Supporting Information on

New Catalytic Asymmetric Formation of Oxygen Heterocycles Bearing Nucleoside Bases at the Anomeric Carbon

Barry M. Trost,[1*] Shiyan Xu,[1] Ehesan U. Sharif [1]

[1] Department of Chemistry, Stanford University, 333 Campus Dr. Stanford, CA 94305, USA

*Corresponding Author: bmtrost@stanford.edu

Table of Contents

1. General Information

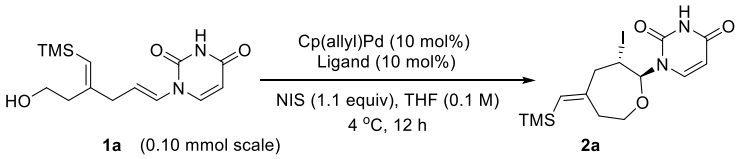
Unless otherwise noted, all reagents were purchased commercially and used as received. Anhydrous tetrahydrofuran (THF) was obtained by distillation from sodium/benzophenone. Anhydrous toluene (PhMe) and benzene was obtained by distillation from sodium. Anhydrous dichloromethane (CH_2Cl_2) and diethyl ether (Et_2O) were purchased as such from Acros Organics in AcroSeal bottles and were used as received. When performing air-sensitive reactions, reagents and solvents were transferred using either stainless steel cannulae or plastic syringes equipped with stainless steel needles. Air-sensitive reactions were performed under a positive pressure of either nitrogen (N_2) or argon (Ar) in reaction vessels sealed with rubber septa.

Analytical thin-layer chromatography (TLC) was performed on glass-backed silica-coated plates (Merck TLC Silicagel 60 F254). Visualization was typically performed using UV light and/or basic potassium permanganate ($KMnO_4$). Purification by flash column chromatography was performed on silica gel (Fisher Scientific, 230 – 400 mesh, grade 60) using bulk solvents.

NMR spectra were recorded on a UI-400, UI-500 or UI-600. ^{1}H NMR spectra were recorded at 400 MHz, 500 MHz or 600 MHz and data are reported as follows: chemical shift in ppm relative to tetramethylsilane (0.00 ppm) or solvent as internal standard ($CDCl_3$ δ 7.26 ppm), (DMSO δ 2.50 ppm), (acetone δ 2.05 ppm) (CD_3OD δ 2.05 ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet or overlap of non-equivalent resonances), and integration. ^{13}C NMR spectra were recorded at 100 MHz or 125 MHz and data are reported as follows: chemical shift in ppm relative to the solvent as internal indicator ($CDCl_3$ δ 77 ppm), (DMSO δ 39.52 ppm), (acetone δ 29.81 ppm), (CD_3OD δ 49.00 ppm) and all the ^{13}CNMR spectra are proton decoupled (13C{1H}). Melting points were measured on a Thomas-Hoover Uni-Melt melting point apparatus in open capillary tubes and are uncorrected. Optical rotations were determined using a Jasco DIP-1000 digital polarimeter using 5 cm glass cells with a Na 589 nm filter and the specific rotations given correspond to the enantiomeric excess reported here. Infrared (IR) spectra were recorded on sodium chloride plates as thin films on a Perkin-Elmer Paragon 500 FT-IR spectrometer, wave-numbers are indicated in cm^{-1}. High resolution mass spectrometry (HRMS) was performed at Stanford University. Enantiomeric excesses were determined by high performance liquid chromatography (HPLC) using an Agilent 1200 series HPLC system using the specified separation conditions.

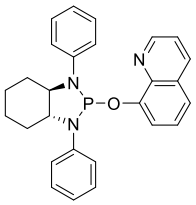
2. Experimental and Spectral Data

Some other unsuccessful asymmetric ligands screened.

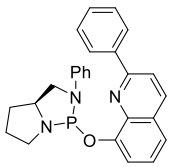


1a (0.10 mmol scale) **2a**

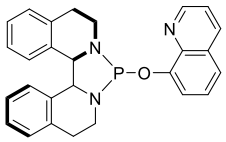
Backbone changed ligands



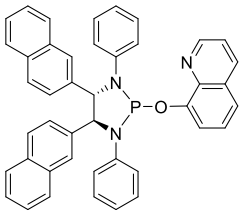
89% yield
36% ee



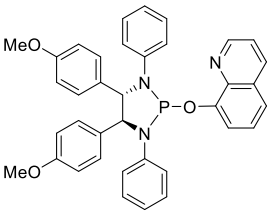
N.R.



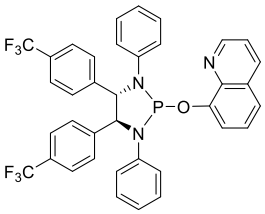
N.R.



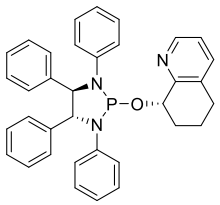
90% yield
52% ee



85% yield
51% ee

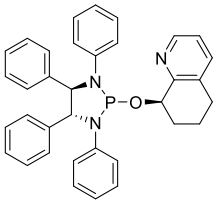


88% yield
0% ee

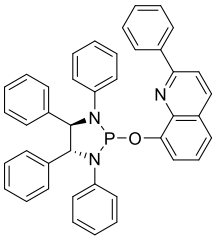


N.R.

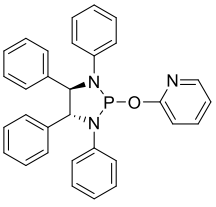
Tether changed ligands



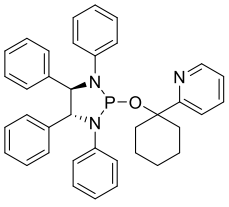
N.R.



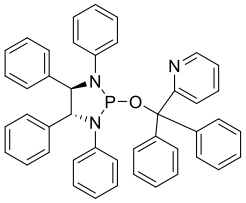
65% yield
24% ee



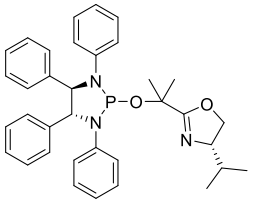
90% yield
14% ee



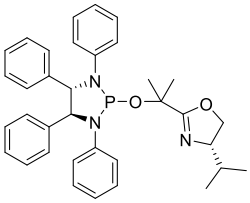
88% yield
50% ee



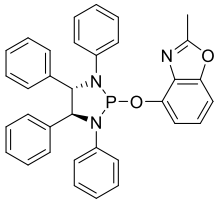
N.R.



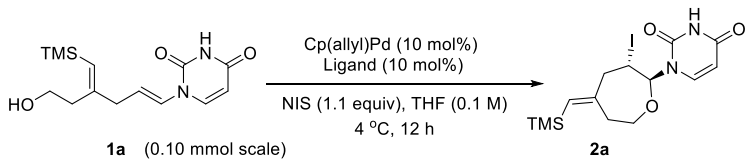
N.R.



N.R.

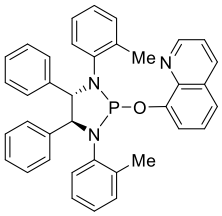


N.R.

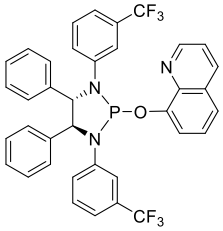


1a (0.10 mmol scale) **2a**

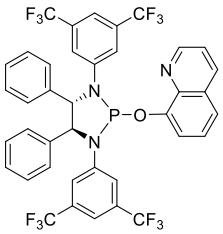
Core changed ligands



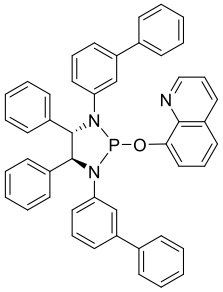
76% yield
14% ee



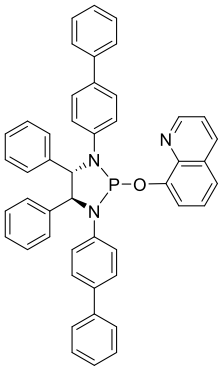
70% yield
30% ee



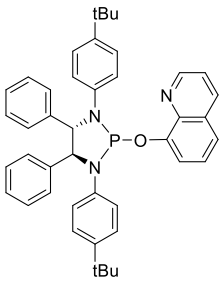
N.R.



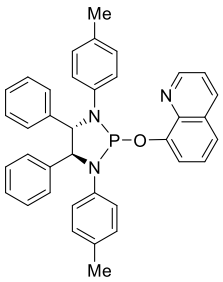
68% yield
50% ee



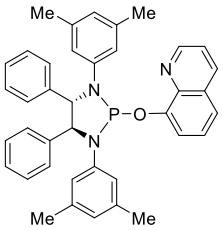
90% yield
58% ee



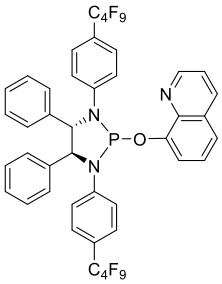
N.R.



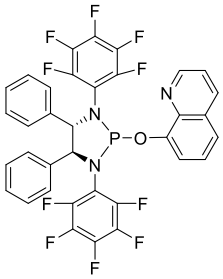
N.R.



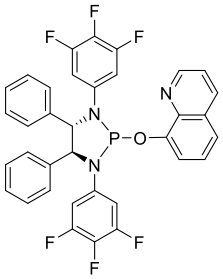
N.R.



N.R.

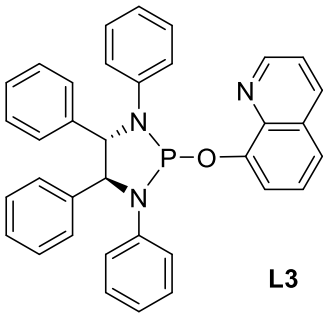


N.R.



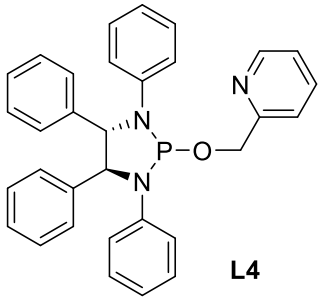
91% yield
72% ee

Procedure for preparing ligands



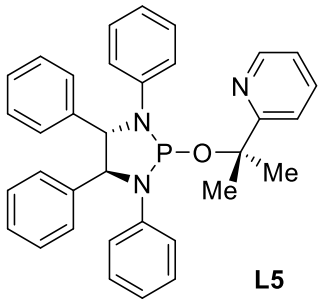
L3

8-(((4*S*,5*S*)-1,3,4,5-tetraphenyl-1,3,2-diazaphospholidin-2-yl)oxy)quinoline (L3). Freshly distilled PCl_3 (0.70 mL, 8.2 mmol) was added dropwise to freshly distilled NEt_3 (2.30 mL, 16.5 mmol) in benzene (52 mL) at 0 ℃. After stirring for 5 min, the mixture was added with a solution of (1*S*,2*S*)-*trans*-N^1,N^2,1,2-tetraphenylethane-1,2-diamine (2.0 g, 5.5 mmol) in benzene (26 mL) at 0 ℃. The mixture was stirred for 5 min, then was heated to 95 ℃ for 1 h. The reaction mixture was cooled to rt, filtered (under nitrogen to prevent decomposition of phosphine chloride), concentrated in vacuum, and dried under high vacuum. The diaminophosphine chloride was resuspended in benzene (27 mL, 0.20 M) and cooled to 0 ℃. NEt_3 (0.92 mL, 6.6 mmol) and 8-hydroxyquinoline (876 mg, 6.04 mmol) were added at 0 ℃. The mixture was heated to 95 ℃ for 1 h and then cooled to rt. The solution was filtered through glass wool and concentrated under reduced pressure. The crude mixture was purified by column chromatography on neutral deactivated alumina (0-5% Et_2O/PE) to yield a white foam (2.06 g, 70%). The foam was dried under high vacuum for several hours and then stored under argon at -20 ℃. **RF:** 0.5 10% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.69 (dd, *J* = 4.1, 1.7 Hz, 1H), 8.11 (dd, *J* = 8.3, 1.6 Hz, 1H), 7.64 – 7.57 (m, 2H), 7.48 (d, *J* = 8.2 Hz, 1H), 7.39 – 7.27 (m, 12H), 7.19 – 7.13 (m, 6H), 6.87 (dd, *J* = 9.3, 5.8 Hz, 3H), 5.52 (d, *J* = 7.6 Hz, 1H), 5.12 (dd, *J* = 7.5, 3.0 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 151.3, 149.1, 144.5, 144.3, 142.8, 142.7, 142.0, 140.2, 139.3, 135.6, 129.5, 129.1, 128.7, 128.6, 128.5, 127.8, 127.7, 127.6, 127.5, 126.6, 122.2, 121.8, 121.7, 121.3, 120.5, 119.7, 119.7, 118.1, 117.9, 114.0, 74.3, 74.2, 72.0, 71.9. **^{31}P NMR** (162 MHz, $CDCl_3$) δ 127.54. **HRMS-ESI** $[C_{35}H_{29}N_3OP]^+$ calcd 538.2048, found: 538.2047. **IR** (thin film): 1598, 1496, 1257, 1085, 1053, 1028, 754, 733, 694 cm^{-1}. **$[\alpha]_D^{22}$** = –330.1 (c 0.3 in DCM).



L4

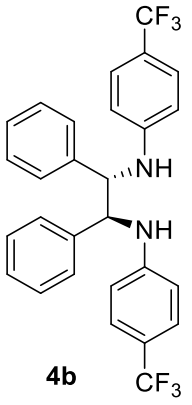
2-((((4*S*,5*S*)-1,3,4,5-tetraphenyl-1,3,2-diazaphospholidin-2-yl)oxy)methyl)pyridine (L4). Freshly distilled PCl_3 (0.70 mL, 8.2 mmol,) was added dropwise to freshly distilled NEt_3 (2.30 mL, 16.5 mmol) in benzene (52 mL) at 0 °C. After stirring for 5 min, the mixture was added with a solution of (1*S*,2*S*)-*trans*-N^1,N^2,1,2-tetraphenylethane-1,2-diamine (2.0 g, 5.5 mmol) in benzene (26 mL) at 0 ℃. The mixture was stirred for 5 min, then was heated to 95 ℃ for 1 h. The reaction mixture was cooled to rt, filtered (under nitrogen to prevent decomposition of phosphine chloride), concentrated in vacuum, and dried under high vacuum. The diaminophosphine chloride was resuspended in benzene (27 mL, 0.20 M) and cooled to 0 ℃. NEt_3 (0.92 mL, 6.6 mmol) and 2-Pyridinemethanol (658 mg, 6.04 mmol) were added at 0 ℃. The mixture was heated to 95 ℃ for 1 h and then cooled to rt. The solution was filtered through glass wool and concentrated under reduced pressure. The crude mixture was purified by column chromatography on neutral deactivated alumina (0-5% Et_2O/PE) to yield a white foam (2.06 g, 75%). The foam was dried under high vacuum for several hours and then stored under argon at -20 ℃. **RF:** 0.5 10% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.54 (ddd, *J* = 4.8, 1.8, 1.0 Hz, 1H), 7.54 (td, *J* = 7.7, 1.8 Hz, 1H), 7.41 – 7.37 (m, 2H), 7.34 – 7.23 (m, 9H), 7.22 – 7.16 (m, 3H), 7.14 – 7.09 (m, 6H), 6.92 – 6.86 (m, 2H), 5.36 (d, *J* = 7.8 Hz, 1H), 5.22 (d, *J* = 7.9 Hz, 2H), 5.10 (dd, *J* = 7.8, 2.6 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 158.6, 158.6, 148.6, 143.9, 143.7, 142.5, 142.4, 139.3, 139.0, 139.0, 136.5, 128.8, 128.7, 128.7, 128.4, 128.4, 127.7, 127.6, 127.5, 127.4, 127.4, 127.3, 122.0, 121.43, 121.40, 120.54, 120.48, 120.4, 117.1, 117.0, 116.96, 73.0, 72.9, 71.8, 71.7, 67.6, 67.4. **^{31}P NMR** (162 MHz, $CDCl_3$) δ 129.72. **HRMS-ESI** $[C_{32}H_{29}N_3OP]^+$ calcd. 502.2048, found: 502.2046. **IR** (thin film): 3063, 3032, 2871, 1597, 1499, 1240, 1116, 1018, 939, 912, 738, 693 cm^{-1}. **$[\alpha]_D^{22}$** = –370.8 (c 0.3 in DCM).



L5

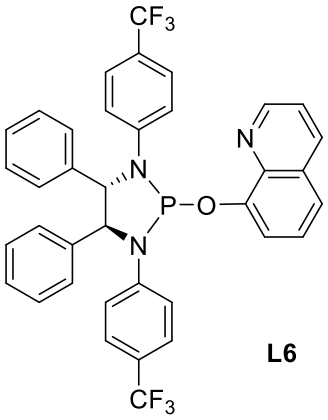
2-(2-(((4*S*,5*S*)-1,3,4,5-tetraphenyl-1,3,2-diazaphospholidin-2-yl)oxy)propan-2-yl)pyridine (L5). Freshly distilled PCl_3 (0.70 mL, 8.2 mmol,) was added dropwise to freshly distilled NEt_3 (2.30 mL, 16.5 mmol) in benzene (52 mL) at 0 ℃. After stirring for 5 min, the mixture was added with a solution of (1*S*,2*S*)-*trans*-N^1,N^2,1,2-tetraphenylethane-1,2-diamine (2.0 g, 5.5 mmol) in benzene (26 mL) at 0 ℃. The mixture was stirred for 5 min, then was heated to 95 ℃ for 1 h. The reaction mixture was cooled to rt, filtered (under nitrogen to prevent decomposition of phosphine chloride), concentrated in vacuum, and dried under high vacuum. The diaminophosphine chloride was resuspended in benzene (27 mL, 0.20 M) and cooled to 0 ℃. NEt_3 (0.90 mL, 6.6 mmol) and

2-(Pyridine-2-yl)propan-2-ol (827.0 mg, 6.04 mmol) were added at 0 ℃. The mixture was heated to 95 ℃ for 1 h and then cooled to rt. The solution was filtered through glass wool and concentrated under reduced pressure. The crude mixture was purified by column chromatography on neutral deactivated alumina (0-5% Et_2O/PE) to yield a white foam (2.12 g, 73%). The foam was dried under high vacuum for several hours and then stored under argon at -20 ℃. **RF:** 0.6 10% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, CDCl3) δ 8.55 (d, *J* = 4.9 Hz, 1H), 7.58 (d, *J* = 6.6 Hz, 2H), 7.48 – 7.42 (m, 2H), 7.29 (dt, *J* = 32.0, 9.0 Hz, 9H), 7.13 (t, *J* = 7.5 Hz, 4H), 7.02 (dd, *J* = 17.2, 8.3 Hz, 4H), 6.84 (dt, *J* = 19.4, 7.5 Hz, 2H), 5.30 (d, *J* = 8.1 Hz, 1H), 4.97 (d, *J* = 8.2 Hz, 1H), 1.88 (s, 3H), 1.50 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 166.1, 148.1, 144.8, 144.5, 142.6, 142.4, 140.7, 139.1, 139.0, 136.4, 128.75, 128.74, 128.67, 128.65, 128.4, 127.8, 127.6, 127.5, 127.4, 122.1, 122.1, 121.8, 121.77, 121.6, 119.5, 119.4, 116.1, 116.0, 79.6, 79.5, 73.9, 73.8, 71.3, 71.2, 30.5, 30.5, 29.9, 29.8. **^{31}P NMR** (162 MHz, $CDCl_3$) δ 121.65. **HRMS-ESI** $[C_{34}H_{33}N_3OP]^+$ calcd. 530.2361, found: 530.2365. **IR** (thin film): 3031, 1596, 1495, 1285, 1257, 1116, 752, 730, 695 cm^{-1}. **$[\alpha]_D^{22}$** = –222.4 (c 0.3 in DCM).



4b

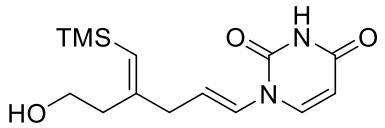
(1*S*,2*S*)-1,2-diphenyl-*N*^{1},*N*^{2}-bis(4-(trifluoromethyl)phenyl)ethane-1,2-diamine. A mixture of $Pd(OAc)_2$ (69.4 mg, 0.309 mmol) and racemic BINAP (385 mg, 0.619 mmol) in toluene (120 mL) were stirred at rt for 30 min under argon atmosphere. To this mixture was added with (1*S*,2*S*)-1,2-diphenylethane-1,2-diamine (1.27 g, 6.00 mmol), 4-bromobenzotrifluoride (2.74 g, 12.2 mmol), and sodium tert-butoxide (1.78 g, 18.6 mmol). The mixture was stirred at 100 ℃ for 14 h. The reaction mixture was filtered through a pad of celite and washed with toluene, and the resulting filtrate was concentrated under reduced pressure. The crude product was purified by column chromatography (hexane/Et_2O = 6/1) to give CF_3-phenyl substituted diamine as a colorless oil (2.4 g, 81%). **RF:** 0.6 20% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.36 (d, *J* = 8.6 Hz, 4H), 7.34 – 7.27 (m, 6H), 7.18 (dd, *J* = 6.4, 3.0 Hz, 4H), 6.58 (d, *J* = 8.5 Hz, 4H), 4.86 (s, 2H), 4.70 (s, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 149.3, 138.5, 128.6, 128.0, 127.2, 126.4, 126.42, 126.38, 124.9 (q, *J* = 270.6 Hz), 119.6 (q, *J* = 32.5 Hz), 113.3, 77.2, 63.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -60.95. **HRMS-ESI** $[C_{28}H_{23}F_6N_2]^+$ calcd 501.1765, found: 501.1765. **IR** (thin film): 1613, 1518, 1326, 1262, 1165, 1117, 1070, 1052, 826 cm^{-1}. **$[\alpha]_D^{22}$** = –424.8 (c 0.3 in DCM).



L6

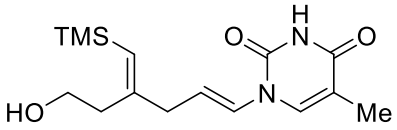
8-(((4*S*,5*S*)-4,5-diphenyl-1,3-bis(4-(trifluoromethyl)phenyl)-1,3,2-diazaphospholidin-2-yl)oxy)quinoline (L6). Freshly distilled PCl_3 (0.70 mL, 8.2 mmol) was added dropwise to freshly distilled NEt_3 (2.30 mL, 16.5 mmol) in benzene (52 mL) at 0 ℃. After stirring for 5 min, a solution of (1*S*,2*S*)-1,2-diphenyl-N^1,N^2-bis(4-(trifluoromethyl)phenyl)ethane-1,2-diamine (2.7 g, 5.5 mmol) in benzene (26 mL) was added at 0 ℃. The mixture was stirred for 5 min, then was heated to 95 ℃ for 1 h. The reaction mixture was cooled to rt, filtered (under nitrogen to prevent decomposition of phosphine chloride), concentrated in vacuum, and dried under high vacuum. The diaminophosphine chloride was resuspended in benzene (27 mL, 0.20 M) and cooled to 0 ℃. NEt_3 (0.92 mL, 6.6 mmol) and 8-hydroxyquinoline (876 mg, 6.04 mmol) were added at 0 ℃. The mixture was heated to 95 ℃ for 1 h and then cooled to rt. The solution was filtered through glass wool and concentrated under reduced pressure. The crude mixture was purified by column chromatography on neutral deactivated alumina (0-5% Et_2O/PE) to yield a white foam (2.73 g, 74%). The foam was dried under high vacuum for several hours and then stored under argon at -20 ℃. **RF:** 0.6 10% EtOAc/PE (UV). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.75 (dd, *J* = 4.1, 1.6 Hz, 1H), 8.18 (dd, *J* = 8.3, 1.5 Hz, 1H), 7.74 (d, *J* = 6.9 Hz, 2H), 7.61 (t, *J* = 7.9 Hz, 3H), 7.55 (d, *J* = 8.8 Hz, 2H), 7.49 – 7.39 (m, 11H), 7.32 (d, *J* = 7.7 Hz, 2H), 7.10 (d, *J* = 7.5 Hz, 1H), 5.70 (d, *J* = 7.2 Hz, 1H), 5.31 (dd, *J* = 7.1, 2.6 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 150.7, 150.6, 149.1, 147.5, 147.3, 146.2, 146.1, 141.6, 141.58, 139.4, 138.6, 138.6, 135.8, 129.6, 129.0, 128.8, 128.21, 128.18, 128.0, 127.6, 127.3, 126.6, 126.0, 125.92, 125.88, 125.8, 125.7, 125.3, 123.4 (q, *J* = 35.4 Hz), 123.0, 122.9, 122.8, 122.3 (q, *J* = 32.7 Hz), 121.0, 120.8, 119.89, 119.85, 117.5, 117.4, 77.2, 74.5, 74.4, 72.0, 71.9. **^{31}P NMR** (162 MHz, $CDCl_3$) δ 125.96. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -61.59, -61.89. **HRMS-ESI** $[C_{37}H_{27}F_6N_3OP]^+$ calcd 674.1796, found: 674.1793. **IR** (thin film): 1613, 1518, 1326, 1262, 1165, 1117, 1070, 827, 740 cm^{-1}. **$[\alpha]_D^{22}$** = –432.8 (c 0.3 in DCM).

Procedure for preparing iodoetherification precursor.



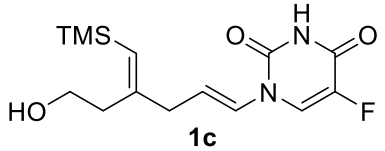
1a

1-((1*E*,4*Z*)-6-hydroxy-4-((trimethylsilyl)methylene)hex-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione (1a). To a dry vial, equiped with a stir bar, was added with 4-(trimethylsilyl)but-3-yn-1-ol (95 mg, 0.67 mmol), *N*-allyl uracil (102 mg, 0.670 mmol) and acetone (2.7 mL, 0.25 M). Solid $[CpRu(MeCN)_3]PF_6$ (29 mg, 0.060 mmol) was then added. The vial was purged with argon and sealed with a screw cap. The solution was stirred for 16 h at rt, after which the solvent was evaporated under reduced pressure and the crude material was purified by flash chromotography eluting with 40-65% EtOAc/PE to give the title compound as a white solid (114 mg, 54%). **RF:** 0.25 60% PE/EtOAc (UV). **MP:** 152 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.14 (s, 1H), 7.47 (d, *J* = 8.2 Hz, 1H), 6.91 (d, *J* = 14.1 Hz, 1H), 5.81 (d, *J* = 7.9 Hz, 1H), 5.64 (dt, *J* = 14.2, 7.2 Hz, 1H), 5.42 (s, 1H), 3.74 (t, *J* = 6.7 Hz, 2H), 2.96 (d, *J* = 7.0 Hz, 2H), 2.45 (t, *J* = 6.7 Hz, 2H), 0.13 (s, 9H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.9, 151.9, 149.3, 140.4, 129.4, 125.3, 118.6, 103.1, 61.2, 39.4, 38.7, 0.3. **HRMS-ESI** $[C_{14}H_{22}N_2NaO_3Si]^+$ calcd. 317.1297, found: 317.1300. **IR** (thin film): 3465, 2953, 2888, 1681, 1247, 834, 766, 711 cm^{-1}.



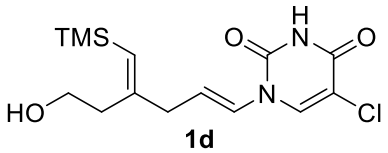
1b

1-((1*E*,4*Z*)-6-hydroxy-4-((trimethylsilyl)methylene)hex-1-en-1-yl)-5-methylpyrimidine-2,4(1*H*,3*H*)-dione (1b). To a dry vial, equiped with a stir bar, was added with 4-(trimethylsilyl)but-3-yn-1-ol (95 mg, 0.67 mmol), *N*-allyl thymine (111 mg, 0.670 mmol) and acetone (2.7 mL, 0.25 M). Solid $[CpRu(MeCN)_3]PF_6$ (29 mg, 0.060 mmol) was then added. The vial was purged with argon and sealed with a screw cap. The solution was stirred for 16 h at rt, after which the solvent was evaporated under reduced pressure and the crude material was purified by flash chromatography eluting with 40-65% EtOAc/PE to give the title compound as a white solid (115 mg, 56%). **RF:** 0.25 60% PE/EtOAc (UV). **MP:** 133 ^{o}C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.30 (s, 1H), 6.92 (d, *J* = 14.3 Hz, 1H), 5.60 (dd, *J* = 14.4, 7.3 Hz, 1H), 5.40 (s, 1H), 3.72 (t, *J* = 6.9 Hz, 2H), 2.94 (d, *J* = 7.3 Hz, 2H), 2.44 (t, *J* = 6.8 Hz, 2H), 1.96 (s, 3H), 0.12 (s, 9H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 163.8, 152.2, 149.6, 136.0, 129.1, 125.2, 117.4, 111.7, 61.2, 39.7, 38.6, 12.5, 0.3. **HRMS-ESI** $[C_{15}H_{25}N_2O_3Si]^+$ calcd 309.1634, found: 309.1631. **IR** (thin film): 3407, 3216, 3071, 2955, 2923, 1698, 1378, 1250, 1043, 840 cm^{-1}.



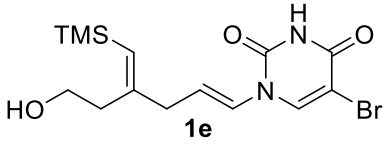
1c

5-fluoro-1-((1*E*,4*Z*)-6-hydroxy-4-((trimethylsilyl)methylene)hex-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione (1c). To a dry vial, equiped with a stir bar, was added with 4-(trimethylsilyl)but-3-yn-1-ol (95 mg, 0.67 mmol), *N*-allyl 5-fluorouracil (131 g, 0.670 mmol) and acetone (2.7 mL, 0.25 M). Solid $[CpRu(MeCN)_3]PF_6$ (29 mg, 0.060 mmol) was then added. The vial was purged with argon and sealed with a screw cap. The solution was stirred for 16 h at rt, after which the solvent was evaporated under reduced pressure and the crude material was purified by flash chromotography eluting with 40-65% EtOAc/PE to give the title compound as a white solid (119 mg, 57%). **RF:** 0.4 60% PE/EtOAc (UV). **MP:** 160 °C. **^{1}H NMR** (400 MHz, CD_3OD) δ 8.13 (d, *J* = 6.6 Hz, 1H), 6.89 (d, *J* = 14.3 Hz, 1H), 5.82 (dt, *J* = 14.5, 7.3 Hz, 1H), 5.41 (s, 1H), 3.65 (t, *J* = 7.4 Hz, 2H), 2.97 (d, *J* = 7.2 Hz, 2H), 2.59 – 2.39 (m, 2H), 0.12 (s, 9H). **^{13}C NMR** (100 MHz, CD_3OD) δ 159.1, 154.6, 149.8, 143.5, 141.1, 128.6, 127.0, 126.7, 126.0, 119.0, 62.2, 40.9, 40.0, 0.4. **^{19}F NMR** (376 MHz, CD_3OD) δ -65.51. **HRMS-ESI** $[C_{14}H_{22}FN_2O_3Si]^+$ calcd 313.1384, found: 313.1382. **IR** (thin film): 3078, 2958, 2807, 1713, 1694, 1381, 1268, 1137, 837, 750 cm^{-1}.



1d

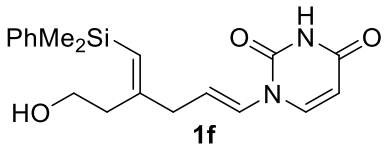
5-chloro-1-((1*E*,4*Z*)-6-hydroxy-4-((trimethylsilyl)methylene)hex-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione (1d). To a dry vial, equiped with a stir bar, was added with 4-(trimethylsilyl)but-3-yn-1-ol (95 mg, 0.67 mmol), *N*-allyl 5-chlorouracil (124 mg, 0.670 mmol) and acetone (2.7 mL, 0.25 M). Solid $[CpRu(MeCN)_3]PF_6$ (29 mg, 0.060 mmol) was then added. The vial was purged with argon and sealed with a screw cap. The solution was stirred for 16 h at rt, after which the solvent was evaporated under reduced pressure and the crude material was purified by flash chromotography eluting with 40-65% EtOAc/PE to give the title compound as a white solid (116 mg, 53%). **RF:** 0.3 60% PE/EtOAc (UV). **MP:** 169 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.63 (s, 1H), 7.69 (s, 1H), 6.88 (d, *J* = 14.4 Hz, 1H), 5.75 – 5.63 (m, 1H), 5.43 (s, 1H), 3.74 (t, *J* = 6.6 Hz, 2H), 3.49 (s, 1H), 2.97 (d, *J* = 7.0 Hz, 2H), 2.45 (t, *J* = 6.7 Hz, 2H), 0.14 (s, 9H). **^{13}C NMR** (125 MHz, Acetone) δ 159.4, 155.3, 149.4, 138.7, 127.4, 125.5, 118.6, 109.7, 61.9, 40.7, 40.0, 0.5. **HRMS-ESI** $[C_{14}H_{22}ClN_2O_3Si]^+$ calcd 329.1088, found: 329.1083. **IR** (thin film): 2954, 1690, 1430, 1334, 1247, 1055, 836 , 750 cm^{-1}.



1e

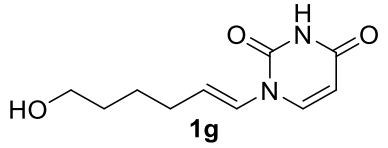
5-bromo-1-((1*E*,4*Z*)-6-hydroxy-4-((trimethylsilyl)methylene)hex-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione (1e). To a dry vial, equiped with a stir bar, was added with 4-(trimethylsilyl)but-3-yn-1-ol (95 mg, 0.67 mmol), *N*-allyl 5-bromouracil (154 mg, 0.670 mmol) and acetone (2.7 mL, 0.25 M).

Solid $[CpRu(MeCN)_3]PF_6$ (29 mg, 0.060 mmol) was then added. The vial was purged with argon and sealed with a screw cap. The solution was stirred for 16 h at rt, after which the solvent was evaporated under reduced pressure and the crude material was purified by flash chromotography eluting with 40-65% EtOAc/PE to give the title compound as a white solid (127 mg, 51%). **RF:** 0.25 60% PE/EtOAc (UV). **MP:** 117 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.98 (s, 1H), 7.50 (s, 1H), 5.88 (d, *J* = 10.3 Hz, 1H), 5.66 (s, 1H), 4.12 (dt, *J* = 9.9, 8.3 Hz, 2H), 4.02 – 3.81 (m, 1H), 3.14 (dd, *J* = 13.8, 4.4 Hz, 1H), 3.04 (dd, *J* = 13.7, 9.7 Hz, 1H), 2.75 (ddd, *J* = 16.5, 9.9, 6.9 Hz, 1H), 2.48 (d, *J* = 15.8 Hz, 1H), 0.14 (s, 9H). **^{13}C NMR** (100 MHz, CD_3OD) δ 161.5, 154.5, 150.7, 142.4, 128.7, 126.0, 120.4, 98.2, 62.2, 40.9, 40.0, 0.4. **HRMS-ESI** $[C_{14}H_{22}BrN_2O_3Si]^+$ calcd 373.0583, found: 373.0579. **IR** (thin film): 3206, 1693, 1613, 1426, 1248, 1035, 837, 750 cm^{-1}.



1f

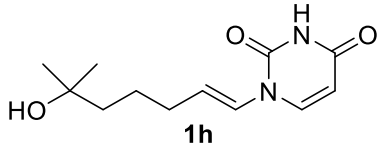
1-((1*E*,4*Z*)-4-((dimethyl(phenyl)silyl)methylene)-6-hydroxyhex-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione (1f). To a dry vial, equiped with a stir bar, was added 4-(dimethyl(phenyl)silyl)but-3-yn-1-ol (137 mg, 0.670 mmol), *N*-allyl uracil (102 mg, 0.670 mmol) and acetone (2.7 mL, 0.25 M). Solid $[CpRu(MeCN)_3]PF_6$ (29 mg, 0.060 mmol) was then added. The vial was purged with argon and sealed with a screw cap. The solution was stirred for 16 h at rt, afterwhich the solvent was evaporated under reduced pressure and the crude material was purified by flash chromotography eluting with 40-65% EtOAc/PE to give the title compound as a white solid (110 mg, 46%). **RF:** 0.25 60% PE/EtOAc (UV). **MP:** 74 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.19 (s, 1H), 7.54 (dd, *J* = 6.4, 3.1 Hz, 2H), 7.46 (d, *J* = 8.2 Hz, 1H), 7.44 – 7.31 (m, 3H), 6.92 (d, *J* = 14.4 Hz, 1H), 5.81 (d, *J* = 7.8 Hz, 1H), 5.77 – 5.60 (m, 1H), 5.56 (s, 1H), 3.56 (t, *J* = 6.7 Hz, 2H), 2.99 (d, *J* = 7.3 Hz, 2H), 2.35 (t, *J* = 6.8 Hz, 2H), 0.40 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.0, 153.9, 149.3, 140.4, 139.4, 133.7, 129.1, 127.9, 127.0, 125.4, 118.4, 103.1, 61.1, 39.5, 38.9, -1.0. **HRMS-ESI** $[C_{19}H_{25}N_2O_3Si]^+$ calcd 357.1634, found: 357.1628. **IR** (thin film): 3455, 3408, 3348, 2962, 1692, 1426, 1386, 1254, 1087, 838, 732 cm^{-1}.



1g

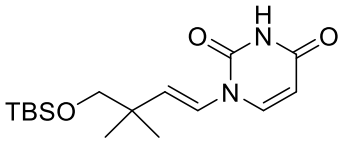
(*E*)-1-(6-hydroxyhex-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione (1g). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. To a separate vial were added (*E*)-6-iodohex-5-en-1-ol (452 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M). The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35

mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 °C. The solution was allowed to stir for 14 h at 80 °C and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (50% EtOAc/PE) provided title compound (231 mg, 55% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 106 °C. **^{1}H NMR** (400 MHz, CD_3OD) δ 7.81 (d, *J* = 8.1 Hz, 1H), 6.86 (d, *J* = 14.3 Hz, 1H), 5.84 (dt, *J* = 14.4, 7.2 Hz, 1H), 5.73 (d, *J* = 8.0 Hz, 1H), 3.58 (t, *J* = 6.1 Hz, 2H), 2.21 (dd, *J* = 13.5, 6.4 Hz, 2H), 1.56 (ddd, *J* = 10.5, 6.8, 2.8 Hz, 4H). **^{13}C NMR** (100 MHz, CD_3OD) δ 166.1, 151.3, 143.1, 125.4, 122.5, 103.1, 62.6, 33.0, 30.7, 26.7. **HRMS-ESI** $[C_{10}H_{15}N_2O_3]^+$ calcd 211.1083, found: 211.1083. **IR** (thin film): 3426, 2931, 1692, 1662, 1387, 1206, 1064, 940, 825 cm^{-1}.

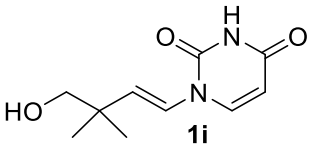


1h

(*E*)-1-(6-hydroxy-6-methylhept-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione (1h). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. To a separate vial were added (*E*)-7-iodo-2-methylhept-6-en-2-ol (508 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M). The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 °C. The solution was allowed to stir for 14 h at 80 °C and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (50% EtOAc/PE) provided title compound (248 mg, 52% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 112 °C. **^{1}H NMR** (400 MHz, CD_3OD) δ 7.81 (d, *J* = 8.0 Hz, 1H), 6.85 (d, *J* = 14.4 Hz, 1H), 5.84 (dt, *J* = 14.2, 7.2 Hz, 1H), 5.72 (d, *J* = 8.0 Hz, 1H), 2.18 (dd, *J* = 12.9, 6.2 Hz, 2H), 1.53 (dt, *J* = 21.7, 8.0 Hz, 4H), 1.18 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.5, 149.5, 140.6, 124.2, 121.1, 102.9, 70.7, 42.9, 30.0, 29.2, 23.9. **HRMS-ESI** $[C_{12}H_{18}N_2NaO_3]^+$ calcd 261.1215, found: 261.1214. **IR** (thin film): 3438, 2968, 1690, 1449, 1383, 1273, 1151, 950, 810 cm^{-1}.

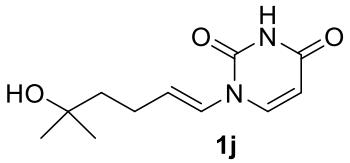


(*E*)-1-(4-((tert-butyldimethylsilyl)oxy)-3,3-dimethylbut-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione. An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-tert-butyl((4-iodo-2,2-dimethylbut-3-en-1-yl)oxy)dimethyl-silane (680 mg, 2.00 mmol) and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (40% EtOAc/PE) provided title compound (330 mg, 51% yield) as a white solid. **RF:** 0.25 80% EtOAc/PE (UV). **MP:** 116 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.20 (s, 1H), 7.43 (d, *J* = 8.1 Hz, 1H), 6.86 (d, *J* = 14.7 Hz, 1H), 5.78 (d, *J* = 8.0 Hz, 1H), 5.69 (d, *J* = 14.7 Hz, 1H), 3.34 (s, 2H), 2.99 (s, 1H), 1.07 (s, 6H), 0.89 (s, 9H), 0.03 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.2, 149.4, 140.5, 128.4, 122.6, 102.8, 71.7, 37.8, 25.8, 24.0, 18.2, -5.5. **HRMS-ESI** $[C_{16}H_{29}N_2O_3Si]^+$ calcd 325.1947, found: 325.1946. **IR** (thin film): 3411, 3025, 2957, 2931, 2887, 2857, 1704, 1384, 1093, 849, 732 cm^{-1}.



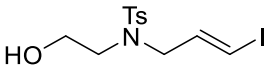
1i

(*E*)-1-(4-hydroxy-3,3-dimethylbut-1-en-1-yl)pyrimidine-2,4(1*H*,3*H*)-dione (1i). TBS alkene (194 mg, 0.600 mmol) was dissolved in MeOH (2 mL, 0.3 M), and Dowex acidic resin 50WX8 (100 mg) was added. The solution was stirred for 4 h after which the Dowex was removed by filtration through a small silica plug, eluting with MeOH, and concentrated under reduced pressure to give pure alcohol **6.4.11** (124 mg, 99% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 127 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.42 (s, 1H), 7.50 (d, *J* = 8.0 Hz, 1H), 6.87 (d, *J* = 14.7 Hz, 1H), 5.77 (d, *J* = 8.1 Hz, 1H), 5.69 (d, *J* = 14.6 Hz, 1H), 3.44 (s, 2H), 2.27 (s, 1H), 1.11 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.3, 149.4, 140.6, 127.8, 123.4, 102.9, 71.6, 37.9, 23.9. **HRMS-ESI** $[C_{10}H_{15}N_2O_3]^+$ calcd 211.1083, found: 211.1084. **IR** (thin film): 3411, 2929, 1725, 1676, 1381, 1094, 1040, 1002, 813 cm^{-1}.



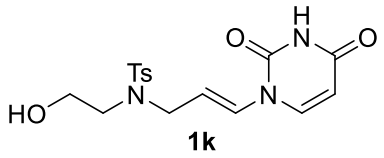
1j

An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. To a separate vial were added (*E*)-6-iodo-2-methylhex-5-en-2-ol (480 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M). The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (50% EtOAc/PE) provided title compound (237 mg, 53% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 117 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.30 (s, 1H), 7.42 (d, *J* = 8.0 Hz, 1H), 7.03 – 6.74 (m, 1H), 5.92 – 5.75 (m, 1H), 5.68 (dt, *J* = 14.2, 7.1 Hz, 1H), 2.28 (q, *J* = 7.5 Hz, 2H), 1.71 – 1.55 (m, 2H), 1.48 (s, 1H), 1.25 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.2, 149.4, 140.7, 124.1, 121.8, 102.9, 70.7, 42.9, 29.3, 24.8. **HRMS-ESI** $[C_{11}H_{17}N_2O_3]^+$ calcd 225.1239, found: 225.1234. **IR** (thin film): 3205, 2965, 2923, 2853, 1688, 1455, 1421, 1383, 1282, 1087, 849, 732 cm^{-1}.



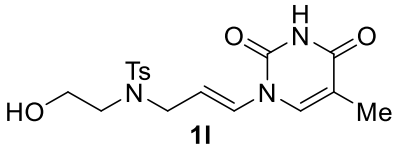
(*E*)-N-(2-hydroxyethyl)-N-(3-iodoallyl)-4-methylbenzenesulfonamide.

N-(2-hydroxyethyl)-4-methylbenzenesulfonamide (860 mg, 4.00 mmol) and Cs_2CO_3 (1.3 g, 4.0 mmol) in DMF (20 mL, 0.20 M) was added with (*E*)-3-bromo-1-iodoprop-1-ene (984 mg, 4.00 mmol) and stirred at rt for 12 h. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with Et_2O (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (30% EtOAc/PE) provided title compound (1.4 g, 92% yield) as a light yellow solid. **RF:** 0.25 60% EtOAc/PE (UV). **MP:** 51 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.73 – 7.64 (m, 2H), 7.38 – 7.29 (m, 2H), 6.42 – 6.25 (m, 2H), 3.83 (d, *J* = 5.4 Hz, 2H), 3.74 (s, 2H), 3.25 (t, *J* = 5.3 Hz, 2H), 2.44 (s, 3H), 2.19 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 143.8, 140.2, 136.0, 129.9, 127.2, 80.5, 61.1, 53.2, 49.8, 21.5. **HRMS-ESI** $[C_{12}H_{17}INO_3S]^+$ calcd 381.9974, found: 381.9973. **IR** (thin film): 3510, 2924, 1602, 1334, 1288, 1190, 1157, 1087, 814, 732 cm^{-1}.



1k

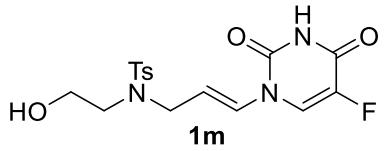
(*E*)-*N*-(3-(2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)allyl)-*N*-(2-hydroxyethyl)-4-methylbenzenes ulfonamide (1k). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. To a separate vial were added (*E*)-N-(2-hydroxyethyl)-N-(3-iodoallyl)-4- methylbenzenesulfonamide (762 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M). The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% PE/EtOAc) provided title compound (394 mg, 54% yield) as a white solid. **RF:** 0.25 50% PE/EtOAc (UV). **MP:** 176 ^oC. **^{1}H NMR** (400 MHz, DMSO) δ 7.80 (d, *J* = 8.1 Hz, 1H), 7.70 (d, *J* = 8.0 Hz, 2H), 7.39 (d, *J* = 7.6 Hz, 2H), 7.01 (d, *J* = 14.4 Hz, 1H), 5.82 – 5.63 (m, 2H), 4.78 (t, *J* = 5.4 Hz, 1H), 3.90 (d, *J* = 6.9 Hz, 2H), 3.47 (dd, *J* = 12.0, 6.3 Hz, 2H), 3.11 (t, *J* = 6.6 Hz, 2H), 2.38 (s, 3H). **^{13}C NMR** (100 MHz, DMSO) δ 163.0, 149.3, 143.2, 140.4, 136.5, 129.9, 127.3, 127.1, 126.7, 112.4, 102.8, 59.7, 49.2, 48.3, 21.0. **HRMS-ESI** $[C_{16}H_{18}N_3O_5S]^-$ calcd 364.0967, found: 364.0956. **IR** (thin film): 3474, 3045, 1727, 1667,1383, 1319, 1278, 1154, 1060, 885 cm^{-1}.



1l

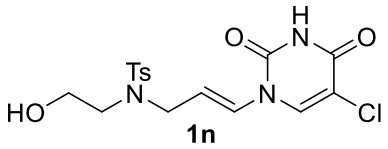
(*E*)-*N*-(2-hydroxyethyl)-4-methyl-*N*-(3-(5-methyl-2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)allyl) benzenesulfonamide (1l). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), thymine (504 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-N-(2-hydroxyethyl)-N- (3-iodoallyl)-4-methylbenzenesulfonamide (762 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to

rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (400 mg, 53% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 156 ^oC. **^{1}H NMR** (500 MHz, DMSO) δ 11.51 (s, 1H), 7.75 (s, 1H), 7.69 (d, *J* = 8.1 Hz, 2H), 7.39 (d, *J* = 7.9 Hz, 2H), 7.01 (d, *J* = 14.5 Hz, 1H), 5.72 (dt, *J* = 14.2, 6.9 Hz, 1H), 4.90 (t, *J* = 5.4 Hz, 1H), 3.89 (d, *J* = 6.8 Hz, 2H), 3.47 (q, *J* = 6.4 Hz, 2H), 3.12 (t, *J* = 6.5 Hz, 2H), 2.37 (s, 3H), 1.80 (s, 3H). **^{13}C NMR** (100 MHz, DMSO) δ 163.6, 149.3, 143.1, 136.6, 135.7, 129.8, 127.1, 126.5, 111.3, 110.7, 59.6, 49.14, 48.3, 21.0, 12.0. **HRMS-ESI** $[C_{17}H_{20}N_3O_5S]^-$ calcd 378.1124, found: 378.1117. **IR** (thin film): 3308, 3252, 1690, 1431, 1446, 1383, 1330, 1287, 1157, 1088, 803, 718 cm^{-1}.



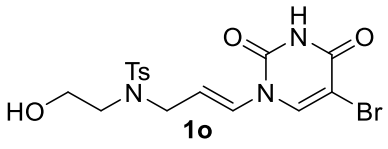
1m

(*E*)-*N*-(3-(5-fluoro-2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)allyl)-*N*-(2-hydroxyethyl)-4-methyl benzenesulfonamide (1m). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), 5-fluorouracil (520 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-N-(2-hydroxyethyl)-N- (3-iodoallyl)-4-methylbenzenesulfonamide (762 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (70% EtOAc/PE) provided title compound (391 mg, 51% yield) as a white solid. **RF:** 0.6 60% PE/EtOAc (UV). **MP:** 162 ^oC. **^{1}H NMR** (500 MHz, DMSO) δ 12.04 (s, 1H), 8.25 (d, *J* = 7.1 Hz, 1H), 7.70 (d, *J* = 8.3 Hz, 2H), 7.40 (d, *J* = 8.1 Hz, 2H), 7.01 (d, *J* = 14.5 Hz, 1H), 5.74 (dt, *J* = 14.1, 6.9 Hz, 1H), 4.77 (t, *J* = 5.2 Hz, 1H), 3.90 (d, *J* = 7.0 Hz, 2H), 3.47 (dd, *J* = 11.9, 6.5 Hz, 2H), 3.11 (t, *J* = 6.7 Hz, 2H), 2.38 (s, 3H). **^{13}C NMR** (125 MHz, DMSO) δ 157.0, 156.8, 148.0, 143.2, 141.6, 139.8, 136.6, 129.8, 127.1, 126.3, 125.0, 124.7, 112.2, 59.6, 49.1, 48.1, 21.0. **^{19}F NMR** (376 MHz, DMSO) δ -64.80. **HRMS-ESI** $[C_{16}H_{18}FN_3NaO_5S]^+$ calcd 406.0849, found: 406.0852. **IR** (thin film): 3342, 1708, 1663, 1385, 1324, 1283, 1156, 1086, 1008, 812 cm^{-1}.



1n

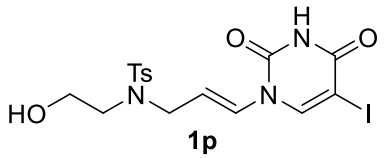
(*E*)-*N*-(3-(5-chloro-2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)allyl)-*N*-(2-hydroxyethyl)-4-methyl benzenesulfonamide (1n). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), 5-chlorouracil (584 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-N-(2-hydroxyethyl)-N- (3-iodoallyl)-4-methylbenzenesulfonamide (762 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (399 mg, 50% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 158 ^oC. **^{1}H NMR** (500 MHz, DMSO) δ 12.03 (s, 1H), 8.20 (s, 1H), 7.70 (d, *J* = 8.2 Hz, 2H), 7.39 (d, *J* = 8.0 Hz, 2H), 6.96 (d, *J* = 14.0 Hz, 1H), 5.83 (dt, *J* = 14.0, 6.9 Hz, 1H), 4.77 (t, *J* = 5.3 Hz, 1H), 3.91 (d, *J* = 6.5 Hz, 2H), 3.48 (dd, *J* = 12.1, 6.3 Hz, 2H), 3.13 (t, *J* = 6.5 Hz, 2H), 2.38 (s, 3H). **^{13}C NMR** (125 MHz, DMSO) δ 158.9, 148.5, 143.1, 137.6, 136.6, 129.8, 127.1, 126.2, 113.3, 108.7, 95.1, 59.6, 49.2, 48.0, 21.0. **HRMS-ESI** $[C_{16}H_{17}ClN_3O_5S]^-$ calcd 398.0577, found: 398.0568. **IR** (thin film): 3484, 3055, 2986, 1708, 1423, 1265, 896, 745 cm^{-1}.



1o

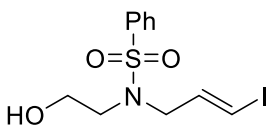
(*E*)-*N*-(3-(5-bromo-2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)allyl)-*N*-(2-hydroxyethyl)-4-methyl benzenesulfonamide (1o). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.2 mmol), 5-bromouracil (760 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-N-(2-hydroxyethyl)-N- (3-iodoallyl)-4-methylbenzenesulfonamide (762 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to

rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (478 mg, 54% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 152 °C. **^{1}H NMR** (500 MHz, DMSO) δ 12.00 (s, 1H), 8.22 (d, *J* = 4.4 Hz, 1H), 7.69 (d, *J* = 7.9 Hz, 2H), 7.38 (d, *J* = 7.5 Hz, 2H), 6.94 (d, *J* = 14.0 Hz, 1H), 5.90 – 5.78 (m, 1H), 4.78 (t, *J* = 5.0 Hz, 1H), 3.90 (d, *J* = 6.3 Hz, 2H), 3.56 – 3.45 (m, 2H), 3.18 – 3.11 (m, 2H), 2.37 (s, 3H). **^{13}C NMR** (125 MHz, DMSO) δ 159.0, 148.8, 143.2, 140.0, 136.7, 129.8, 127.1, 126.2, 113.3, 97.5, 59.6, 49.2, 48.0, 21.0. **HRMS-ESI** $[C16H18BrN3NaO5S]^+$ calcd 466.0048, found: 466.0051. **IR** (thin film): 3440, 1691, 1667, 1618, 1323, 1283, 1259, 1156, 1084, 1009, 724 cm^{-1}.



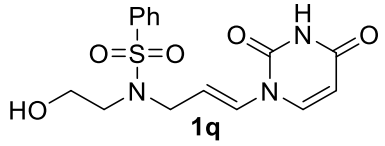
1p

(*E*)-*N*-(3-(5-iodo-2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)allyl)-*N*-(2-hydroxyethyl)-4-methylbenzenesulfonamide (1p). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), 5-iodouracil (952 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-N-(2-hydroxyethyl)-N- (3-iodoallyl)-4-methylbenzenesulfonamide (762 mg, 2.00 mmol), and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 °C. The solution was allowed to stir for 14 h at 80 °C and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (491 mg, 50% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 196 °C. **^{1}H NMR** (400 MHz, DMSO) δ 8.14 (s, 1H), 7.69 (d, *J* = 8.2 Hz, 2H), 7.38 (d, *J* = 8.1 Hz, 2H), 6.90 (d, *J* = 14.5 Hz, 1H), 5.87 – 5.75 (m, 1H), 4.88 (s, 1H), 3.90 (d, *J* = 6.7 Hz, 2H), 3.47 (d, *J* = 6.7 Hz, 2H), 3.14 (t, *J* = 6.5 Hz, 2H), 2.38 (s, 3H). **^{13}C NMR** (125 MHz, DMSO) δ 160.7, 149.3, 144.3, 143.1, 136.7, 129.8, 127.1, 126.2, 113.0, 71.9, 59.6, 49.1, 48.0, 21.1. **HRMS-ESI** $[C_{16}H_{18}IN_3NaO_5S]^+$ calcd 513.9910, found: 513.9918. **IR** (thin film): 3463, 1723, 1692, 1664, 1325, 1160, 1061, 973, 803, 718 cm^{-1}.



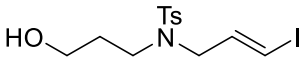
(*E*)-*N*-(2-hydroxyethyl)-*N*-(3-iodoallyl)benzenesulfonamide.

N-(2-hydroxyethyl)benzenesulfonamide (804 mg, 4.00 mmol) and Cs_2CO_3 (1.3 g, 4.0 mmol) in DMF (20 mL, 0.20 M) was added with (*E*)-3-bromo-1-iodoprop-1-ene (984 mg, 4.00 mmol) and stirred at rt for 12 h. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with Et_2O (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (30% EtOAc/PE) provided title compound (1.32 g, 90% yield) as a light yellow solid. **RF:** 0.25 60% EtOAc/PE (UV). **MP:** 53 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.91 – 7.77 (m, 2H), 7.66 – 7.59 (m, 1H), 7.59 – 7.49 (m, 2H), 6.34 (t, *J* = 3.9 Hz, 2H), 3.94 – 3.82 (m, 2H), 3.75 (d, *J* = 5.0 Hz, 2H), 3.28 (t, *J* = 5.3 Hz, 2H), 2.20 (s, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 140.0, 139.1, 133.0, 129.3, 127.2, 80.7, 61.1, 53.1, 49.8. **HRMS-ESI** $[C_{11}H_{15}INO_3S]^+$ calcd 367.9817, found: 367.9811. **IR** (thin film): 3535, 2925, 1446, 1332, 1288, 1158, 1088, 1002, 888, 732 cm^{-1}.



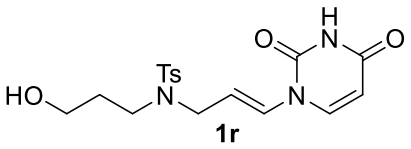
1q

(*E*)-*N*-(3-(2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)allyl)-*N*-(2-hydroxyethyl)benzenesulfonamide (1q). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-*N*-(2-hydroxyethyl)-*N*-(3-iodoallyl)benzenesulfonamide (734 mg, 2.00 mmol) and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (372 mg, 53% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 126 ^oC. **^{1}H NMR** (500 MHz, DMSO) δ 11.52 (s, 1H), 7.81 (dd, *J* = 9.7, 8.3 Hz, 4H), 7.67 (t, *J* = 7.4 Hz, 1H), 7.59 (t, *J* = 7.5 Hz, 2H), 7.03 (d, *J* = 14.4 Hz, 1H), 5.75 – 5.66 (m, 2H), 4.79 (s, 1H), 3.93 (d, *J* = 6.6 Hz, 2H), 3.49 (d, *J* = 5.7 Hz, 2H), 3.14 (t, *J* = 6.4 Hz, 2H). **^{13}C NMR** (125 MHz, DMSO) δ 162.9, 149.3, 140.4, 139.4, 132.8, 129.4, 127.0, 126.8, 112.4, 102.8, 59.6, 49.2, 48.2. **HRMS-ESI** $[C_{15}H_{17}N_3NaO_5S]^+$ calcd 374.0787, found: 374.0784. **IR** (thin film): 3418, 3392, 1728, 1690, 1331, 1158, 737, 692 cm^{-1}.



(*E*)-*N*-(3-hydroxypropyl)-*N*-(3-iodoallyl)-4-methylbenzenesulfonamide.

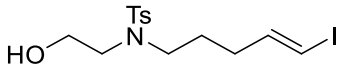
N-(3-hydroxypropyl)-4-methylbenzenesulfonamide (916 mg, 4.00 mmol) and Cs_2CO_3 (1.3 g, 4.0 mmol) in DMF (20 mL, 0.20 M) was added with (*E*)-3-bromo-1-iodoprop-1-ene (984 mg, 4.00 mmol) and stirred at rt for 12 h. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with Et_2O (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (30% EtOAc/PE) provided title compound (1.44 g, 91% yield) as a light yellow oil. **RF:** 0.25 60% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.2 Hz, 2H), 7.31 (d, *J* = 8.1 Hz, 2H), 6.30 (d, *J* = 4.4 Hz, 2H), 3.82 – 3.64 (m, 4H), 3.24 (t, *J* = 6.5 Hz, 2H), 2.42 (s, 3H), 1.71 (dd, *J* = 11.9, 6.0 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 143.7, 140.2, 136.2, 129.8, 127.0, 80.3, 58.5, 52.0, 44.11, 30.6, 21.5. **HRMS-ESI** $[C_{13}H_{19}INO_3S]^+$ calcd 396.0130, found: 396.0126. **IR** (thin film): 3554, 3498, 3463, 2927, 1334, 1157, 1112, 1090, 909, 732 cm^{-1}.



1r

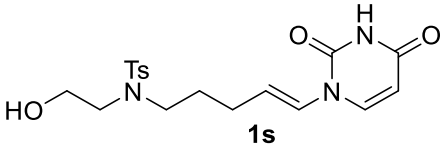
(*E*)-*N*-(3-(2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)allyl)-*N*-(3-hydroxypropyl)-4-methylbenzene sulfonamide (1r). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-*N*-(3-hydroxypropyl)-*N*-(3-iodoallyl)-4-methylbenzenesulfonamide (790 mg, 2.00 mmol) and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^{o}C. The solution was allowed to stir for 14 h at 80 ^{o}C and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (379 mg, 50% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 171 ^{o}C. **^{1}H NMR** (400 MHz, DMSO) δ 7.80 (d, *J* = 8.0 Hz, 1H), 7.68 (d, *J* = 8.0 Hz, 2H), 7.39 (d, *J* = 8.0 Hz, 2H), 5.70 (dd, *J* = 16.9, 7.7 Hz, 2H), 4.49 (d, *J* = 5.1 Hz, 1H), 3.86 (d, *J* = 6.7 Hz, 2H), 3.35 (d, *J* = 5.3 Hz, 2H), 3.13 (d, *J* = 6.3 Hz, 2H), 2.37 (s, 3H), 1.61 (d, *J* = 6.1 Hz, 2H). **^{13}C NMR** (100 MHz, DMSO) δ 163.0, 149.4, 143.2, 140.4, 136.5, 129.9, 127.1, 126.7, 112.5, 102.8, 58.2,

47.4, 44.9, 31.4, 21.0. **HRMS-ESI** $[C_{16}H_{18}N_3O_5S]^-$ calcd 378.1124, found: 378.1117. **IR** (thin film): 3437, 3410, 3389, 1698, 1648,1617, 1317, 1154, 810, 739 cm^{-1}.



(*E*)-*N*-(2-hydroxyethyl)-*N*-(5-iodopent-4-en-1-yl)-4-methylbenzenesulfonamide

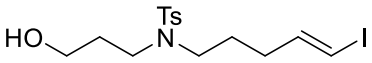
N-(2-hydroxyethyl)-4-methylbenzenesulfonamide (860 mg, 4.00 mmol) and Cs_2CO_3 (1.3 g, 4.0 mmol) in DMF (20 mL, 0.20 M) was added with (*E*)-5-chloro-1-iodopent-1-ene (920 mg, 4.00 mmol) and stirred at rt for 12 h. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with Et_2O (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (30% EtOAc/PE) provided title compound (1.23 g, 75% yield) as a light yellow oil. **RF:** 0.25 60% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 8.2 Hz, 2H), 7.31 (d, *J* = 7.9 Hz, 2H), 6.44 (dt, *J* = 14.3, 7.1 Hz, 1H), 6.01 (d, *J* = 14.4 Hz, 1H), 3.73 (t, *J* = 5.4 Hz, 2H), 3.20 (t, *J* = 5.5 Hz, 2H), 3.17 – 3.07 (m, 2H), 2.42 (s, 3H), 2.06 (dd, *J* = 14.2, 7.5 Hz, 2H), 1.65 (dt, *J* = 14.9, 7.5 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 144.8, 143.6, 135.6, 129.8, 127.2, 75.7, 61.4, 51.0, 49.2, 32.8, 27.3, 21.5. **HRMS-ESI** $[C_{14}H_{21}INO_3S]^+$ calcd 410.0287, found: 410.0286. **IR** (thin film): 3552, 2939, 2873, 1666, 1458, 1382, 1336, 1156, 1117, 1089, 947 cm^{-1}.



1s

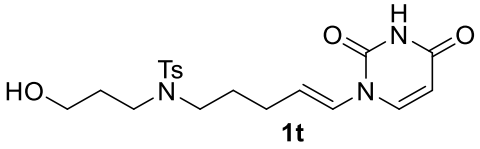
(*E*)-*N*-(5-(2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)pent-4-en-1-yl)-*N*-(2-hydroxyethyl)-4-methyl benzenesulfonamide (1s). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-*N*-(2-hydroxyethyl)-*N*-(5-iodopent-4-en-1-yl)-4-methylbenzenesulfonamide (818 mg, 2.00 mmol) and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (393 mg, 50% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 98 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.04 (s, 1H), 7.66 (d, *J* = 8.5

Hz, 2H), 7.46 (d, *J* = 8.0 Hz, 1H), 7.28 (d, *J* = 8.0 Hz, 2H), 6.84 (d, *J* = 14.4 Hz, 1H), 5.76 (dd, *J* = 8.2, 1.6 Hz, 1H), 5.65 (dt, *J* = 14.4, 7.1 Hz, 1H), 3.74 (d, *J* = 5.9 Hz, 2H), 3.17 (dt, *J* = 21.0, 6.3 Hz, 4H), 3.09 (s, 1H), 2.39 (s, 3H), 2.17 (q, *J* = 7.2 Hz, 2H), 1.73 (q, *J* = 7.3 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.6, 149.6, 143.5, 140.8, 135.6, 129.7, 127.0, 124.6, 120.1, 102.9, 61.3, 51.0, 49.3, 28.2, 26.6, 21.4. **HRMS-ESI** $[C_{18}H_{22}N_3O_5S]^-$ calcd 392.1280, found: 392.1272. **IR** (thin film): 3266, 3194, 3059, 2935, 1689, 1453, 1384, 1334, 1277, 1156, 1089, 814, 732 cm^{-1}.



(*E*)-*N*-(3-hydroxypropyl)-*N*-(5-iodopent-4-en-1-yl)-4-methylbenzenesulfonamide

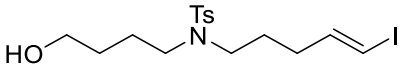
N-(3-hydroxypropyl)-4-methylbenzenesulfonamide (916 mg, 4.00 mmol) and Cs_2CO_3 (1.3 g, 4.0 mmol) in DMF (20 mL, 0.20 M) was added with (*E*)-5-chloro-1-iodopent-1-ene (920 mg, 4.00 mmol) and stirred at rt for 12 h. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with Et_2O (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (30% EtOAc/PE) provided title compound (796 mg, 78% yield) as a light yellow oil. **RF:** 0.25 60% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, CDCl3) δ 7.67 (d, *J* = 8.3 Hz, 2H), 7.31 (d, *J* = 8.3 Hz, 2H), 6.43 (dt, *J* = 14.3, 7.1 Hz, 1H), 6.01 (dt, *J* = 14.4, 1.4 Hz, 1H), 3.87 – 3.65 (m, 2H), 3.22 (t, *J* = 6.5 Hz, 2H), 3.08 (dd, *J* = 8.5, 6.7 Hz, 2H), 2.42 (s, 3H), 2.13 – 1.99 (m, 2H), 1.79 – 1.71 (m, 2H), 1.71 – 1.55 (m, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 144.8, 143.4, 136.1, 129.8, 127.0, 75.7, 58.7, 48.4, 45.3, 33.0, 31.5, 27.5, 21.5. **HRMS-ESI** $[C_{15}H_{23}INO_3S]^+$ calcd 424.0443, found: 424.0446. **IR** (thin film): 2937, 1334, 1157, 1115, 1058, 945, 815, 729 cm^{-1}.



1t

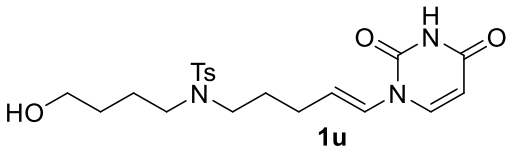
(*E*)-*N*-(5-(2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)pent-4-en-1-yl)-*N*-(3-hydroxypropyl)-4-methylbenzenesulfonamide (1t). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-*N*-(3-hydroxypropyl)-*N*-(5-iodopent-4-en-1-yl)-4-methylbenzenesulfonamide (846 mg, 2.00 mmol) and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution

was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (439 mg, 54% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 119 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.62 (d, *J* = 8.2 Hz, 2H), 7.44 (d, *J* = 8.0 Hz, 1H), 7.25 (d, *J* = 8.2 Hz, 2H), 6.80 (d, *J* = 14.1 Hz, 1H), 5.73 (d, *J* = 8.0 Hz, 1H), 5.62 (dt, *J* = 14.2, 7.1 Hz, 1H), 3.69 – 3.60 (m, 2H), 3.16 (t, *J* = 6.9 Hz, 2H), 3.14 – 3.05 (m, 2H), 2.36 (s, 3H), 2.19 – 2.10 (m, 2H), 1.69 (td, *J* = 16.7, 14.8, 7.0 Hz, 4H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.6, 149.4, 143.4, 140.7, 135.8, 129.6, 126.8, 124.6, 120.0, 102.8, 58.7, 48.3, 45.6, 31.4, 28.3, 26.6, 21.3. ^{13}C NMR (101 MHz, $CDCl_3$) δ 144.97, 143.22, 136.44, 129.67, 127.08, 75.64, 62.22, 48.33, 47.55, 33.01, 29.48, 27.41, 25.25, 21.49. **HRMS-ESI** $[C_{19}H_{24}N_3O_5S]^-$ calcd 406.1437, found: 406.1430. **IR** (thin film): 3206, 3063, 2933, 2878, 1690, 1383, 1333, 1157, 888, 732 cm^{-1}.



(*E*)-*N*-(4-hydroxybutyl)-*N*-(5-iodopent-4-en-1-yl)-4-methylbenzenesulfonamide

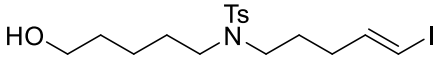
N-(4-hydroxybutyl)-4-methylbenzenesulfonamide (972 mg, 4.00 mmol) and Cs_2CO_3 (1.3 g, 4.0 mmol) in DMF (20 mL, 0.20 M) was added with (*E*)-5-chloro-1-iodopent-1-ene (920 mg, 4.00 mmol) and stirred at rt for 12 h. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with Et_2O (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (30% EtOAc/PE) provided title compound (1.4 g, 80% yield) as a light yellow oil. **RF:** 0.25 60% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.0 Hz, 2H), 7.29 (d, *J* = 8.0 Hz, 2H), 6.44 (dt, *J* = 14.2, 7.1 Hz, 1H), 6.01 (d, *J* = 14.3 Hz, 1H), 3.64 (t, *J* = 6.1 Hz, 2H), 3.09 (dt, *J* = 21.7, 6.9 Hz, 4H), 2.42 (s, 3H), 2.05 (q, *J* = 7.3 Hz, 2H), 1.76 – 1.50 (m, 8H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.0, 143.2, 136.4, 129.7, 127.1, 75.6, 62.2, 48.3, 47.6, 33.0, 29.5, 27.4, 25.2, 21.5. **HRMS-ESI** $[C_{16}H_{25}INO_3S]^+$ calcd 438.0600, found: 438.0600. **IR** (thin film): 3552, 2939, 2873, 1666, 1458, 1382, 1336, 1156, 1117, 1089, 947 cm^{-1}.



1u

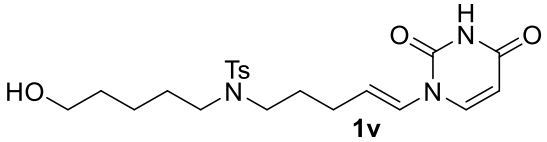
(*E*)-*N*-(5-(2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)pent-4-en-1-yl)-*N*-(4-hydroxybutyl)-4-methylbenzenesulfonamide (1u). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-*N*-(4-hydroxybutyl)-*N*-(5-iodopent-4-en-1-yl)-4-methylbenzenesulfonamide (874 mg, 2.00 mmol) and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed

with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 °C. The solution was allowed to stir for 14 h at 80 °C and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (446 mg, 53% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 72 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.22 (s, 1H), 7.61 (d, *J* = 8.3 Hz, 2H), 7.45 (d, *J* = 8.1 Hz, 1H), 7.33 – 7.21 (m, 2H), 6.81 (d, *J* = 14.4 Hz, 1H), 5.75 (t, *J* = 7.5 Hz, 1H), 5.63 (dt, *J* = 14.3, 7.1 Hz, 1H), 3.58 (q, *J* = 6.0, 4.3 Hz, 2H), 3.21 – 2.94 (m, 4H), 2.75 (s, 1H), 2.36 (s, 3H), 2.13 (q, *J* = 7.3 Hz, 2H), 1.67 (q, *J* = 7.4 Hz, 2H), 1.62 – 1.54 (m, 2H), 1.50 (ddt, *J* = 7.8, 5.6, 2.5 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.6, 149.5, 143.1, 140.7, 136.1, 129.6, 126.8, 124.5, 120.0, 102.8, 61.7, 48.4, 47.6, 29.3, 28.3, 26.6, 25.2, 21.3. **HRMS-ESI** $[C_{20}H_{26}N_3O_5S]^-$ calcd 420.1593, found: 420.1588. **IR** (thin film): 3381, 3278, 3208, 3056, 2940, 2867, 1694, 1453, 1383, 1333, 1276, 1157, 1090, 946, 732 cm^{-1}.



(*E*)-*N*-(5-hydroxypentyl)-*N*-(5-iodopent-4-en-1-yl)-4-methylbenzenesulfonamide

N-(5-hydroxybutyl)-4-methylbenzenesulfonamide (1.03 g, 4.00 mmol) and Cs_2CO_3 (1.3 g, 4.0 mmol) in DMF (20 mL, 0.20 M) was added with (*E*)-5-chloro-1-iodopent-1-ene (920 mg, 4.00 mmol) and stirred at rt for 12 h. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with Et_2O (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (30% EtOAc/PE) provided title compound (1.4 g, 78% yield) as a light yellow oil. **RF:** 0.25 60% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.67 (d, *J* = 8.3 Hz, 2H), 7.30 (d, *J* = 7.9 Hz, 2H), 6.45 (dt, *J* = 14.3, 7.1 Hz, 1H), 6.02 (dd, *J* = 14.4, 1.4 Hz, 1H), 3.63 (t, *J* = 6.3 Hz, 2H), 3.08 (dd, *J* = 14.9, 7.3 Hz, 4H), 2.43 (s, 3H), 2.06 (dd, *J* = 14.7, 7.3 Hz, 2H), 1.59 (dq, *J* = 14.3, 7.8 Hz, 7H), 1.36 (dd, *J* = 15.5, 8.2 Hz, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 145.0, 143.2, 136.5, 129.6, 127.1, 75.6, 62.6, 48.4, 47.5, 33.0, 32.1, 28.5, 27.4, 22.8, 21.5. **HRMS-ESI** $[C_{17}H_{27}INO_3S]^+$ calcd 452.0756, found: 452.0762. **IR** (thin film): 3399, 2939, 2865, 1667, 1335, 1157, 1090, 946, 732 cm^{-1}.



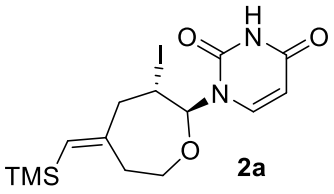
1v

(*E*)-*N*-(5-(2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)pent-4-en-1-yl)-*N*-(5-hydroxypentyl)-4-methylbenzenesulfonamide (1v). An oven dried vial, equipped with a stir bar was charged with CuTc (38 mg, 0.20 mmol), uracil (448 mg, 4.00 mmol), and K_3PO_4 (849 mg, 4.00 mmol). The vial was purged with argon. (*E*)-*N*-(5-hydroxypentyl)-*N*-(5-iodopent-4-en-1-yl)-4-methylbenzenesulfonamide (902 mg, 2.00 mmol) and DMSO (10 mL, 0.20 M) were added to a separate vial. The solution was degassed with argon by bubbling argon through the solution for 10 min. Freshly distilled DMEDA (35 mg, 0.40 mmol) was then added to the solution containing vinyl iodide. This solution was transferred by syringe to the vial containing the Cu salt under argon and placed in an oil bath pre-heated to 80 ^oC. The solution was allowed to stir for 14 h at 80 ^oC and then removed from the heat bath and cooled to rt. The solution was then quenched by pouring into saturated NH_4Cl aqueous solution. The solution was extracted with EtOAc (4 x 20 mL) and washed with brine (3 x 20 mL). The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (80% EtOAc/PE) provided title compound (443 mg, 51% yield) as a white solid. **RF:** 0.5 60% PE/EtOAc (UV). **MP:** 81 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 10.02 (s, 1H), 7.63 (d, *J* = 8.2 Hz, 2H), 7.46 (d, *J* = 8.2 Hz, 1H), 7.30 – 7.25 (m, 2H), 6.85 (d, *J* = 14.3 Hz, 1H), 5.77 (d, *J* = 8.1 Hz, 1H), 5.66 (dd, *J* = 14.2, 7.1 Hz, 1H), 3.58 (t, *J* = 6.4 Hz, 2H), 3.11 – 3.02 (m, 4H), 2.39 (s, 3H), 2.35 (s, 1H), 2.16 (dd, *J* = 14.0, 7.0 Hz, 2H), 1.70 – 1.64 (m, 2H), 1.55 – 1.48 (m, 4H), 1.35 – 1.28 (m, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.5, 149.5, 143.2, 140.7, 136.2, 129.6, 126.9, 124.6, 120.0, 102.9, 62.2, 48.6, 47.7, 31.9, 28.4, 28.4, 26.7, 22.8, 21.4. **HRMS-ESI** $[C_{21}H_{28}N_3O_5S]^-$ calcd 434.1750, found: 434.1743. **IR** (thin film): 3441, 3212, 3061, 2939, 2864, 1692, 1383, 1156, 837, 750 cm^{-1}.

General procedure for Pd-catalyzed iodo-hemi-aminal formation

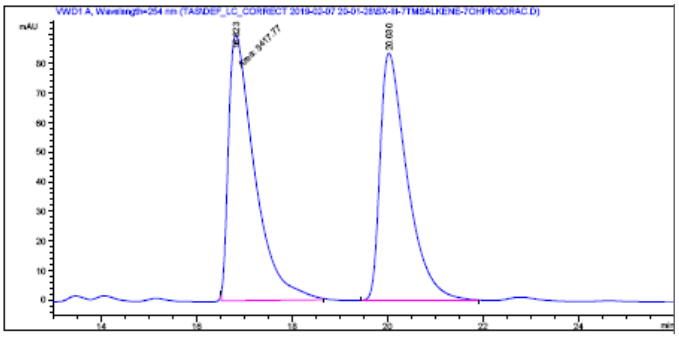
Racemic: Substrate **1** (0.10 mmol) was dissolved in dry DCM (0.75 mL) in a vial under argon. In a separate vial, Cp(allyl)Pd (0.010 mmol) and racemic ligand (0.010 mmol) was added and the vial was flushed with argon, dry DCM (0.25 mL) was then added and stirred at rt for 15-30 min. This catalyst mixture was then added to the substrate solution at 4 ^oC followed by addition of NIS (0.11 mmol). The reaction mixture was then stirred at 4 ^oC for 10 h. Solvent was removed under pressure and the crude reaction mixture was subjected to silica gel chromatography.

Asymmetric: Substrate **1** (0.10 mmol) was dissolved in dry DCM (0.75 mL) in a vial under argon. In a separate vial, Cp(allyl)Pd (0.010 mmol) and chiral ligand (0.010 mmol) was added and the vial was flushed with argon, dry DCM (0.25 mL) was then added and stirred at rt for 15-30 min. This catalyst mixture was then added to the substrate solution at 4 ^oC followed by addition of NIS (0.11 mmol). The reaction mixture was then stirred at 4 ^oC for 10 h. Solvent was removed under pressure and the crude reaction mixture was subjected to silica gel chromatography.

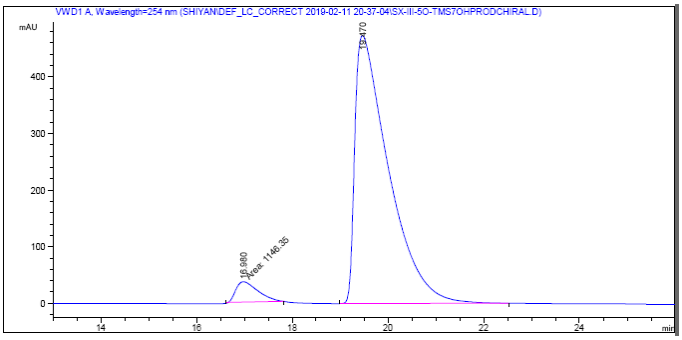


2a

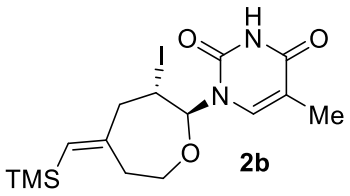
1-((2*S*,3*S*,*E*)-3-iodo-5-((trimethylsilyl)methylene)oxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2a). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1a** (30 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a waxy oil (39 mg, 93% yield). **RF:** 0.25 50% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.95 (s, 1H), 7.18 (d, *J* = 8.2 Hz, 1H), 5.89 (d, *J* = 10.3 Hz, 1H), 5.79 (dd, *J* = 8.1, 2.3 Hz, 1H), 5.64 (s, 1H), 4.23 – 4.06 (m, 2H), 3.85 (ddd, *J* = 12.5, 10.2, 4.9 Hz, 1H), 3.14 (dd, *J* = 13.9, 4.3 Hz, 1H), 3.04 (dd, *J* = 13.7, 9.8 Hz, 1H), 2.75 (ddd, *J* = 16.7, 10.1, 6.9 Hz, 1H), 2.47 (dd, *J* = 12.4, 3.3 Hz, 1H), 0.13 (s, 9H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.0, 151.4, 150.2, 138.7, 132.6, 103.4, 89.3, 69.2, 50.0, 36.2, 29.4, -0.2. **HRMS-ESI** $[C_{15}H_{23}IN_2NaO_3Si]^+$ calcd 443.0263, found: 443.0259. **IR** (thin film): 3244, 3224, 2956, 1695, 1458, 1381, 1254, 1084, 839 cm^{-1}. **$[\alpha]_D^{22}$** = –396.9 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IB column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 90:10, 254 nm absorbance). Major enantiomer (t_R = 19.5 min), minor enantiomer (t_R = 16.9 min): **ee** = 90%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	16.823	MM	0.6345	3417.76636	89.77752	50.9053
2	20.030	BB	0.5906	3296.20776	83.67180	49.0947

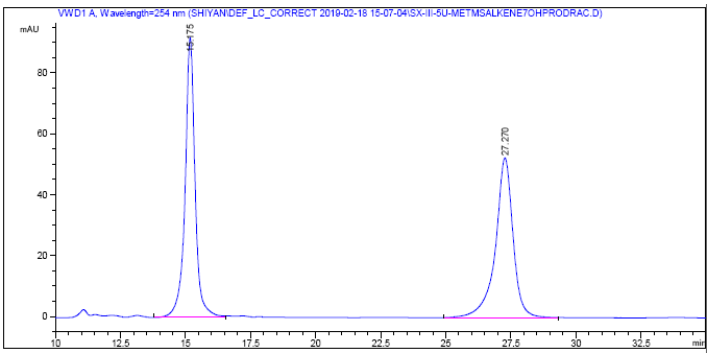


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	16.980	MM	0.5335	1146.34668	35.81141	4.7214
2	19.470	BB	0.7091	2.31334e4	472.81882	95.2786

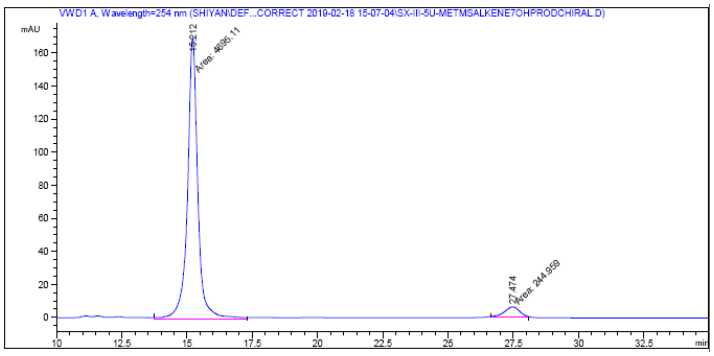


2b

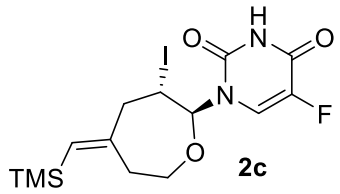
1-((2*S*,3*S*,*E*)-3-iodo-5-((trimethylsilyl)methylene)oxepan-2-yl)-5-methylpyrimidine-2,4(1*H*,3*H*)-dione (2b). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1b** (31 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a waxy oil (39 mg, 90% yield). **RF:** 0.25 50% EtOAc/PE (UV). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.70 (s, 1H), 6.99 (s, 1H), 5.89 (d, *J* = 10.4 Hz, 1H), 5.65 (s, 1H), 4.26 – 4.14 (m, 1H), 4.09 (d, *J* = 8.0 Hz, 1H), 3.90 – 3.77 (m, 1H), 3.14 (dd, *J* = 13.8, 3.7 Hz, 1H), 3.11 – 2.99 (m, 1H), 2.85 – 2.69 (m, 1H), 2.48 (d, *J* = 15.4 Hz, 1H), 1.94 (s, 3H), 0.14 (s, 9H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.3, 151.4, 150.1, 134.3, 132.7, 111.9, 89.3, 69.4, 50.2, 36.3, 29.7, 12.6, -0.1. **HRMS-ESI** $[C_{15}H_{24}IN_2O_3Si]^+$ calcd 435.0601 found: 435.0597. **IR** (thin film): 3229, 3068, 2954, 1693, 1463, 1387, 1252, 1087, 849, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –241.4 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 75:25, 254 nm absorbance). Major enantiomer (t_R = 15.2 min), minor enantiomer (t_R = 27.5 min): **ee** = 90%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	15.175	VB	0.3939	2459.23413	91.85931	49.8401
2	27.270	BB	0.6904	2475.01440	52.43876	50.1599

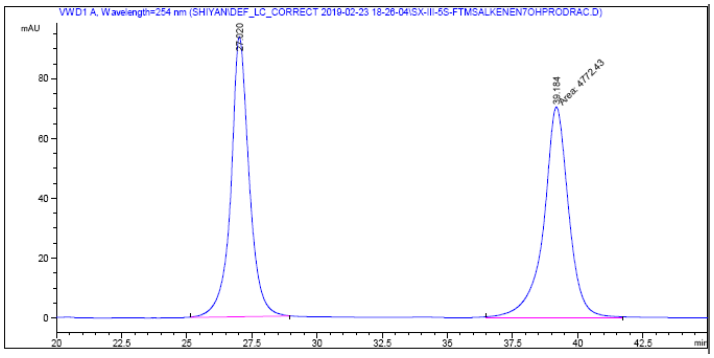


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	15.212	MM	0.4595	4695.11279	170.29936	95.0414
2	27.474	MM	0.6704	244.95897	6.09031	4.9586

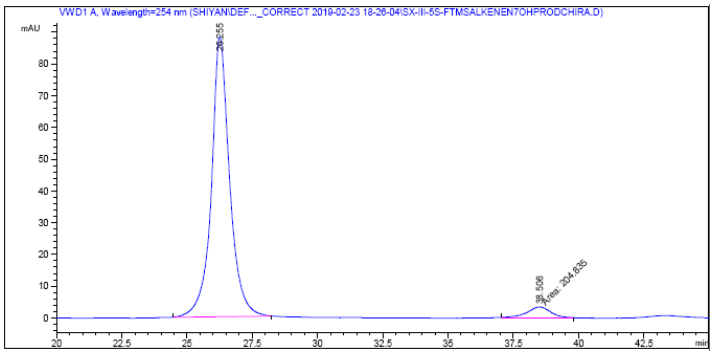


2c

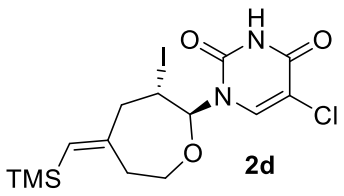
5-fluoro-1-((2*S*,3*S*,*E*)-3-iodo-5-((trimethylsilyl)methylene)oxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2c). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1c** (31 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a waxy oil (40 mg, 91% yield). **RF:** 0.3 50% EtOAc/PE (UV). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.55 (s, 1H), 7.24 (d, *J* = 5.6 Hz, 1H), 5.90 (d, *J* = 10.2 Hz, 1H), 5.64 (s, 1H), 4.24 – 4.01 (m, 2H), 3.87 (td, *J* = 12.4, 4.9 Hz, 1H), 3.13 (dd, *J* = 13.8, 4.0 Hz, 1H), 3.10 – 3.00 (m, 1H), 2.88 – 2.69 (m, 1H), 2.48 (d, *J* = 15.6 Hz, 1H), 0.13 (s, 8H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 156.7, 156.5, 151.2, 148.9, 141.9, 140.0, 132.9, 123.1, 122.8, 89.5, 69.3, 50.0, 36.1, 29.2, -0.2. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -57.37. **HRMS-ESI** $[C_{14}H_{21}FIN_2O_3Si]^+$ calcd 439.0350, found: 439.0348. **IR** (thin film): 3445, 3080, 2954, 1712, 1252, 1129, 1088, 1026, 852, 589 cm^{-1}. **$[\alpha]_D^{22}$** = –282.5 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 95:5, 254 nm absorbance). Major enantiomer (t_R = 26.3 min), minor enantiomer (t_R = 38.5 min): **ee** = 91%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	27.020	BB	0.7143	4586.68799	93.60667	49.0077
2	39.184	MM	1.1277	4772.43213	70.53400	50.9923



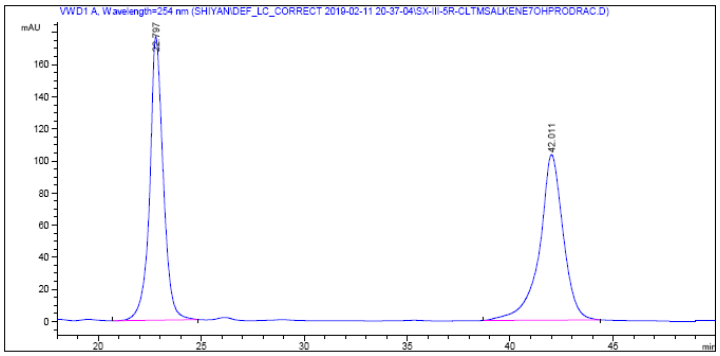
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	26.255	BB	0.7076	4292.45850	88.20078	95.4454
2	38.506	MM	1.0210	204.83533	3.34377	4.5546



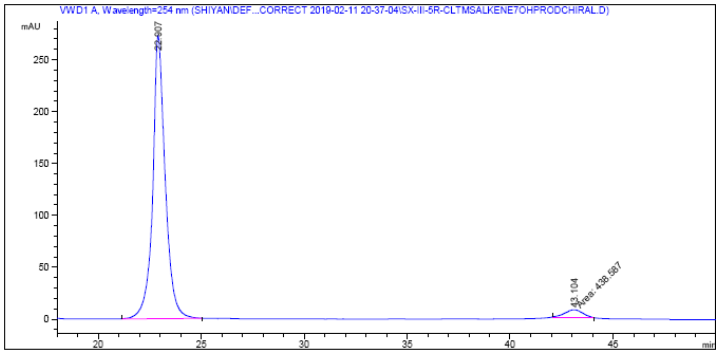
2d

5-chloro-1-((2*S*,3*S*,*E*)-3-iodo-5-((trimethylsilyl)methylene)oxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2d). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1d** (33 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a waxy oil (42 mg, 92% yield). **RF:** 0.25 50% EtOAc/PE (UV). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.92 (s, 1H), 7.39 (s, 1H), 5.88 (d, *J* = 10.3 Hz, 1H), 5.66 (s, 1H), 4.20 – 4.06 (m, 2H), 3.85 (ddd, *J* = 12.5, 10.1, 5.0 Hz, 1H), 3.15 (dd, *J* = 14.0, 4.2 Hz, 1H), 3.04 (dd, *J* = 13.8, 9.7 Hz, 1H), 2.76 (ddd, *J* = 16.5, 10.0, 6.9 Hz, 1H), 2.54 – 2.44 (m, 1H), 0.14 (s, 9H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 158.4, 150.9, 149.1, 135.7, 133.1, 110.1, 89.6, 69.5, 50.1, 36.2, 29.2, -0.1. **HRMS-ESI** $[C_{14}H_{21}ClIN_2O_3Si]^+$ calcd 455.0055, found: 455.0051. **IR** (thin film): 3220, 3071, 2954, 1697, 1628, 1252, 1093, 1053, 845 cm^{-1}. **$[\alpha]_D^{22}$** = –361.2 (c 0.3 in DCM). **Enantiomeric excess** was determined

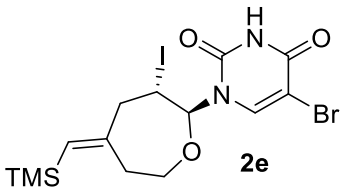
by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 97:3, 254 nm absorbance). Major enantiomer (t_R = 22.9 min), minor enantiomer (t_R = 43.1 min): **ee** = 92%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	22.797	VB	0.6729	8069.61621	176.60542	49.3686
2	42.011	BB	1.1473	8276.02441	103.14059	50.6314



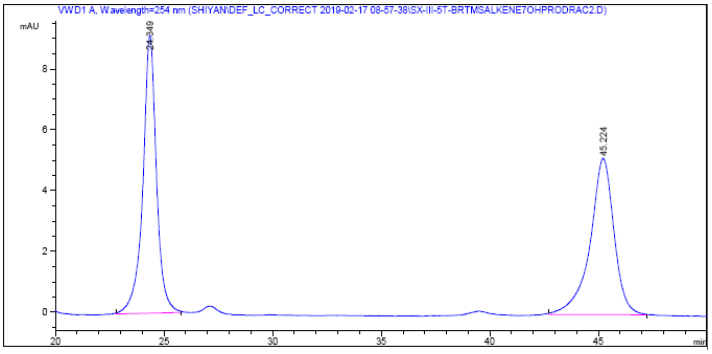
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	22.907	BB	0.6103	1.15488e4	272.85370	96.3413
2	43.104	MM	0.9962	438.58725	7.33749	3.6587



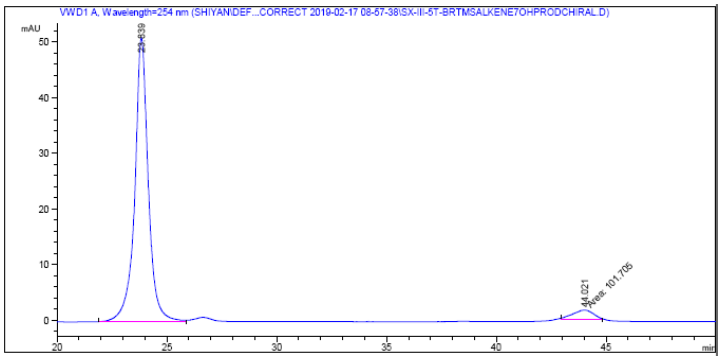
2e

5-bromo-1-((2*S*,3*S*,*E*)-3-iodo-5-((trimethylsilyl)methylene)oxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2e). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1e** (37 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a waxy oil (45 mg, 90% yield). **RF:** 0.25 50% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.98 (s, 1H), 7.50 (s, 1H), 5.88 (d, *J* = 10.3 Hz, 1H), 5.66 (s, 1H), 4.12 (dt, *J* = 9.9, 8.3 Hz, 2H), 4.01 – 3.79 (m, 1H), 3.14 (dd, *J* = 13.8, 4.3 Hz, 1H), 3.12 – 2.94 (m, 1H), 2.75 (ddd, *J* = 16.5, 9.9, 6.9 Hz, 1H), 2.48 (d, *J* = 15.8 Hz, 1H), 0.14 (s, 8H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 158.5, 150.9, 149.3, 138.3, 133.1, 97.9, 89.6, 69.5, 50.1, 36.2, 29.3, -0.1. **HRMS-ESI** $[C_{14}H_{21}BrIN_2O_3Si]^+$ calcd 498.9549, found: 498.9545. **IR** (thin film): 3206, 3073, 2954, 1698, 1622, 1442, 1252, 1091, 1043, 844 cm^{-1}. **$[\alpha]_D^{22}$** = –159.9 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC.

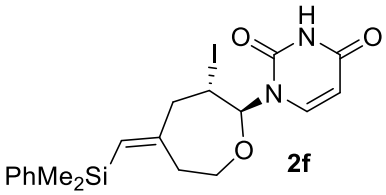
Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 95:5, 254 nm absorbance). Major enantiomer (t_R = 23.8 min), minor enantiomer (t_R = 44.0 min): **ee** = 91%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	24.349	BB	0.6401	399.07239	9.14542	50.2904
2	45.224	BB	1.1047	394.46320	5.14204	49.7096



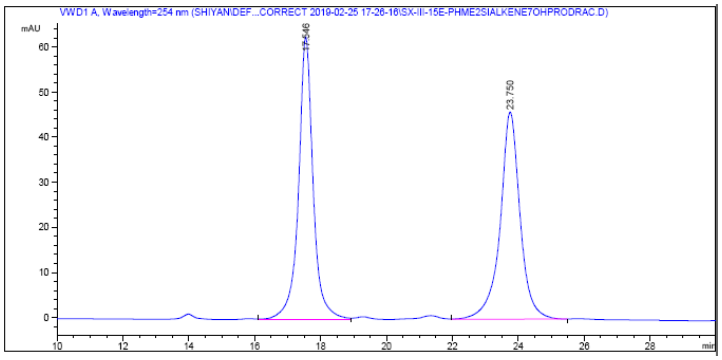
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	23.839	BB	0.6279	2197.14917	50.99540	95.5758
2	44.021	MM	1.0658	101.70547	1.59046	4.4242



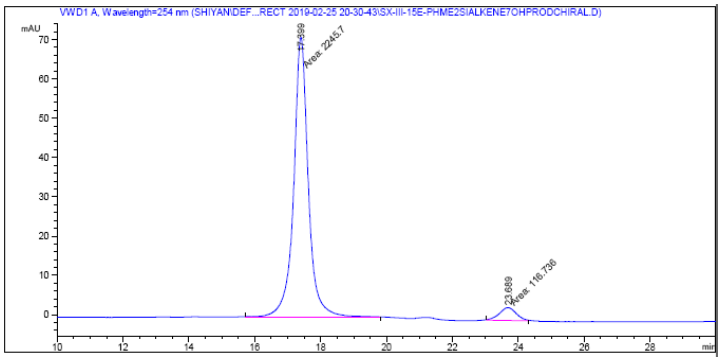
2f

1-((2*S*,3*S*,*E*)-5-((dimethyl(phenyl)silyl)methylene)-3-iodooxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2f). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1f** (36 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a waxy oil (41 mg, 85% yield). **RF:** 0.25 50% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.51 (s, 1H), 7.55 (dd, *J* = 6.4, 2.9 Hz, 2H), 7.50 – 7.34 (m, 3H), 7.16 (d, *J* = 8.2 Hz, 1H), 6.10 – 5.64 (m, 3H), 4.32 – 4.11 (m, 1H), 4.02 – 3.85 (m, 1H), 3.65 (dd, *J* = 13.9, 8.8 Hz, 1H), 3.18 (dd, *J* = 13.8, 4.5 Hz, 1H), 3.14 – 3.00 (m, 1H), 2.74 – 2.52 (m, 1H), 2.34 (d, *J* = 13.5 Hz, 1H), 0.40 (s, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.4, 153.0, 149.9, 138.7, 133.7, 130.7, 129.2, 128.0, 103.4, 89.5, 69.2, 49.9, 36.7, 29.4, -1.1, -1.4. **HRMS-ESI** $[C_{19}H_{24}IN_2O_3Si]^+$ calcd 483.0601, found: 483.0602. **IR** (thin film): 3197, 3066, 2955, 2919, 1692, 1455, 1382, 1256, 1083, 836 cm^{-1}. **$[\alpha]_D^{22}$** = –60.7 (c 0.3

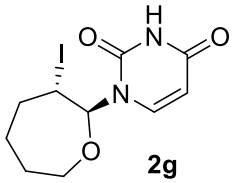
in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 90:10, 254 nm absorbance). Major enantiomer (t_R = 17.4 min), minor enantiomer (t_R = 23.7 min): **ee** = 90%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	17.546	VV	0.4547	1940.86523	62.63926	50.0831
2	23.750	VB	0.6194	1934.42566	45.93750	49.9169



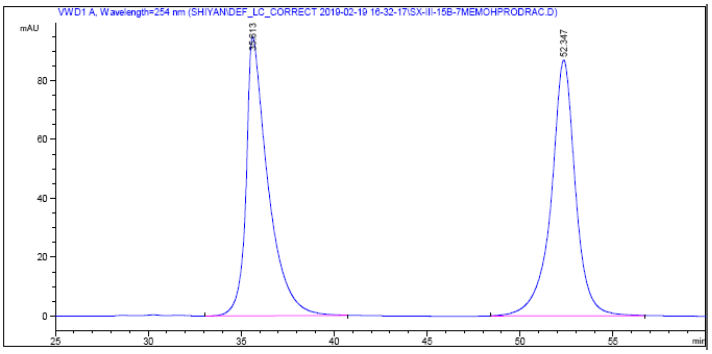
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	17.399	MM	0.5248	2245.69775	71.32191	95.0586
2	23.689	MM	0.5969	116.73641	3.25967	4.9414



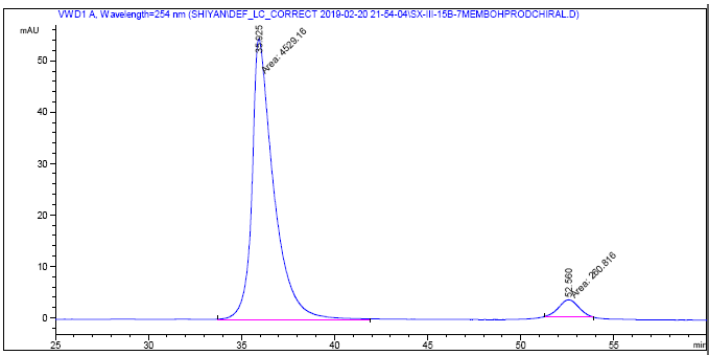
2g

1-((2*S*,3*S*)-3-iodooxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2g). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1g** (21 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a colorless oil (31 mg, 91% yield). **RF:** 0.25 50% EtOAc/PE (UV). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.88 (s, 1H), 7.26 – 7.16 (m, 1H), 5.90 (d, *J* = 10.2 Hz, 1H), 5.87 – 5.69 (m, 1H), 4.38 – 4.20 (m, 1H), 4.03 – 3.93 (m, 1H), 3.88 (dd, *J* = 12.1, 6.0 Hz, 1H), 2.69 – 2.53 (m, 1H), 2.32 – 2.19 (m, 1H), 1.96 (d, *J* = 7.1 Hz, 1H), 1.83 – 1.62 (m, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.7, 150.1, 139.0, 103.4, 87.9, 69.7, 39.7, 30.4, 29.0, 24.4. **HRMS-ESI** $[C_{10}H_{14}IN_2O_3]^+$ calcd 337.0049, found: 337.0045. **IR** (thin film): 3205, 3117, 3060,

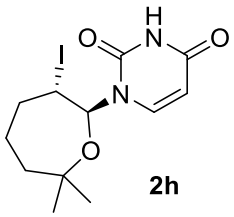
2932, 1690, 1455, 1383, 1266, 1085, 834, 750 cm^{-1}. $[\alpha]_D^{22}$ = –86.9 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 90:10, 254 nm absorbance). Major enantiomer (t_R = 35.9 min), minor enantiomer (t_R = 52.6 min): **ee** = 89%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	35.613	VB	1.1709	7800.31348	94.96434	49.5018
2	52.347	BB	1.3440	7957.31055	86.97933	50.4982



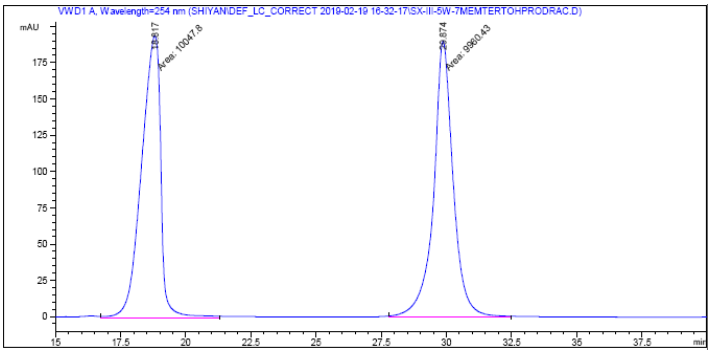
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	35.925	MM	1.3779	4529.16455	54.78340	94.5550
2	52.560	MM	1.2704	260.81622	3.42180	5.4450



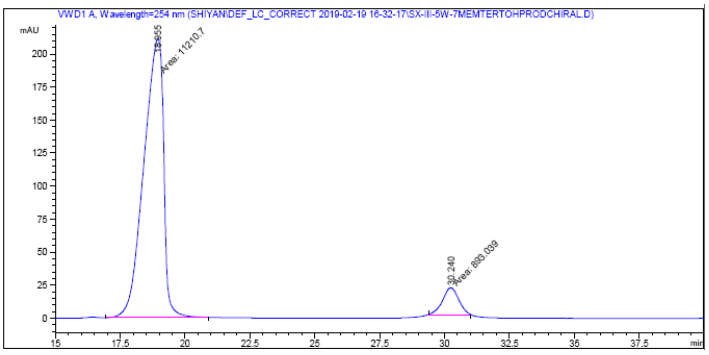
2h

1-((2*S*,3*S*)-3-iodo-7,7-dimethyloxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2h). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1h** (24 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (34 mg, 93% yield). **RF:** 0.3 50% EtOAc/PE (UV). **MP:** 167 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.00 (s, 1H), 7.22 (d, *J* = 8.1 Hz, 1H), 5.99 (d, *J* = 10.1 Hz, 1H), 5.80 (d, *J* = 6.3 Hz, 1H), 4.06 (td, *J* = 11.3, 5.2 Hz, 1H), 2.71 – 2.58 (m, 1H), 2.08 (dd, *J* = 26.3, 15.0 Hz, 1H), 1.82 (d, *J* = 12.0 Hz, 1H), 1.66 (dd,

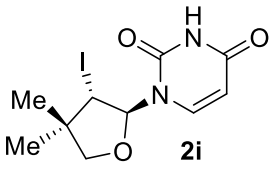
J = 15.5, 5.6 Hz, 1H), 1.59 – 1.51 (m, 2H), 1.28 (s, 3H), 1.15 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 163.0, 149.8, 139.1, 103.4, 79.9, 76.5, 41.9, 40.26, 31.3, 28.0, 26.6, 24.0. **HRMS-ESI** $[C_{12}H_{18}IN_2O_3]^+$ calcd 365.0362, found: 365.0359. **IR** (thin film): 3195, 3061, 2977, 2937, 1688, 1455, 1383, 1273, 1052, 834, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –71.6 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 90:10, 254 nm absorbance). Major enantiomer (t_R = 18.9 min), minor enantiomer (t_R = 30.2 min): **ee** = 85%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	18.817	MM	0.8611	1.00478e4	194.48572	50.2183
2	29.874	MM	0.8739	9960.43164	189.95215	49.7817



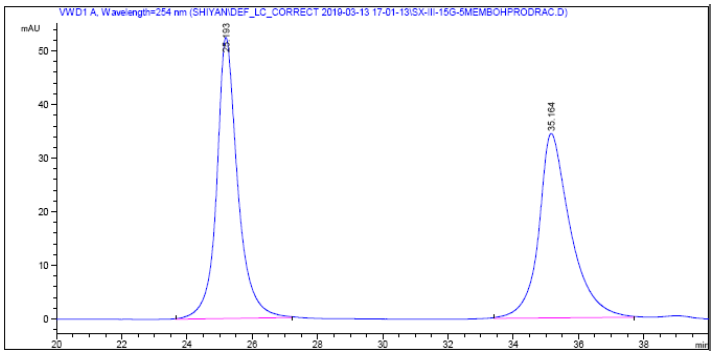
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	18.955	MM	0.8842	1.12107e4	211.30457	92.6218
2	30.240	MM	0.7254	893.03912	20.51894	7.3782



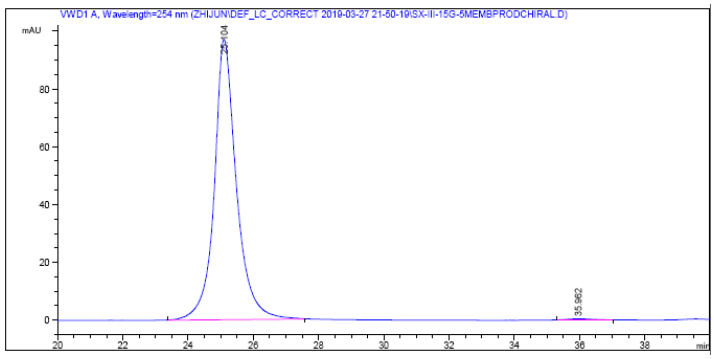
2i

1-((2*S*,3*S*)-3-iodo-4,4-dimethyltetrahydrofuran-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2i). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1i** (21 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (32 mg, 96% yield). **RF:** 0.25 60% EtOAc/PE (UV). **MP:** 165 °C. **^{1}H**

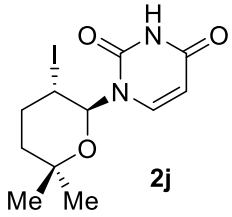
NMR (400 MHz, $CDCl_3$) δ 8.73 (s, 1H), 7.18 (d, *J* = 8.1 Hz, 1H), 6.02 (d, *J* = 8.5 Hz, 1H), 5.78 (d, *J* = 8.3 Hz, 1H), 4.32 (d, *J* = 8.7 Hz, 1H), 4.03 (d, *J* = 8.0 Hz, 1H), 3.93 (d, *J* = 8.0 Hz, 1H), 1.24 (s, 3H), 1.09 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.7, 145.0, 140.8, 103.1, 95.1, 43.2, 36.5, 26.2, 22.5. **HRMS-ESI** $[C_{10}H_{14}IN_2O_3]^+$ calcd 337.0049, found: 337.0043. **IR** (thin film): 3195, 3069, 2967, 1692, 1462, 1376, 1272, 1040, 731 cm^{-1}. **$[\alpha]_D^{22}$** = –57.8 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 90:10, 254 nm absorbance). Major enantiomer (t_R = 25.1 min), minor enantiomer (t_R = 35.9 min): **ee** = 99%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	25.193	BB	0.6578	2367.06226	52.42336	50.4508
2	35.164	BB	0.9695	2324.75879	34.37936	49.5492



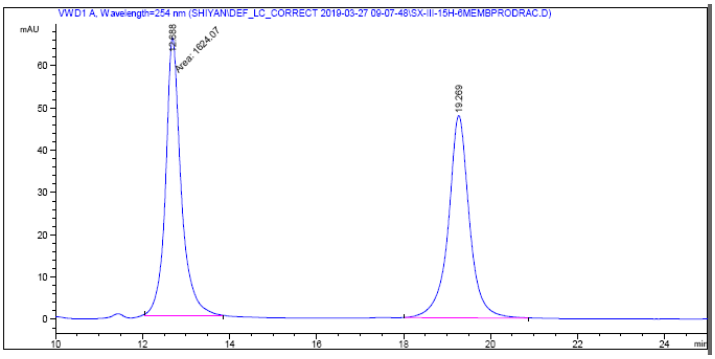
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	25.104	BB	0.6885	4589.87012	97.07749	99.5282
2	35.962	BB	0.6362	21.75847	4.14157e-1	0.4718



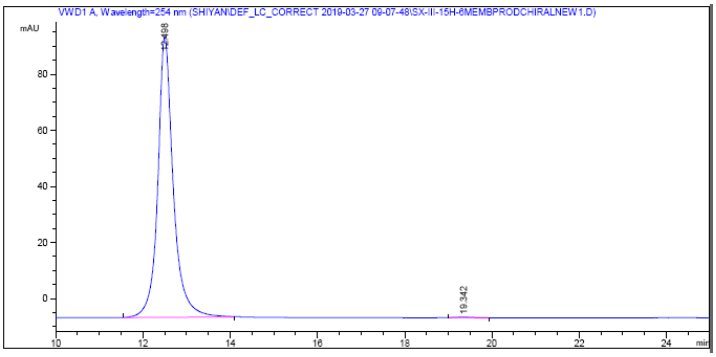
2j

1-((2*S*,3*S*)-3-iodo-6,6-dimethyltetrahydro-2H-pyran-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2j). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed

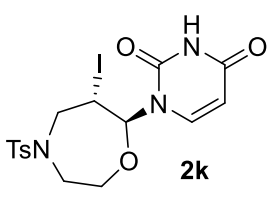
iodo-hemi-aminal formation using: Precursor **1j** (23 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (33 mg, 94% yield). **RF:** 0.3 50% EtOAc/PE (UV). **MP:** 153 ^{o}C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.59 (s, 1H), 7.26 – 7.19 (m, 1H), 6.03 (d, *J* = 10.5 Hz, 1H), 5.78 (d, *J* = 8.1 Hz, 1H), 3.92 (td, *J* = 10.9, 5.9 Hz, 1H), 2.69 – 2.29 (m, 2H), 1.72 – 1.64 (m, 1H), 1.50 (dt, *J* = 13.9, 3.6 Hz, 1H), 1.39 (s, 3H), 1.26 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.5, 150.0, 138.8, 103.3, 80.4, 76.4, 38.8, 33.8, 30.8, 25.6, 21.7. **HRMS-ESI** $[C_{12}H_{18}IN_2O_3]^+$ calcd 365.0362, found: 365.0365. **IR** (thin film): 2975, 2931, 1705, 1668, 1624, 1467, 1429, 1385, 1278, 1255, 1166, 1064, 1030, 811 cm^{-1}. **$[\alpha]_D^{22}$** = –57.9 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 85:15, 254 nm absorbance). Major enantiomer (t_R =12.5 min), minor enantiomer (t_R = 19.3 min): **ee** = 99.5 %.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.688	MM	0.4124	1624.07178	65.63082	50.1125
2	19.269	BB	0.4959	1616.77759	47.87234	49.8875

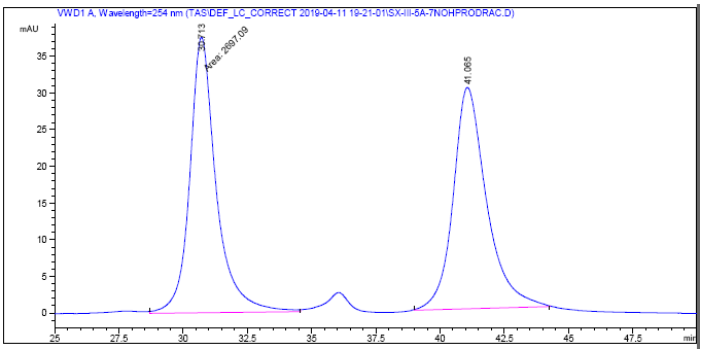


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.498	BB	0.3618	2480.58081	100.12553	99.7595
2	19.342	BB	0.3289	5.97971	2.21960e-1	0.2405

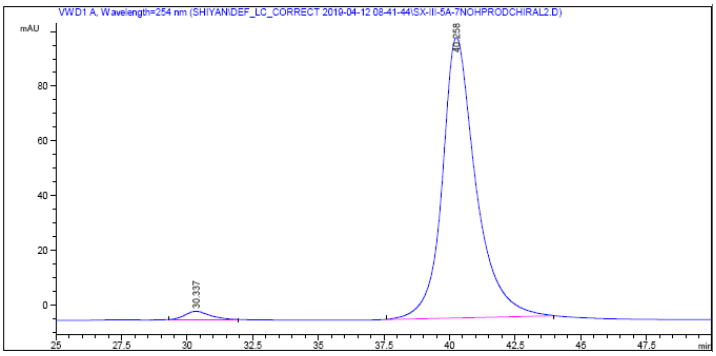


2k

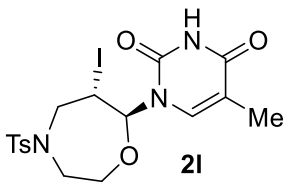
1-((6*S*,7*S*)-6-iodo-4-tosyl-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2k). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1k** (37 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (44 mg, 90% yield). **RF:** 0.2 60% EtOAc/PE (UV). **MP:** 127 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.16 (s, 1H), 7.71 (d, *J* = 8.4 Hz, 2H), 7.35 (d, *J* = 8.5 Hz, 2H), 7.15 (d, *J* = 8.2 Hz, 1H), 5.89 (d, *J* = 10.3 Hz, 1H), 5.80 (dd, *J* = 8.1, 2.2 Hz, 1H), 4.28 (td, *J* = 9.9, 4.4 Hz, 1H), 4.23 – 4.05 (m, 2H), 3.94 – 3.71 (m, 2H), 3.46 (dd, *J* = 15.3, 9.5 Hz, 1H), 3.30 – 3.14 (m, 1H), 2.45 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 162.6, 150.1, 144.1, 138.7, 136.0, 130.0, 126.9, 103.8, 88.1, 67.1, 53.8, 48.8, 26.8, 21.6. **HRMS-ESI** $[C_{16}H_{17}IN_3O_5S]^-$ calcd 489.9934, found: 489.9935. **IR** (thin film): 3241, 3165, 1692, 1463, 1337, 1160, 1091,1027, 849 cm^{-1}. **$[\alpha]_D^{22}$** = –310.4 (c 0.9 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IB column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 75:25, 254 nm absorbance). Major enantiomer (t_R = 40.2 min), minor enantiomer (t_R = 30.3 min): **ee** = 96%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.713	MM	1.1976	2697.09473	37.53446	49.6532
2	41.065	BB	1.3385	2734.77393	30.17126	50.3468

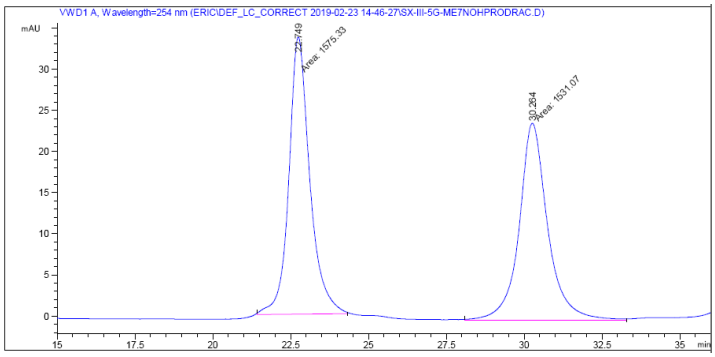


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.337	BB	0.8804	195.60272	2.98150	2.0925
2	40.258	BB	1.3060	9152.14063	102.56767	97.9075

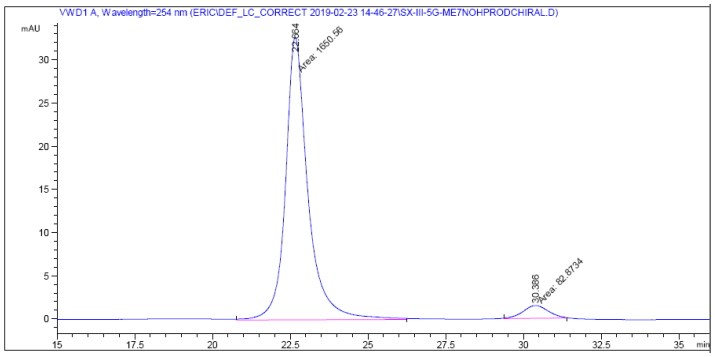


2l

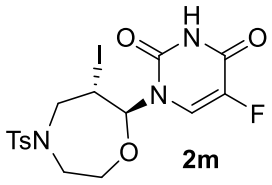
1-((6*S*,7*S*)-6-iodo-4-tosyl-1,4-oxazepan-7-yl)-5-methylpyrimidine-2,4(1*H*,3*H*)-dione (2l). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1l** (38 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (48 mg, 94% yield). **RF:** 0.2 60% EtOAc/PE (UV). **MP:** 175 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.53 (s, 1H), 7.72 (d, *J* = 8.2 Hz, 2H), 7.36 (d, *J* = 8.2 Hz, 2H), 6.98 (s, 1H), 5.86 (d, *J* = 10.3 Hz, 1H), 4.38 – 4.25 (m, 1H), 4.25 – 4.10 (m, 2H), 3.93 – 3.74 (m, 2H), 3.44 (dd, *J* = 15.2, 9.7 Hz, 1H), 3.26 – 3.16 (m, 1H), 2.45 (s, 3H), 1.95 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 163.2, 150.2, 144.1, 136.0, 134.2, 130.1, 126.9, 112.3, 87.9, 67.0, 53.8, 48.7, 27.2, 21.6, 12.5. **HRMS-ESI** $[C_{17}H_{21}IN_3O_5S]^+$ calcd 506.0247, found: 506.0251. **IR** (thin film): 2925, 1694, 1461, 1339, 1160, 1091, 1028, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –61.9 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 75:25, 254 nm absorbance). Major enantiomer (t_R = 22.6 min), minor enantiomer (t_R = 30.4 min): **ee** = 90%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	22.749	MM	0.7809	1575.32861	33.62360	50.7123
2	30.264	MM	1.0675	1531.07397	23.90351	49.2877

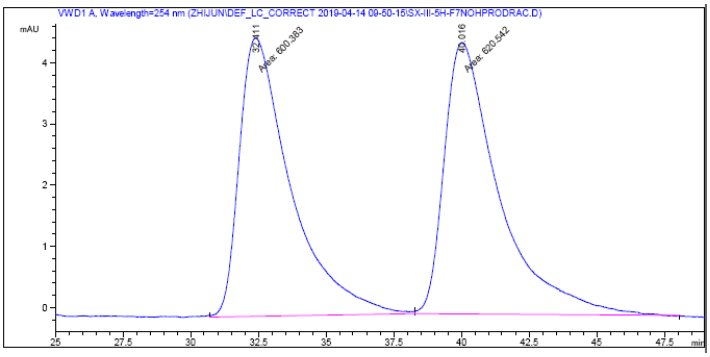


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	22.664	MM	0.8401	1650.56482	32.74404	95.2191
2	30.386	MM	0.9303	82.87337	1.48465	4.7809

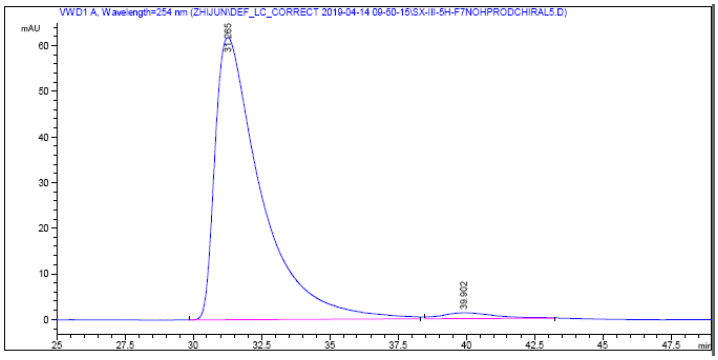


2m

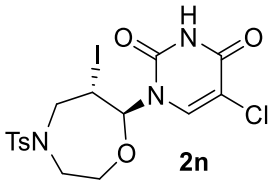
5-fluoro-1-((6*S*,7*S*)-6-iodo-4-tosyl-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2m). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1m** (38 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (48 mg, 92% yield). **RF:** 0.25 60% EtOAc/PE (UV). **MP:** 157 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 9.50 (d, *J* = 4.4 Hz, 1H), 7.72 (d, *J* = 8.3 Hz, 2H), 7.42 – 7.30 (m, 2H), 7.14 (d, *J* = 5.6 Hz, 1H), 5.91 (dd, *J* = 10.1, 1.3 Hz, 1H), 4.25 – 4.08 (m, 3H), 3.89 – 3.79 (m, 2H), 3.54 – 3.39 (m, 1H), 3.26 (dd, *J* = 9.2, 4.0 Hz, 1H), 2.45 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 156.5, 156.3, 148.8, 144.3, 142.0, 140.1, 136.2, 130.1, 126.9, 123.0, 122.8, 88.0, 66.9, 53.6, 48.6, 26.6, 21.5. **^{19}F NMR** (376 MHz, $CDCl_3$) δ -56.69. **HRMS-ESI** $[C_{16}H_{18}FIN_3O_5S]^+$ calcd 509.9996, found: 509.9997. **IR** (thin film): 3278, 3078, 2930, 1709, 1337, 1247, 1158, 1120, 1088, 1026, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –121.6 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IB column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 80:20, 254 nm absorbance). Major enantiomer (t_R = 31.3 min), minor enantiomer (t_R = 39.9 min): **ee** = 95%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	32.411	MM	2.2024	600.38336	4.54342	49.1745
2	40.016	MM	2.3321	620.54156	4.43483	50.8255

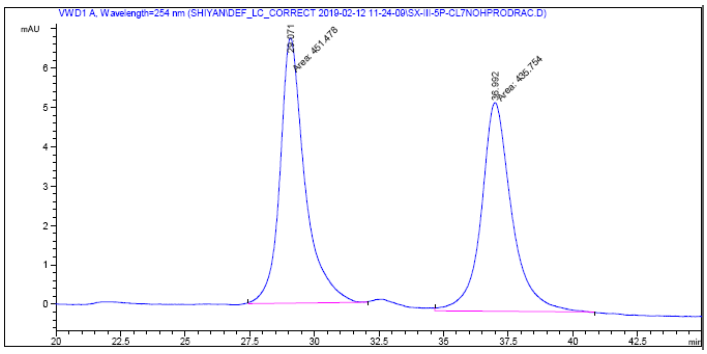


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	31.265	BB	1.6583	7252.88525	61.89683	97.6696
2	39.902	BB	1.5900	173.05318	1.28866	2.3304

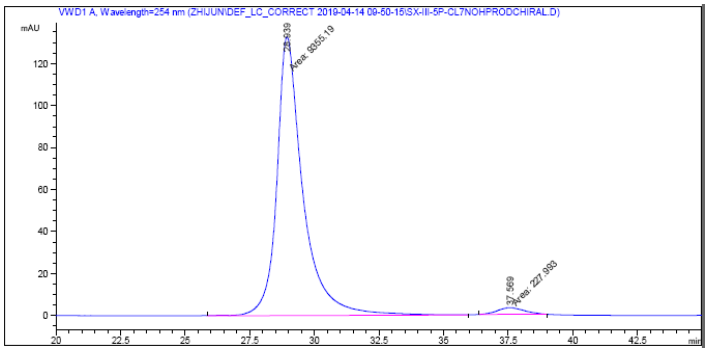


2n

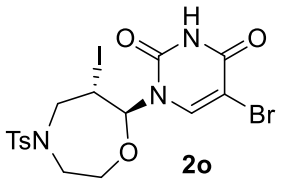
5-chloro-1-((6*S*,7*S*)-6-iodo-4-tosyl-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2n). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1n** (37 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (47 mg, 90% yield). **RF:** 0.2 60% EtOAc/PE (UV). **MP:** 180 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.00 (s, 1H), 7.72 (d, *J* = 8.2 Hz, 2H), 7.37 (d, *J* = 7.8 Hz, 2H), 7.32 (s, 1H), 5.88 (d, *J* = 9.8 Hz, 1H), 4.30 – 4.08 (m, 3H), 3.82 (t, *J* = 6.8 Hz, 2H), 3.53 – 3.44 (m, 1H), 3.26 (d, *J* = 17.2 Hz, 1H), 2.46 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 158.3, 149.1, 144.2, 136.1, 135.5, 130.1, 126.9, 110.6, 88.1, 67.1, 53.7, 48.8, 26.7, 21.6. **HRMS-ESI** $[C_{16}H_{18}ClIN_3O_5S]^+$ calcd 525.9700, found: 525.9702. **IR** (thin film): 3220, 3078, 2920, 1699, 1630, 1445, 1339, 1159, 1092, 1030, 849, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –49.4 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 80:20, 254 nm absorbance). Major enantiomer (t_R = 28.9 min), minor enantiomer (t_R = 37.6 min): **ee** = 95%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	29.071	MM	1.1173	451.47821	6.73449	50.8861
2	36.992	MM	1.3706	435.75430	5.29900	49.1139

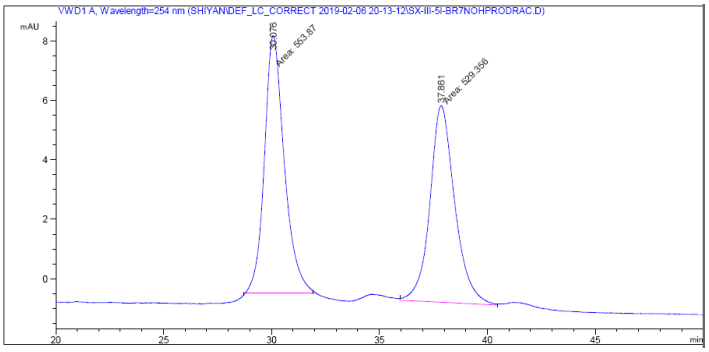


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	28.939	MM	1.1758	9355.19336	132.60820	97.6209
2	37.569	MM	1.1979	227.99266	3.17225	2.3791

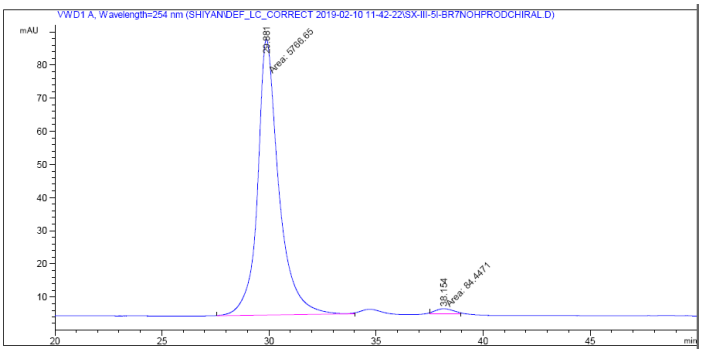


2o

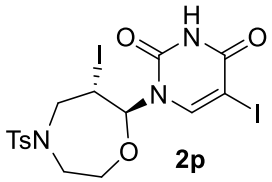
5-bromo-1-((6*S*,7*S*)-6-iodo-4-tosyl-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2o). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1o** (44 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (53 mg, 94% yield). **RF:** 0.2 60% EtOAc/PE (UV). **MP:** 180 °C. **^{1}H NMR** (500 MHz, DMSO) δ 12.05 (s, 1H), 8.24 (s, 1H), 7.76 – 7.70 (m, 2H), 7.44 (d, *J* = 7.7 Hz, 2H), 5.85 (d, *J* = 10.3 Hz, 1H), 4.82 (s, 1H), 4.07 – 3.97 (m, 1H), 3.92 (dd, *J* = 15.1, 3.6 Hz, 1H), 3.85 – 3.74 (m, 2H), 3.47 – 3.39 (m, 1H), 3.29 (d, *J* = 9.7 Hz, 1H), 2.41 (s, 3H). **^{13}C NMR** (125 MHz, DMSO) δ 158.8, 149.6, 143.7, 140.2, 135.5, 130.1, 127.0, 96.9, 79.2, 67.4, 53.3, 49.2, 27.6, 21.1. **HRMS-ESI** $[C_{16}H_{18}BrIN_3O_5S]^+$ calcd 569.9195, found: 569.9200. **IR** (thin film): 3459, 2923, 1699, 1340, 1161, 1091, 1027, 849, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –78.6 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 80:20, 254 nm absorbance). Major enantiomer (t_R = 29.8 min), minor enantiomer (t_R = 38.1 min): **ee** = 97%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	30.076	MM	1.0677	553.87000	8.64623	51.1315
2	37.861	MM	1.3357	529.35614	6.60520	48.8685



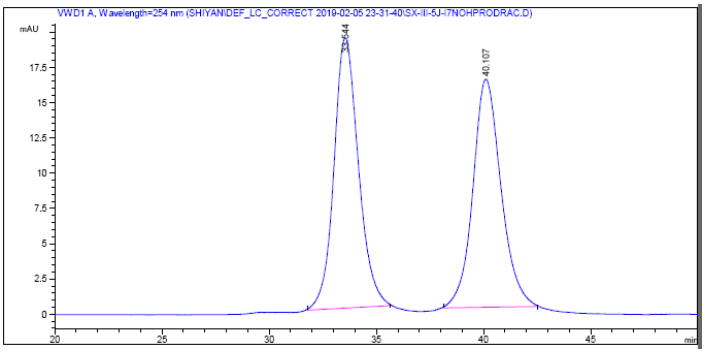
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	29.881	MM	1.1550	5766.64551	83.21296	98.5567
2	38.154	MM	0.9415	84.44707	1.49492	1.4433



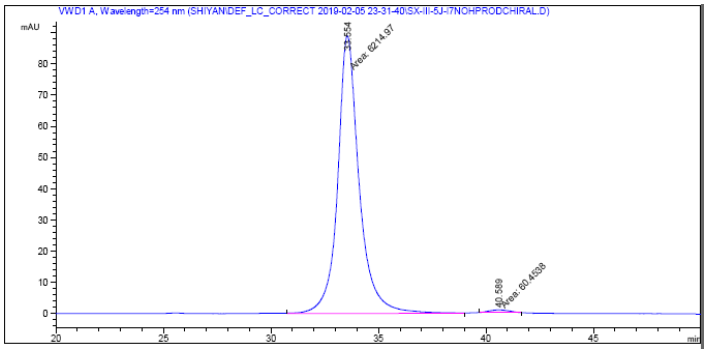
2p

5-iodo-1-((6*S*,7*S*)-6-iodo-4-tosyl-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2p). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1p** (49 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (59 mg, 95% yield). **RF:** 0.2 60% EtOAc/PE (UV). **MP:** 107 °C. **^{1}H NMR** (500 MHz, DMSO) δ 11.89 (s, 1H), 8.15 (s, 1H), 7.74 (d, *J* = 8.3 Hz, 2H), 7.62 – 7.28 (m, 2H), 5.82 (d, *J* = 10.4 Hz, 1H), 4.82 (s, 1H), 4.08 – 3.97 (m, 1H), 3.92 (dd, *J* = 15.1, 3.9 Hz, 1H), 3.88 – 3.64 (m, 2H), 3.41 (dd, *J* = 9.0, 5.1 Hz, 1H), 3.32 – 3.24 (m, 1H), 2.41 (s, 3H). **^{13}C NMR** (125 MHz, DMSO) δ 160.2, 150.0, 144.6, 143.7, 135.5, 130.1, 127.0, 79.2, 70.7, 67.3, 53.3, 49.2, 27.7, 21.1. **HRMS-ESI** $[C_{16}H_{18}I_2N_3O_5S]^+$ calcd 617.9057, found: 617.9064. **IR** (thin film): 3258, 2920, 1713, 1691, 1340, 1160, 1091, 1027, 849, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –70.9 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent:

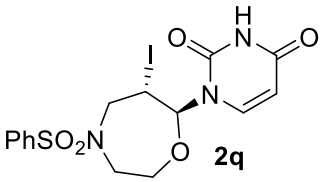
Hept/*i*-PrOH = 80:20, 254 nm absorbance). Major enantiomer (t_R = 33.5 min), minor enantiomer (t_R = 40.6 min): **ee** = 98%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	33.544	BB	1.1875	1519.27917	19.15366	50.7665
2	40.107	BB	1.3285	1473.40417	16.16252	49.2335



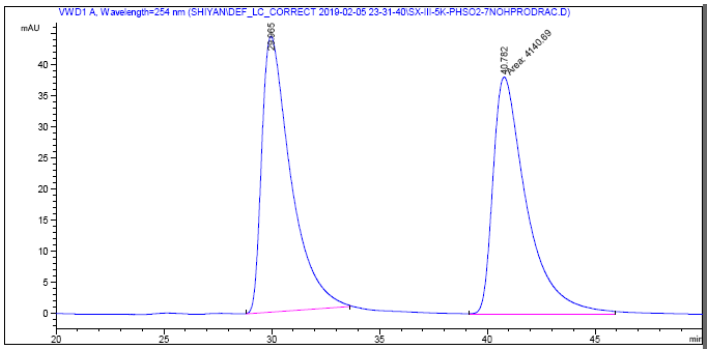
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	33.554	MM	1.1643	6214.97412	88.96442	99.0367
2	40.589	MM	1.0996	60.45376	9.16334e-1	0.9633



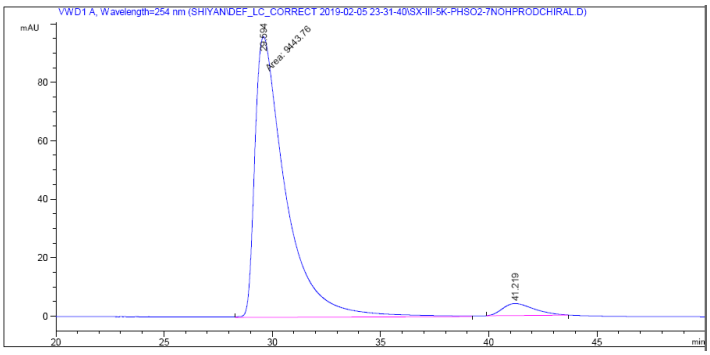
2q

1-((6*S*,7*S*)-6-iodo-4-(phenylsulfonyl)-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2q). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1q** (35 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (44 mg, 92% yield). **RF:** 0.25 60% EtOAc/PE (UV). **MP:** 168 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.74 (s, 1H), 7.91 – 7.76 (m, 2H), 7.64 (t, *J* = 7.4 Hz, 1H), 7.57 (t, *J* = 7.5 Hz, 2H), 7.15 (d, *J* = 8.1 Hz, 1H), 5.88 (d, *J* = 10.4 Hz, 1H), 5.80 (dd, *J* = 8.2, 2.1 Hz, 1H), 4.29 (td, *J* = 9.9, 4.1 Hz, 1H), 4.22 – 4.12 (m, 2H), 3.88 – 3.78 (m, 2H), 3.48 (dd, *J* = 15.2, 9.6 Hz, 1H), 3.27 – 3.20 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 162.29, 149.9, 139.0, 138.7, 133.2, 129.5, 126.9, 103.80, 88.1, 67.1, 53.9, 48.8, 26.7. **HRMS-ESI** $[C_{15}H_{17}IN_3O_5S]^+$ calcd 477.9934, found: 477.9932. **IR** (thin film): 3222, 2923, 2853, 1774, 1709, 1452, 1340, 1164, 1090, 1029 cm^{-1}. **$[\alpha]_D^{22}$** = –128.0 (c 0.3 in

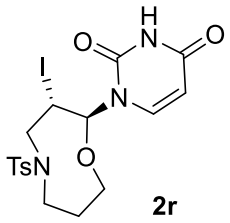
DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IB column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 70:30, 254 nm absorbance). Major enantiomer (t_R = 29.6 min), minor enantiomer (t_R = 41.2 min): **ee** = 91%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	29.965	BB	1.3642	4157.63916	44.36456	50.1021
2	40.782	MM	1.8072	4140.69141	38.18630	49.8979



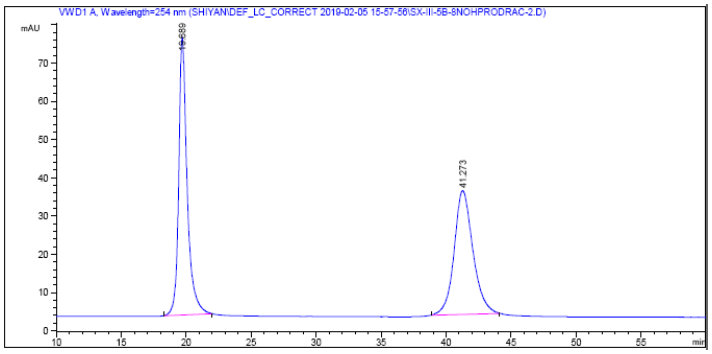
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	29.594	MM	1.6427	9443.75684	95.81363	95.7052
2	41.219	BB	1.2359	423.79227	4.11706	4.2948



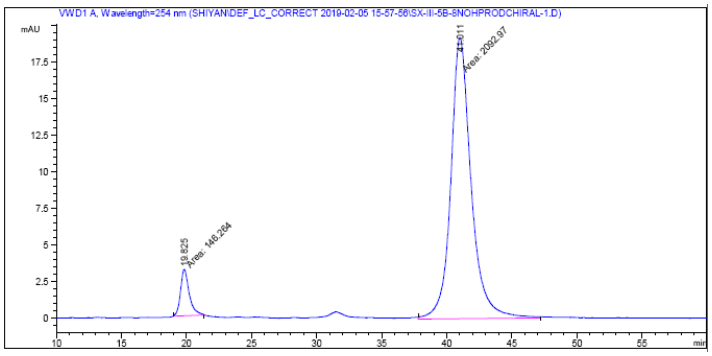
2r

1-((2*S*,3*S*)-3-iodo-5-tosyl-1,5-oxazocan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2r). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1r** (38 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (44 mg, 87% yield). **RF:** 0.25 60% EtOAc/PE (UV). **MP:** 213 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.85 (s, 1H), 7.78 – 7.64 (m, 2H), 7.37 – 7.32 (m, 2H), 7.31 (d, *J* = 8.1 Hz, 1H), 6.08 (d, *J* = 10.5 Hz, 1H), 5.83 (dd, *J* = 8.1, 2.3 Hz, 1H), 4.54 (dd, *J* = 10.7, 7.5 Hz, 1H), 4.28 – 4.14 (m, 2H), 4.02 – 3.92 (m, 1H), 3.92 – 3.81 (m, 1H), 3.34 (dd, *J* = 15.8, 10.8 Hz, 1H), 2.99 – 2.88 (m, 1H), 2.44 (s, 3H), 2.09 (ddd, *J* = 18.8, 11.5, 7.8 Hz, 1H), 2.02 – 1.86 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 162.5, 150.4, 143.8, 138.8, 135.4, 130.0, 126.9, 103.8, 87.8, 72.9, 56.9, 50.1, 30.8, 29.0, 21.5. **HRMS-ESI**

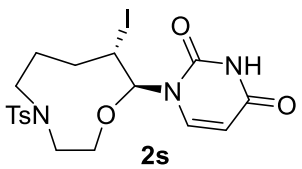
$[C_{17}H_{19}IN_3O_5S]^-$ calcd 504.0090, found: 504.0090. **IR** (thin film): 3324, 2953, 2926, 2853, 1694, 1454, 1157, 1082, 849, 732 cm^{-1}. $[\alpha]_D^{22}$ = –20.1 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 70:30, 254 nm absorbance). Major enantiomer (t_R = 41.0 min), minor enantiomer (t_R = 19.8 min): **ee** = 87%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	19.689	BB	0.6614	3291.67212	72.80539	50.2438
2	41.273	BB	1.4820	3259.72412	32.41178	49.7562



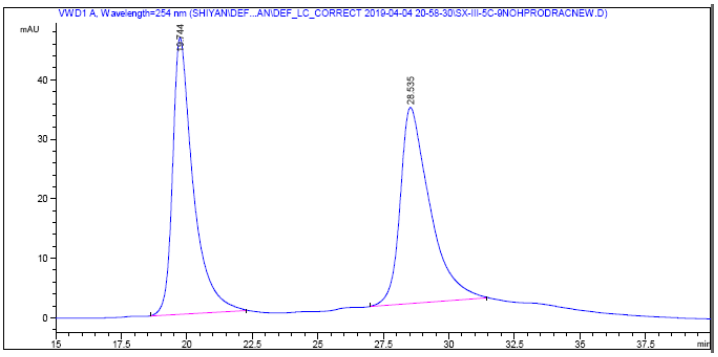
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	19.825	MM	0.7703	146.26436	3.16455	6.5319
2	41.011	MM	1.8182	2092.96851	19.18585	93.4681



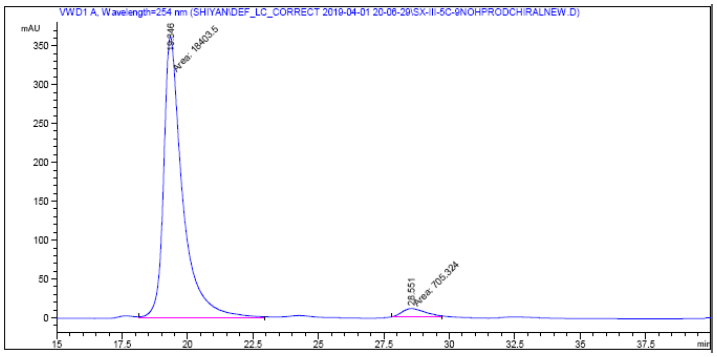
2s

1-((8*S*,9*S*)-8-iodo-4-tosyl-1,4-oxazonan-9-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2s). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1s** (39 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (40 mg, 78% yield). **RF:** 0.25 50% EtOAc/PE (UV). **MP:** 190 °C. **^{1}H NMR** (500 MHz, DMSO) δ 11.39 (s, 1H), 7.75 – 7.71 (m, 2H), 7.69 (d, *J* = 8.0 Hz, 1H), 7.43 (d, *J* = 8.0 Hz, 2H), 6.04 (d, *J* = 10.3 Hz, 1H), 5.71 (d, *J* = 7.6 Hz, 1H), 4.70 (t, *J* = 9.4 Hz, 1H), 3.83 (d, *J* = 12.0 Hz, 1H), 3.67 (t, *J* = 10.9 Hz, 1H), 3.49 – 3.40 (m, 1H), 3.31 (s, 1H), 2.92 (t, *J* = 12.9 Hz, 1H), 2.74 (d, *J* = 13.1 Hz, 1H), 2.62 (t, *J* =

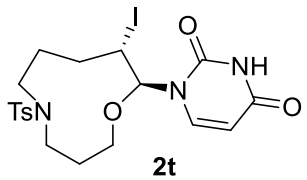
8.0 Hz, 1H), 2.40 (s, 3H), 2.21 (dd, *J* = 9.1, 6.0 Hz, 1H), 1.92 – 1.84 (m, 1H), 1.77 – 1.69 (m, 1H). **^{13}C NMR** (125 MHz, DMSO) δ 163.0, 150.8, 143.5, 140.0, 134.8, 130.0, 127.1, 102.8, 89.0, 70.9, 51.2, 50.1, 35.1, 32.5, 26.2, 21.0. **HRMS-ESI** $[C_{18}H_{21}IN_3O_5S]^-$ calcd 518.0247, found: 518.0245. **IR** (thin film): 3424, 3363, 3345, 2920, 1689, 1455, 1158, 1076, 1026, 849, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –49.0 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 70:30, 254 nm absorbance). Major enantiomer (t_R = 19.3 min), minor enantiomer (t_R = 28.6 min): **ee** = 92%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	19.744	BB	0.7952	2549.82959	46.52176	49.5076
2	28.535	BB	1.1163	2600.55566	32.98879	50.4924



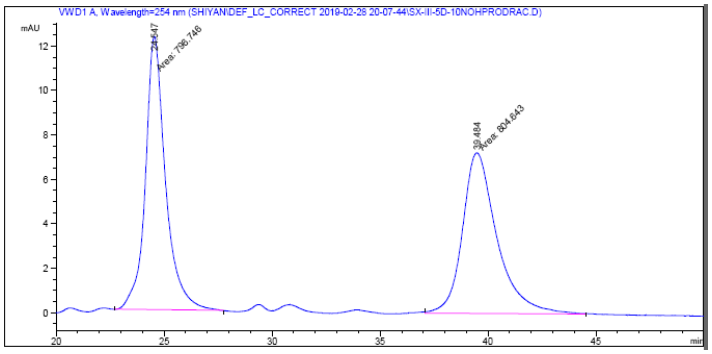
Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	19.346	MM	0.8466	1.84035e4	362.31384	96.3089
2	28.551	MM	1.0699	705.32391	10.98760	3.6911



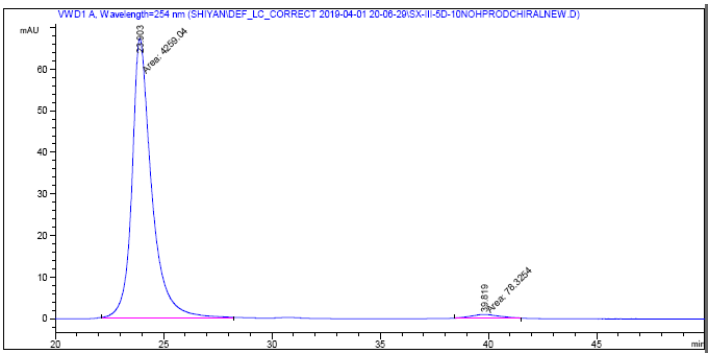
2t

1-((9*S*,10*S*)-9-iodo-5-tosyl-1,5-oxazecan-10-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2t). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1t** (41 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (40 mg, 76% yield). **RF:** 0.2 50% EtOAc/PE (UV). **MP:** 166 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.30 (s, 1H), 7.67 (d, *J* = 8.0 Hz, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 7.24 (s, 1H), 5.98 (dq, *J* = 12.3, 4.6, 3.7 Hz,

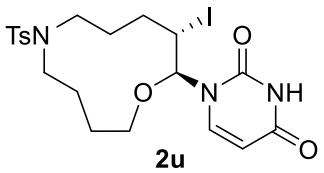
1H), 5.81 (dd, *J* = 8.1, 2.3 Hz, 1H), 4.34 – 4.07 (m, 1H), 4.00 (dt, *J* = 9.9, 3.8 Hz, 1H), 3.85 – 3.75 (m, 1H), 3.17 (d, *J* = 13.7 Hz, 1H), 3.04 (s, 1H), 2.92 (s, 1H), 2.82 (d, *J* = 14.9 Hz, 1H), 2.73 (dd, *J* = 14.9, 7.7 Hz, 1H), 2.44 (s, 4H), 2.31 – 2.21 (m, 1H), 2.02 (dq, *J* = 9.3, 4.8 Hz, 2H), 1.86 – 1.78 (m, 1H), 1.78 – 1.70 (m, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.4, 150.6, 143.7, 133.7, 129.7, 127.6, 127.1, 103.7, 77.2, 70.6, 50.5, 47.1, 33.2, 28.8, 28.7, 25.7, 21.5. **HRMS-ESI** $[C_{19}H_{23}IN_3O_5S]^-$ calcd 532.0403, found: 532.0405. **IR** (thin film): 3209, 2924, 2866, 1689, 1459, 1380, 1335, 1158, 1093, 849, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –84.4 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 70:30, 254 nm absorbance). Major enantiomer (t_R = 23.9 min), minor enantiomer (t_R = 39.8 min): **ee** = 96%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	24.547	MM	1.0812	796.74603	12.28151	49.7534
2	39.484	MM	1.8543	804.64307	7.23225	50.2466

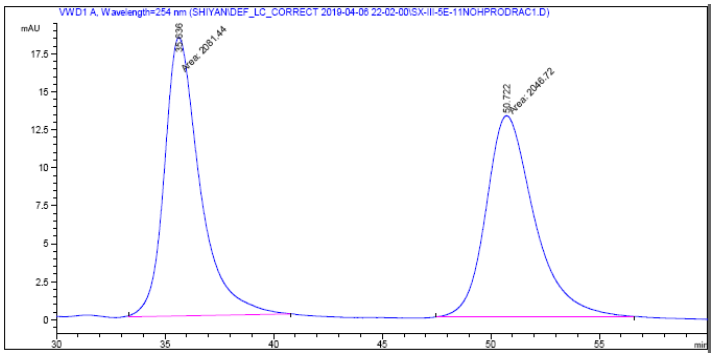


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	23.903	MM	1.0567	4259.03857	67.17318	98.1942
2	39.819	MM	1.5505	78.32539	8.41927e-1	1.8058

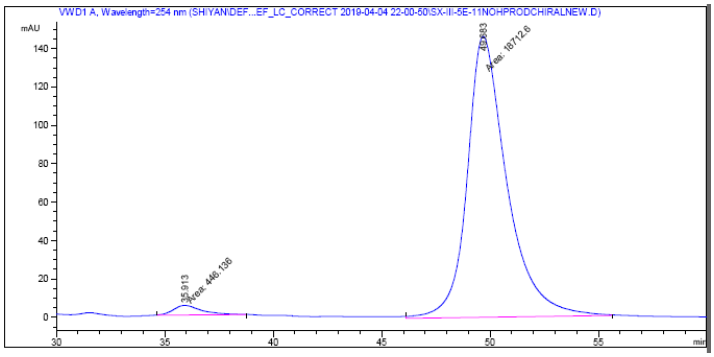


2u

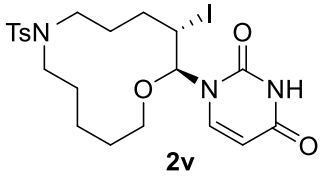
1-((10*S*,11*S*)-10-iodo-6-tosyl-1-oxa-6-azacycloundecan-11-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2u). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1u** (42 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (37 mg, 68% yield). **RF:** 0.25 50% EtOAc/PE (UV). **MP:** 167 °C. **^{1}H NMR** (600 MHz, DMSO) δ 11.38 (s, 1H), 7.69 (d, *J* = 8.0 Hz, 1H), 7.67 – 7.65 (m, 2H), 7.42 (d, *J* = 7.9 Hz, 2H), 5.85 (d, *J* = 10.4 Hz, 1H), 5.70 (d, *J* = 7.9 Hz, 1H), 4.65 (s, 1H), 3.59 (d, *J* = 5.3 Hz, 2H), 3.14 (dt, *J* = 31.9, 8.0 Hz, 2H), 3.00 – 2.94 (m, 1H), 2.86 (dd, *J* = 13.7, 7.0 Hz, 1H), 2.45 (d, *J* = 7.4 Hz, 1H), 2.40 (s, 3H), 2.18 (t, *J* = 7.8 Hz, 1H), 1.89 – 1.78 (m, 2H), 1.76 – 1.64 (m, 4H). **^{13}C NMR** (100 MHz, DMSO) δ 163.0, 151.3, 143.2, 139.8, 134.9, 129.9, 127.1, 103.0, 86.3, 68.7, 49.2, 48.6, 33.5, 31.0, 26.7, 25.8, 25.1, 21.0. **HRMS-ESI** $[C_{20}H_{25}IN_3O_5S]^-$ calcd 546.0560, found: 546.0564. **IR** (thin film): 3422, 2922, 1689, 1460, 1381, 1330, 1158, 1051, 1027, 1005, 824 cm^{-1}. **$[\alpha]_D^{22}$** = –31.4 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IA column, flow rate = 0.8 mL/min, eluent: Hept/*i*-PrOH = 75:25, 254 nm absorbance). Major enantiomer (t_R = 49.7 min), minor enantiomer (t_R = 35.9 min): **ee** = 95%.



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	35.636	MM	1.8930	2081.44434	18.32559	50.4205
2	50.722	MM	2.5791	2046.72302	13.22638	49.5795

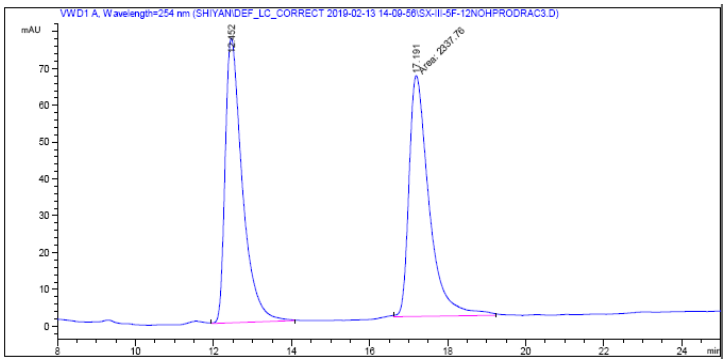


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	35.913	MM	1.5048	446.13623	4.94119	2.3286
2	49.683	MM	2.1320	1.87126e4	146.28163	97.6714

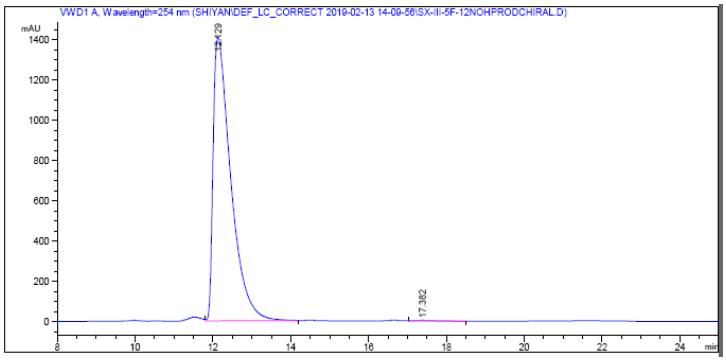


2v

1-((2*S*,3*S*)-3-iodo-7-tosyl-1-oxa-7-azacyclododecan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (2v). The cyclized product was synthesized following general procedure for asymmetric Pd-catalyzed iodo-hemi-aminal formation using: Precursor **1v** (44 mg, 0.10 mmol), Cp(allyl)Pd (2.2 mg, 0.010 mmol), chiral ligand **L6** (6.7 mg, 0.010 mmol) and NIS (25 mg, 0.11 mmol) to give the title compound as a white solid (47 mg, 84% yield). **RF:** 0.3 60% EtOAc/PE (UV). **MP:** 160 °C. **^{1}H NMR** (500 MHz, CD_3OD) δ 7.67 (d, *J* = 7.6 Hz, 3H), 7.40 (d, *J* = 7.8 Hz, 2H), 5.96 (d, *J* = 10.1 Hz, 1H), 5.80 (d, *J* = 7.7 Hz, 1H), 4.73 (dd, *J* = 9.2, 5.8 Hz, 1H), 3.66 – 3.58 (m, 2H), 3.55 – 3.47 (m, 2H), 2.81 (d, *J* = 14.0 Hz, 2H), 2.73 (t, *J* = 13.1 Hz, 1H), 2.43 (s, 3H), 2.15 (ddd, *J* = 15.6, 7.7, 3.0 Hz, 1H), 2.00 – 1.92 (m, 1H), 1.86 – 1.75 (m, 3H), 1.75 – 1.68 (m, 1H), 1.66 – 1.60 (m, 1H), 1.59 – 1.54 (m, 1H), 1.42 (ddd, *J* = 8.3, 6.9, 4.4 Hz, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 162.5, 151.0, 143.3, 137.9, 135.8, 129.71, 127.0, 104.2, 85.5, 67.8, 51.0, 50.7, 32.4, 31.2, 26.7, 26.6, 26.1, 21.5, 20.3. **HRMS-ESI** $[C_{21}H_{27}IN_3O_5S]^-$ calcd 560.0716, found: 560.0715. **IR** (thin film): 3451, 3428, 3393, 1691, 1332, 1157, 1086, 1062, 849, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –29.5 (c 0.3 in DCM). **Enantiomeric excess** was determined by using HPLC. Stationary phase (IB column, flow rate = 0.8 mL/min, eluent: Hept/ EtOAc= 50:50, 254 nm absorbance). Major enantiomer (t_R = 12.1 min), minor enantiomer (t_R = 17.4 min): **ee** = 99.5%.

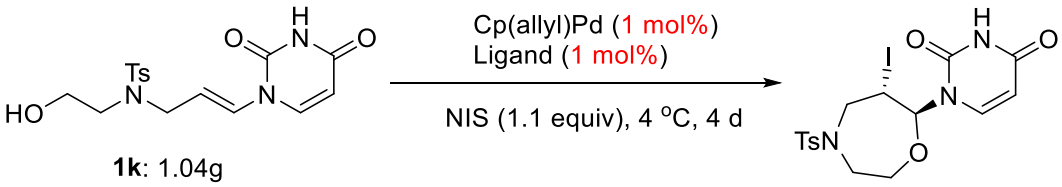


Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.452	VB	0.4603	2364.17505	77.28482	50.2809
2	17.191	MM	0.5952	2337.75708	65.46345	49.7191



Peak #	RetTime [min]	Type	Width [min]	Area mAU *s	Height [mAU]	Area %
1	12.129	VB	0.4698	4.44646e4	1409.93616	99.7597
2	17.382	VB	0.5364	107.09065	2.96518	0.2403

Gram Scale Reaction:

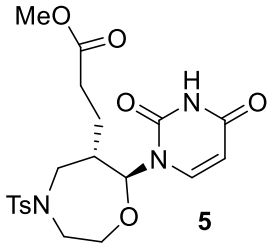


1k: 1.04g

2k: 1.21 g
88% yield, 96% ee, >20:1 dr

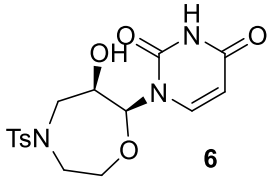
Precursor **1k** (1.04g, 2.80 mmol) was dissolved in dry DCM (13 mL) under argon. In a separate flask flask, Cp(allyl)Pd (5.9 mg, 0.028 mmol) and chiral ligand **L6** (18.8 mg, 0.028 mmol) was added and the vial was flushed with Ar, dry DCM (2 mL) was then added and stirred for 15-30 min. This catalyst mixture was then added to the substrate solution followed by addition of NIS (659mg, 2.94 mmol). The reaction mixture was then stirred at 4 ^{o}C for 4 d. Solvent was removed under pressure and the crude reaction mixture was subjected to silica gel chromatography to give compound **2k** (1.21 g, 88% yield) with >20:1 dr and 96% ee.

Derivatization reaction



5

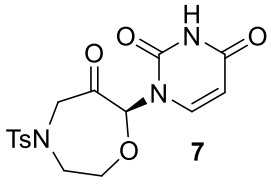
Methyl 3-((6*S*,7*S*)-7-(2,4-dioxo-3,4-dihydropyrimidin-1(2*H*)-yl)-4-tosyl-1,4-oxazepan-6-yl) propanoate (5). Borohydride supported on Amberlyst IRA-400 (BER) (0.1 g, 0.3 mmol) was added to a methanol solution (1 mL) of $Ni(OAc)_2{\cdot}4H_2O$ (5 mg, 0.02 mmol), and the mixture was stirred slowly at rt. Immediately a black coating of nickel boride and a slow hydrogen evolution due to decomposition of BER were observed. After 1 min, ethyl crotonate (0.17 g, 2.0 mmol) and a methanol solution (0.5 mL) of compound **2k** (49 mg, 0.10 mmol) were added, and the mixture was stirred at rt After 6 h, the resin was removed by filtration, and methanol were evaporated under reduced pressure. Flash column chromatography (90% EtOAc/PE) provided title compound as a colorless oil (34 mg, 75%). **RF:** 0.25 90% EtOAc/PE (UV). **^{1}H NMR** (600 MHz, $CDCl_3$) δ 8.32 (s, 1H), 7.67 (d, *J* = 8.3 Hz, 2H), 7.35 (d, *J* = 7.9 Hz, 2H), 7.27 (d, *J* = 8.2 Hz, 1H), 5.75 (dd, *J* = 8.1, 2.3 Hz, 1H), 5.65 (d, *J* = 9.6 Hz, 1H), 5.65 (d, *J* = 9.6 Hz, 1H), 4.13 – 4.06 (m, 1H), 3.87 (ddd, *J* = 12.8, 11.2, 3.5 Hz, 1H), 3.66 (d, *J* = 1.6 Hz, 1H), 3.64 (s, 3H), 3.58 (dd, *J* = 14.8, 2.7 Hz, 1H), 3.08 (dd, *J* = 14.6, 4.4 Hz, 1H), 2.94 (ddd, *J* = 13.0, 11.2, 4.2 Hz, 1H), 2.54 (dt, *J* = 16.9, 6.1 Hz, 1H), 2.45 (s, 3H), 2.44 – 2.39 (m, 1H), 2.25 (qd, *J* = 7.9, 3.5 Hz, 1H), 1.95 – 1.86 (m, 1H), 1.69 – 1.62 (m, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 173.2, 162.4, 150.4, 144.0, 140.0, 134.9, 130.0, 127.2, 103.0, 88.9, 71.6, 52.2, 51.8, 49.4, 43.3, 30.4, 23.3, 21.6. **HRMS-ESI** $[C_{20}H_{25}N_3NaO_7S]^+$ calcd 474.1311, found: 474.1312. **IR** (thin film): 3222, 3067, 2953, 1692, 1450, 1382, 1257, 1162, 1087, 849, 732 cm^{-1}. **$[\alpha]_D^{22}$** = –34.2 (c 0.3 in DCM).



6

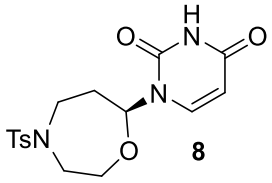
1-((6*R*,7*S*)-6-hydroxy-4-tosyl-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (6). Compound **2k** (49 mg, 0.10 mmol) in H_2O/dioxane (1:1) (1 mL) was stirred at 100 ^oC. After 24 h, cooled to rt and extracted with DCM (4 x 2 mL) and washed with brine 1 mL. The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (60% PE/EtOAc) provided title compound as a white solid (36 mg, 94%). **RF:** 0.25 60% PE/EtOAc (UV). **MP:** 211 ^oC. **^{1}H NMR** (500 MHz, DMSO) δ 11.33 (s, 1H), 7.71 (d, *J* = 8.2 Hz, 2H), 7.43 (d, *J* = 7.9 Hz, 3H), 5.71 (d, *J* = 2.6 Hz, 1H), 5.66 – 5.49 (m, 2H), 4.24 – 4.09 (m, 1H), 4.02 (d, *J* = 6.0 Hz, 1H), 3.83 – 3.77 (m, 1H), 3.74 (dd, *J* = 20.7, 10.5 Hz, 2H), 3.01 (dd, *J* = 17.5, 8.2 Hz, 1H), 2.73 (dd, *J* = 14.1, 8.2 Hz, 1H), 2.40 (s, 3H). **^{13}C NMR** (125 MHz, DMSO) δ 163.3, 149.8, 143.5, 142.3, 135.4,

130.0, 126.8, 100.3, 86.6, 72.2, 68.8, 52.4, 52.1, 21.0. **HRMS-ESI** $[C_{16}H_{20}N_3O_6S]^+$ calcd 382.1073, found: 382.1070. **IR** (thin film): 3389, 2946, 2834, 1664, 1450, 1113, 1028, 732 cm^{-1}. $\mathbf{[\alpha]_D^{22}}$ = +15.6 (c 0.3 in DCM).



7

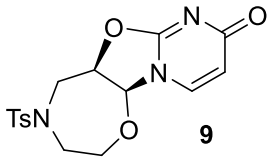
(*S*)-1-(6-oxo-4-tosyl-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (7). Alcohol **6** (38 mg, 0.10 mmol) in DCM (1 mL) was added with DMP (47 mg, 0.11 mmol) and stirred at rt for 4 h. The mixture was extracted with DCM (4 x 2 mL) and washed with brine 1 mL. The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (60% PE/EtOAc) provided title compound as a white solid (34 mg, 90%) .**RF:** 0.25 60% PE/EtOAc (UV). **MP:** 114 ^oC. **^{1}H NMR** (500 MHz, DMSO) δ 11.56 (s, 1H), 7.75 (d, *J* = 8.2 Hz, 2H), 7.62 (d, *J* = 7.9 Hz, 1H), 7.45 (d, *J* = 8.0 Hz, 2H), 6.00 (s, 1H), 5.68 (dd, *J* = 8.0, 2.0 Hz, 1H), 4.38 – 4.26 (m, 1H), 4.21 (d, *J* = 16.6 Hz, 1H), 4.08 (s, 1H), 3.94 (t, *J* = 11.2 Hz, 2H), 3.14 (t, *J* = 13.2 Hz, 1H), 2.41 (s, 3H). **^{13}C NMR** (125 MHz, DMSO) δ 200.7, 163.1, 150.2, 144.0, 143.7, 135.4, 130.2, 126.9, 102.0, 88.7, 73.3, 56.2, 51.4, 21.1. **HRMS-ESI** $[C_{16}H_{18}N_3O_6S]^+$ calcd 380.0916, found: 380.0912. **IR (thin film):** 3233, 2919, 1707, 1347, 1163, 914, 732 cm^{-1}. $\mathbf{[\alpha]_D^{22}}$ = +15.3 (c 0.3 in DCM).



8

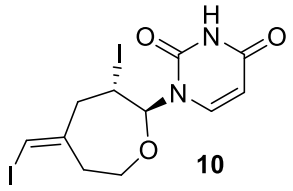
(*S*)-1-(4-tosyl-1,4-oxazepan-7-yl)pyrimidine-2,4(1*H*,3*H*)-dione (8). Borohydride supported on Amberlyst IRA-400 (BER) (0.1 g, 0.3 mmol) was added to a methanol solution (1 mL) of $Ni(OAc)_2{\cdot}4H_2O$ (5 mg, 0.02 mmol), and the mixture was stirred slowly at rt. Immediately a black coating of nickel boride and a slow hydrogen evolution due to decomposition of BER were observed. After 1 min, a methanol solution (0.5 mL) of compound **2k** (49 mg, 0.10 mmol) were added, and the mixture was stirred at rt. After 6 h, the resin was removed by filtration, and methanol were evaporated under reduced pressure. Flash column chromatography (90% EtOAc/PE) provided title compound as a colorless oil (31 mg, 84%). **RF:** 0.25 90% EtOAc/PE (UV). **MP:** 147 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.83 (s, 1H), 7.68 (d, *J* = 8.2 Hz, 2H), 7.33 (d, *J* = 8.1 Hz, 3H), 5.84 (dd, *J* = 9.8, 3.7 Hz, 1H), 5.79 – 5.71 (m, 1H), 4.11 (dt, *J* = 12.8, 3.8 Hz, 1H), 3.82 (ddd, *J* = 12.4, 9.0, 3.0 Hz, 1H), 3.65 (d, *J* = 9.0 Hz, 1H), 3.56 – 3.47 (m, 1H), 3.45 – 3.38 (m, 2H), 2.44 (s, 3H), 2.33 – 2.26 (m, 1H), 2.08 –

1.99 (m, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.8, 149.6, 143.8, 139.6, 135.5, 129.9, 127.0, 102.7, 84.6, 69.2, 50.8, 45.0, 35.1, 21.5. **HRMS-ESI** $[C_{16}H_{19}N_3NaO_5S]^+$ calcd 388.0943, found: 388.0938. **IR** (thin film): 3205, 3065, 1691, 1455, 1383, 1265, 1161, 1091, 718 cm^{-1}. **$[\alpha]_D^{22}$** = –32.5 (c 0.3 in DCM).



9

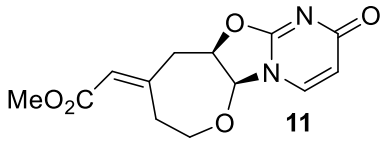
(5a*R*,11a*S*)-4-tosyl-2,3,4,5,5a,11a-hexahydro-8*H*-pyrimido[2',1':2,3]oxazolo[5,4-*f*][1,4]oxazepin-8-one (9). Compound **2k** (49 mg, 0.10 mmol) in THF (1 mL) was added with K_2CO_3 and stirred at rt for 6 h. The mixture was extracted with DCM (4 x 2 mL) and washed with brine 1 mL. The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (10% MeOH/DCM) provided title compound as a white solid (33 mg, 92%). **RF:** 0.25 10% MeOH/DCM (UV). **MP:** 160 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 8.2 Hz, 2H), 7.37 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 7.6 Hz, 1H), 6.09 (d, *J* = 7.5 Hz, 1H), 5.78 (d, *J* = 5.6 Hz, 1H), 5.25 – 5.12 (m, 1H), 4.20 – 4.04 (m, 2H), 3.86 (t, *J* = 10.9 Hz, 2H), 3.22 – 3.10 (m, 1H), 3.02 (d, *J* = 14.4 Hz, 1H), 2.45 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 171.5, 159.7, 144.6, 134.7, 134.6, 130.2, 127.0, 110.9, 89.6, 80.6, 51.8, 48.1, 29.7, 21.6. **HRMS-ESI** $[C_{16}H_{18}N_3O_5S]^+$ calcd 364.0967, found: 364.0966. **IR** (thin film): 2921, 1647, 1540, 1475, 1440, 1163, 913, 734 cm^{-1}. **$[\alpha]_D^{22}$** = +14.0 (c 0.3 in DCM).



10

1-((2*S*,3*S*,*E*)-3-iodo-5-(iodomethylene)oxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (10). Compound **2k** (49 mg, 0.10 mmol) in CH_3CN (1 mL) was added with NIS (34 mg, 0.15 mmol) and stirred at 0 ^oC in dark for 4 h. The mixture was extracted with DCM (4 x 2 mL) and washed with brine 1 mL. The organic layer was dried with $MgSO_4$ and the solvent was evaporated under reduced pressure. Flash column chromatography (90% EtOAc/PE) provided title compound as a white solid (45 mg, 95%). **RF:** 0.25 90% EtOAc/PE (UV). **MP:** 159 ^oC. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 9.26 (s, 1H), 7.18 (d, *J* = 8.1 Hz, 1H), 6.46 (s, 1H), 5.91 (d, *J* = 10.2 Hz, 1H), 5.79 (d, *J* = 8.1 Hz, 1H), 4.16 (ddd, *J* = 12.5, 6.3, 3.5 Hz, 1H), 4.08 (td, *J* = 10.4, 3.7 Hz, 1H), 3.89 (ddd, *J* = 12.5, 10.3, 4.3 Hz, 1H), 3.37 (dd, *J* = 14.5, 3.9 Hz, 1H), 3.10 (dd, *J* = 14.5, 10.4 Hz, 1H), 2.81 (ddd, *J* = 16.6, 10.5, 6.3 Hz, 1H), 2.44 (dd, *J* = 16.6, 4.1 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 162.7, 150.1, 145.5, 138.6, 103.6, 88.8, 82.6, 67.9,

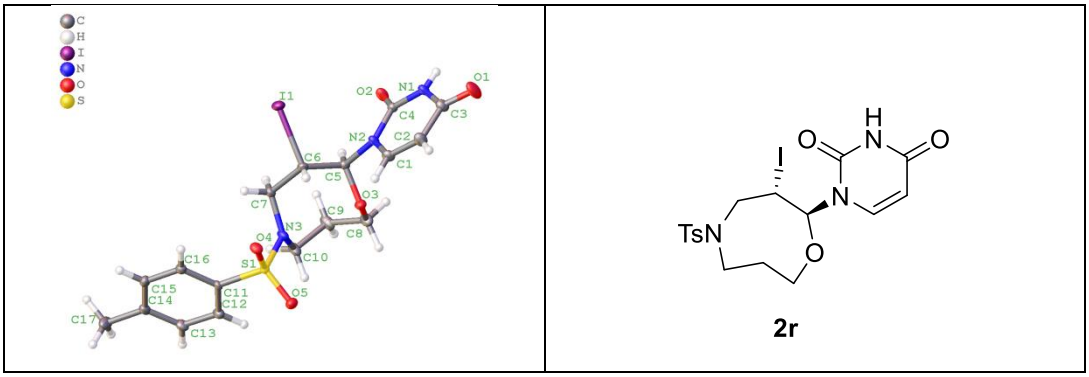
46.9, 39.0, 27.7. **HRMS-ESI** $[C_{11}H_{13}I_2N_2O_3]^+$ calcd 474.9016, found: 474.9009. **IR** (thin film): 3209, 3060, 2957, 1688, 1456, 1382, 1260, 1085, 849, 732 cm^{-1}. $[\alpha]_D^{22}$ = –386 (c 0.3 in DCM).



11

1-((2*S*,3*S*,*E*)-3-iodo-5-(iodomethylene)oxepan-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (11). Vinyl iodide **10** (47 mg, 0.10 mmol) was dissolved in CH_3OH (1 mL) under argon. $Pd(dppf)_2Cl_2$ (7 mg, 0.01 mmol), and Et_3N (0.03 mL, 0.2 mmol) were added. The argon atmosphere was replaced with an atmosphere of CO (repeated evacuation and venting to a balloon with CO). The reaction was heated at 60 ^oC for 1 h, and the solvent was evaporated in vacuum. The residue was purified by flash chromatography on silica gel with MeOH/DCM (20% and 10%) to give ester **11** as an colorless oil (23 mg, 83%). **RF:** 0.25 10% MeOH/DCM (UV). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.32 – 7.27 (m, 1H), 6.09 – 6.01 (m, 1H), 5.92 (s, 1H), 5.65 (d, *J* = 5.9 Hz, 1H), 4.87 (q, *J* = 5.8, 5.1 Hz, 1H), 3.89 (dd, *J* = 12.2, 5.5 Hz, 1H), 3.71 (s, 3H), 3.63 (t, *J* = 10.4 Hz, 1H), 3.33 (d, *J* = 14.0 Hz, 1H), 3.03 (d, *J* = 12.7 Hz, 1H), 2.95 (dd, *J* = 12.7, 4.3 Hz, 1H), 2.82 (t, *J* = 11.1 Hz, 1H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 171.7, 165.8, 159.7, 150.5, 134.6, 121.7, 110.8, 88.7, 79.8, 67.4, 51.4, 38.9, 34.3. **HRMS-ESI** $[C_{13}H_{15}N_2O_5]^+$ calcd 279.0981, found: 279.0986. **IR** (thin film): 3439, 2922, 1716, 1649, 1540, 1474, 1382, 1252, 1199, 1149, 1126, 1029, 732 cm^{-1}. $[\alpha]_D^{22}$ = +48.6 (c 0.3 in DCM).

3. Crystal data and structure refinement of product 2r:



2r

Table 1 Crystal data and structure refinement

Identification code	Sx_iii_5B_8NOHprod_0m
Empirical formula	C17H20IN3O5S
Formula weight	505.32
Temperature/K	150.0
Crystal system	monoclinic

Space group	P21
a/Å	9.7265(6)
b/Å	10.2667(6)
c/Å	9.8174(6)
α/°	90
β/°	102.588(2)
γ/°	90
Volume/Å3	956.79(10)
Z	2
ρcalcg/cm3	1.754
μ/mm-1	1.817
F(000)	504.0
Crystal size/mm3	0.5 × 0.35 × 0.2
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	5.816 to 56.718
Index ranges	-12 ≤ h ≤ 13, -13 ≤ k ≤ 13, -13 ≤ l ≤ 13
Reflections collected	37481
Independent reflections	4750 [Rint = 0.0278, Rsigma = 0.0157]
Data/restraints/parameters	4750/1/248
Goodness-of-fit on F2	1.035
Final R indexes [I>=2σ (I)]	R1 = 0.0219, wR2 = 0.0527
Final R indexes [all data]	R1 = 0.0230, wR2 = 0.0534
Largest diff. peak/hole / e Å-3	0.27/-0.69

Flack parameter (classic fit)	-0.037(15)
Flack parameter (direct-quotients)	-0.046(13)
Post refinement Parsons parameter	-0.017(4)
Hooft parameter, Corr. coeff.	-0.043(7), 0.995

Table 2 Fractional Atomic Coordinates ($\times 10^4$) and Equivalent Isotropic Displacement Parameters ($Å^2 \times 10^3$) for Sx_iii_5B_8NOHprod_0m. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	***x***	***y***	***z***	**U(eq)**
I^1	8168.4(2)	3646.7(3)	6358.7(2)	20.70(7)
S^1	5506.4(8)	4006.9(7)	963.7(9)	12.43(16)
O^1	14500(3)	5706(3)	5822(3)	30.2(6)
O^2	10292(3)	6807(2)	6724(3)	18.9(5)
O^3	8573(2)	6156(2)	2955(2)	16.5(5)
O^4	6190(2)	2780(2)	1415(3)	16.5(5)
O^5	5744(3)	4618(3)	-276(3)	20.0(5)
N^1	12380(3)	6073(3)	6339(3)	14.8(5)
N^2	10265(3)	5463(3)	4858(3)	12.7(5)
N^3	5971(3)	5018(3)	2248(3)	14.9(5)
C^1	11037(4)	4810(3)	4042(3)	16.9(6)

C^{2}	12454(4)	4803(3)	4329(4)	19.3(7)
C^{3}	13230(4)	5535(3)	5511(4)	18.6(6)
C^{4}	10930(3)	6162(3)	6026(3)	13.2(6)
C^{5}	8740(3)	5665(3)	4320(3)	12.8(6)
C^{6}	7915(3)	4395(3)	4260(3)	13.3(6)
C^{7}	6315(3)	4513(3)	3690(3)	15.1(6)
C^{8}	7853(4)	7388(3)	2712(4)	21.4(7)
C^{9}	6363(4)	7354(3)	2933(4)	22.3(7)
C^{10}	5416(4)	6361(3)	2032(4)	20.6(7)
C^{11}	3669(3)	3785(4)	738(3)	12.5(6)
C^{12}	2778(3)	4744(3)	21(3)	16.4(6)
C^{13}	1333(4)	4607(4)	-114(4)	18.9(6)
C^{14}	769(3)	3540(5)	448(3)	18.6(6)
C^{15}	1682(4)	2598(3)	1160(3)	18.1(6)
C^{16}	3137(3)	2706(3)	1317(3)	15.1(6)
C^{17}	-810(3)	3406(5)	268(4)	28.1(10)

Table 3 Anisotropic Displacement Parameters ($Å^2 \times 10^3$) for Sx_iii_5B_8NOHprod_0m. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\ldots]$.

Atom	**U_{11}**	**U_{22}**	**U_{33}**	**U_{23}**	**U_{13}**	**U_{12}**
I^{1}	23.97(11)	24.48(11)	12.16(9)	4.11(10)	0.66(7)	-2.69(11)
S^{1}	9.0(3)	15.6(4)	11.9(3)	1.1(2)	0.8(3)	-0.4(2)
O^{1}	11.0(12)	46.9(18)	32.4(15)	-14.0(13)	3.9(11)	-0.4(11)
O^{2}	14.6(11)	24.3(12)	18.4(12)	-9.4(10)	5.0(9)	-1.1(9)
O^{3}	16.0(11)	18.8(11)	13.8(11)	4.0(9)	1.5(9)	-0.4(9)
O^{4}	14.0(11)	15.7(11)	18.2(12)	1.0(9)	-0.1(9)	3.6(9)
O^{5}	17.6(12)	27.3(13)	15.5(11)	4.5(10)	4.3(9)	-1.7(9)
N^{1}	11.5(12)	18.6(13)	13.1(12)	-4.5(11)	0.1(10)	-0.4(10)
N^{2}	10.0(12)	15.3(13)	12.1(12)	-3.8(10)	0.7(9)	0.5(9)
N^{3}	14.4(13)	14.0(13)	13.6(13)	0.3(10)	-3.1(10)	-1.6(10)
C^{1}	18.3(16)	18.2(16)	14.1(15)	-5.0(12)	3.0(12)	0.3(12)
C^{2}	16.6(16)	21.7(16)	20.2(16)	-7.6(13)	5.4(12)	1.8(12)
C^{3}	13.9(15)	22.9(16)	18.4(16)	-2.9(13)	2.3(12)	2.8(12)
C^{4}	14.1(15)	14.1(15)	11.0(15)	-1.2(11)	2.1(11)	-1.7(11)
C^{5}	11.6(14)	15.4(15)	11.1(14)	-0.8(11)	1.6(11)	0.1(11)
C^{6}	13.9(14)	15.1(15)	10.3(14)	0.0(11)	1.0(11)	-0.7(11)
C^{7}	11.7(14)	18.7(14)	14.0(14)	-0.6(11)	1.0(11)	-2.1(11)
C^{8}	22.4(17)	13.9(15)	24.4(18)	4.5(13)	-2.6(14)	-1.0(13)
C^{9}	20.8(17)	14.0(15)	28.0(19)	-3.0(13)	-3.7(14)	1.3(12)
C^{10}	14.9(15)	16.5(15)	26.3(18)	0.9(13)	-4.5(13)	1.4(12)
C^{11}	9.9(12)	14.7(18)	11.7(12)	-1.3(11)	-0.3(9)	-2.9(11)
C^{12}	15.7(15)	15.9(15)	15.8(15)	1.3(12)	-0.7(12)	-1.3(11)
C^{13}	13.9(15)	21.3(16)	19.2(16)	0.6(13)	-1.5(12)	3.4(12)

C^{14}	12.4(12)	28.9(17)	13.8(12)	-1.3(17)	1.6(10)	-2.3(16)
C^{15}	16.4(16)	23.2(17)	15.1(15)	2.4(12)	3.8(12)	-4.0(12)
C^{16}	14.2(15)	16.7(15)	13.8(15)	-0.2(11)	1.9(12)	-1.1(11)
C^{17}	13.0(14)	47(3)	24.3(16)	12.1(17)	2.7(12)	0.4(15)

Table 4 Bond Lengths for Sx_iii_5B_8NOHprod_0m.

Atom	**Atom**	**Length/Å**	**Atom**	**Atom**	**Length/Å**
I^{1}	C^{6}	2.162(3)	N^{3}	C^{10}	1.479(4)
S^{1}	O^{4}	1.448(2)	C^{1}	C^{2}	1.345(5)
S^{1}	O^{5}	1.432(2)	C^{2}	C^{3}	1.448(5)
S^{1}	N^{3}	1.620(3)	C^{5}	C^{6}	1.525(4)
S^{1}	C^{11}	1.767(3)	C^{6}	C^{7}	1.540(4)
O^{1}	C^{3}	1.219(4)	C^{8}	C^{9}	1.513(5)
O^{2}	C^{4}	1.216(4)	C^{9}	C^{10}	1.522(5)
O^{3}	C^{5}	1.408(4)	C^{11}	C^{12}	1.397(5)
O^{3}	C^{8}	1.440(4)	C^{11}	C^{16}	1.395(5)
N^{1}	C^{3}	1.393(4)	C^{12}	C^{13}	1.389(5)
N^{1}	C^{4}	1.379(4)	C^{13}	C^{14}	1.392(6)
N^{2}	C^{1}	1.385(4)	C^{14}	C^{15}	1.393(6)
N^{2}	C^{4}	1.388(4)	C^{14}	C^{17}	1.513(4)
N^{2}	C^{5}	1.476(4)	C^{15}	C^{16}	1.394(4)
N^{3}	C^{7}	1.476(4)			

Table 5 Bond Angles for Sx_iii_5B_8NOHprod_0m.

Atom	**Atom**	**Atom**	**Angle/°**	**Atom**	**Atom**	**Atom**	**Angle/°**
O^{4}	S^{1}	N^{3}	106.70(14)	N^{1}	C^{4}	N^{2}	114.8(3)
O^{4}	S^{1}	C^{11}	108.09(16)	O^{3}	C^{5}	N^{2}	106.8(3)
O^{5}	S^{1}	O^{4}	119.54(15)	O^{3}	C^{5}	C^{6}	108.6(2)
O^{5}	S^{1}	N^{3}	108.16(15)	N^{2}	C^{5}	C^{6}	111.9(3)
O^{5}	S^{1}	C^{11}	107.24(15)	C^{5}	C^{6}	I^{1}	108.5(2)
N^{3}	S^{1}	C^{11}	106.43(15)	C^{5}	C^{6}	C^{7}	115.4(3)
C^{5}	O^{3}	C^{8}	115.1(3)	C^{7}	C^{6}	I^{1}	105.7(2)
C^{4}	N^{1}	C^{3}	127.2(3)	N^{3}	C^{7}	C^{6}	112.1(3)
C^{1}	N^{2}	C^{4}	121.0(3)	O^{3}	C^{8}	C^{9}	113.7(3)
C^{1}	N^{2}	C^{5}	119.3(3)	C^{8}	C^{9}	C^{10}	114.2(3)
C^{4}	N^{2}	C^{5}	118.3(3)	N^{3}	C^{10}	C^{9}	112.7(3)
C^{7}	N^{3}	S^{1}	119.2(2)	C^{12}	C^{11}	S^{1}	118.2(3)
C^{7}	N^{3}	C^{10}	117.7(3)	C^{16}	C^{11}	S^{1}	120.4(2)
C^{10}	N^{3}	S^{1}	117.1(2)	C^{16}	C^{11}	C^{12}	121.4(3)
C^{2}	C^{1}	N^{2}	122.7(3)	C^{13}	C^{12}	C^{11}	118.7(3)
C^{1}	C^{2}	C^{3}	119.8(3)	C^{12}	C^{13}	C^{14}	121.3(3)

O^{1}	C^{3}	N^{1}	119.6(3)	C^{13}	C^{14}	C^{15}	118.8(3)
O^{1}	C^{3}	C^{2}	126.7(3)	C^{13}	C^{14}	C^{17}	120.2(4)
N^{1}	C^{3}	C^{2}	113.7(3)	C^{15}	C^{14}	C^{17}	121.0(4)
O^{2}	C^{4}	N^{1}	122.3(3)	C^{14}	C^{15}	C^{16}	121.4(3)
O^{2}	C^{4}	N^{2}	122.9(3)	C^{15}	C^{16}	C^{11}	118.4(3)

Table 6 Hydrogen Bonds for Sx_iii_5B_8NOHprod_0m.

D	H	A	d(D-H)/Å	d(H-A)/Å	d(D-A)/Å	D-H-A/ °
N^{1}	H^{1}	O^{41}	0.80(5)	2.13(5)	2.921(4)	176(4)
C^{6}	H^{6}	O^{22}	1.00	2.50	3.431(4)	155.4
C^{7}	H^{7B}	O^{13}	0.99	2.32	3.257(4)	156.7

[1]2-X,1/2+Y,1-Z. [2]2-X,-1/2+Y,1-Z. [3]-1+X,+Y,+Z

Table 7 Hydrogen Atom Coordinates ($Å \times 10^{4}$) and Isotropic Displacement Parameters ($Å^{2} \times 10^{3}$) for Sx_iii_5B_8NOHprod_0m.

Atom	*x*	*y*	*z*	U(eq)
H^{1}	12780(50)	6510(40)	6970(50)	18
H^{1A}	10545.29	4346.91	3245.8	20
H^{2}	12944.3	4320.53	3759.51	23
H^{5}	8377.07	6310.43	4918.34	15
H^{6}	8306.55	3749.49	3682.55	16
H^{7A}	5874.81	3645.94	3713.34	18
H^{7B}	5913.57	5103.09	4300.75	18
H^{8A}	7829.57	7667.33	1742.43	26
H^{8B}	8396.37	8046.77	3345.92	26
H^{9A}	5939.57	8229.46	2734.2	27
H^{9B}	6394.34	7156.73	3926.87	27
H^{10A}	4469.44	6391.93	2248.99	25
H^{10B}	5314.02	6598.49	1037.65	25
H^{12}	3152.03	5476.02	-366.67	20
H^{13}	718.55	5254.55	-599.21	23
H^{15}	1305.68	1866.59	1545.75	22
H^{16}	3751.83	2060.02	1806.22	18
H^{17A}	-1174.73	2816.47	-512.39	42
H^{17B}	-1252.83	4262.59	74.45	42
H^{17C}	-1023.52	3050.91	1125.18	42

Experimental

Single crystals of 1-((2S,3S)-3-iodo-5-tosyl-1,5-oxazocan-2-yl)pyrimidine-2,4(1H,3H)-dione (**2r**) were crystallizes from a $CHCl_3$ solution as colorless rod-like crystals. A suitable crystal was selected and measured on a D8 Venture diffractometer. The crystal was kept at 150.0 K during data collection. Using Apex3 [1], the structure was solved with the ShelXT [2] structure solution program using intrinsic phasing. Using Olex2 [3] refined with the XL [4] refinement package using least squares minimization. The absolute structure was determined using anomalous dispersion. The direct Flack

parameter [5] was determined from 2146 selected quotients during refinement using XL. The post-refinement Flack parameter [5] (2162 pairs) and the post-refinement Hooft parameter (Gaussian distribution of 2243 selected pairs) [6,7] were determined using Platon [8]. Differences between the Flack parameter determined with direct and post-refinement methods is, partly, due to exclusion of outliers during the post-refinement determination [9].

1. Bruker-AXS (2016). APEX3. Version 2016.9-0. Madison, Wisconsin
2. Sheldrick, G.M. (2015). Acta Cryst. A71, 3-8.
3. Dolomanov, O.V., Bourhis, L.J., Gildea, R.J, Howard, J.A.K. & Puschmann, H. (2009), J. Appl. Cryst. 42, 339-341.
4. Sheldrick, G.M. (2008). Acta Cryst. A64, 112-122.
5. Parsons, S., Flack, H. D., & Wagner, T. (2013).69(Pt 3), 249-259
6. Hooft, R. W. W.. Straver, L. H. and Spek, A. L. (2010). J. Appl. Cryst.. 43, 665-668
7. Hooft, R. W. W.. Straver, L. H. and Spek, A. L. (2008). J Appl Crystallogr. 41(Pt 1): 96–103.
8. Platon A.L.Spek, Acta Cryst. 2009, D65, 148-155.
9. Watkin, D. J. & Cooper, R. I. (2016). Acta Cryst. B72, 661–683.

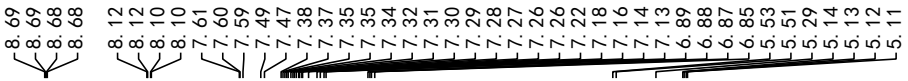
Crystal structure determination of 2r

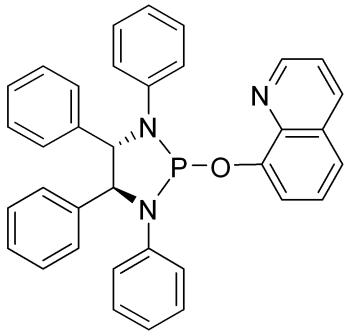
Crystal Data for $C_{29}H_{23}N_3O_4$ (M =477.50 g/mol): triclinic, space group P1 (no. 1), a = 8.2784(4) Å, b = 11.8459(6) Å, c = 13.4907(7) Å, α = 101.689(3) °, β = 105.921(2) °, γ = 95.174(3) °, V = 1230.82(11) Å^3, Z = 2, T = 100.0 K, μ(CuKα) = 0.708 mm^{-1}, *Dcalc* = 1.288 g/cm^3, 65290 reflections measured (7.014° ≤ 2Θ ≤ 149.58°), 9999 unique (R_{int} = 0.0361, R_{sigma} = 0.0232), which were used in all calculations. The final R_1 was 0.0345 (I > 2σ(I)) and wR_2 was 0.0902 (all data).

Refinement model description

Details:
1. Fixed Uiso
At 1.2 times of:
All C(H) groups, All C(H,H) groups
2.a Ternary CH refined with riding coordinates:
C14(H14), C15(H15), C14A(H14A), C15A(H15A)
2.b Secondary CH2 refined with riding coordinates:
C9(H9A,H9B), C13(H13A,H13B), C16(H16A,H16B), C9A(H9AA,H9AB), C13A(H13C,H13D), C16A(H16C,H16D)
2.c Aromatic/amide H refined with riding coordinates:
C3(H3), C4(H4), C5(H5), C6(H6), C10(H10), C19(H19), C20(H20), C21(H21), C22(H22), C23(H23), C25(H25), C26(H26), C27(H27), C28(H28), C29(H29), C3A(H3A), C4A(H4A), C5A(H5A), C6A(H6A), C10A(H10A), C19A(H19A), C20A(H20A), C21A(H21A), C22A(H22A), C23A(H23A), C25A(H25A), C26A(H26A), C27A(H27A), C28A(H28A), C29A(H29A)

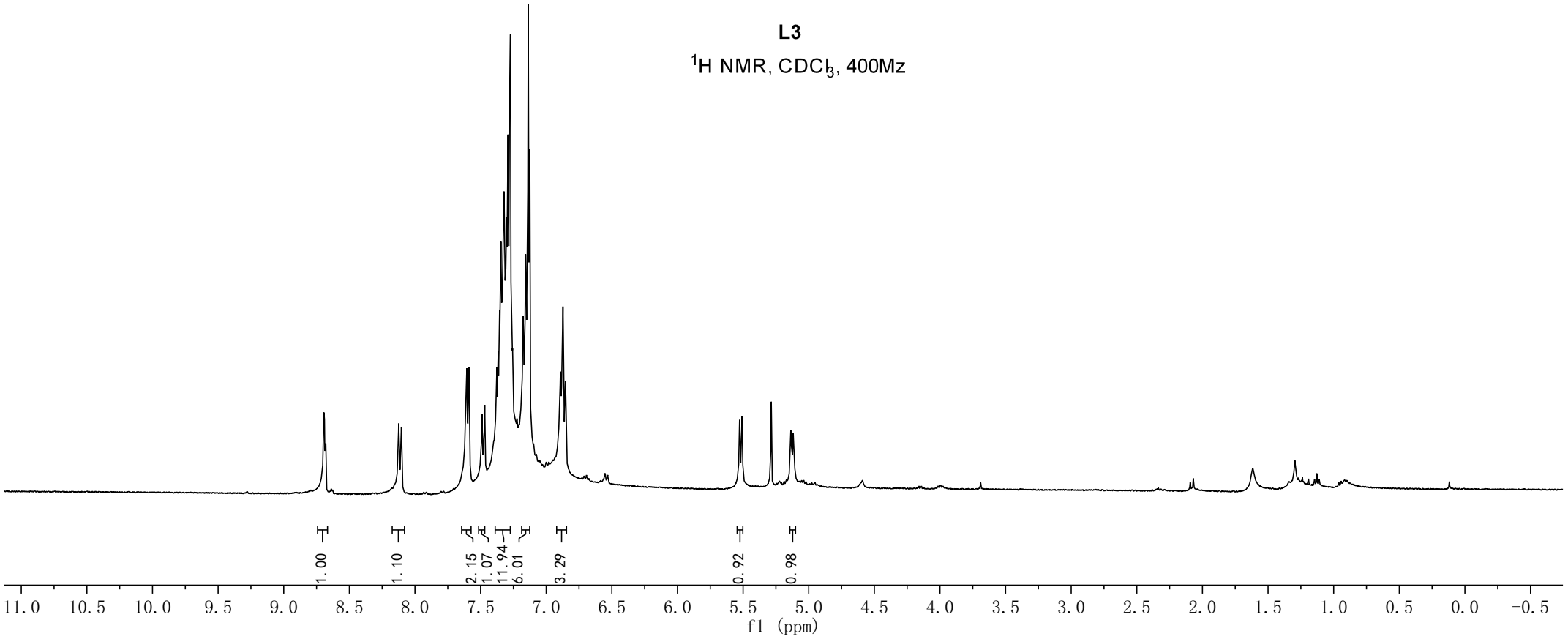
4. Copies of NMR spectra

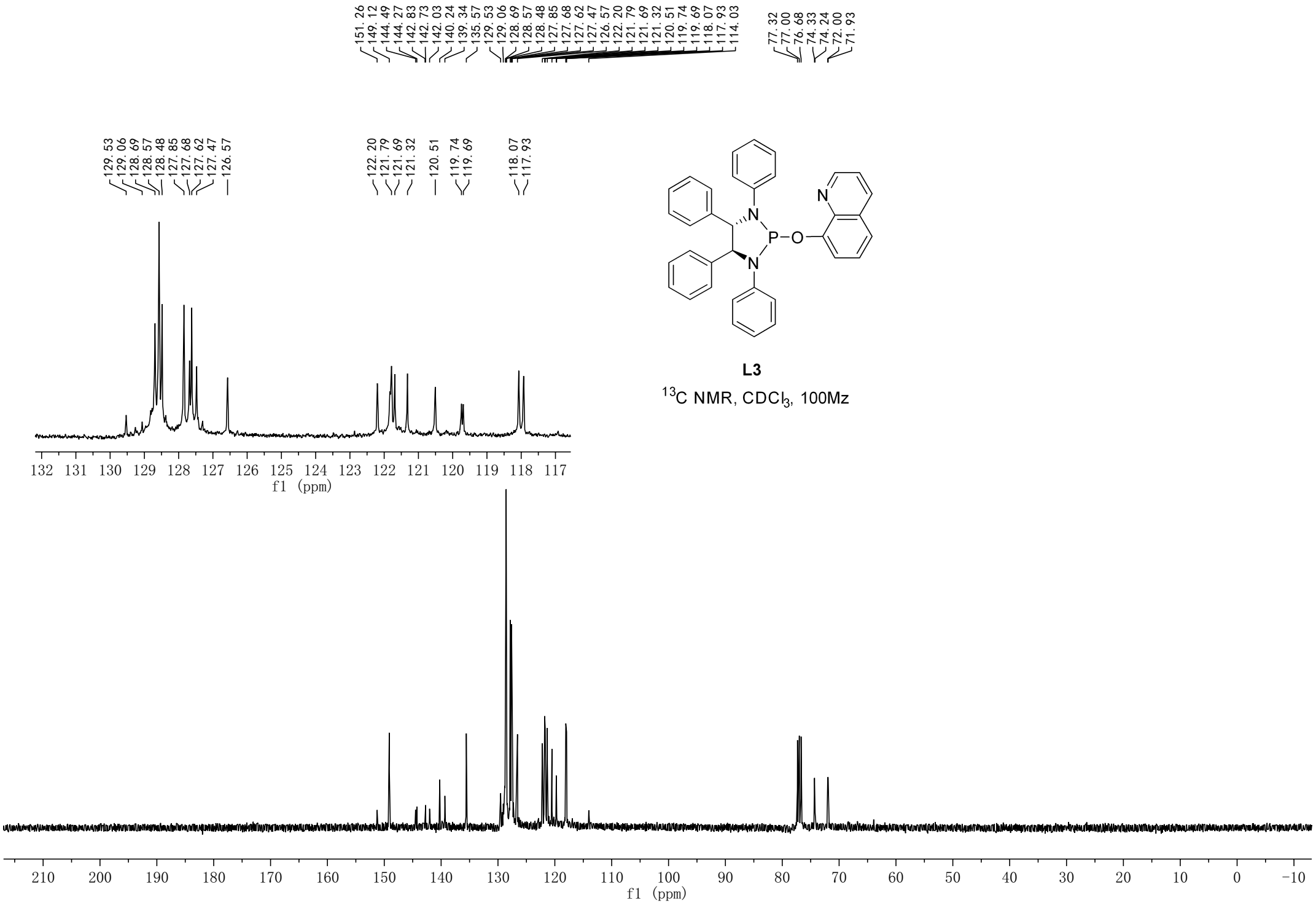


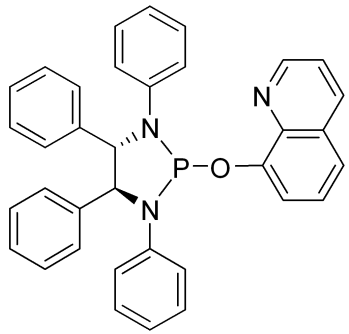


L3

^{1}H NMR, $CDCl_3$, 400Mz

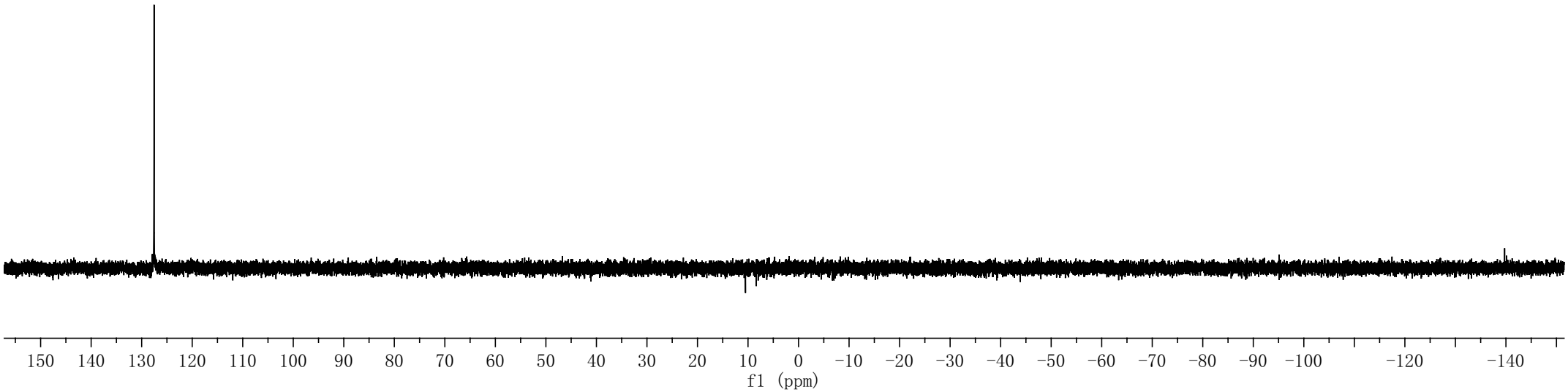


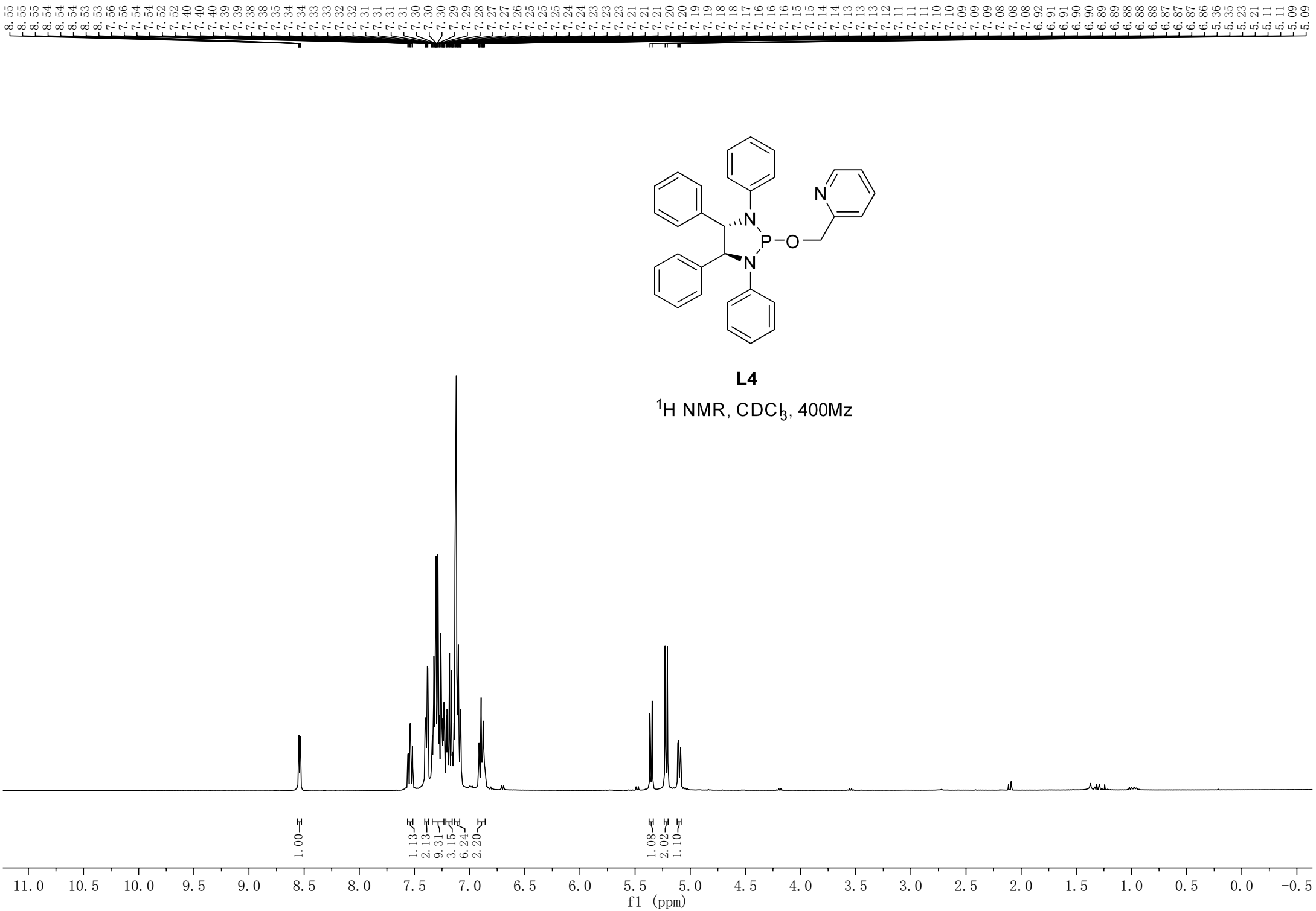

151.26
149.12
144.49
144.27
142.83
142.73
142.03
140.24
139.34
135.57
129.53
129.06
128.69
128.57
128.48
127.85
127.68
127.62
127.47
126.57
122.20
121.79
121.69
121.32
120.51
119.74
119.69
118.07
117.93
114.03
77.32
77.00
76.68
74.33
74.24
72.00
71.93
N
P
O
N
N
L3
^{13}C NMR, CDCl$_3$, 100Mz
f1 (ppm)
f1 (ppm)

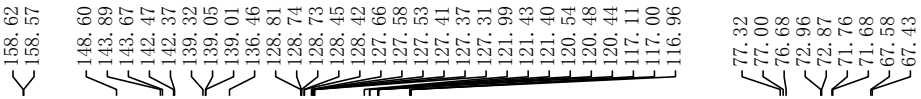


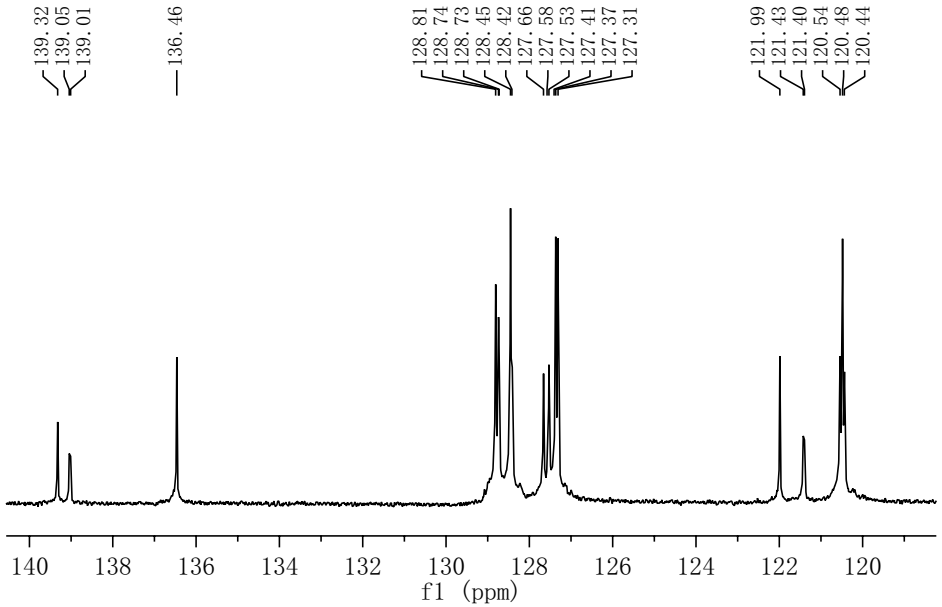
L3

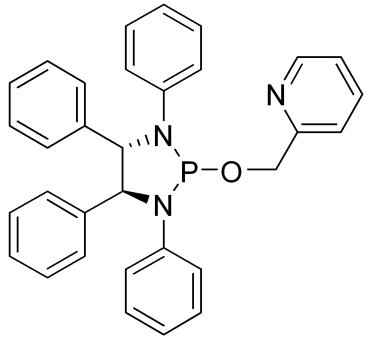
^{31}P NMR, $CDCl_3$, 162Mz




8.55 8.55 8.54 8.54 8.54 8.53 8.53 7.56 7.56 7.54 7.54 7.52 7.52 7.40 7.40 7.39 7.39 7.38 7.38 7.35 7.34 7.34 7.33 7.33 7.32 7.32 7.31 7.31 7.31 7.31 7.30 7.30 7.30 7.29 7.29 7.28 7.27 7.27 7.26 7.25 7.25 7.24 7.24 7.23 7.23 7.21 7.21 7.20 7.20 7.19 7.19 7.18 7.18 7.17 7.16 7.16 7.16 7.15 7.15 7.14 7.14 7.13 7.13 7.12 7.11 7.11 7.10 7.10 7.09 7.09 7.09 7.08 7.08 7.08 6.92 6.91 6.90 6.90 6.89 6.89 6.88 6.88 6.88 6.87 6.87 6.87 6.86 5.36 5.35 5.23 5.21 5.11 5.11 5.09 5.09
N
N
P
O
N
L4
1H NMR, CDCl3, 400Mz
1.00
1.13
2.13
9.31
3.15
6.24
2.20
1.08
2.02
1.10
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

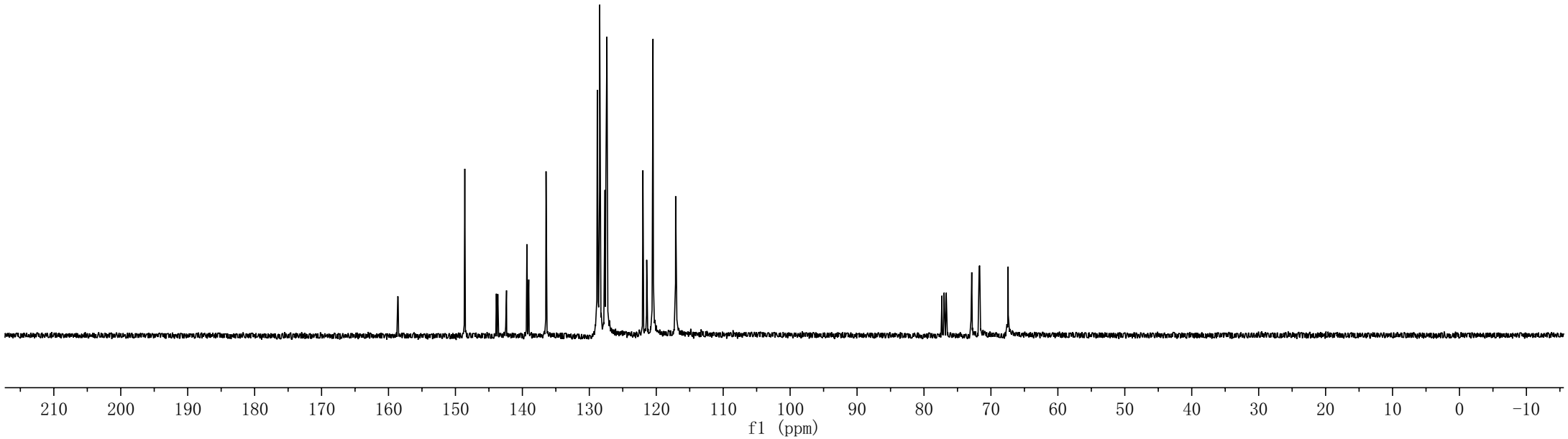




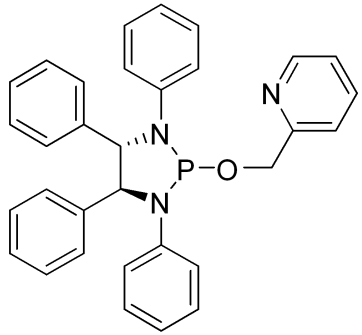


L4

^{13}C NMR, $CDCl_3$, 100Mz

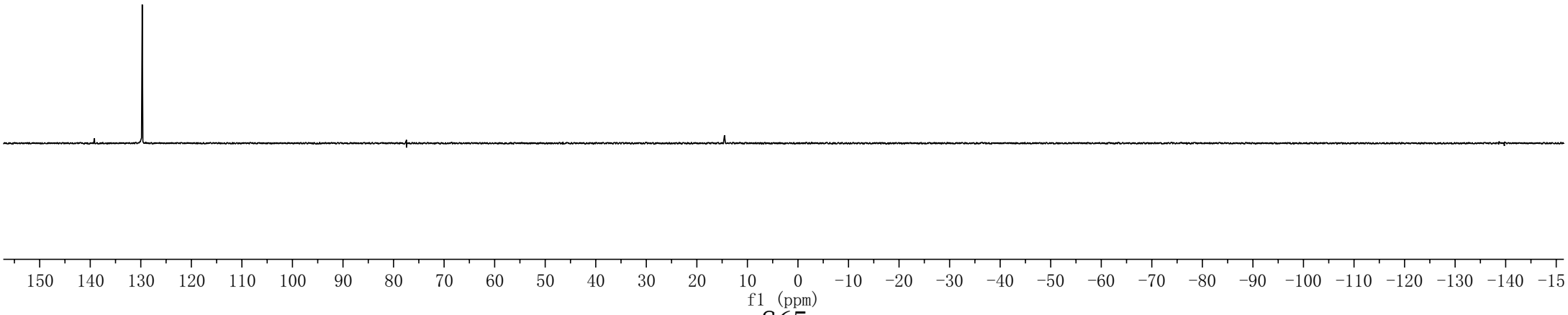


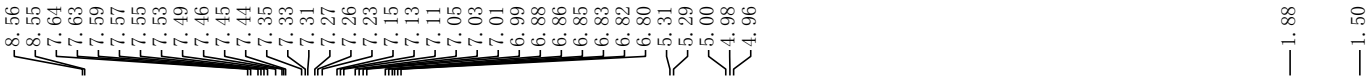
— 129.72

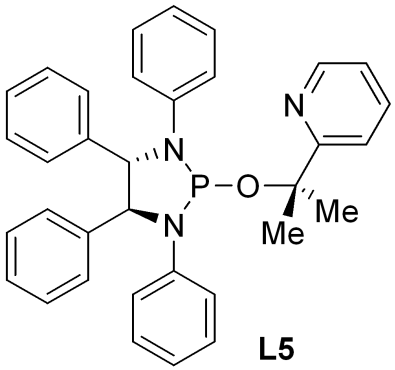


L4

^{31}P NMR, $CDCl_3$, 162Mz

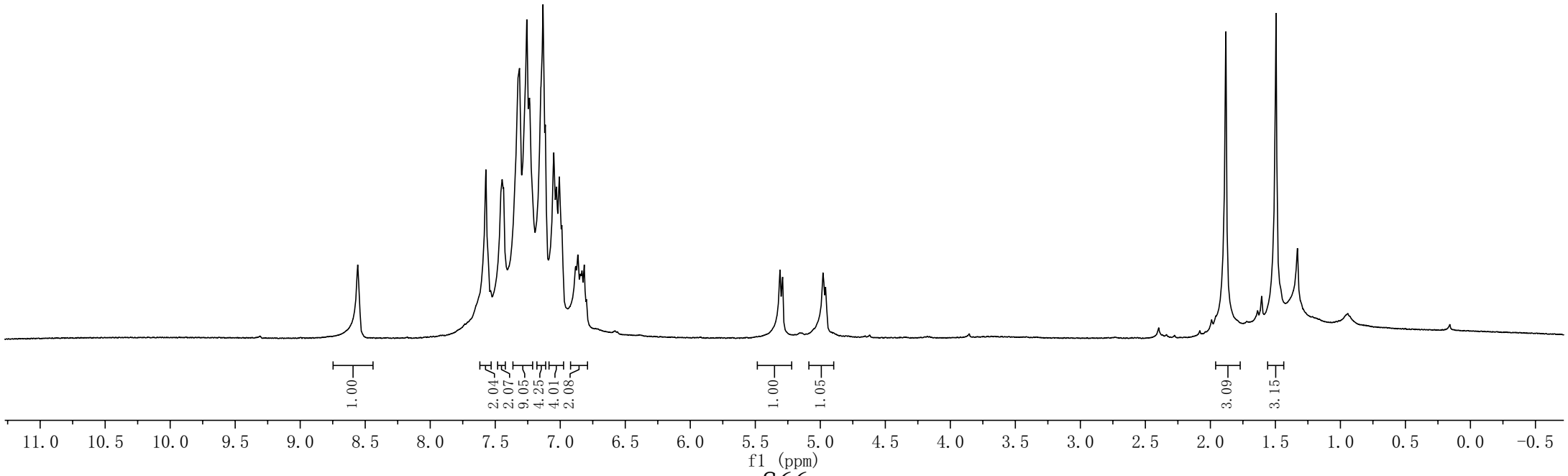


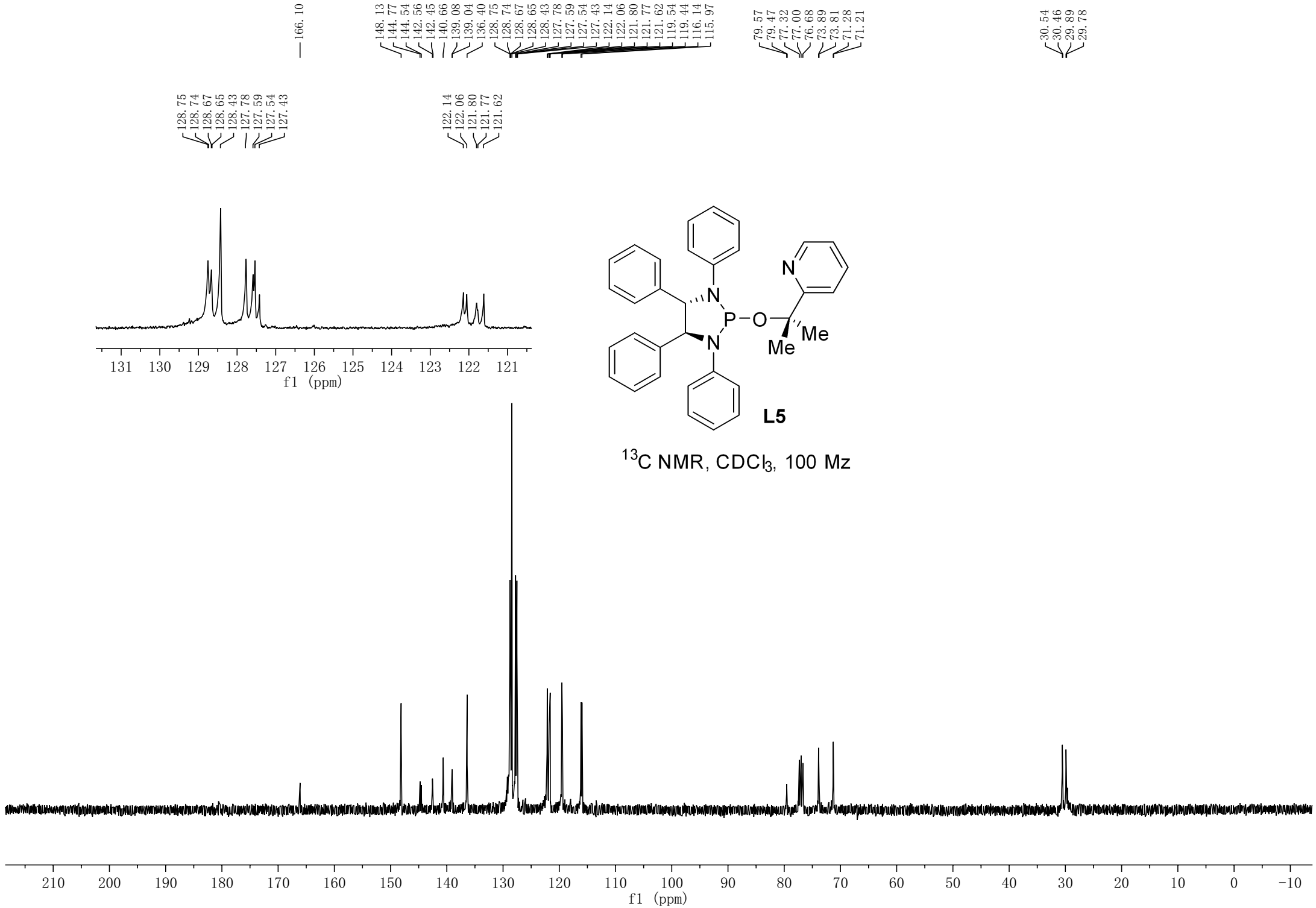


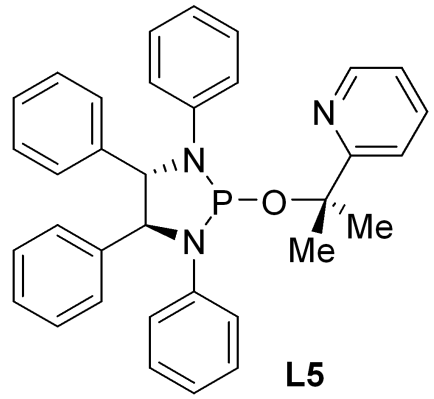


L5

^{1}H NMR, $CDCl_3$, 400 Mz

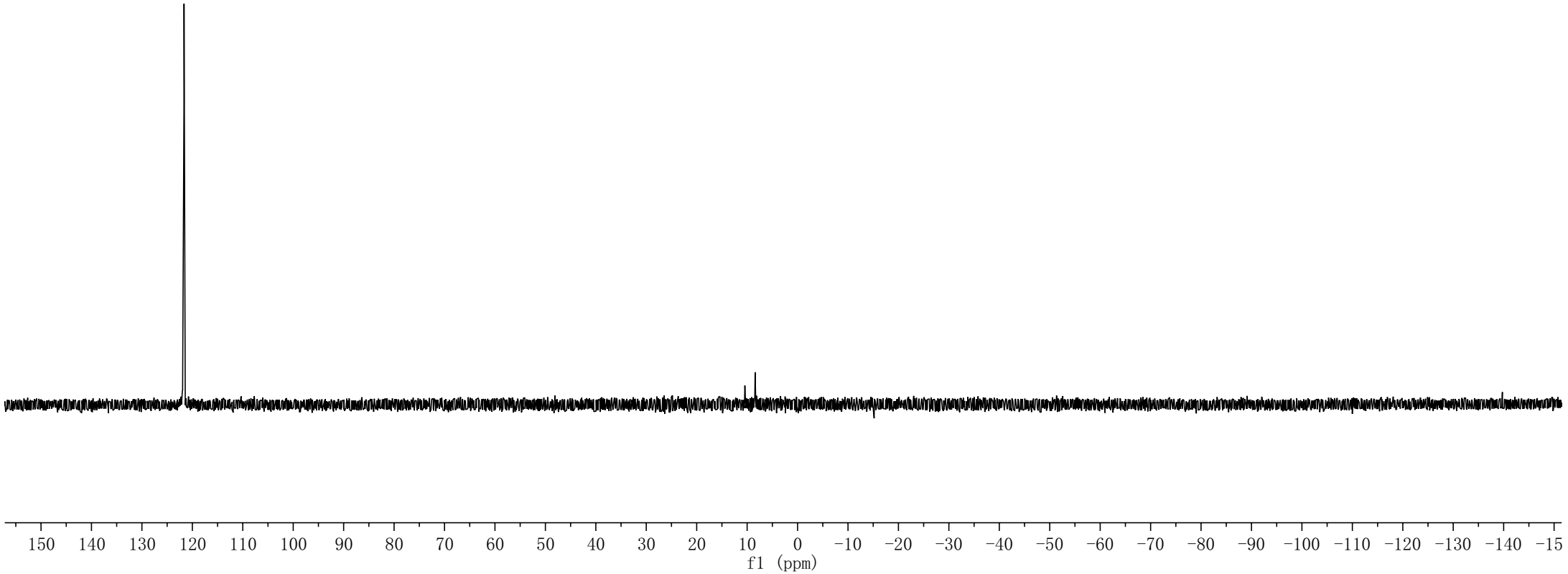


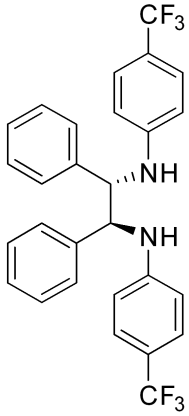

166.10
148.13
144.77
144.54
142.56
142.45
140.66
139.08
139.04
136.40
128.75
128.74
128.67
128.65
128.43
127.78
127.59
127.54
127.43
122.14
122.06
121.80
121.77
121.62
119.54
119.44
116.14
115.97
79.57
79.47
77.32
77.00
76.68
73.89
73.81
71.28
71.21
30.54
30.46
29.89
29.78
N
N
P
O
N
Me
Me
L5
13C NMR, CDCl3, 100 Mz
f1 (ppm)



L5

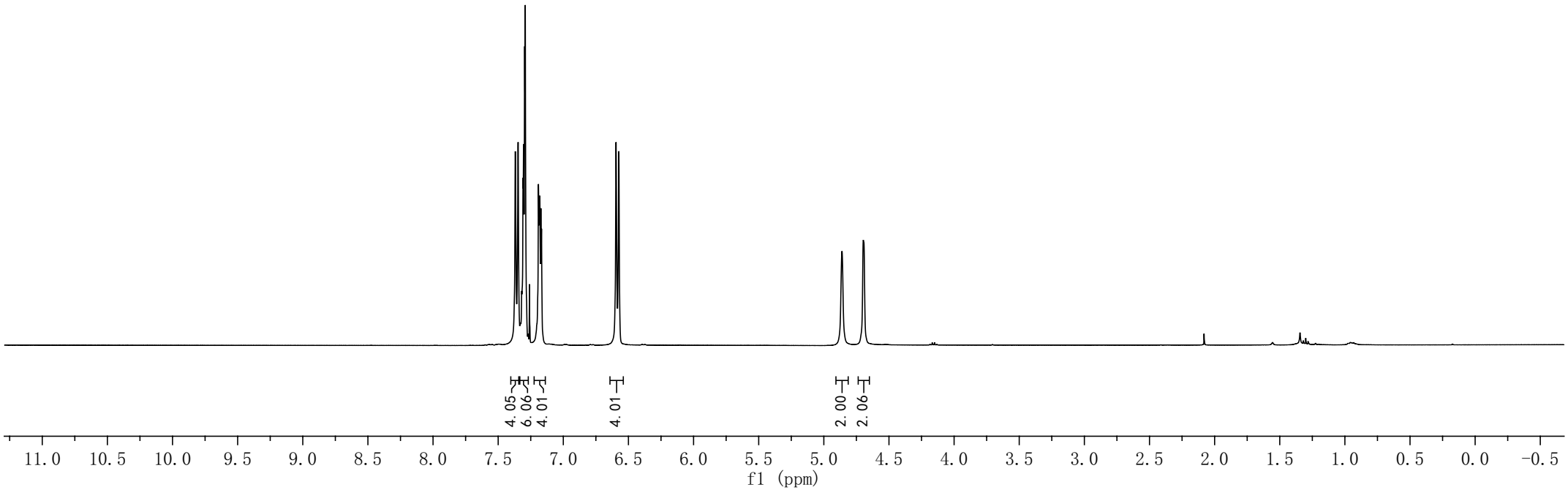
^{31} PNMR, CD_3Cl, 162 Mz

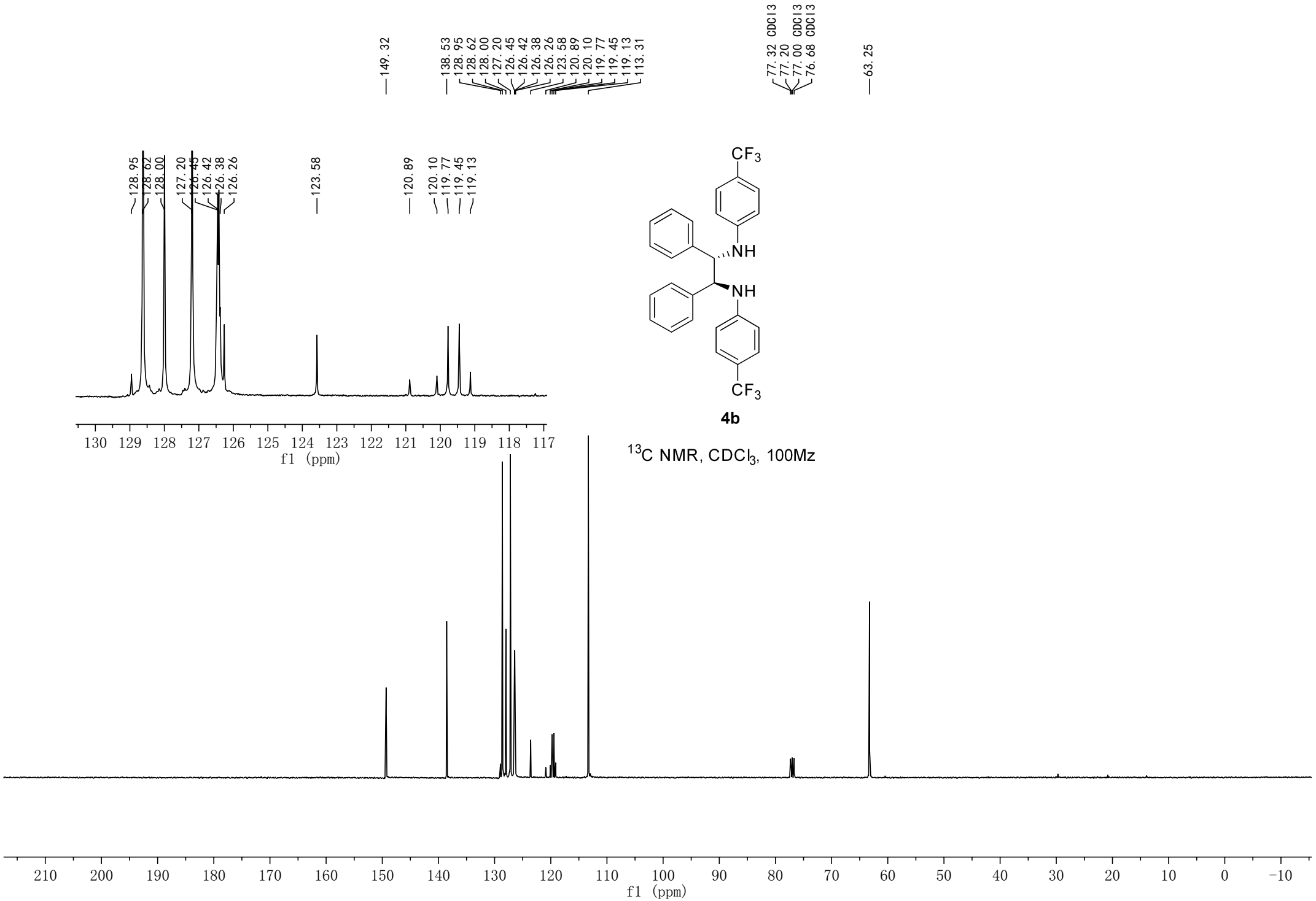


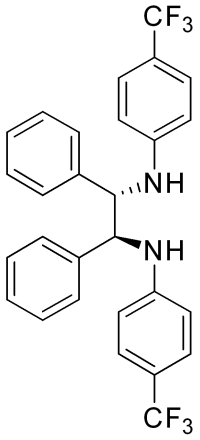


4b

^{1}H NMR, $CDCl_3$, 400Mz

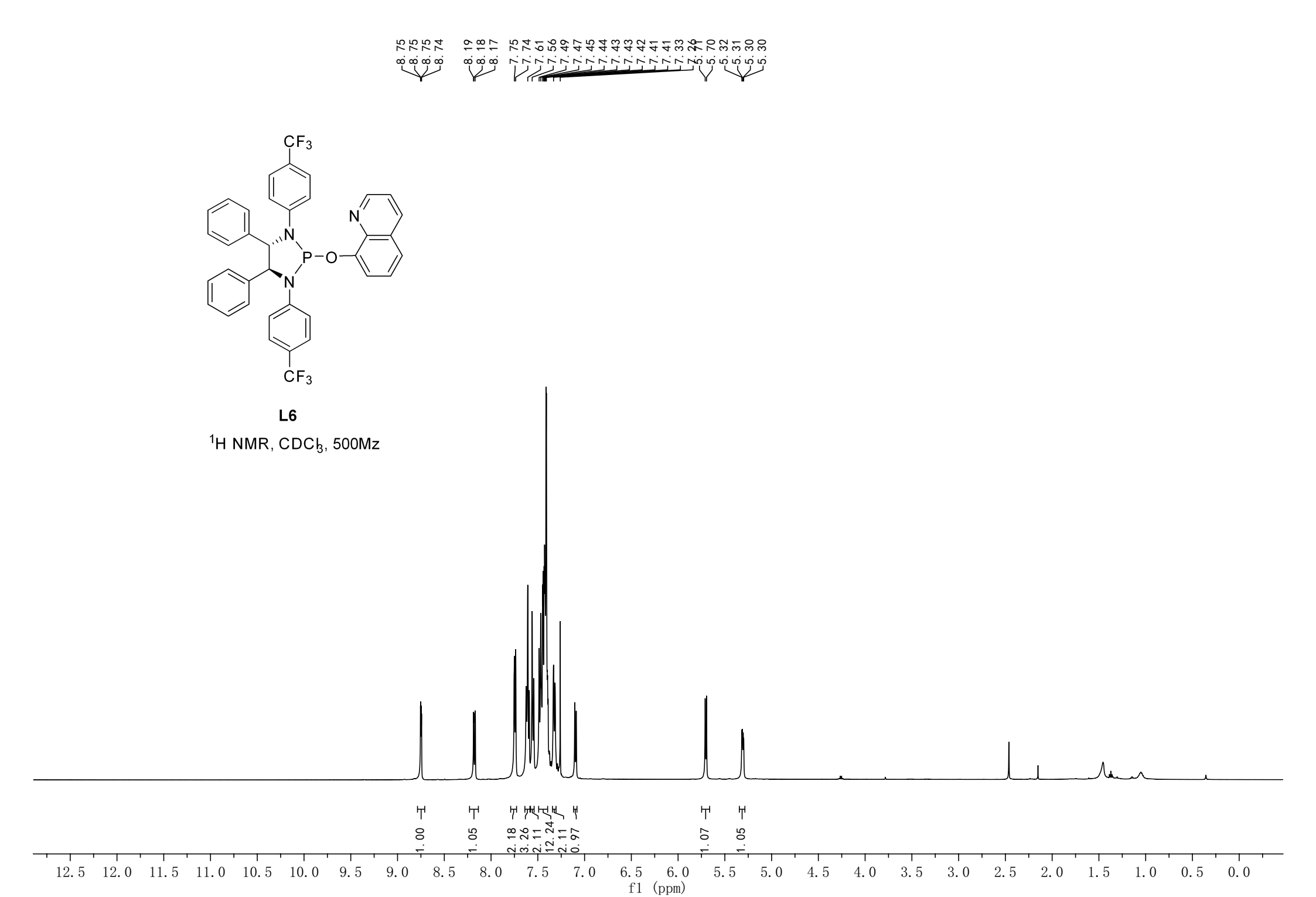


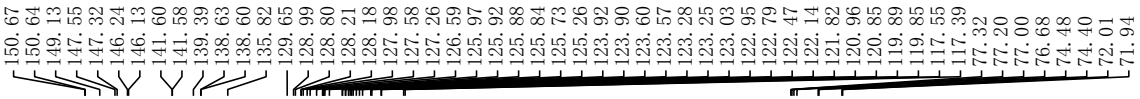

149.32
138.53
128.95
128.62
128.00
127.20
126.45
126.42
126.38
126.26
123.58
120.89
120.10
119.77
119.45
119.13
113.31
77.32 CDCl3
77.20
77.00 CDCl3
76.68 CDCl3
63.25
CF3
NH
NH
CF3
4b
13C NMR, CDCl3, 100Mz
f1 (ppm)

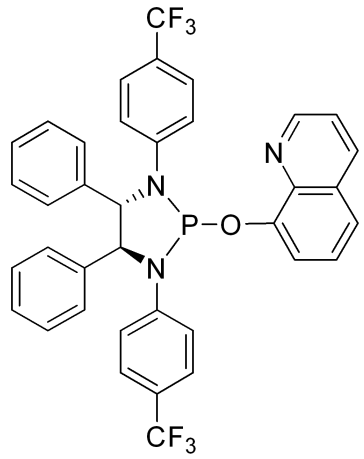


4b

^{19}F NMR, $CDCl_3$, 376 Mz

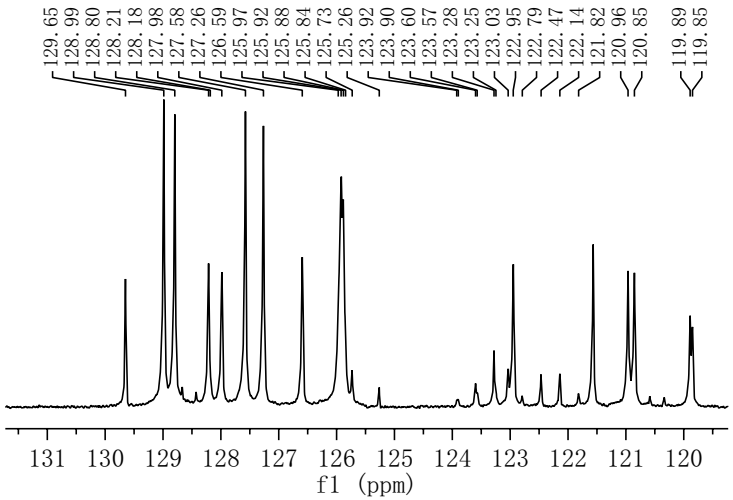

8.75
8.75
8.75
8.74
8.19
8.18
8.17
7.75
7.74
7.61
7.56
7.49
7.47
7.45
7.44
7.43
7.43
7.42
7.41
7.41
7.33
5.70
5.32
5.31
5.30
5.30
CF3
N
N
P
O
N
CF3
L6
1H NMR, CDCl3, 500Mz
1.00
1.05
2.18
3.26
2.11
12.24
2.11
0.97
1.07
1.05
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

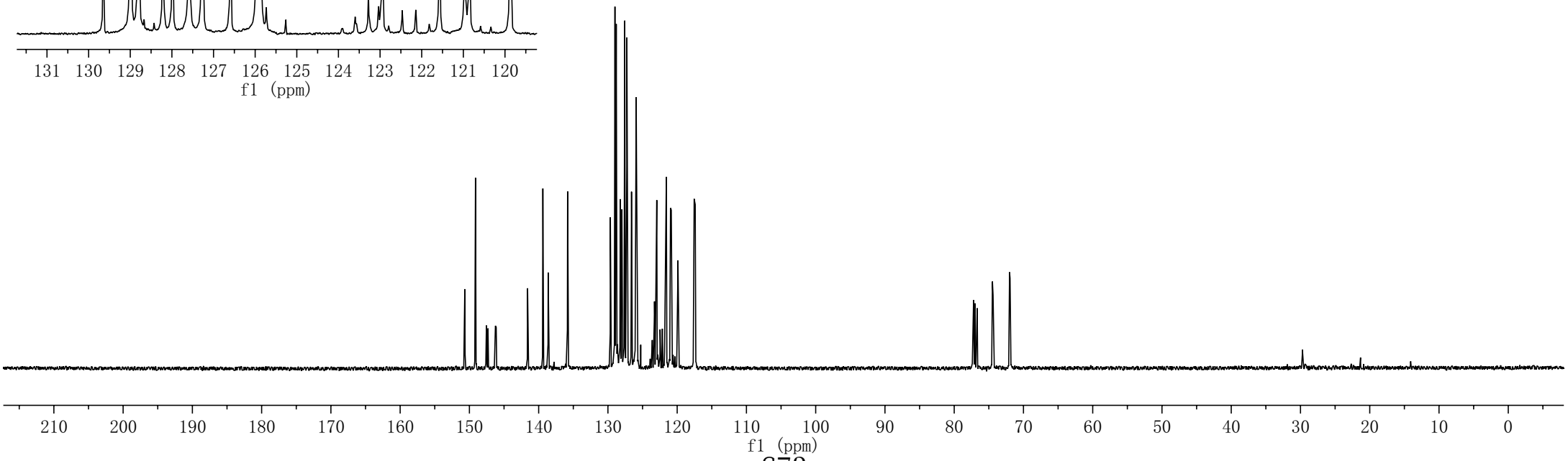


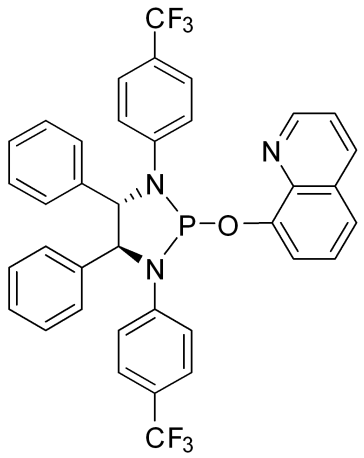


L6

^{13}C NMR, $CDCl_3$, 100Mz

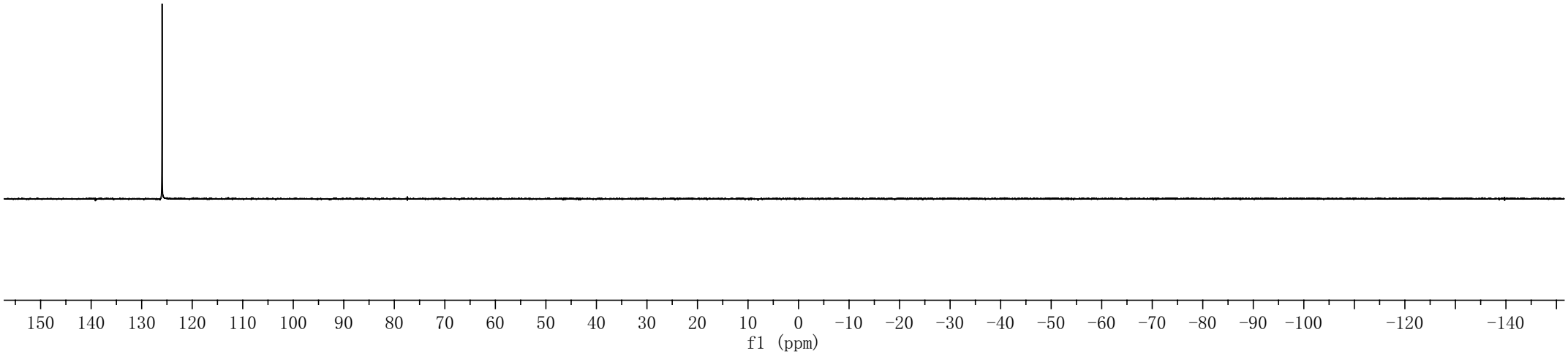


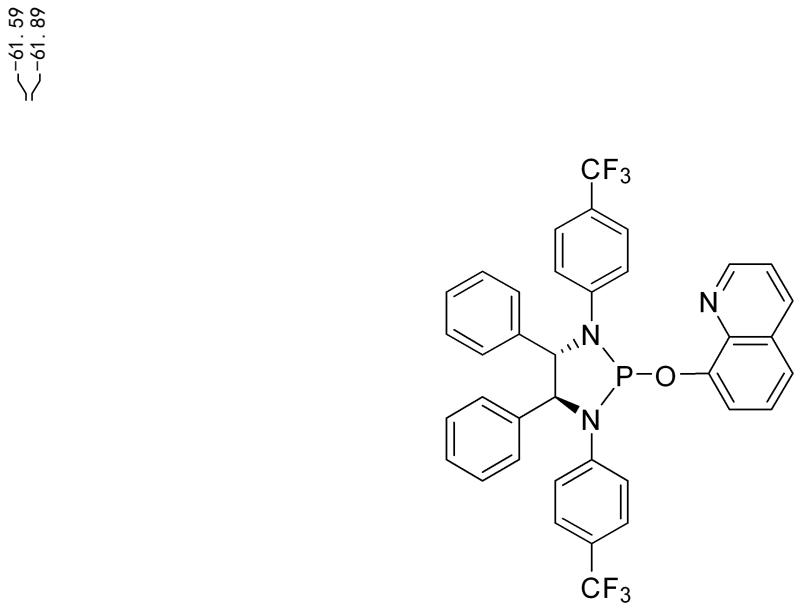




L6

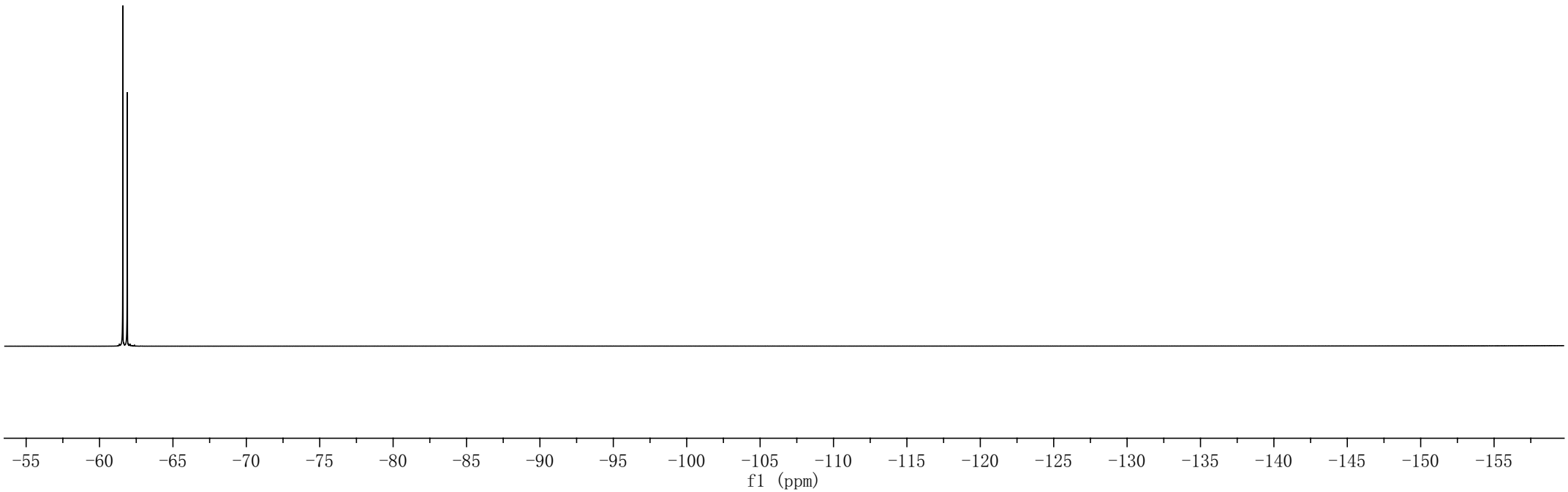
^{31}P NMR, $CDCl_3$, 162Mz

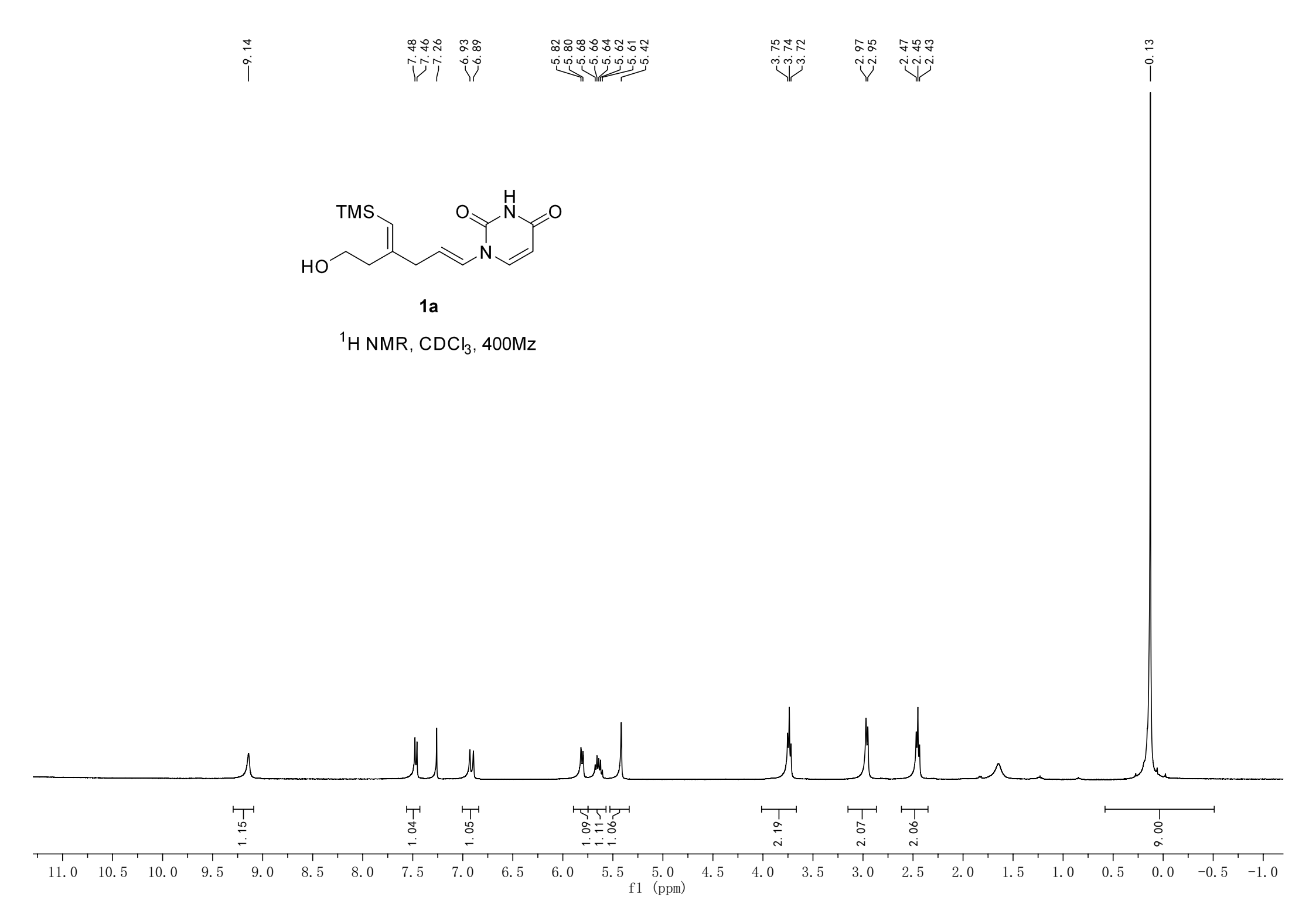


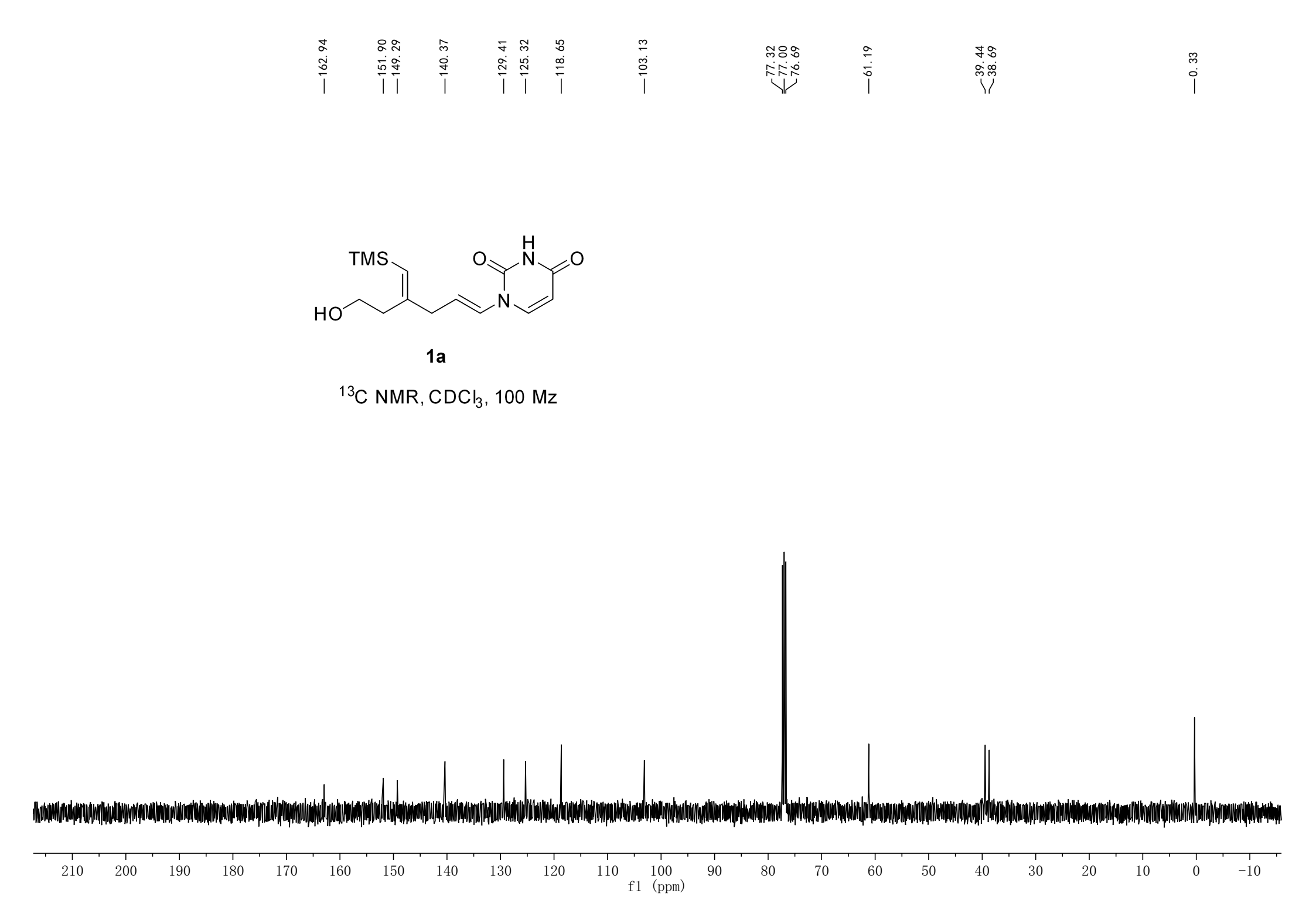


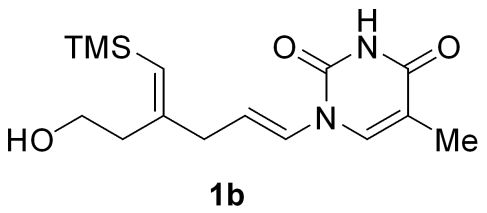
L6

^{19}F NMR, $CDCl_3$, 376 Mz



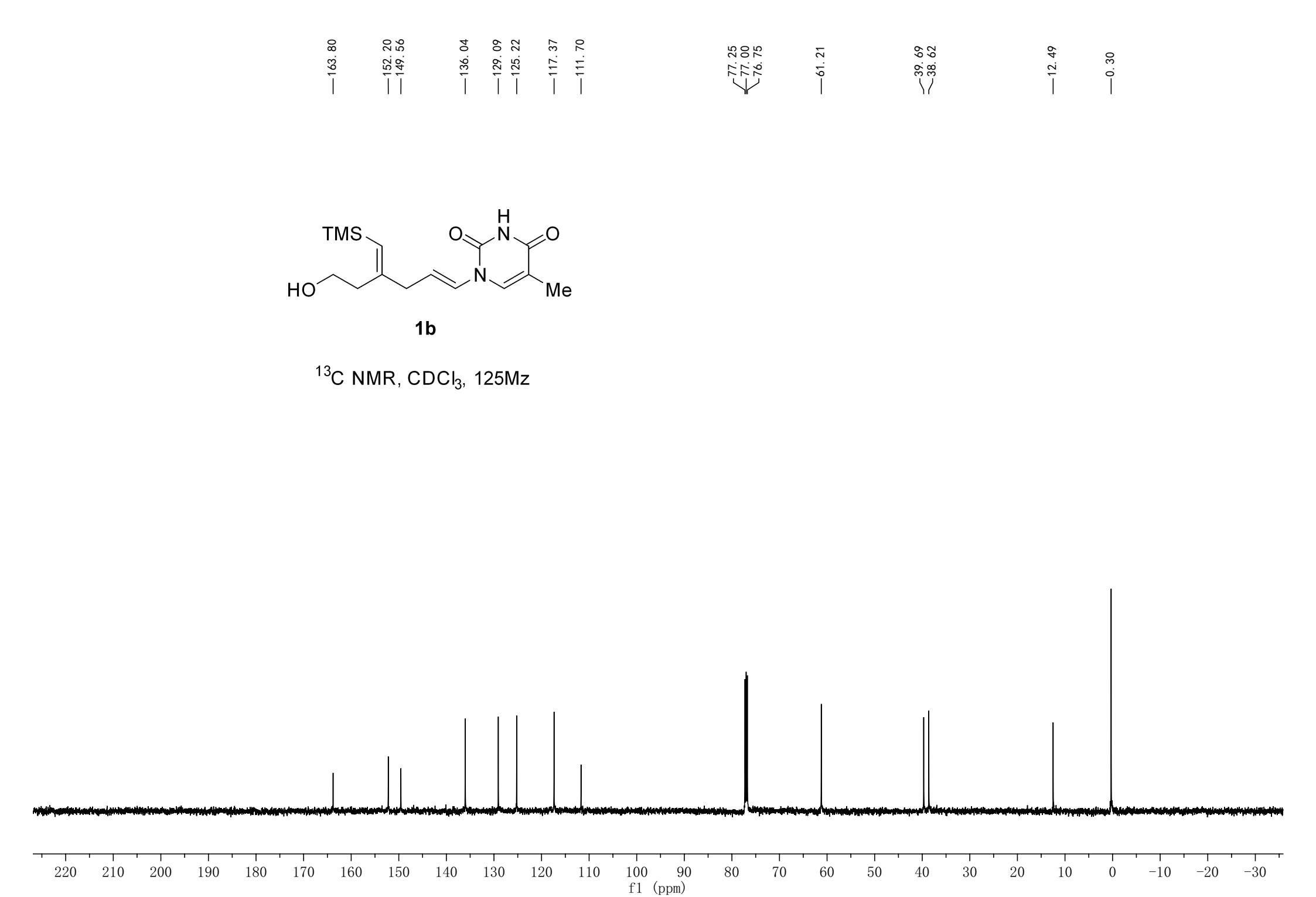

9.14
7.48
7.46
7.26
6.93
6.89
5.82
5.80
5.68
5.66
5.64
5.62
5.61
5.42
3.75
3.74
3.72
2.97
2.95
2.47
2.45
2.43
0.13
TMS
HO
O
H
N
O
N
1a
1H NMR, CDCl3, 400Mz
1.15
1.04
1.05
1.09
1.11
1.06
2.19
2.07
2.06
9.00
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
f1 (ppm)

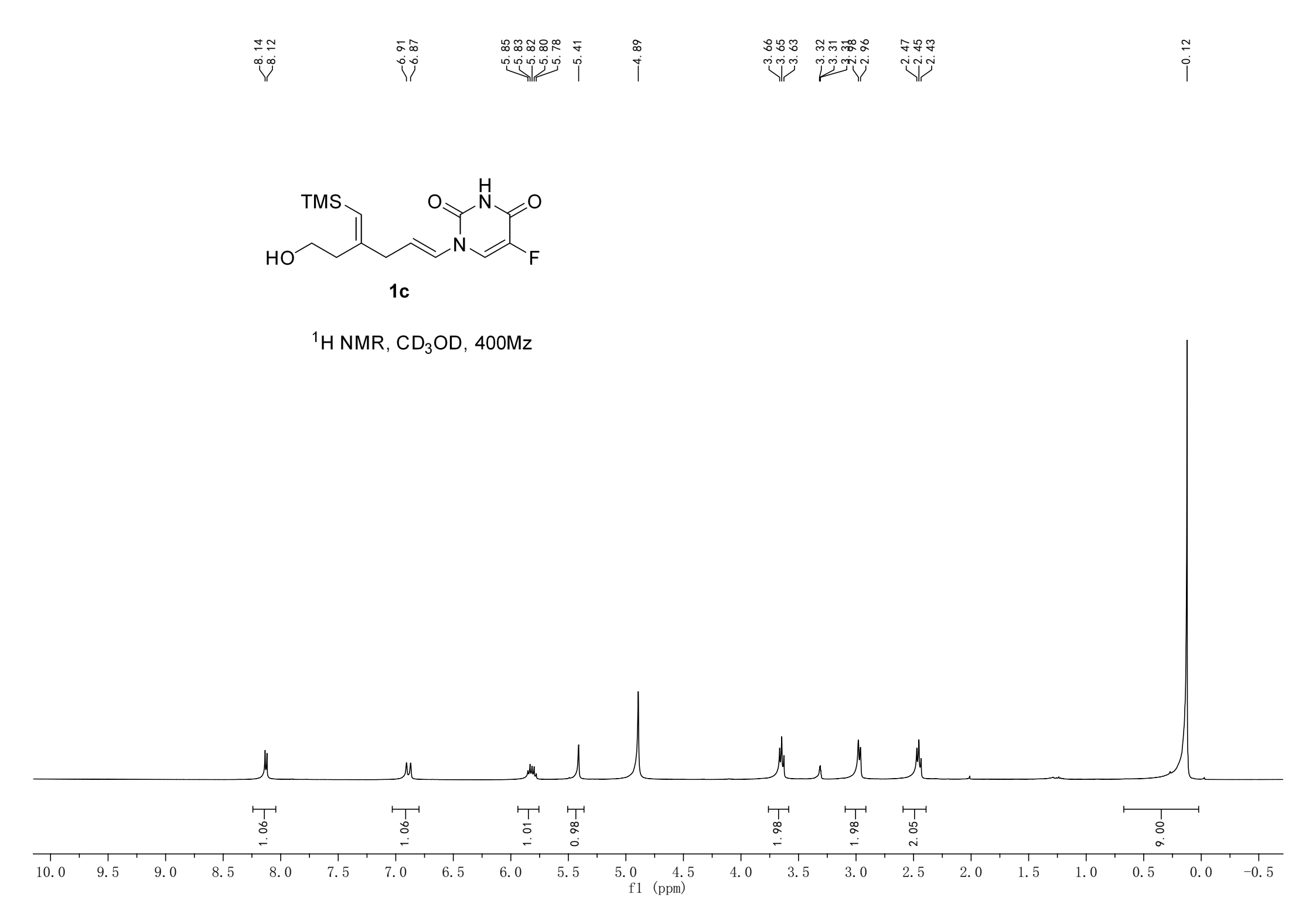

162.94
151.90
149.29
140.37
129.41
125.32
118.65
103.13
77.32
77.00
76.69
61.19
39.44
38.69
0.33
TMS
HO
O
N
H
O
N
1a
^{13}C NMR, $CDCl_3$, 100 Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

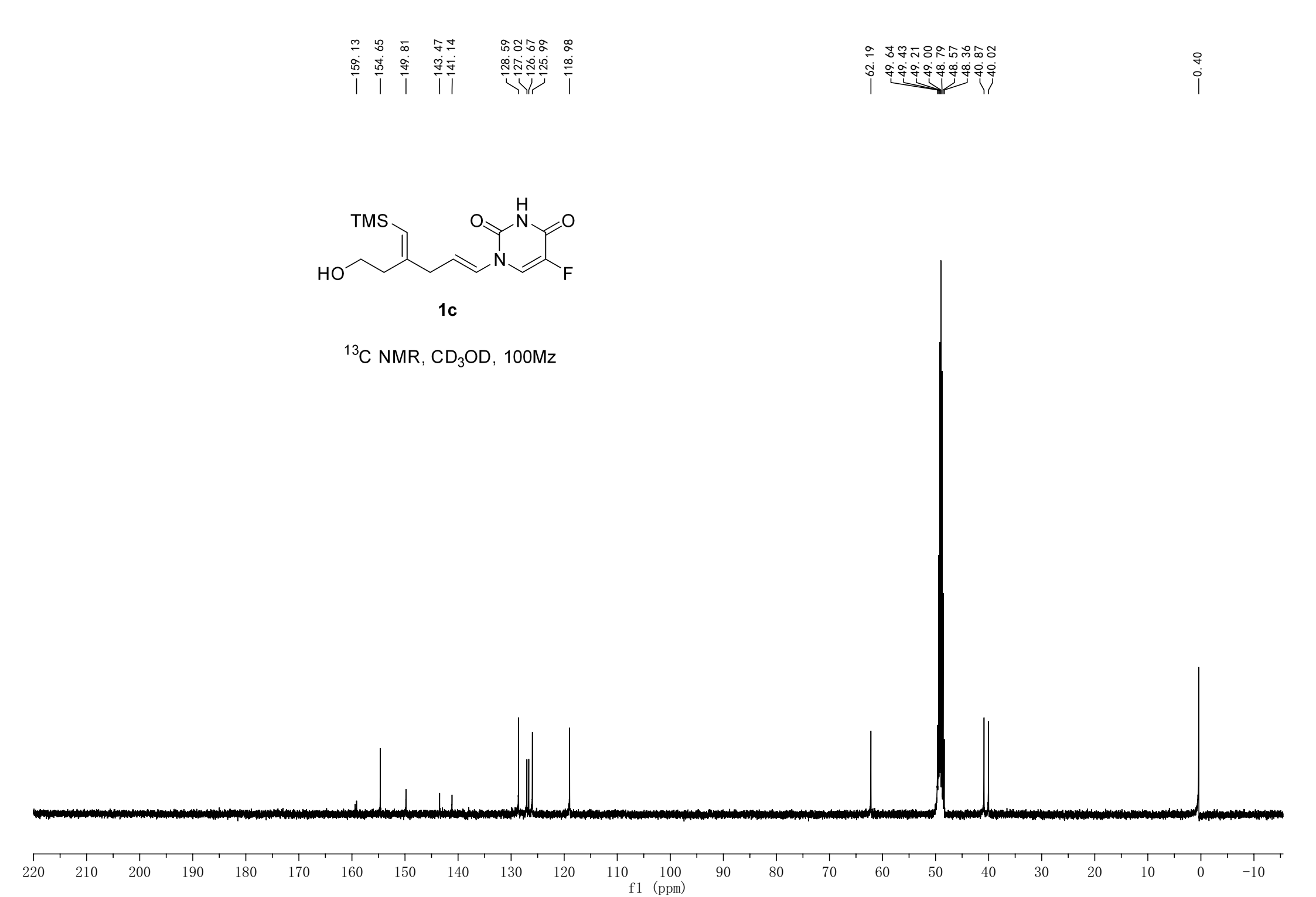


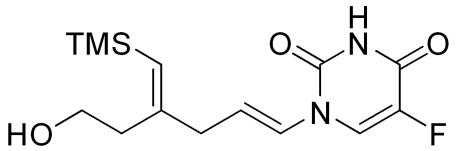
1b

^{1}H NMR, $CDCl_3$, 500Mz


163.80
152.20
149.56
136.04
129.09
125.22
117.37
111.70
77.25
77.00
76.75
61.21
39.69
38.62
12.49
0.30
TMS
HO
O
H
N
O
N
Me
1b
13C NMR, CDCl3, 125Mz
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30
f1 (ppm)

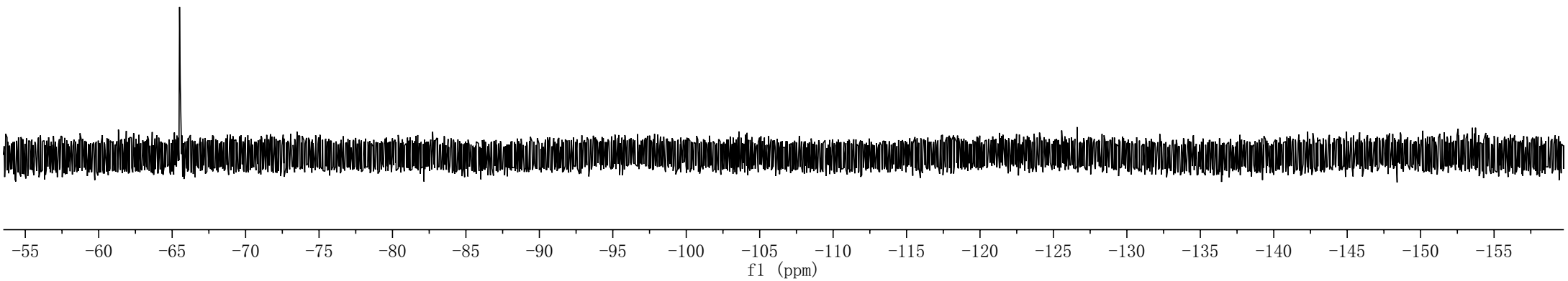

8.14
8.12
6.91
6.87
5.85
5.83
5.82
5.80
5.78
5.41
4.89
3.66
3.65
3.63
3.32
3.31
2.98
2.96
2.47
2.45
2.43
0.12
TMS
HO
O
H
N
O
N
F
1c
1H NMR, CD3OD, 400Mz
1.06
1.06
1.01
0.98
1.98
1.98
2.05
9.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

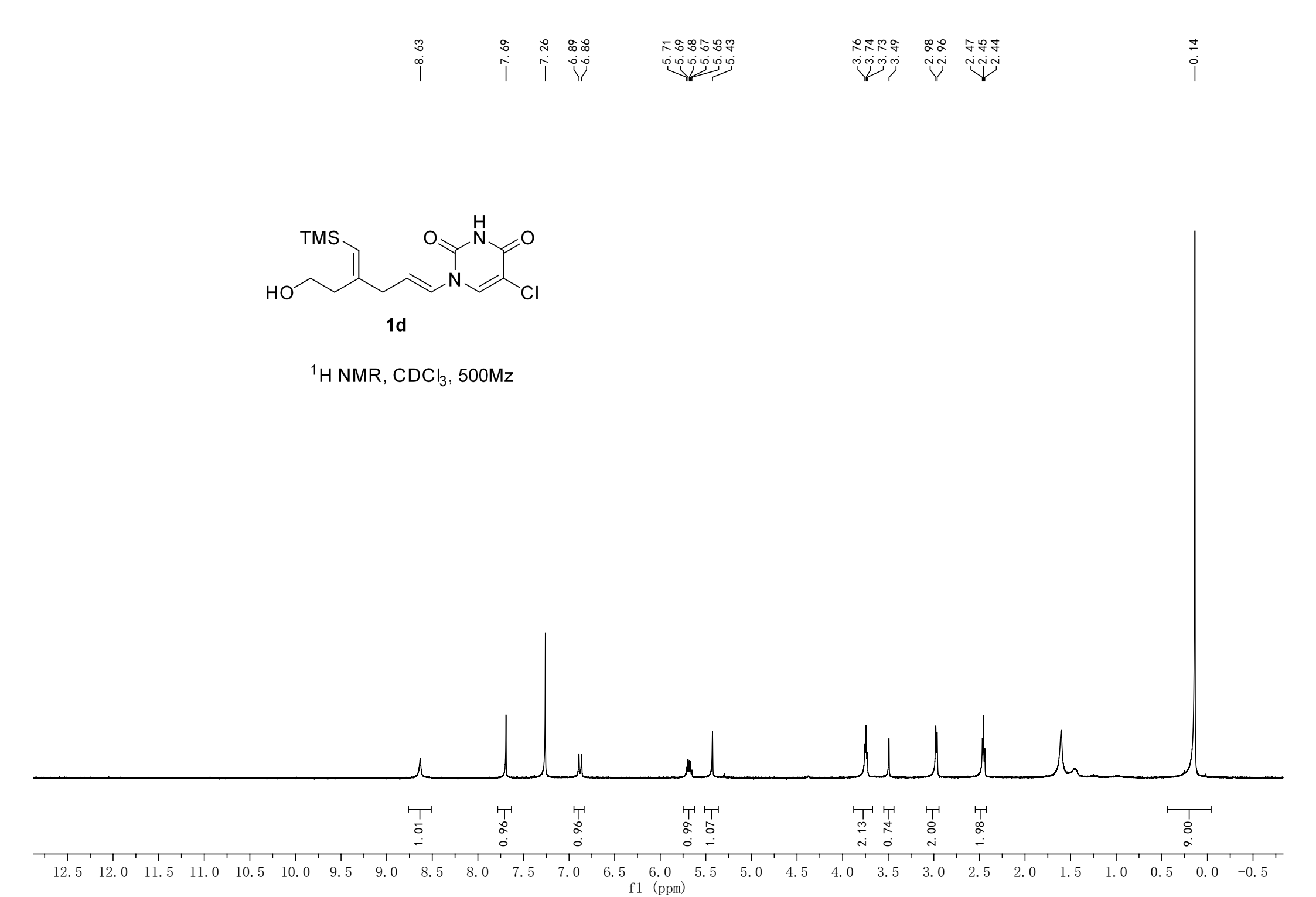

159.13
154.65
149.81
143.47
141.14
128.59
127.02
126.67
125.99
118.98
62.19
49.64
49.43
49.21
49.00
48.79
48.57
48.36
40.87
40.02
0.40
TMS
HO
O
H
N
O
N
F
1c
13C NMR, CD3OD, 100Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

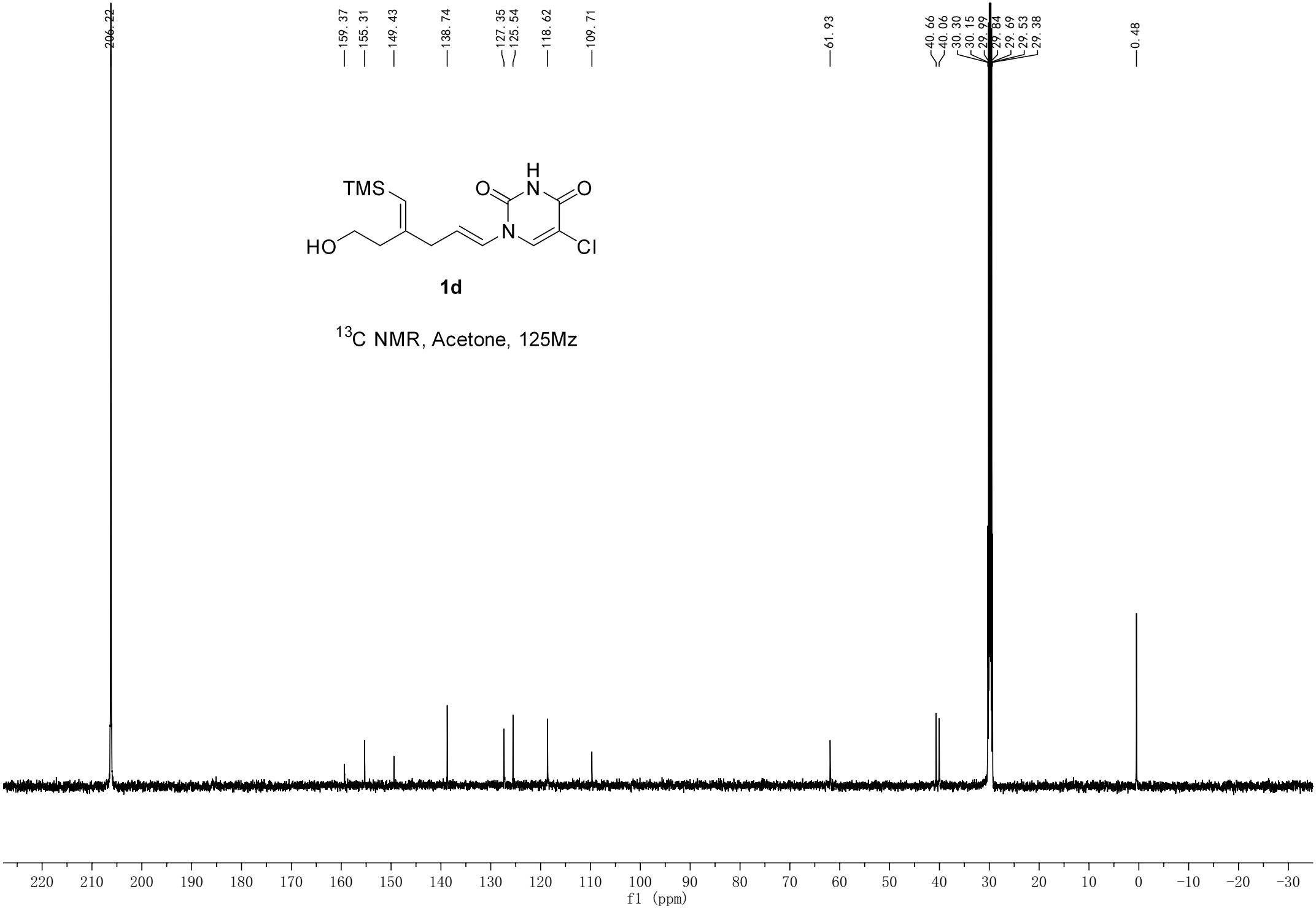


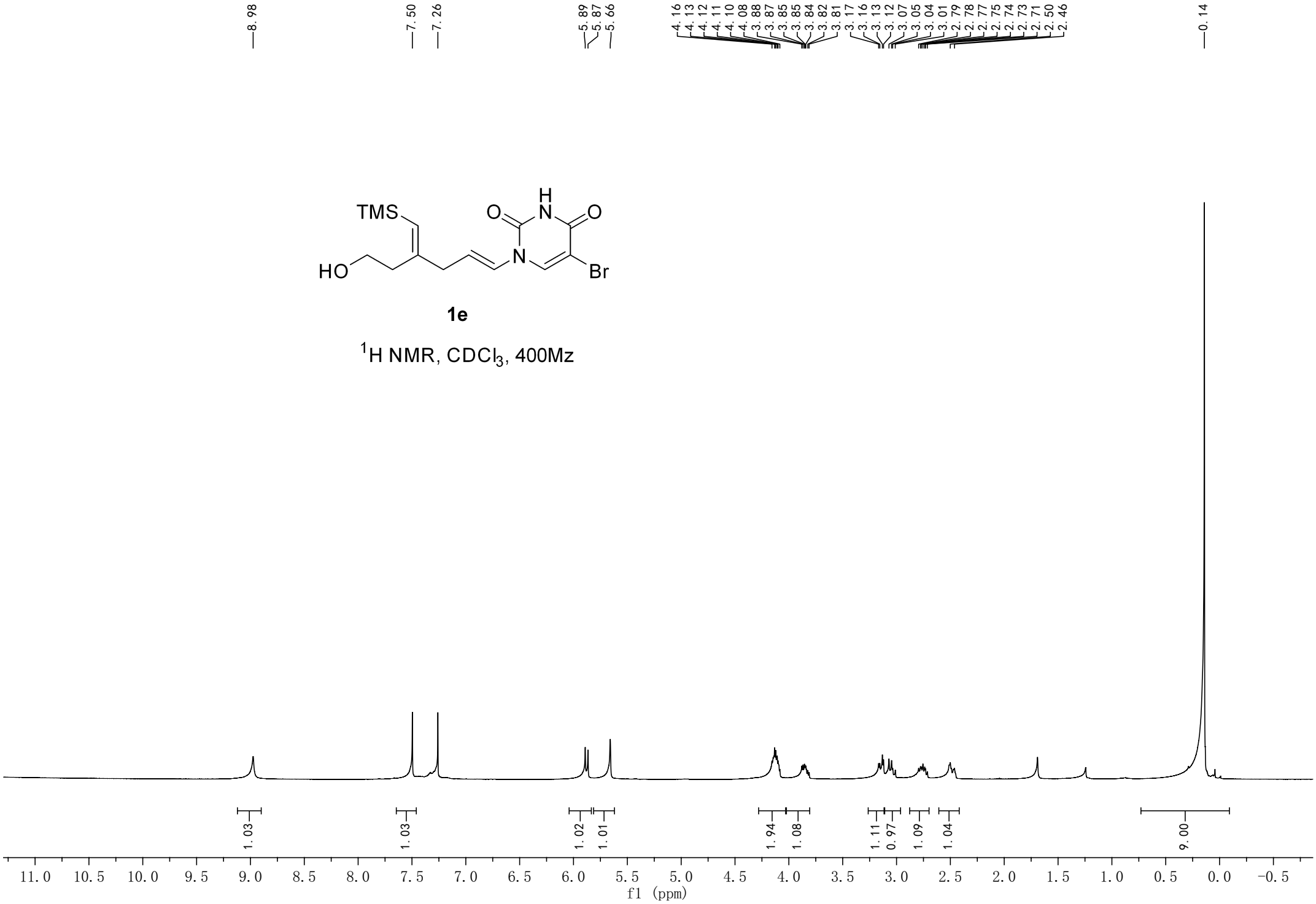
1c

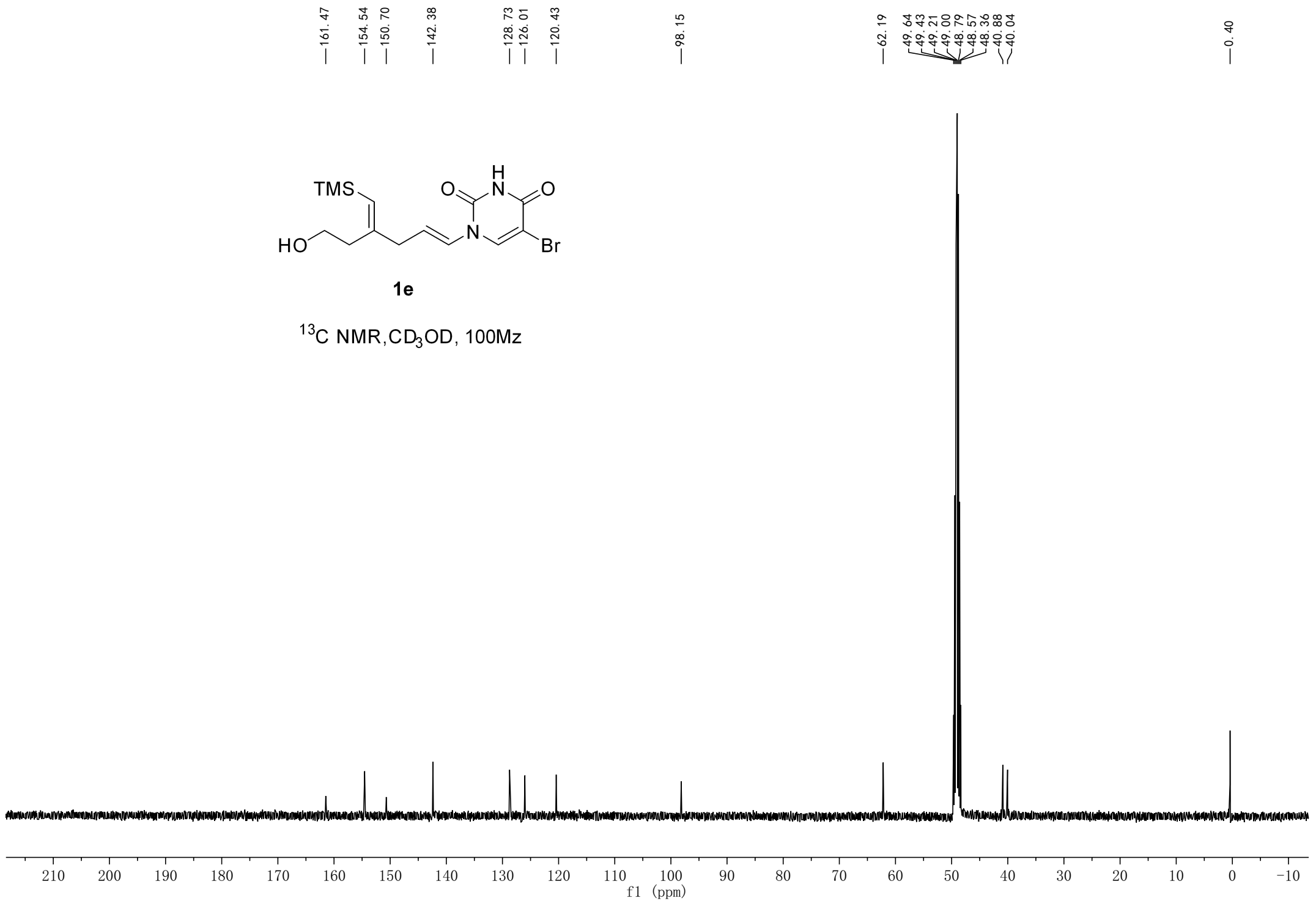
^{19}F NMR, CD_3OD, 376 Mz

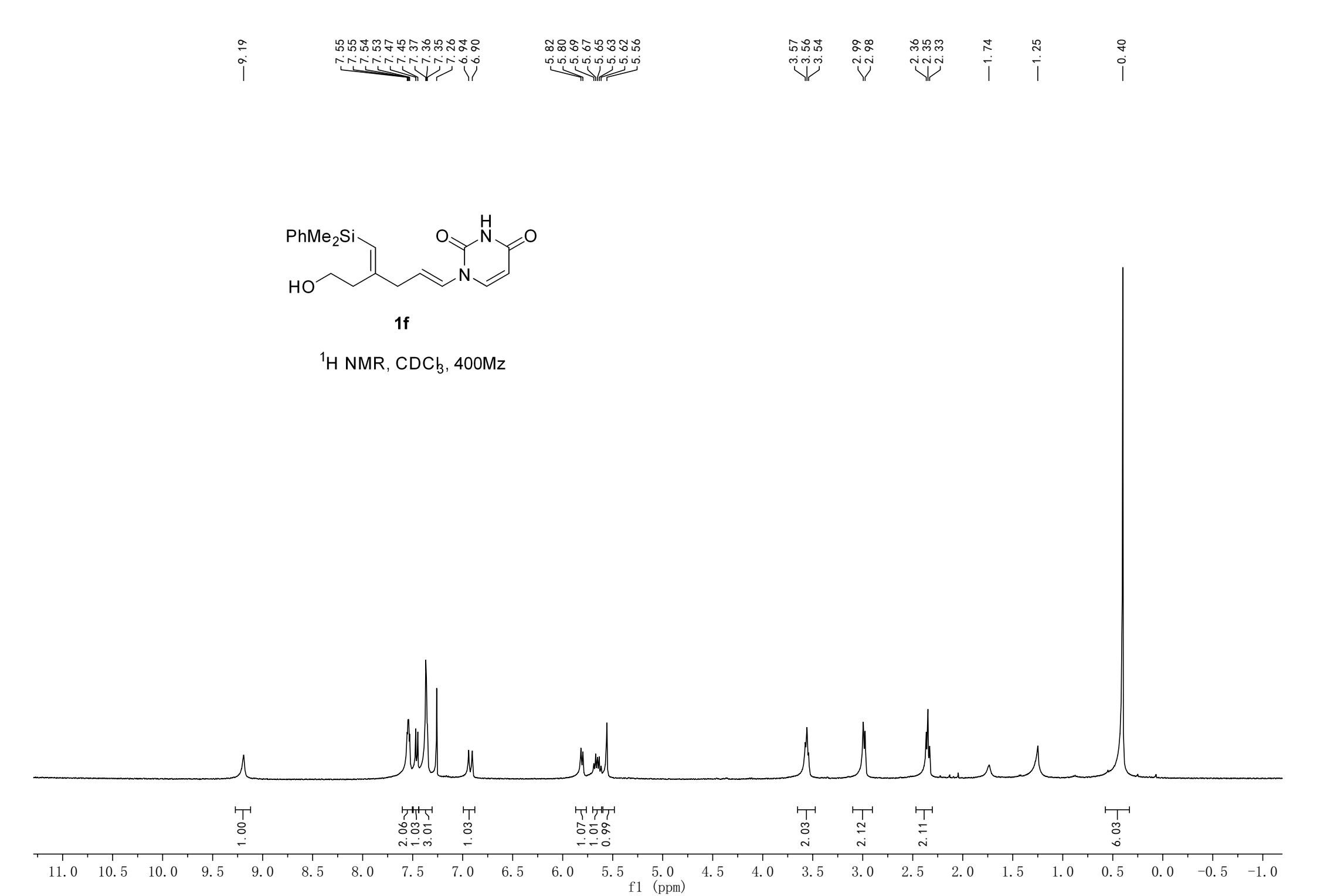


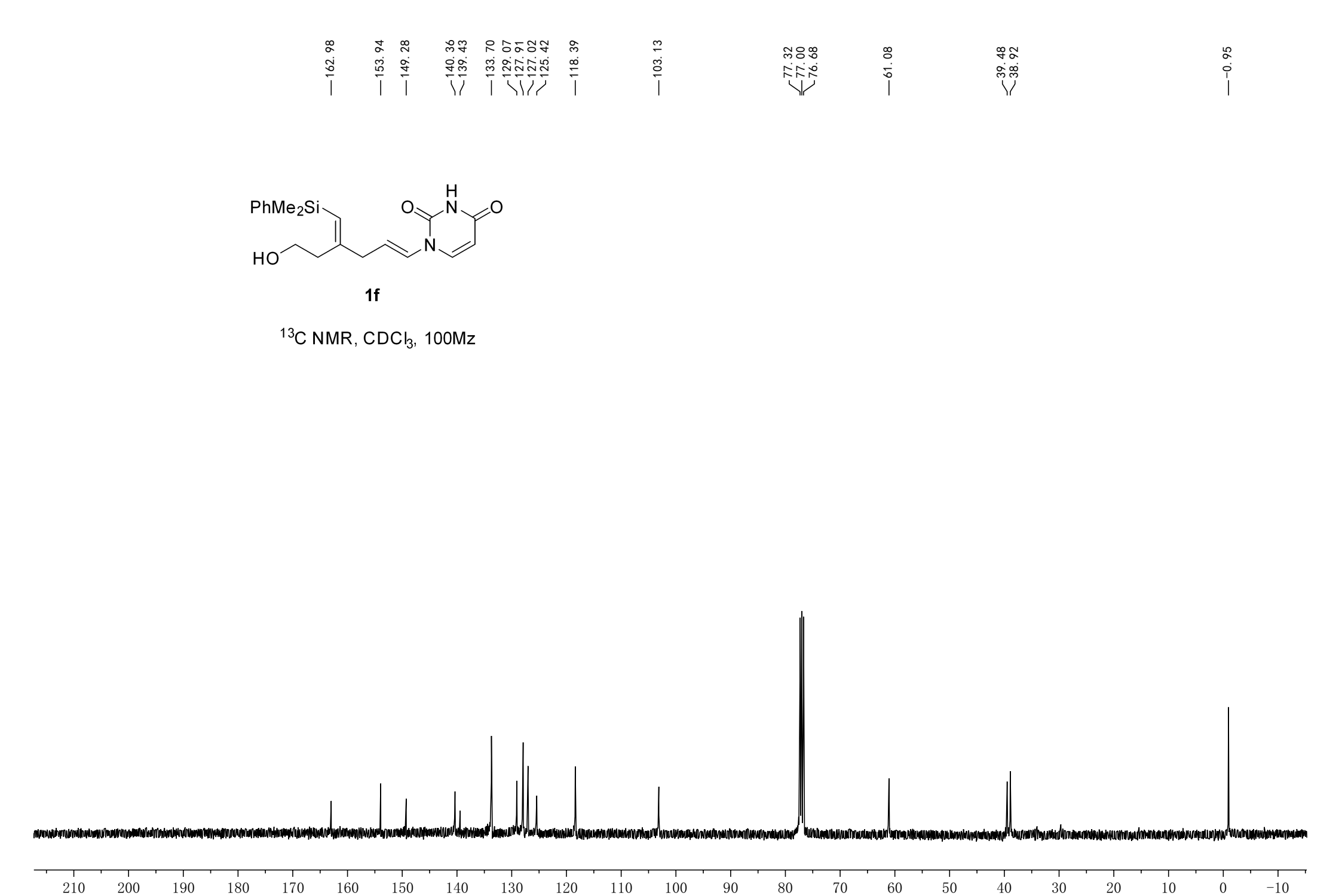

8.63
7.69
7.26
6.89
6.86
5.71
5.69
5.68
5.67
5.65
5.43
3.76
3.74
3.73
3.49
2.98
2.96
2.47
2.45
2.44
0.14
TMS
HO
O
H
N
O
N
Cl
1d
1H NMR, CDCl3, 500Mz
1.01
0.96
0.96
0.99
1.07
2.13
0.74
2.00
1.98
9.00
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

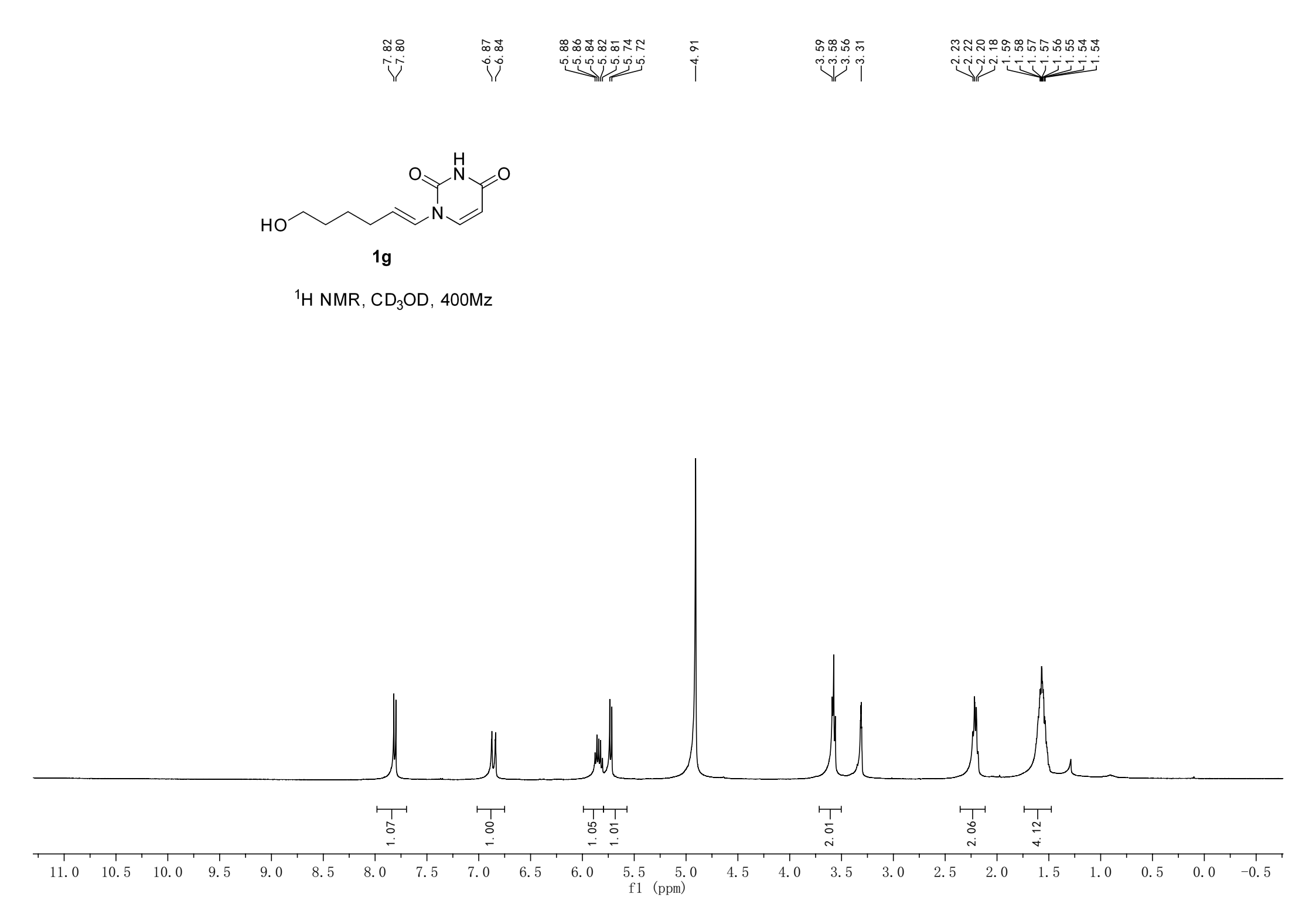

206.22
159.37
155.31
149.43
138.74
127.35
125.54
118.62
109.71
61.93
40.66
40.06
30.30
30.15
29.99
29.84
29.69
29.53
29.38
0.48
TMS
HO
O
H
N
O
N
Cl
1d
13C NMR, Acetone, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
f1 (ppm)

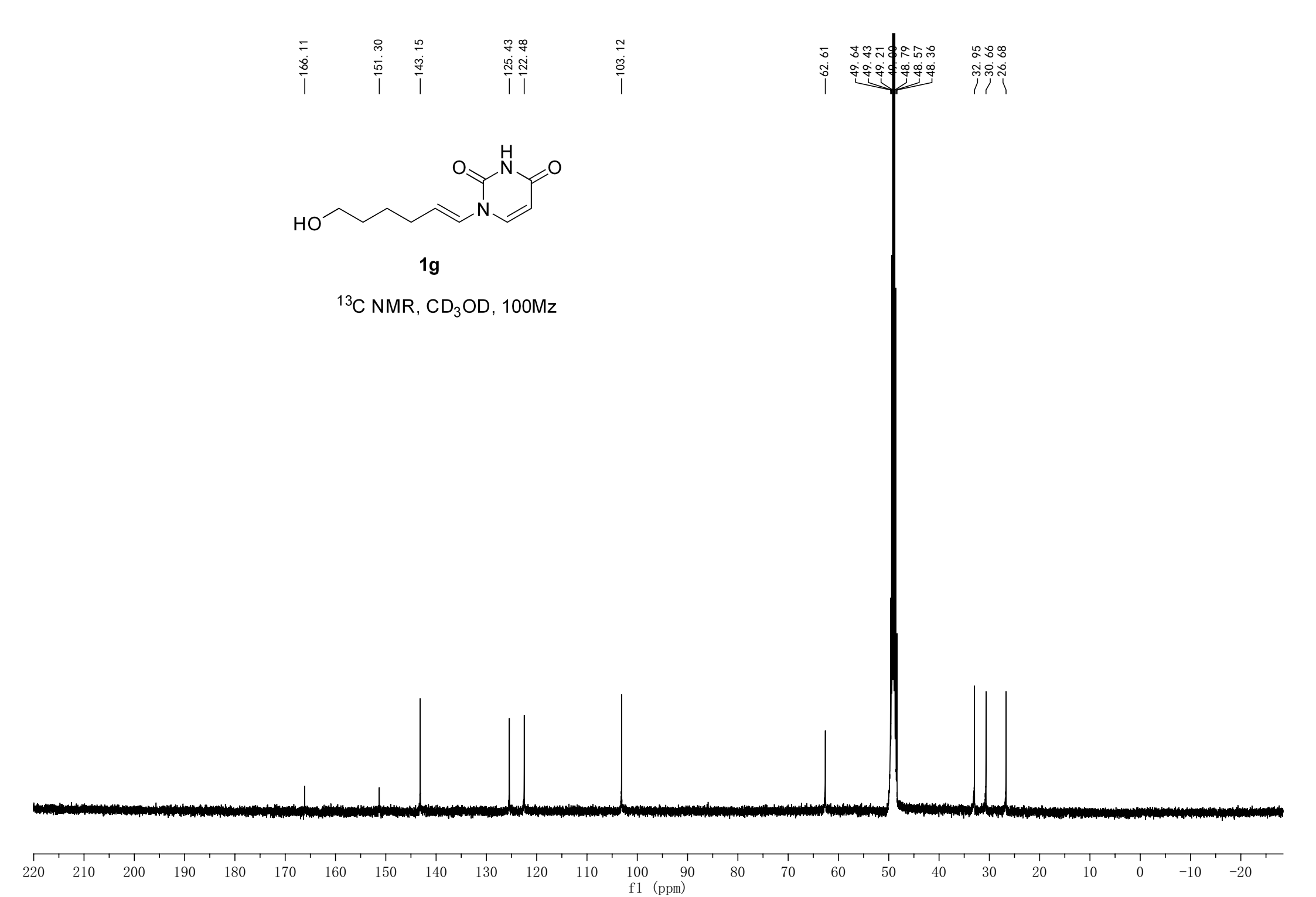

8.98
7.50
7.26
5.89
5.87
5.66
4.16
4.13
4.12
4.11
4.10
4.08
3.88
3.87
3.85
3.85
3.84
3.82
3.81
3.17
3.16
3.13
3.12
3.07
3.05
3.04
3.01
2.79
2.78
2.77
2.75
2.74
2.73
2.71
2.50
2.46
0.14
TMS
HO
O
H
N
O
N
Br
1e
1H NMR, CDCl3, 400Mz
1.03
1.03
1.02
1.01
1.94
1.08
1.11
0.97
1.09
1.04
9.00
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

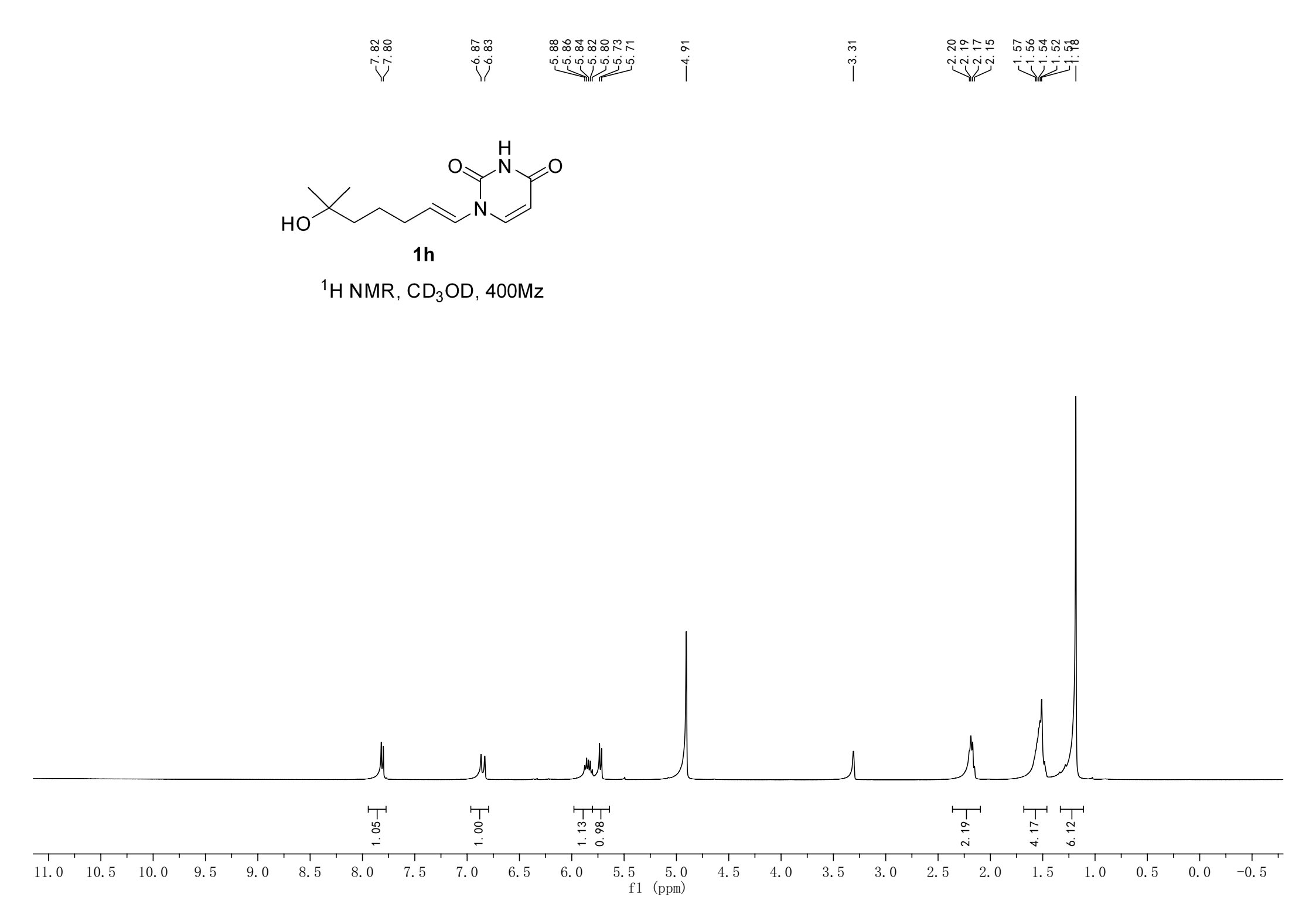

161.47
154.54
150.70
142.38
128.73
126.01
120.43
98.15
62.19
49.64
49.43
49.21
49.00
48.79
48.57
48.36
40.88
40.04
0.40
TMS
HO
O
H
N
O
N
Br
1e
13C NMR,CD3OD, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

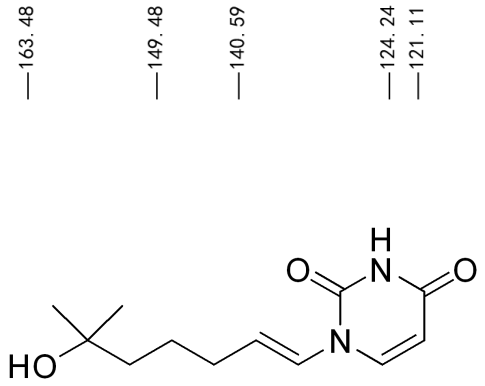

9.19
7.55
7.55
7.54
7.53
7.47
7.45
7.37
7.36
7.35
7.26
6.94
6.90
5.82
5.80
5.69
5.67
5.65
5.63
5.62
5.56
3.57
3.56
3.54
2.99
2.98
2.36
2.35
2.33
1.74
1.25
0.40
PhMe2Si
HO
O
H
N
O
N
1f
1H NMR, CDCl3, 400Mz
1.00
2.06
1.03
3.01
1.03
1.07
1.01
0.99
2.03
2.12
2.11
6.03
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
f1 (ppm)


162.98
153.94
149.28
140.36
139.43
133.70
129.07
127.91
127.02
125.42
118.39
103.13
77.32
77.00
76.68
61.08
39.48
38.92
0.95
PhMe2Si
HO
O
H
N
O
N
1f
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)


7.82
7.80
6.87
6.84
5.88
5.86
5.84
5.82
5.81
5.74
5.72
4.91
3.59
3.58
3.56
3.31
2.23
2.22
2.20
2.18
1.59
1.58
1.57
1.57
1.56
1.55
1.54
1.54
H
O
N
O
N
HO
1g
1H NMR, CD3OD, 400Mz
1.07
1.00
1.05
1.01
2.01
2.06
4.12
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

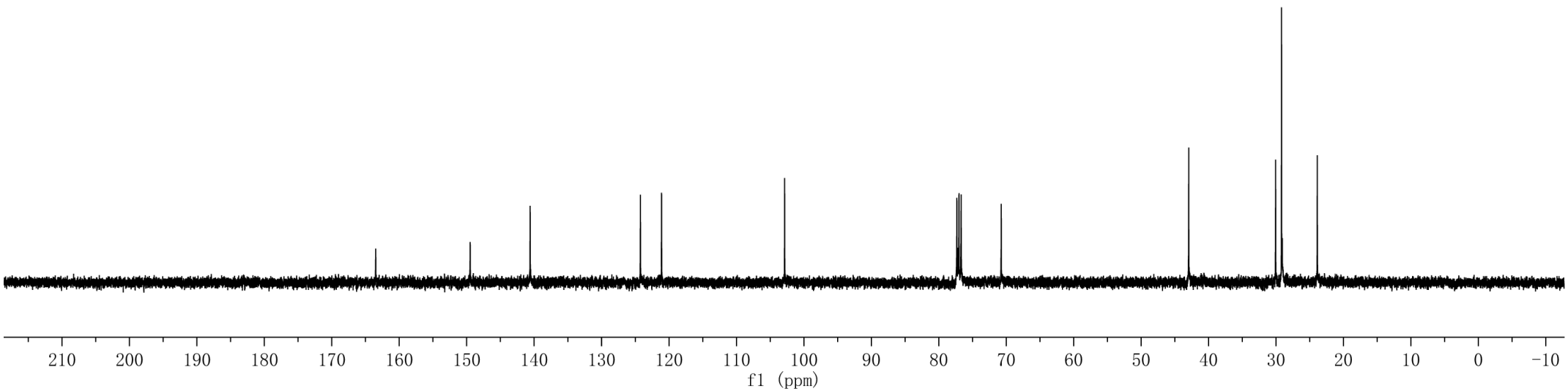

166.11
151.30
143.15
125.43
122.48
103.12
62.61
49.64
49.43
49.21
48.79
48.57
48.36
32.95
30.66
26.68
O
H
N
O
N
HO
1g
13C NMR, CD3OD, 100Mz
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20
f1 (ppm)

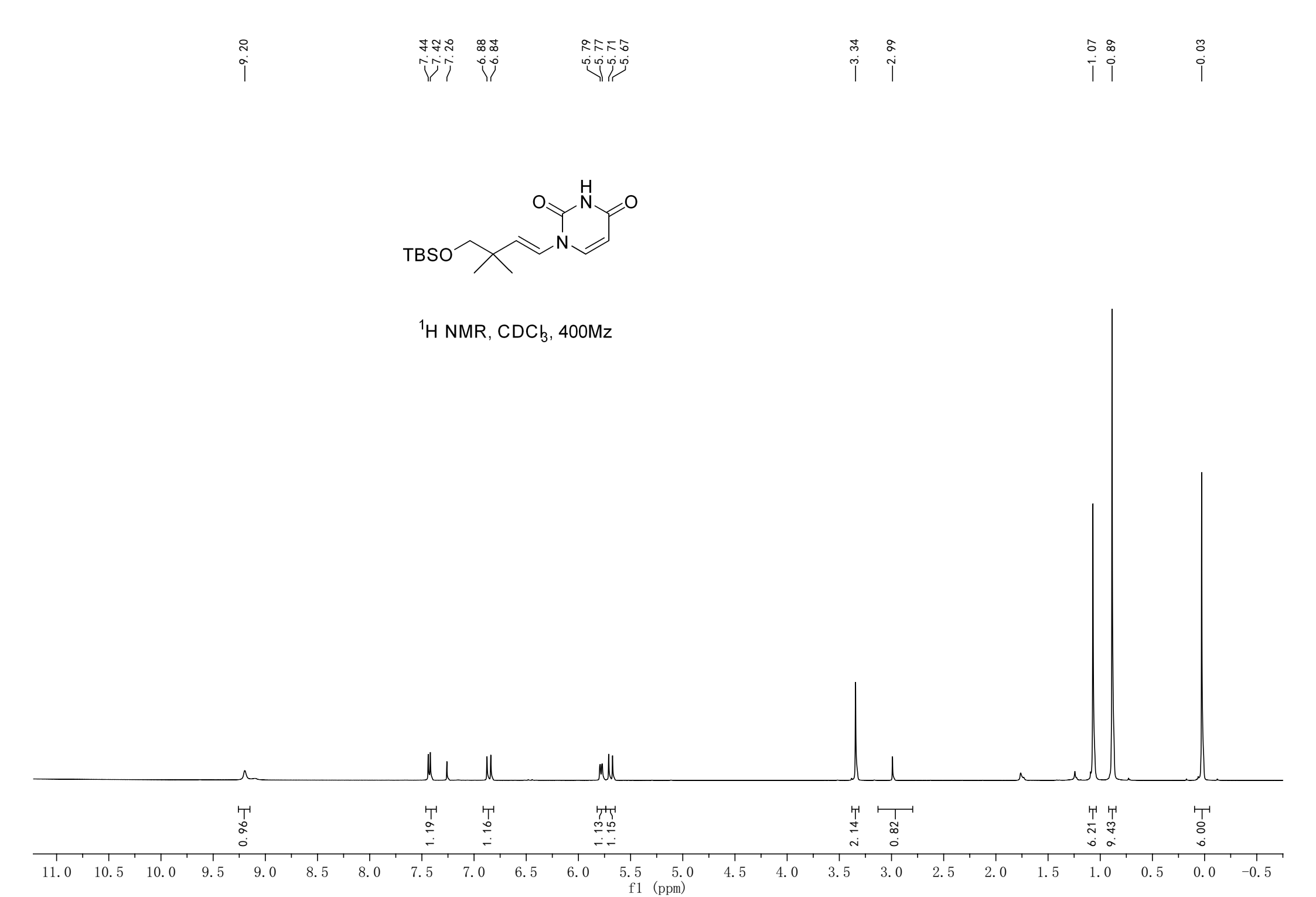

7.82
7.80
6.87
6.83
5.88
5.86
5.84
5.82
5.80
5.73
5.71
4.91
3.31
2.20
2.19
2.17
2.15
1.57
1.56
1.54
1.52
1.51
1.48
H
N
O
O
N
HO
1h
1H NMR, CD3OD, 400Mz
1.05
1.00
1.13
0.98
2.19
4.17
6.12
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

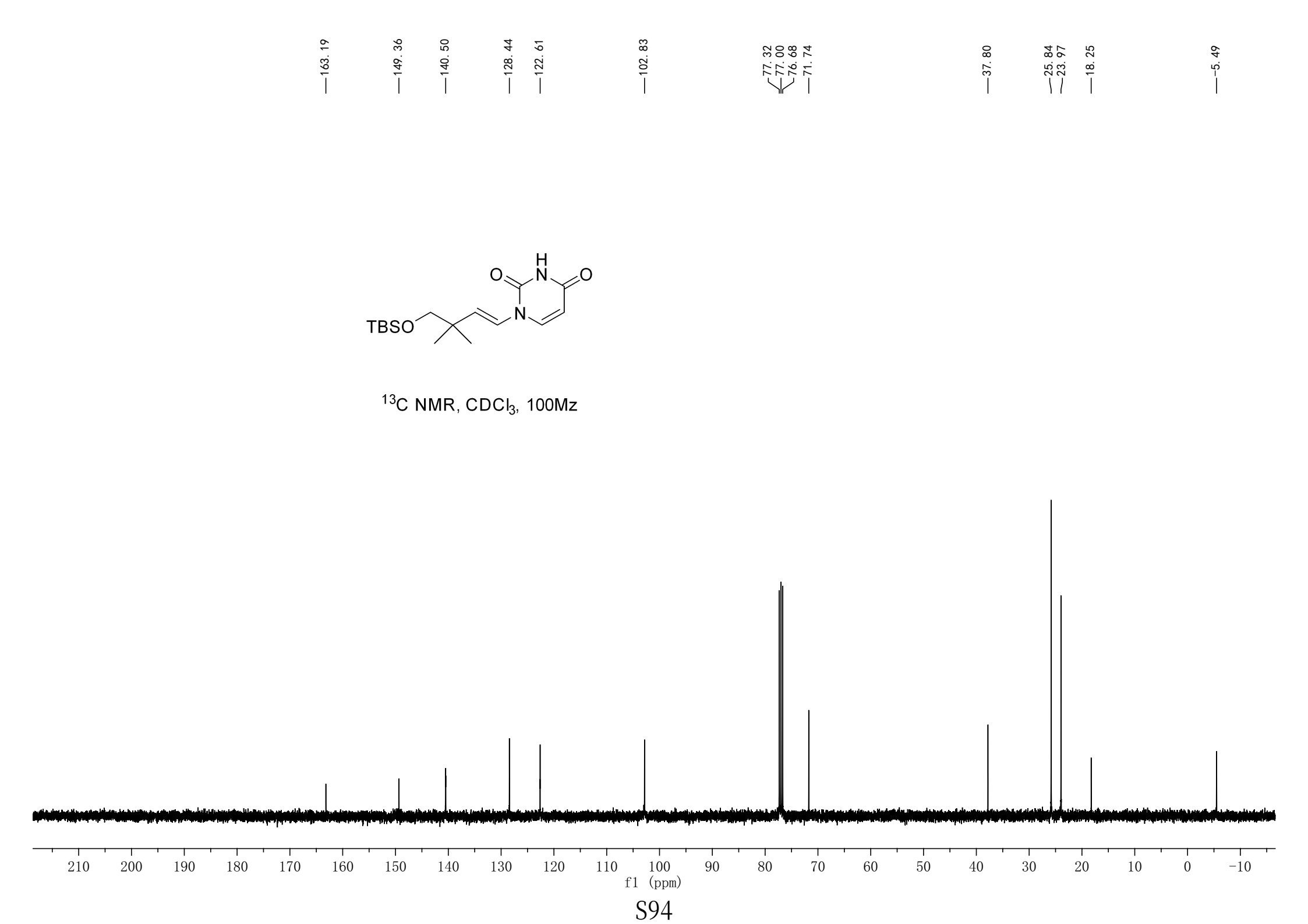


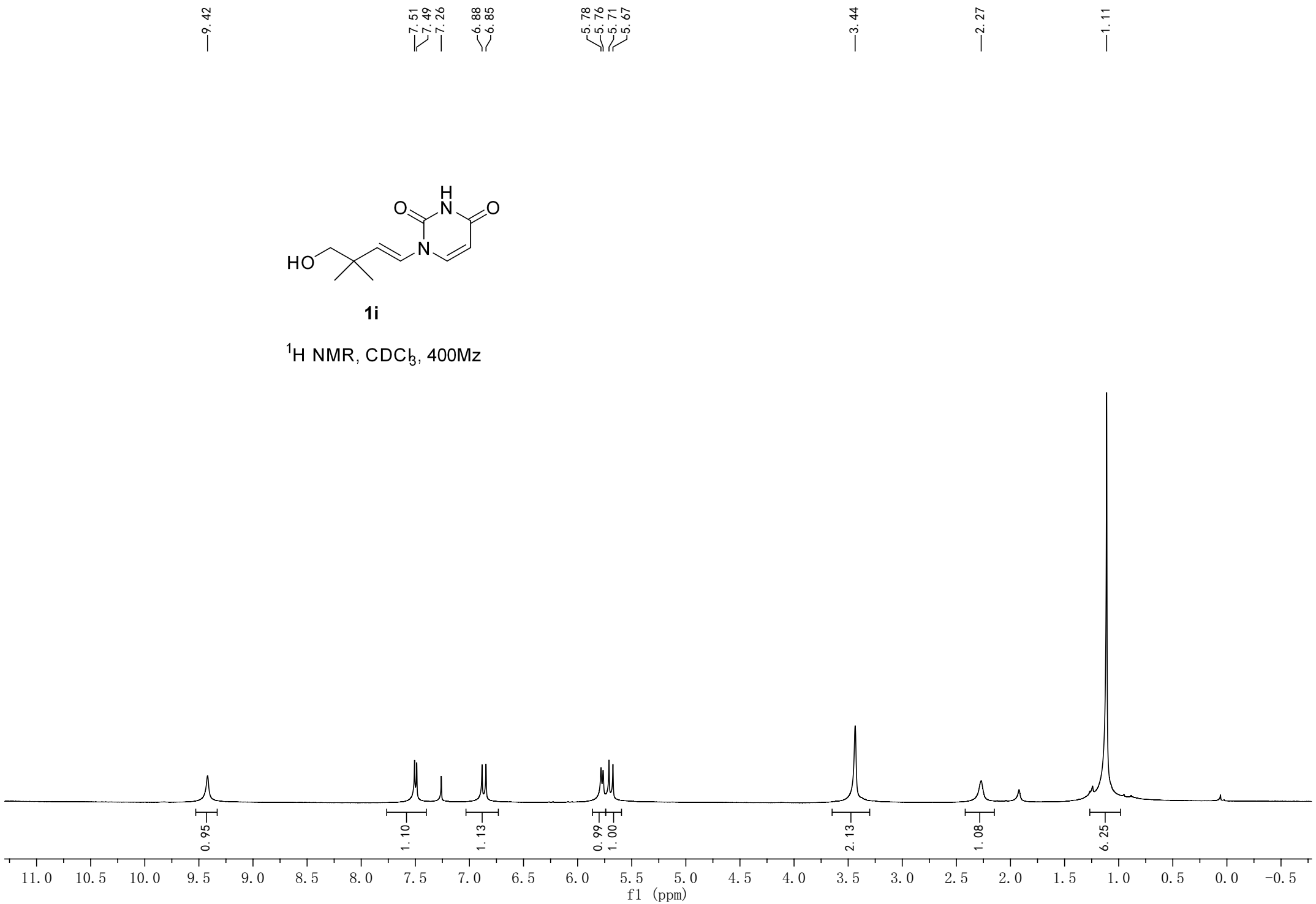
1h

^{13}C NMR, $CDCl_3$, 100Mz



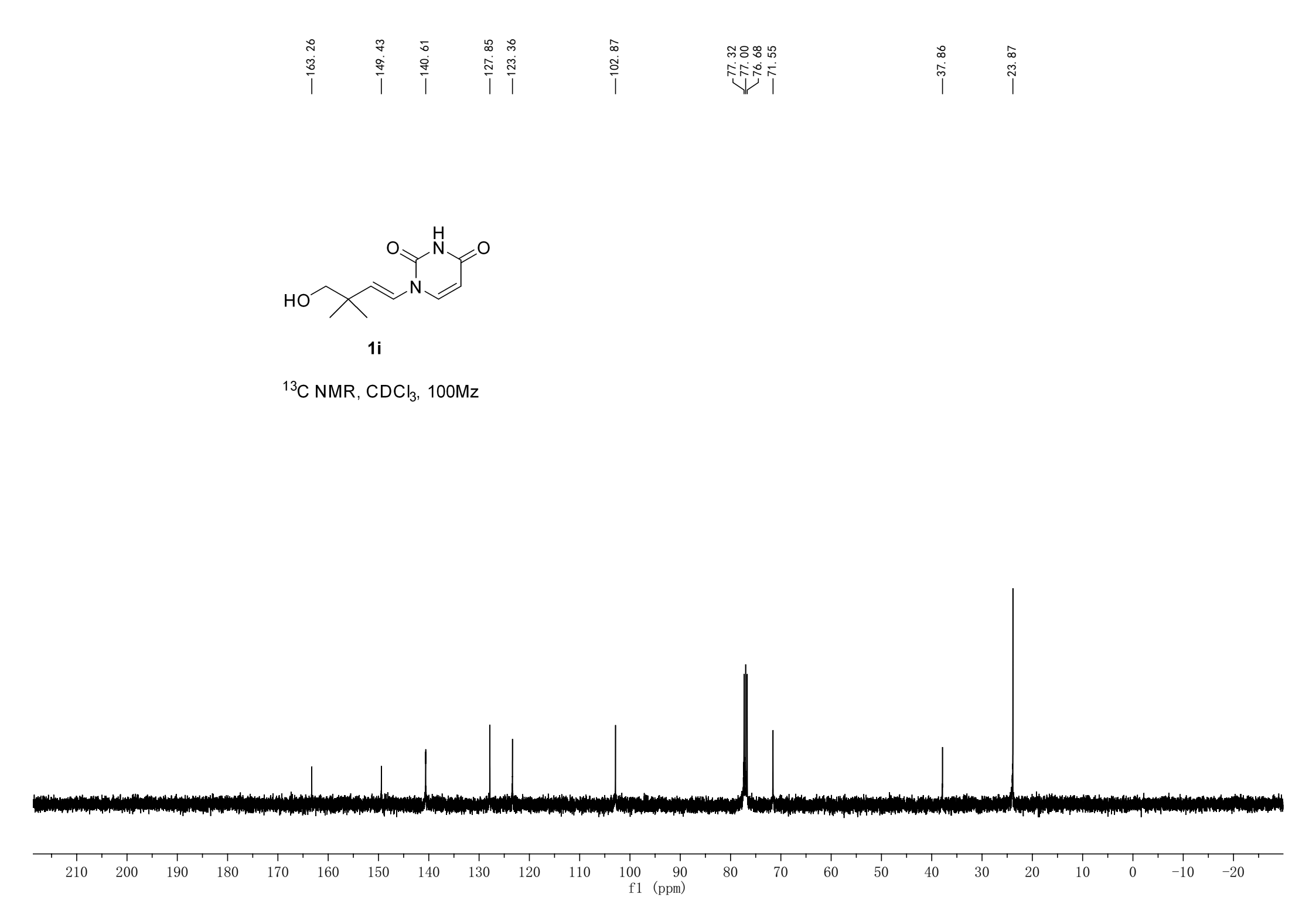

9.20
7.44
7.42
7.26
6.88
6.84
5.79
5.77
5.71
5.67
3.34
2.99
1.07
0.89
0.03
H
N
O
O
N
TBSO
1H NMR, CDCl3, 400Mz
0.96
1.19
1.16
1.13
1.15
2.14
0.82
6.21
9.43
6.00
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

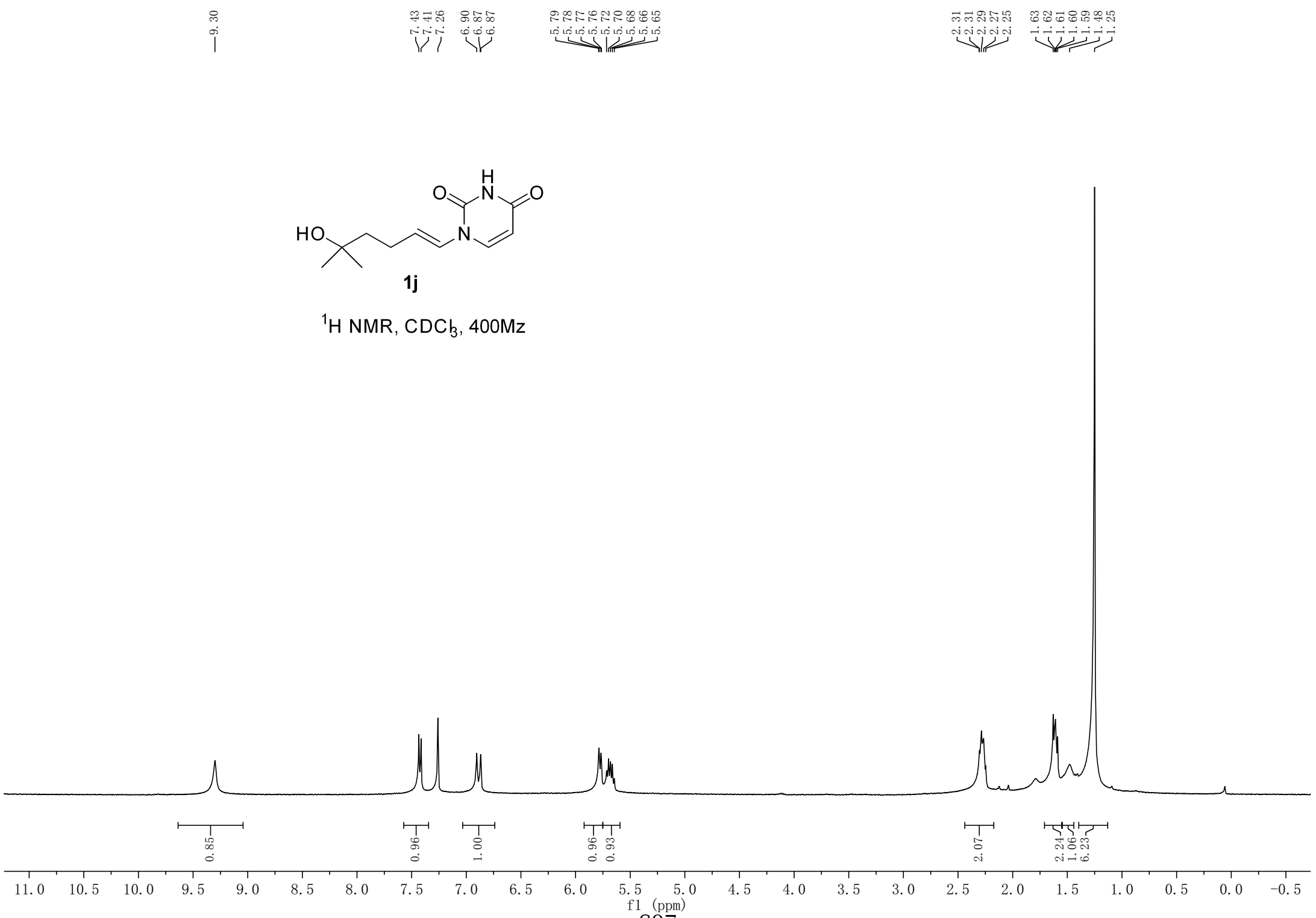

163.19
149.36
140.50
128.44
122.61
102.83
77.32
77.00
76.68
71.74
37.80
25.84
23.97
18.25
-5.49
H
N
O
O
N
TBSO
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

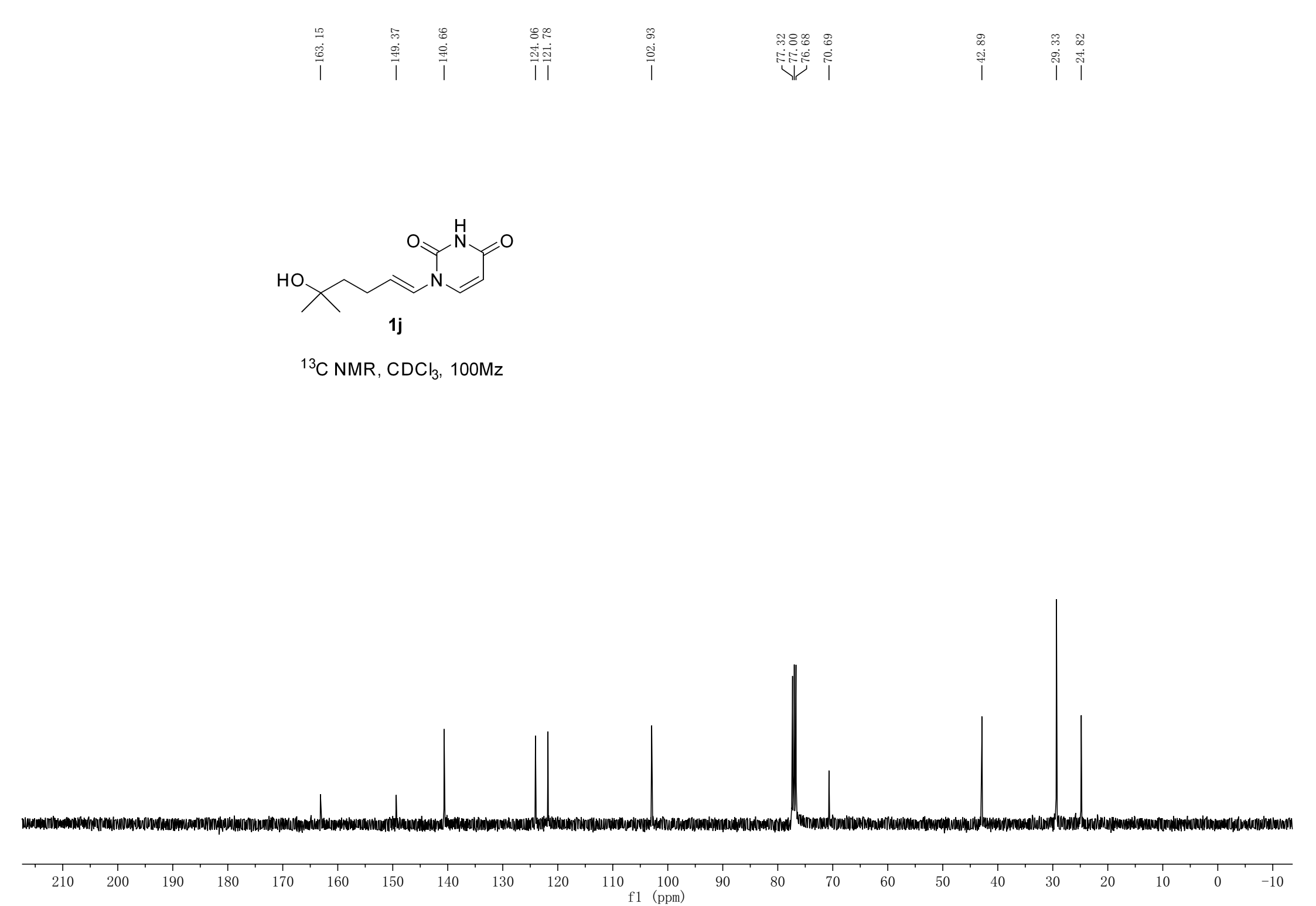


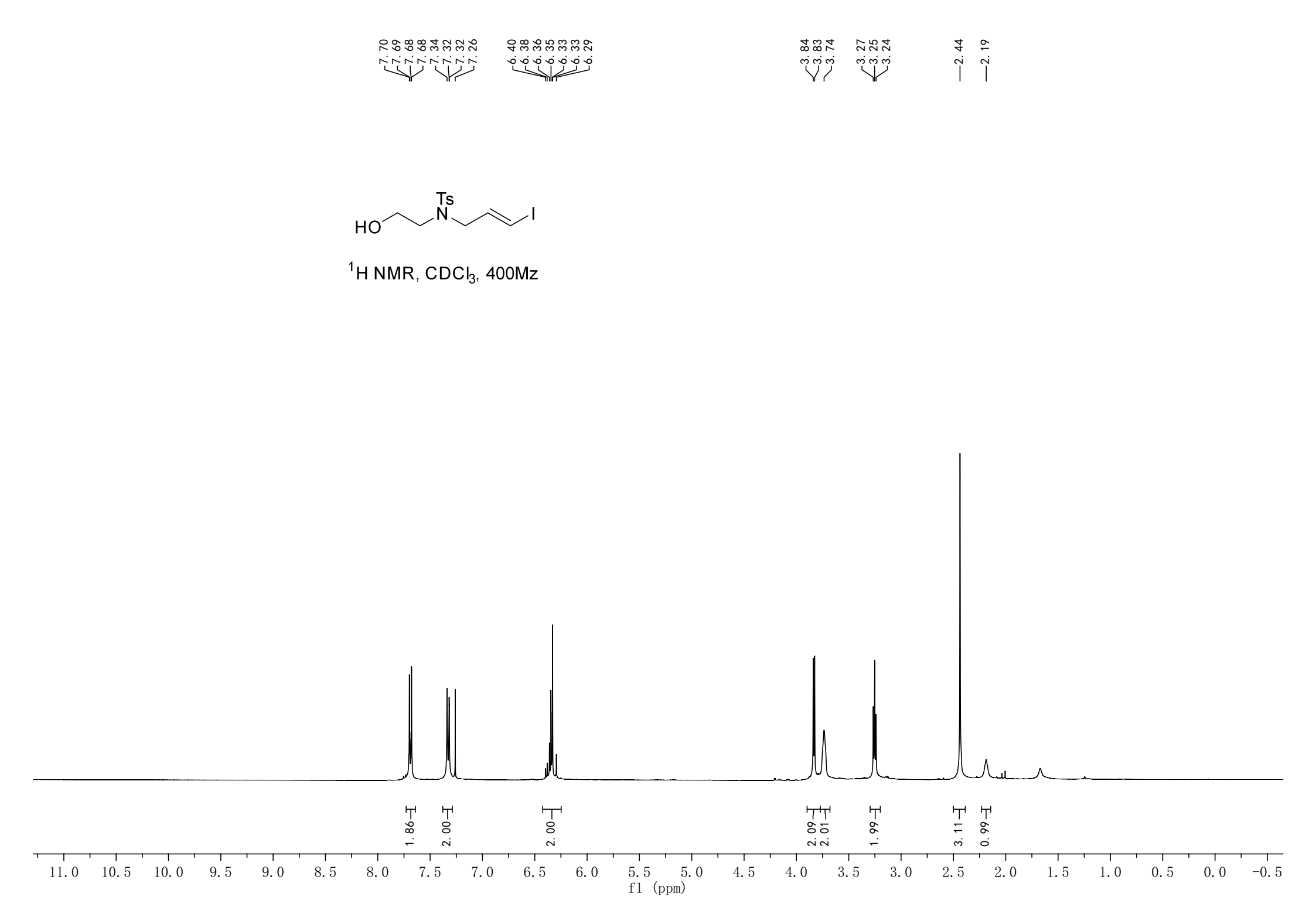
1i

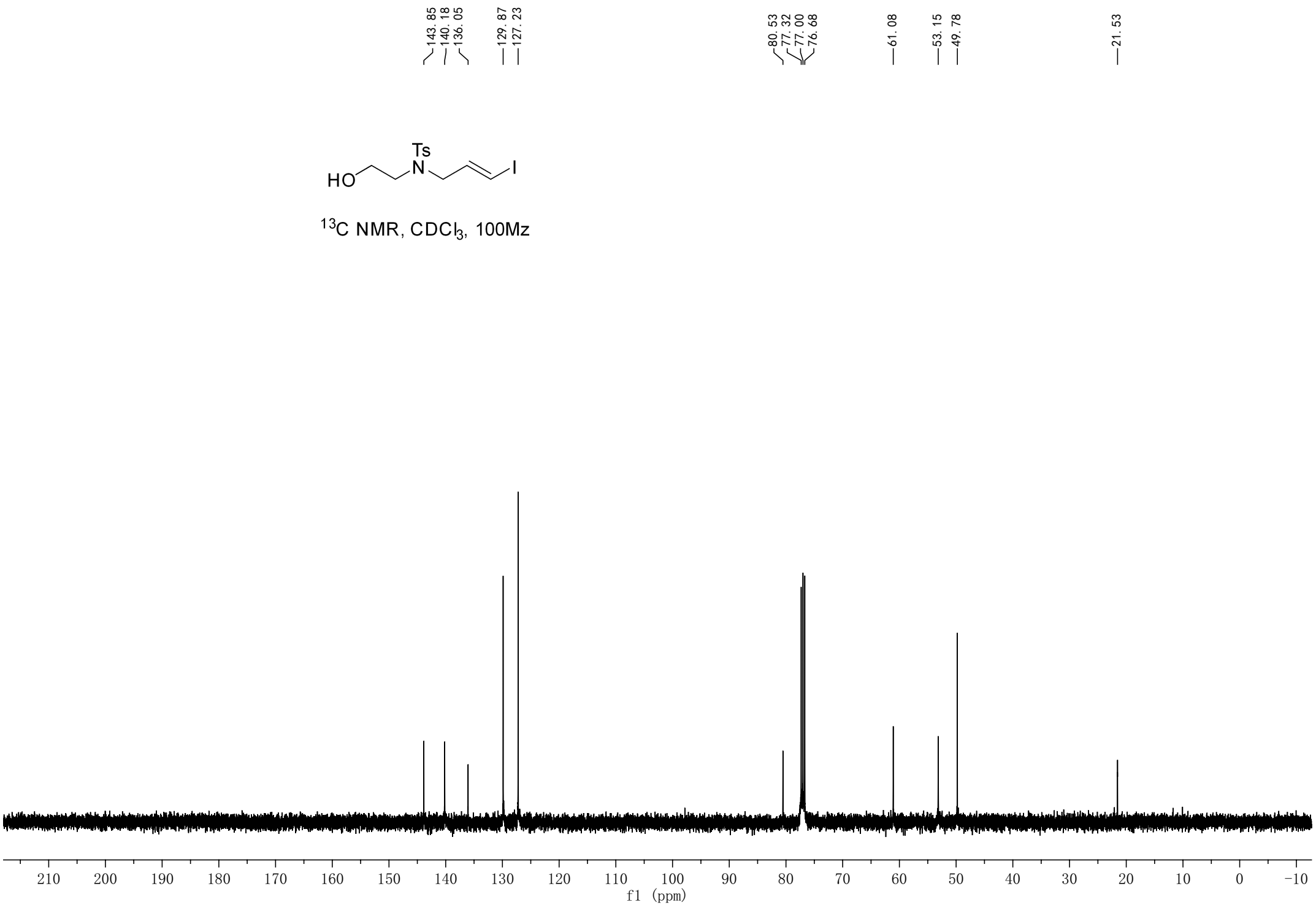
^{1}H NMR, $CDCl_3$, 400Mz

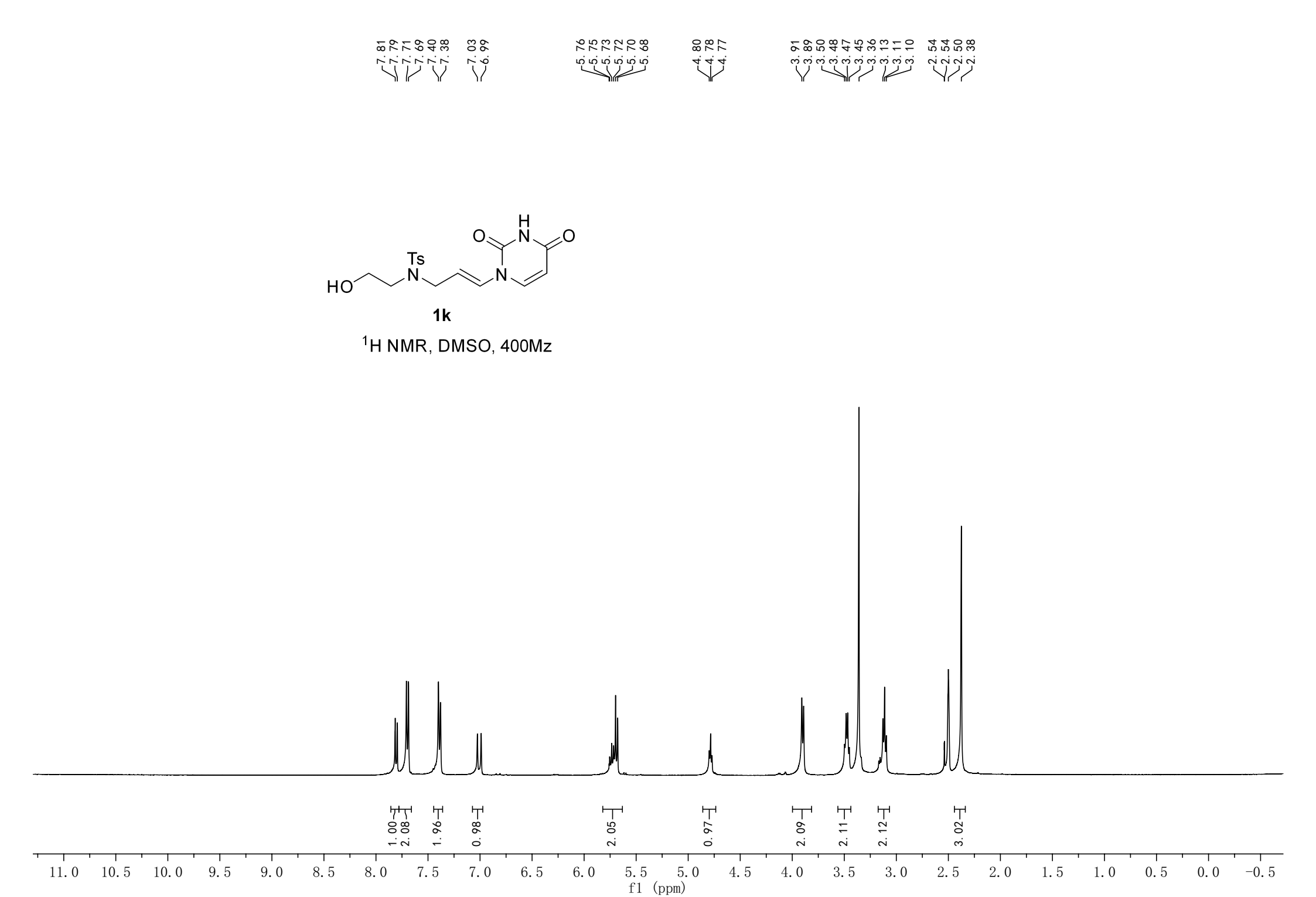

163.26
149.43
140.61
127.85
123.36
102.87
77.32
77.00
76.68
71.55
37.86
23.87
H
N
O
O
N
HO
1i
^{13}C NMR, $CDCl_3$, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
f1 (ppm)

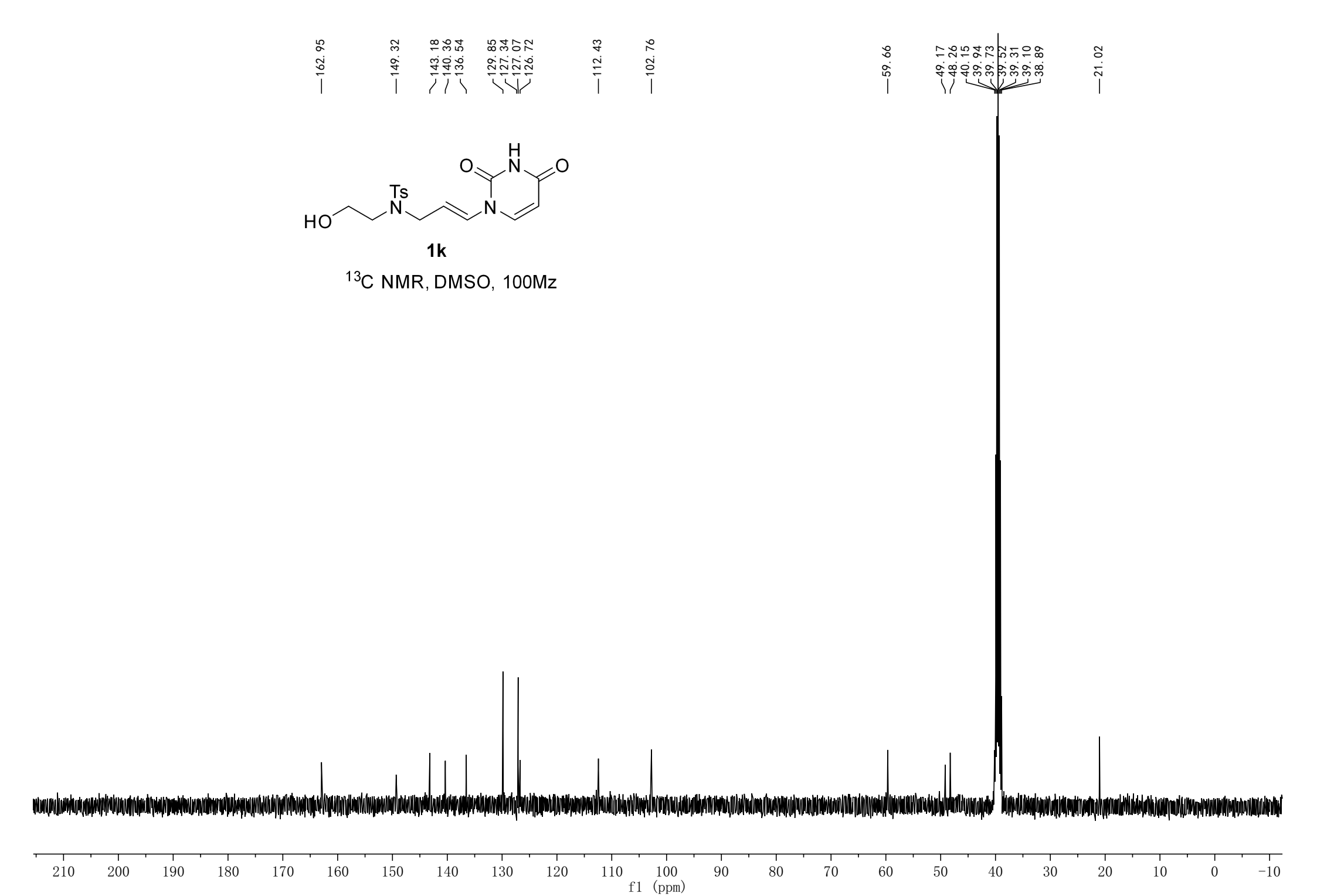

9.30
7.43
7.41
7.26
6.90
6.87
6.87
5.79
5.78
5.77
5.76
5.72
5.70
5.68
5.66
5.65
2.31
2.31
2.29
2.27
2.25
1.63
1.62
1.61
1.60
1.59
1.48
1.25
HO
O
N
H
O
N
1j
1H NMR, CDCl3, 400Mz
0.85
0.96
1.00
0.96
0.93
2.07
2.24
1.06
6.23
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

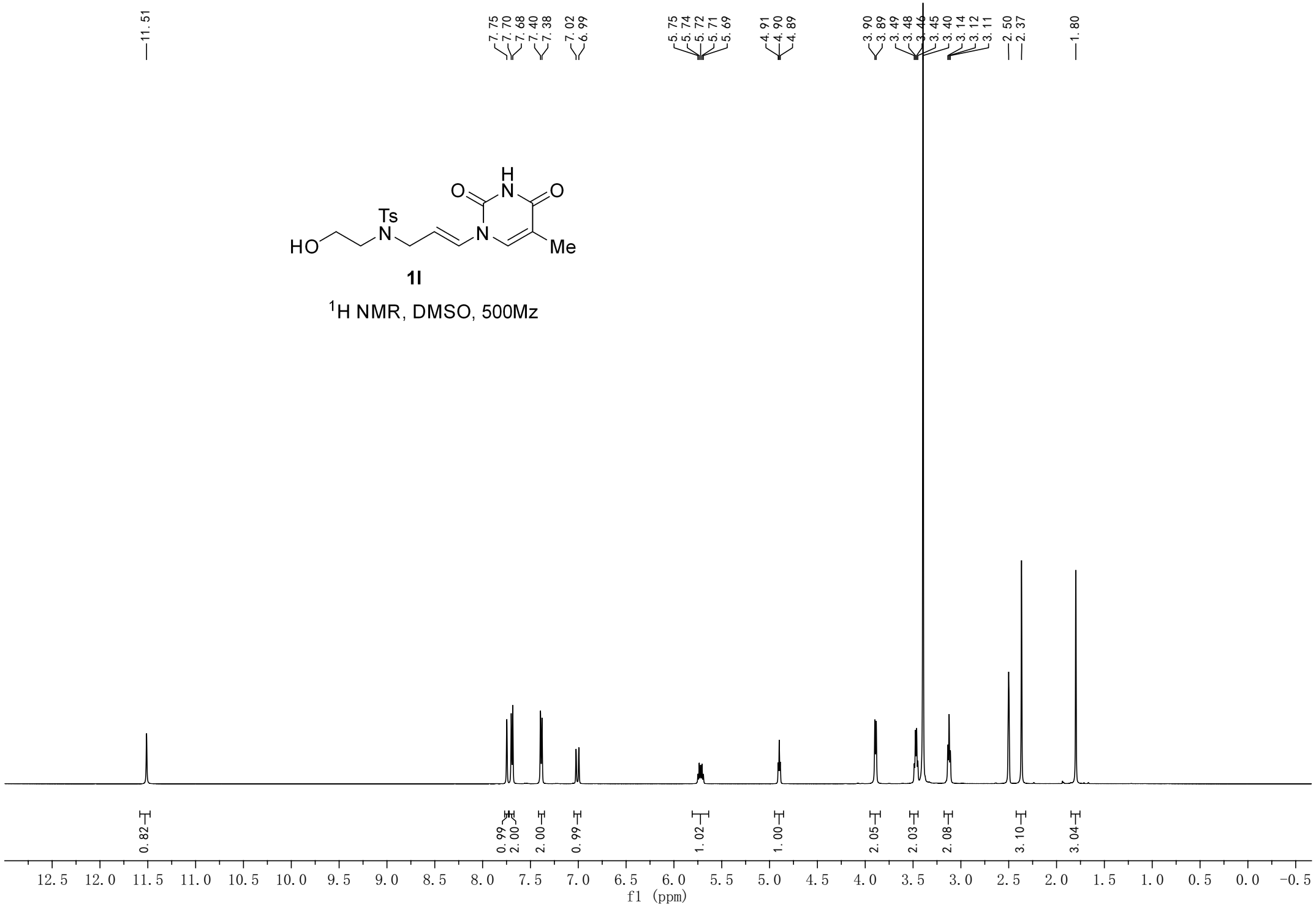

163.15
149.37
140.66
124.06
121.78
102.93
77.32
77.00
76.68
70.69
42.89
29.33
24.82
HO
O
N
H
O
N
1j
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

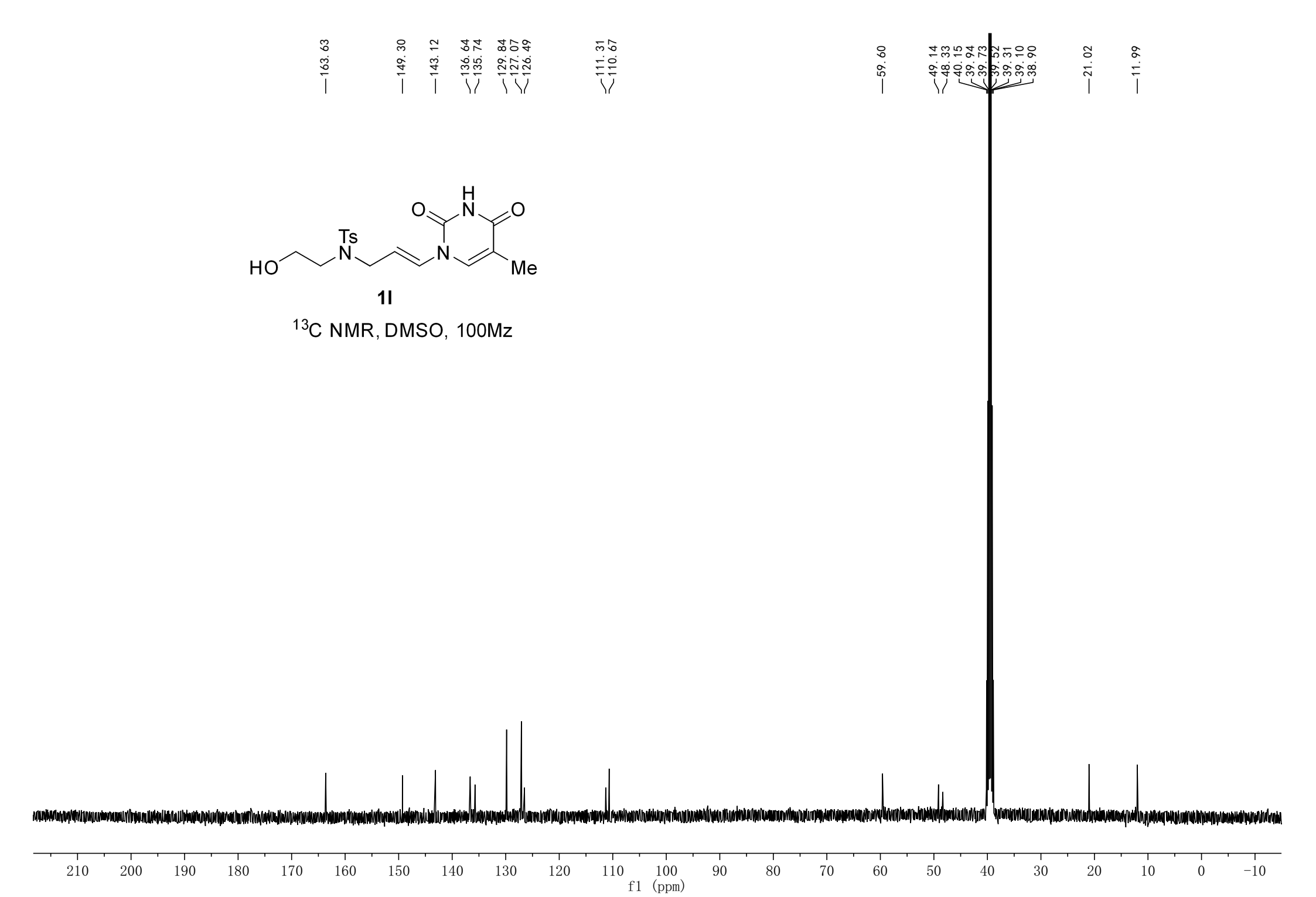

7.70
7.69
7.68
7.68
7.34
7.32
7.32
7.26
6.40
6.38
6.36
6.35
6.33
6.33
6.29
3.84
3.83
3.74
3.27
3.25
3.24
2.44
2.19
Ts
N
HO
I
1H NMR, CDCl3, 400Mz
1.86
2.00
2.00
2.09
2.01
1.99
3.11
0.99
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

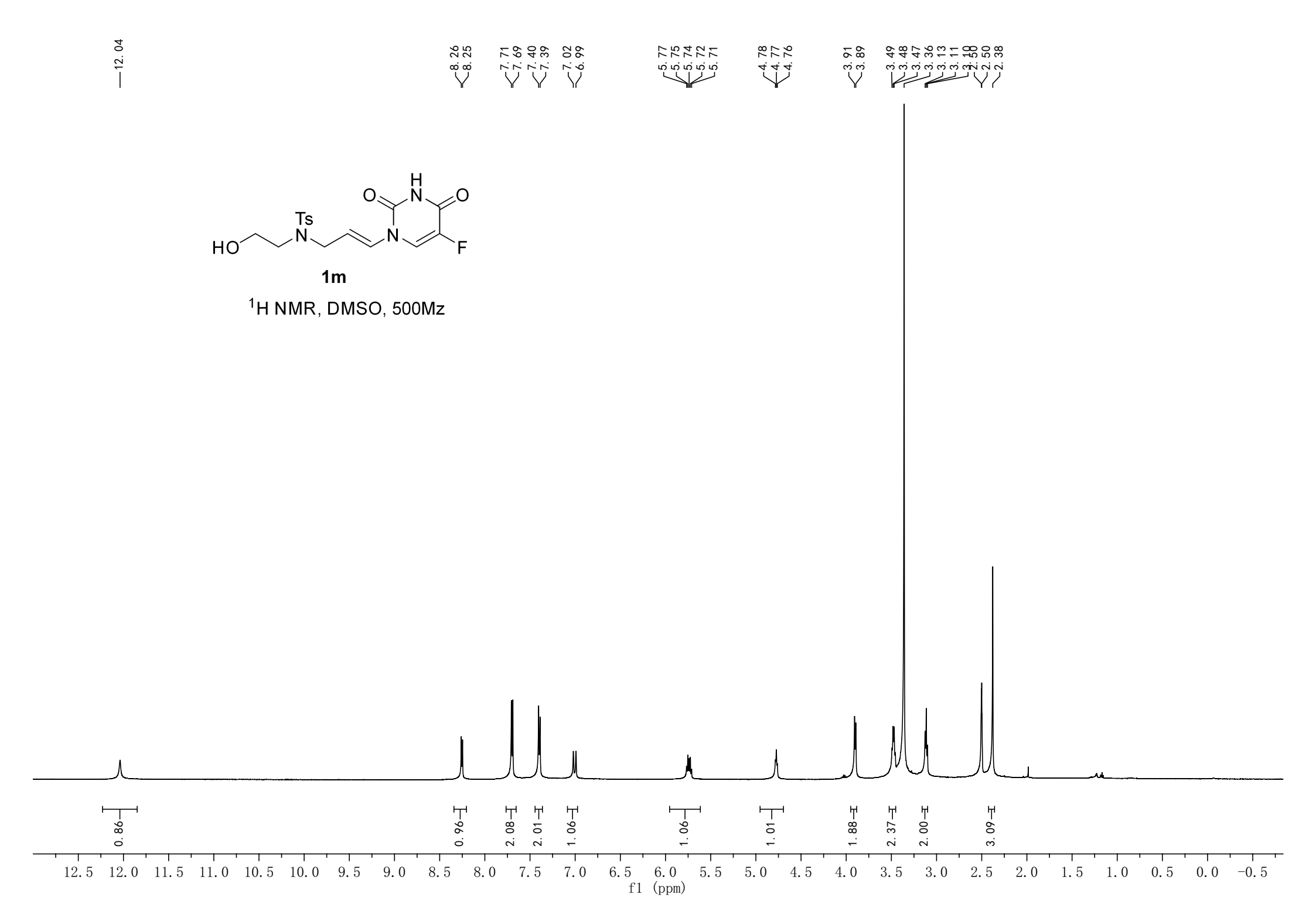

143.85
140.18
136.05
129.87
127.23
80.53
77.32
77.00
76.68
61.08
53.15
49.78
21.53
Ts
N
HO
I
^{13}C NMR, $CDCl_3$, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

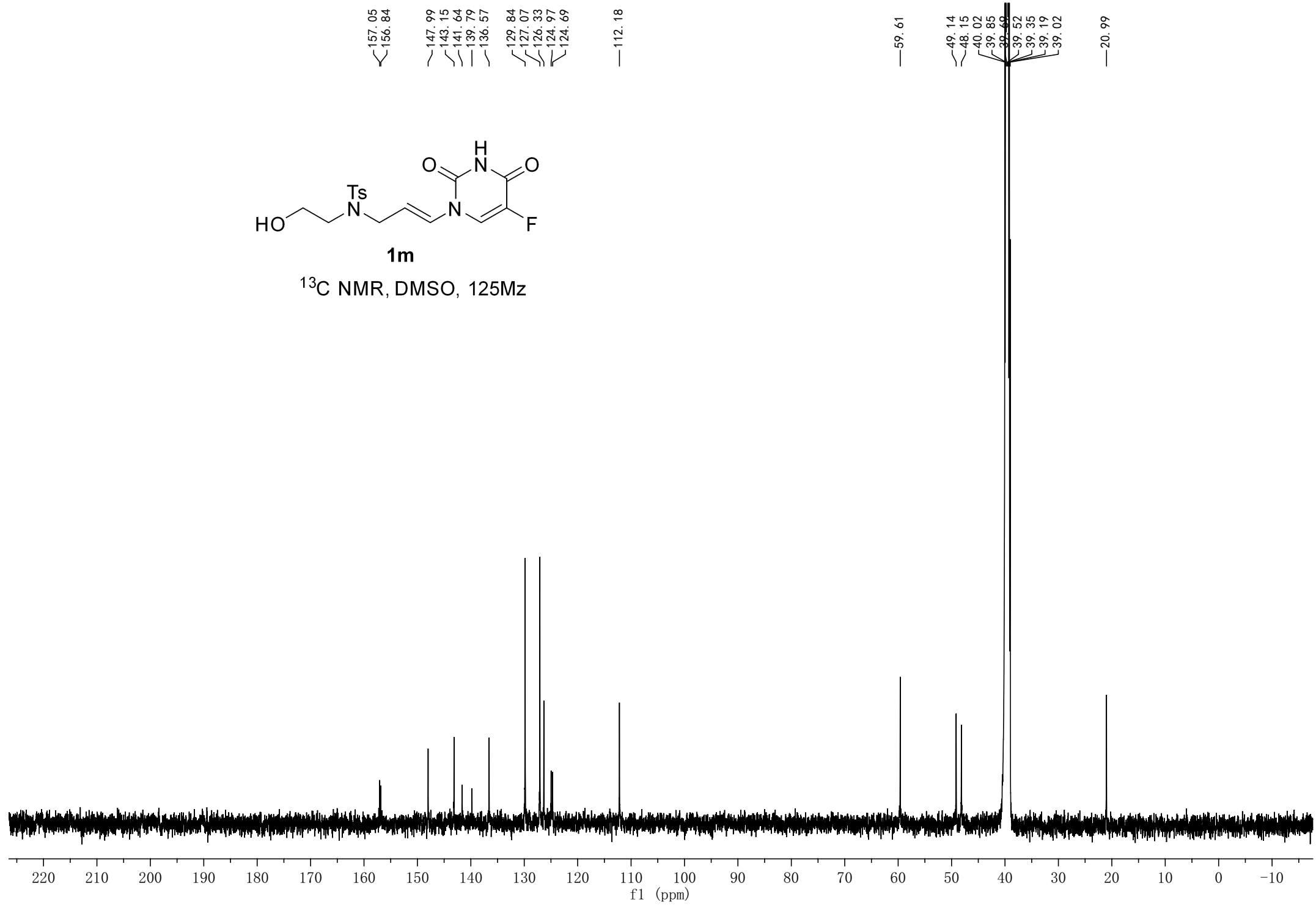

7.81
7.79
7.71
7.69
7.40
7.38
7.03
6.99
5.76
5.75
5.73
5.72
5.70
5.68
4.80
4.78
4.77
3.91
3.89
3.50
3.48
3.47
3.45
3.36
3.13
3.11
3.10
2.54
2.54
2.50
2.38
H
N
O
O
Ts
N
N
HO
1k
1H NMR, DMSO, 400Mz
1.00
2.08
1.96
0.98
2.05
0.97
2.09
2.11
2.12
3.02
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

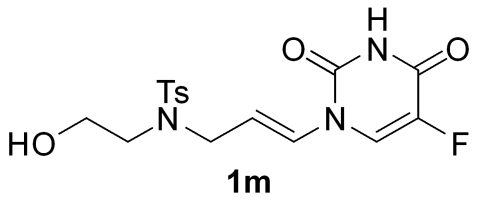

162.95
149.32
143.18
140.36
136.54
129.85
127.34
127.07
126.72
112.43
102.76
59.66
49.17
48.26
40.15
39.94
39.73
39.52
39.31
39.10
38.89
21.02
H
N
O
O
Ts
N
N
HO
1k
13C NMR, DMSO, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)


11.51
7.75
7.70
7.68
7.40
7.38
7.02
6.99
5.75
5.74
5.72
5.71
5.69
4.91
4.90
4.89
3.90
3.89
3.49
3.48
3.46
3.45
3.40
3.14
3.12
3.11
2.50
2.37
1.80
H
N
O
O
Ts
N
N
HO
Me
1I
1H NMR, DMSO, 500Mz
0.82
0.99
2.00
2.00
0.99
1.02
1.00
2.05
2.03
2.08
3.10
3.04
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


163.63
149.30
143.12
136.64
135.74
129.84
127.07
126.49
111.31
110.67
59.60
49.14
48.33
40.15
39.94
39.73
39.52
39.31
39.10
38.90
21.02
11.99
H
N
O
O
Ts
N
N
HO
Me
1l
13C NMR, DMSO, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

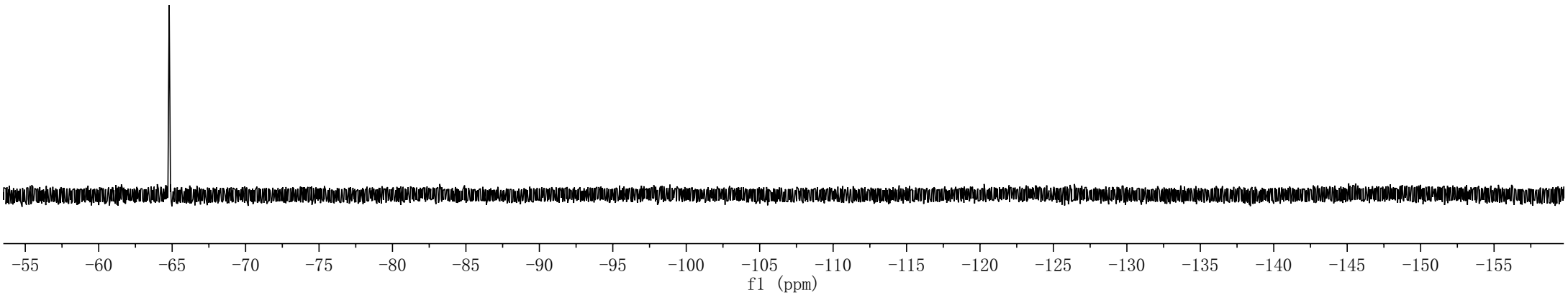

12.04
8.26
8.25
7.71
7.69
7.40
7.39
7.02
6.99
5.77
5.75
5.74
5.72
5.71
4.78
4.77
4.76
3.91
3.89
3.49
3.48
3.47
3.36
3.13
3.11
2.50
2.38
Ts
HO
F
1m
1H NMR, DMSO, 500Mz
0.86
0.96
2.08
2.01
1.06
1.06
1.01
1.88
2.37
2.00
3.09
f1 (ppm)

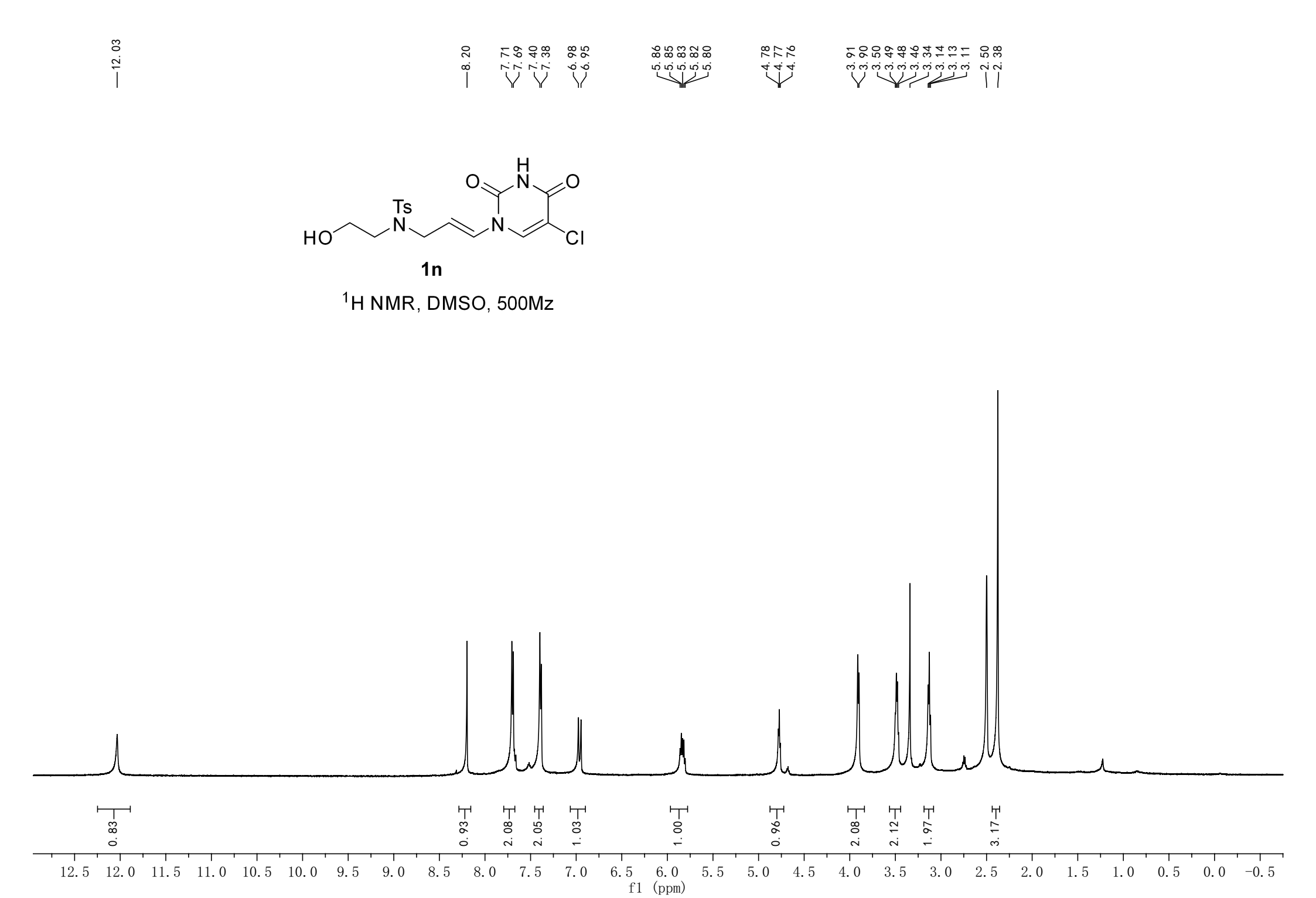

157.05
156.84
147.99
143.15
141.64
139.79
136.57
129.84
127.07
126.33
124.97
124.69
112.18
59.61
49.14
48.15
40.02
39.85
39.69
39.52
39.35
39.19
39.02
20.99
H
N
O
O
Ts
N
N
HO
F
1m
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

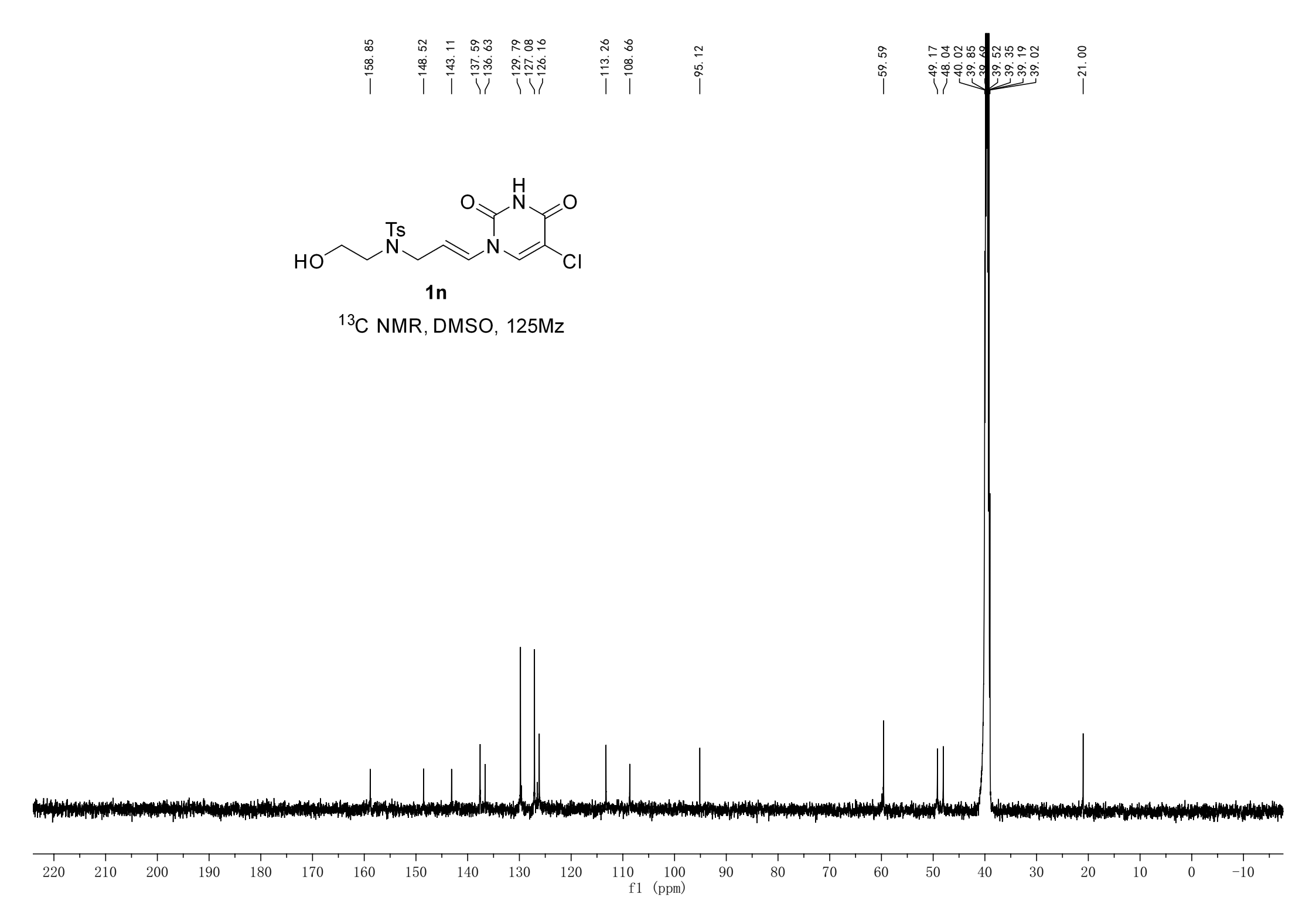


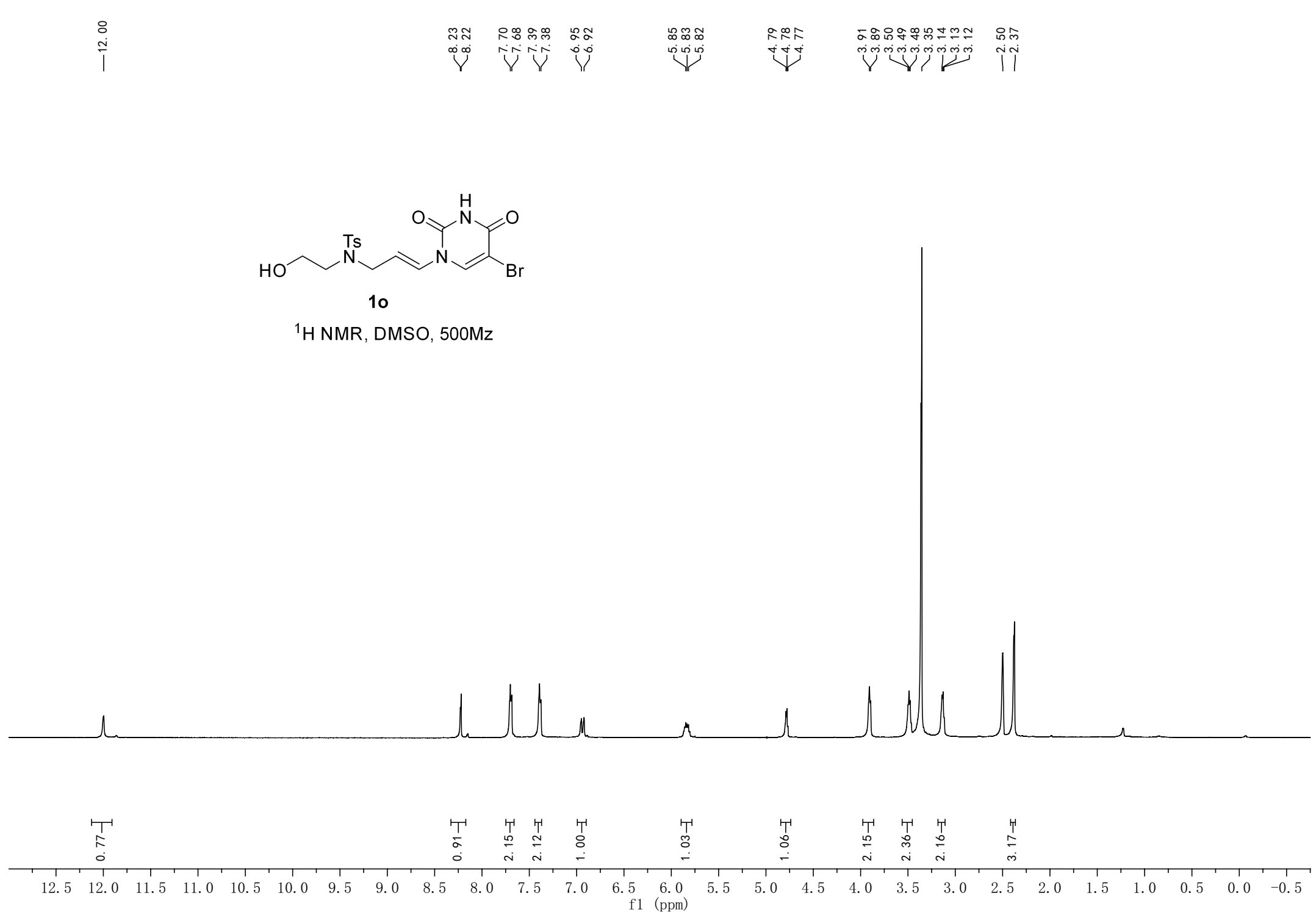
1m

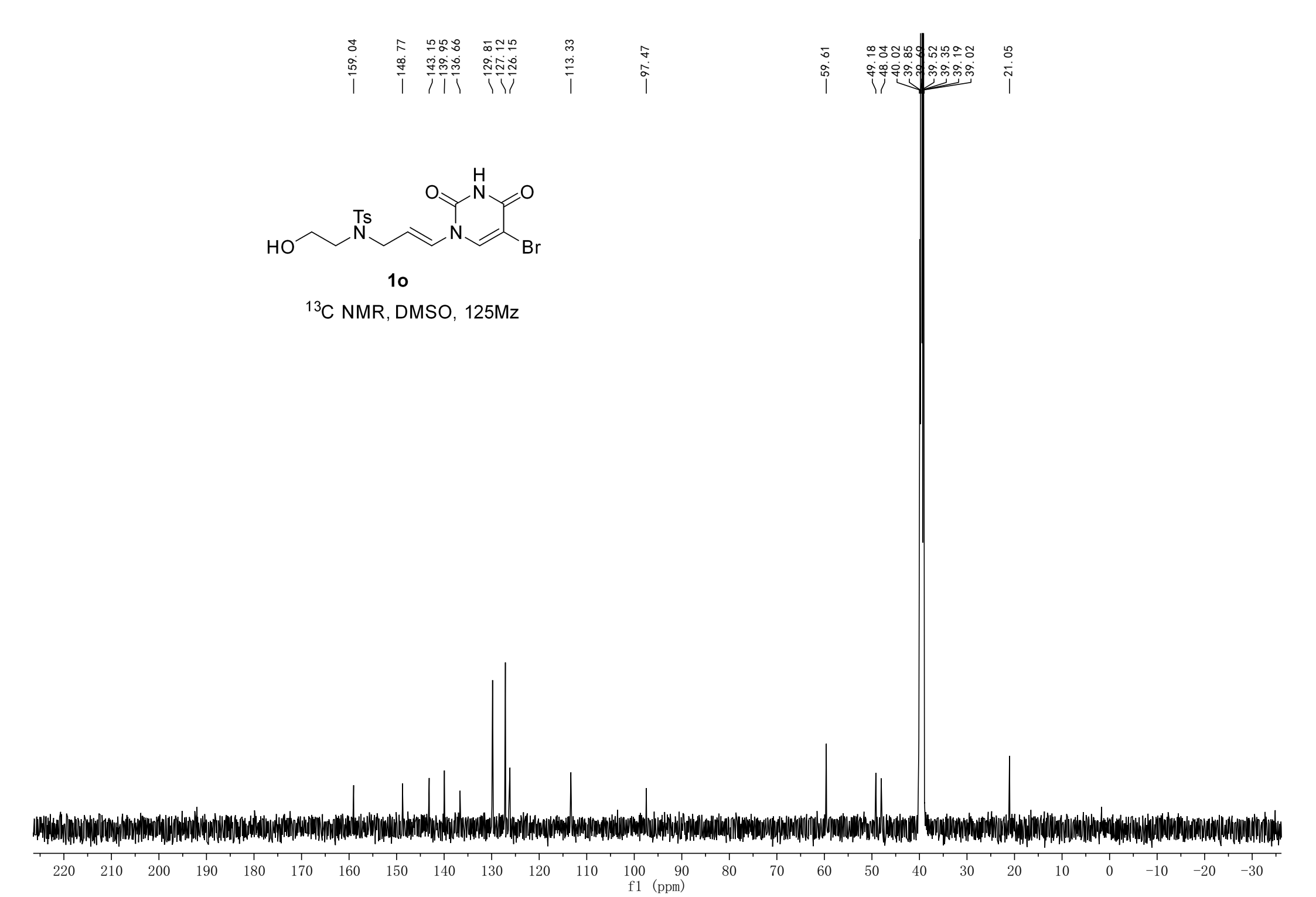
^{19}F NMR, DMSO, 376 Mz

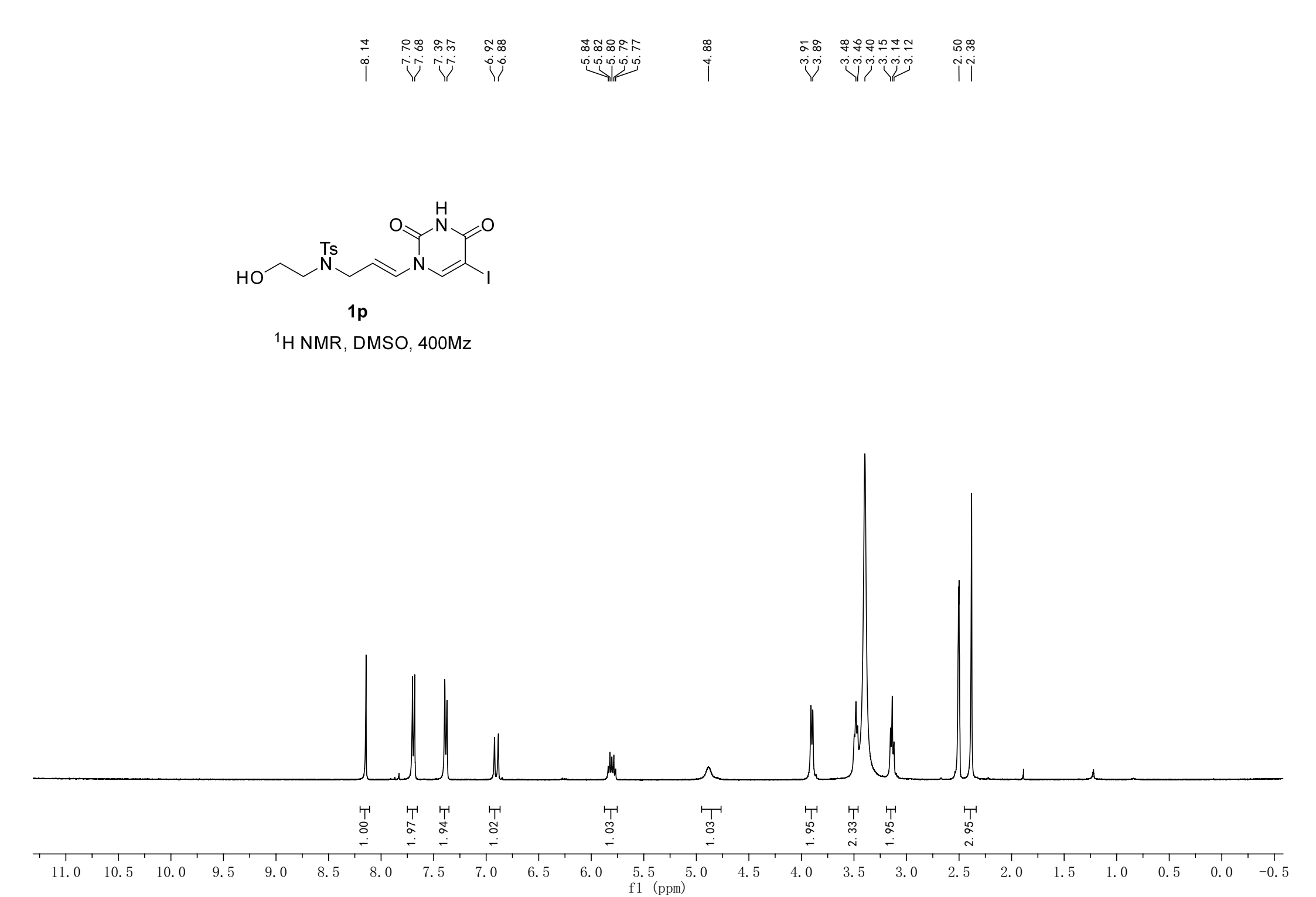


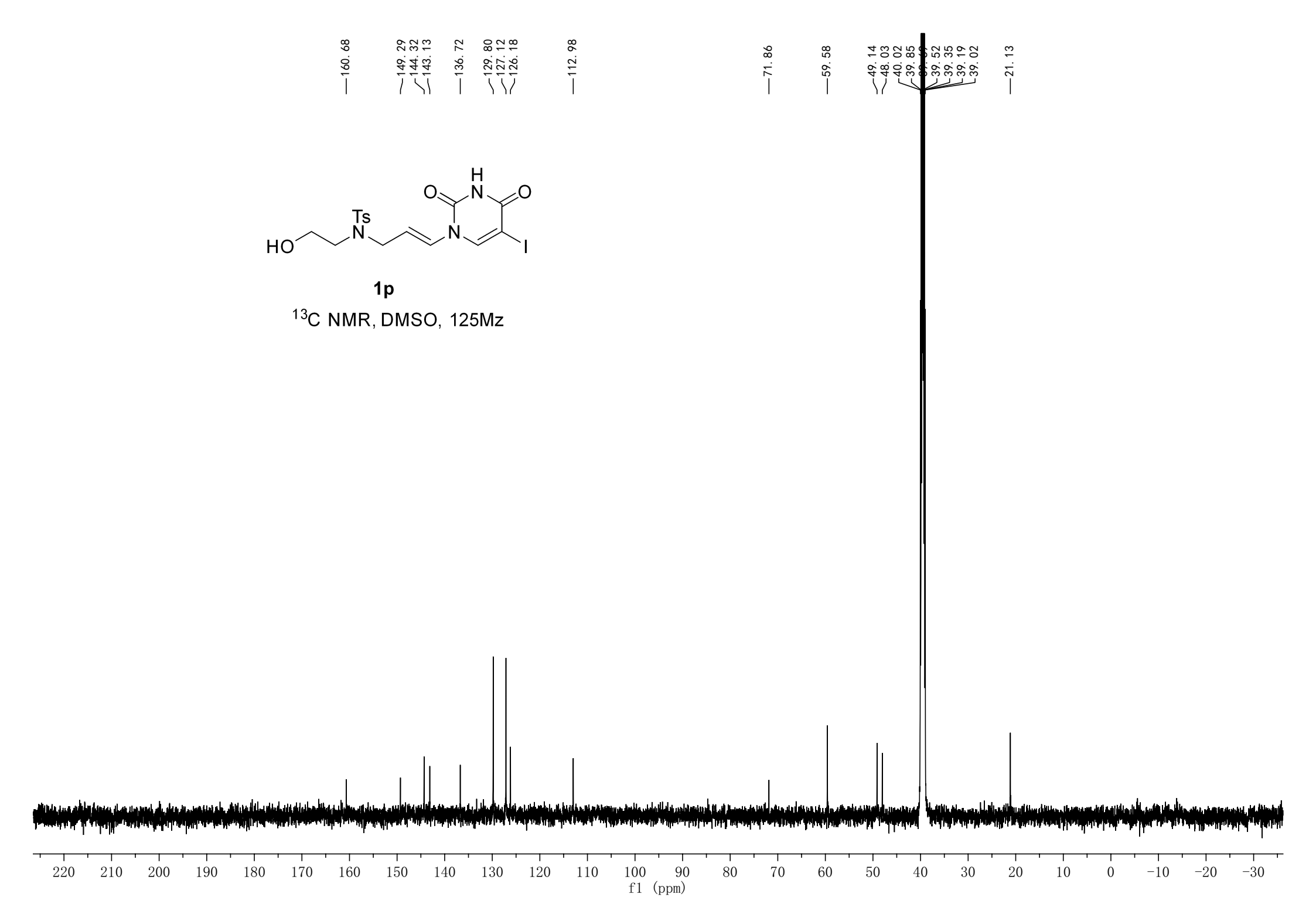

12.03
8.20
7.71
7.69
7.40
7.38
6.98
6.95
5.86
5.85
5.83
5.82
5.80
4.78
4.77
4.76
3.91
3.90
3.50
3.49
3.48
3.46
3.34
3.14
3.13
3.11
2.50
2.38
H
N
O
O
Ts
N
N
HO
Cl
1n
1H NMR, DMSO, 500Mz
0.83
0.93
2.08
2.05
1.03
1.00
0.96
2.08
2.12
1.97
3.17
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

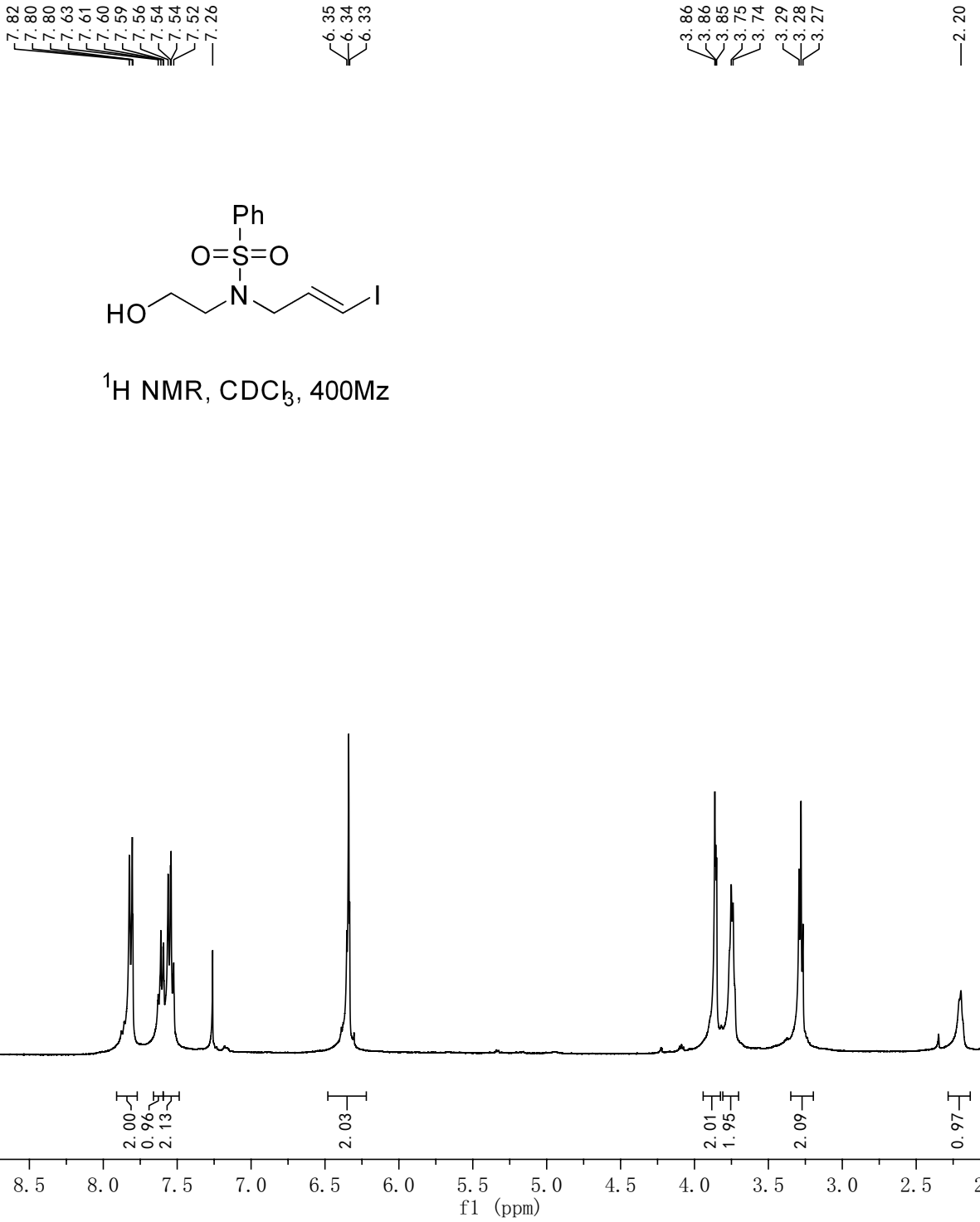

158.85
148.52
143.11
137.59
136.63
129.79
127.08
126.16
113.26
108.66
95.12
59.59
49.17
48.04
40.02
39.85
39.52
39.35
39.19
39.02
21.00
H
N
O
O
Ts
N
N
HO
Cl
1n
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

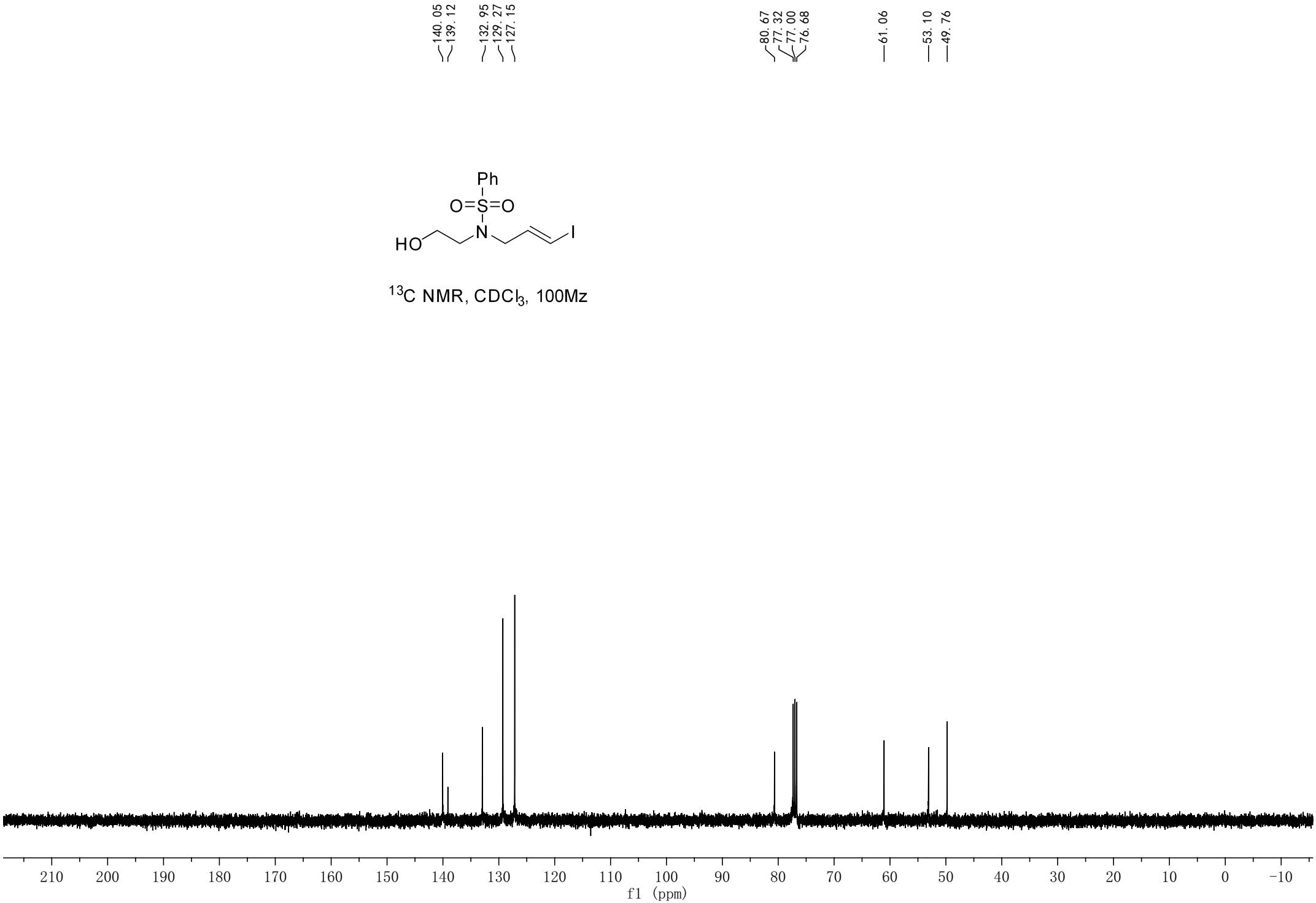

12.00
8.23
8.22
7.70
7.68
7.39
7.38
6.95
6.92
5.85
5.83
5.82
4.79
4.78
4.77
3.91
3.89
3.50
3.49
3.48
3.35
3.14
3.13
3.12
2.50
2.37
H
N
O
O
Ts
N
N
HO
Br
1o
1H NMR, DMSO, 500Mz
0.77
0.91
2.15
2.12
1.00
1.03
1.06
2.15
2.36
2.16
3.17
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


159.04
148.77
143.15
139.95
136.66
129.81
127.12
126.15
113.33
97.47
59.61
49.18
48.04
40.02
39.85
39.52
39.35
39.19
39.02
21.05
H
O
N
O
Ts
N
N
HO
Br
1o
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
f1 (ppm)

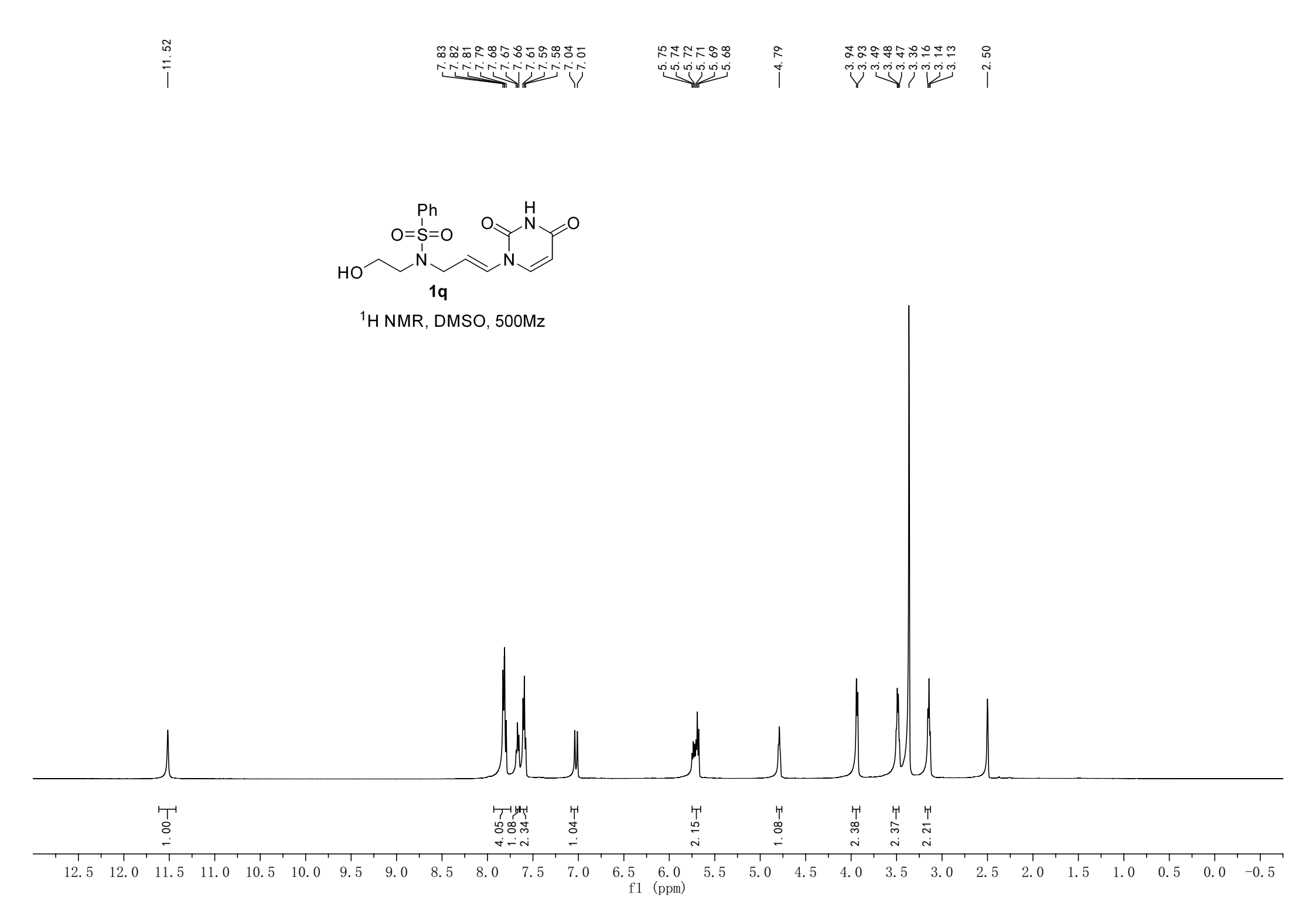

8.14
7.70
7.68
7.39
7.37
6.92
6.88
5.84
5.82
5.80
5.79
5.77
4.88
3.91
3.89
3.48
3.46
3.40
3.15
3.14
3.12
2.50
2.38
H
N
O
O
N
Ts
N
HO
I
1p
1H NMR, DMSO, 400Mz
1.00
1.97
1.94
1.02
1.03
1.03
1.95
2.33
1.95
2.95
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

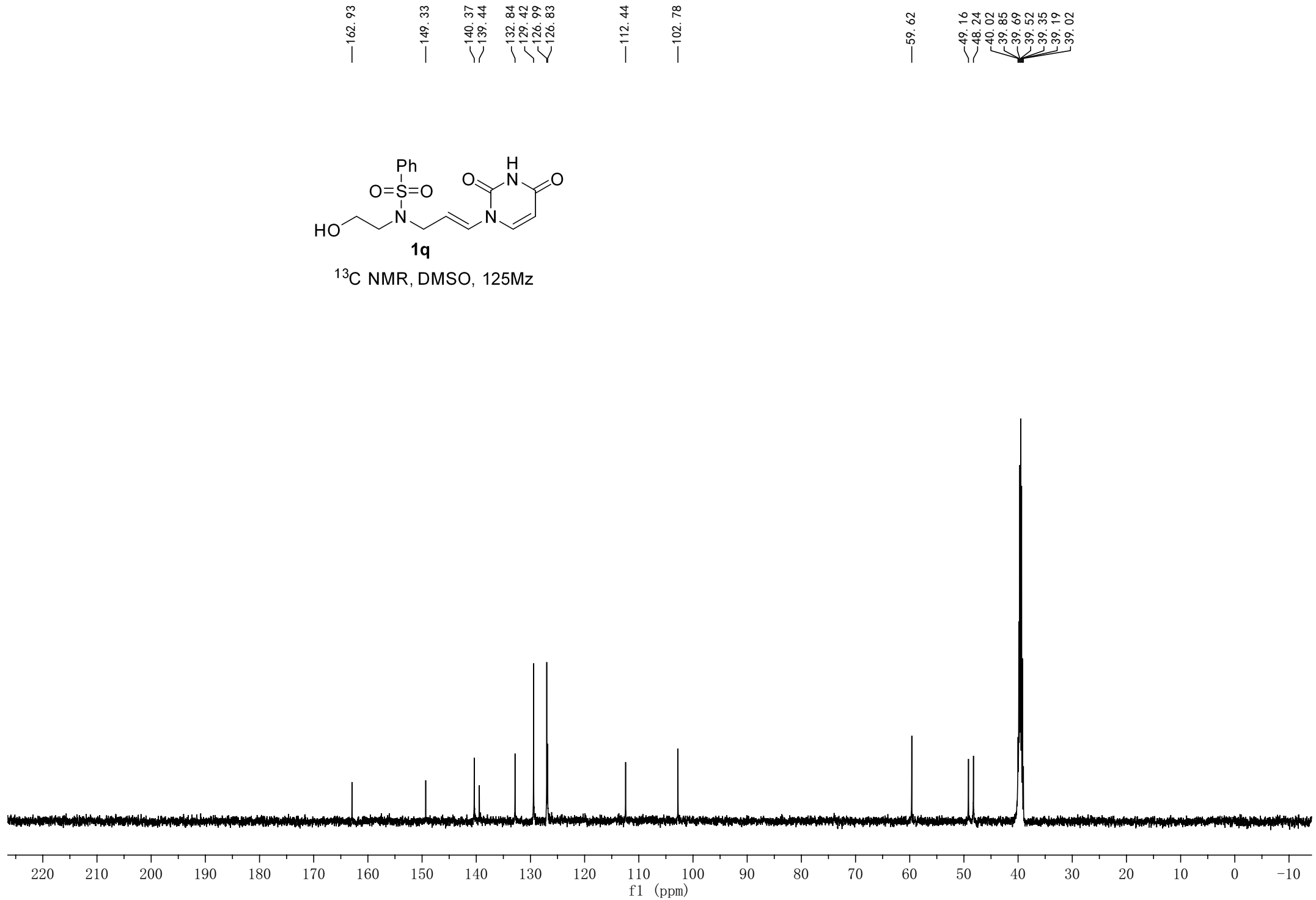

160.68
149.29
144.32
143.13
136.72
129.80
127.12
126.18
112.98
71.86
59.58
49.14
48.03
40.02
39.85
39.52
39.35
39.19
39.02
21.13
H
O
N
O
Ts
N
N
HO
I
1p
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
f1 (ppm)

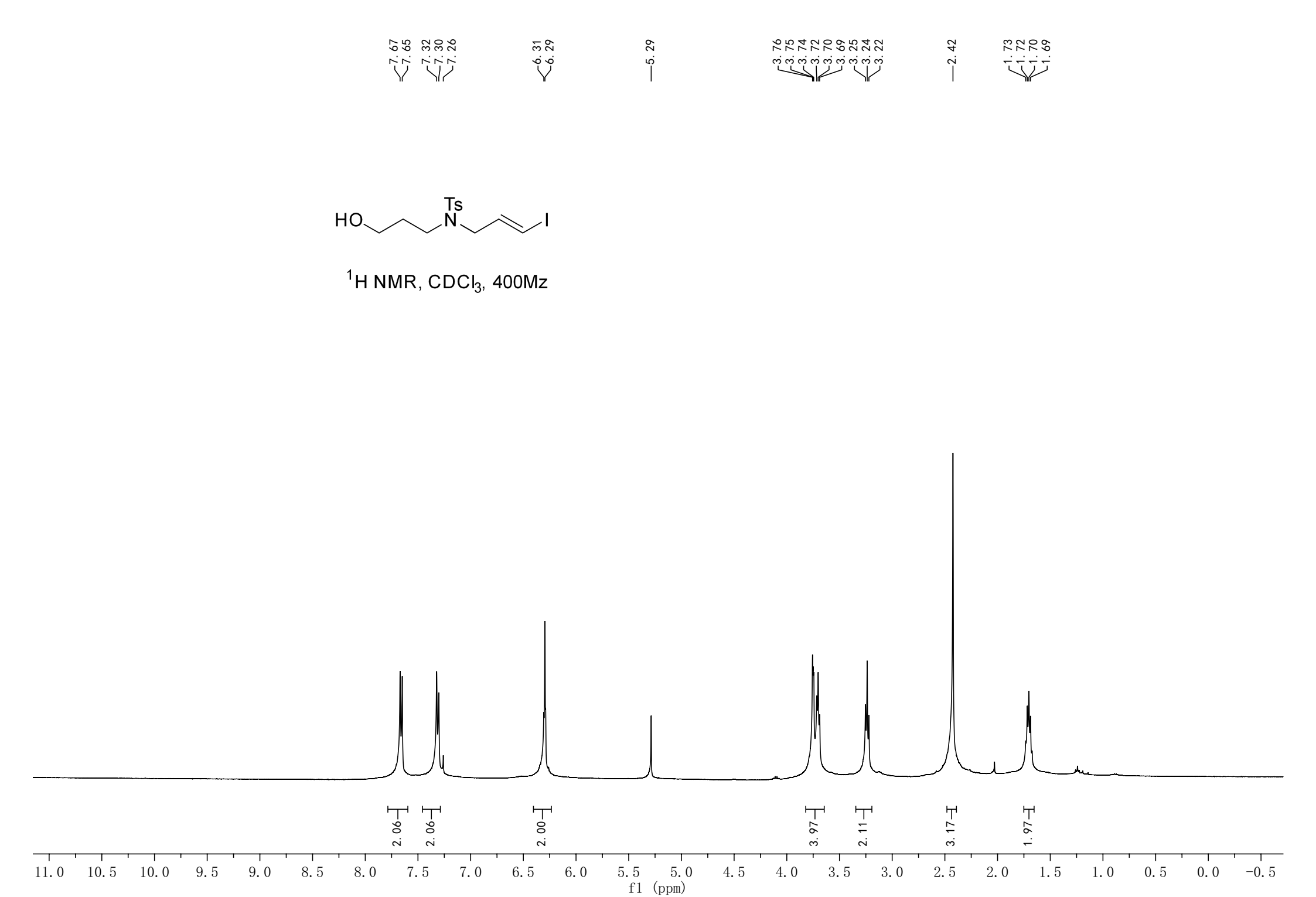

7.82
7.80
7.80
7.63
7.61
7.60
7.59
7.56
7.54
7.54
7.52
7.26
6.35
6.34
6.33
3.86
3.86
3.85
3.75
3.74
3.29
3.28
3.27
2.20
Ph
O=S=O
N
HO
I
1H NMR, CDCl3, 400Mz
2.00
0.96
2.13
2.03
2.01
1.95
2.09
0.97
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

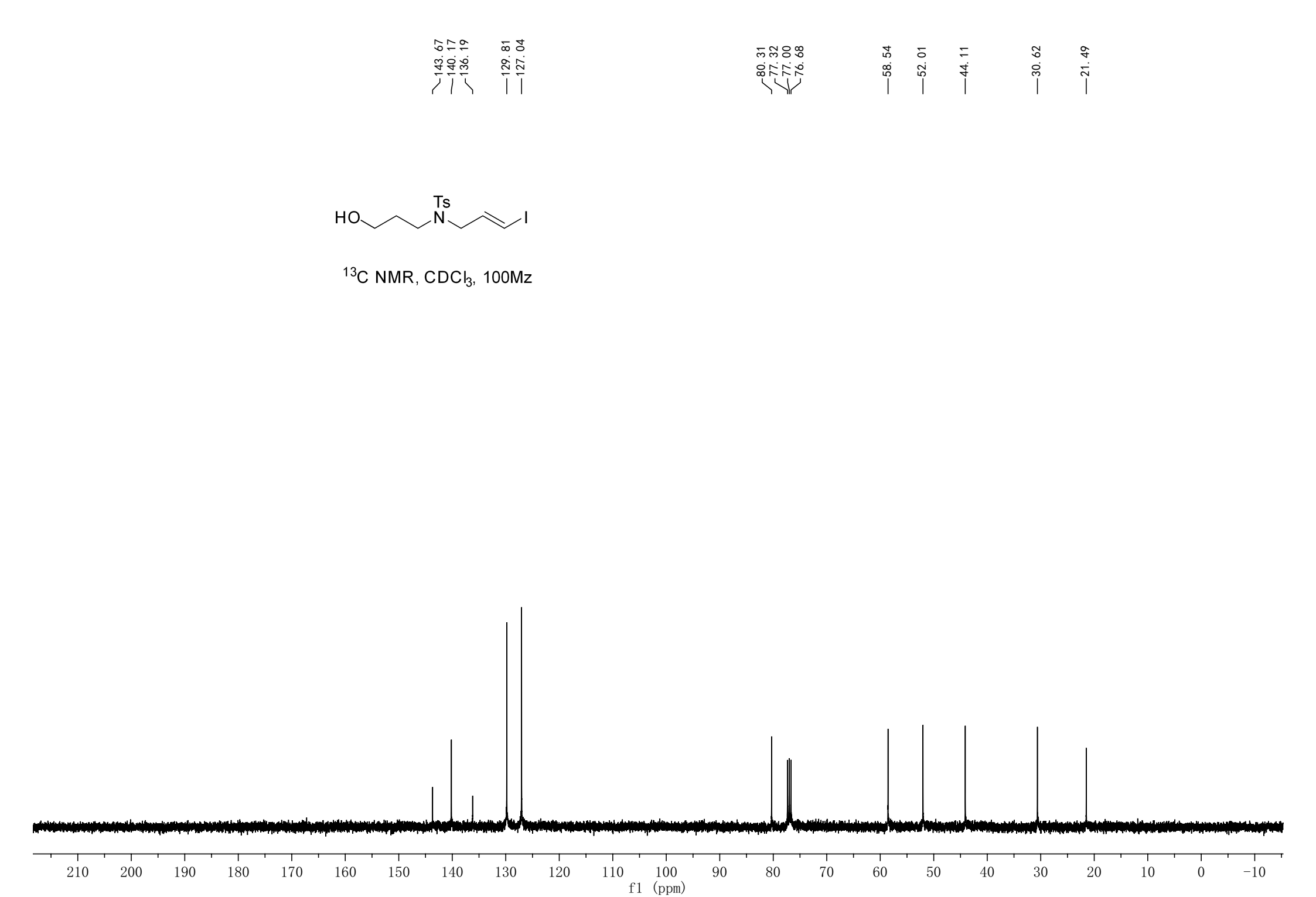


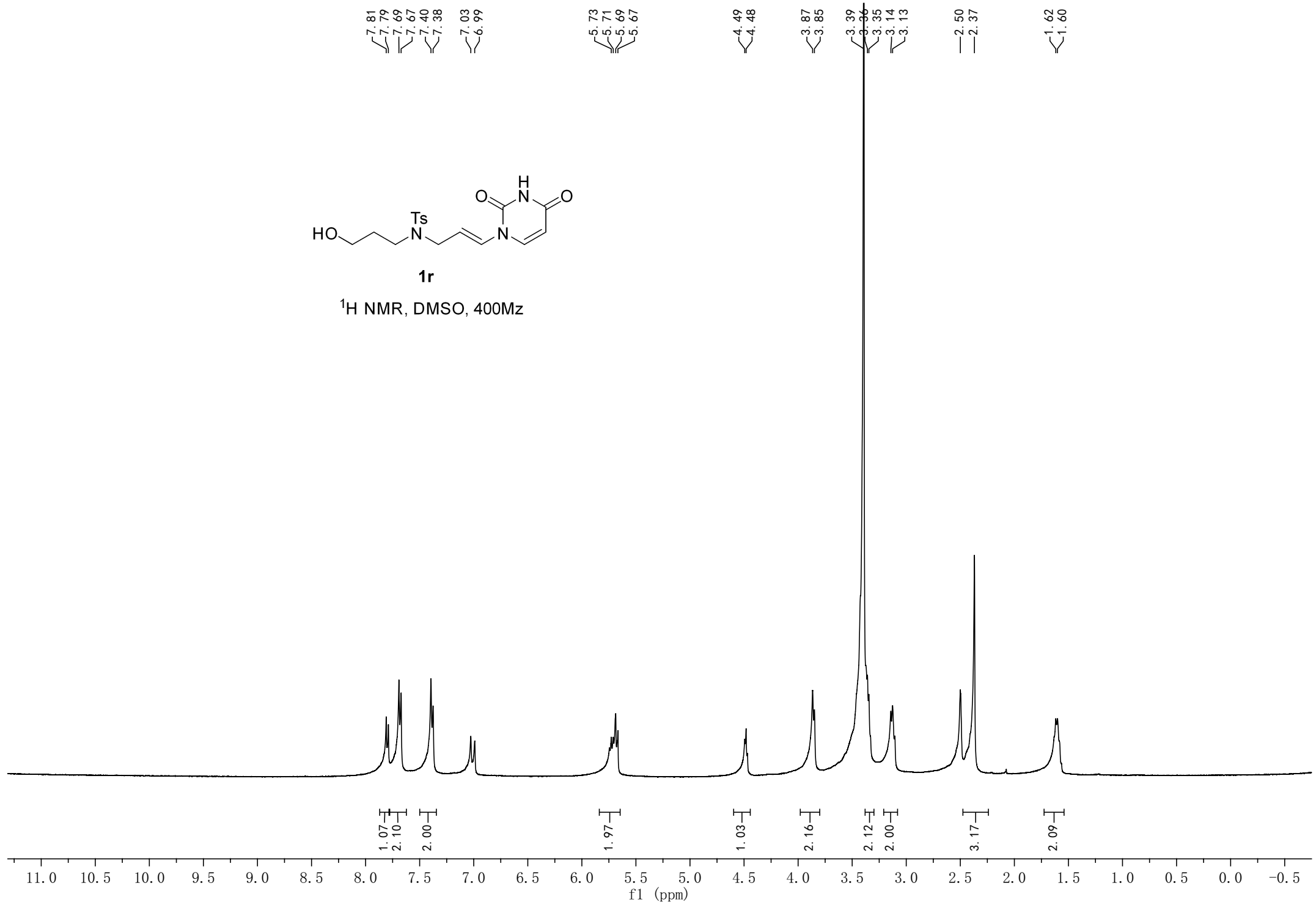
^{13}C NMR, $CDCl_3$, 100Mz

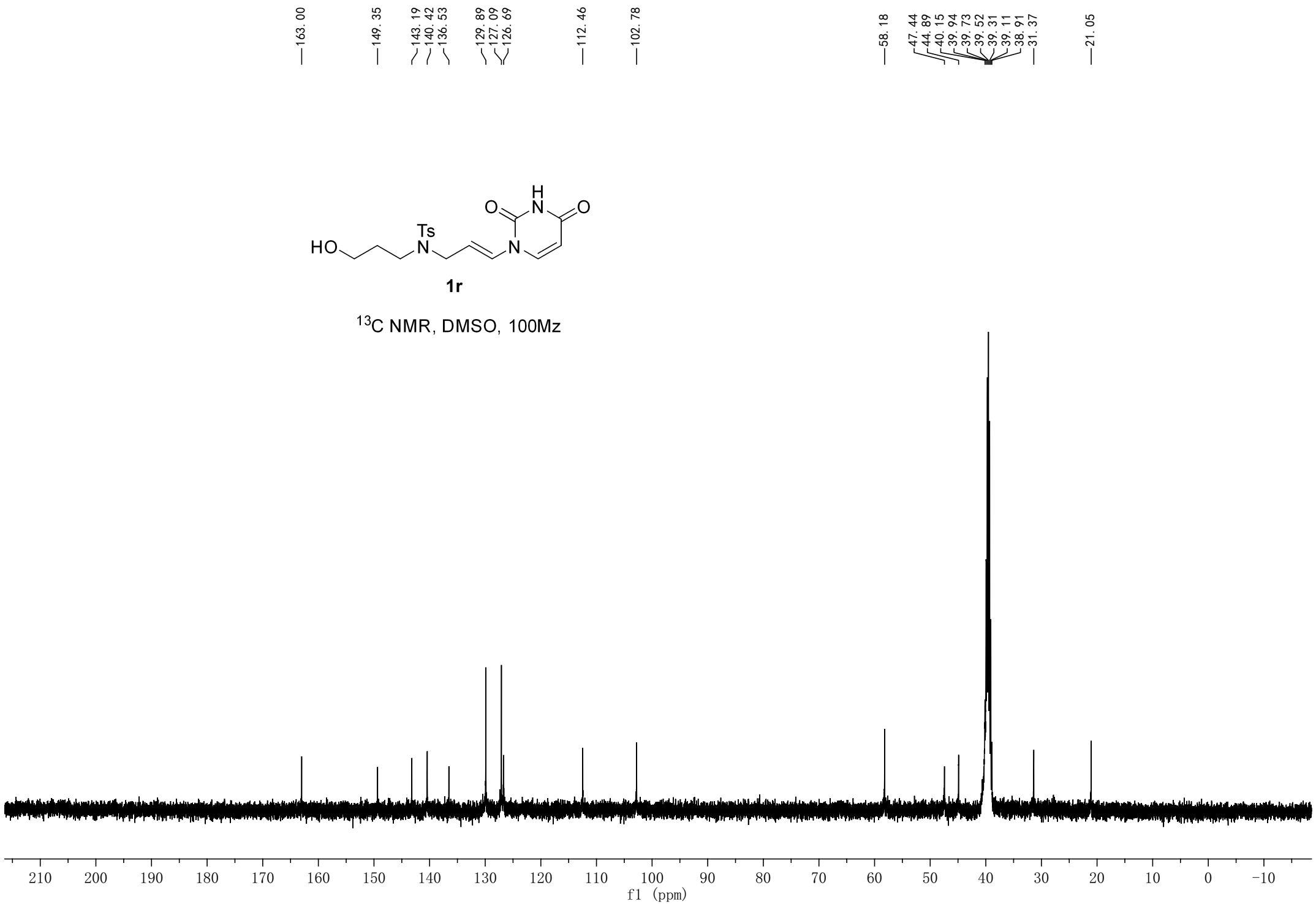

11.52
7.83
7.82
7.81
7.79
7.68
7.67
7.66
7.61
7.59
7.58
7.04
7.01
5.75
5.74
5.72
5.71
5.69
5.68
4.79
3.94
3.93
3.49
3.48
3.47
3.36
3.16
3.14
3.13
2.50
Ph
O=S=O
N
HO
H
N
O
O
N
1q
1H NMR, DMSO, 500Mz
1.00
4.05
1.08
2.34
1.04
2.15
1.08
2.38
2.37
2.21
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

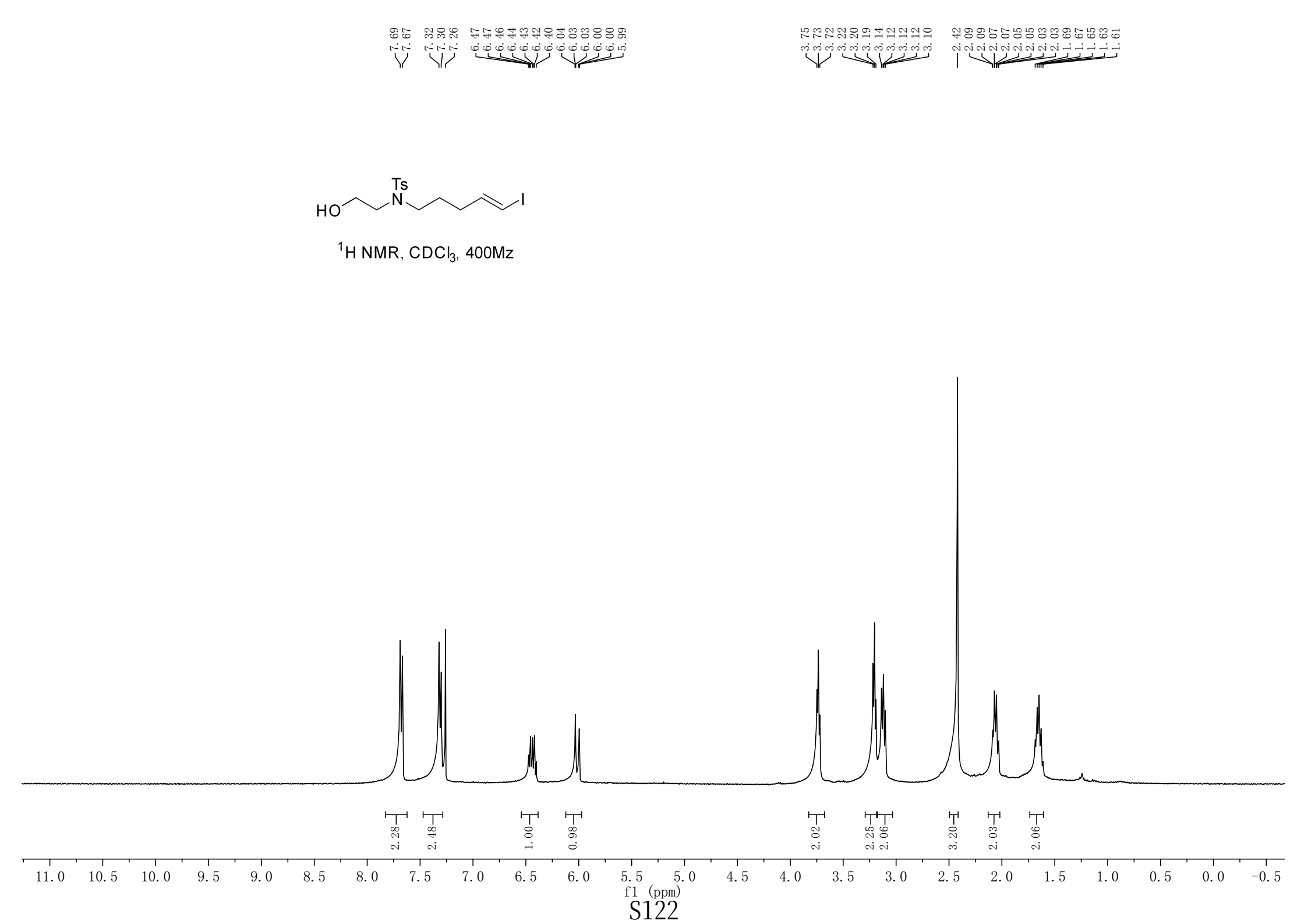

162.93
149.33
140.37
139.44
132.84
129.42
126.99
126.83
112.44
102.78
59.62
49.16
48.24
40.02
39.85
39.69
39.52
39.35
39.19
39.02
Ph
O=S=O
N
HO
H
N
O
O
N
1q
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

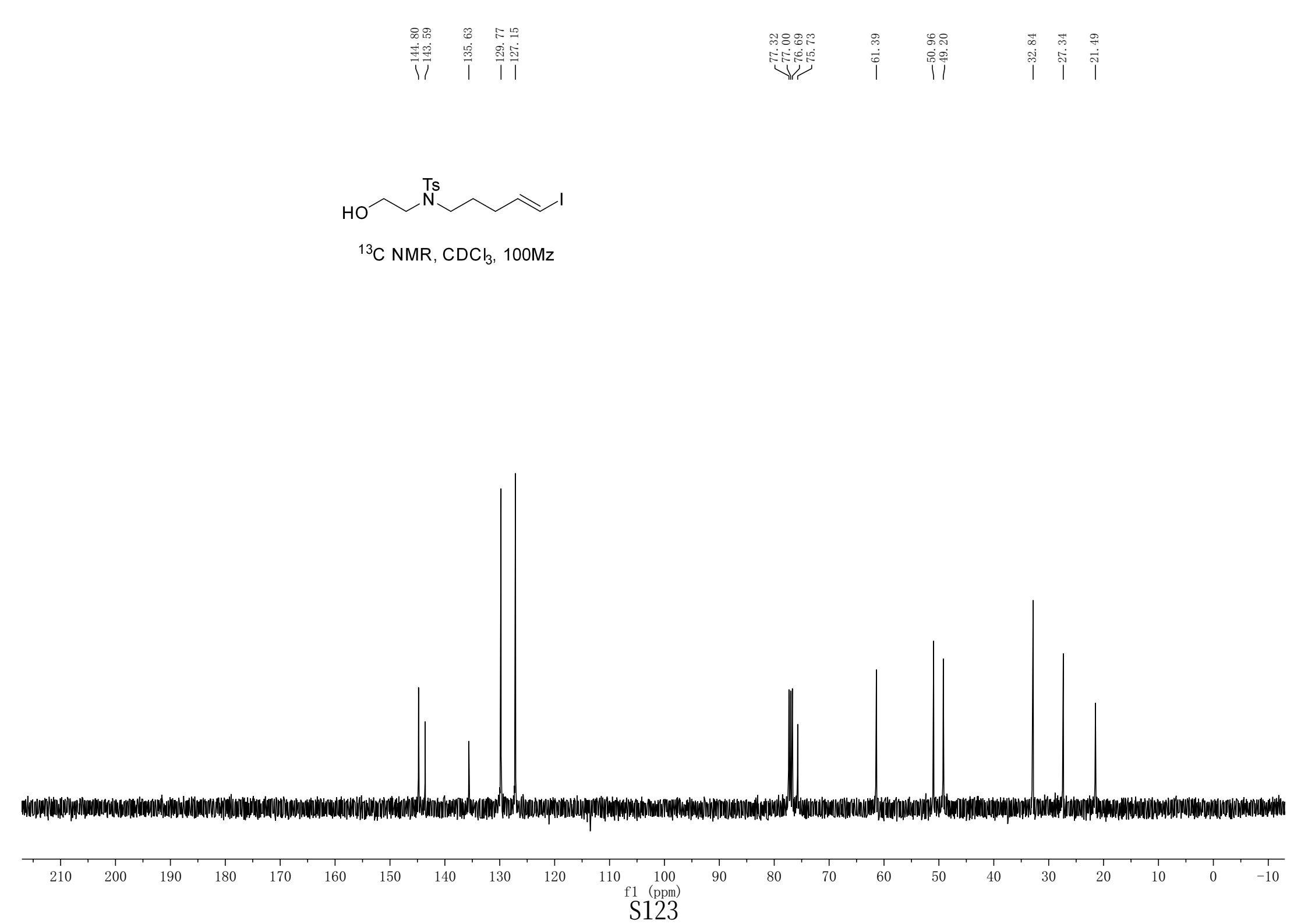

7.67
7.65
7.32
7.30
7.26
6.31
6.29
5.29
3.76
3.75
3.74
3.72
3.70
3.69
3.25
3.24
3.22
2.42
1.73
1.72
1.70
1.69
HO
Ts
N
I
1H NMR, CDCl3, 400Mz
2.06
2.06
2.00
3.97
2.11
3.17
1.97
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

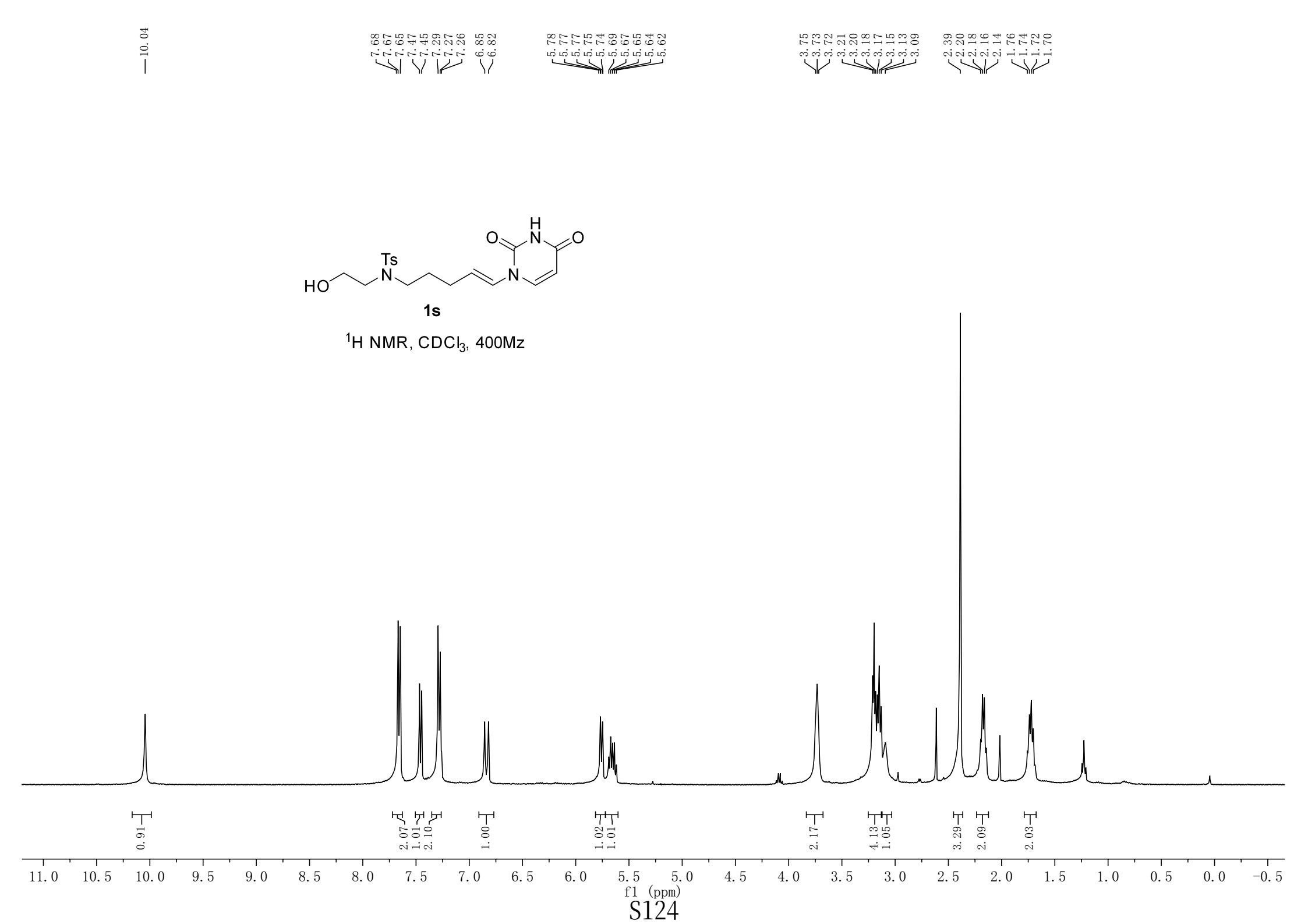

143.67
140.17
136.19
129.81
127.04
80.31
77.32
77.00
76.68
58.54
52.01
44.11
30.62
21.49
Ts
HO
N
I
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

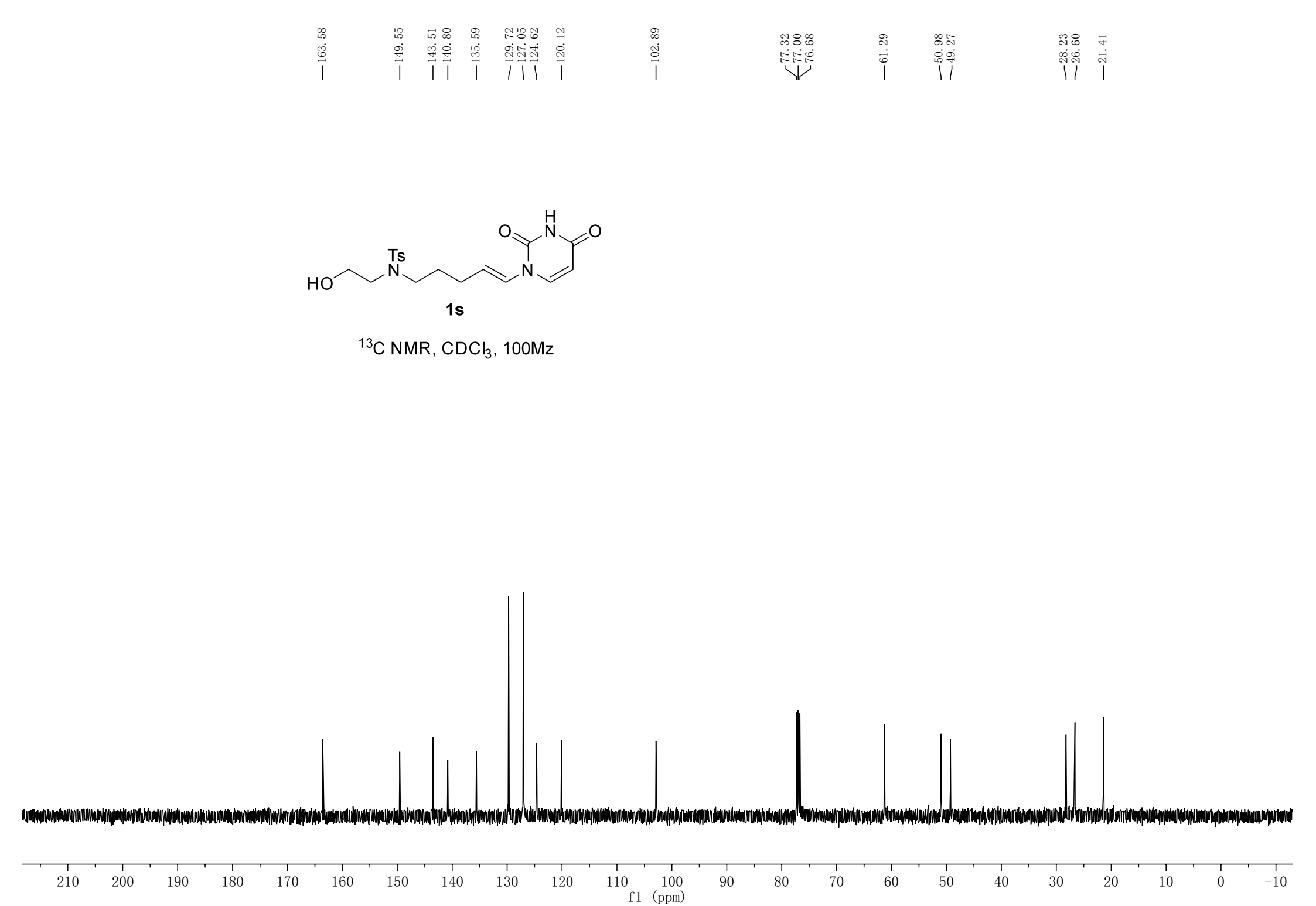

7.81
7.79
7.69
7.67
7.40
7.38
7.03
6.99
5.73
5.71
5.69
5.67
4.49
4.48
3.87
3.85
3.39
3.36
3.35
3.14
3.13
2.50
2.37
1.62
1.60
HO
Ts
N
N
O
O
H
N
1r
1H NMR, DMSO, 400Mz
1.07
2.10
2.00
1.97
1.03
2.16
2.12
2.00
3.17
2.09
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

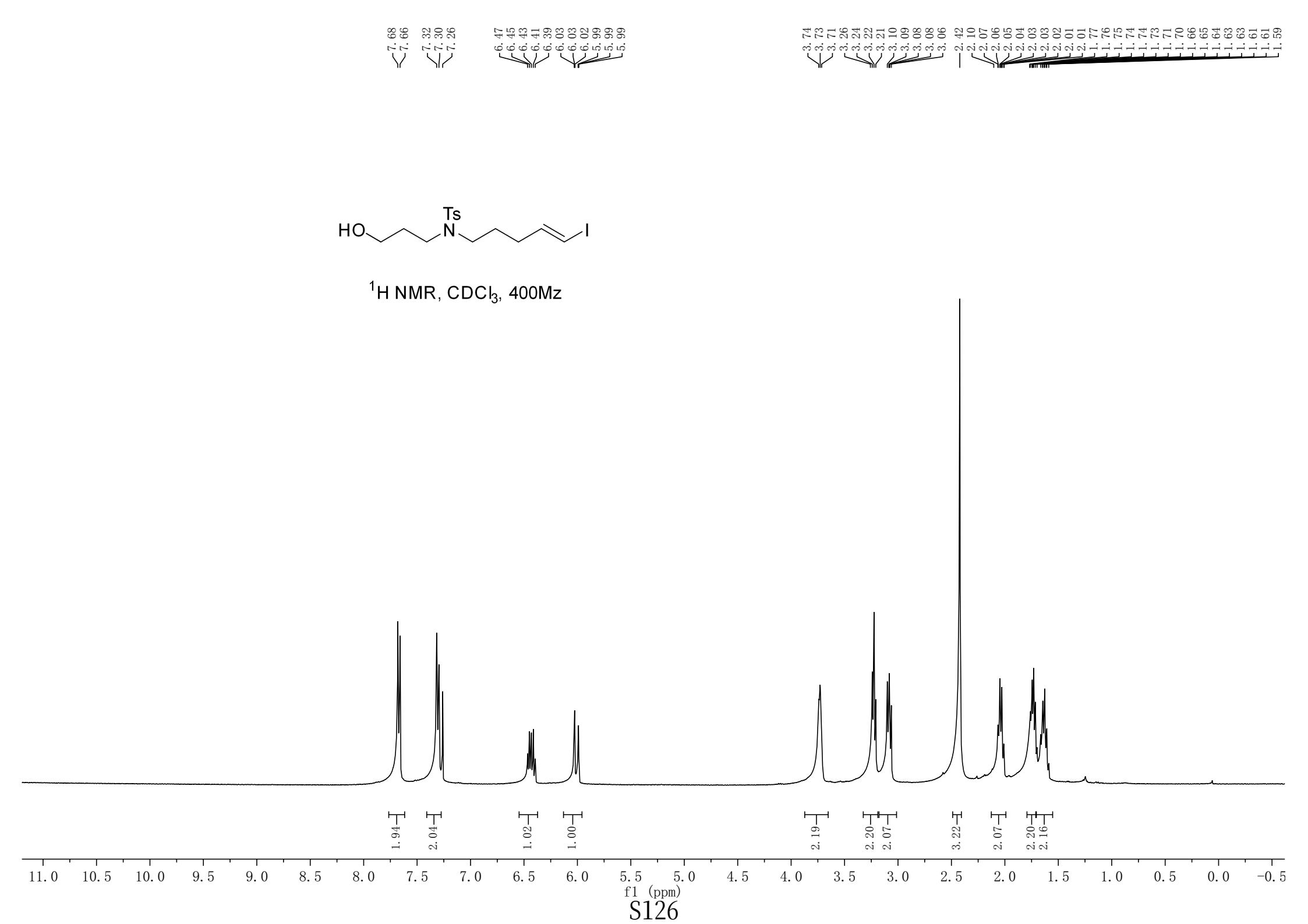

163.00
149.35
143.19
140.42
136.53
129.89
127.09
126.69
112.46
102.78
58.18
47.44
44.89
40.15
39.94
39.73
39.52
39.31
39.11
38.91
31.37
21.05
HO
Ts
N
N
O
N
H
O
1r
13C NMR, DMSO, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

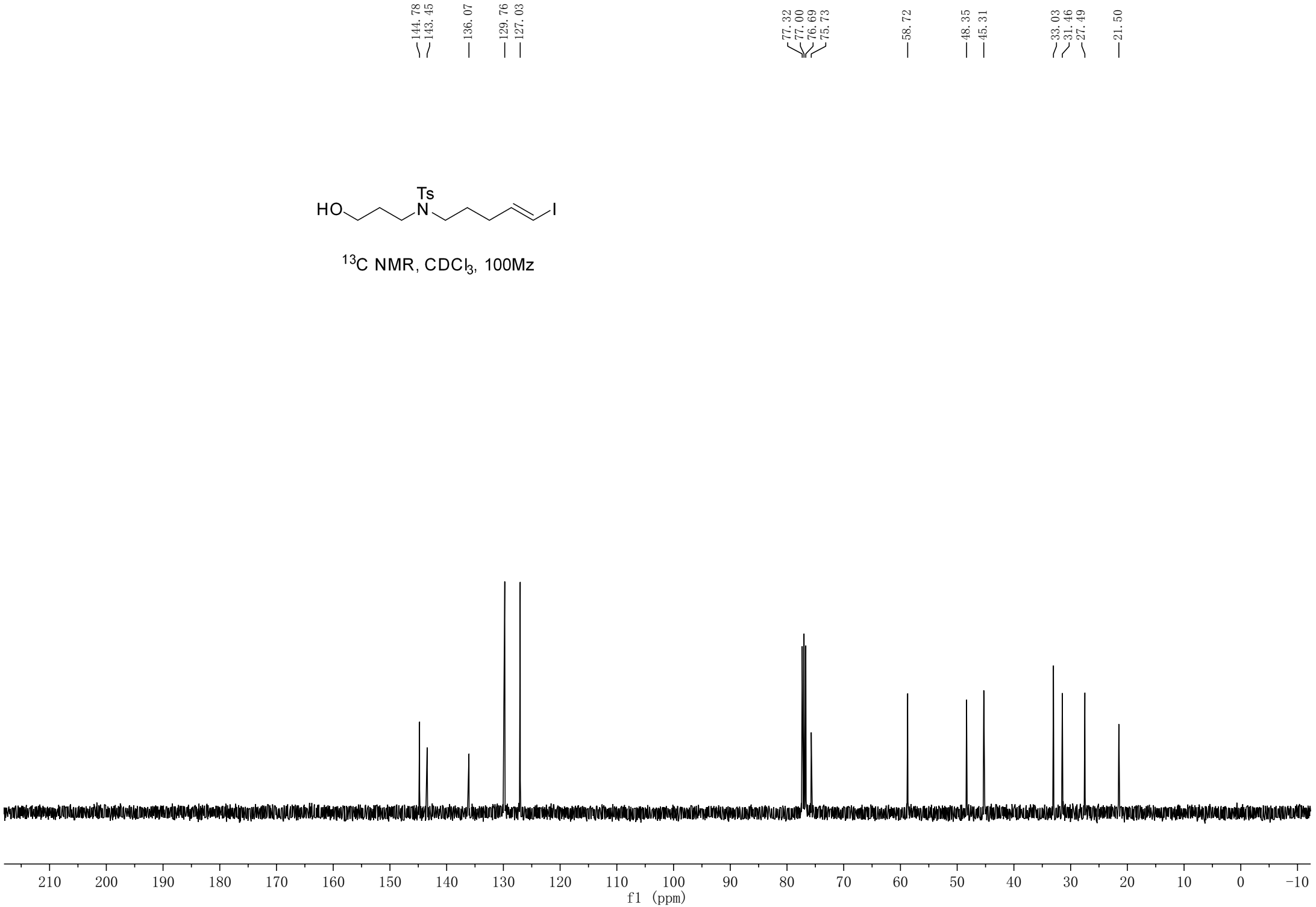

7.69
7.67
7.32
7.30
7.26
6.47
6.47
6.46
6.44
6.43
6.42
6.40
6.04
6.03
6.03
6.00
6.00
5.99
3.75
3.73
3.72
3.22
3.20
3.19
3.14
3.12
3.12
3.12
3.10
2.42
2.09
2.09
2.07
2.07
2.05
2.05
2.03
2.03
1.69
1.67
1.65
1.63
1.61
Ts
N
HO
I
1H NMR, CDCl3, 400Mz
2.28
2.48
1.00
0.98
2.02
2.25
2.06
3.20
2.03
2.06
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

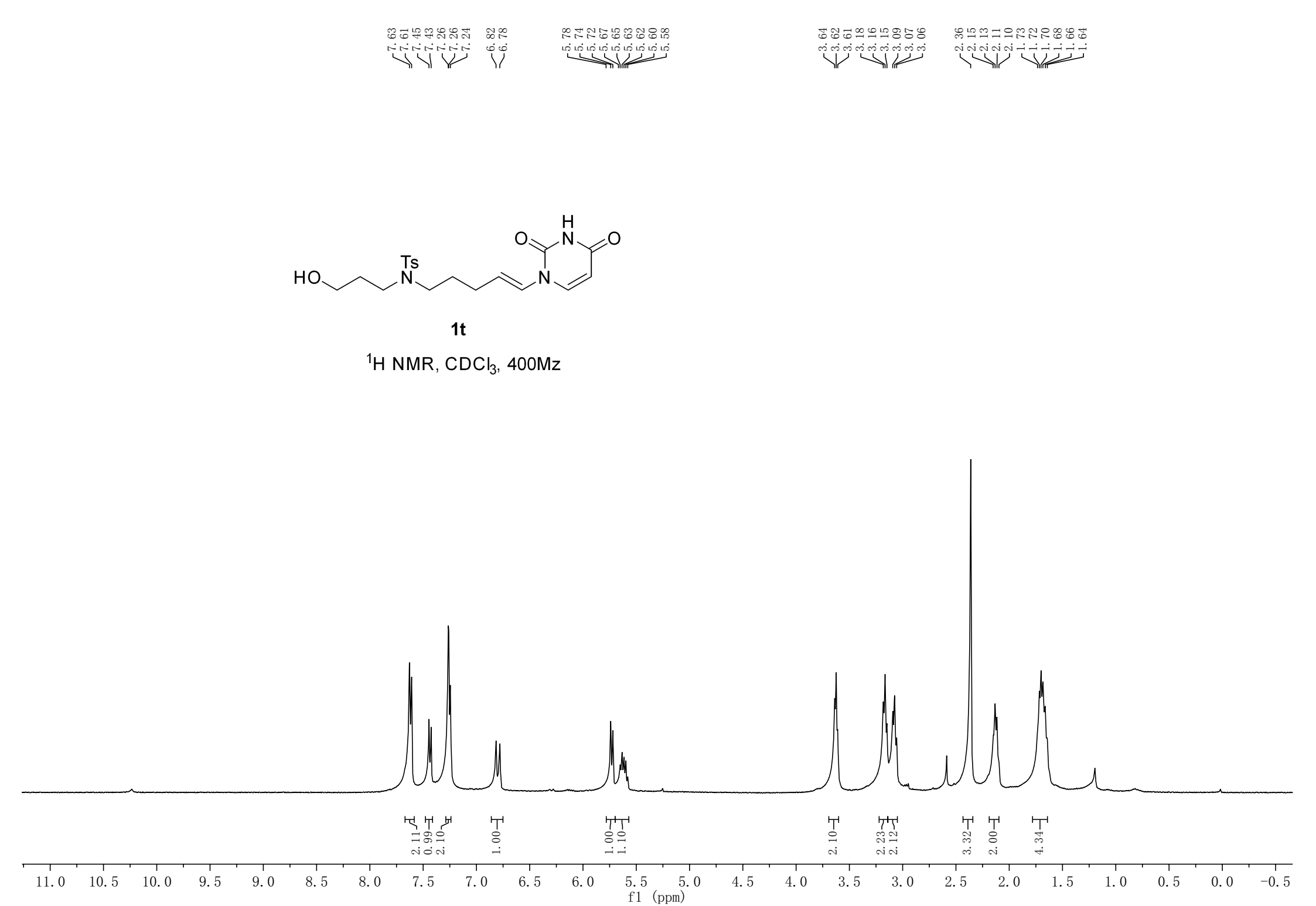

144.80
143.59
135.63
129.77
127.15
77.32
77.00
76.69
75.73
61.39
50.96
49.20
32.84
27.34
21.49
Ts
N
HO
I
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

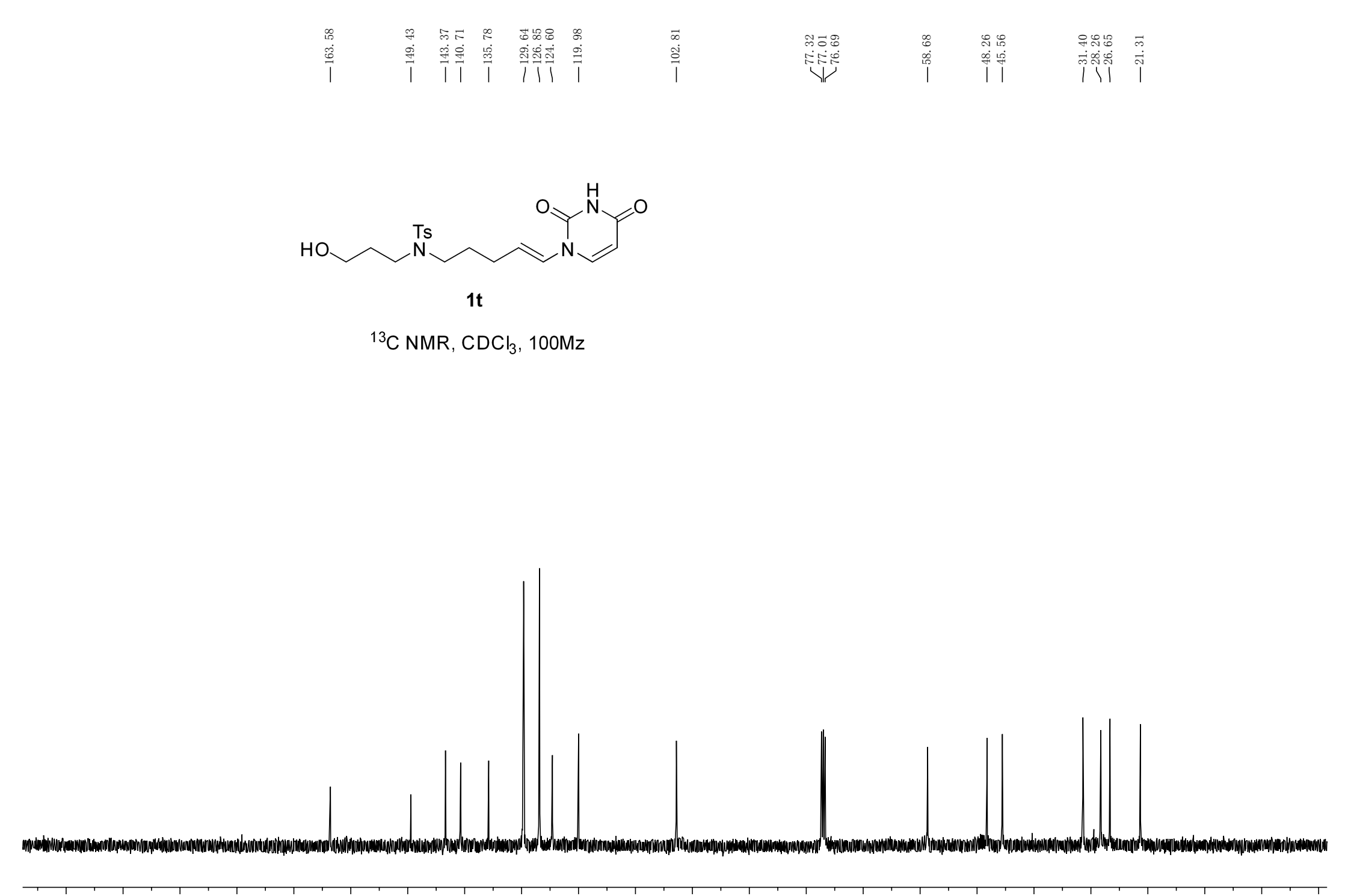

10.04
7.68
7.67
7.65
7.47
7.45
7.29
7.27
7.26
6.85
6.82
5.78
5.77
5.77
5.75
5.74
5.69
5.67
5.65
5.64
5.62
3.75
3.73
3.72
3.21
3.20
3.18
3.17
3.15
3.13
3.09
2.39
2.20
2.18
2.16
2.14
1.76
1.74
1.72
1.70
H
N
O
O
Ts
N
N
HO
1s
1H NMR, CDCl3, 400Mz
0.91
2.07
1.01
2.10
1.00
1.02
1.01
2.17
4.13
1.05
3.29
2.09
2.03
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

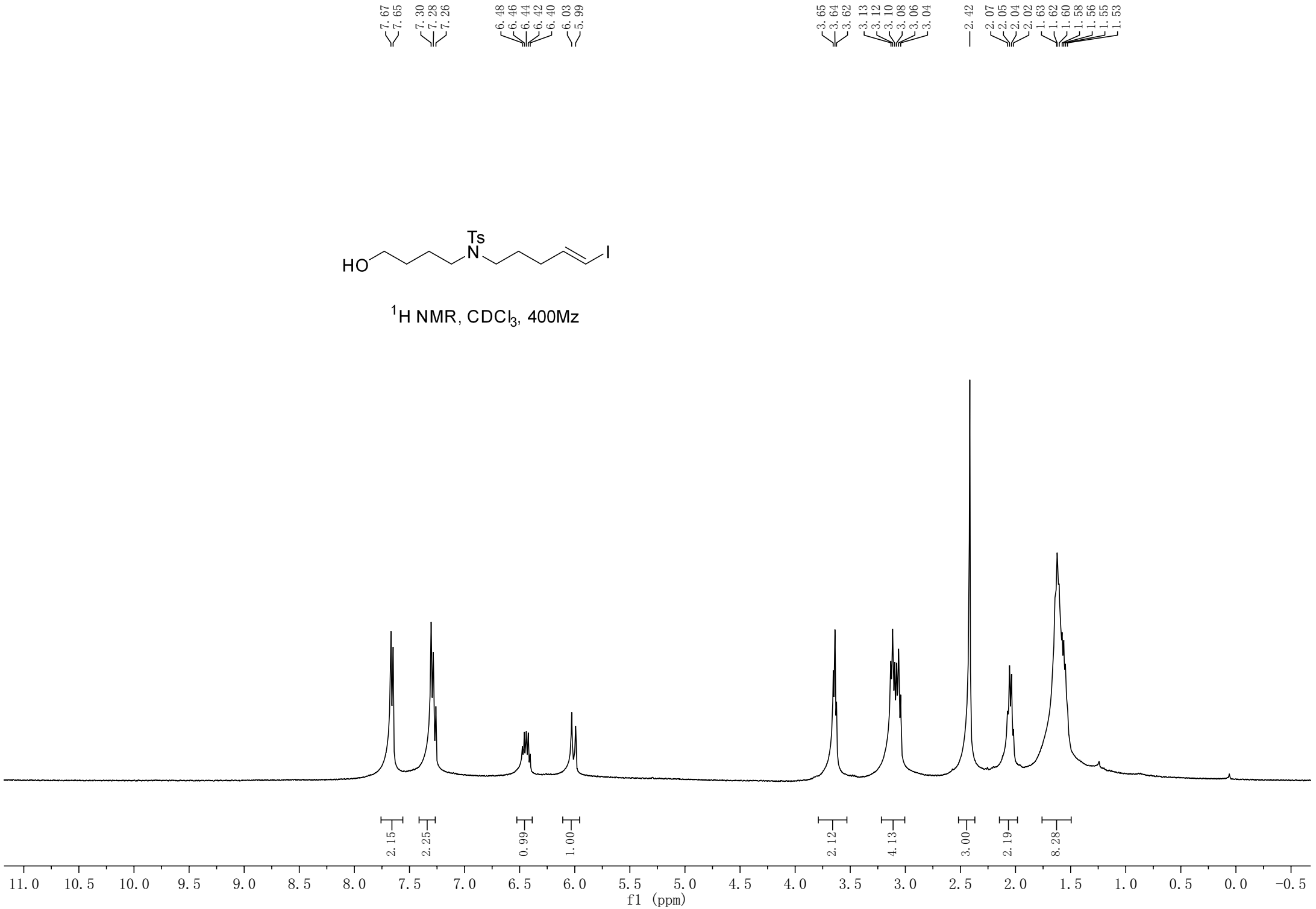

163.58
149.55
143.51
140.80
135.59
129.72
127.05
124.62
120.12
102.89
77.32
77.00
76.68
61.29
50.98
49.27
28.23
26.60
21.41
H
N
O
O
Ts
N
N
HO
1s
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

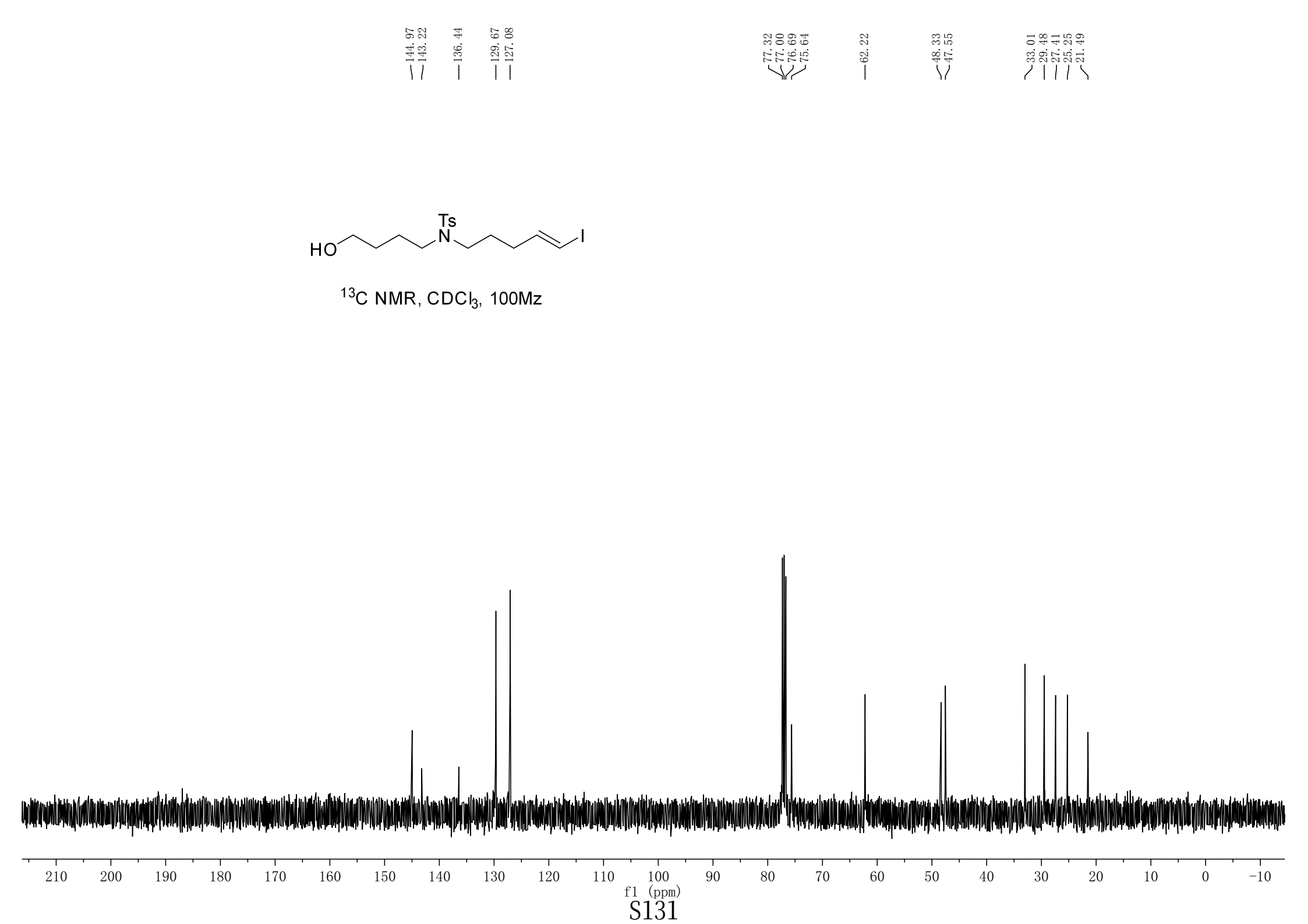

7.68
7.66
7.32
7.30
7.26
6.47
6.45
6.43
6.41
6.39
6.03
6.02
5.99
5.99
5.99
3.74
3.73
3.71
3.26
3.24
3.22
3.21
3.10
3.09
3.08
3.08
3.06
2.42
2.10
2.07
2.06
2.05
2.04
2.03
2.03
2.02
2.01
2.01
1.77
1.76
1.75
1.74
1.74
1.73
1.71
1.70
1.66
1.65
1.64
1.63
1.63
1.61
1.61
1.59
HO
Ts
N
I
1H NMR, CDCl3, 400Mz
1.94
2.04
1.02
1.00
2.19
2.20
2.07
3.22
2.07
2.20
2.16
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

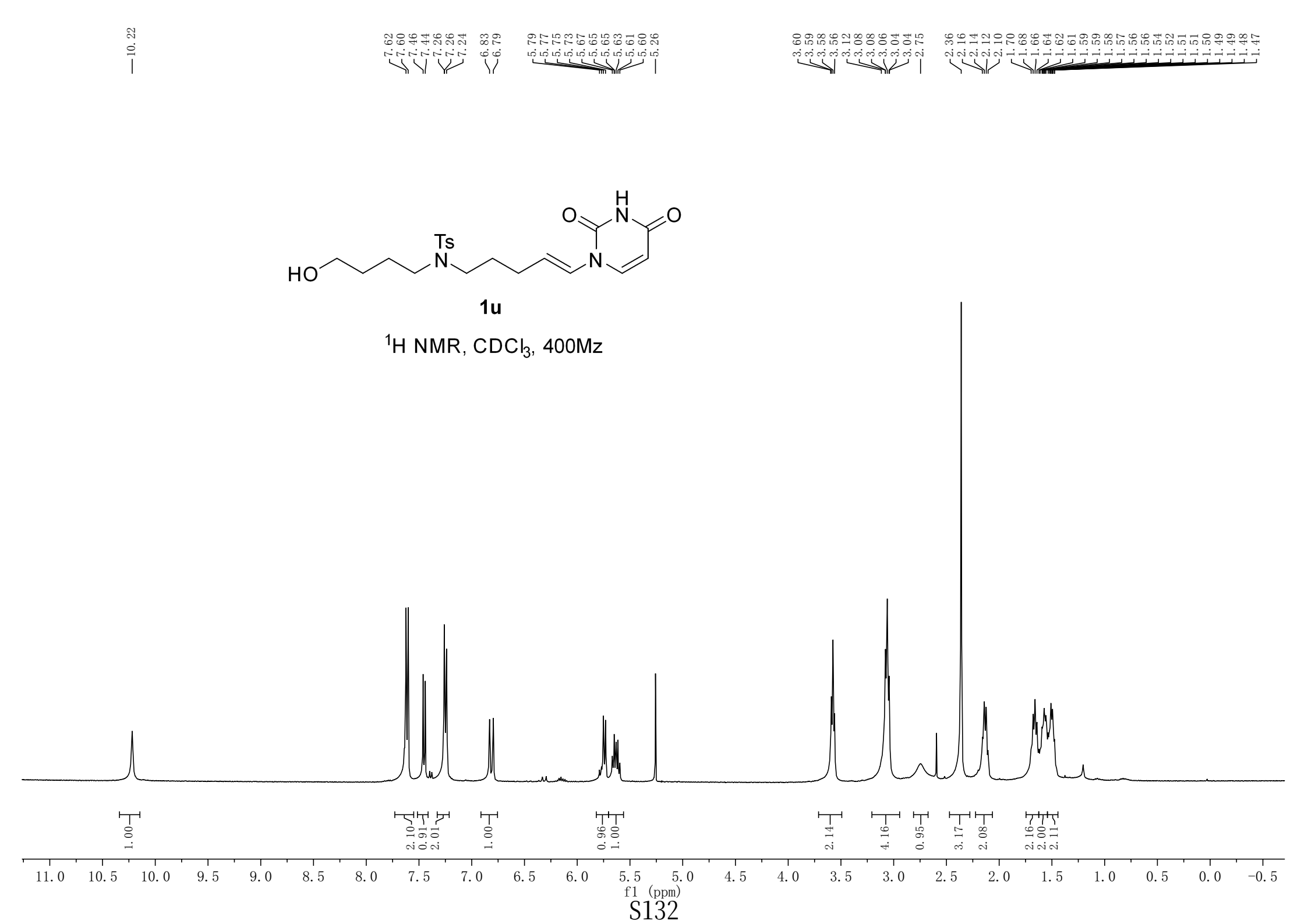

144.78
143.45
136.07
129.76
127.03
77.32
77.00
76.69
75.73
58.72
48.35
45.31
33.03
31.46
27.49
21.50
Ts
HO
N
I
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

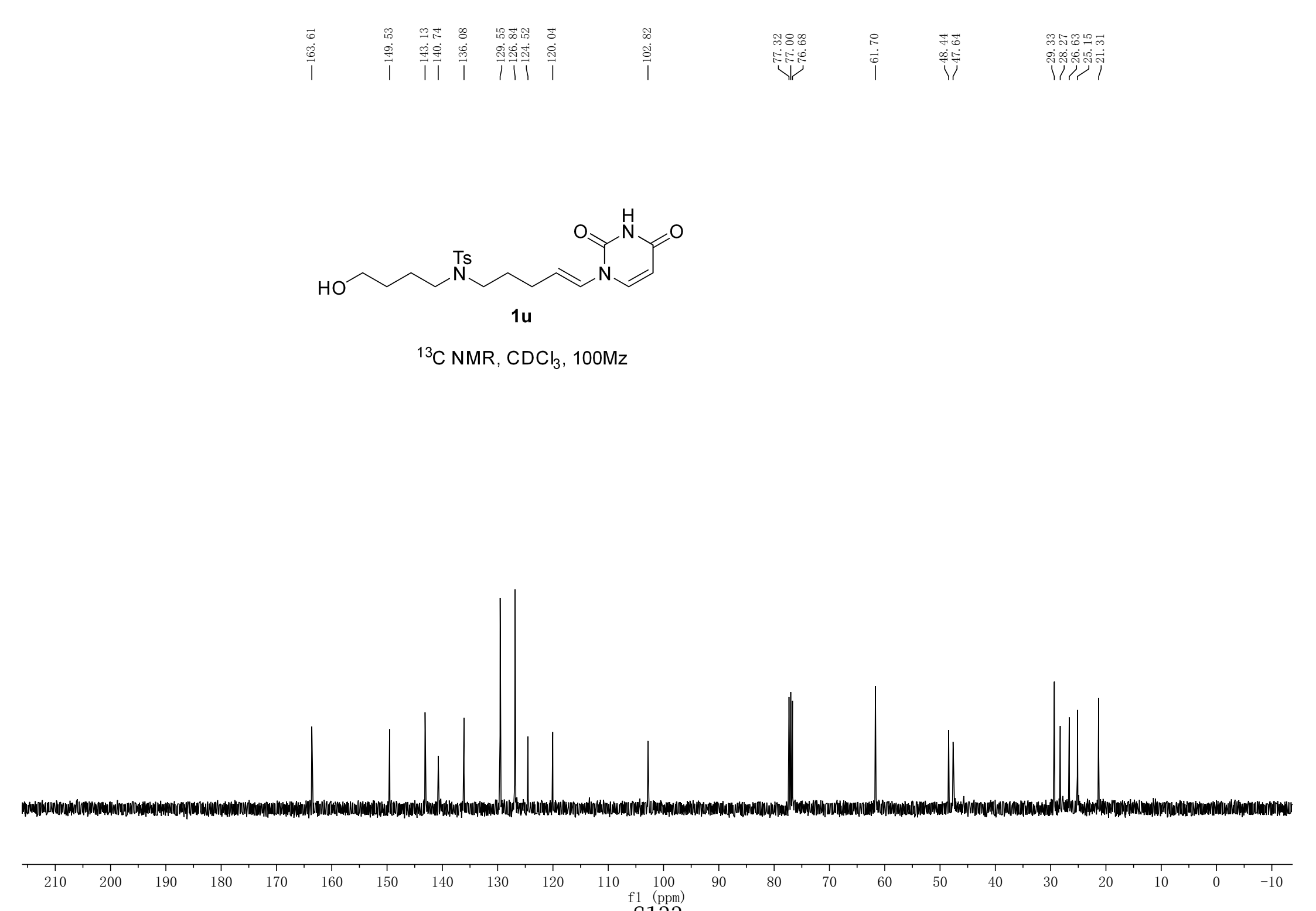

7.63
7.61
7.45
7.43
7.26
7.26
7.24
6.82
6.78
5.78
5.74
5.72
5.67
5.65
5.63
5.62
5.60
5.58
3.64
3.62
3.61
3.18
3.16
3.15
3.09
3.07
3.06
2.36
2.15
2.13
2.11
2.10
1.73
1.72
1.70
1.68
1.66
1.64
H
N
O
O
O
Ts
N
HO
N
1t
1H NMR, CDCl3, 400Mz
2.11
0.99
2.10
1.00
1.00
1.10
2.10
2.23
2.12
3.32
2.00
4.34
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

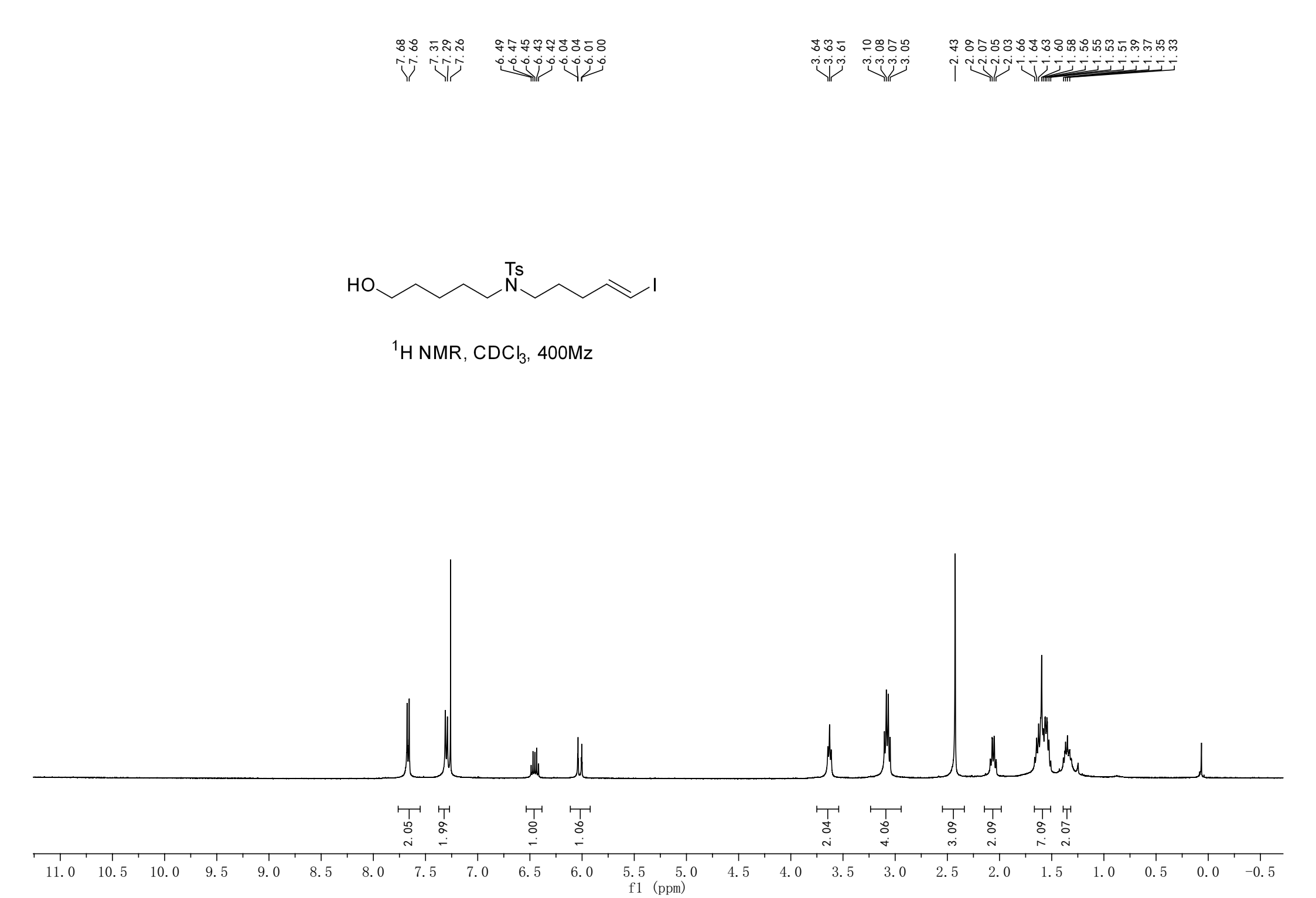

163.58
149.43
143.37
140.71
135.78
129.64
126.85
124.60
119.98
102.81
77.32
77.01
76.69
58.68
48.26
45.56
31.40
28.26
26.65
21.31
HO
Ts
N
N
O
H
N
O
1t
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

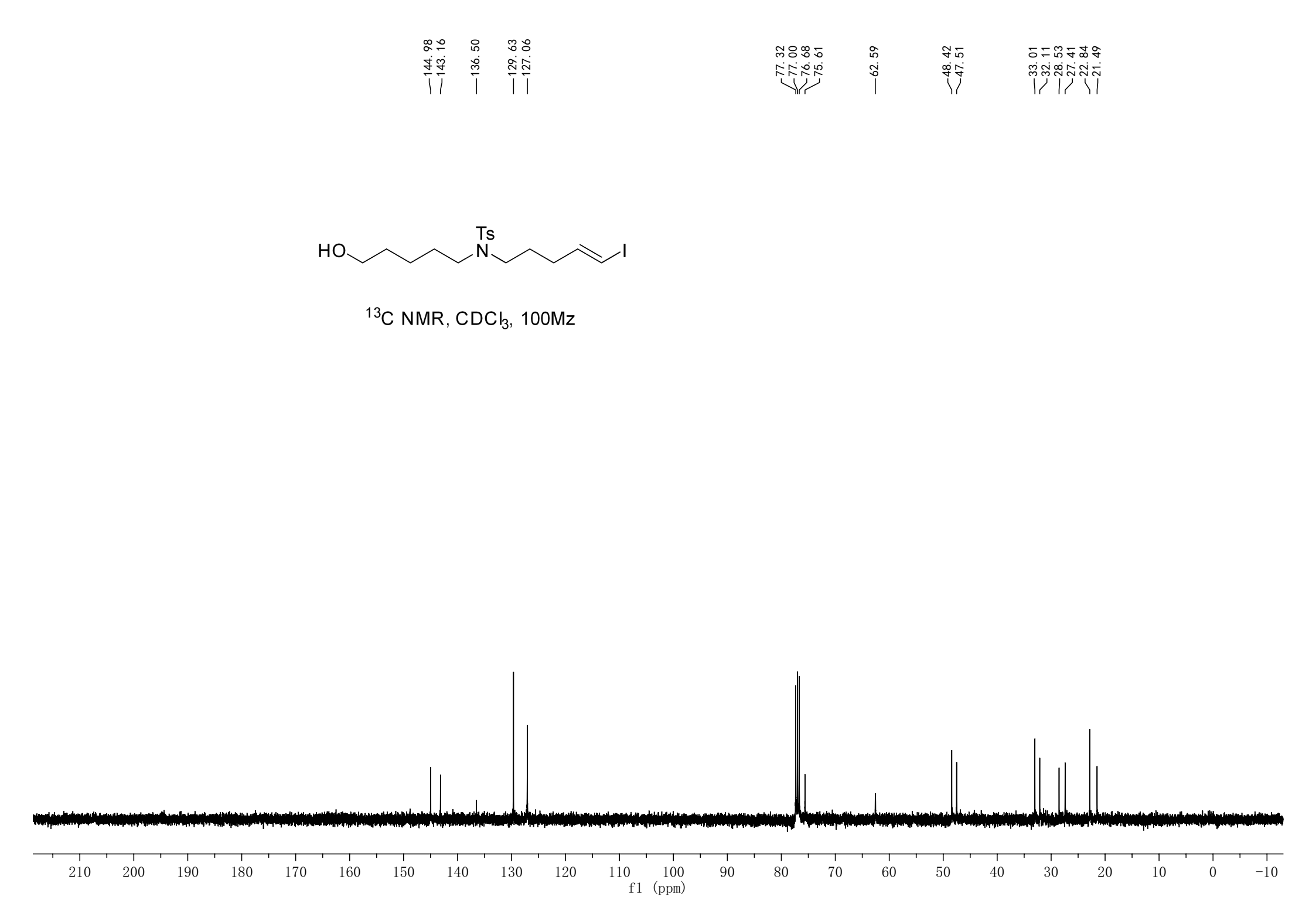

7.67
7.65
7.30
7.28
7.26
6.48
6.46
6.44
6.42
6.40
6.03
5.99
3.65
3.64
3.62
3.13
3.12
3.10
3.08
3.06
3.04
2.42
2.07
2.05
2.04
2.02
1.63
1.62
1.60
1.58
1.56
1.55
1.53
Ts
N
HO
I
1H NMR, CDCl3, 400Mz
2.15
2.25
0.99
1.00
2.12
4.13
3.00
2.19
8.28
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

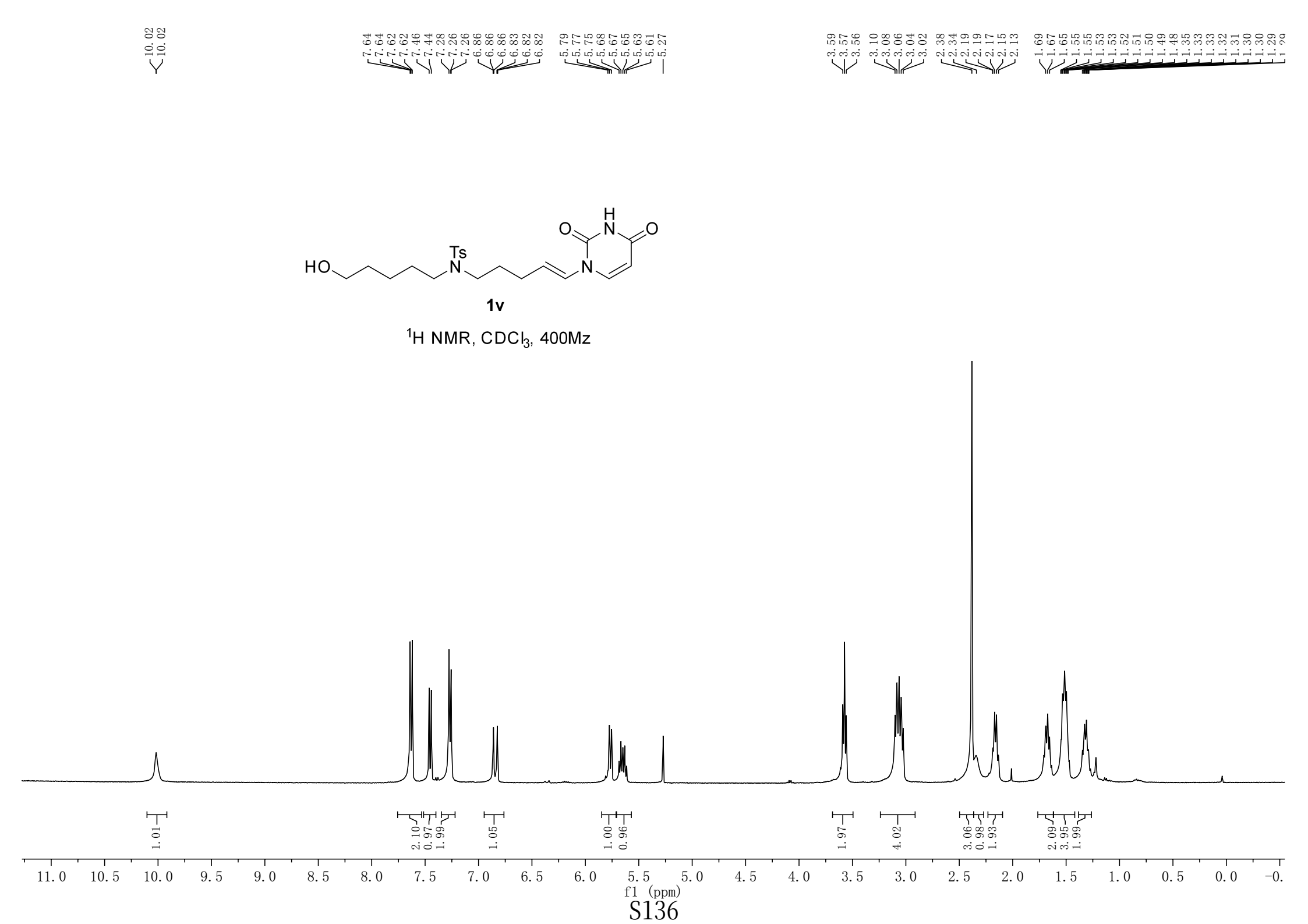

144.97
143.22
136.44
129.67
127.08
77.32
77.00
76.69
75.64
62.22
48.33
47.55
33.01
29.48
27.41
25.25
21.49
Ts
N
HO
I
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

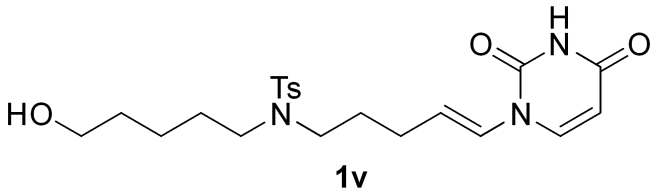

10.22
7.62
7.60
7.46
7.44
7.26
7.26
7.24
6.83
6.79
5.79
5.77
5.75
5.73
5.67
5.65
5.63
5.61
5.60
5.26
3.60
3.59
3.58
3.56
3.12
3.08
3.08
3.06
3.04
3.04
2.75
2.36
2.16
2.14
2.12
2.10
1.70
1.68
1.66
1.64
1.62
1.61
1.59
1.59
1.58
1.57
1.56
1.56
1.54
1.52
1.51
1.51
1.50
1.49
1.49
1.48
1.47
HO
Ts
N
N
N
H
O
O
1u
1H NMR, CDCl3, 400Mz
1.00
2.10
0.91
2.01
1.00
0.96
1.00
2.14
4.16
0.95
3.17
2.08
2.16
2.00
2.11
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


163.61
149.53
143.13
140.74
136.08
129.55
126.84
124.52
120.04
102.82
77.32
77.00
76.68
61.70
48.44
47.64
29.33
28.27
26.63
25.15
21.31
HO
Ts
N
N
H
N
O
O
1u
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


7.68
7.66
7.31
7.29
7.26
6.49
6.47
6.45
6.43
6.42
6.04
6.04
6.01
6.00
3.64
3.63
3.61
3.10
3.08
3.07
3.05
2.43
2.09
2.07
2.05
2.03
1.66
1.64
1.63
1.60
1.58
1.56
1.55
1.53
1.51
1.39
1.37
1.35
1.33
Ts
HO
N
I
1H NMR, CDCl3, 400Mz
2.05
1.99
1.00
1.06
2.04
4.06
3.09
2.09
7.09
2.07
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

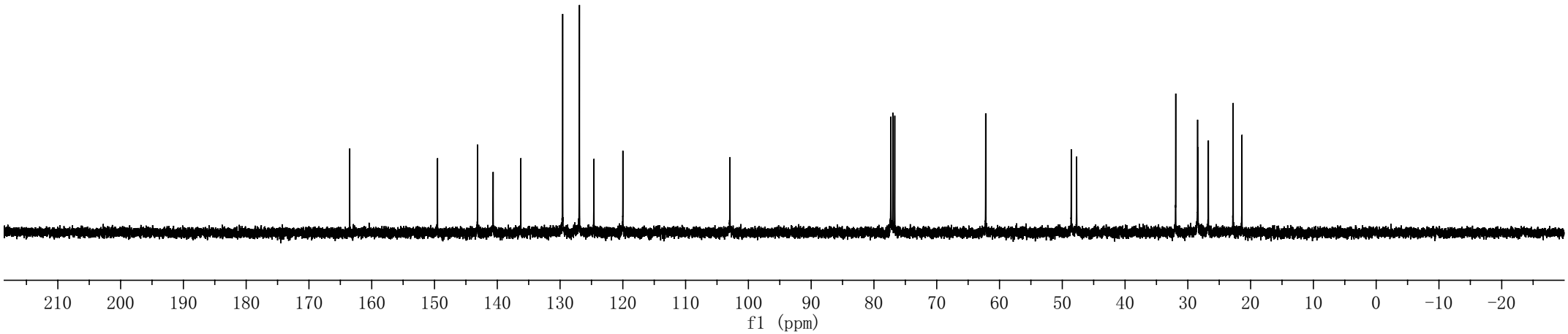

144.98
143.16
136.50
129.63
127.06
77.32
77.00
76.68
75.61
62.59
48.42
47.51
33.01
32.11
28.53
27.41
22.84
21.49
Ts
HO
N
I
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

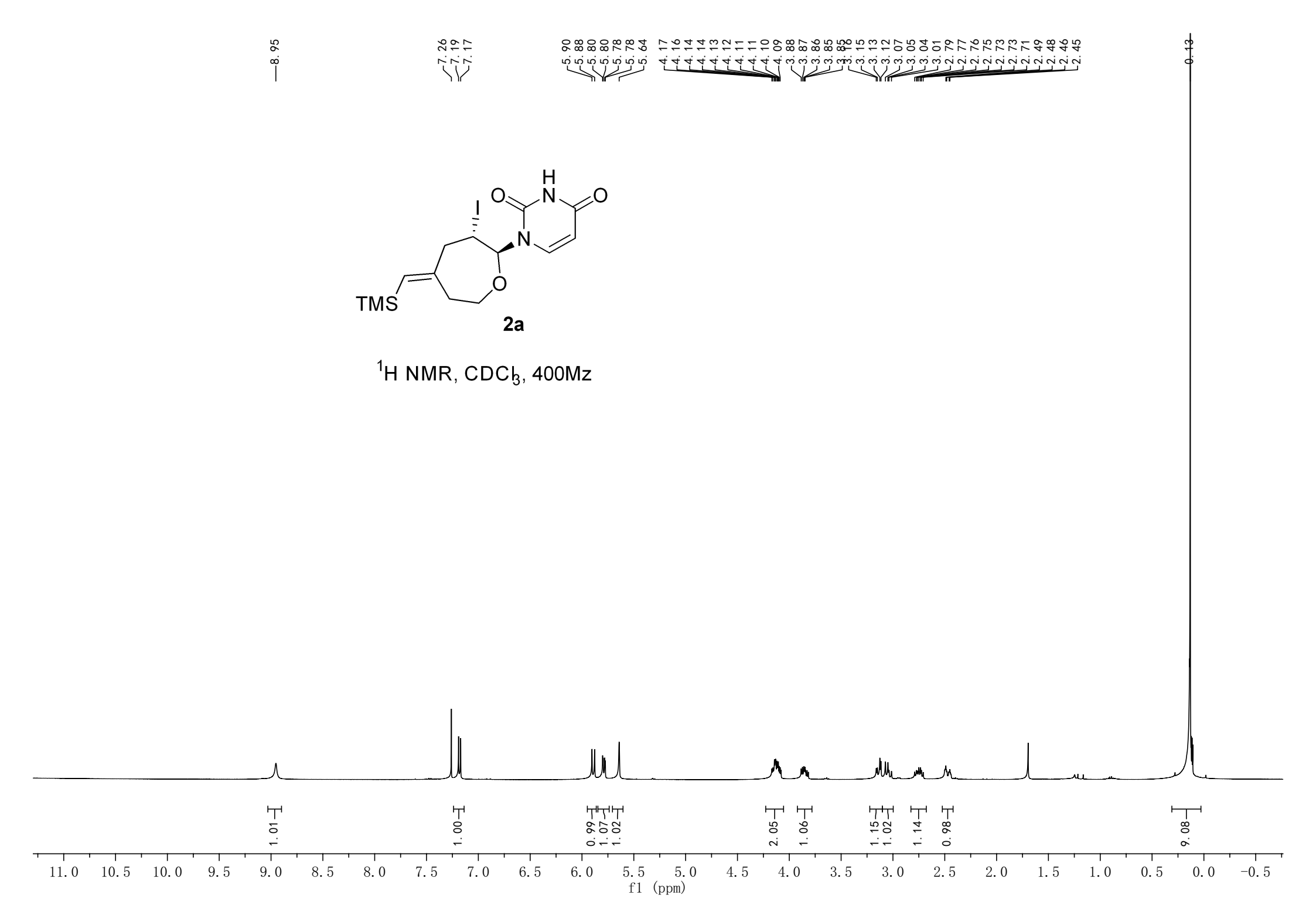

10.02
10.02
7.64
7.64
7.62
7.62
7.46
7.44
7.28
7.26
7.26
6.86
6.86
6.83
6.82
6.82
5.79
5.77
5.75
5.68
5.67
5.65
5.63
5.61
5.27
3.59
3.57
3.56
3.10
3.08
3.06
3.04
3.02
2.38
2.34
2.19
2.19
2.17
2.15
2.13
1.69
1.67
1.65
1.55
1.55
1.53
1.53
1.52
1.51
1.50
1.49
1.48
1.35
1.33
1.33
1.32
1.31
1.30
1.30
1.29
HO
Ts
N
O
H
N
O
N
1v
1H NMR, CDCl3, 400Mz
1.01
2.10
0.97
1.99
1.05
1.00
0.96
1.97
4.02
3.06
0.98
1.93
2.09
3.95
1.99
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.
f1 (ppm)

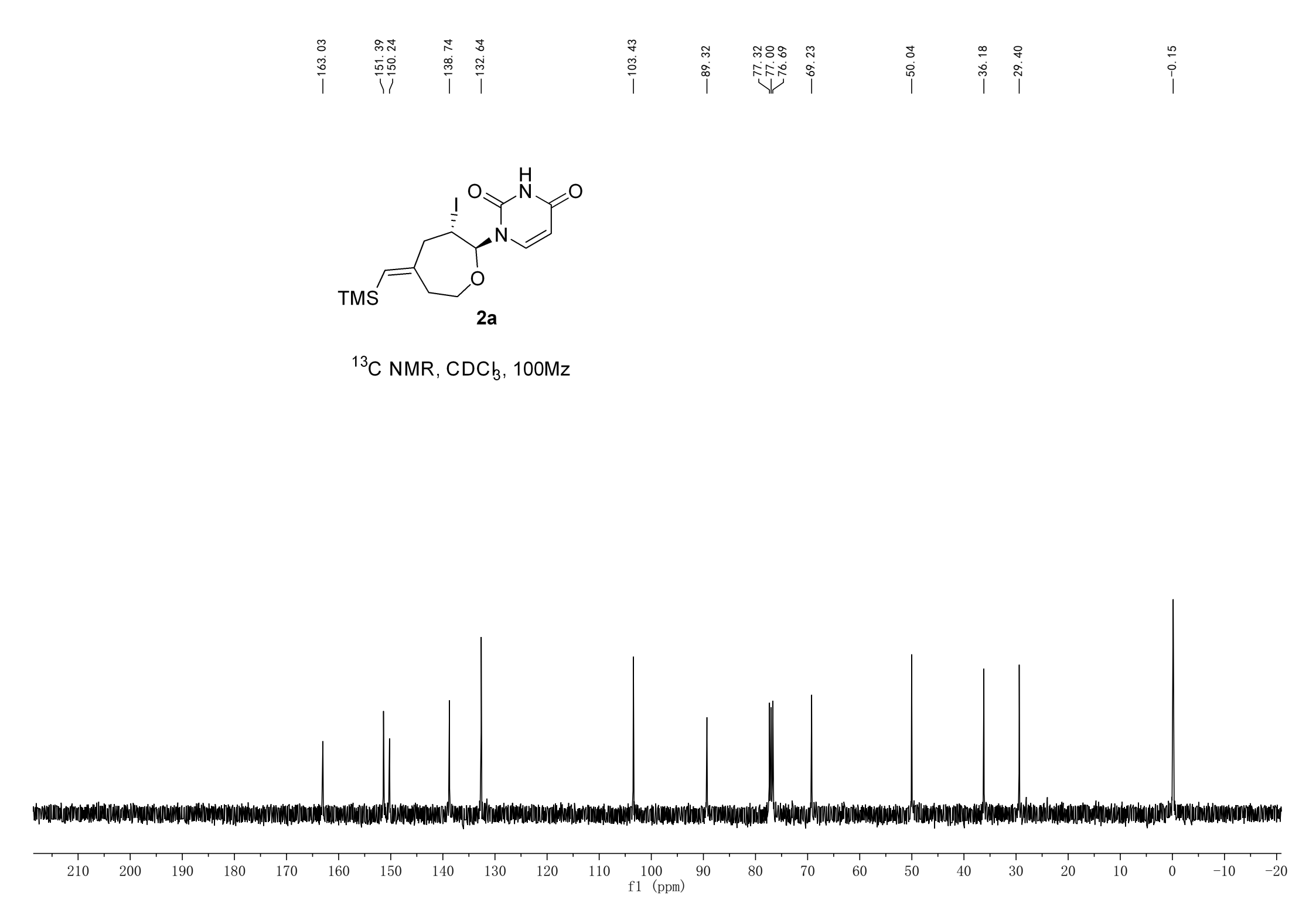


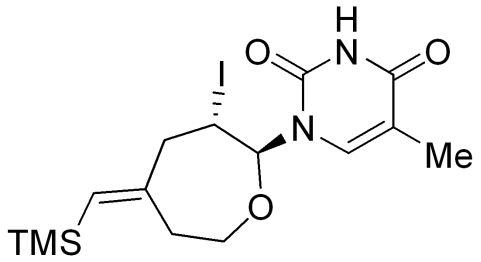
1v

^{13}C NMR, $CDCl_3$, 100Mz



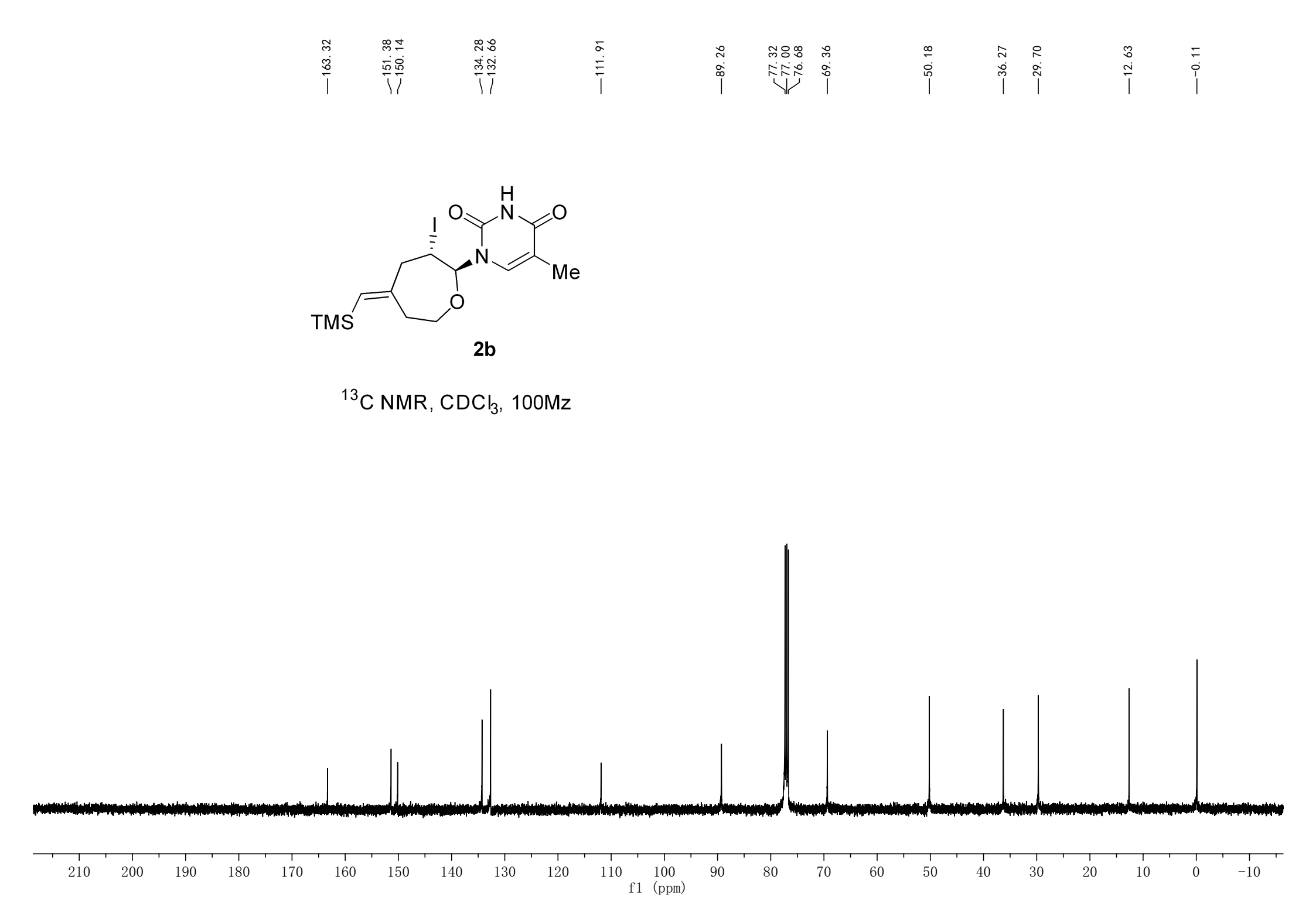

8.95
7.26
7.19
7.17
5.90
5.88
5.80
5.80
5.78
5.78
5.64
4.17
4.16
4.14
4.14
4.13
4.12
4.11
4.11
4.10
4.09
3.88
3.87
3.86
3.85
3.15
3.13
3.12
3.07
3.05
3.04
3.01
2.79
2.77
2.76
2.75
2.73
2.73
2.71
2.49
2.48
2.46
2.45
0.13
H
N
O
O
I
N
O
TMS
2a
1H NMR, CDCl3, 400Mz
1.01
1.00
0.99
1.07
1.02
2.05
1.06
1.15
1.02
1.14
0.98
9.08
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

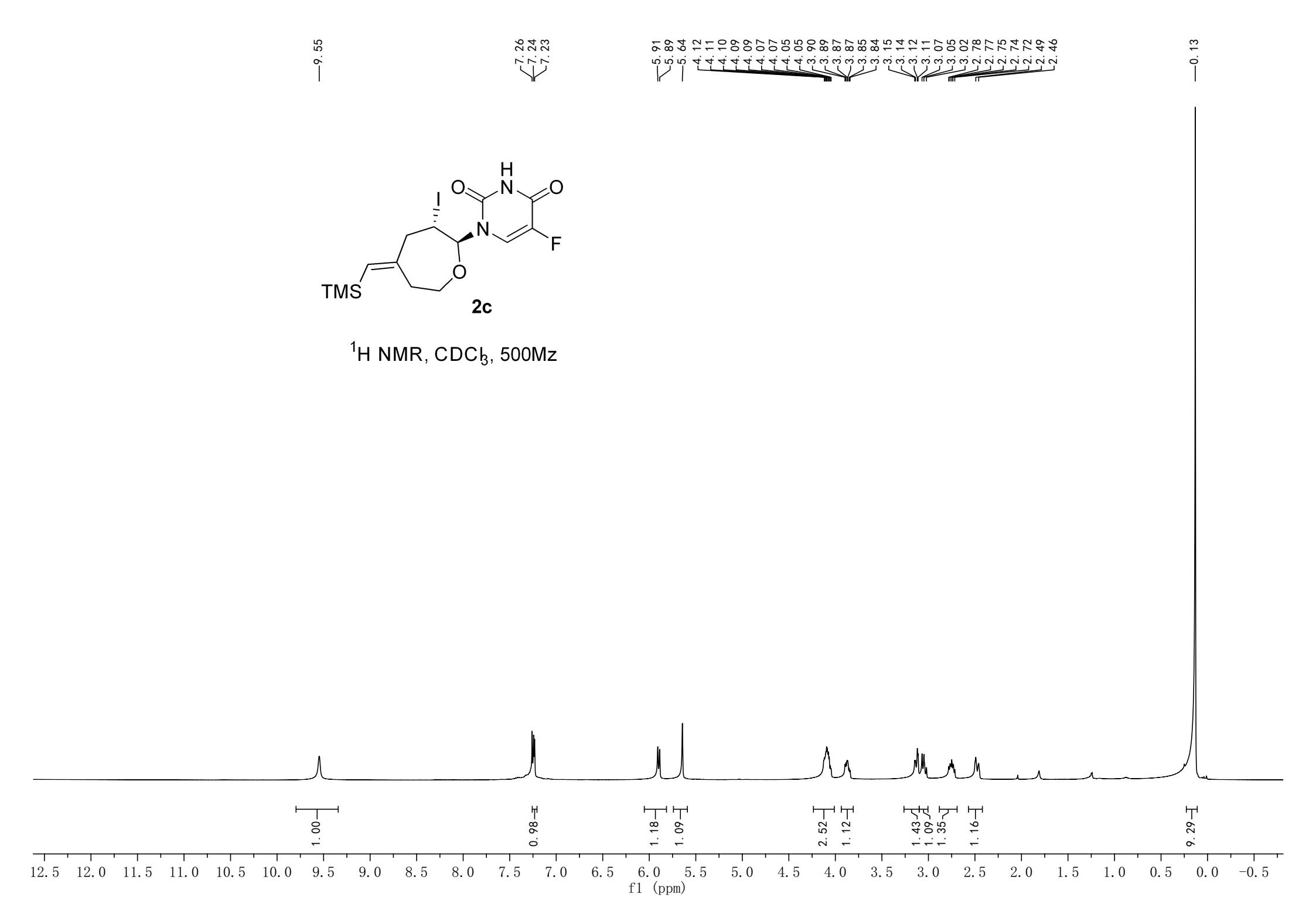

163.03
151.39
150.24
138.74
132.64
103.43
89.32
77.32
77.00
76.69
69.23
50.04
36.18
29.40
-0.15
H
N
O
O
I
N
O
TMS
2a
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)

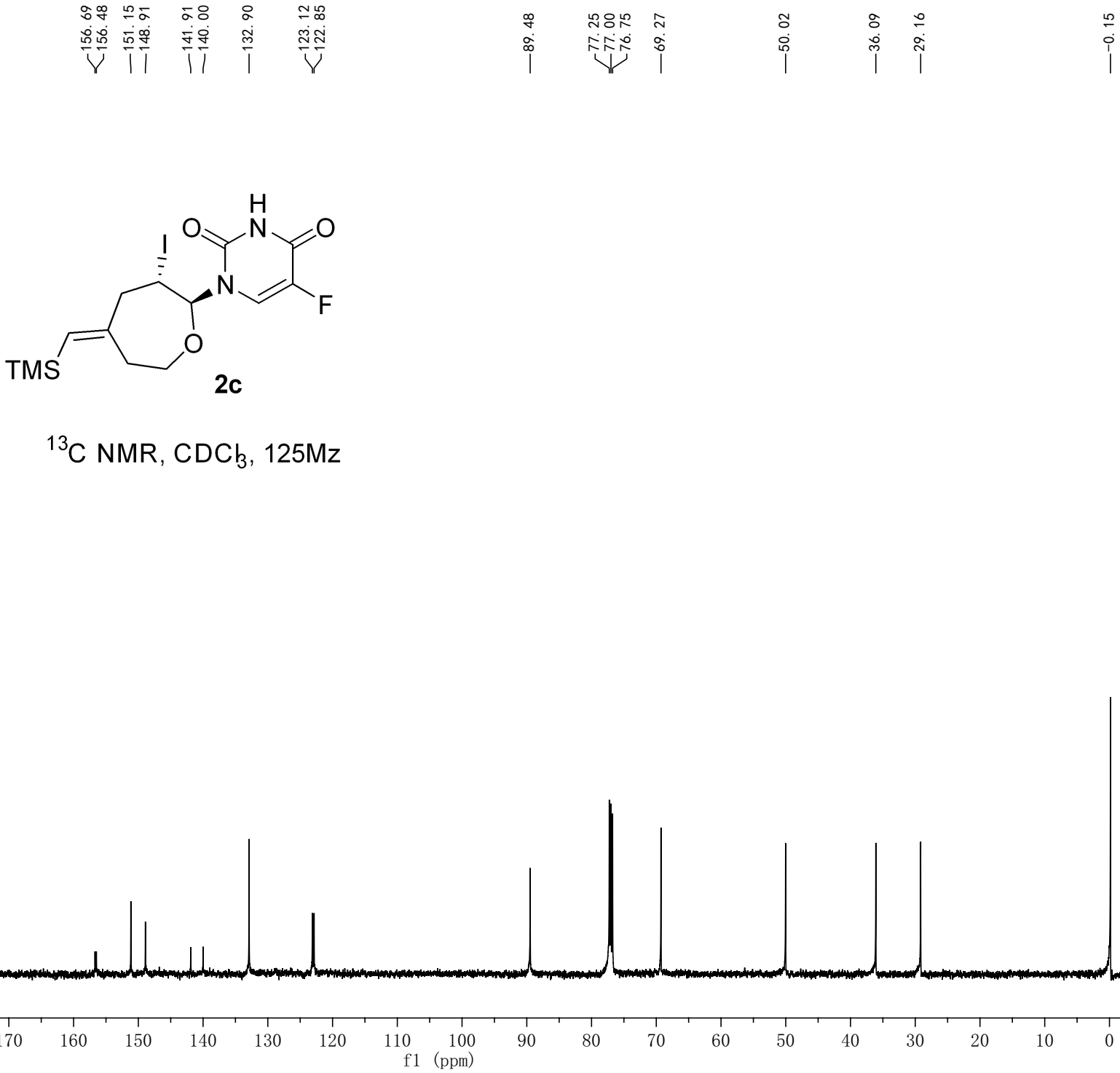


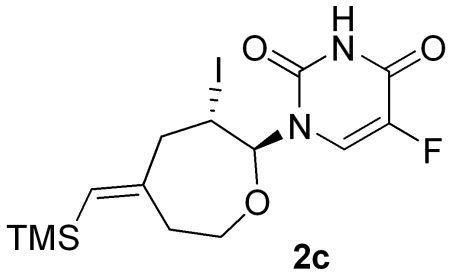
2b

^{1}H NMR, $CDCl_3$, 500Mz


163.32
151.38
150.14
134.28
132.66
111.91
89.26
77.32
77.00
76.68
69.36
50.18
36.27
29.70
12.63
-0.11
H
N
O
O
N
I
Me
O
TMS
2b
13C NMR, CDCl3, 100Mz
f1 (ppm)

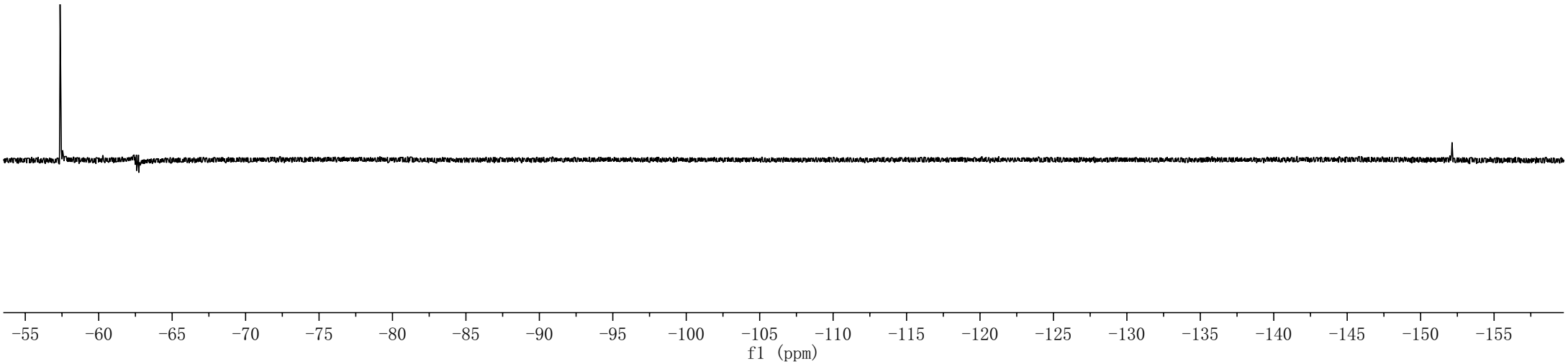

9.55
7.26
7.24
7.23
5.91
5.89
5.64
4.12
4.11
4.10
4.09
4.09
4.07
4.07
4.05
4.05
3.90
3.89
3.87
3.87
3.85
3.84
3.15
3.14
3.12
3.11
3.07
3.05
3.02
2.78
2.77
2.75
2.74
2.72
2.49
2.46
0.13
H
N
O
O
I
N
F
O
TMS
2c
1H NMR, CDCl3, 500Mz
1.00
0.98
1.18
1.09
2.52
1.12
1.43
1.09
1.35
1.16
9.29
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

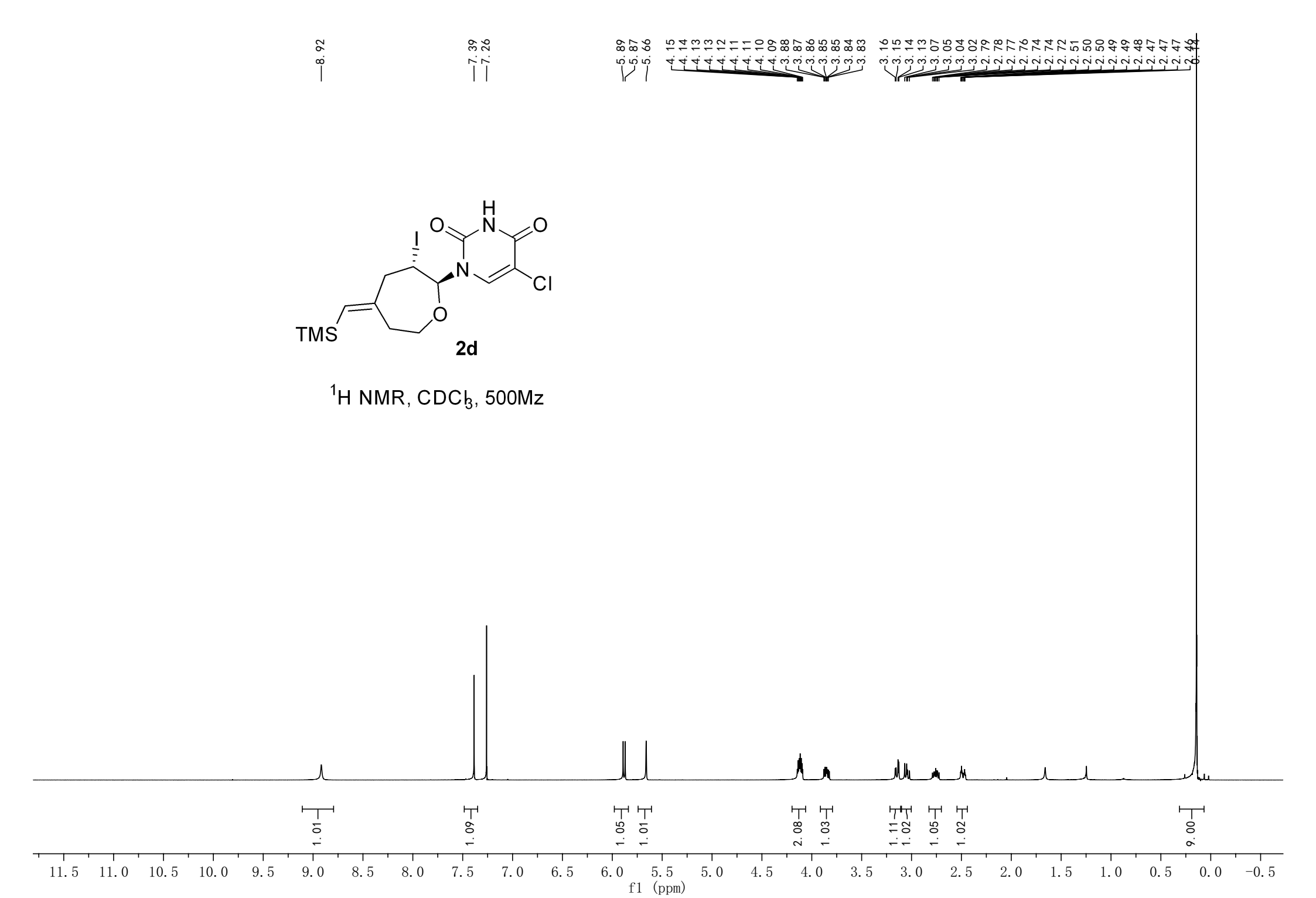

156.69
156.48
151.15
148.91
141.91
140.00
132.90
123.12
122.85
89.48
77.25
77.00
76.75
69.27
50.02
36.09
29.16
-0.15
H
N
O
O
N
I
F
O
TMS
2c
^{13}C NMR, CDCl$_3$, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

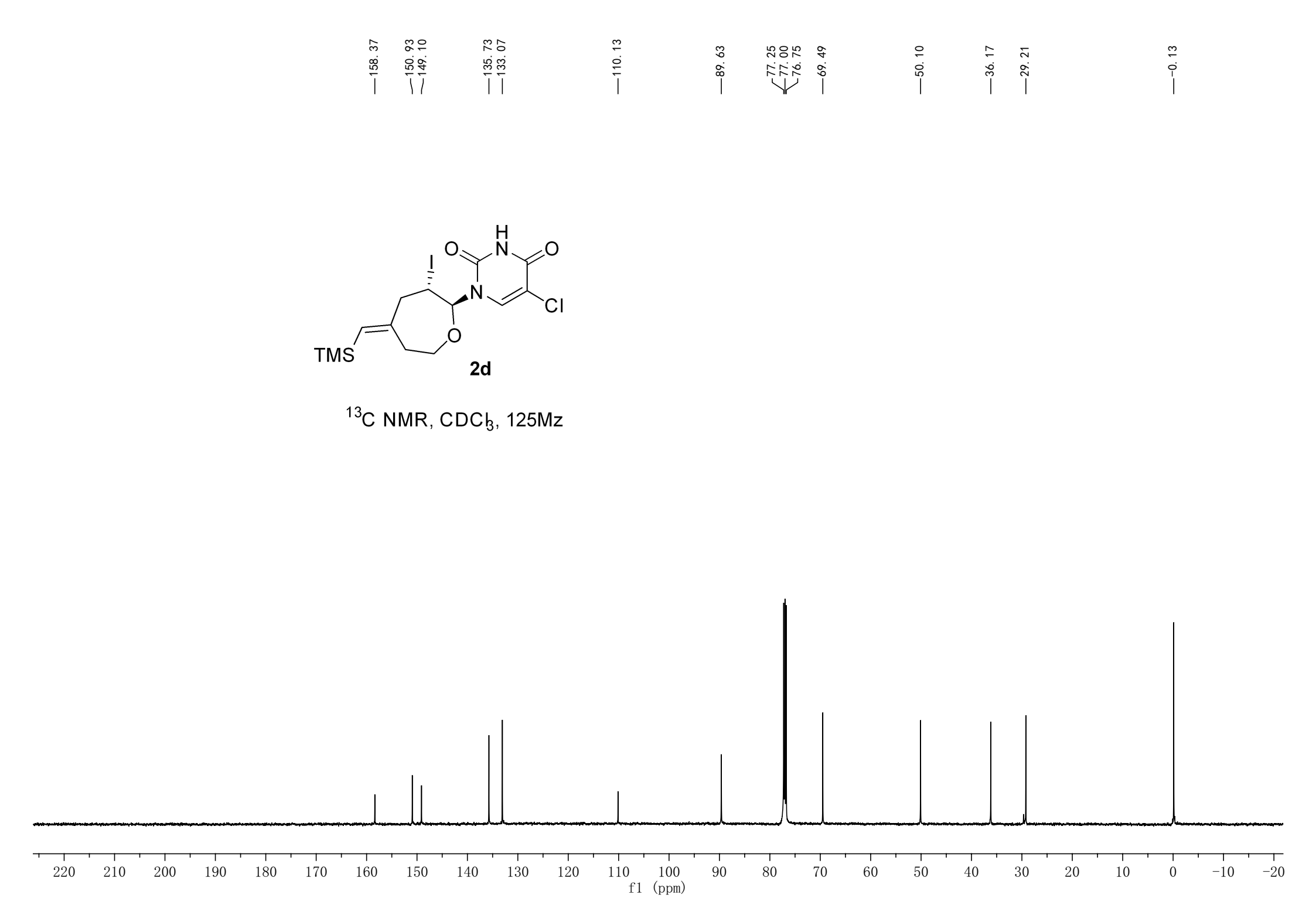


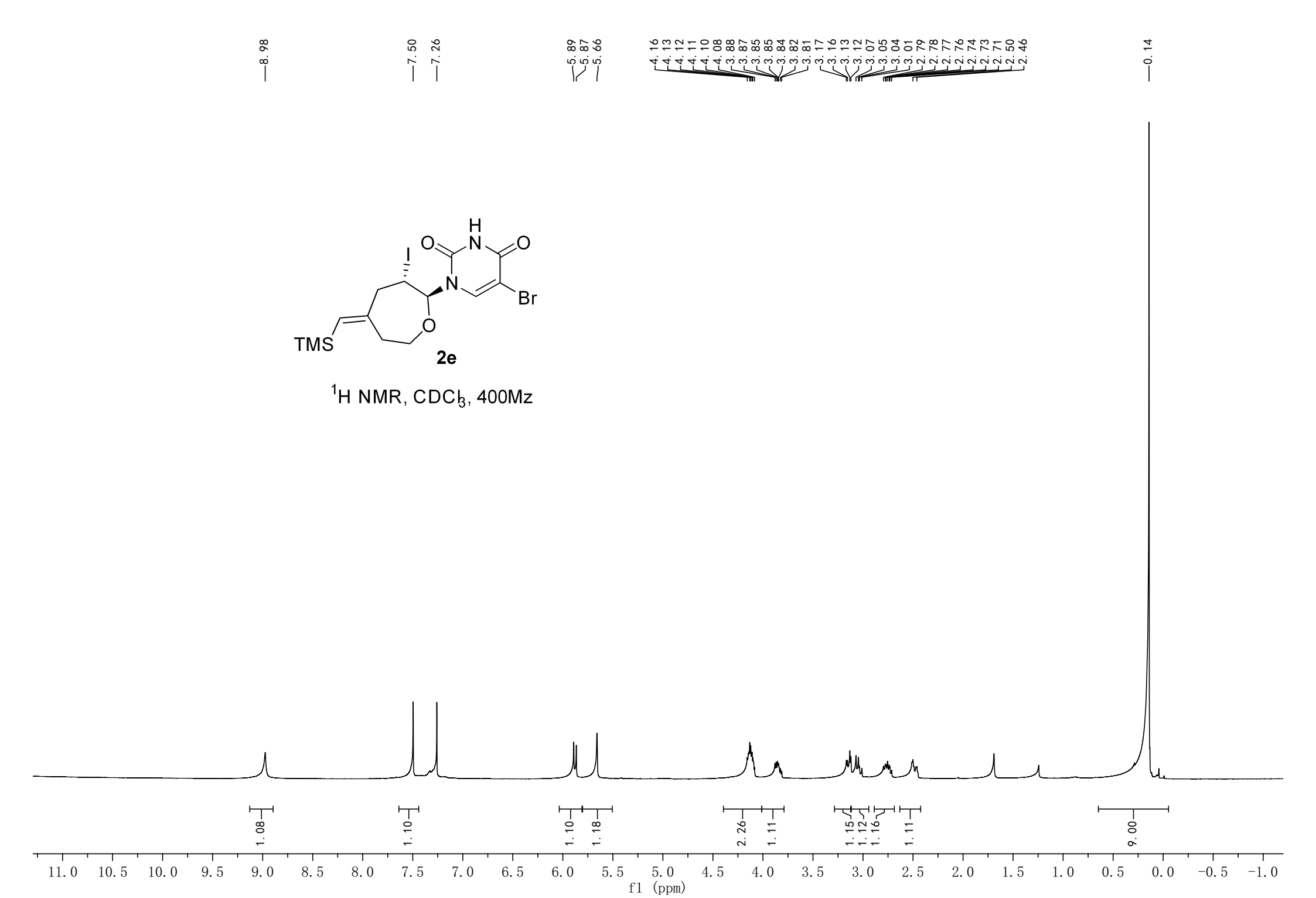
2c

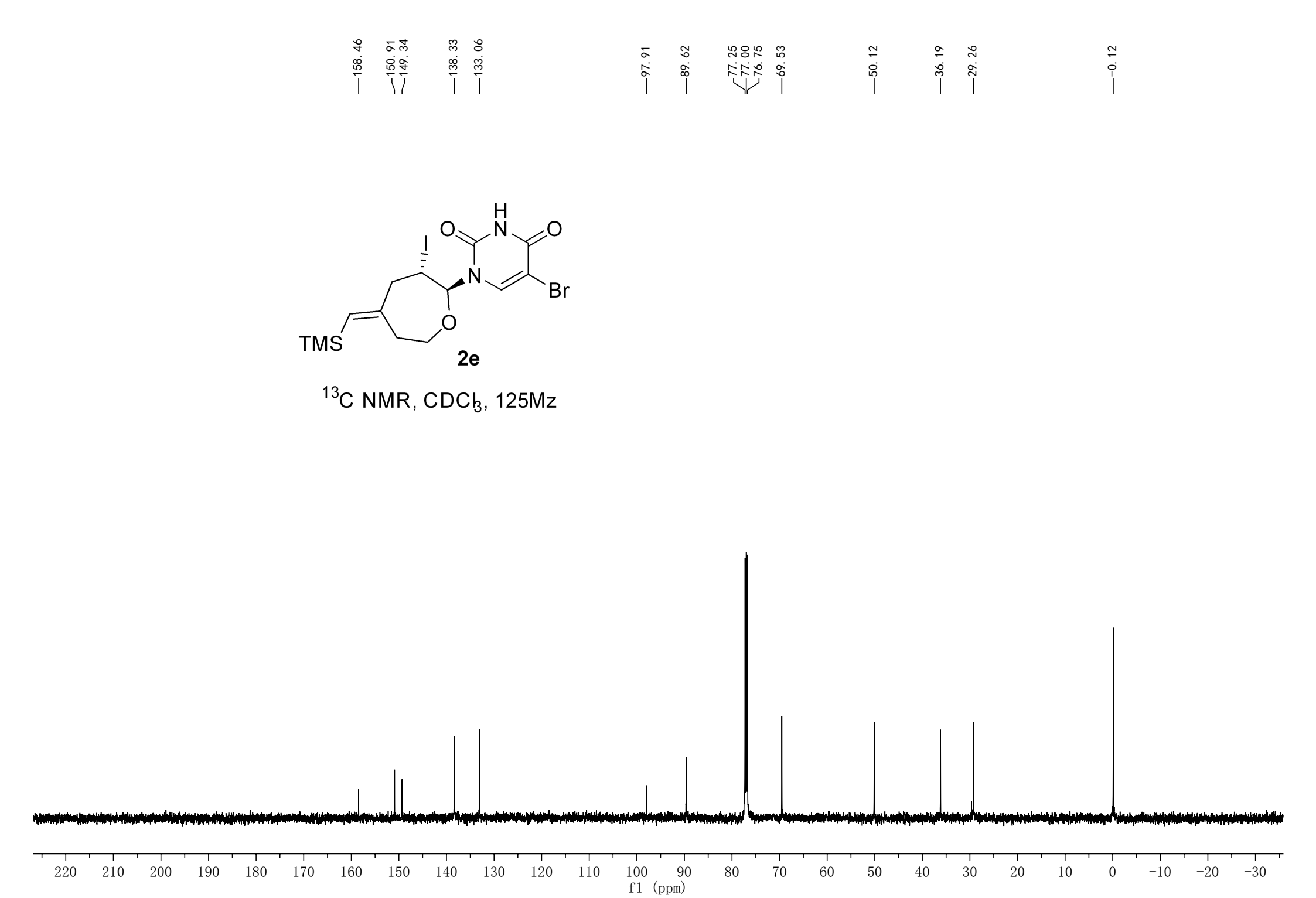
^{19}F NMR, CD_3Cl, 376 Mz

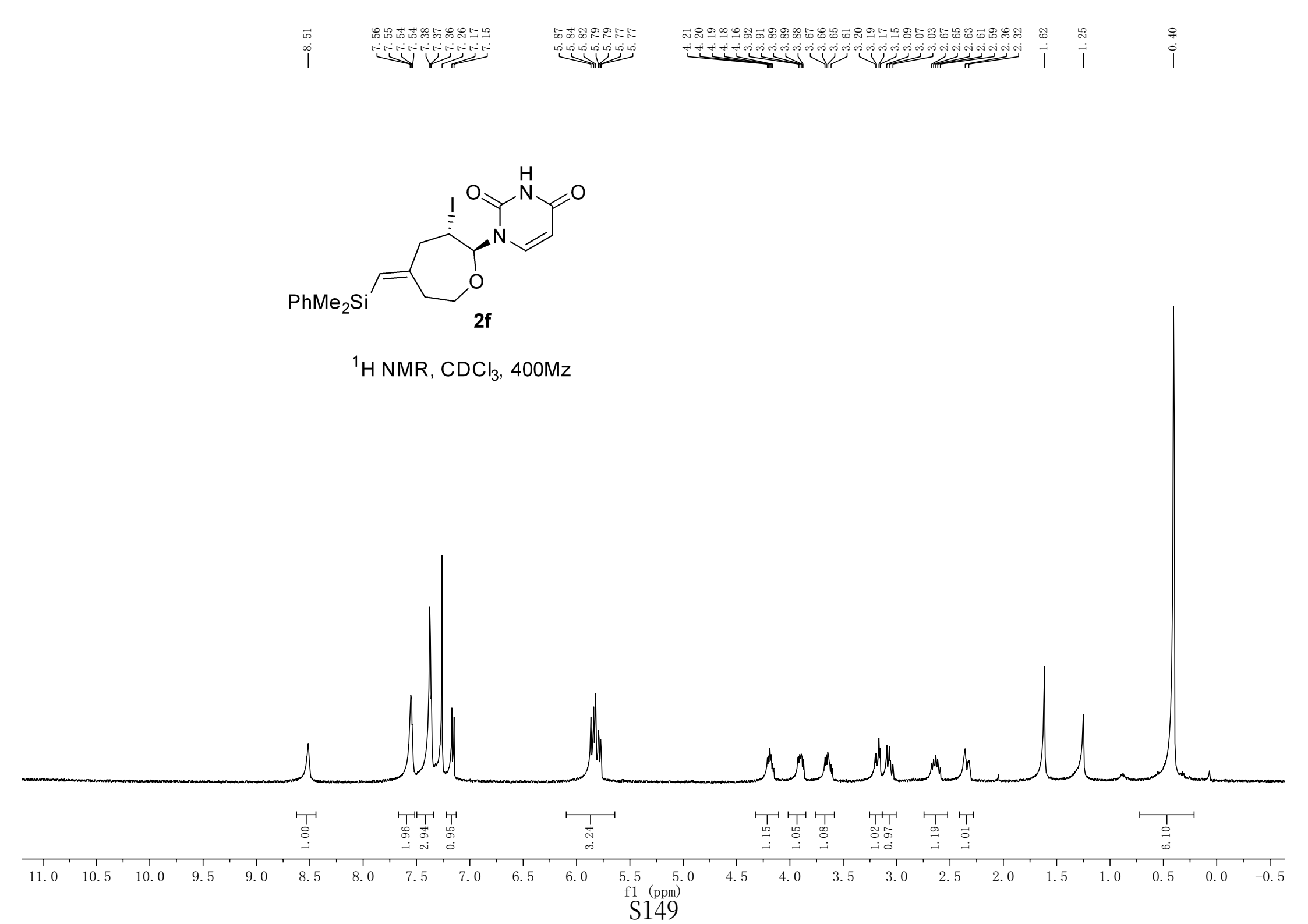


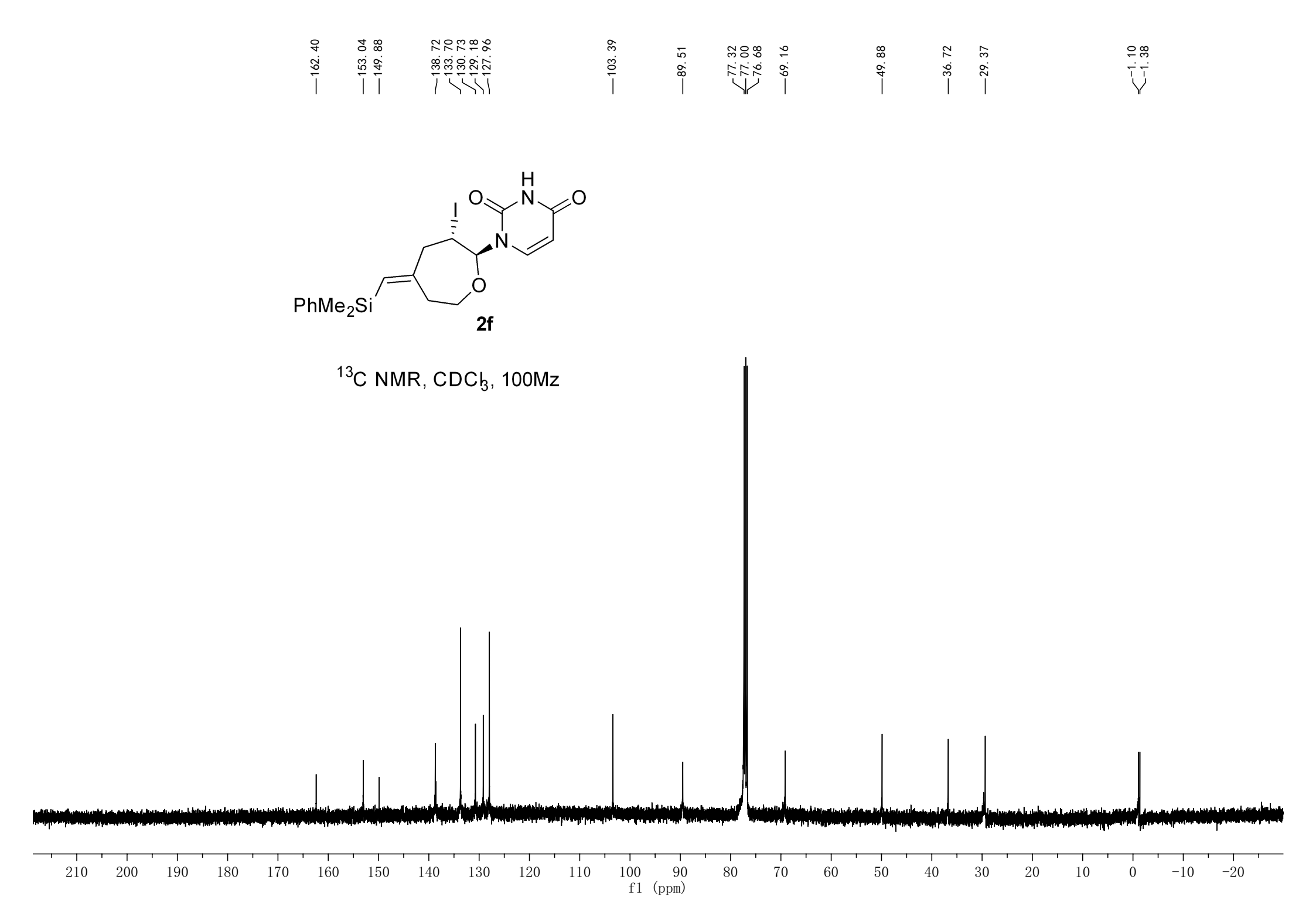

8.92
7.39
7.26
5.89
5.87
5.66
4.15
4.14
4.13
4.13
4.12
4.11
4.11
4.10
4.09
3.88
3.87
3.86
3.85
3.85
3.84
3.83
3.16
3.15
3.14
3.13
3.07
3.05
3.04
3.02
2.79
2.78
2.77
2.76
2.74
2.74
2.72
2.51
2.50
2.50
2.49
2.49
2.48
2.47
2.47
2.46
H
N
O
O
O
N
I
Cl
O
TMS
2d
1H NMR, CDCl3, 500Mz
1.01
1.09
1.05
1.01
2.08
1.03
1.11
1.02
1.05
1.02
9.00
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

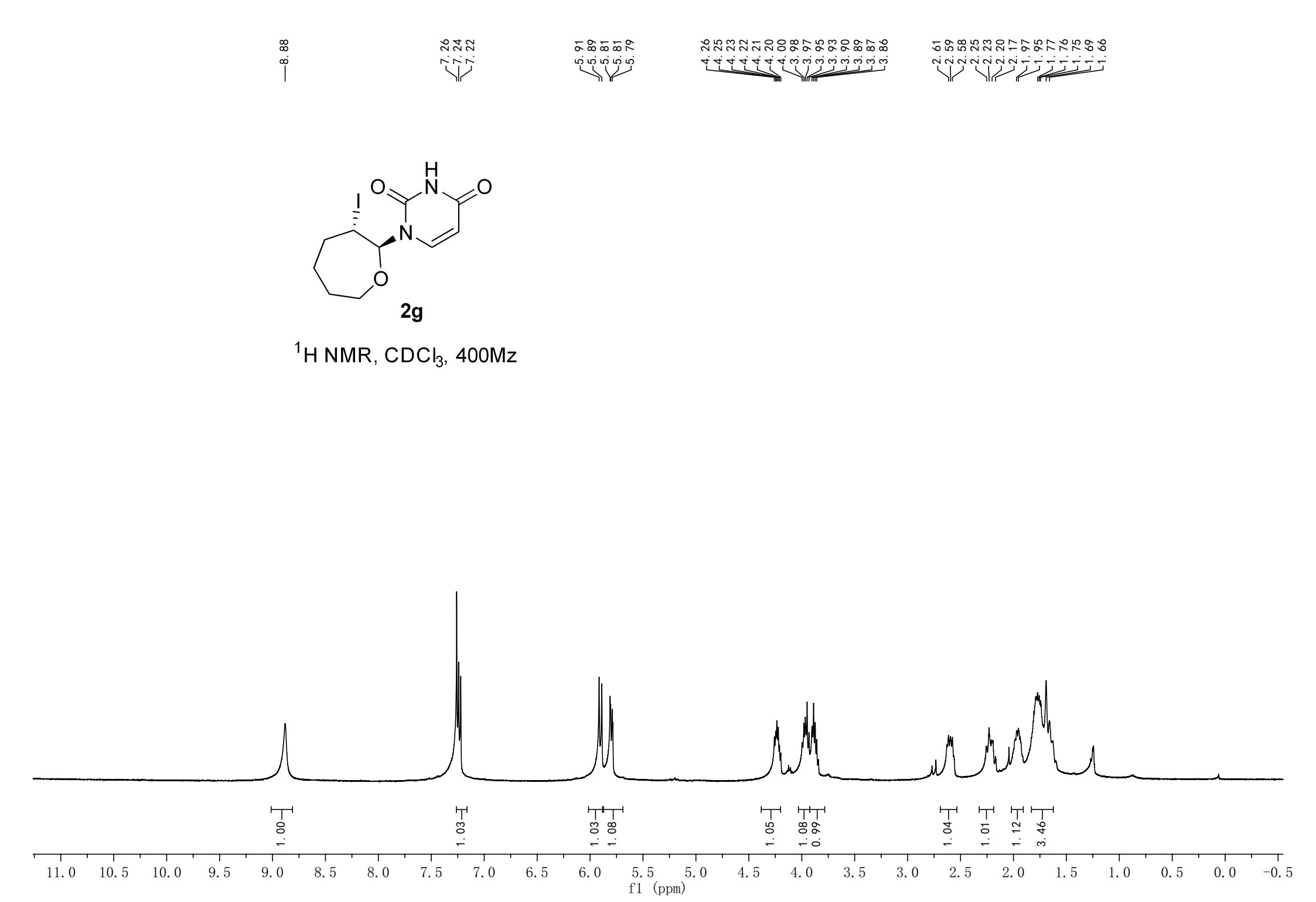

158.37
150.93
149.10
135.73
133.07
110.13
89.63
77.25
77.00
76.75
69.49
50.10
36.17
29.21
-0.13
H
N
O
O
N
I
Cl
O
TMS
2d
13C NMR, CDCl3, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
f1 (ppm)

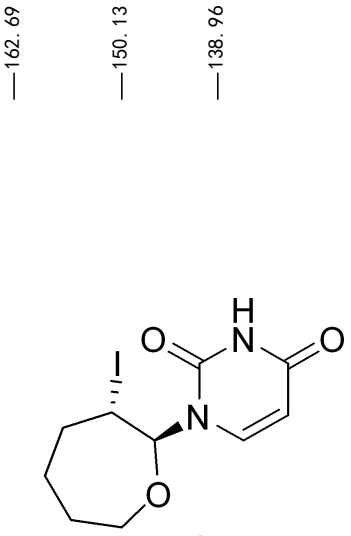

8.98
7.50
7.26
5.89
5.87
5.66
4.16
4.13
4.12
4.11
4.10
4.08
3.88
3.87
3.85
3.85
3.84
3.82
3.81
3.17
3.16
3.13
3.12
3.07
3.05
3.04
3.01
2.79
2.78
2.77
2.76
2.74
2.73
2.71
2.50
2.46
0.14
H
N
O
O
N
I
Br
O
TMS
2e
1H NMR, CDCl3, 400Mz
1.08
1.10
1.10
1.18
2.26
1.11
1.15
1.12
1.16
1.11
9.00
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
f1 (ppm)


158.46
150.91
149.34
138.33
133.06
97.91
89.62
77.25
77.00
76.75
69.53
50.12
36.19
29.26
-0.12
H
N
O
O
N
I
Br
O
TMS
2e
13C NMR, CDCl3, 125Mz
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30
f1 (ppm)


8.51
7.56
7.55
7.54
7.54
7.38
7.37
7.36
7.26
7.17
7.15
5.87
5.84
5.82
5.79
5.79
5.77
5.77
4.21
4.20
4.19
4.18
4.16
3.92
3.91
3.89
3.89
3.88
3.67
3.66
3.65
3.61
3.20
3.19
3.17
3.15
3.09
3.07
3.03
2.67
2.65
2.63
2.61
2.59
2.36
2.32
1.62
1.25
0.40
H
N
O
O
N
O
I
PhMe2Si
2f
1H NMR, CDCl3, 400Mz
1.00
1.96
2.94
0.95
3.24
1.15
1.05
1.08
1.02
0.97
1.19
1.01
6.10
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

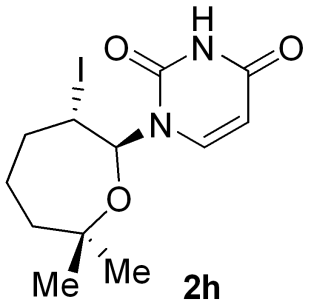

162.40
153.04
149.88
138.72
133.70
130.73
129.18
127.96
103.39
89.51
77.32
77.00
76.68
69.16
49.88
36.72
29.37
1.10
1.38
PhMe2Si
2f
13C NMR, CDCl3, 100Mz
f1 (ppm)


8.88
7.26
7.24
7.22
5.91
5.89
5.81
5.81
5.79
4.26
4.25
4.23
4.22
4.21
4.20
4.00
3.98
3.97
3.95
3.93
3.90
3.89
3.87
3.86
2.61
2.59
2.58
2.25
2.23
2.20
2.17
1.97
1.95
1.77
1.76
1.75
1.69
1.66
H
N
O
O
I
N
O
2g
1H NMR, CDCl3, 400Mz
1.00
1.03
1.03
1.08
1.05
1.08
0.99
1.04
1.01
1.12
3.46
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)



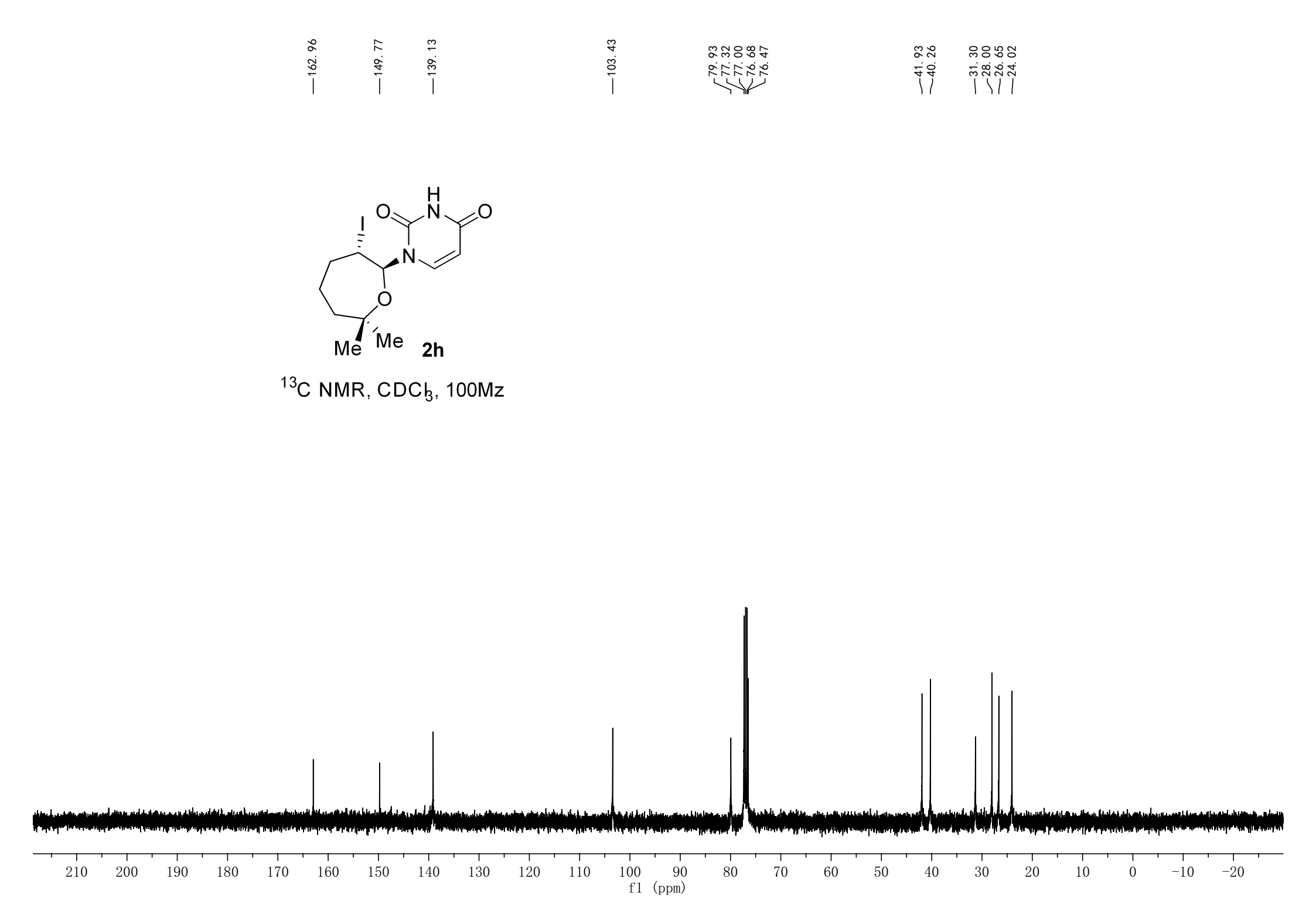
2g

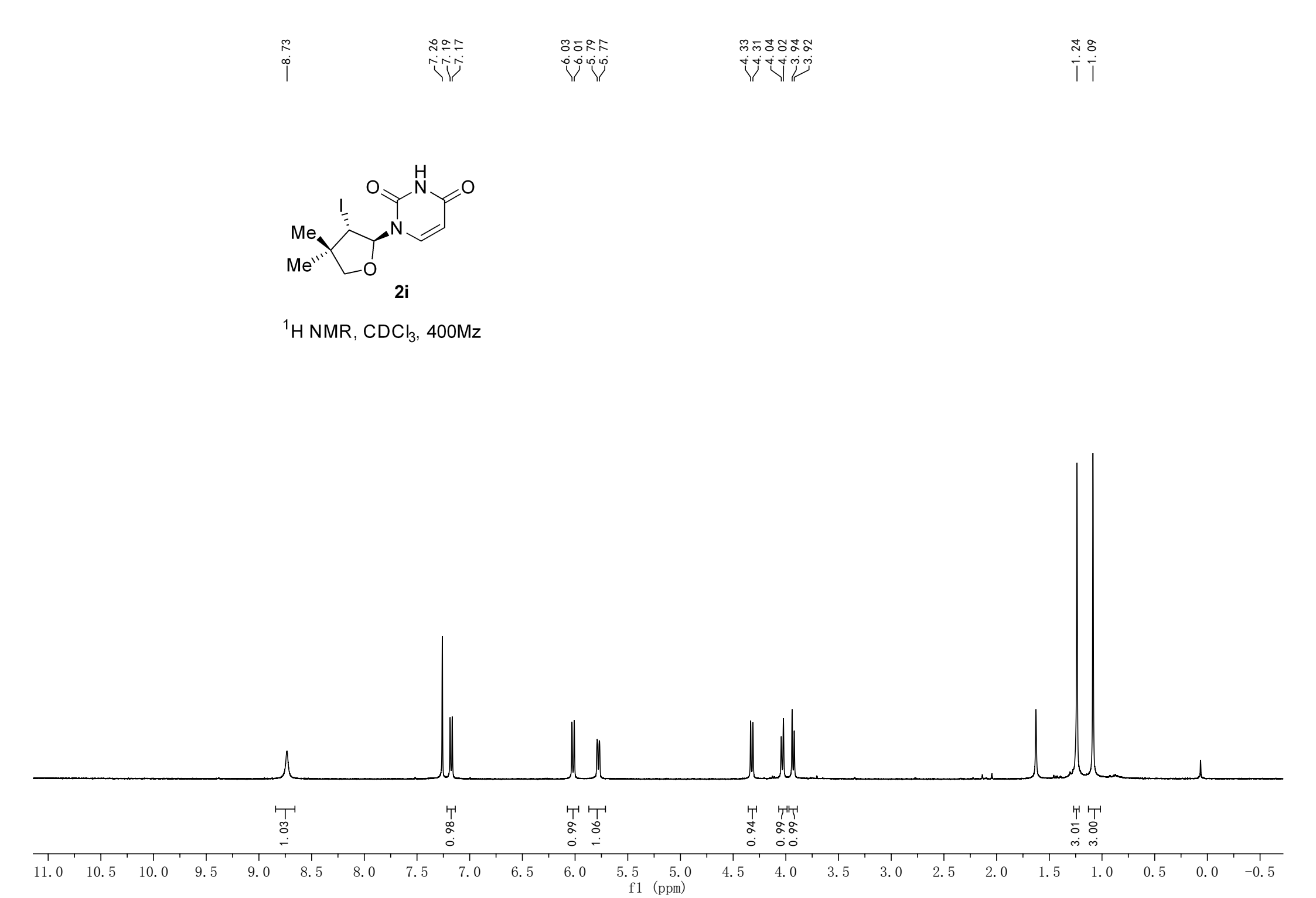
^{13}C NMR, $CDCl_3$, 100Mz

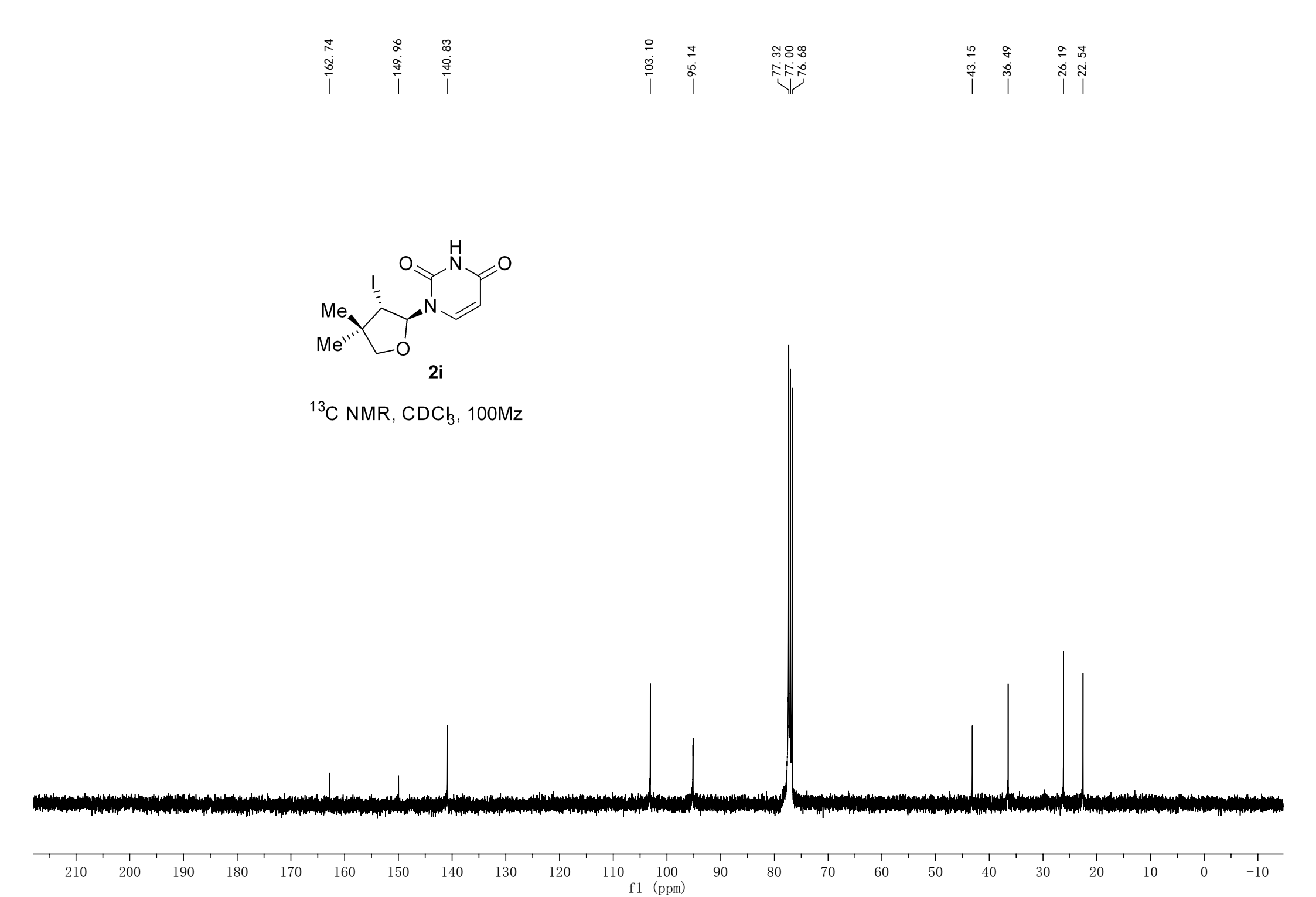


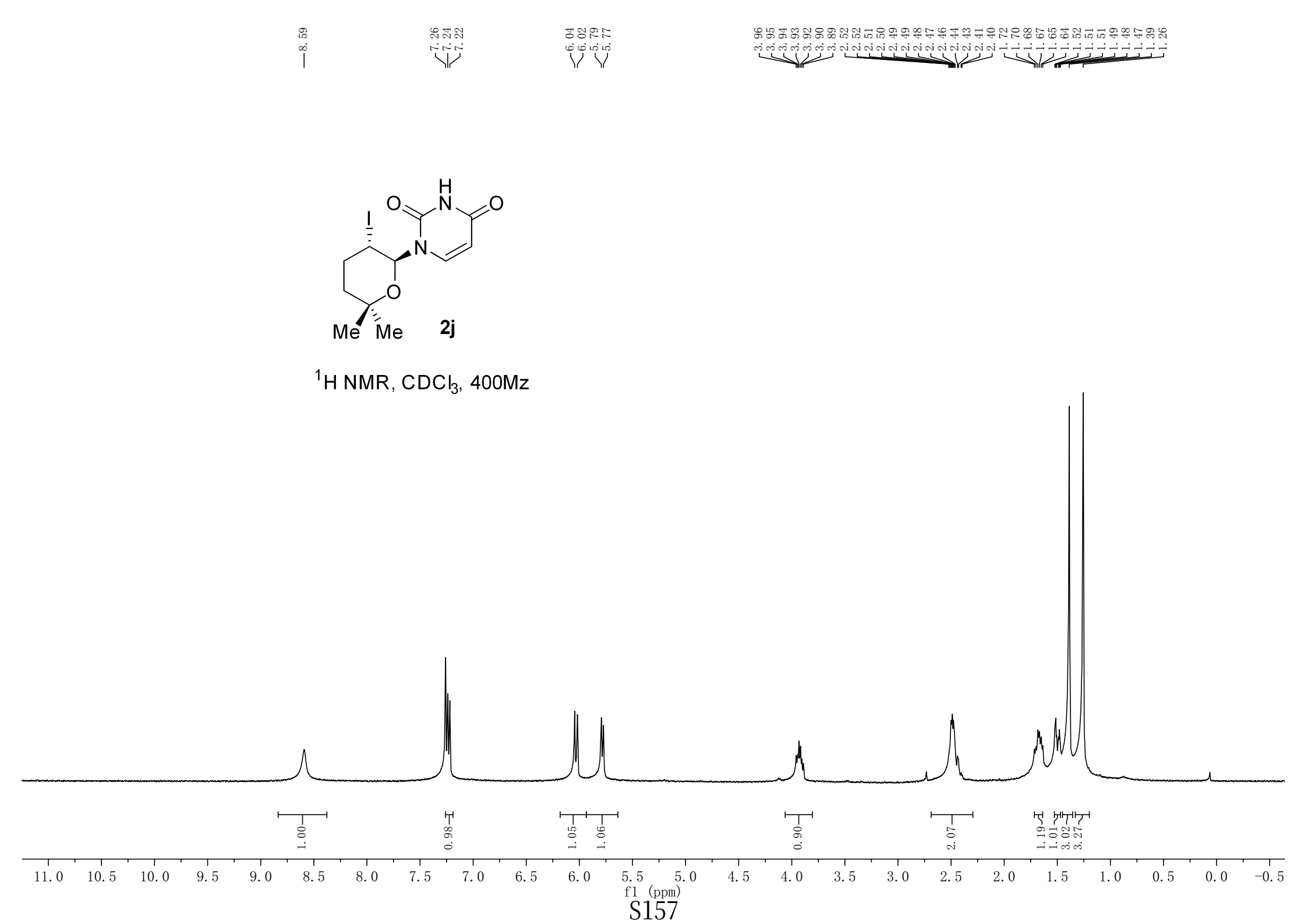
2h

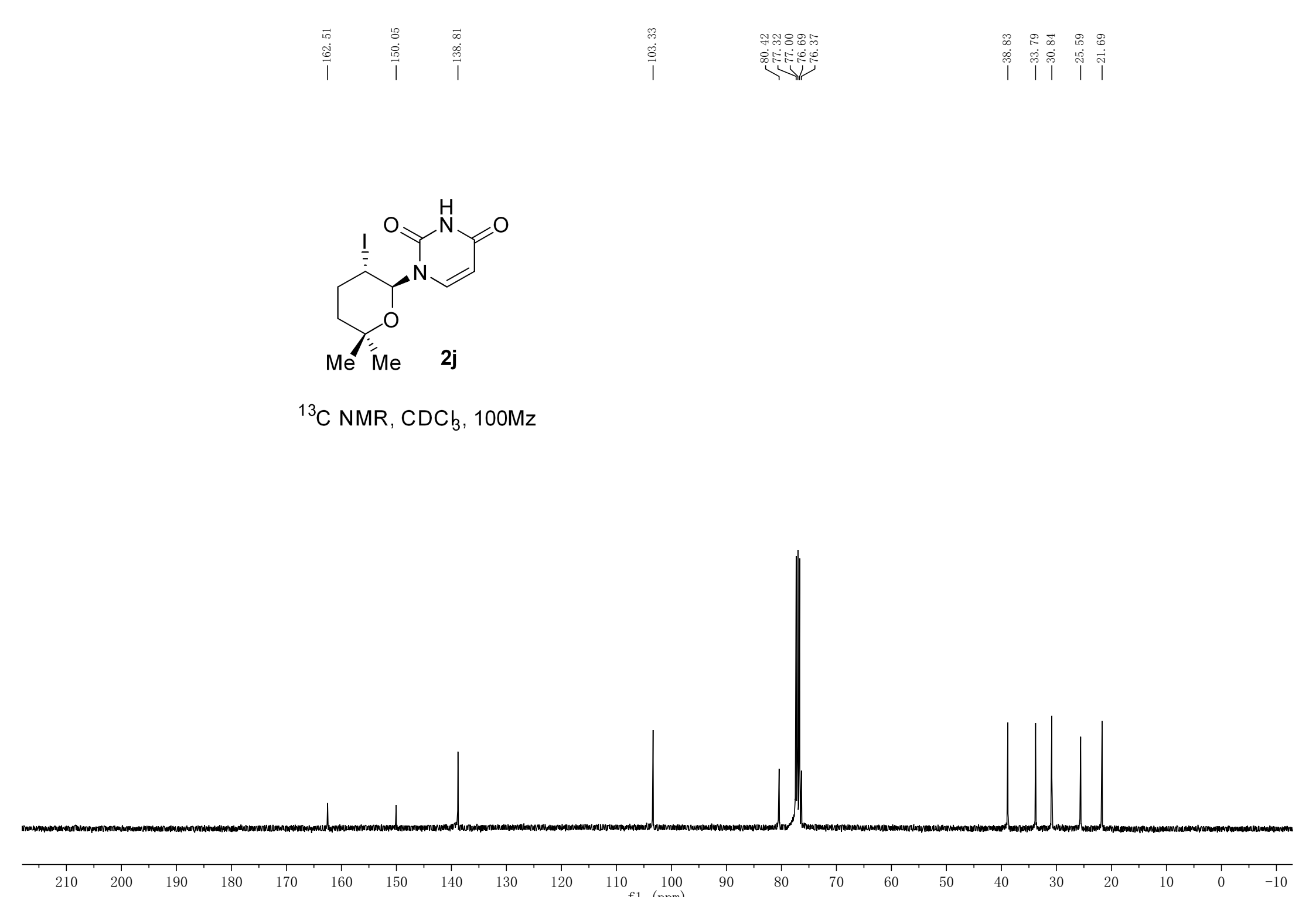
^{1}H NMR, $CDCl_3$, 500Mz

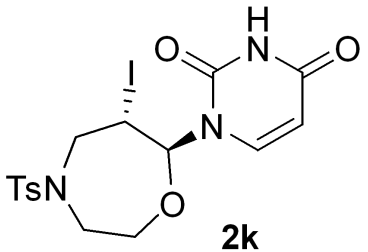

162.96
149.77
139.13
103.43
79.93
77.32
77.00
76.68
76.47
41.93
40.26
31.30
28.00
26.65
24.02
H
N
O
O
N
O
I
Me
Me
2h
13C NMR, CDCl3, 100Mz
f1 (ppm)


8.73
7.26
7.19
7.17
6.03
6.01
5.79
5.77
4.33
4.31
4.04
4.02
3.94
3.92
1.24
1.09
H
N
O
O
I
N
Me
Me
O
2i
1H NMR, CDCl3, 400Mz
1.03
0.98
0.99
1.06
0.94
0.99
0.99
3.01
3.00
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


162.74
149.96
140.83
103.10
95.14
77.32
77.00
76.68
43.15
36.49
26.19
22.54
H
N
O
O
N
I
Me
Me
O
2i
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

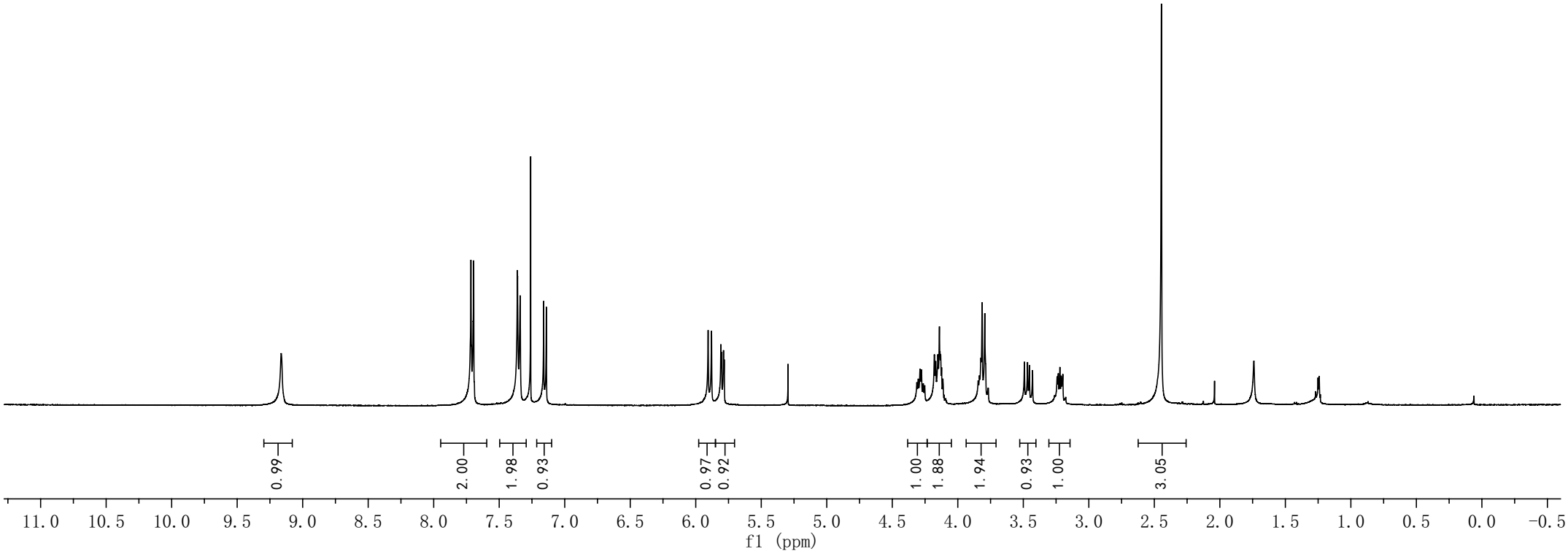

8.59
7.26
7.24
7.22
6.04
6.02
5.79
5.77
3.96
3.95
3.94
3.93
3.92
3.90
3.89
2.52
2.52
2.51
2.50
2.49
2.49
2.48
2.47
2.46
2.44
2.43
2.41
2.40
1.72
1.70
1.68
1.67
1.65
1.64
1.52
1.51
1.51
1.49
1.48
1.47
1.39
1.26
H
N
O
O
I
N
O
Me
Me
2j
1H NMR, CDCl3, 400Mz
1.00
0.98
1.05
1.06
0.90
2.07
1.19
1.01
3.02
3.27
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

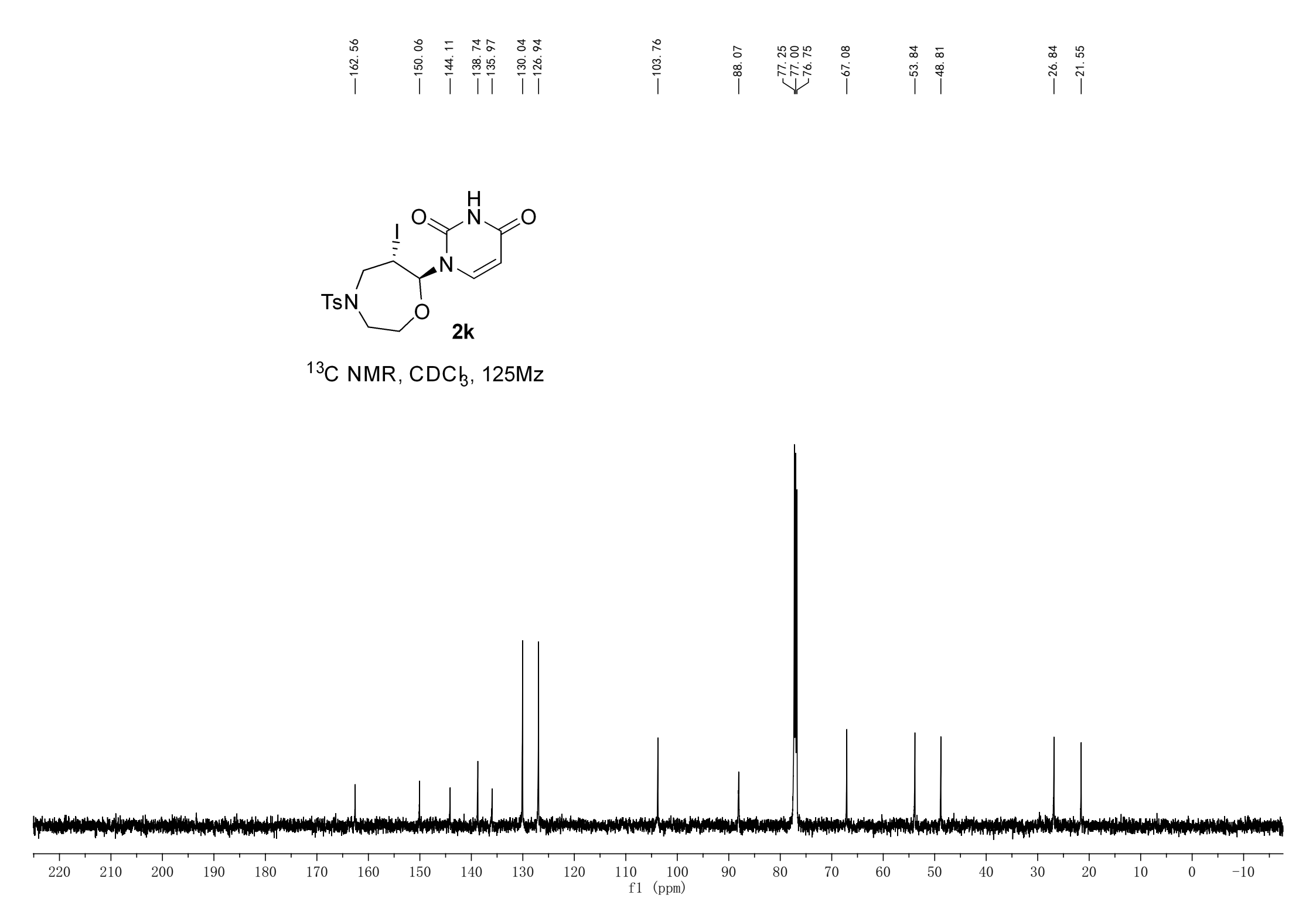

162.51
150.05
138.81
103.33
80.42
77.32
77.00
76.69
76.37
38.83
33.79
30.84
25.59
21.69
H
N
O
O
N
O
I
Me
Me
2j
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

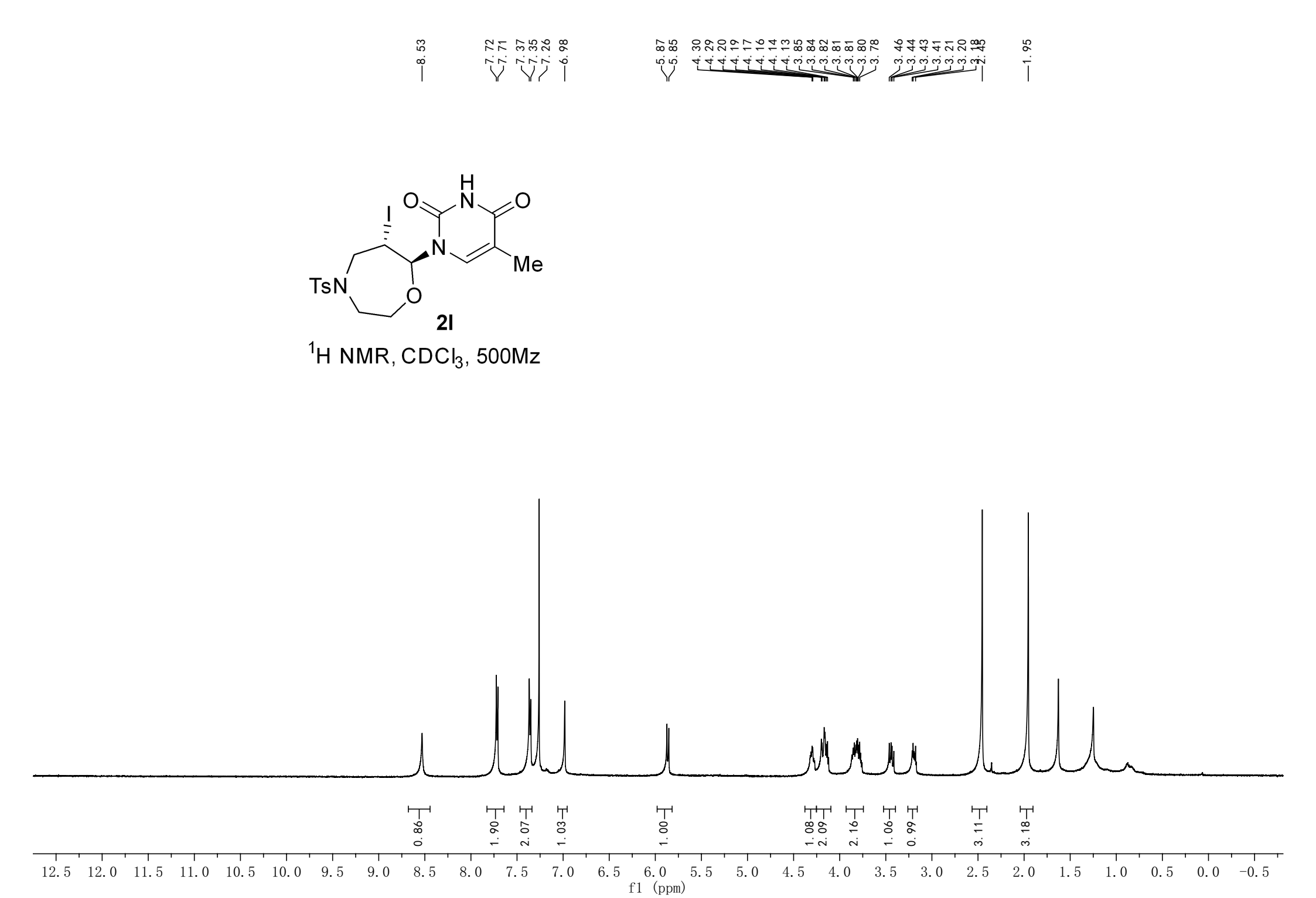


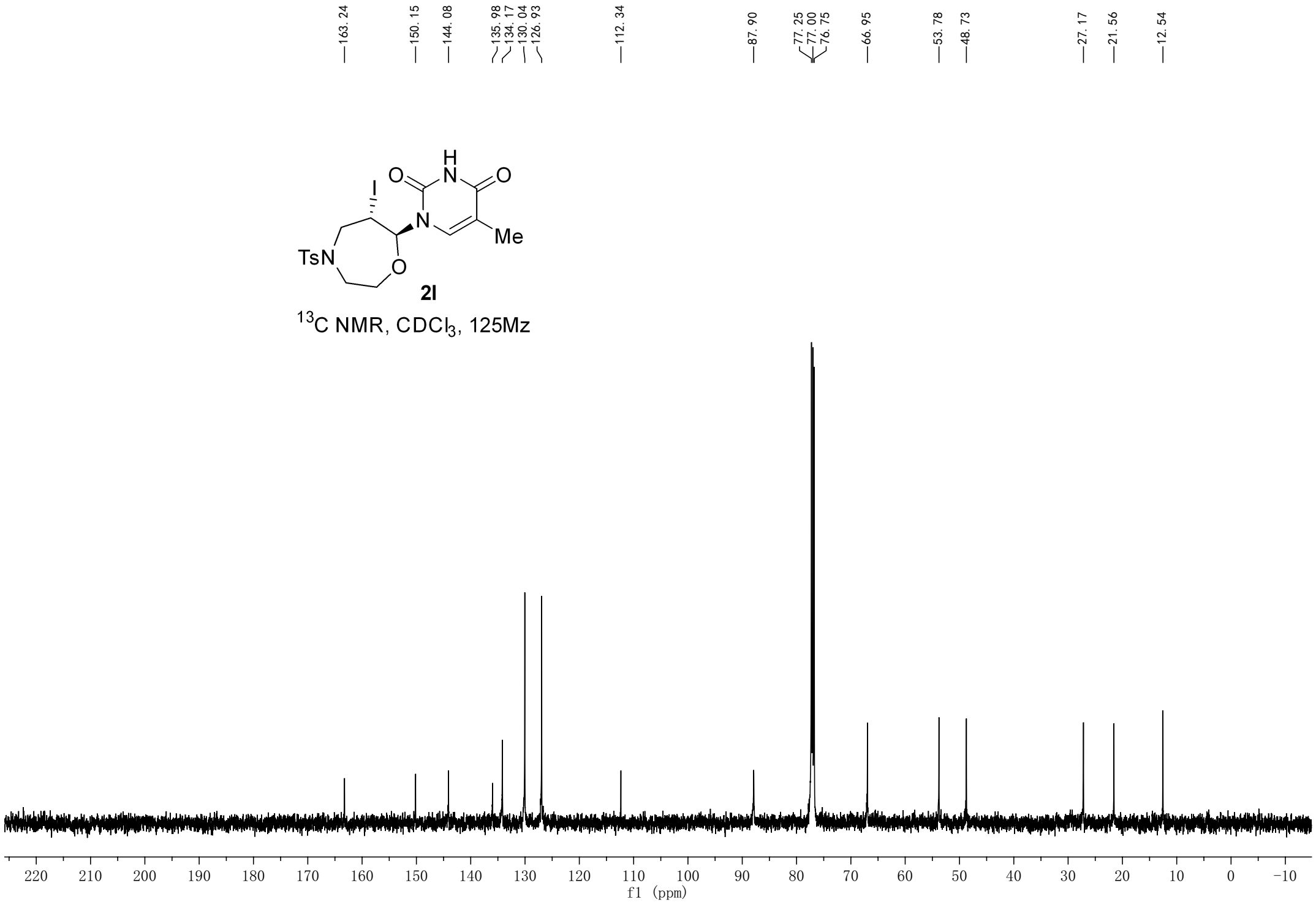
2k

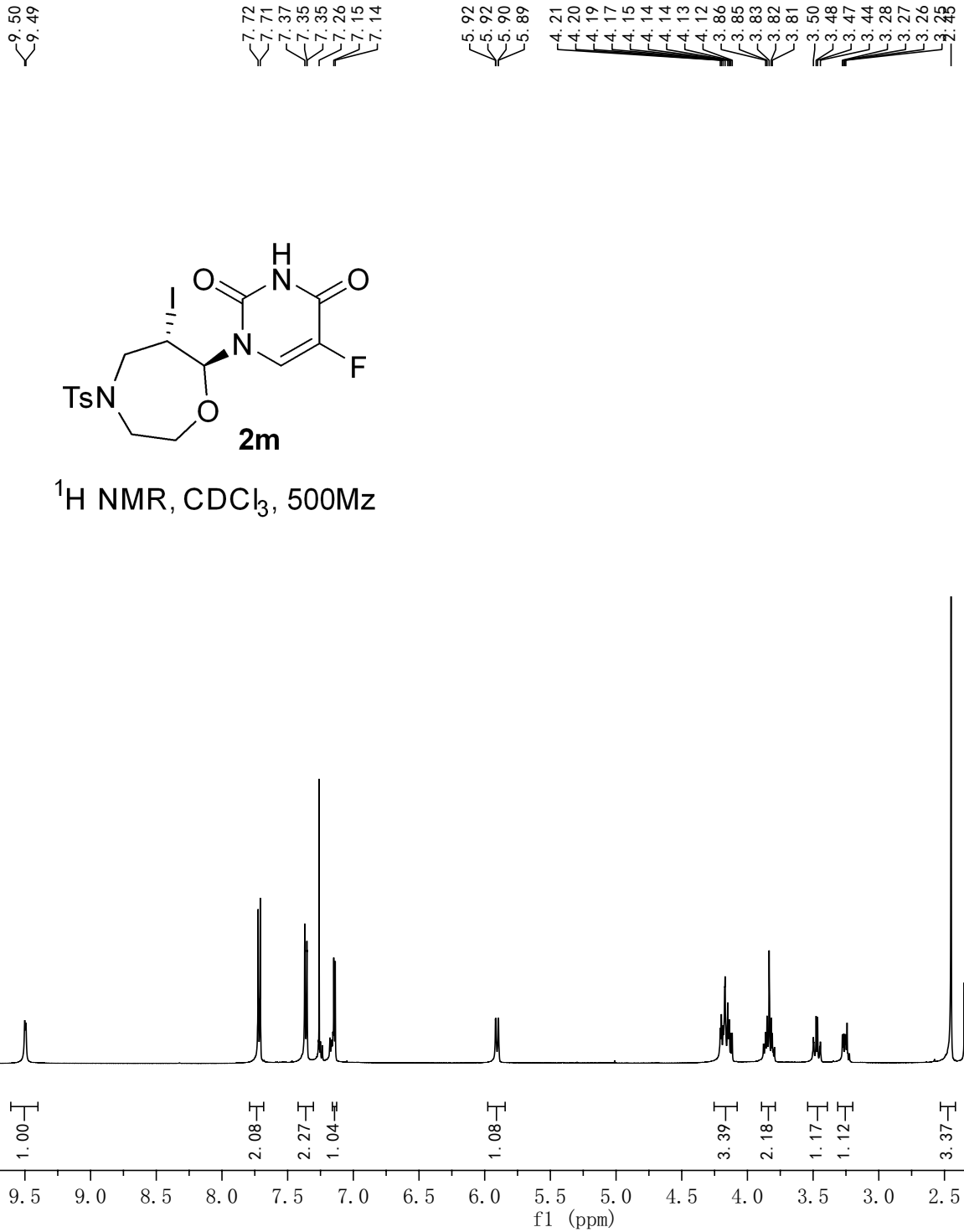
^{1}H NMR, $CDCl_3$, 400Mz

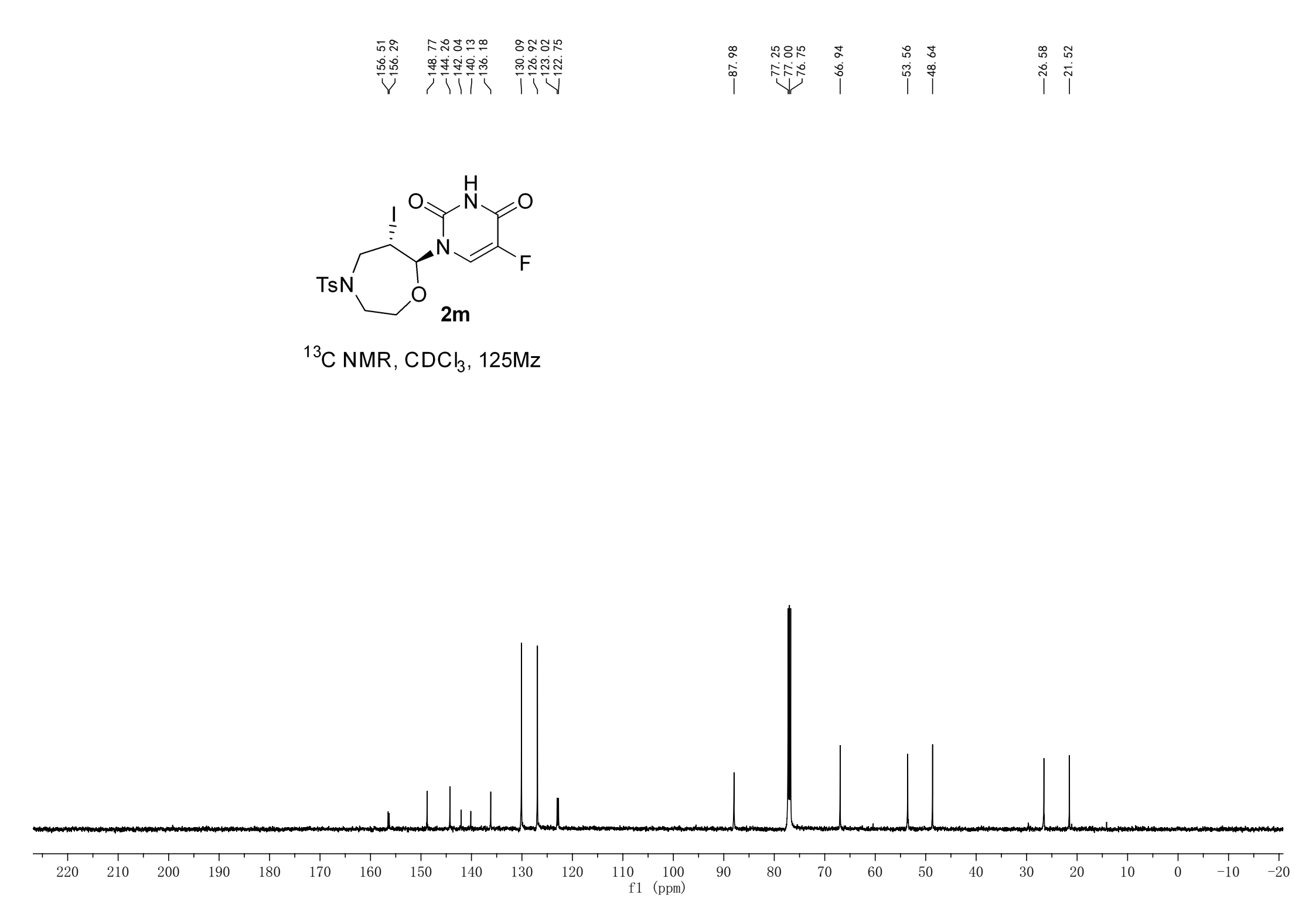


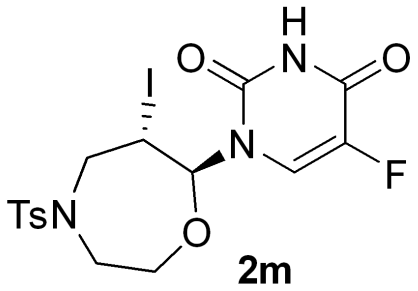

162.56
150.06
144.11
138.74
135.97
130.04
126.94
103.76
88.07
77.25
77.00
76.75
67.08
53.84
48.81
26.84
21.55
H
N
O
O
N
I
TsN
O
2k
13C NMR, CDCl3, 125Mz
f1 (ppm)


8.53
7.72
7.71
7.37
7.35
7.26
6.98
5.87
5.85
4.30
4.29
4.20
4.19
4.17
4.16
4.14
4.13
3.85
3.84
3.82
3.81
3.81
3.80
3.78
3.46
3.44
3.43
3.41
3.21
3.20
3.18
2.45
1.95
O
H
N
O
I
N
Me
TsN
O
2I
1H NMR, CDCl3, 500Mz
0.86
1.90
2.07
1.03
1.00
1.08
2.09
2.16
1.06
0.99
3.11
3.18
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


163.24
150.15
144.08
135.98
134.17
130.04
126.93
112.34
87.90
77.25
77.00
76.75
66.95
53.78
48.73
27.17
21.56
12.54
H
N
O
O
N
I
Me
TsN
O
2l
13C NMR, CDCl3, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

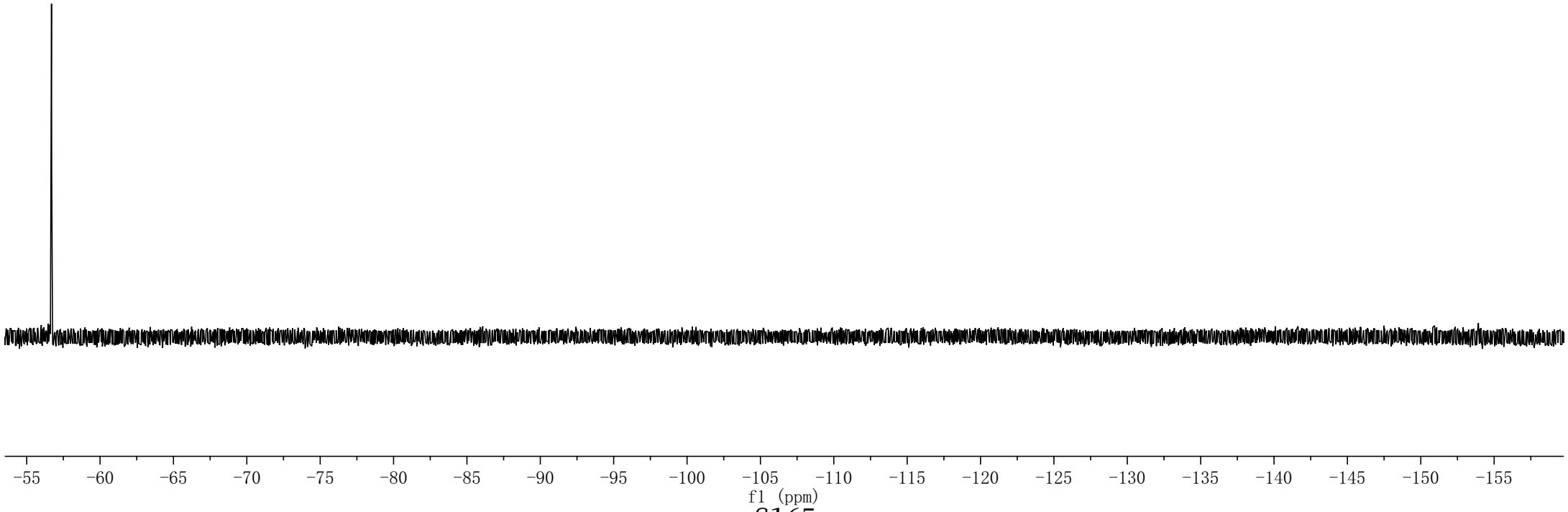

9.50
9.49
7.72
7.71
7.37
7.35
7.35
7.26
7.15
7.14
5.92
5.92
5.90
5.89
4.21
4.20
4.19
4.17
4.15
4.14
4.14
4.13
4.12
3.86
3.85
3.83
3.82
3.81
3.50
3.48
3.47
3.44
3.28
3.27
3.26
2.45
H
N
O
O
I
N
F
TsN
O
2m
1H NMR, CDCl3, 500Mz
1.00
2.08
2.27
1.04
1.08
3.39
2.18
1.17
1.12
3.37
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

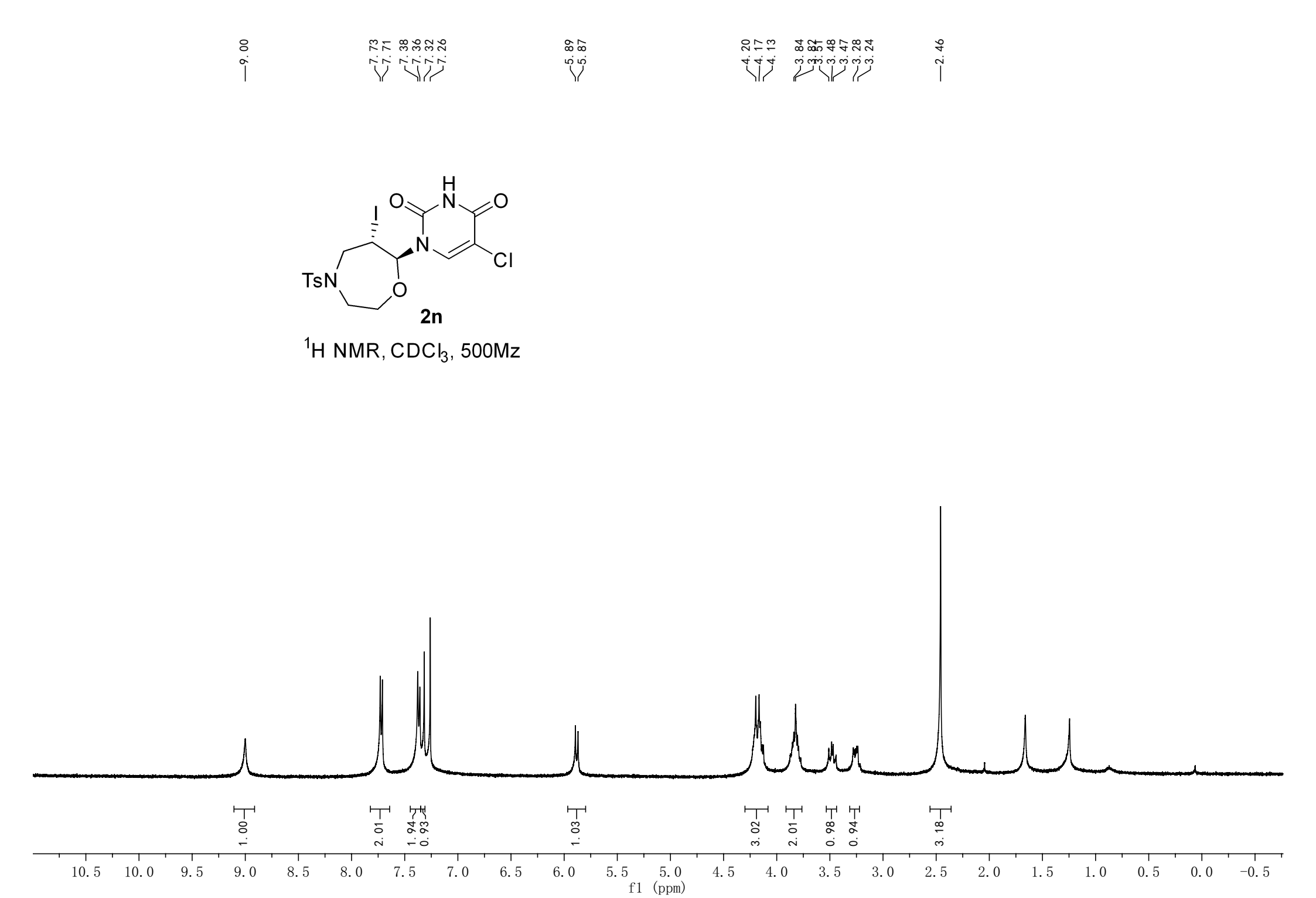

156.51
156.29
148.77
144.26
142.04
140.13
136.18
130.09
126.92
123.02
122.75
87.98
77.25
77.00
76.75
66.94
53.56
48.64
26.58
21.52
H
N
O
O
N
I
F
TsN
O
2m
13C NMR, CDCl3, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
f1 (ppm)

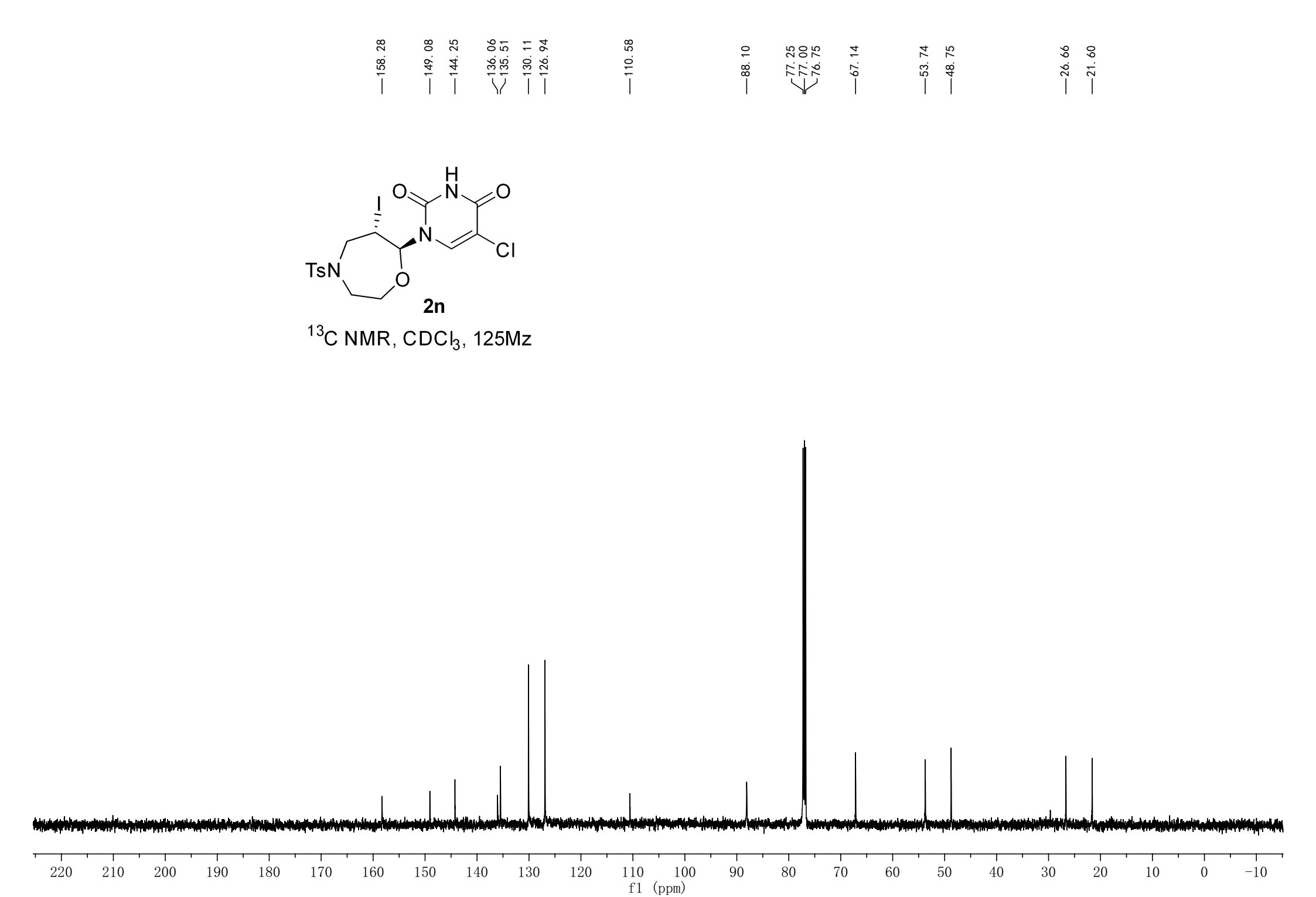


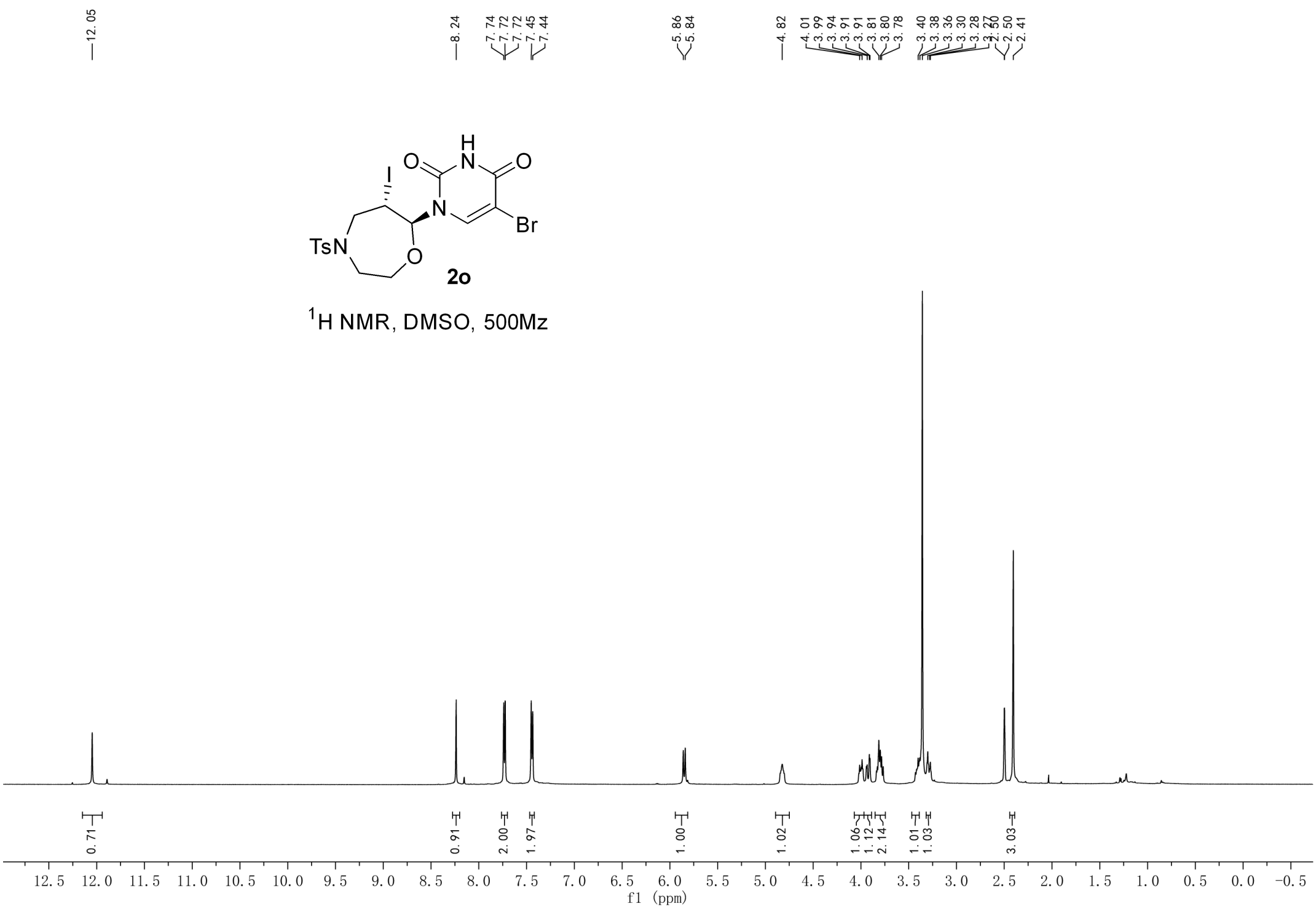
2m

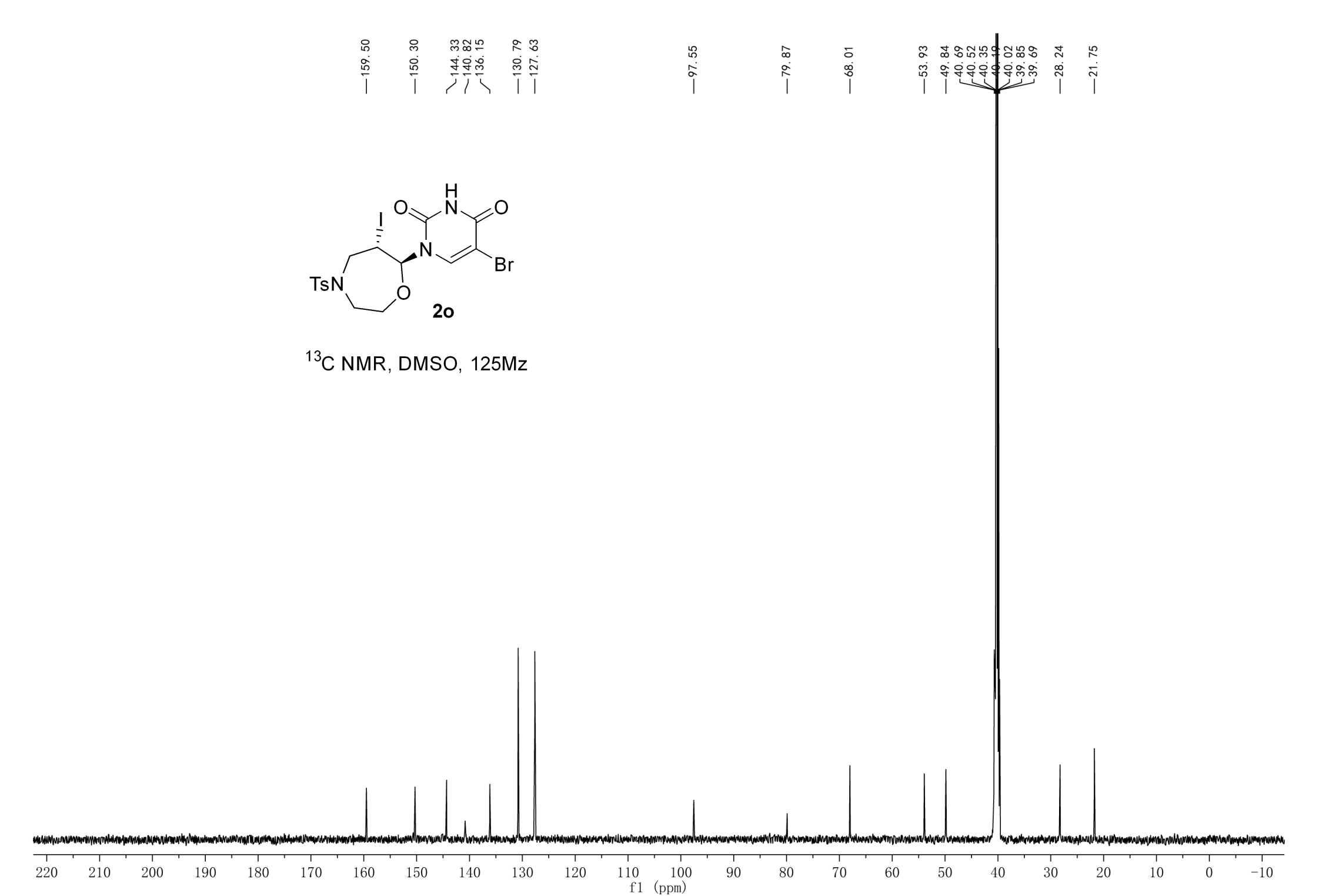
^{19}F NMR, CD_3Cl, 376 Mz

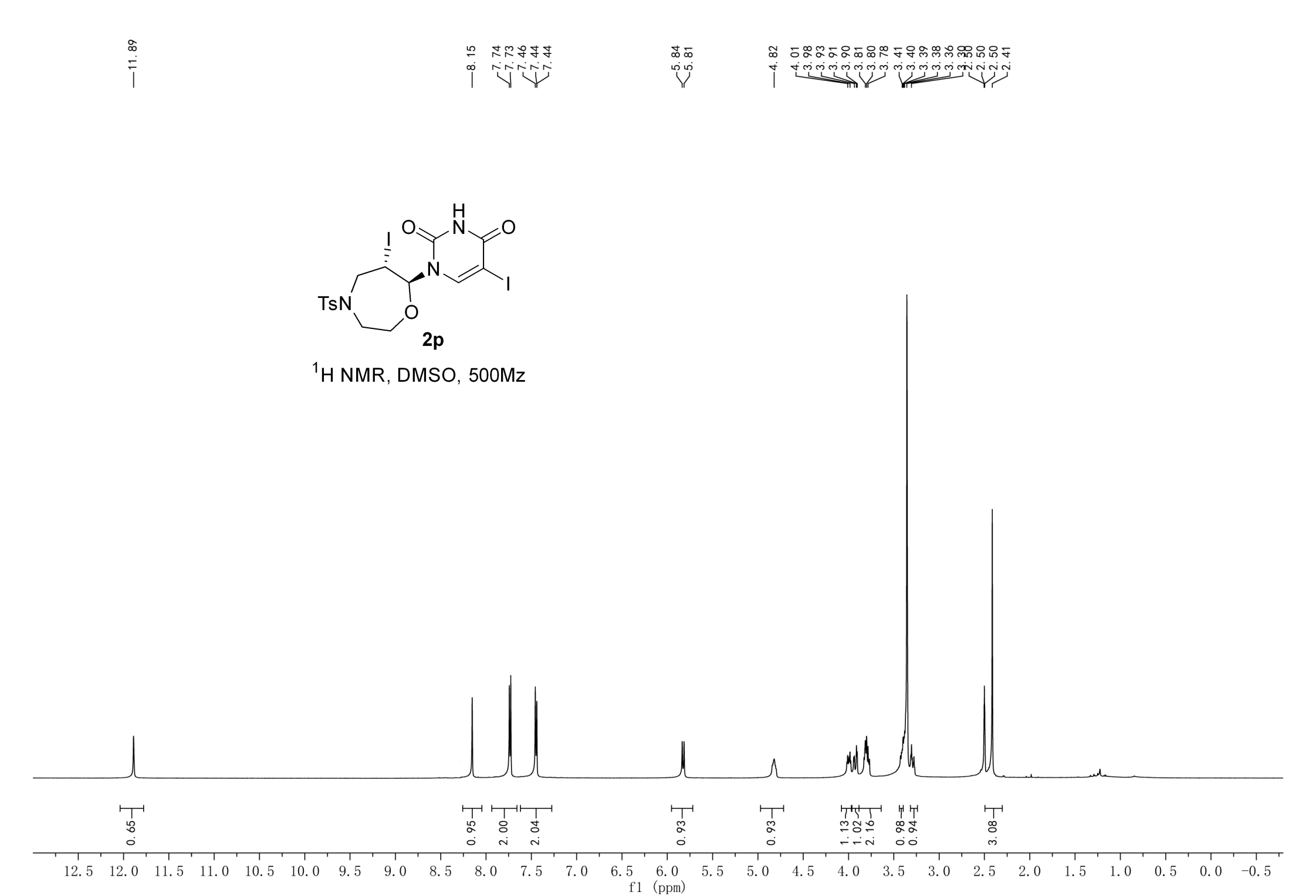


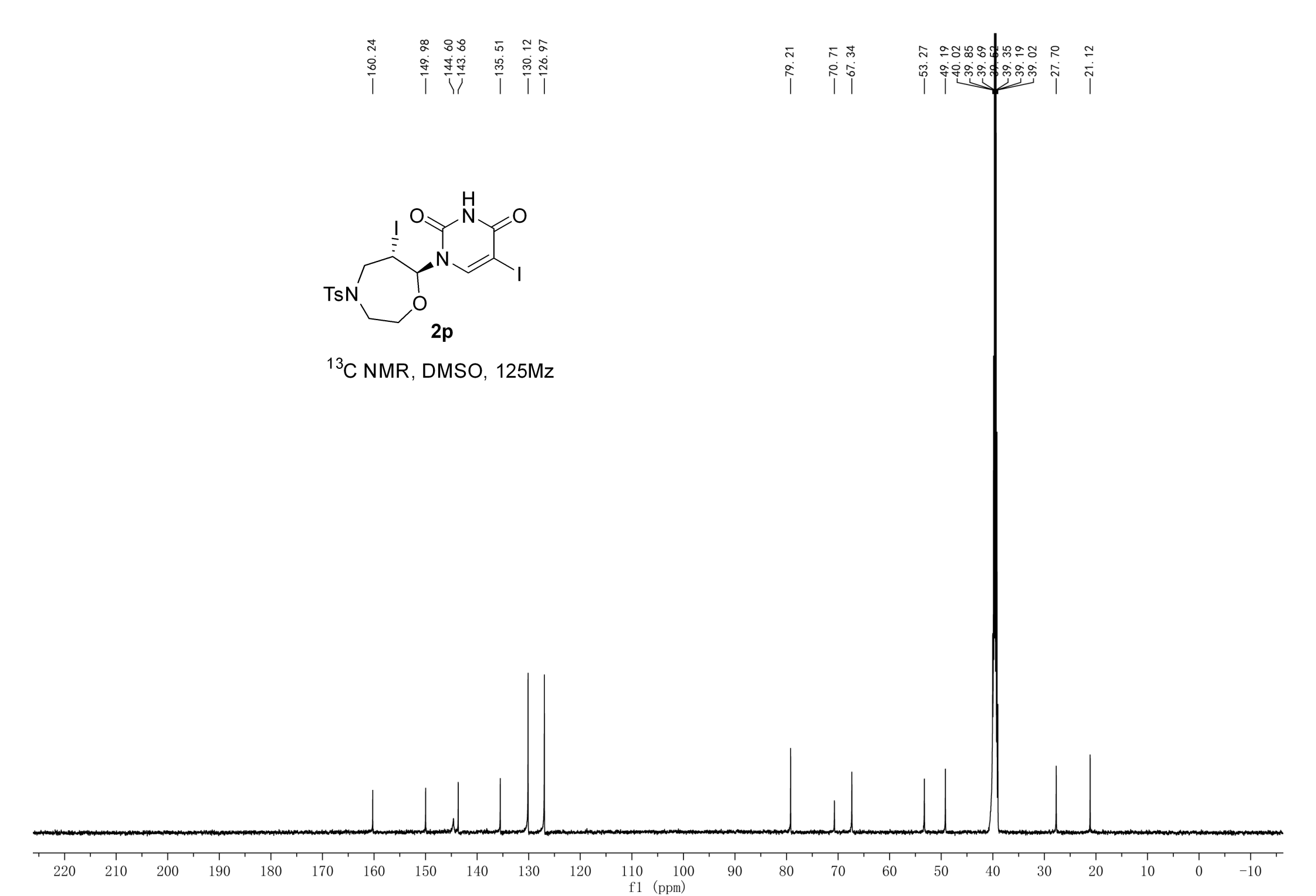

9.00
7.73
7.71
7.38
7.36
7.32
7.26
5.89
5.87
4.20
4.17
4.13
3.84
3.82
3.51
3.48
3.47
3.28
3.24
2.46
H
N
O
O
N
Cl
TsN
O
I
2n
1H NMR, CDCl3, 500Mz
1.00
2.01
1.94
0.93
1.03
3.02
2.01
0.98
0.94
3.18
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

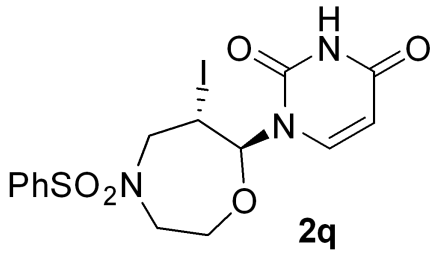

158.28
149.08
144.25
136.06
135.51
130.11
126.94
110.58
88.10
77.25
77.00
76.75
67.14
53.74
48.75
26.66
21.60
H
N
O
O
I
N
Cl
TsN
O
2n
13C NMR, CDCl3, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)


12.05
8.24
7.74
7.72
7.72
7.45
7.44
5.86
5.84
4.82
4.01
3.99
3.94
3.91
3.91
3.81
3.80
3.78
3.40
3.38
3.36
3.30
3.28
2.50
2.50
2.41
H
N
O
O
N
I
Br
TsN
O
2o
1H NMR, DMSO, 500Mz
0.71
0.91
2.00
1.97
1.00
1.02
1.06
1.12
2.14
1.01
1.03
3.03
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


159.50
150.30
144.33
140.82
136.15
130.79
127.63
97.55
79.87
68.01
53.93
49.84
40.69
40.52
40.35
40.19
40.02
39.85
39.69
28.24
21.75
H
N
O
O
I
N
Br
TsN
O
2o
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

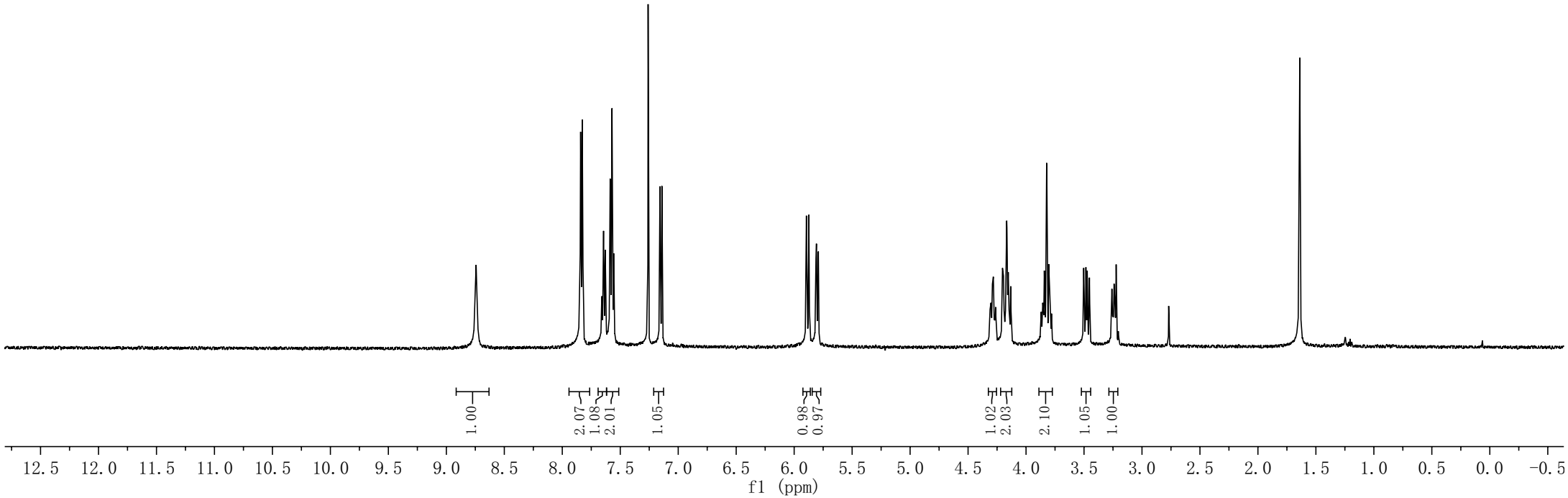

11.89
8.15
7.74
7.73
7.46
7.44
7.44
5.84
5.81
4.82
4.01
3.98
3.93
3.91
3.90
3.81
3.80
3.78
3.41
3.40
3.39
3.38
3.36
2.50
2.50
2.41
TsN
2p
1H NMR, DMSO, 500Mz
0.65
0.95
2.00
2.04
0.93
0.93
1.13
1.02
2.16
0.98
0.94
3.08
f1 (ppm)

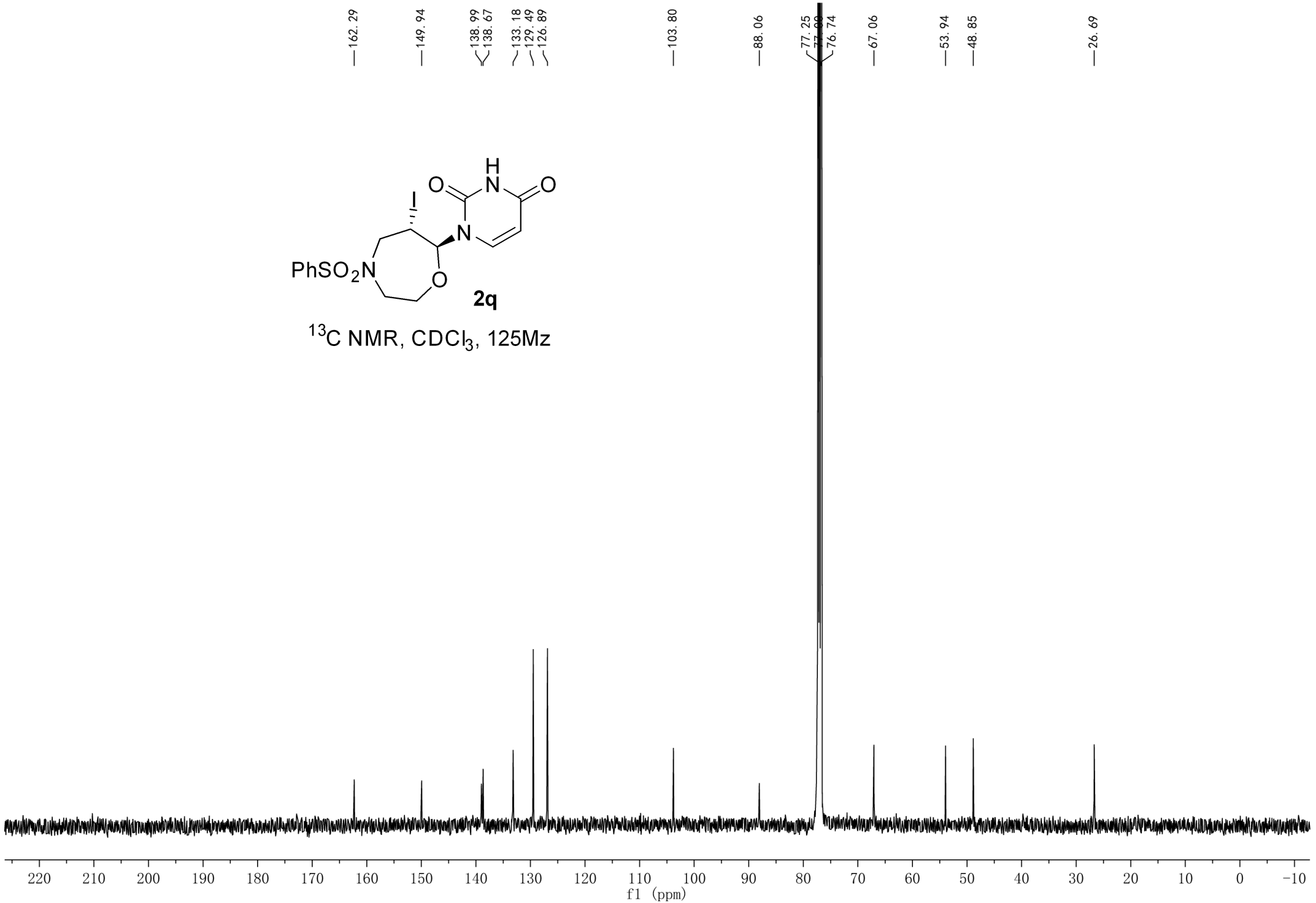

160.24
149.98
144.60
143.66
135.51
130.12
126.97
79.21
70.71
67.34
53.27
49.19
40.02
39.85
39.69
39.35
39.19
39.02
27.70
21.12
H
N
O
O
N
I
I
TsN
O
2p
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

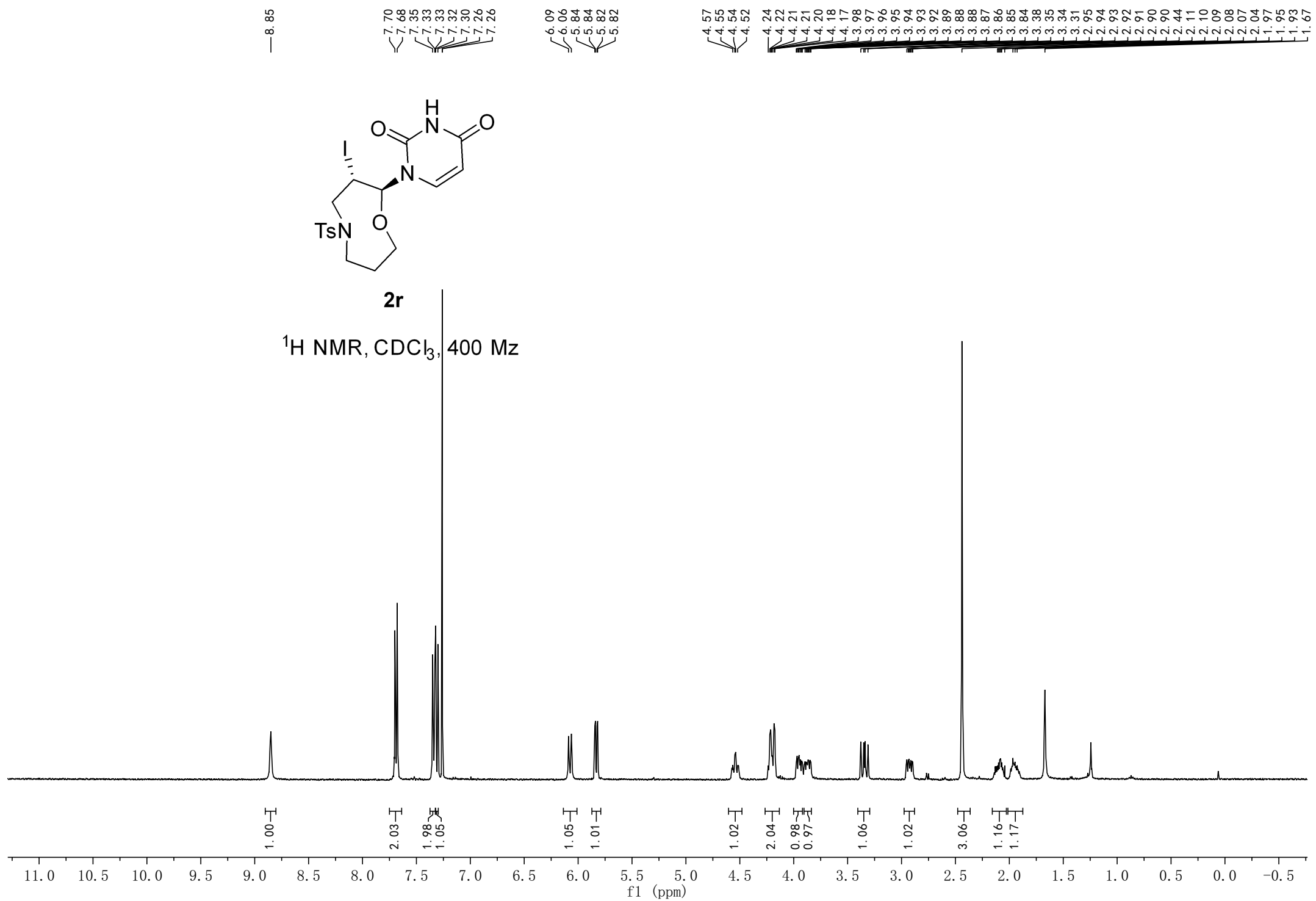


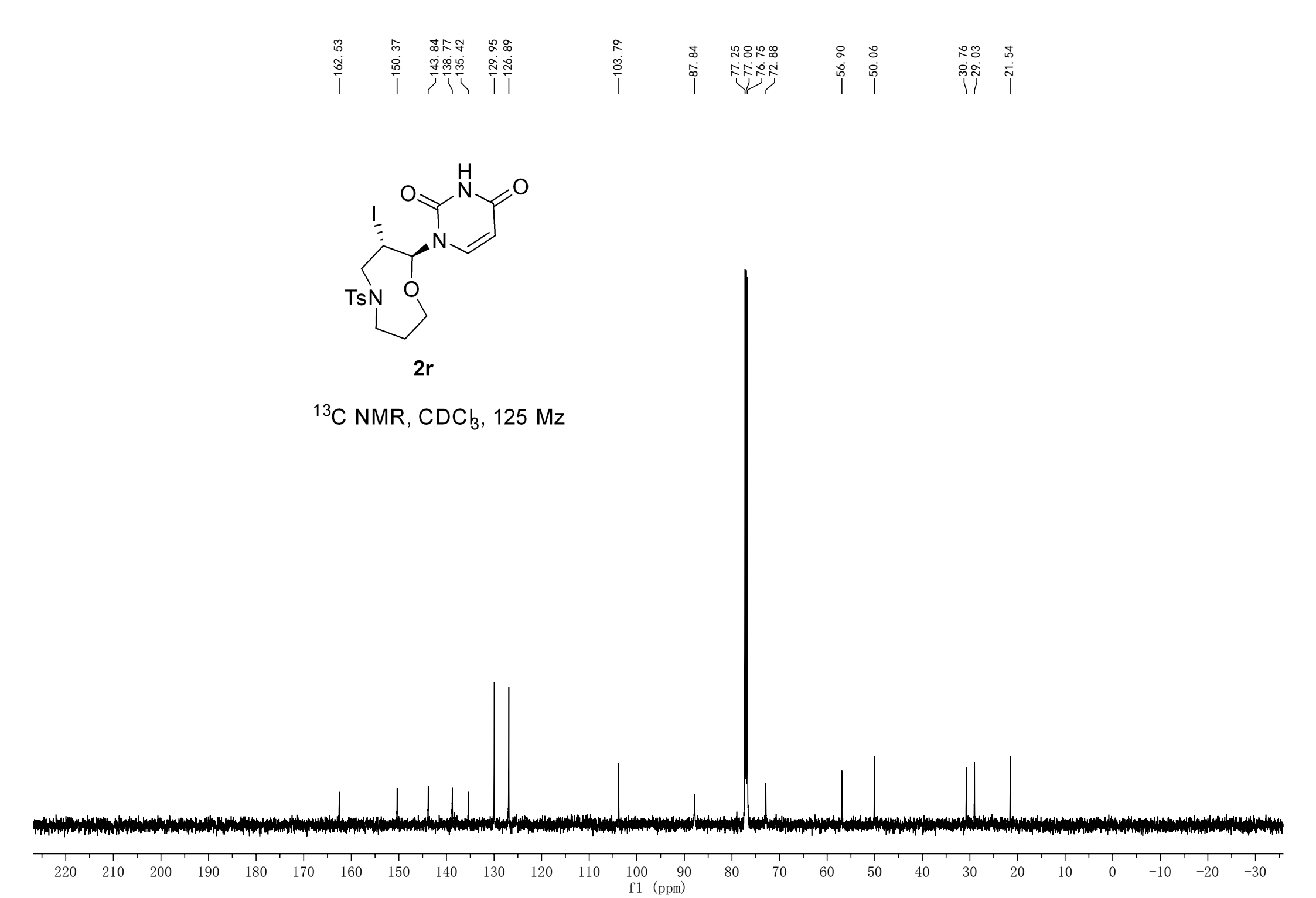
2q

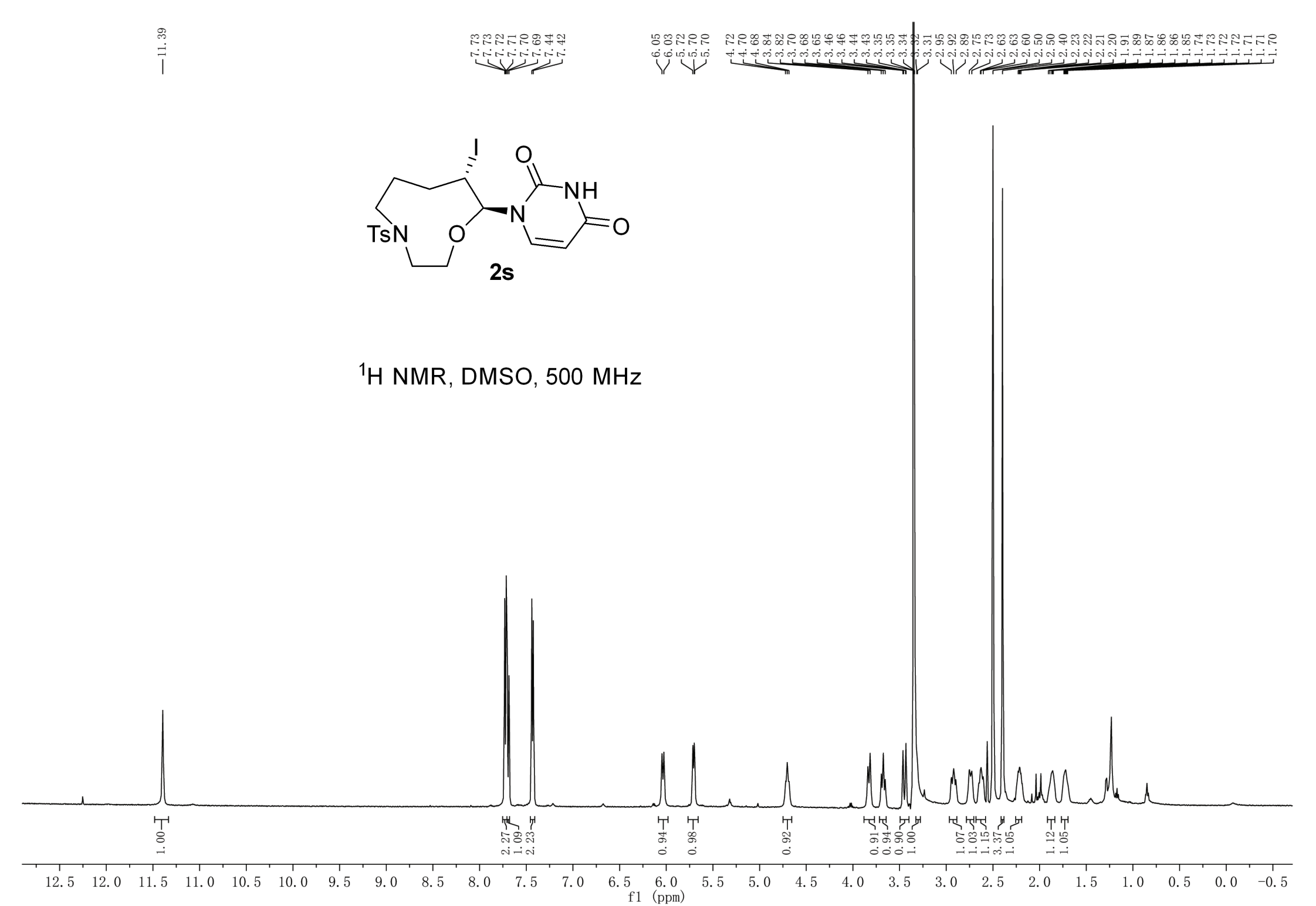
^{1}H NMR, $CDCl_3$, 500Mz

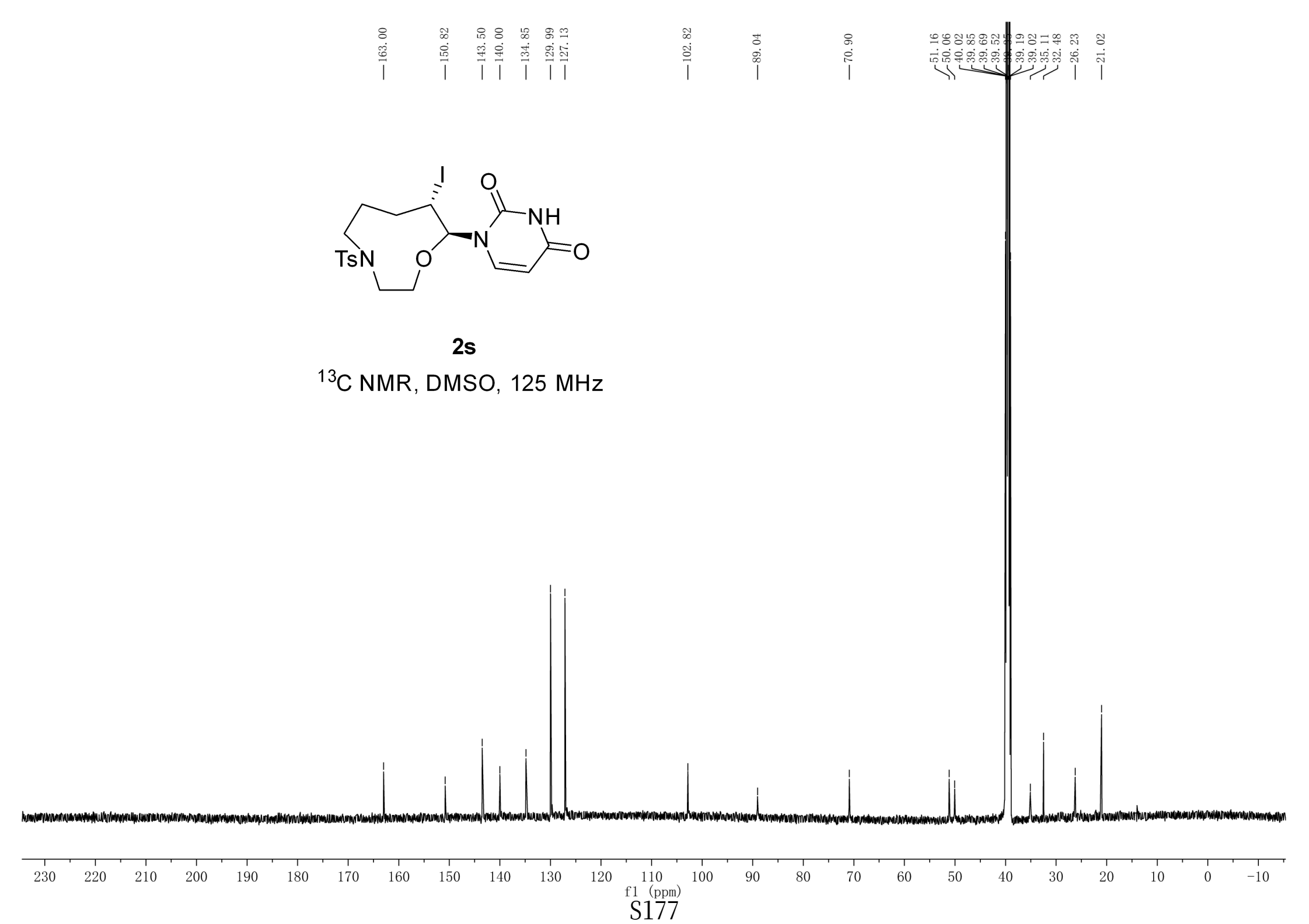


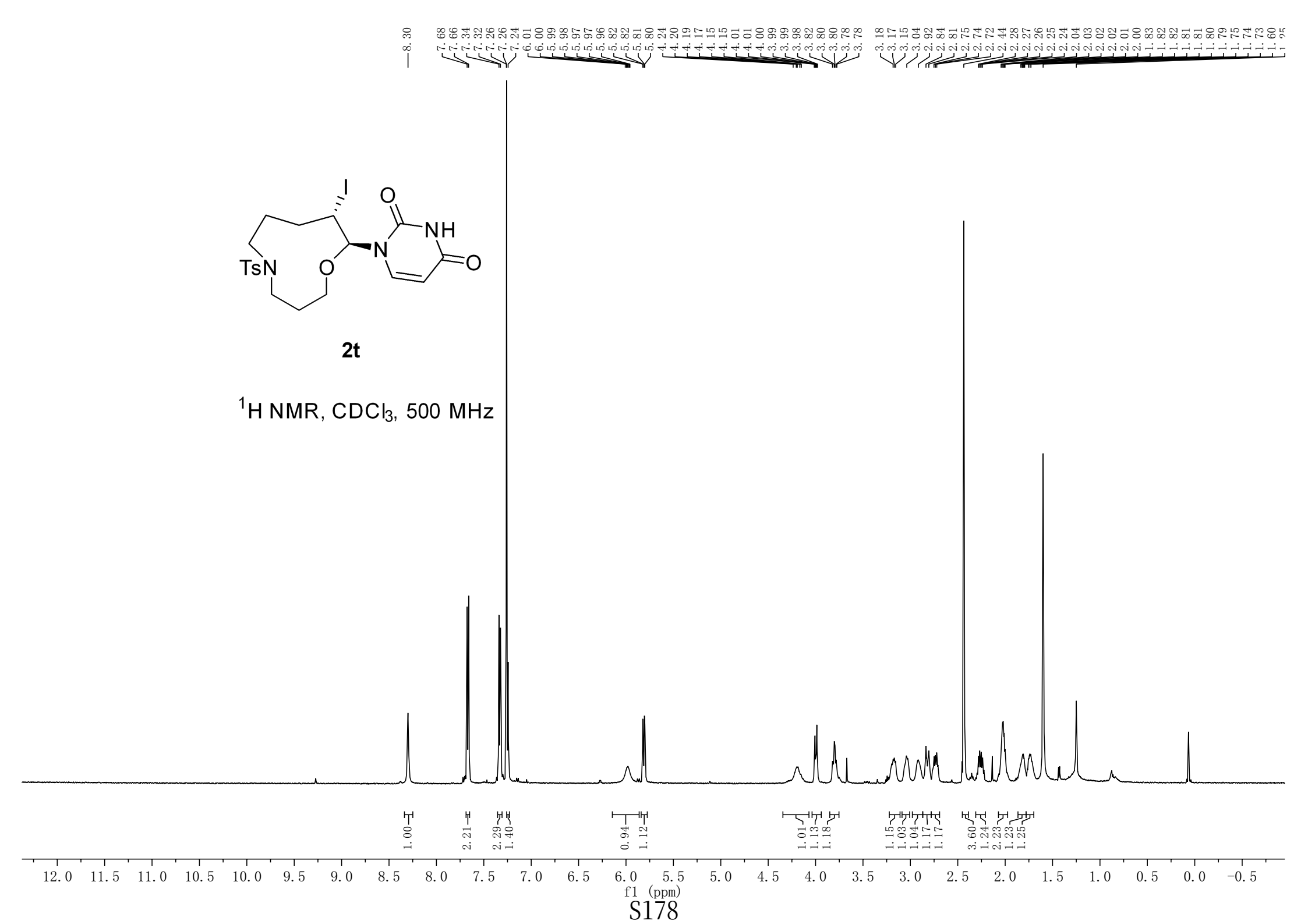

162.29
149.94
138.99
138.67
133.18
129.49
126.89
103.80
88.06
77.25
76.74
67.06
53.94
48.85
26.69
PhSO2N
O
N
H
O
O
I
2q
13C NMR, CDCl3, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

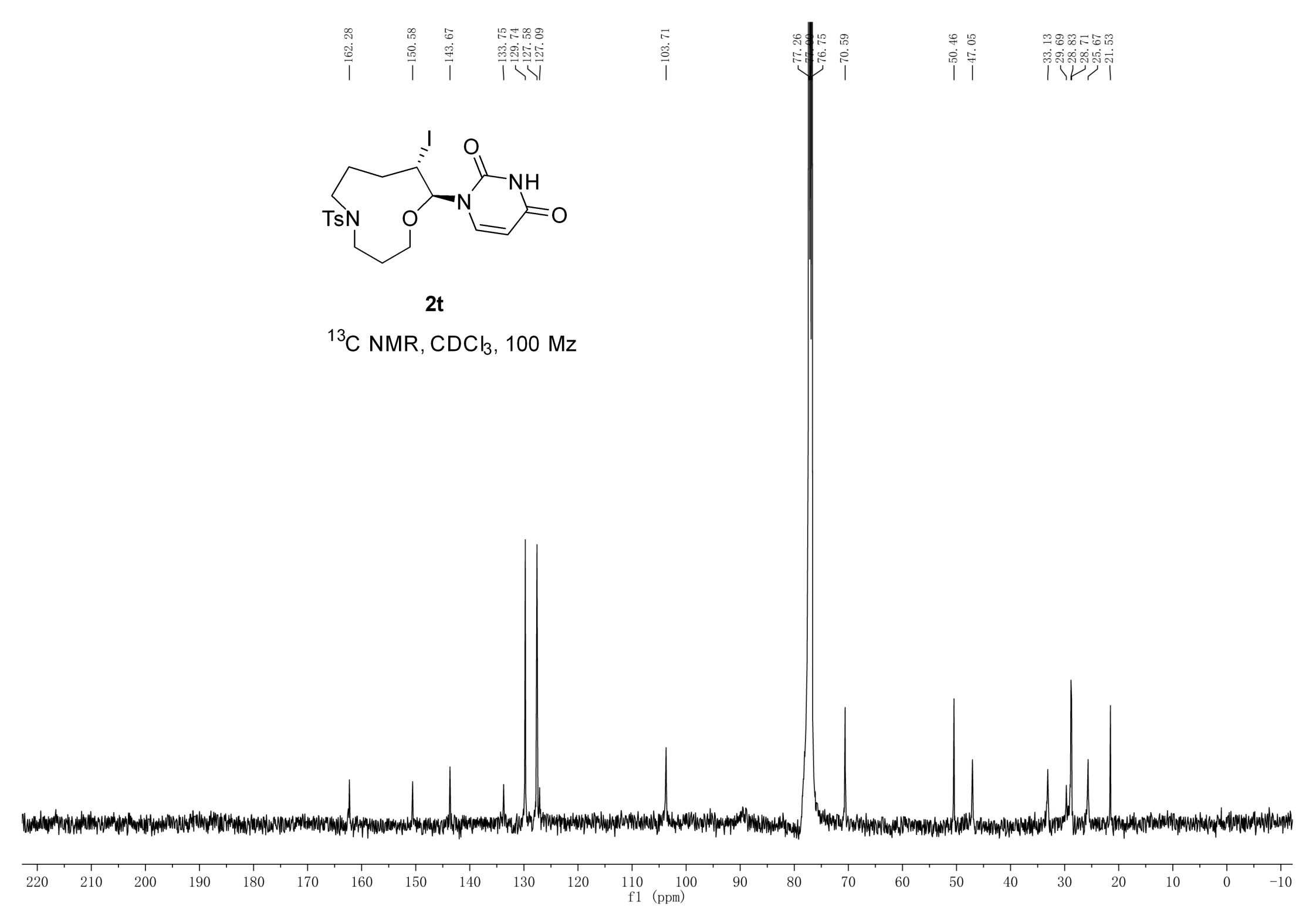

8.85
7.70
7.68
7.35
7.33
7.33
7.32
7.30
7.26
7.26
6.09
6.06
5.84
5.82
5.82
4.57
4.55
4.54
4.52
4.24
4.22
4.21
4.21
4.20
4.18
4.17
3.98
3.97
3.96
3.95
3.94
3.93
3.92
3.89
3.88
3.88
3.87
3.86
3.85
3.84
3.38
3.35
3.34
3.31
2.95
2.94
2.93
2.92
2.91
2.90
2.90
2.44
2.11
2.10
2.09
2.08
2.07
2.04
1.97
1.95
1.93
1.67
H
N
O
O
O
I
N
TsN
O
2r
1H NMR, CDCl3, 400 Mz
1.00
2.03
1.98
1.05
1.05
1.01
1.02
2.04
0.98
0.97
1.06
1.02
3.06
1.16
1.17
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

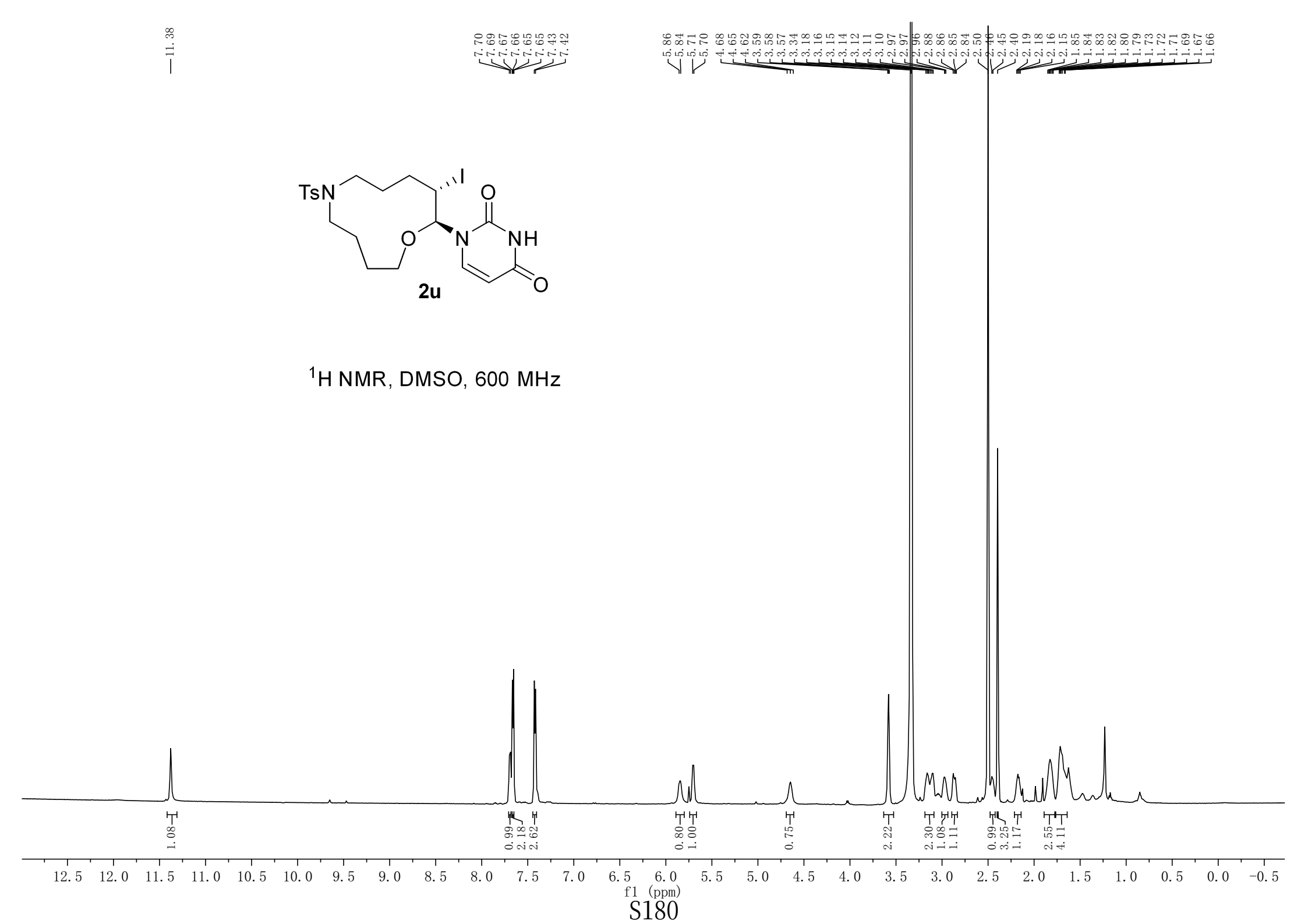

162.53
150.37
143.84
138.77
135.42
129.95
126.89
103.79
87.84
77.25
77.00
76.75
72.88
56.90
50.06
30.76
29.03
21.54
H
N
O
O
I
N
TsN
O
2r
13C NMR, CDCl3, 125 Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
f1 (ppm)

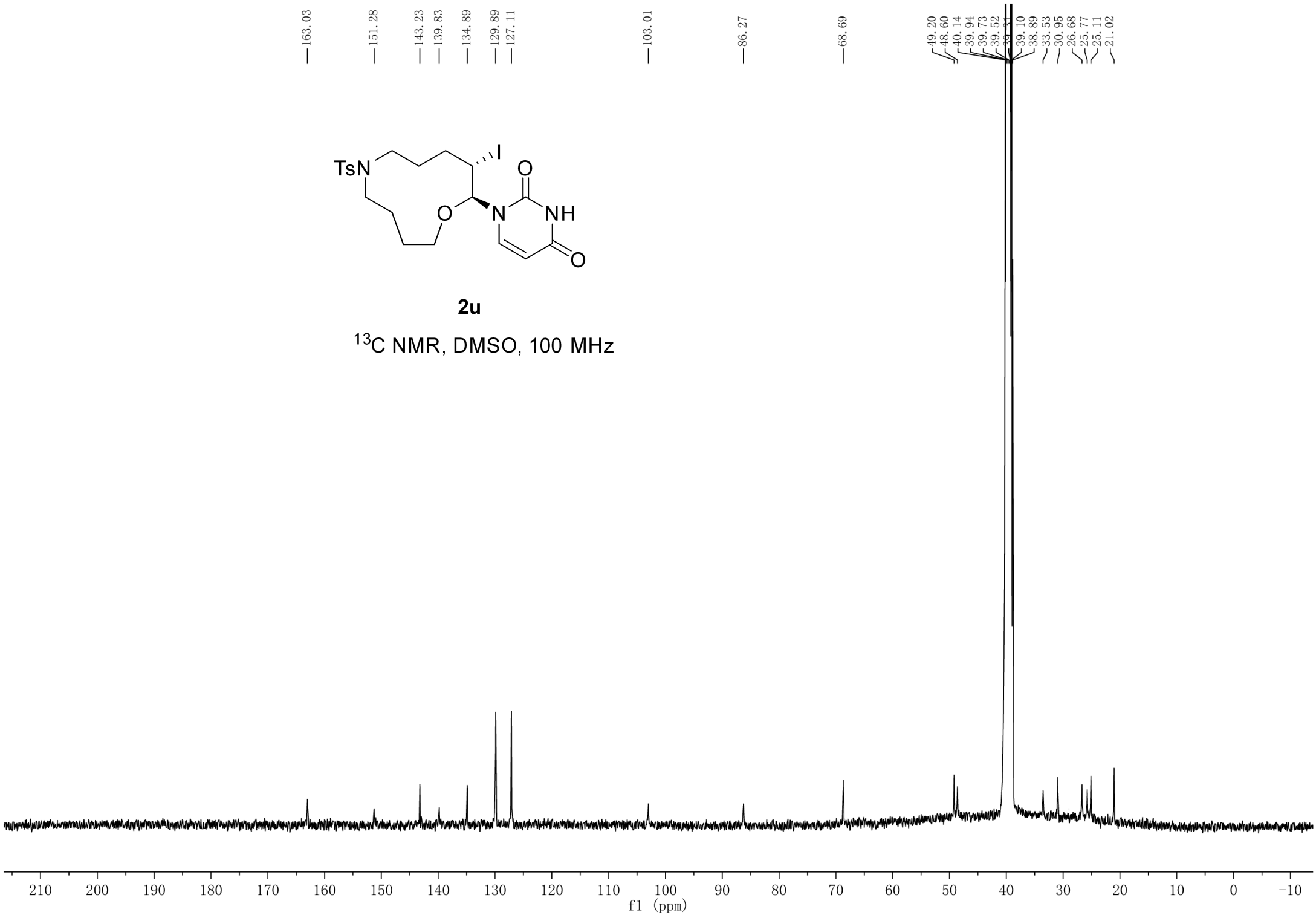

11.39
7.73
7.73
7.72
7.71
7.70
7.69
7.44
7.42
6.05
6.03
5.72
5.70
5.70
4.72
4.70
4.68
3.84
3.82
3.70
3.68
3.65
3.46
3.46
3.44
3.43
3.35
3.35
3.34
3.32
3.31
2.95
2.92
2.89
2.75
2.73
2.63
2.63
2.60
2.50
2.50
2.40
2.23
2.22
2.21
2.20
1.91
1.89
1.87
1.86
1.86
1.85
1.74
1.73
1.72
1.72
1.71
1.71
1.70
I
O
NH
N
O
TsN
O
2s
1H NMR, DMSO, 500 MHz
1.00
2.27
1.09
2.23
0.94
0.98
0.92
0.91
0.94
0.90
1.00
1.07
1.03
1.15
3.37
1.05
1.12
1.05
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

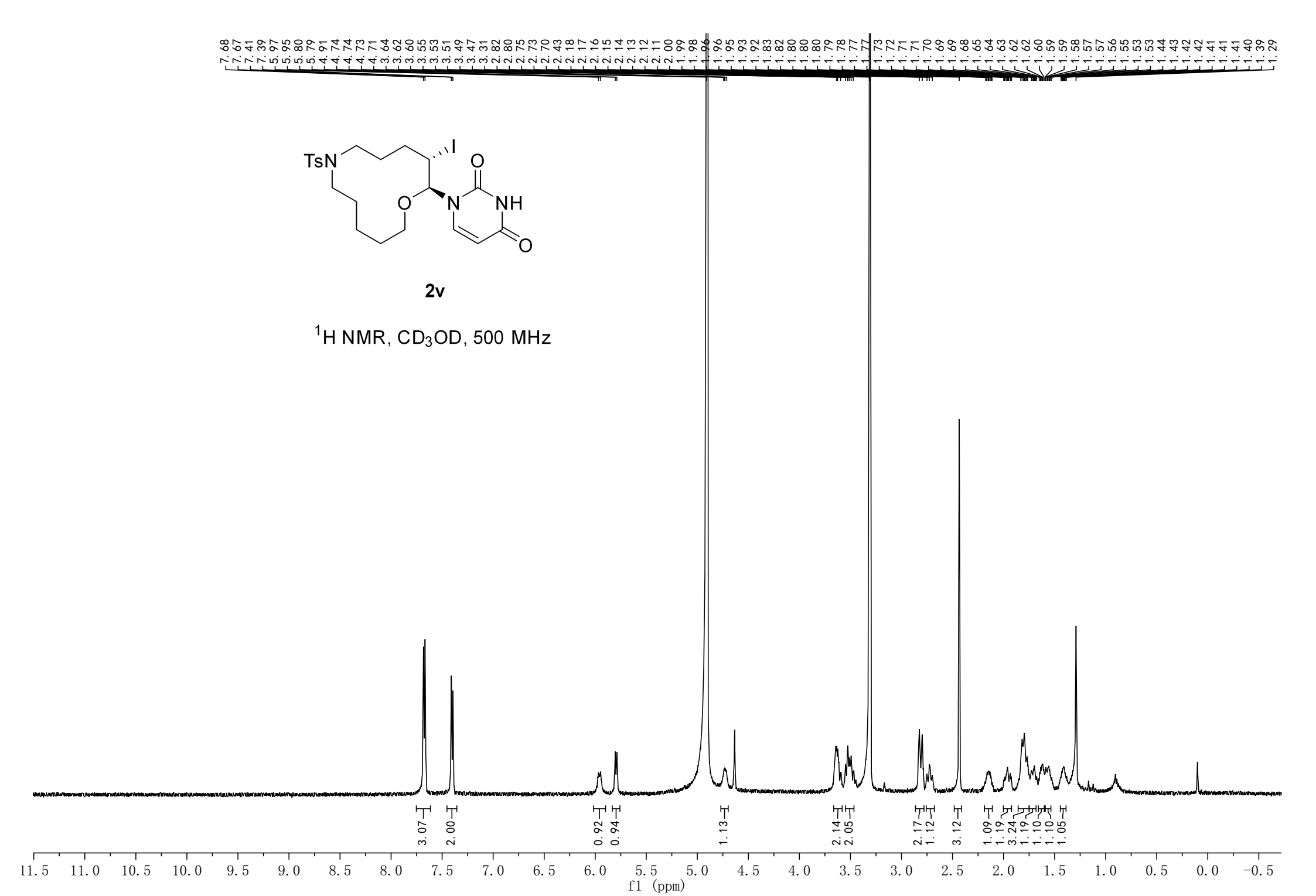

163.00
150.82
143.50
140.00
134.85
129.99
127.13
102.82
89.04
70.90
51.16
50.06
40.02
39.85
39.69
39.52
39.19
39.02
35.11
32.48
26.23
21.02
I
O
NH
N
O
TsN
O
2s
13C NMR, DMSO, 125 MHz
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)

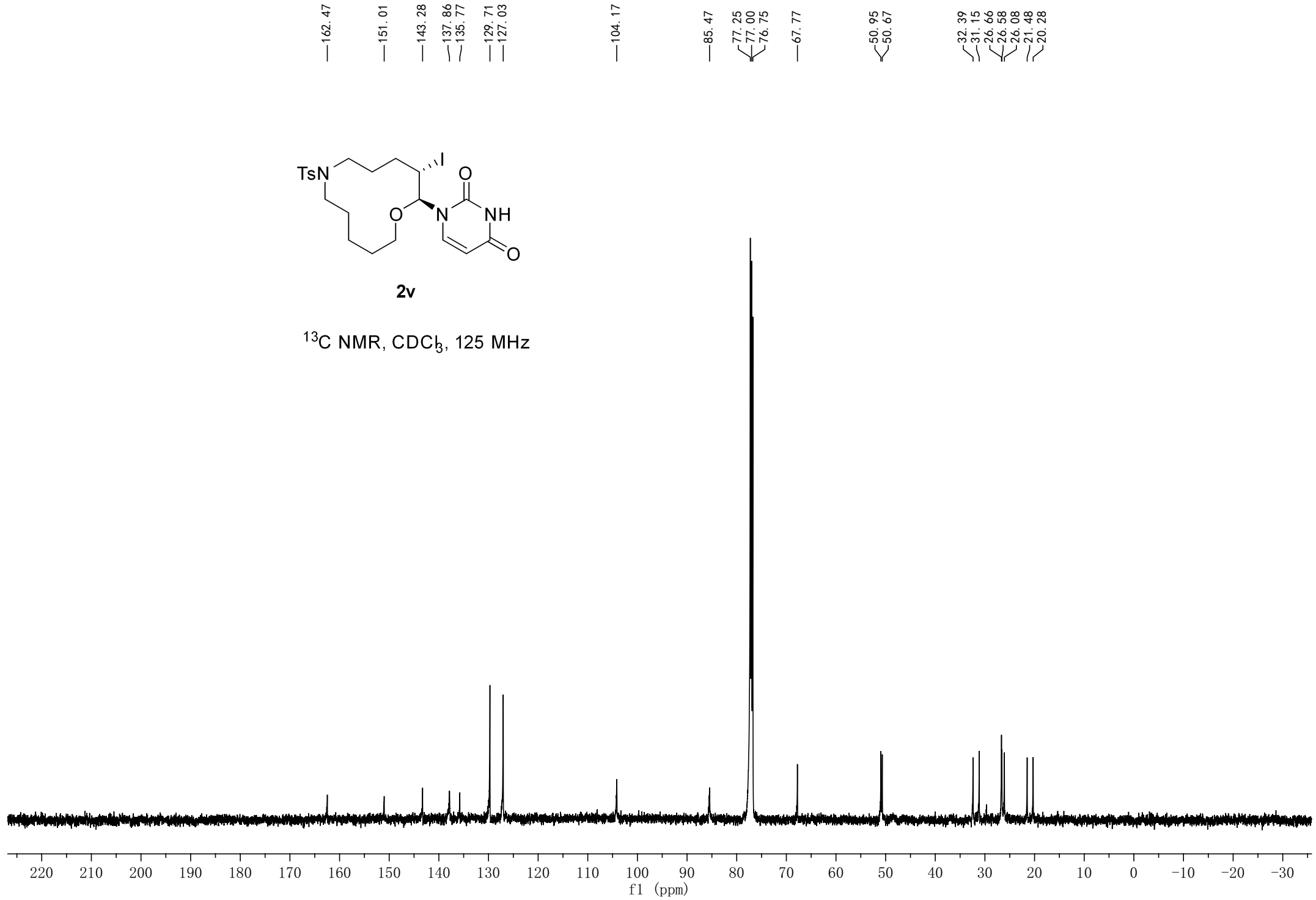

I
O
NH
N
O
TsN
O
2t
1H NMR, CDCl3, 500 MHz
f1 (ppm)

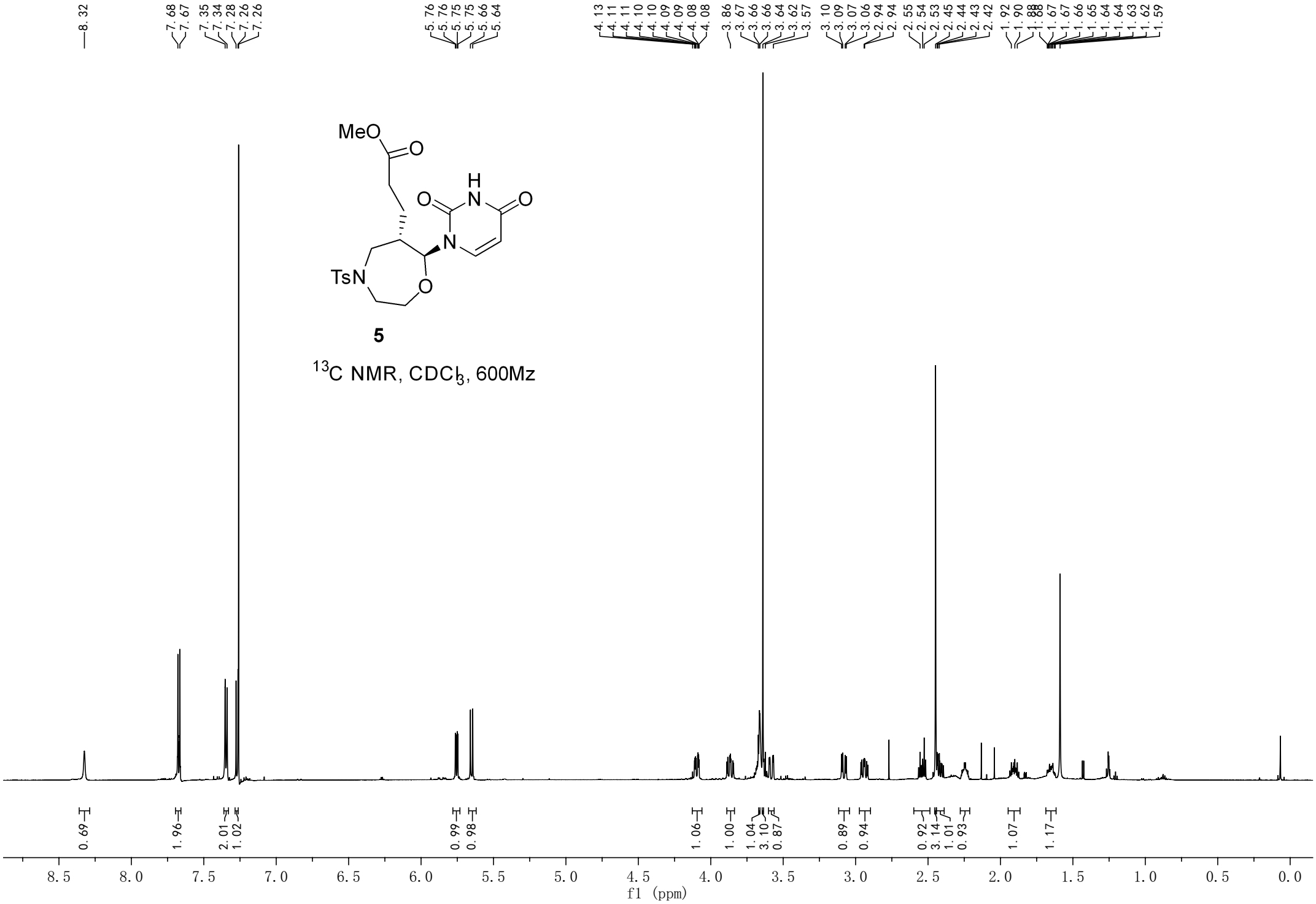

162.28
150.58
143.67
133.75
129.74
127.58
127.09
103.71
77.26
77.00
76.75
70.59
50.46
47.05
33.13
29.69
28.83
28.71
25.67
21.53
I
O
NH
N
O
TsN
O
2t
13C NMR, CDCl3, 100 Mz
f1 (ppm)

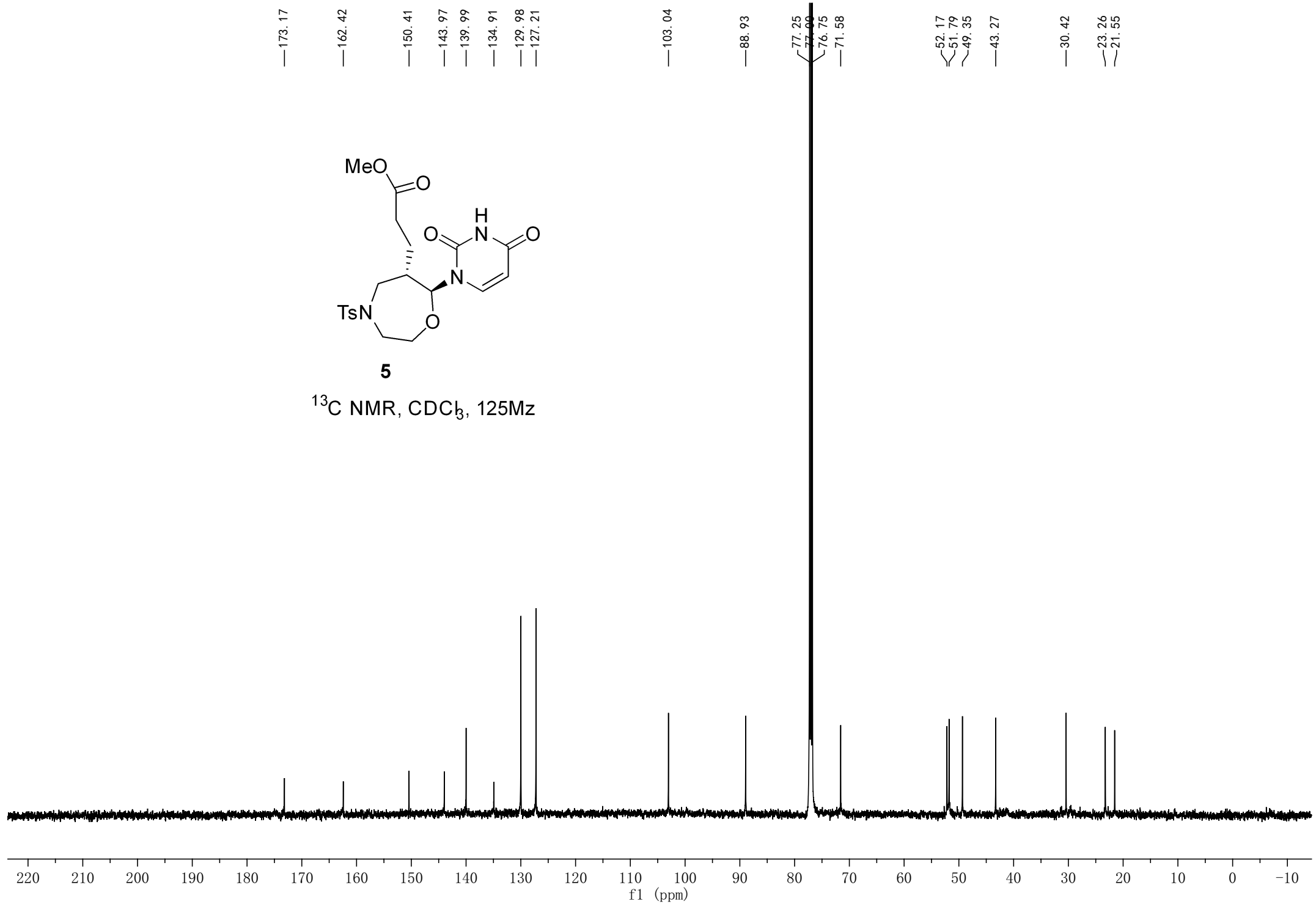

11.38
7.70
7.69
7.67
7.66
7.65
7.65
7.43
7.42
5.86
5.84
5.71
5.70
4.68
4.65
4.62
3.59
3.58
3.57
3.34
3.18
3.16
3.15
3.14
3.12
3.11
3.10
2.97
2.97
2.96
2.88
2.86
2.85
2.84
2.50
2.46
2.45
2.40
2.19
2.18
2.16
2.15
1.85
1.84
1.83
1.82
1.80
1.79
1.73
1.72
1.71
1.69
1.67
1.66
TsN
O
I
O
N
NH
O
2u
1H NMR, DMSO, 600 MHz
1.08
0.99
2.18
2.62
0.80
1.00
0.75
2.22
2.30
1.08
1.11
0.99
3.25
1.17
2.55
4.11
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

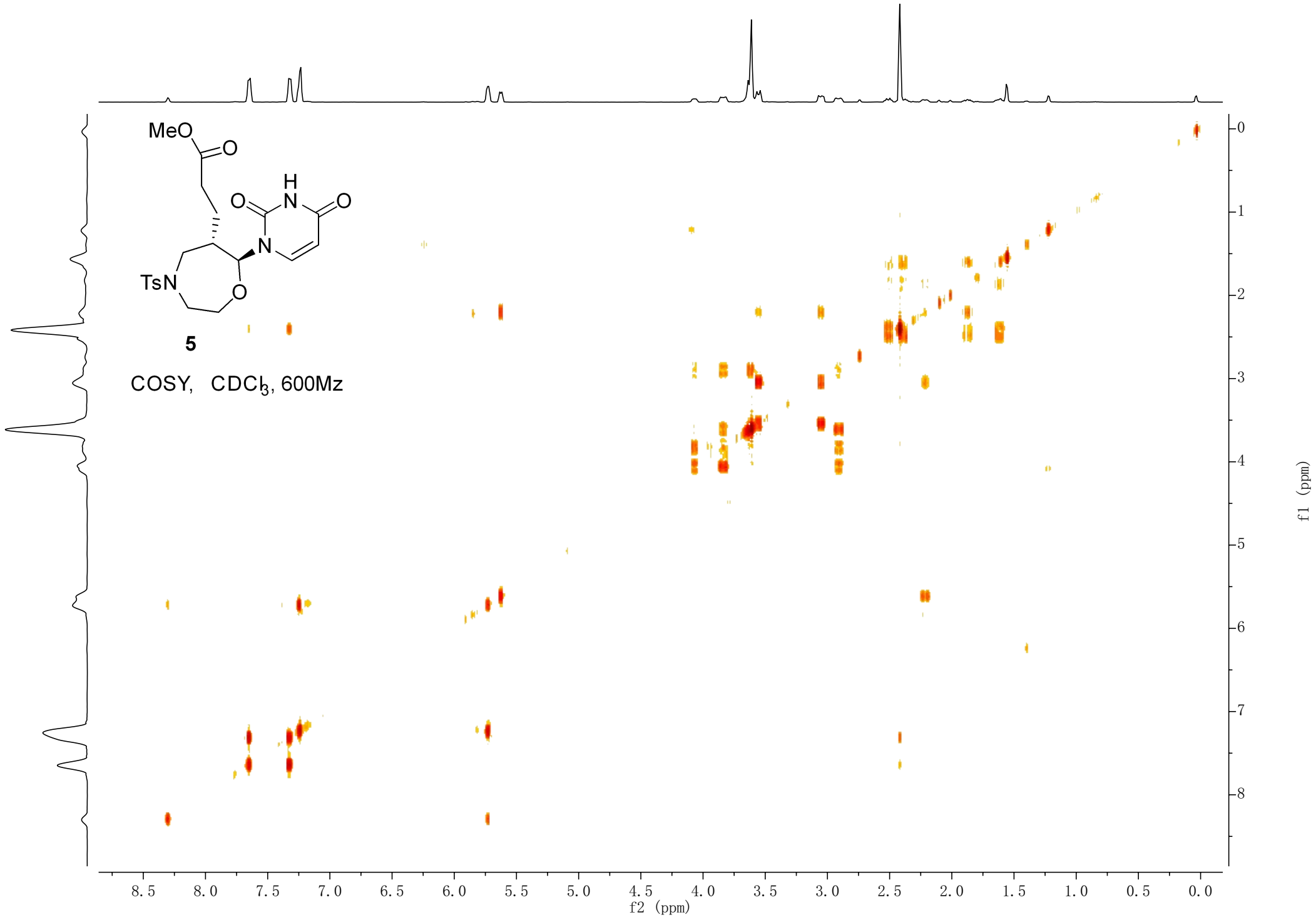

163.03
151.28
143.23
139.83
134.89
129.89
127.11
103.01
86.27
68.69
49.20
48.60
40.14
39.94
39.73
39.52
39.31
39.10
38.89
33.53
30.95
26.68
25.77
25.11
21.02
TsN
I
O
O
N
NH
O
2u
13C NMR, DMSO, 100 MHz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

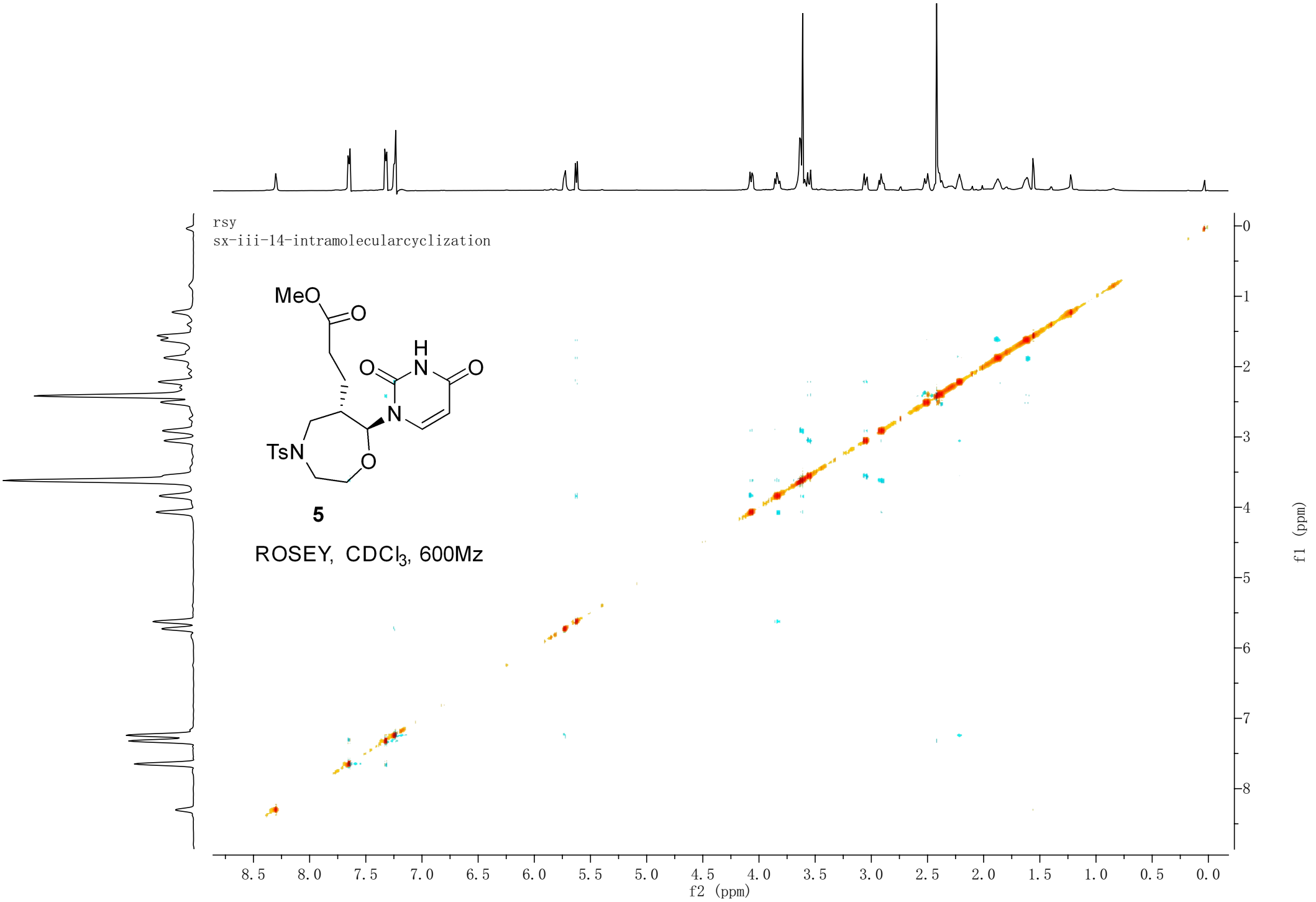

TsN
I
O
O
N
NH
O
2v
1H NMR, CD3OD, 500 MHz
f1 (ppm)

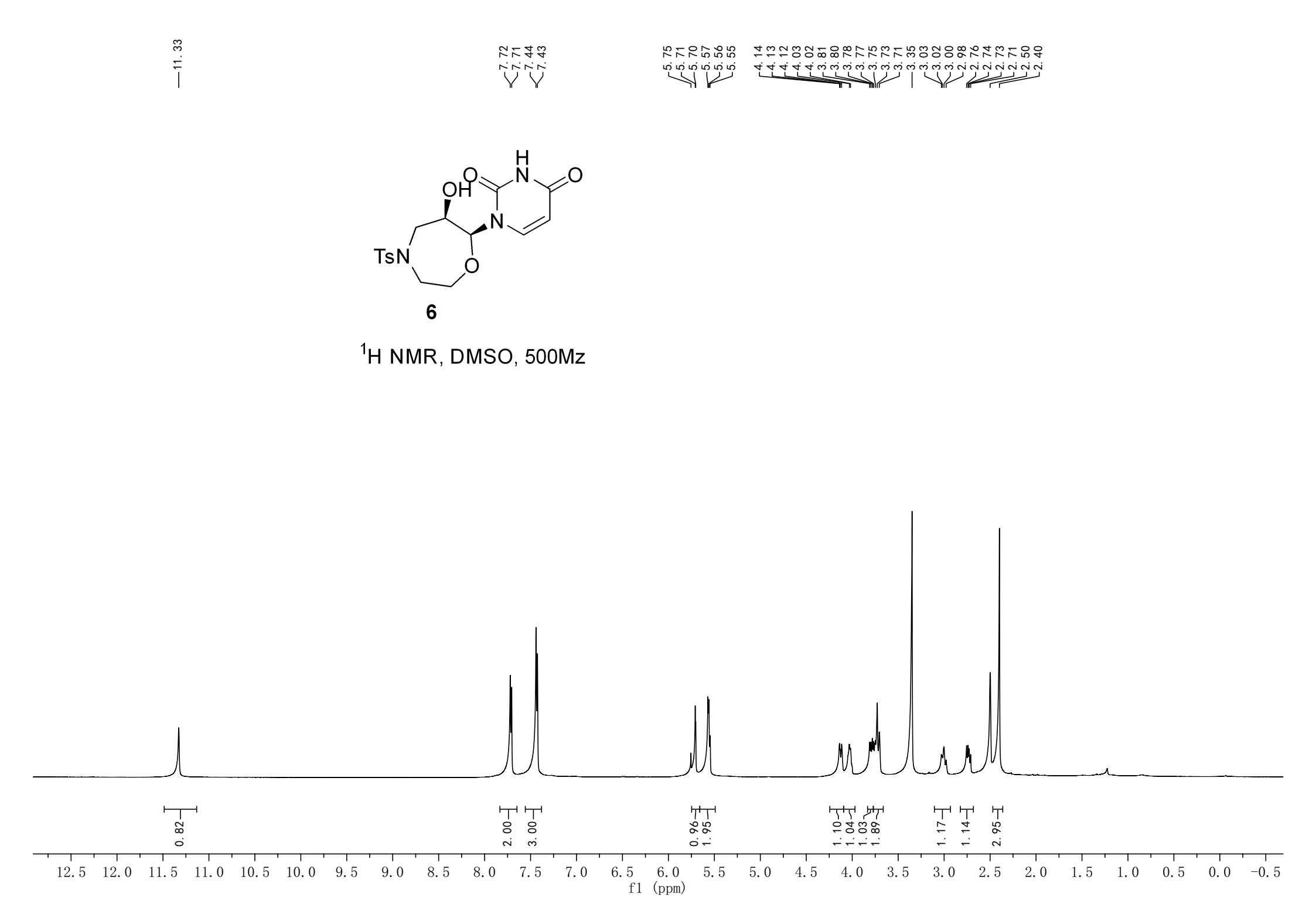

162.47
151.01
143.28
137.86
135.77
129.71
127.03
104.17
85.47
77.25
77.00
76.75
67.77
50.95
50.67
32.39
31.15
26.66
26.58
26.08
21.48
20.28
TsN
O
O
N
NH
O
I
2v
^{13}C NMR, $CDCl_3$, 125 MHz
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20 −30
f1 (ppm)


8.32
7.68
7.67
7.35
7.34
7.28
7.26
7.26
5.76
5.76
5.75
5.75
5.66
5.64
4.13
4.11
4.11
4.10
4.10
4.09
4.09
4.08
4.08
3.86
3.67
3.66
3.66
3.64
3.62
3.57
3.10
3.09
3.07
3.06
2.94
2.94
2.55
2.54
2.53
2.45
2.44
2.43
2.42
1.92
1.90
1.88
1.88
1.67
1.67
1.66
1.65
1.64
1.64
1.63
1.62
1.59
MeO
O
H
N
O
O
N
TsN
O
5
13C NMR, CDCl3, 600Mz
0.69
1.96
2.01
1.02
0.99
0.98
1.06
1.00
1.04
3.10
0.87
0.89
0.94
0.92
3.14
1.01
0.93
1.07
1.17
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


173.17
162.42
150.41
143.97
139.99
134.91
129.98
127.21
103.04
88.93
77.25
77.00
76.75
71.58
52.17
51.79
49.35
43.27
30.42
23.26
21.55
MeO
O
H
N
O
O
N
TsN
O
5
13C NMR, CDCl3, 125Mz
f1 (ppm)

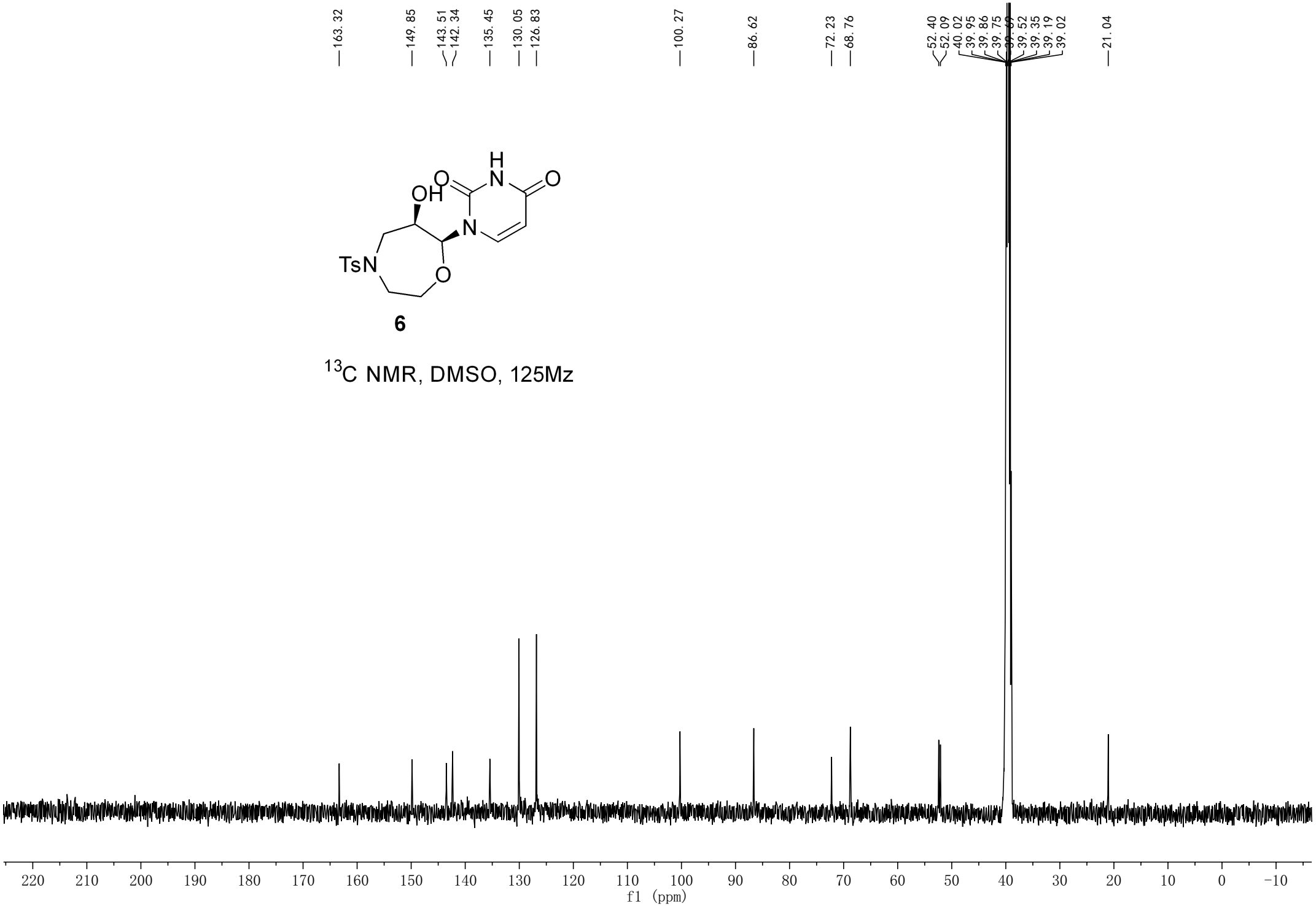

MeO
O
H
N
O
O
N
TsN
O
5
COSY, CDCl3, 600Mz
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f2 (ppm)
0
1
2
3
4
5
6
7
8
f1 (ppm)

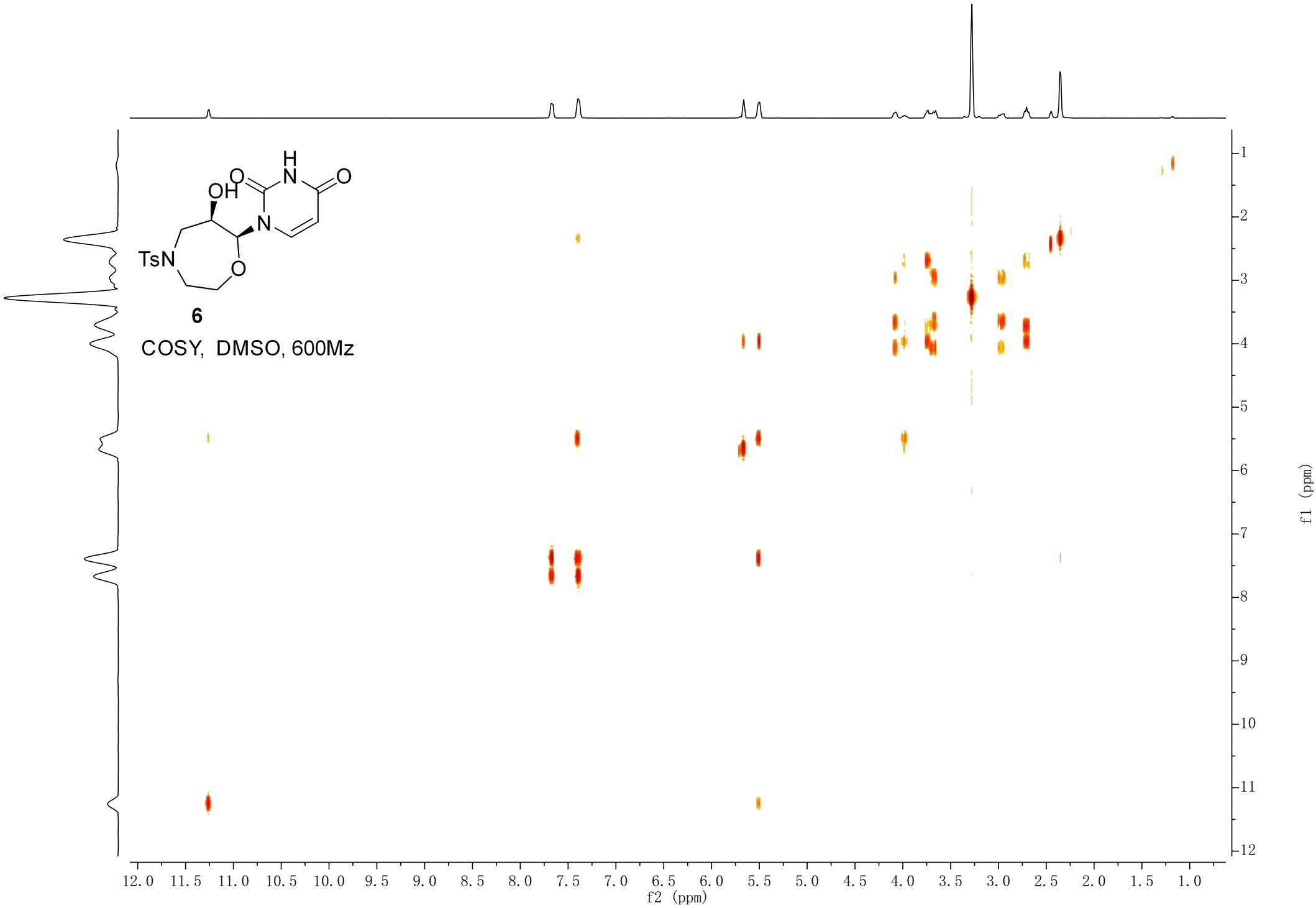

rsy
sx-iii-14-intramolecularcyclization
MeO
O
H
N
O
O
N
TsN
O
5
ROSEY, CDCl3, 600Mz
f2 (ppm)
f1 (ppm)

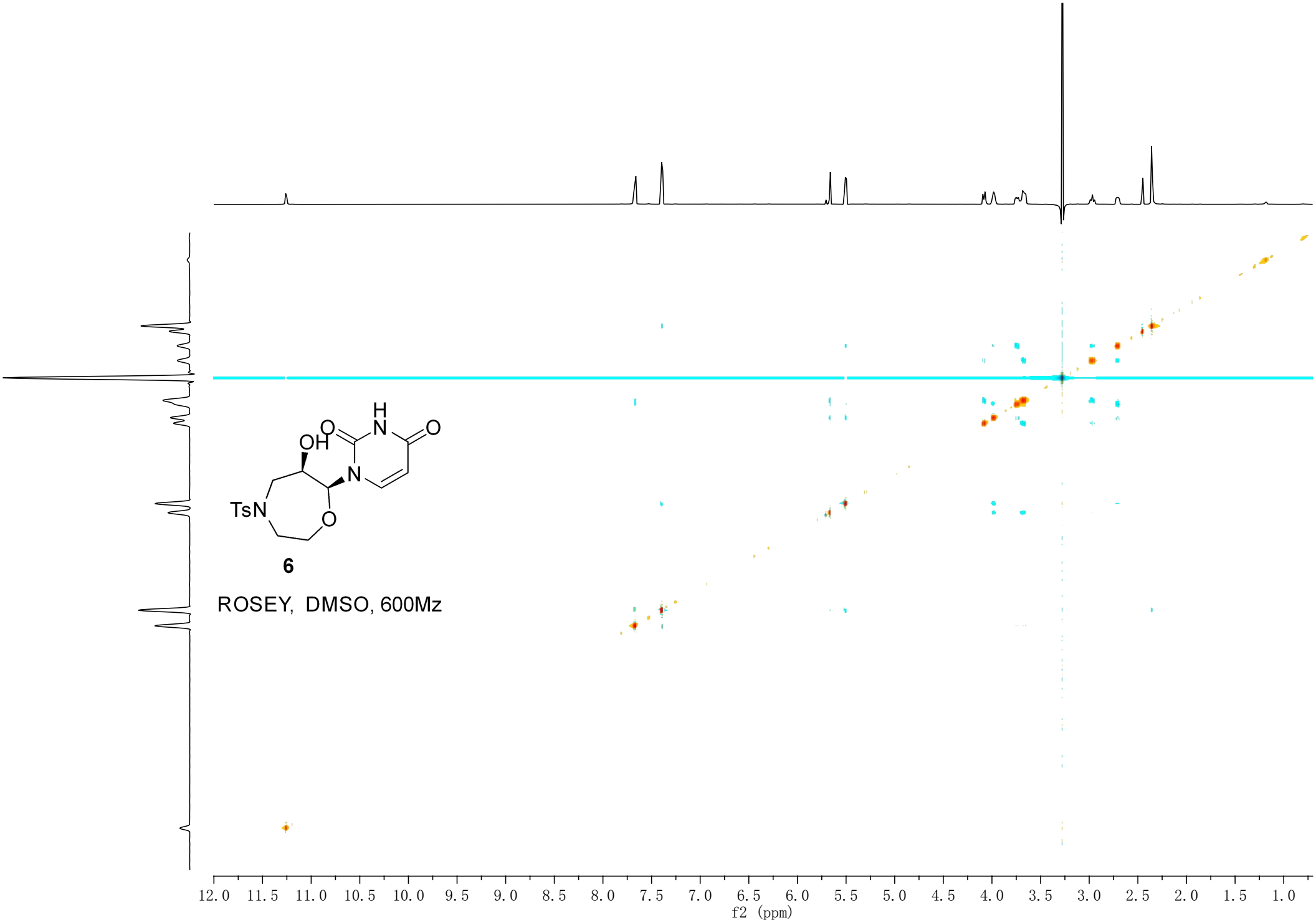


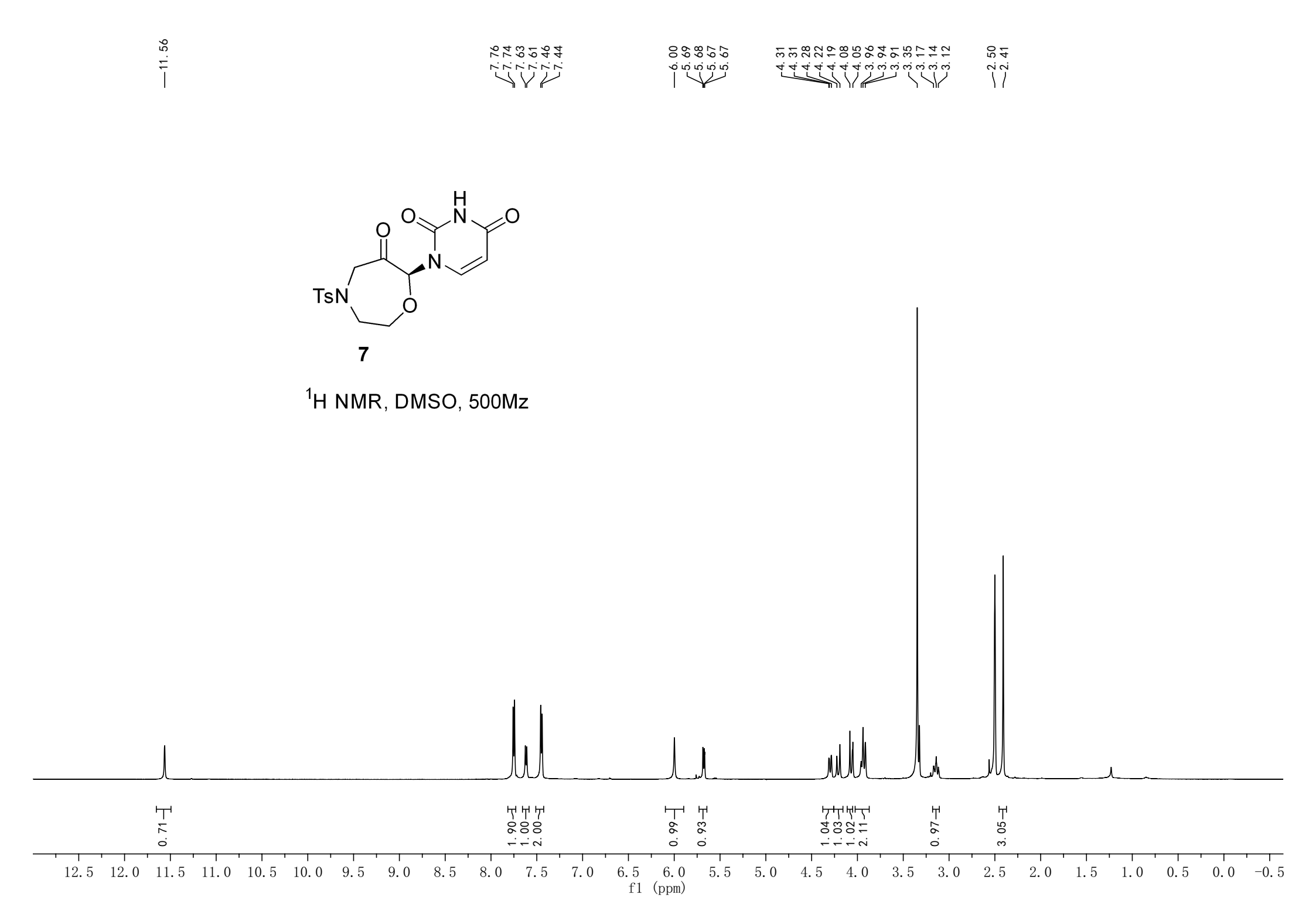
6

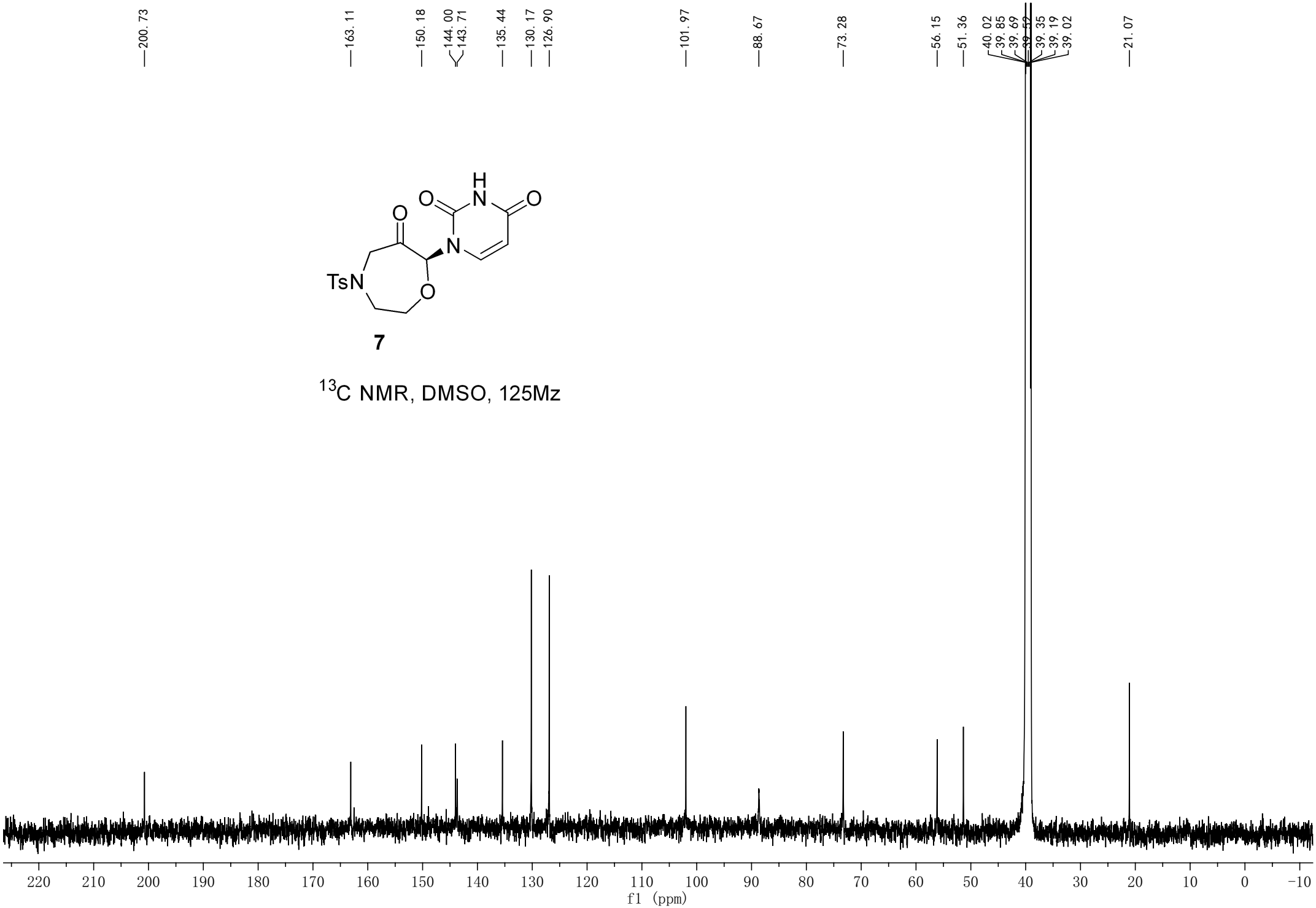
^{1}H NMR, DMSO, 500Mz

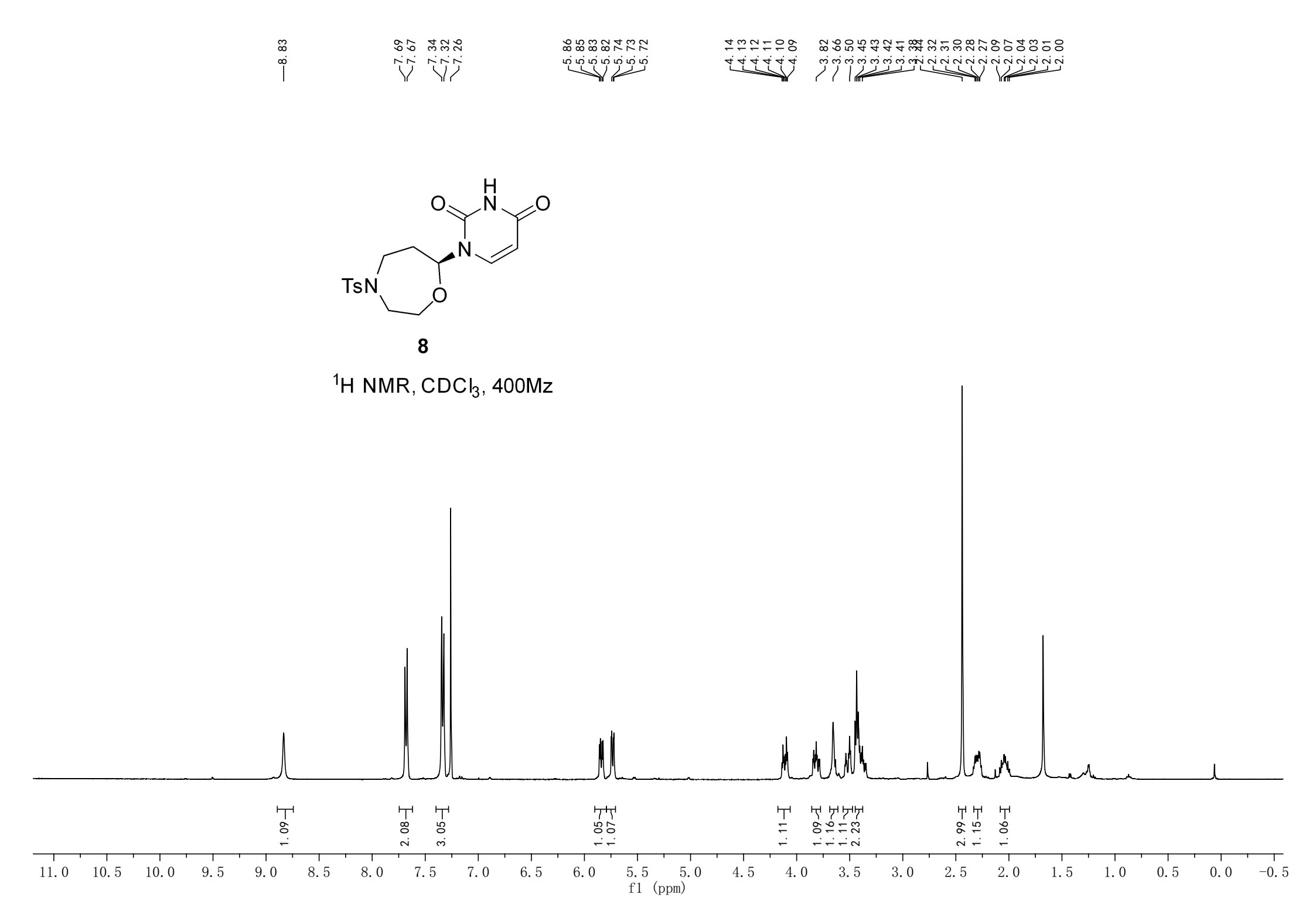

163.32
149.85
143.51
142.34
135.45
130.05
126.83
100.27
86.62
72.23
68.76
52.40
52.09
40.02
39.95
39.86
39.75
39.52
39.35
39.19
39.02
21.04
H
N
O
O
OH
N
TsN
O
6
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

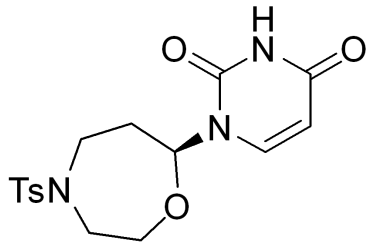

OH
O
H
N
N
O
TsN
O
6
COSY, DMSO, 600Mz
f2 (ppm)
f1 (ppm)


OH
O
H
N
O
N
TsN
O
6
ROSEY, DMSO, 600Mz
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0
f2 (ppm)


11.56
7.76
7.74
7.63
7.61
7.46
7.44
6.00
5.69
5.68
5.67
5.67
4.31
4.31
4.28
4.22
4.19
4.08
4.05
3.96
3.94
3.91
3.35
3.17
3.14
3.12
2.50
2.41
H
N
O
O
O
N
TsN
O
7
1H NMR, DMSO, 500Mz
0.71
1.90
1.00
2.00
0.99
0.93
1.04
1.03
1.02
2.11
0.97
3.05
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)

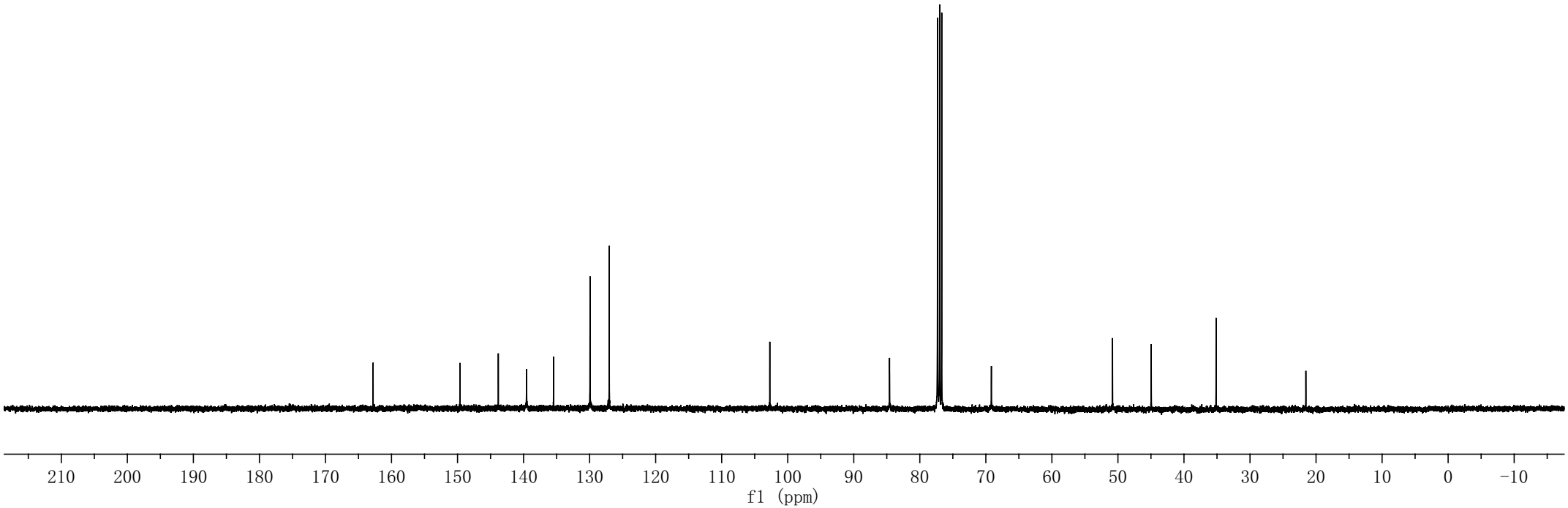

200.73
163.11
150.18
144.00
143.71
135.44
130.17
126.90
101.97
88.67
73.28
56.15
51.36
40.02
39.85
39.69
39.52
39.35
39.19
39.02
21.07
H
N
O
O
O
N
TsN
O
7
13C NMR, DMSO, 125Mz
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

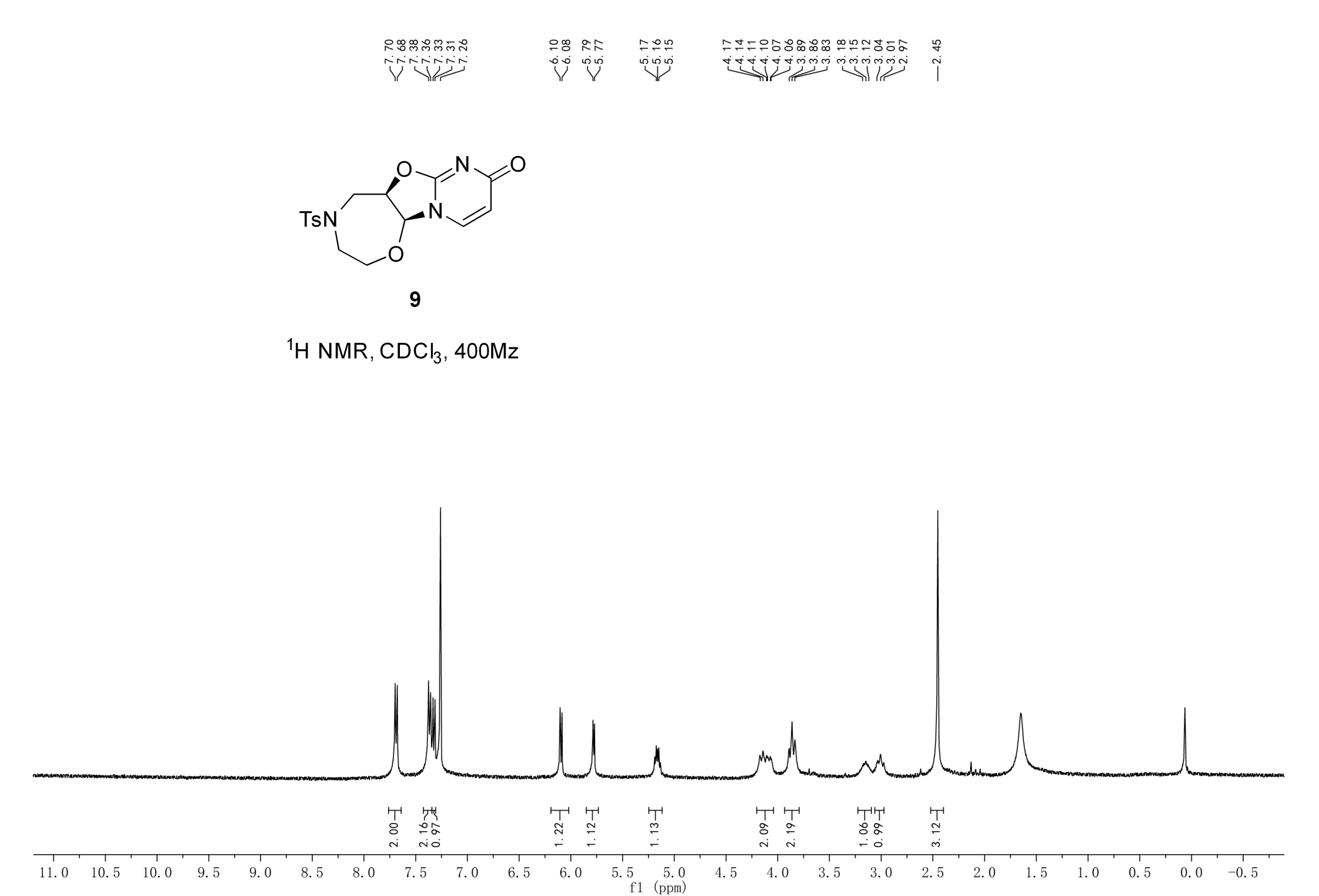

8.83
7.69
7.67
7.34
7.32
7.26
5.86
5.85
5.83
5.82
5.74
5.73
5.72
4.14
4.13
4.12
4.11
4.10
4.09
3.82
3.66
3.50
3.45
3.43
3.42
3.41
2.32
2.31
2.30
2.28
2.27
2.09
2.07
2.04
2.03
2.01
2.00
H
N
O
O
N
TsN
O
8
1H NMR, CDCl3, 400Mz
1.09
2.08
3.05
1.05
1.07
1.11
1.09
1.16
1.11
2.23
2.99
1.15
1.06
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)



8

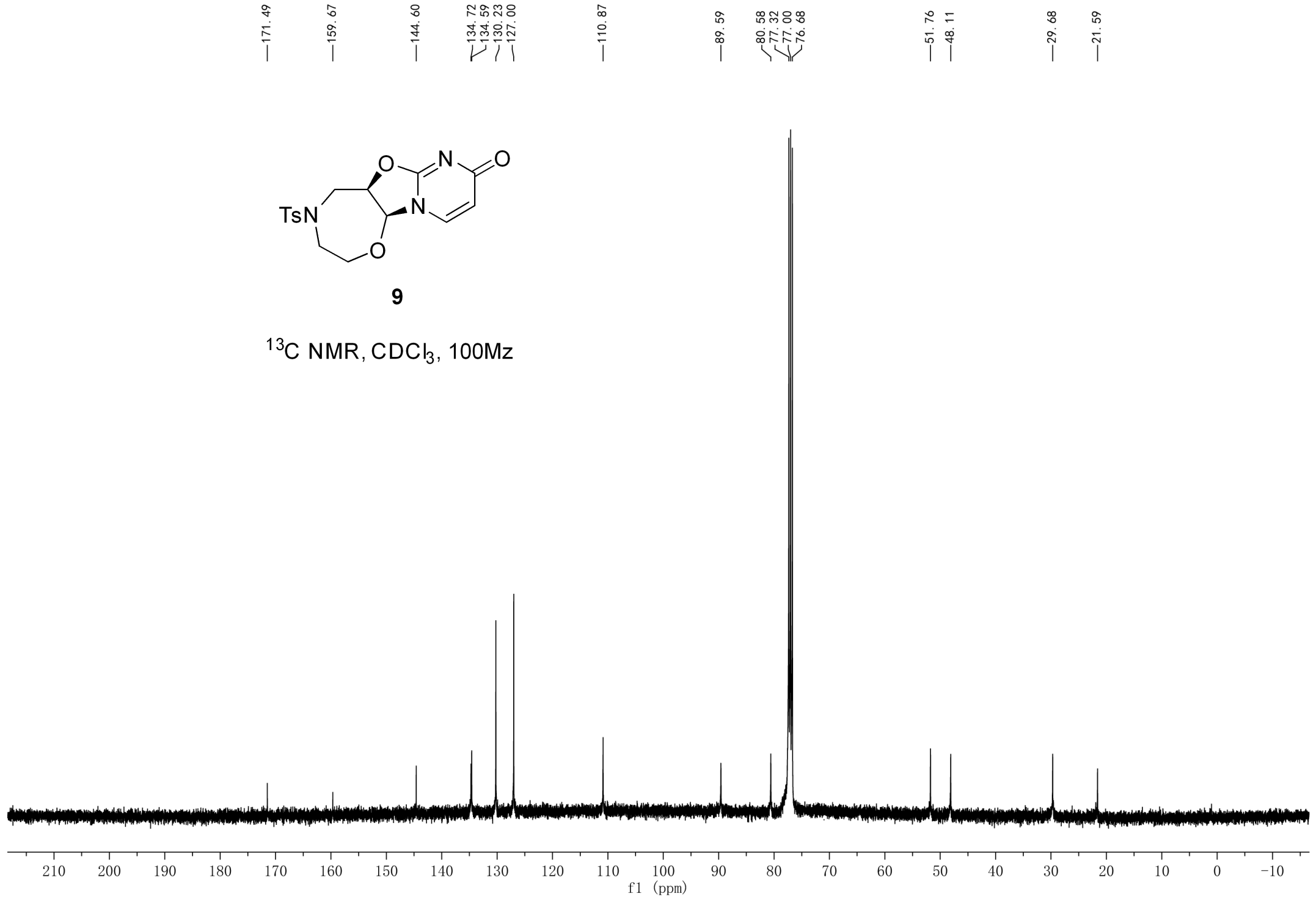
^{13}C NMR, $CDCl_3$, 100Mz

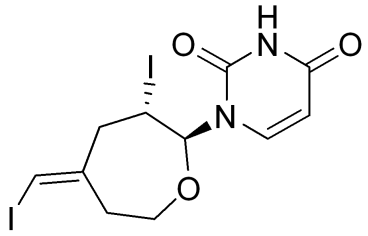




9

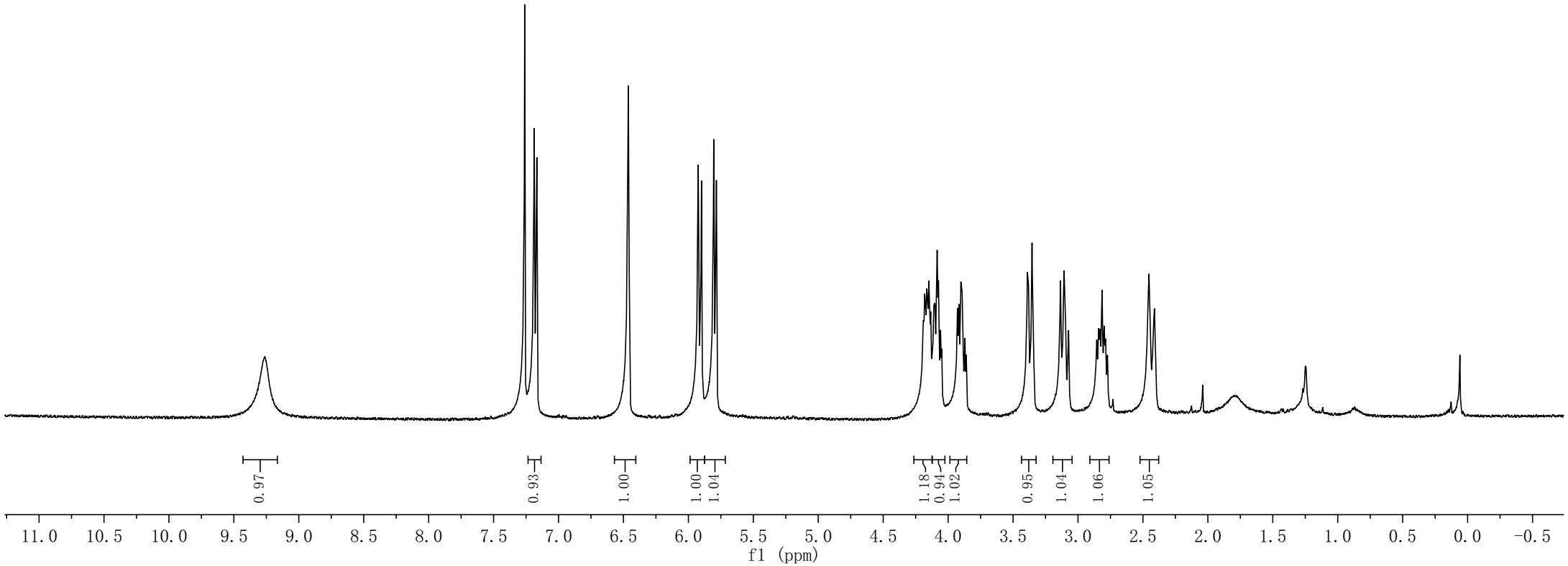
^{1}H NMR, $CDCl_3$, 400Mz

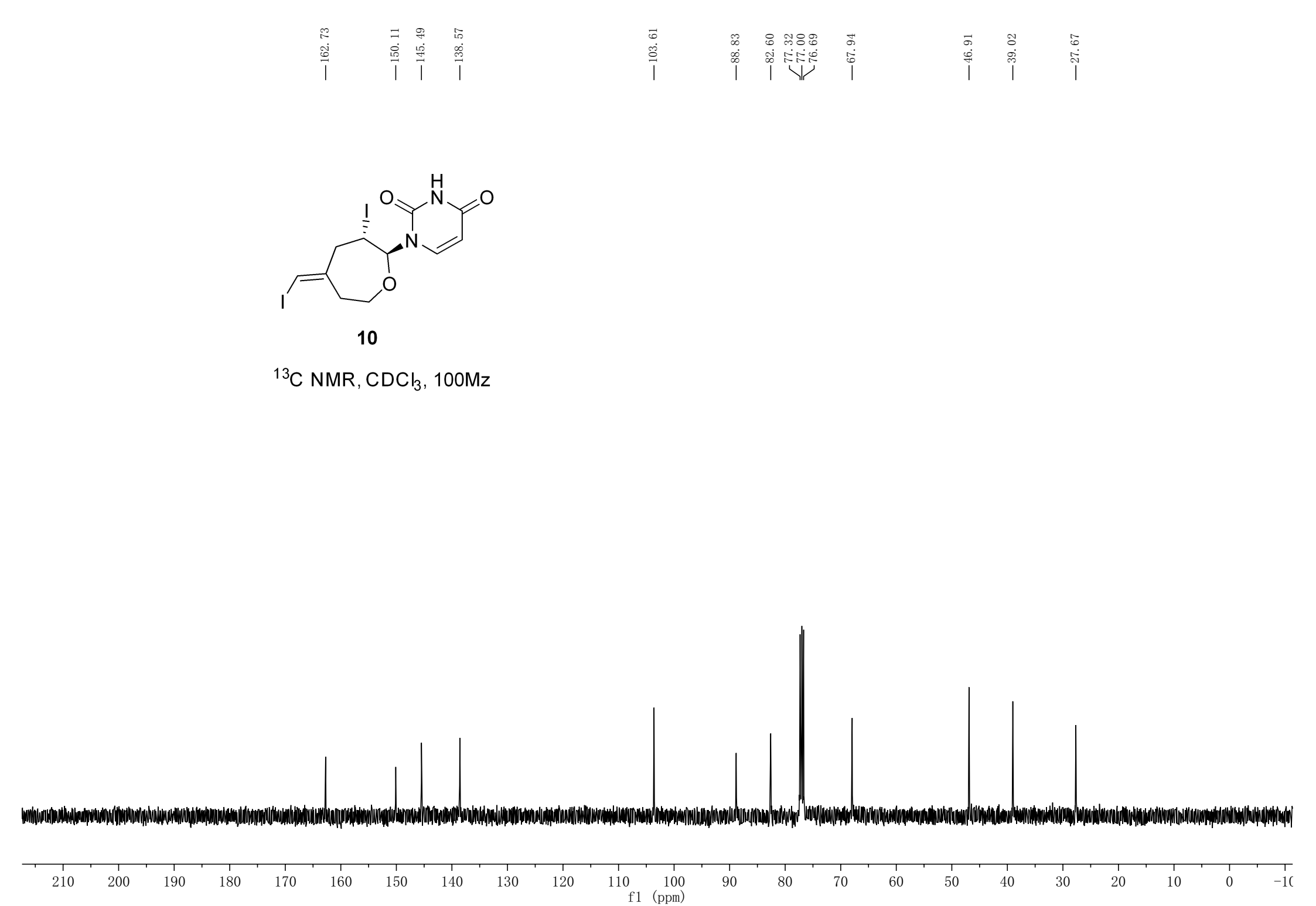

171.49
159.67
144.60
134.72
134.59
130.23
127.00
110.87
89.59
80.58
77.32
77.00
76.68
51.76
48.11
29.68
21.59
O
N
O
TsN
N
O
9
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

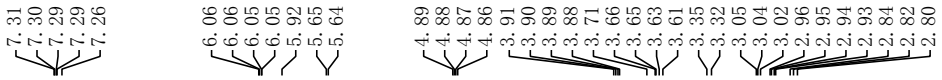


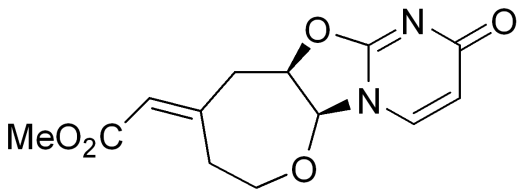
10

^{1}H NMR, $CDCl_3$, 400Mz



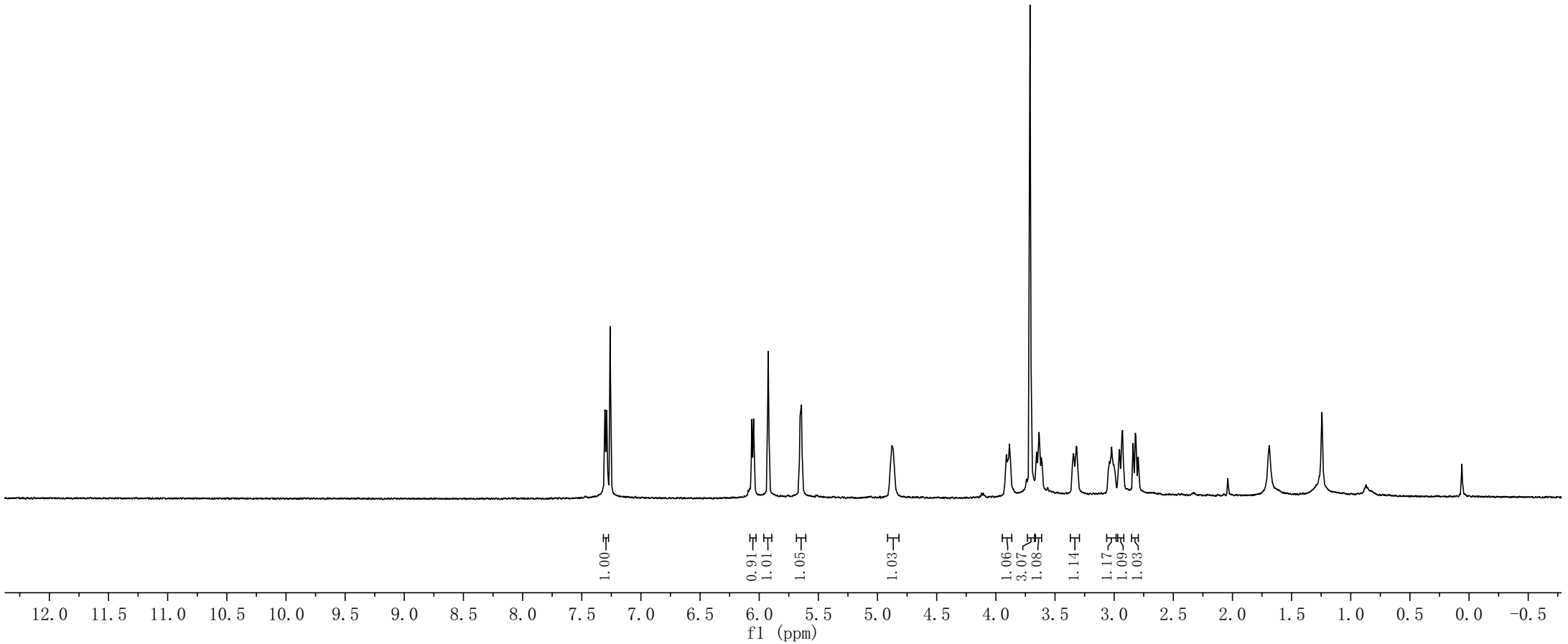

162.73
150.11
145.49
138.57
103.61
88.83
82.60
77.32
77.00
76.69
67.94
46.91
39.02
27.67
H
N
O
O
N
I
O
I
10
13C NMR, CDCl3, 100Mz
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)



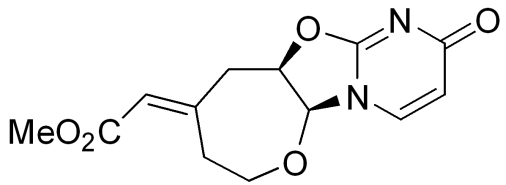


11

^{1}H NMR, $CDCl_3$, 500Mz



171.70
165.85
159.71
150.47
134.56
121.71
110.79
88.73
79.81
77.32
77.00
76.68
67.40
51.44
38.93
34.32



11

^{13}C NMR, $CDCl_3$, 100Mz