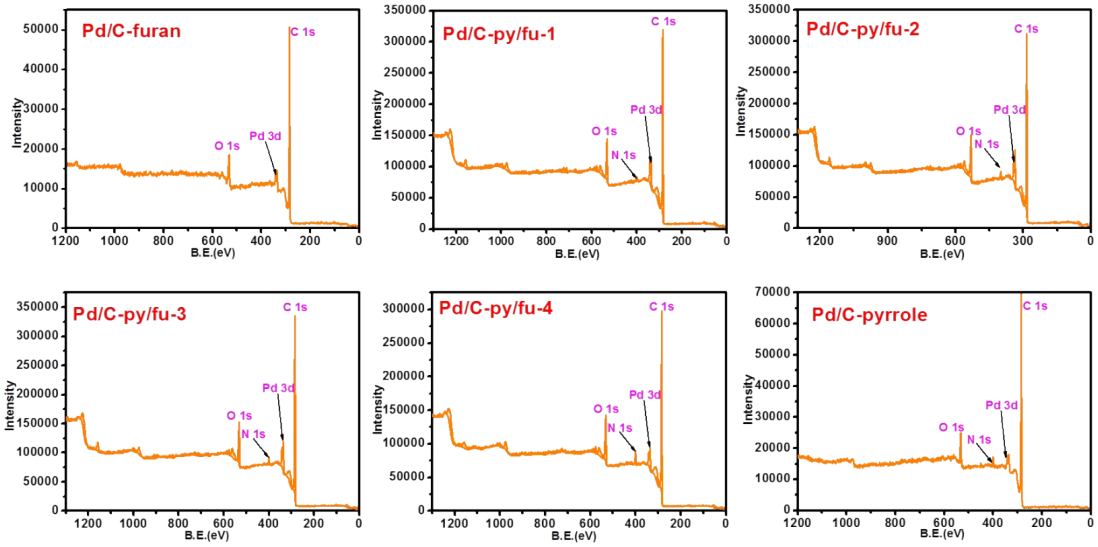
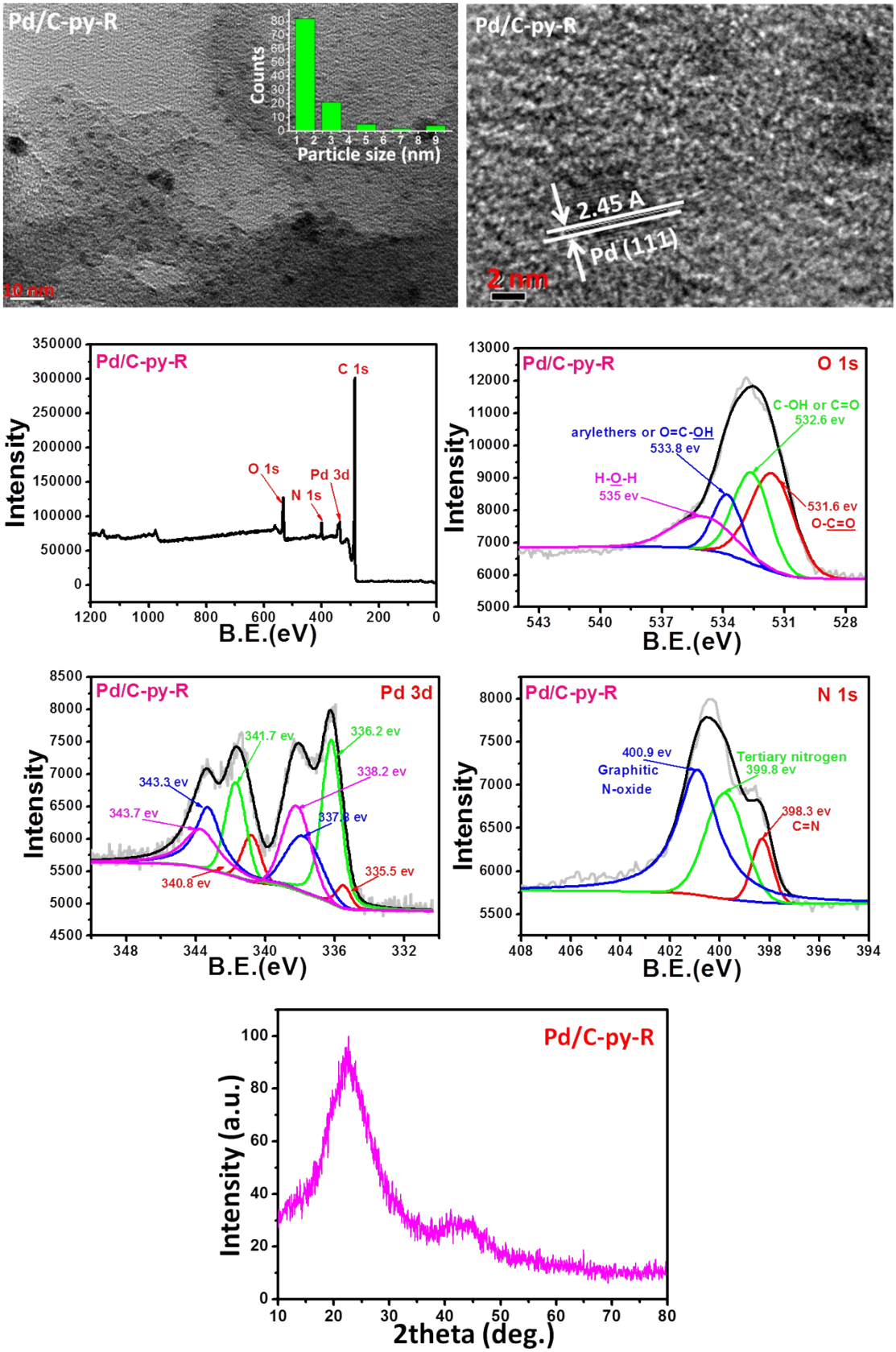
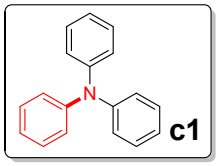


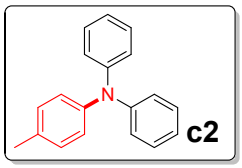
Figure S6. Characterization data of Pd/C-py-R catalyst sample.



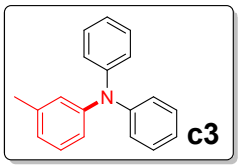
II. NMR peaks and MS-EI of all products



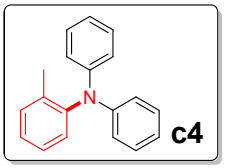
White solid; Mp = 124~126 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.31 (m, 6H), 7.22 – 7.15 (m, 6H), 7.11 (m, *J* = 9.2, 4.7, 3.1 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.99, 129.31, 124.28, 122.78. MS-EI calculated for 245.1204, found 245.1226



Yellowish solid; Mp = 65~67 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (t, *J* = 7.7 Hz, 4H), 7.15 (d, *J* = 7.8 Hz, 6H), 7.12 – 7.02 (m, 4H), 2.40 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.13, 145.36, 132.79, 130.01, 129.20, 125.03, 123.70, 122.31, 20.91. MS-EI calculated for 259.1361, found 259.1338

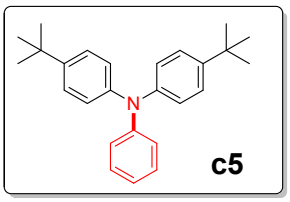


White solid; Mp = 128~131 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (m, *J* = 7.2, 1.9 Hz, 4H), 7.26 – 7.14 (m, 5H), 7.14 – 6.98 (m, 4H), 6.95 (t, *J* = 6.0 Hz, 1H), 2.37 (d, *J* = 5.8 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.11, 147.94, 139.15, 129.27, 129.17, 125.12, 124.20, 123.82, 122.61, 121.69, 21.53. MS-EI calculated for 259.1361, found 259.1327

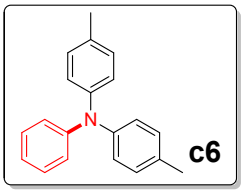


White solid; Mp = 53~55 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 – 7.19 (m, 7H), 7.17 – 7.14 (m, 1H), 7.01 (d, *J* = 7.7 Hz, 4H), 6.95 (t, *J* = 7.3 Hz, 2H), 2.07 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.53,

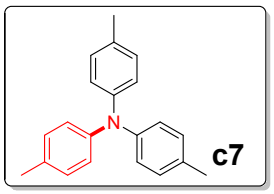
145.43, 136.54, 131.72, 129.65, 129.03, 127.36, 126.00, 121.57, 121.38, 18.57. MS-EI calculated for 259.1361, found 259.1374



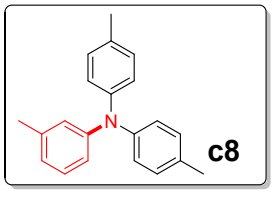
Yellowish solid; Mp = 127~129 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 – 7.31 (m, 7H), 7.15 – 7.11 (m, 6H), 1.44 (s, 18H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.30, 145.53, 145.33, 129.39, 126.21, 123.91, 123.51, 120.51, 34.27, 31.60. MS-EI calculated for 357.2457, found 357.2434



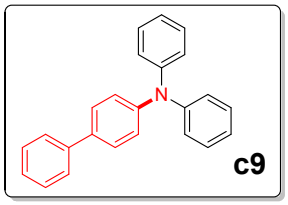
White solid; Mp = 106~109 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.09 – 7.05 (m, 2H), 6.93 (m, *J* = 4.7, 3.6 Hz, 6H), 6.87 (d, *J* = 8.5 Hz, 4H), 6.81 (t, *J* = 7.3 Hz, 1H), 2.18 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.40, 145.60, 132.35, 129.94, 129.13, 124.57, 123.08, 121.83, 20.89. MS-EI calculated for 273.1517, found 273.1541



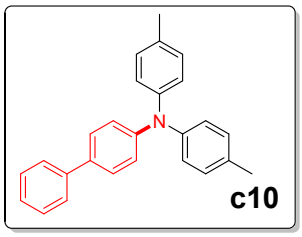
Yellowish solid; Mp = 114~116 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.01 (d, *J* = 8.3 Hz, 6H), 6.94 (d, *J* = 8.4 Hz, 6H), 2.27 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.82, 130.62, 129.04, 123.15, 20.24. MS-EI calculated for 287.1674, found 287.1703



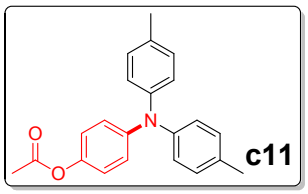
Yellowish solid; Mp = 51~53 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.08 – 6.94 (m, 9H), 6.88 – 6.72 (m, 3H), 2.28 (s, 6H), 2.21 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 148.36, 145.73, 138.93, 132.18, 129.91, 128.99, 124.51, 123.93, 122.90, 120.54, 21.55, 20.91. MS-EI calculated for 287.1674, found 287.1681



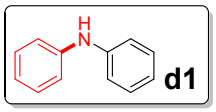
Yellow solid; Mp = 104~106 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (t, *J* = 7.3 Hz, 2H), 7.61 – 7.54 (m, 2H), 7.52 – 7.45 (m, 2H), 7.44 – 7.30 (m, 5H), 7.30 – 7.17 (m, 6H), 7.17 – 7.07 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.81, 147.29, 140.75, 135.25, 129.39, 128.84, 127.88, 126.90, 126.75, 124.52, 124.04, 123.03. MS-EI calculated for 321.1517, found 321.1532



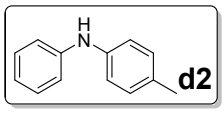
Yellow solid; Mp = 144~147 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (m, *J* = 7.1, 1.1 Hz, 2H), 7.64 – 7.49 (m, 4H), 7.42 (m, *J* = 7.4, 5.8 Hz, 1H), 7.36 – 7.00 (m, 10H), 2.47 (m, *J* = 8.3, 3.4 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 147.77, 145.43, 140.92, 134.33, 132.67, 130.07, 128.84, 127.75, 126.71, 124.84, 122.87, 20.98. MS-EI calculated for 349.1830, found 349.1853



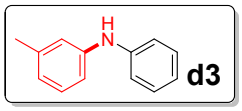
White solid; Mp = 145~147 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.94 (d, *J* = 8.4 Hz, 5H), 6.88 (t, *J* = 6.4 Hz, 5H), 6.84 – 6.78 (m, 2H), 2.20 (s, 6H), 2.16 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 169.76, 145.99, 145.42, 132.48, 129.94, 124.45, 123.59, 122.03, 21.14, 20.83. MS-EI calculated for 331.1572, found 331.1549



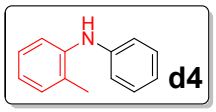
White solid; Mp = 52~54 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (m, *J* = 8.5, 3.2, 1.4 Hz, 4H), 7.16 – 7.12 (m, 4H), 7.03 – 6.98 (m, 2H), 5.75 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 143.21, 129.41, 121.09, 117.93. MS-EI calculated for 169.0891, found 169.0872



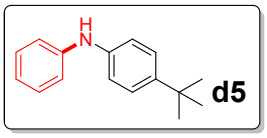
Yellowish solid; Mp = 87~88 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (m, *J* = 4.7, 2.8, 1.0 Hz, 2H), 7.16 (d, *J* = 8.0 Hz, 2H), 7.10 – 7.06 (m, 4H), 6.96 (m, *J* = 7.3, 2.6, 1.1 Hz, 1H), 5.65 (s, 1H), 2.38 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 144.05, 140.39, 130.98, 129.92, 129.37, 120.37, 119.00, 116.96, 20.74. MS-EI calculated for 183.1048, found 183.1021



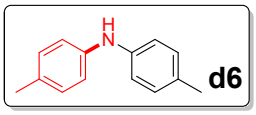
Yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.33 (m, *J* = 11.8, 4.0 Hz, 2H), 7.21 (d, *J* = 8.3 Hz, 1H), 7.15 – 7.11 (m, 2H), 7.02 – 6.93 (m, 3H), 6.83 (d, *J* = 7.5 Hz, 1H), 5.70 (s, 1H), 2.38 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 143.32, 143.15, 139.27, 129.37, 129.23, 121.95, 120.93, 118.60, 117.90, 115.01, 21.58. MS-EI calculated for 183.1048, found 183.1026



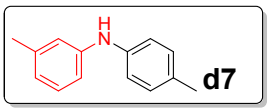
White solid; Mp = 134~137 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 (t, *J* = 7.4 Hz, 3H), 7.29 (d, *J* = 7.3 Hz, 1H), 7.23 (t, *J* = 7.6 Hz, 1H), 7.06 – 6.97 (m, 4H), 5.45 (s, 1H), 2.34 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 144.11, 141.30, 131.03, 129.38, 126.85, 122.12, 120.53, 119.00, 117.52, 17.96. MS-EI calculated for 183.1048, found 183.1068



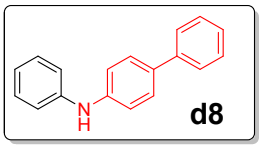
White solid; Mp = 55~57 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.22 (m, *J* = 16.2, 7.9 Hz, 5H), 7.03 (m, *J* = 22.2, 8.2 Hz, 4H), 5.35 (s, 1H), 1.30 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 145.45, 145.20, 129.02, 125.97, 123.78, 123.40, 121.89, 34.27, 31.46. MS-EI calculated for 225.1517, found 225.1508



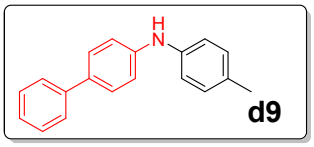
White solid; Mp = 76~79 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.95 (t, *J* = 9.7 Hz, 4H), 6.86 (t, *J* = 7.7 Hz, 4H), 5.29 (s, 1H), 2.20 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 141.22, 129.85, 123.92, 117.99, 20.66. MS-EI calculated for 197.1204, found 197.1231



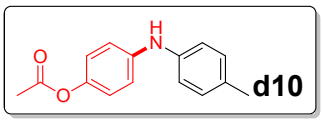
Yellowish solid; Mp = 131~133 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.09 (dt, *J* = 17.8, 8.8 Hz, 3H), 6.99 (d, *J* = 8.4 Hz, 2H), 6.82 (d, *J* = 7.6 Hz, 2H), 6.70 (d, *J* = 7.4 Hz, 1H), 5.58 (s, 1H), 2.29 (d, *J* = 4.3 Hz, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 143.95, 140.44, 139.17, 130.83, 129.84, 129.15, 121.23, 118.98, 117.59, 114.05, 21.53, 20.68. MS-EI calculated for 197.1204, found 197.1235



Yellowish solid; Mp = 109~111 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (d, *J* = 7.9 Hz, 2H), 7.48 (s, 2H), 7.38 (d, *J* = 7.6 Hz, 2H), 7.30 – 7.25 (m, 3H), 7.10 (d, *J* = 7.8 Hz, 4H), 6.93 (d, *J* = 7.3 Hz, 1H), 5.72 (s, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 142.94, 142.64, 140.92, 133.82, 129.47, 128.82, 128.04, 126.67, 126.61, 121.33, 118.20, 117.90. MS-EI calculated for 245.1204, found 245.1193



Yellowish solid; Mp = 132~135 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.52 (m, 2H), 7.46 – 7.44 (m, 2H), 7.40 – 7.36 (m, 2H), 7.25 (d, *J* = 7.0 Hz, 1H), 7.08 – 7.00 (m, 6H), 5.67 (s, 1H), 2.30 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 143.51, 140.99, 138.81, 133.06, 129.22, 128.78, 127.82, 127.44, 126.51, 124.14, 119.23, 116.96, 20.78. MS-EI calculated for 259.1361, found 259.1347



White solid; Mp = 92~96 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.07 (d, *J* = 8.1 Hz, 2H), 7.03 – 6.86 (m, 6H), 5.60 (s, 1H), 2.29 (s, 3H), 2.27 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 170.02, 144.11, 141.85, 140.42, 131.02, 129.91, 122.23, 118.81, 117.73, 21.09, 20.68. MS-EI calculated for 241.1103, found 241.1127

III.NMR spectra of all products

Figure S7. ^{1}HNMR of **c1**

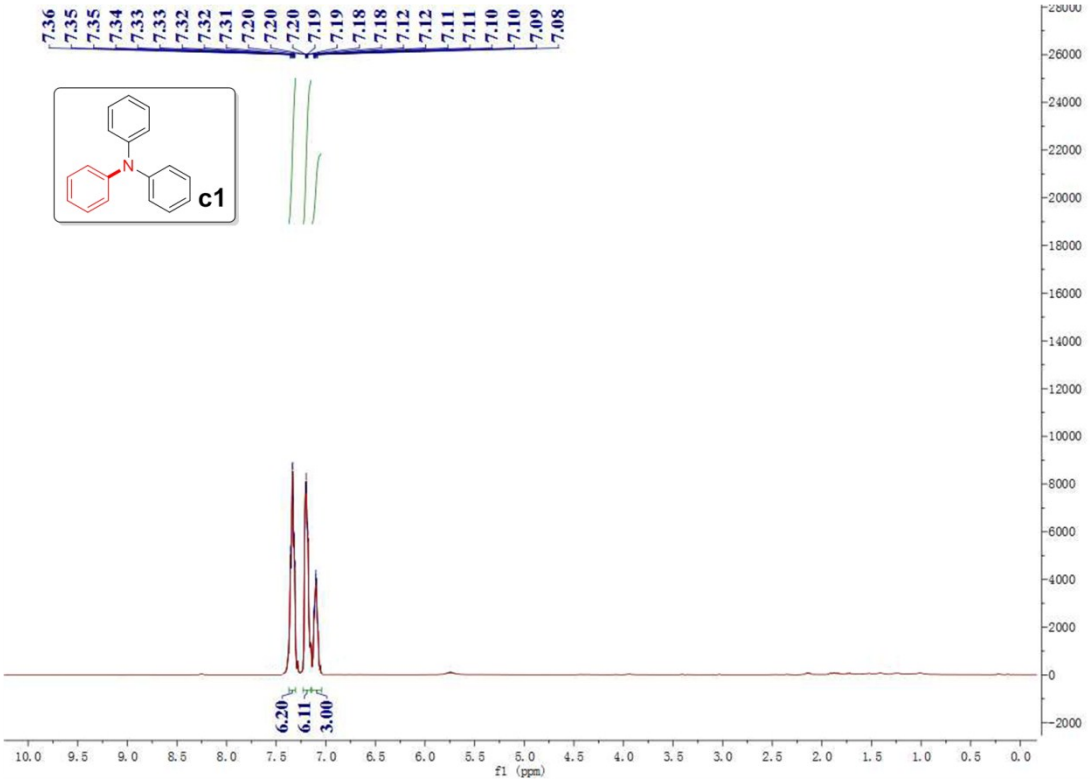


Figure S8. ^{13}CNMR of **c1**

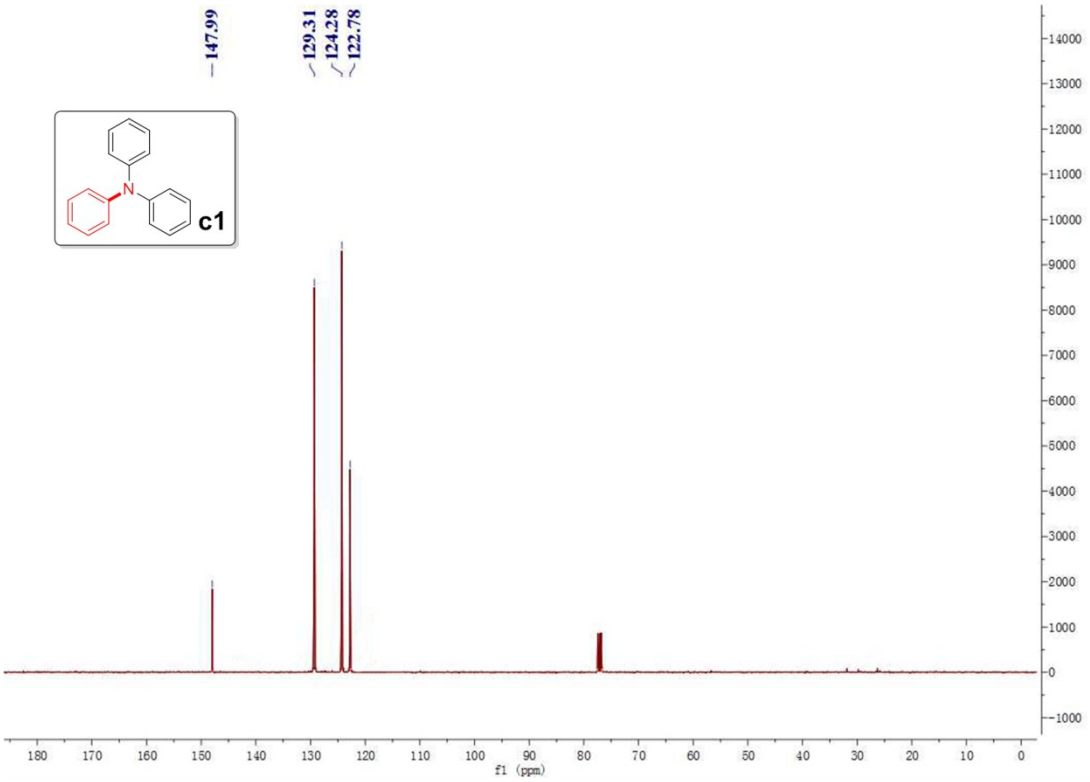


Figure S9. ^{1}HNMR of **c2**

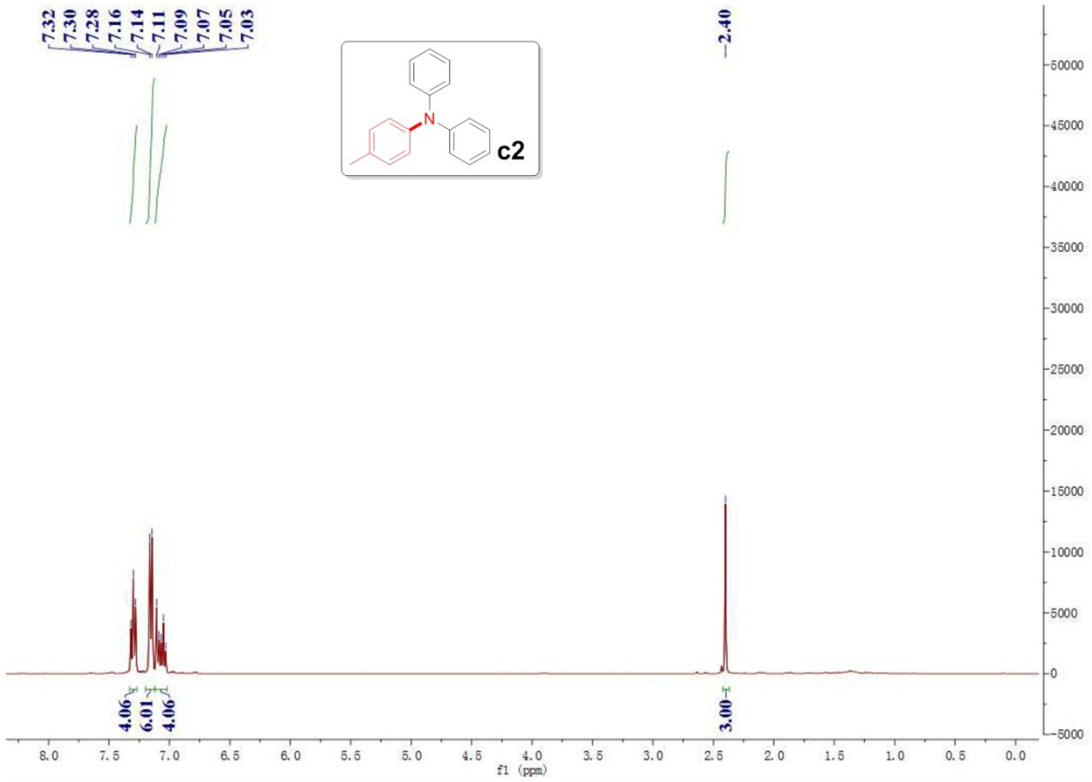


Figure S10. ^{13}CNMR of **c2**

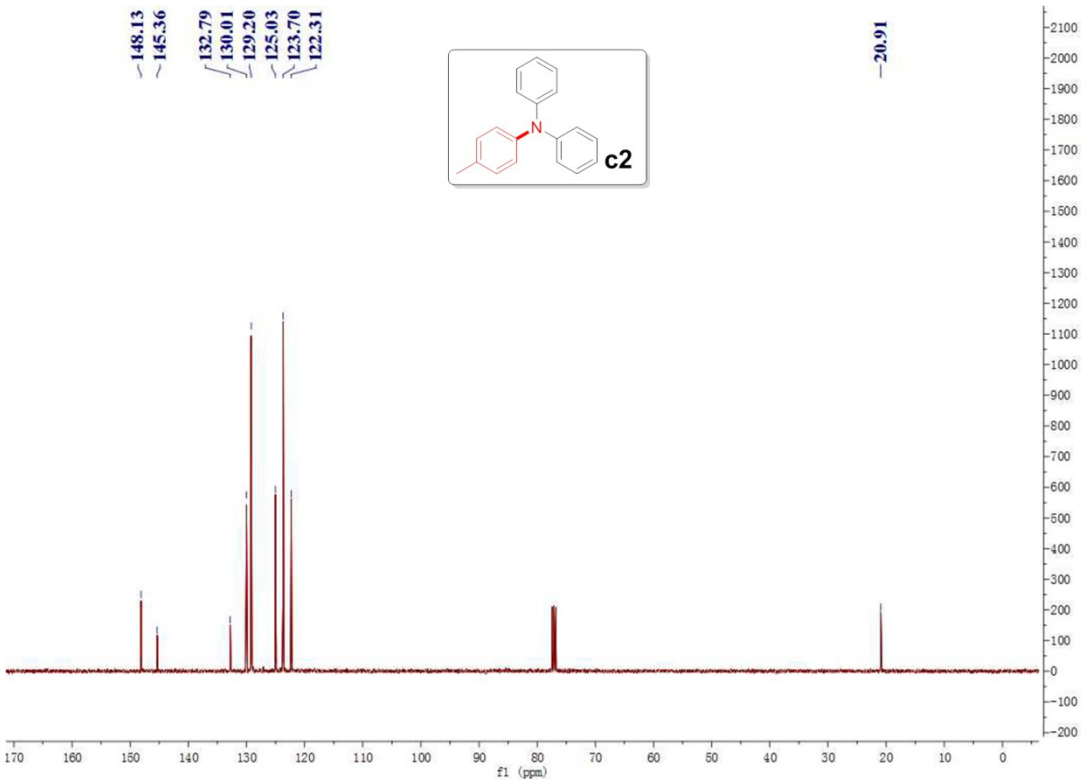


Figure S11. ^{1}HNMR of **c3**

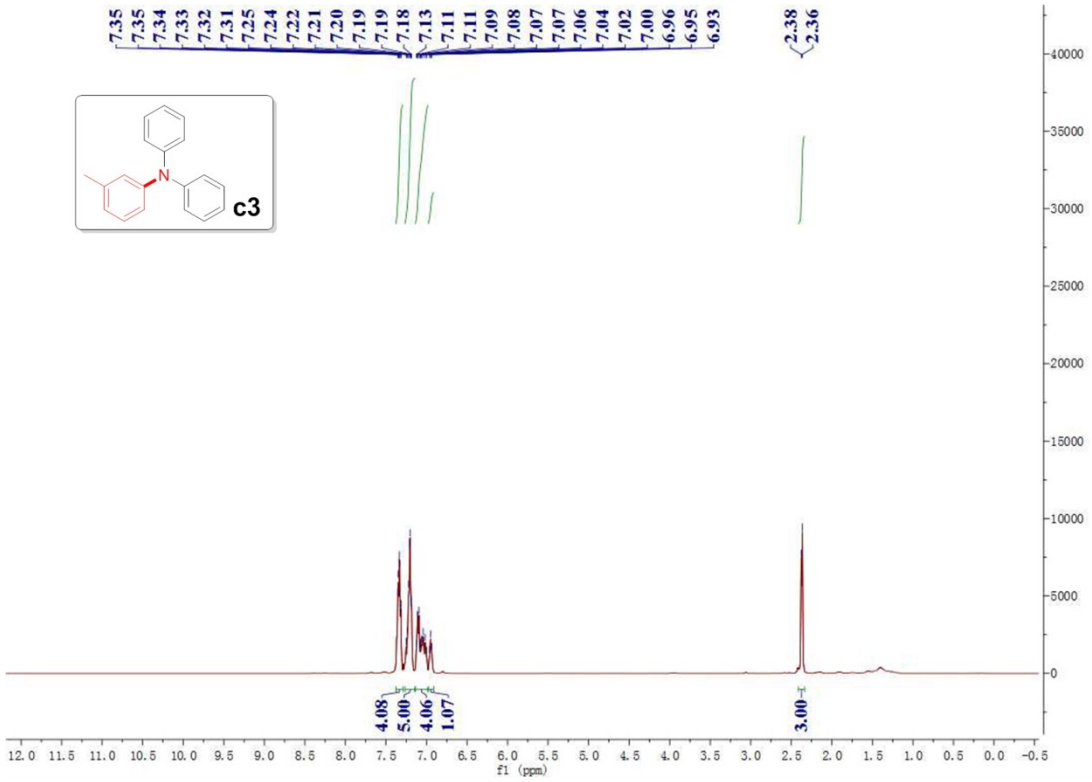


Figure S12. ^{13}CNMR of **c3**

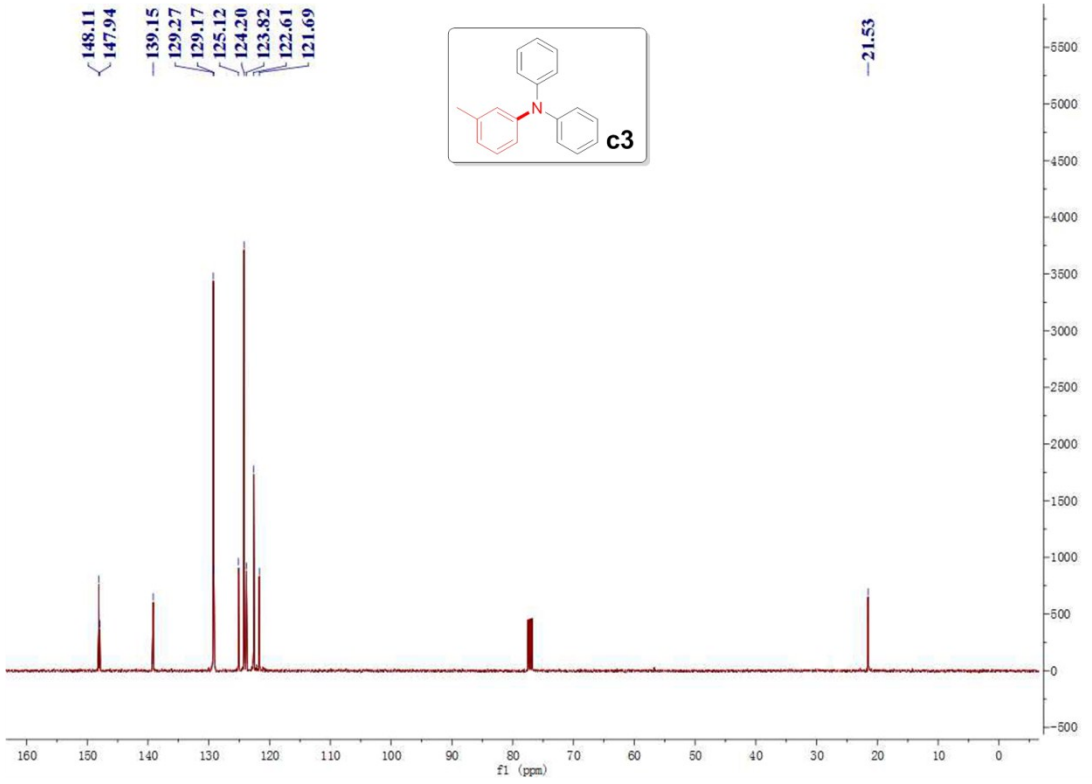


Figure S13. ^{1}HNMR of **c4**

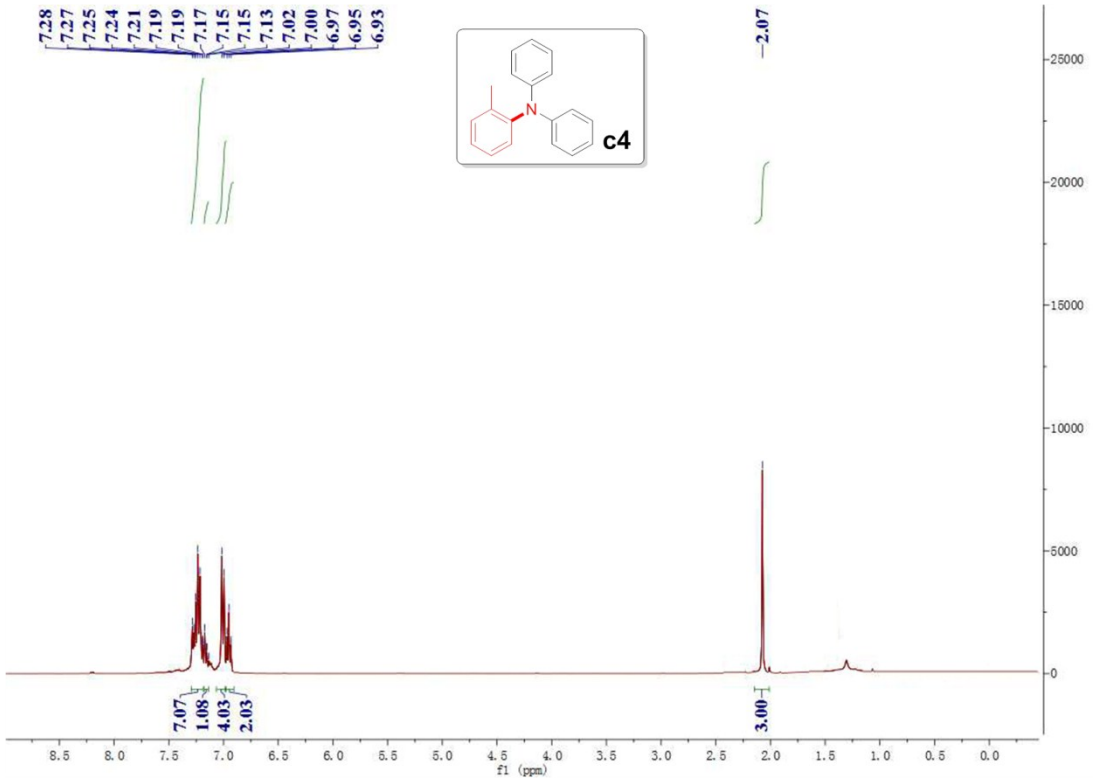


Figure S14. ^{13}CNMR of **c4**

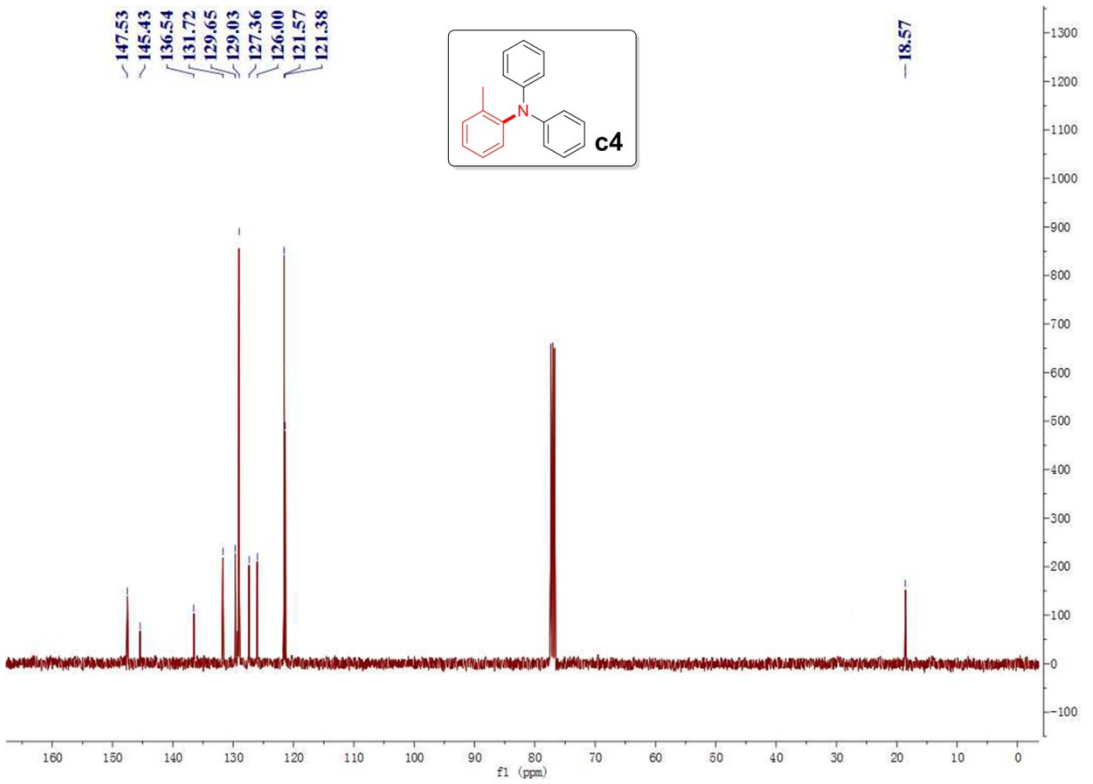


Figure S15. ^{1}HNMR of **c5**

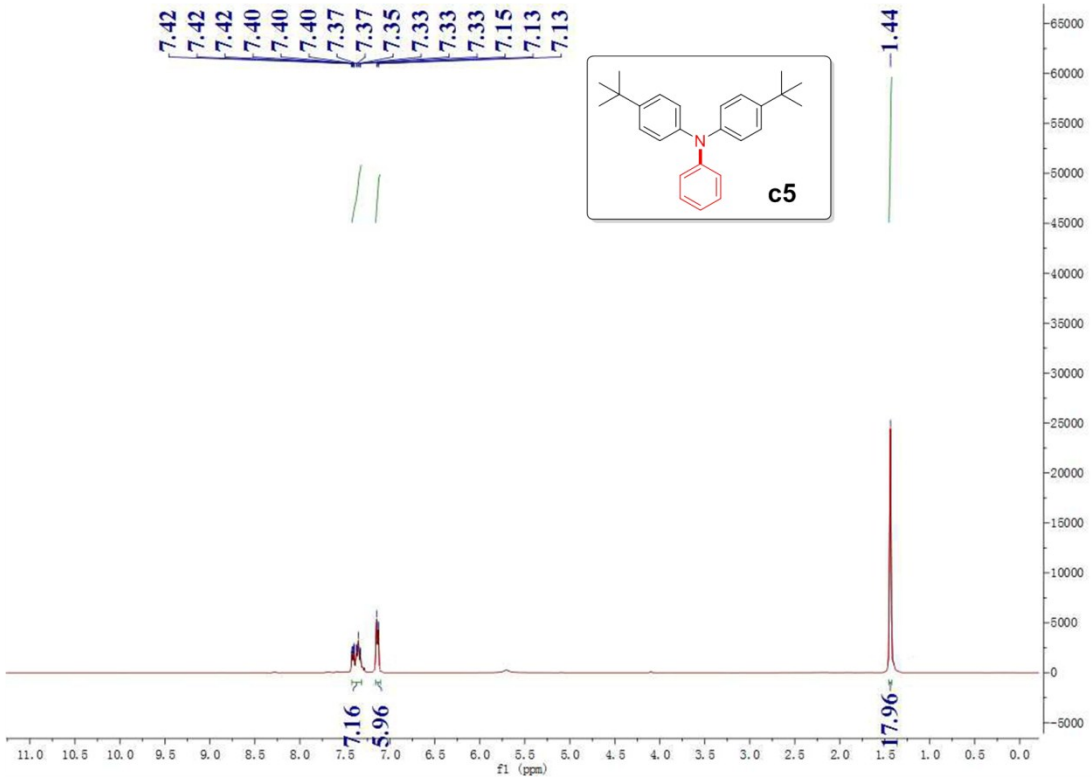


Figure S16. ^{13}CNMR of **c5**

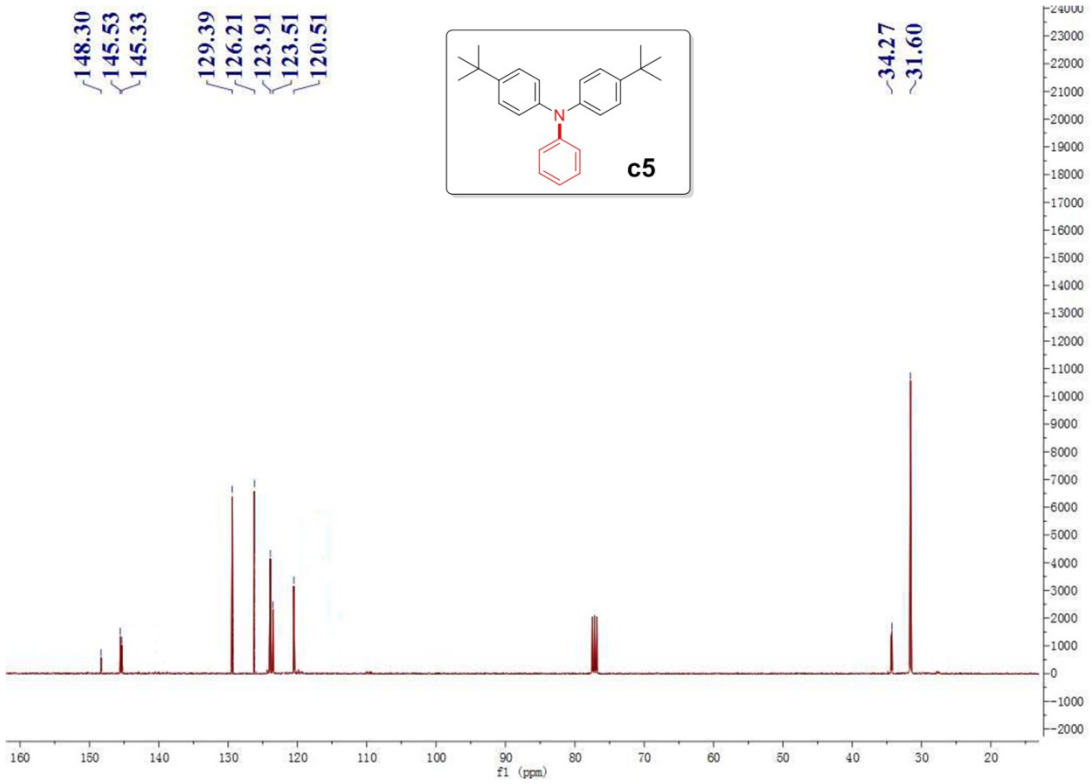


Figure S17. ^{1}HNMR of **c6**

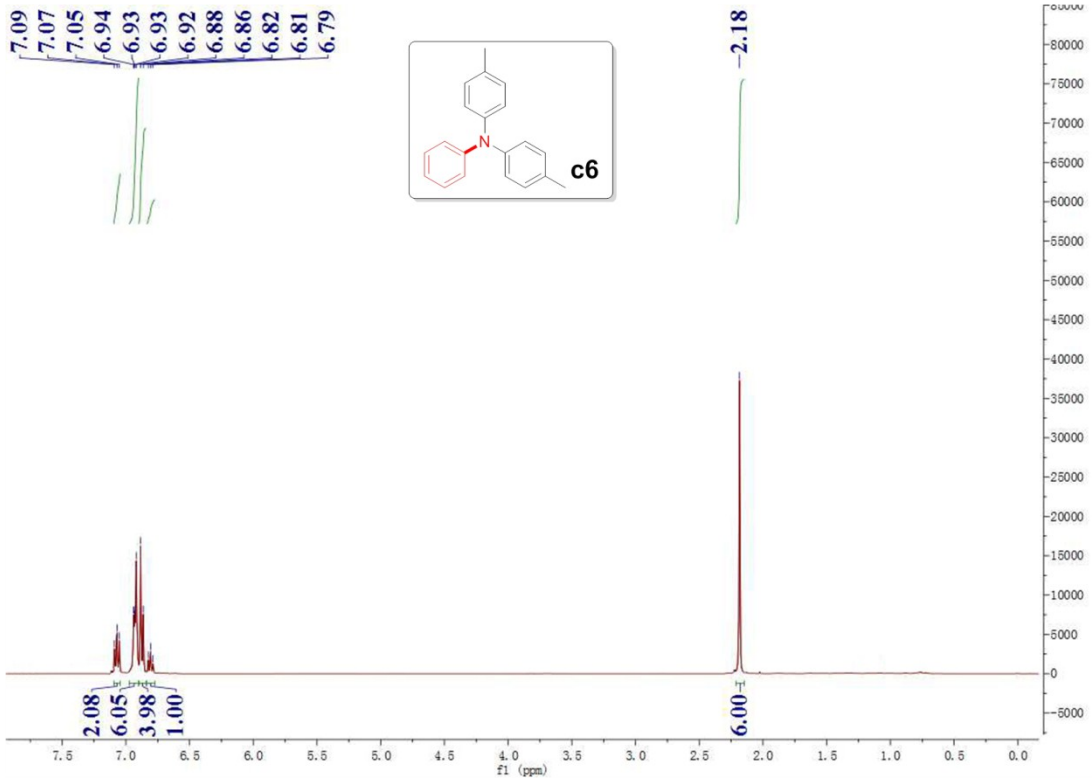


Figure S18. ^{13}CNMR of **c6**

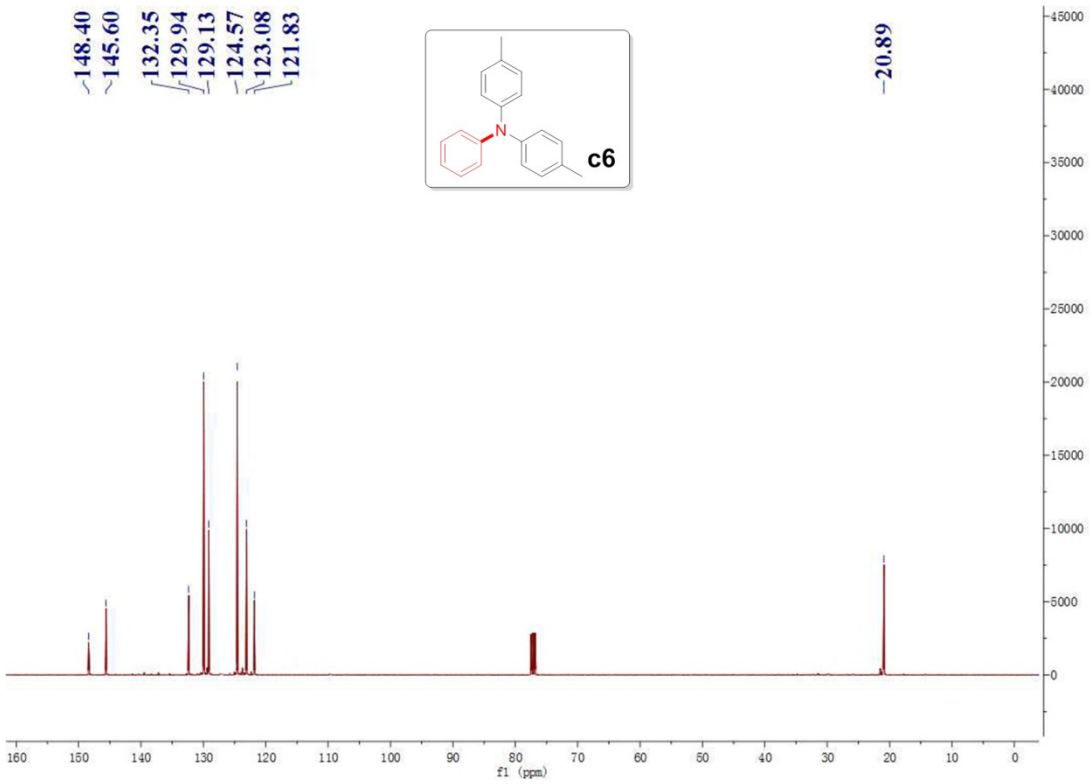


Figure S19. ^{1}HNMR of **c7**

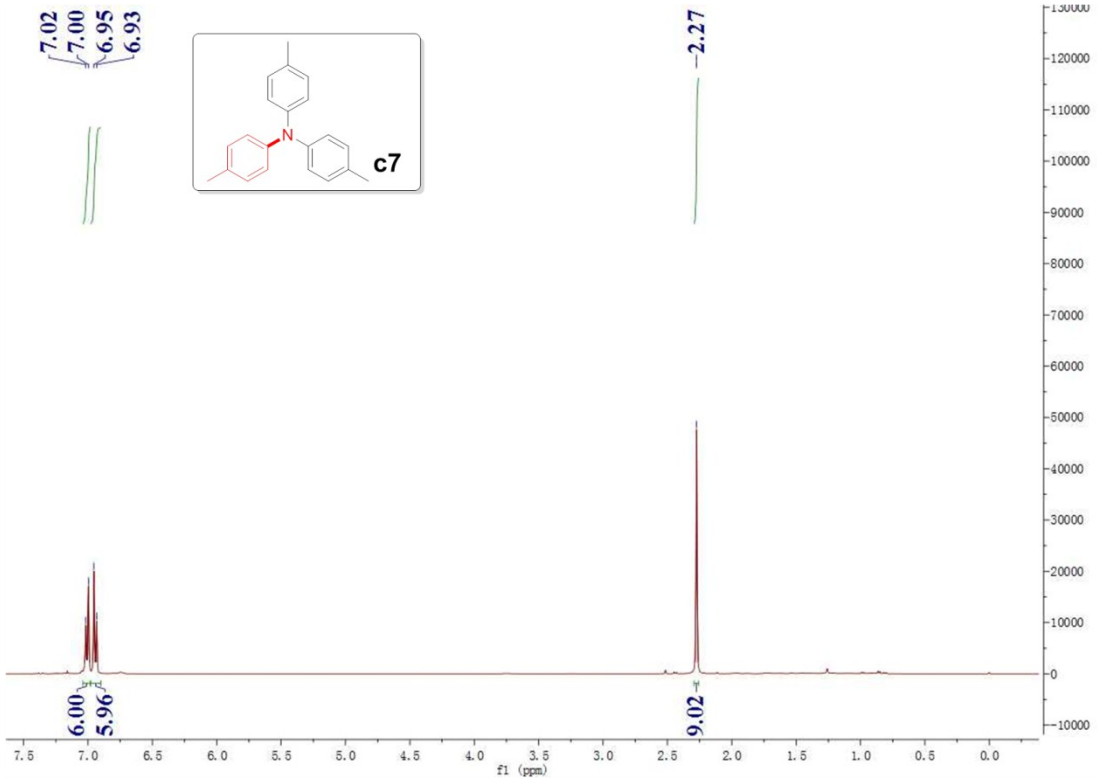


Figure S20. ^{13}CNMR of **c7**

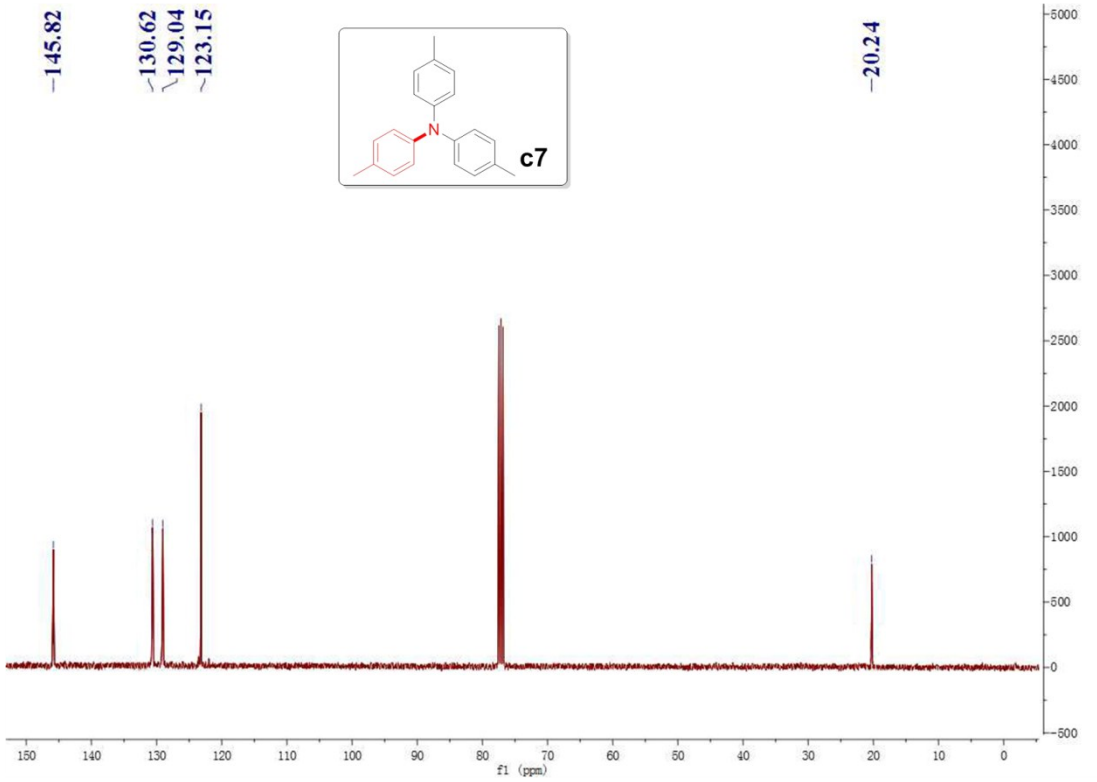


Figure S21. ^{1}HNMR of **c8**

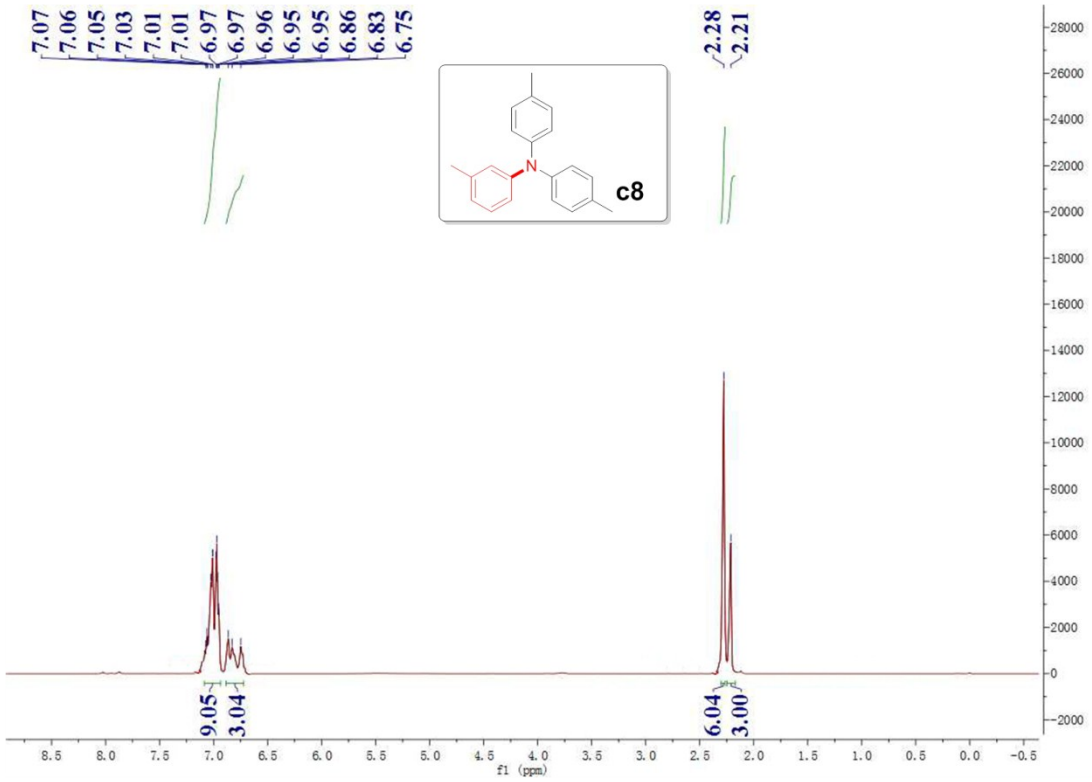


Figure S22. ^{13}CNMR of **c8**

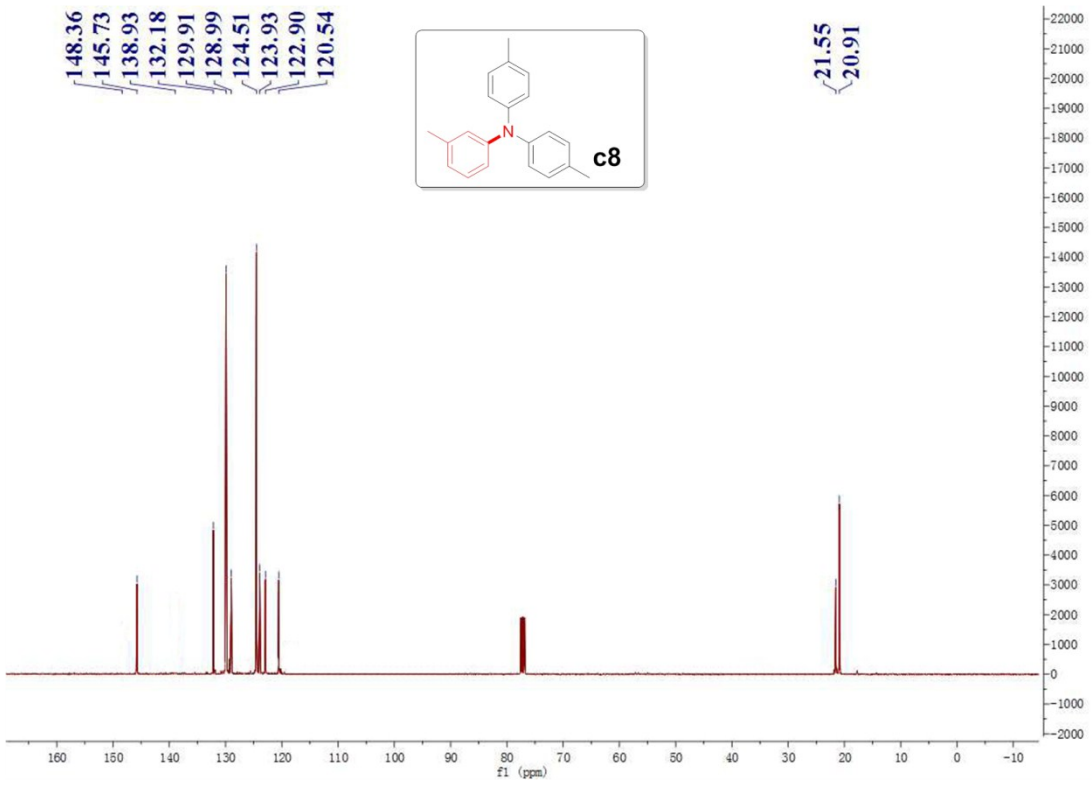


Figure S23. ^{1}HNMR of **c9**

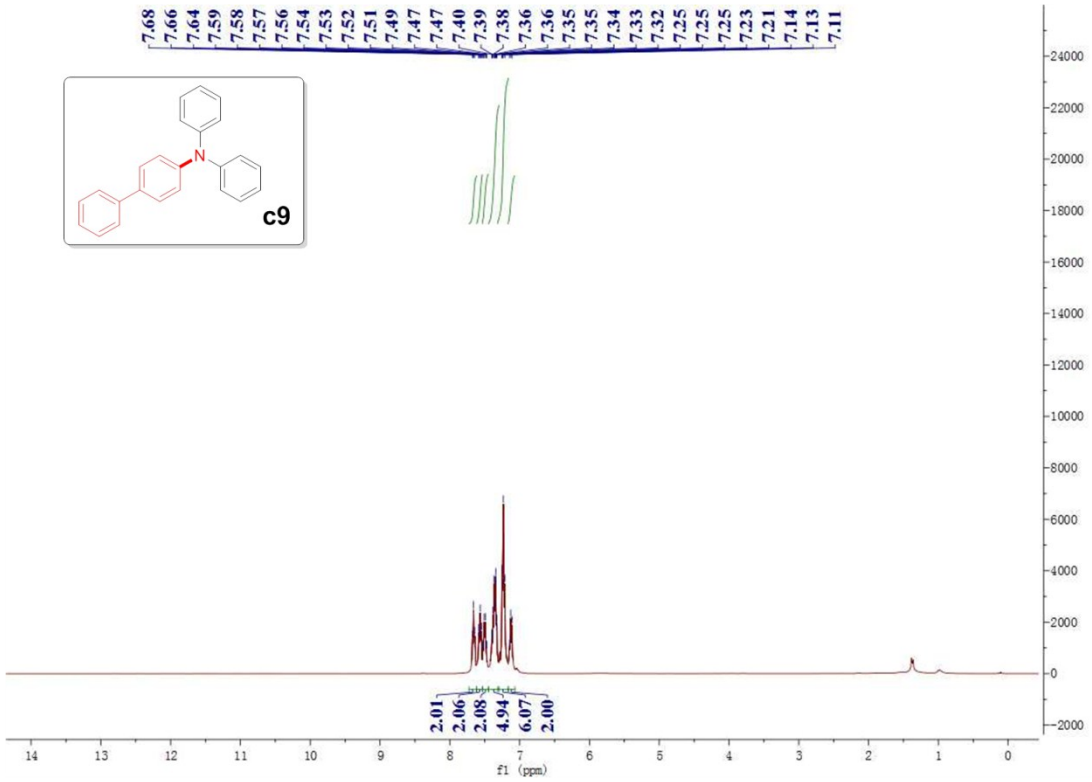


Figure S24. ^{13}CNMR of **c9**

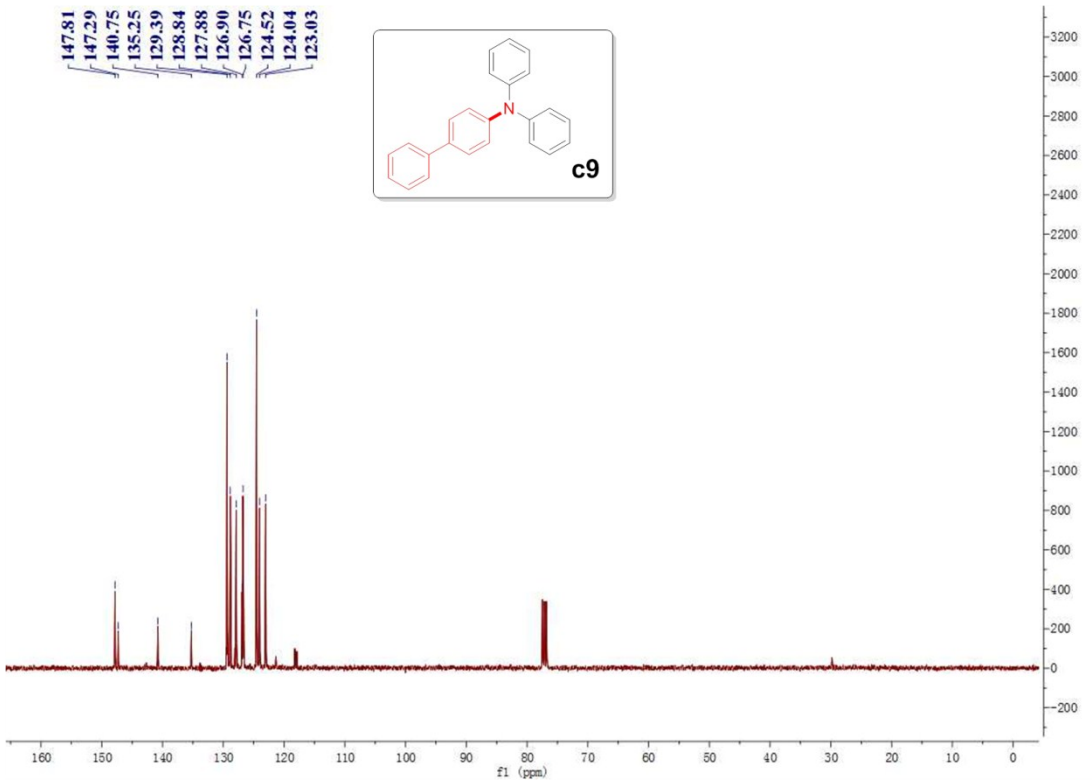


Figure S25. ^{1}HNMR of **c10**

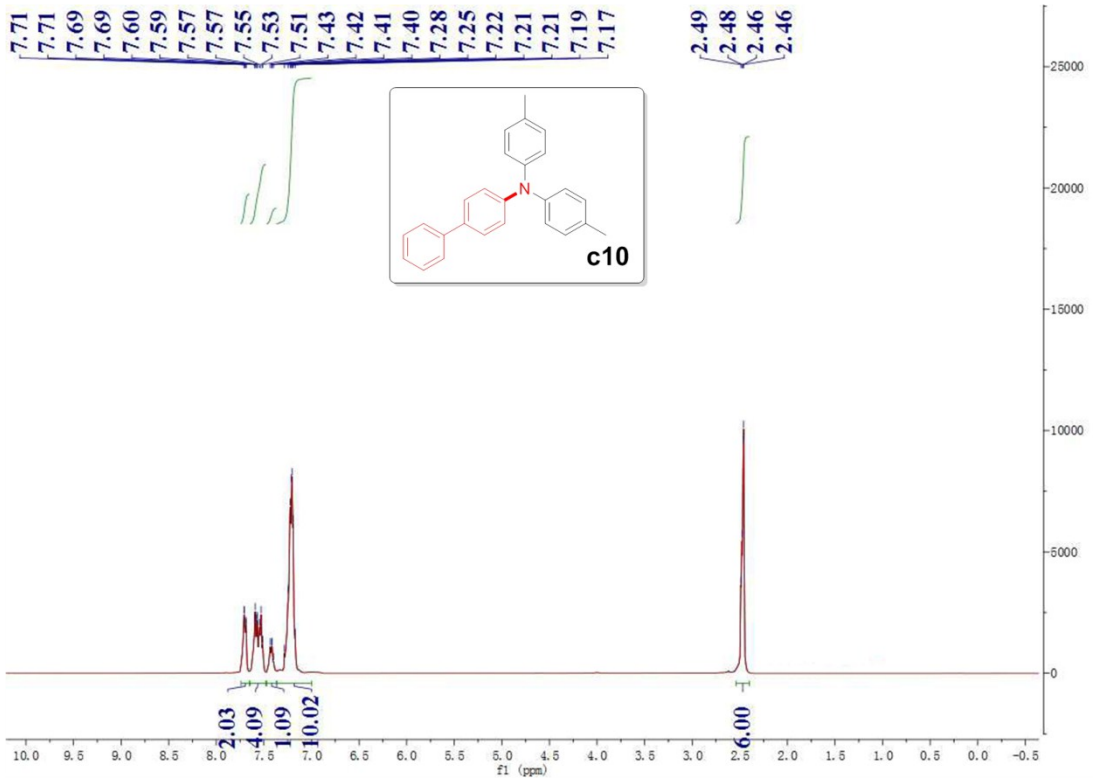


Figure S26. ^{13}CNMR of **c10**

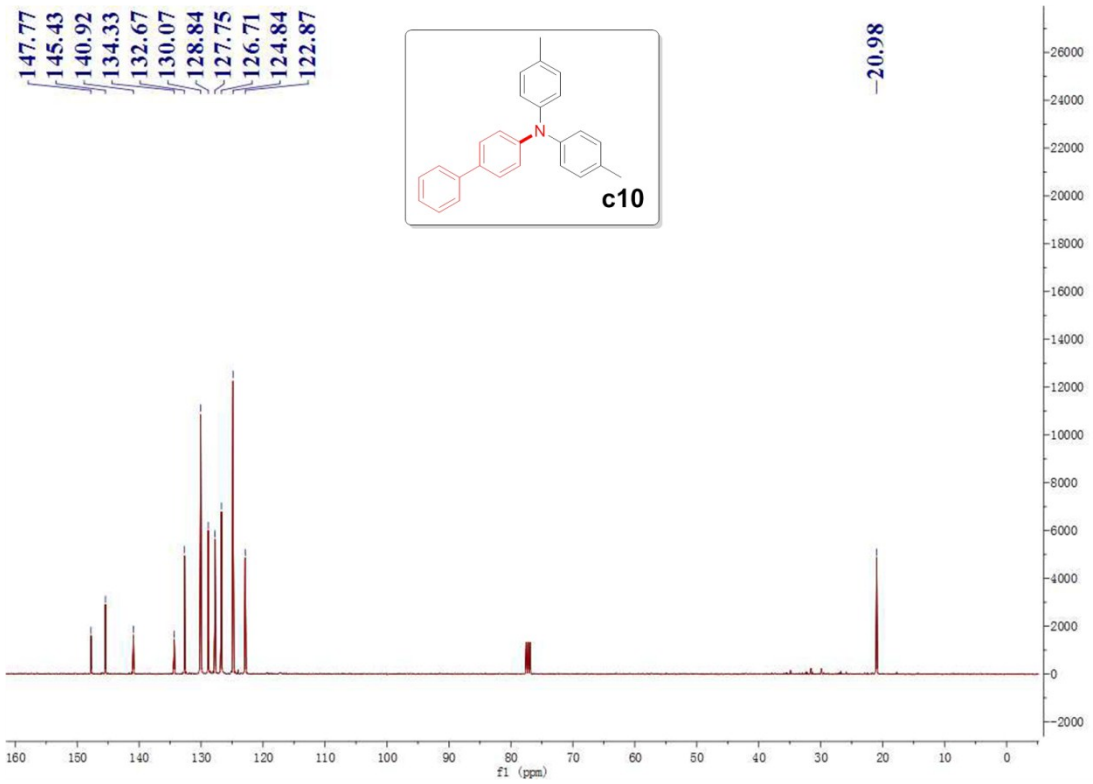


Figure S27. ^{1}HNMR of **c11**

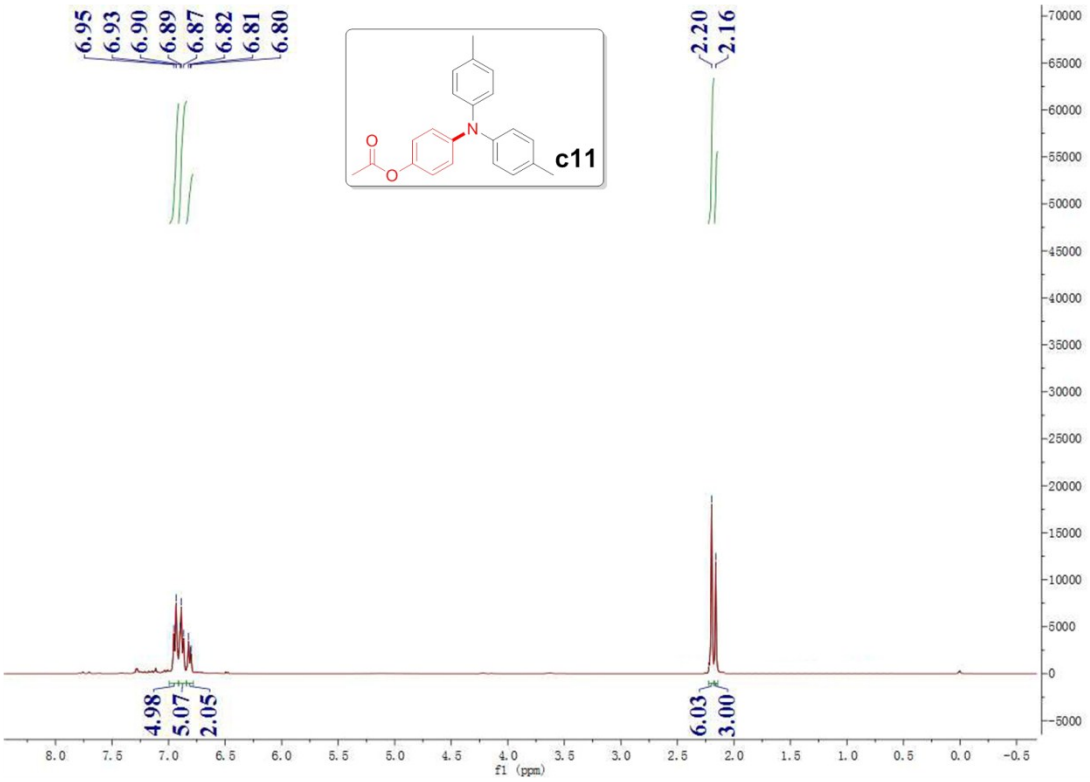


Figure S28. ^{13}CNMR of **c11**

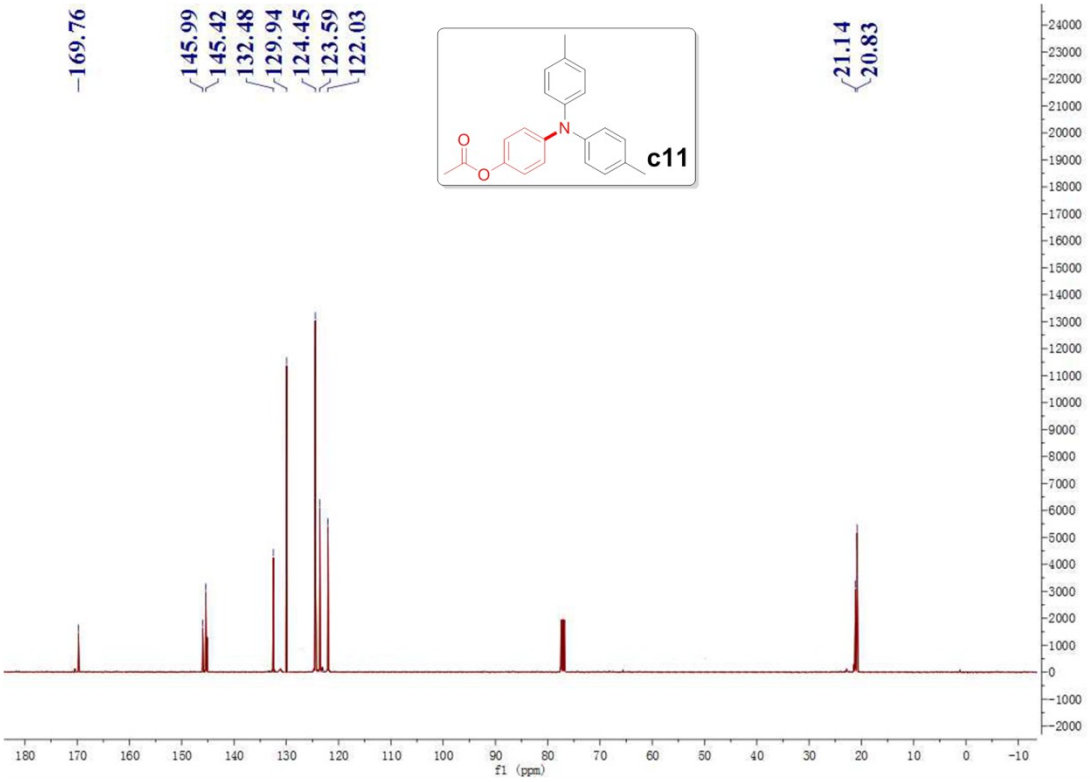


Figure S29. ^{1}HNMR of **d1**

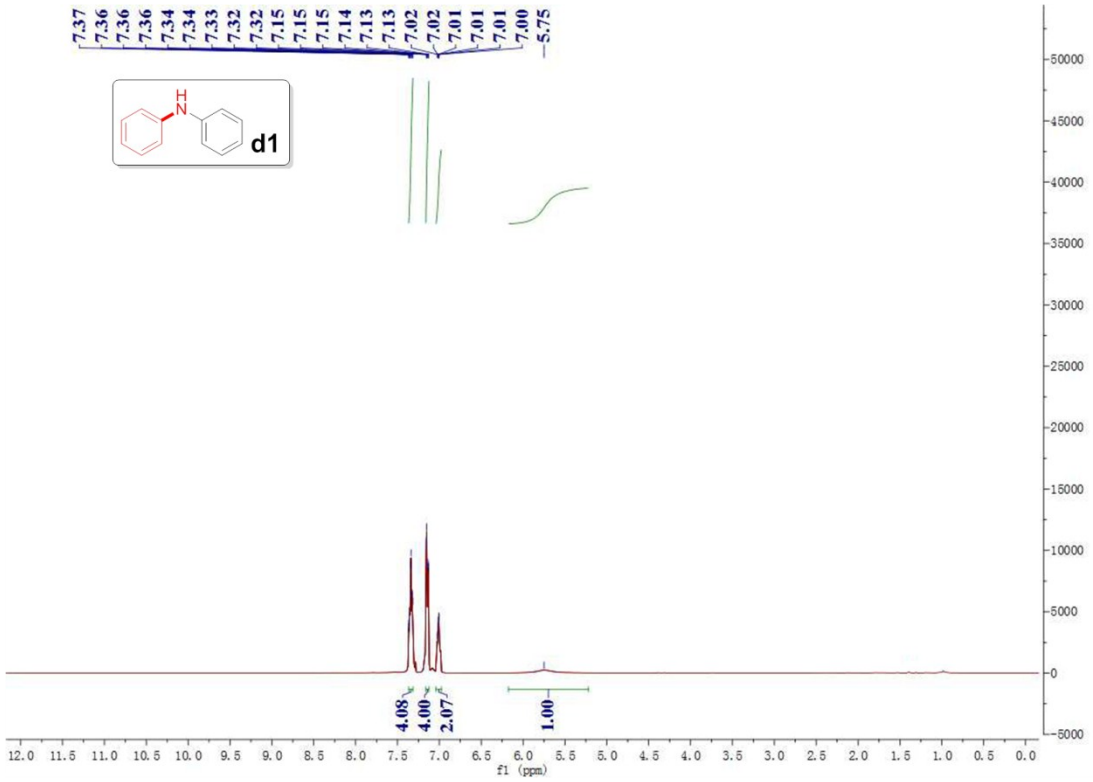


Figure S30. ^{13}CNMR of **d1**

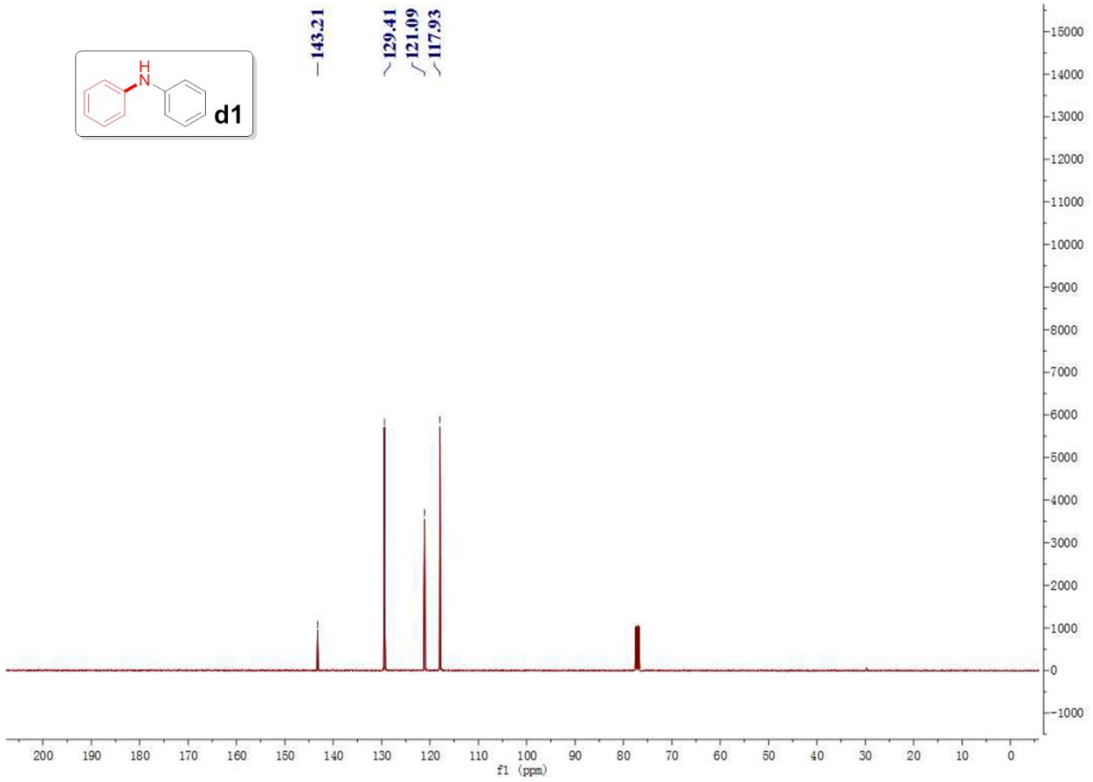


Figure S31. ^{1}HNMR of **d2**

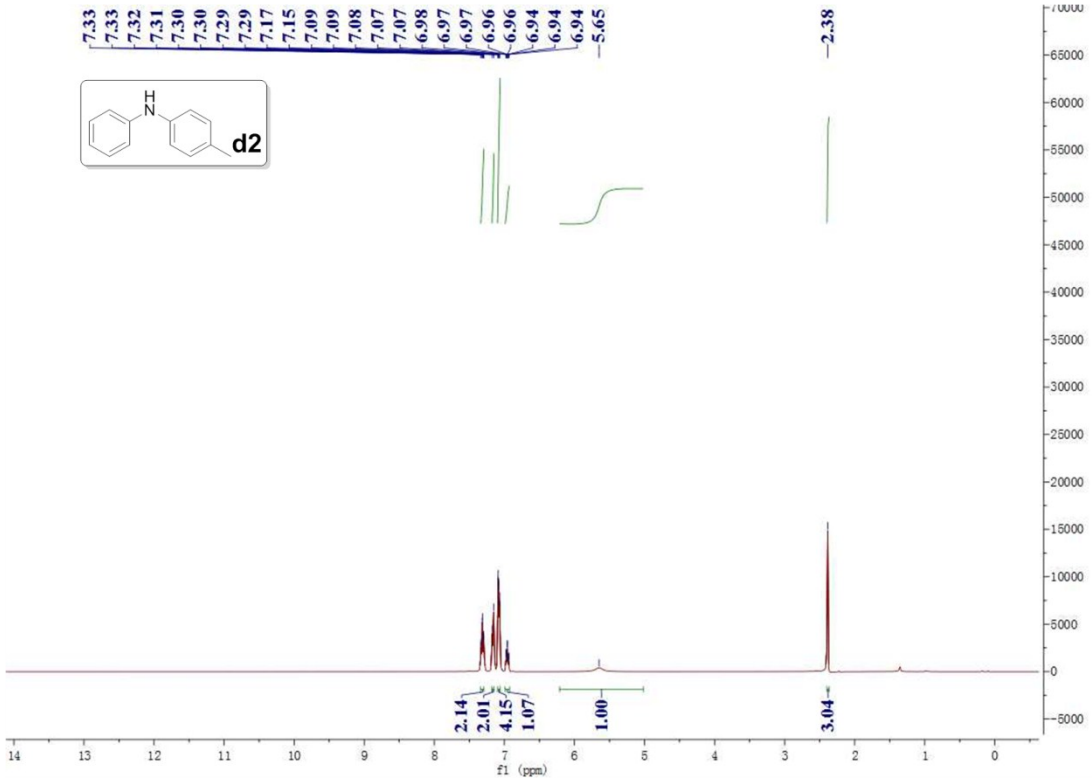


Figure S32. ^{13}CNMR of **d2**

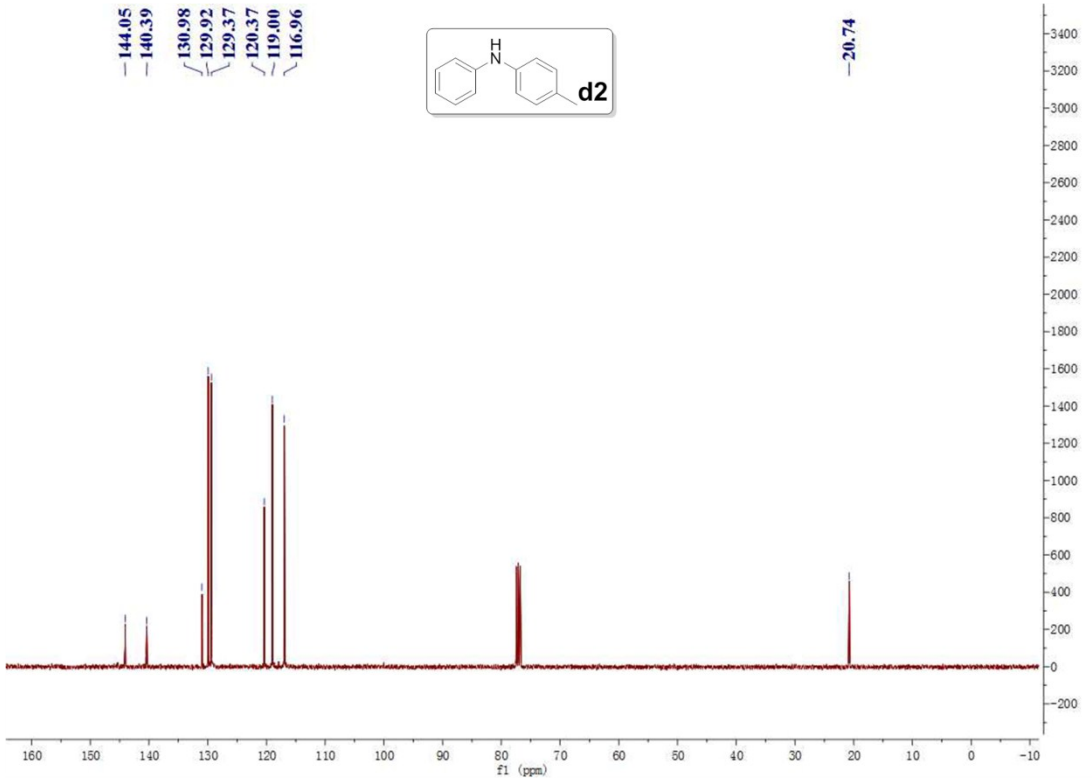


Figure S33. ^{1}HNMR of **d3**

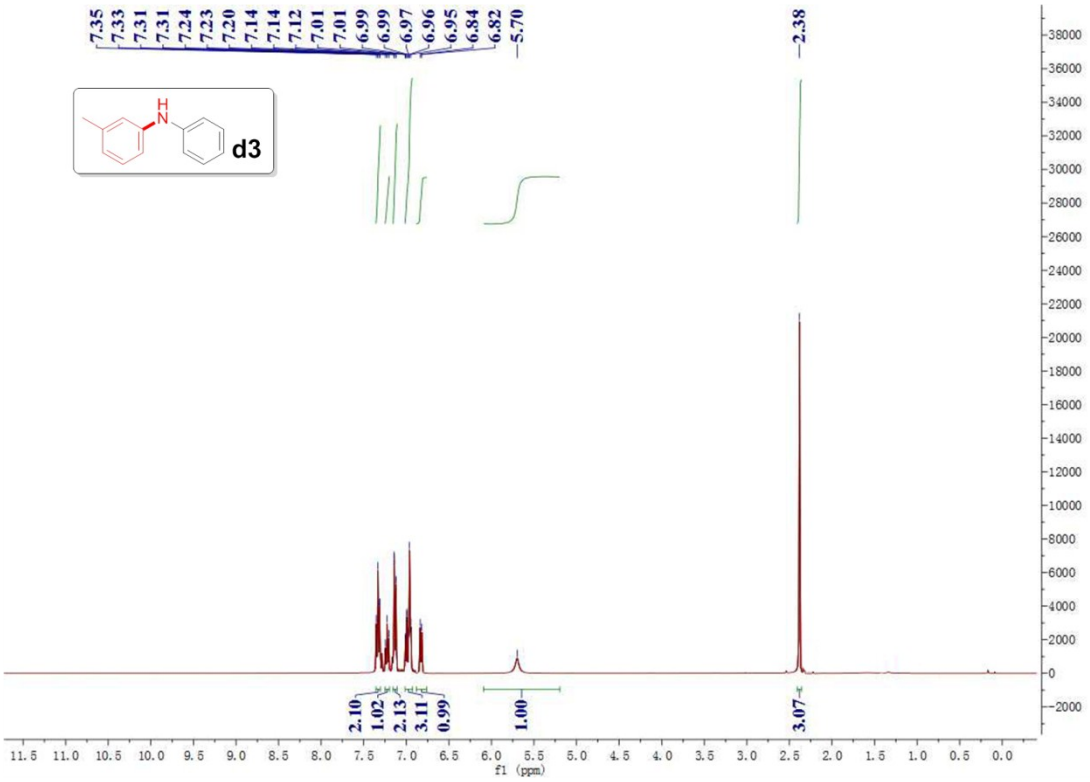


Figure S34. ^{13}CNMR of **d3**

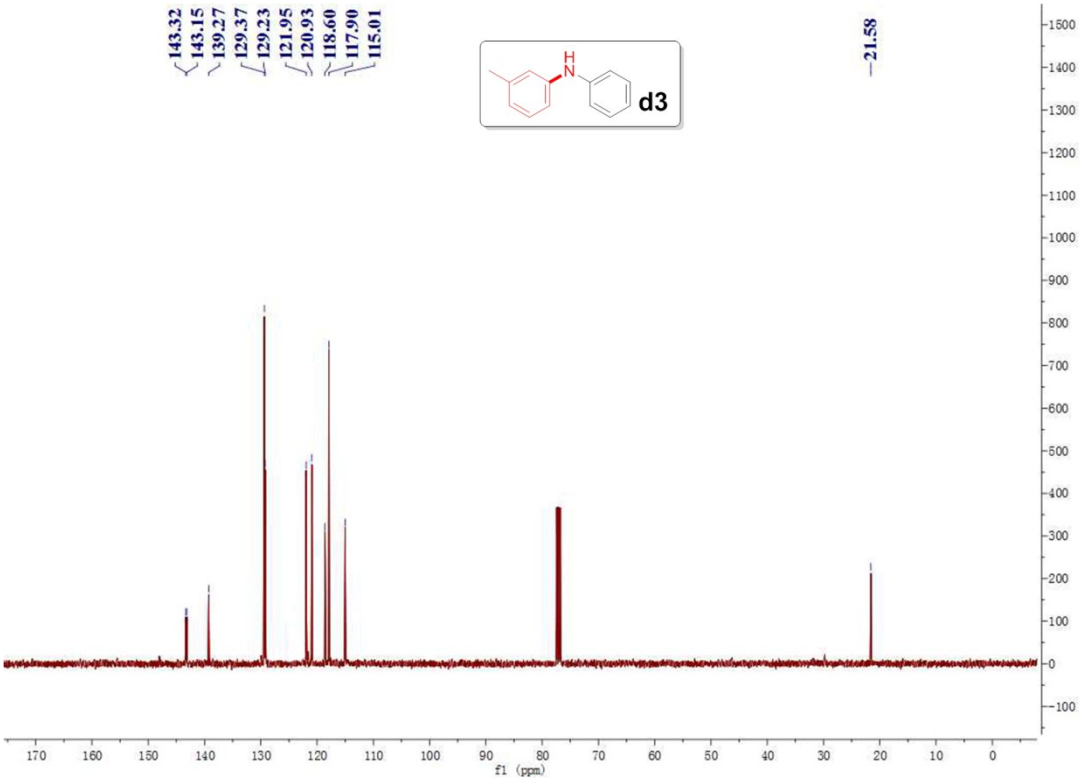


Figure S35. ^{1}HNMR of **d4**

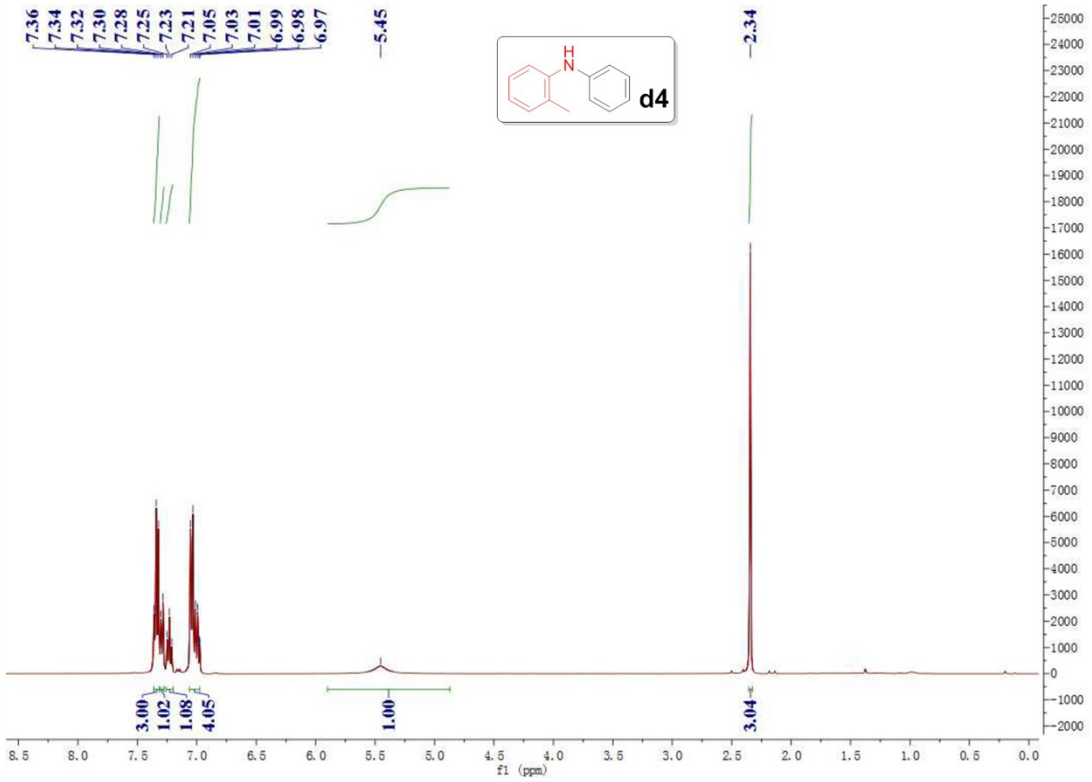


Figure S36. ^{13}CNMR of **d4**

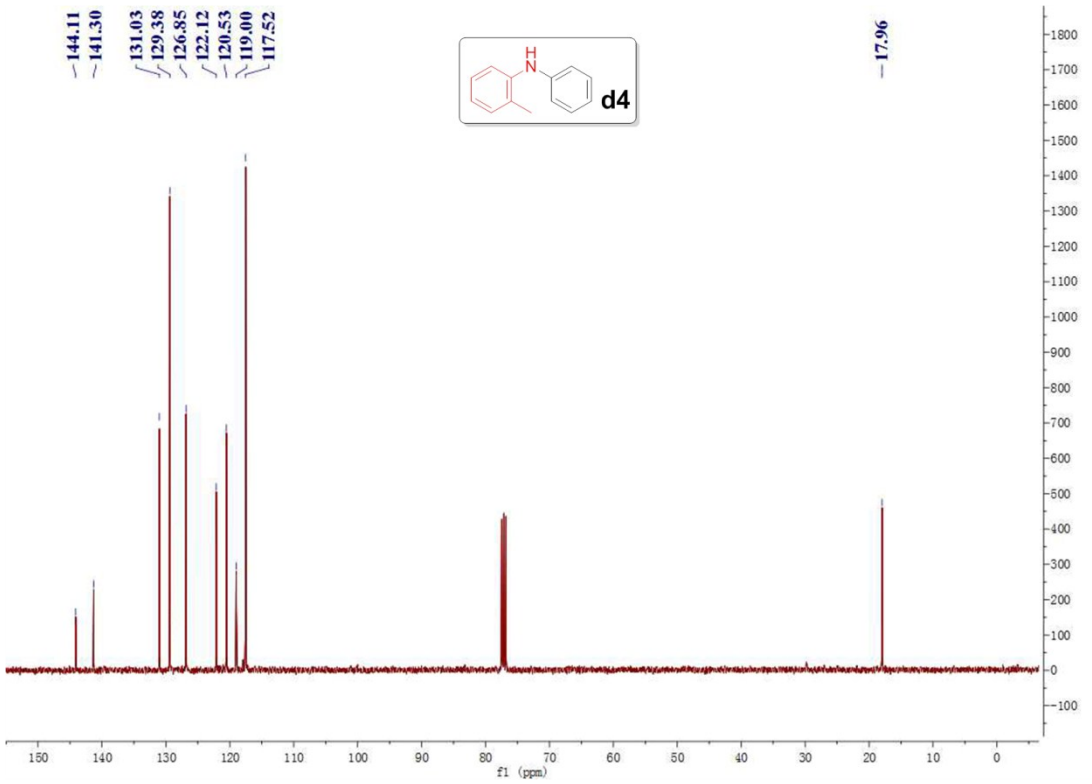


Figure S37. ^{1}HNMR of **d5**

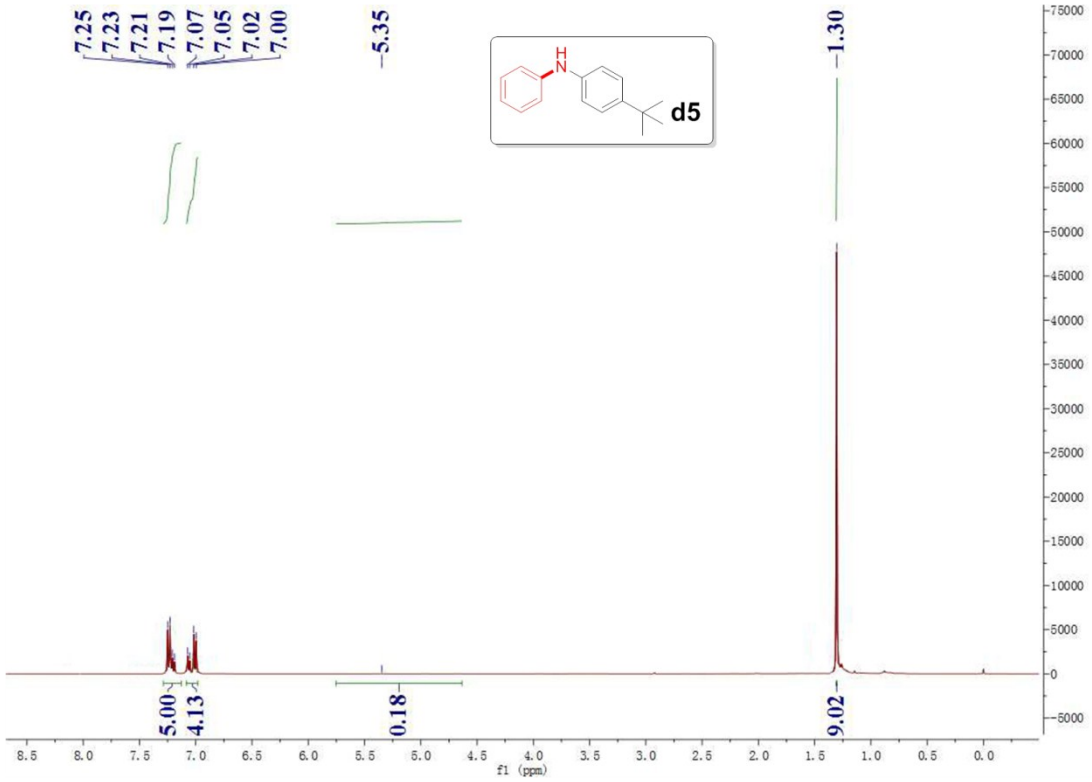


Figure S38. ^{13}CNMR of **d5**

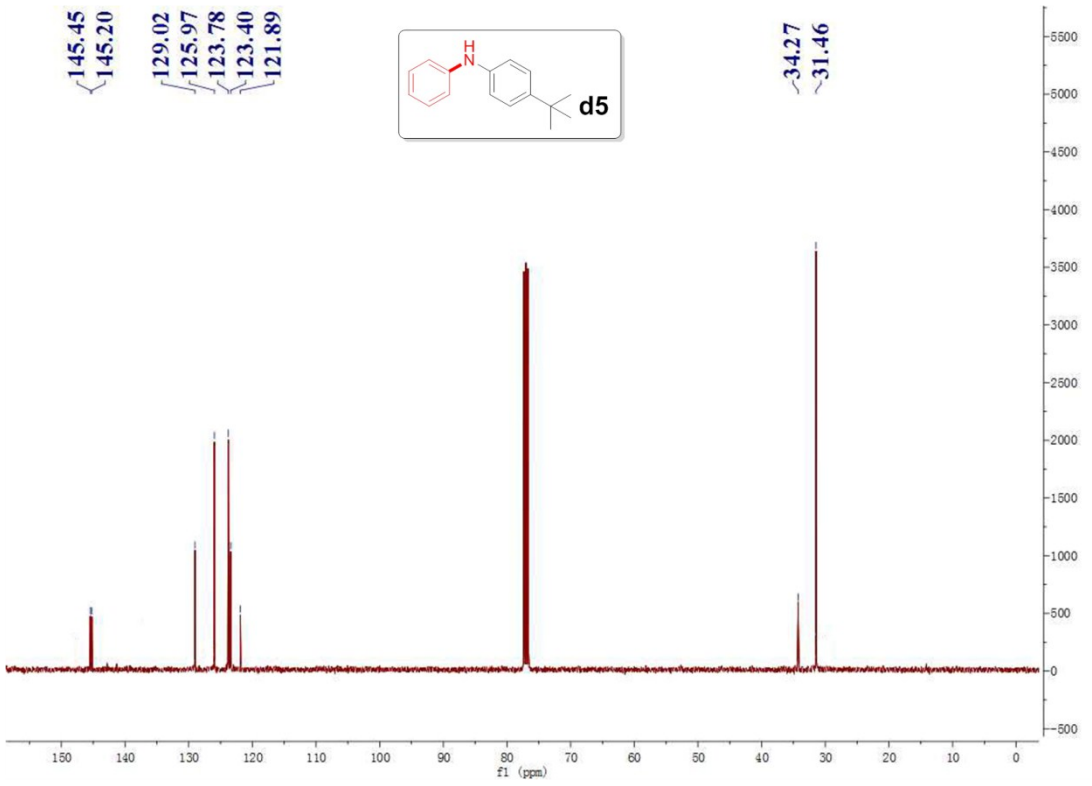


Figure S39. ^{1}HNMR of **d6**

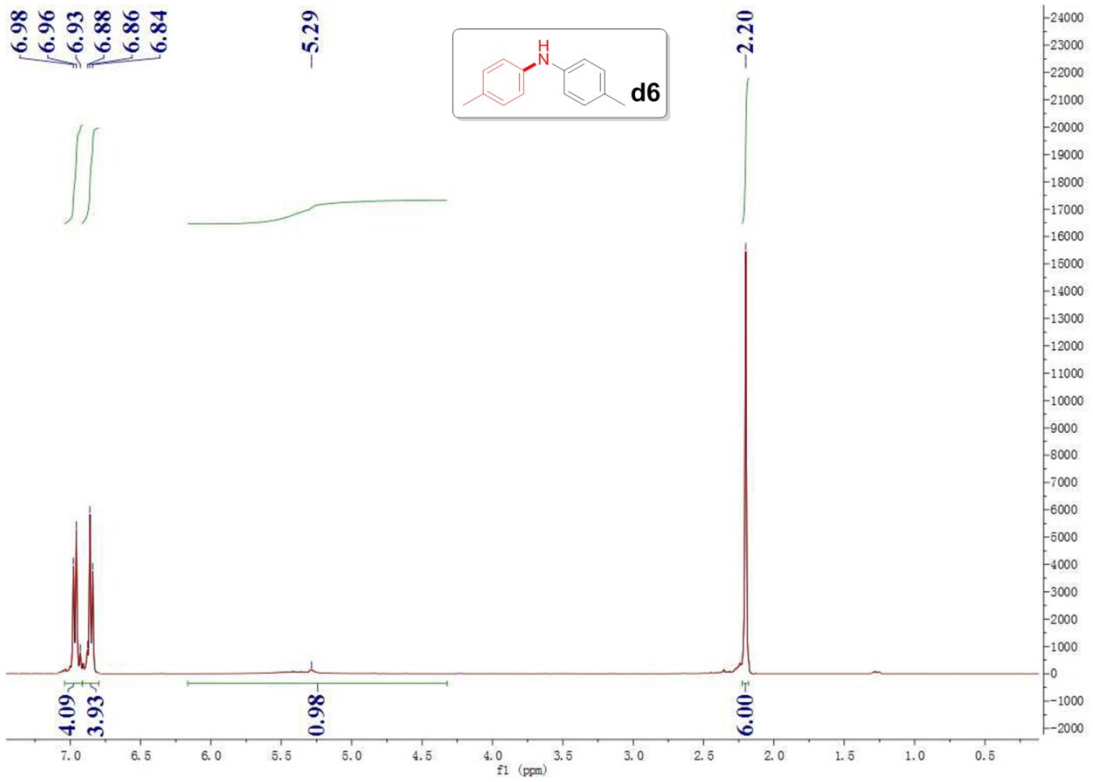


Figure S40. ^{13}CNMR of **d6**

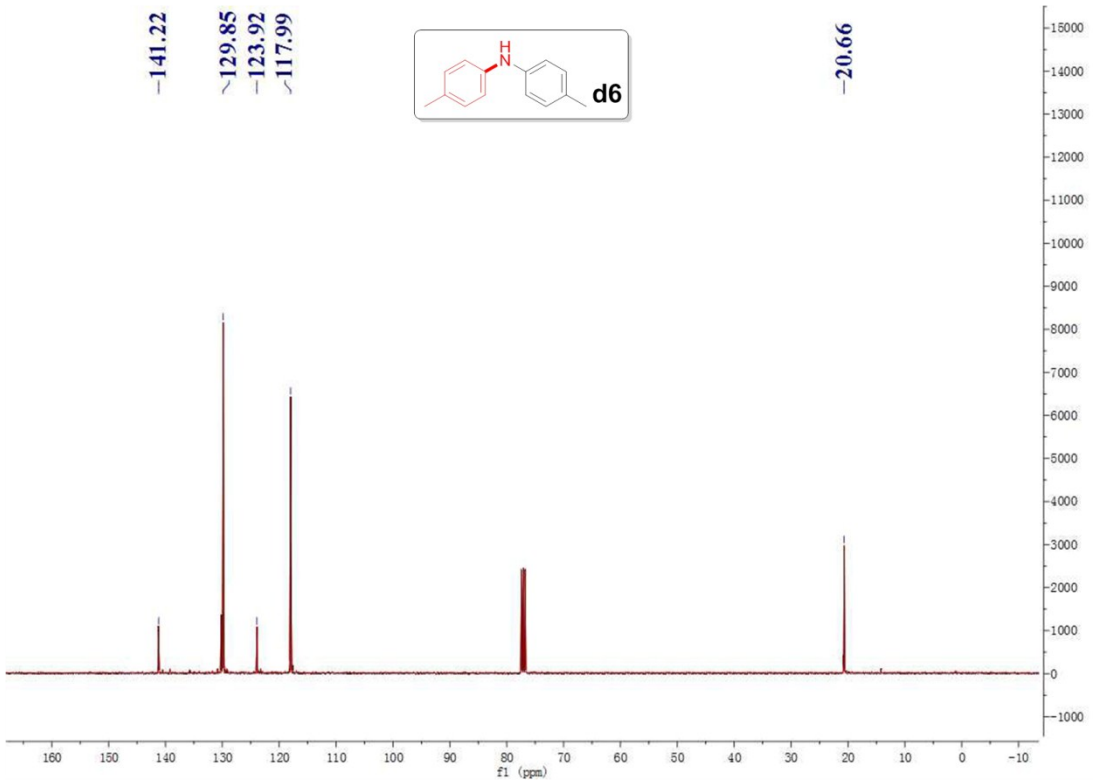


Figure S41. ^{1}HNMR of **d7**

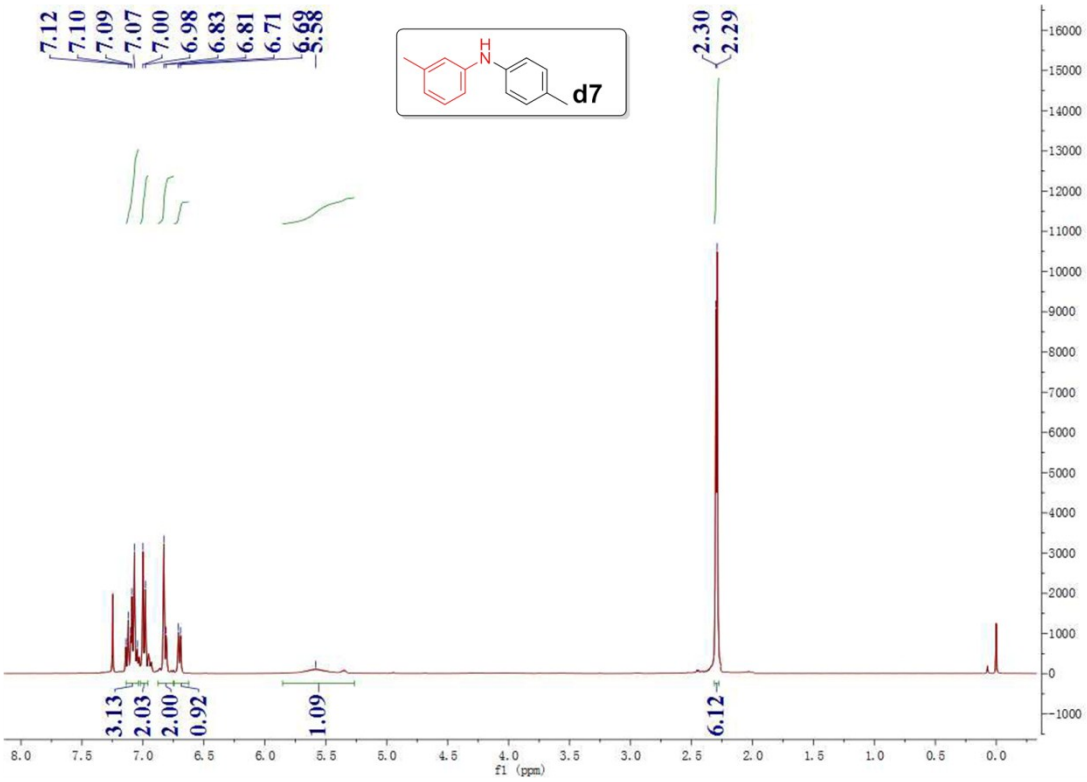


Figure S42. ^{13}CNMR of **d7**

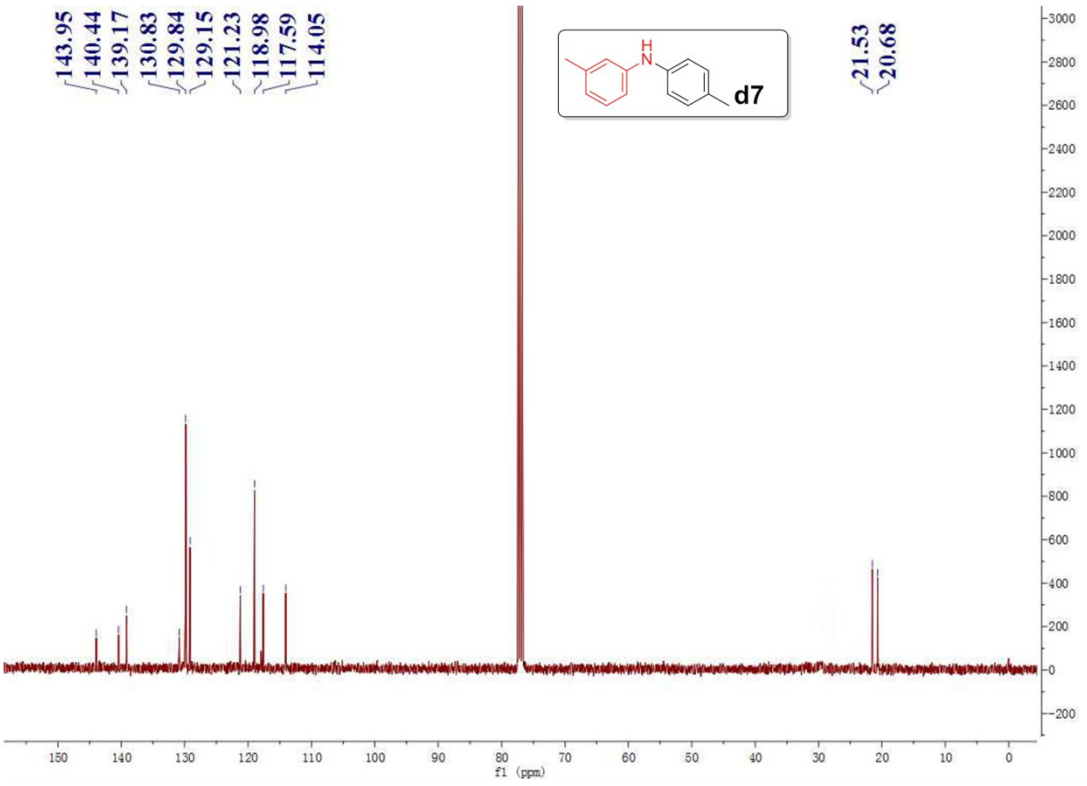


Figure S43. ^{1}HNMR of **d8**

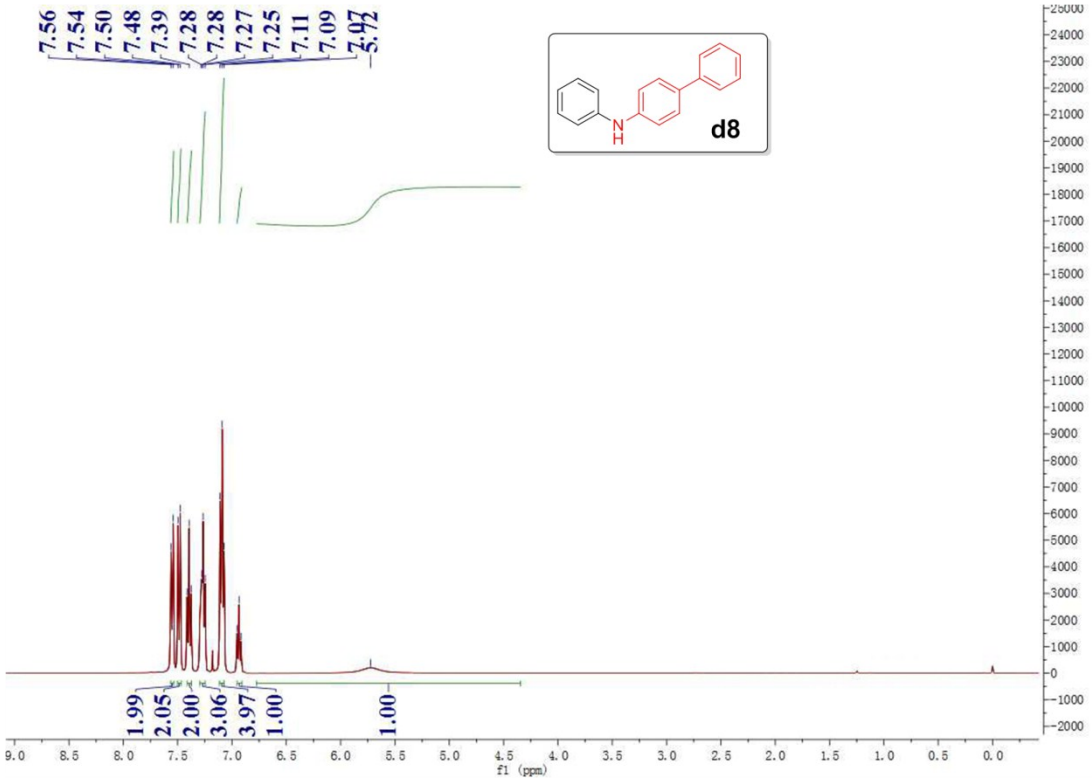


Figure S44. ^{13}CNMR of **d8**

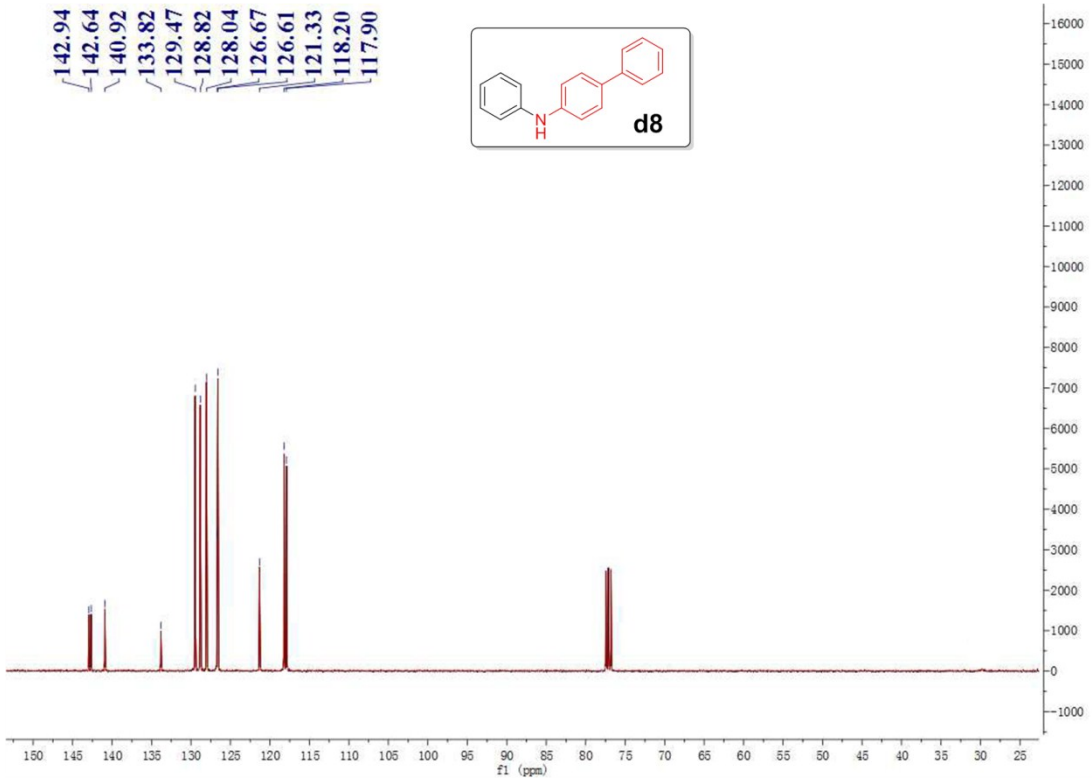


Figure S45. ^{1}HNMR of **d9**

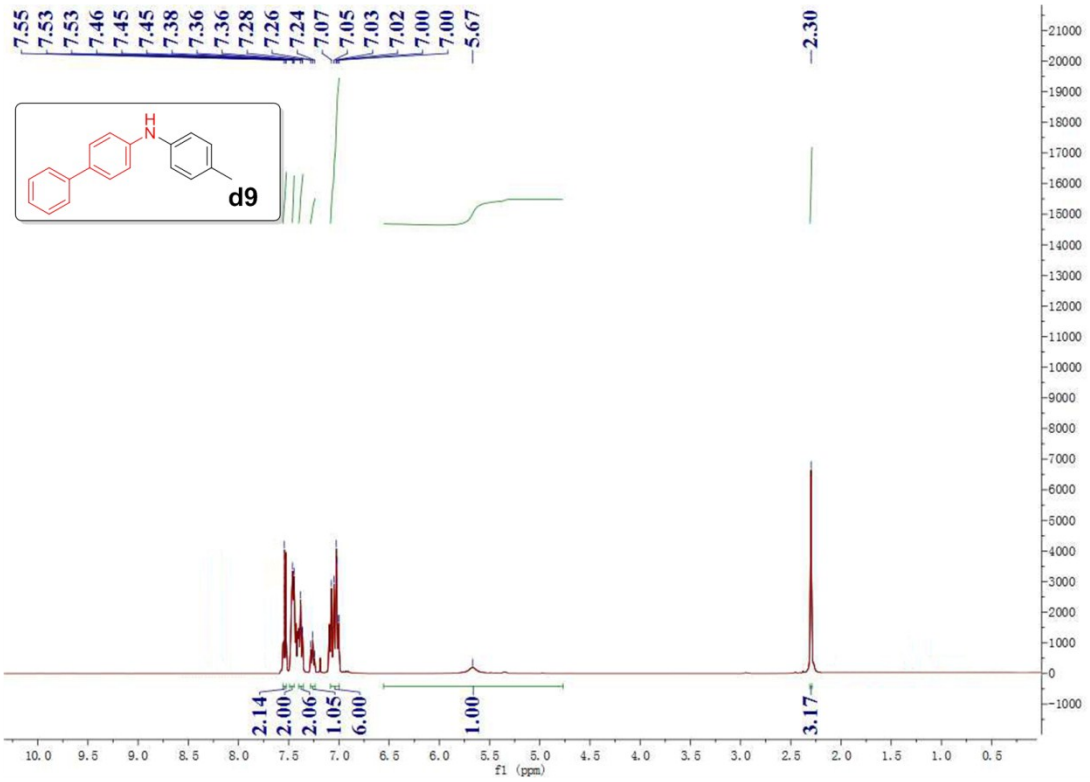


Figure S46. ^{13}CNMR of **d9**

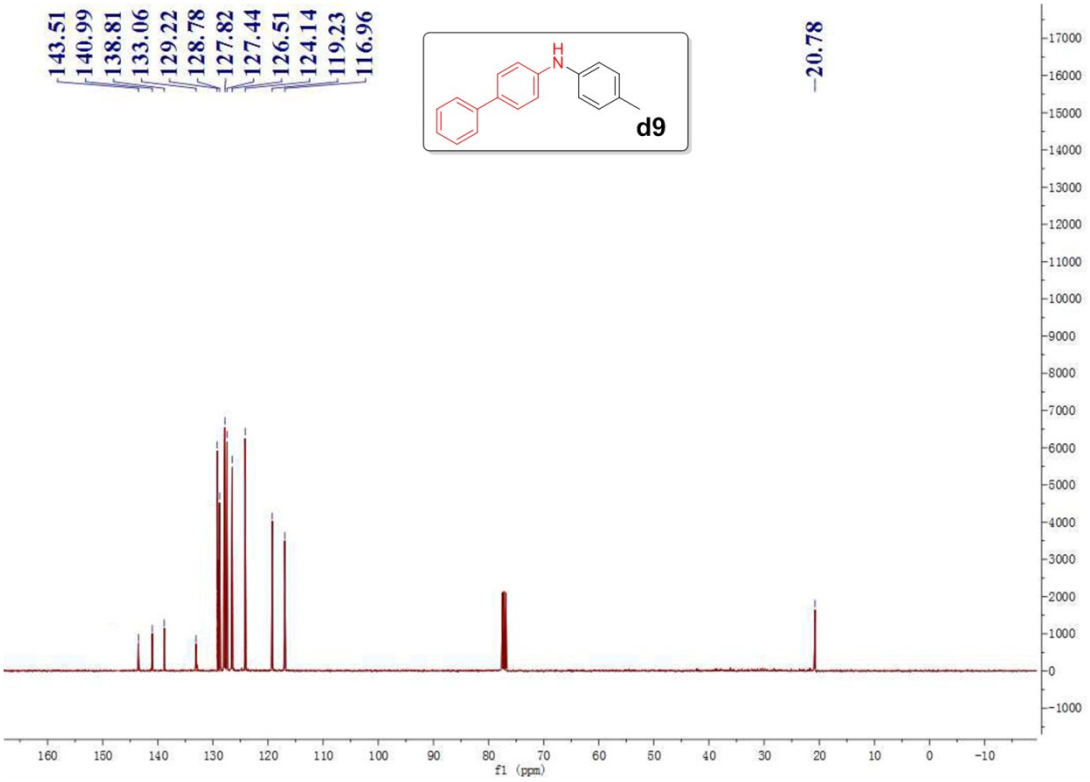


Figure S47. ^{1}HNMR of **d10**

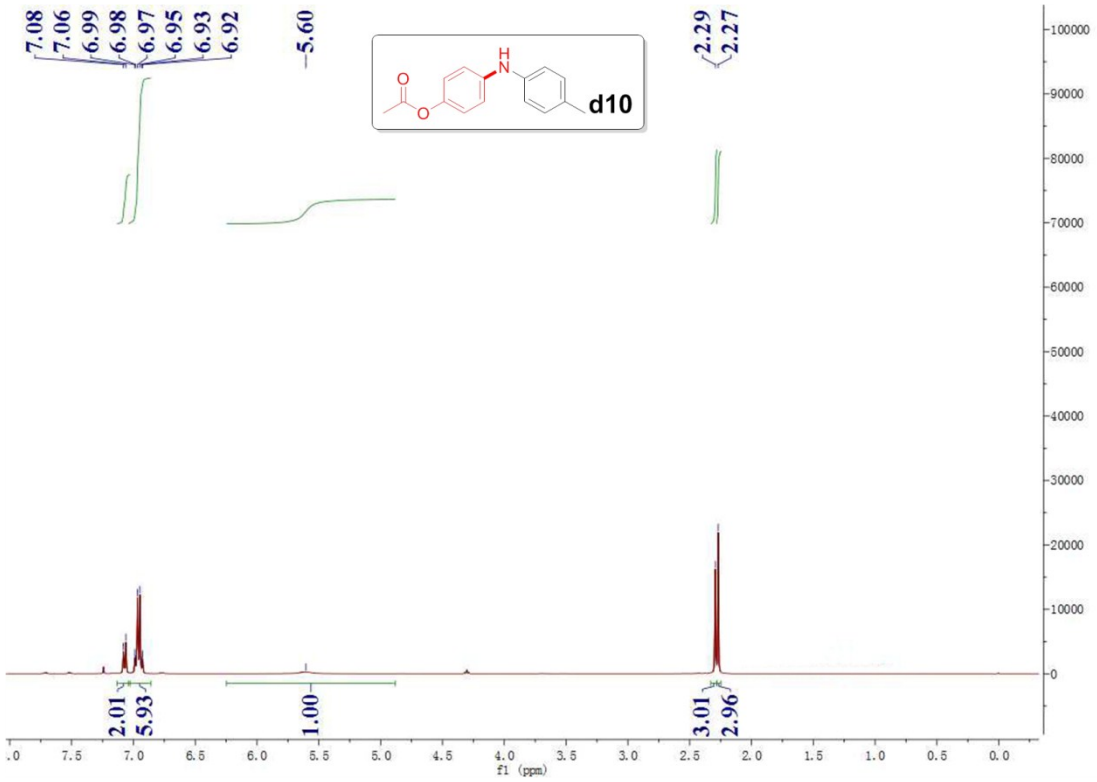


Figure S48. ^{13}CNMR of **d10**