Photocatalytic Aminodecarboxylation of Carboxylic Acids

Simon B. Lang, Kaitie C. Cartwright[‡], Richard S. Welter[‡], Theresa M. Locascio, Jon A. Tunge

Supporting Information

Table of Contents

1: General considerations 2

2: General experimental procedures 3

3: Characterization of products 4

4: References 12

5: ^{1}H and ^{13}N NMR spectroscopy reprints 13+

1. General Considerations

TLC analysis was performed (fluorescence quenching or phosphomolybdic acid stain) with silica gel HL TLC plates with UV254 purchased from Sorbent Technologies.

Silica gel used for column chromatography (60 Å porosity, 230 x 400 mesh, standard grade) was purchased from Sorbent Technologies (catalog # 30930M-25).

Aluminum oxide for column chromatography (58 Å porosity, activated, neutral, Brockman I was purchased from Sigma Aldrich (CAS: 1344-28-1).

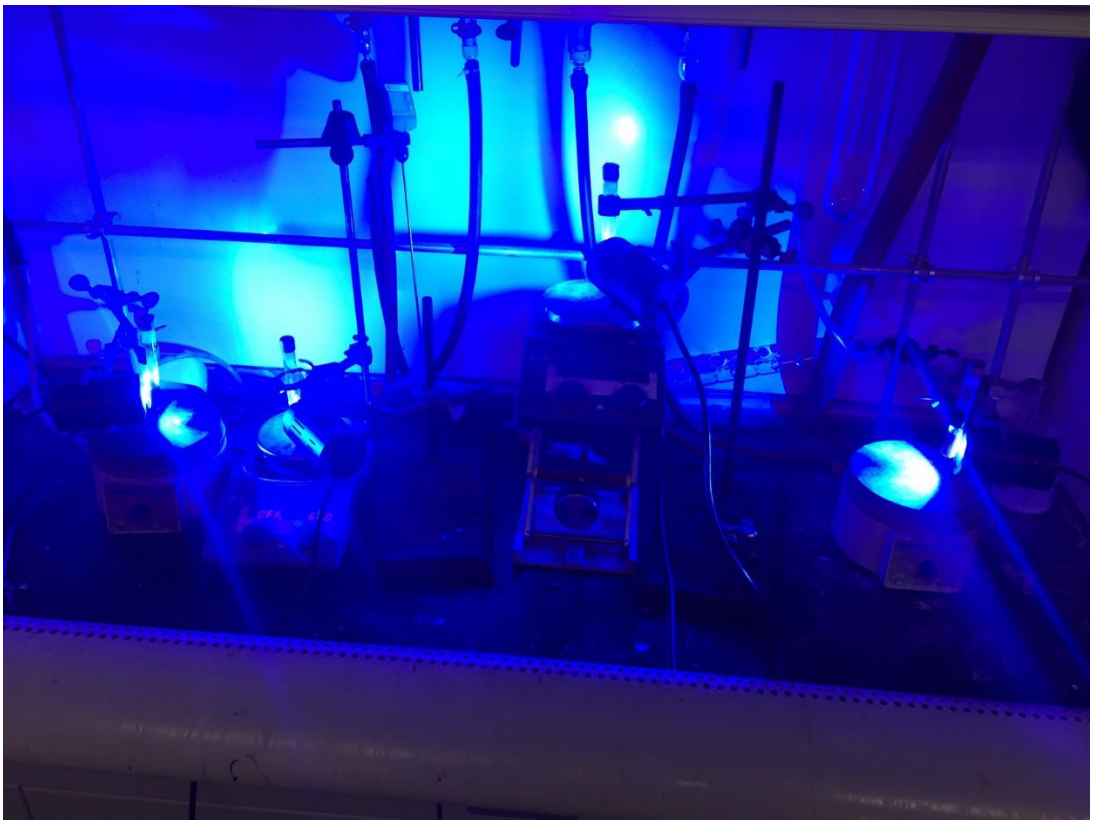
The photocatalyst, Mes-Acr-Ph, and the diisopropyl azidocarboxylate (DIAD) were purchased from Sigma Aldrich.

Anhydrous MeCN was purchased from Sigma Aldrich.

All carboxylic acid starting materials, except for 2-(4-(dibenzylamino)phenyl)acetic acid which was previously made in our lab,[1] are commercially available.

GC/MS data was obtained on a Shimadzu GCMS-QP2010 SE. ^{1}H and ^{13}C NMR spectra were obtained on a Bruker ADVANCE 500 DRX equipped with a QNP cryoprobe. These spectra were referenced to residual protio solvent signals. HRMS data was obtained on an ESI LC-TOF Micromass LCT (Waters).

Final aminodecarboxylation reactions were run in a screw threaded tube from Chemglass (CLS-4208). Kessil H150 Blue LED grow lights provided 450 nm light. A 4.0 mL solution of MeCN had an internal temperature of 33°C after 1 hour under standard reaction conditions.



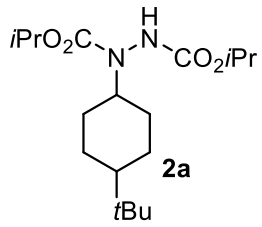
2. General Experimental Procedures

Aminodecarboxylation: A 16 x 125 mm threaded glass tube was charged with a stir bar, 0.4 mmol carboxylic acid starting material, and 0.002 g (1 mol%) of Mes-Acr-Ph photocatalyst. 4.0 mL of MeCN was added to the vial which was then capped and sparged with Ar for 5 minutes. After sparging, DBU (0.1 mmol) and DIAD (0.5 mmol) were added sequentially via syringe. The reaction was placed in front of 450 nm blue LEDs and analyzed by GC/MS. When the reaction was complete the solvent was removed *in vacuo* and the residue was purified by flash column chromatography on silica gel with 1% Et_3N in the eluent. If decomposition of the product was observed by GC/MS post chromatography, then neutral aluminum oxide was used as the stationary phase.

Product Manipulation[2]: A 10 mL oven dried Schlenk flask was cooled under an atmosphere of argon. A stir bar, Cs_2CO_3 (0.196g, 0.6 mmol) and 3 mL MeCN were added. Next, product **2c** (0.068g, 0.22 mmol) was added followed by methyl bromoacetate (0.069g, 0.4 mmol) and the reaction mixture was capped and heated at 50 ^oC overnight. Lastly, the reaction was quenched with 5 mL of aq NH_4Cl and extracted with EtOAc (3x10 mL). The combined organics were washed with brine, dried with $MgSO_4$, and concentrated *in vacuo*.

The crude material was dissolved in 1.0 mL MeCN and transferred to a 16 x 125 mm threaded glass tube that was charged with a stir bar and Cs_2CO_3 (0.130g, 0.4 mmol). The tube was capped and heated overnight (bath temperature 115 ^oC). The crude reaction was loaded directly onto a silica gel column and purified (1:15 to 1:10 EtOAc to hexanes) to provide 0.0455g (93%) of the desired carbamate **3c**.

3. Characterization of Products



2a

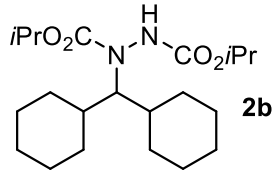
A mixture of rotamers and diastereomers (1:1 d.r.).

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.22 (m, 1H), 4.94 (m, 2H), 4.05 (m, 1H), 2.03 (m, 1H), 1.81 (m, 2H), 1.54 (m, 2H), 1.37 (m, 1H), 1.24 (m, 12 H), 1.01 (m, 3H), 0.83 (s, 9H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.8, 156.0, 69.9, 69.7, 52.4, 46.9, 32.6, 30.1, 27.7, 26.3, 22.9, 22.2.

IR (film) 3298, 2943, 2867, 1731, 1467, 1373, 1307, 1226, 1180, 1110, 1033, 914, 763 cm^{-1}.

HRMS: Calc'd $C_{18}H_{34}N_2O_4Na$ $(M+Na)^+$ = 365.2416, found = 365.2410.



2b

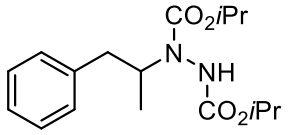
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.02 (m, 1H), 4.91 (m, 2H), 3.72 (m, 1H), 1.65 (m, 13H), 1.19 (m, 22H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 157.3, 156.4, 70.2, 69.6, 66.4, 38.4, 36.6, 30.3, 29.9, 26.6, 22.8, 22.1.

IR (film) 3257, 2979, 2925, 2852, 1755, 1712, 1448, 1384, 1294, 1110, 1031, 912, 734 cm^{-1}.

HRMS: Calc'd $C_{21}H_{39}N_2O_4Na$ $(M+Na)^+$ = 383.2910, found = 383.2916.



2c

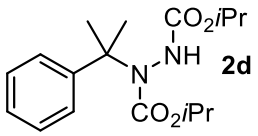
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28 (m, 2H), 7.30 (m, 3H), 6.00 (m, 1H), 4.98 (p, *J* = 6.23 Hz, 1H), 4.86 (m, 1H), 4.61 (m, 1H), 2.83 (m, 2H), 1.21 (m, 15H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.9, 155.5, 138.9, 129.1, 128.6, 126.5, 70.1, 69.8, 54.8, 40.7, 22.2, 22.1, 17.6.

IR (film) 3298, 2979, 2935, 1708, 1467, 1407, 1375, 1292, 1234, 1108, 1047, 746 cm^{-1}.

HRMS: Calc'd $C_{17}H_{26}N_2O_4Na$ $(M+Na)^+$ = 345.1790, found = 345.1777.



2d

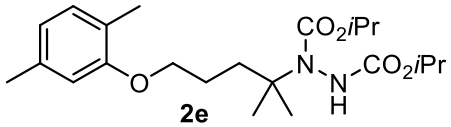
Purified on alumina instead of silica gel. A mixture of rotamers.

^1H NMR (500 MHz, $CDCl_3$) δ 7.47 (m, 2H), 7.30 (t, *J* = 7.73 Hz, 2H), 7.20 (t, *J* = 7.25 Hz, 1H), 6.50 (m, 1H), 5.03 (m, 1H), 4.71 (m, 1H), 1.72 (br s, 3H), 1.60 (s, 3H), 1.33 (m, 6H), 0.95 (m, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 157.3, 155.3, 148.6, 128.2, 126.3, 124.8, 70.3, 69.9, 64.1, 28.8, 27.9, 22.2, 21.7.

IR (film) 3299, 2981, 2937, 2358, 2331, 1712, 1521, 1496, 1467, 1384, 1321, 1261, 1180, 1108, 1029, 912, 763, 742, 700.

HRMS: Calc'd $C_{17}H_{26}N_2O_4Na$ $(M+Na)^+$ = 345.1790, found = 345.1797.



2e

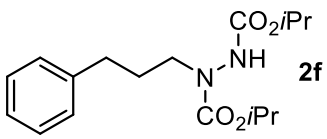
A mixture of rotamers.

^1H NMR (500 MHz, $CDCl_3$) δ 7.01 (d, *J* = 7.42 Hz, 1H), 6.66 (d, *J* = 7.50 Hz, 1H), 6.63 (s, 1H), 6.30 (m, 1H), 4.94 (m, 2H), 3.94 (t, *J* = 6.27 Hz, 2H), 2.31 (s, 3H), 2.19 (s, 3H), 2.08 (m, 1H), 1.89 (m, 2H), 1.77 (m, 1H), 1.49 (m, 3H), 1.34 (m, 3H), 1.26 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 157.1, 156.9, 155.1, 136.6, 130.4, 123.6, 120.7, 112.1, 70.0, 69.6, 68.2, 62.4, 36.9, 27.0, 26.5, 24.9, 22.3, 21.6, 16.0.

IR (film) 3315, 2979, 2935, 1712, 1614, 1585, 1510, 1467, 1373, 1315, 1265, 1130, 1112, 1047, 912, 802 cm^{-1}.

HRMS: Calc'd $C_{22}H_{36}N_2O_5Na$ $(M+Na)^+$ = 431.2522, found = 431.2506.



2f

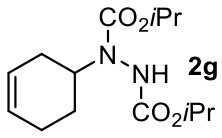
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28 (m, 2H), 7.20 (d, *J* = 7.35 Hz, 3H), 6.30 (m, 1H), 4.96 (m, 2H), 3.55 (br s, 2H), 2.65 (t, *J* = 7.72 Hz, 2H), 1.92 (p, *J* = 7.33 Hz, 2H), 1.25 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.3, 156.0, 141.8, 128.5, 126.1, 70.2, 69.9, 49.8, 33.1, 29.9, 22.3, 22.2.

IR (film) 3299, 2981, 2933, 1712, 1467, 1413, 1375, 1274, 1180, 1108, 1029, 912, 742 cm^{-1}.

HRMS: Calc'd $C_{17}H_{26}N_2O_4Na$ $(M+Na)^+$ = 345.1790, found = 345.1783.



2g

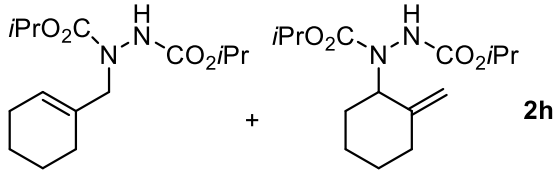
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.18 (m, 1H), 5.61 (br s, 2H), 4.95 (br s, 2H), 4.30 (br s 1H), 2.18 (m, 4H), 1.77 (m, 2H), 1.25 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 157.0, 155.3, 126.5, 125.4, 70.1, 69.8, 53.4, 28.8, 26.5, 25.6, 22.3, 22.1.

IR (film) 3298, 2979, 2933, 1708, 1514, 1467, 1409, 1375, 1301, 1238, 1180, 1108, 1039, 914, 763 cm^{-1}.

HRMS: Calc'd $C_{14}H_{24}N_2O_4Na$ $(M+Na)^+$ = 307.1634, found = 307.1639.



2h

16:1, major resonances reported

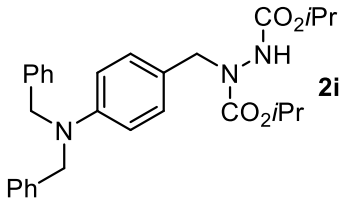
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.32 (m, 1H), 5.54 (s, 1H), 4.93 (m, 2H), 3.97 (s, 2H), 2.00 (br s, 2H), 1.92 (br s, 2H), 1.59 (m, 4H), 1.25 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.3, 155.6, 133.0, 125.5, 70.2, 69.7, 56.3, 26.4, 25.2, 22.7, 22.4, 22.2, 22.1.

IR (film) 3301, 2979, 2931, 1708, 1411, 1373, 1263, 1217, 1178, 1108, 1035, 912, 742 cm^{-1}.

HRMS: Calc'd $C_{15}H_{26}N_2O_4Na$ $(M+Na)^+$ = 321.1790, found = 321.1796.



2i

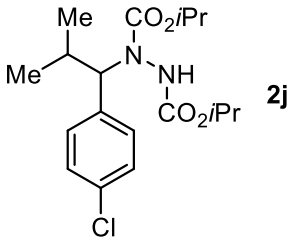
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 (t, *J* = 7.44 Hz, 4H), 7.25 (m, 6H), 7.08 (d, *J* = 8.11 Hz, 2H), 6.68 (d, *J* = 8.27 Hz, 2H), 6.26 (m, 1H), 4.96 (m, 2H), 4.60 (m, 6H), 1.25 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.0, 155.8, 148.8, 138.5, 128.8, 127.0, 126.7, 112.3, 70.1, 69.6, 54.4, 52.9, 22.2, 22.1.

IR (film) 3299, 2979, 2935, 2250, 1712, 1614, 1585, 1452, 1384, 1261, 1218, 1108, 1029, 956, 912, 804, 732 cm^{-1}.

HRMS: Calc'd $C_{29}H_{35}N_3O_4Na$ $(M+Na)^+$ = 512.2525, found = 512.2527.



2j

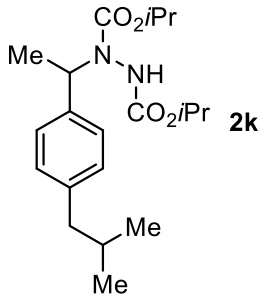
Purified on alumina. A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28 (m, 4H), 5.83 (m, 1H), 4.73 (m, 3H), 2.33 (br s, 1H), 1.22 (m, 12H), 0.94 (m, 2H), 0.69 (m, 4H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.6, 155.9, 136.9, 133.7, 130.5, 130.4, 128.7, 128.6, 70.3, 69.8, 66.9, 28.6, 22.2, 22.1, 21.0, 20.5, 20.2, 20.0.

IR (film) 3286, 2979, 1712, 1492, 1469, 1404, 1384, 1317, 1282, 1226, 1180, 1145, 1108, 1033, 966, 912, 746 cm^{-1}.

HRMS: Calc'd $C_{18}H_{27}ClN_2O_4Na$ $(M+Na)^+$ = 393.1557, found = 393.1561.



2k

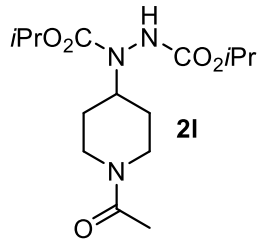
Purified on alumina. A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.23 (m, 2H), 7.10 (d, *J* = 7.82 Hz, 2H), 5.86 (m, 1H), 5.48 (m, 1H), 4.96 (m, 2H), 2.45 (d, *J* = 7.16 Hz, 2H), 1.85 (dh, *J* = 13.5, 6.79 Hz, 1H), 1.54 (m, 3H), 1.25 (m, 12H), 0.90 (d, *J* = 6.62 Hz, 6H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.5, 155.6, 141.2, 138.2, 129.3, 127.1, 70.2, 69.7, 55.1, 45.2, 30.4, 22.5, 22.3, 22.2, 22.1, 22.0, 16.7.

IR (film) 3294, 2979, 1714, 1514, 1469, 1384, 1303, 1230, 1108 cm^{-1}.

HRMS: Calc'd $C_{20}H_{32}N_2O_4Na$ $(M+Na)^+$ = 387.2260, found = 387.2252.



2l

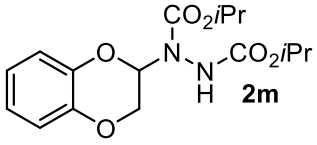
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.34 (m, 1H), 4.93 (m, 2H), 4.70 (m, 1H), 4.19 (m, 1H), 3.84 (m, 1H), 3.10 (t, *J* = 12.6 Hz, 1H), 2.55 (t, *J* = 13.1 Hz, 1H), 2.08 (s, 3H), 1.70 (m, 4H), 1.25 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 169.0, 156.7, 155.1, 70.4, 70.0, 54.7, 45.7, 40.9, 30.0, 29.0, 22.2, 22.1, 21.6.

IR (film) 3284, 2935, 2869, 1731, 1631, 1454, 1411, 1373, 1303, 1249, 1108, 103, 912, 732 cm^{-1}.

HRMS: Calc'd $C_{15}H_{27}N_3O_5Na$ $(M+Na)^+$ = 352.1848, found = 352.1849.



2m

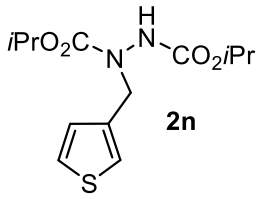
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.88 (m, 4H), 6.49 (m, 1H), 6.06 (m, 1H), 5.00 (m, 2H), 4.42 (m, 1H), 4.03 (t, *J* = 9.64 Hz, 1H), 1.28 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 154.5, 142.9, 142.5, 122.1, 121.9, 117.4, 117.2, 79.2, 72.0, 70.4, 64.6, 22.1.

IR (film) 3307, 2981, 2937, 1731, 1595, 1494, 1409, 1377, 1303, 1267, 1244, 1182, 1108, 1076, 962, 912, 869, 748 cm^{-1}.

HRMS: Calc'd $C_{16}H_{22}N_2O_6Na$ $(M+Na)^+$ = 361.1376, found = 361.1383.



2n

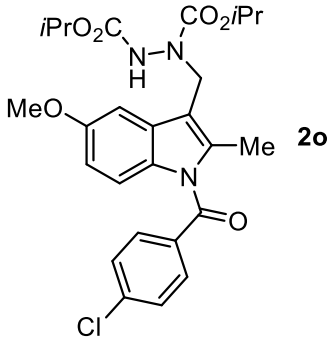
Purified on alumina. A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28 (dd, *J* = 4.96, 2.92 Hz, 1H), 7.18 (br s, 1H), 7.04 (br s, 1H), 6.29 (m, 1H), 4.95 (m, 2H), 4.67 (br s, 2H), 1.25 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 155.9, 137.5, 128.1, 126.3, 123.7, 70.5, 69.9, 49.3, 48.4, 22.2, 22.1.

IR (film) 3298, 2979, 1712, 1502, 1407, 1384, 1269, 1238, 1207, 1180, 1107, 1039, 912, 742 cm^{-1}.

HRMS: Calc'd $C_{13}H_{20}N_2O_4SNa$ $(M+Na)^+$ = 323.1042, found = 323.1038.



2o

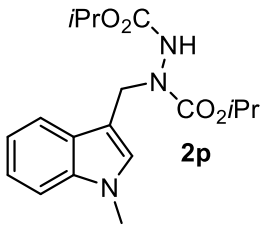
Purified on alumina. A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.63 (d, *J* = 8.46 Hz, 2H), 7.46 (d, *J* = 8.33 H, 2H), 7.06 (br m, 1H), 6.84 (m, 1H), 6.66 (dd, *J* = 9.09, 2.51 Hz, 1H), 6.25 (br m, 1H), 4.95 (m, 4H), 3.81 (s, 3H), 2.38 (s, 3H), 1.23 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 168.5, 156.2, 156.0, 155.8, 139.5, 137.7, 133.8, 131.3, 130.9, 130.6, 129.3, 115.0, 114.7, 114.4, 112.3, 111.8, 101.6, 101.4, 70.4, 69.9, 55.8, 43.1, 42.7, 42.3, 22.3, 22.1, 13.2.

IR (film) 3305, 2981, 2935, 2252, 1731, 1712, 1693, 1591, 1479, 1373, 1323, 1238, 1180, 1108, 1043, 912 cm^{-1}.

HRMS: Calc'd $C_{26}H_{30}ClN_3O_6Na$ $(M+Na)^+$ = 538.1721, found = 538.1725.



2p

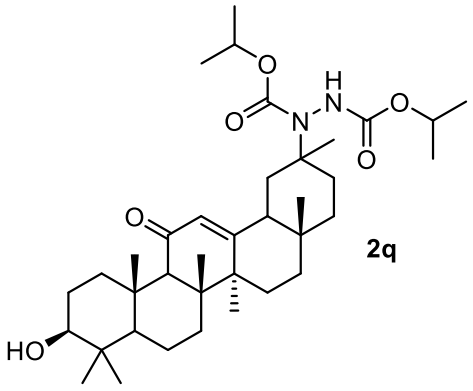
Purified on alumina instead of silica gel. A mixture of rotamers.

^1H NMR (500 MHz, $CDCl_3$) δ 7.69 (br s, 1H), 7.32 (d, *J* = 8.21 Hz, 1H), 7.26 (m, 1H), 7.14 (m, 1H), 7.05 (br s, 1H), 6.23 (m, 1H), 4.94 (m, 4H), 3.78 (s, 3H), 1.26 (m, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.0, 155.7, 137.2, 129.3, 127.6, 122.1, 119.6, 109.7, 109.4, 70.1, 69.7, 44.5, 32.9, 22.3, 22.1.

IR (film) 3299, 2981, 2935, 1731, 1714, 1693, 1469, 1328, 1269, 1220, 1108, 912, 742 cm^{-1}.

HRMS: Calc'd $C_{18}H_{25}O_4N_3Na$ $(M+Na)^+$ = 370.1743, found = 370.1730.



2q

A mixture of rotamers and diastereomers.

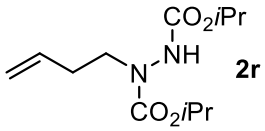
^1H NMR (500 MHz, $CDCl_3$) δ 6.37 (m, 1H), 5.57 (m, 1H), 4.90 (m, 2H), 3.20 (d, *J* = 6.46 Hz, 1H), 2.75 (d, *J* = 12.8 z, 1H), 2.32 (m, 2H), 2.11 (m, 3H), 1.67 (m, 7H), 1.37 (m, 9H), 1.23 (m, 14H), 1.11 (s, 6H), 0.98 (m, 5H), 0.84 (s, 3H), 0.78 (s, 3H), 0.67 (d, *J* = 11.6 Hz, 1H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 200.45, 200.34, 200.31, 200.25, 200.21, 169.53, 169.43, 169.24, 169.04, 168.77, 168.66, 157.18, 157.05, 157.03, 156.94, 155.64, 155.03, 154.70, 154.58, 128.61, 128.57, 128.53, 128.41, 78.83, 70.07, 69.99, 69.92, 69.82, 69.76, 69.69, 69.63, 69.46, 69.37, 63.14, 63.03, 62.30, 61.93, 61.90, 61.86, 55.02, 55.00, 48.56, 48.46, 48.37, 47.56, 46.41, 45.53, 45.46, 45.43, 43.45, 43.41, 43.35, 42.85, 42.08, 40.27, 40.02, 39.92, 39.25, 39.23, 37.41, 37.25, 37.19, 37.16, 37.13, 36.66, 36.03, 32.95,

32.91, 32.84, 32.55, 32.32, 32.29, 31.83, 31.80, 31.33, 30.35, 30.11, 29.83, 28.72, 28.53, 28.36, 28.24, 27.40, 26.80, 26.74, 26.62, 26.59, 26.54, 26.48, 26.45, 26.18, 23.53, 23.35, 23.29, 23.18, 22.34, 22.31, 22.29, 22.23, 22.19, 22.12, 22.11, 22.09, 22.06, 20.82, 20.75, 20.63, 20.51, 18.85, 18.83, 18.80, 18.79, 17.61, 16.50, 16.49, 16.47, 15.75.

IR (film) 3498, 3303, 2979, 2993, 2252, 1730, 1697, 1650, 1508, 1467, 1454, 1384, 1373, 1319, 1261, 1180, 1110, 1037, 995, 912, 732, 646.

HRMS: Calc'd $C_{37}H_{60}N_2O_6Na$ $(M+Na)^+$ = 651.4349, found = 651.4343.



2r

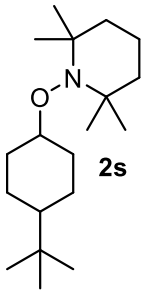
A mixture of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 6.32 (m, 1H), 5.79 (dq, *J* = 16.9, 7.80 Hz, 1H), 5.07 (m, 2H), 4.96 (m, 2H), 3.59 (br s, 2H), 2.35 (q, *J* = 7.08 Hz, 2H), 1.27 (d, *J* = 6.34 Hz, 12H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 156.5, 135.5, 117.0, 70.2, 69.9, 49.1, 32.0, 22.3, 22.2.

IR (film) 3301, 2981, 2935, 1714, 1415, 1386, 1265, 1211, 1108, 742 cm^{-1}.

HRMS: Calc'd $C_{12}H_{22}N_2O_4Na$ $(M+Na)^+$ = 281.1477, found = 281.1472.



2s

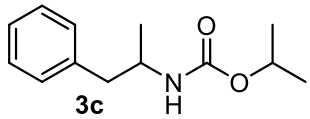
1.0:1.2 d.r.

^{1}H NMR (500 MHz, $CDCl_3$) δ 3.85 (p, *J* = 2.99 Hz, 0.45 H), 3.53 (tt, *J* = 11.2, 4.11 Hz, 0.55 H), 2.17 (m, 2H), 1.78 (m, 1H), 1.49 (m, 6H), 1.32 (m, 3H), 1.13 (m, 13H), 0.98 (m, 2H), 0.87 (s, 4H), 0.83 (s, 5H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 82.6, 77.7, 59.9, 59.8, 48.0, 47.7, 40.5, 40.4, 34.7, 34.4, 33.2, 32.7, 32.4, 31.4, 27.9, 27.8, 26.4, 22.2, 20.5, 17.5, 17.3.

IR (film) 2939, 1458, 1365, 1242, 1132, 1049, 958, 914.

HRMS: Calc'd $C_{19}H_{38}NO$ $(M+H)^+$ = 296.2953, found = 296.2961.



3c

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.30 (m, 2H), 7.23 (m, 1H), 7.19 (m, 2H), 4.90 (hept, *J* = 6.28 Hz, 1H), 4.48 (br s, 1H), 3.97 (br s, 1H), 2.86 (dd, *J* = 14.0, 5.25 Hz, 1H), 2.68 (dd, *J* = 13.4, 7.31 Hz, 1H), 1.22 (d, *J* = 6.28 Hz, 6H), 1.11 (d, *J* = 6.63 Hz, 3H).

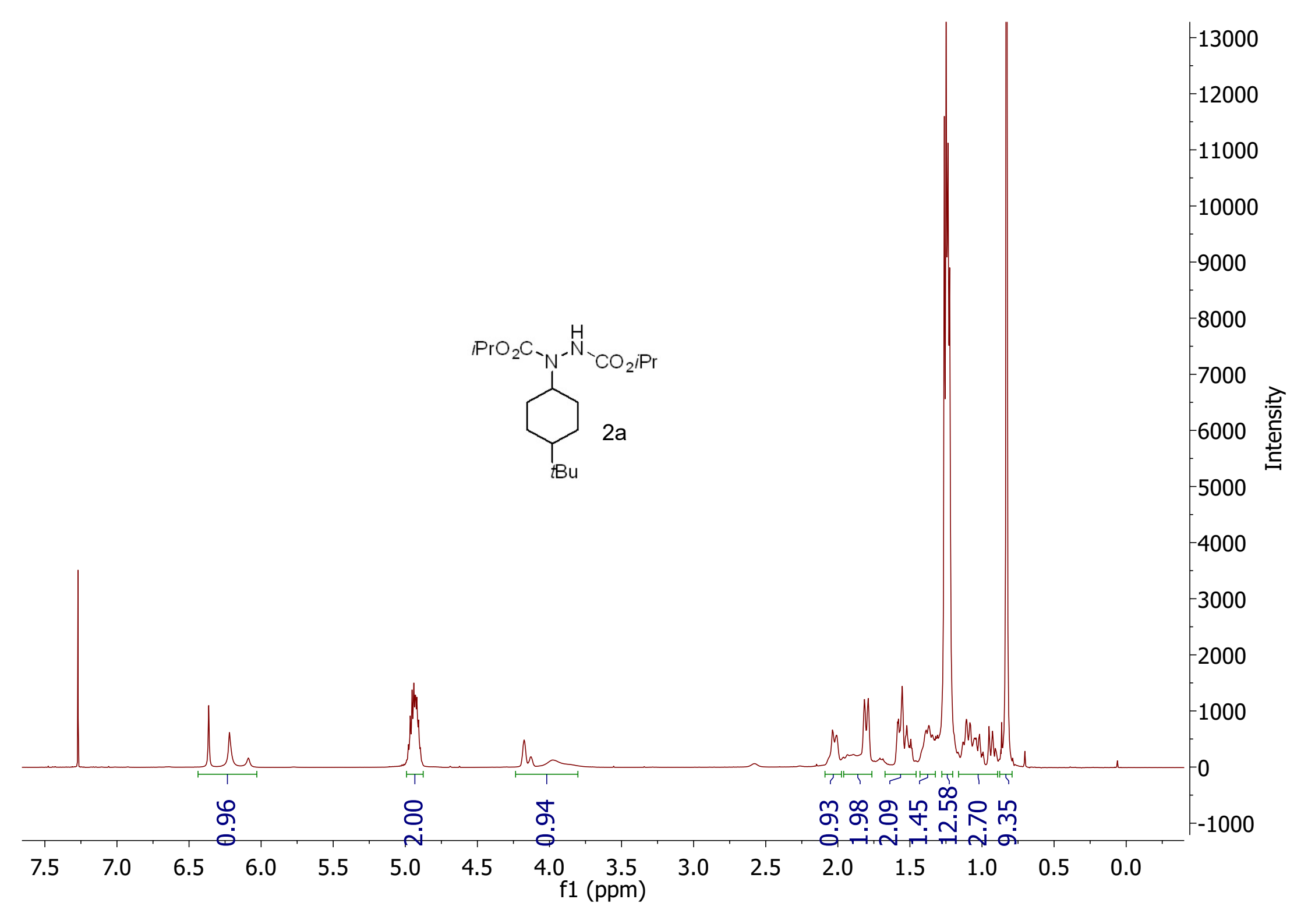
^{13}C NMR (126 MHz, $CDCl_3$) δ 155.7, 138.2, 129.6, 128.5, 126.5, 67.9, 47.9, 43.1, 22.4, 20.3.

IR (film) 3328, 2977, 2931, 1693, 1531, 1454, 1373, 1251, 1180, 1114, 1045, 700 cm^{-1}.

HRMS: Calc'd $C_{13}H_{19}NO_2Na$ $(M+Na)^+$ = 244.1313, found = 244.1312.

4. References

[1] Lang, S. B.; O'Nele, K. M.; Tunge, J. A. *J. Am. Chem. Soc.* **2014**, 13606.
[2] Chen, X.; Liu, X.; Mohr, J. T. *Org. Lett.* **2016**, *18*, 716-719.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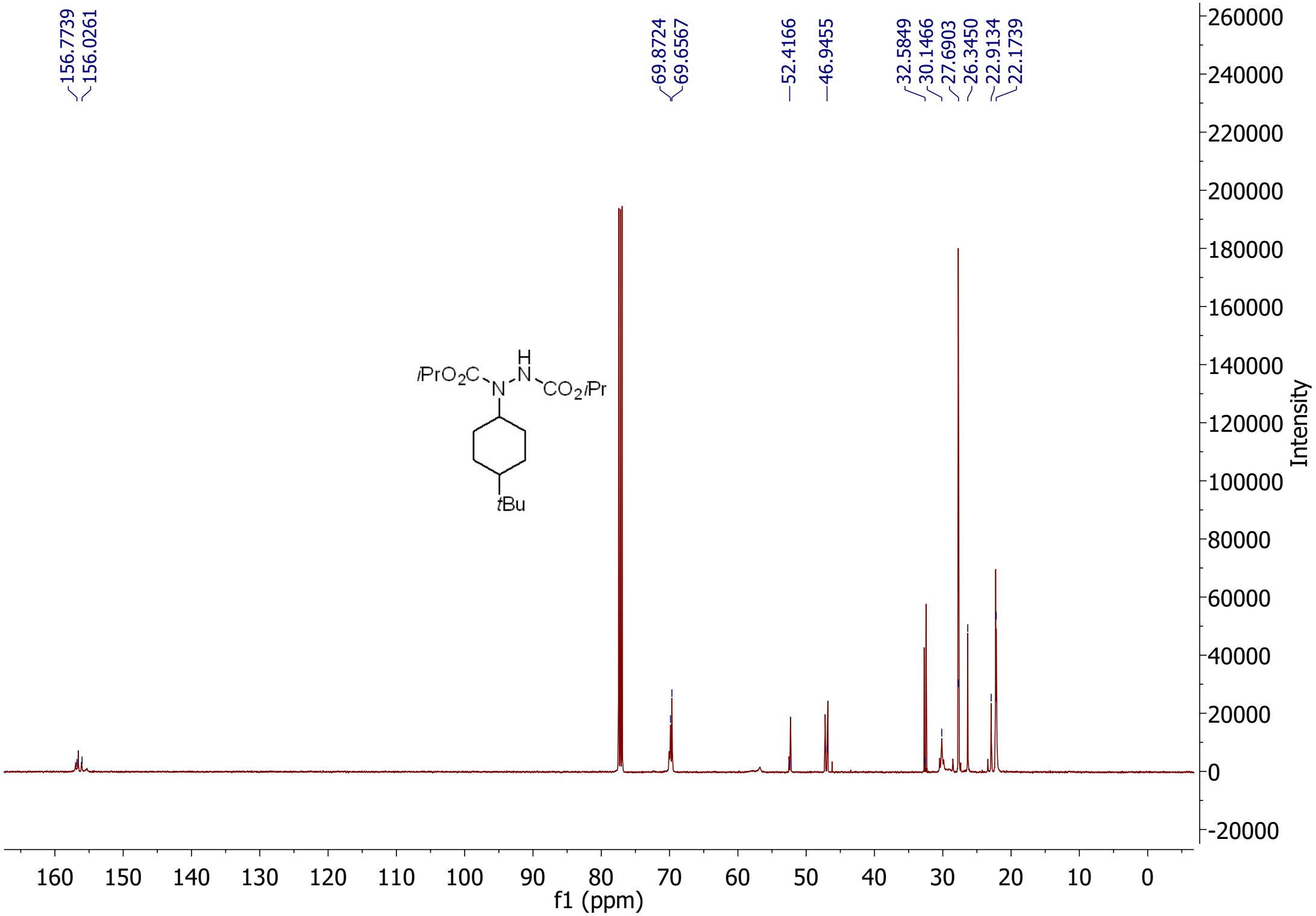
N
H
N
CO2iPr
tBu
2a
0.96
2.00
0.94
0.93
1.98
2.09
1.45
12.58
2.70
9.35
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Intensity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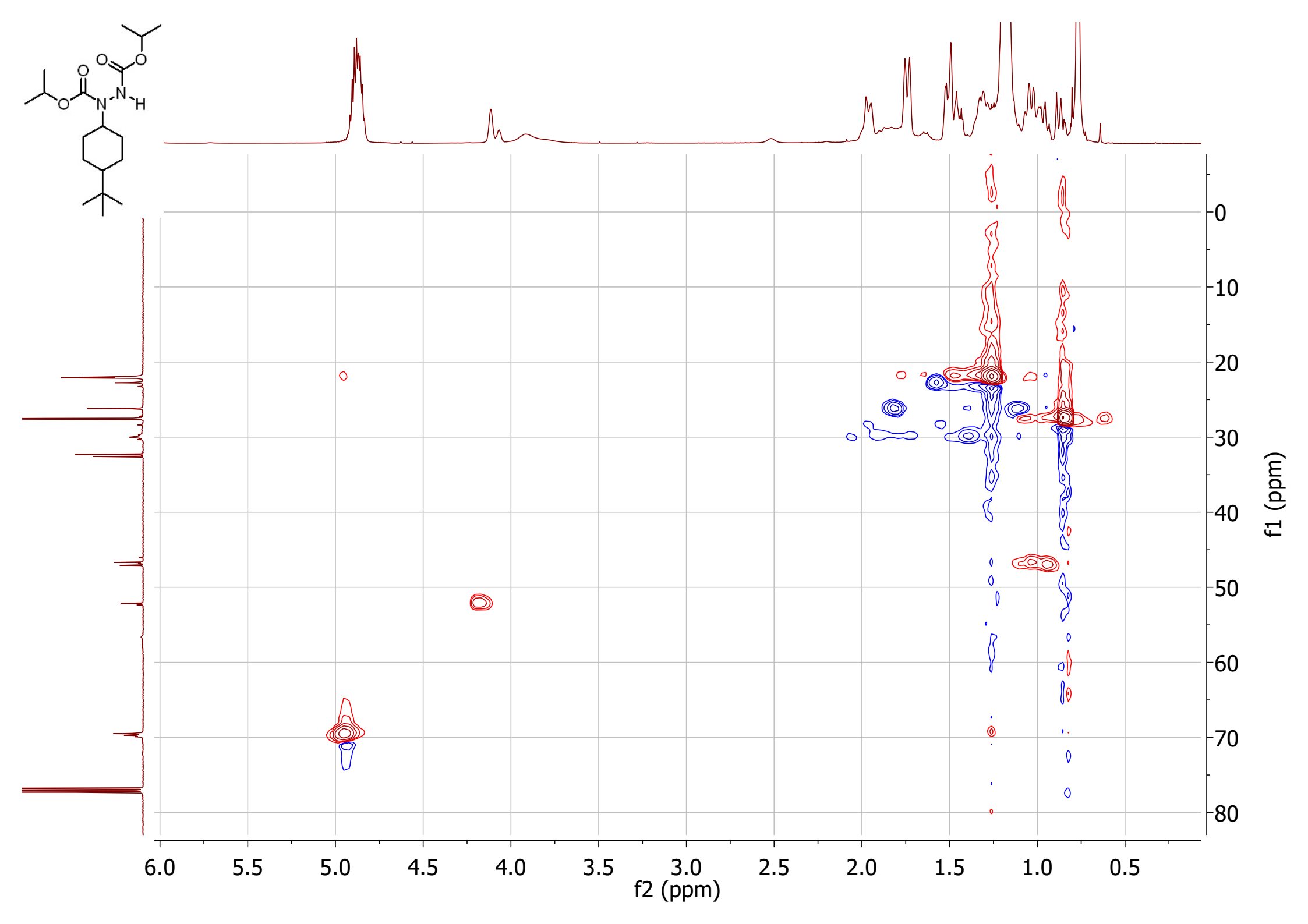
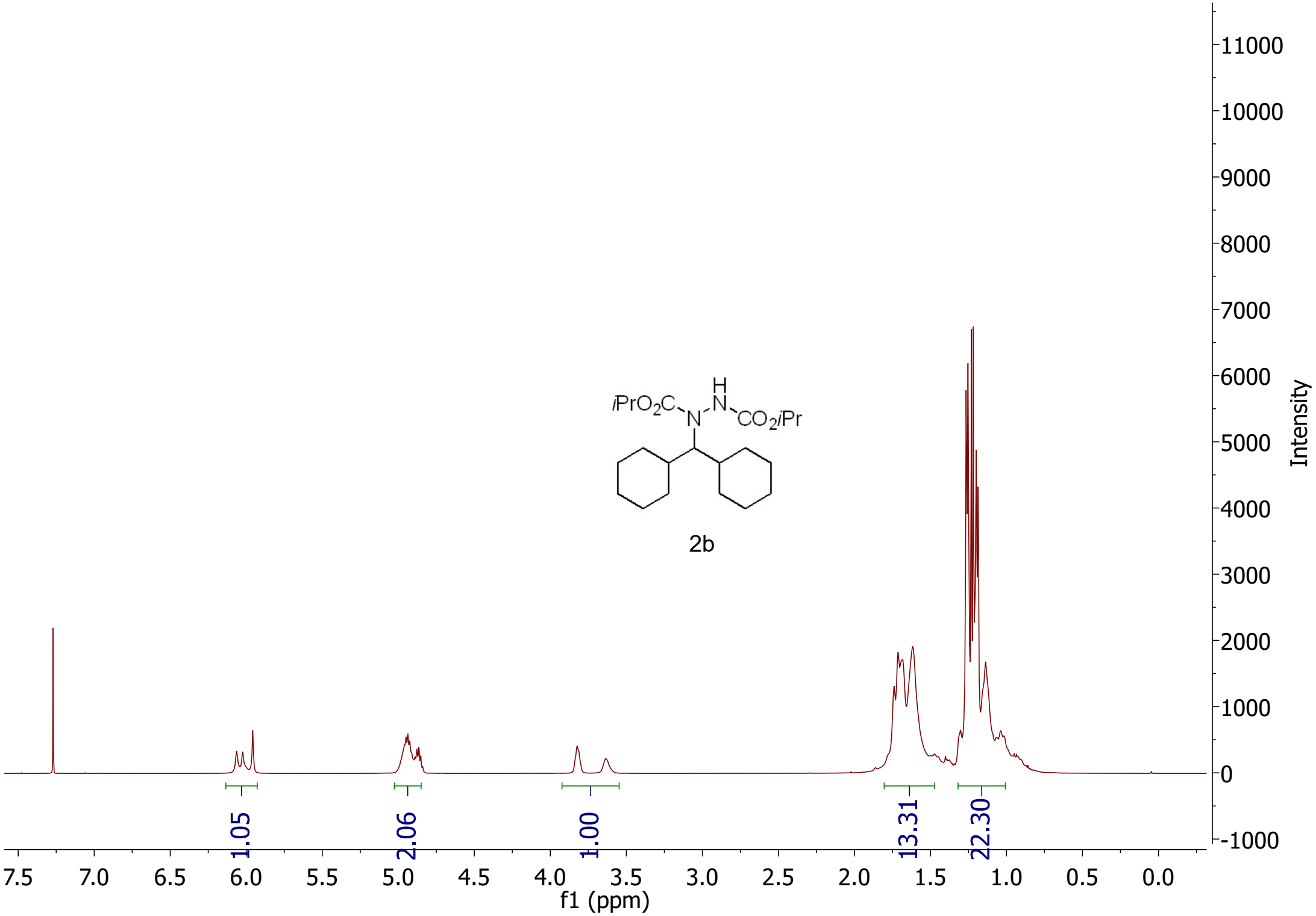
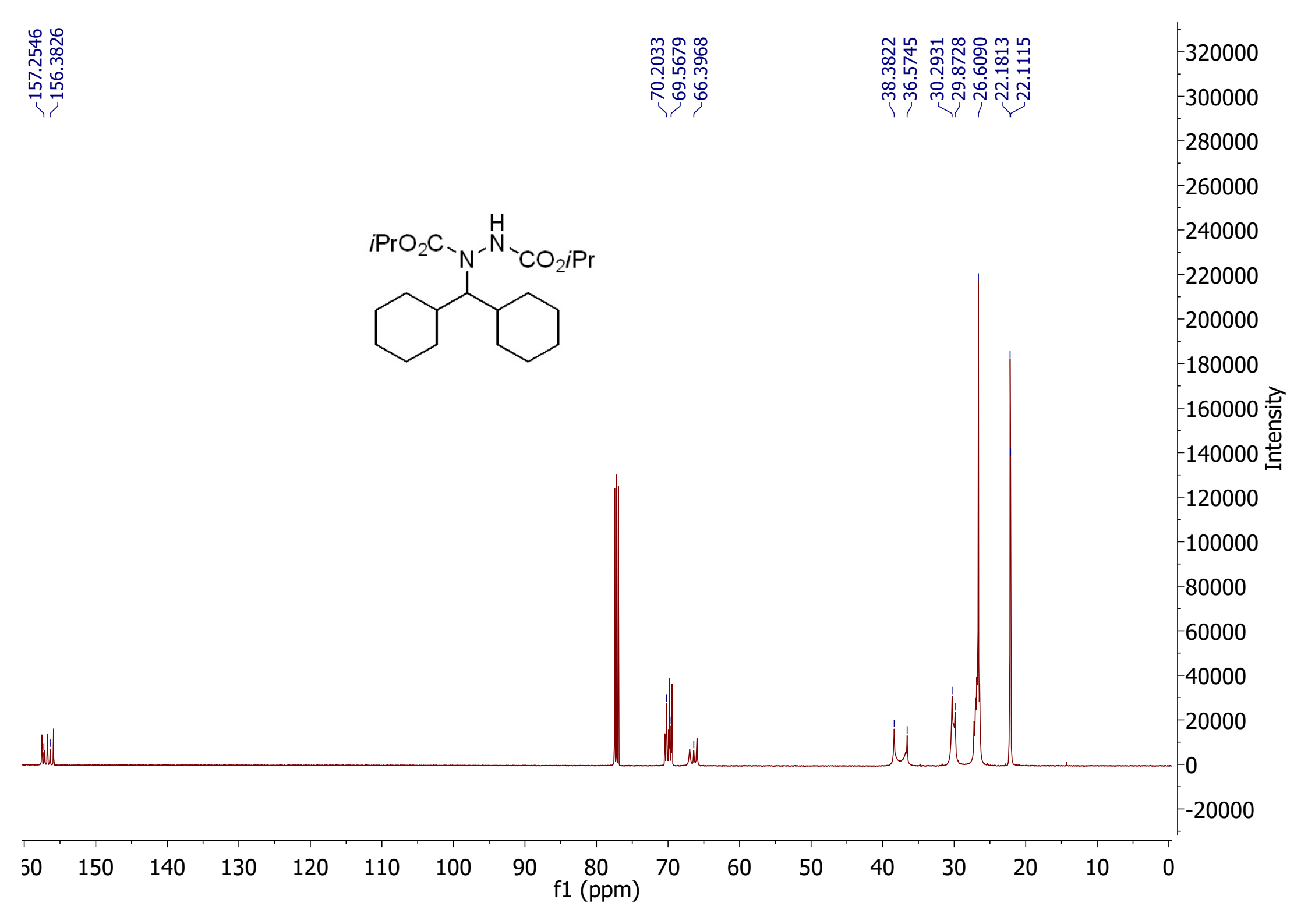
156.0261
69.8724
69.6567
52.4166
46.9455
32.5849
30.1466
27.6903
26.3450
22.9134
22.1739
iPrO2C
N
H
N
CO2iPr
tBu
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
Intensity
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


O
O
O
N
N
H
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f2 (ppm)
0
10
20
30
40
50
60
70
80
f1 (ppm)


iPrO2C
N
H
N
CO2iPr
2b
1.05
2.06
1.00
13.31
22.30
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Intensity
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
0.0
f1 (ppm)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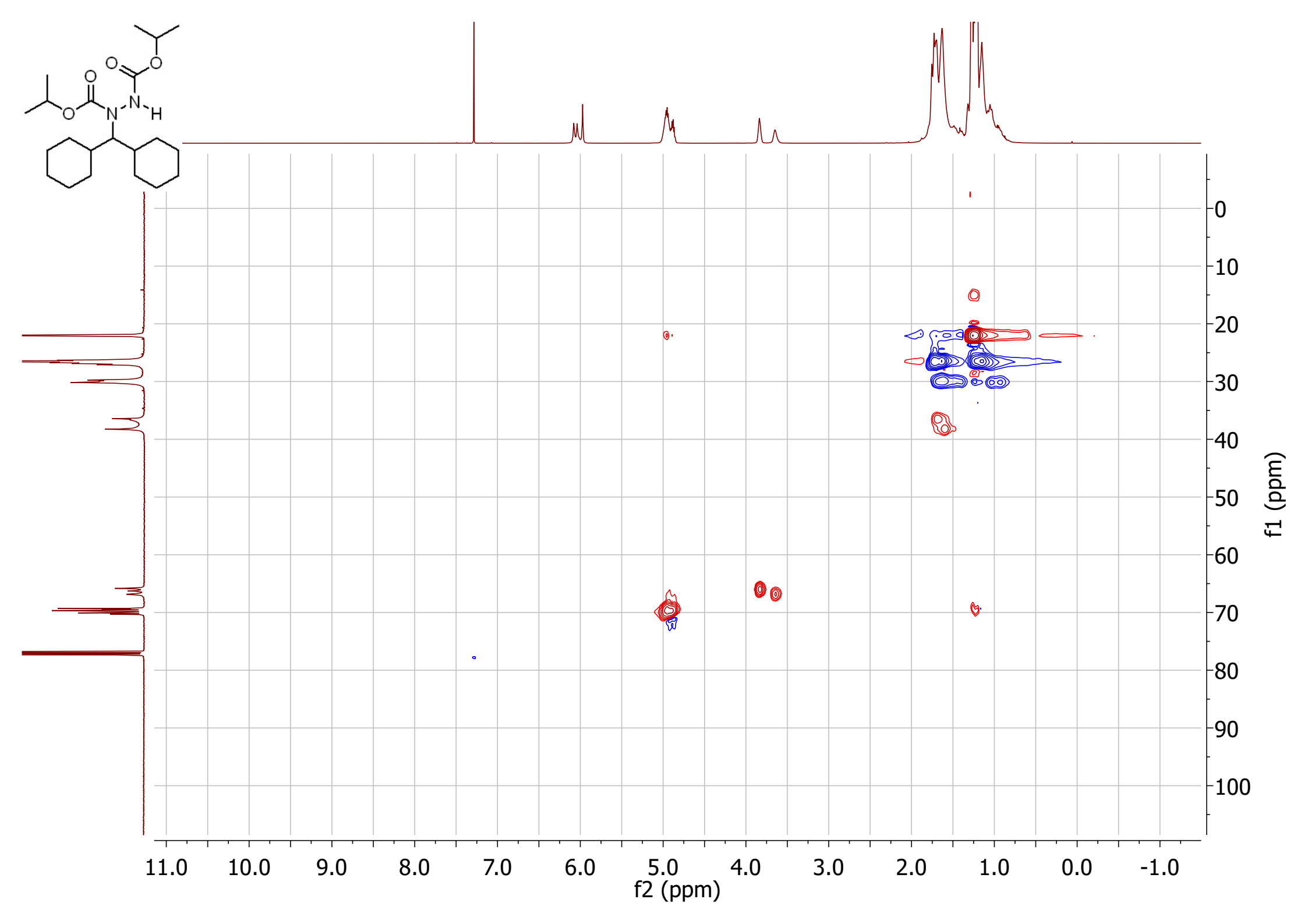
156.3826
70.2033
69.5679
66.3968
38.3822
36.5745
30.2931
29.8728
26.6090
22.1813
22.1115
iPrO2C
N
H
N
CO2iPr
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
Intensity
50
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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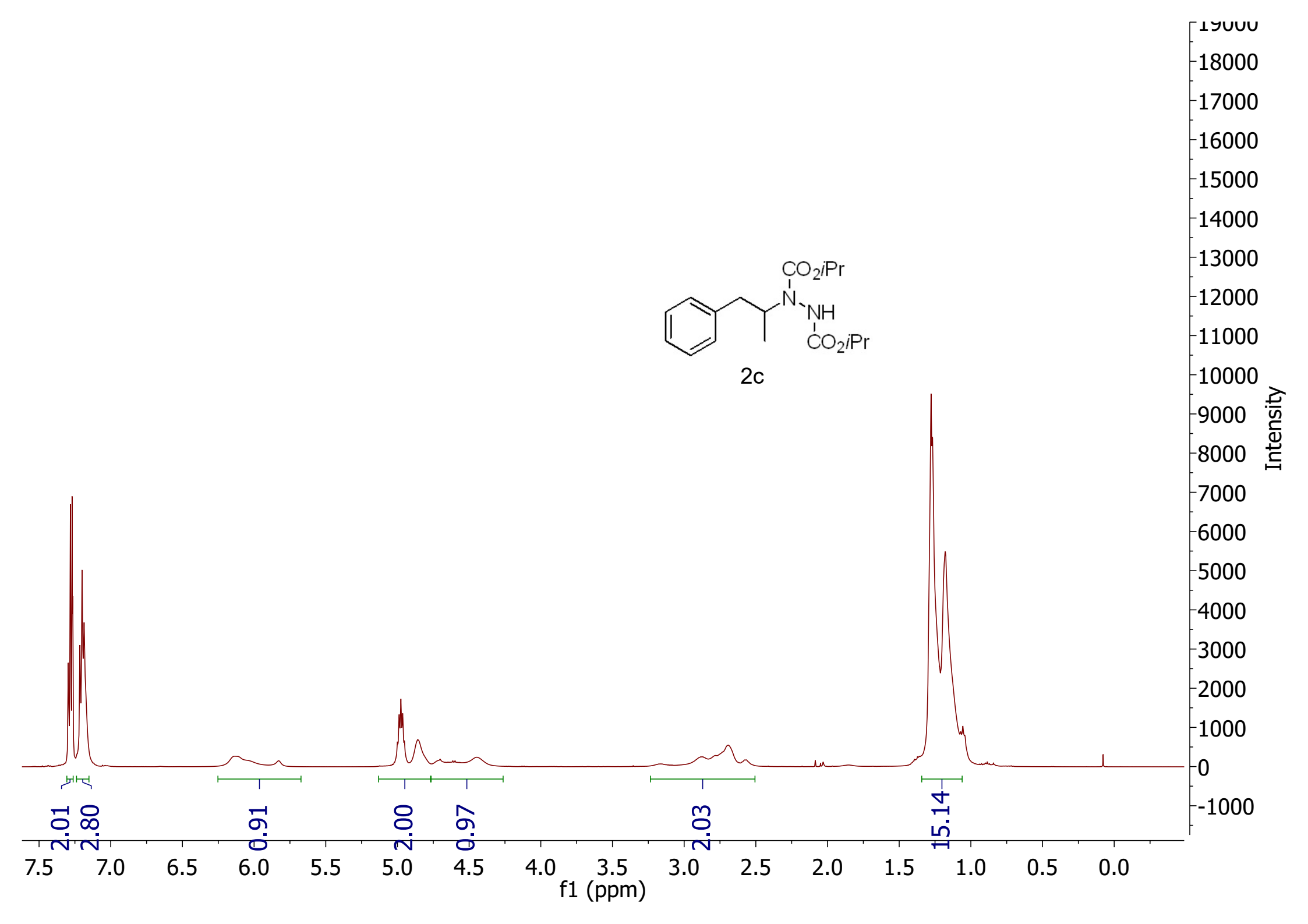
O
O
N
N
H
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
f2 (ppm)
0
10
20
30
40
50
60
70
80
90
100
f1 (ppm)


CO2iPr
N
NH
CO2iPr
2c
Intensity
f1 (ppm)
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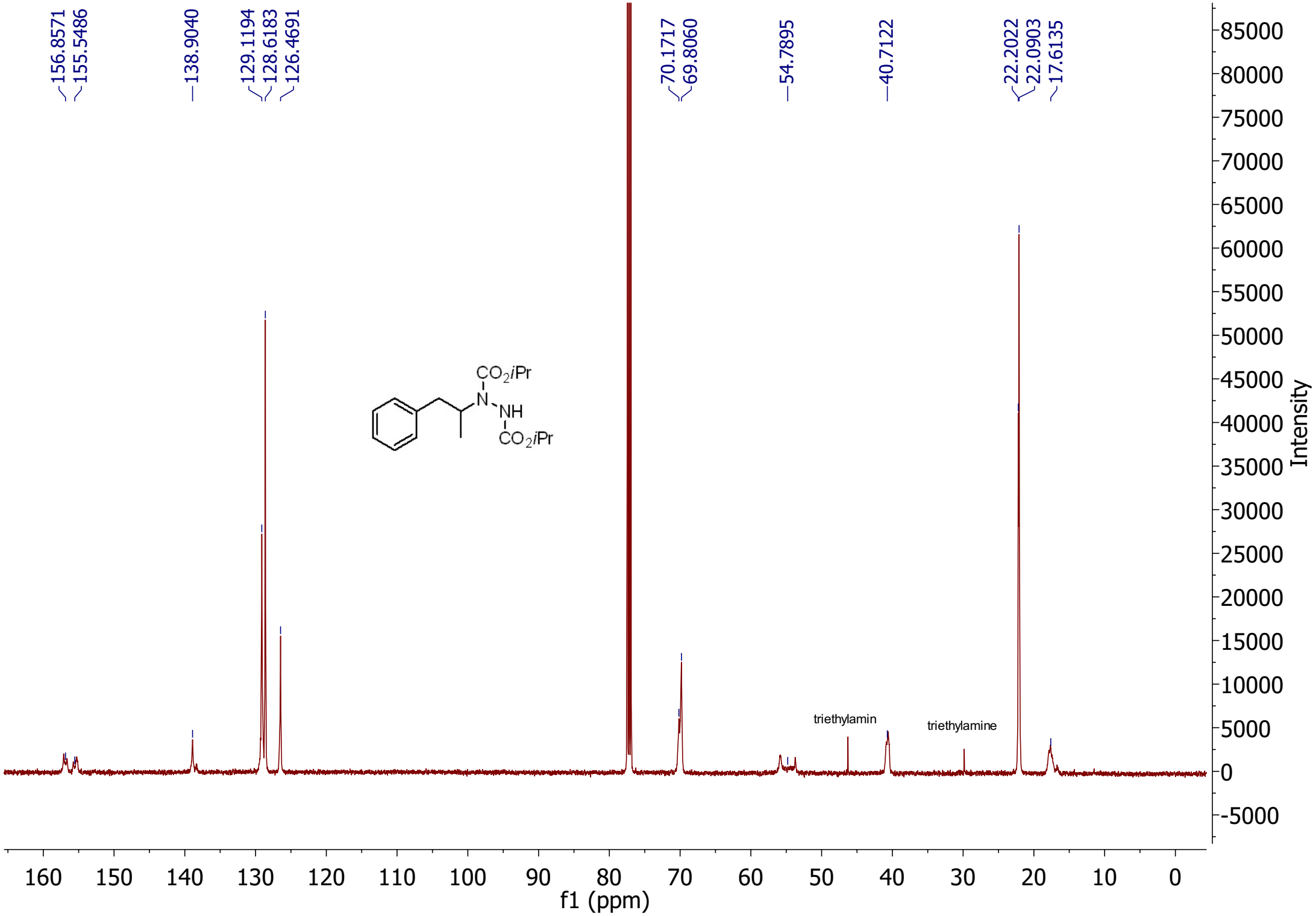
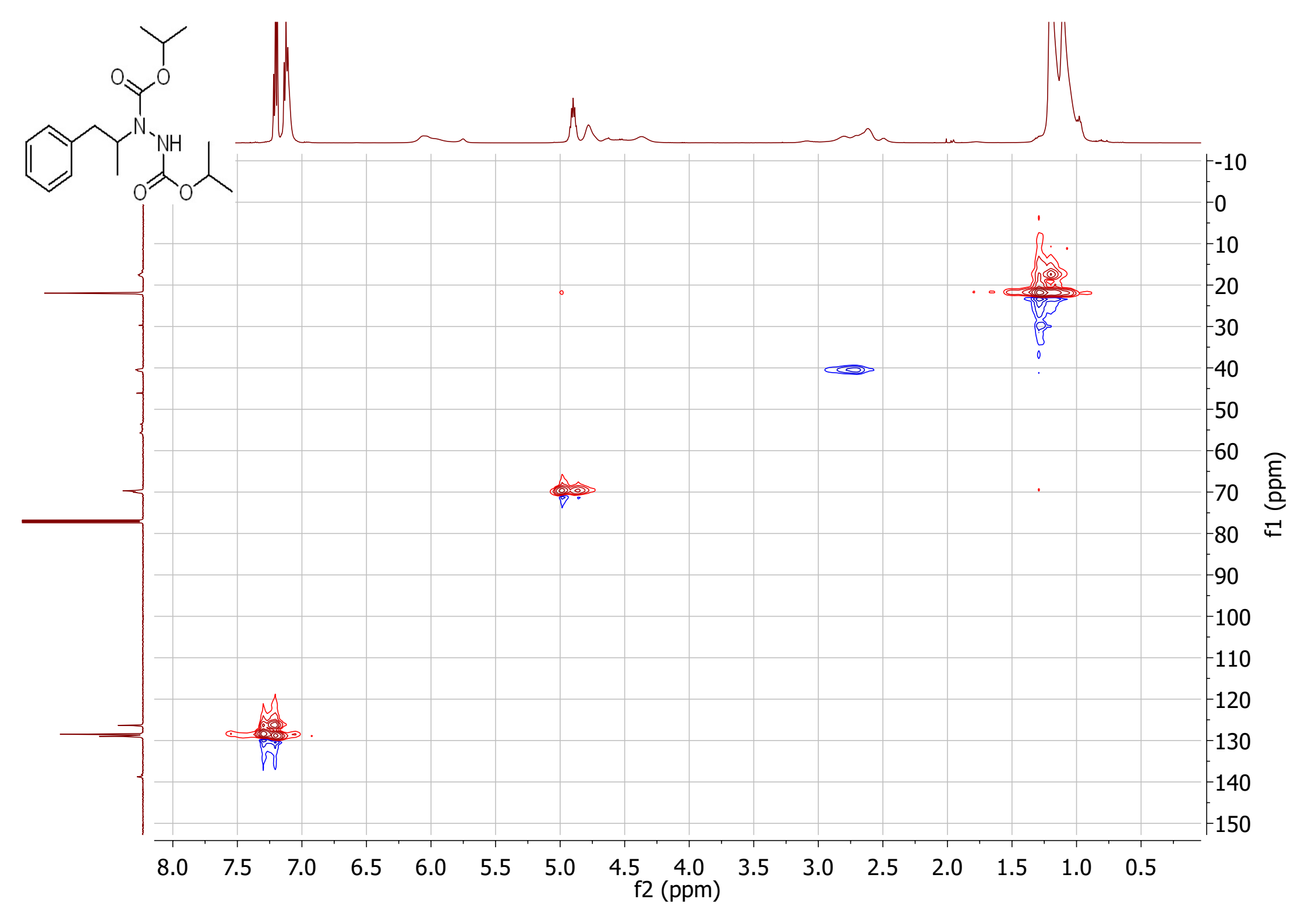
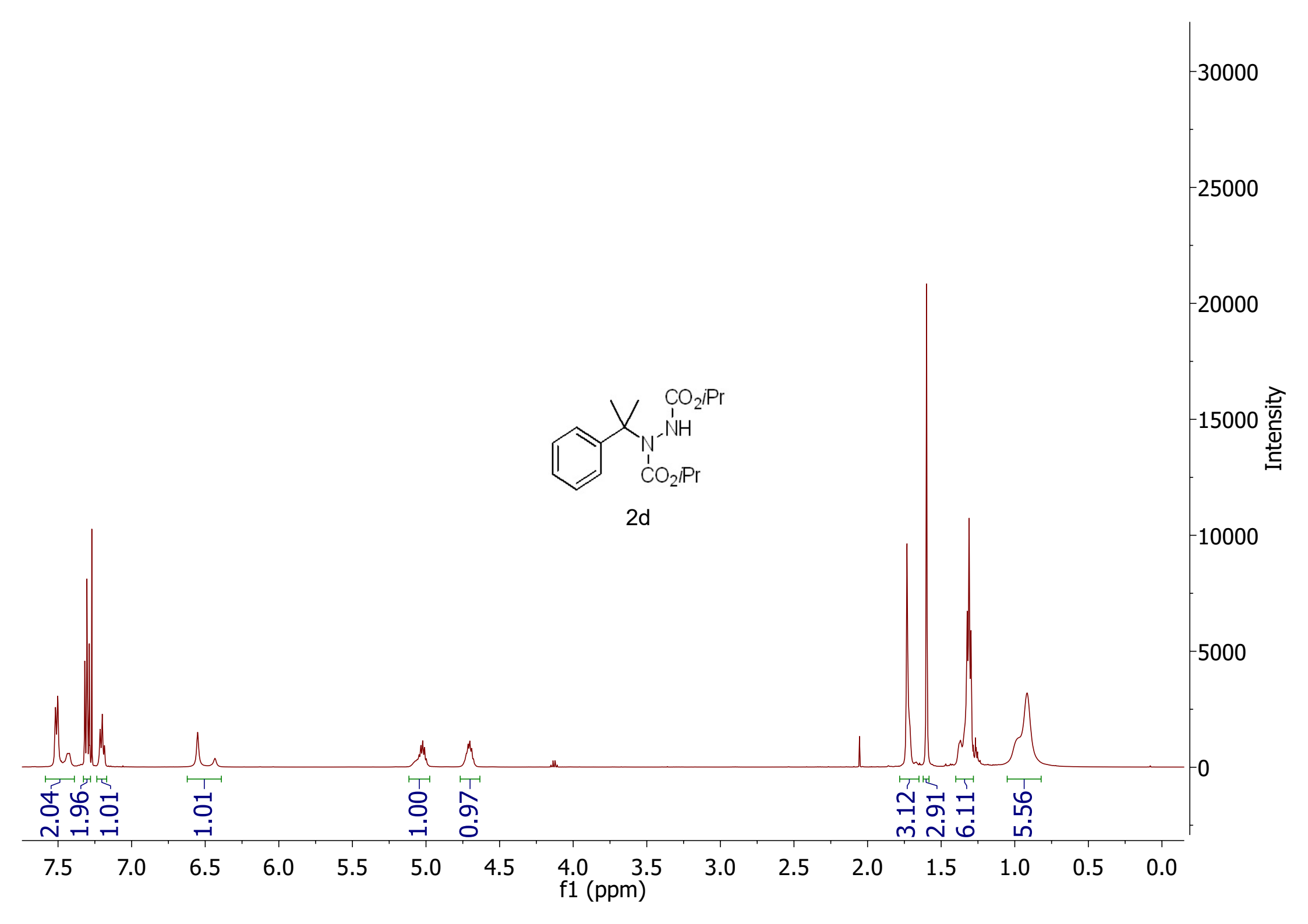
2.80
0.91
2.00
0.97
2.03
15.14


156.8571
155.5486
138.9040
129.1194
128.6183
126.4691
70.1717
69.8060
54.7895
40.7122
22.2022
22.0903
17.6135
CO2iPr
N
NH
CO2iPr
triethylamin
triethylamine
Intensity
f1 (ppm)


O
O
N
NH
O
O
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
f2 (ppm)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
f1 (ppm)


CO2iPr
NH
N
CO2iPr
2d
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1.96
1.01
1.01
1.00
0.97
3.12
2.91
6.11
5.56
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
0.0
f1 (ppm)
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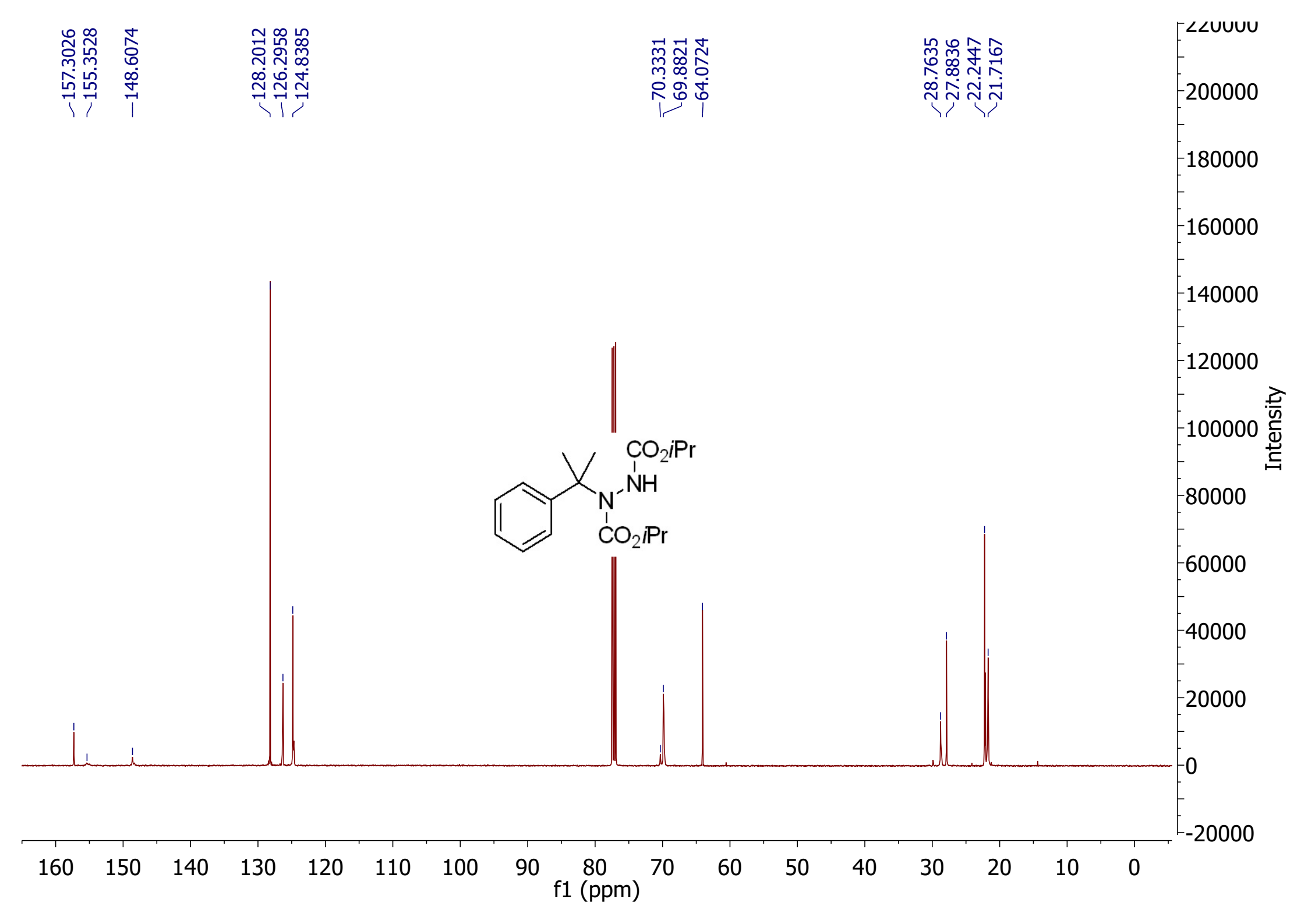
25000
20000
15000
10000
5000
0
Intensity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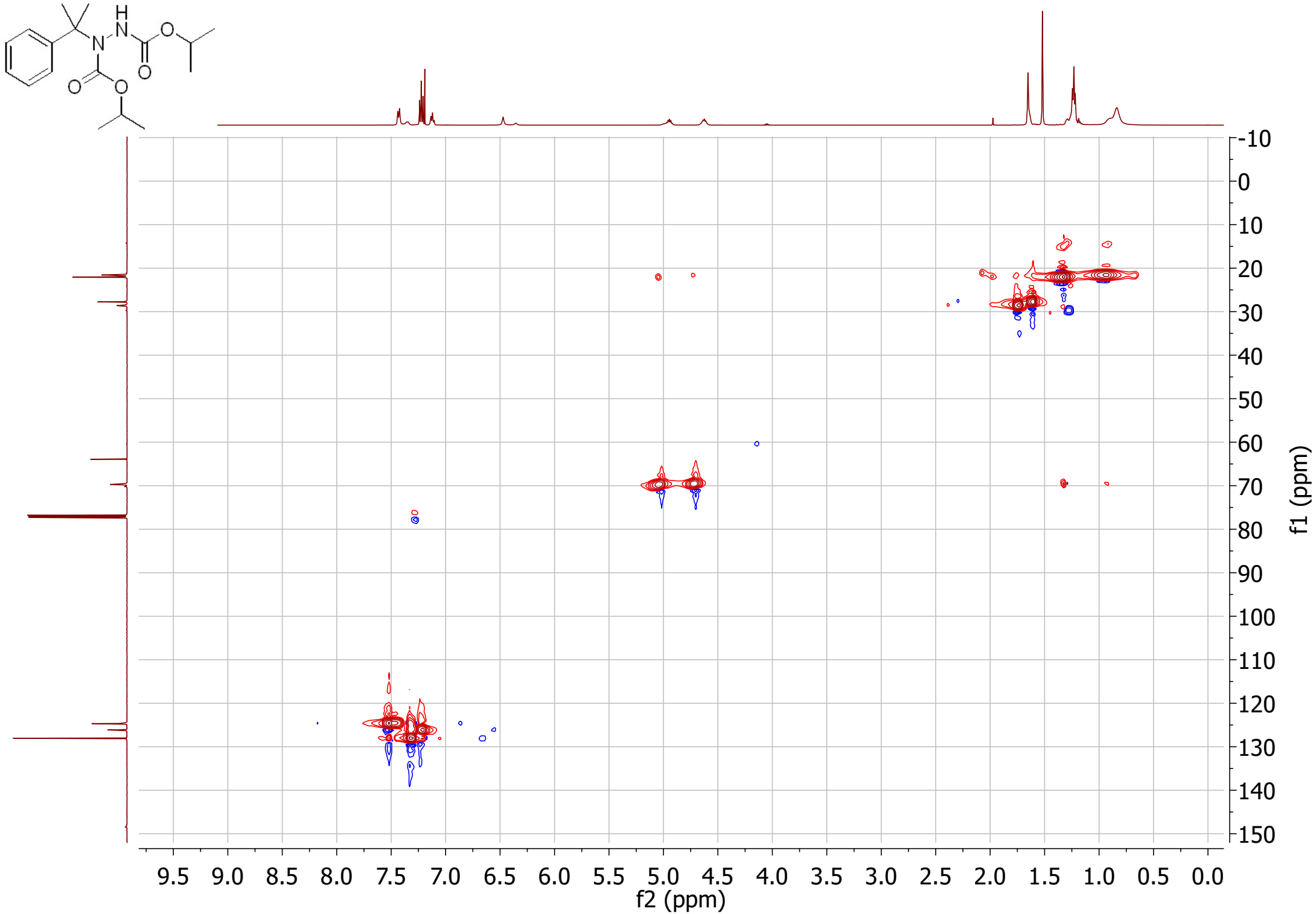
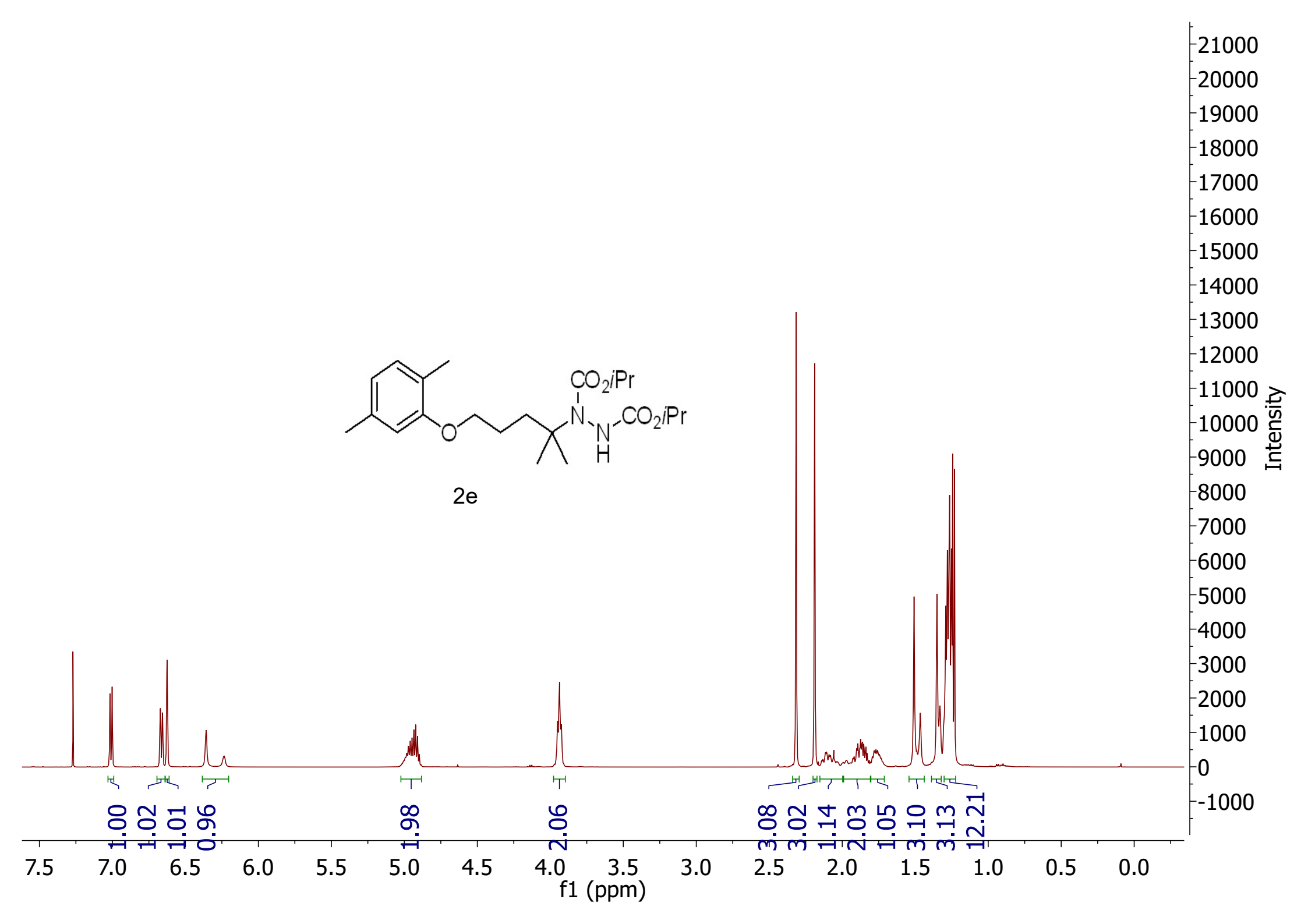
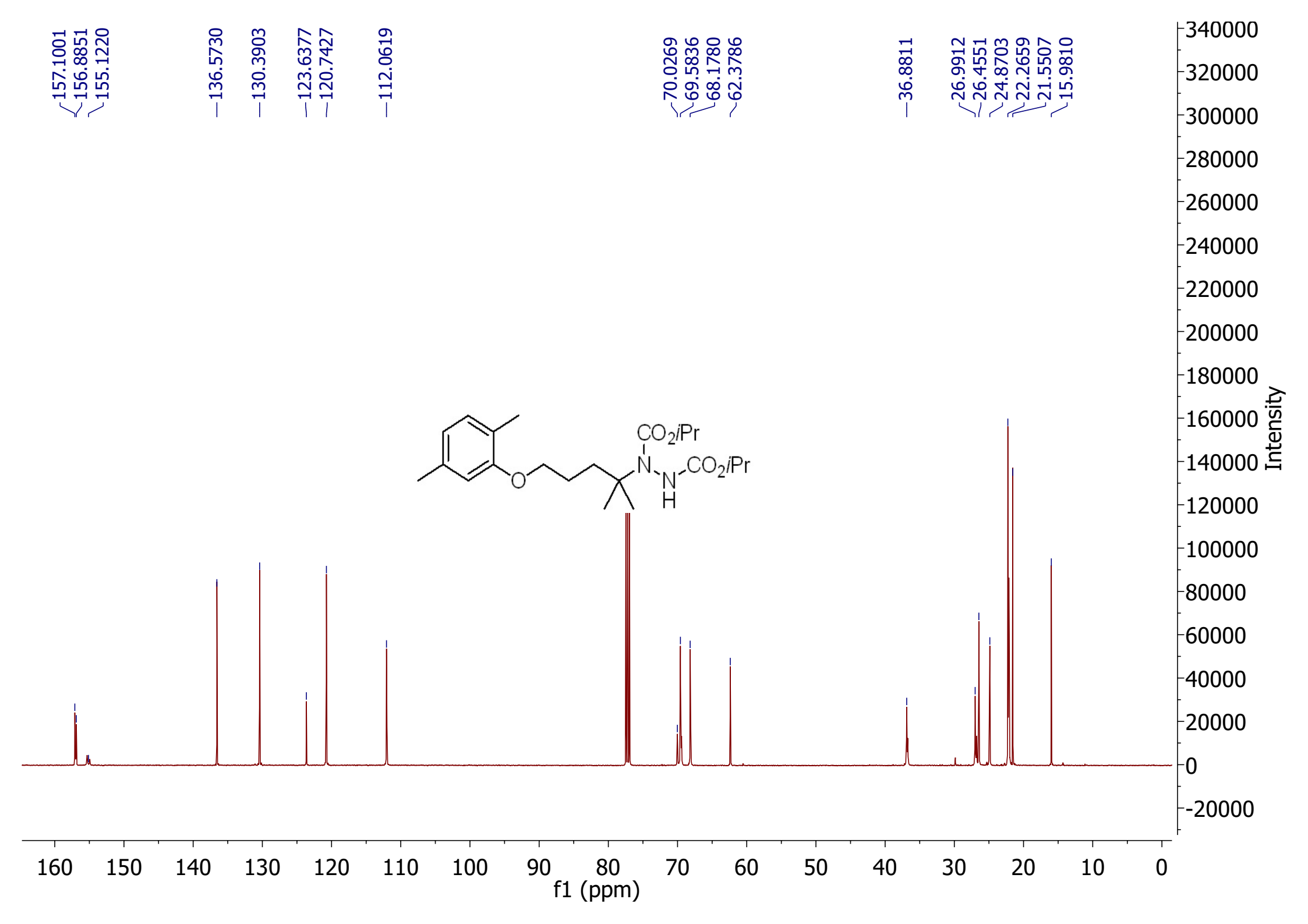
148.6074
128.2012
126.2958
124.8385
70.3331
69.8821
64.0724
28.7635
27.8836
22.2447
21.7167
CO2iPr
NH
N
CO2iPr
Intensity
f1 (ppm)


H
N
N
O
O
O
O
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
f1 (ppm)
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
0.0
f2 (ppm)


CO2iPr
N
N
H
CO2iPr
O
2e
1.00
1.02
1.01
0.96
1.98
2.06
3.08
3.02
1.14
2.03
1.05
3.10
3.13
12.21
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
0.0
f1 (ppm)
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Intensity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130.3903
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120.7427
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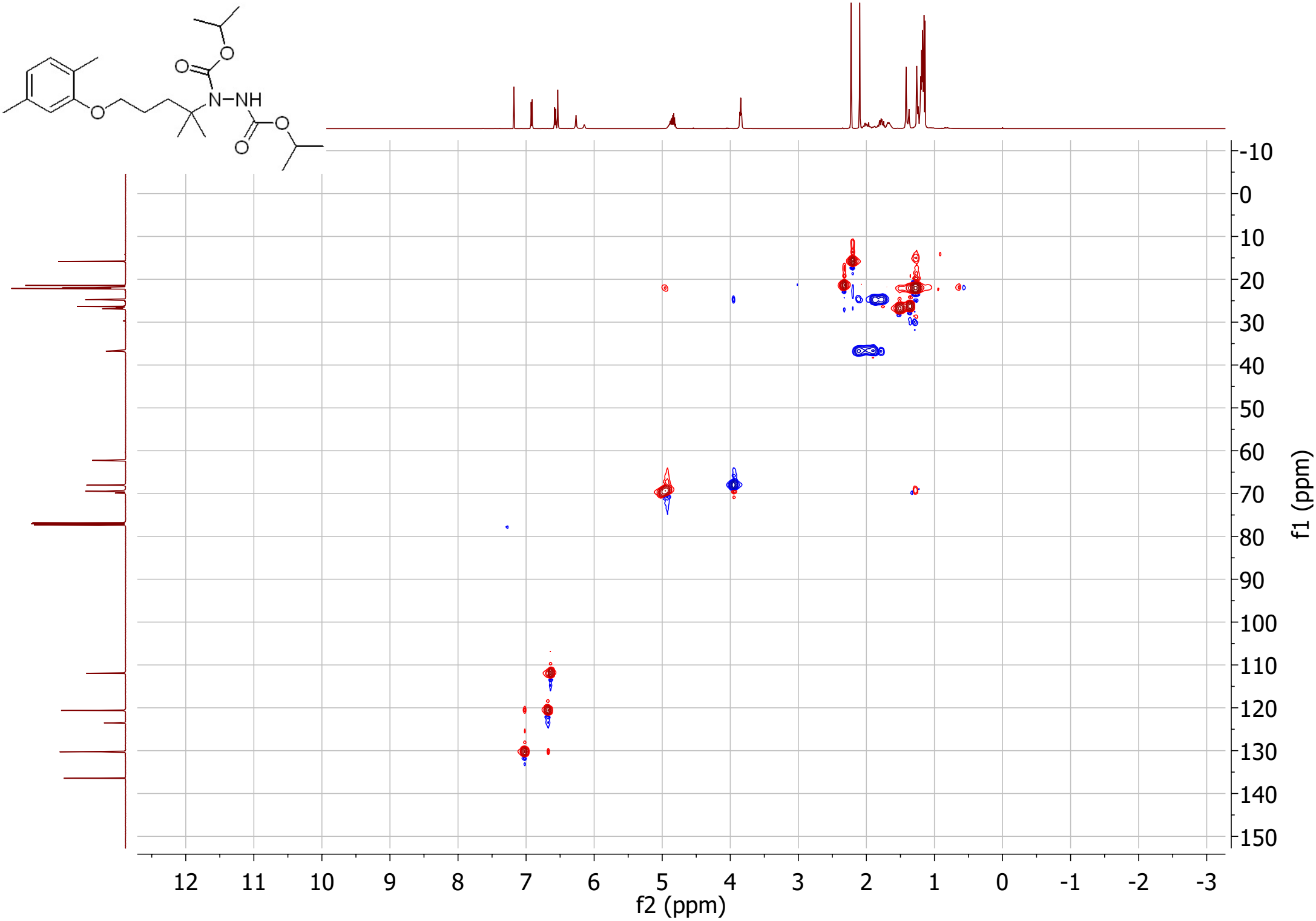
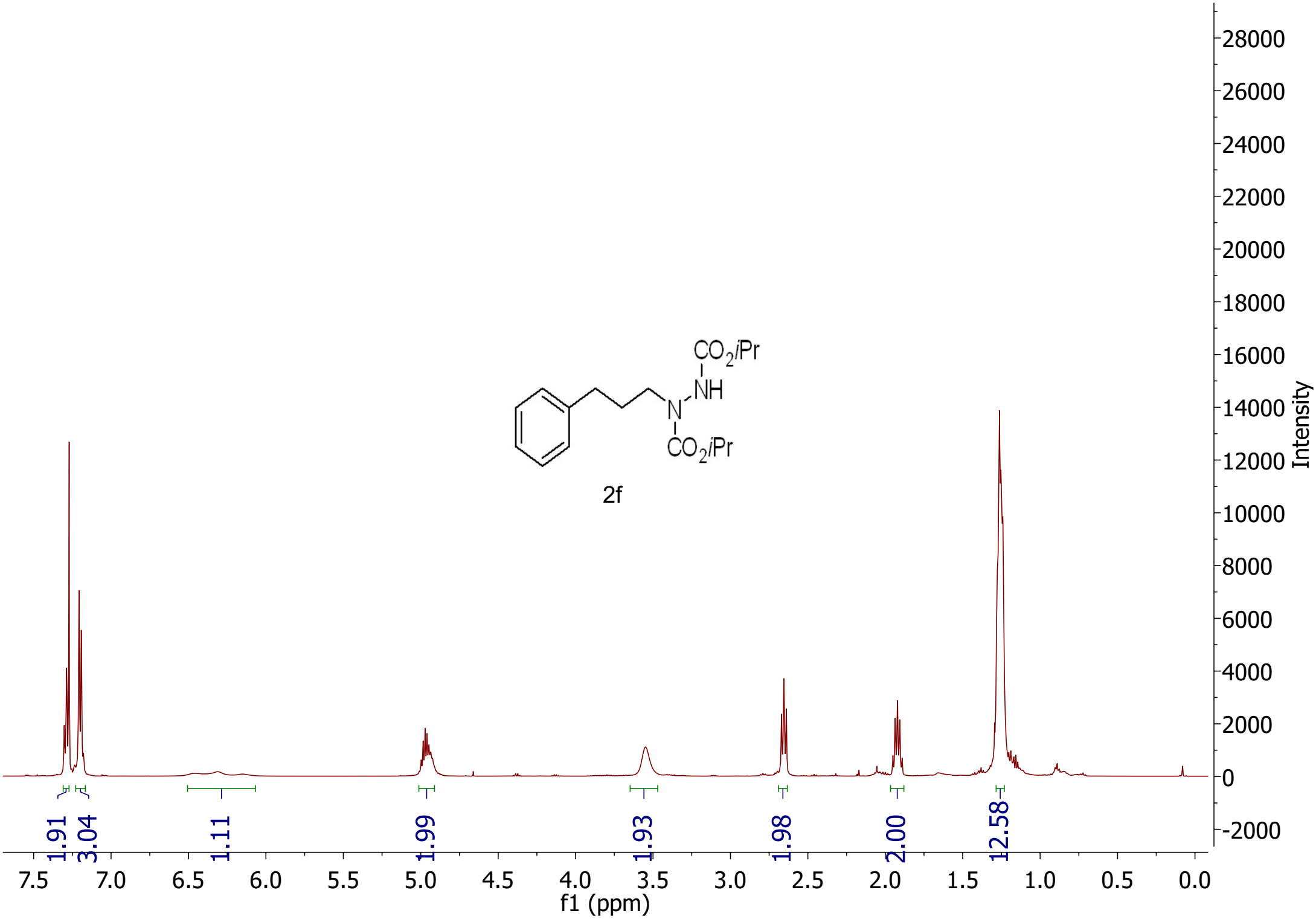
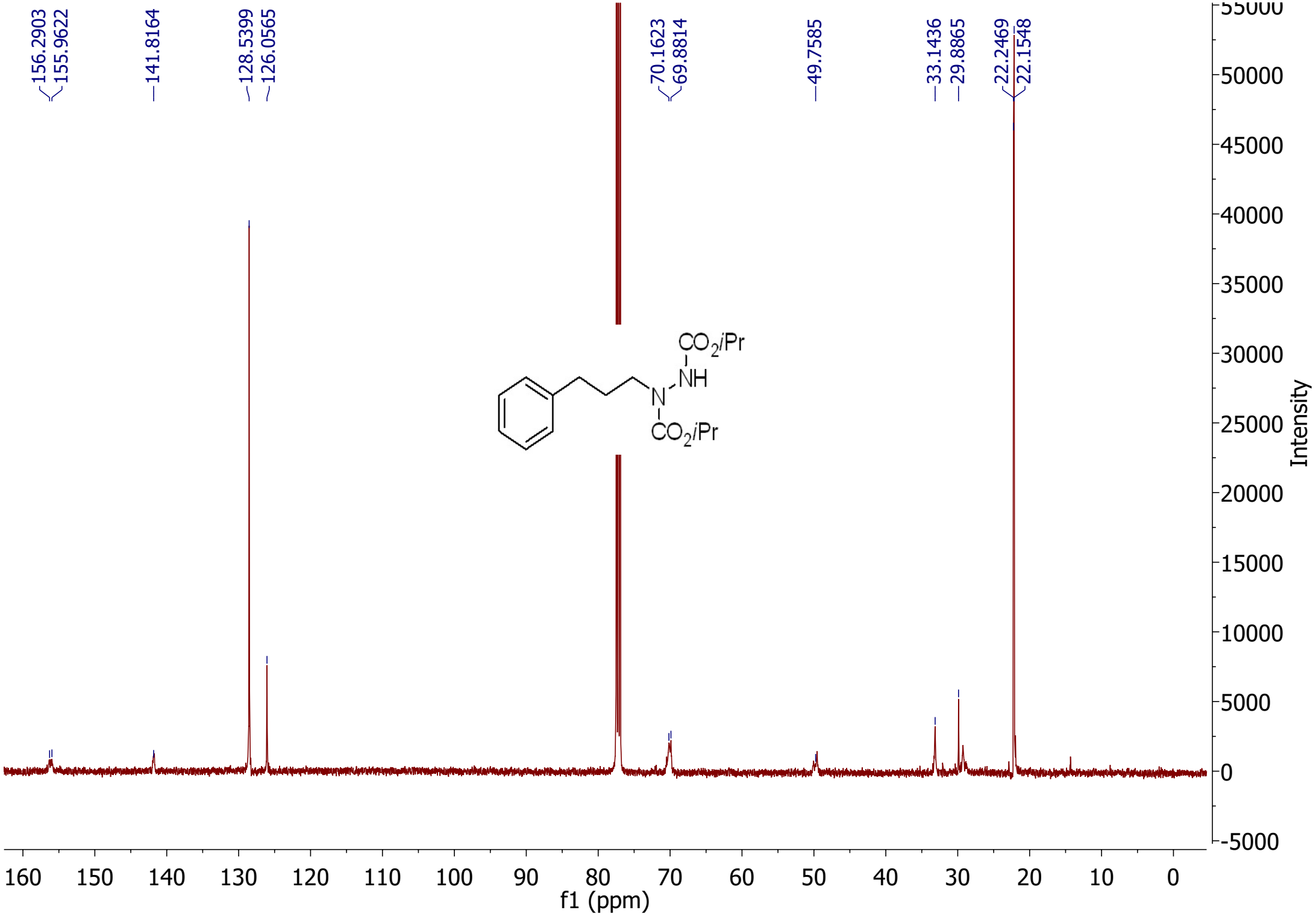
68.1780
62.3786
36.8811
26.9912
26.4551
24.8703
22.2659
21.5507
15.9810
CO2iPr
N
N
H
CO2iPr
O
340000
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
Intensity
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


N–NH
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f2 (ppm)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
f1 (ppm)


CO2iPr
NH
N
CO2iPr
2f
1.91
3.04
1.11
1.99
1.93
1.98
2.00
12.58
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
0.0
f1 (ppm)
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Intensity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141.8164
128.5399
126.0565
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69.8814
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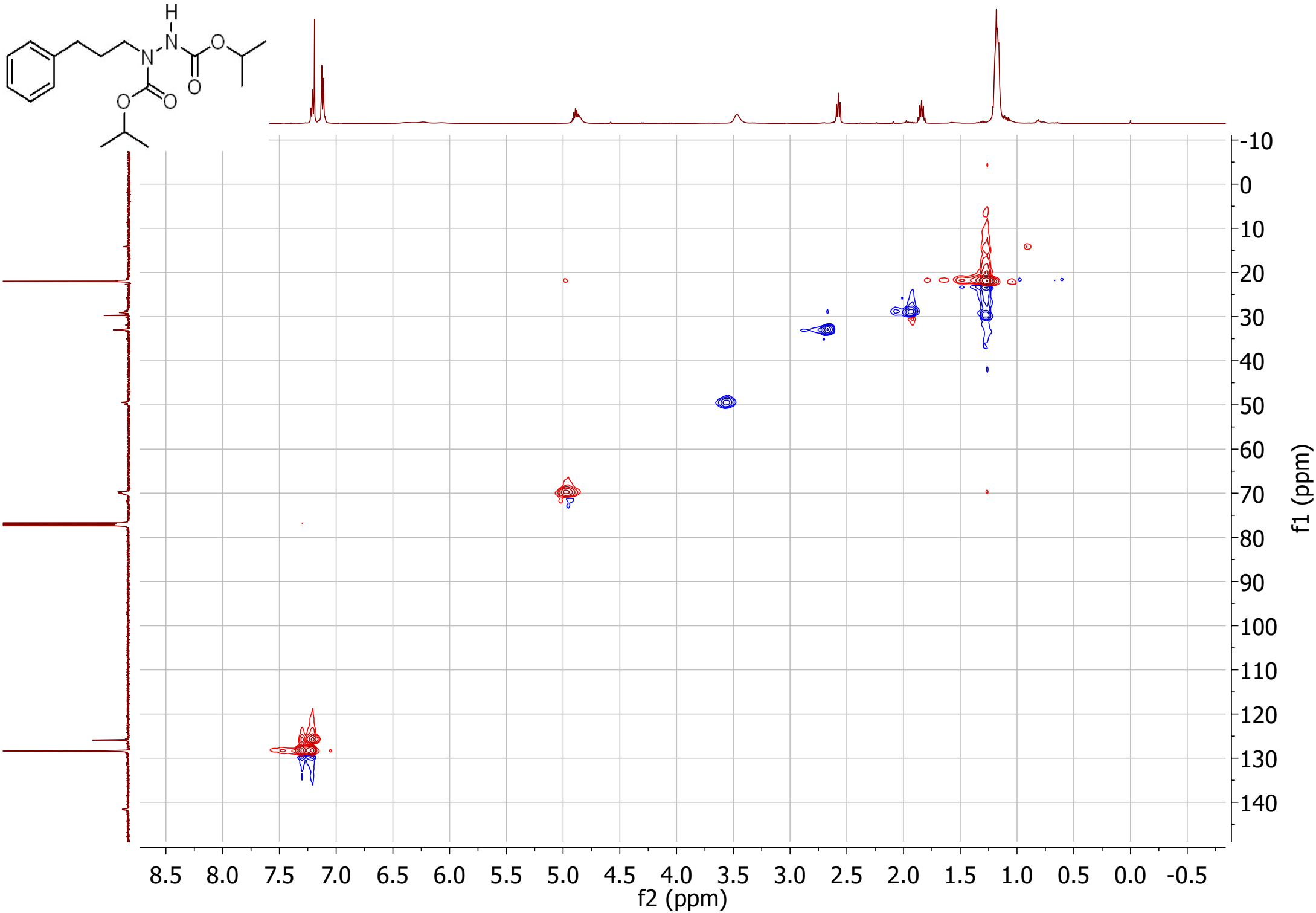
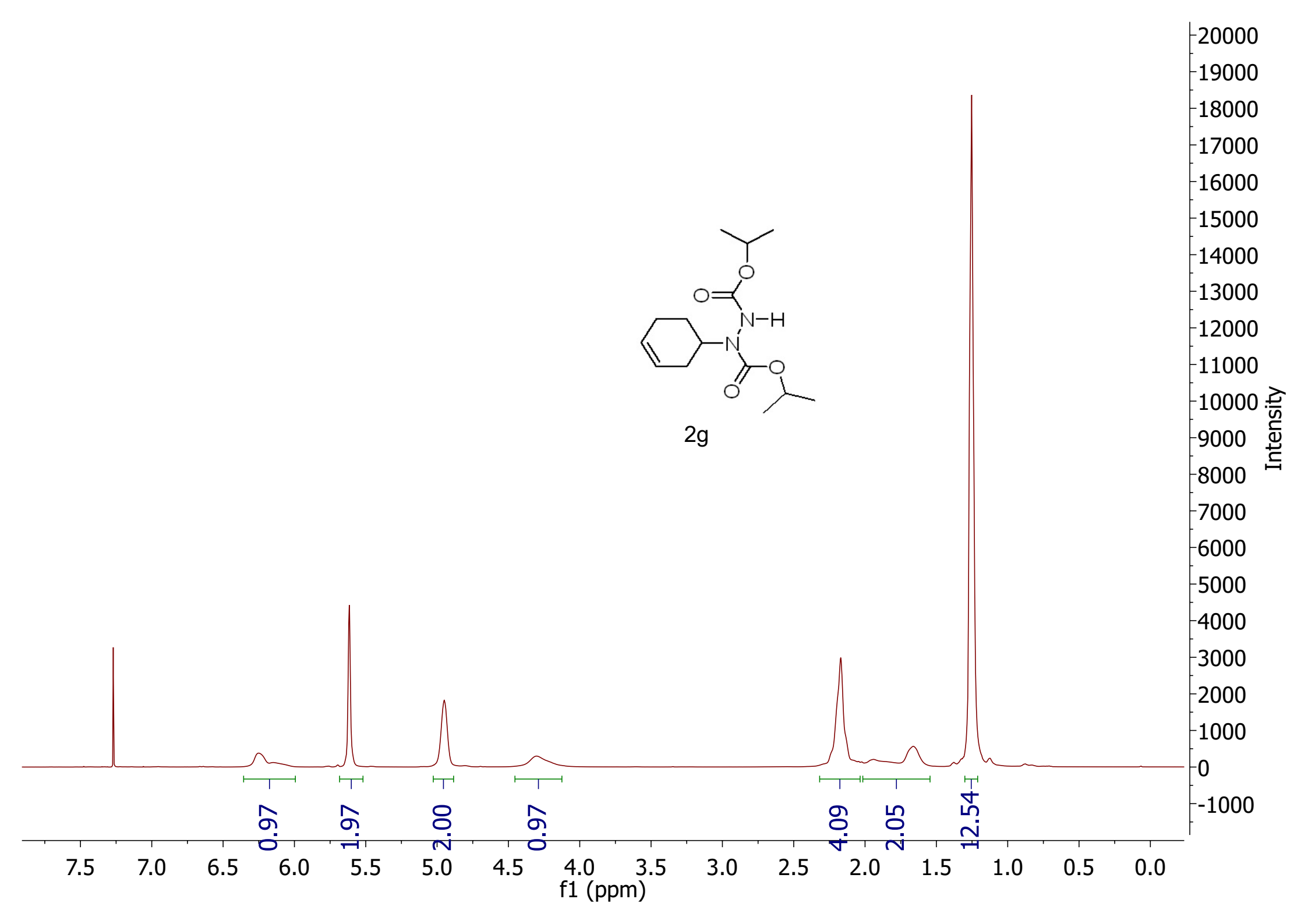
33.1436
29.8865
22.2469
22.1548
CO2iPr
NH
N
CO2iPr
Intensity
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


H
N
N
O
O
O
O
O
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
0.0
-0.5
f2 (ppm)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
f1 (ppm)


2g
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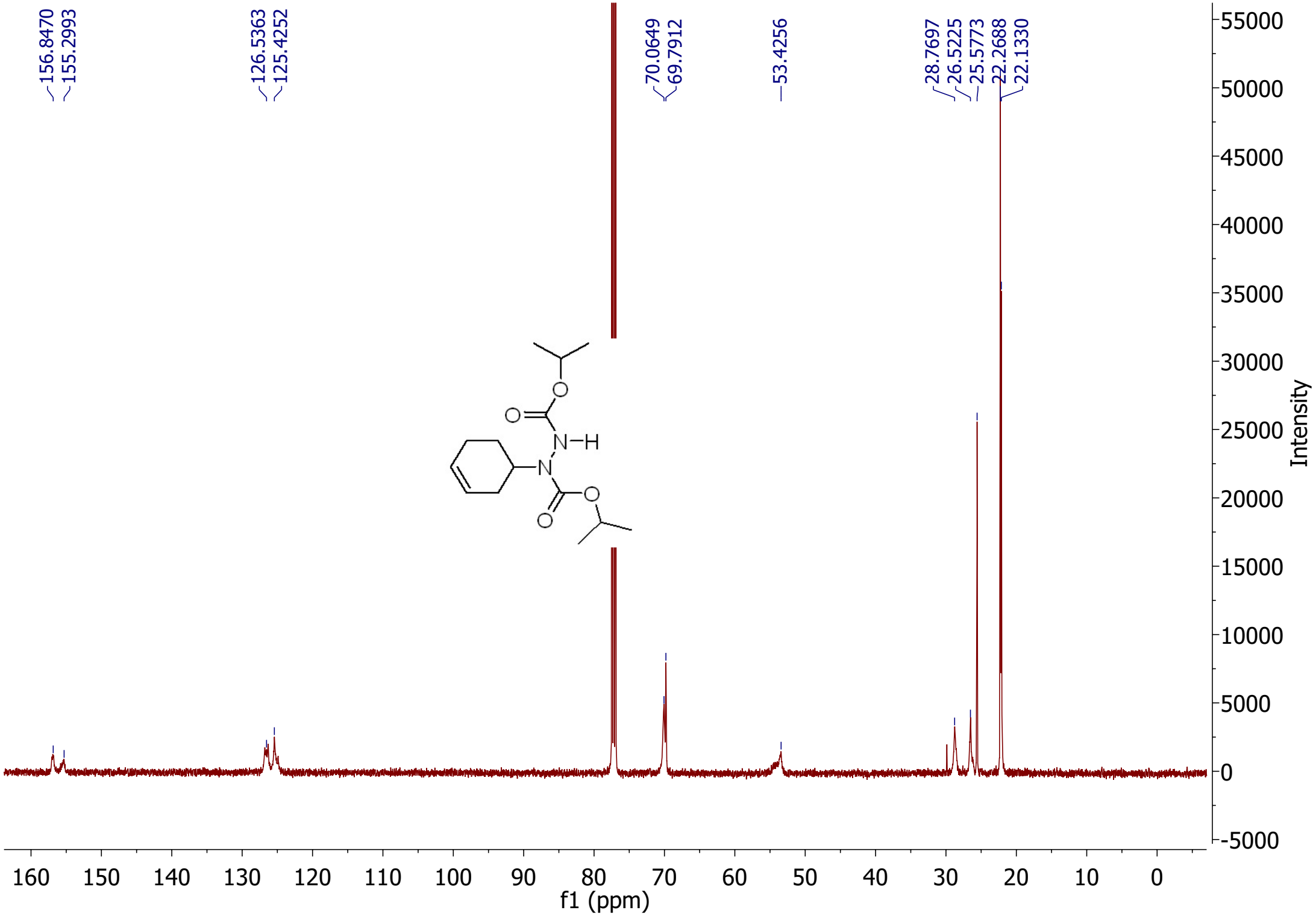
1.97
2.00
0.97
4.09
2.05
12.54
f1 (ppm)
Intensity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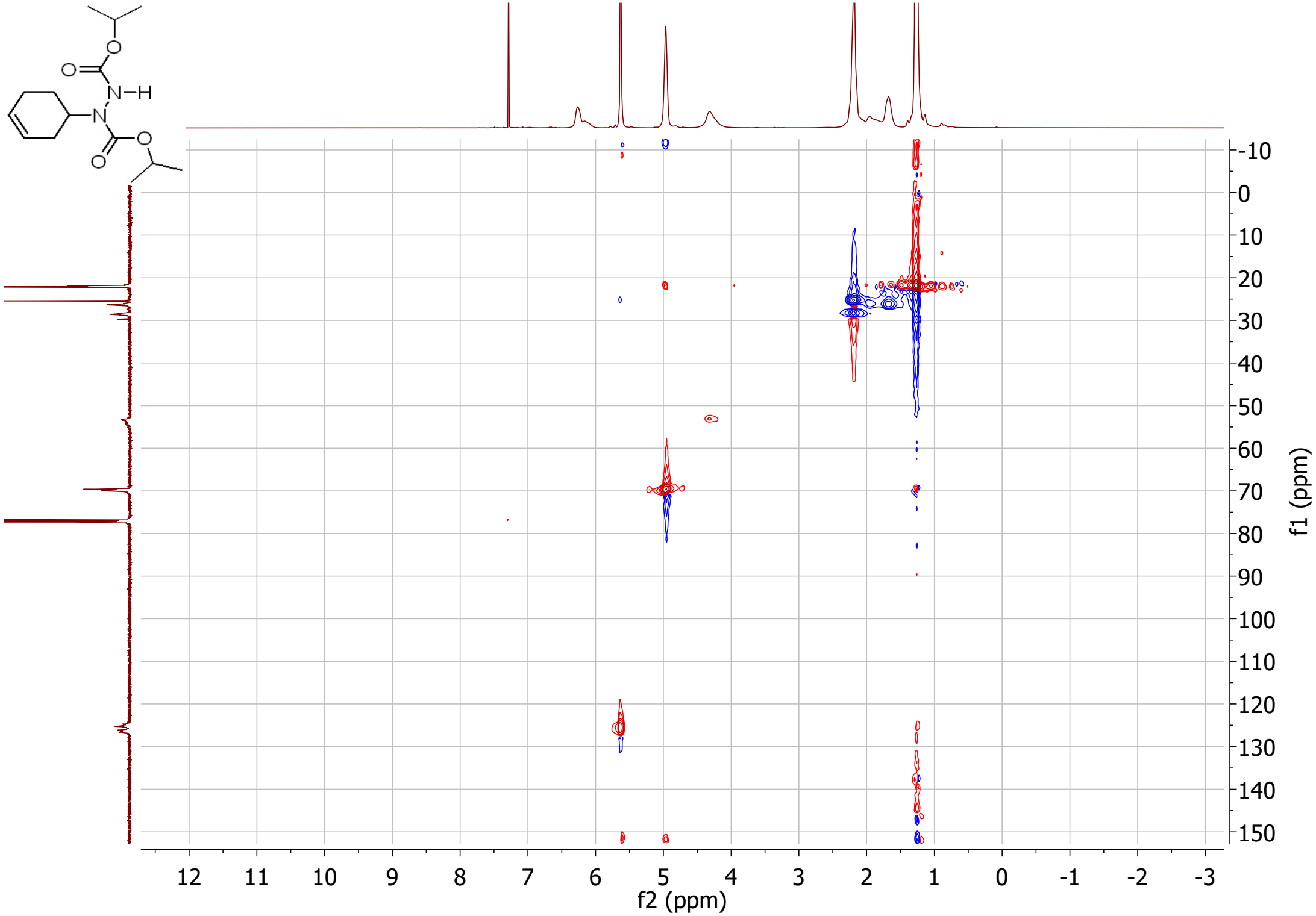
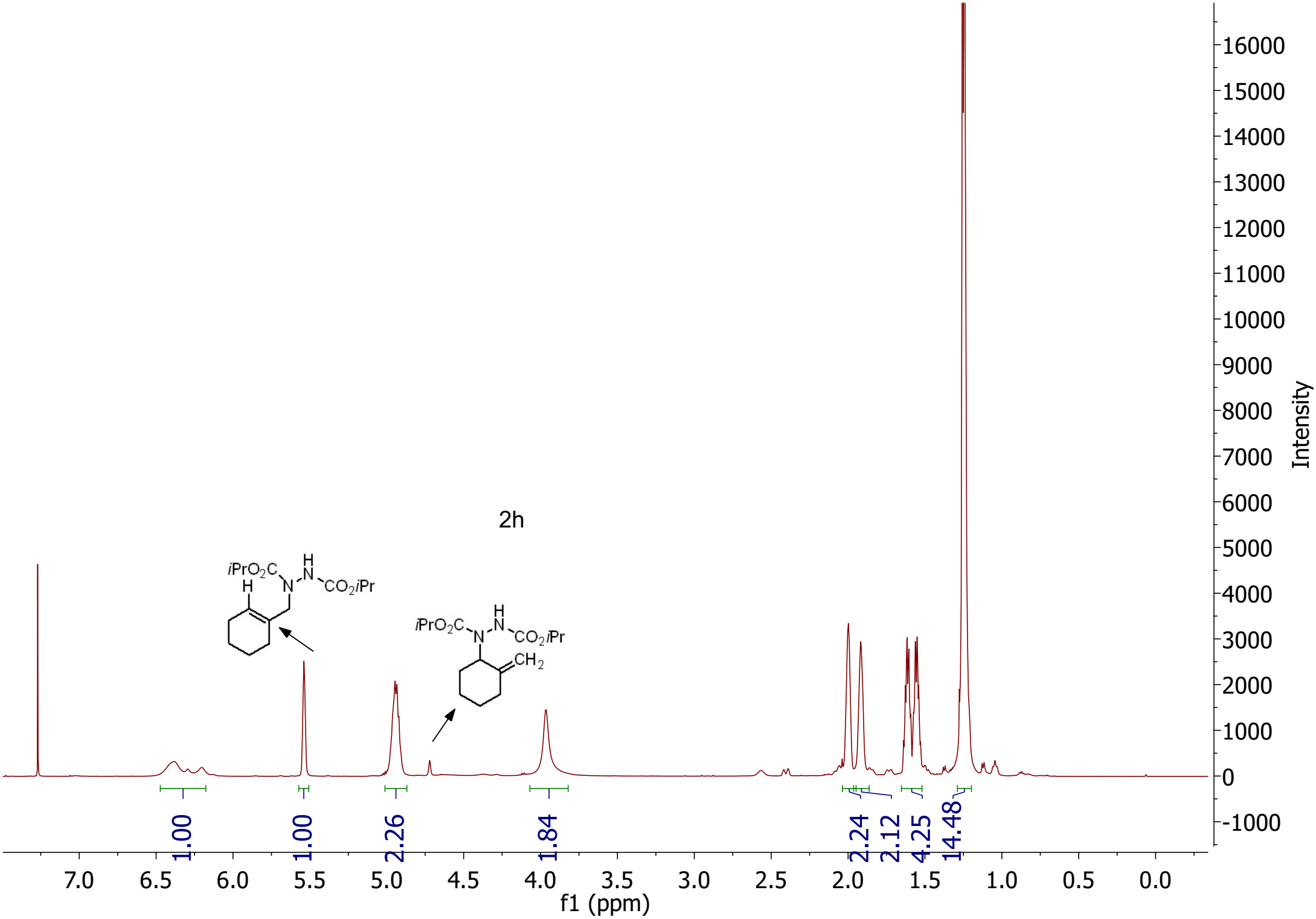
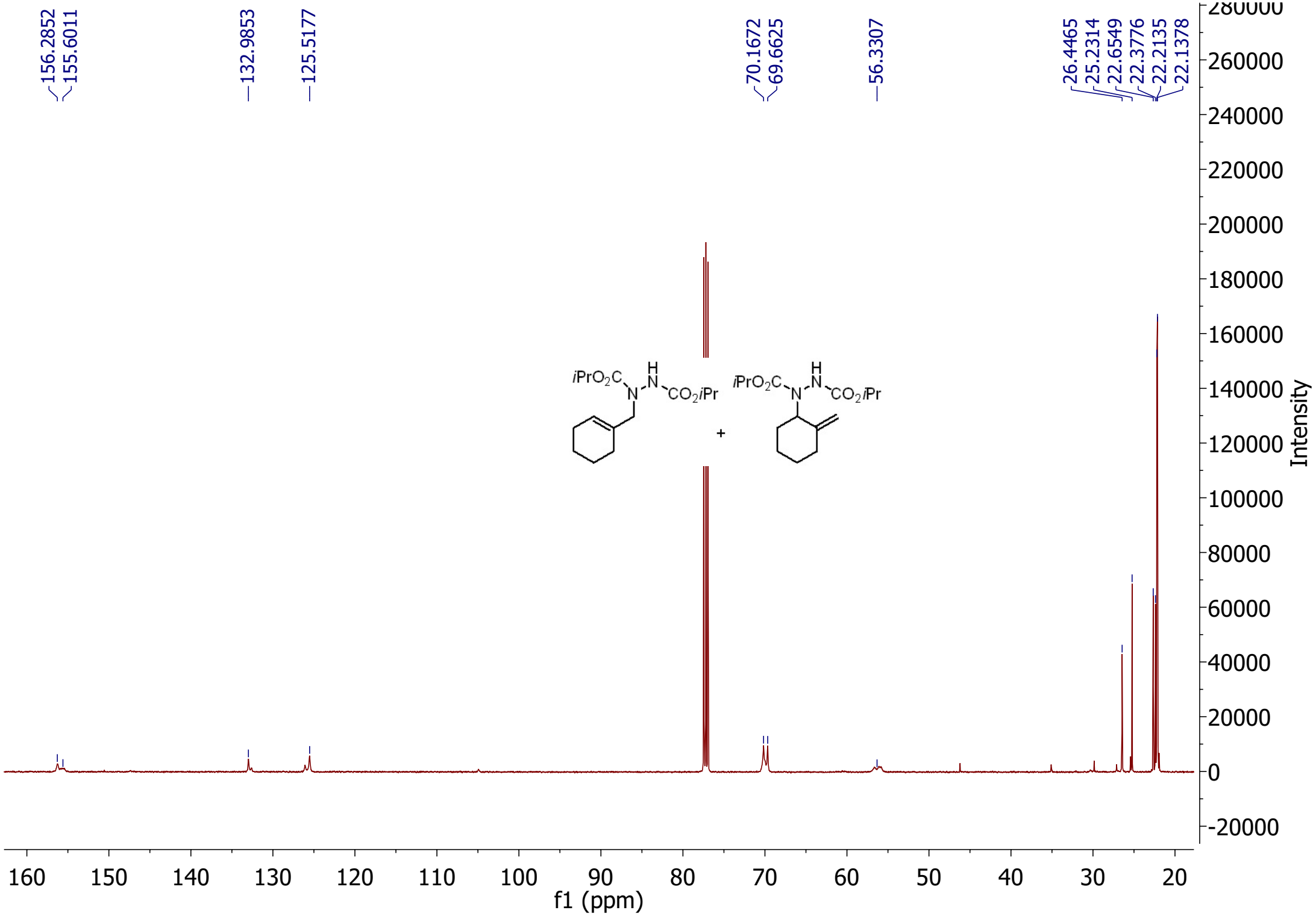
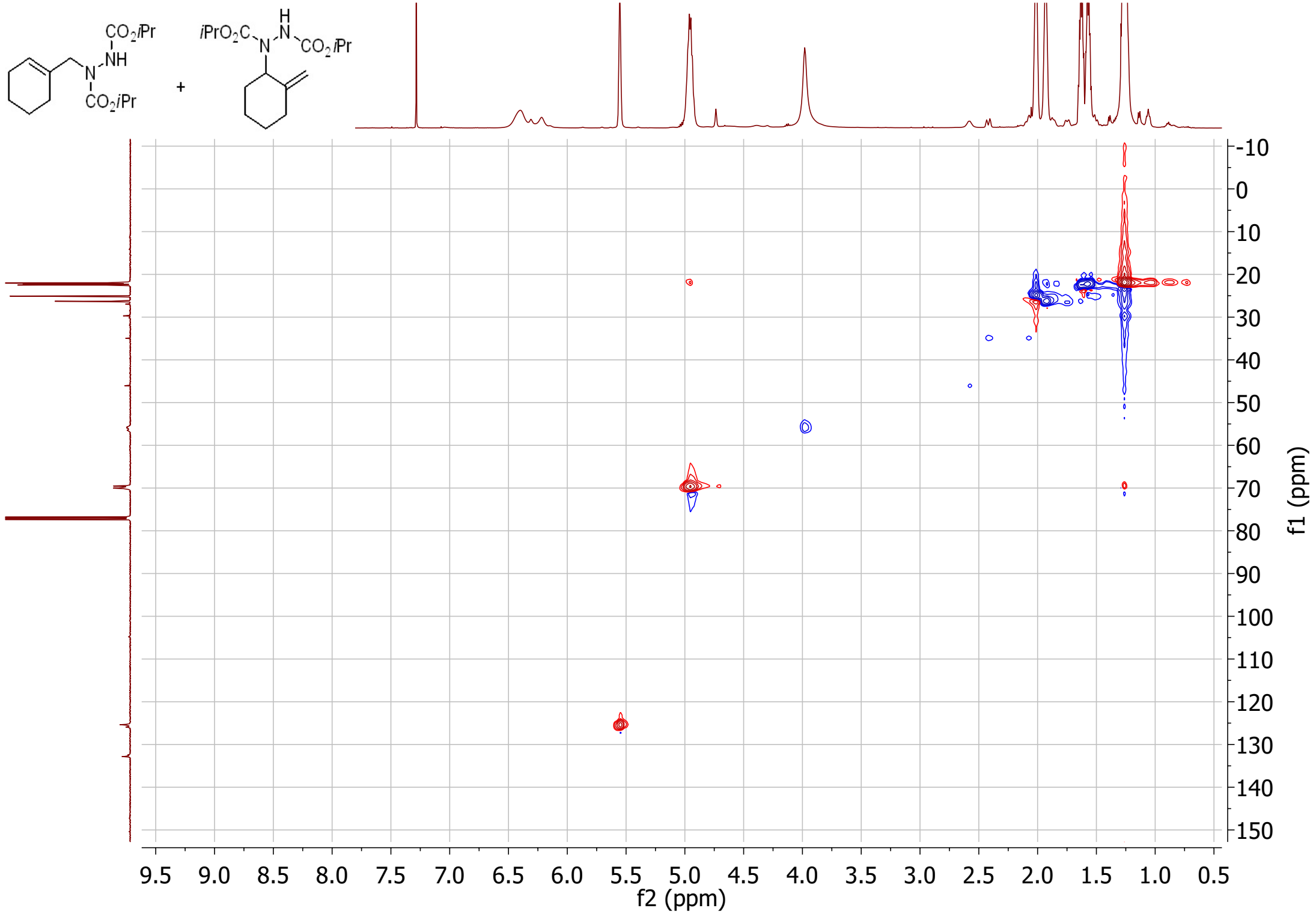
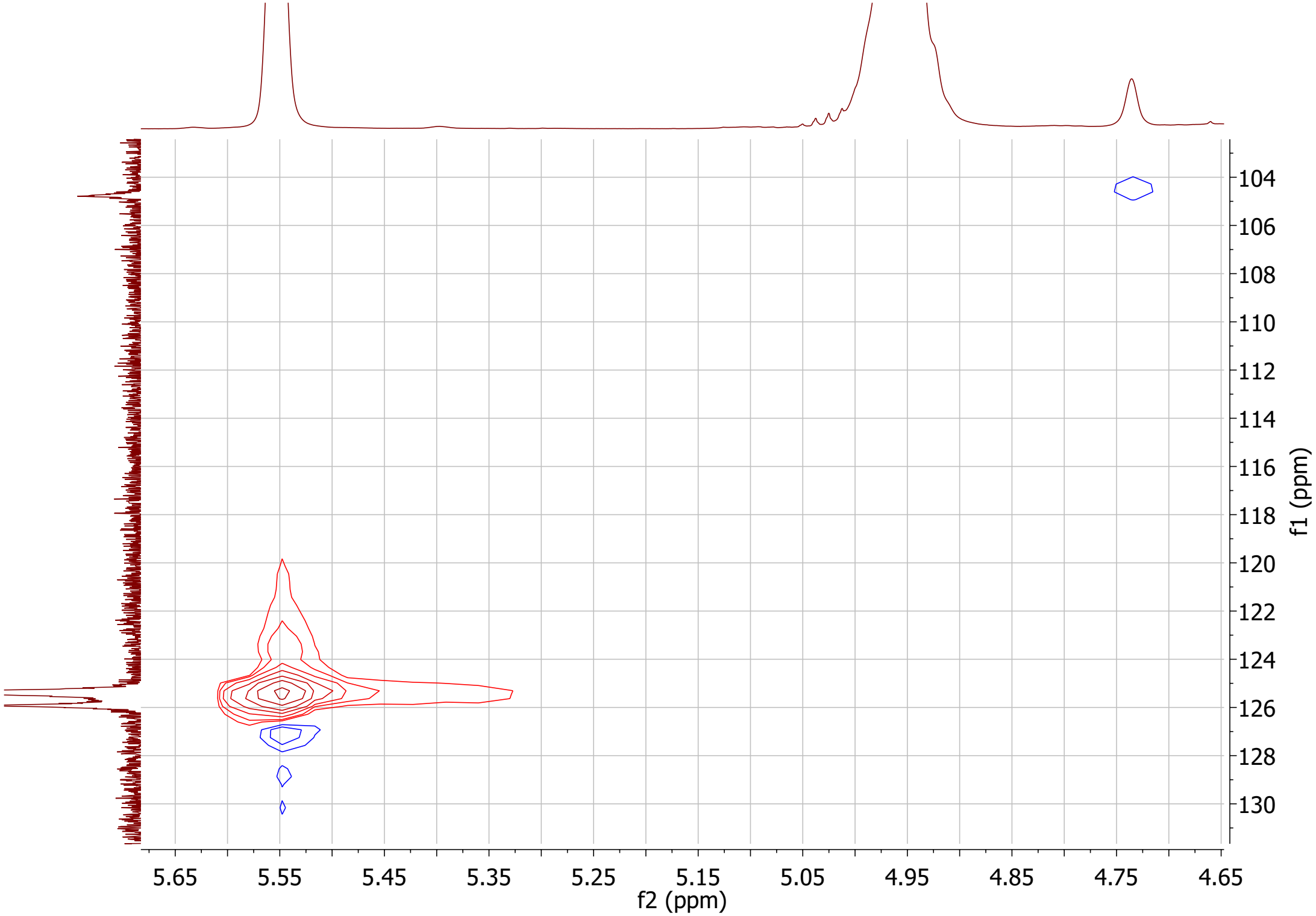
155.2993
126.5363
125.4252
70.0649
69.7912
53.4256
28.7697
26.5225
25.5773
22.2688
22.1330
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
Intensity
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

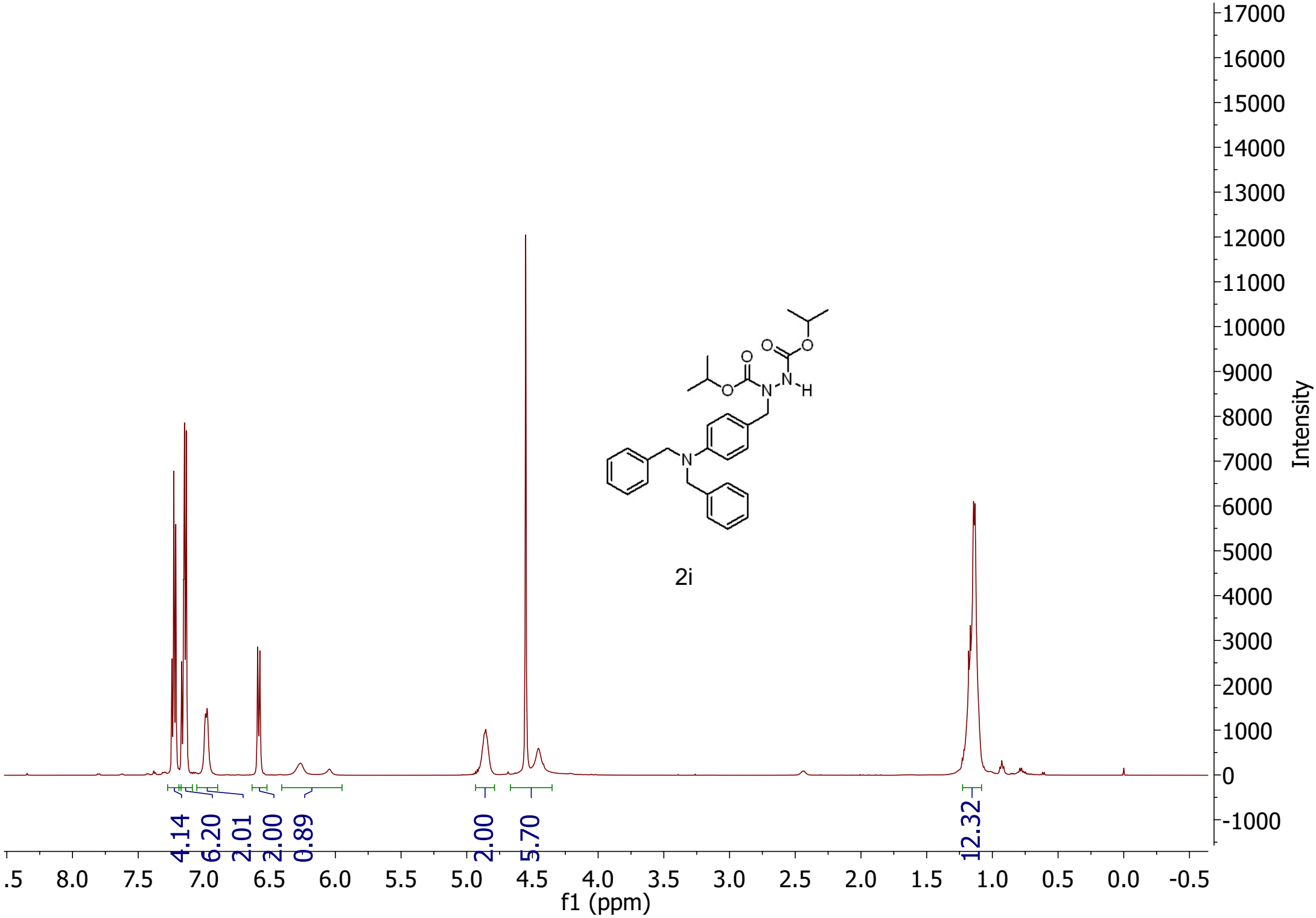

O
O
N–H
N
O
O
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f2 (ppm)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
f1 (ppm)

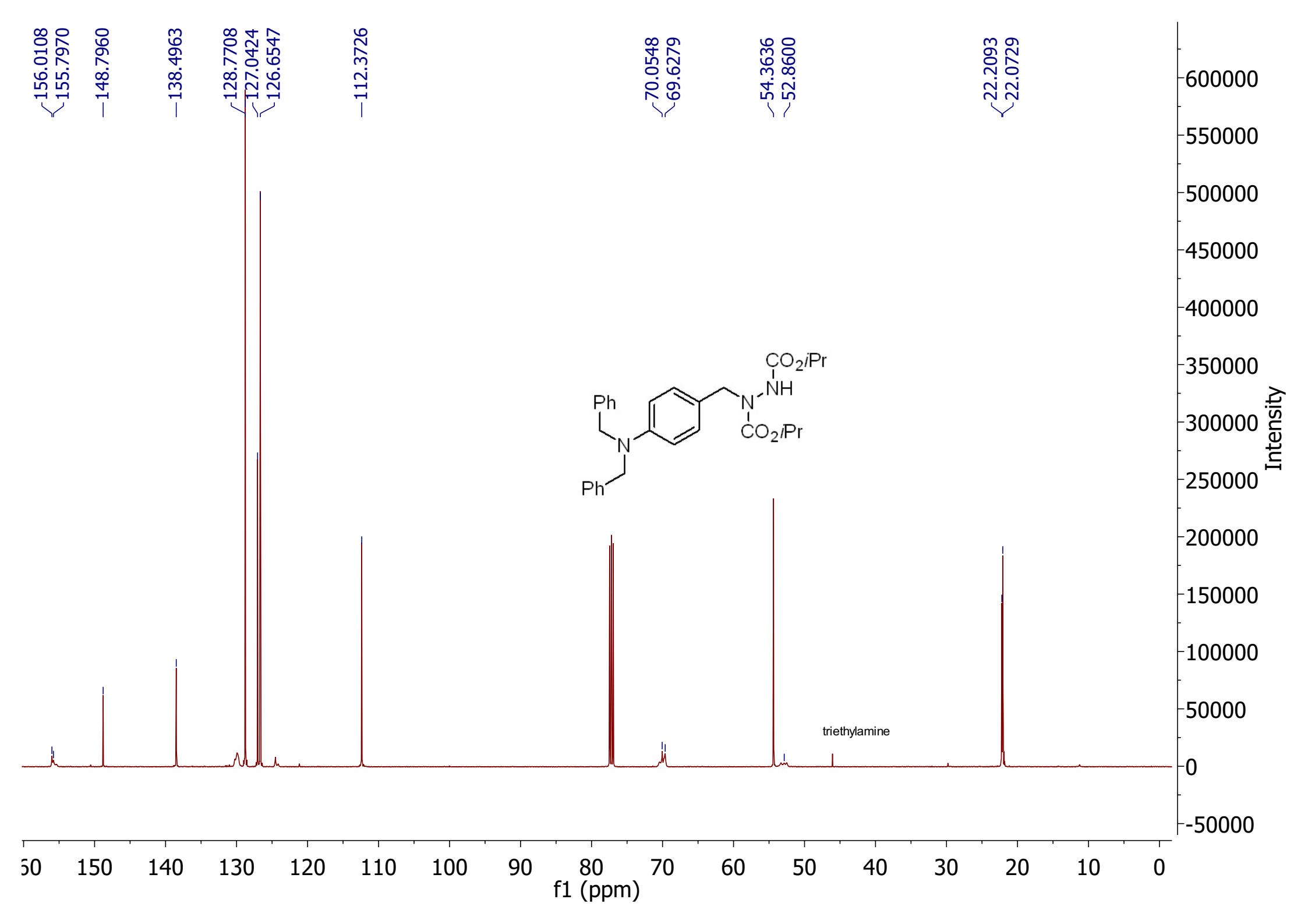

2h
iPrO2C
H
N
H
N
CO2iPr
iPrO2C
N
H
N
CO2iPr
CH2
1.00
1.00
2.26
1.84
2.24
2.12
4.25
14.48
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Intensity

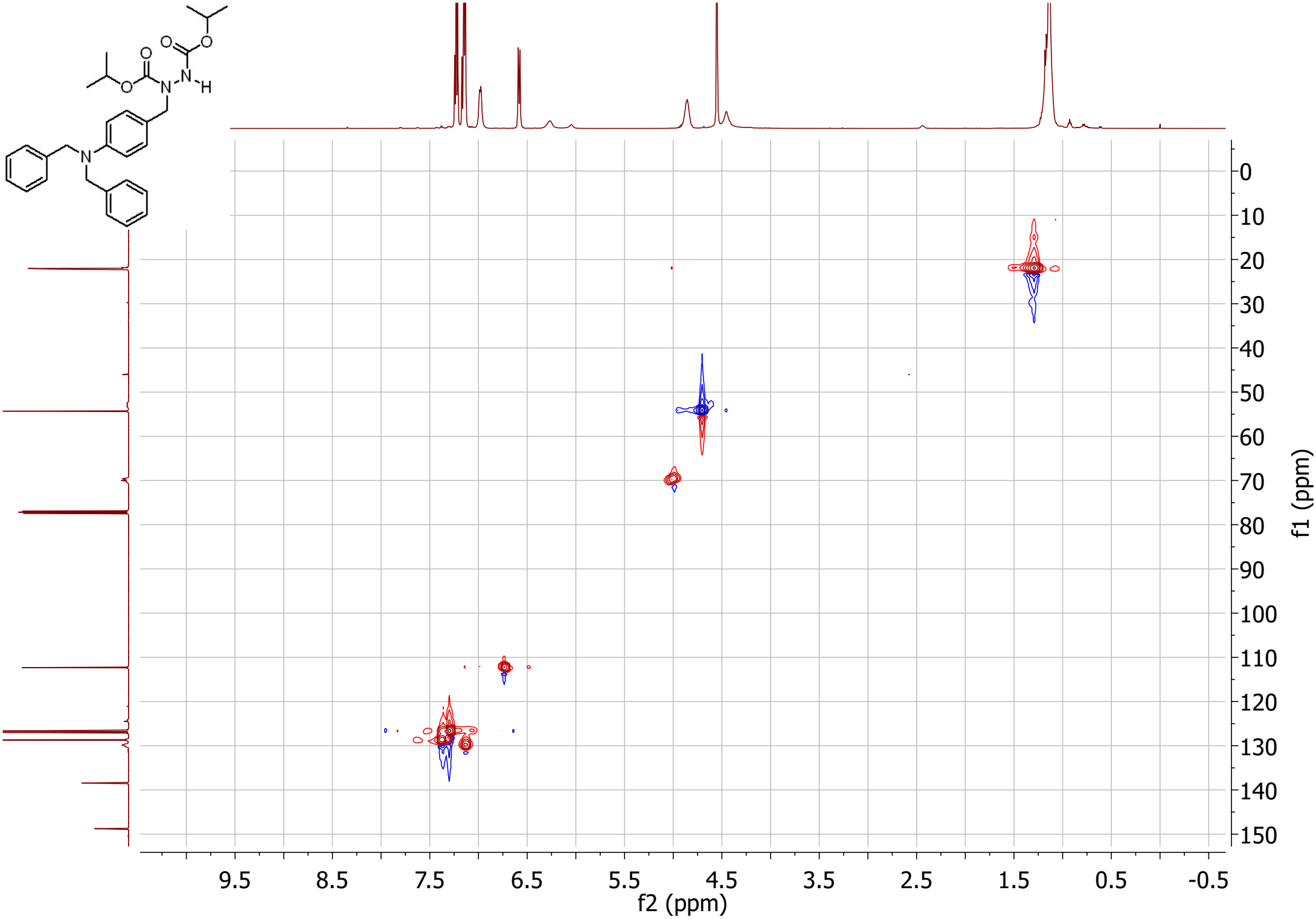

156.2852
155.6011
132.9853
125.5177
70.1672
69.6625
56.3307
26.4465
25.2314
22.6549
22.3776
22.2135
22.1378
iPrO2C
N
H
N
CO2iPr
+
Intensity
f1 (ppm)

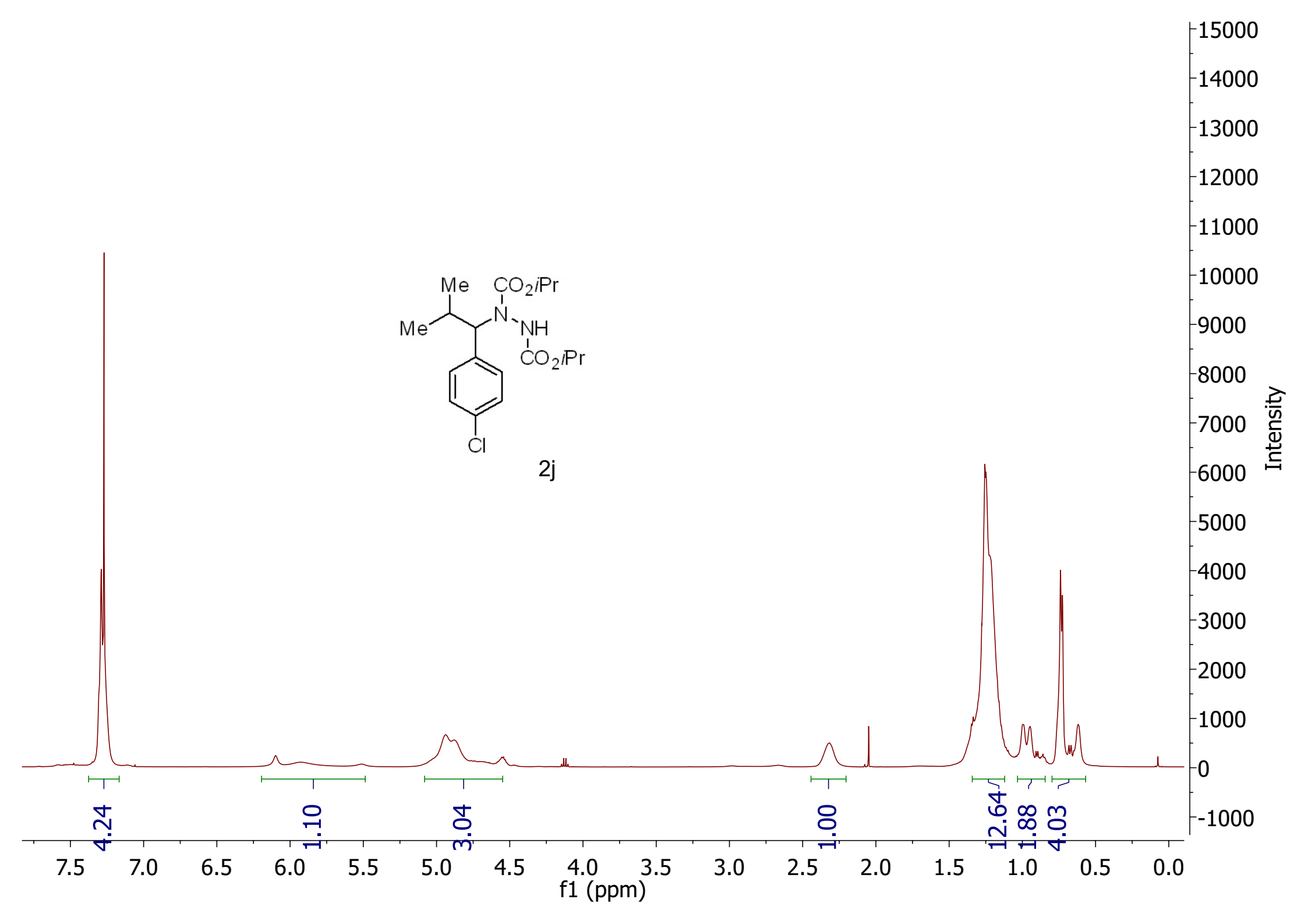

CO2iPr
NH
N
CO2iPr
+
iPrO2C
N
H
N
CO2iPr
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
f1 (ppm)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f2 (ppm)

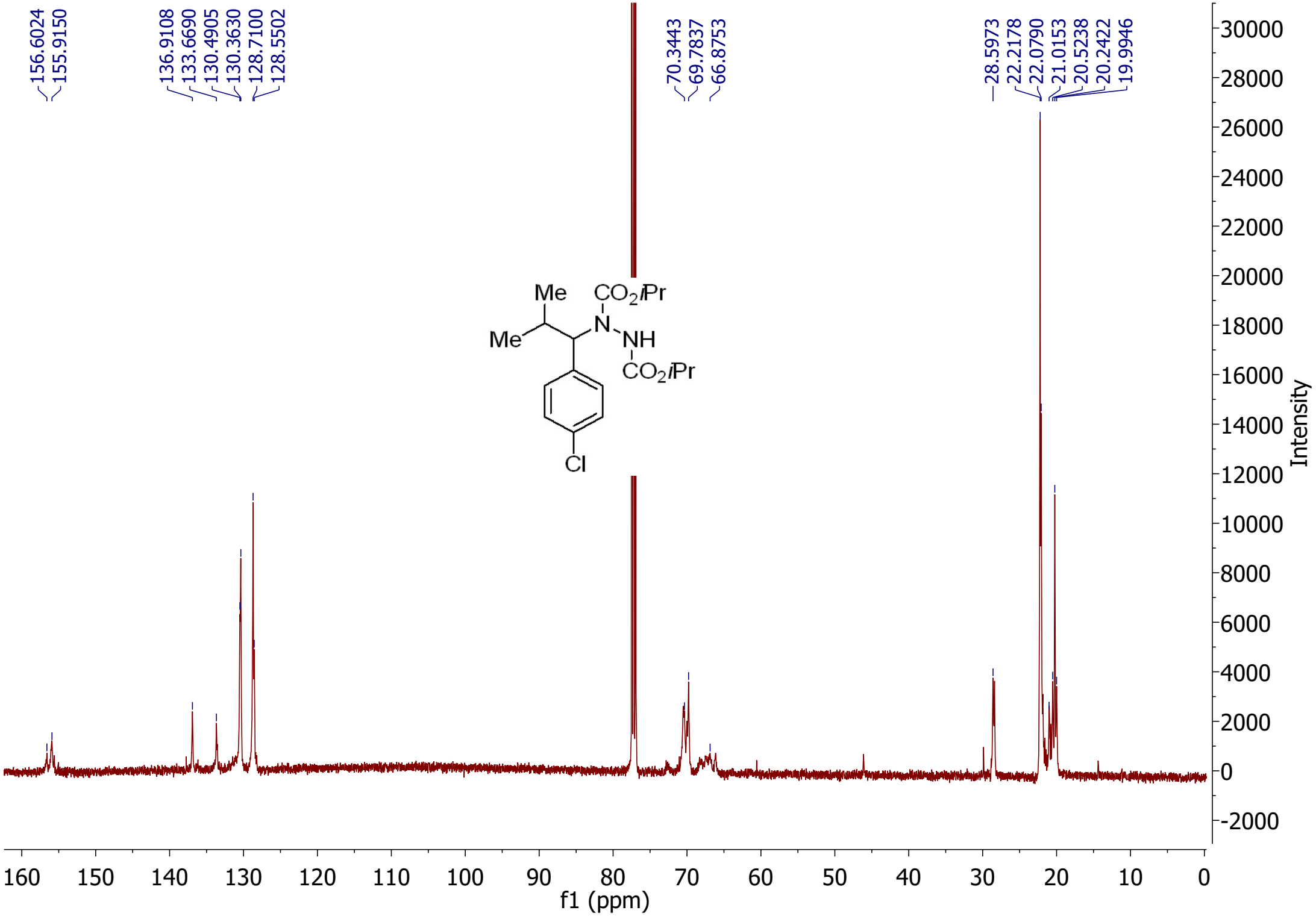

104
106
108
110
112
114
116
118
120
122
124
126
128
130
f1 (ppm)
5.65
5.55
5.45
5.35
5.25
5.15
5.05
4.95
4.85
4.75
4.65
f2 (ppm)

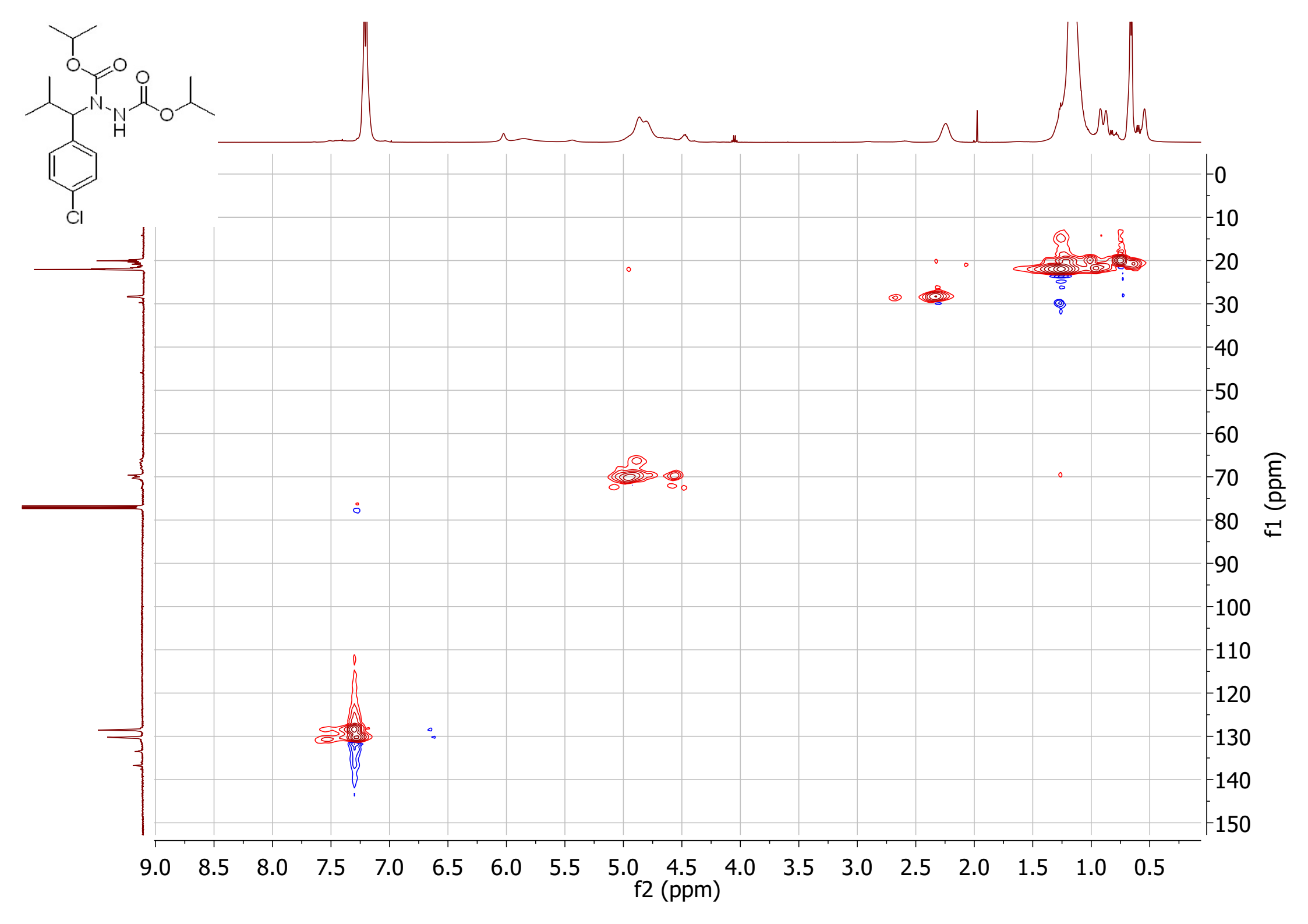

2i
4.14
6.20
2.01
2.00
0.89
2.00
5.70
12.32
f1 (ppm)
Intensity

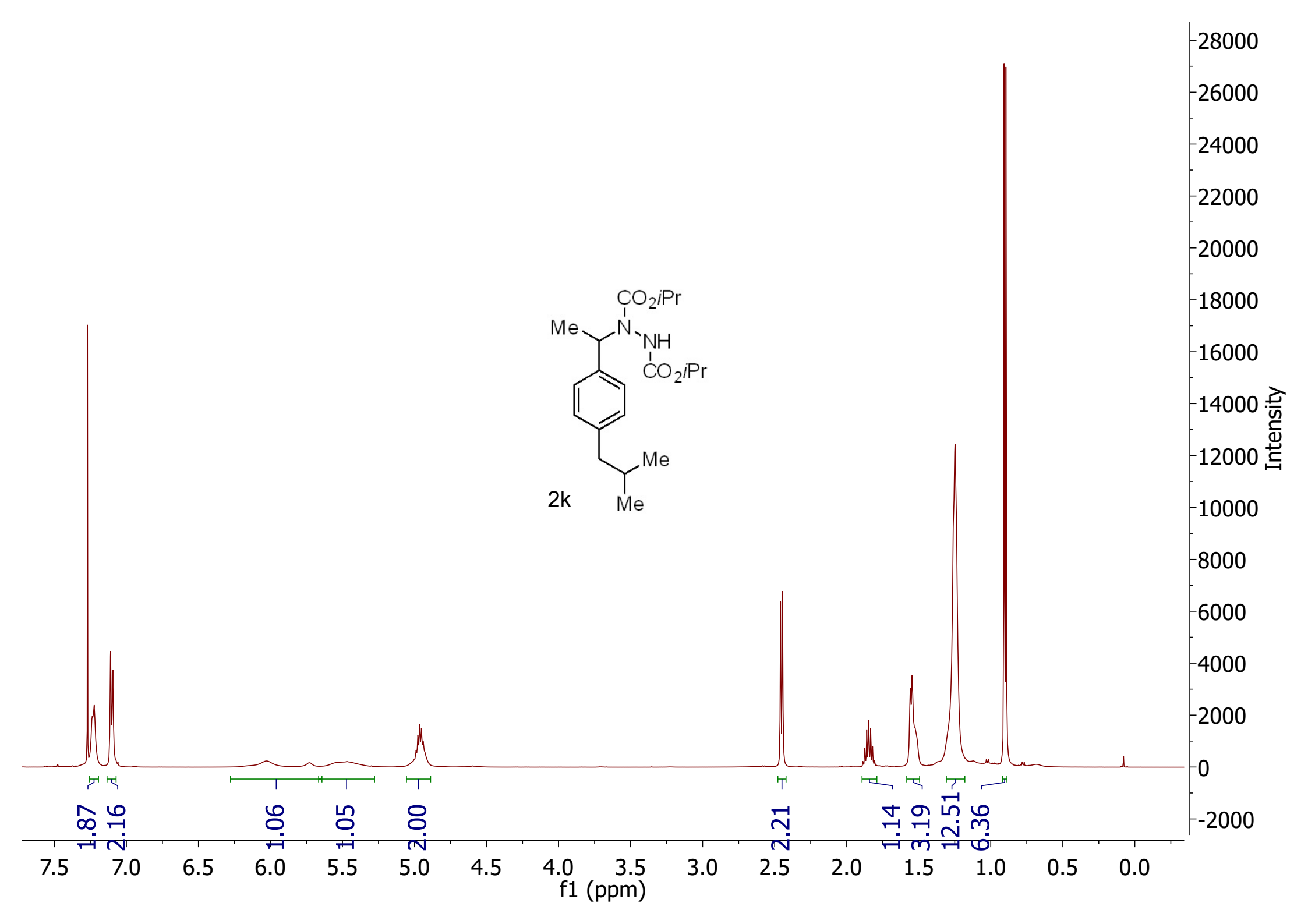

156.0108
155.7970
148.7960
138.4963
128.7708
127.0424
126.6547
112.3726
70.0548
69.6279
54.3636
52.8600
22.2093
22.0729
CO2iPr
NH
N
CO2iPr
Ph
N
Ph
triethylamine
600000
550000
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
-50000
Intensity
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

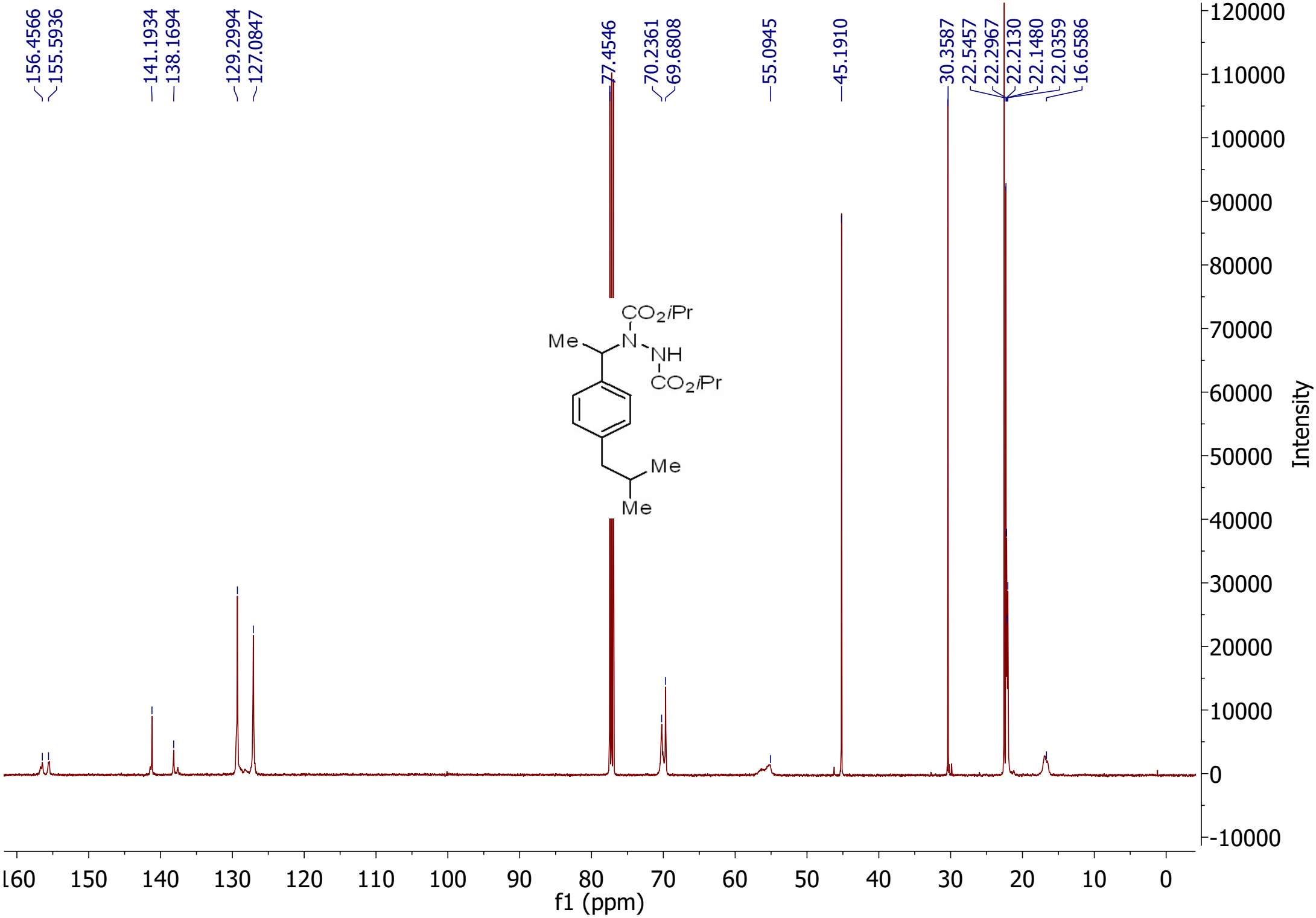

O
O
O
O
N
N
H
N
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
f2 (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
f1 (ppm)

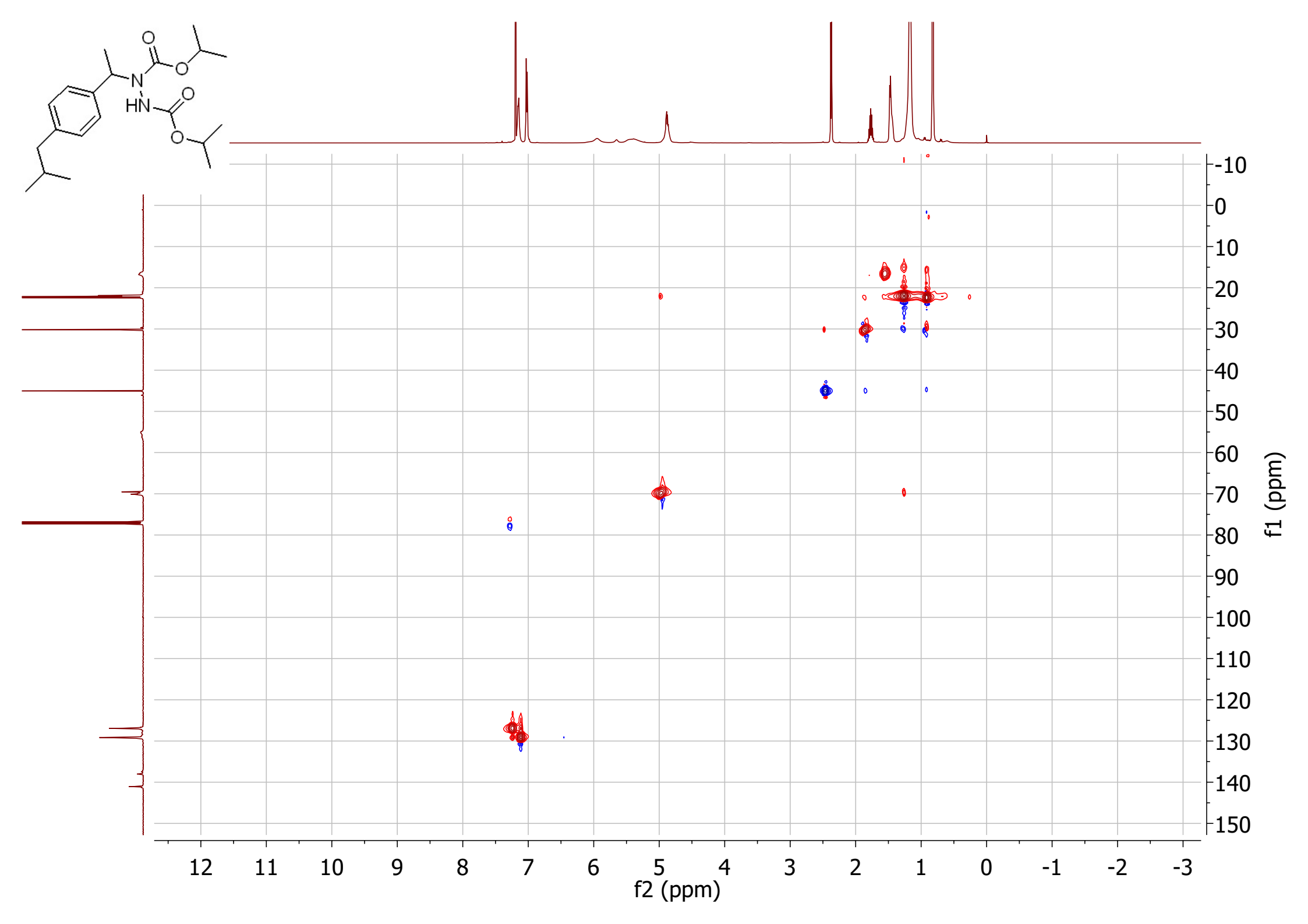

Me
CO2iPr
N
Me
NH
CO2iPr
Cl
2j
4.24
1.10
3.04
1.00
12.64
1.88
4.03
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Intensity

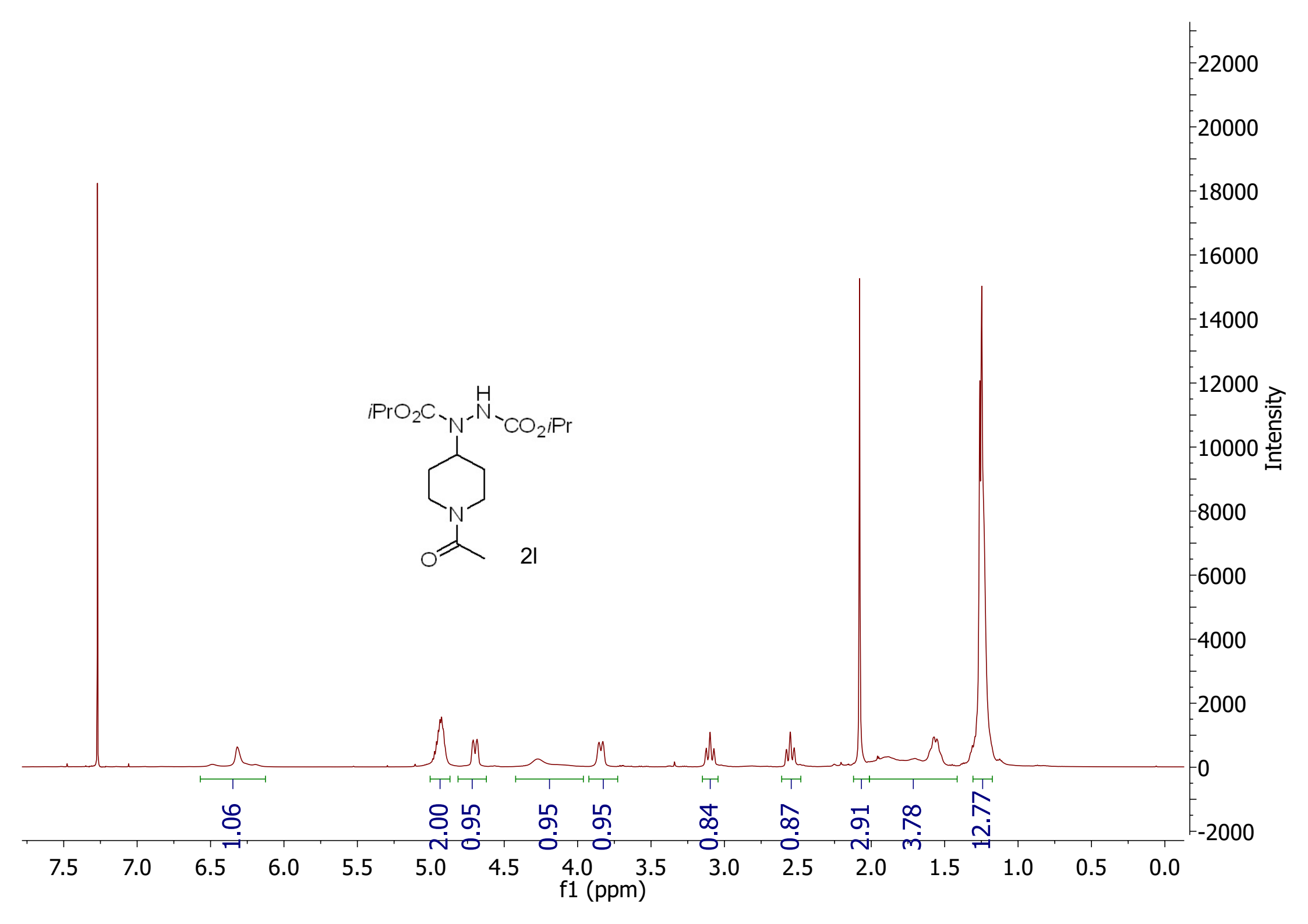

156.6024
155.9150
136.9108
133.6690
130.4905
130.3630
128.7100
128.5502
70.3443
69.7837
66.8753
28.5973
22.2178
22.0790
21.0153
20.5238
20.2422
19.9946
Me
CO2iPr
N
Me
NH
CO2iPr
Cl
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Intensity
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

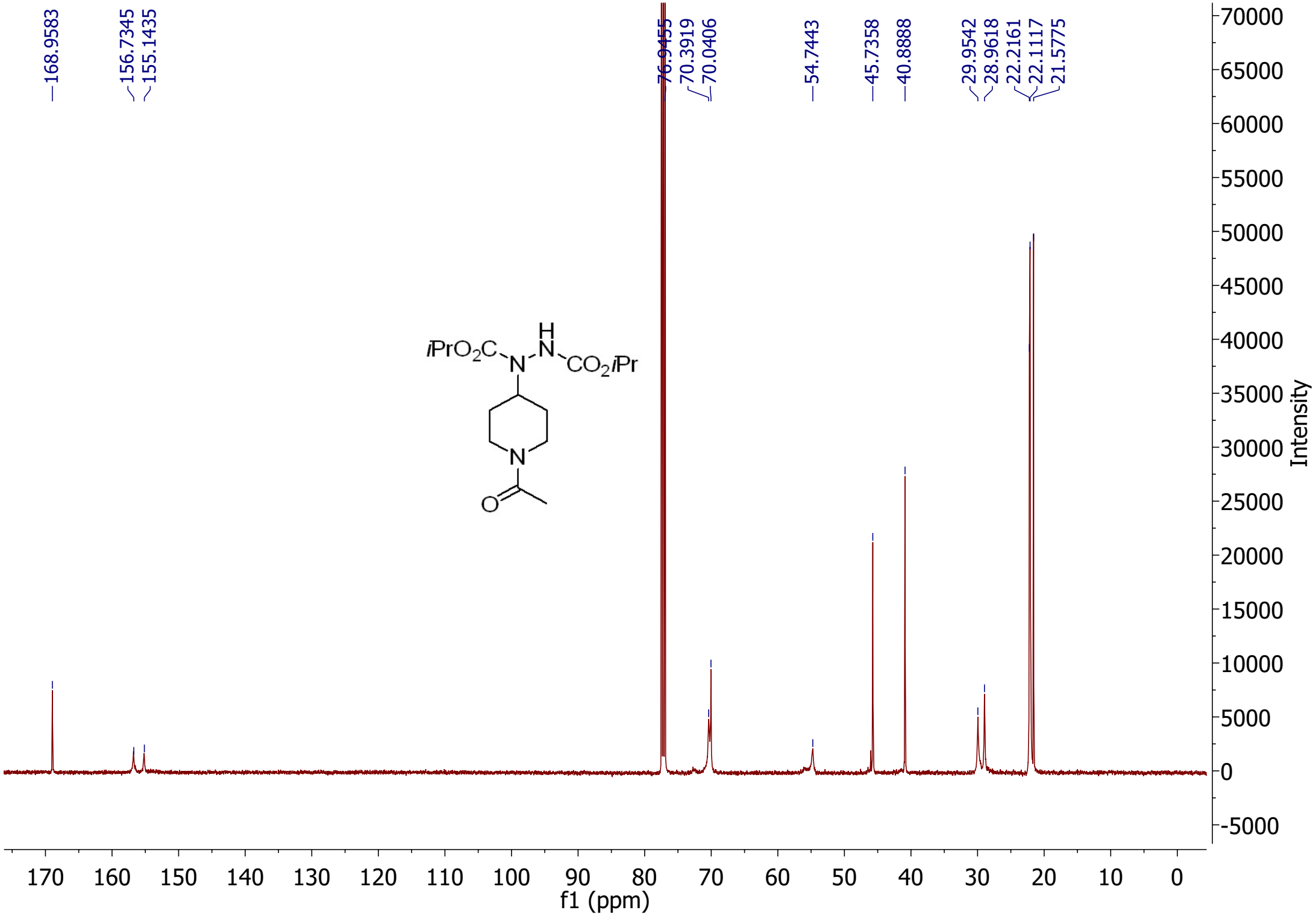

O
O
O
N
N
H
O
Cl
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f2 (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
f1 (ppm)

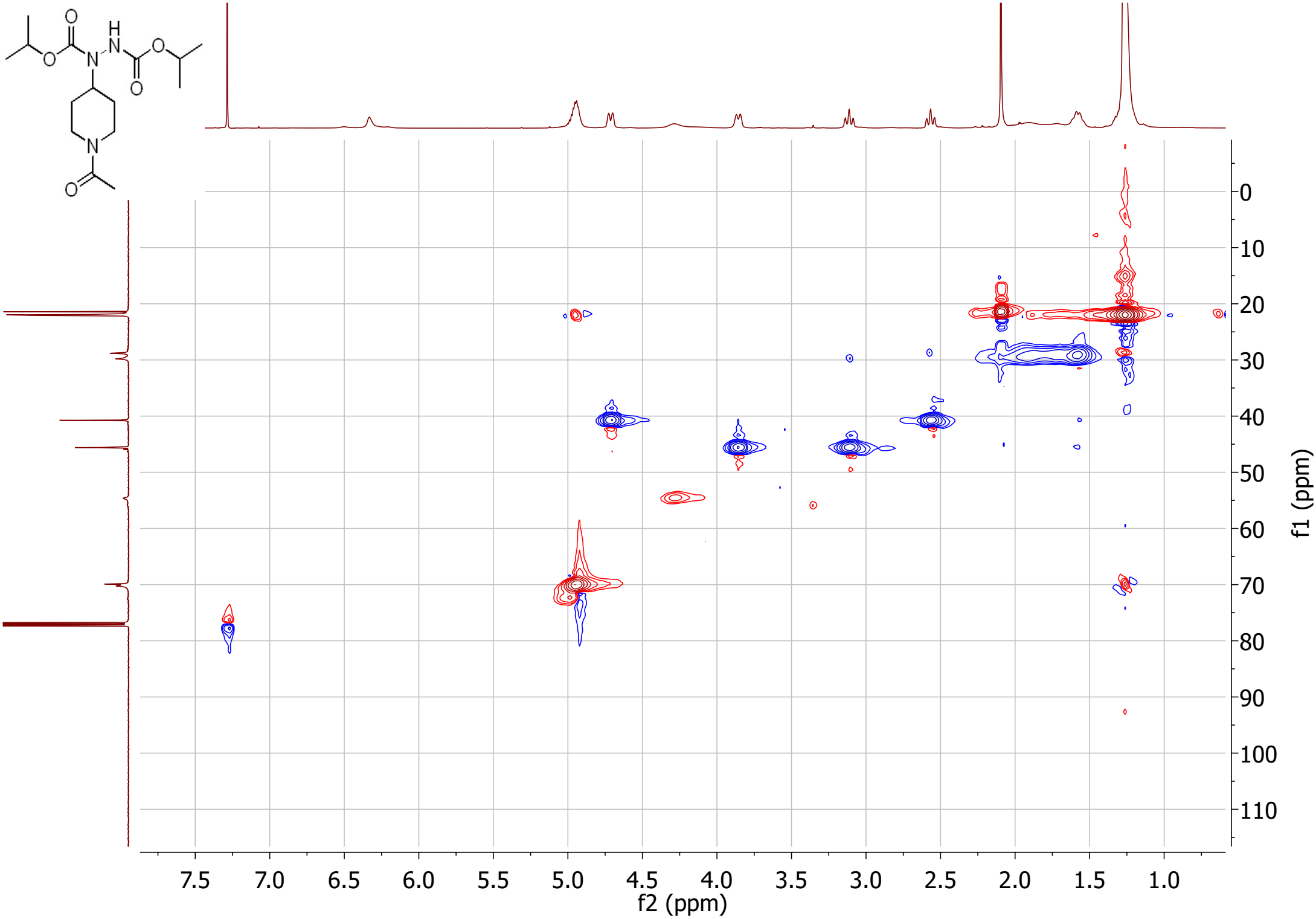

CO2iPr
Me
N
NH
CO2iPr
Me
Me
2k
1.87
2.16
1.06
1.05
2.00
2.21
1.14
3.19
12.51
6.36
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Intensity

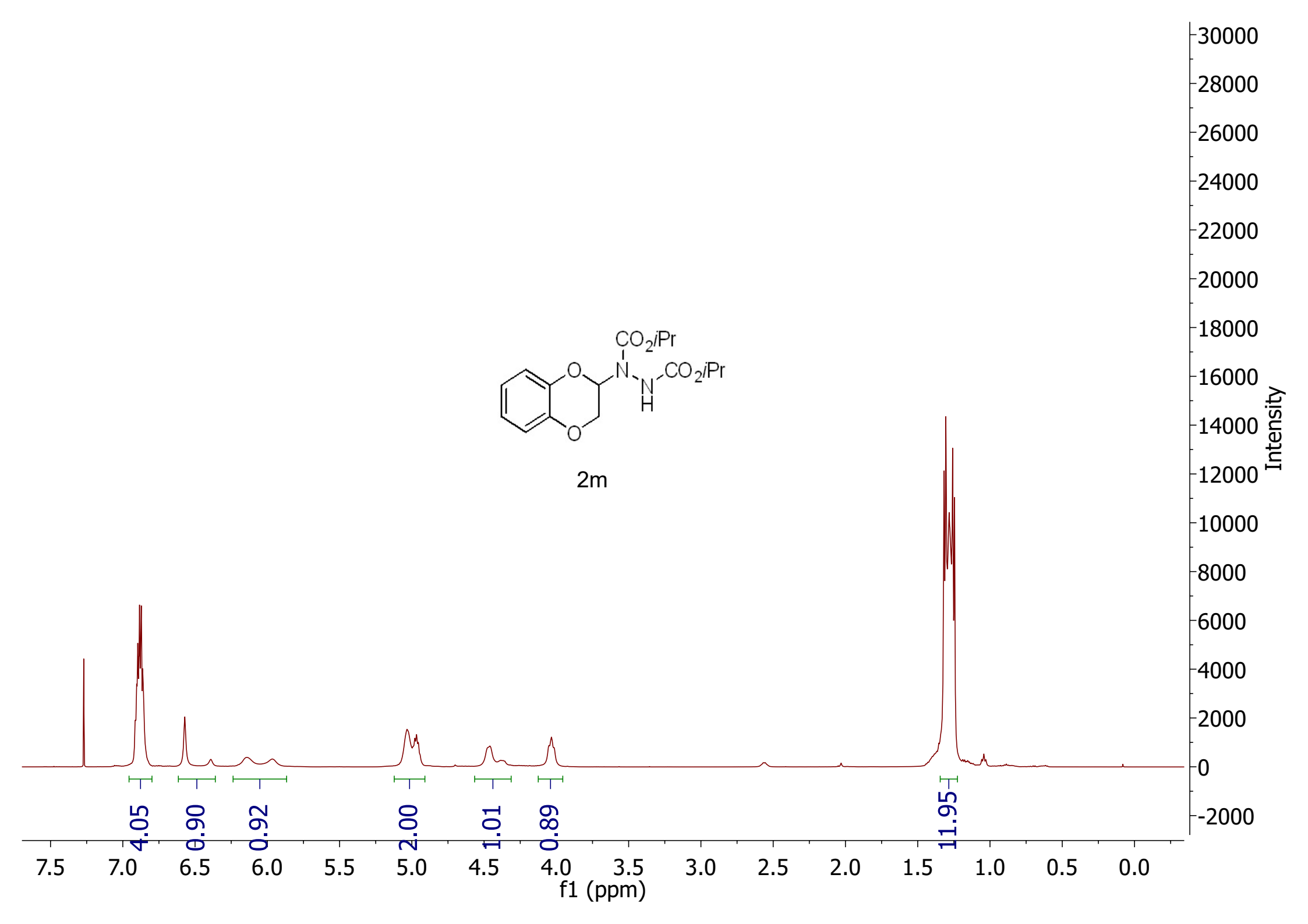

156.4566
155.5936
141.1934
138.1694
129.2994
127.0847
77.4546
70.2361
69.6808
55.0945
45.1910
30.3587
22.5457
22.2967
22.2130
22.1480
22.0359
16.6586
CO2iPr
Me
N
NH
CO2iPr
Me
Me
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
Intensity
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

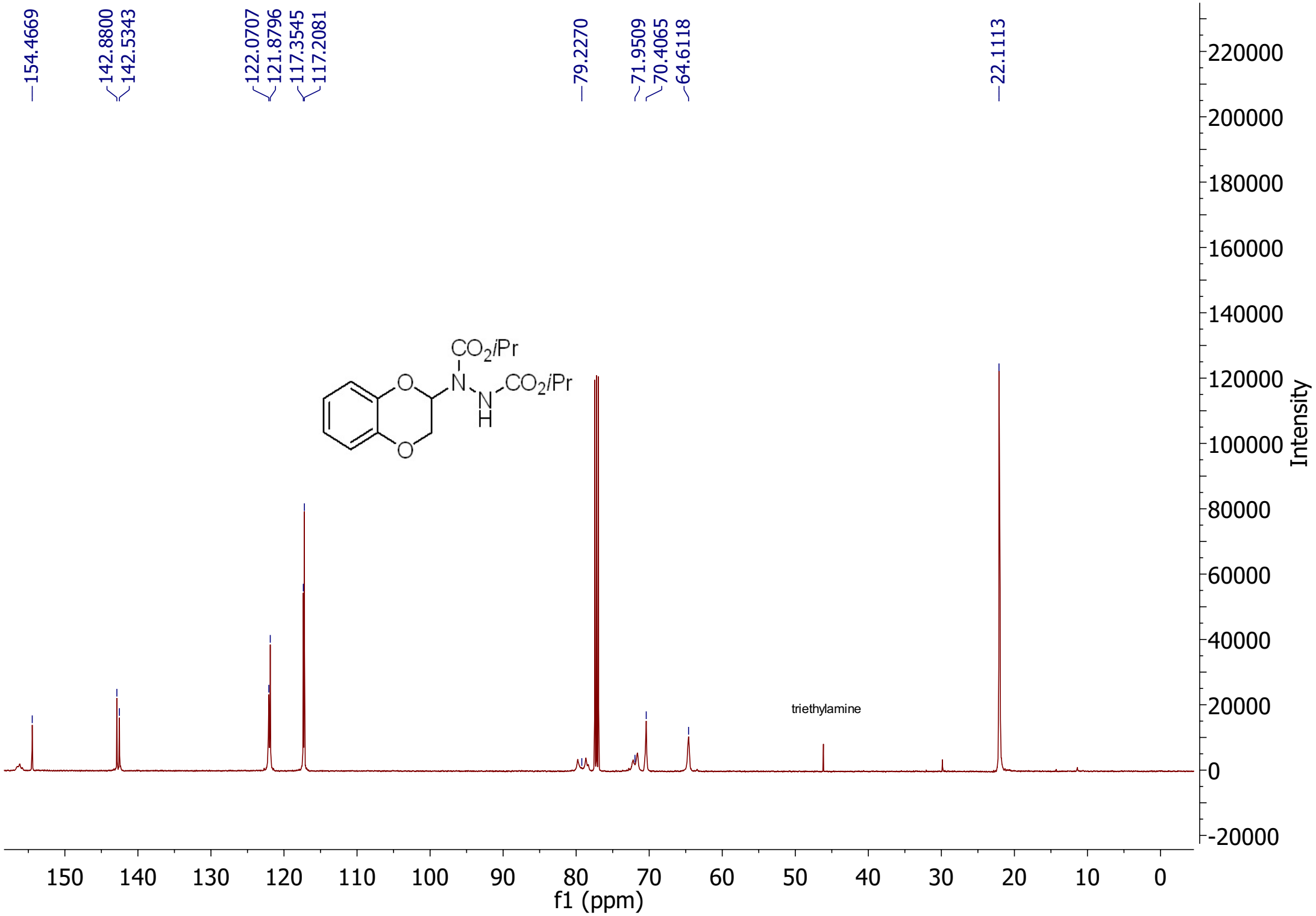

O
N
HN
O
O
O
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
f2 (ppm)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
f1 (ppm)

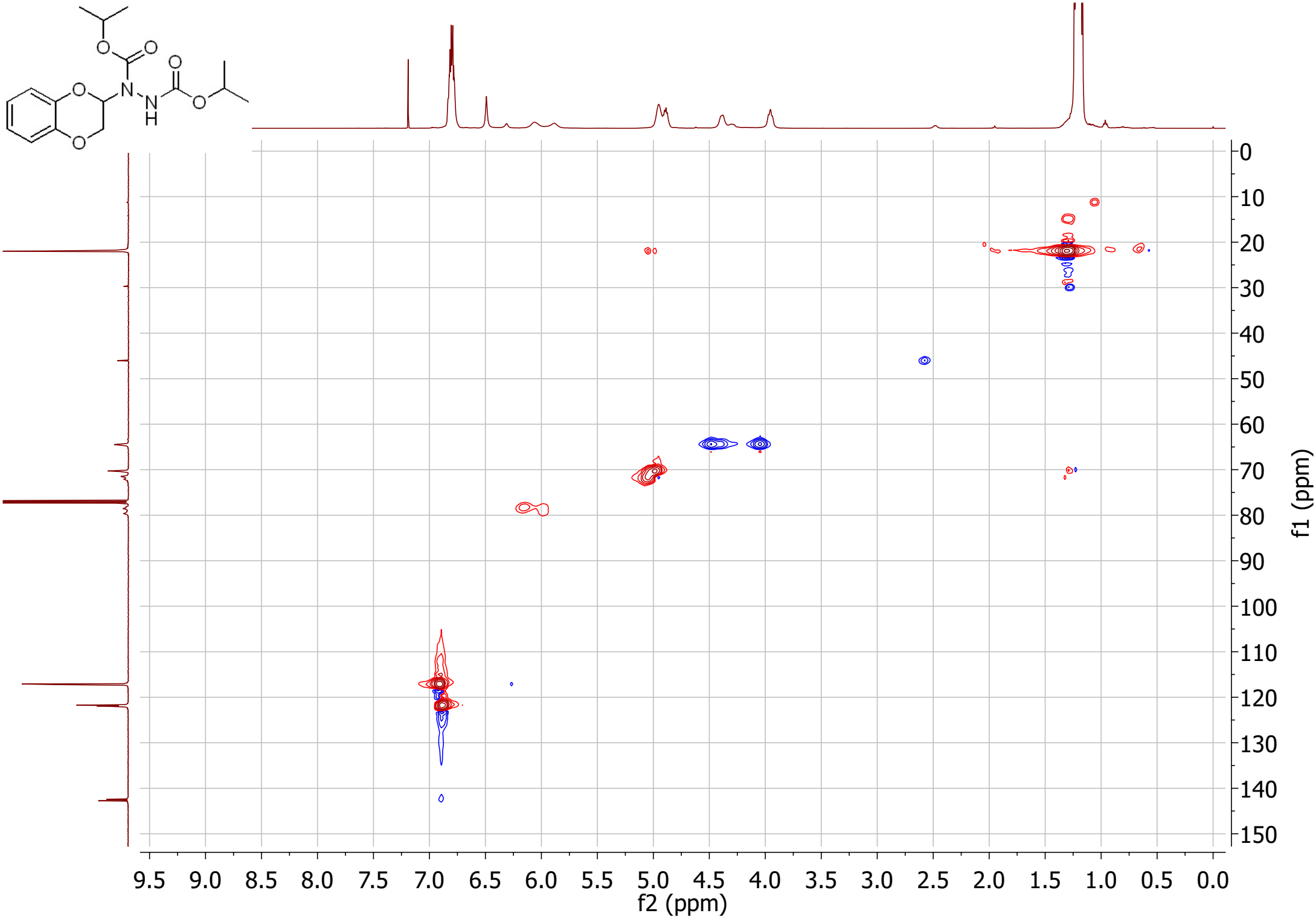

iPrO2C
N
H
N
CO2iPr
N
O
2l
1.06
2.00
0.95
0.95
0.95
0.84
0.87
2.91
3.78
12.77
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Intensity

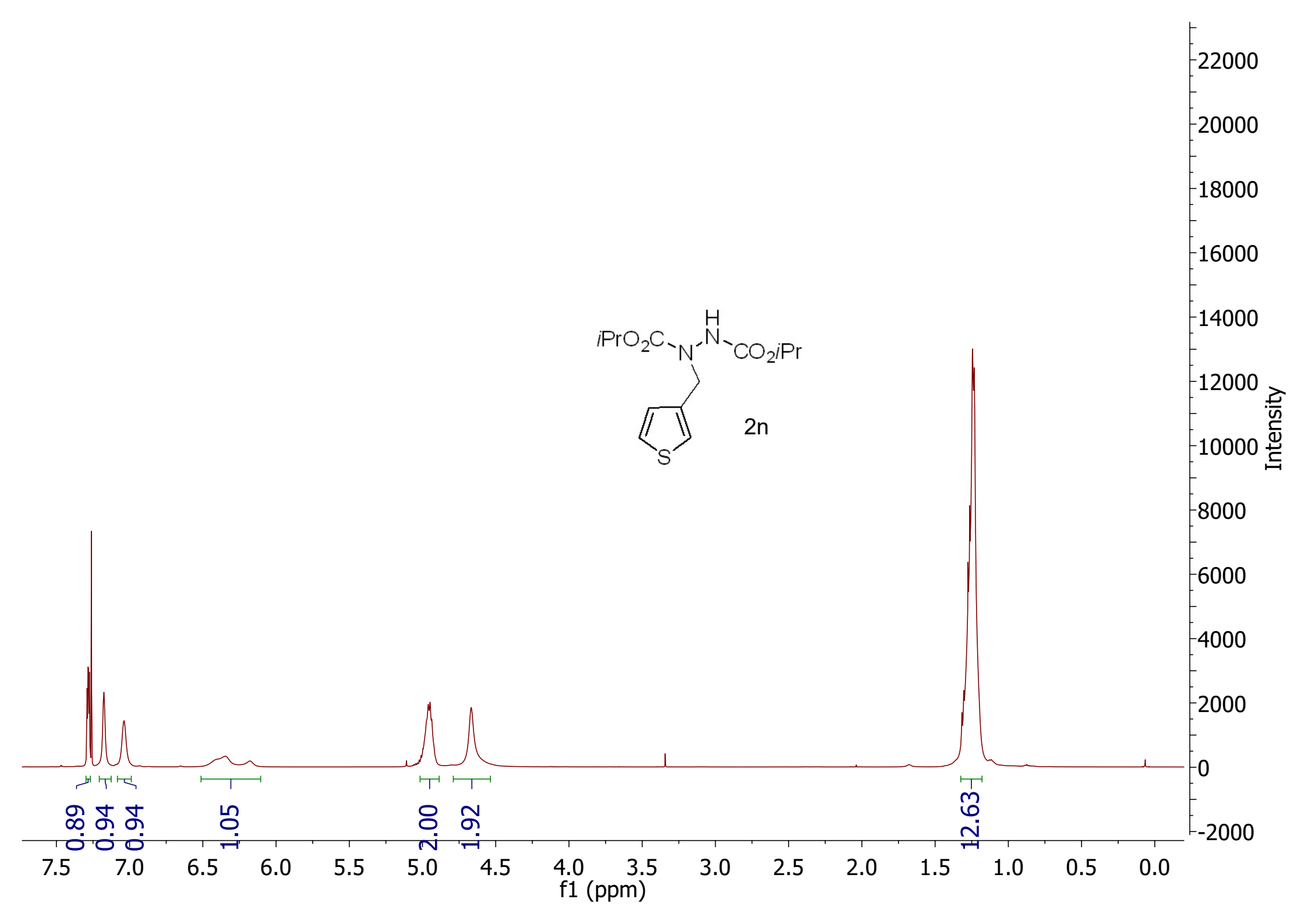

168.9583
156.7345
155.1435
76.9455
70.3919
70.0406
54.7443
45.7358
40.8888
29.9542
28.9618
22.2161
22.1117
21.5775
iPrO2C
N
H
N
CO2iPr
N
O
70000
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
Intensity
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

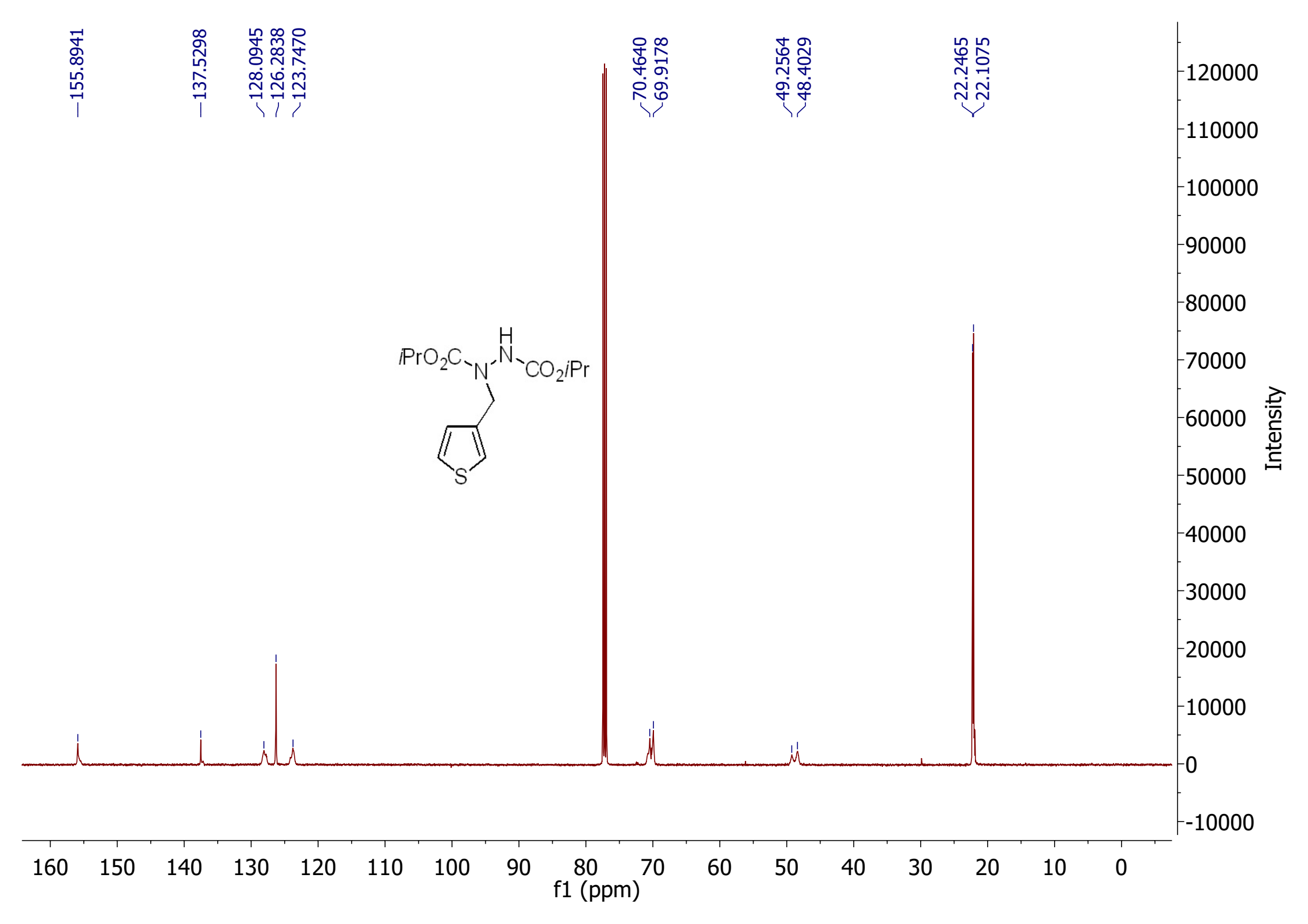

O
H
N
O
O
N
O
N
O
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
f2 (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
f1 (ppm)

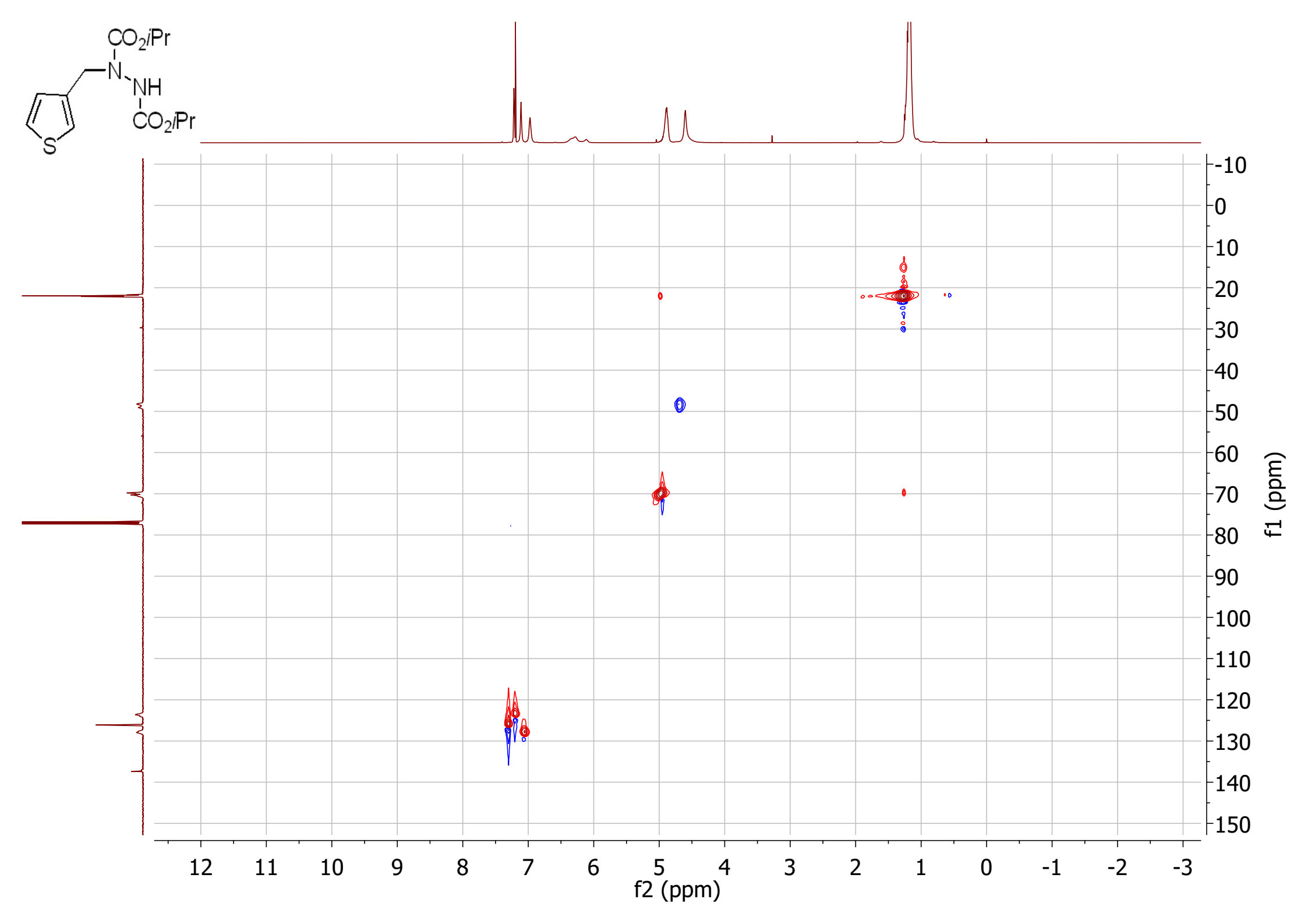

CO2iPr
O
N
N
CO2iPr
H
O
2m
4.05
0.90
0.92
2.00
1.01
0.89
11.95
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Intensity

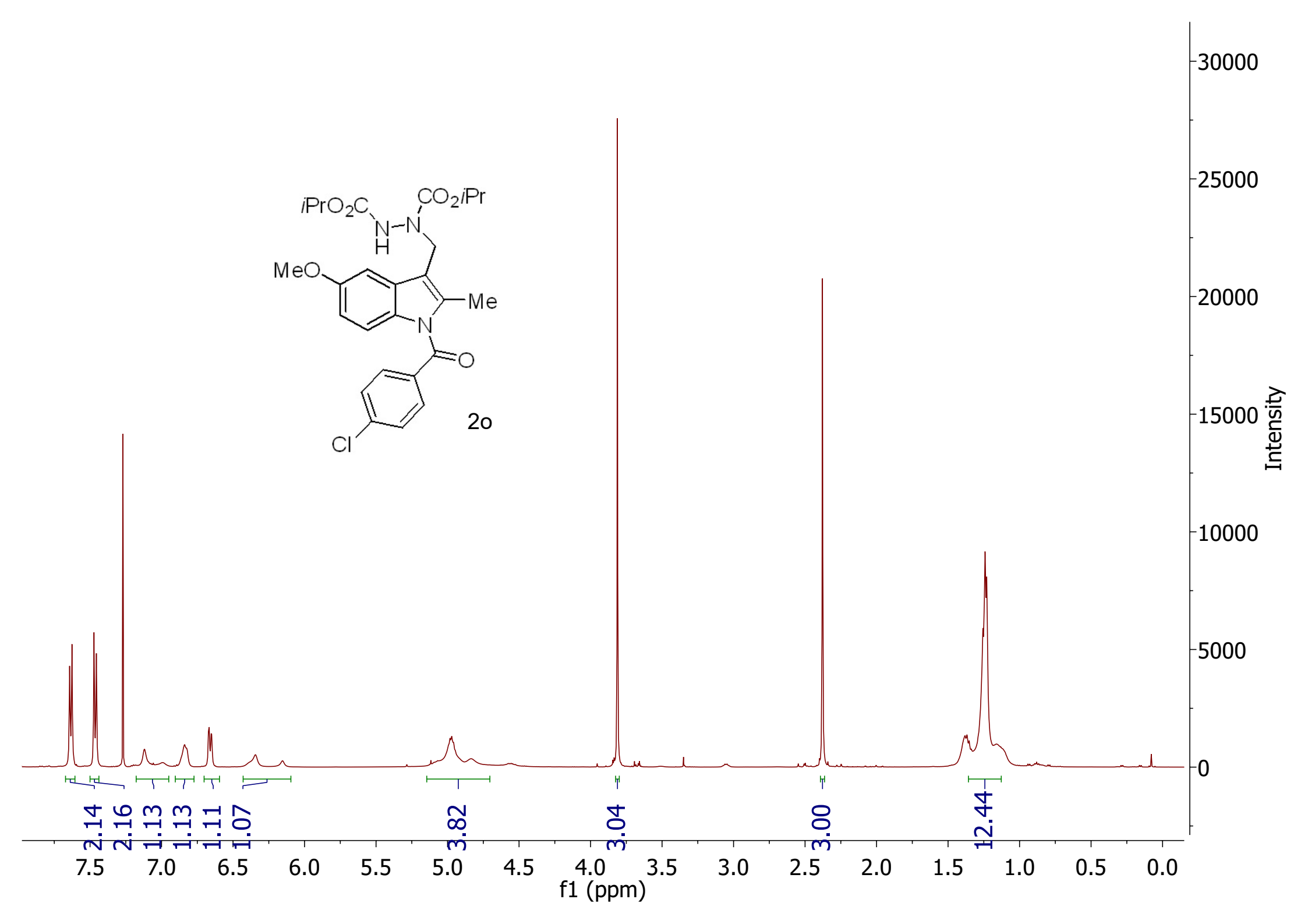

154.4669
142.8800
142.5343
122.0707
121.8796
117.3545
117.2081
79.2270
71.9509
70.4065
64.6118
22.1113
CO2iPr
N
N
H
CO2iPr
O
O
triethylamine
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
Intensity
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

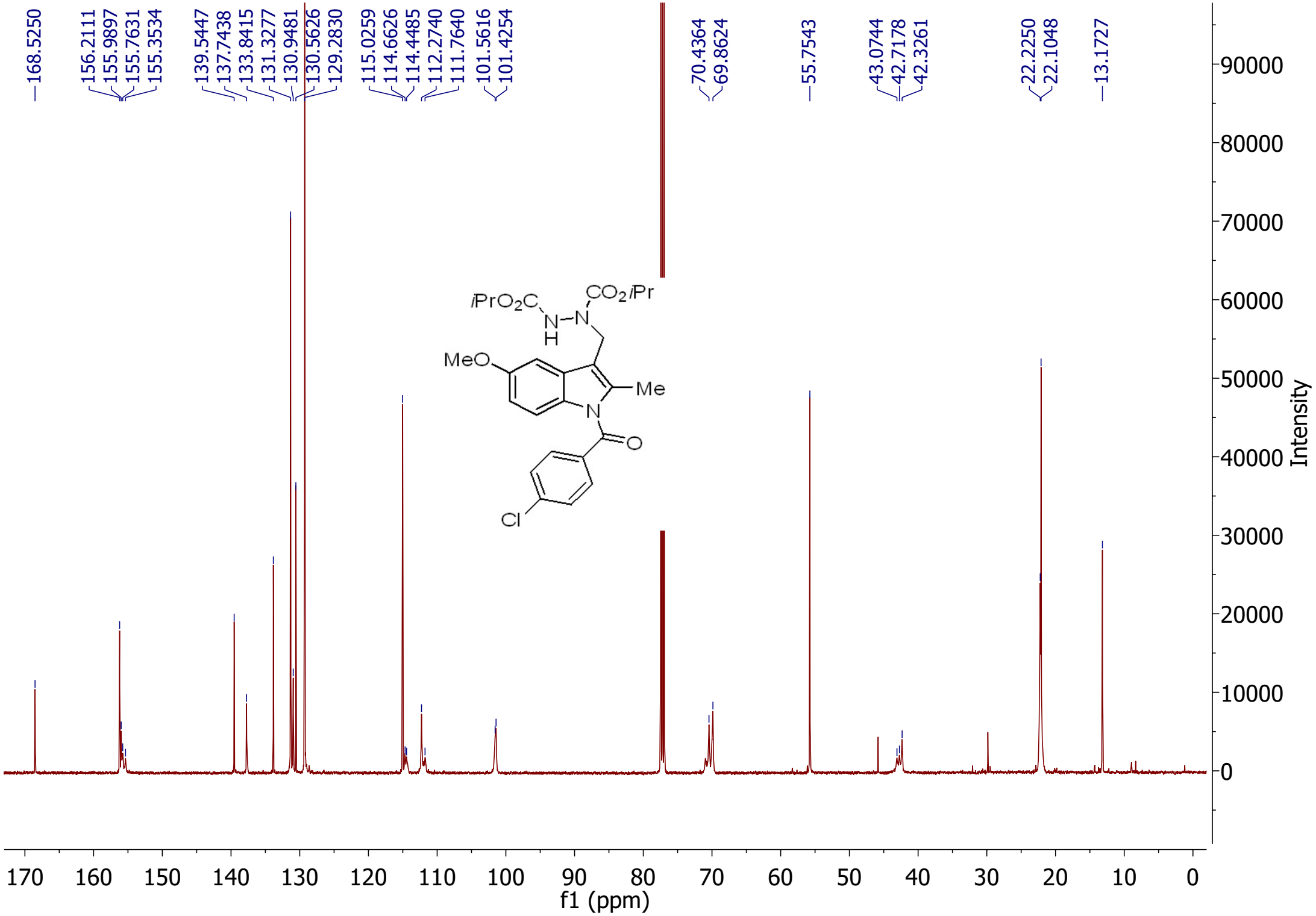

f2 (ppm)
f1 (ppm)

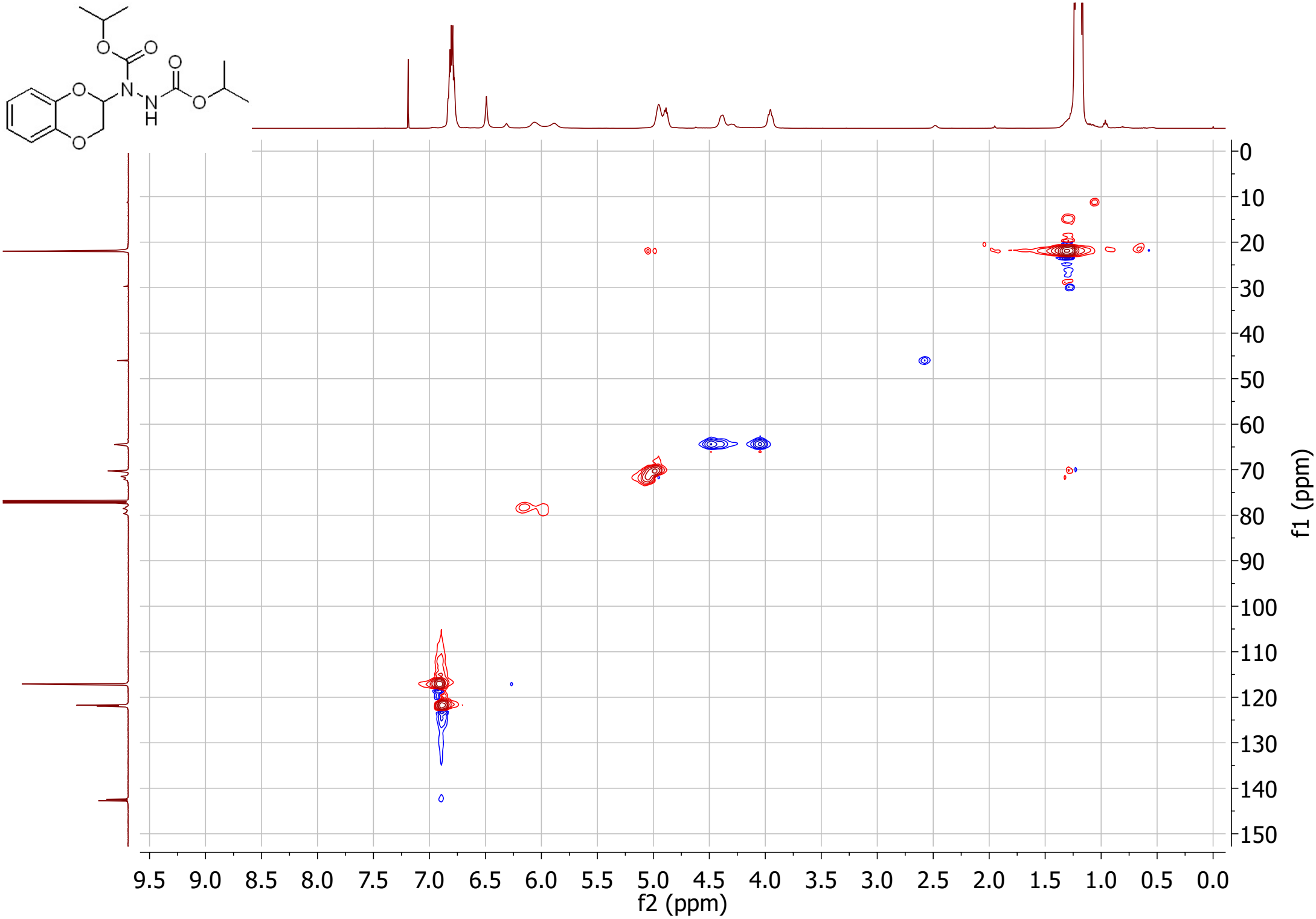

iPrO2C
N
H
N
CO2iPr
S
2n
0.89
0.94
0.94
1.05
2.00
1.92
12.63
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Intensity

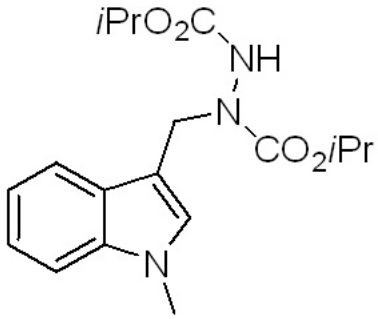

155.8941
137.5298
128.0945
126.2838
123.7470
70.4640
69.9178
49.2564
48.4029
22.2465
22.1075
iPrO2C
N
H
N
CO2iPr
S
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
Intensity
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


CO2iPr
N
NH
CO2iPr
S
f2 (ppm)
f1 (ppm)
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150


iPrO2C
CO2iPr
N
N
H
MeO
Me
N
O
Cl
2o
30000
25000
20000
15000
10000
5000
0
Intensity
2.14
2.16
1.13
1.13
1.11
1.07
3.82
3.04
3.00
12.44
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
0.0
f1 (ppm)

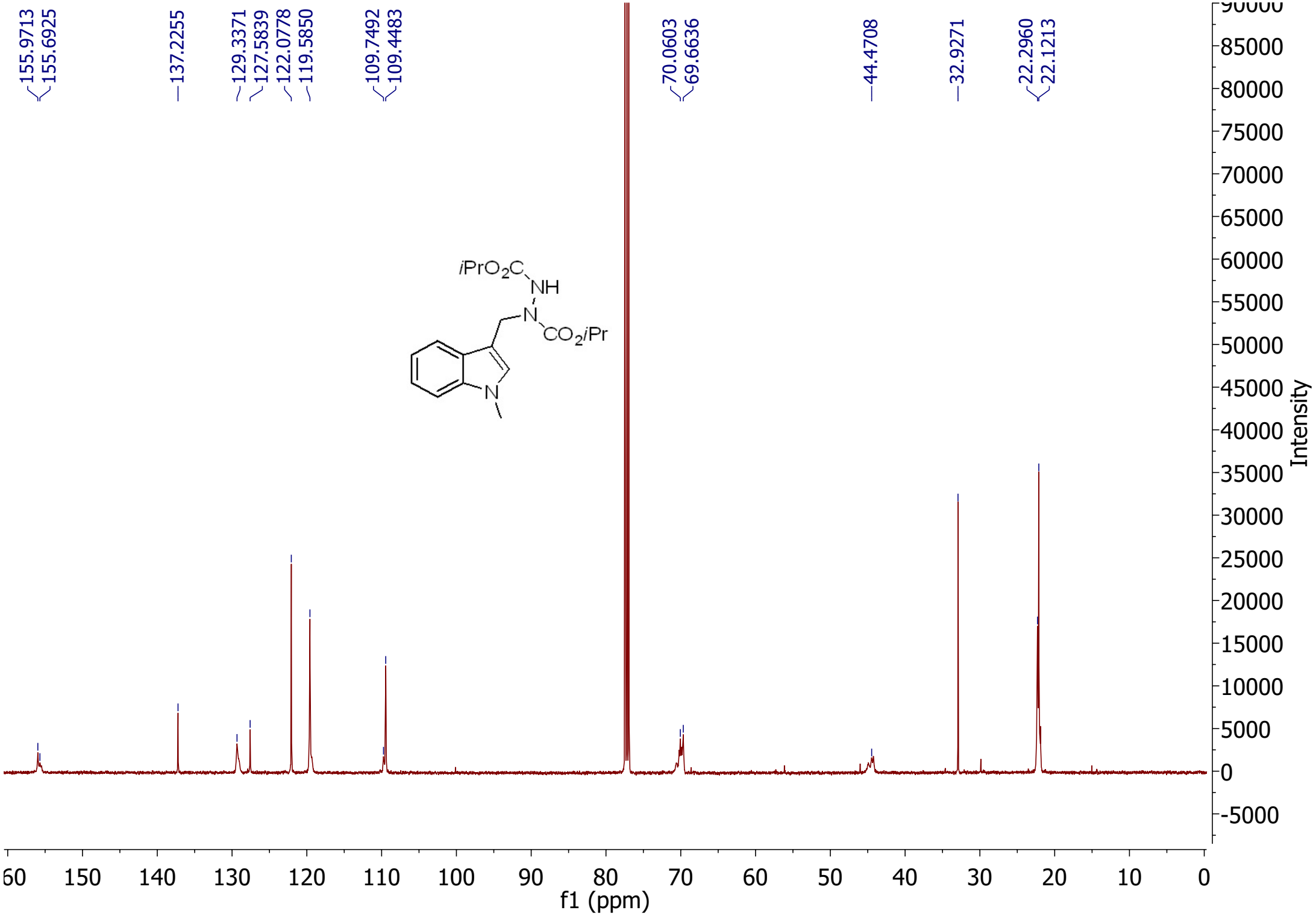

168.5250
156.2111
155.9897
155.7631
155.3534
139.5447
137.7438
133.8415
131.3277
130.9481
130.5626
129.2830
115.0259
114.6626
114.4485
112.2740
111.7640
101.5616
101.4254
70.4364
69.8624
55.7543
43.0744
42.7178
42.3261
22.2250
22.1048
13.1727
iPrO2C
CO2iPr
N
N
H
MeO
Me
N
O
Cl
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Intensity
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

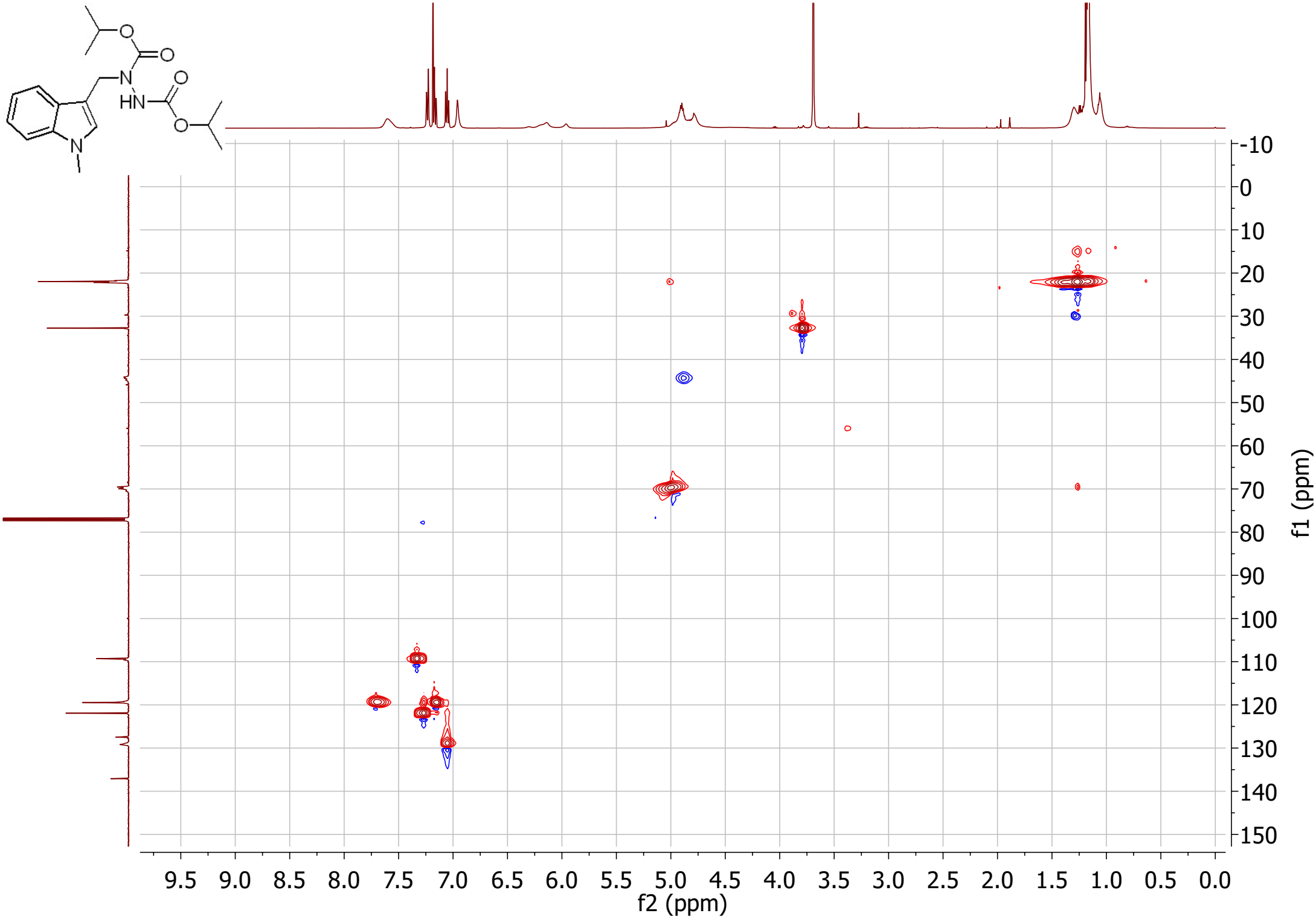

f2 (ppm)
f1 (ppm)

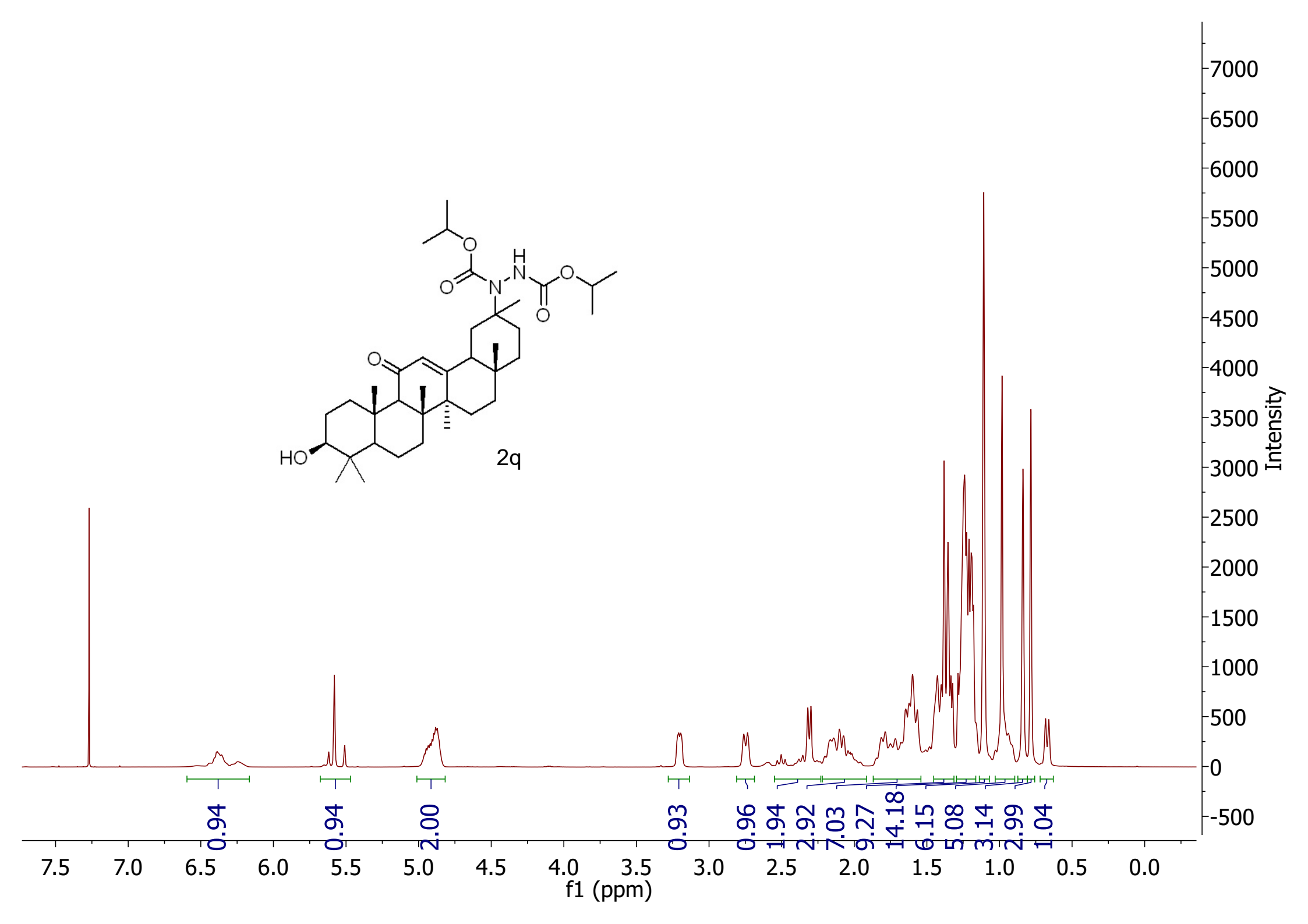

iPrO2C
NH
N
CO2iPr
N

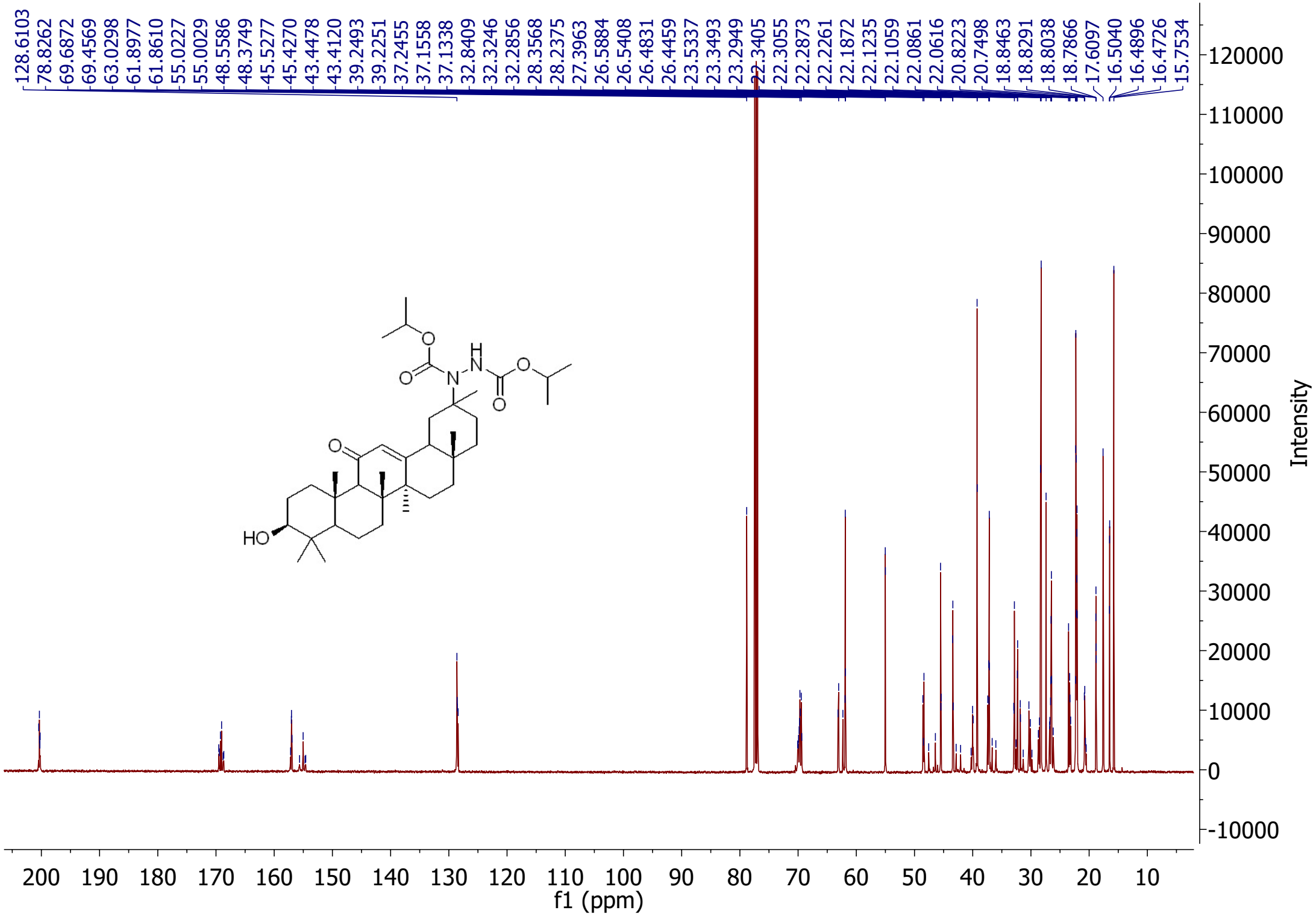
2p

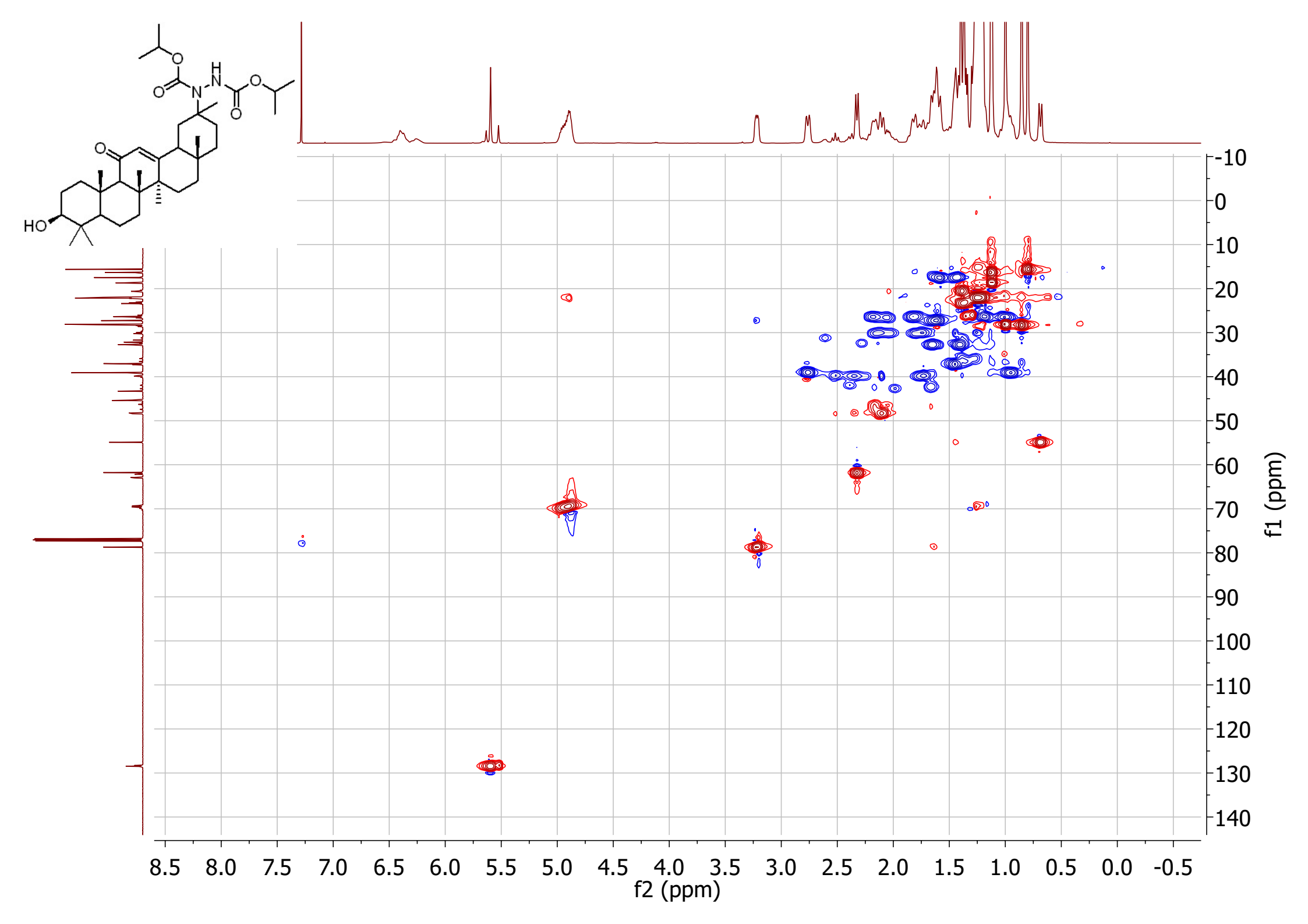
1.19
1.09
1.17
1.15
1.08
1.24
3.94
3.00
12.84
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
40000
38000
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Intensity

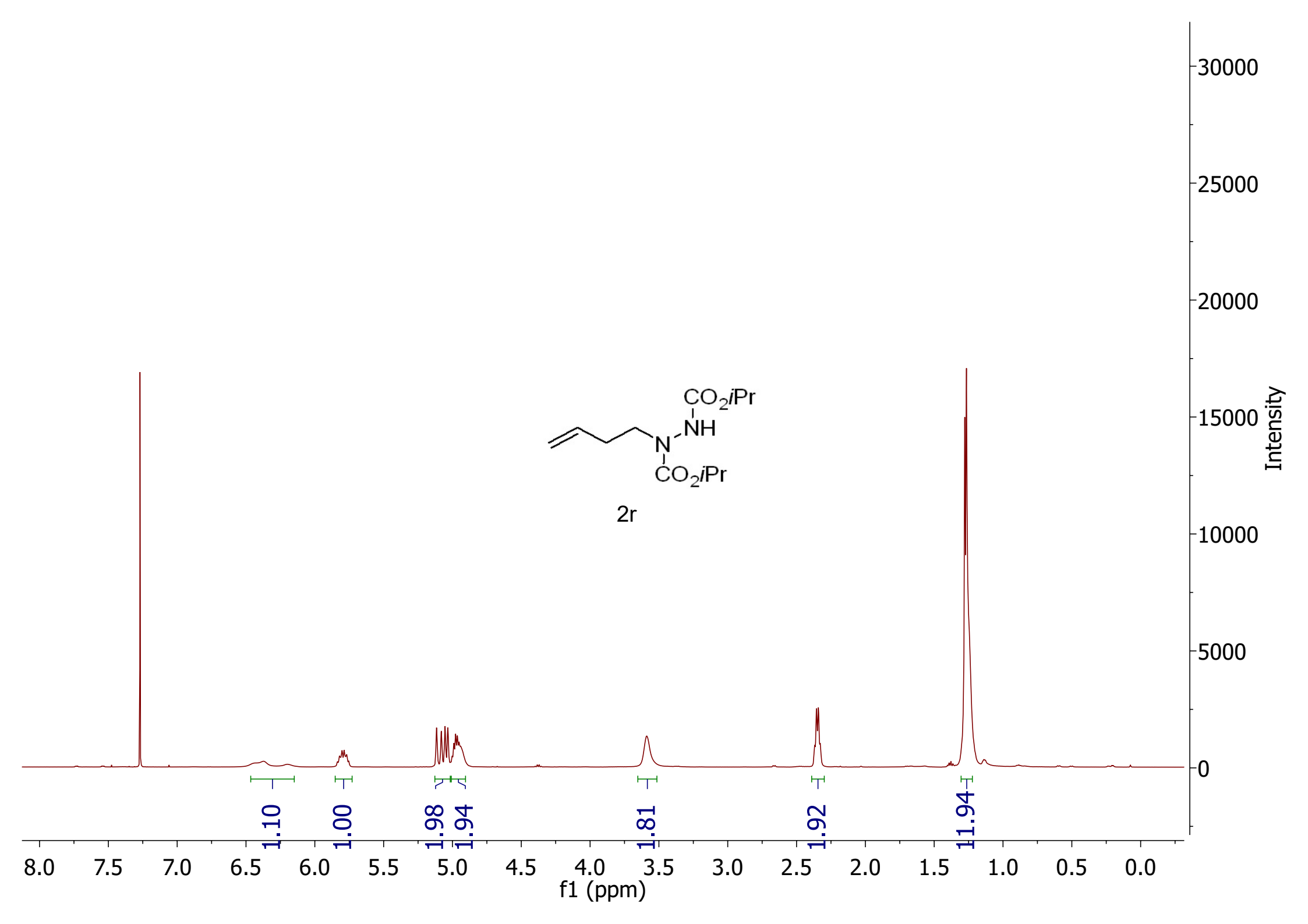

155.9713
155.6925
137.2255
129.3371
127.5839
122.0778
119.5850
109.7492
109.4483
70.0603
69.6636
44.4708
32.9271
22.2960
22.1213
iPrO2C
NH
N
CO2iPr
N
Intensity
f1 (ppm)

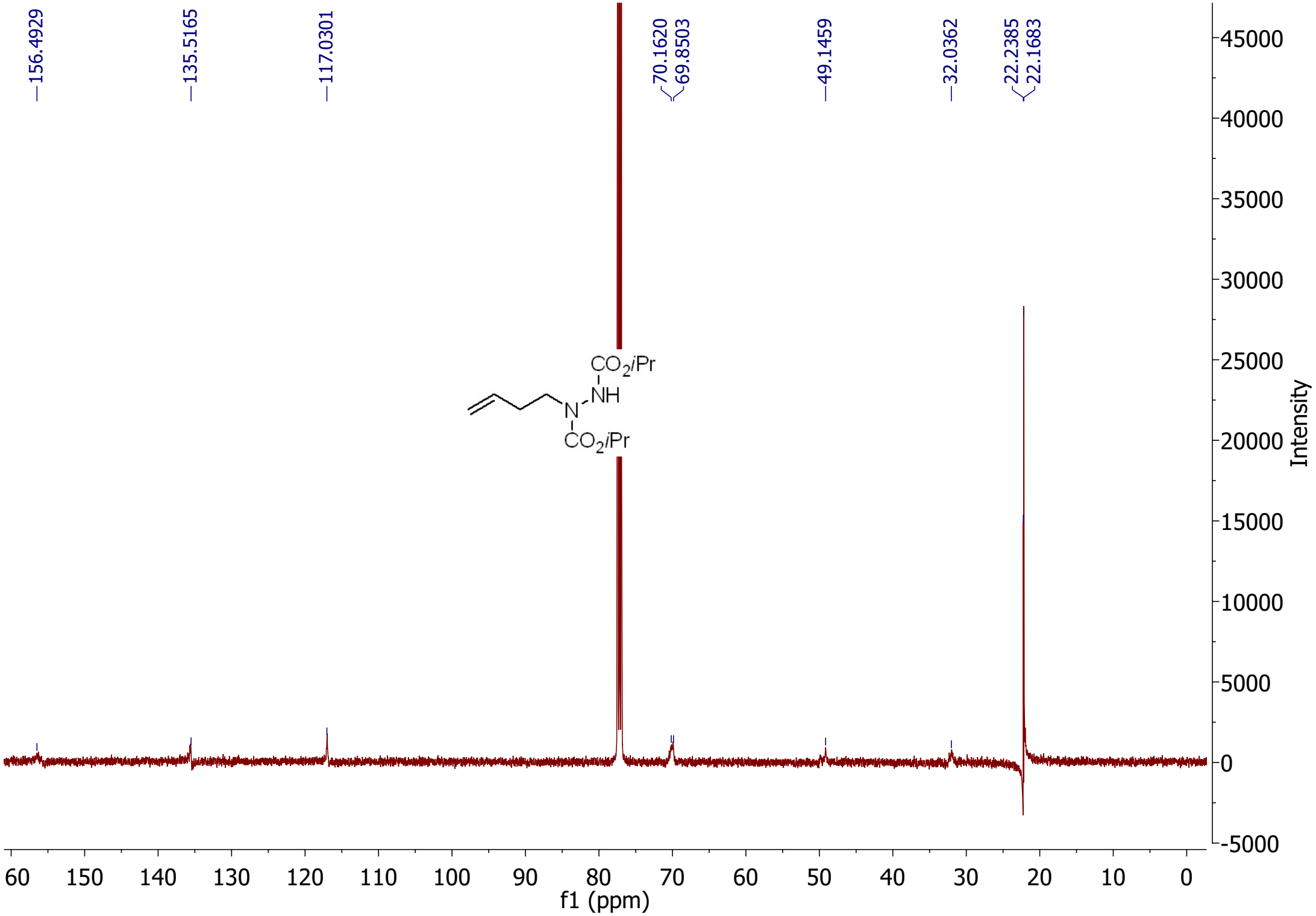

O
O
N
HN
O
O
N
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f2 (ppm)
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
f1 (ppm)

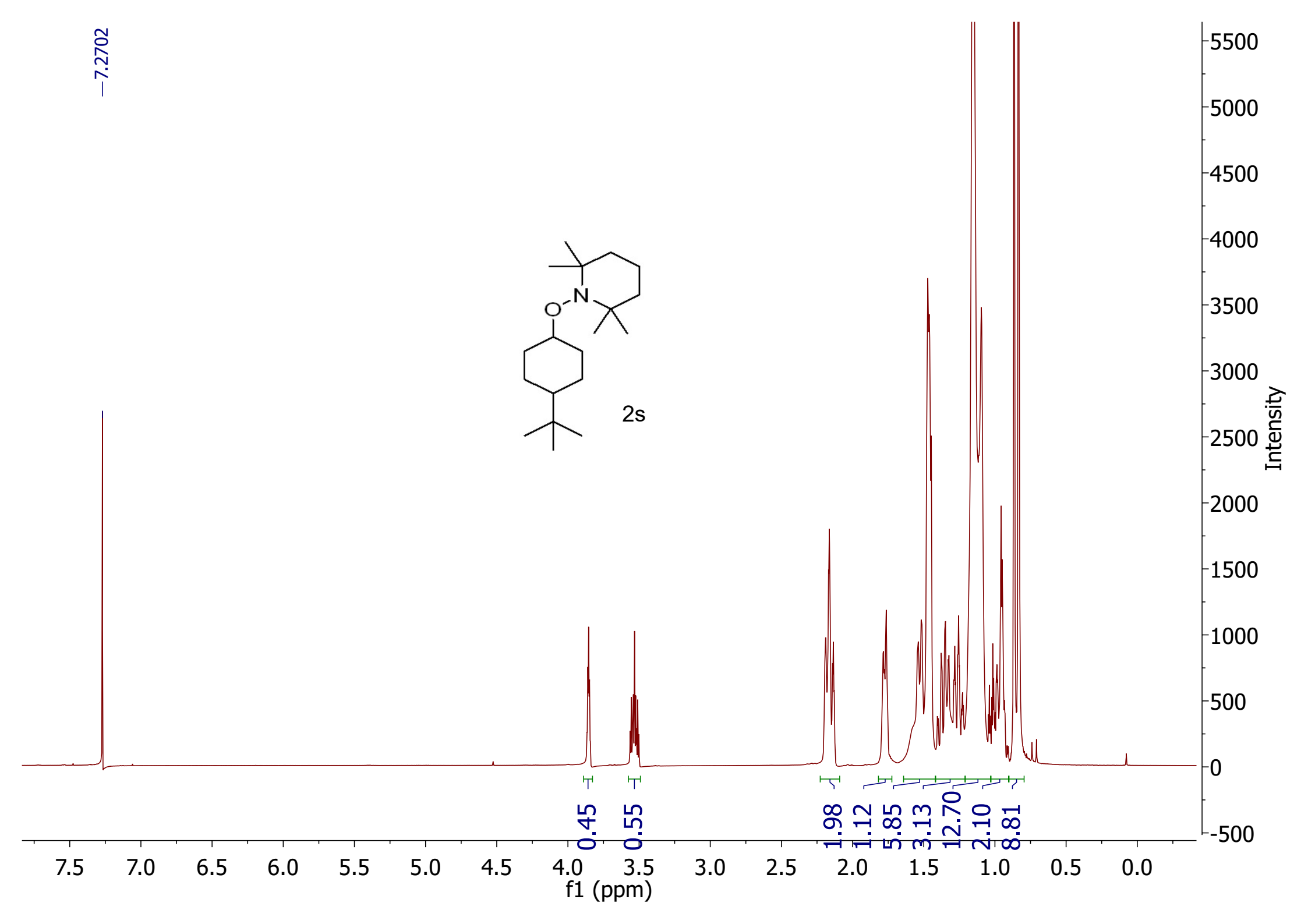

HO
O
O
O
N
H
N
O
O
O
2q
0.94
0.94
2.00
0.93
0.96
1.94
2.92
7.03
9.27
14.18
6.15
5.08
3.14
2.99
1.04
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
Intensity

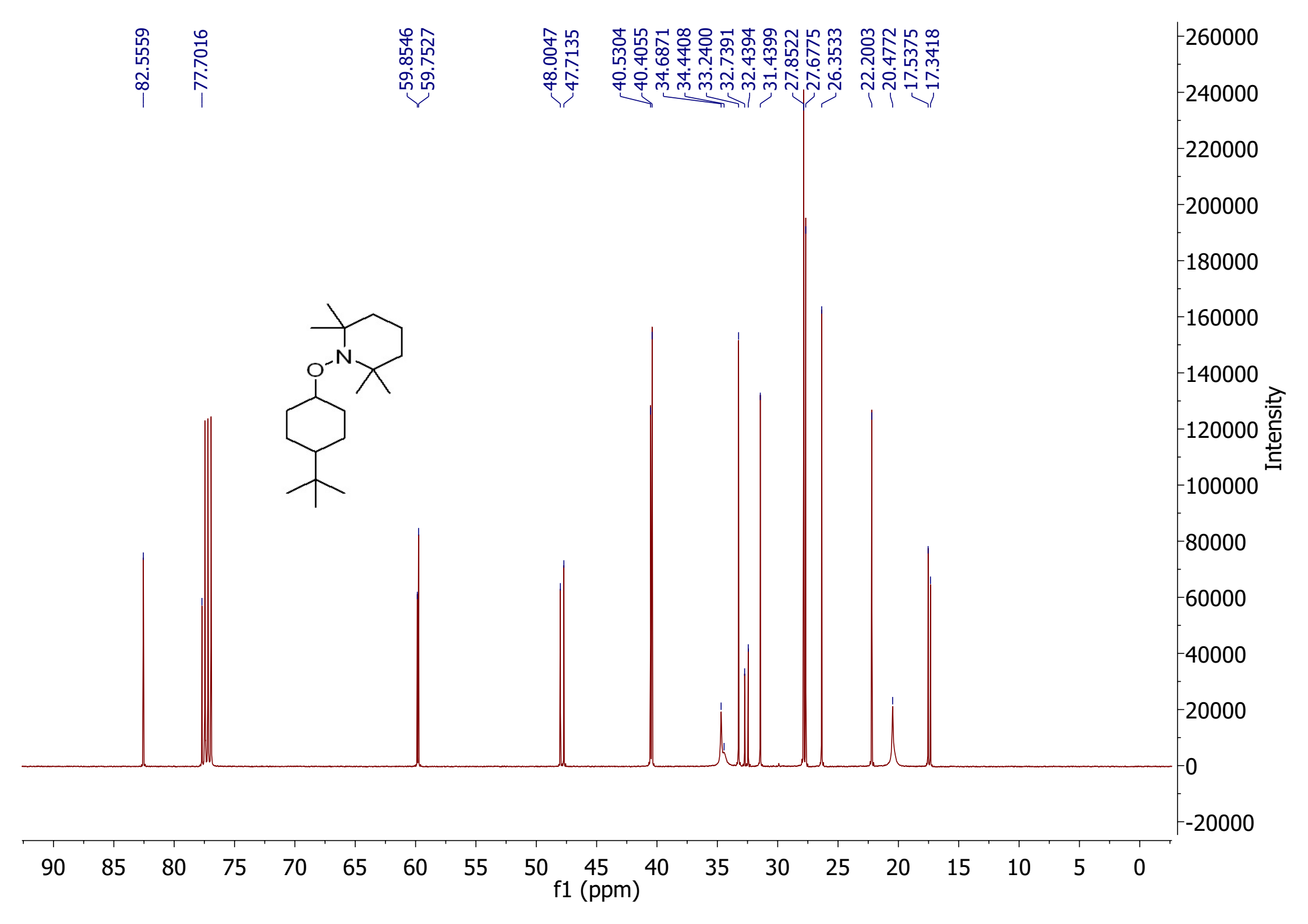

128.6103
78.8262
69.6872
69.4569
63.0298
61.8977
61.8610
55.0227
55.0029
48.5586
48.3749
45.5277
45.4270
43.4478
43.4120
39.2493
39.2251
37.2455
37.1558
37.1338
32.8409
32.3246
32.2856
28.3568
28.2375
27.3963
26.5884
26.5408
26.4831
26.4459
23.5337
23.3493
23.2949
22.3405
22.3055
22.2873
22.2261
22.1872
22.1235
22.1059
22.0861
22.0616
20.8223
20.7498
18.8463
18.8291
18.8038
18.7866
17.6097
16.5040
16.4896
16.4726
15.7534
HO
O
N
H
N
O
O
O
O
O
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
Intensity
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)

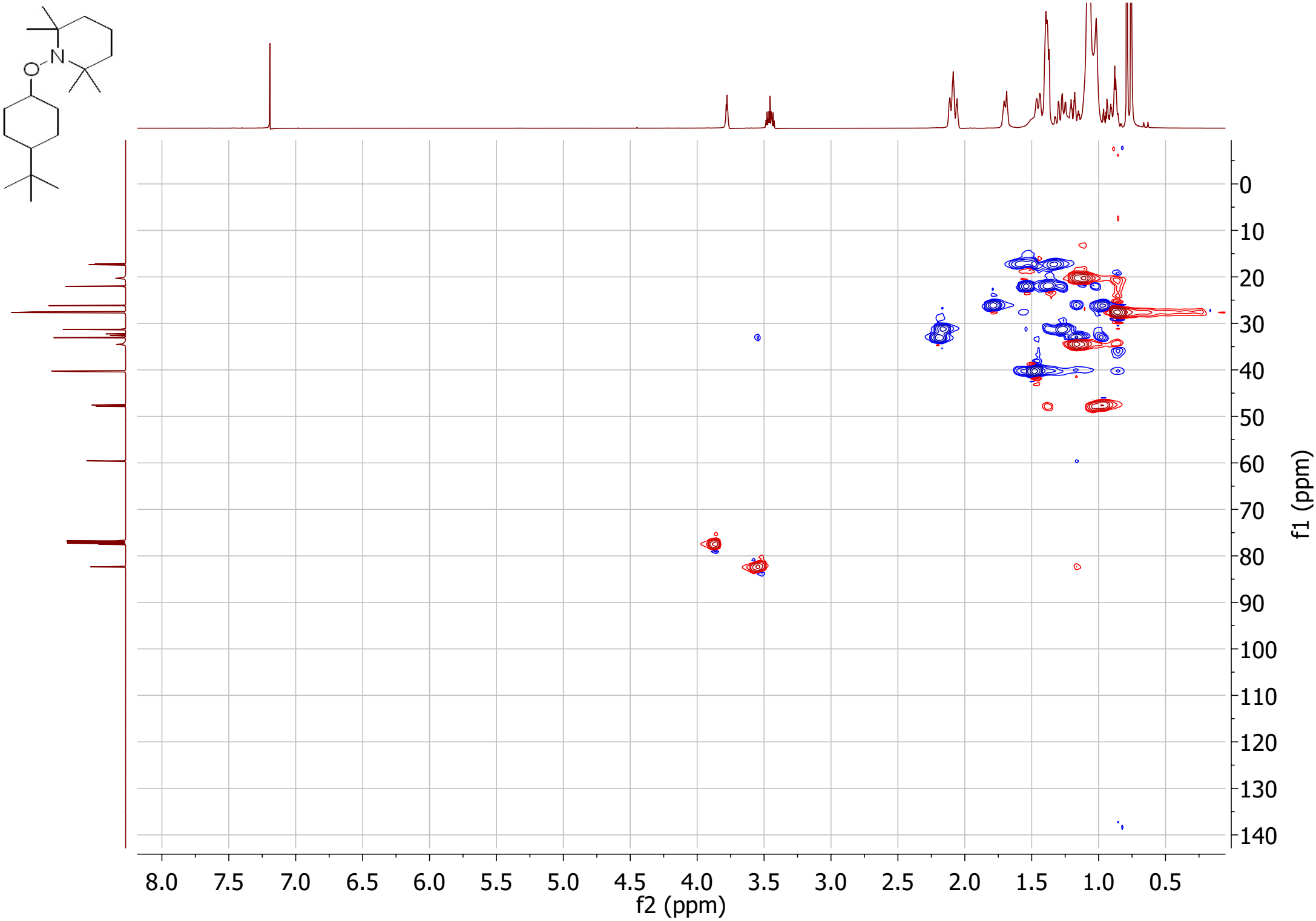

HO
O
O
N
H
N
O
O
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f2 (ppm)
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
f1 (ppm)

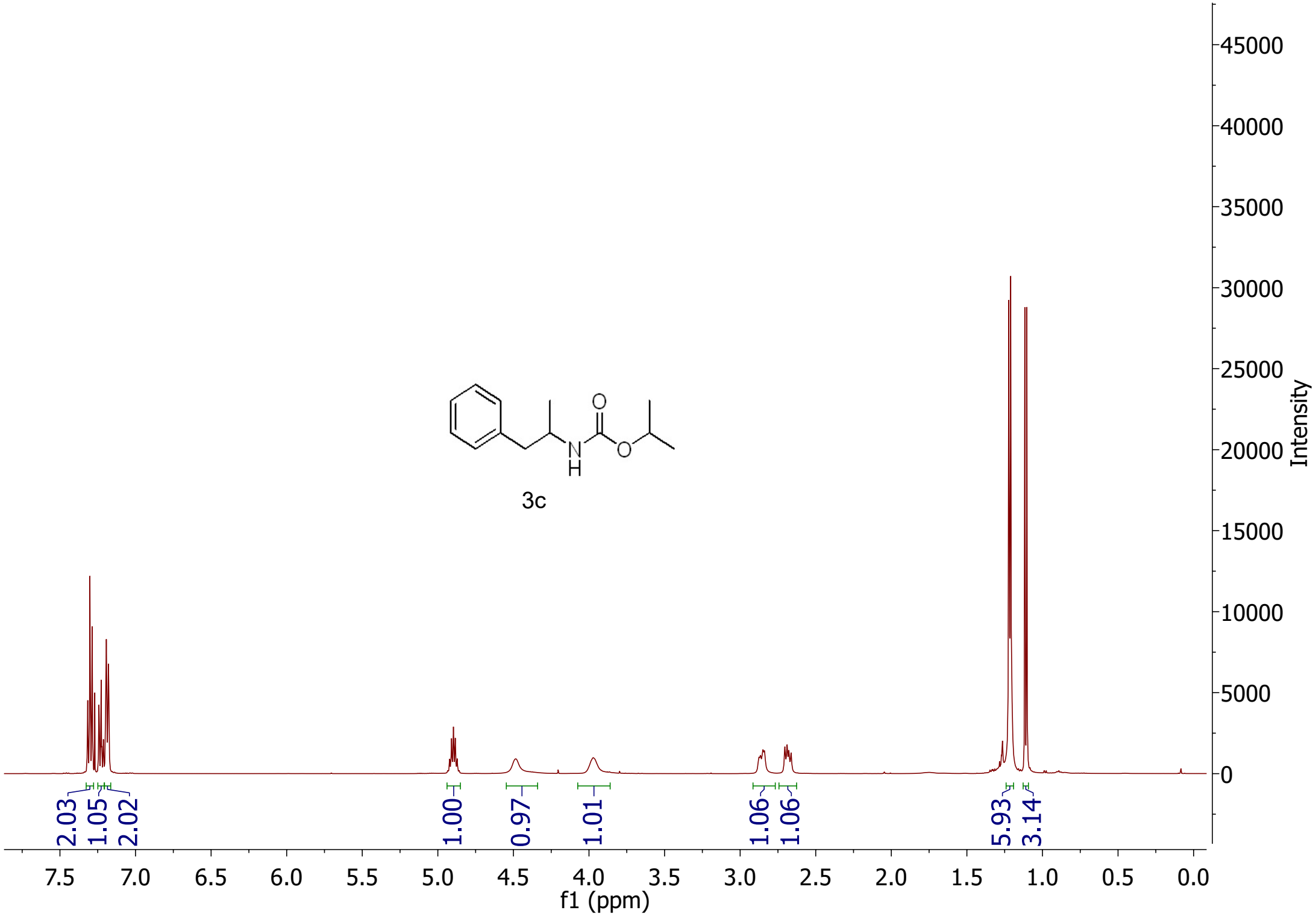

CO2iPr
NH
N
CO2iPr
2r
1.10
1.00
1.98
1.94
1.81
1.92
11.94
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
30000
25000
20000
15000
10000
5000
0
Intensity

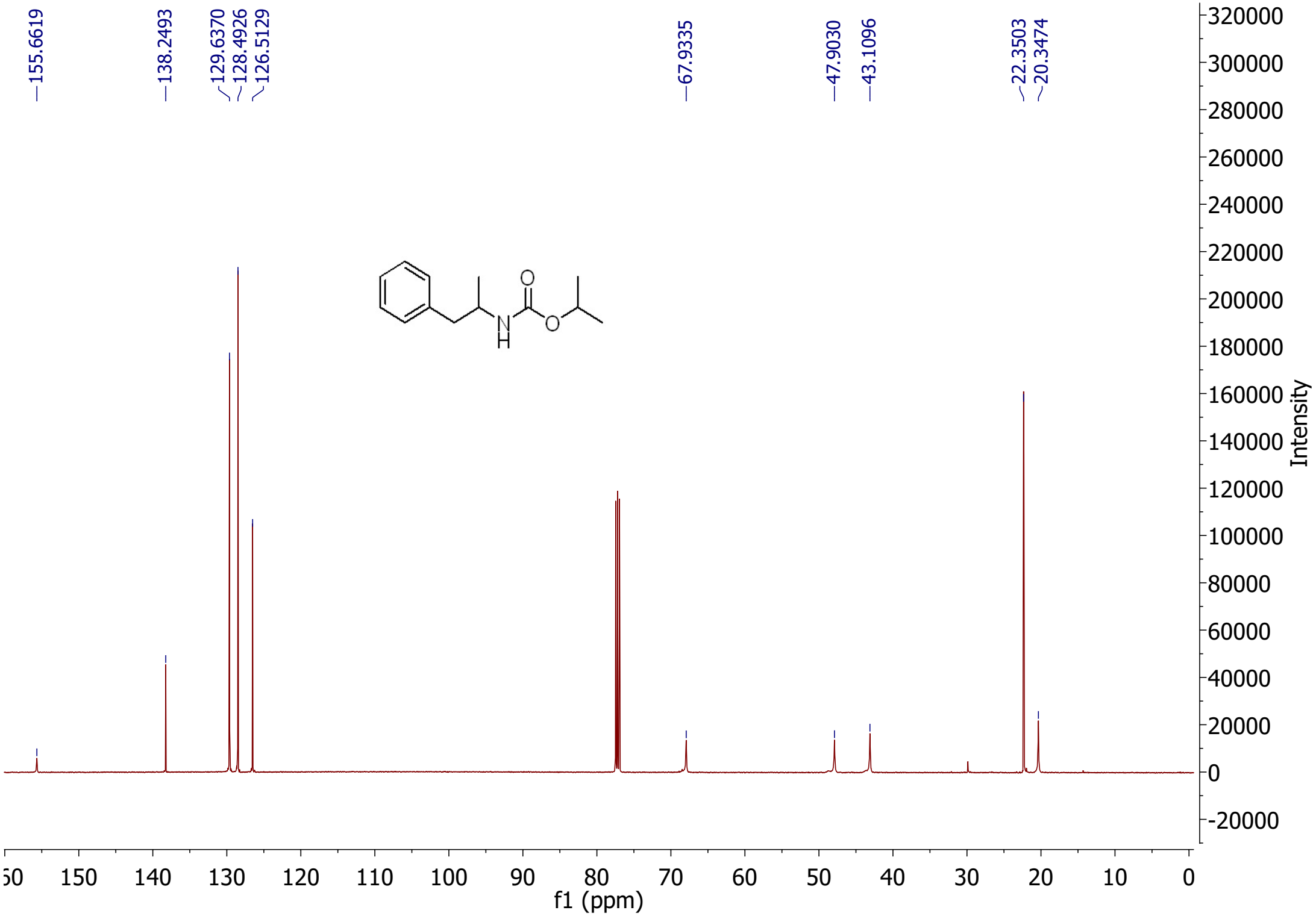

156.4929
135.5165
117.0301
70.1620
69.8503
49.1459
32.0362
22.2385
22.1683
CO2iPr
NH
N
CO2iPr
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
Intensity
60
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.2702
2s
0.45
0.55
1.98
1.12
5.85
3.13
12.70
2.10
8.81
f1 (ppm)
Intensity


82.5559
77.7016
59.8546
59.7527
48.0047
47.7135
40.5304
40.4055
34.6871
34.4408
33.2400
32.7391
32.4394
31.4399
27.8522
27.6775
26.3533
22.2003
20.4772
17.5375
17.3418
O
N
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
Intensity
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
f1 (ppm)


N
O
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
f2 (ppm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
f1 (ppm)


3c
2.03
1.05
2.02
1.00
0.97
1.01
1.06
1.06
5.93
3.14
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
0.0
f1 (ppm)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Intensity


155.6619
138.2493
129.6370
128.4926
126.5129
67.9335
47.9030
43.1096
22.3503
20.3474
320000
300000
280000
260000
240000
220000
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
-20000
Intensity
O
N
H
O
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)