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

1. General information

Commercially available reagents were used without additional purification. **1a**,[1] 2-(pyrrolidin-1-yl)benzaldehyde, 2-morpholinobenzaldehyde,[2] 2-(piperidin-1-yl)benzaldehyde,[3] 2-(benzyl(methyl)amino)benzaldehyde, 2-(3,4-dihydroisoquinolin-2(1H)-yl)benzaldehyde,[4] 2-(dimethylamino)-5-methoxybenzaldehyde[5] and 5-methoxy-2-(pyrrolidin-1-yl)benzaldehyde[6] were synthesized according to the literature methods. E. Merck Kieselgel 60 was used for column chromatography. Thin layer chromatography (TLC) was performed on silica gel 60 F_{254} glass-backed plates (MERCK). Visualization was effected by UV light (254 or 312 nm) and staining with $KMnO_4$.

X-ray data from single crystal of **2'r** was collected with Bruker APEX2 DUO CCD diffractometer, using graphite monochromated Mo-K ω radiation. The structures were solved by direct method and refined by the full-matrix least-squares technique against F2hkl in the anisotropic-isotropic approximation. Positions of hydrogen atoms were calculated, and they were refined in the isotropic approximation within the riding model. All calculations were performed using SHELXTL PLUS.

NMR spectra were recorded on a 700 MHz Bruker Avance III NMR at 303 K and Avance III 800 (with a 5-mm CPTXI cryoprobe). Chemical shifts are reported relative to residue peaks of $CDCl_3$ (7.27 ppm for ^1H and 77.0 ppm for ^{13}C) or DMSO-d_6 (2.51 ppm for ^1H and 39.5 ppm for ^{13}C). Melting points were measured on a SMP 30 apparatus without correction. High-resolution mass spectra (HRMS) spectra were recorded on a Bruker micrOTOF II instrument using electrospray ionization (ESI). The measurements were done in a positive ion mode (interface capillary voltage – 4500 V) or in a negative ion mode (3200 V); mass range from m/z 50 to m/z 3000; external or internal calibration was done with ESI Tuning Mix, Agilent. A syringe injection was used for solutions in acetonitrile, methanol, or water (flow rate 3 mL/min). Nitrogen was applied as a dry gas; interface temperature was set at 180°C.

2. Optimization of 1,1',2-trimethyl-1',4'-dihydro-2'H-spiro[imidazole-4,3'-quinolin]-5(1H)-one (2a) synthesis

General procedure

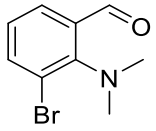
Compound **1a** (244 mg, 1 mmol) was dissolved in dry solvent (5 mL) in argon. Then catalyst\promotor was added and the reaction mixture was stirred at the condition listed in Table 1. In case of $TiCl_4$, BBr_3, $SnCl_4$ and $AlCl_3$ the solution was precooled to 0°C and then warmed up to room temperature. $TiCl_4$, BBr_3, $SnCl_4$ was used as solution in CH_2Cl_2 (2 mL). 3% aqueous solution of $NaHCO_3$ (50 mL) was carefully added and the resulted mixture was extracted with EtOAc (3×50 mL). Combined organic layers were washed with brine (3×50 mL), dried over anhydrous Na_2SO_4. All volatiles were removed in vacuo and the residue was purified with column chromatography (eluent – mixture of hexane and EtOAc, v/v 1:3).

3. Synthesis of the starting materials

General method for 2-aminobenzaldehyde synthesis

Mixture of the corresponding 2-fluorobenzaldehyde (10 mmol), amine (12 mmol) and K_2CO_3 (2.07 g, 15 mmol) in of freshly distilled DMF (20 mL) was heated at 100°C for 12 h. EtOAc (150 mL) was added and the resulted mixture was washed with brine (3×30 mL). Organic layer was dried over anhydrous Na_2SO_4, all volatiles were removed in vacuo and the residue was purified with flash chromatography (eluent – mixture of hexane and EtOAc, v/v 10:1).

3-bromo-2-(dimethylamino)benzaldehyde



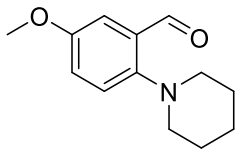
Yield 1.20 g (53%), yellow oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.83 (s, 6 H), 7.12 (d, *J*=8.4 Hz, 1 H), 7.15 (d, *J*=7.8 Hz, 1 H), 7.33 (t, *J*=8.1 Hz, 1 H), 10.11 (s, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 44.3, 44.3, 116.9, 116.9, 122.6, 122.6, 123.9, 124.7, 134.1, 134.1, 155.3, 190.1.

HRMS found, *m/z*: 228.0018 $[M+H]^+$. $C_9H_{11}BrNO^+$. Calculated, *m/z*: 228.0019.

5-methoxy-2-(piperidin-1-yl)benzaldehyde



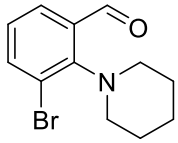
Yield 1.55 g (71%), yellow oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.53 - 1.58 (m, 2 H), 1.67 - 1.72 (m, 4 H), 2.99 - 3.03 (m, 4 H), 3.84 (s, 3 H), 6.60 (d, *J*=2.3 Hz, 1 H), 6.68 (dd, *J*=8.6, 2.1 Hz, 1 H), 7.66 (d, *J*=8.6 Hz, 1 H), 10.01 (s, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 23.6, 25.6, 54.7, 55.4, 104.1, 107.8, 121.4, 131.6, 158.3, 164.7, 188.7.

HRMS found, *m/z*: 220.1331 $[M+H]^+$. $C_{13}H_{18}NO_2^+$. Calculated, *m/z*: 220.1332.

3-bromo-2-(piperidin-1-yl)benzaldehyde



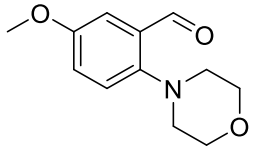
Yield 1.28 g (48%), yellow oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.53 - 1.57 (m, 2 H), 1.67 (ddd, *J*=11.1, 5.8, 5.6 Hz, 4 H), 2.97 - 3.00 (m, 4 H), 7.22 (dd, *J*=8.3, 0.7 Hz, 1 H), 7.32 (d, *J*=7.8 Hz, 1 H), 7.42 (t, *J*=8.1 Hz, 1 H), 10.04 (s, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 23.4, 25.5, 54.4, 118.9, 122.1, 126.8, 134.5, 157.0, 190.3.

HRMS found, *m/z*: 268.0333 $[M+H]^+$. $C_{12}H_{15}BrNO^+$. Calculated, *m/z*: 268.0332.

5-methoxy-2-morpholinobenzaldehyde



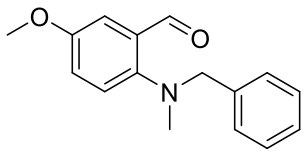
Yield 1.56 g (71%), yellow oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.99 - 3.07 (m, 4 H), 3.74 - 3.81 (m, 4 H), 3.85 (s, 3 H), 6.63 (d, *J*=2.3 Hz, 1 H), 6.73 (dd, *J*=8.6, 2.3 Hz, 1 H), 7.71 (d, *J*=8.6 Hz, 1 H), 10.04 (s, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 53.5, 55.5, 66.1, 104.2, 108.2, 121.3, 132.7, 157.0, 164.8, 188.7.

HRMS found, *m/z*: 222.1123 $[M+H]^+$. $C_{12}H_{16}NO_3^+$. Calculated, *m/z*: 222.1125.

2-(benzyl(methyl)amino)-5-methoxybenzaldehyde



Yield 1.91 g (75%), yellow oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.78 (s, 3 H), 3.80 (s, 3 H), 4.36 (s, 2 H), 6.60 (d, *J*=2.3 Hz, 1 H), 6.65 (dd, *J*=8.6, 2.1 Hz, 1 H), 7.26 (t, *J*=7.2 Hz, 1 H), 7.28 - 7.31 (m, 2 H), 7.31 - 7.36 (m, 2 H), 7.68 (d, *J*=8.6 Hz, 1 H), 10.07 (s, 1 H).

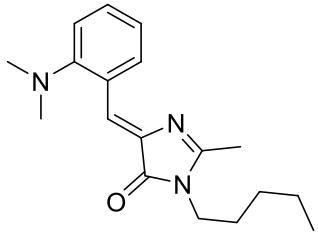
^{13}C NMR (176 MHz, DMSO-d_6): δ 42.3, 55.4, 60.6, 104.4, 107.3, 121.0, 127.1, 127.7, 128.4, 132.7, 137.7, 156.8, 164.5, 188.6.

HRMS found, *m/z*: 256.1332 $[M+H]^+$. $C_{16}H_{18}NO_2^+$. Calculated, *m/z*: 256.1332.

General method for synthesis of 1b-p.

The corresponding aromatic aldehyde (5 mmol) was dissolved in $CHCl_3$ (25 mL) and mixed with 0.87 ml of 40% aq. methylamine solution (10 mmol) and Na_2SO_4 (5 g). The mixture was stirred for 48 h at room temperature and filtered. The solvent was evaporated, 1.13 g (7 mmol) of ethyl((1-methoxy)amino)acetate was added and the mixture was stirred for 24 h at room temperature. The solution was evaporated and the residue was purified with column chromatography (eluent – mixture of $CHCl_3$ and EtOH, v/v 100:1).

(Z)-5-(2-(dimethylamino)benzylidene)-2-methyl-3-pentyl-3,5-dihydro-4H-imidazol-4-one (1b)



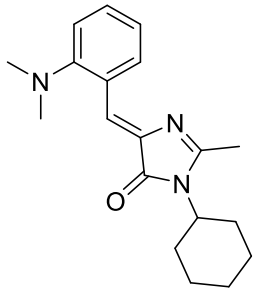
Yield 1.25 g (84%), yellow viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 0.87 (t, *J*=7.2 Hz, 3 H), 1.23 - 1.28 (m, 2 H), 1.32 (quin, *J*=7.2 Hz, 2 H), 1.56 (quin, *J*=7.5 Hz, 2 H), 2.37 (s, 3 H), 2.71 (s, 6 H), 3.55 (t, *J*=7.4 Hz, 2 H), 7.07 (t, *J*=7.5 Hz, 1 H), 7.13 (d, *J*=7.8 Hz, 1 H), 7.25 (s, 1 H), 7.31 - 7.37 (m, 1 H), 8.55 (dd, *J*=7.8, 1.5 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 13.7, 15.3, 21.6, 28.2, 28.3, 39.8, 45.0, 118.4, 121.5, 122.0, 126.7, 130.6, 132.6, 137.6, 154.6, 163.2, 170.1.

HRMS found, *m/z*: 300.2066 $[M+H]^+$. $C_{18}H_{26}N_3O^+$. Calculated, *m/z*: 300.2070.

(Z)-3-cyclohexyl-5-(2-(dimethylamino)benzylidene)-2-methyl-3,5-dihydro-4H-imidazol-4-one (1c)



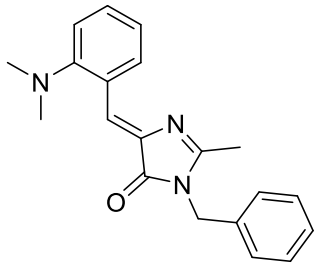
Yield 1.38 g (89%), yellow viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.11 - 1.19 (m, 1 H), 1.28 - 1.37 (m, 2 H), 1.63 (d, *J*=13.2 Hz, 1 H), 1.73 (d, *J*=12.0 Hz, 2 H), 1.79 (d, *J*=13.4 Hz, 2 H), 2.06 (qd, *J*=12.4, 3.7 Hz, 2 H), 2.39 (s, 3 H), 2.71 (s, 6 H), 3.71 - 3.78 (m, 1 H), 7.06 (t, *J*=7.5 Hz, 1 H), 7.12 (d, *J*=8.0 Hz, 1 H), 7.19 (s, 1 H), 7.30 - 7.36 (m, 1 H), 8.53 (dd, *J*=8.0, 1.3 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 13C NMR (176 MHz, DMSO-d_6) δ ppm 16.3, 24.8, 25.4, 29.5, 45.0, 53.2, 118.3, 121.1, 122.0, 126.7, 130.5, 132.5, 137.7, 154.6, 163.4, 170.2.

HRMS found, *m/z*: 312.2073 $[M+H]^+$. $C_{19}H_{26}N_3O^+$. Calculated, *m/z*: 312.2070.

(Z)-3-benzyl-5-(2-(dimethylamino)benzylidene)-2-methyl-3,5-dihydro-4H-imidazol-4-one (1d)



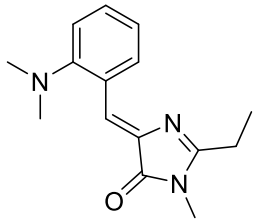
Yield 1.44 g (90%), yellow viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.27 (s, 3 H), 2.73 (s, 6 H), 4.84 (s, 2 H), 7.08 (t, *J*=7.5 Hz, 1 H), 7.14 (d, *J*=8.2 Hz, 1 H), 7.26 (d, *J*=7.4 Hz, 2 H), 7.30 (t, *J*=7.3 Hz, 1 H), 7.33 - 7.39 (m, 4 H), 8.57 (dd, *J*=7.8, 1.3 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.5, 43.0, 45.0, 118.4, 122.0, 122.3, 126.6, 126.9, 127.5, 128.8, 130.8, 132.7, 136.7, 137.3, 154.8, 162.8, 170.1.

HRMS found, *m/z*: 320.1755 $[M+H]^+$. $C_{20}H_{22}N_3O^+$. Calculated, *m/z*: 320.1757.

(Z)-5-(2-(dimethylamino)benzylidene)-2-ethyl-3-methyl-3,5-dihydro-4H-imidazol-4-one (1e)



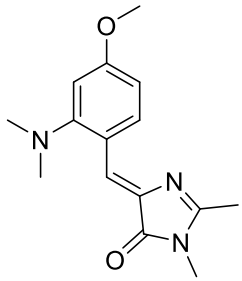
Yield 783 mg (61%), yellow solid, m.p. 120-122°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.26 (t, *J*=7.4 Hz, 3 H), 2.68 (q, *J*=7.4 Hz, 2 H), 2.72 (s, 6 H), 3.10 (s, 3 H), 7.08 (t, *J*=7.4 Hz, 1 H), 7.13 (d, *J*=8.2 Hz, 1 H), 7.27 (s, 1 H), 7.32 - 7.36 (m, 1 H), 8.59 (dd, *J*=7.8, 1.5 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 9.1, 21.3, 25.9, 45.0, 118.3, 121.5, 122.0, 126.8, 130.6, 132.6, 137.8, 154.6, 167.1, 170.3.

HRMS found, *m/z*: 258.1602 $[M+H]^+$. $C_{15}H_{20}N_3O^+$. Calculated, *m/z*: 258.1601.

(Z)-5-(2-(dimethylamino)-4-methoxybenzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1f)



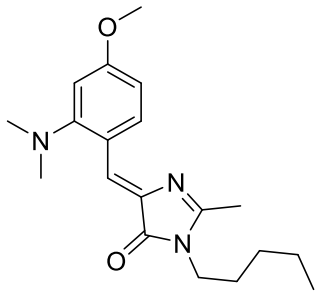
Yield 783 mg (78%), yellow solid, m.p. 134-135°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.33 (s, 3 H) 2.72 (s, 6 H) 3.09 (s, 3 H) 3.80 (s, 3 H) 6.62 (d, *J*=2.5 Hz, 1 H) 6.69 (dd, *J*=8.8, 2.3 Hz, 1 H) 7.19 (s, 1 H) 8.58 (d, *J*=8.8 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.2, 26.1, 44.9, 55.2, 104.2, 108.1, 119.5, 121.6, 134.2, 135.9, 156.6, 161.5, 162.1, 170.0.

HRMS found, *m/z*: 274.1546 $[M+H]^+$. $C_{15}H_{20}N_3O_2^+$. Calculated, *m/z*: 274.1550.

(Z)-5-(2-(dimethylamino)-4-methoxybenzylidene)-2-methyl-3-pentyl-3,5-dihydro-4H-imidazol-4-one (1g)



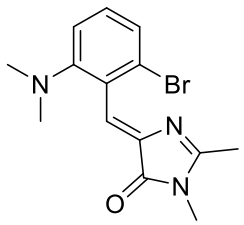
Yield 1.53 g (93%), yellow viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 0.87 (t, *J*=7.2 Hz, 3 H), 1.22 - 1.28 (m, 2 H), 1.31 (quin, *J*=7.2 Hz, 2 H), 1.55 (quin, *J*=7.5 Hz, 2 H), 2.35 (s, 3 H), 2.72 (s, 6 H), 3.54 (t, *J*=7.4 Hz, 2 H), 3.81 (s, 3 H), 6.62 (d, *J*=2.5 Hz, 1 H), 6.69 (dd, *J*=8.9, 2.4 Hz, 1 H), 7.19 (s, 1 H), 8.59 (d, *J*=9.0 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 13.8, 15.2, 21.7, 28.3, 28.3, 44.9, 55.2, 104.2, 108.1, 119.5, 121.7, 134.3, 135.7, 156.7, 161.5, 161.6, 170.0.

HRMS found, *m/z*: 330.2174 $[M+H]^+$. $C_{19}H_{28}N_3O_2^+$. Calculated, *m/z*: 330.2176.

(Z)-5-(2-bromo-6-(dimethylamino)benzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1h)



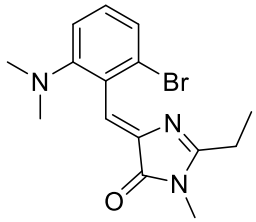
Yield 1.10 g (69%), yellow viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.25 (s, 3 H), 2.60 (s, 7 H), 3.09 (s, 3 H), 6.99 (s, 1 H), 7.09 (d, *J*=8.0 Hz, 1 H), 7.21 (t, *J*=8.0 Hz, 1 H), 7.24 - 7.27 (m, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.2, 26.2, 43.8, 117.2, 123.6, 124.9, 125.3, 127.9, 130.1, 141.2, 154.5, 164.0, 168.8.

HRMS found, *m/z*: 322.0551 $[M+H]^+$. $C_{14}H_{17}BrN_3O^+$. Calculated, *m/z*: 322.0550.

(Z)-5-(2-bromo-6-(dimethylamino)benzylidene)-2-ethyl-3-methyl-3,5-dihydro-4H-imidazol-4-one (1i)



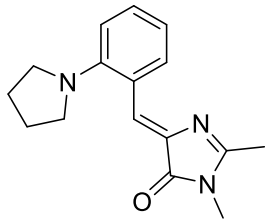
Yield 783 mg (61%), yellow viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.13 (t, *J*=7.3 Hz, 3 H), 2.59 - 2.61 (m, 2 H), 2.61 (s, 6 H), 3.09 (s, 3 H), 7.00 (s, 1 H), 7.10 (d, *J*=7.1 Hz, 1 H), 7.20 - 7.23 (m, 1 H), 7.23 - 7.26 (m, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 9.1, 21.3, 26.0, 43.6, 117.4, 123.8, 124.9, 125.2, 127.4, 130.2, 140.8, 154.6, 167.3, 169.2.

HRMS found, *m/z*: 336.0700 $[M+H]^+$. $C_{15}H_{19}BrN_3O^+$. Calculated, *m/z*: 336.0706.

(Z)-2,3-dimethyl-5-(2-(pyrrolidin-1-yl)benzylidene)-3,5-dihydro-4H-imidazol-4-one (1j)



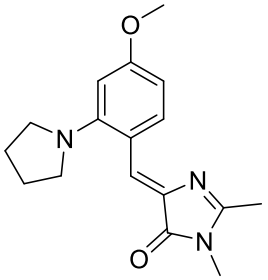
Yield 768 mg (57%), yellow viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.88 - 1.92 (m, 4 H), 2.33 (s, 3 H), 3.09 (s, 3 H), 3.23 (t, *J*=6.4 Hz, 4 H), 6.88 (t, *J*=7.3 Hz, 1 H), 6.94 (d, *J*=8.4 Hz, 1 H), 7.17 (s, 1 H), 7.21 - 7.25 (m, 1 H), 8.40 (dd, *J*=7.8, 1.5 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.2, 24.9, 26.2, 52.5, 115.6, 119.2, 123.1, 123.5, 130.4, 132.9, 136.4, 151.2, 162.9, 169.9.

HRMS found, *m/z*: 270.1596 $[M+H]^+$. $C_{16}H_{20}N_3O^+$. Calculated, *m/z*: 270.1601.

(Z)-5-(4-methoxy-2-(pyrrolidin-1-yl)benzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1k)



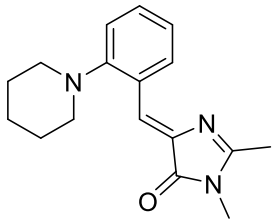
Yield 910 mg (61%), yellow solid, m.p. 117-119°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.88 - 1.92 (m, 4 H), 2.32 (s, 3 H), 3.08 (s, 3 H), 3.24 - 3.28 (m, 4 H), 3.78 (s, 3 H), 6.42 (d, *J*=2.5 Hz, 1 H), 6.52 (dd, *J*=8.8, 2.3 Hz, 1 H), 7.15 (s, 1 H), 8.48 (d, *J*=8.8 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 24.9, 26.1, 52.5, 55.0, 100.7, 105.9, 116.2, 123.7, 134.3, 134.6, 153.1, 161.2, 161.5, 169.8.

HRMS found, *m/z*: 300.1706 $[M+H]^+$. $C_{17}H_{22}N_3O_2^+$. Calculated, *m/z*: 300.1707.

(Z)-2,3-dimethyl-5-(2-(piperidin-1-yl)benzylidene)-3,5-dihydro-4H-imidazol-4-one (1l)



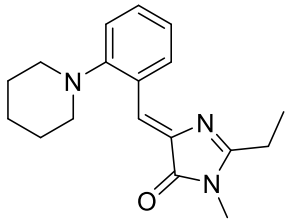
Yield 1.04 g (74%), yellow solid, m.p. 172-174°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.56 (br. s., 2 H), 1.65 - 1.74 (m, 4 H), 2.34 (s, 3 H), 2.83 - 2.90 (m, 4 H), 3.10 (s, 3 H), 7.05 - 7.13 (m, 2 H), 7.27 (s, 1 H), 7.32 - 7.37 (m, 1 H), 8.54 (dd, *J*=7.8, 1.3 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.2, 23.6, 25.9, 26.2, 54.1, 118.7, 121.0, 122.2, 127.1, 130.6, 132.5, 138.1, 154.5, 163.6, 170.0.

HRMS found, *m/z*: 284.1755 $[M+H]^+$. $C_{17}H_{22}N_3O^+$. Calculated, *m/z*: 284.1757.

(Z)-2-ethyl-3-methyl-5-(2-(piperidin-1-yl)benzylidene)-3,5-dihydro-4H-imidazol-4-one (1m)



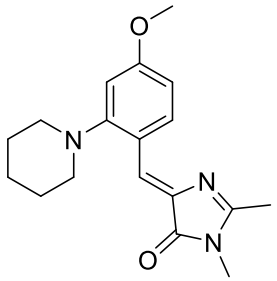
Yield 756 mg (51%), yellow solid, m.p. 140-142°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.25 (t, *J*=7.4 Hz, 3 H), 1.56 (br. s., 2 H), 1.69 (dq, *J*=5.8, 5.6 Hz, 4 H), 2.68 (q, *J*=7.2 Hz, 2 H), 2.82 - 2.91 (m, 5 H), 3.10 (s, 3 H), 7.07 - 7.12 (m, 2 H), 7.28 (s, 1 H), 7.32 - 7.36 (m, 1 H), 8.59 (dd, *J*=7.7, 1.4 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 9.1, 21.3, 23.6, 25.9, 54.1, 118.7, 121.1, 122.2, 127.2, 130.6, 132.5, 138.0, 154.6, 167.0, 170.3.

HRMS found, *m/z*: 298.1913 $[M+H]^+$. $C_{18}H_{24}N_3O^+$. Calculated, *m/z*: 298.1914.

(Z)-5-(4-methoxy-2-(piperidin-1-yl)benzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1n)



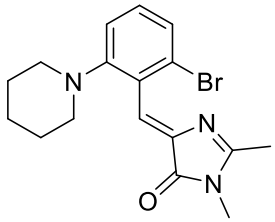
Yield 1.15 g (74%), yellow solid, m.p. 148-150°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.56 (br. s., 2 H), 1.67 - 1.72 (m, 4 H), 2.32 (s, 3 H), 2.85 - 2.89 (m, 4 H), 3.09 (s, 3 H), 3.80 (s, 3 H), 6.59 (d, *J*=2.5 Hz, 1 H), 6.71 (dd, *J*=8.8, 2.3 Hz, 1 H), 7.20 (s, 1 H), 8.58 (d, *J*=8.8 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 23.6, 25.9, 26.1, 54.1, 55.1, 104.6, 108.2, 119.9, 121.2, 134.0, 136.1, 156.6, 161.5, 162.0, 170.0.

HRMS found, *m/z*: 314.1863 $[M+H]^+$. $C_{18}H_{24}N_3O_2^+$. Calculated, *m/z*: 314.1863.

(Z)-5-(2-bromo-6-(piperidin-1-yl)benzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1o)



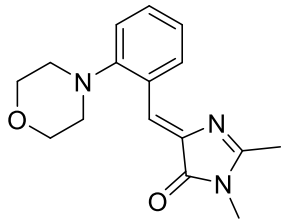
Yield 1.06 g (59%), yellow solid, m.p. 71-73°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.43 (br. s., 1 H), 1.47 - 1.50 (m, 4 H), 2.26 (s, 3 H), 2.77 – 2.81 (m, 4 H), 3.09 (s, 3 H), 6.97 (s, 1 H), 7.07 (d, *J*=8.0 Hz, 1 H), 7.24 (t, *J*=8.0 Hz, 1 H), 7.29 (d, *J*=7.25 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 23.5, 25.8, 26.2, 52.9, 79.1, 118.0, 123.3, 124.0, 126.2, 129.6, 130.3, 141.2, 154.7, 163.7, 168.8.

HRMS found, *m/z*: 362.0864 $[M+H]^+$. $C_{17}H_{21}BrN_3O^+$. Calculated, *m/z*: 362.0863.

(Z)-2,3-dimethyl-5-(2-morpholinobenzylidene)-3,5-dihydro-4H-imidazol-4-one (1p)



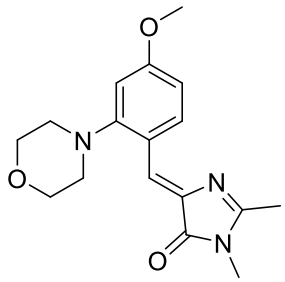
Yield 1.14 g (80%), yellow solid, m.p. 138-140°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.32 (s, 3 H), 2.89 - 2.92 (m, 4 H), 3.09 (s, 3 H), 3.76 - 3.79 (m, 4 H), 3.81 (s, 3 H), 6.64 (d, *J*=2.5 Hz, 1 H), 6.76 (dd, *J*=8.8, 2.5 Hz, 1 H), 7.20 (s, 1 H), 8.59 (d, *J*=9.0 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6) δ ppm 15.2, 26.2, 53.1, 66.3, 118.7, 120.6, 122.8, 127.1, 130.7, 132.6, 138.4, 153.2, 164.0, 170.0.

HRMS found, *m/z*: 286.1546 $[M+H]^+$. $C_{16}H_{20}N_3O_2^+$. Calculated, *m/z*: 286.1550.

(Z)-5-(4-methoxy-2-morpholinobenzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1q)



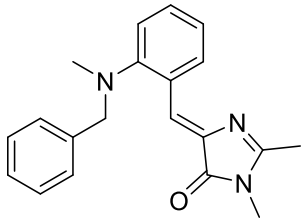
Yield 1.16 g (74%), yellow solid, m.p. 141-143°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.32 (s, 3 H) 2.89 - 2.92 (m, 4 H) 3.09 (s, 3 H) 3.76 - 3.79 (m, 4 H) 3.81 (s, 3 H) 6.64 (d, *J*=2.5 Hz, 1 H) 6.76 (dd, *J*=8.8, 2.5 Hz, 1 H) 7.20 (s, 1 H) 8.59 (d, *J*=9.0 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.2, 26.1, 53.1, 55.2, 66.3, 104.7, 108.8, 119.8, 120.7, 134.2, 136.4, 155.2, 161.6, 162.5, 169.9.

HRMS found, *m/z*: 316.1654 $[M+H]^+$. $C_{17}H_{22}N_3O_3^+$. Calculated, *m/z*: 316.1656.

(Z)-5-(2-(benzyl(methyl)amino)benzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1r)



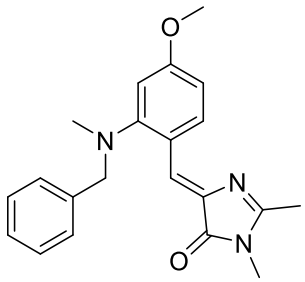
Yield 1.07 g (67%), yellow solid, m.p. 125-127°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.35 (s, 3 H), 2.61 (s, 3 H), 3.10 (s, 3 H), 4.09 (s, 2 H), 7.11 (t, *J*=7.4 Hz, 1 H), 7.15 (d, *J*=8.0 Hz, 1 H), 7.24 - 7.27 (m, 1 H), 7.30 - 7.34 (m, 6 H), 7.50 (s, 1 H), 8.57 (dd, *J*=7.7, 1.1 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.3, 26.2, 41.6, 61.1, 120.0, 121.2, 122.6, 127.1, 127.6, 128.2, 128.4, 130.5, 132.6, 137.8, 138.3, 153.5, 163.9, 170.0.

HRMS found, *m/z*: 320.1754 $[M+H]^+$. $C_{20}H_{22}N_3O^+$. Calculated, *m/z*: 320.1757.

(Z)-5-(2-(benzyl(methyl)amino)-4-methoxybenzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1s)



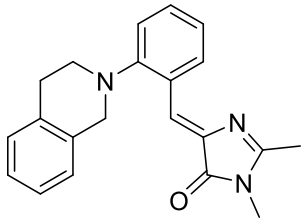
Yield 1.36 g (78%), yellow solid, m.p. 98-100°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.33 (s, 3 H), 2.61 (s, 3 H), 3.09 (s, 3 H), 3.78 (s, 3 H), 4.11 (s, 2 H), 6.66 (d, *J*=2.5 Hz, 1 H), 6.74 (dd, *J*=8.8, 2.48 Hz, 1 H), 7.25 - 7.28 (m, 1 H), 7.32 - 7.35 (m, 4 H), 7.44 (s, 1 H), 8.62 (d, *J*=8.8 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.2, 26.1, 41.7, 55.2, 60.9, 106.0, 108.6, 120.4, 121.3, 127.1, 128.2, 128.4, 134.2, 136.4, 137.8, 155.6, 161.4, 162.3, 170.0.

HRMS found, *m/z*: 350.1866 $[M+H]^+$. $C_{21}H_{24}N_3O_2^+$. Calculated, *m/z*: 350.1863.

(Z)-5-(2-(3,4-dihydroisoquinolin-2(1H)-yl)benzylidene)-2,3-dimethyl-3,5-dihydro-4H-imidazol-4-one (1t)



Yield 776 mg (47%), yellow viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.36 (s, 3 H), 2.98 (t, *J*=5.3 Hz, 2 H), 3.09 (s, 3 H), 3.21 (t, *J*=5.6 Hz, 2 H), 4.19 (s, 2 H), 7.13 - 7.24 (m, 6 H), 7.27 (s, 1 H), 7.39 (t, *J*=7.6 Hz, 1 H), 8.59 (d, *J*=9.0 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.3, 26.2, 28.8, 52.2, 53.8, 119.0, 120.7, 122.6, 125.7, 126.3, 126.4, 128.1, 128.7, 128.8, 130.7, 132.6, 134.5, 138.3, 153.2, 163.9, 170.0.

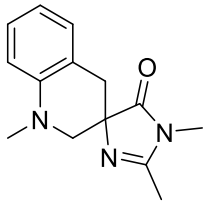
HRMS found, *m/z*: 332.1758 $[M+H]^+$. $C_{21}H_{22}N_3O^+$. Calculated, *m/z*: 332.1757.

4. Synthesis of the spirocyclic imidazolones

General method for synthesis of 2a-p

Compound **1** (1 mmol) was dissolved in dry CH_2Cl_2 (20 mL) in argon and cooled to 0°C. Solution of $TiCl_4$ (285 mg, 1.5 mmol) in 2 mL of dry CH_2Cl_2 was added dropwise, the resulted mixture was stirred at the same temperature for 30 min and then was warmed to RT. Stirring was continued until no starting material was detected with TLC (typically 3 h, 12 h for **2k** and **2l**). 3% aqueous solution of $NaHCO_3$ (50 mL) was carefully added and the resulted mixture was extracted with EtOAc (3×50 mL). Combined organic layers were washed with brine (3×50 mL), dried over anhydrous Na_2SO_4. All volatiles were removed in vacuo and the residue was purified with column chromatography (eluent – mixture of hexane and EtOAc, v/v 1:3).

1,1',2-trimethyl-1',4'-dihydro-2'*H*-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2a)



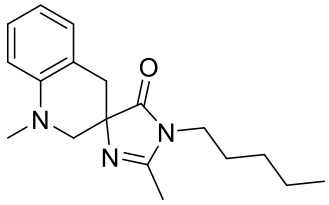
Yield 230 mg (95%), dark solid, m.p. 88–90°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.14 (s, 3 H), 2.44 (dd, *J* = 15.6, 2.1 Hz, 1 H), 2.86 (s, 3 H), 2.89–2.95 (m, 2 H), 3.01 (s, 3 H), 3.32 (d, *J* = 11.8 Hz, 1 H), 6.54 (td, *J* = 7.3, 1.1 Hz, 1 H), 6.62 (dd, *J* = 8.3, 1.1 Hz, 1 H), 6.89 (dd, *J* = 7.4, 1.4 Hz, 1 H), 7.04 (t, *J* = 7.8, 1.5 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 26.3, 35.0, 38.5, 55.6, 66.3, 110.4, 115.6, 119.3, 127.0, 128.6, 144.8, 160.9, 182.6.

HRMS found, *m/z*: 244.1441 $[M+H]^+$. $C_{14}H_{18}N_3O^+$. Calculated, *m/z*: 244.1444.

1',2-dimethyl-1-pentyl-1',4'-dihydro-2'H-spiro[imidazole-4,3'-quinolin]-5(1H)-one (2b)



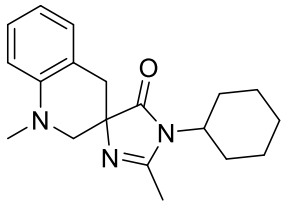
Yield 157 mg (53%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 0.88 (t, *J*=7.2 Hz, 3 H), 1.22 - 1.25 (m, 2 H), 1.28 - 1.34 (m, 2 H), 1.52 (quin, *J*=7.5 Hz, 2 H), 2.16 (s, 3 H), 2.42 (dd, *J*=15.8, 2.3 Hz, 1 H), 2.86 (s, 3 H), 2.89 - 2.96 (m, 2 H), 3.33 (d, *J*=11.6 Hz, 1 H), 3.45 (t, *J*=7.3 Hz, 2 H), 6.54 (t, *J*=7.2 Hz, 1 H), 6.62 (d, *J*=8.0 Hz, 1 H), 6.90 (d, *J*=7.2 Hz, 1 H), 7.04 (t, *J*=7.6 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 14.3, 15.7, 22.2, 28.6, 28.7, 35.7, 39.0, 40.3, 56.2, 66.7, 111.0, 116.1, 119.8, 127.5, 129.2, 145.4, 161.0, 183.3.

HRMS found, *m/z*: 300.2073 $[M+H]^+$. $C_{18}H_{26}N_3O^+$. Calculated, *m/z*: 300.2070.

1-cyclohexyl-1',2-dimethyl-1',4'-dihydro-2'H-spiro[imidazole-4,3'-quinolin]-5(1H)-one (2c)



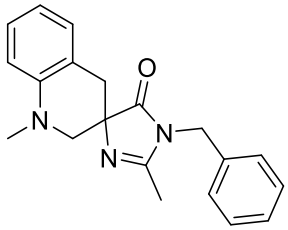
Yield 240 mg (77%), dark solid, m.p. 130–132°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.08 - 1.16 (m, 1 H), 1.26 - 1.34 (m, 2 H), 1.62 (d, *J*=12.8 Hz, 1 H), 1.70 (d, *J*=12.2 Hz, 2 H), 1.77 (d, *J*=13.4 Hz, 2 H), 2.00 (qd, *J*=12.6, 3.3 Hz, 2 H), 2.18 (s, 3 H), 2.39 (dd, *J*=15.6, 2.3 Hz, 1 H), 2.86 (s, 3 H), 2.87 - 2.93 (m, 2 H), 3.30 (d, J=11.4 Hz, 1 H), 3.60 (tt, *J*=12.2, 3.6 Hz, 1 H), 6.53 (t, *J*=7.2 Hz, 1 H), 6.61 (d, *J*=8.0 Hz, 1 H), 6.89 (d, *J*=7.2 Hz, 1 H), 7.03 (t, *J*=7.3 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 24.7, 25.3, 29.2, 29.3, 35.2, 38.5, 53.1, 55.7, 65.8, 110.4, 115.6, 119.4, 127.0, 128.6, 144.8, 160.7, 183.1.

HRMS found, *m/z*: 312.2068 $[M+H]^+$. $C_{19}H_{26}N_3O^+$. Calculated, *m/z*: 312.2070.

1-benzyl-1',2-dimethyl-1',4'-dihydro-2'H-spiro[imidazole-4,3'-quinolin]-5(1H)-one (2d)



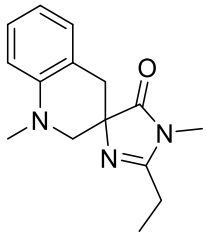
Yield 155 mg (49%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.03 (s, 3 H), 2.89 (s, 3 H), 2.99 - 3.04 (m, 2 H), 3.41 (d, *J*=11.8 Hz, 1 H), 4.73 (s, 2 H), 6.52 - 6.57 (m, 1 H), 6.64 (d, *J*=8.0 Hz, 1 H), 6.93 (d, *J*=7.1 Hz, 1 H), 7.05 (t, *J*=7.7 Hz, 1 H), 7.23 (d, *J*=7.1 Hz, 2 H), 7.31 (t, *J*=7.4 Hz, 1 H), 7.39 (t, *J*=7.6 Hz, 2 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.4, 35.2, 38.5, 42.8, 59.7, 66.4, 110.5, 115.7, 119.2, 126.6, 127.1, 127.5, 128.7, 128.8, 136.8, 144.8, 160.2, 182.8.

HRMS found, *m/z*: 320.1760 $[M+H]^+$. $C_{20}H_{22}N_3O^+$. Calculated, *m/z*: 320.1757.

2-ethyl-1,1'-dimethyl-1',4'-dihydro-2'*H*-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2e)



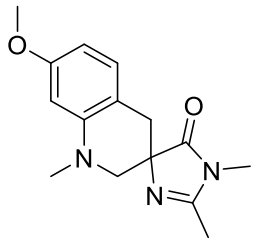
Yield 59 mg (23%), dark solid, m.p. 86–88°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.09 (t, *J* = 7.4 Hz, 3 H), 2.46 (dd, *J* = 15.8, 2.3 Hz, 1 H), 2.55–2.58 (m, 2H), 2.86 (s, 3 H), 2.89–2.96 (m, 2 H), 3.01 (s, 3 H), 3.27 (d, *J* = 11.5 Hz, 1 H), 6.55 (t, *J* = 7.2 Hz, 1 H), 6.64 (d, *J* = 8.0 Hz, 1 H), 6.90 (d, *J* = 7.2 Hz, 1 H), 7.05 (t, *J* = 7.5 Hz, 1 H).

^{13}C NMR (201 MHz, DMSO-d_6): δ 9.1, 21.3, 26.1, 35.0, 38.7, 55.7, 66.3, 110.8, 115.8, 119.5, 127.0, 128.7, 145.0, 164.4, 182.8.

HRMS found, *m/z*: 258.1599 $[M+H]^+$. $C_{15}H_{20}N_3O^+$. Calculated, *m/z*: 258.1601.

7'-methoxy-1,1',2-trimethyl-1',4'-dihydro-2'*H*-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2f)



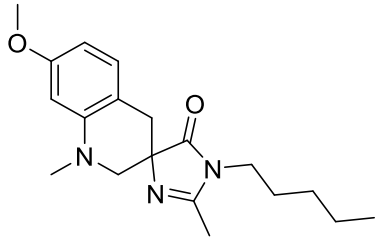
Yield 193 mg (71%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.14 (s, 3 H), 2.38 (d, *J* = 16.0 Hz, 1 H), 2.83– 2.86 (m, 4 H), 2.91 (dd, *J* = 11.2, 1.8 Hz, 1 H), 3.00 (s, 3 H), 3.30–3.32 (m, 1 H), 3.70 (s, 3 H), 6.14 (dd, *J* = 8.1, 2.4 Hz, 1 H), 6.15 (d, *J* = 2.4 Hz, 1 H), 6.78 (d, *J* = 8.1 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 26.3, 34.4, 38.5, 54.8, 55.5, 66.4, 96.9, 100.7, 111.9, 129.1, 145.7, 159.0, 182.6.

HRMS found, *m/z*: 274.1550 $[M+H]^+$. $C_{15}H_{20}N_3O_2^+$. Calculated, *m/z*: 274.1550.

7'-methoxy-1',2-dimethyl-1-pentyl-1',4'-dihydro-2'H-spiro[imidazole-4,3'-quinolin]-5(1H)-one (2g)



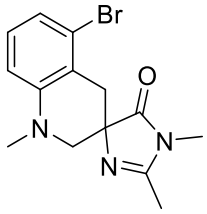
Yield 92 mg (28%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 0.87 (t, *J*=7.2 Hz, 3 H), 1.22 - 1.25 (m, 2 H), 1.28 - 1.34 (m, 2 H), 1.52 (quin, *J*=7.5 Hz, 2 H), 2.15 (s, 3 H), 2.36 (dd, *J*=15.5, 2.2 Hz, 1 H), 2.83 - 2.87 (m, 4 H), 2.89 (dd, *J*=11.7, 2.4 Hz, 1 H), 3.31 (d, *J*=11.8 Hz, 1 H), 3.42 - 3.46 (m, 2 H), 3.70 (s, 3 H), 6.13 (dd, *J*=8.1, 2.4 Hz, 1 H), 6.15 (d, *J*=2.3 Hz, 1 H), 6.79 (d, *J*=8.0 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 13.8, 15.2, 21.6, 28.1, 28.2, 34.5, 38.5, 39.7, 54.8, 55.5, 66.3, 96.9, 100.7, 111.9, 129.1, 145.6, 159.0, 160.4, 182.8.

HRMS found, *m/z*: 330.2179 $[M+H]^+$. $C_{19}H_{28}N_3O_2^+$. Calculated, *m/z*: 330.2176.

5'-bromo-1,1',2-trimethyl-1',4'-dihydro-2'*H*-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2h)



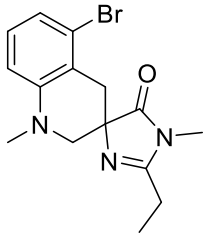
Yield 190 mg (57%), dark solid, m.p. 143–145°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.15 (s, 3 H), 2.59 (dd, *J* = 16.4, 2.4 Hz, 1 H), 2.78 (d, *J* = 16.4 Hz, 1 H), 2.90 (s, 3 H), 2.99 (dd, *J* = 11.9, 2.4 Hz, 1 H), 3.02 (s, 3 H), 3.32 (d, *J* = 11.9 Hz, 1 H), 6.65 (d, *J* = 8.3 Hz, 1 H), 6.83 (d, *J* = 7.8 Hz, 1 H), 6.99 (t, *J* = 8.1 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 26.4, 35.8, 55.0, 65.9, 110.1, 118.2, 119.1, 124.5, 128.2, 146.7, 161.4, 182.3.

HRMS found, *m/z*: 336.0703 $[M+H]^+$. $C_{15}H_{19}BrN_3O^+$. Calculated, *m/z*: 336.0706.

5'-bromo-2-ethyl-1,1'-dimethyl-1',4'-dihydro-2'H-spiro[imidazole-4,3'-quinolin]-5(1H)-one (2i)



Yield 79 mg (29%), dark solid, m.p. 127–129°C.

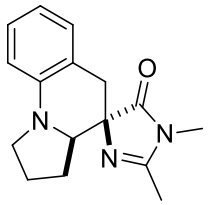
^{1}H NMR (700 MHz, DMSO-d_6): δ 1.10 (t, *J* = 7.3 Hz, 3 H), 2.56–2.59 (m, 3 H), 2.78 (d, *J* = 16.8 Hz, 1 H), 2.90 (s, 3 H), 2.98–3.03 (m, 4 H), 3.28 (d, *J* = 11.8 Hz, 1 H), 6.68 (d, *J* = 8.3 Hz, 1 H), 6.85 (d, *J* = 7.9 Hz, 1 H), 7.00 (t, *J* = 8.1 Hz, 1 H).

^{13}C NMR (176 MHz, $CDCl_3$), 10.3, 22.6, 26.7, 36.3, 39.9, 55.9, 67.2, 110.8, 119.0, 120.9, 125.5, 128.0, 146.7, 164.9, 183.3.

HRMS found, *m/z*: 274.1550 $[M+H]^+$. $C_{15}H_{20}N_3O_2^+$. Calculated, *m/z*: 274.1550.

1,2-dimethyl-1',2',3',3a'-tetrahydro-5'*H*-spiro[imidazole-4,4'-pyrrolo[1,2-a]quinolin]-5(1*H*)-one (2j and **2'j)**

(3a'*R,4*R**)-1,2-dimethyl-2',3',3a',5'-tetrahydro-1'*H*-spiro[imidazole-4,4'-pyrrolo[1,2-a]quinolin]-5(1*H*)-one (2j)**:



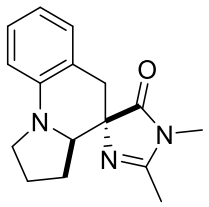
Yield 145 mg (55%), dark solid, m.p. 70–72°C.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.07–1.14 (m, 1 H), 1.61 (dtd, *J* = 11.4, 6.3, 1.9 Hz, 1 H), 1.82–1.95 (m, 2 H), 2.15 (s, 3 H), 2.44 (d, *J* = 15.4 Hz, 1 H), 2.98–3.05 (m, 5 H), 3.46 (td, *J* = 8.5, 1.5 Hz, 1 H), 3.61 (dd, *J* = 9.5, 5.9 Hz, 1 H), 6.45 (d, *J* = 8.0 Hz, 1 H), 6.48 (t, *J* = 7.2 Hz, 1 H), 6.91 (d, *J* = 7.4 Hz, 1 H), 7.02 (t, *J* = 7.7 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 14.9, 23.0, 25.6, 26.3, 36.5, 47.4, 61.1, 65.8, 110.4, 114.7, 118.6, 127.0, 128.5, 143.5, 161.5, 181.7.

HRMS found, *m/z*: 270.1603 $[M+H]^+$. $C_{16}H_{20}N_3O^+$. Calculated, *m/z*: 270.1601.

(3a'*R,4*S**)-1,2-dimethyl-2',3',3a',5'-tetrahydro-1'*H*-spiro[imidazole-4,4'-pyrrolo[1,2-a]quinolin]-5(1*H*)-one (2'j)**:



Yield 35 mg (13%), dark viscous oil.

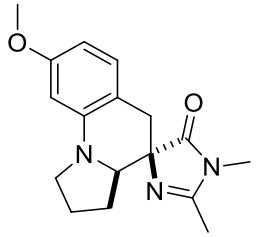
^{1}H NMR (700 MHz, DMSO-d_6): δ 1.05 - 1.14 (m, 1 H), 1.80 - 1.92 (m, 3 H), 2.20 (s, 3 H), 2.50 – 2.52 (m, 1H), 2.90 (s, 3 H), 3.05 - 3.11 (m, 1 H), 3.12 (d, *J*=16.0 Hz, 1 H), 3.46 (td, *J*=8.1, 1.2 Hz, 1 H), 3.73 (dd, *J*=9.4, 5.6 Hz, 1 H), 6.43 (d, *J*=8.0 Hz, 1 H), 6.48 (t, *J*=7.2 Hz, 1 H), 6.89 (d, *J*=7.2 Hz, 1 H), 7.01 (t, *J*=7.7 Hz, 1 H).

^{13}C NMR (201 MHz, DMSO-d_6): δ 15.1, 22.8, 25.7, 27.2, 35.5, 47.7, 61.3, 66.7, 110.3, 114.8, 117.4, 126.9, 128.4, 143.9, 161.0, 180.2.

HRMS found, *m/z*: 270.1604 $[M+H]^+$. $C_{16}H_{20}N_3O^+$. Calculated, *m/z*: 270.1601.

8'-methoxy-1,2-dimethyl-1',2',3',3a'-tetrahydro-5'*H*-spiro[imidazole-4,4'-pyrrolo[1,2-a]quinolin]-5(1*H*)-one (2k and **2'k)**

(3a'*R,4*R**)-8'-methoxy-1,2-dimethyl-2',3',3a',5'-tetrahydro-1'*H*-spiro[imidazole-4,4'-pyrrolo[1,2-a]quinolin]-5(1*H*)-one (2k)**:



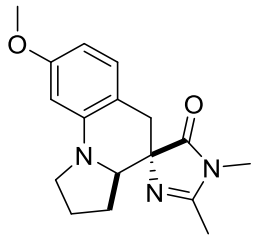
Yield 90 mg (30%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.05–1.13 (m, 1 H), 1.60 (dt, *J* = 11.8, 6.4 Hz, 1 H), 1.82–1.94 (m, 2 H), 2.14 (s, 3 H), 2.39 (d, *J* = 15.4 Hz, 1 H), 2.95 (d, *J* = 15.4 Hz, 1 H), 2.99–3.03 (m, 4 H), 3.43 (td, *J* = 8.8, 2.2 Hz, 1 H), 3.58 (dd, *J* = 9.6, 5.8 Hz, 1 H), 3.69 (s, 3 H), 6.00 (d, *J* = 2.5 Hz, 1 H), 6.08 (dd, *J* = 8.1, 2.5 Hz, 1 H), 6.80 (d, *J* = 8.1 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 14.9, 23.0, 25.6, 26.3, 36.5, 47.4, 54.8, 61.1, 65.8, 96.6, 100.0, 111.3, 128.9, 144.4, 159.0, 161.5, 183.3.

HRMS found, *m/z*: 300.1707 $[M+H]^+$. $C_{17}H_{22}N_3O_2^+$. Calculated, *m/z*: 300.1707.

(3a'*R,4*S**)-8'-methoxy-1,2-dimethyl-2',3',3a',5'-tetrahydro-1'*H*-spiro[imidazole-4,4'-pyrrolo[1,2-a]quinolin]-5(1*H*)-one (2'k)**:



Yield 27 mg (9%), dark viscous oil.

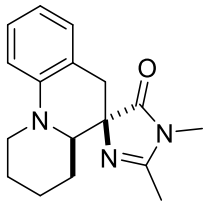
^{1}H NMR (700 MHz, DMSO-d_6): δ 1.82 - 1.86 (m, 2 H), 1.87 - 1.91 (m, 1 H), 2.19 (s, 3 H), 2.89 (s, 3 H), 3.01 - 3.07 (m, 2 H), 3.07 - 3.10 (m, 1 H), 3.42 - 3.46 (m, 1 H), 3.69 (s, 3 H), 3.70 - 3.72 (m, 1 H), 5.98 (d, *J*=2.5 Hz, 1 H), 6.08 (dd, *J*=8.0, 2.5 Hz, 1 H), 6.78 (d, *J*=8.4 Hz, 1 H).

^{13}C NMR (201 MHz, DMSO-d_6): δ 22.8, 25.7, 27.3, 30.4, 35.0, 47.7, 54.7, 61.3, 67.0, 96.6, 100.1, 110.1, 128.9, 144.8, 158.9, 161.0, 180.2.

HRMS found, *m/z*: 300.1704 $[M+H]^+$. $C_{17}H_{22}N_3O_2^+$. Calculated, *m/z*: 300.1707.

1,2-dimethyl-2',3',4',4a'-tetrahydro-1'*H*,6'*H*-spiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2l and **2'l)**

(4*R,4a'*R**)-1,2-dimethyl-1',2',3',4',4a',6'-hexahydrospiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2l)**:



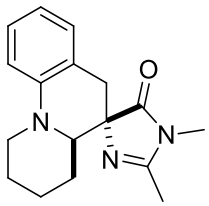
Yield 62 mg (22%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 0.95–1.04 (m, 1 H), 1.18 (d, *J* = 12.2 Hz, 1 H), 1.25–1.34 (m, 1 H), 1.38–1.46 (m, 1 H), 1.68 (app. d, *J* = 11.3 Hz, 2 H), 2.16 (s, 3 H), 2.33 (d, *J* = 15.6 Hz, 1 H), 2.66 (td, *J* = 12.4, 2.0 Hz, 1 H), 3.00 (s, 3 H), 3.02 (d, *J* = 15.6 Hz, 1 H), 3.07 (dd, *J* = 11.3, 2.5 Hz, 1 H), 4.02 (dt, *J* = 12.5, 3.2 Hz, 1 H), 6.56 (t, *J* = 7.3 Hz, 1 H), 6.85 (d, *J* = 7.4 Hz, 1 H), 6.87 (d, *J* = 8.3 Hz, 1 H), 7.02 (t, *J* = 7.8 Hz, 1 H).

^{13}C NMR (201 MHz, DMSO-d_6): δ 15.0, 23.1, 25.1, 25.7, 26.2, 36.4, 48.0, 59.6, 70.2, 113.0, 116.7, 120.8, 126.9, 128.9, 145.4, 161.3, 182.8.

HRMS found, *m/z*: 284.1757 $[M+H]^+$. $C_{17}H_{22}N_3O^+$. Calculated, *m/z*: 284.1757.

(4*S,4a'*R**)-1,2-dimethyl-1',2',3',4',4a',6'-hexahydrospiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2'l)**:



Yield 139 mg (49%), dark viscous oil.

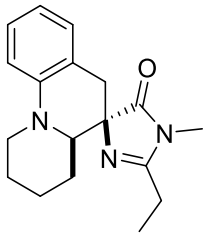
^{1}H NMR (700 MHz, DMSO-d_6): δ 1.03–1.13 (m, 1 H), 1.36–1.46 (m, 2 H), 1.50–1.58 (m, 1 H), 1.75 (app. d, *J* = 10.5 Hz, 2 H), 2.15 (s, 3 H), 2.63 (d, *J* = 16.0 Hz, 1 H), 2.72 (td, *J* = 12.5, 2.5 Hz, 1 H), 2.80 (d, *J* = 16.0 Hz, 1 H), 2.95 (s, 3 H), 2.97 (ddd, *J* = 12.2, 2.0, 0.8 Hz, 1 H), 4.04 (dt, *J* = 13.4, 3.2 Hz, 1 H), 6.54 (t, *J* = 7.2 Hz, 1 H), 6.84 (d, *J* = 8.2 Hz, 1 H), 6.87 (dd, *J* = 7.4, 1.7 Hz, 1 H), 7.02 (td, *J* = 7.7, 1.7 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.0, 23.8, 24.0, 25.2, 26.0, 33.4, 47.9, 60.4, 69.0, 112.0, 116.2, 119.5, 127.0, 129.0, 144.4, 160.6, 181.2.

HRMS found, *m/z*: 284.1755 $[M+H]^+$. $C_{17}H_{22}N_3O^+$. Calculated, *m/z*: 284.1757.

2-ethyl-1-methyl-2',3',4',4a'-tetrahydro-1'*H*,6'*H*-spiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2m and **2'm)**

(4*R,4a'*R**)-2-ethyl-1-methyl-1',2',3',4',4a',6'-hexahydrospiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2m)**:



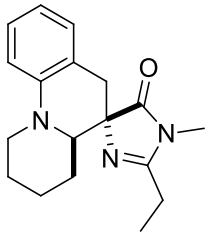
Yield 68 mg (23%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.10 (t, *J*=7.4 Hz, 3 H), 1.14 – 1.19 (m, 1 H), 1.25 – 1.32 (m, 1 H), 1.38 - 1.47 (m, 1 H), 1.65 – 1.70 (m, 2 H), 2.33 (d, *J*=15.8 Hz, 1 H), 2.53 (q, *J*=7.4 Hz, 2 H), 2.61 - 2.70 (m, 1 H), 3.01 (s, 3 H), 3.05 (dd, *J*=11.3, 8.5 Hz, 1 H), 3.99 - 4.06 (m, 1 H), 6.57 (t, *J*=7.2 Hz, 1 H), 6.83 - 6.92 (m, 2 H), 7.03 (t, *J*=7.7 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 9.6, 21.4, 23.1, 25.1, 25.6, 26.0, 36.3, 48.0, 59.5, 70.0, 113.0, 116.8, 120.8, 126.9, 129.0, 145.4, 165.0, 183.1.

HRMS found, *m/z*: 298.1910 $[M+H]^+$. $C_{18}H_{24}N_3O^+$. Calculated, *m/z*: 298.1914.

(4*S,4a'*R**)-2-ethyl-1-methyl-1',2',3',4',4a',6'-hexahydrospiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2'm)**:



Yield 222 mg (75%), dark viscous oil.

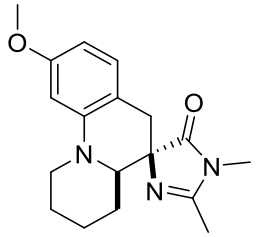
^{1}H NMR (700 MHz, DMSO-d_6): δ 1.01 (qd, *J* = 12.3, 3.4 Hz, 1 H), 1.13 (t, *J* = 7.3 Hz, 3 H), 1.30–1.47 (m, 2 H), 1.55–1.59 (m, 1 H), 1.67–1.77 (m, 2 H), 2.70 (td, *J* = 12.7, 2.7 Hz, 1 H), 2.72 (d, *J* = 16.1 Hz, 1 H), 2.75 (d, *J* = 16.1 Hz, 1 H), 2.94 (s, 3 H), 3.00 (dd, *J* = 11.6, 2.2 Hz, 1 H), 4.04 (dt, *J* = 13.6, 3.0 Hz, 1 H), 6.56 (t, *J* = 7.3 Hz, 1 H), 6.85 (d, *J* = 8.4 Hz, 1 H), 6.87 (dd, *J* = 7.4, 1.6 Hz, 1 H), 7.03 (ddd, *J* = 8.4, 7.2, 1.6 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 9.1, 21.3, 23.9, 24.0, 25.3, 25.8, 33.9, 47.9, 60.3, 68.8, 112.2, 116.4, 119.5, 126.9, 129.0, 144.8, 164.4, 181.3.

HRMS found, *m/z*: 298.1914 $[M+H]^+$. $C_{18}H_{24}N_3O^+$. Calculated, *m/z*: 298.1914.

9'-methoxy-1,2-dimethyl-2',3',4',4a'-tetrahydro-1'*H*,6'*H*-spiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2n and **2'n)**

(4*R,4a'*R**)-9'-methoxy-1,2-dimethyl-1',2',3',4',4a',6'-hexahydrospiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2n)**:



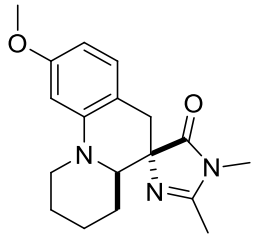
Yield 37 mg (12%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 0.98 (dd, *J*=11.7, 3.1 Hz, 1 H), 1.16 (d, *J*=2.9 Hz, 1 H), 1.25 - 1.32 (m, 1 H), 1.38 - 1.45 (m, 1 H), 1.67 (d, *J*=12.0 Hz, 2 H), 2.16 (s, 3 H), 2.28 (d, *J*=15.3 Hz, 1 H), 2.62 - 2.68 (m, 1 H), 2.93 (d, *J*=15.3 Hz, 1 H), 2.99 (s, 3 H), 3.04 (dd, *J*=11.3, 2.4 Hz, 1 H), 3.69 (s, 3 H), 3.98 (d, *J*=12.4 Hz, 1 H), 6.17 (dd, *J*=8.1, 2.4 Hz, 1 H), 6.41 (d, *J*=2.3 Hz, 1 H), 6.74 (d, *J*=8.2 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.0, 23.1, 25.1, 25.7, 26.1, 35.7, 48.1, 54.9, 59.5, 70.3, 99.3, 102.3, 113.4, 129.3, 146.3, 158.8, 161.2, 182.9.

HRMS found, *m/z*: 314.1861 $[M+H]^+$. $C_{18}H_{24}N_3O_2^+$. Calculated, *m/z*: 314.1863.

(4*S,4a'*R**)-9'-methoxy-1,2-dimethyl-1',2',3',4',4a',6'-hexahydrospiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2'n)**:



Yield 178 mg (57%), dark solid, m.p. 73–75°C.

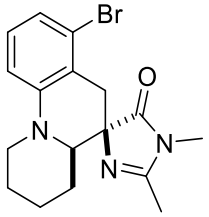
^{1}H NMR (700 MHz, DMSO-d_6): δ 1.02–1.10 (m, 1 H), 1.35–1.46 (m, 2 H), 1.51–1.56 (m, 1 H), 1.71–1.79 (m, 2 H), 2.14 (s, 3 H), 2.55 (d, *J* = 15.8 Hz, 1 H), 2.69–2.76 (m, 2 H), 2.93–2.97 (m, 4 H), 3.69 (s, 3 H), 4.01 (dt, *J* = 13.4, 3.6 Hz, 1 H), 6.16 (dd, *J* = 8.2, 2.4 Hz, 1 H), 6.36 (d, *J* = 2.4 Hz, 1 H), 6.77 (d, *J* = 8.2 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.0, 23.8, 24.0, 25.2, 26.0, 32.8, 48.0, 54.8, 60.4, 69.0, 98.4, 101.7, 112.1, 129.5, 145.3, 159.0, 160.6, 181.2.

HRMS found, *m/z*: 314.1863 $[M+H]^+$. $C_{18}H_{24}N_3O_2^+$. Calculated, *m/z*: 314.1863.

7'-bromo-1,2-dimethyl-2',3',4',4a'-tetrahydro-1'*H*,6'*H*-spiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2o and **2'o)**

(4*R,4a'*R**)-7'-bromo-1,2-dimethyl-1',2',3',4',4a',6'-hexahydrospiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2o)**:



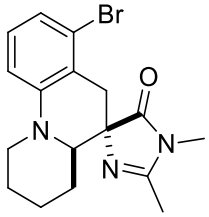
Yield 36 mg (10%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.00 (qd, *J* = 12.9, 3.8 Hz, 1 H), 1.20–1.34 (m, 2 H), 1.37–1.48 (m, 1 H), 1.62–1.72 (m, 2 H), 2.18 (s, 3 H), 2.55 (d, *J* = 16.1 Hz, 1 H), 2.69 (td, *J* = 12.5, 2.7 Hz, 1 H), 2.83 (d, *J* = 16.1 Hz, 1 H), 3.01 (s, 3 H), 3.08 (dd, *J* = 11.3, 2.7 Hz, 1 H), 4.01 (dt, *J* = 12.6, 3.0 Hz, 1 H), 6.87 (dd, *J* = 7.7, 1.0 Hz, 1 H), 6.93 (dd, *J* = 8.4, 1.0 Hz 1 H), 6.98 (t, *J* = 8.1 Hz, 1 H).

^{13}C NMR (201 MHz, DMSO-d_6): δ 15.0, 22.7, 24.9, 25.5, 26.3, 36.8, 48.4, 58.7, 69.8, 112.7, 119.9, 120.3, 124.6, 128.1, 147.6, 161.9, 182.5.

HRMS found, *m/z*: 362.0865 $[M+H]^+$. $C_{17}H_{21}BrN_3O^+$. Calculated, *m/z*: 362.0863.

(4*S,4a'*R**)-7'-bromo-1,2-dimethyl-1',2',3',4',4a',6'-hexahydrospiro[imidazole-4,5'-pyrido[1,2-a]quinolin]-5(1*H*)-one (2'o)**:



Yield 205 mg (57%), dark viscous oil.

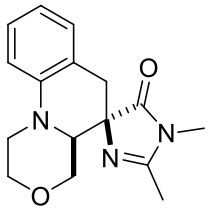
^{1}H NMR (700 MHz, DMSO-d_6): δ 1.02–1.11 (m, 1 H), 1.38–1.45 (m, 2 H), 1.49–1.54 (m, 1 H), 1.73–1.78 (m, 1 H), 1.79–1.84 (m, 1 H), 2.16 (s, 3 H), 2.60 (d, *J* = 16.6 Hz, 1 H), 2.76–2.82 (m, 2 H), 2.97 (s, 3 H), 3.01 (dd, *J* = 11.7, 2.9 Hz, 1 H), 4.07 (dt, *J* = 13.4, 3.8 Hz, 1 H), 6.84 (d, *J* = 7.8, 1.0 Hz, 1 H), 6.90 (dd, *J* = 8.4, 1.0 Hz, 1 H), 6.98 (t, *J* = 8.1 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 23.4, 23.9, 24.7, 26.2, 33.9, 48.4, 59.9, 68.5, 79.1, 111.6, 118.5, 119.7, 124.8, 128.3, 146.2, 161.1, 181.1.

HRMS found, *m/z*: 362.0864 $[M+H]^+$. $C_{17}H_{21}BrN_3O^+$. Calculated, *m/z*: 362.0863.

1,2-dimethyl-1',2',4',4a'-tetrahydro-6'*H*-spiro[imidazole-4,5'-[1,4]oxazino[4,3-a]quinolin]-5(1*H*)-one (2p and **2'p)**

(4a*R,4'*S**)-1',2'-dimethyl-2,4,4a,6-tetrahydro-1H-spiro[[1,4]oxazino[4,3-a]quinoline-5,4'-imidazol]-5'(1'*H*)-one (2p)**:



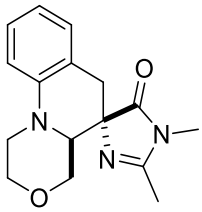
Yield 68 mg (24%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.16 (s, 3 H), 2.36 (d, *J* = 15.8 Hz, 1 H), 2.82 (td, *J* = 12.1, 3.7 Hz, 1 H), 2.95 (t, *J* = 10.7 Hz, 1 H), 3.01 (s, 3 H), 3.06 (d, *J* = 15.8 Hz, 1 H), 3.23 (dd, *J* = 10.6, 3.1 Hz, 1 H), 3.35 (ddd, *J* = 11.3, 3.7, 0.8 Hz, 1 H), 3.47 (td, *J* = 11.6, 3.0 Hz, 1 H), 3.81 (ddd, *J* = 12.6, 3.0, 0.8 Hz, 1 H), 3.87 (dd, *J* = 11.3, 3.1 Hz, 1 H), 6.64 (t, *J* = 7.4 Hz, 1 H), 6.84 (d, *J* = 8.4 Hz, 1 H), 6.90 (d, *J* = 7.5 Hz, 1 H), 7.07 (t, *J* = 7.8 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.0, 26.3, 36.5, 46.1, 57.5, 66.0, 66.1, 67.9, 79.1, 112.2, 117.5, 120.5, 127.0, 129.1, 144.5, 161.8, 182.1.

HRMS found, *m/z*: 286.1551 $[M+H]^+$. $C_{16}H_{20}N_3O_2^+$. Calculated, *m/z*: 286.1550.

(4a*S,4'*S**)-1',2'-dimethyl-2,4,4a,6-tetrahydro-1*H*-spiro[[1,4]oxazino[4,3-a]quinoline-5,4'-imidazol]-5'(1'*H*)-one (2'p)**:



Yield 74 mg (26%), dark viscous oil.

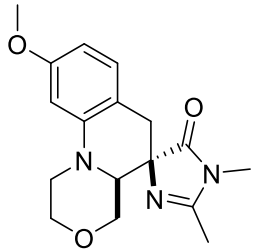
^{1}H NMR (700 MHz, DMSO-d_6): δ 2.17 (s, 3 H), 2.61 (d, *J* = 16.0 Hz, 1 H), 2.82 (td, *J* = 12.2, 3.6 Hz, 1 H), 2.93 (s, 3 H), 2.96 (d, *J* = 16.0 Hz, 1 H), 3.03 (t, *J* = 10.9 Hz, 1 H), 3.22 (dd, *J* = 10.6, 3.1 Hz, 1 H), 3.45 (td, *J* = 11.7, 2.8 Hz, 1 H), 3.66 (dd, *J* = 11.0, 3.1 Hz, 1 H), 3.79 (ddd, *J* = 12.4, 2.8, 1.5 Hz, 1 H), 3.86 (ddd, *J* = 11.5, 3.6, 1.5 Hz, 1 H), 6.66 (t, *J* = 7.3 Hz, 1 H), 6.87 (d, *J* = 8.2 Hz, 1 H), 6.91 (d, *J* = 7.3 Hz, 1 H), 7.07 (t, *J* = 7.8 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 26.0, 34.5, 46.4, 58.2, 65.9, 66.4, 67.1, 112.0, 117.8, 119.9, 126.9, 128.9, 144.8, 161.8, 180.3.

HRMS found, *m/z*: 286.1551 $[M+H]^+$. $C_{16}H_{20}N_3O_2^+$. Calculated, *m/z*: 286.1551.

9'-methoxy-1,2-dimethyl-1',2',4',4a'-tetrahydro-6'H-spiro[imidazole-4,5'-[1,4]oxazino[4,3-a]quinolin]-5(1*H*)-one (2q and **2'q)**

(4a*R,4'*R**)-9-methoxy-1',2'-dimethyl-2,4,4a,6-tetrahydro-1*H*-spiro[[1,4]oxazino[4,3-a]quinoline-5,4'-imidazol]-5'(1'*H*)-one (2q)**:



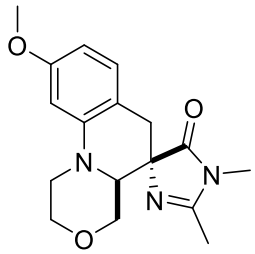
Yield 78 mg (25%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 2.15 (s, 3 H), 2.30 (d, *J*=16.2 Hz, 1 H), 2.82 (td, *J*=12.2, 3.6 Hz, 1 H), 2.94 (t, *J*=10.2 Hz, 1 H), 2.97 (d, *J*=16.2 Hz, 1 H), 3.00 (s, 3 H), 3.21 (dd, *J*=10.5, 3.2 Hz, 1 H), 3.35 (d, *J*=2.9 Hz, 1 H), 3.43 - 3.48 (m, 1 H), 3.70 (s, 3 H), 3.80 (d, *J*=13.5 Hz, 1 H), 3.86 (dd, *J*=11.1, 2.7 Hz, 1 H), 6.25 (dd, *J*=8.1, 2.4 Hz, 1 H), 6.43 (d, *J*=2.3 Hz, 1 H), 6.80 (d, *J*=8.0 Hz, 1 H).

^{13}C NMR (201 MHz, DMSO-d_6): δ 15.0, 26.3, 35.9, 46.1, 54.9, 57.5, 58.0, 66.0, 66.1, 68.0, 98.6, 103.0, 113.0, 129.5, 145.4, 158.9, 161.6, 182.2.

HRMS found, *m/z*: 316.1655 $[M+H]^+$. $C_{17}H_{22}N_3O_3^+$. Calculated, *m/z*: 316.1656.

(4a*S,4'*R**)-9-methoxy-1',2'-dimethyl-2,4,4a,6-tetrahydro-1*H*-spiro[[1,4]oxazino[4,3-a]quinoline-5,4'-imidazol]-5'(1'*H*)-one (2'q)**:



Yield 120 mg (38%), dark viscous oil.

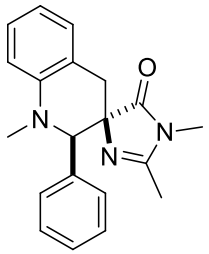
^{1}H NMR (700 MHz, DMSO-d_6): δ 2.16 (s, 3 H), 2.54 (d, *J*=16.4 Hz, 1 H), 2.82 (td, *J*=12.3, 3.5 Hz, 1 H), 2.88 (d, *J*=16.4 Hz, 1 H), 2.92 (s, 3 H), 3.21 (dd, *J*=10.8, 3.0 Hz, 1 H), 3.44 (td, *J*=11.5, 2.7 Hz, 1 H), 3.65 (dd, *J*=10.9, 2.7 Hz, 1 H), 3.71 (s, 3 H), 3.74 - 3.80 (m, 2 H), 3.84 (dd, *J*=11.6, 3.4 Hz, 1 H), 6.26 (dd, *J*=8.1, 2.4 Hz, 1 H), 6.41 (d, *J*=2.3 Hz, 1 H), 6.80 (d, *J*=8.2 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.1, 26.0, 33.9, 46.4, 54.9, 58.2, 65.9, 66.4, 67.1, 98.5, 103.1, 112.2, 129.4, 145.6, 158.9, 161.7, 180.2.

HRMS found, *m/z*: 316.1658 $[M+H]^+$. $C_{17}H_{22}N_3O_3^+$. Calculated, *m/z*: 316.1656.

1,1',2-trimethyl-2'-phenyl-1',4'-dihydro-2'H-spiro[imidazole-4,3'-quinolin]-5(1H)-one (2r and **2'r)**

(2'*R,3'*R**)-1,1',2-trimethyl-2'-phenyl-2',4'-dihydro-1'H-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2r)**:



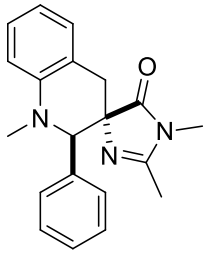
Yield 77 mg (23%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.84 (s, 3 H), 2.51 (d, *J* = 15.4 Hz, 1 H), 2.62 (s, 3 H), 2.66 (s, 3 H), 3.11 (d, *J*=15.4 Hz, 1 H), 4.47 (s, 1 H), 6.60 (t, *J* = 7.3 Hz, 1 H), 6.75 (d, *J*= 8.2 Hz, 1 H), 6.92 (d, *J*=7.2 Hz, 1 H), 7.04 - 7.08 (m, 2 H), 7.09 (t, *J* = 7.7 Hz, 1 H), 7.21–7.26 (m, 3 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 14.6, 25.9, 34.6, 37.6, 67.5, 70.3, 111.9, 116.2, 120.3, 127.1, 127.2, 127.6, 128.3, 137.3, 146.1, 160.6, 182.0.

HRMS found, *m/z*: 334.1915 $[M+H]^+$. $C_{21}H_{24}N_3O^+$. Calculated, *m/z*: 334.1914.

(2'*R,3'*S**)-1,1',2-trimethyl-2'-phenyl-2',4'-dihydro-1'H-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2'r)**:



Yield 239 mg (72%), dark solid, m.p. 83–85°C.

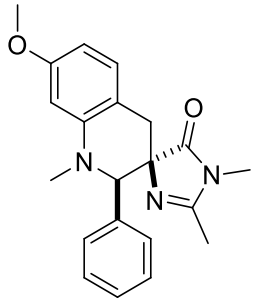
^{1}H NMR (700 MHz, DMSO-d_6): δ 2.08 (s, 3 H), 2.55 (d, *J*=16.0 Hz, 1 H), 2.72 (s, 3 H), 2.85 (s, 3 H), 2.89 (d, *J* = 16.0 Hz, 1 H), 4.14 (s, 1 H), 6.58 (t, *J* = 7.1 Hz, 1 H), 6.65 (d, *J* = 8.2 Hz, 1 H), 6.94 (d, *J* = 7.2 Hz, 1 H), 6.95–6.99 (m, 2 H), 7.10 (t, *J* = 7.6 Hz, 1 H), 7.20–7.27 (m, 3 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.0, 26.1, 31.9, 37.5, 67.7, 68.7, 109.8, 115.3, 118.3, 127.3, 127.4, 127.9, 128.6, 138.3, 145.0, 160.6, 180.4.

HRMS found, *m/z*: 334.1915 $[M+H]^+$. $C_{21}H_{24}N_3O^+$. Calculated, *m/z*: 334.1914.

7'-methoxy-1,1',2-trimethyl-2'-phenyl-1',4'-dihydro-2'*H*-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2s and **2'’s)**

(2'*R,3'*R**)-7'-methoxy-1,1',2-trimethyl-2'-phenyl-2',4'-dihydro-1'*H*-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2s)**:



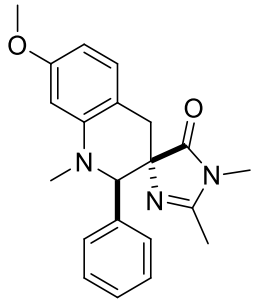
Yield 52 mg (15%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.84 (s, 3 H), 2.47 (d, J = 15.4 Hz, 1 H), 2.62 (s, 3 H), 2.65 (s, 3 H), 2.99 (d, J = 15.4 Hz, 1 H), 3.72 (s, 3 H), 4.44 (s, 1 H), 6.20 (dd, J = 8.2, 2.4 Hz, 1 H), 6.28 (d, J = 2.4 Hz, 1 H), 6.81 (d, J = 8.2 Hz, 1 H), 7.12–7.10 (m, 2 H), 7.22–7.26 (m, 3 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 14.6, 25.8, 33.8, 37.7, 54.8, 67.3, 70.3, 98.2, 101.3, 112.8, 127.1, 127.6, 128.3, 128.7, 137.3, 146.9, 159.1, 160.5, 182.0.

HRMS found, *m/z*: 350.1865 $[M+H]^+$. $C_{21}H_{24}N_3O_2^+$. Calculated, *m/z*: 350.1863.

(2'*R,3'*S**)-7'-methoxy-1,1',2-trimethyl-2'-phenyl-2',4'-dihydro-1'*H*-spiro[imidazole-4,3'-quinolin]-5(1*H*)-one (2'’s)**:



Yield 94 mg (27%), dark viscous oil.

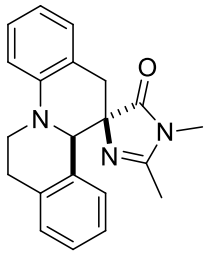
^{1}H NMR (700 MHz, DMSO-d_6): δ 2.08 (s, 3 H), 2.47 (d, J = 16.1 Hz, 1 H), 2.71 (s, 3 H), 2.83 (d, J = 16.1 Hz, 1 H), 2.86 (s, 3 H), 3.73 (s, 3 H), 4.10 (s, 1 H), 6.16–6.20 (m, 2 H), 6.83 (d, J = 7.8 Hz, 1 H), 6.94–6.99 (m, 2 H), 7.21–7.25 (m, 3 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 15.0, 26.1, 31.2, 37.6, 54.8, 67.6, 68.9, 96.3, 100.4, 111.0, 125.2, 127.3, 127.4, 127.9, 128.1, 128.8, 129.1, 138.3, 145.9, 159.2, 180.4.\

HRMS found, *m/z*: 350.1865 $[M+H]^+$. $C_{21}H_{24}N_3O_2^+$. Calculated, *m/z*: 350.1863.

1,2-dimethyl-6',7',11b',13'-tetrahydrospiro[imidazole-4,12'-isoquinolino[2,1-a]quinolin]-5(1*H*)-one (2t and **2't)**

(4*R,11b'*R**)-1,2-methyl-6',7',11b',13'-tetrahydrospiro[imidazole-4,12'-isoquinolino[2,1-a]quinolin]-5(1*H*)-one (2t)**:



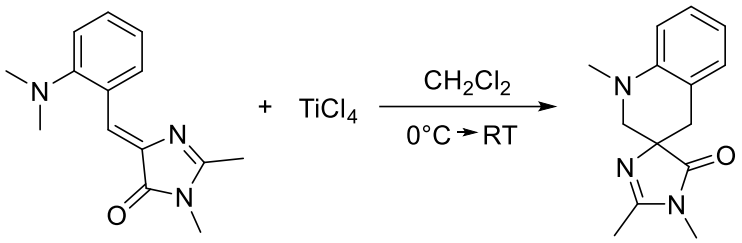
Yield 109 mg (33%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.80 (s, 3 H), 2.56 (d, *J* = 16.4 Hz, 1 H), 2.63 (dt, *J* = 14.6, 3.4 Hz, 1 H), 2.68 (s, 3 H), 3.10 (ddd, *J* = 14.6, 11.6, 4.9 Hz, 1 H), 3.21 (td, *J* = 11.6, 3.0 Hz, 1 H), 3.34 (d, *J* = 16.4 Hz, 1 H), 3.90 (ddd, *J* = 11.7, 4.9, 3.8 Hz, 1 H), 4.59 (s, 1 H), 6.65 (t, *J* = 7.3 Hz, 1 H), 6.82 (d, *J* = 8.2 Hz, 1 H), 6.99 (d, *J* = 7.5 Hz, 1 H), 7.02 (d, *J* = 7.5 Hz, 1 H), 7.07–7.12 (m, 2 H), 7.14 (d, J = 7.1 Hz, 1 H), 7.17 (td, *J* = 7.4, 1.2 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 14.5, 25.9, 29.4, 35.9, 45.3, 60.9, 72.0, 113.7, 116.5, 120.0, 125.0, 126.7, 126.9, 127.0, 127.4, 128.8, 132.3, 137.4, 145.8, 160.5, 183.3.

HRMS found, *m/z*: 332.1757 $[M+H]^+$. $C_{21}H_{22}N_3O^+$. Calculated, *m/z*: 332.1757.

5. Procedure for the gram scale synthesis



1a

(9.7 g, 40 mmol)

2a

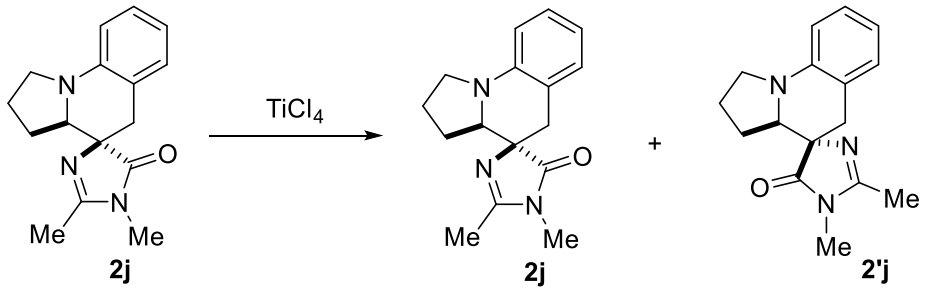
Compound **1a** (9.7 g, 40 mmol) was dissolved in dry CH_2Cl_2 (500 mL) in argon and cooled to 0°C. Solution of $TiCl_4$ (11.4 g, 60 mmol) in 40 mL of dry CH_2Cl_2 was added dropwise for 10 min, the resulted mixture was stirred at the same temperature for 30 min and then was warmed to RT. Stirring was continued for 3 h and then 5% aqueous solution of $NaHCO_3$ (500 mL) was carefully added, the resulted mixture was filtered and the resulted clear solution extracted with EtOAc (3×800 mL). Combined organic layers were washed with brine (3×300 mL), dried over anhydrous Na_2SO_4. All volatiles were removed in vacuo and the residue was purified with column chromatography (eluent – mixture of hexane and EtOAc, v/v 1:3).

2a. Yield 9.0 g (93%).

6. Proof of the reaction reversibility

Compound **2** or **2'** (0.5 mmol) was dissolved in dry CH_2Cl_2 (10 mL) in argon and cooled to 0°C. Solution of $TiCl_4$ (142 mg, 0.75 mmol) in 2 mL of dry CH_2Cl_2 was added dropwise, the resulted mixture was stirred at the same temperature for 30 min and then was warmed to RT. Stirring was continued overnight. 3% aqueous solution of $NaHCO_3$ (30 mL) was carefully added and the resulted mixture was extracted with EtOAc (3×30 mL). Combined organic layers were washed with brine (3×30 mL), dried over anhydrous Na_2SO_4. All volatiles were removed in vacuo and the residue was purified with column chromatography (eluent – mixture of hexane and EtOAc, v/v 1:3).

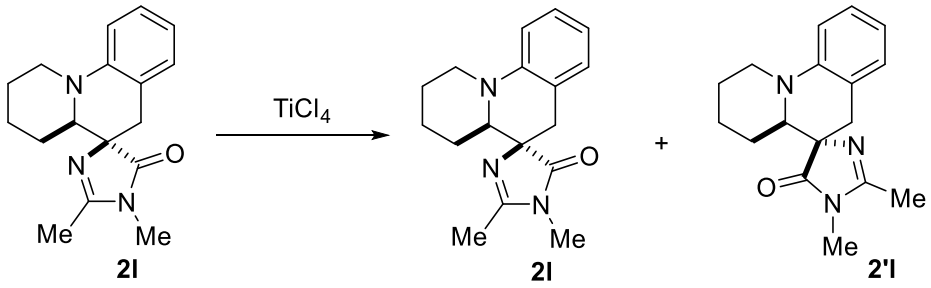
Reaction of 2j.



2j: yield 77 mg (57%).

2'j: yield 17 mg (13%).

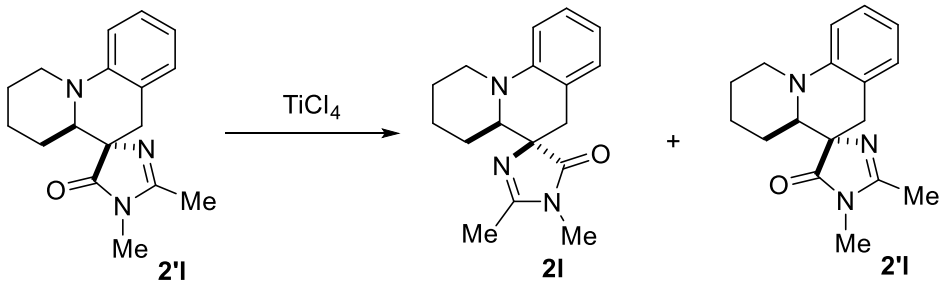
Reaction of 2l.



2l: yield 25 mg (18%).

2'l: yield 75 mg (54%).

Reaction of 2'l



2l: yield 28 mg (19%).

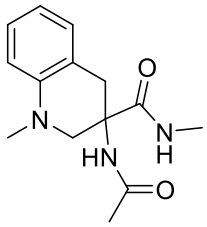
2'l: yield 72 mg (51%).

7. Hydrolysis procedure

General method for synthesis of 3a, 3e and 3'm

Compound **2** or **2'** (0.5 mmol) was dissolved in the mixture of MeOH (5 mL) and H_2O (15 mL). 80 mg (2 mmol) of NaOH was added and the resulted mixture was refluxed for 2 h. The mixture was cooled, EtOAc was added (200 ml) and the resulted solution was washed with brine (3 × 30 ml). Separated organic layer was dried over anhydrous Na_2SO_4. All volatiles were removed in vacuo and the residue was purified with column chromatography (eluent – mixture of $CHCl_3$ and EtOH, v/v 25:1).

3-acetamido-N,1-dimethyl-1,2,3,4-tetrahydroquinoline-3-carboxamide (3a)



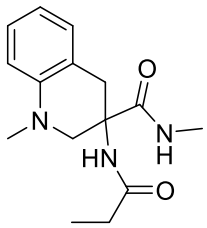
Yield 79 mg (60%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.76 (s, 3 H), 2.58 (d, *J*=4.6 Hz, 3 H), 2.83 (s, 3 H), 2.97 (dd, *J*=16.2, 2.1 Hz, 1 H), 3.10 (d, *J*=16.4 Hz, 1 H), 3.28 (m, 1 H), 3.48 (dd, *J*=11.6, 2.5 Hz, 1 H), 6.56 (t, *J*=7.2 Hz, 1 H), 6.60 (d, *J*=8.2 Hz, 1 H), 6.89 (d, *J*=7.2 Hz, 1 H), 7.01 (t, *J*=8.1 Hz, 1 H), 7.63 (d, *J*=4.2 Hz, 1 H), 7.67 (s, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 23.1, 26.1, 34.7, 38.6, 54.7, 55.6, 110.7, 116.1, 119.7, 126.8, 129.3, 144.9, 169.6, 172.3.

HRMS found, *m/z*: 262.1548 $[M+H]^+$. $C_{14}H_{20}N_3O_2^+$. Calculated, *m/z*: 262.1550.

N,1-dimethyl-3-propionamido-1,2,3,4-tetrahydroquinoline-3-carboxamide (3e)



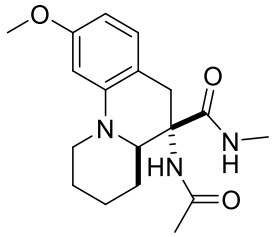
Yield 66 mg (49%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 0.85 (t, *J*=7.6 Hz, 3 H), 1.98 - 2.08 (m, 2 H), 2.58 (d, *J*=4.6 Hz, 3 H), 2.82 (s, 3 H), 2.97 (dd, *J*=16.5, 1.8 Hz, 1 H), 3.09 (d, *J*=16.2 Hz, 1 H), 3.31 (m, 1 H), 3.50 (dd, *J*=11.6, 2.5 Hz, 1 H), 6.53 - 6.57 (m, 1 H), 6.59 (d, *J*=8.0 Hz, 1 H), 6.89 (d, *J*=7.4 Hz, 1 H), 7.01 (t, *J*=7.5 Hz, 1 H), 7.52 (s, 1 H), 7.61 (d, *J*=4.2 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 9.6, 26.1, 28.5, 34.8, 38.5, 54.6, 55.5, 110.5, 116.0, 119.7, 126.8, 129.3, 144.8, 172.4, 173.4.

HRMS found, *m/z*: 276.1707 $[M+H]^+$. $C_{15}H_{22}N_3O_2^+$. Calculated, *m/z*: 276.1707.

(4aR*,5S*)-9-methoxy-N-methyl-5-propionamido-2,3,4,4a,5,6-hexahydro-1H-pyrido[1,2-a]quinoline-5-carboxamide (3'n)



Yield 95 mg (58%), dark viscous oil.

^{1}H NMR (700 MHz, DMSO-d_6): δ 1.05 - 1.11 (m, 1 H), 1.17 – 1.21 (m, 1 H), 1.36 - 1.42 (m, 2 H), 1.47 - 1.54 (m, 1 H), 1.71 (s, 3 H), 1.75 - 1.78 (m, 1 H), 2.57 (d, *J*=4.6 Hz, 3 H), 2.86 - 2.92 (m, 1 H), 3.04 - 3.08 (m, 1 H), 3.08 - 3.12 (m, 1 H), 3.23 (d, *J*=11.8 Hz, 1 H), 3.68 (s, 3 H), 4.09 (d, *J*=15.3 Hz, 1 H), 6.18 (dd, *J*=8.2, 2.3 Hz, 1 H), 6.36 (d, *J*=2.3 Hz, 1 H), 6.79 (d, *J*=8.2 Hz, 1 H), 7.37 (s, 1 H), 7.64 (d, *J*=4.6 Hz, 1 H).

^{13}C NMR (176 MHz, DMSO-d_6): δ 21.9, 23.0, 24.7, 24.9, 26.2, 27.6, 48.3, 54.8, 58.5, 61.4, 98.4, 101.9, 113.2, 130.5, 143.1, 158.9, 168.9, 171.2.

HRMS found, *m/z*: 332.1972 $[M+H]^+$. $C_{18}H_{26}N_3O_3^+$. Calculated, *m/z*: 332.1969.

8. Crystal Data

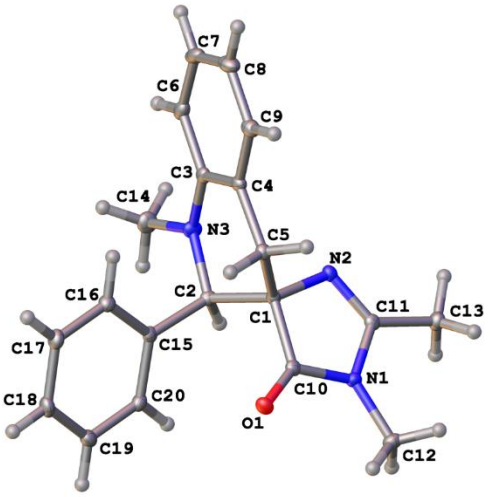


Fig. S1. General view of the compound **2'r** in representation of atoms *via* thermal ellipsoids at 50% probability level; the solvent acetonitrile molecule is not shown.

Crystallographic data: Crystals of **2'r** ($C_{22}H_{24}N_4O$, M = 360.45) are triclinic, space group P-1, at 120 K: a = 6.9795(8), b = 9.9569(11), c = 14.5673(17)Å, α = 108.531(2), β = 92.161(3)°, γ = 97.846(3), V = 947.32(19)Å^3, Z = 2 (Z' = 0.5), d_{calc} = 1.264 gcm^{-3}, μ(MoKα) = 0.080 cm^{-1}, F(000) = 384. Intensities of 10970 reflections were measured for **2'r**, respectively, with a Bruker APEX2 DUO CCD diffractometer [λ(MoKα) = 0.71073 Å, ω-scans, 2θ<60°]; 4568 independent reflections [R_{int} = 0.0565] were used in further refinement. Using Olex2,[7] the structure was solved with the ShelXT[8] structure solution program using Intrinsic Phasing and refined with the olex2.refine[9] refinement package using Gauss-Newton minimisation. Positions of hydrogen atoms were calculated, and they were refined in the isotropic approximation within the riding model. The refinement converged to wR2 = 0.1227 and GOF = 0.995 for all the independent reflections (R1 = 0.0523 was calculated against F for 2838 observed reflections with I>2σ(I))**.** CCDC 2026499 contains the supplementary crystallographic information for **2'r.**

9. Configuration determination by NMR

Methods

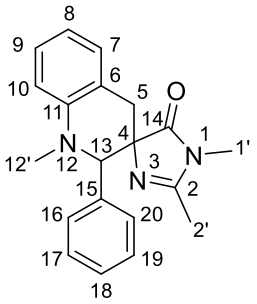
All NMR spectra were recorded using the Bruker Avance 700 MHz spectrometer. Heteronuclear *J*-coupling were measured using the PIP-HSQCMBC pulse sequences.[10] Two spectra (in-phase and anti-phase variants of HSQMBC were acquired in the interleaved manner), *J*-couplings were determined as a distance between the cross-peak positions in the sum and difference of two spectra. NOESY was recorded with the mixing time of 300 ms. Ratio between the integrals of cross- and diagonal peaks was taken as the NOE value. Conformations of **2** and **2'** were generated using the Avogadro 1.2.0 software, applying the energy minimization in MMFF94s force field.[11]

Results

The stereoisomery of **2r** and **2'r** was studied using NMR conformational analysis. We measured directly all $^3J_{HN}$, $^3J_{HC}$ and NOE connectivities, which allowed the straightforward interpretation. Due to the presence of adjacent aromatic ring, there are only two possible half-chair conformations of piperidine ring (Figure S2),[12] thus one needs to consider four options to determine the relative configuration. In both compounds the upfield shifted proton of 5-CH_2 group in the piperidine cycle is equatorial. This follows from the large $^3J_{H5/C13}$ coupling (5.8 Hz), as well as the intense NOE to the C7 proton (Figure S2, Tables). In turn, the second axial 5-CH_2 proton is in *trans*- conformation with respect to the nitrogen-3 of the imidazolone ring ($^3J_{HN}$=3.6 Hz), this observation allows excluding two out of four conformations. In **2r** we observe a strong NOE between the C13 proton and axial C5 proton, which implies that phenyl ring and nitrogen are on the same side of piperidine cycle, and configuration of the compound is *4,13-cis.* This is supported by a weak NOE between the ε/δ protons of phenyl ring and 3-methyl group of imidazolone. In **2'r** we found a weak NOE between the C13 proton and equatorial C5 proton, as well as a strong peak between the δ protons of phenyl ring and axial proton of 5-CH_2 group. Thus, phenyl ring and nitrogen are on the opposite sides of piperidine cycle, and configuration of the compound is *4,13-trans.*

Stereoisomery of **2l** and **2'l** was investigated analogously, analyzing four possible structures of the piperidine ring, which is adjacent to the phenyl group: two half-chair conformations of two stereoisomers (Figure S3). Like in compound **2l**, the downfield shifted proton of 5-CH_2 group of **2l** is axial ($^3J_{H5a/C13}$=2.0 Hz) and is in trans-conformation to the nitrogen-3 of the imidazolone ring ($^3J_{HN}$=3.6 Hz). The C13 proton of **2l** is as well axial ($^3J_{H13/C5}$=2.2 Hz). This leaves us with single possible configuration, when the C5 and C13 axial protons are on the same side of the piperidine ring and are in *trans*-position to the nitrogene of imidazolone. This conformation is supproted by the absence of NOE peak between the C5 protons and C14 protons of the second piperidine, and a NOE peak between the axial C5 and C13 protons. In **2'l** the C13 proton becomes equatorial ($^3J_{H13/C5}$=4.1 Hz), while the axial C5 proton is still in *trans*-position to the nitrogen-3 of imidazolone ($^3J_{HN}$=2.7 Hz). This leaves us with the second configuration shown in Fig. S1. This configuration is as well supported by the NOESY data.

Table S1: Key NMR data obtained for the 4,13-*cis*-isomer – **2r.**



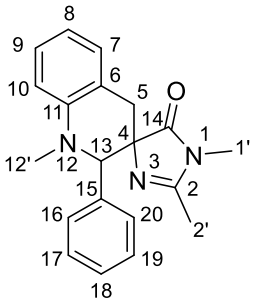
Position	δ(^{1}H), ppm (mult)[a]	δ(^{13}C/^{15}N) ppm	$^{3}J_{HN}$ Hz[b]	$^{3}J_{HC,}$ Hz	NOE[c]
1N		150			
1'	2.63 (s)	26.4			
2		161.1			
2'	1.85 (s)	15.1			16(5)
3N		253			
4		70.8			
5ax	3.12 (d,16Hz)	35.1	3(3.6)	13(3.2);11(2.9);7(3.2);14(2.8)	7(60);13(141)
5eq	2.51 (d,16Hz)	35.1		13(5.8);11(4.2);7(4.5);14(2.7)	7(207)
6		120.8			
7	6.92 (d,8Hz)	128.9			
8	6.61 (t,8Hz)	116.7			
9	7.11 (t,8Hz)	127.7			
10	6.76 (d,8Hz)	112.4			
11		146.6			
12N		60			
12'	2.66 (s)	38.2			
13	4.48 (s)	68.0	3(2.4)	16 (4.2);12'(1.9);11(1.6);5(2.3);14(2.0)	5ax(141)
14		182.6			
15		137.5			
16/20	7.07 (d,8Hz)	128.9			2'(5)
17/19	7.24 (na)	128.1			
18	7.25(na)	127.6			

[a]signal multiplicities are denoted as **s** - singleton, **d** - doubleton, **t** - tripleton.

[b]Only the key vicinal *J*-couplings that are significant for the conformation analysis are provided. Number denotes the position of heteroatom, *J*-coupling in Hz is provided in parentheses.

[c]first number is the position of proton, relative intensity is given in parentheses. 150-160 r.u. corresponds to 2.5 angstroms.

Table S2: key NMR data obtained for the 4,13-*trans*-isomer – **2'r.**



Position	δ(^{1}H), ppm (mult)[a]	δ(^{13}C/^{15}N) ppm	$^{3}J_{HN}$ Hz[b]	$^{3}J_{HC}$, Hz	NOE[c]
1N		150			
1'	2.86 (s)	26.7			
2		161.2			
2'	2.09 (s)	15.6			
3N		258			
4		69.3			
5ax	2.91 (d,16Hz)	32.5	3(3.5)	13(2.7);11(2.9);7(3.0);14(2.5)	7(97), 16(70)
5eq	2.56 (d,16Hz)	32.5	3(1)	13(4.6);11(3.9);7(4.2);14(3.2)	7(170),13(30)
6		118.8			
7	6.95 (d,8Hz)	129.1			
8	6.59 (t,8Hz)	115.9			
9	7.11 (t,8Hz)	127.79			
10	6.67 (d,8Hz)	110.3			
11		145.6			
12N		60			
12'	2.74 (s)	38.0			
13	4.15 (s)	68.2	3(0.6)	16 (4.6);12'(2.6);11(2.9);5(3.6);14(2.7)	5eq(30)
14		180.9			
15		138.9			
16/20	6.98(d,8Hz)	128.6			5ax(70)
17/19	7.24 (na)	127.9			
18	7.24(na)	127.9			

[a]signal multiplicities are denoted as **s** - singleton, **d** - doubleton, **t** - tripleton.
[b]Only the key vicinal *J*-couplings that are significant for the conformation analysis are provided. Number denotes the position of heteroatom, *J*-coupling in Hz is provided in parentheses.
cfirst number is the position of proton, relative intensity is given in parentheses. 150-160 r.u. corresponds to 2.5 angstroms.

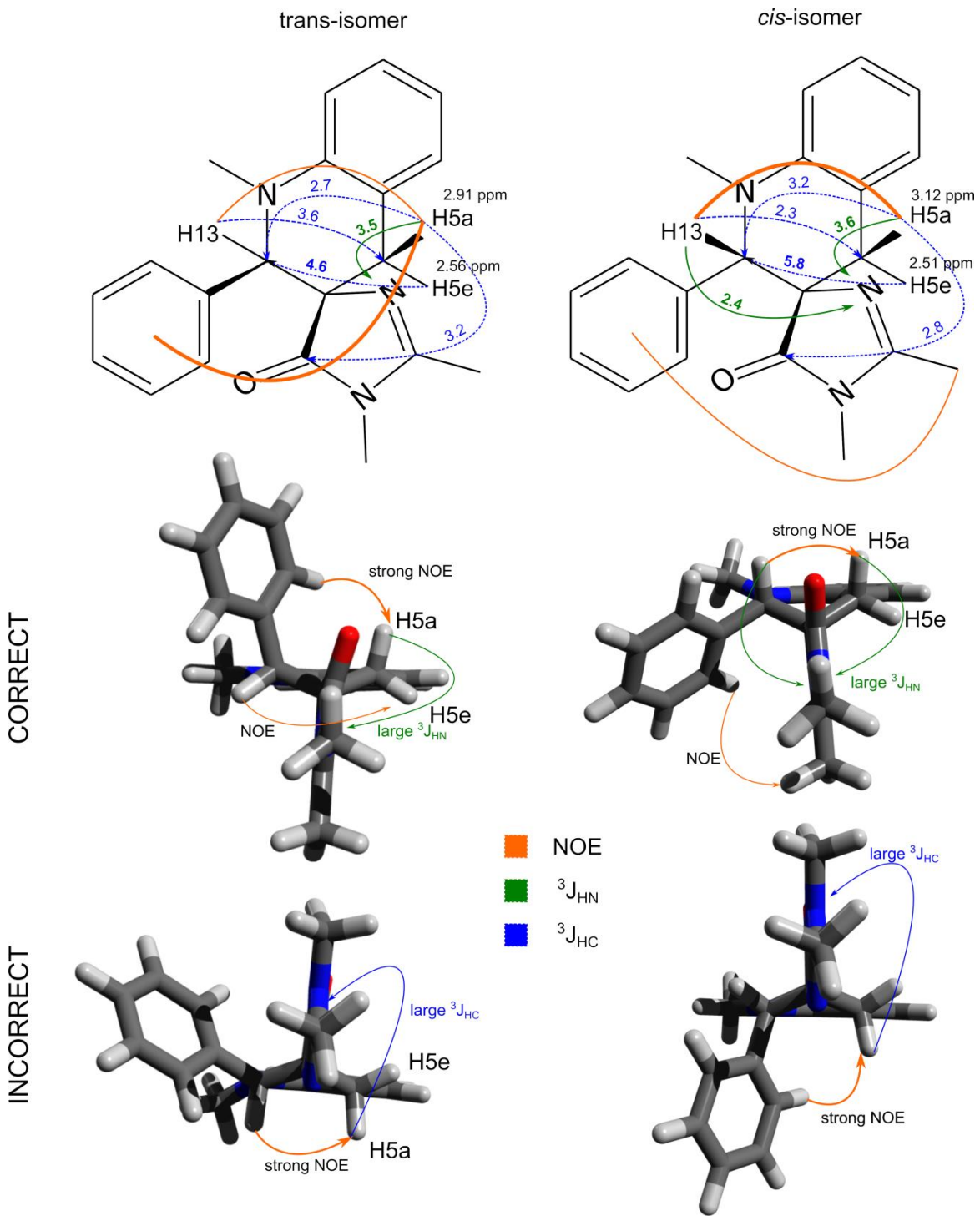
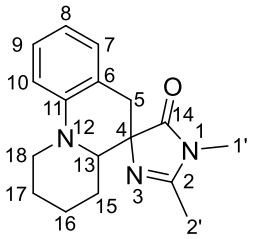


Fig. S2: Conformational analysis of **2r** isomers. on top - key NMR data (3JHN, 3JHC and NOE contacts are plotted on the structure of **2r**. Below, four possible conformations of **2r** isomers are shown, with predicted NMR parameters.

Table S3: Key NMR data obtained for the 4,13-*cis*-isomer – **2l.**



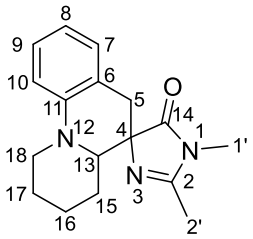
Position	δ(^{1}H), ppm (mult)[a]	δ(^{13}C/^{15}N) ppm	$^{3}J_{HN}$ Hz[b]	$^{3}J_{HC,}$ Hz
1N		151		
1'	2.67 (s)	26.7		
2		161.5		
2'	2.17 (s)	15.5		
3N		254		
4		70.8		
5ax	3.04 (d,16Hz)	36.9	3(3.7)	13(2.0);14(2.6)
5eq	2.34 (d,16Hz)	36.9	3(1.3)	13(5.8); 14(2.0)
6		121.3		
7	6.86 (d,8Hz)	129.4		
8	6.57 (t,8Hz)	117.2		
9	7.03 (t,8Hz)	127.4		
10	6.88 (d,8Hz)	113.6		
11		145.9		
12N		75		
13ax	3.08 (na)	60.1	3(2.0)	5(2.2);14(1.6)
14		183.4		
15ax	1.01 (na)	26.2		
15eq	1.19 (na)	26.2		
16	1.30 (na) 1.69 (na)	23.6		
17	1.43 (na) 1.69 (na)	25.7		
18	2.66(na) 4.03 (na)	48.5		

[a]signal multiplicities are denoted as **s** - singleton, **d** - doubleton, **t** - tripleton.

[b]Only the key vicinal *J*-couplings that are significant for the conformation analysis are provided. Number denotes the position of heteroatom, *J*-coupling in Hz is provided in parentheses.

[c]first number is the position of proton, relative intensity is given in parentheses. 150-160 r.u. corresponds to 2.5 angstroms.

Table S4: key NMR data obtained for the 4,13-*trans*-isomer – **2'l.**



Position	δ(^{1}H), ppm (mult)[a]	δ(^{13}C/^{15}N) ppm	$^{3}J_{HN}$ Hz[b]	$^{3}J_{HC}$, Hz
1N		150		
1'	2.96 (s)	26.6		
2		161.2		
2'	2.09 (s)	15.6		
3N		259		
4		69.5		
5ax	2.81 (d,16Hz)	33.9	3(2.7)	13(3.4); 14(2.7)
5eq	2.63 (d,16Hz)	33.9	3(1.0)	13(4.0); 14(4.1)
6		120.1		
7	6.88 (d,8Hz)	129.7		
8	6.55 (t,8Hz)	116.9		
9	7.03 (t,8Hz)	127.7		
10	6.85 (d,8Hz)	112.6		
11		145.0		
12N		75		
13	2.98 (na)	60.9		5(3.6);14(4.2)
14		181.7		
15ax	1.08 (na)	25.8		
15eq	1.76 (na)	25.8		
16ax	1.41(na)	24.7		
16eq	1.76 (na)	24.7		
17ax	1.42 (na)	24.3		
17eq	1.55 (na)	24.3		
18ax	2.73 (na)	48.4		
18eq	4.06 (na)	48.4		

[a]signal multiplicities are denoted as **s** - singleton, **d** - doubleton, **t** - tripleton.
[b]Only the key vicinal *J*-couplings that are significant for the conformation analysis are provided. Number denotes the position of heteroatom, *J*-coupling in Hz is provided in parentheses.
cfirst number is the position of proton, relative intensity is given in parentheses. 150-160 r.u. corresponds to 2.5 angstroms.

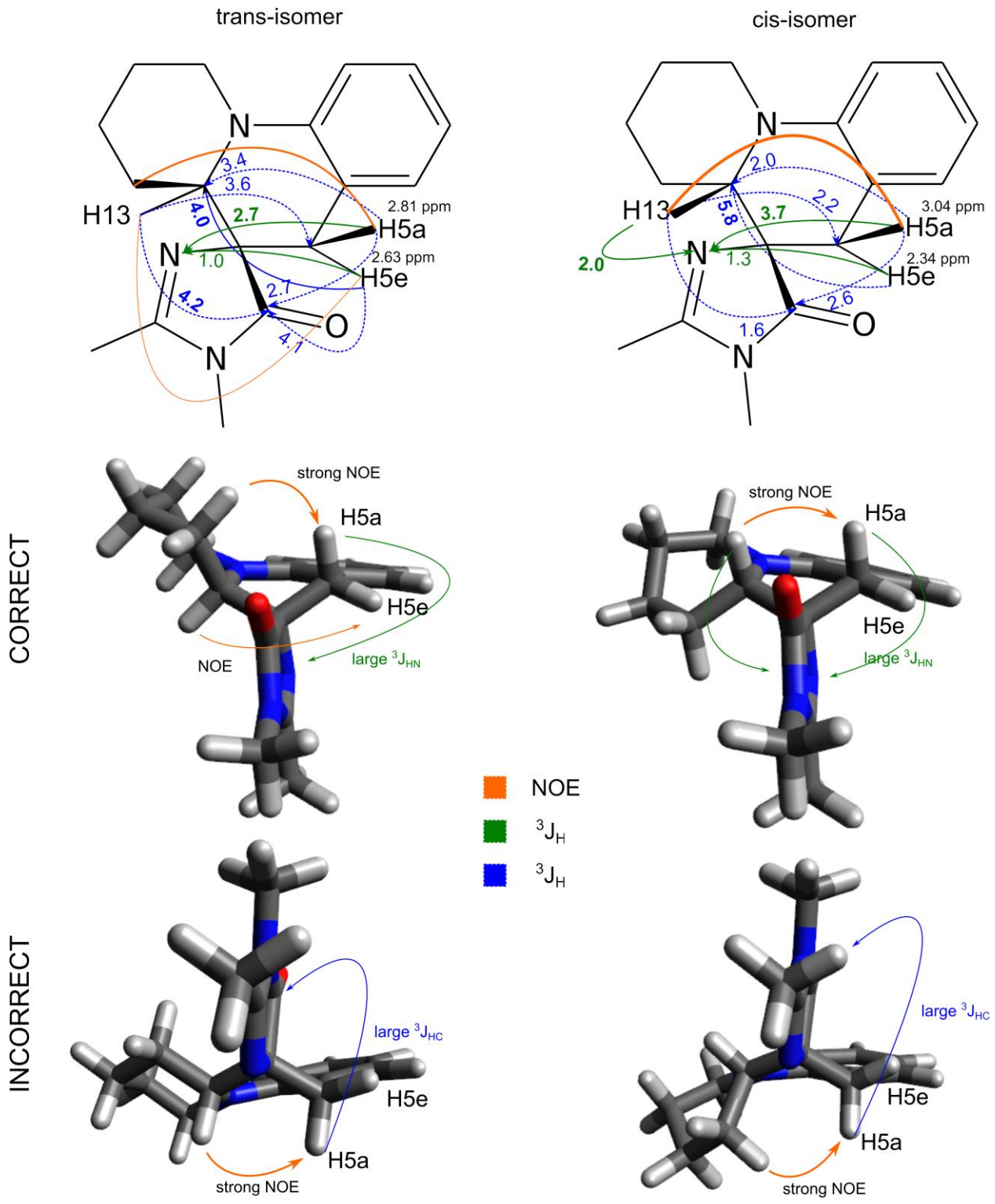


Fig. S3: Conformational analysis of **2l** isomers. on top - key NMR data (3JHN, 3JHC and NOE contacts are plotted on the structure of **2l**. Below, four possible conformations of **2l** isomers are shown, with predicted NMR parameters.

10. References.

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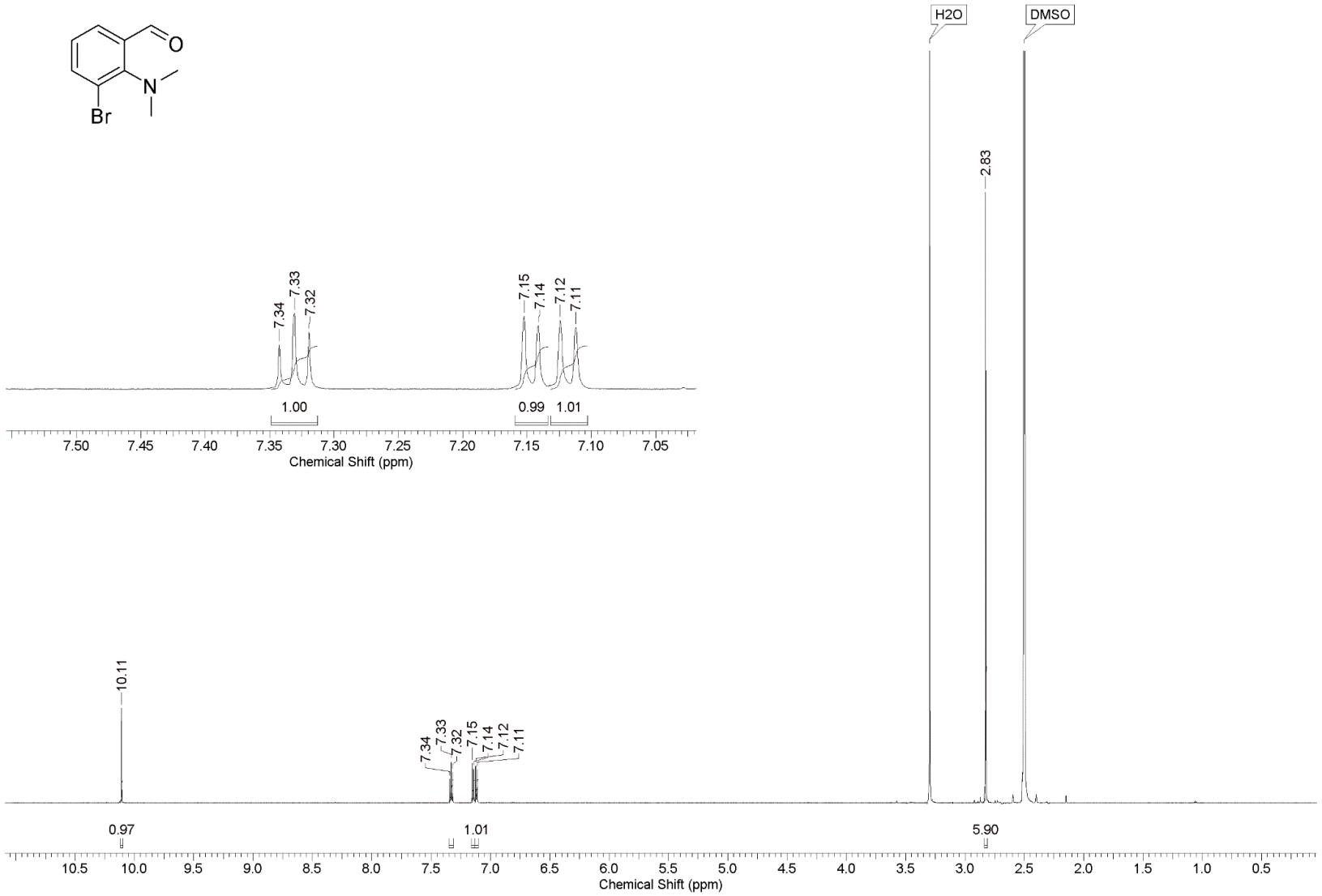
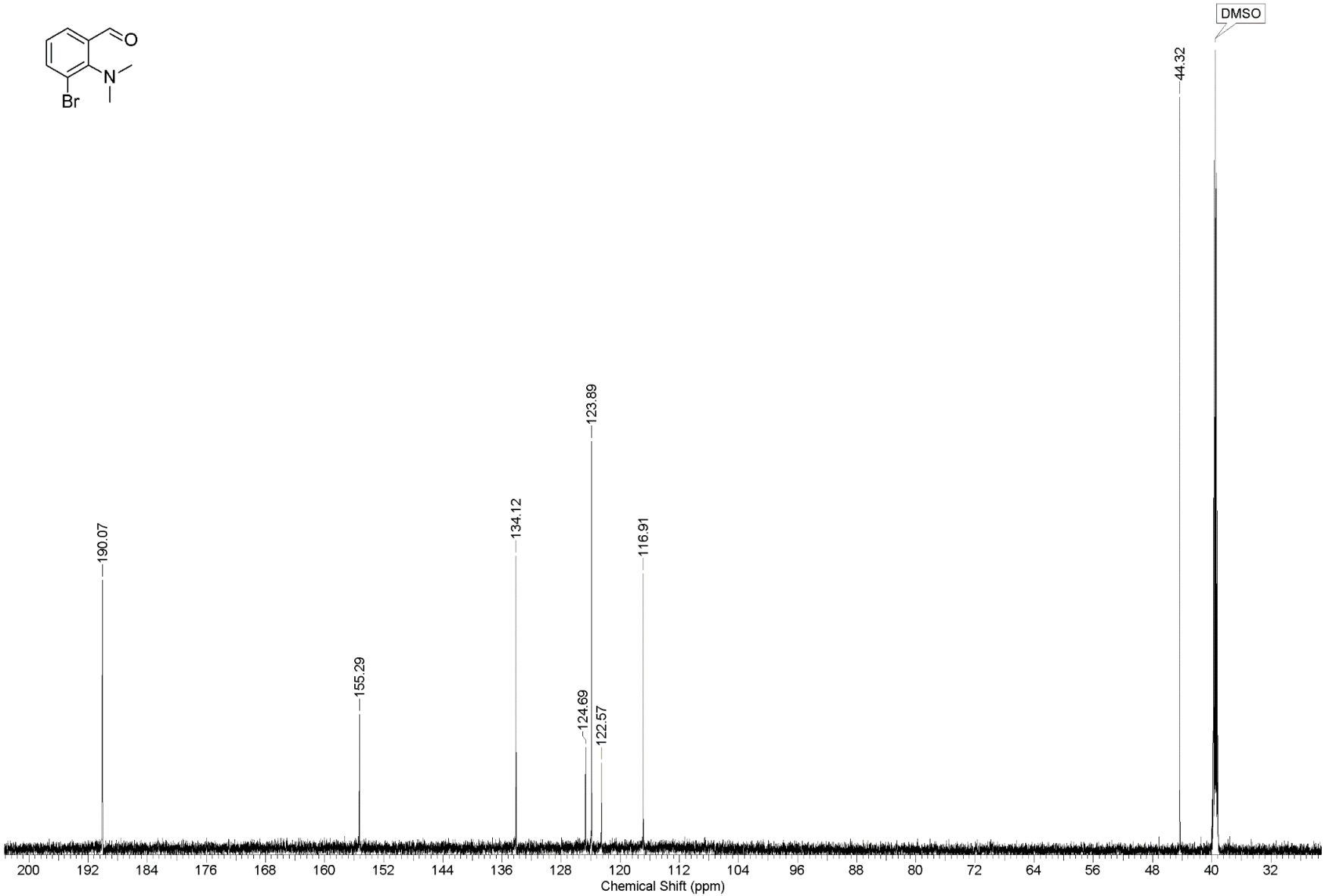
11. Copies of ^{1}H and ^{13}C NMR spectra

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Br
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190.07
155.29
134.12
124.69
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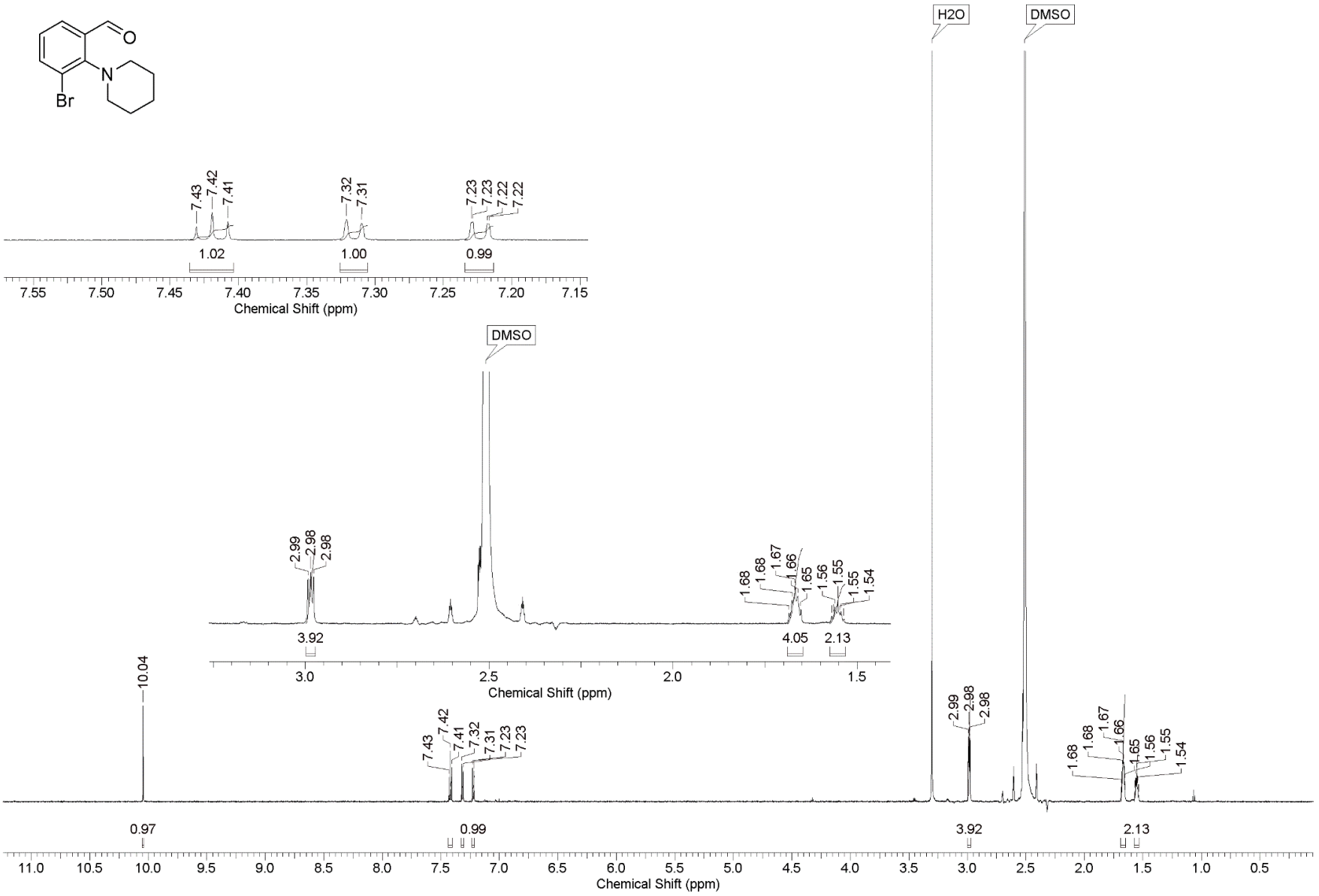
122.57
116.91
200
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
Chemical Shift (ppm)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N
Br
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7.42
7.41
7.32
7.31
7.23
7.23
7.22
7.22
1.02
1.00
0.99
7.55 7.50 7.45 7.40 7.35 7.30 7.25 7.20 7.15
Chemical Shift (ppm)
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2.98
2.98
1.68
1.68
1.67
1.66
1.65
1.56
1.55
1.55
1.54
3.92
4.05
2.13
3.0 2.5 2.0 1.5
Chemical Shift (ppm)
H2O
DMSO
10.04
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7.41
7.32
7.31
7.23
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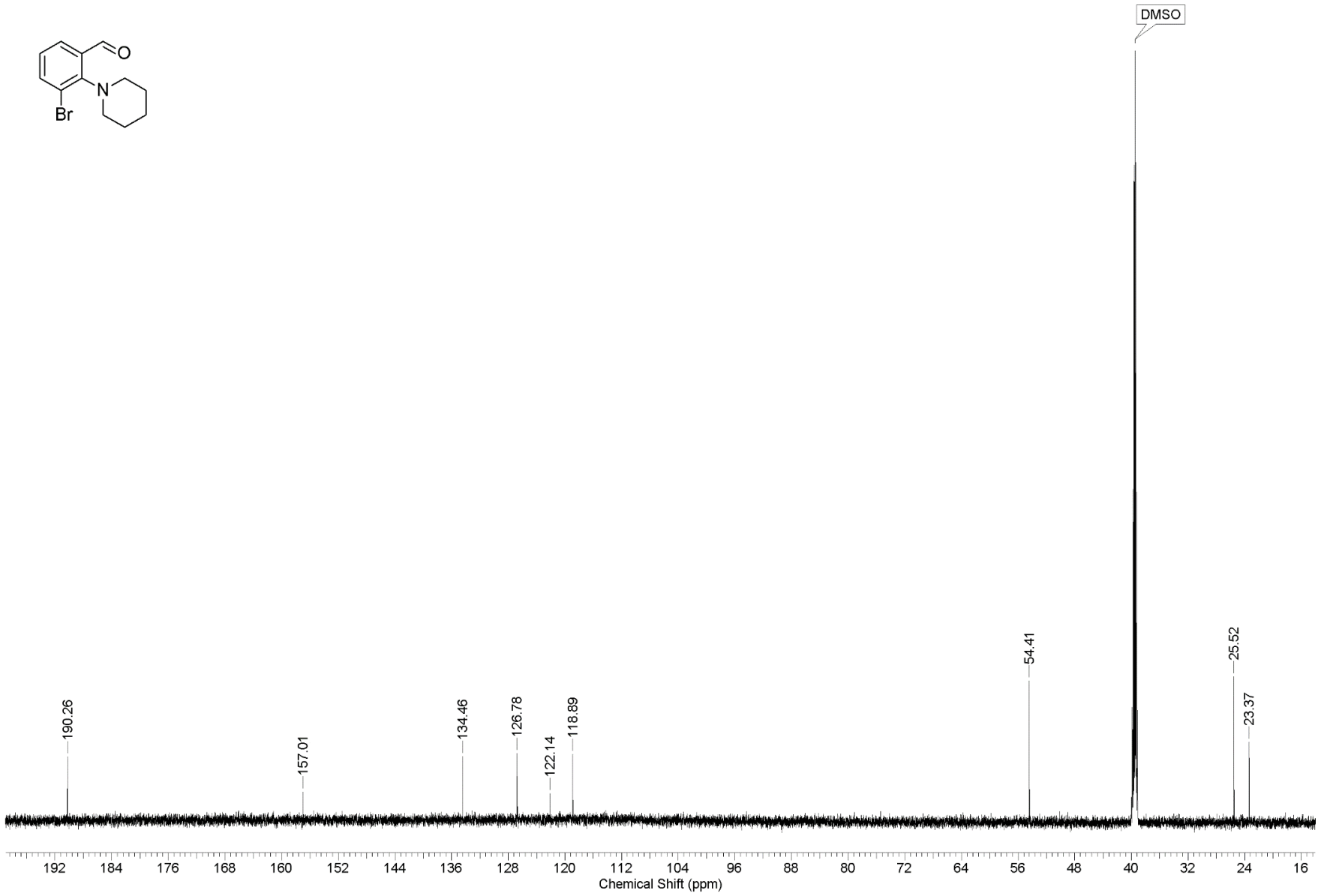
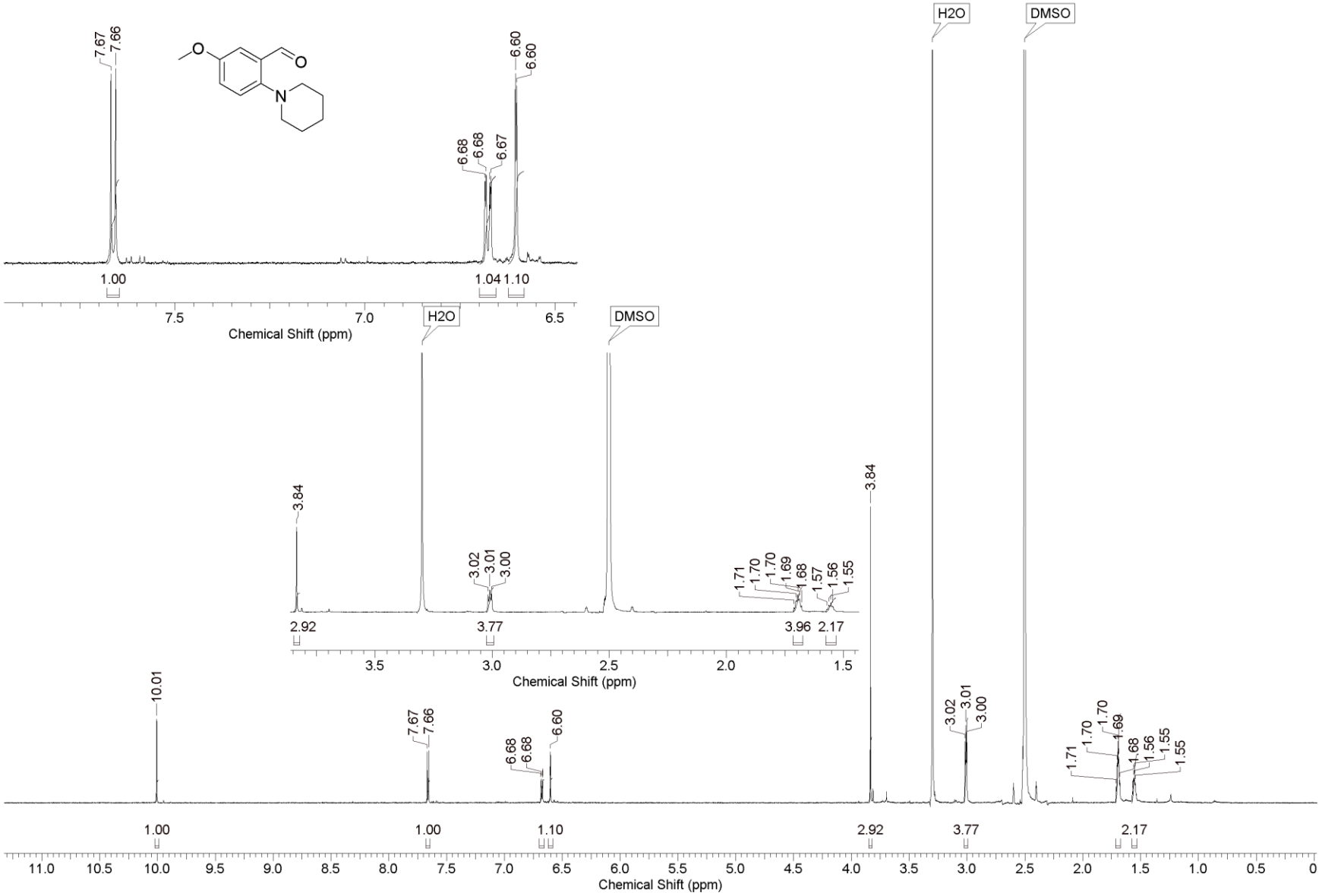
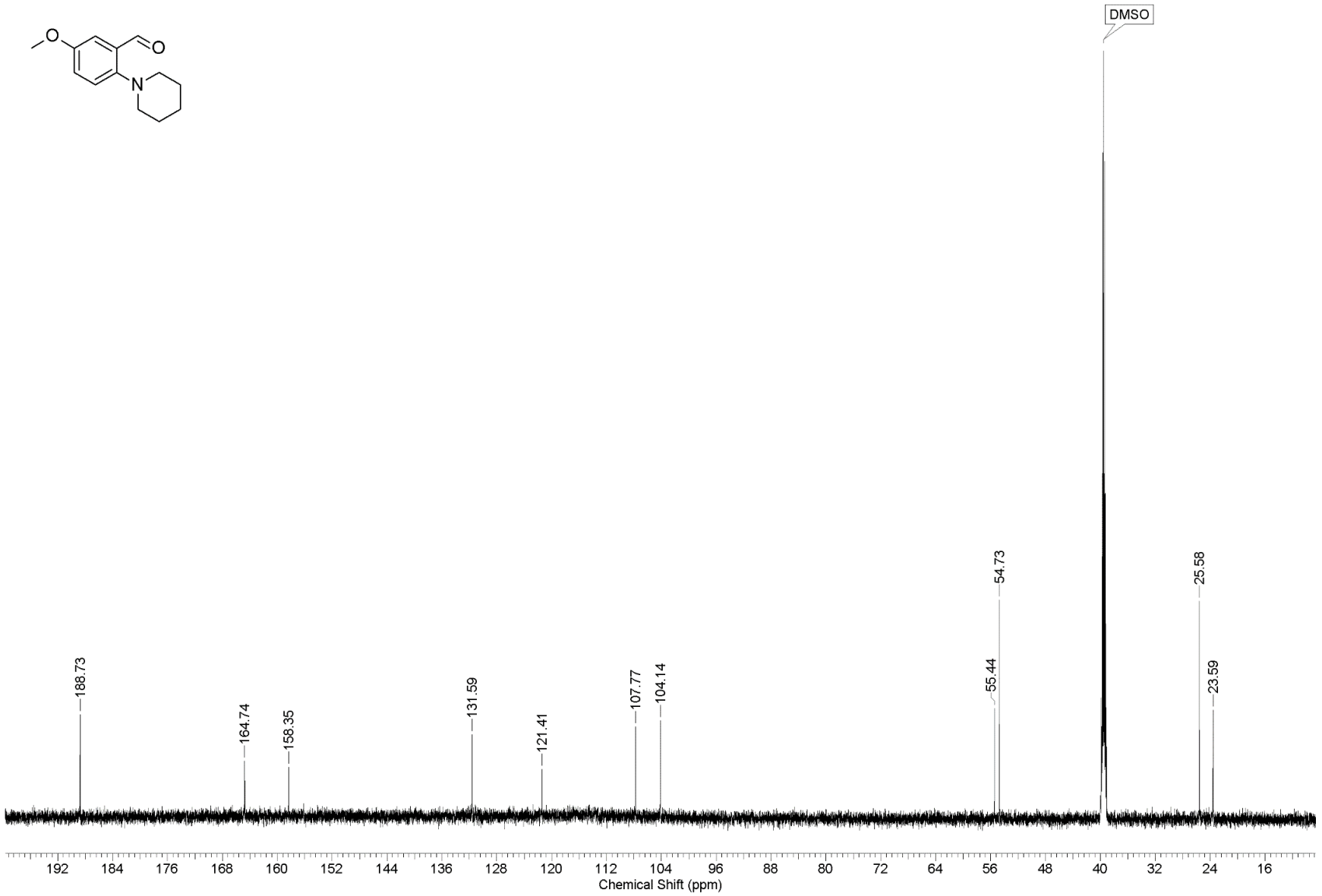
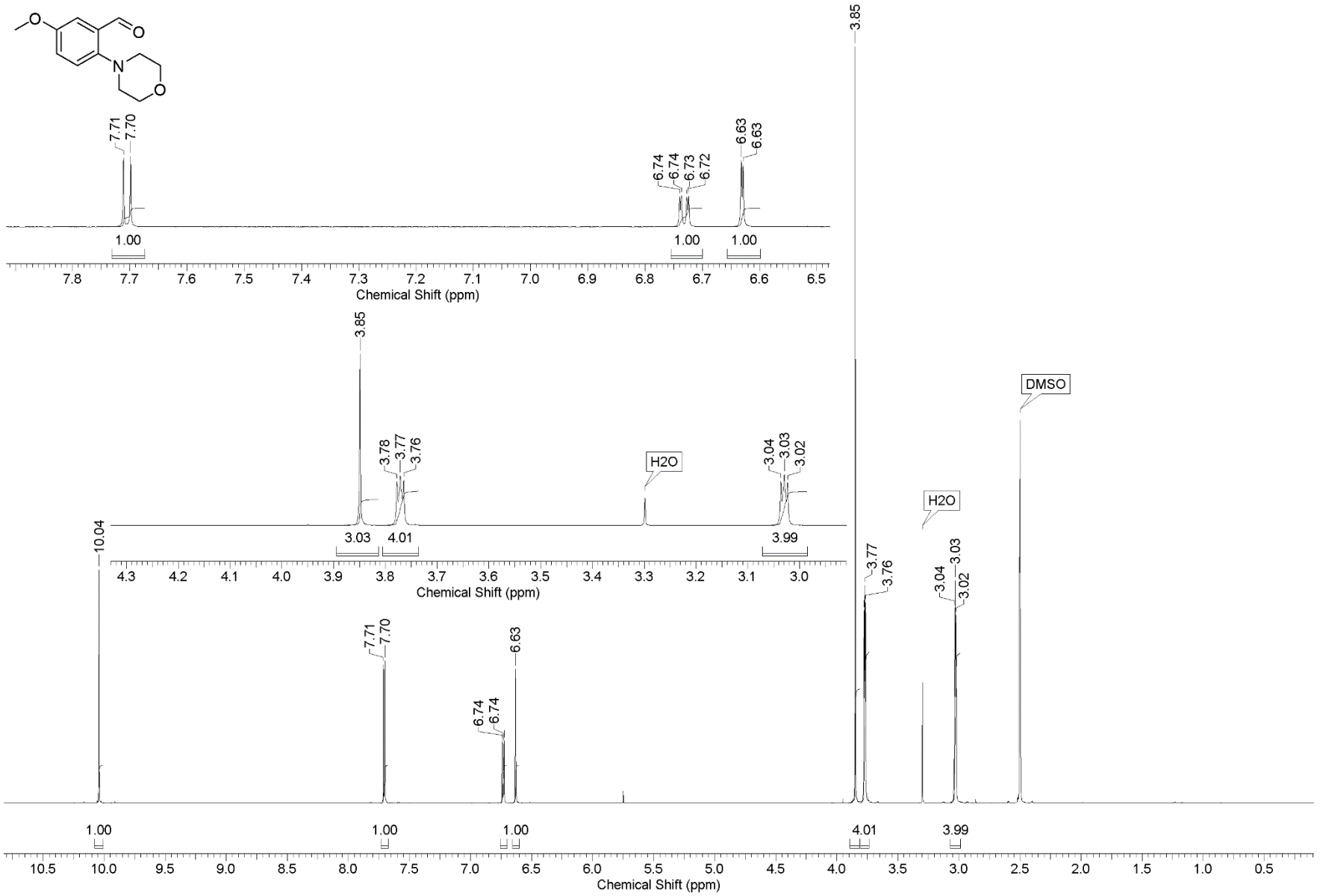
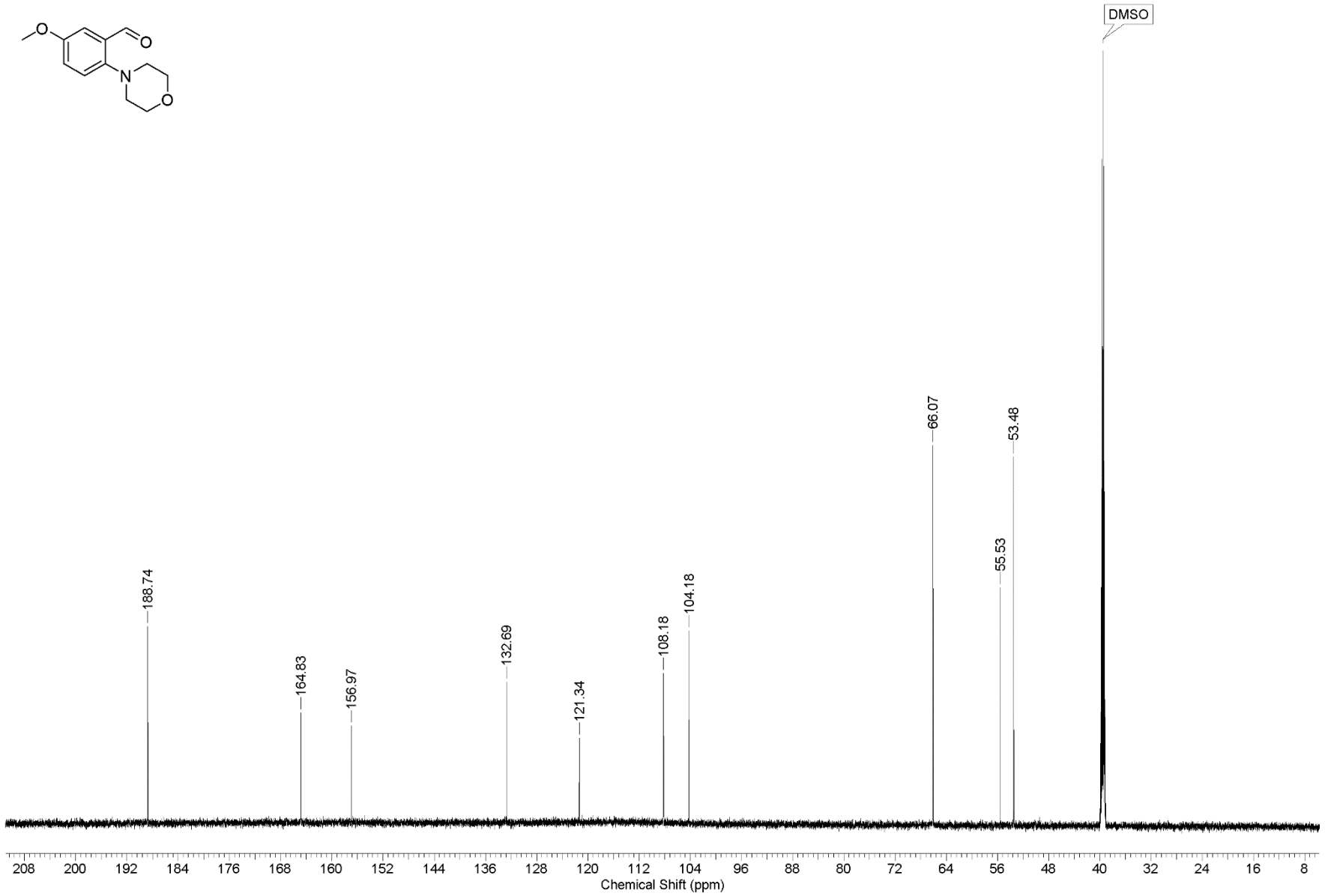
3.92
2.13
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
Chemical Shift (ppm)

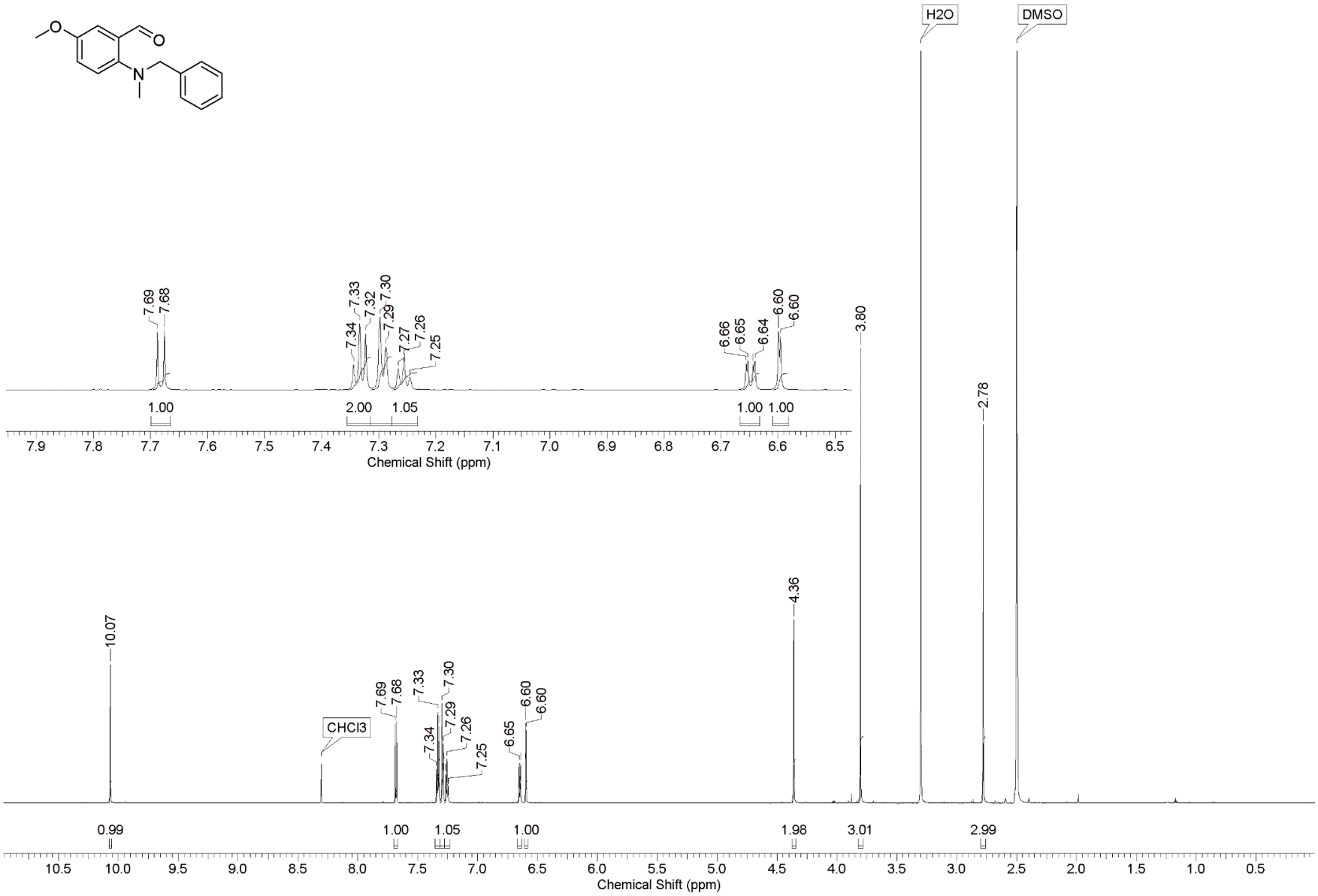

O
N
Br
DMSO
190.26
157.01
134.46
126.78
122.14
118.89
54.41
25.52
23.37
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

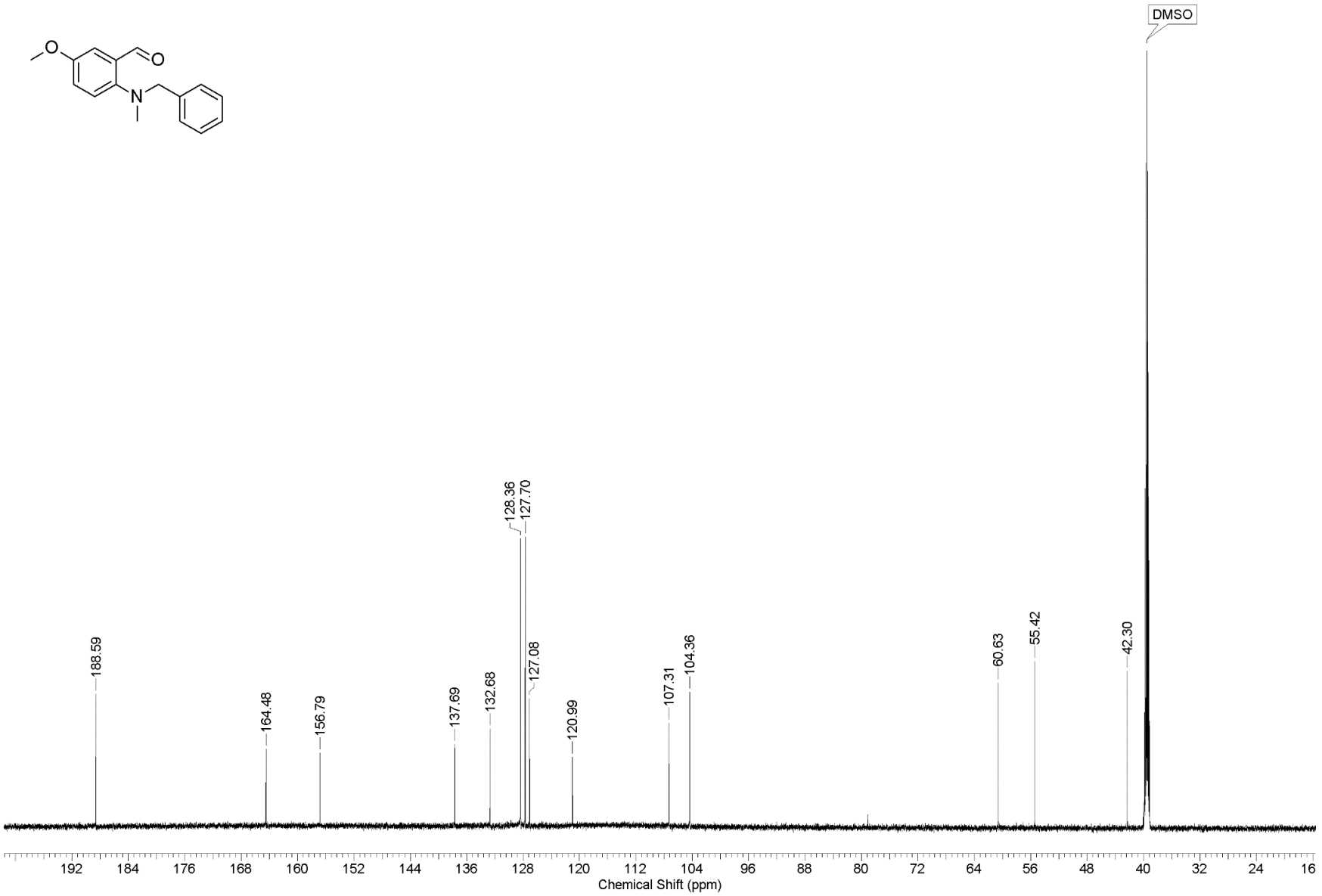

H2O
DMSO
7.67
7.66
6.68
6.68
6.67
6.60
6.60
1.00
1.04
1.10
7.5
7.0
6.5
Chemical Shift (ppm)
3.84
3.02
3.01
3.00
1.71
1.70
1.70
1.69
1.68
1.57
1.56
1.55
2.92
3.77
3.96
2.17
3.5
3.0
2.5
2.0
1.5
Chemical Shift (ppm)
10.01
1.00
1.00
1.10
2.92
3.77
2.17
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Chemical Shift (ppm)

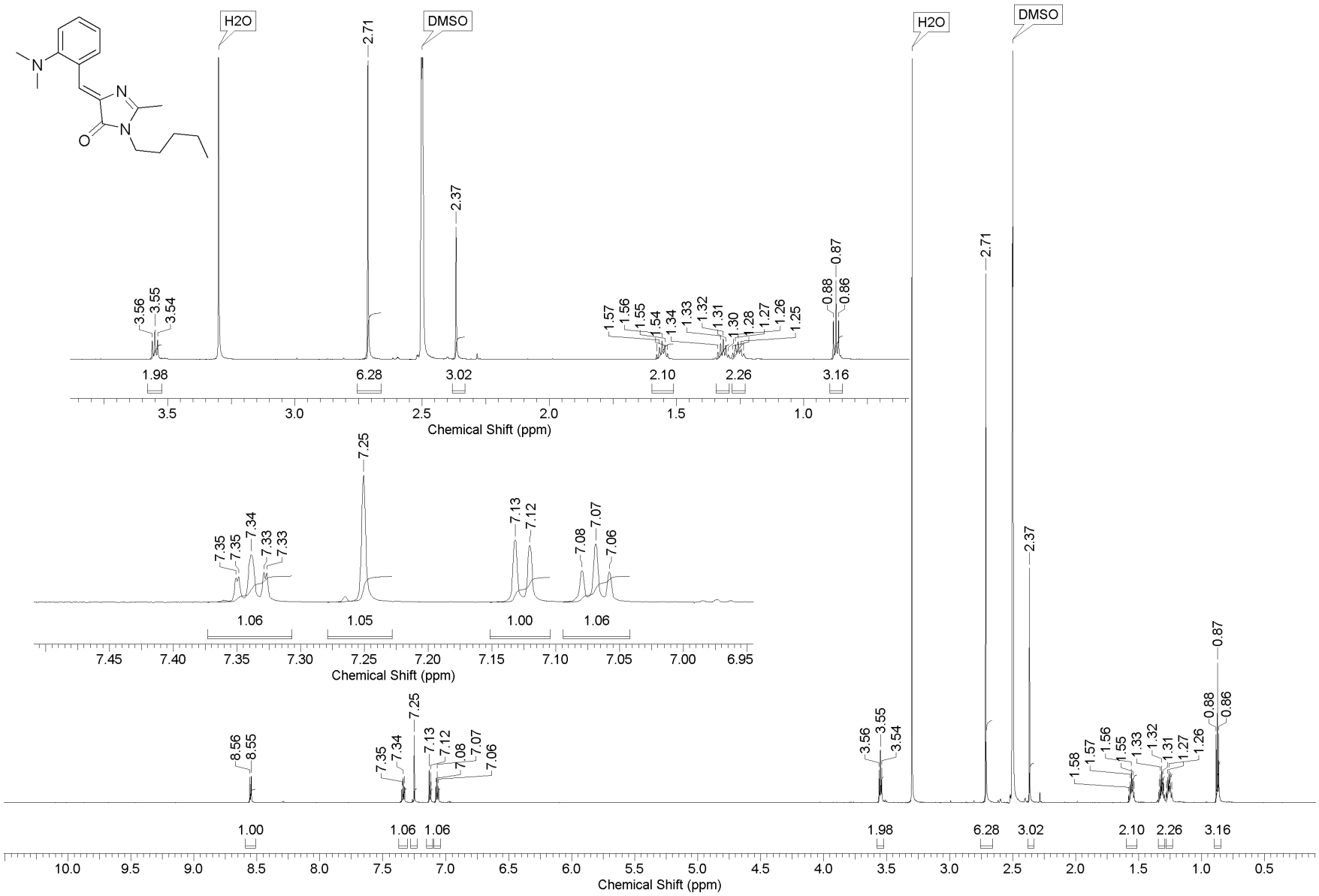

O
O
N
DMSO
188.73
164.74
158.35
131.59
121.41
107.77
104.14
55.44
54.73
25.58
23.59
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

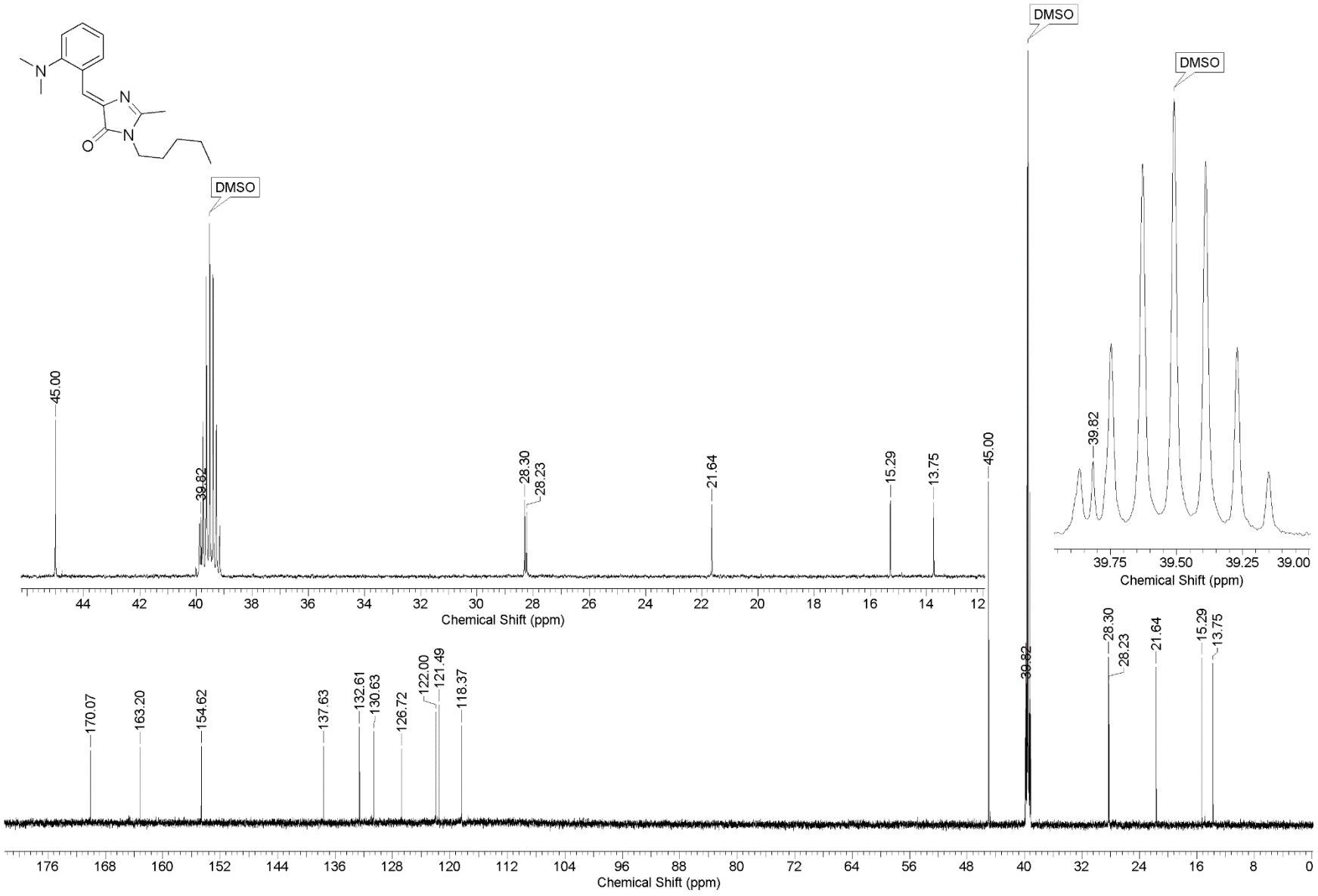

O
O
N
O
7.71
7.70
6.74
6.74
6.73
6.72
6.63
6.63
1.00
1.00
1.00
7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8 6.7 6.6 6.5
Chemical Shift (ppm)
3.85
3.78
3.77
3.76
H2O
3.04
3.03
3.02
10.04
3.03
4.01
3.99
4.3 4.2 4.1 4.0 3.9 3.8 3.7 3.6 3.5 3.4 3.3 3.2 3.1 3.0
Chemical Shift (ppm)
7.71
7.70
6.74
6.74
6.63
3.85
3.77
3.76
H2O
3.04
3.03
3.02
DMSO
1.00
1.00
1.00
4.01
3.99
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
Chemical Shift (ppm)

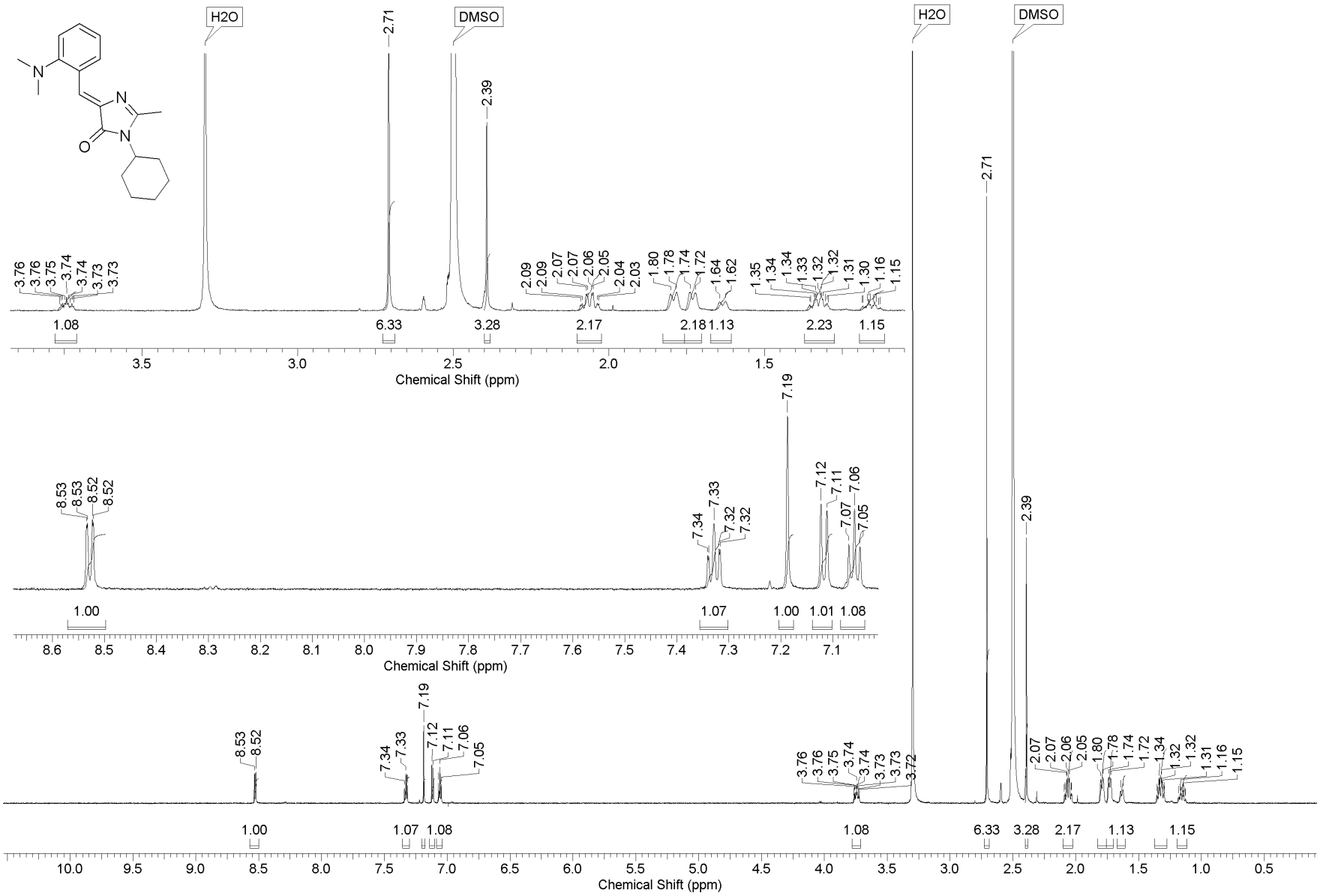

O
O
N
O
DMSO
188.74
164.83
156.97
132.69
121.34
108.18
104.18
66.07
55.53
53.48
208 200 192 184 176 168 160 152 144 136 128 120 112 104 96 88 80 72 64 56 48 40 32 24 16 8
Chemical Shift (ppm)

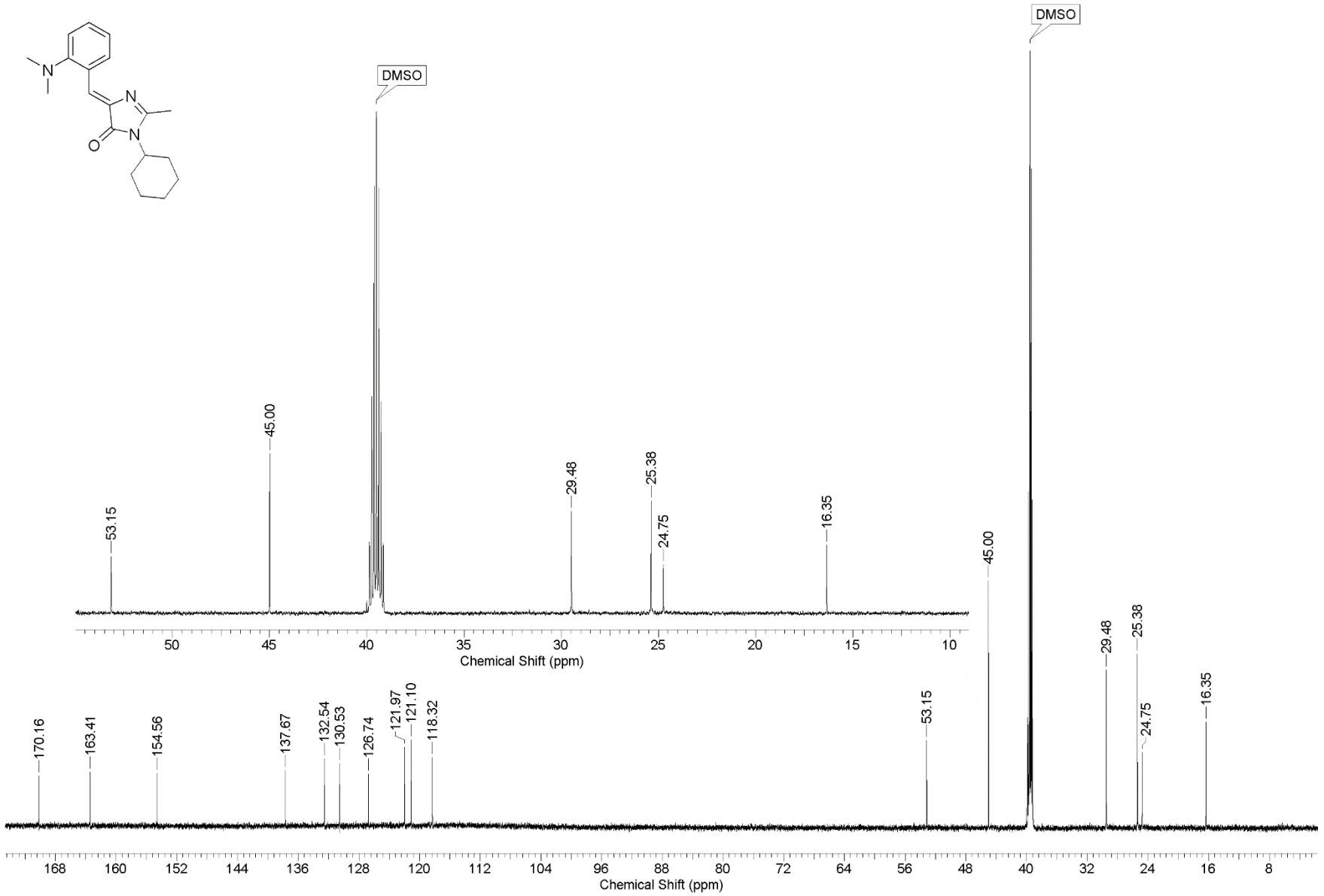

H2O
DMSO
CHCl3
10.07
7.69
7.68
7.34
7.33
7.32
7.30
7.29
7.27
7.26
7.25
6.66
6.65
6.64
6.60
6.60
4.36
3.80
2.78
0.99
1.00
1.05
2.00
1.05
1.00
1.00
1.00
1.98
3.01
2.99
Chemical Shift (ppm)
Chemical Shift (ppm)

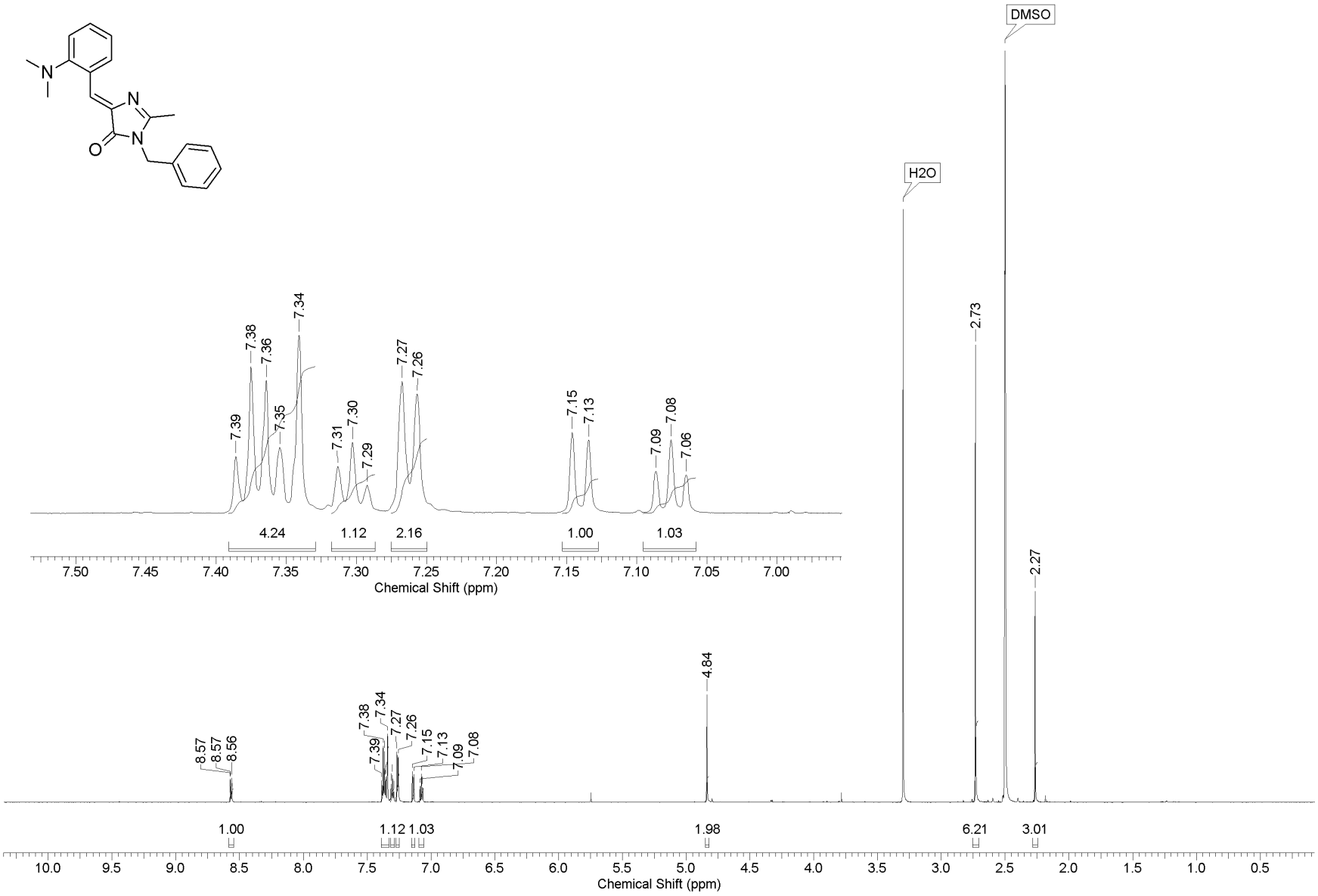

O
O
N
DMSO
188.59
164.48
156.79
137.69
132.68
128.36
127.70
127.08
120.99
107.31
104.36
60.63
55.42
42.30
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

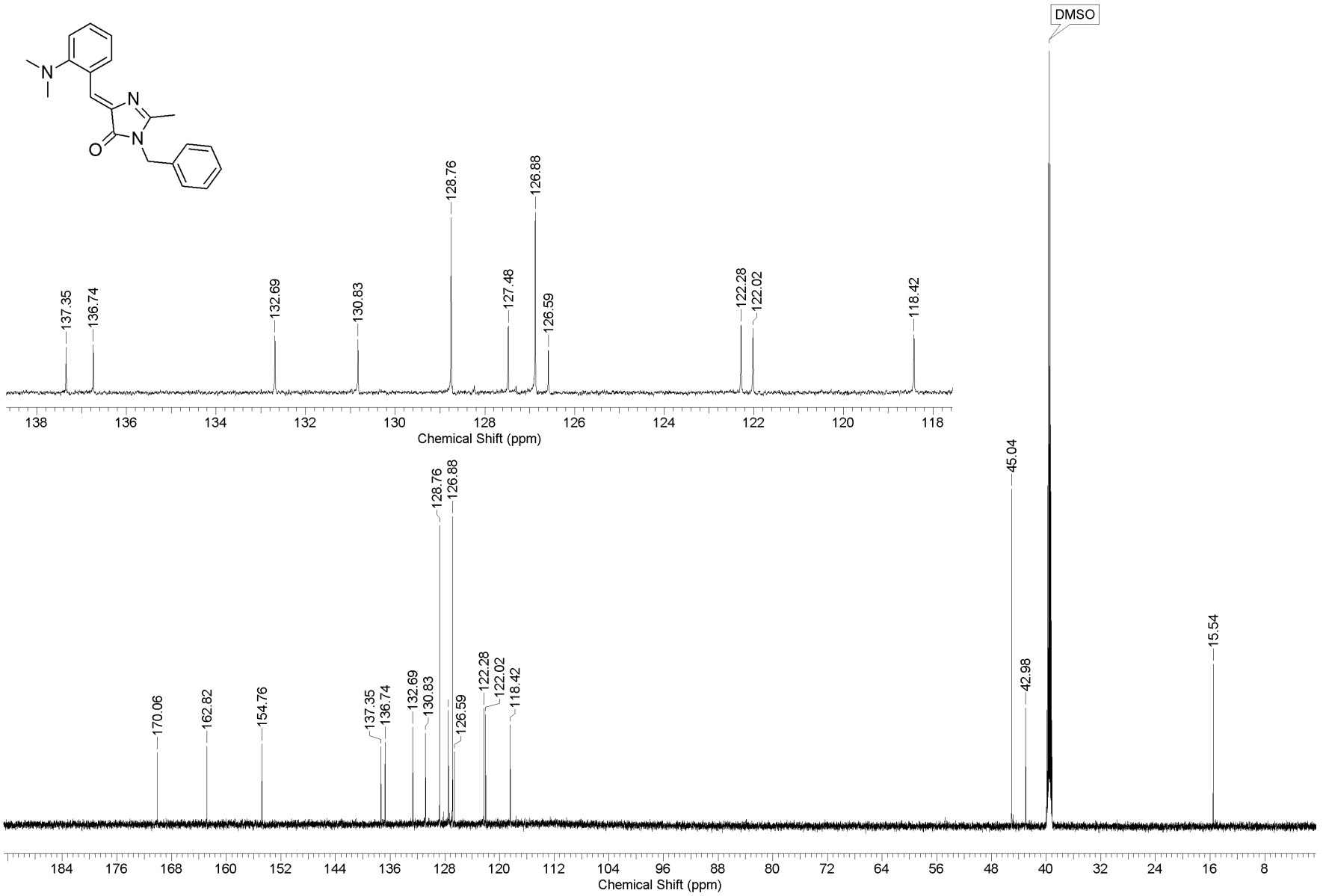

H2O
DMSO
2.71
2.37
0.87
0.88
0.86
3.56
3.55
3.54
1.57
1.56
1.55
1.54
1.34
1.33
1.32
1.31
1.30
1.28
1.27
1.26
1.25
1.98
6.28
3.02
2.10
2.26
3.16
Chemical Shift (ppm)
7.25
7.35
7.35
7.34
7.33
7.33
7.13
7.12
7.08
7.07
7.06
1.06
1.05
1.00
1.06
Chemical Shift (ppm)
8.56
8.55
7.35
7.34
7.25
7.13
7.12
7.08
7.07
7.06
1.00
1.06
1.06
Chemical Shift (ppm)

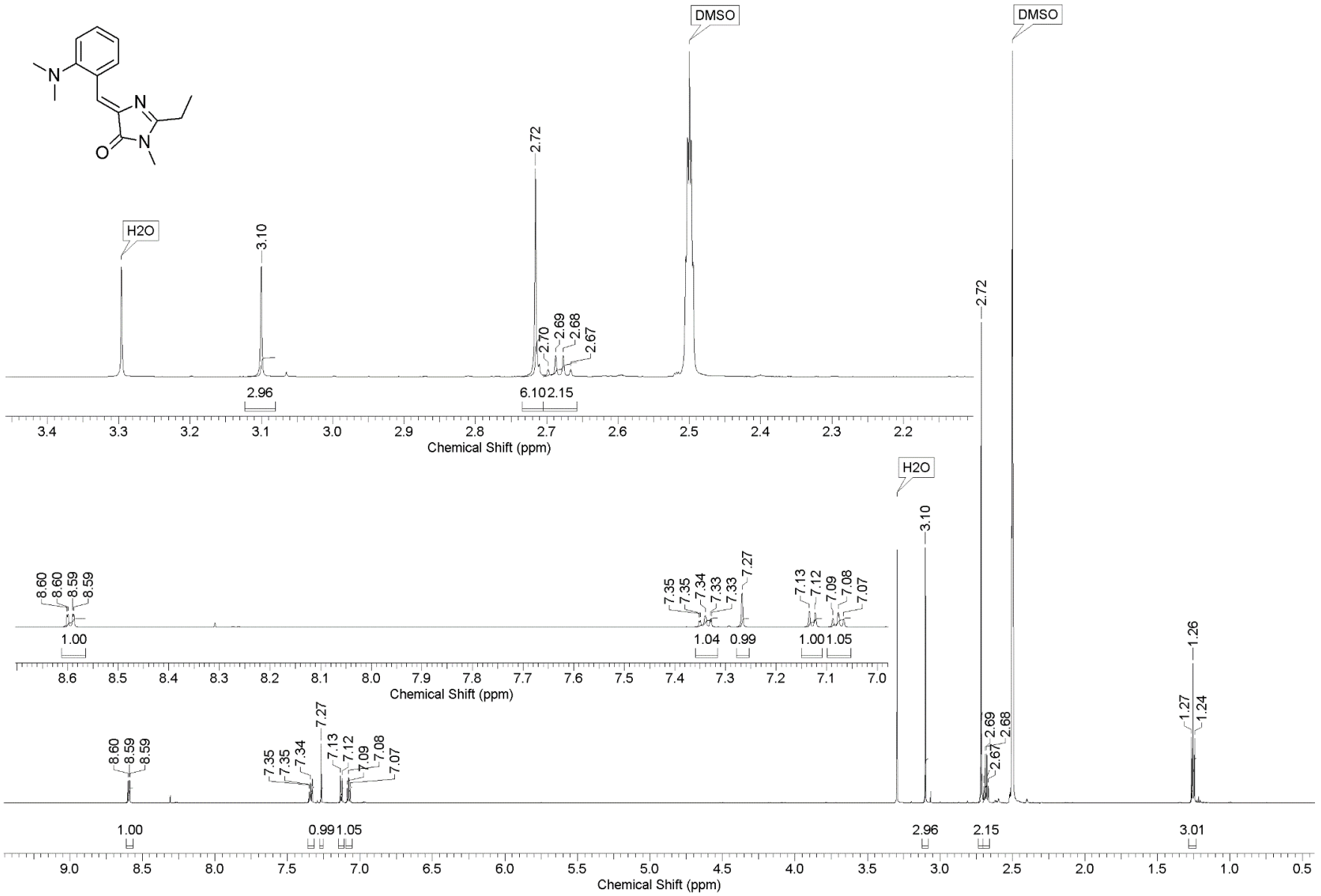

DMSO
DMSO
DMSO
45.00
39.82
28.30
28.23
21.64
15.29
13.75
45.00
39.82
28.30
28.23
21.64
15.29
13.75
170.07
163.20
154.62
137.63
132.61
130.63
126.72
122.00
121.49
118.37
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)

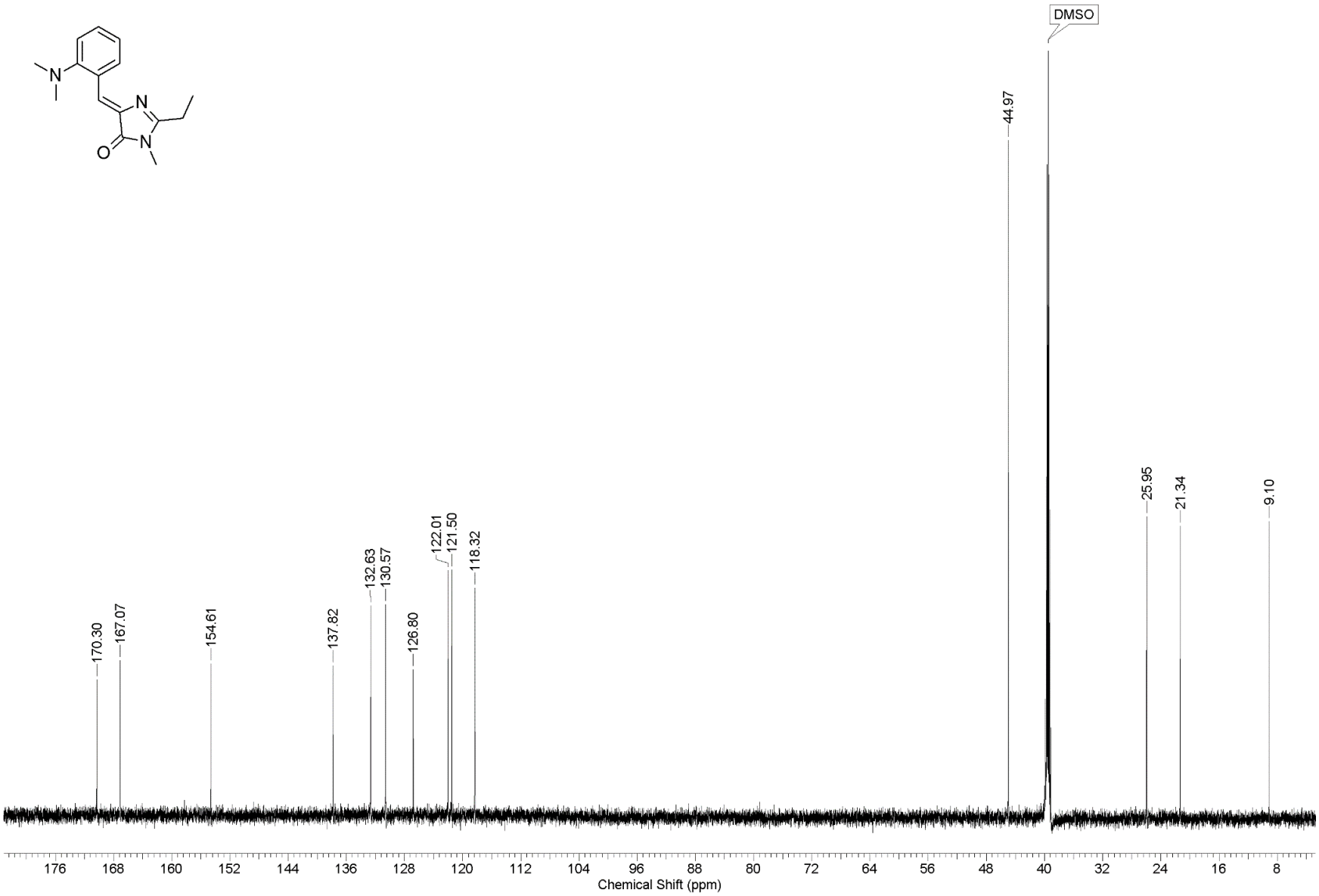

H2O
2.71
DMSO
2.39
Chemical Shift (ppm)
7.19
8.53
8.52
7.34
7.33
7.32
7.12
7.11
7.06
7.07
7.05
3.76
3.75
3.74
3.73
3.72
2.09
2.07
2.06
2.05
2.04
2.03
1.80
1.78
1.74
1.72
1.64
1.62
1.35
1.34
1.33
1.32
1.31
1.30
1.16
1.15

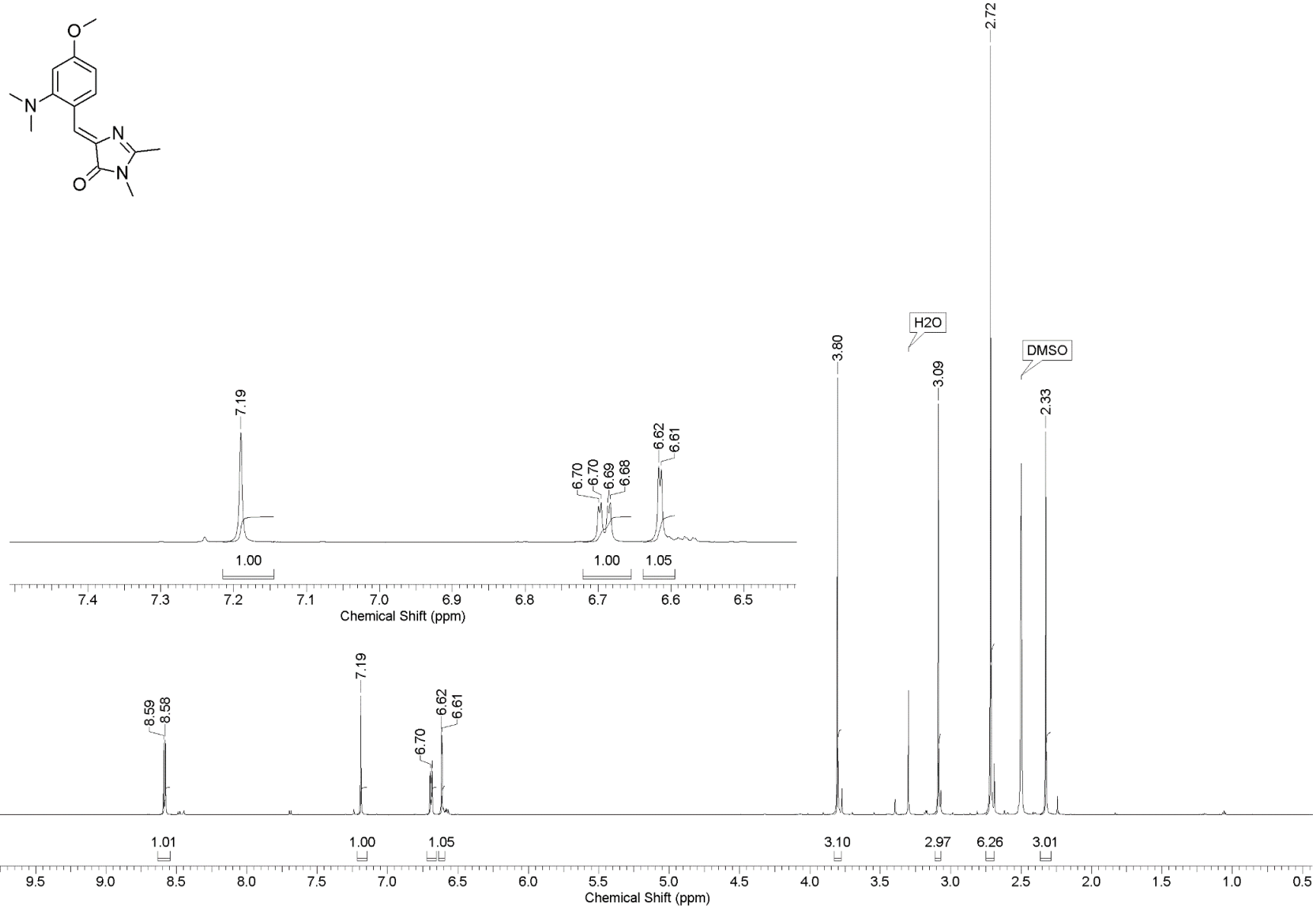

DMSO
DMSO
45.00
53.15
29.48
25.38
24.75
16.35
Chemical Shift (ppm)
45.00
53.15
29.48
25.38
24.75
16.35
170.16
163.41
154.56
137.67
132.54
130.53
126.74
121.97
121.10
118.32
Chemical Shift (ppm)

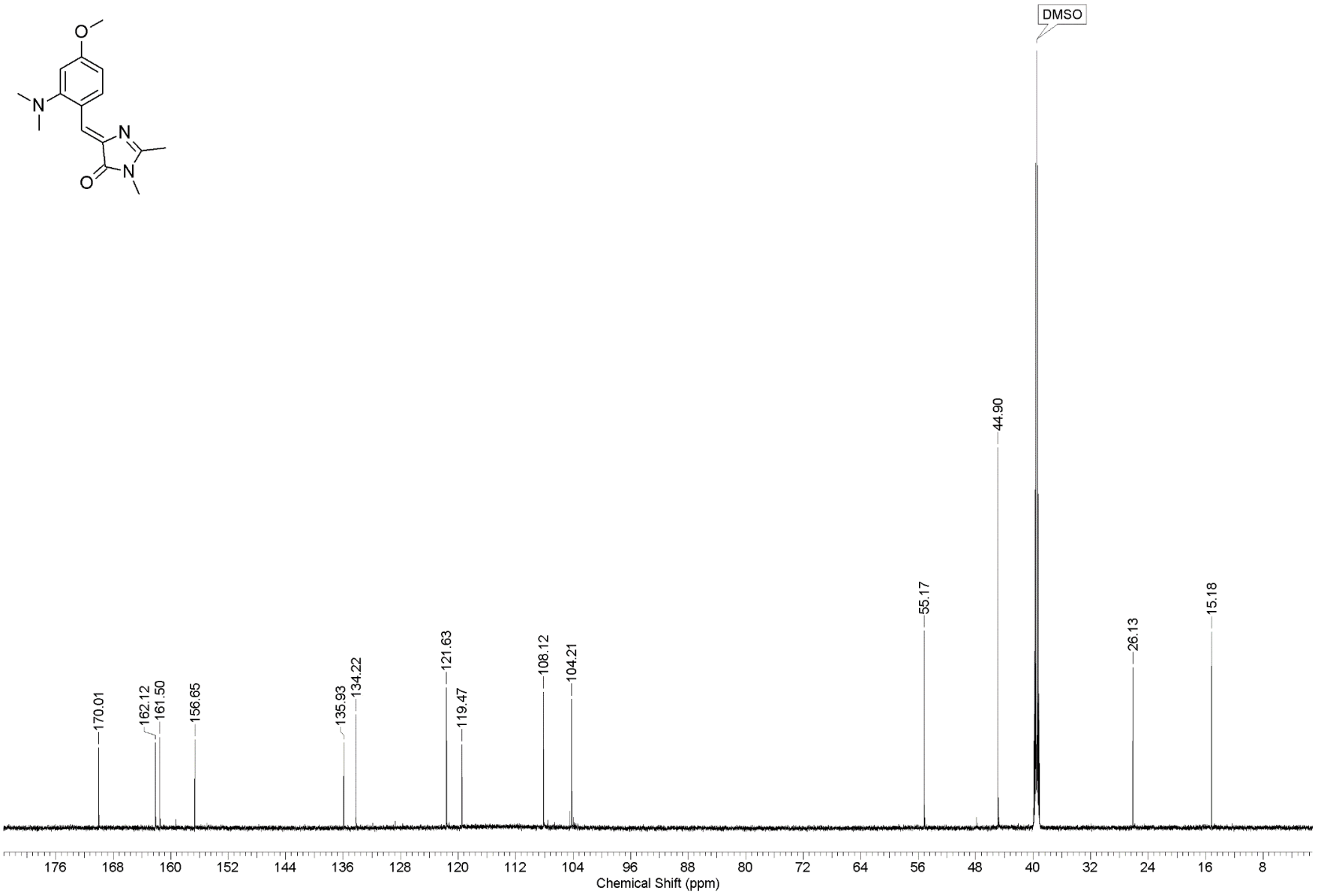

DMSO
H2O
2.73
2.27
4.84
7.39
7.38
7.36
7.35
7.34
7.31
7.30
7.29
7.27
7.26
7.15
7.13
7.09
7.08
7.06
8.57
8.57
8.56
4.24
1.12
2.16
1.00
1.03
1.00
1.12
1.03
1.98
6.21
3.01
Chemical Shift (ppm)
Chemical Shift (ppm)

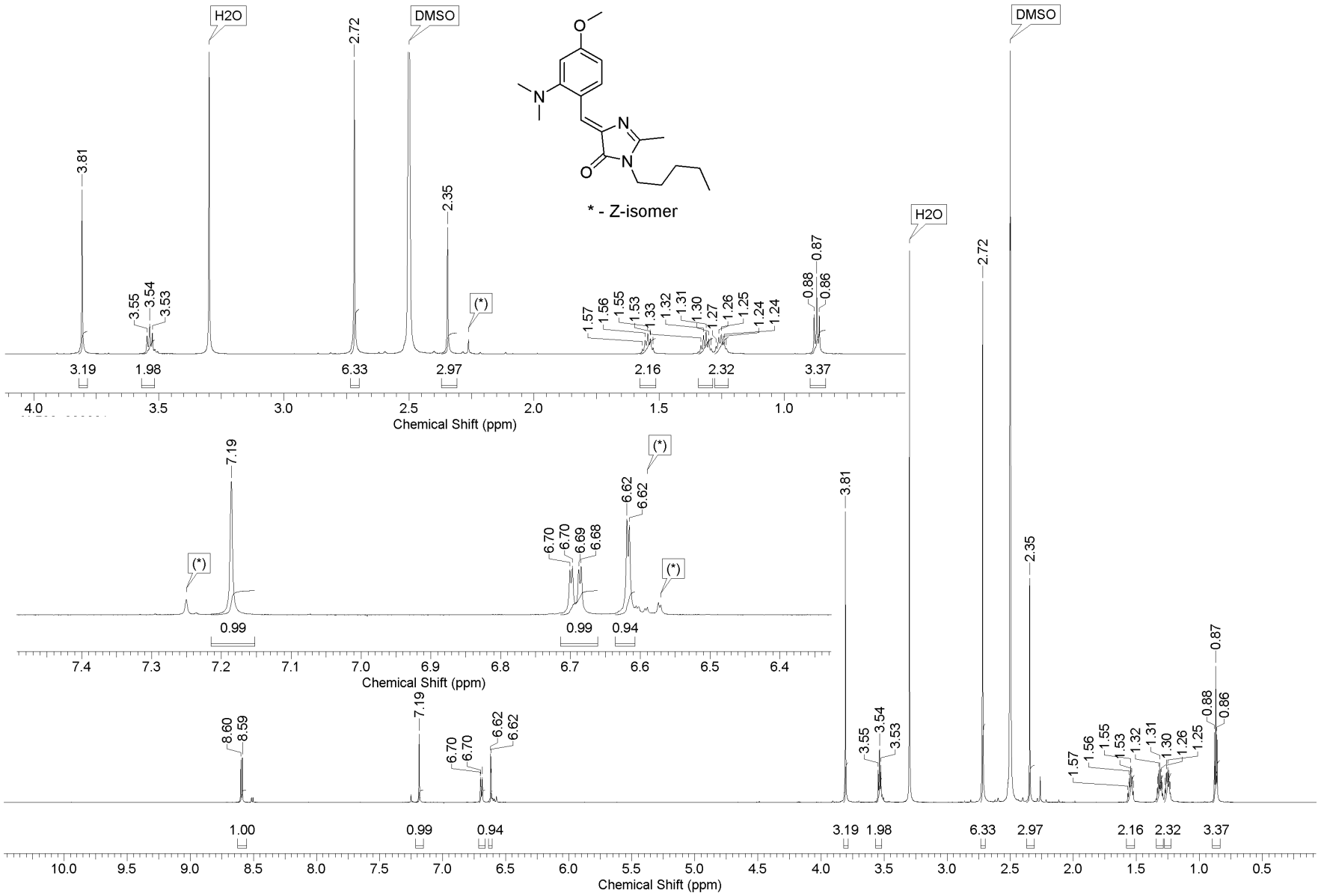

DMSO
128.76
126.88
137.35
136.74
132.69
130.83
127.48
126.59
122.28
122.02
118.42
138
136
134
132
130
128
126
124
122
120
118
Chemical Shift (ppm)
45.04
15.54
42.98
170.06
162.82
154.76
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

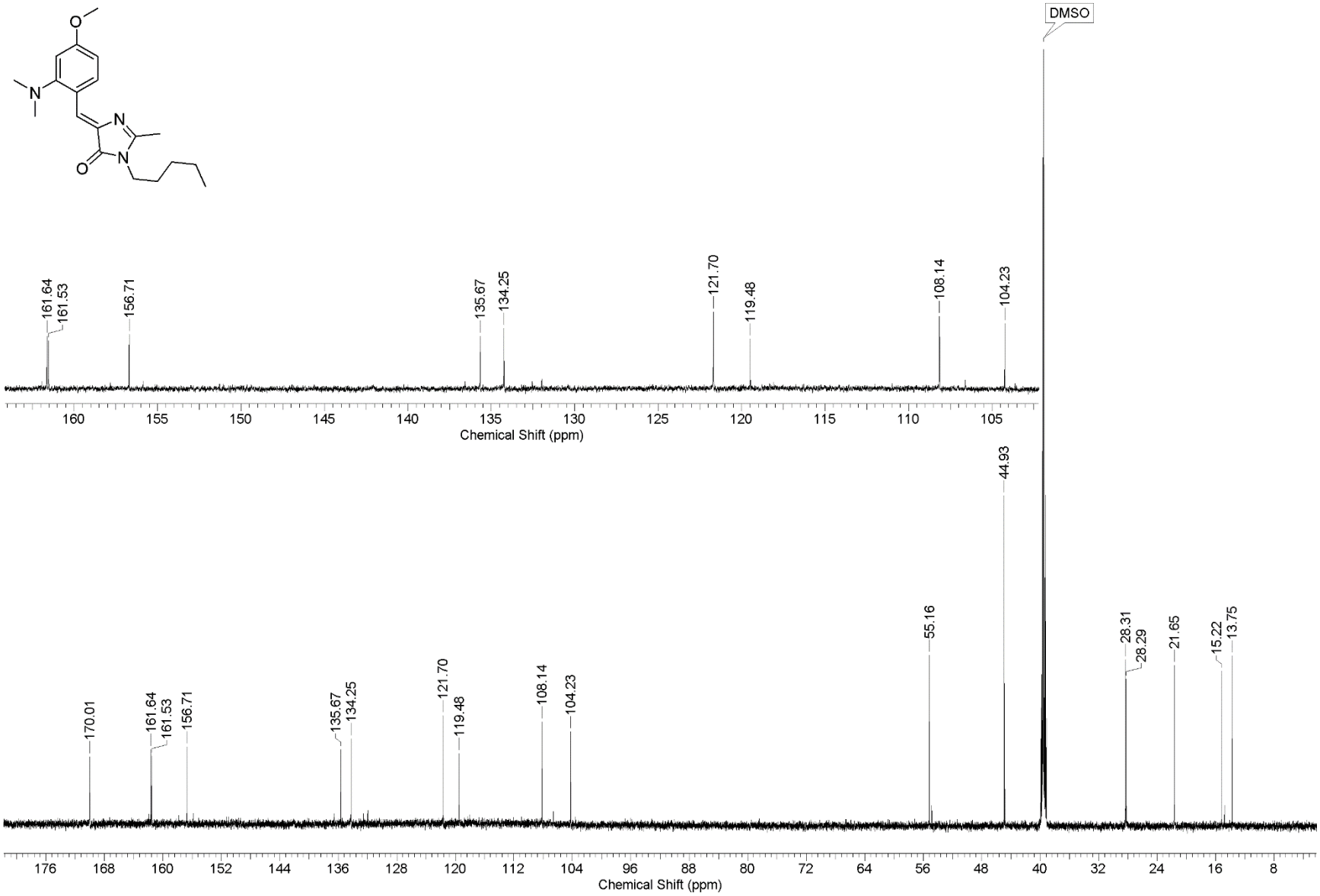

DMSO
DMSO
H2O
3.10
2.72
2.70
2.69
2.68
2.67
2.96
6.10
2.15
Chemical Shift (ppm)
H2O
3.10
2.72
8.60
8.60
8.59
8.59
7.35
7.35
7.34
7.33
7.33
7.27
7.13
7.12
7.09
7.08
7.07
1.00
1.04
0.99
1.00
1.05
Chemical Shift (ppm)
1.26
1.27
1.24
2.69
2.68
8.60
8.59
8.59
7.35
7.35
7.34
7.27
7.13
7.12
7.09
7.08
7.07
1.00
0.99
1.05
2.96
2.15
3.01
Chemical Shift (ppm)

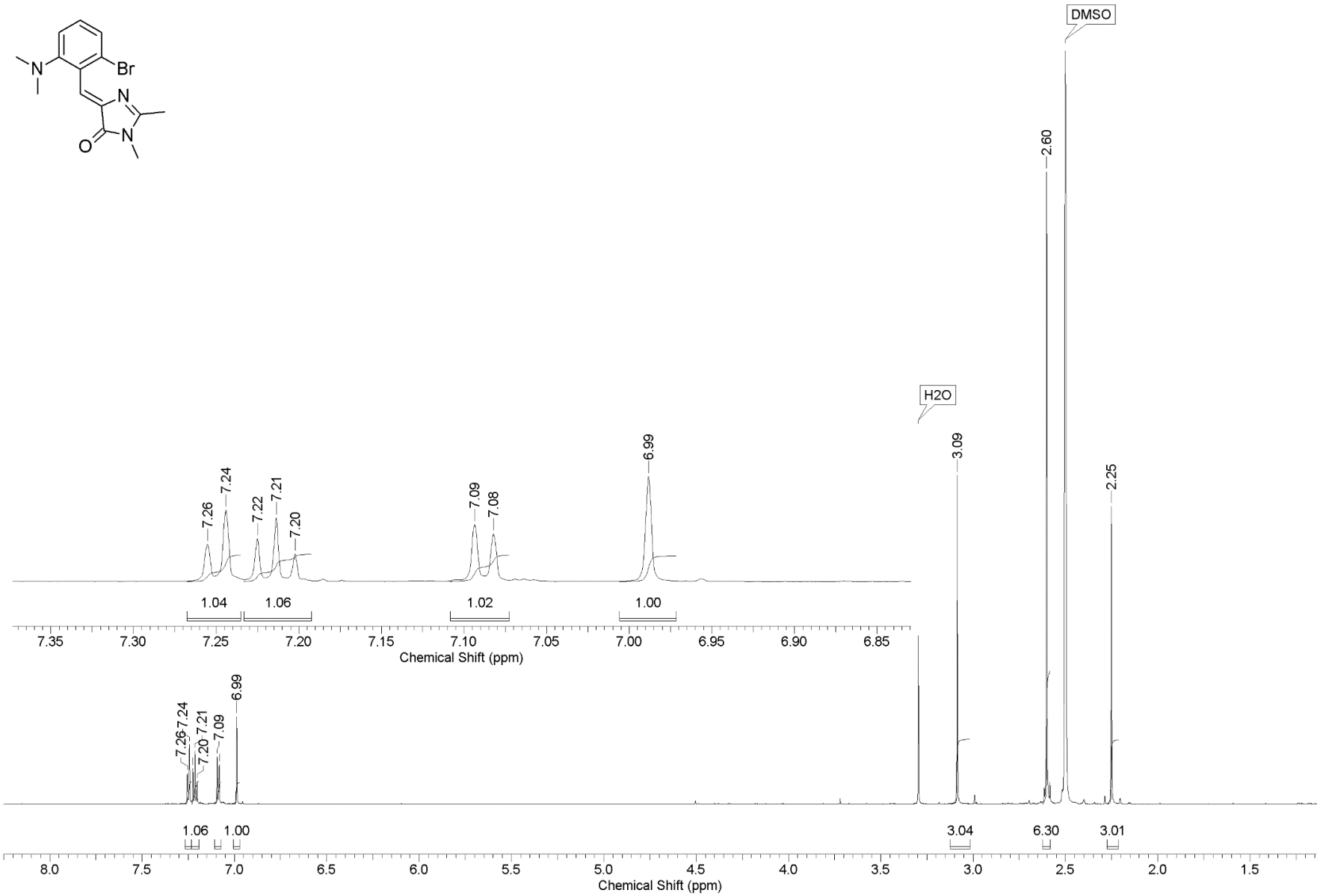

DMSO
44.97
25.95
21.34
9.10
170.30
167.07
154.61
137.82
132.63
130.57
126.80
122.01
121.50
118.32
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

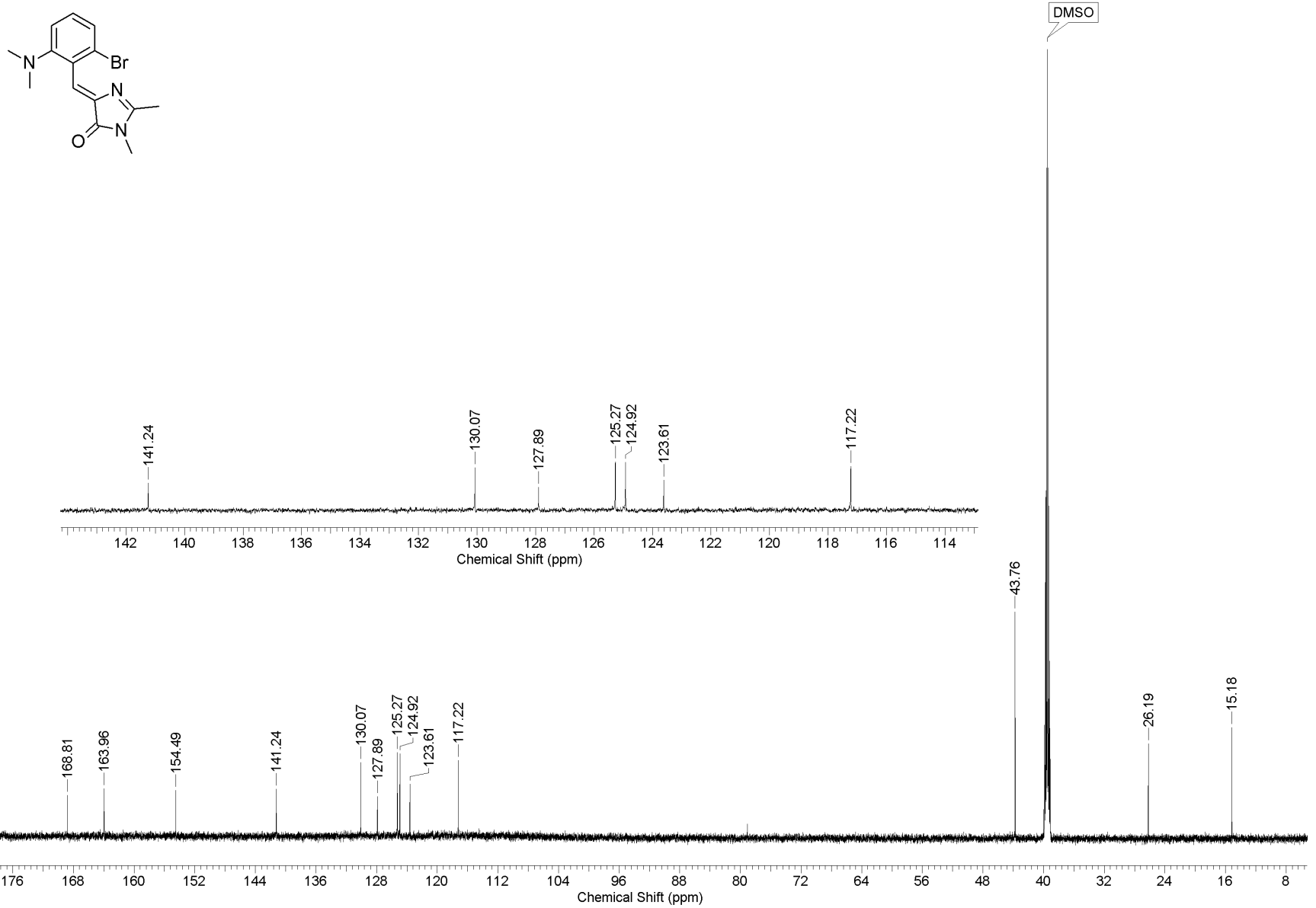

O
N
N
O
N
7.19
6.70
6.70
6.69
6.68
6.62
6.61
1.00
1.00
1.05
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
6.6
6.5
Chemical Shift (ppm)
2.72
H2O
3.80
3.09
DMSO
2.33
8.59
8.58
7.19
6.70
6.62
6.61
1.01
1.00
1.05
3.10
2.97
6.26
3.01
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Chemical Shift (ppm)

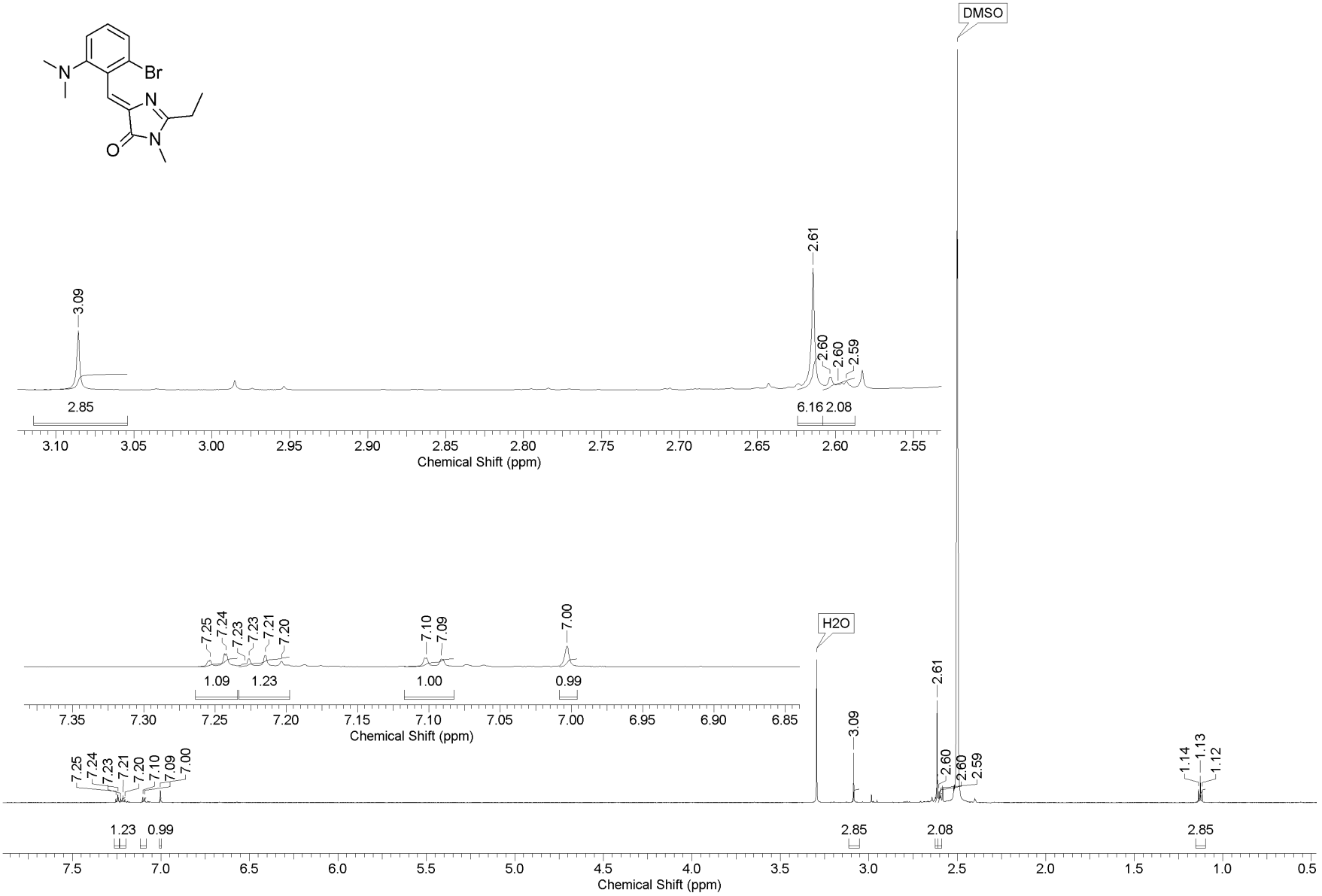

O
N
N
O
N
DMSO
170.01
162.12
161.50
156.65
135.93
134.22
121.63
119.47
108.12
104.21
55.17
44.90
26.13
15.18
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

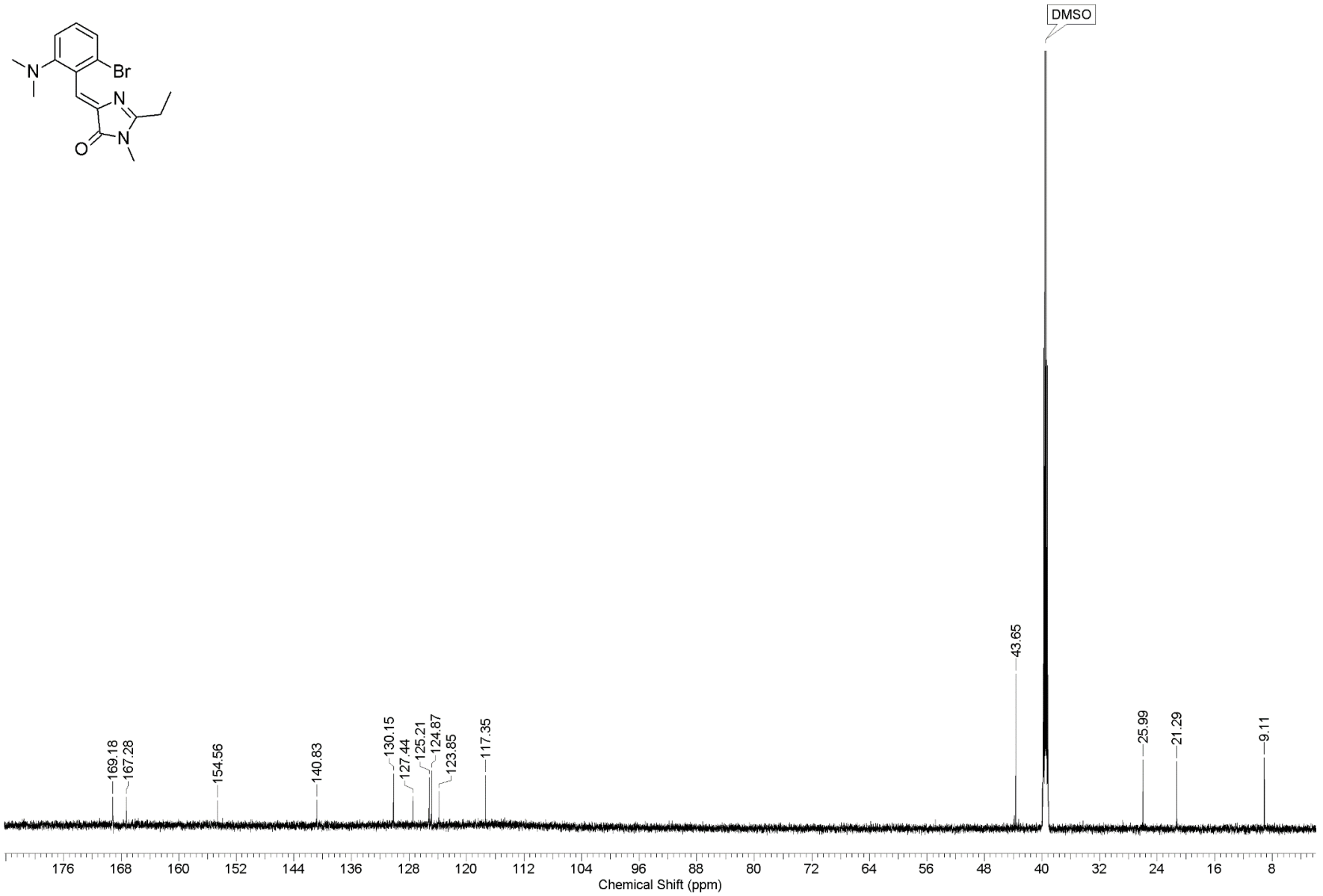

H2O
DMSO
2.72
3.81
2.35
3.55
3.54
3.53
(*)
1.57
1.56
1.55
1.53
1.33
1.32
1.31
1.30
1.27
1.26
1.25
1.24
1.24
0.88
0.87
0.86
* - Z-isomer
3.19
1.98
6.33
2.97
2.16
2.32
3.37
Chemical Shift (ppm)
7.19
6.62
6.62
6.70
6.70
6.69
6.68
0.99
0.99
0.94
8.60
8.59
6.70
6.70
1.00
0.99
0.94
3.19
1.98
6.33
2.97
2.16
2.32
3.37

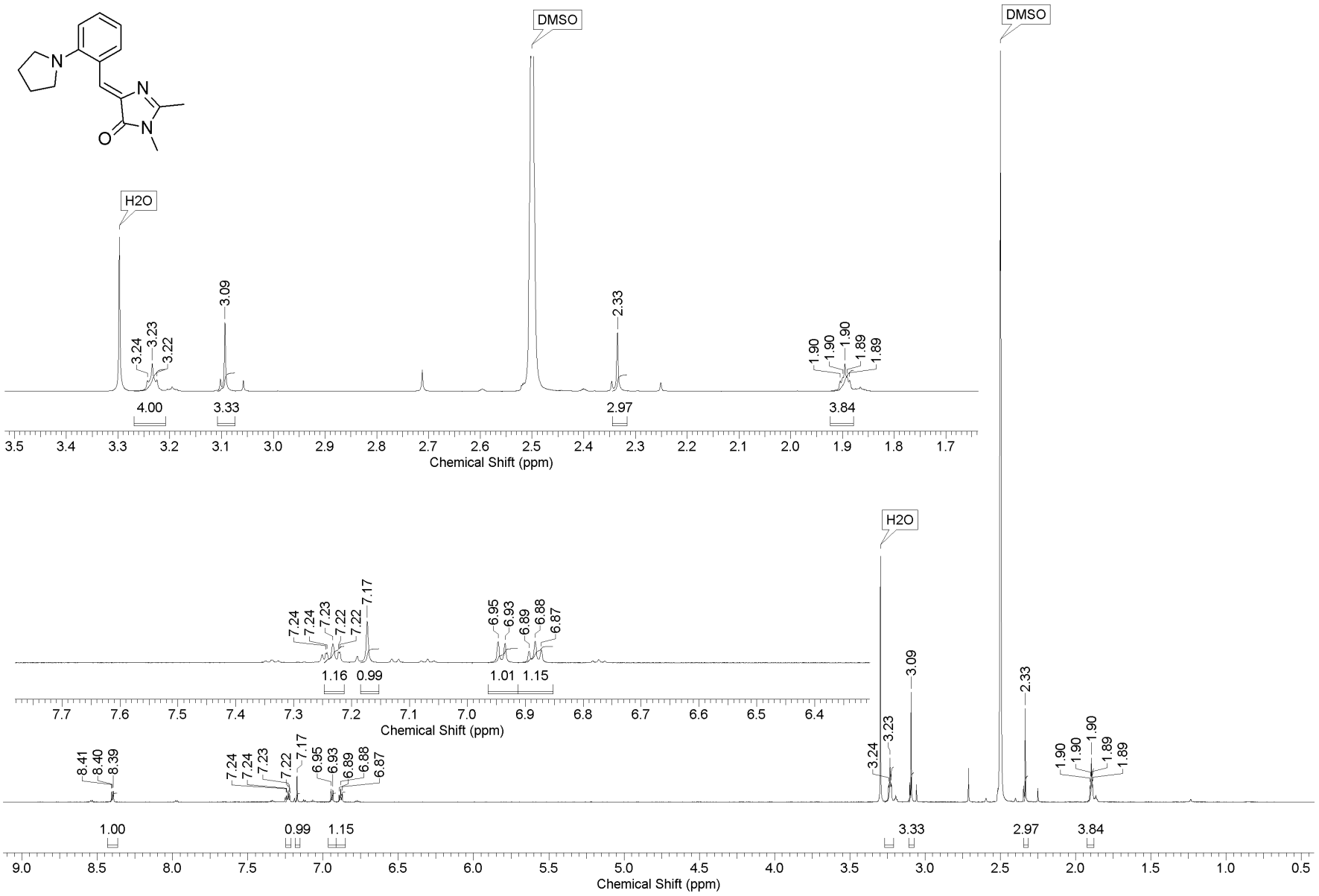

DMSO
161.64
161.53
156.71
135.67
134.25
121.70
119.48
108.14
104.23
Chemical Shift (ppm)
170.01
161.64
161.53
156.71
135.67
134.25
121.70
119.48
108.14
104.23
55.16
44.93
28.31
28.29
21.65
15.22
13.75
Chemical Shift (ppm)

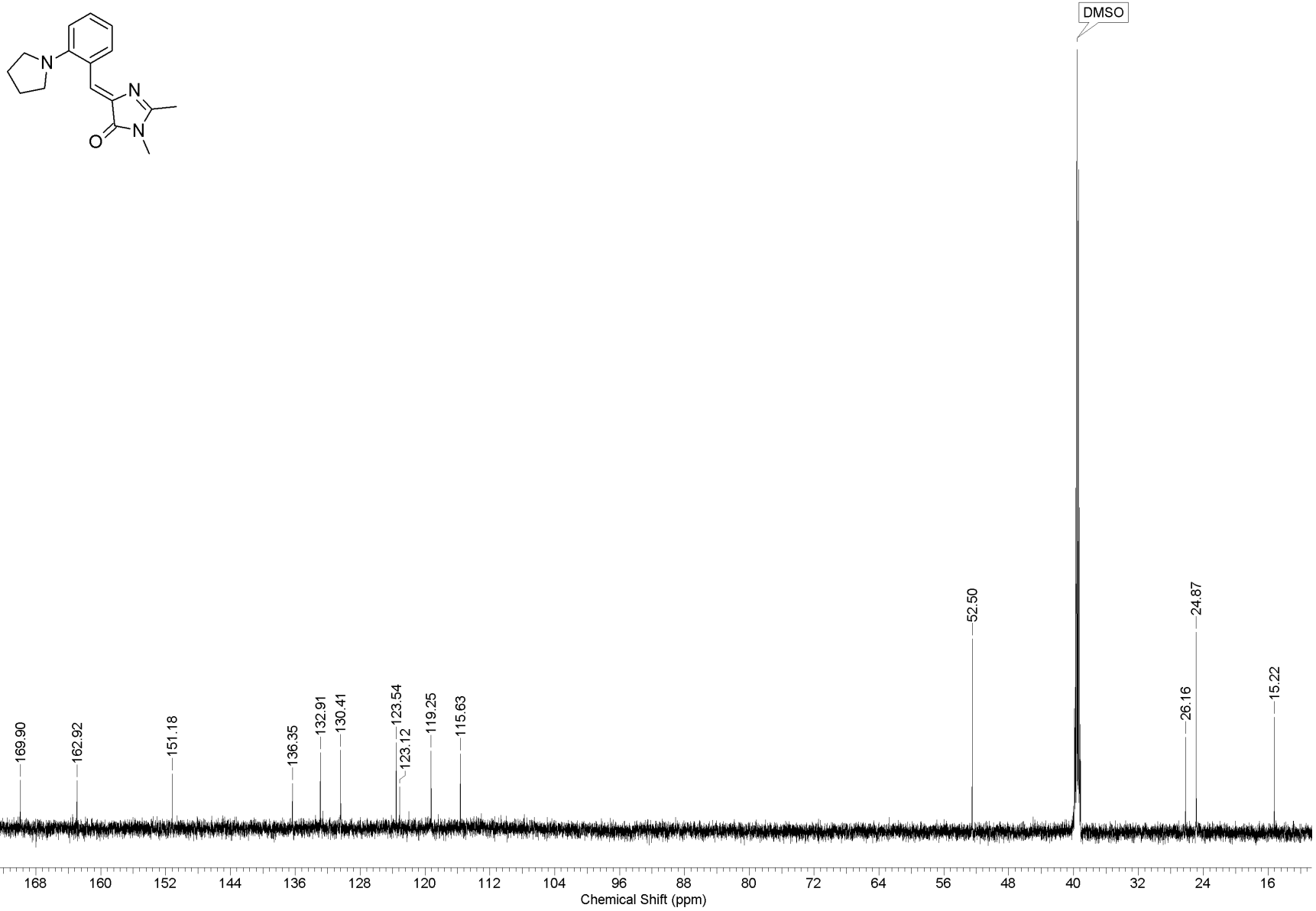

N
Br
N
O
N
DMSO
2.60
H2O
3.09
2.25
6.99
7.24
7.26
7.22
7.21
7.20
7.09
7.08
1.04
1.06
1.02
1.00
7.35
7.30
7.25
7.20
7.15
7.10
7.05
7.00
6.95
6.90
6.85
Chemical Shift (ppm)
6.99
7.24
7.26
7.21
7.20
7.09
1.06
1.00
3.04
6.30
3.01
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
Chemical Shift (ppm)

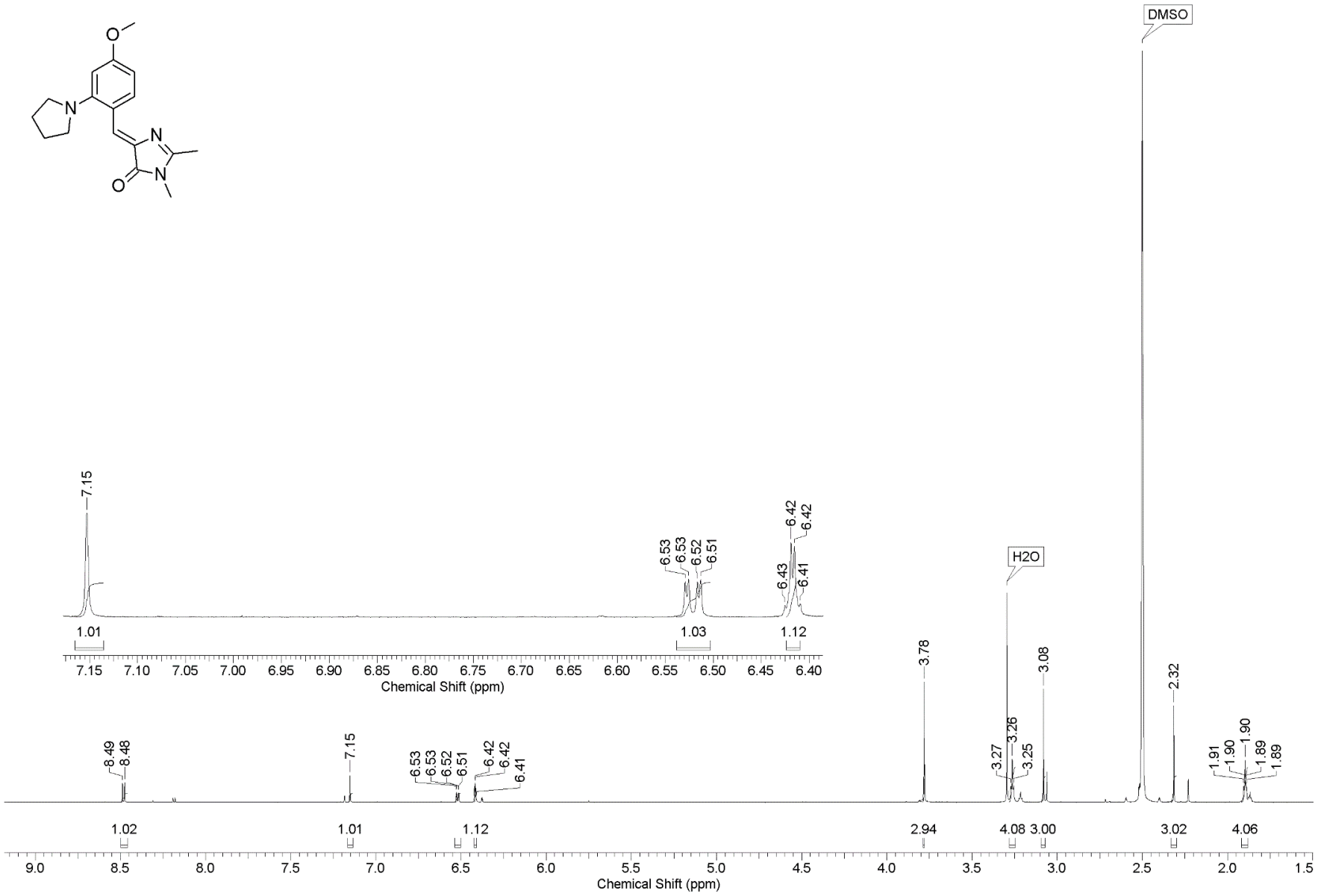

N
Br
N
O
N
DMSO
141.24
130.07
127.89
125.27
124.92
123.61
117.22
142
140
138
136
134
132
130
128
126
124
122
120
118
116
114
Chemical Shift (ppm)
43.76
168.81
163.96
154.49
141.24
130.07
127.89
125.27
124.92
123.61
117.22
26.19
15.18
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

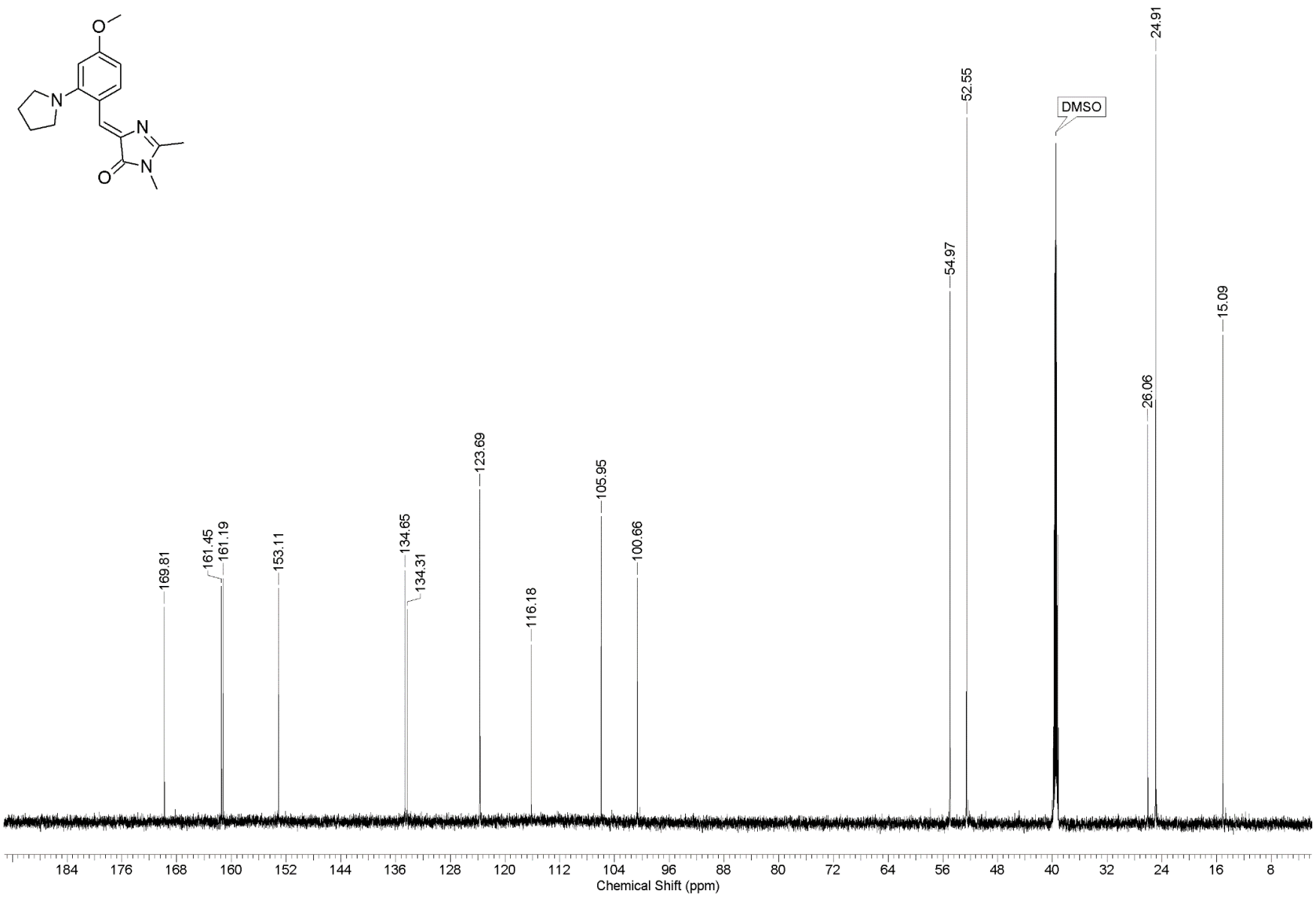

DMSO
H2O
3.09
2.61
2.60
2.60
2.59
2.85
6.16 2.08
Chemical Shift (ppm)
7.25
7.24
7.23
7.23
7.21
7.20
7.10
7.09
7.00
1.09
1.23
1.00
0.99
Chemical Shift (ppm)
1.14
1.13
1.12
1.23
0.99
2.85
2.08
2.85
Chemical Shift (ppm)

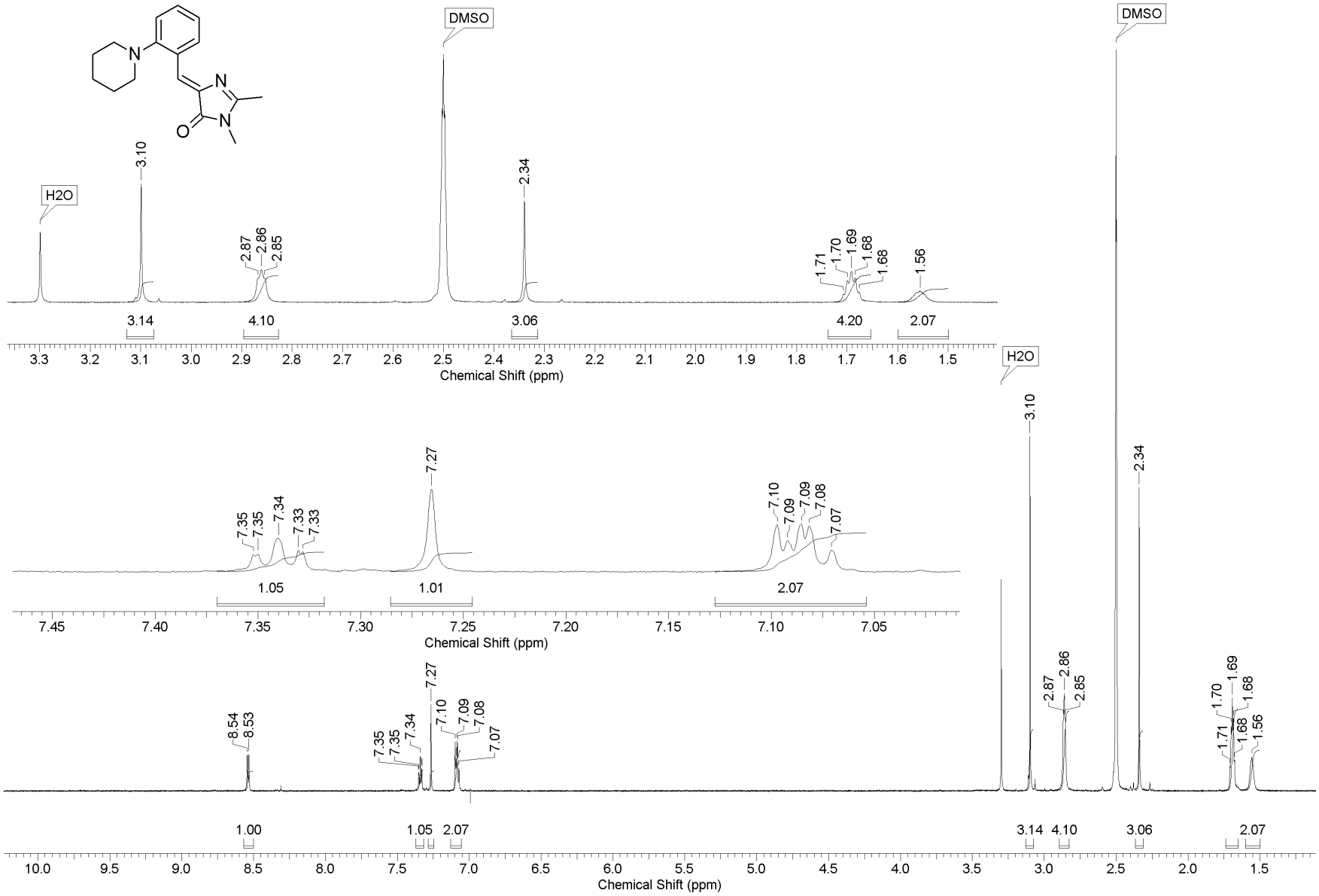

N
Br
N
N
O
DMSO
169.18
167.28
154.56
140.83
130.15
127.44
125.21
124.87
123.85
117.35
43.65
25.99
21.29
9.11
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

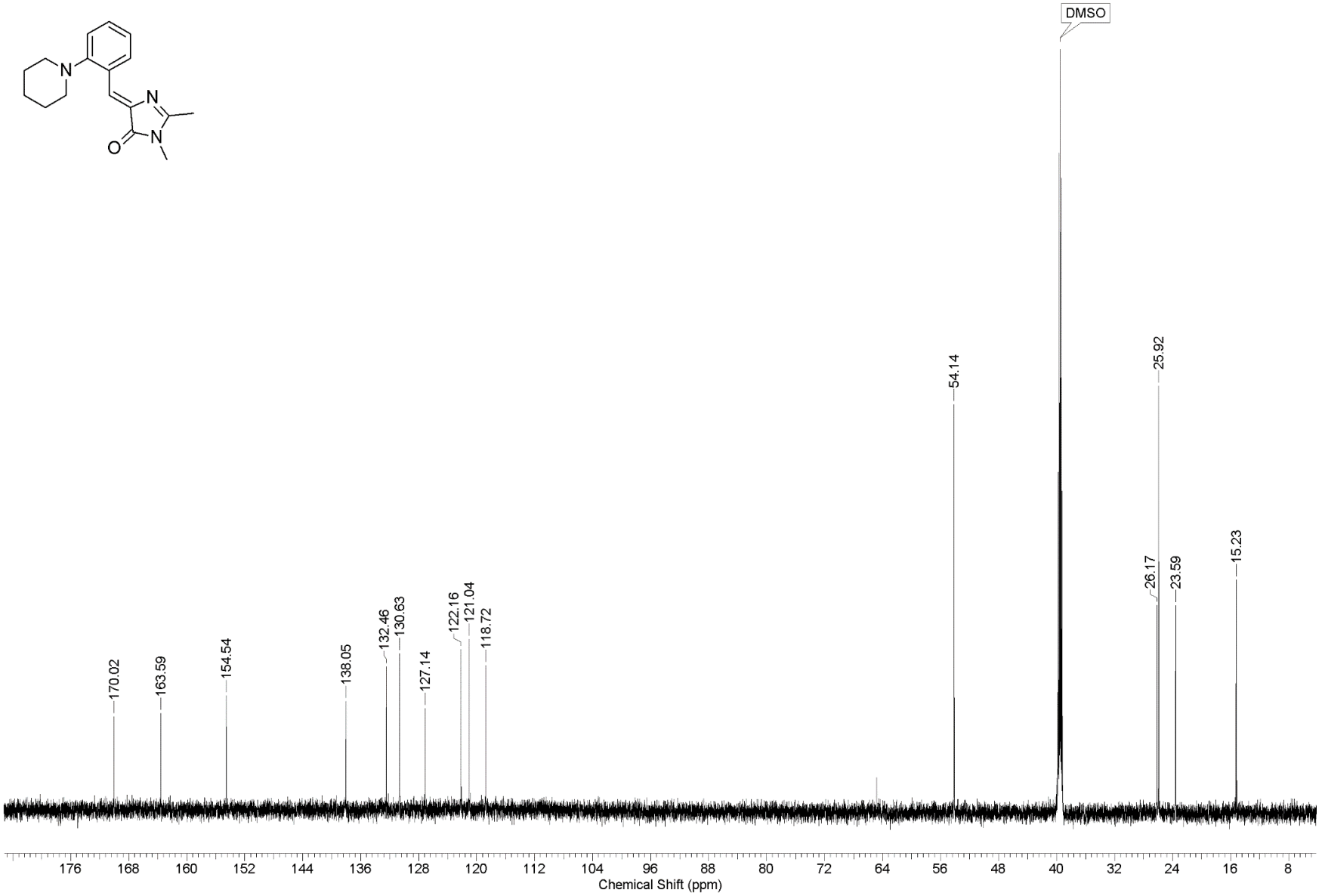

DMSO
DMSO
H2O
3.24
3.23
3.22
3.09
2.33
1.90
1.90
1.90
1.89
1.89
4.00
3.33
2.97
3.84
Chemical Shift (ppm)
H2O
7.24
7.24
7.23
7.22
7.22
7.17
6.95
6.93
6.89
6.88
6.87
1.16
0.99
1.01
1.15
Chemical Shift (ppm)
8.41
8.40
8.39
7.24
7.24
7.23
7.22
7.17
6.95
6.93
6.89
6.88
6.87
3.24
3.23
3.09
2.33
1.90
1.90
1.90
1.89
1.89
1.00
0.99
1.15
3.33
2.97
3.84
Chemical Shift (ppm)

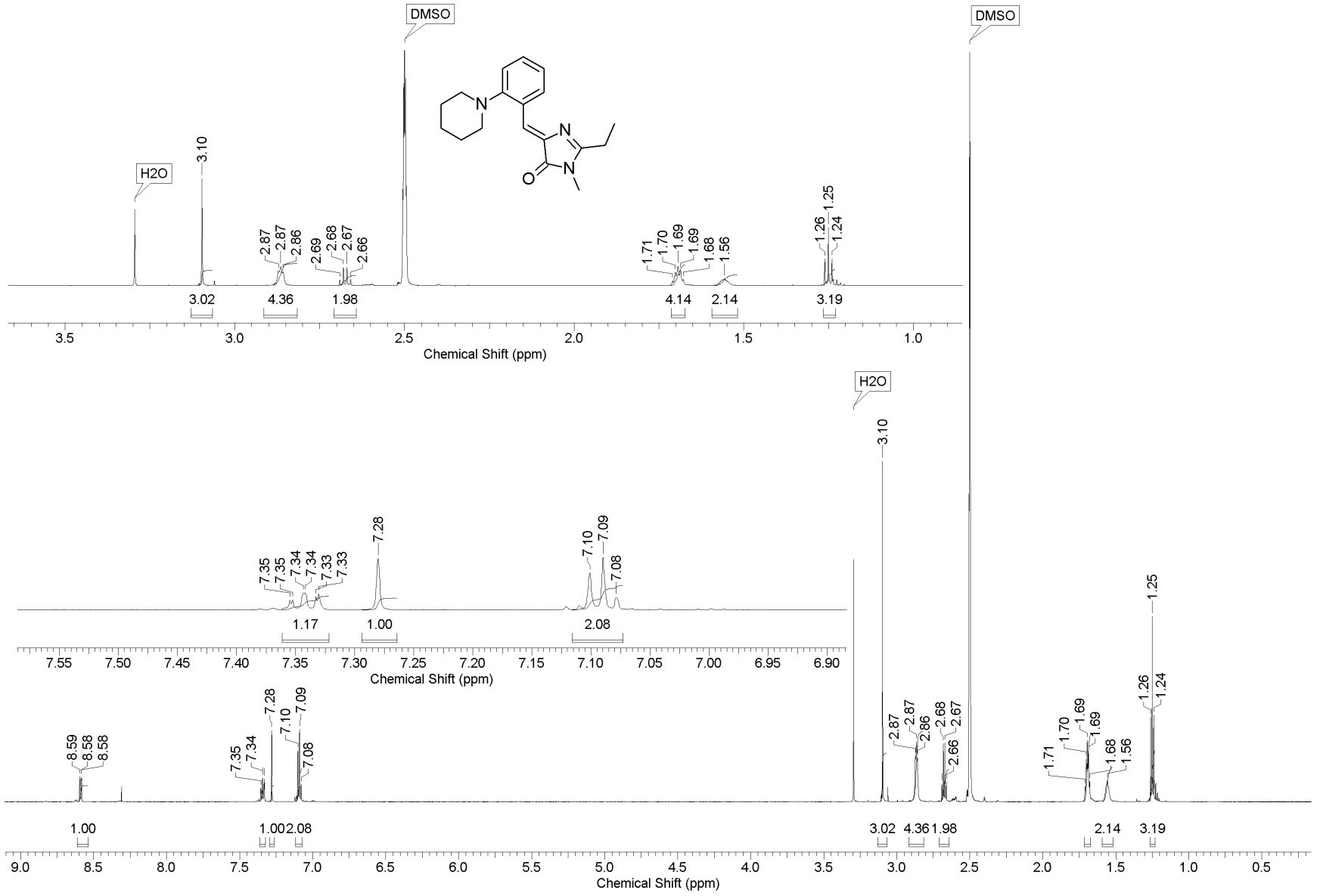

DMSO
169.90
162.92
151.18
136.35
132.91
130.41
123.54
123.12
119.25
115.63
52.50
26.16
24.87
15.22
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

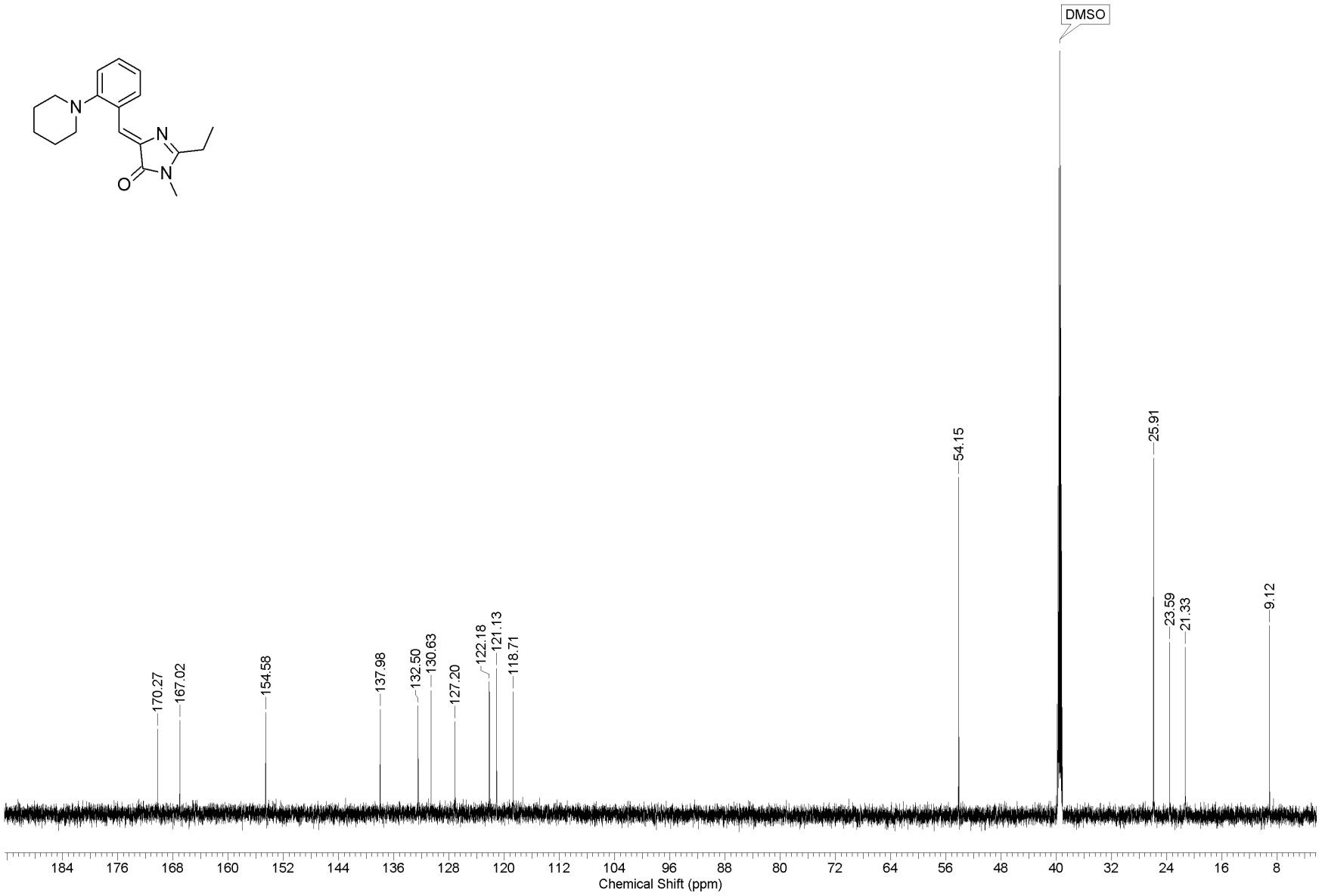

DMSO
H2O
7.15
6.53
6.53
6.52
6.51
6.43
6.42
6.42
6.41
1.01
1.03
1.12
7.15 7.10 7.05 7.00 6.95 6.90 6.85 6.80 6.75 6.70 6.65 6.60 6.55 6.50 6.45 6.40
Chemical Shift (ppm)
8.49
8.48
7.15
6.53
6.53
6.52
6.51
6.42
6.42
6.41
3.78
3.27
3.26
3.25
3.08
2.32
1.91
1.90
1.90
1.89
1.89
1.02
1.01
1.12
2.94
4.08
3.00
3.02
4.06
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5
Chemical Shift (ppm)

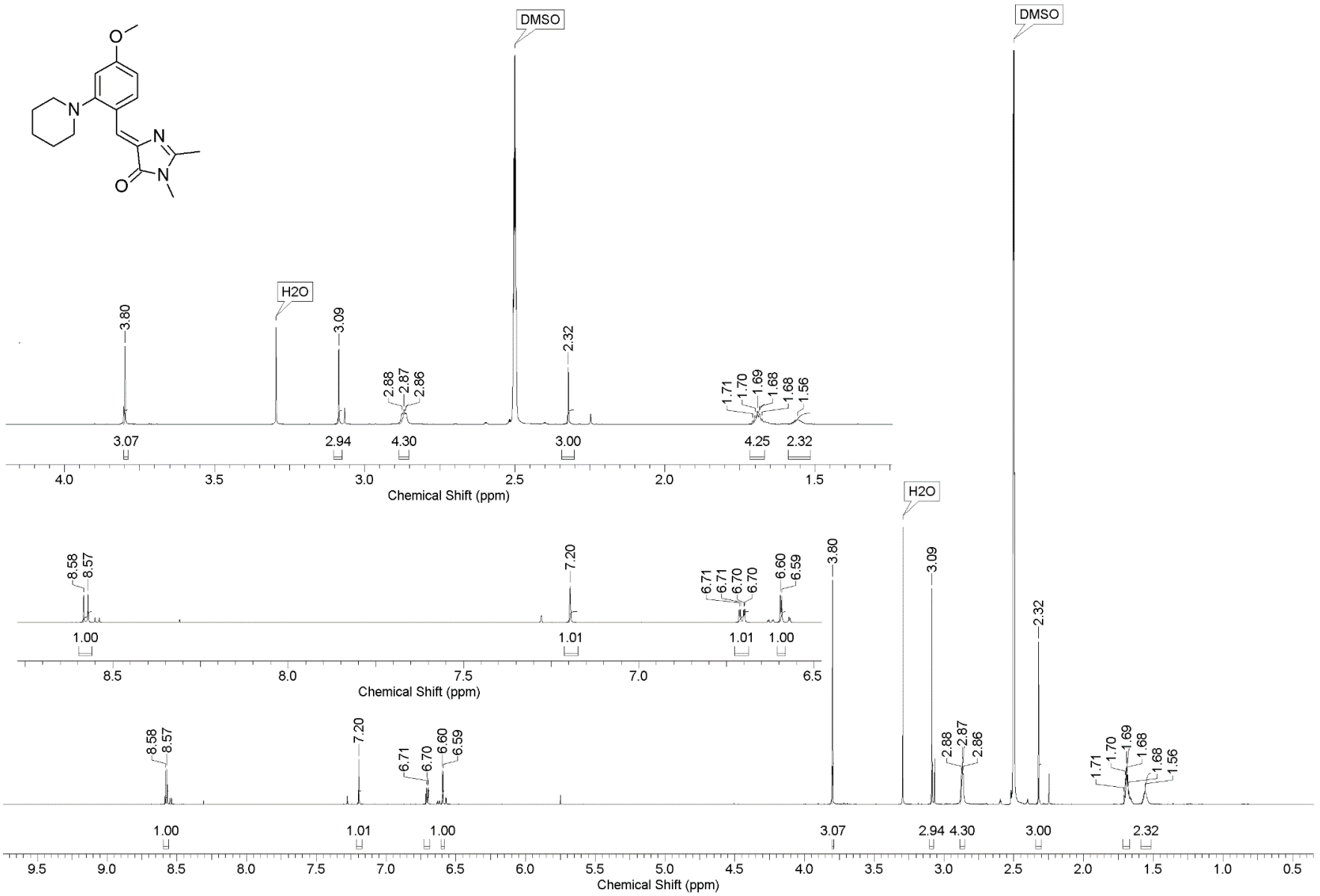

O
N
N
N
O
169.81
161.45
161.19
153.11
134.65
134.31
123.69
116.18
105.95
100.66
54.97
52.55
DMSO
26.06
24.91
15.09
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

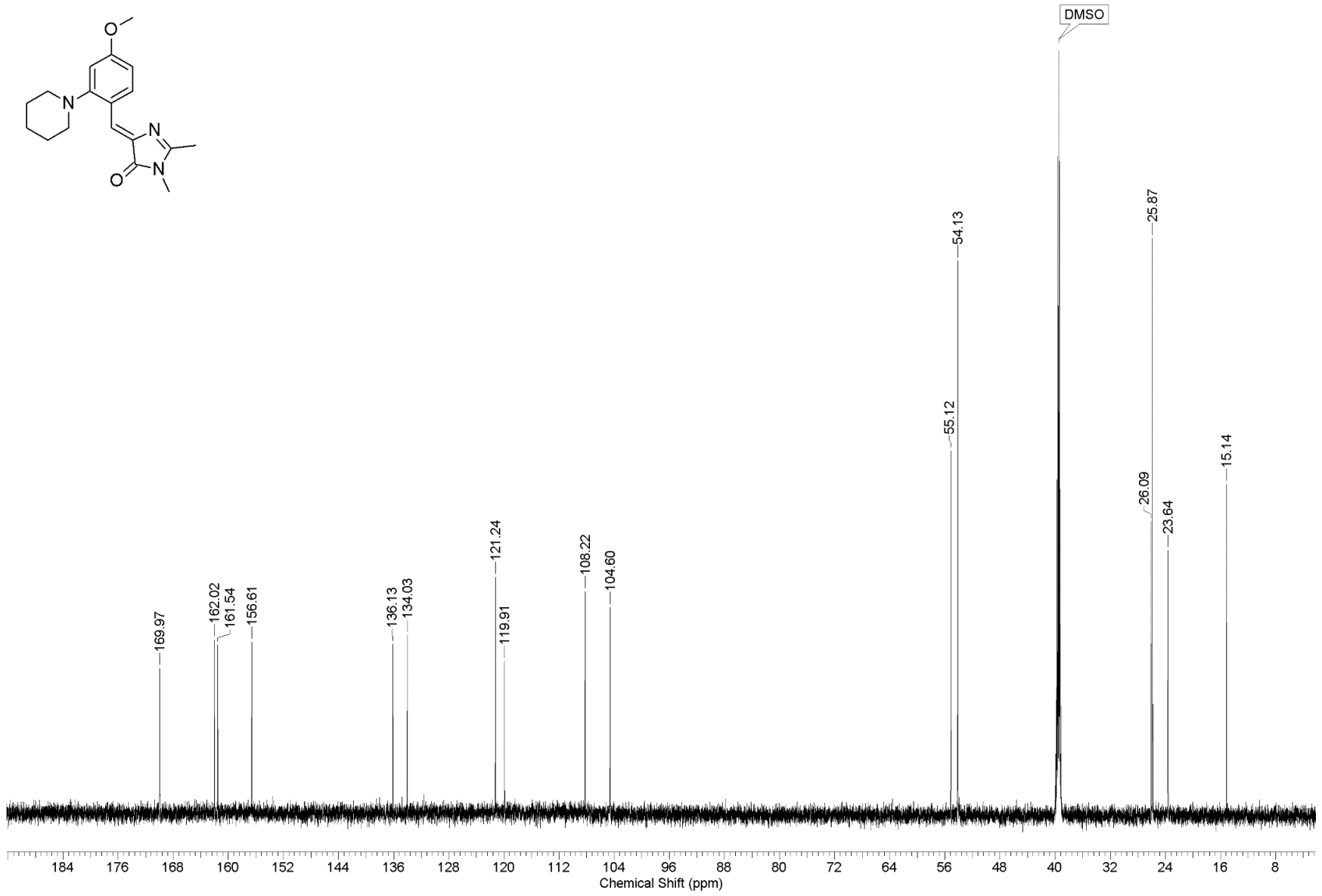

DMSO
H2O
3.10
2.34
2.87
2.86
2.85
1.71
1.70
1.69
1.68
1.68
1.56
3.14
4.10
3.06
4.20
2.07
Chemical Shift (ppm)
7.27
7.35
7.35
7.34
7.33
7.33
7.10
7.09
7.09
7.08
7.07
1.05
1.01
2.07
Chemical Shift (ppm)
8.54
8.53
1.00
1.05
2.07
3.14
4.10
3.06
2.07
Chemical Shift (ppm)

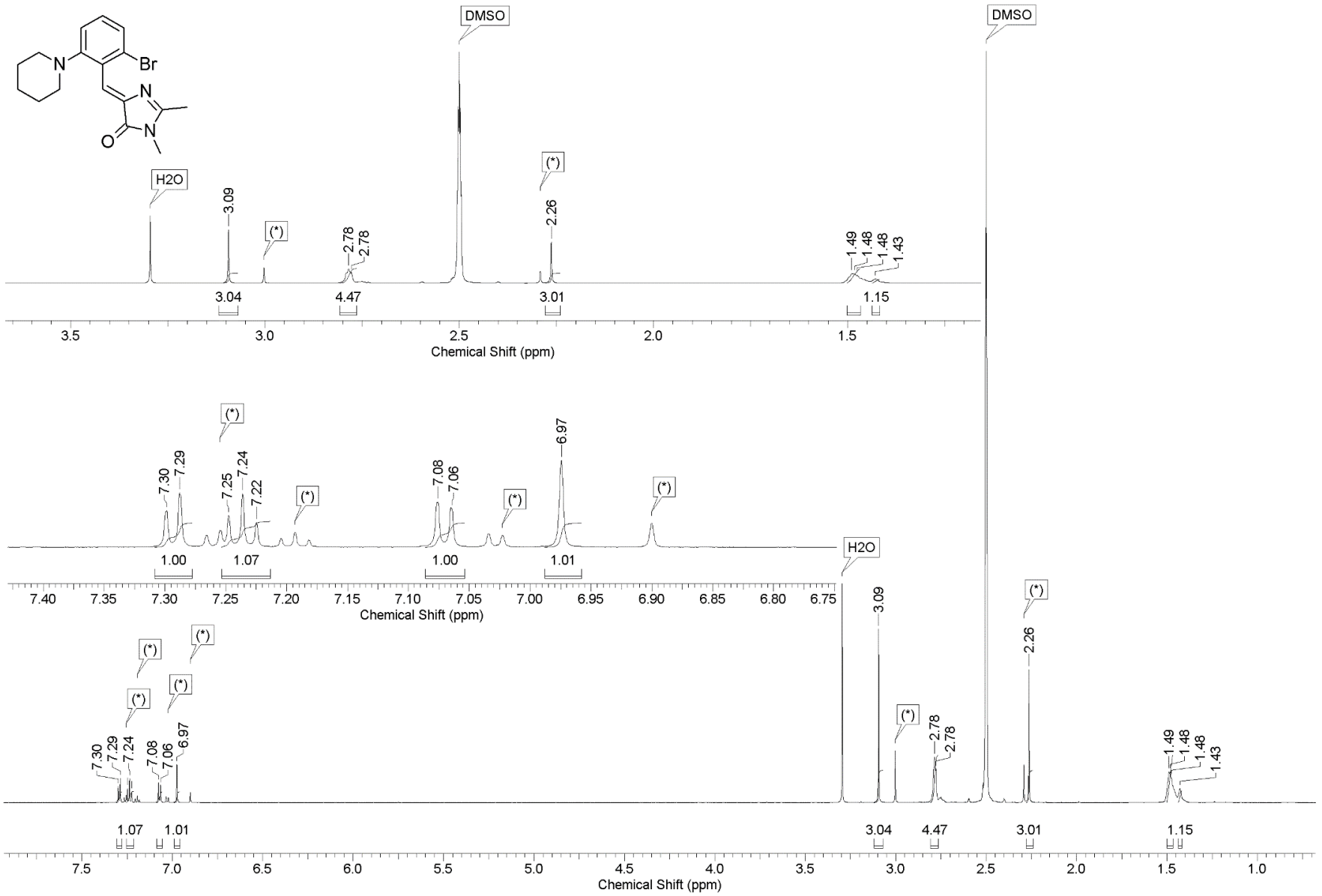

N
N
N
O
DMSO
170.02
163.59
154.54
138.05
132.46
130.63
127.14
122.16
121.04
118.72
54.14
25.92
26.17
23.59
15.23
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

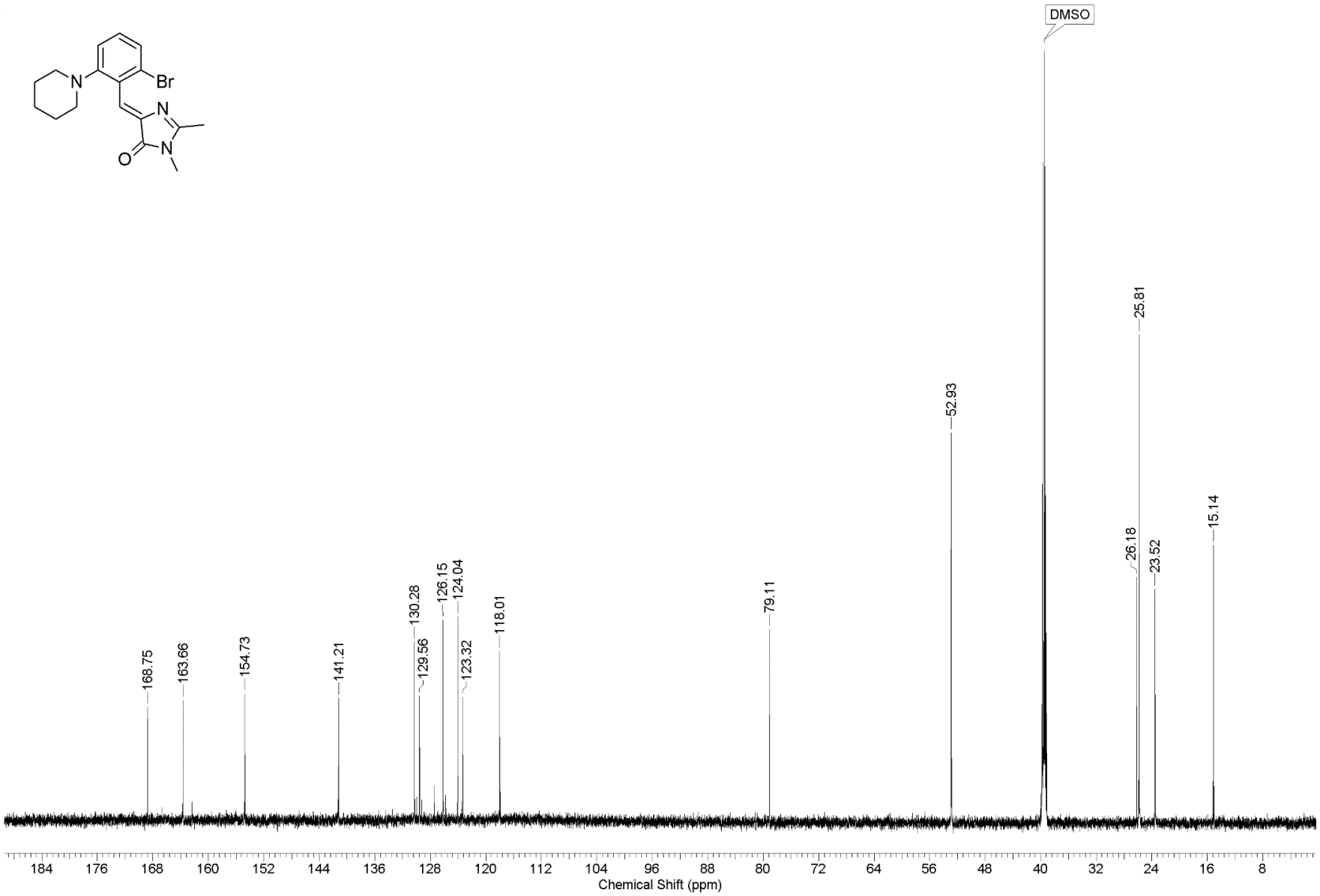

DMSO
DMSO
H2O
3.10
2.87
2.87
2.86
2.69
2.68
2.67
2.66
1.71
1.70
1.69
1.69
1.68
1.56
1.26
1.25
1.24
3.02
4.36
1.98
4.14
2.14
3.19
Chemical Shift (ppm)
H2O
3.10
7.35
7.35
7.34
7.34
7.33
7.33
7.28
7.10
7.09
7.08
1.17
1.00
2.08
Chemical Shift (ppm)
8.59
8.58
8.58
7.35
7.34
7.28
7.10
7.09
7.08
2.87
2.87
2.86
2.68
2.67
2.66
1.71
1.70
1.69
1.69
1.68
1.56
1.26
1.24
1.25
1.00
1.00
2.08
3.02
4.36
1.98
2.14
3.19
Chemical Shift (ppm)

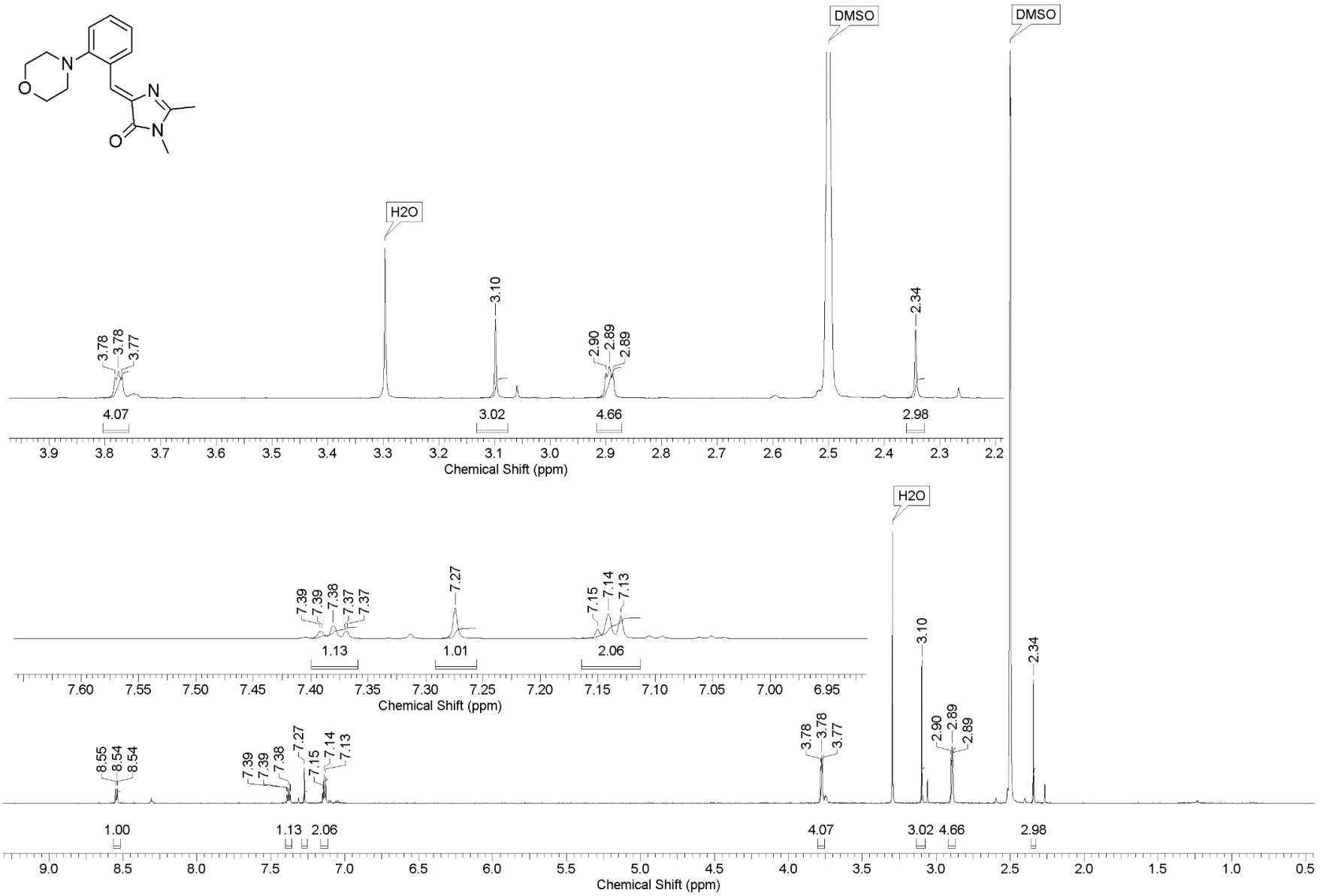

DMSO
54.15
25.91
23.59
21.33
9.12
170.27
167.02
154.58
137.98
132.50
130.63
127.20
122.18
121.13
118.71
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

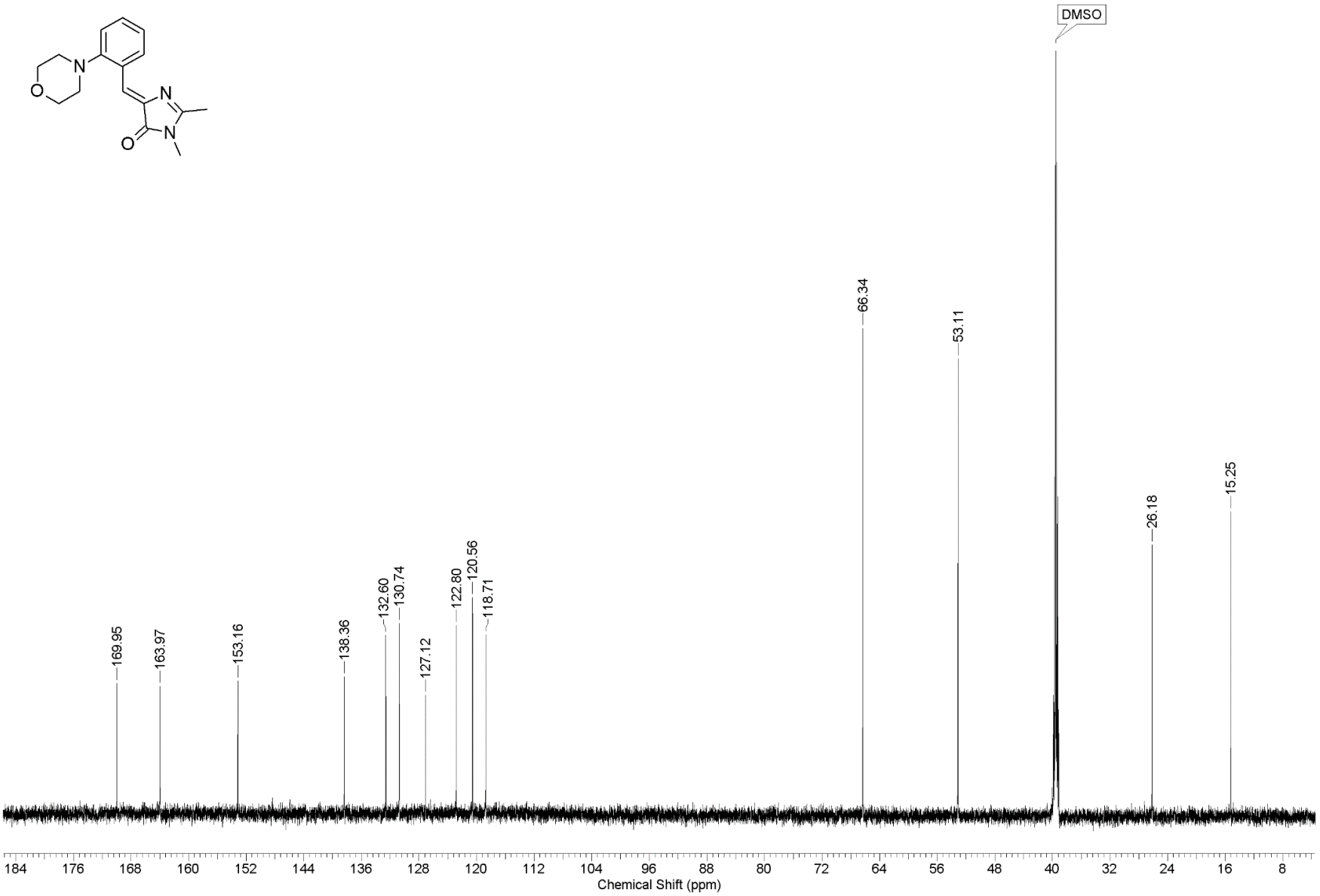

DMSO
H2O
3.80
3.09
2.88
2.87
2.86
2.32
1.71
1.70
1.69
1.68
1.68
1.56
3.07
2.94
4.30
3.00
4.25
2.32
Chemical Shift (ppm)
8.58
8.57
7.20
6.71
6.71
6.70
6.70
6.60
6.59
1.00
1.01
1.01
1.00
Chemical Shift (ppm)
Chemical Shift (ppm)

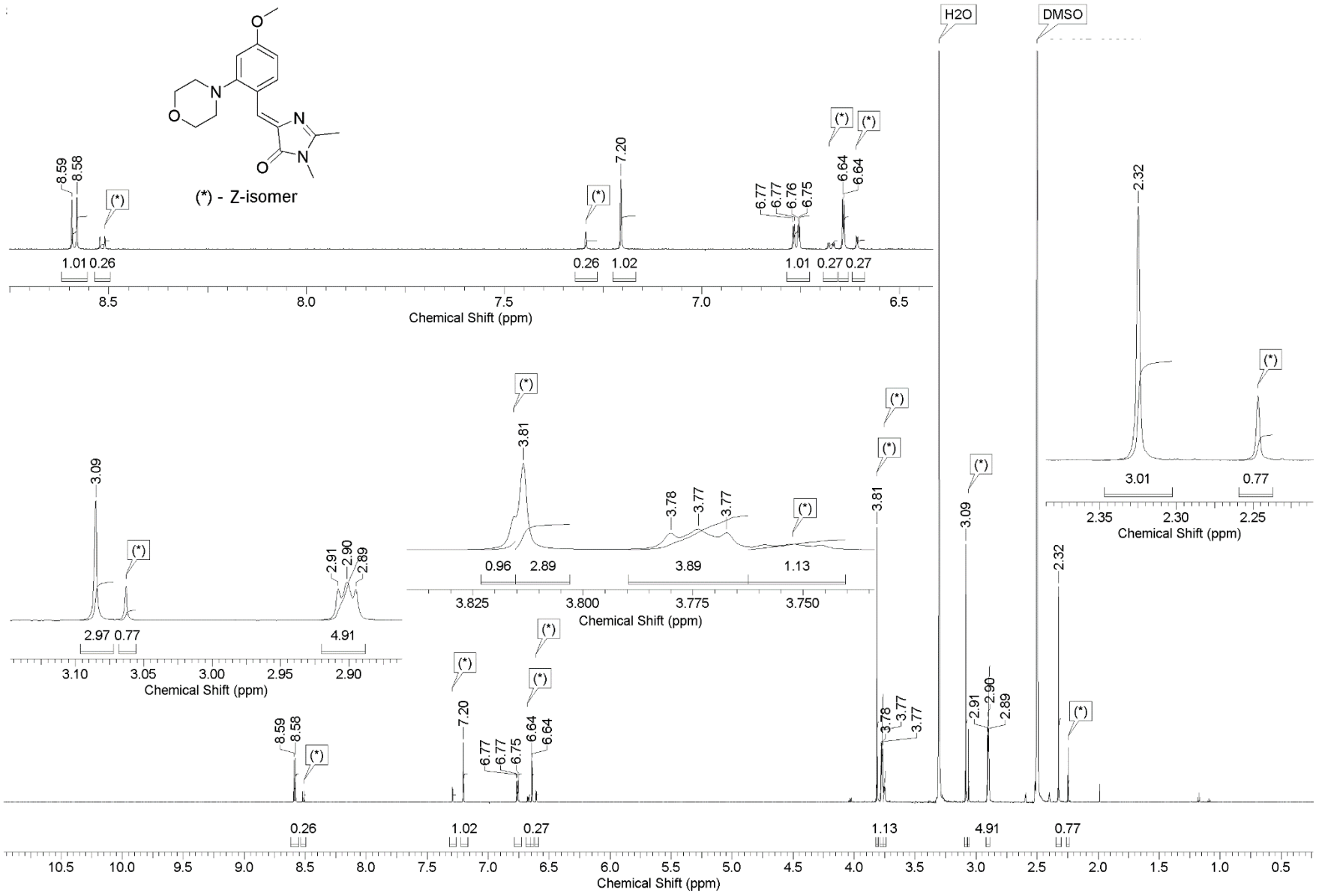

O
N
N
O
N
DMSO
169.97
162.02
161.54
156.61
136.13
134.03
121.24
119.91
108.22
104.60
55.12
54.13
26.09
25.87
23.64
15.14
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

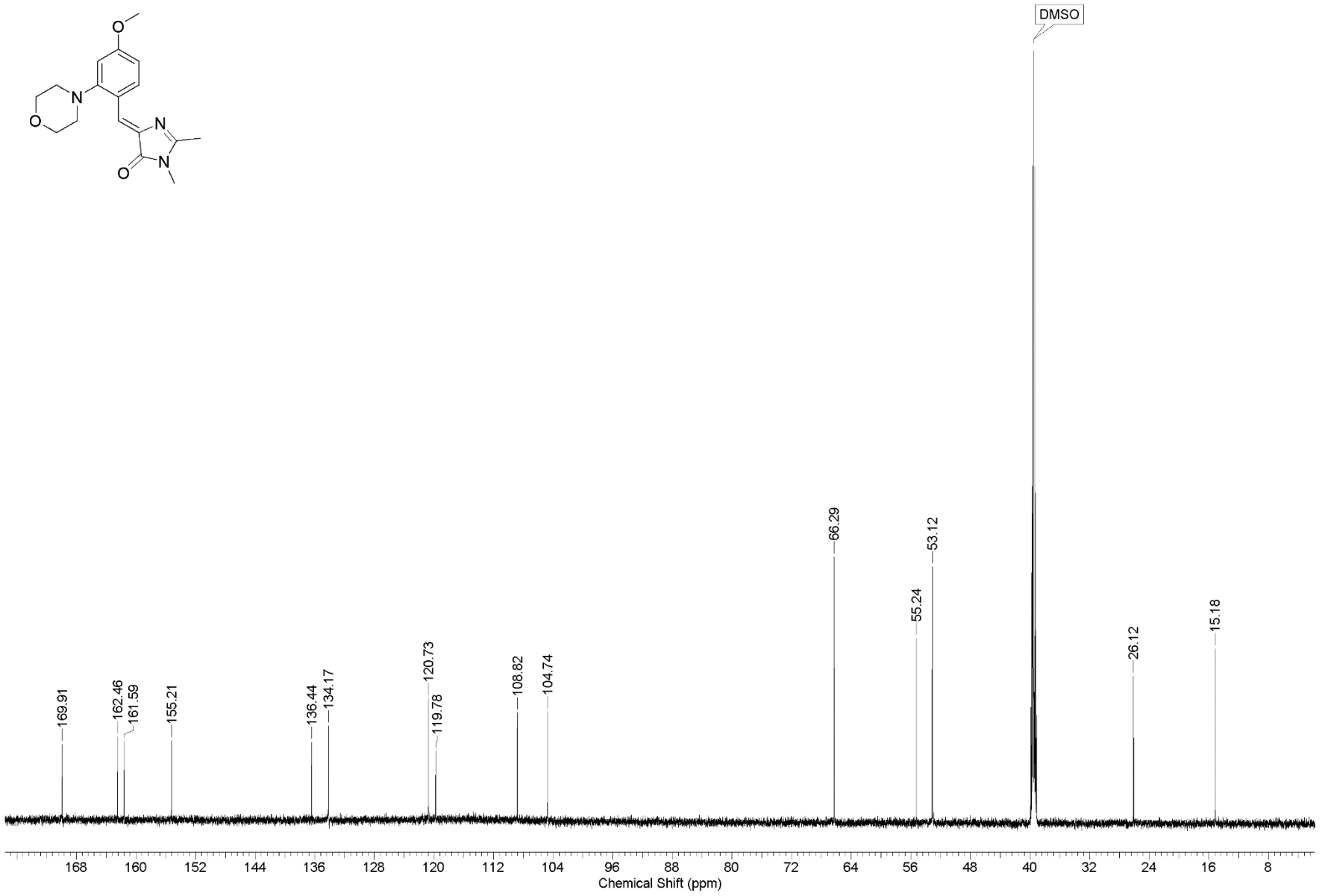

Br
N
N
O
N
DMSO
H2O
(*)
3.09
2.78
2.78
2.26
1.49
1.48
1.48
1.43
3.04
4.47
3.01
1.15
Chemical Shift (ppm)
7.30
7.29
7.25
7.24
7.22
7.08
7.06
6.97
1.00
1.07
1.00
1.01
Chemical Shift (ppm)
1.07
1.01
3.04
4.47
3.01
1.15
Chemical Shift (ppm)

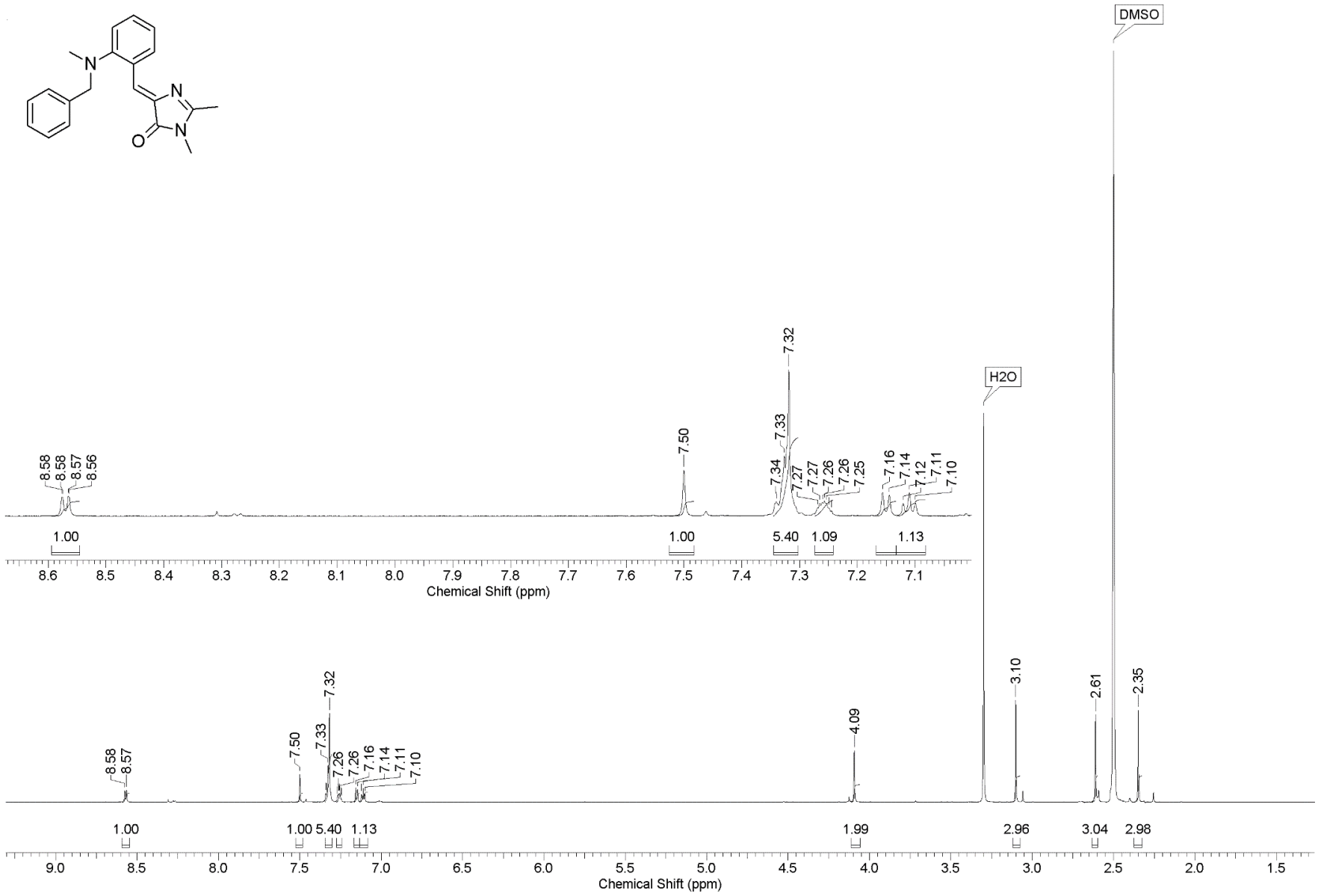

Br
N
N
O
N
DMSO
168.75
163.66
154.73
141.21
130.28
129.56
126.15
124.04
123.32
118.01
79.11
52.93
25.81
26.18
23.52
15.14
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

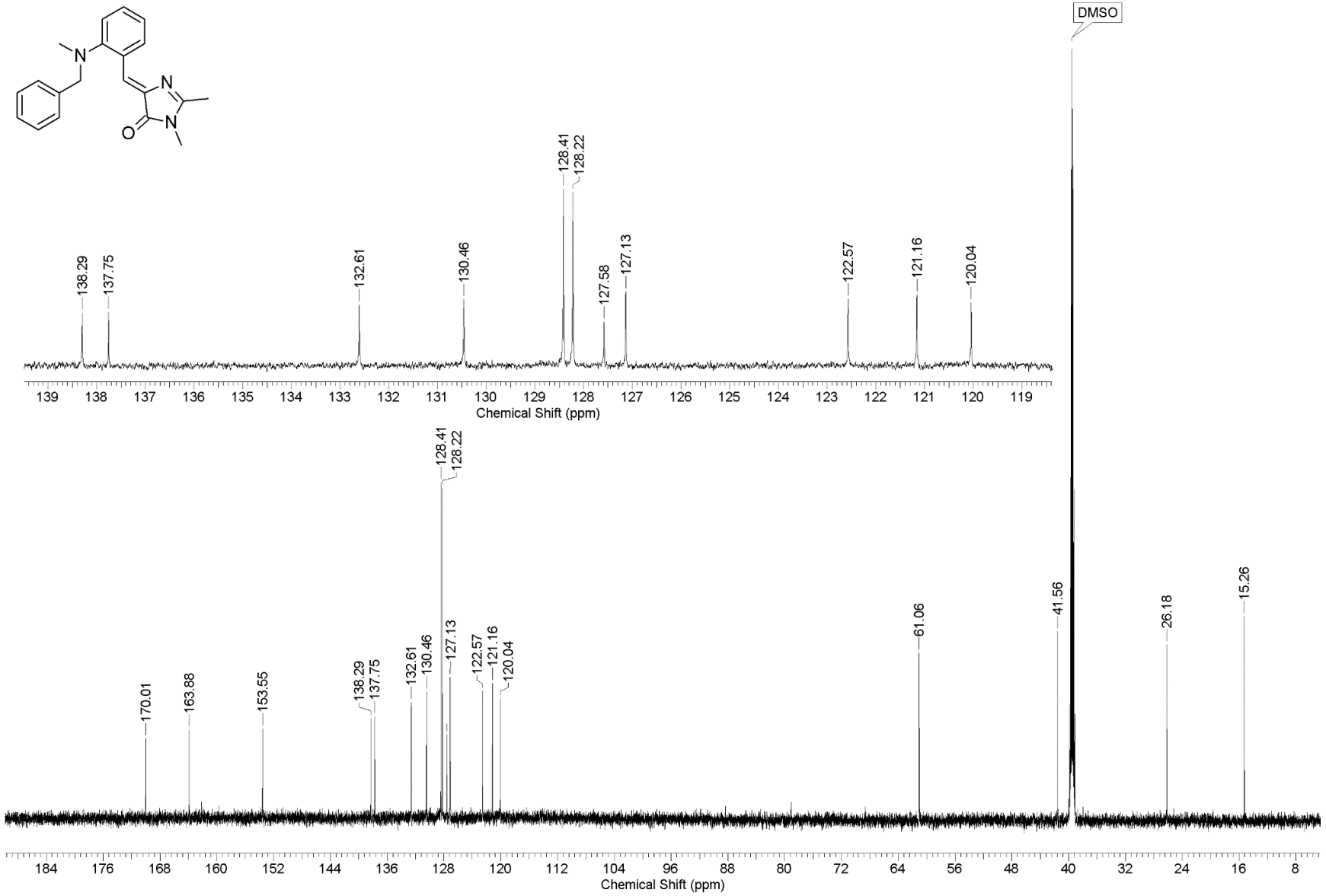

DMSO
DMSO
H2O
3.10
2.34
3.78
3.78
3.77
2.90
2.89
2.89
4.07
3.02
4.66
2.98
Chemical Shift (ppm)
H2O
7.39
7.39
7.38
7.37
7.37
7.27
7.15
7.14
7.13
1.13
1.01
2.06
Chemical Shift (ppm)
8.55
8.54
8.54
7.39
7.39
7.38
7.27
7.15
7.14
7.13
3.78
3.78
3.77
3.10
2.90
2.89
2.34
1.00
1.13
2.06
4.07
3.02
4.66
2.98
Chemical Shift (ppm)

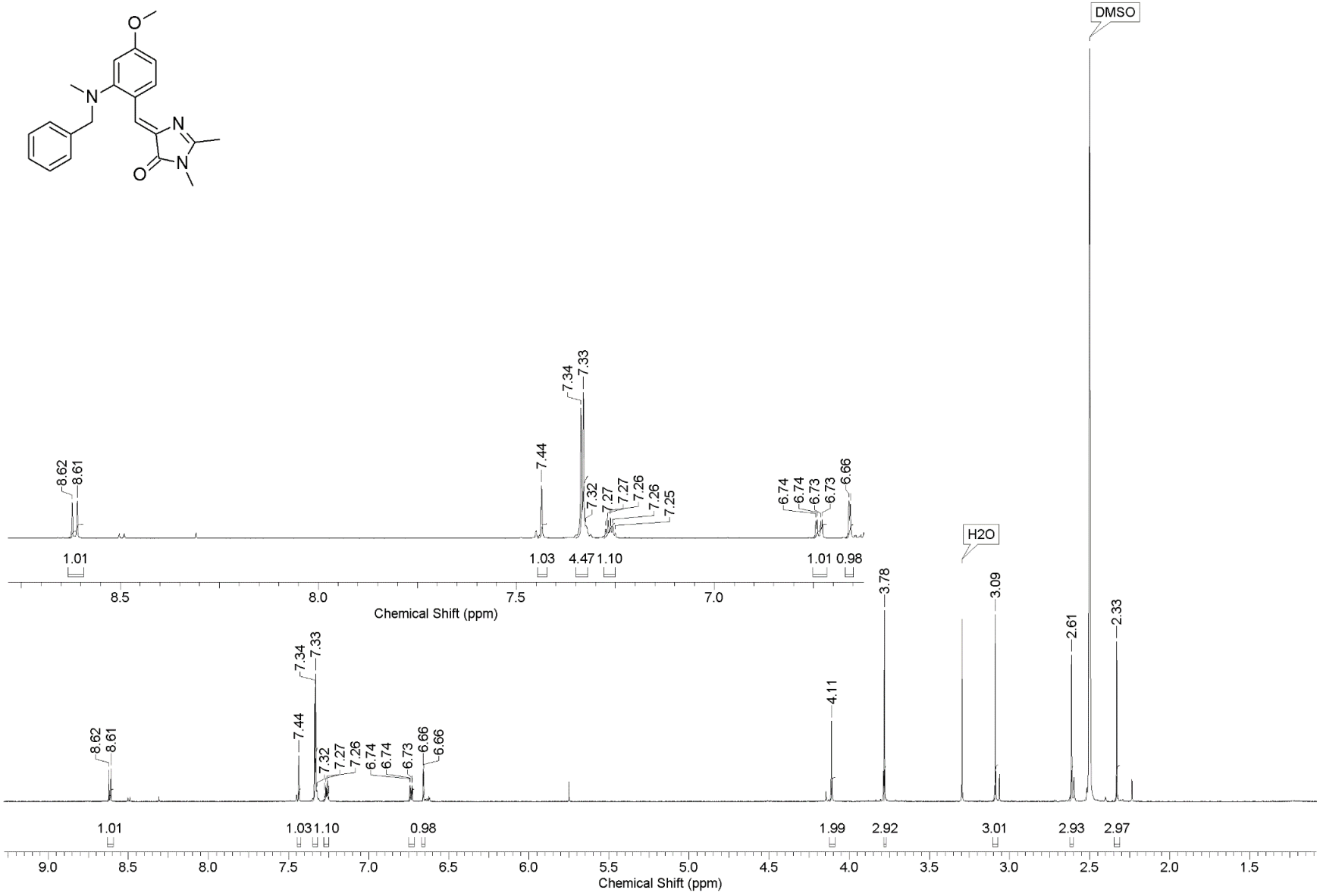

DMSO
66.34
53.11
26.18
15.25
169.95
163.97
153.16
138.36
132.60
130.74
127.12
122.80
120.56
118.71
184 176 168 160 152 144 136 128 120 112 104 96 88 80 72 64 56 48 40 32 24 16 8
Chemical Shift (ppm)

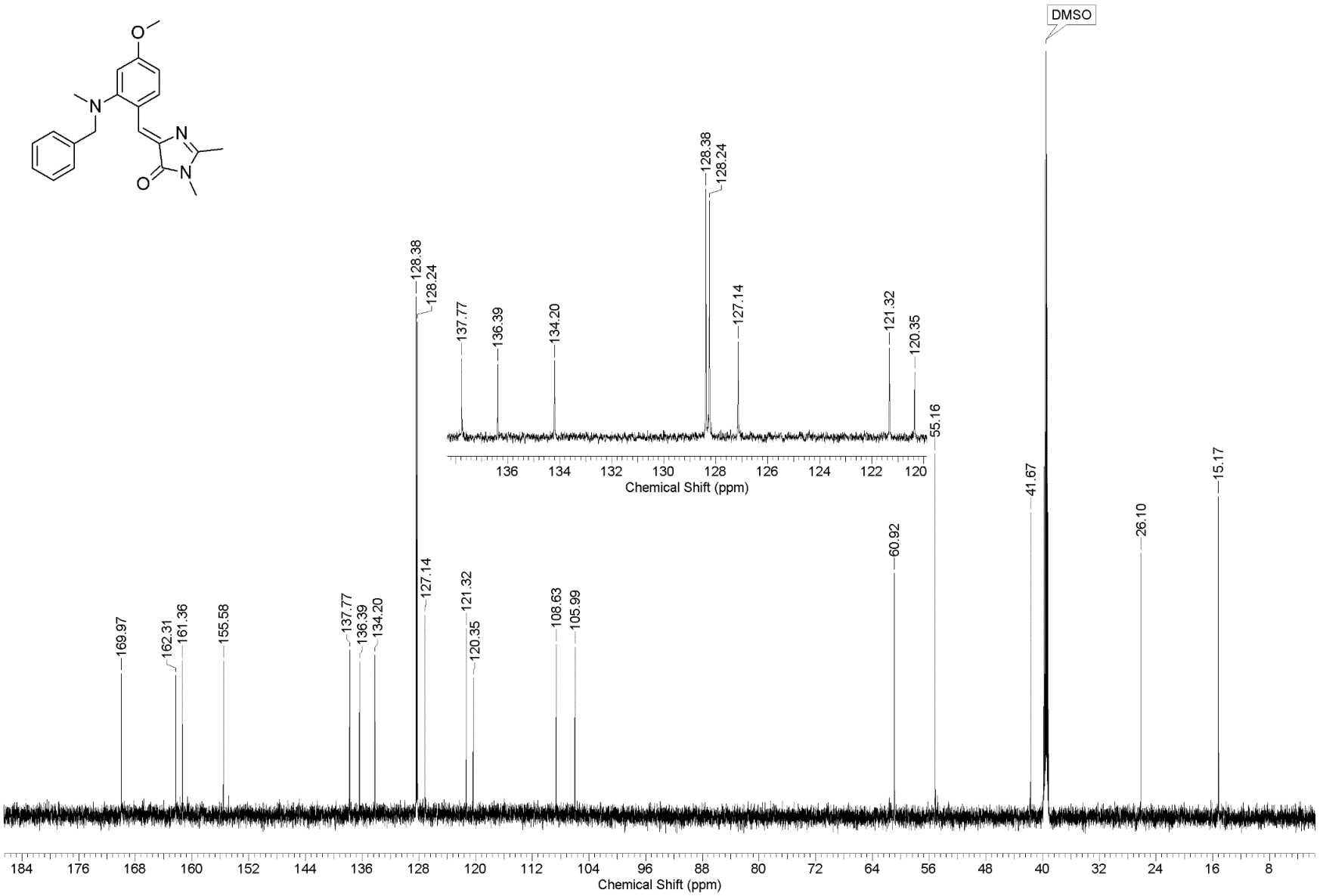

(*) - Z-isomer
H2O
DMSO
Chemical Shift (ppm)

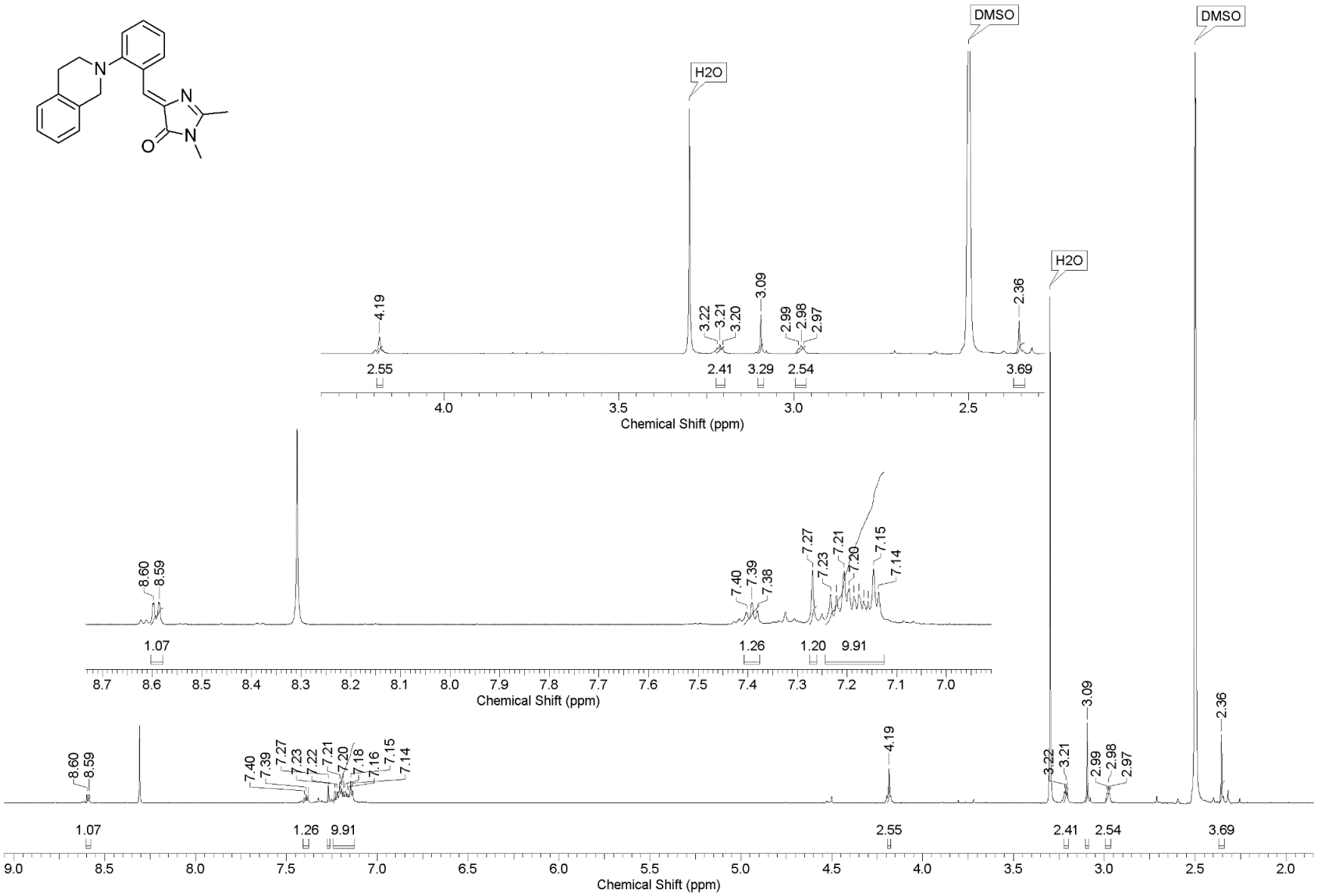

O
N
O
N
N
O
DMSO
169.91
162.46
161.59
155.21
136.44
134.17
120.73
119.78
108.82
104.74
66.29
55.24
53.12
26.12
15.18
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

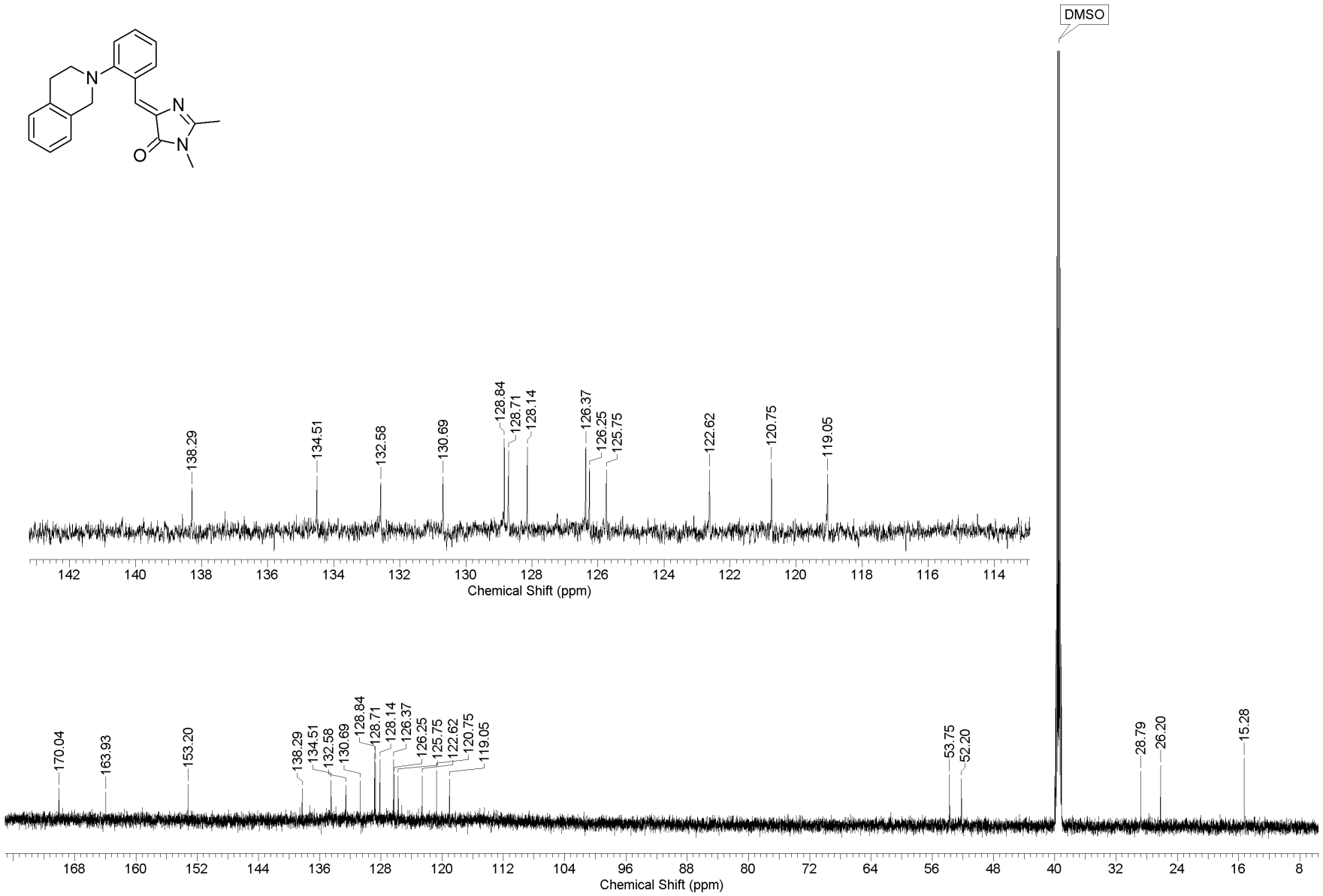

DMSO
H2O
8.58
8.58
8.57
8.56
7.50
7.32
7.33
7.34
7.27
7.27
7.26
7.26
7.25
7.16
7.14
7.12
7.11
7.10
1.00
1.00
5.40
1.09
1.13
Chemical Shift (ppm)
8.58
8.57
7.50
7.32
7.33
7.26
7.26
7.16
7.14
7.11
7.10
4.09
3.10
2.61
2.35
1.00
1.00
5.40
1.13
1.99
2.96
3.04
2.98
Chemical Shift (ppm)

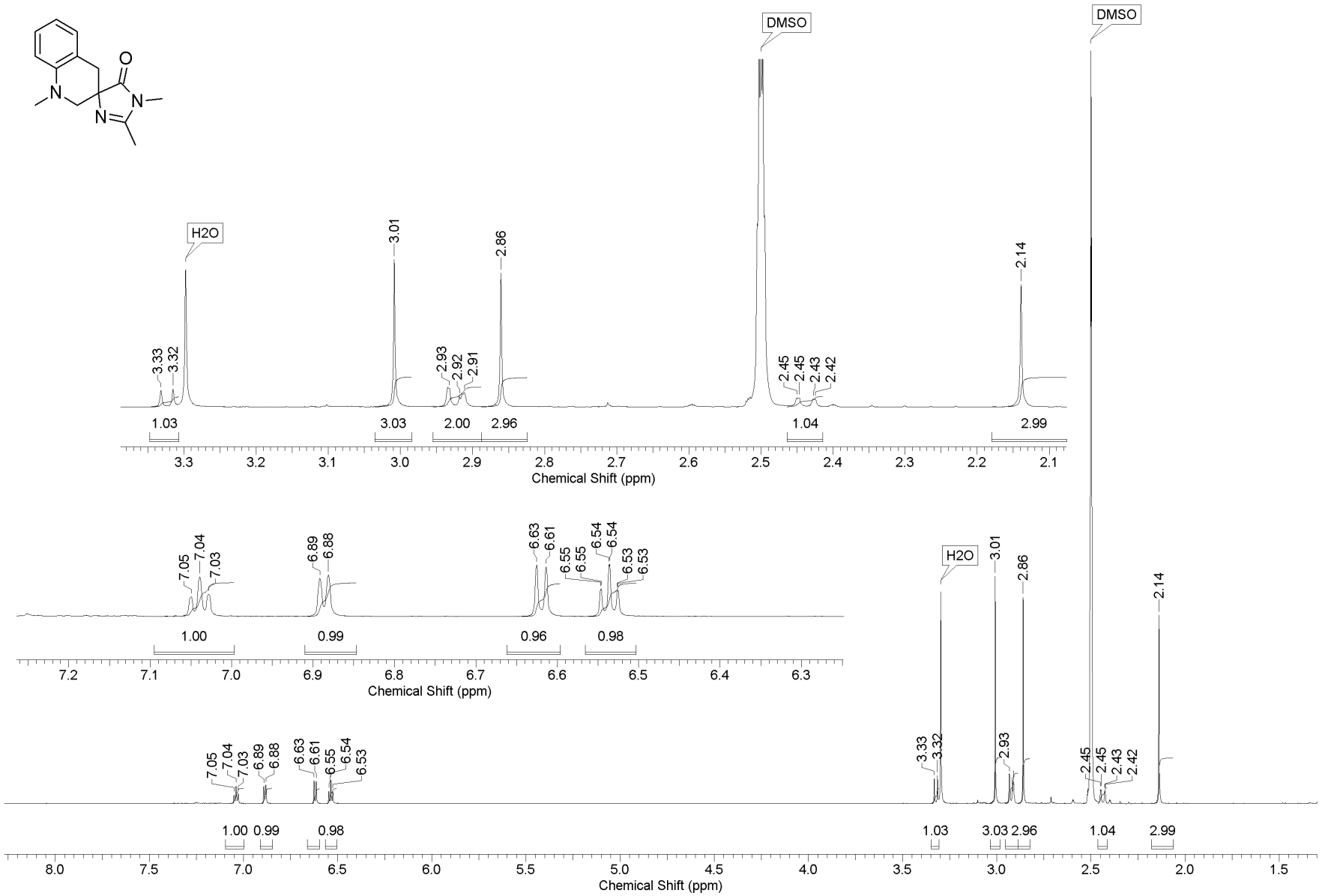

DMSO
128.41
128.22
138.29
137.75
132.61
130.46
127.58
127.13
122.57
121.16
120.04
Chemical Shift (ppm)
170.01
163.88
153.55
61.06
41.56
26.18
15.26
Chemical Shift (ppm)

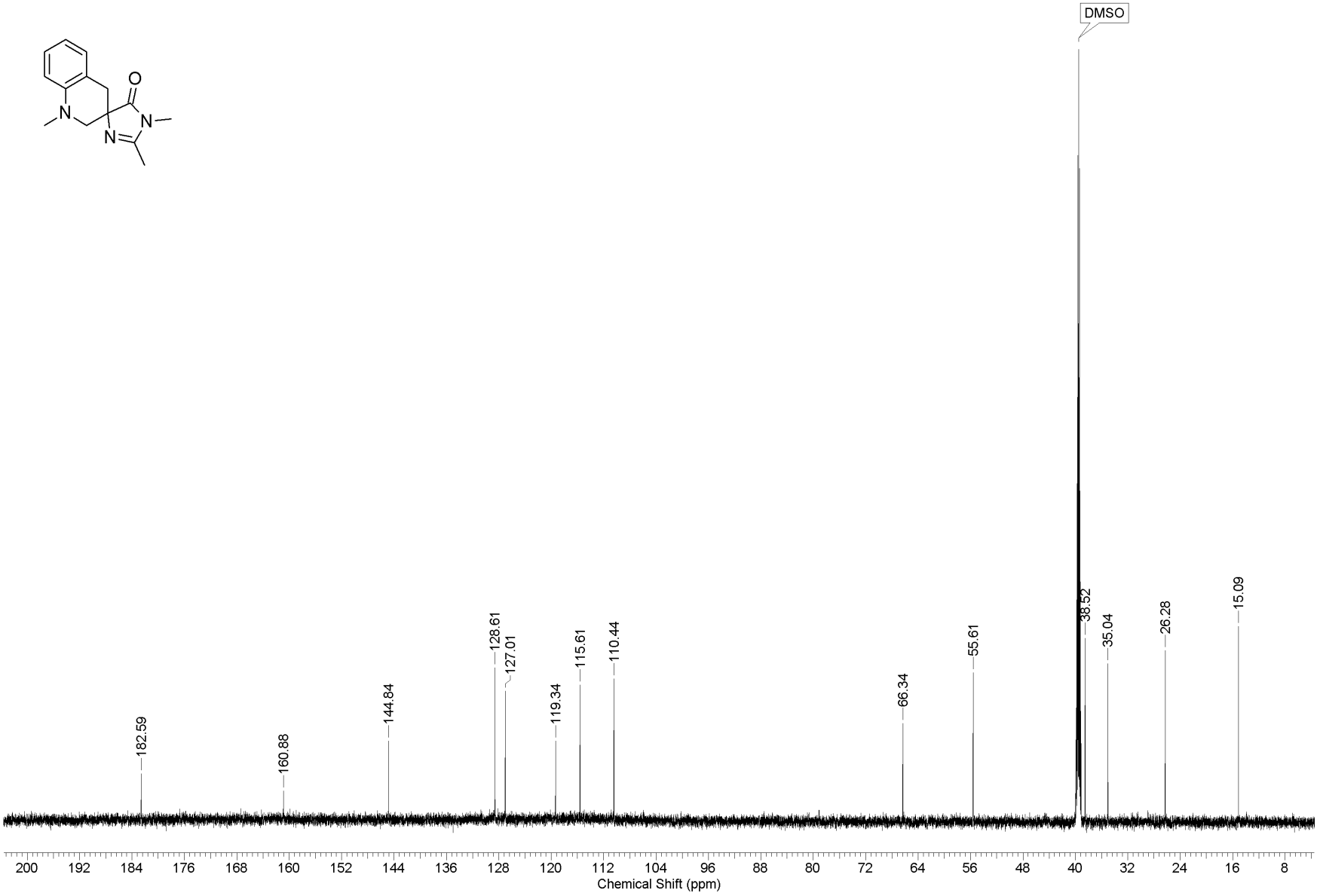

DMSO
H2O
8.62
8.61
7.44
7.34
7.33
7.32
7.27
7.26
7.25
6.74
6.74
6.73
6.73
6.66
6.66
4.11
3.78
3.09
2.61
2.33
1.01
1.03
4.47
1.10
1.01
0.98
1.99
2.92
3.01
2.93
2.97
Chemical Shift (ppm)

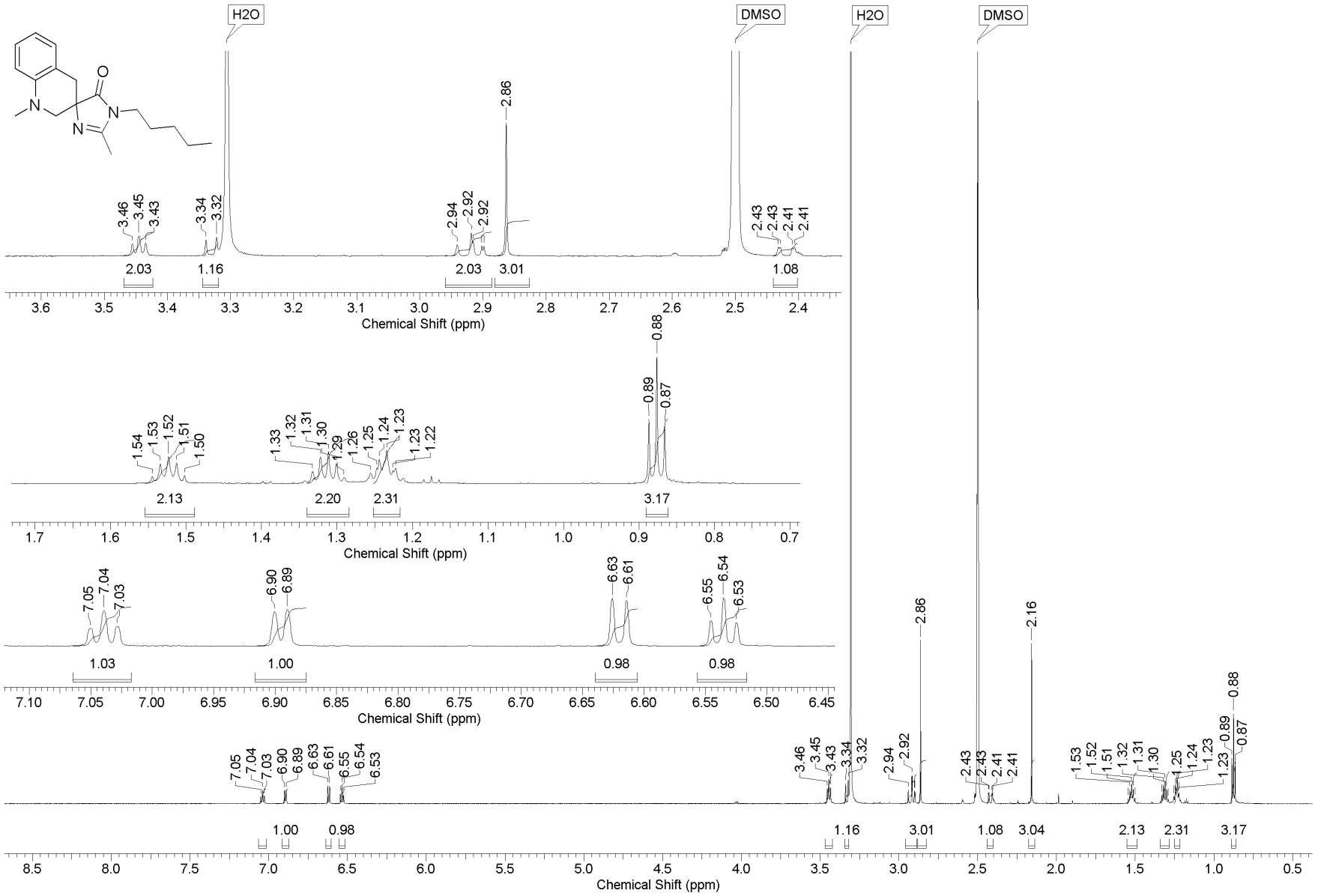

O
N
N
O
N
DMSO
128.38
128.24
137.77
136.39
134.20
127.14
121.32
120.35
55.16
136
134
132
130
128
126
124
122
120
Chemical Shift (ppm)
169.97
162.31
161.36
155.58
137.77
136.39
134.20
128.38
128.24
127.14
121.32
120.35
108.63
105.99
60.92
55.16
41.67
26.10
15.17
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

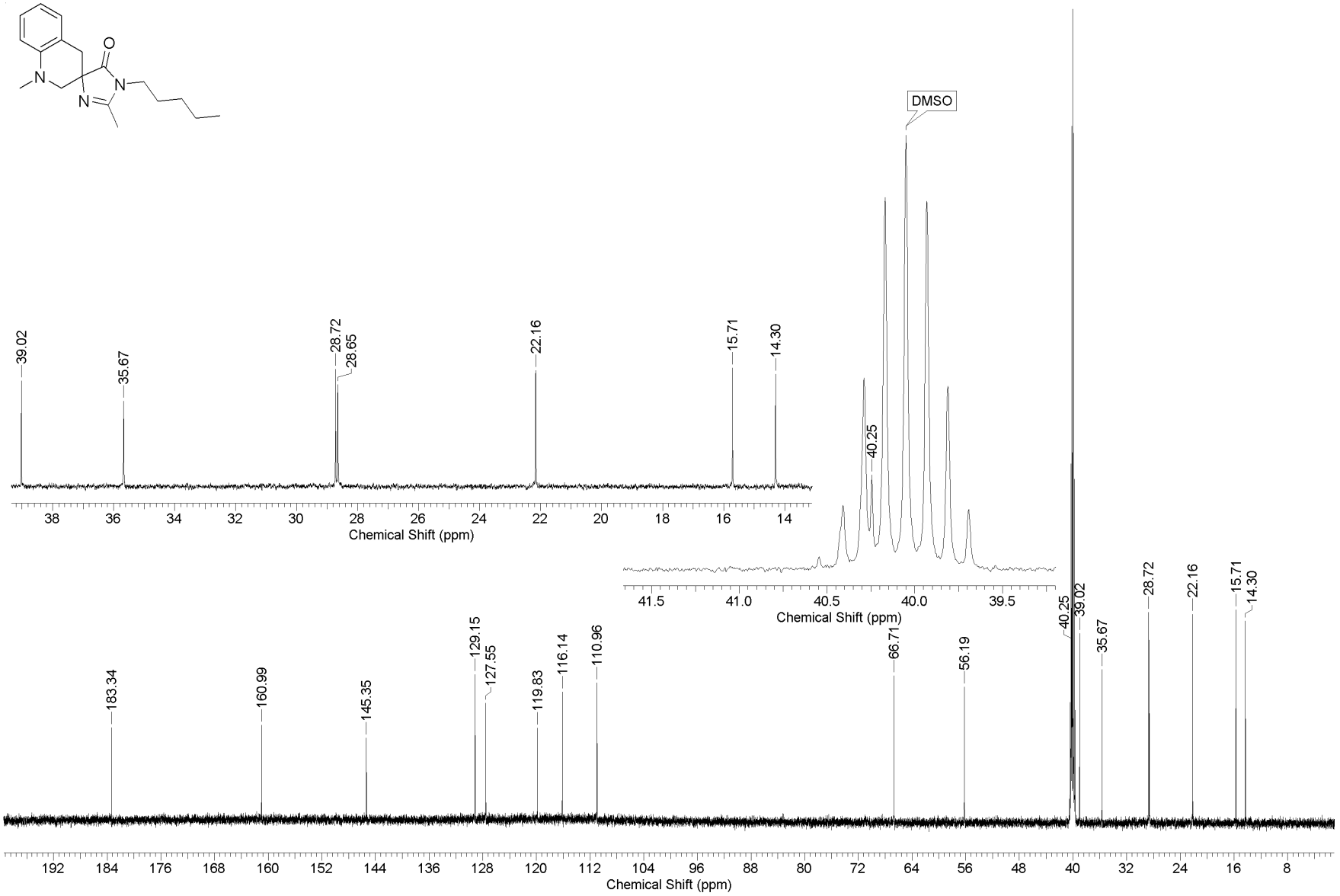

DMSO
H2O
DMSO
H2O
4.19
3.22
3.21
3.20
3.09
2.99
2.98
2.97
2.36
2.55
2.41
3.29
2.54
3.69
Chemical Shift (ppm)
8.60
8.59
7.40
7.39
7.38
7.27
7.23
7.21
7.20
7.15
7.14
1.07
1.26
1.20
9.91
Chemical Shift (ppm)
8.60
8.59
7.40
7.39
7.27
7.23
7.22
7.21
7.20
7.18
7.16
7.15
7.14
4.19
3.22
3.21
2.99
2.98
2.97
3.09
2.36
1.07
1.26
9.91
2.55
2.41
2.54
3.69
Chemical Shift (ppm)

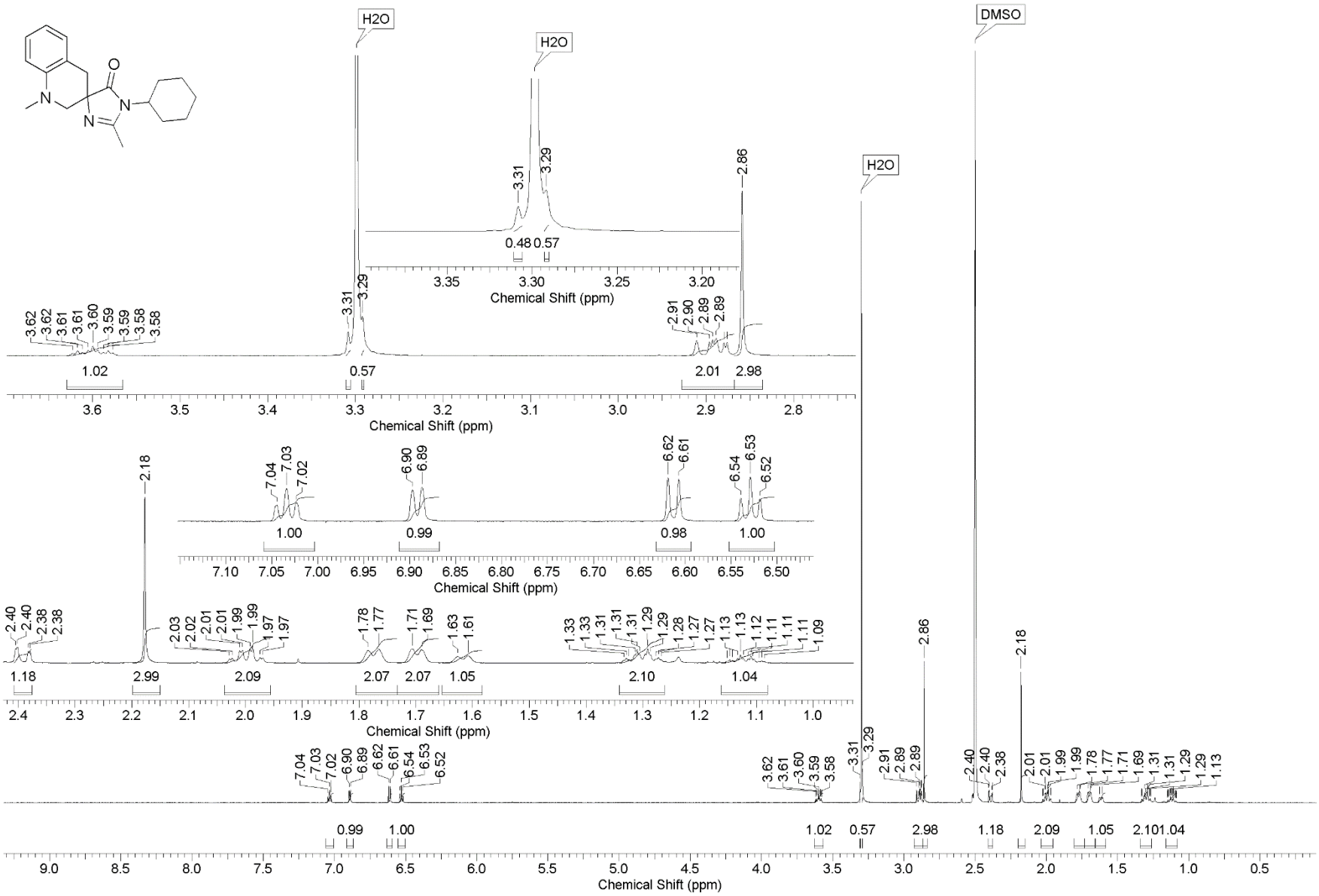

DMSO
138.29
134.51
132.58
130.69
128.84
128.71
128.14
126.37
126.25
125.75
122.62
120.75
119.05
Chemical Shift (ppm)
170.04
163.93
153.20
53.75
52.20
28.79
26.20
15.28
Chemical Shift (ppm)

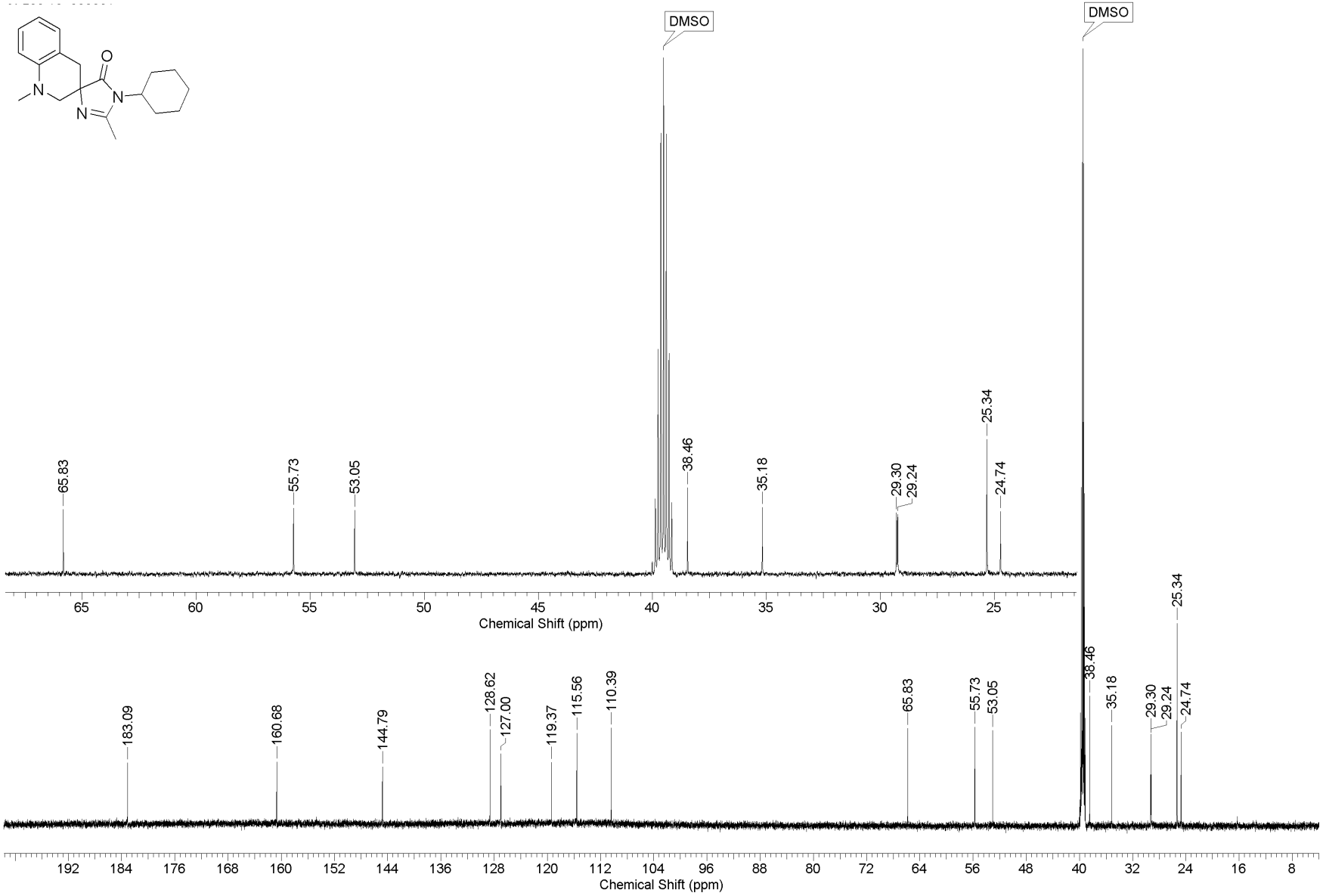

DMSO
DMSO
H2O
3.01
2.86
2.14
3.33
3.32
2.93
2.92
2.91
2.45
2.45
2.43
2.42
1.03
3.03
2.00
2.96
1.04
2.99
Chemical Shift (ppm)
7.05
7.04
7.03
6.89
6.88
6.63
6.61
6.55
6.55
6.54
6.54
6.53
6.53
1.00
0.99
0.96
0.98
Chemical Shift (ppm)
H2O
3.01
2.86
2.14
3.33
3.32
2.93
2.45
2.45
2.43
2.42
7.05
7.04
7.03
6.89
6.88
6.63
6.61
6.55
6.54
6.53
1.00
0.99
0.98
1.03
3.03
2.96
1.04
2.99
Chemical Shift (ppm)

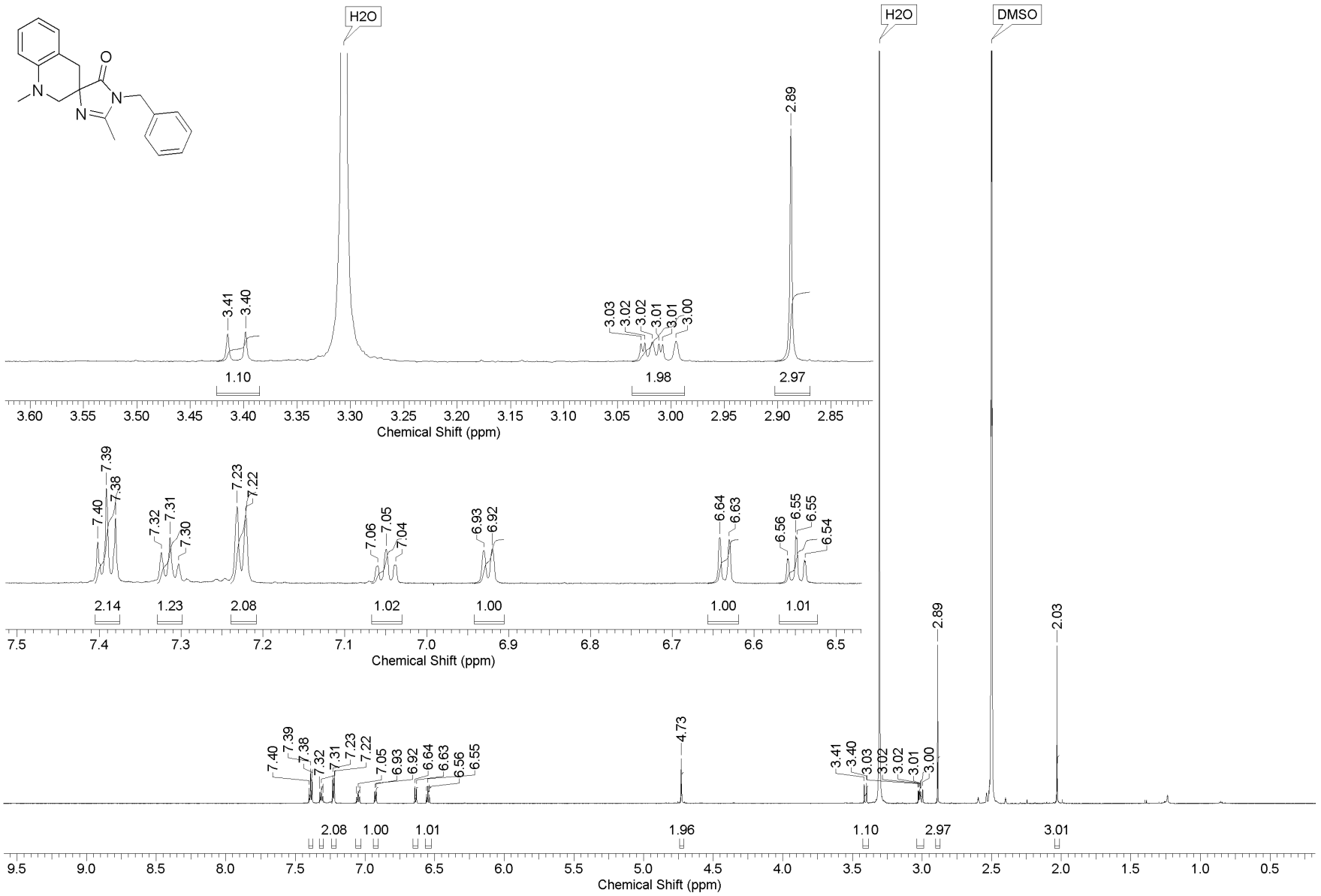

DMSO
182.59
160.88
144.84
128.61
127.01
119.34
115.61
110.44
66.34
55.61
38.52
35.04
26.28
15.09
200 192 184 176 168 160 152 144 136 128 120 112 104 96 88 80 72 64 56 48 40 32 24 16 8
Chemical Shift (ppm)

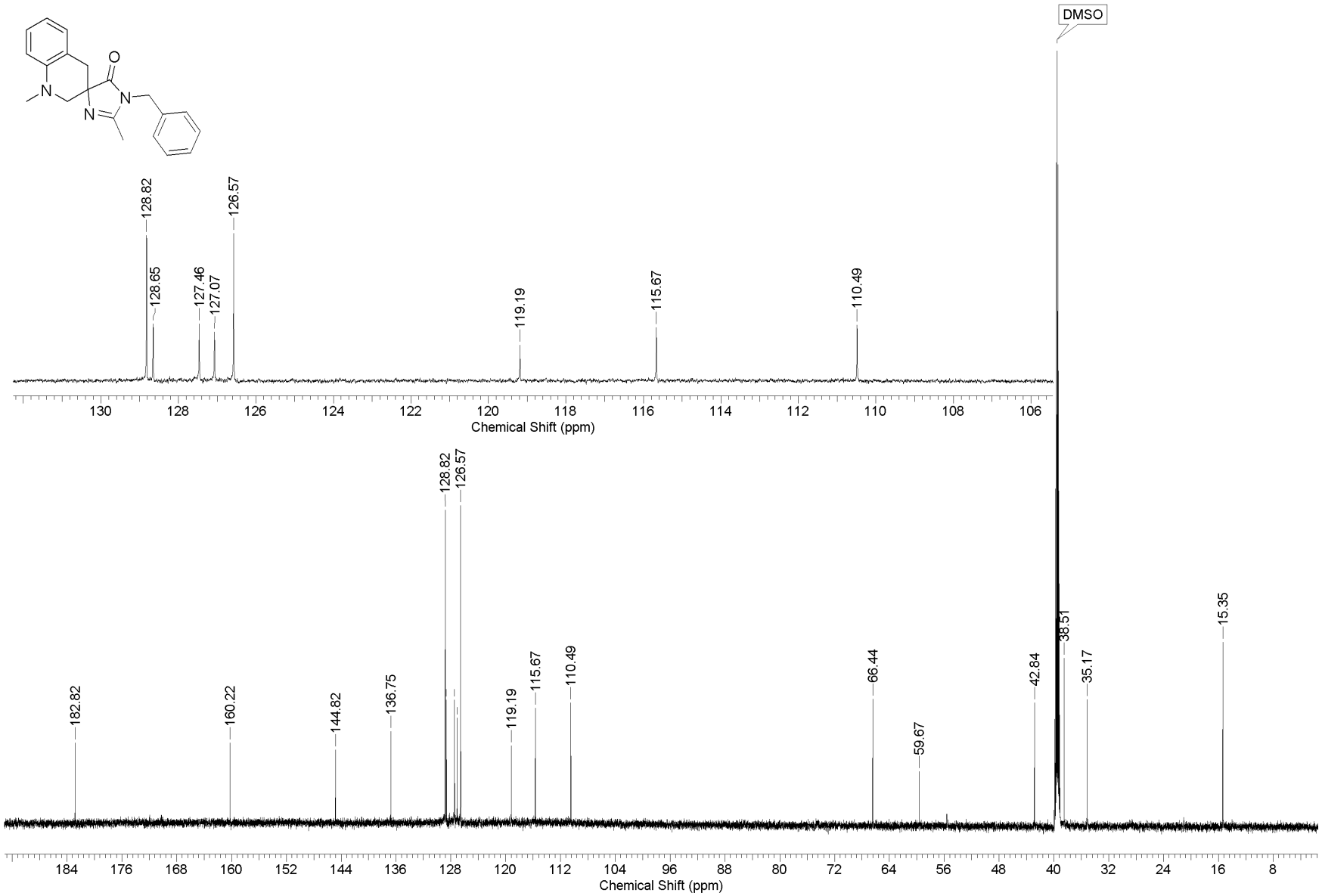

H2O
DMSO
H2O
DMSO
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)

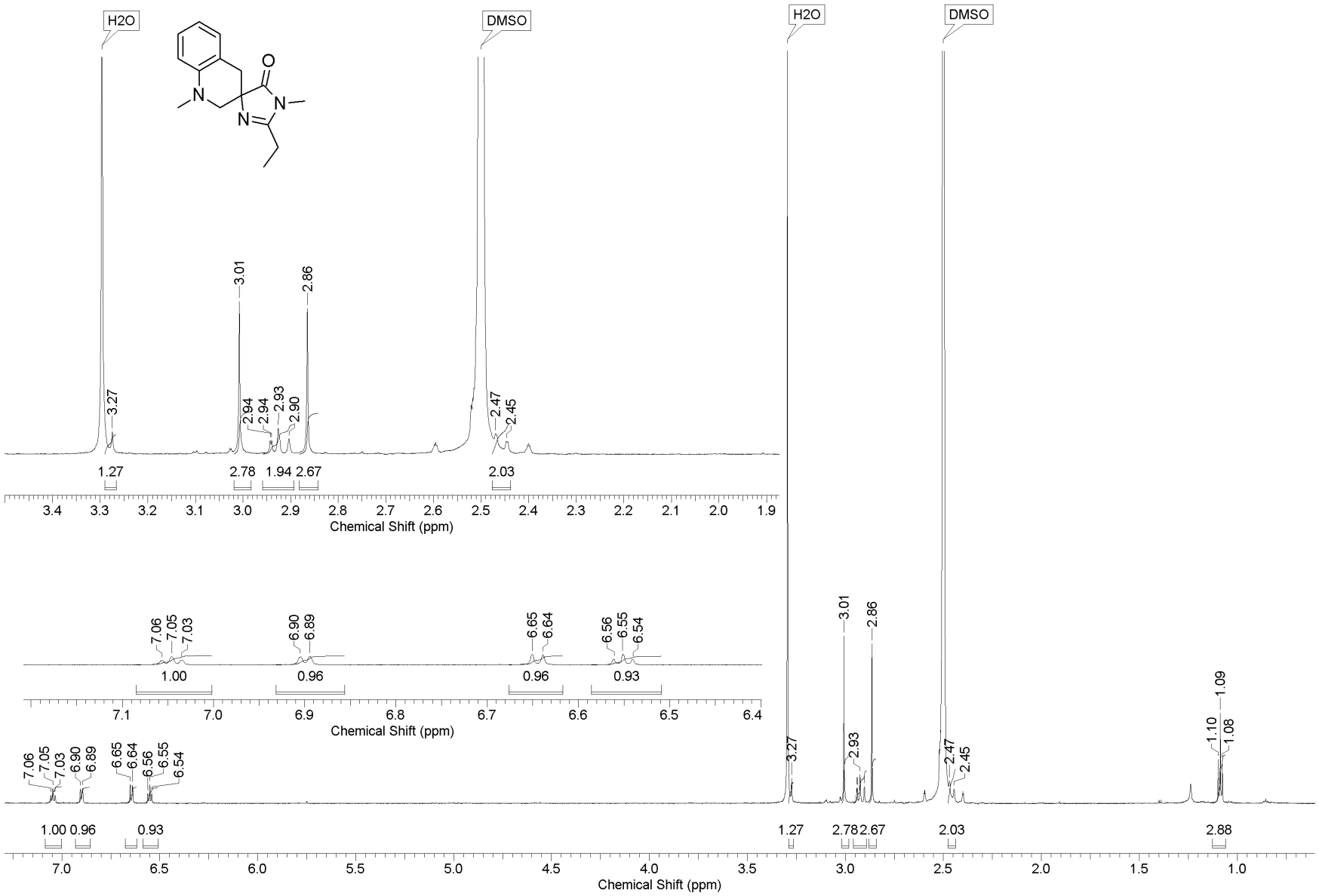

O
N
N
N
DMSO
39.02
35.67
28.72
28.65
22.16
15.71
14.30
40.25
183.34
160.99
145.35
129.15
127.55
119.83
116.14
110.96
66.71
56.19
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)

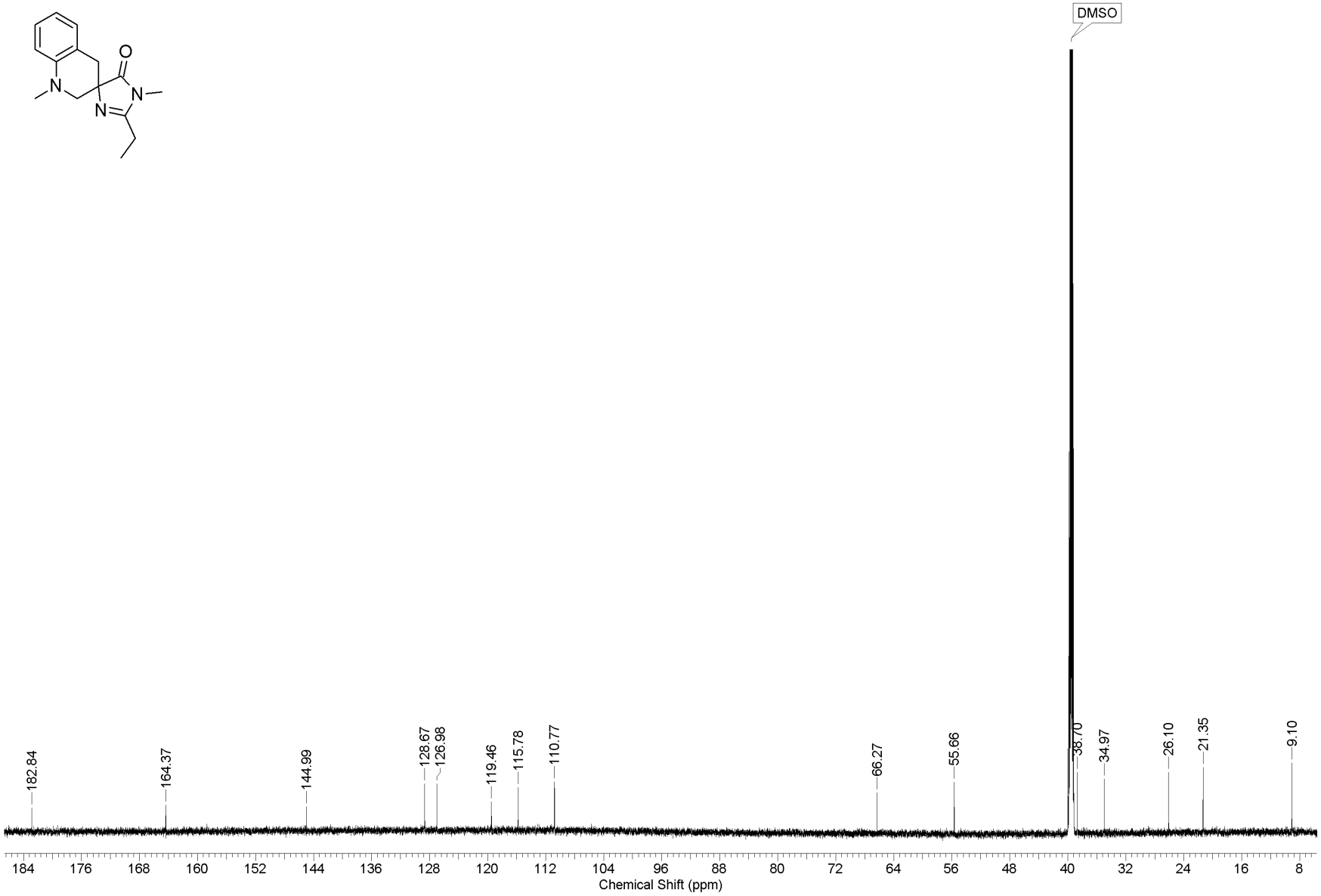

H2O
H2O
DMSO
H2O
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)

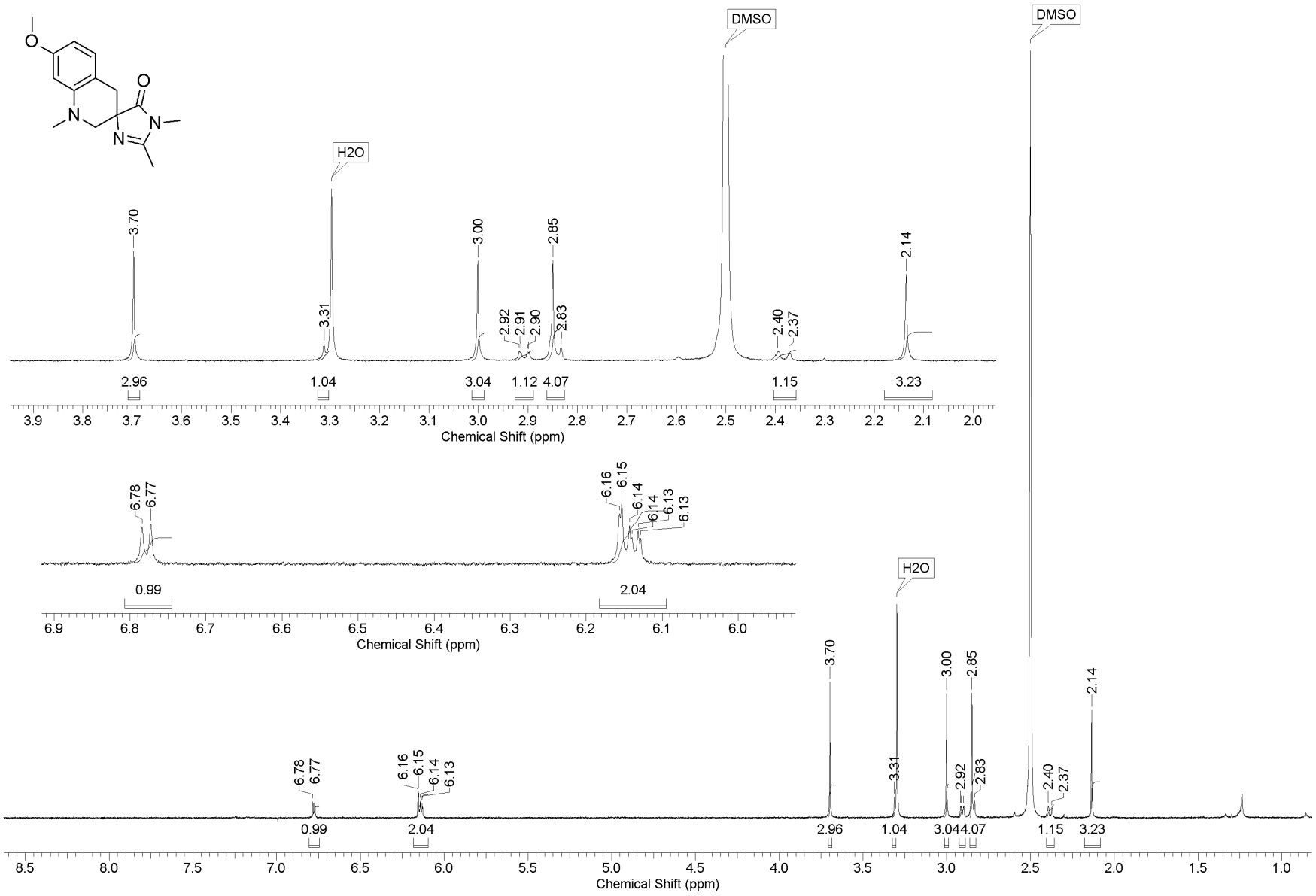

DMSO
DMSO
65.83
55.73
53.05
38.46
35.18
29.30
29.24
25.34
24.74
Chemical Shift (ppm)
183.09
160.68
144.79
128.62
127.00
119.37
115.56
110.39
65.83
55.73
53.05
38.46
35.18
29.30
29.24
25.34
24.74
Chemical Shift (ppm)

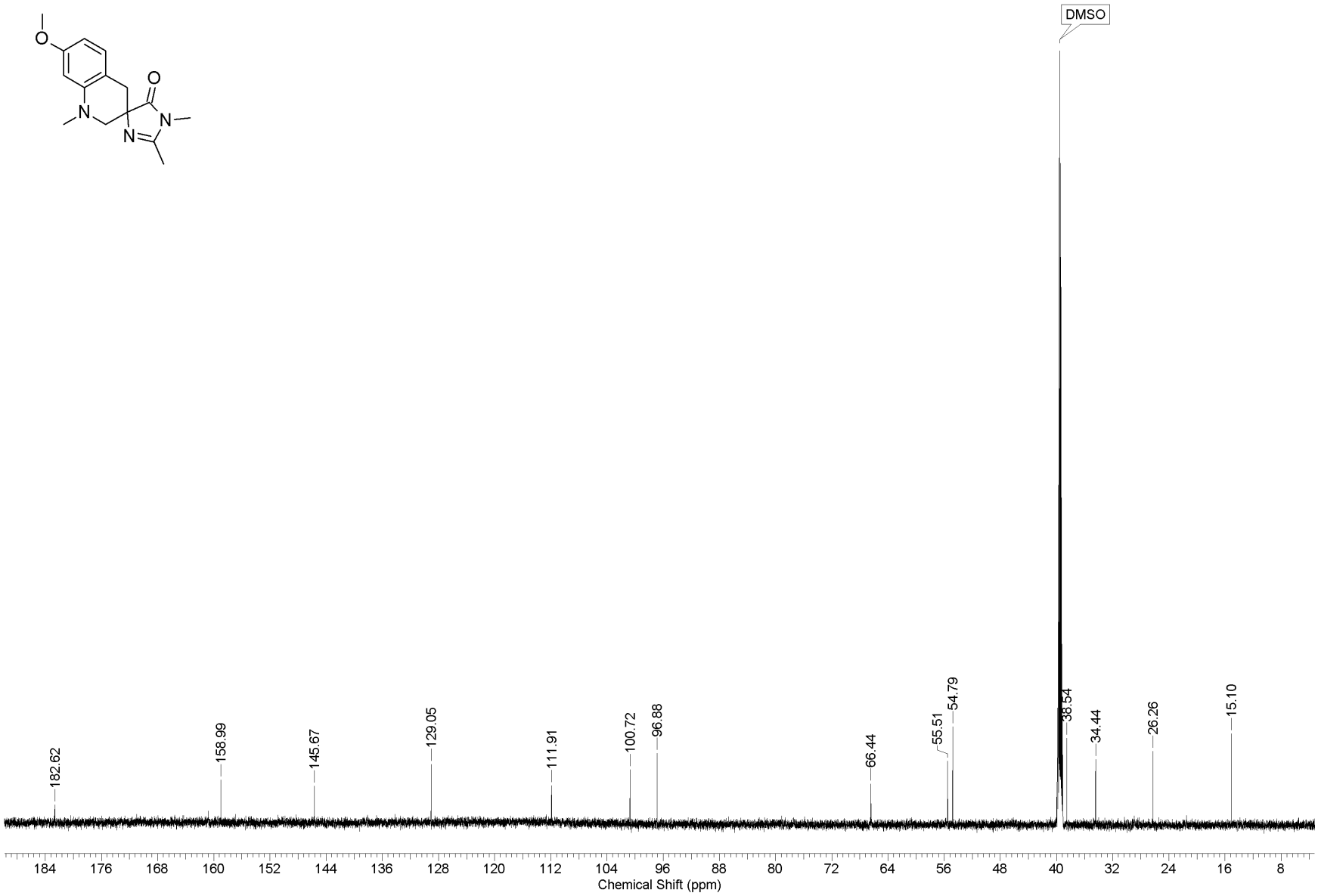

H2O
H2O
DMSO
3.41
3.40
3.03
3.02
3.02
3.01
3.01
3.00
2.89
1.10
1.98
2.97
Chemical Shift (ppm)
7.40
7.39
7.38
7.32
7.31
7.30
7.23
7.22
7.06
7.05
7.04
6.93
6.92
6.64
6.63
6.56
6.55
6.55
6.54
2.14
1.23
2.08
1.02
1.00
1.00
1.01
Chemical Shift (ppm)
7.40
7.39
7.38
7.32
7.31
7.23
7.22
7.05
6.93
6.92
6.64
6.63
6.56
6.55
4.73
3.41
3.40
3.03
3.02
3.02
3.01
3.00
2.89
2.03
2.08
1.00
1.01
1.96
1.10
2.97
3.01
Chemical Shift (ppm)

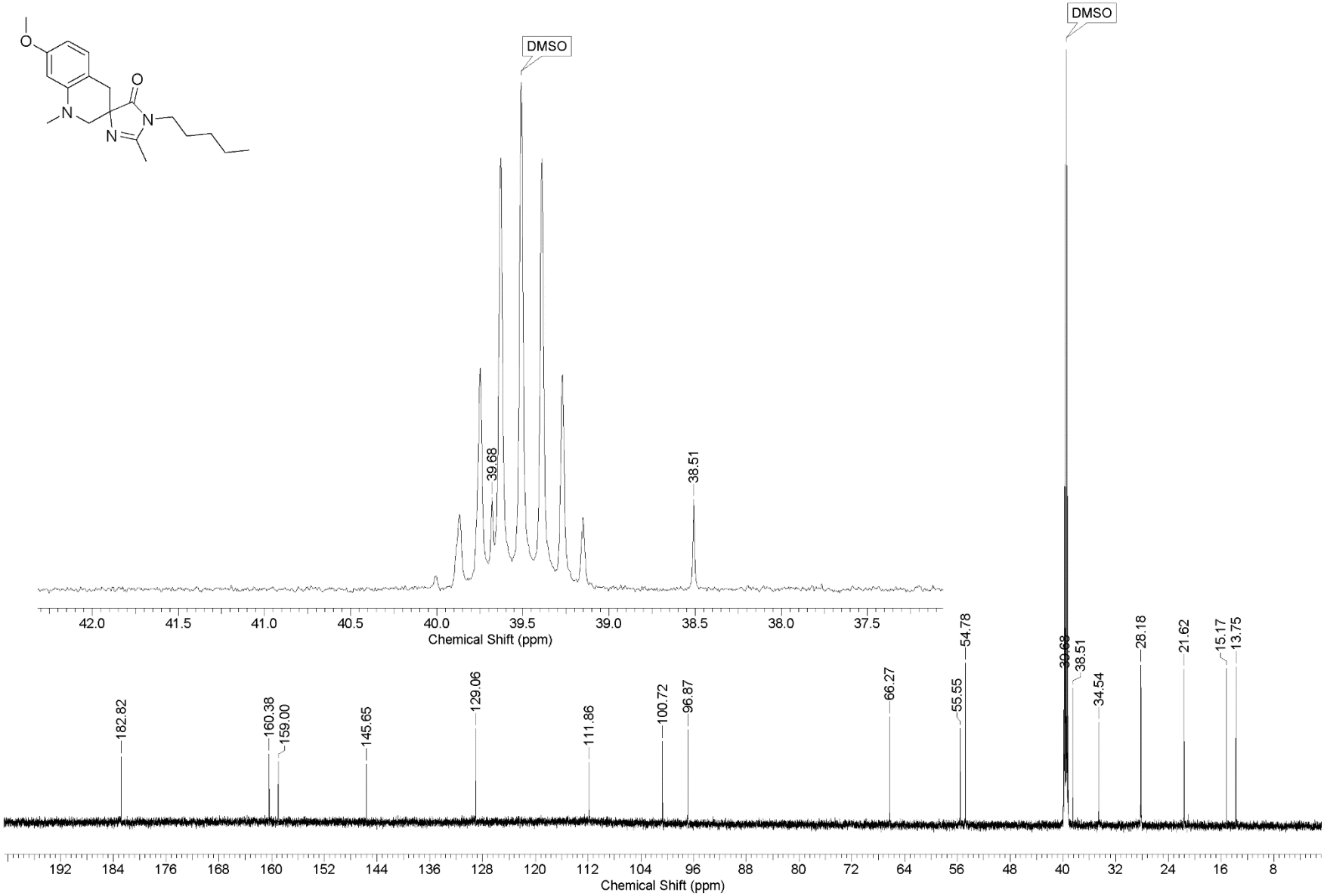

O
N
N
N
DMSO
128.82
128.65
127.46
127.07
126.57
119.19
115.67
110.49
130
128
126
124
122
120
118
116
114
112
110
108
106
Chemical Shift (ppm)
128.82
126.57
182.82
160.22
144.82
136.75
119.19
115.67
110.49
66.44
59.67
42.84
38.51
35.17
15.35
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

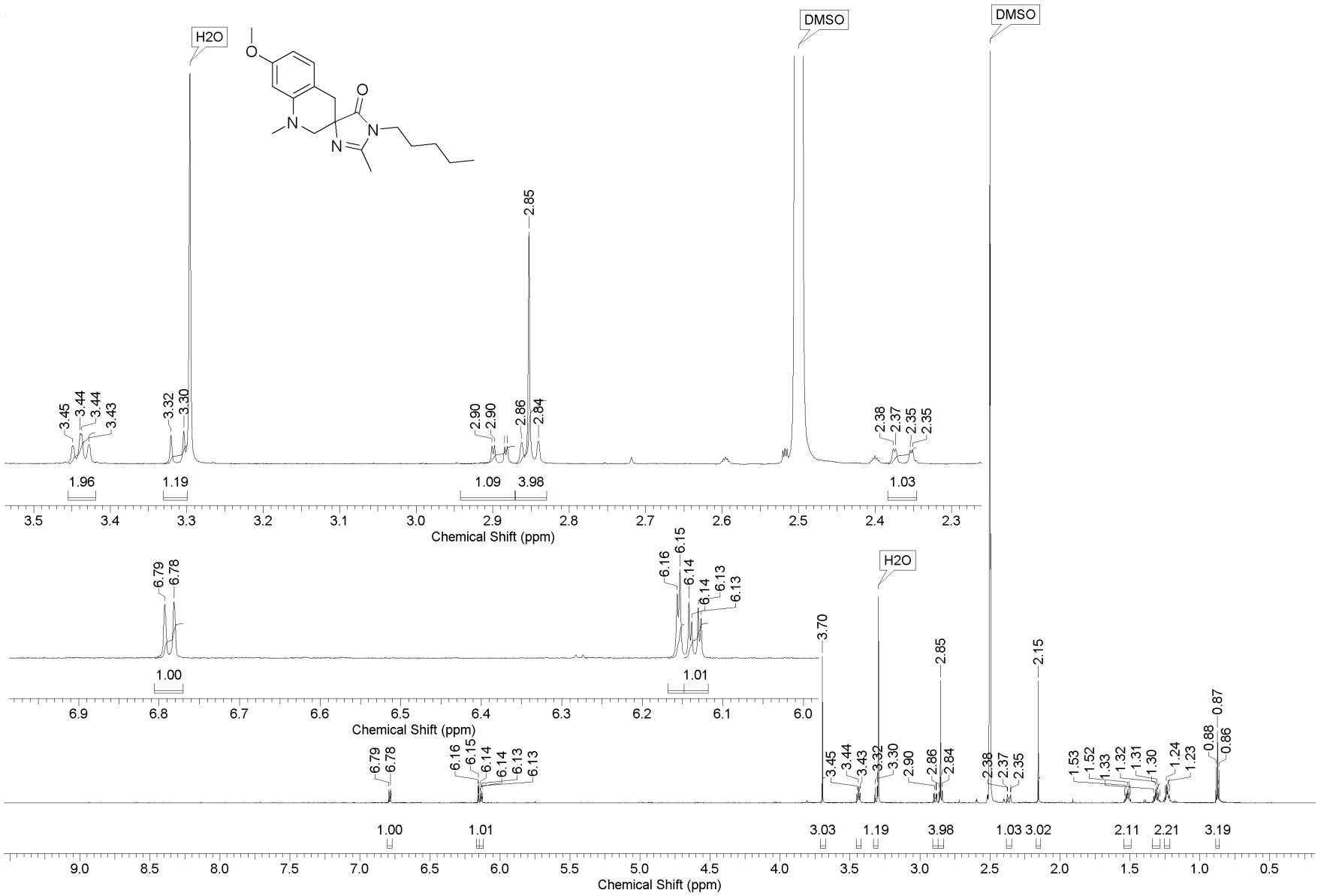

H2O
DMSO
O
N
N
N
3.01
2.86
3.27
2.94
2.94
2.93
2.90
2.47
2.45
1.27
2.78
1.94
2.67
2.03
Chemical Shift (ppm)
7.06
7.05
7.03
6.90
6.89
6.65
6.64
6.56
6.55
6.54
1.00
0.96
0.96
0.93
Chemical Shift (ppm)
1.09
1.10
1.08
1.00
0.96
0.93
1.27
2.78
2.67
2.03
2.88
Chemical Shift (ppm)

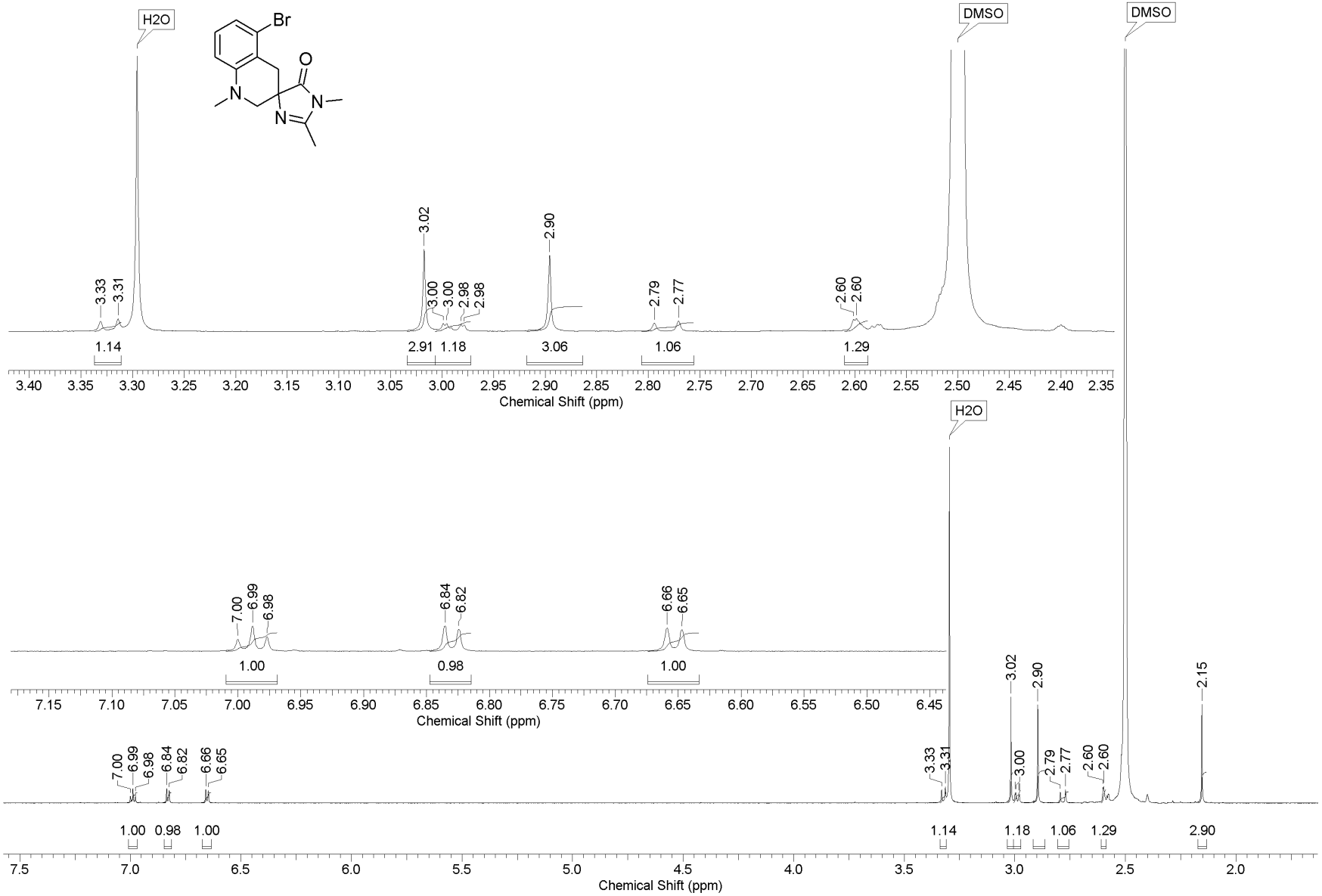

O
N
N
N
DMSO
182.84
164.37
144.99
128.67
126.98
119.46
115.78
110.77
66.27
55.66
38.70
34.97
26.10
21.35
9.10
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

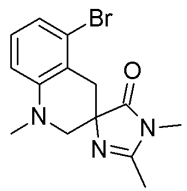

O
O
N
N
N
H2O
DMSO
DMSO
3.70
3.31
3.00
2.92
2.91
2.90
2.85
2.83
2.40
2.37
2.14
2.96
1.04
3.04
1.12
4.07
1.15
3.23
Chemical Shift (ppm)
6.78
6.77
6.16
6.15
6.14
6.14
6.13
6.13
0.99
2.04
Chemical Shift (ppm)
H2O
3.70
3.31
3.00
2.92
2.85
2.83
2.14
2.40
2.37
6.78
6.77
6.16
6.15
6.14
6.13
0.99
2.04
2.96
1.04
3.04
4.07
1.15
3.23
Chemical Shift (ppm)


DMSO
182.62
158.99
145.67
129.05
111.91
100.72
96.88
66.44
55.51
54.79
38.54
34.44
26.26
15.10
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

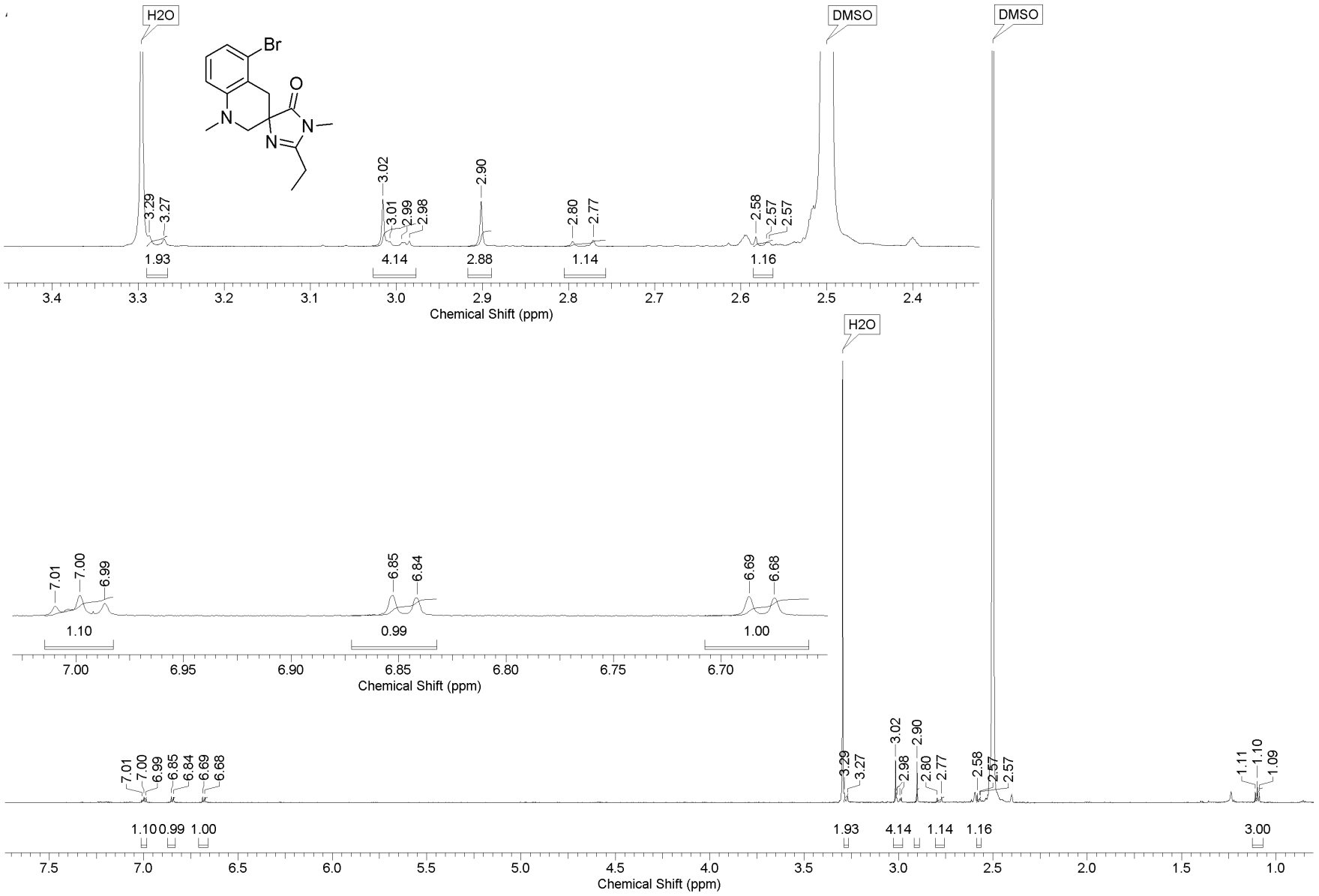

O
O
N
N
N
DMSO
DMSO
39.68
38.51
42.0
41.5
41.0
40.5
40.0
39.5
39.0
38.5
38.0
37.5
Chemical Shift (ppm)
182.82
160.38
159.00
145.65
129.06
111.86
100.72
96.87
66.27
55.55
54.78
38.51
34.54
28.18
21.62
15.17
13.75
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

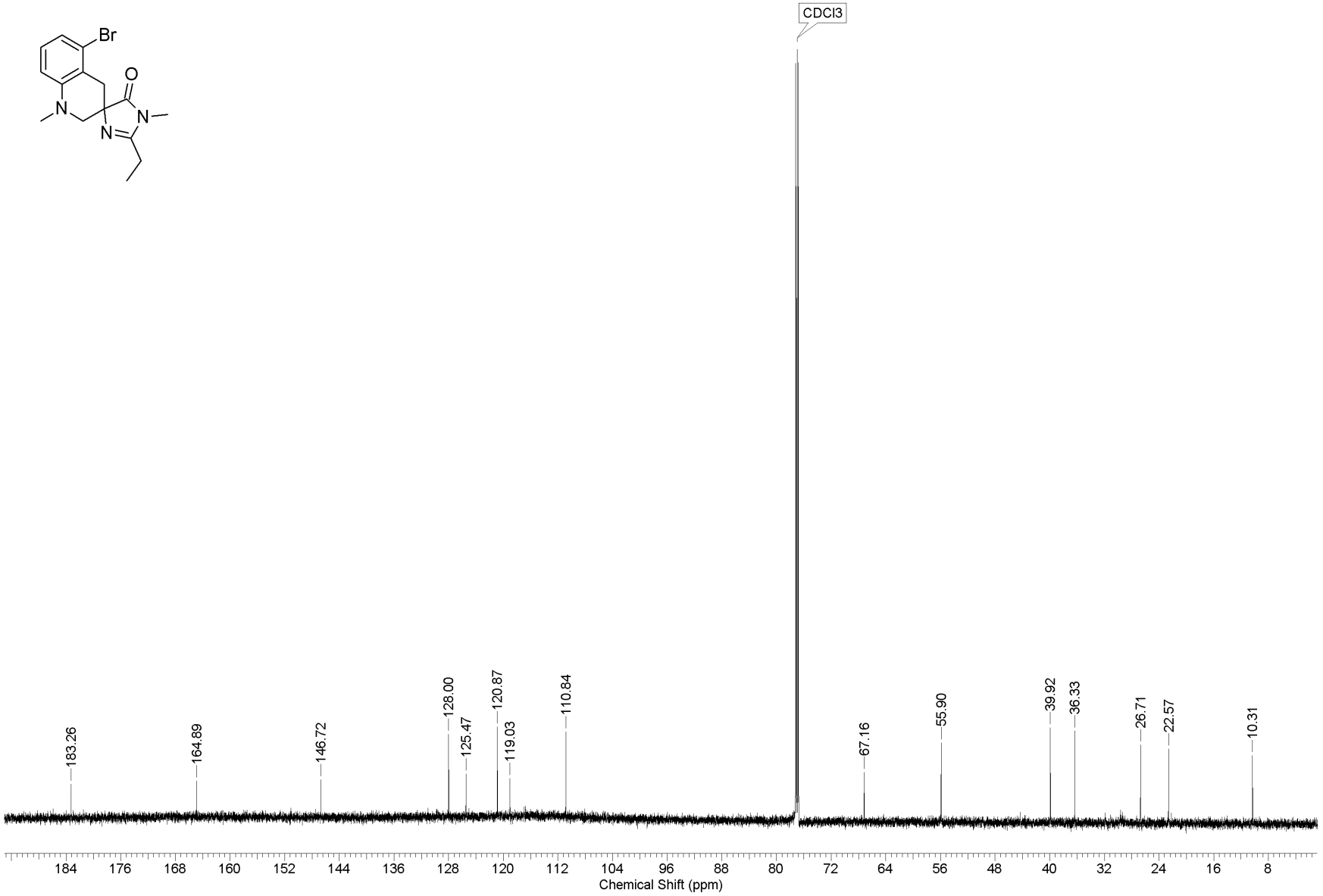

H2O
DMSO
DMSO
O
O
N
N
N
3.45
3.44
3.44
3.43
3.32
3.30
2.90
2.90
2.86
2.85
2.84
2.38
2.37
2.35
2.35
1.96
1.19
1.09
3.98
1.03
Chemical Shift (ppm)
6.79
6.78
6.16
6.15
6.14
6.14
6.13
6.13
3.70
H2O
2.85
2.15
1.00
1.01
Chemical Shift (ppm)
6.79
6.78
6.16
6.15
6.14
6.14
6.13
6.13
3.45
3.44
3.43
3.32
3.30
2.90
2.86
2.84
2.38
2.37
2.35
1.53
1.52
1.33
1.32
1.31
1.30
1.24
1.23
0.88
0.87
0.86
1.00
1.01
3.03
1.19
3.98
1.03
3.02
2.11
2.21
3.19
Chemical Shift (ppm)


H2O
DMSO
DMSO
Br
O
N
N
N
3.33
3.31
3.02
3.00
3.00
2.98
2.98
2.90
2.79
2.77
2.60
2.60
1.14
2.91
1.18
3.06
1.06
1.29
Chemical Shift (ppm)
H2O
7.00
6.99
6.98
6.84
6.82
6.66
6.65
1.00
0.98
1.00
Chemical Shift (ppm)
3.02
2.90
2.15
3.33
3.31
3.00
2.79
2.77
2.60
2.60
1.00
0.98
1.00
1.14
1.18
1.06
1.29
2.90
Chemical Shift (ppm)


Br
O
N
N
N

DMSO
182.25
161.38
146.69
128.20
124.51
119.11
118.19
110.05
65.89
55.03
35.84
26.36
15.14
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


H2O
DMSO
DMSO
Br
O
N
N
N
3.29
3.27
3.02
3.01
2.99
2.98
2.90
2.80
2.77
2.58
2.57
2.57
1.93
4.14
2.88
1.14
1.16
Chemical Shift (ppm)
H2O
7.01
7.00
6.99
6.85
6.84
6.69
6.68
1.10
0.99
1.00
Chemical Shift (ppm)
7.01
7.00
6.99
6.85
6.84
6.69
6.68
3.29
3.27
3.02
2.98
2.90
2.80
2.77
2.58
2.57
2.57
1.11
1.10
1.09
1.10
0.99
1.00
1.93
4.14
1.14
1.16
3.00
Chemical Shift (ppm)


Br
O
N
N
N
CDCl3
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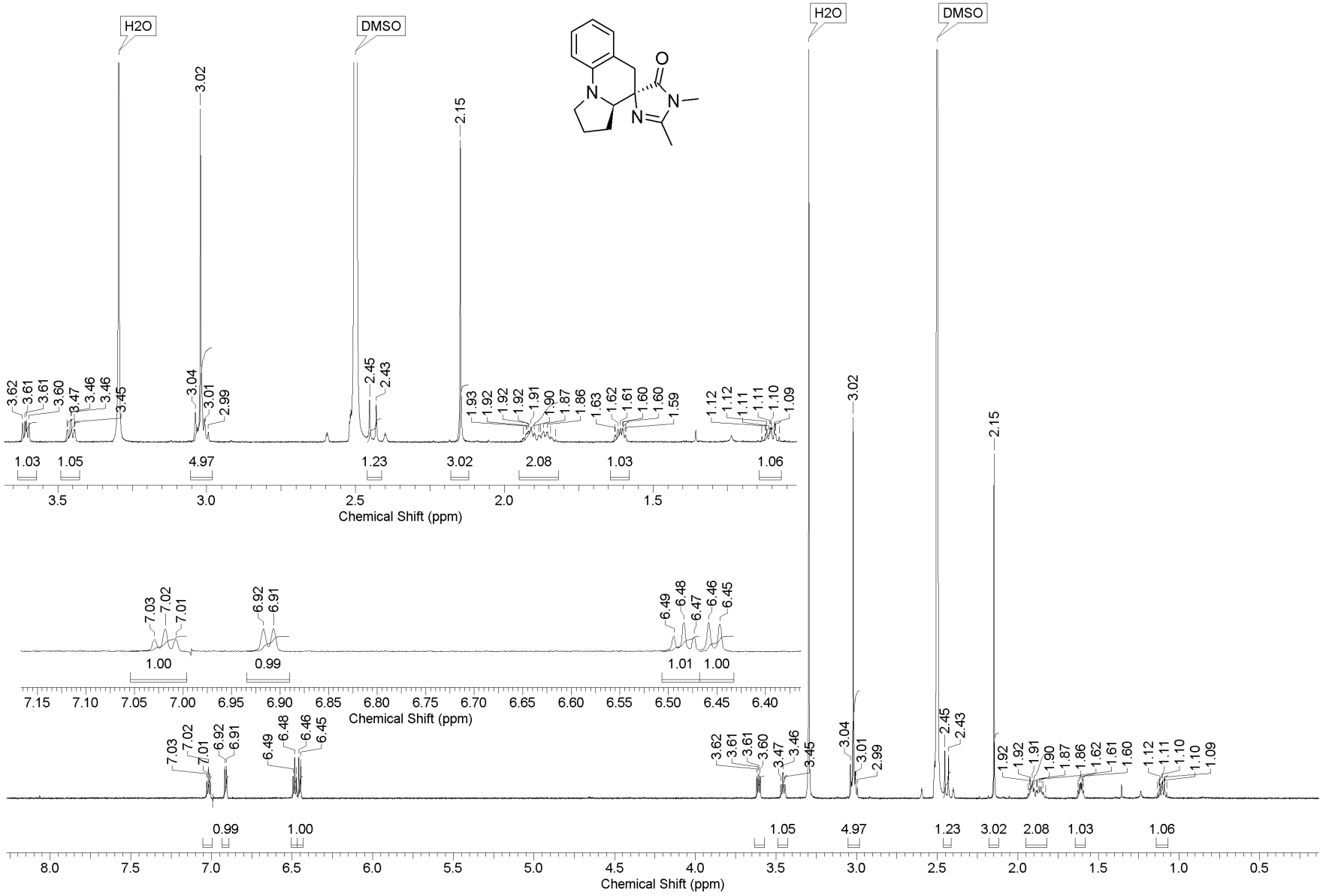
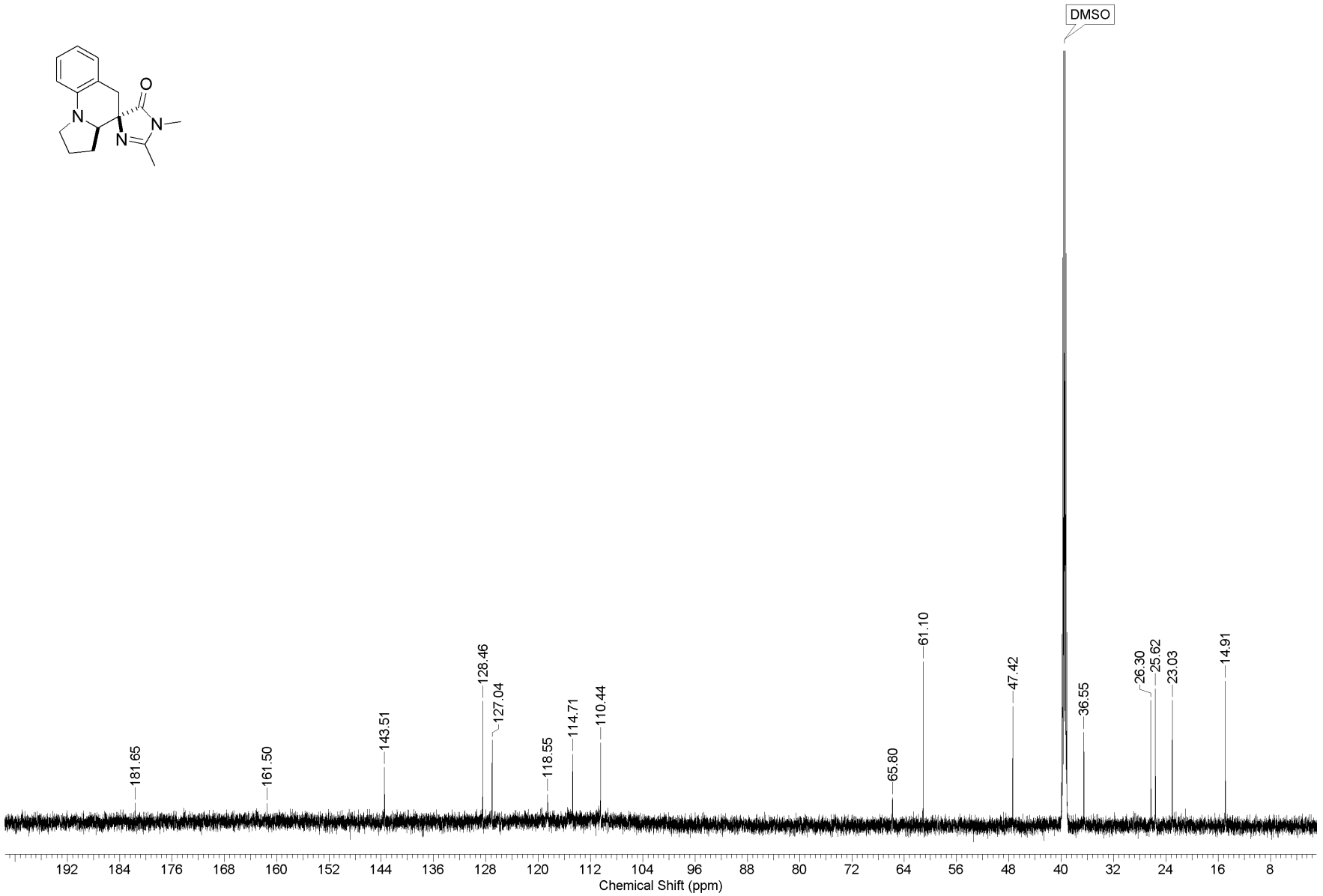
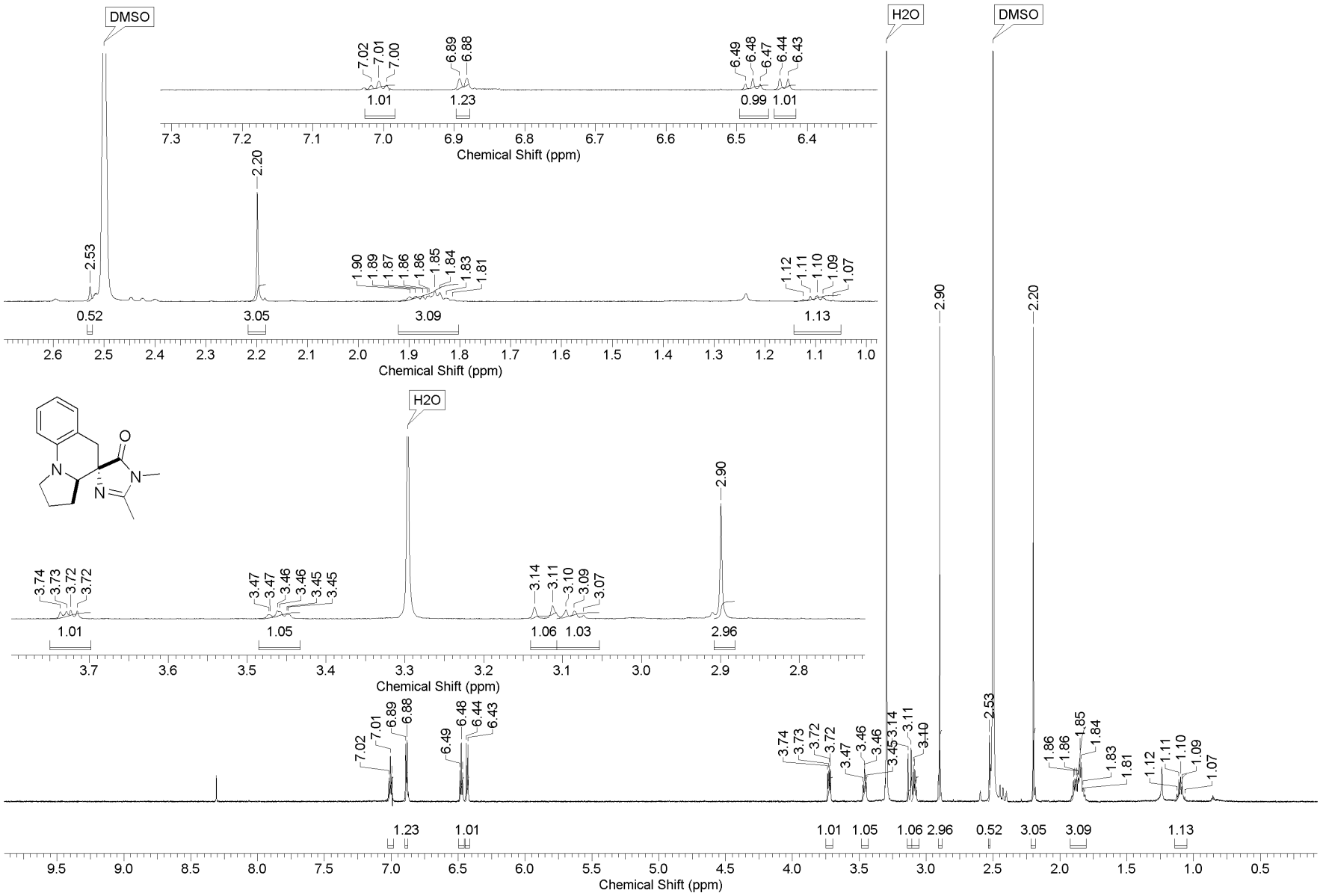
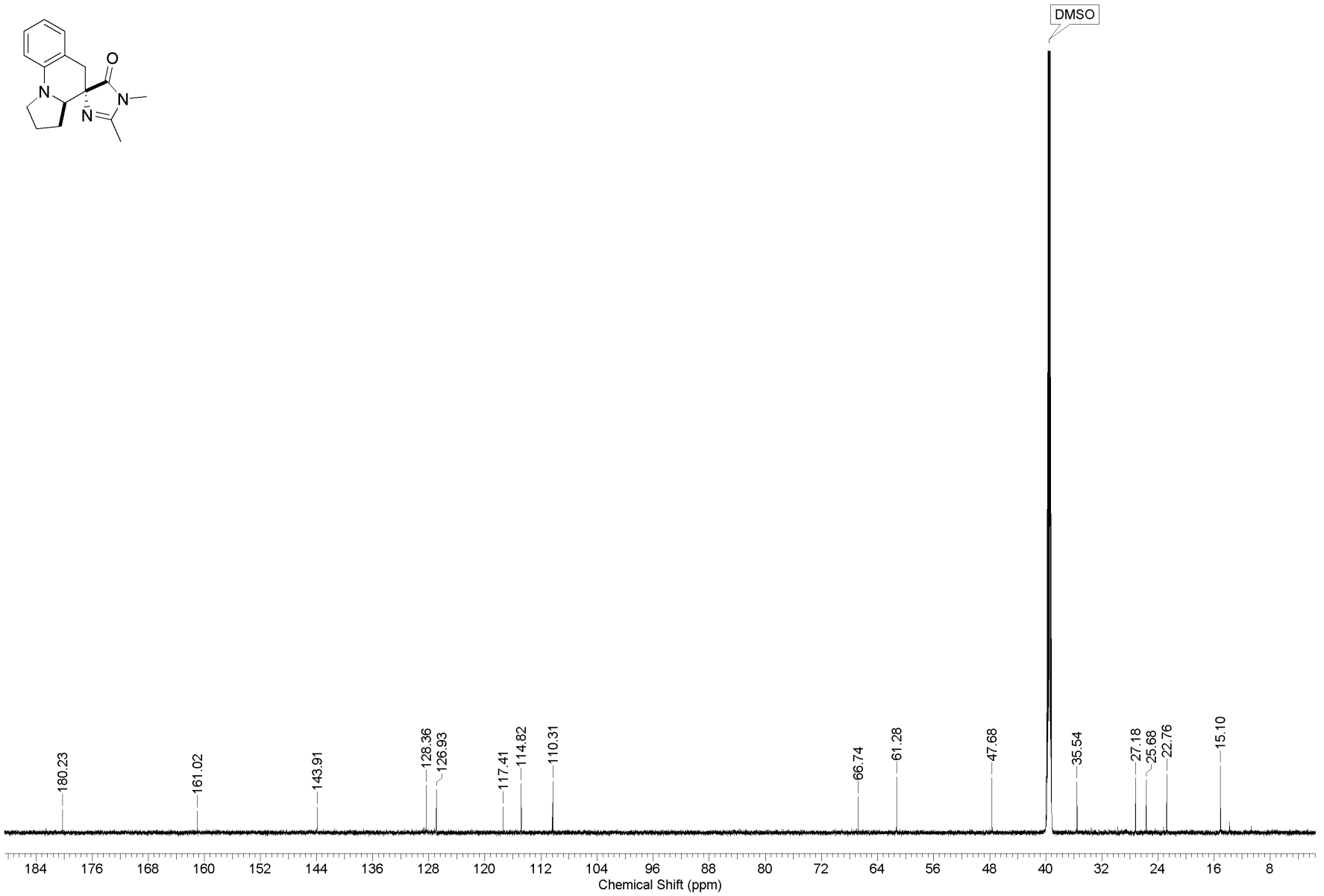
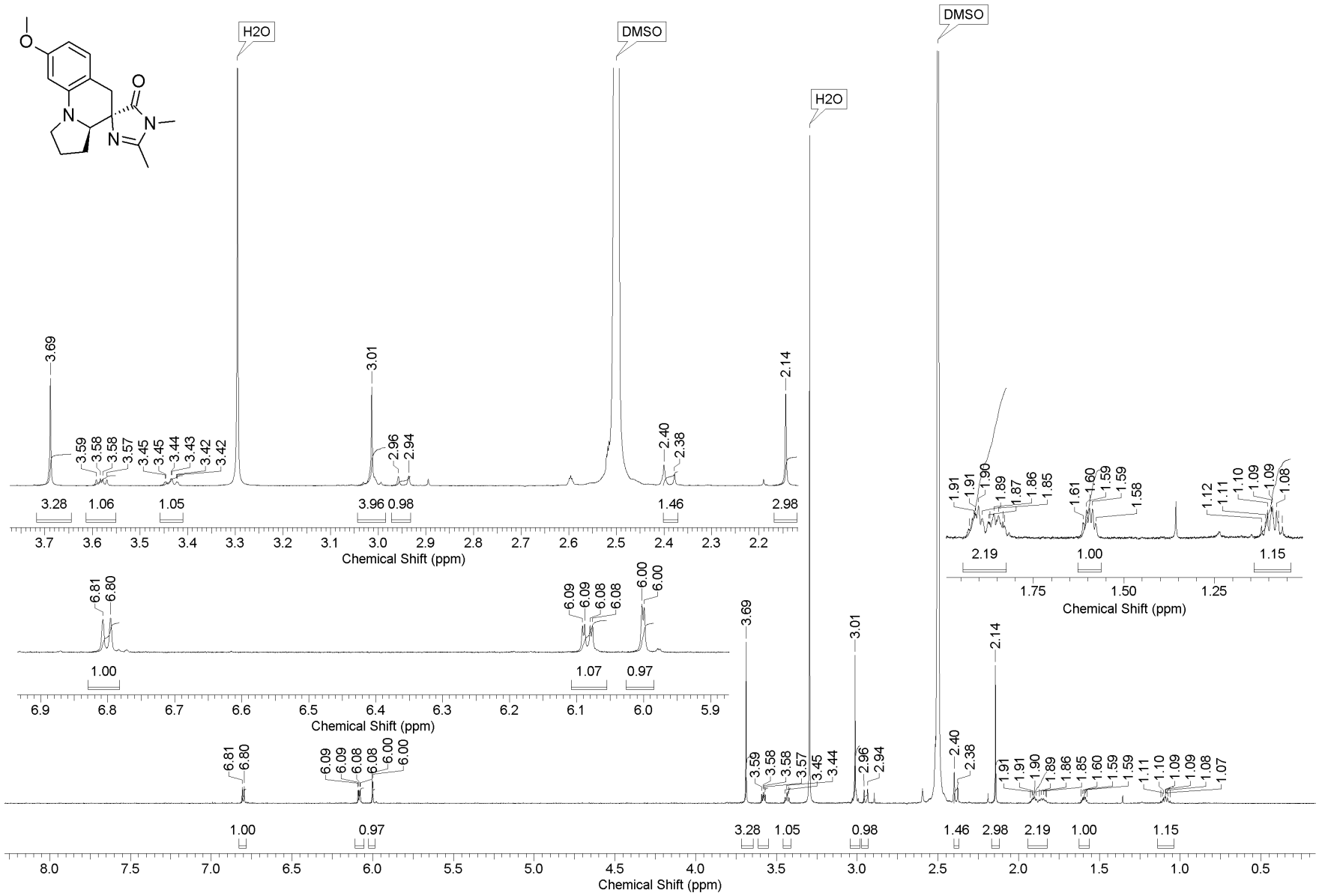
164.89
146.72
128.00
125.47
120.87
119.03
110.84
67.16
55.90
39.92
36.33
26.71
22.57
10.31
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

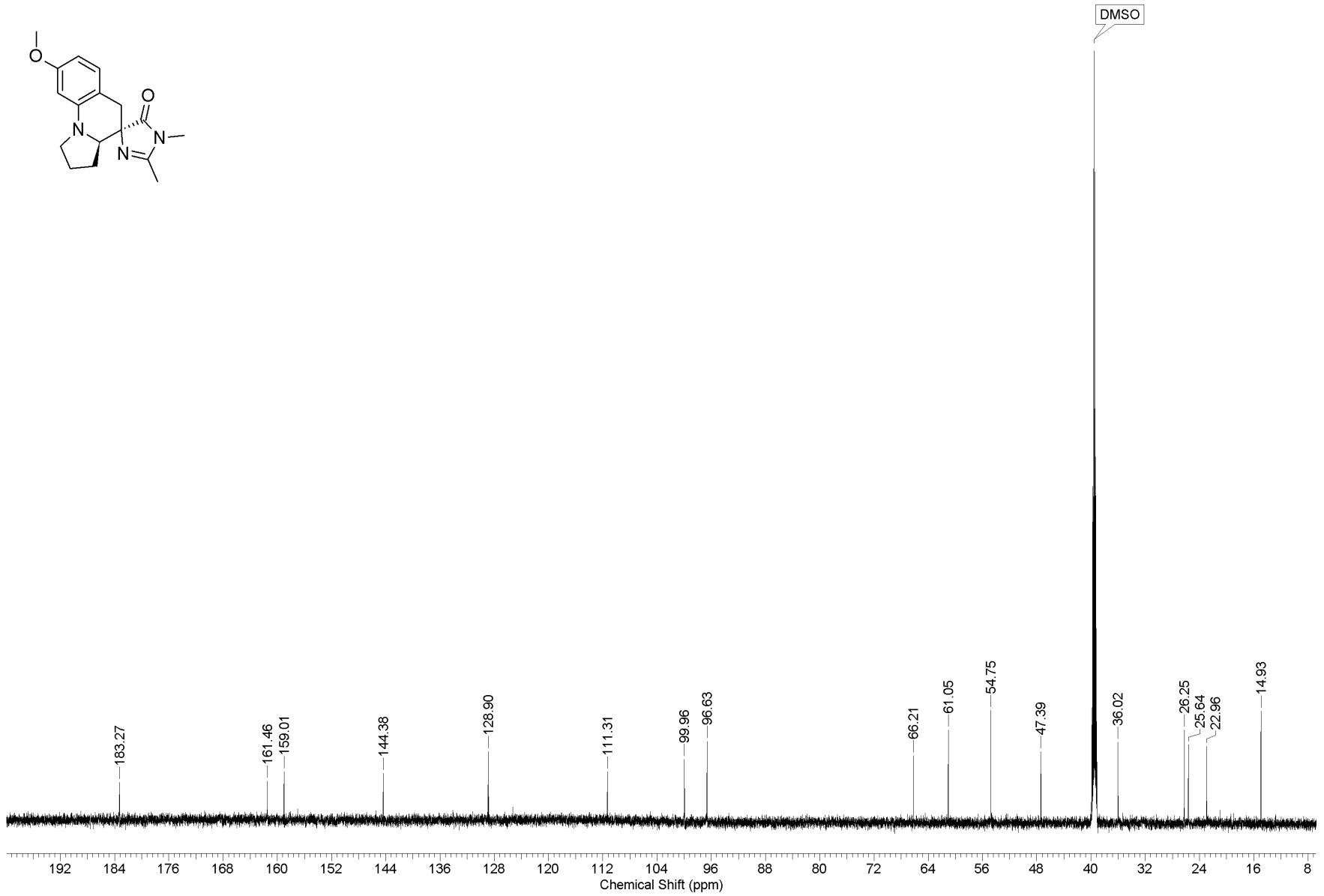

H2O
DMSO
3.02
2.15
3.62
3.61
3.61
3.60
3.47
3.46
3.46
3.45
3.04
3.01
2.99
2.45
2.43
1.93
1.92
1.92
1.92
1.91
1.90
1.87
1.86
1.63
1.62
1.61
1.60
1.60
1.59
1.12
1.12
1.11
1.11
1.10
1.09
1.03
1.05
4.97
1.23
3.02
2.08
1.03
1.06
Chemical Shift (ppm)
7.03
7.02
7.01
6.92
6.91
6.49
6.48
6.47
6.46
6.45
1.00
0.99
1.01
1.00
Chemical Shift (ppm)
0.99
1.00
1.05
4.97
1.23
3.02
2.08
1.03
1.06
Chemical Shift (ppm)

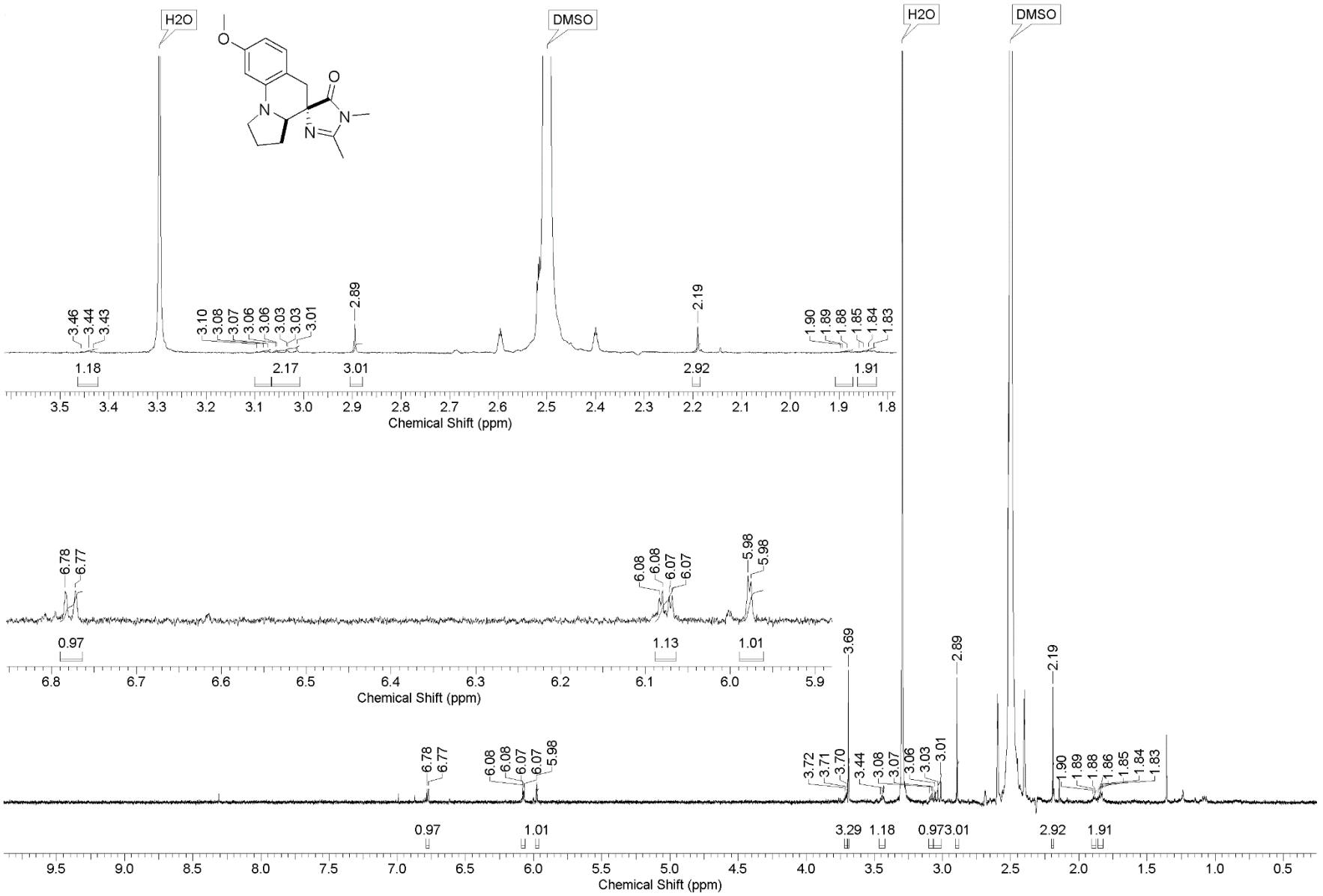

O
N
N
N
DMSO
181.65
161.50
143.51
128.46
127.04
118.55
114.71
110.44
65.80
61.10
47.42
36.55
26.30
25.62
23.03
14.91
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

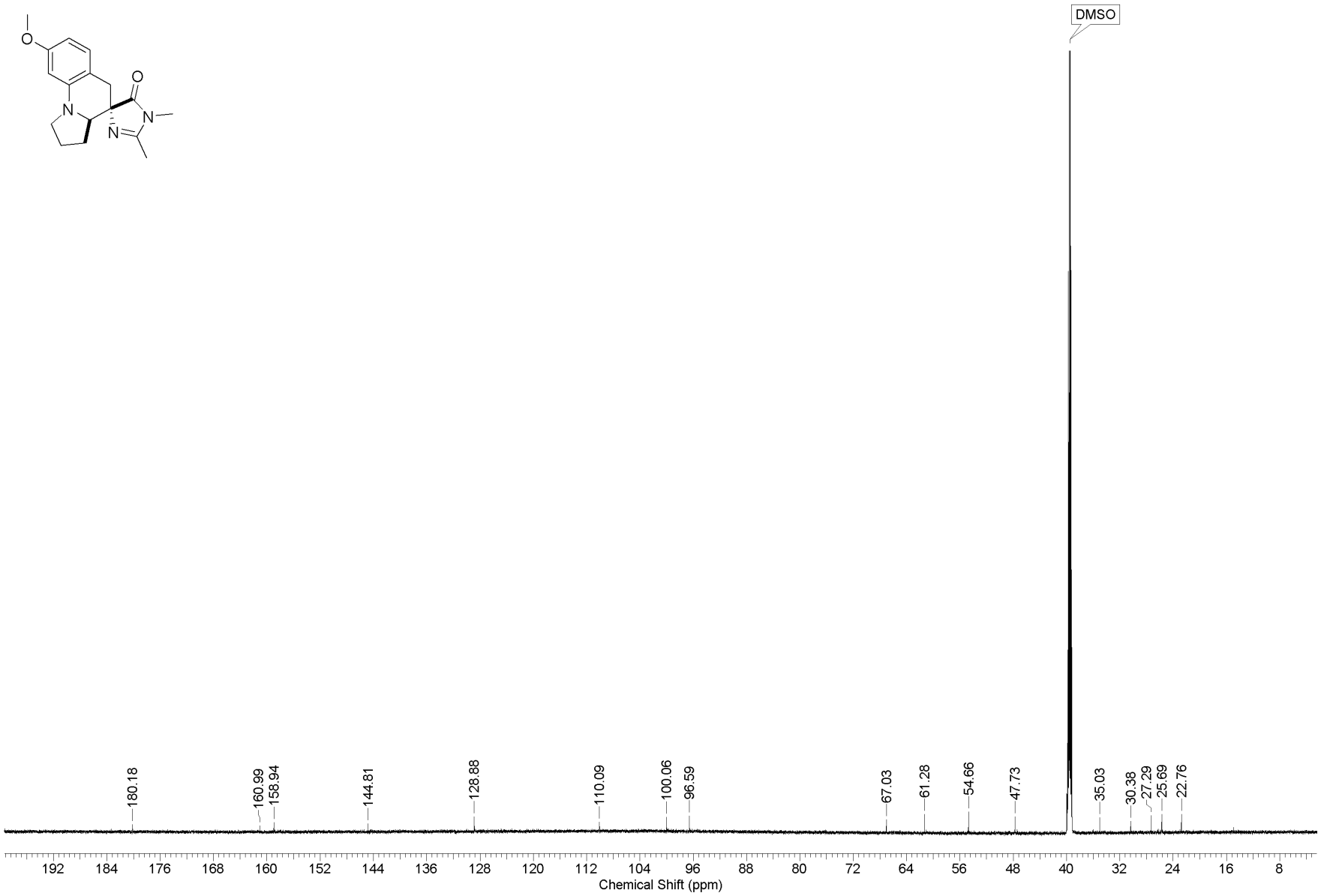

DMSO
H2O
DMSO
Chemical Shift (ppm)
H2O
Chemical Shift (ppm)
Chemical Shift (ppm)


O
N
N
N
DMSO
180.23
161.02
143.91
128.36
126.93
117.41
114.82
110.31
66.74
61.28
47.68
35.54
27.18
25.68
22.76
15.10
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


H2O
DMSO
H2O
DMSO
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)


DMSO
183.27
161.46
159.01
144.38
128.90
111.31
99.96
96.63
66.21
61.05
54.75
47.39
36.02
26.25
25.64
22.96
14.93
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


H2O
DMSO
H2O
DMSO
3.46
3.44
3.43
3.10
3.08
3.07
3.06
3.06
3.03
3.03
3.01
2.89
2.19
1.90
1.89
1.88
1.85
1.84
1.83
1.18
2.17
3.01
2.92
1.91
Chemical Shift (ppm)
6.78
6.77
6.08
6.08
6.07
6.07
5.98
5.98
0.97
1.13
1.01
3.69
2.89
2.19
Chemical Shift (ppm)
6.78
6.77
6.08
6.08
6.07
6.07
5.98
3.72
3.71
3.70
3.44
3.08
3.07
3.06
3.03
3.01
1.90
1.89
1.88
1.86
1.85
1.84
1.83
0.97
1.01
3.29
1.18
0.97
3.01
2.92
1.91
Chemical Shift (ppm)


O
O
N
N
N
DMSO
180.18
160.99
158.94
144.81
128.88
110.09
100.06
96.59
67.03
61.28
54.66
47.73
35.03
30.38
27.29
25.69
22.76
192
184
176
168
160
152
144
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112
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96
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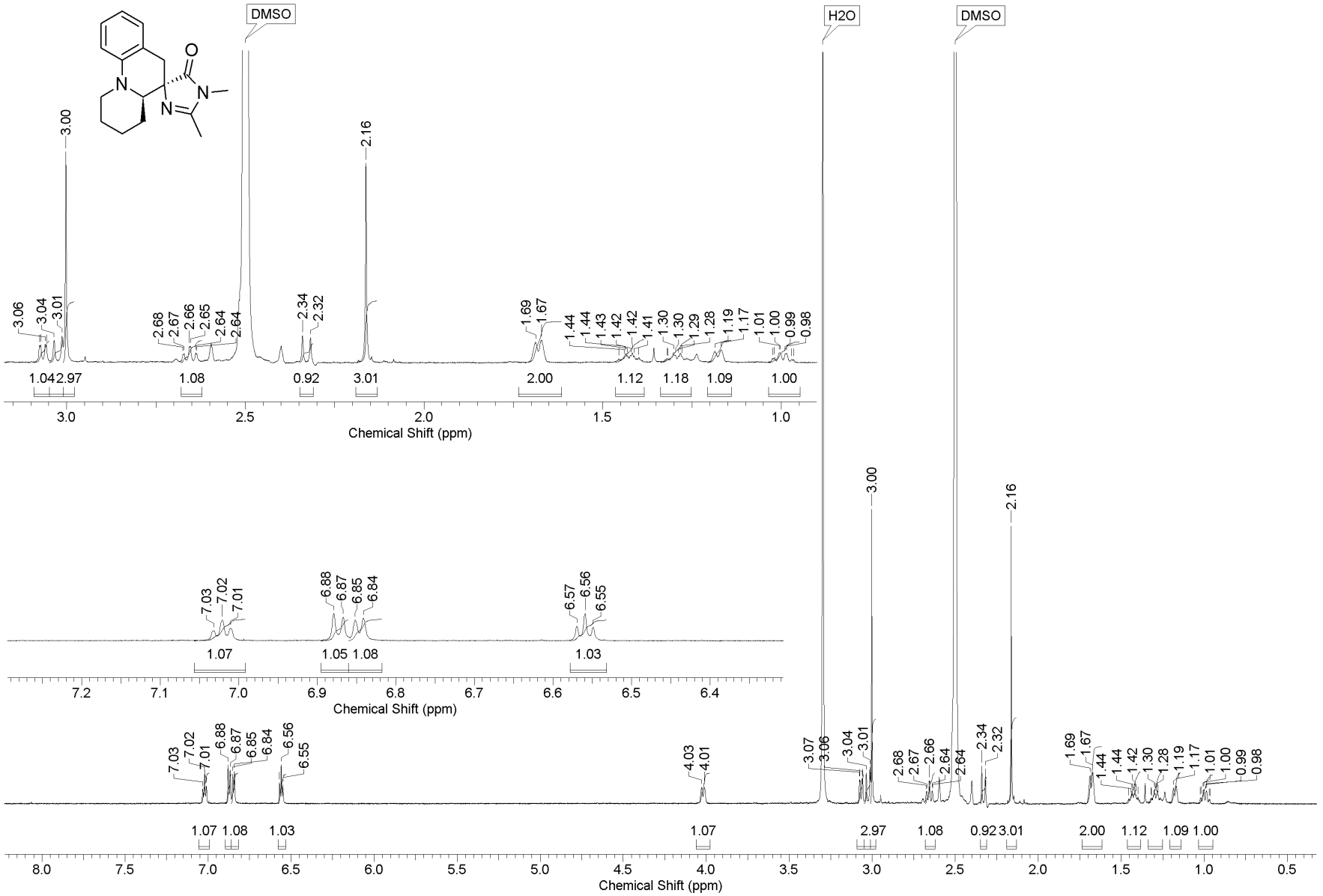
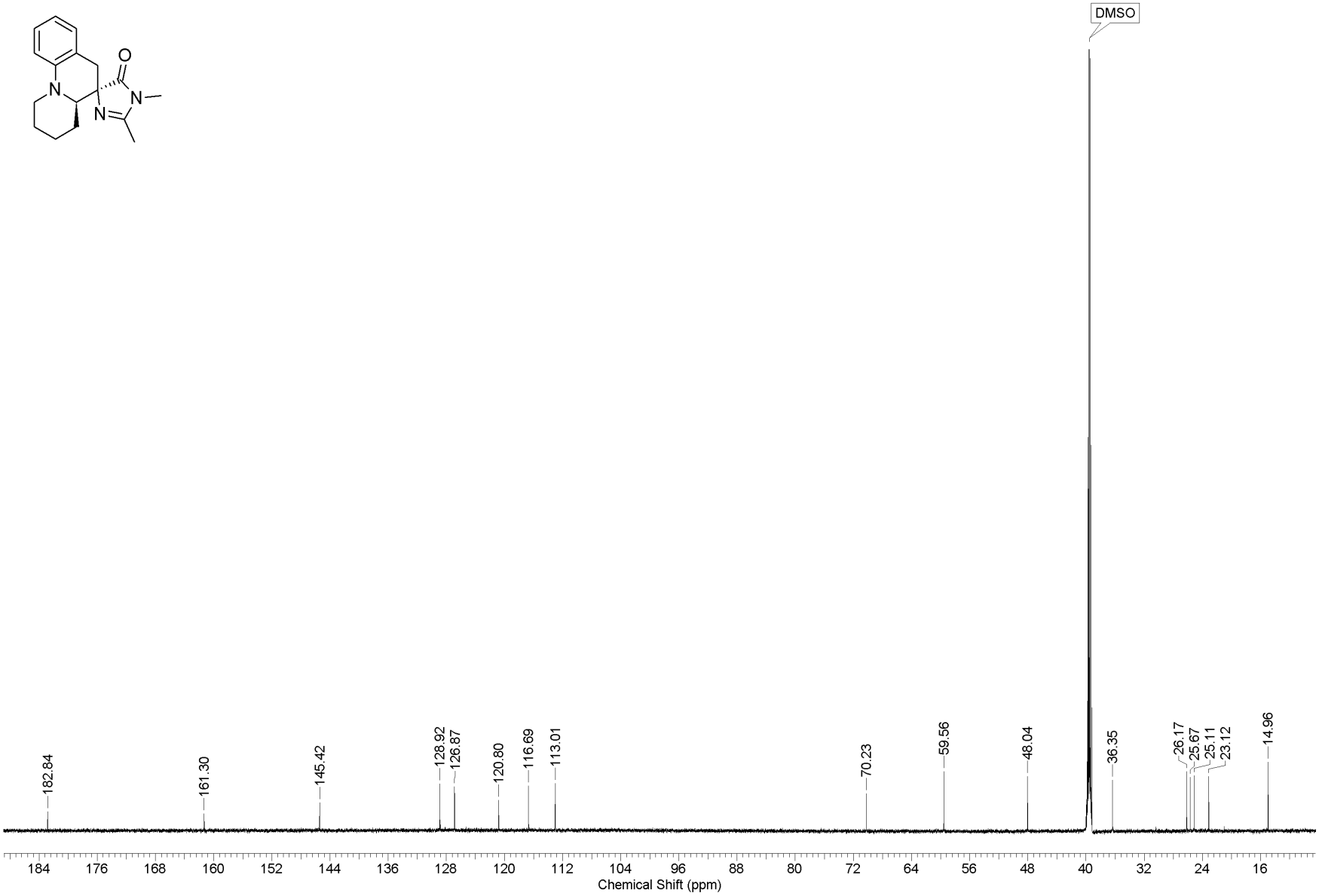
48
40
32
24
16
8
Chemical Shift (ppm)


DMSO
H2O
DMSO
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)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N
N
DMSO
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161.30
145.42
128.92
126.87
120.80
116.69
113.01
70.23
59.56
48.04
36.35
26.17
25.67
25.11
23.12
14.96
184
176
168
160
152
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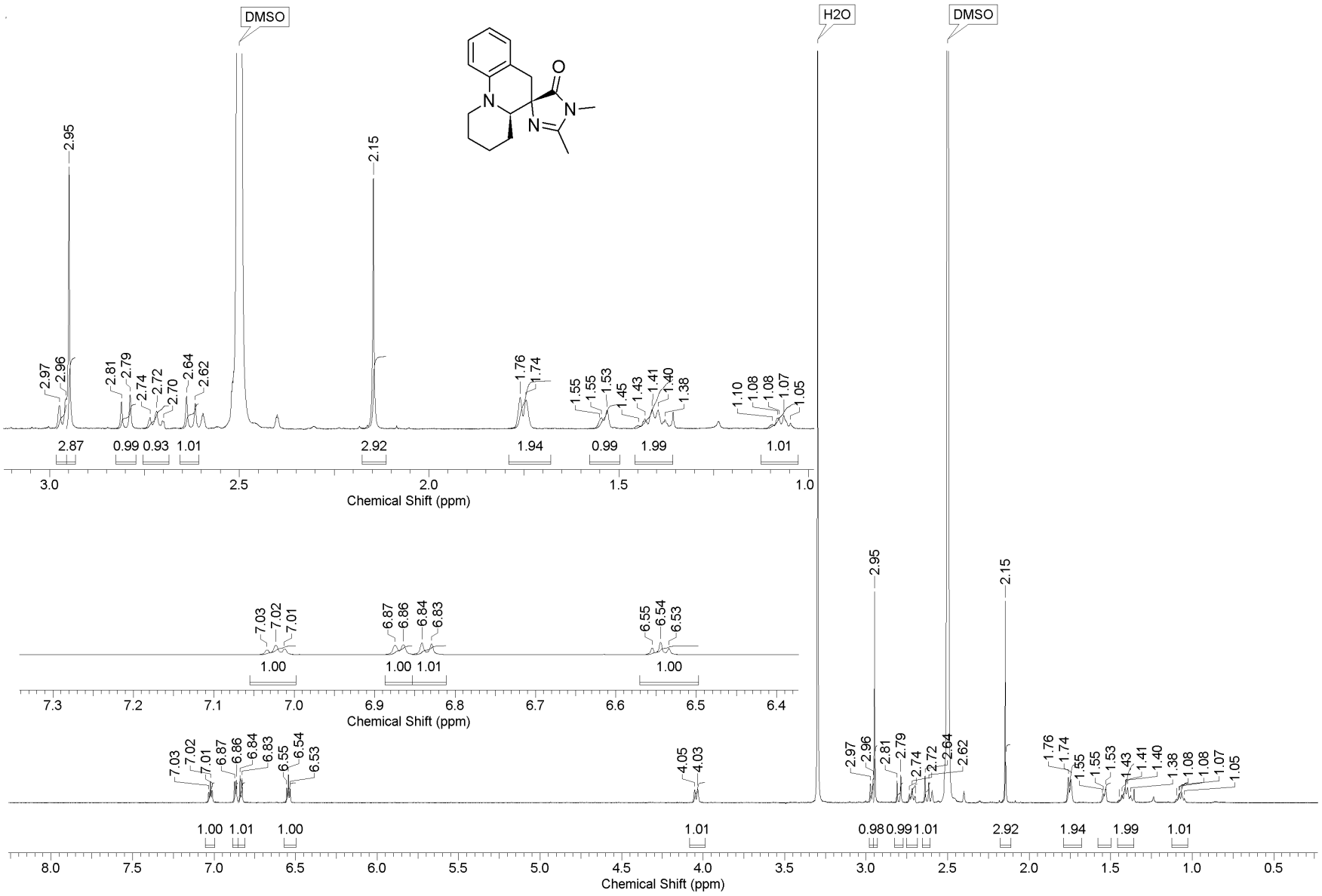
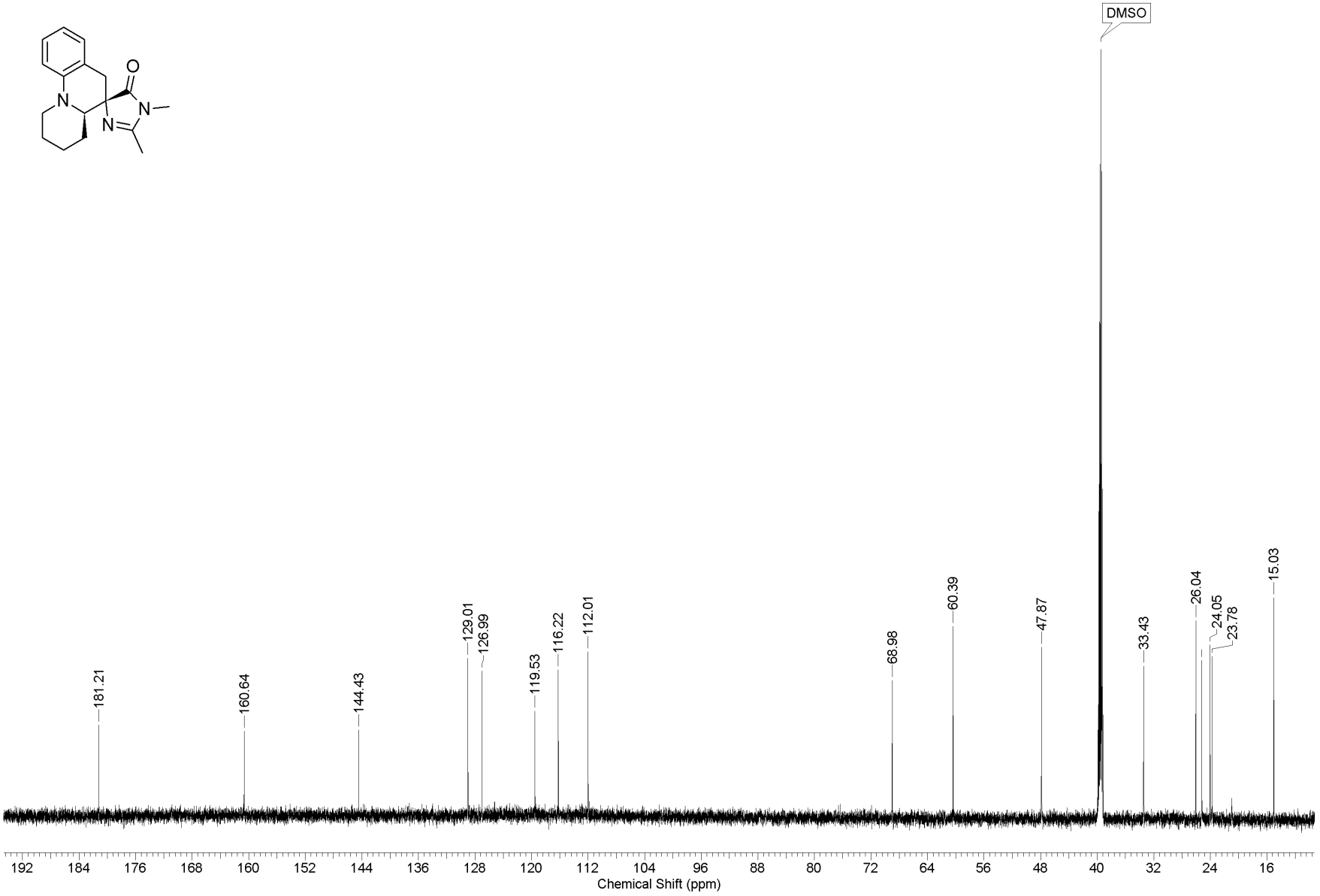
24
16
Chemical Shift (ppm)


DMSO
H2O
DMSO
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)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N
N
DMSO
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129.01
126.99
119.53
116.22
112.01
68.98
60.39
47.87
33.43
26.04
24.05
23.78
15.03
192
184
176
168
160
152
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88
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72
64
56
48
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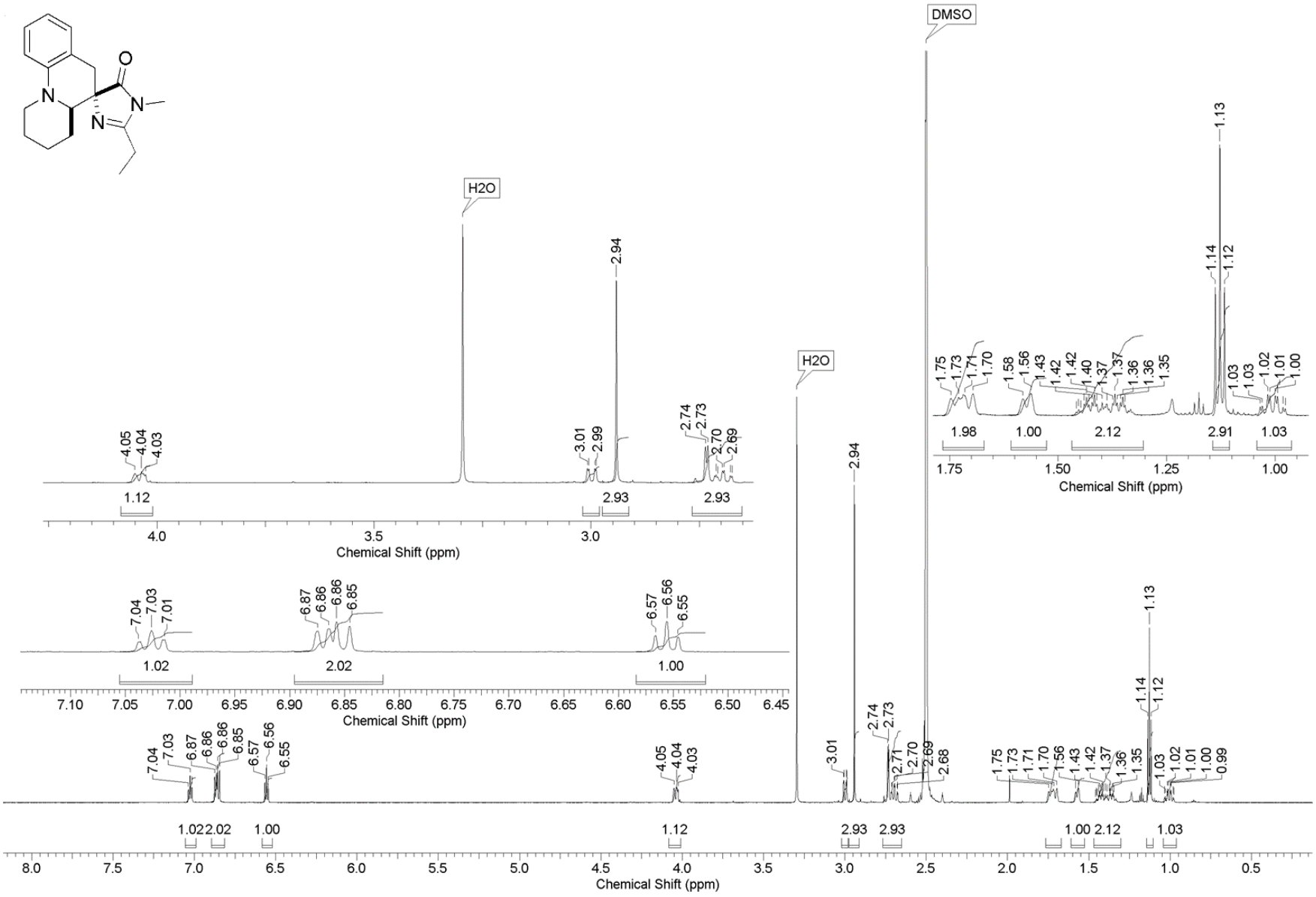
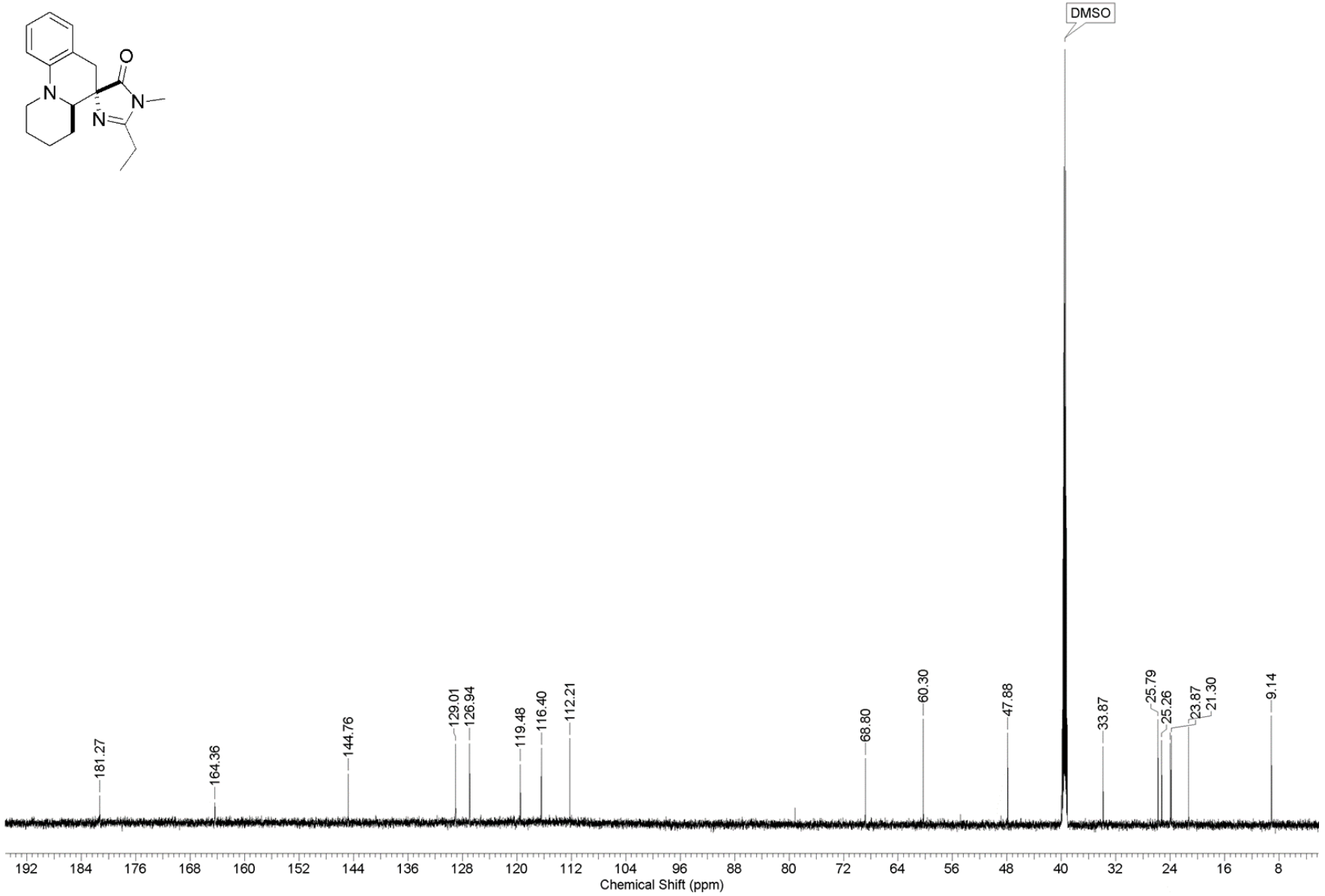
32
24
16
Chemical Shift (ppm)


H2O
DMSO
Chemical Shift (ppm)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N
N
DMSO
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144.76
129.01
126.94
119.48
116.40
112.21
68.80
60.30
47.88
33.87
25.79
25.26
23.87
21.30
9.14
192
184
176
168
160
152
144
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128
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112
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96
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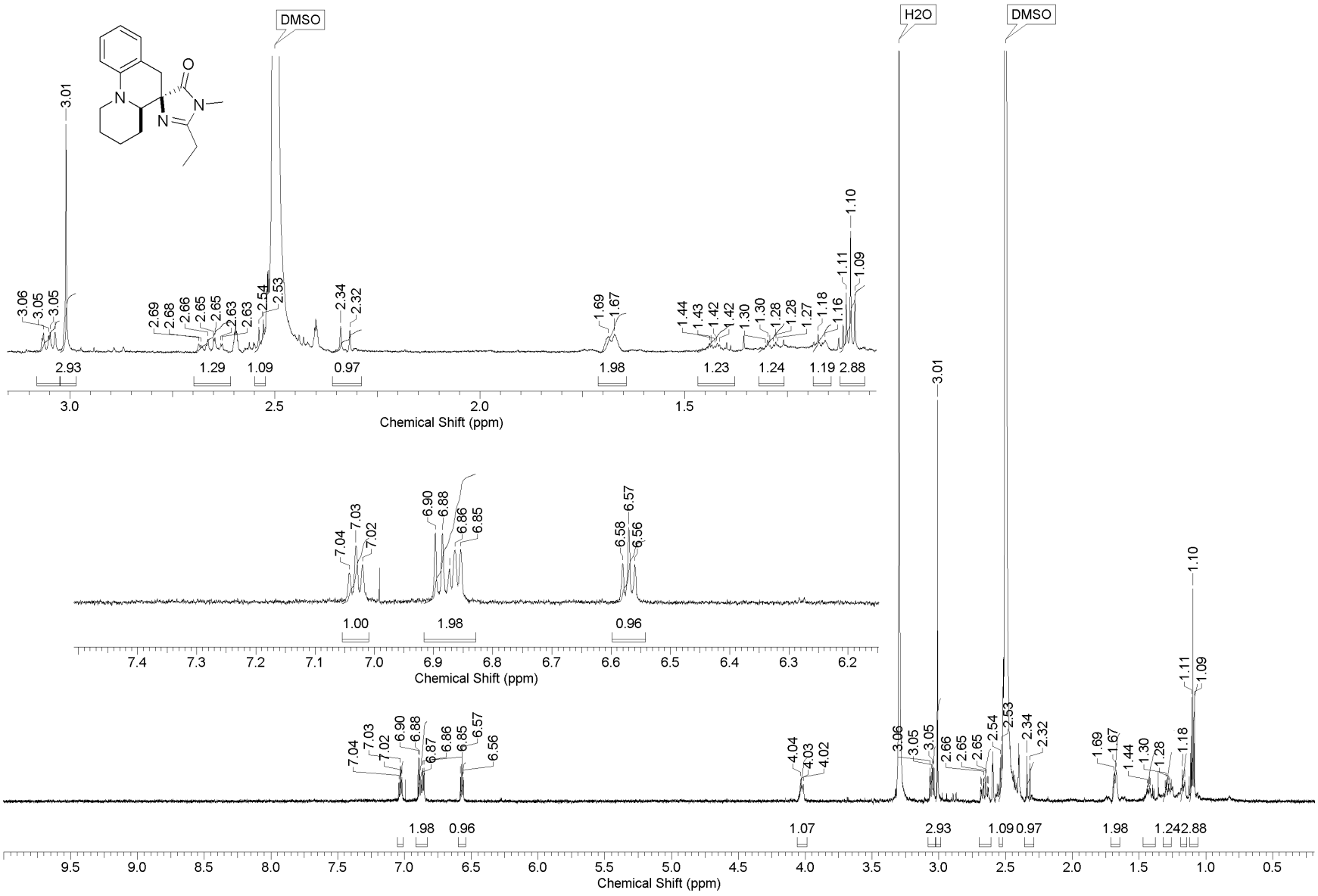
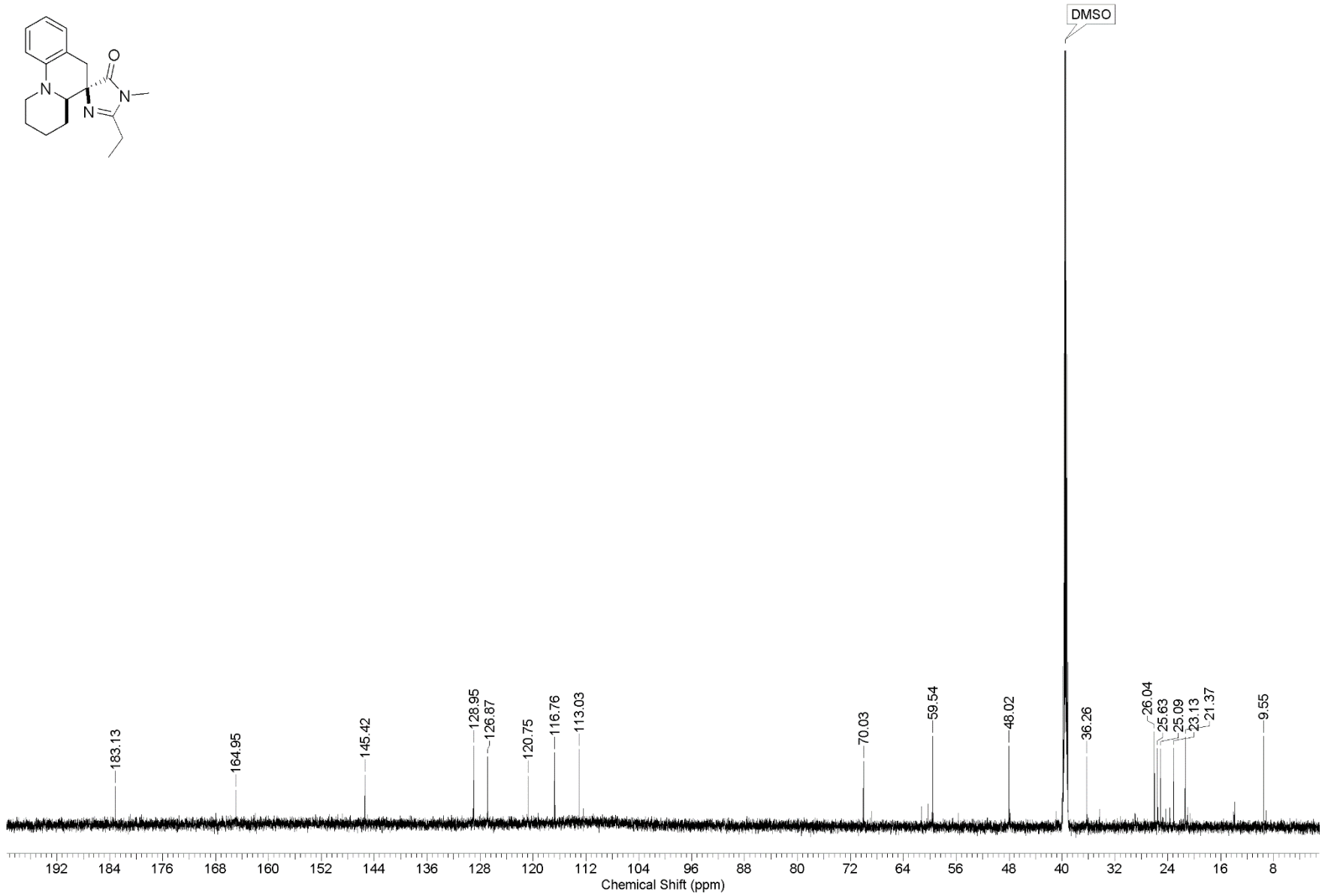
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


DMSO
H2O
DMSO
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)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N
N
DMSO
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128.95
126.87
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116.76
113.03
70.03
59.54
48.02
36.26
26.04
25.63
25.09
23.13
21.37
9.55
192
184
176
168
160
152
144
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128
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112
104
96
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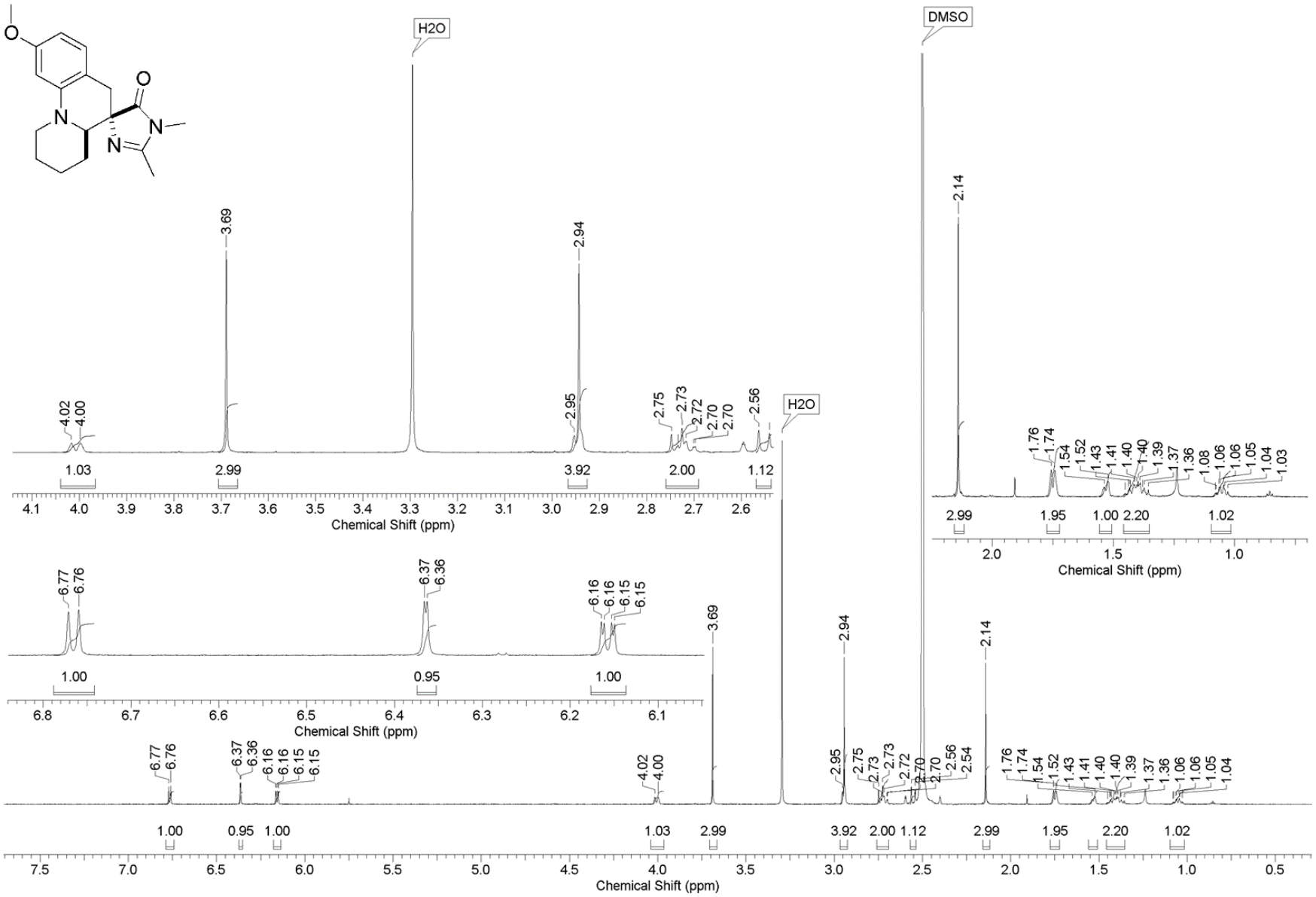
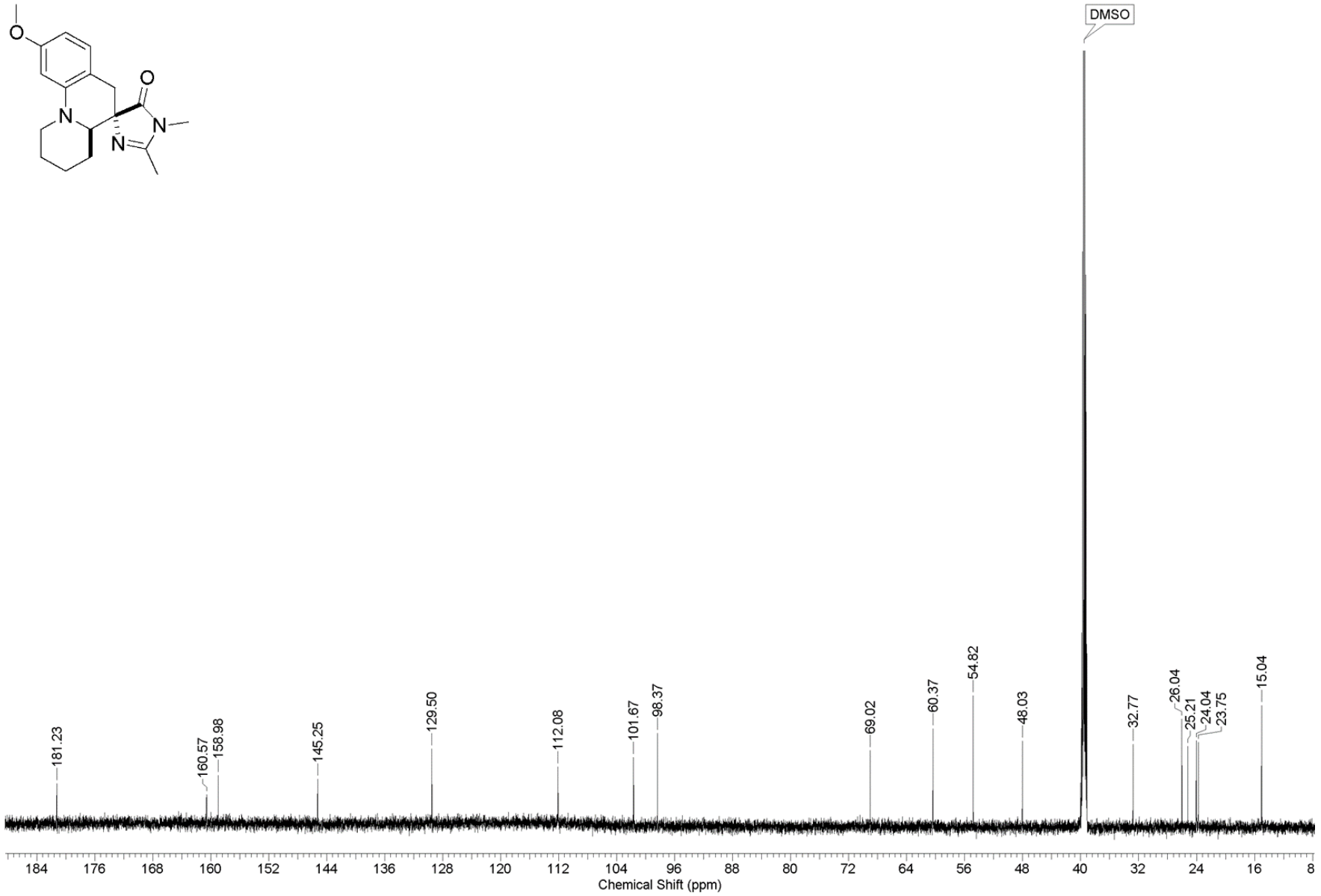
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


H2O
DMSO
H2O
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)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N
N
N
DMSO
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160.57
158.98
145.25
129.50
112.08
101.67
98.37
69.02
60.37
54.82
48.03
32.77
26.04
25.21
24.04
23.75
15.04
184
176
168
160
152
144
136
128
120
112
104
96
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80
72
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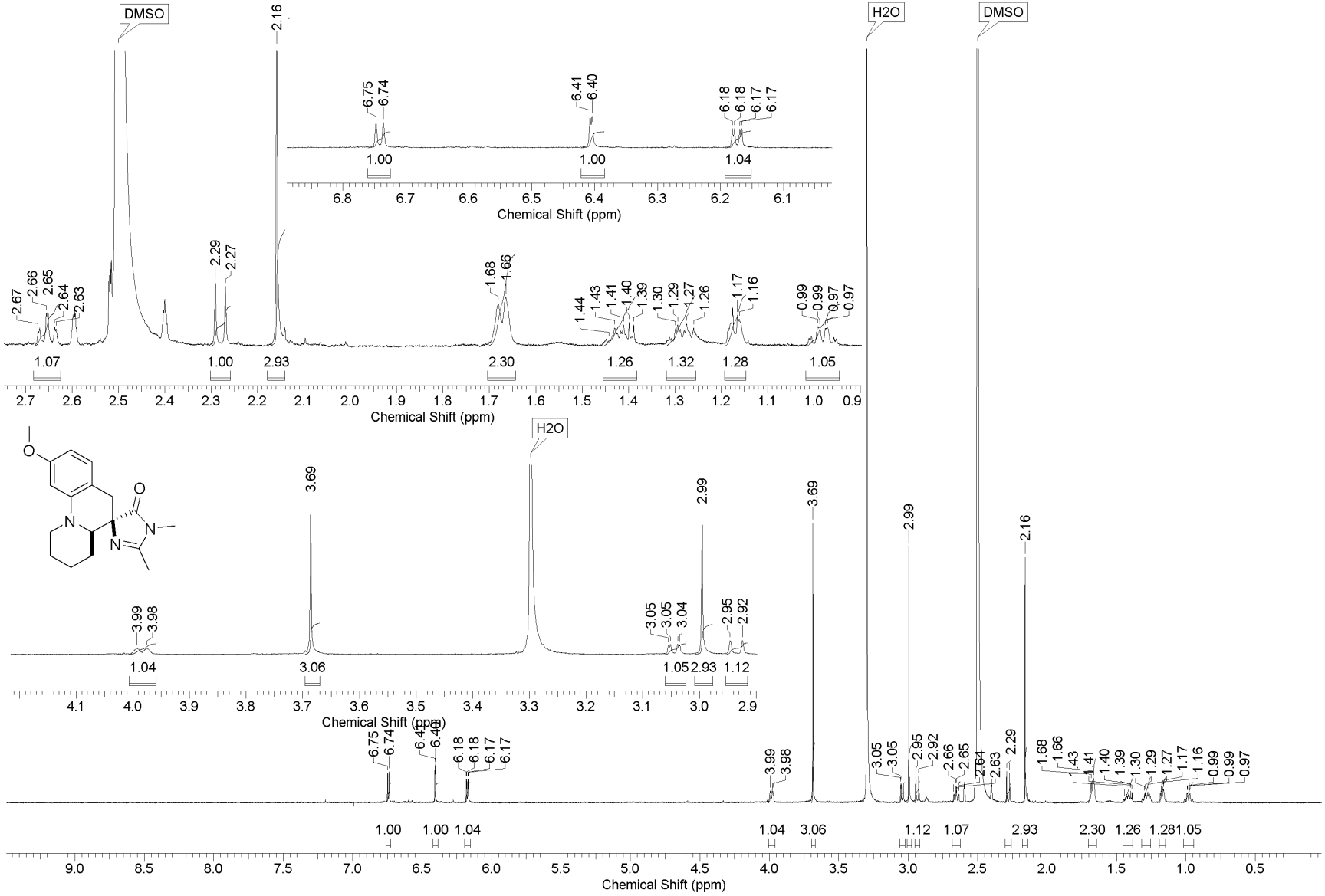
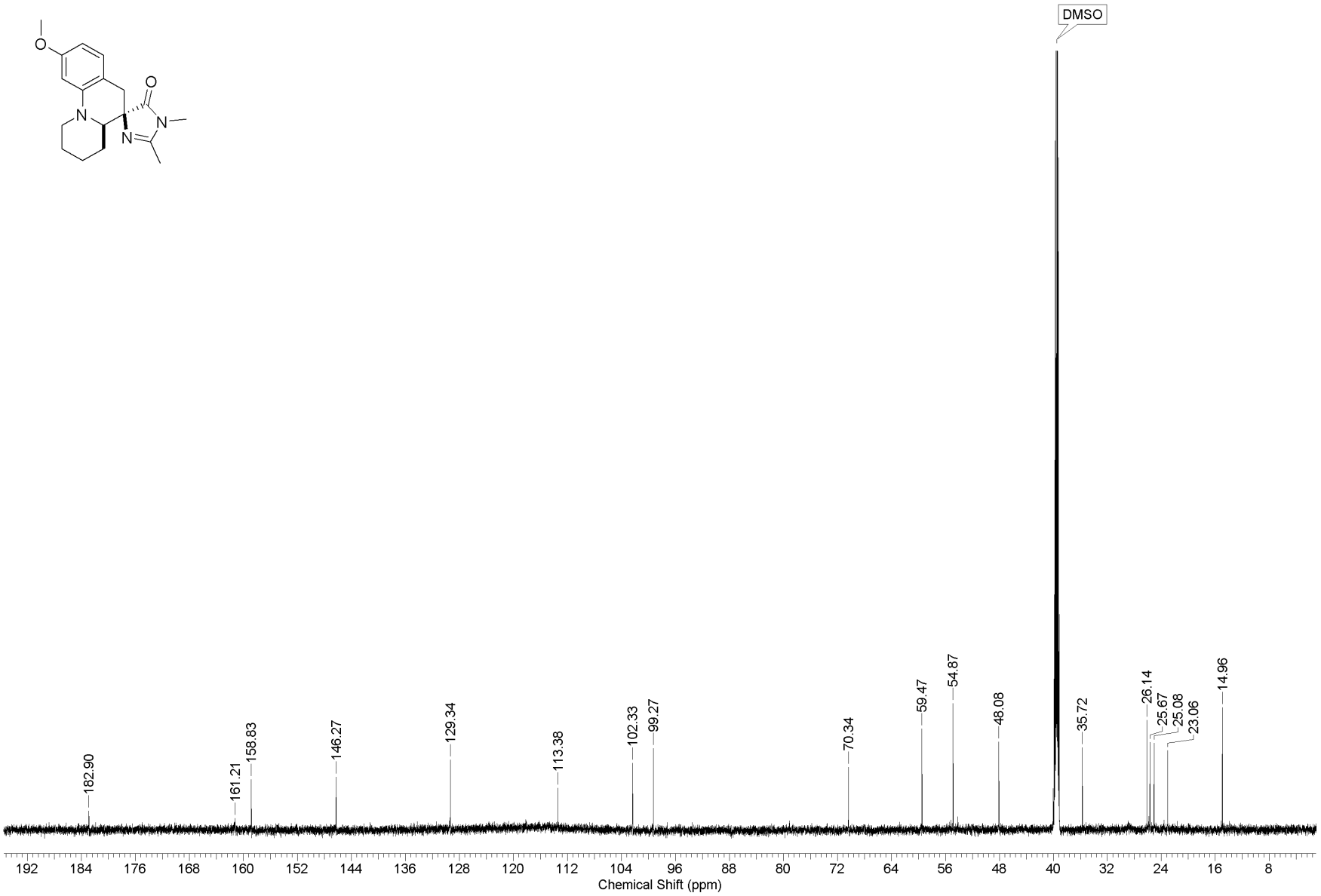
56
48
40
32
24
16
8
Chemical Shift (ppm)


DMSO
2.16
H2O
DMSO
Chemical Shift (ppm)
H2O
Chemical Shift (ppm)
Chemical Shift (ppm)


O
O
N
N
N
DMSO
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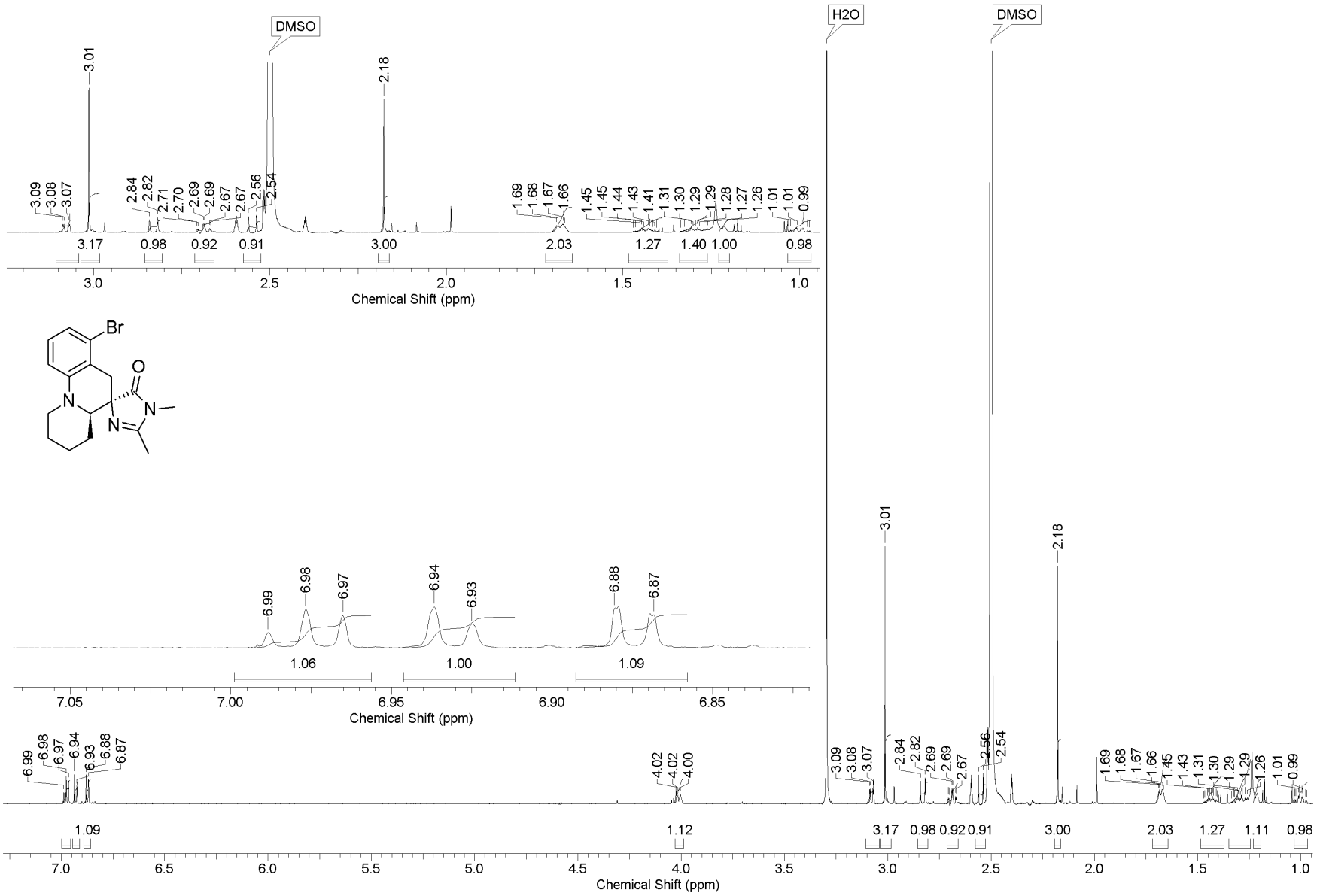
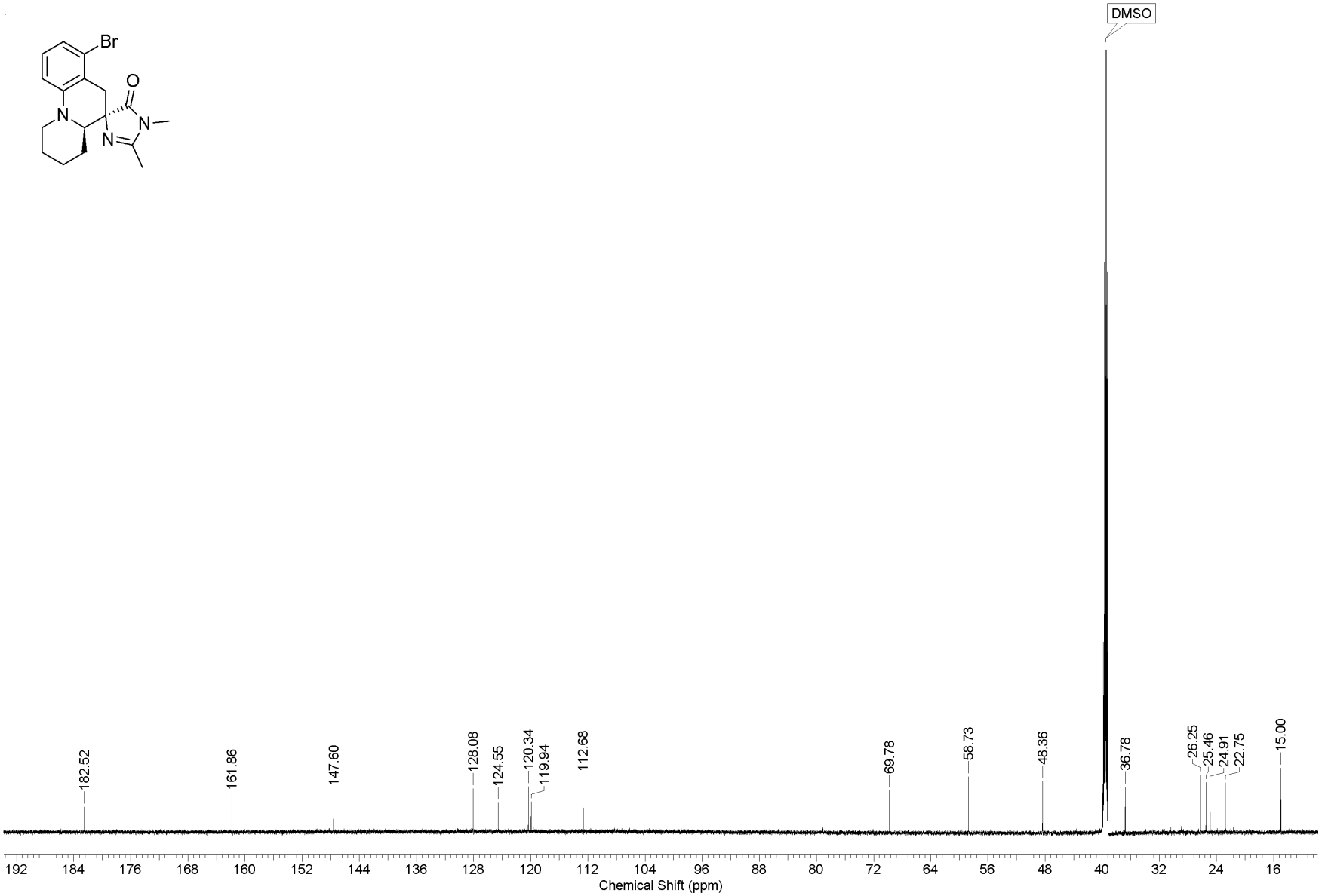
158.83
146.27
129.34
113.38
102.33
99.27
70.34
59.47
54.87
48.08
35.72
26.14
25.67
25.08
23.06
14.96
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


DMSO
H2O
DMSO
Br
O
N
N
N
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)


Br
O
N
N
N
DMSO
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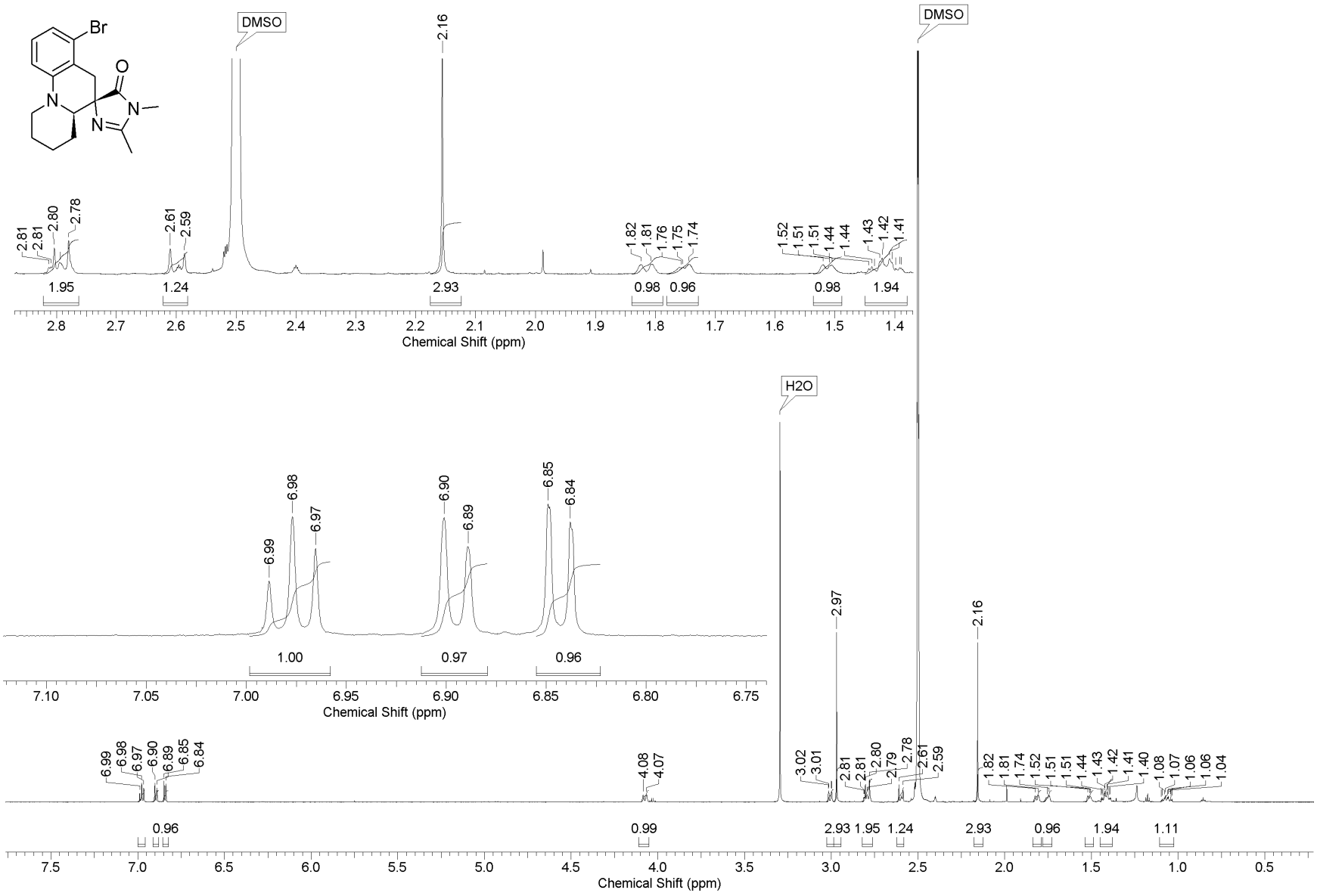
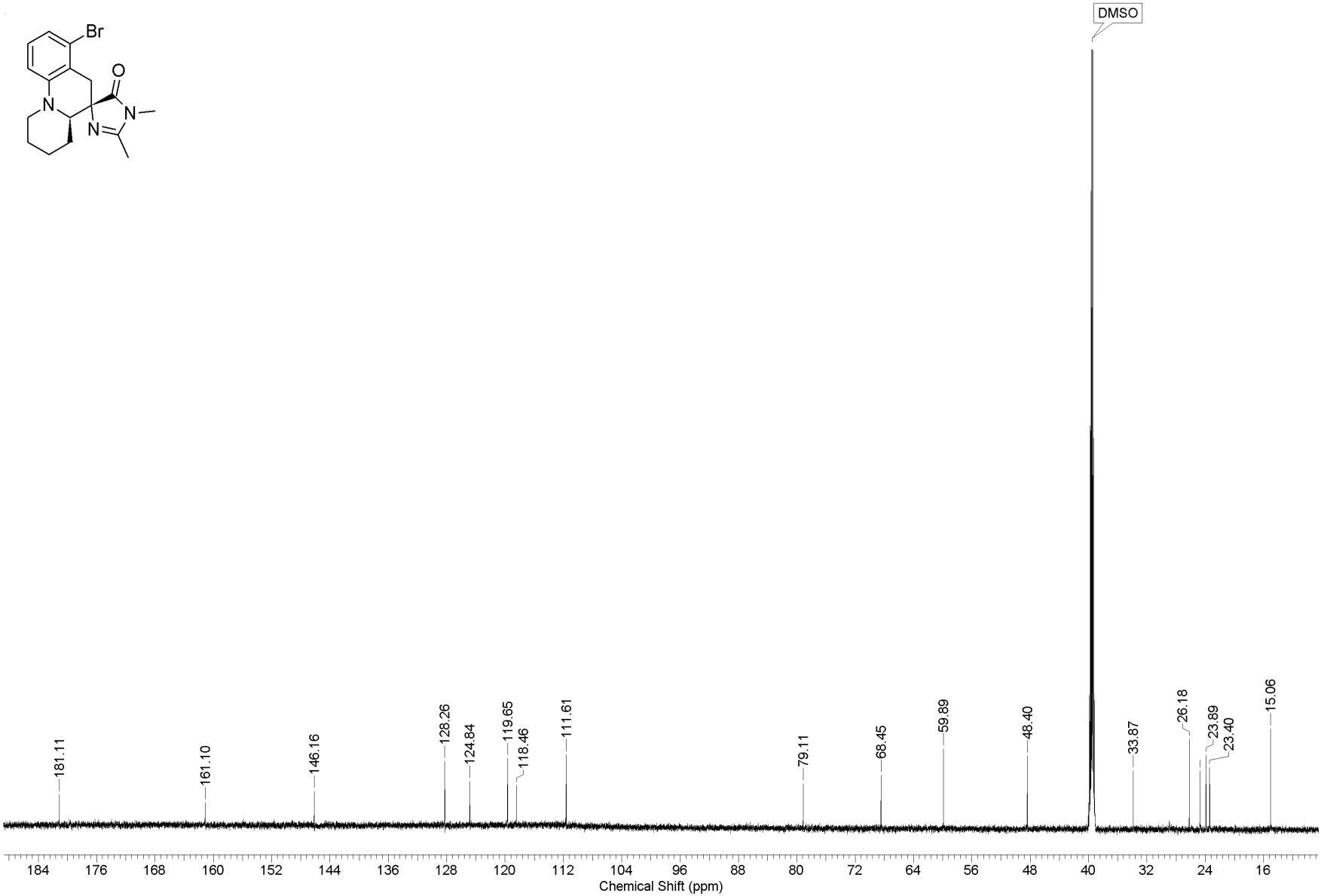
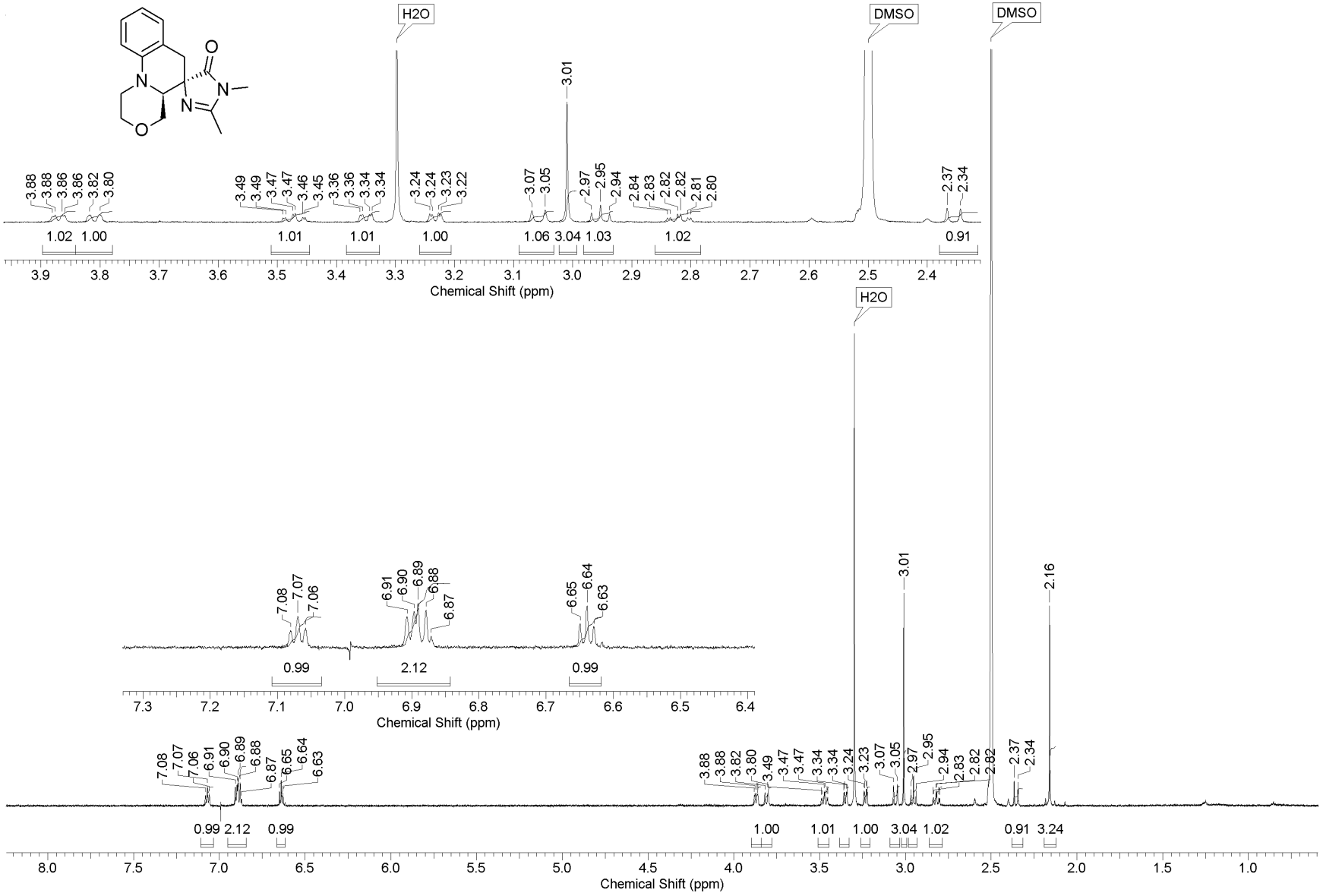
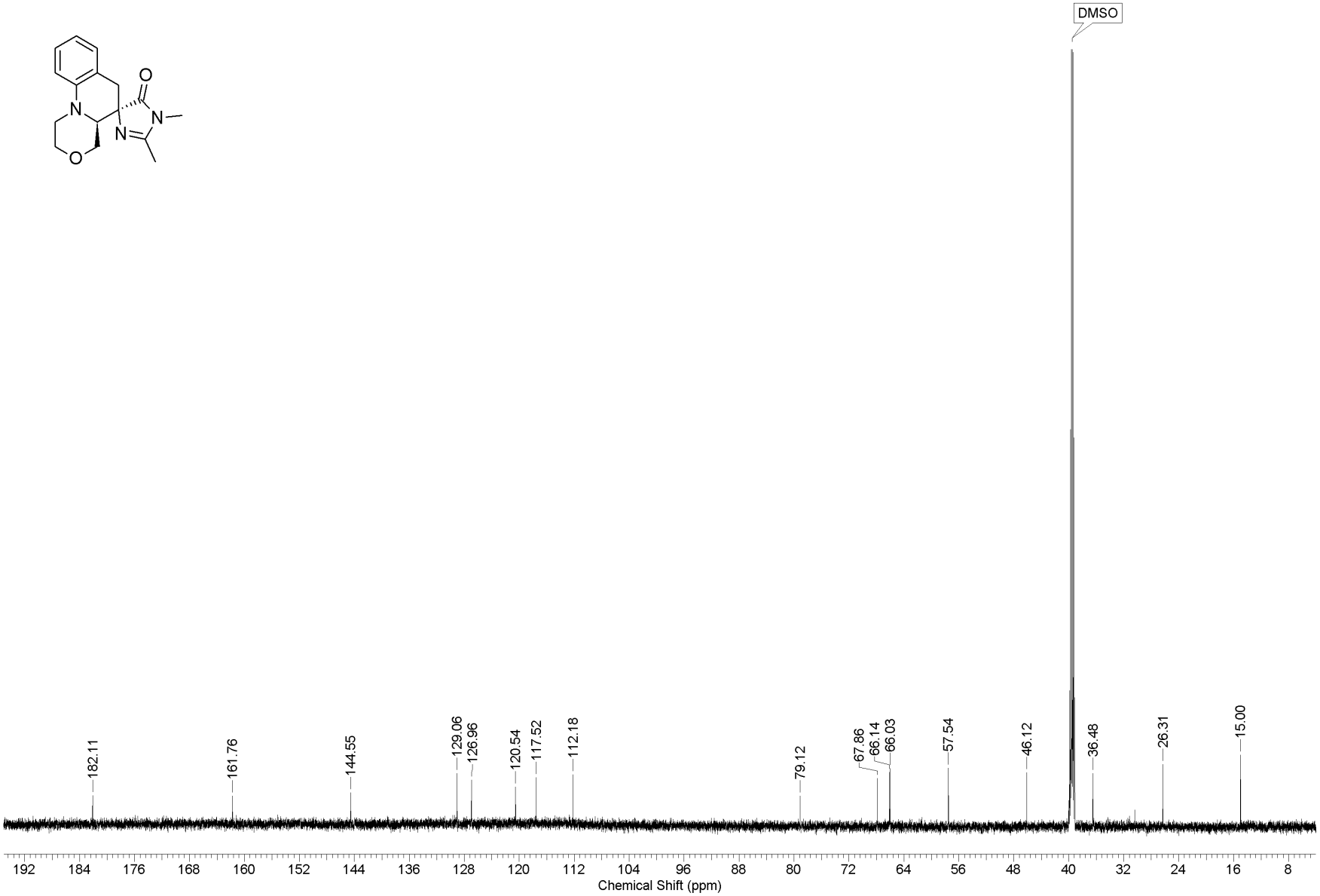
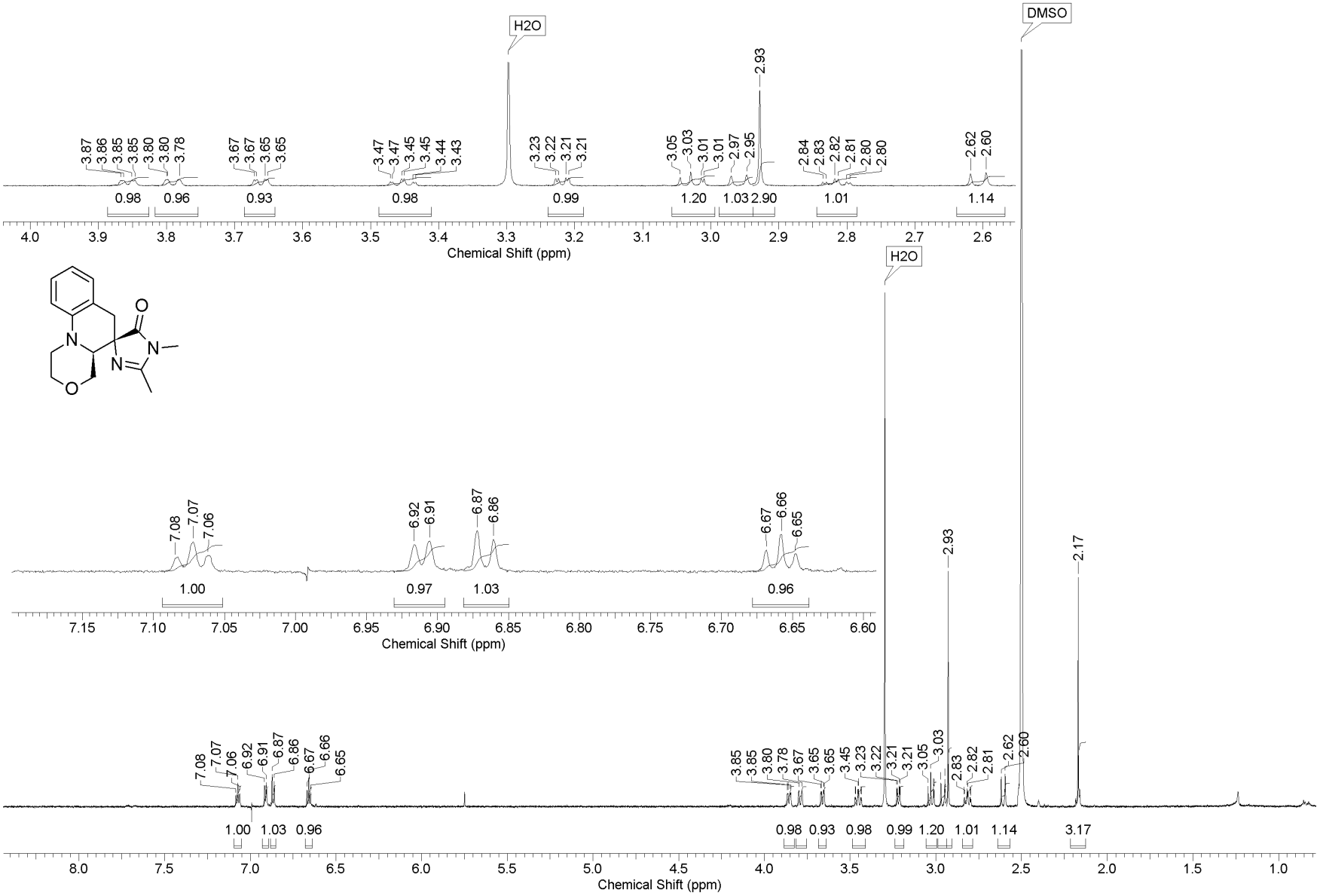
147.60
128.08
124.55
120.34
119.94
112.68
69.78
58.73
48.36
36.78
26.25
25.46
24.91
22.75
15.00
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

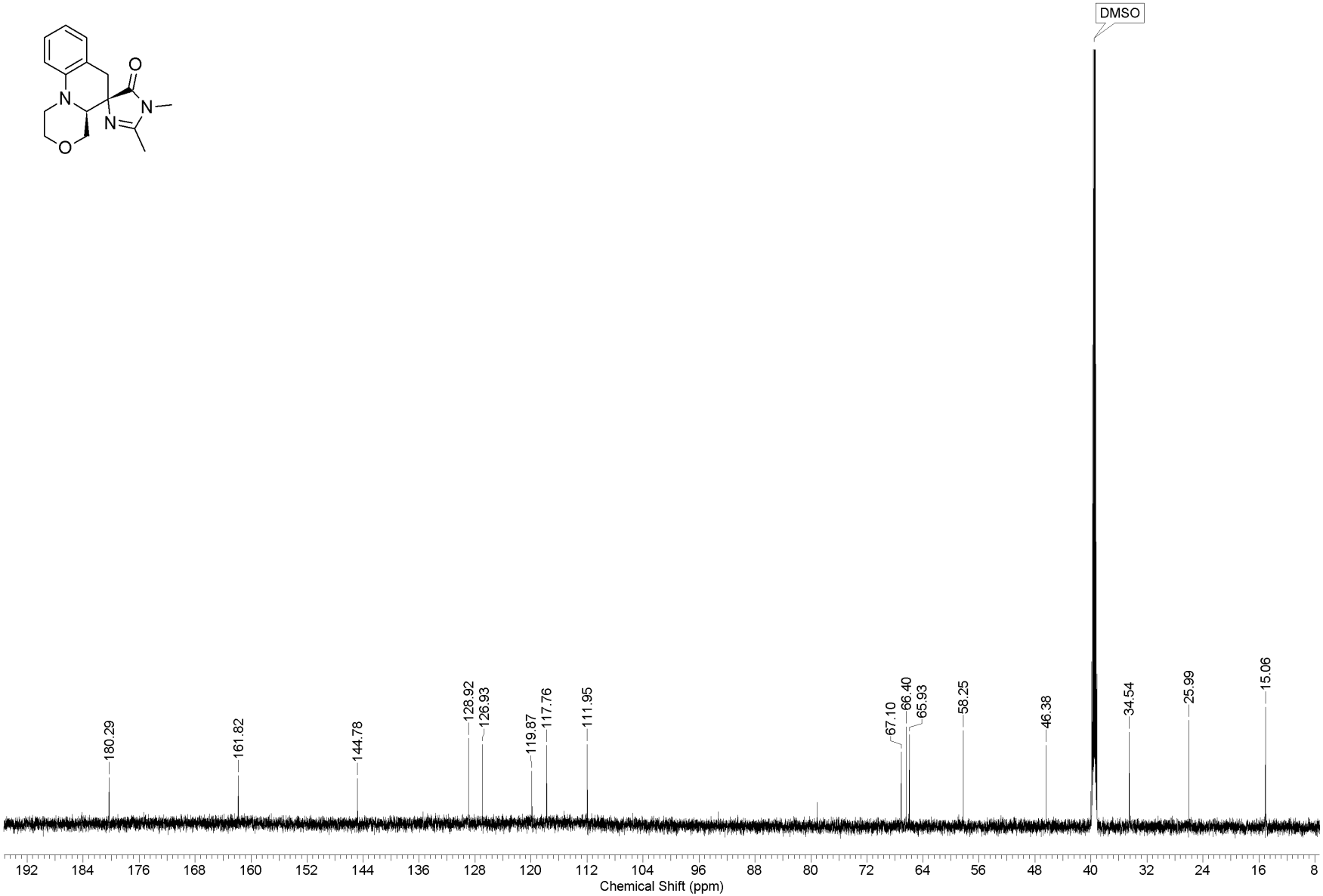

Br
O
N
N
N
DMSO
2.16
DMSO
2.81
2.81
2.80
2.78
2.61
2.59
1.82
1.81
1.76
1.75
1.74
1.52
1.51
1.51
1.44
1.44
1.43
1.42
1.41
1.95
1.24
2.93
0.98
0.96
0.98
1.94
Chemical Shift (ppm)
H2O
6.99
6.98
6.97
6.90
6.89
6.85
6.84
1.00
0.97
0.96
Chemical Shift (ppm)
6.99
6.98
6.97
6.90
6.89
6.85
6.84
4.08
4.07
3.02
3.01
2.97
2.81
2.81
2.80
2.79
2.78
2.61
2.59
2.16
1.82
1.81
1.74
1.52
1.51
1.51
1.44
1.43
1.42
1.41
1.40
1.08
1.07
1.06
1.06
1.04
0.96
0.99
2.93
1.95
1.24
2.93
0.96
1.94
1.11
Chemical Shift (ppm)

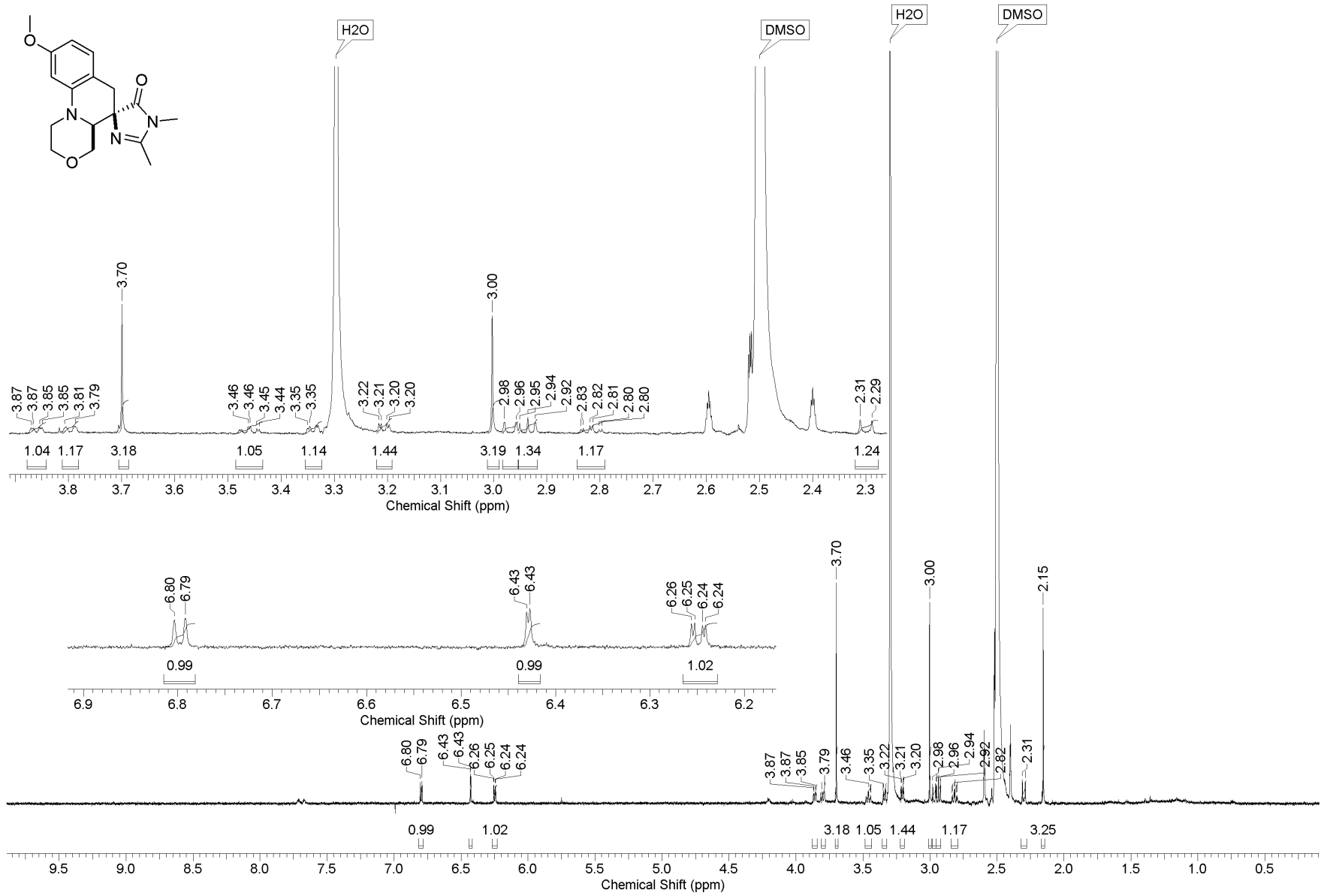

Br
O
N
N
N
DMSO
181.11
161.10
146.16
128.26
124.84
119.65
118.46
111.61
79.11
68.45
59.89
48.40
33.87
26.18
23.89
23.40
15.06
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
Chemical Shift (ppm)

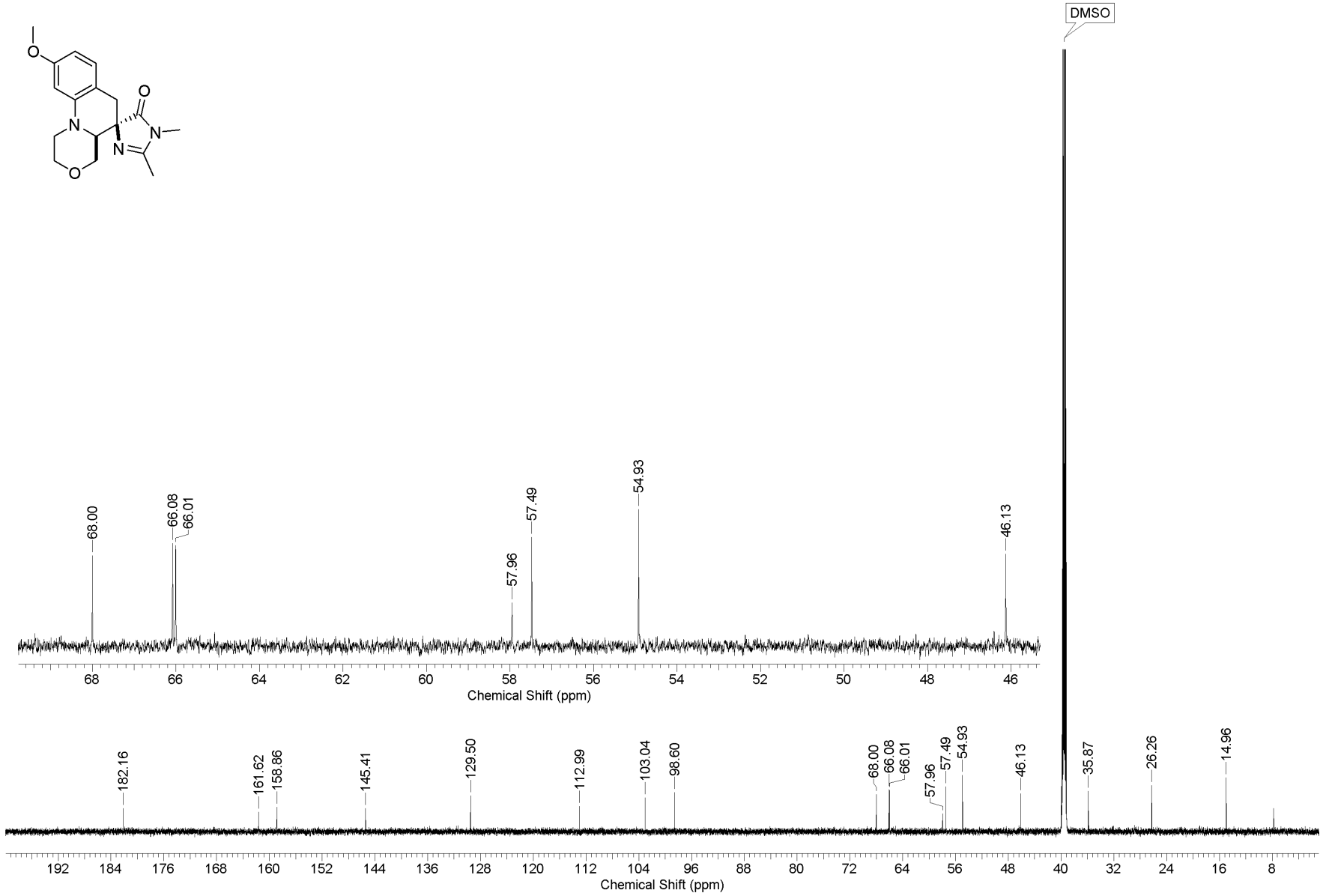

H2O
DMSO
DMSO
3.01
3.88 3.88 3.86 3.86 3.82 3.80
3.49 3.49 3.47 3.47 3.46 3.45 3.36 3.36 3.34 3.34
3.24 3.24 3.23 3.22
3.07 3.05
2.97 2.95 2.94
2.84 2.83 2.82 2.82 2.81 2.80
2.37 2.34
1.02 1.00 1.01 1.01 1.00 1.06 3.04 1.03 1.02 0.91
Chemical Shift (ppm)
H2O
3.01
2.16
7.08 7.07 7.06
6.91 6.90 6.89 6.88 6.87
6.65 6.64 6.63
0.99 2.12 0.99
Chemical Shift (ppm)
7.08 7.07 7.06 6.91 6.90 6.89 6.88 6.87 6.65 6.64 6.63
3.88 3.88 3.82 3.80 3.49 3.47 3.47 3.34 3.34 3.24 3.23 3.07 3.05 2.97 2.95 2.94 2.83 2.82 2.82 2.37 2.34
0.99 2.12 0.99 1.00 1.01 1.00 3.04 1.02 0.91 3.24
Chemical Shift (ppm)

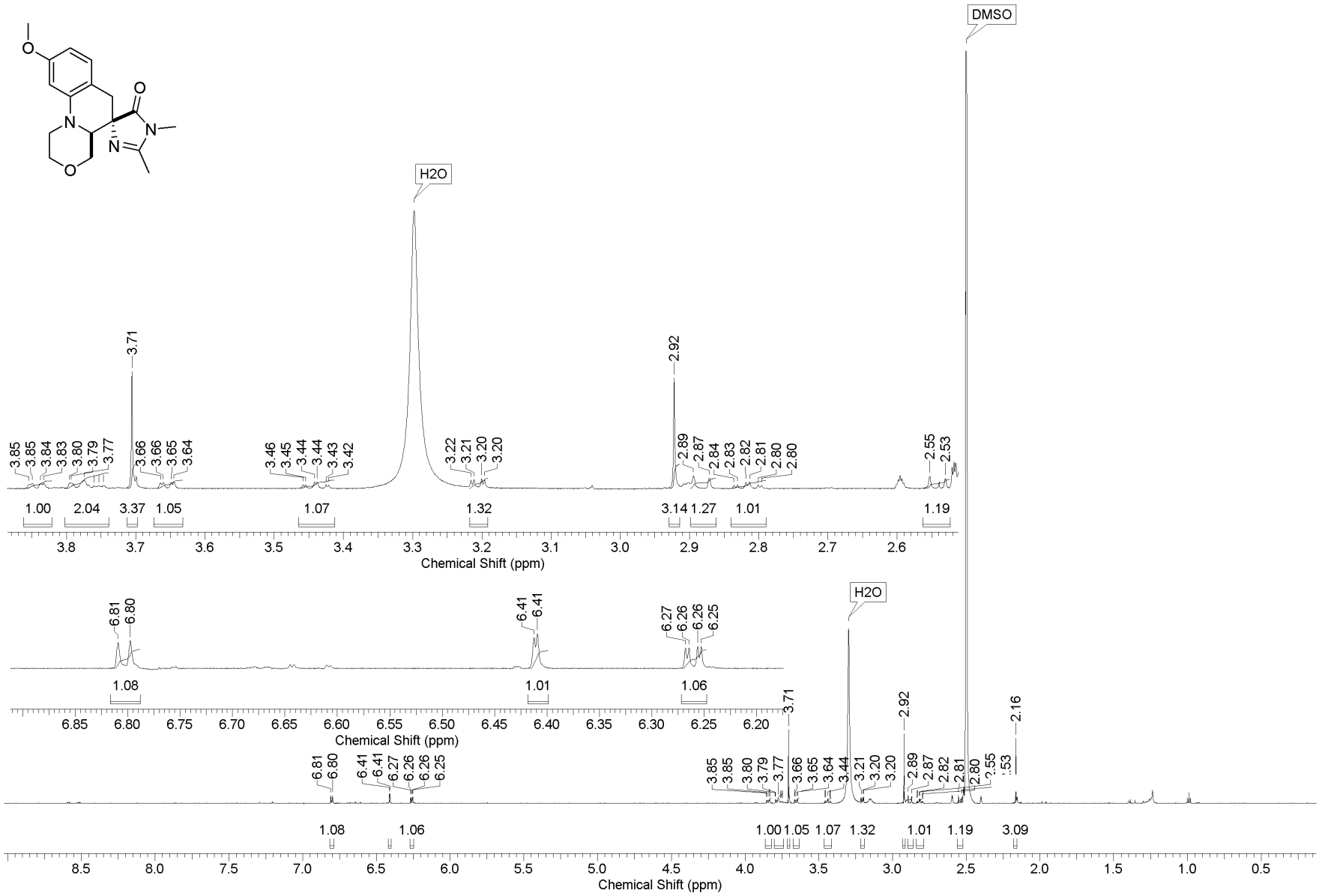

O
N
N
N
O
DMSO
182.11
161.76
144.55
129.06
126.96
120.54
117.52
112.18
79.12
67.86
66.14
66.03
57.54
46.12
36.48
26.31
15.00
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

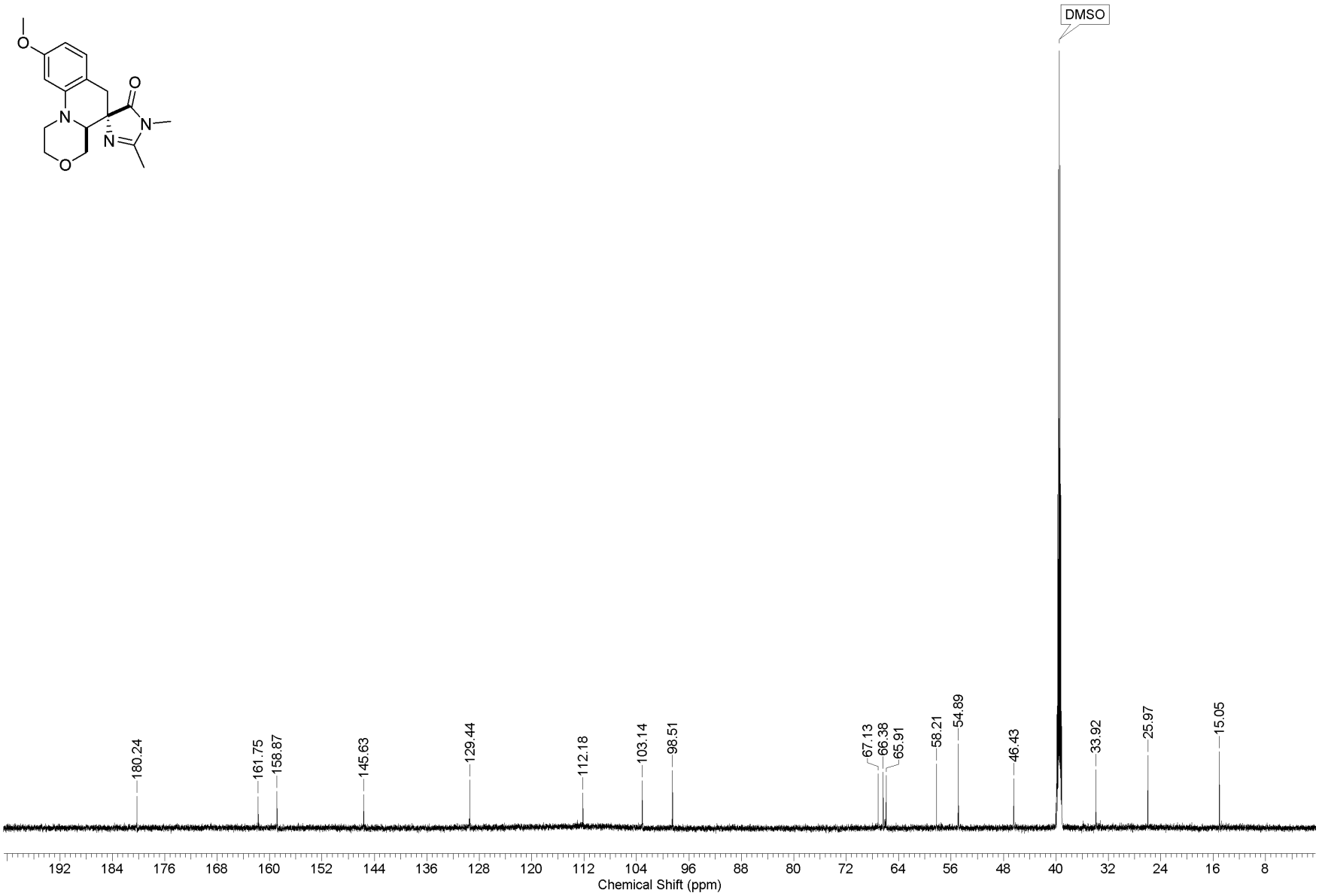

H2O
DMSO
2.93
3.87 3.86 3.85 3.85 3.80 3.80 3.78
3.67 3.67 3.65 3.65
3.47 3.47 3.45 3.45 3.44 3.43
3.23 3.22 3.21 3.21
3.05 3.03 3.01 3.01 2.97 2.95
2.84 2.83 2.82 2.81 2.80 2.80
2.62 2.60
0.98 0.96 0.93 0.98 0.99 1.20 1.03 2.90 1.01 1.14
Chemical Shift (ppm)
O
N
N
N
O
H2O
7.08 7.07 7.06
6.92 6.91
6.87 6.86
6.67 6.66 6.65
2.93
2.17
1.00 0.97 1.03 0.96
Chemical Shift (ppm)
7.08 7.07 7.06 6.92 6.91 6.87 6.86 6.67 6.66 6.65
3.85 3.85 3.80 3.78 3.67 3.65 3.65 3.45 3.23 3.22 3.21 3.21 3.05 3.03 2.83 2.82 2.81 2.62 2.60
1.00 1.03 0.96 0.98 0.93 0.98 0.99 1.20 1.01 1.14 3.17
Chemical Shift (ppm)


DMSO
180.29
161.82
144.78
128.92
126.93
119.87
117.76
111.95
67.10
66.40
65.93
58.25
46.38
34.54
25.99
15.06
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


H2O
DMSO
H2O
DMSO
3.70
3.00
2.15
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)


DMSO
68.00
66.08
66.01
57.96
57.49
54.93
46.13
Chemical Shift (ppm)
182.16
161.62
158.86
145.41
129.50
112.99
103.04
98.60
68.00
66.08
66.01
57.96
57.49
54.93
46.13
35.87
26.26
14.96
Chemical Shift (ppm)


DMSO
H2O
3.71
2.92
Chemical Shift (ppm)
H2O
6.81
6.80
6.41
6.41
6.27
6.26
6.26
6.25
1.08
1.01
1.06
Chemical Shift (ppm)
3.71
2.92
2.16
1.08
1.06
1.00
1.05
1.07
1.32
1.01
1.19
3.09
Chemical Shift (ppm)


DMSO
180.24
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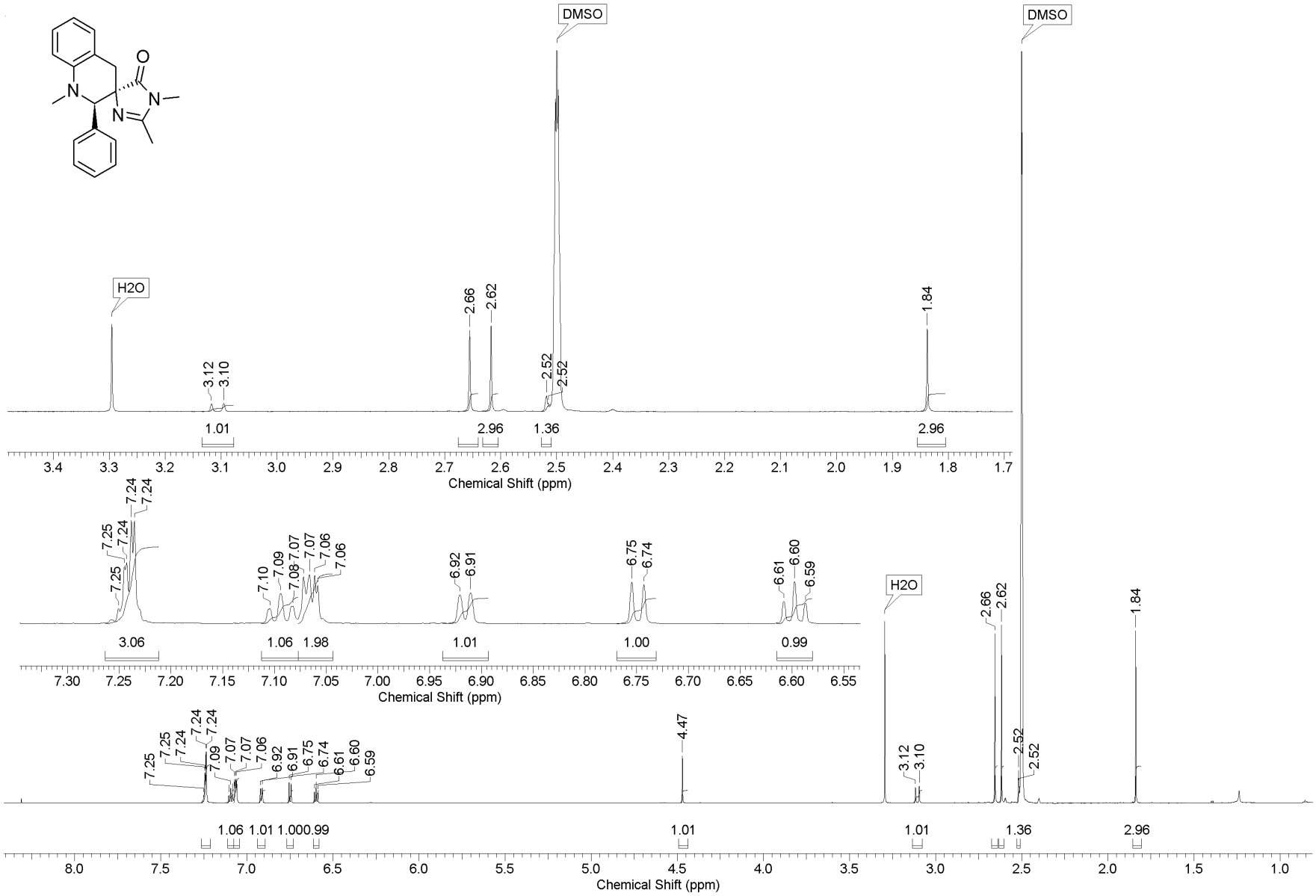
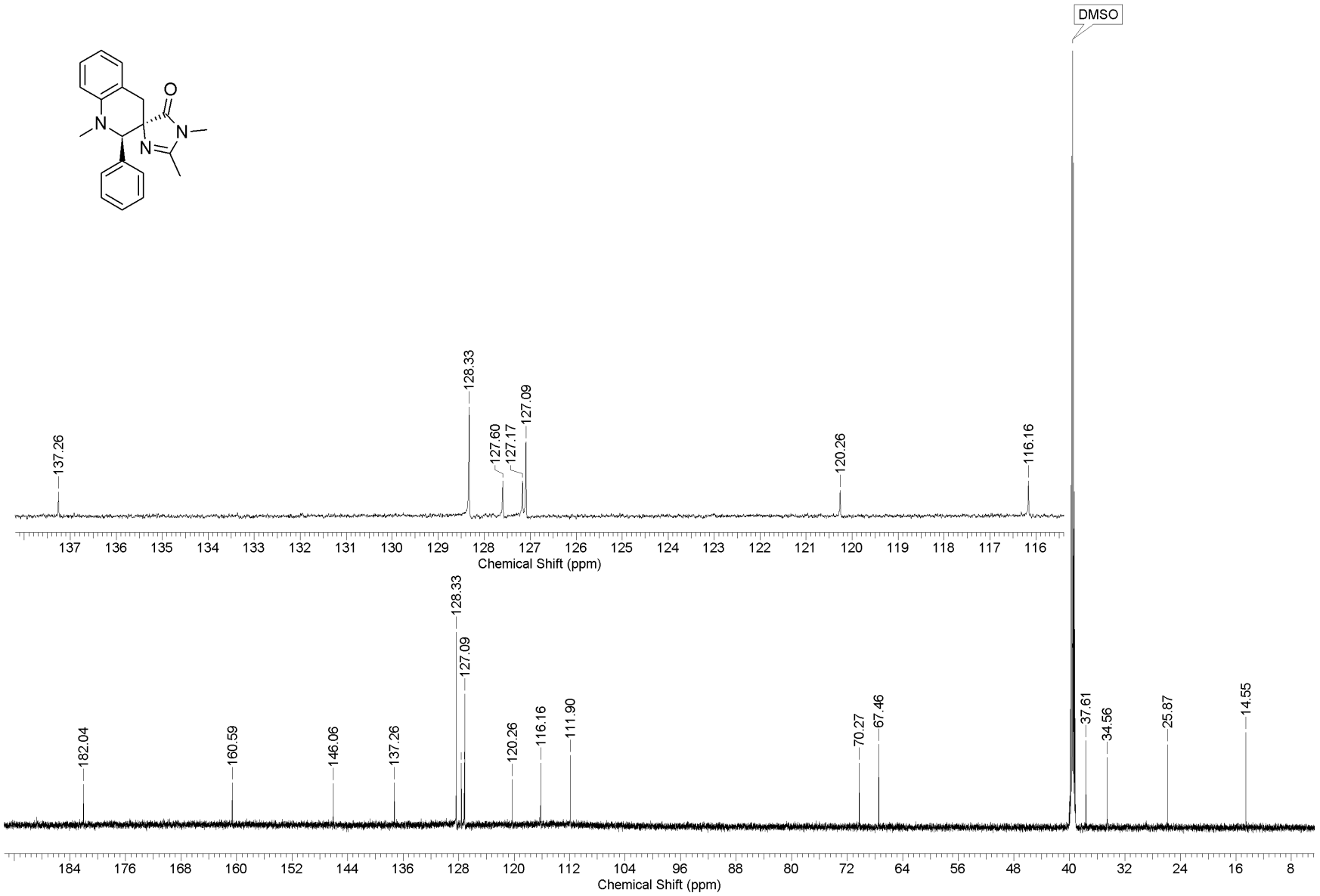
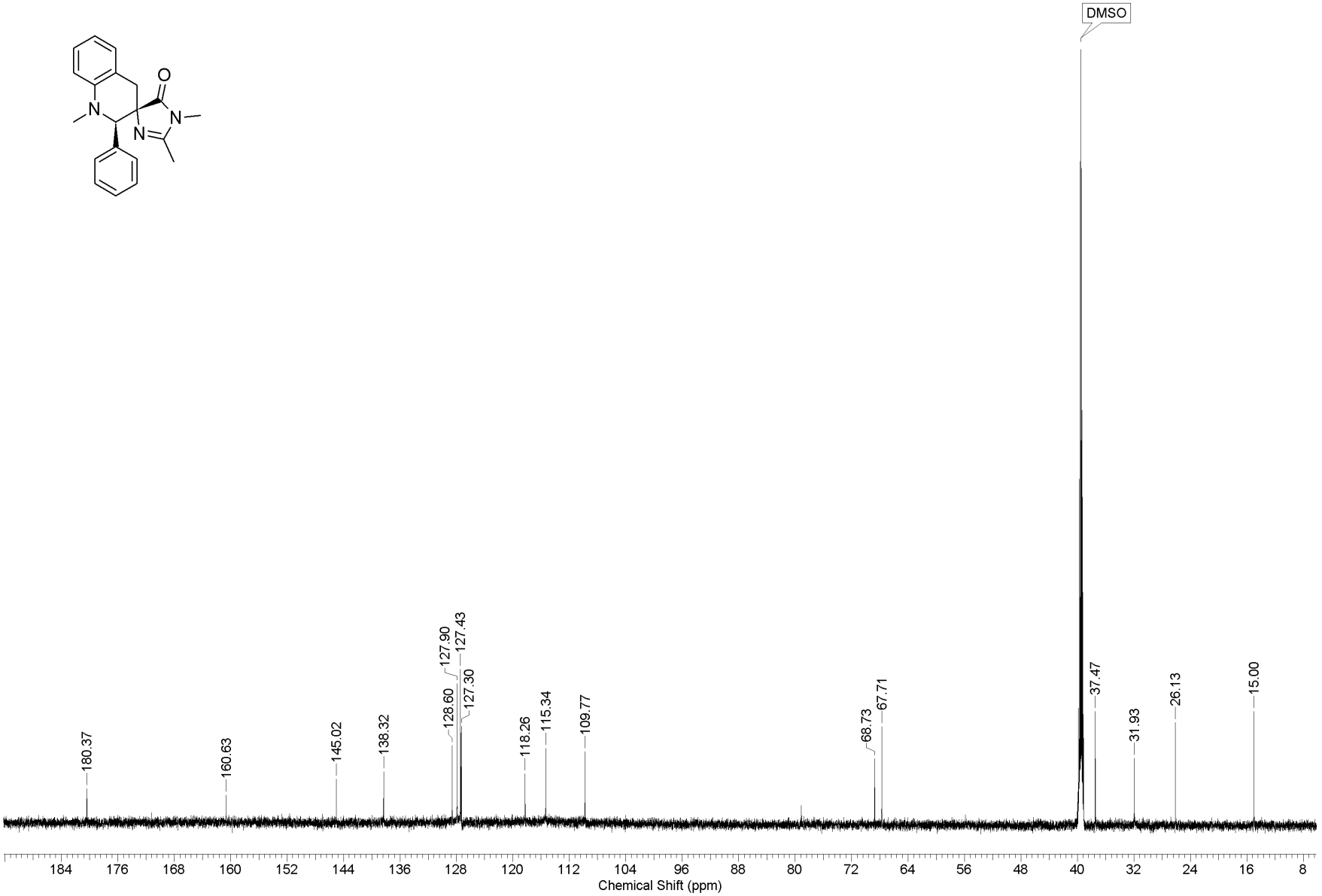
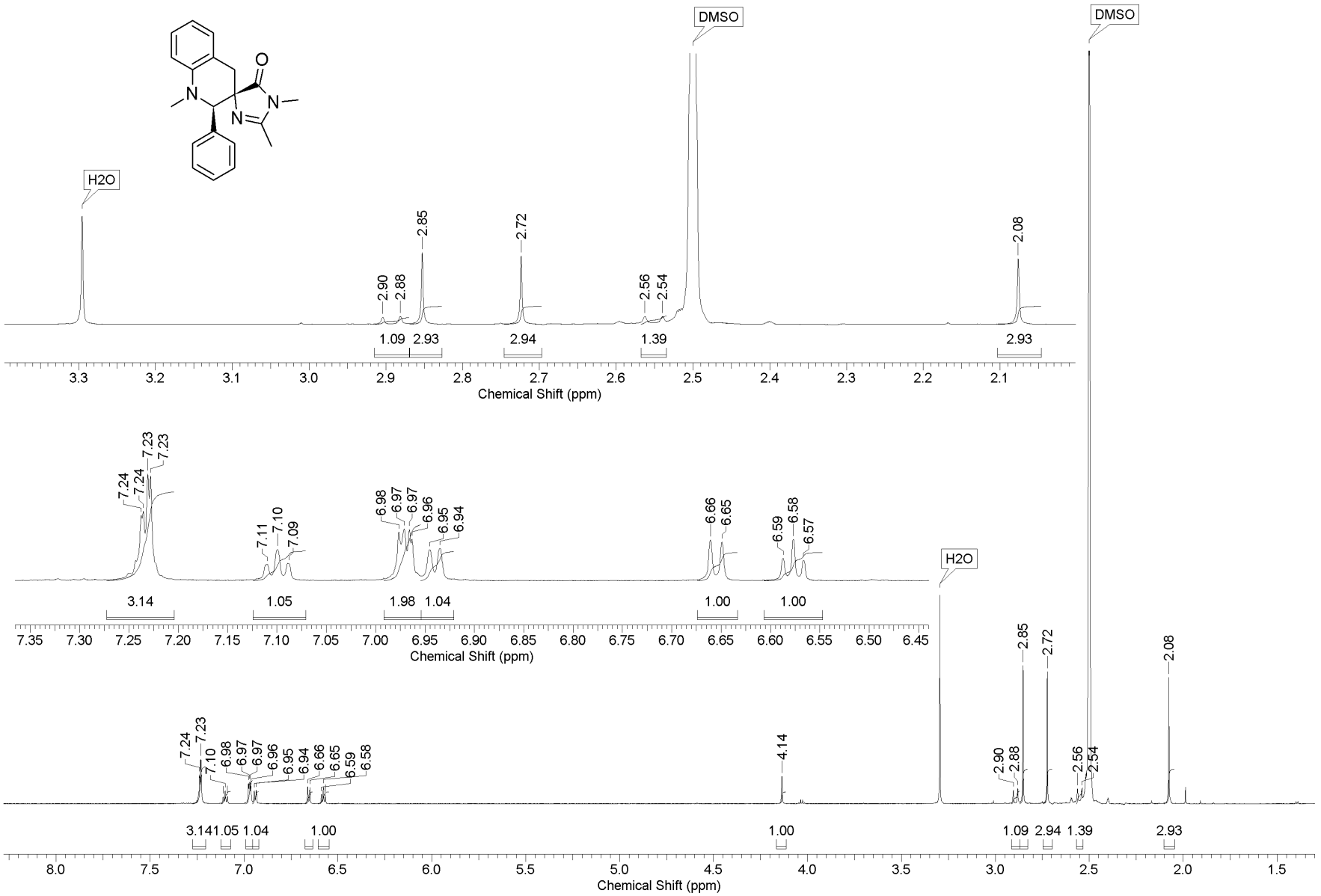
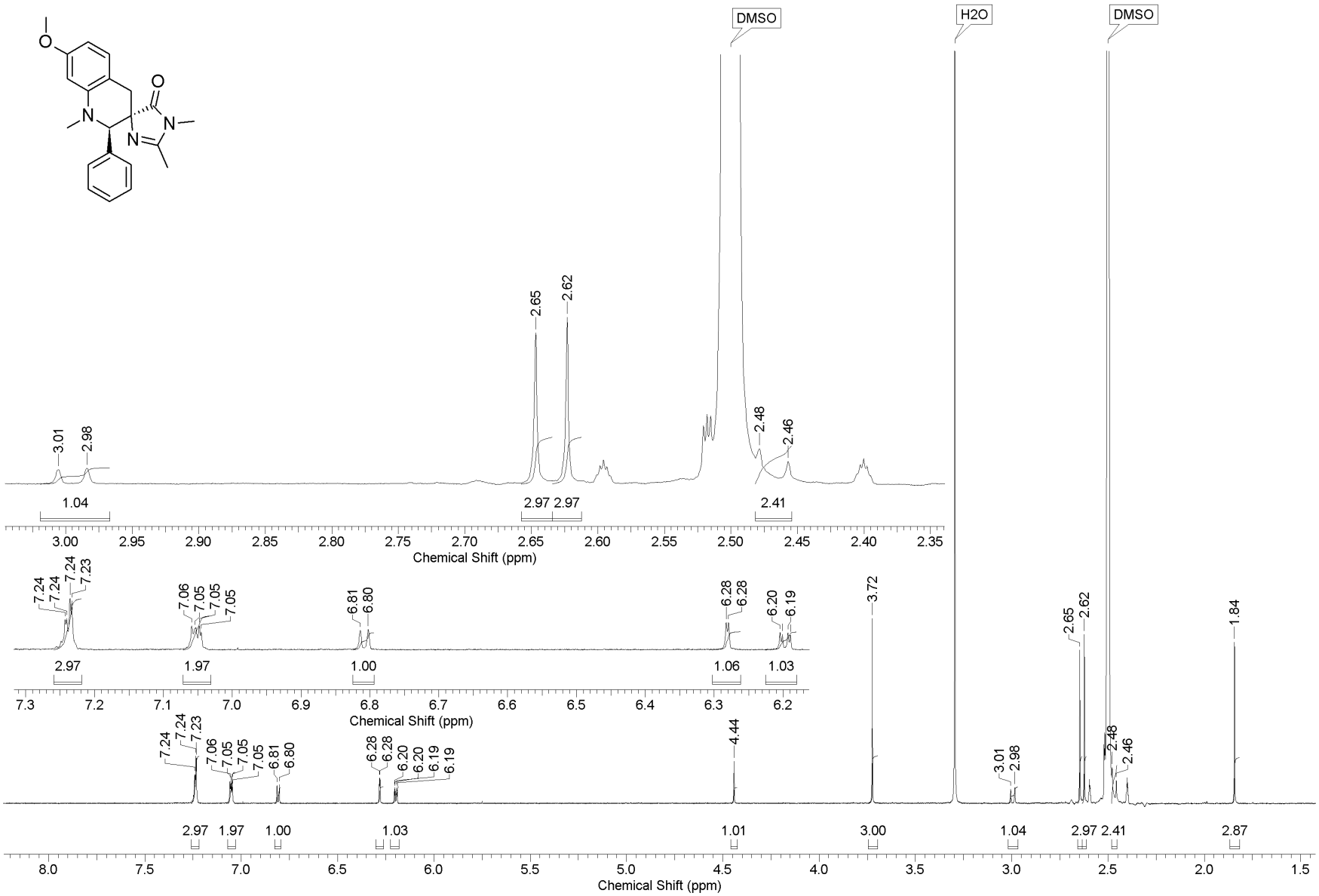
158.87
145.63
129.44
112.18
103.14
98.51
67.13
66.38
65.91
58.21
54.89
46.43
33.92
25.97
15.05
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

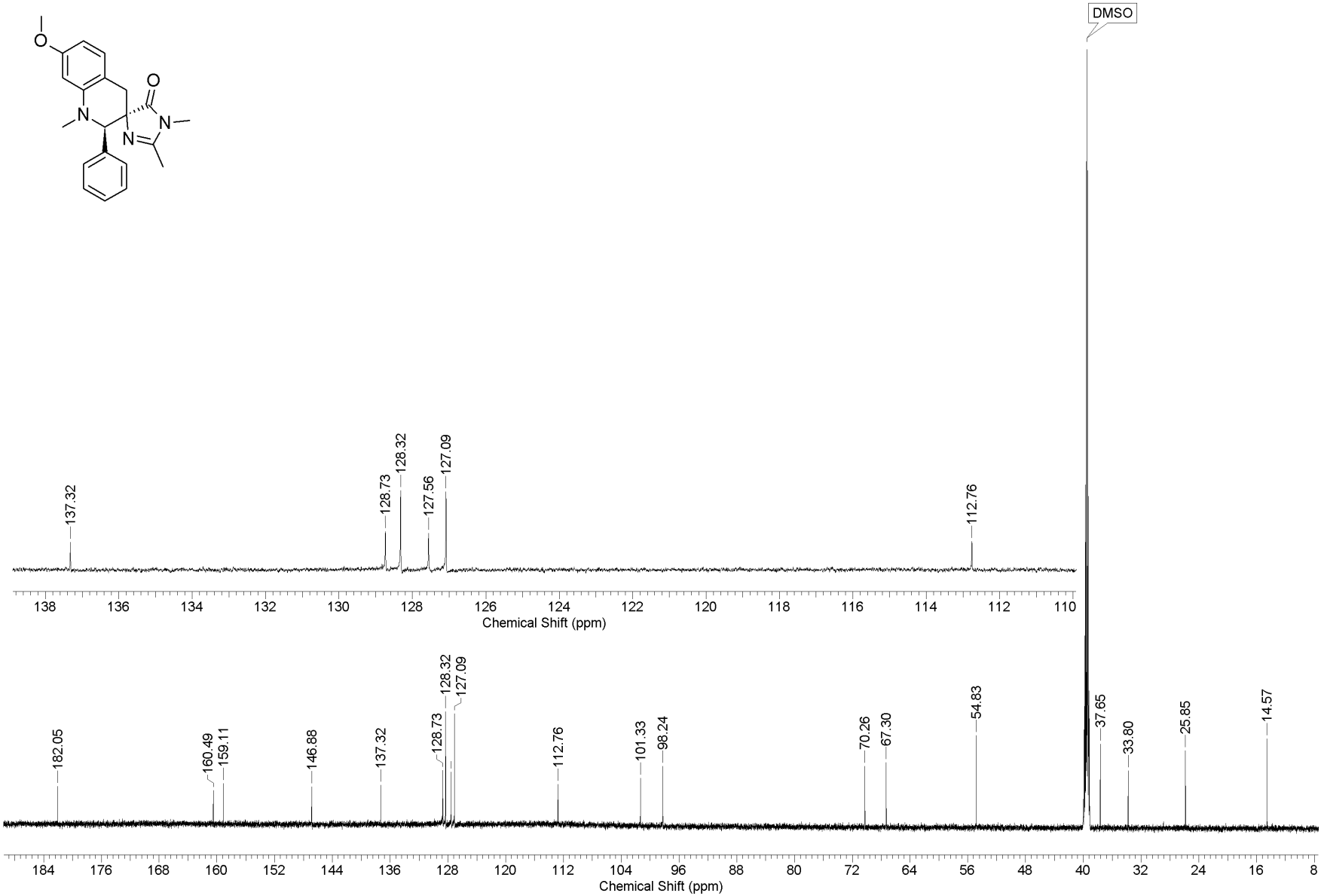

DMSO
DMSO
H2O
2.66
2.62
1.84
3.12
3.10
2.52
2.52
1.01
2.96
1.36
2.96
Chemical Shift (ppm)
7.24
7.24
7.25
7.24
7.25
7.10
7.09
7.08
7.07
7.07
7.06
7.06
6.92
6.91
6.75
6.74
6.61
6.60
6.59
3.06
1.06
1.98
1.01
1.00
0.99
Chemical Shift (ppm)
H2O
2.66
2.62
1.84
7.25
7.24
7.24
7.24
7.24
7.09
7.07
7.07
7.06
6.92
6.91
6.75
6.74
6.61
6.60
6.59
4.47
3.12
3.10
2.52
2.52
1.06
1.01
1.00
0.99
1.01
1.01
1.36
2.96
Chemical Shift (ppm)

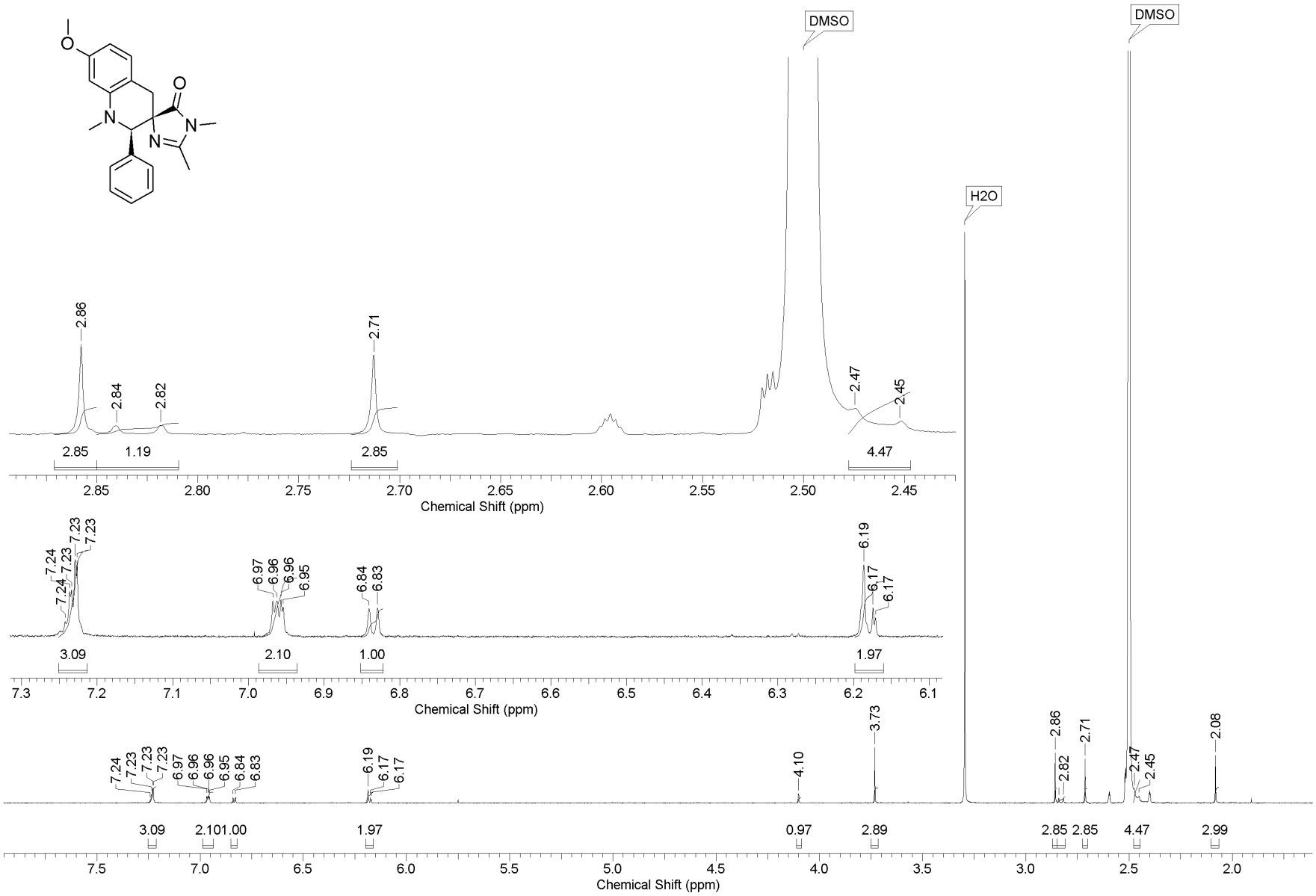

O
N
N
N
DMSO
128.33
127.09
127.60
127.17
137.26
120.26
116.16
137 136 135 134 133 132 131 130 129 128 127 126 125 124 123 122 121 120 119 118 117 116
Chemical Shift (ppm)
128.33
127.09
182.04
160.59
146.06
137.26
120.26
116.16
111.90
70.27
67.46
37.61
34.56
25.87
14.55
184 176 168 160 152 144 136 128 120 112 104 96 88 80 72 64 56 48 40 32 24 16 8
Chemical Shift (ppm)

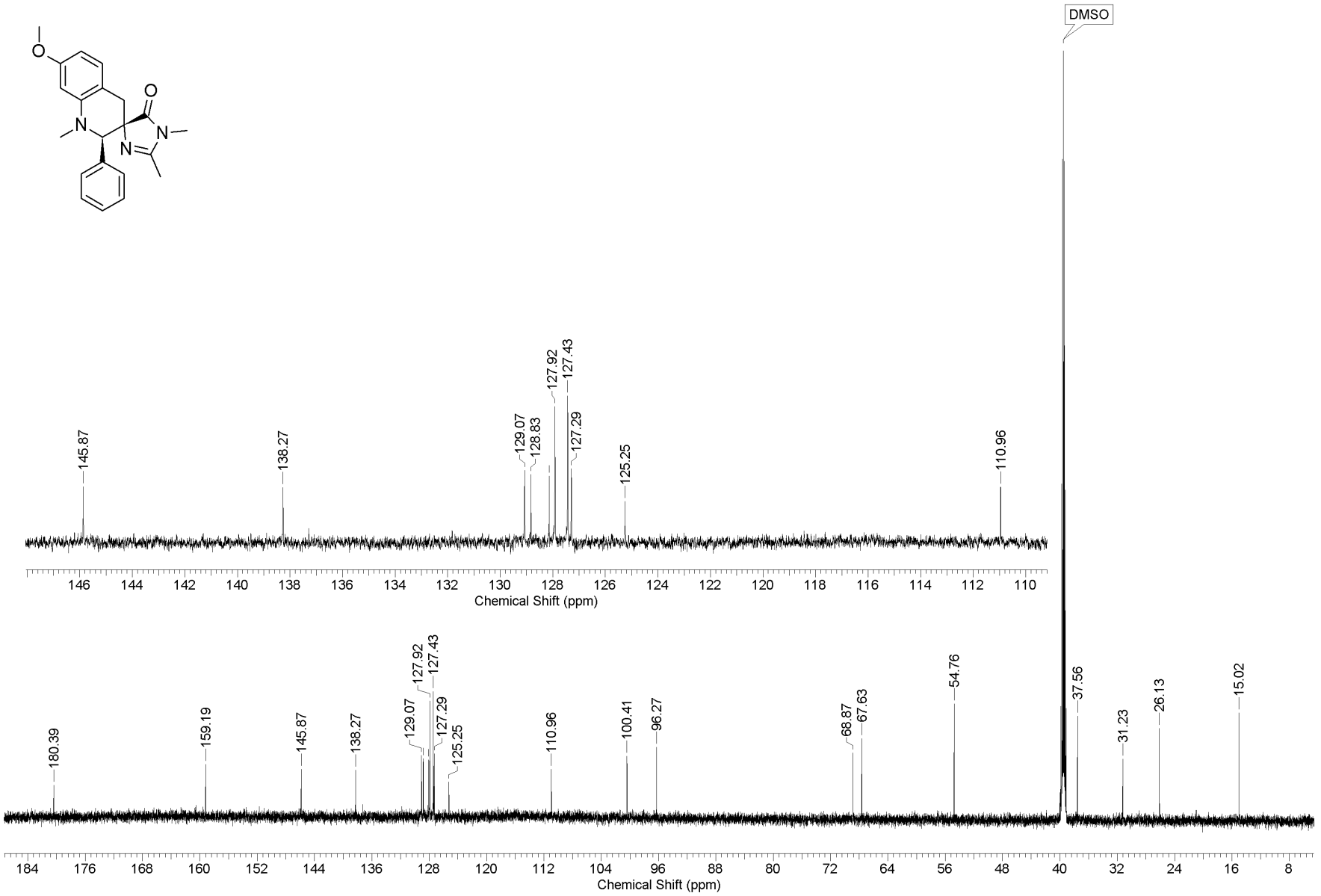

DMSO
180.37
160.63
145.02
138.32
128.60
127.90
127.43
127.30
118.26
115.34
109.77
68.73
67.71
37.47
31.93
26.13
15.00
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)

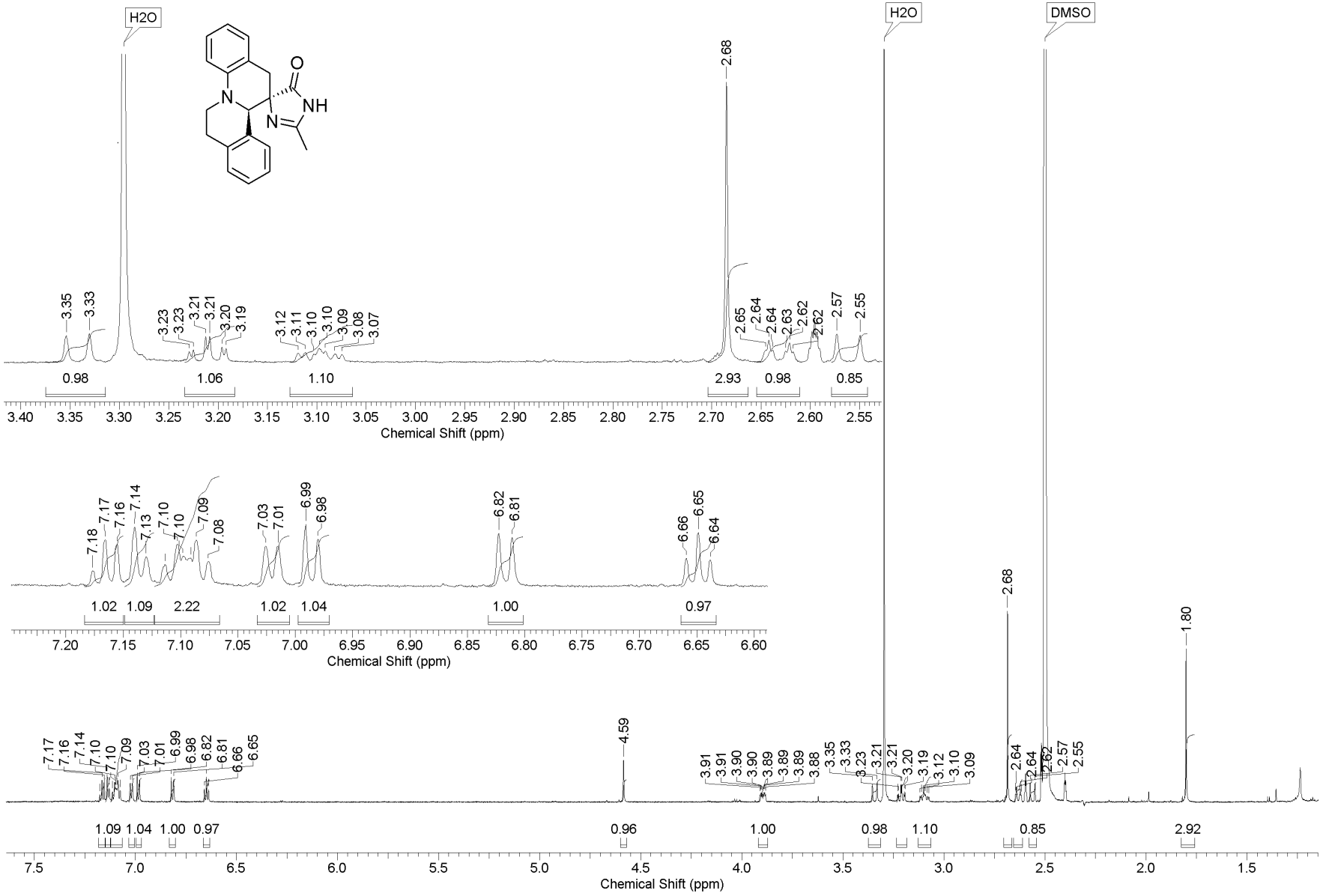

DMSO
DMSO
H2O
2.85
2.72
2.08
2.90
2.88
2.56
2.54
1.09 2.93
2.94
1.39
2.93
Chemical Shift (ppm)
7.24
7.23
7.23
7.24
7.11
7.10
7.09
6.98
6.97
6.97
6.96
6.95
6.94
6.66
6.65
6.59
6.58
6.57
3.14
1.05
1.98 1.04
1.00
1.00
Chemical Shift (ppm)
H2O
2.85
2.72
2.08
7.24
7.23
7.10
6.98
6.97
6.97
6.96
6.95
6.94
6.66
6.65
6.59
6.58
4.14
2.90
2.88
2.56
2.54
3.14 1.05 1.04
1.00
1.00
1.09 2.94 1.39
2.93
Chemical Shift (ppm)

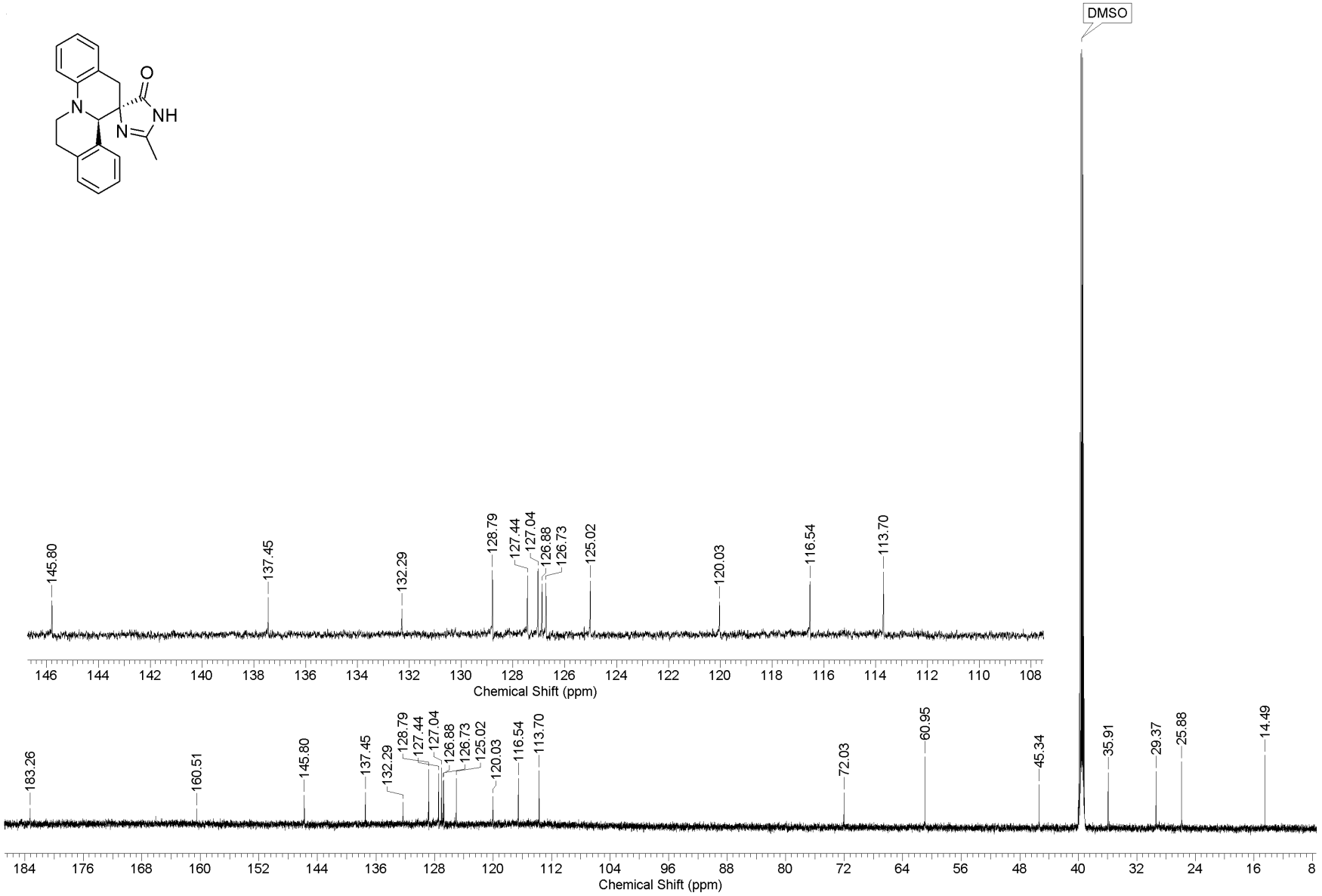

DMSO
H2O
DMSO
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)

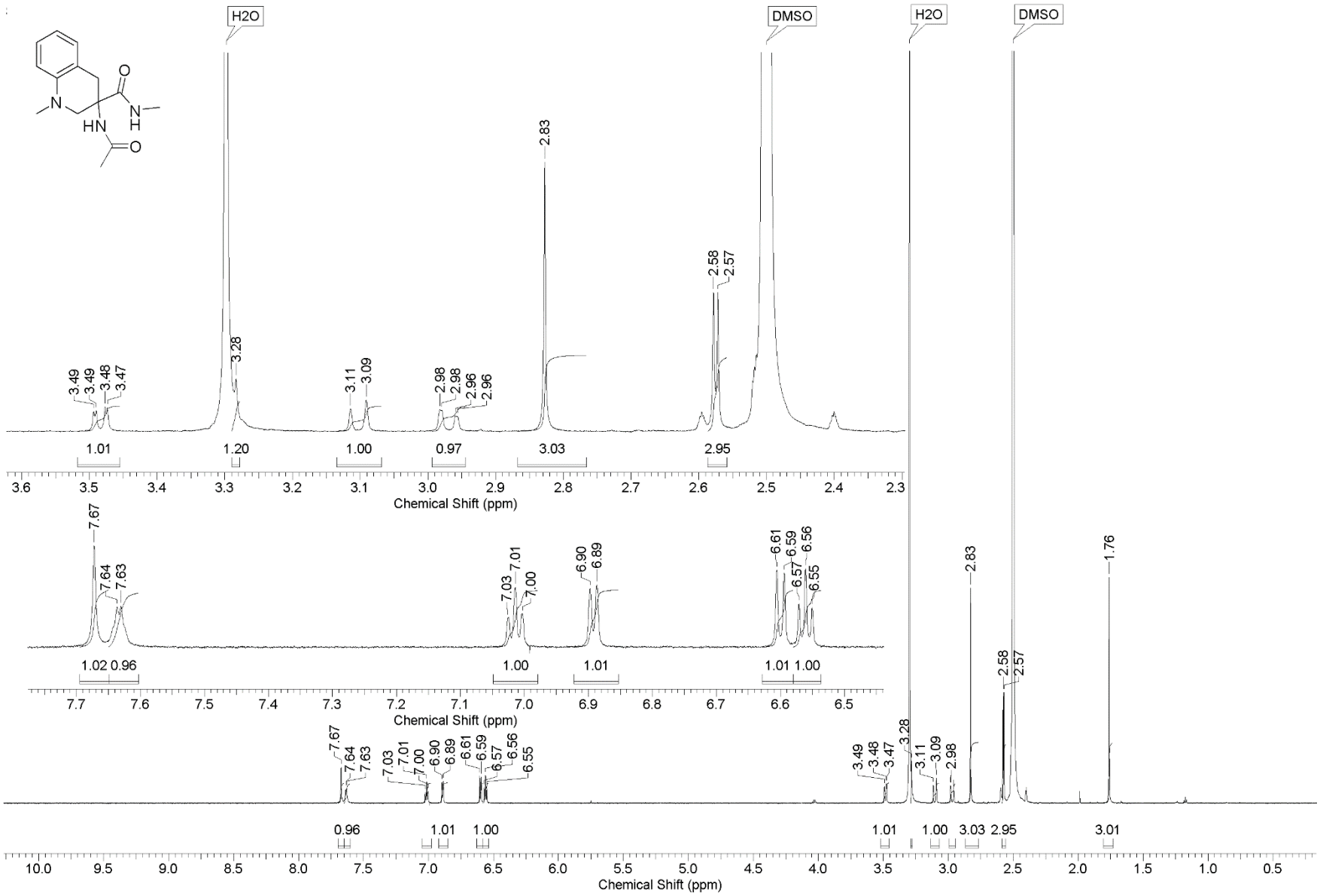

DMSO
137.32
128.73
128.32
127.56
127.09
112.76
Chemical Shift (ppm)
182.05
160.49
159.11
146.88
137.32
128.73
128.32
127.09
112.76
101.33
98.24
70.26
67.30
54.83
37.65
33.80
25.85
14.57
Chemical Shift (ppm)

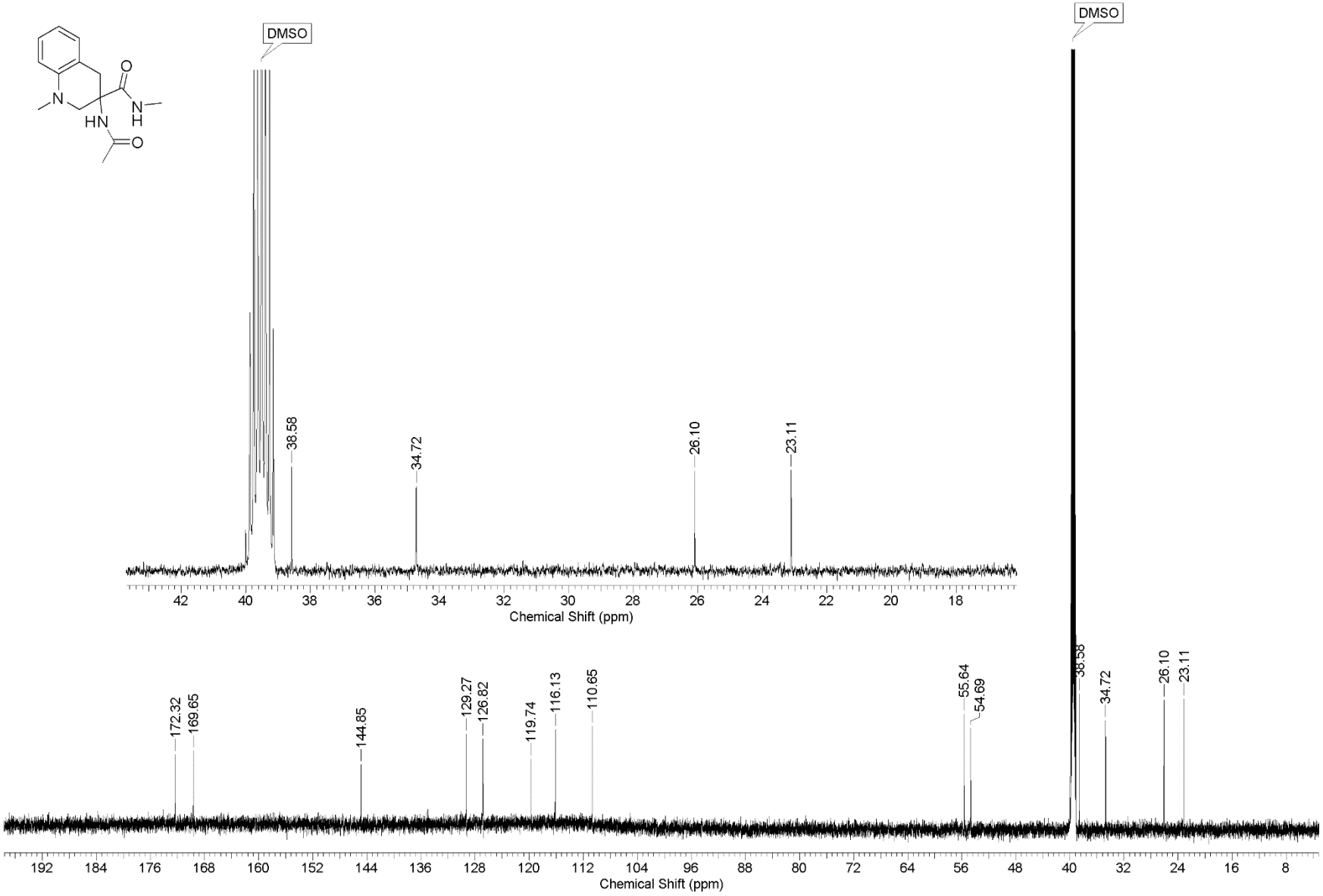

DMSO
DMSO
H2O
2.86
2.84
2.82
2.71
2.47
2.45
2.85
1.19
2.85
4.47
Chemical Shift (ppm)
7.24
7.23
7.23
7.23
7.24
7.23
6.97
6.96
6.96
6.95
6.84
6.83
6.19
6.17
6.17
3.09
2.10
1.00
1.97
Chemical Shift (ppm)
7.24
7.23
7.23
7.23
6.97
6.96
6.96
6.95
6.84
6.83
6.19
6.17
6.17
4.10
3.73
2.86
2.82
2.71
2.47
2.45
2.08
3.09
2.10
1.00
1.97
0.97
2.89
2.85
2.85
4.47
2.99
Chemical Shift (ppm)

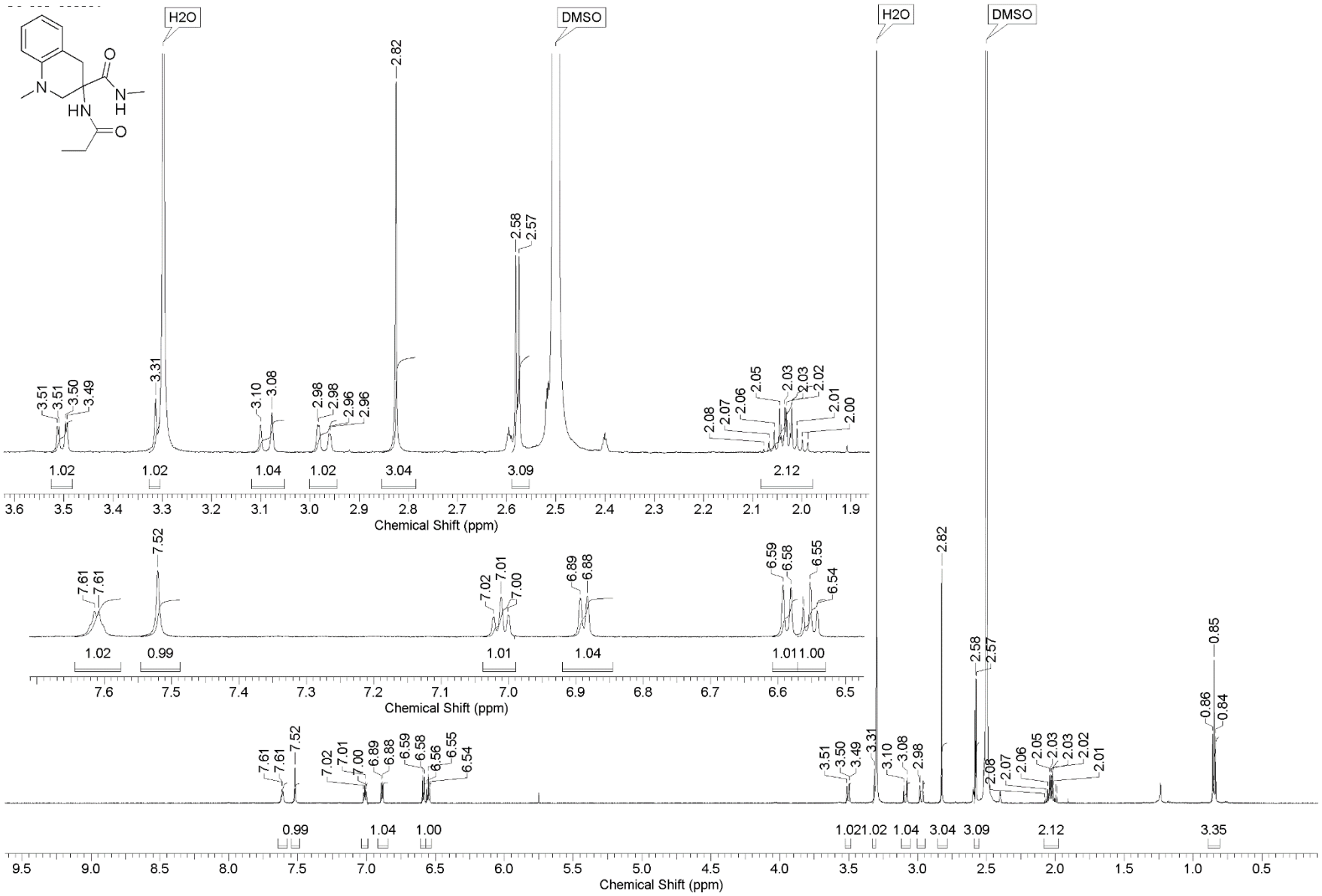

DMSO
145.87
138.27
129.07
128.83
127.92
127.43
127.29
125.25
110.96
Chemical Shift (ppm)
180.39
159.19
145.87
138.27
129.07
127.92
127.43
127.29
125.25
110.96
100.41
96.27
68.87
67.63
54.76
37.56
31.23
26.13
15.02
Chemical Shift (ppm)

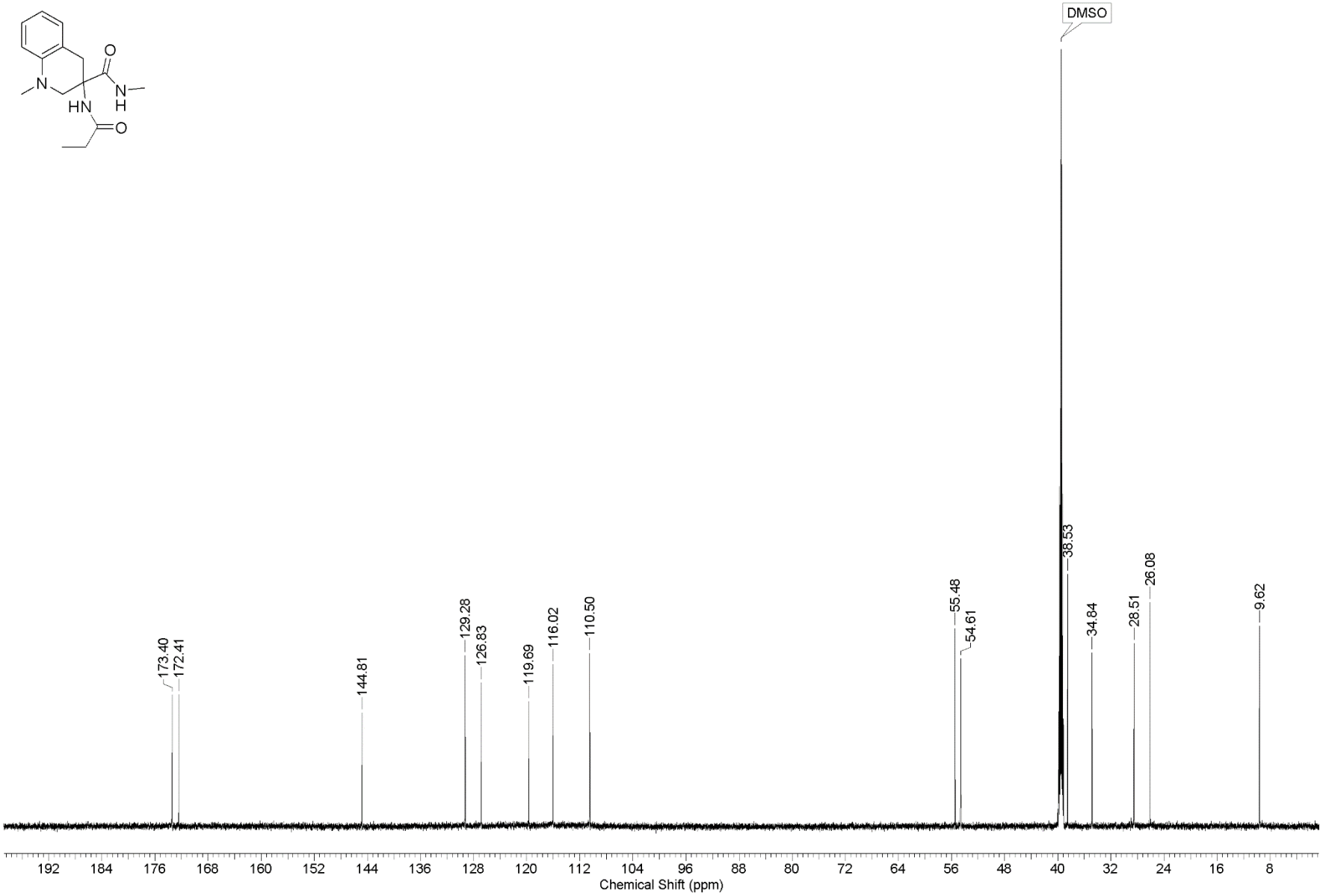

H2O
H2O
DMSO
O
NH
N
N
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)

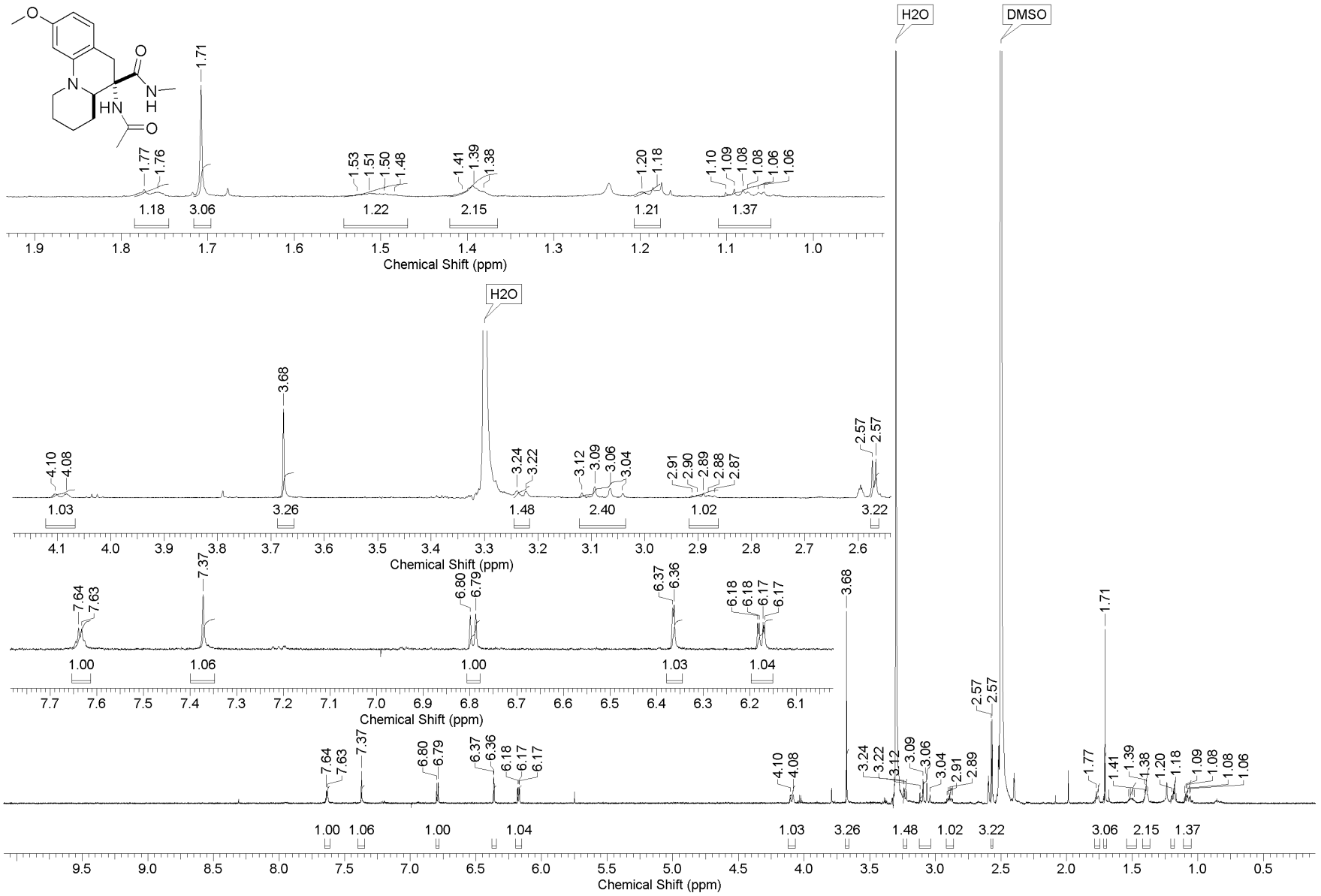

O
NH
N
N
DMSO
145.80
137.45
132.29
128.79
127.44
127.04
126.88
126.73
125.02
120.03
116.54
113.70
Chemical Shift (ppm)
183.26
160.51
145.80
137.45
132.29
128.79
127.44
127.04
126.88
126.73
125.02
120.03
116.54
113.70
72.03
60.95
45.34
35.91
29.37
25.88
14.49
Chemical Shift (ppm)

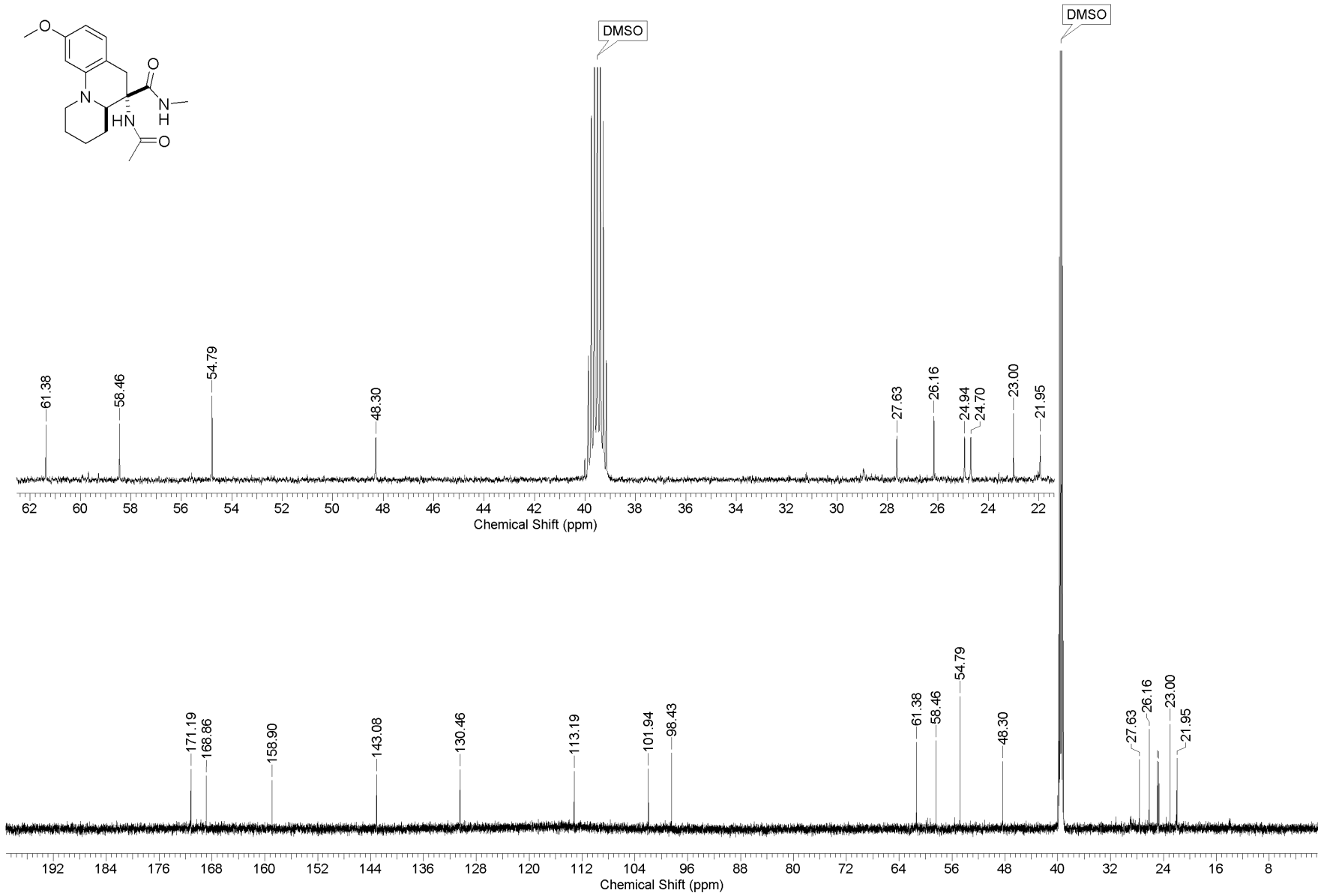

H2O
DMSO
H2O
DMSO
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)


DMSO
DMSO
38.58
34.72
26.10
23.11
Chemical Shift (ppm)
172.32
169.65
144.85
129.27
126.82
119.74
116.13
110.65
55.64
54.69
38.58
34.72
26.10
23.11
Chemical Shift (ppm)


H2O
DMSO
H2O
DMSO
Chemical Shift (ppm)
Chemical Shift (ppm)
Chemical Shift (ppm)


DMSO
173.40
172.41
144.81
129.28
126.83
119.69
116.02
110.50
55.48
54.61
38.53
34.84
28.51
26.08
9.62
192
184
176
168
160
152
144
136
128
120
112
104
96
88
80
72
64
56
48
40
32
24
16
8
Chemical Shift (ppm)


H2O
DMSO
1.71
1.77
1.76
1.53
1.51
1.50
1.48
1.41
1.39
1.38
1.20
1.18
1.10
1.09
1.08
1.08
1.06
1.06
1.18
3.06
1.22
2.15
1.21
1.37
Chemical Shift (ppm)
H2O
3.68
4.10
4.08
3.24
3.22
3.12
3.09
3.06
3.04
2.91
2.90
2.89
2.88
2.87
2.57
2.57
1.03
3.26
1.48
2.40
1.02
3.22
Chemical Shift (ppm)
7.37
7.64
7.63
6.80
6.79
6.37
6.36
6.18
6.18
6.17
6.17
1.00
1.06
1.00
1.03
1.04
Chemical Shift (ppm)
7.64
7.63
7.37
6.80
6.79
6.37
6.36
6.18
6.17
6.17
4.10
4.08
3.68
3.24
3.22
3.12
3.09
3.06
3.04
2.91
2.89
2.57
2.57
1.71
1.77
1.41
1.39
1.38
1.20
1.18
1.09
1.08
1.08
1.06
1.00
1.06
1.00
1.04
1.03
3.26
1.48
1.02
3.22
3.06
2.15
1.37
Chemical Shift (ppm)


DMSO
DMSO
61.38
58.46
54.79
48.30
27.63
26.16
24.94
24.70
23.00
21.95
Chemical Shift (ppm)
171.19
168.86
158.90
143.08
130.46
113.19
101.94
98.43
61.38
58.46
54.79
48.30
27.63
26.16
23.00
21.95
Chemical Shift (ppm)