Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Supporting Information

Microwave-assisted Catalyst-free Multicomponent One-Pot Green synthesis of highly functionalized Aminocyanopyridnes and Dihydroquinolines in aqua medium and its In-Silico Studies

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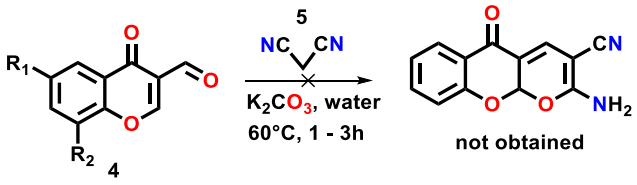
General Information

Unless otherwise noted, chemicals were purchased from commercial suppliers at the highest purity grade available and were used without further purification. Thin layer chromatography was performed on Merck pre-coated 0.25 mm silica gel plates (60F-254) using UV light as visualizing agent. Silica gel (60-120 mesh) was used for column chromatography. IR spectra were recorded on FT-IR spectrometer and expressed as wave numbers (cm^{-1}). ^{1}H and ^{13}C NMR spectra were recorded on a Bruker (500 MHz & 125 MHz) and JEOL (400 MHz & 100 MHz) spectrometer. Spectra were referenced internally to the residual proton resonance in $CDCl_3$ (δ 7.26 ppm), DMSO-d^6 (δ 2.50 ppm) or with tetramethylsilane (TMS, δ 0.00 ppm) as the internal standard. Chemical shifts (δ) were reported as part per million (ppm) in δ scale downfield from

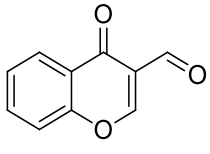
TMS. ^{13}C NMR spectra were referenced to $CDCl_3$ (δ 77.0 ppm, the middle peak) and DMSO-d^6 (δ 39.5 ppm, the middle peak). Coupling constants were expressed in Hz. The following abbreviations were used to explain the multiplicities: s = singlet, d = doublet, t = triplet, dt = doublet of triplet, m = multiples, br = broad, dd = doublet of doublet. High-resolution mass spectra (HRMS) were obtained on a BrukermicrOTOF™-Q II mass spectrometer (ESIMS).

Failed Scheme:



Scheme S1: Synthesis of 2*H*-Pyran

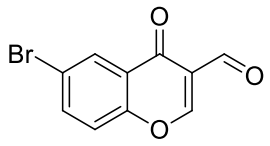
Compound characterizations:



4a

4-oxo-4H-chromene-3-carbaldehyde 4a:

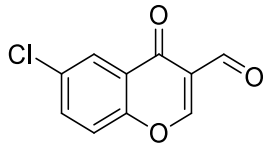
Colour and state: Yellow solid; (1.67 g, 96% yield). ^1H NMR(500MHz, $CDCl_3$) δ ppm: 7.50(t, *J* = 7.5Hz, 1H), 7.53(d, *J* = 8Hz, 1H), 7.53(t, *J* = 7Hz, 1H), 8.29(d, *J* = 7.5Hz, 1H), 8.54(s, 1H), 10.38(s, 1H); ^{13}C NMR (125MHz, $CDCl_3$) δ ppm: 118.5, 120.3, 125.2, 126.1, 126.6, 134.8, 156.1, 160.5, 175.9, 188.5; FTIR (KBr, ν = cm^{-1}) 764, 844, 1310, 1400, 13, 1561, 1613, 1648, 1693, 2866, 3133, 3415; HRMS (ESI+): *m/z* calcd. for $C_{10}H_6O_3Na$ $[M+Na]^+$: 197.0215 , found 197.0211.



4b

6-bromo-4-oxo-4H-chromene-3-carbaldehyde 4b:

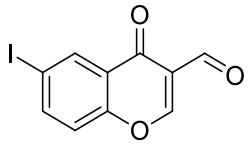
Colour and state: Pale Yellow solid .Yield**:** 87 %; ^{1}H NMR (400MHz, $CDCl_3$) δ ppm: 7.44 (1H, d, J = 8.7 Hz), 7.83 (1H, dd, J = 8.9, 2.5 Hz), 8.40 (1H, d, J = 2.3 Hz), 8.53 (1H, s), 10.35 (1H, s). ^{13}C NMR (100MHz, $CDCl_3$) δ ppm: 115.9, 120.3, 120.4, 126.5, 128.7, 137.7, 154.9, 160.6, 174.6, 188.0; FTIR (KBr, v = cm^{-1}) 604, 768, 831, 1118, 1300, 1442, 1460, 1553, 1653, 1692, 2866, 3074, 3416; HRMS (ESI+): *m/z* calcd. for $C_{10}H_5BrO_3Na$ $[M+Na]^+$: 274.9320, found 274.9318



4c

6-chloro-4-oxo-4H-chromene-3-carbaldehyde 4c:

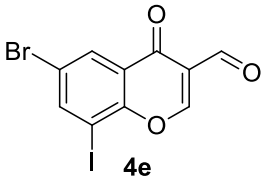
Colour and state: Yellow solid; Yield**:** 90 %; ^{1}H-NMR (400 MHz, $CDCl_3$) δ ppm 7.50 (1H, d, J = 8.7 Hz), 7.68 (1H, dd, J = 8.7, 2.3 Hz), 8.22 (1H, d, J = 2.7 Hz), 10.33 (1H, s), 8.53 (1H, s); ^{13}C NMR (100MHz, $CDCl_3$) δppm: 120.1, 120.2, 125.5, 126.2, 132.7, 134.9, 154.4, 160.6, 174.7, 188.0. FTIR (KBr, v = cm^{-1}) 670, 768, 115, 1303, 1446, 1465, 1559, 1605, 1657, 1694, 2857, 3079, 3420; HRMS (ESI+): *m/z* calcd. for $C_{10}H_5ClO_3Na$ $[M+Na]^+$: 230.9825, found 230.9822



4d

6-iodo-4-oxo-4H-chromene-3-carbaldehyde 4d:

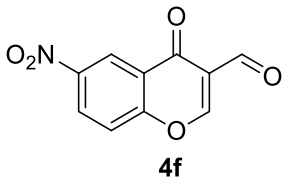
Colour and state : Yellow solid; Yield**:** 88 %; ^{1}H-NMR (400MHz, $CDCl_3$) δ ppm: 7.29 (1H, d, J = 8.7 Hz), 7.99 (1H, d, J = 8.7 Hz), 8.52 (1H, s), 8.56 (1H, s),10.31 (1H, s); ^{13}C NMR(100MHz, $CDCl_3$) δ ppm: 90.8, 120.4, 132.7, 134.9, 138.9, 143.3, 151.8, 160.6, 174.4, 188.0; FTIR (KBr, ν = cm^{-1}) 766, 817, 953, 1115, 1395, 1400, 1550, 1594, 1658, 1691, 2866, 3141, 3420; HRMS (ESI+): *m/z* calcd. for $C_{10}H_5IO_3Na$ $[M+Na]^+$: 322.9181, found 322.9177.



4e

6-bromo-8-iodo-4-oxo-4H-chromene-3-carbaldehyde 4e:

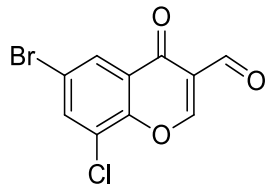
Colour and state: Yellow solid; Yield**:** 84 %; ^{1}H NMR (400MHz, $CDCl_3$) δ ppm: 8.29 (1H, d, J = 2.3 Hz), 8.36 (1H, d, J = 2.3 Hz), 8.60 (1H, s), 10.33 (1H, s). ^{13}C NMR (100MHz, $CDCl_3$) δ ppm: 86.5, 120.0, 120.8, 126.8, 129.0, 146.5, 14.2, 160.7, 174.3, 187.6; FTIR (KBr, ν = cm^{-1}) 769, 782, 956, 1295, 1400, 1442, 1541, 1590, 1665, 1695, 2863, 3063, 3451; HRMS (ESI+): *m/z*calcd.for $C_{10}H_4BrIO_3Na$ $[M+Na]^+$: 400.8286, found 400.8281.



4f

6-nitro-4-oxo-4H-chromene-3-carbaldehyde 4f:

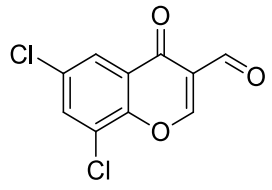
Colour and state : Yellow solid; Yield**:** 86 %; ^{1}H NMR (400MHz, $CDCl_3$) δ ppm: 7.73 (1H, d, J = 9.2 Hz), 8.57 – 8.60 (2H, m), 9.15 (1H, d, J = 2.7 Hz) 10.37 (1H, s); ^{13}C NMR (100MHz, $CDCl_3$) δppm: 120.5, 122.6, 125.6, 129.1, 145.6, 158.7, 160.7, 174.4, 187.4; FTIR (KBr, ν = cm^{-1}) 517, 657, 773, 892, 1122, 1304, 1349, 1460, 1529, 1564, 1626, 1659, 1700, 2890, 3069, 3101, 3416; HRMS (ESI+): *m/z*calcd.for $C_{10}H_5NO_5Na$ $[M+Na]^+$: 242.0065, found 242.0063.



4g

6-bromo-8-chloro-4-oxo-4H-chromene-3-carbaldehyde 4g:

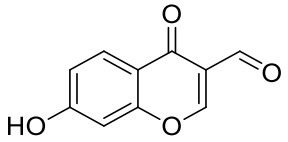
Colour and state: Yellow solid; Yield**:** 87 %; ^{1}H NMR (400MHz, $CDCl_3$) δ ppm: 7.93 (1H, s), 8.29 (1H, s), 8.59 (1H, s), 10.32 (1H, s); ^{13}C NMR (100MHz, $CDCl_3$) δ ppm: 119.7, 120.2, 125.8, 127.3, 132.9, 137.6, 140.6, 160.6, 174.1, 187.6; FTIR (KBr, ν = cm^{-1}) 767, 1059, 1300, 1400, 1447, 1554, 1598, 1657, 1701, 2866, 3141, 3417; HRMS (ESI+): *m/z* calcd. for $C_{10}H_4BrClO_3Na$ $[M+Na]^+$: 308.8930, found 308.8926.



4h

6,8-dichloro-4-oxo-4H-chromene-3-carbaldehyde 4h:

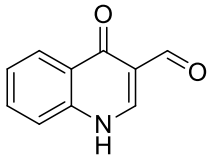
Colour and state : Yellow solid; Yield**:** 89 %; ^{1}H NMR (400MHz, $CDCl_3$) δ ppm: 7.78 (1H, d, J = 1.8 Hz), 8.14 (1H, d, J = 1.8 Hz), 8.58 (1H, s), 10.33 (1H, s); ^{13}C NMR (100MHz, $CDCl_3$) δ ppm: 120.2, 124.1, 125.0, 127.1, 132.5, 134.9, 150.5, 160.4, 174.1, 187.5; FTIR (KBr, ν = cm^{-1}) 672, 770, 844, 1303, 1399, 1451, 1561, 1600, 1664, 1700, 2872, 3066, 3122, 3417; HRMS (ESI+): *m/z* calcd. for $C_{10}H_4Cl_2O_3Na$ $[M+Na]^+$: 264.9435, found 264.9434.



4i

7-hydroxy-4-oxo-4H-chromene-3-carbaldehyde 4i:

Colour and state: Dark brownish solid; Yield**:** 72 %. ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 6.93 (1H, s) 6.97 (1H, d, J = 8.8 Hz), 7.94 (1H, d, J = 8.8 Hz), 8.73 (1H, s), (10.07 (1H, s); ^{13}C NMR (100MHz, $CDCl_3$) δ ppm: 103.1, 116.1, 116.9, 119.6, 127.1, 157.4, 162.7, 163.6, 174.1, 188.7; FTIR (KBr, ν = cm^{-1}) 770, 850, 1093, 1306, 1401, 1460, 1613, 1639, 1685, 3121, 3420; HRMS (ESI+): *m/z* calcd. for $C_{10}H_6O_4Na$ $[M+Na]^+$: 213.0164, found 213.0158

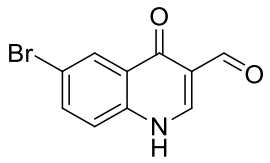


10a

4-oxo-1,4-dihydroquinoline-3-carbaldehyde 10a[1] :

Colour and state : Pale yellow solid; Yield**:** 87 %; ^{1}H NMR(400MHz, DMSO-D6)δ ppm: 7.45 (1H, t, J = 7.6 Hz), 7.64 (1H, d, J = 8.2 Hz), 7.74 (1H, t, J = 7.6 Hz), 8.19 (1H, d, J = 7.8 Hz),), 8.46 (1H, s), 10.18 (1H, s),12.68(1H, s); ^{13}C NMR(100MHz, DMSO-D6) δ ppm: 116.3, 119.4,

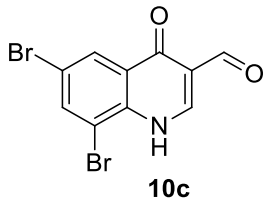
125.3, 125.4, 127.7, 133.0, 139.3, 143.2, 176.2, 188.7; FTIR (KBr, ν = cm^{-1}) 438, 628, 768, 852, 974, 1284, 1389, 1558, 1620, 1666, 2737, 3126, 3419; HRMS (ESI+): *m/z* calcd. for $C_{10}H_7O_2NNa$ $[M+Na]^+$: 196.0374, found 196.0371.



10b

6-bromo-4-oxo-1,4-dihydroquinoline-3-carbaldehyde 10b:

Colour and state: yellow solid; Yield**:** 87 %; ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 7.62 (1H, d, J = 9.2 Hz), 7.91 (1H, d, J = 9.2 Hz), 8.25 (1H, s), 8.51 (1H, d, J = 6.4 Hz), 10.15 (1H, s),12.83 (1H, s). ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 116.5, 118.2, 121.2, 127.4, 129.2, 135.7, 138.4, 143.6, 174.9, 188.5; FTIR (KBr, ν = cm^{-1}); 540, 625, 826, 826, 991, 1068, 1306, 13999, 1471, 1531, 1582, 1624, 1682, 1701, 3453; HRMS (ESI+): *m/z* calcd. for $C_{10}H_6BrO_2NNa$ $[M+Na]^+$: 273.9480, found 273.9478.

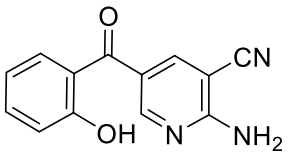


10c

6,8-dibromo-4-oxo-1,4-dihydroquinoline-3-carbaldehyde 10c:

Colour and state : yellow solid; Yield**:** 87 %; ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 8.18 (1H, d, J = 2.8 Hz), 8.23 (1H, s), 8.27 (1H, d, J = 1.8 Hz), 10.10 (1H, s), 12.01 (1H, s); ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 114.0, 116.6, 117.9, 127.3, 130.0, 136.3, 138.2, 143.9, 174.2,

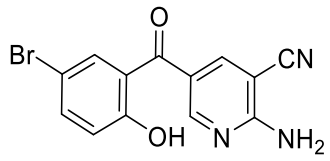
188.2; FTIR (KBr, ν = cm^{-1}); 626, 765, 965, 1097, 1331, 1398, 1458, 1574, 1688, 2878, 3139. 3416. HRMS (ESI+): *m/z* calcd. for $C_{10}H_5Br_2O_2NNa$ $[M+Na]^+$: 351.8585, found 351.8581.



7a

2-amino-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile 7a:

Colour and state : Yellow solid; Yield**:** 98%; ^{1}H NMR (400MHz, DMSO-D6) δ ppm 6.90-6.96 (2H, m), 7.33 (1H, d, J = 7.8 Hz), 7.40 (1H, t, J = 7.6 Hz), 7.81 (2H, s, br. D_2O exchangeable), 8.11 (1H, d, J = 1.8 Hz), 8.48 (1H, d, J = 2.3 Hz), 10.27 (1H, s, br. D_2O exchangeable); ^{1}H-NMR (400 MHz, DMSO-D6) (After D_2O exchange) δ ppm 6.82-6.97 (2H, m), 7.26 (1H, d, J = 7.8 Hz), 7.37 (1H, t, J = 7.8 Hz), 8.04 (1H, s), 8.40 (1H, s); ^{13}C NMR (100MHz, DMSO-D6) δppm: 88.9, 116.1, 116.6, 119.3, 121.8, 124.7, 130.1, 133.0, 143.9, 155.6, 156.0, 161.3, 192.1; FTIR (KBr, ν = cm^{-1}) 759, 1150, 1250, 1346, 1402, 1595, 1621, 1672, 2222, 2878, 3138, 3416; HRMS (ESI+): *m/z* calcd. for $C_{13}H_9N_3O_2Na$ $[M+Na]^+$: 262.0592, found 262.0588.

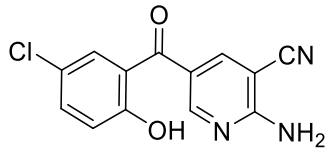


7b

2-amino-7-bromo-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile 7b:

Colour and state: Yellow solid; Yield**:** 92 %; ^{1}H NMR(400MHz, DMSO-D6) δ ppm: 6.91 (1H, d, J = 8.7 Hz), 7.41 (1H, d, J = 2.3 Hz), 7.52 (1H, dd, J = 8.7, 2.3 Hz), 7.86 (2H, s, br. D_2O exchangeable), 8.12 (1H, d, J = 1.8 Hz), 8.47 (1H, d, J = 2.3 Hz), 10.38 (1H, s, br. D_2O

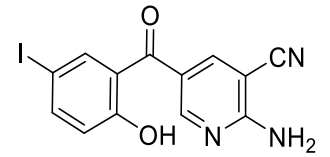
exchangeable); ^{13}C NMR(100MHz, DMSO-D6) δppm: 88.9, 110.3, 116.0, 118.8, 121.4, 127.6, 131.7, 134.8, 143.9, 154.5, 155.7, 161.4, 190.1; FTIR (KBr, *v* = cm^{-1}) 496, 1167, 1270, 1409, 1498, 1579, 1626, 1640; 2227, 2856, 3220, 3329, 3445; HRMS (ESI+): *m/z* calcd. for $C_{13}H_8BrN_3O_2Na$ $[M+Na]^+$: 339.9698, found 339.9697.



7c

2-amino-7-chloro-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile 7c:

Colour and state: Yellow solid; Yield**:** 94 %; ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 6.96 (1H, d, J = 8.7 Hz), 7.30 (1H, d, J = 2.7 Hz), 7.41 (1H, dd, J = 8.9, 2.5 Hz), 7.86 (2H, s, br. D_2O exchangeable), 8.12 (1H, d, J = 1.8 Hz), 8.47 (1H, d, J = 1.8 Hz), 10.37 (1H, s, br. D_2O exchangeable); ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 88.9, 116.0, 118.3, 121.1, 122.9, 127.0, 128.9, 132.0, 144.0, 154.1, 155.7, 161.4, 190.2; FTIR (KBr, *v* = cm^{-1}) 496, 539, 785, 1166, 1268, 1336, 1499, 1578, 1629, 1640, 2227, 2845, 3220, 3327, 3445; HRMS (ESI+): *m/z*calcd.for $C_{13}H_8ClN_3O_2Na$ $[M+Na]^+$: 296.0203, found 292.0201.

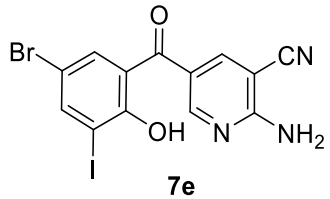


7d

2-amino-7-iodo-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile 7d:

Colour and state: Brown solid; Yield**:** 91 %; ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 6.79 (1H, d, J = 8.7 Hz), 7.54 (1H, s), 7.67 (1H, d, J = 8.2 Hz), 7.86 (2H, s, br. D_2O exchangeable), 8.11

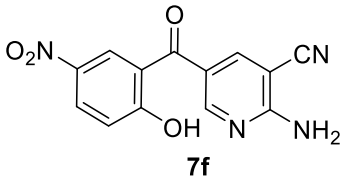
(1H, s), 8.46 (1H, s), 10.37 (1H, s, br. D_2O exchangeable); ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 81.2, 88.9, 116.0, 119.2, 121.1, 128.1, 137.4, 140.6, 143.9, 155.0, 155.7, 161.4, 190.1; FTIR (KBr, ν = cm^{-1}) 529, 788, 1077, 1294, 1400, 1546, 1618, 1649, 2216, 2878, 3131, 3432; HRMS (ESI+): *m/z* calcd. for $C_{13}H_8IN_3O_2Na$ $[M+Na]^+$: 387.9559, found 387.9552.



7e

2-amino-7-bromo-9-iodo-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile 7e:

Colour and state: Yellow solid; Yield**:** 86 %; ^1H NMR (400MHz, DMSO-D6) δ ppm: 7.50 (1H, d, J = 2.3 Hz), 7.91 (2H, s, br. D_2O exchangeable), 8.09 (1H, d, J = 1.8 Hz), 8.16 (1H, d, J = 2.3 Hz), 8.48 (1H, d, J = 1.8 Hz), 10.60 (1H, s, br. D_2O exchangeable); ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 89.0, 90.3, 116.6, 115.9, 120.8, 126.5, 132.3, 143.3, 144.3, 154.7, 155.7, 161.4, 190.5; FTIR (KBr, ν = cm^{-1}) 791,1062, 1274, 1404, 1578, 1616, 1635, 2227, 2875, 3185, 3416; HRMS (ESI+): *m/z* calcd. for $C_{13}H_7BrIN_3O_2Na$ $[M+Na]^+$: 465.8664, found 465.8659

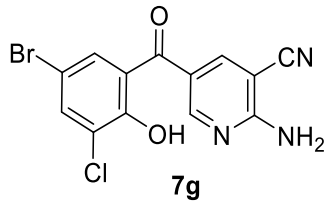


7f

2-amino-7-nitro-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile 7f:

Colour and state: Brownish solid; Yield**:** 78 %; ^1H NMR (400MHz, DMSO-D6) δ ppm: 7.11 (1H, d, J = 9.2 Hz), 7.92 (2H, s, br. D_2O exchangeable), 8.15 (1H, d, J = 2.7 Hz), 8.19 (1H, d, J = 2.3 Hz), 8.26 (1H, dd, J = 8.9, 3.0 Hz), 8.52 (1H, d, J = 2.3 Hz), 11.74 (1H, s, br. D_2O

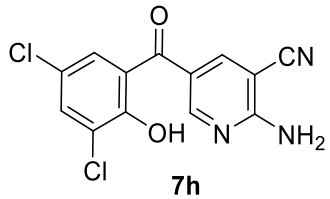
exchangeable); ^{13}C NMR(100MHz, DMSO-D6) δppm: 89.0, 115.9, 117.2, 121.2, 125.9, 126.1, 127.8, 139.5, 144.1, 155.8, 161.2, 161.5, 189.5; FTIR (KBr, *v* = cm^{-1}) 534, 650, 806, 1100, 1266, 1349, 1400, 1475, 1542, 1594, 1631, 1660, 2227, 2879, 3146, 3412; HRMS (ESI+): *m/z* calcd. for $C_{13}H_8N_4O_4Na$ $[M+Na]^+$: 307.0443, found 307.0438.



7g

2-amino-7-bromo-9-chloro-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile

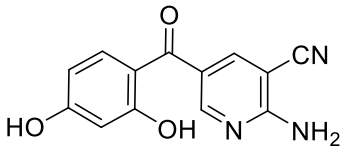
7g: Colour and state: Yellow solid; Yield**:** 82 %; ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 7.43 (1H, d, J = 2.3 Hz), 7.82 (1H, d, J = 2.3 Hz), 7.91 (2H, s, br. D_2O exchangeable), 8.17 (1H, d, J = 2.3 Hz), 8.49 (1H, d, J = 1.8 Hz), 10.38 (1H, s, br. D_2O exchangeable);^{13}C NMR (100MHz, DMSO-D6) δ ppm: 89.0, 110.7, 115.9, 121.0, 123.3, 129.3, 130.6, 134.2, 144.2, 150.4, 155.7, 161.5, 189.6; FTIR (KBr, *v* = cm^{-1}) 514, 791, 1168, 1244, 1327, 1400, 1430, 1620, 1655, 2219, 2874, 3134, 3434; HRMS (ESI+): *m/z* calcd. for $C_{13}H_7BrClN_3O_2Na$ $[M+Na]^+$: 373.9308, found 373.9302.



7h

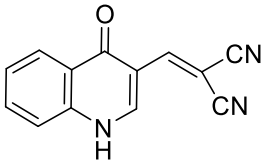
2-amino-7,9-dichloro-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile 7h: Colour and state: Yellow solid; Yield**:** 74 %; ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 7.33 (1H, d, J = 2.3 Hz), 7.71 (1H, d, J = 2.3 Hz), 7.93 (2H, s, br. D_2O exchangeable), 8.17 (1H, d, J = 1.8

Hz), 8.50 (1H, d, J = 2.3 Hz), 10.38 (1H, s, br. D_2O exchangeable); ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 89.5, 116.5, 121.5, 123.6, 124.1, 128.3, 129.3, 132.1, 144.8, 150.6, 196.3, 162.0, 190.2; FTIR (KBr, v = cm^{-1}) 533, 1233, 1330, 1400, 1424, 1584, 1624, 1638, 2236, 2879, 3178, 3446; HRMS (ESI+): *m/z* calcd. for $C_{13}H_8Cl_2N_3O_2Na$ $[M+Na]^+$: 329.9813, found 329.9809.



7i

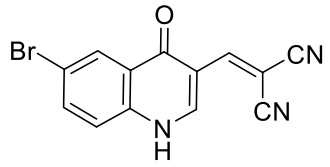
2-amino-8-hydroxy-5-oxo-2,5-dihydro-1H-chromeno[2,3-b]pyridine-3-carbonitrile 7i: Colour and state: Reddish brown solid; Yield**:** 64 %; ^1H NMR (400MHz, DMSO-D6) δ ppm: 6.33 (1H, d, J = 2.3 Hz), 6.38 (1H, dd, J = 8.7, 1.8 Hz), 7.40 (1H, d, J = 8.7 Hz), 7.69 (2H, s, br. D_2O exchangeable), 8.12 (1H, d, J = 2.3 Hz), 8.47 (1H, d, J = 1.8 Hz), 10.52 (1H, s, br. D_2O exchangeable), 11.54 (1H, s, br. D_2O exchangeable); ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 88.6, 102.7, 108.1, 113.6, 116.2, 122.2, 134.1, 143.7, 154.8, 161.0, 162.4, 164.0, 192.9; FTIR (KBr, v = cm^{-1}) 617, 815, 1142, 1258, 1278, 1398, 1497, 1587, 1630, 1627, 2232, 2876, 3157, 3320, 3401; HRMS (ESI+): *m/z* calcd. for $C_{13}H_9N_3O_3Na$ $[M+Na]^+$: 278.0542, found 278.0537.



11a

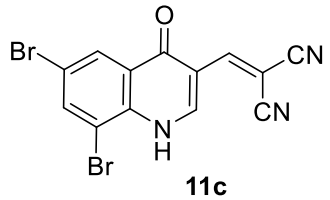
5-oxo-5,10-dihydrobenzo[b][1,8]naphthyridine-3-carbonitrile 11a: Colour and state : Yellow solid; Yield**:** 92 %; ^1H NMR (400MHz, DMSO-D6) δ ppm: 7.48 (1H, t, J = 7.8 Hz) 7.59 (1H, d,

J = 8.3 Hz), 7.76 (1H, t, J = 7.8 Hz), 8.11 - 8.14 (2H, m), 8.74 (1H, s), 12.99 (1H, s); ^{13}C NMR(100MHz, DMSO-D6) δppm: 74.3, 112.6, 114.0, 115.7, 119.5, 125.4, 125.9, 126.0, 133.4, 138.3, 144.3, 154.4, 174.0; FTIR (KBr, ν = cm^{-1}) 572, 762, 1141, 1283, 1313, 1366, 1400, 1470, 1546, 1625, 2225, 3136, 3420; HRMS (ESI+): *m/z* calcd. for $C_{13}H_7N_3ONa$ $[M+Na]^+$: 244.0487, found 244.0481.



11b

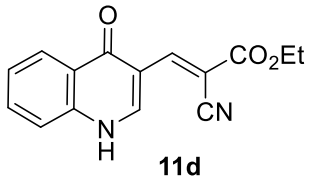
7-bromo-5-oxo-5,10-dihydrobenzo[b][1,8]naphthyridine-3-carbonitrile 11b: Colour and state : Yellow solid; Yield**:** 88 %; ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 7.53 (1H, d, J = 9.2 Hz), 7.87 (1H, dd, J = 9.0, 2.5 Hz), 8.08 (1H, s), 8.13 (1H, d, J = 1.8 Hz), 8.73 (1H, s), 13.07 (1H, s); ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 75.3, 112.8, 115.5, 118.8, 121.9, 126.7, 127.9, 136.1, 137.3, 144.5, 154.1, 172.8, 188.4; FTIR (KBr, ν = cm^{-1})542, 614, 829, 1309, 1367, 1400, 1536, 1555, 1626, 1682, 2226, 3075, 3166, 3453; HRMS (ESI+): *m/z* calcd. for $C_{13}H_6BrN_3ONa$ $[M+Na]^+$: 321.9592, found 321.9589.



11c

7,9-dibromo-5-oxo-5,10-dihydrobenzo[b][1,8]naphthyridine-3-carbonitrile 11c: Colour and state : Yellow solid; Yield**:** 84 %; ^{1}H NMR(400MHz, DMSO-D6) δ ppm 8.15-8.28 (2H,m), 8.77 (1H, s), 10.10 (1H, s), 12.05 (1H, s); ^{13}C NMR(100MHz, DMSO-D6) δ ppm: 88.2, 114.0, 116.6,

117.9, 127.3, 127.8, 130.0, 138.2, 138.4, 143.9, 153.6, 174.3, 188.2 ; FTIR (KBr, ν = cm^{-1}) 530, 805, 873, 1080, 1208, 1365, 1389, 1516, 1561, 1600, 1639, 1700, 2230, 3241, 3450; HRMS (ESI+): *m/z* calcd. for $C_{13}H_5Br_2N_3ONa$ $[M+Na]^+$: 399.8697, found 399.8692.

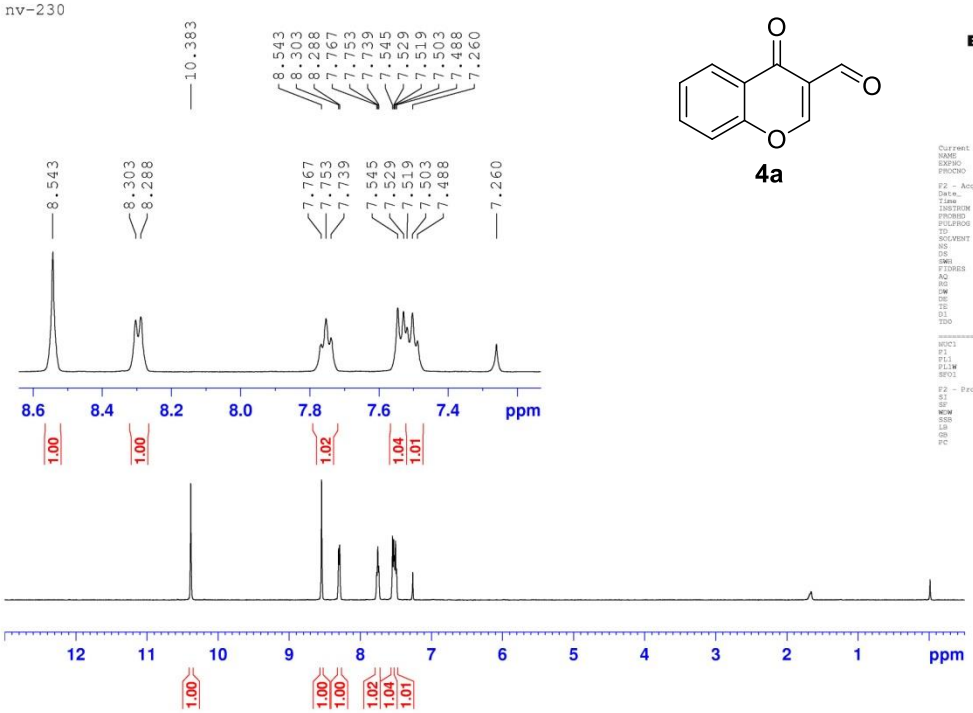


11d

ethyl 5-oxo-5,10-dihydrobenzo[b][1,8]naphthyridine-3-carboxylate 11d: Colour and state : Yellow solid; Yield**:** 82 %; ^{1}H NMR (400MHz, DMSO-D6) δ ppm: 1.28 (3H, t, J = 6.4 Hz) 4.27 (2H, m), 7.46 (1H, t, J = 6.9 Hz), 7.59 (1H, d, J = 7.3 Hz), 7.74 (1H, t, J = 6.4 Hz), 8.15 (1H, d, J = 8.3 Hz), 8.59 (1H, s), 8.95 (1H, s), 12.87 (1H, s); ^{13}C NMR (100MHz, DMSO-D6) δ ppm: 14.1, 61.8, 95.3, 111.8, 116.7, 119.4, 125.4, 125.7, 125.9, 133.3, 138.6, 142.1, 148.6, 162.7, 174.7; FTIR (KBr, ν = cm^{-1}) 1294, 1400, 1555, 1610, 1632, 1718, 3451; HRMS (ESI+): *m/z* calcd. for $C_{15}H_{12}N_2O_3Na$ $[M+Na]^+$: 291.0746, found 291.0742

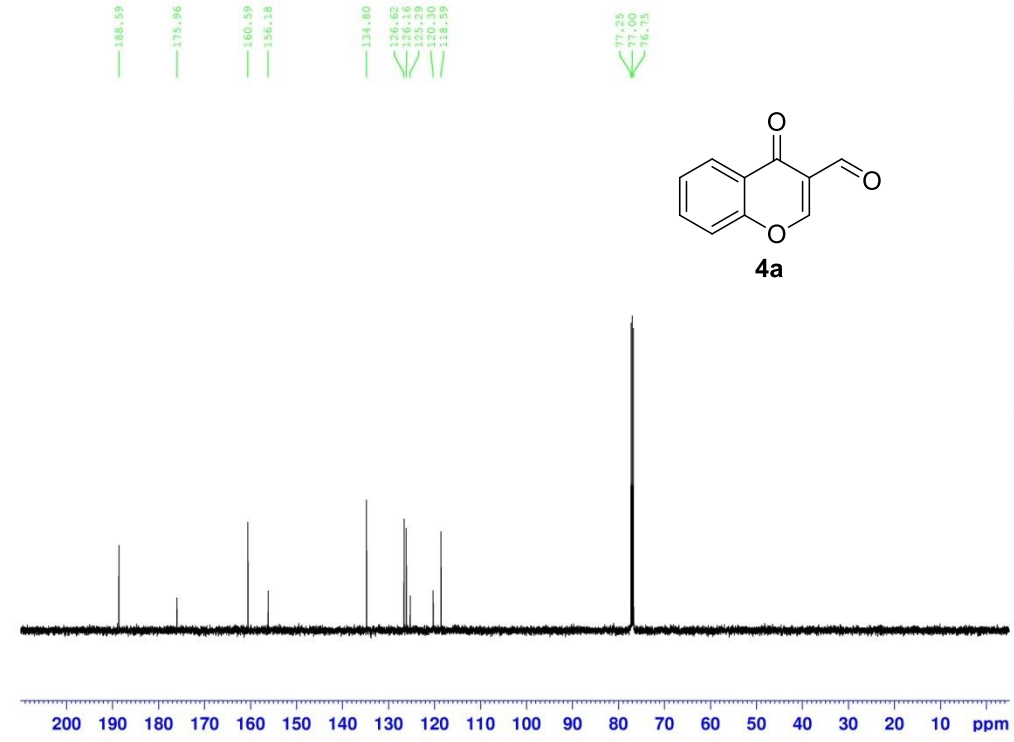
Spectra:

nv-230

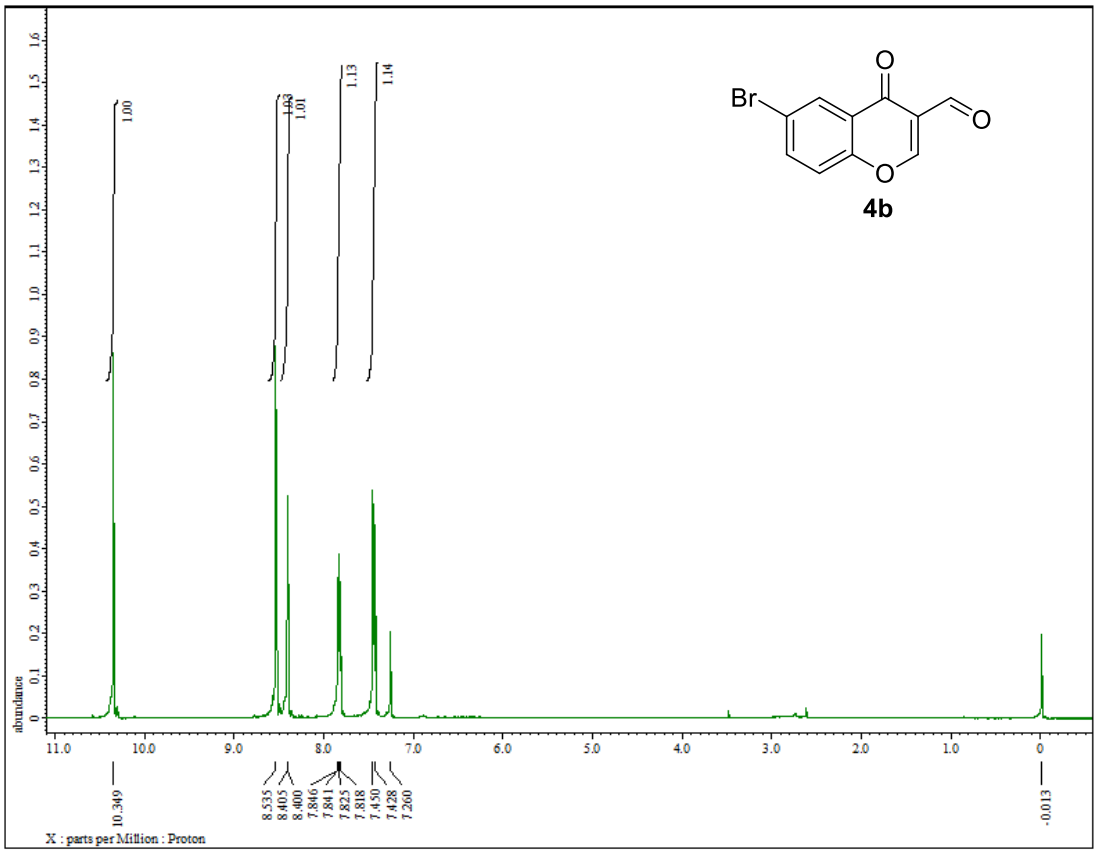


4a

nv-230- c13



4a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1.01
1.13
1.14
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8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
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8.535
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7.818
7.450
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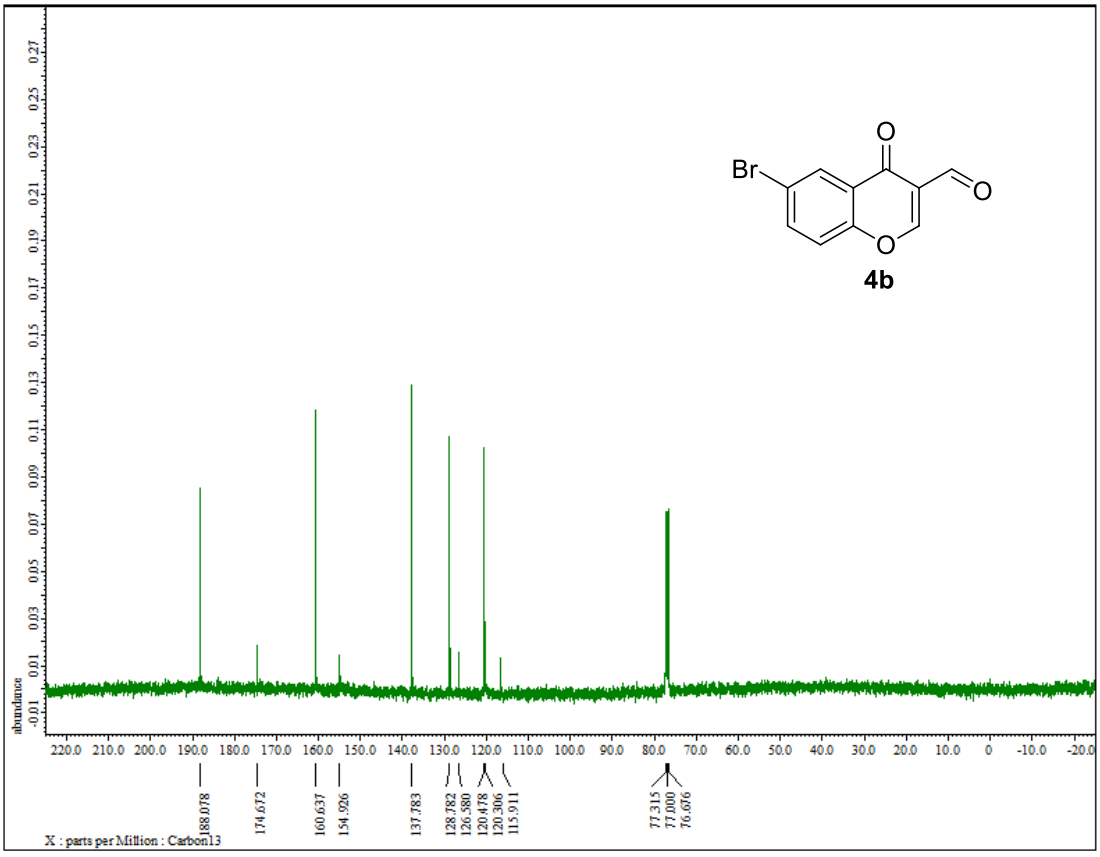
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O
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170.0
160.0
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120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
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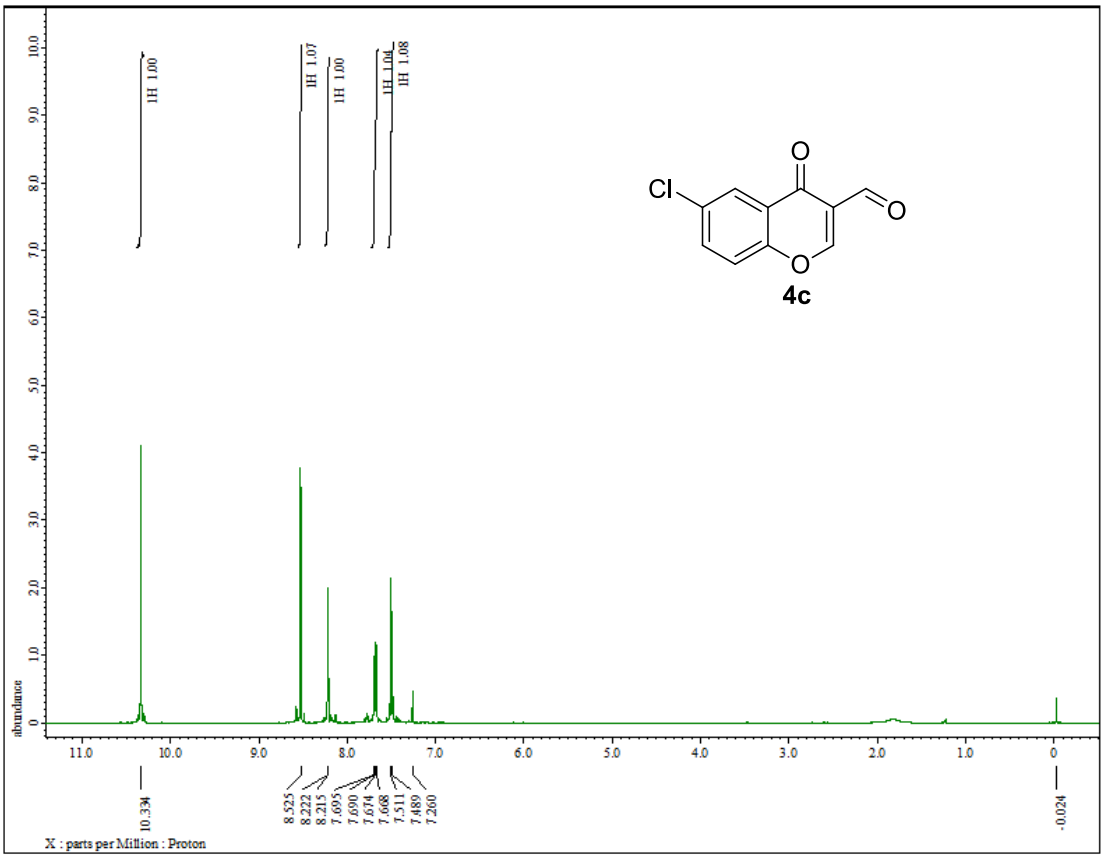
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7.0
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4.0
3.0
2.0
1.0
0
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7.668
7.511
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7.260
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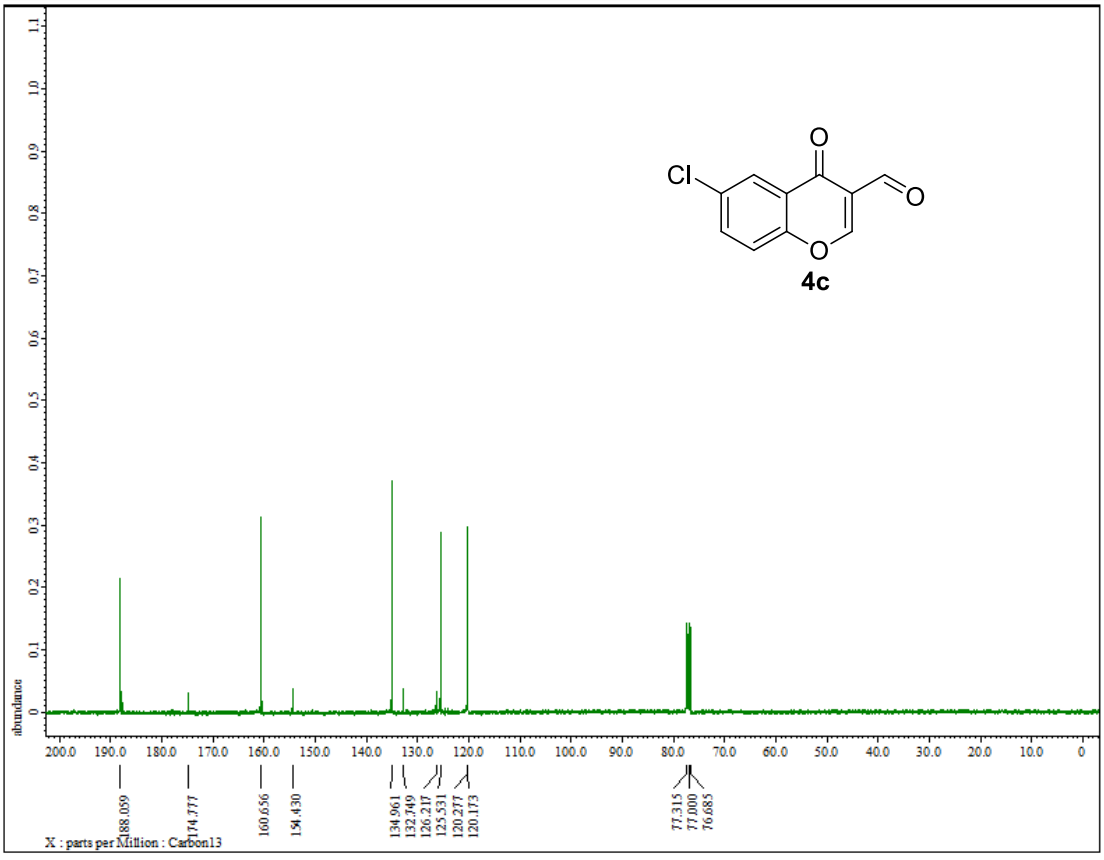
X : parts per Million : Proton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O
O
4c
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120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
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174.777
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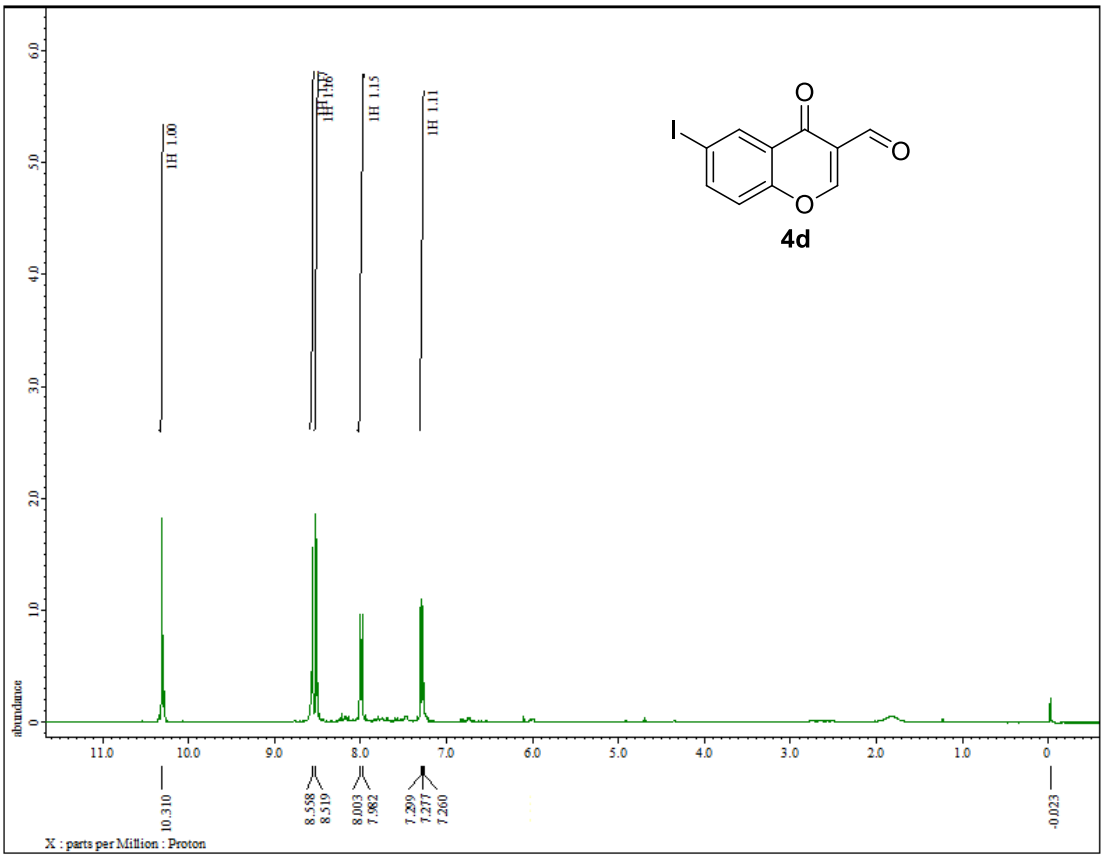
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1H 1.11
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7.260
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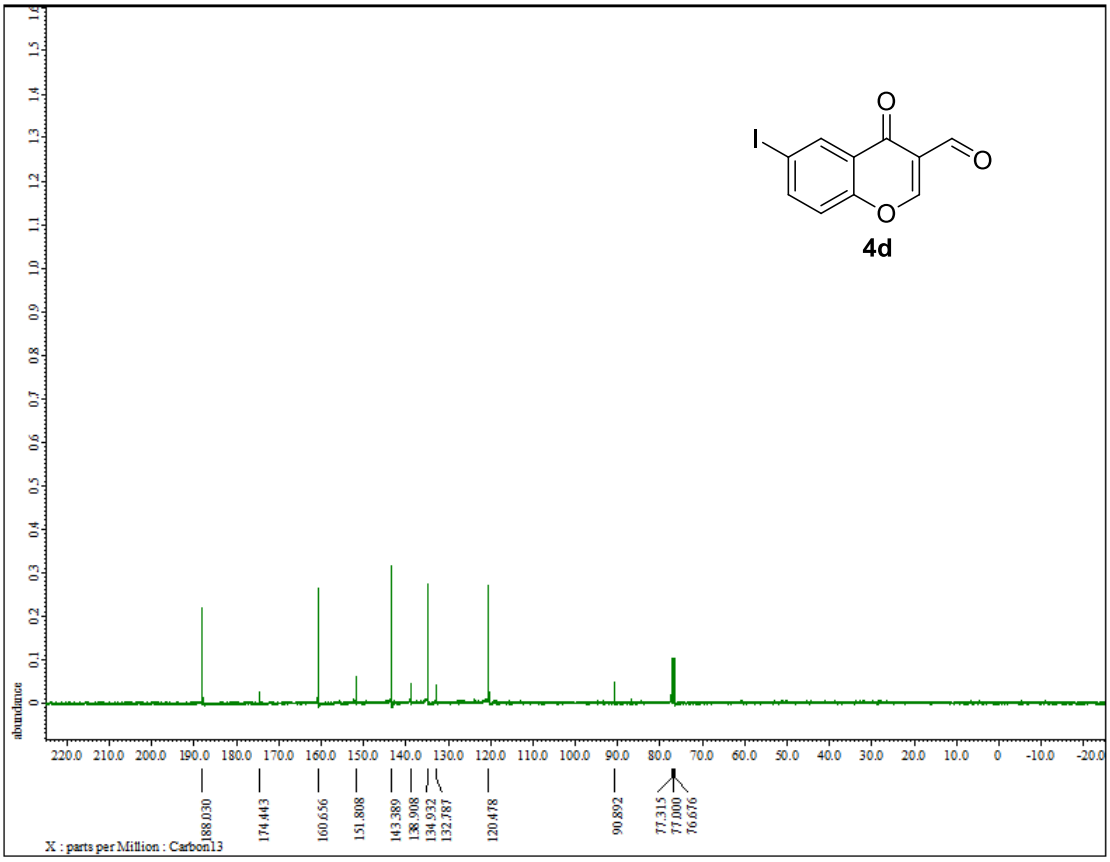
X : parts per Million : Proton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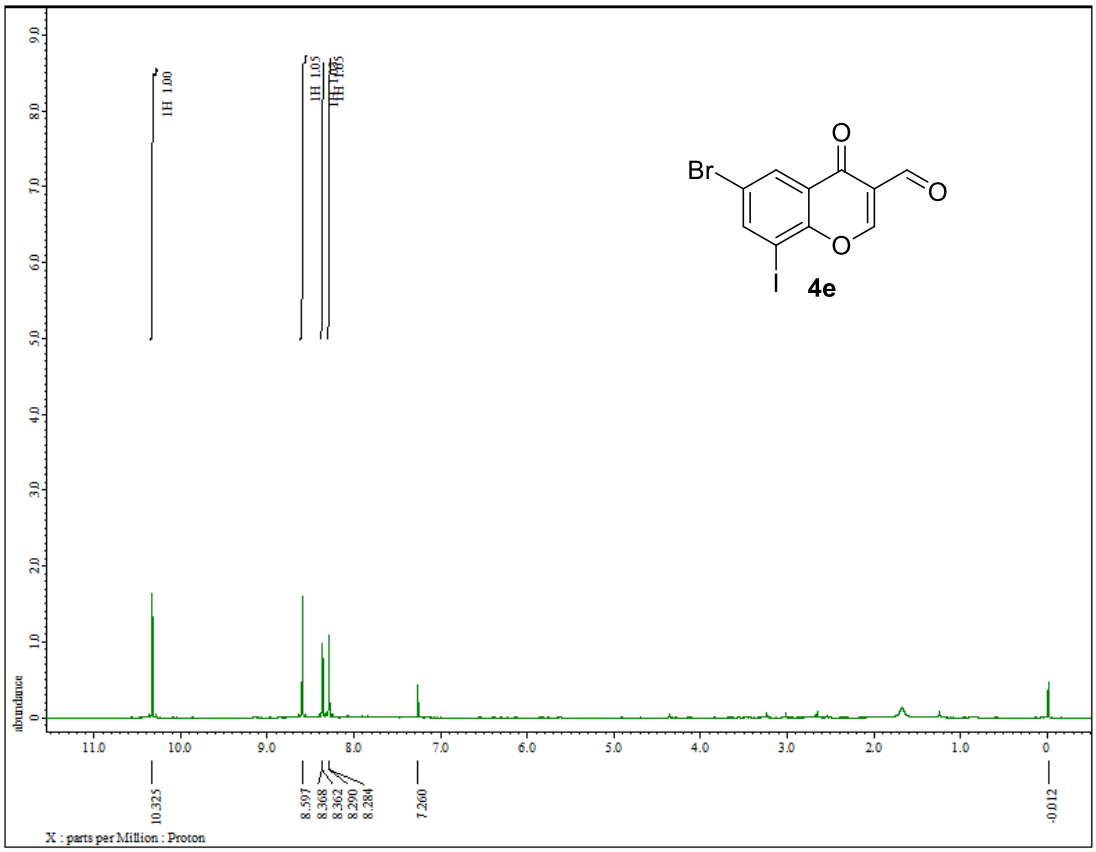
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I
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abundance
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8.0
7.0
6.0
5.0
4.0
3.0
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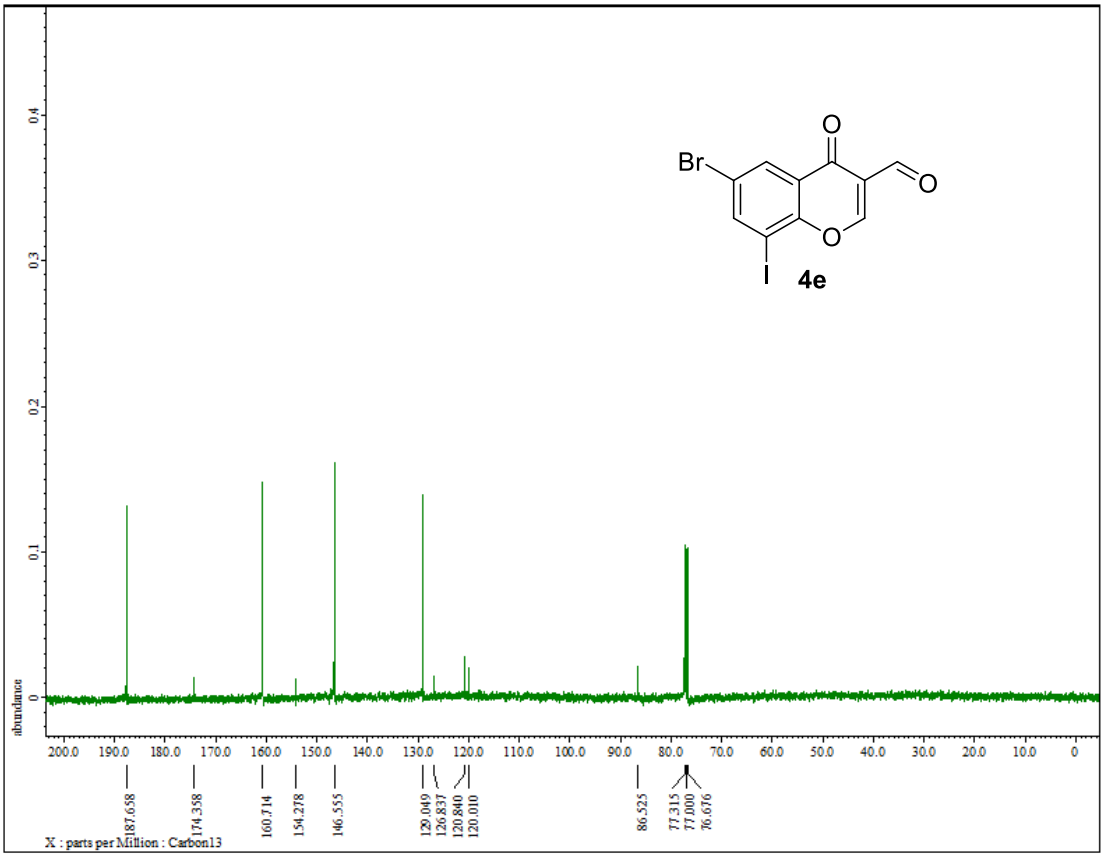
X : parts per Million : Proton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170.0
160.0
150.0
140.0
130.0
120.0
110.0
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90.0
80.0
70.0
60.0
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40.0
30.0
20.0
10.0
0
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174.358
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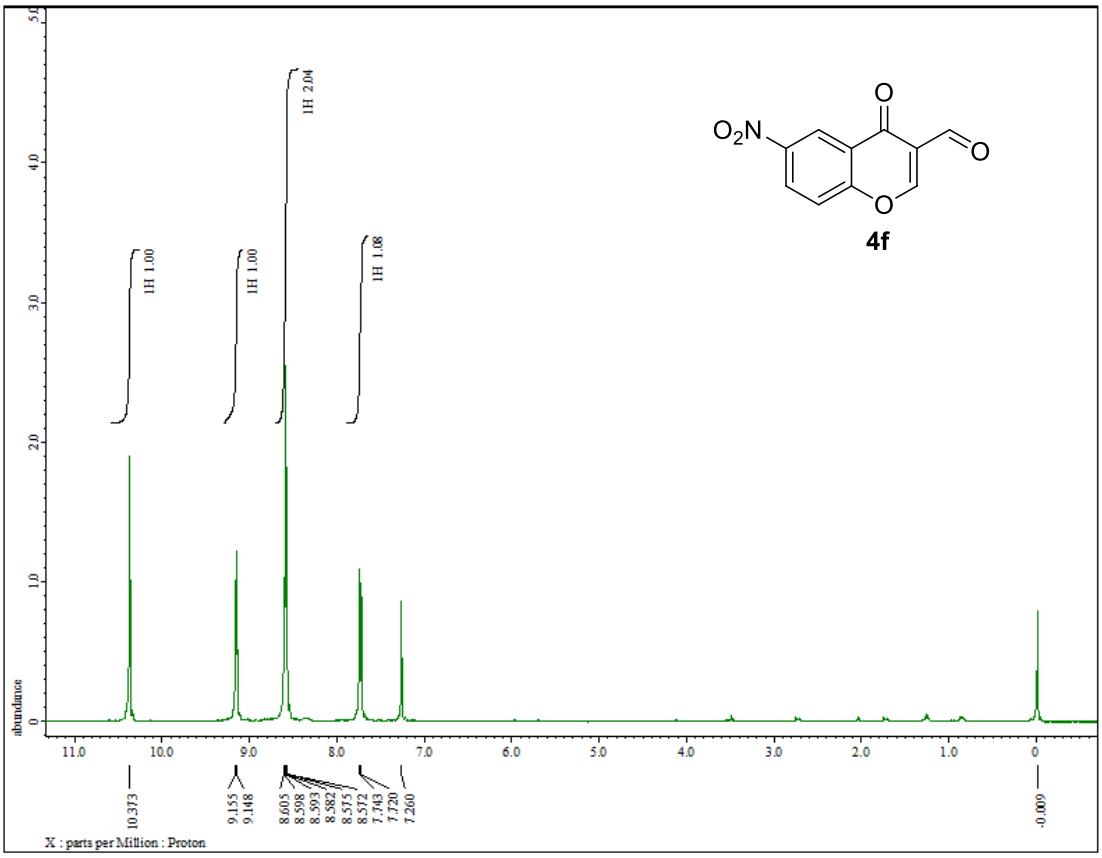
77.315
77.000
76.676
X : parts per Million : Carbon13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1H 1.08
abundance
X : parts per Million : Proton
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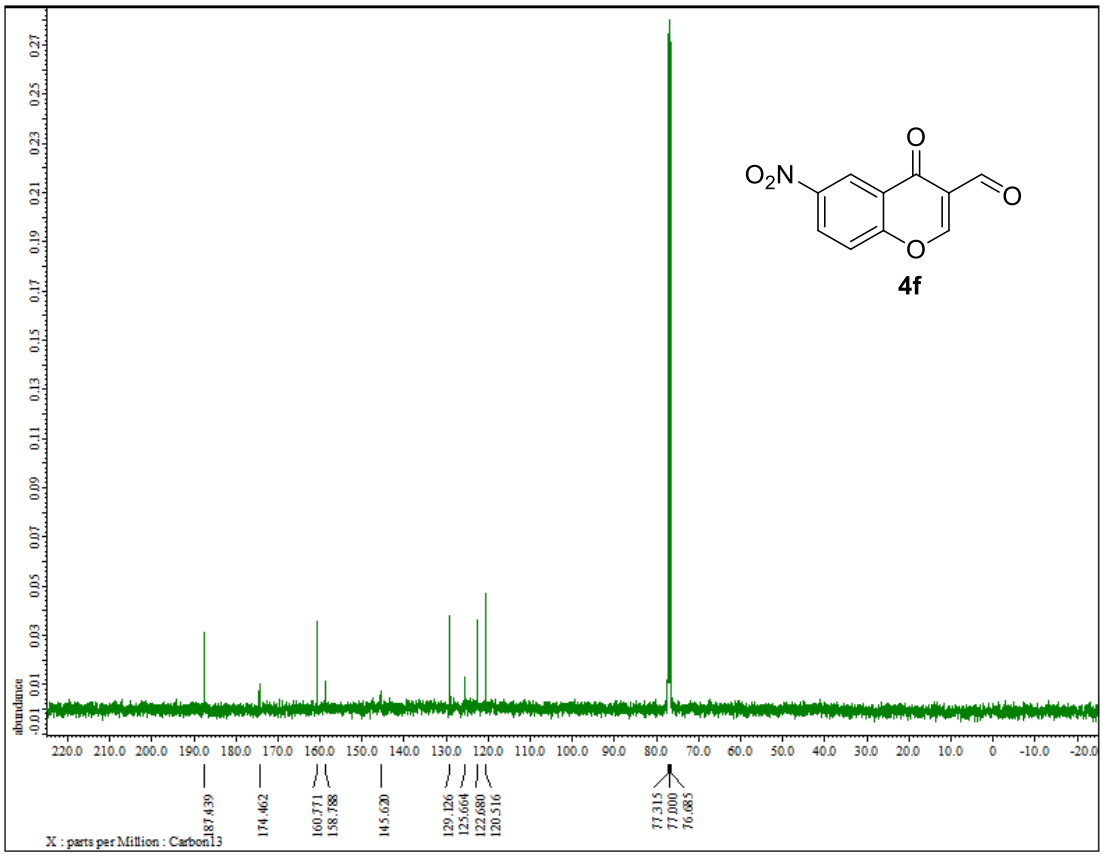
O2N
O

4f


abundance
X : parts per Million : Carbon13
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77.000
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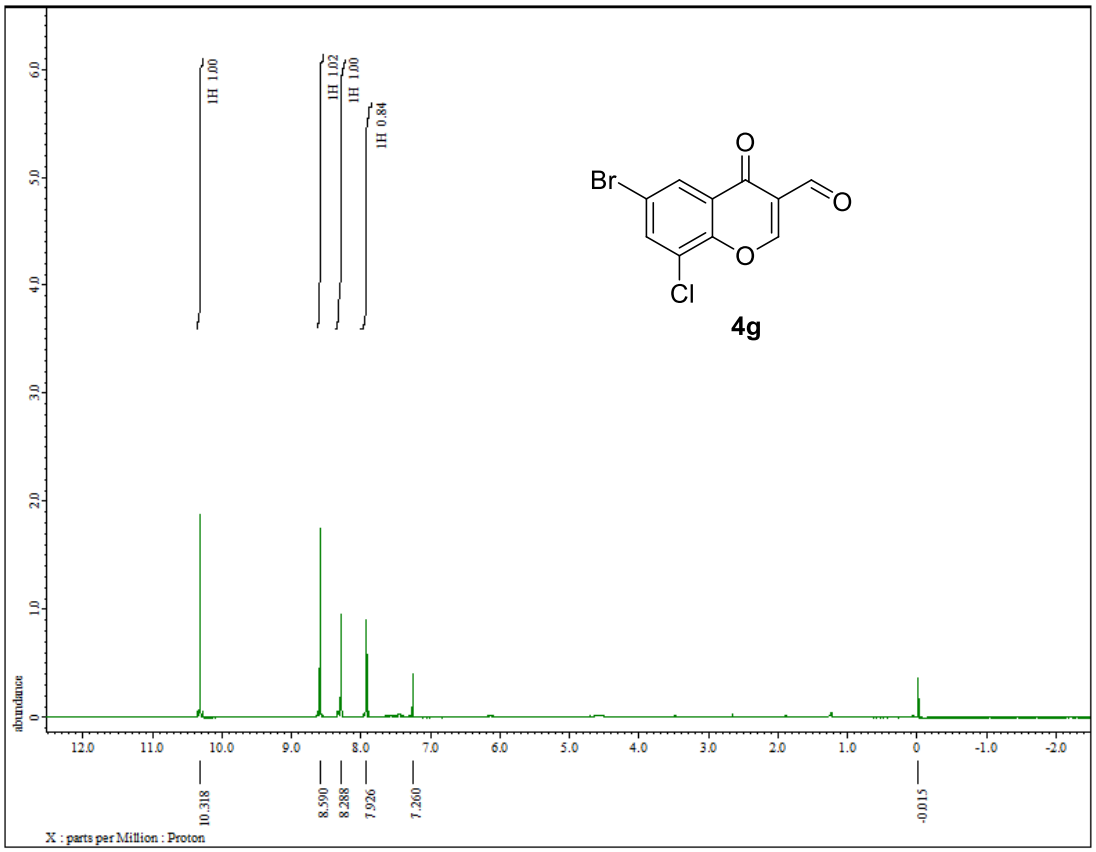
O2N
O

4f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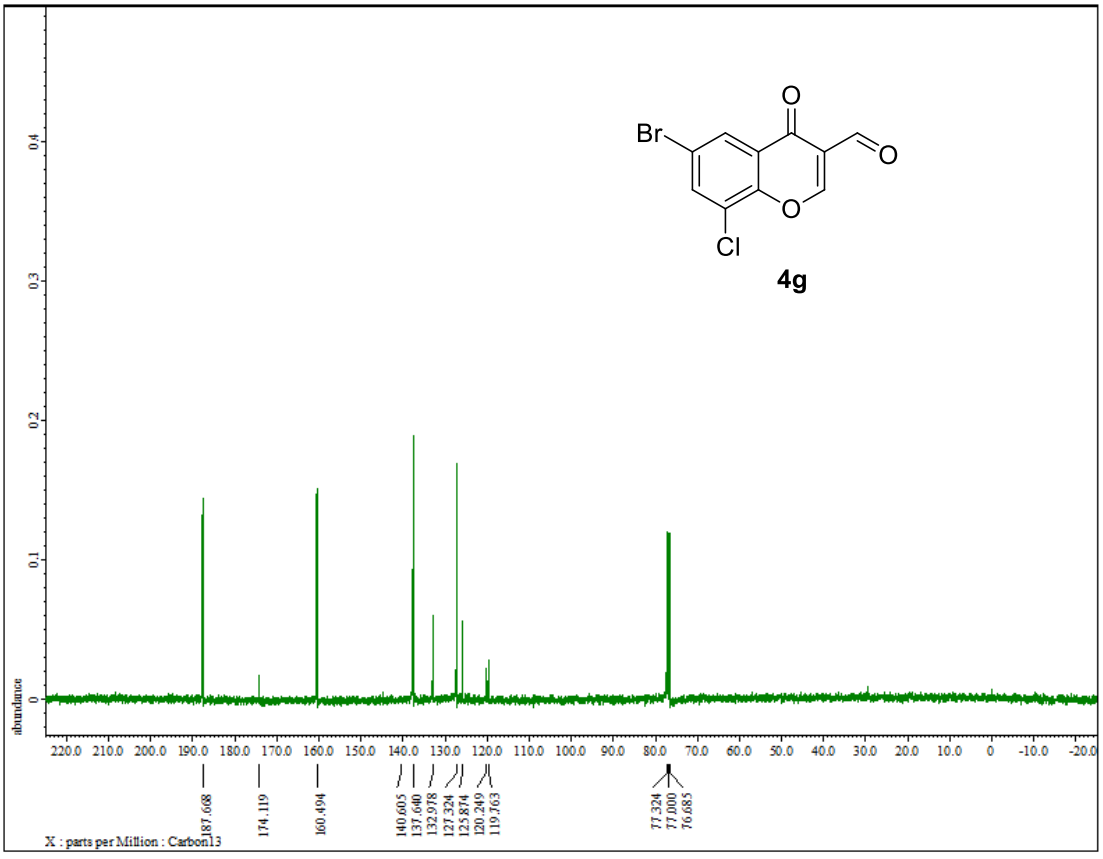
X : parts per Million : Proton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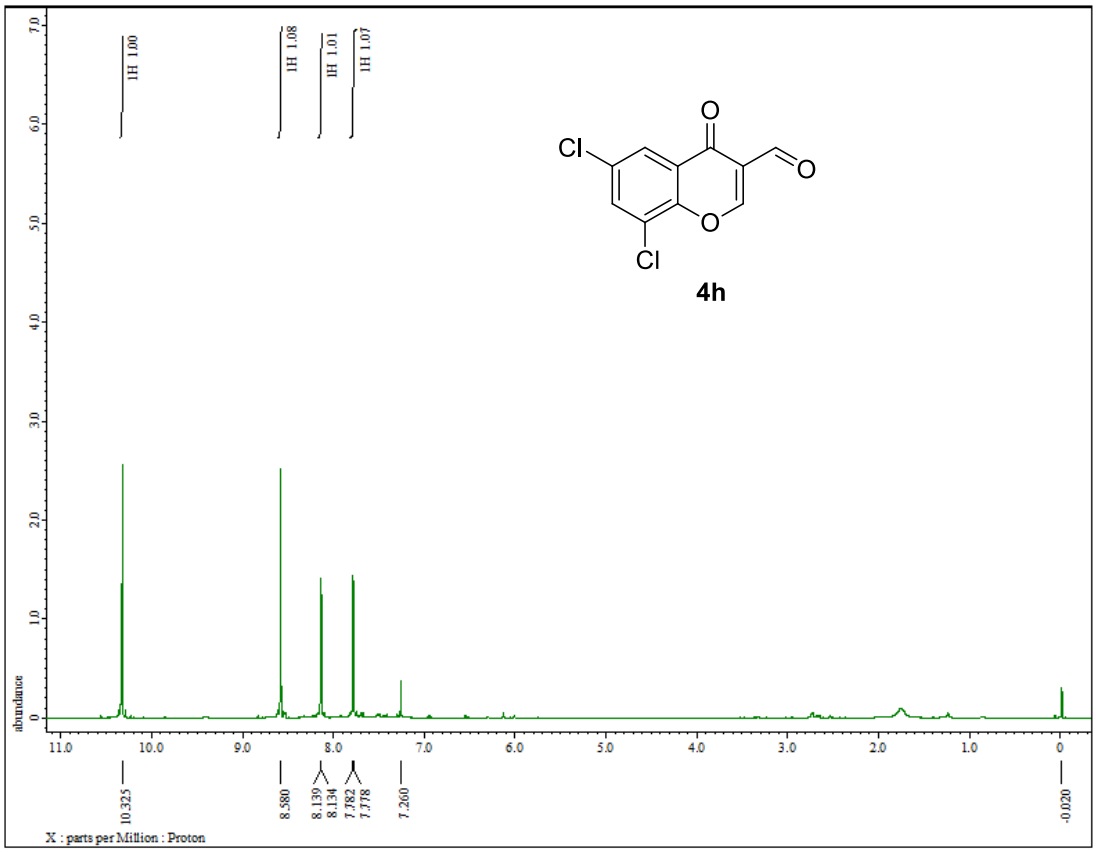
X : parts per Million : Carbon13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4.0
3.0
2.0
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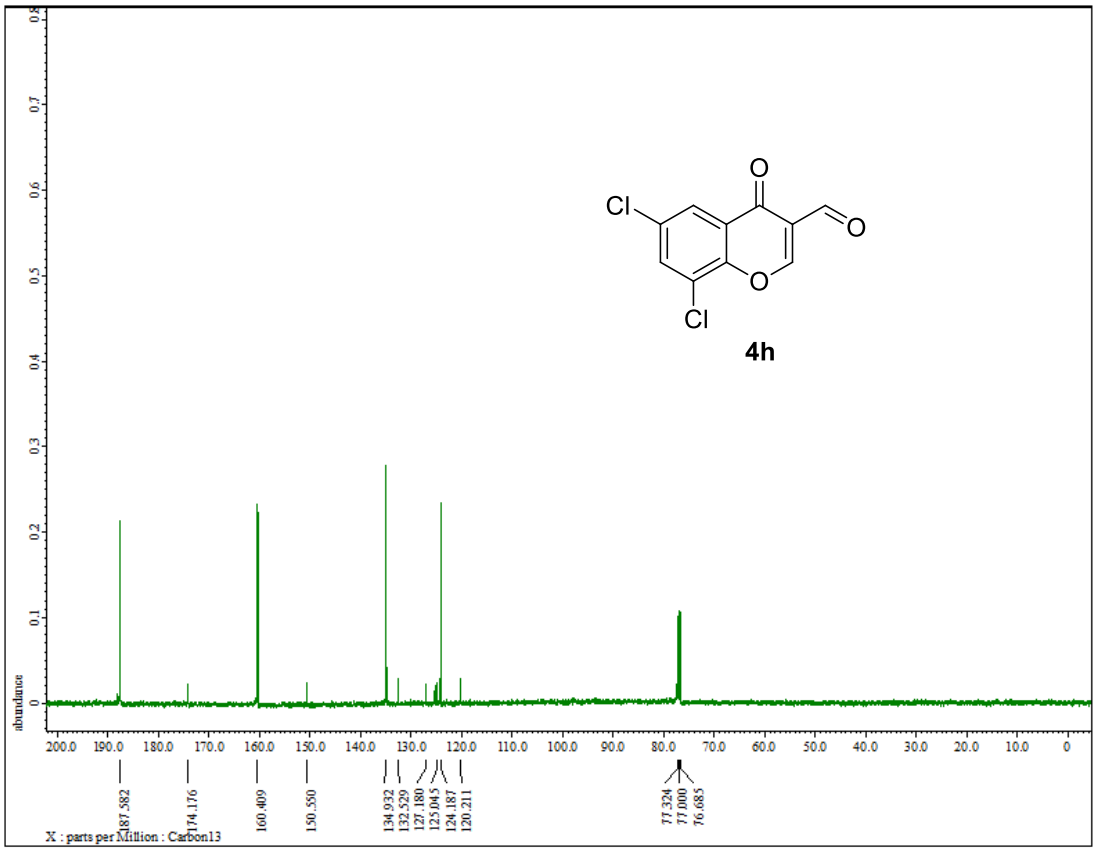
X : parts per Million : Proton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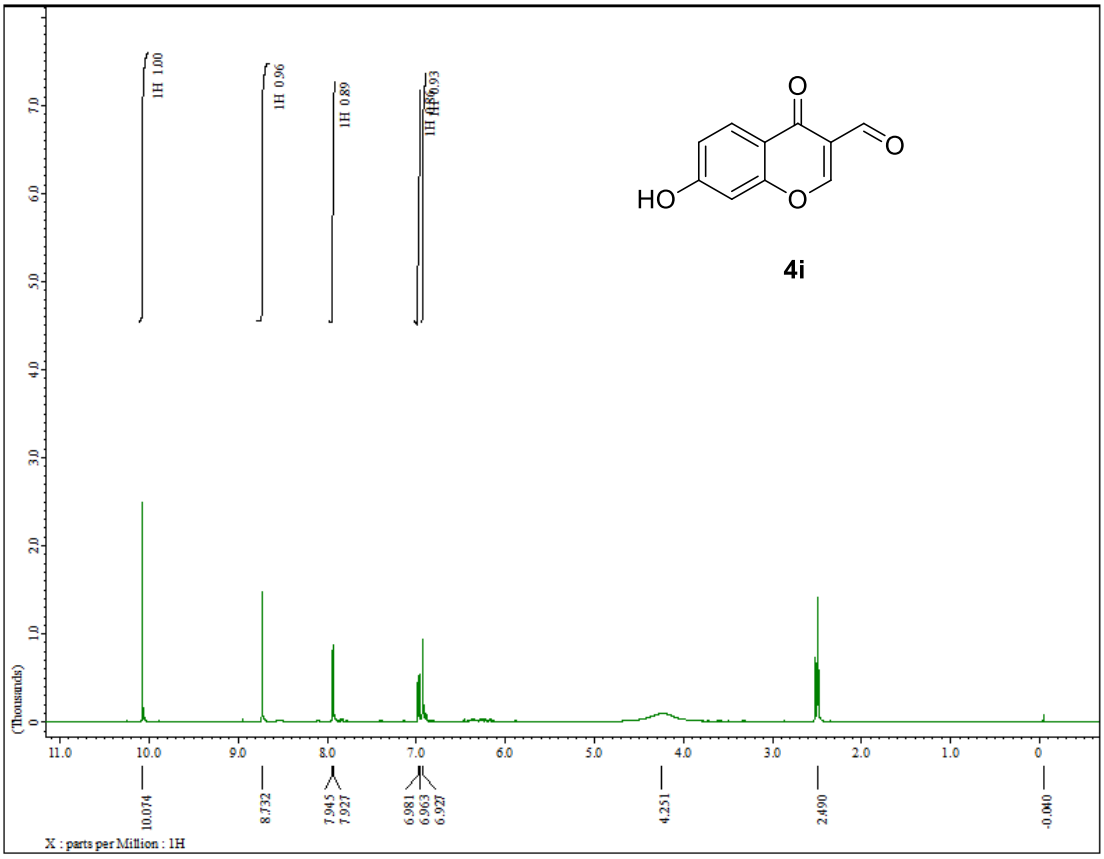
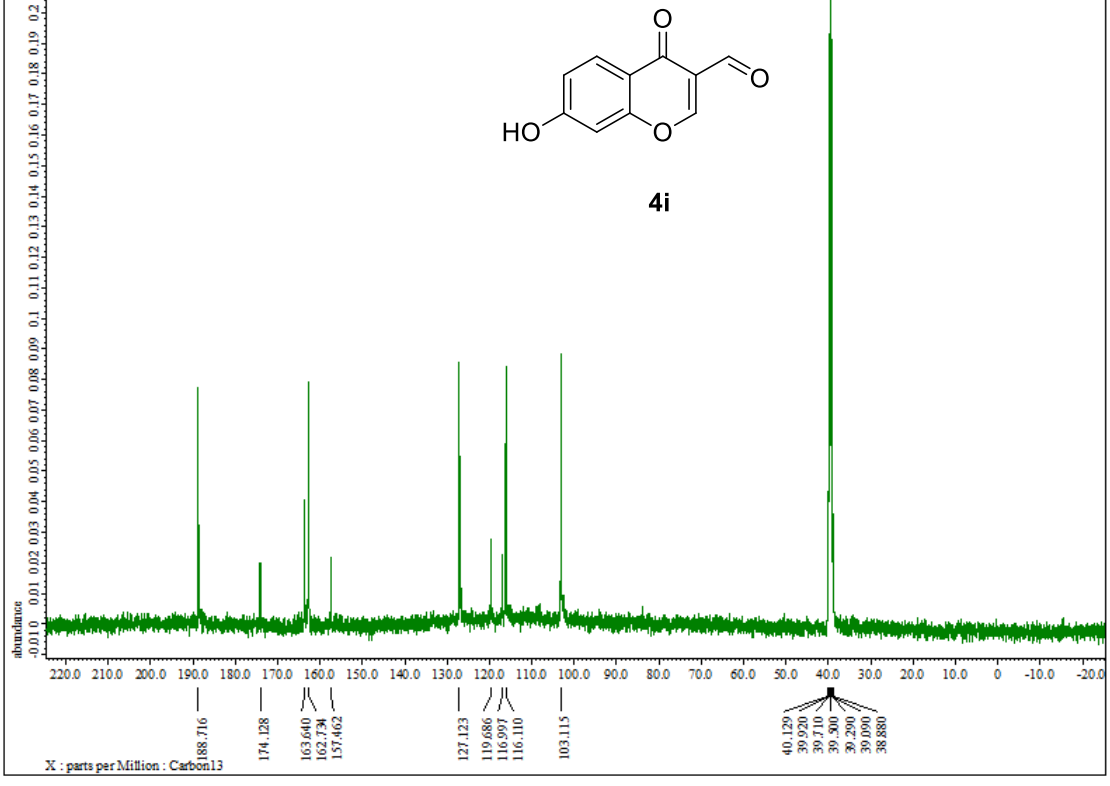
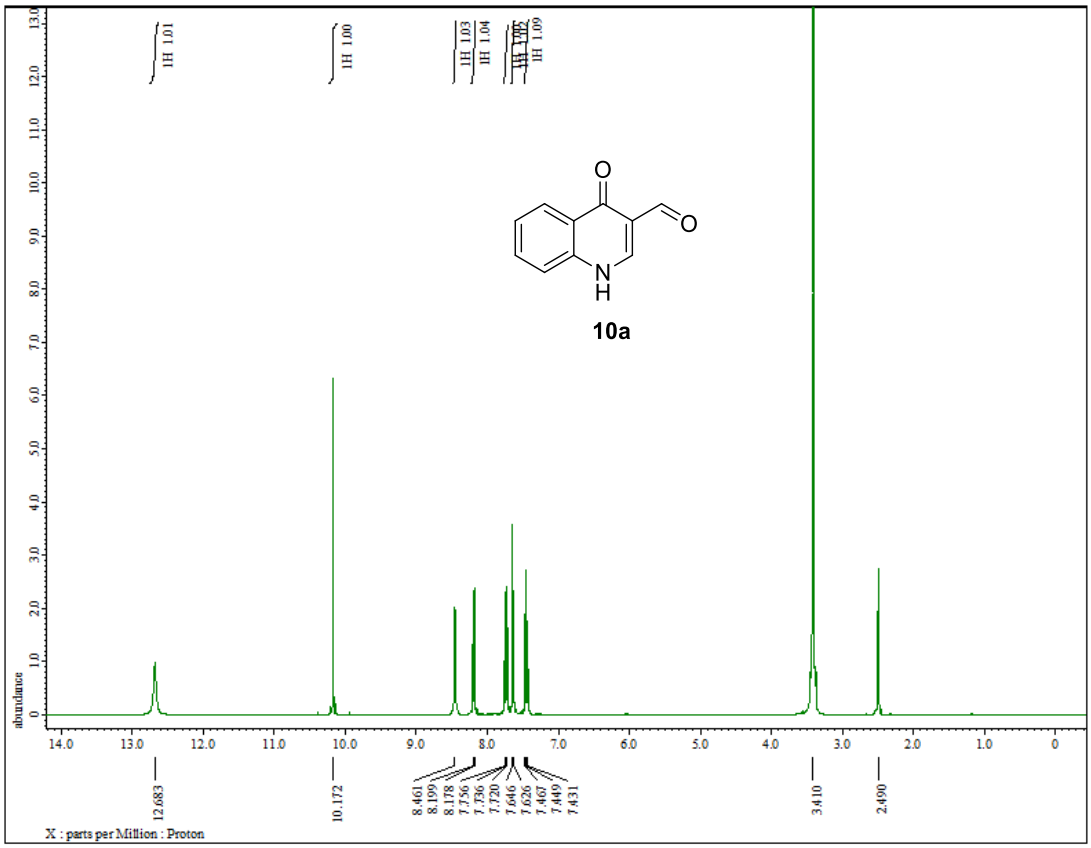
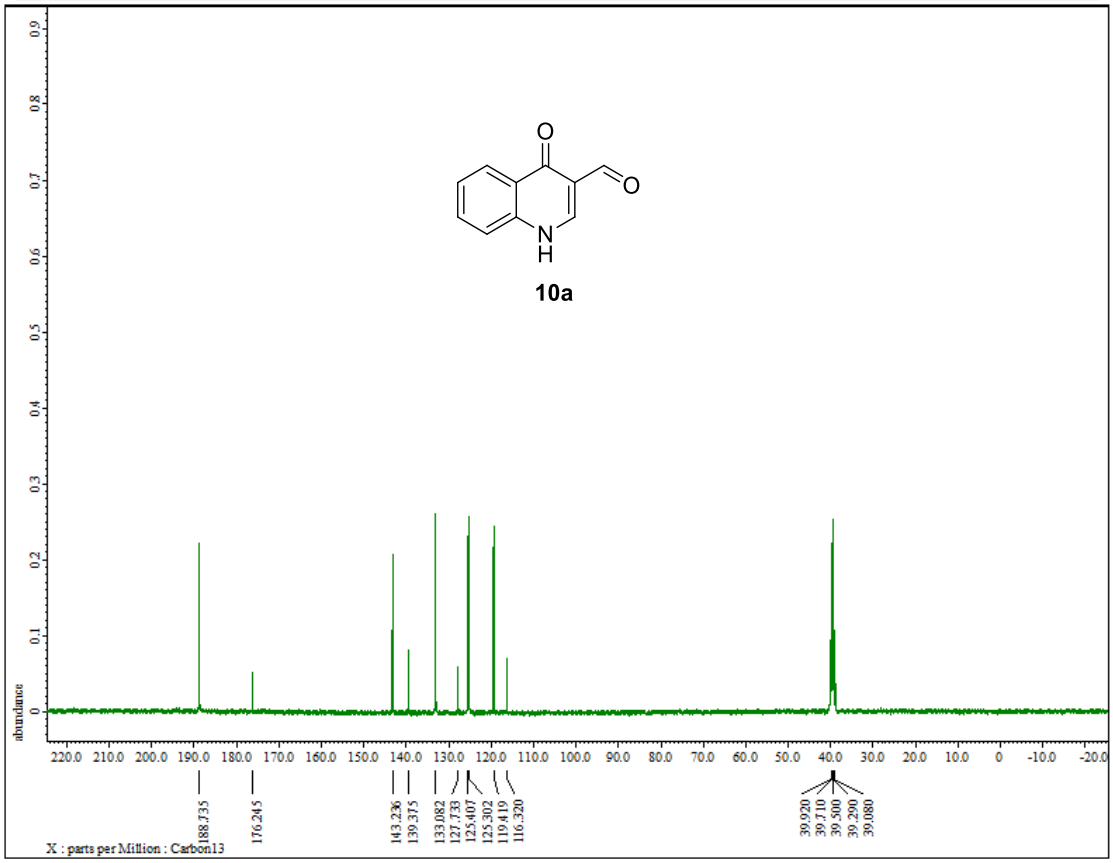
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
187.582
174.176
160.409
150.550
134.932
132.529
127.180
125.045
124.187
120.211
77.324
77.000
76.685
X : parts per Million : Carbon13

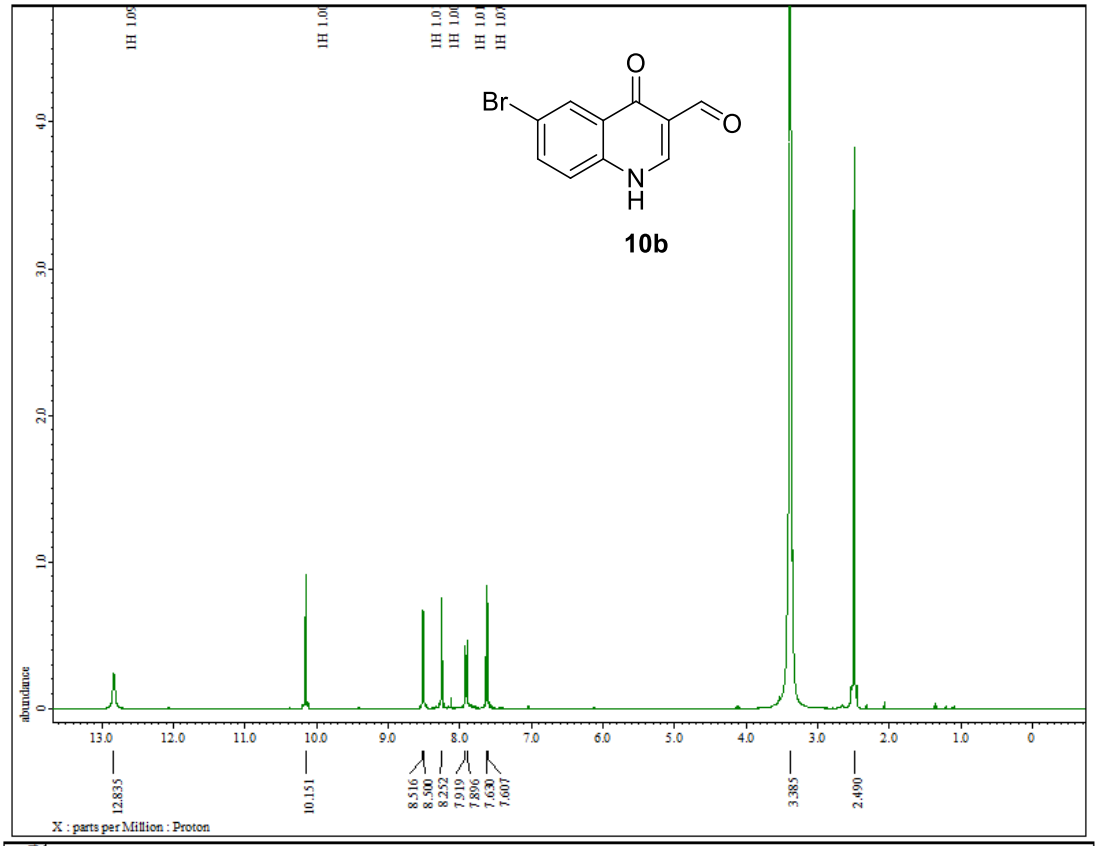

1H 1.00
1H 0.96
1H 0.89
1H 0.93
(Thousands)
10.074
8.732
7.945
7.927
6.981
6.963
6.927
4.251
2.490
-0.040
X : parts per Million : 1H

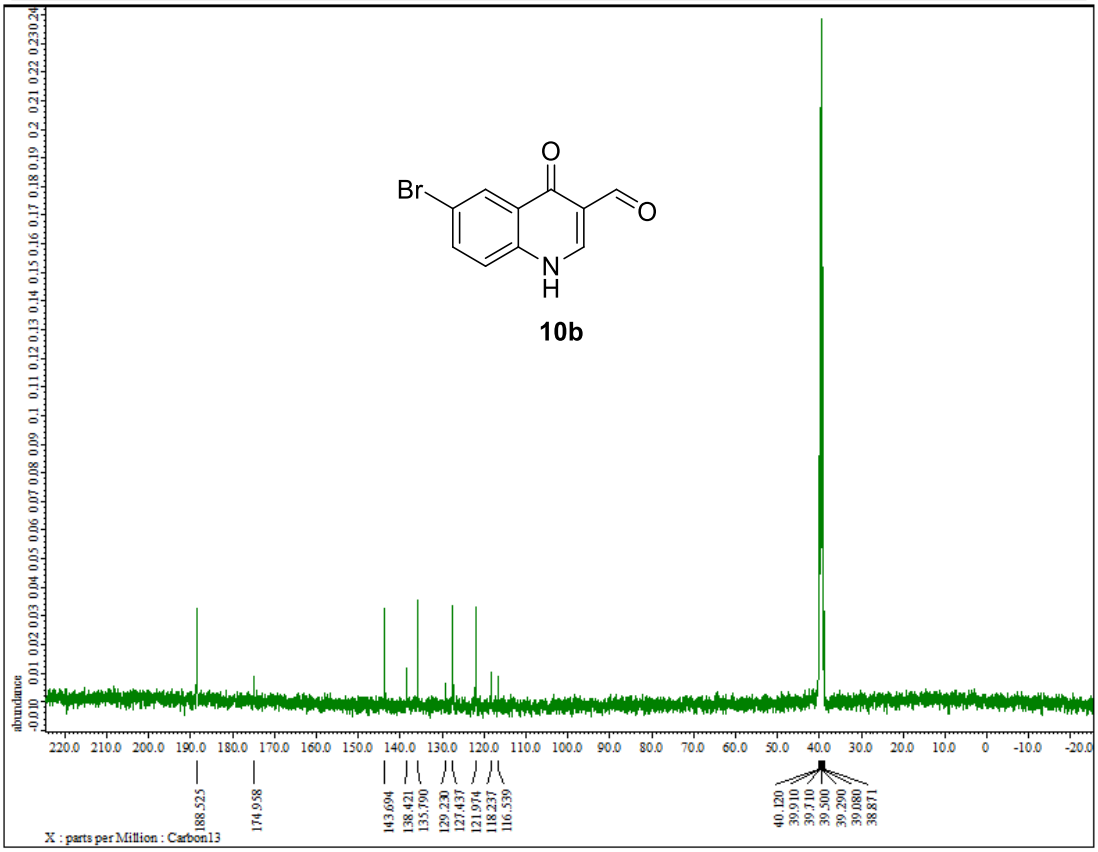

abundance
188.716
174.128
163.640
162.734
157.462
127.123
119.686
116.997
116.110
103.115
40.129
39.920
39.710
39.500
39.290
39.090
38.880
X : parts per Million : Carbon13

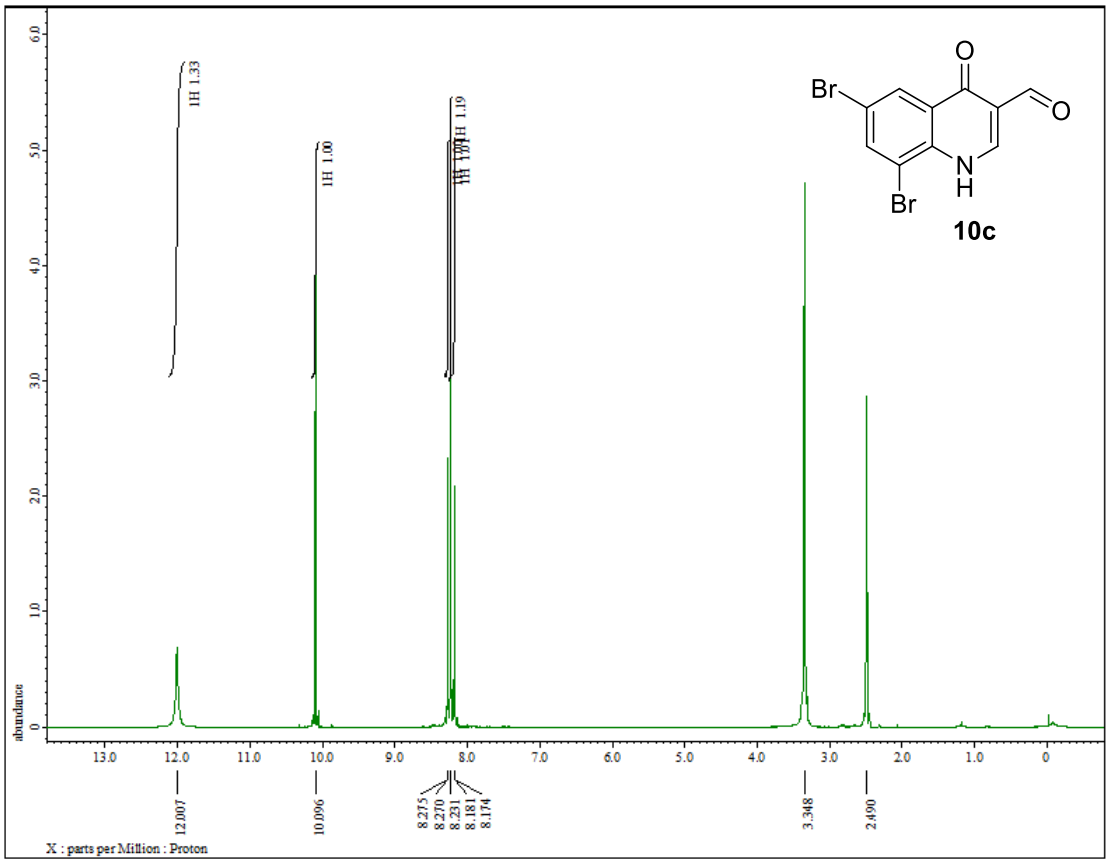
4i

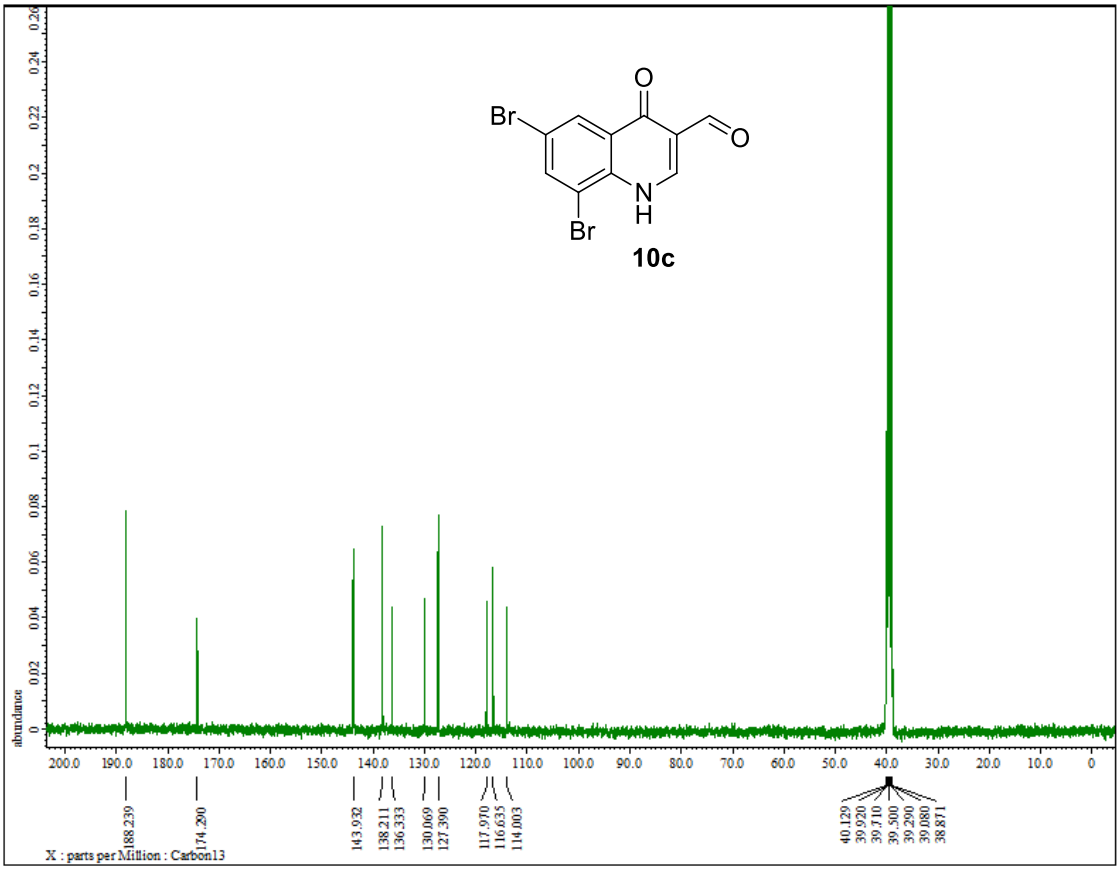

1H 1.01
1H 1.00
1H 1.03
1H 1.04
1H 1.09
O
O
N
H
10a
abundance
14.0 13.0 12.0 11.0 10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0
12.683
10.172
8.461
8.199
8.178
7.756
7.736
7.720
7.646
7.626
7.467
7.449
7.431
3.410
2.490
X : parts per Million : Proton

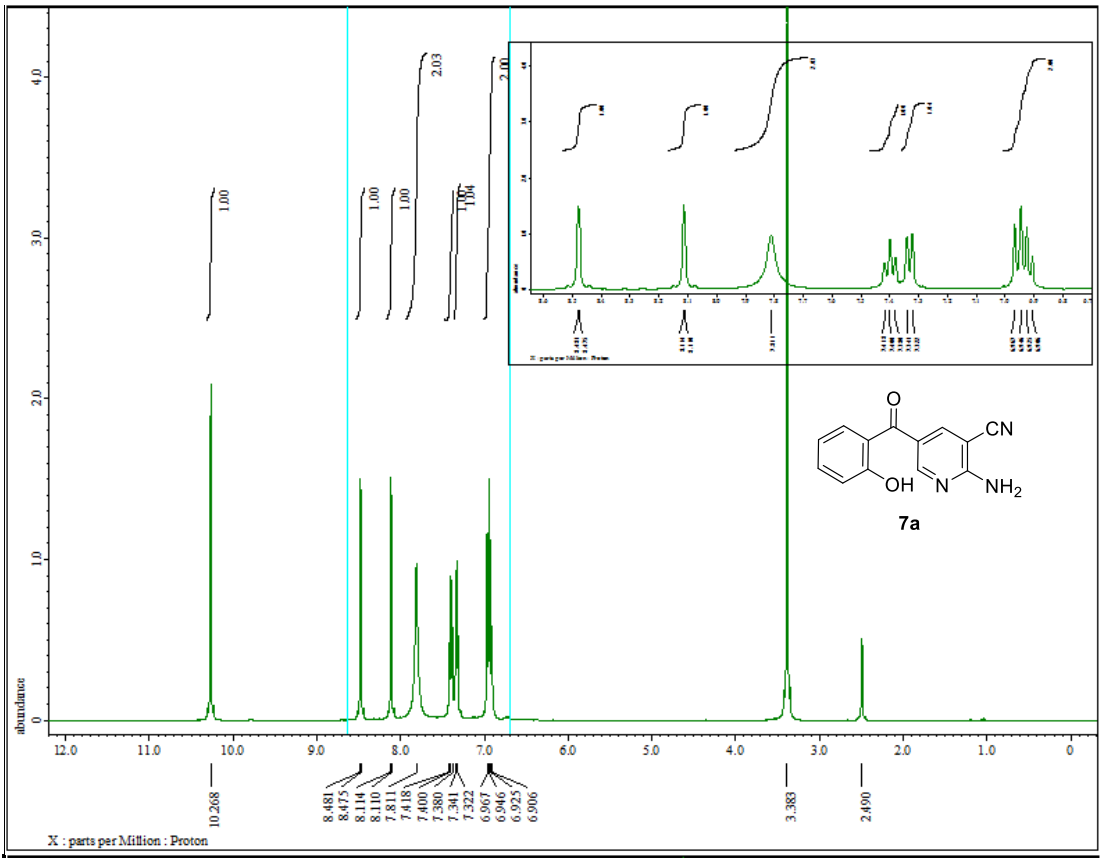

O
O
N
H
10a
abundance
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0 -20.0
188.735
176.245
143.236
139.375
133.082
127.733
125.407
125.302
119.419
116.320
39.920
39.710
39.500
39.290
39.080
X : parts per Million : Carbon13


Br
O
O
N
H
10b
abundance
X : parts per Million : Proton
12.835
10.151
8.516
8.500
8.252
7.919
7.896
7.630
7.607
3.385
2.490

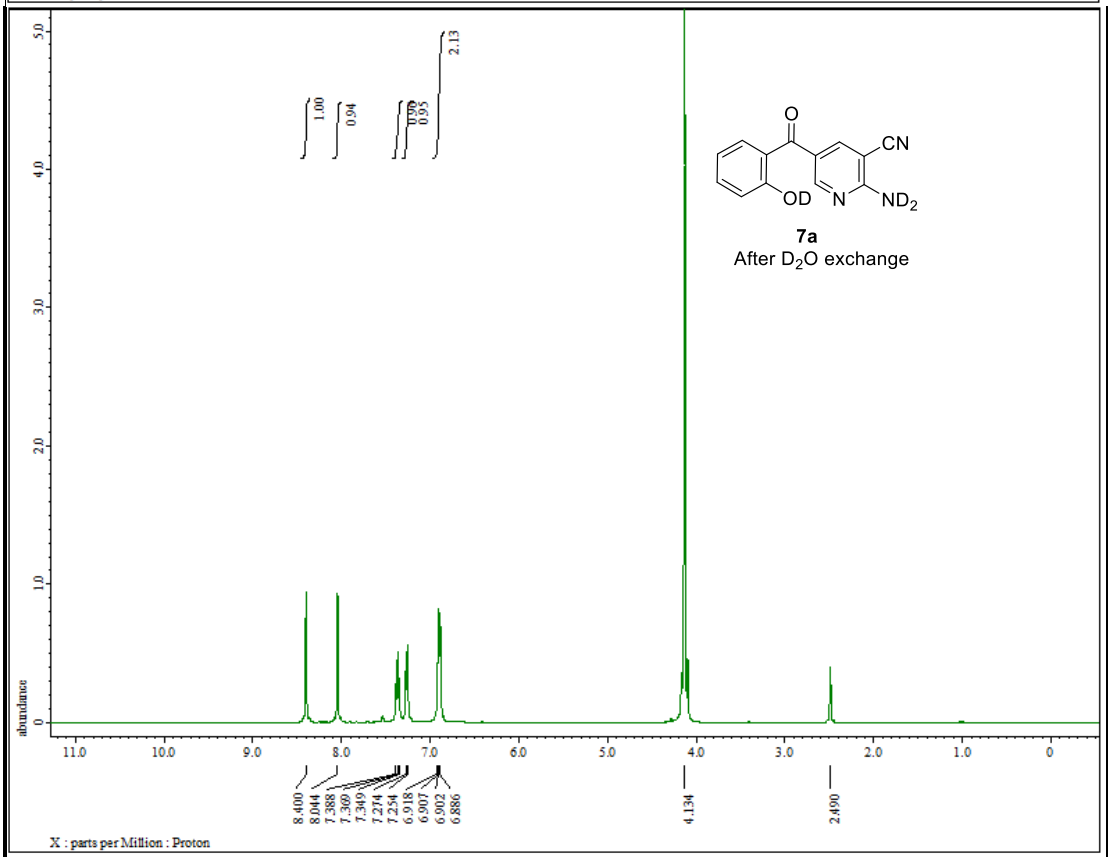

Br
O
O
N
H
10b
abundance
X : parts per Million : Carbon13
188.525
174.958
143.694
138.421
135.790
129.230
127.437
121.974
118.237
116.539
40.120
39.910
39.710
39.500
39.290
39.080
38.871


Br
O
O
N
H
Br
10c
1H 1.33
1H 1.00
1H 1.19
abundance
X : parts per Million : Proton
12.007
10.096
8.275
8.270
8.231
8.181
8.174
3.348
2.490

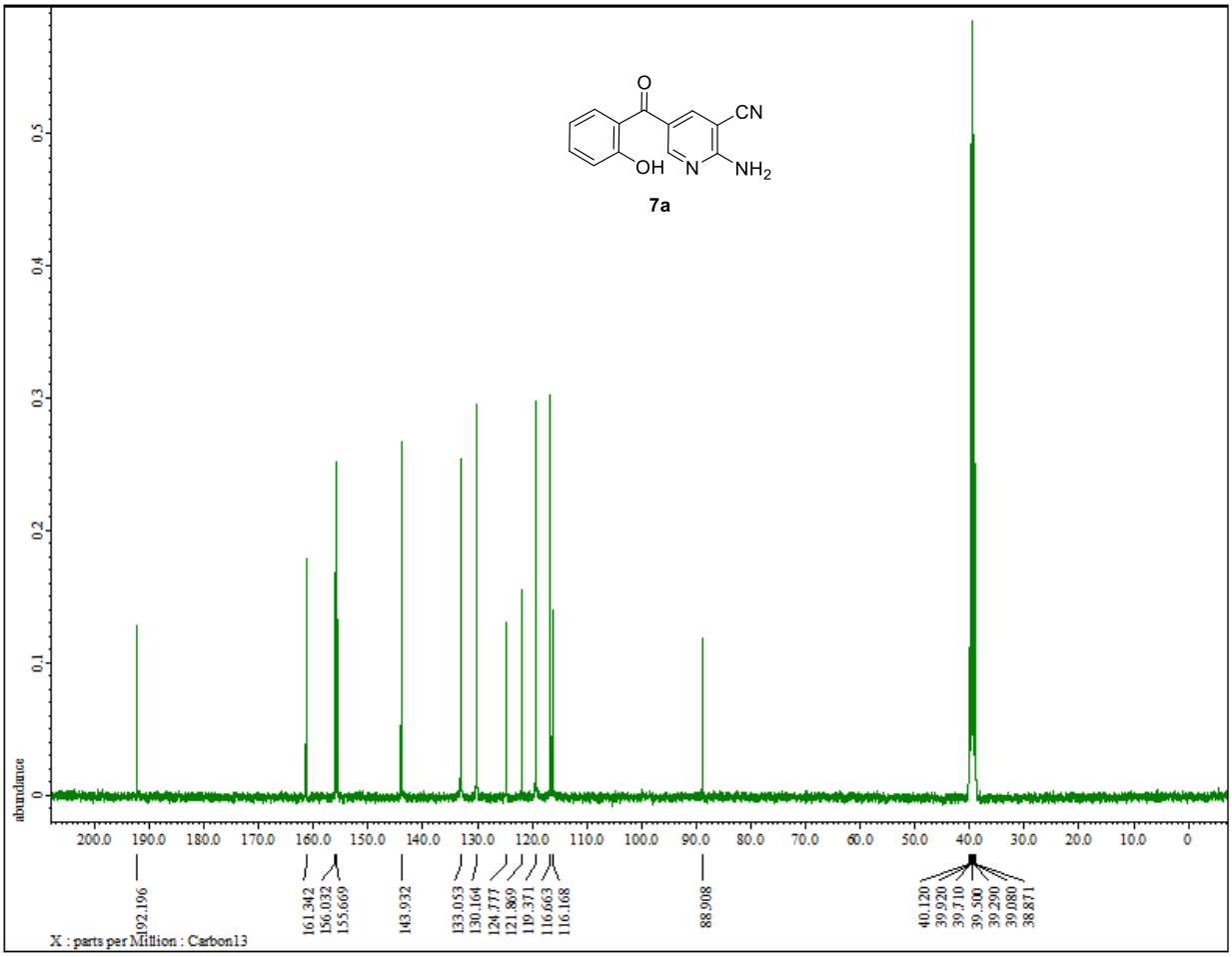

Br
O
O
N
H
Br
10c
abundance
X : parts per Million : Carbon13
188.239
174.290
143.932
138.211
136.333
130.069
127.390
117.970
116.635
114.003
40.129
39.920
39.710
39.500
39.290
39.080
38.871

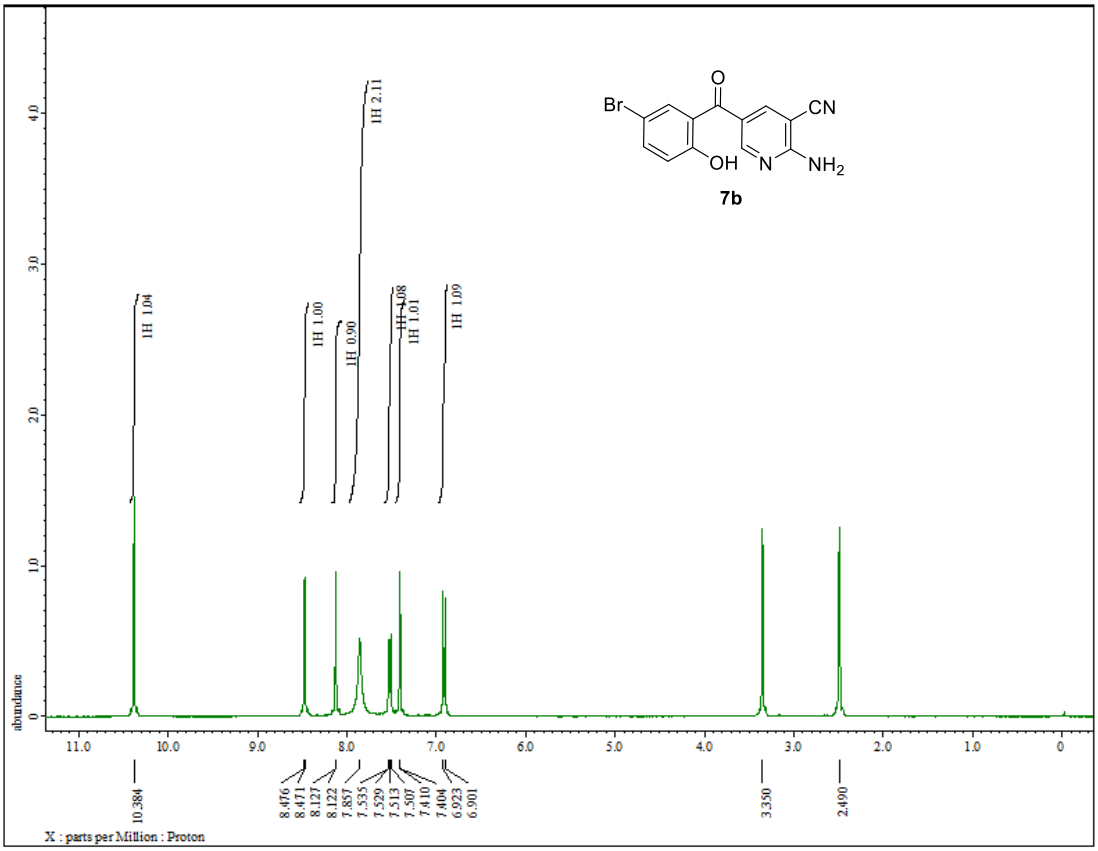


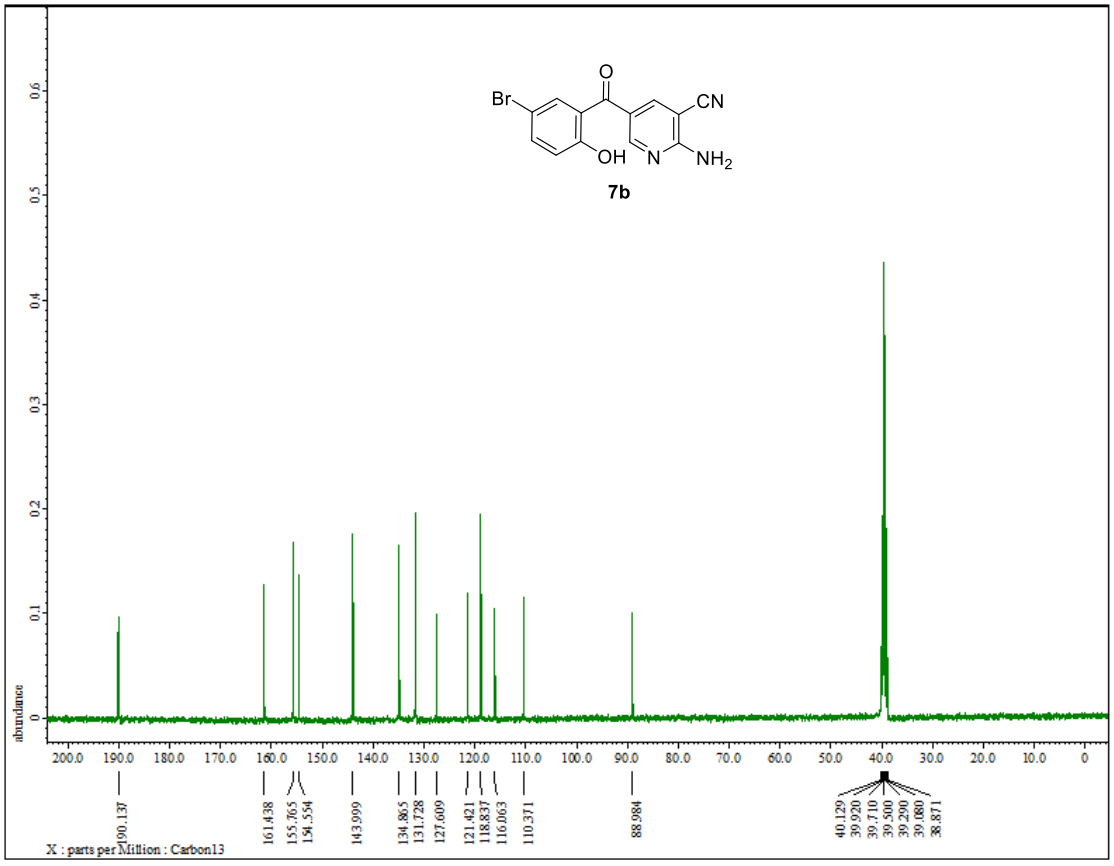
7a

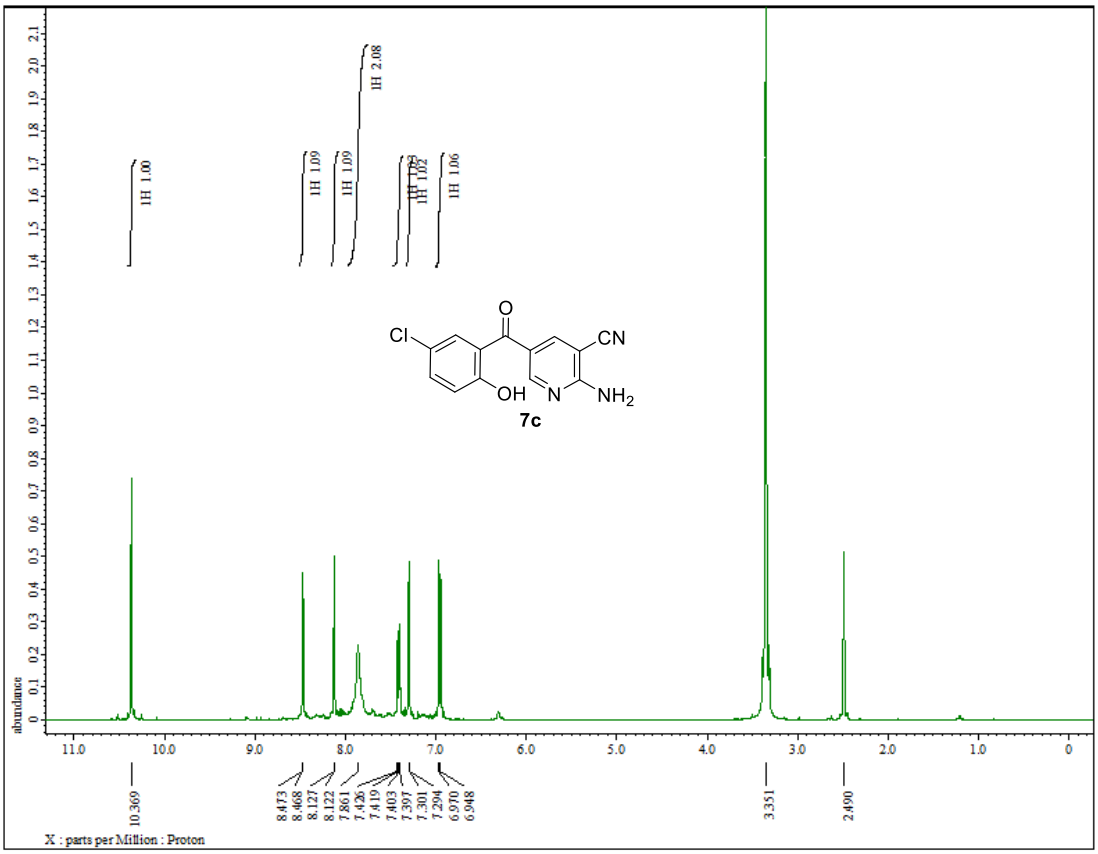


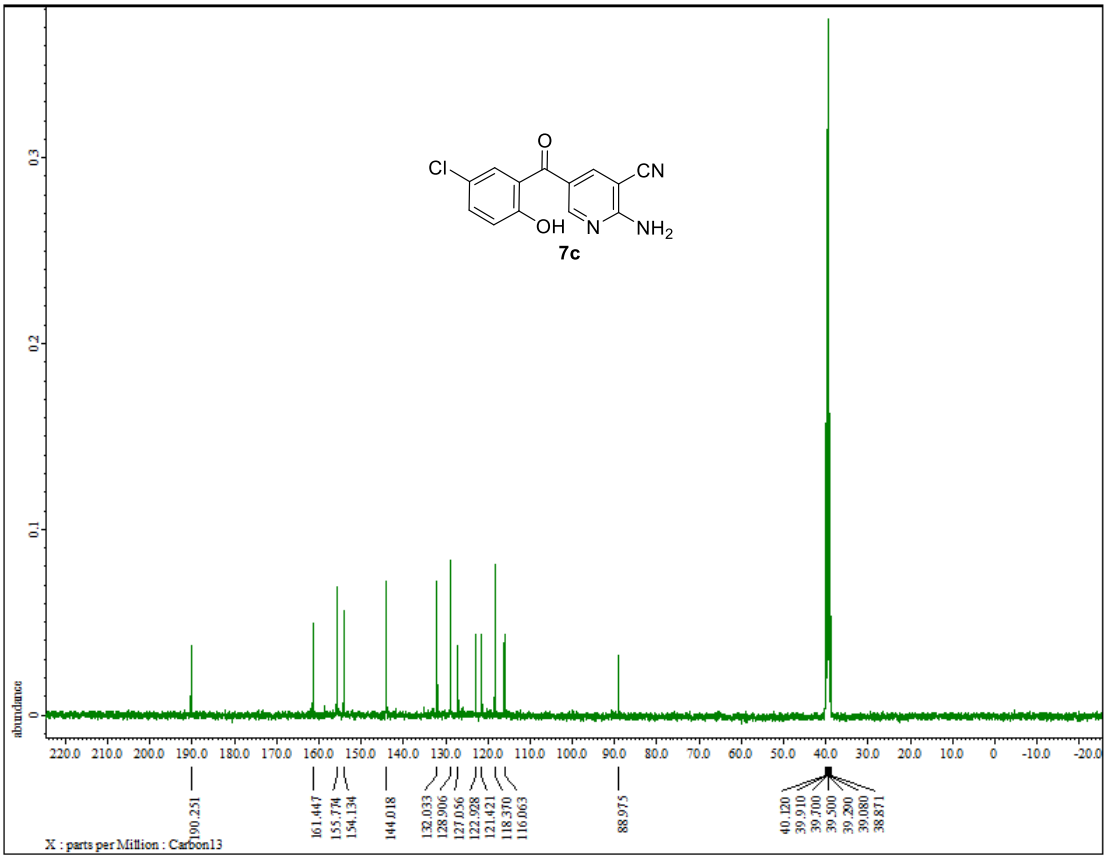
7a
After D_2O exchange

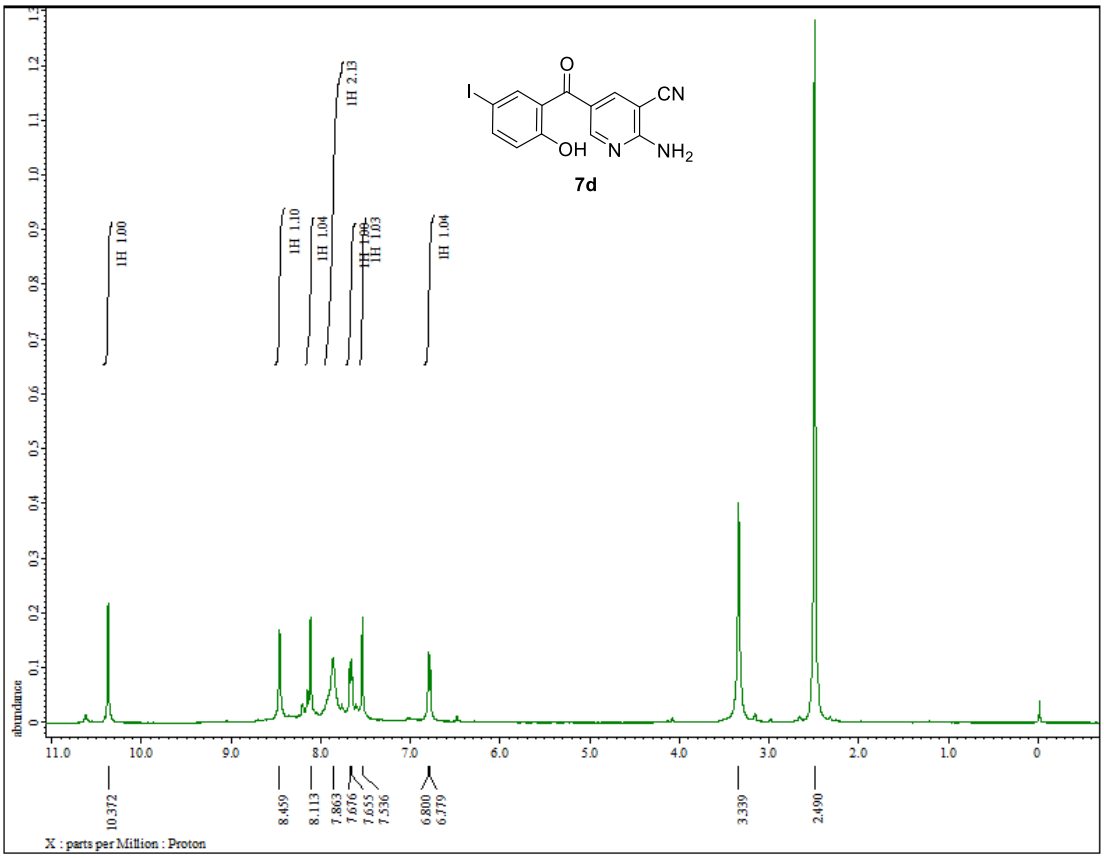

O
CN
OH
N
NH2
7a
abundance
0
0.1
0.2
0.3
0.4
0.5
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
192.196
161.342
156.032
155.669
143.932
133.053
130.164
124.777
121.869
119.371
116.663
116.168
88.908
40.120
39.920
39.710
39.500
39.290
39.080
38.871
X : parts per Million : Carbon13

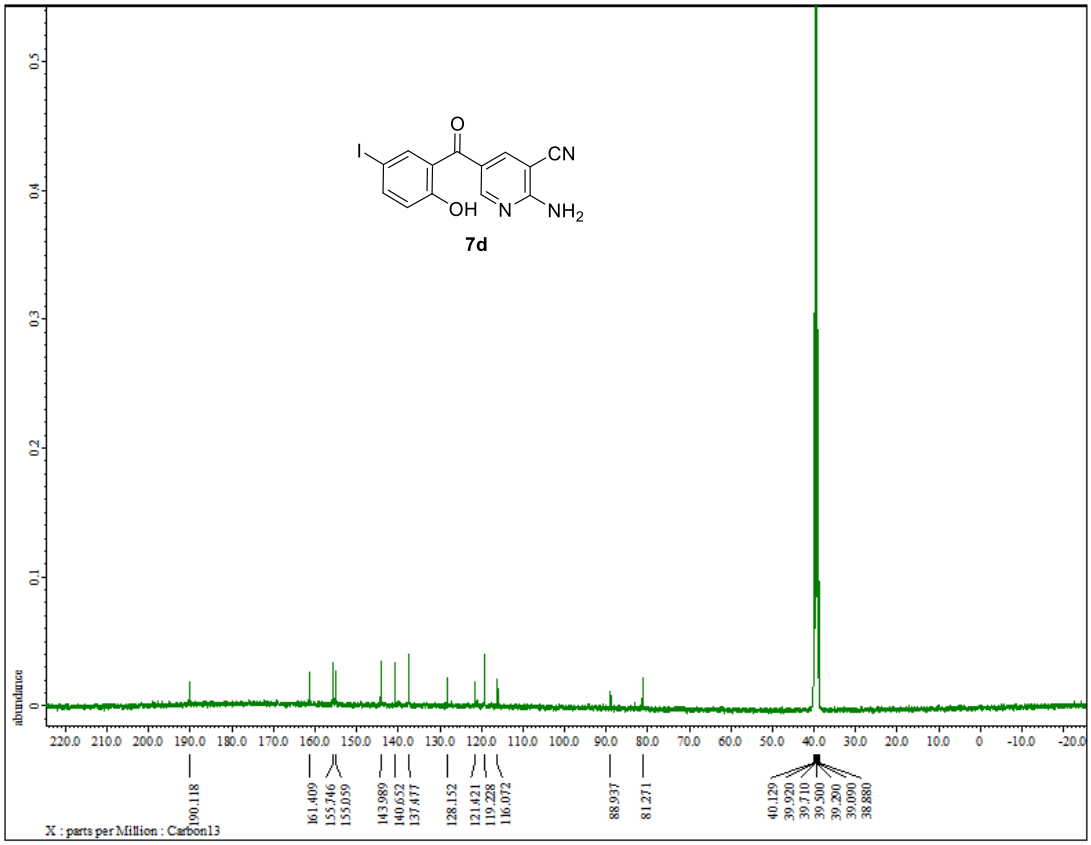

Br
O
CN
OH
N
NH2
7b
1H 1.04
1H 1.00
1H 0.90
1H 2.11
1H 1.08
1H 1.01
1H 1.09
abundance
10.384
8.476
8.471
8.127
8.122
7.857
7.535
7.529
7.513
7.507
7.410
7.404
6.923
6.901
3.350
2.490
X : parts per Million : Proton

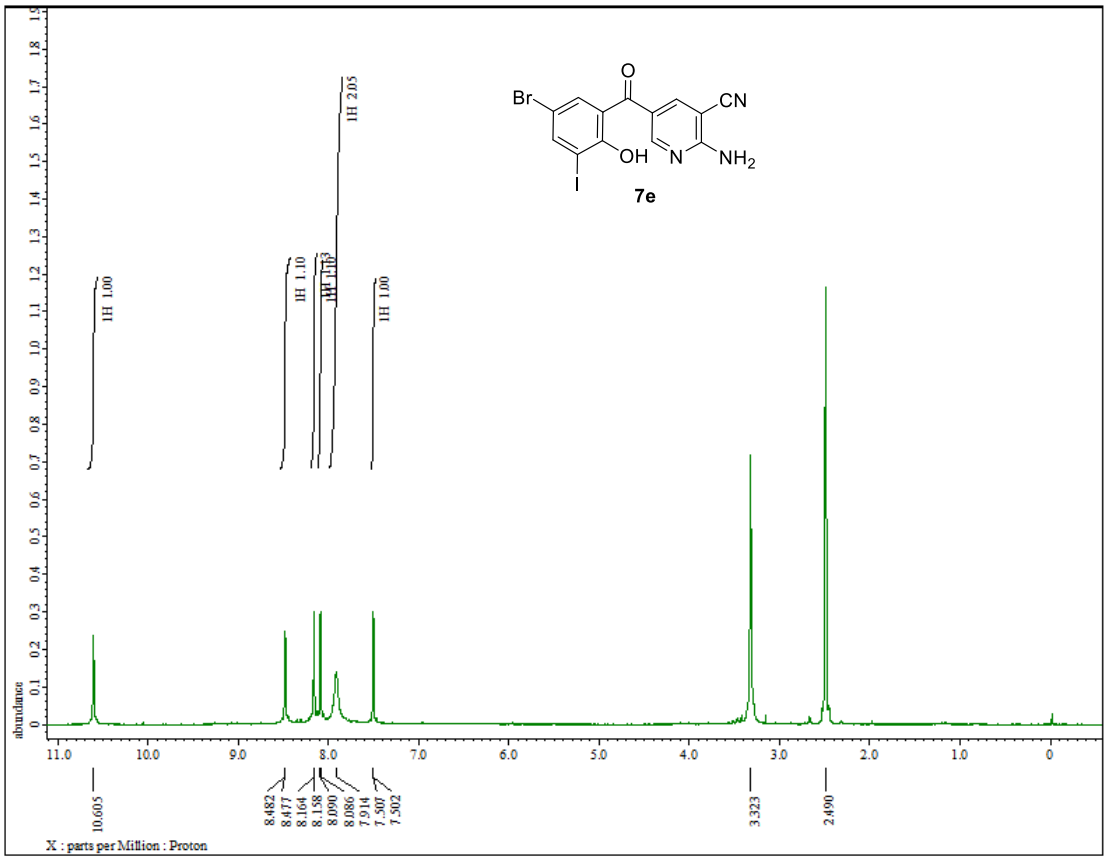

Br
O
CN
OH
N
NH2
7b
abundance
190.137
161.438
155.765
154.554
143.999
134.865
131.728
127.609
121.421
118.837
116.063
110.371
88.984
40.129
39.920
39.710
39.500
39.290
39.080
38.871
X : parts per Million : Carbon13

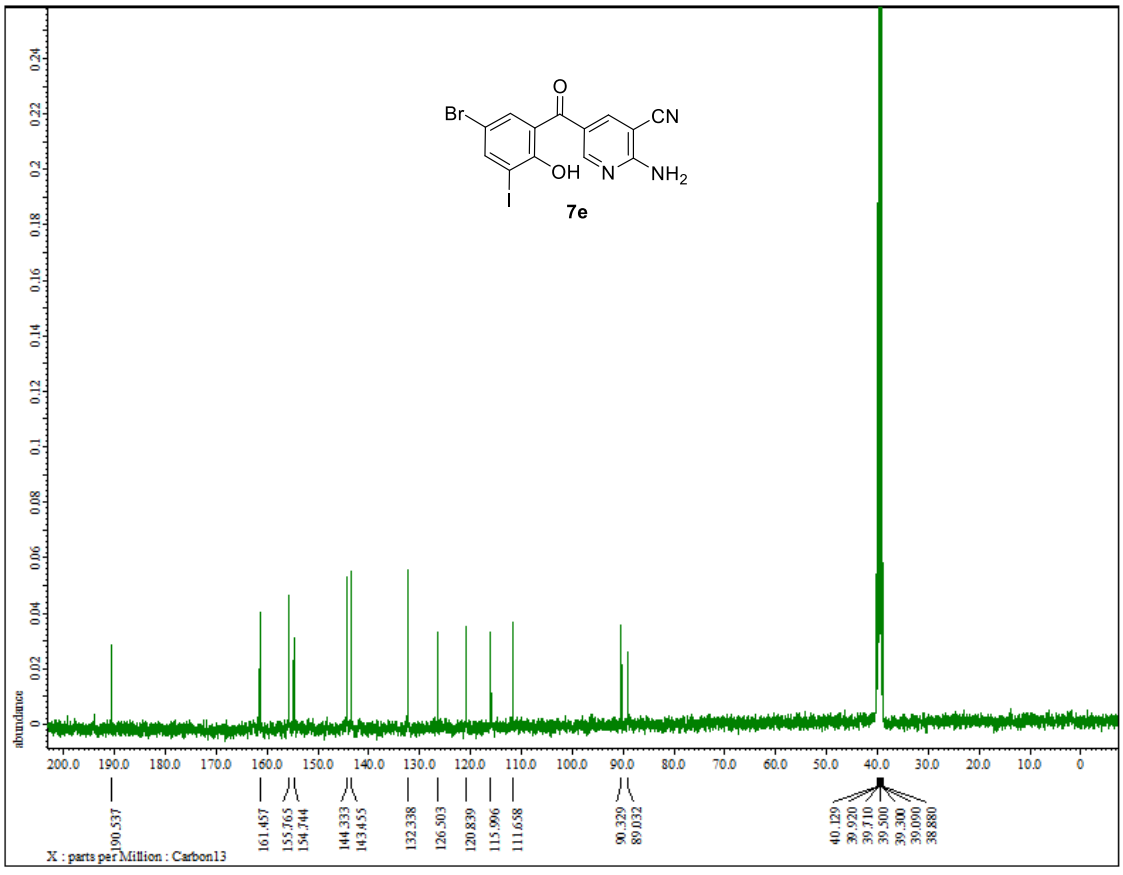

1H 1.00
1H 1.09
1H 1.09
1H 2.08
1H 1.02
1H 1.06
O
Cl
CN
OH
N
NH2
7c
abundance
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
10.369
8.473
8.468
8.127
8.122
7.861
7.426
7.419
7.403
7.397
7.301
7.294
6.970
6.948
3.351
2.490
X : parts per Million : Proton

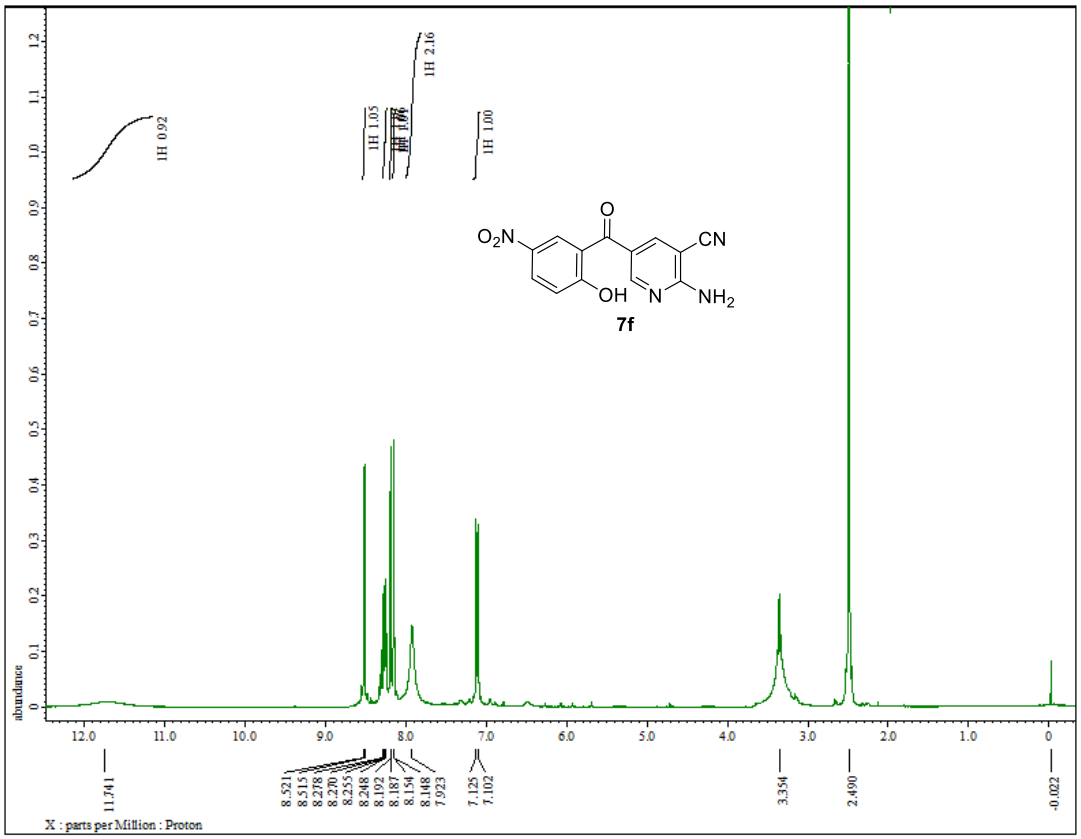

O
Cl
CN
OH
N
NH2
7c
abundance
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
190.251
161.447
155.774
154.134
144.018
132.033
128.906
127.056
122.928
121.421
118.370
116.063
88.975
40.120
39.910
39.700
39.500
39.290
39.080
38.871
X : parts per Million : Carbon13

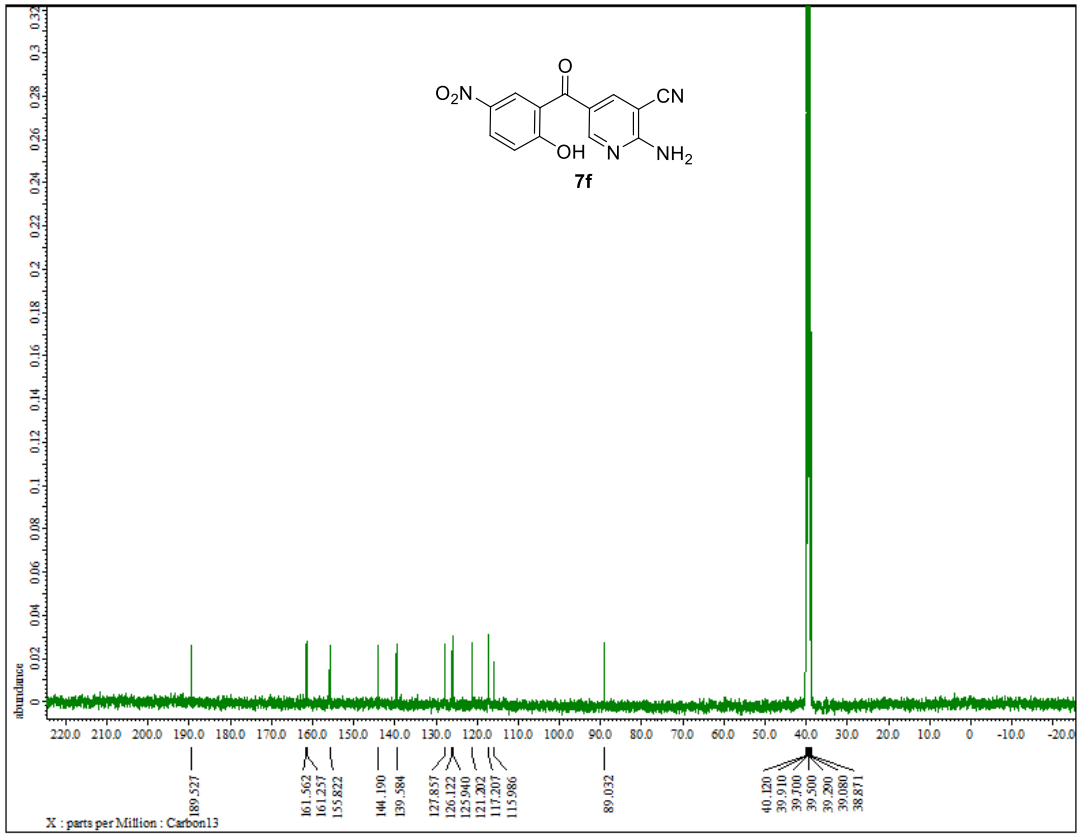

O
I
CN
OH
N
NH2
7d
1H 1.00
1H 1.10
1H 1.04
1H 2.13
1H 1.03
1H 1.04
abundance
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
10.372
8.459
8.113
7.863
7.676
7.655
7.536
6.800
6.779
3.339
2.490
X : parts per Million : Proton

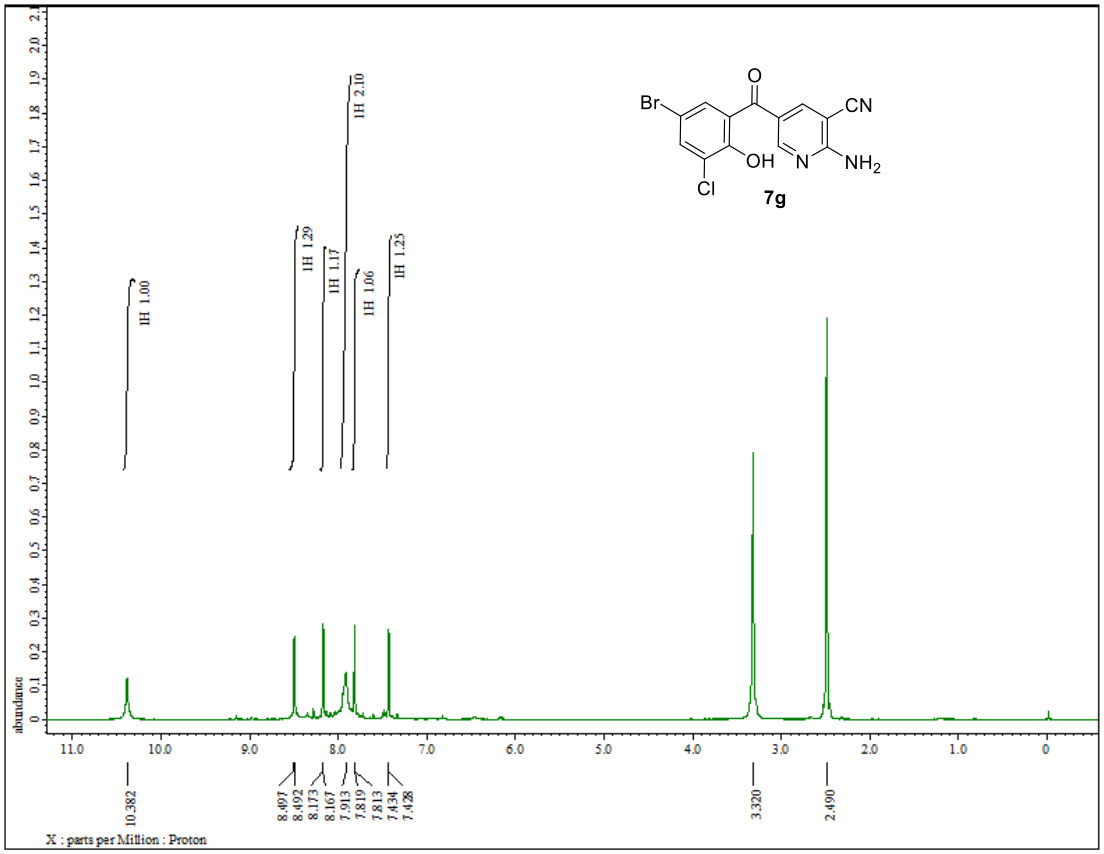

O
I
CN
OH
N
NH2
7d
abundance
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
190.118
161.409
155.746
155.059
143.989
140.652
137.477
128.152
121.421
119.228
116.072
88.937
81.271
40.129
39.920
39.710
39.500
39.290
39.090
38.880
X : parts per Million : Carbon13

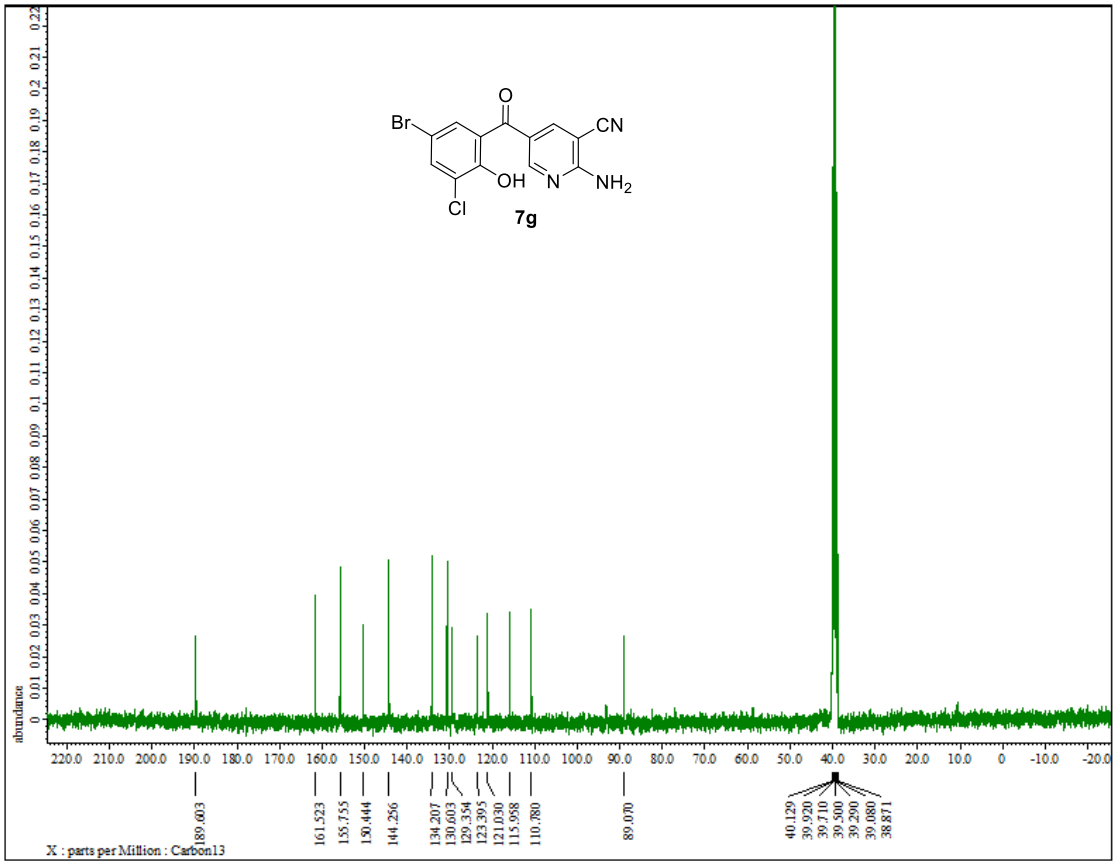

O
Br
CN
OH
N
NH2
I
7e
1H 2.05
1H 1.10
1H 1.00
1H 1.00
abundance
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
10.605
8.482
8.477
8.164
8.158
8.090
8.086
7.914
7.507
7.502
3.323
2.490
X : parts per Million : Proton

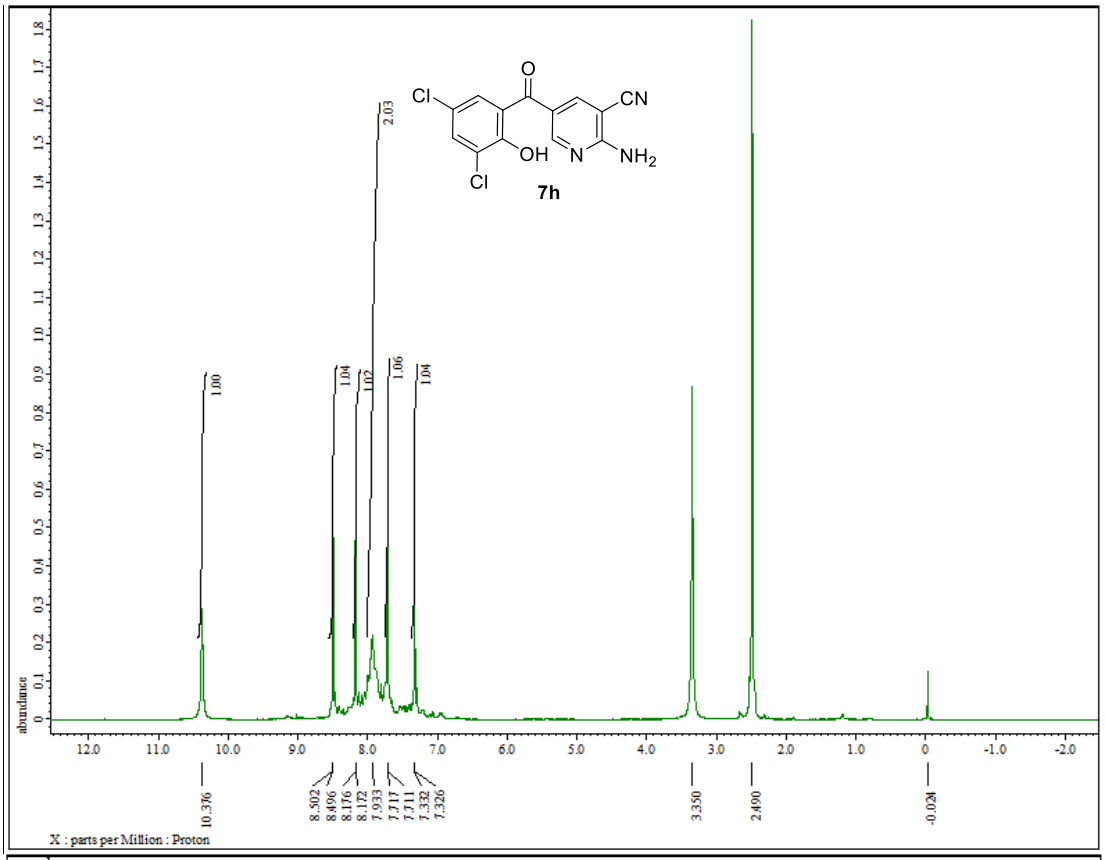

O
Br
CN
OH
N
NH2
I
7e
abundance
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
190.537
161.457
155.765
154.744
144.333
143.455
132.338
126.503
120.839
115.996
111.658
90.329
89.032
40.129
39.920
39.710
39.500
39.300
39.090
38.880
X : parts per Million : Carbon13

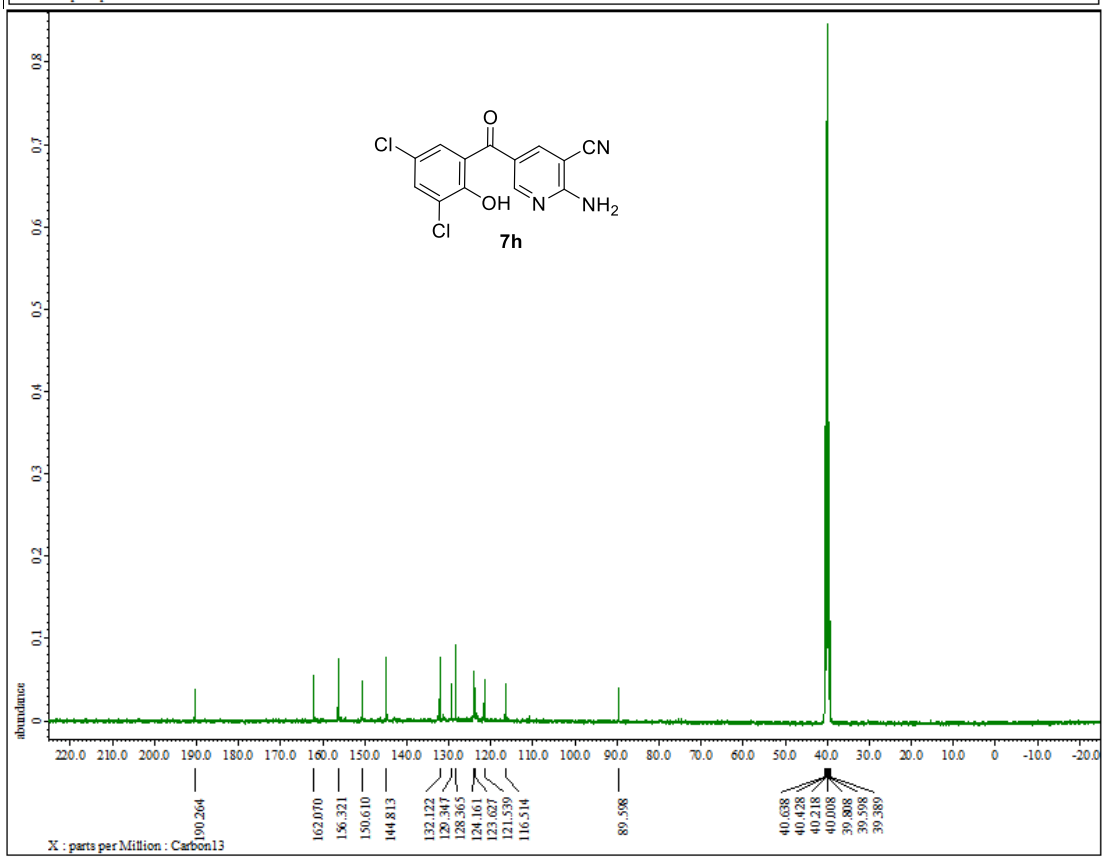

1H 0.92
1H 1.05
1H 2.16
1H 1.00
O
O2N
CN
OH
N
NH2
7f
abundance
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
11.741
8.521
8.515
8.278
8.270
8.255
8.248
8.192
8.187
8.154
8.148
7.923
7.125
7.102
3.354
2.490
-0.022
X : parts per Million : Proton

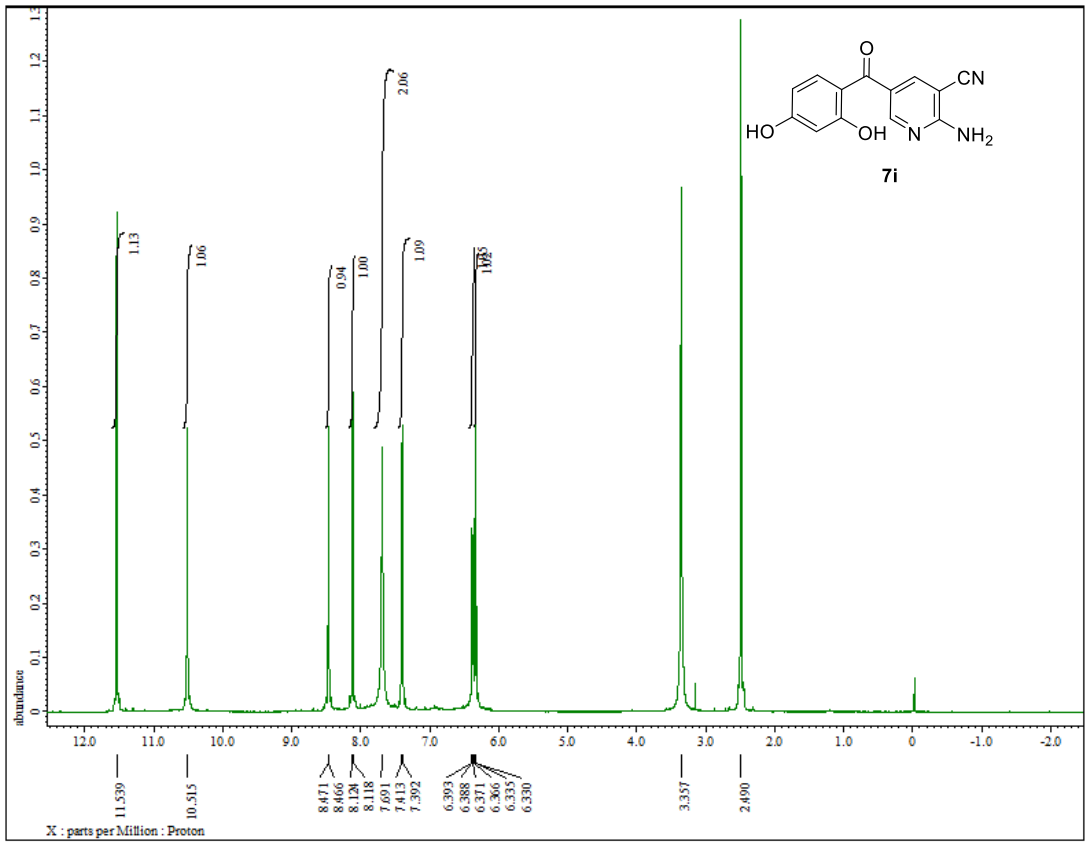

O
O2N
CN
OH
N
NH2
7f
abundance
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
189.527
161.562
161.257
155.822
144.190
139.584
127.857
126.122
125.940
121.202
117.207
115.986
89.032
40.120
39.910
39.700
39.500
39.290
39.080
38.871
X : parts per Million : Carbon13

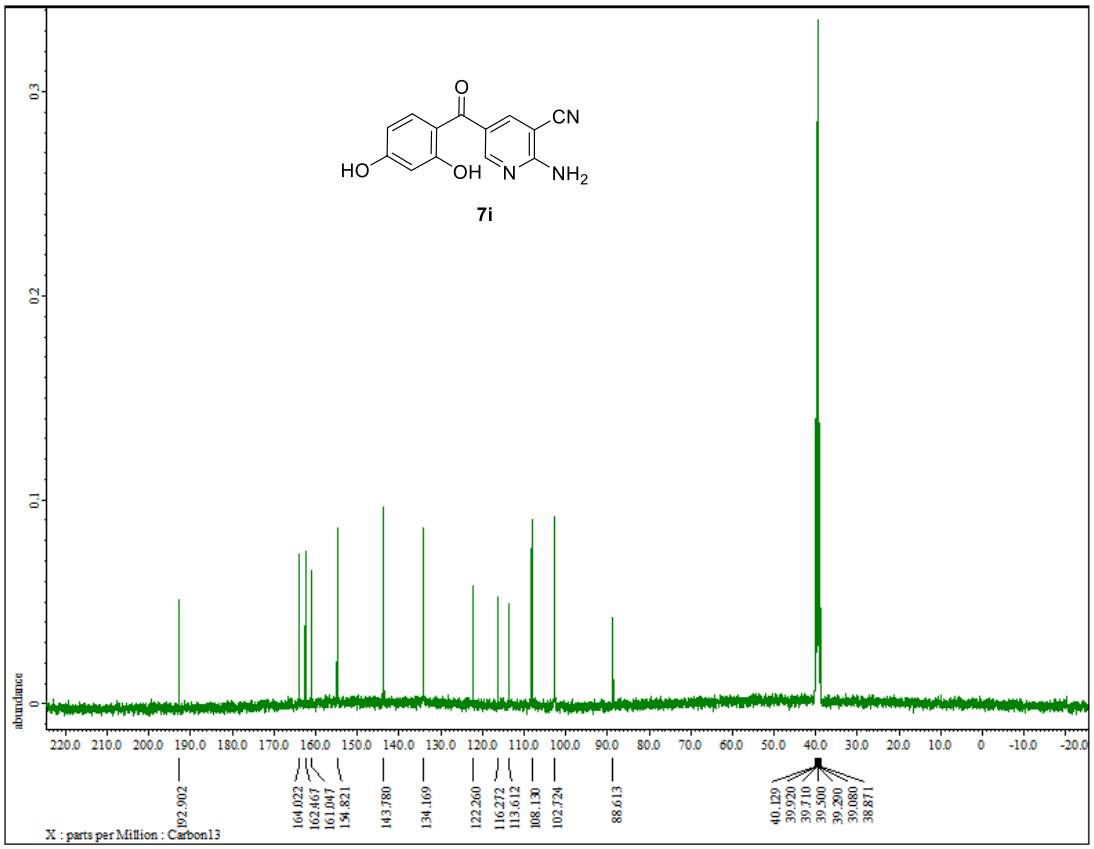

1H 1.00
1H 1.29
1H 1.17
1H 2.10
1H 1.06
1H 1.25
abundance
11.0 10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0
10.382
8.497
8.492
8.173
8.167
7.913
7.819
7.813
7.434
7.428
3.320
2.490
X : parts per Million : Proton
Br
O
CN
OH
N
NH2
Cl
7g

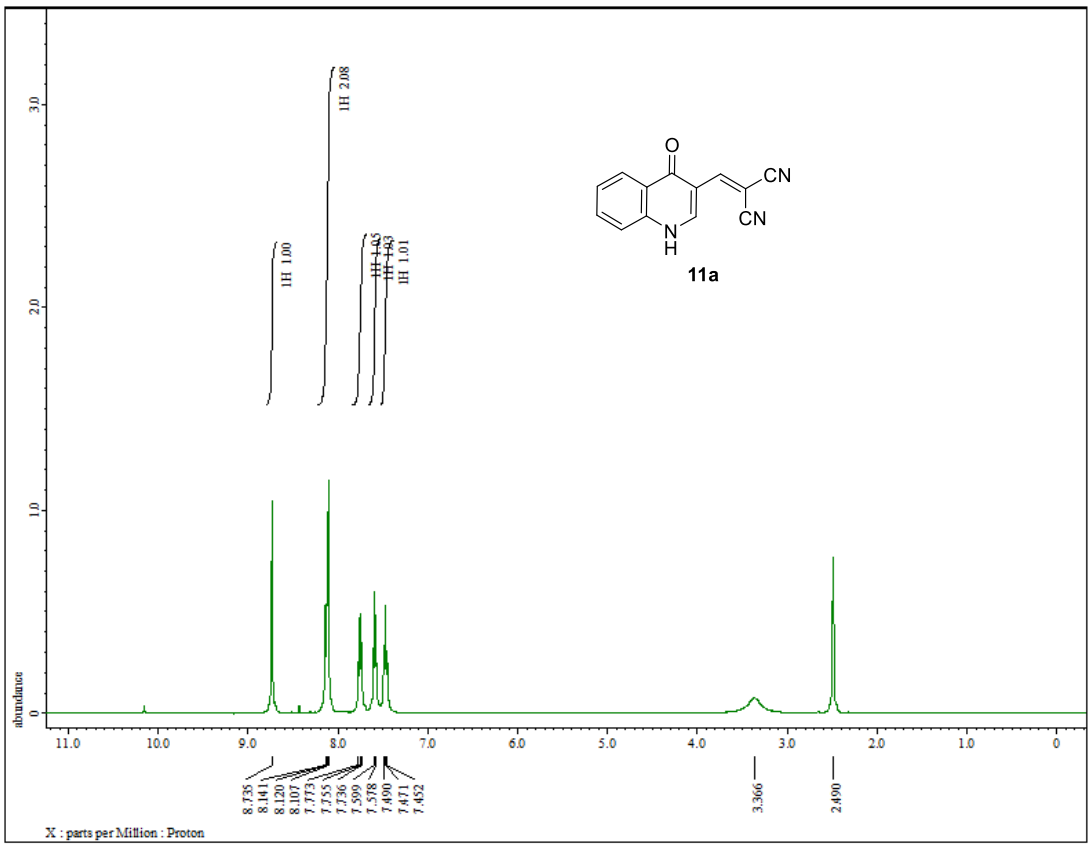

abundance
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0 -20.0
189.603
161.523
155.755
150.444
144.256
134.207
130.603
129.354
123.395
121.030
115.598
110.780
89.070
40.129
39.920
39.710
39.500
39.290
39.080
38.871
X : parts per Million : Carbon13
Br
O
CN
OH
N
NH2
Cl
7g

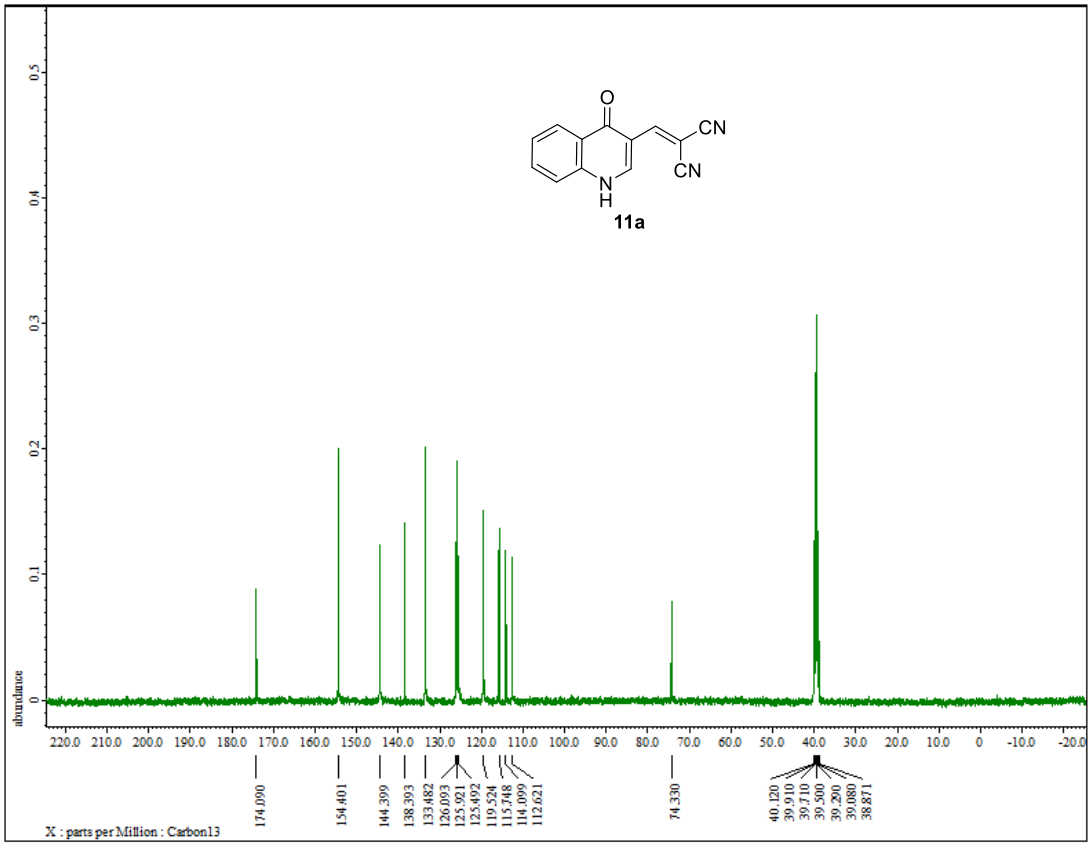

O
Cl
CN
OH
N
NH2
Cl
7h
2.03
1.00
1.04
1.02
1.06
1.04
abundance
12.0 11.0 10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0 -1.0 -2.0
10.376
8.502
8.496
8.176
8.172
7.933
7.717
7.711
7.332
7.326
3.350
2.490
-0.024
X : parts per Million : Proton

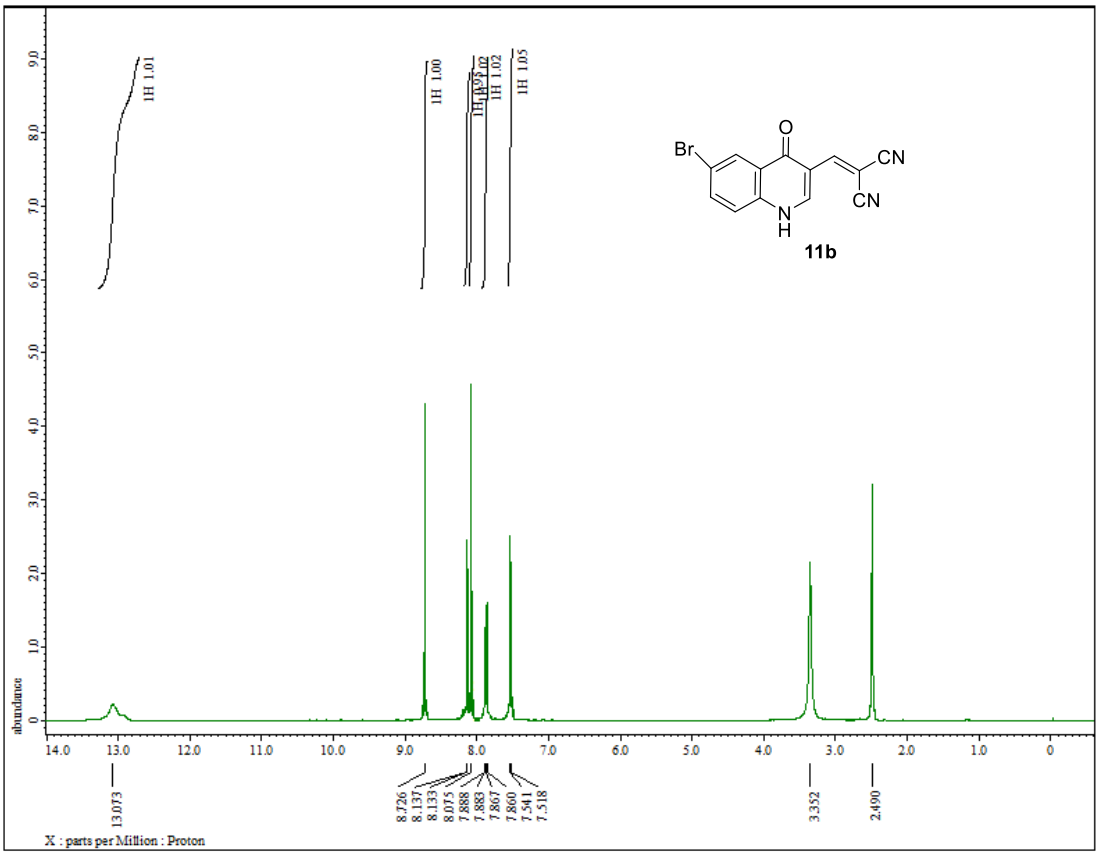

O
Cl
CN
OH
N
NH2
Cl
7h
abundance
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0 -20.0
190.264
162.070
156.321
150.610
144.813
132.122
129.347
128.365
124.161
123.627
121.539
116.514
89.598
40.638
40.428
40.218
40.008
39.808
39.598
39.389
X : parts per Million : Carbon13

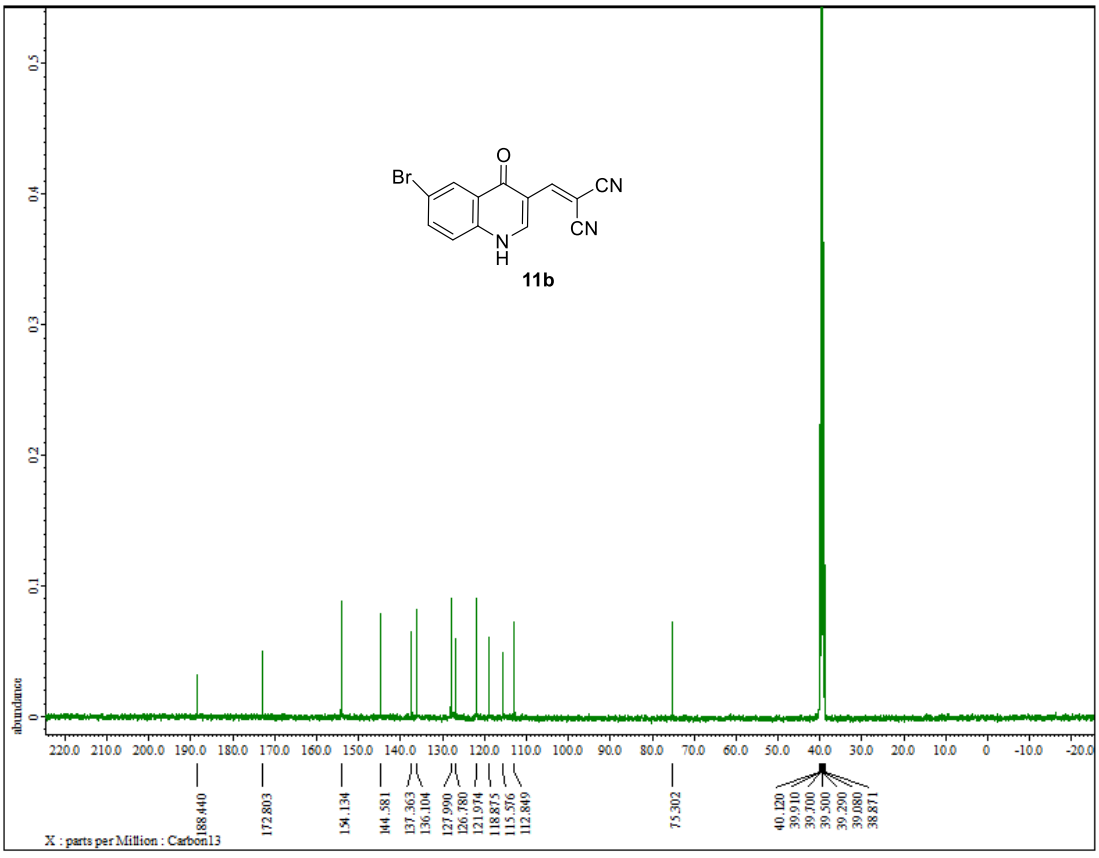

O
CN
HO
OH
N
NH2
7i
1.13
1.06
0.94
1.00
2.06
1.09
1.02
1.05
abundance
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
11.539
10.515
8.471
8.466
8.124
8.118
7.691
7.413
7.392
6.393
6.388
6.371
6.366
6.335
6.330
3.357
2.490
X : parts per Million : Proton

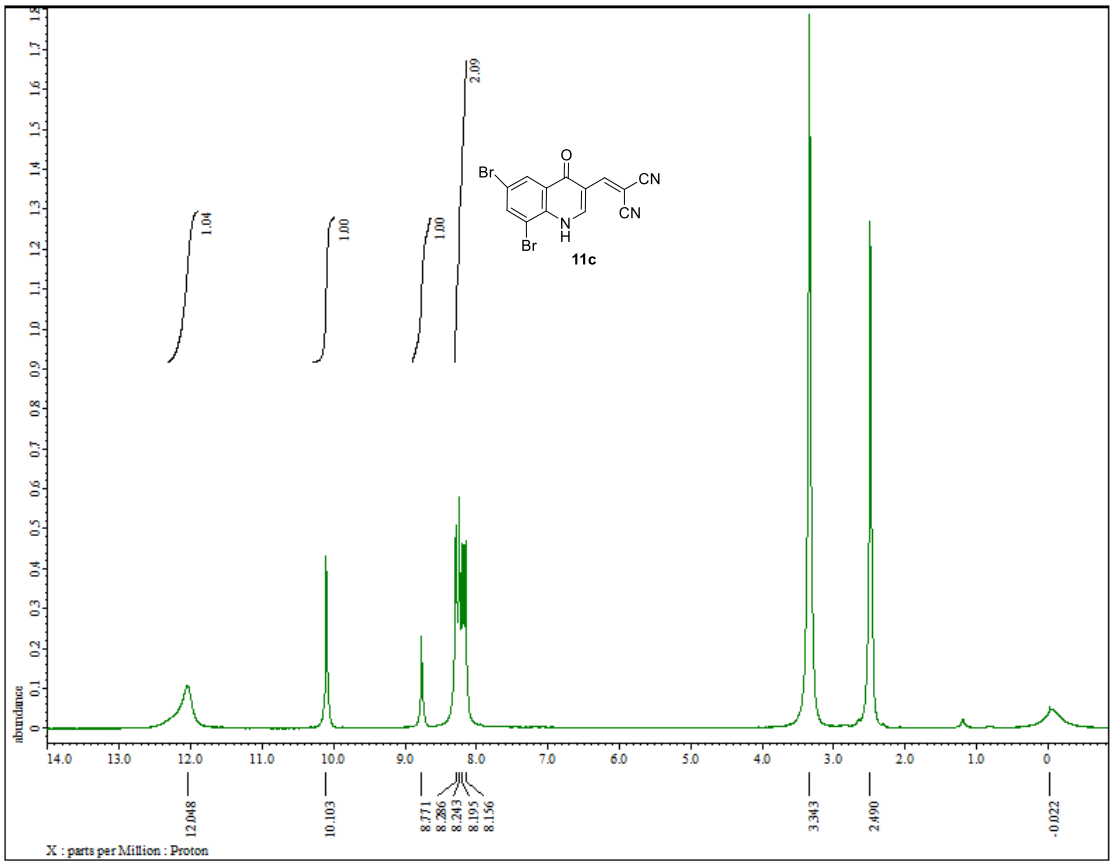

O
CN
HO
OH
N
NH2
7i
abundance
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
-10.0
-20.0
192.902
164.022
162.467
161.047
154.821
143.780
134.169
122.260
116.272
113.612
108.130
102.724
88.613
40.129
39.920
39.710
39.500
39.290
39.080
38.871
X : parts per Million : Carbon13

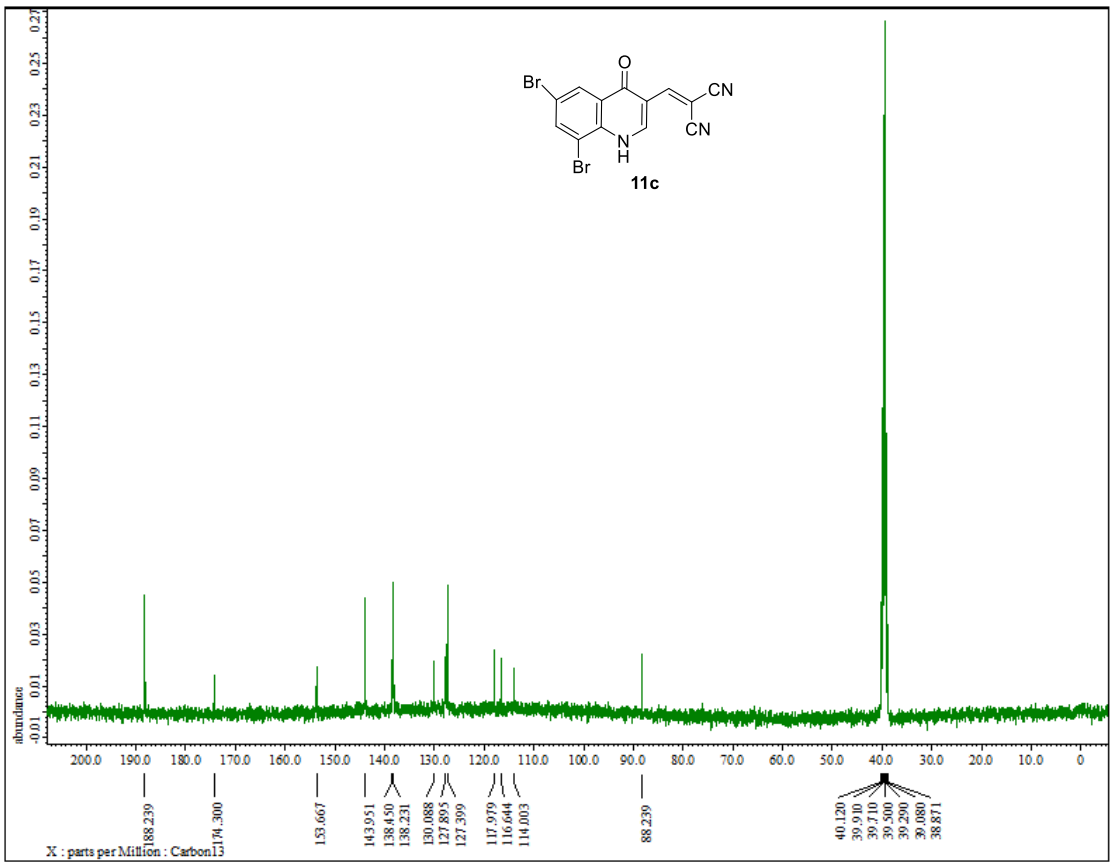

1H 1.00
1H 2.08
1H 1.01
O
CN
CN
N
H
11a
abundance
X : parts per Million : Proton
8.735
8.141
8.120
8.107
7.773
7.755
7.736
7.599
7.578
7.490
7.471
7.452
3.366
2.490

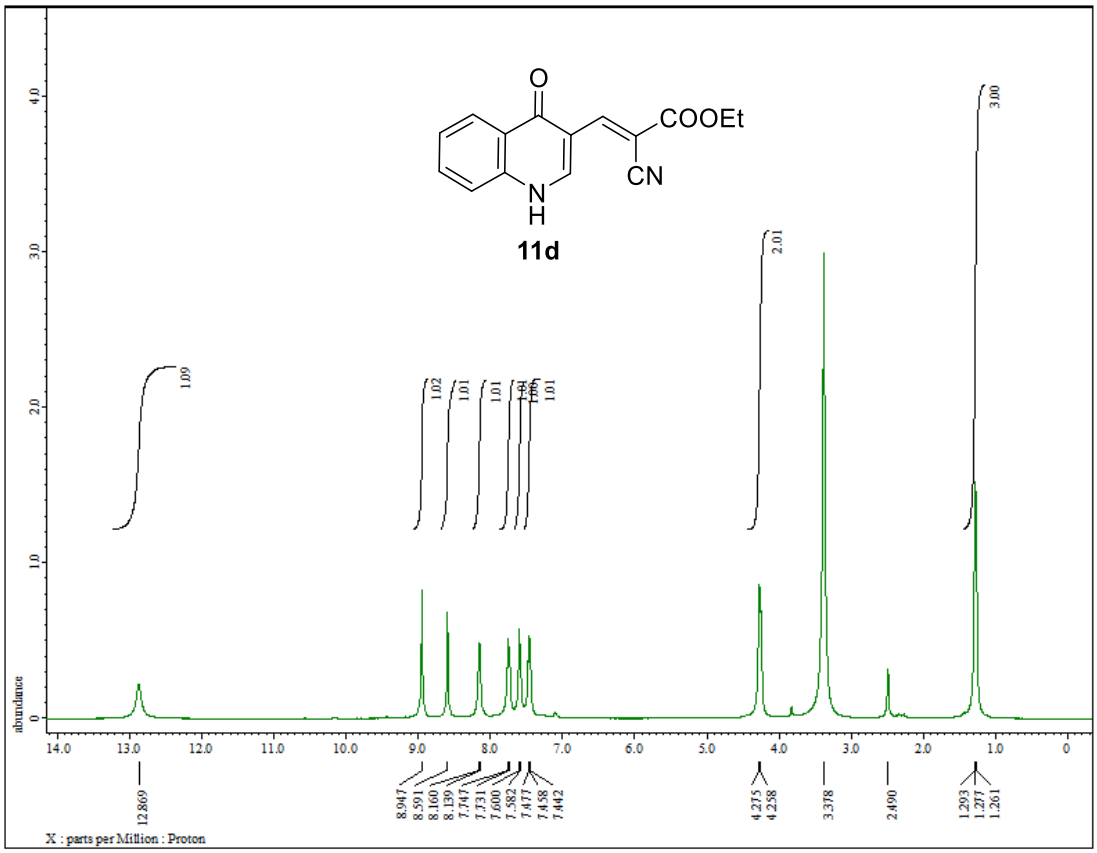

O
CN
CN
N
H
11a
abundance
X : parts per Million : Carbon13
174.090
154.401
144.399
138.393
133.482
126.093
125.921
125.492
119.524
115.748
114.099
112.621
74.330
40.120
39.910
39.710
39.500
39.290
39.080
38.871

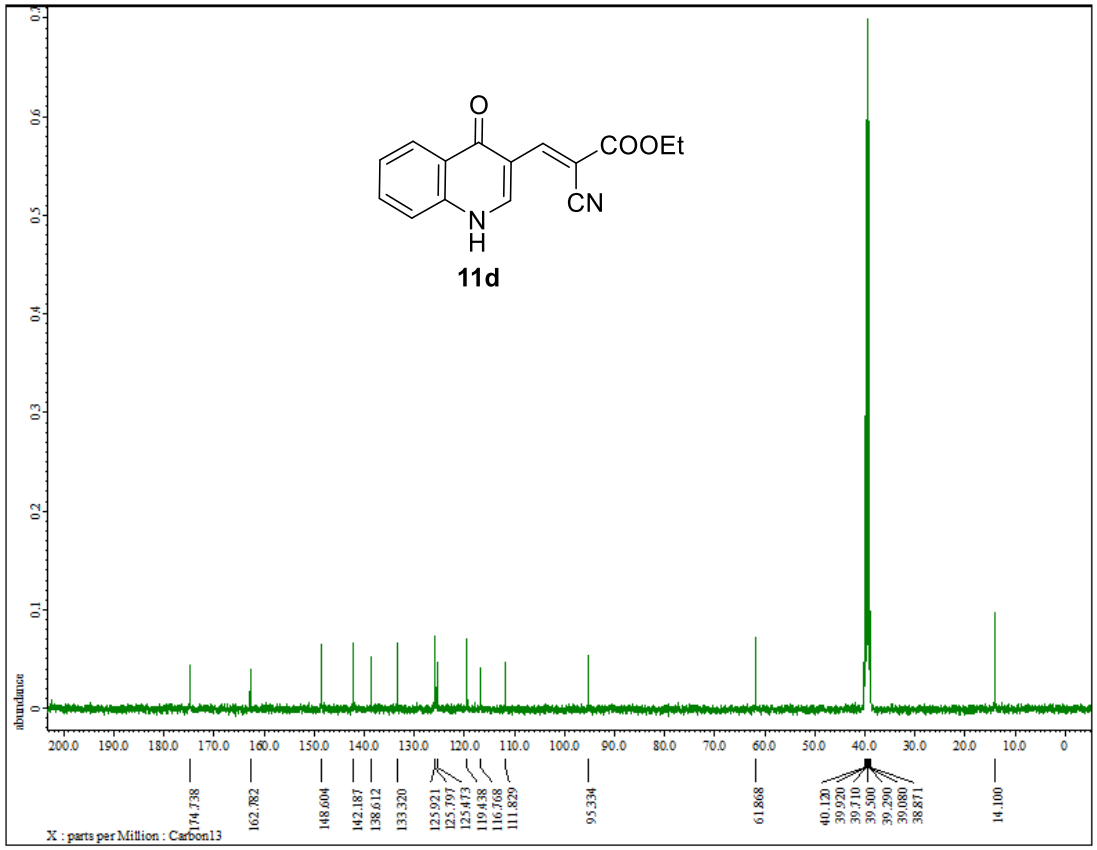

1H 1.01
1H 1.00
1H 1.02
1H 1.05
Br
O
CN
CN
N
H
11b
abundance
X : parts per Million : Proton
13.073
8.726
8.137
8.133
8.075
7.888
7.883
7.867
7.860
7.541
7.518
3.352
2.490


Br
O
CN
CN
N
H
11b
abundance
X : parts per Million : Carbon13
188.440
172.803
150.134
144.581
137.363
136.104
127.990
126.780
121.974
118.875
115.576
112.849
75.302
40.120
39.910
39.700
39.500
39.290
39.080
38.871


1.04
1.00
1.00
2.09
Br
O
CN
CN
N
H
Br
11c
abundance
14.0 13.0 12.0 11.0 10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0
12.048
10.103
8.771
8.286
8.243
8.195
8.156
3.343
2.490
-0.022
X : parts per Million : Proton


Br
O
CN
CN
N
H
Br
11c
abundance
200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
188.239
174.300
153.667
143.951
138.450
138.231
130.088
127.895
127.399
117.979
116.644
114.003
88.239
40.120
39.910
39.710
39.500
39.290
39.080
38.871
X : parts per Million : Carbon13


O
COOEt
CN
N
H
11d
1.09
1.02
1.01
1.01
1.01
1.01
2.01
3.00
abundance
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
12.869
8.947
8.591
8.160
8.139
7.747
7.731
7.600
7.582
7.477
7.458
7.442
4.275
4.238
3.378
2.490
1.293
1.277
1.261
X : parts per Million : Proton


O
COOEt
CN
N
H
11d
abundance
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
174.738
162.782
148.604
142.187
138.612
133.320
125.921
125.797
125.473
119.438
116.768
111.829
95.334
61.868
40.120
39.920
39.710
39.500
39.290
39.080
38.871
14.100
X : parts per Million : Carbon13

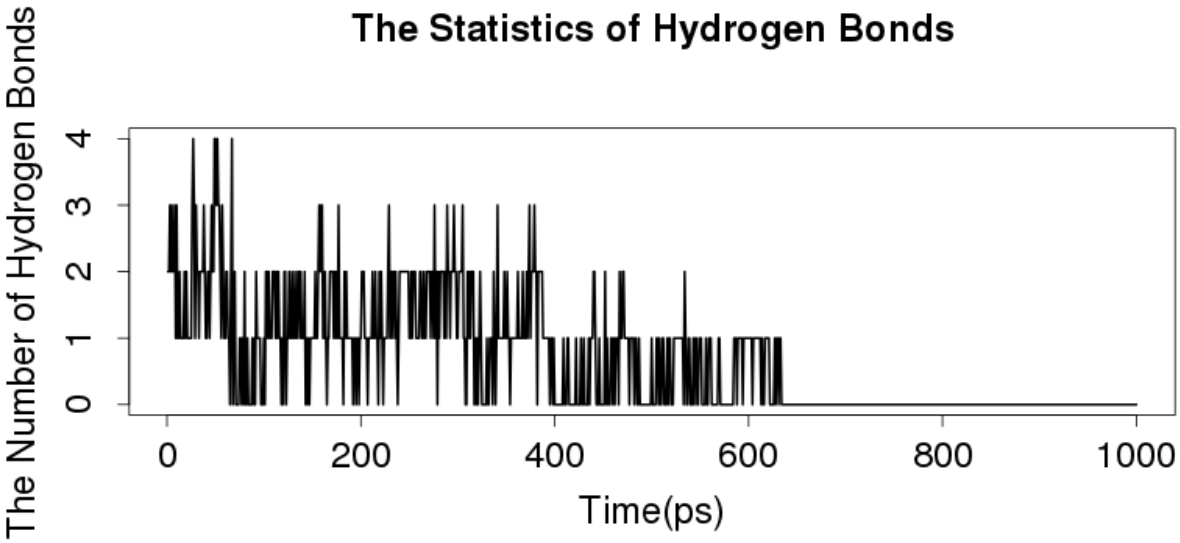


Figure: Hydrogen Bond Statistics using AMBER program