Supporting Information

Rhodium-Catalyzed Regioselectiv Addition of the ortho C-H Bonds in Aromatic Amides to C-C Double Bonds in α,β-Unsaturated γ-Lactones and Dihydrofurans

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Contents

I. General Information.

^{1}H NMR and ^{13}C NMR spectra were recorded on a JEOL ECS-400 spectrometer in $CDCl_3$ with tetramethylsilane as the internal standard. Data are reported as follows: chemical shift in ppm (δ), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, bs = broad singlet, and m = multiplet), coupling constant (Hz), and integration. Infrared spectra (IR) were obtained using a JASCO FT/IR-4200 spectrometer; absorptions are reported in reciprocal centimeters with the following relative intensities: s (strong), m (medium), or w (weak). Mass spectra and high resolution mass spectra (HRMS) were obtained using a JEOL JMS-700 spectrometer.

Analytical gas chromatography (GC) was carried out on a Shimadzu GC-2014 gas chromatograph, equipped with a flame ionization detector. Melting points were determined using a Yamato melting point apparatus. Column chromatography was performed with SiO_2 (Silicycle SiliaFlash F60 (230-400 mesh)). Some compounds were purified by LC-908 HPLC (GPC).

II. Materials.

Toluene (Kanto Chemical) was purified by passage through activated alumina using a GlassContour Solvent Dispensing System. $[RhCl(cod)]_2$ (CAS 12092-47-6) was purchased from Wako Pure Chemicals. KOAc (CAS 127-08-2), K_2HPO_4 (CAS 7758-11-4), Na_2CO_3 (CAS 497-19-8), were purchased from Nacalai Tesque. 2(5*H*)-Furanone (CAS 497-23-4), 3-methylfuran-2(5H)-one (CAS 22122-36-7), 2,3-dihydrofuran (CAS 1191-99-7), 2,5-dihydrofuran (CAS 1708-29-8), 8-Aminoquinoline (CAS 578-66-5) were purchased from Tokyo Chemical Industry Co., Ltd.

III. Synthesis of Starting Materials.

All amides bearing an 8-aminoquinoline moiety were prepared by reacting the corresponding acid chlorides with 8-aminoquinoline[1].

General Procedure for the Preparation of Starting Amides.

Synthesis of amides from acid halides.

[1] (a) Y. Ano, M. Tobisu, N. Chatani, *Org. Lett*. **2012**, *14*, 354. (b) Y. Aihara, N. Chatani, *Chem. Sci*. **2012**, *4*, 664.

The acid chloride (15 mmol) was dissolved in CH_2Cl_2 (20 mL). After cooling the reaction mixture to 0 °C, a solution of 8-Aminoquinoline (15 mmol) and triethylamine (36 mmol) in 10 mL of CH_2Cl_2 was added dropwise. The resulting mixture was allowed to warm to rt and was then stirred overnight. The crude mixture was then washed with saturated aqueous $NaHCO_3$ (20 mL), and CH_2Cl_2 (3x20 mL). The combined organic layers were washed with 1 M HCl aq. (20 mL). The organic phase was dried over anhydrous Na_2SO_4 and the solution taken to dryness.The resulting crude amide was purified by flash chromatography on silica gel (eluent: hexanes/EtOAc = 5/1).

Synthesis of amides from carboxylic acid.
To a stirred solution of carboxylic acid (15 mmol) in CH_2Cl_2 (10 mL), $(COCl)_2$, (1.5 mL, 18 mmol) was added dropwise. The solution was magnetically stirred at room temperature for 2 h. The solvent was then eliminated under reduced pressure, and the resulting residue was dissolved in CH_2Cl_2 (15 mL). After cooling the reaction mixture to 0 °C, a solution of 8-Aminoquinoline (15 mmol) and triethylamine (36 mmol) in 10 mL of the same solvent were added dropwise. The resulting mixture was allowed to warm to rt and stirred overnight. The crude product was washed with saturated aqueous $NaHCO_3$ (20 mL), and CH_2Cl_2 (3x20 mL). The organic phase was washed with 1 M HCl aq. (20 mL).The organic phase was dried over anhydrous Na_2SO_4 and the solvent removed by evaporation of the solvent. The resulting crude amide was purified by flash chromatography on silica gel (eluent: hexanes/EtOAc = 5/1).

All lactones except for the furan-2(5H)-one and 3-methylfuran-2(5H)-one were prepared according to literature procedures[2].
General Procedure for the Preparation of the Starting Lactones.
To a stirred solution of 3-bromo-2-triisopropylsilyloxyfuran (10 mmol) in THF (20 mL) at -78 °C, *n*-BuLi (1.6 M in hexanes, 11 mmol) was added dropwise. After stirring for 2 h, the mixture was warmed to -25 °C and, a solution of benzylbromide (13 mmol) was added dropwise. The temperature was kept at -25 °C for 30 min, the mixture was then allowed to warm to room temperature and 1 M HCl aq. (25 mL) was added. The solution was magnetically stirred at room temperature for 1 h. After separating the organic phase, the aqueous phase was washed with Et_2O (3x20 mL). The organic phase was dried over $MgSO_4$ and the solvent removed by evaporation of the solvent. The resulting crude product was purified by flash chromatography on silica gel (eluent: hexanes/EtOAc = 3/1).

3-phenyl-2,3-dihydrofuran was prepared accoding to literature procedure[3]. 2-phenyl-2,3-dihydrofuran was prepared according to literature procedure[4].

IV. Typical Procedures.

The Rh-Catalyzed Synthesis of 3aa.
To an oven-dried 5 mL screw-capped vial, 2-methyl-*N*-(8-quinolinyl)benzamide **1a** (79 mg, 0.3 mmol), furan-2(5H)-one (76 mg, 0.9 mmol), $[RhCl(cod)]_2$ (7.4 mg, 0.015 mmol), K_2HPO_4 (13 mg, 0.075 mmol) and toluene (1.0 mL) were added. The mixture was stirred for 24 h at 160 °C followed by cooling. The mixture was filtered through a celite pad and concentrated *in vacuo*. The residue was purified by column chromatography on silica gel (eluent: hexane/EtOAc= 10/1) to afford the desired alkylated product **3aa** (85 mg, 82%) as a colorless oil.

The Rh-Catalyzed Synthesis of 6aa. (Method A)
To an oven-dried 5 mL screw-capped vial, 2-methyl-*N*-(8-quinolinyl)benzamide **1a** (79 mg, 0.3 mmol), 2,3-dihydrofuran (42 mg, 0.6 mmol), $[RhCl(cod)]_2$ (3.7 mg, 0.0075 mmol), KOAc (7.4 mg, 0.075 mmol) and toluene (1.0 mL) were added. The mixture was stirred for 12 h at 160 °C followed by cooling. The mixture was filtered through a celite pad and concentrated *in vacuo*. The residue was purified by column

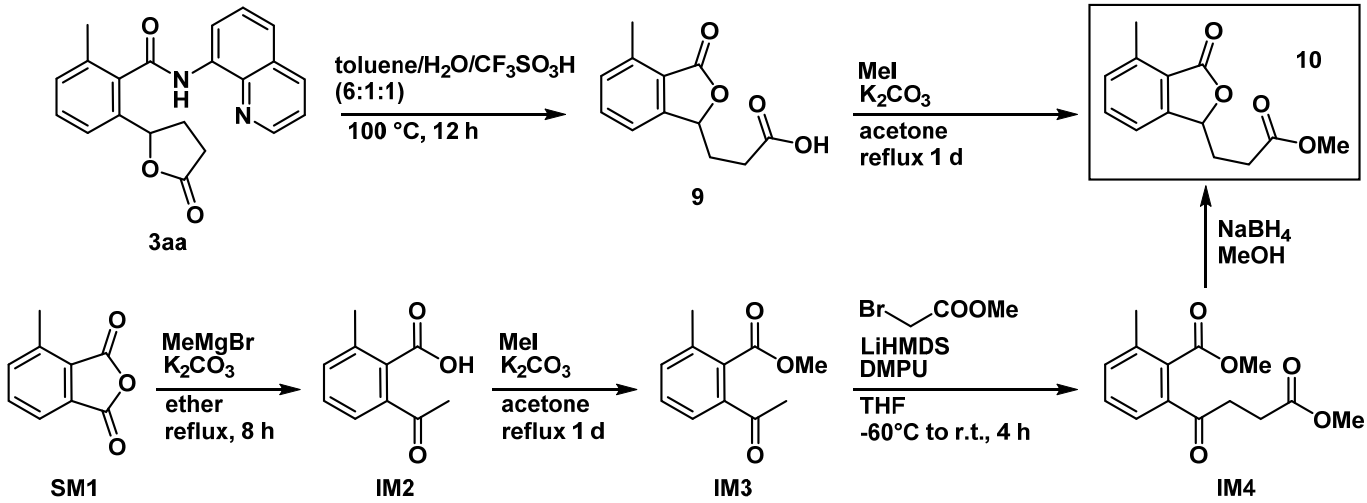
[2] J. Boukouvalas, R. P. Loach, *J. Org. Chem*. **2008**, *73*, 8109.
[3] R. C. Larock, B. E. Baker, *Tetrahedron Lett*. **1988**, *29*, 905.
[4] T. Jeffery, M. David, *Tetrahedron Lett*. **1998**, *39*, 5751.

chromatography on silica gel (eluent: hexane/EtOAc= 10/1) to afford the desired alkylated product **6aa** (69 mg, 69%) as a colorless oil.

The Rh-Catalyzed Synthesis of 6aa. (Method B)
To an oven-dried 5 mL screw-capped vial, 2-methyl-*N*-(8-quinolinyl)benzamide **1a** (79 mg, 0.3 mmol), 2,3-dihydrofuran (42 mg, 0.6 mmol), $[Rh(OAc)(cod)]_2$ (4.1 mg, 0.0075 mmol), HOPiv (30.6 mg, 0.3 mmol) and toluene (1.0 mL) were added. The mixture was stirred for 12 h at 160 °C followed by cooling. The crude product was washed with saturated aqueous Na_2CO_3 (2x3 mL), and EtOAc (2x3 mL). The organic phase was washed with Brine (5 mL).The organic phase was dried over anhydrous Na_2SO_4 and the solvent removed by evaporation of the solvent. The residue was purified by column chromatography on silica gel (eluent: hexane/EtOAc= 10/1) to afford the desired alkylated product **6aa** (79 mg, 80%) as a colorless oil.

Removal of directing group (Scheme 5.).
Compound **3ha** (0.2 mmol) and CF_3SO_3H (0.5 mL) were dissolved in a mixture of toluene (2.5 mL) and water (0.5 mL) and the resulting solution was heated at 100 °C for 12 h. The reaction mixture was diluted with EtOAc, and extracted with a saturated aqueous Na_2CO_3 solution. The combined aqueous layers were then acidified to pH 2 with 1 N HCl. The aqueous layers were extracted with EtOAc, the combined organic layers were dried over anhydrous Na_2SO_4 and the solvent removed by evaporation to give the carboxylic acid **8**.

The structure of **8** was confirmed by an alternative synthesis, as shown below.



6-Methyl-2-acetylbenzoic acid(**IM2**) was prepared as a minor product accoding to literature procedure[5].

IM2(1 equiv.), K_2CO_3(2.4 equiv.) and MeI(1.2 equiv.) were dissolved in acetone and the resulting solution was refluxed for 1 d. The reaction mixture was cooled to room temperature. The mixture was diluted with ether, and washed with 1M HCl aq, Na_2CO_3 aq and Brine. The organic phase was dried over Na_2SO_4 and the solvent was removed by evaporation. The resulting crude product was purified by flash chromatography on silica gel. (eluent: hexanes/EtOAc = 3/1, Rf=0.37(**IM3** as a minor product), 0.29(major product))

IM4 was prepared accoding to a literature procedure[6].

10 was prepared accoding to a literature procedure[7].

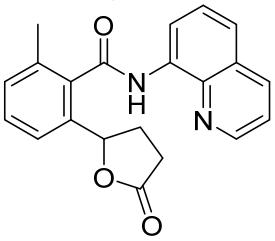
[5] P. R. Jones, P. J. Desio. *J. Org. Chem.* **1965**, *30*, 4293.
[6] Eur. *J. Org. Chem*. **2014**, *22*, 4714.
[7] K. Inoue, Y. Shiobara, H. Inouye *Chem. Pharm. Bull*. **1977**, *25*, 1462.

The Rh-Catalyzed alkylation of 3fa (Scheme 5.).

To an oven-dried 5 mL screw-capped vial, **3fa** (0.15 mmol), methylacrylate (0.3 mmol), $[RhCl(cod)]_2$ (0.00375 mmol), K_2HPO_4 (0.00375 mmol) and toluene (1.0 mL) were added. The mixture was stirred for 24 h at 160 °C and then allowed to cool. The resulting mixture was filtered through a celite pad and the filtrate concentrated *in vacuo*. The residue was purified by column chromatography on silica gel (eluent: hexane/EtOAc= 3/1) to afford the desired alkylated product **8**.

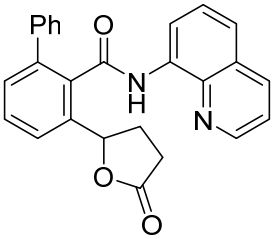
V. Spectroscopic Data.

2-methyl-6-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3aa)



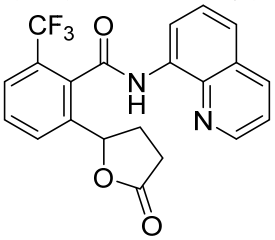
colorless oil. R_f 0.09 (Hexane/EtOAc = 4/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.21-2.28 (m, 1H), 2.48 (s, 3H), 2.53-2.68 (m, 2H), 2.71-2.79 (m, 1H), 5.73 (dd, *J* = 8.0, 6.4 Hz, 1H), 7.28 (dd, *J* = 7.2, 1.2 Hz, 1H), 7.38-7.47 (m, 3H), 7.58-7.63 (m, 2H), 8.19 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.75 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.93 (dd, *J* = 6.4, 2.8 Hz, 1H), 10.0 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.5, 29.0, 31.8, 79.3, 116.7, 121.8, 122.39, 122.43, 127.2, 127.9, 129.8, 130.4, 133.8, 134.7, 135.4, 136.3, 137.1, 138.3, 148.5, 167.3, 176.9. IR (ATR): 3339 w, 3013 w, 1777 m, 1737 w, 1669 m, 1596 w, 1578 w, 1519 s, 1482 s, 1423 m, 1385 m, 1325 m, 1265 m, 1216 w, 1178 m, 1138 m, 1033 m, 986 w, 901 m, 827 m, 791 m, 753 s, 732 m, 690 m. MS, m/z (relative intensity, %): 346 (M^+, 44), 203 (11), 202 (45), 186 (13), 185 (14), 174 (13), 171 (35), 160 (14), 157 (18), 145 (14), 144 (100), 91 (10). Exact Mass (EI): Calcd for $C_{21}H_{18}N_2O_3$ 346.1317, found 346.1319.

3-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)-[1,1'-biphenyl]-2-carboxamide (3ba)



colorless oil. R_f 0.37 (Hexane/EtOAc = 1/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.23-2.33 (m, 1H), 2.63-2.68 (m, 2H), 2.85-2.93 (m, 1H), 5.90 (dd, *J* = 8.4, 6.8 Hz, 1H), 7.03-7.07 (m, 1H), 7.20 (t, *J* = 8.0 Hz, 2H), 7.32-7.35 (m, 1H), 7.44-7.52 (m, 5H), 7.56-7.61 (m, 2H), 8.05 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.55 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.69 (dd, *J* = 7.6, 1.6 Hz, 1H), 9.61 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 29.1, 31.9, 79.5, 116.2, 121.5, 122.1, 124.0, 127.0, 127.56, 127.61, 128.3, 128.5, 130.1, 130.1, 133.9, 134.2, 136.0, 138.1, 138.6, 139.5, 139.9, 148.0, 167.0, 177.1. IR (ATR): 3331 w, 3017 w, 1775 m, 1666 m, 1595 w, 1521 s, 1483 m, 1460 w, 1424 m, 1387 w, 1326 m, 1294 w, 1266 w, 1218 w, 1183 m, 1139 m, 1029 w, 985 w, 948 w, 905 w, 826 w, 792 w, 755 s, 733 m, 699 m. MS, *m/z* (relative intensity, %): 408 (M^+, 62), 265 (25), 264 (35), 247 (11), 237 (15), 236 (12), 222 (27), 221 (42), 219 (20), 203 (18), 191 (19), 186 (15), 181 (15), 178 (31), 171 (38), 165 (22), 153 (19), 152 (42), 151 (10), 145 (13), 144 (100), 116 (11). Exact Mass (EI): Calcd for $C_{26}H_{20}N_2O_3$ 408.1474, found 408.1472.

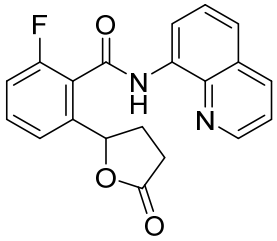
2-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)-6-(trifluoromethyl)benzamide (3ca)



colorless oil. R_f 0.06 (Hexane/EtOAc = 3/2). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.14-2.25 (m, 1H), 2.63 (bd, *J* = 8.4 Hz, 2H), 2.81 (bs, 1H), 5.74 (bs, 1H), 7.44-7.47 (m, 1H), 7.58-7.68 (m, 3H), 7.76-7.82 (m, 1H), 8.75 (dd, *J* = 4.0, 1.6 Hz,

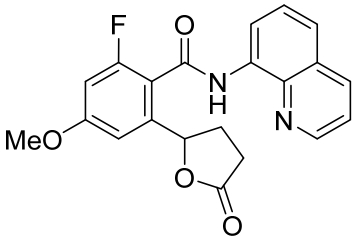
1H), 8.87-8.2 (m, 1H), 10.2 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 29.0, 32.2, 78.4, 117.0, 121.9, 122.8, 123.8 (q, J = 272.7 Hz), 126.2 (d, J = 4.7 Hz), 127.2, 127.3 (q, J = 34.3 Hz), 127.9, 128.9, 130.3, 133.2, 133.6, 136.4, 138.2, 139.2, 148.5, 164.2, 176.4. IR (ATR): 3330 w, 3017 w, 1778 m, 1674 m, 1523 s, 1485 m, 1424 m, 1388 w, 1317 s, 1264 w, 1217 w, 1171 s, 1128 s, 1107 m, 1086 m, 1029 w, 901 m, 826 m, 792 m, 756 s, 733 m, 678 w, 665 m. MS, m/z (relative intensity, %): 400 (M^+, 43), 371 (22), 272 (18), 228 (12), 214 (12), 201 (13), 173 (13), 171 (60), 145 (23), 144 (100), 143 (10), 116 (15). Exact Mass (EI): Calcd for $C_{21}H_{15}F_3N_2O_3$ 400.1035, found 400.1037.

2-fluoro-6-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3da)



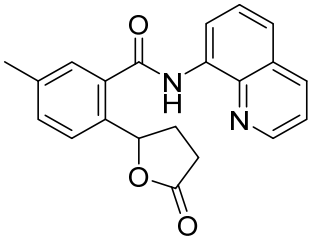
colorless oil. R_f 0.10 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.17-2.27 (m, 1H), 2.63-2.67(m, 2H), 2.88- 2.97 (m, 1H), 5.95 (t, J = 7.6 Hz, 1H), 7.20 (td, J = 8.8, 0.8 Hz, 1H), 7.41 (d, J = 8.0 Hz, 1H), 7.47-7.56 (m, 2H), 7.59-7.61 (m, 2H), 8.20 (dd, J = 8.0, 2.0 Hz, 1H), 8.81 (dd, J = 4.0, 1.6 Hz, 1H), 8.87-8.91 (m, 1H), 10.43 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 28.8, 31.7, 78.9 (d, J = 1.9 Hz), 115.9 (d, J = 22.9 Hz), 116.9, 121.2 (d, J = 2.9 Hz), 121.8, 122.55 (d, J = 17.1 Hz), 122.57, 127.2, 128.0, 132.1 (d, J = 8.5 Hz), 134.0, 136.4, 138.3, 141.8, 148.5, 159.3 (d, J = 246.9 Hz), 162.1, 177.0. IR (ATR): 3344 w, 2950 w, 1776 m, 1735 m, 1671 m, 1614 w, 1579 w, 1522 s, 1483 m, 1459 m, 1425 m, 1385 m, 1326 m, 1269 m, 1175 m, 1142 m, 1090 w, 1042 w, 979 w, 915 m, 826 m, 792 m, 756 m, 686 w. MS, m/z (relative intensity, %): 350 (M^+, 43), 321 (15), 222 (22), 206 (20), 178 (18), 171 (38), 164 (20), 151 (13), 145 (17), 144 (100), 133 (14), 123 (13), 116 (11), 115 (13), 95 (11). Exact Mass (EI): Calcd for $C_{20}H_{15}FN_2O_3$ 350.1067, found 350.1065.

2-fluoro-4-methoxy-6-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3ea)



pale yellow oil. R_f 0.10 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.14-2.22 (m, 1H), 2.62- 2.66 (m, 2H), 2.94-3.02 (m, 1H), 3.87 (s, 3H), 6.06 (t, J = 7.2 Hz, 1H), 6.71 (dd, J = 12.0, 2.0 Hz, 1H), 6.95 (s, 1H), 7.47 (dd, J = 8.0, 4.0 Hz, 1H), 7.56-7.61 (m, 2H), 8.18 (d, J = 8.4 Hz, 1H), 8.81 (dd, J = 4.0, 1.6 Hz, 1H), 8.87 (dd, J = 6.0, 3.6 Hz, 1H), 10.47 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 28.7, 31.6, 55.9, 79.0 (d, J = 3.8 Hz), 101.3 (d, J = 27.7 Hz), 107.3 (d, J = 1.9 Hz), 114.4 (d, J = 16.2 Hz), 116.6, 121.8, 122.2, 127.2, 127.9, 134.2, 136.3, 138.4, 143.7 (d, J = 3.8 Hz), 148.4, 160.9 (d, J = 273.7 Hz), 162.0, 162.4, 177.0. IR (ATR): 3346 w, 3012 w, 1776 m, 1665 m, 1620 m, 1577 w, 1526 s, 1484 m, 1425 m, 1386 w, 1325 m, 1266 m, 1217 w, 1178 m, 1152 s, 1076 w, 1040 w, 982 w, 963 w, 914 w, 854 w, 827 m, 792 w, 756 m, 733 m, 699 w. MS, m/z (relative intensity, %): 380 (M^+, 70), 351 (10), 252 (13), 237 (23), 236 (67), 219 (12), 209 (15), 208 (39), 194 (23), 193 (18), 191 (20), 181 (23), 175 (11), 171 (44), 163 (18), 153 (22), 145 (33), 144 (100), 129 (11), 116 (14). Exact Mass (EI): Calcd for $C_{21}H_{17}FN_2O_4$ 380.1172, found 380.1170.

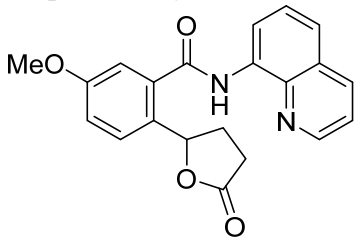
5-methyl-2-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3fa)



colorless oil. R_f 0.09 (Hexane/EtOAc = 4/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.13-2.22 (m, 1H), 2.48 (s, 3H), 2.63-2.67 (m, 2H), 2.93-3.01 (m, 1H), 6.09 (t, J = 7.6 Hz, 1H), 7.40 (d, J = 8.4 Hz, 1H), 7.45-7.53 (m, 2H), 7.57-7.62 (m, 3H), 8.20 (dd, J = 8.0, 1.6 Hz, 1H), 8.82-8.86 (m, 2H), 10.37 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 21.1, 29.0, 31.9, 79.4, 116.5, 121.8, 122.2, 125.8, 127.3, 127.6, 128.0, 132.0, 134.0, 134.4, 136.4, 136.8, 138.3, 138.5, 148.4, 166.9, 177.5.

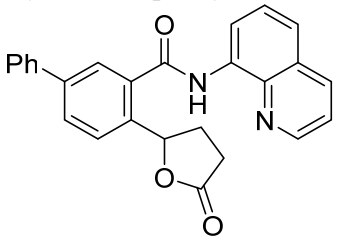
IR (ATR): 3344 w, 2925 w, 1774 m, 1668 m, 1596 w, 1577 w, 1520 s, 1481 s, 1423 m, 1385 m, 1325 m, 1293 w, 1263 m, 1173 m, 1135 m, 1024 m, 988 w, 938 m, 910 w, 826 m, 791 m, 755 m, 731 m, 687 m. MS, m/z (relative intensity, %): 346 (M^+, 67), 317 (22), 287 (12), 218 (11), 203 (11), 202 (63), 185 (20), 175 (12), 174 (38), 171 (33), 160 (56), 157 (13), 147 (10), 145 (17), 144 (100), 129 (13), 119 (12), 116 (11), 91 (13). Exact Mass (EI): Calcd for $C_{21}H_{18}N_2O_3$ 346.1317, found 346.1316.

5-methoxy-2-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3ga)



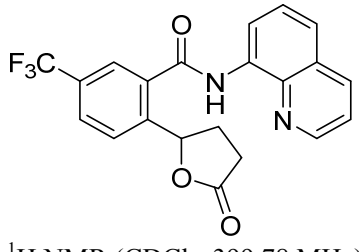
pale yellow oil. R_f 0.07 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.13-2.24 (m, 1H), 2.65 (dd, *J* = 9.6, 7.2 Hz, 2H), 2.90- 2.98 (m, 1H),3.90 (s, 3H), 6.04 (dd, *J* = 8.4, 6.8 Hz, 1H), 7.10 (dd, *J* = 8.8, 2.8 Hz, 1H), 7.31 (d, *J* = 2.8 Hz, 1H), 7.49 (dd, *J* = 8.4, 4.0 Hz, 1H), 7.55 (d, *J* = 8.4 Hz, 1H), 7.58-7.62 (m, 2H), 8.20 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.81 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.84 (dd, *J* = 6.0, 3.2 Hz, 1H), 10.38 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 29.2, 32.0, 55.6, 79.3, 113.1, 116.1, 116.5, 121.8, 122.3, 127.2, 127.4, 128.0, 131.4, 134.2, 135.5, 136.4, 138.5, 148.4, 159.2, 166.5, 177.4. IR (ATR): 3343 w, 2934 w, 1773 m, 1671 m, 1607 w, 1579 w, 1522 s, 1482 s, 1424 m, 1385 m, 1326 m, 1293 w, 1266 m, 1210 w, 1173 m, 1135 w, 1099 w, 1039 w, 985 w, 940 w, 911 w, 892 w, 857 w, 825 m, 791 m, 753 m, 732 m, 684 w. MS, m/z (relative intensity, %): 362 (M^+, 56), 333 (25), 303 (16), 234 (11), 218 (40), 201 (13), 191 (13), 190 (39), 177 (11), 176 (100), 173 (10), 171 (30), 163 (11), 145 (20), 144 (100), 135 (20), 129 (11). Exact Mass (EI): Calcd for $C_{21}H_{18}N_2O_4$ 362.1267, found 362.1265.

4-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)-[1,1'-biphenyl]-3-carboxamide (3ha)



colorless oil. R_f 0.11 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.19-2.29 (m, 1H), 2.67 (dd, *J* = 9.6, 6.8 Hz, 2H), 2.97- 3.06 (m, 1H), 6.14 (t, *J* = 7.2 Hz, 1H), 7.40 (t, *J* = 6.8 Hz, 1H), 7.45-7.50 (m, 3H), 7.57-7.66 (m, 4H), 7.71 (d, *J* = 8.4 Hz, 1H), 7.80 (d, *J* = 8.4 Hz, 1H), 7.99 (d, *J* = 1.2 Hz, 1H), 8.18 (d, *J* = 8.4 Hz, 1H), 8.79 (d, *J* = 4.0 Hz, 1H), 8.87 (dd, *J* = 6.8, 2.0 Hz, 1H), 10.46 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 29.0, 31.8, 79.2, 116.5, 121.8, 122.3, 125.6, 126.3, 127.1, 127.2, 127.9, 128.0, 129.0, 130.0, 134.2, 134.7, 136.4, 138.45, 138.55, 139.4, 141.3, 148.4, 166.7, 177.3. IR (ATR): 3340 w, 3030 w, 1774 m, 1668 m, 1597 w, 1522 s, 1482 w, 1424 m, 1386 w, 1326 m, 1262 w, 1213 w, 1174 m, 1137 m, 1105 w, 1019 w, 990 w, 938 w, 910 m, 826 m, 791 m, 757 s, 731 s, 697 m. MS, m/z (relative intensity, %): 408 (M^+, 46), 264 (34), 247 (15), 237 (11), 236 (33), 223 (16), 222 (100), 219 (12), 191 (12), 181 (12), 178 (17), 171 (26), 165 (10), 153 (10), 152 (22), 145 (13), 144 (85). Exact Mass (EI): Calcd for $C_{26}H_{20}N_2O_3$ 408.1474, found 408.1471.

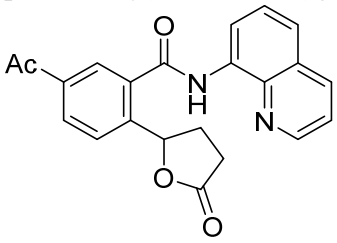
2-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)-5-(trifluoromethyl)benzamide (3ia)



colorless oil. R_f 0.11 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.13-2.23 (m, 1H), 2.62- 2.74 (m, 2H), 2.99-3.07 (m, 1H), 6.11 (t, *J* = 7.6 Hz, 1H), 7.51 (dd, *J* = 7.6, 4.0 Hz, 1H), 7.59-7.62 (m, 2H), 7.79-7.86 (m, 2H), 8.03 (s, 1H), 8.22 (d, *J* = 8.4 Hz, 1H), 8.82-8.83 (m, 2H), 10.43 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 28.8, 31.6, 78.7, 116.8, 121.9, 122.7, 123.4 (q, *J* = 271.1 Hz), 124.0 (d, *J* = 3.7 Hz), 126.5, 127.2, 127.9, 128.0 (d, *J* = 3.9 Hz), 130.6 (q, *J* = 33.1 Hz), 133.9, 134.7, 136.5, 138.4, 143.7, 148.6, 165.3, 176.8. IR (ATR): 3334 w, 3014 w, 1779 m, 1737 w, 1672 m,

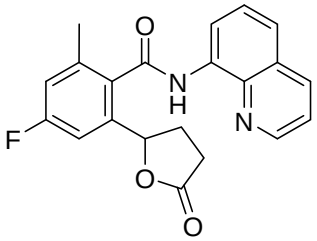
1619 w, 1596 w, 1579 w, 1523 s, 1484 m, 1460 w, 1424 m, 1387 m, 1326 s, 1297 w, 1251 m, 1231 w, 1213 m, 1172 s, 1127 s, 1083 m, 1025 m, 994 w, 939 w, 912 m, 850 w, 827 m, 792 m, 759 m, 732 m, 691 w. MS, m/z (relative intensity, %): 400 (M^+, 40), 371 (22), 315 (13), 272 (25), 256 (11), 228 (22), 214 (26), 171 (35), 145 (26), 144 (100), 116 (14). Exact Mass (EI): Calcd for $C_{21}H_{15}F_3N_2O_3$ 400.1035, found 400.1037.

5-acetyl-2-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3ja)



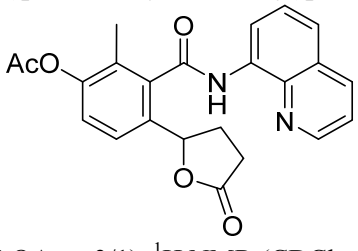
pale yellow oil. R_f 0.06 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.13-2.23 (m, 1H), 2.65-2.72 (m, 5H), 2.99-3.08 (m, 1H), 6.14 (t, *J* = 8.0 Hz, 1H), 7.50 (dd, *J* = 8.0, 4.4 Hz, 1H), 7.61 (d, *J* = 4.0 Hz, 2H), 7.76 (d, *J* = 8.0 Hz, 1H), 8.40 (d, *J* = 8.4 Hz, 1H), 8.22 (d, *J* = 8.4 Hz, 1H), 8.40 (d, *J* = 1.6 Hz, 1H), 8.81-8.84 (m, 2H), 10.46 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 26.7, 28.8, 31.6, 78.9, 116.7, 121.9, 122.5, 126.1, 126.8, 127.2, 127.9, 131.1, 134.0, 134.4, 136.4, 136.7, 138.4, 144.7, 148.5, 165.9, 177.0, 196.6. IR (ATR): 3338 w, 3011 w, 1776 m, 1670 s, 1600 w, 1576 w, 1523 s, 1483 m, 1424 m, 1386 m, 1358 w, 1326 m, 1291 w, 1261 w, 1227 m, 1173 m, 1137 m, 1025 m, 984 w, 938 w, 914 w, 827 m, 792 m, 753 m, 732 m, 688 w, 667 w. MS, m/z (relative intensity, %): 374 (M^+, 49), 246 (14), 230 (27), 202 (26), 188 (32), 187 (11), 171 (43), 145 (24), 144 (100), 143 (10), 129 (11), 117 (12), 116 (11), 115 (12). Exact Mass (EI): Calcd for $C_{22}H_{18}N_2O_4$ 374.1267, found 374.1266.

4-fluoro-2-methyl-6-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3ka)



pale yellow oil. R_f 0.10 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.17-2.28 (m, 1H), 2.48 (s, 3H), 2.55-2.68 (m, 2H), 2.73-2.81 (m, 1H), 5.72 (dd, *J* = 8.8, 6.8 Hz, 1H), 6.98 (dd, *J* = 8.8, 2.4 Hz, 1H), 7.11 (dd, *J* = 9.6, 2.4 Hz, 1H), 7.48 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.59-7.64 (m, 2H), 8.21 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.77 (dd, *J* = 4.0, 2.0 Hz, 1H), 8.88-8.92 (m, 1H), 10.04 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.7, 28.9, 31.7, 78.6, 109.7 (d, *J* = 22.9 Hz), 116.8, 117.1 (d, *J* = 21.0 Hz), 121.9, 122.6, 127.2, 128.0, 131.5 (d, *J* = 3.8 Hz), 133.7, 136.4, 138.0 (d, *J* = 8.6 Hz), 138.3, 140.2 (d, *J* = 7.6 Hz), 148.5, 163.0 (d, *J* = 247.9 Hz), 166.6, 176.5. IR (ATR): 3338 w, 2956 w, 1779 m, 1668 m, 1602 m, 1521 s, 1482 m, 1423 m, 1385 m, 1325 m, 1305 m, 1264 w, 1216 w, 1177 m, 1139 m, 1036 m, 977 w, 912 m, 892 w, 866 w, 827 w, 792 m, 756 m, 730 s, 699 m. MS, m/z (relative intensity, %): 364 (M^+, 32), 220 (37), 203 (10), 192 (13), 186 (10), 178 (14), 175 (21), 171 (35), 165 (12), 145 (15), 144 (100), 109 (12). Exact Mass (EI): Calcd for $C_{21}H_{17}FN_2O_3$ 364.1223, found 364.1222.

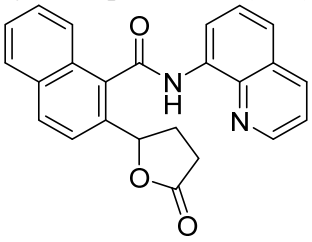
2-methyl-4-(5-oxotetrahydrofuran-2-yl)-3-(quinolin-8-ylcarbamoyl)phenyl acetate (3la)



white solid. mp = 129 °C. R_f 0.06 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.18-2.26 (m, 1H), 2.29 (s, 3H), 2.37 (s, 3H), 2.52-2.76 (m, 3H), 5.70 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.21 (d, *J* = 8.4 Hz, 1H), 7.44 (d, *J* = 8.8 Hz, 1H), 7.48 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.61 (dd, *J* = 8.8, 4.0 Hz, 2H), 8.20 (dd, *J* = 8.4, 1.2 Hz, 1H), 8.77 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.89-8.93 (m, 1H), 10.07 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 13.3, 20.8, 29.0, 31.7, 79.0, 116.9, 121.9, 122.6, 123.6, 123.8, 127.2, 127.4, 127.9, 133.7, 134.8, 136.4, 137.1, 138.3, 148.5, 149.2, 166.3, 169.1, 176.8. IR (ATR): 3336 w, 3015 w, 2360 w, 1767 m, 1671 m, 159 w, 1521 s, 1483 m, 1424 m, 1385 w, 1370 w, 1325 m, 1268 w, 1202 s,

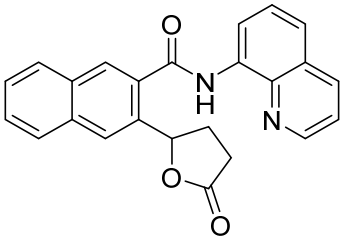
1175 s, 1139 m, 1084 w, 1033 m, 979 w, 905 m, 867 w, 827 m, 792 m, 753 , 701 w. MS, m/z (relative intensity, %): 404 (M^+, 27), 260 (23), 219 (10), 218 (15), 201 (15), 190 (14), 186 (13), 176 (17), 173 (10), 171 (32), 145 (19), 144 (100). Exact Mass (EI): Calcd for $C_{23}H_{20}N_2O_5$ 404.1372, found 404.1375.

2-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)-1-naphthamide (3ma)



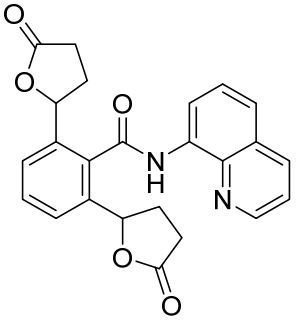
pale yellow oil. R_f 0.09 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.27-2.35 (m, 1H), 2.61- 2.74 (m, 2H) , 2.78-2.89 (m, 1H), 5.73 (dd, *J* = 8.4, 6.8 Hz, 1H), 7.43 (dd, *J* = 8.4, 4.8 Hz, 1H), 7.50-7.57 (m, 2H), 7.61-7.68 (m, 3H), 7.92 (dd, *J* = 6.8, 2.0 Hz, 1H), 8.01-8.07 (m, 2H), 8.19 (d, *J* = 8.4 Hz, 1H), 8.66 (dd, *J* = 4.0, 1.6 Hz, 1H), 9.07 (dd, *J* = 6.8, 1.2 Hz, 1H), 10.26 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 29.3, 31.8, 79.5, 116.9, 121.8, 122.0, 122.6, 125.1, 126.9, 127.2, 127.6, 128.0, 128.2, 129.5,130.5, 132.9, 133.1, 134.0, 134.2, 136.3, 138.3,148.5, 166.8, 176.9. IR (ATR): 3331 w, 3014 w, 1777 m, 1668 m, 1597 w, 1576 w, 1520 s, 1482 m, 1460 w, 1424 m, 1388 w, 1324 m, 1258 w, 1216 w, 1177 m, 1135 m, 1028 w, 986 w, 910 m, 825 m, 792 m, 750 s, 731 s, 698 w. MS, m/z (relative intensity, %): 382 (M^+, 28), 239 (13), 238 (41), 221 (20), 196 (28), 195 (10), 193 (12), 186 (17), 183 (11), 177 (11), 171 (31), 167 (15), 165 (27), 155 (12), 15 (13), 145 (13), 144 (100), 127 (25). Exact Mass (EI): Calcd for $C_{24}H_{18}N_2O_3$ 382.1317, found 382.1316.

3-(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)-2-naphthamide (3na)



white solid. mp = 114 °C. R_f 0.13 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.21-2.30 (m, 1H), 2.64-2.68 (m, 2H), 2.98-3.07 (m, 1H), 6.31 (t, *J* = 7.2 Hz, 1H), 7.47 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.56-7.63 (m, 4H), 7.90 (d, *J* = 8.0 Hz, 1H), 7.96 (d, *J* = 8.0 Hz, 1H), 8.07 (s, 1H), 8.19 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.31 (s, 1H), 8.81 (dd, *J* = 4.0, 1.2 Hz, 1H), 8.89 (dd, *J* = 7.2, 1.6 Hz, 1H), 10.55 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 28.7, 31.6, 79.4, 116.5, 121.8, 122.2, 124.9, 127.16, 127.25, 127.8, 127.96, 128.02, 128.19, 128.24, 131.8, 131.9,134.0, 134.4, 136.3, 136.4, 138.5, 148.4, 166.9, 177.5. IR (ATR): 3342 w, 3014 w, 1774 m, 1668 m, 1596 w, 1577 w, 1522 s, 1483 m, 1458 w, 1423 m, 1385 m, 1325 m, 1267 w, 1217 w, 1179 m, 1136 m, 1025 w, 991 w, 941 w, 909 m, 826 m, 791 m, 750 s, 731 m, 666 w. MS, m/z (relative intensity, %): 382 (M^+, 74), 354 (15), 353 (37), 323 (12), 254 (10), 238 (23), 221 (16), 211 (17), 210 (51), 197 (13), 196 (85), 194 (10), 193 (32), 183 (13), 171 (27), 167 (16), 166 (11), 165 (32), 155 (23), 154 (10), 152 (13), 145 (14), 144 (100), 127 (25). Exact Mass (EI): Calcd for $C_{24}H_{18}N_2O_3$ 382.1317, found 382.1318.

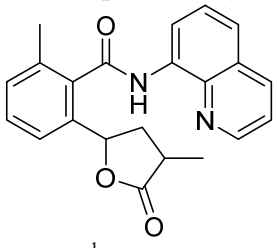
2,6-bis(5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3oa)



dr = 1:1.1. white solid. mp = 128 °C. R_f 0.17 (Hexane/EtOAc = 1/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.20-2.32 (m, 4.3H), 2.52- 2.78 (m, 12.9H), 5.71-5.75 (m, 4.3 H), 7.47-7.51 (m, 2.2H), 7.55-7.65 (m, 10.8H), 8.21 (dd, *J* = 8.0, 2.0 Hz, 2.2H), 8.76-8.78 (m, 2.2H), 8.86-8.91 (m, 2.2H), 10.09 (bs, 1.2H), 10.16 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 28.91, 28.97, 31.62(two overlaping peaks), 78.74, 78.75, 116.98, 117.08, 121.99, 122.02, 122.97(two overlaping peaks), 125.27, 125.40, 127.08, 127.18, 127.97, 127.99, 130.62, 130.68, 133.36, 133.42, 133.49(two overlaping peaks), 136.41,

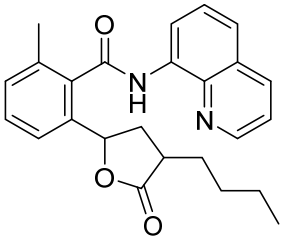
136.51, 137.24, 137.30, 138.24, 138.29, 148.67, 148.74, 165.88, 166.02, 176.47(two overlaping peaks). IR (ATR):3329 w, 3017 w, 1771 s, 1668 m, 1597 w, 1520 m, 1483 m, 1423 w, 1387 w, 1325 m, 1299 w, 1267 w, 1217 w, 1181 m, 1137 m, 1028 m, 905 m, 827 w, 793 m, 747 s, 698 m, 665 m. MS, m/z (relative intensity, %): 417 (15), 416 (M^+, 52), 387 (25), 357 (18), 301 (13), 272 (18), 216 (24), 171 (52), 145 (17), 144 (100), 143 (12), 115 (12). Exact Mass (EI): Calcd for $C_{24}H_{20}N_2O_5$ 416.1372, found 416.1371.

2-methyl-6-(4-methyl-5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3ab)



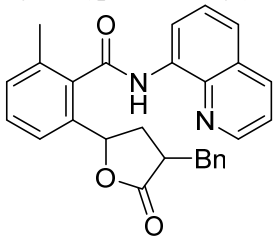
dr = 1:1.6. colorless oil. R_f 0.27 (Hexane/EtOAc = 4/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.25 (d, *J* = 7.6 Hz, 3H), 1.28 (d, *J* = 7.6 Hz, 4.8H), 1.88 (ddd, *J* = 12.0, 12.0, 12.0 Hz, 1.6H), 2.34-2.41 (m, 1H), 2.47-2.57 (m, 8.8H), 2.68 (m, 2.6H), 2.90-2.97 (m, 1.6H), 5.58 (dd, *J* = 10.4, 5.6 Hz, 1.6H), 5.84 (dd, *J* = 8.4, 5.6 Hz, 1H), 7.28-7.32 (m, 3.6H), 7.38 (d, *J* = 7.6 Hz, 1.0H), 7.42 (d, *J* = 5.6 Hz, 3.2H), 7.46 (dd, *J* = 8.0, 4.8 Hz, 2.6H), 7.59-7.64 (m, 5.2H), 8.19 (dd, *J* = 8.0, 1.6 Hz, 2.6H), 8.75 (dd, *J* = 4.0, 1.6 Hz, 2.6H), 8.93 (dd, *J* = 6.0, 2.4 Hz, 2.6H), 10.04 (bs, 2.6H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 14.82, 15.45, 19.48, 19.54, 33.48, 36.25, 38.70, 40.94, 76.56, 116.75, 121.80, 121.99, 122.39, 122.64, 127.18, 127.93, 129.61, 129.81, 130.29, 130.37, 133.83, 133.86, 134.58, 135.00, 135.18, 135.66, 136.33, 136.88, 137.53, 138.37, 148.45, 167.29, 167.42, 179.08, 180.09. IR (ATR): 3340 w, 2956 w, 2930 w, 2861 w, 1772 m, 1671 m, 1597 w, 1579 w, 1520 s, 1482 m, 1424 m, 1386 m, 1325 m, 1262 w, 1213 w, 1158 m, 1130 w, 1107 w, 1033 w, 956 w, 900 w, 849 w, 827 m, 791 m, 755 m, 731 s, 694 m. MS, m/z (relative intensity, %): 361 (11), 360 (M^+, 52), 217 (16), 216 (48), 200 (13), 189 (11), 188 (31), 172 (12), 171 (93), 147 (100), 145 (16), 144 (74), 91 (13). Exact Mass (EI): Calcd for $C_{22}H_{20}N_2O_3$ 360.1474, found 360.1475.

2-(4-butyl-5-oxotetrahydrofuran-2-yl)-6-methyl-N-(quinolin-8-yl)benzamide (3ac)



dr = 1:1.5. colorless oil. R_f 0.17 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 0.81 (t, *J* = 6.0 Hz, 3H), 0.87 (t, *J* = 6.4 Hz, 4.5H), 1.20-1.30 (m, 10H), 1.39-1.48 (m, 2.5H), 1.76-1.95 (m, 4.0H), 2.39-2.52 (m, 9.5H), 2.60-2.71 (m, 2.5H), 2.88-2.95 (m, 1.5H), 5.56 (dd, *J* = 10.4, 5.6 Hz, 1.5H), 5.80 (m, 1.0H), 7.27-7.31 (m, 3.5H), 7.38-7.42 (m, 4.0H), 7.45-7.48 (m, 2.5H), 7.59-7.64 (m, 5.0H), 8.19 (dd, *J* = 8.0, 1.2 Hz, 2.5H), 8.75 (dd, *J* = 4.0, 1.2 Hz, 2.5H), 8.93 (dd, *J* = 6.0, 2.0 Hz, 2.5H), 10.04 (bs, 2.5H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 13.72, 13.80, 19.47, 19.51, 22.25, 22.31, 29.24, 29.29, 29.79, 30.14, 36.91, 38.69, 39.11, 41.24, 76.91,121.79, 121.98, 122.39, 122.63, 127.18, 127.94, 129.63, 129.82, 130.26, 130.34, 133.83, 133.86, 134.57, 134.98, 135.18, 135.64, 136.33, 137.07, 137.69, 138.37, 148.43, 167.33, 167.44, 178.61, 179.55. IR (ATR): 3339 w, 2973 w, 1772 m, 1670 m, 1597 w, 1578 w, 1519 s, 1482 m, 1457 m, 1424 m, 1385 m, 1325 m, 1264 w, 1186 m, 1159 m, 1129 w, 1082 w, 1011 w, 900 w, 827 m, 791 m, 755 m, 731 m, 696 m. MS, m/z (relative intensity, %): 403 (16), 402 (M^+, 57), 259 (12), 258 (46), 230 (17), 213 (11), 199 (39), 172 (12), 171 (100), 161 (18), 160 (20), 147 (61), 145 (25), 144 (97), 129 (10), 91 (14). Exact Mass (EI): Calcd for $C_{25}H_{26}N_2O_3$ 402.1943, found 382.1318.

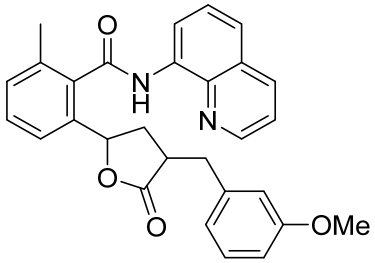
2-(4-benzyl-5-oxotetrahydrofuran-2-yl)-6-methyl-N-(quinolin-8-yl)benzamide (3ad)



dr = 1:1.5. colorless oil. R_f 0.20 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.92-2.01 (m, 1.5H), 2.30-

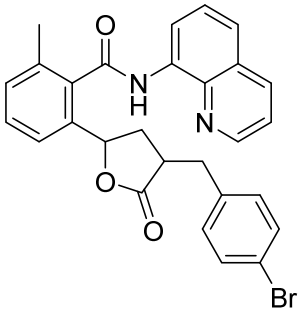
2.37 (m, 1H), 2.88 (s, 3H), 2.45 (s, 3H), 2.48-2.53 (m, 1H), 2.75-2.84 (m, 4H), 2.91-3.09 (m, 3.5H), 3.28 (dd, *J* = 13.6, 4.0 Hz, 1.5H), 5.5 (dd, *J* = 6.8, 6.8 Hz, 1H), 5.51 (dd, *J* = 10.8, 6.0 Hz, 1.5H), 6.91-6.94 (m, 1H), 6.99-7.05 (m, 4H), 7.13 (d, *J* = 8.0 Hz, 3H), 7.17-7.29 (m, 9.5H), 7.35-7.40 (m, 2.5H), 7.42-7.48 (m, 2.5H), 7.57-7.67 (m, 5H), 8.17 (d, *J* = 8.0 Hz, 1.5H), 8.21 (d, *J* = 8.0 Hz, 1H), 8.66 (d, *J* = 4.0 Hz, 1.5H), 8.70 (d, *J* = 4.0 Hz, 1H), 8.85-8.89 (m, 1.5H), 8.93 (dd, *J* = 6.8, 2.0 Hz, 1H), 9.93 (bs, 1H), 9.99 (bs, 1.5H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.42, 19.46, 36.10, 36.17, 38.69, 41.01, 43.18, 77.51, 116.86, 121.77, 121.91, 122.38, 122.39, 122.77, 126.54, 127.18, 127.24, 127.92, 128.45, 128.54, 128.78, 129.62, 129.85, 130.23, 130.41, 133.76, 133.86, 134.59, 134.95, 135.16, 135.67, 136.35, 136.82, 137.28, 137.55, 138.30, 148.40, 167.19, 167.34, 177.70, 178.78. IR (ATR): 3338 w, 3026 w, 2925 w, 1771 m, 1670 m, 1597 w, 1520 s, 1483 m, 1455 w, 1424 w, 1386 w, 1325 m, 1266 w, 1205 w, 1162 m, 1129 w, 1087 w, 1037 w, 1007 w, 963 w, 907 m, 826 w, 791 m, 750 s, 729 s, 699 s. MS, m/z (relative intensity, %): 437 (19), 436(M^+, 60), 292 (22), 276 (13), 275 (33), 229 (17), 173 (40), 172 (10), 171 (84), 161 (15), 149 (10), 147 (64), 145 (21), 144 (100), 132 (24), 104 (10), 91 (59). Exact Mass (EI): Calcd for $C_{28}H_{24}N_2O_3$ 436.1787, found 436.1780.

2-(4-(3-methoxybenzyl)-5-oxotetrahydrofuran-2-yl)-6-methyl-N-(quinolin-8-yl)benzamide (3ae)



dr = 1:1.6. colorless oil R_f 0.16 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.96 (ddd, *J* = 12.0, 12.0, 12.0 Hz, 1.6H), 2.32-2.39 (m, 1H), 2.44- 2.54 (m, 8.8H), 2.71-2.83 (m, 4.2H), 2.91-3.04 (m, 2.6H), 3.06-3.11 (m, 1H), 3.27 (dd, *J* = 13.6, 4.0 Hz, 1.6H), 3.68 (s, 3H), 3.75 (s, 4.8H), 5.49-5.55 (m, 2.6H), 6.54 (dd, *J* = 8.0, 2.4 Hz, 1H), 6.62-6.76 (m, 6.8H), 6.92 (t, *J* = 8.0 Hz, 1H), 7.15 (t, *J* = 8.0 Hz, 1.6H), 7.26-7.30 (m, 4.8H), 7.35-7.48 (m, 5.6H), 7.58-7.66 (m, 5.2H), 8.16-8.22 (m, 2.6H), 8.67 (d, *J* = 4.0 Hz, 1.6H), 8.70 (d, *J* = 4.0 Hz, 1.0H), 8.85-8.90 (m, 1.6H), 8.92 (dd, *J* = 7.2, 2.0 Hz, 1H), 9.94 (bs, 1H), 9.98 (bs, 1.6H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.49, 36.12, 36.20, 36.24, 38.82, 40.84, 43.19, 54.99, 55.07, 77.55, 111.99, 112.18, 114.22, 114.33, 116.82, 121.08, 121.12, 121.78, 121.94, 122.37, 122.40, 122.80, 127.18, 127.24, 127.92, 129.46, 129.56, 129.64, 129.87, 130.28, 130.44, 133.79, 133.86, 134.61, 134.98, 135.18, 135.69, 136.31, 136.81, 137.33, 138.35, 139.23, 139.91, 148.44, 159.57, 159.67, 167.20, 167.33, 177.74, 178.85. IR (ATR): 3339 w, 3011 w, 2938 w, 1769 m, 1670 m, 1597 w, 1520 s, 1483 s, 1424 m, 1386 w, 1325 m, 1263 m, 1205 w, 1156 m, 1129 w, 1091 w, 1039 m, 1008 w, 907 w, 827 m, 790 m, 754 s, 732 m, 697 m. MS, m/z (relative intensity, %): 467 (20), 466 (M^+, 63), 305 (23), 259 (21), 173 (12), 171 (54), 163 (11), 162 (100), 147 (36), 145 (17), 144 (83), 121 (22), 91 (14). Exact Mass (EI): Calcd for $C_{29}H_{26}N_2O_4$ 466.1893, found 466.1891.

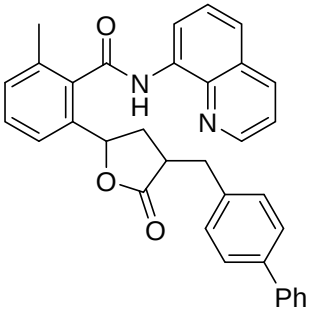
2-(4-(4-bromobenzyl)-5-oxotetrahydrofuran-2-yl)-6-methyl-N-(quinolin-8-yl)benzamide (3af)



dr = 1:1.5. white solid. mp = 84 °C. R_f 0.20 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.92 (m, 1.5H), 2.30-2.37 (m, 1H), 2.45-2.53 (m, 8.5H), 2.71-2.80 (m, 4H), 2.88-3.05 (m, 3.5H), 3.21 (dd, *J* = 14.0, 4.0 Hz, 1.5H), 5.48-5.54 (m, 2.5H), 6.91 (d, *J* = 8.4 Hz, 2H), 7.00 (d, *J* = 8.0 Hz, 3H), 7.12 (d, *J* = 8.8 Hz, 2H), 7.24-7.29 (m, 5H), 7.33-7.41 (m, 5.5H), 7.45-7.50 (m, 2.5H), 7.59 (d, *J* = 4.4 Hz, 3H), 7.63-7.68 (m, 2H), 8.19 (dd, *J* = 8.4, 1.6 Hz, 1.5H), 8.22 (dd, *J* = 8.4, 1.6 Hz, 1H), 8.65 (dd, *J* = 4.0, 1.6 Hz, 1.5H), 8.69 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.85-8.89 (m, 1.5H), 8.94 (dd, *J* = 6.4, 2.8 Hz, 1H), 9.94 (bs, 1H), 9.97 (bs, 1.5H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.46, 19.49, 35.44, 35.49, 36.06, 38.54, 40.74, 42.95, 77.54, 116.77, 116.85, 120.50, 120.62, 121.80, 121.83, 121.88, 122.46, 122.49, 122.66, 127.21, 127.28, 127.96, 128.03, 129.68, 129.90, 130.31, 130.49, 130.55, 130.59, 131.59, 131.64, 133.77, 133.86, 134.69, 135.03, 135.11, 135.59, 136.38, 136.43, 16.55, 136.72, 137.18, 137.26, 138.32, 138.34, 148.45, 148.50, 167.21, 167.33, 177.35, 178.39. IR (ATR): 3339 w, 2930 w, 2361 w, 1773 m, 1671 m, 1596 w, 1521 s, 1483 m, 1424 w, 1386 w, 1325 m, 1264 w, 1216 w, 1162 w, 1072 w, 1011 w, 963 w, 898 w, 827 w, 792 m, 754 m, 697 w. MS, m/z (relative intensity, %): 517 (12), 516 (40), 515 (13), 514 (M^+, 39), 372 (22), 370 (22), 355 (13), 353 (13), 287 (11), 245 (10), 173 (61), 172 (10), 171

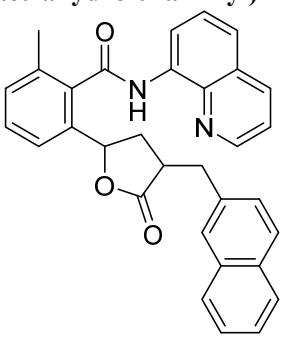
(80), 169 (28), 161 (25), 147 (67), 145 (21), 144 (100), 116 (11), 91 (14). Exact Mass (EI): Calcd for $C_{28}H_{23}BrN_2O_3$ 514.0892, found 514.0890.

2-(4-([1,1'-biphenyl]-4-ylmethyl)-5-oxotetrahydrofuran-2-yl)-6-methyl-N-(quinolin-8-yl)benzamide (3ag)



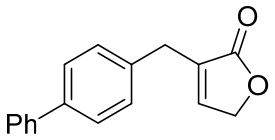
dr = 1:1.5. white solid. mp = 95 °C. R_f 0.07 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.00 (ddd, *J* = 12.4, 12.0, 10.8 Hz, 1.5H), 2.34-2.41 (m, 1H), 2.43 (s, 3.0H), 2.45 (s, 4.5H), 2.54-2.61 (m, 1H), 2.79-2.90 (m, 4H), 2.94-3.14 (m, 3.5H), 3.32 (dd, *J* = 13.6, 4.0 Hz, 1.5H), 5.45-5.55 (m, 2.5H), 7.12 (d, *J* = 8.4 Hz, 2H), 7.19-7.24 (m, 6H), 7.26-7.39 (m, 15H), 7.42-7.60 (m, 6H), 7.54-7.62 (m, 8.5H), 8.13 (td, *J* = 8.0, 1.6 Hz,2.5H), 8.63 (td, *J* = 4.0, 1.6 Hz,2.5H), 8.87 (dd, *J* = 6.4, 2.4 Hz, 1.5H), 8.94 (dd, *J* = 6.4, 2.0 Hz, 1.0H), 9.93 (bs, 1H), 9.98 (bs, 1.5H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.46, 19.49, 35.77, 35.85, 36.31, 38.72, 41.09, 43.19,77.55, 116.74, 116.85, 121.77, 121.85, 122.40, 122.42, 122.76, 126.85, 126.93, 127.04, 127.19, 127.22, 127.27, 127.91, 127.93, 128.57, 128.74, 129.28, 128.69, 129.89, 130.24, 130.44, 133.79, 133.88, 134.64, 134.94, 135.13, 135.65, 136.29, 136.32, 136.6, 136.88, 137.38, 138.28, 138.37, 139.50, 139.56, 140.53, 140.71, 148.40, 148.44, 167.24, 167.37, 177.71, 178.76 IR (ATR): 3338 w, 3027 w, 2925 w, 2251 w, 1770 m, 1670 m, 1597 w, 1520 s, 1483 m, 1424 m, 1386 m, 1325 m, 1265 w, 1202 w, 1161 m, 1129 m, 1039 w, 1008 w, 963 w, 907 m, 858 w, 826 m, 791 m, 757 s, 729 s, 696 s. MS, m/z (relative intensity, %): 513 (28), 512 (M^+, 73), 351 (21), 305 (11), 287 (10), 209 (11), 208 (70), 207 (18), 171 (39), 168 (14), 167 (100), 165 (14), 147 (33), 145 (17), 144 (88). Exact Mass (EI): Calcd for $C_{34}H_{28}N_2O_3$ 512.2100, found 512.2101.

2-methyl-6-(4-(naphthalen-2-ylmethyl)-5-oxotetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (3ah)



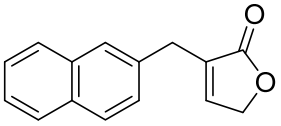
dr = 1:1.5. white solid. mp = 108 °C. R_f 0.17 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.97-2.06 (m, 1.5H), 2.33- 2.40 (m, 1H), 2.42 (s, 3H), 2.43 (m, 4.5H), 2.51-2.58 (m, 1H), 2.79 (ddd, *J* = 13.6, 8.0, 5.2 Hz, 1.5H), 2.89-3.16 (m, 5H), 3.29 (dd, *J* = 13.6, 4.0 Hz, 1H), 3.46 (dd, *J* = 13.6, 4.0 Hz, 1.5H), 5.51 (dd, *J* = 10.4, 6.0 Hz, 1.5H), 5.58 (dd, *J* = 8.0, 6.0 Hz, 1H), 7.19-7.39 (m, 14H), 7.42-7.47 (m, 3H), 7.52-7.65 (m, 11H), 7.71 (d, *J* = 8.0 Hz, 3H), 7.77-7.81 (m, 1.5H), 8.12 (dd, *J* = 8.0, 1.6 Hz, 1.5H), 8.16 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.45 (dd, *J* = 4.0, 1.2 Hz, 1.5H), 8.54 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.84 (dd, *J* = 5.2, 4.0 Hz, 1.5H), 8.89 (dd, *J* = 6.4, 2.0 Hz, 1H), 9.89 (bs, 1H), 9.93 (bs, 1.5H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.46, 36.13, 36.31, 36.36, 38.88, 40.81, 43.22, 77.17, 77.59, 116.80, 116.85, 121.71, 121.75, 121.89, 122.37, 122.75, 125.46, 125.54, 125.98, 126.08, 126.98, 127.02, 127.16, 127.28, 127.41, 127.43, 127.50, 127.56, 127.89, 127.94, 128.24, 128.29, 129.63, 129.85, 130.28, 130.42, 132.14, 132.22, 133.30, 133.44, 133.76, 133.86, 134.66, 135.03, 135.13, 135.26, 135.62, 135.85, 136.25, 136.79, 137.36, 138.30, 148.35, 167.20, 167.29, 177.69, 178.76. IR (ATR): 3339 w, 3015 w, 2361 w, 1771 s, 1670 m, 1597 w, 1520 s, 1482 m, 1424 m, 1385 m, 1325 m, 1265 w, 1217 m, 1163 m, 1039 w, 964 w, 898 w, 859 w, 826 w, 791 m, 751 s, 696 w, 667 w. MS, m/z (relative intensity, %): 487 (30), 486 (M^+, 84), 325 (24), 287 (13), 279 (18), 183 (14), 182 (100), 181 (20), 173 (12), 171 (45), 167 (10), 147 (33), 145 (20), 144 (99), 142 (11), 141 (78), 115 (12). Exact Mass (EI): Calcd for $C_{32}H_{26}N_2O_3$ 486.1943, found 486.1946.

3-([1,1'-biphenyl]-4-ylmethyl)furan-2(5H)-one (3g)



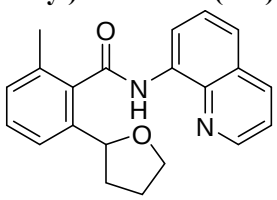
white solid. mp = 110 °C. R_f 0.20 (Hexane/EtOAc = 2/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 3.65 (d, *J* = 2.0 Hz, 2H), 4.78 (d, *J* = 2.4 Hz, 2H), 7.00 (t, *J* =1.6 Hz, 1H), 7.31-7.36 (m, 3H), 7.44 (dd, *J* = 8.0, 8.0 Hz, 1H), 7.57 (m, 4H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 31.45, 70.25, 126.99, 127.28, 127.46, 128.77, 129.33, 134.20, 136.38, 139.80, 140.67, 145.56, 173.91. IR (ATR): 3029 w, 2926 w, 1751 s, 1631 w, 1602 w, 1521 w, 1487 m, 1446 w, 1410 w, 1348 w, 1269 w, 1208 w, 1114 w, 1066 m, 1043 m, 1007 w, 948 w, 913 w, 832 w, 760 m, 731 w, 698 m. MS, m/z (relative intensity, %): 250 (M^+, 48), 206 (18), 205 (100), 204 (16), 203 (11), 165 (11). Exact Mass (EI): Calcd for $C_{17}H_{14}O_2$ 250.0994, found 250.0992.

3-(naphthalen-2-ylmethyl)furan-2(5H)-one (3h)



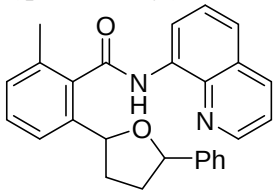
white solid. mp = 62 °C. R_f 0.20 (Hexane/EtOAc = 2/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 3.73 (s, 2H), 4.69 (s, 2H), 6.89 (t, *J* = 1.2 Hz, 1H), 7.32 (dd, *J* = 8.4, 1.6 Hz, 1H), 7.42-7.48 (m, 2H), 7.67 (s, 1H), 7.76-7.81 (m, 3H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 31.8, 10.19, 125.65, 126.14, 127.04, 127.28, 127.43, 127.55, 128.33, 132.18, 133.43, 133.93, 134.73, 145.79, 173.86. IR (ATR): 2970 w, 2361 w, 1747 s, 1651 w, 1558 w, 1523 w, 1509 w, 1366 m, 1218 m, 1065 w, 1043 w, 772 s, 670 w. MS, m/z (relative intensity, %): 224 (M^+, 25), 180 (11), 179 (100), 178 (33), 82 (13). Exact Mass (EI): Calcd for $C_{15}H_{12}O_2$ 224.0837, found 224.0837.

2-methyl-N-(quinolin-8-yl)-6-(tetrahydrofuran-2-yl)benzamide (6aa)



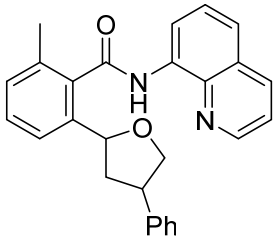
colorless oil. R_f 0.34 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.81-1.93 (m, 2H), 1.95-2.04 (m, 1H), 2.34-2.40 (m, 1H), 2.44 (s, 3H), 3.80-3.85 (m, 1H), 4.05 (dd, *J* = 14.8, 7.2 Hz, 1H), 5.08 (t, *J* = 7.2 Hz, 1H), 7.18 (d, *J* = 7.6 Hz, 1H), 7.35 (d, *J* = 7.6 Hz, 1H), 7.41-7.44 (m, 2H), 7.54-7.62 (m, 2H), 8.16 (dd, *J* = 8.4, 2.0 Hz, 1H), 8.73 (dd, *J* = 4.4, 1.6 Hz, 1H), 8.97 (dd, *J* = 7.6, 1.6 Hz, 1H), 9.98 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.34, 26.27, 35.31, 68.82, 78.67, 116.58, 121.64, 121.90, 123.02, 127.30, 127.95, 129.12, 129.29, 134.28, 134.38, 135.87, 136.21, 138.44, 140.73, 148.30, 168.36. IR (ATR): 3343 w, 2976 w, 2871 w, 1672 m, 1596 w, 1578 w, 1519 s, 1481 s, 1424 m, 1385 m, 1325 m, 1263 m, 1127 w, 1063 m, 903 m, 826 m, 791 m, 754 s, 730 , 693 m, 667 m. MS, m/z (relative intensity, %): 332 (M^+, 7), 190 (13), 189 (100), 188 (45), 160 (14), 147 (66), 145 (13), 144 (17), 91 (12). Exact Mass (EI): Calcd for $C_{21}H_{20}N_2O_2$ 332.1525, found 332.1519.

2-methyl-6-(5-phenyltetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (6ac)



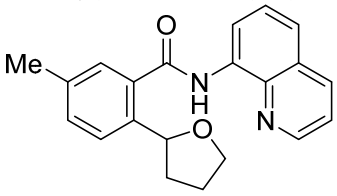
dr = 1:1.3. white solid. mp = 54 °C. R_f 0.43 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.84-2.15 (m, 4.6H), 2.28- 2.36 (m, 1.3H), 2.40-2.56 (m, 10.2H), 4.88 (t, *J* = 7.6 Hz, 1.3H), 5.20-5.26 (m, 2.3H), 5.45 (dd, *J* = 8.8, 6.4 Hz, 1H), 7.12-7.42 (m, 16.1H), 7.51-7.64 (m, 6.9H), 8.14 (d, *J* = 8.4 Hz, 2.3H), 8.66-8.69 (m, 2.3H), 8.98 (dd, *J* = 7.2, 6.0 Hz, 2.3H), 10.04 (bs, 2.3H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.36, 19.41, 34.09, 34.88, 35.90, 36.17, 78.74, 79.51, 80.96, 81.66, 116.62, 121.62, 121.64, 121.95, 121.97, 123.17, 123.30, 125.38, 125.93, 126.90, 127.18, 127.26, 127.92, 128.03, 128.20,129.27, 129.31, 129.34, 129.42, 134.26, 134.31, 134.46, 135.92, 136.04, 136.17, 138.40, 139.92, 140.59, 142.45, 143.22, 148.29, 168.28, 168.41. IR (ATR): 3343 w, 2952 w, 2908 w,2874 w, 2361 w, 2340 w, 1675 m, 1587 w, 1519 s, 1482 s, 1423 m, 1385 m, 1325 m, 1263 w, 1127 w, 1057 m, 943 w, 899 w, 827 m, 788 m, 744 s, 699 s. MS, m/z (relative intensity, %): 408 (M^+, 7), 304 (10), 286 (14), 247 (15), 233 (41), 229 (18), 207 (18), 147 (34), 145 (14), 144 (100), 104 (14), 91 (17). Exact Mass (EI): Calcd for $C_{27}H_{24}N_2O_2$ 408.1838, found 408.1831.

2-methyl-6-(4-phenyltetrahydrofuran-2-yl)-N-(quinolin-8-yl)benzamide (6ad)



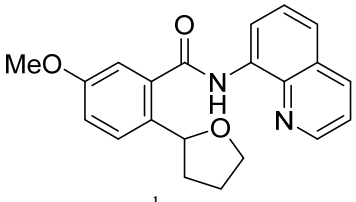
dr = 1:1.1. white solid. mp = 68 °C. R_f 0.57 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.08-2.16 (m, 1.1H), 2.40-2.55 (m, 8.3H), 2.79-2.86 (m, 1.1H), 3.47-3.57 (m, 2.1H), 3.78 (t, *J* = 8.0 Hz, 1H), 3.97 (t, *J* = 8.4 Hz, 1.1H), 4.24 (t, *J* = 8.4 Hz, 1.1H), 4.42 (t, *J* = 8.0 Hz, 1H), 5.29 (dd, *J* = 10.8, 6.0 Hz, 1H), 5.46 (t, *J* = 6.0 Hz, 1H), 7.09-7.27 (m,10.5H), 7.36-7.41 (m, 4.2H), 7.47-7.60 (m, 6.3H), 8.12 (dd, *J* = 8.4, 1.6 Hz, 2.1H), 8.70 (m, 2.1H), 8.98 (ddd, *J* = 10.8, 7.6, 1.6 Hz, 2.1H), 10.01 (bs, 2.1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ:19.33, 19.35, 42.58, 44.20, 44.25, 46.00, 75.12, 75.26, 78.71, 80.02, 116.57, 116.61, 121.62, 121.94, 123.09, 123.14, 126.34, 126.47, 127.15, 127.19, 127.25, 127.91, 128.34, 128.42, 129.26, 129.34, 129.41,134.24, 134.29, 134.39, 134.52, 135.60, 135.89, 136.20, 138.36, 139.97, 140.71, 141.22, 141.49, 148.25, 148.27, 168.22, 168.32. IR (ATR): 3342 w, 3026 w, 2940 w, 2869 w, 1671 m, 1596 w, 1579 w, 1517 s, 1481 s, 1423 m, 1384 m, 1324 m, 1263 w, 1172 w, 1127 w, 1069 w, 1045 w, 990 w, 900 w, 826 m, 790 m, 754 s, 732 m, 698 s. MS, *m/z* (relative intensity, %): 408 (M^+, 7), 265 (33), 264 (43), 247 (16), 229 (15), 148 (10), 147 (100), 144 (17), 104 (15), 91 (21). Exact Mass (EI): Calcd for $C_{27}H_{24}N_2O_2$ 408.1838, found 408.1838.

5-methyl-N-(quinolin-8-yl)-2-(tetrahydrofuran-2-yl)benzamide (6fa)



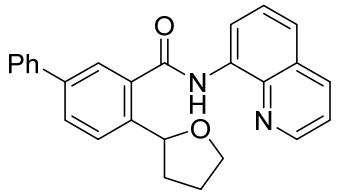
white solid. mp = 201 °C. R_f 0.40 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.79-1.88 (m, 1H), 1.91-2.01 (m, 2H), 2.41 (s, 3H), 2.48-2.56 (m, 1H), 3.87 (dd, *J* = 14.4, 7.6 Hz, 1H), 4.08 (dd, *J* = 14.4, 7.6 Hz, 1H), 5.38 (t, *J* = 7.2 Hz, 1H), 7.31 (d, *J* = 8.0 Hz, 1H), 7.41-7.44 (m, 1H), 7.47 (s, 1H), 7.52-7.60 (m, 3H), 8.15 (d, *J* = 8.2 Hz, 1H), 8.77 (d, *J* = 4.0 Hz, 1H), 8.91 (d, *J* = 7.6 Hz, 1H), 10.26 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 20.97, 26.12, 34.96, 68.67, 78.13, 116.44, 121.58, 121.75, 126.27, 127.26, 127.43, 127.91, 131.26, 134.68, 134.99, 136.22, 136.87, 138.52, 139.46, 148.20, 167.99. IR (ATR): 3347 w, 2971 w, 2868 w, 2360 w, 1736 w, 1670 m, 1597 w, 1574 w, 1519 s, 1481 m, 1423 m, 1383 m, 1324 m, 1261 w, 1196 w, 1172 w, 1106 w, 1057 m, 940 w, 914 w, 825 m, 790 m, 754 m, 695 w. MS, m/z (relative intensity, %): 332 (M^+, 16), 190 (12), 189 (81), 188 (100), 171 (12), 161 (14), 160 (59), 159 (12), 147 (84), 145 (25), 144 (67), 143 (27), 130 (13), 129 (17), 128 (19), 119 (42), 117 (10), 116 (1), 115 (17), 105 (11), 91 (31), 89 (11), 71 (12), 65 (10). Exact Mass (EI): Calcd for $C_{21}H_{20}N_2O_2$ 332.1525, found 332.1522.

5-methoxy-N-(quinolin-8-yl)-2-(tetrahydrofuran-2-yl)benzamide (6ga)



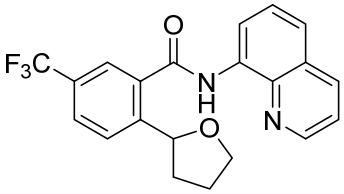
white solid. mp = 101 °C. R_f 0.31 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.80-1.89 (m, 1H), 1.92-2.02 (m, 2H), 2.45-2.52 (m, 1H), 3.83-3.88 (m, 4H), 4.08 (dd, *J* = 14.4, 7.6 Hz, 1H), 5.28 (t, *J* = 7.2 Hz, 1H), 7.05 (dd, *J* = 8.8, 2.8 Hz, 1H), 7.20 (d, *J* = 2.8 Hz, 1H), 7.44 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.53-7.61 (m, 3H), 8.16 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.77 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.91 (d, *J* = 6.8 Hz, 1H), 10.31 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 26.15, 34.83, 55.46, 68.59, 78.00, 112.46, 116.04, 116.55, 121.64, 121.89, 127.27, 127.84, 127.94, 134.04, 134.63, 136.25, 136.30, 138.55, 148.28, 158.47, 167.58. IR (ATR): 3344 w, 2946 w, 2868 w, 2361 w, 1671 m, 1606 w, 1574 w, 1520 s, 1481 m, 1423 m, 1383 m, 1324 m, 1285 m, 1262 m, 1239 w, 1220 w, 1173 w, 1133 w, 1100 w, 1055 m, 1042 m, 914 w, 825 m, 790 m, 755 m, 732 m, 695 w. MS, m/z (relative intensity, %): 348 (M^+, 30), 303 (12), 205 (70), 204 (100), 177 (17), 176 (85), 163 (53), 145 (13), 144 (88), 135 (35). Exact Mass (EI): Calcd for $C_{21}H_{20}N_2O_3$ 348.1474, found 348.1477.

N-(quinolin-8-yl)-4-(tetrahydrofuran-2-yl)-[1,1'-biphenyl]-3-carboxamide (6ha)



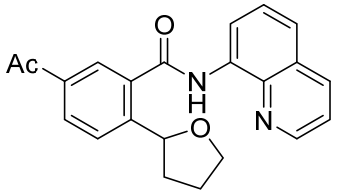
white solid. mp = 73 °C. R_f 0.54 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.86-1.95 (m, 1H), 1.96-2.04 (m, 2H), 2.54-2.60 (m, 1H), 3.91 (dd, *J* = 14.6, 7.2 Hz, 1H), 4.13 (dd, *J* = 14.6, 7.2 Hz, 1H), 5.39-5.43 (m, 1H), 7.34-7.38 (m, 1H), 7.40-7.47 (m, 3H), 7.53-7.65 (m, 4H), 7.75 (dd, *J* = 11.2, 8.0 Hz, 2H), 7.89 (d, *J* = 2.0 Hz, 1H), 8.14 (d, *J* = 8.4 Hz, 1H), 8.75 (d, *J* = 4.0 Hz, 1H), 8.93-8.94 (m, 1H), 10.34 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 26.22, 35.06, 68.83, 78.13, 116.53, 121.64, 121.91, 125.52, 126.88, 127.05, 127.27, 127.57, 127.92, 128.84, 129.15, 134.63, 135.58, 136.25, 138.51, 140.02, 140.10, 141.56, 148.30, 167.8. IR (ATR): 3343 w, 2972 w, 2869 w, 1671 m, 1596 w, 1578 w, 1520 s, 1481 m, 1424 m, 1383 m, 1325 m, 1260 w, 1243 w, 1228 w, 1177 w, 1147 w, 1108 w, 1057 m, 1024 w, 912 w, 825 m, 790 m, 756 s, 697 m. MS, m/z (relative intensity, %): 394 (M^+, 16), 252 (11), 251 (67), 250 (100), 223 (16), 222 (70), 209 (49), 205 (14), 181 (24), 178 (14), 167 (13), 165 (13), 153 (14), 152 (29), 144 (49). Exact Mass (EI): Calcd for $C_{26}H_{22}N_2O_2$ 394.1681, found 394.1683.

N-(quinolin-8-yl)-2-(tetrahydrofuran-2-yl)-5-(trifluoromethyl)benzamide (6ia)



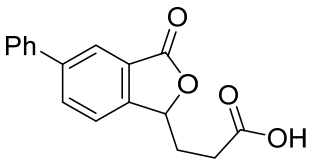
white solid. mp = 70 °C. R_f 0.40 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.80-1.89 (m, 1H), 1.96-2.03 (m, 2H), 2.54-2.62 (m, 1H), 3.92 (dd, *J* = 15.2, 8.4 Hz, 1H), 4.12 (dd, *J* = 15.2, 8.4 Hz, 1H), 5.40 (t, *J* = 7.6 Hz, 1H), 7.46 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.58-7.63 (m, 2H), 7.76 (d, *J* = 8.4 Hz, 1H), 7.83 (d, *J* = 8.0 Hz, 1H), 7.91 (s, 1H), 8.19 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.80 (dd, *J* = 4.0, 1.6 Hz, 1H), 8.88 (dd, *J* = 6.0, 2.4 Hz, 1H), 10.28 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 26.19, 35.10, 69.05, 77.95, 116.74, 121.81, 122.31, 123.77 (d, *J* = 3.9 Hz), 123.88 (q, *J* = 270.8 Hz), 127.00, 127.22, 127.26, 127.97, 129.48 (q, *J* = 32.4 Hz), 134.29, 135.47, 136.36, 138.51, 146.88, 148.48, 166.43. IR (ATR): 3340 w, 2973 w, 2872 w, 2361 w, 1734 w, 1674 m, 1617 w, 1596 w, 1578 w, 1522 s, 1482 m, 1424 m, 1385 m, 1324 s, 1248 m, 1231 w, 1167 m, 1123 s, 1077 m, 1059 s, 915 w, 826 m, 790 m, 756 m, 699 w. MS, m/z (relative intensity, %): 386 (M^+, 30), 341 (10), 330 (17), 243 (34), 342 (89), 215 (16), 214 (96), 202 (10), 201 (100), 197 (10), 173 (47), 172 (12), 171 (10), 145 (29), 144 (96), 130 (11), 129 (10), 116 (12), 115 (10). Exact Mass (EI): Calcd for $C_{21}H_{17}F_3N_2O_2$ 386.1242, found 386.1244.

5-acetyl-N-(quinolin-8-yl)-2-(tetrahydrofuran-2-yl)benzamide (6ja)



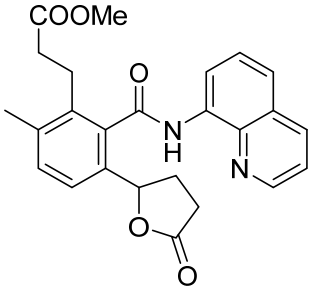
white solid. mp = 125 °C. R_f 0.23 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.82-1.89 (m, 1H), 1.96-2.03 (m, 2H), 2.55- 2.63 (m, 1H), 2.66 (s, 3H), 3.93 (dd, *J* = 15.2, 6.8 Hz, 1H), 4.13 (dd, *J* = 15.2, 6.8 Hz, 1H), 5.41 (t, *J* = 7.2 Hz, 1H), 7.48 (dd, *J* = 8.0, 4.0 Hz, 1H), 7.58-7.63 (m, 2H), 7.81 (d, *J* = 8.4 Hz, 1H), 8.09 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.20 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.26 (d, *J* = 1.2 Hz, 1H), 8.79 (dd, *J* = 4.0, 2.0 Hz, 1H), 8.89 (dd, *J* = 6.4, 2.0 Hz, 1H), 10.30 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 26.20, 26.65, 35.11, 69.04, 78.12, 116.65, 121.75, 122.18, 126.67, 126.84, 127.25, 127.96, 130.32, 134.37, 135.24, 135.89, 136.34, 138.48, 148.17, 148.40, 166.95, 197.03. IR (ATR): 3342 w, 2971 w, 2870 w, 2361 w, 1734 w, 1672 s, 1599 w, 1573 w, 1520 s, 1482 m, 1424 m, 1384 m, 1356 w, 1325 m, 1286 w, 1240 m, 1225 w, 1173 w, 1131 w, 1058 m, 972 w, 915 w, 826 m, 790 m, 756 m, 731 m, 690 w, 667 w. MS, m/z (relative intensity, %): 360 (M^+, 26), 217 (53), 216 (100), 189 (11), 188 (62), 175 (71), 173 (21), 171 (12), 147 (23), 145 (11), 144 (55), 129 (10), 115 (10). Exact Mass (EI): Calcd for $C_{22}H_{20}N_2O_3$ 360.1474, found 360.1477.

3-(3-oxo-5-phenyl-1,3-dihydroisobenzofuran-1-yl)propanoic acid (7)



pale yellow solid. mp = 175 °C. R_f 0.06 (Hexane/EtOAc = 3/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 1.99-2.08 (m, 1H), 2.47-2.59 (m, 2H), 2.63-2.72 (m, 1H), 5.62 (dd, *J* = 8.8, 4.8 Hz, 1H), 7.38-7.44 (m,1H), 7.47-7.51 (m, 2H), 7.55 (d, *J* = 8.0 Hz, 1H), 7.61-7.62 (m, 2H), 7.92 (dd, *J* = 8.0, 1.6 Hz, 1H), 8.11 (s, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 29.03, 29.65, 79.78, 122.18, 124.1, 126.80, 127.24, 128.23, 129.10, 133.36, 139.28, 143.10, 147.75, 170.17, 177.15. IR (ATR): 3370 w, 2976 w, 1720 m, 1579 w, 1523 s, 1484 m, 1456 w, 1424 w, 1385 w, 1367 w, 1327 w, 1289 w, 1246 m, 1218 m, 1155 s, 1090 w, 1069 w, 1030 w, 1001 m, 913 w, 866 w, 850 w, 825 w, 789 w, 753 s, 699 w, 664 w. MS, m/z (relative intensity, %): 283 (14), 282 (M^+, 58), 236 (31), 223 (50), 222 (100), 210 (11), 209 (70), 182 (10), 181 (52), 153 (23), 152 (54), 151 (12). Exact Mass (EI): Calcd for $C_{17}H_{14}O_4$ 282.0892, found 282.0894.

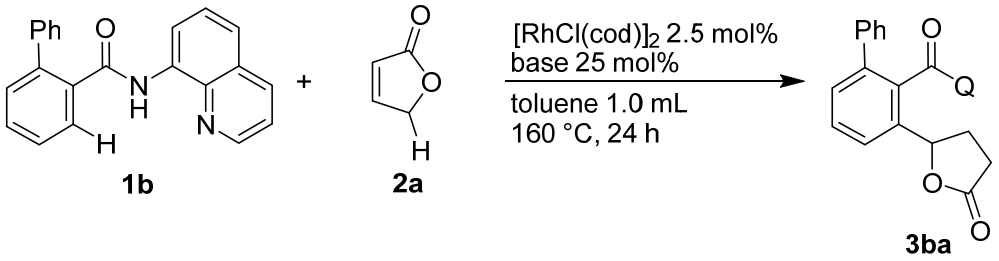
methyl 3-(4-(5-oxotetrahydrofuran-2-yl)-3-(quinolin-8-ylcarbamoyl)-[1,1'-biphenyl]-2-yl)propanoate (8)



colorless oil. R_f 0.27 (Hexane/EtOAc = 1/1). ^{1}H NMR ($CDCl_3$, 399.78 MHz) δ: 2.17-2.27 (m, 1H), 2.41 (s, 3H), 2.50-2.72 (m, 5H), 3.06 (t, *J* = 8.4 Hz, 2H), 3.54 (s, 3H), 5.66 (dd, *J* = 8.8, 6.4 Hz, 1H), 7.34 (s, 3H), 7.47 (dd, *J* = 8.4, 4.0 Hz, 1H), 7.60-7.64 (m, 2H), 8.20 (dd, *J* = 8.0, 2.0 Hz, 1H), 8.75 (dd, *J* = 4.4, 1.6 Hz, 1H), 8.89-8.93 (m, 1H), 10.01 (bs, 1H). ^{13}C NMR ($CDCl_3$, 100.53 MHz) δ: 19.34, 26.05, 29.16, 31.83, 34.33, 51.57, 79.19, 117.01, 121.84, 122.55, 123.26, 127.25, 127.97, 132.02, 133.78, 134.56, 135.51, 136.21, 136.40, 137.36, 138.36, 48.50, 167.47, 172.93, 176.87. IR (ATR): 3337 w, 2952 w, 1776 m, 1733 m, 1669 m, 1595 w, 1577 w, 1518 s, 1482 m, 1458 m, 1424 m, 1386 w, 1324 m, 1294 w, 1268 w, 1176 m, 1139 m, 1081 w, 1031 w, 985 w, 913 w, 866 w, 828 m, 809 w, 792 w, 755 m, 731 m. MS, m/z (relative intensity, %): 433 (15), 432 (M^+, 49), 401 (17), 373 (29), 289 (12), 288 (21), 257 (46), 246 (10), 186 (22), 173 (15), 171 (39), 145 (21), 144 (100), 143 (13). Exact Mass (EI): Calcd for $C_{25}H_{24}N_2O_5$ 432.1685, found 432.1688.

VI. Optimization of the Rh-Catalyzed Alkylation of 1b

Table S1. Optimazation of the Rh-Catalyzed Alkylation of **1b** withα,β-unsaturated γ-lactone [a]



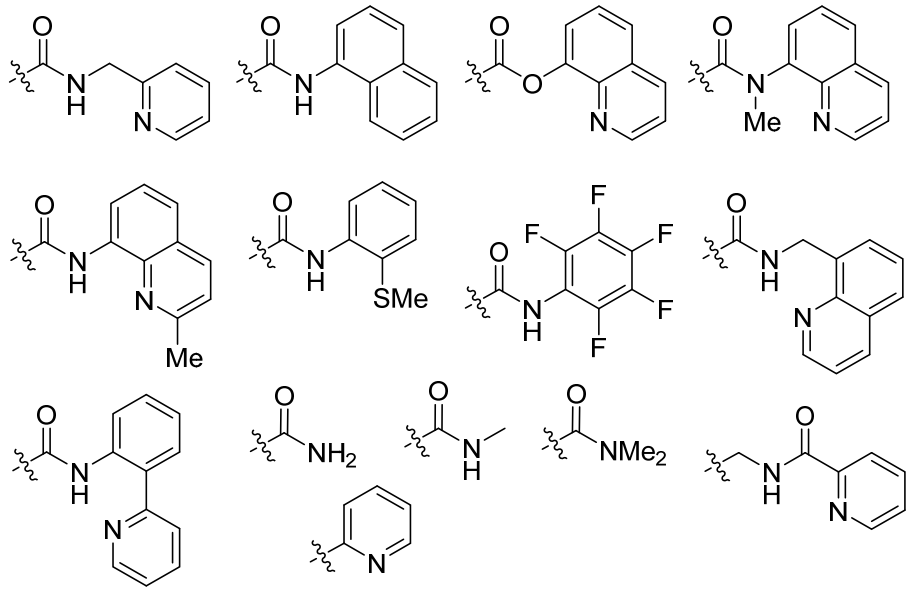
		NMR yields	
entry	base	**1b**	**3ba**
1	KOAc	69%	33%
2	K_2HPO_4	55%	<46%
3	NaOAc	33%	74%
4	Na_2CO_3	24%	76%
5[b]	**Na_2CO_3**	**8%(7%)**	**84%(73%)**
6	$NaHCO_3$	24%	74%
7	Na_3PO_4	26%	67%
8	NaOPiv	61%	33%
9[c]	-	33%	59%

The number in parentheses is the isolated yields.

[a] Reaction conditions, unless otherwise specified: benzamide **1b** (0.3 mmol), lactone (0.6 mmol), catalyst (0.0075 mmol), base (0.075 mmol), solvent (1.0 mL), 160 °C, 24 h. [b] catalyst (0.015 mmol), lactone (0.9 mmol) [c] $[Rh(OAc)(cod)]_2$ (0.0075 mmol) was used in place of $[RhCl(cod)]_2$.

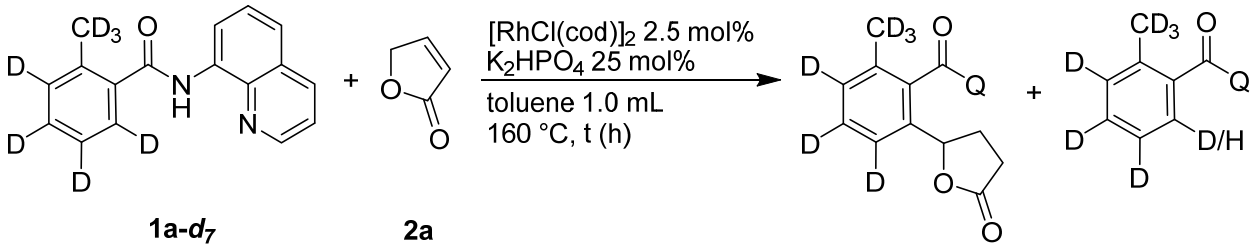
VII. Effect of Directing Group

Figure S1. Ineffective directing groups



VIII. Deuterium Labeling Experiments (butenolide)

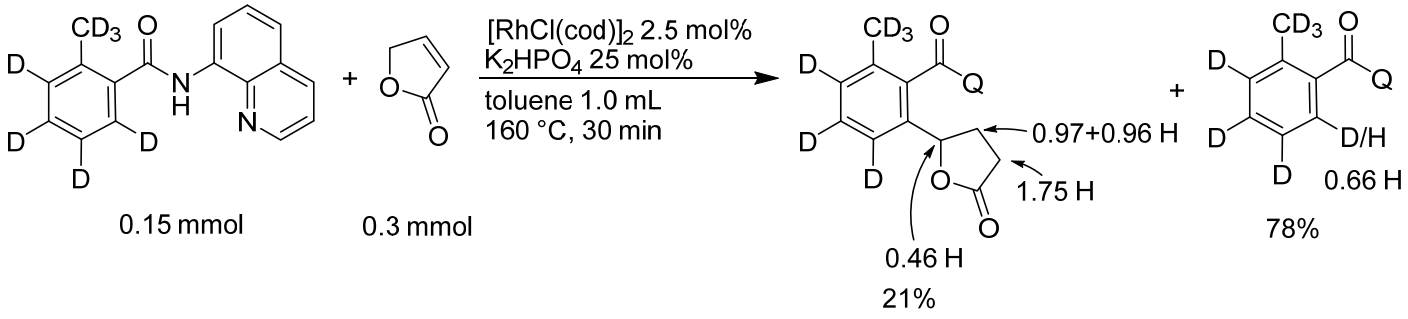
Representative procedure.

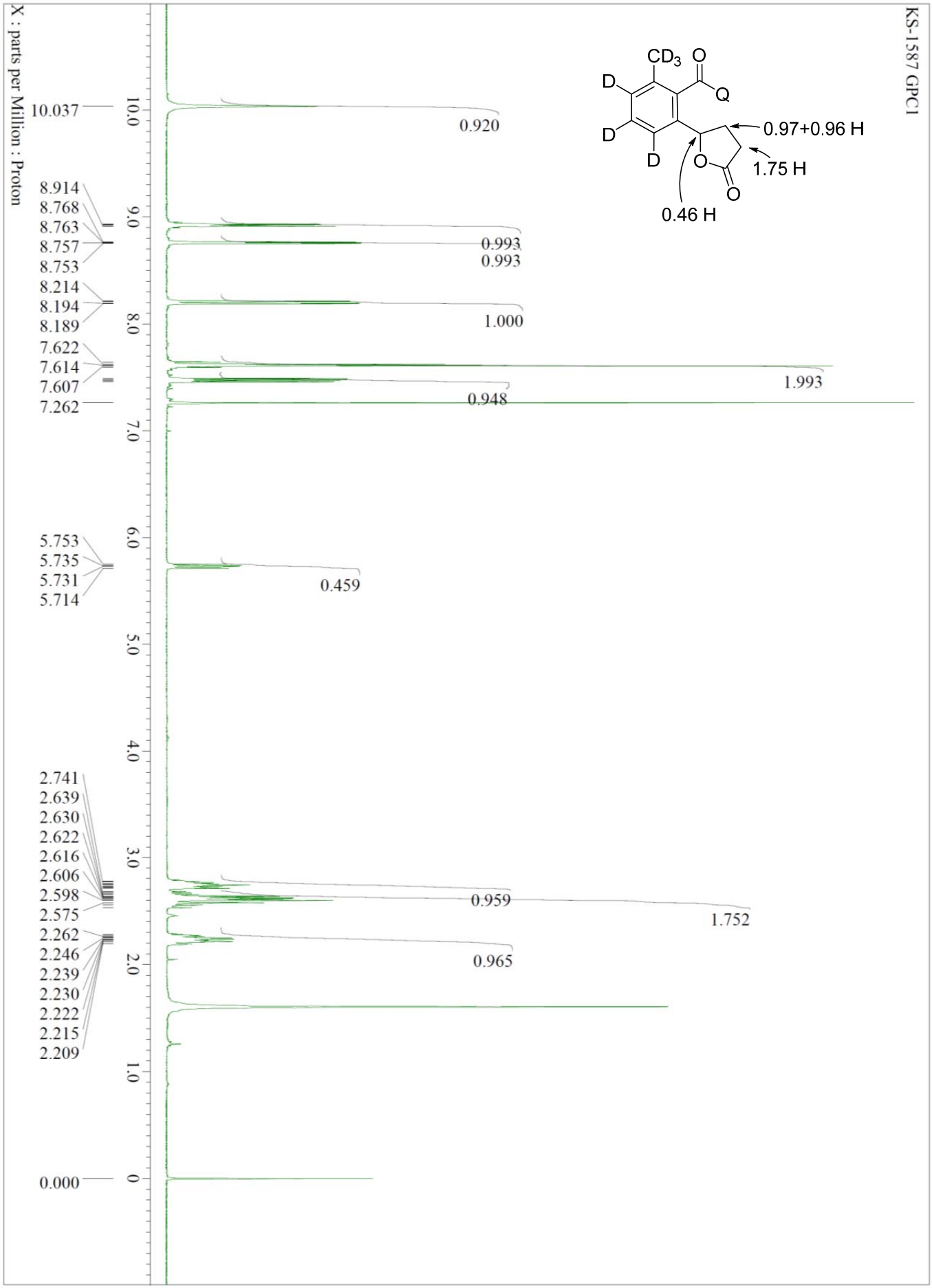


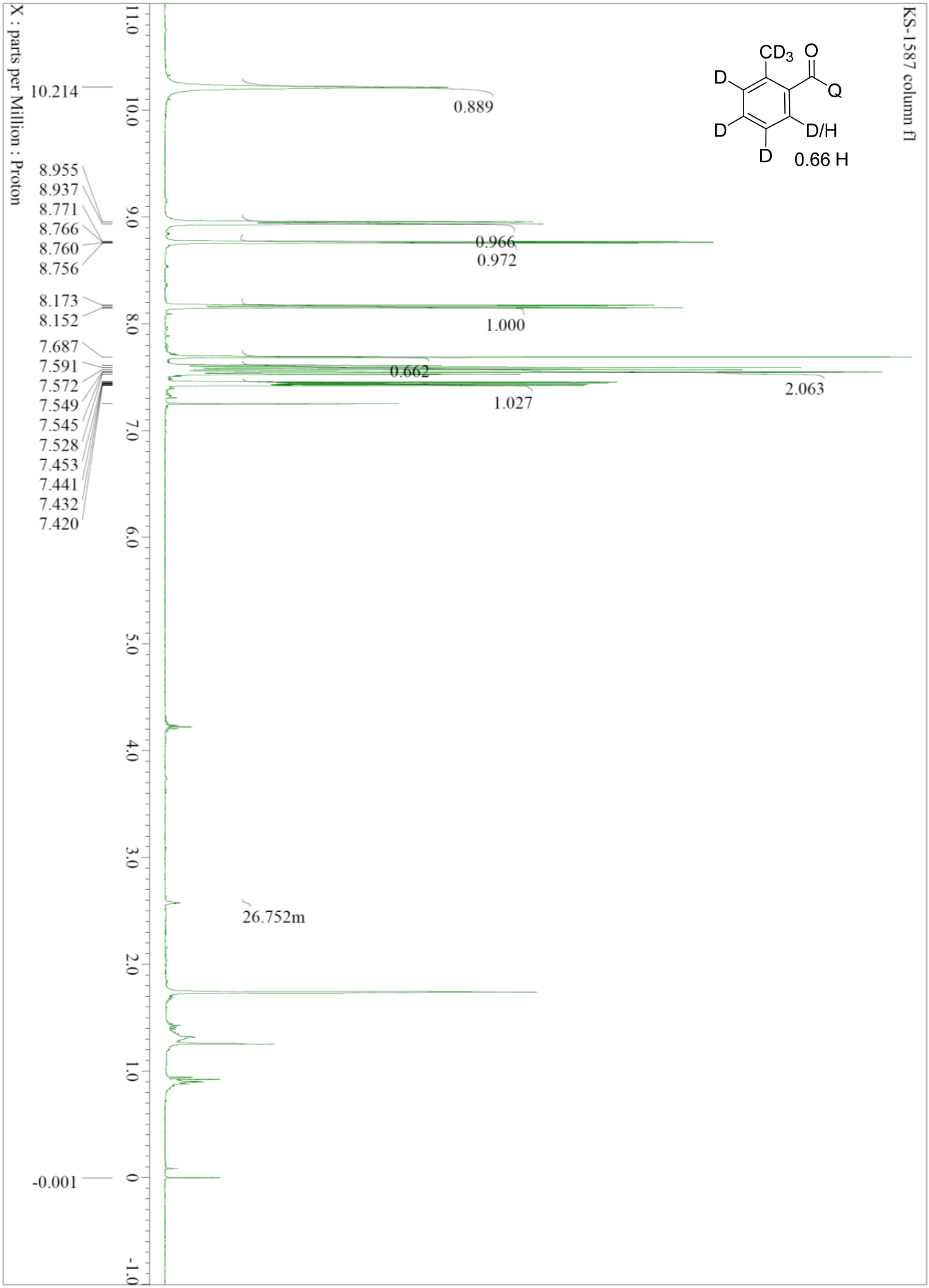
To an oven-dried 5 mL screw-capped vial, 2-methyl-*N*-(8-quinolinyl)benzamide **1a-*d*$_7$** (40 mg, 0.15 mmol), furan-2(5H)-one (25 mg, 0.3 mmol), $[RhCl(cod)]_2$ (1.8 mg, 0.00375 mmol), K_2HPO_4 (6.5 mg, 0.0375 mmol) and toluene (1.0 mL) were added. The mixture was stirred for the appropriate time at 160 °C followed by cooling. The mixture was filtered through a celite pad and concentrated *in vacuo*. The residue was purified by column chromatography on silica gel (eluent: hexane/EtOAc= 10/1) to afford the desired alkylated product and starting amide.

Experiments wtihout **2a** were conducted in a similar way.

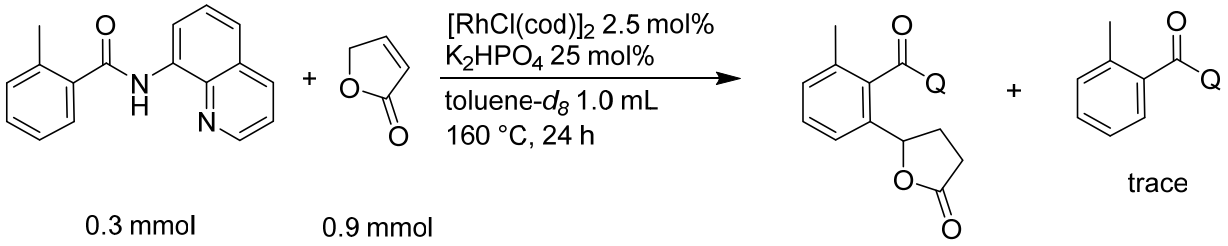
(A) Estimation of deuterium and hydrogen incorporation. (30 min)




KS-1587 GPC1
X : parts per Million : Proton
10.037
8.914
8.768
8.763
8.757
8.753
8.214
8.194
8.189
7.622
7.614
7.607
7.262
5.753
5.735
5.731
5.714
2.741
2.639
2.630
2.622
2.616
2.606
2.598
2.575
2.262
2.246
2.239
2.230
2.222
2.215
2.209
0.000
0.920
0.993
0.993
1.000
1.993
0.948
0.459
0.959
1.752
0.965
CD3
O
Q
D
D
D
O
O
0.97+0.96 H
1.75 H
0.46 H


KS-1587 column fl
X : parts per Million : Proton
CD3
O
D
Q
D
D/H
D
0.66 H
10.214
8.955
8.937
8.771
8.766
8.760
8.756
8.173
8.152
7.687
7.591
7.572
7.549
7.545
7.528
7.453
7.441
7.432
7.420
-0.001
0.889
0.966
0.972
1.000
0.662
2.063
1.027
26.752m
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

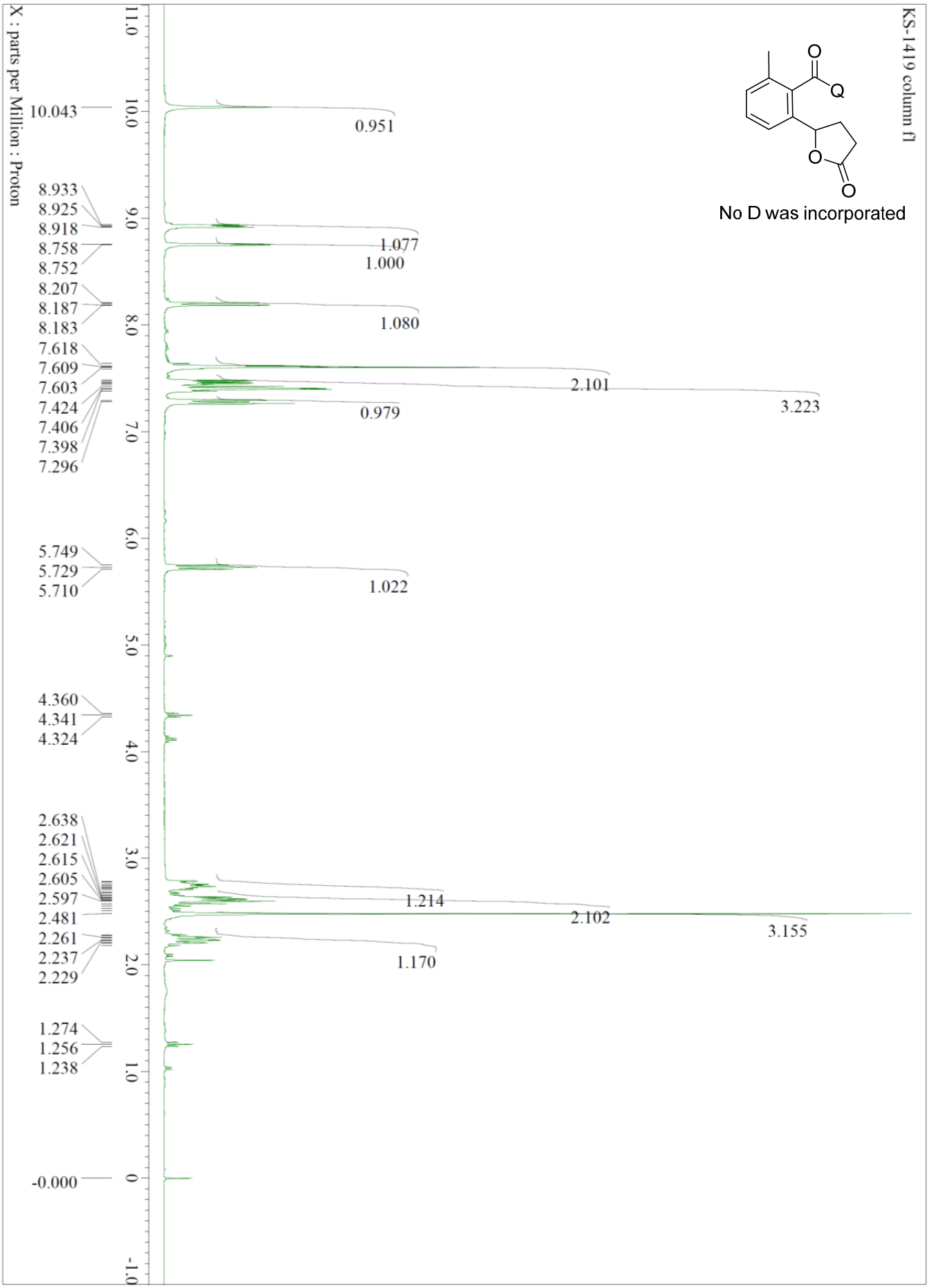
(B) Estimation of deuterium and hydrogen incorporation. (solvent: toluene-d_8)



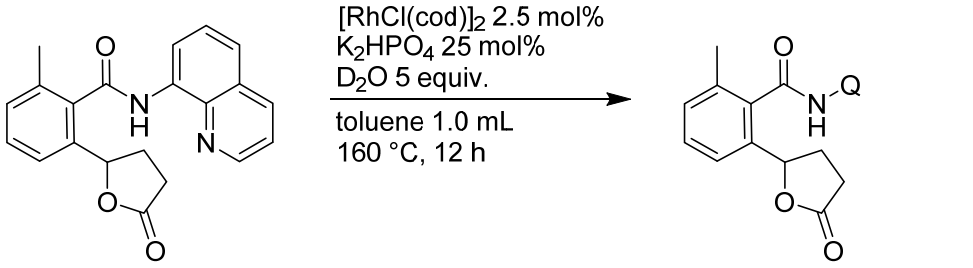
0.3 mmol 0.9 mmol

No D was incorporated

82%


KS-1419 column fl
X : parts per Million : Proton
No D was incorporated
10.043
8.933
8.925
8.918
8.758
8.752
8.207
8.187
8.183
7.618
7.609
7.603
7.424
7.406
7.398
7.296
5.749
5.729
5.710
4.360
4.341
4.324
2.638
2.621
2.615
2.605
2.597
2.481
2.261
2.237
2.229
1.274
1.256
1.238
-0.000
0.951
1.077
1.000
1.080
2.101
3.223
0.979
1.022
1.214
2.102
3.155
1.170

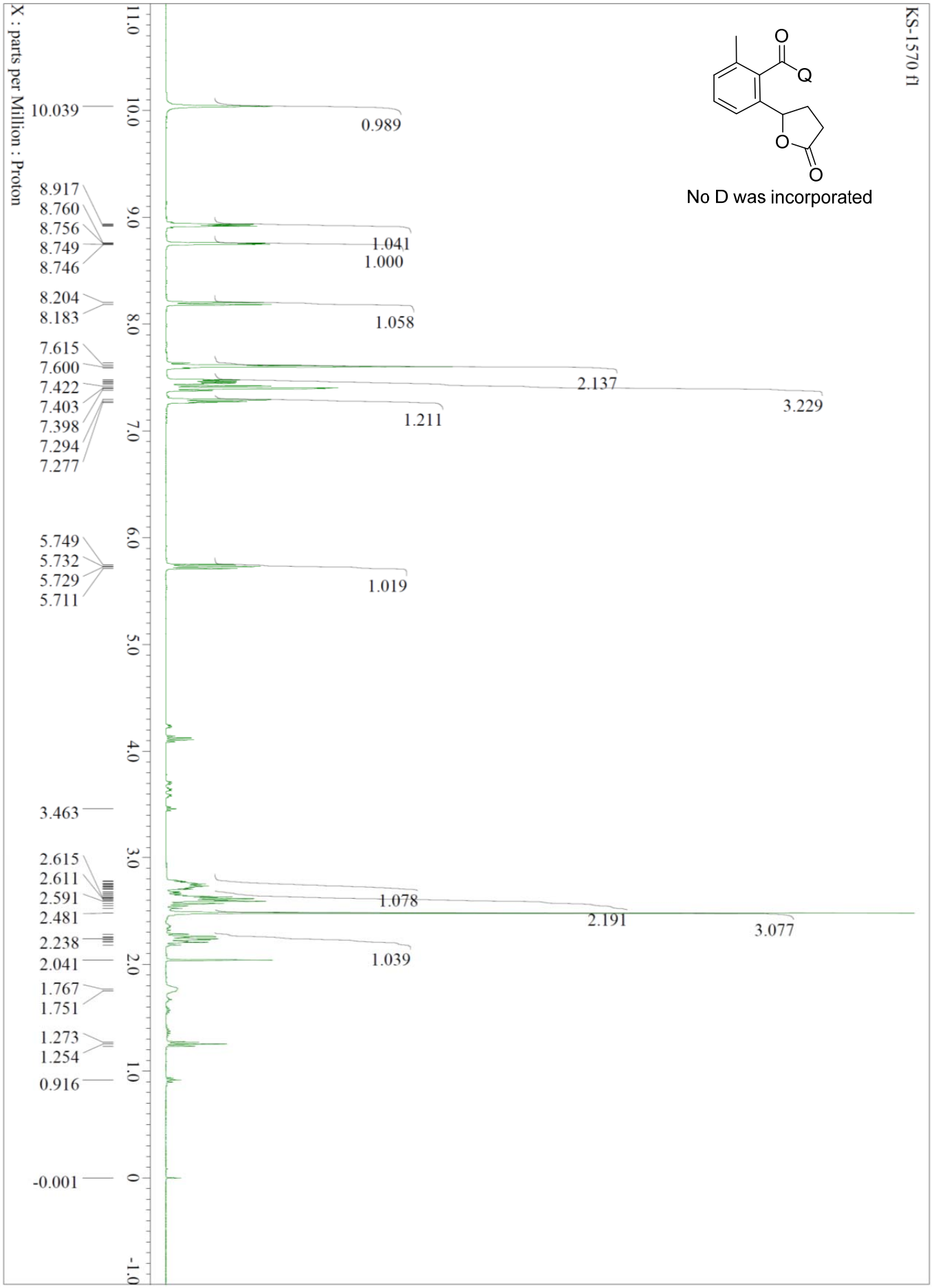
(C) Estimation of H/D Exchange in the Product 3aa. (with Catalyst)



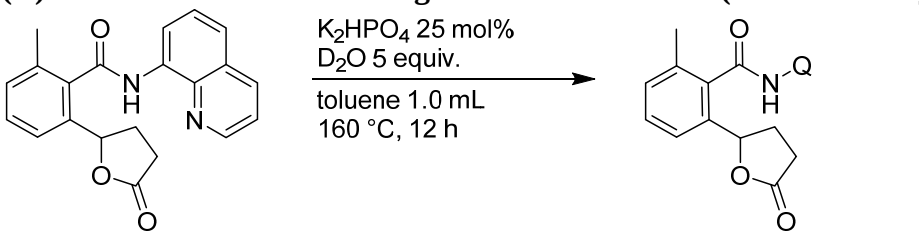
0.15 mmol

No D was incorporated

85%


KS-1570 f1
X : parts per Million : Proton
No D was incorporated
10.039
8.917
8.760
8.756
8.749
8.746
8.204
8.183
7.615
7.600
7.422
7.403
7.398
7.294
7.277
5.749
5.732
5.729
5.711
3.463
2.615
2.611
2.591
2.481
2.238
2.041
1.767
1.751
1.273
1.254
0.916
-0.001
0.989
1.041
1.000
1.058
2.137
3.229
1.211
1.019
1.078
2.191
3.077
1.039

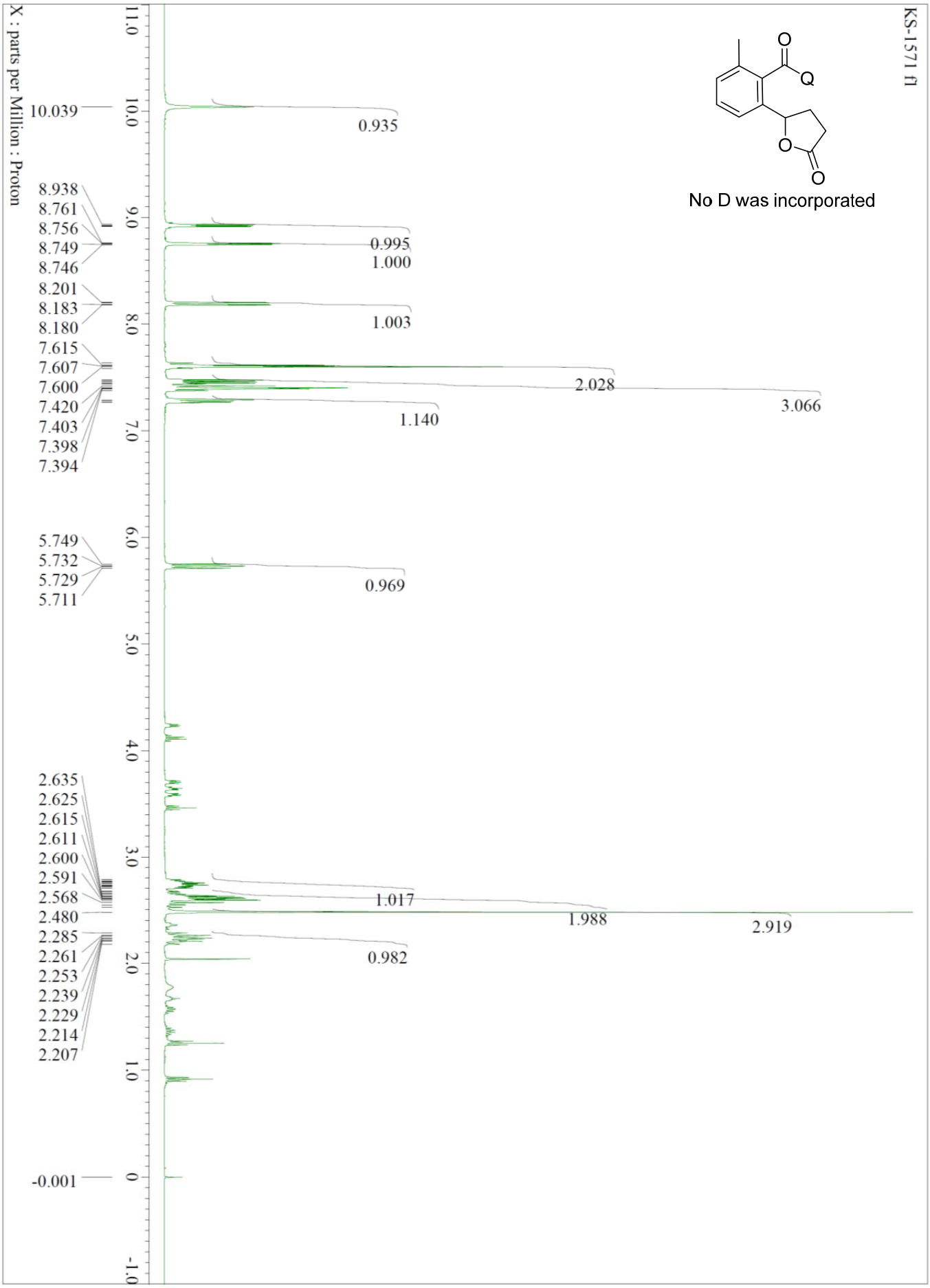
(D) Estimation of H/D Exchange in the Product 3aa. (without Catalyst)



0.15 mmol

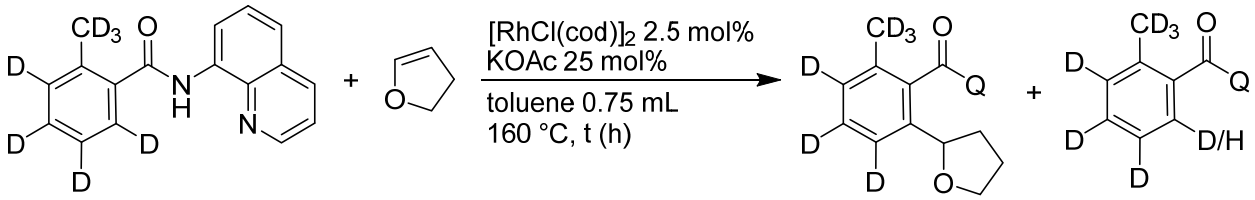
No D was incorporated

92%


KS-1571 f1
X : parts per Million : Proton
No D was incorporated
10.039
8.938
8.761
8.756
8.749
8.746
8.201
8.183
8.180
7.615
7.607
7.600
7.420
7.403
7.398
7.394
5.749
5.732
5.729
5.711
2.635
2.625
2.615
2.611
2.600
2.591
2.568
2.480
2.285
2.261
2.253
2.239
2.229
2.214
2.207
-0.001
0.935
0.995
1.000
1.003
2.028
3.066
1.140
0.969
1.017
1.988
2.919
0.982

IX. Deuterium Labeling Experiments (dihidrofuran)

Representative procedure.(Method A)

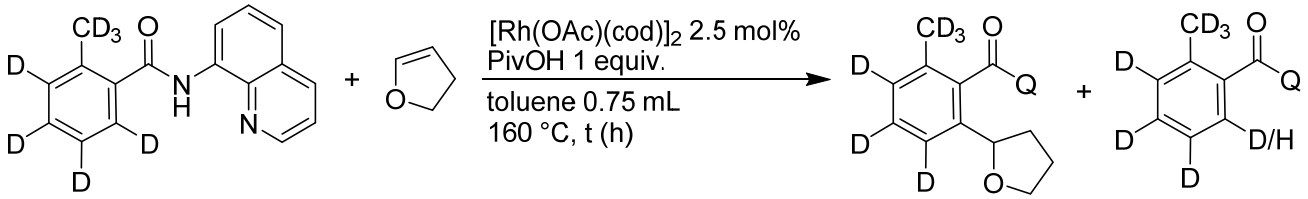


1a-d_7 **5a**

To an oven-dried 5 mL screw-capped vial, 2-methyl-*N*-(8-quinolinyl)benzamide **1a-d_7** (40 mg, 0.15 mmol), 2,3-dihydrofuran (21 mg, 0.3 mmol), $[RhCl(cod)]_2$ (1.8 mg, 0.00375 mmol), KOAc (3.7 mg, 0.0375 mmol) and toluene (0.75 mL) were added. The mixture was stirred for the appropriate time at 160 °C followed by cooling. The mixture was filtered through a celite pad and concentrated *in vacuo*. The residue was purified by column chromatography on silica gel (eluent: hexane/EtOAc= 10/1) to afford the desired alkylated product and starting amide.

Experiments wtihout **2a** were conducted in a similar way.

Representative procedure.(Method B)

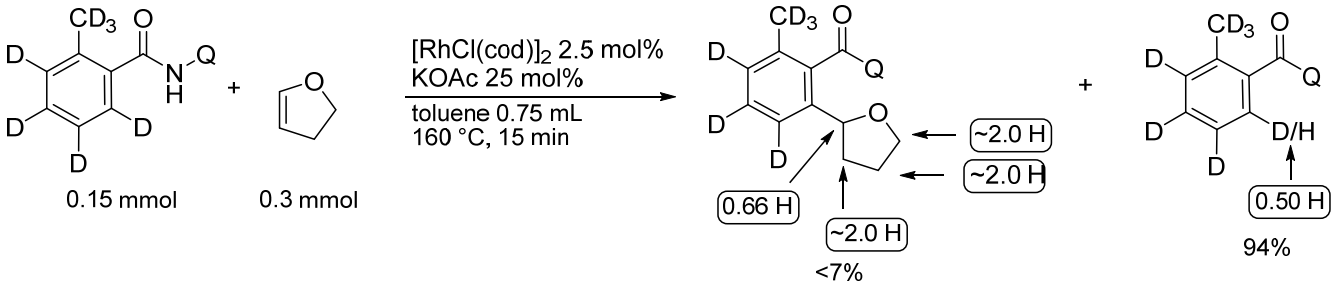


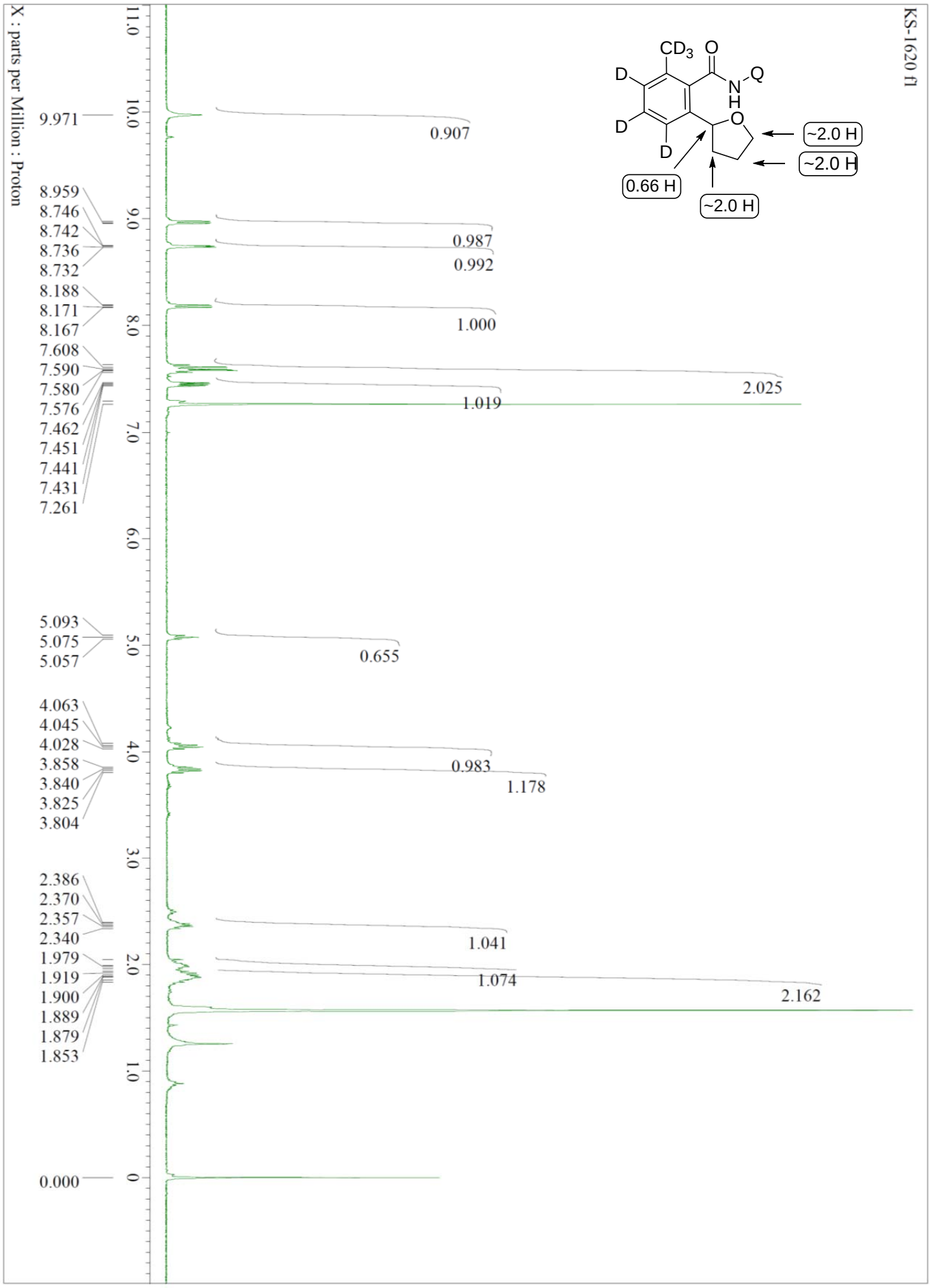
1a-d_7 **5a**

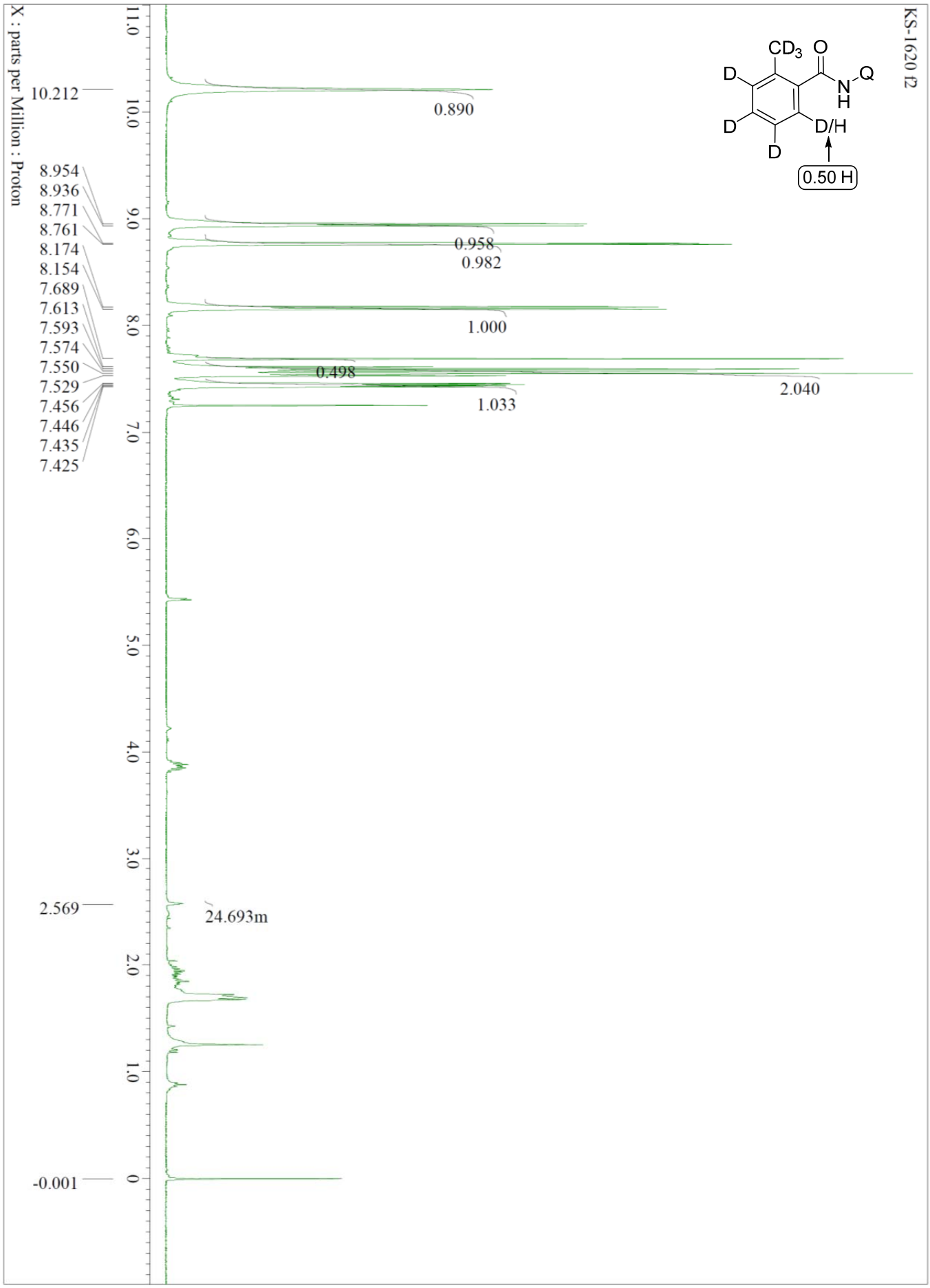
To an oven-dried 5 mL screw-capped vial, 2-methyl-*N*-(8-quinolinyl)benzamide **1a-d_7** (40 mg, 0.15 mmol), 2,3-dihydrofuran (21 mg, 0.3 mmol), $[Rh(OAc)(cod)]_2$ (2.0 mg, 0.00375 mmol), PivOH (15.3 mg, 0.15 mmol) and toluene (0.75 mL) were added. The mixture was stirred for the appropriate time at 160 °C followed by cooling. The mixture was filtered through a celite pad and concentrated *in vacuo*. The residue was purified by column chromatography on silica gel (eluent: hexane/EtOAc= 10/1) to afford the desired alkylated product and starting amide.

Experiments wtihout **2a** were conducted in a similar way.

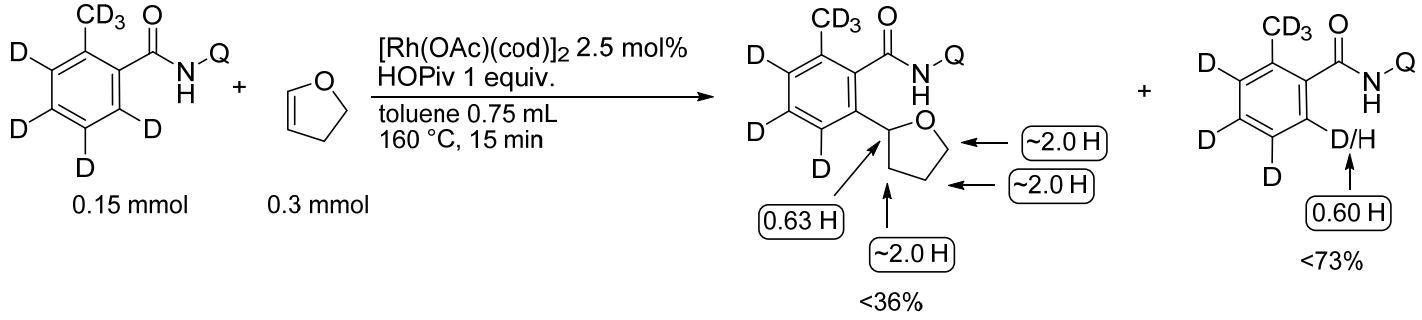
(A) Estimation of deuterium and hydrogen incorporation. (15 min, Method A)

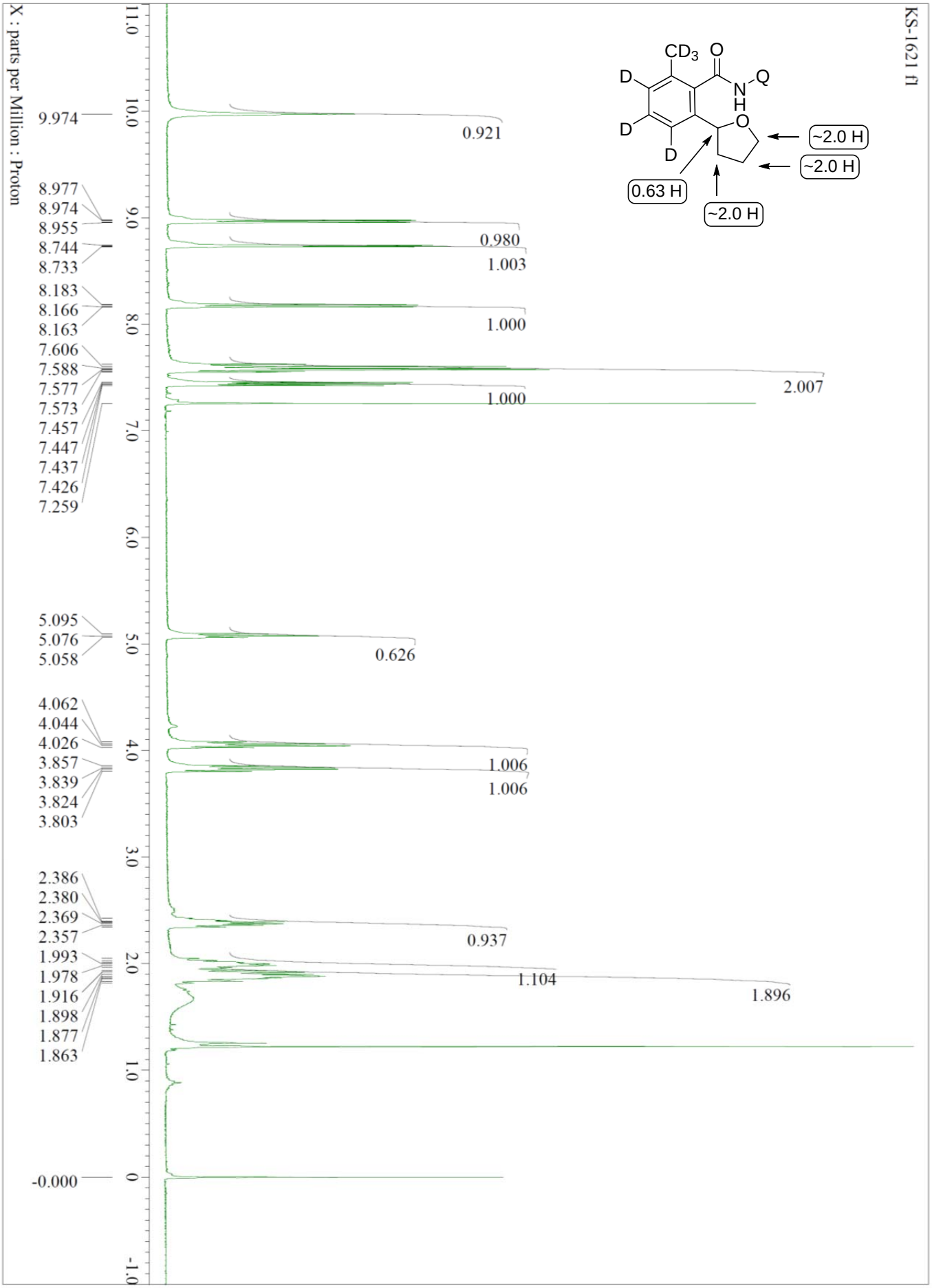


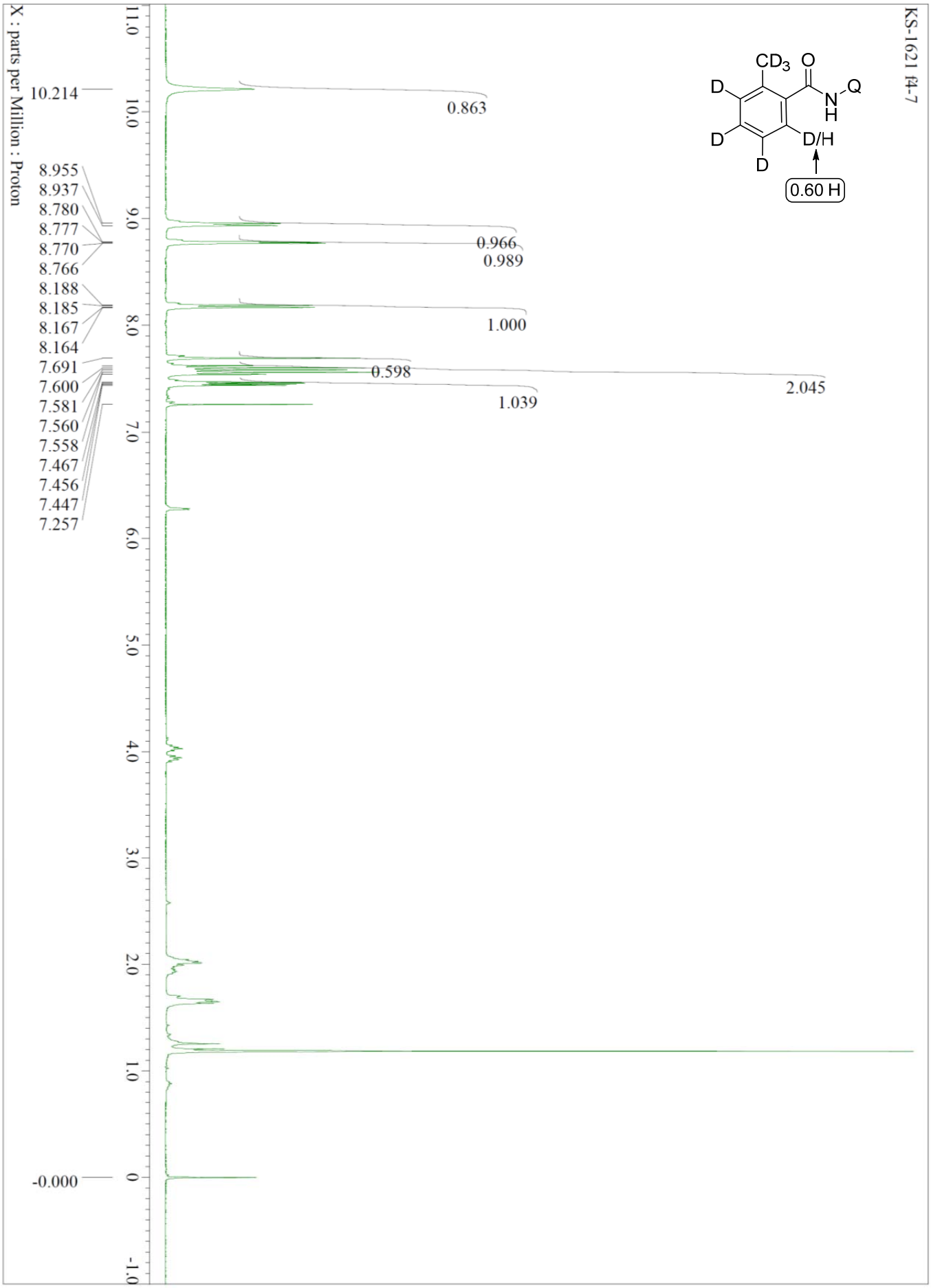

KS-1620 f1
X : parts per Million : Proton
9.971
8.959
8.746
8.742
8.736
8.732
8.188
8.171
8.167
7.608
7.590
7.580
7.576
7.462
7.451
7.441
7.431
7.261
5.093
5.075
5.057
4.063
4.045
4.028
3.858
3.840
3.825
3.804
2.386
2.370
2.357
2.340
1.979
1.919
1.900
1.889
1.879
1.853
0.000
0.907
0.987
0.992
1.000
2.025
1.019
0.655
0.983
1.178
1.041
1.074
2.162
CD3
O
D
D
D
N
H
Q
O
~2.0 H
~2.0 H
0.66 H
~2.0 H


KS-1620 f2
X : parts per Million : Proton
10.212
8.954
8.936
8.771
8.761
8.174
8.154
7.689
7.613
7.593
7.574
7.550
7.529
7.456
7.446
7.435
7.425
2.569
-0.001
0.890
0.958
0.982
1.000
0.498
2.040
1.033
24.693m
CD3
O
D
N
Q
H
D
D/H
D
0.50 H

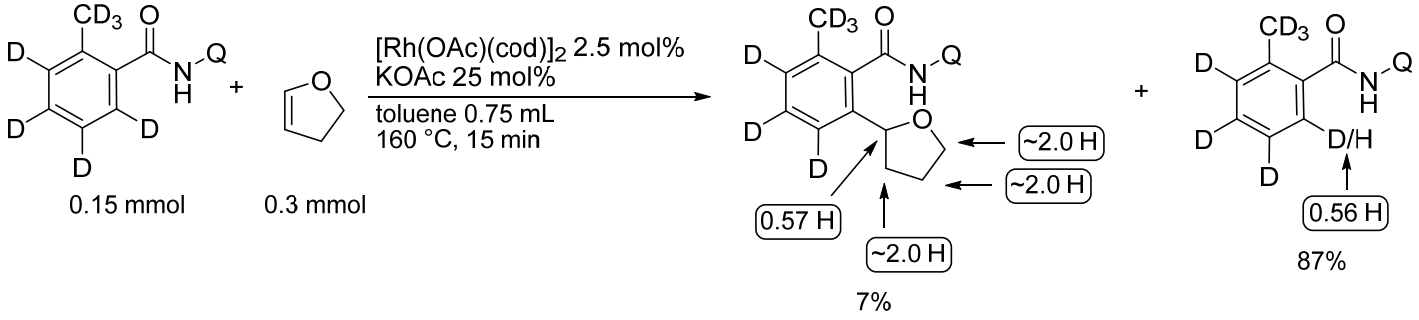
(B) Estimation of deuterium and hydrogen incorporation. (15 min, Method B, Scheme 3)

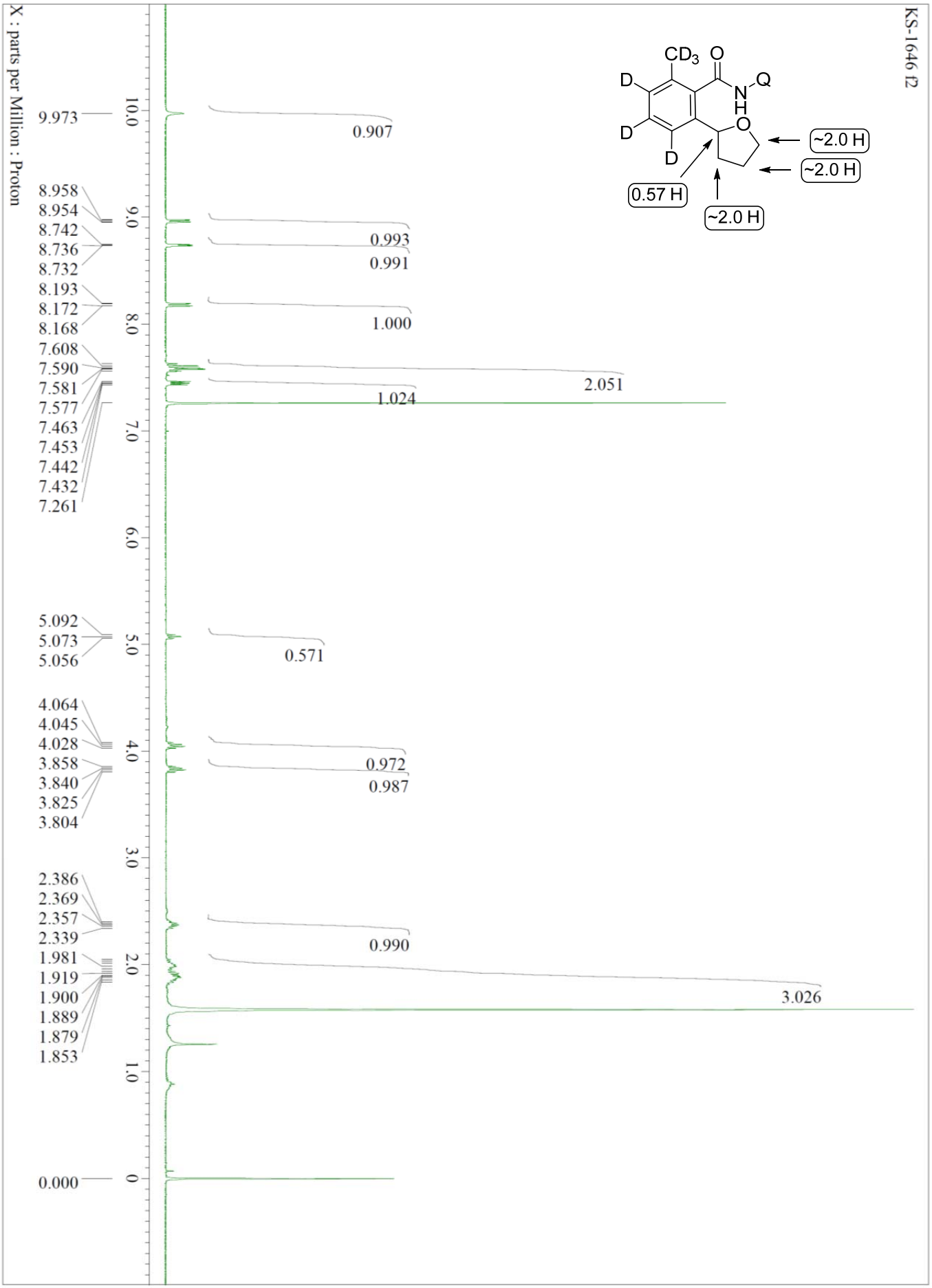


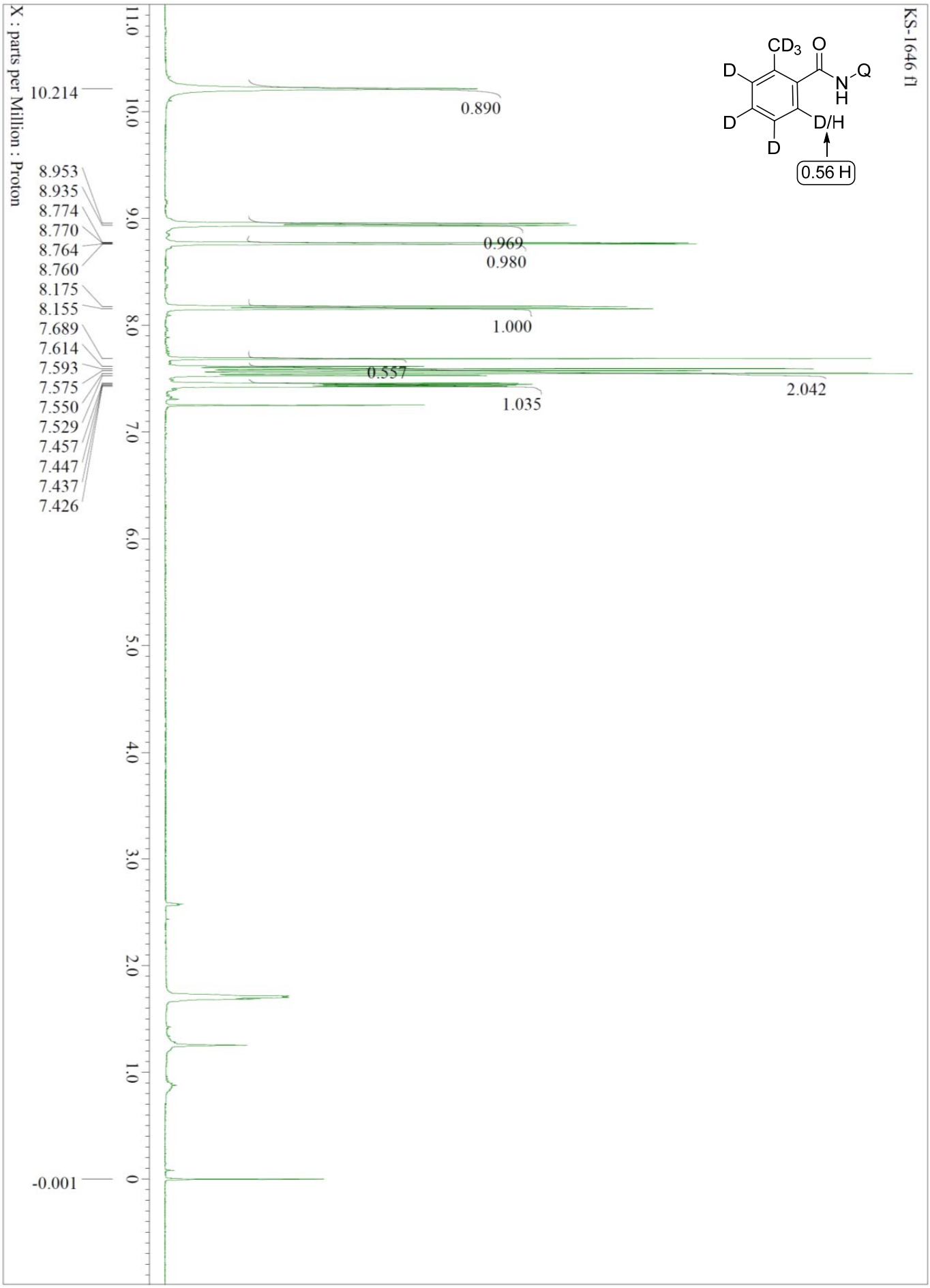

KS-1621 f1
X : parts per Million : Proton
9.974
8.977
8.974
8.955
8.744
8.733
8.183
8.166
8.163
7.606
7.588
7.577
7.573
7.457
7.447
7.437
7.426
7.259
5.095
5.076
5.058
4.062
4.044
4.026
3.857
3.839
3.824
3.803
2.386
2.380
2.369
2.357
1.993
1.978
1.916
1.898
1.877
1.863
-0.000
0.921
0.980
1.003
1.000
2.007
1.000
0.626
1.006
1.006
0.937
1.104
1.896
CD3
O
D
N
Q
H
D
O
D
~2.0 H
~2.0 H
0.63 H
~2.0 H


KS-1621 f4-7
X : parts per Million : Proton
10.214
8.955
8.937
8.780
8.777
8.770
8.766
8.188
8.185
8.167
8.164
7.691
7.600
7.581
7.560
7.558
7.467
7.456
7.447
7.257
-0.000
0.863
0.966
0.989
1.000
0.598
2.045
1.039
CD3
O
D
N
Q
H
D
D/H
D
0.60 H

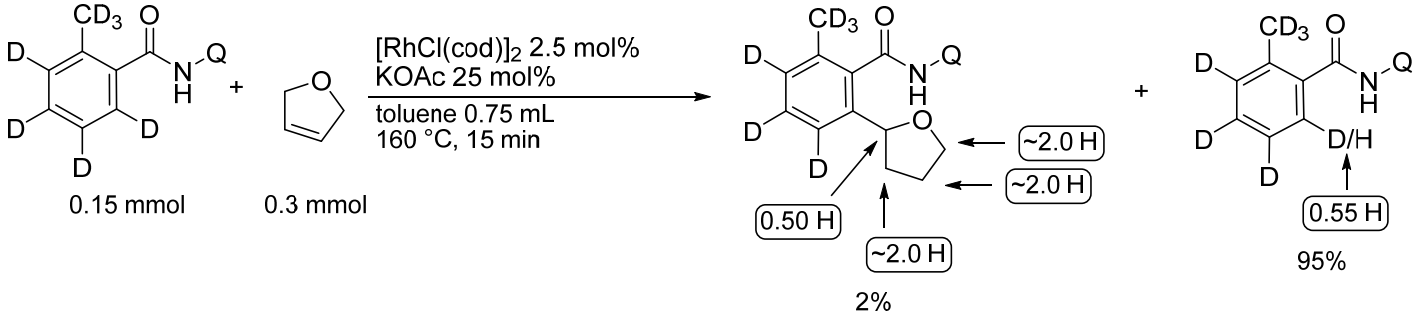
(C) Estimation of deuterium and hydrogen incorporation. (15 min, Scheme 3)

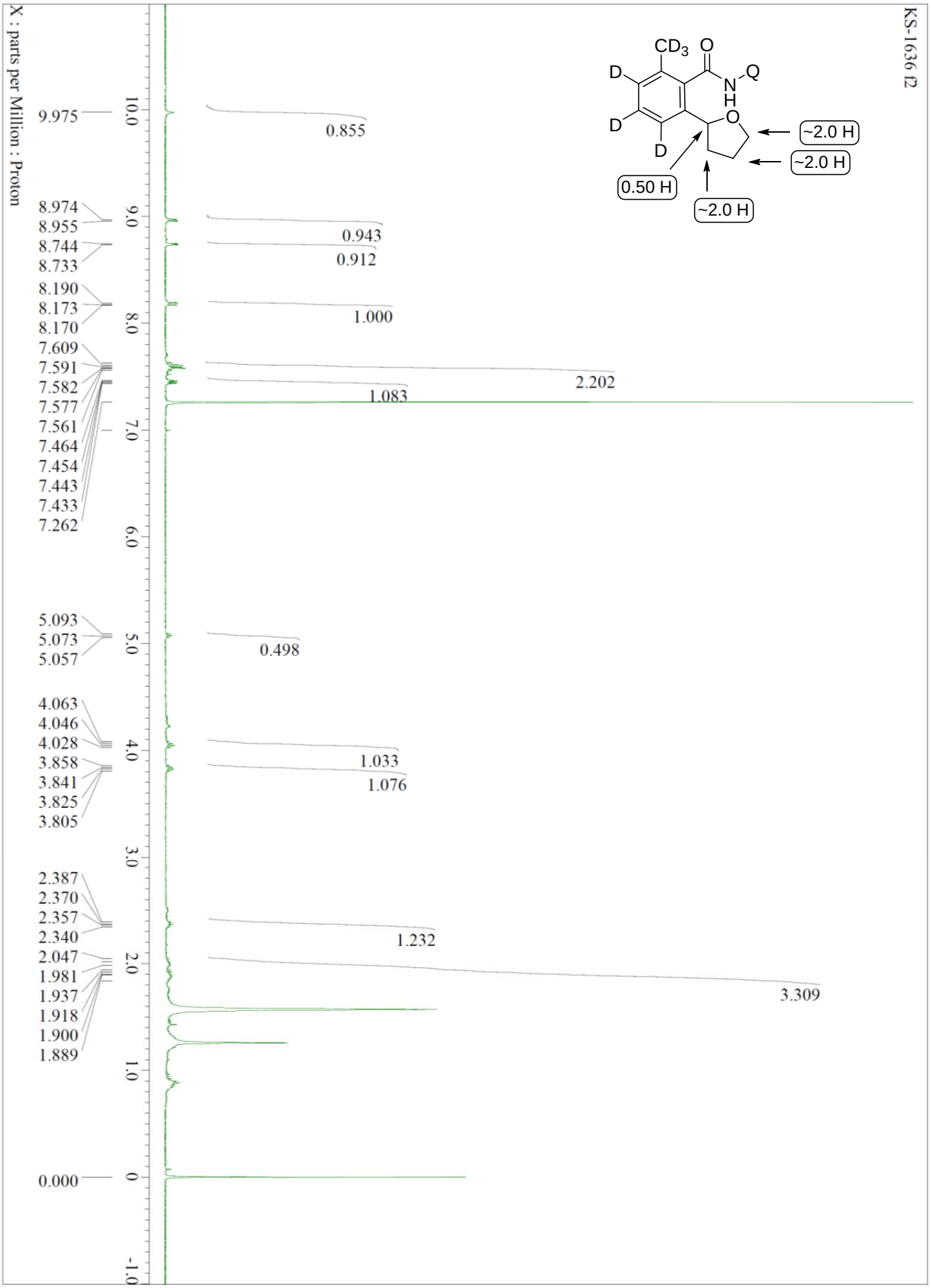


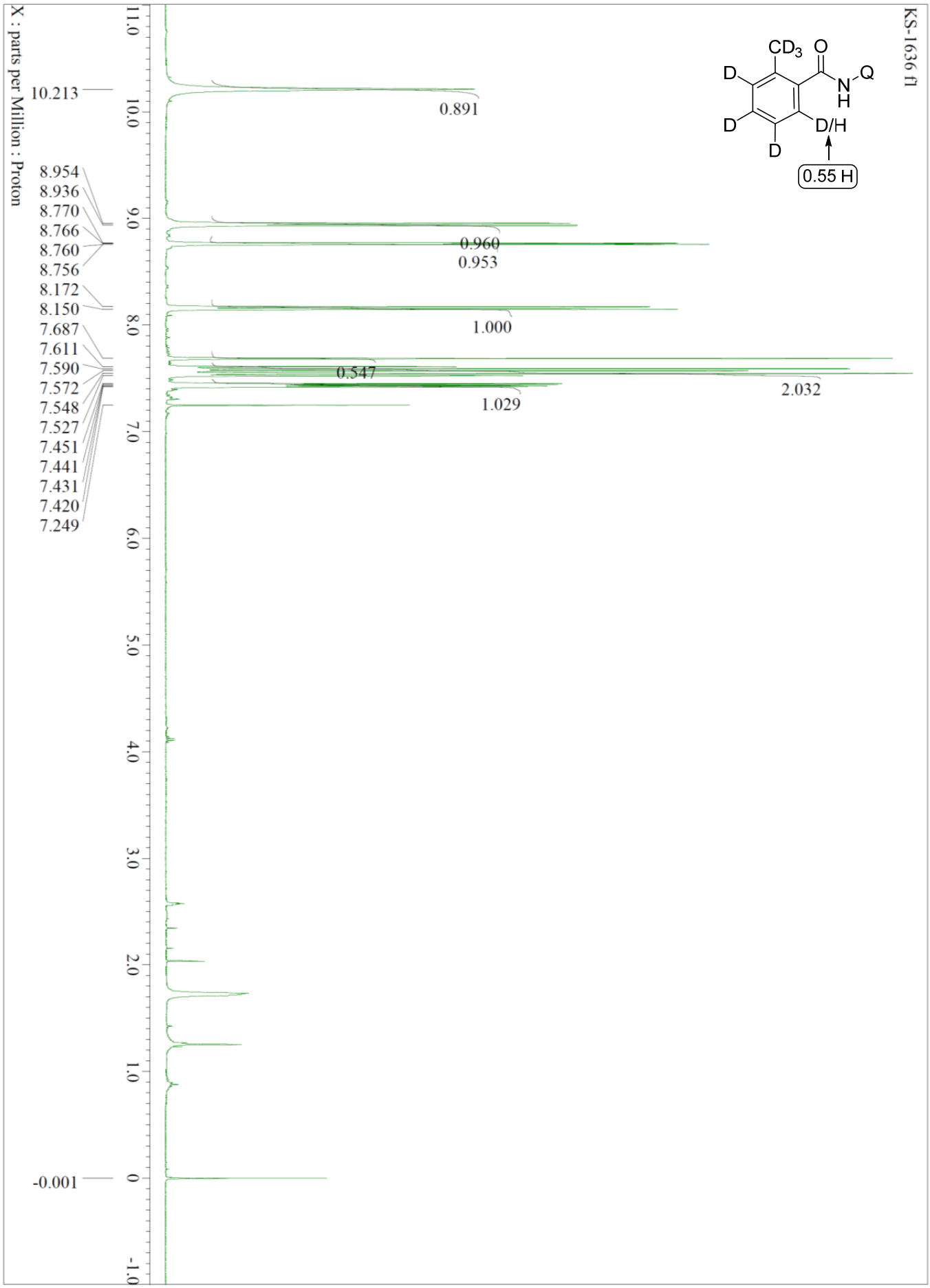

KS-1646 f2
X : parts per Million : Proton
9.973
8.958
8.954
8.742
8.736
8.732
8.193
8.172
8.168
7.608
7.590
7.581
7.577
7.463
7.453
7.442
7.432
7.261
5.092
5.073
5.056
4.064
4.045
4.028
3.858
3.840
3.825
3.804
2.386
2.369
2.357
2.339
1.981
1.919
1.900
1.889
1.879
1.853
0.000
0.907
0.993
0.991
1.000
2.051
1.024
0.571
0.972
0.987
0.990
3.026
CD3
O
D
N
Q
H
O
D
D
~2.0 H
~2.0 H
0.57 H
~2.0 H


KS-1646 f1
X : parts per Million : Proton
10.214
8.953
8.935
8.774
8.770
8.764
8.760
8.175
8.155
7.689
7.614
7.593
7.575
7.550
7.529
7.457
7.447
7.437
7.426
-0.001
0.890
0.969
0.980
1.000
0.557
2.042
1.035
CD3
O
D
N
Q
H
D
D/H
D
0.56 H

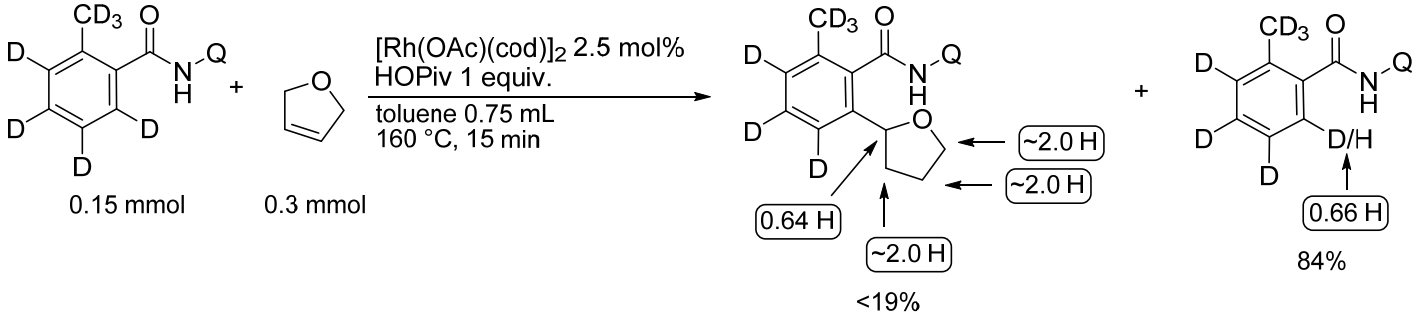
(D) Estimation of deuterium and hydrogen incorporation. (2,5-dihydrofuran, 15 min, Method A)

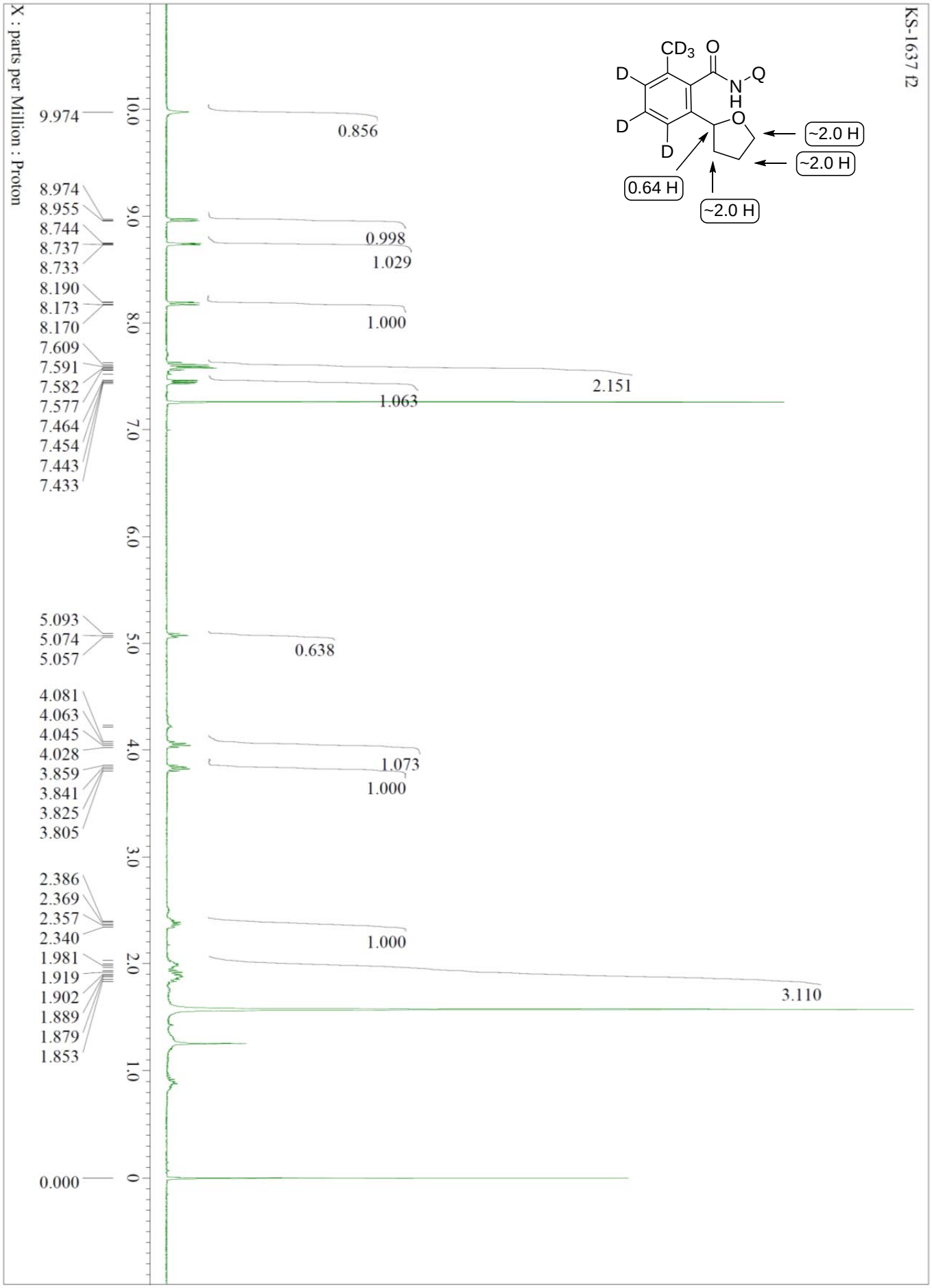


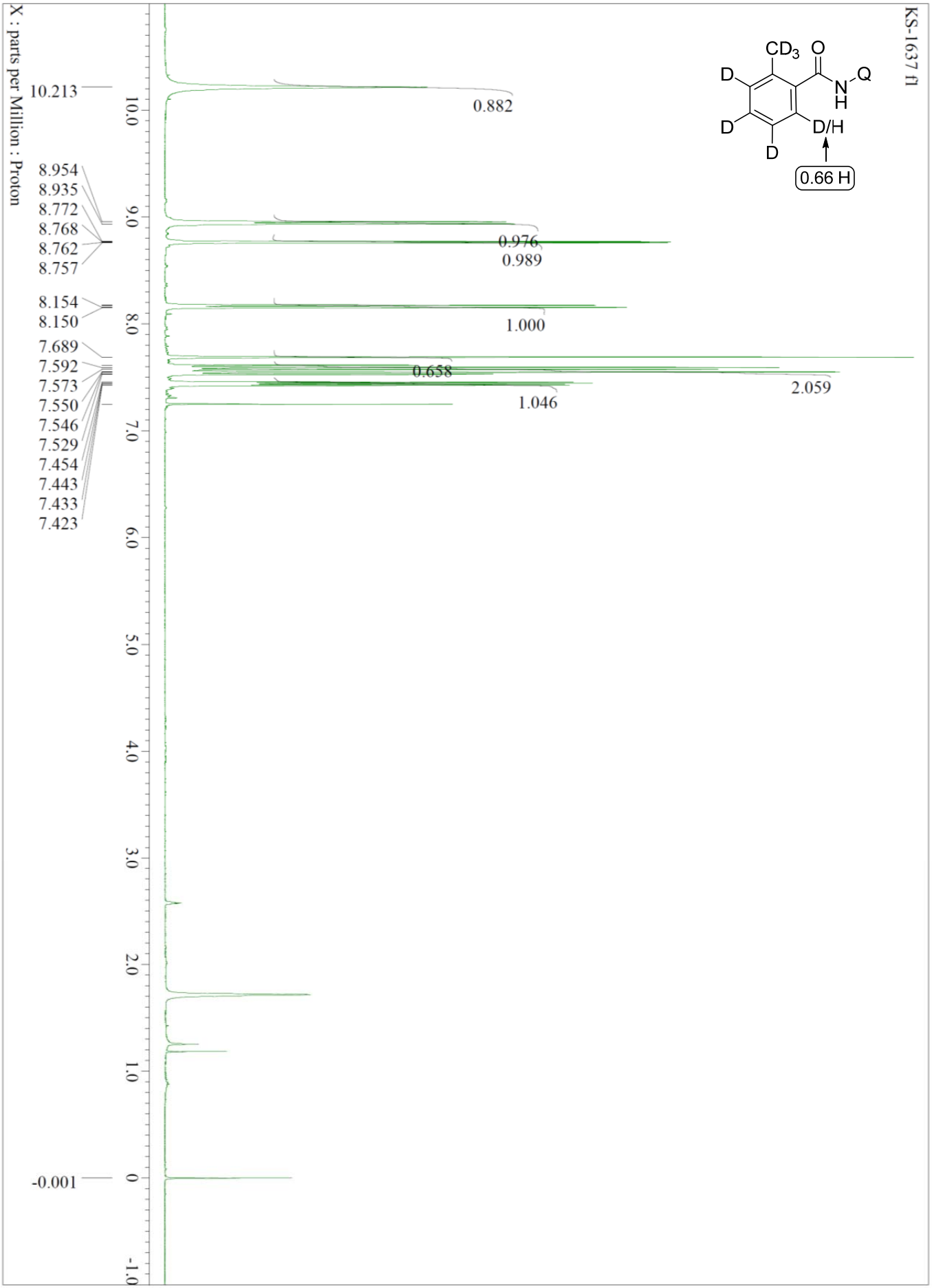

KS-1636 f2
X : parts per Million : Proton
9.975
8.974
8.955
8.744
8.733
8.190
8.173
8.170
7.609
7.591
7.582
7.577
7.561
7.464
7.454
7.443
7.433
7.262
5.093
5.073
5.057
4.063
4.046
4.028
3.858
3.841
3.825
3.805
2.387
2.370
2.357
2.340
2.047
1.981
1.937
1.918
1.900
1.889
0.000
0.855
0.943
0.912
1.000
2.202
1.083
0.498
1.033
1.076
1.232
3.309
CD3
O
D
N
Q
H
O
D
D
~2.0 H
~2.0 H
0.50 H
~2.0 H


KS-1636 fl
X : parts per Million : Proton
10.213
8.954
8.936
8.770
8.766
8.760
8.756
8.172
8.150
7.687
7.611
7.590
7.572
7.548
7.527
7.451
7.441
7.431
7.420
7.249
-0.001
0.891
0.960
0.953
1.000
0.547
2.032
1.029
CD3
O
N
H
Q
D
D
D
D/H
0.55 H

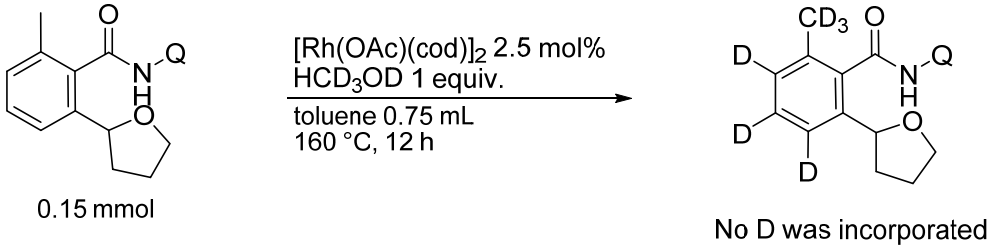
(E) Estimation of deuterium and hydrogen incorporation. (2,5-dihydrofuran, 15 min, Method B)




KS-1637 f2
X : parts per Million : Proton
9.974
8.974
8.955
8.744
8.737
8.733
8.190
8.173
8.170
7.609
7.591
7.582
7.577
7.464
7.454
7.443
7.433
5.093
5.074
5.057
4.081
4.063
4.045
4.028
3.859
3.841
3.825
3.805
2.386
2.369
2.357
2.340
1.981
1.919
1.902
1.889
1.879
1.853
0.000
0.856
0.998
1.029
1.000
2.151
1.063
0.638
1.073
1.000
1.000
3.110
CD3
O
D
N
Q
H
O
D
D
~2.0 H
~2.0 H
0.64 H
~2.0 H

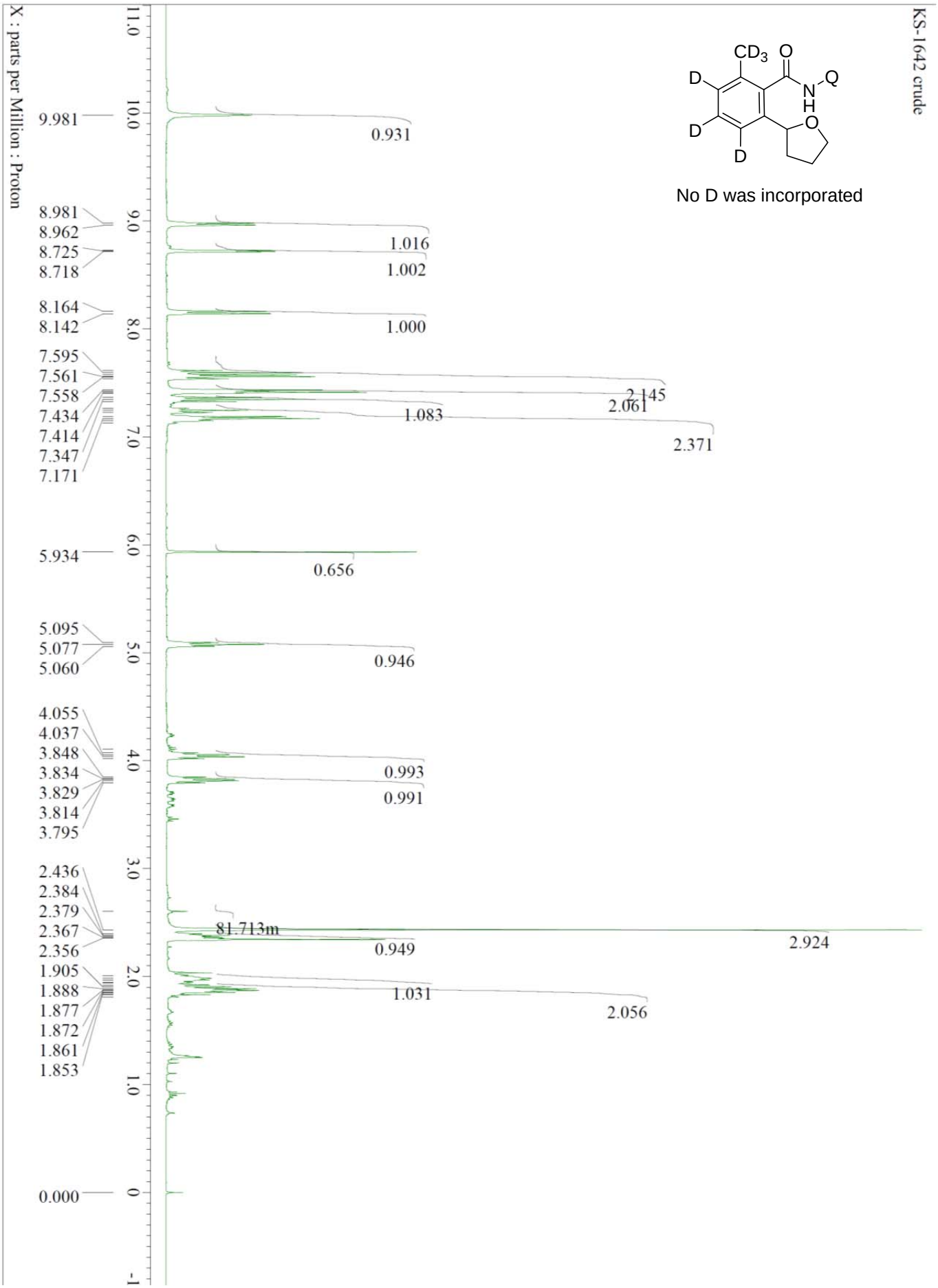

KS-1637 f1
X : parts per Million : Proton
10.213
8.954
8.935
8.772
8.768
8.762
8.757
8.154
8.150
7.689
7.592
7.573
7.550
7.546
7.529
7.454
7.443
7.433
7.423
-0.001
0.882
0.976
0.989
1.000
0.658
2.059
1.046
CD3
O
D
Q
N
H
D
D/H
D
0.66 H

(F) Estimation of H/D Exchange in the Product 6aa. (with Catalyst)

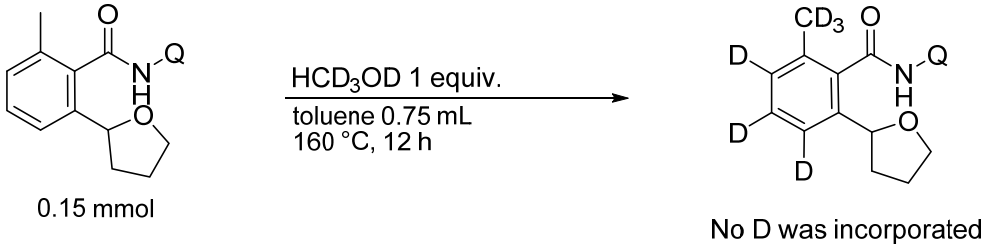


0.15 mmol

No D was incorporated

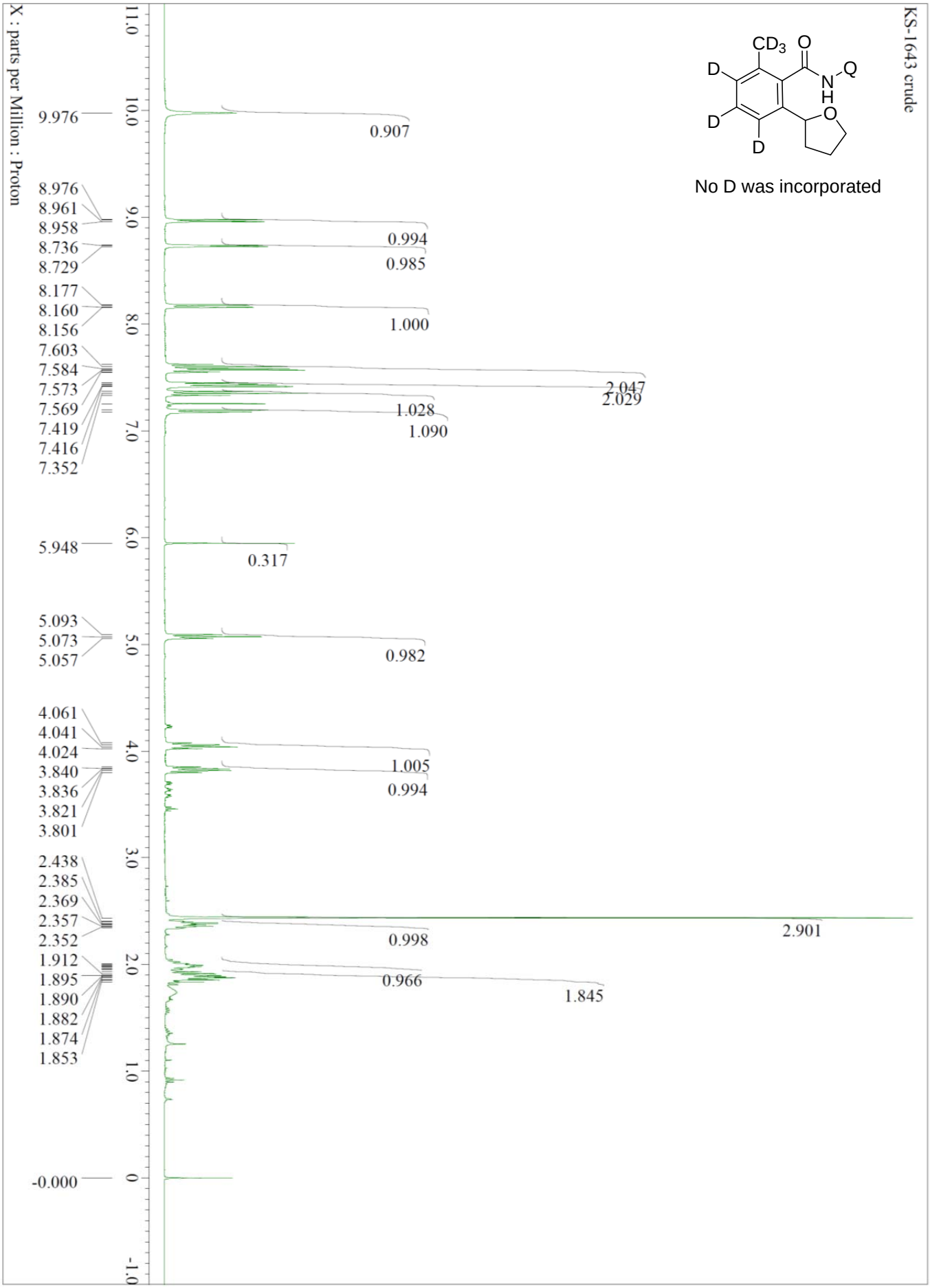

KS-1642 crude
X : parts per Million : Proton
CD3
O
D
N
Q
H
O
D
D
No D was incorporated
9.981
8.981
8.962
8.725
8.718
8.164
8.142
7.595
7.561
7.558
7.434
7.414
7.347
7.171
5.934
5.095
5.077
5.060
4.055
4.037
3.848
3.834
3.829
3.814
3.795
2.436
2.384
2.379
2.367
2.356
1.905
1.888
1.877
1.872
1.861
1.853
0.000
0.931
1.016
1.002
1.000
2.145
2.061
1.083
2.371
0.656
0.946
0.993
0.991
81.713m
0.949
2.924
1.031
2.056

(G) Estimation of H/D Exchange in the Product 6aa. (with Catalyst)

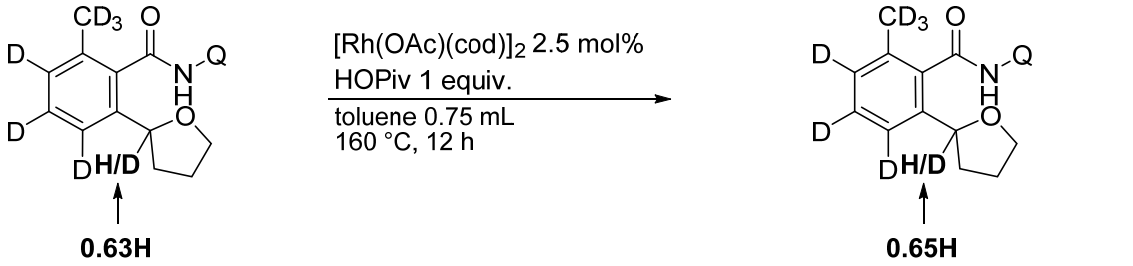


0.15 mmol

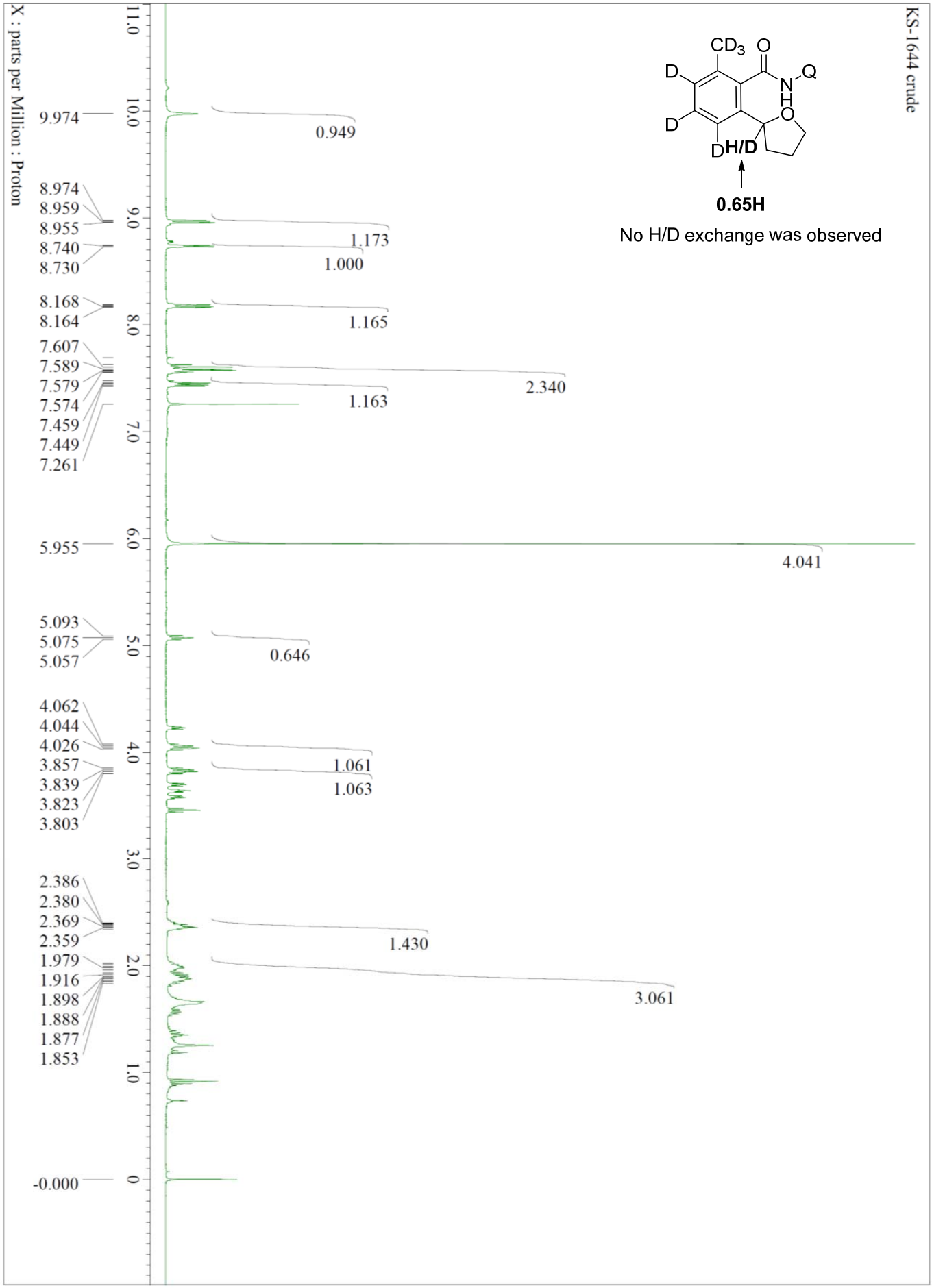
No D was incorporated


KS-1643 crude
X : parts per Million : Proton
CD3
O
D
N
Q
H
O
D
D
No D was incorporated
9.976
8.976
8.961
8.958
8.736
8.729
8.177
8.160
8.156
7.603
7.584
7.573
7.569
7.419
7.416
7.352
5.948
5.093
5.073
5.057
4.061
4.041
4.024
3.840
3.836
3.821
3.801
2.438
2.385
2.369
2.357
2.352
1.912
1.895
1.890
1.882
1.874
1.853
-0.000
0.907
0.994
0.985
1.000
2.047
2.029
1.028
1.090
0.317
0.982
1.005
0.994
0.998
2.901
0.966
1.845
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

(H) Estimation of H/D Exchange in the Product 6aa. (with Catalyst)



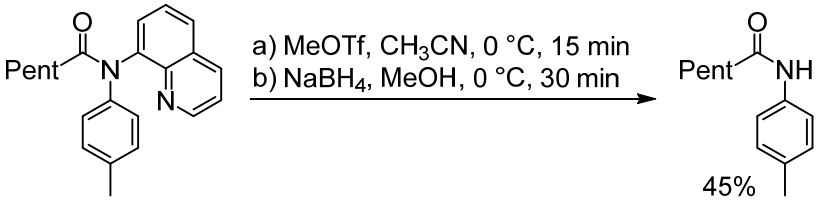
No H/D exchange was observed


KS-1644 crude
X : parts per Million : Proton
9.974
8.974
8.959
8.955
8.740
8.730
8.168
8.164
7.607
7.589
7.579
7.574
7.459
7.449
7.261
5.955
5.093
5.075
5.057
4.062
4.044
4.026
3.857
3.839
3.823
3.803
2.386
2.380
2.369
2.359
1.979
1.916
1.898
1.888
1.877
1.853
-0.000
0.949
1.173
1.000
1.165
2.340
1.163
4.041
0.646
1.061
1.063
1.430
3.061
CD3
O
D
Q
N
H
O
D
D
H/D
0.65H
No H/D exchange was observed

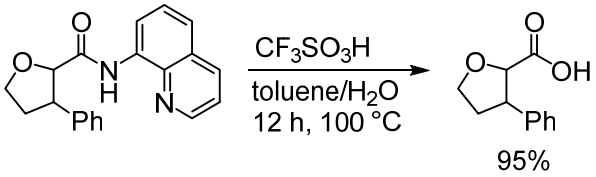
X. Cleavage of the 8-Aminoquinoline Directing Group

Figure S1. 8-Aminoquinoline directing group is easily removed by several methods, as shown below.

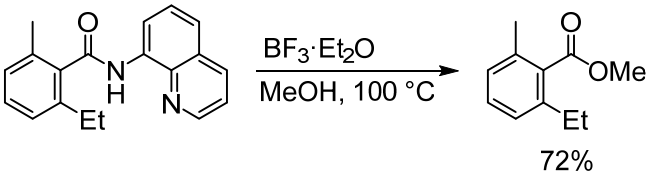
Kathiravan, S.; Ghosh, S.; Hogarth, G.; Nicholls, lan A. *Chem. Commun*. **2015**, *51*, 4834.



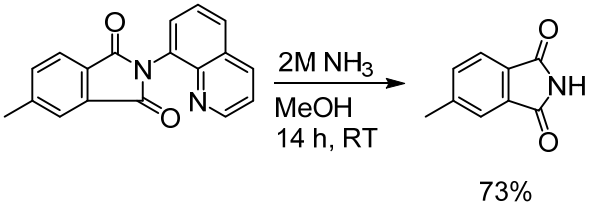
Parella, R.; Babu, S. A. *J. Org. Chem*. **2015**, *80*, 2339.



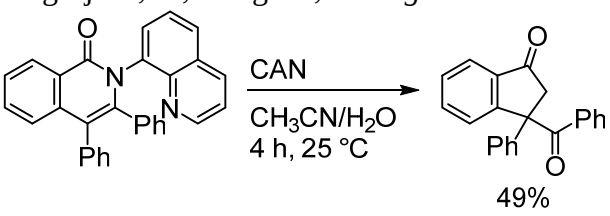
Zhang, S.-Y.; Li, Q.; He, G.; Nack, W. A.; Chen, G. *J. Am. Chem. Soc.* **2015**, *137*, 531.



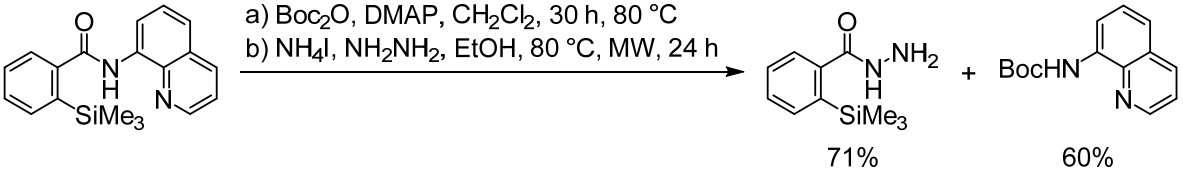
Grigorjeva, L.; Daugulis, O. *Org. Lett*. **2014**, *16*, 4688.



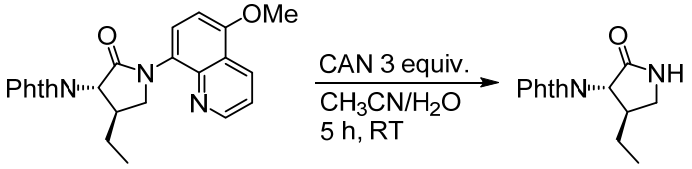
Grigorjeva, L.; Daugulis, O. *Angew. Chem. Int. Ed*. **2014**, *53*, 10209.



Kanyiva, K. S.; Kuninobu, Y.; Kanai, M. *Org. Lett*. **2014**, *16*, 1968.

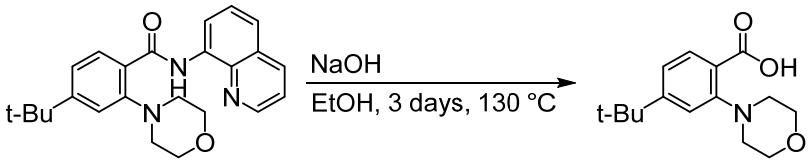


He, G.; Zhang, S-Y.; Nack, W. A.; Li, Q.; Chen, G. *Angew. Chem. Int. Ed*. **2013**, *52*, 11124.



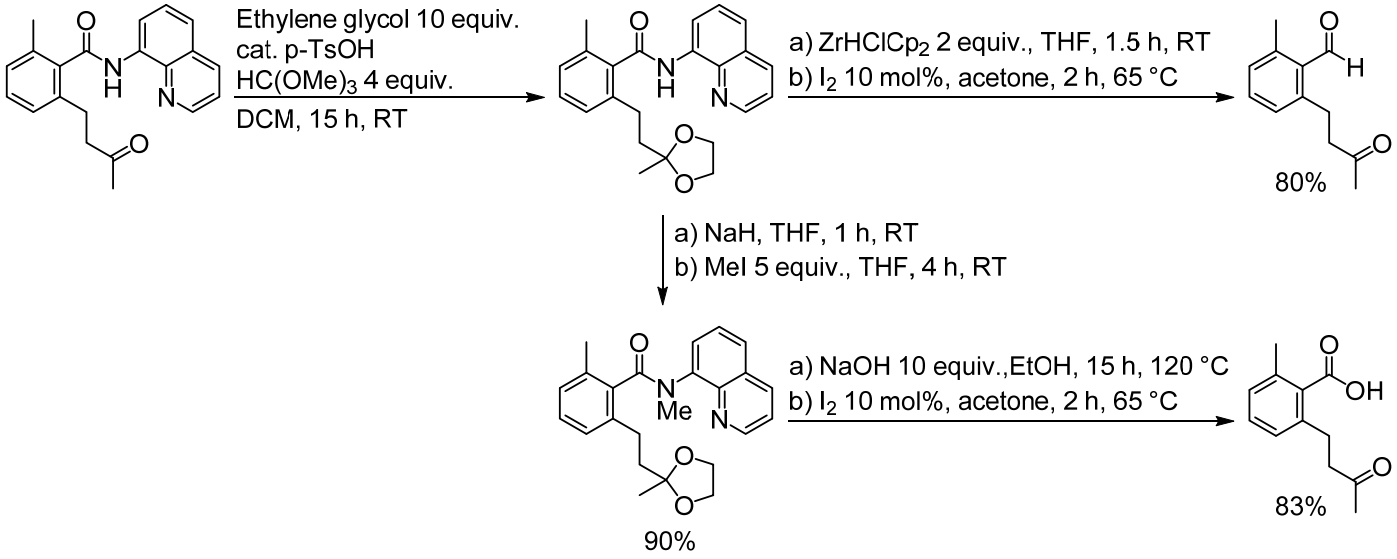
65%

Tran, L. D.; Roane, J.; Daugulis, O. *Angew. Chem. Int. Ed*. **2013**, *52*, 6043.

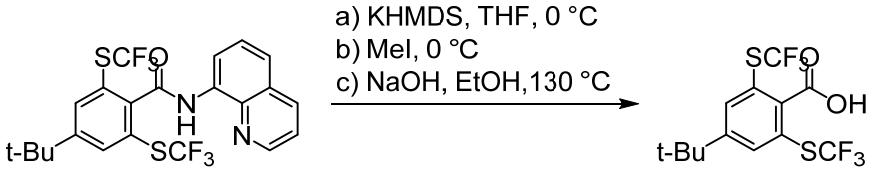


91%

Rouquet, G.; Chatani, N. *Chem. Sci*. **2013**, *4*, 2201.

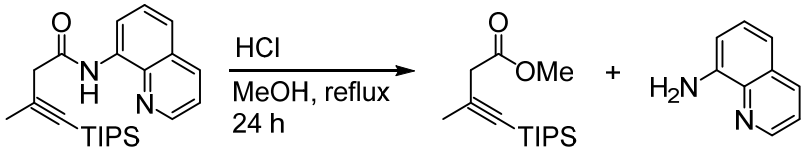


Tran, L. D.; Popov, I.; Daugulis, O. *J. Am. Chem. Soc*. **2012**, *134*, 18237.



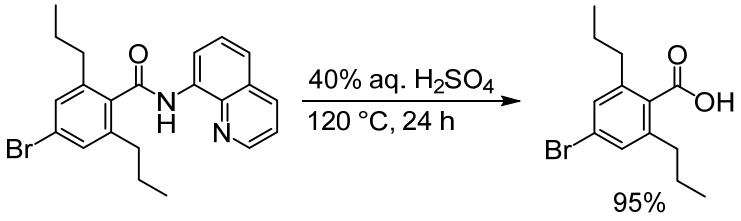
85% over 3 steps

Ano, Y.; Tobisu, M.; Chatani, N. *J. Am. Chem. Soc*. **2011**, *133*, 12984.

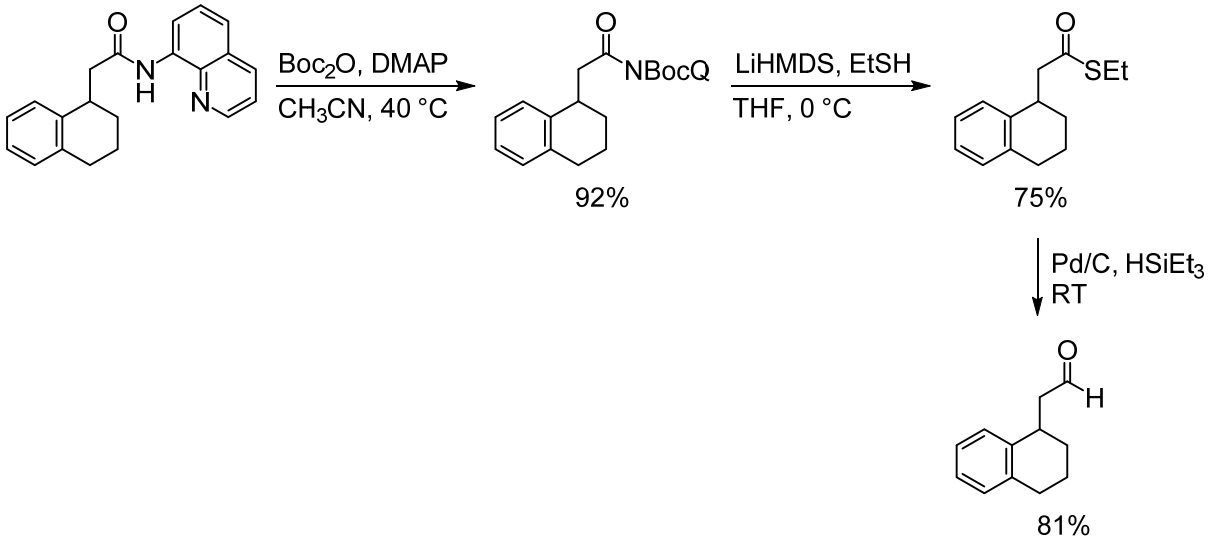


77% 83%

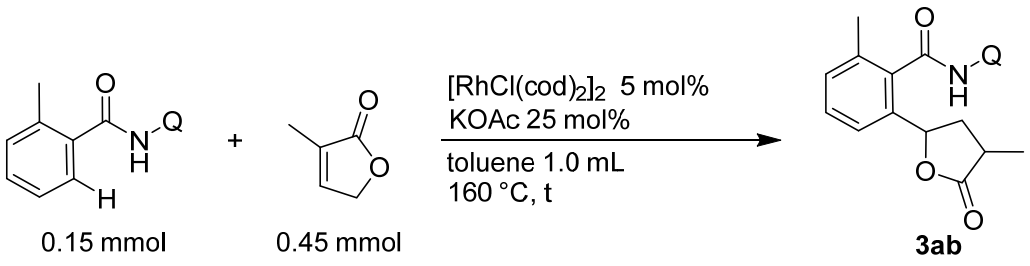
Shabashov, D. Daugulis, O. *J. Am. Chem. Soc*. **2010**, *132*, 3965.



Feng, Y.; Wang, Y.; Landgraf, B.; Liu, S.; Chen, G. *Org. Lett.* **2010**, *12*, 3414.



XI. The Ratio of Cis and Trans Isomers

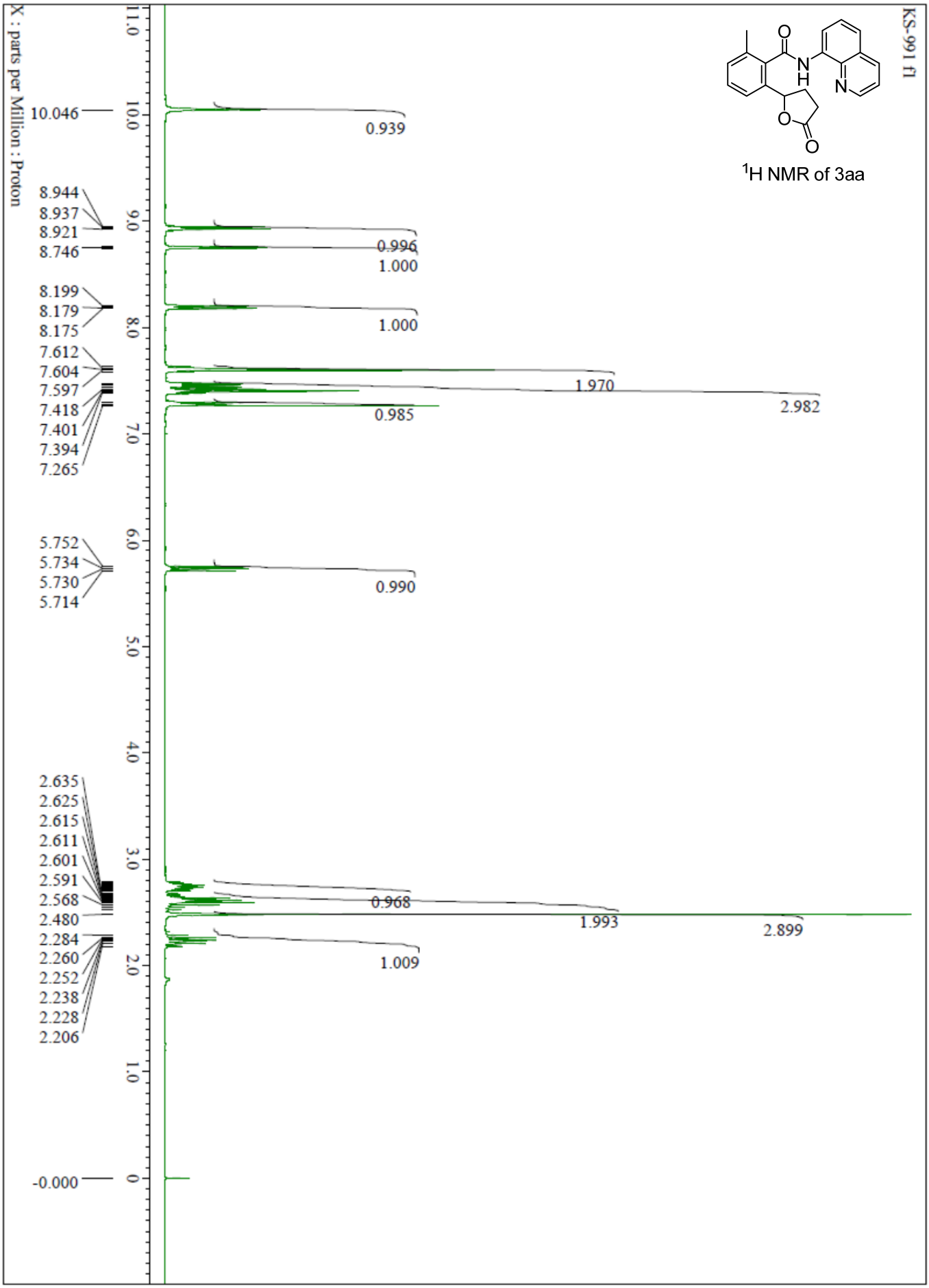


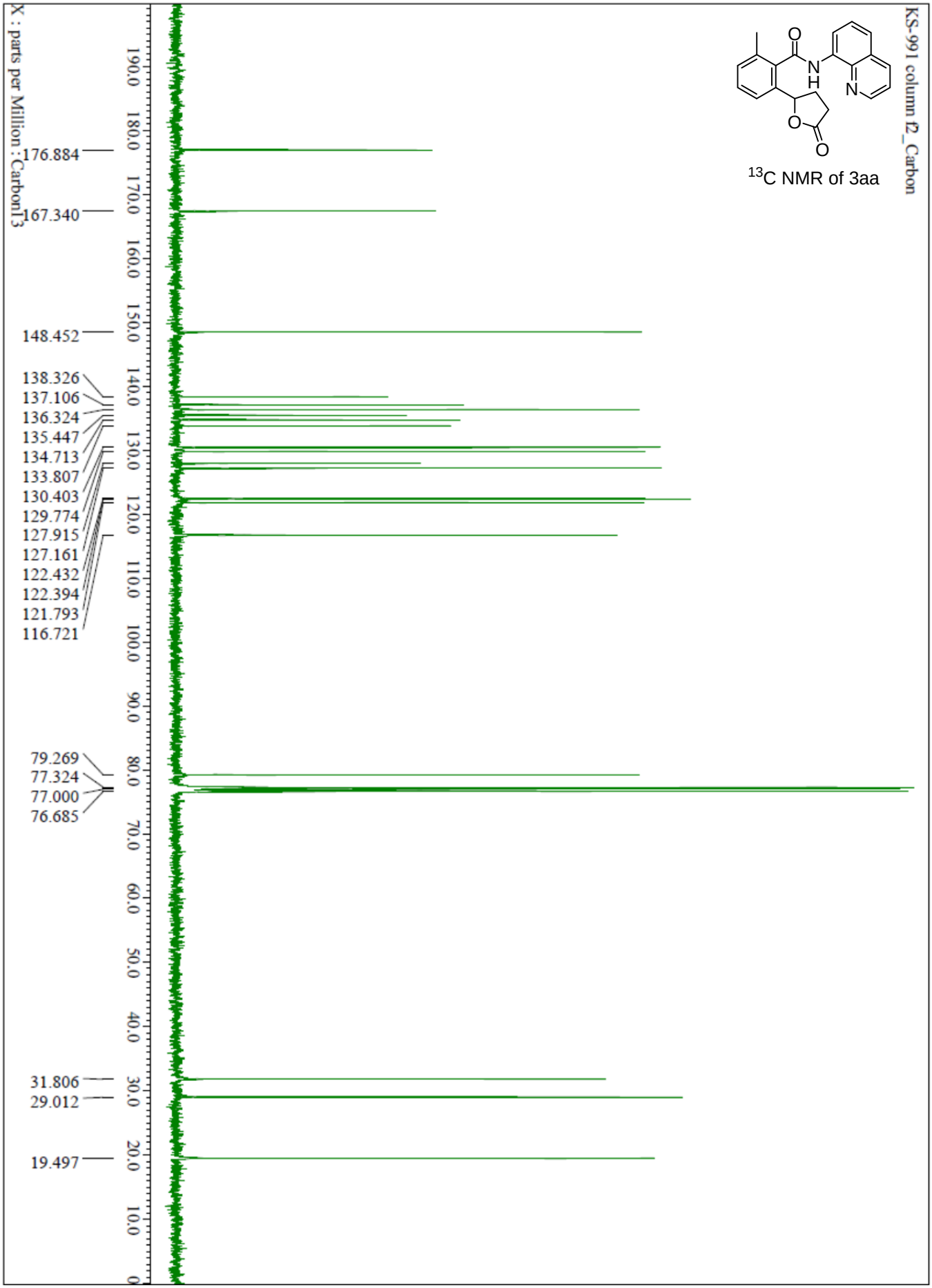
		NMR yield		
entry	t (h)	SM(amide)	**3ab**	dr
1	6	46%	26%	1:1.6
2	3	70%	10%	1:1.5
3	1	90%	3%	1:1.6

The ratio of cis and trans isomers was constant regardless of the reaction times.

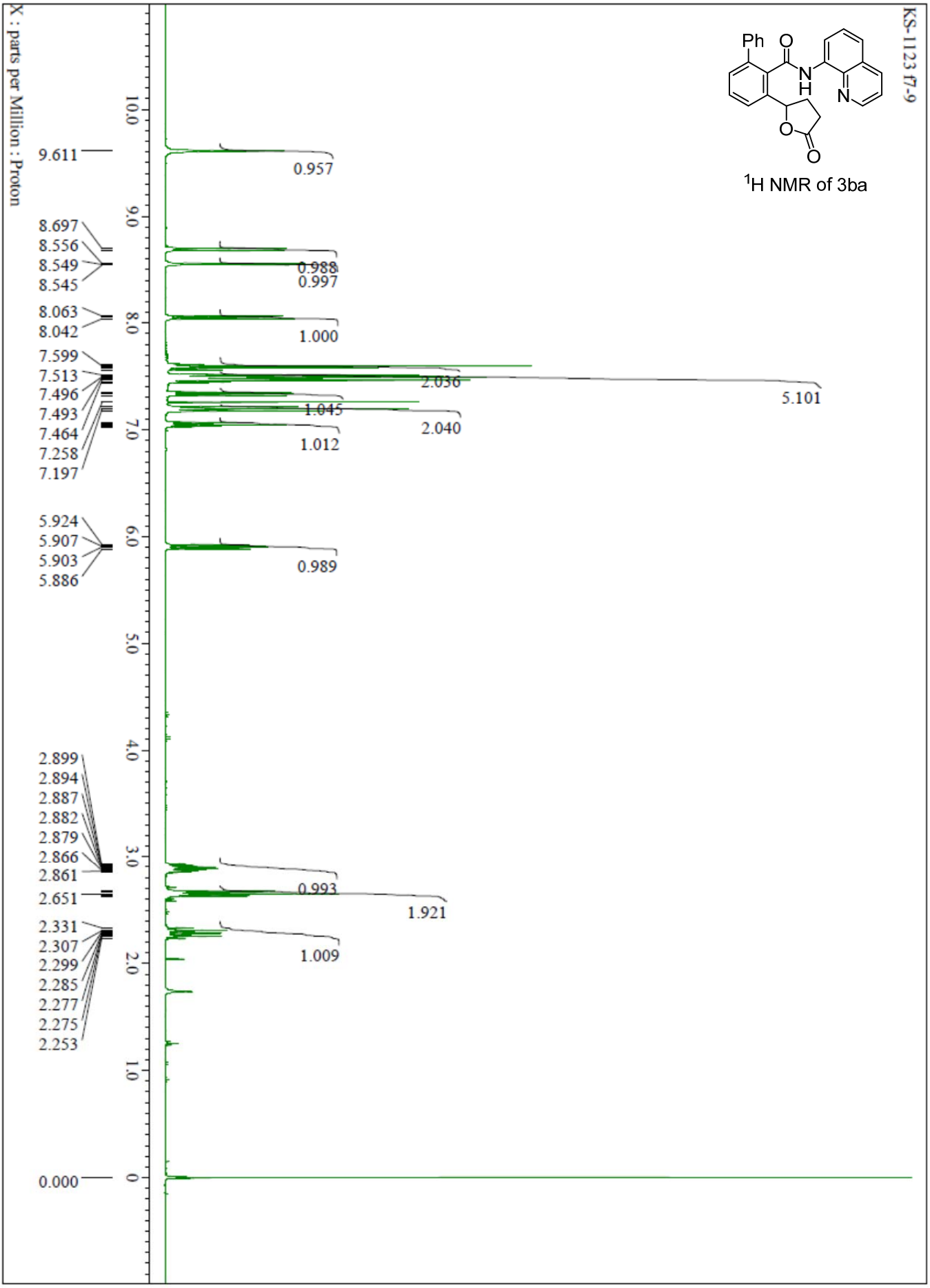
XII. Copies of ^{1}H and ^{13}C NMR Spectra

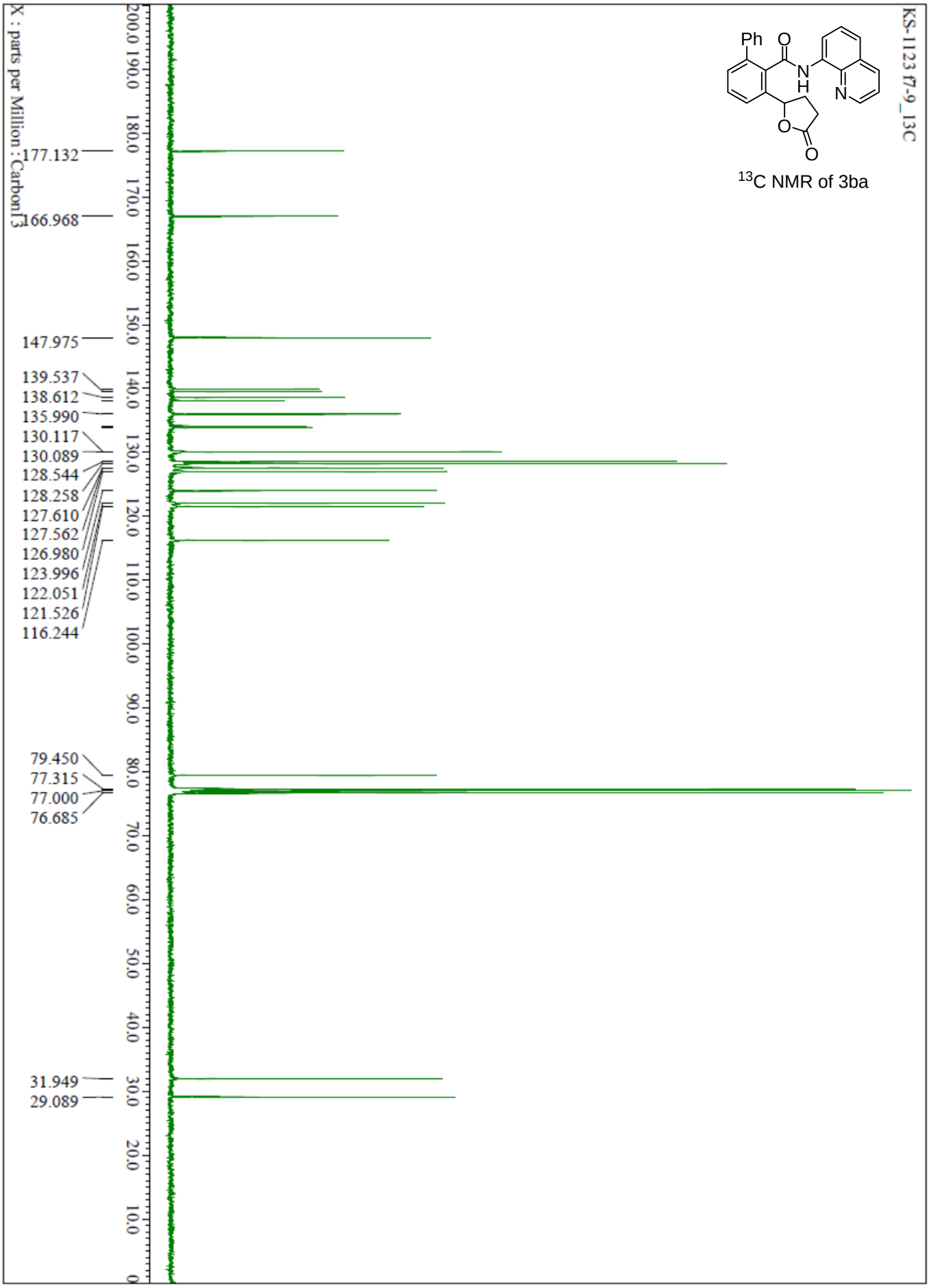
XII. Copies of ^{1}H and ^{13}C NMR Spectra



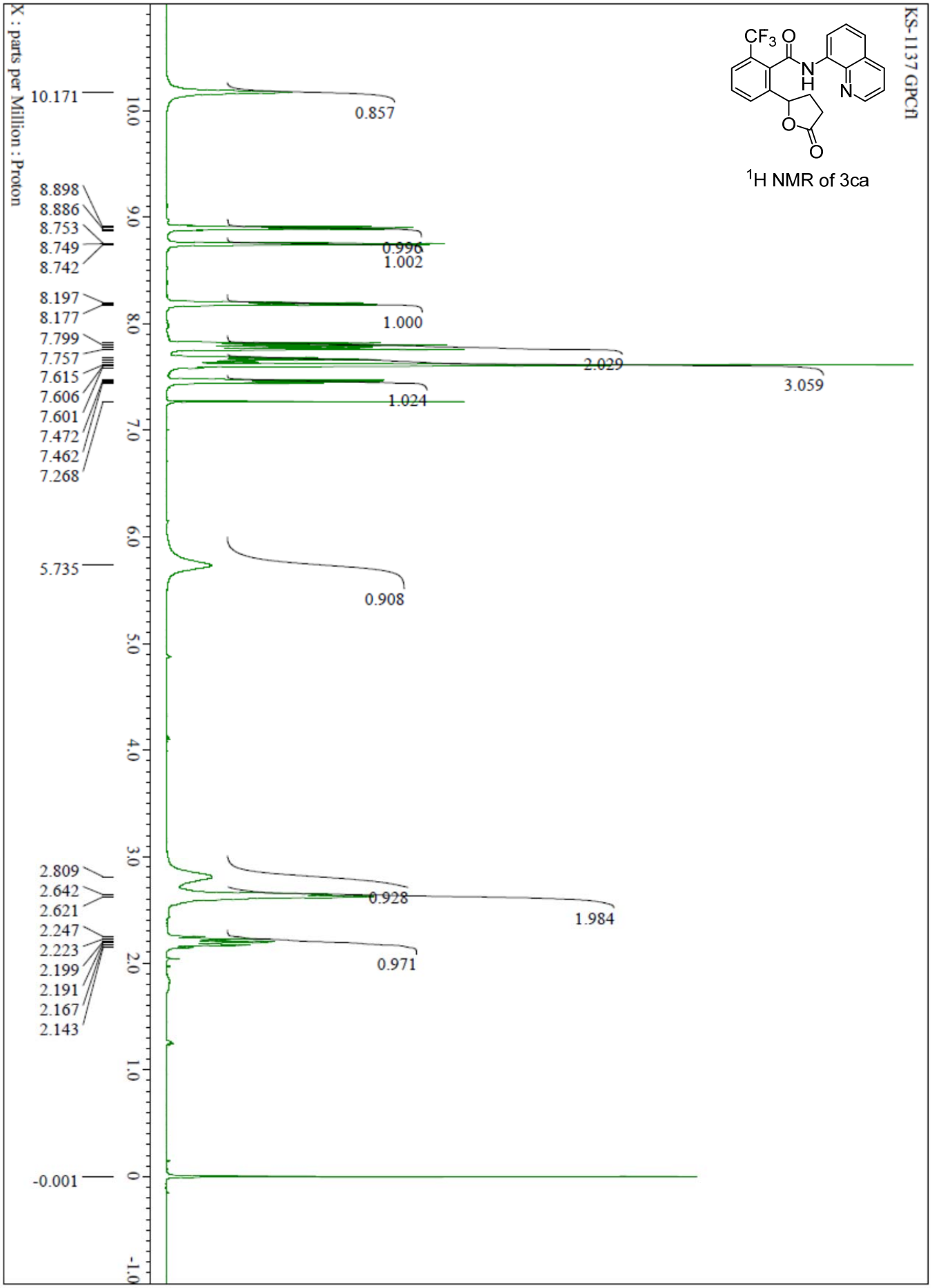


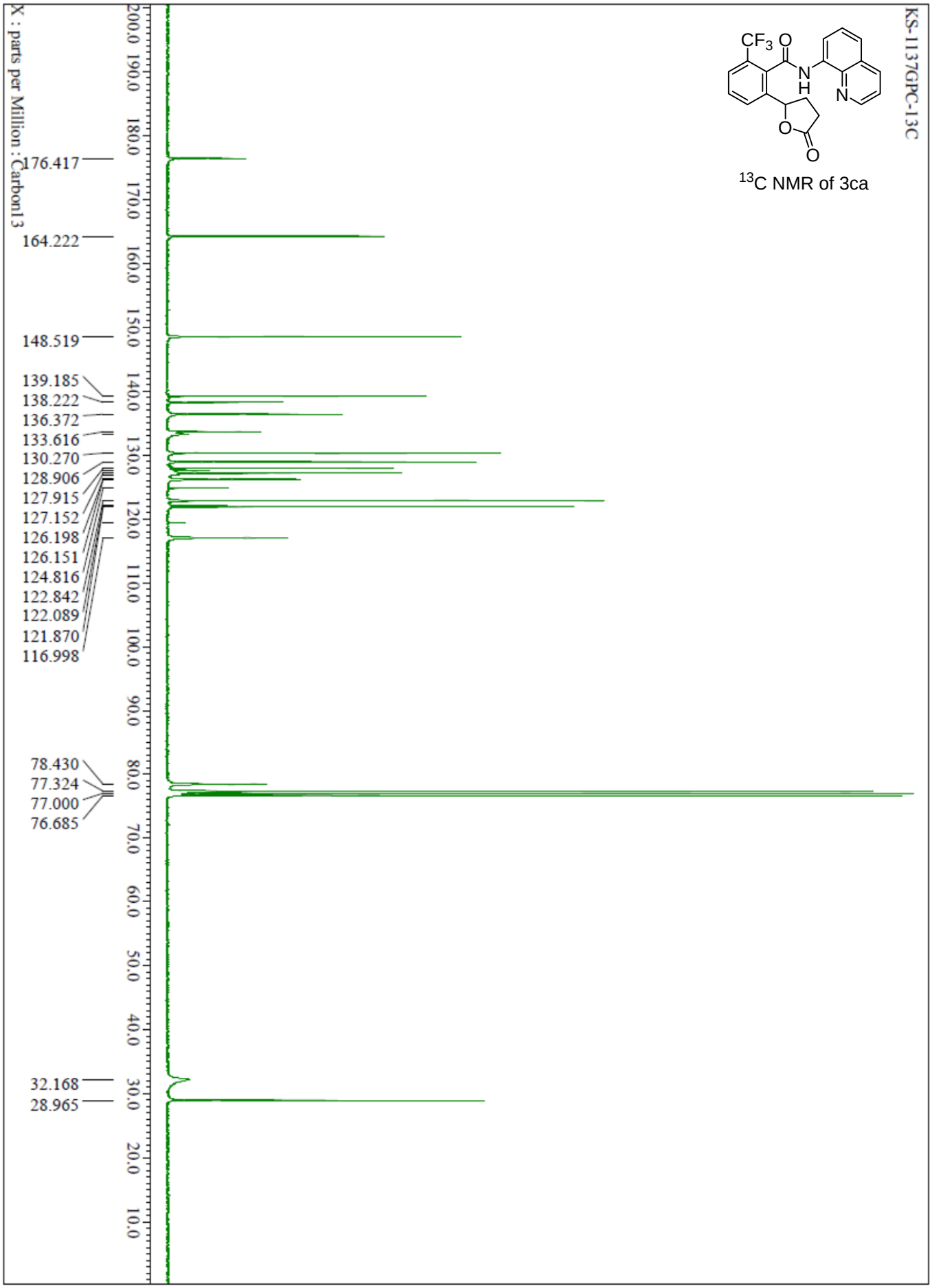
^{13}C NMR of 3aa


KS-1123 f7-9
X : parts per Million : Proton
Ph
O
N
H
N
O
O
1H NMR of 3ba
9.611
8.697
8.556
8.549
8.545
8.063
8.042
7.599
7.513
7.496
7.493
7.464
7.258
7.197
5.924
5.907
5.903
5.886
2.899
2.894
2.887
2.882
2.879
2.866
2.861
2.651
2.331
2.307
2.299
2.285
2.277
2.275
2.253
0.000
0.957
0.988
0.997
1.000
2.036
5.101
1.045
2.040
1.012
0.989
0.993
1.921
1.009
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0

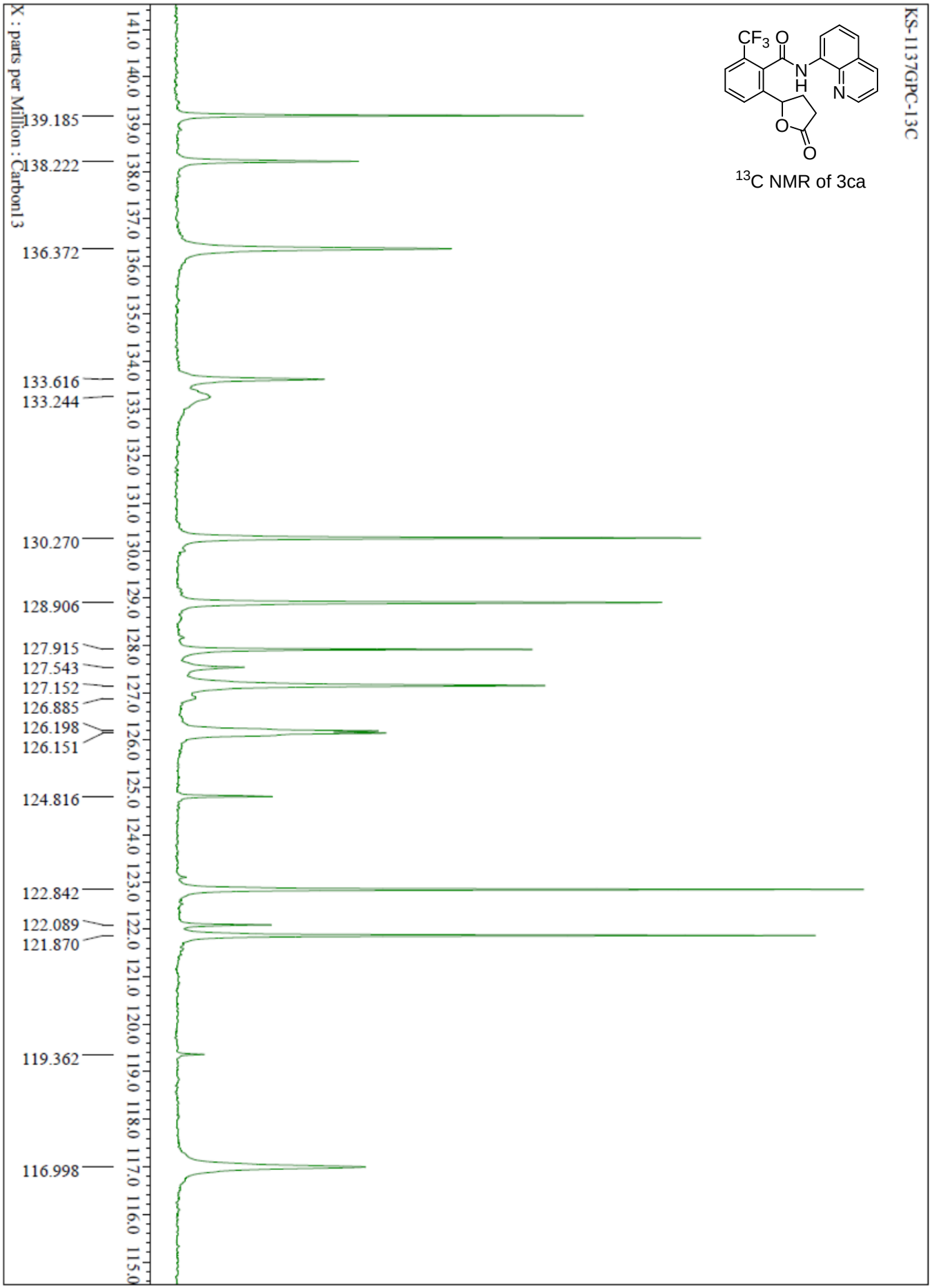


^{13}C NMR of 3ba

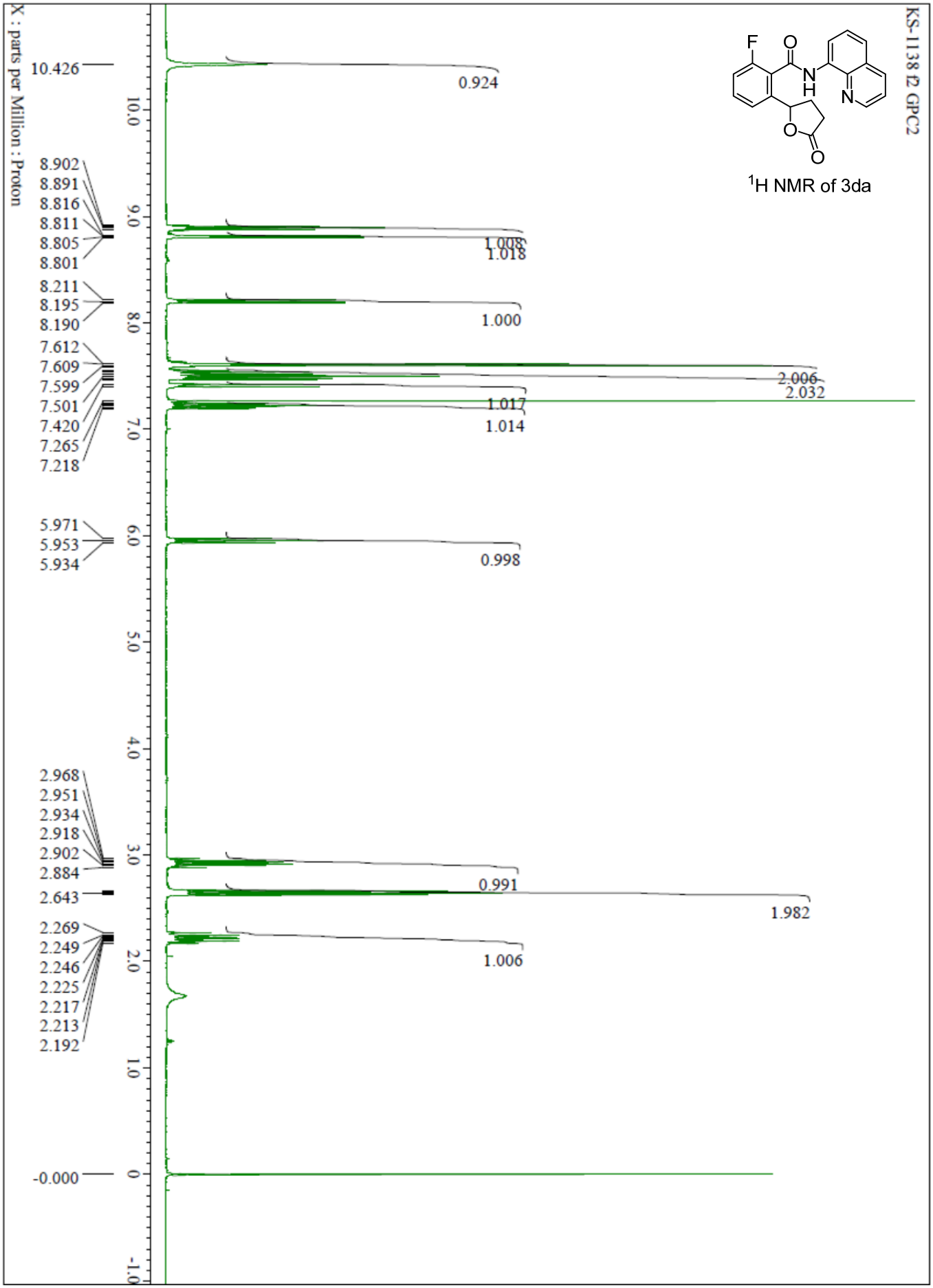

KS-1137 GPCfl
X : parts per Million : Proton
CF_3 O
N
H
N
O
O
^{1}H NMR of 3ca
10.171
8.898
8.886
8.753
8.749
8.742
8.197
8.177
7.799
7.757
7.615
7.606
7.601
7.472
7.462
7.268
5.735
2.809
2.642
2.621
2.247
2.223
2.199
2.191
2.167
2.143
-0.001
0.857
0.996
1.002
1.000
2.029
3.059
1.024
0.908
0.928
1.984
0.971



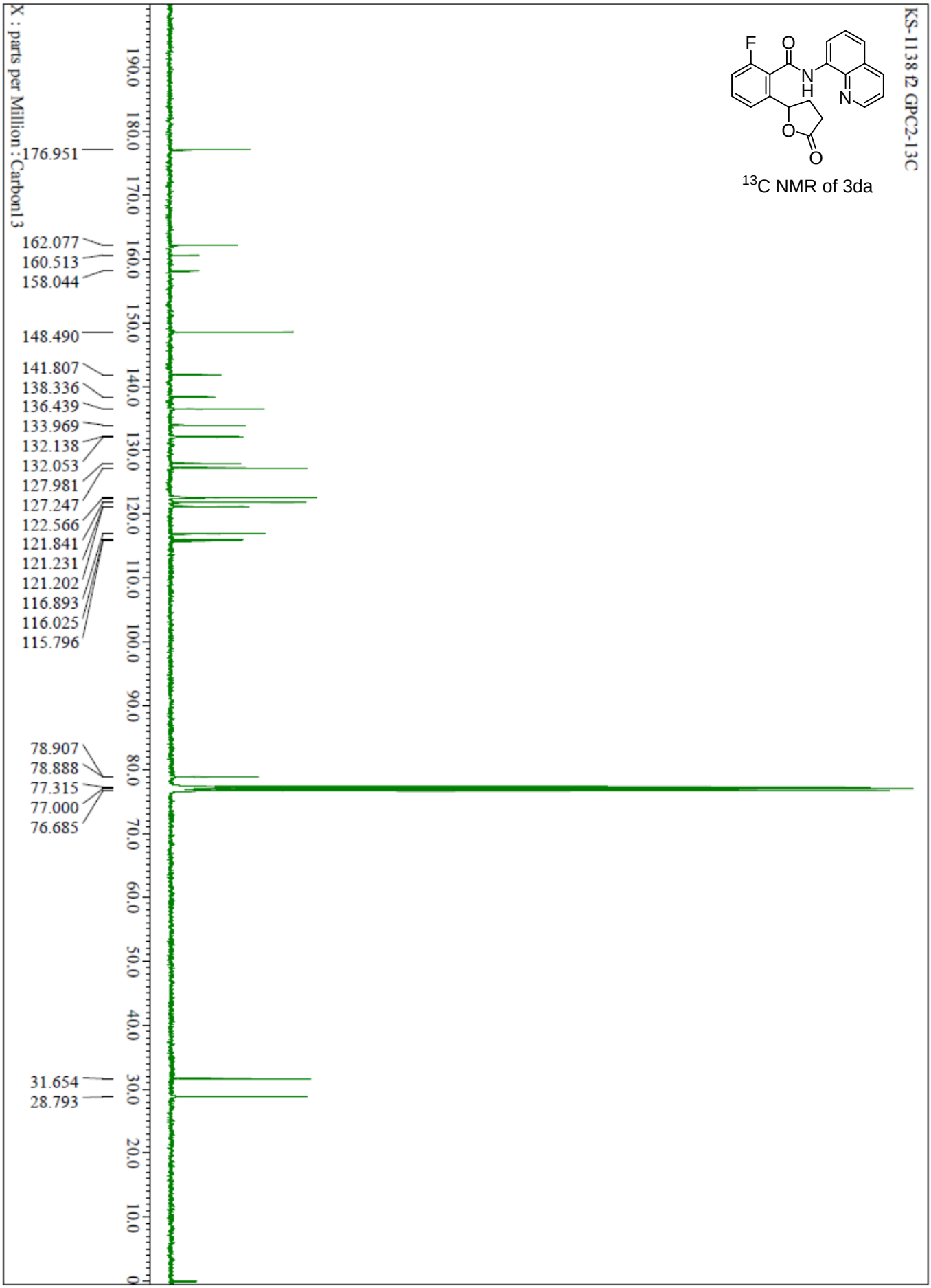
^{13}C NMR of 3ca



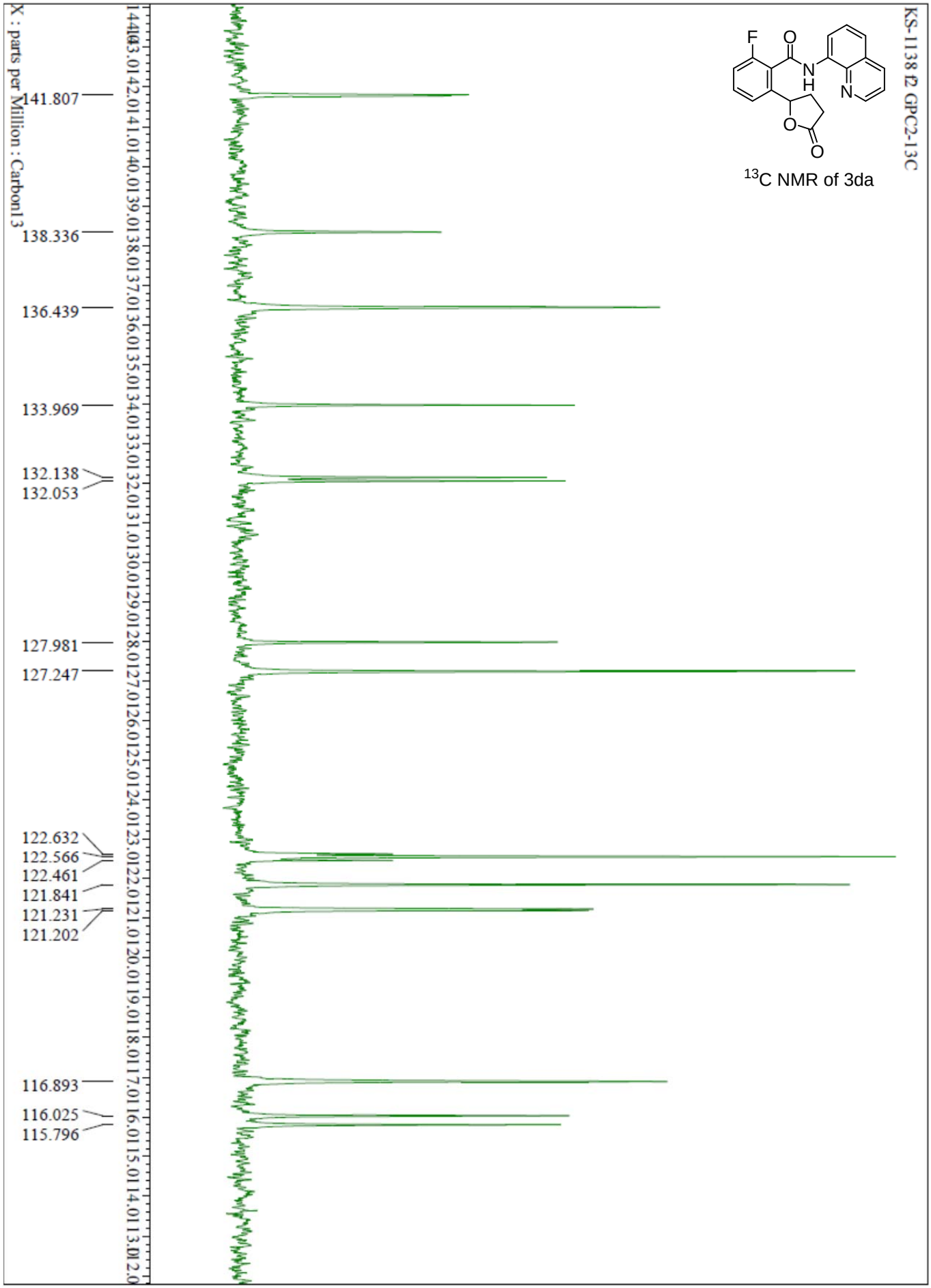
^{13}C NMR of 3ca


KS-1138 f2 GPC2
X : parts per Million : Proton
F
O
N
H
N
O
O
10.426
8.902
8.891
8.816
8.811
8.805
8.801
8.211
8.195
8.190
7.612
7.609
7.599
7.501
7.420
7.265
7.218
5.971
5.953
5.934
2.968
2.951
2.934
2.918
2.902
2.884
2.643
2.269
2.249
2.246
2.225
2.217
2.213
2.192
-0.000
0.924
1.008
1.018
1.000
2.006
2.032
1.017
1.014
0.998
0.991
1.982
1.006
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

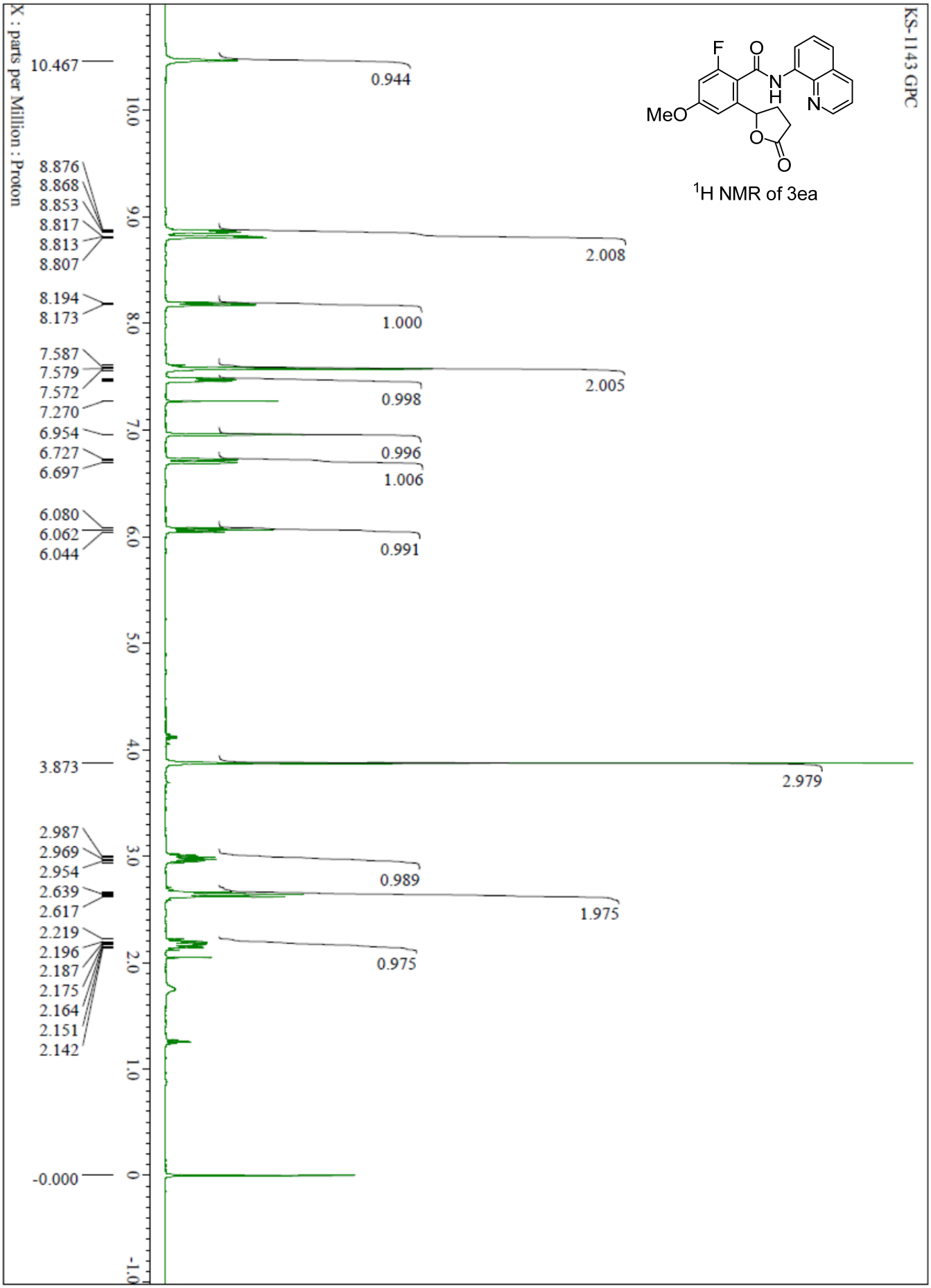
^{1}H NMR of 3da



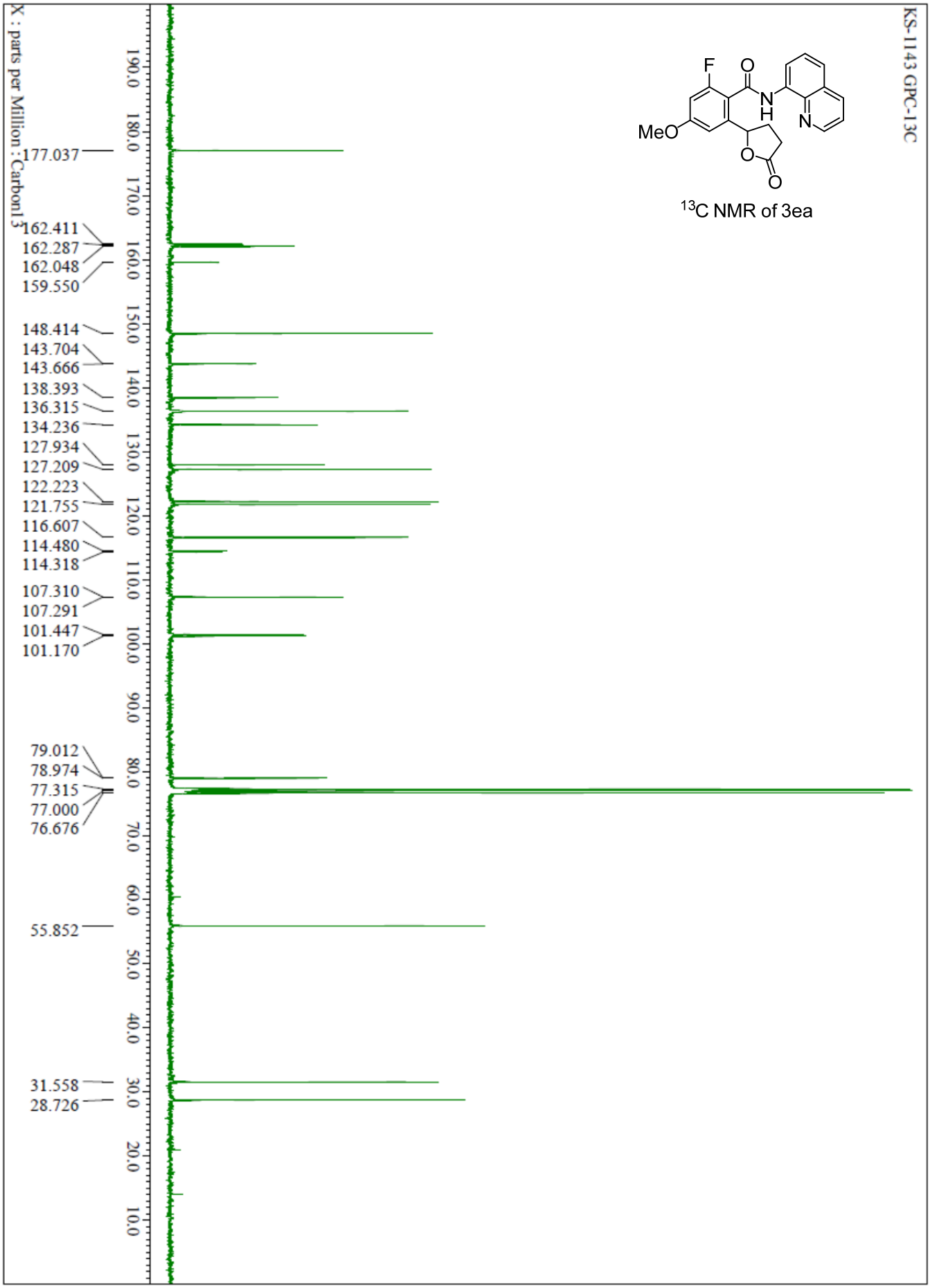
^{13}C NMR of 3da



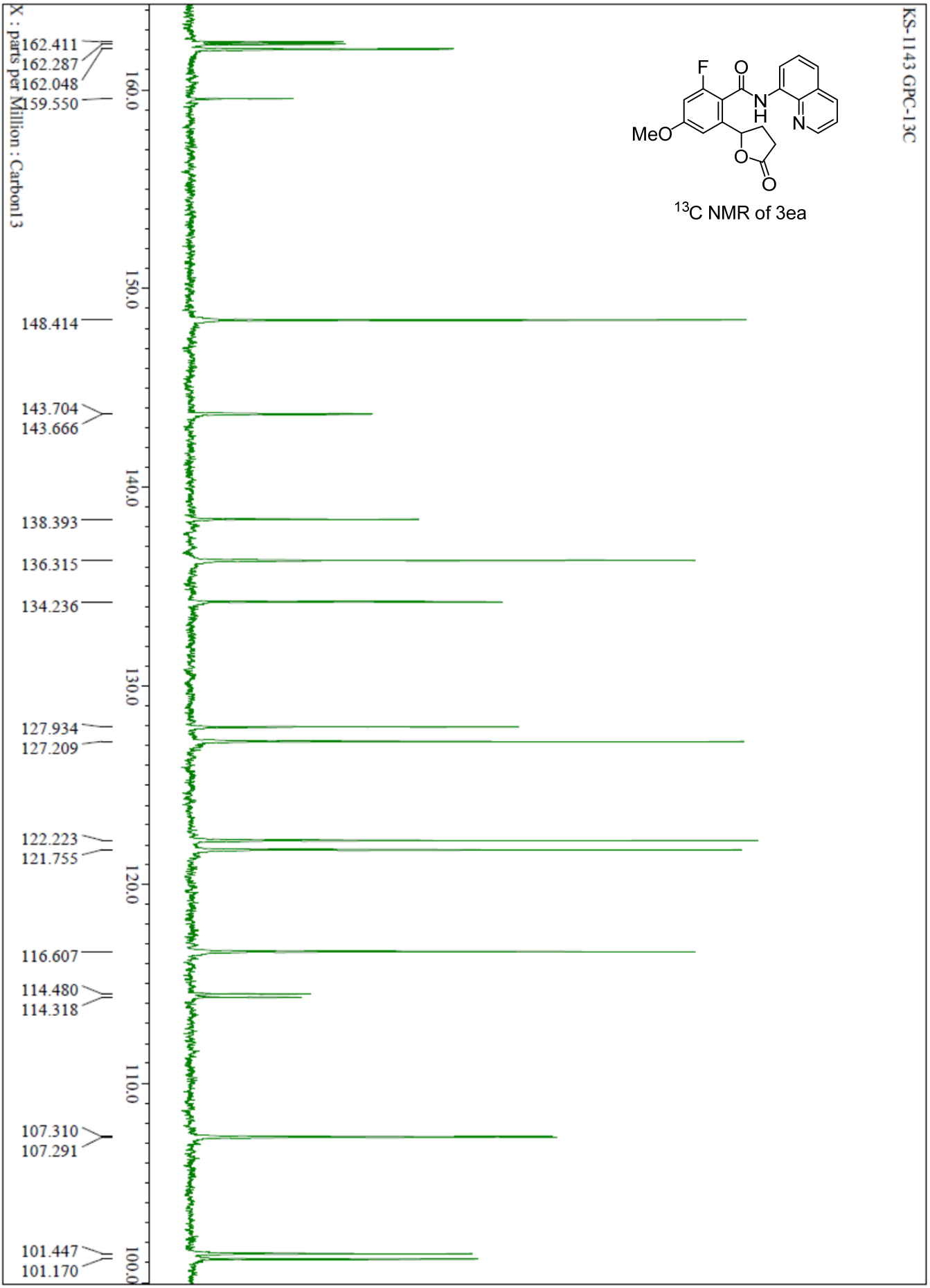
^{13}C NMR of 3da


KS-1143 GPC
X : parts per Million : Proton
10.467
8.876
8.868
8.853
8.817
8.813
8.807
8.194
8.173
7.587
7.579
7.572
7.270
6.954
6.727
6.697
6.080
6.062
6.044
3.873
2.987
2.969
2.954
2.639
2.617
2.219
2.196
2.187
2.175
2.164
2.151
2.142
-0.000
0.944
2.008
1.000
2.005
0.998
0.996
1.006
0.991
2.979
0.989
1.975
0.975
F
O
N
H
N
MeO
O
O
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

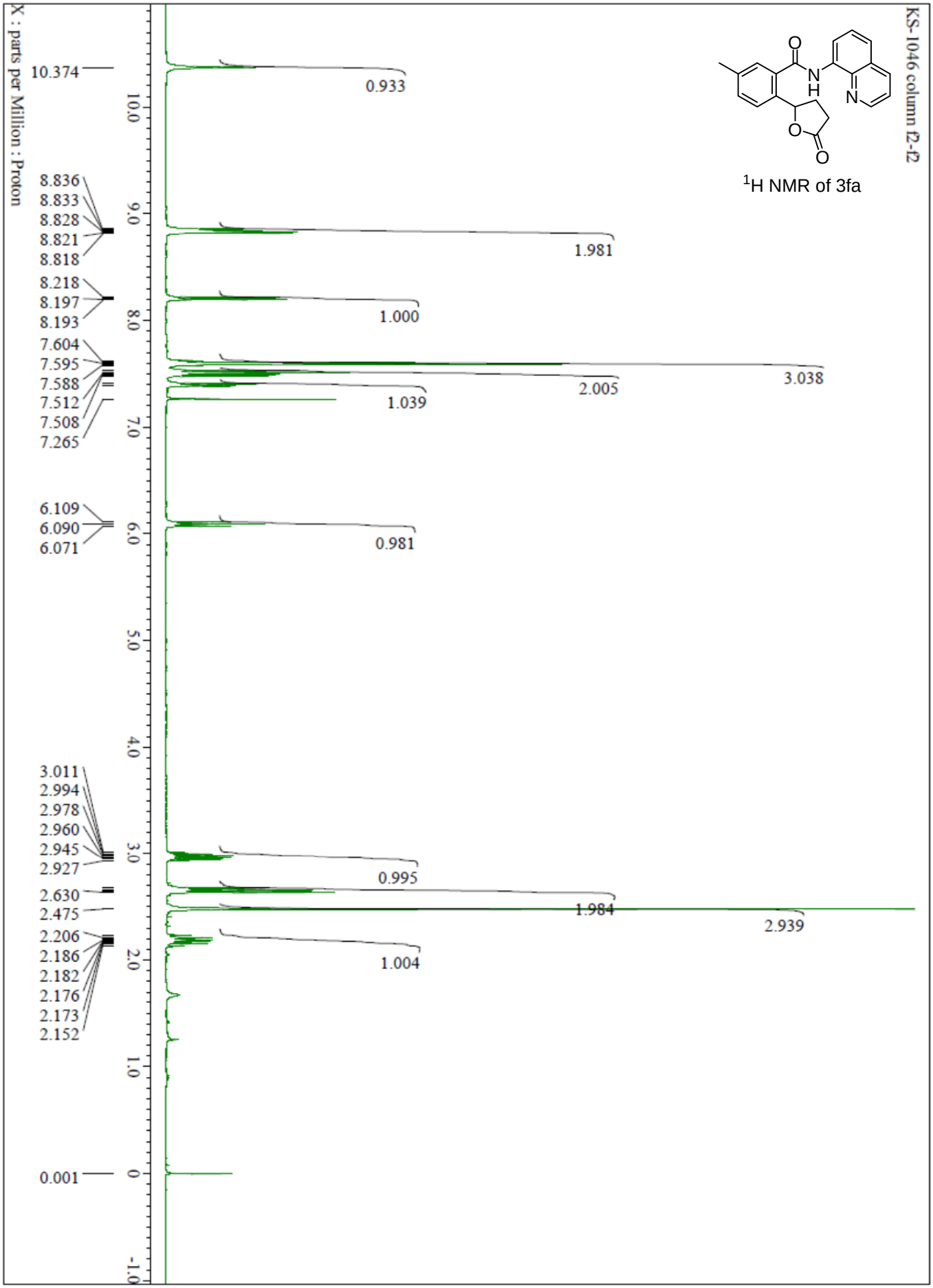
^{1}H NMR of 3ea



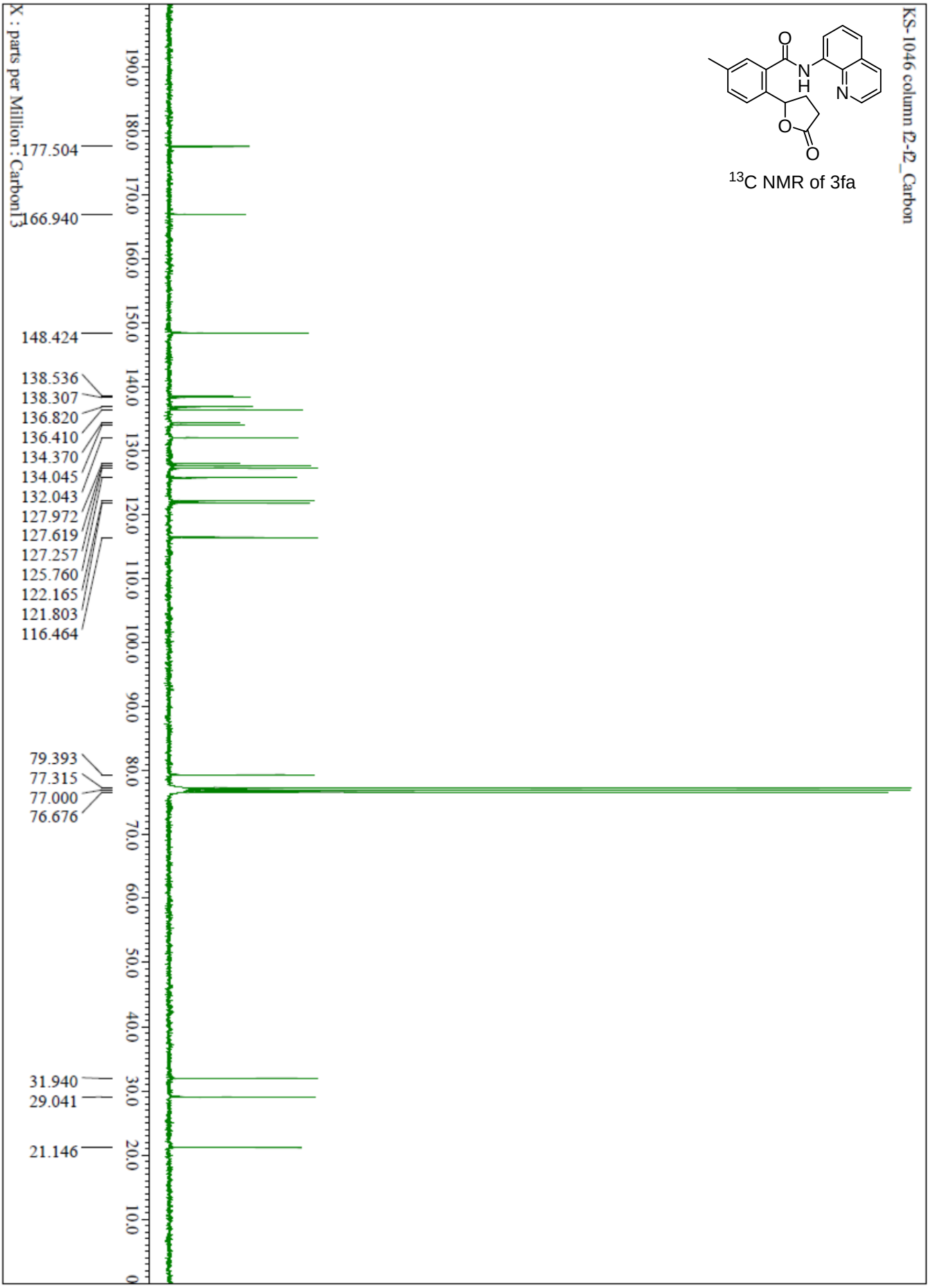
^{13}C NMR of 3ea



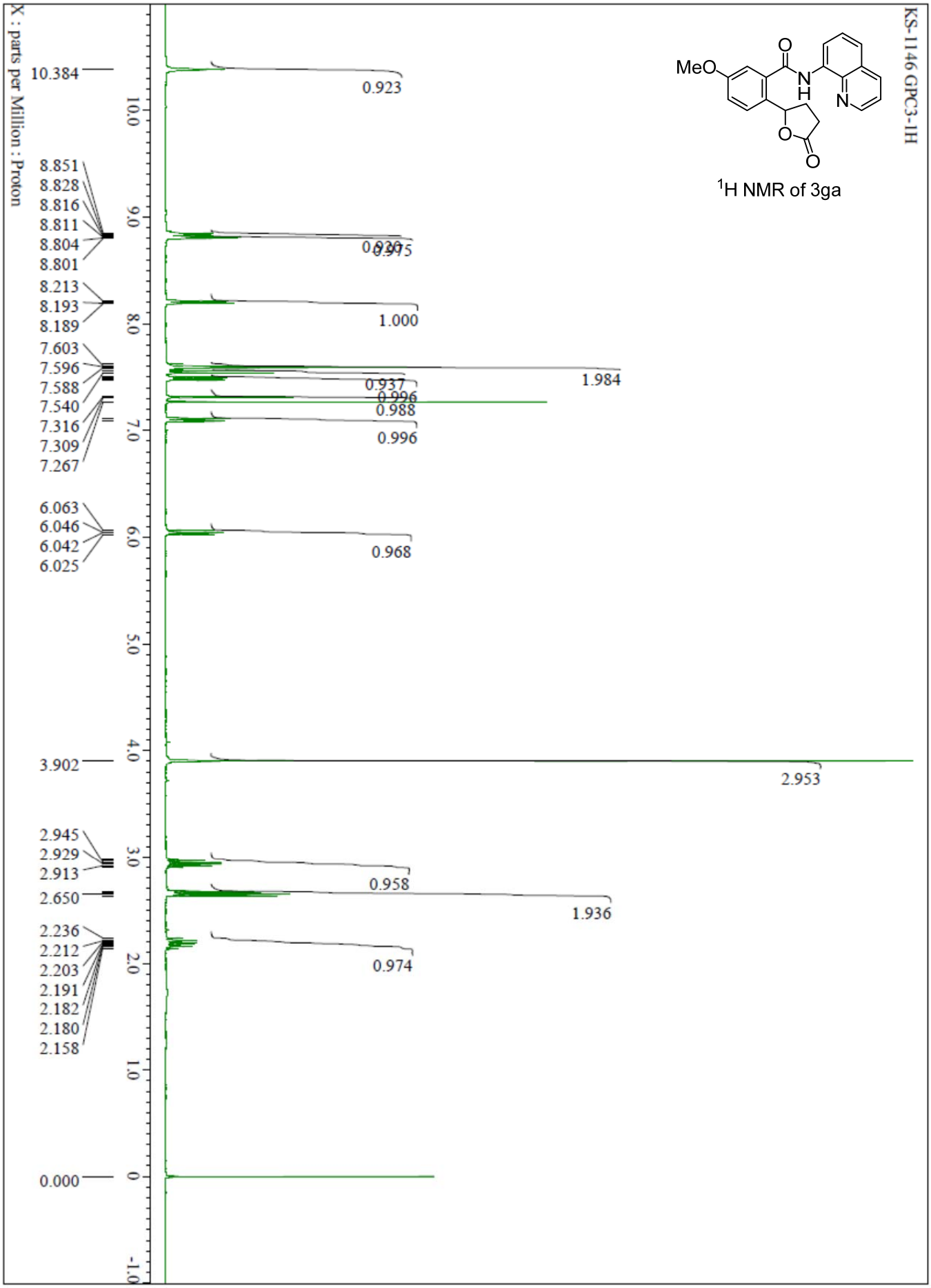
^{13}C NMR of 3ea

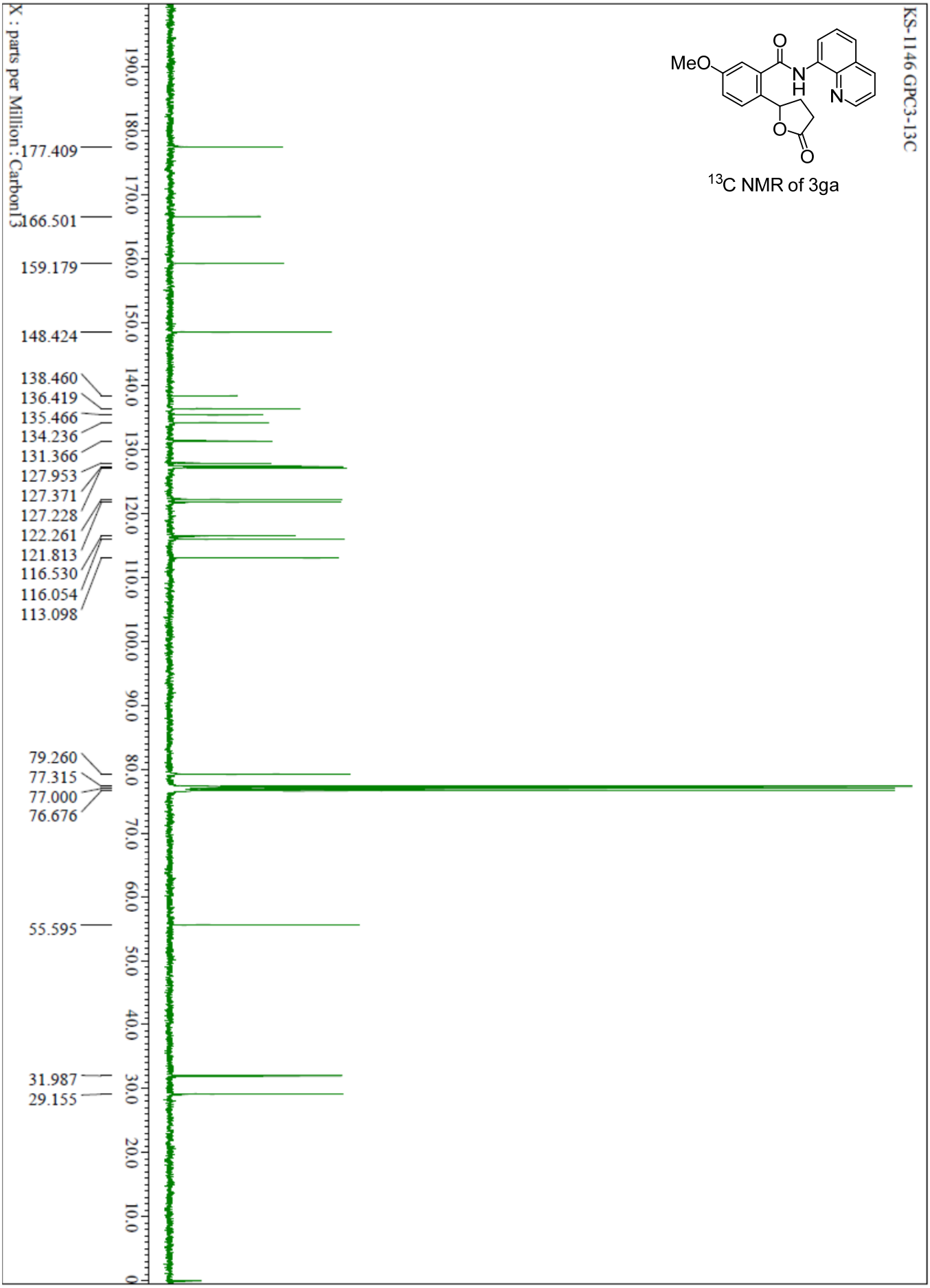

KS- 1046 column f2-f2
X : parts per Million : Proton
10.374
8.836
8.833
8.828
8.821
8.818
8.218
8.197
8.193
7.604
7.595
7.588
7.512
7.508
7.265
6.109
6.090
6.071
3.011
2.994
2.978
2.960
2.945
2.927
2.630
2.475
2.206
2.186
2.182
2.176
2.173
2.152
0.001
0.933
1.981
1.000
3.038
2.005
1.039
0.981
0.995
1.984
2.939
1.004
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

^{1}H NMR of 3fa

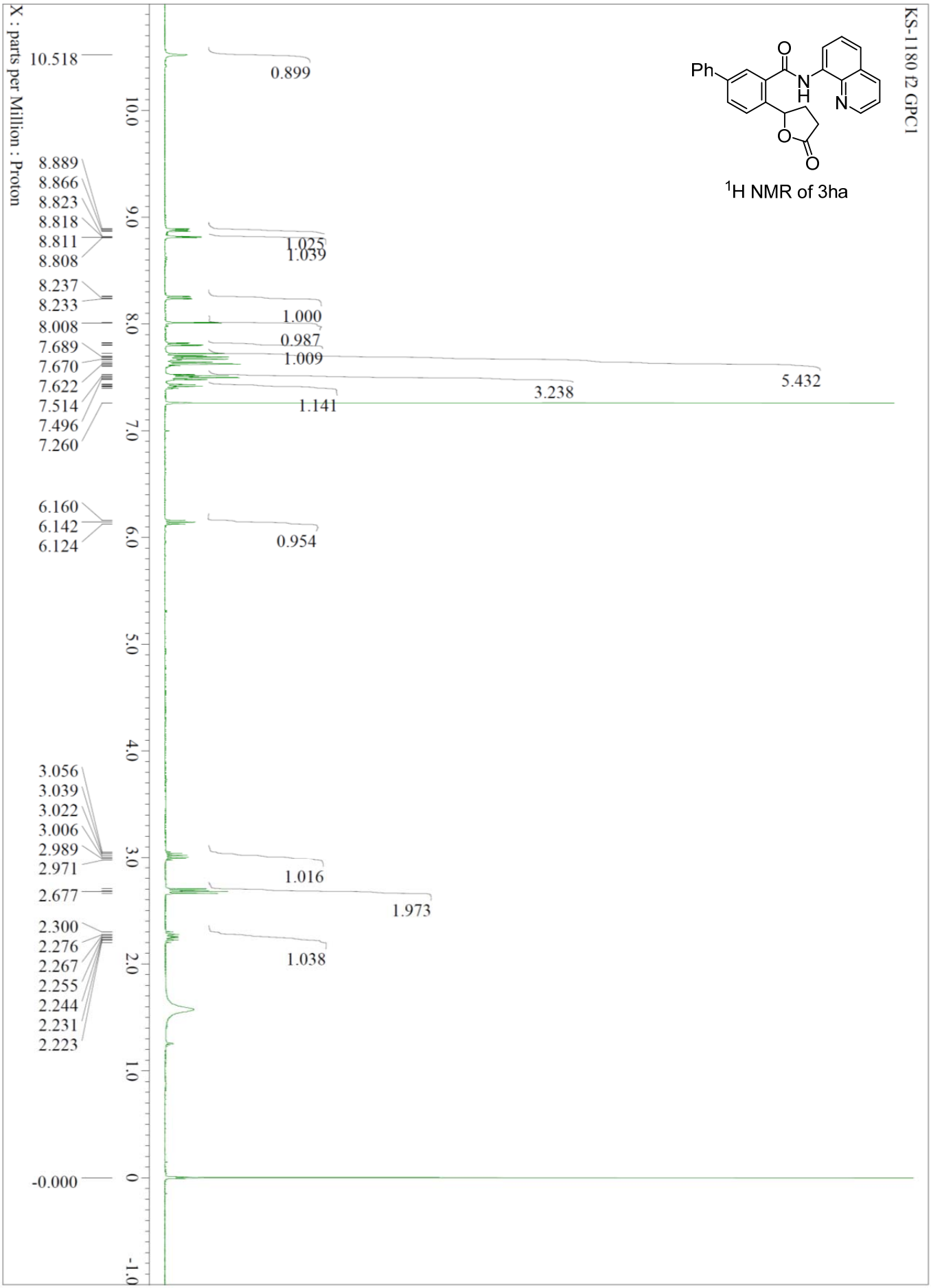


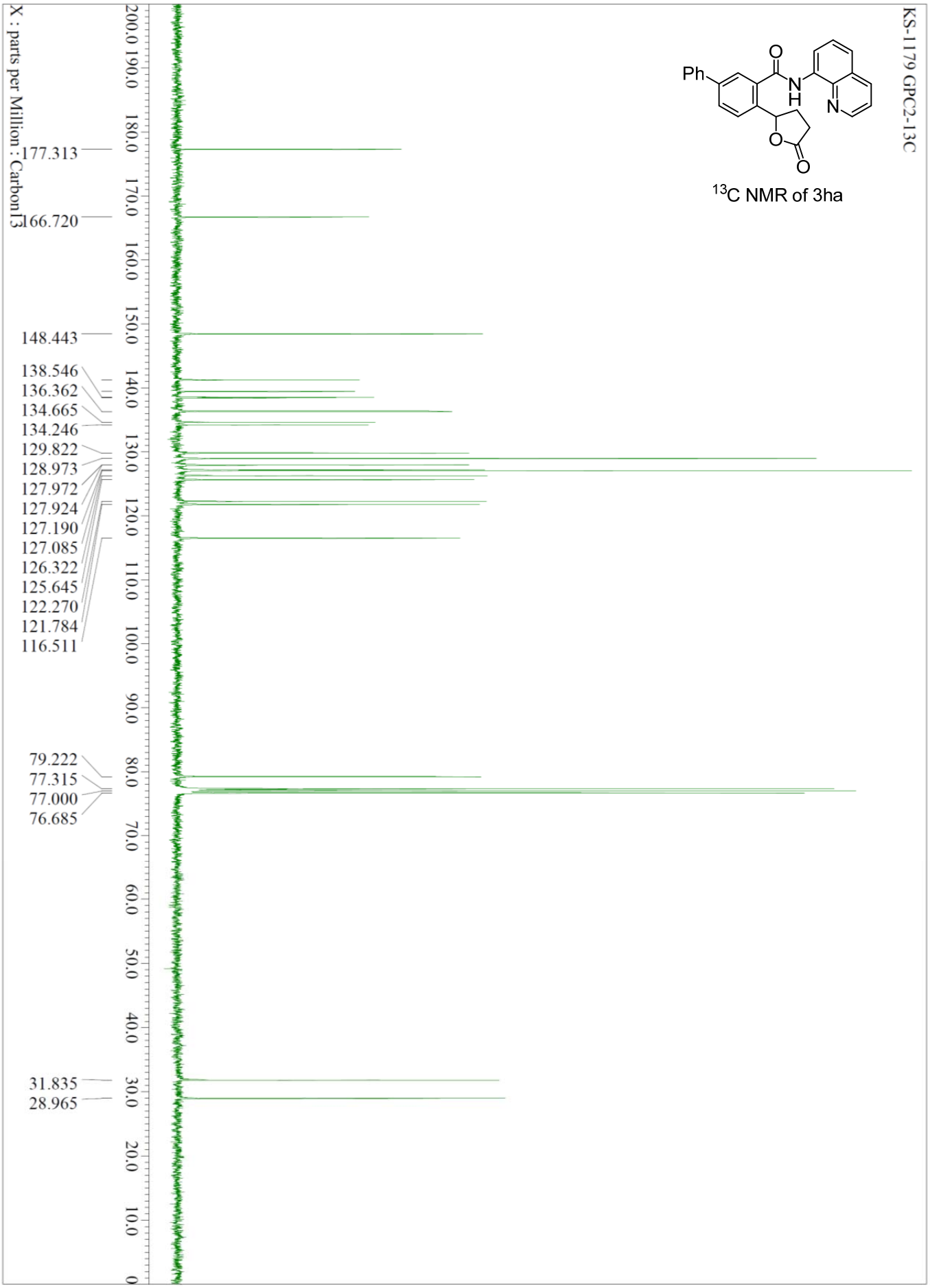
^{13}C NMR of 3fa


KS-1146 GPC3-1H
X : parts per Million : Proton
10.384
8.851
8.828
8.816
8.811
8.804
8.801
8.213
8.193
8.189
7.603
7.596
7.588
7.540
7.316
7.309
7.267
6.063
6.046
6.042
6.025
3.902
2.945
2.929
2.913
2.650
2.236
2.212
2.203
2.191
2.182
2.180
2.158
0.000
0.923
0.975
1.000
1.984
0.937
0.996
0.988
0.996
0.968
2.953
0.958
1.936
0.974
MeO
O
N
H
N
O
O
^{1}H NMR of 3ga

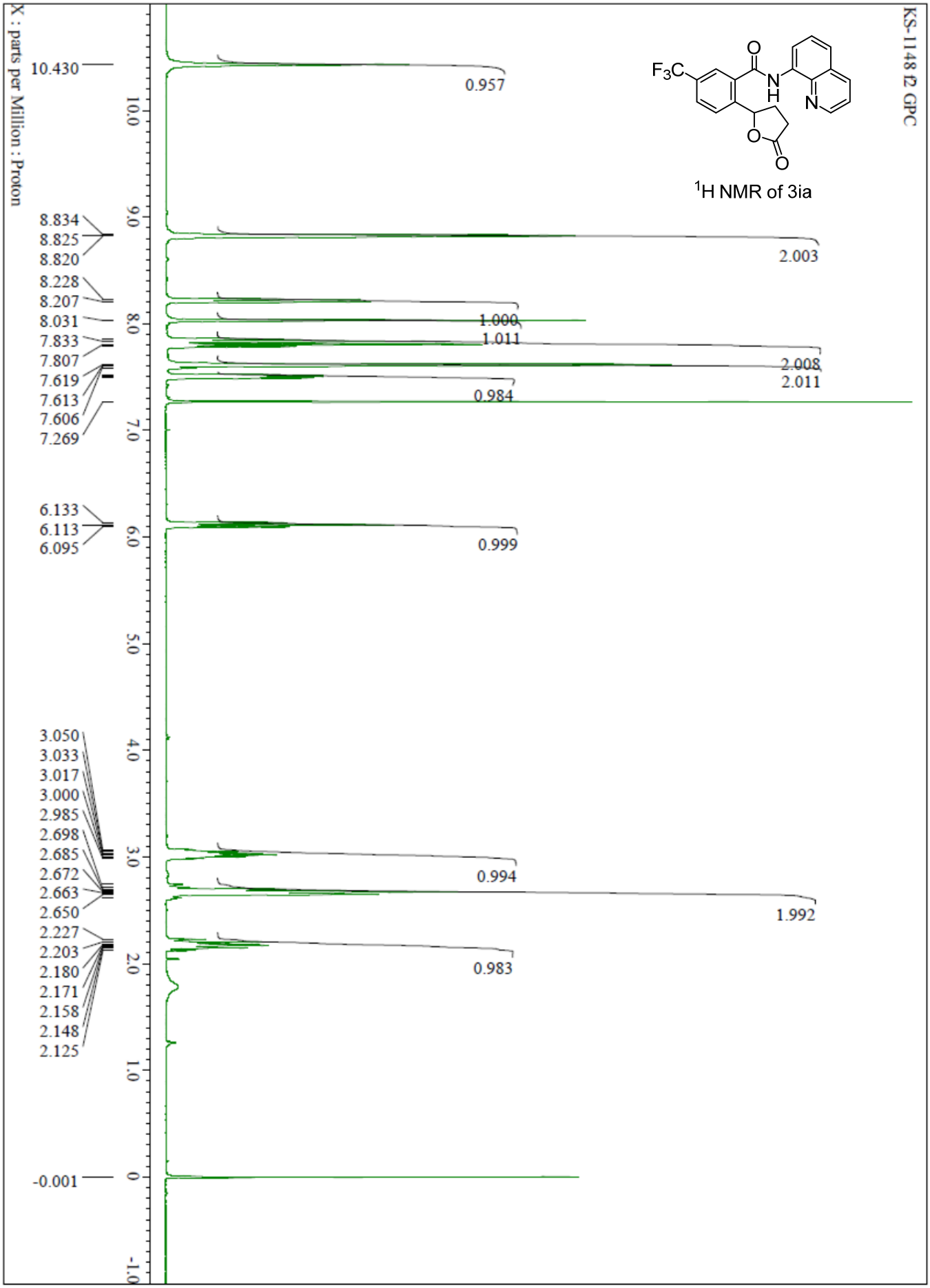


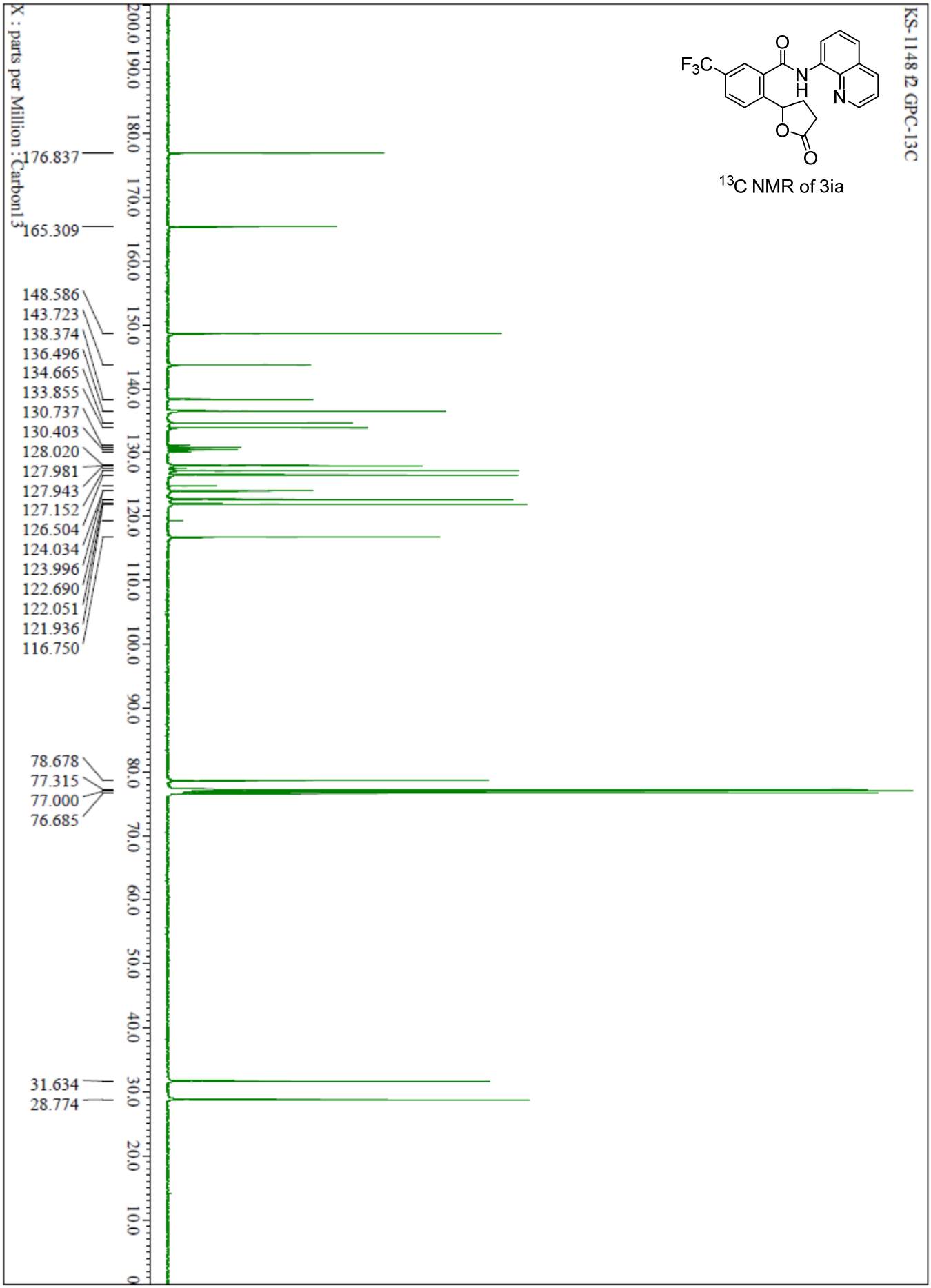
^{13}C NMR of 3ga


KS-1180 f2 GPC1
X : parts per Million : Proton
10.518
8.889
8.866
8.823
8.818
8.811
8.808
8.237
8.233
8.008
7.689
7.670
7.622
7.514
7.496
7.260
6.160
6.142
6.124
3.056
3.039
3.022
3.006
2.989
2.971
2.677
2.300
2.276
2.267
2.255
2.244
2.231
2.223
-0.000
0.899
1.025
1.039
1.000
0.987
1.009
5.432
3.238
1.141
0.954
1.016
1.973
1.038
Ph
O
N
H
N
O
O
^{1}H NMR of 3ha

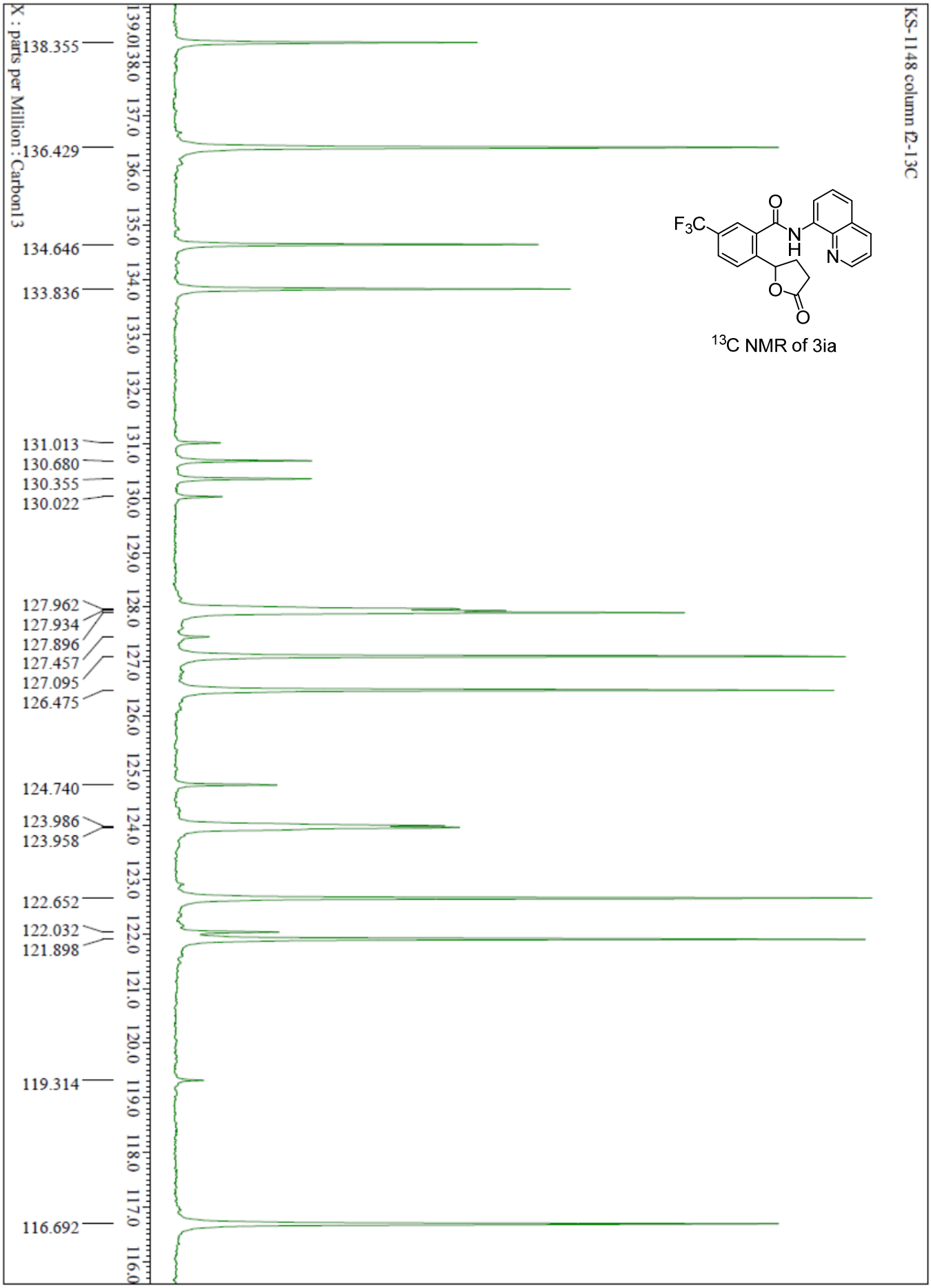


^{13}C NMR of 3ha

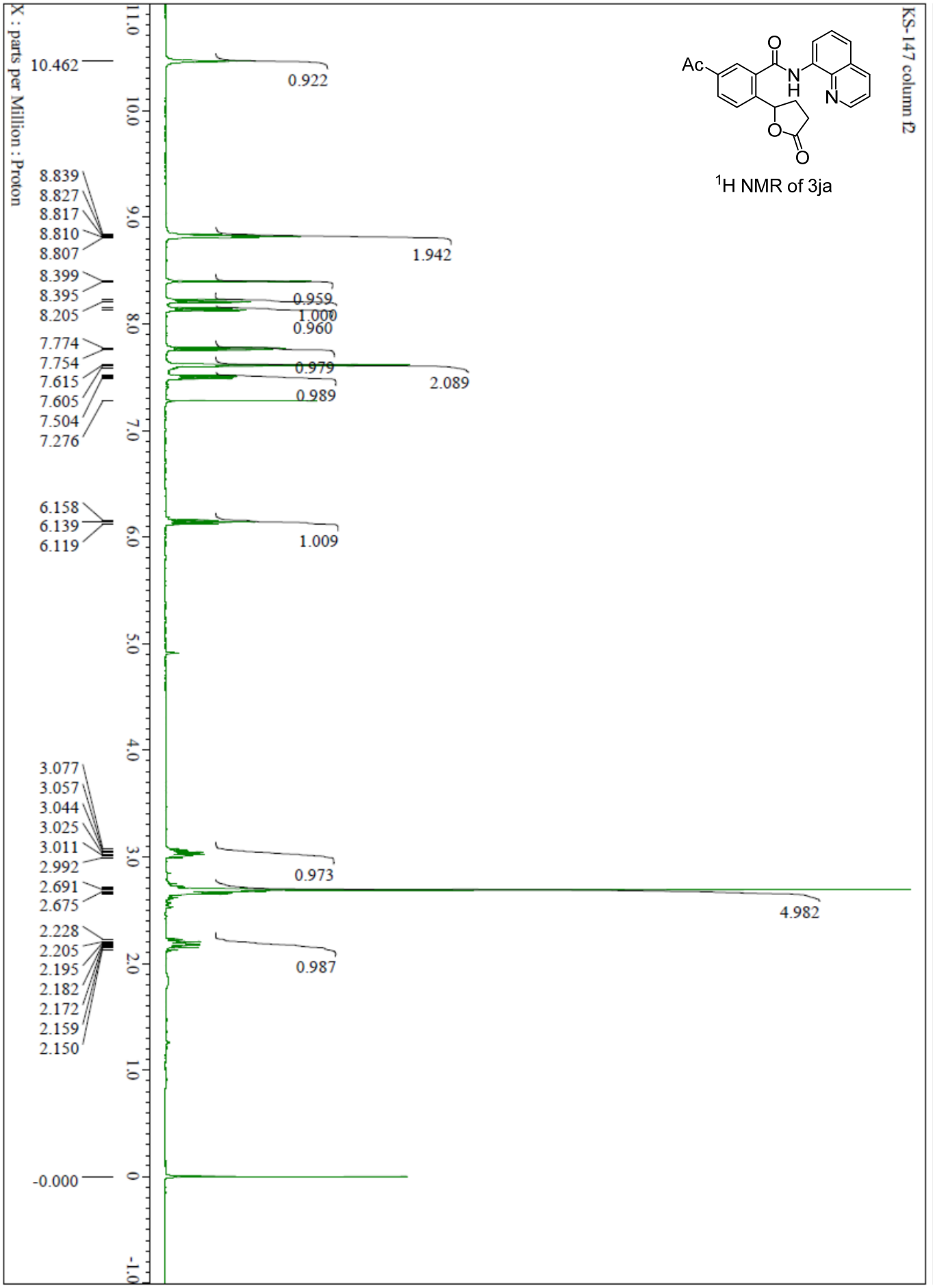

KS-1148 f2 GPC
X : parts per Million : Proton
10.430
8.834
8.825
8.820
8.228
8.207
8.031
7.833
7.807
7.619
7.613
7.606
7.269
6.133
6.113
6.095
3.050
3.033
3.017
3.000
2.985
2.698
2.685
2.672
2.663
2.650
2.227
2.203
2.180
2.171
2.158
2.148
2.125
-0.001
0.957
2.003
1.000
1.011
2.008
2.011
0.984
0.999
0.994
1.992
0.983
F3C
O
N
H
N
O
O
1H NMR of 3ia



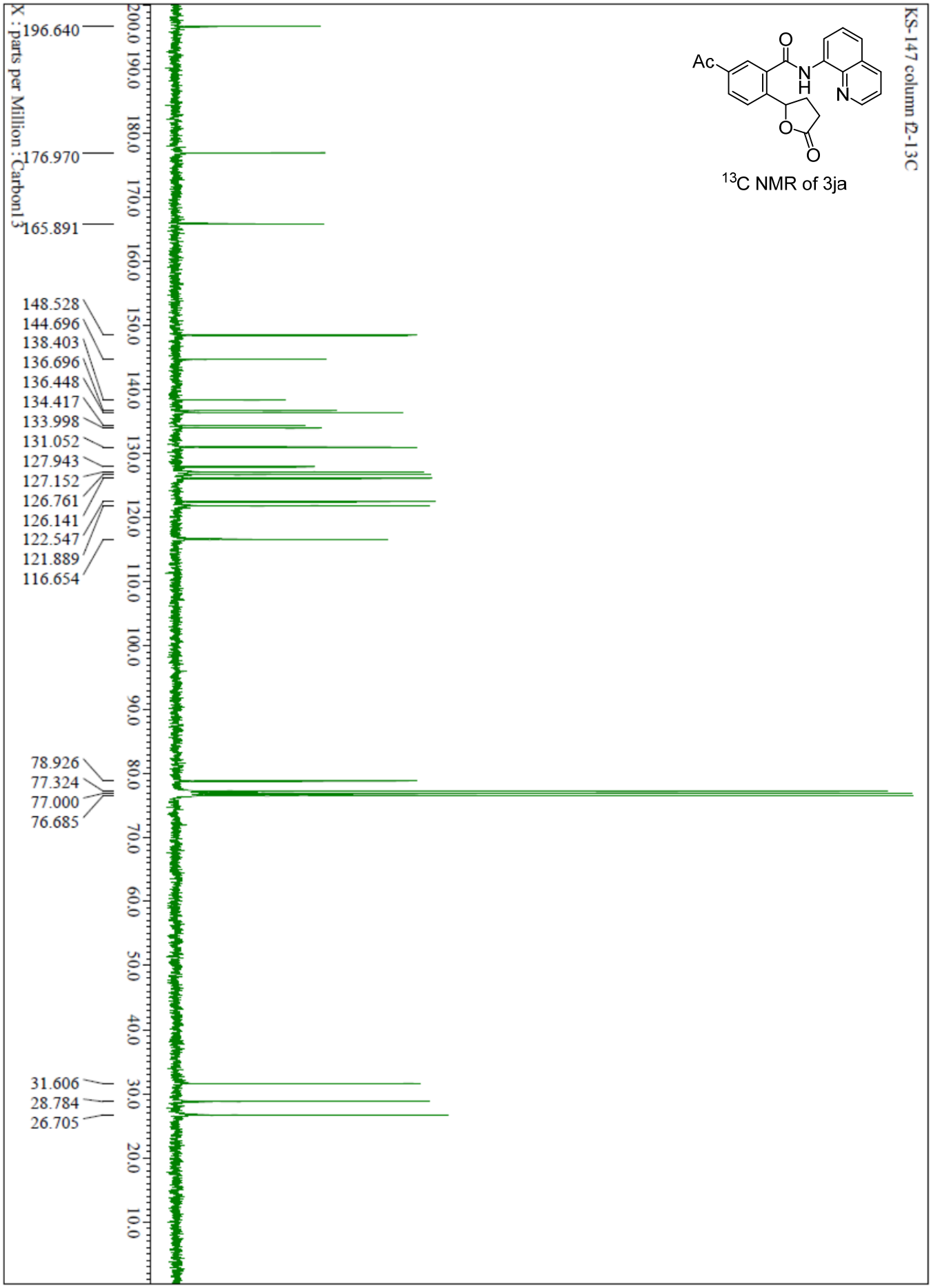
^{13}C NMR of 3ia

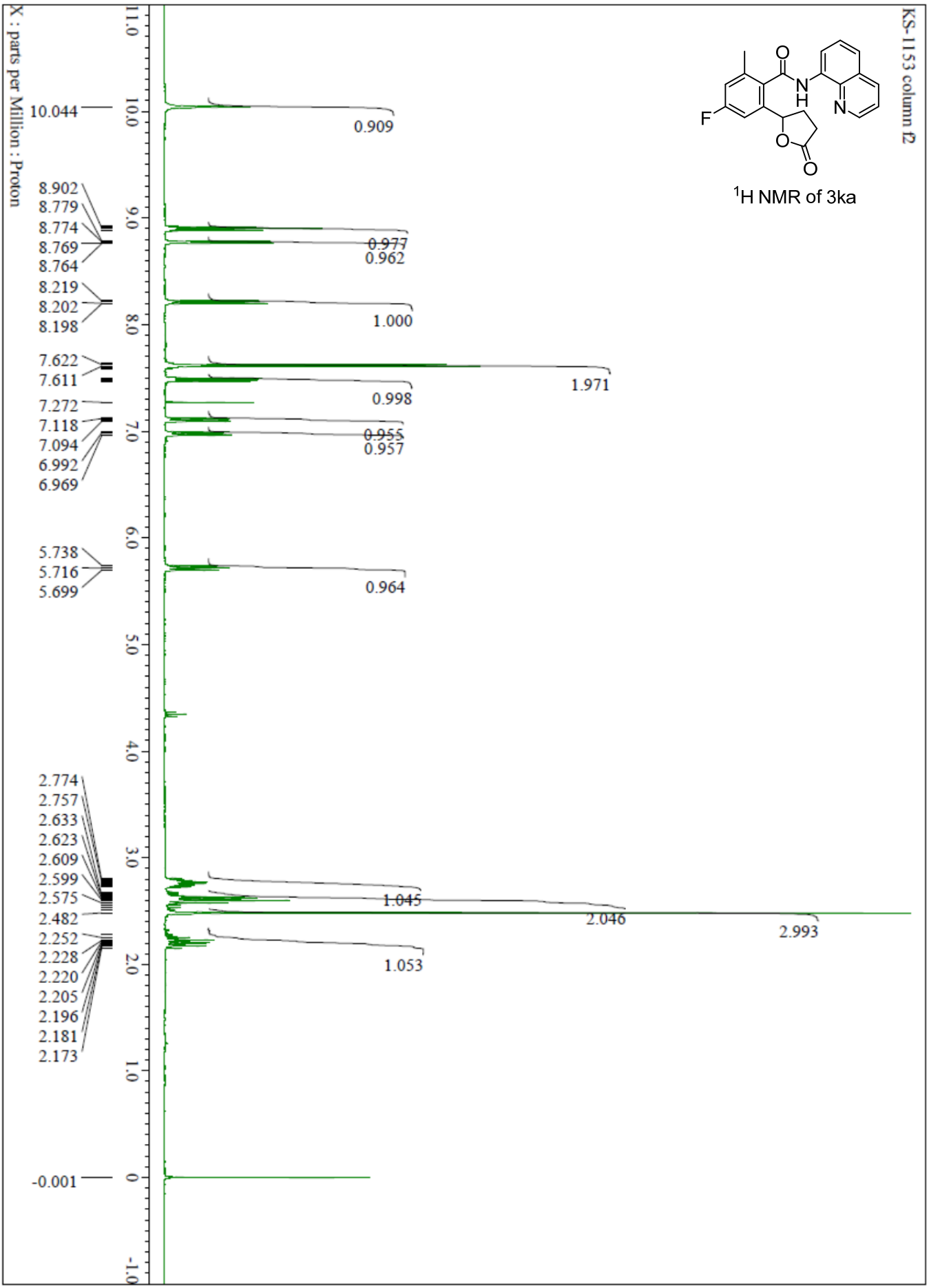


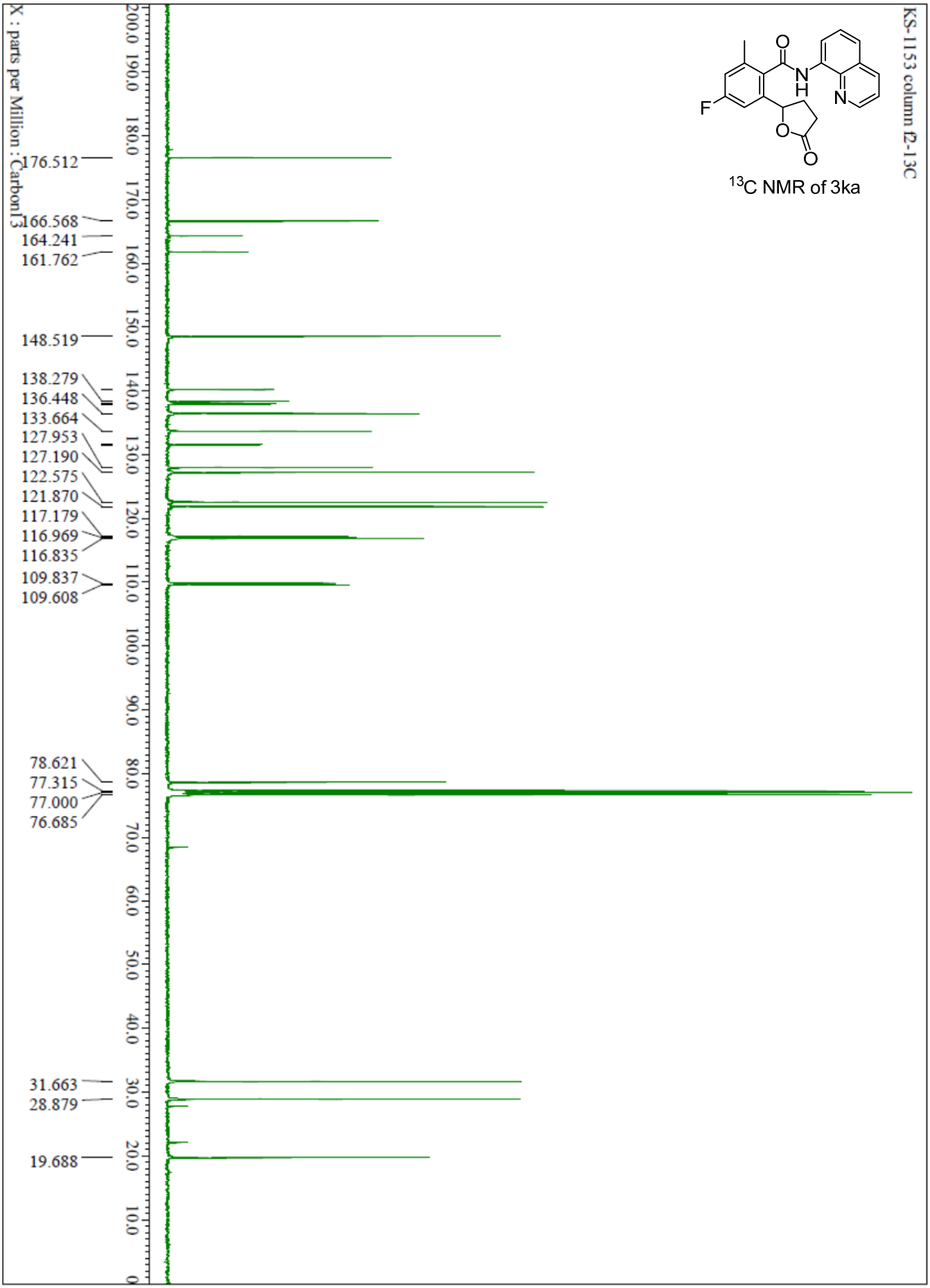
^{13}C NMR of 3ia


X : parts per Million : Proton
KS-147 column f2
10.462
8.839
8.827
8.817
8.810
8.807
8.399
8.395
8.205
7.774
7.754
7.615
7.605
7.504
7.276
6.158
6.139
6.119
3.077
3.057
3.044
3.025
3.011
2.992
2.691
2.675
2.228
2.205
2.195
2.182
2.172
2.159
2.150
-0.000
0.922
1.942
0.959
1.000
0.960
0.979
2.089
0.989
1.009
0.973
4.982
0.987
Ac
O
N
H
N
O
O

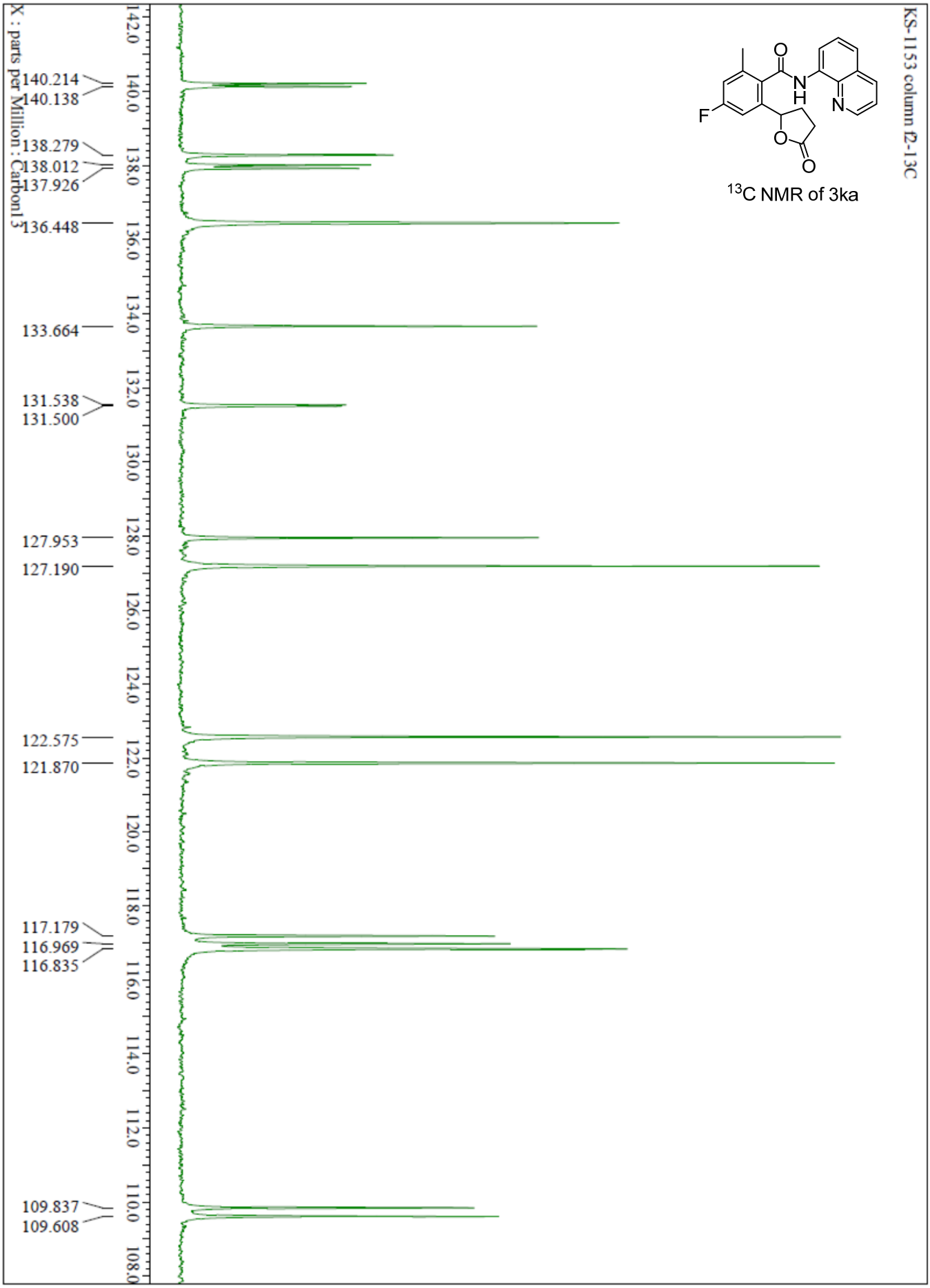
^{1}H NMR of 3ja


KS-147 column f2-13C
X : parts per Million : Carbon13
196.640
176.970
165.891
148.528
144.696
138.403
136.696
136.448
134.417
133.998
131.052
127.943
127.152
126.761
126.141
122.547
121.889
116.654
78.926
77.324
77.000
76.685
31.606
28.784
26.705
Ac
O
N
H
N
O
O
13C NMR of 3ja

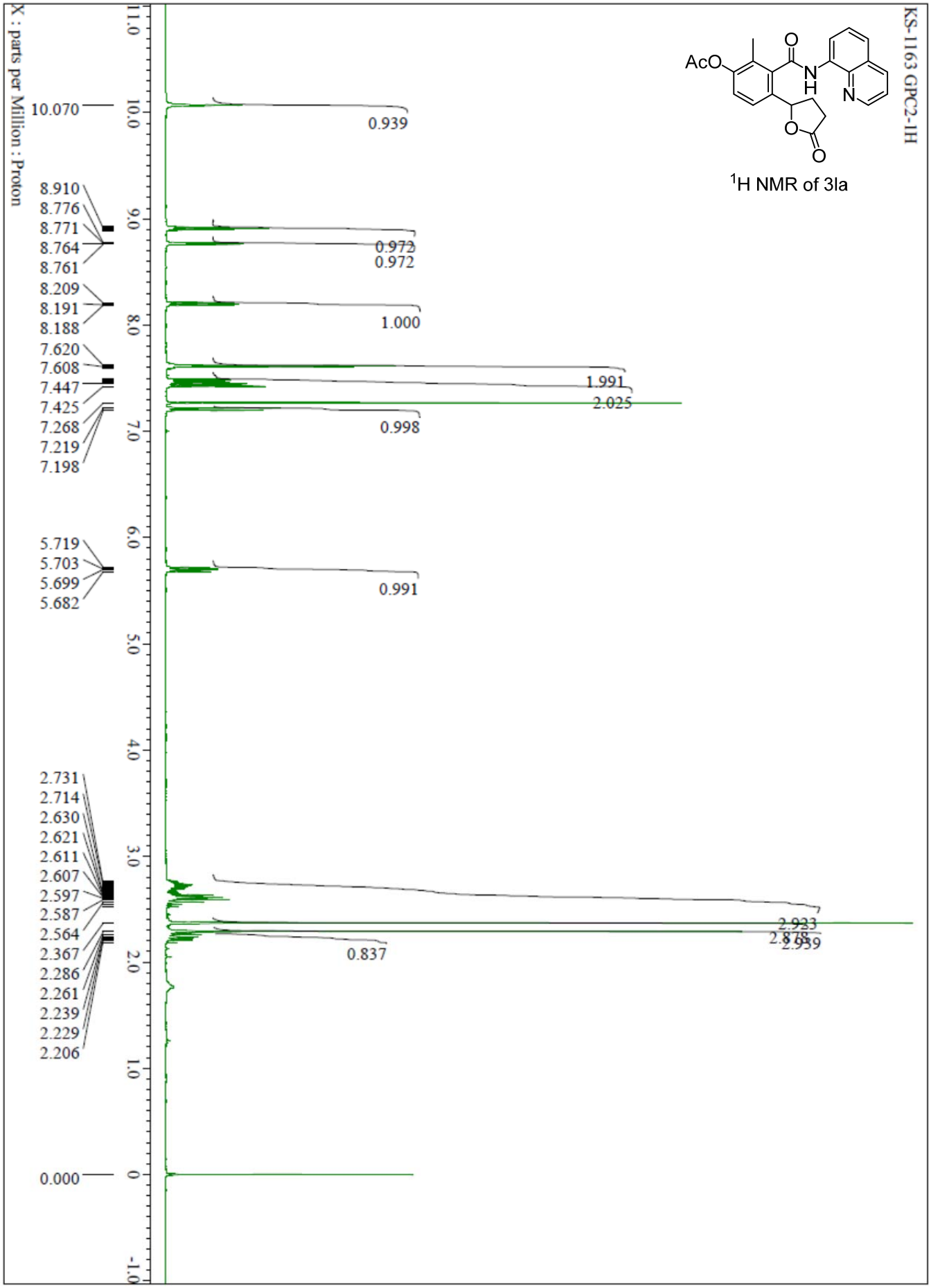

KS-1153 column f2
X : parts per Million : Proton
10.044
8.902
8.779
8.774
8.769
8.764
8.219
8.202
8.198
7.622
7.611
7.272
7.118
7.094
6.992
6.969
5.738
5.716
5.699
2.774
2.757
2.633
2.623
2.609
2.599
2.575
2.482
2.252
2.228
2.220
2.205
2.196
2.181
2.173
-0.001
0.909
0.977
0.962
1.000
1.971
0.998
0.955
0.957
0.964
1.045
2.046
2.993
1.053
F
O
N
H
N
O
O
^{1}H NMR of 3ka

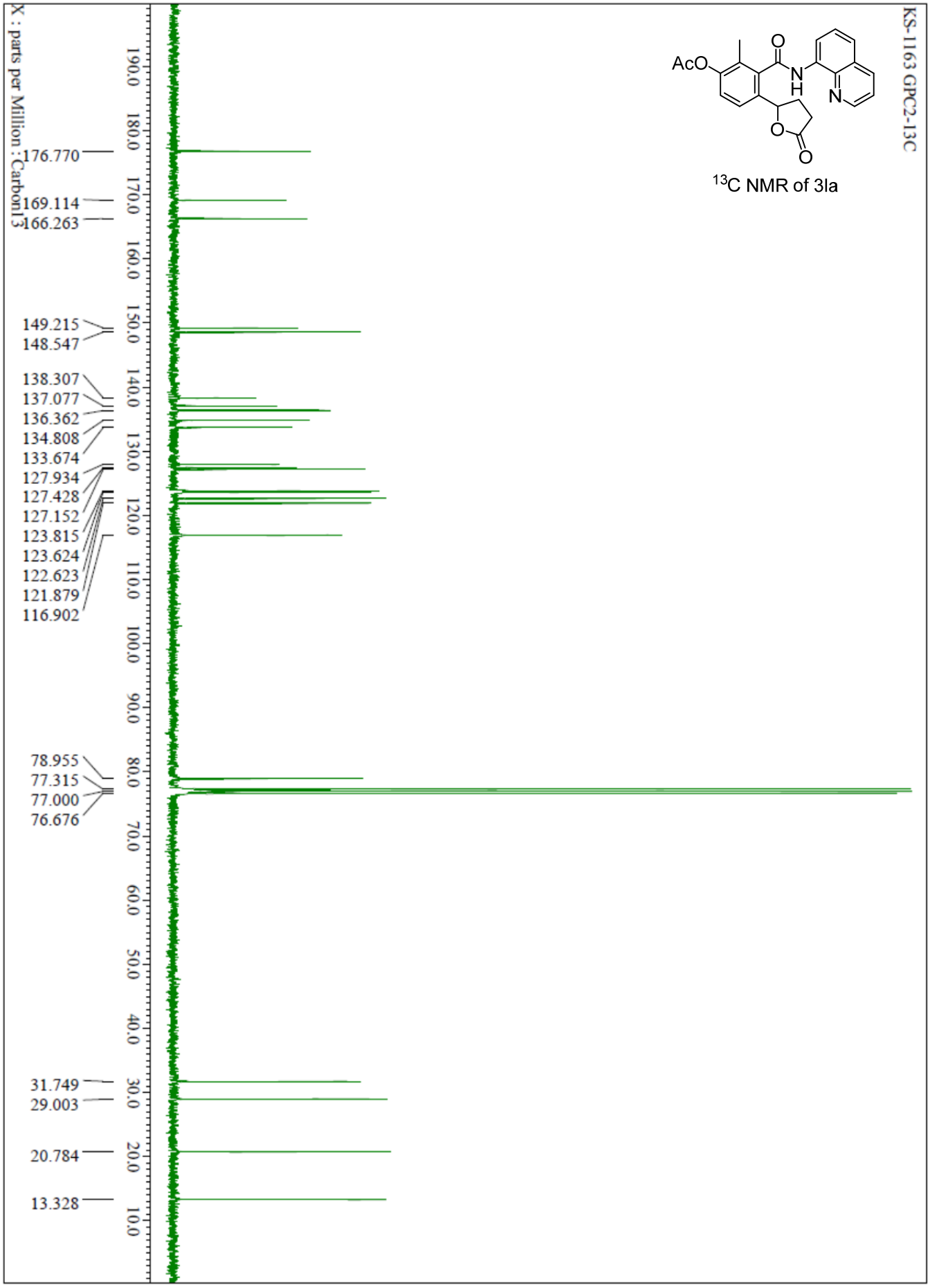


^{13}C NMR of 3ka

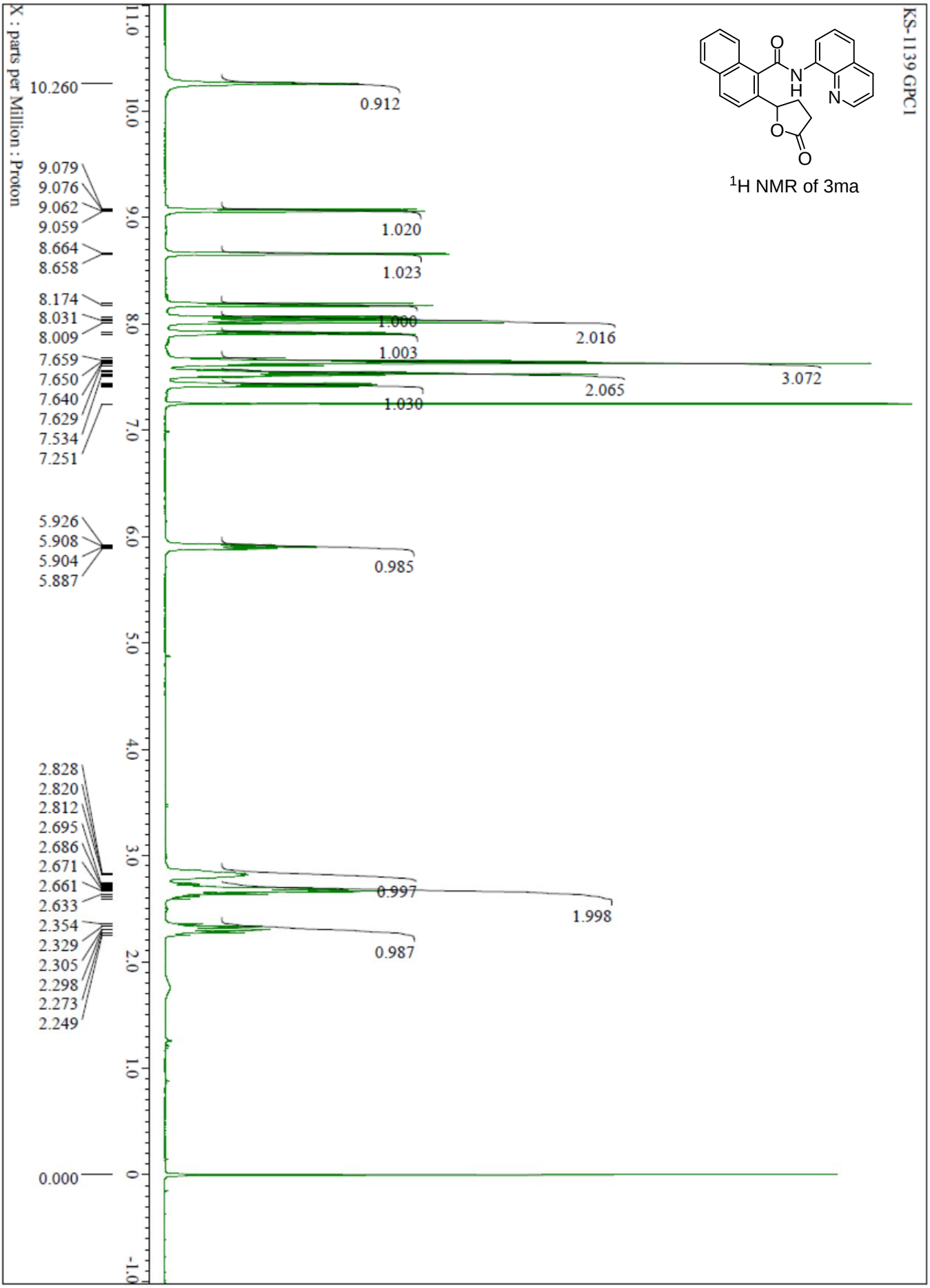


^{13}C NMR of 3ka

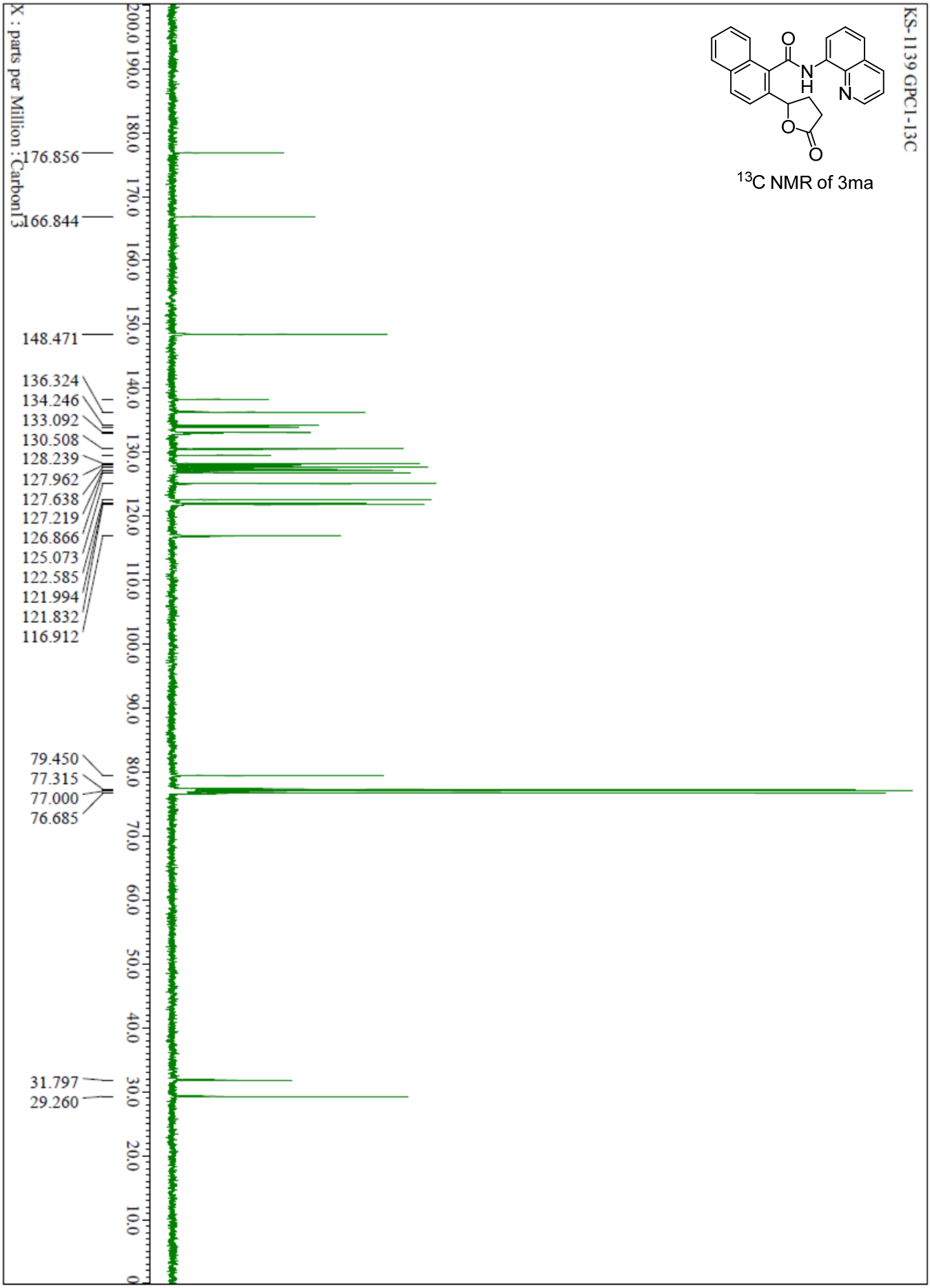

KS-1163 GPC2-1H
X : parts per Million : Proton
AcO
O
N
H
N
O
O
1H NMR of 3la
10.070
8.910
8.776
8.771
8.764
8.761
8.209
8.191
8.188
7.620
7.608
7.447
7.425
7.268
7.219
7.198
5.719
5.703
5.699
5.682
2.731
2.714
2.630
2.621
2.611
2.607
2.597
2.587
2.564
2.367
2.286
2.261
2.239
2.229
2.206
0.000
0.939
0.972
0.972
1.000
1.991
2.025
0.998
0.991
0.837
2.933
2.878
2.939
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0



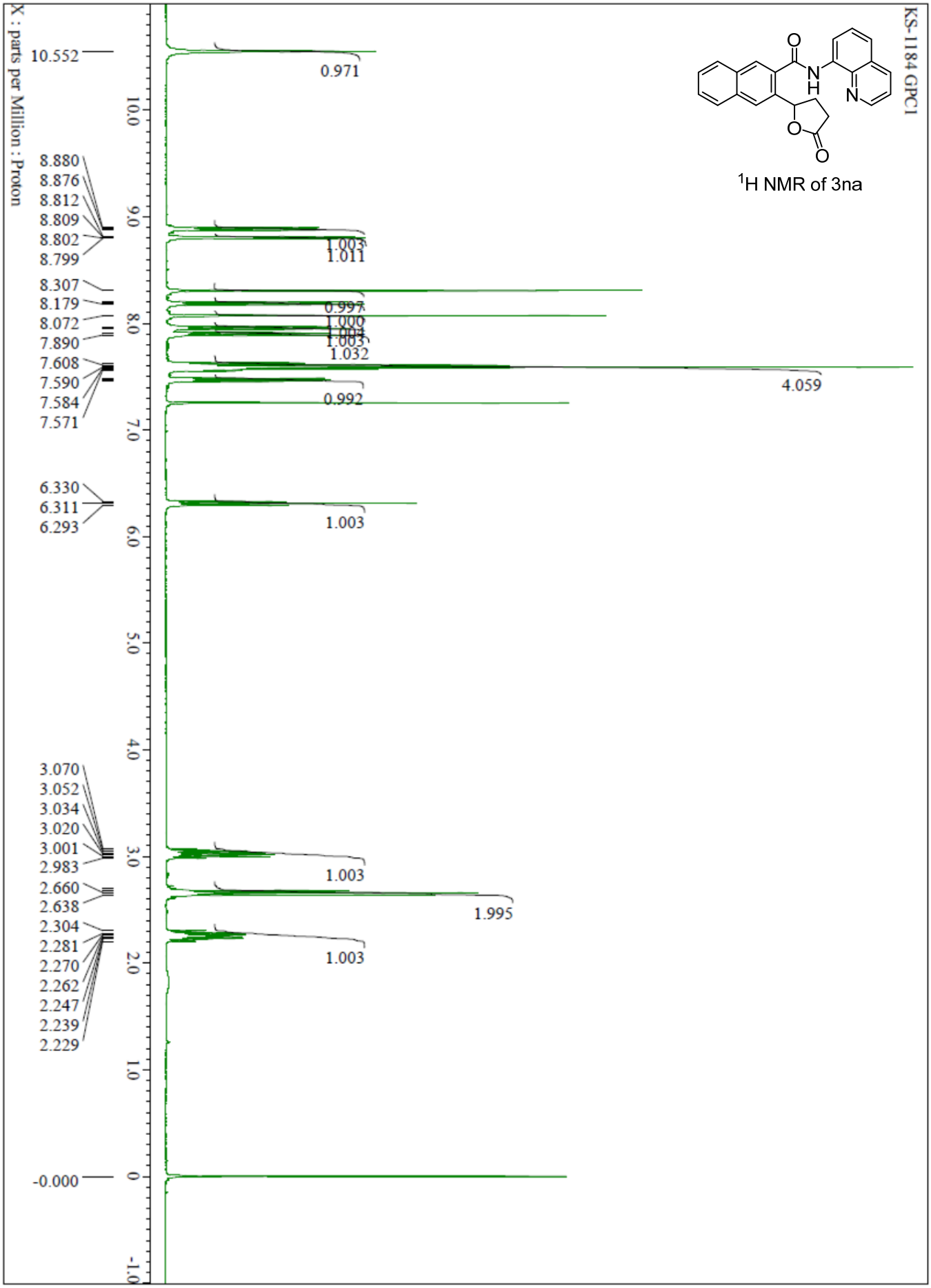
^{13}C NMR of 3la

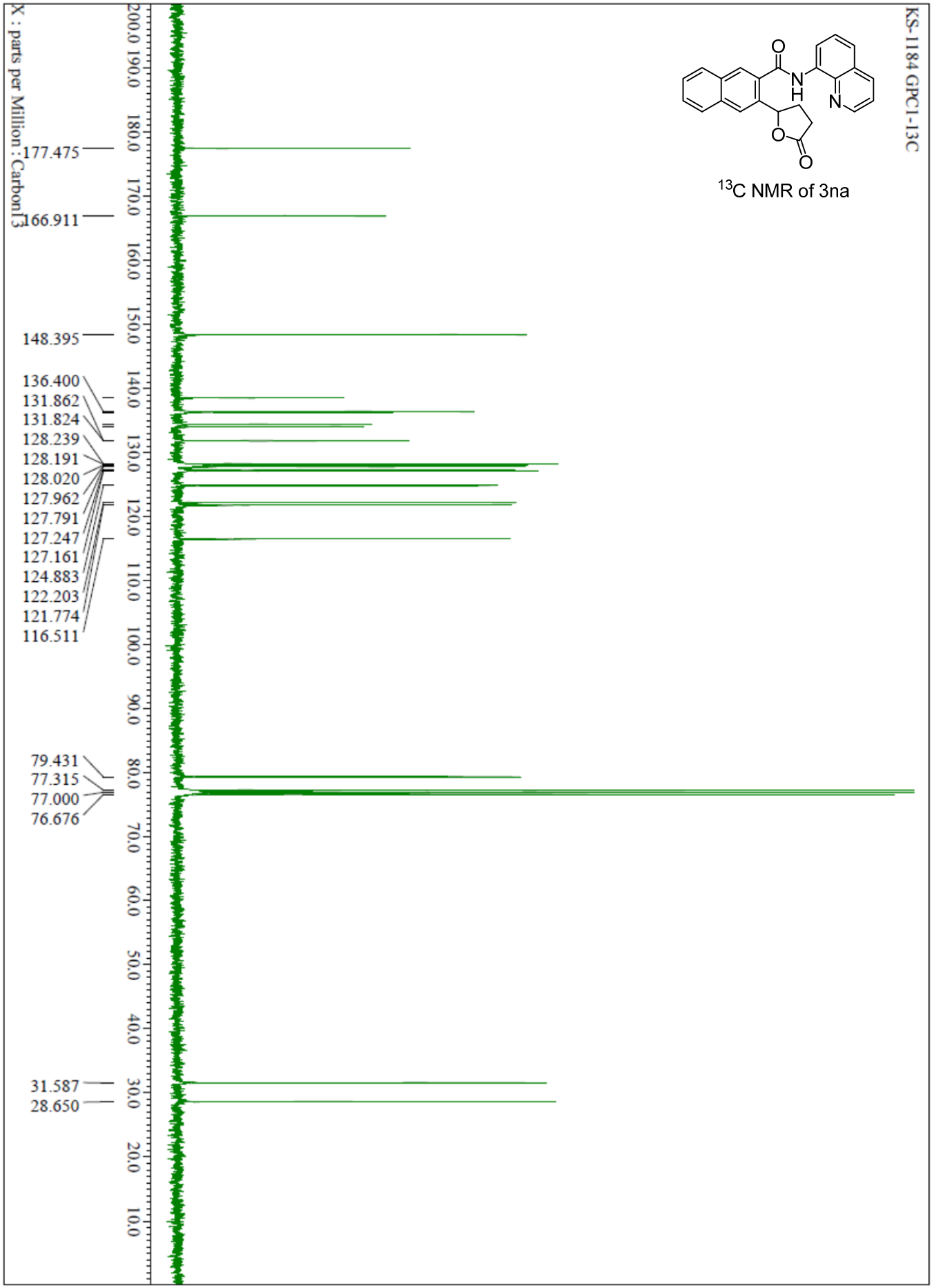

KS-1139 GPC1
X : parts per Million : Proton
10.260
9.079
9.076
9.062
9.059
8.664
8.658
8.174
8.031
8.009
7.659
7.650
7.640
7.629
7.534
7.251
5.926
5.908
5.904
5.887
2.828
2.820
2.812
2.695
2.686
2.671
2.661
2.633
2.354
2.329
2.305
2.298
2.273
2.249
0.000
0.912
1.020
1.023
1.000
2.016
1.003
3.072
2.065
1.030
0.985
0.997
1.998
0.987
O
N
H
N
O
O
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

^{1}H NMR of 3ma

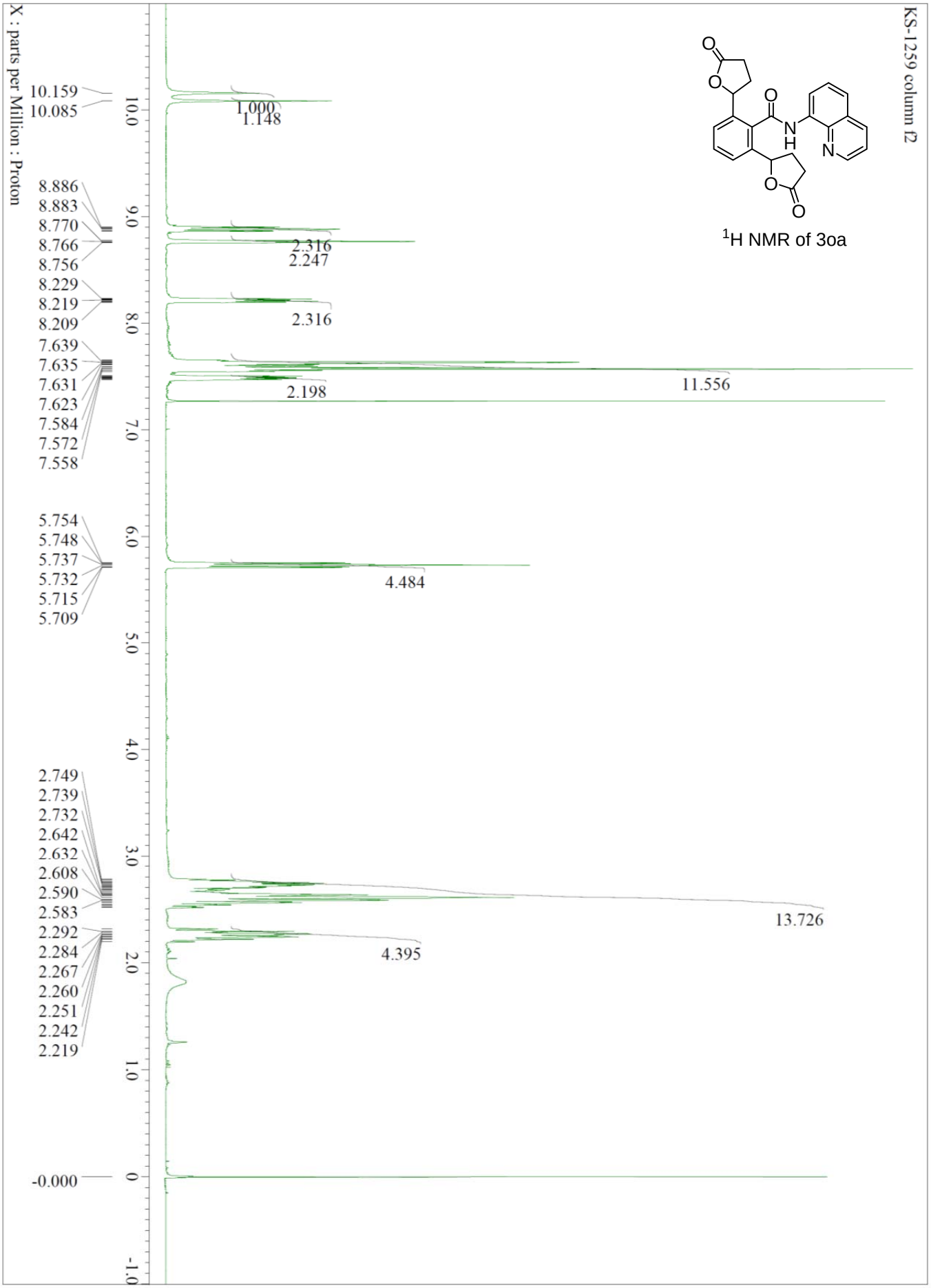


^{13}C NMR of 3ma

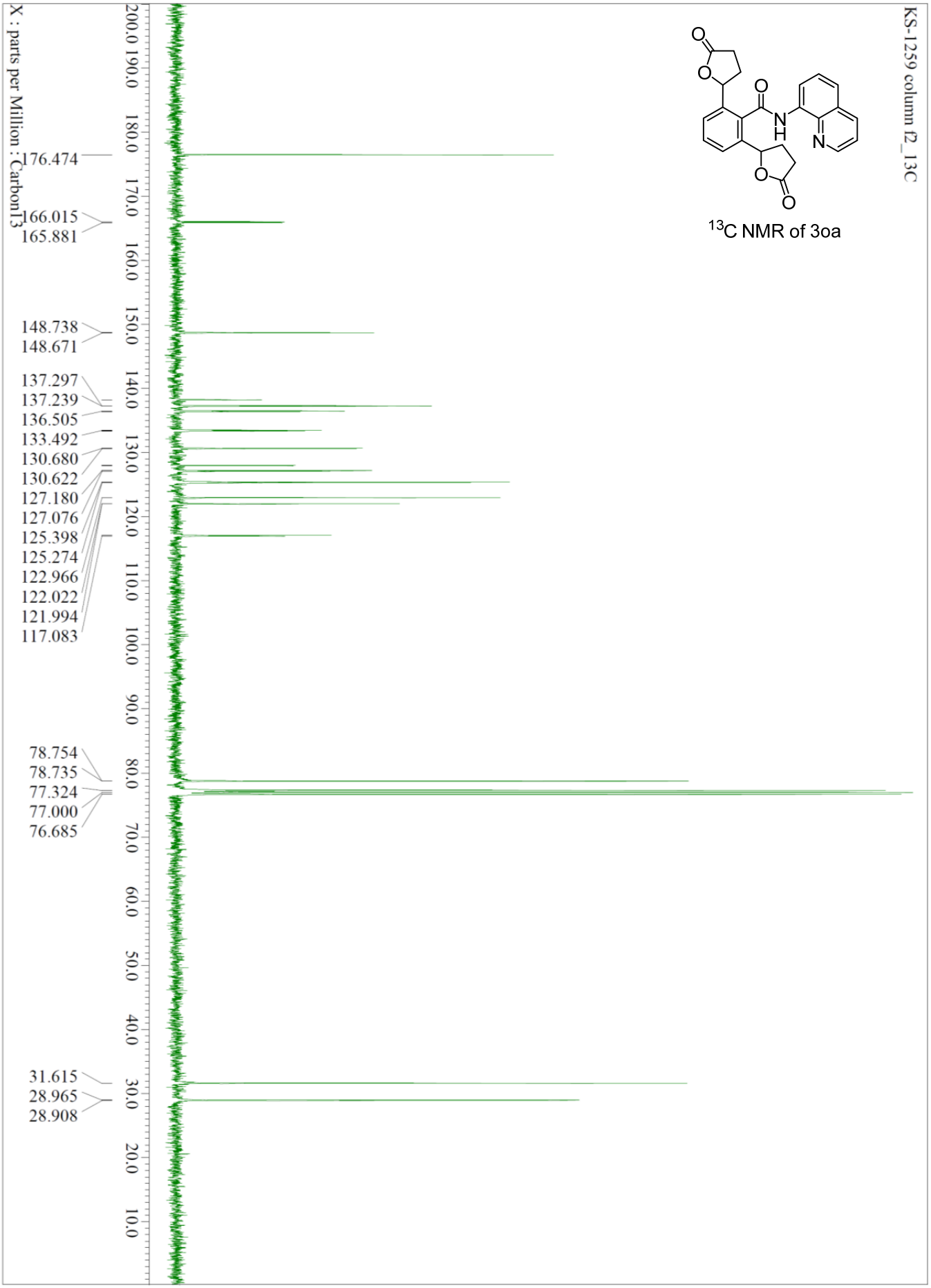

KS-1184 GPC1
X : parts per Million : Proton
10.552
8.880
8.876
8.812
8.809
8.802
8.799
8.307
8.179
8.072
7.890
7.608
7.590
7.584
7.571
6.330
6.311
6.293
3.070
3.052
3.034
3.020
3.001
2.983
2.660
2.638
2.304
2.281
2.270
2.262
2.247
2.239
2.229
-0.000
0.971
1.003
1.011
0.997
1.000
1.003
1.032
4.059
0.992
1.003
1.003
1.995
1.003
O
N
H
N
O
O
1H NMR of 3na



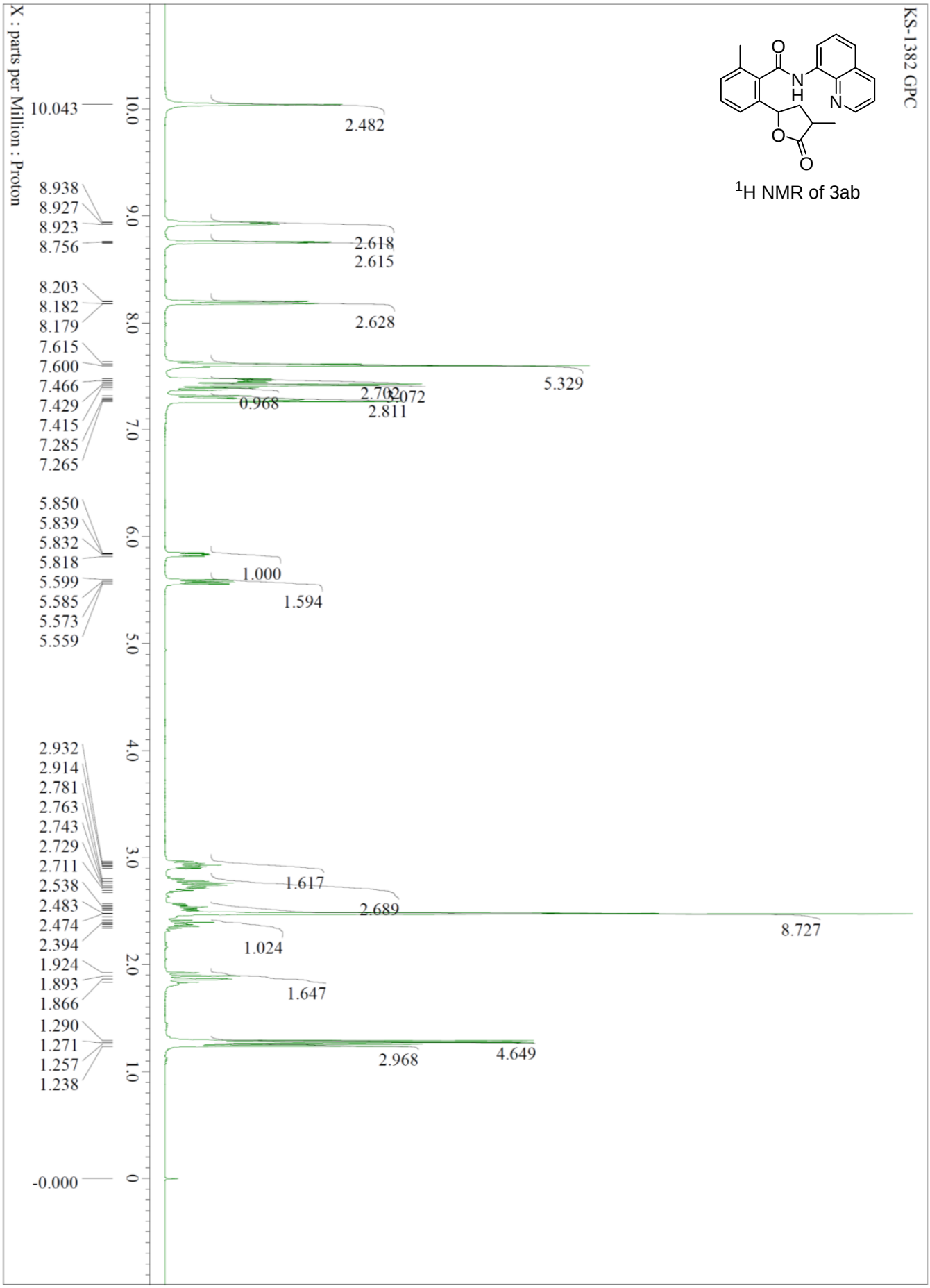
^{13}C NMR of 3na


KS-1259 column f2
X : parts per Million : Proton
10.159
10.085
1.000
1.148
8.886
8.883
8.770
8.766
8.756
2.316
2.247
8.229
8.219
8.209
2.316
7.639
7.635
7.631
7.623
7.584
7.572
7.558
2.198
11.556
5.754
5.748
5.737
5.732
5.715
5.709
4.484
2.749
2.739
2.732
2.642
2.632
2.608
2.590
2.583
13.726
2.292
2.284
2.267
2.260
2.251
2.242
2.219
4.395
-0.000
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
O
O
O
N
H
N
O
O

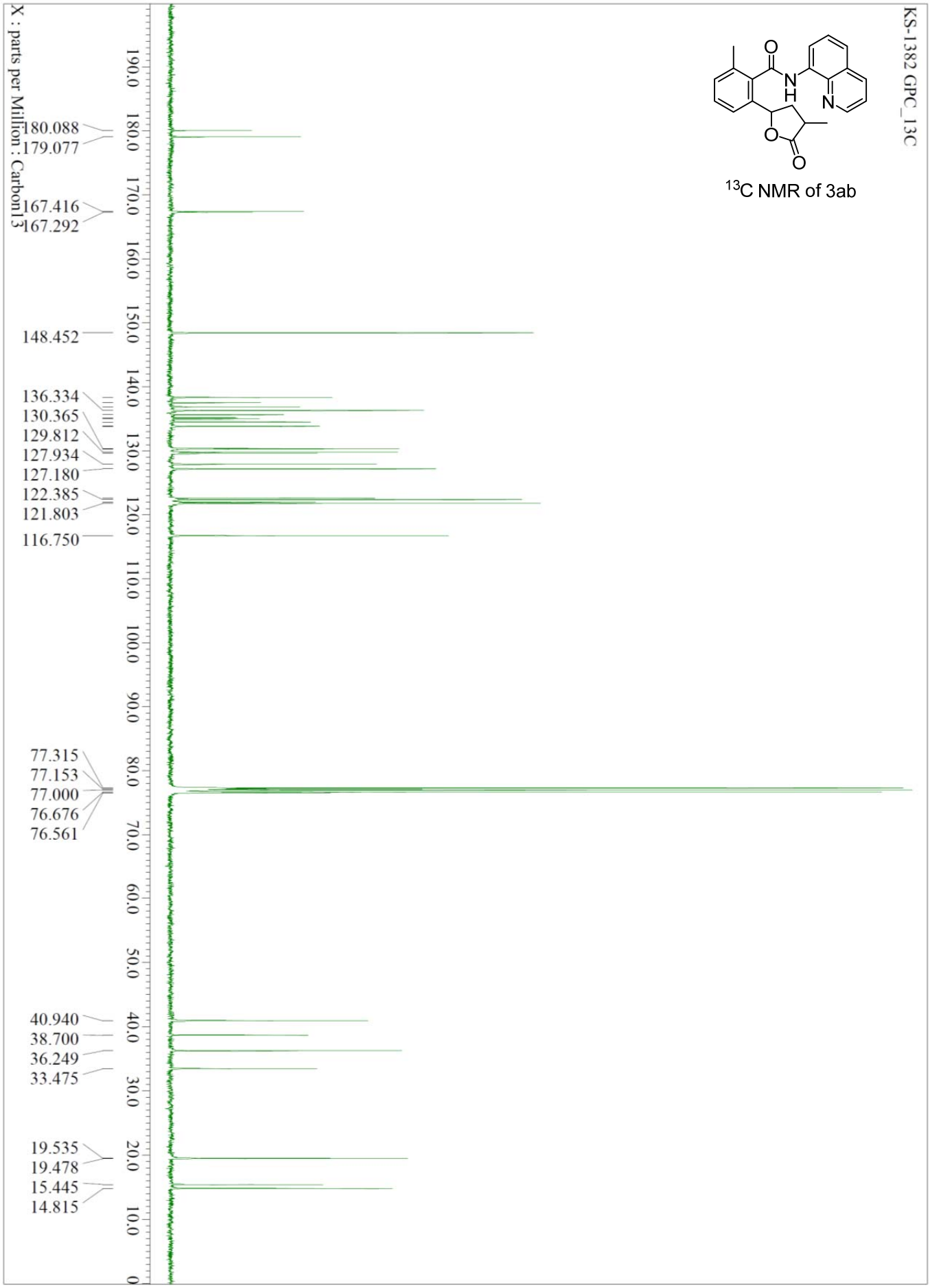
^{1}H NMR of 3oa



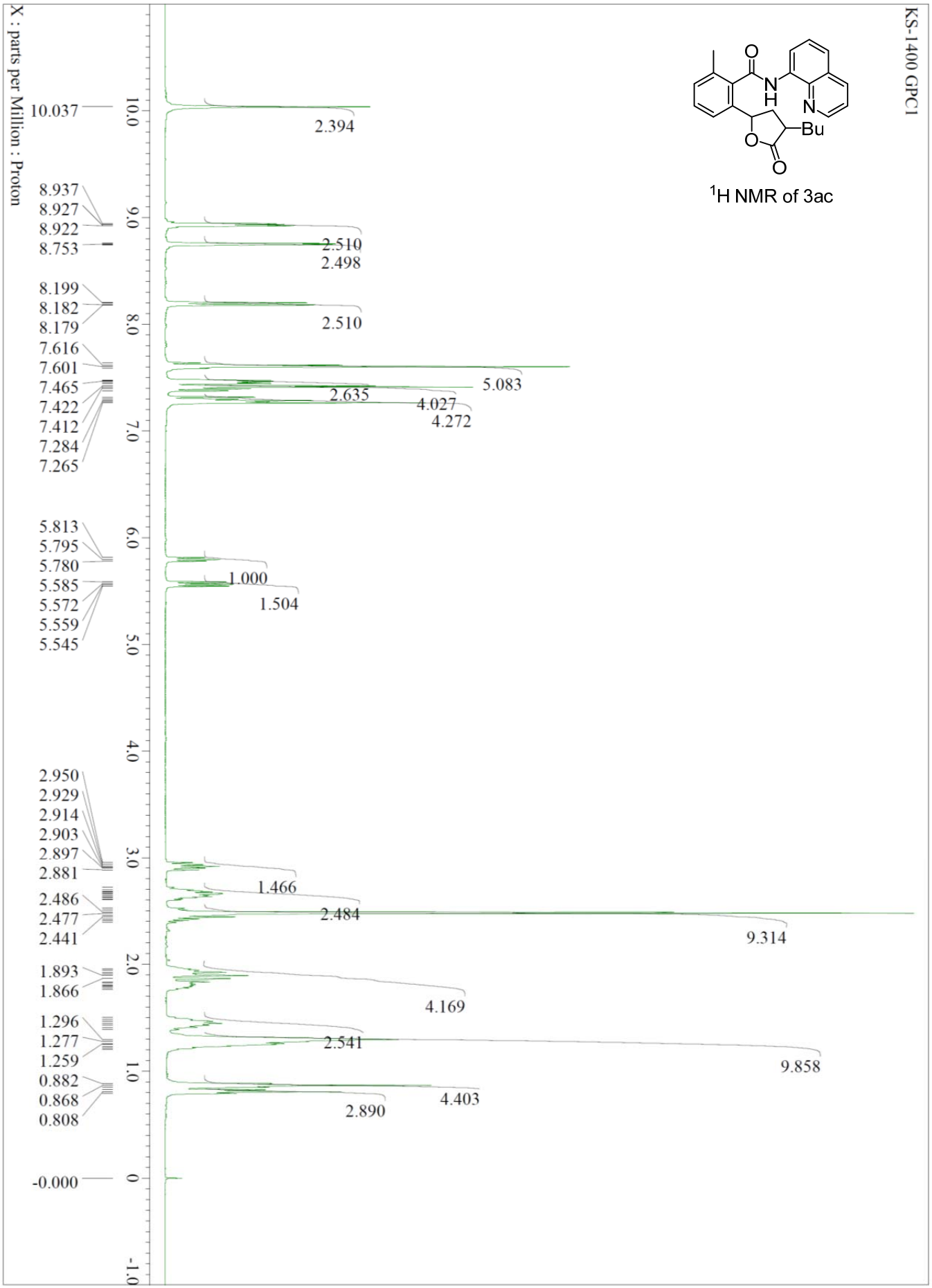
^{13}C NMR of 3oa

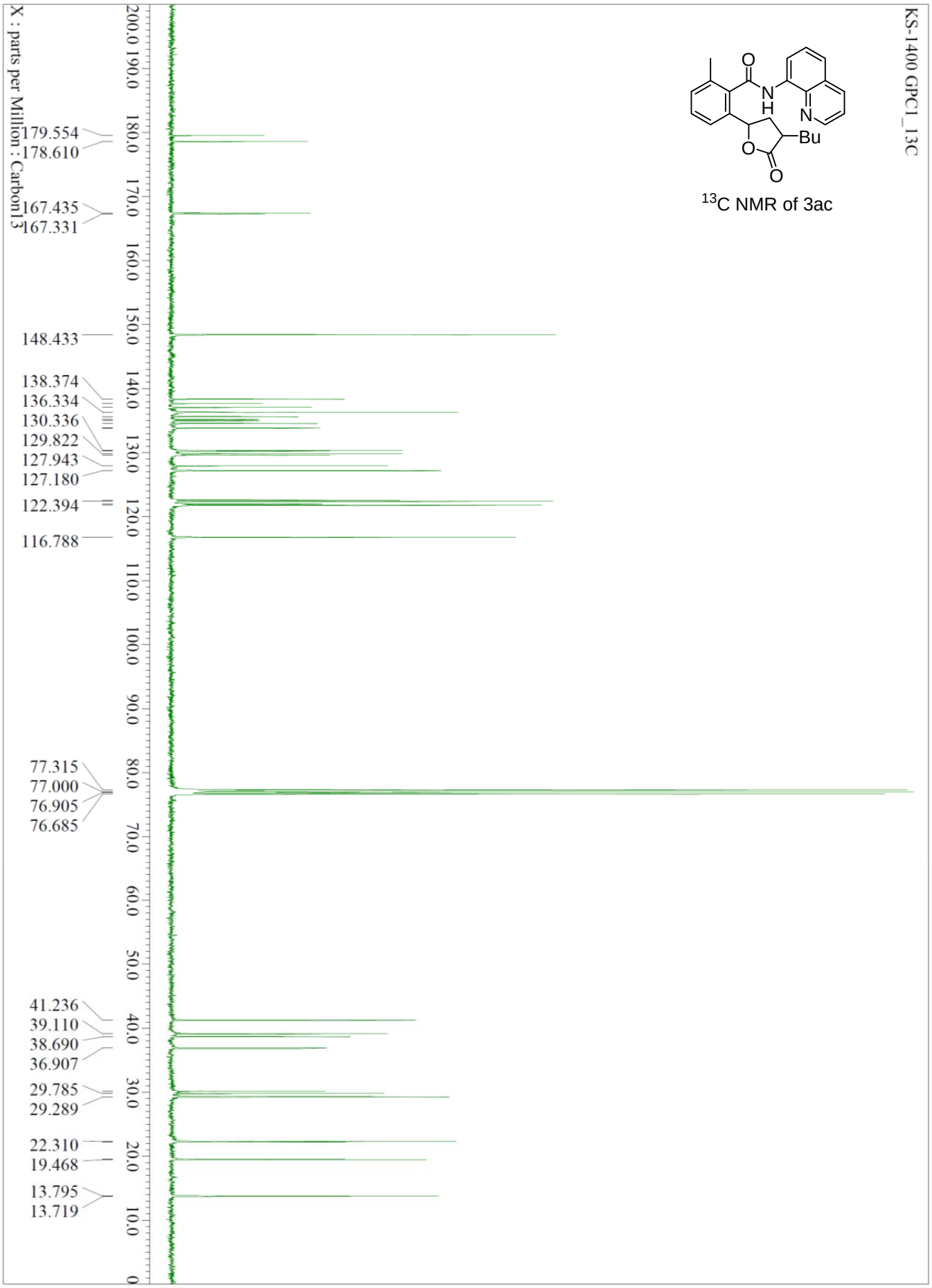

KS-1382 GPC
X : parts per Million : Proton
10.043
8.938
8.927
8.923
8.756
8.203
8.182
8.179
7.615
7.600
7.466
7.429
7.415
7.285
7.265
5.850
5.839
5.832
5.818
5.599
5.585
5.573
5.559
2.932
2.914
2.781
2.763
2.743
2.729
2.711
2.538
2.483
2.474
2.394
1.924
1.893
1.866
1.290
1.271
1.257
1.238
-0.000
2.482
2.618
2.615
2.628
5.329
0.968
2.702
2.072
2.811
1.000
1.594
1.617
2.689
8.727
1.024
1.647
2.968
4.649
O
N
H
N
O
O

^{1}H NMR of 3ab

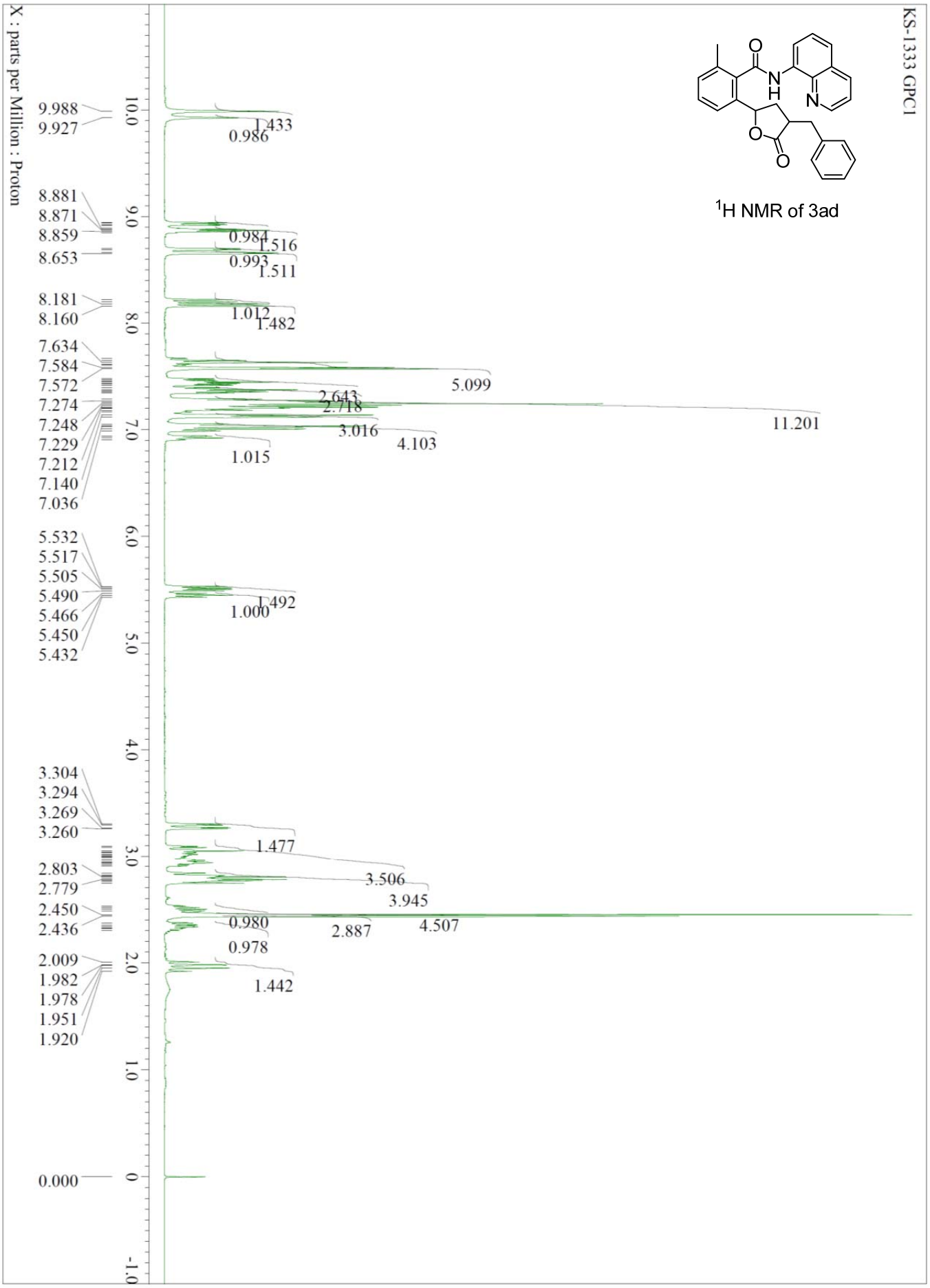


^{13}C NMR of 3ab

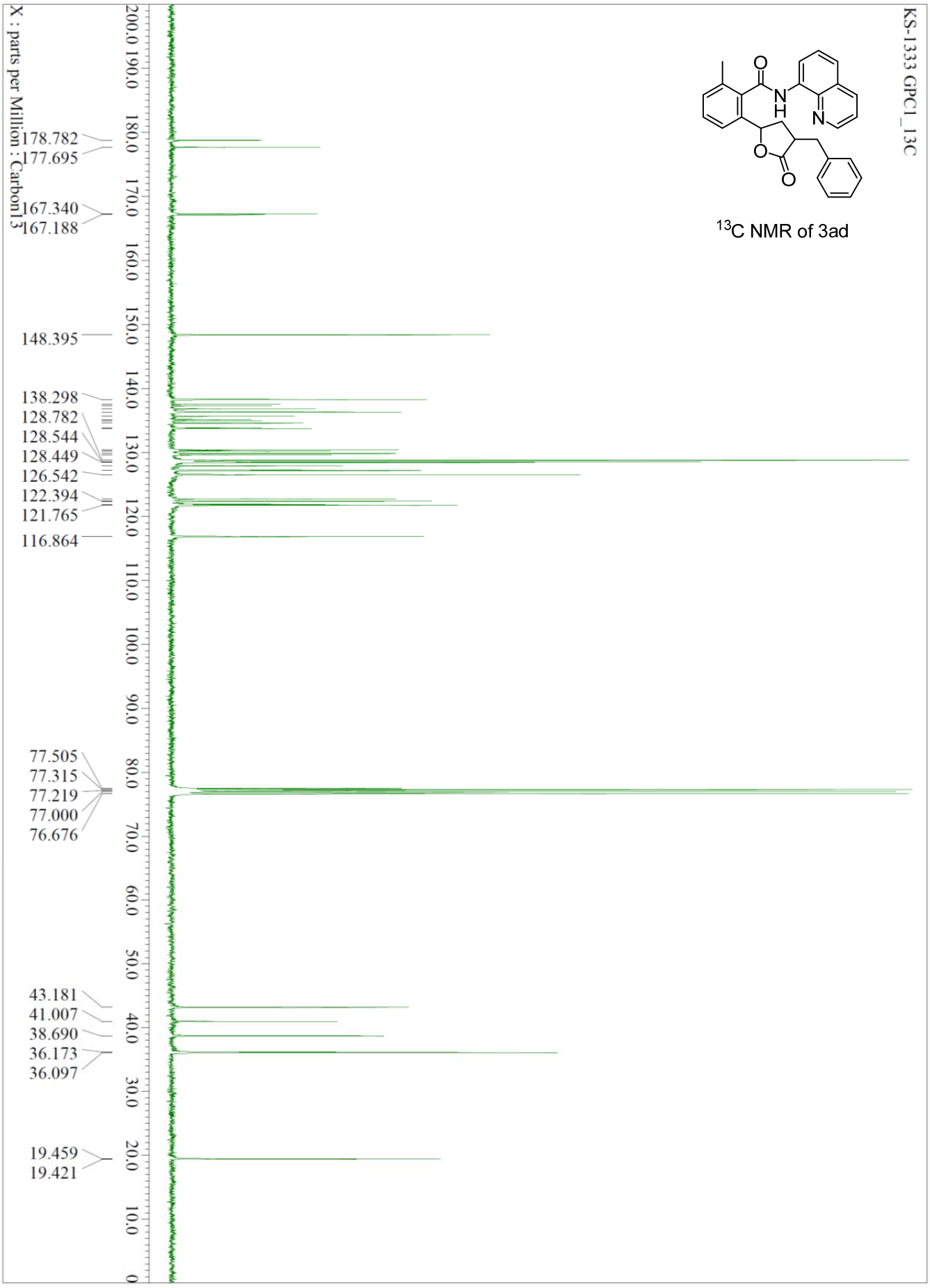

KS-1400 GPC1
X : parts per Million : Proton
10.037
8.937
8.927
8.922
8.753
8.199
8.182
8.179
7.616
7.601
7.465
7.422
7.412
7.284
7.265
5.813
5.795
5.780
5.585
5.572
5.559
5.545
2.950
2.929
2.914
2.903
2.897
2.881
2.486
2.477
2.441
1.893
1.866
1.296
1.277
1.259
0.882
0.868
0.808
-0.000
2.394
2.510
2.498
2.510
5.083
2.635
4.027
4.272
1.000
1.504
1.466
2.484
9.314
4.169
2.541
9.858
4.403
2.890
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
O
N
H
N
Bu
O
O
1H NMR of 3ac



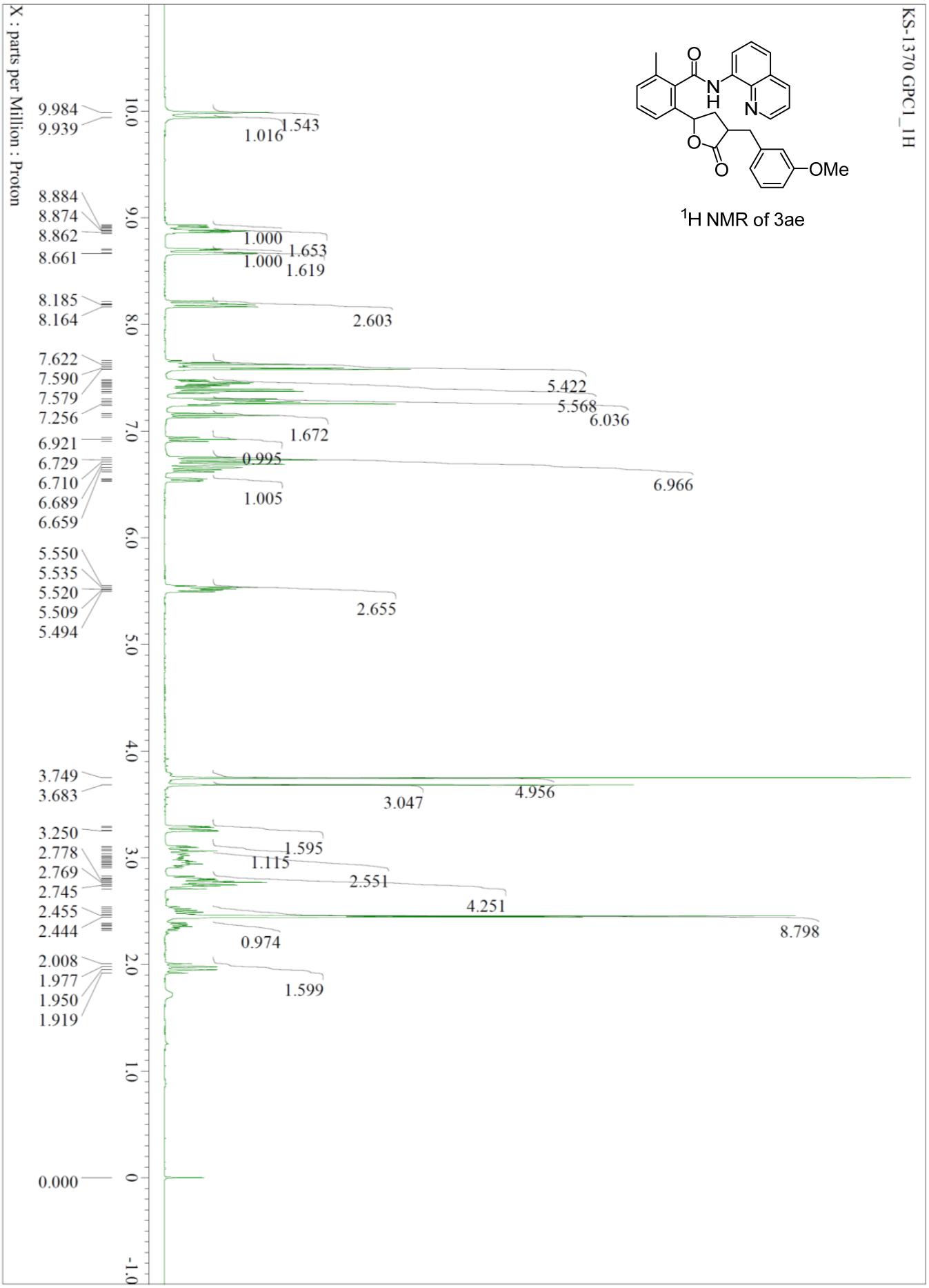
^{13}C NMR of 3ac


KS-1333 GPC1
X : parts per Million : Proton
9.988
9.927
8.881
8.871
8.859
8.653
8.181
8.160
7.634
7.584
7.572
7.274
7.248
7.229
7.212
7.140
7.036
5.532
5.517
5.505
5.490
5.466
5.450
5.432
3.304
3.294
3.269
3.260
2.803
2.779
2.450
2.436
2.009
1.982
1.978
1.951
1.920
0.000
1.433
0.986
0.984
1.516
0.993
1.511
1.012
1.482
5.099
2.643
2.718
11.201
3.016
4.103
1.015
1.492
1.000
1.477
3.506
3.945
0.980
2.887
4.507
0.978
1.442
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

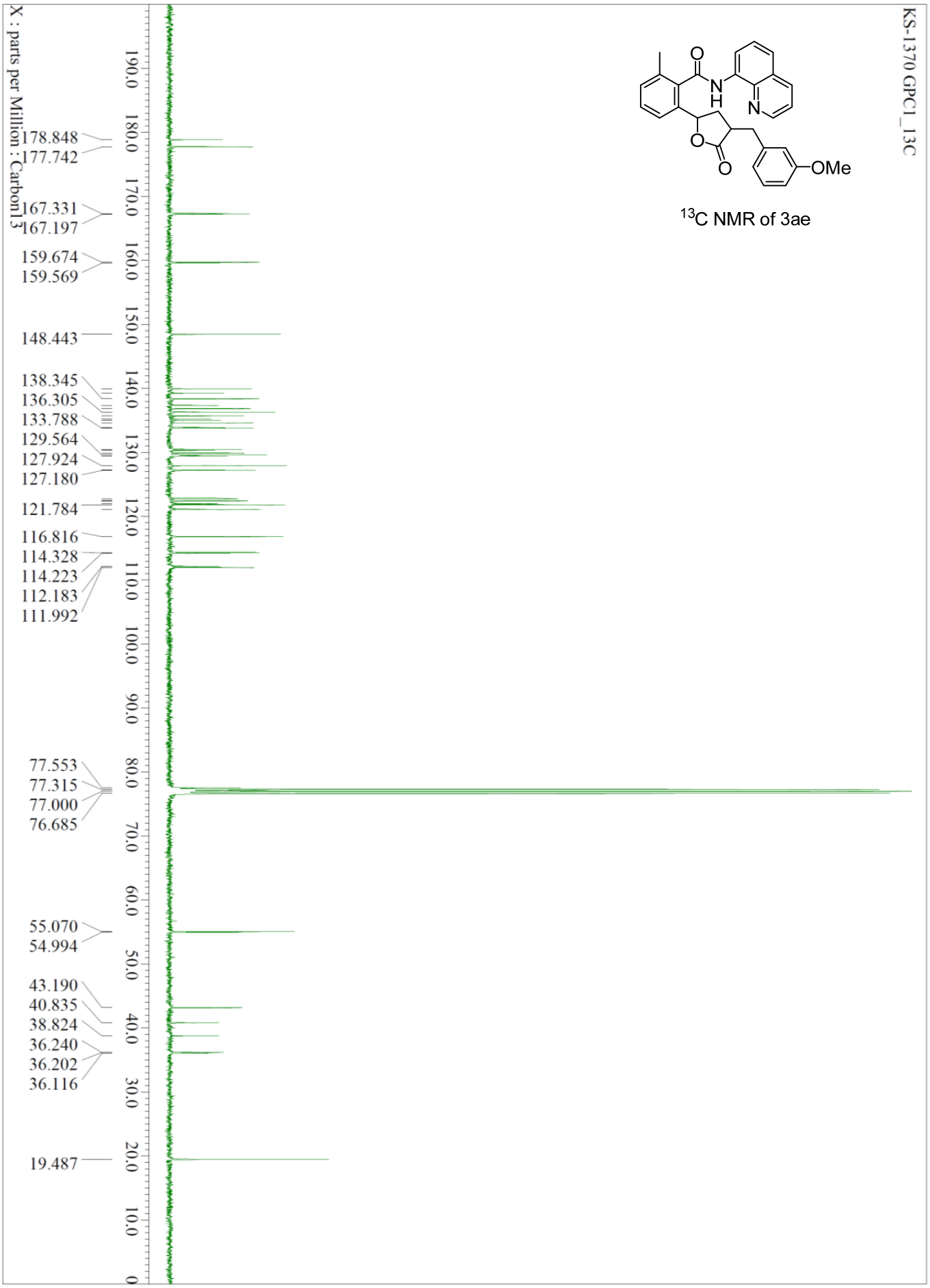
^{1}H NMR of 3ad



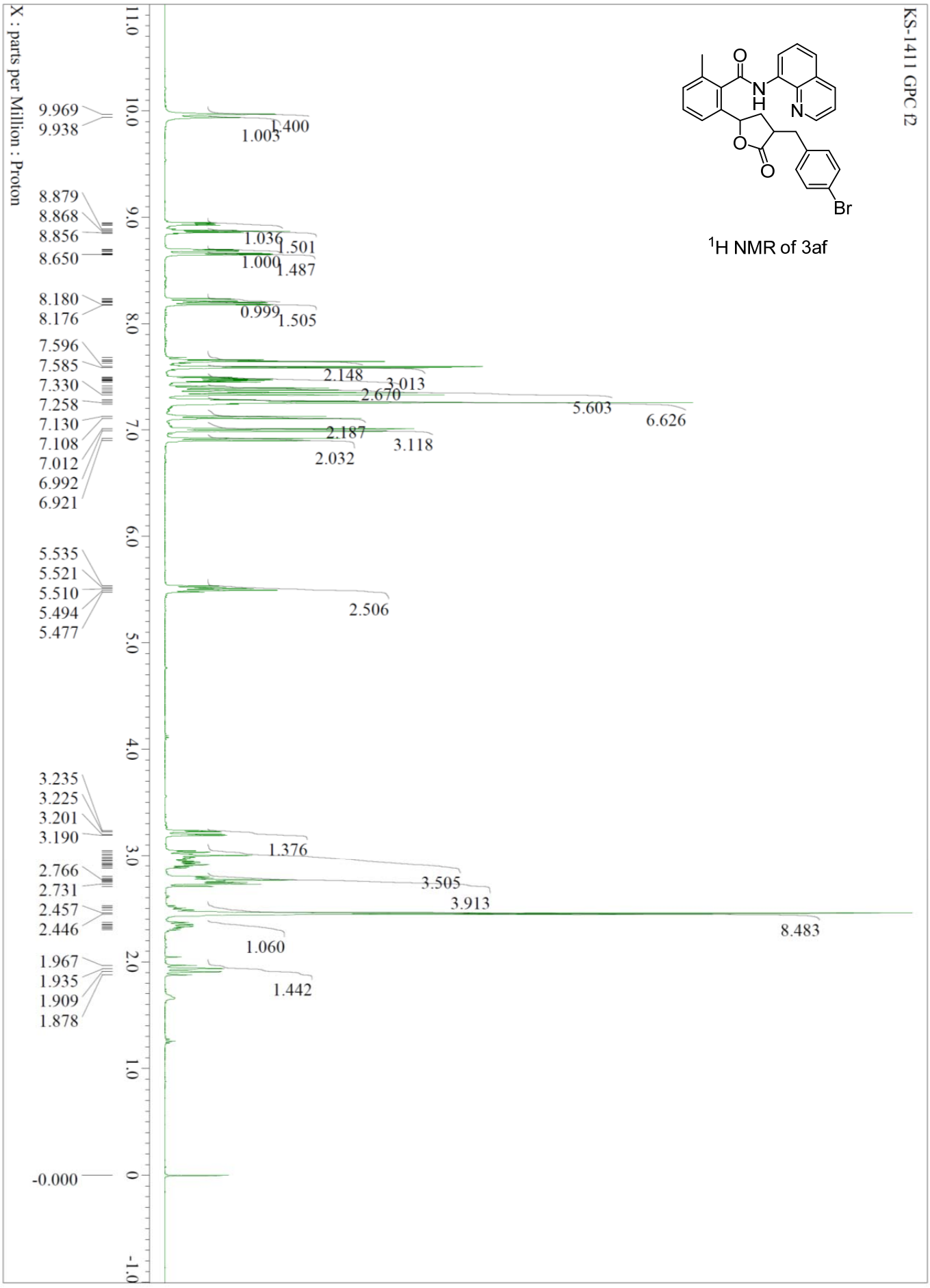
^{13}C NMR of 3ad

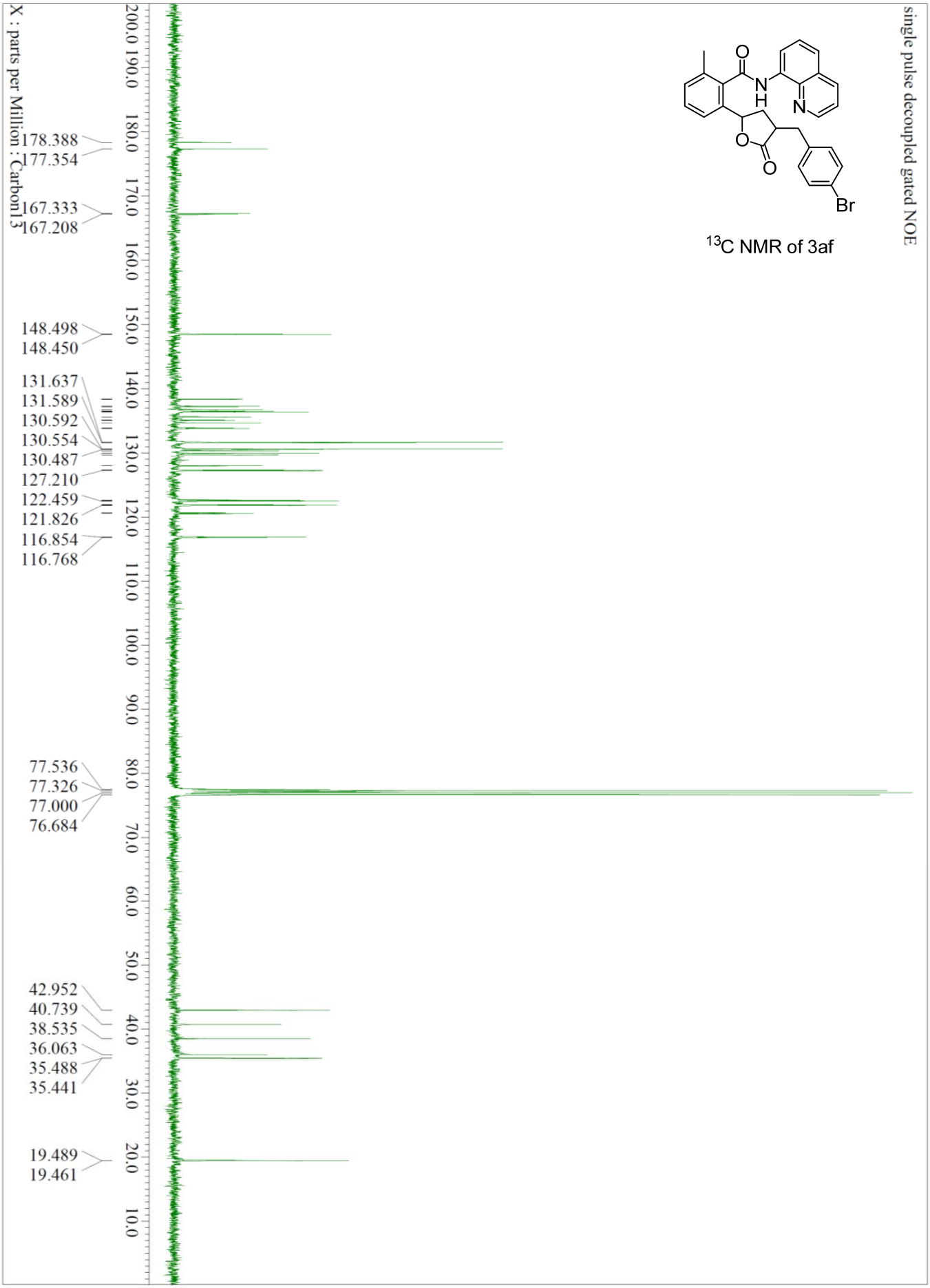

KS-1370 GPC1_1H
X : parts per Million : Proton
9.984
9.939
8.884
8.874
8.862
8.661
8.185
8.164
7.622
7.590
7.579
7.256
6.921
6.729
6.710
6.689
6.659
5.550
5.535
5.520
5.509
5.494
3.749
3.683
3.250
2.778
2.769
2.745
2.455
2.444
2.008
1.977
1.950
1.919
0.000
1.016
1.543
1.000
1.653
1.000
1.619
2.603
5.422
5.568
6.036
1.672
0.995
6.966
1.005
2.655
3.047
4.956
1.595
1.115
2.551
4.251
8.798
0.974
1.599
O
N
H
N
O
O
OMe

^{1}H NMR of 3ae

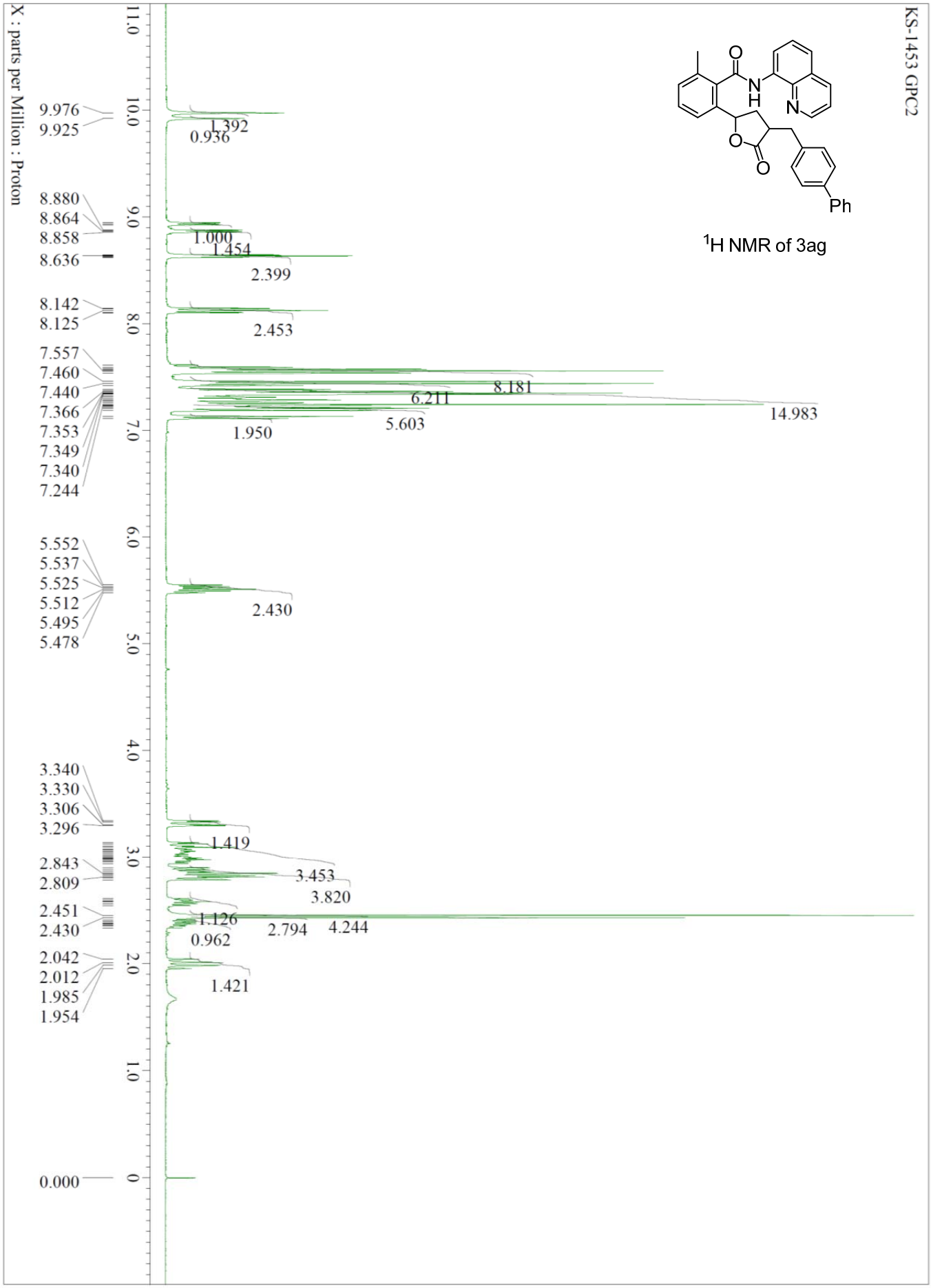


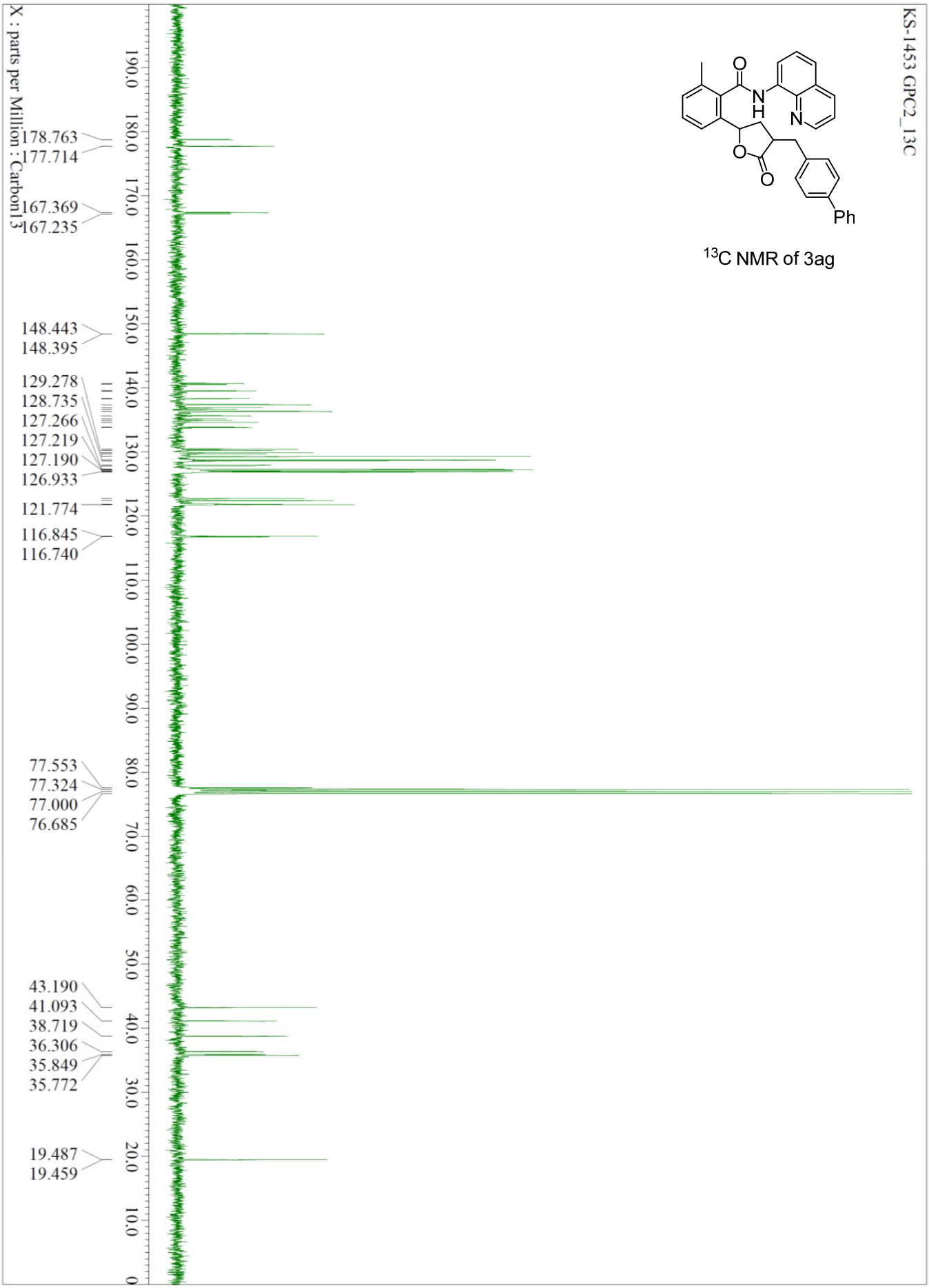
^{13}C NMR of 3ae


KS-1411 GPC f2
X : parts per Million : Proton
9.969
9.938
8.879
8.868
8.856
8.650
8.180
8.176
7.596
7.585
7.330
7.258
7.130
7.108
7.012
6.992
6.921
5.535
5.521
5.510
5.494
5.477
3.235
3.225
3.201
3.190
2.766
2.731
2.457
2.446
1.967
1.935
1.909
1.878
-0.000
1.003
1.400
1.036
1.501
1.000
1.487
0.999
1.505
2.148
3.013
2.670
5.603
6.626
2.187
3.118
2.032
2.506
1.376
3.505
3.913
8.483
1.060
1.442
O
N
H
N
O
O
Br
^{1}H NMR of 3af

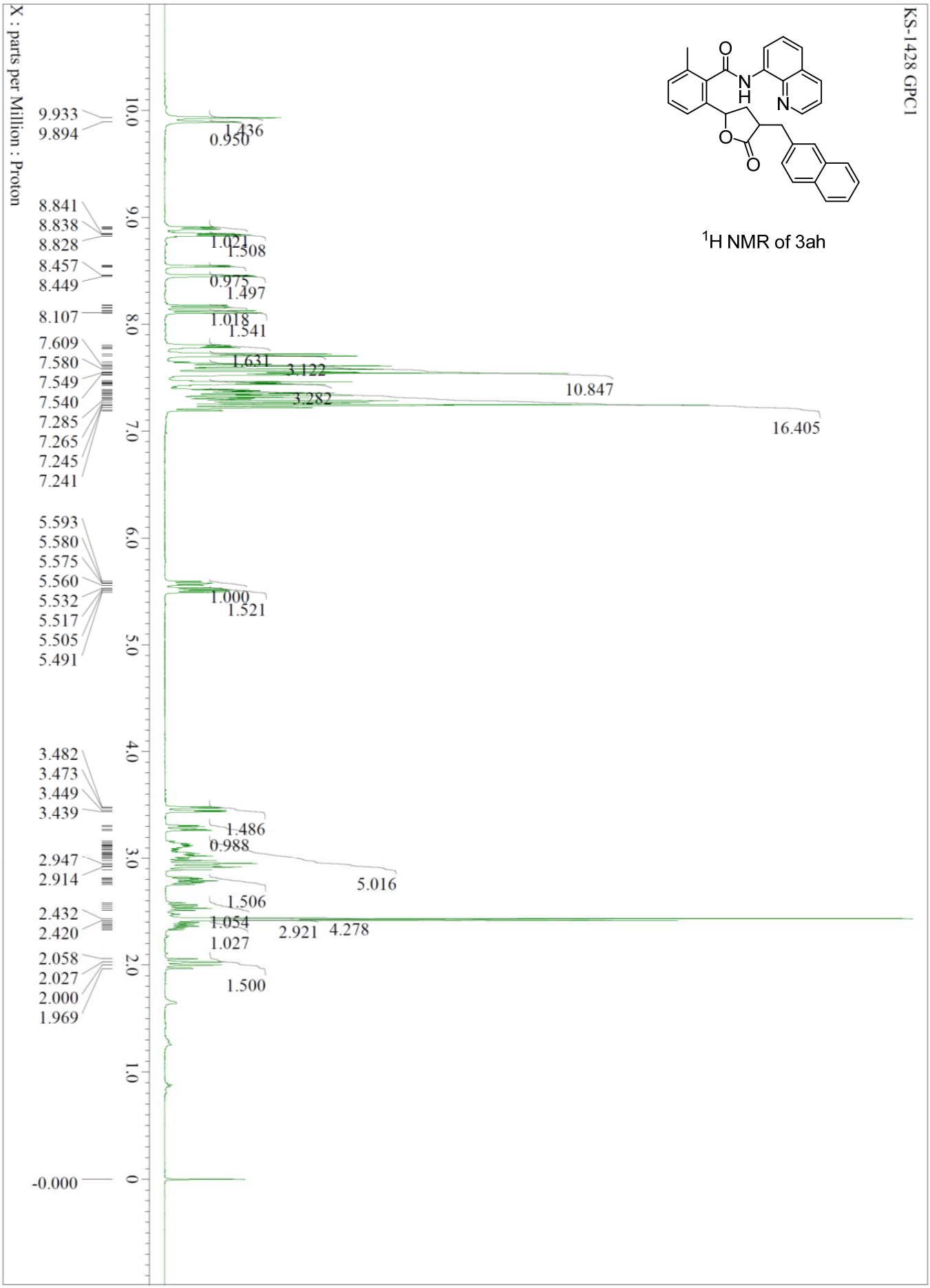


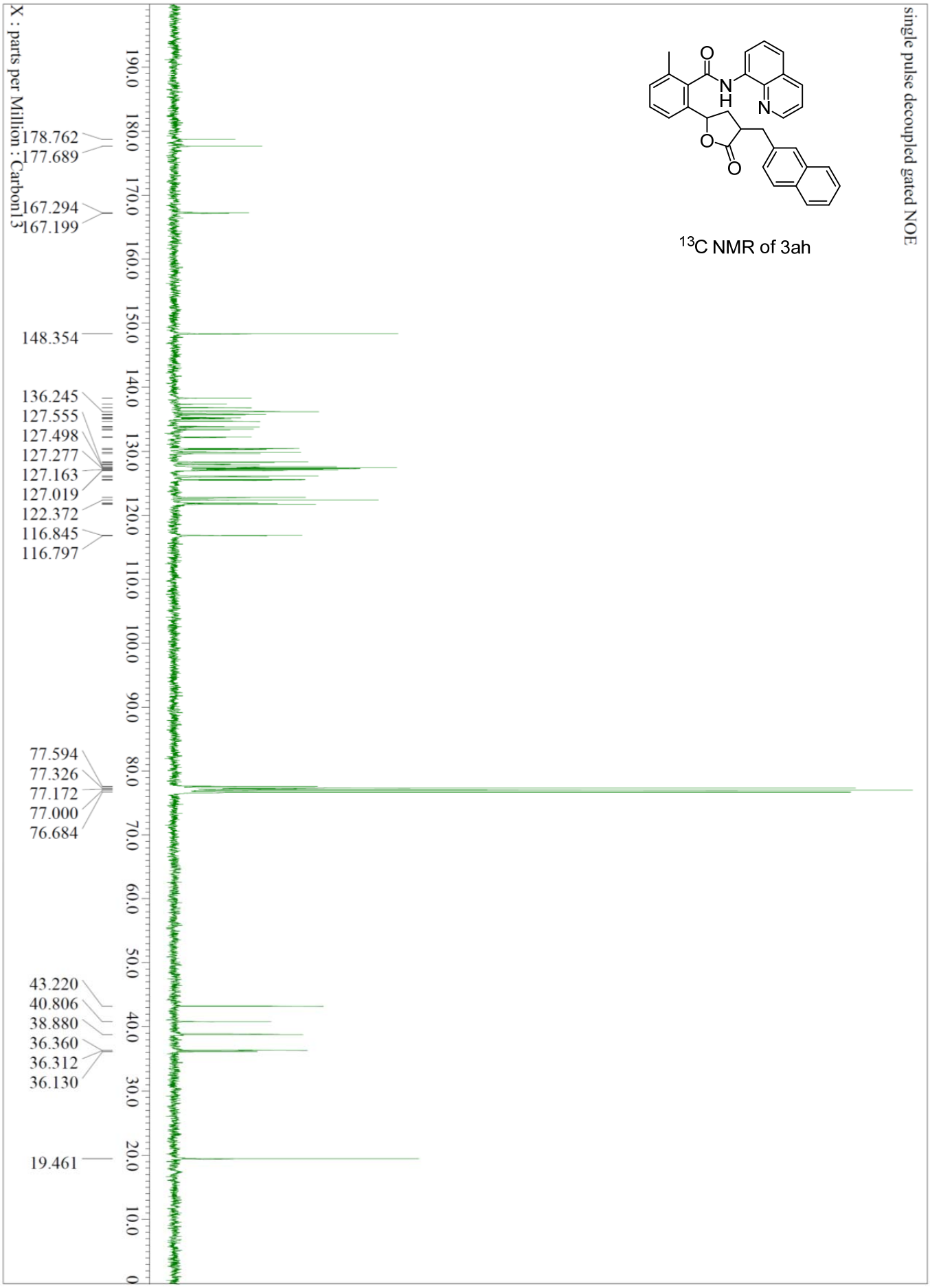
^{13}C NMR of 3af


KS-1453 GPC2
X : parts per Million : Proton
9.976
9.925
8.880
8.864
8.858
8.636
8.142
8.125
7.557
7.460
7.440
7.366
7.353
7.349
7.340
7.244
5.552
5.537
5.525
5.512
5.495
5.478
3.340
3.330
3.306
3.296
2.843
2.809
2.451
2.430
2.042
2.012
1.985
1.954
0.000
1.392
0.936
1.000
1.454
2.399
2.453
8.181
6.211
14.983
5.603
1.950
2.430
1.419
3.453
3.820
1.126
2.794
4.244
0.962
1.421
O
N
H
N
O
O
Ph
1H NMR of 3ag

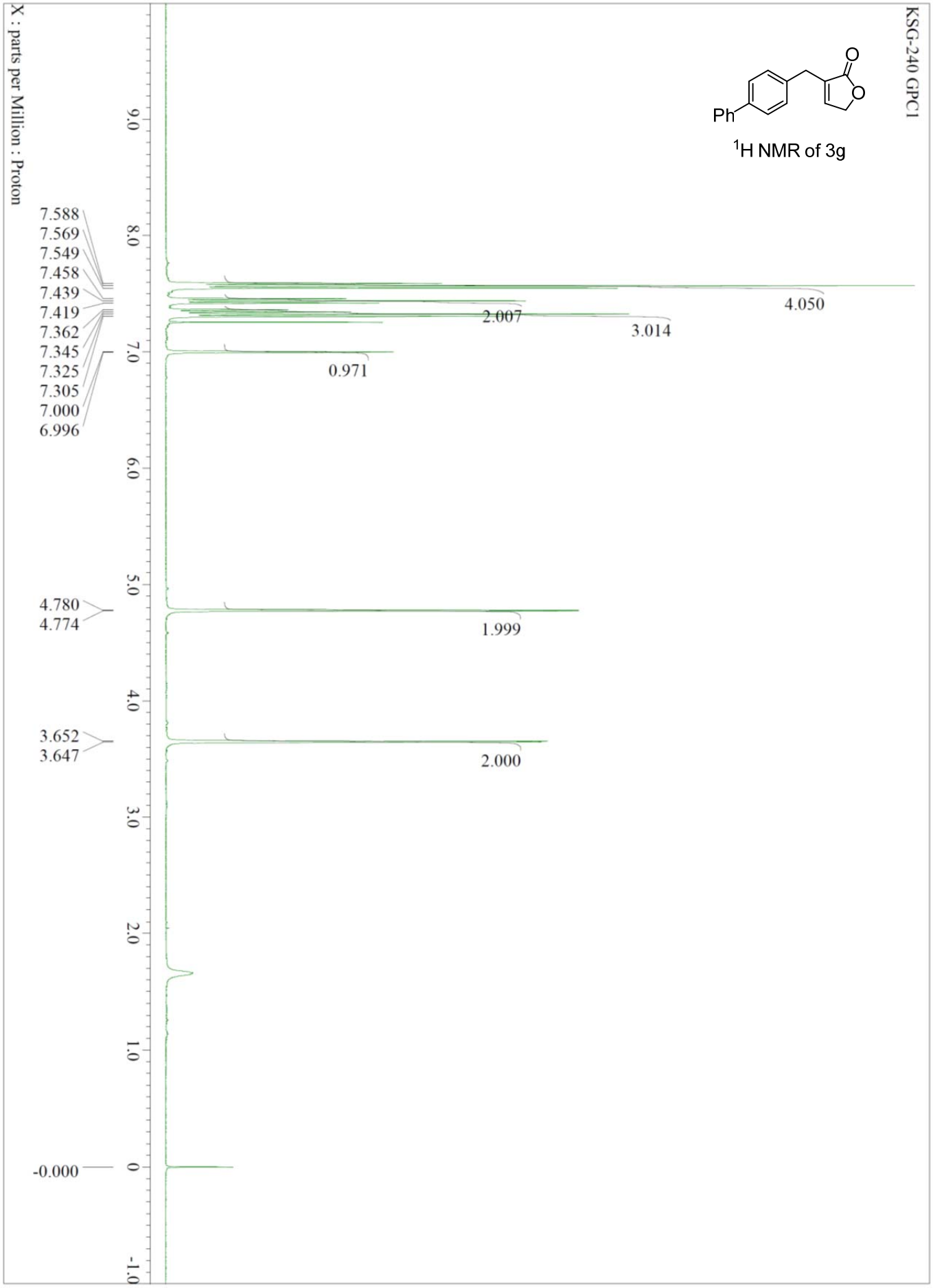


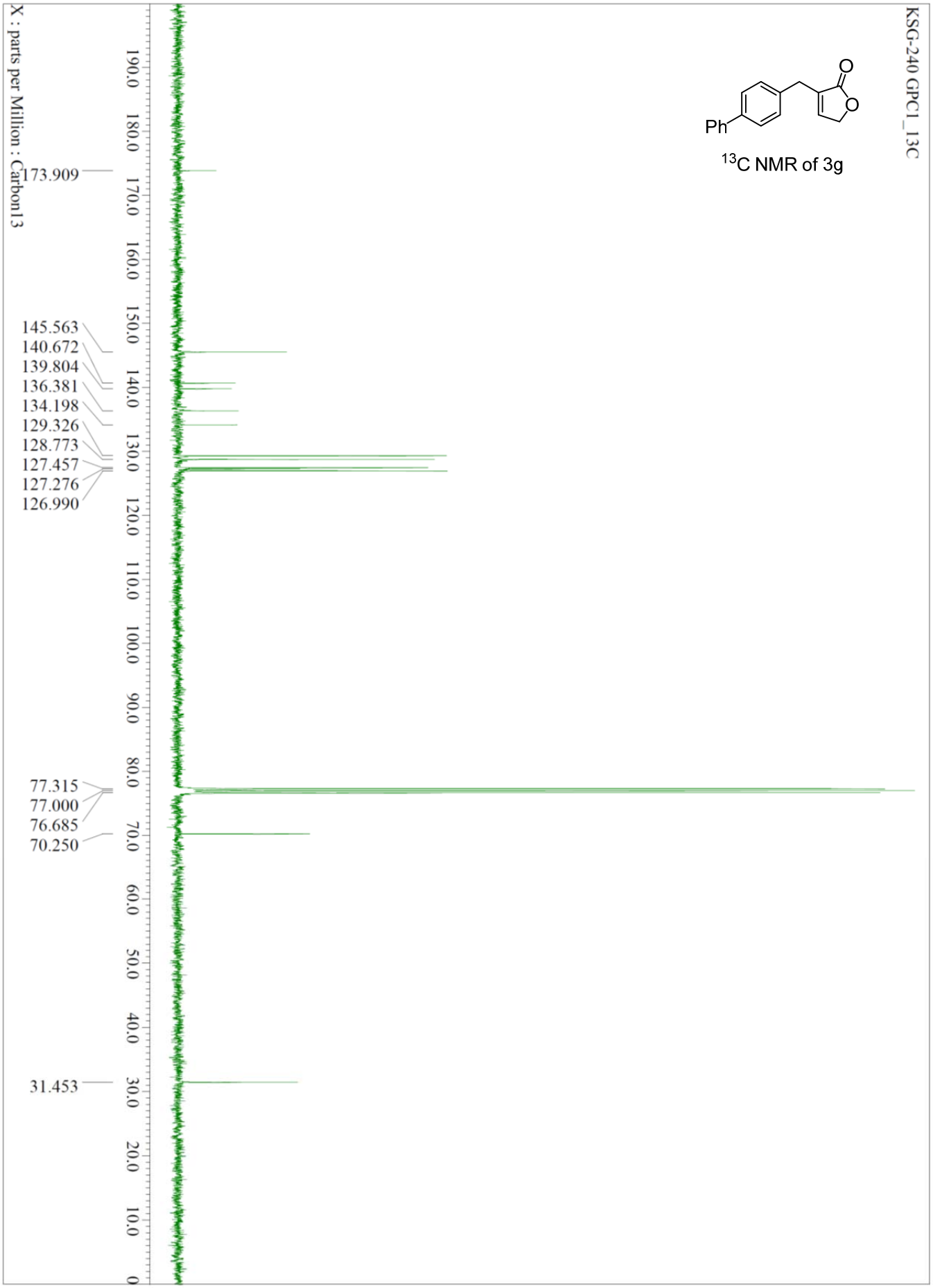
^{13}C NMR of 3ag


KS-1428 GPC1
X : parts per Million : Proton
9.933
9.894
8.841
8.838
8.828
8.457
8.449
8.107
7.609
7.580
7.549
7.540
7.285
7.265
7.245
7.241
5.593
5.580
5.575
5.560
5.532
5.517
5.505
5.491
3.482
3.473
3.449
3.439
2.947
2.914
2.432
2.420
2.058
2.027
2.000
1.969
-0.000
1.436
0.950
1.021
1.508
0.975
1.497
1.018
1.541
1.631
3.122
10.847
3.282
16.405
1.000
1.521
1.486
0.988
5.016
1.506
1.054
2.921
4.278
1.027
1.500
O
N
H
N
O
O
1H NMR of 3ah

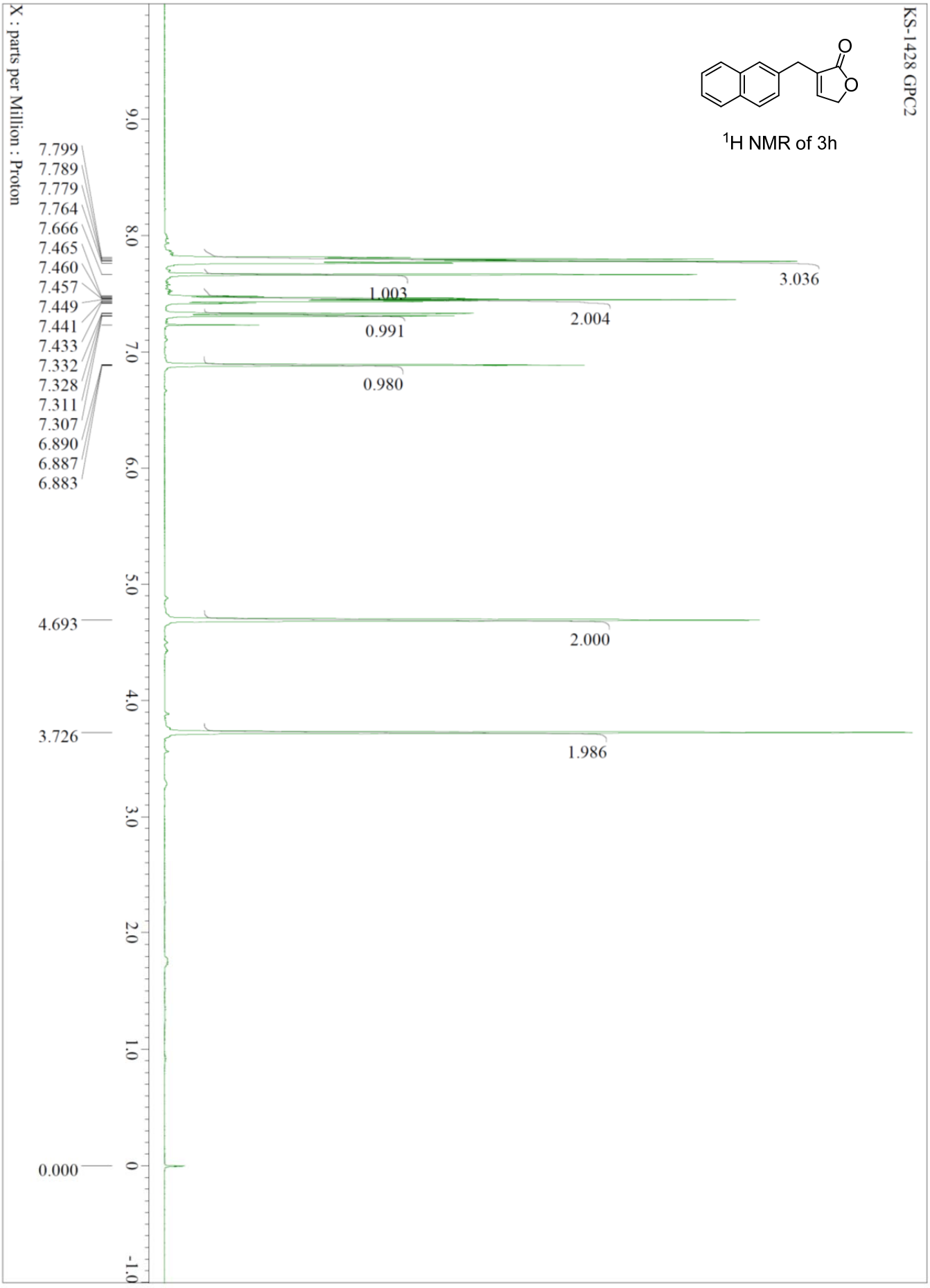


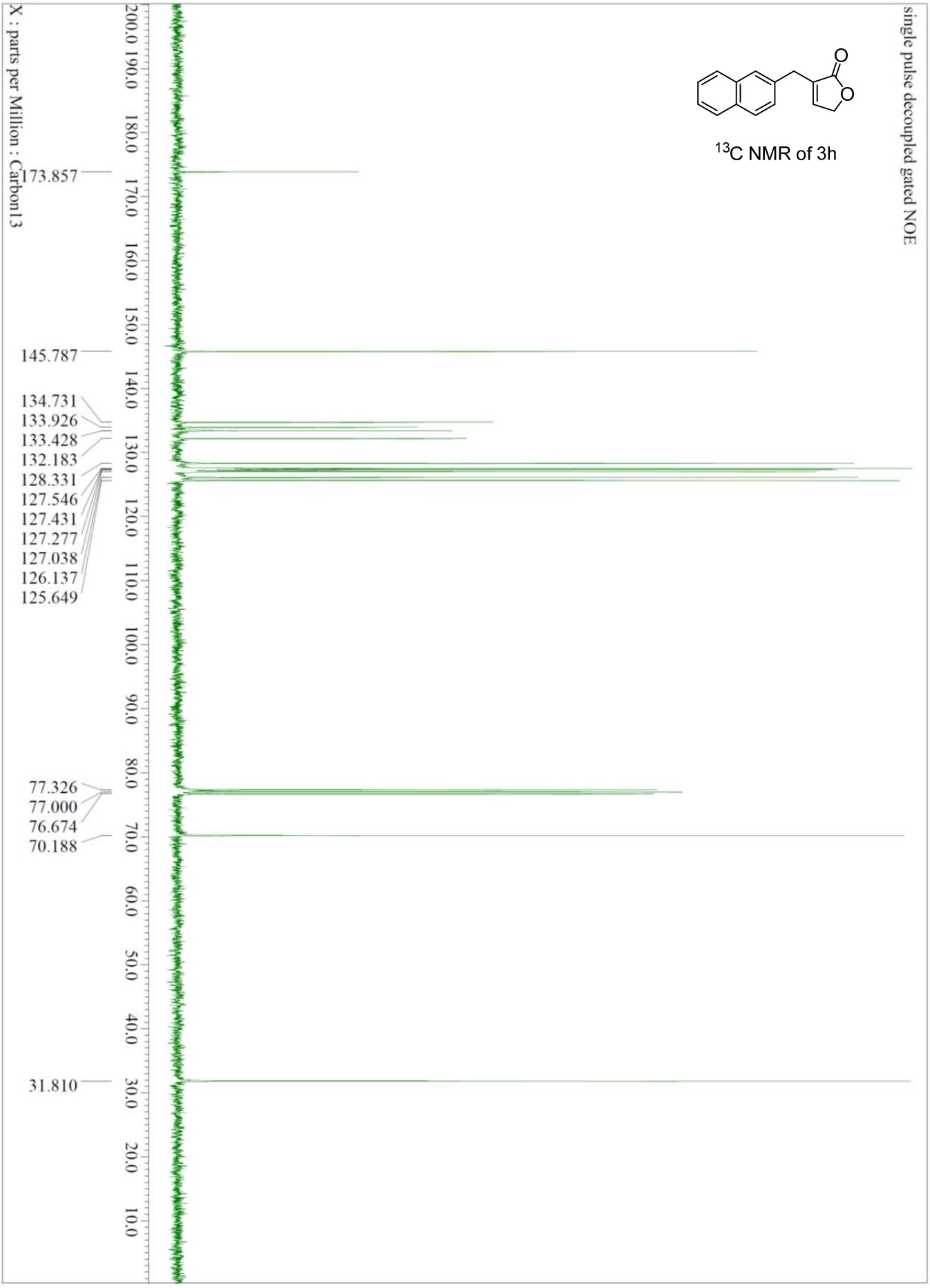
^{13}C NMR of 3ah


KSG-240 GPC1
X : parts per Million : Proton
Ph
O
O
1H NMR of 3g
7.588
7.569
7.549
7.458
7.439
7.419
7.362
7.345
7.325
7.305
7.000
6.996
4.780
4.774
3.652
3.647
-0.000
4.050
2.007
3.014
0.971
1.999
2.000
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

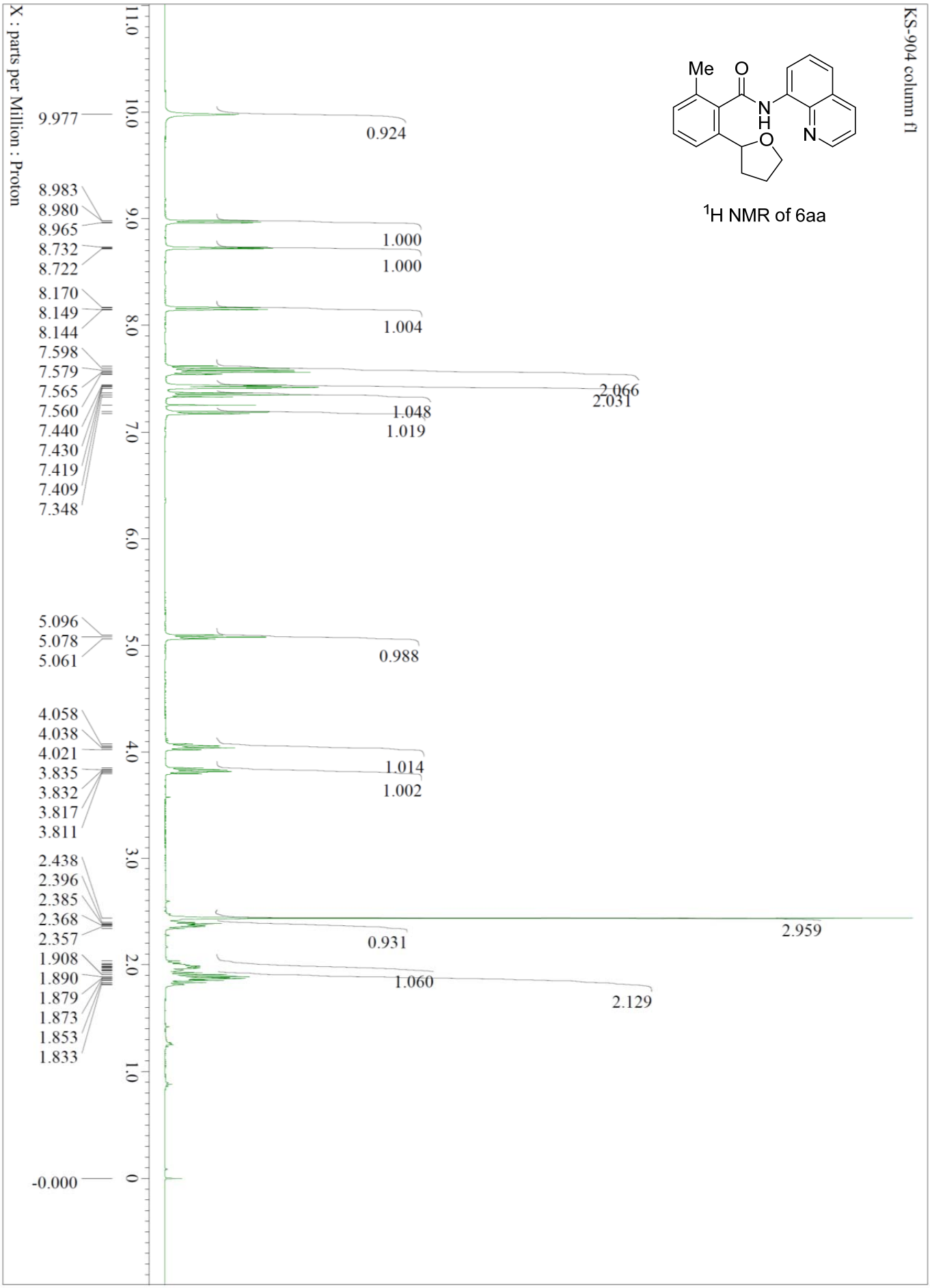

KSG-240 GPC1_13C
X : parts per Million : Carbon13
173.909
145.563
140.672
139.804
136.381
134.198
129.326
128.773
127.457
127.276
126.990
77.315
77.000
76.685
70.250
31.453
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
O
O
Ph

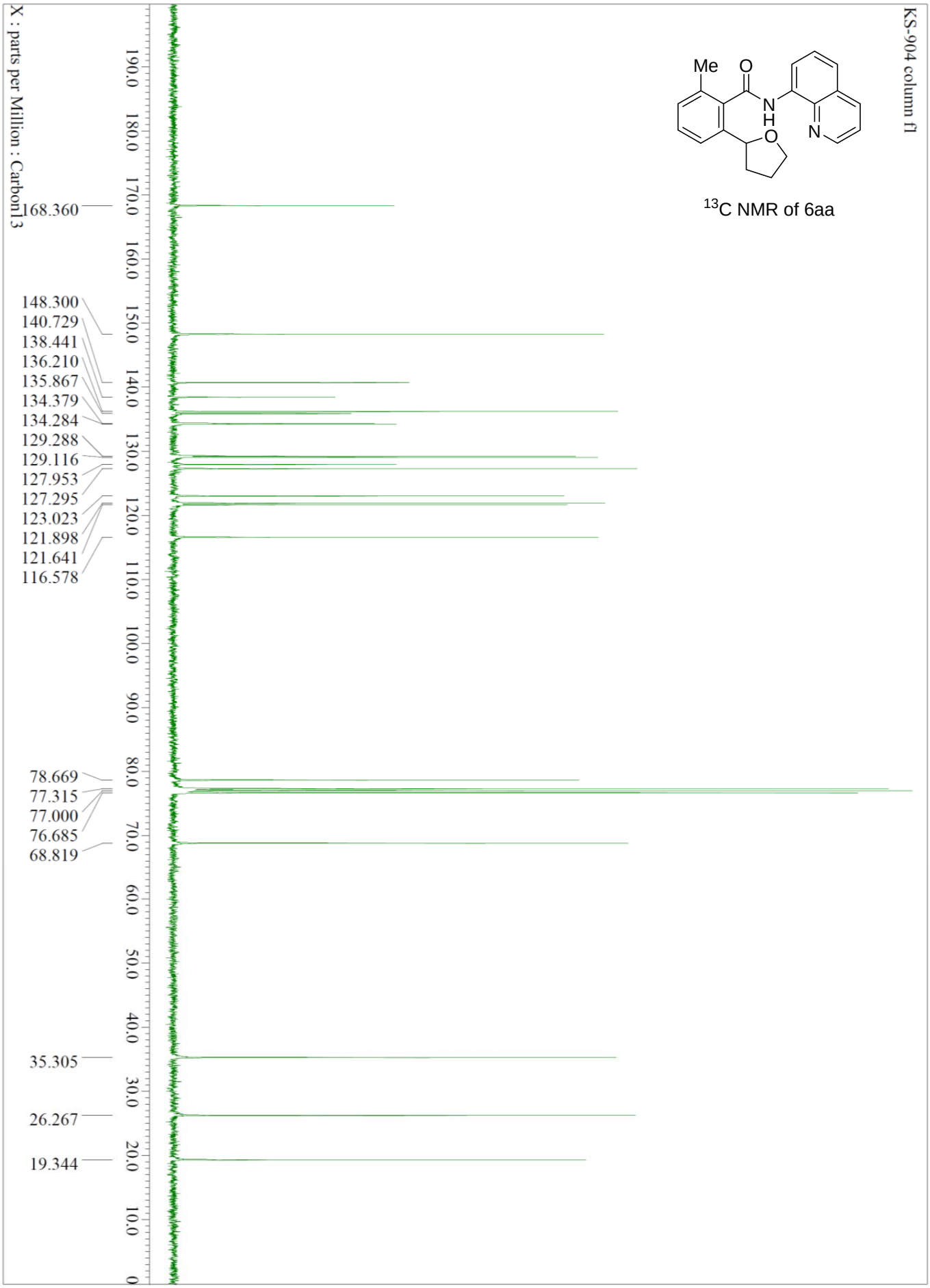
^{13}C NMR of 3g


KS-1428 GPC2
X : parts per Million : Proton
^{1}H NMR of 3h
7.799
7.789
7.779
7.764
7.666
7.465
7.460
7.457
7.449
7.441
7.433
7.332
7.328
7.311
7.307
6.890
6.887
6.883
4.693
3.726
0.000
3.036
1.003
2.004
0.991
0.980
2.000
1.986
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

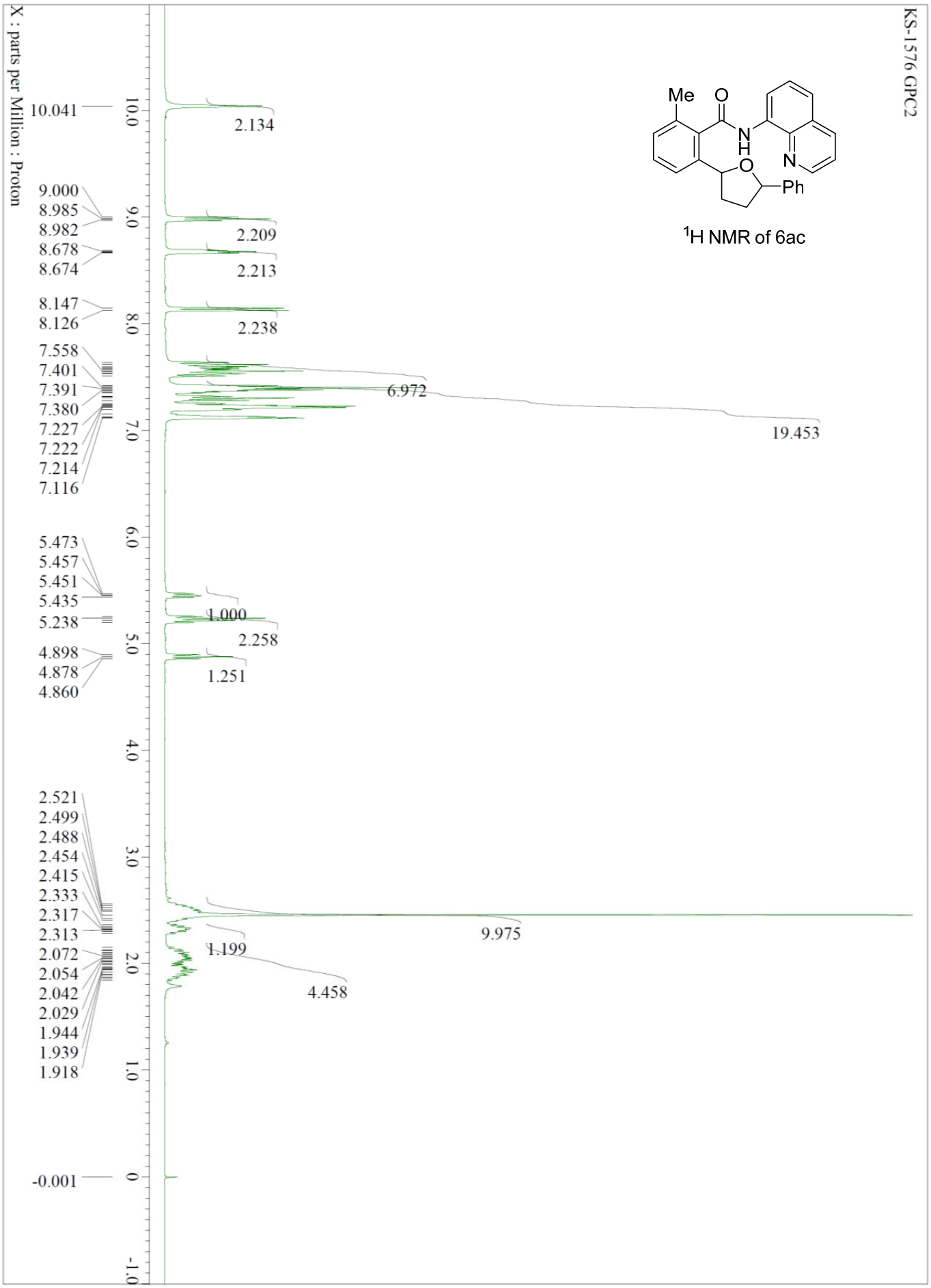

single pulse decoupled gated NOE
X : parts per Million : Carbon13
200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0
173.857
145.787
134.731
133.926
133.428
132.183
128.331
127.546
127.431
127.277
127.038
126.137
125.649
77.326
77.000
76.674
70.188
31.810
O
O

^{13}C NMR of 3h

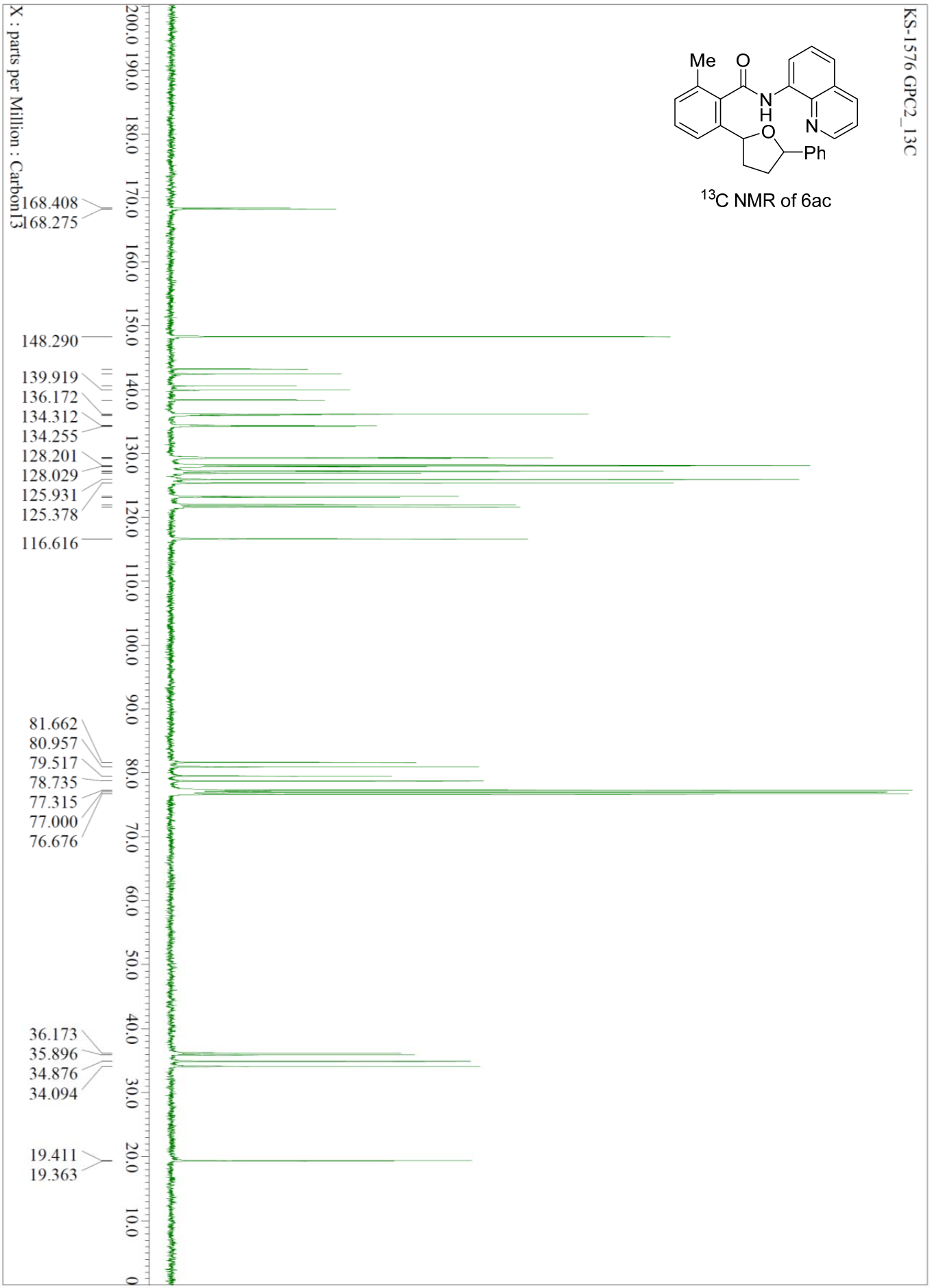

KS-904 column f1
X : parts per Million : Proton
Me
O
N
H
O
N
1H NMR of 6aa
9.977
8.983
8.980
8.965
8.732
8.722
8.170
8.149
8.144
7.598
7.579
7.565
7.560
7.440
7.430
7.419
7.409
7.348
5.096
5.078
5.061
4.058
4.038
4.021
3.835
3.832
3.817
3.811
2.438
2.396
2.385
2.368
2.357
1.908
1.890
1.879
1.873
1.853
1.833
-0.000
0.924
1.000
1.000
1.004
2.066
2.031
1.048
1.019
0.988
1.014
1.002
2.959
0.931
1.060
2.129
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0

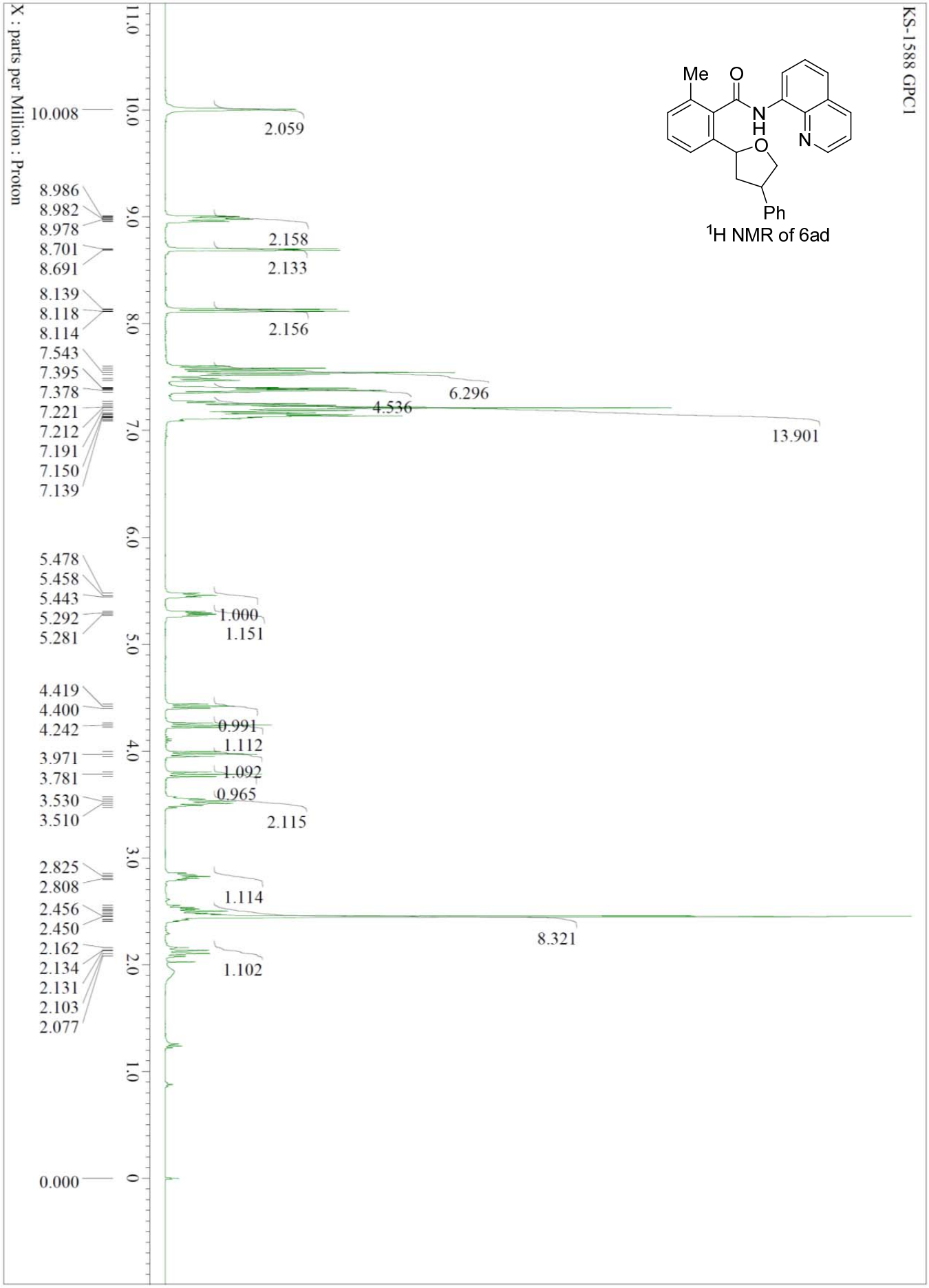


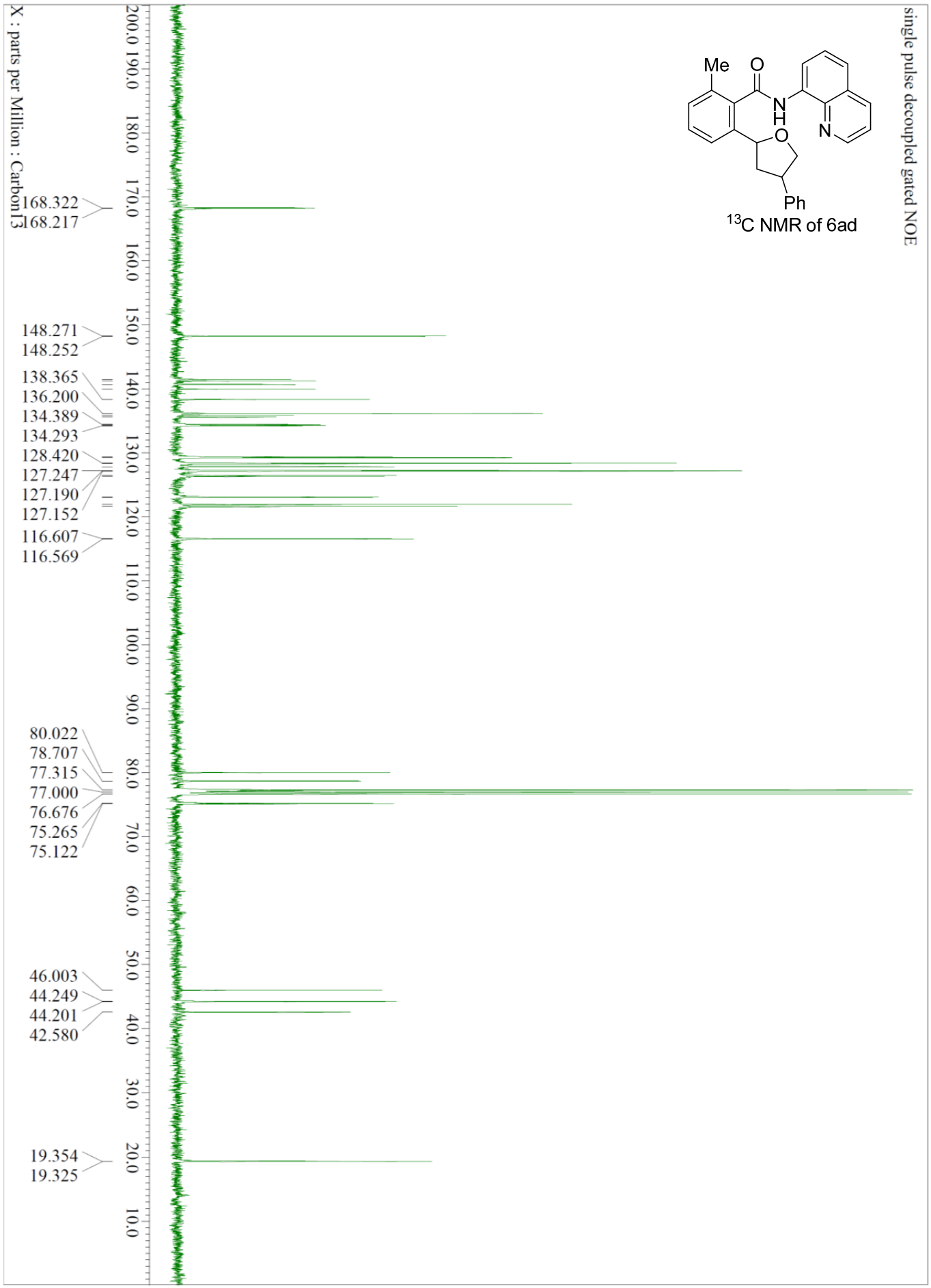
^{13}C NMR of 6aa

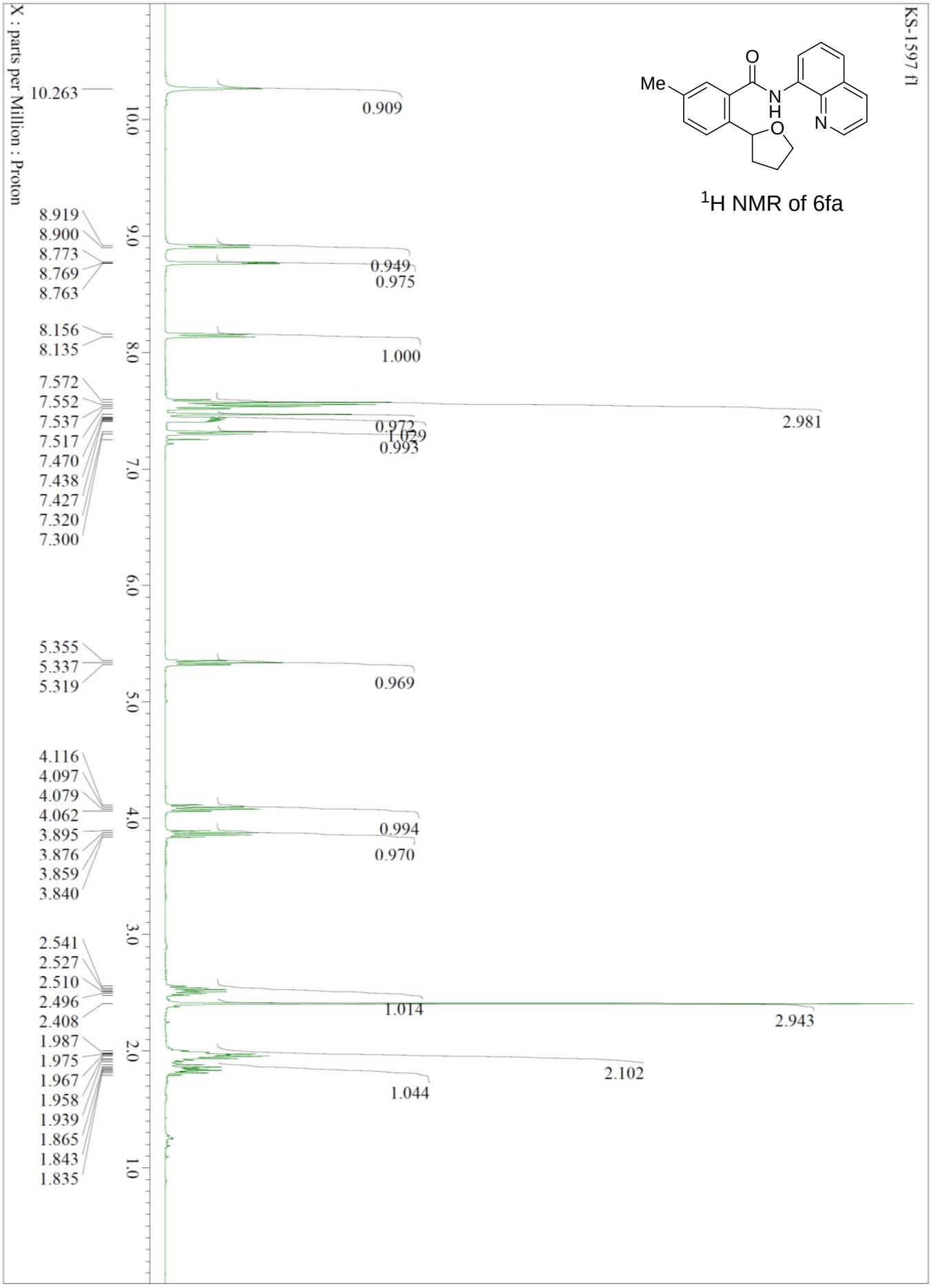

KS-1576 GPC2
X : parts per Million : Proton
Me
O
N
H
O
N
Ph
10.041
9.000
8.985
8.982
8.678
8.674
8.147
8.126
7.558
7.401
7.391
7.380
7.227
7.222
7.214
7.116
5.473
5.457
5.451
5.435
5.238
4.898
4.878
4.860
2.521
2.499
2.488
2.454
2.415
2.333
2.317
2.313
2.072
2.054
2.042
2.029
1.944
1.939
1.918
-0.001
2.134
2.209
2.213
2.238
6.972
19.453
1.000
2.258
1.251
9.975
1.199
4.458
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0

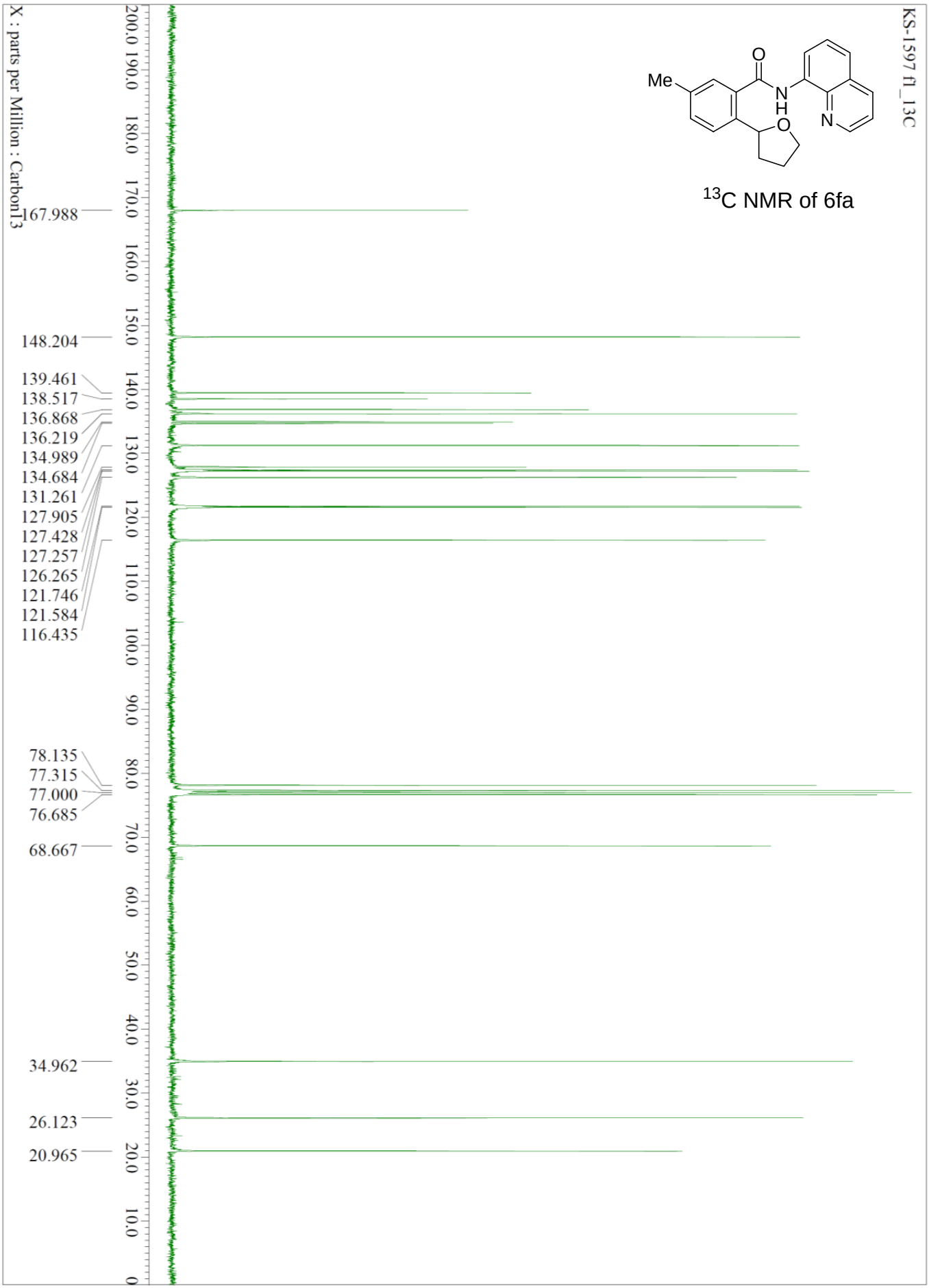
^{1}H NMR of 6ac


KS-1576 GPC2_13C
X : parts per Million : Carbon13
Me
O
N
H
O
N
Ph
^{13}C NMR of 6ac
168.408
168.275
148.290
139.919
136.172
134.312
134.255
128.201
128.029
125.931
125.378
116.616
81.662
80.957
79.517
78.735
77.315
77.000
76.676
36.173
35.896
34.876
34.094
19.411
19.363

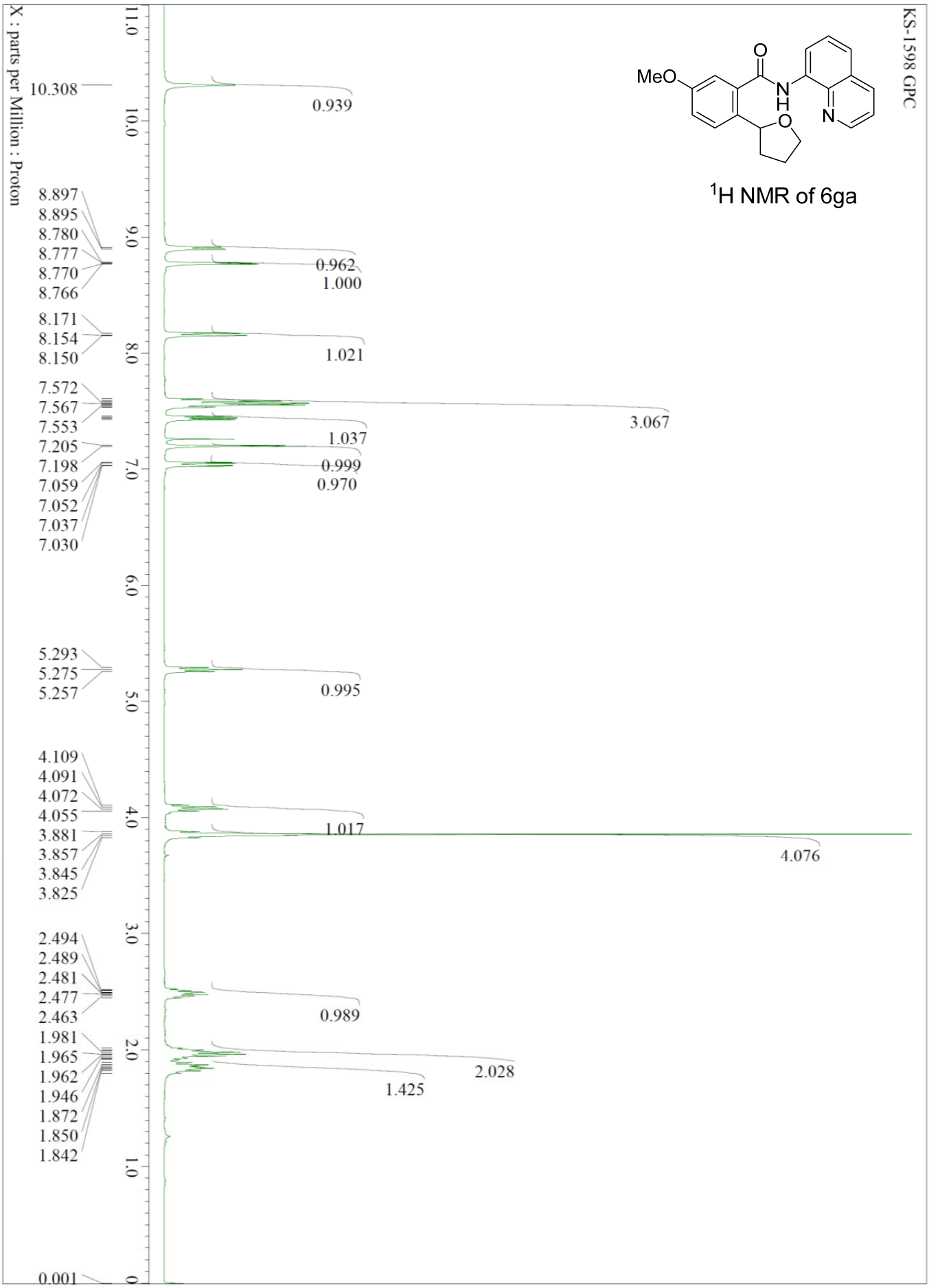

KS-1588 GPC1
X : parts per Million : Proton
Me
O
N
H
O
N
Ph
^{1}H NMR of 6ad
10.008
8.986
8.982
8.978
8.701
8.691
8.139
8.118
8.114
7.543
7.395
7.378
7.221
7.212
7.191
7.150
7.139
5.478
5.458
5.443
5.292
5.281
4.419
4.400
4.242
3.971
3.781
3.530
3.510
2.825
2.808
2.456
2.450
2.162
2.134
2.131
2.103
2.077
0.000
2.059
2.158
2.133
2.156
6.296
4.536
13.901
1.000
1.151
0.991
1.112
1.092
0.965
2.115
1.114
8.321
1.102

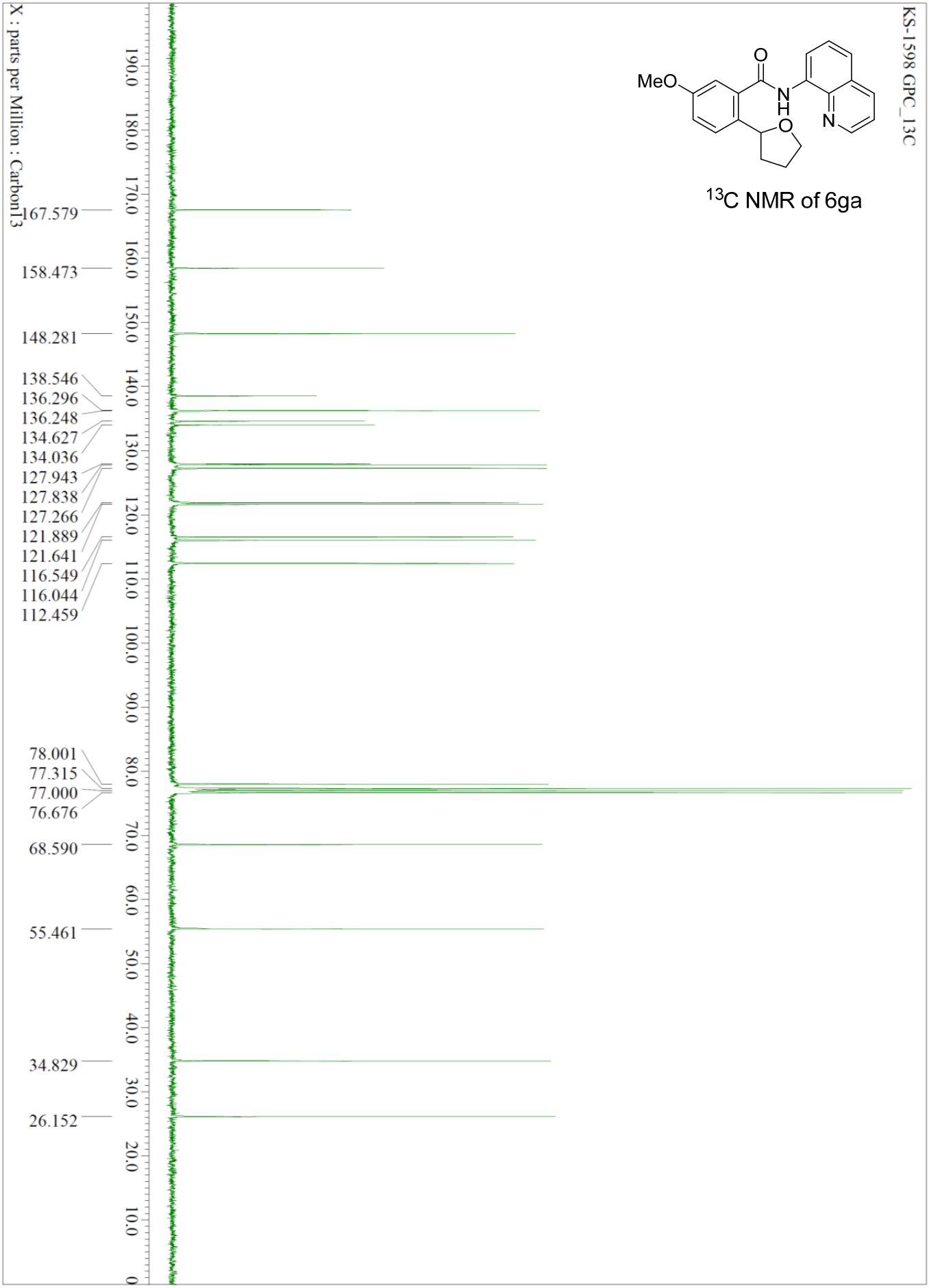

single pulse decoupled gated NOE
X : parts per Million : Carbon13
200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0
168.322
168.217
148.271
148.252
138.365
136.200
134.389
134.293
128.420
127.247
127.190
127.152
116.607
116.569
80.022
78.707
77.315
77.000
76.676
75.265
75.122
46.003
44.249
44.201
42.580
19.354
19.325
Me
O
N
H
O
N
Ph
13C NMR of 6ad

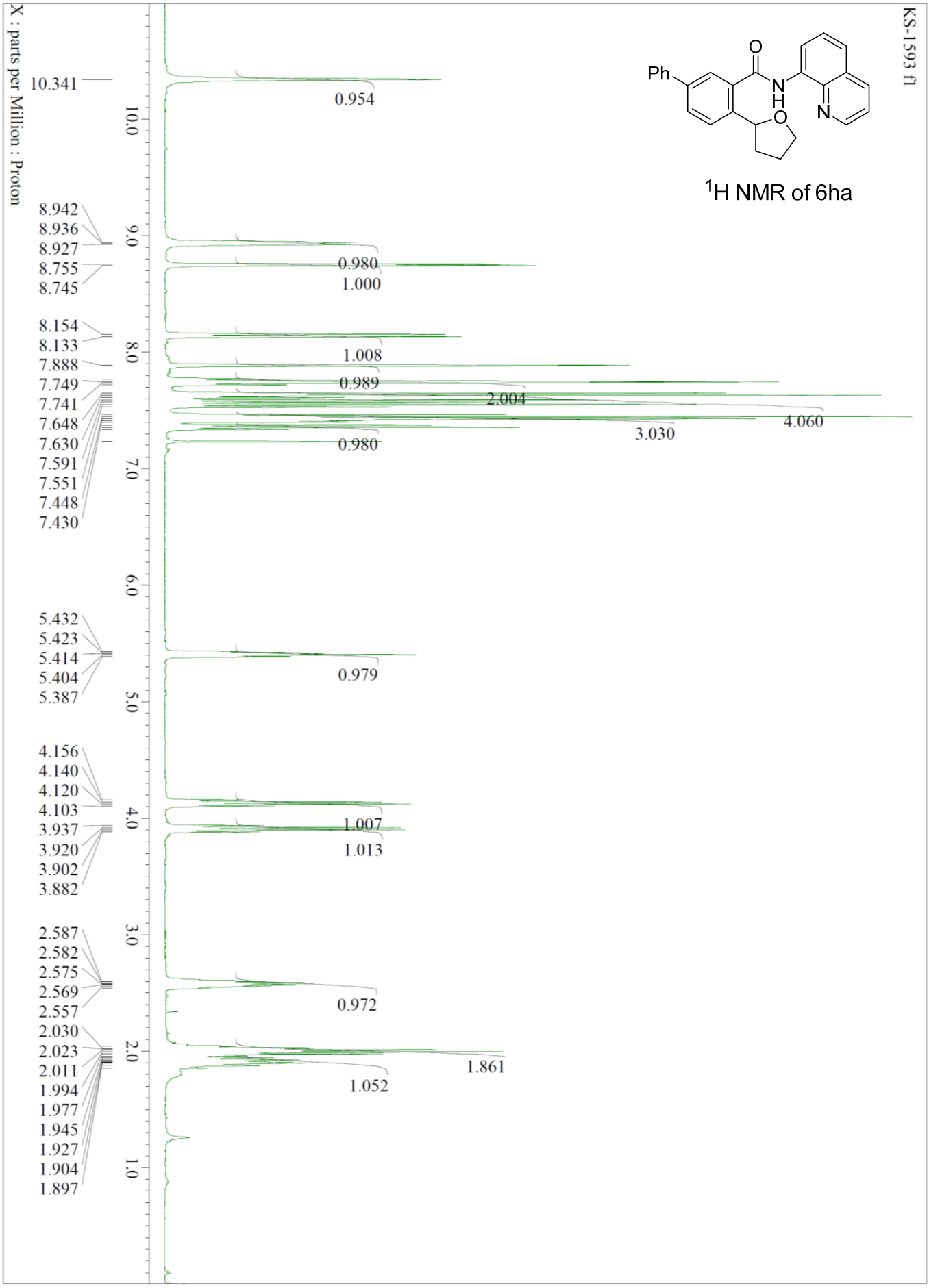

KS-1597 f1
X : parts per Million : Proton
Me
O
N
H
N
O
^{1}H NMR of 6fa
10.263
8.919
8.900
8.773
8.769
8.763
8.156
8.135
7.572
7.552
7.537
7.517
7.470
7.438
7.427
7.320
7.300
5.355
5.337
5.319
4.116
4.097
4.079
4.062
3.895
3.876
3.859
3.840
2.541
2.527
2.510
2.496
2.408
1.987
1.975
1.967
1.958
1.939
1.865
1.843
1.835
0.909
0.949
0.975
1.000
2.981
0.972
1.029
0.993
0.969
0.994
0.970
1.014
2.943
2.102
1.044
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

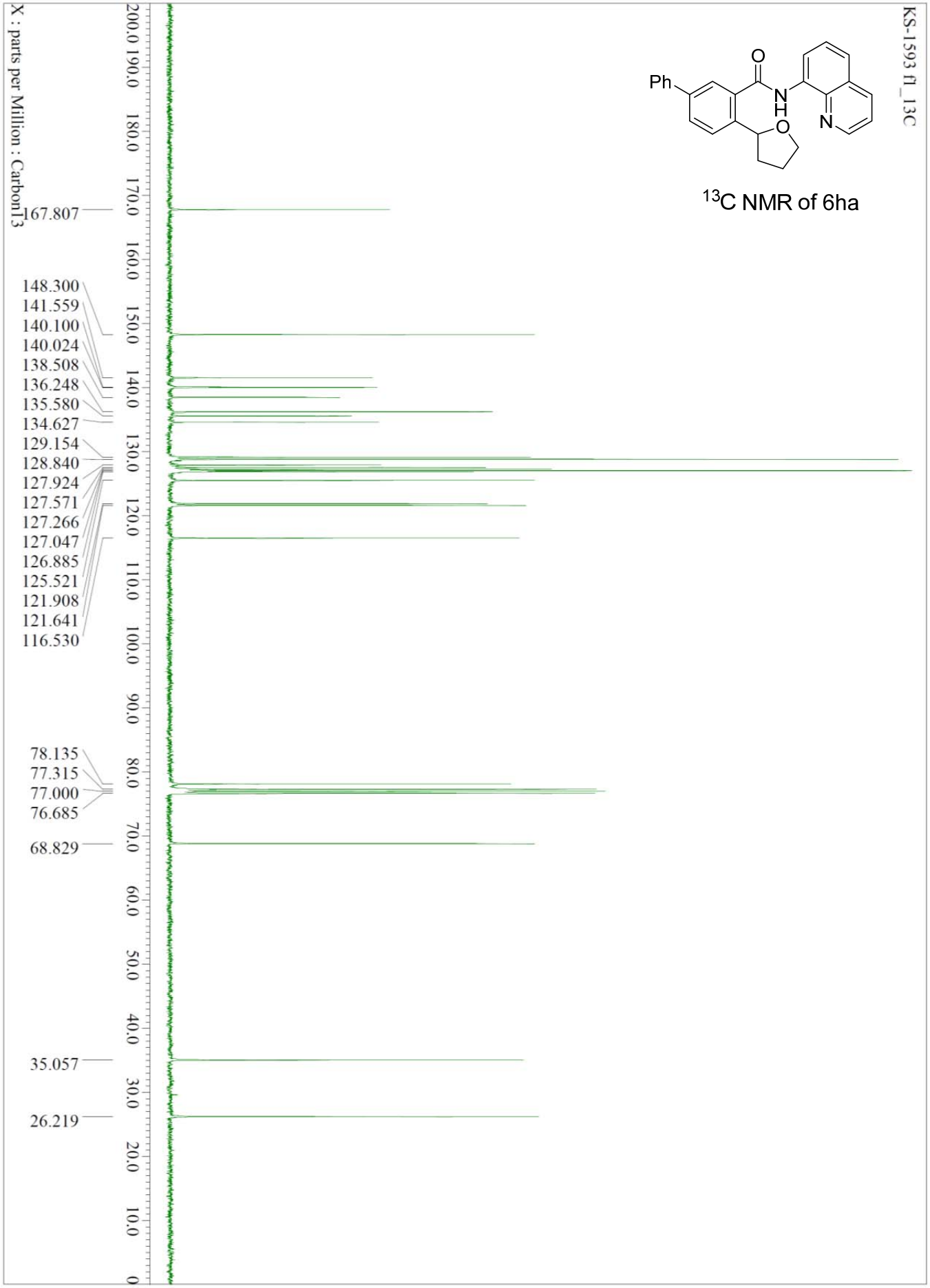


^{13}C NMR of 6fa

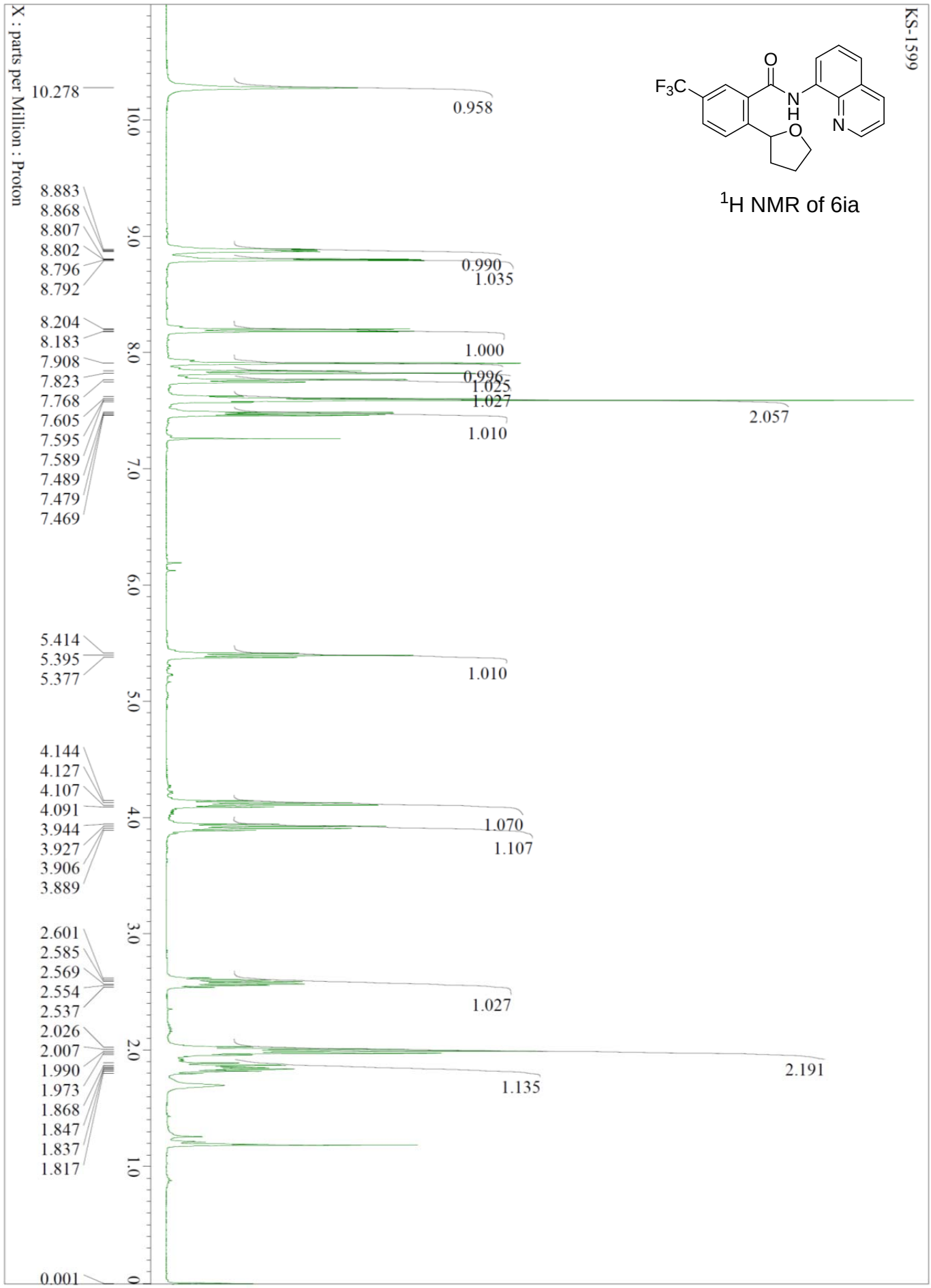

KS-1598 GPC
X : parts per Million : Proton
MeO
O
N
H
O
N
1H NMR of 6ga
10.308
8.897
8.895
8.780
8.777
8.770
8.766
8.171
8.154
8.150
7.572
7.567
7.553
7.205
7.198
7.059
7.052
7.037
7.030
5.293
5.275
5.257
4.109
4.091
4.072
4.055
3.881
3.857
3.845
3.825
2.494
2.489
2.481
2.477
2.463
1.981
1.965
1.962
1.946
1.872
1.850
1.842
0.001
0.939
0.962
1.000
1.021
3.067
1.037
0.999
0.970
0.995
1.017
4.076
0.989
2.028
1.425


KS-1598 GPC_13C
X : parts per Million : Carbon13
MeO
O
N
H
N
O
^{13}C NMR of 6ga
167.579
158.473
148.281
138.546
136.296
136.248
134.627
134.036
127.943
127.838
127.266
121.889
121.641
116.549
116.044
112.459
78.001
77.315
77.000
76.676
68.590
55.461
34.829
26.152
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

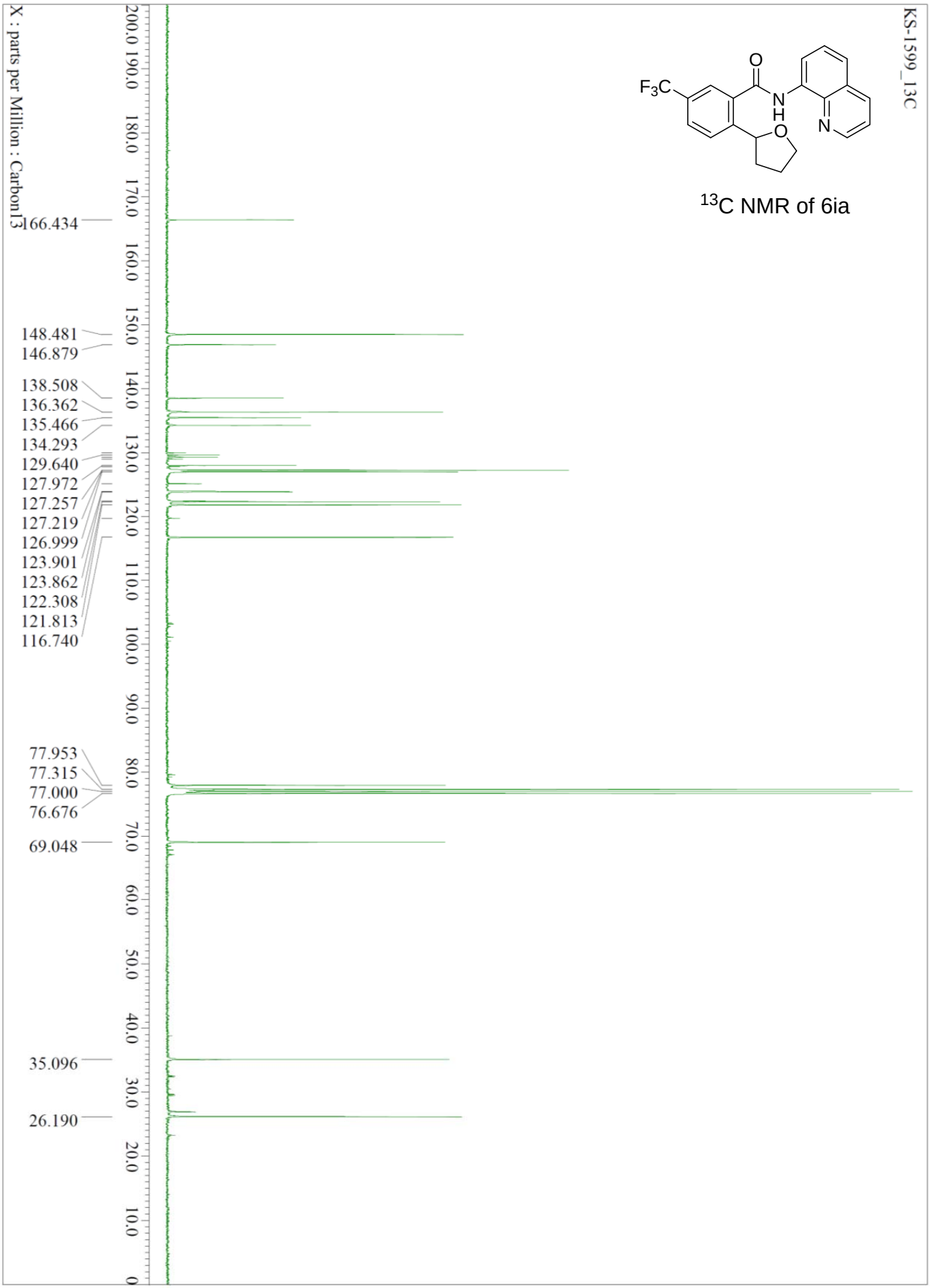

KS-1593 f1
X : parts per Million : Proton
10.341
8.942
8.936
8.927
8.755
8.745
8.154
8.133
7.888
7.749
7.741
7.648
7.630
7.591
7.551
7.448
7.430
5.432
5.423
5.414
5.404
5.387
4.156
4.140
4.120
4.103
3.937
3.920
3.902
3.882
2.587
2.582
2.575
2.569
2.557
2.030
2.023
2.011
1.994
1.977
1.945
1.927
1.904
1.897
0.954
0.980
1.000
1.008
0.989
2.004
4.060
3.030
0.980
0.979
1.007
1.013
0.972
1.861
1.052
Ph
O
N
H
O
N
^{1}H NMR of 6ha



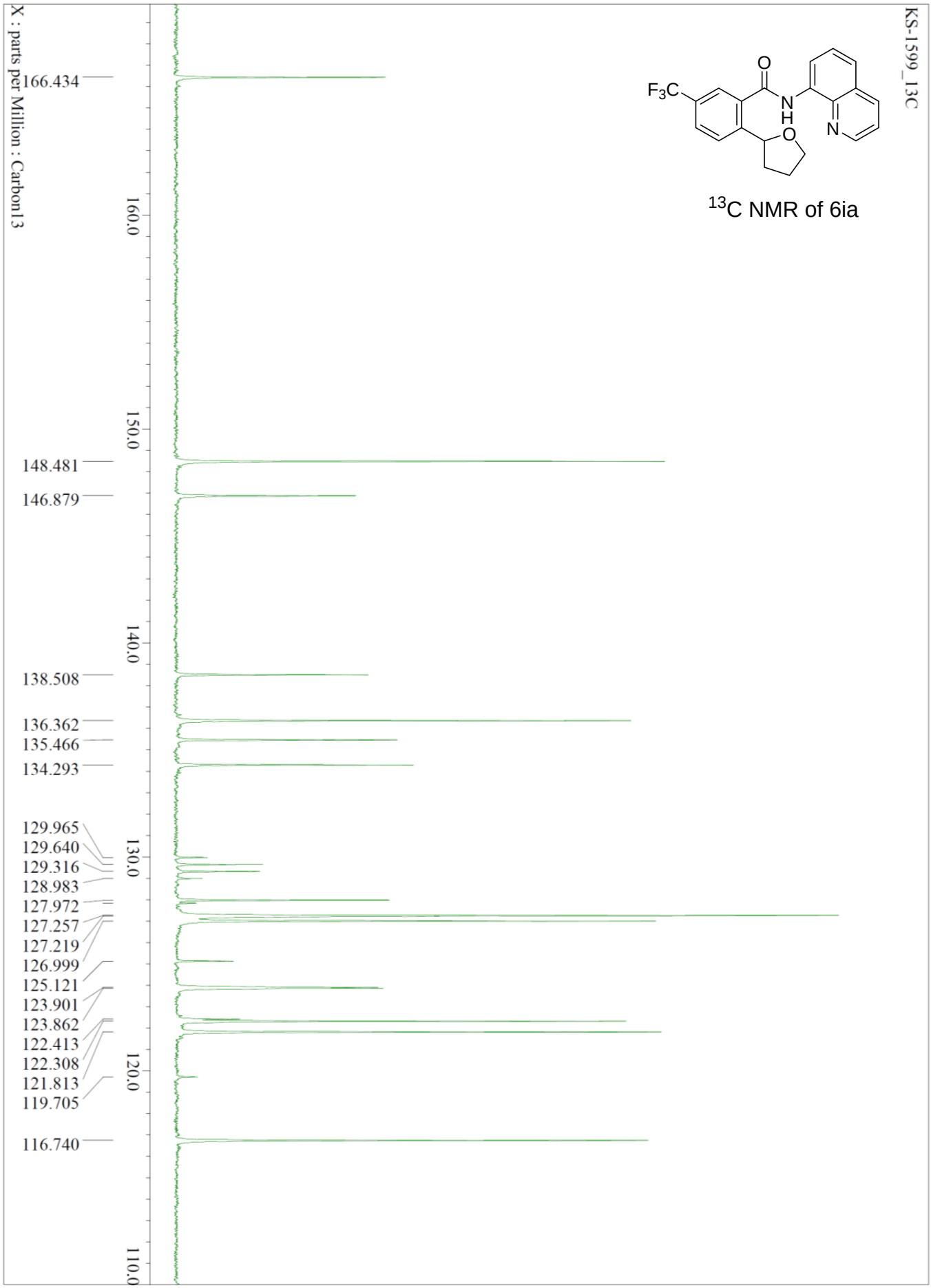
^{13}C NMR of 6ha


KS-1599
X : parts per Million : Proton
10.278
8.883
8.868
8.807
8.802
8.796
8.792
8.204
8.183
7.908
7.823
7.768
7.605
7.595
7.589
7.489
7.479
7.469
5.414
5.395
5.377
4.144
4.127
4.107
4.091
3.944
3.927
3.906
3.889
2.601
2.585
2.569
2.554
2.537
2.026
2.007
1.990
1.973
1.868
1.847
1.837
1.817
0.001
0.958
0.990
1.035
1.000
0.996
1.025
1.027
1.010
2.057
1.010
1.070
1.107
1.027
1.135
2.191
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
F3C
O
N
H
O
N

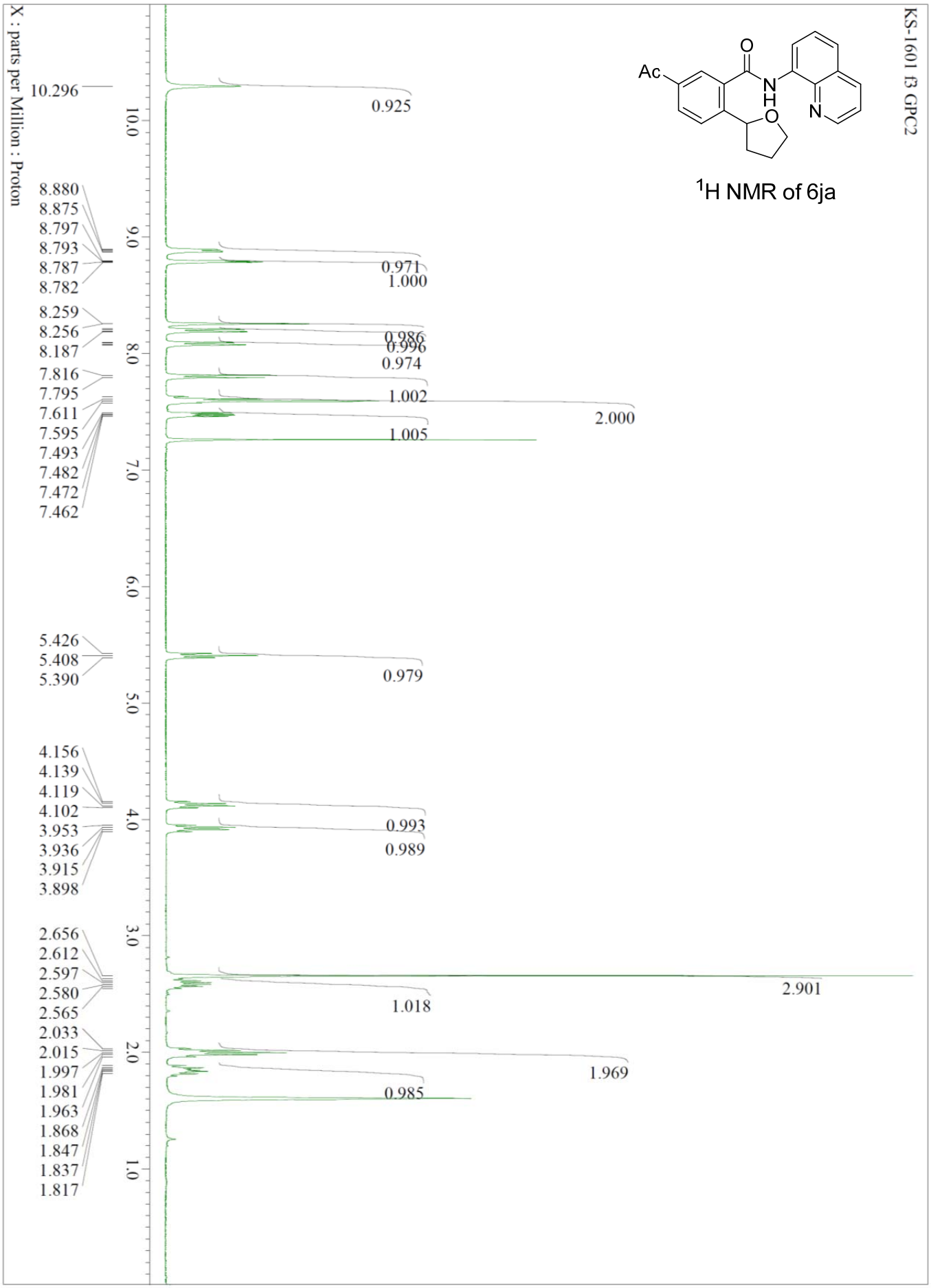
^{1}H NMR of 6ia

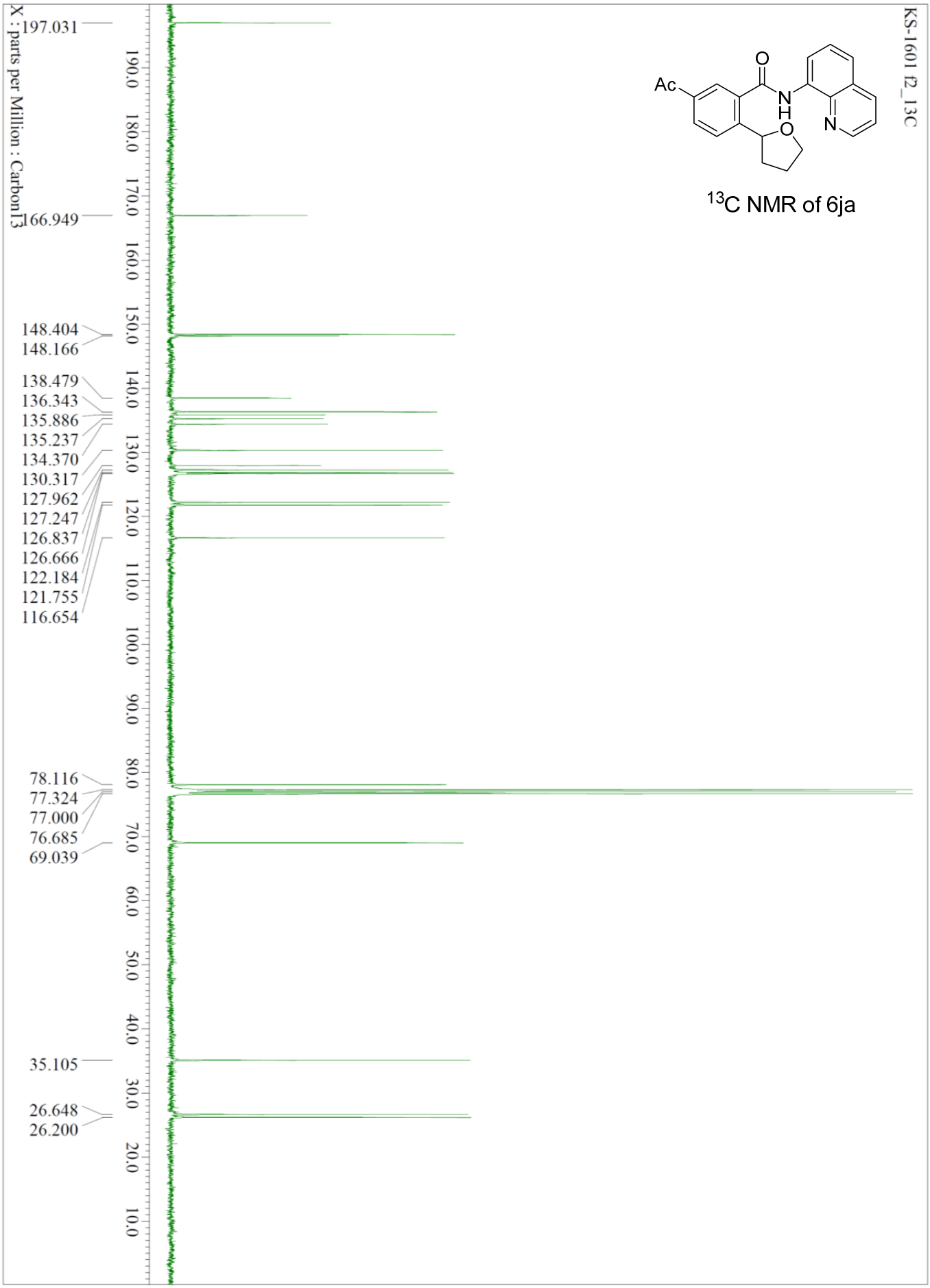


^{13}C NMR of 6ia

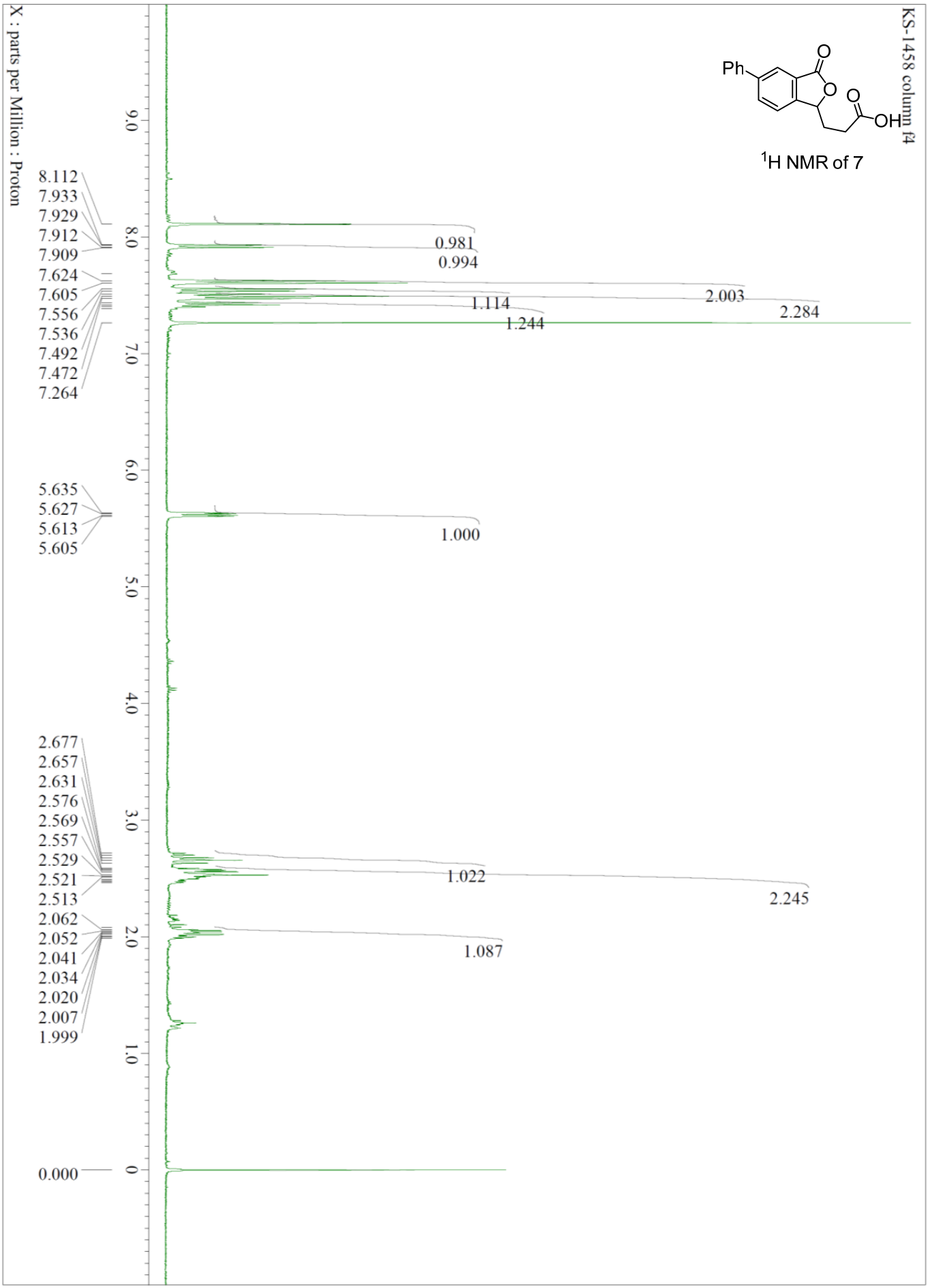


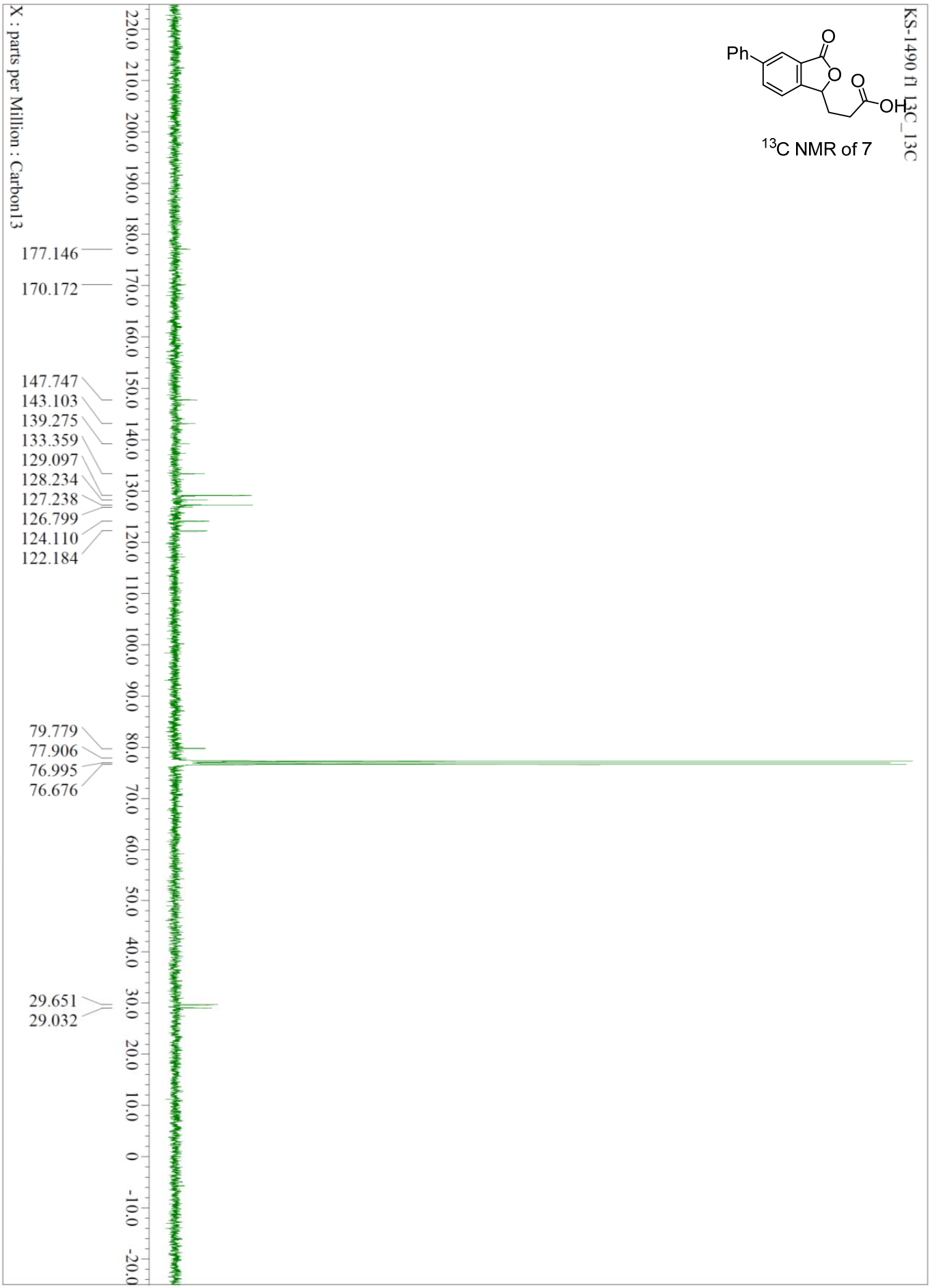
^{13}C NMR of 6ia


KS-1601 f3 GPC2
X : parts per Million : Proton
Ac
O
N
H
O
N
^{1}H NMR of 6ja
10.296
8.880
8.875
8.797
8.793
8.787
8.782
8.259
8.256
8.187
7.816
7.795
7.611
7.595
7.493
7.482
7.472
7.462
5.426
5.408
5.390
4.156
4.139
4.119
4.102
3.953
3.936
3.915
3.898
2.656
2.612
2.597
2.580
2.565
2.033
2.015
1.997
1.981
1.963
1.868
1.847
1.837
1.817
0.925
0.971
1.000
0.986
0.996
0.974
1.002
2.000
1.005
0.979
0.993
0.989
2.901
1.018
1.969
0.985
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0

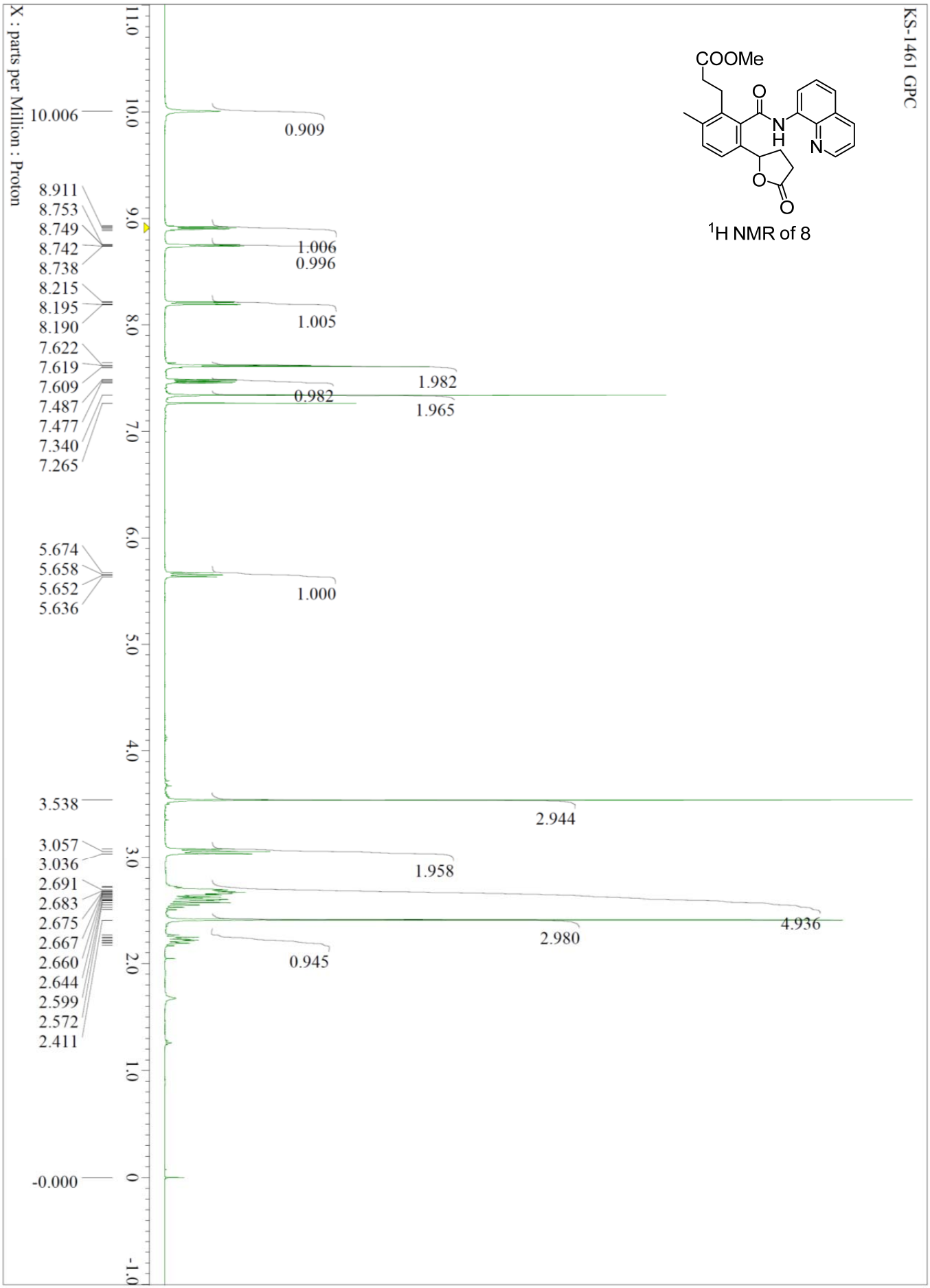


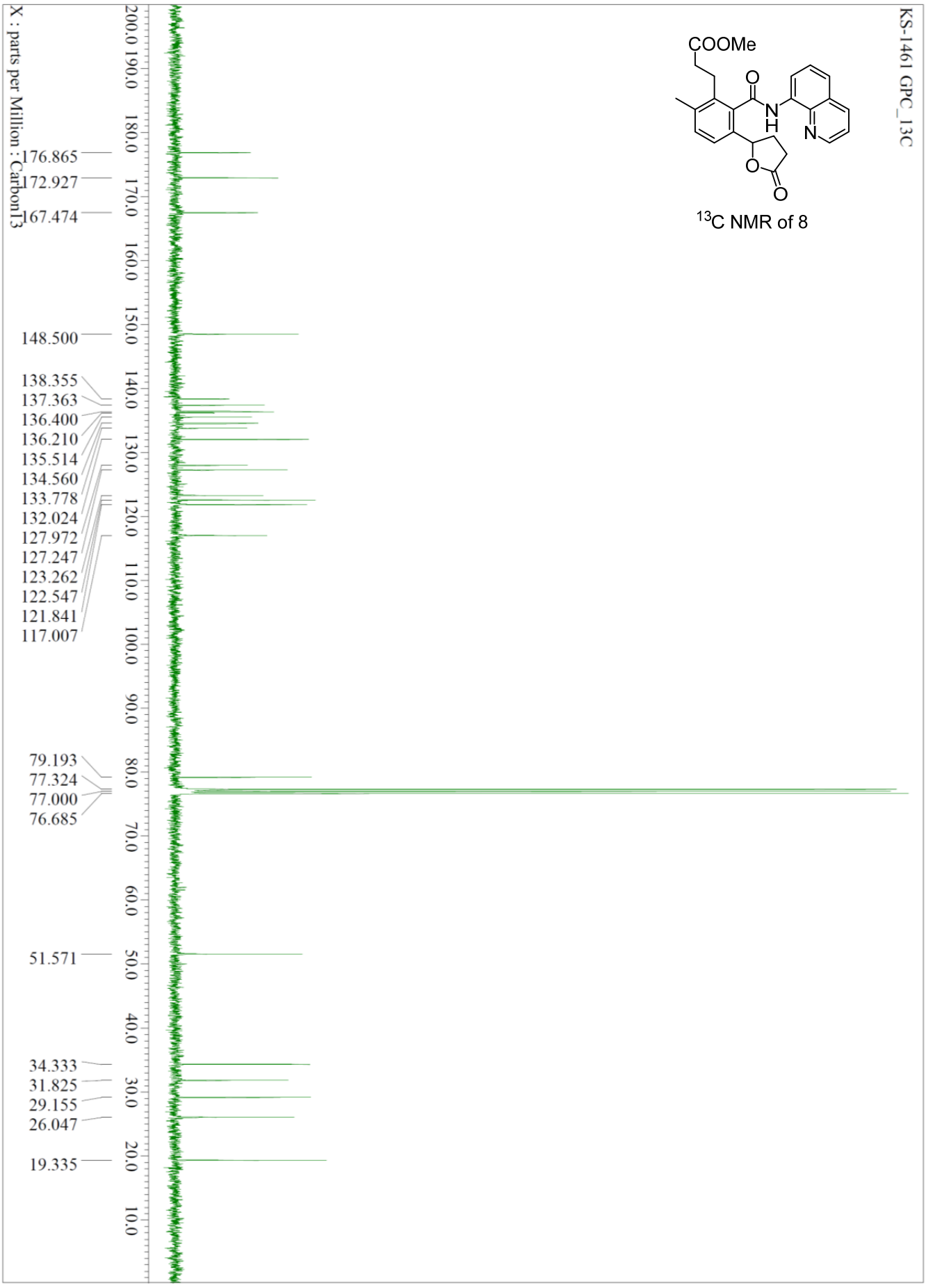
^{13}C NMR of 6ja


KS-1458 column f4
X : parts per Million : Proton
Ph
O
O
O
OH
1H NMR of 7
8.112
7.933
7.929
7.912
7.909
7.624
7.605
7.556
7.536
7.492
7.472
7.264
5.635
5.627
5.613
5.605
2.677
2.657
2.631
2.576
2.569
2.557
2.529
2.521
2.513
2.062
2.052
2.041
2.034
2.020
2.007
1.999
0.000
0.981
0.994
1.114
1.244
2.003
2.284
1.000
1.022
2.245
1.087
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0


KS-1490 f1 13C_13C
X : parts per Million : Carbon13
220.0 210.0 200.0 190.0 180.0 170.0 160.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 60.0 50.0 40.0 30.0 20.0 10.0 0 -10.0 -20.0
177.146
170.172
147.747
143.103
139.275
133.359
129.097
128.234
127.238
126.799
124.110
122.184
79.779
77.906
76.995
76.676
29.651
29.032
Ph
O
O
O
OH

^{13}C NMR of 7


KS-1461 GPC
X : parts per Million : Proton
COOMe
O
N
H
N
O
O
^{1}H NMR of 8
10.006
8.911
8.753
8.749
8.742
8.738
8.215
8.195
8.190
7.622
7.619
7.609
7.487
7.477
7.340
7.265
5.674
5.658
5.652
5.636
3.538
3.057
3.036
2.691
2.683
2.675
2.667
2.660
2.644
2.599
2.572
2.411
-0.000
0.909
1.006
0.996
1.005
1.982
0.982
1.965
1.000
2.944
1.958
4.936
2.980
0.945
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0


KS-1461 GPC_13C
X : parts per Million : Carbon13
176.865
172.927
167.474
148.500
138.355
137.363
136.400
136.210
135.514
134.560
133.778
132.024
127.972
127.247
123.262
122.547
121.841
117.007
79.193
77.324
77.000
76.685
51.571
34.333
31.825
29.155
26.047
19.335
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
COOMe
O
N
H
N
O
O
^{13}C NMR of 8