Supporting Online Material for

Tandem Synthesis of 3-Halo-5-Substituted Isoxazoles from 1-Copper(I) Alkynes and Dihaloformaldoximes

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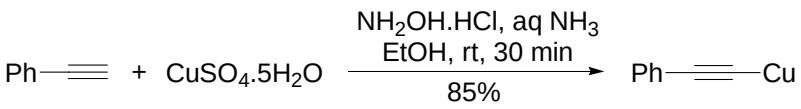
Table 2. Effects of the solvents and ligands on the yield of 1a [a]

entry	solvent	ligand	**1a** (%)[b]
1	$ClCH_2CH_2Cl$	--	94
2	$CHCl_3$	--	76
3	PhMe	--	74
4	CH_2Cl_2	--	70
5	EtOAc	--	67
6	NMP	--	10
7	DMF	--	20
8	MeCN	--	30
9	THF	--	73
10	$ClCH_2CH_2Cl$	1,10-Phen	57
11	$ClCH_2CH_2Cl$	dppf	70
12	$ClCH_2CH_2Cl$	dppp	73
13	$ClCH_2CH_2Cl$	PPh_3	74

[a] The mixture of **3** (0.6 mmol) and **7a** (0.5 mmol) in a solvent (1 mL) was stirred in a stoppered glass tube at 45 °C for 1 h. [b] The isolated yields.

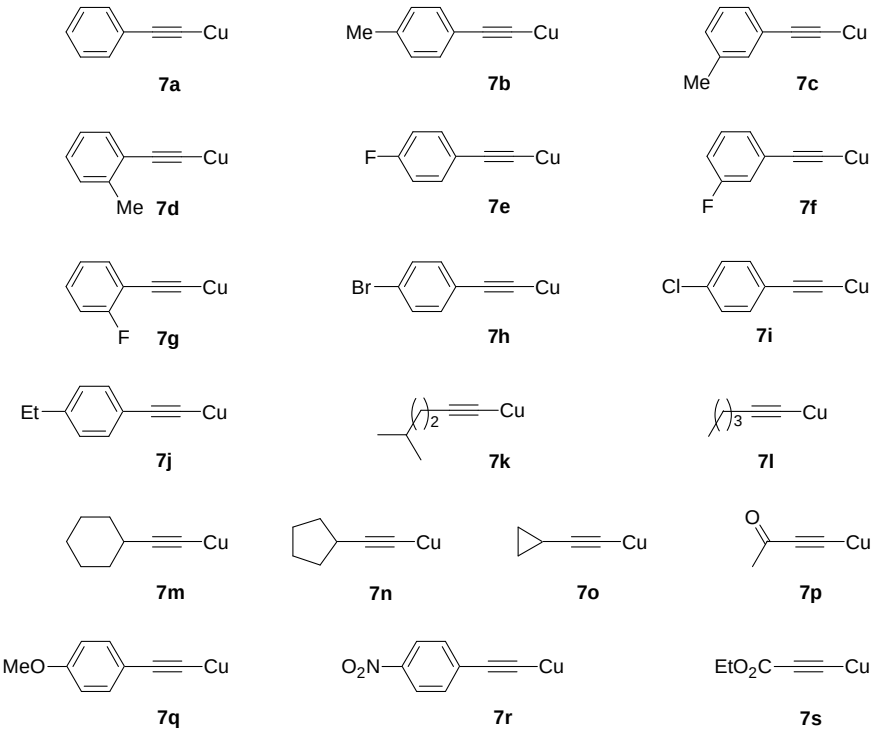
Experimental Section

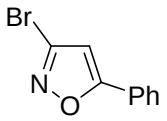
All melting points were determined on a Yanaco melting point apparatus and were uncorrected. IR spectra were recorded as KBr pellets on a Nicolet FT-IR 5DX spectrometer. The spectra of ^{1}H NMR (300 or 400 MHz) and ^{13}C NMR (75 or 100 MHz) were recorded in $CDCl_3$. TMS was used as an internal reference and *J* values are given in Hz. HRMS were obtained on a Bruker micrOTOF-Q II spectrometer. Dibromoformaldoxime (**3**),[1] dichloroformaldoxime (**4**)[1] and 1-copper(I) alkynes (**7a-s**)[2] were prepared by reported references in literature.



A typical procedure for the synthesis of copper(I) phenylethyne (7a).[2c] To a cooled (ice bath) and stirred solution of $CuSO_4 \cdot 5H_2O$ (25 g, 100 mmol), aqueous ammonia (28%, 100 mL) and water (400 mL) is added solid $NH_2OH \cdot HCl$ (13.9 g, 200 mmol) under N_2. Ten minutes later, a solution of phenylethyne (10.25 g, 100.5 mmol) in EtOH (95%, 500 mL) was added rapidly. The resultant mixture is stirred for another five min, yellow solid is produced and water (500 mL) is added. After the mixture stands for 5 minute, the solid is collected on a sintered glass filter and washed successively with water (5 x 100 mL), EtOH (5 x 100 mL) and Et_2O (5 x 100 mL). After the solid is dried in vacuum for 6 h at room temperature, copper(I) phenylethyne (**7a**) was obtained in 85% (14 g) as bright yellow crystals. The sample is stored in a bottle and no notable decomposition is observed within one year.

By the similar procedure, 1-copper(I) alkynes (**7b-s**) were prepared.

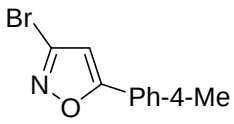




1a

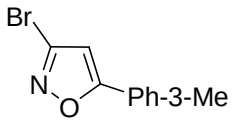
A typical procedure for the preparation of 3-bromo-5-phenylisoxazole (1a). To a suspension of 1-copper(I) phenylethyne (**7a**) (83 mg, 0.5 mmol) in DCE (1 mL) was added dibromoformaldoxime (**3**) (122 mg, 0.6 mmol). After the mixture was stirred at 45 ^{o}C (water bath) for 1 h (the end-point was judged by the disappearance of the bright yellow colour of **7a**), it was purified directly by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give 106 mg (94%) of product **1a** as a white solid, mp 70−71 ^{o}C (Lit.[3] 72−73 ^{o}C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76−7.74 (m, 2H), 7.49−7.48 (m, 3H), 6.58 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.3, 140.8, 130.9, 129.1 (2C), 126.3, 125.8 (2C), 102.8.

The products **1b-1p** were prepared by the similar procedure.



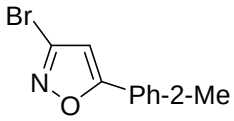
1b

3-Bromo-5-(4-methylphenyl)isoxazole (1b). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (4-methyl-phenyl)ethyne (**7b**) (90 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 °C for 70 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1b** as a yellowish solid (107 mg, 90%), mp 61−63 ^{o}C. IR ν 3159, 1612, 1504, 1430 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.63 (d, J = 8.3 Hz, 2H), 7.28 (d, J = 7.9 Hz, 2H), 6.52 (s, 1H), 2.41 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.6, 141.4, 140.8, 129.8 (2C), 125.8 (2C), 123.7, 102.3, 21.5. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_{10}H_8BrNO$, $[M+H]^+$ 237.9862; found 237.9866.



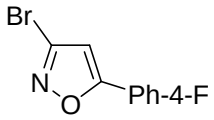
1c

3-Bromo-5-(3-methylphenyl)isoxazole (1c). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (3-methylphenyl)-ethyne (**7c**) (90 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 75 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1c** as a yellow oil (95 mg, 80%). IR ν 3138, 2922, 1566, 1428 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56–7.53 (m, 2H), 7.38−7.34 (m, 1H), 7.29−7.26 (m, 1H), 6.56 (s, 1H), 2.41 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.5, 140.7, 138.9, 131.7, 129.0, 126.3, 126.2, 123.0, 102.7, 21.3. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_{10}H_8BrNO$, $[M+H]^+$ 237.9862; found 237.9864.



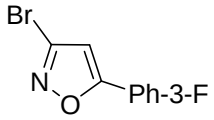
1d

3-Bromo-5-(2-methylphenyl)isoxazole (1d). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (2-methylphenyl)-ethyne (**7d**) (90 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 80 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1d** as a yellowish oil (104 mg, 87%). IR ν 3066, 2968, 1565, 1345 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69−7.67 (m, 1H), 7.40−7.36 (m, 1H), 7.33−7.30 (m, 2H), 6.49 (s, 1H), 2.50 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.4, 140.5, 136.4, 131.4, 130.7, 128.4, 126.4, 125.9, 105.9, 21.3. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_{10}H_8BrNO$, $[M-H]^+$ 235.9716; found 235.9712.



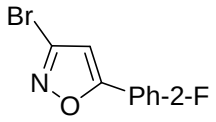
1e

3-Bromo-5-(4-fluorophenyl)isoxazole (1e). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (4-fluorophenyl)ethyne (**7e**) (92 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 70 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1e** as a white solid (91 mg, 75%), mp 112−113 ^{o}C. IR ν 3070, 1632, 1529, 1351, 1082, 690 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76−7.73 (m, 2H), 7.20−7.16 (m, 2H), 6.54 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.4, 164.1 (d, J = 251.0 Hz), 140. 9, 128.0 (d, J = 8.6 Hz, 2C), 122.7, 116.4 (d, J = 22.2 Hz, 2C), 102.7. HRMS (ESI-TOF) (*m/z*): Calcd. for C_9H_5BrFNO, $[M+H]^+$ 241.9611; found 241.9609.



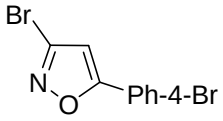
1f

3-Bromo-5-(3-fluorophenyl)isoxazole (1f). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (3-fluorophenyl)ethyne (**7f**) (92 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 150 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1f** as a white solid (108 mg, 89%), mp 77−79 ^{o}C. IR ν 3150, 3132, 1573, 1350 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.56−7.43 (m, 3H), 7.21−7.15 (m, 1H), 6.61 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.0, 162.9 (d, J = 236.6 Hz), 140.9, 131.0 (d, J = 8.6 Hz), 128.0, 121.6, 118.0 (d, J = 20.8 Hz), 112.9 (d, J = 23.7 Hz), 103.7. HRMS (ESI-TOF) (*m/z*): Calcd. for C_9H_5BrFNO, $[M-H]^+$ 239.9466; found 239.9466.



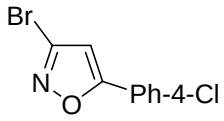
1g

3-Bromo-5-(2-fluorophenyl)isoxazole (1g). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (2-fluorophenyl)ethyne (**7g**) (92 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 80 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1g** as a yellowish solid (104 mg, 86%), mp 55−57 ^{o}C. IR ν 3185, 2926, 1621, 1493 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.97−7.92 (m, 1H), 7.51−7.44 (m, 1H), 7.33−7.27 (m, 1H), 7.25−7.18 (m, 1H), 6.79 (d, J = 3.8 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.1, 159.1 (d, J = 252.4 Hz), 141.1, 132.4 (d, J = 9.3 Hz), 127.4, 124.8 (d, J = 3.6 Hz), 116.3 (d, J = 21.5 Hz), 114.7 (d, J = 12.2 Hz), 106.8 (d, J = 12.2 Hz). HRMS (ESI-TOF) (*m/z*): Calcd. for C_9H_5BrFNO, $[M+H]^+$ 241.9611; found 241.9605.



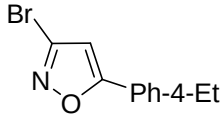
1h

3-Bromo-5-(4-bromophenyl)isoxazole (1h). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (4-bromophenyl)ethyne (**7h**) (122 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 90 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1h** as a white solid (126 mg, 83%), mp 159−160 ^{o}C. IR ν 3148, 1605, 1428, 1350 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64−7.59 (m, 4H), 6.59 (s, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 170.3, 141.0, 132.4 (2C), 127.3 (2C), 125.5, 125.1, 103.2. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_9H_5Br_2NO$, $[M+H]^+$ 301.8811; found 301.8809.



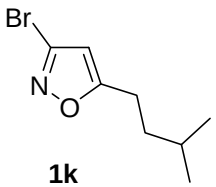
1i

3-Bromo-5-(4-chlorophenyl)isoxazole (1i). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (4-chlorophenyl)ethyne (**7i**) (100 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 120 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1i** as a white solid (103 mg, 80%), mp 145−146 ^{o}C (Lit.[3] 154−155 ^{o}C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, J = 8.2 Hz, 2H), 7.47 (d, J = 8.2 Hz, 2H), 6.58 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.2, 140.9, 137.1, 129.5 (2C), 127.1 (2C), 124.7, 103.2.



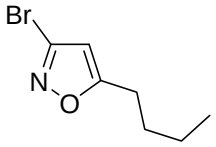
1j

3-Bromo-5-(4-ethylphenyl)isoxazole (1j). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) (4-ethylphenyl)ethyne (**7j**) (97 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 50 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1j** as a yellow oil (111 mg, 88%). IR ν 2968, 2933, 1615, 1506, 1431 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.66 (d, J = 8.2 Hz, 2H), 7.30 (d, J = 8.2 Hz, 2H), 6.53 (s, 1H), 2.70 (q, J = 7.6 Hz, 2H), 1.26 (t, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.6, 147.6, 140.8, 128.6 (2C), 125.9 (2C), 123.8, 102.2, 28.8, 15.2. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_{11}H_{10}BrNO$, $[M+H]^+$ 252.0019; found 252.0014.



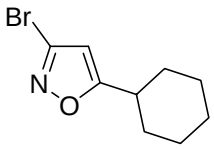
1k

3-Bromo-5-isopentylisoxazole (1k). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I)-5-methyl-hex-1-yne (**7k**) (80 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 10 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1k** as a yellowish oil (97 mg, 89%). IR ν 2959, 2930, 1586, 1438, 1359, 951 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.07 (s, 1H), 2.76 (t, J = 7.8 Hz, 2H), 1.63−1.55 (m, 3H), 0.94 (d, J = 6.4 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.8, 140.2, 104.3, 36.0, 27.4, 24.7, 22.1 (2C). HRMS (ESI-TOF) (*m/z*): Calcd. for $C_8H_{12}BrNO$, $[M+H]^+$ 218.0175; found 218.0178.



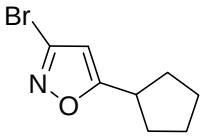
1l

3-Bromo-5-butylisoxazole (1l). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I)-hex-1-yne (**7l**) (73 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 °C for 30 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1l** as a yellowish oil (85 mg, 83%). IR ν 2960, 2934, 2872, 1586, 1439 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.07 (s, 1H), 2.76 (t, J = 7.9 Hz, 2H), 1.72−1.62 (m, 2H), 1.46−1.33 (m, 2H), 0.94 (t, J = 7.6 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 175.7, 140.2, 104.4, 29.2, 26.4, 22.0, 13.6. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_7H_{10}BrNO$, $[M+H]^+$ 204.0019; found 204.0021.



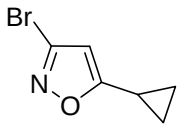
1m

3-Bromo-5-cyclohexylisoxazole (1m). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) cyclohexylethyne (**7m**) (86 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 40 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1m** as a colorless oil (112 mg, 97%). IR ν 2932, 2856, 1580, 1448, 1349, 951 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 6.03 (d, J = 0.7 Hz, 1H), 2.82−2.73 (m, 1H), 2.05−1.97 (m, 2H), 1.83−1.71 (m, 4H), 1.49−1.22 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.6, 140.0, 102.8, 36.3, 30.8 (2C), 25.6, 25.5 (2C). HRMS (ESI-TOF) (*m/z*): Calcd. for $C_9H_{12}BrNO$, $[M+H]^+$ 230.0175; found 230.0179.



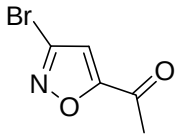
1n

3-Bromo-5-cyclopentylisoxazole (1n). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) cyclopentylethyne (**7n**) (79 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 15 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1n** as a yellowish oil (94 mg, 87%). IR ν 2961, 2872, 1581, 1439 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.05 (s, 1H), 3.24−3.16 (m, 1H), 2.13−2.04 (m, 2H), 1.82−1.65 (m, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.7, 153.0, 100.4, 37.7, 31.6 (2C), 25.2 (2C). HRMS (ESI-TOF) (*m/z*): Calcd. for $C_8H_{10}BrNO$, $[M+H]^+$ 216.0019; found 216.0015.



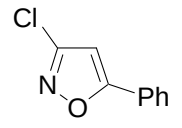
1o

3-Bromo-5-cyclopropylisoxazole (1o). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I) cyclopropylethyne (**7o**) (65 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 35 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1o** as a yellowish oil (72 mg, 77%). IR (KBr) *v* 2961, 2926, 1589, 1444, 1346, 1261, 1048 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.94 (s, 1H), 2.05−1.98 (m, 1H), 1.12−1.08 (m, 2H), 1.01−0.97 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 176.5, 140.3, 102.4, 8.7 (2C), 8.1. HRMS (ESI-TOF) (*m/z*): calcd. for C_6H_6BrNO, $[M+H]^+$ 187.9706; found 187.9702.



1p

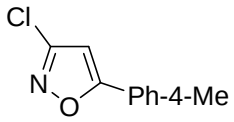
1-(3-Bromoisoxazol-5-yl)ethanone (1p). The title compound was prepared by the same procedure as **1a**. After a suspension of 1-copper(I)-3-oxo-but-1-yne (**7p**) (66 mg, 0.5 mmol) and dibromoformaldoxime (**3**) (122 mg, 0.6 mmol) in DCE (1.0 mL) was stirred at 45 ^{o}C for 6 h, the crude product was purified by a column chromatography [silica gel, 4% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **1p** as a white solid (54 mg, 57%), mp 54−55 ^{o}C (Lit.[4] 61−62 ^{o}C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.95 (s, 1H), 2.62 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 185.8, 167.3, 141.1, 110.3, 27.0.



2a

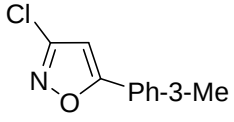
A typical procedure for preparation of 3-chloro-5-phenylisoxazole (2a). To a suspension of 1-copper(I) phenylethyne (**7a**) (83 mg, 0.5 mmol) in DMF (0.5 mL) was added a solution of dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (0.5 mL). After the mixture was stirred at 45 ^{o}C (water bath) for 1 h (the end-point was judged by the conversion of the suspension into a transparent solution), it was purified directly by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give 83 mg (92%) of product **2a** as a yellowish solid, mp 35−37 ^{o}C (Lit.[3] 36−37 ^{o}C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76−7.73 (m, 2H), 7.51−7.47 (m, 3H), 6.52 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.6, 153.8, 131.0, 129.1 (2C), 126.4, 125.7 (2C), 100.1.

The products **2b-2p** were prepared by the similar procedure.



2b

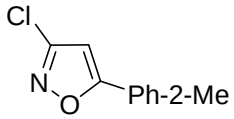
3-Chloro-5-(4-methylphenyl)isoxazole (2b). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (4-methylphenyl)-ethyne (**7b**) (90 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 ^{o}C for 30 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **2b** as a white solid (82 mg, 85%), mp 55−56 ^{o}C (Lit.[3] 61−62 ^{o}C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 (d, J = 7.8 Hz, 2H), 7.27 (d, J = 7.8 Hz, 2H), 6.46 (s, 1H), 2.41 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.8, 153.7, 141.4, 129.8 (2C), 125.7 (2C), 123.8, 99.4, 21.5.



2c

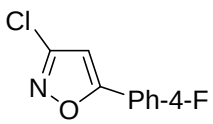
3-Chloro-5-(3-methylphenyl)isoxazole (2c). The title compound was prepared

by the same procedure as **2a**. After a suspension of 1-copper(I) (3-methylphenyl)-ethyne (**7c**) (90 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 ^{o}C for 41 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **2c** as a white solid (90 mg, 93%), mp 42−43 ^{o}C. IR ν 3148, 2923, 1608, 1570, 1448 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55−7.53 (m, 2H), 7.36 (t, J = 7.8 Hz, 1H), 7.29-7.25 (m, 1H), 6.50 (s, 1H), 2.41 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.8, 153.7, 138.9, 131.7, 129.0, 126.4, 126.3, 122.9, 99.9, 21.3. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_{10}H_8ClNO$, $[M+H]^+$ 194.0367; found 194.0372.



2d

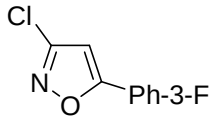
3-Chloro-5-(2-methylphenyl)isoxazole (2d). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (2-methylphenyl)-ethyne (**7d**) (90 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 ^{o}C for 54 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **2d** as a colorless oil (87 mg, 90%). IR ν 2962, 2865, 1567, 1359 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70−7.68 (m, 1H), 7.41−7.37 (m, 1H), 7.33−7.30 (m, 2H), 6.44 (s, 1H), 2.50 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.7, 153.3, 136.3, 131.4, 130.7, 128.3, 126.3, 126.1, 103.1, 21.3. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_{10}H_8ClNO$, $[M+H]^+$ 194.0367; found 194.0369.



2e

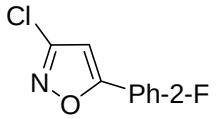
3-Chloro-5-(4-fluorophenyl)isoxazole (2e). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (4-fluorophenyl)ethyne (**7e**) (92 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF

(1.0 mL) was stirred at 45 °C for 90 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 °C)] to give product **2e** as a white solid (90 mg, 90%), mp 88−90 °C. IR ν 3165, 3148, 1614, 1505 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.76−7.72 (m, 2H), 7.21−7.15 (m, 2H), 6.49 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.8, 164.3 (d, J = 251.0 Hz), 154.0, 128.1 (d, J = 8.6 Hz, 2C), 123.0 (d, J = 2.9 Hz), 116.5 (d, J = 22.2 Hz, 2C), 100.0. HRMS (ESI-TOF) (*m/z*): Calcd. for C_9H_5ClFNO, $[M+H]^+$ 198.0116; found 198.0115.



2f

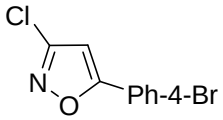
3-Chloro-5-(3-fluorophenyl)isoxazole (2f). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (3-fluorophenyl)ethyne (**7f**) (92 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 °C for 80 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 °C)] to give product **2f** as a yellowish solid (81 mg, 82%), mp 72−73 °C. IR ν 3154, 3072, 1576, 1457 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.54−7.52 (m, 1H), 7.49−7.44 (m, 2H), 7.21−7.16 (m, 1H), 6.56 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.2 (d, J = 2.9 Hz), 162.8 (d, J = 245.9 Hz), 153.9, 130.9 (d, J = 8.6 Hz), 128.2 (d, J = 7.9 Hz), 121.5 (d, J = 2.9 Hz), 117.9 (d, J = 21.5 Hz), 112.7 (d, J = 23.7 Hz), 100.9. HRMS (ESI-TOF) (*m/z*): Calcd. for C_9H_5ClFNO, $[M+H]^+$ 198.0116; found 198.0113.



2g

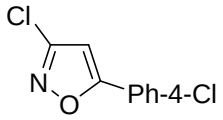
3-Chloro-5-(2-fluorophenyl)isoxazole (2g). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (2-fluorophenyl)ethyne (**7g**) (92 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF

(1.0 mL) was stirred at 45 °C for 30 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 °C)] to give product **2g** as a white solid (88 mg, 89%), mp 54−55 °C. IR ν 3180, 2925, 1622, 1493 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ 7.96−7.90 (m, 1H), 7.51−7.43 (m, 1H), 7.32−7.17 (m, 2H), 6.72 (d, J = 3.8 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.6 (d, J = 2.1 Hz), 159.3 (d, J = 252.4 Hz), 154.2, 132.6 (d, J = 8.6 Hz), 127.4, 125.0 (d, J = 3.6 Hz), 116.5 (d, J = 20.8 Hz), 115.1 (d, J = 12.2 Hz), 104.2 (d, J = 11.5 Hz). HRMS (ESI-TOF) (*m/z*): Calcd. for C_9H_5ClFNO, $[M+H]^+$ 198.0116; found 198.0118.



2h

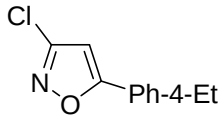
3-Chloro-5-(4-bromophenyl)isoxazole (2h). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (4-bromophenyl)-ethyne (**7h**) (122 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 °C for 35 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 °C)] to give product **2h** as a white solid (118 mg, 91%), mp 141−142 °C. IR ν 3147, 3075, 1605, 1434 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.64−7.59 (m, 4H), 6.54 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.6, 153.9, 132.4 (2C), 127.2 (2C), 125.5, 125.3, 100.5. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_9H_5BrClNO$, $[M-H]^+$ 255.9170; found 255.9169.



2i

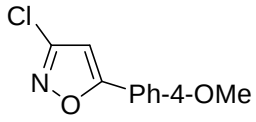
3-Chloro-5-(4-chlorophenyl)isoxazole (2i). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (4-chlorophenyl)ethyne (**7i**) (100 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 °C for 47 min, the crude product was purified by a column

chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 °C)] to give product **2i** as a white solid (102 mg, 95%), mp 122−124 °C (Lit.[3] 140−141 °C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, J = 8.7 Hz, 2H), 7.46 (d, J = 8.7 Hz, 2H), 6.53 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.5, 153.9, 137.1, 129.5 (2C), 127.0 (2C), 124.9, 100.4.



2j

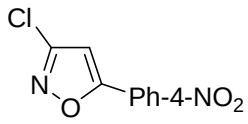
3-Chloro-5-(4-ethylphenyl)isoxazole (2j). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (4-ethylphenyl)ethyne (**7j**) (97 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 °C for 37 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 °C)] to give product **2j** as a yellowish oil (101 mg, 97%). IR ν 3138, 2968, 1615, 1506, 1435 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, J = 8.2 Hz, 2H), 7.30 (d, J = 8.2 Hz, 2H), 6.47 (s, 1H), 2.70 (q, J = 7.8 Hz, 2H), 1.26 (t, J = 7.8 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.8, 153.6, 147.6, 128.6 (2C), 125.8 (2C), 124.0, 99.4, 28.8, 15.2. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_{11}H_{10}ClNO$, $[M+H]^+$ 208.0524; found 208.0523.



2k

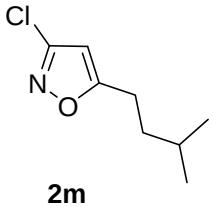
3-Chloro-5-(4-methoxyphenyl)isoxazole (2k). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (4-methoxyphenyl)-ethyne (**7q**) (98 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 °C for 47 min, the crude product was purified by a column chromatography [silica gel, 4% EtOAc in petroleum ether (60–90 °C)] to give product **2k** as a white solid (100 mg, 95%), mp 65−66 °C. IR ν 3136, 2966, 2837, 1614, 1508, 1435 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, J = 8.7 Hz, 2H), 6.98

(d, J = 8.7 Hz, 2H), 6.40 (s, 1H), 3.86 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 171.6, 161.6, 153.7, 127.4 (2C), 119.2, 114.5 (2C), 98.6, 55.4. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_{10}H_8ClNO_2$, $[M+H]^+$ 210.0316; found 210.0310.



2l

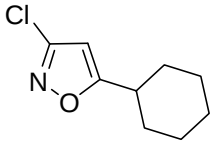
3-Chloro-5-(4-nitrophenyl)isoxazole (2l). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) (4-nitrophenyl)ethyne (**7r**) (105 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 ^{o}C for 33 min, the crude product was purified by a column chromatography [silica gel, 7% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **2l** as a yellowish solid (93 mg, 83%), mp 212−214 ^{o}C (Lit.[3] 213−214 ^{o}C). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (d, J = 8.7 Hz, 2H), 7.95 (d, J = 8.7 Hz, 2H), 6.73 (s, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 169.0, 154.3, 148.9, 131.8, 126.7 (2C), 124.5 (2C), 102.7.



2m

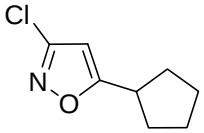
3-Chloro-5-isopentylisoxazole (2m). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I)-5-methyl-hex-1-yne (**7k**) (80 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 ^{o}C for 12 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **2m** as a yellowish oil (70 mg, 81%). IR ν 2960, 2932, 1592, 1447 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.02 (s, 1H), 2.74 (t, J = 7.4 Hz, 2H), 1.64−1.57 (m, 3H), 0.94 (d, J = 6.0 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.1, 153.1, 101.6, 36.0, 27.4, 25.0,

22.1 (2C). HRMS (ESI-TOF) (*m/z*): Calcd. for $C_8H_{12}ClNO$, $[M+H]^+$ 174.0679; found 174.0680.



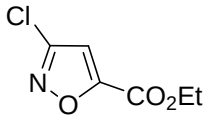
2n

3-Chloro-5-cyclohexylisoxazole (2n). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) cyclohexylethyne (**7m**) (86 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) was stirred at 45 °C for 30 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 °C)] to give product **2n** as a colorless oil (86 mg, 93%). IR ν 2933, 2857, 1585, 1448 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 5.98 (s, 1H), 2.82−2.76 (m, 1H), 2.08−2.02 (m, 2H), 1.89−1.74 (m, 3H), 1.51−1.36 (m, 4H), 1.37−1.25 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 179.9, 153.0, 100.1, 36.5, 30.8 (2C), 25.6, 25.5 (2C). HRMS (ESI-TOF) (*m/z*): Calcd. for $C_9H_{12}ClNO$, $[M+H]^+$ 186.0680; found 186.0679.



2o

3-Chloro-5-cyclopentylisoxazole (2o). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) cyclopentylethyne (**7n**) (79 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) at 45 °C for 10 min, the crude product was purified by a column chromatography [silica gel, 2% EtOAc in petroleum ether (60–90 °C)] to give product **2o** as a yellowish oil (69 mg, 80%). IR ν 2962, 2873, 1587, 1446 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 6.00 (s, 1H), 3.22−3.14 (m, 1H), 2.12−2.04 (m, 2H), 1.78−1.63 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 179.7, 152.9, 100.4, 37.7, 31.6 (2C), 25.2 (2C). HRMS (ESI-TOF) (*m/z*): Calcd. for $C_8H_{10}ClNO$, $[M+H]^+$ 172.0524; found 172.0524.

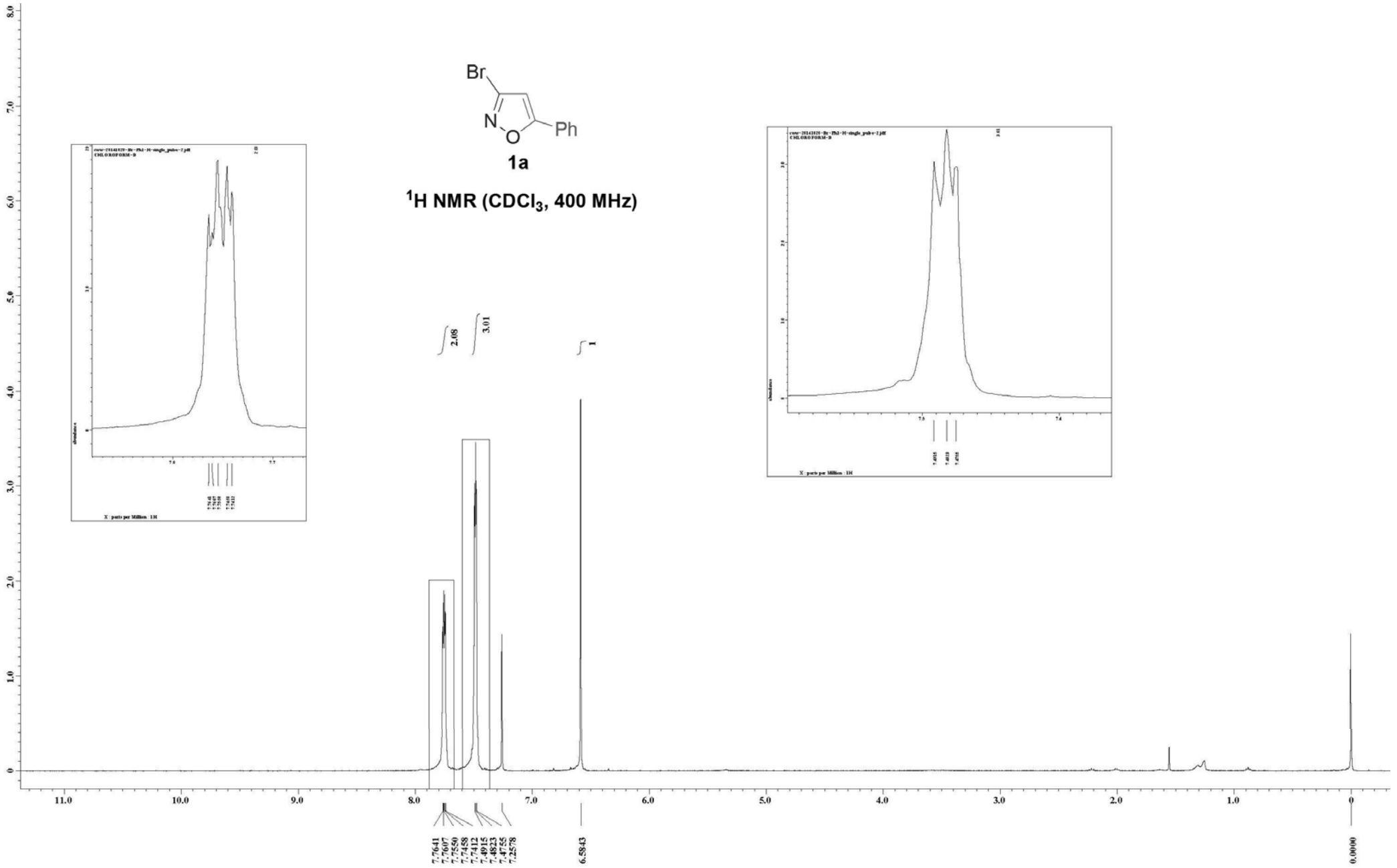


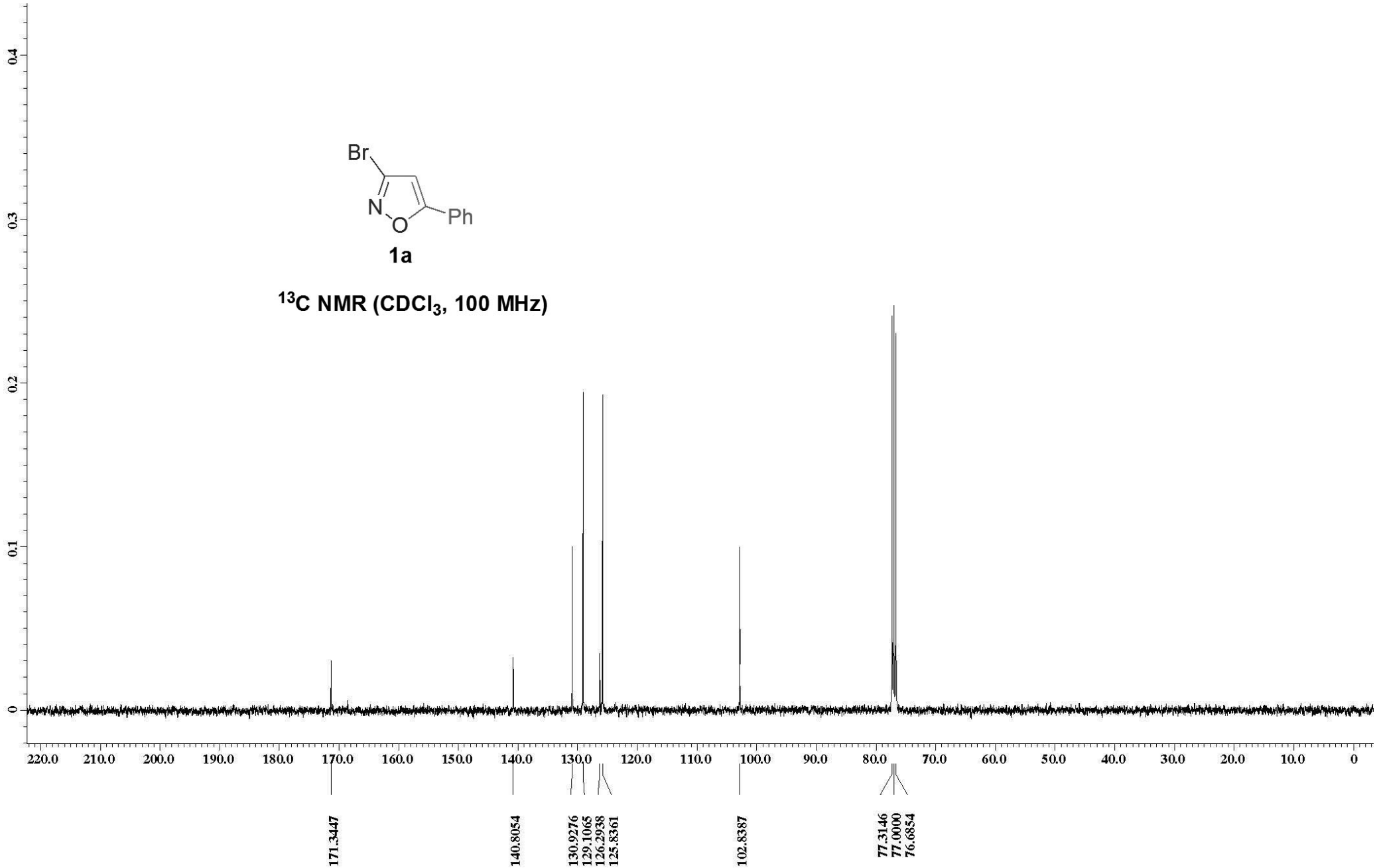
2p

Ethyl 3-chloroisoxazole-5-carboxylate (2p). The title compound was prepared by the same procedure as **2a**. After a suspension of 1-copper(I) ethyl propiolate (**7s**) (81 mg, 0.5 mmol) and dichloroformaldoxime (**4**) (68 mg, 0.6 mmol) in DMF (1.0 mL) at 45 ^{o}C for 34 min, the crude product was purified by a column chromatography [silica gel, 4% EtOAc in petroleum ether (60–90 ^{o}C)] to give product **2p** as a yellowish oil (55 mg, 63%). IR ν 2988, 1745, 1581, 1366 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.94 (s, 1H), 4.44 (q, J = 6.9 Hz, 2H), 1.42 (t, J = 6.9 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 161.7, 155.8, 153.8, 109.7, 62.7, 14.1. HRMS (ESI-TOF) (*m/z*): Calcd. for $C_6H_6ClNO_3$, $[M+H]^+$ 176.0109; found 176.0106.

References

1. Orth, R.; Bottcher, T.; Sieber, S. A. *Chem. Commun.* **2010**, *46*, 8475−8477.
2. (a) Jouvin, K.; Heimburger, J.; Evano, G. *Chem. Sci.* **2012**, *3*, 756−760. (b) Woon, E. C. Y.; Dhami, A.; Mahon, M. F.; Threadgill, M. D. *Tetrahedron* **2006**, *62*, 4829–4837; (c) Owsley, D. C.; Castro, C. E. *Org. Synth.* **1972**, *52*, 128–130.
3. Carr, J. B.; Durham, H. G.; Hass, D. K. *J. Med. Chem.* **1977**, *20*, 934−939.
4. Amici, M. D.; Micheli, C. D.; Carrea, G.; Spezia, S. *J. Org. Chem.* **1989**, *54*, 2646−2650.


Br
N
O
Ph
1a
1H NMR (CDCl3, 400 MHz)
2.08
3.01
1
7.7641
7.7607
7.7550
7.7458
7.7412
7.4915
7.4823
7.4755
7.2578
6.5843
0.0000


Br
N
O
Ph
1a
13C NMR (CDCl3, 100 MHz)
0.4
0.3
0.2
0.1
0
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0
171.3447
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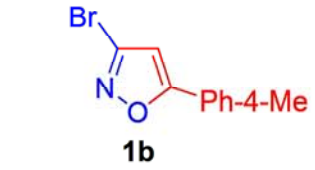
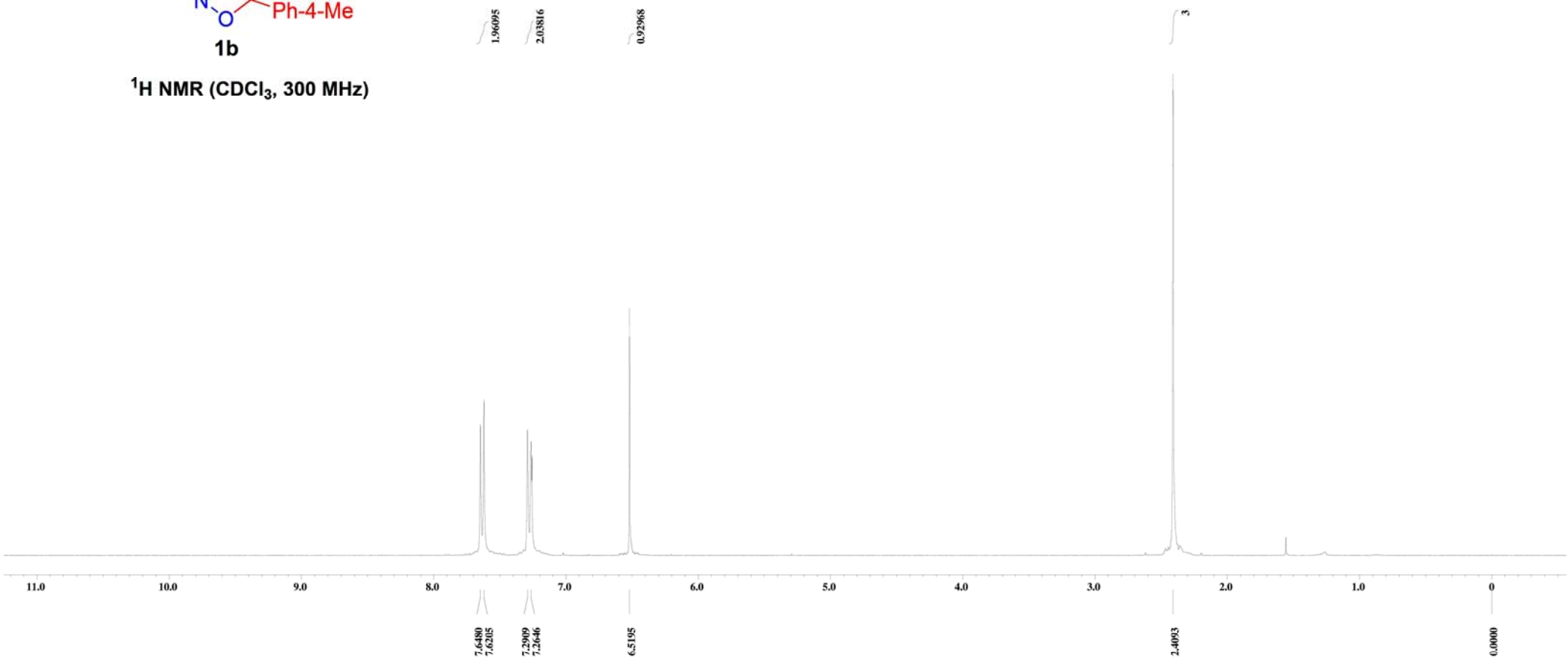
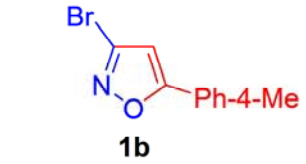
130.9276
129.1065
126.2938
125.8361
102.8387
77.3146
77.0000
76.6854



1b

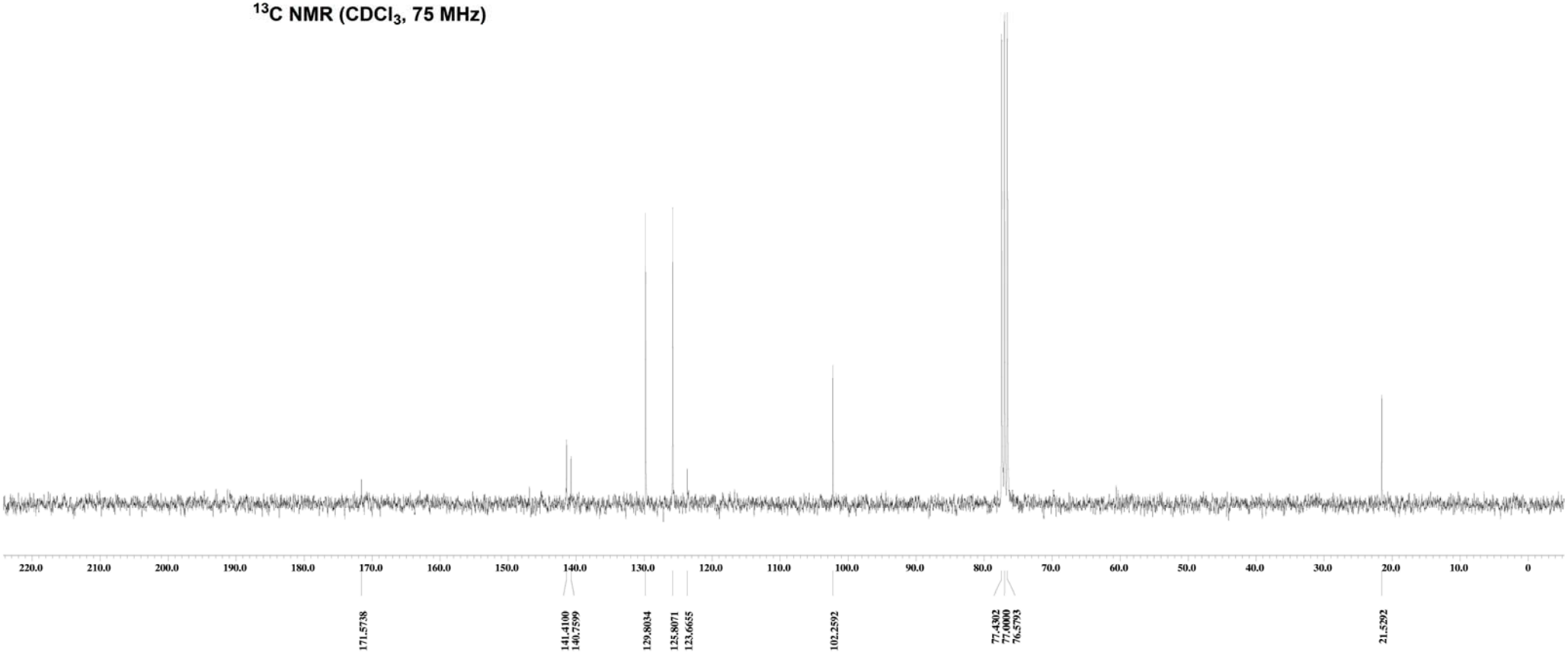
^{1}H NMR ($CDCl_3$, 300 MHz)

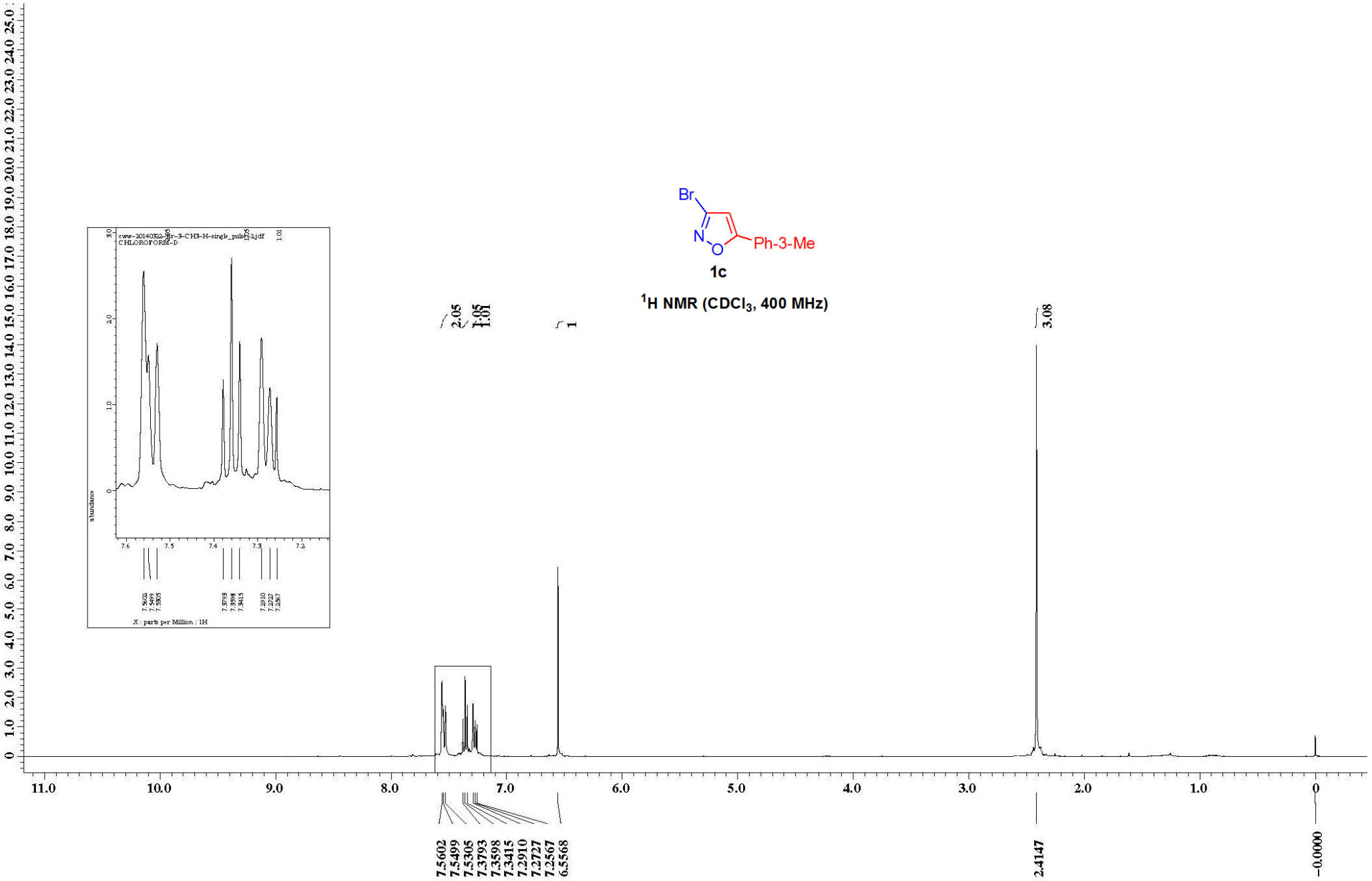


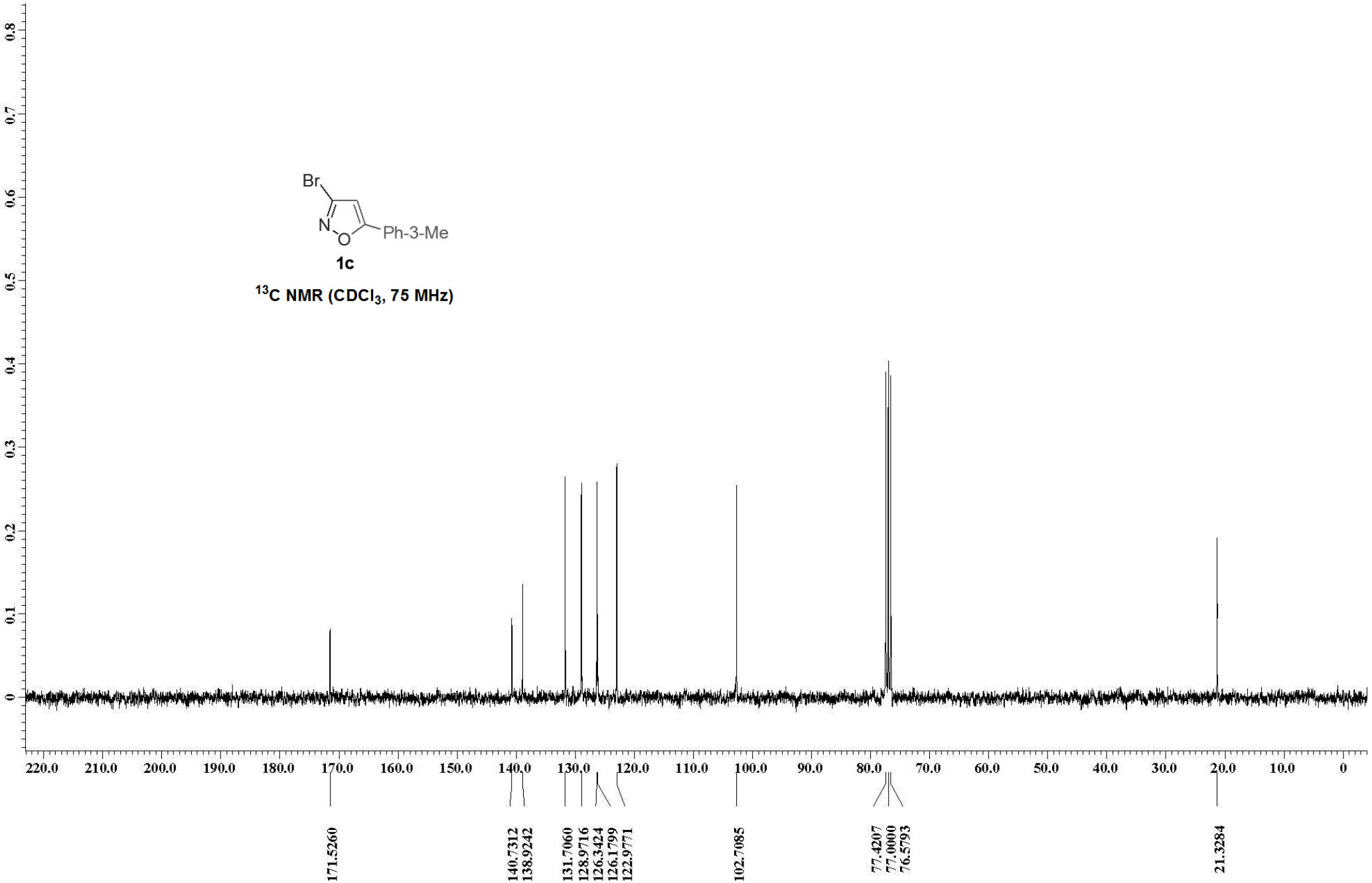


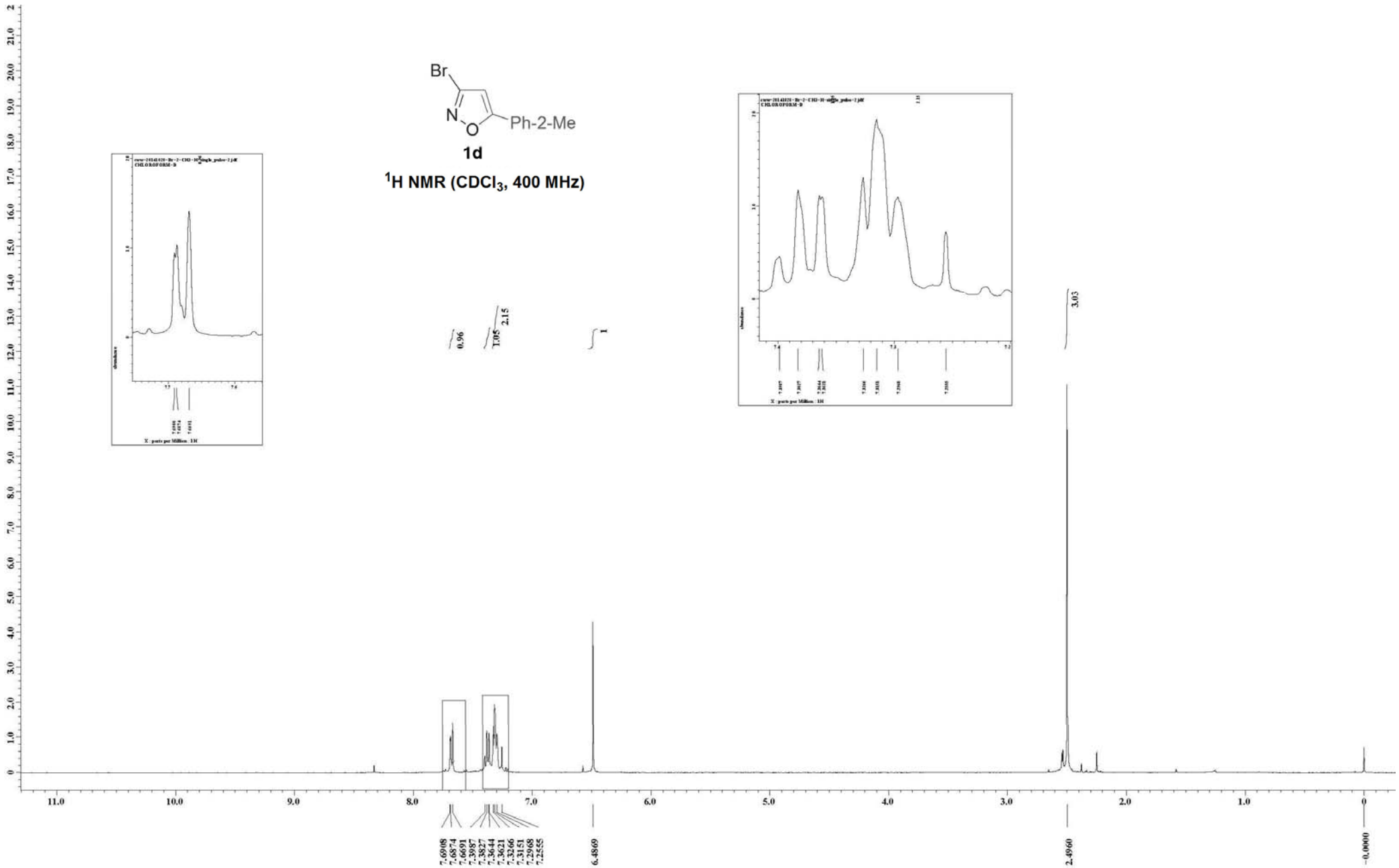
1b

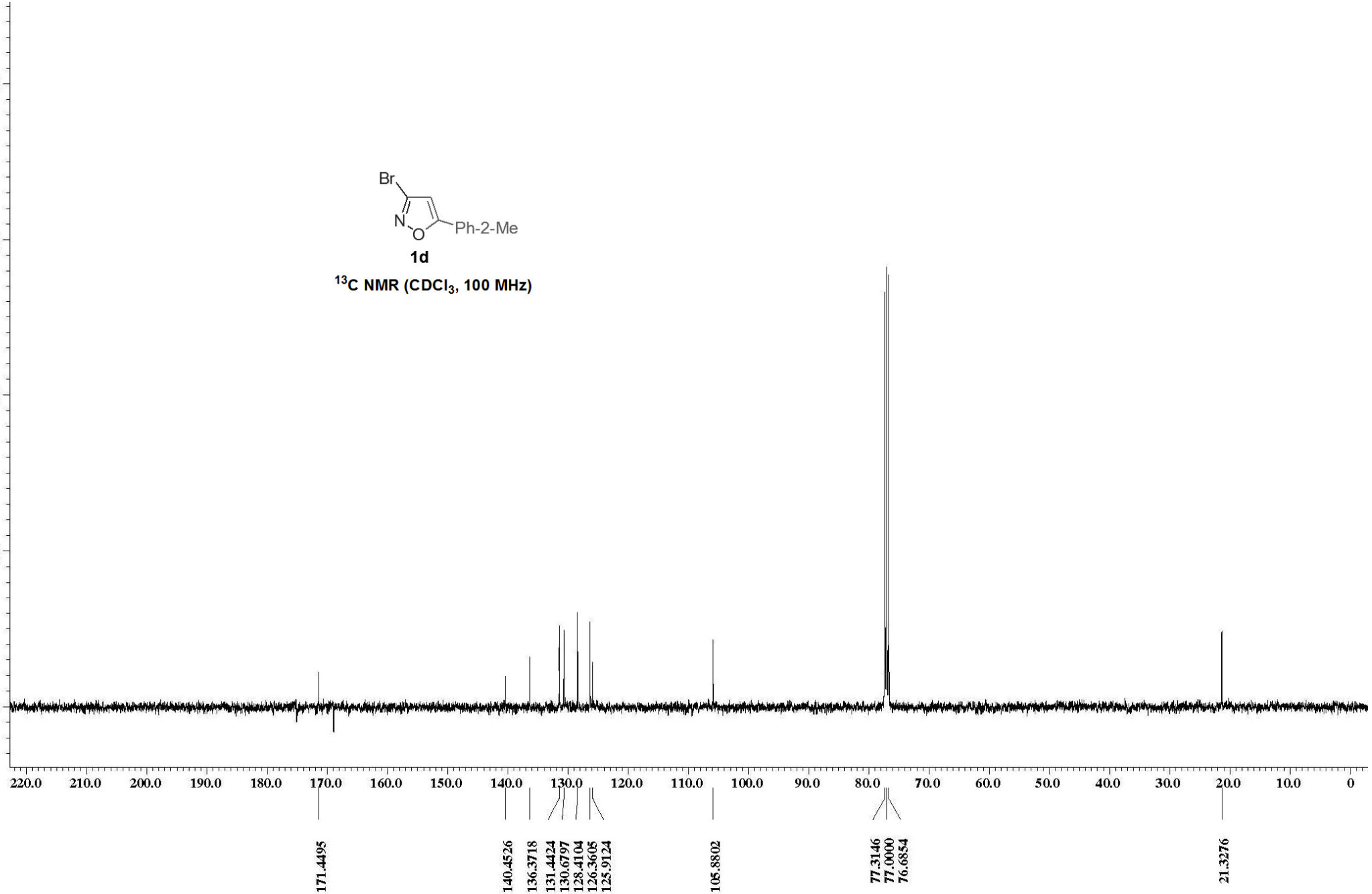
^{13}C NMR ($CDCl_3$, 75 MHz)




Br
N
O
Ph-3-Me
1c
^{1}H NMR ($CDCl_3$, 400 MHz)
2.05
1.05
1.01
1
3.08
7.5602
7.5499
7.5305
7.3793
7.3598
7.3415
7.2910
7.2727
7.2567
6.5568
2.4147
-0.0000
CHLOROFORM-D
X : parts per Million : 1H


Br
N
O
Ph-3-Me
1c
13C NMR (CDCl3, 75 MHz)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
171.5260
140.7312
138.9242
131.7060
128.9716
126.3424
126.1799
122.9771
102.7085
77.4207
77.0000
76.5793
21.3284


Br
N
O
Ph-2-Me
1d
^{1}H NMR ($CDCl_3$, 400 MHz)
0.96
1.05
2.15
1
3.03
7.6908
7.6874
7.6691
7.3087
7.3827
7.3644
7.3621
7.3266
7.3151
7.2968
7.2555
6.4869
2.4960
-0.0000


Br
N
O
Ph-2-Me
1d
^{13}C NMR ($CDCl_3$, 100 MHz)
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
171.4495
140.4526
136.3718
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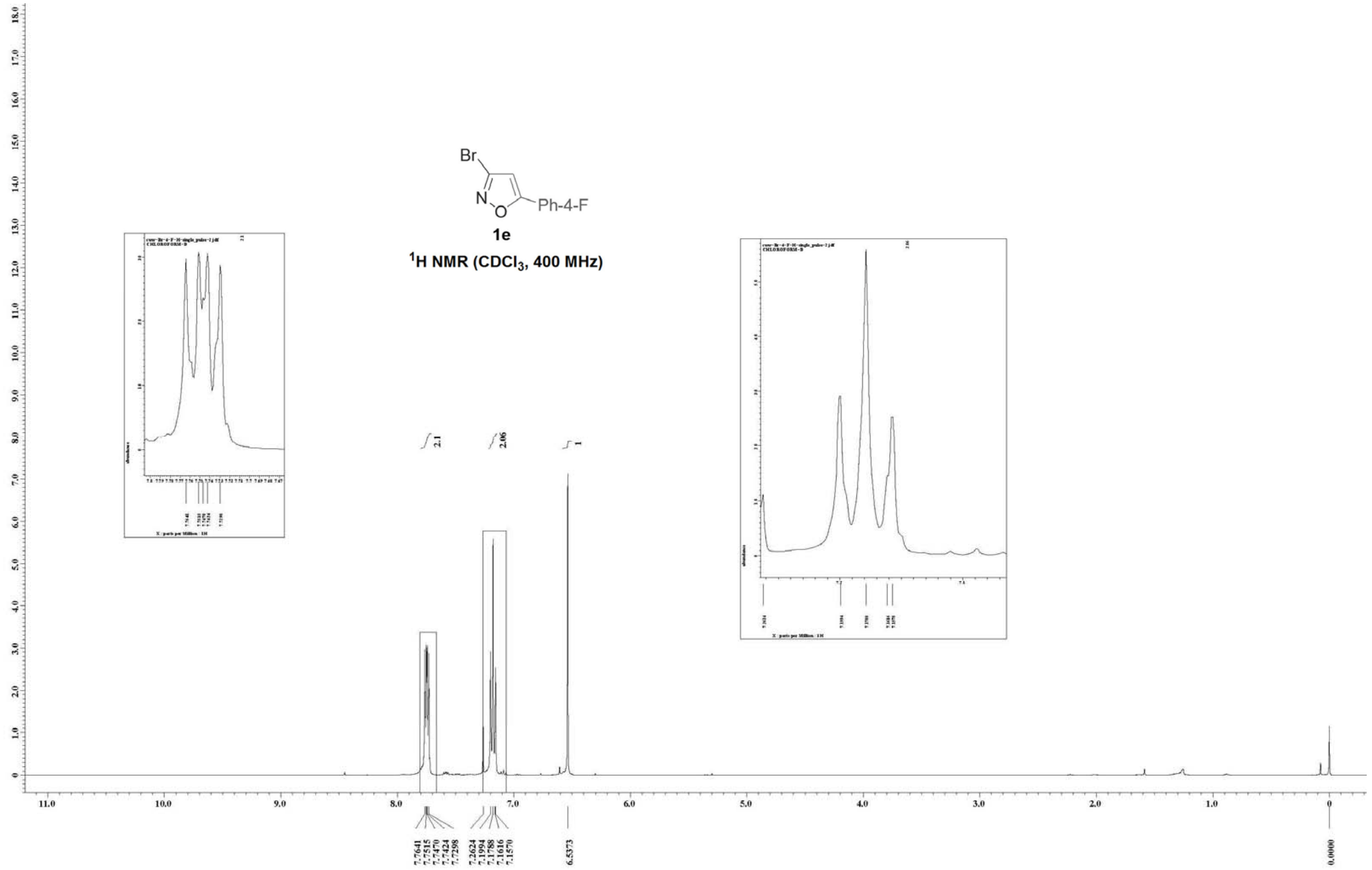
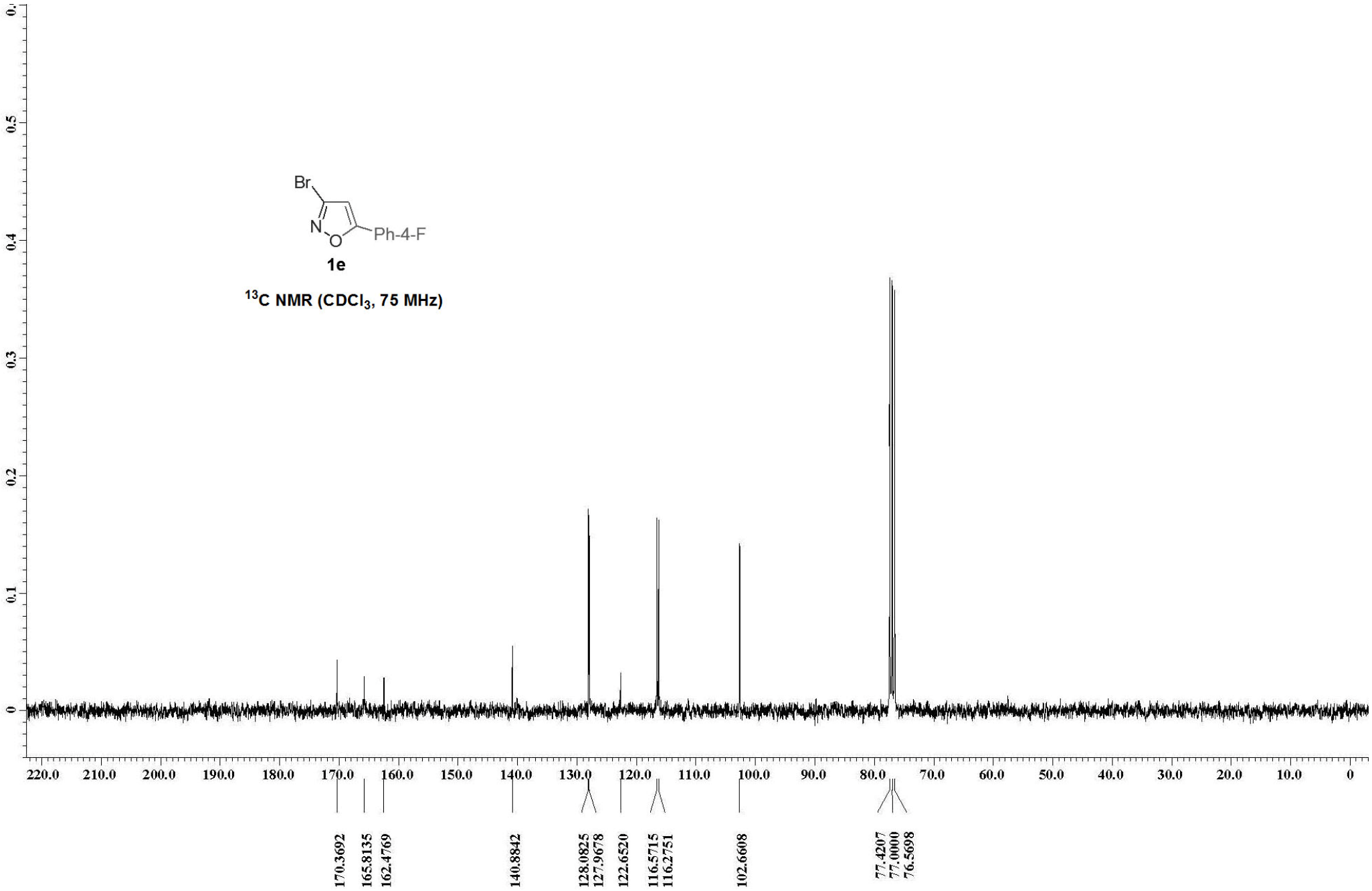
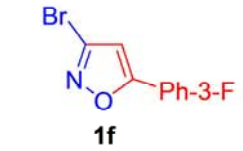
105.8802
77.3146
77.0000
76.6854
21.3276

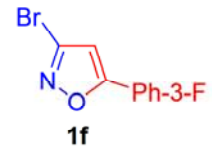

Br
N
O
Ph-4-F
1e
1H NMR (CDCl3, 400 MHz)
2.1
2.06
1
7.7641
7.7515
7.7470
7.7424
7.7298
7.2624
7.1994
7.1788
7.1616
7.1570
6.5373
0.0000


Br
N
O
Ph-4-F
1e
13C NMR (CDCl3, 75 MHz)
0.5
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
170.3692
165.8135
162.4769
140.8842
128.0825
127.9678
122.6520
116.5715
116.2751
102.6608
77.4207
77.0000
76.5698



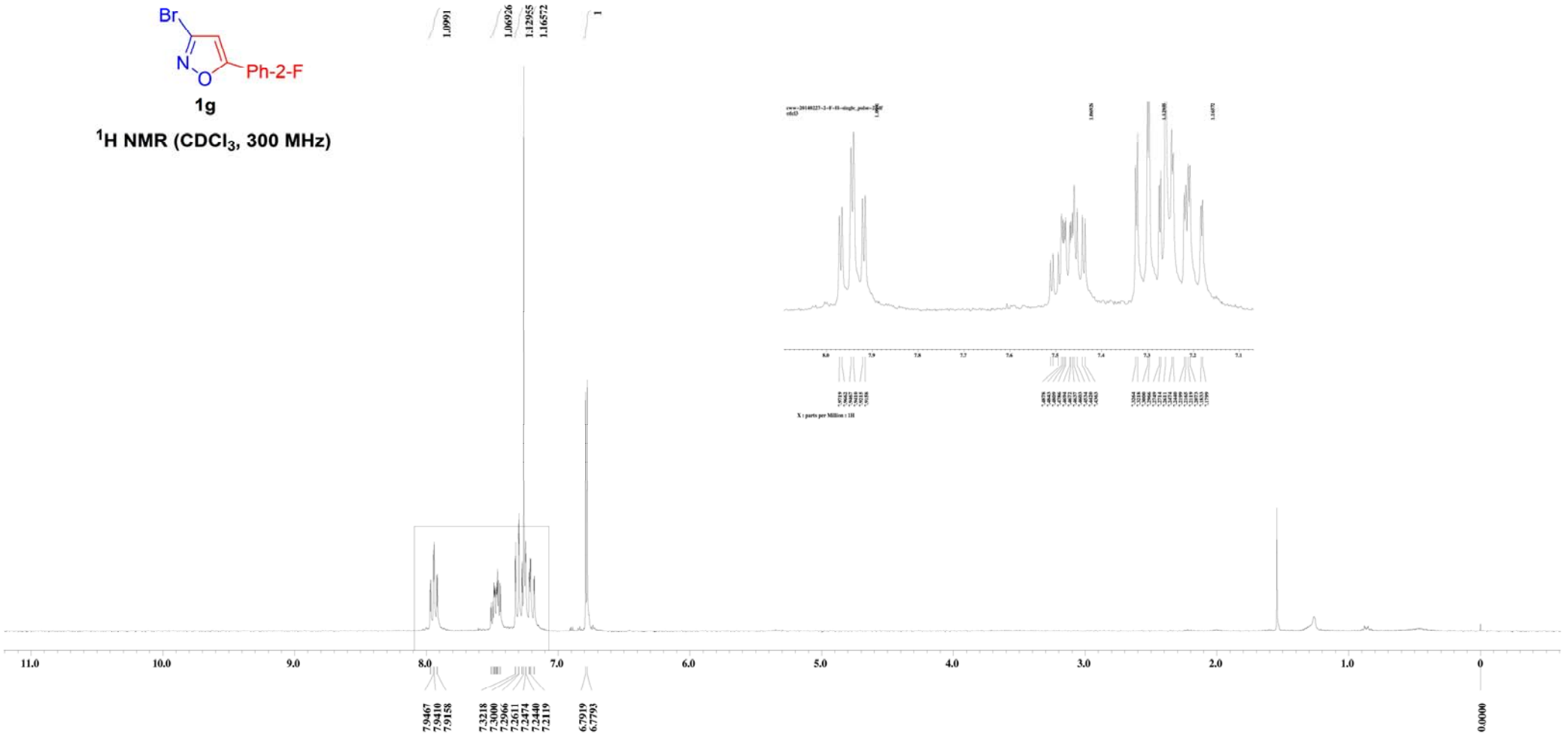
1f

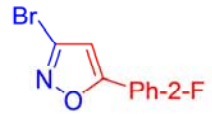
^{1}H NMR ($CDCl_3$, 300 MHz)



1f

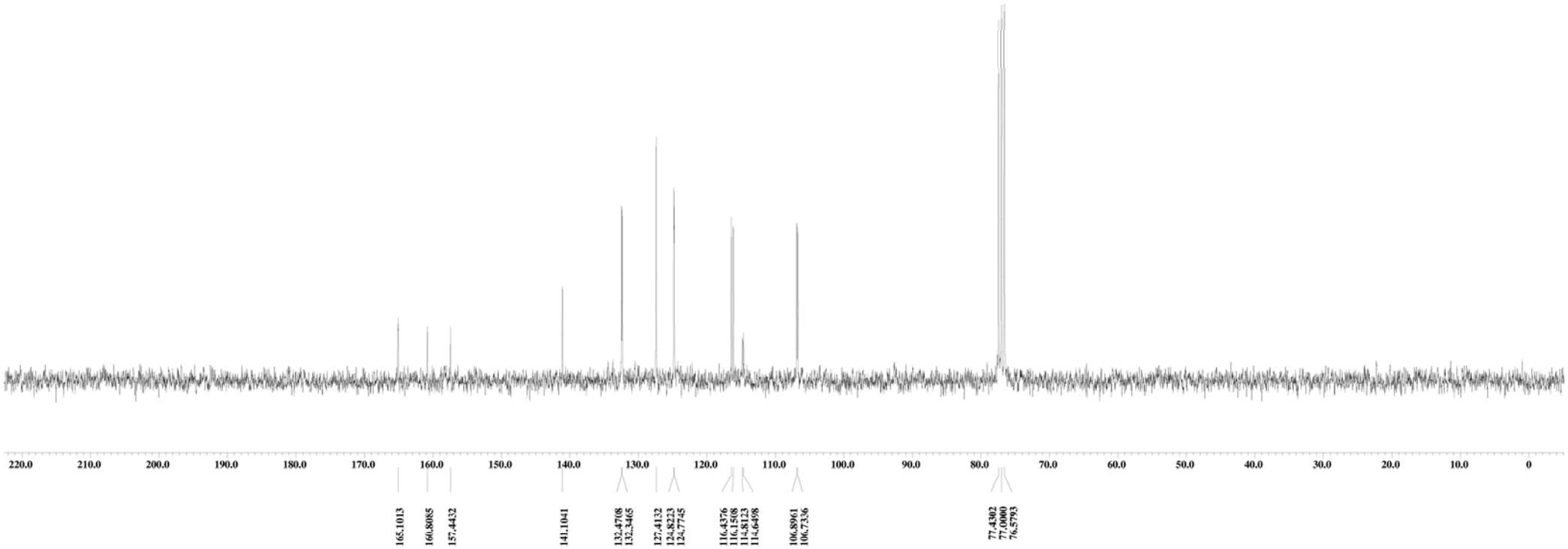
^{13}C NMR ($CDCl_3$, 75 MHz)

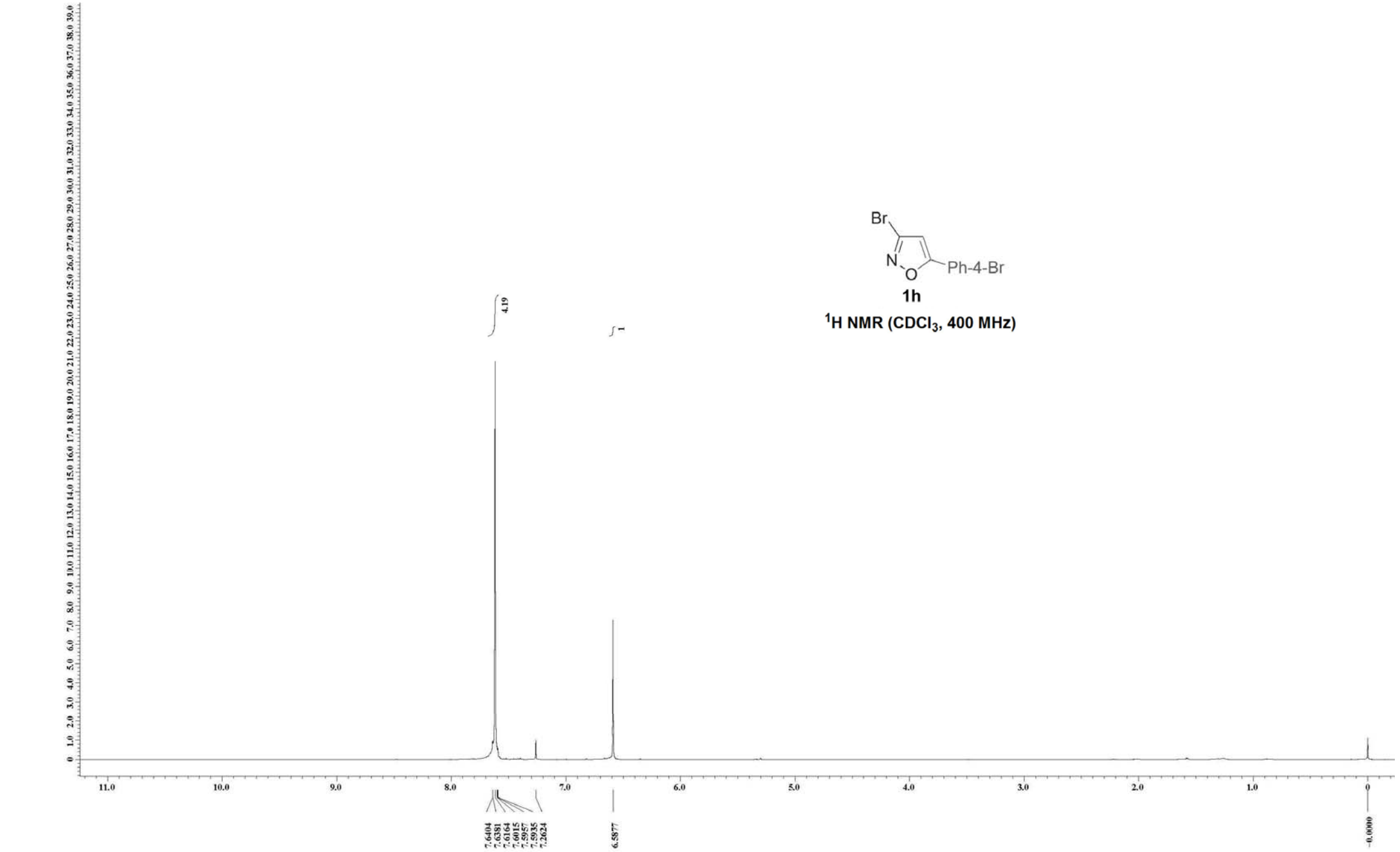

Br
N
O
Ph-2-F
1g
1H NMR (CDCl3, 300 MHz)
1.0991
1.06926
1.12955
1.16572
1
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.9467
7.9410
7.9158
7.3218
7.3000
7.2966
7.2611
7.2474
7.2440
7.2119
6.7919
6.7793
0.0000

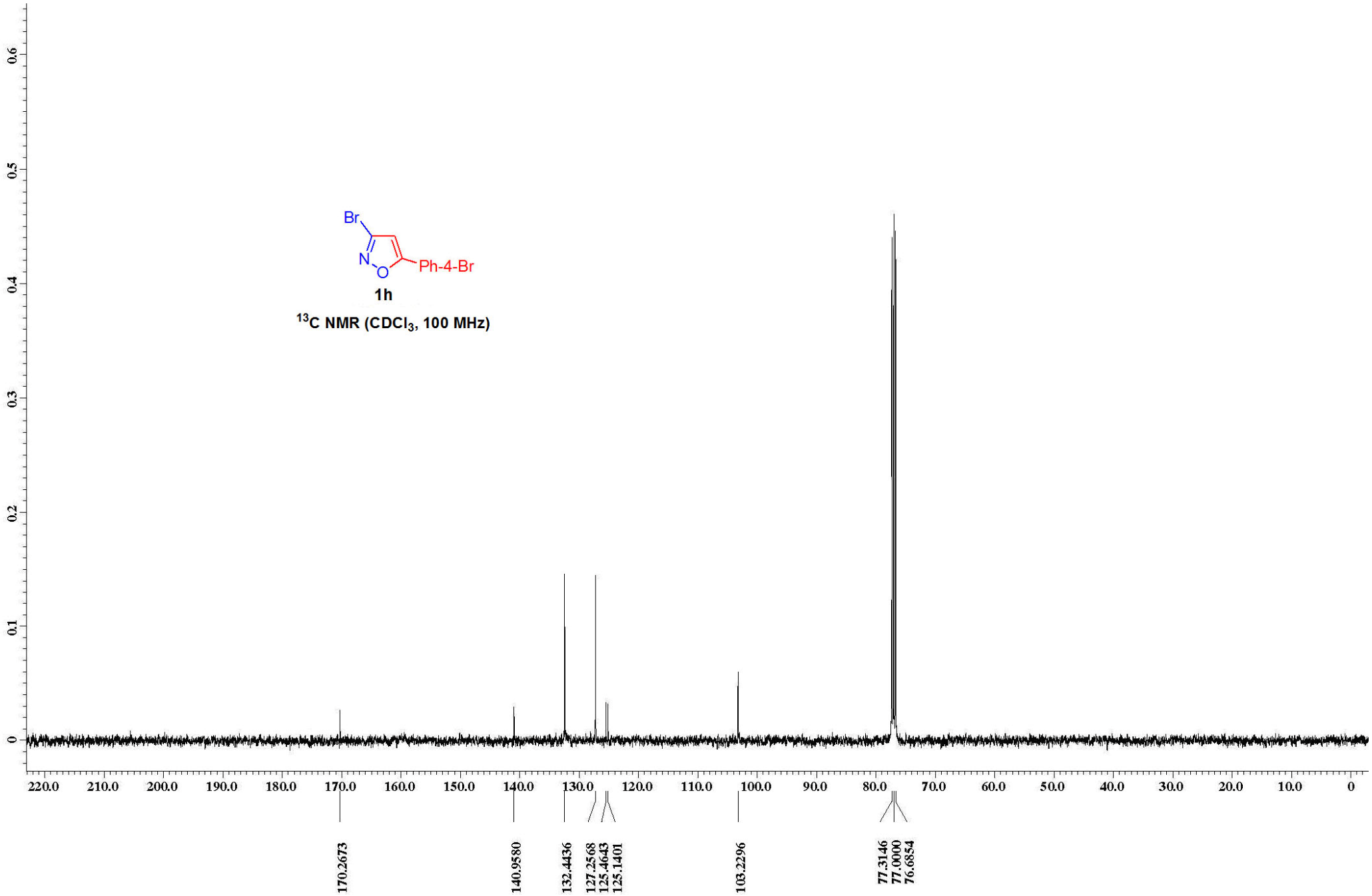


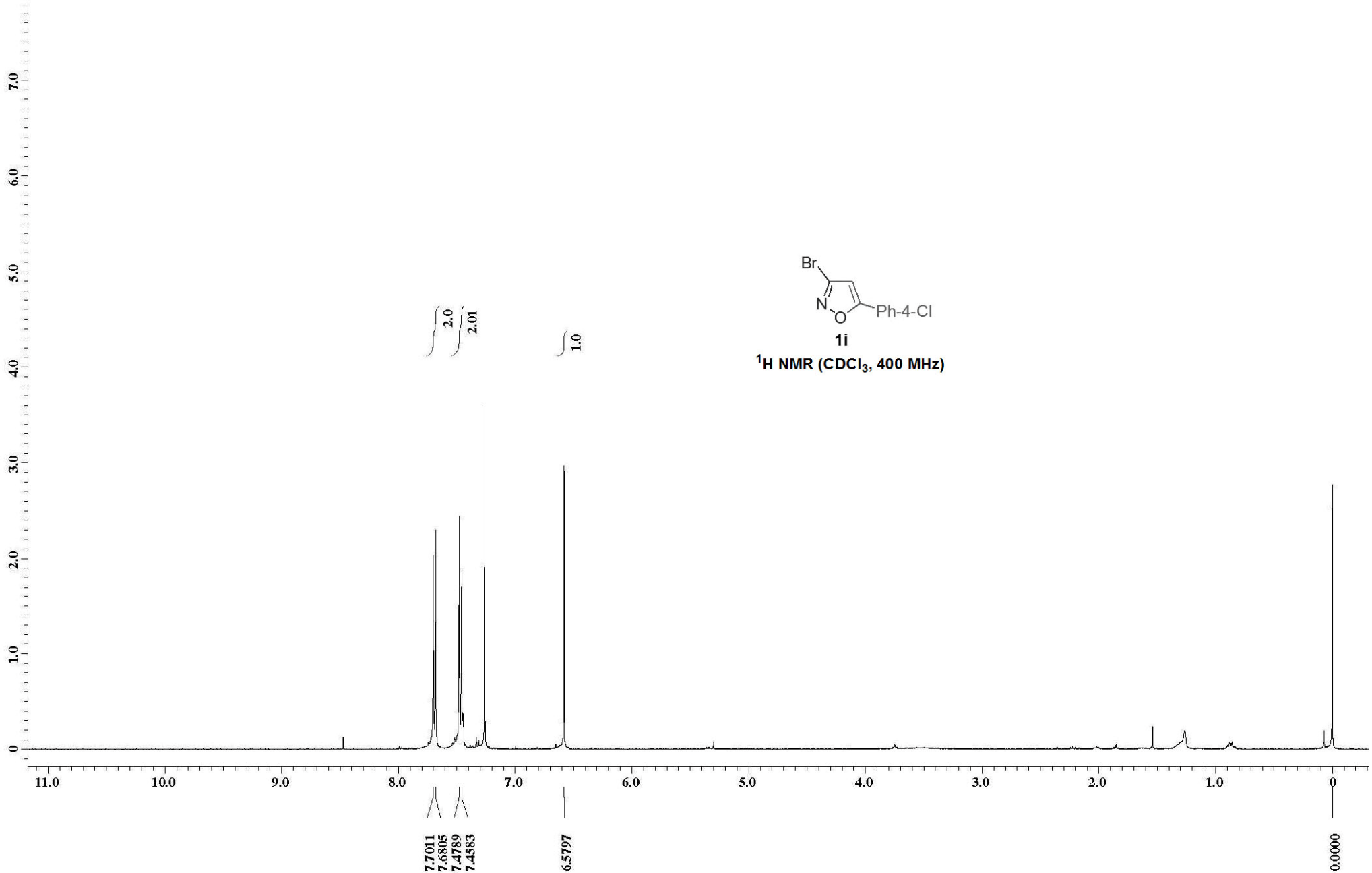
1g

^{13}C NMR ($CDCl_3$, 75 MHz)




Br
N
O
Ph-4-Br
1h
1H NMR (CDCl3, 400 MHz)
4.19
1
7.6404
7.6381
7.6164
7.6015
7.5957
7.5935
7.2624
6.5877
0.0000


Br
N
O
Ph-4-Br
1h
^{13}C NMR ($CDCl_3$, 100 MHz)
0.6
0.5
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
170.2673
140.9580
132.4436
127.2568
125.4643
125.1401
103.2296
77.3146
77.0000
76.6854


Br
N
O
Ph-4-Cl
1i
^{1}H NMR ($CDCl_3$, 400 MHz)
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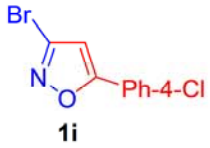
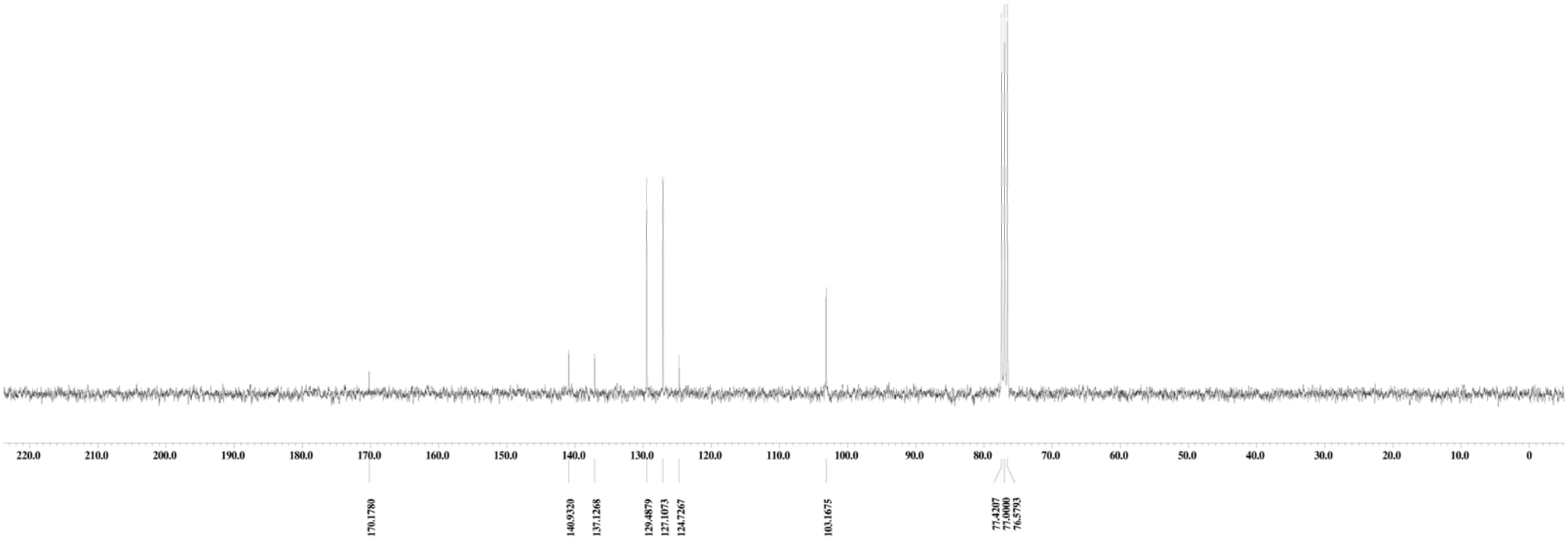
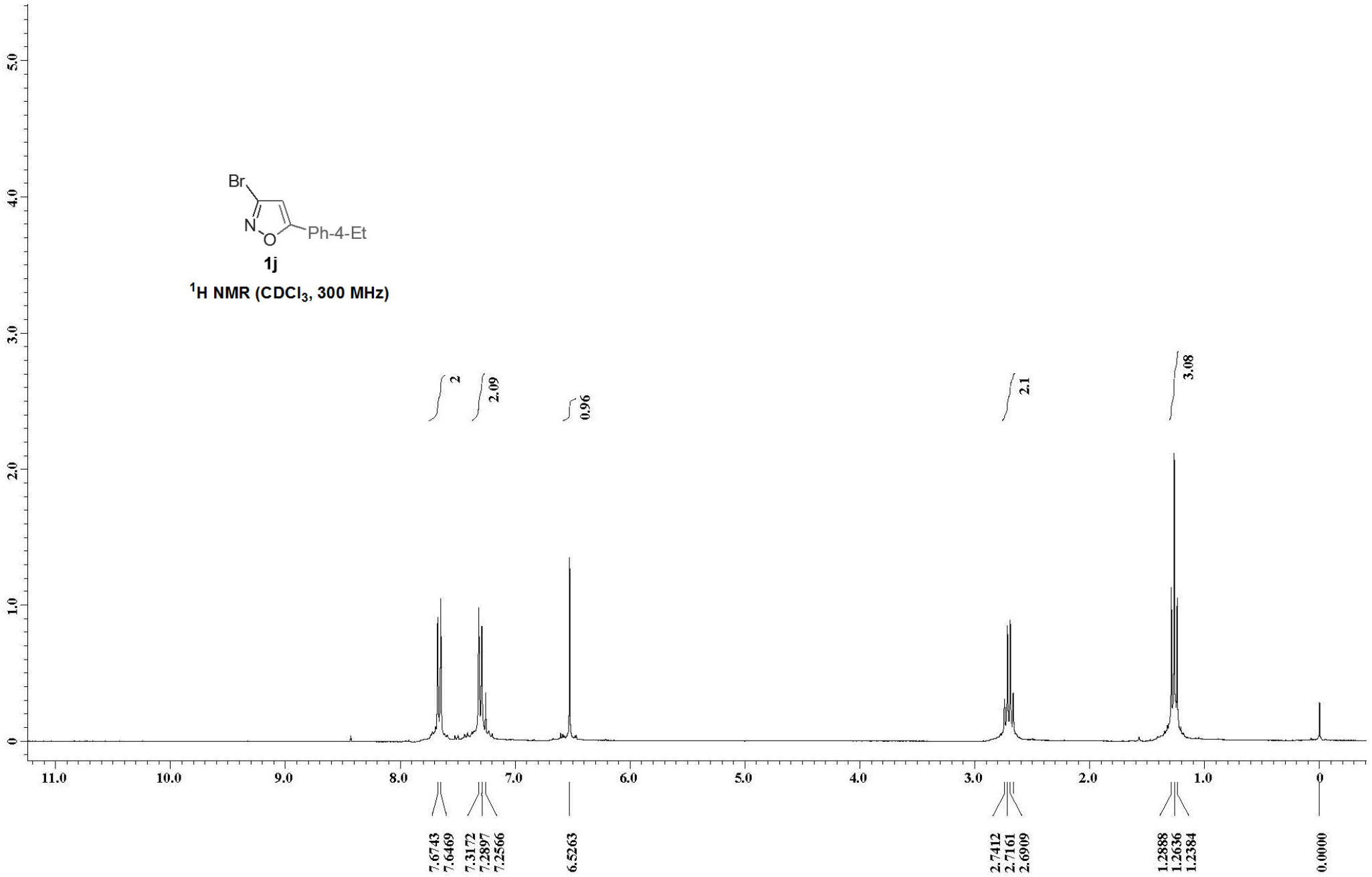
2.01
1.0
7.7011
7.6805
7.4789
7.4583
6.5797
0.0000

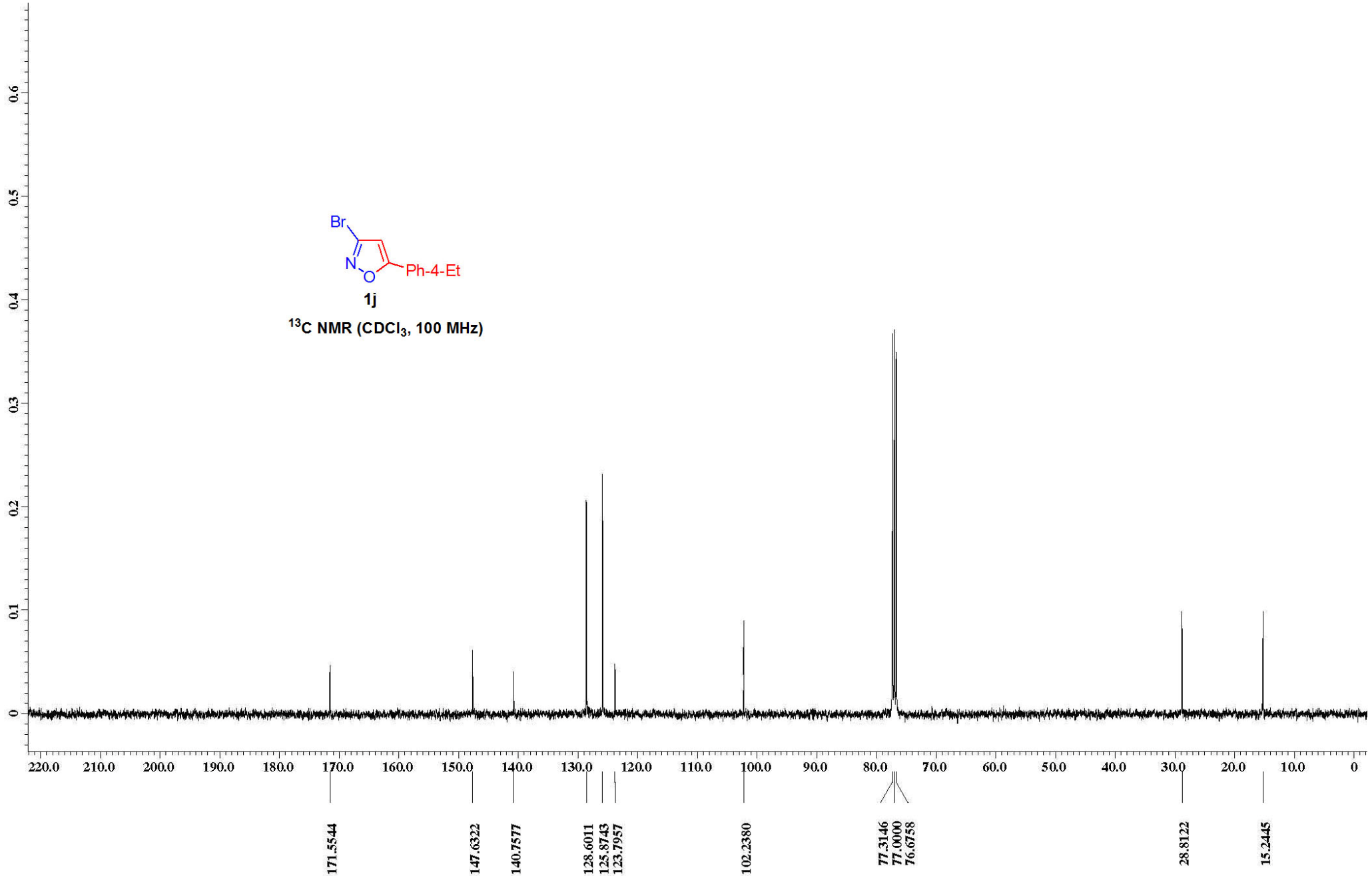


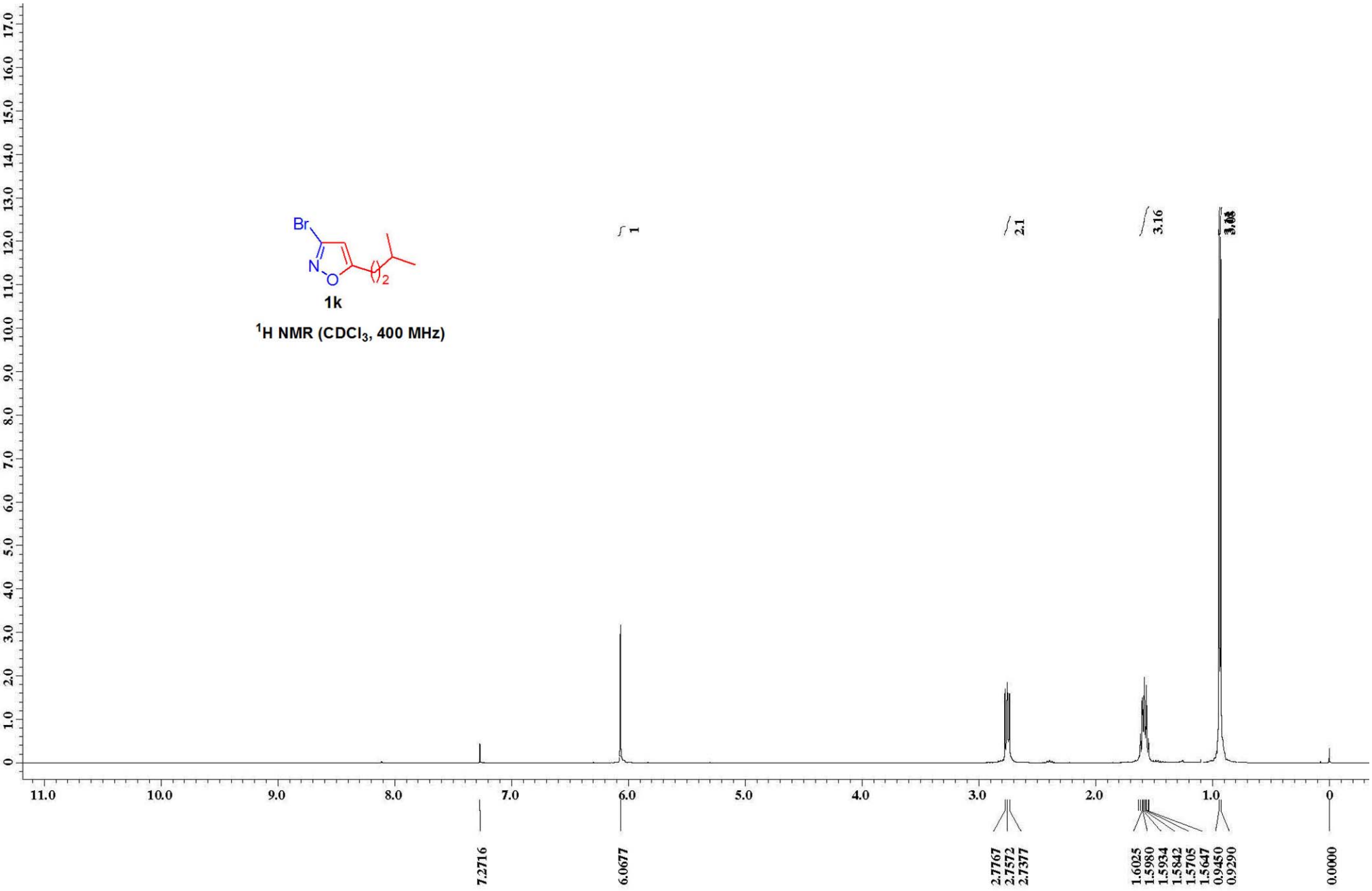
1i

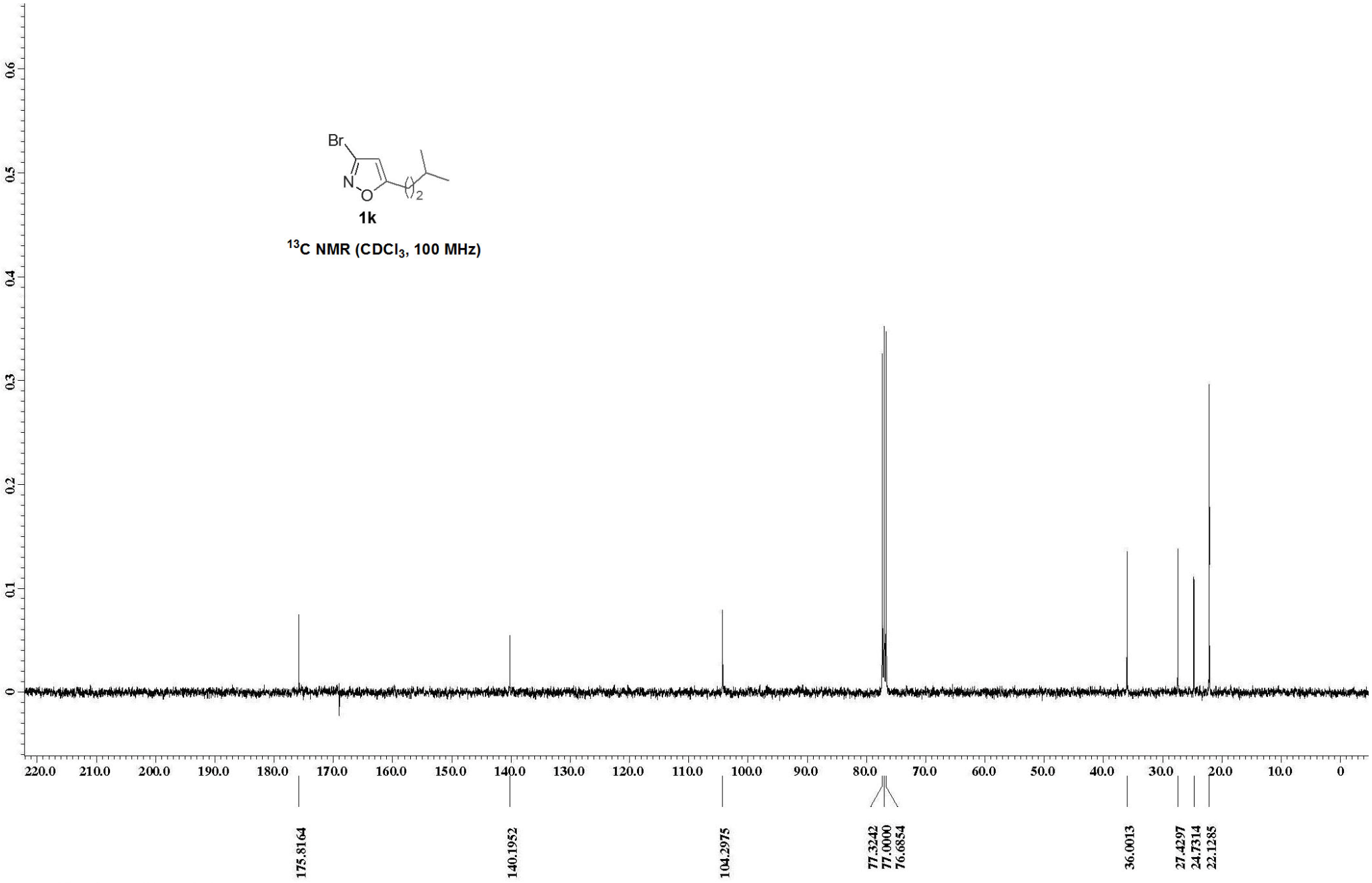
^{13}C NMR ($CDCl_3$, 75 MHz)

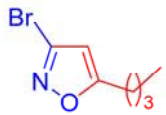



Br
N
O
Ph-4-Et
1j
^{1}H NMR ($CDCl_3$, 300 MHz)
2
2.09
0.96
2.1
3.08
7.6743
7.6469
7.3172
7.2897
7.2566
6.5263
2.7412
2.7161
2.6909
1.2888
1.2636
1.2384
0.0000


Br
N
O
Ph-4-Et
1j
13C NMR (CDCl3, 100 MHz)
0.6
0.5
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
171.5544
147.6322
140.7577
128.6011
125.8743
123.7957
102.2380
77.3146
77.0000
76.6758
28.8122
15.2445


Br
N
O
2
1k
1H NMR (CDCl3, 400 MHz)
1
2.1
3.16
7.2716
6.0677
2.7767
2.7572
2.7377
1.6025
1.5980
1.5934
1.5842
1.5705
1.5647
0.9450
0.9290
0.0000


Br
N
O
1k
13C NMR (CDCl3, 100 MHz)
175.8164
140.1952
104.2975
77.3242
77.0000
76.6854
36.0013
27.4297
24.7314
22.1285

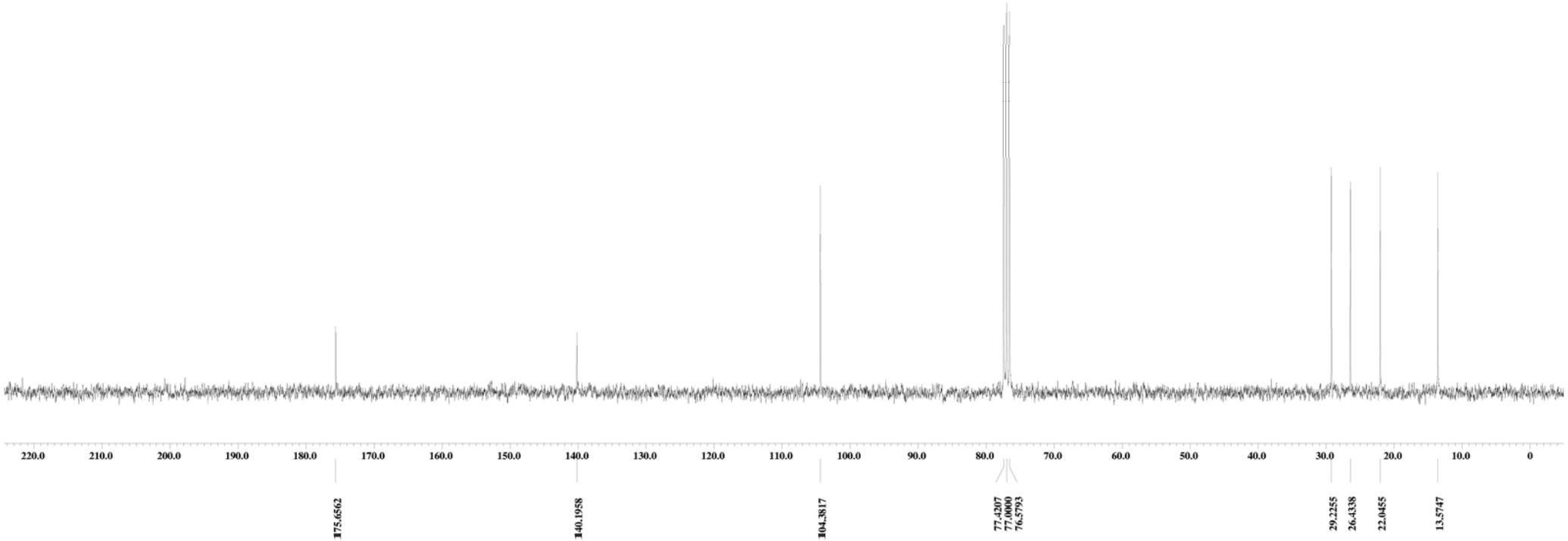


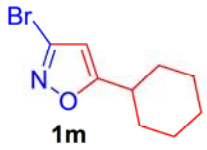
1l

^{1}H NMR ($CDCl_3$, 300 MHz)

1l

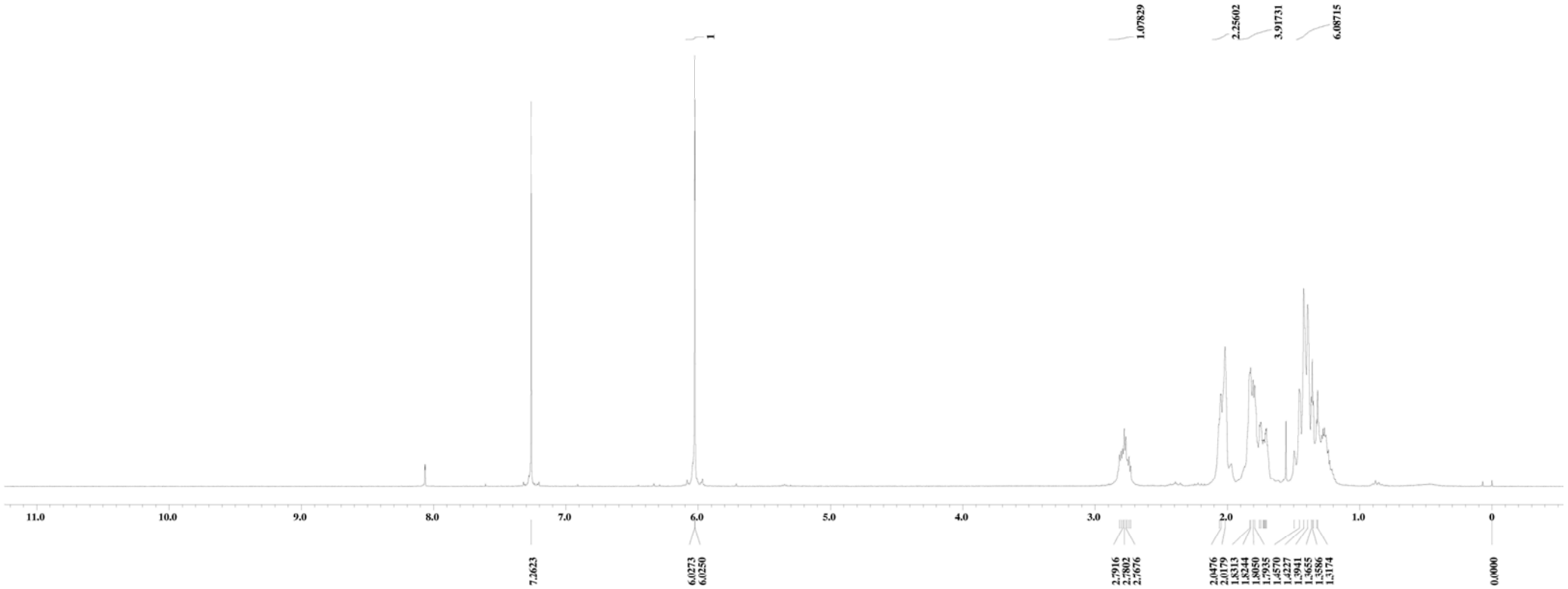
^{13}C NMR ($CDCl_3$, 75 MHz)





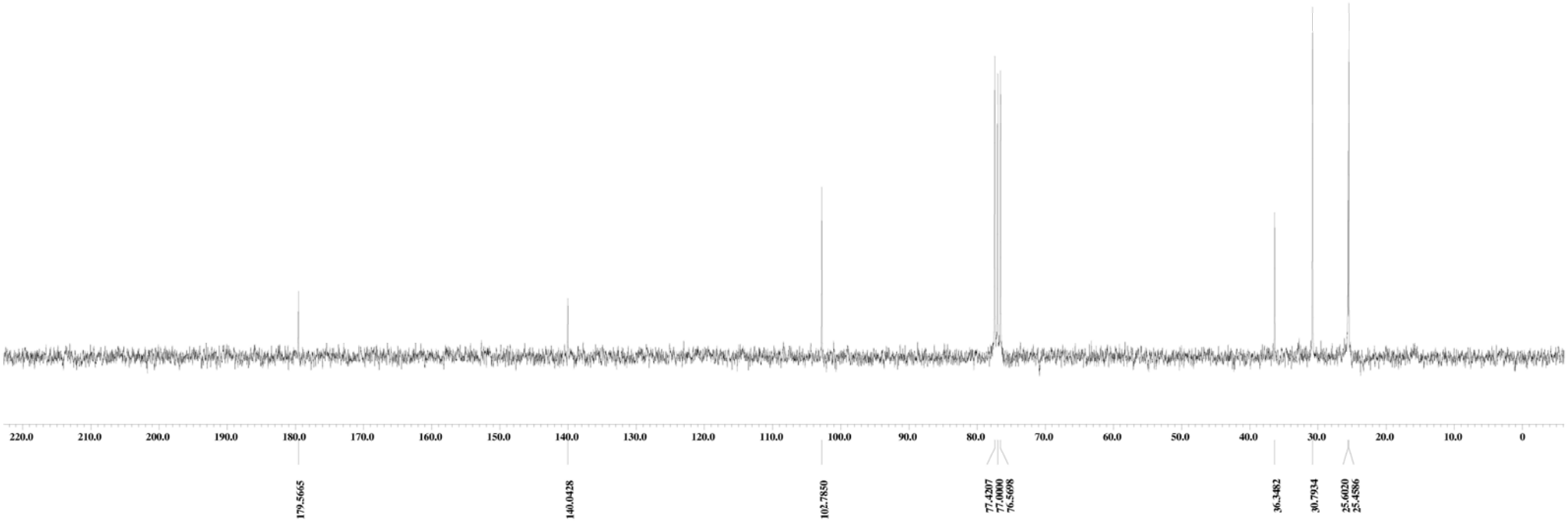
1m

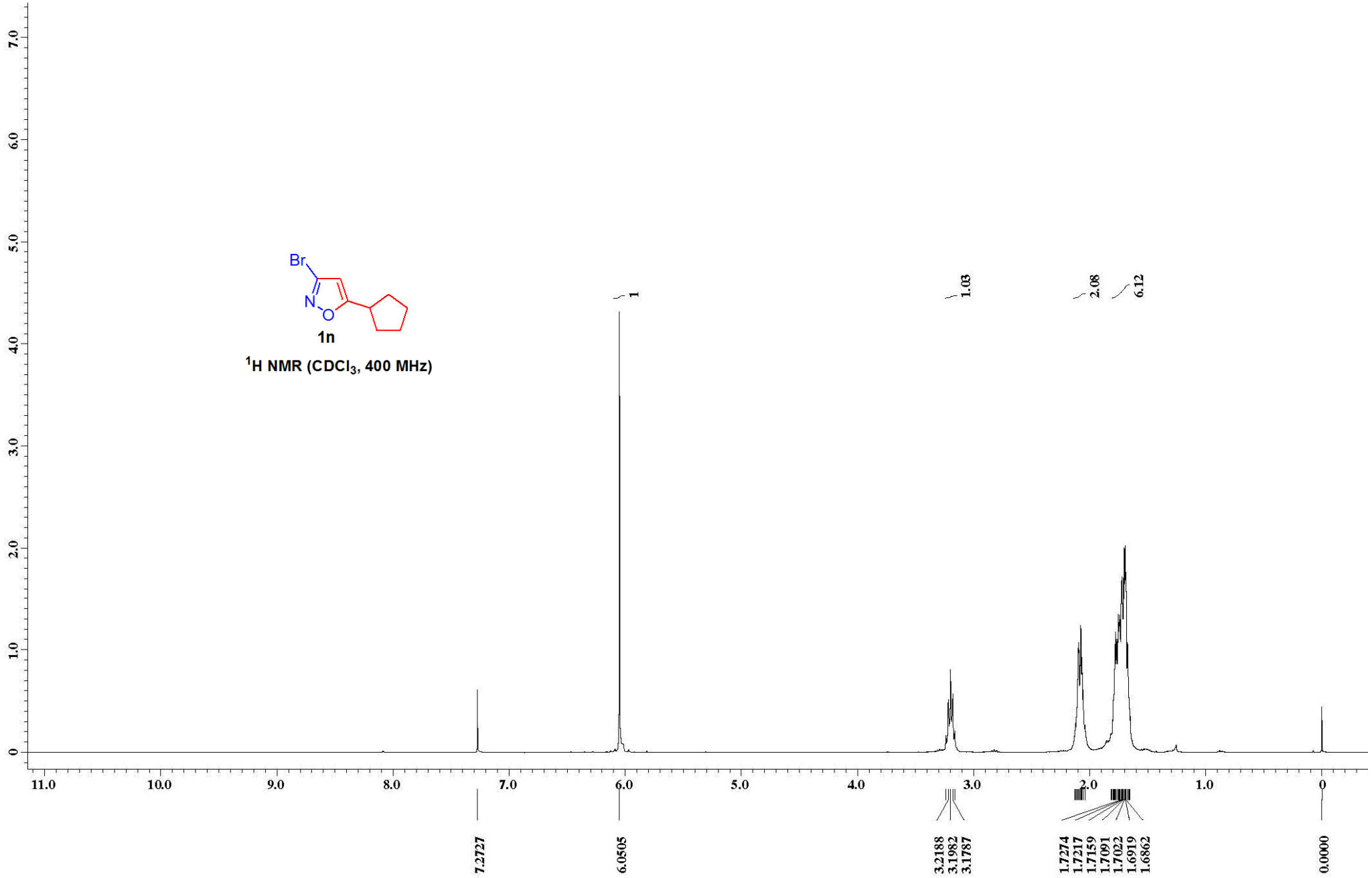
^{1}H NMR ($CDCl_3$, 300 MHz)

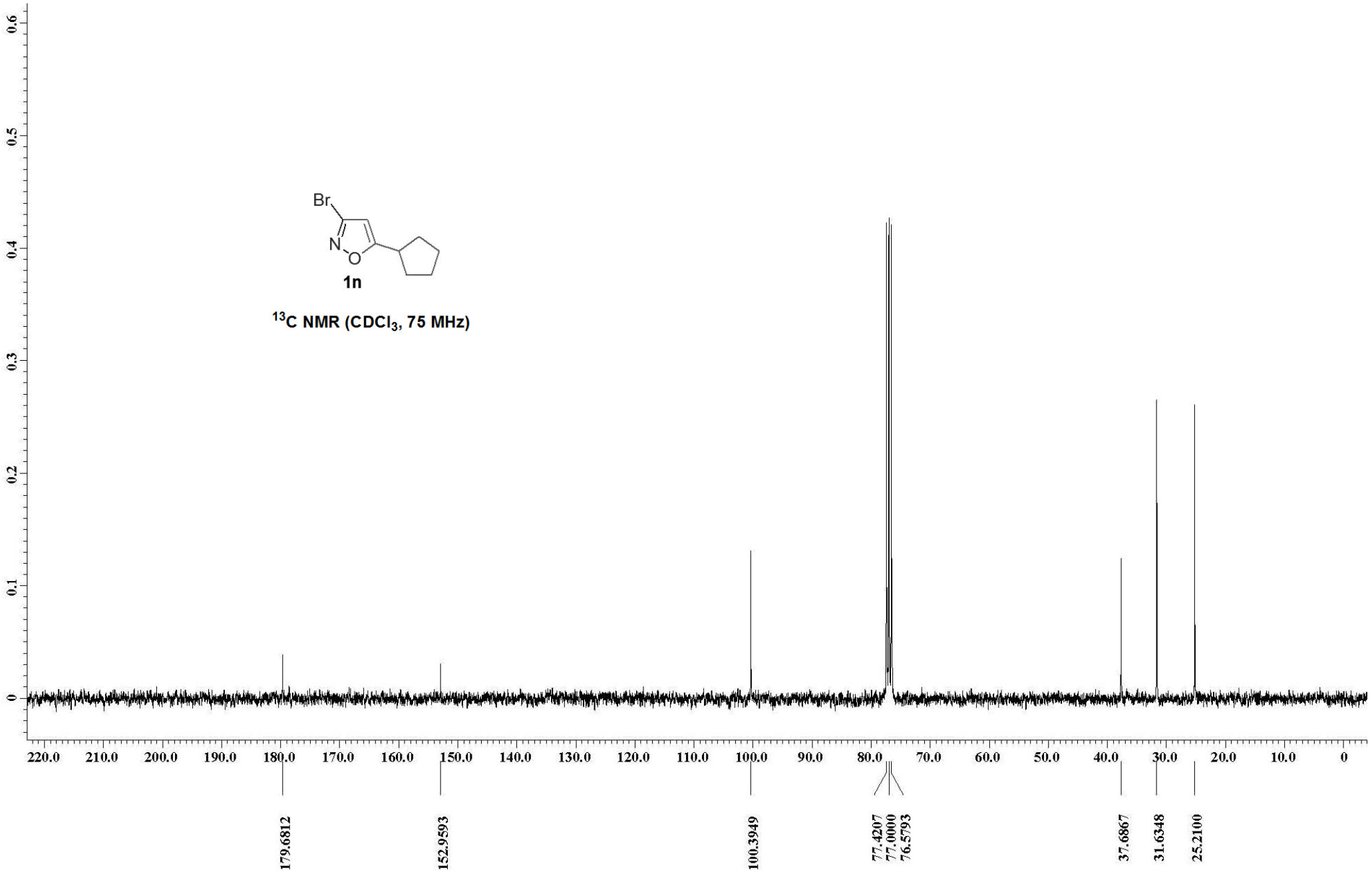


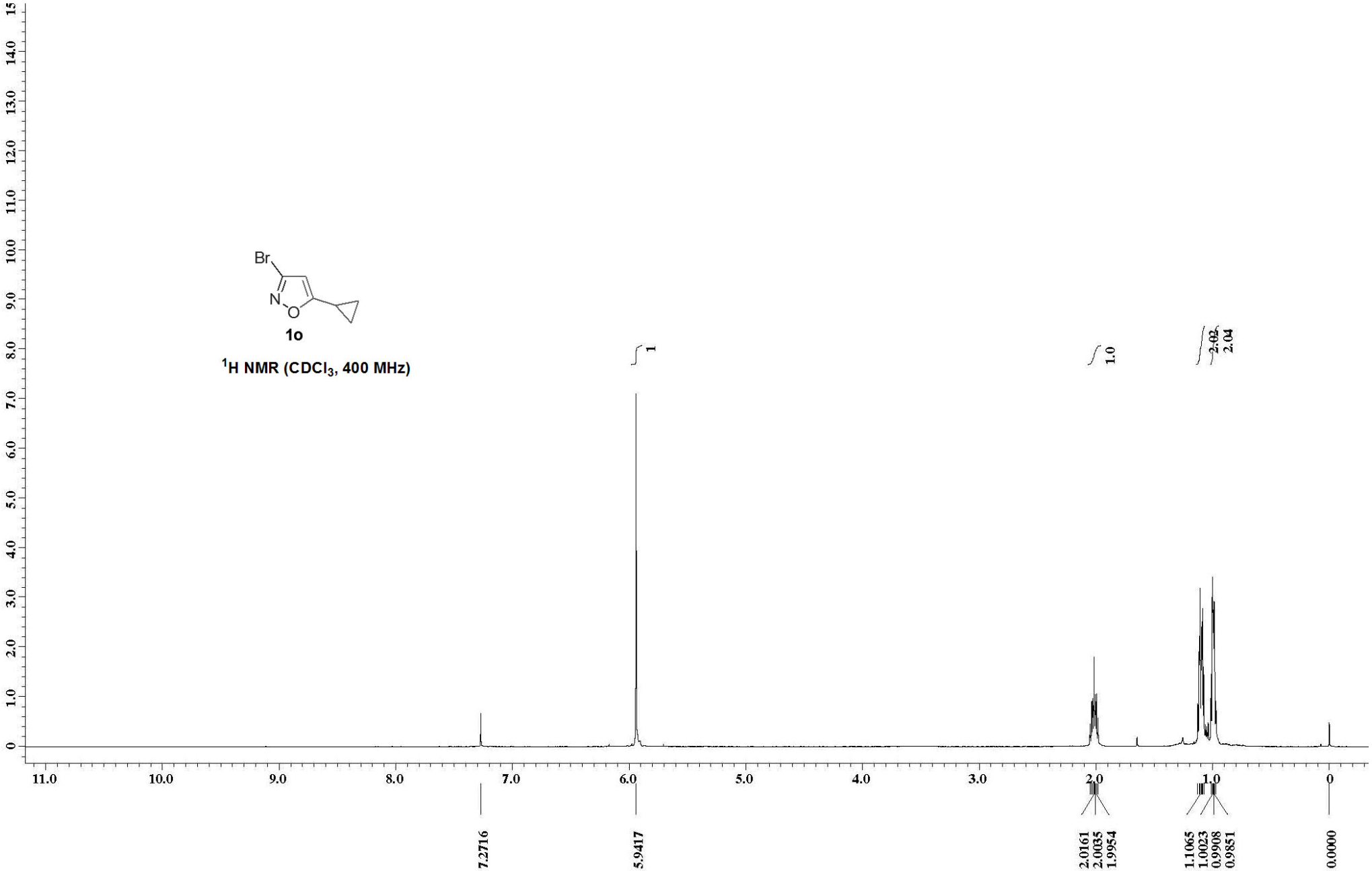
1m

^{13}C NMR ($CDCl_3$, 75 MHz)



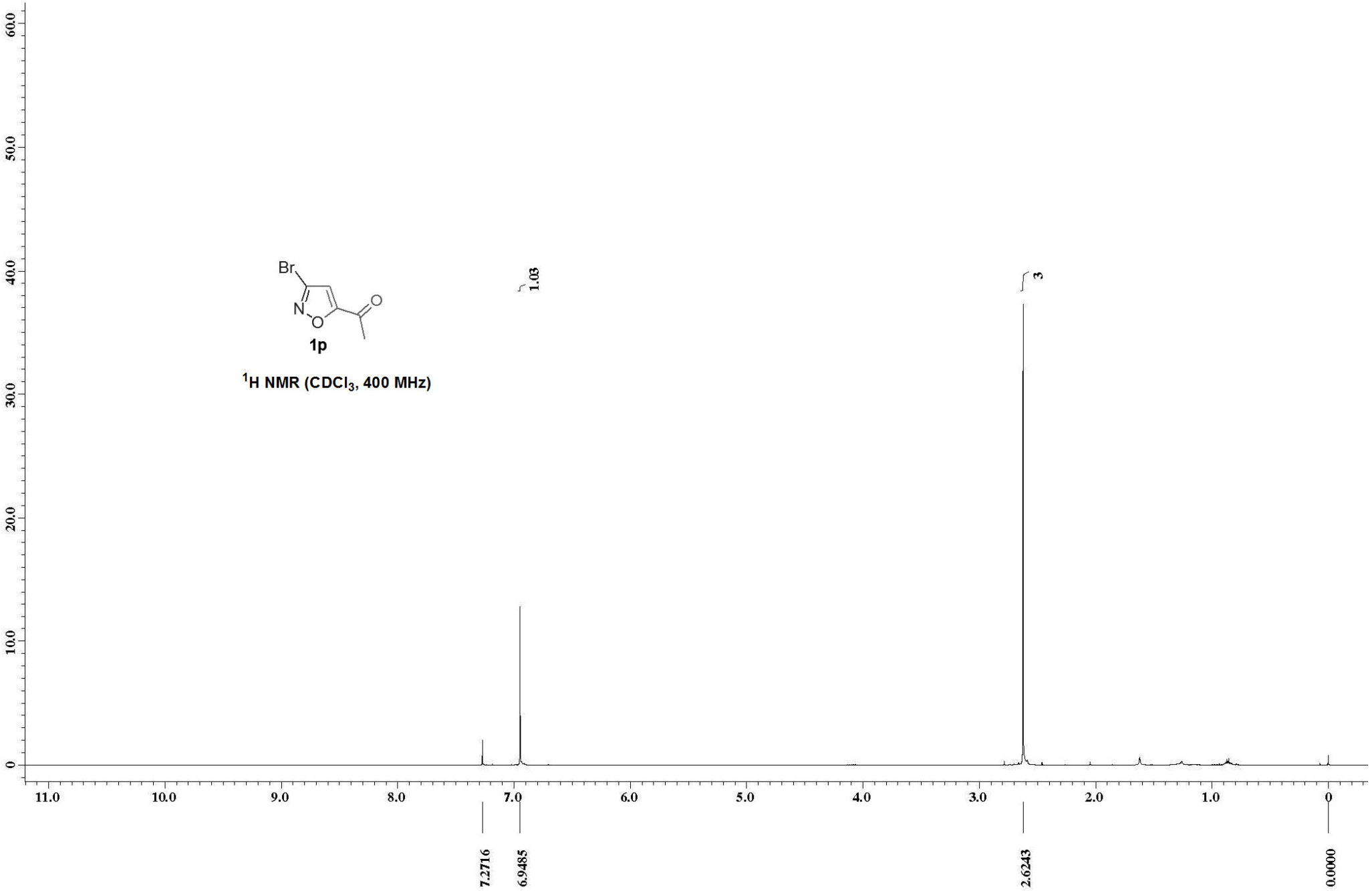

Br
N
O
1n
1H NMR (CDCl3, 400 MHz)
1
1.03
2.08
6.12
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.2727
6.0505
3.2188
3.1982
3.1787
1.7274
1.7217
1.7159
1.7091
1.7022
1.6919
1.6862
0.0000

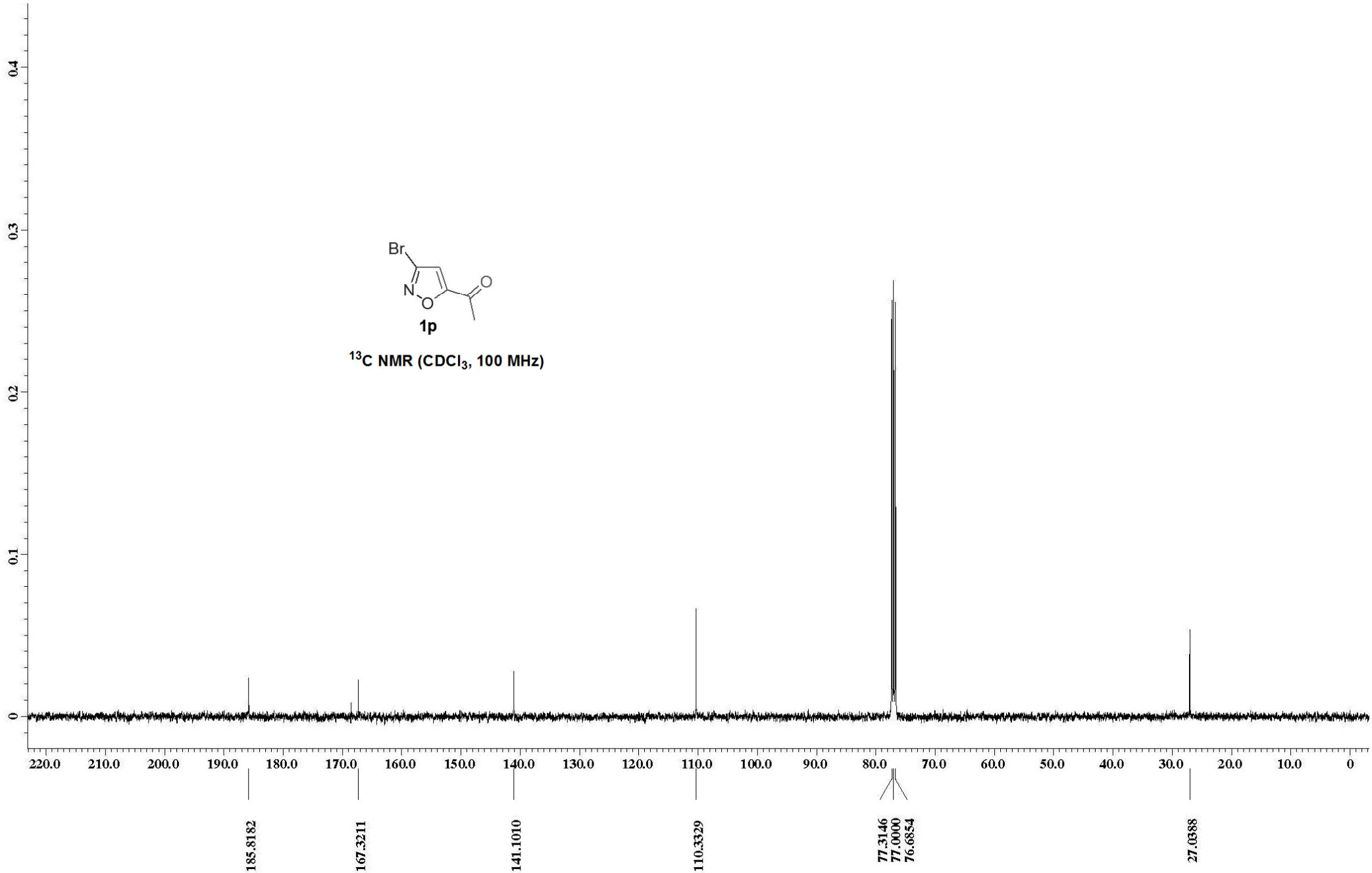

Br
N
O
1n
13C NMR (CDCl3, 75 MHz)
0.6
0.5
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
179.6812
152.9593
100.3949
77.4207
77.0000
76.5793
37.6867
31.6348
25.2100

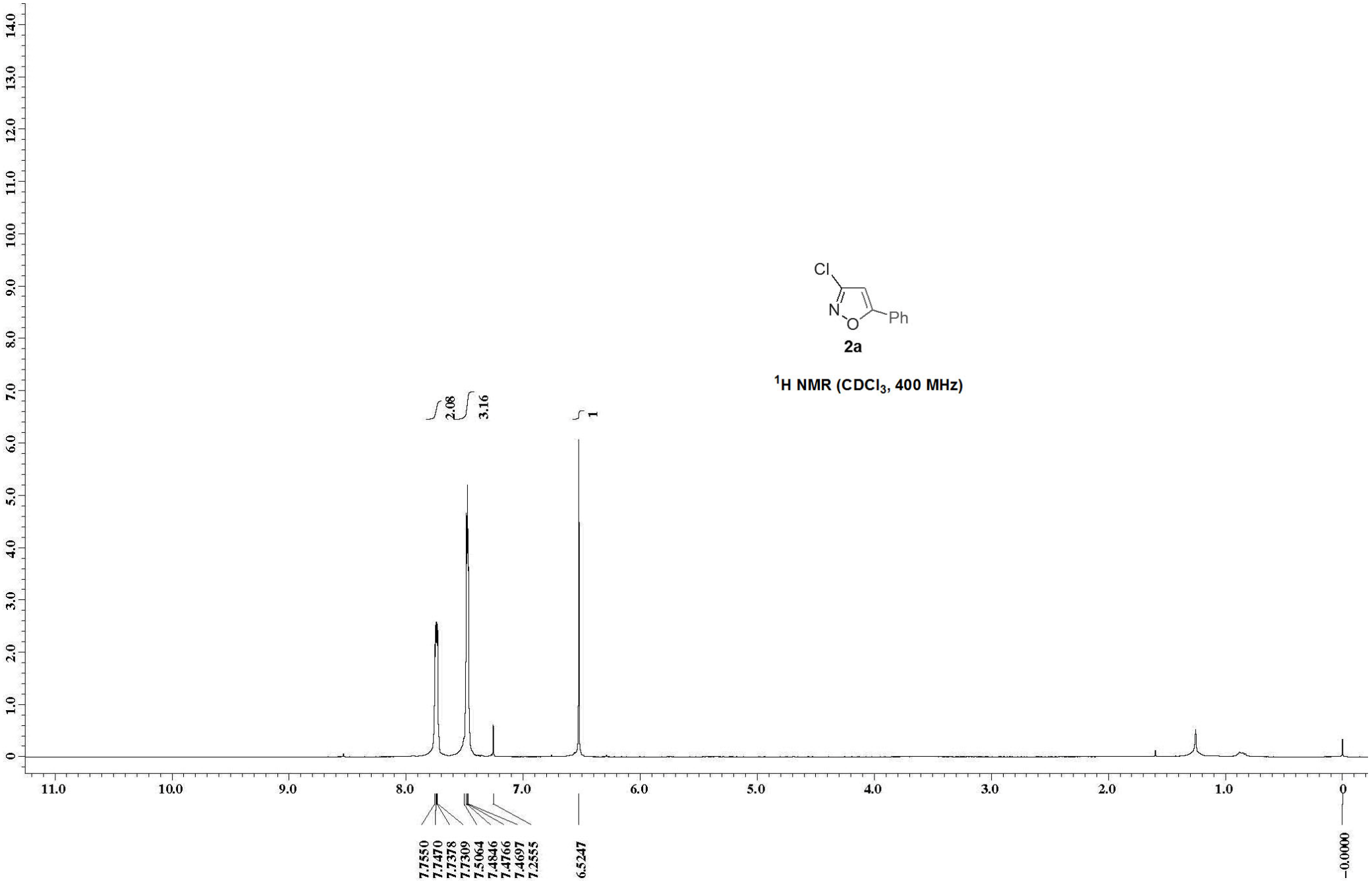

Br
N
O
1o
^{1}H NMR ($CDCl_3$, 400 MHz)
1
1.0
2.02
2.04
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.2716
5.9417
2.0161
2.0035
1.9954
1.1065
1.0023
0.9908
0.9851
0.0000

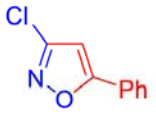
1o

^{13}C NMR ($CDCl_3$, 75 MHz)


Br
N
O
O
1p
1H NMR (CDCl3, 400 MHz)
1.03
3
60.0
50.0
40.0
30.0
20.0
10.0
0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.2716
6.9485
2.6243
0.0000

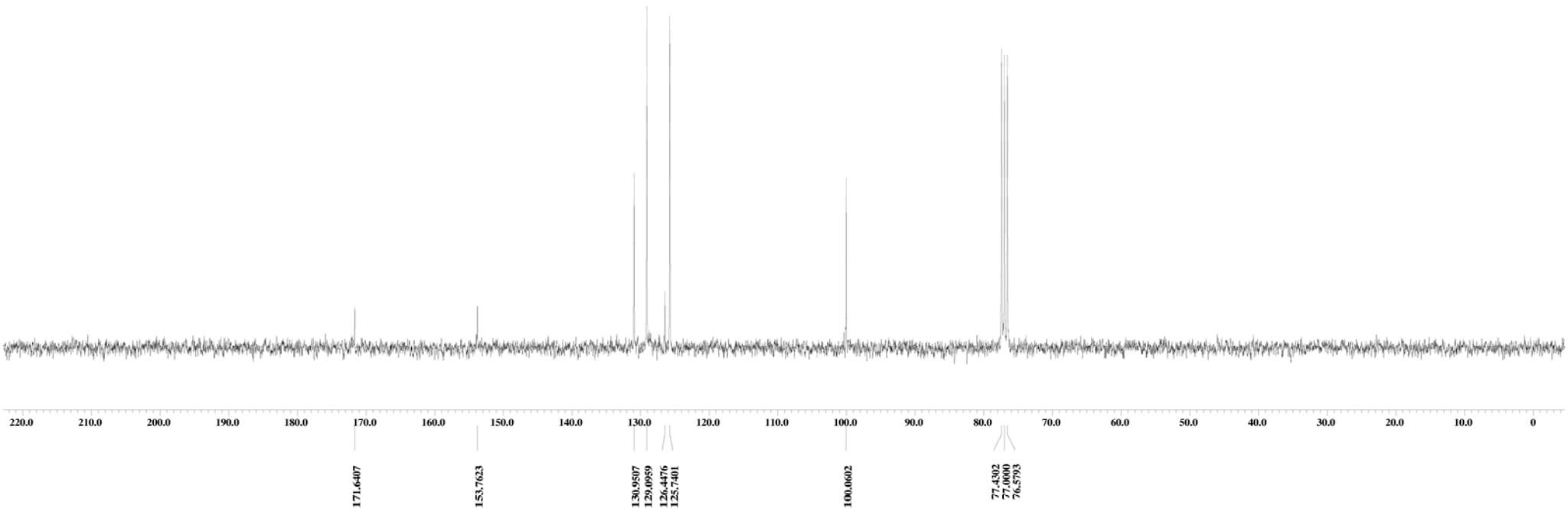

Br
N
O
O
1p
13C NMR (CDCl3, 100 MHz)
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
185.8182
167.3211
141.1010
110.3329
77.3146
77.0000
76.6854
27.0388

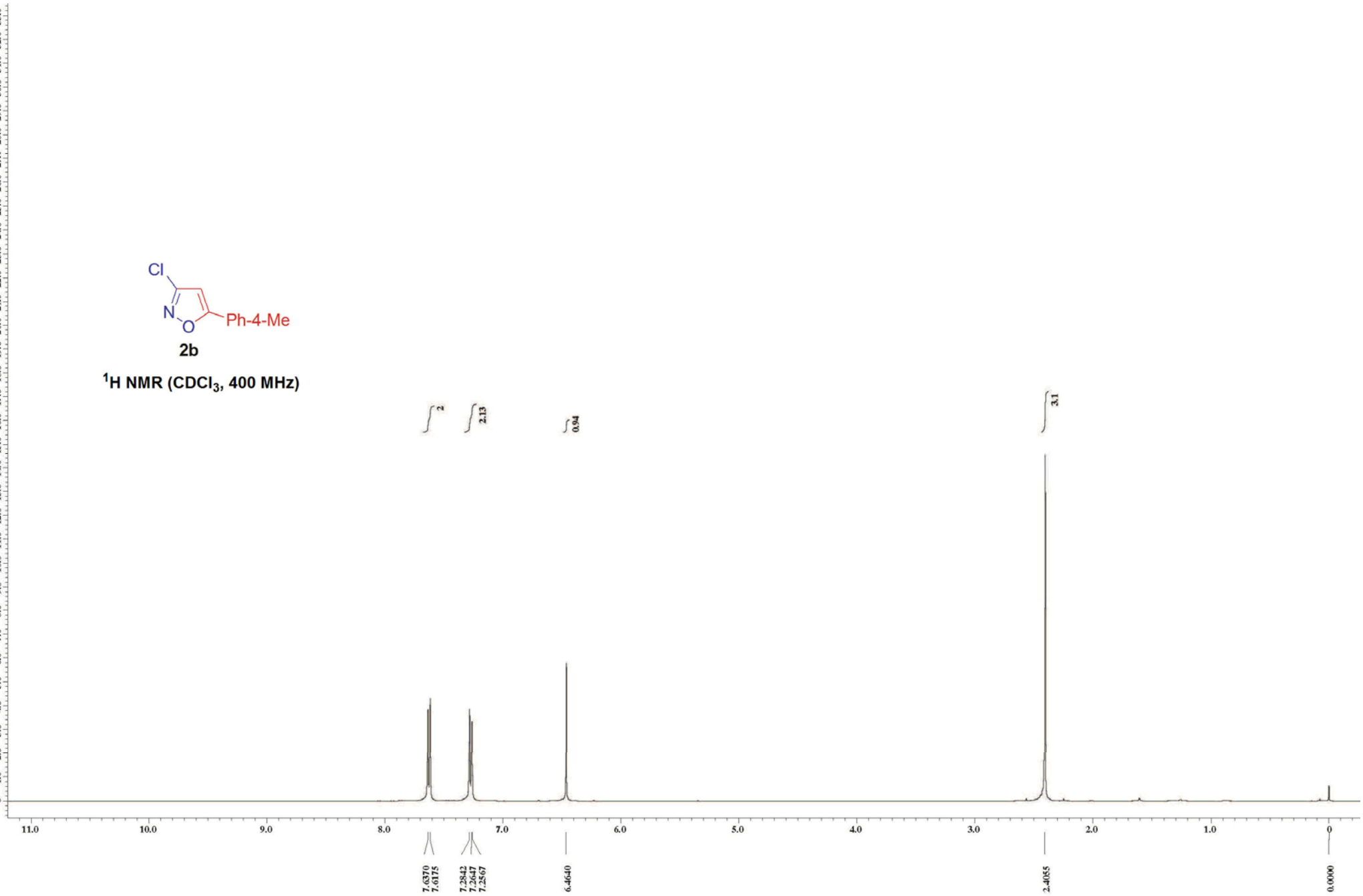

Cl
N
O
Ph
2a
^{1}H NMR ($CDCl_3$, 400 MHz)
2.08
3.16
1
7.7550
7.7470
7.7378
7.7309
7.5064
7.4846
7.4766
7.4697
7.2555
6.5247
-0.0000

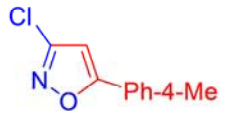


2a

^{13}C NMR ($CDCl_3$, 75 MHz)

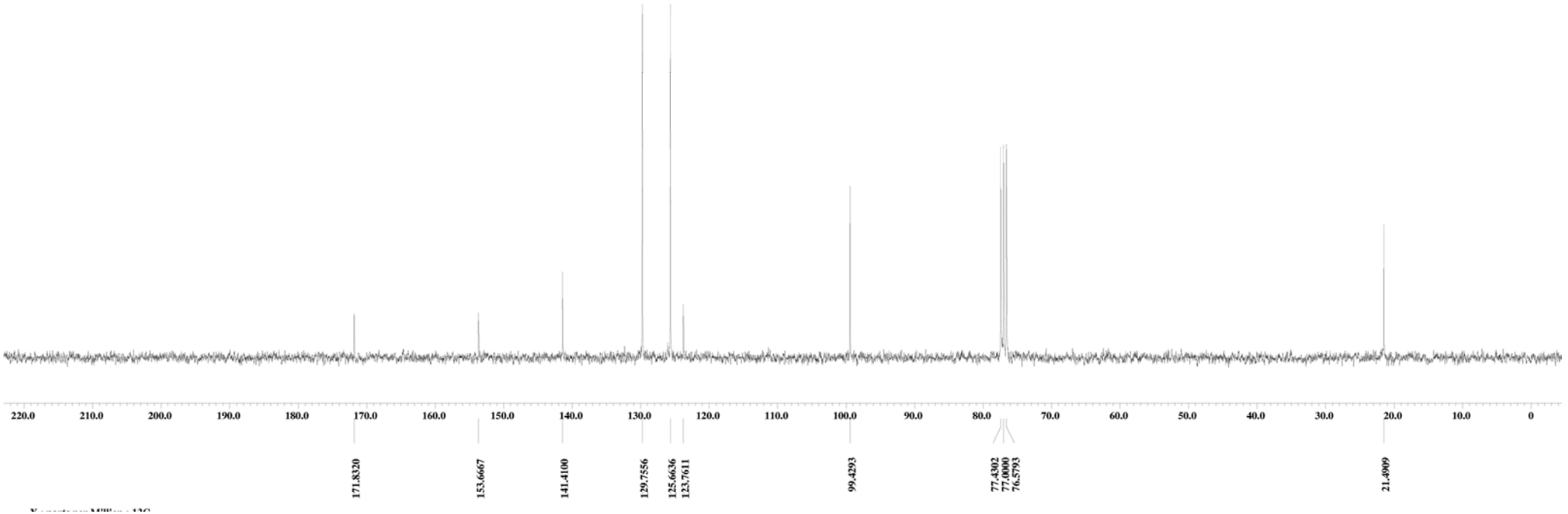


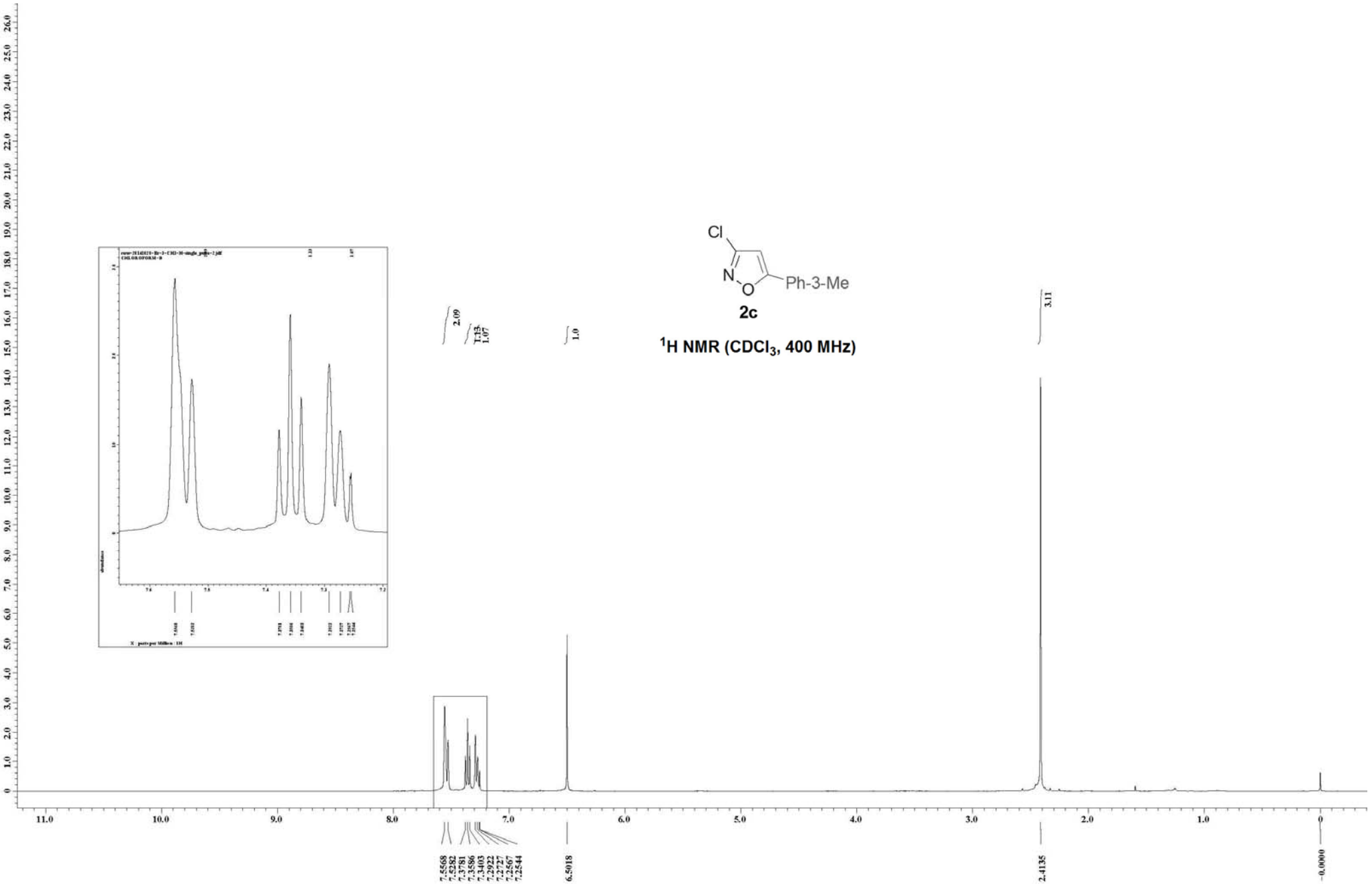

Cl
N
O
Ph-4-Me
2b
^{1}H NMR ($CDCl_3$, 400 MHz)
2
2.13
0.94
3.1
7.6370
7.6175
7.2842
7.2647
7.2567
6.4640
2.4055
0.0000

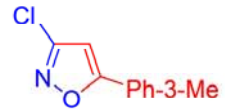


2b

^{13}C NMR ($CDCl_3$, 75 MHz)

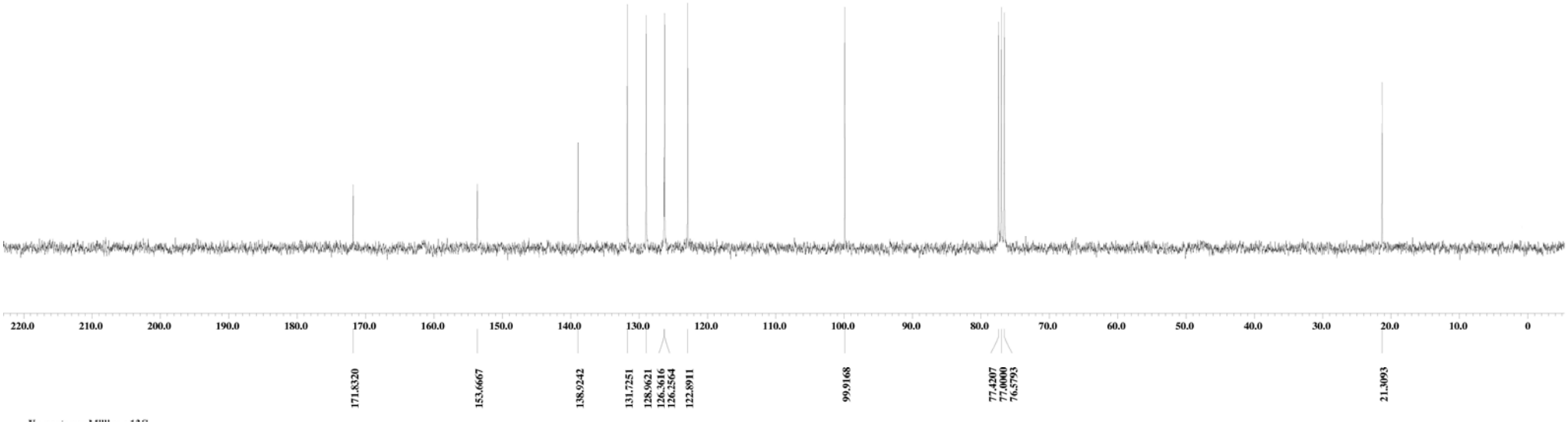


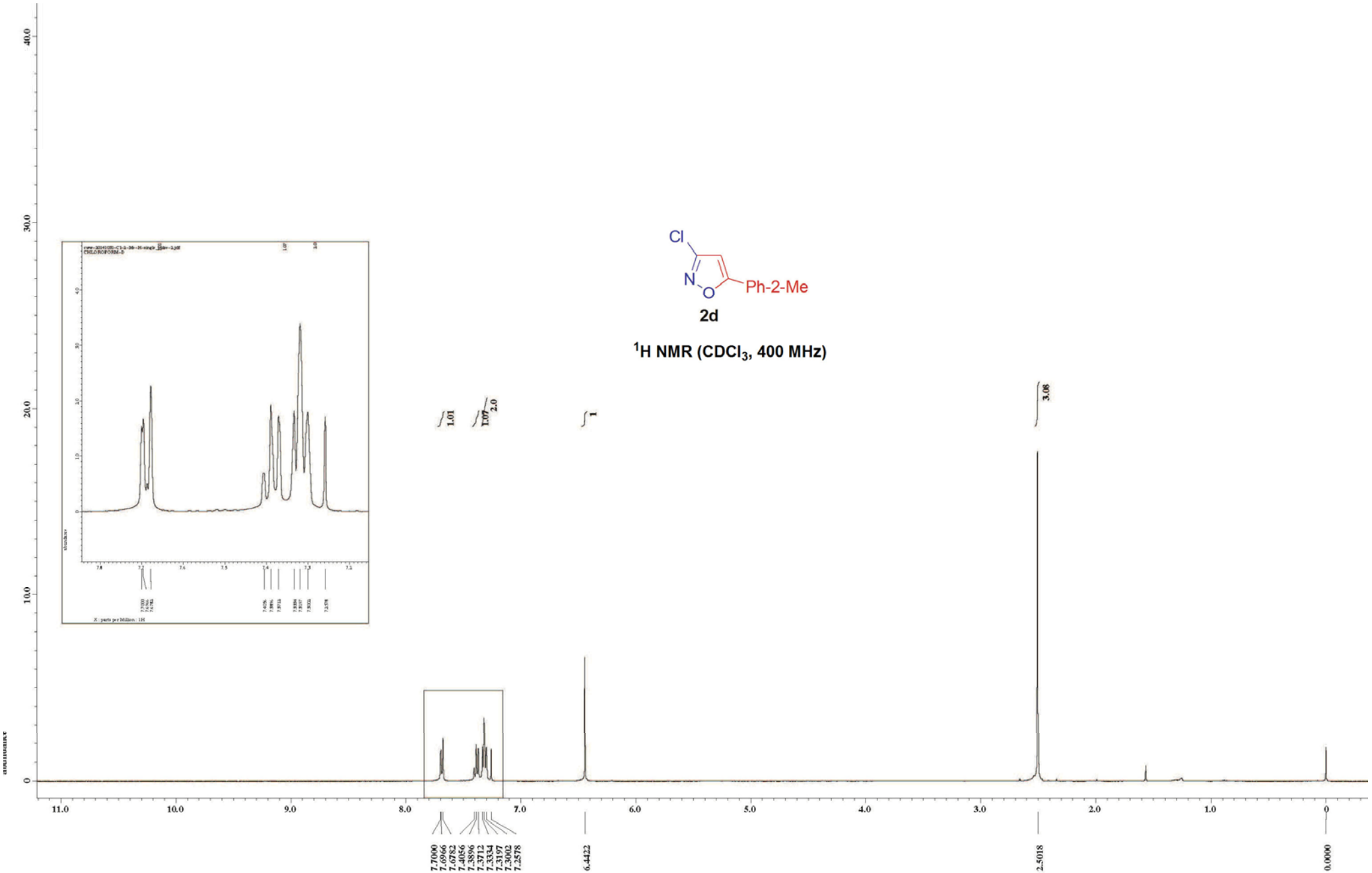

Cl
N
O
Ph-3-Me
2c
^{1}H NMR ($CDCl_3$, 400 MHz)
2.09
1.13
1.07
1.0
3.11
7.5568
7.5382
7.3781
7.3586
7.3403
7.2922
7.2727
7.2567
7.2544
6.5018
2.4135
0.0000

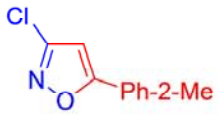


2c

^{13}C NMR ($CDCl_3$, 75 MHz)

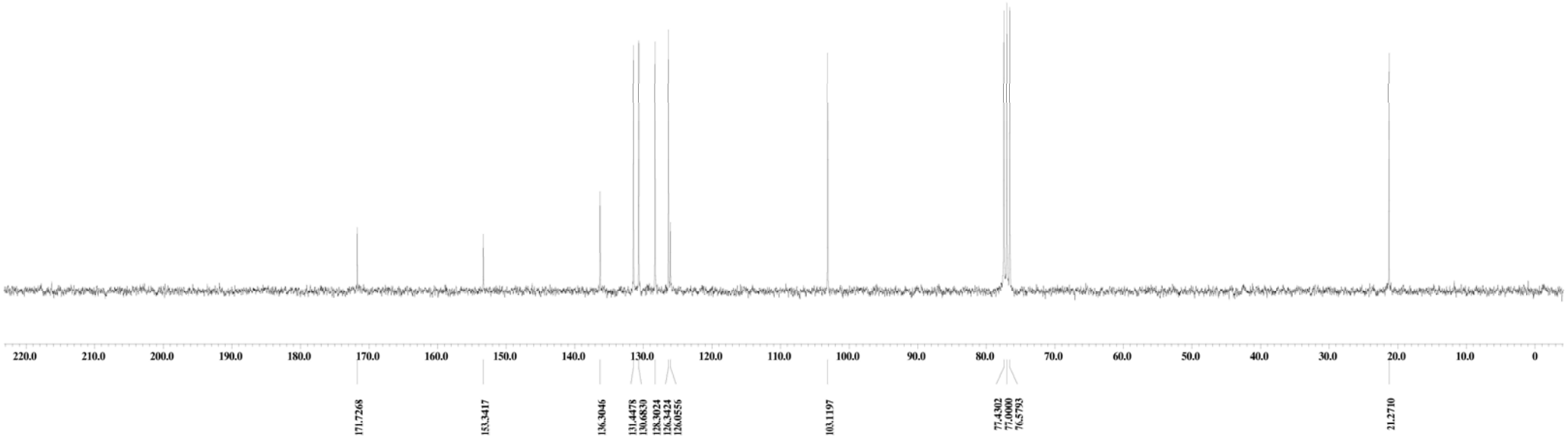


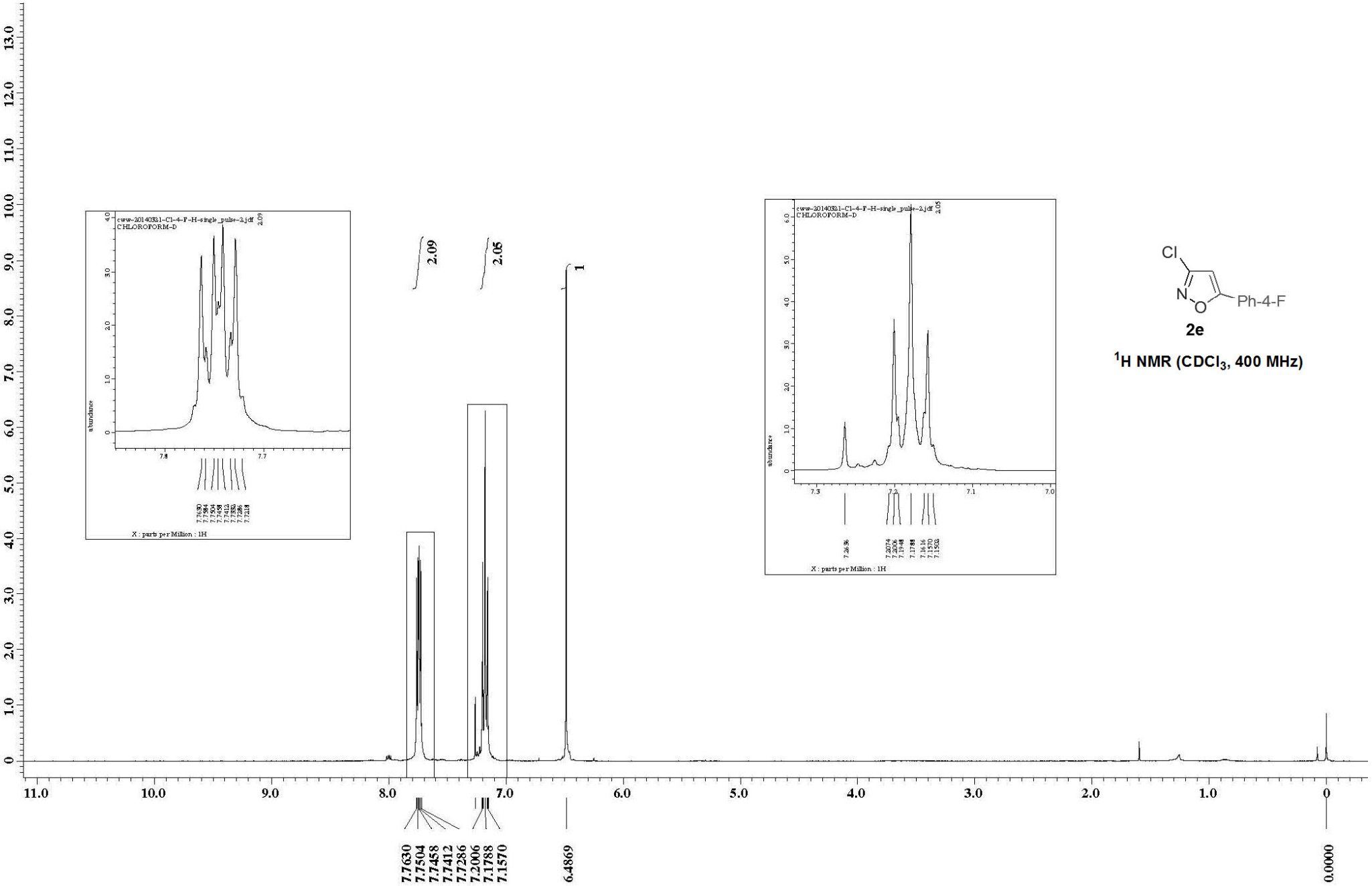

Cl
N
O
Ph-2-Me
2d
1H NMR (CDCl3, 400 MHz)
1.01
2.0
1
3.08
7.7000
7.6966
7.6782
7.4656
7.3896
7.3712
7.3334
7.3197
7.3002
7.2578
6.4422
2.5018
0.0000

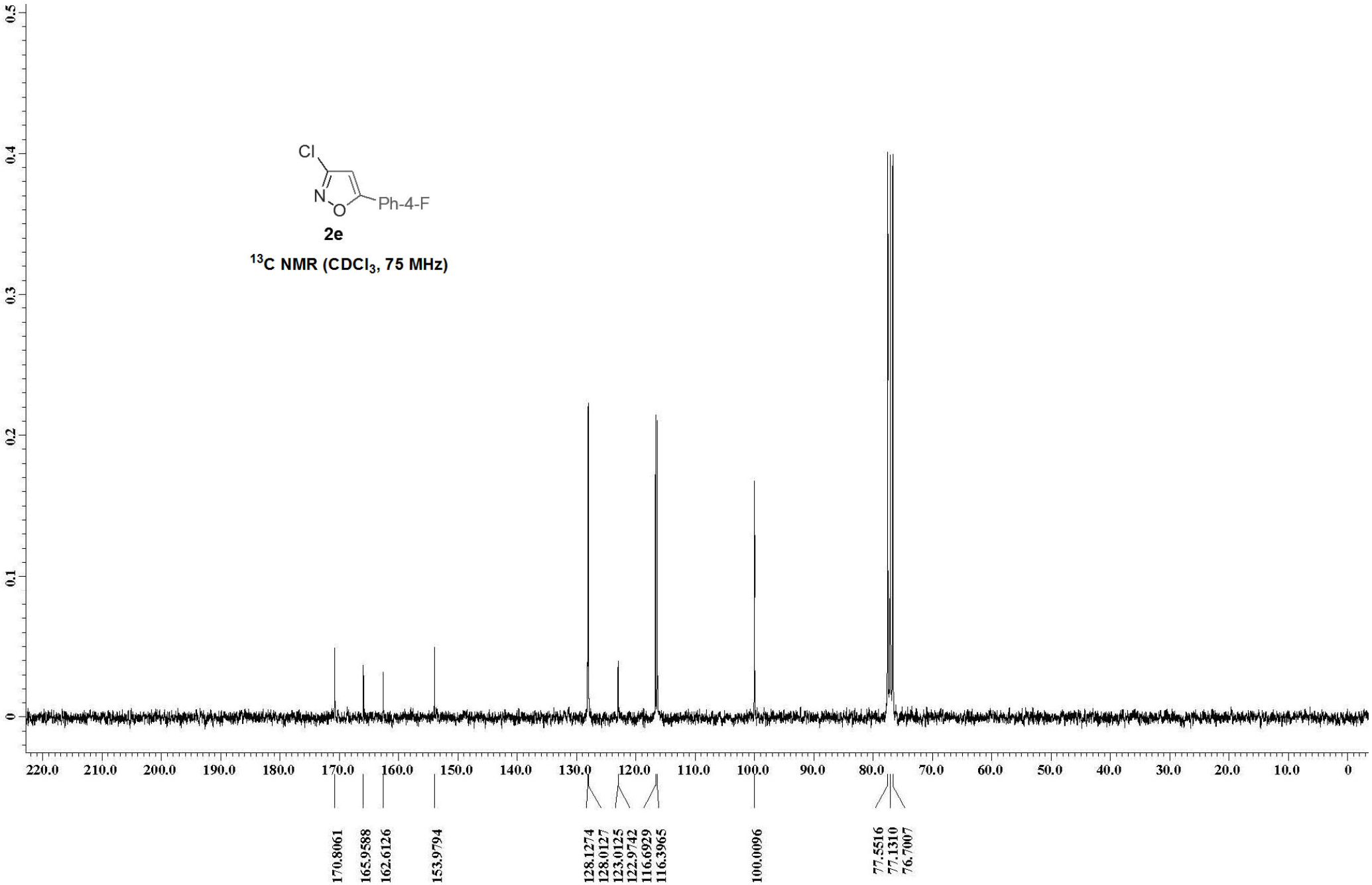


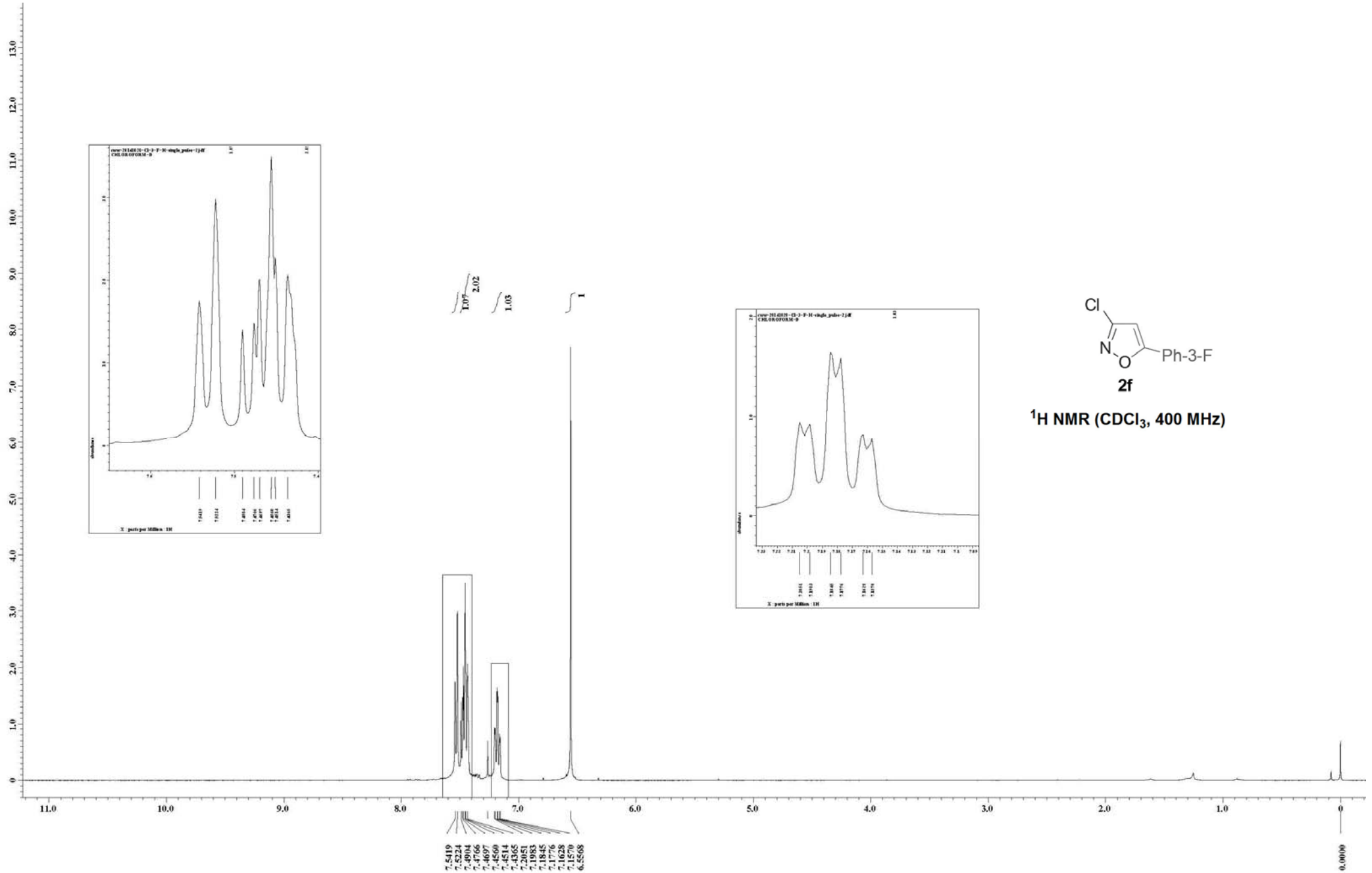
2d

^{13}C NMR ($CDCl_3$, 75 MHz)



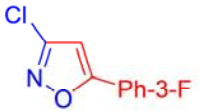

2.09
2.05
1
7.7630
7.7504
7.7458
7.7412
7.7286
7.2006
7.1788
7.1570
6.4869
0.0000
Cl
N
O
Ph-4-F
2e
^{1}H NMR ($CDCl_3$, 400 MHz)


Cl
N
O
Ph-4-F
2e
13C NMR (CDCl3, 75 MHz)
0.5
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
170.8061
165.9588
162.6126
153.9794
128.1274
128.0127
123.0125
122.9742
116.6929
116.3965
100.0096
77.5516
77.1310
76.7007



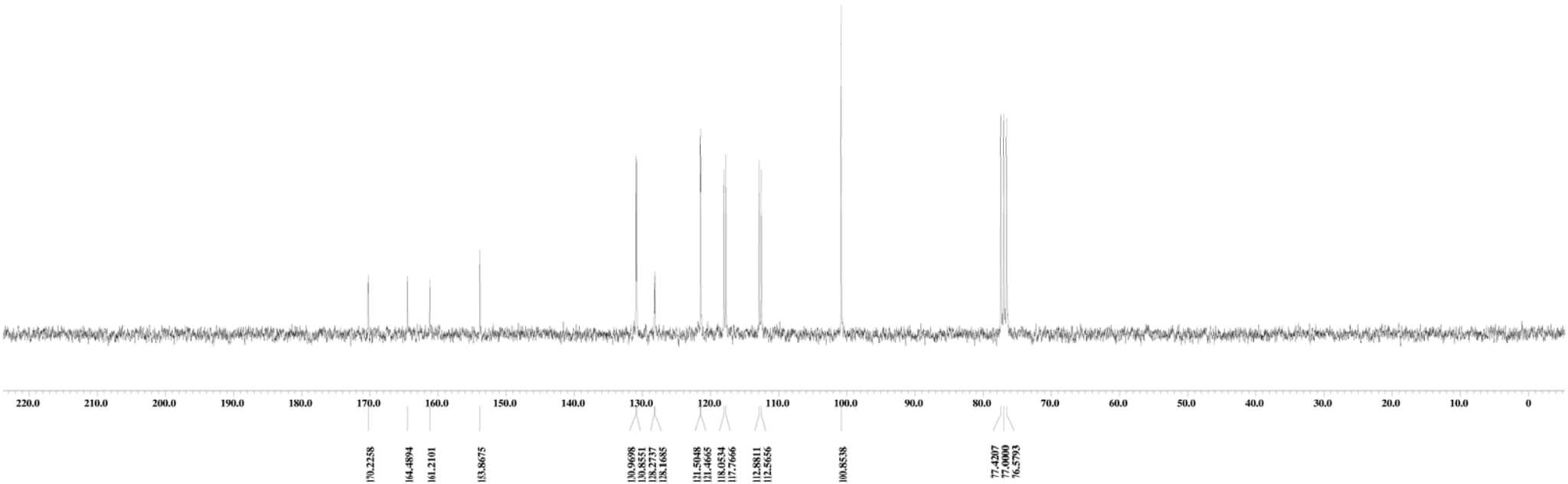
2f

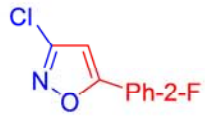
^{1}H NMR ($CDCl_3$, 400 MHz)



2f

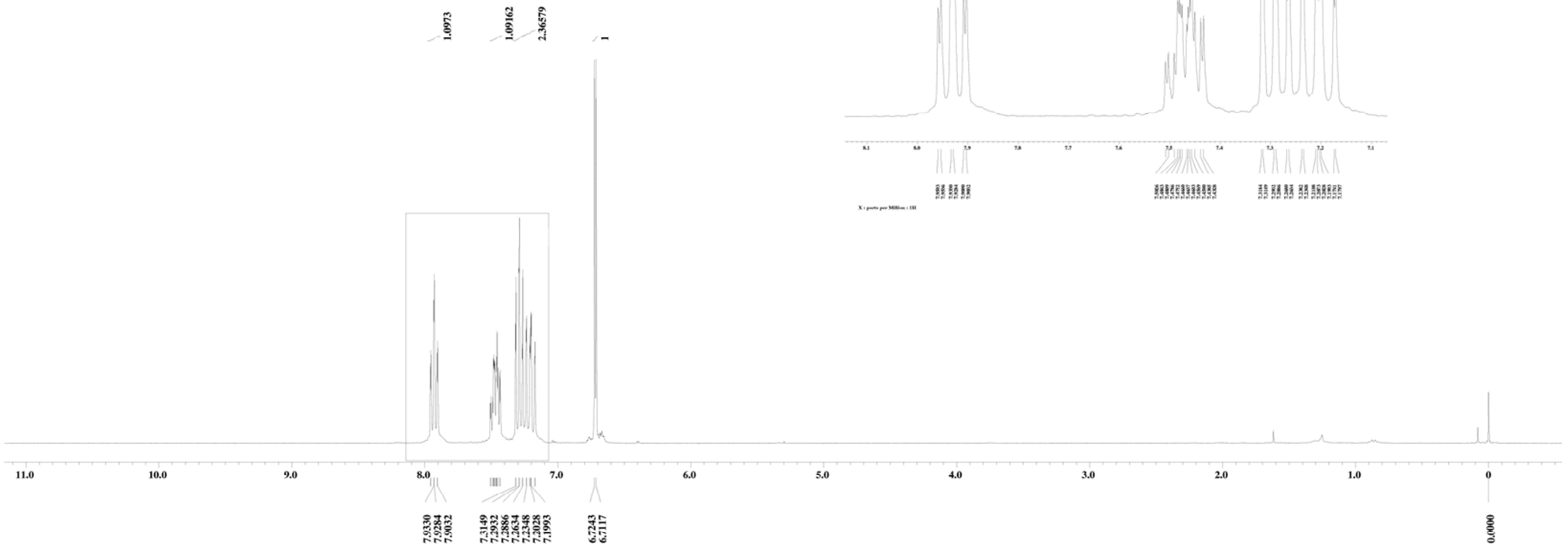
^{13}C NMR ($CDCl_3$, 75 MHz)

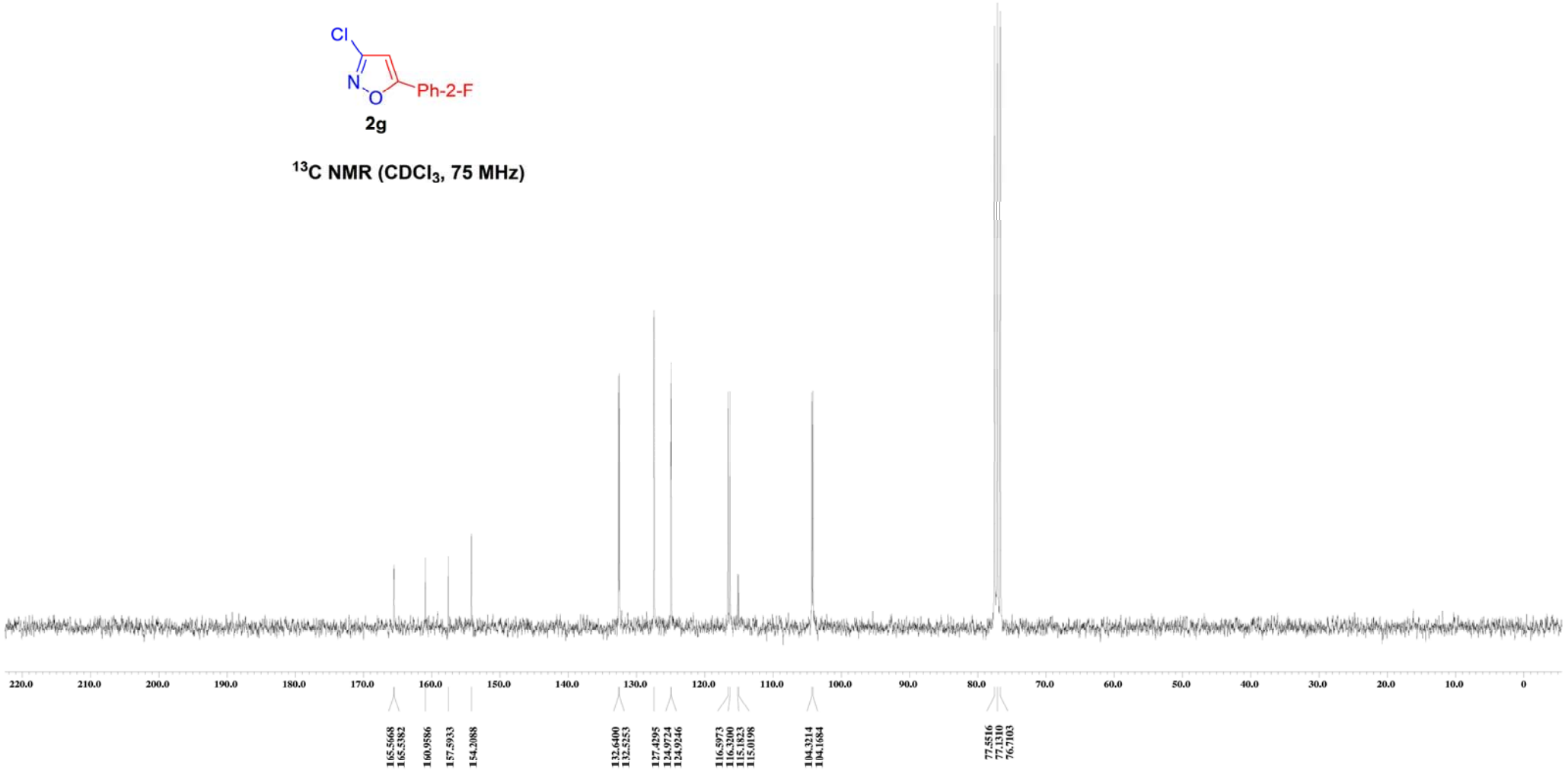


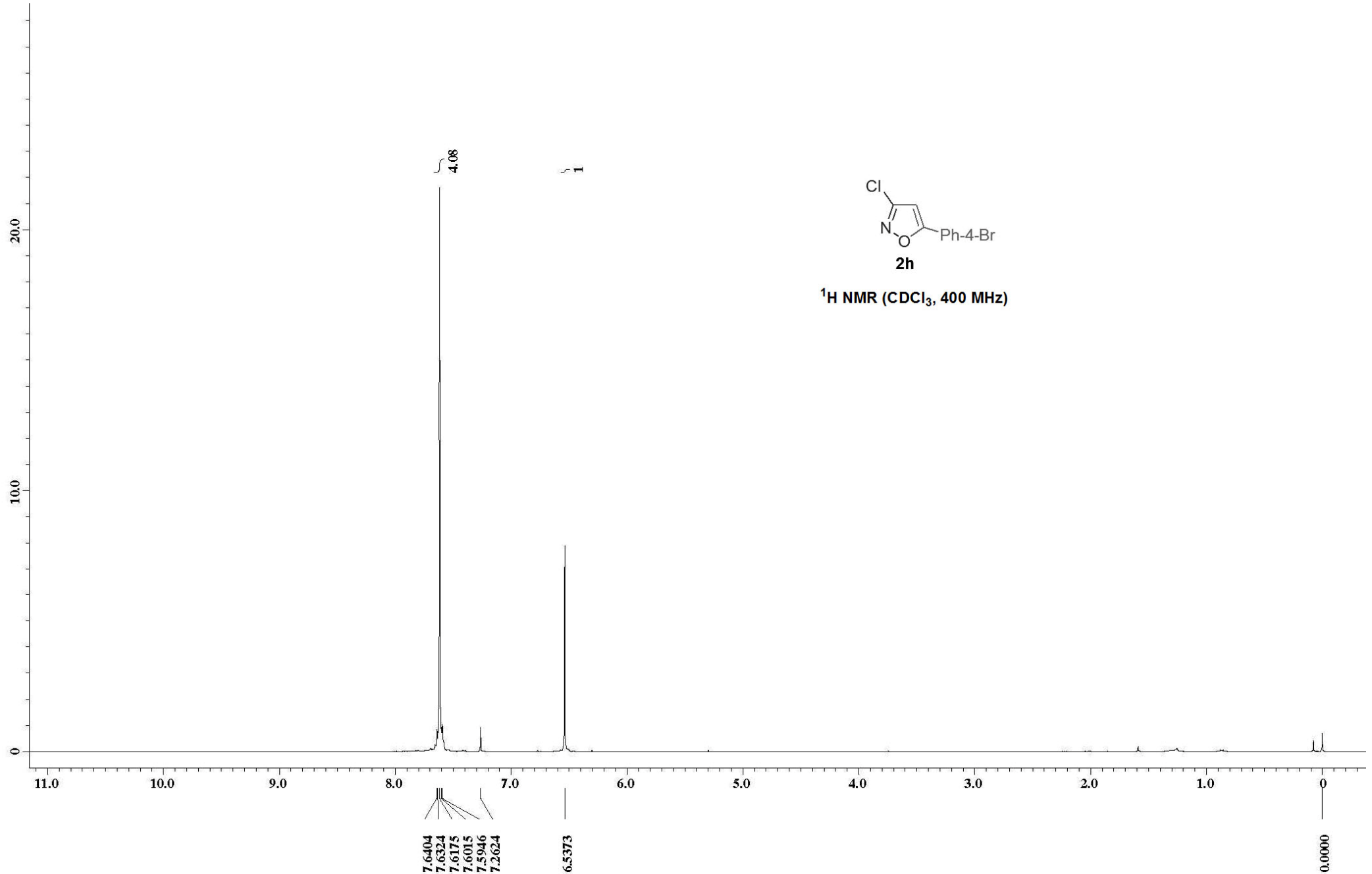


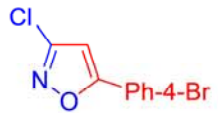
2g

^{1}H NMR ($CDCl_3$, 300 MHz)



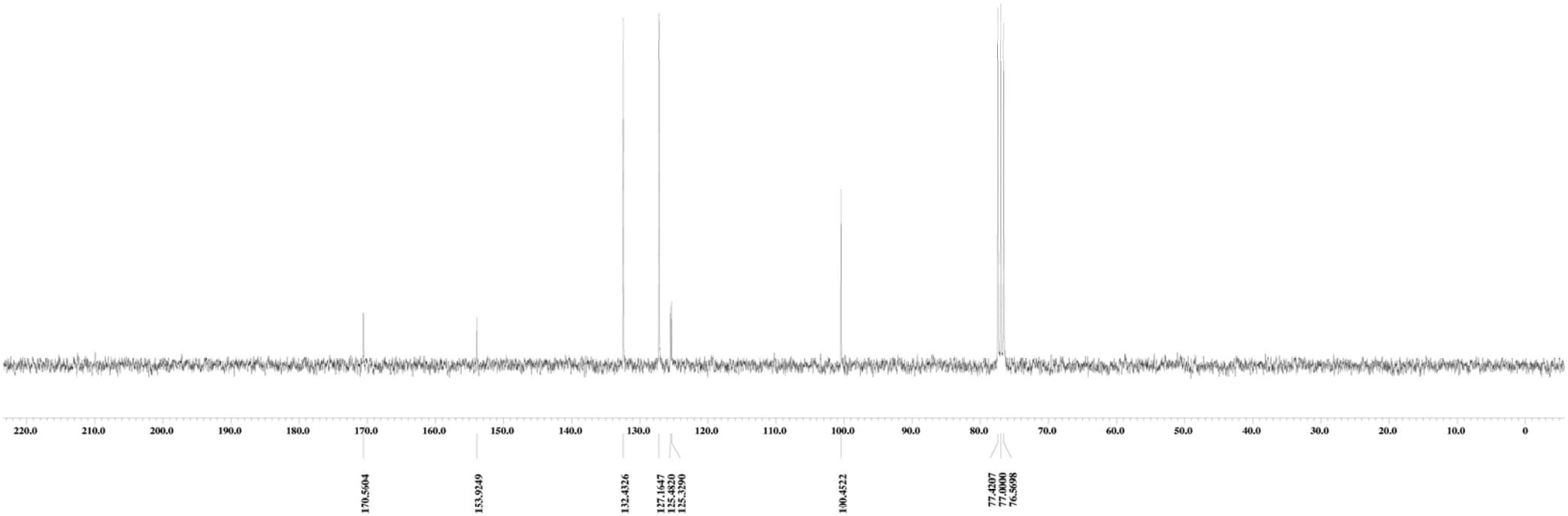

Cl
N
O
Ph-2-F
2g
^{13}C NMR ($CDCl_3$, 75 MHz)
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
165.5668
165.5382
160.9586
157.5933
154.2088
132.6400
132.5253
127.4295
124.9724
124.9246
116.5973
116.3300
115.1823
115.0198
104.3214
104.1684
77.5516
77.1310
76.7103

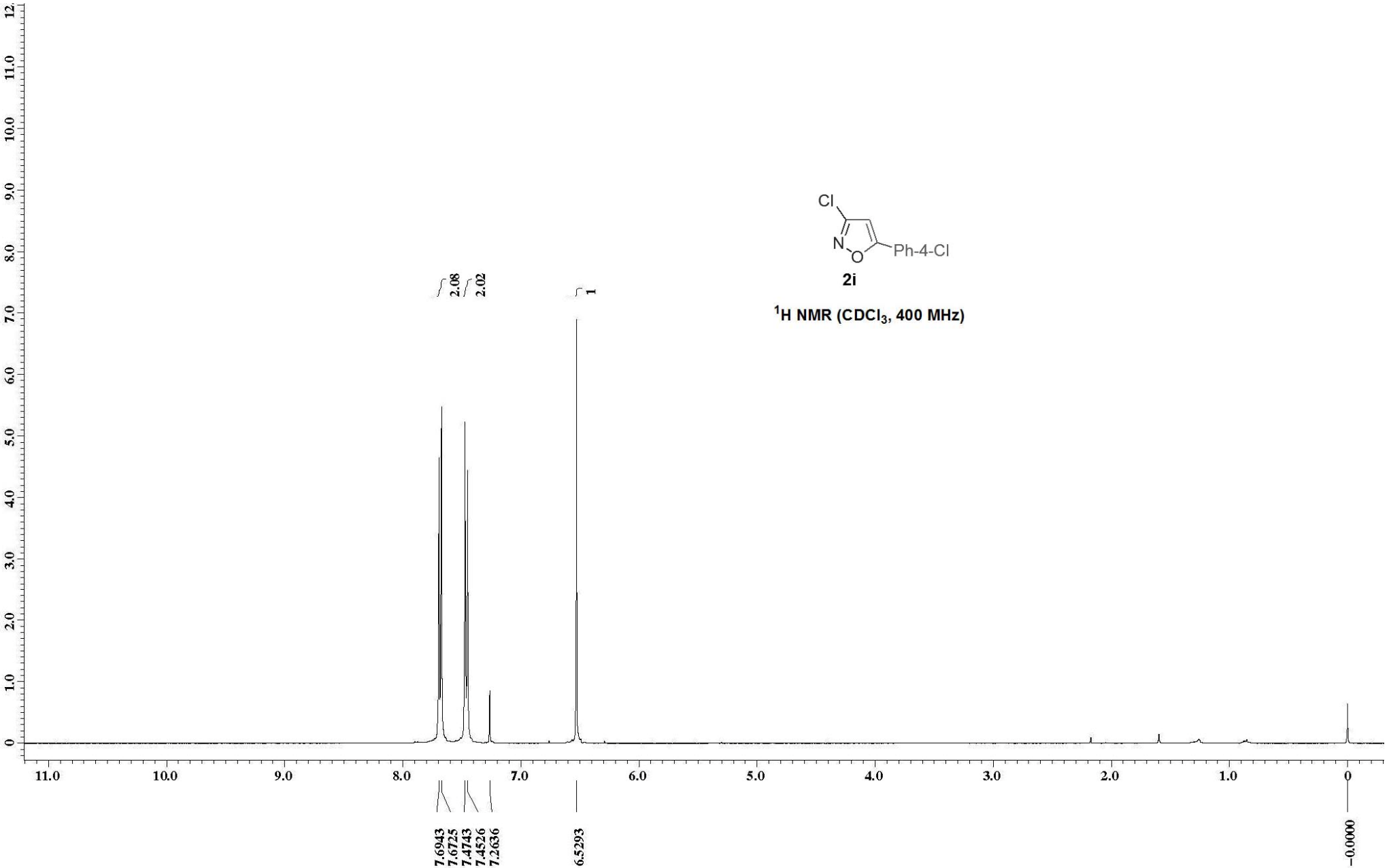

4.08
1
Cl
N
O
Ph-4-Br
2h
^{1}H NMR ($CDCl_3$, 400 MHz)
20.0
10.0
0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.6404
7.6324
7.6175
7.6015
7.5946
7.2624
6.5373
0.0000

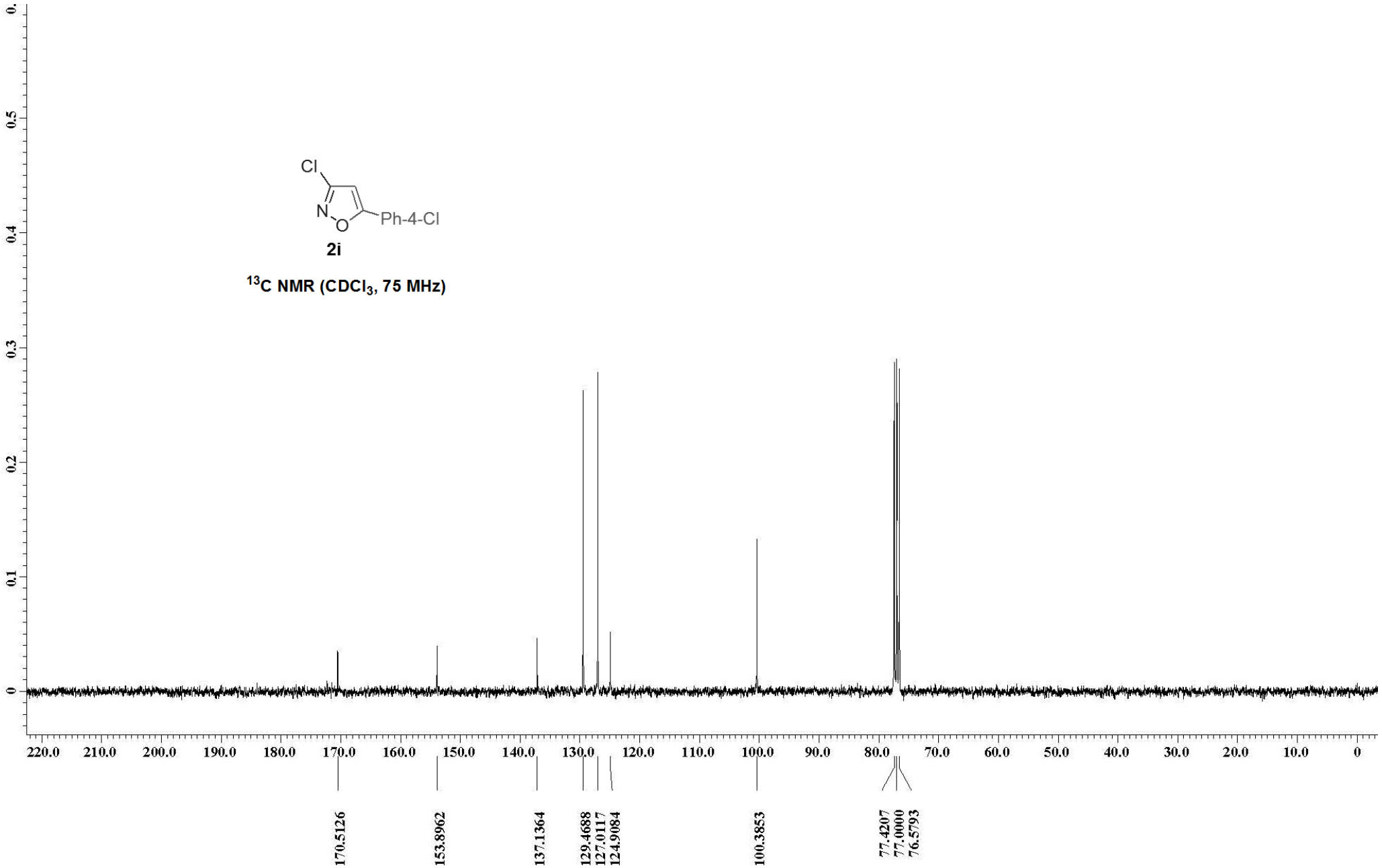


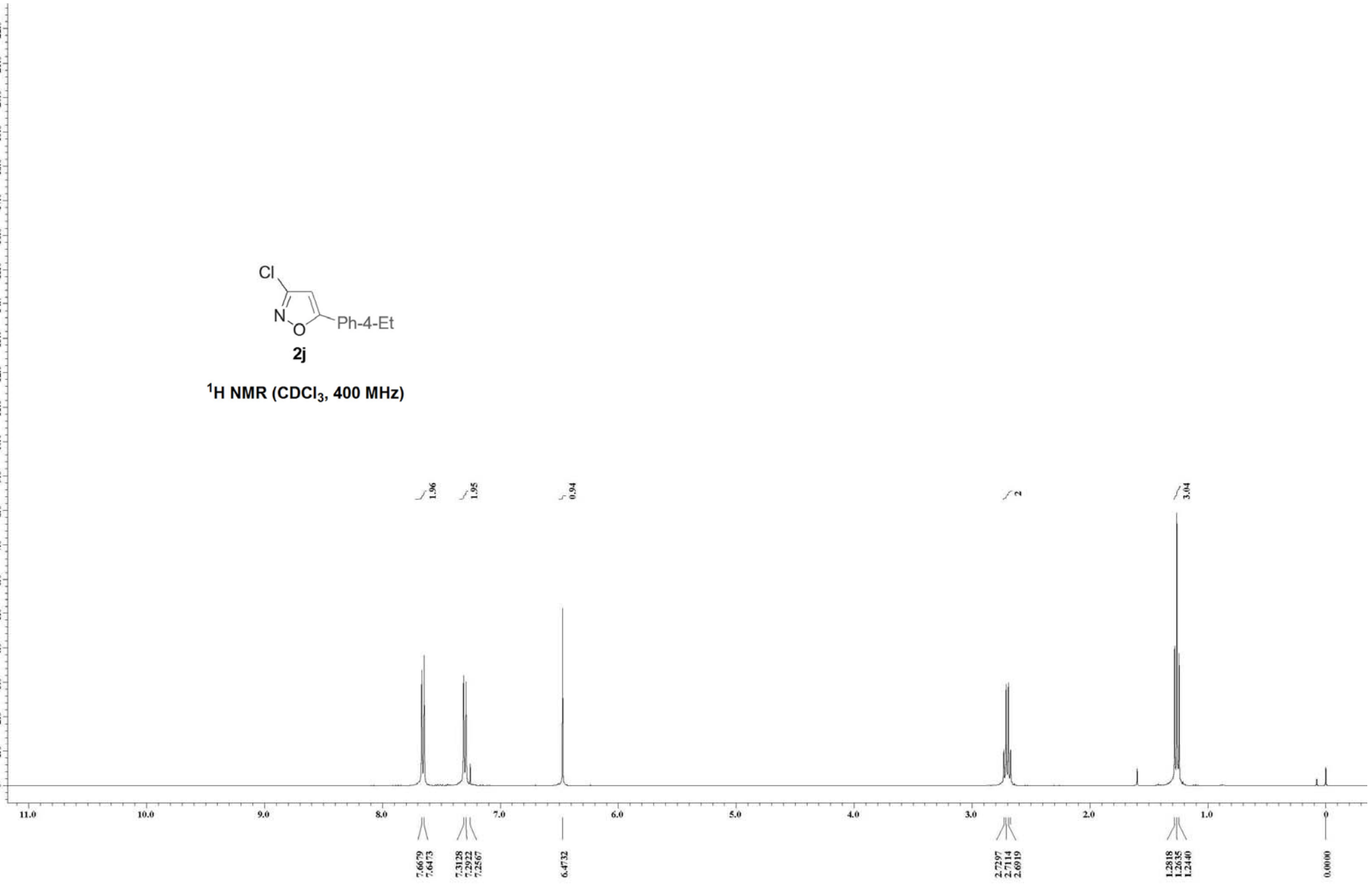
2h

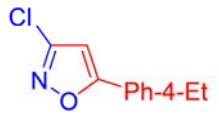
^{13}C NMR ($CDCl_3$, 75 MHz)




Cl
N
O
Ph-4-Cl
2i
^{1}H NMR ($CDCl_3$, 400 MHz)
2.08
2.02
1
7.6943
7.6725
7.4743
7.4526
7.2636
6.5293
-0.0000

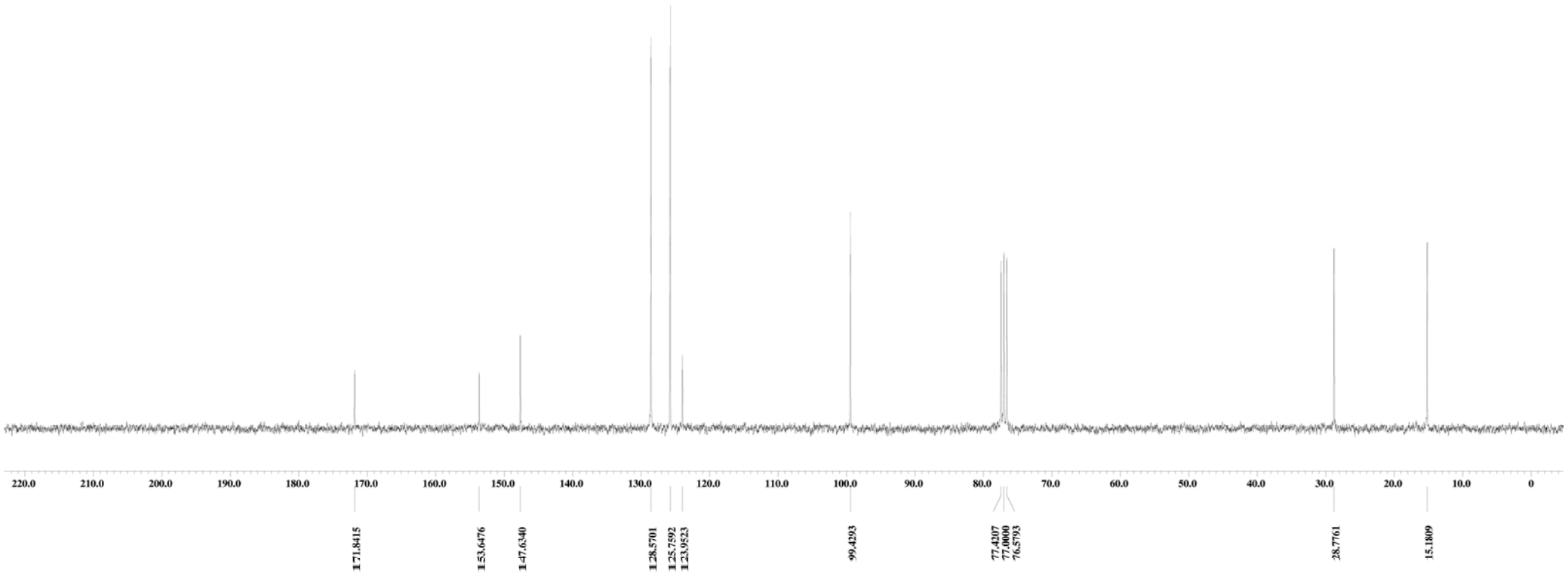

Cl
N
O
Ph-4-Cl
2i
13C NMR (CDCl3, 75 MHz)
170.5126
153.8962
137.1364
129.4688
127.0117
124.9084
100.3853
77.4207
77.0000
76.5793

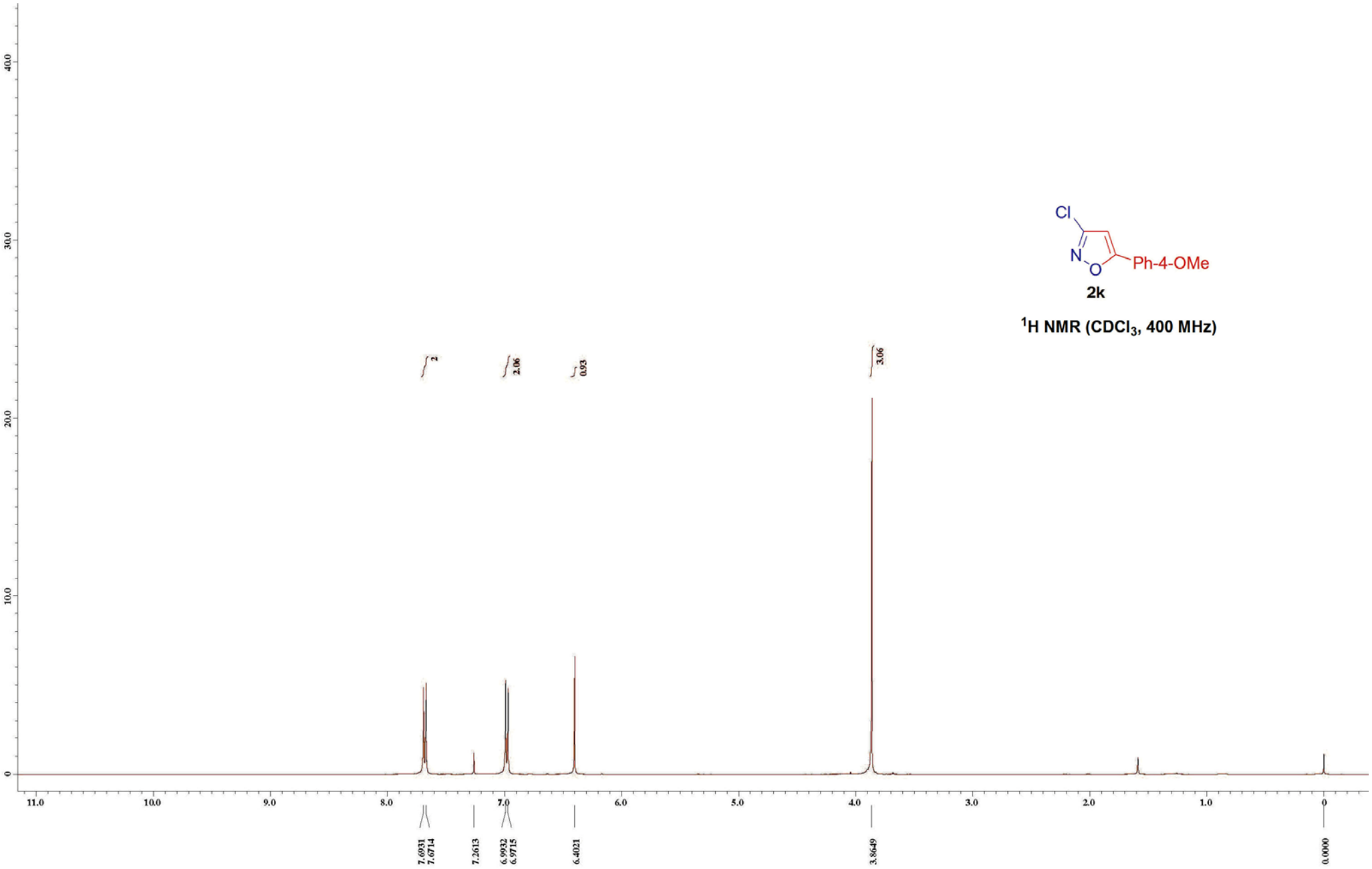

Cl
N
O
Ph-4-Et
2j
1H NMR (CDCl3, 400 MHz)
1.96
1.95
0.94
2
3.04
7.6679
7.6473
7.3128
7.2922
7.2567
6.4732
2.7297
2.7114
2.6919
1.2818
1.2635
1.2440
0.0000

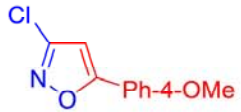


2j

^{13}C NMR ($CDCl_3$, 75 MHz)

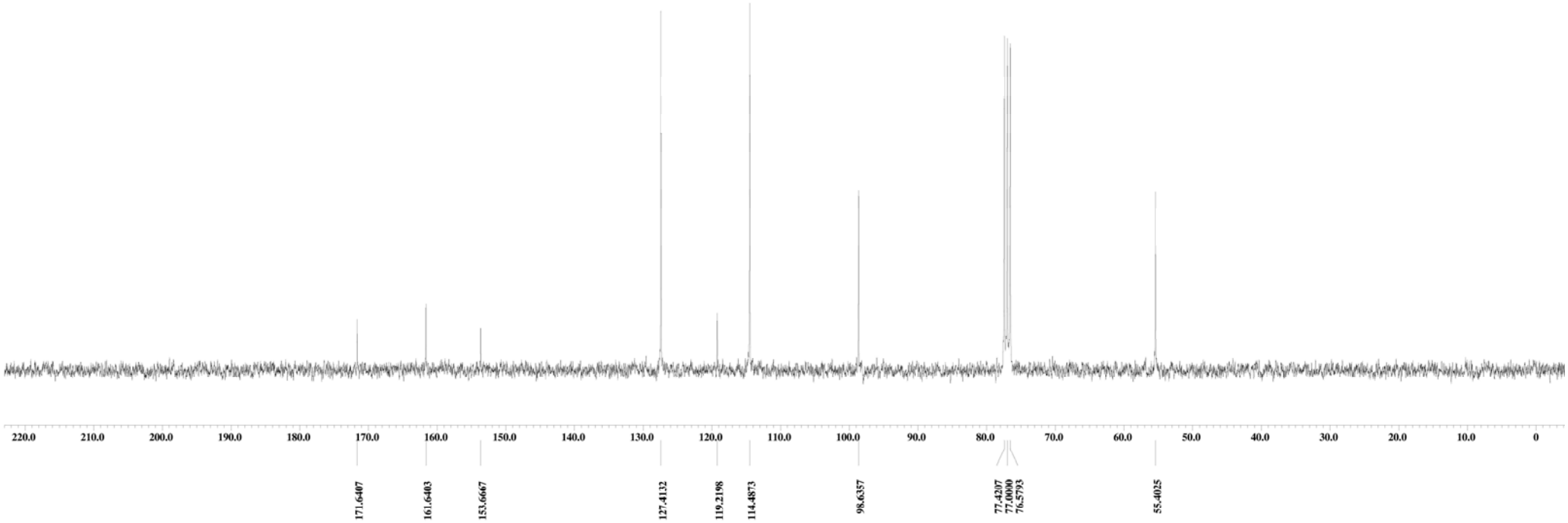


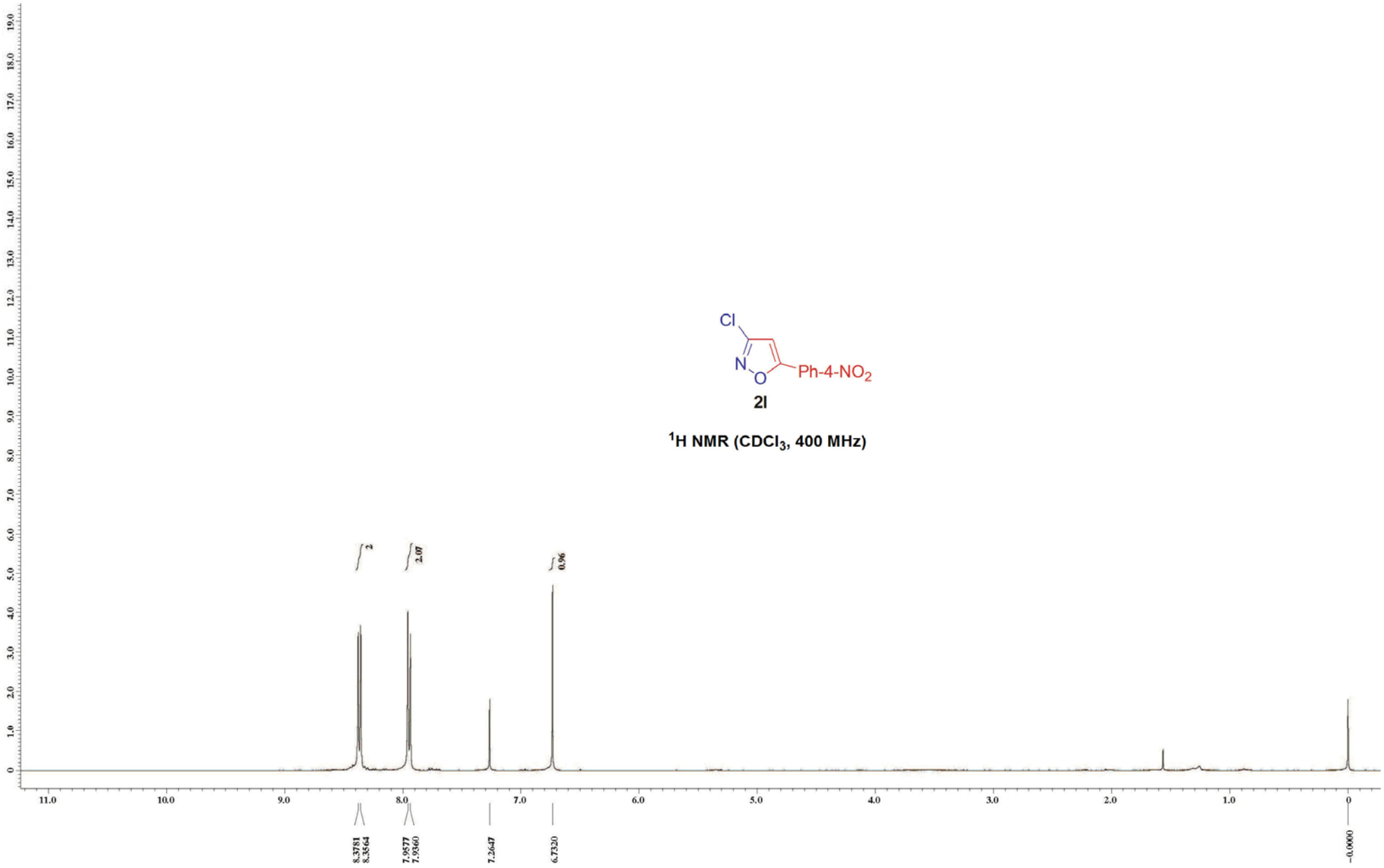

Cl
N
O
Ph-4-OMe
2k
^{1}H NMR ($CDCl_3$, 400 MHz)
2
2.06
0.93
3.06
40.0
30.0
20.0
10.0
0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
7.6931
7.6714
7.2613
6.9932
6.9715
6.4021
3.8649
0.0000

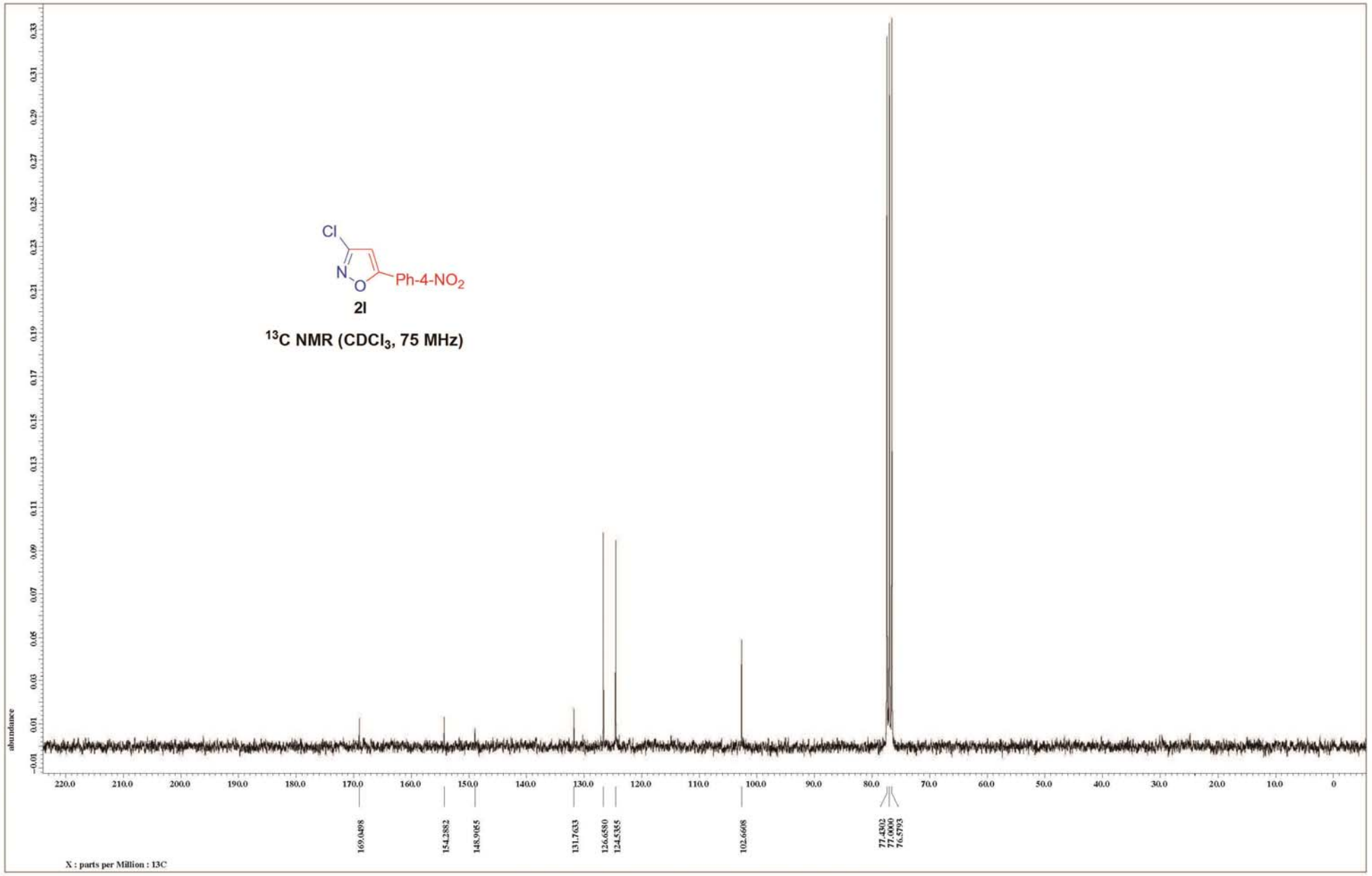


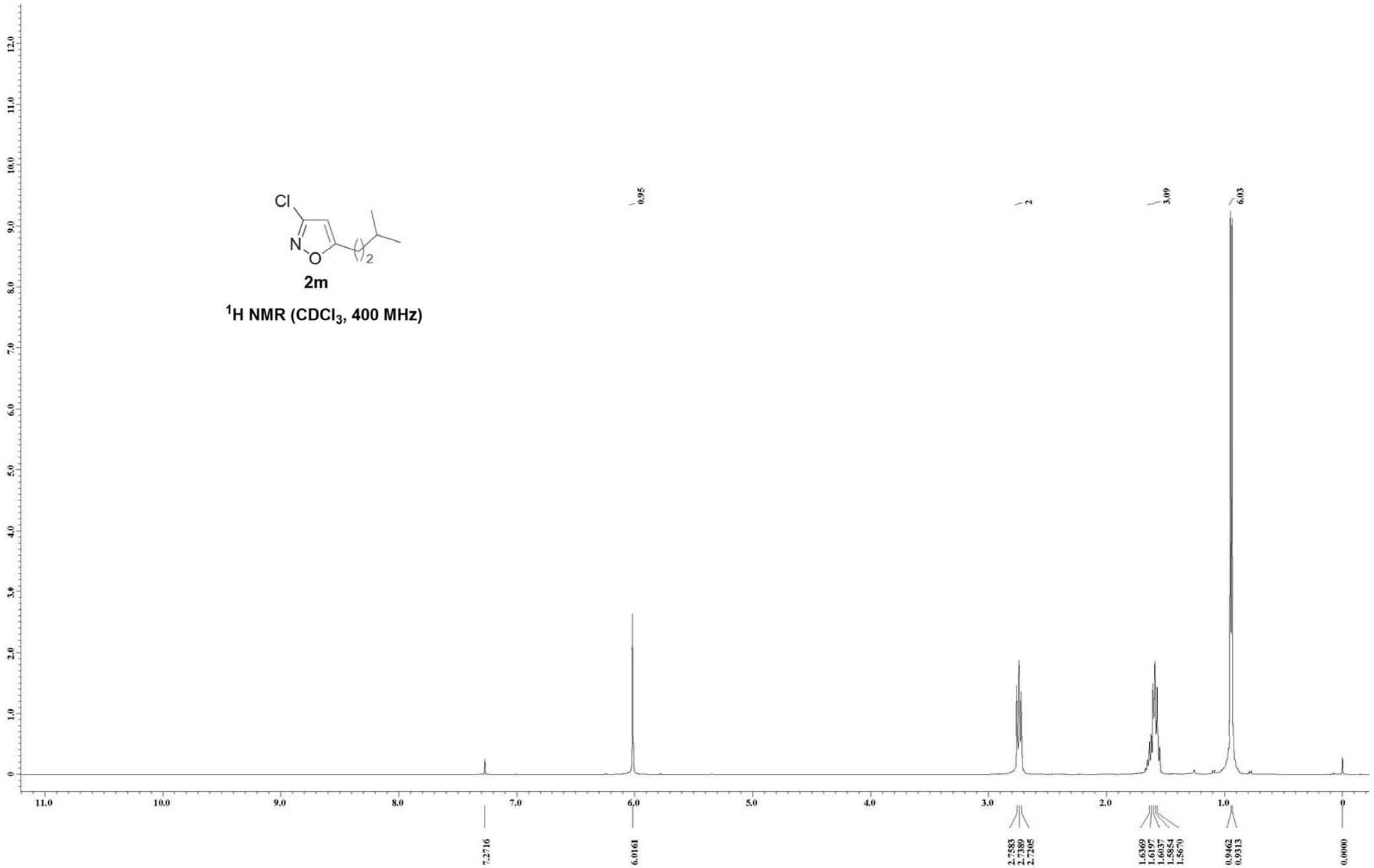
2k

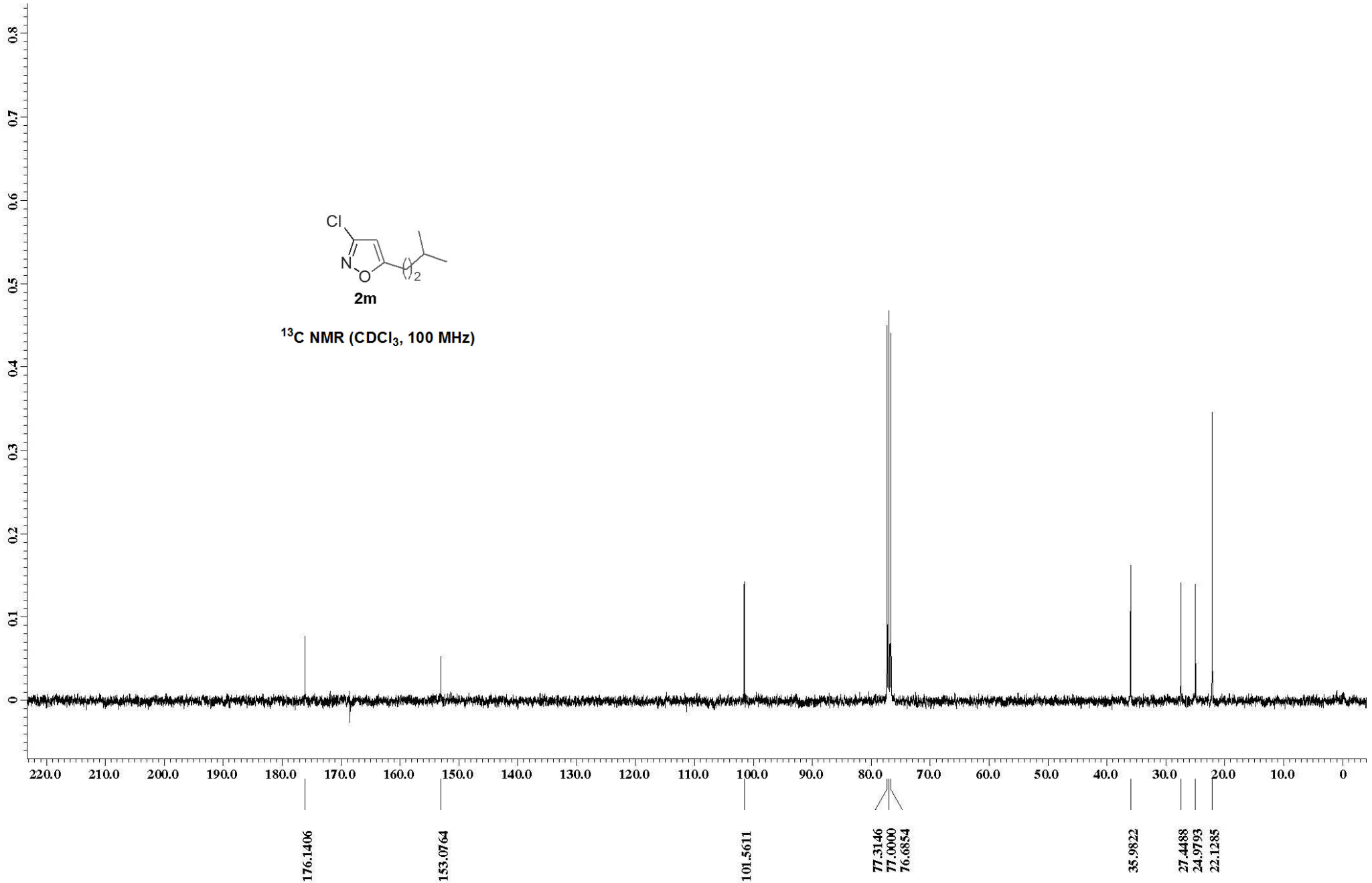
^{13}C NMR ($CDCl_3$, 75 MHz)

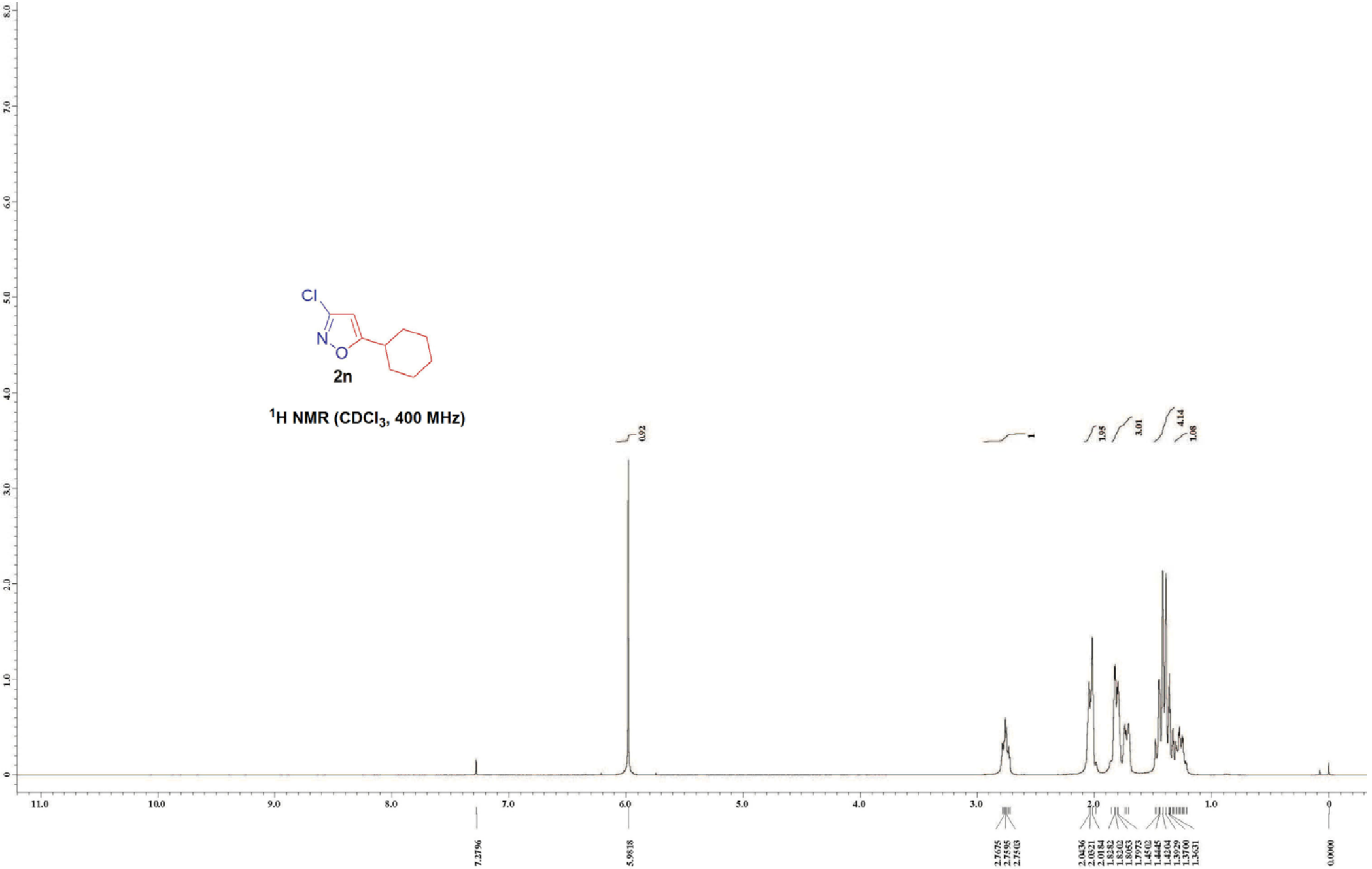


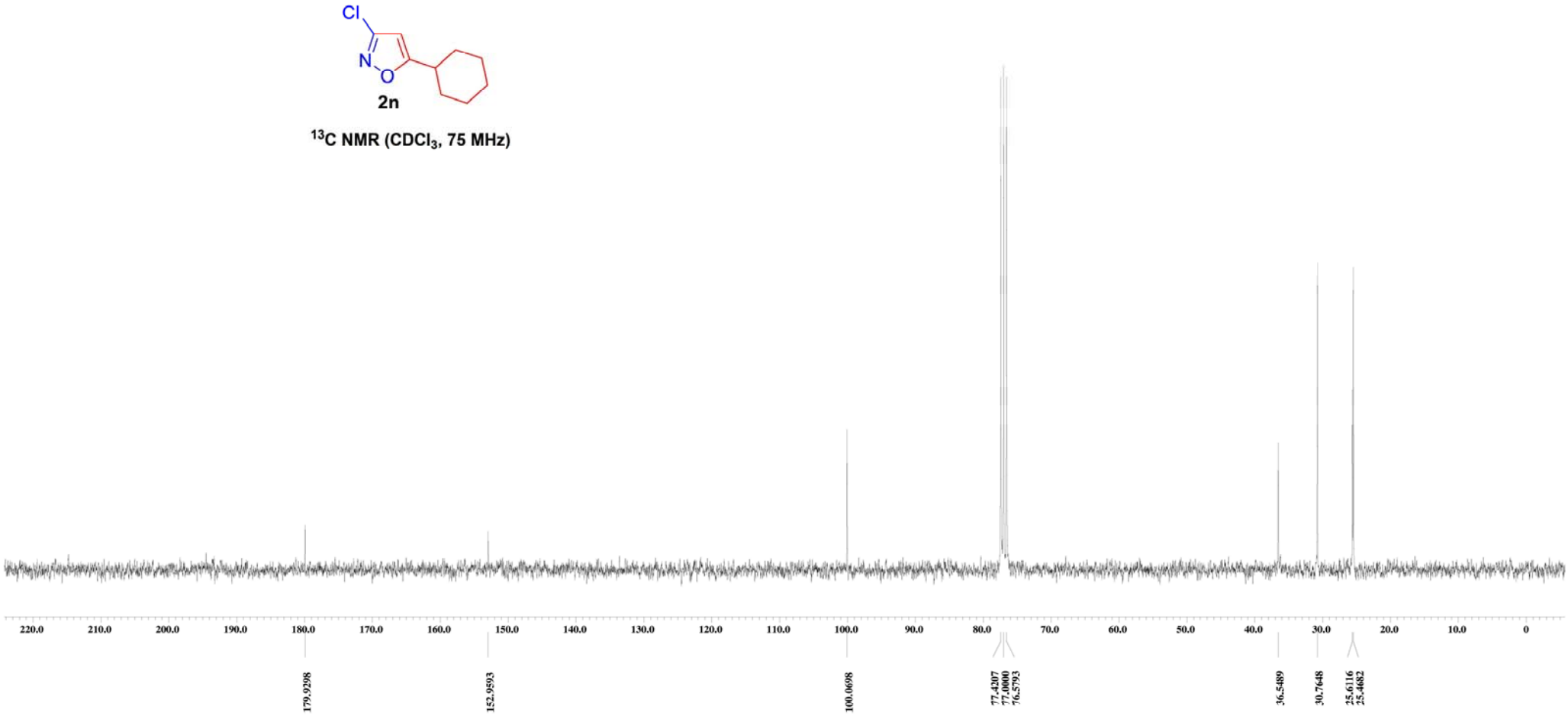

Cl
N
O
Ph-4-NO2
2l
1H NMR (CDCl3, 400 MHz)
2
2.07
0.96
8.3781
8.3564
7.9577
7.9360
7.2647
6.7320
0.0000

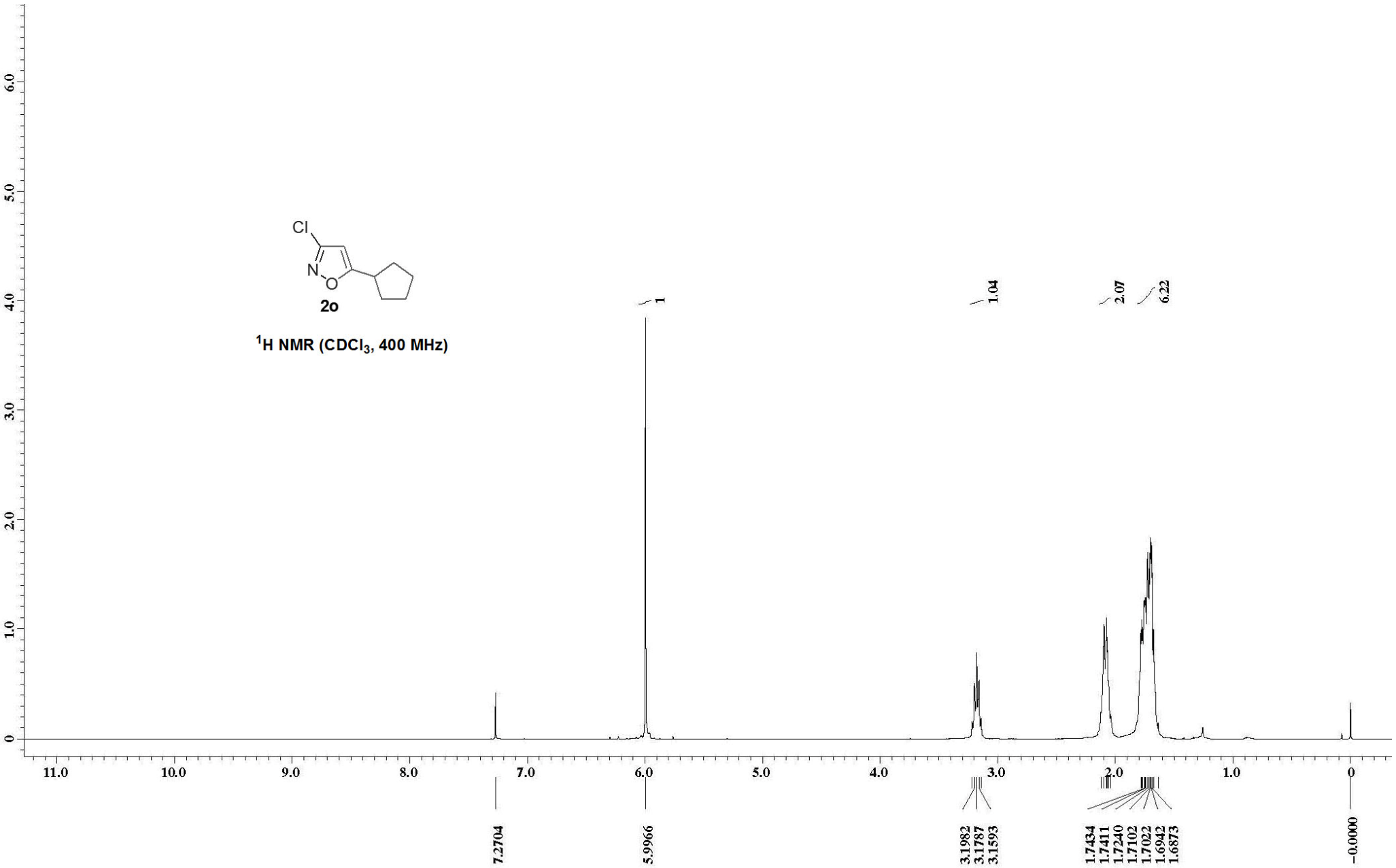

Cl
N
O
Ph-4-NO2
2l
13C NMR (CDCl3, 75 MHz)
abundance
169.0498
154.2882
148.9085
131.7633
126.6580
124.5395
102.6608
77.4302
77.0000
76.5793
X : parts per Million : 13C

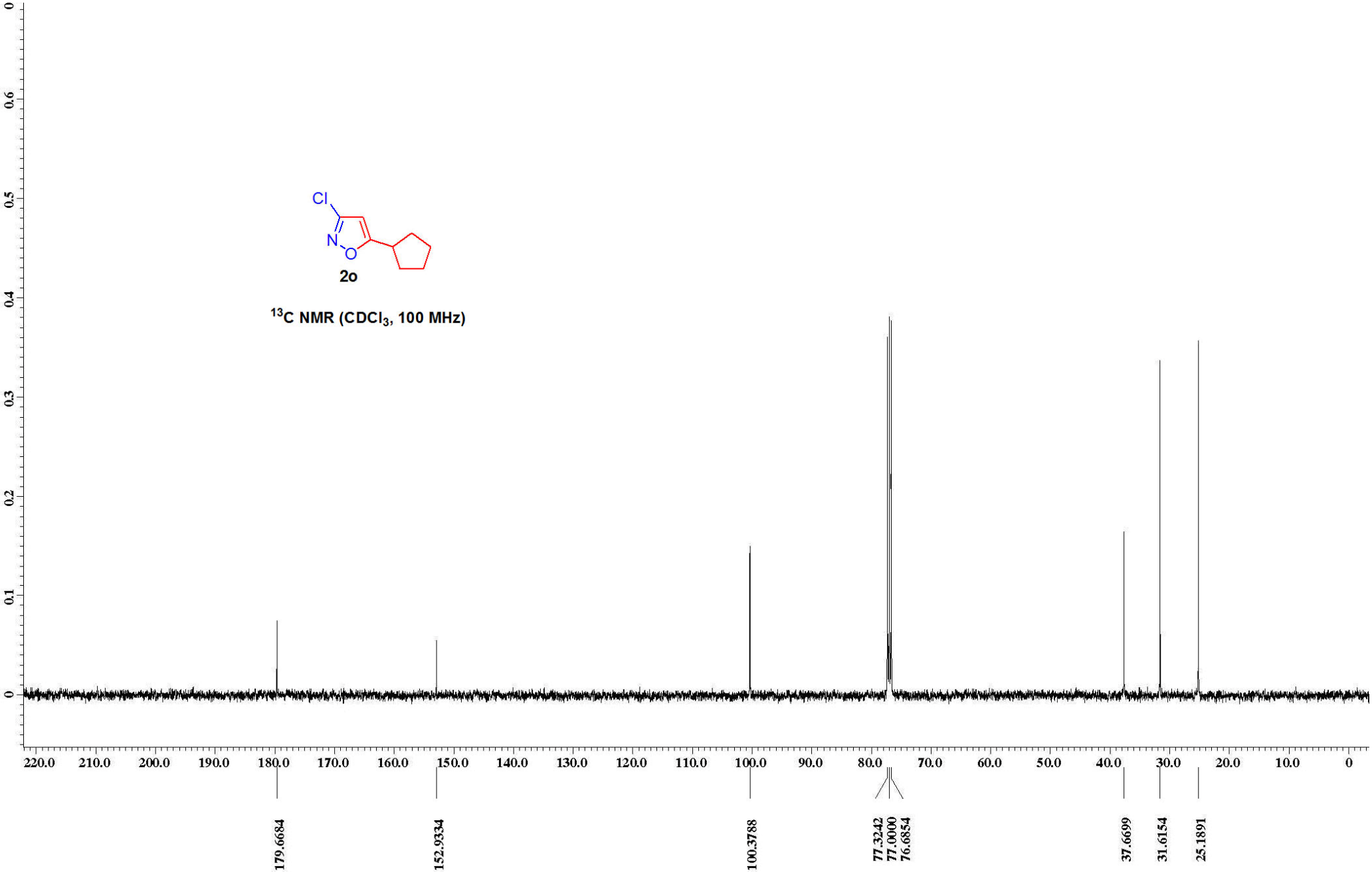

Cl
N
O
2
2m
^{1}H NMR ($CDCl_3$, 400 MHz)
0.95
2
3.09
6.03
7.2716
6.0161
2.7583
2.7389
2.7205
1.6369
1.6197
1.6037
1.5854
1.5670
0.9462
0.9313
0.0000

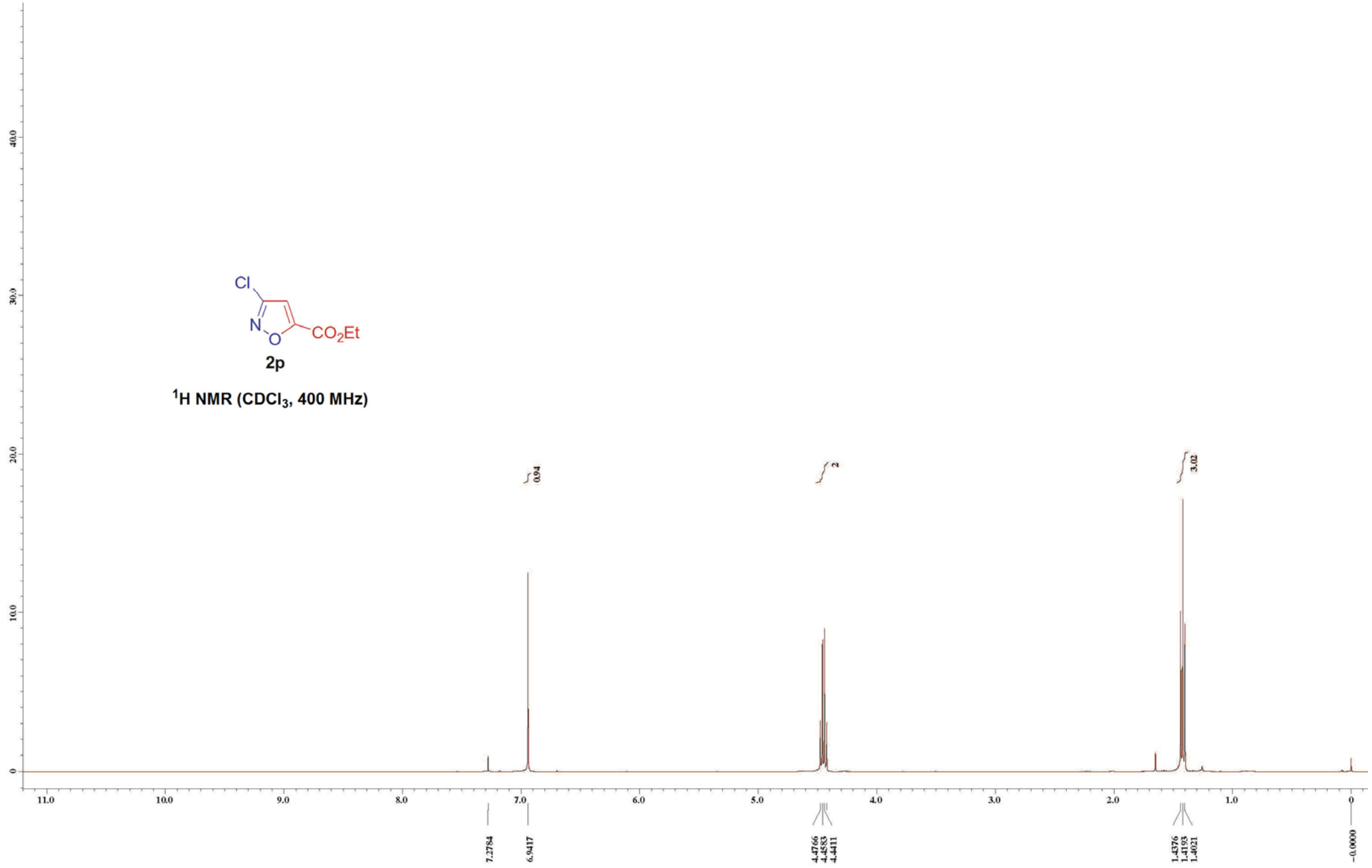

Cl
N
O
2
2m
13C NMR (CDCl3, 100 MHz)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
176.1406
153.0764
101.5611
77.3146
77.0000
76.6854
35.9822
27.4488
24.9793
22.1285

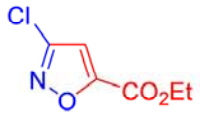

Cl
N
O
2n
^{1}H NMR ($CDCl_3$, 400 MHz)
0.92
1
1.95
3.01
4.14
1.08
7.2796
5.9818
2.7675
2.7595
2.7503
2.0436
2.0321
2.0184
1.8383
1.8302
1.8053
1.7973
1.4502
1.4445
1.4204
1.3929
1.3700
1.3631
0.0000


Cl
N
O
2n
^{13}C NMR ($CDCl_3$, 75 MHz)
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
179.9298
152.9593
100.0698
77.4207
77.0000
76.5793
36.5489
30.7648
25.6116
25.4682


Cl
N
O
2o
1H NMR (CDCl3, 400 MHz)
1
1.04
2.07
6.22
7.2704
5.9966
3.1982
3.1787
3.1593
1.7434
1.7411
1.7240
1.7102
1.7022
1.6942
1.6873
−0.0000


Cl
N
O
2o
^{13}C NMR ($CDCl_3$, 100 MHz)
0
0.1
0.2
0.3
0.4
0.5
0.6
220.0
210.0
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
179.6684
152.9334
100.3788
77.3242
77.0000
76.6854
37.6699
31.6154
25.1891


Cl
N
O
CO2Et
2p
1H NMR (CDCl3, 400 MHz)
0.94
2
3.02
7.2784
6.9417
4.4766
4.4583
4.4411
1.4376
1.4193
1.4021
-0.0000



2p

^{13}C NMR ($CDCl_3$, 75 MHz)