An unexpected palladium-catalyzed reaction of 2-alkynylhalobenzene with 2-alkynylaniline: A novel and efficient route to 11*H*-indeno[1,2-*c*]quinolin-11-ols

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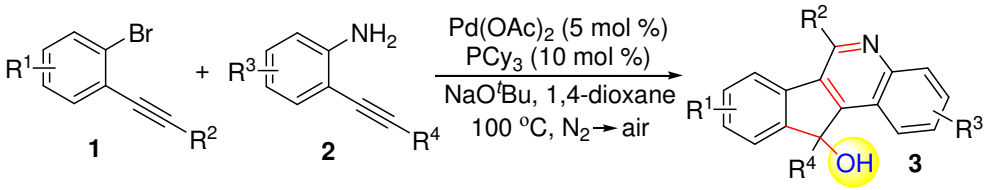
Supporting Information

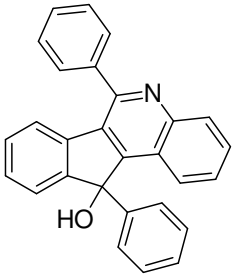
General experimental methods:

All reactions were performed in reaction tubes. Flash column chromatography was performed using silica gel (60-Å pore size, 32–63 μm, standard grade). Analytical thin–layer chromatography was performed using glass plates pre-coated with 0.25 mm 230–400 mesh silica gel impregnated with a fluorescent indicator (254 nm). Thin layer chromatography plates were visualized by exposure to ultraviolet light. Organic solutions were concentrated on rotary evaporators at ~20 Torr (house vacuum) at 25–35°C. Commercial reagents and solvents were used as received. Nuclear magnetic resonance (NMR) spectra are recorded in parts per million from internal tetramethylsilane on the δ scale.

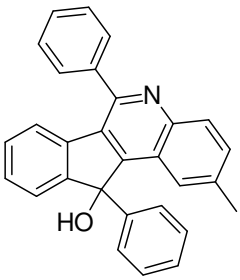
General Experimental Procedure for Palladium-Catalyzed Cascade Reaction of 2-Alkynylbromobenzene with 2-Alkynylaniline



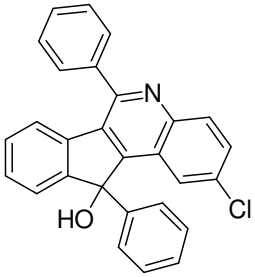
2-Alkynylbromobenzene **1** (0.20 mmol) was added to a mixture of $Pd(OAc)_2$ (5 mol %), tricyclohexylphosphine (10 mol %), *t*-BuONa (0.8 mmol), and 2-alkynylaniline (0.20 mmol) in 1,4-dioxane (2.0 mL) under nitrogen atmosphere. The mixture was heated at 100 °C. After consumption of the starting material as indicated by TLC, the reaction was stirred in air for half an hour. After the reaction mixture was cool to room temperature, the solvent was diluted by EtOAc (10 mL), washed with saturated brine (2 × 10 mL), and dried by anhydrous Na_2SO_4. Evaporation of the solvent followed by purification on silica gel provides the product **3**.



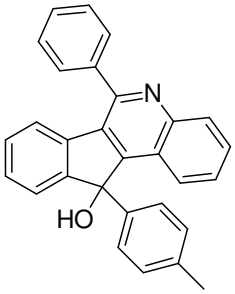
6,11-Diphenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3a**): 73.1 mg, yield: 95%; yellow solid; m.p. 261.4-261.8 °C; IR: 3335.5, 3064.2, 1601.0, 1567.5, 1498.2, 1451.7 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.4 Hz, 1H), 7.88 (d, *J* = 8.0 Hz, 1H), 7.69-7.68 (m, 2H), 7.54-7.53 (m, 4H), 7.42 (d, *J* = 7.6 Hz, 2H), 7.35 (t, *J* = 8.0 Hz, 1H), 7.27-7.24 (m, 4H), 7.11 (t, *J* = 7.6 Hz, 1H), 7.04 (t, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.0 Hz, 1H), 3.24 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 154.8, 151.6, 147.8, 141.7, 139.9, 137.3, 134.3, 130.7, 129.8, 129.4, 129.0, 128.8, 128.7, 128.5, 128.3, 127.4, 126.9, 124.8, 124.7, 124.3, 123.2, 123.1, 83.7. HRMS (ESI) calcd for $C_{28}H_{19}NO$: 386.1545 ($M + H^+$), found: 386.1544.



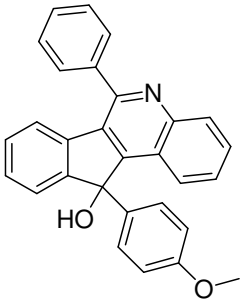
2-Methyl-6,11-diphenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3b**): 67.0 mg, yield: 84%; yellow solid; m.p. 220.9-221.2 °C; IR: 3369.0, 3055.0, 2920.9, 2847.8, 1625.4, 1564.4, 1491.3, 1469.9, 1442.5, 1366.3 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.01 (d, *J* = 8.4 Hz, 1H), 7.73-7.71 (m, 2H), 7.63 (s, 1H), 7.56-7.55 (m, 3H), 7.45-7.39 (m, 3H), 7.31-7.24 (m, 4H), 7.14 (t, *J* = 7.6 Hz, 1H), 7.06 (t, *J* = 7.2 Hz, 1H), 6.93 (d, *J* = 7.6 Hz, 1H), 3.02 (s, 1H), 2.37 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.7, 153.8, 151.7, 146.6, 141.7, 140.1, 137.5, 136.9, 134.3, 131.9, 131.6, 130.7, 129.6, 128.9, 128.9, 128.7, 128.5, 128.2, 127.4, 124.8, 124.2, 123.3, 123.1, 83.8. HRMS (ESI) calcd for $C_{29}H_{21}NO$: 400.1701 ($M + H^+$), found: 400.1696.



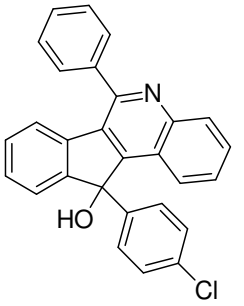
2-Chloro-6,11-diphenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3c**): 76.2 mg, yield: 91%; yellow solid; m.p. 279.7-280.3 °C; IR: 3341.6, 3052.0, 1598.0, 1567.5, 1494.3, 1457.8 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 8.8 Hz, 1H), 7.87-7.86 (m, 1H), 7.69-7.66 (m, 2H), 7.55-7.53 (m, 3H), 7.47 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.40 (d, *J* = 7.2 Hz, 2H), 7.34-7.27 (m, 4H), 7.14 (t, *J* = 7.6 Hz, 1H), 7.08-7.04 (m, 1H), 6.93 (d, *J* = 8.0 Hz, 1H), 3.32 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 154.1, 151.7, 146.0, 141.2, 139.5, 136.9, 132.6, 131.5, 131.4, 130.3, 129.1, 128.7, 128.6, 128.3, 128.2, 127.6, 124.7, 124.3, 123.8, 123.4, 123.2, 83.6. HRMS (ESI) calcd for $C_{28}H_{18}ClNO$: 420.1155 ($M + H^+$), found: 420.1147.



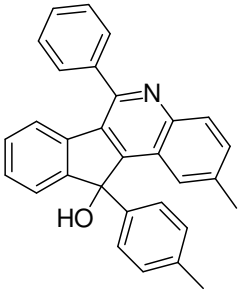
6-Phenyl-11-(p-tolyl)-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3d**): 40.1 mg, yield: 50%; yellow solid; m.p. 209.9-210.4 °C; IR: 3323.3, 3055.0, 2917.9, 2856.9, 1604.2, 1567.5, 1506.5, 1466.9, 1448.6, 1369.4 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (d, *J* = 8.4 Hz, 1H), 7.92 (d, *J* = 8.4 Hz, 1H), 7.74-7.72 (m, 2H), 7.62-7.56 (m, 4H), 7.41-7.40 (m, 1H), 7.34-7.30 (m, 3H), 7.17-7.13 (m, 1H), 7.10-7.05 (m, 3H), 6.94 (d, *J* = 7.6 Hz, 1H), 2.92 (s, 1H), 2.29 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 154.7, 151.7, 147.9, 140.1, 138.7, 137.3, 137.1, 134.2, 130.7, 129.9, 129.4, 129.2, 129.0, 128.8, 128.7, 128.4, 126.9, 124.8, 124.7, 124.2, 123.3, 123.1, 83.7, 21.1. HRMS (ESI) calcd for $C_{29}H_{21}NO$: 400.1701 ($M + H^+$), found: 400.1696.



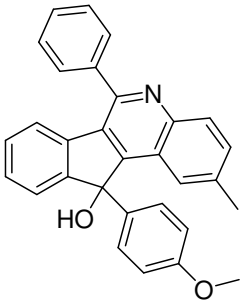
11-(4-Methoxyphenyl)-6-phenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3e**): 43.1 mg, yield: 52%; yellow solid; m.p. 297.2-297.6 °C; IR: 3423.9, 3055.0, 2948.4, 2832.5, 1610.2, 1577.4, 1463.8, 1433.4, 1412.0, 1375.4 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.4 Hz, 1H), 7.93 (d, *J* = 8.4 Hz, 1H), 7.76-7.74 (m, 2H), 7.67-7.59 (m, 4H), 7.44-7.34 (m, 4H), 7.21-7.17 (m, 1H), 7.12-7.08 (m, 1H), 6.96 (d, *J* = 7.6 Hz, 1H), 6.82 (d, *J* = 8.4 Hz, 2H), 3.77 (s, 3H), 2.69(s, 1H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 158.1, 155.8, 155.2, 147.3, 140.2, 136.8, 134.8, 130.1, 129.5, 129.4, 129.0, 128.7, 128.6, 128.2, 128.1, 126.7, 126.0, 124.9, 124.4, 123.0, 122.2, 113.8, 82.6, 54.9. HRMS (ESI) calcd for $C_{29}H_{21}NO_2$: 416.1651 ($M + H^+$), found: 416.1666.



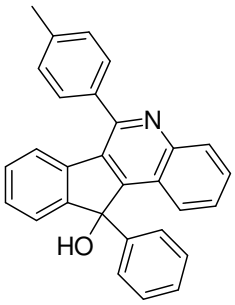
11-(4-Chlorophenyl)-6-phenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3f**): 43.6 mg, yield: 52%; yellow solid; m.p. 224.7-225.7 °C; IR: 3308.0, 3058.1, 1603.7, 1567.5, 1493.3, 1470.0 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.14 (d, *J* = 8.4 Hz, 1H), 7.85 (d, *J* = 8.4 Hz, 1H), 7.73-7.70 (m, 2H), 7.64-7.56 (m, 4H), 7.42-7.37 (m, 3H), 7.29-7.24 (m, 3H), 7.19-7.15 (m, 1H), 7.11-7.08 (m, 1H), 6.95 (d, *J* = 7.6 Hz, 1H), 2.96 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 154.1, 151.1, 148.0, 140.4, 139.9, 137.3, 133.2, 130.0, 129.6, 129.1, 129.0, 128.7, 128.6, 128.6, 128.5, 128.4, 127.1, 126.4, 124.5, 124.3, 123.2, 123.1, 83.4. HRMS (ESI) calcd for $C_{28}H_{18}ClNO$: 420.1155 ($M + H^+$), found: 420.1154.



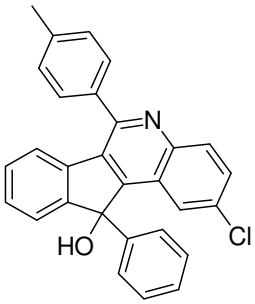
2-Methyl-6-phenyl-11-(*p*-tolyl)-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3g**): 47.1 mg, yield: 57%; yellow solid; m.p. 239.6-240.6 °C; IR: 3359.9, 3055.0, 2920.9, 2856.9, 1616.3, 1564.4, 1506.5, 1469.9, 1439.5, 1366.3 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 8.4 Hz, 1H), 7.75-7.73 (m, 2H), 7.67 (s, 1H), 7.58-7.56 (m, 3H), 7.44 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.34-7.32 (m, 3H), 7.17-7.14 (m, 1H), 7.12-7.06 (m, 3H), 6.94 (d, *J* = 7.6 Hz, 1H), 2.78 (s, 1H), 2.40 (s, 3H), 2.30(s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.7, 153.8, 151.8, 146.7, 140.3, 138.7, 137.5, 137.0, 136.9, 131.9, 130.7, 129.7, 129.3, 128.9, 128.9, 128.7, 128.7, 128.3, 124.3, 124.2, 123.3, 123.1, 83.9, 22.0, 21.1. HRMS (ESI) calcd for $C_{30}H_{23}NO$: 414.1858 ($M + H^+$), found: 414.1845.



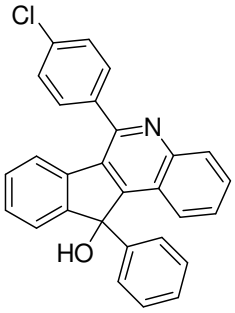
11-(4-Methoxyphenyl)-2-methyl-6-phenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3h**): 45.5 mg, yield: 53%; yellow solid; m.p. 271.9-272.6 °C; IR: 3356.8, 3015.4, 2954.5, 2917.8, 1613.2, 1561.4, 1512.6, 1457.8, 1424.2, 1369.9 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.8 Hz, 1H), 7.76-7.73 (m, 2H), 7.67 (s, 1H), 7.60-7.58 (m, 3H), 7.48 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.39-7.34 (m, 3H), 7.20-7.16 (m, 1H), 7.11-7.07 (m, 1H), 6.95 (d, *J* = 7.6 Hz, 1H), 6.83 (d, *J* = 8.8 Hz, 2H), 3.78 (s, 3H), 2.64(s, 1H), 2.42 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.1, 155,0, 154.3, 153.4 146.0, 140.2, 136.9, 135.9, 134.8, 131.6, 130.0, 129.3, 128.9, 128.7, 128.6, 128.1, 128.0, 125.90, 124.4, 123.5, 123.1, 122.08, 113.7, 82.6, 54.9, 21.6. HRMS (ESI) calcd for $C_{30}H_{23}NO_2$: 430.1807 ($M + H^+$), found: 430.1787.



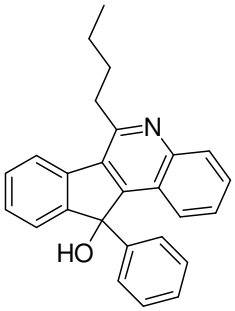
11-Phenyl-6-(*p*-tolyl)-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3i**): 75.8 mg, yield: 95%; yellow solid; m.p. 220.0-221.0 °C; IR: 3351.8, 3064.2, 2966.6, 2841.7, 1607.1, 1561.4, 1503.5, 1469.9, 1445.6, 1369.4 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.4 Hz, 1H), 7.86 (d, *J* = 7.6 Hz, 1H), 7.60-7.58 (m, 2H), 7.55-7.53 (m, 1H), 7.43 (d, *J* = 7.2 Hz, 2H), 7.34 (d, *J* = 7.6 Hz, 3H), 7.27-7.24 (m, 4H), 7.12-7.00 (m, 3H), 3.20 (s, 1H), 2.49 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 154.7, 151.6, 147.9, 141.8, 138.8, 137.5, 137.1, 130.7, 129.8, 129.3, 129.3, 128.7, 128.6, 128.5, 128.2, 127.4, 126.8, 124.9, 124.7, 124.3, 123.2, 83.7, 21.5. HRMS (ESI) calcd for $C_{29}H_{21}NO$: 400.1701 (M + H^+), found: 400.1702.



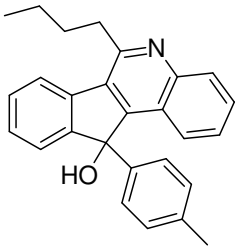
2-Chloro-11-phenyl-6-(*p*-tolyl)-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3j**): 58.9 mg, yield: 68%; yellow solid; m.p. 257.4-257.8 °C; IR: 3372.1, 3058.1, 2960.5, 2838.6, 1619.3, 1570.5, 1497.4, 1463.8, 1445.6, 1363.3 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.8 Hz, 1H), 7.87-7.86 (m, 1H), 7.62-7.60 (m, 2H), 7.50 (dd, *J* = 9.2, 2.0 Hz, 1H), 7.43-7.41 (m, 2H), 7.38-7.36 (m, 2H), 7.32-7.25 (m, 4H), 7.19-7.15 (m, 1H), 7.12-7.06 (m, 2H), 2.95 (s, 1H), 2.50 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.0, 153.9, 151.7, 146.3, 141.1, 139.1, 137.1, 136.8, 134.2, 132.5, 131.5, 131.4, 130.3, 129.4, 128.8, 128.7, 128.7, 127.7, 124.8, 124.3, 123.8, 123.4, 83.7, 21.5. HRMS (ESI) calcd for $C_{29}H_{20}ClNO$: 434.1312 (M + H^+), found: 434.1305.



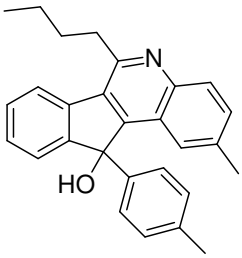
6-(4-Chlorophenyl)-11-phenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3k**): 72.1 mg, yield: 86%; yellow solid; m.p. 268.4-268.6 °C; IR: 3284.4, 3065.6, 1597.0, 1569.5, 1491.2, 1446.9 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.12 (d, *J* = 8.4 Hz, 1H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.71 (d, *J* = 8.4 Hz, 2H), 7.64-7.60 (m, 1H), 7.57 (d, *J* = 8.4 Hz, 2H), 7.46-7.38 (m, 3H), 7.35-7.27 (m, 4H), 7.21-7.12 (m, 2H), 7.02 (d, *J* = 7.6 Hz, 1H), 2.87 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.9, 154.3, 151.6, 148.0, 141.5, 138.6, 137.1, 135.1, 134.3, 130.4, 129.9, 129.7, 129.0, 128.9, 128.6, 127.5, 127.2, 124.8, 124.7, 124.5, 123.3, 123.0, 83.8. HRMS (ESI) calcd for $C_{28}H_{18}ClNO$: 420.1155 ($M + H^+$), found: 420.1148.



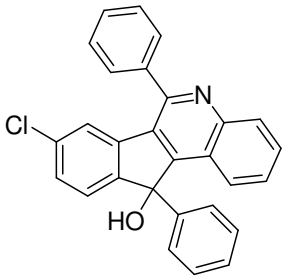
6-Butyl-11-phenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3l**): 65.7 mg, yield: 90%; yellow solid; m.p. 228.1-229.0 °C; IR: 3318.9, 3016.5, 2957.7, 2919.1, 2861.2, 2848.9, 1593.0, 1562.7, 1504.6, 1457.9, 1446.3, 1383.5 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.4 Hz, 1H), 7.78 (t, *J* = 9.2 Hz, 2H), 7.54-7.50 (m, 1H), 7.44-7.40 (m, 2H), 7.38-7.36 (m, 2H), 7.32-7.21 (m, 5H), 3.31-2.27 (m, 2H), 3.10 (s, 1H), 1.92-1.84 (m, 2H), 1.65-1.56 (m, 2H), 1.04 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) δ 157.4, 154.8, 153.1, 147.3, 143.3, 137.1, 130.7, 129.0, 128.9, 128.9, 128.3, 127.9, 126.9, 125.8, 124.8, 124.6, 124.5, 122.8, 122.7, 82.7, 36.8, 29.9, 22.2, 14.0. HRMS (ESI) calcd for $C_{26}H_{23}NO$: 366.1858 ($M + H^+$), found: 366.1852.



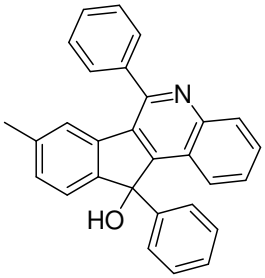
6-Butyl-11-(p-tolyl)-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3m**): 70.5 mg, yield: 93%; yellow solid; m.p. 198.4-198.9 °C; IR: 3414.7, 3023.2, 2954.5, 2930.1, 2869.7, 2852.6, 1604.5, 1558.3, 1506.5, 1457.8, 1446.3, 1375.4 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 8.4 Hz, 1H), 7.78 (d, *J* = 7.6 Hz, 1H), 7.68 (d, *J* = 7.6 Hz, 1H), 7.45-7.39 (m, 3H), 7.29-7.21 (m, 4H), 7.03 (d, *J* = 8.0 Hz, 2H), 3.19-3.14 (m, 2H), 2.26 (s, 3H), 2.10 (s, 1H), 1.83-1.77 (m, 2H), 1.58-1.52 (m, 2H), 1.01 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.2, 154.0, 152.2, 147.5, 138.9, 137.4, 136.9, 134.3, 131.0, 129.2, 129.0, 128.7, 128.2, 126.1, 124.7, 124.7, 124.5, 122.9, 122.8, 83.5, 37.5, 30.6, 23.0, 21.1, 14.1. HRMS (ESI) calcd for $C_{28}H_{27}NO$: 380.2014 ($M + H^+$), found: 380.2000.



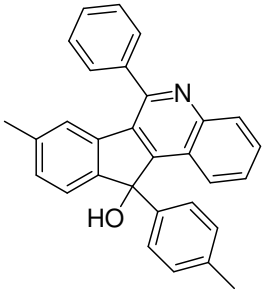
6-Butyl-2-methyl-11-(p-tolyl)-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3n**): 53.4 mg, yield: 68%; yellow solid; m.p. 188.7-189.5 °C; IR: 3347.7, 3024.2, 2948.4, 2920.9, 2869.1, 2845.7, 1594.1, 1582.7, 1503.5, 1463.8, 1445.6, 1369.4 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, *J* = 8.8 Hz, 1H), 7.57 (d, *J* = 7.6 Hz, 1H), 7.45 (s, 1H), 7.41-7.35 (m, 2H), 7.25-7.24 (m, 1H), 7.20-7.15 (m, 3H), 7.01-6.99 (m, 2H), 3.01-2.89 (m, 2H), 2.31 (s, 3H), 2.24 (s, 3H), 2.07 (s, 1H), 1.75-1.67 (m, 2H), 1.53-1.44 (m, 2H), 0.97 (t, *J* = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2, 153.4, 152.5, 145.8, 139.0, 137.3, 136.6, 135.5, 134.3, 131.1, 130.8, 129.1, 128.7, 128.2, 128.1, 124.6, 124.5, 123.5, 122.7, 83.4, 37.0, 30.4, 22.9, 21.8, 21.1, 14.0. HRMS (ESI) calcd for $C_{28}H_{27}NO$: 394.2171 ($M + H^+$), found: 394.2169.



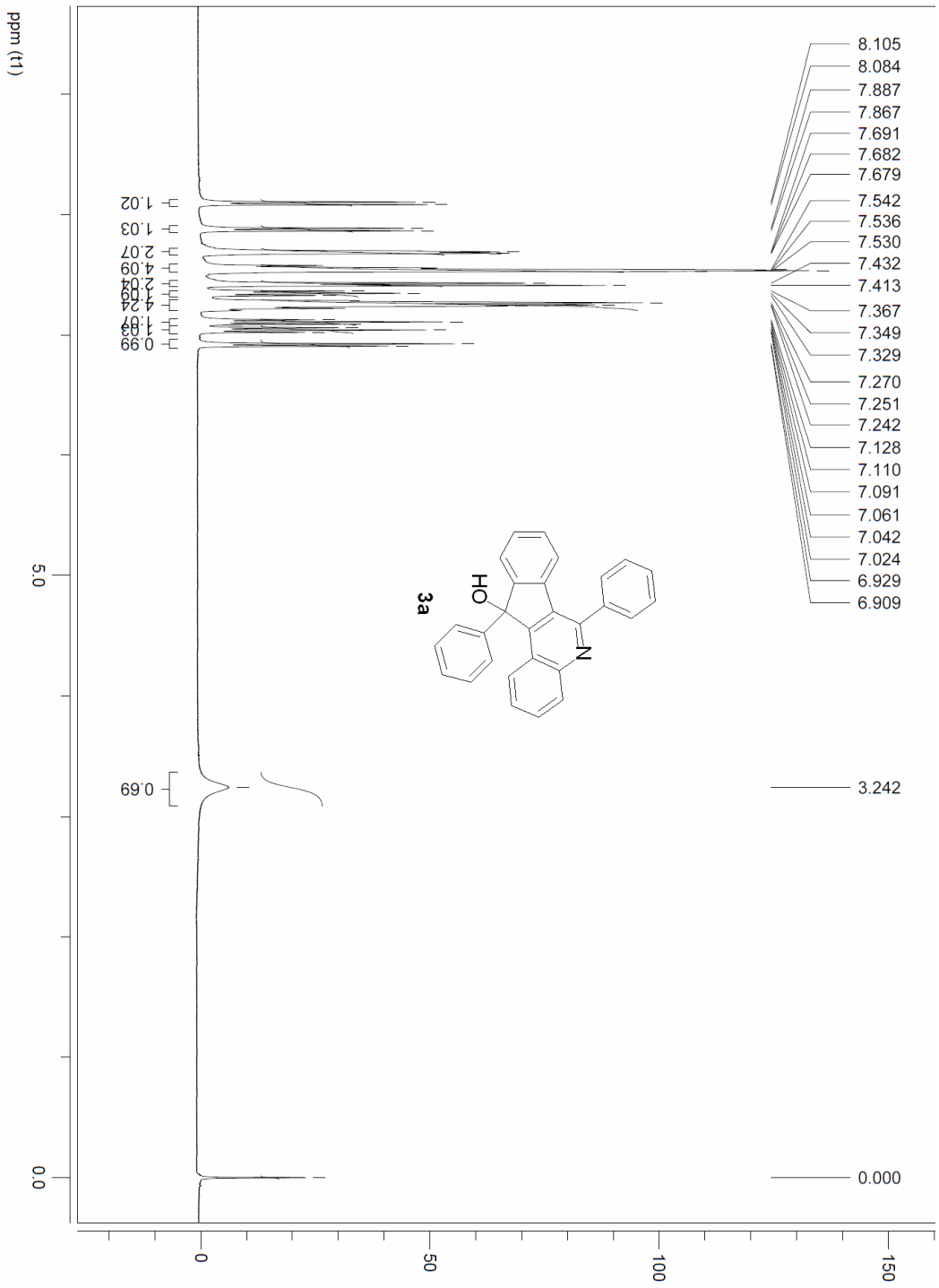
8-Chloro-6,11-diphenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3o**): 76.2 mg, yield: 91%; yellow solid; m.p. 243.9-244.3 °C; IR: 3393.4, 3058.1, 2957.5, 2841.7, 1598.0, 1576.6, 1498.5, 1448.6 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.18 (d, *J* = 8.4 Hz, 1H), 7.90 (d, *J* = 8.4 Hz, 1H), 7.75-7.73 (m, 2H), 7.68-7.61 (m, 4H), 7.45-7.42 (m, 3H), 7.35-7.28 (m, 4H), 7.15 (dd, *J* = 8.0, 2.0 Hz, 1H), 6.92-6.91 (m, 1H), 2.79 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.8, 155.3, 150.1, 147.9, 141.4, 139.2, 139.0, 134.3, 129.8, 129.5, 129.3, 128.7, 128.6, 128.1, 127.5, 127.0, 125.3, 124.8, 124.7, 123.2, 123.1, 83.1. HRMS (ESI) calcd for $C_{28}H_{18}ClNO$: 420.1155 ($M + H^+$), found: 420.1156.



8-Methyl-6,11-diphenyl-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3p**): 72.6 mg, yield: 91%; yellow solid; m.p. 203.2-203.6 °C; IR: 3235.2, 3058.1, 2958.6, 2861.1, 1608.2, 1572.3, 1509.8, 1462.6, 1447.6, 1364.5 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 8.11 (d, *J* = 8.4 Hz, 1H), 7.87 (d, *J* = 8.0 Hz, 1H), 7.72-7.70 (m, 2H), 7.57-7.55 (m, 4H), 7.42 (d, *J* = 7.2 Hz, 2H), 7.35 (t, *J* = 7.2 Hz, 1H), 7.28-7.22 (m, 3H), 7.16 (d, *J* = 7.6 Hz, 1H), 6.94 (d, *J* = 7.6 Hz, 1H), 6.72 (s, 1H), 3.04 (s, 1H), 2.13 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 155.0, 148.9, 147.9, 141.9, 140.0, 138.6, 137.5, 130. 8, 129.8, 129.3, 129.0, 129.0, 128.8, 128.6, 128.5, 127.3, 126.9, 124.8, 124.7, 124.0, 123.9, 123.3, 83.5, 21.6. HRMS (ESI) calcd for $C_{29}H_{21}NO$: 400.1701 ($M + H^+$), found: 400.1686.



8-Methyl-6-phenyl-11-(*p*-tolyl)-11*H*-indeno[1,2-*c*]quinolin-11-ol (**3q**): 80.9 mg, yield: 98%; yellow solid; m.p. 159.1-160.1°C; IR: 3408.6, 3025.2, 2960.5, 2853.9, 1613.2, 1567.5, 1512.6, 1466.9, 1439.5, 1375.4 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.11 (d, *J* = 8.4 Hz, 1H), 7.90 (d, *J* = 8.4 Hz, 1H), 7.72-7.70 (m, 2H), 7.56-7.55 (m, 3H), 7.38-7.34 (m, 2H), 7.31-7.29 (m, 2H), 7.17 (d, *J* = 7.6 Hz, 1H), 7.06 (d, *J* = 8.0 Hz, 2H), 6.94 (d, *J* = 7.6 Hz, 1H), 6.72 (s, 1H), 3.00 (s, 1H), 2.28 (s, 3H), 2.13 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 155.1, 149.0, 147.8, 140.0, 138.9, 138.5, 137.4, 136.9, 132.4, 130.7, 129.8, 129.3, 129.2, 129.0, 129.0, 128.8, 128.6, 126.8, 124.7, 123.9, 123.8, 123.3, 83.5, 21.6, 21.1. HRMS (ESI) calcd for $C_{30}H_{23}NO$: 414.1858 ($M + H^+$), found: 414.1844.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7.367
7.349
7.329
7.270
7.251
7.242
7.128
7.110
7.091
7.061
7.042
7.024
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6.909
3.242
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1.03
2.07
4.09
2.04
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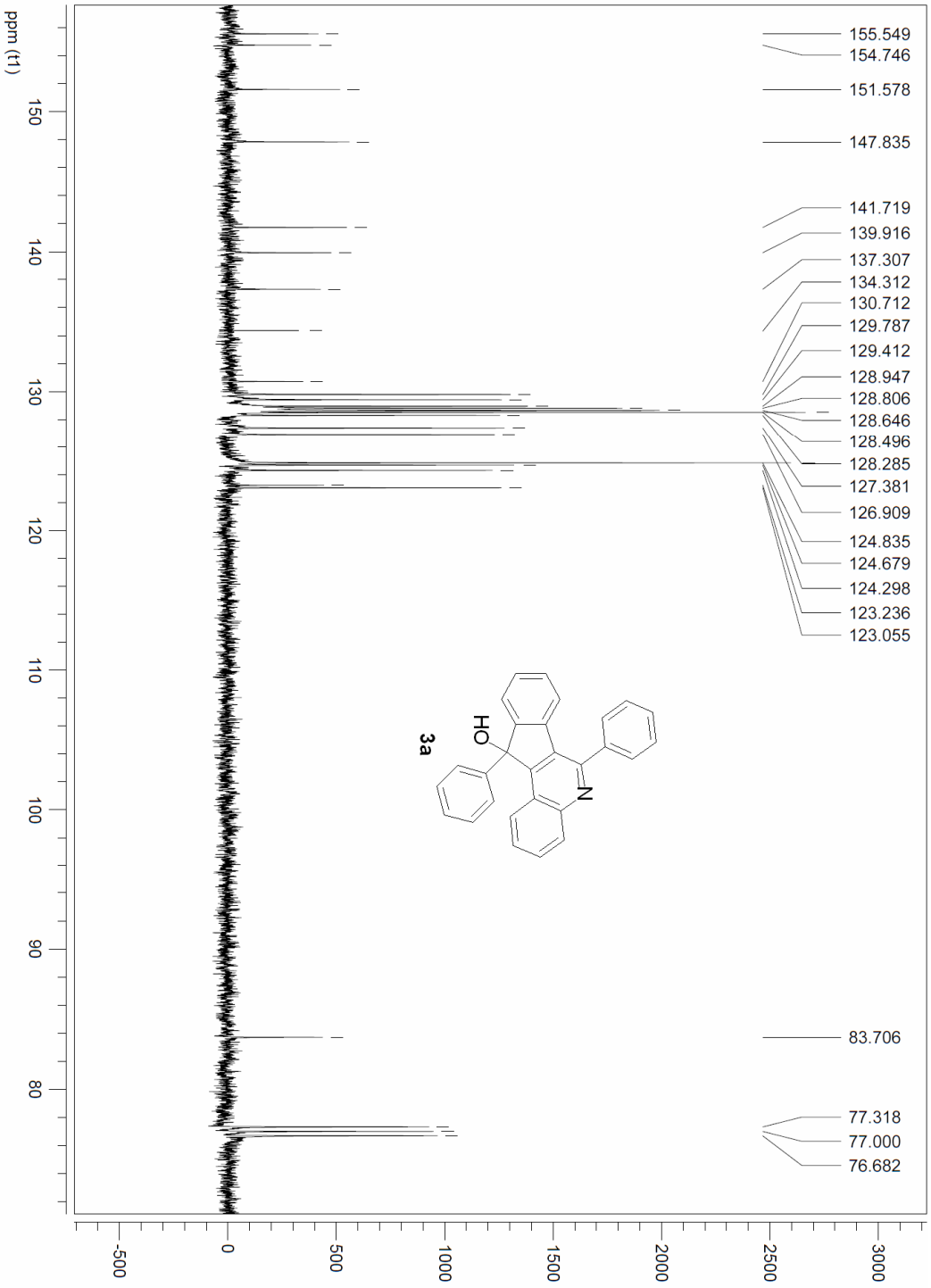
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77.318
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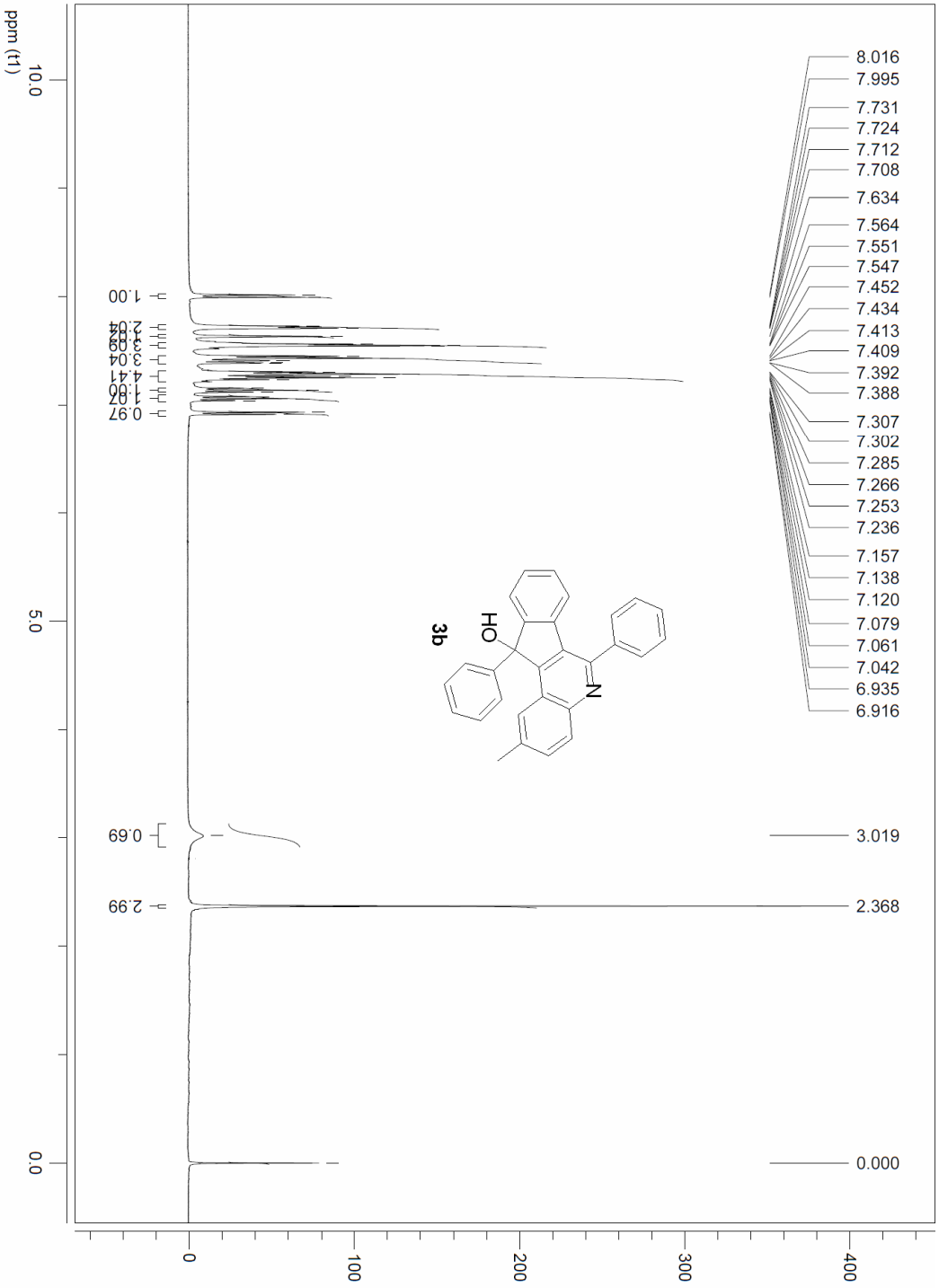
HO
N
3a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7.547
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7.434
7.413
7.409
7.392
7.388
7.307
7.302
7.285
7.266
7.253
7.236
7.157
7.138
7.120
7.079
7.061
7.042
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6.916
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300
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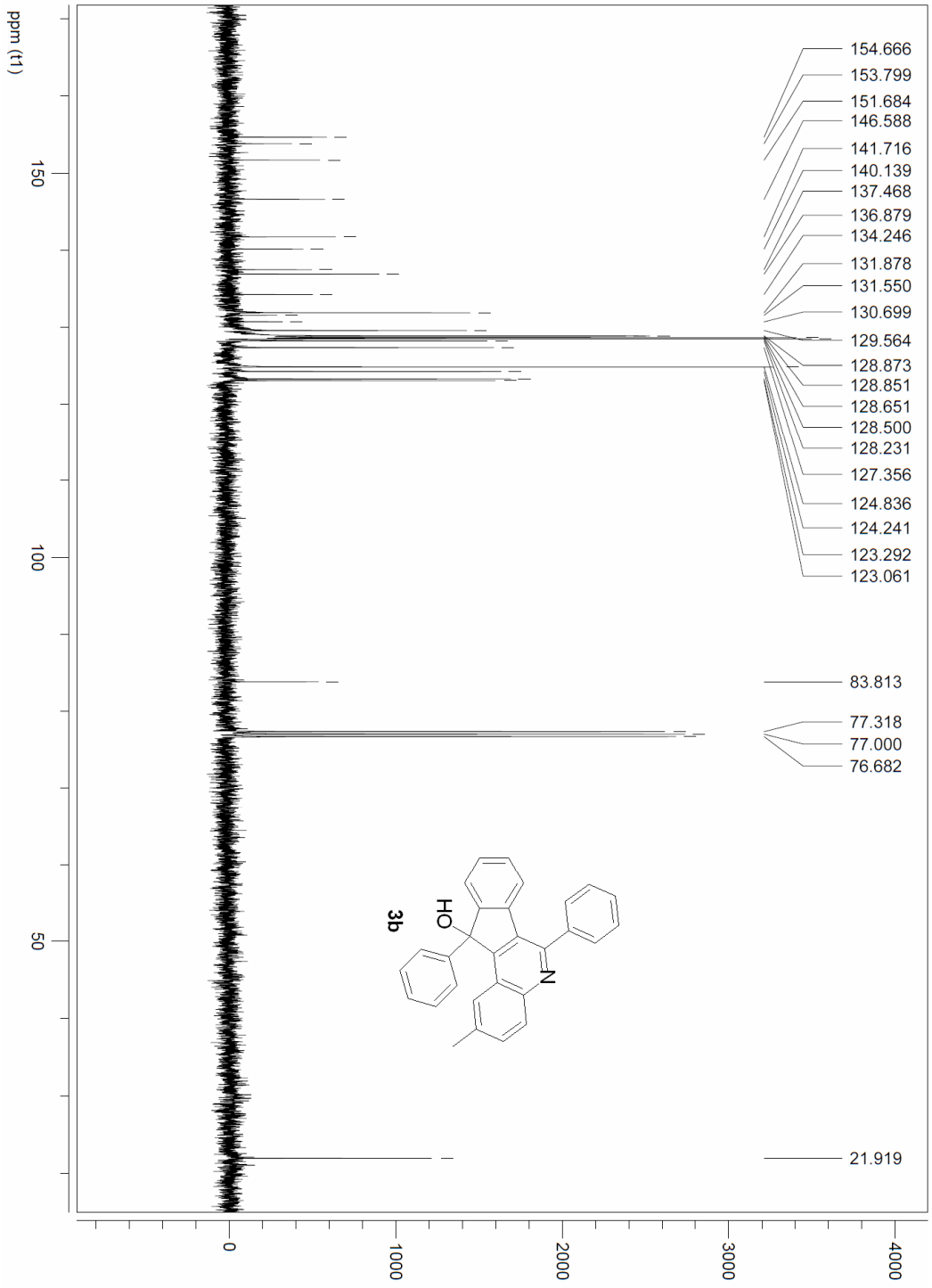
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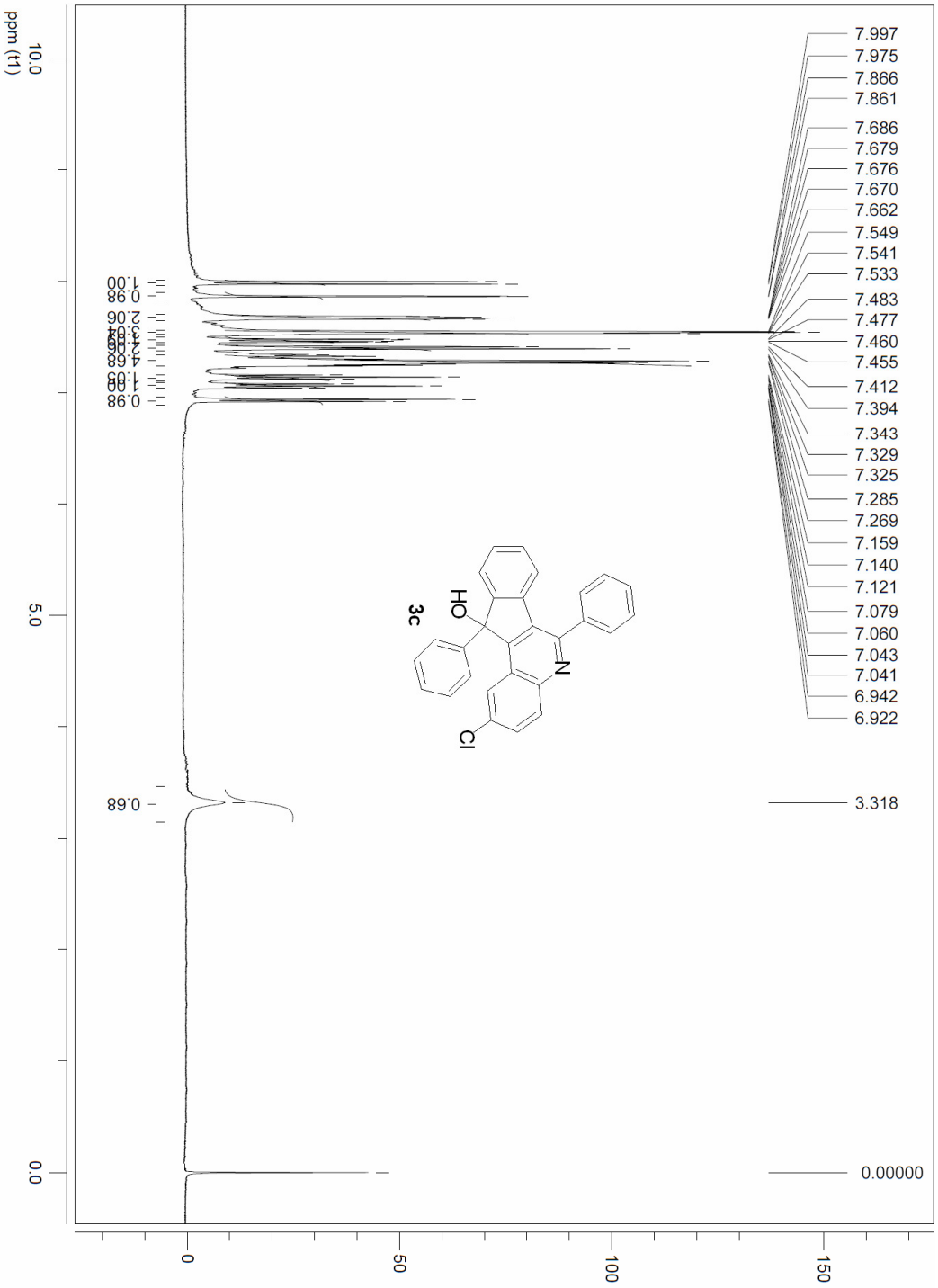
N
3b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7.477
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7.455
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7.329
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7.285
7.269
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7.140
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7.079
7.060
7.043
7.041
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6.922
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Cl
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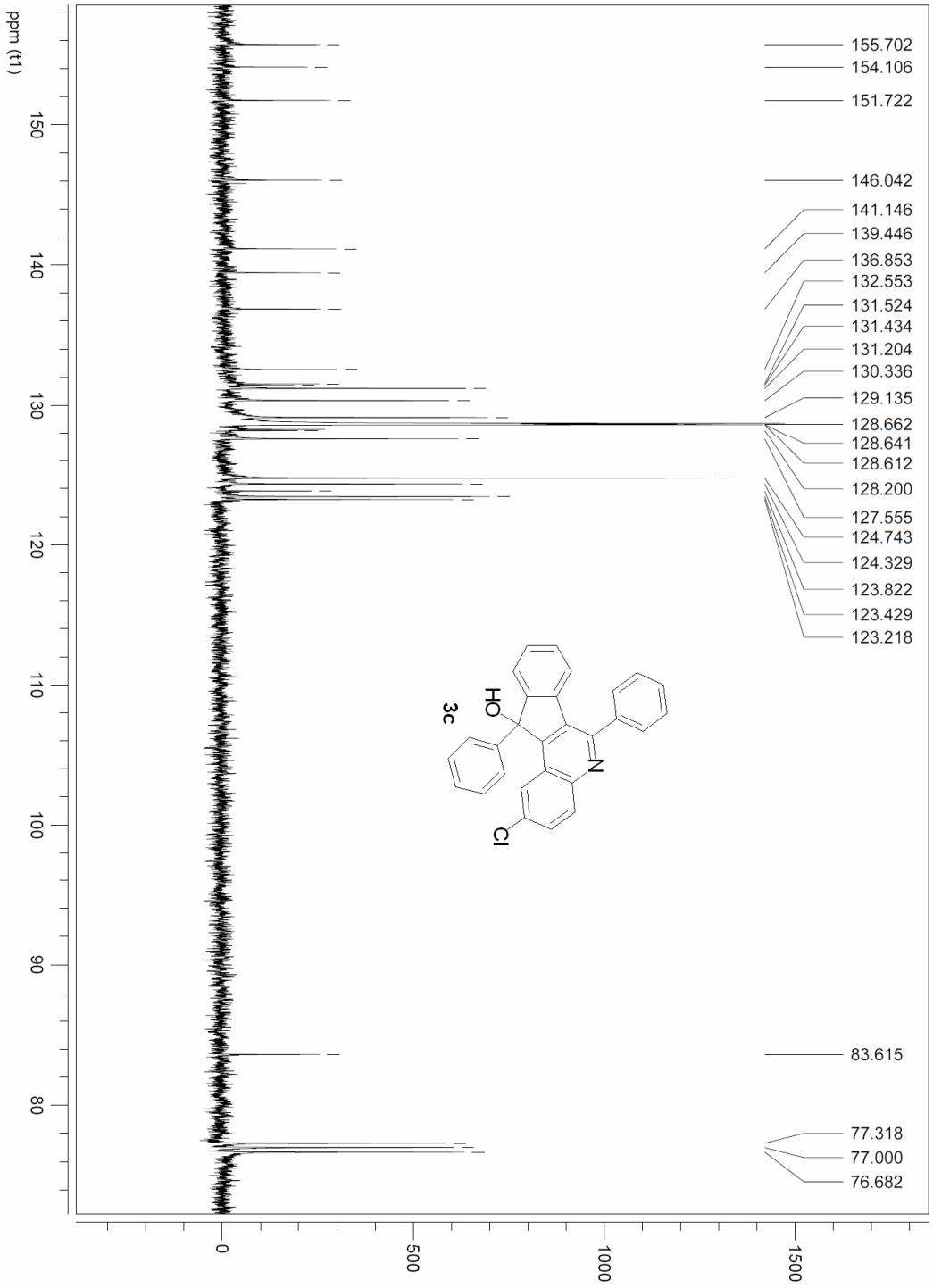
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1000
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139.446
136.853
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131.524
131.434
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129.135
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128.612
128.200
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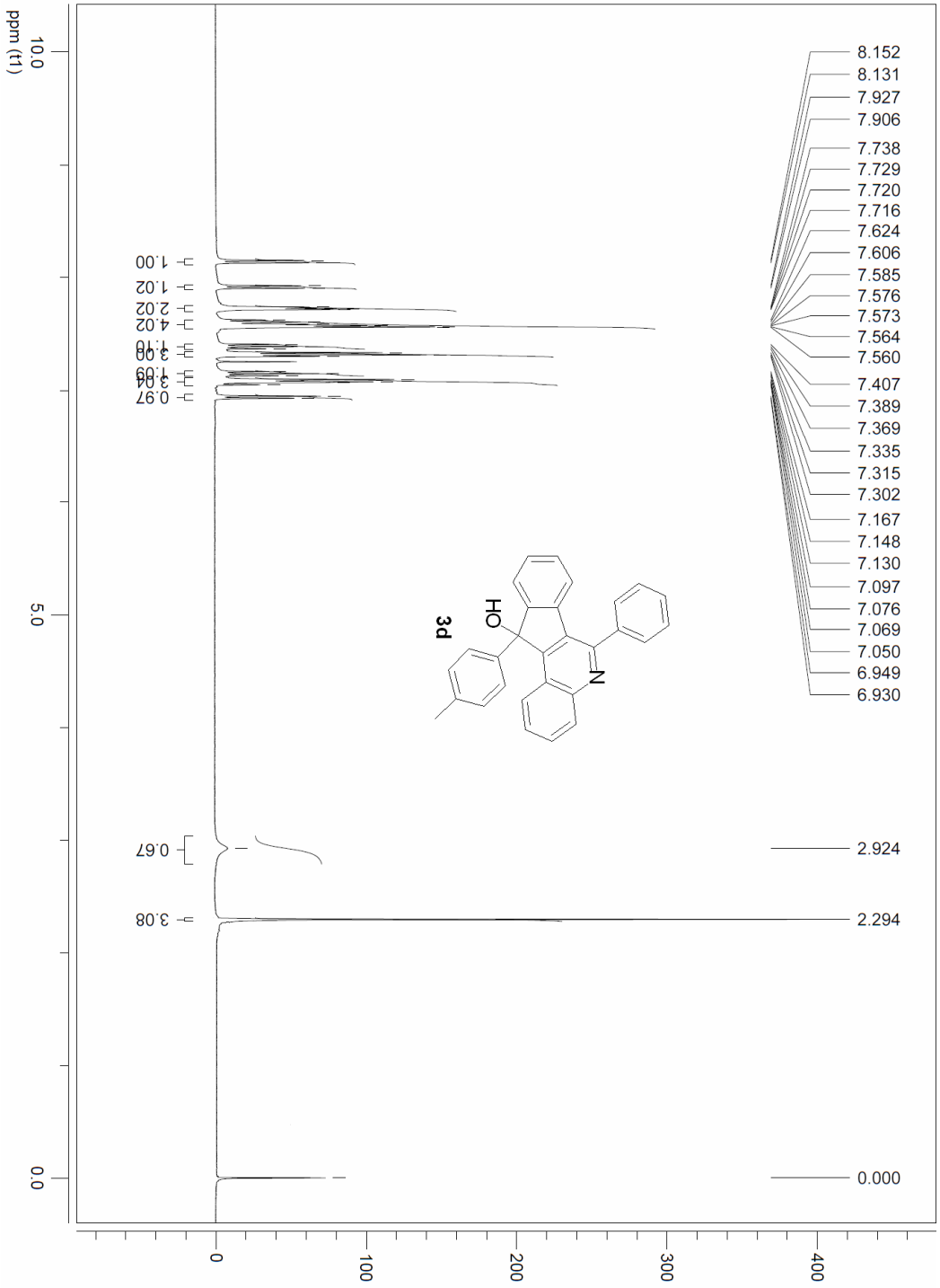
3c
HO
N
Cl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7.576
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7.302
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OH
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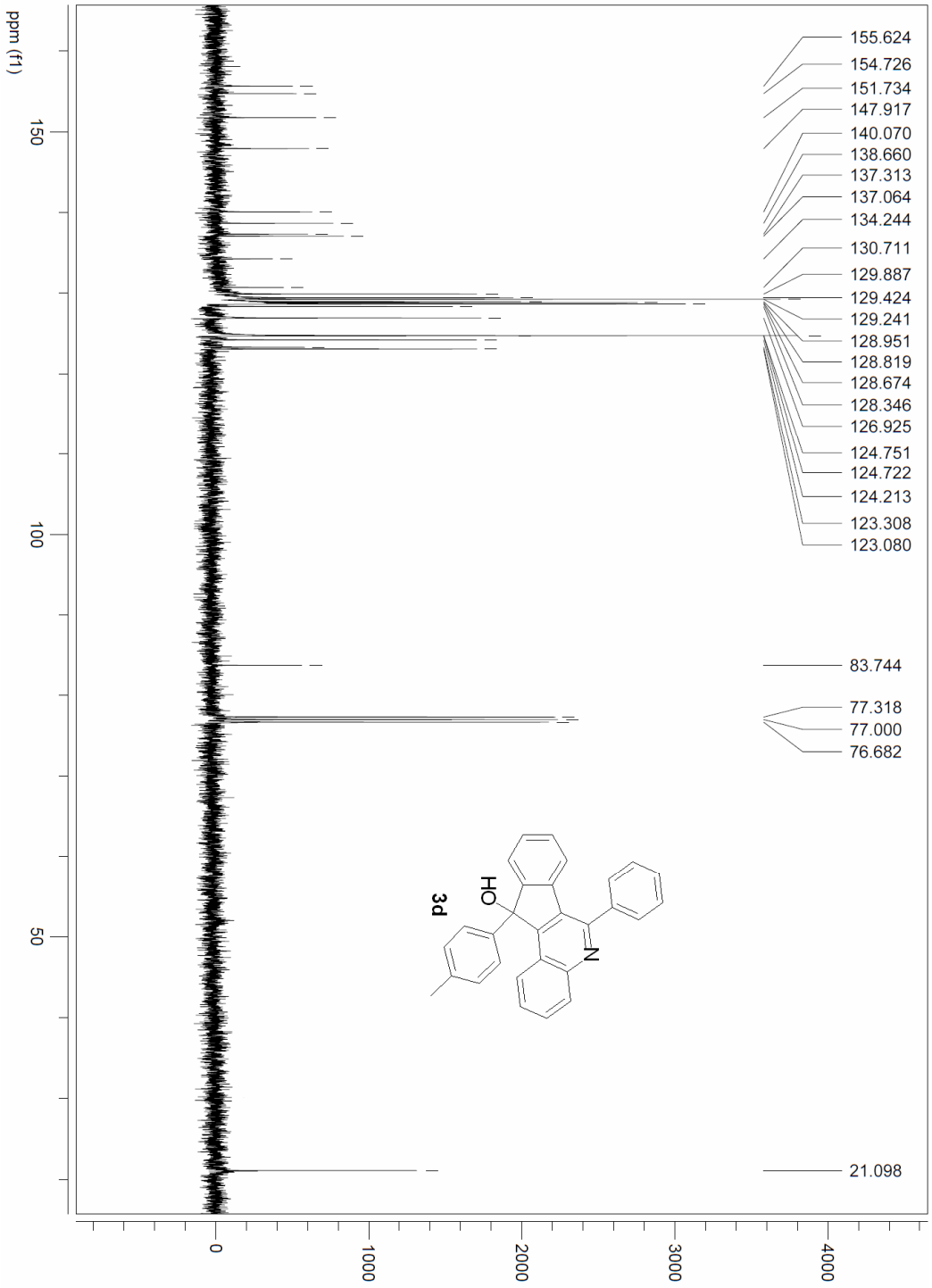
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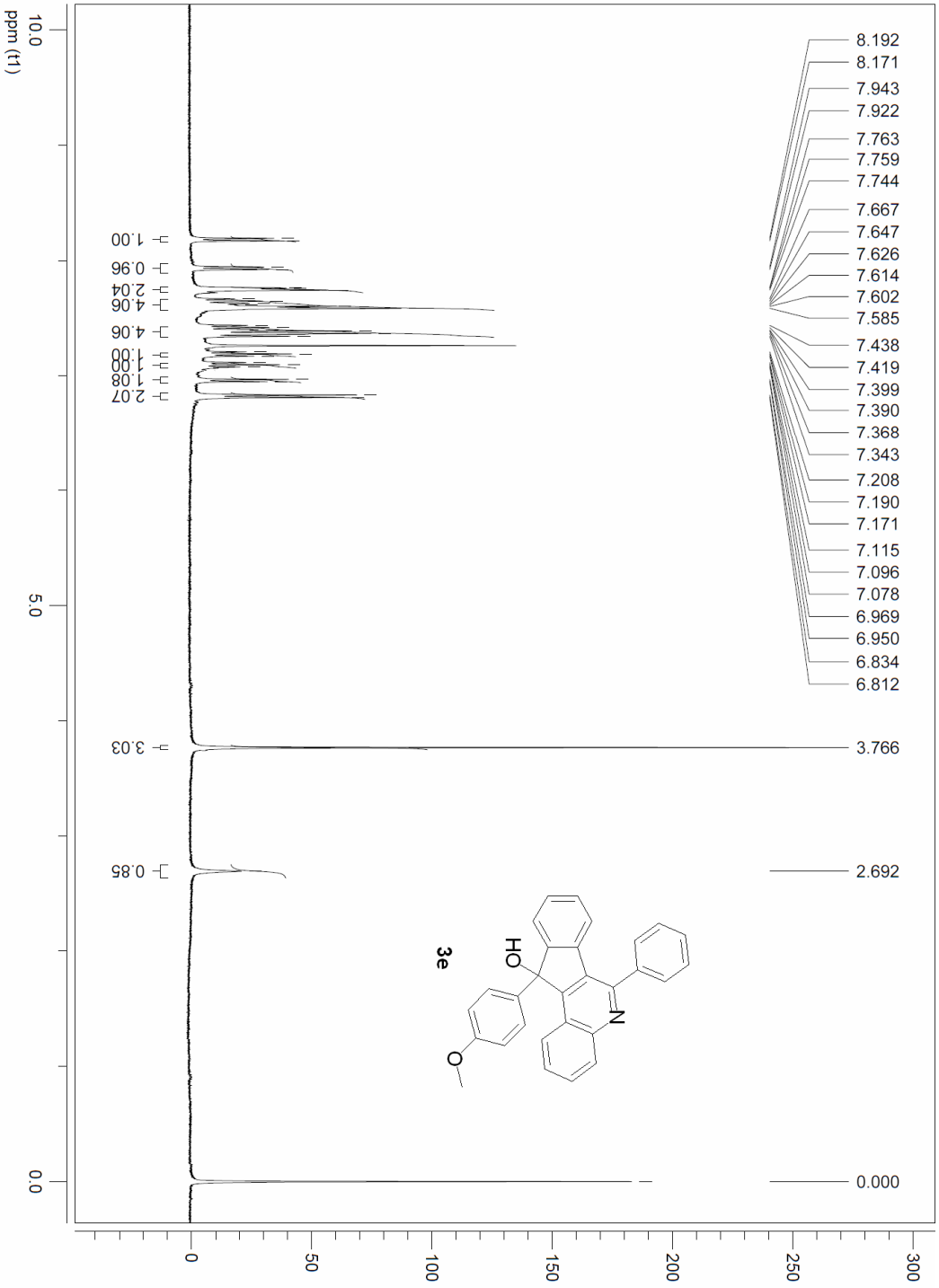
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7.647
7.626
7.614
7.602
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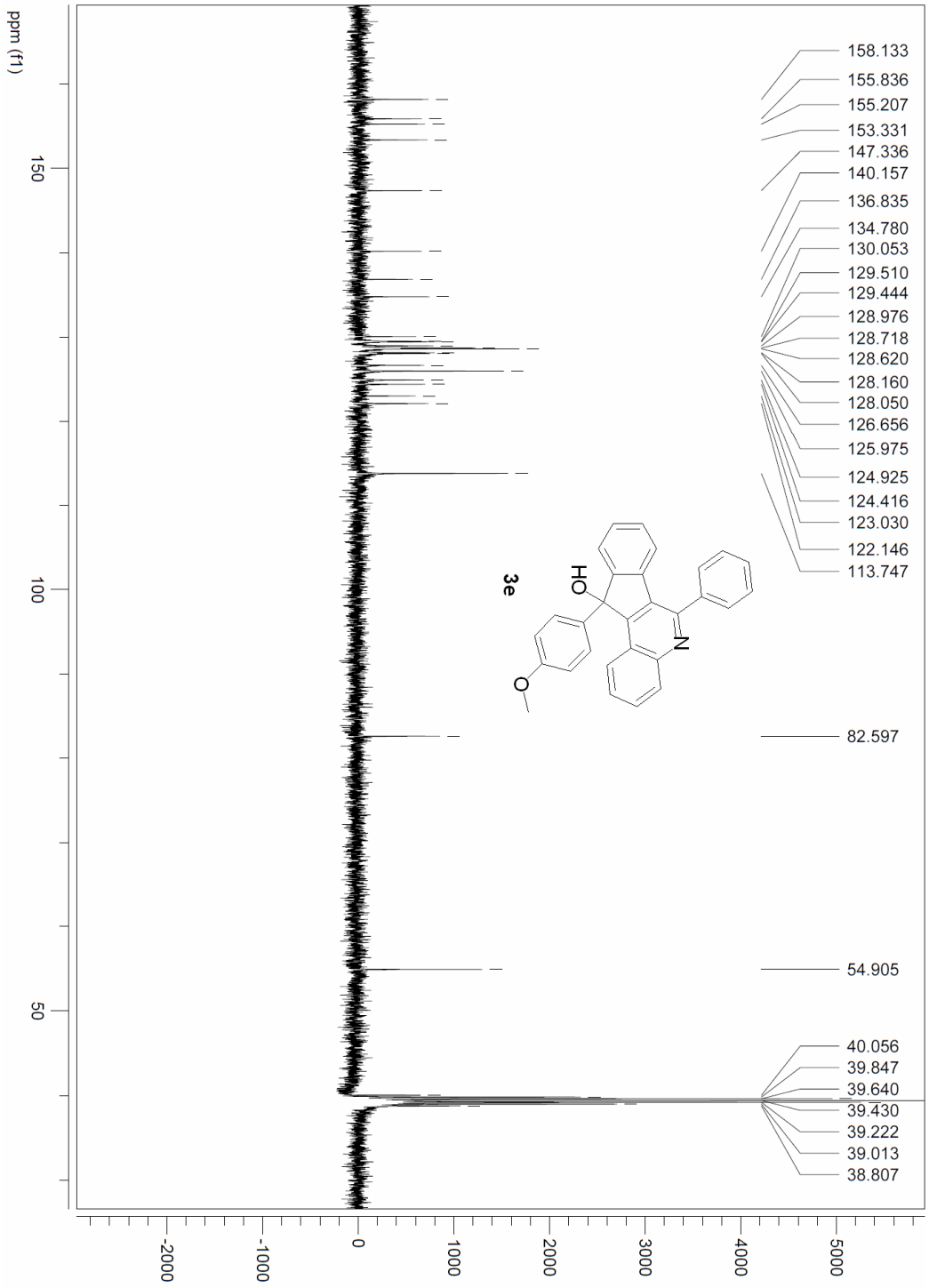
250
300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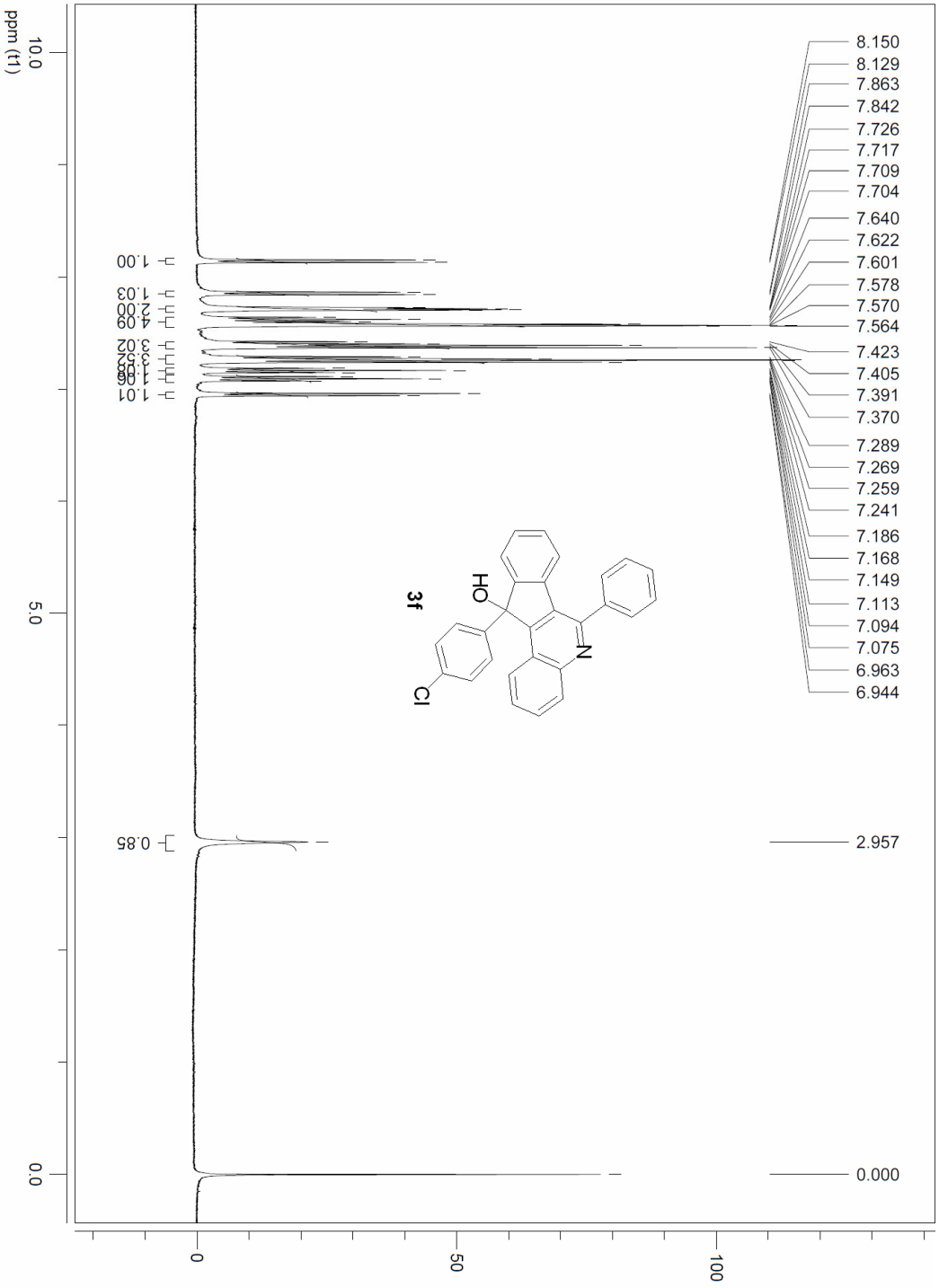
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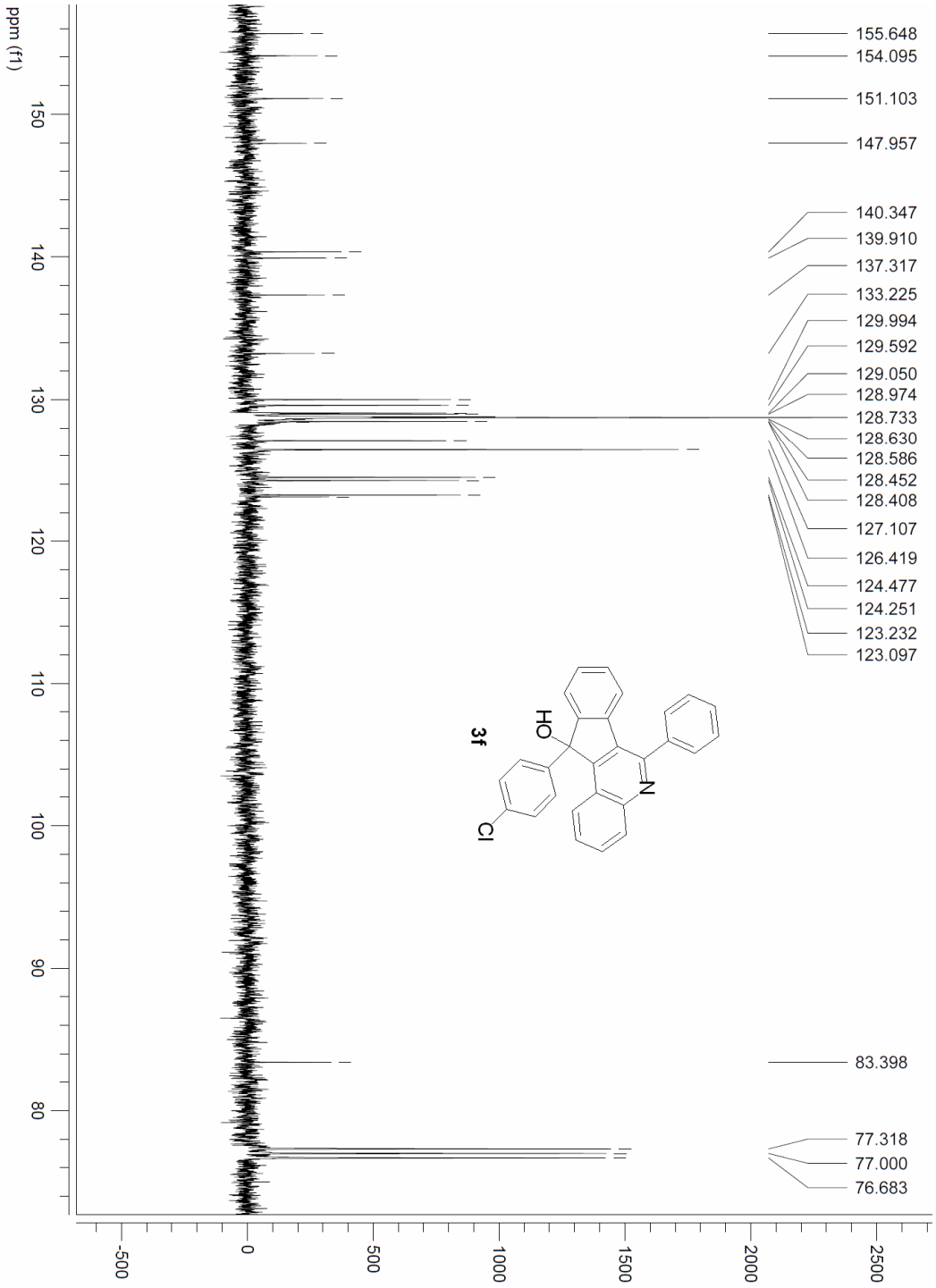
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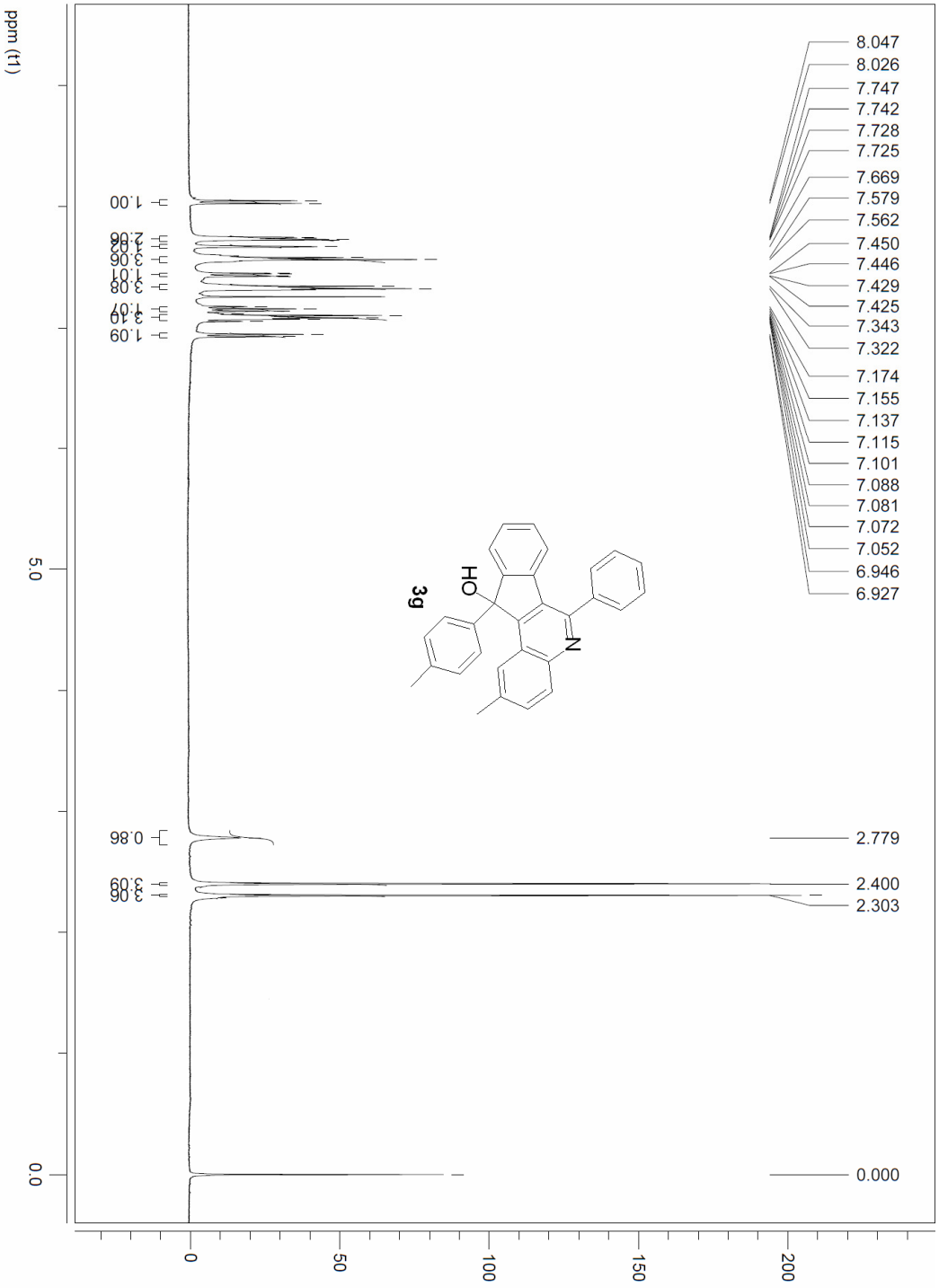
3f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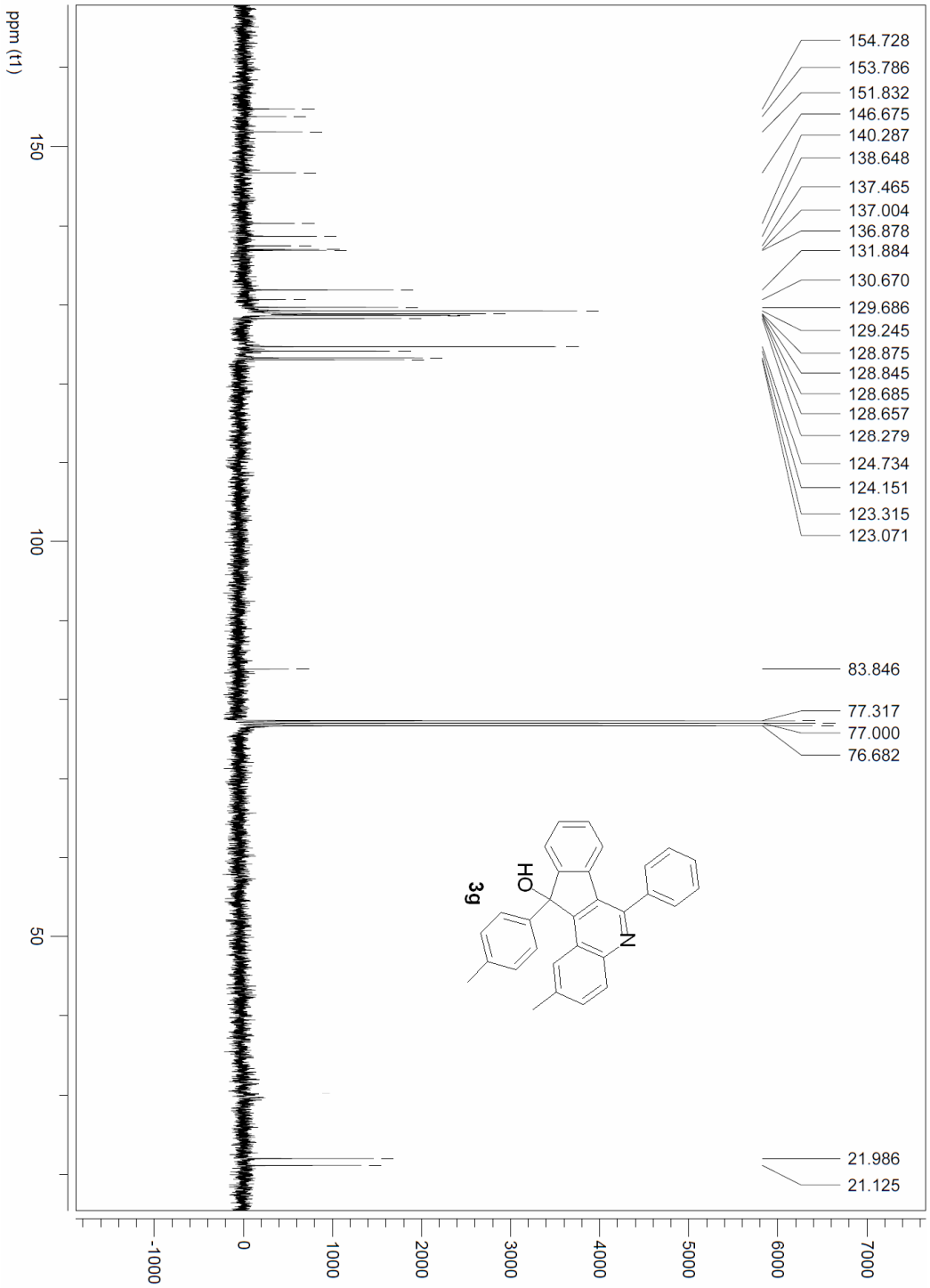
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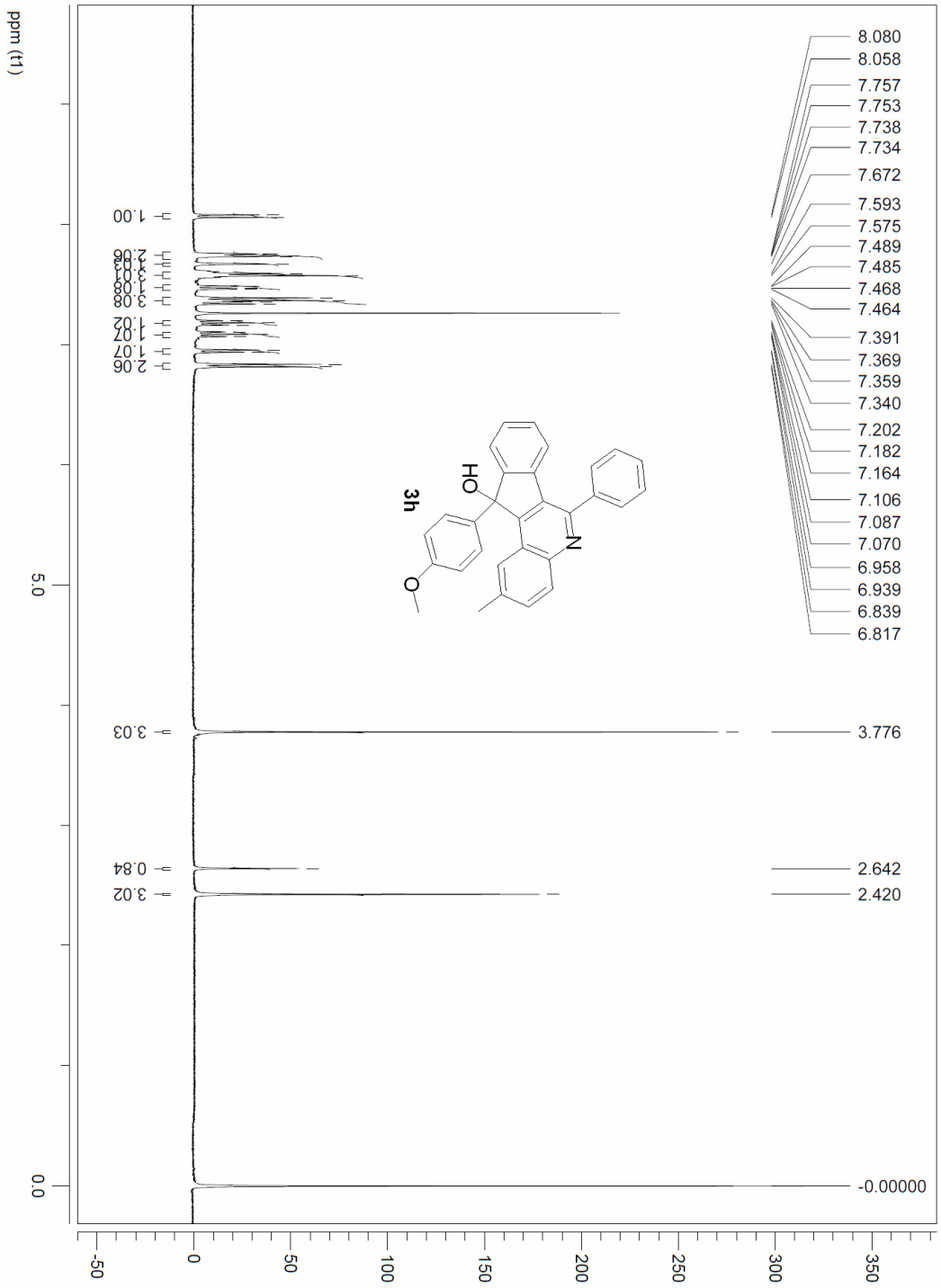
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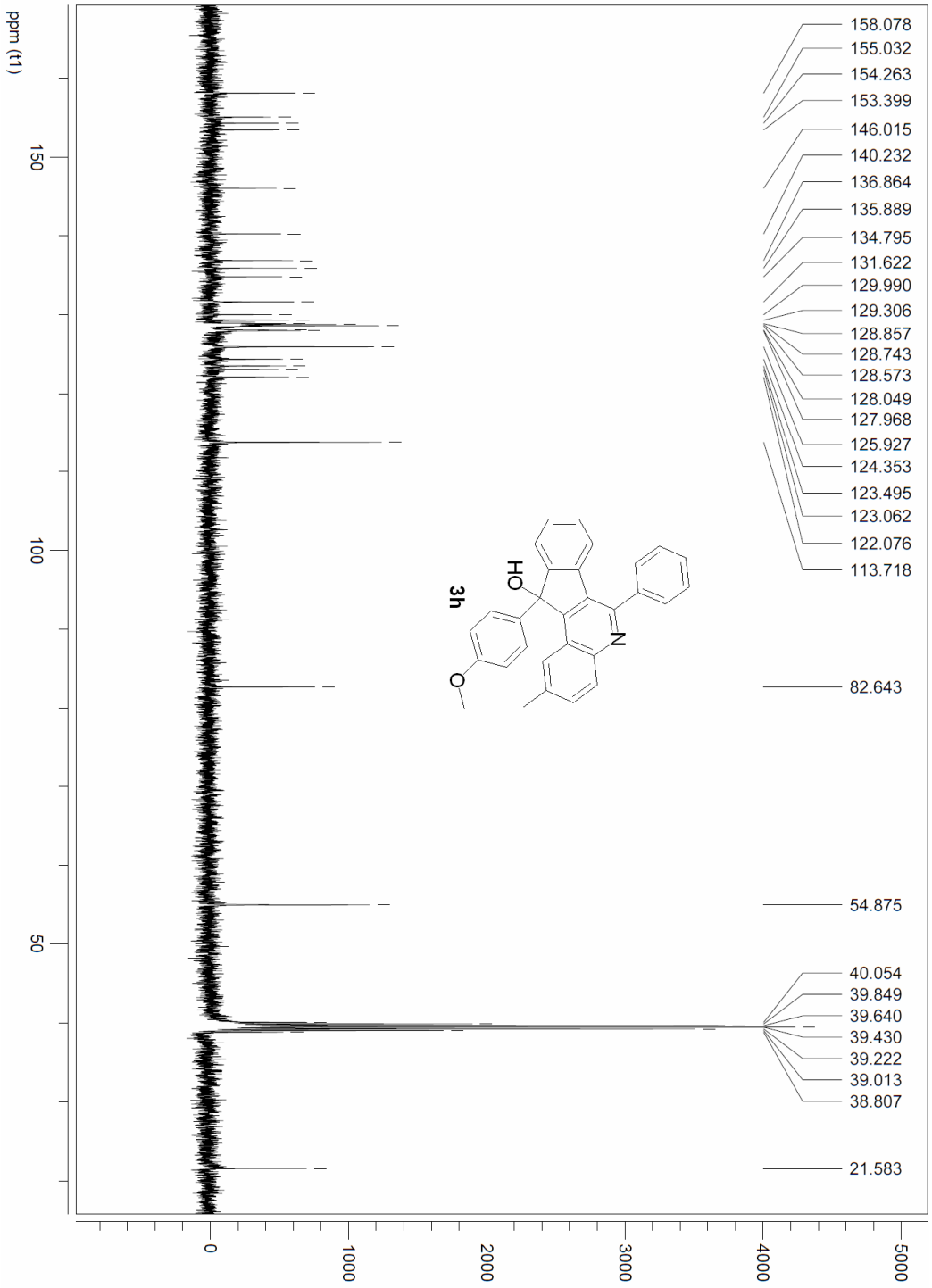
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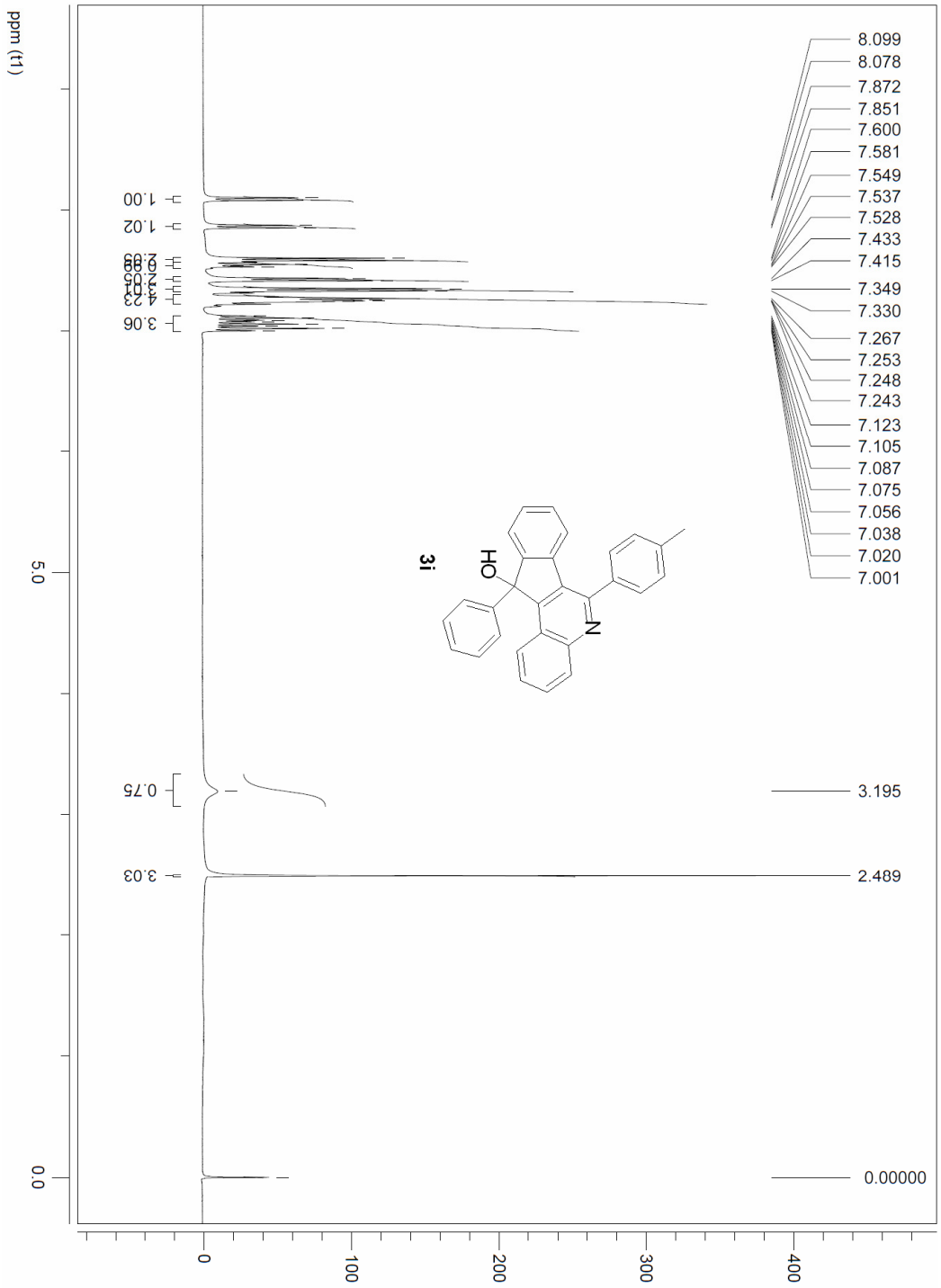
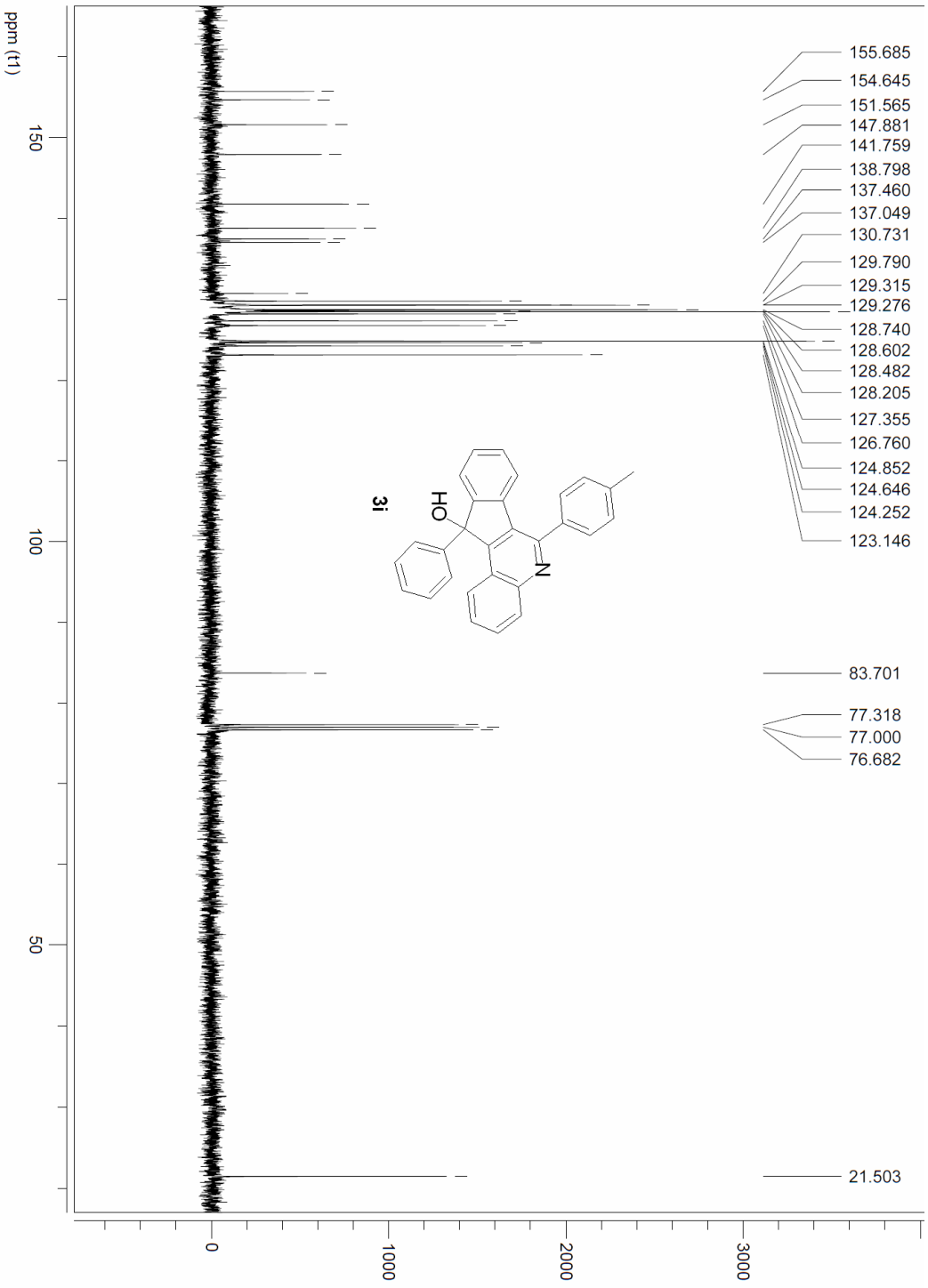
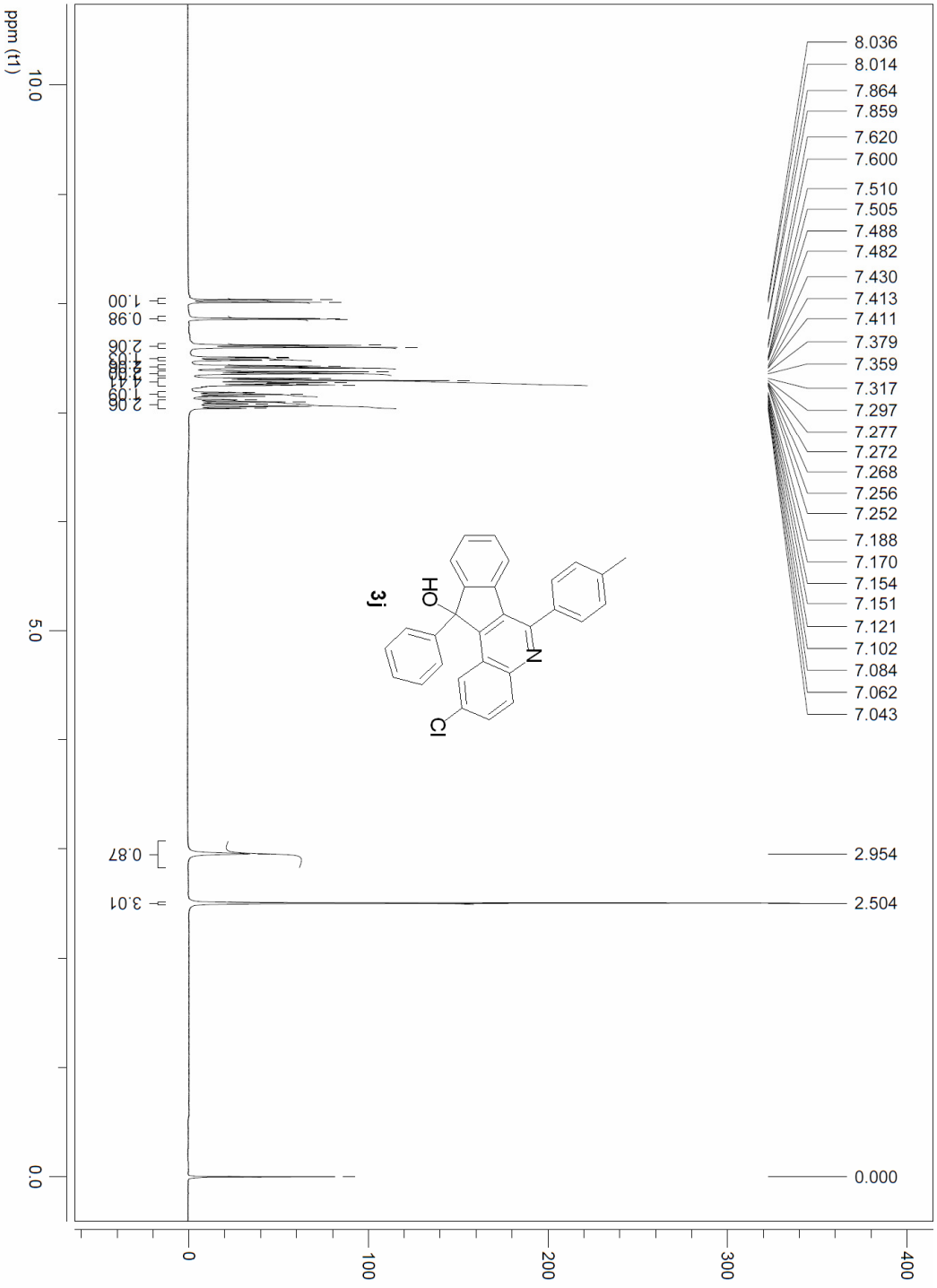
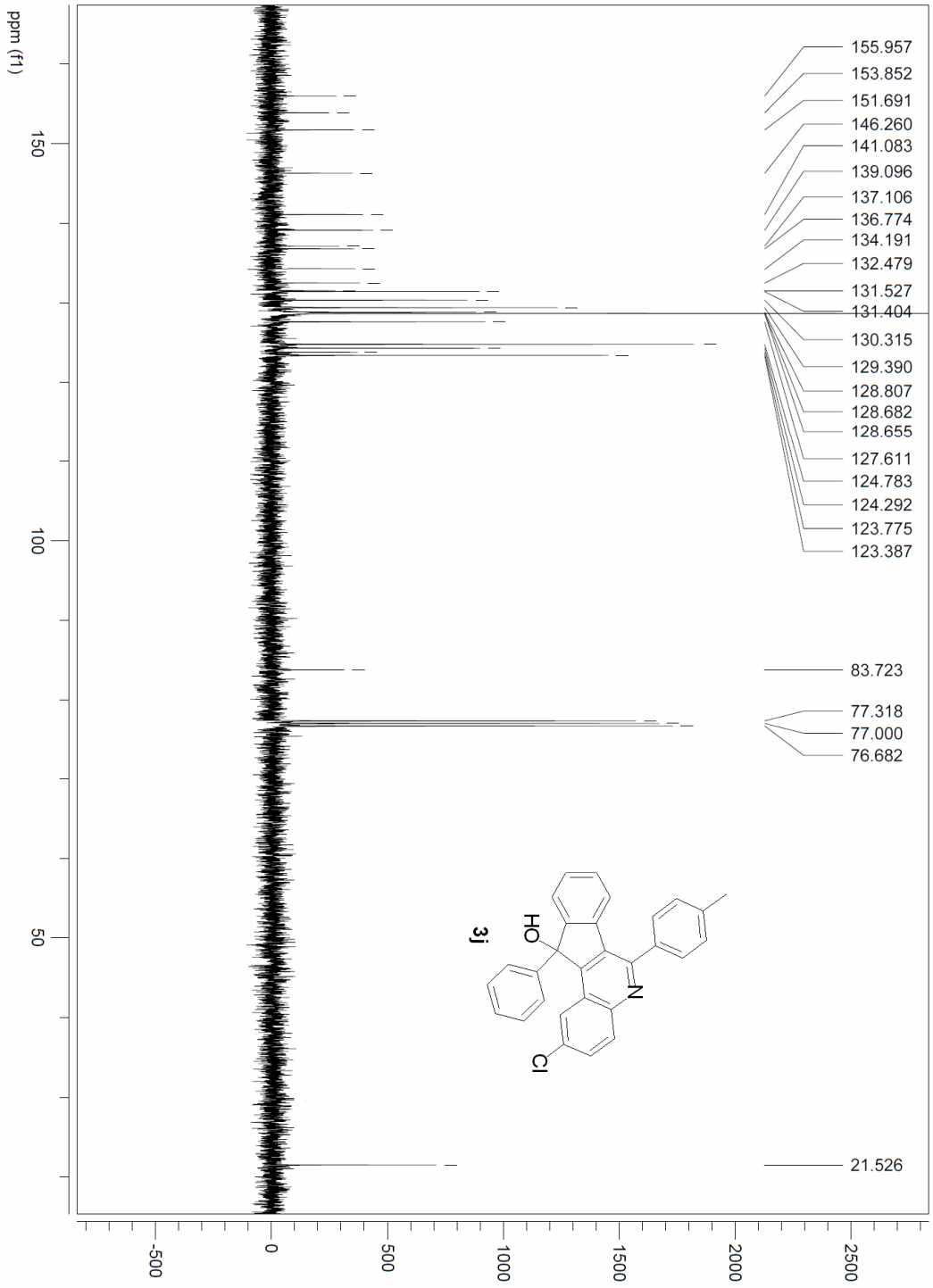
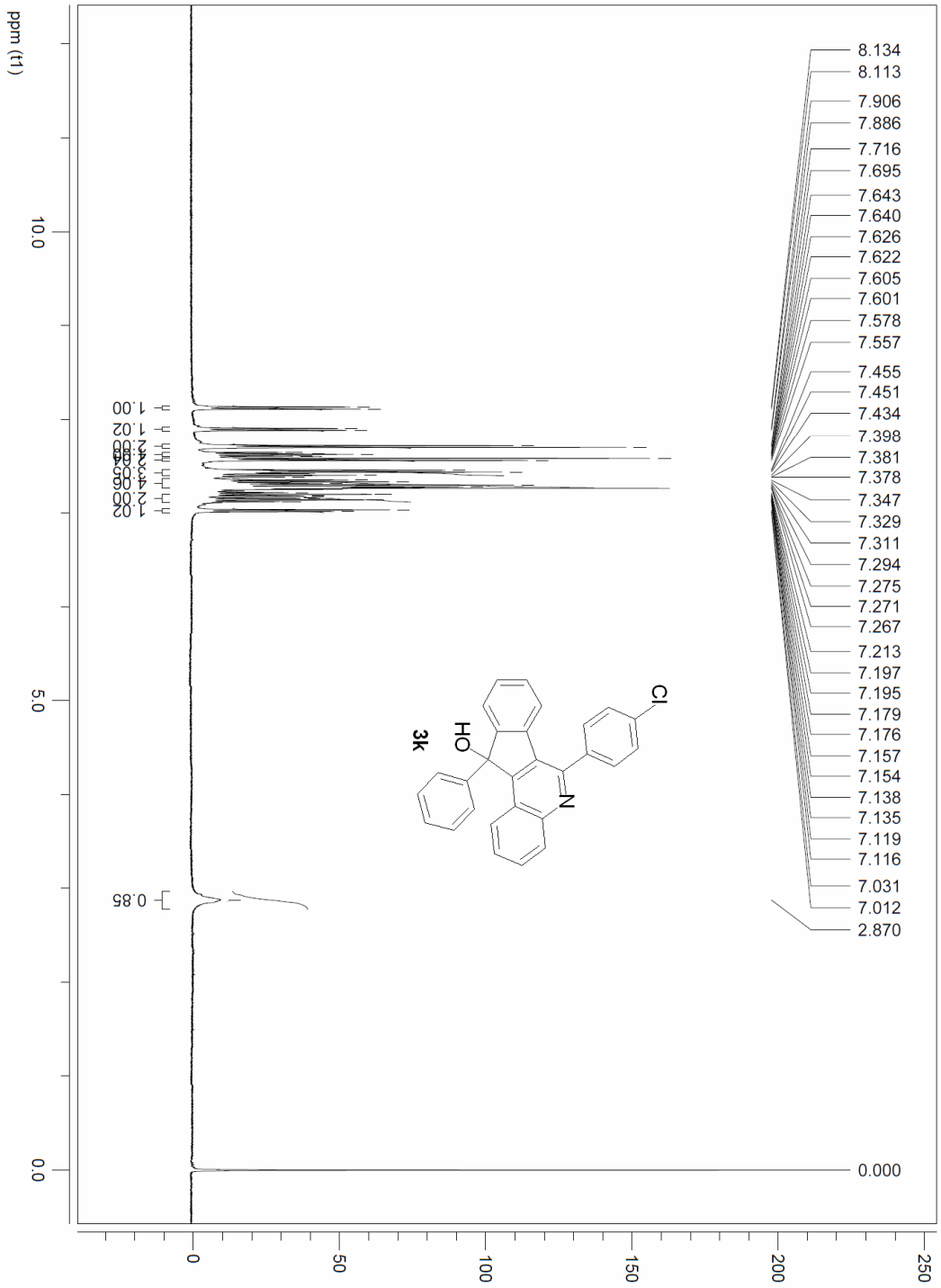
2000
3000
4000
5000
158.078
155.032
154.263
153.399
146.015
140.232
136.864
135.889
134.795
131.622
129.990
129.306
128.857
128.743
128.573
128.049
127.968
125.927
124.353
123.495
123.062
122.076
113.718
82.643
54.875
40.054
39.849
39.640
39.430
39.222
39.013
38.807
21.583
3h
HO
N
O

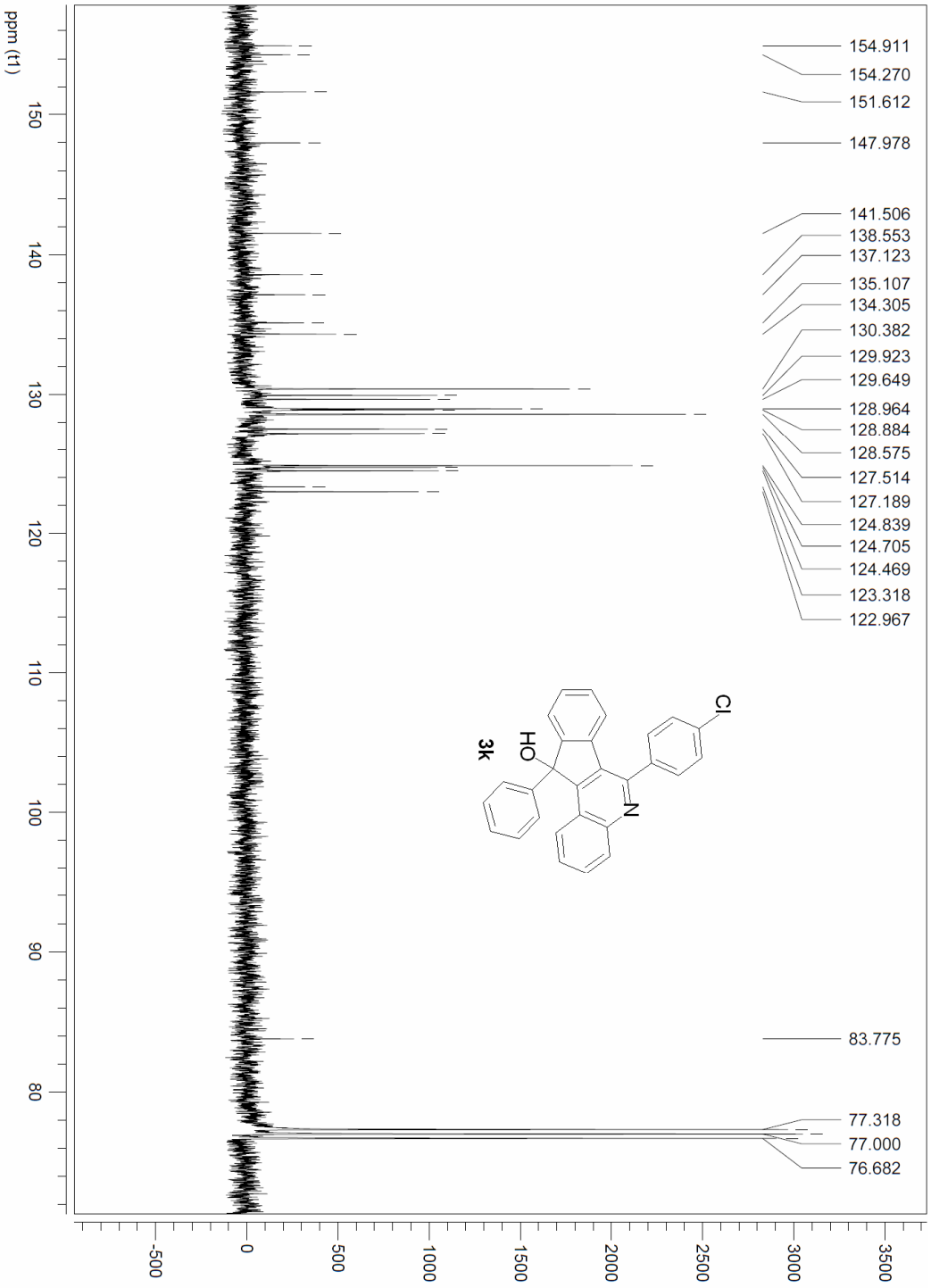

ppm (t1)
5.0
0.0
0
100
200
300
400
1.00
1.02
3.06
0.75
3.03
3.195
2.489
0.00000
8.099
8.078
7.872
7.851
7.600
7.581
7.549
7.537
7.528
7.433
7.415
7.349
7.330
7.267
7.253
7.248
7.243
7.123
7.105
7.087
7.075
7.056
7.038
7.020
7.001
3i
HO
N

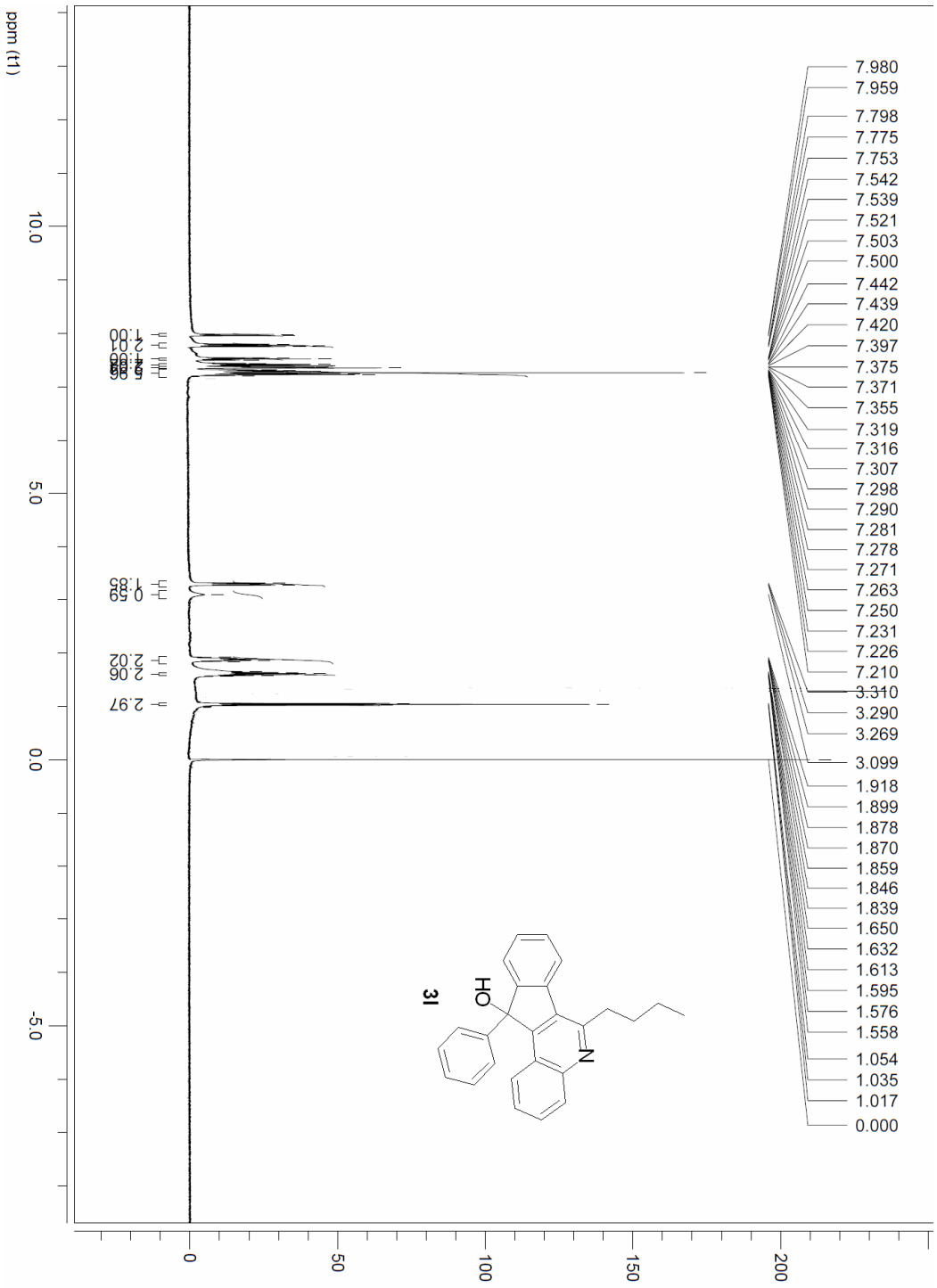

ppm (t1)
150
100
50
0
1000
2000
3000
155.685
154.645
151.565
147.881
141.759
138.798
137.460
137.049
130.731
129.790
129.315
129.276
128.740
128.602
128.482
128.205
127.355
126.760
124.852
124.646
124.252
123.146
83.701
77.318
77.000
76.682
21.503
3i
HO
N

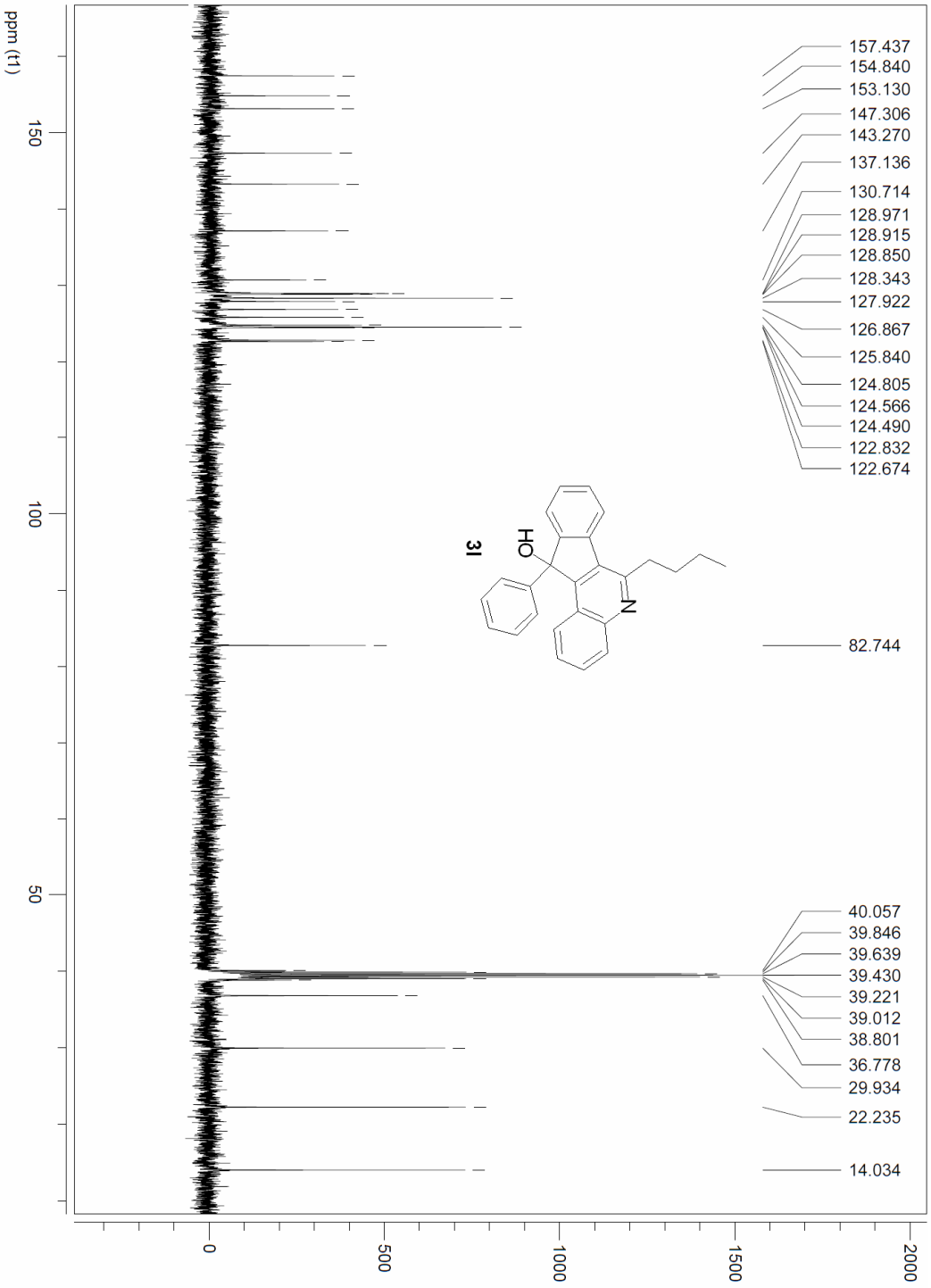

ppm (t1)
10.0
5.0
0.0
0
100
200
300
400
8.036
8.014
7.864
7.859
7.620
7.600
7.510
7.505
7.488
7.482
7.430
7.413
7.411
7.379
7.359
7.317
7.297
7.277
7.272
7.268
7.256
7.252
7.188
7.170
7.154
7.151
7.121
7.102
7.084
7.062
7.043
2.954
2.504
0.000
1.00
0.98
2.06
0.87
3.01
3j
HO
N
Cl

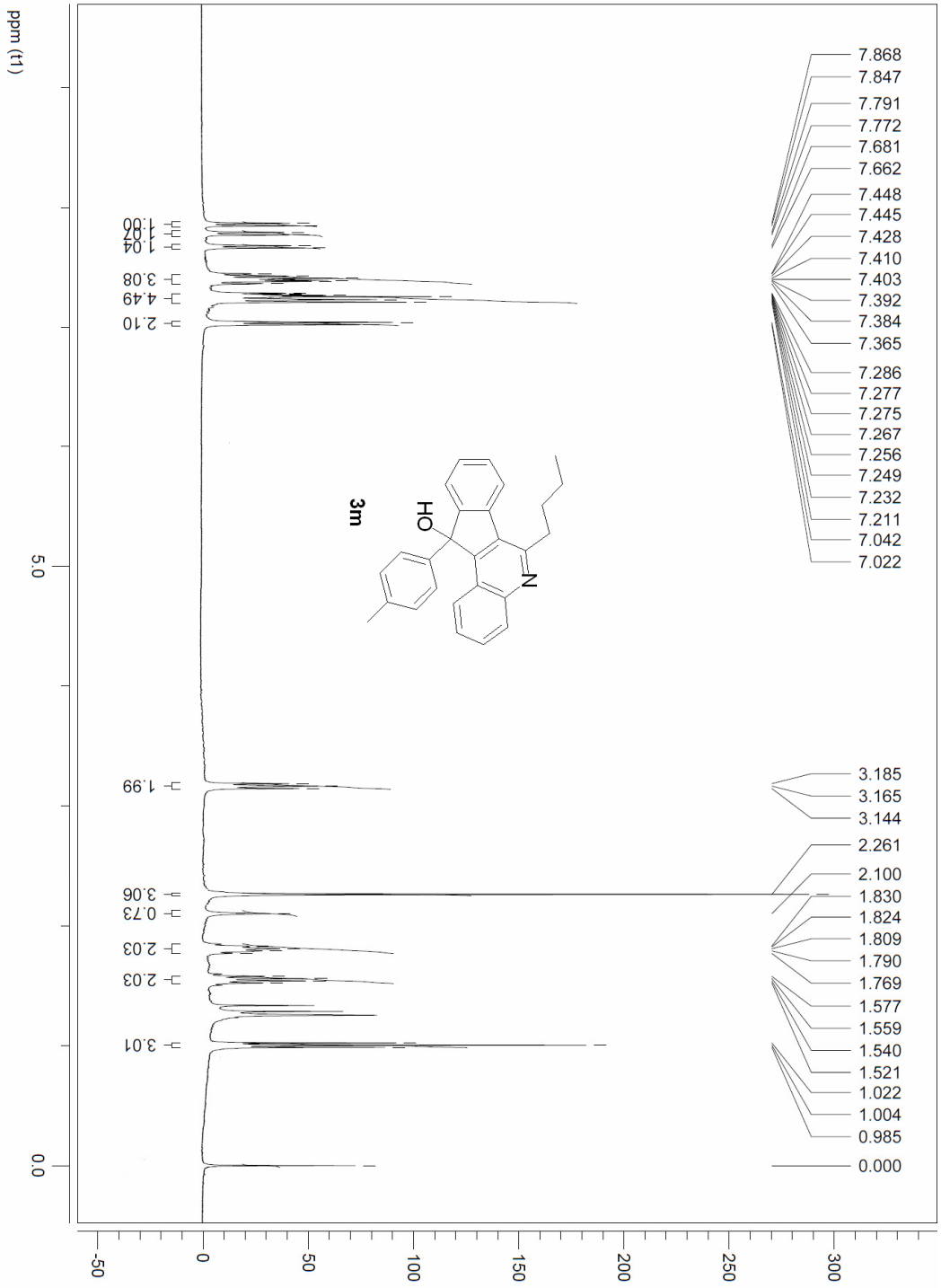

ppm (f1)
150
100
50
155.957
153.852
151.691
146.260
141.083
139.096
137.106
136.774
134.191
132.479
131.527
131.404
130.315
129.390
128.807
128.682
128.655
127.611
124.783
124.292
123.775
123.387
83.723
77.318
77.000
76.682
21.526
3j
HO
N
Cl
-500
0
500
1000
1500
2000
2500

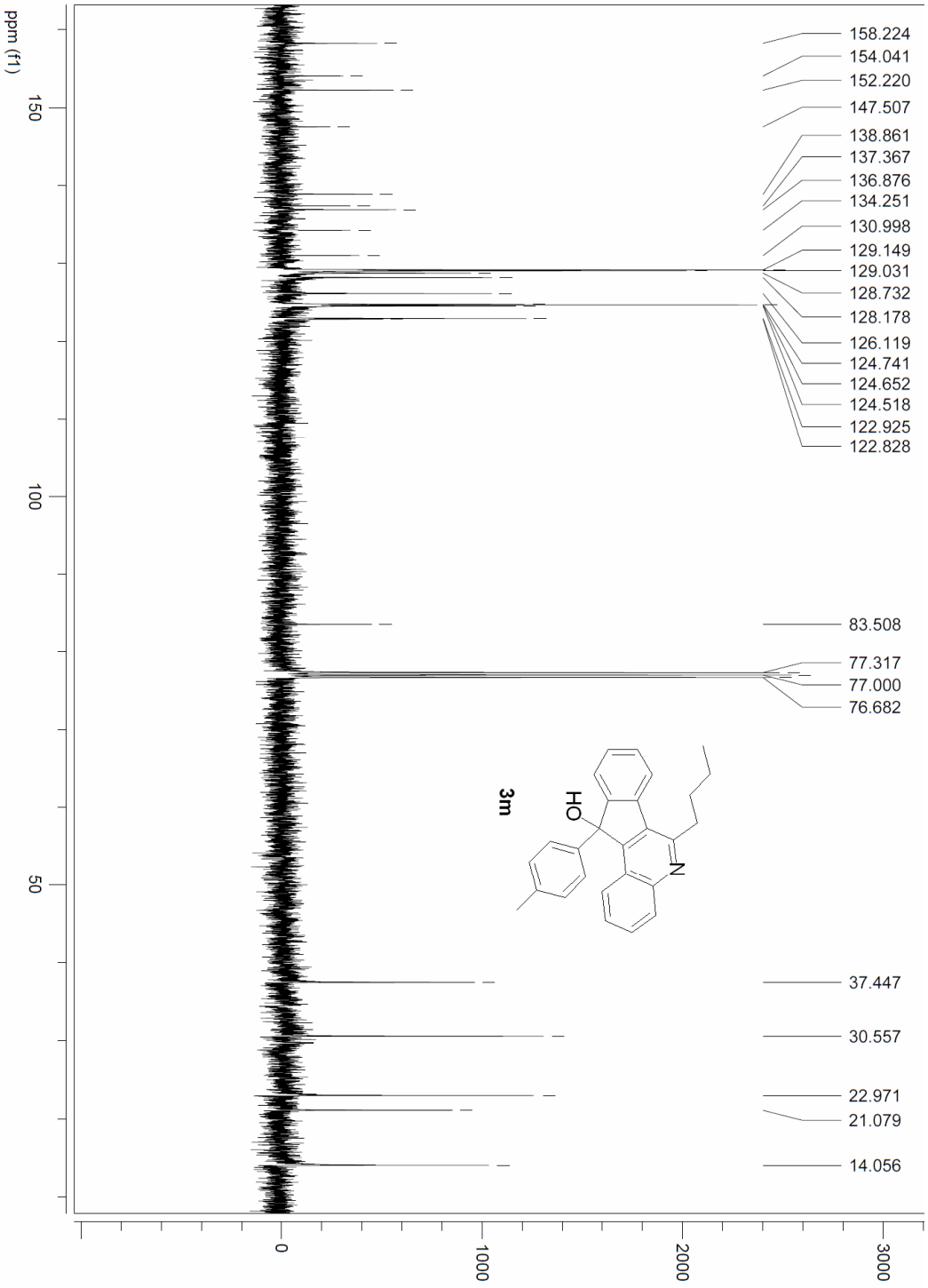

ppm (t1)
10.0
5.0
0.0
0
50
100
150
200
250
8.134
8.113
7.906
7.886
7.716
7.695
7.643
7.640
7.626
7.622
7.605
7.601
7.578
7.557
7.455
7.451
7.434
7.398
7.381
7.378
7.347
7.329
7.311
7.294
7.275
7.271
7.267
7.213
7.197
7.195
7.179
7.176
7.157
7.154
7.138
7.135
7.119
7.116
7.031
7.012
2.870
0.000
1.00
1.02
2.00
4.06
1.02
0.85
3k
HO
N
Cl

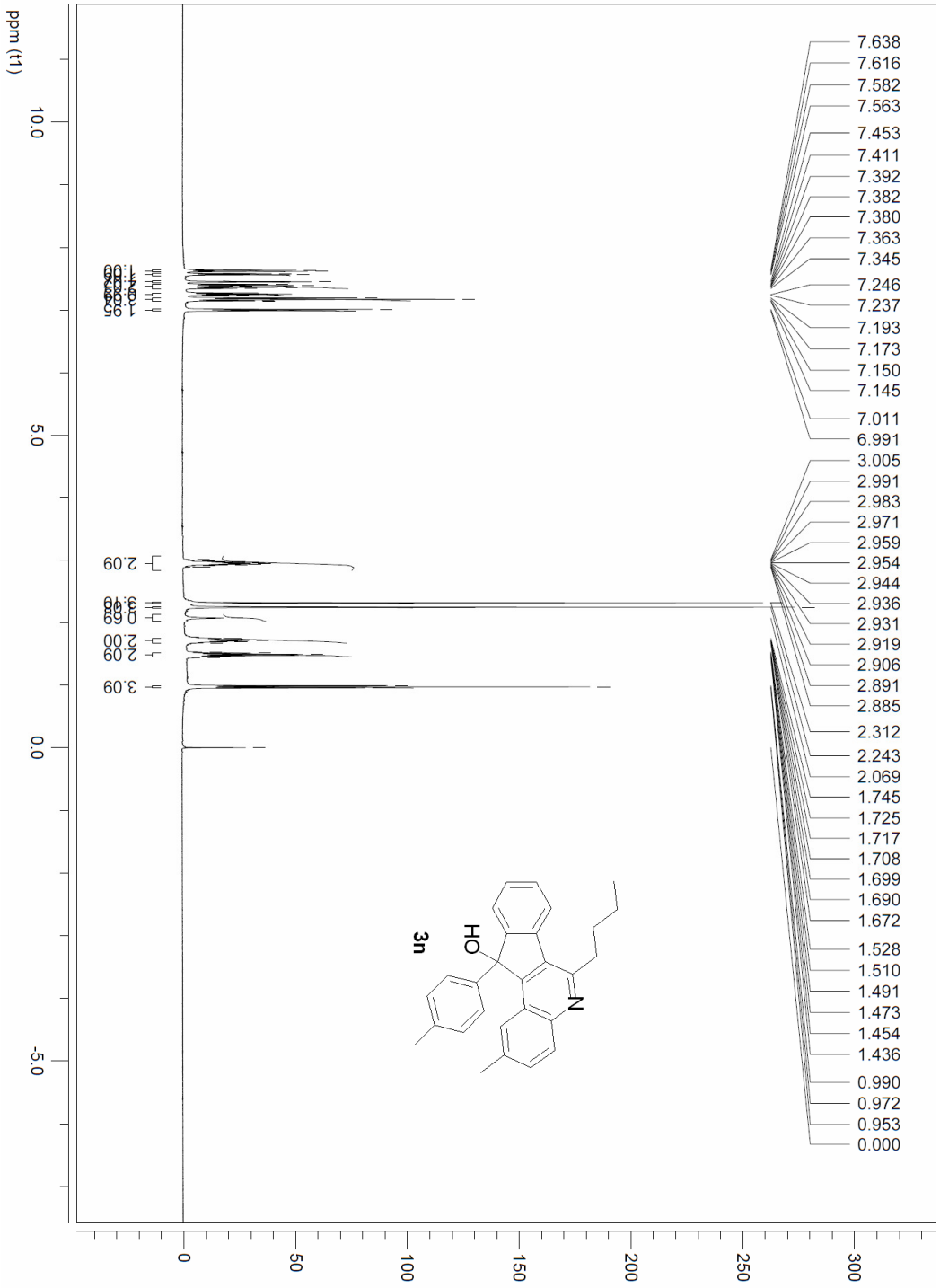

ppm (t1)
154.911
154.270
151.612
147.978
141.506
138.553
137.123
135.107
134.305
130.382
129.923
129.649
128.964
128.884
128.575
127.514
127.189
124.839
124.705
124.469
123.318
122.967
83.775
77.318
77.000
76.682
3k
HO
Cl
N

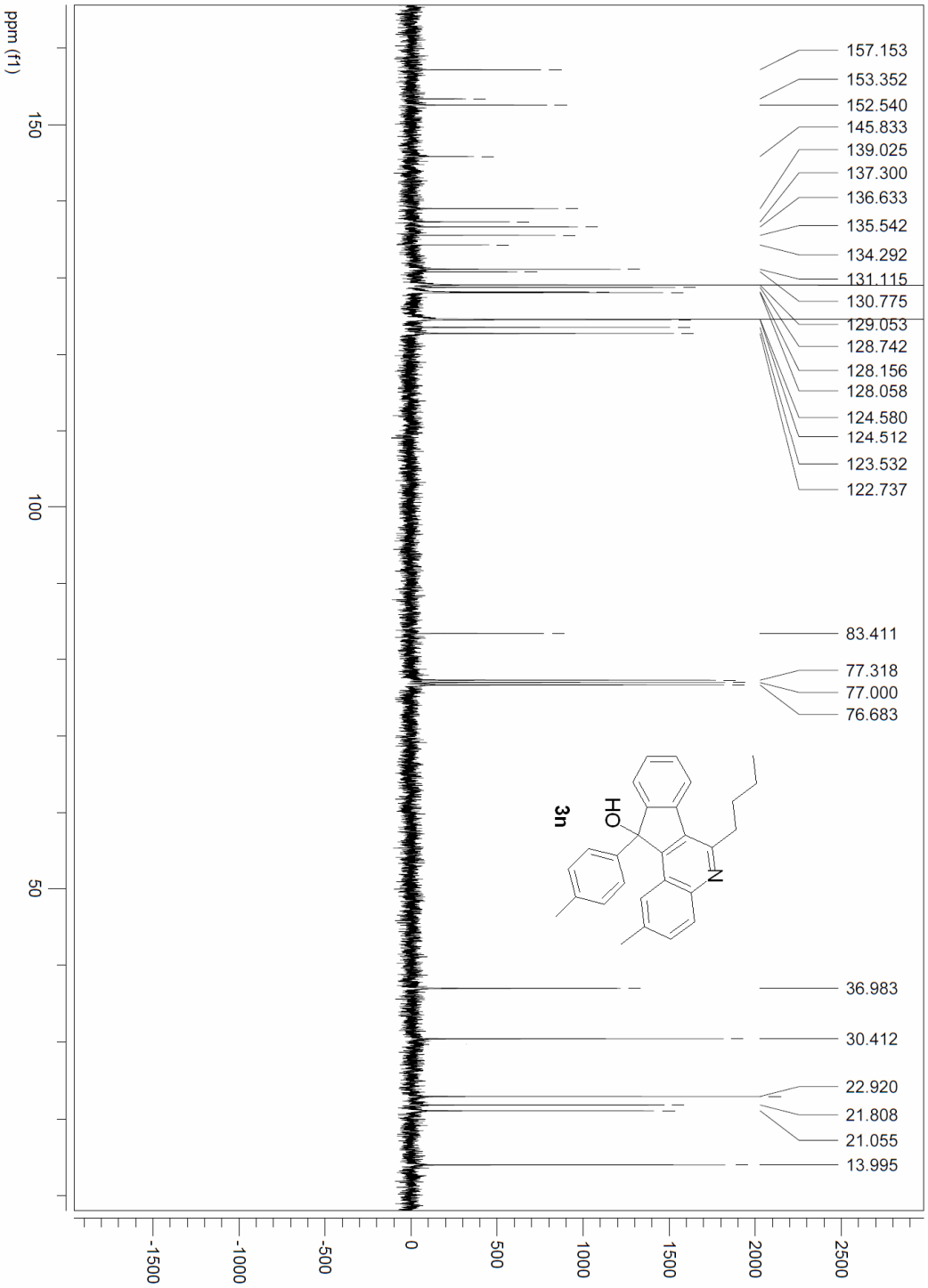

ppm (t1)
10.0
5.0
0.0
-5.0
0
50
100
150
200
1.00
2.01
5.86
0.59
1.85
2.02
2.06
2.97
7.980
7.959
7.798
7.775
7.753
7.542
7.539
7.521
7.503
7.500
7.442
7.439
7.420
7.397
7.375
7.371
7.355
7.319
7.316
7.307
7.298
7.290
7.281
7.278
7.271
7.263
7.250
7.231
7.226
7.210
3.310
3.290
3.269
3.099
1.918
1.899
1.878
1.870
1.859
1.846
1.839
1.650
1.632
1.613
1.595
1.576
1.558
1.054
1.035
1.017
0.000
3l
HO
N

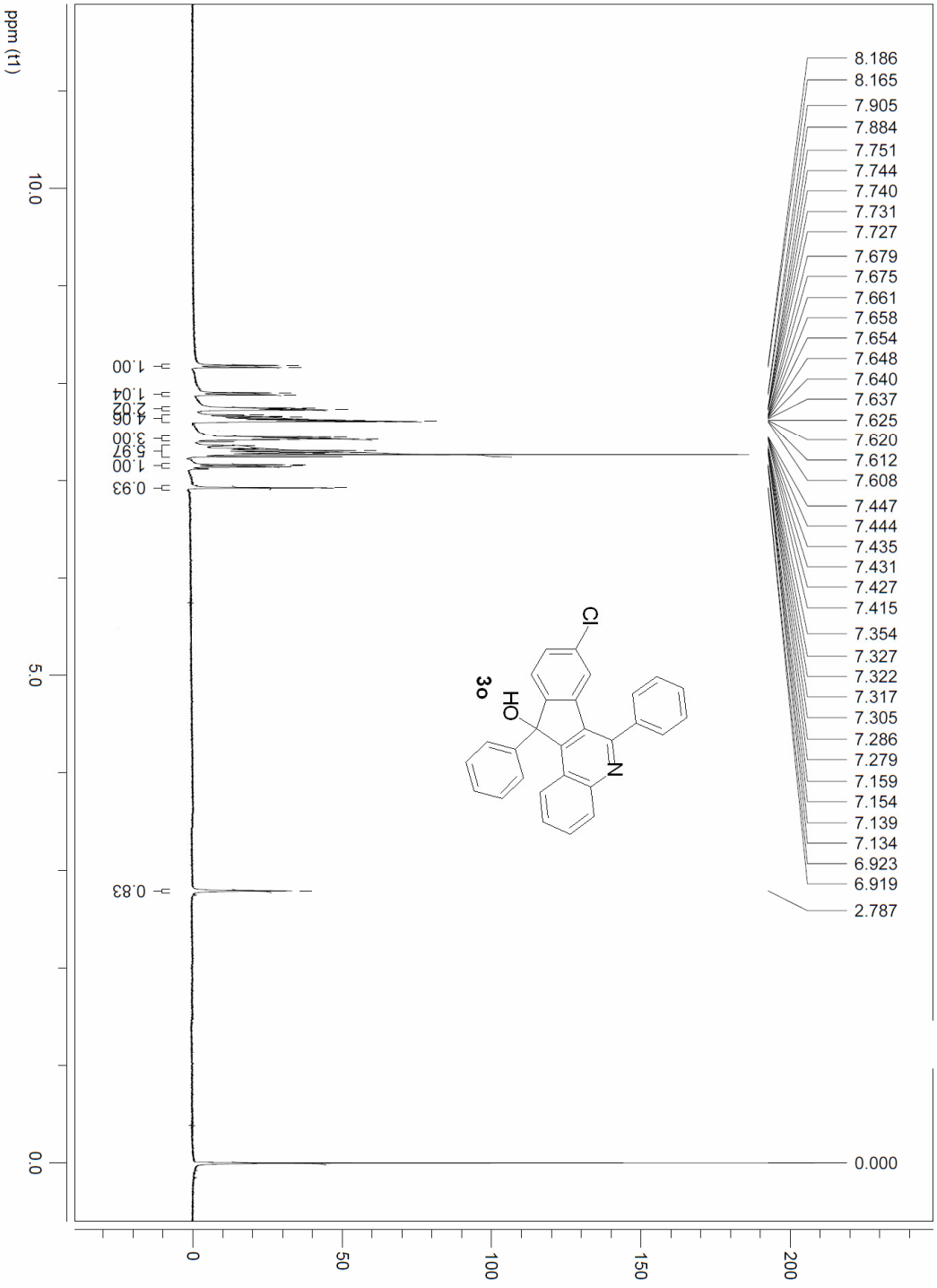

ppm (t1)
150
100
50
0
500
1000
1500
2000
157.437
154.840
153.130
147.306
143.270
137.136
130.714
128.971
128.915
128.850
128.343
127.922
126.867
125.840
124.805
124.566
124.490
122.832
122.674
82.744
40.057
39.846
39.639
39.430
39.221
39.012
38.801
36.778
29.934
22.235
14.034
3l
HO
N

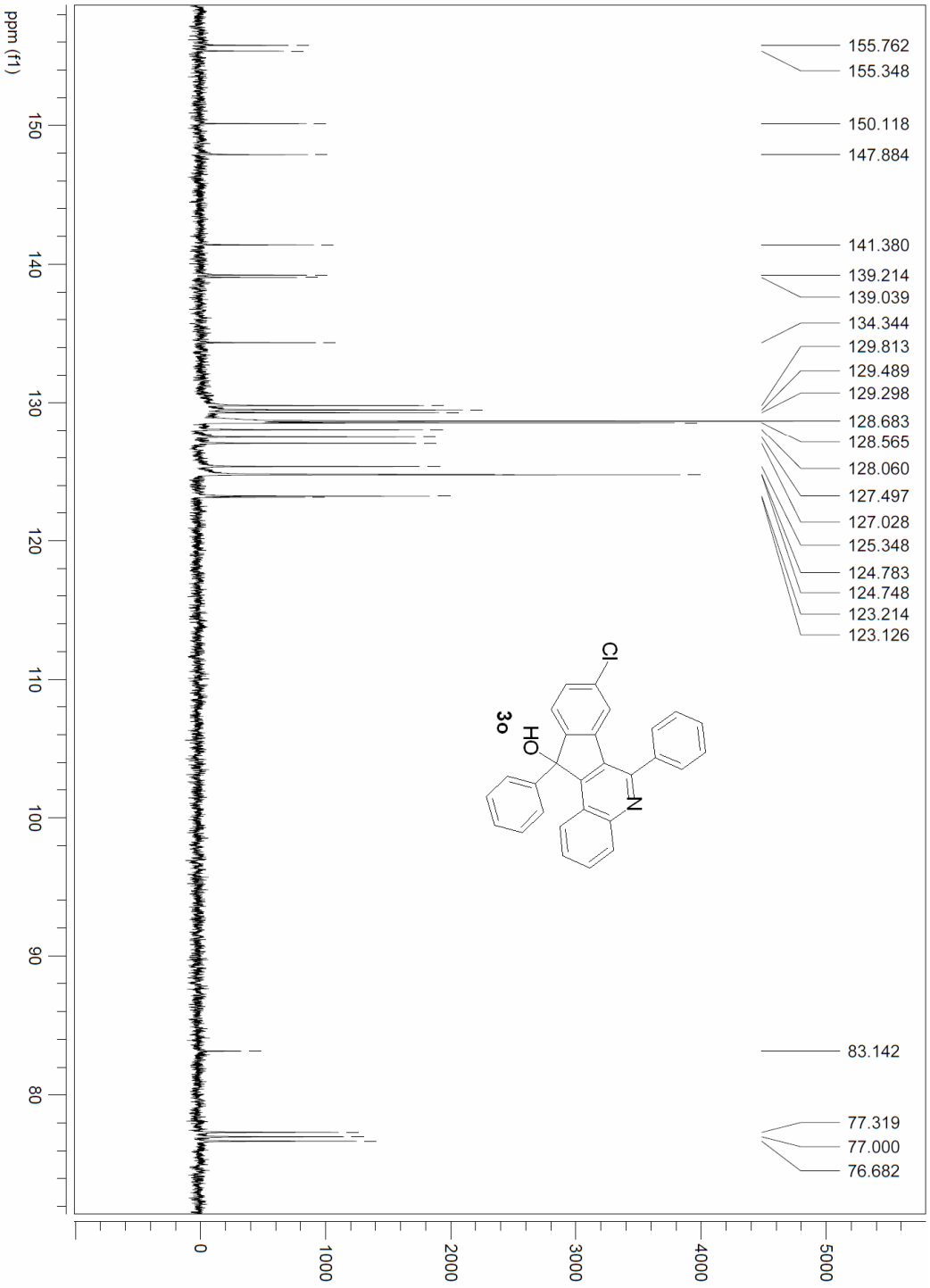

ppm (t1)
5.0
0.0
7.868
7.847
7.791
7.772
7.681
7.662
7.448
7.445
7.428
7.410
7.403
7.392
7.384
7.365
7.286
7.277
7.275
7.267
7.256
7.249
7.232
7.211
7.042
7.022
3.185
3.165
3.144
2.261
2.100
1.830
1.824
1.809
1.790
1.769
1.577
1.559
1.540
1.521
1.022
1.004
0.985
0.000
1.00
1.02
1.04
3.08
4.49
2.10
1.99
3.06
0.73
2.03
2.03
3.01
3m
HO
N
-50
0
50
100
150
200
250
300

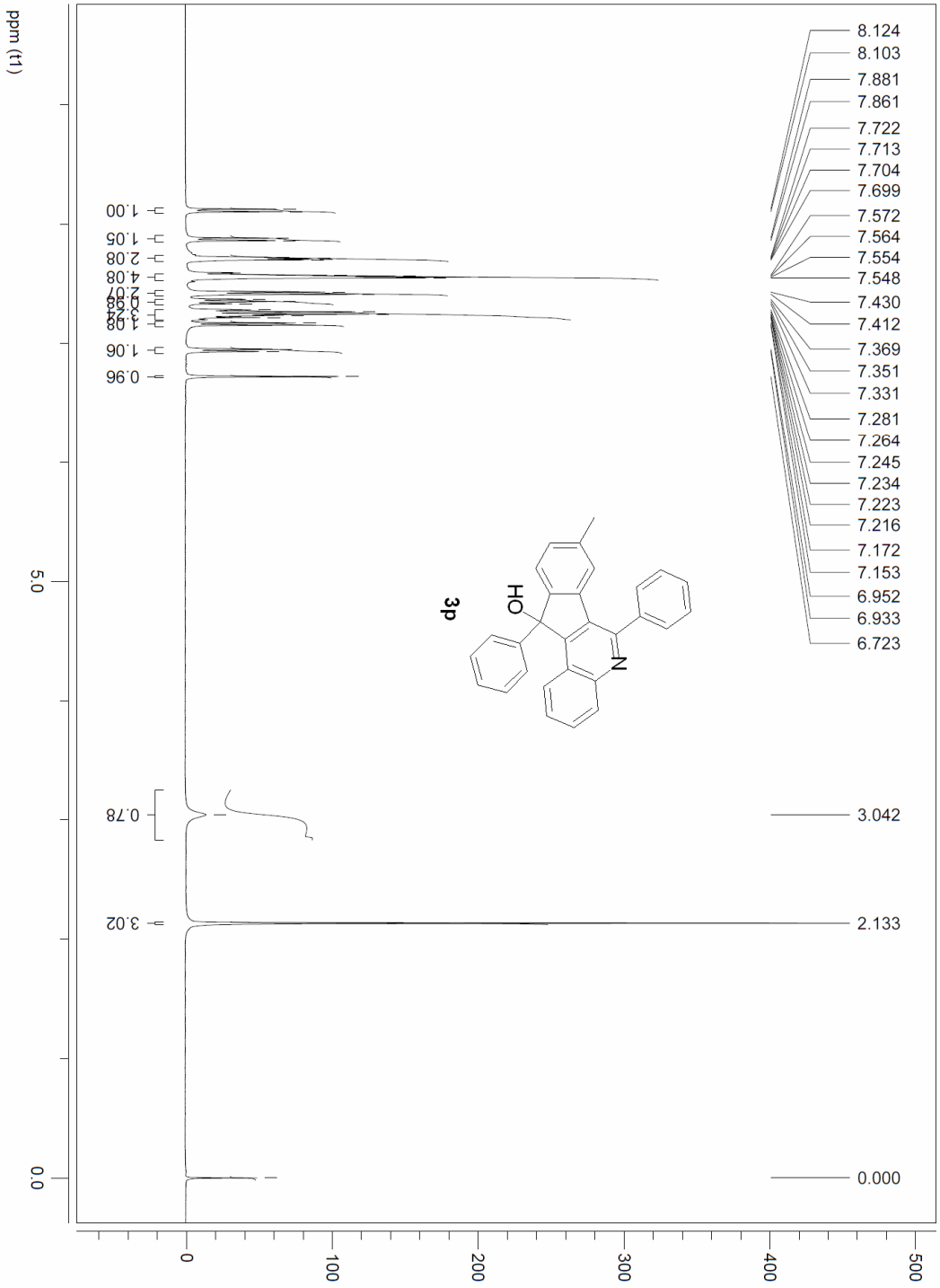

ppm (f1)
150
100
50
0
1000
2000
3000
158.224
154.041
152.220
147.507
138.861
137.367
136.876
134.251
130.998
129.149
129.031
128.732
128.178
126.119
124.741
124.652
124.518
122.925
122.828
83.508
77.317
77.000
76.682
37.447
30.557
22.971
21.079
14.056
3m
HO
N

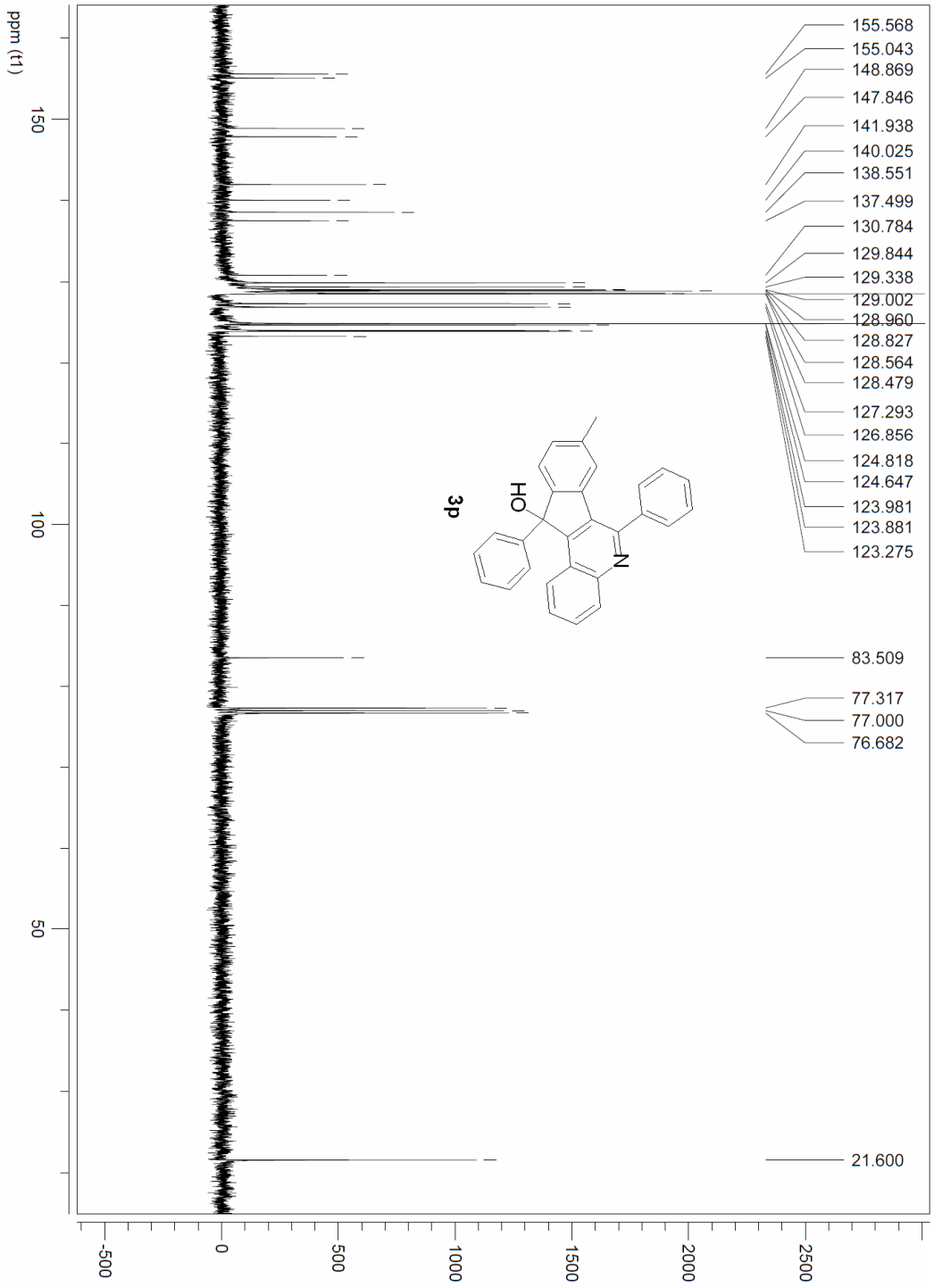

ppm (t1)
10.0
5.0
0.0
-5.0
0
50
100
150
200
250
300
7.638
7.616
7.582
7.563
7.453
7.411
7.392
7.382
7.380
7.363
7.345
7.246
7.237
7.193
7.173
7.150
7.145
7.011
6.991
3.005
2.991
2.983
2.971
2.959
2.954
2.944
2.936
2.931
2.919
2.906
2.891
2.885
2.312
2.243
2.069
1.745
1.725
1.717
1.708
1.699
1.690
1.672
1.528
1.510
1.491
1.473
1.454
1.436
0.990
0.972
0.953
0.000
2.09
3.09
2.00
2.09
HO
N
3n

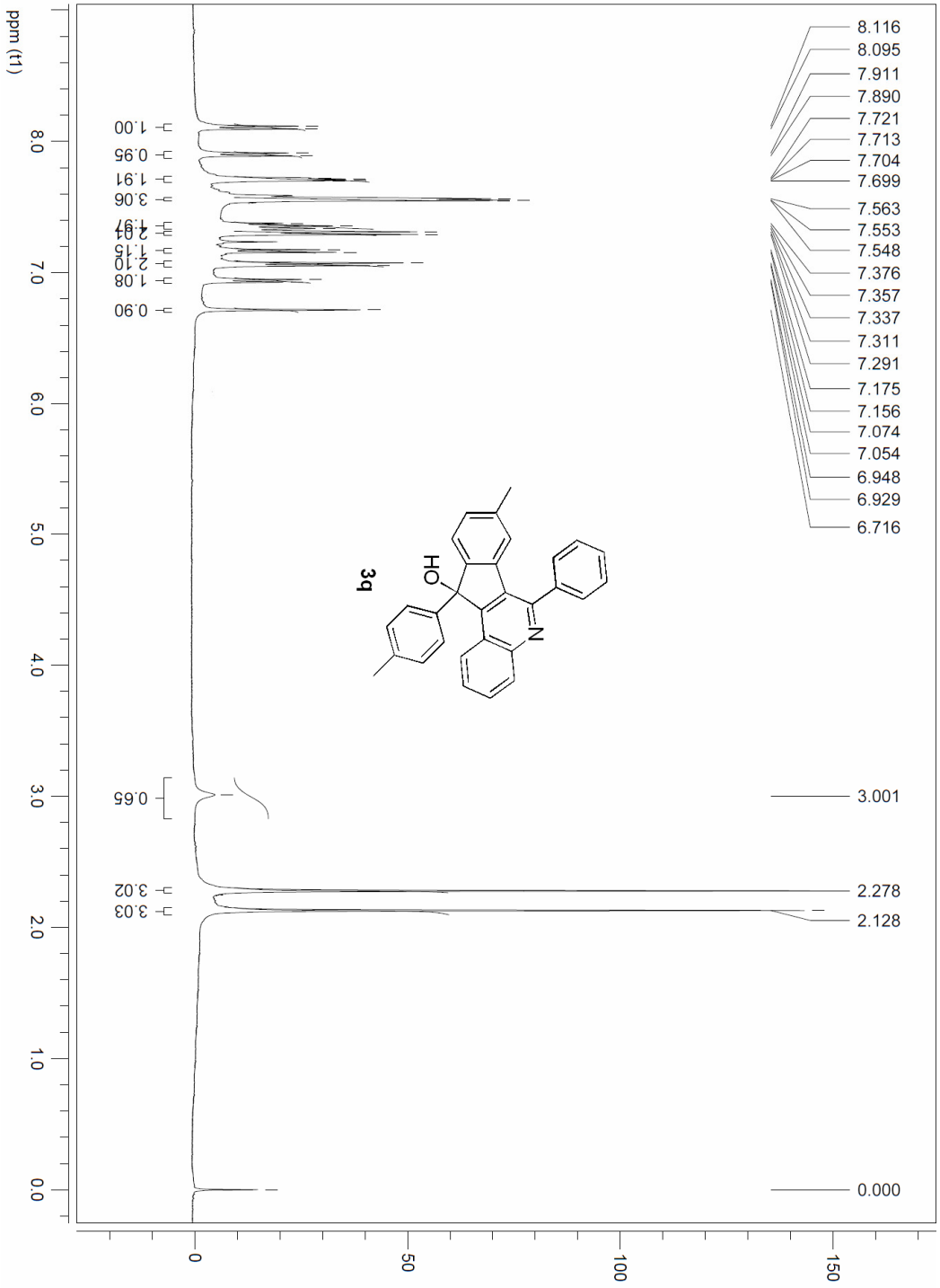

ppm (f1)
150
100
50
157.153
153.352
152.540
145.833
139.025
137.300
136.633
135.542
134.292
131.115
130.775
129.053
128.742
128.156
128.058
124.580
124.512
123.532
122.737
83.411
77.318
77.000
76.683
3n
HO
N
36.983
30.412
22.920
21.808
21.055
13.995
-1500
-1000
-500
0
500
1000
1500
2000
2500

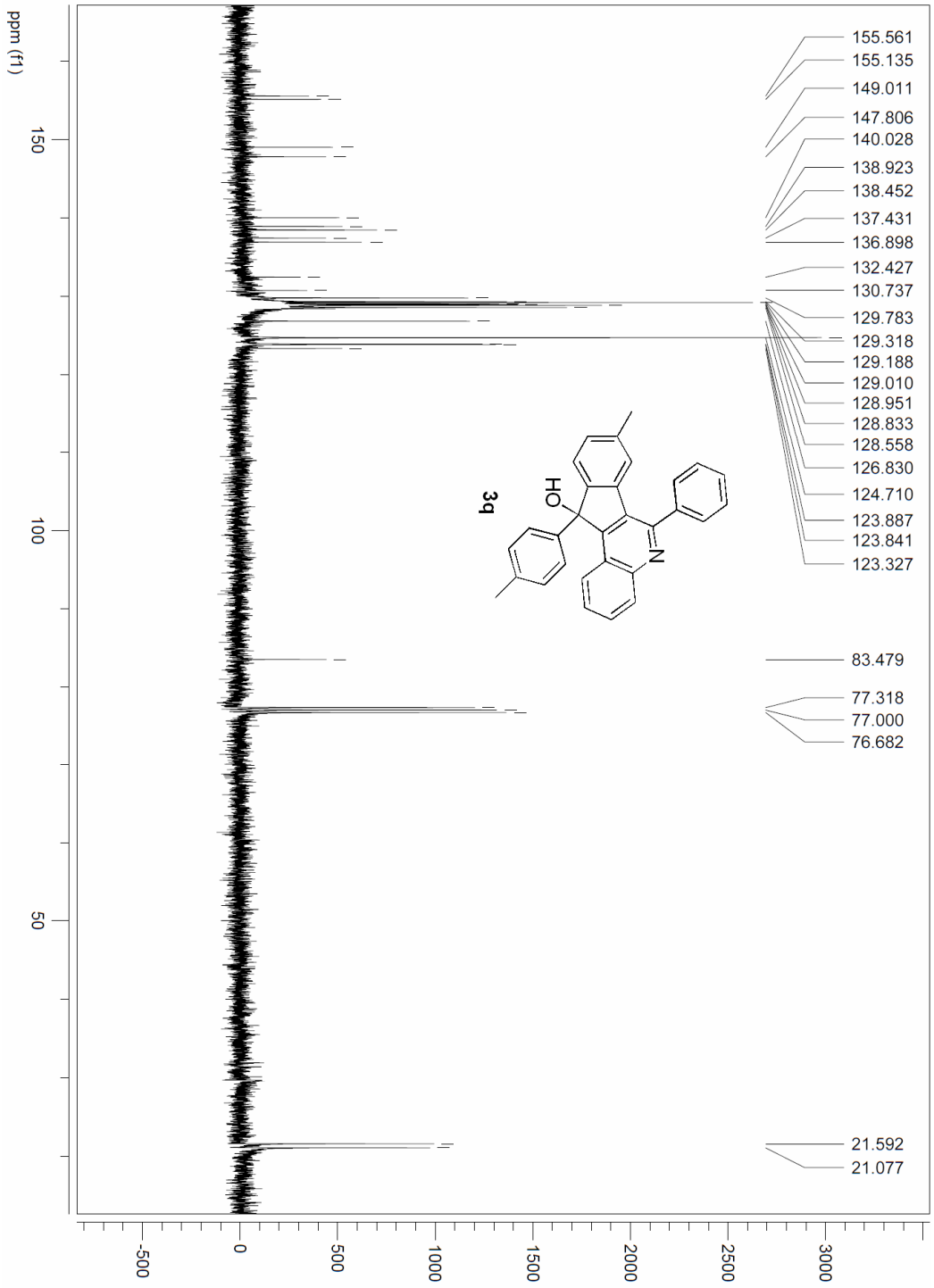

ppm (t1)
10.0
5.0
0.0
8.186
8.165
7.905
7.884
7.751
7.744
7.740
7.731
7.727
7.679
7.675
7.661
7.658
7.654
7.648
7.640
7.637
7.625
7.620
7.612
7.608
7.447
7.444
7.435
7.431
7.427
7.415
7.354
7.327
7.322
7.317
7.305
7.286
7.279
7.159
7.154
7.139
7.134
6.923
6.919
2.787
0.000
1.00
1.04
2.02
4.06
3.00
5.97
1.00
0.93
0.83
Cl
HO
N
3o
0
50
100
150
200


ppm (f1)
150
140
130
120
110
100
90
80
0
1000
2000
3000
4000
5000
155.762
155.348
150.118
147.884
141.380
139.214
139.039
134.344
129.813
129.489
129.298
128.683
128.565
128.060
127.497
127.028
125.348
124.783
124.748
123.214
123.126
83.142
77.319
77.000
76.682
Cl
HO
N
3o


ppm (t1)
5.0
0.0
0
100
200
300
400
500
1.00
1.05
2.08
4.08
2.07
1.08
1.06
0.96
0.78
3.02
8.124
8.103
7.881
7.861
7.722
7.713
7.704
7.699
7.572
7.564
7.554
7.548
7.430
7.412
7.369
7.351
7.331
7.281
7.264
7.245
7.234
7.223
7.216
7.172
7.153
6.952
6.933
6.723
3.042
2.133
0.000
3p
HO
N


ppm (t1)
150
100
50
-500
0
500
1000
1500
2000
2500
155.568
155.043
148.869
147.846
141.938
140.025
138.551
137.499
130.784
129.844
129.338
129.002
128.960
128.827
128.564
128.479
127.293
126.856
124.818
124.647
123.981
123.881
123.275
83.509
77.317
77.000
76.682
21.600
HO
N
3p


ppm (t1)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
50
100
150
1.00
0.95
1.91
3.06
1.97
2.01
1.15
2.10
1.08
0.90
0.65
3.02
3.03
8.116
8.095
7.911
7.890
7.721
7.713
7.704
7.699
7.563
7.553
7.548
7.376
7.357
7.337
7.311
7.291
7.175
7.156
7.074
7.054
6.948
6.929
6.716
3.001
2.278
2.128
0.000
3q
HO
N


ppm (f1)
150
100
50
-500
0
500
1000
1500
2000
2500
3000
155.561
155.135
149.011
147.806
140.028
138.923
138.452
137.431
136.898
132.427
130.737
129.783
129.318
129.188
129.010
128.951
128.833
128.558
126.830
124.710
123.887
123.841
123.327
83.479
77.318
77.000
76.682
21.592
21.077
3q
HO
N