Supporting Information for

Chemical Synthesis of Quillaic Acid, the Aglycone of QS-21

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Contents

S1-S2 List of the Contents

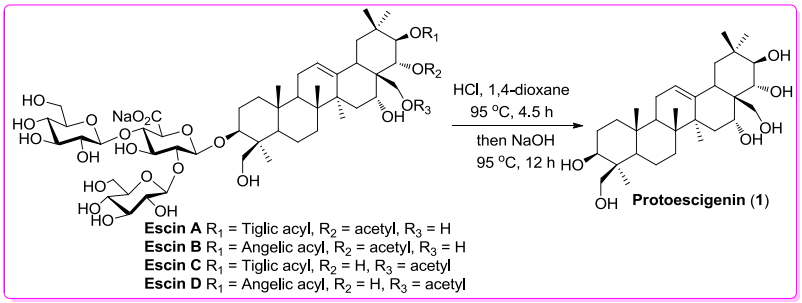
S3-S41 Experimental Section and Characterization Data for New Compounds

General Comments:

All reactions were monitored by thin-layer chromatography over silica-gel-coated TLC plates (Yantai Chemical Industry Research Institute). The spots on TLC were visualized by warming 5% H_2SO_4 (5% H_2SO_4 in ethanol) sprayed plates on a hot plate. Column chromatography was performed using silica gel (Qingdao Marine Chemical Inc., China), and Sephadex LH-20 (GE Healthcare Bio-Sciences AB, Sweden). NMR spectra were recorded on a Bruker AM-400 spectrometer (400 MHz). Optical rotations were measured at 25 ℃ with a Rudolph Autopol IV automatic polarimeter using a quartz cell with 2 mL capacity and a 1 dm path length. Concentrations (*c*) are given in g/100 mL. High resolution mass spectra were recorded on a Bruker micrOTOF II spectrometer using electrospray ionization (ESI).

All solvents were processed under conventional way before using, and all reagents were purchased from Adamas and used without further purification.

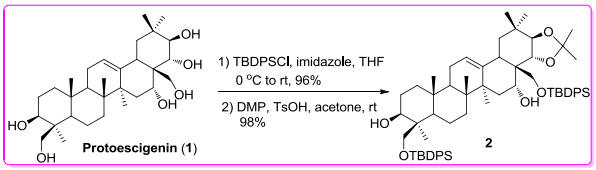
Protoescigenin (1)



To a stirred suspension of commercially available escins (20.00 g) in 1,4-dioxane (100.00 mL) was added 2M HCl (100.00 mL). The resulting slurry was then heated to 95 ^{o}C, at which temperature all solids were dissolved and a brown solution was formed. The stirring was continued for another 4.5 h at the same temperature. The reaction mixture was then cooled down to 0 ^{o}C, to which NaOH solid was added to adjust the pH value of the reaction mixture to above 13. After being diluted with methanol (2.00 mL) and stirred at room temperature for 10 min, the reaction mixture was then heated to 95 ^{o}C and the stirring was continued overnight. After being cooled to room temperature, the reaction mixture was diluted with ethyl acetate under vigorous stirring, and all solids were removed by filtration through a pad of *Celit*. The

solids were thoroughly washed with ethyl acetate until TLC showed no **1** was detected from the new filtrate. All filtrate was combined, and the organic layer was separated. Filtration was followed by concentration under reduced pressure to give a residue, which was further purified by silica gel column chromatography (dichloromethane/MeOH = 16 : 1 to 6 : 1) to provide protoescigenin **1** (4.21 g) as a white solid, whose ^{1}H NMR spectrum was shown essentially identical to that reported in literature.[S1]

21,22-O-Isopropylidene-24,28-di-O-tert-butyldiphenylsilyl-protoescigenin (2)

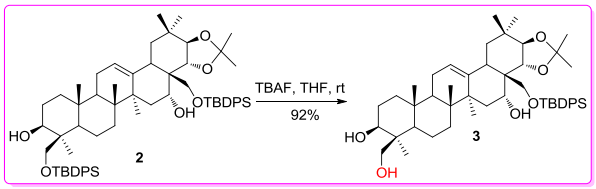


To a stirred solution of **1** (20.00 g, 39.47 mmol) and imidazole (16.12 g, 263.82 mmol) in dry THF (200.00 mL) was added TBDPSCl (41.05 mL, 157.88 mmol) dropwise at room temperature under N_2 atmosphere. The stirring was continued at the same temperature for another 2 h before ethyl acetate was added to dilute the reaction. The resulting mixture was washed saturated aqueous $NaHCO_3$ and brine, and the organic layer was then dried over anhydrous Na_2SO_4. The solid was removed by filtration and the filtrate was concentrated *in vacuo* to afford the crude product, which was then subjected to silica gel column chromatography purification (petroleum ether/ethyl acetate = 3 : 1 to 2 : 1) to provide the disilylated intermediate (37.31 g, 96%).[S1]

To a stirred solution of the above obtained intermediate (15.00 g, 15.25 mmol) and DMP (48.76 mL, 396.53 mmol) in dry acetone (200.00 mL) was added *p*-TsOH (262.6 mg, 1.53 mmol) at room temperature under N_2 atmosphere. The mixture was then stirred at the same temperature for 15 min before saturated aqueous $NaHCO_3$ was added to quench the reaction. After being diluted with ethyl acetate, the resulting mixture was washed with saturated aqueous $NaHCO_3$ and brine. The organic layer was then dried over anhydrous Na_2SO_4. Afterwards, the volatile solvent was removed *in vacuo* and the obtained residue was purified by silica gel column chromatography (petroleum ether/ethyl acetate = 15 : 1) to provide **2** (15.30 g, 98%) as a white

solid.[S1]

21,22-O-Isopropylidene-28-O-tert-butyldiphenylsilyl-protoescigen (3)



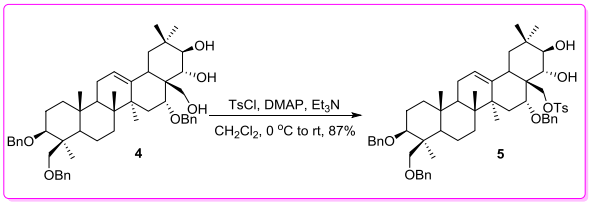
To a stirred solution of **2** (5.00 g, 4.88 mmol) in dry THF (300.00 mL) was added TBAF (1.53 g, 5.86 mmol) at room temperature under N_2 atmosphere. The resulting mixture was stirred at the same temperature for 13 min, and was then diluted with ethyl acetate. The resulting mixture was washed with water and brine, and the organic layer was then dried over anhydrous Na_2SO_4. Filtration and concentration under reduced pressure gave a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 2 : 1 to 1 : 1) to provide **3** (3.53 g, 92%) as a white solid: $[\alpha]_D^{25}$ = 32.7 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68-7.64 (m, 4 H), 7.44-7.31 (m, 6 H), 5.39 (dd, *J* = 3.2, 4.0 Hz, 1 H), 4.30 (*J* = 10.0 Hz, 1 H), 4.20 (d, *J* = 10.8 Hz, 1 H), 4.17 (d, *J* = 10.0 Hz, 1 H), 3.91 (q, *J* = 4.0 Hz, 1 H), 3.44 (d, *J* = 9.6 Hz, 1 H), 3.40 (d, *J* = 9.6 Hz, 1 H), 3.33 (dd, *J* = 9.2, 10.0 Hz, 1 H), 3.18 (d, *J* = 9.6 Hz, 1 H), 2.98 (d, *J* = 8.4 Hz, 1 H), 2.81 (d, *J* = 1.2 Hz, 1 H), 2.75 (dd, *J* = 5.2, 14.0 Hz, 1 H), 2.40 (d, *J* = 3.2 Hz, 1 H), 2.14 (t, *J* = 14.0 Hz, 1 H), 1.91-1.53 (m, 9 H), 1.51 (s, 3 H), 1.48 (s, 3 H), 1.43 (m, 1 H), 1.32 (s, 3 H), 1.28-1.24 (m, 2 H), 1.22 (s, 3 H), 1.07 (s, 6 H), 1.04 (s, 9 H), 1.00-0.91 (m, 2 H), 0.86 (s, 3 H), 0.83 (d, *J* = 12.0 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.5, 135.8 (2 C), 133.2, 133.0, 129.8 (2 C), 127.8 (2 C), 124.4, 108.4, 83.0, 80.8, 76.1, 70.1, 65.2, 64.6, 55.9, 48.3, 47.0, 45.5, 42.8, 41.7, 40.0, 39.7, 38.5, 36.8, 34.4, 34.2, 33.3, 29.7, 27.7, 27.6, 27.2, 27.1, 26.8, 23.9, 22.5, 19.3, 18.4, 17.2 (2 C), 16.3; HRMS (ESI) calcd for $C_{49}H_{72}O_6SiK$ $[M+K]^+$ 823.4730, found 823.4753.

3,16,24-Tri-O-benzyl-protoescigenin (4)

To a stirred solution of **3** (2.00 g, 2.55 mmol) and BnBr (3.63 mL, 30.57 mmol) in dry DMF (4.00 mL) was added NaH (60% dispersed in mineral oil, 815.0 mg, 20.38 mmol) portionwise at 0 ^{o}C (**caution**: H_2 gas evolved). After the addition was completed, the stirring was continued at the same temperature under N_2 atmosphere for another 12 h before ethyl acetate was added to dilute the reaction mixture. The resulting mixture was thoroughly washed with water and brine, and the organic layer was then dried over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* gave a residue, which was put to the next step without further purification after co-evaporated with toluene for three times.

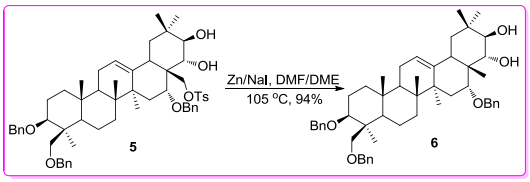
The above obtained residue was then disollved in a mixed solvent of CH_2Cl_2/MeOH (15.00 ml, v/v = 1 : 2), to which CSA (2.96 g, 12.74 mmol) was added at room temperature. The stirring was continued at the same temperature for 6 h before Et_3N was added to quench the reaction. The volatile solvent was evaporated under reduced pressure and the resulting residue was then subjected silica gel column chromatography (petroleum ether/ethyl acetate = 3 : 1 to 2 : 1) to furnish **4** (1.19 g, 60% over 2 steps) as a white solid: $[\alpha]_D^{25}$ = 9.2 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36-7.26 (m, 15 H), 5.30 (dd, *J* = 3.2, 4.0 Hz, 1 H), 4.72 (d, *J* = 11.2 Hz, 1 H), 4.67 (d, *J* = 12.0 Hz, 1 H), 4.47 (s, 2 H), 4.44 (d, *J* = 11.6 Hz, 1 H), 4.43 (d, *J* = 11.2 Hz, 1 H), 4.22 (brs, 1 H), 3.95 (d, *J* = 9.6 Hz, 1 H), 3.81 (d, *J* = 9.6 Hz, 1 H), 3.66 (d, *J* = 9.6 Hz, 1 H), 3.58 (d, *J* = 10.8 Hz, 1 H), 3.56 (d, *J* = 9.2 Hz, 1 H), 3.36 (d, *J* = 11.2 Hz, 1 H), 3.04 (dd, *J* = 4.4, 12.0 Hz, 1 H), 2.59 (brs, 3 H), 2.45 (t, *J* = 13.6 Hz, 1 H), 2.04 (dd, *J* = 4.4, 14.0 Hz, 1 H), 1.92 (dd, *J* = 3.6, 8.8 Hz, 2 H), 1.83-1.44 (m, 9 H), 1.42 (s, 3 H), 1.39-1.35 (m, 1 H), 1.22 (s, 3 H), 1.12 (dd, *J* = 4.4, 13.2 Hz, 1 H), 0.98 (s, 3 H), 0.92 (s, 3 H), 0.89 (s, 3 H), 0.86 (s, 3 H), 0.82 (dd, *J* = 2.8, 10.0 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.7, 139.5, 139.3, 138.9, 128.4, 128.3, 128.2, 127.8, 127.5, 127.4 (2 C), 127.2, 123.6, 86.8, 80.1, 78.2, 75.0, 73.5, 73.2, 72.1, 71.9, 71.3, 56.6, 47.0, 46.9, 46.3, 43.2, 41.6, 41.2, 39.9, 39.1, 37.1, 35.5, 33.6, 29.4, 26.9, 26.4, 23.7, 22.9, 20.5, 18.7, 16.5, 15.1; HRMS (ESI) calcd for $C_{51}H_{69}O_6$ $[M+H]^+$ 777.5089, found 777.5084.

3,16,23-Tri-O-benzyl-28-O-tosyl-protoescigenin (5)



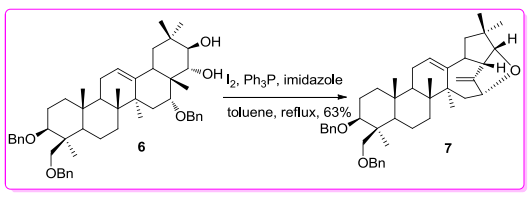
To a stirred solution of **4** (1.00 g, 1.29 mmol) in dry CH_2Cl_2 (60.00 mL) was added DMAP (47.2 mg, 386.05 μmol), Et_3N (0.72 mL, 5.15 mmol), TsCl (981.3 mg, 5.15 mmol) at 0 ^oC under N_2 atmosphere. The reaction mixture was gradually warmed up to room temperature and the stirring was continued for another 8 h before ethyl acetate was added to dilute the reaction. The resulting mixture was washed successively with water, and brine, and then the organic layer was dried over anhydrous Na_2SO_4. Filtration was followed by concentration *in vacuo* to give the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 4 : 1) to furnish tosylate **5** (1.04 g, 87%) as a yellow solid: $[\alpha]_D^{25}$ = 4.0 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.78 (d, *J* = 8.0 Hz, 2 H), 7.36-7.27 (m, 17 H), 5.17 (t, *J* = 3.6 Hz, 1 H), 4.66 (d, *J* = 12.0 Hz, 1 H), 4.63 (d, *J* = 11.6 Hz, 1 H), 4.50 (AB, 2 H), 4.44 (d, *J* = 11.6 Hz, 1 H), 4.42 (d, *J* = 11.2 Hz, 1 H), 3.92 (d, *J* = 9.2 Hz, 1 H), 3.89 (d, *J* = 9.6 Hz, 1 H), 3.86 (brs, 1 H), 3.82 (d, *J* = 9.6 Hz, 1 H), 3.72 (d, *J* = 9.2 Hz, 1 H), 3.59 (d, *J* = 9.2 Hz, 1 H), 3.55 (d, *J* = 9.6 Hz, 1 H), 3.02 (dd, *J* = 4.4, 12.0 Hz, 1 H), 2.43 (s, 3 H), 2.39-2.28 (m, 2 H), 2.09 (brs, 2 H), 1.87-1.50 (m, 9 H), 1.42 (dd, *J* = 4.0, 12.8 Hz, 1 H), 1.32-1.23 (m, 2 H), 1.35 (s, 3 H), 1.21 (s, 3 H), 1.09 (dd, *J* = 2.4, 11.2 Hz, 1 H), 0.94 (s, 3 H), 0.90 (s, 3 H), 0.85 (s, 3 H), 0.78 (dd, *J* = 2.4, 11.6 Hz, 1 H), 0.51 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.0, 140.4, 139.5, 139.3, 138.4, 132.7, 130.0, 128.4, 128.3, 128.2 (2 C), 127.9, 127.6, 127.5, 127.4, 127.3, 127.2, 124.7, 86.7, 78.2, 75.1, 74.2, 73.5, 73.3, 73.0, 71.9, 71.5, 56.5, 46.8, 46.6, 46.4, 43.1, 41.2, 39.9, 39.7, 39.1, 37.0, 35.3, 33.4, 29.3, 27.4, 26.3, 23.7, 23.6, 22.9, 21.8, 20.4, 18.6, 16.1, 15.0; HRMS (ESI) calcd for $C_{58}H_{78}NO_8S$ $[M+NH_4]^+$ 948.5443, found 948.5442.

3,24-Di-O-benzyl-28-deoxy-protoescigenin (6)



To a sealed tube **5** (600.0 mg, 644.27 μmol), zinc dust (421.2 mg, 6.44 mmol), NaI (1.93 g, 12.89 mmol), and DMF/dimethoxyethane (12.00 mL, v/v = 3 : 1) were added sequentially. The tube was sealed and the mixture was then heated to 105 ^{o}C under vigorous stirring for 12 h. After being cooled to room temperature, filtration through a pad of *Celite* was conducted. The filtrate was diluted with ethyl acetate, which was followed by washing with water, 1M HCl, and brine successively. After being dried over anhydrous Na_2SO_4, the organic layer was evaporated under reduced pressure. The resulting residue was then subjected to silica gel column chromatography purification (petroleum ether/ethyl acetate = 5 : 1) to furnish **6** (460.9 mg, 94%) as a white solid: $[\alpha]_D^{25}$ = 27.4 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.24 (m, 15 H), 5.33 (t, *J* = 3.6 Hz, 1 H), 4.68 (d, *J* = 10.8 Hz, 1 H), 4.65 (d, *J* = 11.2 Hz, 1 H), 4.45 (s, 2 H), 4.42 (d, *J* = 12.0 Hz, 1 H), 4.33 (d, *J* = 11.2 Hz, 1 H), 3.89 (d, *J* = 9.6 Hz, 1 H), 3.80 (d, *J* = 9.6 Hz, 1 H), 3.78 (s, 1 H), 3.54 (d, *J* = 9.6 Hz, 1 H), 3.28 (d, *J* = 9.6 Hz, 1 H), 3.03 (dd, *J* = 4.4, 12.0 Hz, 1 H), 2.40 (t, *J* = 13.6 Hz, 1 H), 2.17 (dd, *J* = 4.0, 14.0 Hz, 1 H), 1.92-1.89 (m, 3 H), 1.81-1.55 (m, 9 H), 1.49-1.41 (m, 1 H), 1.38 (s, 3 H), 1.20 (s, 3 H), 1.08 (dd, *J* = 4.4, 13.2 Hz, 1 H), 0.971 (s, 3 H), 0.966 (s, 3 H), 0.93 (s, 3 H), 0.88 (s, 3 H), 0.86 (s, 3 H), 0.81 (dd, *J* = 3.6, 10.4 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 142.4, 139.5, 139.3, 138.8, 128.5, 128.3, 128.2, 127.8, 127.5, 127.4 (2 C), 127.1, 123.4, 86.8, 81.4, 78.8, 73.5, 73.3, 71.9, 70.9, 56.6, 47.3, 47.0, 45.6, 43.2, 42.9, 41.6, 39.9, 39.1, 37.1, 35.5, 33.7, 29.6, 27.3, 26.9, 26.3, 23.7, 22.9, 20.6, 18.7, 16.6, 15.1, 13.9; HRMS (ESI) calcd for $C_{52}H_{69}O_7$ $[M+HCOO]^-$ 805.5038, found 805.5033.

Compound (7)



To a flask containing **6** (100.0 mg, 131.39 μmol), I_2 (200.1 mg, 788.33 μmol), PPh_3 (206.8 mg, 788.33 μmol), and imidazole (89.5 mg, 1.31 mmol) was charged dry toluene (2.00 mL). The resulting mixture was then heated to reflux, and the stirring was continued for 6 h, at which time TLC showed that all starting material was consumed. The reaction mixture was then cooled to room temperature, and was then diluted with ethyl acetate. The resulting mixture was washed with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration *in vacuo* to yield a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 50 : 1) to provide **7** (52.5 mg, 63%) as a white solid: $[\alpha]_D^{25}$ = 20.5 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.24 (m, 10 H), 5.36 (t, *J* = 3.6 Hz, 1 H), 4.86 (d, *J* = 1.2 Hz, 1 H), 4.73 (dd, *J* = 2.0, 3.2 Hz, 1 H), 4.70 (s, 1 H), 4.65 (d, *J* = 11.6 Hz, 1 H), 4.47 (AB, 2 H), 4.43 (d, *J* = 11.6 Hz, 1 H), 3.79 (d, *J* = 9.6 Hz, 1 H), 3.68 (d, *J* = 2.4 Hz, 1 H), 3.54 (d, *J* = 9.6 Hz, 1 H), 3.20-3.13 (m, 1 H), 3.10 (dd, *J* = 2.8, 10.8 Hz, 1 H), 3.02 (dd, *J* = 4.4, 12.0 Hz, 1 H), 2.22 (dd, *J* = 7.2, 13.2 Hz, 1 H), 1.90-1.43 (m, 12 H), 1.40 (s, 3 H), 1.38 (t, *J* = 6.0 Hz, 2 H), 1.20 (s, 3 H), 1.12 (s, 3 H), 0.91 (s, 3 H), 0.90 (s, 3 H), 0.80 (s, 3 H), 0.77 (d, *J* = 5.2 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.6, 145.0, 139.5, 139.3, 128.3, 128.2, 127.6, 127.4, 127.3, 127.1, 126.7, 104.3, 94.7, 86.9, 82.5, 73.5, 73.3, 71.9, 56.3, 53.2, 51.8, 47.7, 46.8, 56.0, 43.1, 42.6, 41.1, 40.8, 38.8, 37.1, 33.9, 31.2, 27.3, 24.2, 23.7, 23.4, 23.0, 20.5, 17.8, 14.6; HRMS (ESI) calcd for $C_{44}H_{59}O_3$ $[M+H]^+$ 635.4459, found 635.4454.

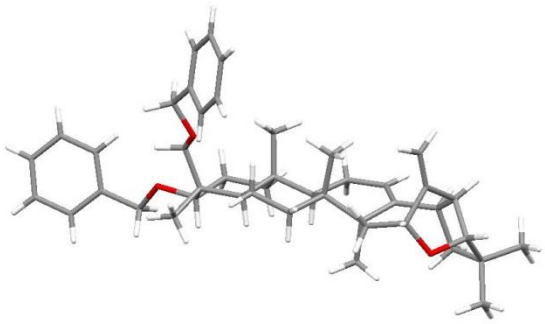
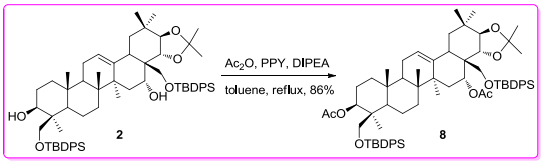


Figure S1.The ORTEP drawing of **7** with 50% probability ellipsoids.

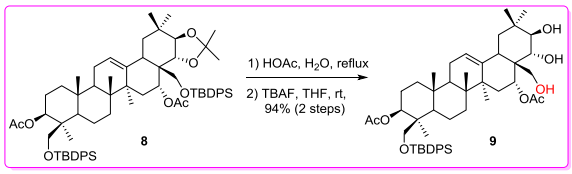
3,16-Di-O-acetyl-21,22-O-isopropylidene-24,28-di-O-tert-butyldiphenylsilyl-protoes

cigenin (8)



To a stirred solution of **2** (1.00 g, 976.95 μmol), PPY (29.0 mg, 195.39 μmol), and DIPEA (3.23 mL, 19.54 mmol) in dry toluene (1.00 mL) was added Ac_2O (0.92 mL, 9.77 mmol) at room temperature. After the addition was completed, the reaction mixture was heated to reflux and the stirring was continued for 12 h. After being cooled to room temperature, the reaction mixture was diluted with ethyl acetate. The resulting mixture was successively washed with water, saturated aqueous $NaHCO_3$, and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration under reduced pressure to afford a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 16 : 1) to provide **8** (928.8 mg, 86%) as a light yellow foam: $[\alpha]_D^{25}$ = 12.0 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, acetone-d_6) δ 7.76-7.72 (m, 8 H), 7.53-7.40 (m, 12 H), 5.50 (t, *J* = 3.6 Hz, 1 H), 5.16 (s, 1 H), 4.53 (dd, *J* = 5.2, 11.2 Hz, 1 H), 4.23 (d, *J* = 10.0 Hz, 1 H), 4.10 (dd, *J* = 10.4 Hz, 1 H), 3.94 (d, *J* = 10.8 Hz, 1 H), 3.83 (d, *J* = 10.8 Hz, 1 H), 3.52 (d, *J* = 9.2 Hz, 1 H), 3.39 (d, *J* = 9.2 Hz, 1 H), 2.84 (m, 1 H), 2.26 (t, *J* = 13.6 Hz, 1 H), 2.09 (s, 3 H), 1.94 (dd, *J* = 4.4, 11.2 Hz, 2 H), 1.88 (s, 3 H), 1.75-1.48 (m, 8 H), 1.45 (s, 3 H), 1.42-1.35 (m, 2 H), 1.33 (s, 3 H), 1.31 (s, 3 H), 1.29-1.19 (m, 2 H), 1.09 (s, 12 H), 1.07 (s, 12 H), 1.05 (s, 3 H), 0.99 (dd, *J* = 1.6, 12.0 Hz, 1 H), 0.91 (s, 3 H); ^{13}C NMR (100 MHz, acetone-d_6) δ 170.5, 169.0, 140.6, 136.6 (2 C), 136.5, 134.4, 133.7, 133.6, 130.8, 130.7 (2 C), 130.6, 128.7 (2 C), 128.6, 128.5, 126.2, 108.8, 82.4, 80.7, 75.9, 71.2, 65.7, 65.4, 56.7, 49.0, 47.4, 45.1, 43.6, 42.3, 40.5 (2 C), 39.3, 37.6, 34.8, 34.1, 31.4, 30.4, 27.6, 27.5, 27.4, 27.1, 24.4 (2 C), 23.1, 22.0, 21.1, 20.8, 19.9, 19.8, 17.7, 17.2, 15.9; HRMS (ESI) calcd for $C_{69}H_{94}O_8Si_2Na$ $[M+Na]^+$ 1129.6380, found 1129.6426.

3,16-Di-O-acetyl-24-O-tert-butyldiphenylsilyl-protoescgenin (9)

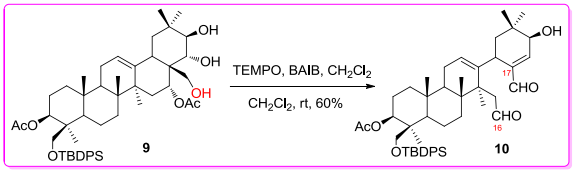


A solution of **8** (600.0 mg, 541.68 μmol) in a mixed solvent of HOAc and H_2O (50 mL, v/v = 4 : 1) was heated to reflux, and the stirring was continued at the same temperature for 30 min. The reaction mixture was cooled down to room temperature, and was then diluted with ethyl acetate. The resulting solution was thoroughly washed with water, saturated aqueous $NaHCO_3$, and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration to afford the diol intermediate, which was used directly to the next step without further purification.

The above obtained diol intermediate was then dissolved in dry THF (5.00 mL), to which TBAF (708.2 mg, 2.71 mmol) was added at room temperature. The reaction mixture was stirred at the same temperature for 4 h before ethyl acetate was added to dilute the reaction. The resulting solution was washed successively with water, saturated $NaHCO_3$, and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* gave the crude product, which was further purified by silica gel column chromatography (CH_2Cl_2/MeOH = 40 : 1) to furnish **9** (422.2 mg, 94%) as a white solid: $[\alpha]_D^{25}$ = 12.3 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70-7.67 (m, 4 H), 7.45-7.35 (m, 6 H), 5.57 (brs, 1 H), 5.33 (t, *J* = 3.6 Hz, 1 H), 4.55 (dd, *J* = 6.8, 8.0 Hz, 1 H), 3.84 (d, *J* = 10.8 Hz, 1 H), 3.72 (d, *J* = 10.8 Hz, 1 H), 3.71 (d, *J* = 10.4 Hz, 1 H), 3.61 (d, *J* = 10.8 Hz, 1 H), 3.51 (d, *J* = 9.6 Hz, 1 H), 3.38 (d, *J* = 11.2 Hz, 1 H), 2.94 (brs, 4 H), 2.29 (t, *J* = 13.6 Hz, 1 H), 2.10 (s, 3 H), 1.97 (dd, *J* = 4.0, 16.0 Hz, 1 H), 1.90 (s, 3 H), 1.86 (dd, *J* = 3.6, 9.2 Hz, 2 H), 1.74 (d, *J* = 14.0 Hz, 1 H), 1.61-1.30 (m, 9 H), 1.27 (s, 3 H), 1.22 (dd, *J* = 4.4, 9.6 Hz, 1 H), 1.07 (s, 9 H), 1.01 (s, 6 H), 0.96 (s, 3 H), 0.87 (s, 3 H), 0.85 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 171.1, 170.8, 140.6, 136.0, 135.9, 133.8 (2 C), 129.7, 129.6, 127.7, 127.6, 124.4, 80.6, 78.6, 78.0, 71.1, 70.5, 64.4, 56.2, 47.0, 46.8, 45.3, 42.9, 41.3, 40.9, 39.9, 38.7, 36.9, 35.5, 33.3, 30.4, 30.0, 29.8, 27.0, 26.8, 23.6 (2 C), 22.8, 22.4, 21.3, 20.0, 19.4, 18.6, 16.6, 15.5; HRMS (ESI) calcd for $C_{50}H_{72}O_8SiK$ $[M+K]^+$ 867.4628, found

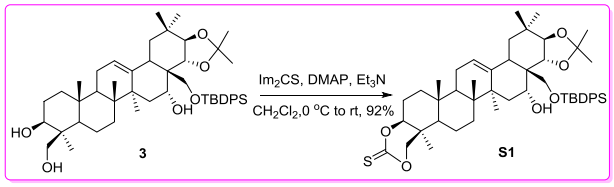
867.4643.

Compound (10)



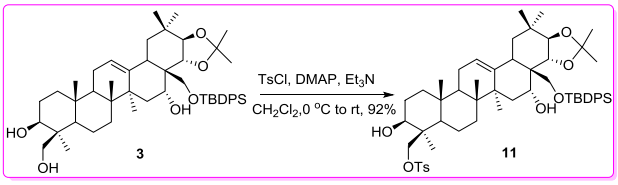
BAIB ($PhI(OAc)_2$) (97.1 mg, 301.49 μmol) was added to a stirred solution of **9** (100.0 mg, 120.60 μmol) and TEMPO (4.7 mg, 30.15 μmol) in dry dichloromethane (10.00 mL) at room temperature under N_2 atmosphere. The reaction mixture was stirred at the same temperature for 1.5 h, at which time TLC showed that no starting material was detected in the reaction mixture. The reaction mixture was diluted with ethyl acetate, and was then washed with saturated aqueous $Na_2S_2O_3$ and brine. After being dried over anhydrous Na_2SO_4, the volatile solvent was removed under reduced pressure. The resulting residue was then subjected to silica gel column chromatography purification to furnish dialdehyde **10** (55.5 mg, 60%) as a white solid: $[\alpha]_D^{25}$ = 16.3 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.41 (s, 1 H), 9.33 (s, 1 H), 7.70-7.66 (m, 4 H), 7.44-7.35 (m, 6 H), 6.84 (dd, *J* = 3.2, 6.0 Hz, 1 H), 5.39 (t, *J* = 3.6 Hz, 1 H), 4.55 (dd, *J* = 5.6, 10.8 Hz, 1 H), 3.87 (d, *J* = 10.8 Hz, 1 H), 3.70 (d, *J* = 10.8 Hz, 1 H), 3.43 (dd, *J* = 4.8, 8.8 Hz, 1 H), 2.68 (dd, *J* = 6.0, 19.6 Hz, 1 H), 2.07 (dd, *J* = 3.2, 19.2 Hz, 1 H), 1.97-1.88 (m, 1 H), 1.89 (s, 3 H), 1.85-1.41 (m, 12 H), 1.28 (s, 3 H), 1.19 (s, 3 H), 1.11 (m, 1 H), 1.08 (s, 3 H), 1.07 (s, 9 H), 1.02 (s, 3 H), 0.94 (dd, *J* = 2.0, 12.0 Hz, 1 H), 0.82 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 206.1, 192.3, 170.8, 152.2, 145.1, 138.9, 136.0, 135.9, 133.7 (2 C), 129.7 (2 C), 127.7, 127.6, 125.0, 80.4, 64.6, 56.4, 47.4, 46.6, 43.9, 42.8, 42.6, 39.7, 38.5, 37.9, 37.2, 33.6, 27.6, 27.1, 23.6, 23.1, 22.8, 21.4, 21.3, 20.3, 19.4, 17.3, 15.4; HRMS (ESI) calcd for $C_{48}H_{67}O_6Si$ $[M+H]^+$ 767.4702, found 767.4692.

3,24-O-Thionocarbonyl-21,22-O-isopropylidene-28-O-tert-butyldiphynylsilyl-protoescigenin (S1)



Thiocarbonyl imidazole (45.4 mg, 254.7 μmol) and DMAP (15.6 mg, 127.36 μmol) , Et_3N (177.0 μL, 1.27 mmol) were added to a stirred solution of **3** (100 mg, 127.36 μmol) in dry chloromethane (1.00 mL) at 0 ^oC under N_2 atmosphere. The reaction mixture was then gradually warmed up to room temperature, and the stirring was continued for 6 h before ethyl acetate was added to dilute the reaction. The resulting solution was washed successively with water, saturated aqueous $NaHCO_3$, and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* gave the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 5 : 1) to furnish **S1** (96.9 mg, 92%) as a white solid: $[\alpha]_D^{25}$ = +38.4 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, acetone-d_6) δ 7.77-7.72 (m, 4 H), 7.49-7.39 (m, 6 H), 5.45 (t, *J* = 3.6 Hz, 1 H), 4.76 (d, *J* = 11.2 Hz, 1 H), 4.63 (d, *J* = 10.0 Hz, 1 H), 4.26-4.20 (m, 2 H), 4.08 (d, *J* = 2.8 Hz, 1 H), 4.02 (dd, *J* = 2.0, 11.2 Hz, 1 H), 3.80 (d, *J* = 4.0 Hz, 1 H), 3.43 (d, *J* = 9.2 Hz, 1 H), 3.32 (d, *J* = 9.6 Hz, 1 H), 2.80 (dd, *J* = 4.8, 14.0 Hz, 1 H), 2.36 (t, *J* = 13.6 Hz, 1 H), 2.02-1.53 (m, 9 H), 1.47 (s, 3 H), 1.46 (s, 3 H), 1.41 (s, 3 H), 1.36-1.13 (m, 6 H), 1.21 (s, 3 H), 1.08 (s, 3 H), 1.07 (s, 3 H), 1.05 (s, 9 H), 1.02 (s, 3 H), 0.55 (s, 3 H); ^{13}C NMR (100 MHz, acetone-d_6) δ 142.4, 136.5, 133.9, 133.8, 130.7, 130.6, 128.6 (2 C), 125.3, 108.4, 85.4, 82.2, 76.6, 76.0, 69.3, 65.9, 52.6, 49.1, 46.1, 45.6, 43.0, 41.0, 40.9, 39.8, 37.3, 36.4, 34.9, 34.8, 33.3, 28.1, 27.8, 27.7, 27.6, 27.5, 27.2, 27.1, 24.4, 19.8, 18.9, 18.1, 17.9 (2 C), 12.9; HRMS (ESI) calcd for $C_{51}H_{71}O_8SSi$ $[M+HCOO]^-$ 871.4633, found 871.4633.

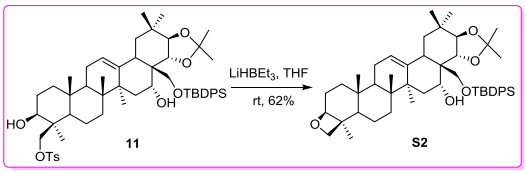
21,22-Isopropylidene-24-O-tosyl-28-O-tert-butyldiphenylsilyl-protoescigenin (11)



To a stirred solution of **3** (6.00 g, 7.64 mmol) in dry CH_2Cl_2 (80.00 mL) was added

DMAP (933.6 mg, 7.64 mmol), Et_3N (21.24 mL, 152.83 mmol) and TsCl (11.65 g, 61.13 mmol) successively at 0 ^oC under N_2 atmosphere. The reaction mixture was then warmed gradually up to room temperature, and the stirring was continued for 12 h at the same temperature. Ethyl acetate was added to dilute the reaction mixture, and the obtained solution was washed with water and brine, and then dried over anhydrous Na_2SO_4. Finally, filtration as well as concentration *in vacuo* was conducted to get the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 3.5 : 1) to provide **11** (6.61 g, 92%) as a light yellow solid: $[\alpha]_D^{25}$ = +34.3 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, *J* = 8.4 Hz, 2 H), 7.69-7.65 (m, 4 H), 7.45-7.32 (m, 8 H), 5.38 (t, *J* = 3.6 Hz, 1 H), 4.29 (d, *J* = 10.4 Hz, 1 H), 4.23 (d, *J* = 10.0 Hz, 1 H), 4.16 (d, *J* = 10.4 Hz, 1 H), 4.13 (d, *J* = 10.0 Hz, 1 H), 3.91 (dd, *J* = 3.2, 4.8 Hz, 1 H), 3.41 (d, *J* = 9.6 Hz, 1 H), 3.28 (d, *J* = 11.2 Hz, 1 H), 3.18 (d, *J* = 9.6 Hz, 1 H), 2.75 (dd, *J* = 5.2, 14.0 Hz, 1 H), 2.45 (s, 3 H), 2.36 (d, *J* = 3.6 Hz, 1 H), 2.13 (t, *J* = 14.0 Hz, 1 H), 1.89-1.56 (m, 8 H), 1.51 (s, 3 H), 1.48 (s, 3 H), 1.39-1.21 (m, 6 H), 1.30 (s, 3 H), 1.07 (s, 6 H), 1.06 (s, 3 H), 1.05 (s, 9 H), 1.00-0.94 (m, 2 H), 0.81 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.9, 140.5, 135.8 (2 C), 133.2, 133.0, 129.9, 129.8 (2 C), 128.1, 127.8 (2 C), 124.3, 108.4, 83.0, 78.7, 76.1, 72.2, 70.1, 65.2, 55.7, 48.3, 47.0, 45.5, 42.4, 41.7, 40.0, 39.6, 38.6, 36.9, 34.3, 34.2, 33.4, 29.7, 27.6, 27.1 (2 C), 27.0, 26.8, 23.7, 22.4, 21.8, 19.3, 19.2, 17.2, 17.0, 15.6; HRMS (ESI) calcd for $C_{56}H_{78}O_8SSiNa$ $[M+Na]^+$ 961.5079, found 961.5081.

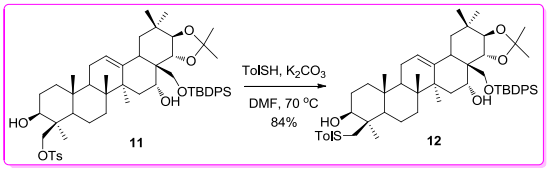
3,24-Anhydro-21,22-O-isopropylidene-28-O-tert-butyldiphenylsilyl-protoescigenin (S2)



To a flask containing **11** (100.0 mg, 106.45 μmol) was charged with 1M $LiHBEt_3$ (1.06 mL, 1.06 mmol) at room temperature under N_2 atmosphere. The resulting mixture was stirred at the same temperature for 2 h before ethyl acetate was added to

dilute the reaction. The resulting solution was washed with saturated aqueous $NaHCO_3$ and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration gave a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 15 : 1) to provide **S2** (50.6 mg, 62%) as a white solid: $[\alpha]_D^{25}$ = +48.0 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, acetone-d_6) δ 7.78-7.73 (m, 4 H), 7.50-7.40 (m, 6 H), 5.49 (t, *J* = 3.6 Hz, 1 H), 4.63 (d, *J* = 10.0 Hz, 1 H), 4.56 (dd, *J* = 2.4, 9.2 Hz, 1 H), 4.36 (d, *J* = 6.0 Hz, 1 H), 4.26 (d, *J* = 10.0 Hz, 1 H), 4.09 (dd, *J* = 2.8, 4.4 Hz, 1 H), 4.01 (d, *J* = 6.0 Hz, 1 H), 3.78 (d, *J* = 4.0 Hz, 1 H), 3.44 (d, *J* = 9.2 Hz, 1 H), 3.35 (d, *J* = 9.2 Hz, 1 H), 2.81 (dd, *J* = 5.2, 14.4 Hz, 1 H), 2.37 (t, *J* = 13.2 Hz, 1 H), 2.02 (m, 2 H), 1.88-1.78 (m, 2 H), 1.67 (t, *J* = 8.4 Hz, 1 H), 1.60-1.56 (m, 2 H), 1.47 (s, 3 H), 1.46 (s, 3 H), 1.41 (s, 3 H), 1.39 (s, 3 H), 1.36 (dd, *J* = 2.8, 12.0 Hz, 1 H), 1.29 (s, 3 H), 1.27-1.21 (m, 4 H), 1.08 (s, 3 H), 1.06 (s, 9 H), 1.02 (s, 3 H), 0.96-0.84 (m, 3 H); ^{13}C NMR (100 MHz, acetone-d_6) δ 142.5, 136.5, 134.0, 133.8, 130.7, 130.6, 128.6 (2 C), 125.3, 108.4, 85.4, 82.3, 79.2, 76.6, 76.1, 69.3, 66.0, 52.6, 49.1, 46.1, 45.6, 43.0, 41.0, 40.9, 39.8, 37.3, 36.4, 34.9, 34.8, 33.3, 28.1, 27.8, 27.7, 27.6, 27.5, 27.2, 27.1, 24.4, 19.8, 18.9, 18.1, 17.9, 12.9; HRMS (ESI) calcd for $C_{49}H_{70}O_5SiNa$ $[M+Na]^+$ 789.4885, found 789.4883.

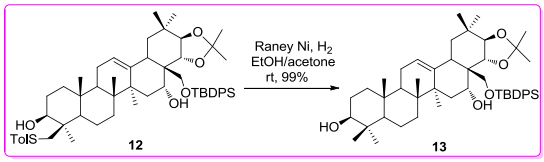
21,22-O-Isopropylidene-24-S-methylphenyl-28-O-tert-butyldiphenylsilyl-protoescigenin (12)



To a stirred solution of **11** (5.00 g, 5.32 mmol) and TolSH (3.31 g, 26.61 mmol) in dry DMF (100.00 mL) was added K_2CO_3 (2.94 g, 21.29 mmol) at room temperature under N_2 atmosphere. The resulting suspension was then heated to 70 ^{o}C by oil bath and was stirred at the same temperature for 8 h. The reaction mixture was then diluted by addition of ethyl acetate, and the obtained solution was washed with water and brine successively. After being dried over anhydrous Na_2SO_4, the volatile solvent was evaporated *in vacuo* to yield the crude product, which was then subjected to silica gel

column chromatography purification (petroleum ether/ethyl acetate = 8 : 1) to provide **12** (3.98 g, 84%) as a white solid: $[\alpha]_D^{25}$ = 76.7 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69-7.65 (m, 4 H), 7.45-7.32 (m, 6 H), 7.27 (d, *J* = 8.0 Hz, 2 H), 7.12 (d, *J* = 7.6 Hz, 2 H), 5.41 (t, *J* = 3.6 Hz, 1 H), 4.31 (d, *J* = 10.4 Hz, 1 H), 4.18 (d, *J* = 10.0 Hz, 1 H), 3.92 (q, *J* = 4.0 Hz, 1 H), 3.42 (d, *J* = 9.6 Hz, 1 H), 3.38-3.32 (m, 1 H), 3.24 (d, *J* = 12.4, 1 H), 3.20 (d, *J* = 9.6 Hz, 1 H), 3.09 (d, *J* = 12.0 Hz, 1 H), 2.76 (dd, *J* = 5.2, 14.0 Hz, 1 H), 2.39 (s, 1 H), 2.38 (d, *J* = 4.0 Hz, 1 H), 2.32 (s, 3 H), 2.16 (t, *J* = 10.0 Hz, 1 H), 1.93-1.54 (m, 9 H), 1.52 (s, 3 H), 1.49 (s, 3 H), 1.45-1.36 (m, 3 H), 1.33 (s, 3 H), 1.31-1.27 (m, 2 H), 1.26 (s, 3 H), 1.081 (s, 3 H), 1.077 (s, 3 H), 1.06 (s, 9 H), 0.98 (s, 3 H), 0.88 (d, *J* = 10.0 Hz, 1 H), 0.49 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.5, 136.1, 135.8 (2 C), 134.8, 133.2, 133.0, 129.8, 129.7 (2 C), 127.8 (2 C), 124.4, 108.4, 83.0, 80.5, 76.1, 70.2, 65.2, 57.2, 48.3, 47.2, 45.5, 42.8, 41.7, 40.0, 39.7, 39.1, 38.0, 37.1, 34.4, 34.2, 33.3, 29.7, 27.6, 27.3, 27.2, 27.1, 26.8, 24.5, 23.6, 21.1, 19.3 (2 C), 17.2, 17.1, 16.2; HRMS (ESI) calcd for $C_{56}H_{78}O_5SSiNa$ $[M+Na]^+$ 913.5232, found 913.5230.

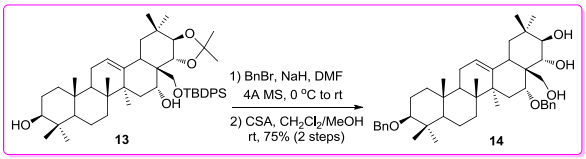
21,22-O-Isopropylidene-28-O-tert-butyldiphenylsilyl-24-deoxy-protoescigenin (13)



To a solution of **12** (4.00 g, 4.49 mmol) in a mixed solvent of acetone and ethanol (120 mL, v/v = 1 : 9) was added ethanol-rinsed Raney Ni (30.00 g). The reaction flask was cooled to -78 ^{o}C, evacuated under reduced pressure, and was then filled with H_2 (balloon). After the process was repeated for three times, the reaction mixture was warmed up to room temperature and the stirring was continued for 8 h at the same temperature. Filtration and concentration *in vacuo* afforded the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 8 : 1) to furnish **13** (3.42 mg, 99%) as a white solid: $[\alpha]_D^{25}$ = 34.5 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70-7.66 (m, 4 H), 7.45-7.32 (m, 6 H), 5.41 (t, *J* = 3.6 Hz, 1 H), 4.31 (d, *J* = 10.0 Hz, 1 H), 4.18 (d, *J* = 10.0 Hz, 1 H), 3.92 (q, *J* = 4.0 Hz, 1 H), 3.42 (d, *J* = 9.2 Hz, 1 H), 3.24-3.20 (m, 1 H), 3.21 (d, *J* = 9.6 Hz, 1 H),

2.76 (dd, *J* = 4.8, 14.0 Hz, 1 H), 2.42 (d, *J* = 3.2 Hz, 1 H), 2.16 (t, *J* = 13.6 Hz, 1 H), 1.92-1.60 (m, 6 H), 1.58-1.42 (m, 4 H), 1.52 (s, 3 H), 1.49 (s, 3 H), 1.38-1.25 (m, 5 H), 1.34 (s, 3 H), 1.080 (s, 3 H), 1.076 (s, 3 H), 1.06 (s, 9 H), 0.98 (s, 3 H), 0.92 (s, 3 H), 0.78 (s, 3 H), 0.73 (dd, *J* = 1.6, 12.4 Hz, 1 H), 0.50 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.5, 135.8 (2 C), 133.2, 133.0, 129.8, 129.7, 127.8, 124.5, 108.4, 83.0, 79.0, 76.1, 70.2, 65.2, 55.3, 48.2, 46.9, 45.5, 41.8, 40.1, 39.8, 38.9, 38.8, 37.1, 34.4, 34.2, 33.0, 29.7, 28.2, 27.6, 27.3 (2 C), 27.1, 26.8, 23.6, 19.3, 18.3, 17.3, 17.2, 15.8, 15.7; HRMS (ESI) calcd for $C_{49}H_{76}NO_5Si$ $[M+NH_4]^+$ 786.5487, found 786.5481.

3,16-Di-O-benzyl-24-deoxy-protoescigenin (14)

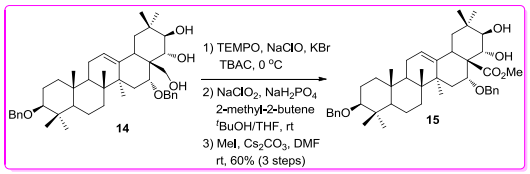


To a stirred solution of **13** (2.00 g, 2.60 mmol) and BnBr (4.63 mL, 39.00 mmol) in dry DMF (1.00 mL) was added freshly activated powdered 4A MS at room temperature. The suspension was stirred at the same temperature for 10 min before it was chilled to 0 ^{o}C, to which NaH (60% dispersed in mineral oil, 1.04 g, 26.00 mmol) was added portionwise (**Caution**: H_2 gas evolved during the addition of NaH). The stirring was continued for another 12 h at the same temperature before ethyl acetate was added to dilute the reaction mixture. Thus obtained solution was thoroughly washed with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* afforded the benzylated intermediate, which was directly put to the next step without further purification.

The above obtained residue was dissolved in a mixed solvent of CH_2Cl_2 and MeOH (12.00 mL, v/v = 1 : 2), to which CSA (3.02 g, 13.00 mmol) was added at room temperature under N_2 atmosphere. The resulting mixture was stirred for 6 h at the same temperature before ethyl acetate was added. Thus obtained mixture was washed with saturated aqueous $NaHCO_3$ and brine successively, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration under reduced pressure to afford the crude product, which was further subjected to silica gel column chromatography purification (petroleum ether/ethyl acetate = 3 : 1 to 2 : 1) to furnish

tiol intermediate **14** (1.31 g, 75% for 2 steps) as a white solid: $[\alpha]_D^{25}$ = 29.7 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38-7.32 (m, 8 H), 7.29-7.24 (m, 2 H), 5.30 (t, *J* = 3.6 Hz, 1 H), 4.71 (dd, *J* = 8.8, 11.6 Hz, 1 H), 4.46 (dd, *J* = 12.0, 12.8 Hz, 1 H), 4.23 (t, *J* = 2.8 Hz, 1 H), 3.94 (d, *J* = 9.6 Hz, 1 H), 3.65 (d, *J* = 9.6 Hz, 1 H), 3.58 (d, *J* = 11.2 Hz, 1 H), 3.35 (d, *J* = 11.2 Hz, 1 H), 2.96 (dd, *J* = 4.0, 11.6 Hz, 1 H), 2.58 (brs, 3 H), 2.44 (t, *J* = 13.6 Hz, 1 H), 2.02 (dd, *J* = 4.4, 14.0 Hz, 1 H), 1.91-1.36 (m, 12 H), 1.42 (s, 3 H), 1.11 (dd, *J* = 4.8, 13.6 Hz, 1 H), 1.01 (s, 3 H), 0.97 (s, 3 H), 0.94 (s, 3 H), 0.88 (s, 3 H), 0.86 (s, 3 H), 0.85 (s, 3 H), 0.76 (d, *J* = 11.2 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 141.7, 139.6, 138.9, 128.4, 128.3, 127.8, 127.6, 127.4, 127.3, 123.7, 86.6, 80.2, 78.2, 74.9, 72.2, 71.5, 71.3, 55.8, 47.0, 46.7, 46.3, 41.8, 41.2, 40.0, 39.0, 38.7, 37.0, 35.5, 32.9, 29.4, 28.4, 26.8, 26.4, 23.6, 22.9, 18.7, 18.4, 16.8 (2 C), 15.7; HRMS (ESI) calcd for $C_{44}H_{62}O_5K$ $[M+K]^+$ 709.4229, found 709.4232.

Methyl 3,16-di-O-benzyl-24-deoxy-28-protoescigeninate (15)



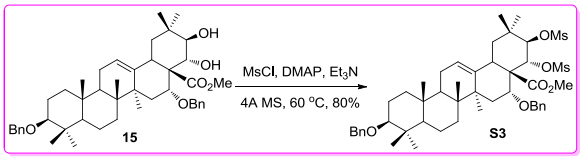
To a saturated aqueous $NaHCO_3$ solution (20.00 mL) were added KBr (354.7 mg, 2.98 mmol) and TBACl (497.1 mg, 1.79 mmol) successively at room temperature to form solution **A**. To a mixed solution of saturated aqueous $NaHCO_3$ (6.00 mL) and brine (12.00 mL) was added 5% aqueous NaOCl (17.74 mL, 14.90 mmol) at room temperature to form solution **B**. To a stirred solution of **14** (2.00 g, 2.98 mmol) in CH_2Cl_2 (50.00 mL) were added TEMPO (46.57 mg, 298.1 μmol) and solution **A** successively at room temperature. The mixture was then cooled to 0 °C, to which solution **B** (1.00 mL) was added. The stirring was continued at the same temperature and additional solution **B** (0.50 mL) was added at the interval of 30 min until TLC showed that all starting material was consumed completely. Dichloromethane was added to dilute the reaction. The resulting mixture was washed successively with water, saturated aqueous $Na_2S_2O_3$, and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed concentration *in vacuo* to afford a syrup, which was

put to the next step without further purification.

The above obtained syrup was dissolved a mixed solvent of ^{t}BuOH and THF (160 mL, v/v = 3 : 1), to which 2-methyl-2-butene (2.50 mL, 29.81 mmol) and a solution of NaH_2PO_4 (3.58 g, 29.81 mmol) and $NaClO_2$ (1.62 g, 17.9 mmol) in 30 mL water were added successively at room temperature. The reaction mixture was stirred at the same temperature overnight, then 3M HCl was added to adjust the pH value of the reaction to 2-3. Extracted with ethyl acetate for three times and the organic layers were combined, which were then washed with brine and dried over anhydrous Na_2SO_4. Filtration and concentration under reduced pressure afforded the crude product, which was put the next step without further purification.

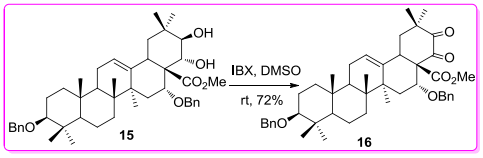
The above obtained crude carboxylic acid intermediate was finally dissolved in DMF (20.00 mL), to which Cs_2CO_3 (3.88 g, 11.92 mmol) and MeI (1.86 mL, 29.81 mmol) were added at room temperature under N_2 atmosphere. The reaction mixture was stirred at the same temperature for another 6 h before ethyl acetate was added. The resulting solution was washed successively with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* gave the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 6 : 1 to 4 : 1) to provide methyl ester **15** (1.25 g, 60% over 3 steps) as a white solid: $[\alpha]_D^{25}$ = 33.2 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38-7.31 (m, 8 H), 7.30-7.24 (m, 2 H), 5.39 (t, *J* = 4.0 Hz, 1 H), 4.69 (d, *J* = 11.6 Hz, 2 H), 4.50 (t, *J* = 2.8 Hz, 1 H), 4.47 (dd, *J* = 9.6, 10.4 Hz, 2 H), 3.95 (d, *J* = 9.2 Hz, 1 H), 3.67 (s, 3 H), 3.63 (d, *J* = 9.2 Hz, 1 H), 3.08 (dd, *J* = 4.4, 14.4 Hz, 1 H), 2.96 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.45 (t, *J* = 14.0 Hz, 1 H), 2.18 (brs, 2 H), 1.92 (dd, *J* = 3.6, 8.8 Hz, 2 H), 1.84-1.78 (m, 1 H), 1.70-1.47 (m, 7 H), 1.38 (s, 3 H), 1.36-1.26 (m, 2 H), 1.14 (dd, *J* = 4.4, 13.2 Hz, 1 H), 1.00 (s, 3 H), 0.96 (s, 3 H), 0.94 (s, 3 H), 0.92 (m, 1 H), 0.86 (s, 3 H), 0.85 (s, 3 H), 0.76 (dd, *J* = 1.5, 12.0 Hz, 1 H), 0.71 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.6, 141.6, 139.6, 138.6, 128.4, 128.3, 127.9, 127.5, 127.3, 123.6, 86.6, 76.0, 75.8, 71.6, 71.5, 55.9, 52.5, 46.8, 46.5, 41.7, 40.4, 39.7, 39.0, 38.5, 37.1, 35.2, 33.0, 29.2, 28.6, 28.4, 26.3, 23.5, 22.9, 18.9, 18.4, 16.9, 16.8, 15.5; HRMS (ESI) calcd for $C_{45}H_{63}O_6$ $[M+H]^+$ 699.4619, found 699.4598

Methyl 3,16-di-O-benzyl-21,22-di-O-mesyl-24-deoxy-28-protoescigeninate (S3)



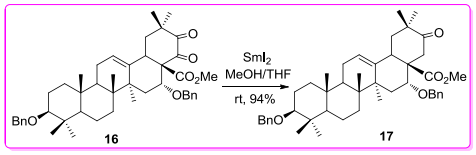
To a stirred solution of **15** (200 mg, 286.13 μmol), DMAP (174.8 mg, 1.43 mmol), and Et_3N (0.60 mL, 4.29 mmol) in dry CH_2Cl_2 (2.00 mL) was added freshly activated 4A MS at room temperature. The suspension was stirred at the same temperature for 30 min before MsCl (0.22 mL, 2.86 mmol) was added under N_2 atmosphere. The resulting mixture was heated to 60 ^oC, and the stirring was continued for another 6 h. Filtration was conducted to remove the MS, and the filtrate was diluted with ethyl acetate. The solution was washed with water and brine, and then dried over anhydrous Na_2SO_4. Filtration was followed by concentration under reduced pressure to afford the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 10 : 1 to 8 : 1) to provide **S3** (195.7 mg, 80%) as a white solid: $[\alpha]_D^{25}$ = -3.0 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.50 (d, *J* = 1.6, 8.4 Hz, 2 H), 7.39-7.26 (m, 8 H), 5.44 (d, *J* = 9.6 Hz, 1 H), 5.38 (t, *J* = 3.6 Hz, 1 H), 5.12 (d, *J* = 9.6 Hz, 1 H), 4.685 (d, *J* = 12.0 Hz, 1 H), 4.682 (d, *J* = 10.8 Hz, 1 H), 4.46 (d, *J* = 10.8 Hz, 1 H), 4.45 (d, *J* = 12.0 Hz, 1 H), 4.35 (dd, *J* = 1.6, 3.6 Hz, 1 H), 3.65 (s, 3 H), 3.14 (s, 3 H), 3.10 (m, 1 H), 2.96 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.86 (s, 3 H), 2.55 (t, *J* = 14.0 Hz, 1 H), 1.94-1.37 (m, 12 H), 1.35 (s, 3 H), 1.17 (dd, *J* = 4.4, 13.6 Hz, 1 H), 1.09 (s, 3 H), 1.01 (s, 3 H), 1.00 (s, 3 H), 0.92 (s, 3 H), 0.85 (s, 3 H), 0.76 (dd, *J* = 2.0, 12.8 Hz, 1 H), 0.67 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.2, 139.8, 139.5, 136.9, 129.9, 128.5, 128.3, 128.1, 127.6, 127.3, 125.1, 86.5, 85.1, 82.3, 73.5, 71.5, 70.7, 56.3, 55.8, 53.1, 46.6, 46.1, 41.7, 41.2, 39.8, 39.2, 39.0, 38.8, 38.5, 37.0, 36.6, 33.0, 30.0, 28.4, 27.0, 26.5, 23.6, 22.8, 20.0, 18.3, 16.8 (2 C), 15.4; HRMS (ESI) calcd for $C_{47}H_{67}O_{10}S_2$ $[M+H]^+$ 855.4170, found 855.4208.

Methyl 3,16-di-O-benzyl-21,22-di-oxo-24-deoxy-28-protoescigeninate (16)



To a stirred solution of **15** (200.0 mg, 286.13 μmol) in dry DMSO (2.00 mL) was added IBX (801.2 mg, 2.86 mmol) at room temperature under N_2 atmosphere. The reaction mixture was stirred at the same temperature for 8 h, and then ethyl acetate was added. The resulting mixture was washed with saturated aqueous $Na_2S_2O_3$, water, and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* gave the crude product, which was then subjected to further purification by silica gel column chromatography (petroleum ether/ethyl acetate = 20 : 1 to 15 : 1) to provide **16** (143.2 mg, 72%) as a light yellow foam: $[\alpha]_D^{25}$ = -28.0 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.37-7.24 (m, 8 H), 7.21-7.19 (m, 2 H), 5.50 (t, *J* = 3.6 Hz, 1 H), 4.68 (d, *J* = 11.6 Hz, 1 H), 4.45-4.39 (m, 3 H), 4.20 (d, *J* = 10.8 Hz, 1 H), 3.72 (s, 3 H), 3.62 (dd, 4.8, 14.0 Hz, 1 H), 3.03 (t, *J* = 14.0 Hz, 1 H), 2.96 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.00 (dd, *J* = 4.4, 8.0 Hz, 1 H), 1.93 (dd, *J* = 3.6, 9.2 Hz, 2 H), 1.84-1.78 (m, 1 H), 1.70-1.48 (m, 7 H), 1.43-1.32 (m, 2 H), 1.38 (s, 3 H), 1.20 (s, 3 H), 1.01 (s, 3 H), 0.96 (s, 3 H), 0.93 (s, 3 H), 0.92 (dd, *J* = 3.6, 13.6 Hz, 1 H), 0.85 (s, 3 H), 0.76 (dd, *J* = 2.0, 12.4 Hz, 1 H), 0.70 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 200.1, 198.1, 169.5, 139.6, 138.8, 136.6, 128.9, 128.4, 128.3, 128.1, 127.6, 127.4, 125.8, 86.5, 80.8, 72.0, 71.5, 65.4, 55.8, 52.9, 46.8, 46.2, 41.0, 40.9, 39.8, 39.0, 38.5, 37.1, 32.9, 28.4, 28.3, 26.8, 24.0, 23.7, 23.3, 22.8, 18.3, 17.0, 16.8, 15.4; HRMS (ESI) calcd for $C_{45}H_{59}O_6$ $[M+H]^+$ 695.4306, found 695.4280.

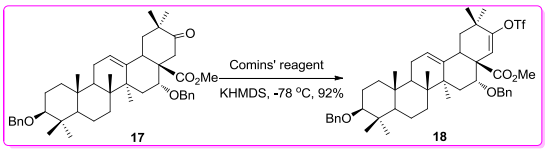
Methyl 3,16-di-O-benzyl-21-oxo-echinocystate (17)



A flame-dried flask containing **16** (1.00 g, 1.44 mmol) were treated with THF (10.00 mL) and methanol (60.00 mL). After being cooled to -78 ^oC, the flask was evacuated under recued pressure and refilled with N_2. After this process was repeated for 3 times, SmI_2 (0.1M in THF, 144 mL, 14.4 mmol) was added via a syringe at the same temperature. Afterwards, the evacuation/refilling process was repeated for another 3 times (**caution**: the reaction is highly air-sensitive, thus the air should be strictly excluded by gas exchange from air to N_2). The reaction mixture was then warmed up

to room temperature and the stirring was continued at the same temperature for 4 h, during which time the reaction system changed from blackish green to purple and then to colorless. Ethyl acetate was added to dilute the reaction and the resulting mixture was washed with saturated aqueous $NaHCO_3$ and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration *in vacuo* to provide a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 18 : 1 to 15 : 1) to afford **17** (921.1 mg, 94%) as a white solid: $[\alpha]_D^{25}$ = 30 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35-7.24 (m, 10 H), 5.46 (t, *J* = 3.6 Hz, 1 H), 4.68 (d, *J* = 12.0 Hz, 1 H), 4.47 (d, *J* = 10.0 Hz, 1 H), 4.44 (d, *J* = 11.2 Hz, 1 H), 4.34 (d, *J* = 10.4 Hz, 1 H), 4.08 (dd, *J* = 2.0, 2.8 Hz, 1 H), 3.64 (s, 3 H), 3.37 (dd, *J* = 5.6, 14.4 Hz, 1 H), 2.95 (dd, *J* = 4.0, 11.6 Hz, 1 H), 2.67 (d, *J* = 15.2 Hz, 1 H), 2.64 (t, *J* = 14.0 Hz, 1 H), 2.39 (d, *J* = 15.6 Hz, 1 H), 1.93-1.90 (m, 2 H), 1.82-1.77 (m, 1 H), 1.71-1.47 (m, 7 H), 1.39-1.25 (m, 4 H), 1.32 (s, 3 H), 1.19 (s, 3 H), 1.00 (s, 3 H), 0.93 (s, 3 H), 0.91 (m, 1 H), 0.85 (s, 3 H), 0.78 (s, 3 H), 0.75 (dd, *J* = 2.0, 12.4 Hz, 1 H), 0.69 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 211.9, 174.5, 141.2, 139.6, 137.5, 129.2, 128.3 (2 C), 127.8, 127.6, 127.4, 124.2, 86.6, 80.5, 72.5, 71.5, 55.8, 53.7, 52.4, 47.3, 46.8, 44.5, 44.4, 41.1, 40.4, 39.8, 39.0, 38.5, 37.1, 32.8, 28.9, 28.4, 27.2, 26.6, 24.8, 18.4, 16.9, 16.8, 15.4; HRMS (ESI) calcd for $C_{45}H_{64}NO_5$ $[M+NH_4]^+$ 698.4779, found 698.4748.

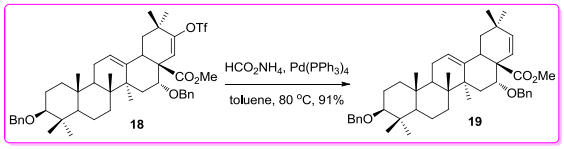
Methyl oleana-3,16-di-O-benzyloxyl-12,21-dien-28-oate-21-trifluoromethylsulfonate (18)



To a stirred solution of **17** (681.0 mg, 1.0 mmol) in dry THF (20.00 mL) was added 1M KHMDS in THF (10.00 mL, 10.0 mmol) at -78 ^{o}C under N_2 atmosphere. After being stirred for 10 min at the same temperature, Comins' reagent (785.4 mg, 2.00 mmol) was added, and the stirring was continued at -78 ^{o}C for another 8 h before ethyl acetate was added to dilute the reaction mixture. The resulting solution was washed successively with saturated aqueous $NaHCO_3$ and brine, and was then dried

over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* afforded the crude product, which was then subjected to purification by silica gel column chromatography (petroleum ether/ethyl acetate = 50 : 1 to 20 : 1) to provide **18** (748.0 mg, 92%) as a white solid: $[\alpha]_D^{25}$ = 16.8 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38-7.24 (m, 10 H), 5.60 (s, 1 H), 5.46 (t, *J* = 3.6 Hz, 1 H), 4.69 (d, *J* = 12.0 Hz, 1 H), 4.60 (d, *J* = 11.2 Hz, 1 H), 4.46 (d, *J* = 11.6 Hz, 1 H), 4.43 (d, *J* = 11.2 Hz, 1 H), 4.15 (t, *J* = 3.6 Hz, 1 H), 3.67 (s, 3 H), 3.14 (dd, *J* = 4.0, 14.8 Hz, 1 H), 2.97 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.78 (dd, *J* = 13.2, 14.8 Hz, 1 H), 1.95-1.91 (m, 2 H), 1.85-1.79 (m, 1 H), 1.72-1.50 (m, 7 H), 1.44 (m, 2 H), 1.34 (s, 3 H), 1.33 (dd, *J* = 3.6, 12.8 Hz, 1 H), 1.21 (s, 3 H), 1.01 (s, 3 H), 0.99 (s, 3 H), 0.96 (s, 3 H), 0.93-0.89 (m, 1 H), 0.86 (s, 3 H), 0.77 (s, 3 H), 0.77 (dd, *J* = 1.6, 12.4 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 173.3, 158.3, 141.0, 139.6, 138.4, 128.3, 127.9, 127.6 (2 C), 127.4, 124.3, 120.1, 116.9, 116.8, 86.6, 78.7, 72.5, 71.5, 55.9, 53.6, 52.8, 46.8 (2 C), 41.6, 39.6, 39.1, 39.0, 38.6, 37.2, 36.0, 33.3, 29.0, 28.4, 26.3, 25.8, 25.5, 23.6, 22.9, 18.4, 17.0, 16.8, 15.6; HRMS (ESI) calcd for $C_{46}H_{60}F_3O_7S$ $[M+H]^+$ 813.4006, found 813.3963.

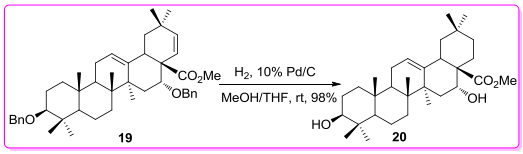
Methyl oleana-3,16-di-benzyloxyl-12,21-dien-28-oate (19)



To a sealed tube charged with **18** (200.0 mg, 245.99 μmol), HCO_2NH_4 (62.1 mg, 984 μmol), and $Pd(PPh_3)_4$ (28.4 mg, 24.60 μmol) was added dry toluene (2 mL) under N_2 atmosphere. The mixture was then heated to 80 °C by an oil bath and the stirring was continued at the same temperature for 6 h. After being cooled to room temperature, the reaction mixture was diluted with ethyl acetate, washed with brine, and then dried over anhydrous Na_2SO_4. Filtration as well concentration under reduced pressure provided a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 50 : 1 to 20 : 1) to afford **19** (148.9 mg, 91%) as a white solid: $[\alpha]_D^{25}$ = 27.4 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38-7.22 (m, 10 H), 5.68 (dd, *J* = 1.2, 9.6 Hz, 1 H), 5.45 (d, *J* = 10.0 Hz, 1 H), 5.44 (t, *J* = 3.6 Hz, 1 H), 4.69 (d, *J* = 12.0 Hz, 1 H), 4.62 (d, *J* = 12.0 Hz, 1 H), 4.45 (d, *J* = 12.0 Hz, 1 H),

4.42 (d, *J* = 11.6 Hz, 1 H), 4.17 (t, *J* = 3.2 Hz, 1 H), 3.63 (s, 3 H), 3.17 (dd, *J* = 3.6, 14.4 Hz, 1 H), 2.97 (dd, *J* = 4.4, 12.0 Hz, 1 H), 2.52 (dd, *J* = 12.4, 14.4 Hz, 1 H), 1.94-1.91 (m, 2 H), 1.84-1.79 (m, 1 H), 1.70-1.50 (m, 7 H), 1.42-1.36 (m, 2 H), 1.34 (s, 3 H), 1.22-1.17 (m, 1 H), 1.05 (s, 3 H), 1.00 (s, 3 H), 0.95 (s, 3 H), 0.94 (dd, *J* = 3.6, 13.6 Hz, 1 H), 0.90 (s, 3 H), 0.85 (s, 3 H), 0.77 (s, 3 H), 0.77 (dd, *J* = 2.0, 12.8 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.4, 142.9, 140.9, 139.6, 139.3, 128.3, 128.2, 127.6, 127.3, 127.2, 125.3, 123.1, 86.6, 79.4, 72.4, 71.5, 55.9, 53.2, 52.4, 46.8, 44.9, 41.7, 39.7, 39.5, 39.0, 28.5, 37.2, 33.4, 33.0, 30.6, 29.8, 29.4, 28.4, 28.0, 25.6, 23.5, 22.9, 18.4, 17.1, 16.8, 15.6; HRMS (ESI) calcd for $C_{45}H_{61}O_4$ $[M+H]^+$ 665.4564, found 665.4547.

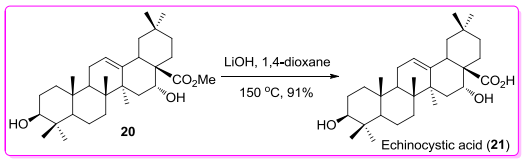
Methyl echinocystate (20)



To a solution of **19** (140.0 mg, 210.54 μmol) in mixed solvent of MeOH and THF (5.00 mL, v/v = 4: 1), was added 10% Pd/C (45.0 mg). The reaction flask was then subjected to gas-exchange from air to H_2 at low temperature for three times. The resulting suspension was stirred at room temperature for 12 h, then the black solid was removed by filtration through a pad of *Celite* and silica gel. The filtrate was concentrated *in vacuo* to yield a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 6 : 1 to 4 : 1) to provide **20** (100.4 mg, 98%) as a white solid: $[\alpha]_D^{25}$ = 24.8 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.39 (t, *J* = 3.6 Hz, 1 H), 4.52 (td, *J* = 1.2, 3.6 Hz, 1 H), 3.60 (s, 3 H), 3.23-3.19 (m, 1 H), 3.06 (dd, *J* = 4.4, 14.4 Hz, 1 H), 2.17 (dd, *J* = 12.8, 14.8 Hz, 1 H), 1.90-1.70 (m, 6 H), 1.65-1.44 (m, 9 H), 1.40-1.29 (m, 3 H), 1.34 (s, 3 H), 1.20-1.16 (m, 1 H), 1.13 (ddd, *J* = 1.6, 4.8, 12.8 Hz, 1 H), 0.98 (s, 3 H), 0.96 (s, 3 H), 0.905 (s, 3 H), 0.895 (s, 3 H), 0.77 (s, 3 H), 0.75 (dd, *J* = 2.0, 12.8 Hz, 1 H), 0.72 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.6, 142.9, 123.0, 79.1, 75.1, 55.4, 52.0, 48.9, 46.9, 46.5, 41.4, 40.7, 39.6, 38.9, 38.6, 37.2, 35.7, 35.6, 33.0, 32.9, 30.7, 30.5, 28.2, 27.3, 27.2, 24.9, 23.4, 18.4, 17.1, 15.7, 15.6; HRMS (ESI) calcd for $C_{31}H_{50}O_4K$ $[M+K]^+$

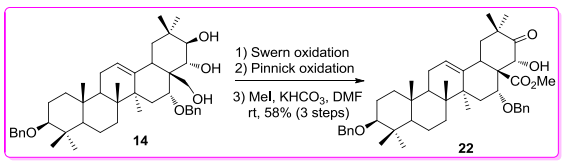
525.3341, found 525.3338.

Echinocystic acid (21)



To a sealed tube charged with **20** (100.0 mg, 205.45 μmol) was added LiOH (59.0 mg, 2.47 mmol) and 1,4-dioxane (0.5 mL). The tube was sealed and was then heated to 150 ^{o}C via an oil bath. The stirring was continued at the same temperature for 8 h. After being cooled to room temperature, 3M HCl was added to the reaction mixture to adjust the pH value of the reaction mixture to 2-3, which was followed by the addition of ethyl acetate to dilute the reaction mixture. The resulting mixture was washed with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* gave a residue, which was further purified by silica gel chromatography (DCM/MeOH = 10 : 1) to provide echinocystic acid (88.3 mg, 91%) as a white solid: $[\alpha]_D^{25}$ = 48.5 (*c* 0.1, MeOH); ^{1}H NMR (400 MHz, DMSO-d_6) δ 5.20 (t, *J* = 3.6 Hz, 1 H), 4.72 (d, *J* = 3.2 Hz, 1 H), 4.32 (brs, 1 H), 4.30 (d, *J* = 5.2 Hz, 1 H), 3.35 (brs, 1 H), 3.02-2.97 (m, 1 H), 2.91 (dd, *J* = 4.4, 14.0 Hz, 1 H), 2.24 (dd, *J* = 12.4, 14.4 Hz, 1 H), 1.95 (td, *J* = 4.8, 12.8 Hz, 1 H), 1.82-1.39 (m, 12 H), 1.31 (s, 3 H), 1.27-1.17 (m, 3 H), 1.09-1.04 (m, 1 H), 0.97 (dd, *J* = 3.6, 12.8 Hz, 2 H), 0.90 (s, 3 H), 0.89 (s, 3 H), 0.85 (s, 3 H), 0.83 (s, 3 H), 0.68 (s, 3 H), 0.67 (s, 3 H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 178.2, 144.0, 121.2, 76.8, 73.0, 54.9, 47.3, 46.4, 46.2, 41.0, 40.1, 38.9, 38.4, 38.1, 36.6, 35.2, 34.7, 32.9, 32.7, 31.5, 30.3, 28.3, 27.0, 26.5, 24.2, 22.9, 18.1, 16.8, 16.1, 15.2; HRMS (ESI) calcd for $C_{30}H_{52}NO_4$ $[M+NH_4]^+$ 490.3891, found 490.3874.

Methyl 3,16-di-O-benzyl-21-oxo-24-deoxy-28-protoescigeninate (22)



To a stirred solution of $(COCl)_2$ (3.78 mL, 44.71 mmol) in dry dichloromethane (35.00 mL) was added a solution of DMSO (6.35 mL, 89.42 mmol) in dry

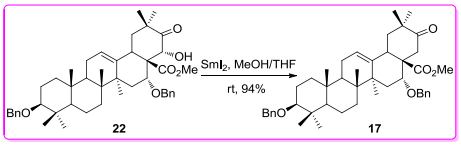
dichloromethane (60.00 mL), which was dried over freshly activated powdered 4A MS, dropwise at -78 ^{o}C under N_2 atmosphere. After the addition was completed, the stirring was continued for another 15 min at the same temperature before a solution of **14** (2.00 g, 2.98 mmol) in dry dichloromethane (10 mL) was added. The resulting mixture was stirred at -78 ^{o}C for another 16 h, then Et_3N (20.00 mL) was added carefully at the same temperature. After the addition was completed, the stirring was continued for another 15 min at the same temperature. Then the mixture was gradually warmed up to room temperature, to which ethyl acetate was added. The resulting solution was washed successively with saturated aqueous $NaHCO_3$ and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration under reduced pressure to afford a residue, which was put to the next step directly without further purification.

The above obtained residue was dissolved in a mixed solvent of ^{t}BtOH (120.00 mL) and THF (80.00 mL), to which 2-methyl-2-butene (2.50 mL, 29.81 mmol) and a solution of $NaClO_2$ (2.16 g, 23.85 mmol) and NaH_2PO_4 (3.58 g, 29.81 mmol) in water (30.00 mL) were added successively at room temperature. The reaction mixture was stirred at the same temperature for 8 h before 3M HCl was added to adjust the pH value of the reaction mixture to 2-3. Ethyl acetate was then added to dilute the reaction mixture, and the resulting mixture was washed successively with saturated aqueous $Na_2S_2O_3$, water, and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration under reduced pressure presented the crude product, which was put to the next step without further purification.

The above obtained crude carboxylic acid intermediate was then dissolved in dry DMF (20 mL), to which $KHCO_3$ (1.19 g, 11.9 mmol) and MeI (1.86 mL, 29.81 mmol) were added successively at room temperature under N_2 atmosphere. The reaction mixture was stirred at the same temperature for 6 h before ethyl acetate was added. The resulting mixture was washe with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration and evaporation under reduced pressure gave a residue, which was finally purified by silica gel column chromatography (petroleum ether/ethyl acetate = 10 : 1 to 6 : 1) to provide **22** (1.21 g, 58% over 3 steps) as a

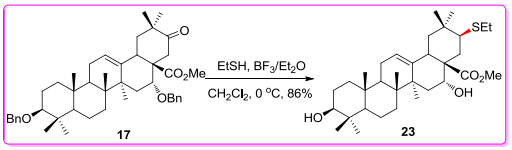
white solid: $[\alpha]_D^{25}$ = 40.4 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.37-7.24 (m, 10 H), 5.44 (t, *J* = 3.6 Hz, 1 H), 4.68 (d, *J* = 12.0 Hz, 1 H), 4.44-4.36 (m, 4 H), 4.20 (d, *J* = 10.0 Hz, 1 H), 3.71 (s, 3 H), 3.39 (dd, *J* = 5.6, 14.0 Hz, 1 H), 2.95 (dd, *J* = 4.0, 11.6 Hz, 1 H), 2.66 (t, *J* = 14.0 Hz, 1 H), 1.93-1.88 (m, 3 H), 1.83-1.77 (m, 1 H), 1.66-1.47 (m, 6 H), 1.43-1.36 (m, 2 H), 1.33 (s, 3 H), 1.33-1.29 (m, 1 H), 1.24 (s, 3 H), 1.00 (s, 3 H), 0.92 (s, 3 H), 0.90 (m, 1 H), 0.85 (s, 3 H), 0.74 (s, 3 H), 0.72 (m, 1 H), 0.68 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 212.2, 173.2, 140.6, 139.6, 137.3, 129.6, 128.3, 128.2, 127.9, 127.6, 127.4, 124.6, 68.5, 74.6, 73.2, 72.5, 71.5, 59.7, 55.8, 52.6, 47.5, 46.8, 42.9, 41.6, 40.5, 40.0, 39.0, 38.4, 37.1, 32.6, 28.8, 28.4, 27.9, 27.5, 24.8, 23.6, 22.8, 18.3, 16.8, 16.7, 15.3; HRMS (ESI) calcd for $C_{46}H_{61}O_8$ $[M+HCOO]^-$ 741.4361, found 741.4348.

Methyl 3,16-di-O-benzyl-21-oxo-28-echinocystate (17)



Except for the applied amount of SmI_2 (10 eq), similar procedure as that used for the synthesis of **17** from **16** was adopted to mediate the transformation form **22** (600 mg, 860.87 μmol) to **17** (551.1 mg, 94%) as a white solid after silica gel column chromatography purification.

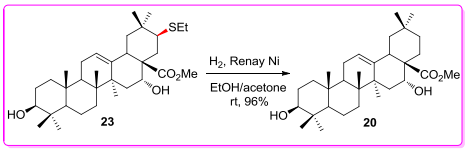
Methyl 21-β-ethylsulfenyl-echinocystate (23)



To a stirred solution of **17** (100.0 mg, 146.85 mmol) and EtSH (87.0 μL, 1.17 mmol) in dry dichloromethane (1.00 mL) was added BF_3•Et_2O (72.5 μL, 587.40 μmol) dropwise at 0 ^oC under N_2 atmosphere. The mixture was gradually warmed up to room temperature and the stirring was continued at the same temperature for 5 h before an additional portion of BF_3•Et_2O (36.3 μL, 293.70 μmol) was added. The reaction mixture was then stirred at room temperature for another 3 h, at which time TLC showed that all starting material was consumed. Ethyl acetate was added to

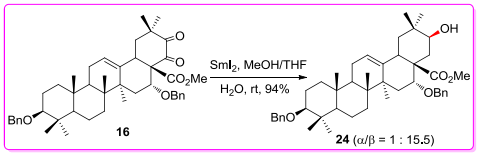
dilute the reaction mixture, and the resulting solution was washed successively with saturated aqueous $NaHCO_3$ and brine. Dried over anhydrous Na_2SO_4, filtered through a pad of *Celite*, and evaporated *in vacuo* gave a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 12 : 1 to 10 : 1) to provide **23** (69.1 mg, 86%) as a white solid: $[\alpha]_D^{25}$ = 33.6 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 5.38(t, *J* = 3.6 Hz, 1 H), 4.64 (dd, *J* = 3.2, 4.0 Hz, 1 H), 3.30 (dd, *J* = 4.8, 12.4 Hz, 1 H), 3.23 (d, *J* = 10.4 Hz, 1 H), 3.11 (dd, *J* = 3.2, 14.8 Hz, 1 H), 2.57 (td, *J* = 2.4, 7.6 Hz, 1 H), 2.38 (t, *J* = 13.6 Hz, 1 H), 2.25 (dd, *J* = 4.8, 14.0 Hz), 1.90-1.82 (m, 4 H), 1.67-1.50 (m, 7 H), 1.47-1.30 (m, 6 H), 1.37 (s, 3 H), 1.26 (t, *J* = 7.2 Hz, 3 H), 1.07 (s, 3 H), 0.98 (s, 3 H), 0.96 (s, 3 H), 0.91 (s, 3 H), 0.77 (s, 3 H), 0.74 (dd, *J* = 1.6, 11.6 Hz, 1 H), 0.68 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.1, 142.2, 123.4, 79.1, 75.2, 55.4, 52.2, 51.6, 50.4, 48.7, 46.8, 41.3, 40.7, 40.0, 39.5, 38.9, 38.6, 37.2, 36.2, 35.3, 33.1, 30.9, 28.2, 27.3, 27.2, 26.4, 23.4, 19.7, 18.4, 17.0, 15.7, 15.5, 15.4; HRMS (ESI) calcd for $C_{33}H_{54}O_4SNa$ $[M+Na]^+$ 569.3635, found 569.3606.

Methyl echinocystate (20)



Similar procedure as that used for the synthesis of **13** was adopted to mediate the transformation of **23** (60.0 mg, 109.72 μmol) to **20** (51.3 mg, 96%).

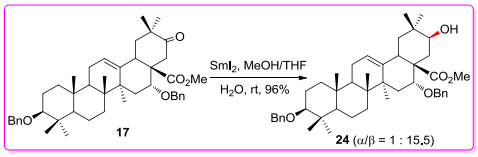
Methyl 3,16-di-O-benzyl-21-β-hydroxyl-echinocystate (24)---*From diketone (**16**)*



To a flask charged with **16** (500.0 mg, 719.47 μmol) were added THF (5.0 mL) and methanol (25.0 mL) successively. The reaction flask was then subjected to gas-exchange from air to N_2 at -78 ^oC for three times. To the reaction flask SmI_2 (0.1M in THF, 115.0 mL, 11.51 mmol) and H_2O (2.0 mL) were added successively at -78 ^oC, the reaction flask was then subjected to gas-exchange for another 3 times. The reaction mixture was then warmed up to room temperature, and the stirring was

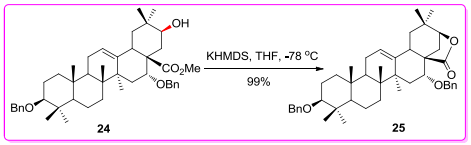
continued for 4 h at room temperature before ethyl acetate was added to dilute the reaction mixture. The resulting mixture was washed with saturated aqueous $Na_2S_2O_3$, saturated aqueous $NaHCO_3$, and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration under reduced pressure to give a residue, which was further purified by silica gel column chromatography (toluene/ethyl acetate = 18 : 1 to 10 : 1) to furnish **24β** (432.6 mg, 88%) and **24α** (27.9 mg, 6%), respectively. The pure **24β** was obtained as a white solid: $[\alpha]_D^{25}$ = 29.4 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.24 (m, 10 H), 5.39 (t, *J* = 4.0 Hz, 1 H), 4.75 (d, *J* = 11.2 Hz, 1 H), 4.68 (d, *J* = 12.0 Hz, 1 H), 4.44 (d, *J* = 12.0 Hz, 1 H), 4.37 (d, *J* = 11.2 Hz, 1 H), 4.22 (t, *J* = 2.8 Hz, 1 H), 4.07 (dd, *J* = 1.2, 11.2 Hz, 1 H), 3.61 (s, 3 H), 3.08 (dd, *J* = 4.4, 14.4 Hz, 1 H), 2.95 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.34 (t, *J* = 14.0 Hz, 1 H), 1.96-1.88 (m, 3 H), 1.83-1.77 (m, 1 H), 1.69-1.46 (m, 8 H), 1.41-1.29 (m, 3 H), 1.34 (s, 3 H), 1.17 (dd, *J* = 4.8, 13.2 Hz, 1 H), 0.99 (s, 3 H), 0.93 (s, 3 H), 0.91 (s, 3 H), 0.86 (s, 3 H), 0.84 (s, 3 H), 0.74 (dd, *J* = 2.0, 11.6 Hz, 1 H), 0.71 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.0, 142.0, 139.6, 138.6, 128.4, 128.3, 127.7, 127.6, 127.6, 123.4, 86.6, 82.0, 73.8, 71.8, 71.5, 55.9, 52.2, 51.6, 47.2, 46.8, 41.4, 40.0, 39.8, 39.6, 39.0, 38.5, 37.2, 35.7, 33.2, 28.9, 28.4, 28.3, 26.0, 23.5, 22.9, 18.4, 17.5, 17.0, 16.8, 15.5; HRMS (ESI) calcd for $C_{45}H_{62}O_5K$ $[M+K]^+$ 721.4229, found 721.4231. The pure **24α** was obtained as a white solid: $[\alpha]_D^{25}$ = 25.0 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40-7.24 (m, 10 H), 5.40 (t, *J* = 3.6 Hz, 1 H), 4.86 (brs, 1 H), 4.84 (d, *J* = 10.4 Hz, 1 H), 4.69 (d, *J* = 12.0 Hz, 1 H), 4.45 (d, *J* = 11.6 Hz, 1 H), 4.40 (d, *J* = 10.8 Hz, 1 H), 4.16 (t, *J* = 3.2 Hz, 1 H), 3.61 (s, 3 H), 3.21 (dd, *J* = 4.4, 10.4 Hz, 1 H), 3.13 (dd, *J* = 4.4, 14.8 Hz, 1 H), 2.96 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.15-2.08 (m, 2 H), 1.93-1.78 (m, 5 H), 1.70-1.49 (m, 7 H), 1.42-1.32 (m, 2 H), 1.39 (s, 3 H), 1.00 (s, 3 H), 0.96 (s, 3 H), 0.95 (s, 3 H), 0.94 (s, 3 H), 0.92 (m, 1 H), 0.85 (s, 3 H), 0.77 (d, *J* = 10.8 Hz, 1 H), 0.84 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 142.1, 139.6, 135.9, 129.0, 128.8, 128.6, 128.3, 127.6, 127.4, 123.6, 86.5, 79.9, 72.2, 71.7, 71.5, 56.0, 52.4, 50.1, 46.8, 41.39, 41.35, 39.8, 39.5, 39.0, 38.6, 38.2, 37.2, 35.8, 33.4, 28.4, 28.0, 27.4, 25.6, 25.2, 23.5, 22.8, 18.4, 17.0, 16.8, 15.6; HRMS (ESI) calcd for $C_{45}H_{62}O_5Na$ $[M+Na]^+$ 705.4490, found 705.4439.

Methyl 3,16-di-O-benzyl-21-β-hydroxyl-echinocystate (24)---*From monoketone (**17**)*



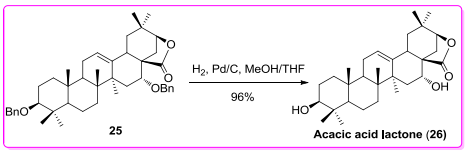
Except for the applied amount of SmI_2 (6.0 eq), similar procedure as that used for the synthesis of **24** from **16** was adopted to mediate the transformation of **17** (200.0 mg, 293.70 μmol) to **24** (192.6 mg, 96%).

3,16-Di-O-benzyl-acacic acid lactone (25)



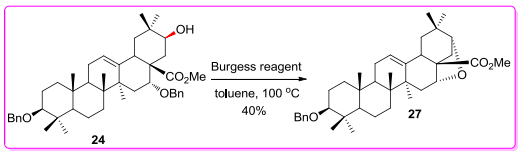
To a stirred solution of **24** (100.0 mg, 146.42 μmol) in dry THF (1.00 mL) was added 1M KHMDS in THF (0.59 mL, 590.00 μmol) at -78 ^{o}C under N_2 atmosphere. The reaction mixture was stirred at the same temperature for 6 h before ethyl acetate was added to dilute the reaction mixture. The resulting solution was washed with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration and concentration *in vacuo* gave the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 12 : 1 to 10 : 1) to provide **25** (94.3 mg, 99%) as a white solid: $[\alpha]_D^{25}$ = 24.6 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.24 (m, 10 H), 5.42 (dd, *J* = 3.2, 4.8 Hz, 1 H), 4.68 (d, *J* = 12.0 Hz, 1 H), 4.56 (s, 2 H), 4.44 (d, *J* = 12.0 Hz, 1 H), 4.20 (d, *J* = 5.6 Hz, 1 H), 3.89 (dd, *J* = 5.2, 10.4 Hz, 1 H), 2.94 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.56-2.52 (m, 1 H), 2.45 (dd, *J* = 5.6, 12.0 Hz, 1 H), 2.12 (d, *J* = 11.6 Hz, 1 H), 2.10 (dd, *J* = 5.6, 14.0 Hz, 1 H), 1.93-1.75 (m, 4 H), 1.66-1.36 (m, 8 H), 1.20 (s, 3 H), 1.14 (dd, *J* = 10.4, 14.4 Hz, 1 H), 1.03 (s, 3 H), 1.00 (s, 3 H), 0.99 (s, 3 H), 0.90 (s, 3 H), 0.88 (dd, *J* = 3.6, 11.2 Hz, 1 H), 0.85 (s, 3 H), 0.74 (s, 3 H), 0.74 (d, *J* = 11.6 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 180.9, 139.5, 139.4, 138.9, 128.3 (2 C), 127.9, 127.6, 127.5, 127.3, 124.6, 86.4, 83.7, 74.9, 72.2, 71.4, 56.0, 49.1, 47.0, 43.0, 41.6, 41.2, 40.1, 39.0, 38.4, 37.1, 34.0, 33.5, 32.3, 28.6, 28.4 (2 C), 27.9, 24.7, 23.6, 22.8, 18.3, 16.7, 16.2, 15.6; HRMS (ESI) calcd for $C_{44}H_{58}O_4K$ $[M+K]^+$ 689.3967, found 689.3954.

Acacic acid lactone (26)



Except for the reaction media (MeOH/THF = 3 mL : 1 mL), similar procedure as that used for the synthesis of **20** was adopted to convert **25** (80.0 mg, 122.9 μmol) to acacic acid lactone **26** (55.5 mg, 96%) as a white solid:[S2] $[\alpha]_D^{25}$ = -0.4 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.39 (td, *J* = 1.2, 3.6 Hz, 1 H), 4.24 (d, *J* = 5.6 Hz, 1 H), 4.01 (dd, *J* = 4.8, 12.4 Hz, 1 H), 3.23 (dd, *J* = 4.8, 10.8 Hz, 1 H), 2.61 (dd, *J* = 6.8, 12.4 Hz, 1 H), 2.44 (dd, *J* = 5.6, 11.6 Hz, 1 H), 2.11-2.04 (m, 2 H), 1.92-1.89 (m, 4 H), 1.77 (dd, *J* = 12.8, 14.4 Hz, 1 H), 1.64-1.53 (m, 4 H), 1.49-1.39 (m, 4 H), 1.23 (s, 3 H), 1.13-1.06 (m, 1 H), 1.03 (s, 3 H), 1.00 (s, 6 H), 0.96 (dd, *J* = 1.6, 6.4 Hz, 1 H), 0.91 (s, 3 H), 0.89 (s, 3 H), 0.80 (s, 3 H), 0.75-0.71 (m, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 125.1, 83.9, 79.0, 67.4, 55.5, 49.8, 47.0, 43.7, 43.3, 40.6, 40.3, 38.8, 38.6, 37.1, 36.4, 33.9, 32.2, 29.0 (2 C), 28.1, 27.2, 26.6, 23.9, 23.5, 18.3, 16.1, 15.7, 15.6; HRMS (ESI) calcd for $C_{31}H_{47}O_6$ $[M+HCOO]^-$ 515.3367, found 515.3380.

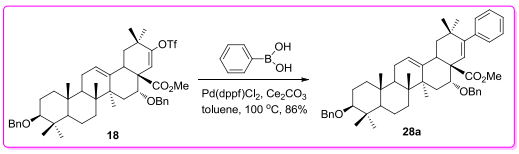
Methyl 3-O-benzyl-16,21-anhydro-echinocystate (27)



To a stirred solution of **24** (100.0 mg, 146.42 μmol) in dry toluene (1.00 mL) was added Burgess' reagent (69.8 mg, 292.83 μmol) at room temperature under N_2 atmosphere. The reaction mixture was then heated to 100 °C and the stirring was continued at the same temperature for 2 h. The reaction mixture was then cooled to room temperature, to which ethyl acetate was added. The resulting mixture was washed with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration to afford the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 40 : 1 to 20 : 1) to provide **27** (33.6 mg, 40%) as a white solid: $[\alpha]_D^{25}$ = 10.8 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37-7.23 (m, 5 H), 5.32 (t, *J* = 3.6 Hz, 1 H), 4.68 (d, *J* = 11.6

Hz, 1 H), 4.47-4.45 (m, 1 H), 4.44 (d, *J* = 11.6 Hz, 1 H), 3.76 (d, *J* = 6.8 Hz, 1 H), 3.62 (s, 3 H), 3.02-2.97 (m, 1 H), 2.95 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.14 (d, *J* = 11.6 Hz, 1 H), 2.09 (dd, *J* = 6.4, 11.6 Hz, 1 H), 2.01 (dd, *J* = 6.0, 16.0 Hz, 1 H), 1.90-1.86 (m, 2 H), 1.81-1.74 (m, 2 H), 1.66-1.47 (m, 8 H), 1.42 (s, 3 H), 1.40 (dd, *J* = 3.6, 12.0 Hz, 1 H), 1.34-1.26 (m, 2 H), 1.00 (s, 3 H), 0.97 (s, 3 H), 0.89 (s, 6 H), 0.84 (s, 3 H), 0.76 (dd, *J* = 2.0, 11.6 Hz, 1 H), 0.63 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.2, 143.0, 139.6, 128.3, 127.6, 127.3, 122.7, 86.6, 83.0, 79.7, 71.5, 55.7, 51.8, 50.3, 47.2, 40.3, 40.2, 40.1, 39.8, 39.0, 38.4, 37.6, 37.1, 36.1, 32.0, 31.8, 30.4, 29.1, 28.4, 27.0, 23.5, 22.8, 18.3, 16.8, 16.7, 15.2; HRMS (ESI) calcd for $C_{38}H_{54}O_4Na$ $[M+Na]^+$ 597.3914, found 597.3936.

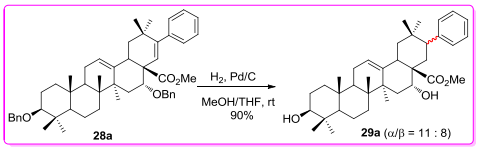
Methyl 3,16-di-O-benzyl-21,22-dehydro-21-phenyl-echinocystate (28a)



A sealed tube was charged **18** (60.0 mg, 73.80 μmol), phenyl boronic acid (18.0 mg, 146.60 μmol), $PdCl_2$(dppf) (16.2 mg, 22.14 μmol), and Cs_2CO_3 (96.18 mg, 295.19 μmol) successively. The sealed tube was then evacuated and refilled with N_2 for two times, to which dry toluene (1.00 mL) was added. The resulting suspension was again subjected to gas-exchange at -78 °C for three times, and then heated to 100 °C. The stirring was continued for 16 h at the same temperature before the reaction mixture was cooled to room temperature. Ethyl acetate was added to dilute the reaction mixture, and the resulting mixture was washed with water and brine successively, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration to give the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 60 : 1 to 50 : 1) to provide **28a** (47.0 mg, 86%) as a white solid: $[\alpha]_D^{25}$ = 10.2 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41-7.32 (m, 8 H), 7.30-7.21 (m, 5 H), 7.09-7.07 (m, 2 H), 5.51 (t, *J* = 4.0 Hz, 1 H), 5.35 (s, 1 H), 4.71 (d, *J* = 12.0 Hz, 1 H), 4.70 (d, *J* = 11.6 Hz, 1 H), 4.48 (dd, *J* = 8.8, 11.6 Hz, 1 H), 4.24 (t, *J* = 3.2 Hz, 1 H), 3.63 (s, 3 H), 3.37 (dd, *J* = 3.6, 14.8 Hz, 1 H), 2.98 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.78 (dd, *J* = 12.8, 14.8 Hz, 1 H), 1.97-1.94 (m, 2 H),

1.85-1.79 (m, 1 H), 1.74-1.61 (m, 4 H), 1.55-1.51 (m, 2 H), 1.43-1.33 (m, 2 H), 1.39 (s, 3 H), 1.29-1.22 (m, 3 H), 1.25 (s, 3 H), 1.01 (s, 3 H), 0.97 (s, 3 H), 0.95 (dd, *J* = 3.6, 14.0 Hz, 1 H), 0.86 (s, 3 H), 0.80 (s, 3 H), 0.79 (s, 3 H), 0.79 (dd, *J* = 2.0, 13.2 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.1, 150.6, 142.7, 142.6, 139.6, 139.3, 129.0, 128.3 (2 C), 127.6, 127.5, 127.3 (3 C), 126.5, 126.4, 123.3, 86.7, 79.8, 72.5, 71.5, 56.0, 53.9, 52.4, 47.5, 46.9, 41.8, 39.6, 39.5, 39.1, 38.6, 37.2, 35.7, 33.5, 29.3, 29.0, 28.4, 27.8, 25.6, 23.6, 22.9, 18.4, 17.2, 16.8, 15.6; HRMS (ESI) calcd for $C_{51}H_{64}O_4Na$ $[M+Na]^+$ 763.4697, found 763.4703.

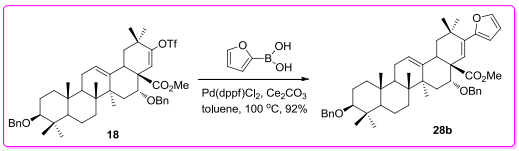
Methyl 21-phynyl-echinocystate (29a)



Similar procedure as that used for the synthesis of **20** was adopted to convert **28a** (40.0 mg, 53.98 μmol) to **29a** (27.3 mg, 90%) as a mixture of α/β stereoisomers (α/β = 11 : 8), which were separated by silica gel column chromatography (petroleum ether/ethyl acetate = 12 : 1 to 10 : 1). The α-isomer was obtained as a white solid: $[\alpha]_D^{25}$ = 41.8 (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24-7.12 (m, 5 H), 5.44 (t, *J* = 4.0 Hz, 1 H), 4.65 (t, *J* = 3.6 Hz, 1 H), 3.62 (s, 3 H), 3.39 (dd, *J* = 4.0, 13.2 Hz, 1 H), 3.22-3.18 (m, 2 H), 2.49 (dd, *J* = 12.8, 14.4 Hz, 1 H), 2.22 (t, *J* = 14.0 Hz, 1 H), 1.97 (dd, *J* = 4.4, 14.4 Hz, 1 H), 1.93 (dd, *J* = 4.0, 8.4 Hz, 2 H), 1.86 (dd, *J* = 4.0, 15.6 Hz, 1 H), 1.67-1.46 (m, 10 H), 1.43 (s, 3 H), 1.38-1.24 (m, 6 H), 1.00 (s, 3 H), 0.93 (s, 3 H), 0.90 (s, 3 H), 0.78 (s, 3 H), 0.75 (s, 3 H), 0.73 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.9, 142.7, 129.4, 127.6, 126.2, 123.2, 79.1, 75.4, 55.4, 52.2, 49.7 (2 C), 49.0, 46.8, 41.4, 40.4, 39.5, 38.9, 38.6, 37.8, 37.2, 36.0, 34.6, 33.1, 31.0, 28.2, 27.4, 27.1, 23.5, 19.6, 18.4, 17.0, 15.7, 15.6; HRMS (ESI) calcd for $C_{37}H_{54}O_4Na$ $[M+Na]^+$ 585.3914, found 585.3912. The β-isomer was obtained as a white solid: $[\alpha]_D^{25}$ = 45.4 (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28-7.11 (m, 5 H), 5.59 (t, *J* = 3.6 Hz, 1 H), 4.12 (dd, *J* = 3.6, 10.0 Hz, 1 H), 3.66 (s, 3 H), 3.32 (dd, *J* = 3.2, 14.8 Hz, 1 H), 3.24 (dd, *J* = 5.2, 11.2 Hz, 1 H), 2.46 (dd, *J* = 2.0, 6.0 Hz, 1 H), 2.12 (dd, *J* = 13.2, 14.8 Hz, 1 H), 1.93-1.90 (m, 2 H), 1.87 (dd, *J* = 3.6, 14.4 Hz, 1 H), 1.74-1.50 (m, 15

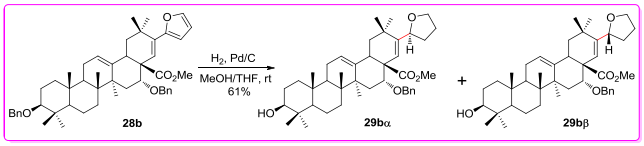
H), 1.23 (s, 3 H), 1.22 (d, *J* = 2.8 Hz, 1 H), 1.08 (s, 3 H), 1.00 (s, 3 H), 0.93 (s, 3 H), 0.87 (s, 3 H), 0.79 (s, 3 H), 0.77 (dd, *J* = 1.6, 11.6 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 178.2, 143.4, 140.6, 128.8, 127.8, 126.1, 123.5, 79.1, 71.4, 55.6, 52.9, 52.5, 47.5, 47.1, 45.9, 42.1, 41.6, 40.4, 39.0, 38.9, 37.2, 34.8, 34.2, 32.9, 29.2, 28.3, 28.2, 27.4, 27.0, 23.5, 18.4, 17.9, 16.1, 15.7; HRMS (ESI) calcd for $C_{37}H_{55}O_4$ $[M+H]^+$ 563.4095, found 563.4092.

Methyl 3,16-di-O-benzyl-21,22-dehydro-21-furanyl-echinocystate (28b)



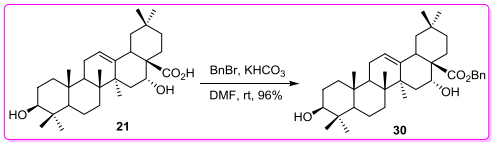
Similar procedure as that used for the synthesis of **28a** was adopted to mediate the coupling between **18** (100.0 mg, 123.00 μmol) and furanyl boronic acid (27.5 mg, 245.99 μmol) to provide **28b** (82.7 mg, 92%) as a light yellow solid: $[\alpha]_D^{25}$ = -28.7 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38-7.18 (m, 11 H), 6.36 (dd, *J* = 1.6, 3.2 Hz, 1 H), 6.28 (d, *J* = 3.2 Hz, 1 H), 5.98 (s, 1 H), 5.48 (t, *J* = 4.0 Hz, 1 H), 4.69 (d, *J* = 12.0 Hz, 1 H), 4.63 (d, *J* = 11.6 Hz, 1 H), 4.45 (d, *J* = 12.0 Hz, 2 H), 4.25 (t, *J* = 3.2 Hz, 1 H), 3.62 (s, 3 H), 3.27 (dd, *J* = 3.6, 14.8 Hz, 1 H), 2.96 (dd, *J* = 4.4, 11.6 Hz, 1 H), 2.74 (dd, *J* = 12.8, 14.8 Hz, 1 H), 1.95-1.92 (m, 2 H), 1.83-1.78 (m, 1 H), 1.72-1.50 (m, 8 H), 1.40-1.33 (m, 1 H), 1.38 (s, 3 H), 1.34 (s, 3 H), 1.26 (dd, *J* = 3.6, 12.8 Hz, 1 H), 1.02 (s, 3 H), 1.00 (s, 3 H), 0.96 (s, 3 H), 0.94 (dd, *J* = 3.2, 14.6 Hz, 1 H), 0.85 (s, 3 H), 0.78 (s, 3 H), 0.77 (dd, *J* = 2.4, 12.8 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.9, 155.1, 142.4, 141.0, 139.8, 139.6, 139.2, 128.3, 128.2, 127.6, 127.4, 127.3, 127.2, 126.4, 123.3, 110.7, 107.0, 86.6, 79.8, 72.5, 71.5, 56.0, 53.8, 52.5, 47.9, 46.8, 41.7, 39.6, 39.0, 38.6, 37.2, 34.6, 33.4, 29.5, 29.0, 28.4, 27.7, 25.6, 23.6, 22.9, 18.4, 17.1, 16.8, 15.6; HRMS (ESI) calcd for $C_{49}H_{63}O_5$ $[M+H]^+$ 731.4670, found 731.4657.

Methyl 16-O-benzyl-21,22-dehydro-21-tetrahydrofuranyl-chinocystate (29b)



Similar procedure as that used for the synthesis of **29a** was adopted to convert **28b** (60.0 mg, 82.08 μmol) to **29b** (32.3 mg, 61%) as a mixture of diasteroisomers (α/β = 4 : 3), which were separated by silica gel column chromatography (petroleum ether/ethyl acetate = 10 : 1 to 8 ： 1). The pure **29bα** was obtained as a white solid: $[\alpha]_D^{25}$ = +15.1 (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39-7.28 (m, 4 H), 7.24-7.19 (m, 1 H), 5.70 (s, 1 H), 5.42 (t, *J* = 3.6 Hz, 1 H), 4.57 (d, *J* = 11.6 Hz, 1 H), 4.48 (d, *J* = 12.0 Hz, 1 H), 4.39-4.35 (m, 1 H), 4.18 (dd, *J* = 2.8, 4.4 Hz, 1 H), 3.95-3.89 (m, 1 H), 3.80-3.74 (m, 1 H), 3.62 (s, 3 H), 3.24 (dd, *J* = 4.4, 10.8 Hz, 1 H), 3.19 (dd, *J* = 3.6, 14.8 Hz, 1 H), 2.66 (dd, *J* = 12.8 Hz, 1 H), 2.13-2.06 (m, 1 H), 1.92 (m, 2 H), 1.67-1.53 (m, 12 H), 1.42-1.35 (m, 3 H), 1.32 (s, 3 H), 1.12 (s, 3 H), 1.11 (dd, *J* = 3.6, 12.4 Hz, 1 H), 0.99 (s, 3 H), 0.95 (s, 3 H), 0.93 (s, 3 H), 0.78 (s, 3 H), 0.76 (s, 3 H), 0.73 (m, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.4, 148.6, 142.8, 139.5, 128.1, 127.5, 127.1, 123.0, 121.4, 79.6, 79.1, 78.1, 72.7, 67.6, 55.4, 53.5, 52.3, 48.1, 46.9, 41.7, 39.5, 39.4, 38.9, 38.6, 37.2, 34.5, 34.1, 33.4, 28.4, 28.2, 27.4, 26.5, 25.6, 23.5, 18.5, 17.1, 15.7, 15.6; HRMS (ESI) calcd for $C_{42}H_{61}O_5$ $[M+H]^+$ 645.4514, found 645.4503. **29bβ** was obtained as a white solid: $[\alpha]_D^{25}$ = +42.5 (*c* 0.5, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32-7.21 (m, 5 H), 5.60 (d, *J* = 1.2 Hz, 1 H), 5.43 (t, *J* = 3.6 Hz, 1 H), 4.63 (d, *J* = 11.6 Hz, 1 H), 4.34 (d, *J* = 11.6 Hz, 1 H), 4.26 (t, *J* = 7.2 Hz, 1 H), 4.16 (t, *J* = 3.2 Hz, 1 H), 4.00-3.95 (m, 1 H), 3.71-3.65 (m, 1 H), 3.61 (s, 3 H), 3.24 (dd, *J* = 4.4, 10.4 Hz, 1 H), 3.20 (dd, *J* = 3.6, 16.0 Hz, 1 H), 2.61 (dd, *J* = 12.4, 14.8 Hz, 1 H), 2.04-1.79 (m, 5 H), 1.69-1.38 (m, 13 H), 1.35 (s, 3 H), 1.17 (dd, *J* = 3.6, 12.8 Hz, 1 H), 0.99 (s, 3 H), 0.93 (s, 3 H), 0.88 (s, 3 H), 0.78 (s, 3 H), 0.764 (s, 3 H), 0.756 (dd, *J* = 2.0, 12.4 Hz, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.4, 150.0, 142.7, 139.2, 128.2, 127.2 (2 C), 123.0, 120.8, 79.8, 79.1, 77.6, 72.4, 68.0, 55.5, 53.2, 52.4, 47.2, 46.9, 41.6, 39.5, 39.1, 38.9, 38.6, 37.2, 34.4, 34.2, 33.4, 28.4, 28.2, 27.6, 27.4, 26.2, 25.6, 23.5, 18.5, 17.1, 15.7, 15.6; HRMS (ESI) calcd for $C_{42}H_{61}O_5$ $[M+H]^+$ 645.4514, found 645.4502.

Benzyl echinocystate (30)



To a stirred solution of **21** (120.0 mg, 253.86 μmol) in dry DMF (1.00 mL) were added $KHCO_3$ (101.7 mg, 1.02 mmol) and BnBr (180.9 μL, 1.52 mmol) successively at room temperature under N_2 atmosphere. The reaction mixture was stirred at the same temperature for 5 h before ethyl acetate was added to dilute the reaction mixture. The resulting mixture was washed successively with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration to give a residue, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 12 : 1 to 10 : 1) to furnish **30** (137.2 mg, 96%) as a white solid: $[\alpha]_D^{25}$ = 27.5 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 (m, 5 H), 5.38 (t, *J* = 3.6 Hz, 1 H), 5.08 (AB, 2 H), 4.55 (td, *J* = 1.2, 3.6 Hz, 1 H), 3.23 (dd, *J* = 4.0, 10.8 Hz, 1 H), 3.11 (dd, *J* = 4.8, 14.8 Hz, 1 H), 2.19 (dd, *J* = 12.8, 14.4 Hz, 1 H), 1.93-1.72 (m, 6 H), 1.64-1.42 (m, 8 H), 1.31-1.09 (m, 4 H), 0.98 (s, 3 H), 0.96 (s, 3 H), 0.90 (s, 3 H), 0.88 (s, 3 H), 0.77 (s, 3 H), 0.74 (dd, *J* = 2.0, 12.0 Hz, 1 H), 0.59 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 142.8, 136.2, 128.6, 128.4, 128.2 (2 C), 123.1, 79.1, 75.1, 66.5, 55.4, 48.9, 46.8, 46.5, 41.5, 40.8, 39.6, 38.9, 38.6, 37.1, 35.6 (2 C), 33.0, 32.9, 30.7, 30.5, 28.2, 27.3, 27.1, 24.8, 23.4, 18.4, 17.1, 15.7, 15.6; HRMS (ESI) calcd for $C_{37}H_{58}NO_4$ $[M+NH_4]^+$ 580.4360, found 580.4344.

Benzyl 3-O-tert-butyldimethylsilyl-echinocystate (31)

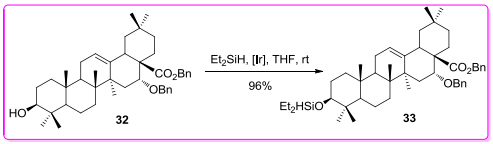
To a stirred solution of **30** (130.0 mg, 230.97 μmol) in dry THF (0.30 mL) were added imidazole (94.4 mg, 1.39 mmol) and TBSCl (139.3 mg, 923.89 μmol) successively at room temperature under N_2 atmosphere. The reaction mixture was stirred at the same temperature for 8 h before ethyl acetate was added. The resulting mixture was washed with water and brine, and was then dried over anhydrous Na_2SO_4. Filtration as well as concentration *in vacuo* gave the crude product, which was further purified by silica

gel column chromatography (petroleum ether/ethyl acetate = 60 : 1) to provide **31** (143.9 mg, 92%) as a white solid: $[\alpha]_D^{25}$ = 23.6 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.37-7.28 (m, 5 H), 5.39 (t, *J* = 3.6 Hz, 1 H), 5.08 (AB, 2 H), 4.56 (td, *J* = 1.2, 4.0 Hz, 1 H), 3.20 (dd, *J* = 4.8, 11.1 Hz, 1 H), 3.11 (dd, *J* = 4.8, 14.8 Hz, 1 H), 2.19 (dd, *J* = 13.2, 14.8 Hz, 1 H), 1.92-1.72 (m, 6 H), 1.59-1.42 (m, 8 H), 1.34 (s, 3 H), 1.31-1.10 (m, 4 H), 0.96 (s, 3 H), 0.905 (s, 3 H), 0.898 (s, 3 H), 0.89 (s, 12 H), 0.74 (s, 3 H), 0.71 (dd, *J* = 2.0, 12.0 Hz, 1 H), 0.59 (s, 3 H), 0.04 (s, 6 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 142.7, 136.2, 128.6, 128.2 (2 C), 123.2, 79.6, 75.1, 66.5, 55.5, 49.0, 46.9, 46.5, 41.5, 40.8, 39.7, 39.5, 38.7, 37.0, 35.6 (2 C), 33.1, 32.9, 30.7, 30.5, 28.6, 27.8, 27.2, 26.1, 25.8, 24.8, 23.5, 18.6, 18.3, 17.1, 16.3, 15.6; HRMS (ESI) calcd for $C_{43}H_{69}O_4Si$ $[M+H]^+$ 677.4960, found 677.4954.

Benzyl 16-O-benzyl-echinocystate (32)

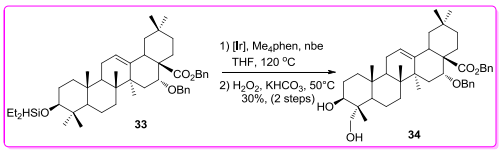
Similar procedure as those used for the synthesis of **14** was adopted to mediate the transformation of **31** (130.0 mg, 192.00 μmol) to **32** (111.6 mg, 89% over 2 steps), and **32** was obtained as a white solid after silica gel column chromatography (petroleum ether/ethyl acetate = 12 : 1): $[\alpha]_D^{25}$ = 3.5 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.38-7.25 (m, 10 H), 5.36 (t, *J* = 3.6 Hz, 1 H), 5.08 (AB, 2 H), 4.73 (d, *J* = 11.2 Hz, 1 H), 4.37 (d, *J* = 11.6 Hz, 1 H), 4.26 (t, *J* = 2.8 Hz, 1 H), 3.23 (dd, *J* = 3.6, 5.6 Hz, 1 H), 3.10 (dd, *J* = 4.4, 14.4 Hz, 1 H), 2.26 (dd, *J* = 13.2, 14.4 Hz, 1 H), 1.89-1.79 (m, 4 H), 1.77 (dd, *J* = 4.8, 6.0 Hz, 1 H), 1.70-1.45 (m, 10 H), 1.38-1.25 (m, 2 H), 1.35 (s, 3 H), 1.10-1.04 (m, 2 H), 0.98 (s, 3 H), 0.93 (s, 3 H), 0.89 (s, 3 H), 0.79 (s, 3 H), 0.78 (s, 3 H), 0.73 (dd, *J* = 2.0, 12.0 Hz, 1 H), 0.58 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 143.1, 138.9, 136.2, 128.6, 128.3, 128.2, 127.7, 127.4, 122.9, 82.5, 79.1, 71.8, 66.4, 55.4, 49.0, 46.8, 46.3, 41.6, 40.7, 39.5, 38.9, 38.6, 37.1, 35.3, 33.2, 32.9, 32.0, 30.6, 28.8, 28.2, 27.3, 25.9, 24.5, 23.4, 18.4, 17.0, 15.7, 15.5; HRMS (ESI) calcd for $C_{44}H_{60}O_4K$ $[M+K]^+$ 691.4123, found 691.4122.

Benzyl 3-O-diethylhydrosilyl-16-O-benzyl-echnocystate (33)



A sealed tube was charged with **32** (100.0 mg, 153.15 μmol) and $[Ir(cod)OMe]_2$ (1.0 mg, 1.53 μmol). After being sealed, the tube was chilled to -78 ^oC and gas-exchanged from air to N_2 was then conducted for three times. Afterwards, to the sealed tube dry THF (0.50 mL) and Et_2SiH_2 (23.8 μL, 183.78 μmol) were added successively at the same temperature. After the gas-exchange process was repeated for another 3 times, the reaction mixture was warmed up to room temperature, and the stirring was continued for 16 h. Evaporation under reduced pressure afforded the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 100 : 1) to give **33** (108.7 mg, 96%) as a colorless syrup: $[\alpha]_D^{25}$ = 1.3 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, acetone-d_6) δ 7.42-7.25 (m, 10 H), 5.33 (t, *J* = 4.0, 1 H), 5.10 (AB, 2 H), 4.79 (d, *J* = 11.2 Hz, 1 H), 4.49 (t, *J* = 2.4 Hz, 1 H), 4.41 (d, *J* = 11.2 Hz, 1 H), 4.31 (t, *J* = 2.8 Hz, 1 H), 3.30 (dd, *J* = 4.8, 10.8 Hz, 1 H), 3.14 (dd, *J* = 4.4, 14.4 Hz, 1 H), 2.32 (t, *J* = 13.6 Hz, 1 H), 2.06-1.51 (m, 13 H), 1.40 (s, 3 H), 1.36-1.29 (m, 2 H), 1.09 (dd, *J* = 4.0, 12.4 Hz, 2 H), 1.02-0.97 (m, 8 H), 0.95 (s, 3 H), 0.94 (s, 3 H), 0.93 (s, 3 H), 0.78 (s, 3 H), 0.77 (s, 3 H), 0.70-0.64 (m, 4 H), 0.63 (s, 3 H); ^{13}C NMR (100 MHz, acetone-d_6) δ 176.4, 143.9, 139.7, 139.7, 137.4, 129.2, 129.0, 128.9, 128.8, 128.6, 128.1, 123.6, 83.2, 82.0, 72.3, 66.8, 56.1, 49.5, 47.6, 47.0, 42.2, 41.5, 40.3, 40.0, 39.8, 39.2, 37.7, 36.0, 33.9, 33.2, 32.6, 31.1, 29.2, 28.8, 27.8, 26.4, 24.7, 24.1, 19.2, 17.5, 16.6, 15.9, 7.2, 7.1, 6.4, 6.0; HRMS (ESI) calcd for $C_{48}H_{71}O_4$ $[M+H]^+$ 739.5116, found 739.5108.

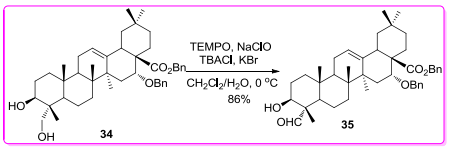
Benzyl 16-O-benzyl-23-hydroxyl-echinocystate (34)



A sealed tube was charged with **33** (120.0 mg, 162.34 μmol), Me_4Phen (4.8 mg, 20.29 μmol), norbornene (22.9 mg, 243.52 μmol) successively. The reaction tube was then evacuated under reduced pressure for 30 min, then $[Ir(cod)OMe]_2$ (5.38 mg, 8.12

μmol) was added under N_2 atmosphere. Afterwards, the reaction tube was chilled to -78 ^oC, and the gas-exchange process was conducted for 3 times at the same temperature. To the reaction tube, dry THF (1.00 mL) was then added, which was followed by 3 times of gas-exchange at -78 ^oC. After being stirred at room temperature for 1 h, the reaction mixture was then heated to 120 ^oC, and the stirring was continued for another 36 h. After being cooled to room temperature, $KHCO_3$ (162.5 mg, 1.62 mmol), MeOH (1.00 mL), and 30% H_2O_2 (331.65 μL, 3.25 mmol) were added successively. The resulting mixture was then heated to 50 ^oC, and the stirring was continued for another 16 h before ethyl acetate was added. The resulting mixture was washed with $NaHSO_3$, water, and brine, and was then dried over anhydrous Na_2SO_4. Filtration was followed by concentration to give the crude product, which was further purified by silica gel column chromatography (petroleum ether/ethyl acetate = 3 : 1 to 2 : 1) to afford **34** (32.6 mg, 30% over 2 steps) as a white solid: $[\alpha]_D^{25}$ = 18.1 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 7.37-7.24 (m, 10 H), 5.35 (t, *J* = 3.6 Hz, 1 H), 5.07 (AB, 2 H), 4.71 (d, *J* = 11.2 Hz, 1 H), 4.36 (d, *J* = 11.2 Hz, 1 H), 4.25 (t, *J* = 3.2 Hz, 1 H), 3.73 (d, *J* = 9.6 Hz, 1 H), 3.65 (dd, *J* = 6.8, 8.4 Hz, 1 H), 3.43 (d, *J* = 10.4 Hz, 1 H), 3.09 (dd, *J* = 4.4, 14.4 Hz, 1 H), 2.25 (dd, *J* = 13.2, 14.6 Hz, 1 H), 1.92-1.81 (m, 4 H), 1.79-1.68 (m, 2 H), 1.65-1.57 (m, 5 H), 1.51-1.38 (m, 3 H), 1.34 (s, 3 H), 1.25-1.19 (m, 1 H), 1.09-0.97 (m, 3 H), 0.933 (s, 3 H), 0.927 (s, 3 H), 0.89 (s, 3 H), 0.85 (dd, *J* = 3.6, 10.4 Hz, 1 H), 0.78 (s, 3 H), 0.57 (s, 3 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 143.1, 138.8, 136.2, 128.6, 128.3, 128.2, 127.7, 127.4, 122.8, 82.5, 77.1, 72.4, 71.8, 66.4, 50.0, 49.0, 46.8, 46.3, 41.9, 41.6, 40.7, 39.5, 38.3, 37.0, 35.3, 33.0, 32.9, 32.0, 30.6, 28.8, 26.9, 26.0, 24.5, 23.4, 18.6, 17.0, 15.9; HRMS (ESI) calcd for $C_{44}H_{61}O_5$ $[M+H]^+$ 669.4514, found 669.4509.

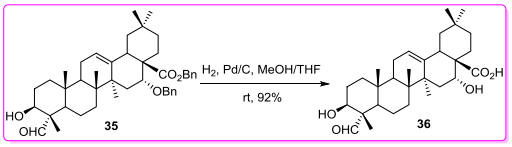
Benzyl 16-O-benzyl-quillaic ester (35)



Similar procedure as that used for the transformation of **14** to its aldehyde intermediate (Anelli oxidation) was applied to convert **34** (30.0 mg, 44.85 μmol) to **35**

(25.7 mg, 86%) as a white solid after silica gel column chromatography (petroleum ether/ethyl acetate = 8 : 1 to 6 : 1): $[\alpha]_D^{25}$ = 46.5 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, acetone-d_6) δ 9.31 (s, 1 H), 7.42-7.28 (m, 10 H), 5.34 (t, *J* = 3.6 Hz, 1 H), 5.10 (AB, 2 H), 4.78 (d, *J* = 11.2 Hz, 1 H), 4.42 (d, *J* = 11.2 Hz, 1 H), 4.30 (dd, *J* = 1.2, 3.2 Hz, 1 H), 3.83-3.78 (m, 1 H), 3.73 (d, *J* = 5.2 Hz, 1 H), 3.14 (dd, *J* = 4.4, 14.4 Hz, 1 H), 2.31 (dd, *J* = 12.8, 14.4 Hz, 1 H), 1.99-1.84 (m, 4 H), 1.78-1.65 (m, 6 H), 1.62-1.44 (m, 3 H), 1.41 (s, 3 H), 1.37-1.29 (m, 2 H), 1.25 (dt, *J* = 3.2, 12.4 Hz, 1 H), 1.17-1.04 (m, 3 H), 1.00 (s, 3 H), 0.97 (s, 3 H), 0.94 (s, 3 H), 0.91 (dd, *J* = 1.2, 12.4 Hz, 1 H); ^{13}C NMR (100 MHz, acetone-d_6) δ 203.9, 176.4, 144.0, 139.8, 137.4, 129.3, 129.0, 128.9, 128.8, 128.7, 128.2, 123.4, 83.2, 72.3 (2 C), 66.8, 56.2, 49.5, 47.9, 47.5, 47.1, 42.3, 41.6, 40.6, 39.0, 36.6, 36.0, 33.2 (2 C), 32.6, 31.1, 29.2, 27.2, 26.4, 24.7, 24.1, 21.3, 17.5, 16.0, 9.4; HRMS (ESI) calcd for $C_{44}H_{59}O_5$ $[M+H]^+$ 667.4357, found 667.4336.

Quillaic acid (36)



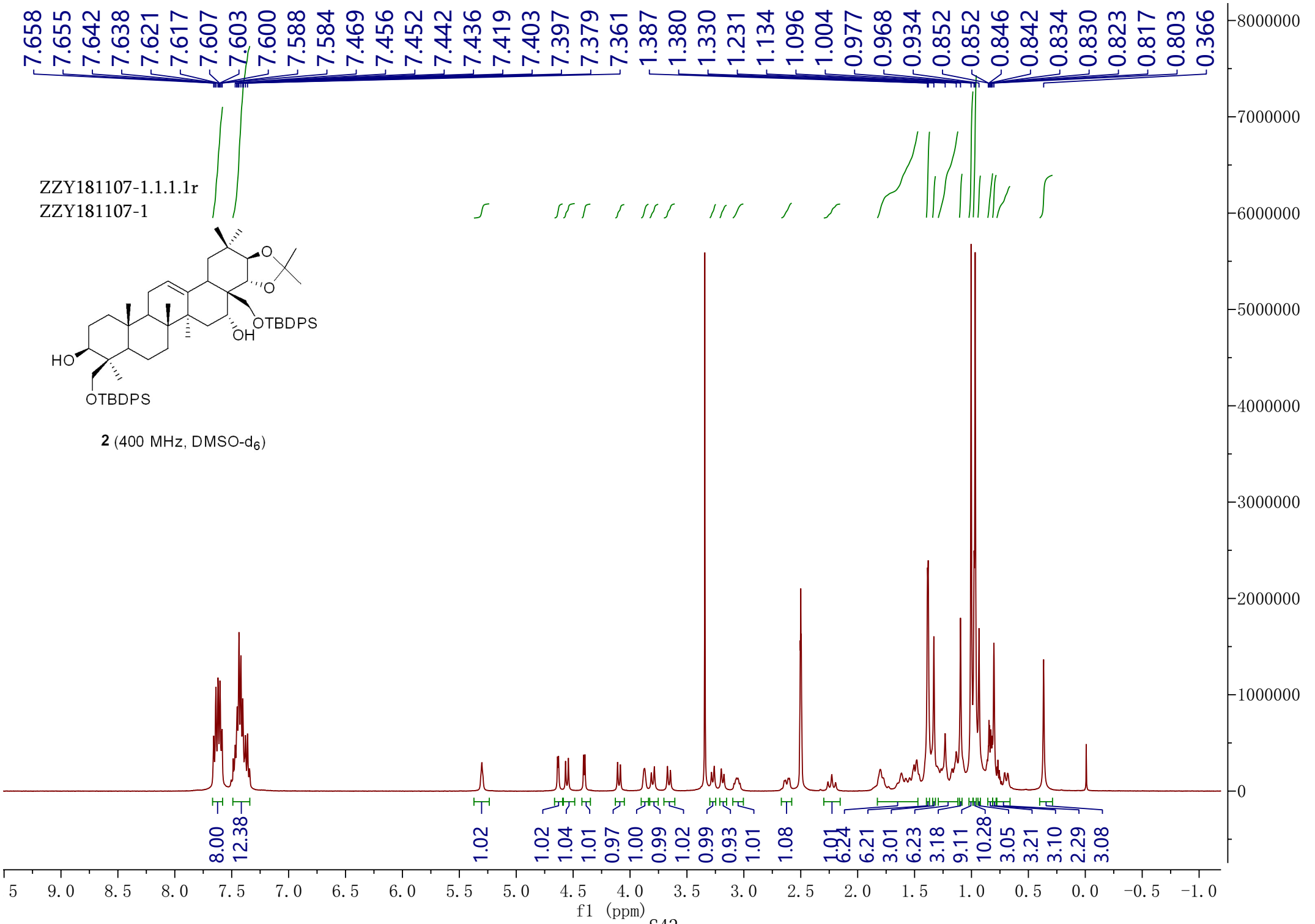
Except for the reaction media (MeOH/THF = 3 mL : 1 mL), similar procedure as that used for the synthesis of **20** was adopted to convert **35** (23.0 mg, 34.49 μmol) to **36** (15.4 mg, 92%) as a white solid after silica gel column chromatography (dichloromethane/methanol = 16 : 1 to 12 : 1):[S3] $[\alpha]_D^{25}$ = 70.0 (*c* 0.1, MeOH); ^{1}H NMR (400 MHz, DMSO-d_6) δ 12.01 (s, 1 H), 9.24 (s, 1 H), 5.22 (t, *J* = 3.6 Hz, 1 H), 4.72 (d, *J* = 4.4 Hz, 1 H), 4.65 (d, *J* = 5.2 Hz, 1 H), 4.23 (d, *J* = 3.6 Hz, 1 H), 3.69-3.64 (m, 1 H), 2.91 (dd, *J* = 4.4, 14.0 Hz, 1 H), 2.25 (dd, *J* = 12.4, 14.4 Hz), 1.95-1.77 (m, 4 H), 1.69-1.49 (m, 6 H), 1.46-1.39 (m, 1 H), 1.34 (s, 3 H), 1.30-0.94 (m, 7 H), 0.90 (s, 3 H), 0.88 (s, 3 H), 0.87 (s, 3 H), 0.83 (s, 3 H), 0.77 (d, *J* = 11.6 Hz, 1 H), 0.68 (s, 3 H); ^{13}C NMR (100 MHz, DMSO-d_6) δ 207.1, 178.2, 144.0, 121.0, 72.9, 70.4, 55.1, 47.2, 46.4, 46.0, 41.1, 40.1, 39.3, 37.7, 35.4, 35.2, 34.6, 32.9, 31.8, 31.4, 30.2, 26.5, 26.0, 24.1, 22.8, 20.3, 16.8, 15.3, 8.9; HRMS (ESI) calcd for $C_{30}H_{50}NO_5$ $[M+NH_4]^+$ 504.3684, found 504.3692.

References

[S1] a) Gruza, M. M.; Jatczak, K.; Zagrodzki, B.; Laszcz, M.; Koziak, K.; Malinska, M.; Cmoch, P.; Tomasz, G.; Zegrocka-Stendel, O.; Wozniak, K.; Grynkiewicz, G. *Molecules* **2013**, *18*, 4389-4402. b) Jatczak, K.; Gruza, M.; Filip, K.; Cmoch, P.; Grynkiewicz, G. *Cent. Eur. J. Chem*. **2014**, *12*, 1222-1231.

[S2] Gafur, M. A.; Obata, T.; Kiuchi, F.; Tsuda, Y. *Chem. Pharm. Bull*. **1997**, *45*, 620-625. In this literature, the ^{1}H NMR spectra was recorded in deuterated pyridine. To avoid the disturbance of the fake impurity-signals originated from the deuterated pyridine, the NMR data were collected in $CDCl_3$. For direct comparison with the data reported in the above literature, the ^{1}H NMR experiment has also been conducted in pyridine-d_5, and identical ^{1}H NMR spectrum as that reported in the above literature was obtained.

[S3] The comparison of spectroscopic data of the synthetic sample with those of the authentic sample has been made, and the authentic sample has been purchased form Nanjing Spring & Autumn Biological Engineering Co., Ltd.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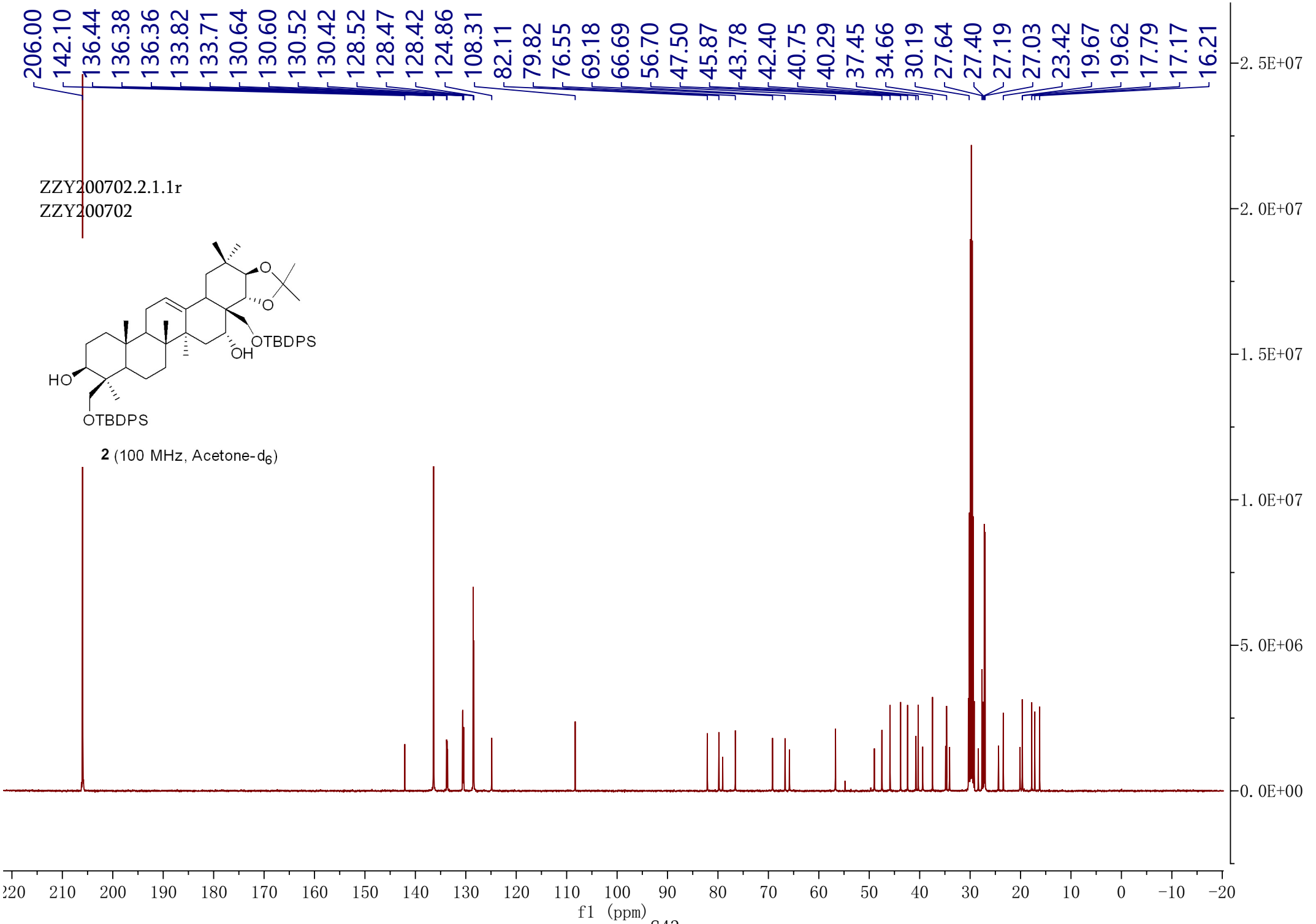
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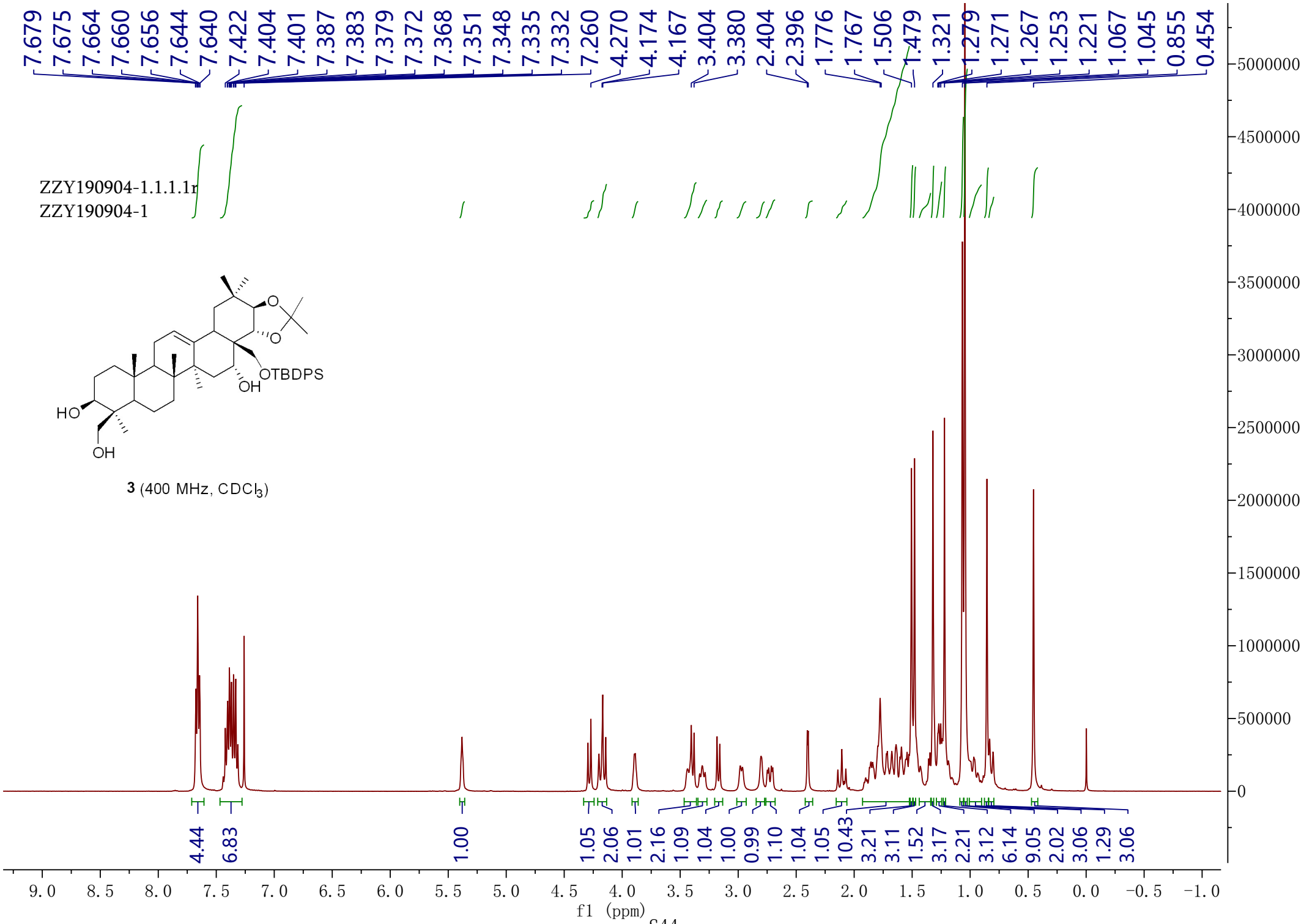
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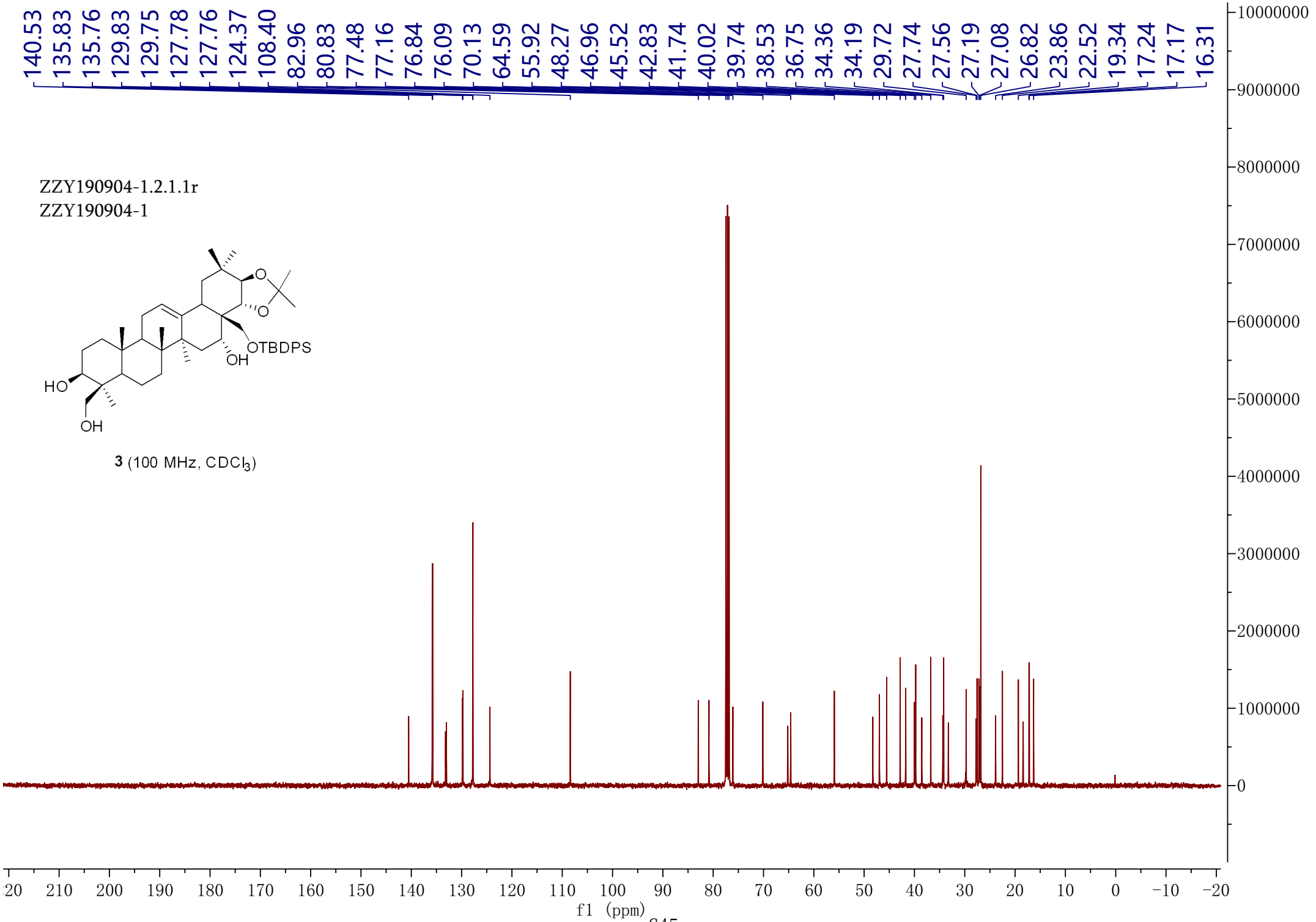
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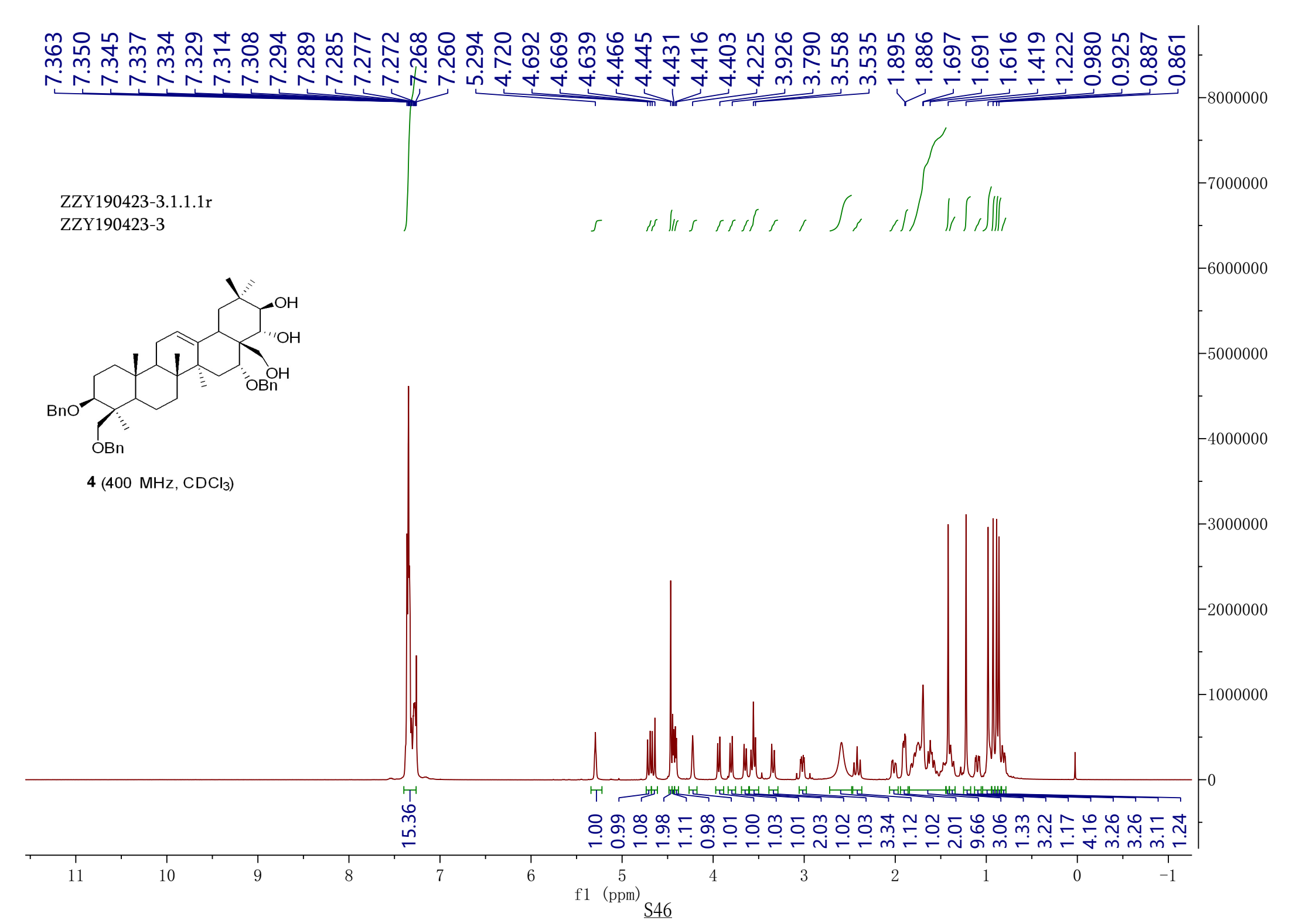
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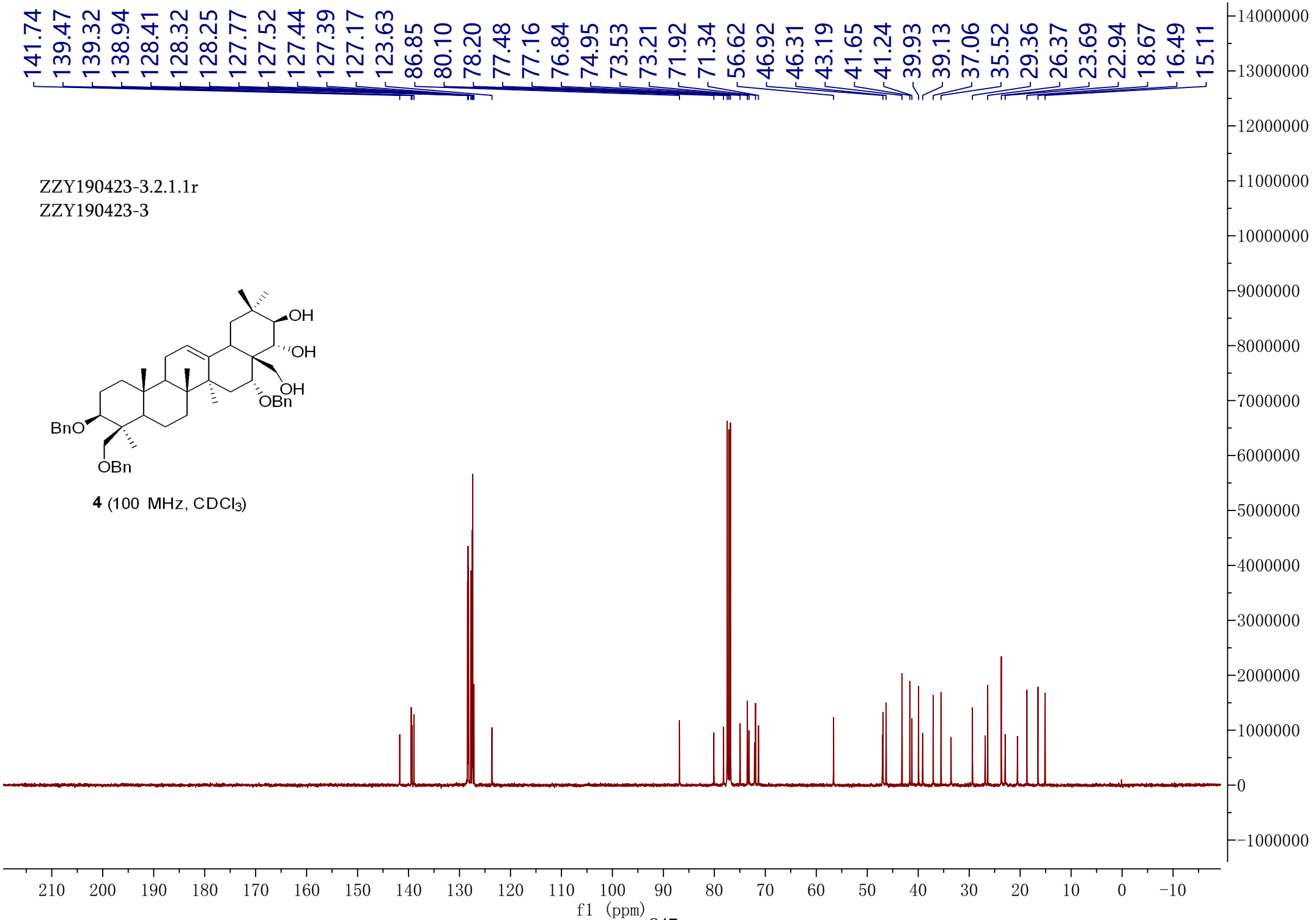
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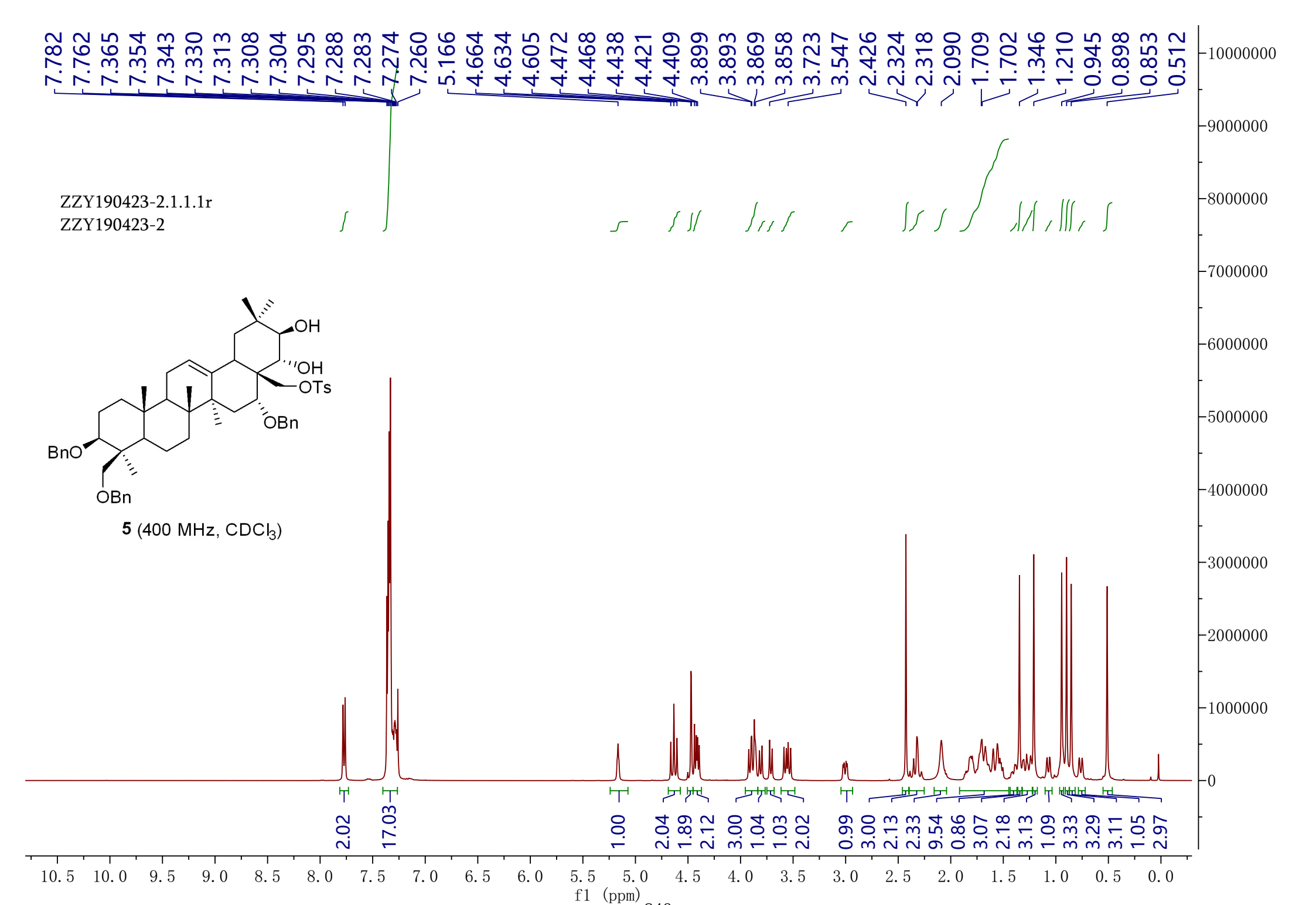
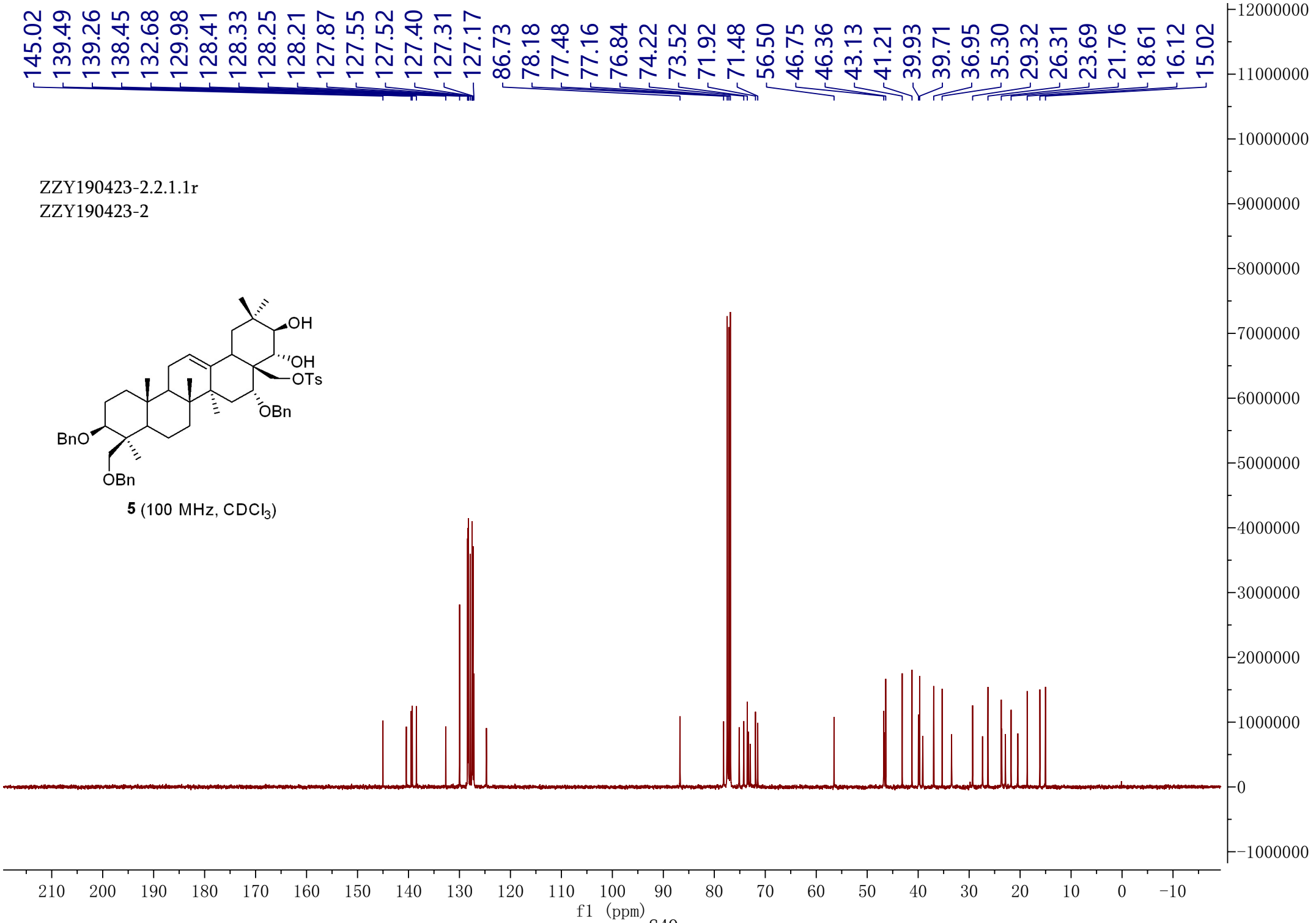
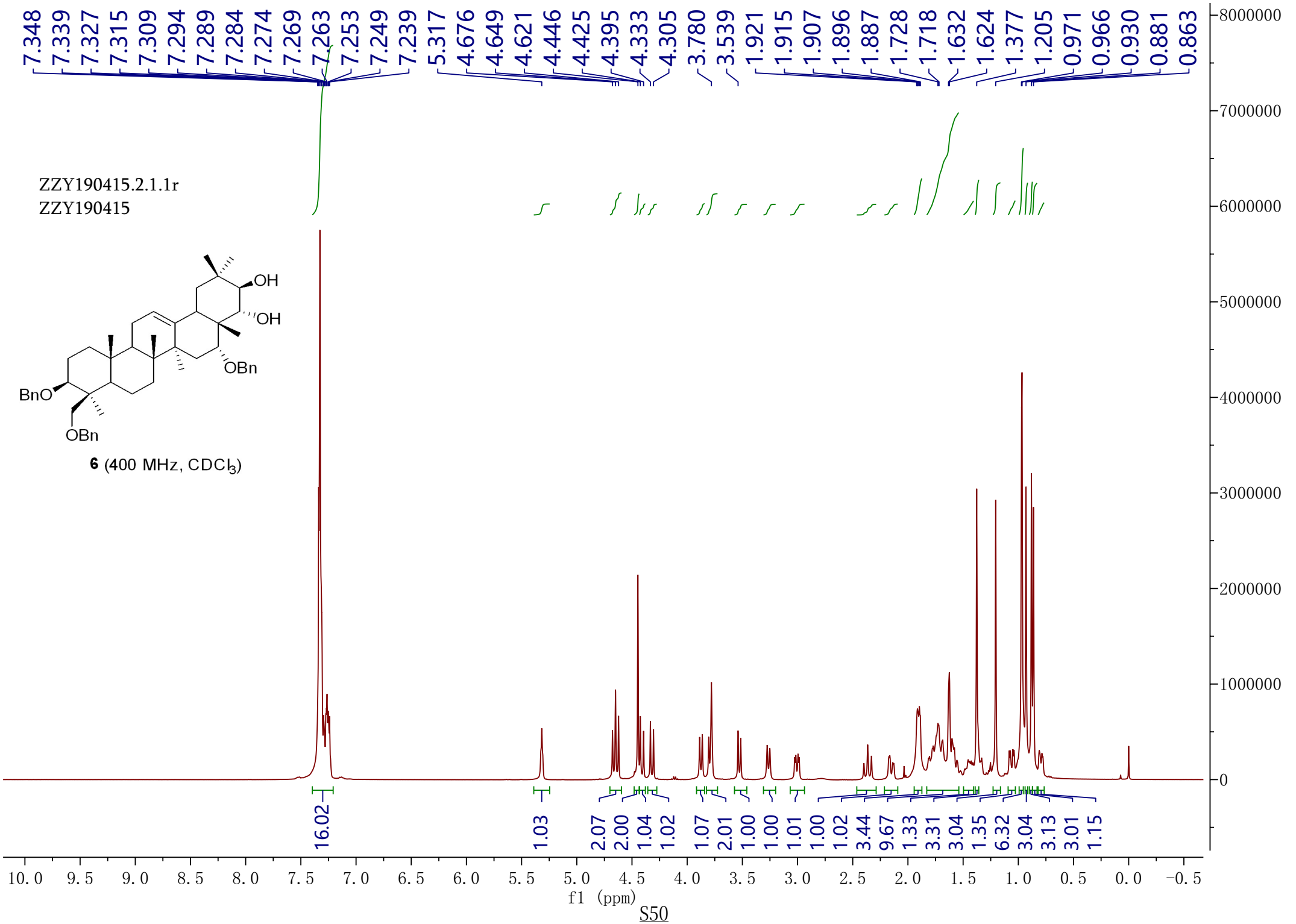
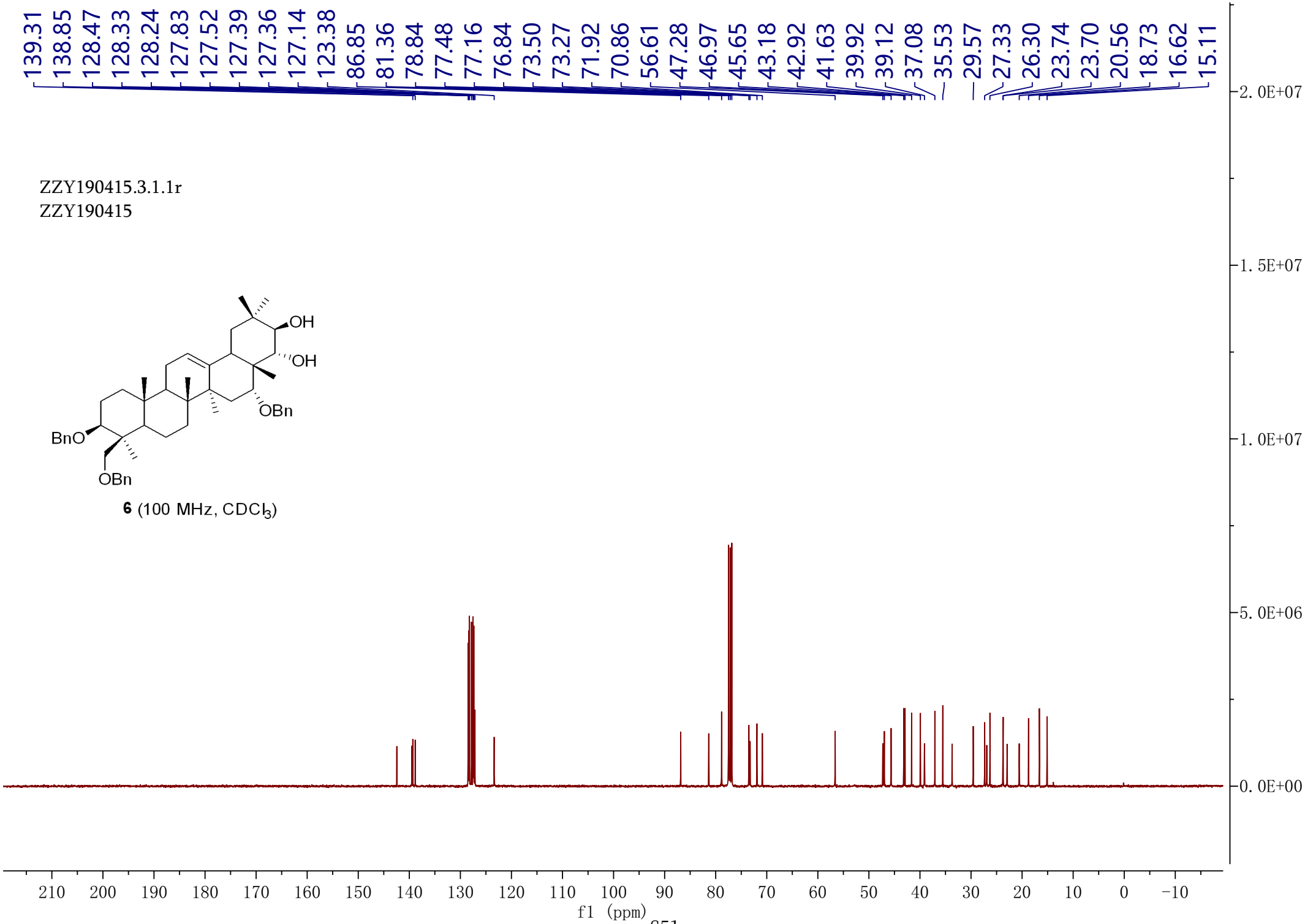
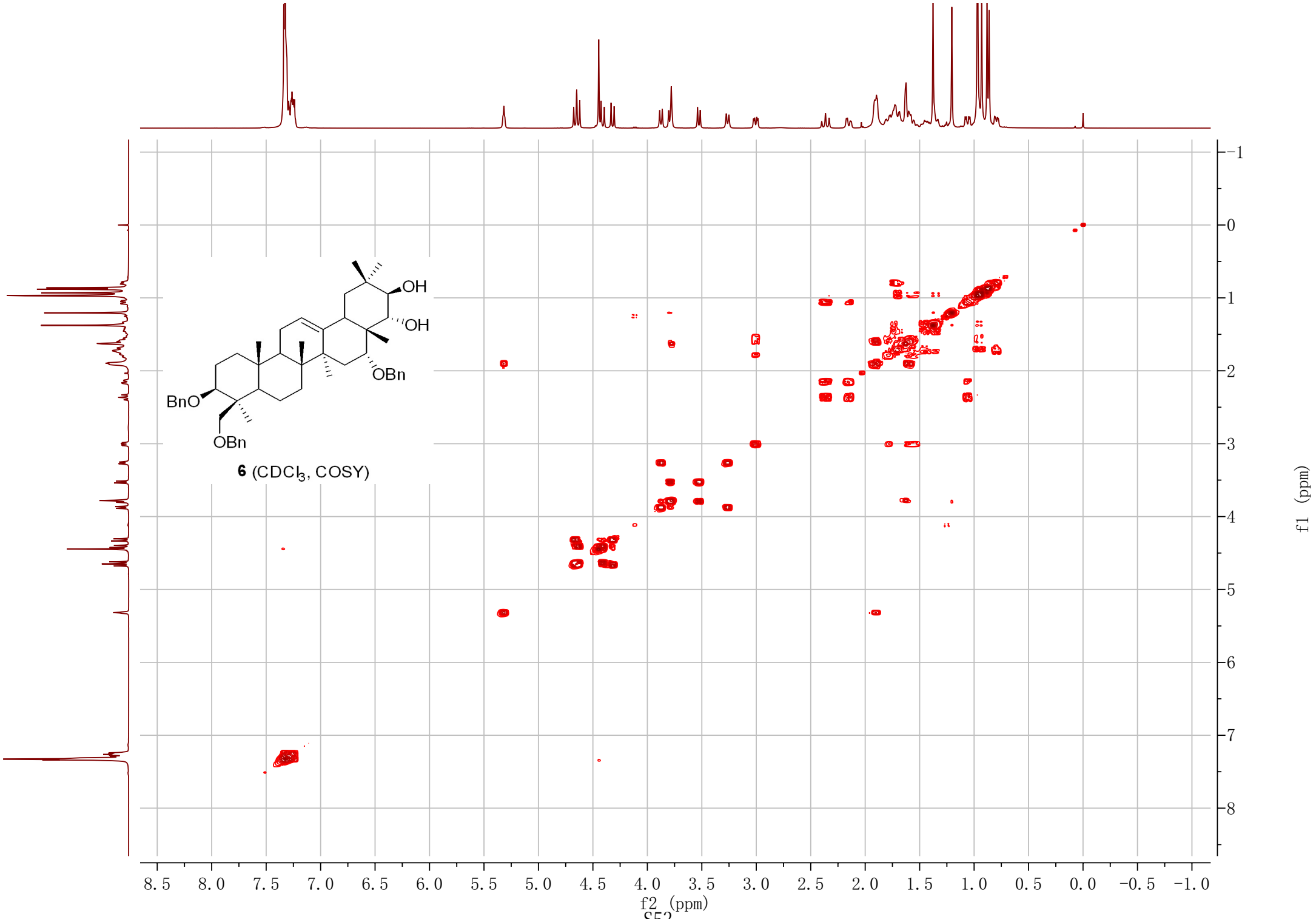
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)

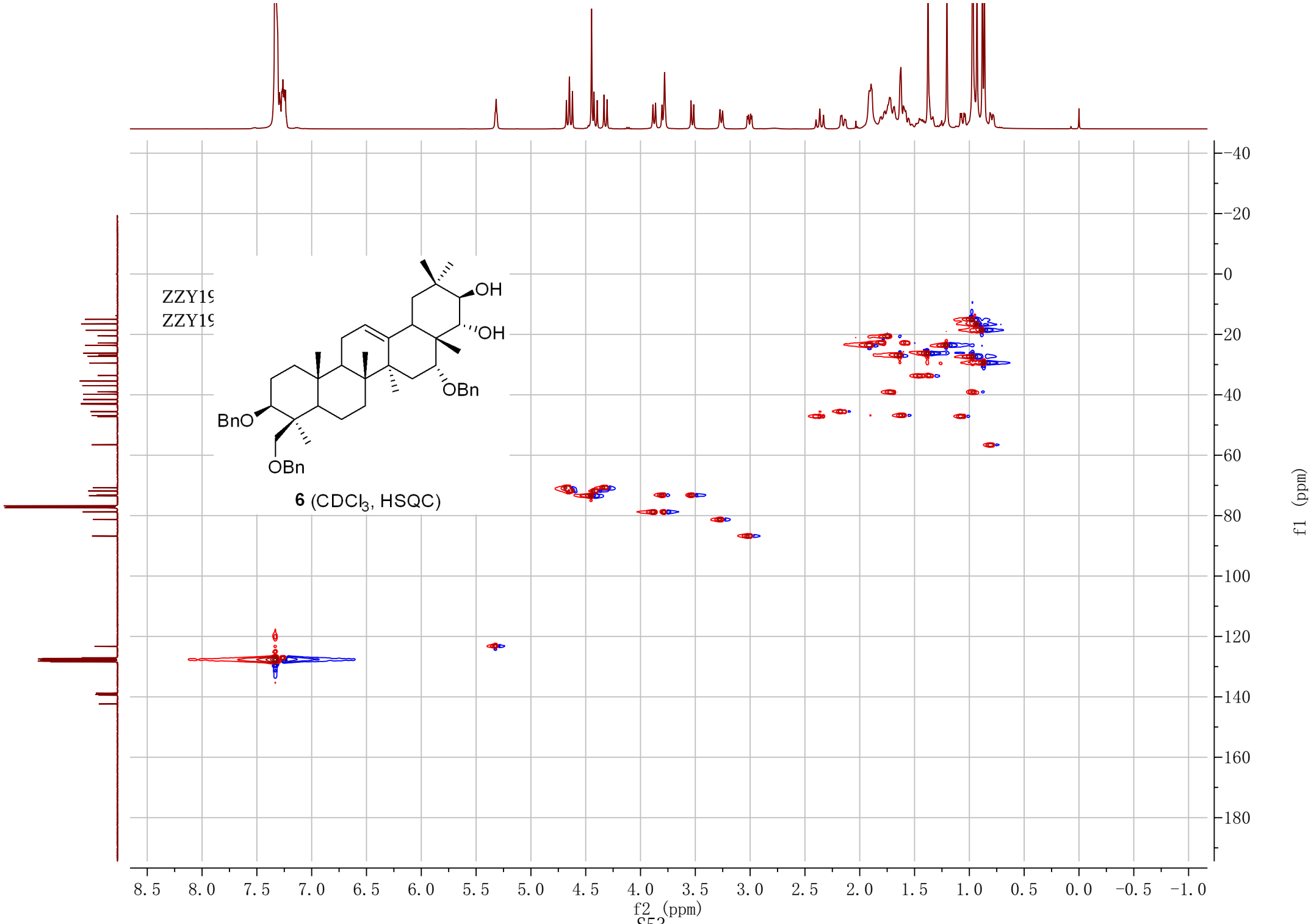

7.782
7.762
7.365
7.354
7.343
7.330
7.313
7.308
7.304
7.295
7.288
7.283
7.274
7.260
5.166
4.664
4.634
4.605
4.472
4.468
4.438
4.421
4.409
3.899
3.893
3.869
3.858
3.723
3.547
2.426
2.324
2.318
2.090
1.709
1.702
1.346
1.210
0.945
0.898
0.853
0.512
ZZY190423-2.1.1.1r
ZZY190423-2
OH
OH
OTs
OBn
BnO
OBn
5 (400 MHz, CDCl3)
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
2.02
17.03
1.00
2.04
1.89
2.12
3.00
1.04
1.03
2.02
0.99
3.00
2.13
2.33
9.54
0.86
3.07
2.18
3.13
1.09
3.33
3.29
3.11
1.05
2.97
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)

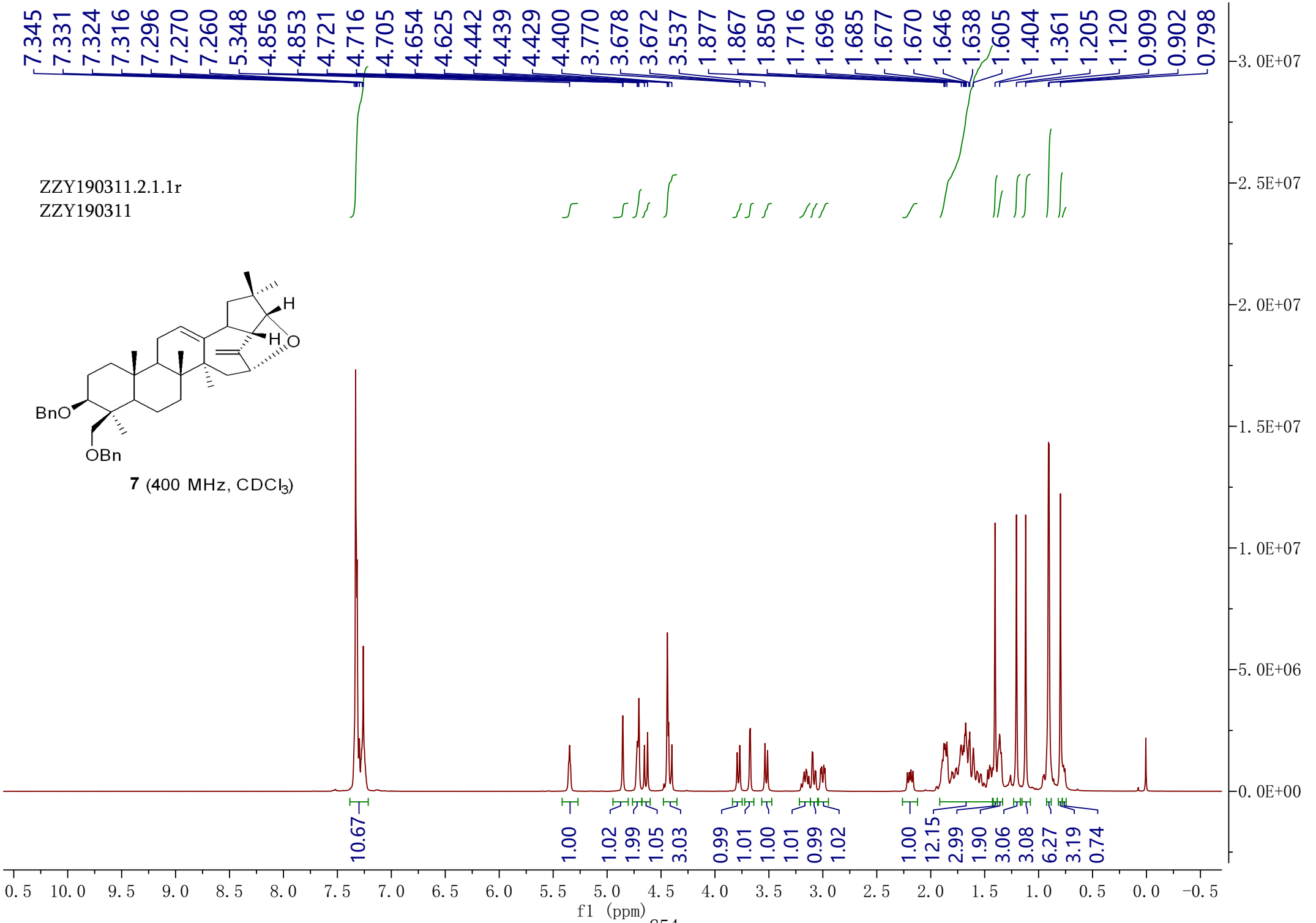

145.02
139.49
139.26
138.45
132.68
129.98
128.41
128.33
128.25
128.21
127.87
127.55
127.52
127.40
127.31
127.17
86.73
78.18
77.48
77.16
76.84
74.22
73.52
71.92
71.48
56.50
46.75
46.36
43.13
41.21
39.93
39.71
36.95
35.30
29.32
26.31
23.69
21.76
18.61
16.12
15.02
ZZY190423-2.2.1.1r
ZZY190423-2
OH
OH
OTs
OBn
BnO
OBn
5 (100 MHz, CDCl3)
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

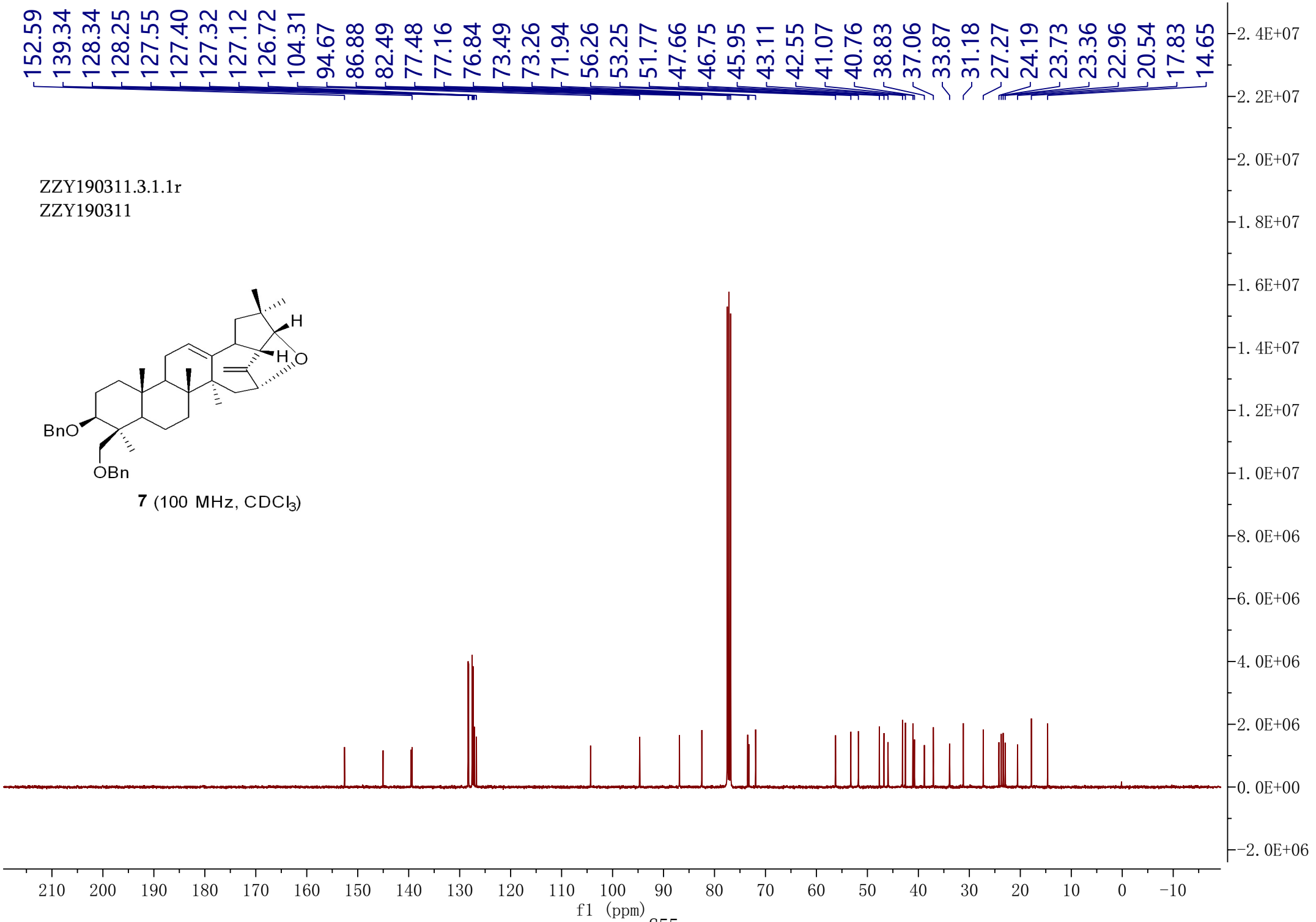

7.348
7.339
7.327
7.315
7.309
7.294
7.289
7.284
7.274
7.269
7.263
7.253
7.249
7.239
5.317
4.676
4.649
4.621
4.446
4.425
4.395
4.333
4.305
3.780
3.539
1.921
1.915
1.907
1.896
1.887
1.728
1.718
1.632
1.624
1.377
1.205
0.971
0.966
0.930
0.881
0.863
ZZY190415.2.1.1r
ZZY190415
OH
OH
OBn
BnO
OBn
6 (400 MHz, CDCl3)
16.02
1.03
2.07
2.00
1.04
1.02
1.07
2.01
1.00
1.00
1.01
1.00
1.02
3.44
9.67
1.33
3.31
3.04
1.35
6.32
3.04
3.13
3.01
1.15
f1 (ppm)


139.31
138.85
128.47
128.33
128.24
127.83
127.52
127.39
127.36
127.14
123.38
86.85
81.36
78.84
77.48
77.16
76.84
73.50
73.27
71.92
70.86
56.61
47.28
46.97
45.65
43.18
42.92
41.63
39.92
39.12
37.08
35.53
29.57
27.33
26.30
23.74
23.70
20.56
18.73
16.62
15.11
ZZY190415.3.1.1r
ZZY190415
OH
OH
OBn
BnO
OBn
6 (100 MHz, CDCl3)
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
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)

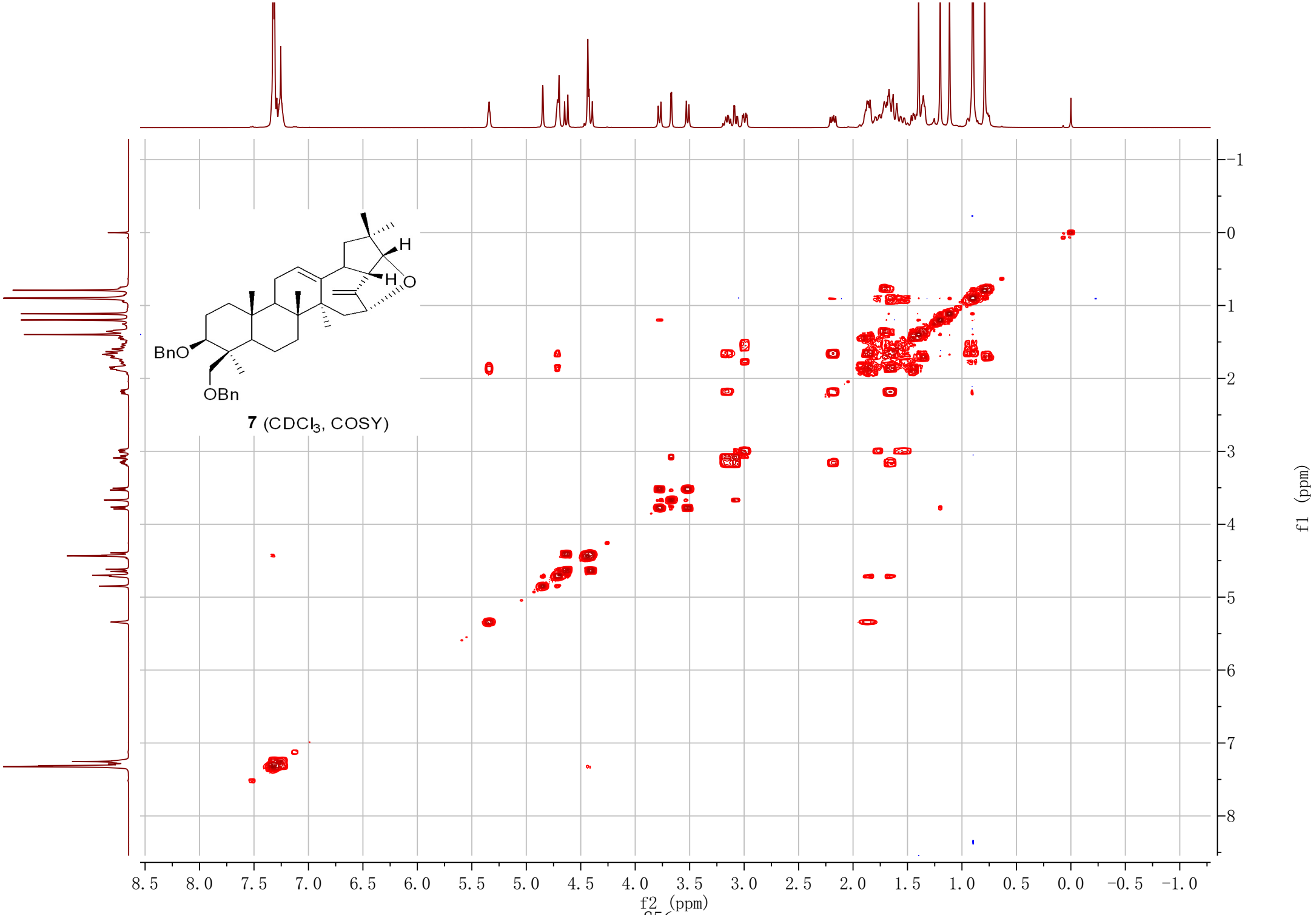

OH
OH
OBn
BnO
OBn
6 (CDCl3, COSY)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
f2 (ppm)
-1
0
1
2
3
4
5
6
7
8
f1 (ppm)

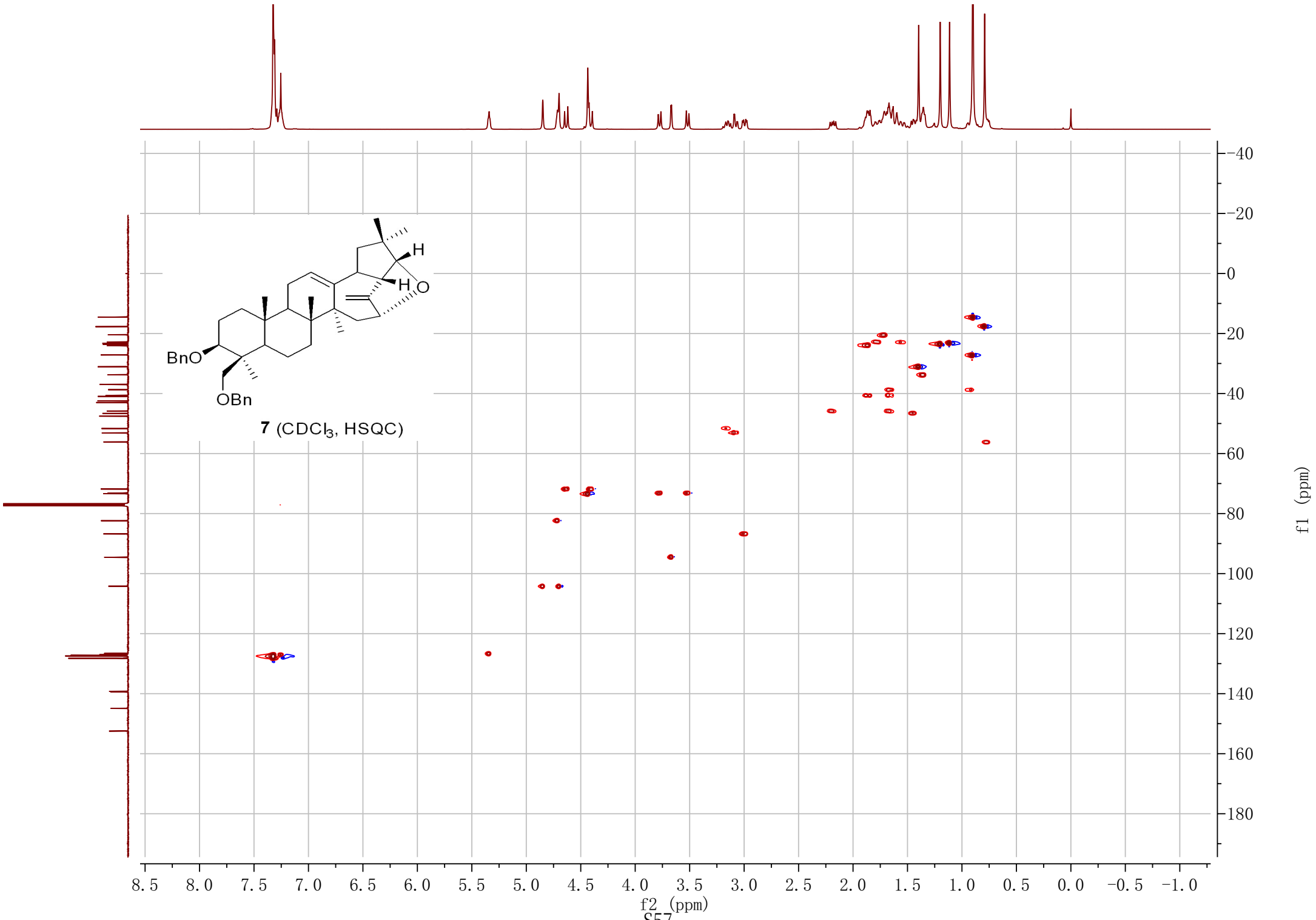

ZZY19
ZZY19
OH
OH
OBn
BnO
OBn
6 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

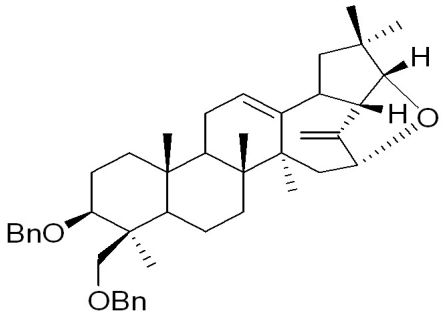

7.345
7.331
7.324
7.316
7.296
7.270
7.260
5.348
4.856
4.853
4.721
4.716
4.705
4.654
4.625
4.442
4.439
4.429
4.400
3.770
3.678
3.672
3.537
1.877
1.867
1.850
1.716
1.696
1.685
1.677
1.670
1.646
1.638
1.605
1.404
1.361
1.205
1.120
0.909
0.902
0.798
ZZY190311.2.1.1r
ZZY190311
BnO
OBn
H
H
O
7 (400 MHz, CDCl3)
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
10.67
1.00
1.02
1.99
1.05
3.03
0.99
1.01
1.00
1.01
0.99
1.02
1.00
12.15
2.99
1.90
3.06
3.08
6.27
3.19
0.74
0.5
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)



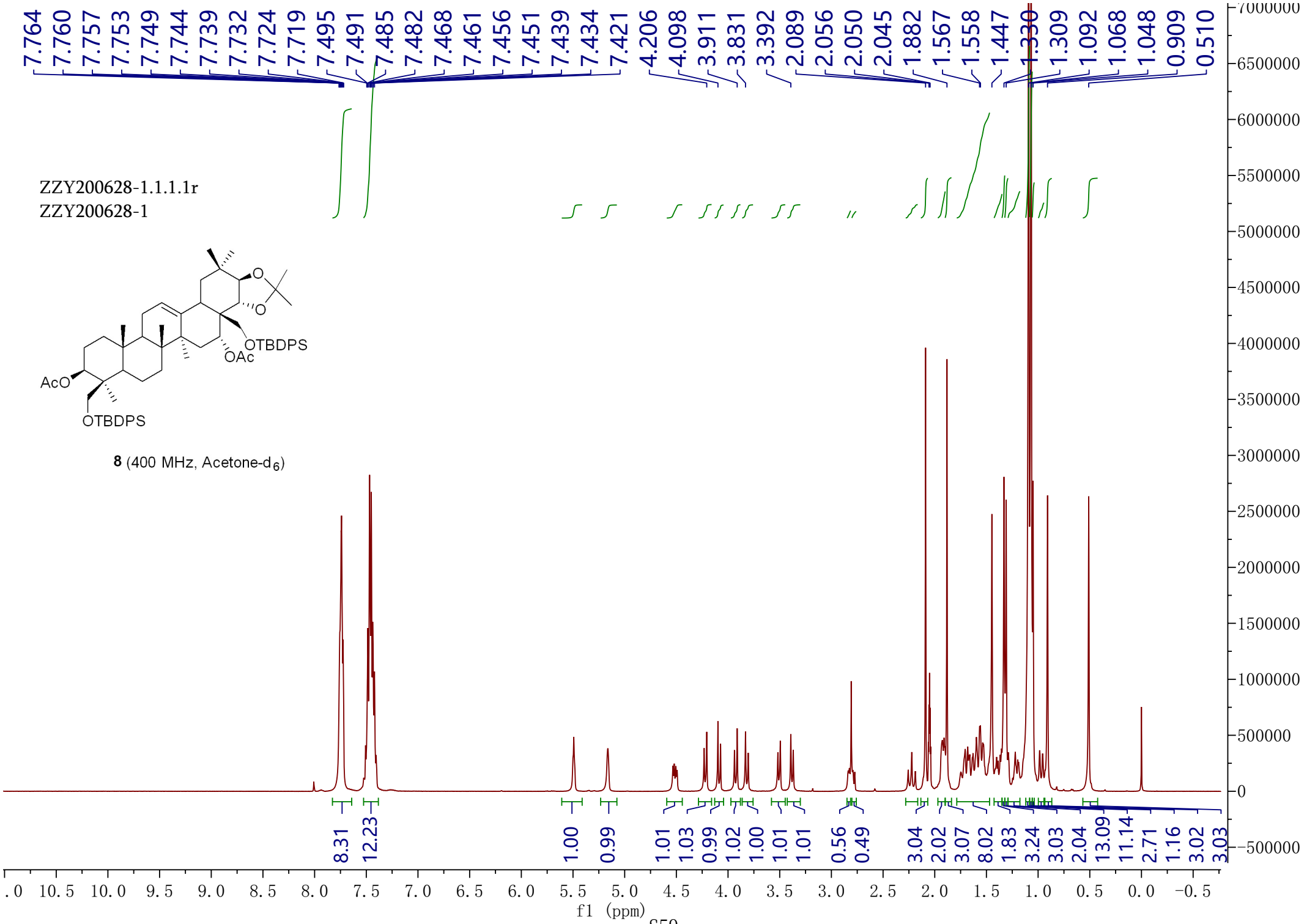
7 (100 MHz, $CDCl_3$)

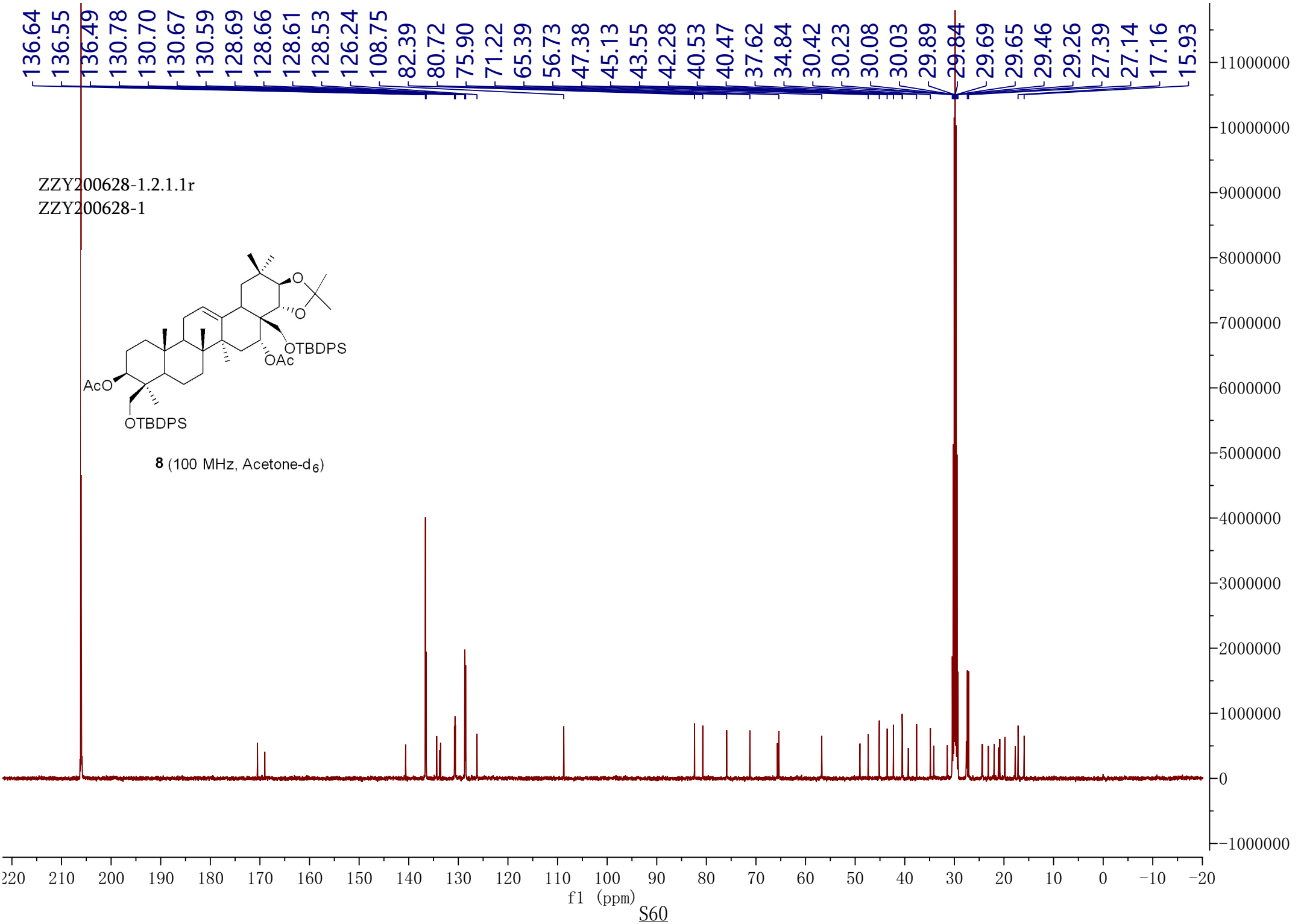

H
H
O
BnO
OBn
7 (CDCl3, COSY)
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f2 (ppm)
-1 0 1 2 3 4 5 6 7 8
f1 (ppm)

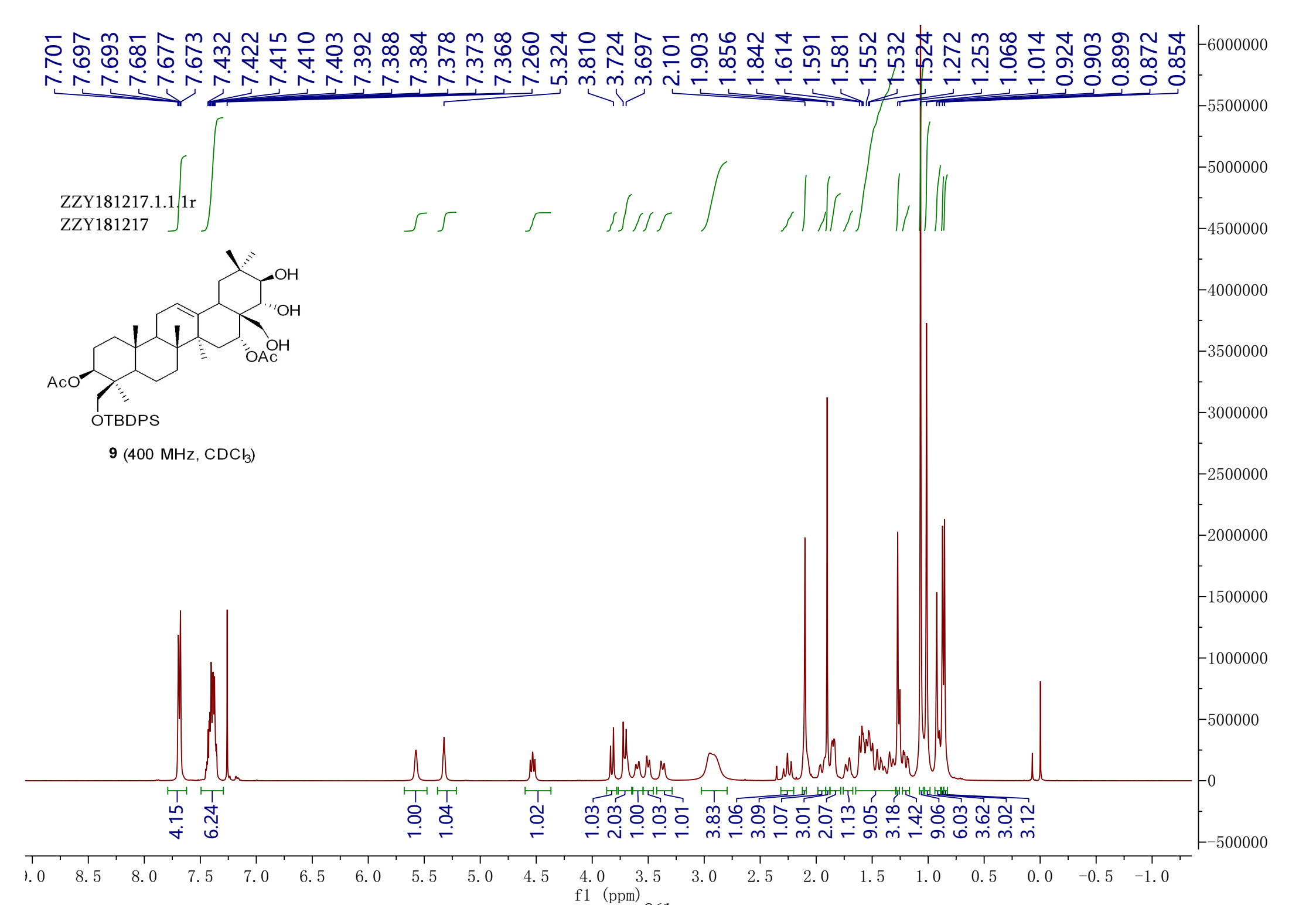

BnO
OBn
H
H
O
7 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

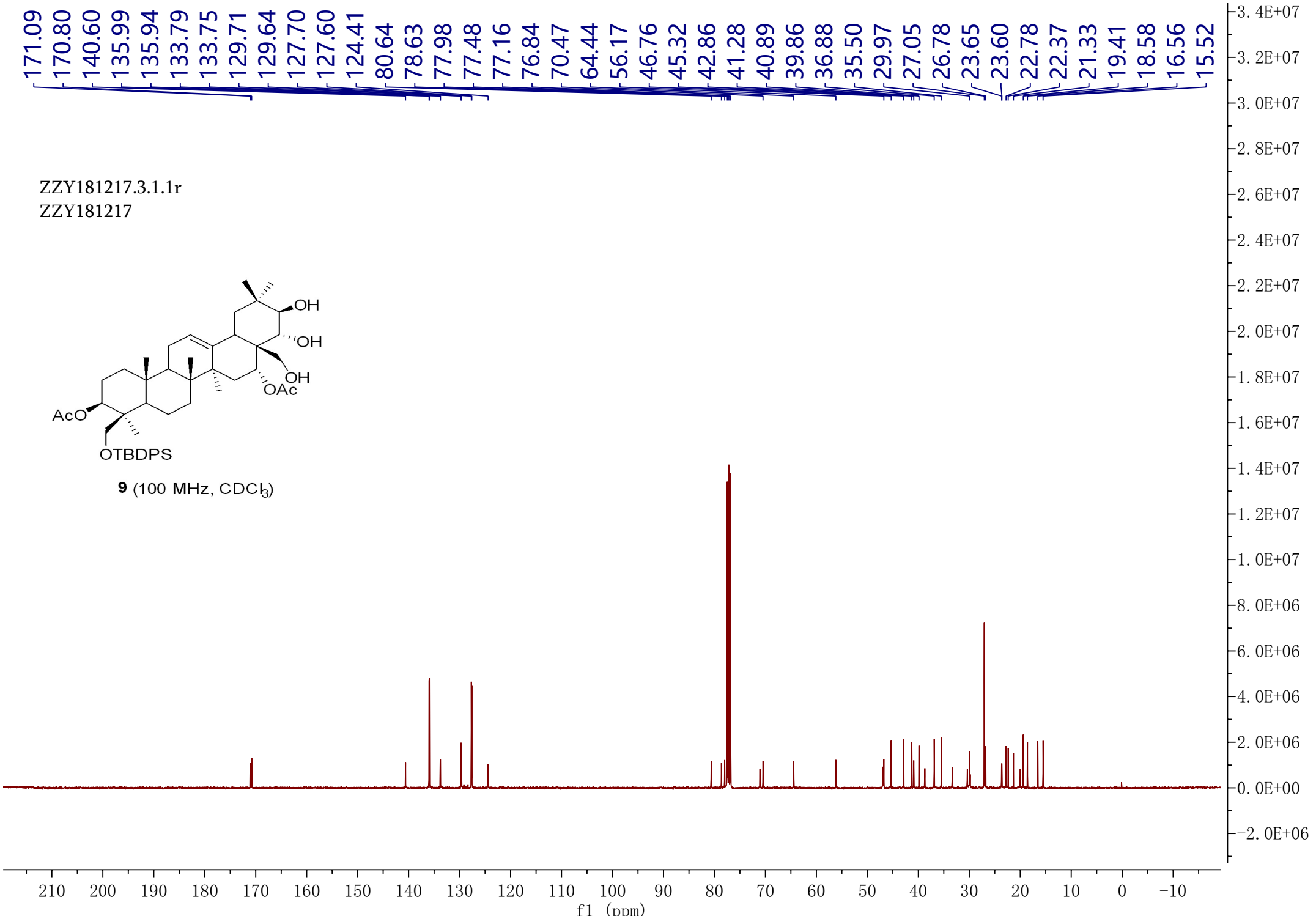


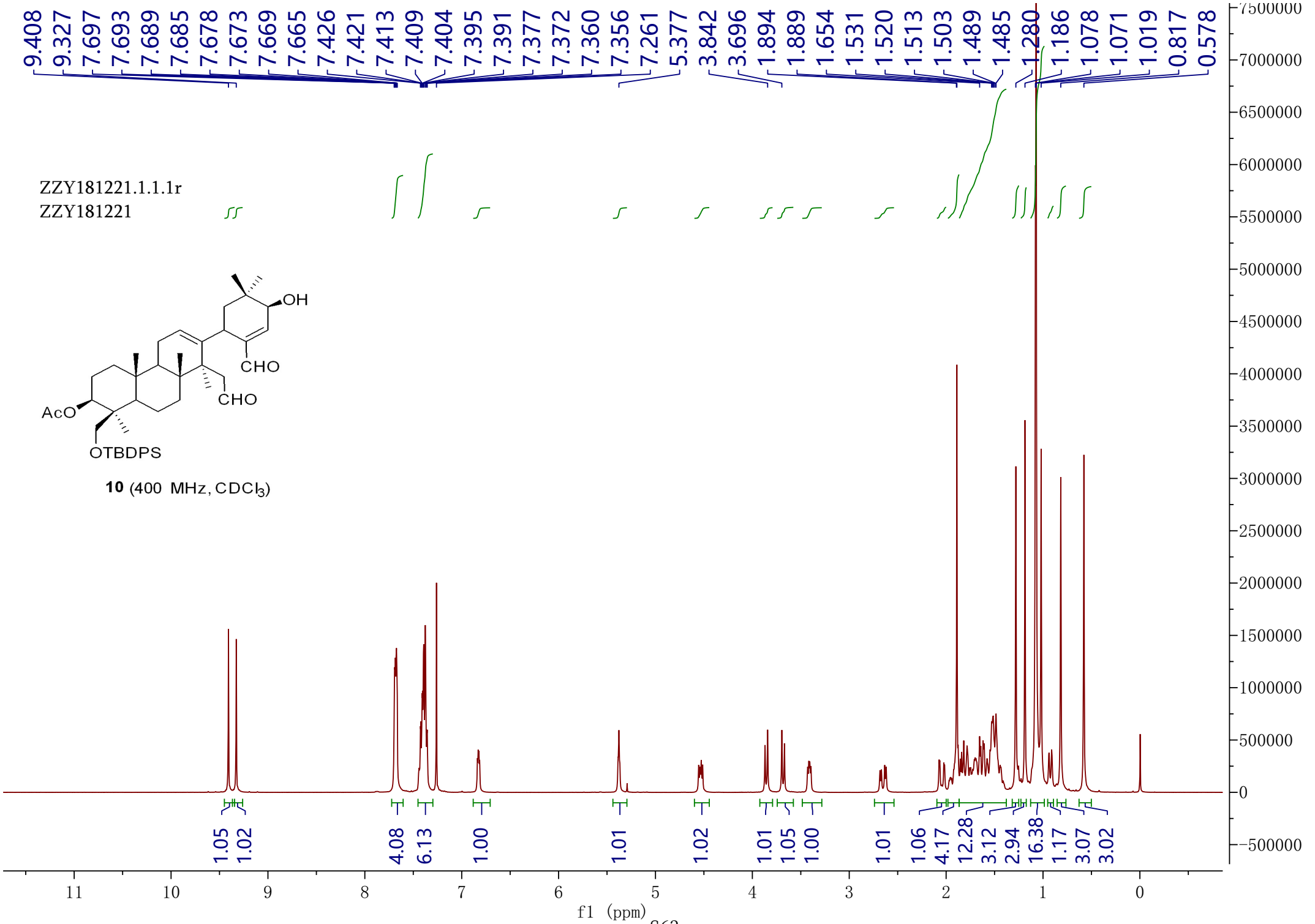
7 ($CDCl_3$, DEPT 135°)

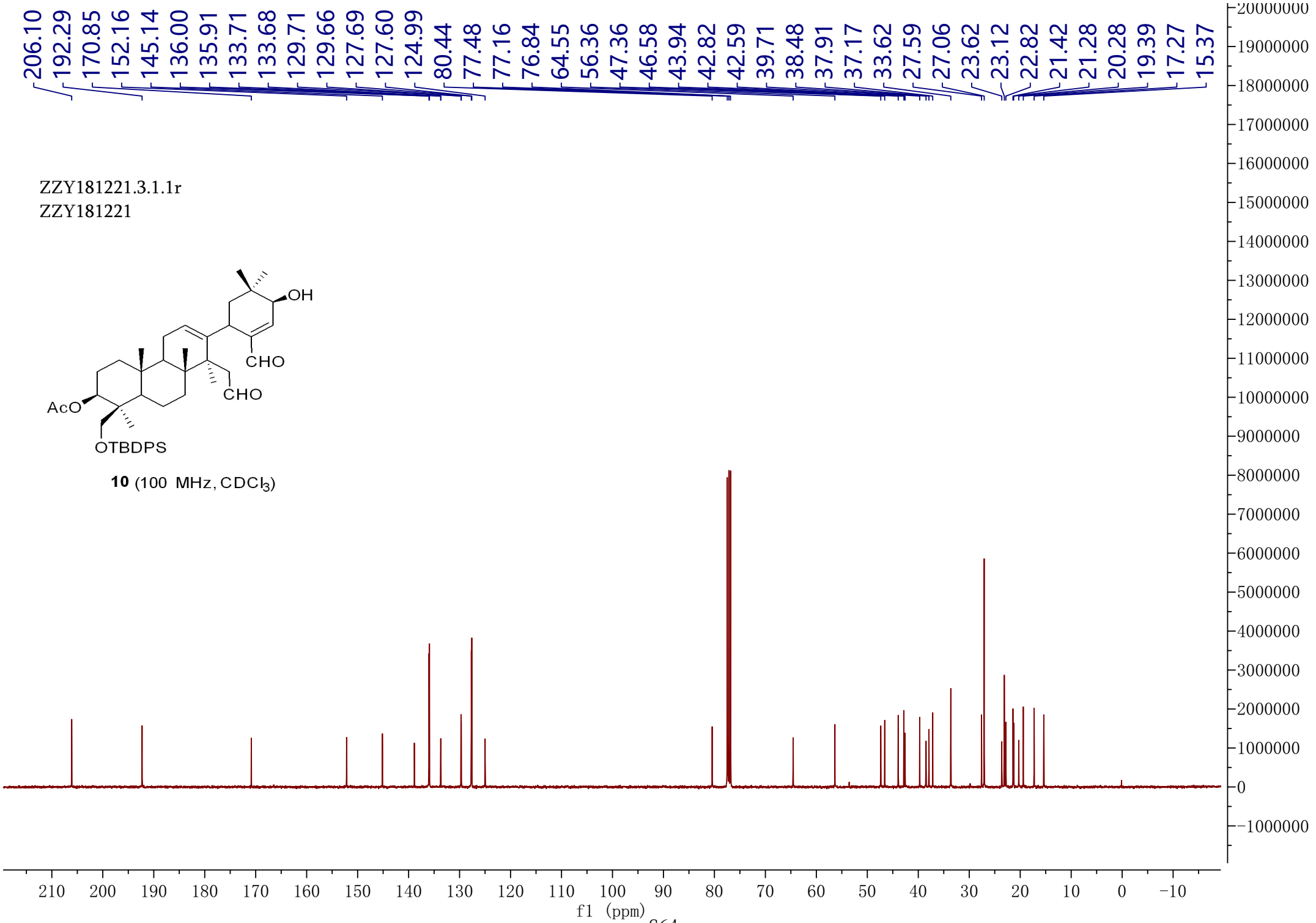

7.764
7.760
7.757
7.753
7.749
7.744
7.739
7.732
7.724
7.719
7.495
7.491
7.485
7.482
7.468
7.461
7.456
7.451
7.439
7.434
7.421
4.206
4.098
3.911
3.831
3.392
2.089
2.056
2.050
2.045
1.882
1.567
1.558
1.447
1.330
1.309
1.092
1.068
1.048
0.909
0.510
ZZY200628-1.1.1.1r
ZZY200628-1
AcO
OAc
OTBDPS
OTBDPS
8 (400 MHz, Acetone-d6)
8.31
12.23
1.00
0.99
1.01
1.03
0.99
1.02
1.00
1.01
1.01
0.56
0.49
3.04
2.02
3.07
8.02
1.83
3.24
3.03
2.04
13.09
11.14
2.71
1.16
3.02
3.03
f1 (ppm)

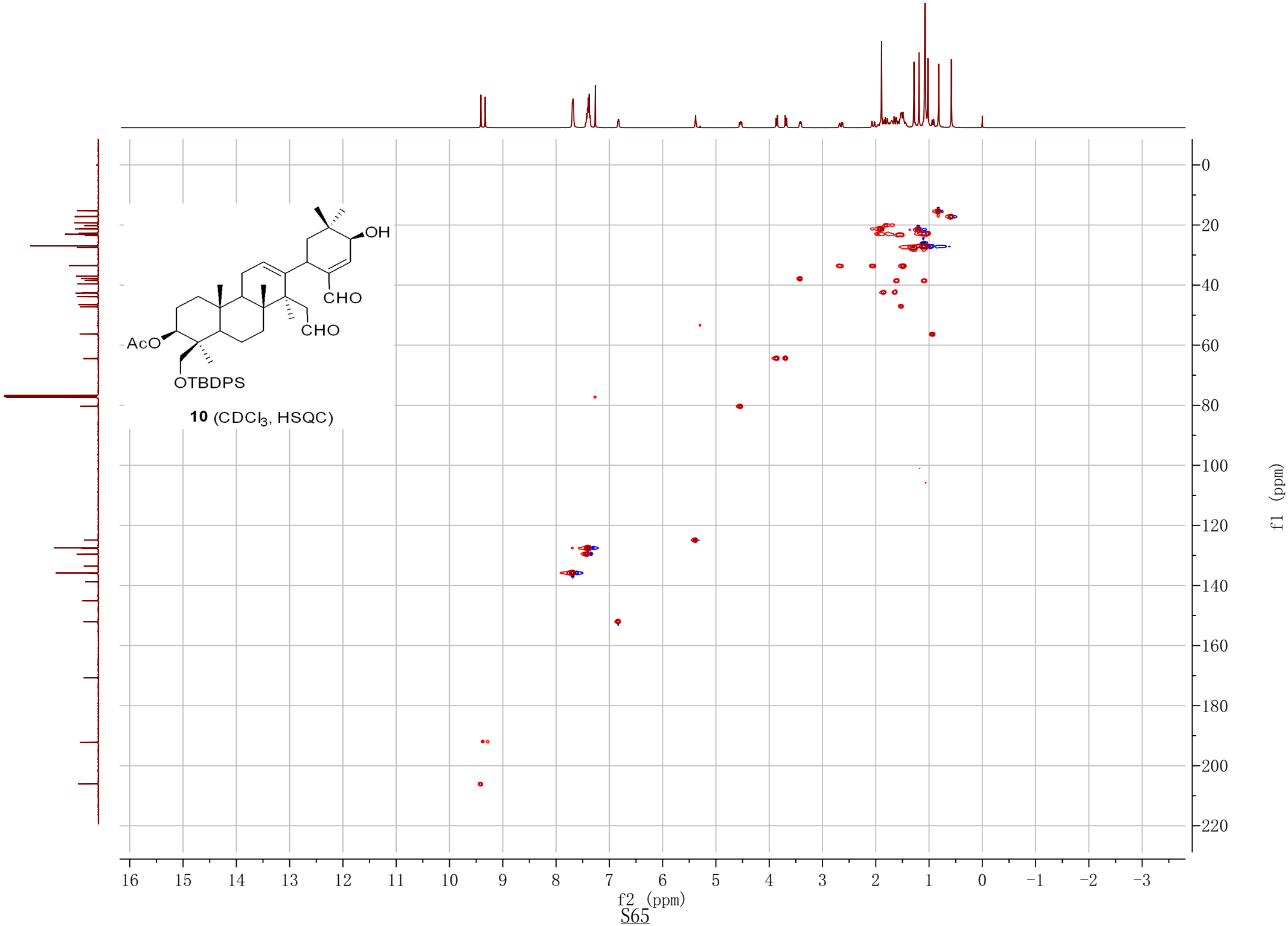

136.64
136.55
136.49
130.78
130.70
130.67
130.59
128.69
128.66
128.61
128.53
126.24
108.75
82.39
80.72
75.90
71.22
65.39
56.73
47.38
45.13
43.55
42.28
40.53
40.47
37.62
34.84
30.42
30.23
30.08
30.03
29.89
29.84
29.69
29.65
29.46
29.26
27.39
27.14
17.16
15.93
ZZY200628-1.2.1.1r
ZZY200628-1
OTBDPS
OAc
AcO
OTBDPS
8 (100 MHz, Acetone-d6)
f1 (ppm)

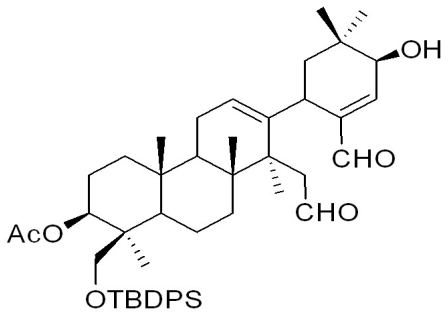

7.701
7.697
7.693
7.681
7.677
7.673
7.432
7.422
7.415
7.410
7.403
7.392
7.388
7.384
7.378
7.373
7.368
7.260
5.324
3.810
3.724
3.697
2.101
1.903
1.856
1.842
1.614
1.591
1.581
1.552
1.532
1.524
1.272
1.253
1.068
1.014
0.924
0.903
0.899
0.872
0.854
ZZY181217.1.1.1r
ZZY181217
OH
OH
OH
OAc
AcO
OTBDPS
9 (400 MHz, CDCl3)
4.15
6.24
1.00
1.04
1.02
1.03
2.03
1.00
1.03
1.01
3.83
1.06
3.09
1.07
3.01
2.07
1.13
9.05
3.18
1.42
9.06
6.03
3.62
3.02
3.12
f1 (ppm)


171.09
170.80
140.60
135.99
135.94
133.79
133.75
129.71
129.64
127.70
127.60
124.41
80.64
78.63
77.98
77.48
77.16
76.84
70.47
64.44
56.17
46.76
45.32
42.86
41.28
40.89
39.86
36.88
35.50
29.97
27.05
26.78
23.65
23.60
22.78
22.37
21.33
19.41
18.58
16.56
15.52
ZZY181217.3.1.1r
ZZY181217
OH
OH
OH
OAc
AcO
OTBDPS
9 (100 MHz, CDCl3)
3.4E+07
3.2E+07
3.0E+07
2.8E+07
2.6E+07
2.4E+07
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
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)

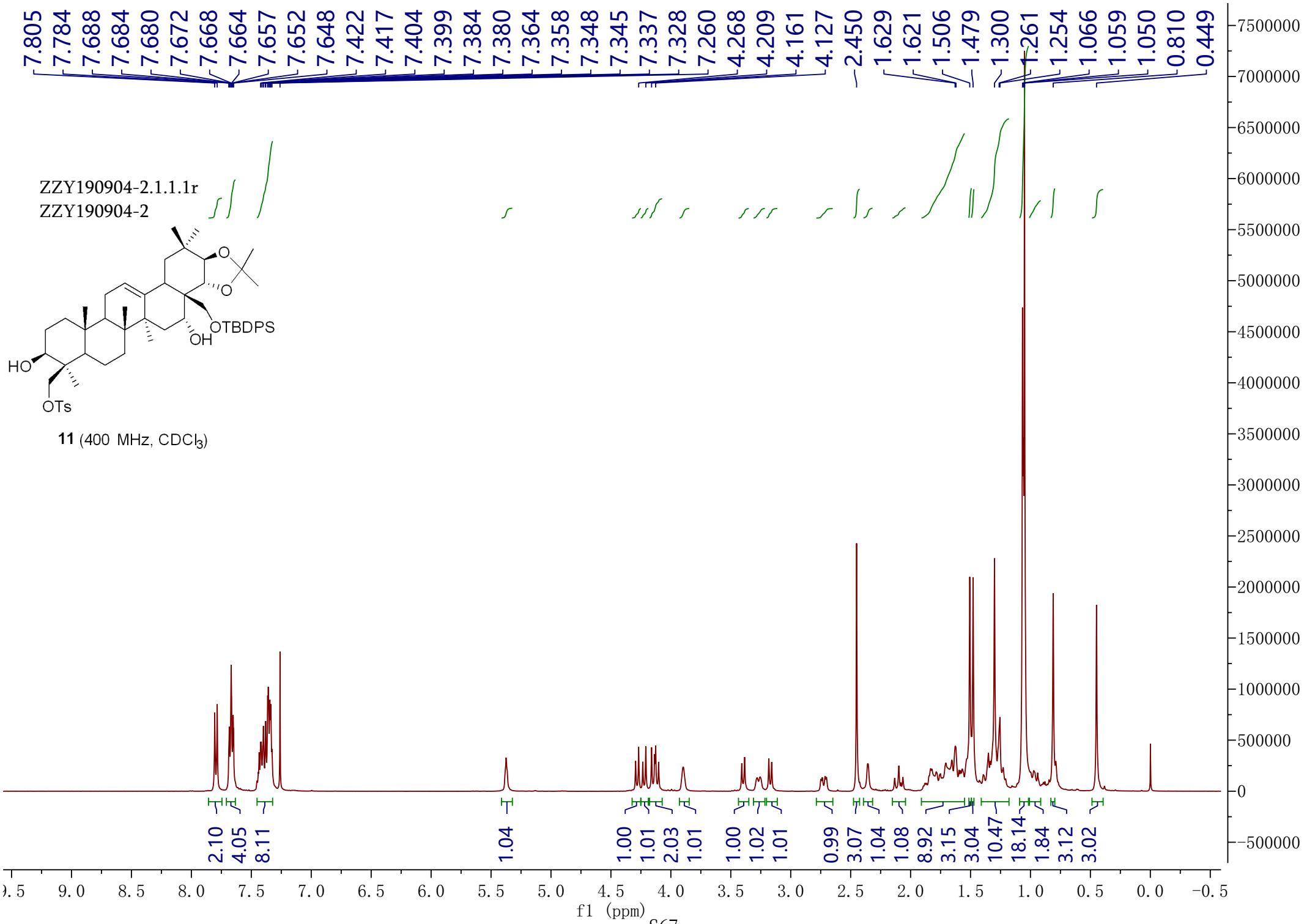

9.408
9.327
7.697
7.693
7.689
7.685
7.678
7.673
7.669
7.665
7.426
7.421
7.413
7.409
7.404
7.395
7.391
7.377
7.372
7.360
7.356
7.261
5.377
3.842
3.696
1.894
1.889
1.654
1.531
1.520
1.513
1.503
1.489
1.485
1.280
1.186
1.078
1.071
1.019
0.817
0.578
ZZY181221.1.1.1r
ZZY181221
OH
CHO
CHO
AcO
OTBDPS
10 (400 MHz, CDCl3)
1.05
1.02
4.08
6.13
1.00
1.01
1.02
1.01
1.05
1.00
1.01
1.06
4.17
12.28
3.12
2.94
16.38
1.17
3.07
3.02
f1 (ppm)

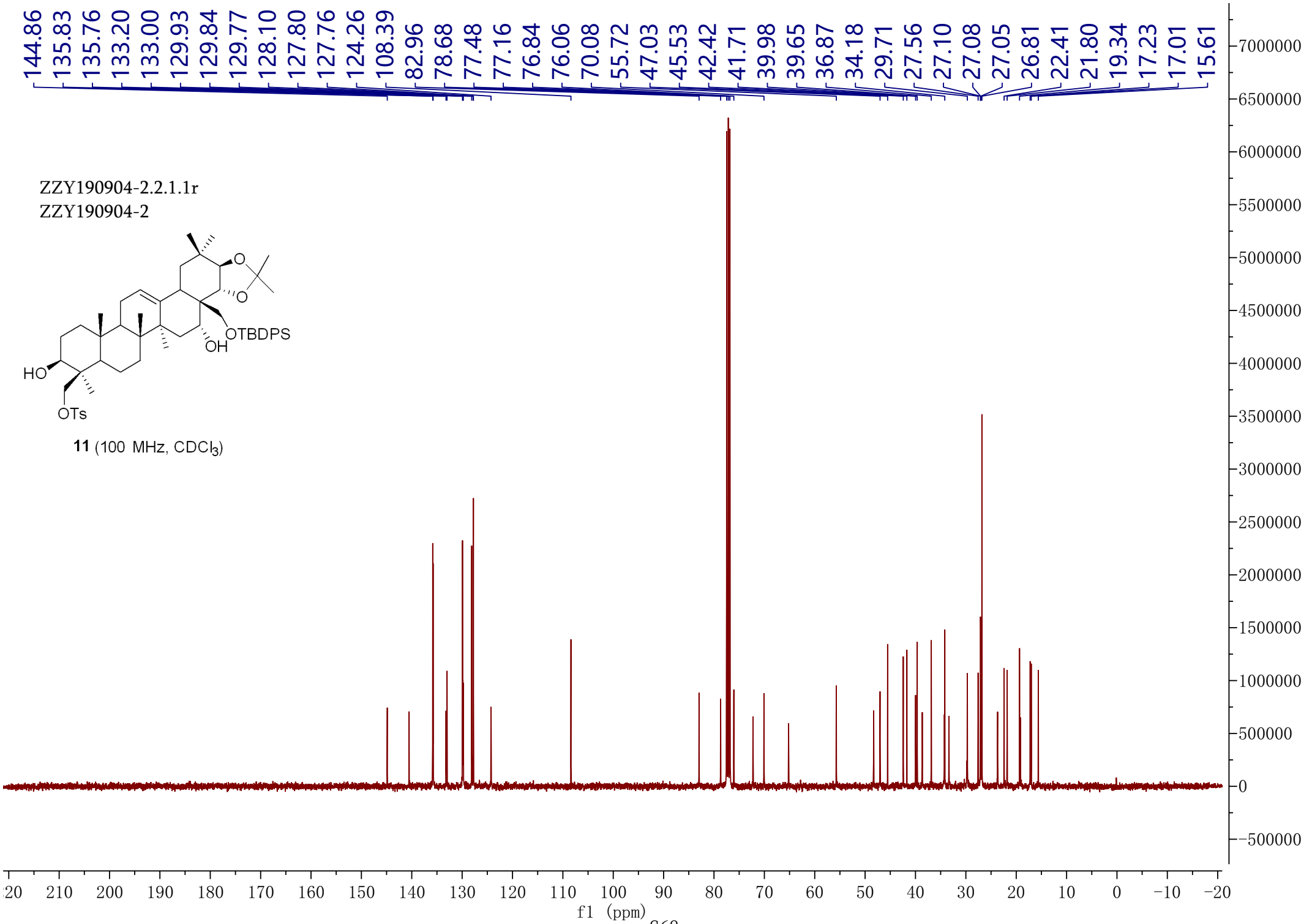

206.10
192.29
170.85
152.16
145.14
136.00
135.91
133.71
133.68
129.71
129.66
127.69
127.60
124.99
80.44
77.48
77.16
76.84
64.55
56.36
47.36
46.58
43.94
42.82
42.59
39.71
38.48
37.91
37.17
33.62
27.59
27.06
23.62
23.12
22.82
21.42
21.28
20.28
19.39
17.27
15.37
ZZY181221.3.1.1r
ZZY181221
OH
CHO
CHO
AcO
OTBDPS
10 (100 MHz, CDCl3)
f1 (ppm)

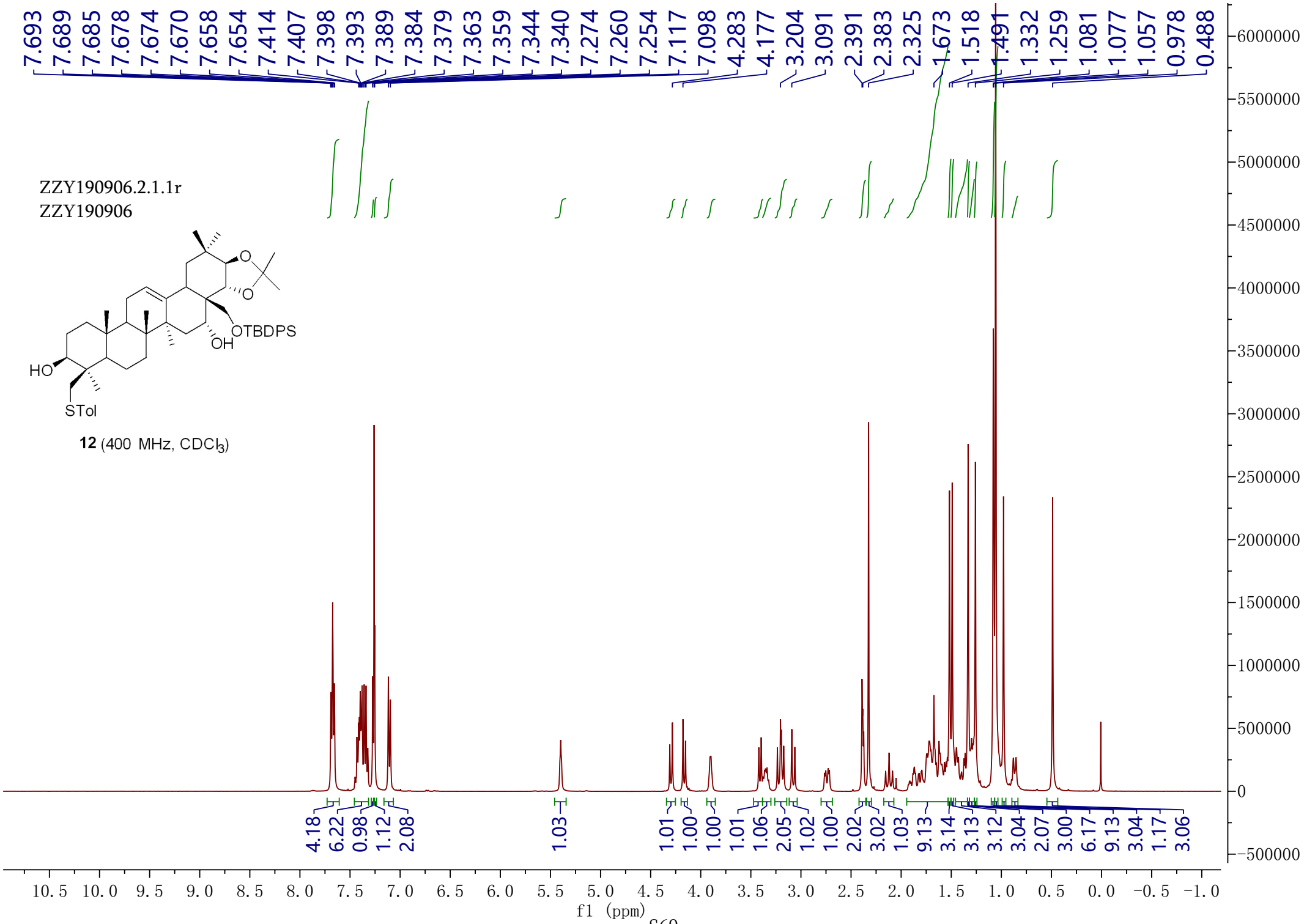

OH
CHO
CHO
AcO
OTBDPS
10 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

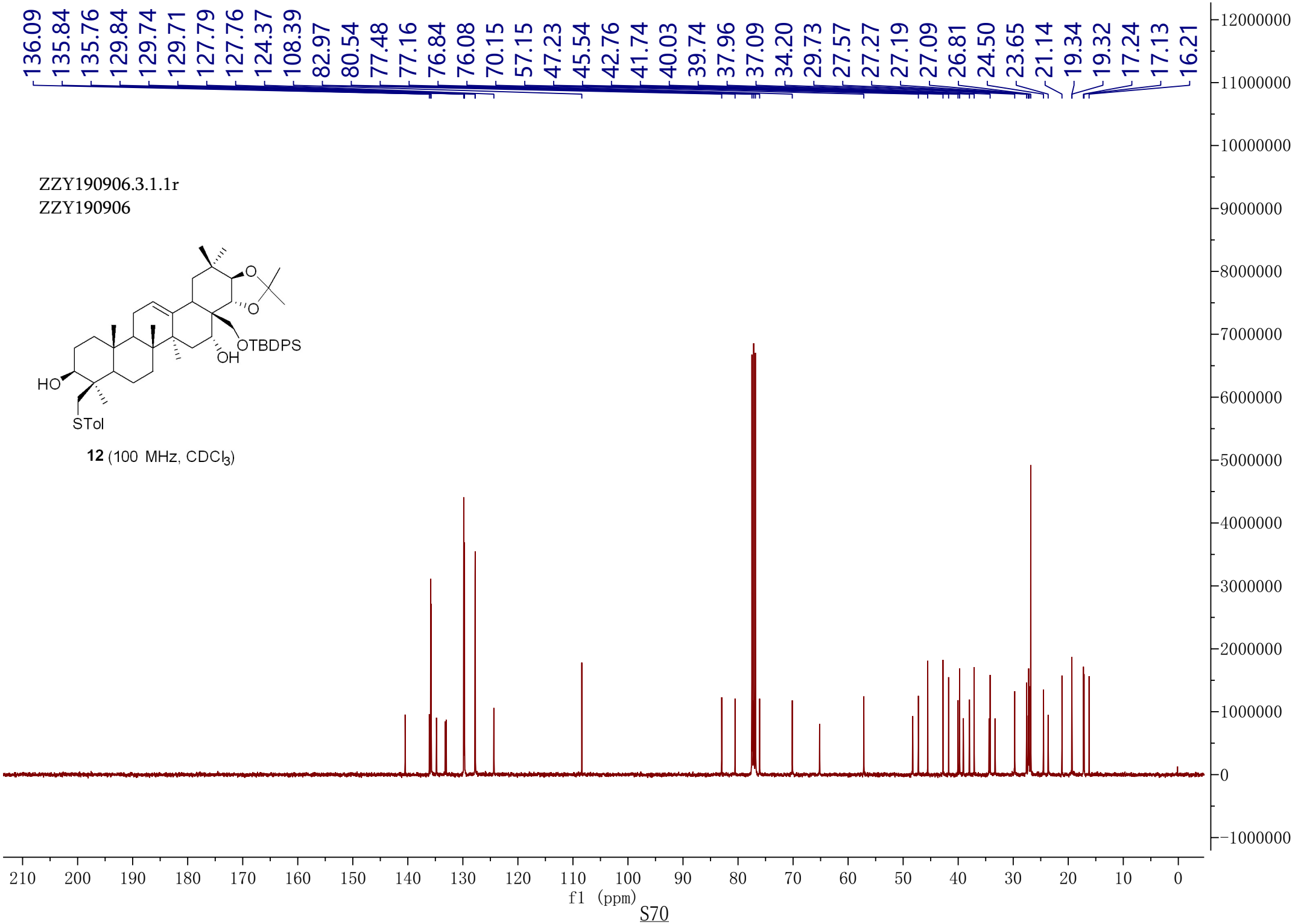


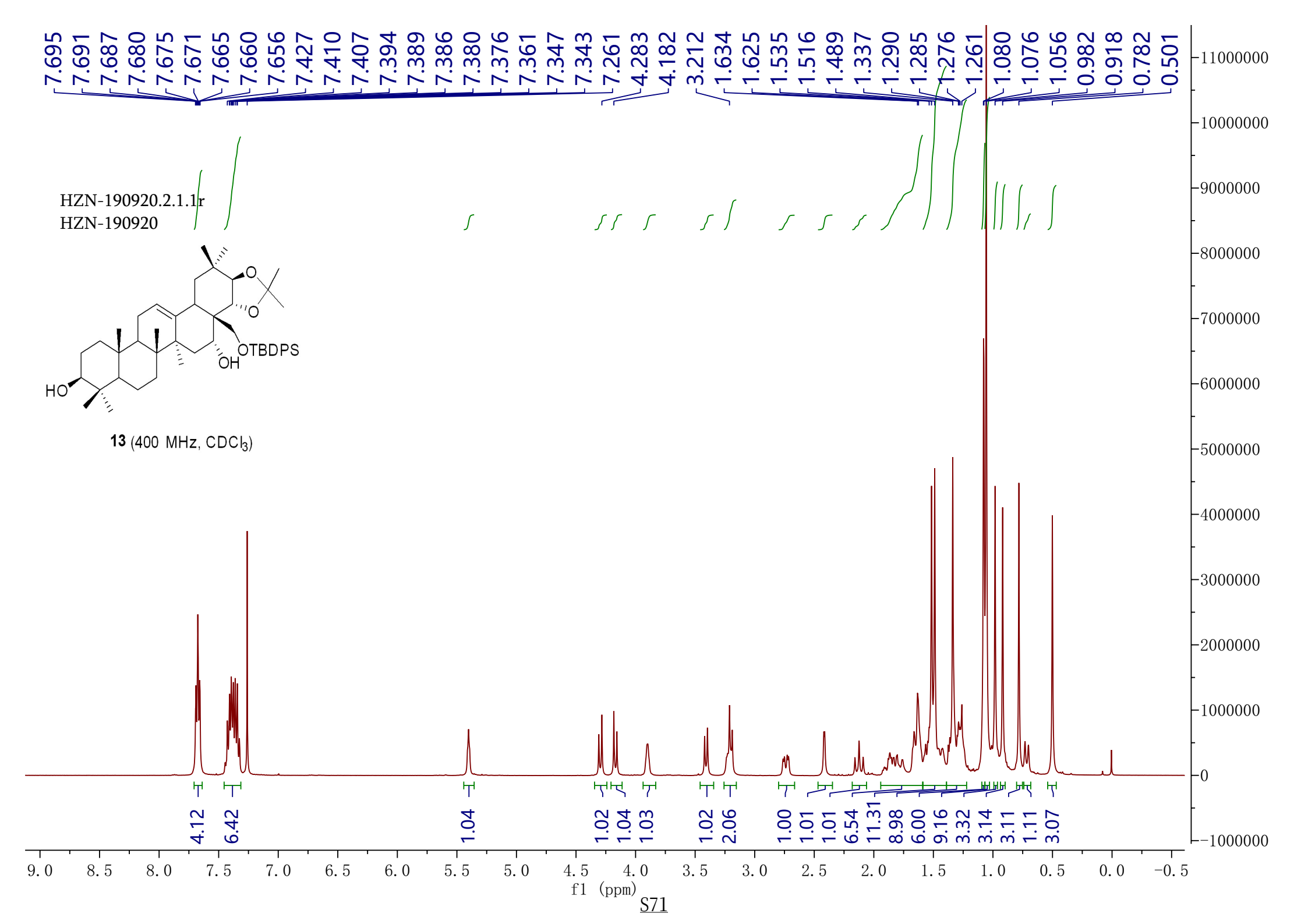
10 ($CDCl_3$, DEPT 135°)

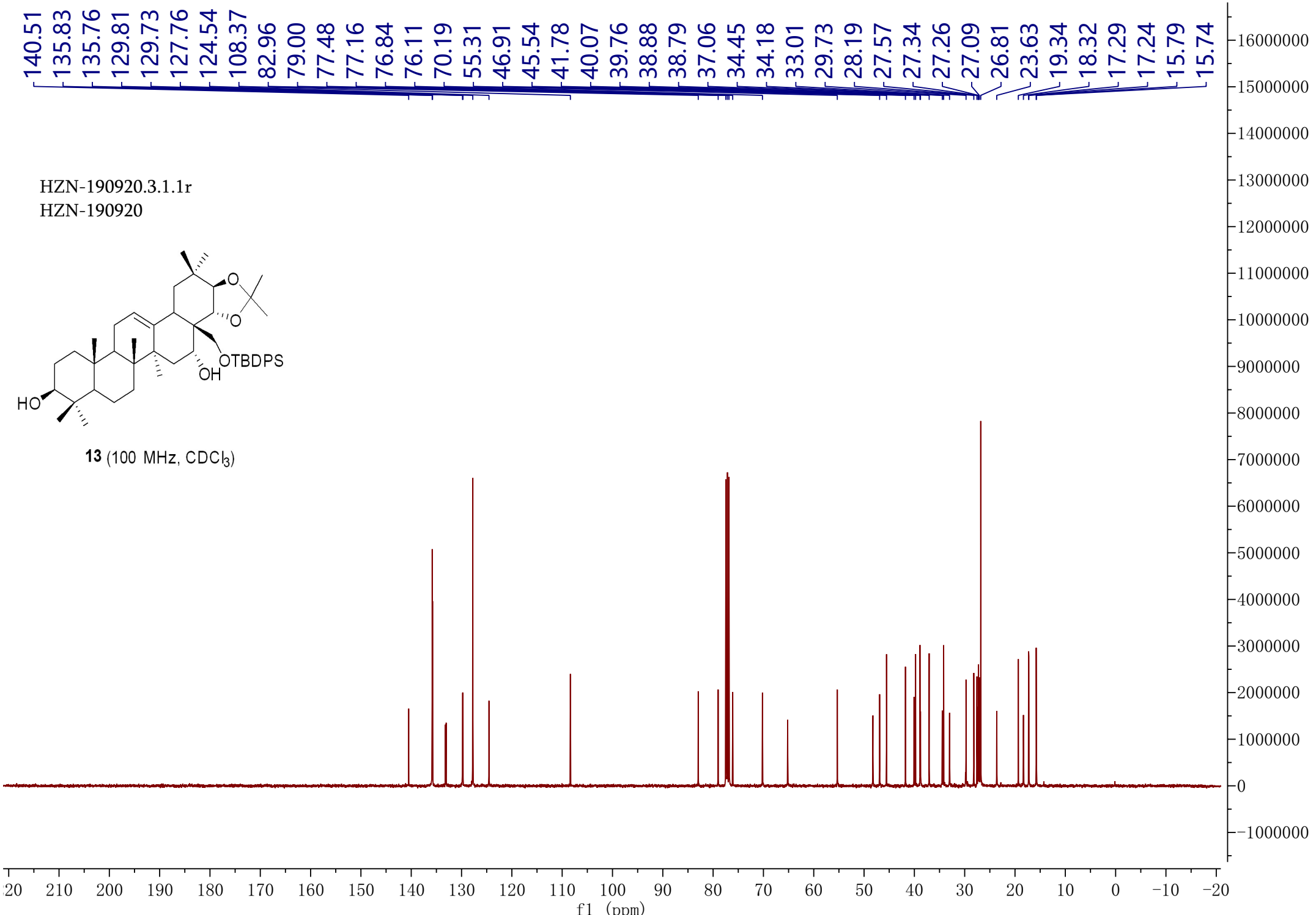

7.805
7.784
7.688
7.684
7.680
7.672
7.668
7.664
7.657
7.652
7.648
7.422
7.417
7.404
7.399
7.384
7.380
7.364
7.358
7.348
7.345
7.337
7.328
7.260
4.268
4.209
4.161
4.127
2.450
1.629
1.621
1.506
1.479
1.300
1.261
1.254
1.066
1.059
1.050
0.810
0.449
ZZY190904-2.1.1.1r
ZZY190904-2
HO
OTs
OH
OTBDPS
O
O
11 (400 MHz, CDCl3)
2.10
4.05
8.11
1.04
1.00
1.01
2.03
1.01
1.00
1.02
1.01
0.99
3.07
1.04
1.08
8.92
3.15
3.04
10.47
18.14
1.84
3.12
3.02
f1 (ppm)

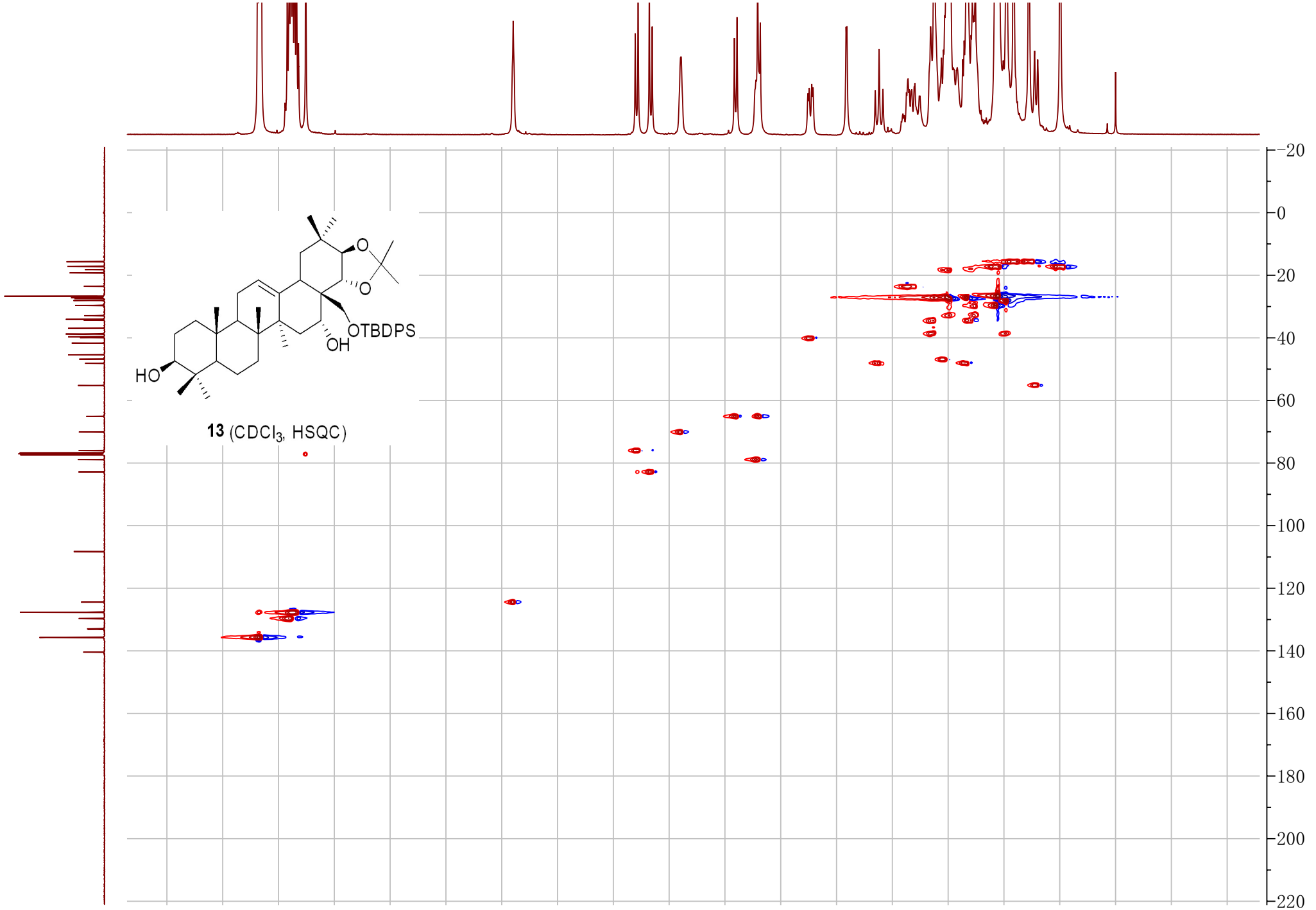

144.86
135.83
135.76
133.20
133.00
129.93
129.84
129.77
128.10
127.80
127.76
124.26
108.39
82.96
78.68
77.48
77.16
76.84
76.06
70.08
55.72
47.03
45.53
42.42
41.71
39.98
39.65
36.87
34.18
29.71
27.56
27.10
27.08
27.05
26.81
22.41
21.80
19.34
17.23
17.01
15.61
ZZY190904-2.2.1.1r
ZZY190904-2
O
O
OTBDPS
OH
HO
OTs
11 (100 MHz, CDCl3)
7000000
6500000
6000000
5500000
5000000
4500000
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
−500000
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)

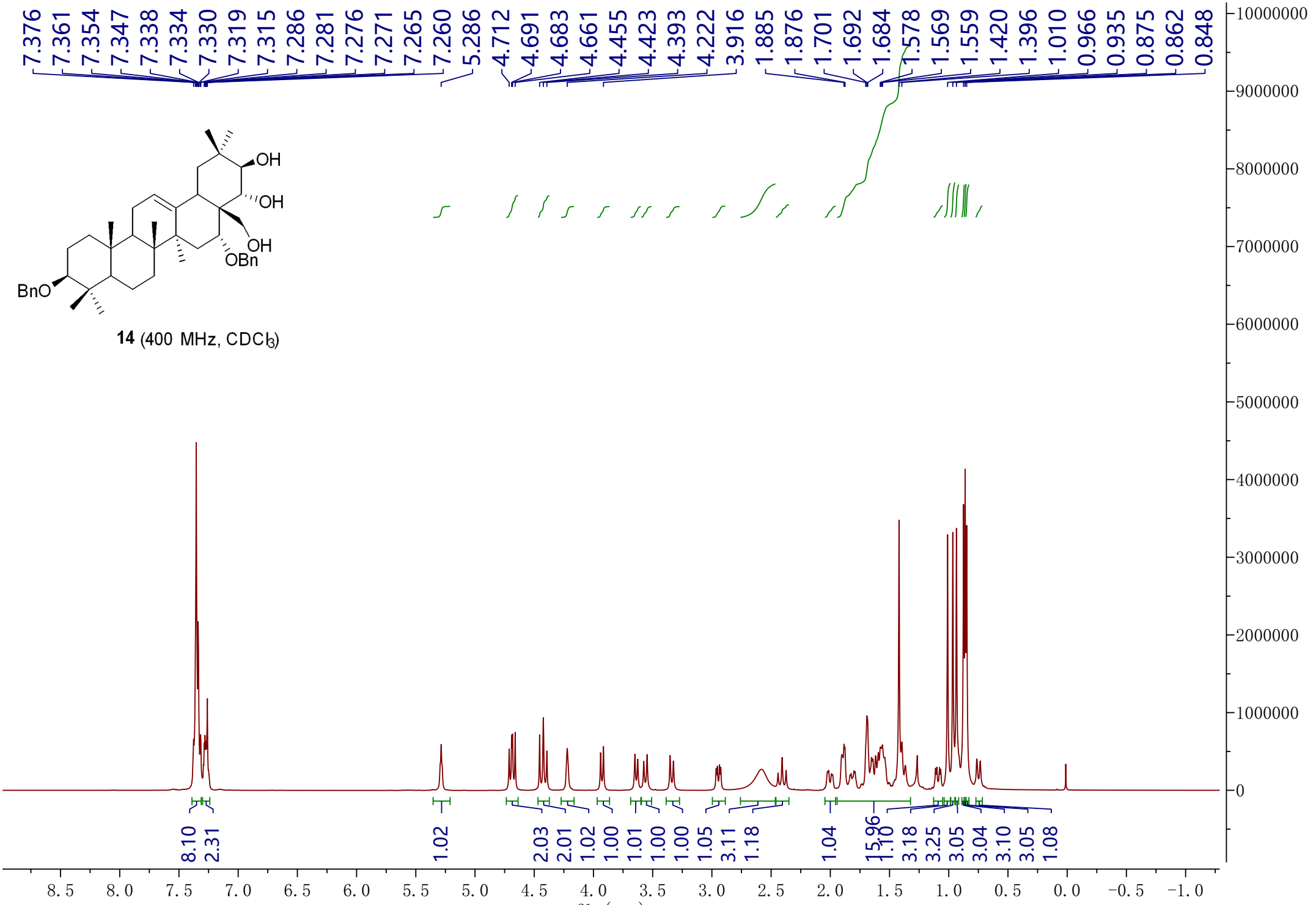

7.693
7.689
7.685
7.678
7.674
7.670
7.658
7.654
7.414
7.407
7.398
7.393
7.389
7.384
7.379
7.363
7.359
7.344
7.340
7.274
7.260
7.254
7.117
7.098
4.283
4.177
3.204
3.091
2.391
2.383
2.325
1.673
1.518
1.491
1.332
1.259
1.081
1.077
1.057
0.978
0.488
ZZY190906.2.1.1r
ZZY190906
OTBDPS
OH
HO
STol
12 (400 MHz, CDCl3)
4.18
6.22
0.98
1.12
2.08
1.03
1.01
1.00
1.00
1.01
1.06
2.05
1.02
1.00
2.02
3.02
1.03
9.13
3.14
3.13
3.12
3.04
2.07
3.00
6.17
9.13
3.04
1.17
3.06
f1 (ppm)

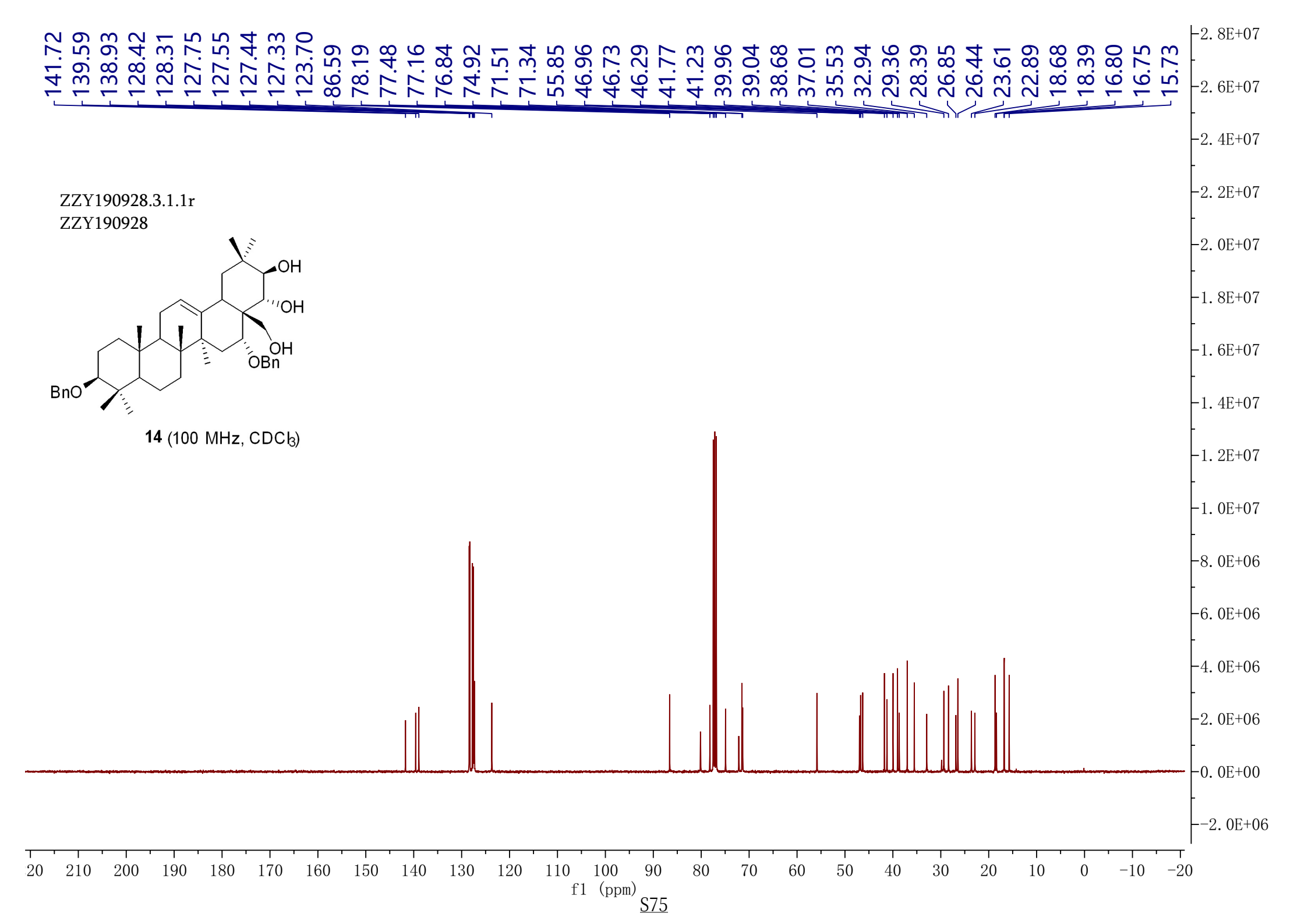

136.09
135.84
135.76
129.84
129.74
129.71
127.79
127.76
124.37
108.39
82.97
80.54
77.48
77.16
76.84
76.08
70.15
57.15
47.23
45.54
42.76
41.74
40.03
39.74
37.96
37.09
34.20
29.73
27.57
27.27
27.19
27.09
26.81
24.50
23.65
21.14
19.34
19.32
17.24
17.13
16.21
ZZY190906.3.1.1r
ZZY190906
HO
STol
OH
OTBDPS
O
O
12 (100 MHz, CDCl3)
f1 (ppm)

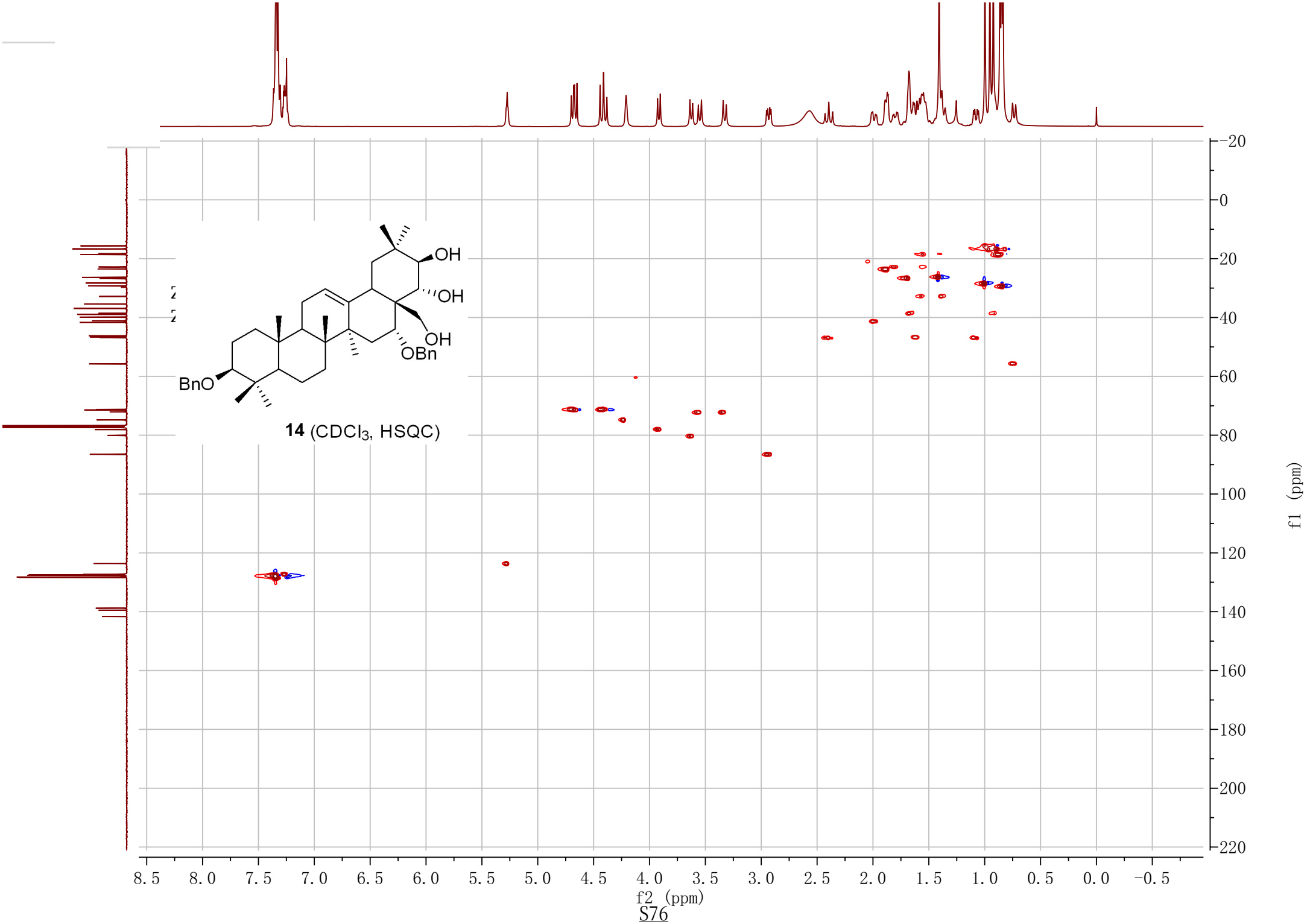

HZN-190920.2.1.1r
HZN-190920
HO
OH
OTBDPS
O
O
13 (400 MHz, CDCl3)
f1 (ppm)

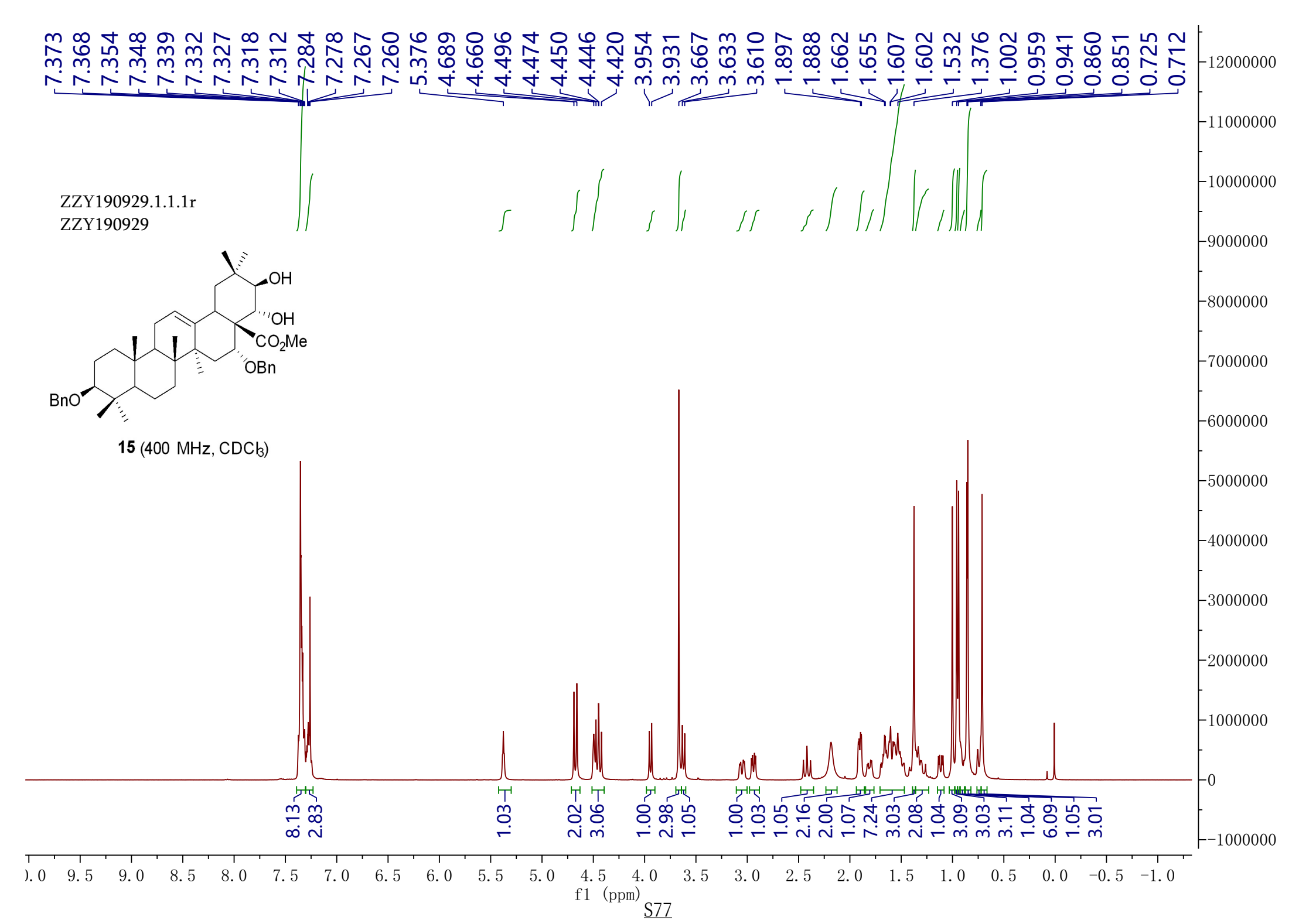

140.51
135.83
135.76
129.81
129.73
127.76
124.54
108.37
82.96
79.00
77.48
77.16
76.84
76.11
70.19
55.31
46.91
45.54
41.78
40.07
39.76
38.88
38.79
37.06
34.45
34.18
33.01
29.73
28.19
27.57
27.34
27.26
27.09
26.81
23.63
19.34
18.32
17.29
17.24
15.79
15.74
HZN-190920.3.1.1r
HZN-190920
HO
OH
OTBDPS
O
O
13 (100 MHz, CDCl3)
f1 (ppm)

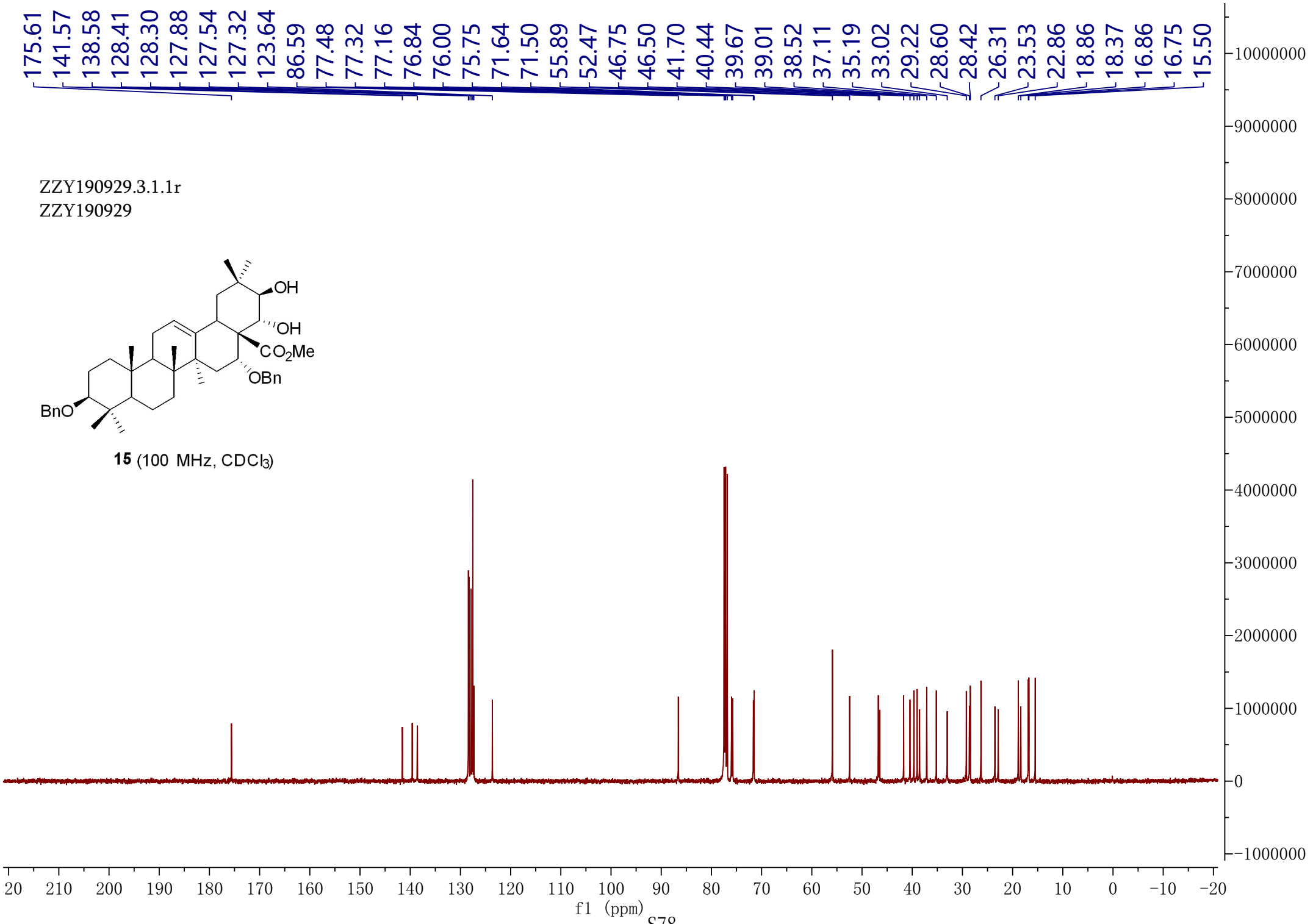

HO
OH
OTBDPS
O
O
13 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-20
0
20
40
60
80
100
120
140
160
180
200
220

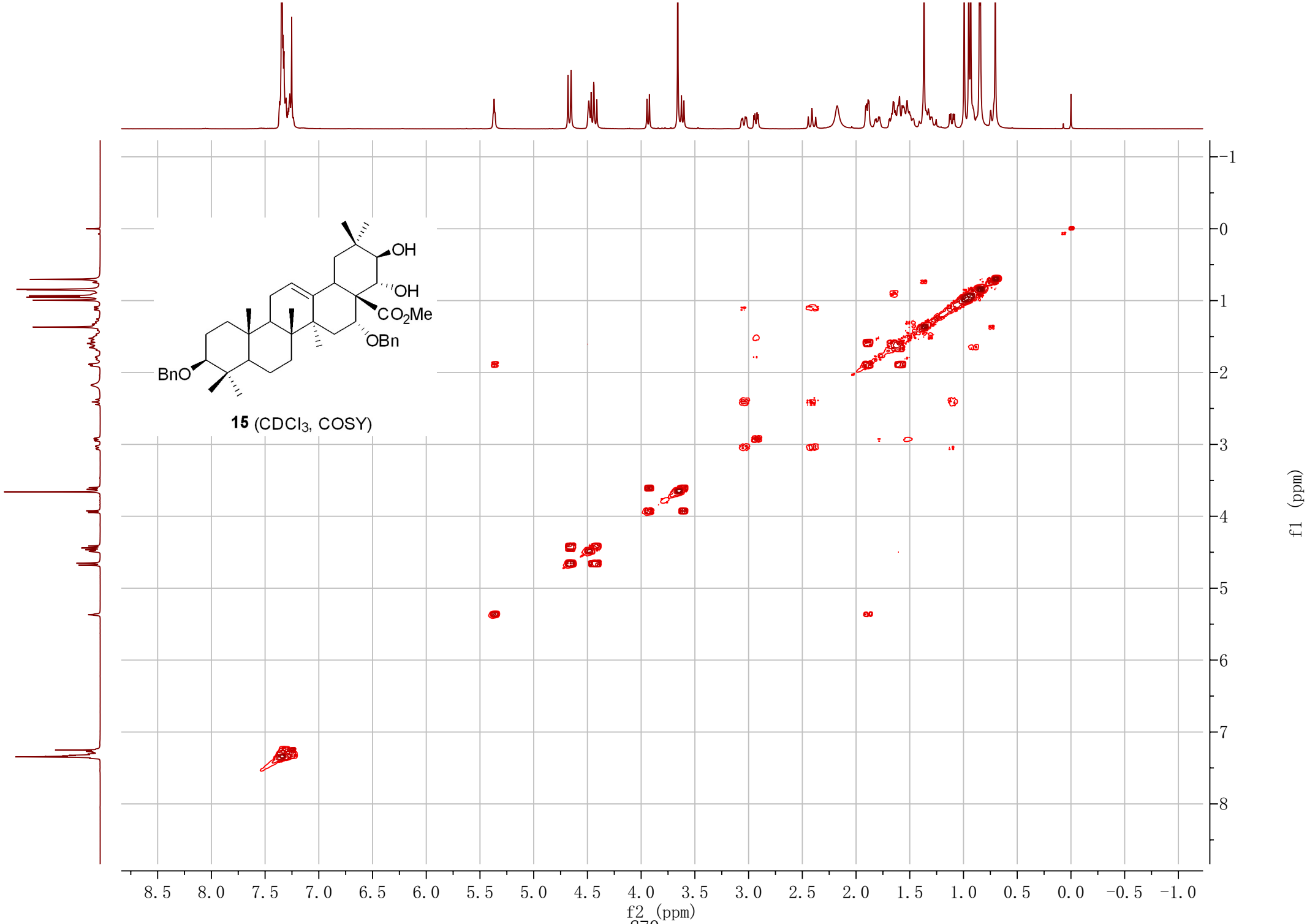

7.376
7.361
7.354
7.347
7.338
7.334
7.330
7.319
7.315
7.286
7.281
7.276
7.271
7.265
7.260
5.286
4.712
4.691
4.683
4.661
4.455
4.423
4.393
4.222
3.916
1.885
1.876
1.701
1.692
1.684
1.578
1.569
1.559
1.420
1.396
1.010
0.966
0.935
0.875
0.862
0.848
OH
OH
OH
OBn
BnO
14 (400 MHz, CDCl3)
8.10
2.31
1.02
2.03
2.01
1.02
1.00
1.01
1.00
1.00
1.05
3.11
1.18
1.04
15.96
1.10
3.18
3.25
3.05
3.04
3.10
3.05
1.08
f1 (ppm)

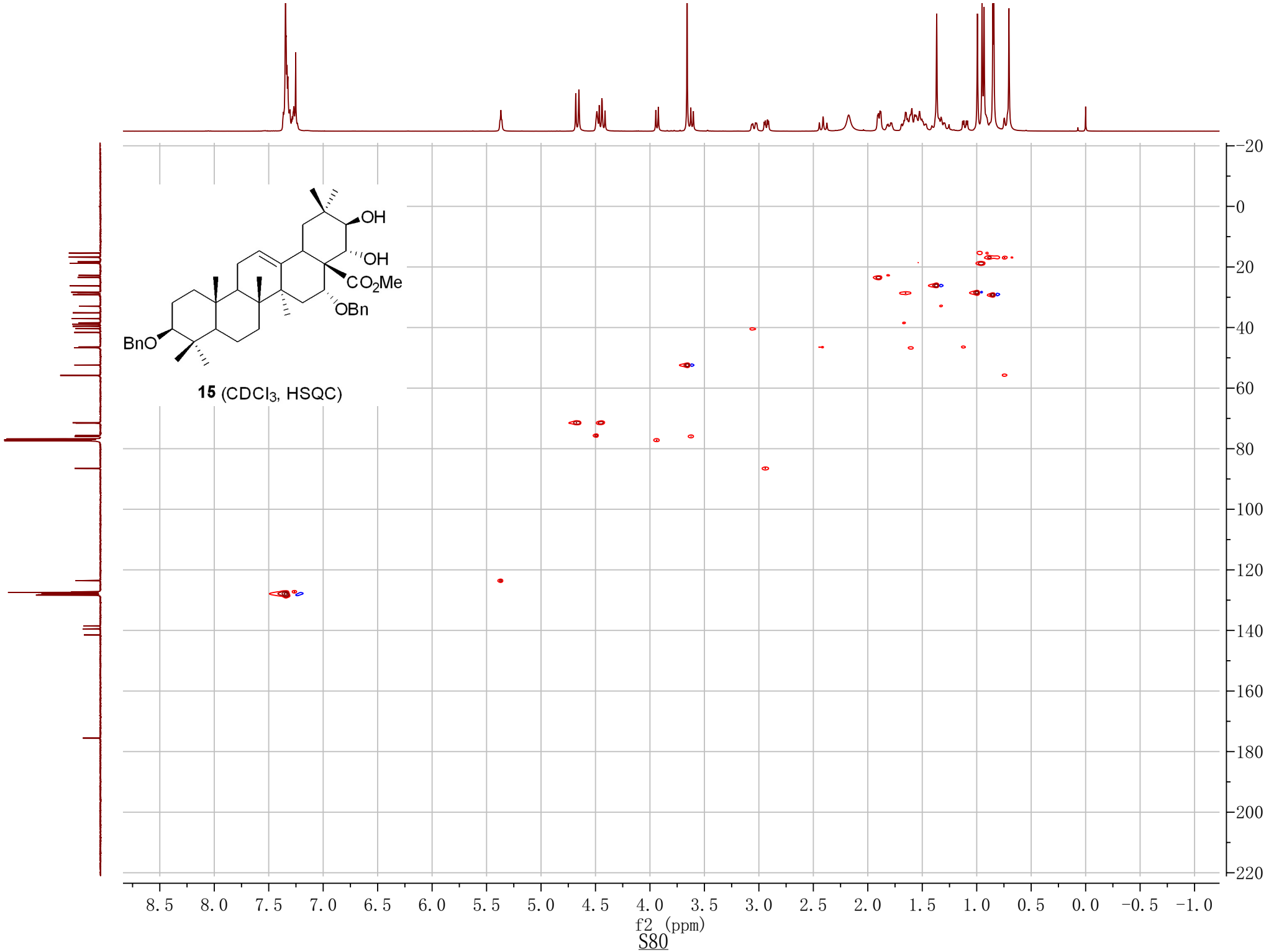

141.72
139.59
138.93
128.42
128.31
127.75
127.55
127.44
127.33
123.70
86.59
78.19
77.48
77.16
76.84
74.92
71.51
71.34
55.85
46.96
46.73
46.29
41.77
41.23
39.96
39.04
38.68
37.01
35.53
32.94
29.36
28.39
26.85
26.44
23.61
22.89
18.68
18.39
16.80
16.75
15.73
ZZY190928.3.1.1r
ZZY190928
OH
OH
OH
OBn
BnO
14 (100 MHz, CDCl3)
2.8E+07
2.6E+07
2.4E+07
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
20 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20
f1 (ppm)

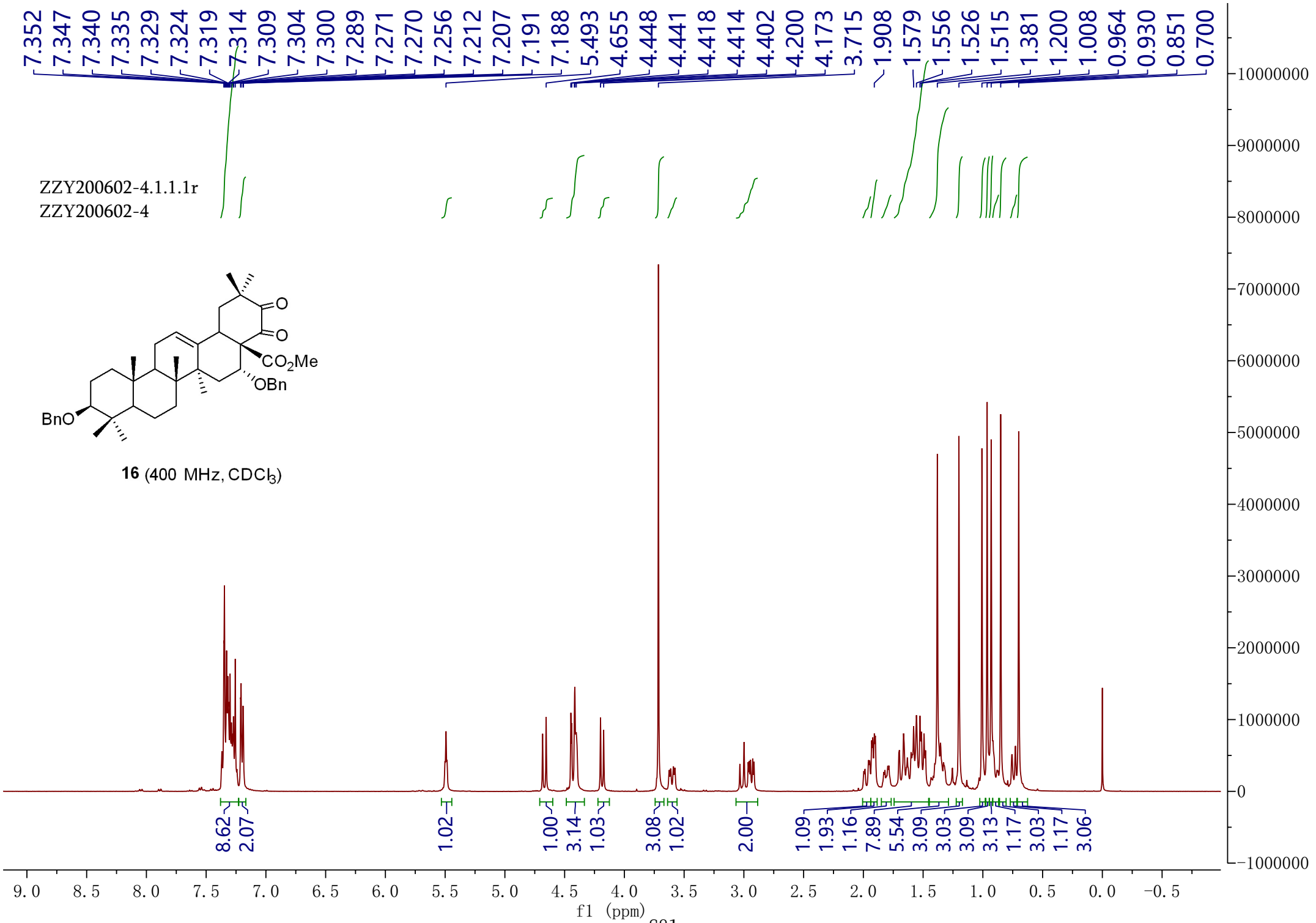

OH
OH
OH
OBn
BnO
14 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

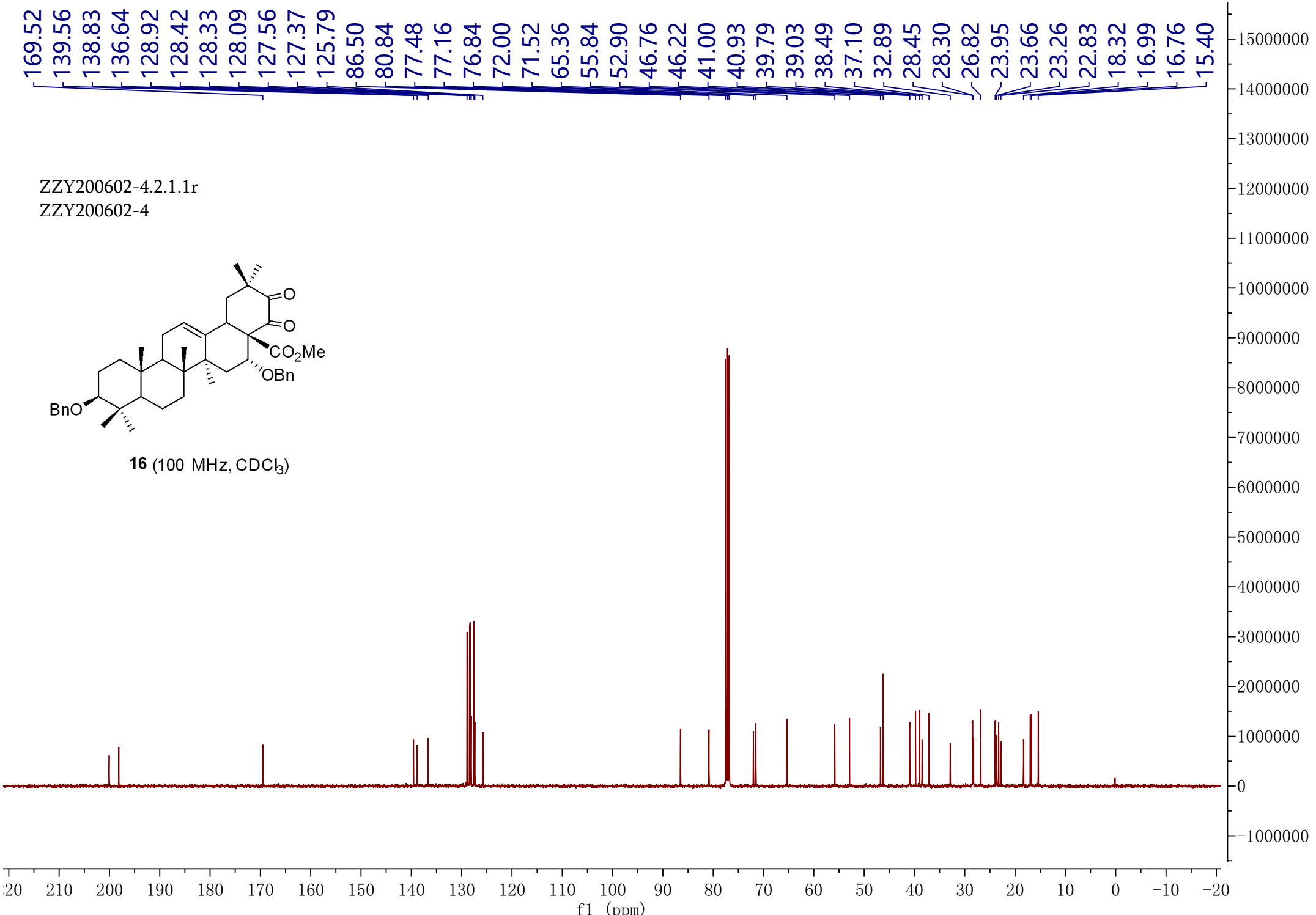

7.373
7.368
7.354
7.348
7.339
7.332
7.327
7.318
7.312
7.284
7.278
7.267
7.260
5.376
4.689
4.660
4.496
4.474
4.450
4.446
4.420
3.954
3.931
3.667
3.633
3.610
1.897
1.888
1.662
1.655
1.607
1.602
1.532
1.376
1.002
0.959
0.941
0.860
0.851
0.725
0.712
ZZY190929.1.1.1r
ZZY190929
OH
OH
CO2Me
OBn
BnO
15 (400 MHz, CDCl3)
8.13
2.83
1.03
2.02
3.06
1.00
2.98
1.05
1.00
1.03
1.05
2.16
2.00
1.07
7.24
3.03
2.08
1.04
3.09
3.03
3.11
1.04
6.09
1.05
3.01
f1 (ppm)

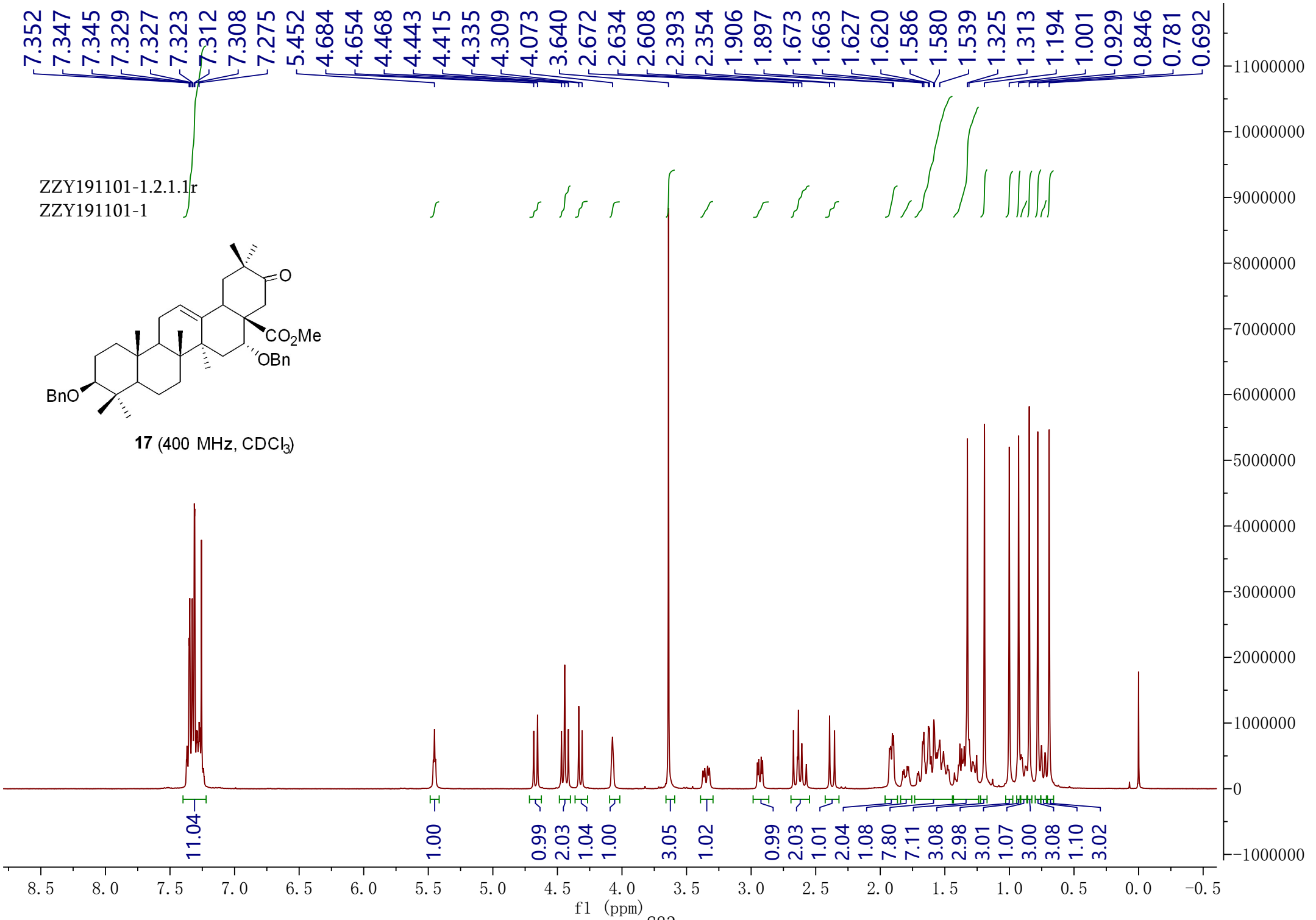

175.61
141.57
138.58
128.41
128.30
127.88
127.54
127.32
123.64
86.59
77.48
77.32
77.16
76.84
76.00
75.75
71.64
71.50
55.89
52.47
46.75
46.50
41.70
40.44
39.67
39.01
38.52
37.11
35.19
33.02
29.22
28.60
28.42
26.31
23.53
22.86
18.86
18.37
16.86
16.75
15.50
ZZY190929.3.1.1r
ZZY190929
OH
OH
CO2Me
OBn
BnO
15 (100 MHz, CDCl3)
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
20 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20
f1 (ppm)

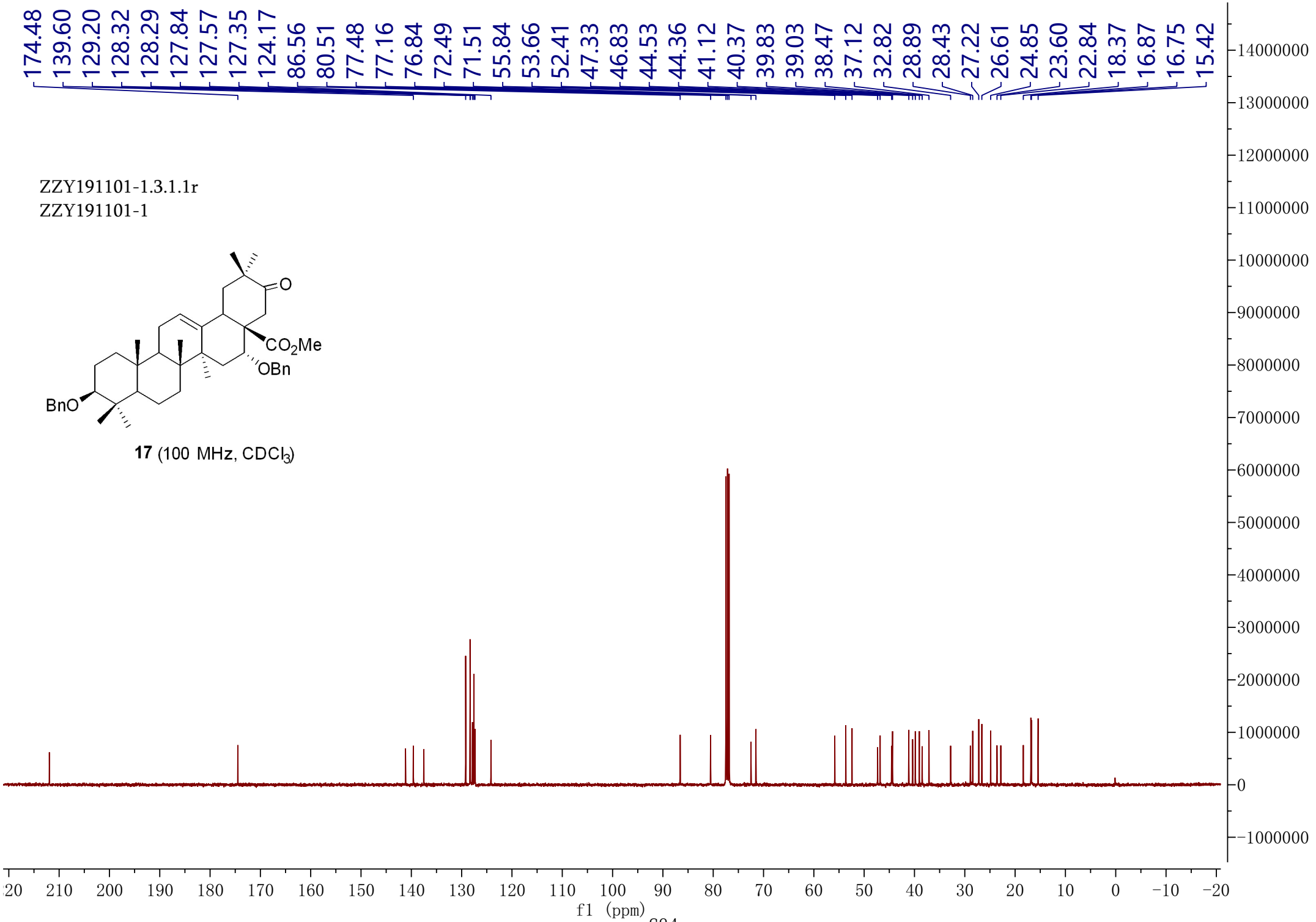

OH
OH
CO2Me
OBn
BnO
15 (CDCl3, COSY)
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f2 (ppm)
-1 0 1 2 3 4 5 6 7 8
f1 (ppm)

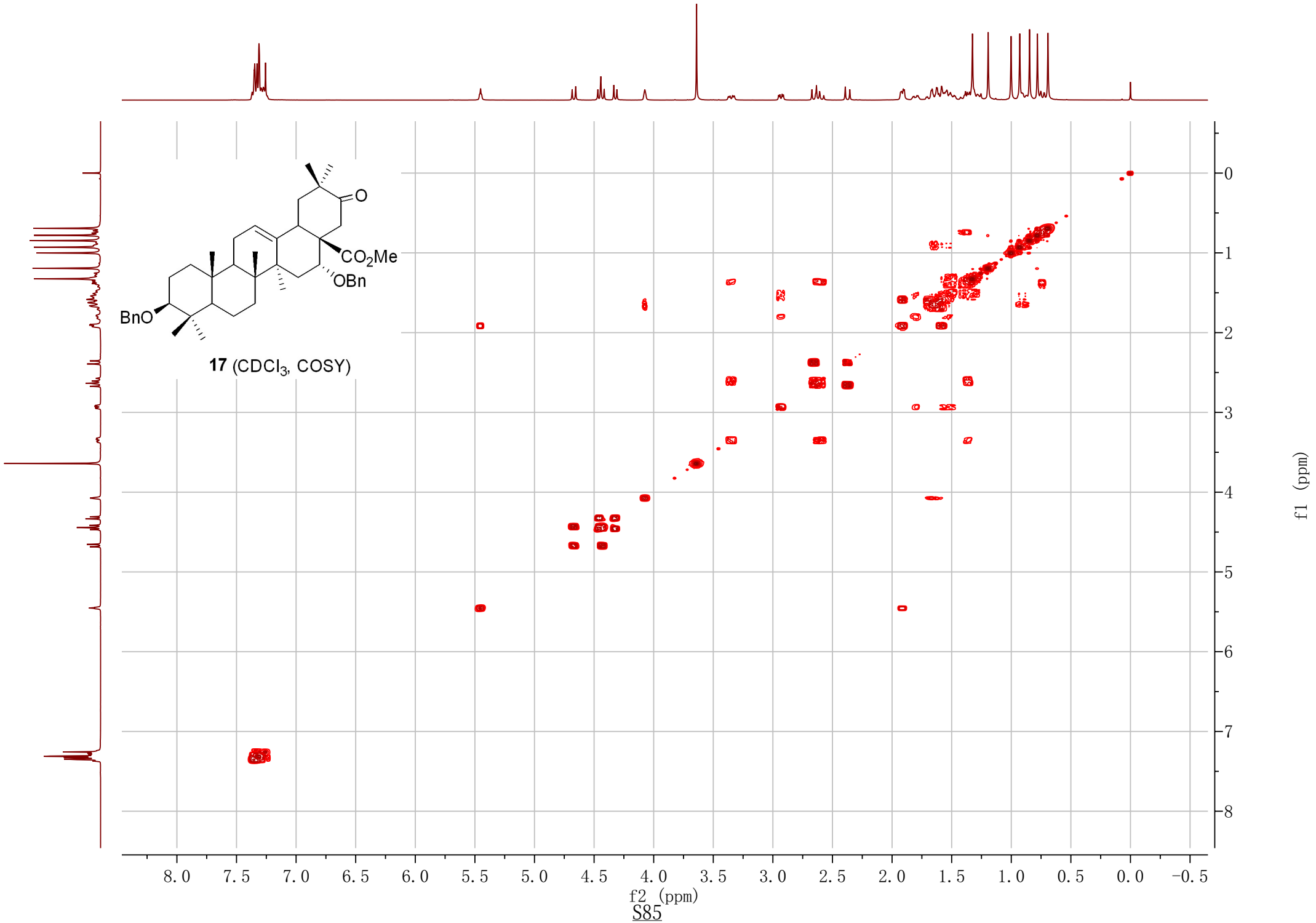

OH
OH
CO2Me
OBn
BnO
15 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

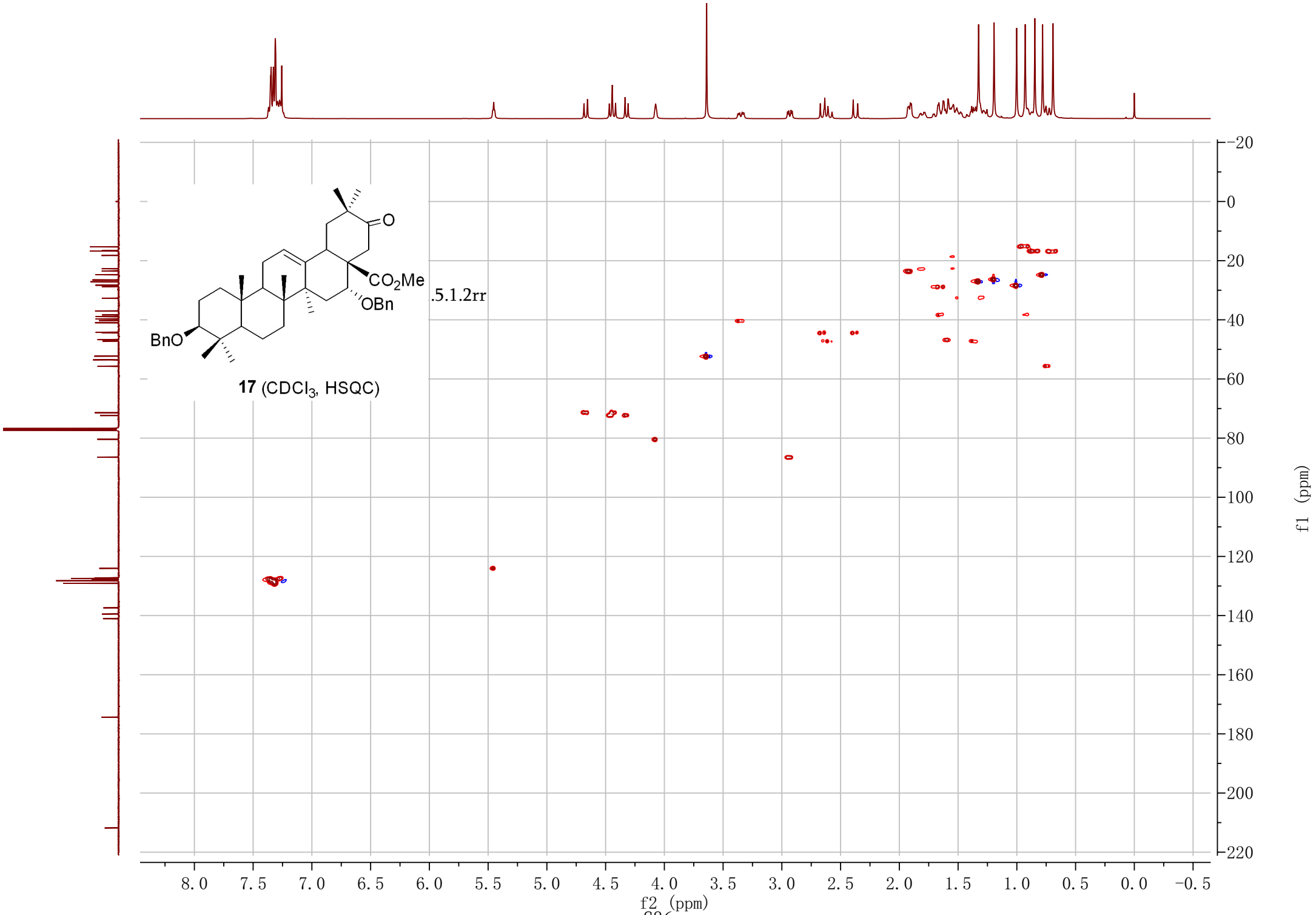

7.352
7.347
7.340
7.335
7.329
7.324
7.319
7.314
7.309
7.304
7.300
7.289
7.271
7.270
7.256
7.212
7.207
7.191
7.188
5.493
4.655
4.448
4.441
4.418
4.414
4.402
4.200
4.173
3.715
1.908
1.579
1.556
1.526
1.515
1.381
1.200
1.008
0.964
0.930
0.851
0.700
ZZY200602-4.1.1.1r
ZZY200602-4
O
O
CO2Me
OBn
BnO
16 (400 MHz, CDCl3)
8.62
2.07
1.02
1.00
3.14
1.03
3.08
1.02
2.00
1.09
1.93
1.16
7.89
5.54
3.09
3.03
3.09
3.13
1.17
3.03
1.17
3.06
f1 (ppm)

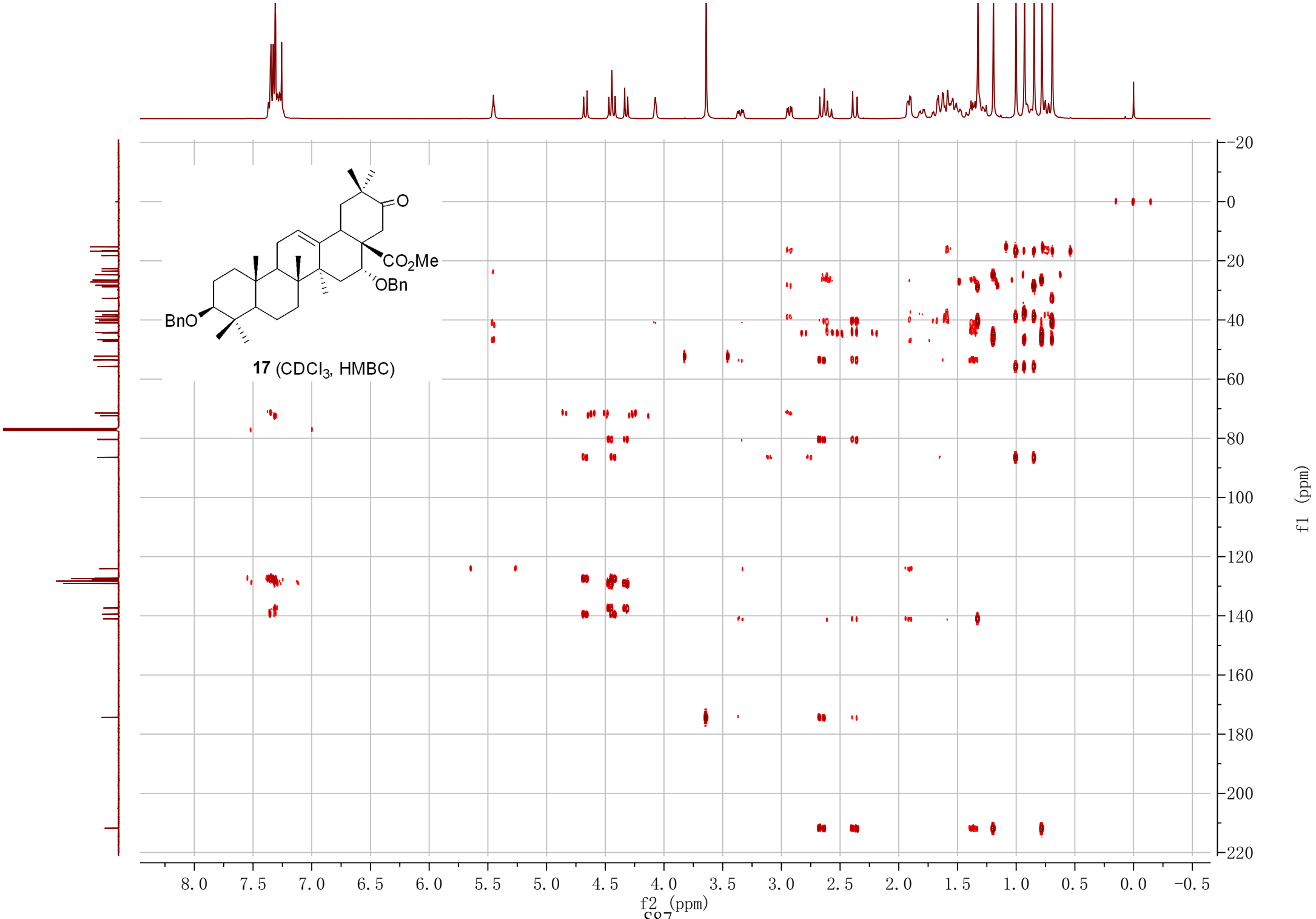

169.52
139.56
138.83
136.64
128.92
128.42
128.33
128.09
127.56
127.37
125.79
86.50
80.84
77.48
77.16
76.84
72.00
71.52
65.36
55.84
52.90
46.76
46.22
41.00
40.93
39.79
39.03
38.49
37.10
32.89
28.45
28.30
26.82
23.95
23.66
23.26
22.83
18.32
16.99
16.76
15.40
ZZY200602-4.2.1.1r
ZZY200602-4
O
O
CO2Me
OBn
BnO
16 (100 MHz, CDCl3)
15000000
14000000
13000000
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

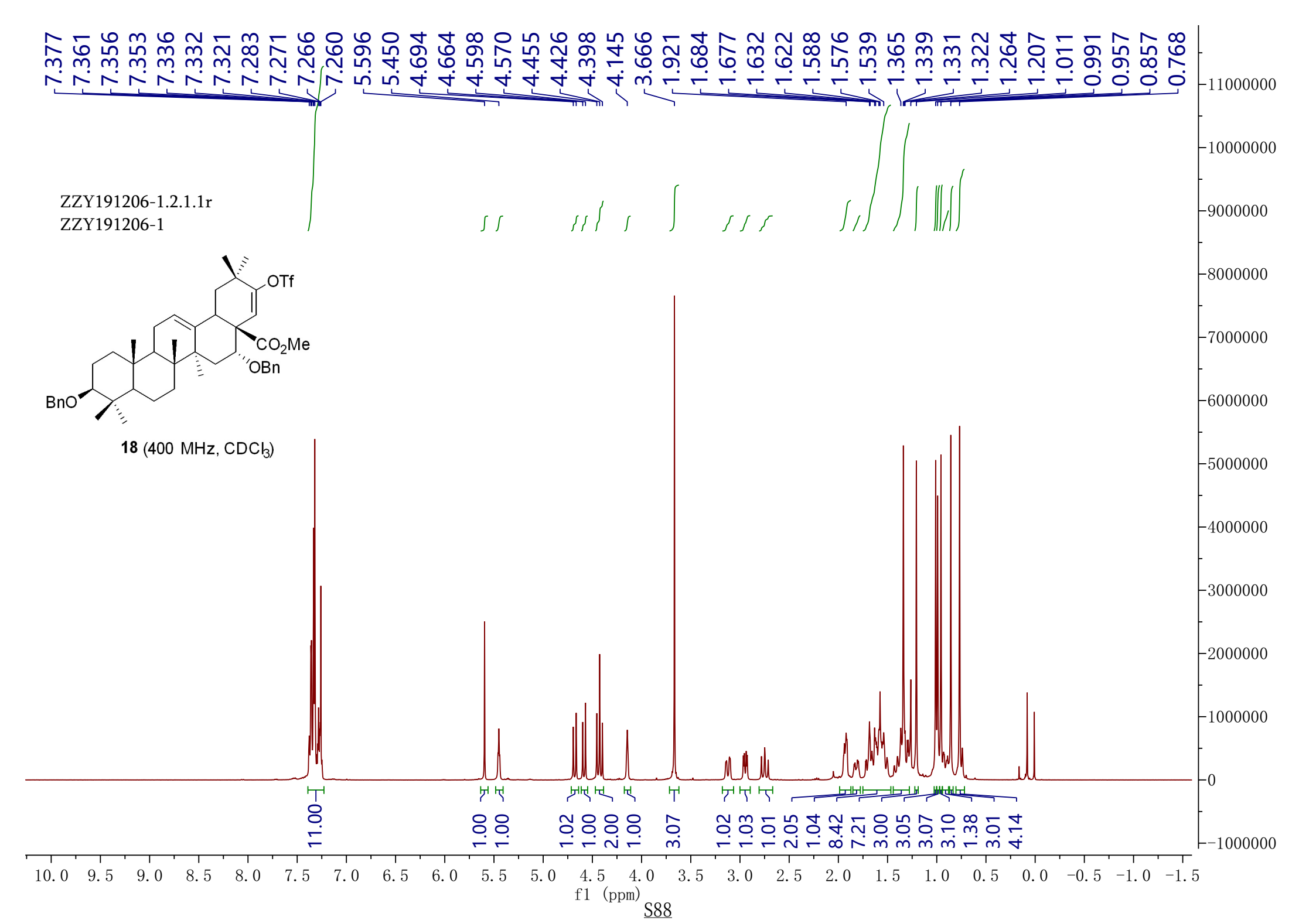

ZZY191101-1.2.1.1r
ZZY191101-1
O
CO2Me
OBn
BnO
17 (400 MHz, CDCl3)
f1 (ppm)

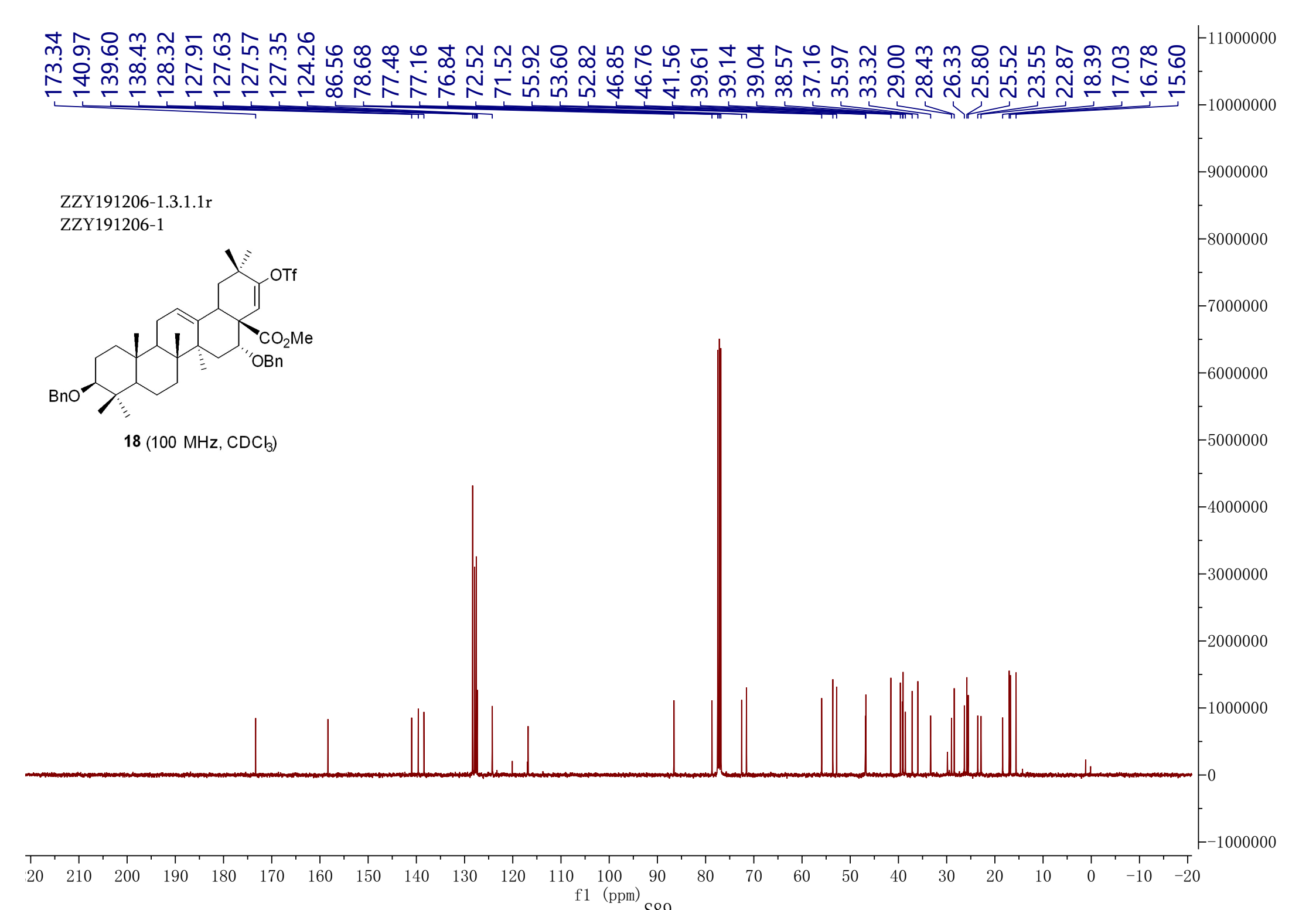

174.48
139.60
129.20
128.32
128.29
127.84
127.57
127.35
124.17
86.56
80.51
77.48
77.16
76.84
72.49
71.51
55.84
53.66
52.41
47.33
46.83
44.53
44.36
41.12
40.37
39.83
39.03
38.47
37.12
32.82
28.89
28.43
27.22
26.61
24.85
23.60
22.84
18.37
16.87
16.75
15.42
ZZY191101-1.3.1.1r
ZZY191101-1
O
CO2Me
OBn
BnO
17 (100 MHz, CDCl3)
14000000
13000000
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

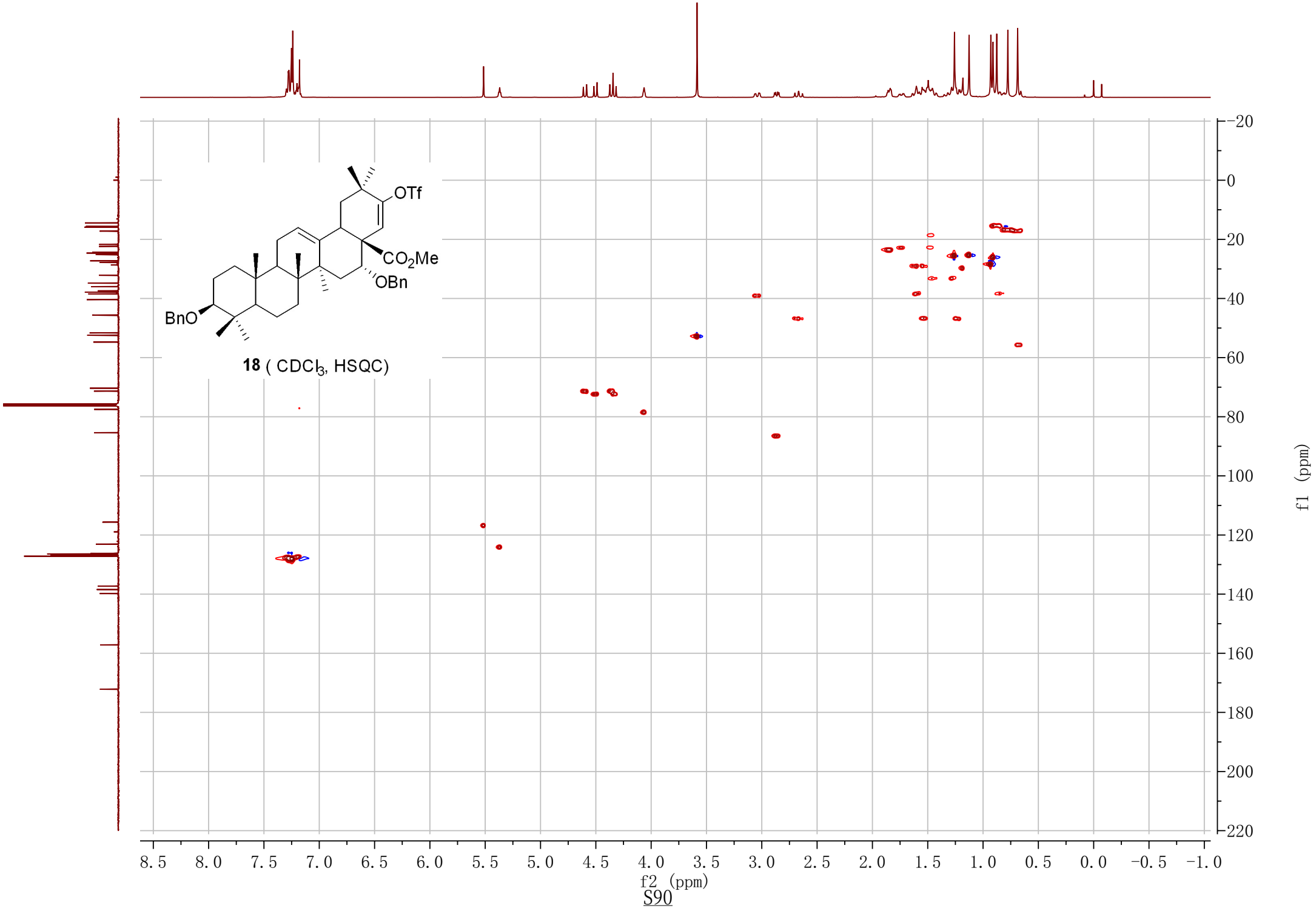

O
CO2Me
OBn
BnO
17 (CDCl3, COSY)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f2 (ppm)
0
1
2
3
4
5
6
7
8
f1 (ppm)

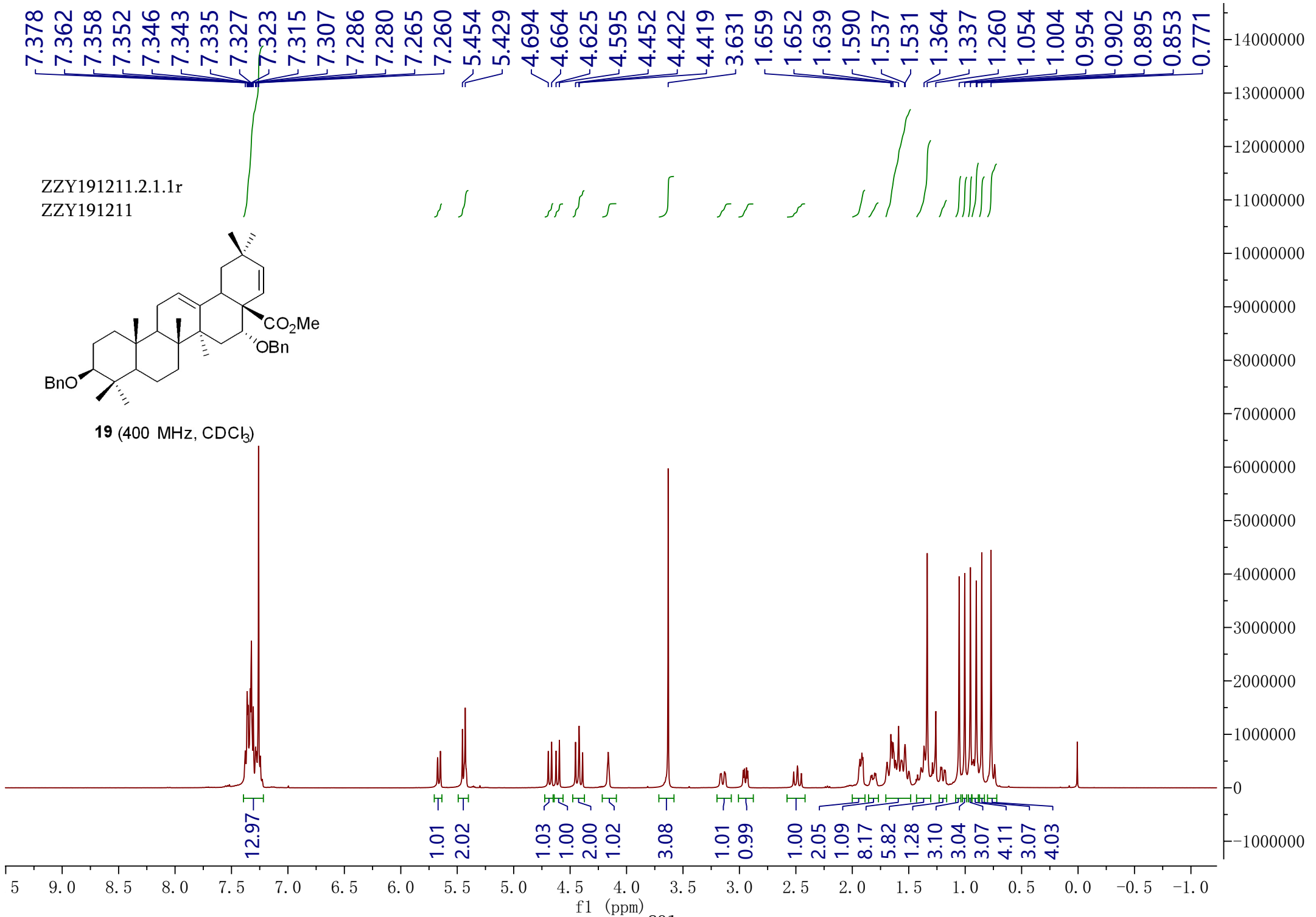

O
CO2Me
OBn
BnO
.5.1.2rr
17 (CDCl3, HSQC)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f2 (ppm)
-20
0
20
40
60
80
100
120
140
160
180
200
220
f1 (ppm)

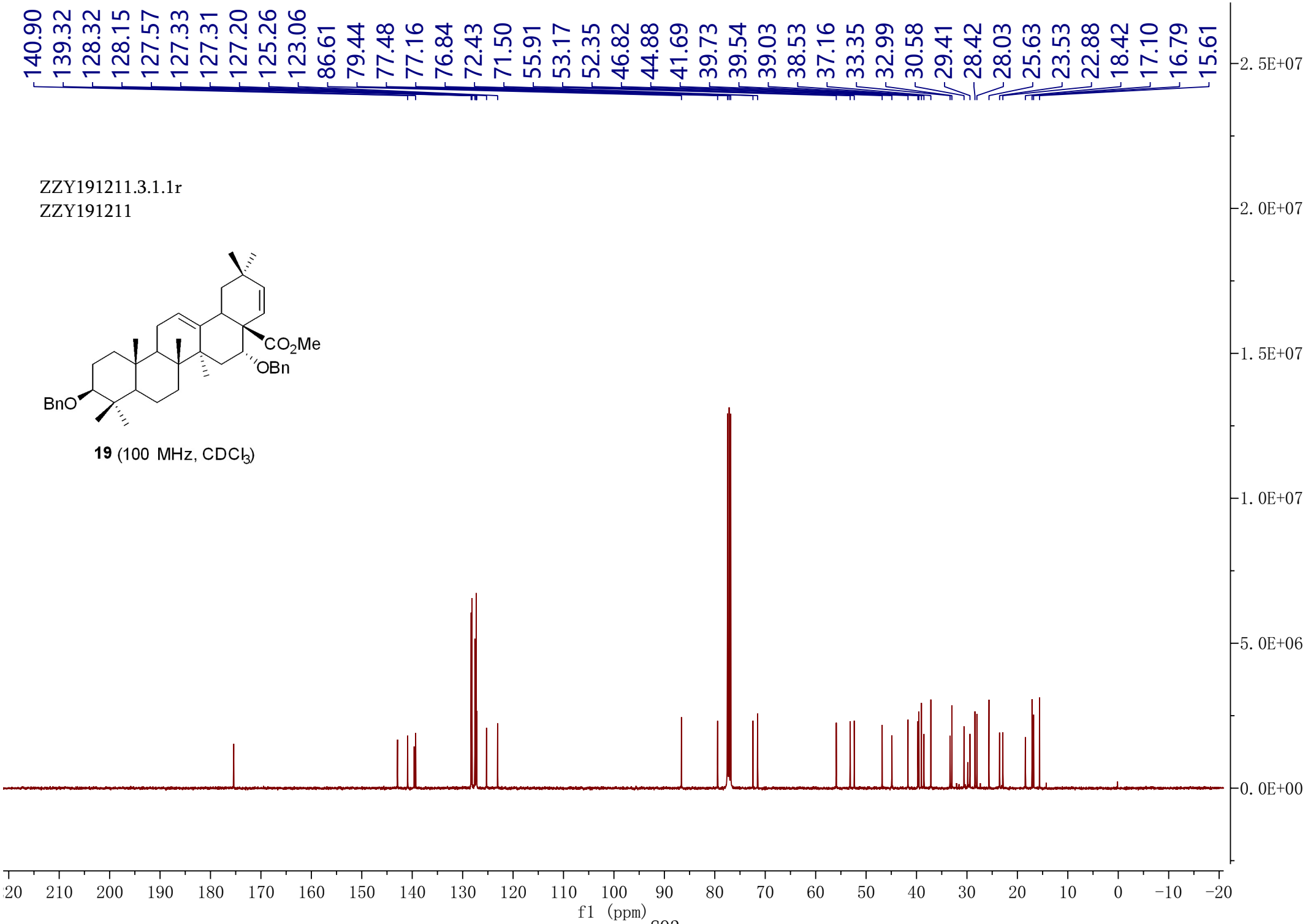

O
CO2Me
OBn
BnO
17 (CDCl3, HMBC)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f2 (ppm)
-20
0
20
40
60
80
100
120
140
160
180
200
220
f1 (ppm)

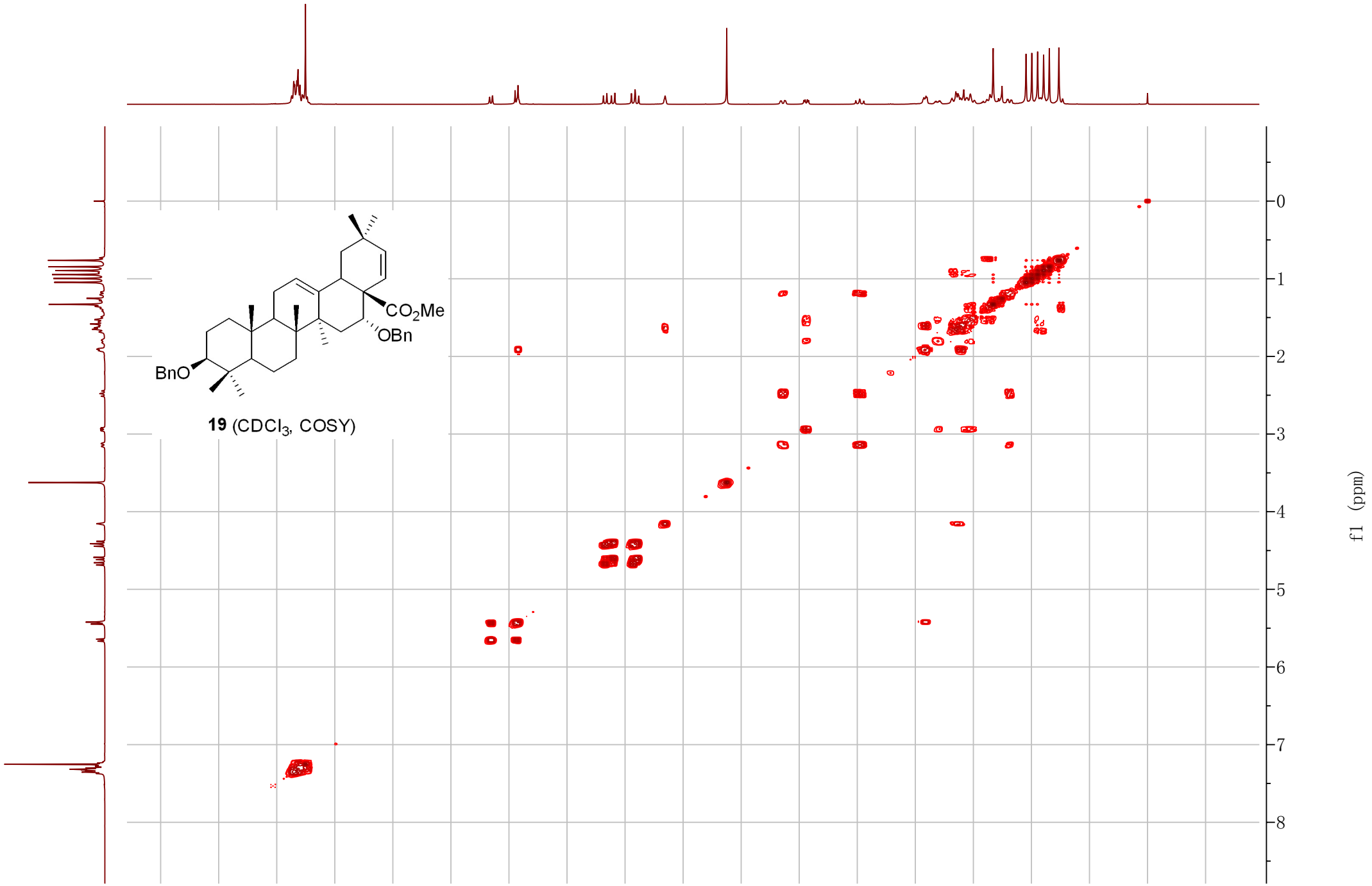

ZZY191206-1.2.1.1r
ZZY191206-1
OTf
CO2Me
OBn
BnO
18 (400 MHz, CDCl3)
f1 (ppm)

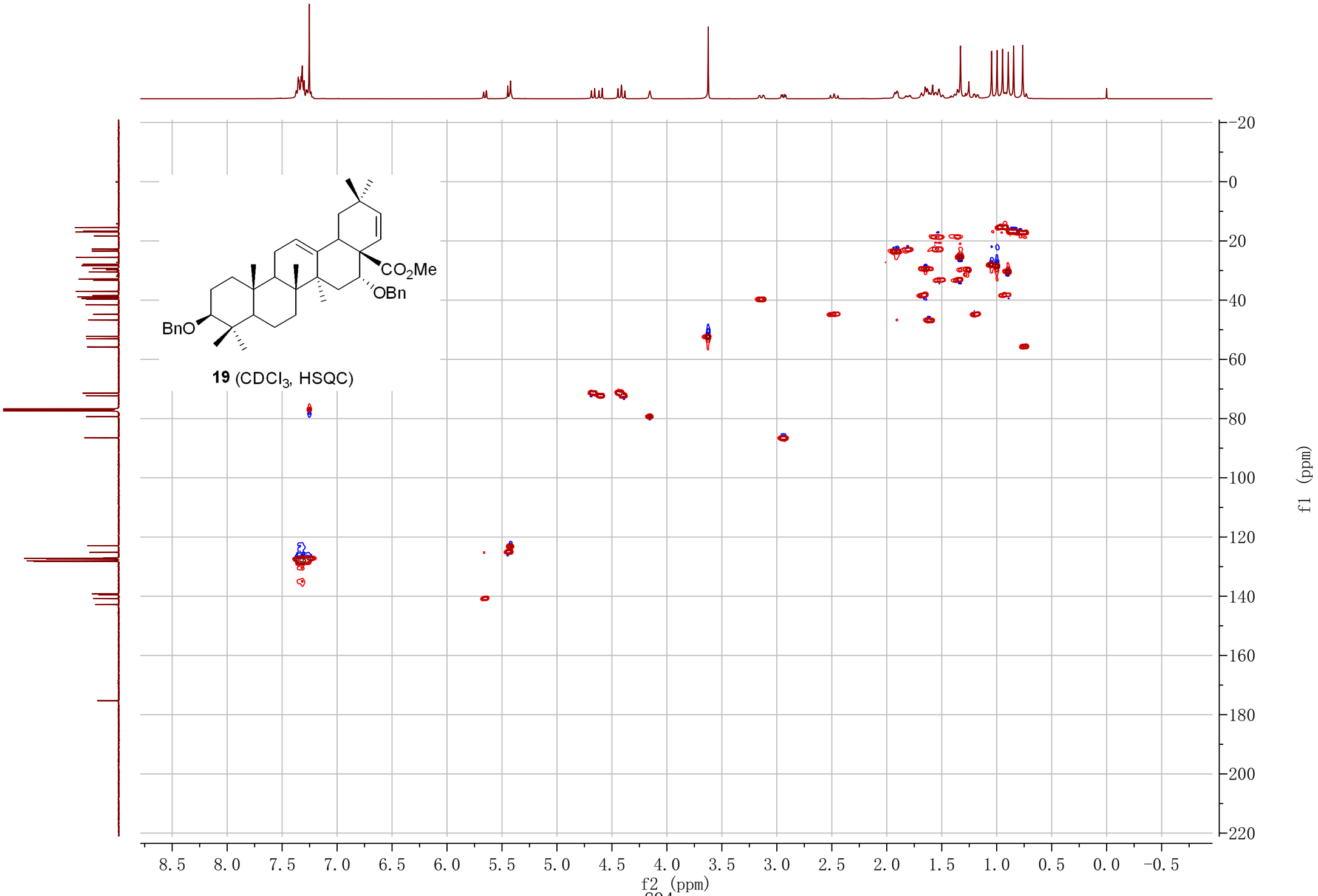

173.34
140.97
139.60
138.43
128.32
127.91
127.63
127.57
127.35
124.26
86.56
78.68
77.48
77.16
76.84
72.52
71.52
55.92
53.60
52.82
46.85
46.76
41.56
39.61
39.14
39.04
38.57
37.16
35.97
33.32
29.00
28.43
26.33
25.80
25.52
23.55
22.87
18.39
17.03
16.78
15.60
ZZY191206-1.3.1.1r
ZZY191206-1
OTf
CO2Me
OBn
BnO
18 (100 MHz, CDCl3)
f1 (ppm)

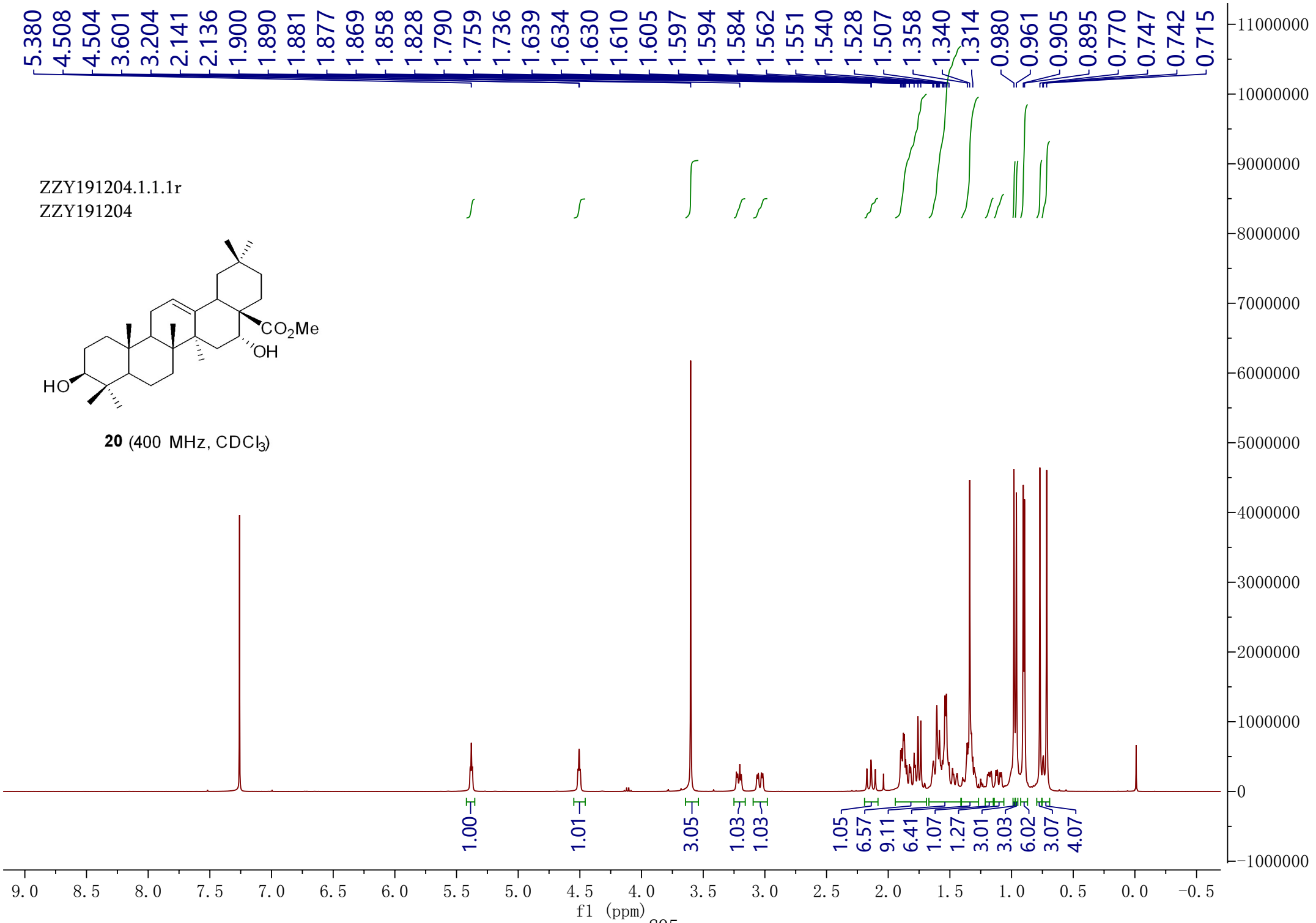

OTf
CO2Me
OBn
BnO
18 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

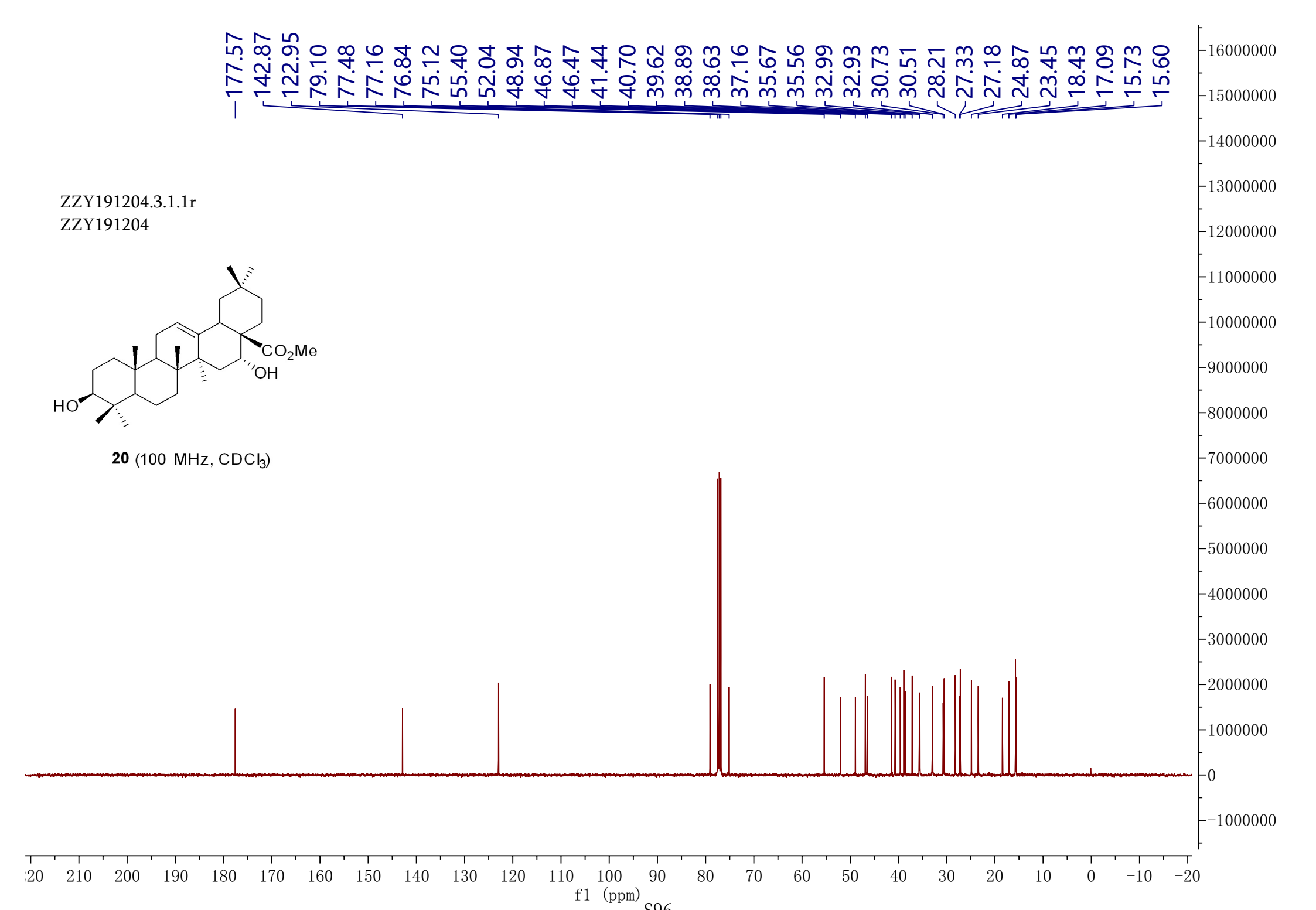

7.378
7.362
7.358
7.352
7.346
7.343
7.335
7.327
7.323
7.315
7.307
7.286
7.280
7.265
7.260
5.454
5.429
4.694
4.664
4.625
4.595
4.452
4.422
4.419
3.631
1.659
1.652
1.639
1.590
1.537
1.531
1.364
1.337
1.260
1.054
1.004
0.954
0.902
0.895
0.853
0.771
ZZY191211.2.1.1r
ZZY191211
CO2Me
OBn
BnO
19 (400 MHz, CDCl3)
12.97
1.01
2.02
1.03
1.00
2.00
1.02
3.08
1.01
0.99
1.00
2.05
1.09
8.17
5.82
1.28
3.10
3.04
3.07
4.11
3.07
4.03
f1 (ppm)

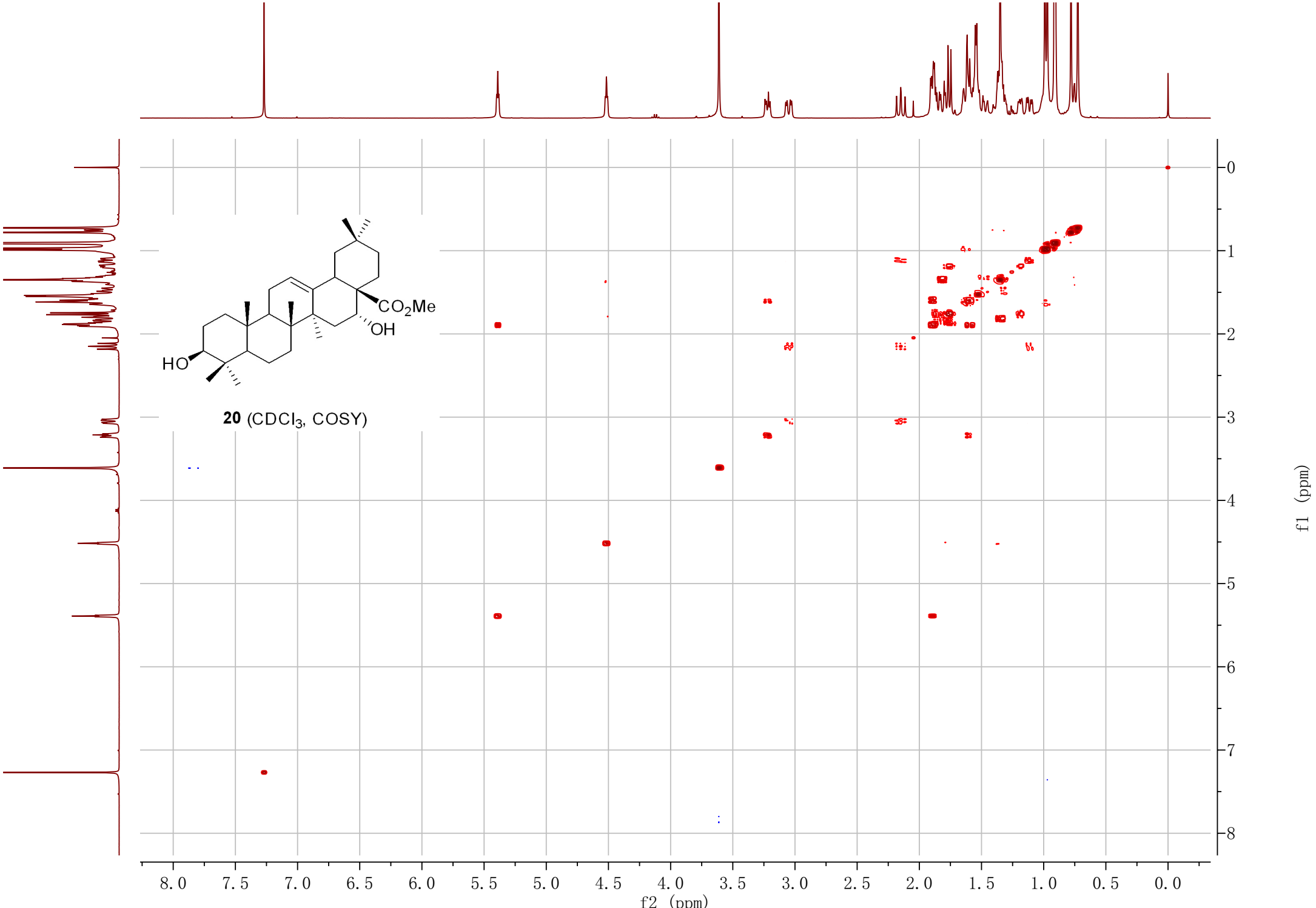

140.90
139.32
128.32
128.15
127.57
127.33
127.31
127.20
125.26
123.06
86.61
79.44
77.48
77.16
76.84
72.43
71.50
55.91
53.17
52.35
46.82
44.88
41.69
39.73
39.54
39.03
38.53
37.16
33.35
32.99
30.58
29.41
28.42
28.03
25.63
23.53
22.88
18.42
17.10
16.79
15.61
ZZY191211.3.1.1r
ZZY191211
CO2Me
OBn
BnO
19 (100 MHz, CDCl3)
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
f1 (ppm)

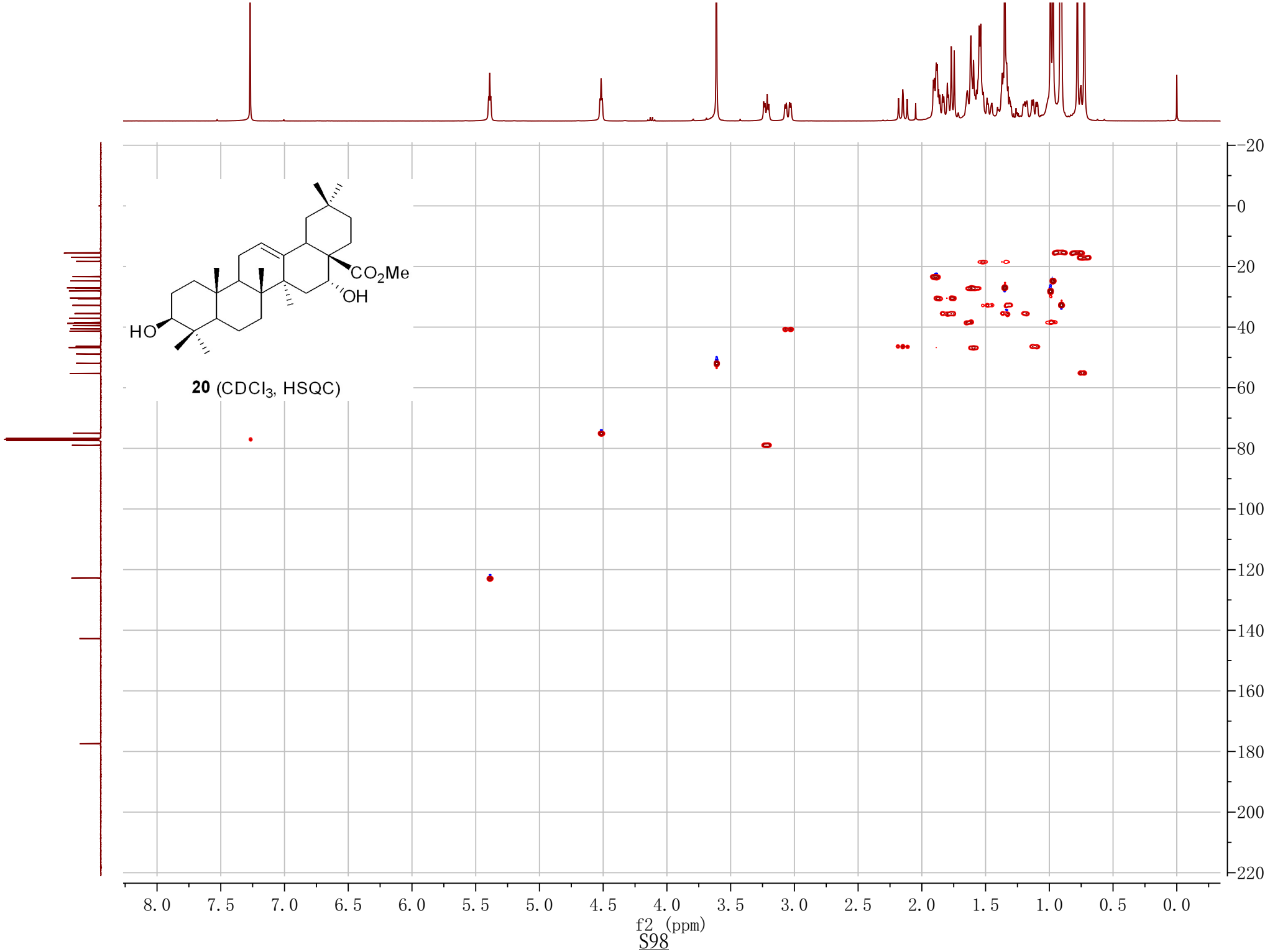

CO2Me
OBn
BnO
19 (CDCl3, COSY)
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f2 (ppm)
0 1 2 3 4 5 6 7 8
f1 (ppm)

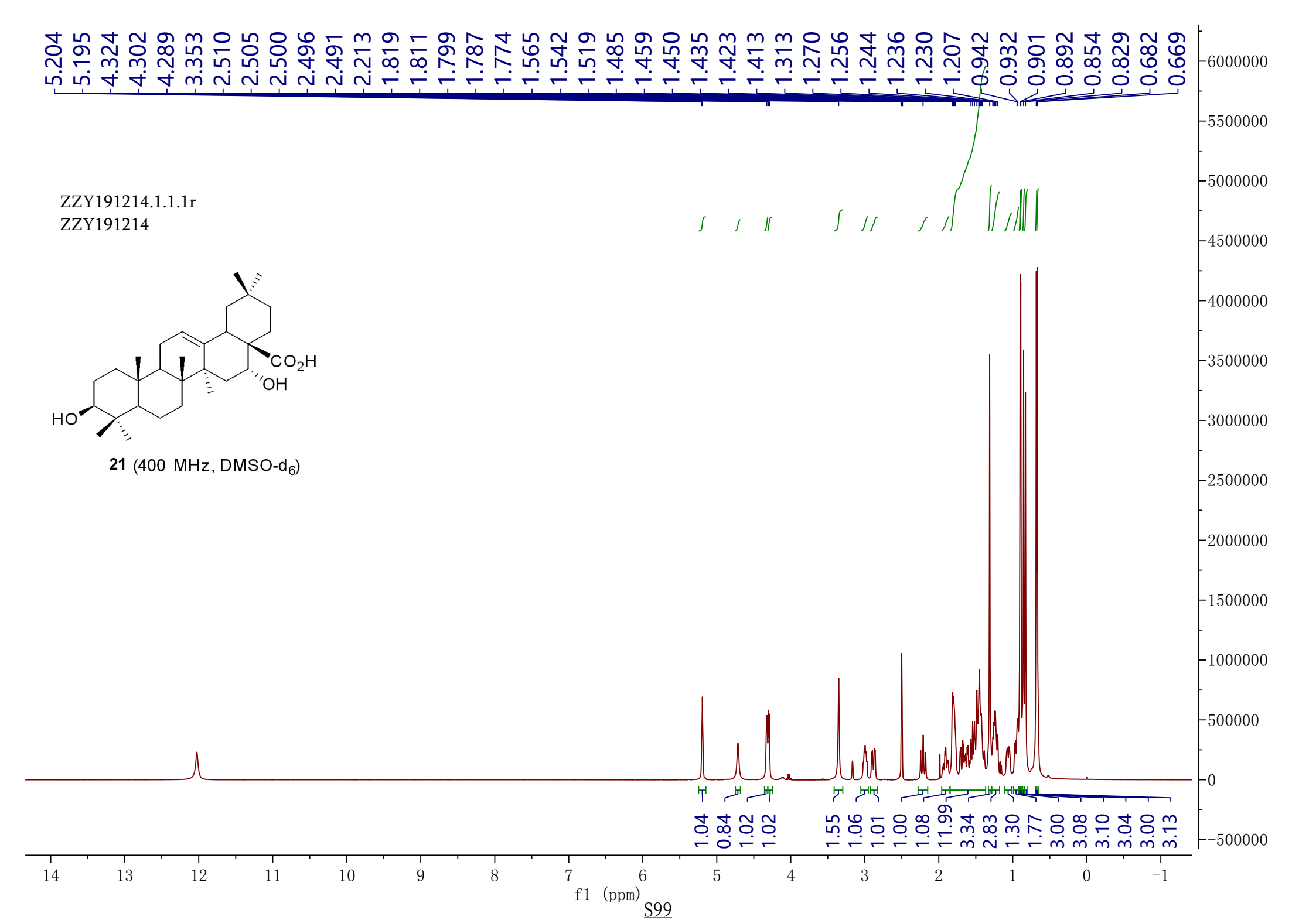

CO2Me
OBn
BnO
19 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

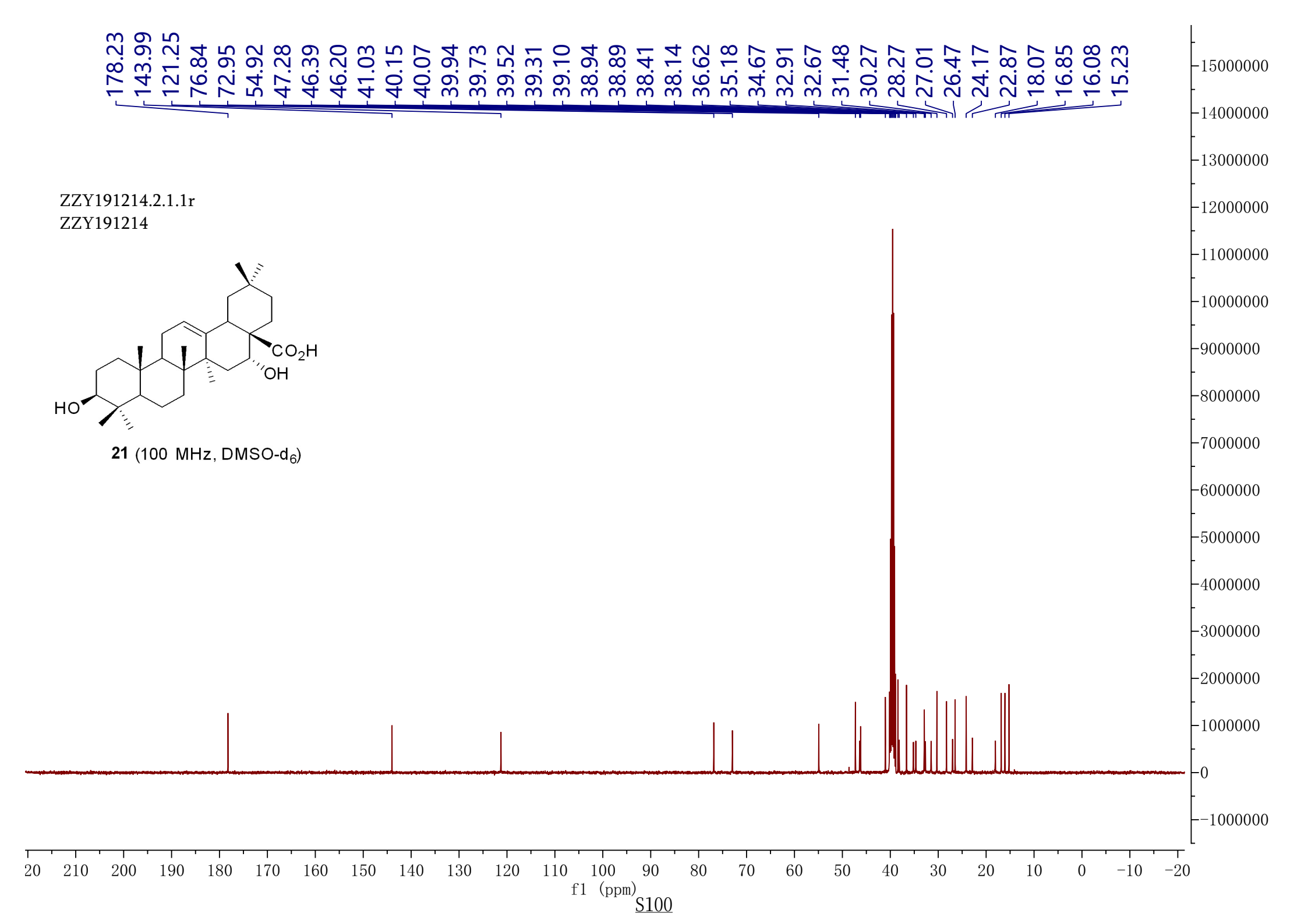

5.380
4.508
4.504
3.601
3.204
2.141
2.136
1.900
1.890
1.881
1.877
1.869
1.858
1.828
1.790
1.759
1.736
1.639
1.634
1.630
1.610
1.605
1.597
1.594
1.584
1.562
1.551
1.540
1.528
1.507
1.358
1.340
1.314
0.980
0.961
0.905
0.895
0.770
0.747
0.742
0.715
ZZY191204.1.1.1r
ZZY191204
CO2Me
OH
HO
20 (400 MHz, CDCl3)
1.00
1.01
3.05
1.03
1.03
1.05
6.57
9.11
6.41
1.07
1.27
3.01
3.03
6.02
3.07
4.07
f1 (ppm)

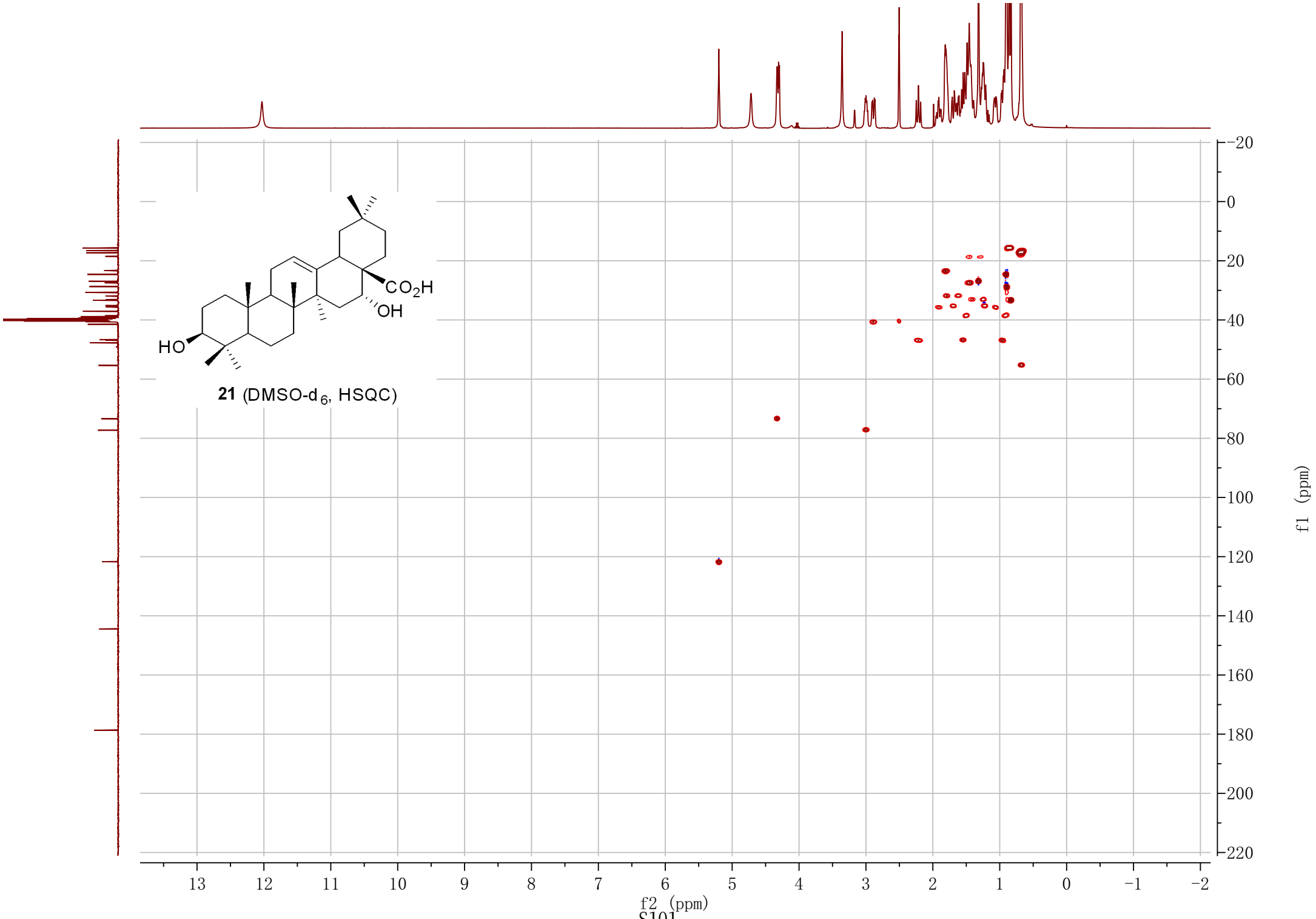

177.57
142.87
122.95
79.10
77.48
77.16
76.84
75.12
55.40
52.04
48.94
46.87
46.47
41.44
40.70
39.62
38.89
38.63
37.16
35.67
35.56
32.99
32.93
30.73
30.51
28.21
27.33
27.18
24.87
23.45
18.43
17.09
15.73
15.60
ZZY191204.3.1.1r
ZZY191204
CO2Me
OH
HO
20 (100 MHz, CDCl3)
16000000
15000000
14000000
13000000
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

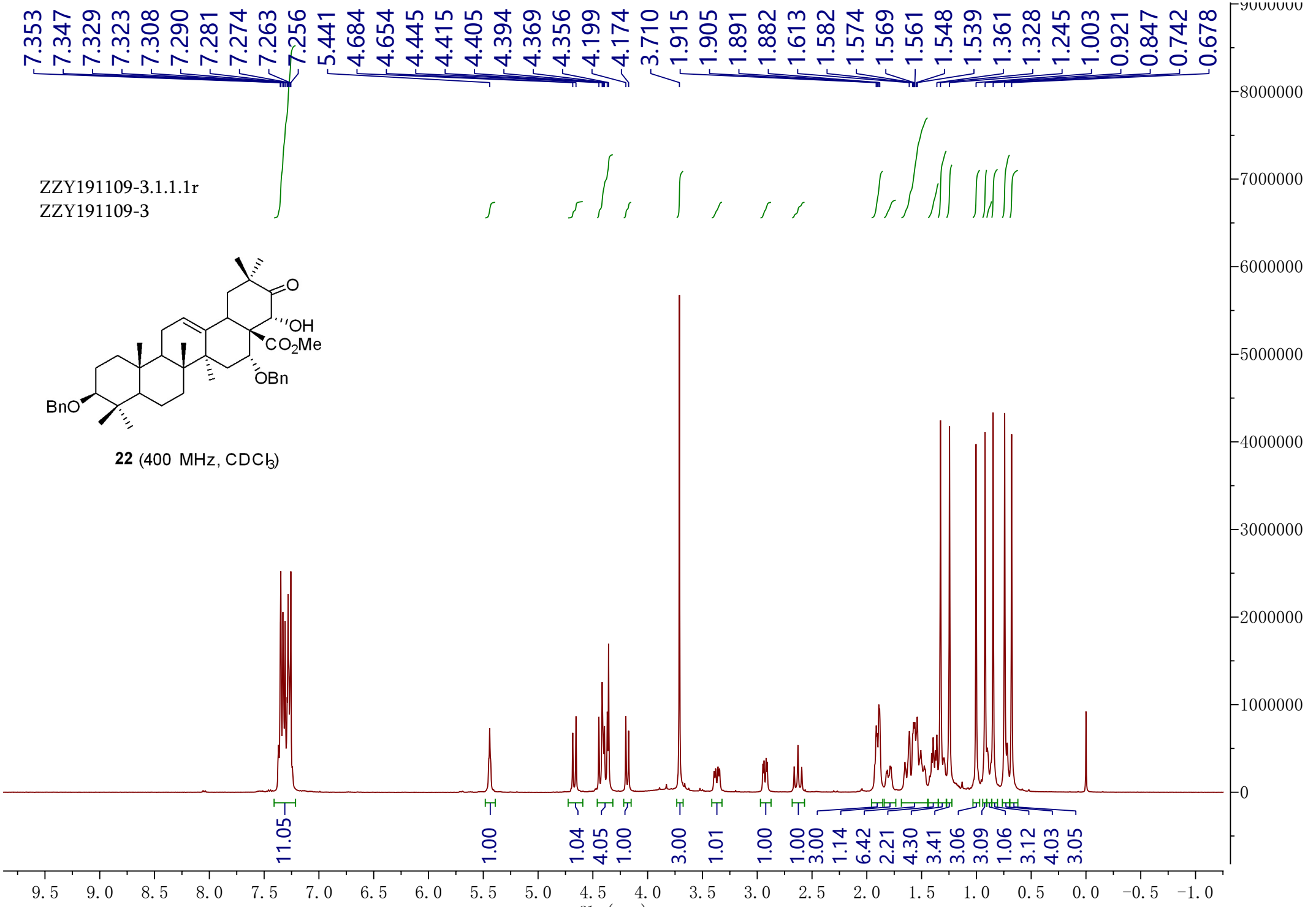

HO
OH
CO2Me
20 (CDCl3, COSY)
f2 (ppm)
f1 (ppm)

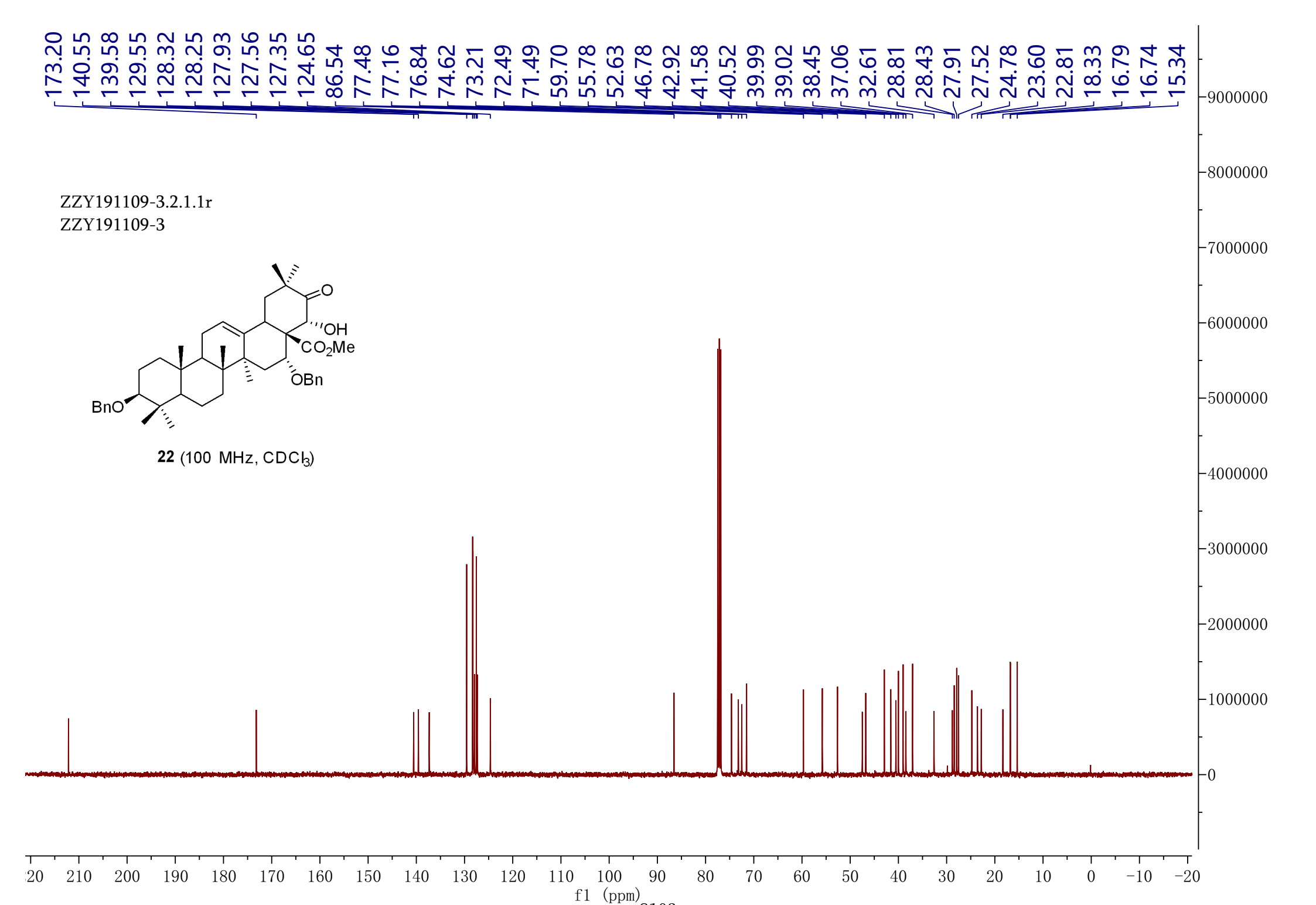

HO
OH
CO2Me
20 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

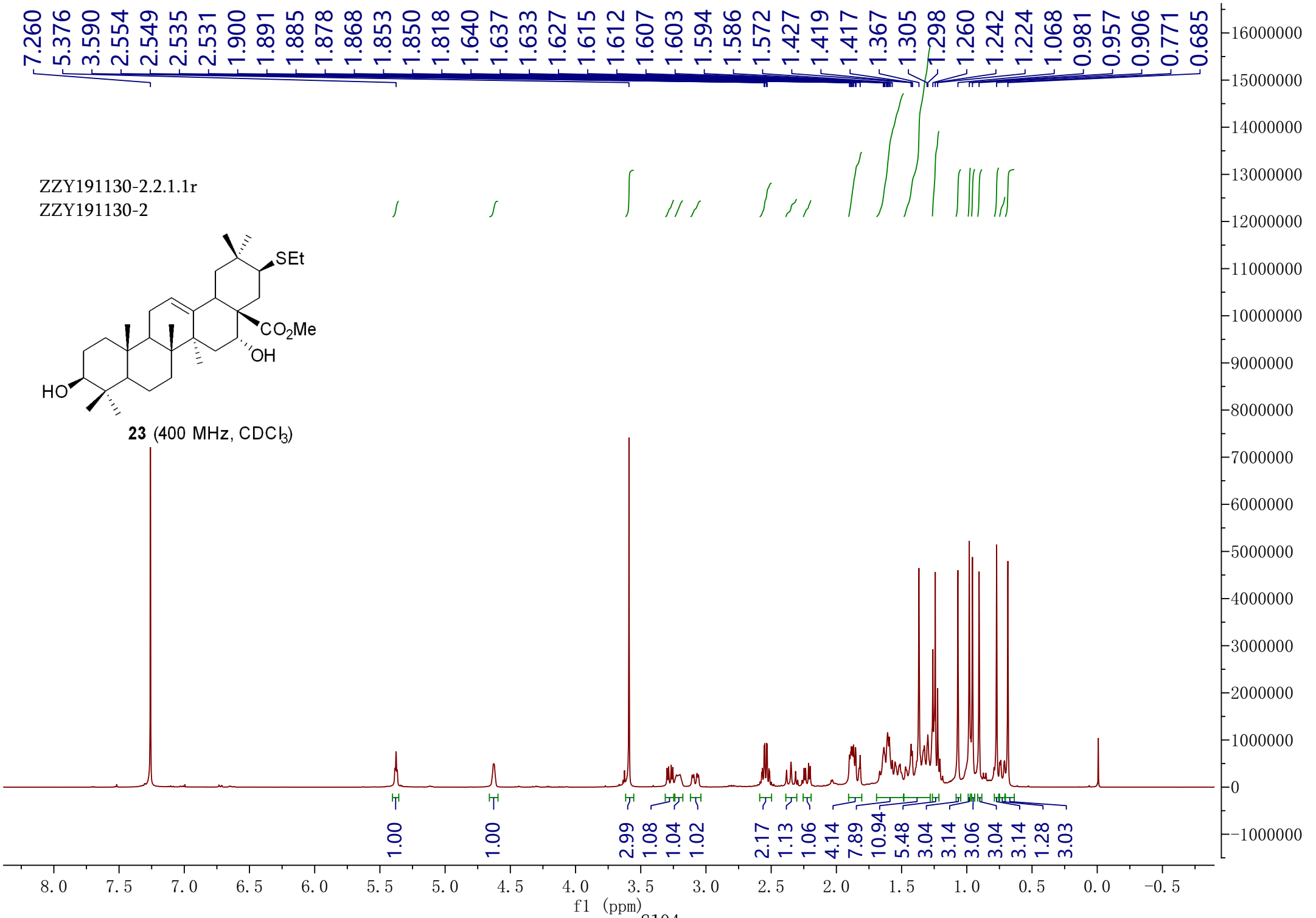

5.204
5.195
4.324
4.302
4.289
3.353
2.510
2.505
2.500
2.496
2.491
2.213
1.819
1.811
1.799
1.787
1.774
1.565
1.542
1.519
1.485
1.459
1.450
1.435
1.423
1.413
1.313
1.270
1.256
1.244
1.236
1.230
1.207
0.942
0.932
0.901
0.892
0.854
0.829
0.682
0.669
ZZY191214.1.1.1r
ZZY191214
CO2H
OH
HO
21 (400 MHz, DMSO-d6)
1.04
0.84
1.02
1.02
1.55
1.06
1.01
1.00
1.08
11.99
3.34
2.83
1.30
1.77
3.00
3.08
3.10
3.04
3.00
3.13
f1 (ppm)

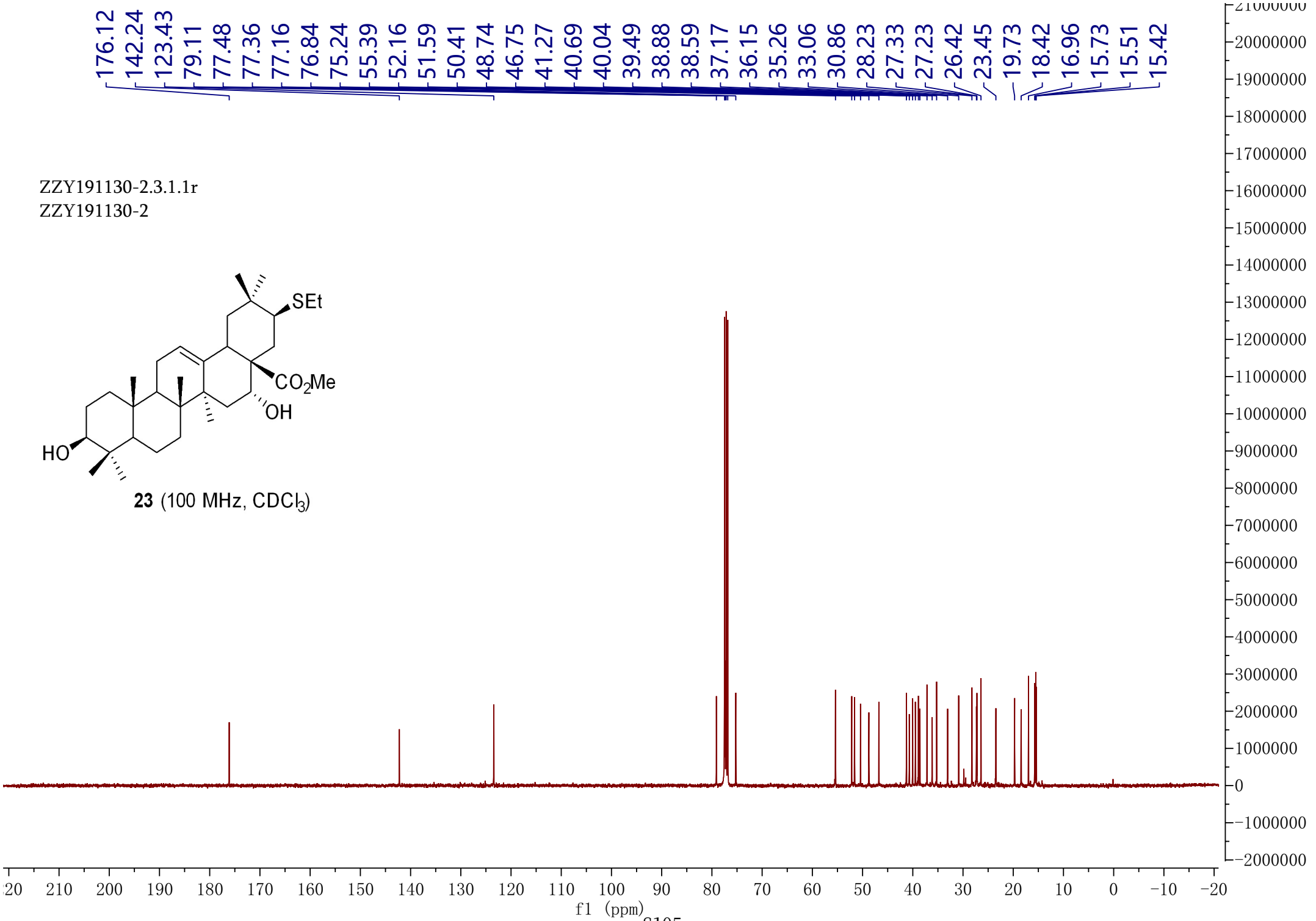

178.23
143.99
121.25
76.84
72.95
54.92
47.28
46.39
46.20
41.03
40.15
40.07
39.94
39.73
39.52
39.31
39.10
38.94
38.89
38.41
38.14
36.62
35.18
34.67
32.91
32.67
31.48
30.27
28.27
27.01
26.47
24.17
22.87
18.07
16.85
16.08
15.23
ZZY191214.2.1.1r
ZZY191214
CO2H
OH
HO
21 (100 MHz, DMSO-d6)
15000000
14000000
13000000
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

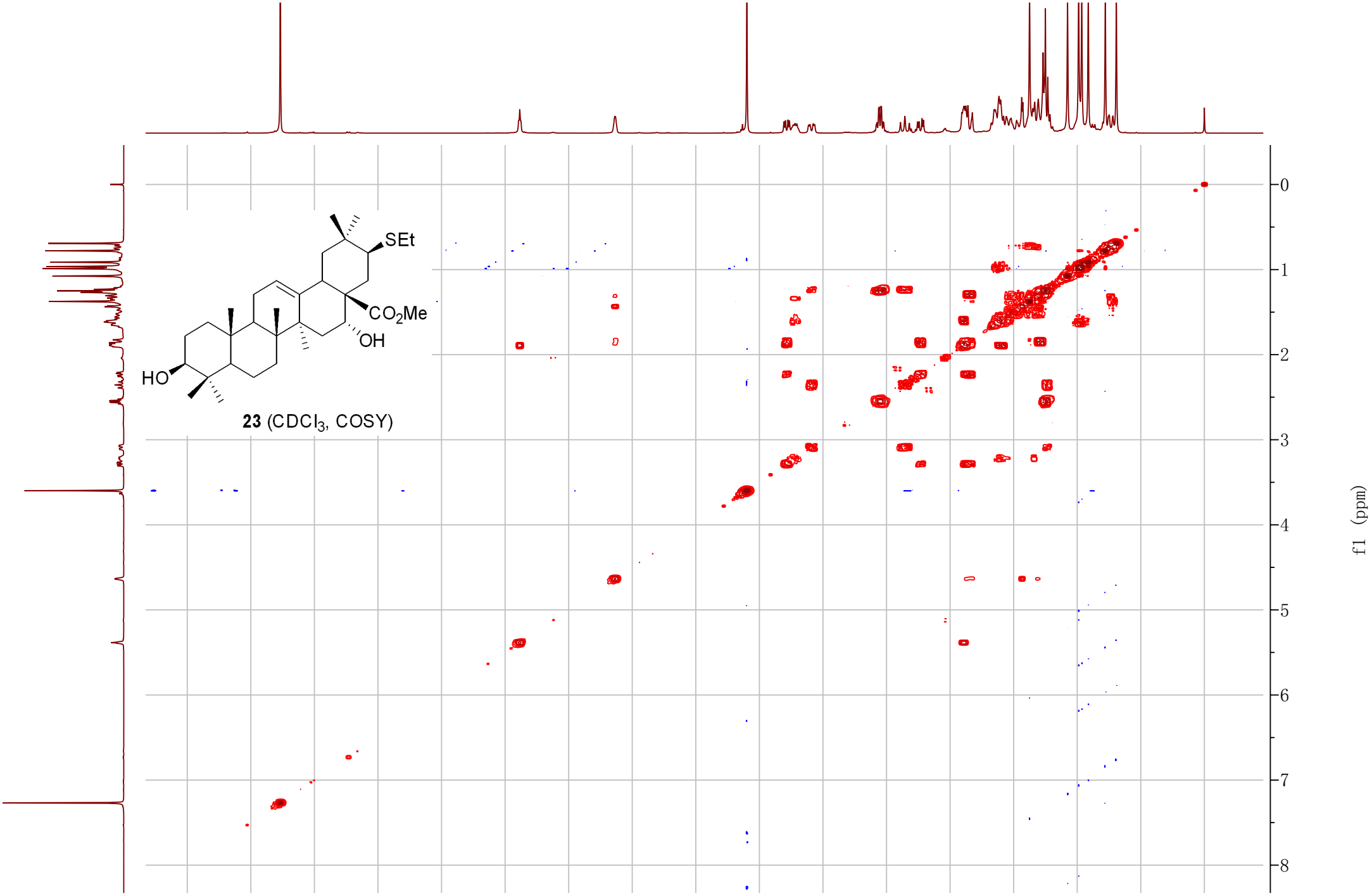

CO2H
OH
HO
21 (DMSO-d6, HSQC)
f2 (ppm)
f1 (ppm)

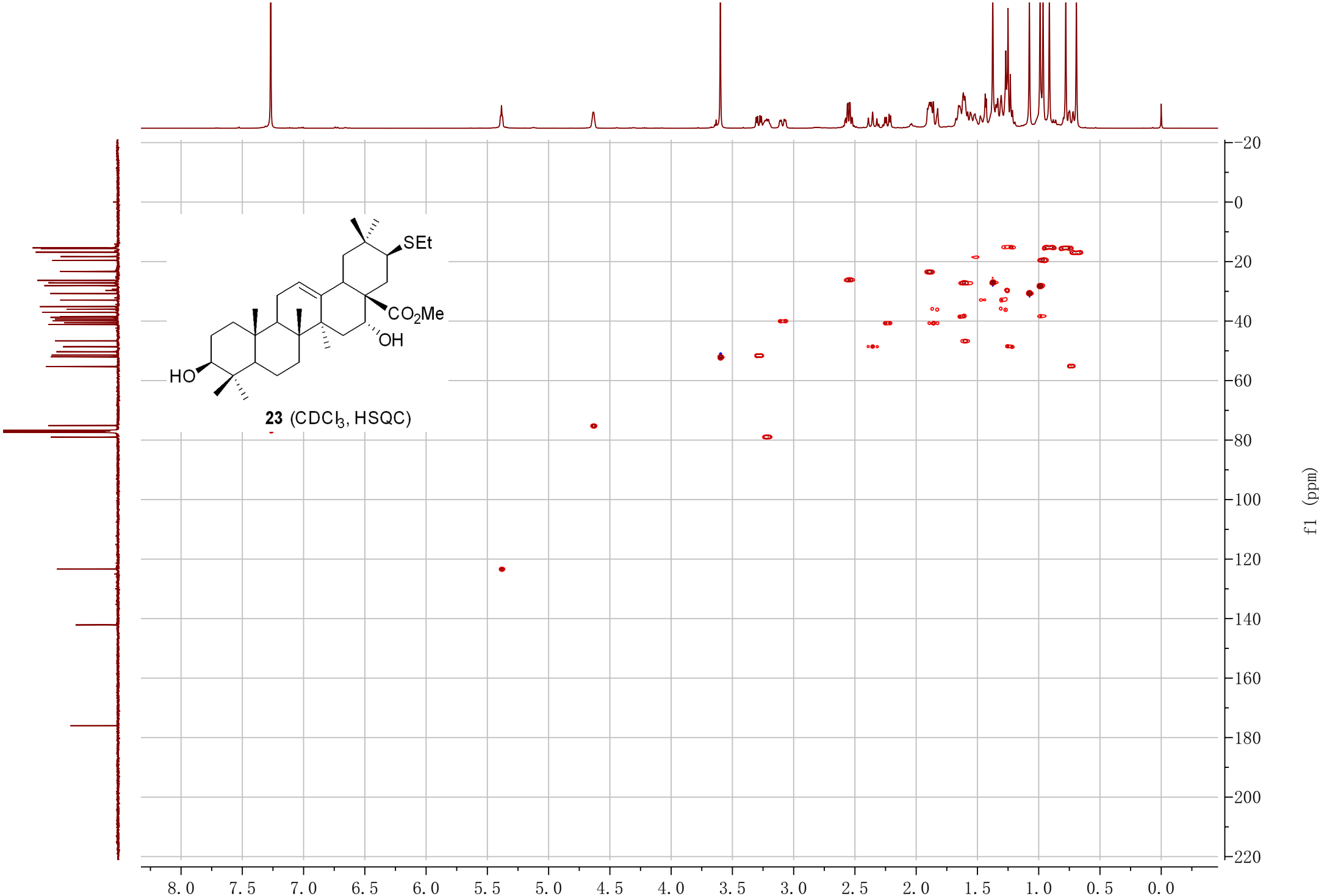

7.353
7.347
7.329
7.323
7.308
7.290
7.281
7.274
7.263
7.256
5.441
4.684
4.654
4.445
4.415
4.405
4.394
4.369
4.356
4.199
4.174
3.710
1.915
1.905
1.891
1.882
1.613
1.582
1.574
1.569
1.561
1.548
1.539
1.361
1.328
1.245
1.003
0.921
0.847
0.742
0.678
ZZY191109-3.1.1.1r
ZZY191109-3
O
OH
CO2Me
OBn
BnO
22 (400 MHz, CDCl3)
11.05
1.00
1.04
4.05
1.00
3.00
1.01
1.00
1.00
3.00
1.14
6.42
2.21
4.30
3.41
3.06
3.09
1.06
3.12
4.03
3.05
f1 (ppm)

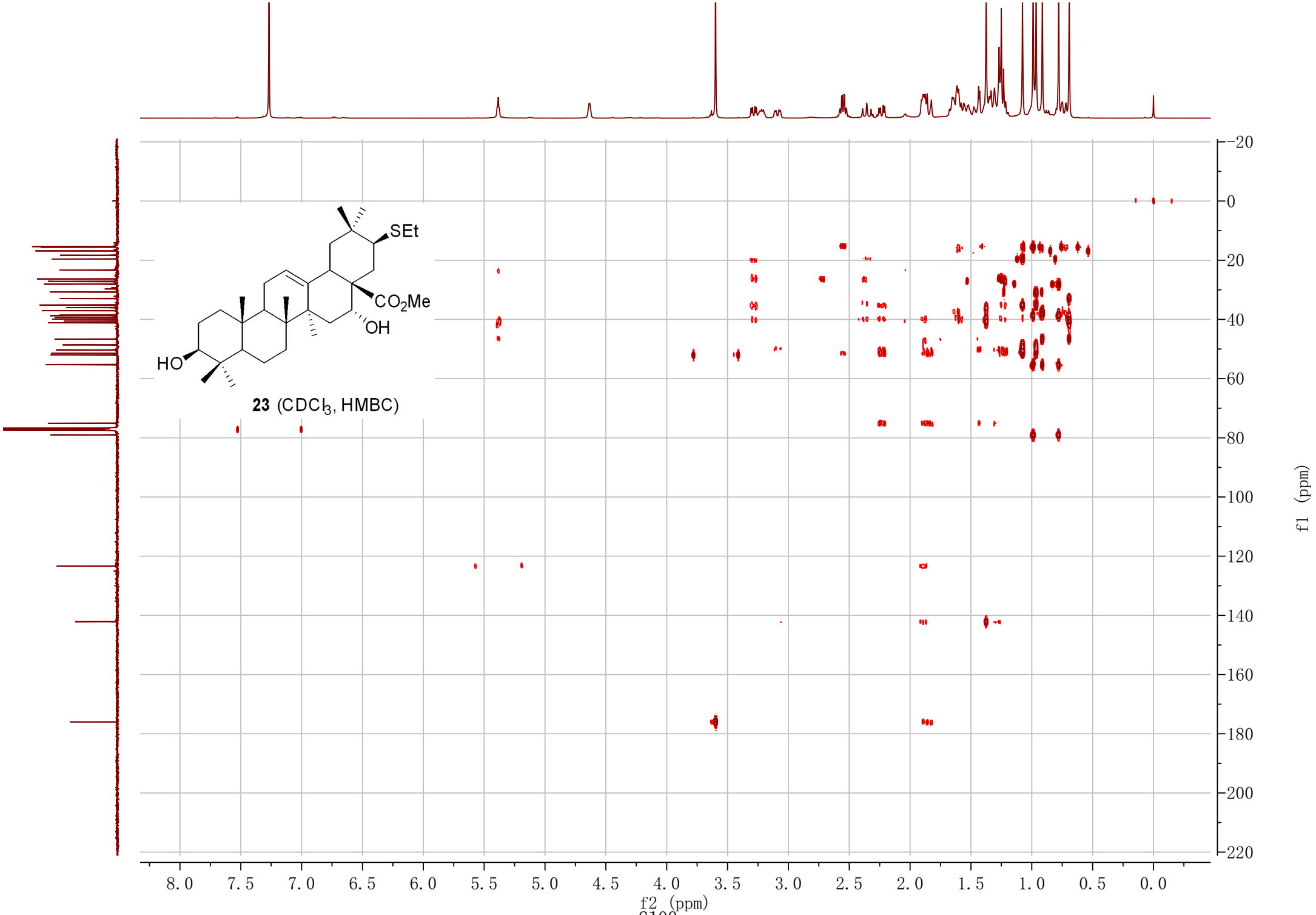

173.20
140.55
139.58
129.55
128.32
128.25
127.93
127.56
127.35
124.65
86.54
77.48
77.16
76.84
74.62
73.21
72.49
71.49
59.70
55.78
52.63
46.78
42.92
41.58
40.52
39.99
39.02
38.45
37.06
32.61
28.81
28.43
27.91
27.52
24.78
23.60
22.81
18.33
16.79
16.74
15.34
ZZY191109-3.2.1.1r
ZZY191109-3
O
OH
CO2Me
OBn
BnO
22 (100 MHz, CDCl3)
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
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)

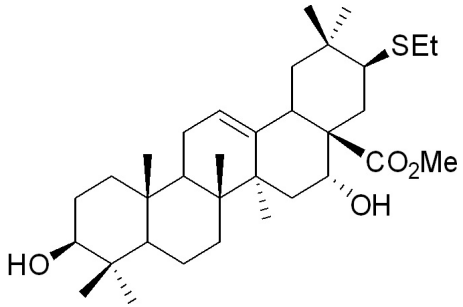

7.260
5.376
3.590
2.554
2.549
2.535
2.531
1.900
1.891
1.885
1.878
1.868
1.853
1.850
1.818
1.640
1.637
1.633
1.627
1.615
1.612
1.607
1.603
1.594
1.586
1.572
1.427
1.419
1.417
1.367
1.305
1.298
1.260
1.242
1.224
1.068
0.981
0.957
0.906
0.771
0.685
ZZY191130-2.2.1.1r
ZZY191130-2
SEt
CO2Me
OH
HO
23 (400 MHz, CDCl3)
1.00
1.00
2.99
1.08
1.04
1.02
2.17
1.13
1.06
4.14
7.89
10.94
5.48
3.04
3.14
3.06
3.04
3.14
1.28
3.03
f1 (ppm)


176.12
142.24
123.43
79.11
77.48
77.36
77.16
76.84
75.24
55.39
52.16
51.59
50.41
48.74
46.75
41.27
40.69
40.04
39.49
38.88
38.59
37.17
36.15
35.26
33.06
30.86
28.23
27.33
27.23
26.42
23.45
19.73
18.42
16.96
15.73
15.51
15.42
ZZY191130-2.3.1.1r
ZZY191130-2
SEt
CO2Me
OH
HO
23 (100 MHz, CDCl3)
f1 (ppm)

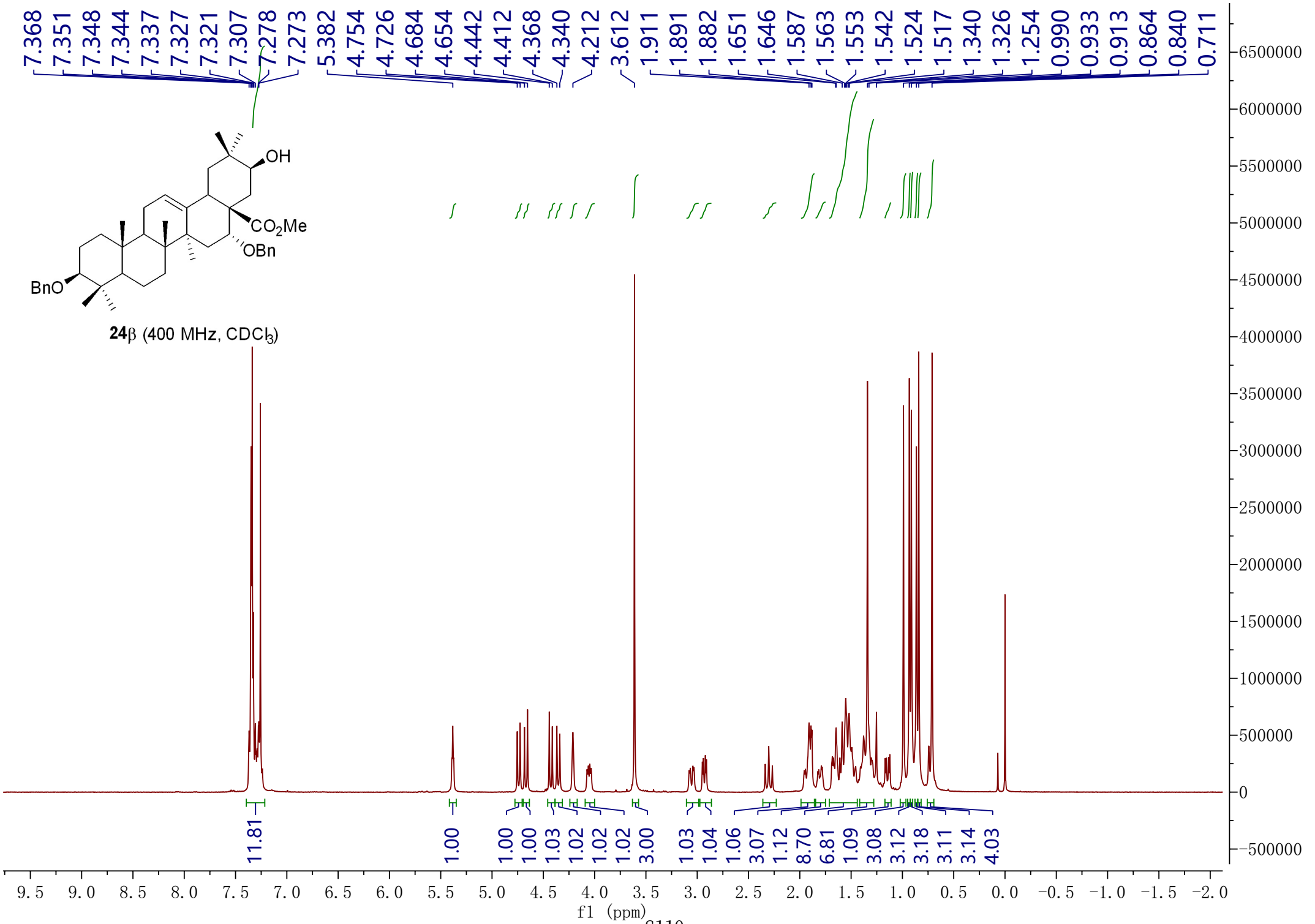

SEt
CO2Me
OH
HO
23 (CDCl3, COSY)
f2 (ppm)
f1 (ppm)

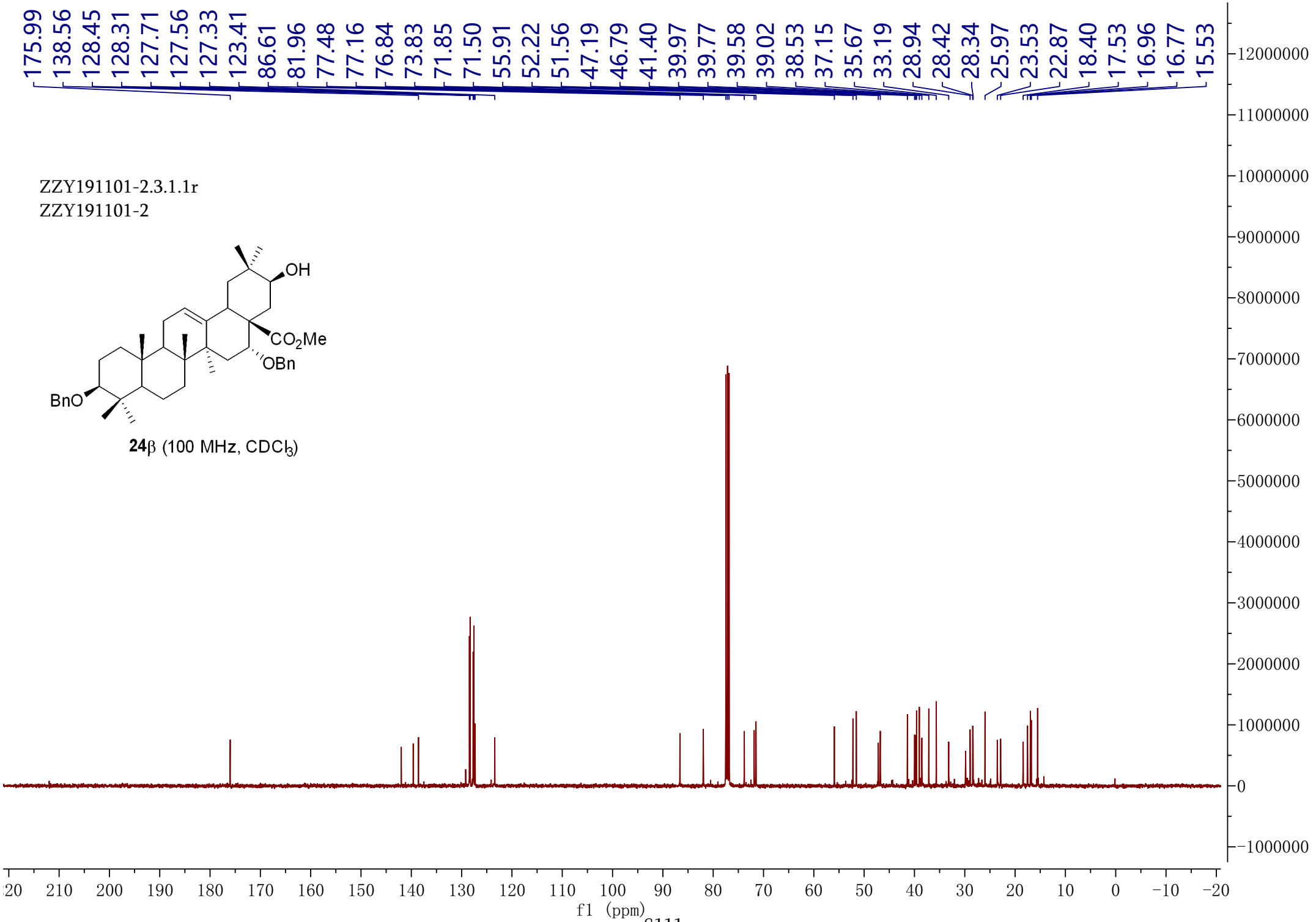

SEt
CO2Me
OH
HO
23 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

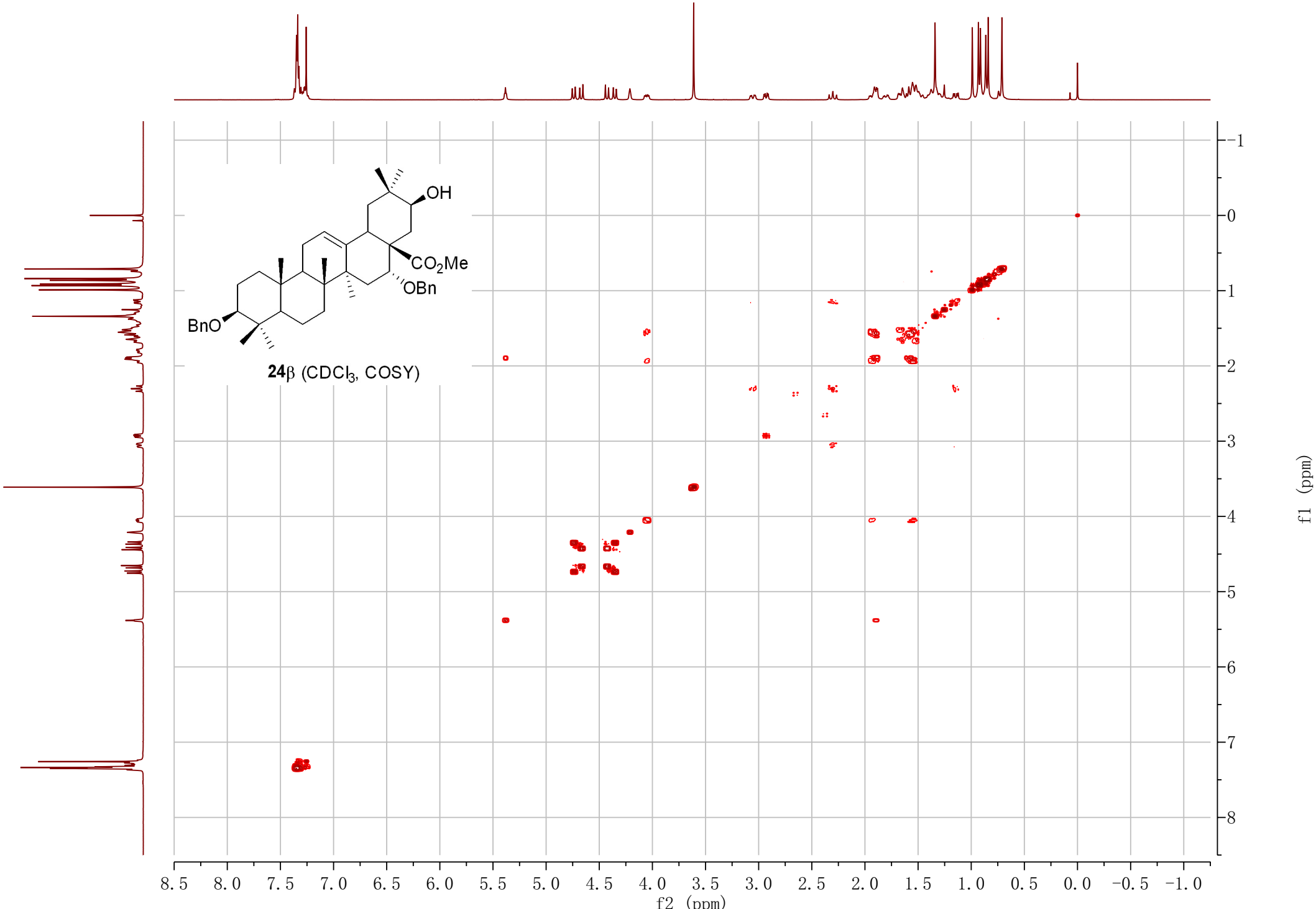

SEt
CO2Me
OH
HO
23 (CDCl3, HMBC)
f2 (ppm)
f1 (ppm)

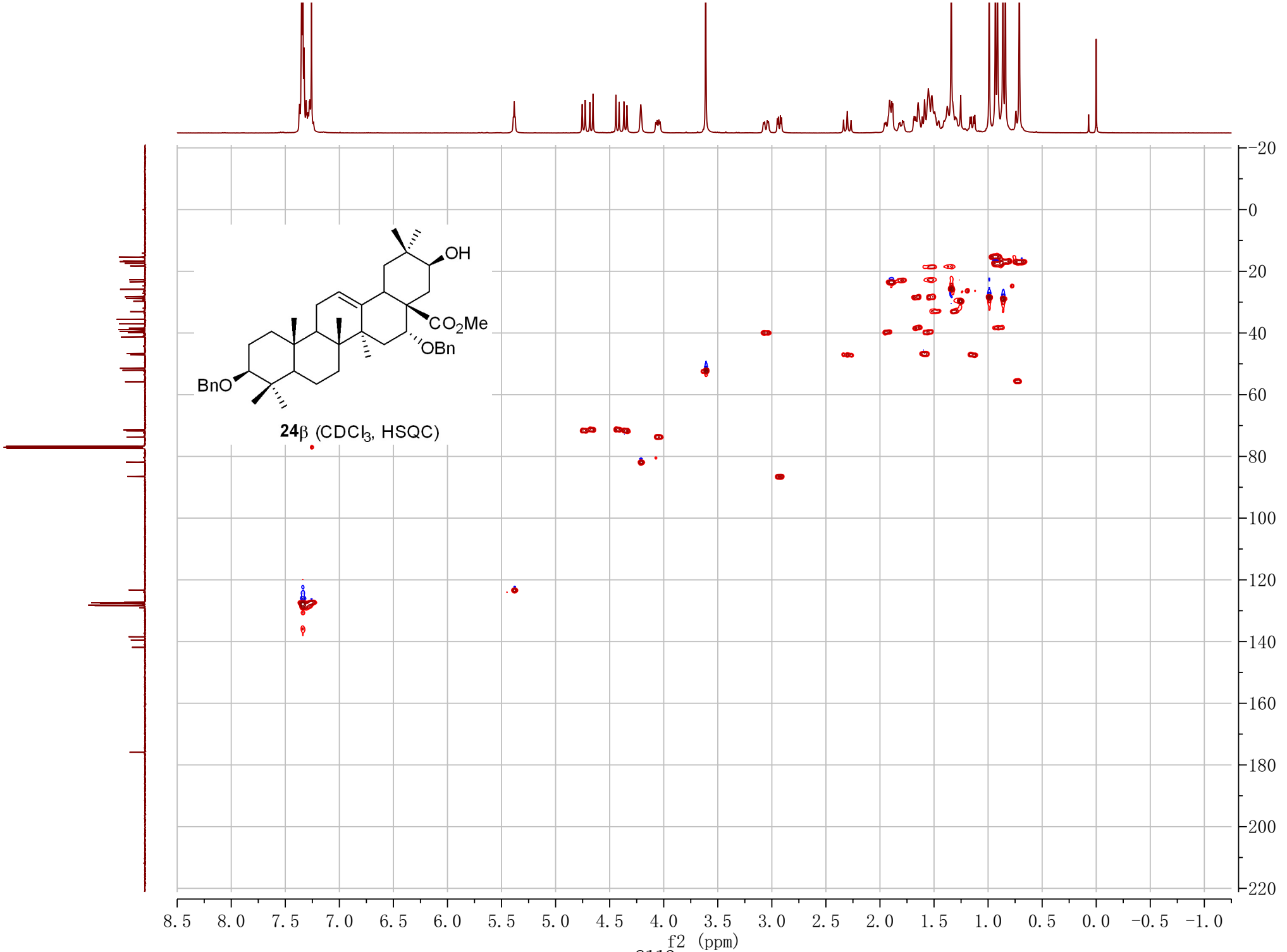


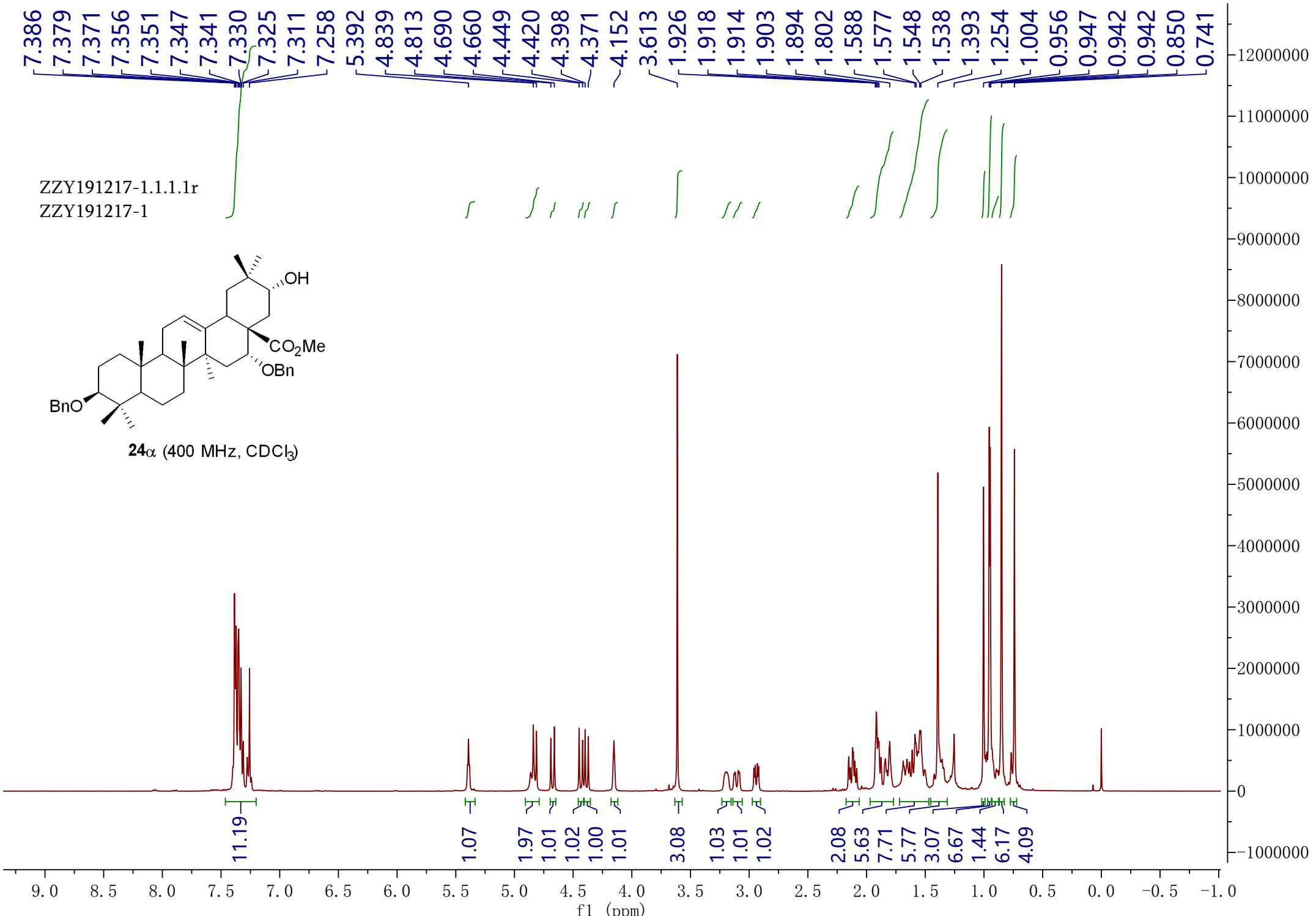
23 ($CDCl_3$, DEPT135°)

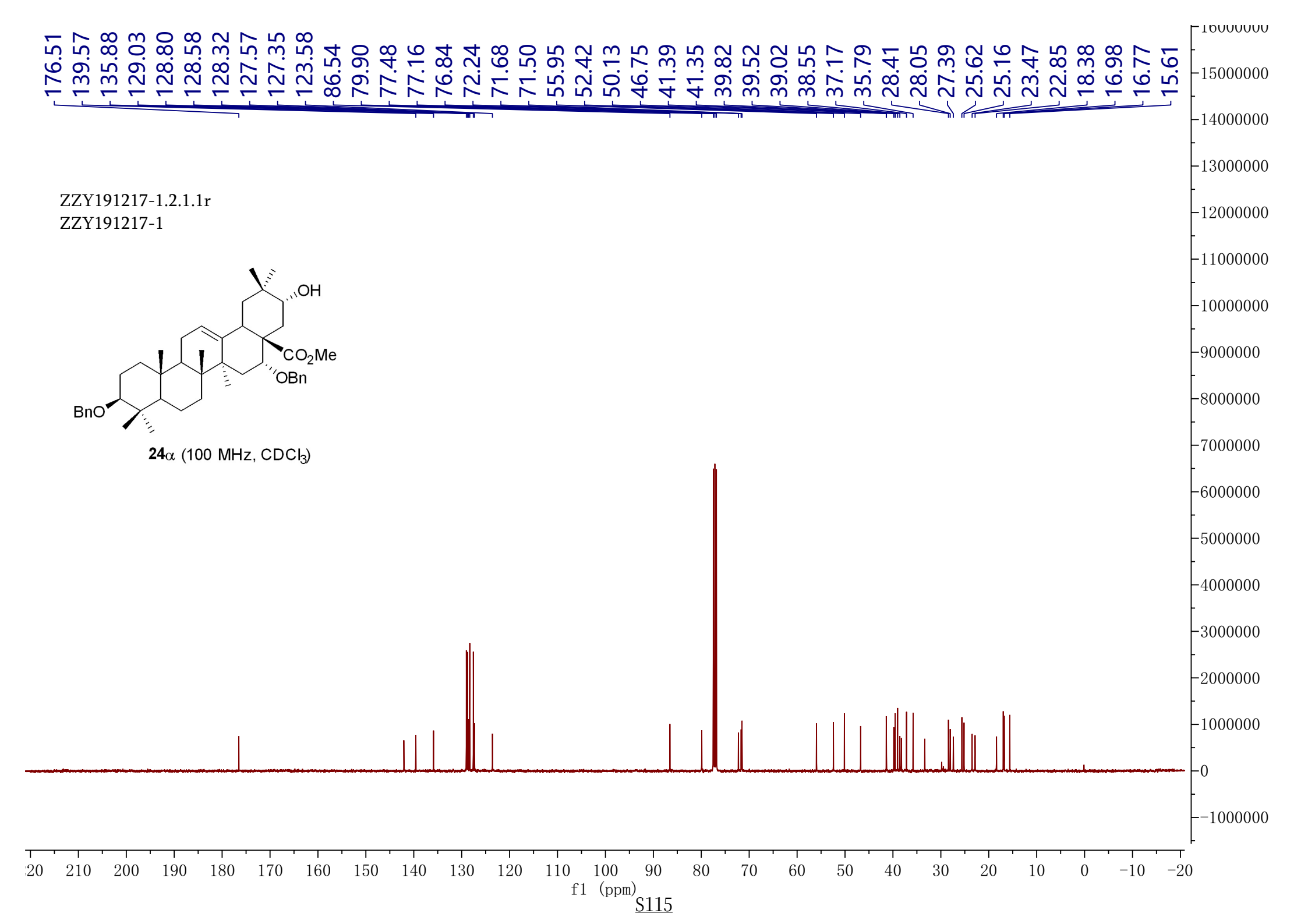

7.368
7.351
7.348
7.344
7.337
7.327
7.321
7.307
7.278
7.273
5.382
4.754
4.726
4.684
4.654
4.442
4.412
4.368
4.340
4.212
3.612
1.911
1.891
1.882
1.651
1.646
1.587
1.563
1.553
1.542
1.524
1.517
1.340
1.326
1.254
0.990
0.933
0.913
0.864
0.840
0.711
OH
CO2Me
OBn
BnO
24β (400 MHz, CDCl3)
11.81
1.00
1.00
1.00
1.03
1.02
1.02
1.02
3.00
1.03
1.04
1.06
3.07
1.12
8.70
6.81
1.09
3.08
3.12
3.18
3.11
3.14
4.03
f1 (ppm)

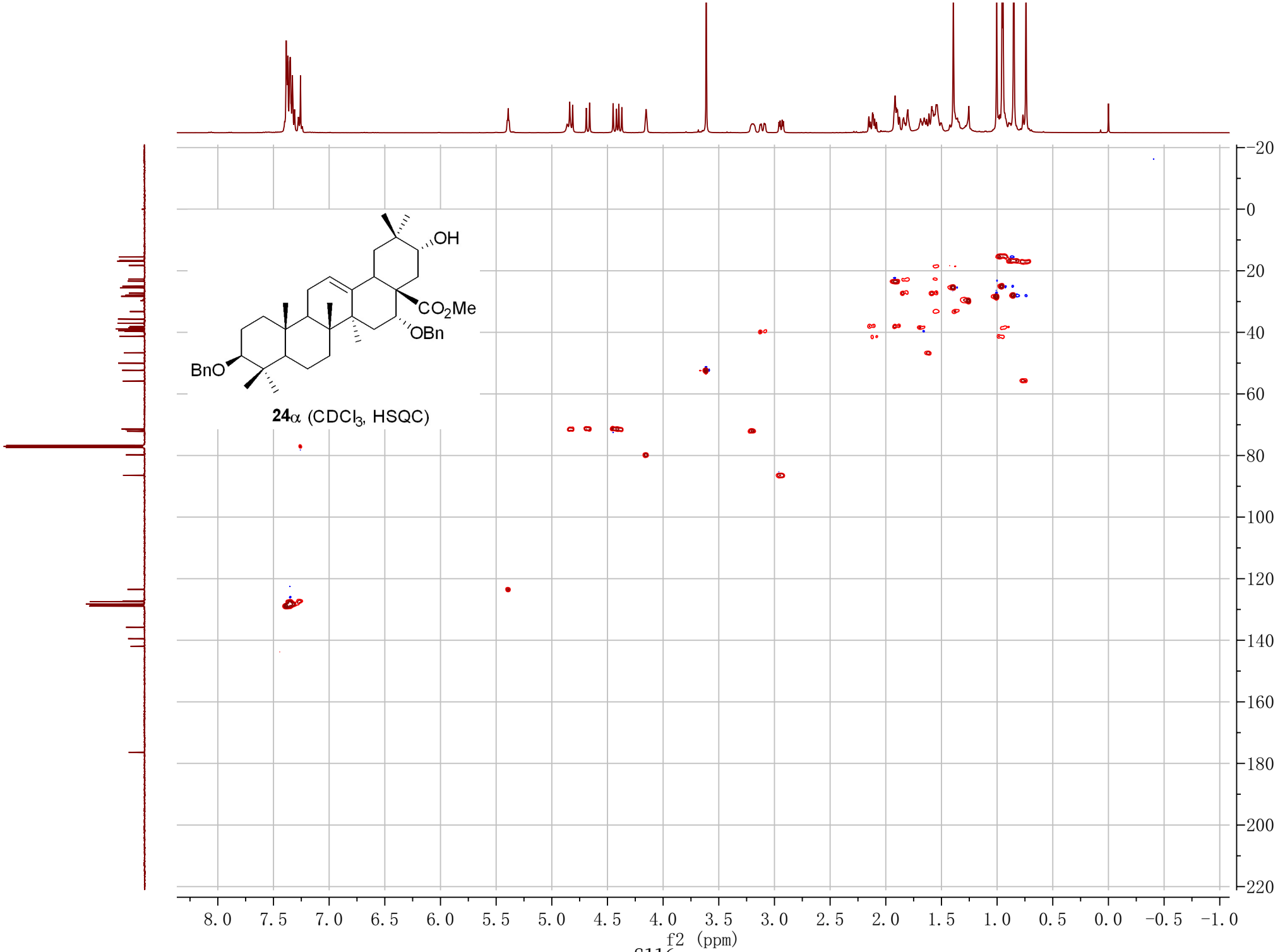

175.99
138.56
128.45
128.31
127.71
127.56
127.33
123.41
86.61
81.96
77.48
77.16
76.84
73.83
71.85
71.50
55.91
52.22
51.56
47.19
46.79
41.40
39.97
39.77
39.58
39.02
38.53
37.15
35.67
33.19
28.94
28.42
28.34
25.97
23.53
22.87
18.40
17.53
16.96
16.77
15.53
ZZY191101-2.3.1.1r
ZZY191101-2
OH
CO2Me
OBn
BnO
24β (100 MHz, CDCl3)
f1 (ppm)

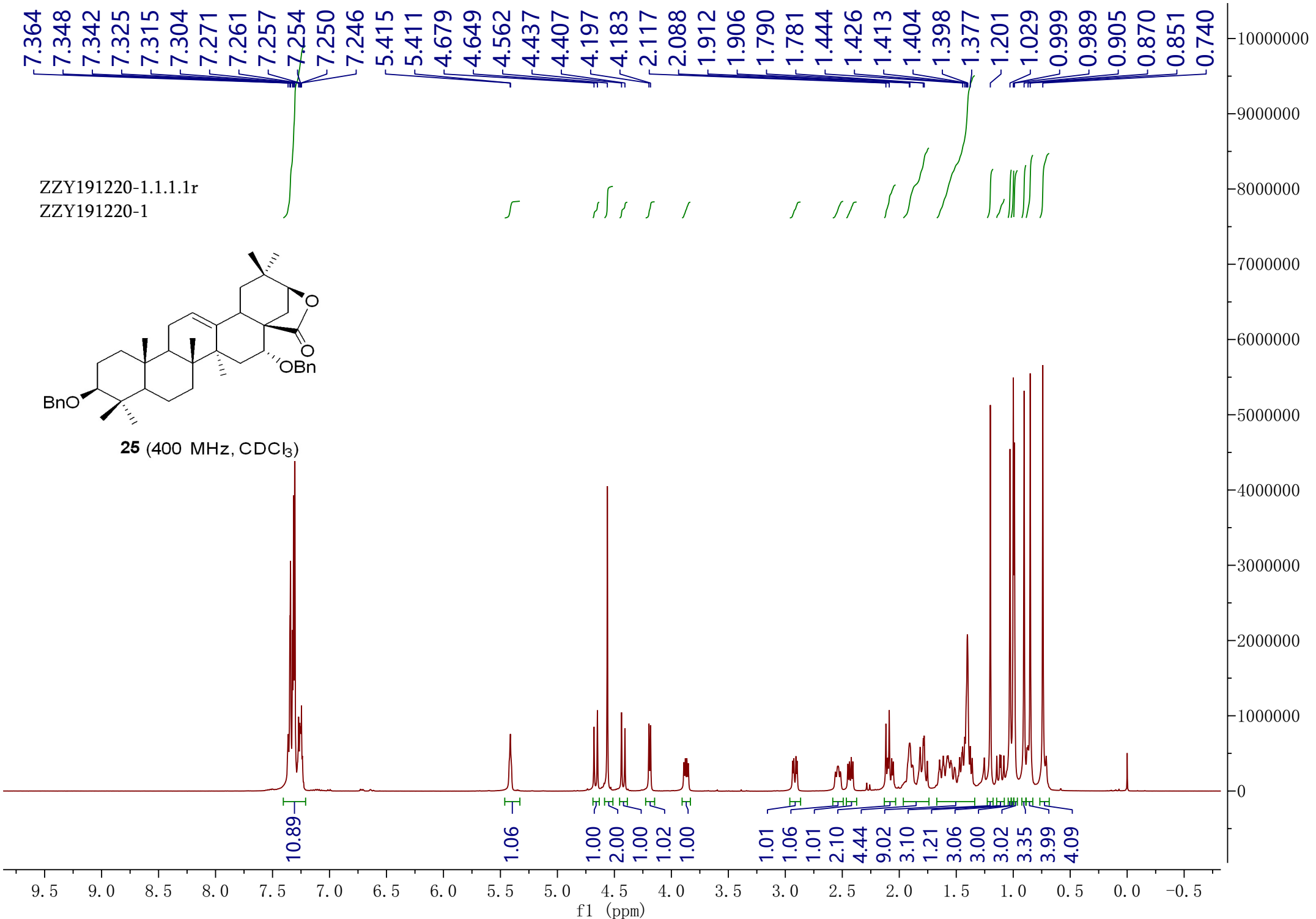

OH
CO2Me
OBn
BnO
24β (CDCl3, COSY)
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f2 (ppm)
-1 0 1 2 3 4 5 6 7 8
f1 (ppm)

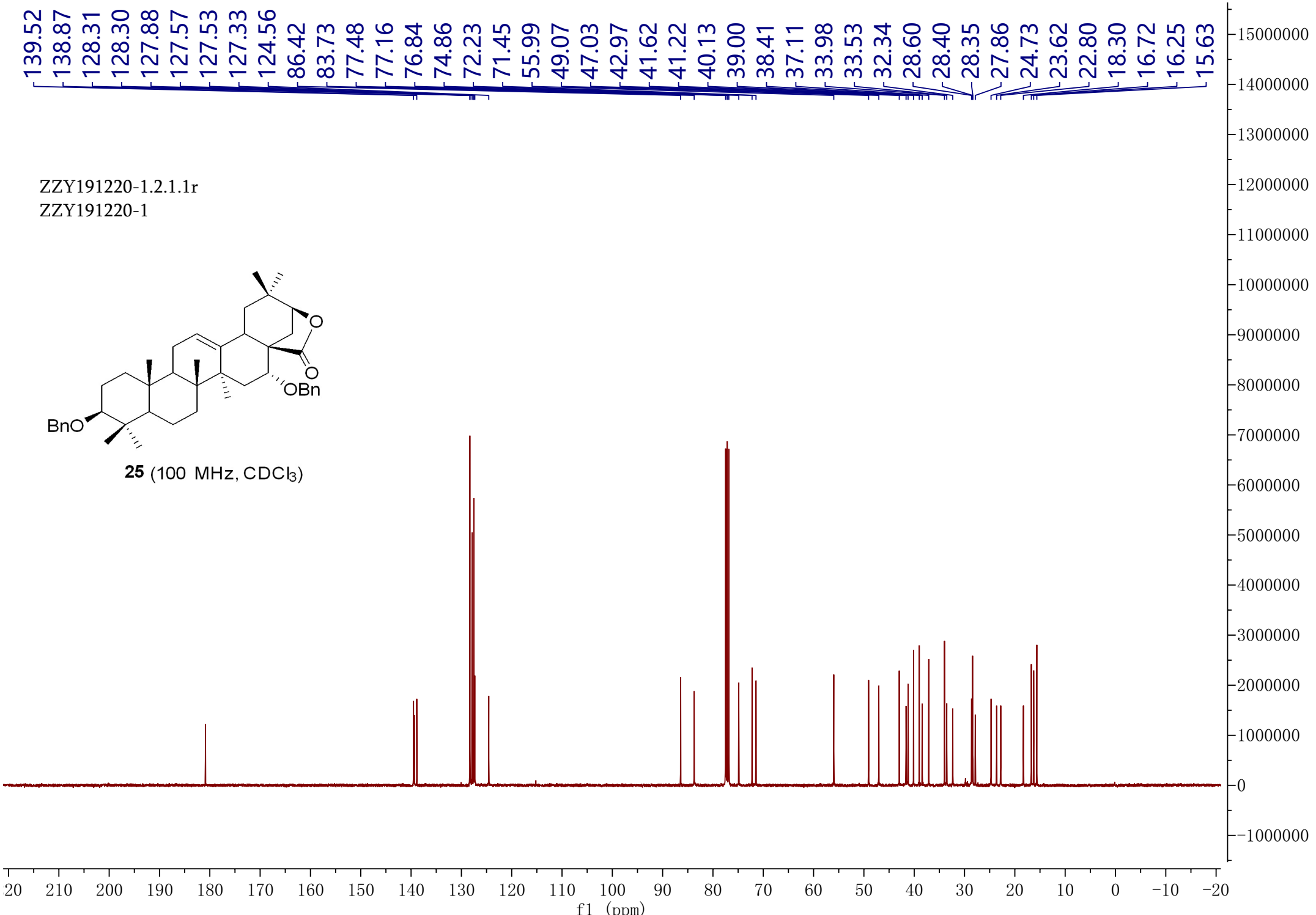

OH
CO2Me
OBn
BnO
24β (CDCl3, HSQC)
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f2 (ppm)
-20 0 20 40 60 80 100 120 140 160 180 200 220
f1 (ppm)

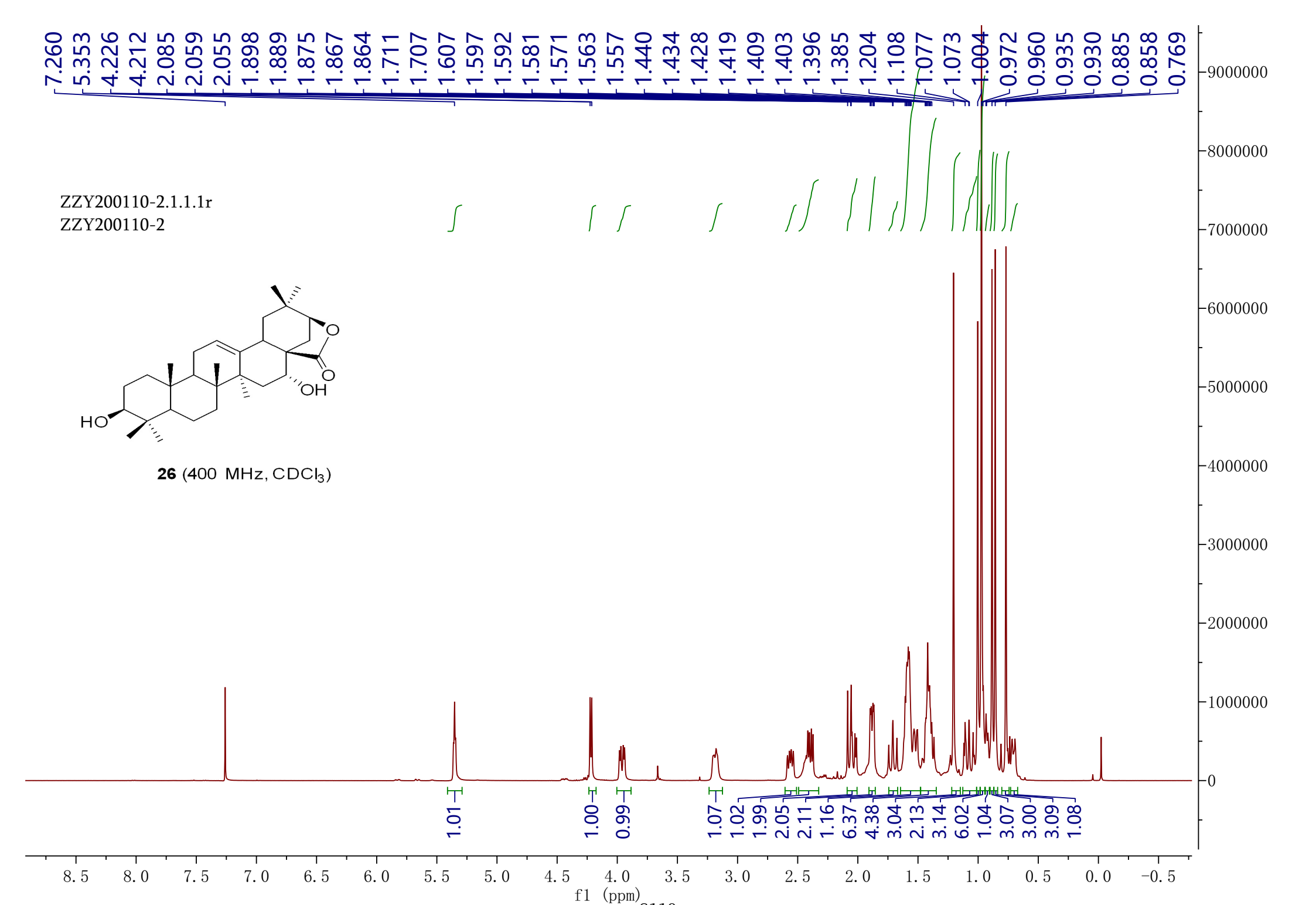

7.386
7.379
7.371
7.356
7.351
7.347
7.341
7.330
7.325
7.311
7.258
5.392
4.839
4.813
4.690
4.660
4.449
4.420
4.398
4.371
4.152
3.613
1.926
1.918
1.914
1.903
1.894
1.802
1.588
1.577
1.548
1.538
1.393
1.254
1.004
0.956
0.947
0.942
0.942
0.850
0.741
ZZY191217-1.1.1.1r
ZZY191217-1
OH
CO2Me
OBn
BnO
24α (400 MHz, CDCl3)
11.19
1.07
1.97
1.01
1.02
1.00
1.01
3.08
1.03
1.01
1.02
2.08
5.63
7.71
5.77
3.07
6.67
1.44
6.17
4.09
f1 (ppm)


176.51
139.57
135.88
129.03
128.80
128.58
128.32
127.57
127.35
123.58
86.54
79.90
77.48
77.16
76.84
72.24
71.68
71.50
55.95
52.42
50.13
46.75
41.39
41.35
39.82
39.52
39.02
38.55
37.17
35.79
28.41
28.05
27.39
25.62
25.16
23.47
22.85
18.38
16.98
16.77
15.61
ZZY191217-1.2.1.1r
ZZY191217-1
OH
CO2Me
OBn
BnO
24α (100 MHz, CDCl3)
f1 (ppm)

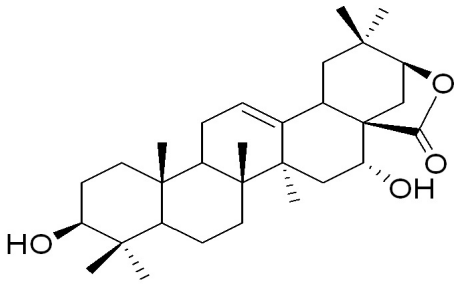

OH
CO2Me
OBn
BnO
24α (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)


7.364
7.348
7.342
7.325
7.315
7.304
7.271
7.261
7.257
7.254
7.250
7.246
5.415
5.411
4.679
4.649
4.562
4.437
4.407
4.197
4.183
2.117
2.088
1.912
1.906
1.790
1.781
1.444
1.426
1.413
1.404
1.398
1.377
1.201
1.029
0.999
0.989
0.905
0.870
0.851
0.740
ZZY191220-1.1.1.1r
ZZY191220-1
BnO
OBn
O
O
25 (400 MHz, CDCl3)
10.89
1.06
1.00
2.00
1.00
1.02
1.00
1.01
1.06
1.01
2.10
4.44
9.02
3.10
1.21
3.06
3.00
3.02
3.35
3.99
4.09
f1 (ppm)


139.52
138.87
128.31
128.30
127.88
127.57
127.53
127.33
124.56
86.42
83.73
77.48
77.16
76.84
74.86
72.23
71.45
55.99
49.07
47.03
42.97
41.62
41.22
40.13
39.00
38.41
37.11
33.98
33.53
32.34
28.60
28.40
28.35
27.86
24.73
23.62
22.80
18.30
16.72
16.25
15.63
ZZY191220-1.2.1.1r
ZZY191220-1
BnO
OBn
O
O
25 (100 MHz, CDCl3)
15000000
14000000
13000000
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
20 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20
f1 (ppm)

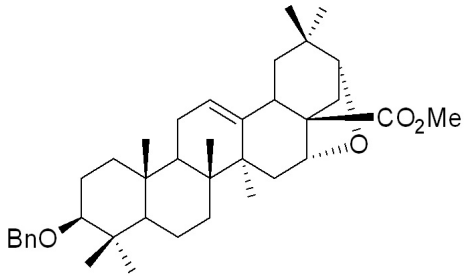

7.260
5.353
4.226
4.212
2.085
2.059
2.055
1.898
1.889
1.875
1.867
1.864
1.711
1.707
1.607
1.597
1.592
1.581
1.571
1.563
1.557
1.440
1.434
1.428
1.419
1.409
1.403
1.396
1.385
1.204
1.108
1.077
1.073
1.004
0.972
0.960
0.935
0.930
0.885
0.858
0.769
ZZY200110-2.1.1.1r
ZZY200110-2
HO
OH
O
O
26 (400 MHz, CDCl3)
1.01
1.00
0.99
1.07
1.02
1.99
2.05
2.11
1.16
6.37
4.38
3.04
2.13
3.14
6.02
1.04
3.07
3.00
3.09
1.08
f1 (ppm)

ZZY200110-2.2.1.1r
ZZY200110-2

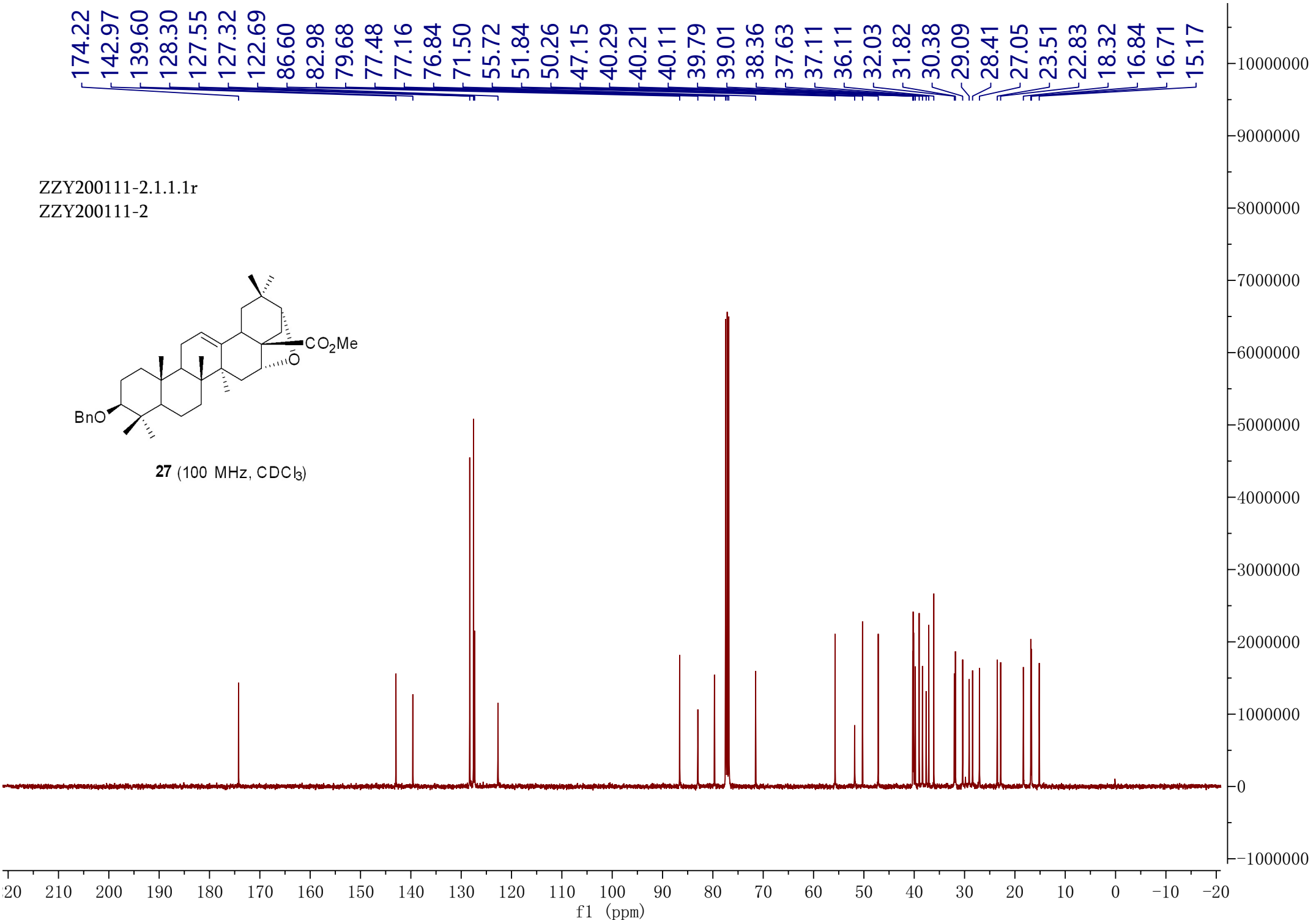


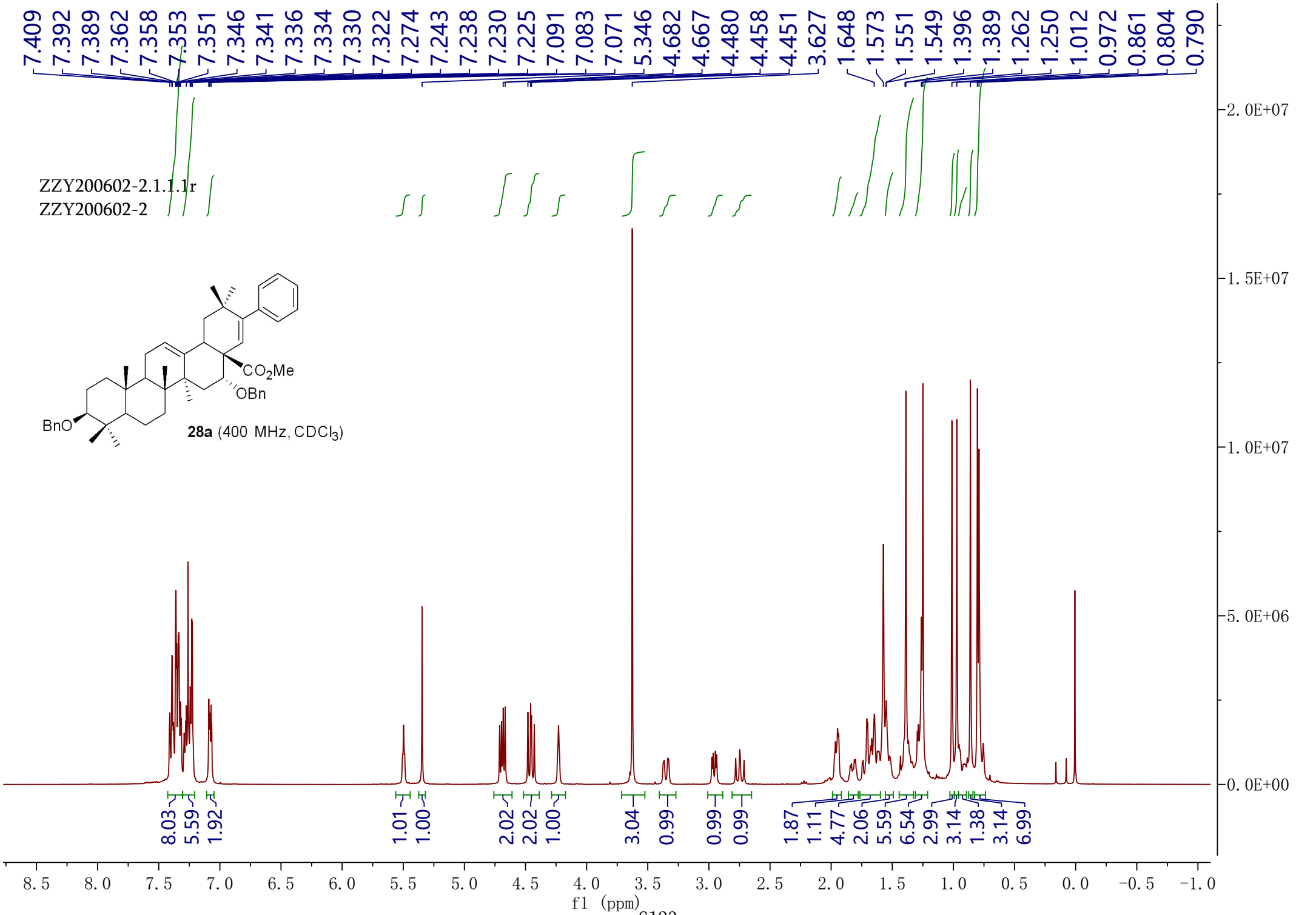
26 (100 MHz, $CDCl_3$)

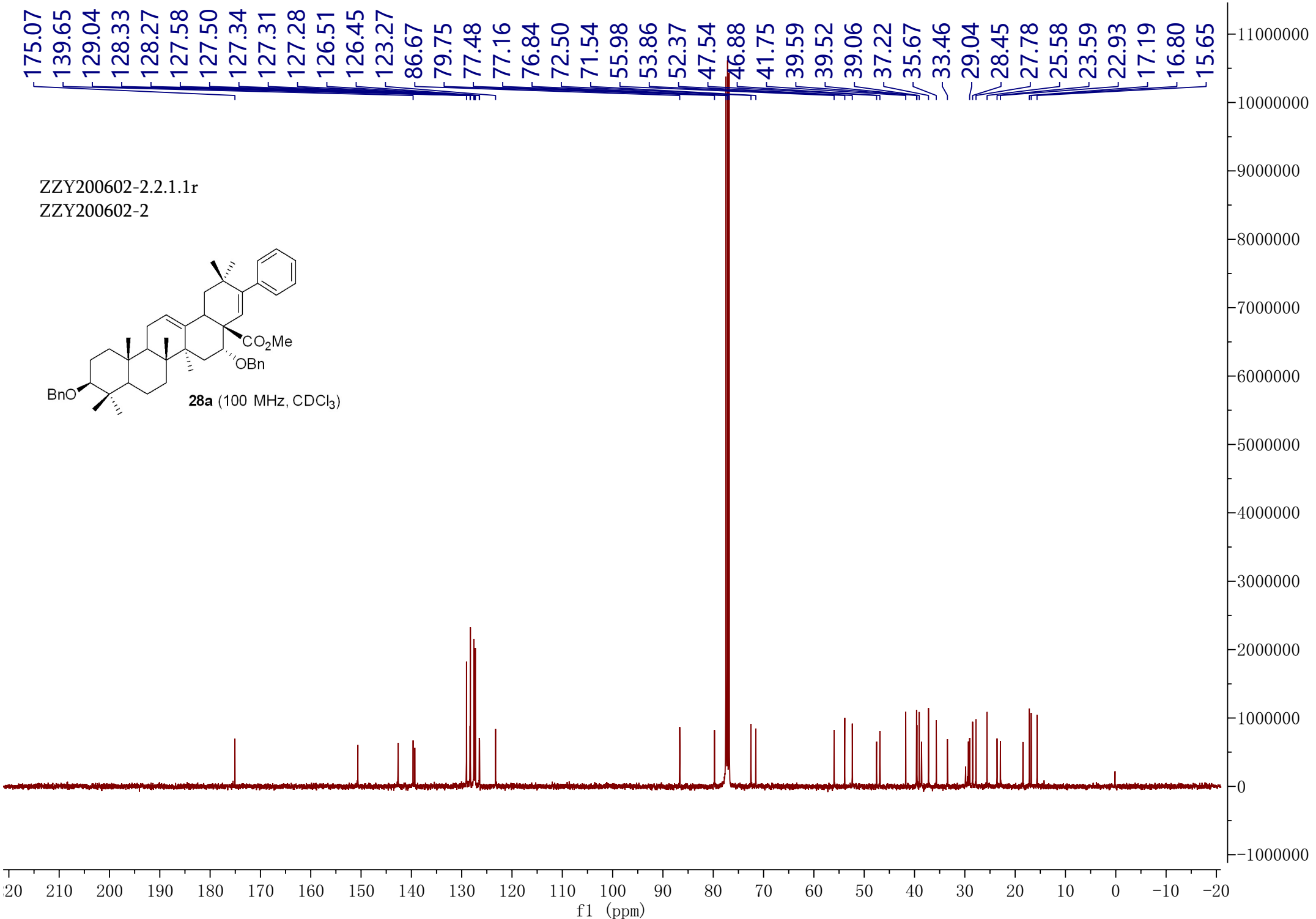
ZZY200111-2.1.1.1r
ZZY200111-2

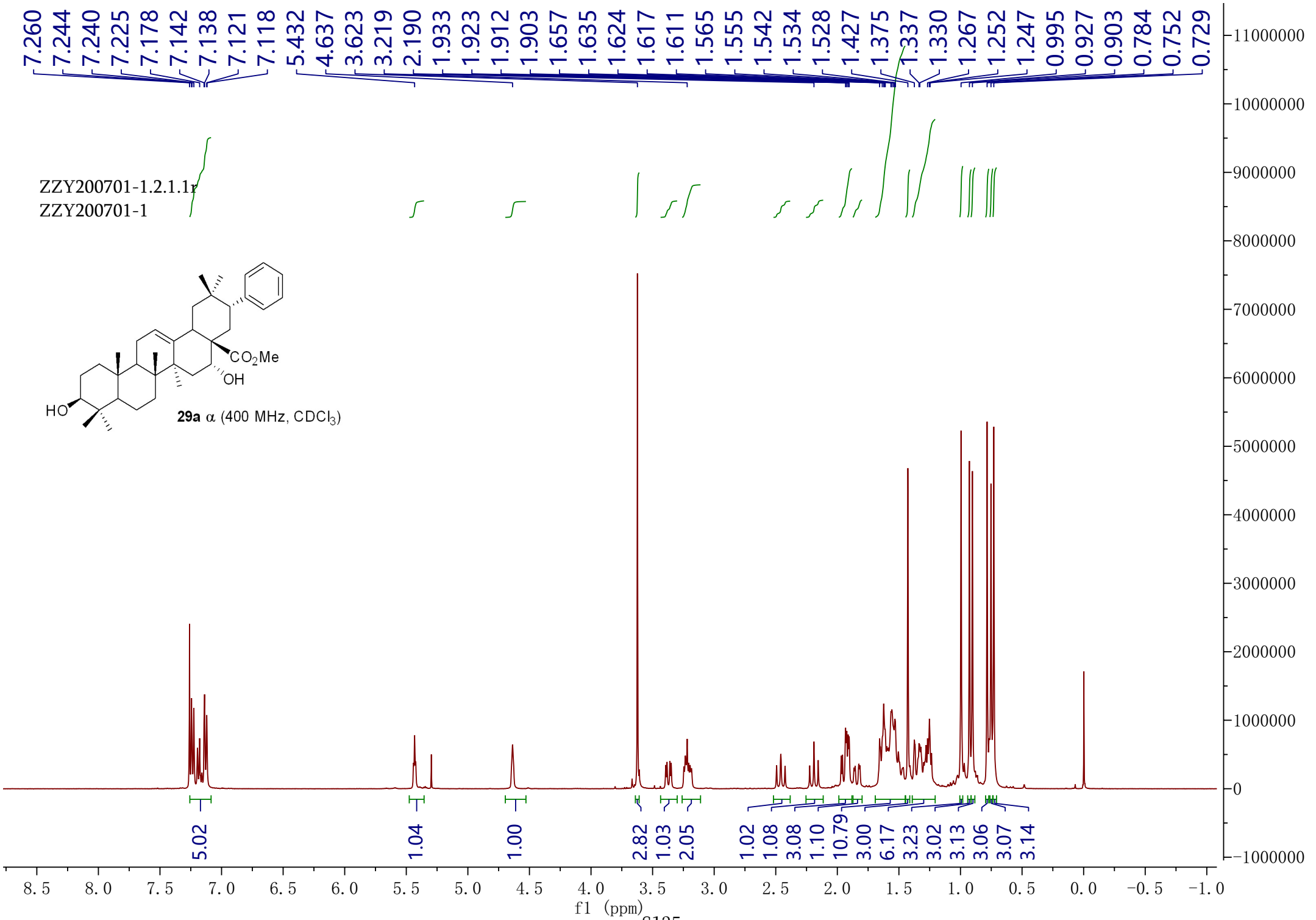


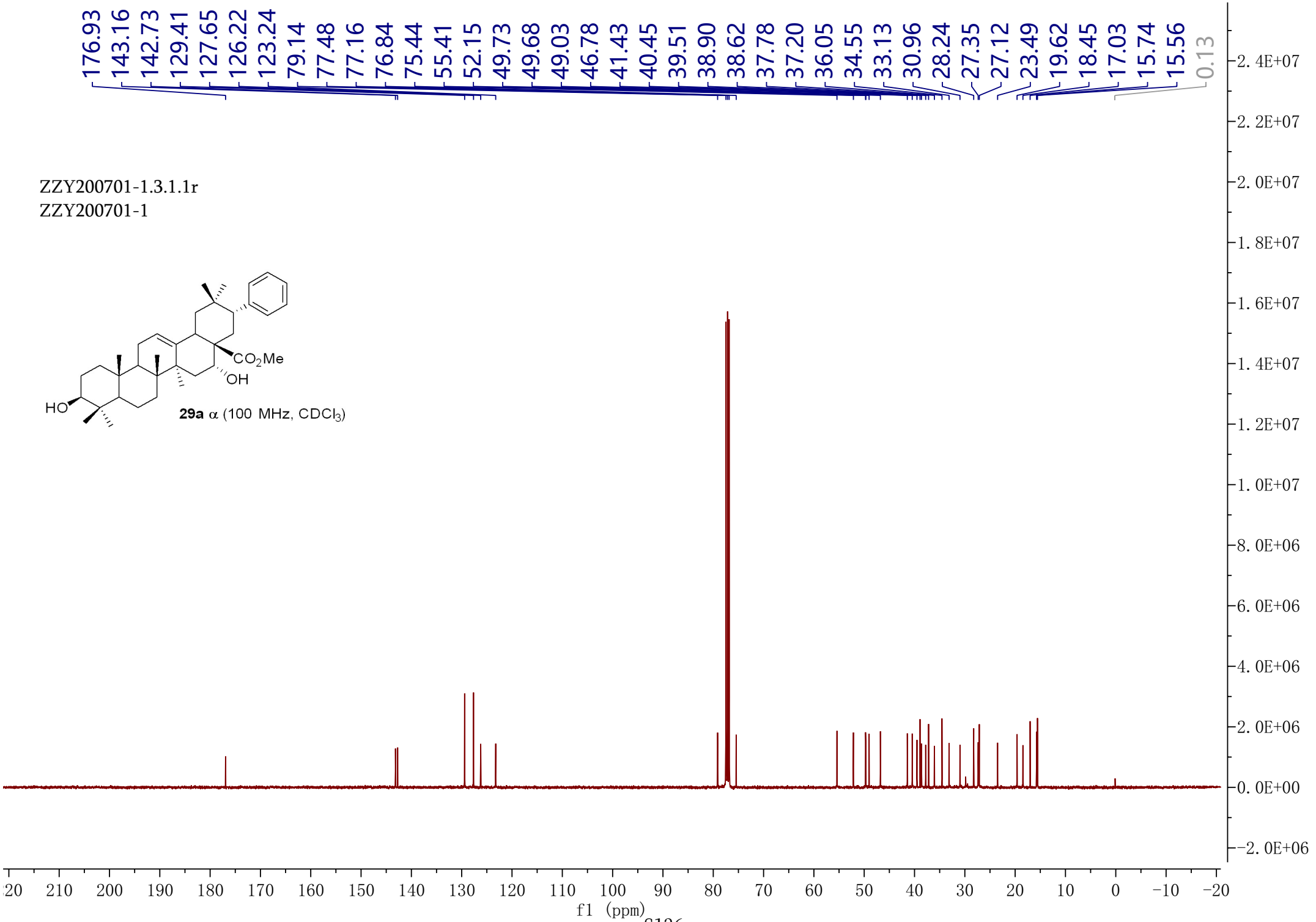
27 (400 MHz, $CDCl_3$)

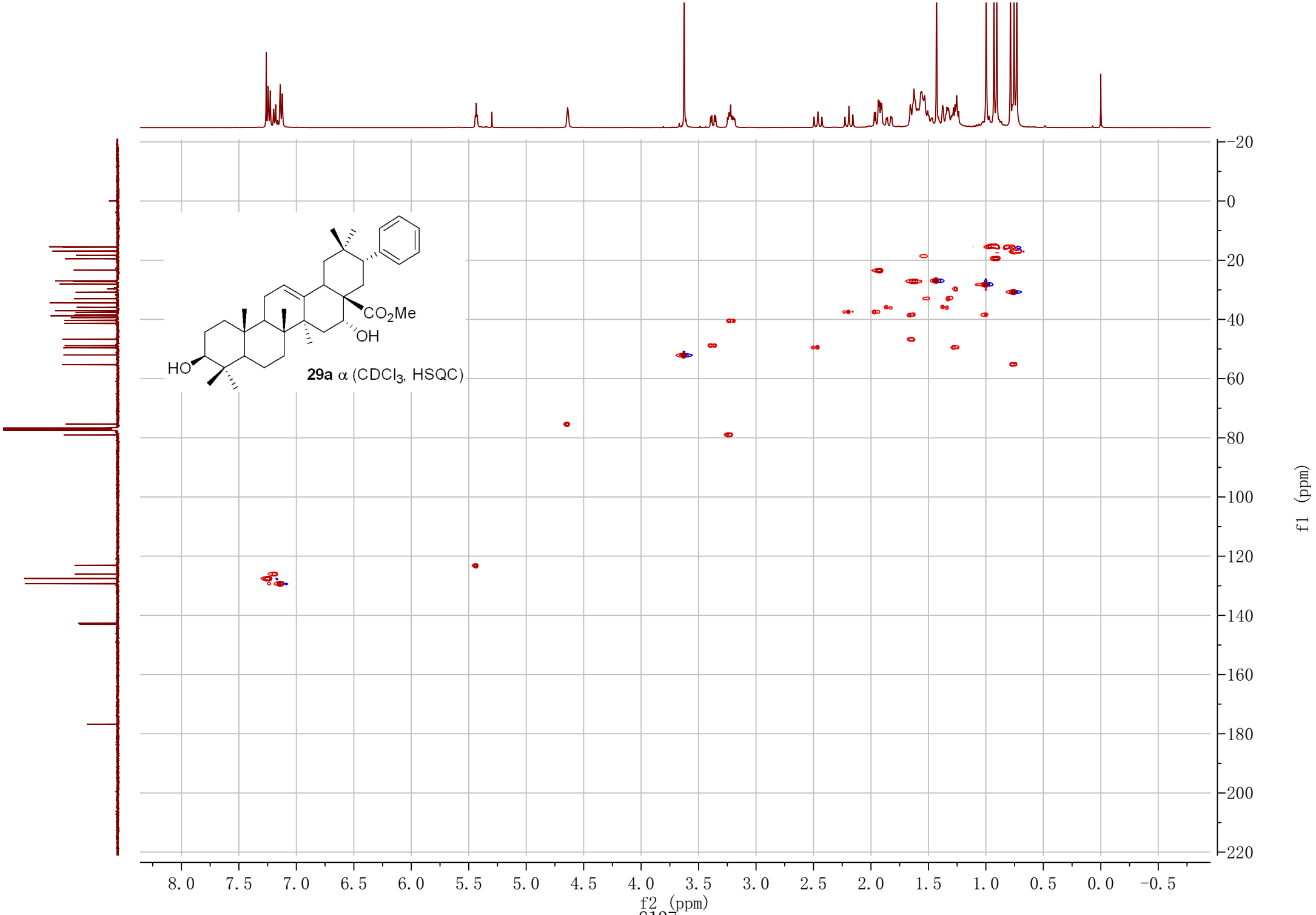

174.22
142.97
139.60
128.30
127.55
127.32
122.69
86.60
82.98
79.68
77.48
77.16
76.84
71.50
55.72
51.84
50.26
47.15
40.29
40.21
40.11
39.79
39.01
38.36
37.63
37.11
36.11
32.03
31.82
30.38
29.09
28.41
27.05
23.51
22.83
18.32
16.84
16.71
15.17
ZZY200111-2.1.1.1r
ZZY200111-2
CO2Me
O
BnO
27 (100 MHz, CDCl3)
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

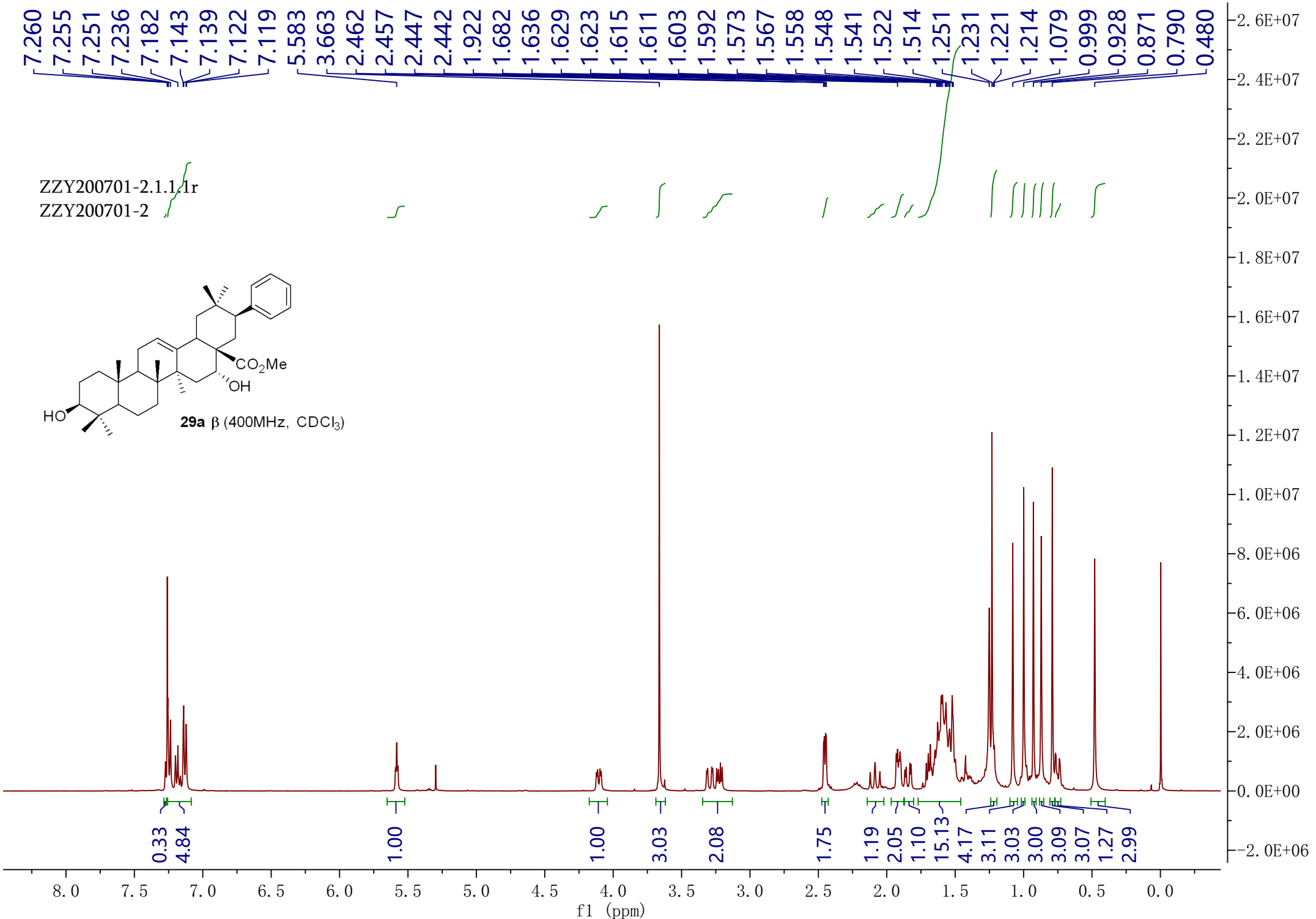

7.409
7.392
7.389
7.362
7.358
7.353
7.351
7.346
7.341
7.336
7.334
7.330
7.322
7.274
7.243
7.238
7.230
7.225
7.091
7.083
7.071
5.346
4.682
4.667
4.480
4.458
4.451
3.627
1.648
1.573
1.551
1.549
1.396
1.389
1.262
1.250
1.012
0.972
0.861
0.804
0.790
ZZY200602-2.1.1.1r
ZZY200602-2
CO2Me
OBn
BnO
28a (400 MHz, CDCl3)
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
8.03
5.59
1.92
1.01
1.00
2.02
2.02
1.00
3.04
0.99
0.99
0.99
1.87
1.11
4.77
2.06
5.59
6.54
2.99
3.14
1.38
3.14
6.99
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)

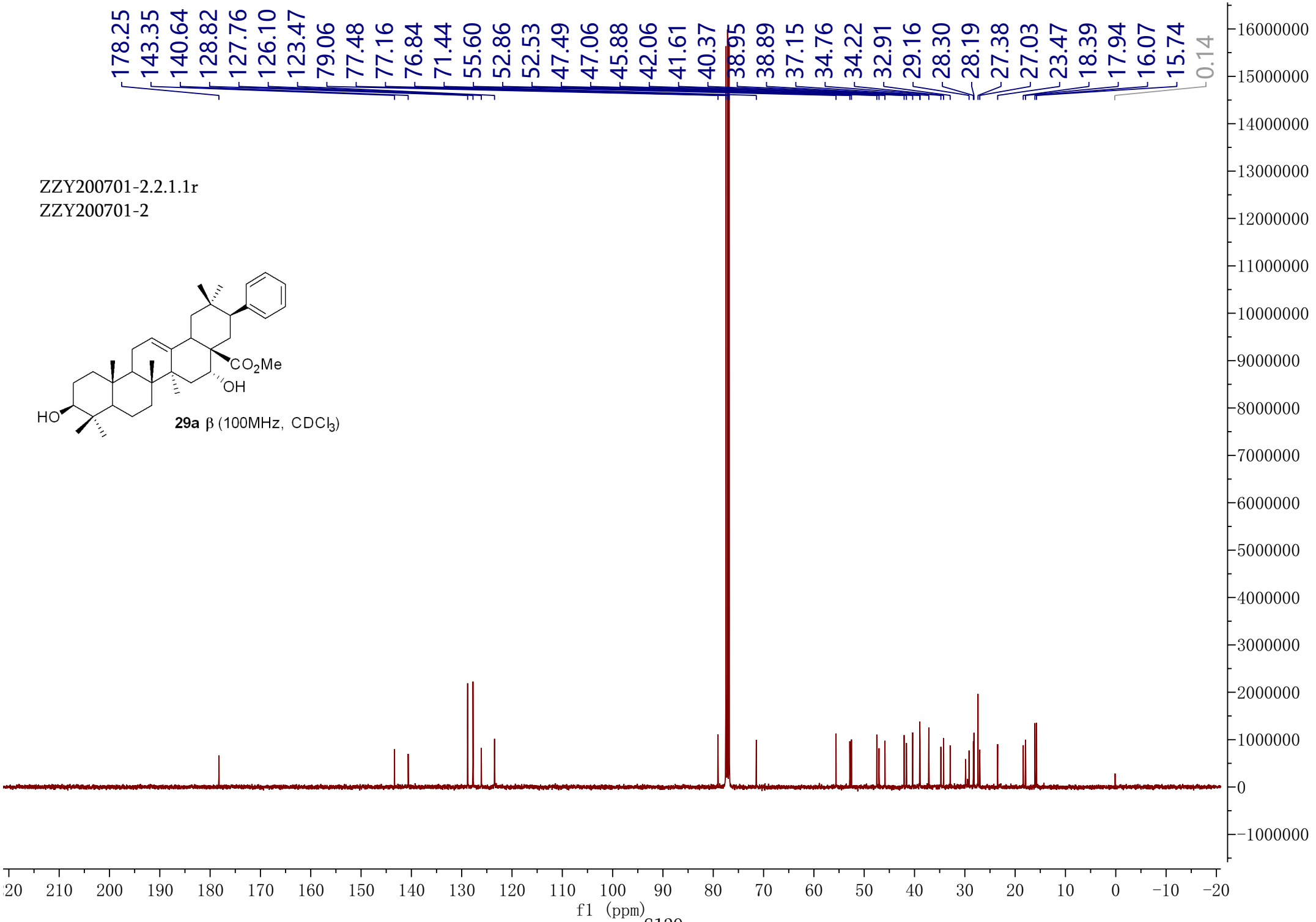

175.07
139.65
129.04
128.33
128.27
127.58
127.50
127.34
127.31
127.28
126.51
126.45
123.27
86.67
79.75
77.48
77.16
76.84
72.50
71.54
55.98
53.86
52.37
47.54
46.88
41.75
39.59
39.52
39.06
37.22
35.67
33.46
29.04
28.45
27.78
25.58
23.59
22.93
17.19
16.80
15.65
ZZY200602-2.2.1.1r
ZZY200602-2
CO2Me
OBn
BnO
28a (100 MHz, CDCl3)
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

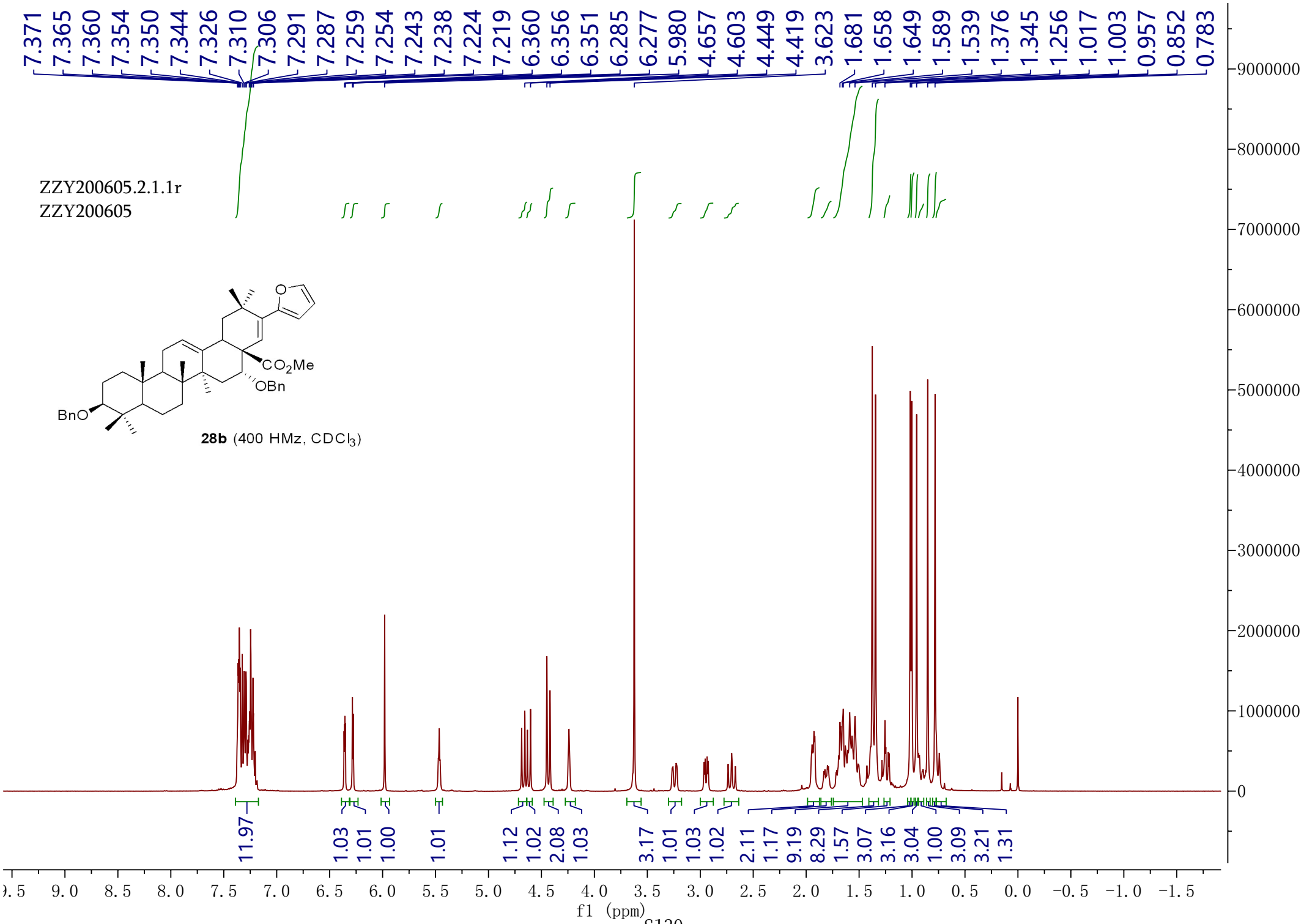

ZZY200701-1.2.1.1r
ZZY200701-1
CO2Me
OH
HO
29a α (400 MHz, CDCl3)
f1 (ppm)

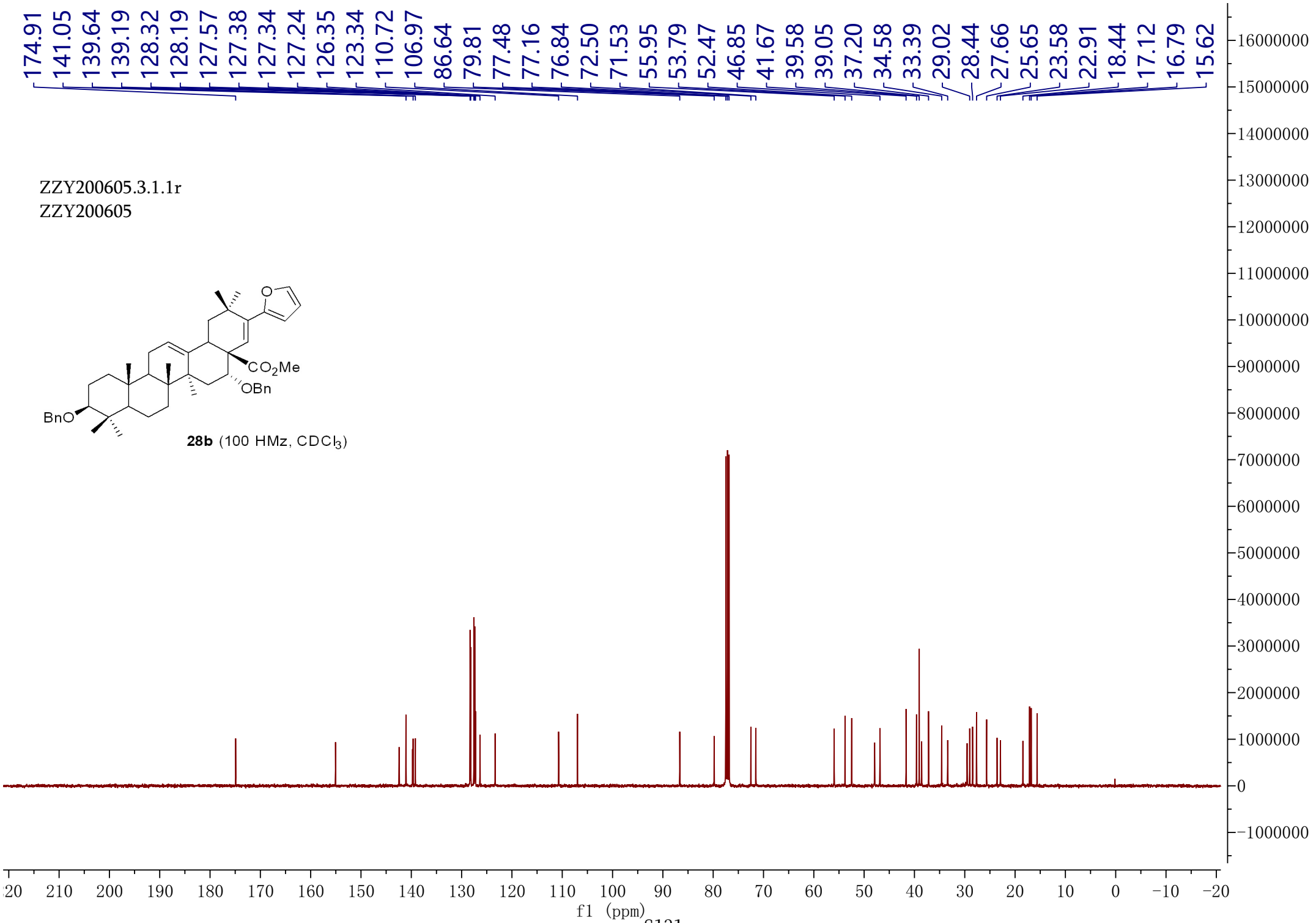

176.93
143.16
142.73
129.41
127.65
126.22
123.24
79.14
77.48
77.16
76.84
75.44
55.41
52.15
49.73
49.68
49.03
46.78
41.43
40.45
39.51
38.90
38.62
37.78
37.20
36.05
34.55
33.13
30.96
28.24
27.35
27.12
23.49
19.62
18.45
17.03
15.74
15.56
0.13
ZZY200701-1.3.1.1r
ZZY200701-1
CO2Me
OH
HO
29a α (100 MHz, CDCl3)
2.4E+07
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
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)

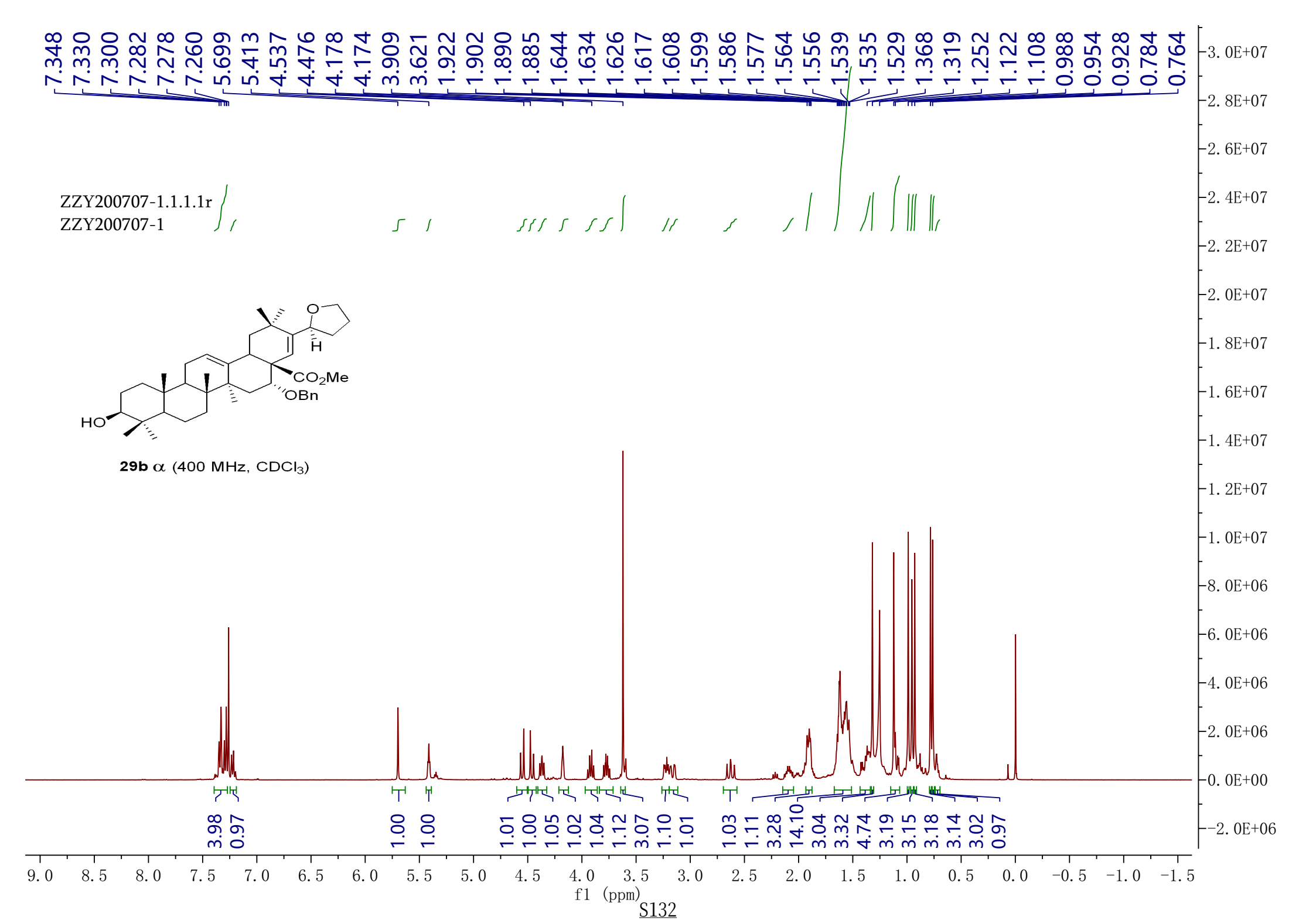

CO2Me
OH
HO
29a α (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

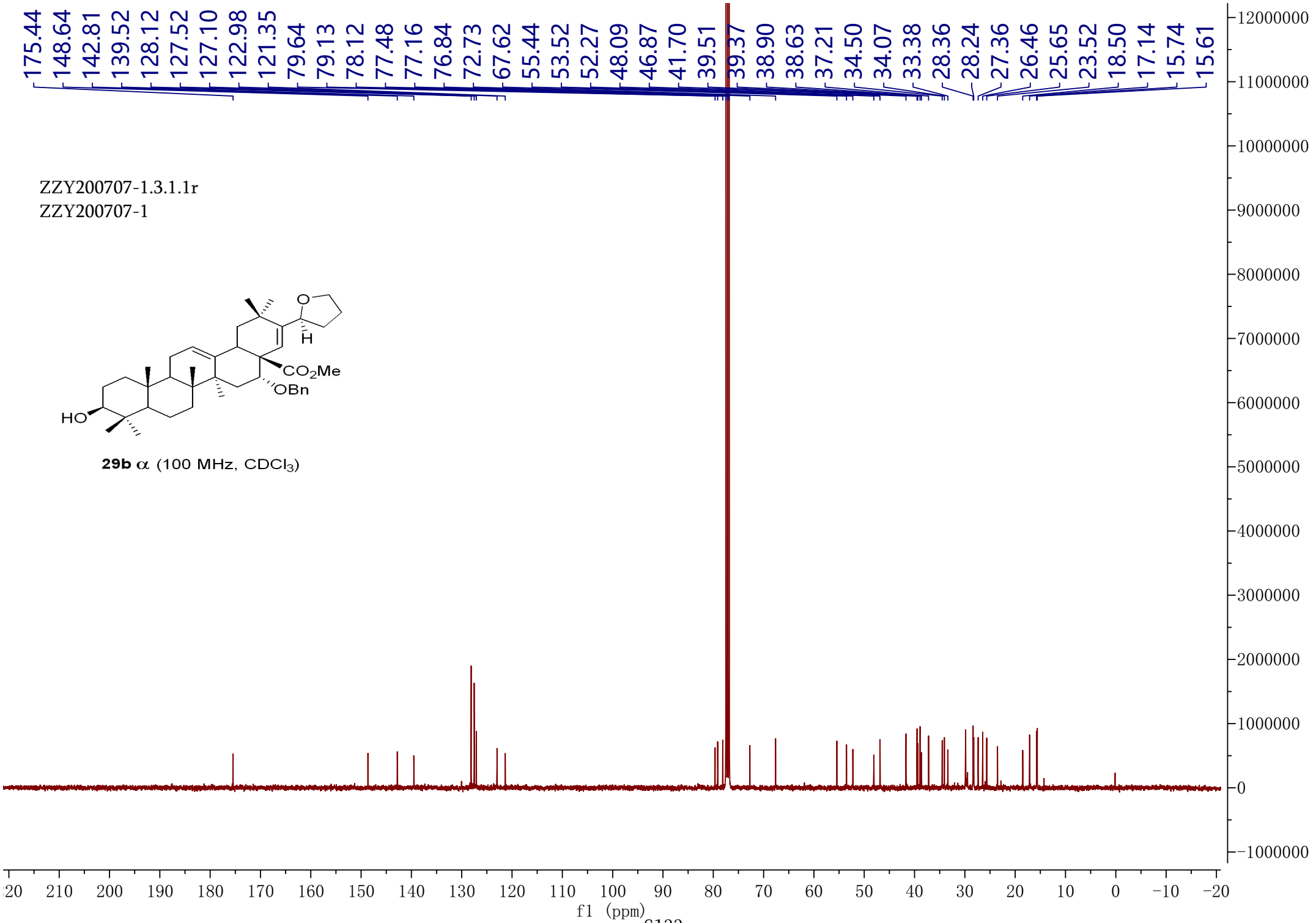

7.260
7.255
7.251
7.236
7.182
7.143
7.139
7.122
7.119
5.583
3.663
2.462
2.457
2.447
2.442
1.922
1.682
1.636
1.629
1.623
1.615
1.611
1.603
1.592
1.573
1.567
1.558
1.548
1.541
1.522
1.514
1.251
1.231
1.221
1.214
1.079
0.999
0.928
0.871
0.790
0.480
ZZY200701-2.1.1.1r
ZZY200701-2
CO2Me
OH
HO
29a β (400MHz, CDCl3)
0.33
4.84
1.00
1.00
3.03
2.08
1.75
1.19
2.05
1.10
15.13
4.17
3.11
3.03
3.00
3.09
3.07
1.27
2.99
f1 (ppm)

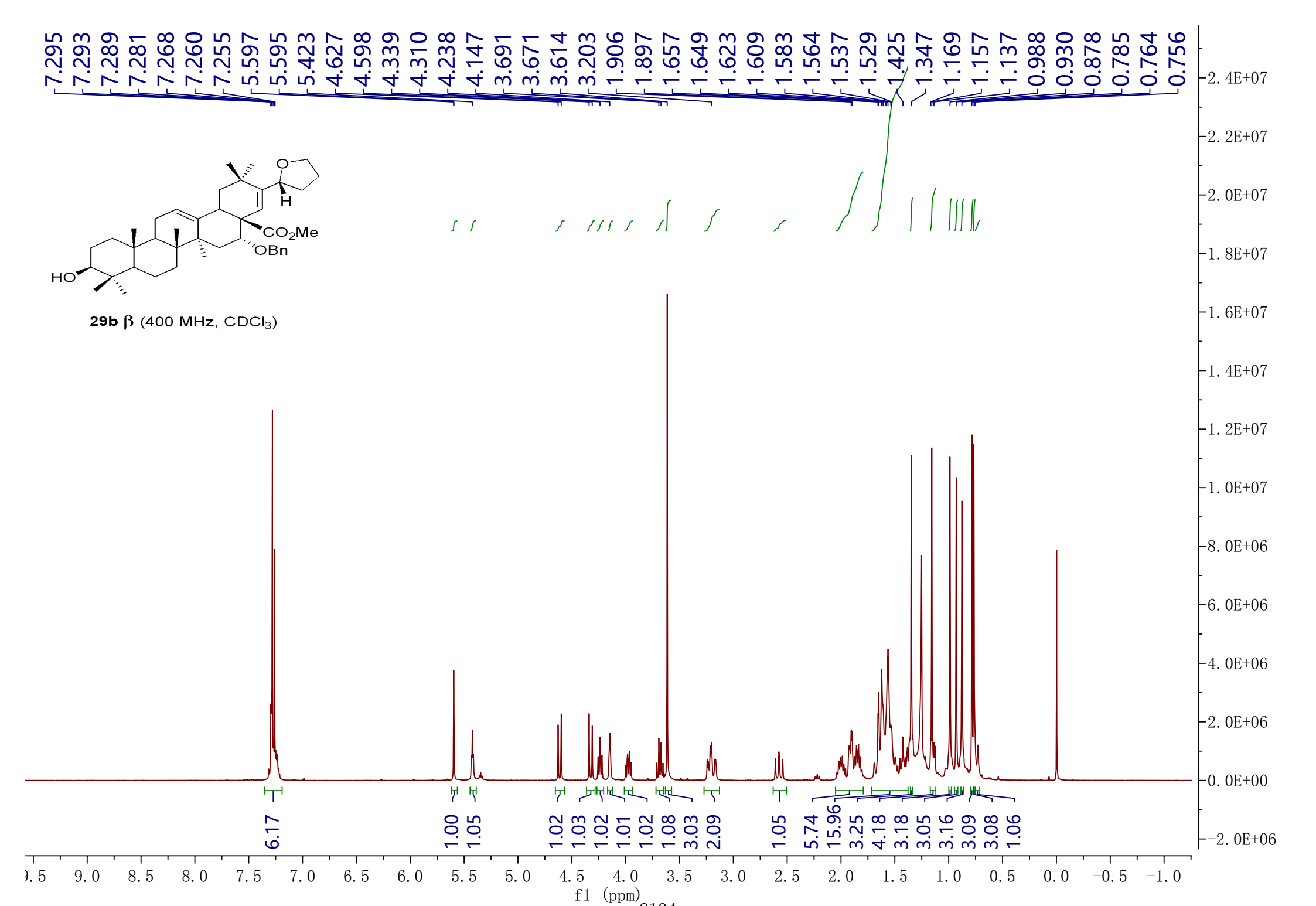

178.25
143.35
140.64
128.82
127.76
126.10
123.47
79.06
77.48
77.16
76.84
71.44
55.60
52.86
52.53
47.49
47.06
45.88
42.06
41.61
40.37
38.95
38.89
37.15
34.76
34.22
32.91
29.16
28.30
28.19
27.38
27.03
23.47
18.39
17.94
16.07
15.74
0.14
ZZY200701-2.2.1.1r
ZZY200701-2
CO2Me
OH
HO
29a β (100MHz, CDCl3)
f1 (ppm)

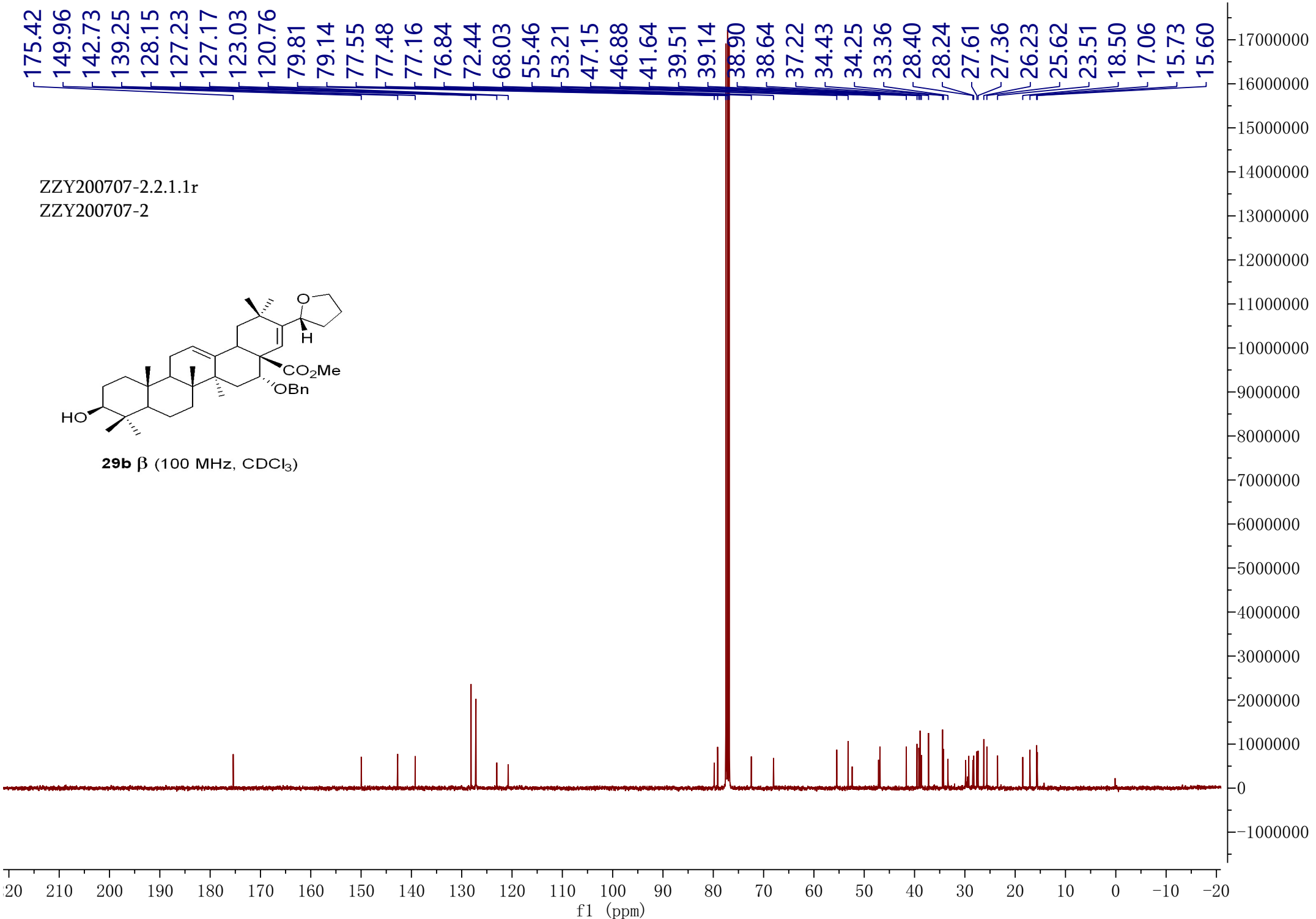

7.371
7.365
7.360
7.354
7.350
7.344
7.326
7.310
7.306
7.291
7.287
7.259
7.254
7.243
7.238
7.224
7.219
6.360
6.356
6.351
6.285
6.277
5.980
4.657
4.603
4.449
4.419
3.623
1.681
1.658
1.649
1.589
1.539
1.376
1.345
1.256
1.017
1.003
0.957
0.852
0.783
ZZY200605.2.1.1r
ZZY200605
CO2Me
OBn
BnO
28b (400 HMz, CDCl3)
11.97
1.03
1.01
1.00
1.01
1.12
1.02
2.08
1.03
3.17
1.01
1.03
1.02
2.11
1.17
9.19
8.29
1.57
3.07
3.16
3.04
1.00
3.09
3.21
1.31
f1 (ppm)

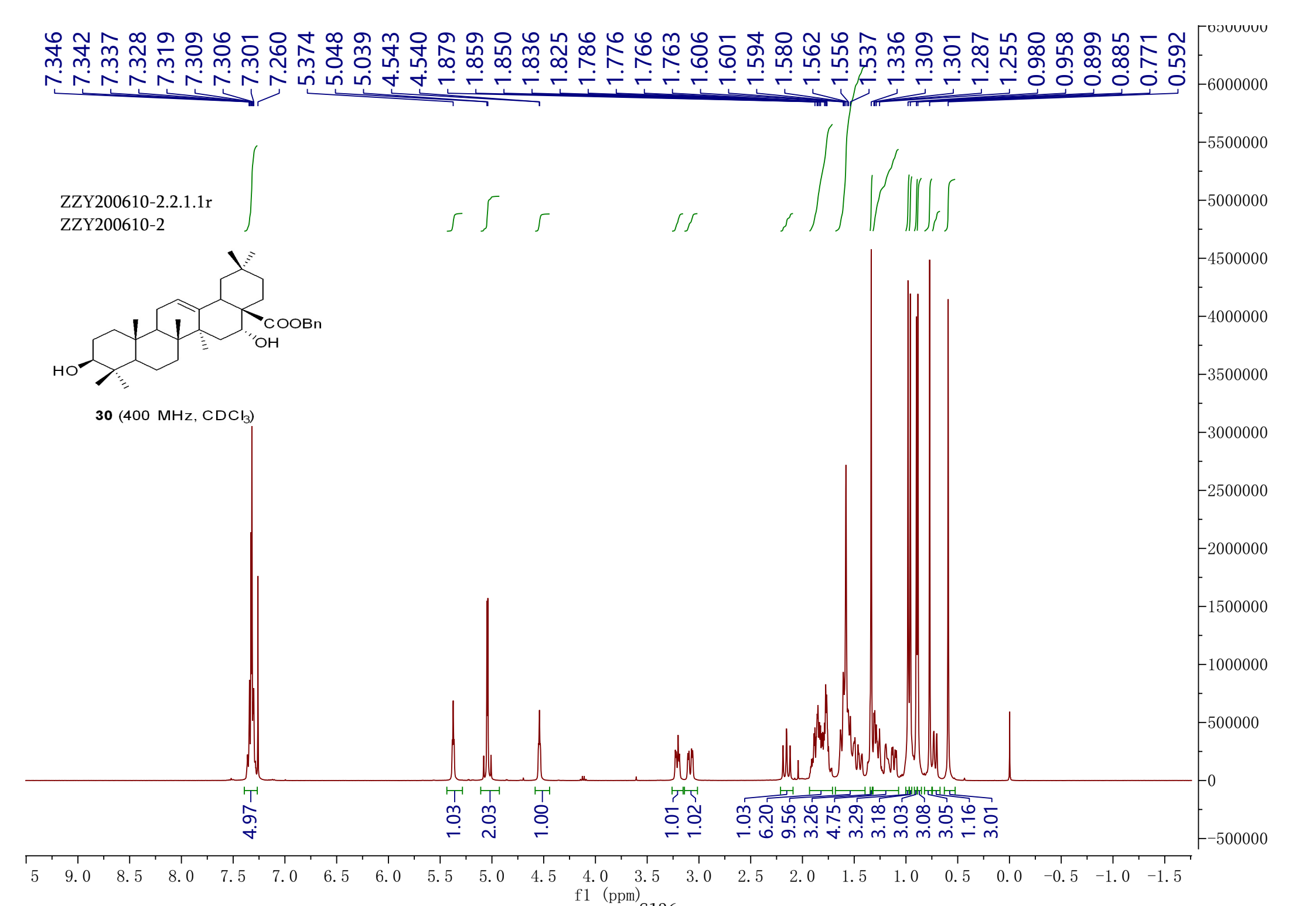

174.91
141.05
139.64
139.19
128.32
128.19
127.57
127.38
127.34
127.24
126.35
123.34
110.72
106.97
86.64
79.81
77.48
77.16
76.84
72.50
71.53
55.95
53.79
52.47
46.85
41.67
39.58
39.05
37.20
34.58
33.39
29.02
28.44
27.66
25.65
23.58
22.91
18.44
17.12
16.79
15.62
ZZY200605.3.1.1r
ZZY200605
O
CO2Me
OBn
BnO
28b (100 HMz, CDCl3)
16000000
15000000
14000000
13000000
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

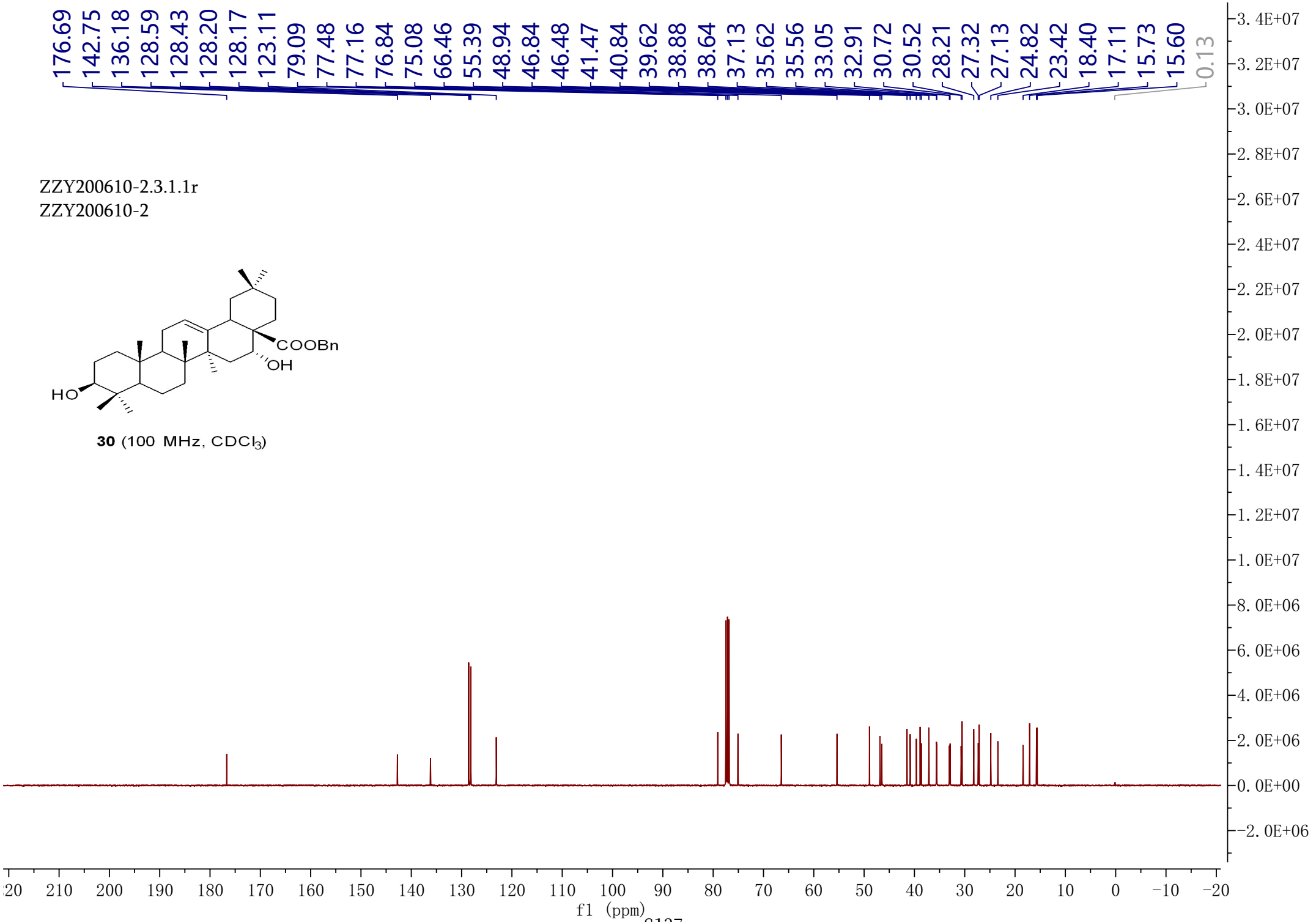

7.348
7.330
7.300
7.282
7.278
7.260
5.699
5.413
4.537
4.476
4.178
4.174
3.909
3.621
1.922
1.902
1.890
1.885
1.644
1.634
1.626
1.617
1.608
1.599
1.586
1.577
1.564
1.556
1.539
1.535
1.529
1.368
1.319
1.252
1.122
1.108
0.988
0.954
0.928
0.784
0.764
ZZY200707-1.1.1.1r
ZZY200707-1
O
H
CO2Me
OBn
HO
29b α (400 MHz, CDCl3)
3.98
0.97
1.00
1.00
1.01
1.00
1.05
1.02
1.04
1.12
3.07
1.10
1.01
1.03
1.11
3.28
14.10
3.04
3.32
4.74
3.19
3.15
3.18
3.14
3.02
0.97
f1 (ppm)

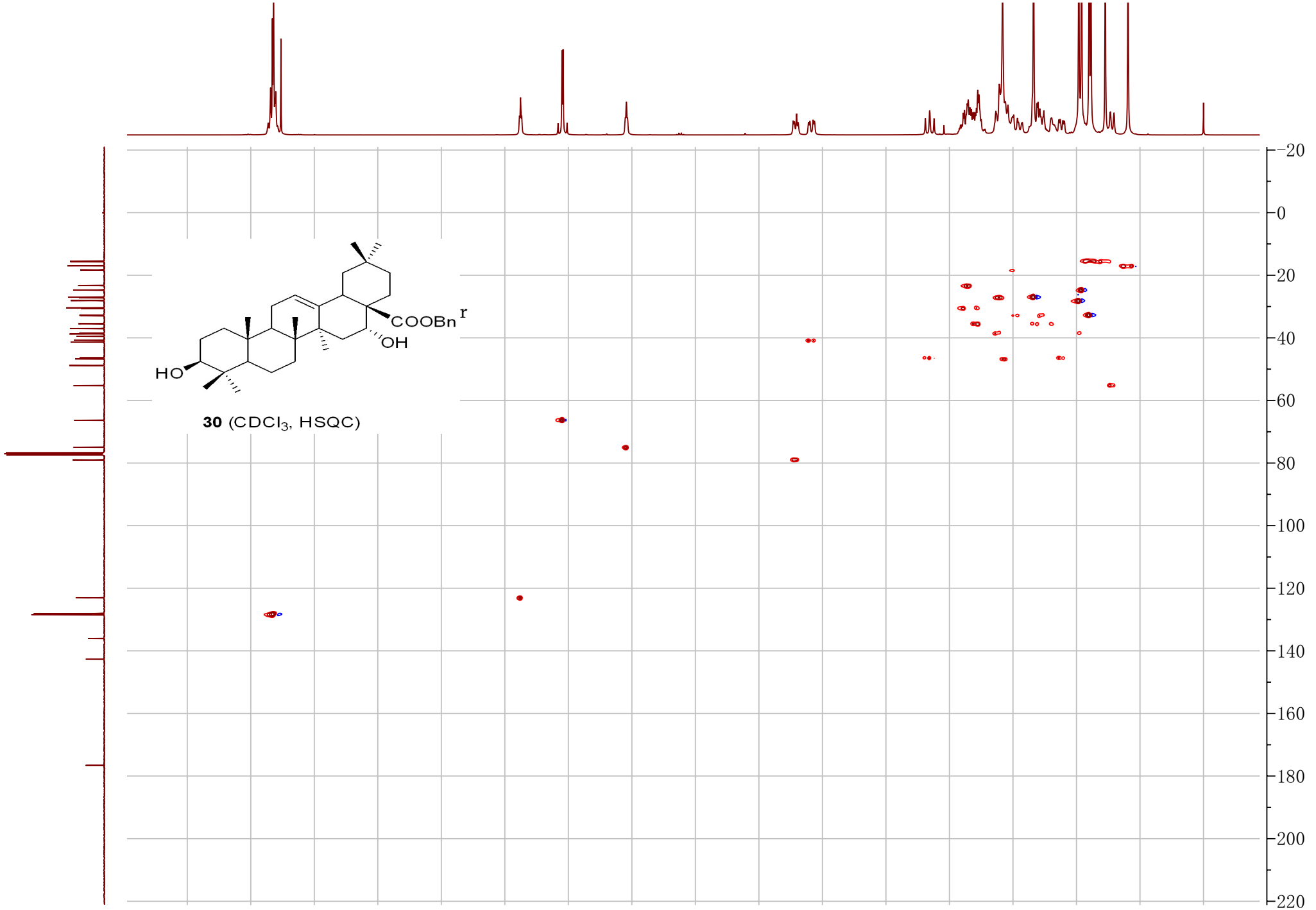

175.44
148.64
142.81
139.52
128.12
127.52
127.10
122.98
121.35
79.64
79.13
78.12
77.48
77.16
76.84
72.73
67.62
55.44
53.52
52.27
48.09
46.87
41.70
39.51
39.37
38.90
38.63
37.21
34.50
34.07
33.38
28.36
28.24
27.36
26.46
25.65
23.52
18.50
17.14
15.74
15.61
ZZY200707-1.3.1.1r
ZZY200707-1
O
H
CO2Me
OBn
HO
29b α (100 MHz, CDCl3)
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

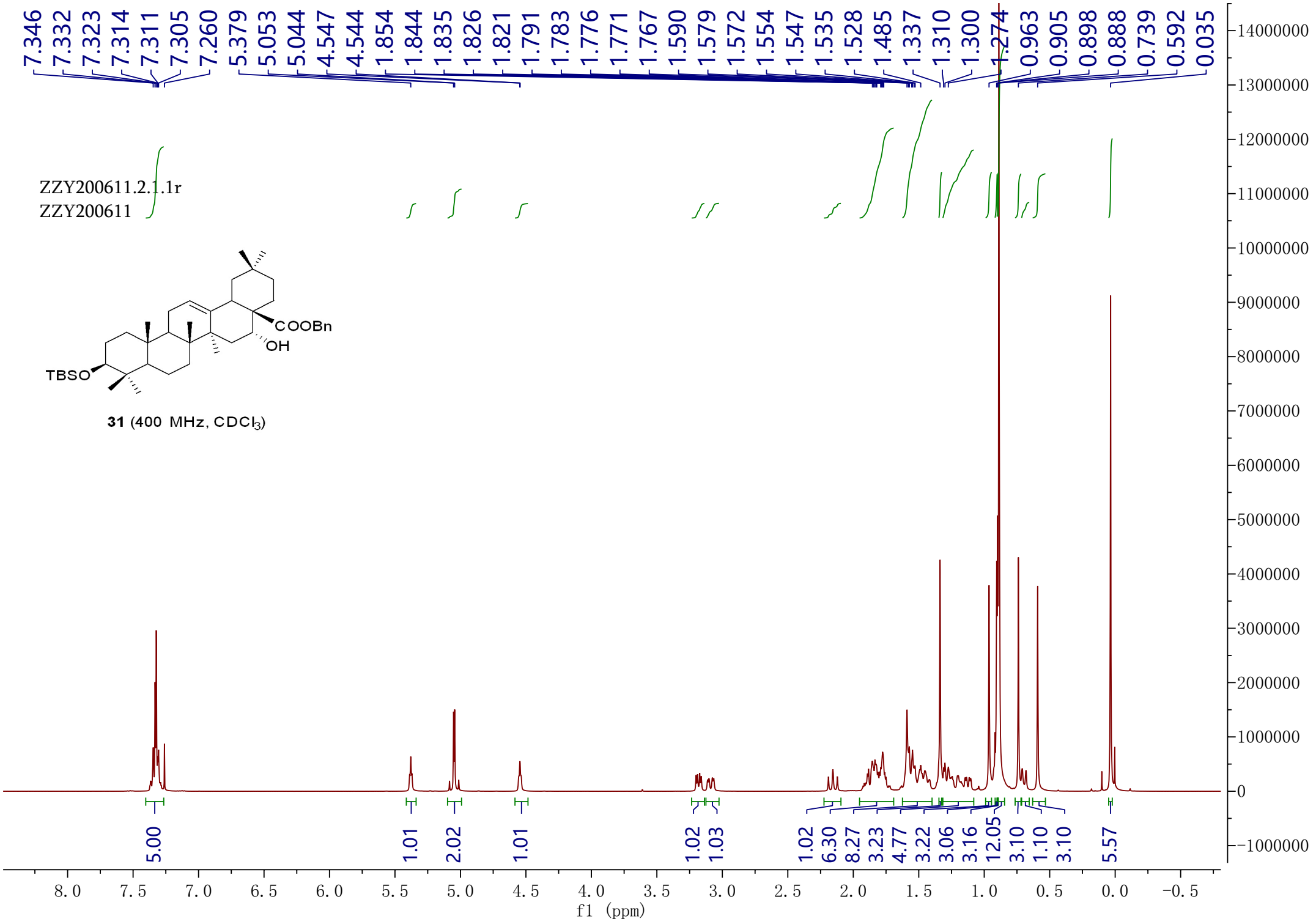

7.295
7.293
7.289
7.281
7.268
7.260
7.255
5.597
5.595
5.423
4.627
4.598
4.339
4.310
4.238
4.147
3.691
3.671
3.614
3.203
1.906
1.897
1.657
1.649
1.623
1.609
1.583
1.564
1.537
1.529
1.425
1.347
1.169
1.157
1.137
0.988
0.930
0.878
0.785
0.764
0.756
O
H
CO2Me
OBn
HO
29b β (400 MHz, CDCl3)
2.4E+07
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
6.17
1.00
1.05
1.02
1.03
1.02
1.01
1.02
1.08
3.03
2.09
1.05
5.74
15.96
3.25
4.18
3.18
3.05
3.16
3.09
3.08
1.06
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)

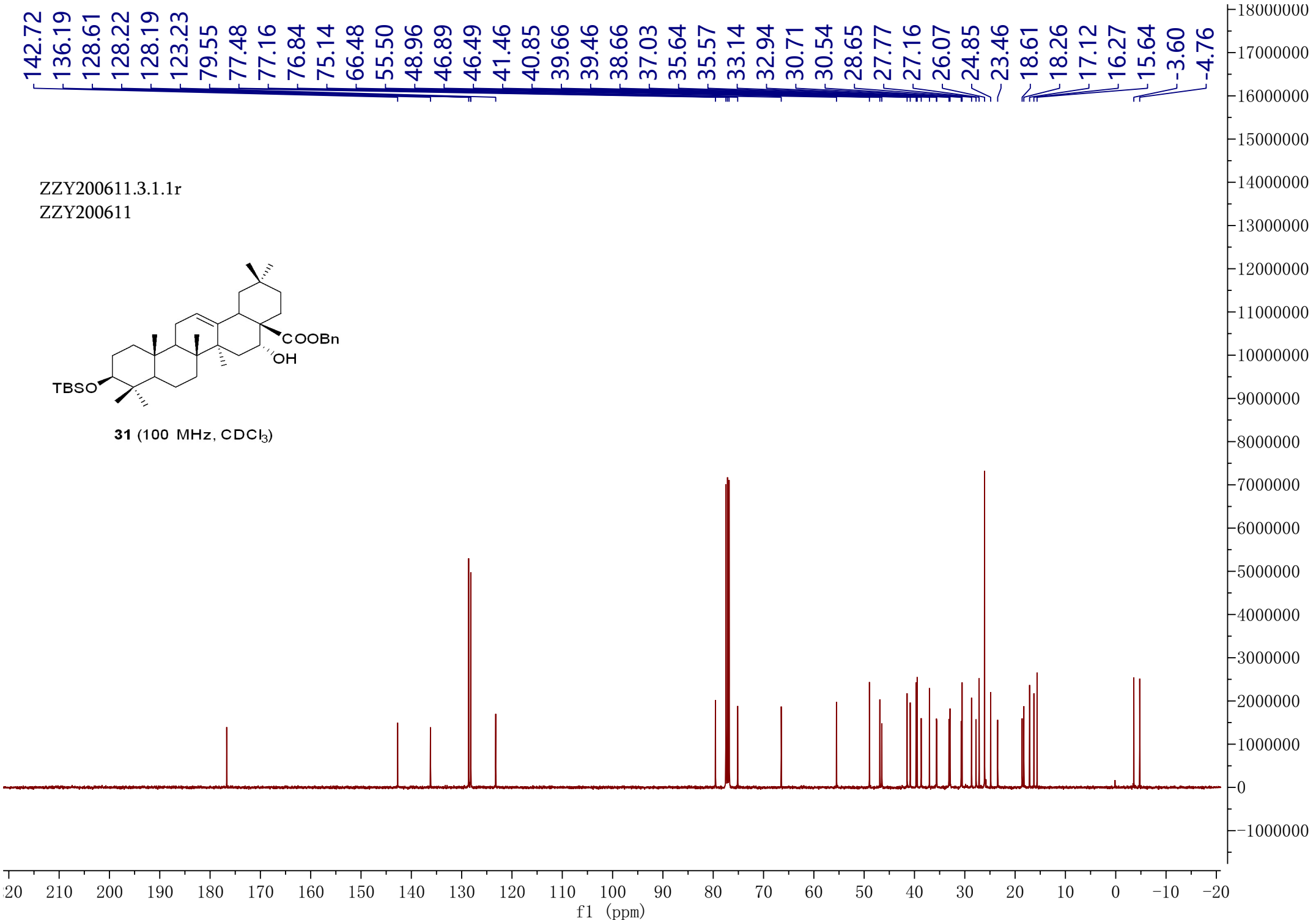

175.42
149.96
142.73
139.25
128.15
127.23
127.17
123.03
120.76
79.81
79.14
77.55
77.48
77.16
76.84
72.44
68.03
55.46
53.21
47.15
46.88
41.64
39.51
39.14
38.90
38.64
37.22
34.43
34.25
33.36
28.40
28.24
27.61
27.36
26.23
25.62
23.51
18.50
17.06
15.73
15.60
ZZY200707-2.2.1.1r
ZZY200707-2
O
H
CO2Me
OBn
HO
29b β (100 MHz, CDCl3)
17000000
16000000
15000000
14000000
13000000
12000000
11000000
10000000
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
−1000000
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)

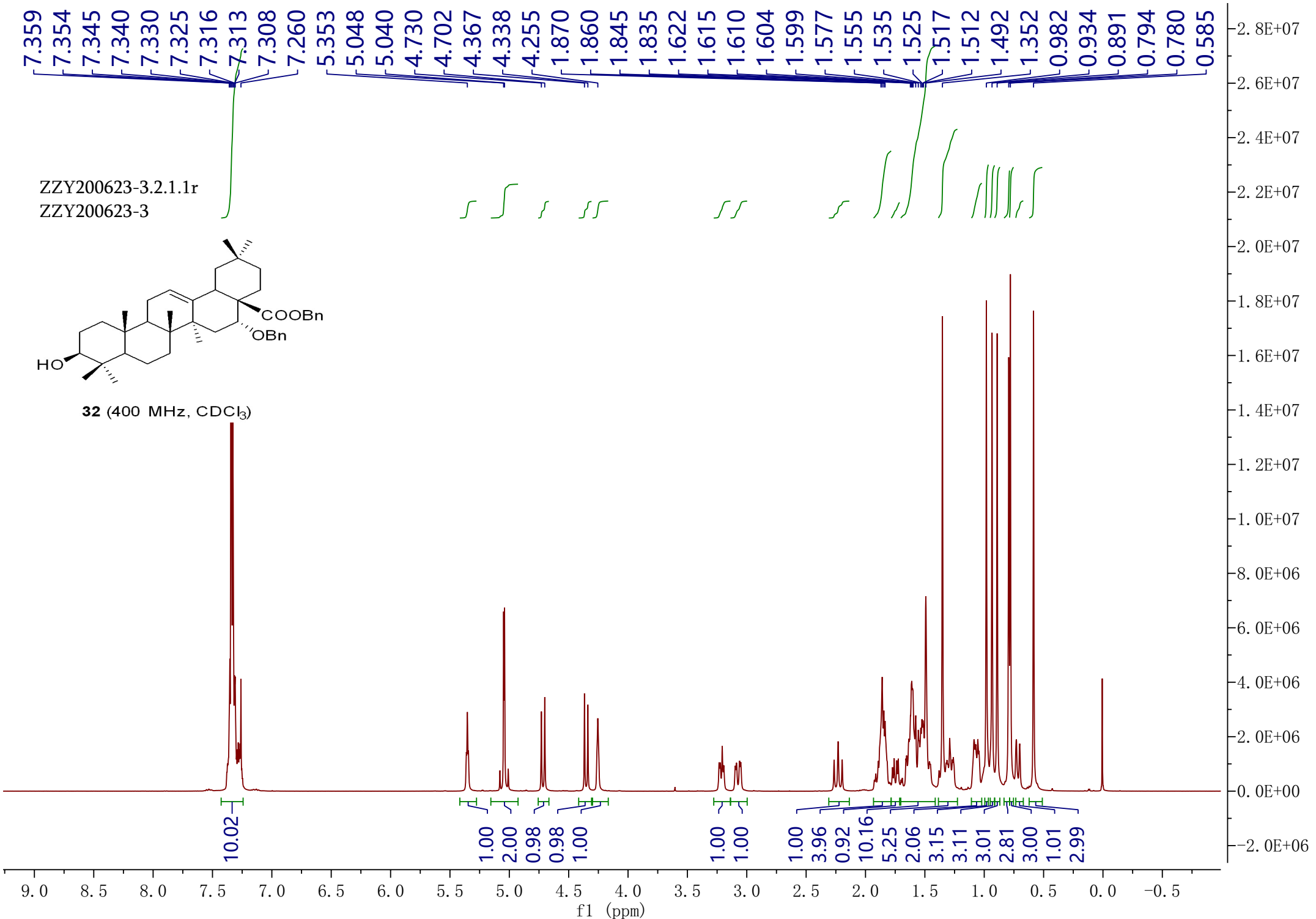

7.346
7.342
7.337
7.328
7.319
7.309
7.306
7.301
7.260
5.374
5.048
5.039
4.543
4.540
1.879
1.859
1.850
1.836
1.825
1.786
1.776
1.766
1.763
1.606
1.601
1.594
1.580
1.562
1.556
1.537
1.336
1.309
1.301
1.287
1.255
0.980
0.958
0.899
0.885
0.771
0.592
ZZY200610-2.2.1.1r
ZZY200610-2
COOBn
OH
HO
30 (400 MHz, CDCl3)
4.97
1.03
2.03
1.00
1.01
1.02
1.03
6.20
9.56
3.26
4.75
3.29
3.18
3.03
3.08
3.05
1.16
3.01
f1 (ppm)

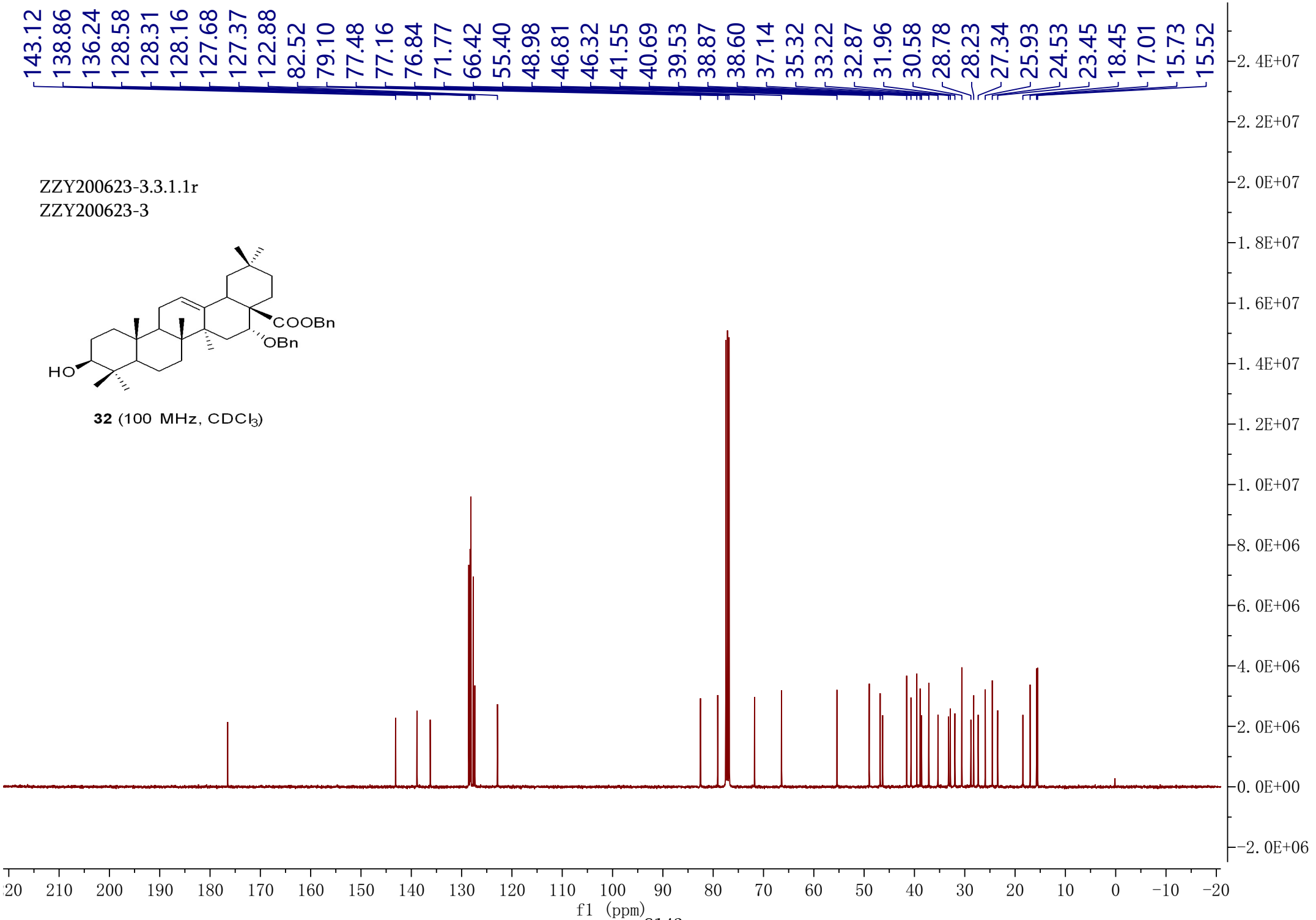

176.69
142.75
136.18
128.59
128.43
128.20
128.17
123.11
79.09
77.48
77.16
76.84
75.08
66.46
55.39
48.94
46.84
46.48
41.47
40.84
39.62
38.88
38.64
37.13
35.62
35.56
33.05
32.91
30.72
30.52
28.21
27.32
27.13
24.82
23.42
18.40
17.11
15.73
15.60
0.13
ZZY200610-2.3.1.1r
ZZY200610-2
COOBn
OH
HO
30 (100 MHz, CDCl3)
3.4E+07
3.2E+07
3.0E+07
2.8E+07
2.6E+07
2.4E+07
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
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)

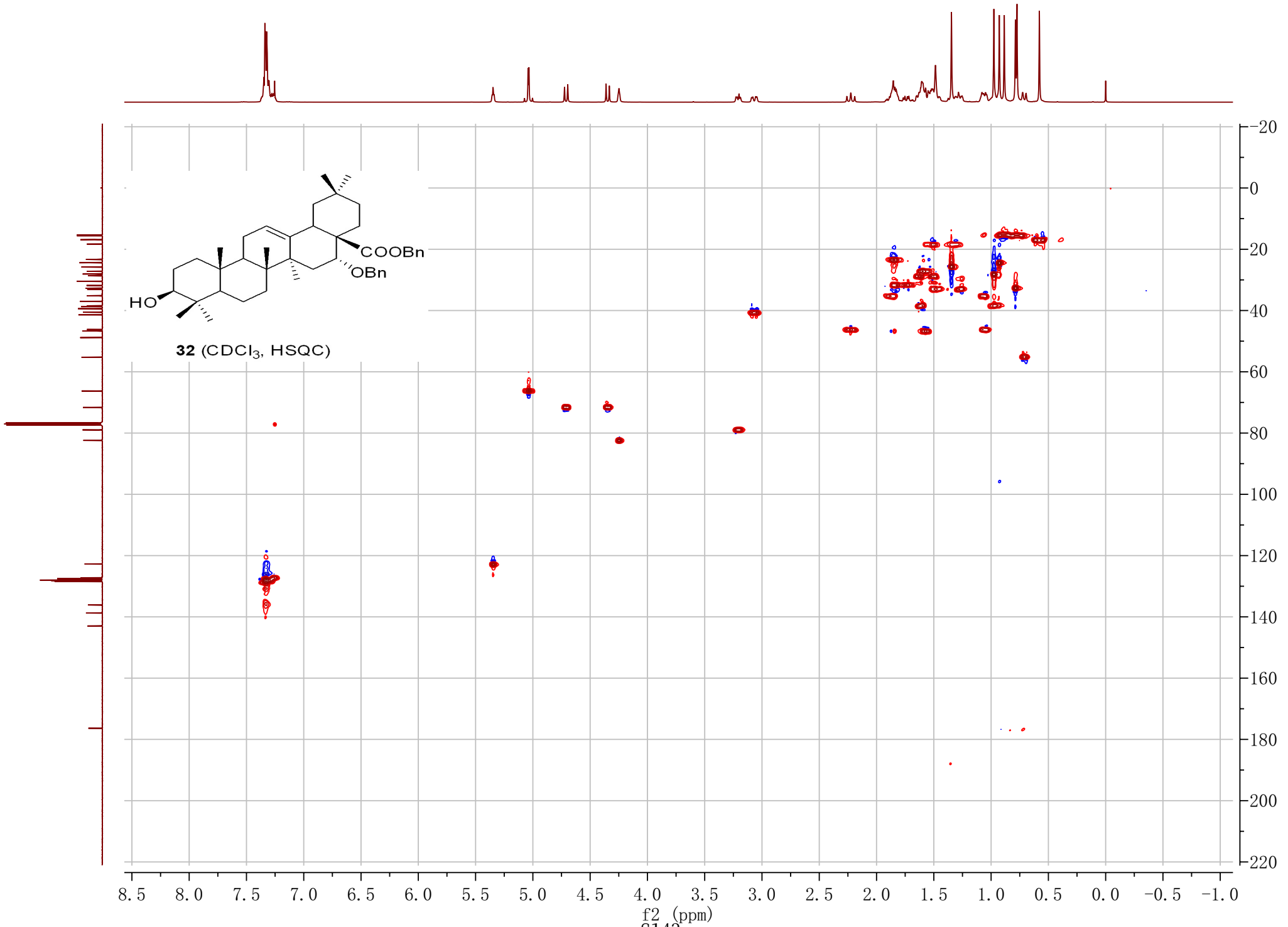

COOBn
OH
HO
30 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

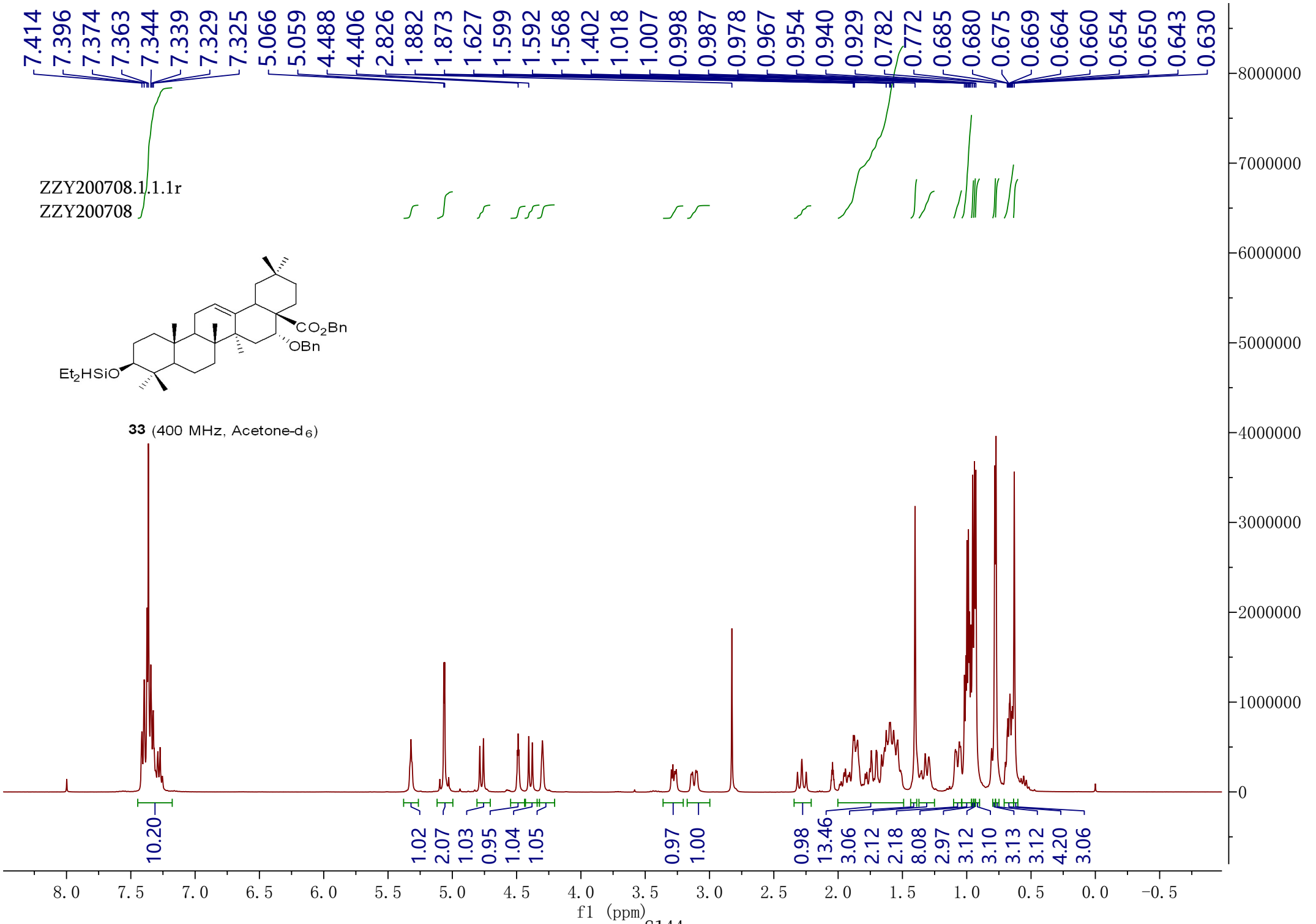

7.346
7.332
7.323
7.314
7.311
7.305
7.260
5.379
5.053
5.044
4.547
4.544
1.854
1.844
1.835
1.826
1.821
1.791
1.783
1.776
1.771
1.767
1.590
1.579
1.572
1.554
1.547
1.535
1.528
1.485
1.337
1.310
1.300
1.274
0.963
0.905
0.898
0.888
0.739
0.592
0.035
ZZY200611.2.1.1r
ZZY200611
COOBn
OH
TBSO
31 (400 MHz, CDCl3)
5.00
1.01
2.02
1.01
1.02
1.03
1.02
6.30
8.27
3.23
4.77
3.22
3.06
3.16
12.05
3.10
1.10
3.10
5.57
f1 (ppm)

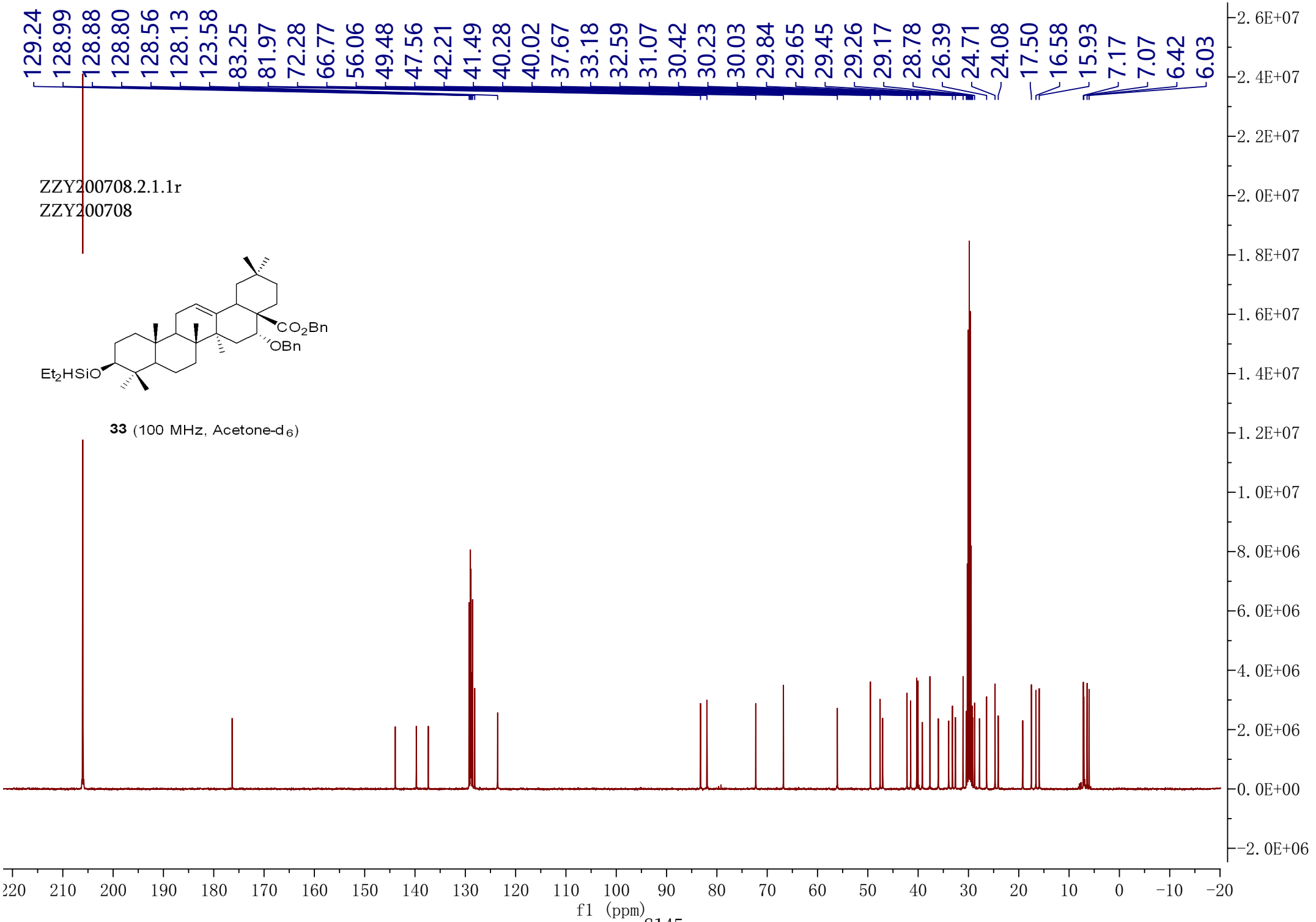

142.72
136.19
128.61
128.22
128.19
123.23
79.55
77.48
77.16
76.84
75.14
66.48
55.50
48.96
46.89
46.49
41.46
40.85
39.66
39.46
38.66
37.03
35.64
35.57
33.14
32.94
30.71
30.54
28.65
27.77
27.16
26.07
24.85
23.46
18.61
18.26
17.12
16.27
15.64
-3.60
-4.76
ZZY200611.3.1.1r
ZZY200611
COOBn
OH
TBSO
31 (100 MHz, CDCl3)
f1 (ppm)

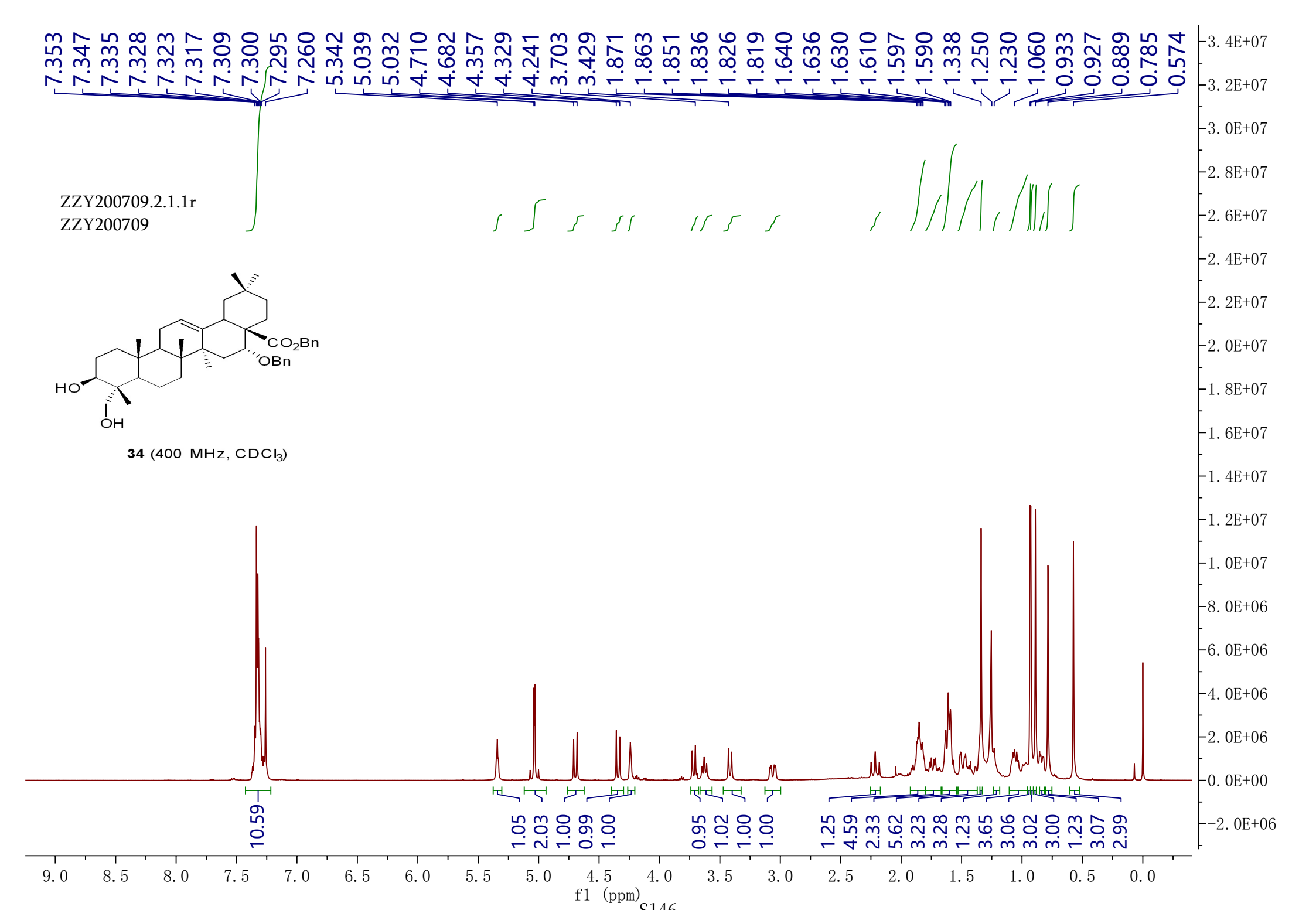

7.359
7.354
7.345
7.340
7.330
7.325
7.316
7.313
7.308
7.260
5.353
5.048
5.040
4.730
4.702
4.367
4.338
4.255
1.870
1.860
1.845
1.835
1.622
1.615
1.610
1.604
1.599
1.577
1.555
1.535
1.525
1.517
1.512
1.492
1.352
0.982
0.934
0.891
0.794
0.780
0.585
ZZY200623-3.2.1.1r
ZZY200623-3
COOBn
OBn
HO
32 (400 MHz, CDCl3)
10.02
1.00
2.00
0.98
0.98
1.00
1.00
1.00
1.00
3.96
0.92
10.16
5.25
2.06
3.15
3.11
3.01
2.81
3.00
1.01
2.99
f1 (ppm)

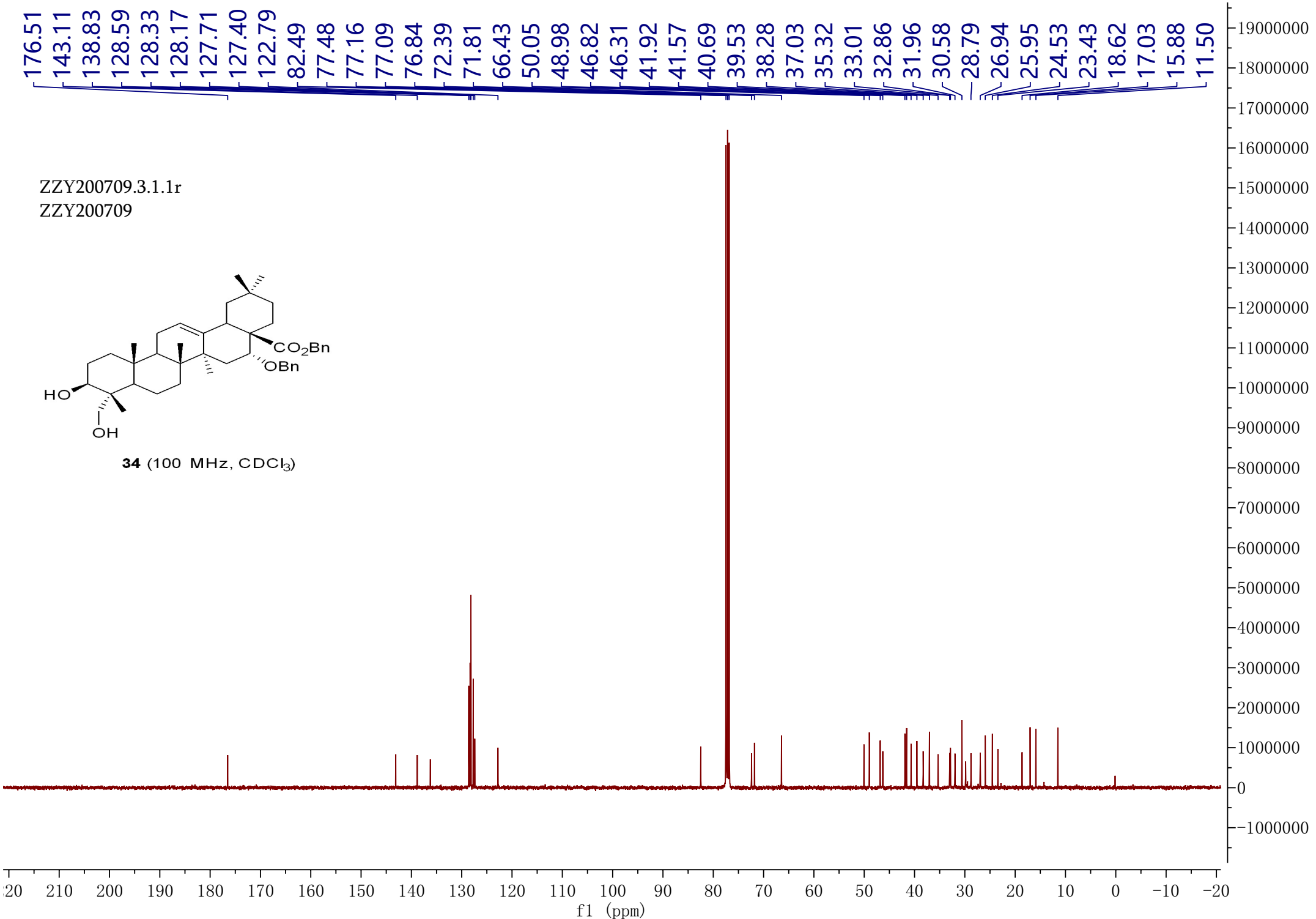

143.12
138.86
136.24
128.58
128.31
128.16
127.68
127.37
122.88
82.52
79.10
77.48
77.16
76.84
71.77
66.42
55.40
48.98
46.81
46.32
41.55
40.69
39.53
38.87
38.60
37.14
35.32
33.22
32.87
31.96
30.58
28.78
28.23
27.34
25.93
24.53
23.45
18.45
17.01
15.73
15.52
ZZY200623-3.3.1.1r
ZZY200623-3
COOBn
OBn
HO
32 (100 MHz, CDCl3)
2.4E+07
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
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)

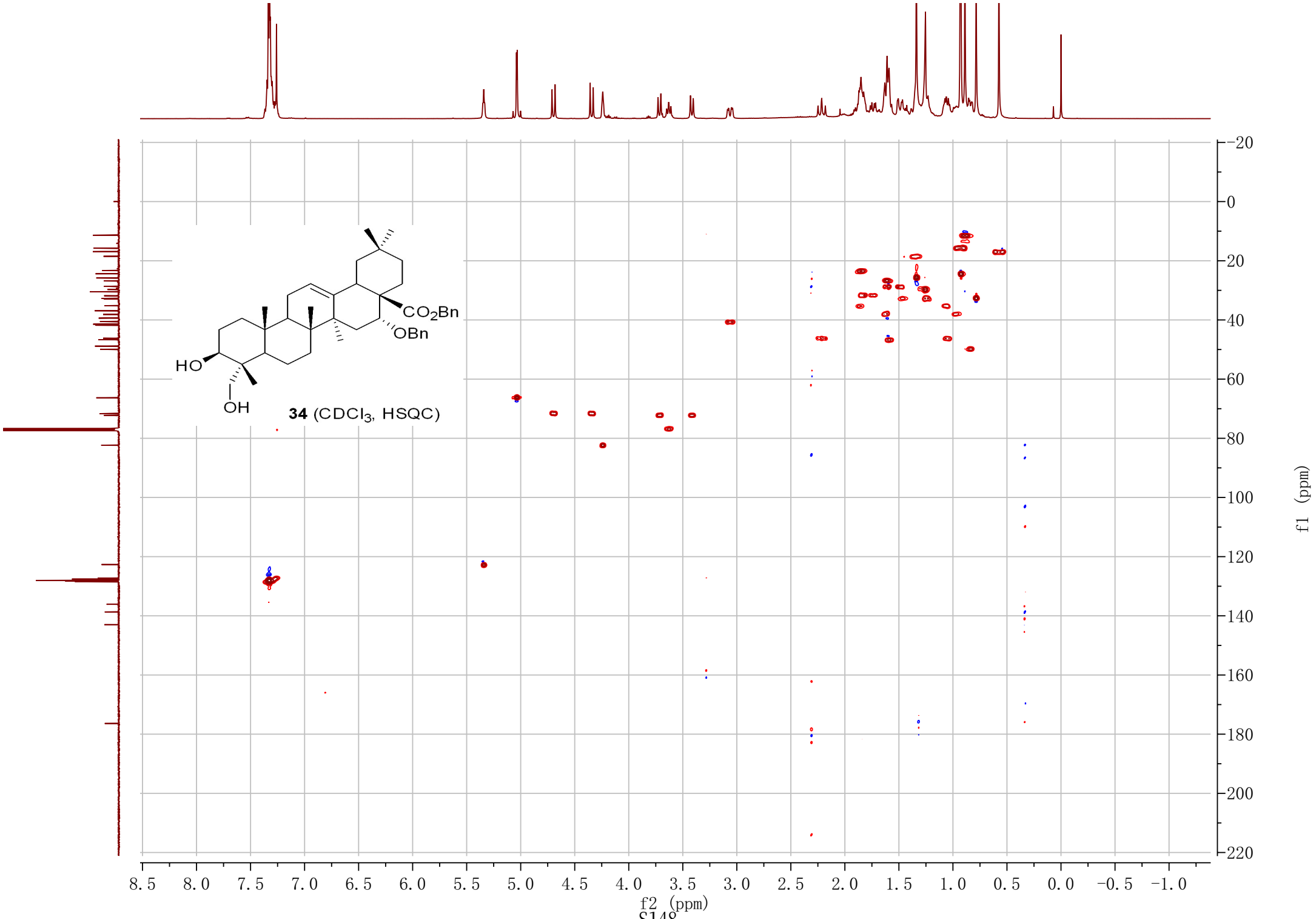

COOBn
OBn
HO
32 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

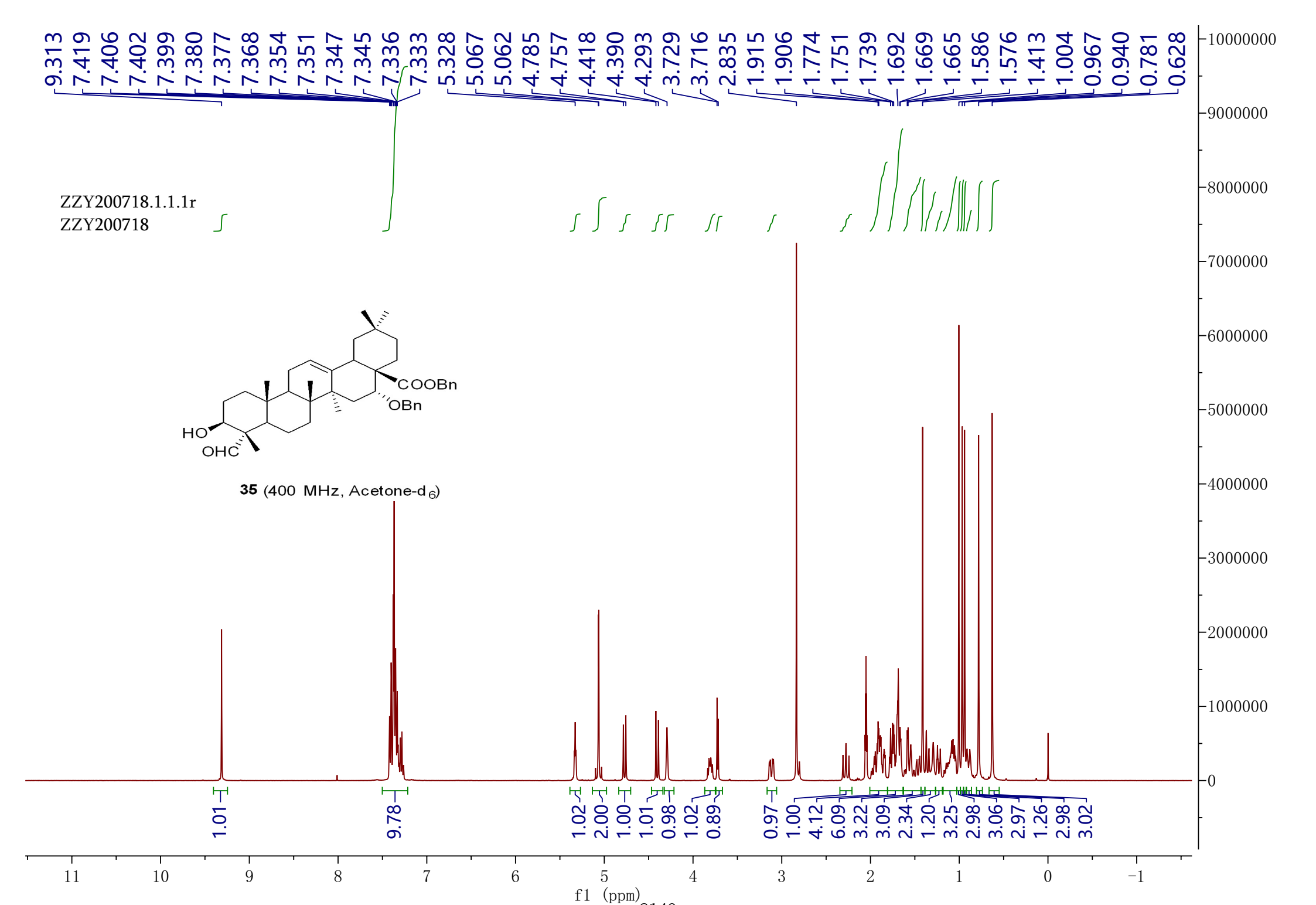

7.414
7.396
7.374
7.363
7.344
7.339
7.329
7.325
5.066
5.059
4.488
4.406
2.826
1.882
1.873
1.627
1.599
1.592
1.568
1.402
1.018
1.007
0.998
0.987
0.978
0.967
0.954
0.940
0.929
0.782
0.772
0.685
0.680
0.675
0.669
0.664
0.660
0.654
0.650
0.643
0.630
ZZY200708.1.1.1r
ZZY200708
CO2Bn
OBn
Et2HSiO
33 (400 MHz, Acetone-d6)
10.20
1.02
2.07
1.03
0.95
1.04
1.05
0.97
1.00
0.98
13.46
3.06
2.12
2.18
8.08
2.97
3.12
3.10
3.13
3.12
4.20
3.06
f1 (ppm)

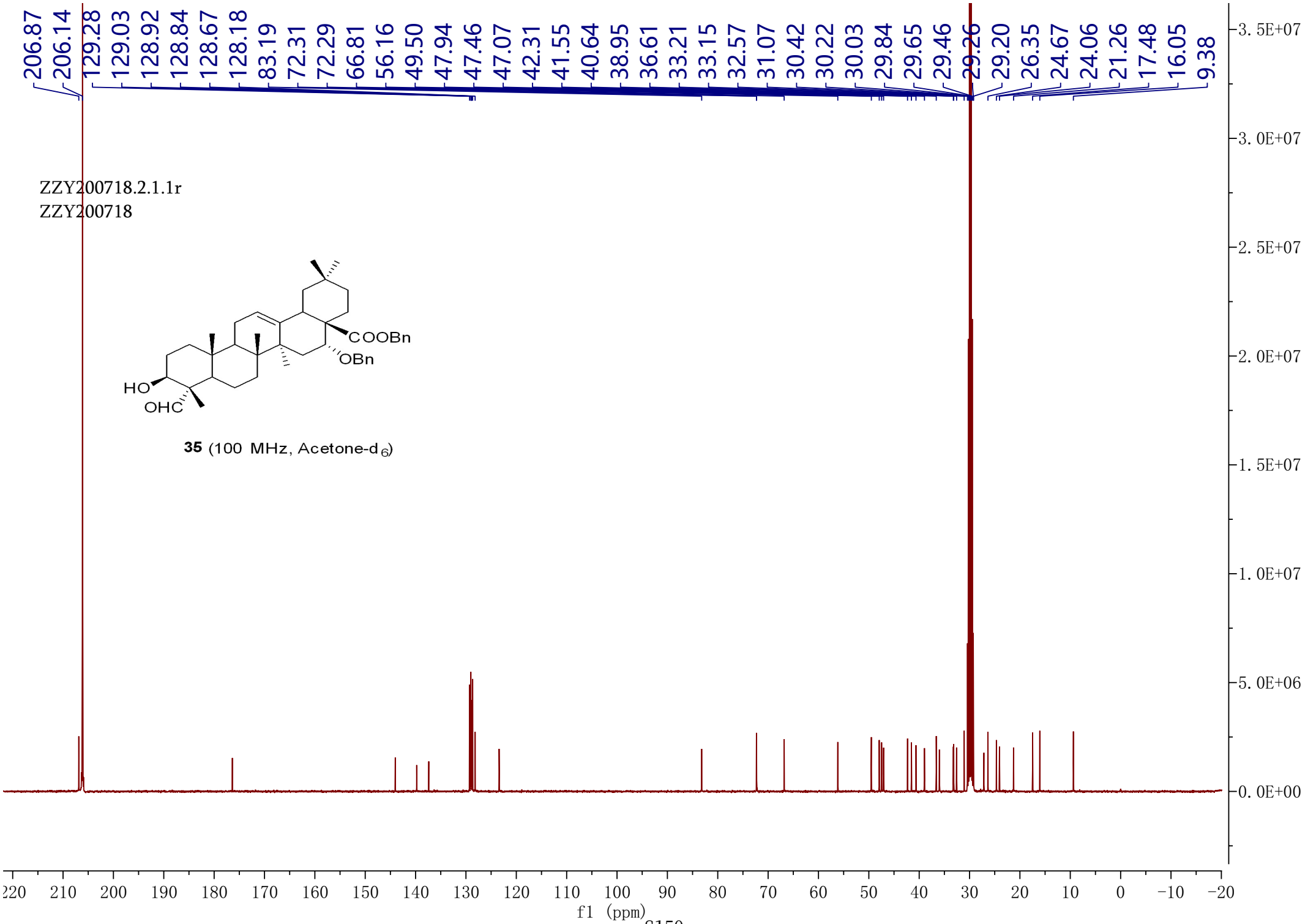

129.24
128.99
128.88
128.80
128.56
128.13
123.58
83.25
81.97
72.28
66.77
56.06
49.48
47.56
42.21
41.49
40.28
40.02
37.67
33.18
32.59
31.07
30.42
30.23
30.03
29.84
29.65
29.45
29.26
29.17
28.78
26.39
24.71
24.08
17.50
16.58
15.93
7.17
7.07
6.42
6.03
ZZY200708.2.1.1r
ZZY200708
CO2Bn
OBn
Et2HSiO
33 (100 MHz, Acetone-d6)
2.6E+07
2.4E+07
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
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)


7.353
7.347
7.335
7.328
7.323
7.317
7.309
7.300
7.295
7.260
5.342
5.039
5.032
4.710
4.682
4.357
4.329
4.241
3.703
3.429
1.871
1.863
1.851
1.836
1.826
1.819
1.640
1.636
1.630
1.610
1.597
1.590
1.338
1.250
1.230
1.060
0.933
0.927
0.889
0.785
0.574
ZZY200709.2.1.1r
ZZY200709
CO2Bn
OBn
HO
OH
34 (400 MHz, CDCl3)
10.59
1.05
2.03
1.00
0.99
1.00
0.95
1.02
1.00
1.00
1.25
4.59
2.33
5.62
3.23
3.28
1.23
3.65
3.06
3.02
3.00
1.23
3.07
2.99
f1 (ppm)

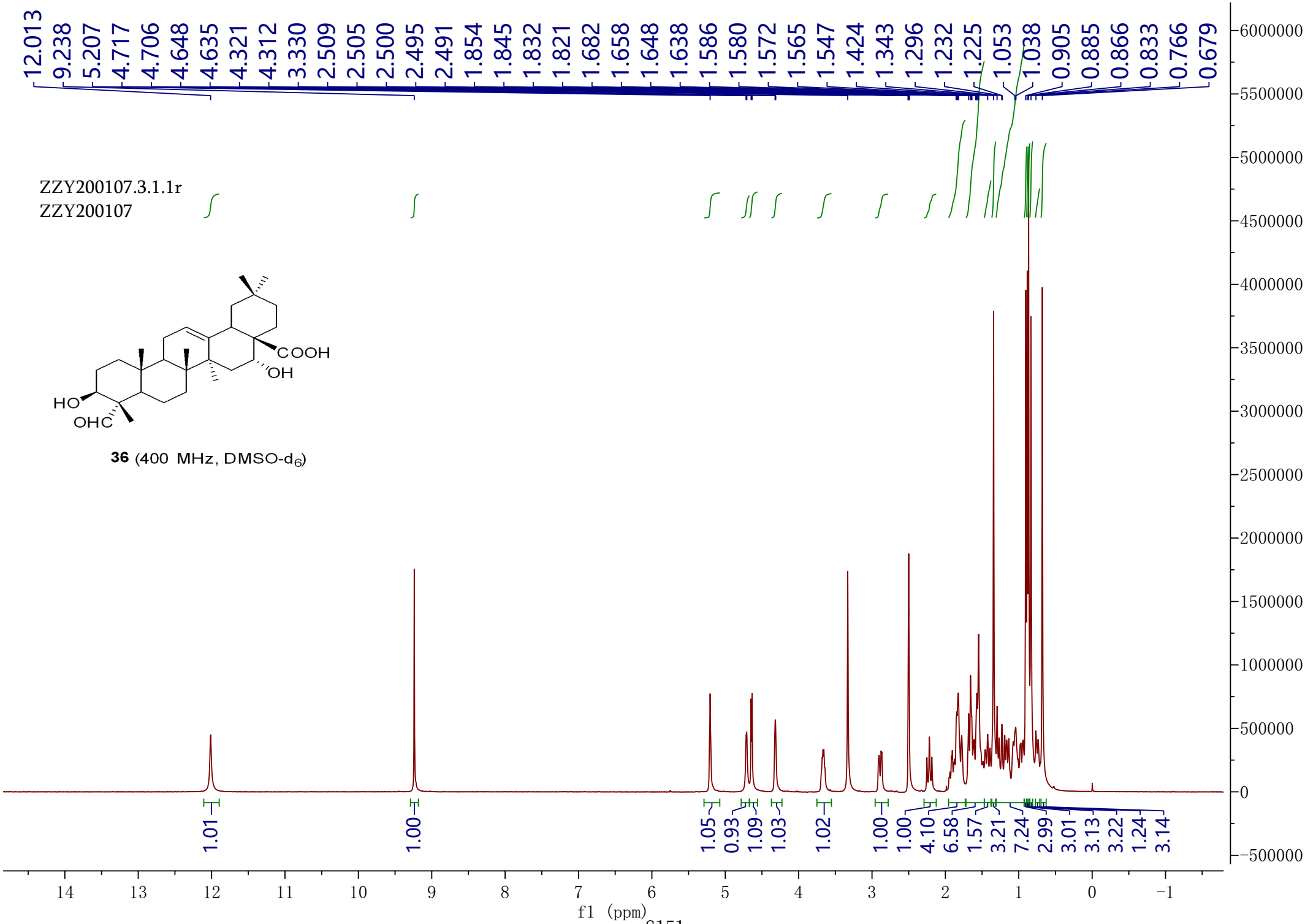

176.51
143.11
138.83
128.59
128.33
128.17
127.71
127.40
122.79
82.49
77.48
77.16
77.09
76.84
72.39
71.81
66.43
50.05
48.98
46.82
46.31
41.92
41.57
40.69
39.53
38.28
37.03
35.32
33.01
32.86
31.96
30.58
28.79
26.94
25.95
24.53
23.43
18.62
17.03
15.88
11.50
ZZY200709.3.1.1r
ZZY200709
CO2Bn
OBn
HO
OH
34 (100 MHz, CDCl3)
f1 (ppm)

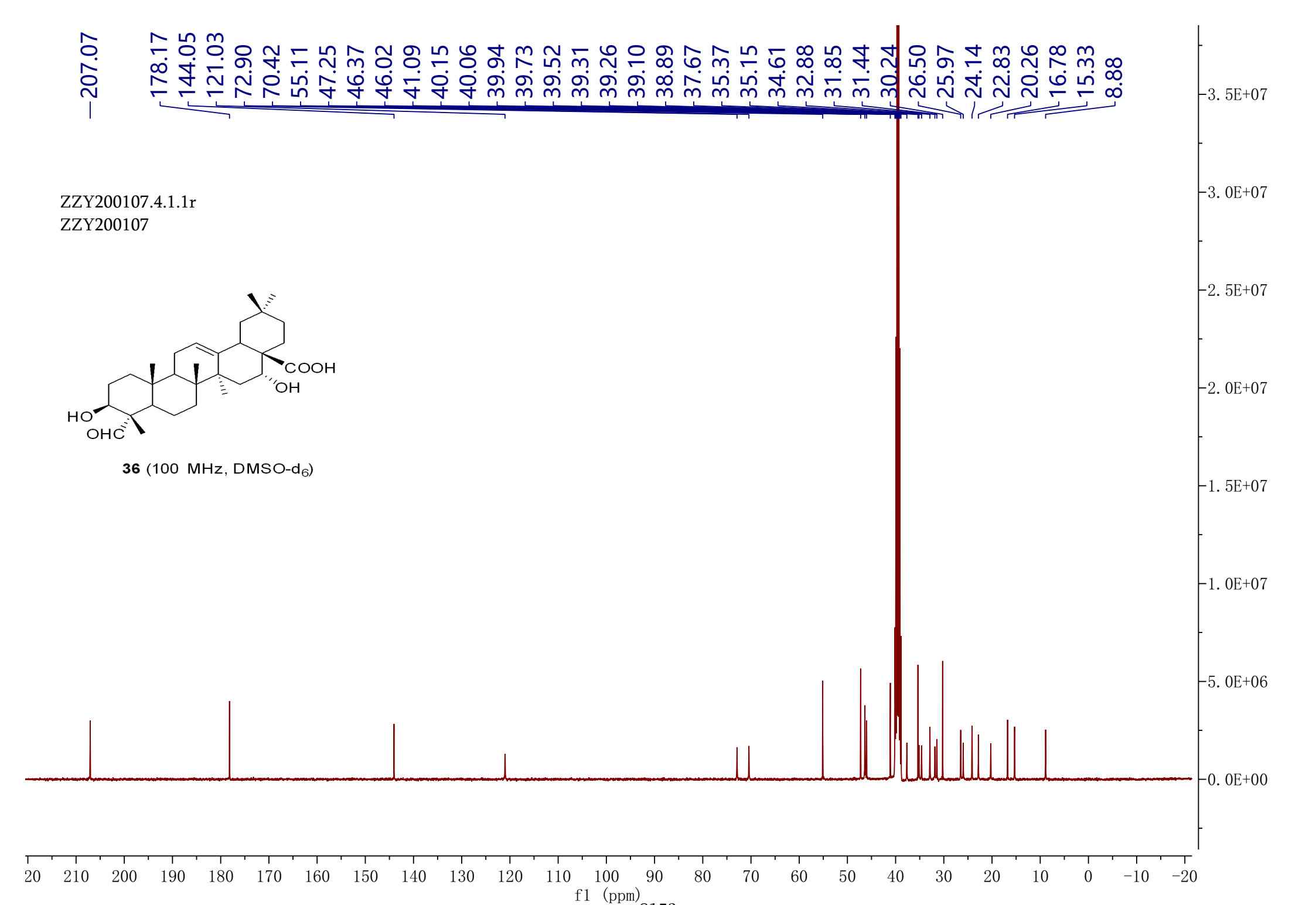

HO
OH
CO2Bn
OBn
34 (CDCl3, HSQC)
f2 (ppm)
f1 (ppm)

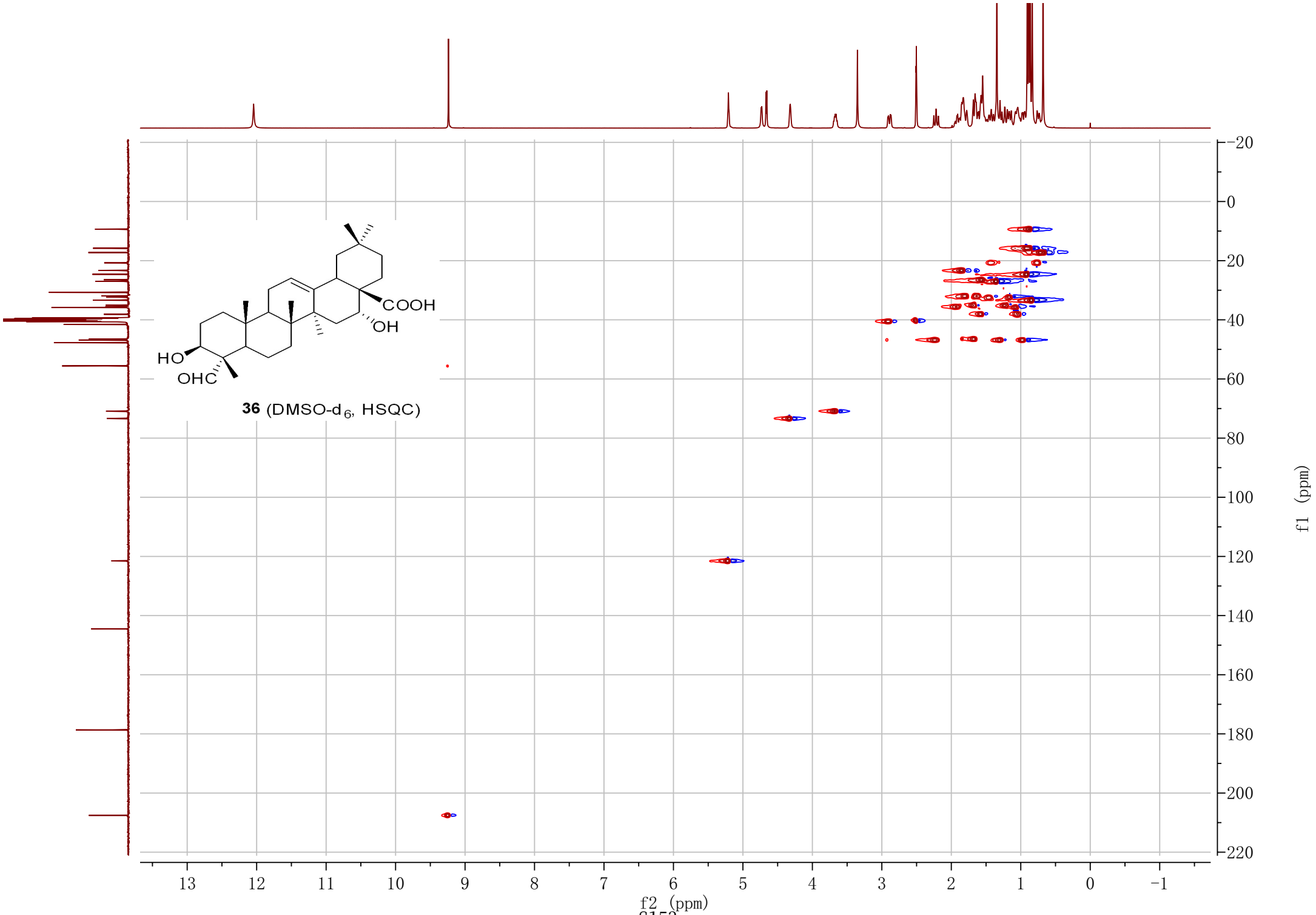

9.313
7.419
7.406
7.402
7.399
7.380
7.377
7.368
7.354
7.351
7.347
7.345
7.336
7.333
5.328
5.067
5.062
4.785
4.757
4.418
4.390
4.293
3.729
3.716
2.835
1.915
1.906
1.774
1.751
1.739
1.692
1.669
1.665
1.586
1.576
1.413
1.004
0.967
0.940
0.781
0.628
ZZY200718.1.1.1r
ZZY200718
COOBn
OBn
HO
OHC
35 (400 MHz, Acetone-d6)
1.01
9.78
1.02
2.00
1.00
1.01
0.98
1.02
0.89
0.97
1.00
4.12
6.09
3.22
3.09
2.34
1.20
3.25
2.98
3.06
2.97
1.26
2.98
3.02
f1 (ppm)

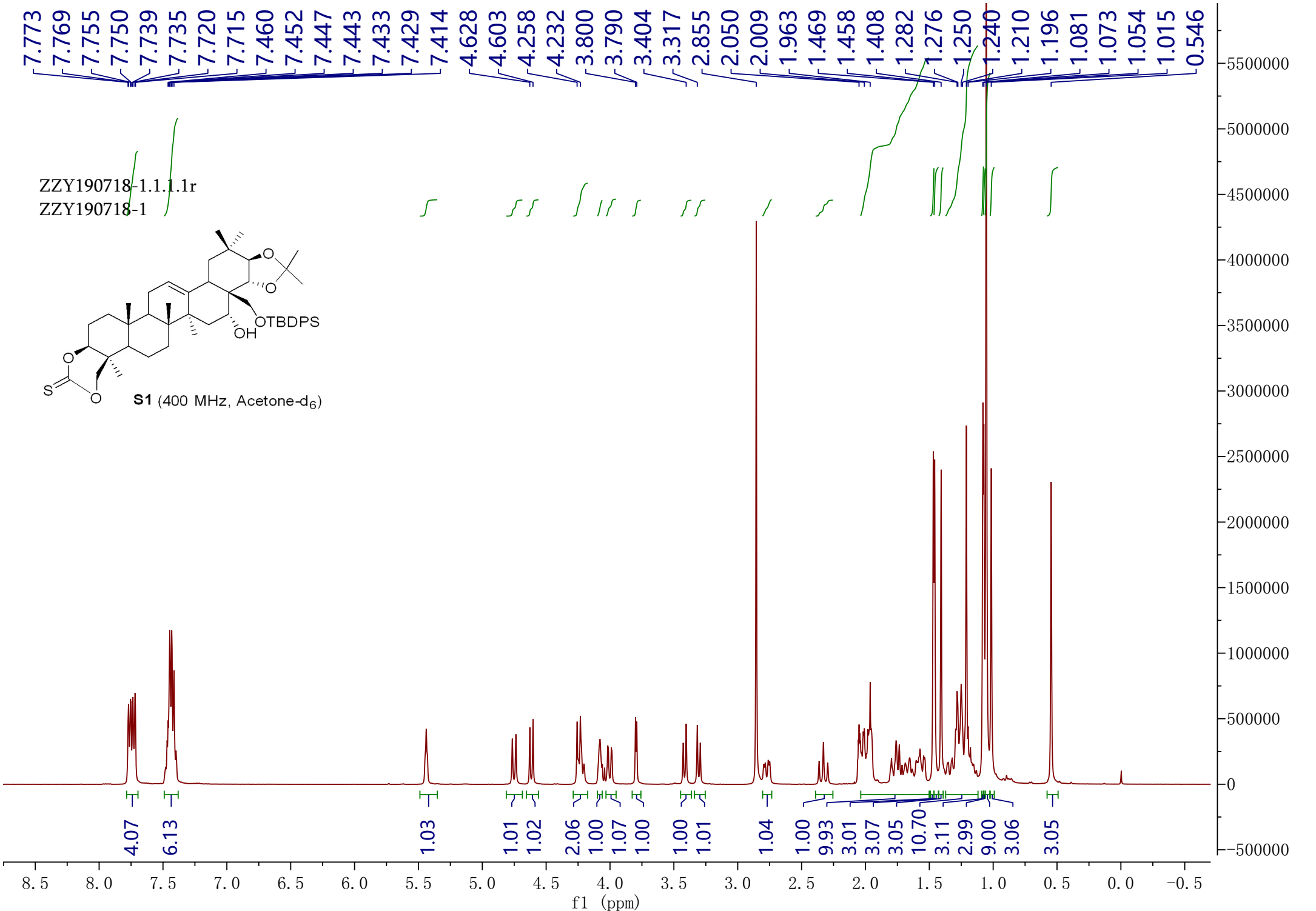


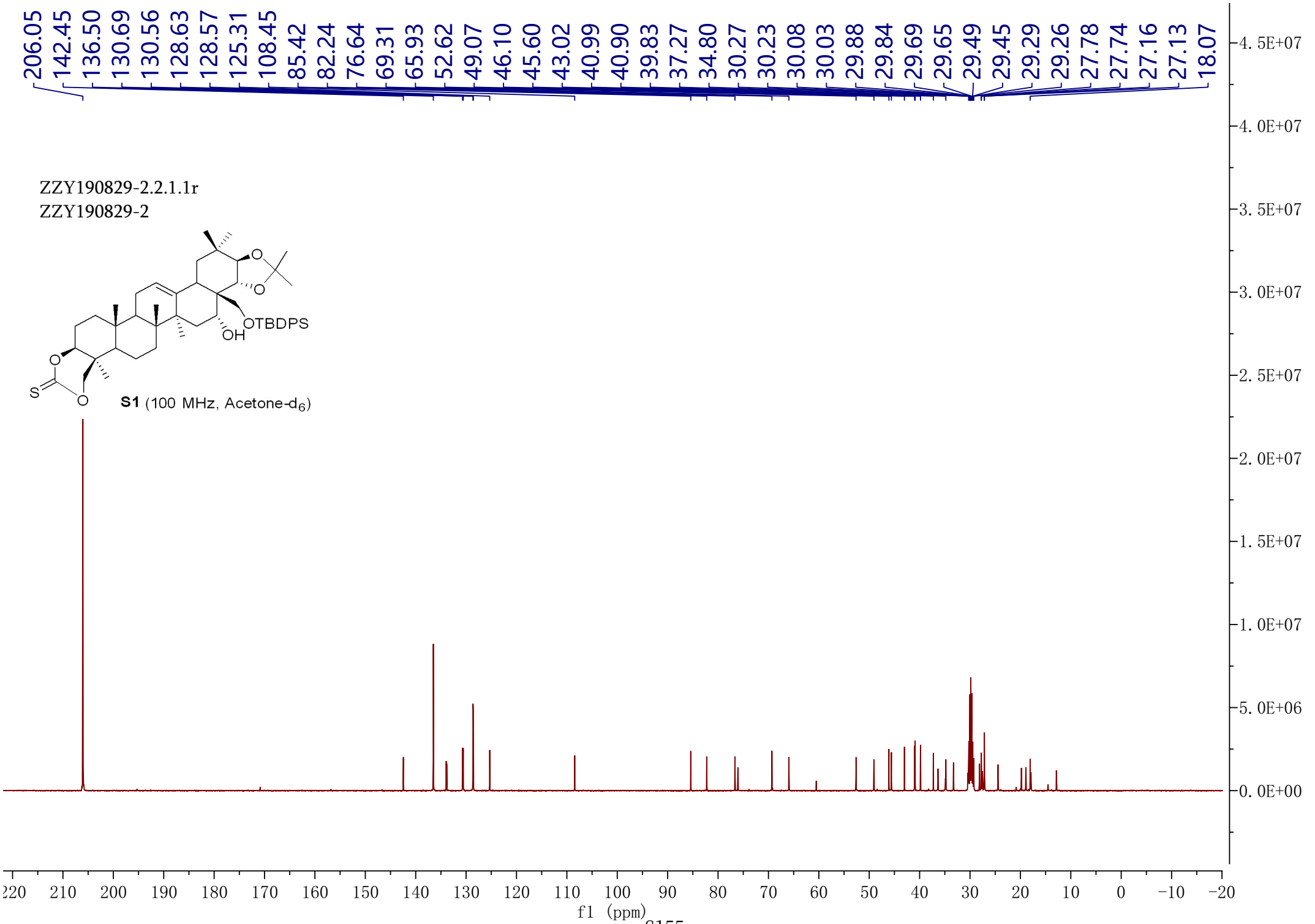
35 (100 MHz, Acetone-d_6)

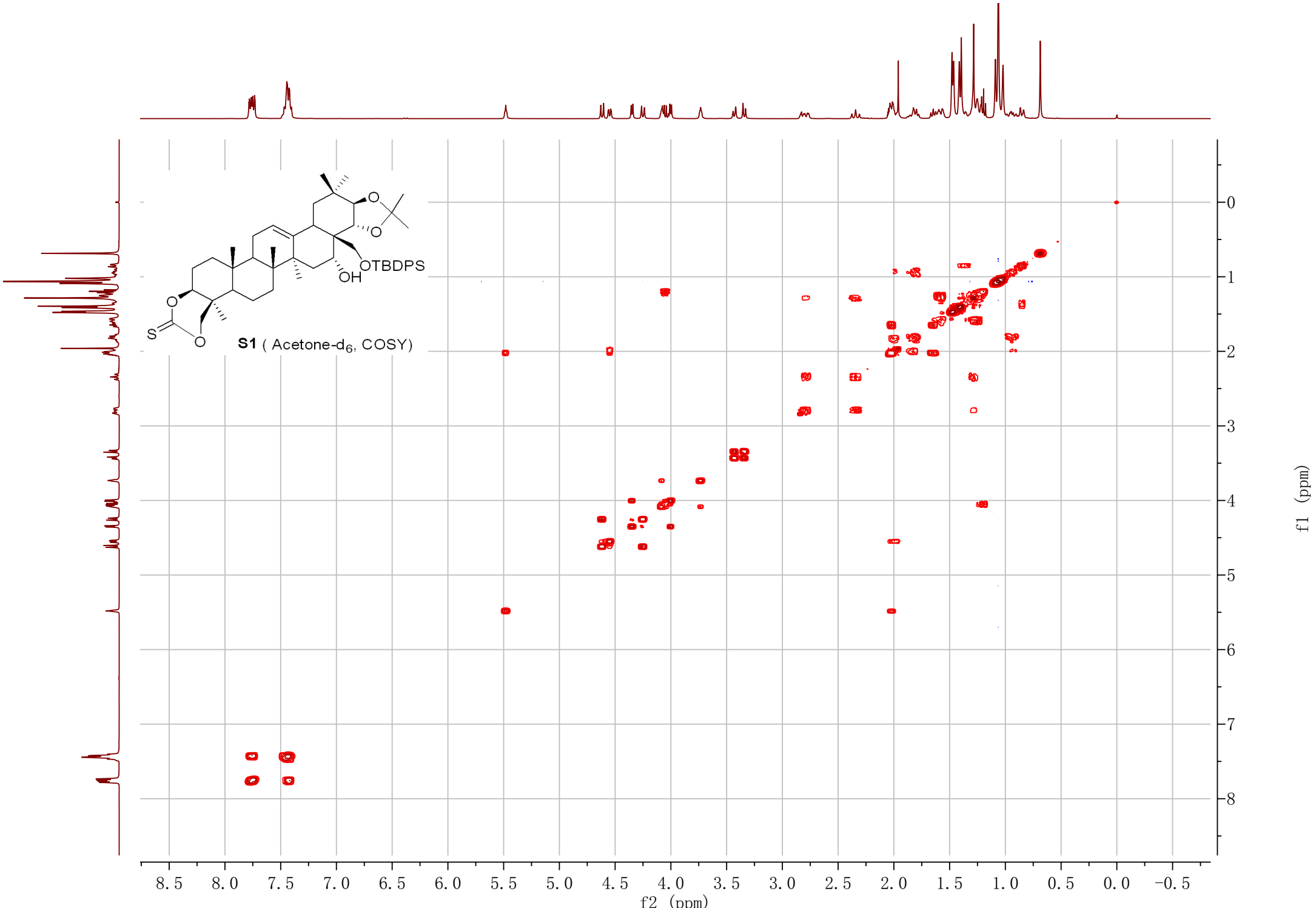

12.013
9.238
5.207
4.717
4.706
4.648
4.635
4.321
4.312
3.330
2.509
2.505
2.500
2.495
2.491
1.854
1.845
1.832
1.821
1.682
1.658
1.648
1.638
1.586
1.580
1.572
1.565
1.547
1.424
1.343
1.296
1.232
1.225
1.053
1.038
0.905
0.885
0.866
0.833
0.766
0.679
ZZY200107.3.1.1r
ZZY200107
COOH
OH
HO
OHC
36 (400 MHz, DMSO-d6)
1.01
1.00
1.05
0.93
1.09
1.03
1.02
1.00
1.00
4.10
6.58
1.57
3.21
7.24
2.99
3.01
3.13
3.22
1.24
3.14
f1 (ppm)

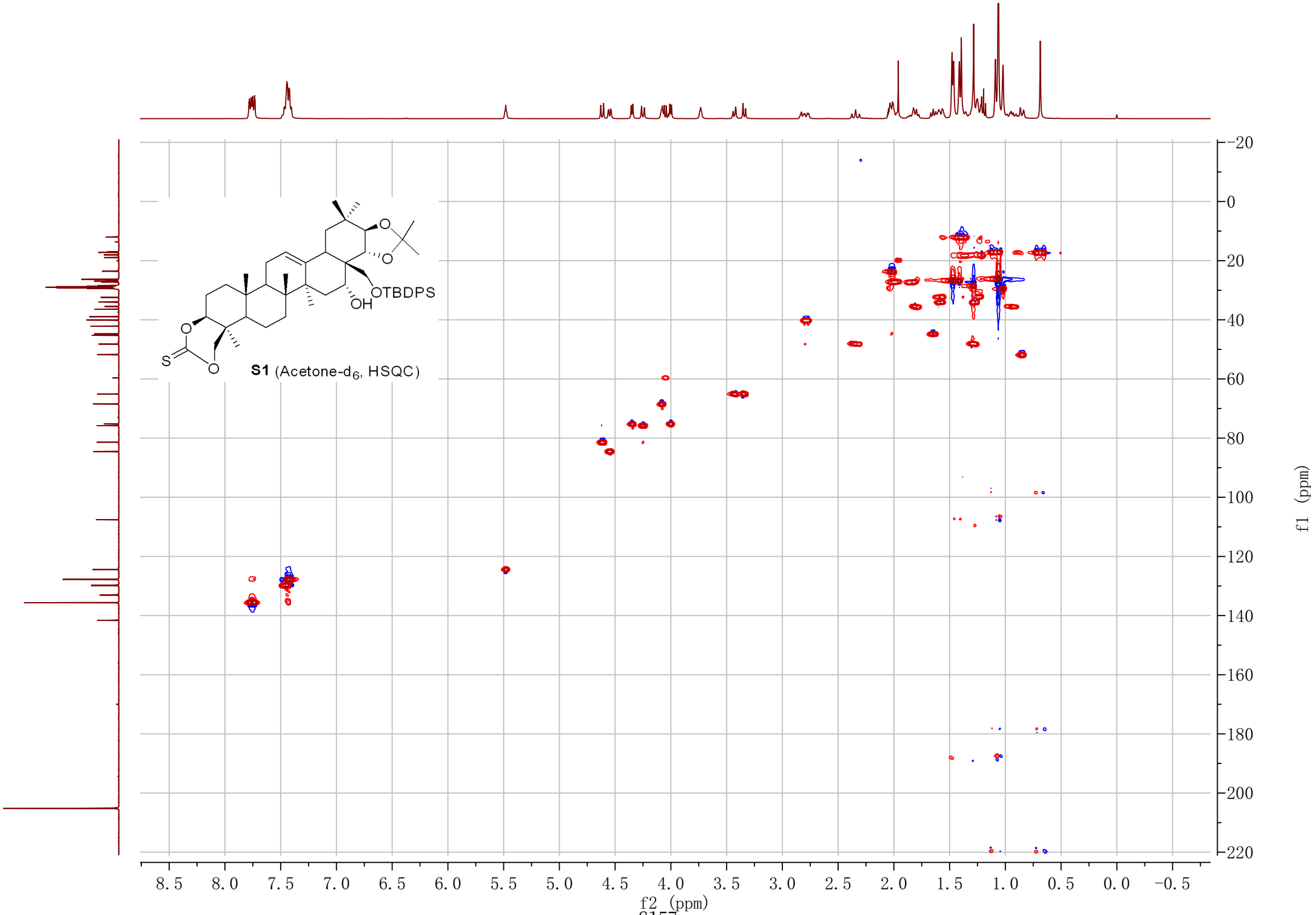

207.07
178.17
144.05
121.03
72.90
70.42
55.11
47.25
46.37
46.02
41.09
40.15
40.06
39.94
39.73
39.52
39.31
39.26
39.10
38.89
37.67
35.37
35.15
34.61
32.88
31.85
31.44
30.24
26.50
25.97
24.14
22.83
20.26
16.78
15.33
8.88
ZZY200107.4.1.1r
ZZY200107
COOH
OH
HO
OHC
36 (100 MHz, DMSO-d6)
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
f1 (ppm)

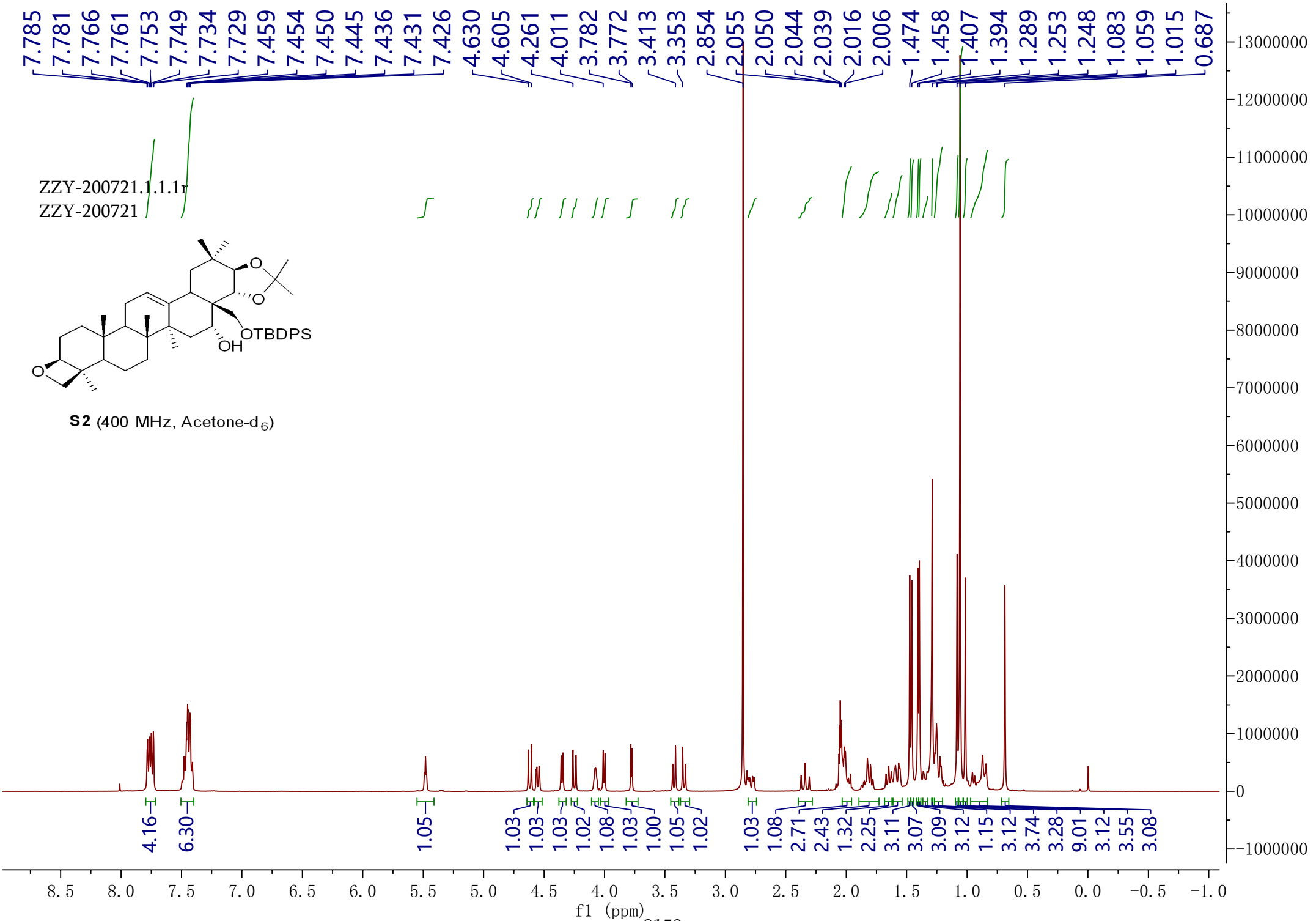

COOH
OH
HO
OHC
36 (DMSO-d6, HSQC)
f2 (ppm)
f1 (ppm)

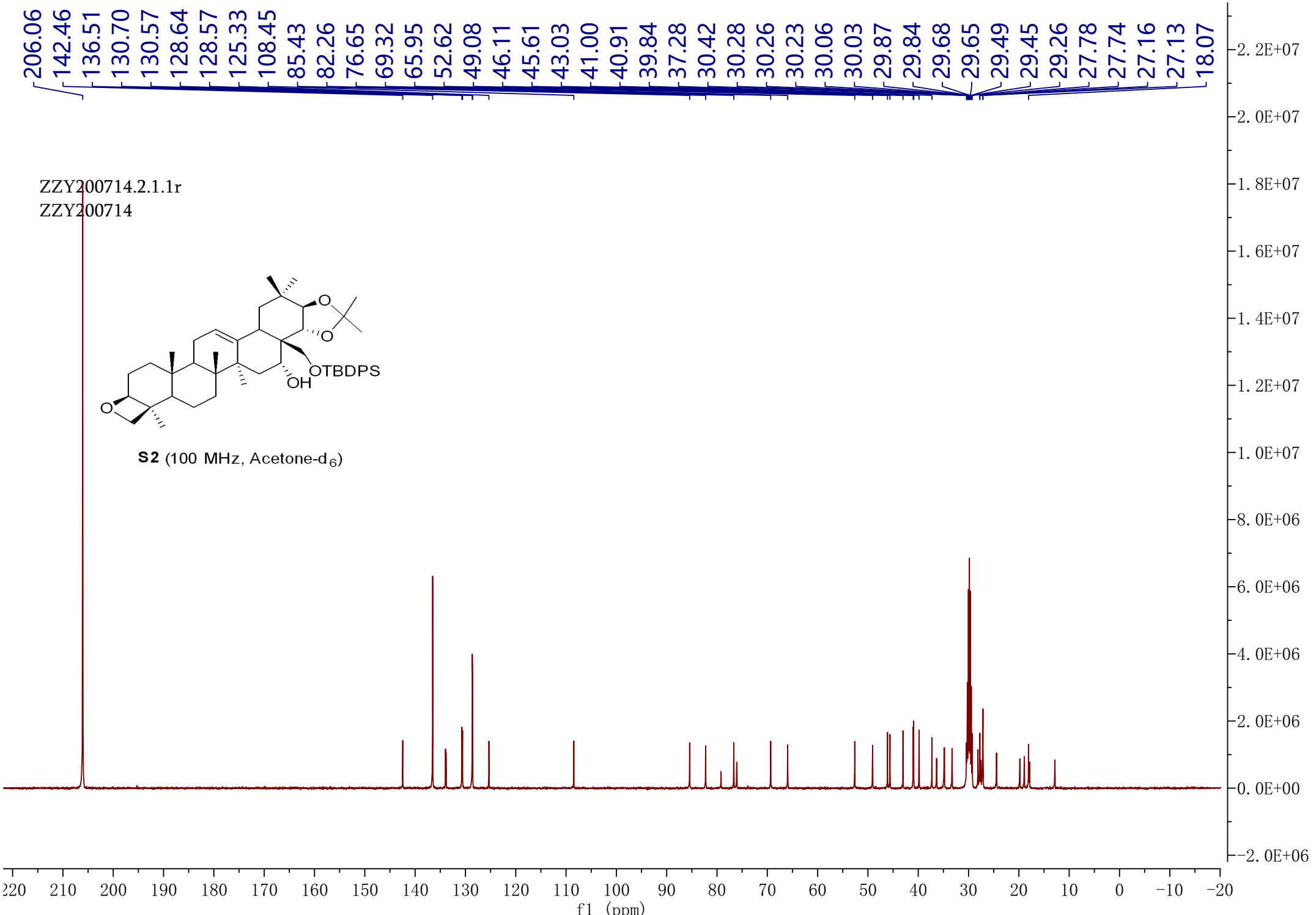

7.773
7.769
7.755
7.750
7.739
7.735
7.720
7.715
7.460
7.452
7.447
7.443
7.433
7.429
7.414
4.628
4.603
4.258
4.232
3.800
3.790
3.404
3.317
2.855
2.050
2.009
1.963
1.469
1.458
1.408
1.282
1.276
1.250
1.240
1.210
1.196
1.081
1.073
1.054
1.015
0.546
ZZY190718-1.1.1.1r
ZZY190718-1
OTBDPS
OH
S
O
S1 (400 MHz, Acetone-d6)
4.07
6.13
1.03
1.01
1.02
2.06
1.00
1.07
1.00
1.00
1.01
1.04
1.00
9.93
3.01
3.07
3.05
10.70
3.11
2.99
9.00
3.06
3.05
f1 (ppm)

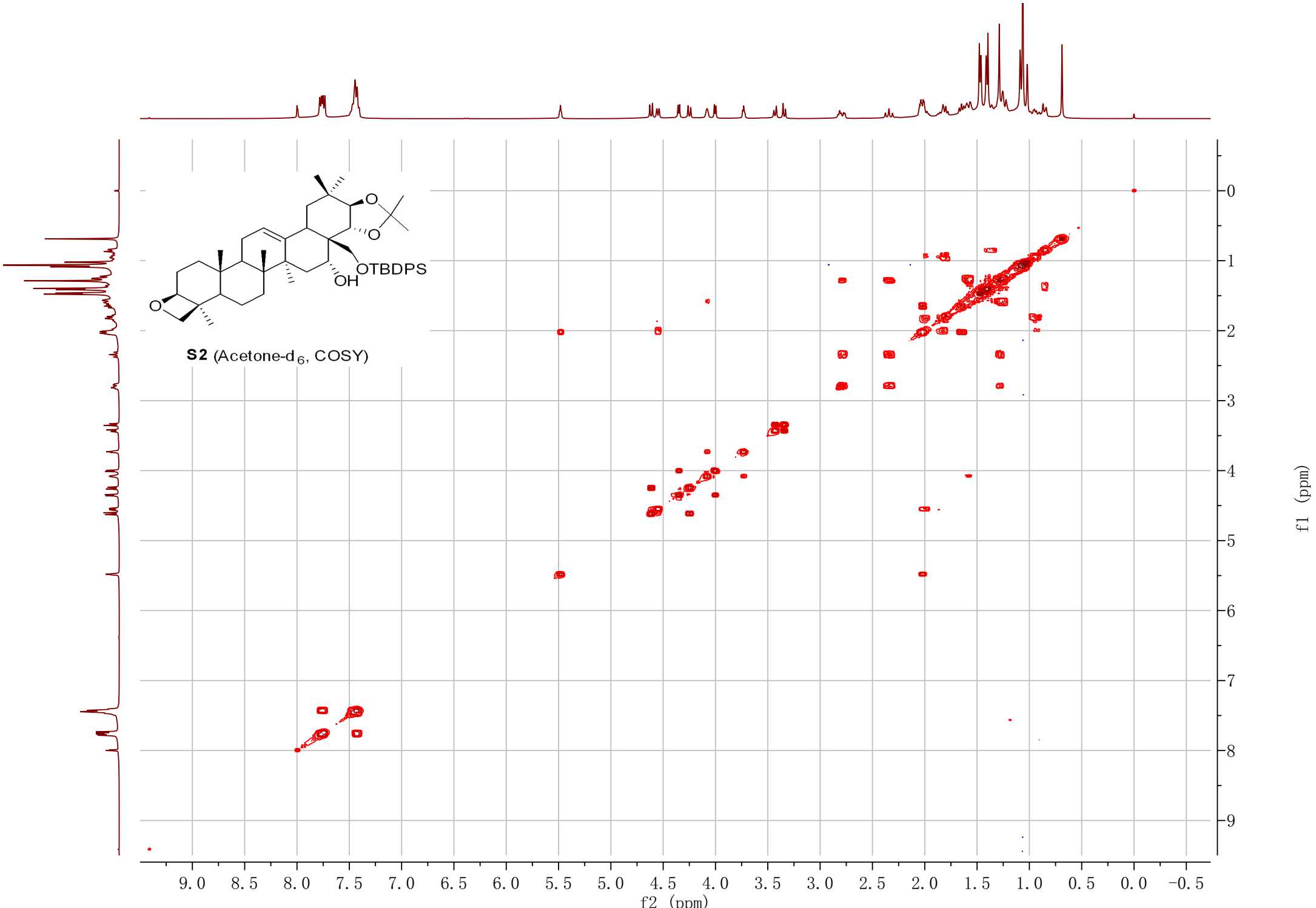

206.05
142.45
136.50
130.69
130.56
128.63
128.57
125.31
108.45
85.42
82.24
76.64
69.31
65.93
52.62
49.07
46.10
45.60
43.02
40.99
40.90
39.83
37.27
34.80
30.27
30.23
30.08
30.03
29.88
29.84
29.69
29.65
29.49
29.45
29.29
29.26
27.78
27.74
27.16
27.13
18.07
ZZY190829-2.2.1.1r
ZZY190829-2
OTBDPS
OH
S1 (100 MHz, Acetone-d6)
4.5E+07
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
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)

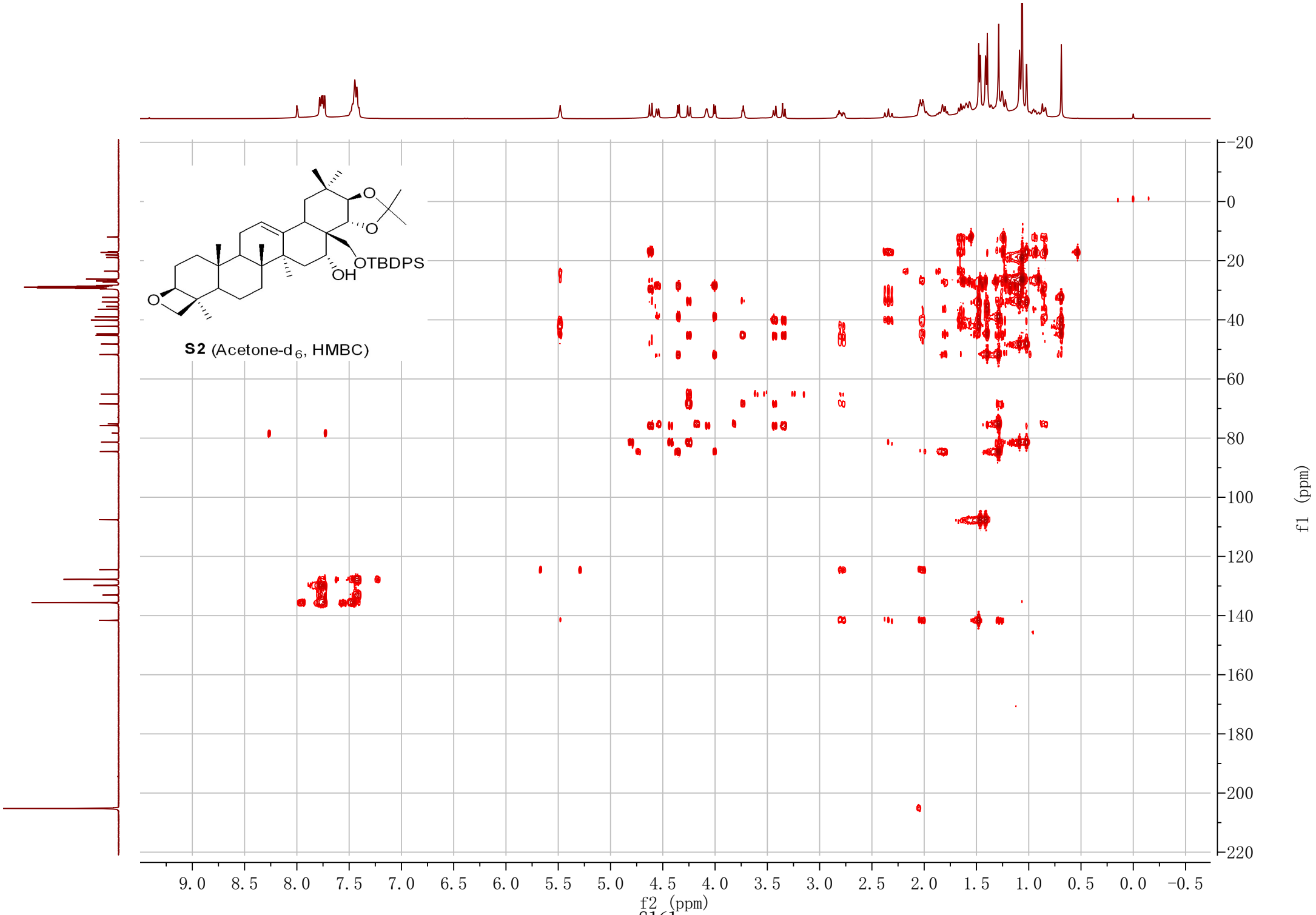

OTBDPS
OH
S
O
O
O
O
S1 (Acetone-d6, COSY)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f2 (ppm)
0
1
2
3
4
5
6
7
8
f1 (ppm)

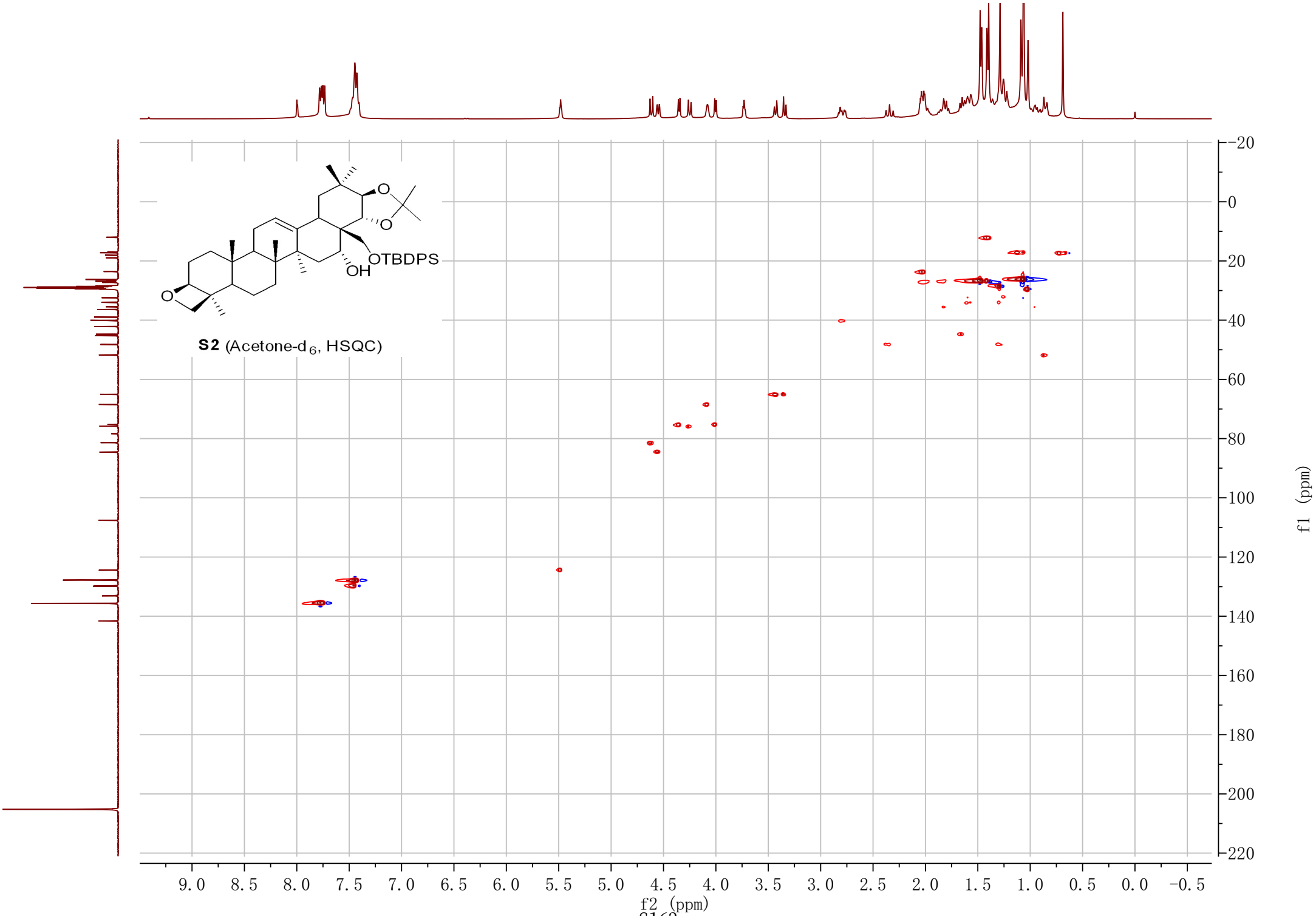

OTBDPS
OH
S
O
S1 (Acetone-d6, HSQC)
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f2 (ppm)
-20 0 20 40 60 80 100 120 140 160 180 200 220
f1 (ppm)

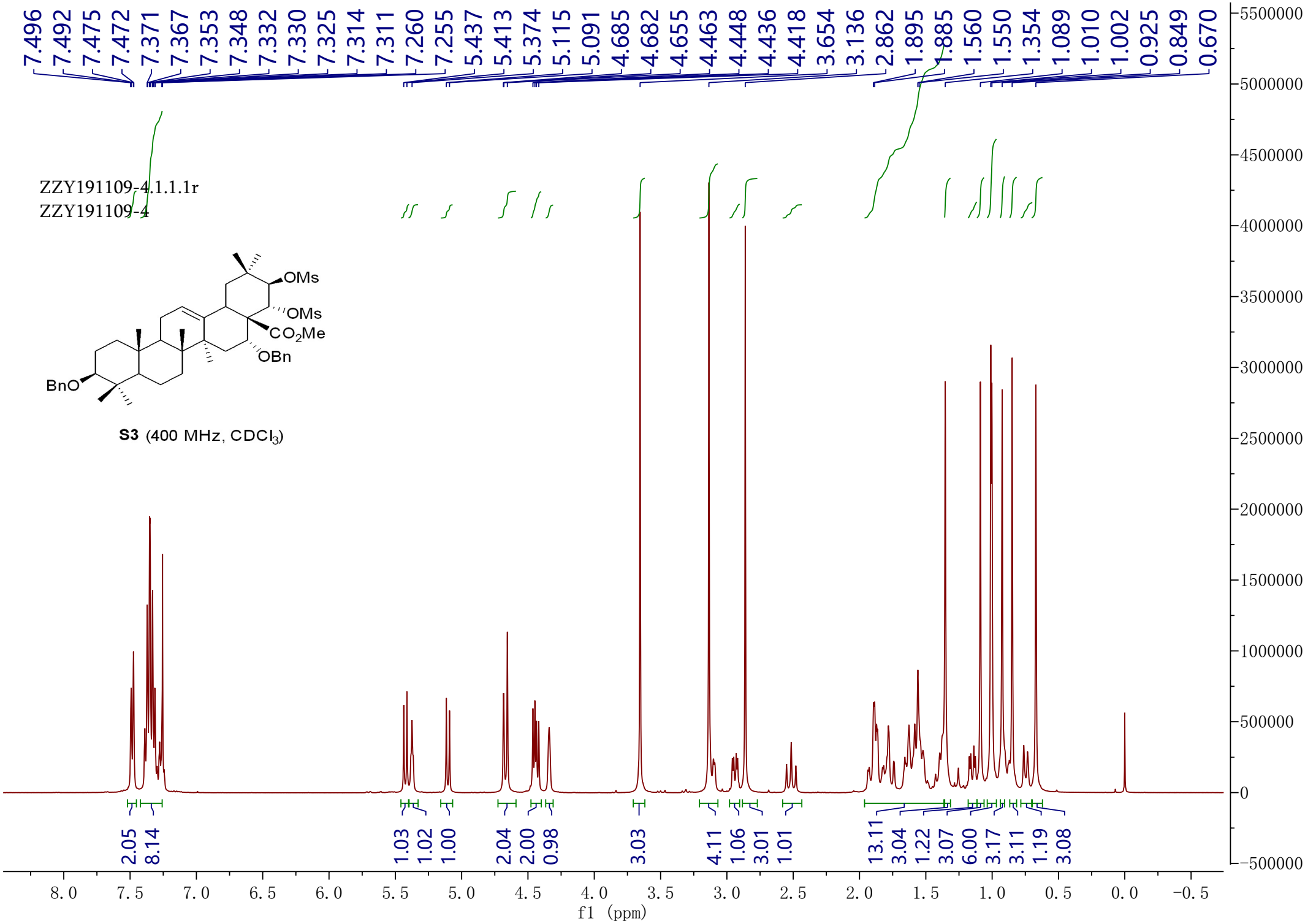

7.785
7.781
7.766
7.761
7.753
7.749
7.734
7.729
7.459
7.454
7.450
7.445
7.436
7.431
7.426
4.630
4.605
4.261
4.011
3.782
3.772
3.413
3.353
2.854
2.055
2.050
2.044
2.039
2.016
2.006
1.474
1.458
1.407
1.394
1.289
1.253
1.248
1.083
1.059
1.015
0.687
ZZY-200721.1.1.1r
ZZY-200721
OTBDPS
OH
O
O
O
S2 (400 MHz, Acetone-d6)
4.16
6.30
1.05
1.03
1.03
1.03
1.02
1.08
1.03
1.00
1.05
1.02
1.03
1.08
2.71
2.43
1.32
2.25
3.11
3.07
3.09
3.12
1.15
3.12
3.74
3.28
9.01
3.12
3.55
3.08
f1 (ppm)

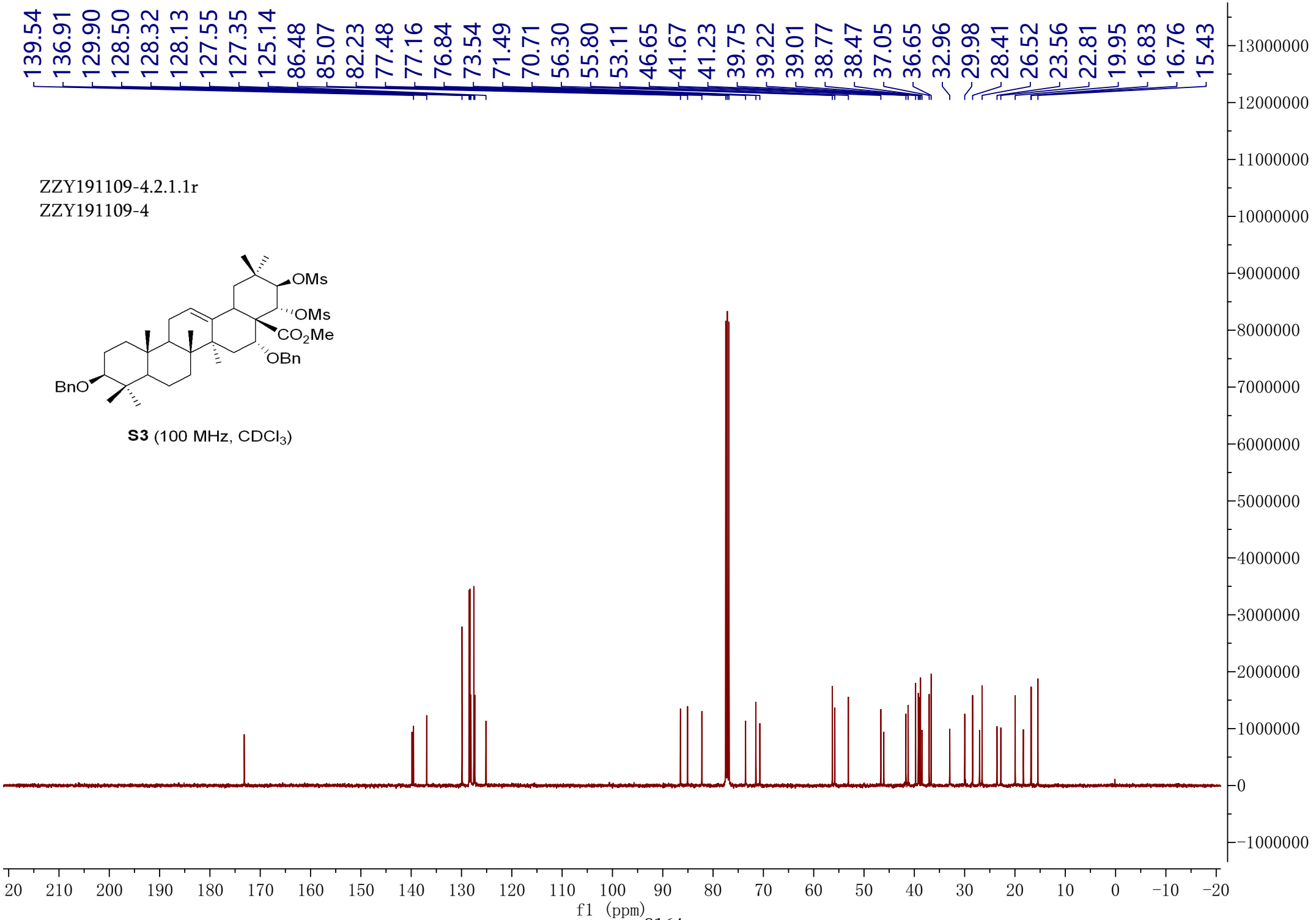

206.06
142.46
136.51
130.70
130.57
128.64
128.57
125.33
108.45
85.43
82.26
76.65
69.32
65.95
52.62
49.08
46.11
45.61
43.03
41.00
40.91
39.84
37.28
30.42
30.28
30.26
30.23
30.06
30.03
29.87
29.84
29.68
29.65
29.49
29.45
29.26
27.78
27.74
27.16
27.13
18.07
ZZY200714.2.1.1r
ZZY200714
OTBDPS
OH
O
O
O
S2 (100 MHz, Acetone-d6)
2.2E+07
2.0E+07
1.8E+07
1.6E+07
1.4E+07
1.2E+07
1.0E+07
8.0E+06
6.0E+06
4.0E+06
2.0E+06
0.0E+00
-2.0E+06
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)


OTBDPS
OH
O
O
O
S2 (Acetone-d6, COSY)
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
f2 (ppm)
0 1 2 3 4 5 6 7 8 9
f1 (ppm)


OTBDPS
OH
O
O
O
S2 (Acetone-d6, HMBC)
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
f2 (ppm)
−20 0 20 40 60 80 100 120 140 160 180 200 220
f1 (ppm)


OTBDPS
OH
O
O
O
S2 (Acetone-d6, HSQC)
f2 (ppm)
f1 (ppm)
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
-20 0 20 40 60 80 100 120 140 160 180 200 220


7.496
7.492
7.475
7.472
7.371
7.367
7.353
7.348
7.332
7.330
7.325
7.314
7.311
7.260
7.255
5.437
5.413
5.374
5.115
5.091
4.685
4.682
4.655
4.463
4.448
4.436
4.418
3.654
3.136
2.862
1.895
1.885
1.560
1.550
1.354
1.089
1.010
1.002
0.925
0.849
0.670
ZZY191109-4.1.1.1r
ZZY191109-4
OMs
OMs
CO2Me
OBn
BnO
S3 (400 MHz, CDCl3)
2.05
8.14
1.03
1.02
1.00
2.04
2.00
0.98
3.03
4.11
1.06
3.01
1.01
13.11
3.04
1.22
3.07
6.00
3.17
3.11
1.19
3.08
f1 (ppm)



S3 (100 MHz, $CDCl_3$)