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SUPPORTING INFORMATION

Structural Modification of Oridonin via DAST Induced Rearrangement

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Experimental

1.1 General information

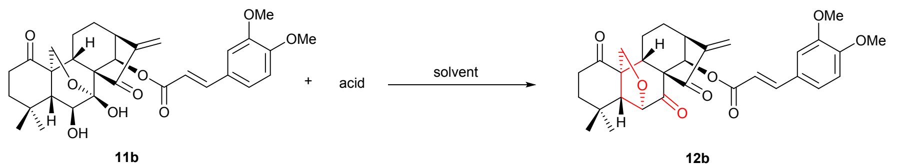
Unless otherwise stated, all commercial reagents were used without additional purification and solvents were distilled prior to use. All reactions were carried out under nitrogen atmosphere. ^1H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$ at 500 MHz, using $CDCl_3$ as a reference standard (δ = 7.26 ppm) for ^1H NMR and (δ = 77.00 ppm) for ^{13}C NMR or DMSO-d6 as a reference standard (δ = 2.50 ppm) for ^1H NMR and (δ = 39.52 ppm) for ^{13}C NMR. Melting points were measured with a Laboratory Device MEL-TEMP and were uncorrected. TLC was performed using commercially prepared silica gel plates (GF254), and visualization was effected at 254 nm and 365 nm. High resolution mass spectra (HRMS) were recorded on the Exactive Mass Spectrometer equipped with ESI ionization source.

1.2 Control experiments

Various acids were used to treat with compound **11b** to afford **12b** under the optimized conditions.

Compound **11b** (50 mg, 0.09 mmol) was mixed with the acid in anhydrous dichloromethane (5 mL) and the resulting mixture was stirred under nitrogen atmosphere at -78 °C for 10 min, warmed up to room temperature and stirred overnight, then heated to 40 °C and further stirred for 8 h. The reaction was poured into water, and the mixture was extracted with dichloromethane (3 × 5 mL). The organic layers were combined, washed with water and brine, dried over anhydrous $MgSO_4$, filtered and concentrated in vacuo.

Table S-1 The results of the reaction with the acids.

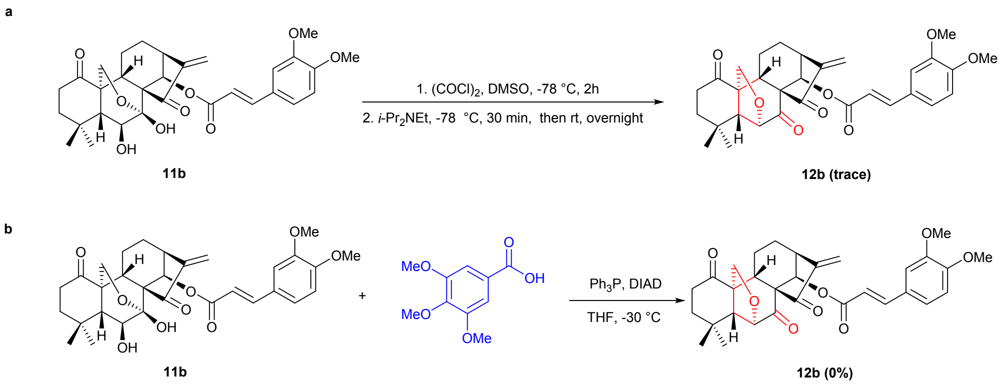


Entry	Acid	Solvent	Temp (time)	Yield (%)[a] 12b
1	DAST	DCM	-78 °C (10min) to RT (2 h)	80
2	DAST	DCM	-78 °C (10min) to 40 °C (1 h)	68

3	*p*-TsOH	DCM	-78 °C (10min) to RT (8 h) to 40 °C (8 h)	0
4	CF_3COOH	DCM	-78 °C (10min) to RT (8 h) to 40 °C (8 h)	0.
5	CF_3SO_3H	DCM	-78 °C (10min) to RT (8 h) to 40 °C (8 h)	0
6	(+)-10-Camph-orsulfonic acid	DCM	-78 °C (10min) to RT (8 h) to 40 °C (8 h)	0
7	HCl	THF	-78 °C (10min) to RT (8 h) to 40 °C (8 h)	N.R.
8	HNO_3	THF	-78 °C (10min) to RT (8 h) to 40 °C (8 h)	N.R.
9	$AlCl_3$	toluene	-78 °C (10min) to RT (8 h) to 40 °C (8 h)	N.R.
10	$FeCl_3$	toluene	-78 °C (10min) to RT (8 h) to 40 °C (8 h)	N.R.

Reaction conditions: **11b** (0.09 mmol), DAST (0.24 mL), 1 M HCl (0.90 mL), 1 M HNO_3 (0.90 mL), *p*-TsOH (0.90 mmol), CF_3COOH (0.90 mL), CF_3SO_3H (0.90 mL), $AlCl_3$ (0.90 mmol), $FeCl_3$ (0.90 mmol), (+)-10-Camphorsulfonic acid (0.90 mmol). [a]Yield of isolated product **12b**.

The model substrate **11b** was synthesized and tested in the control experiments **a** and **b**. One-equivalent of *i*-Pr_2NEt was used in the control experiment **a** and the additive of sterically hindered acid in the control experiment **b**. A trace amount of **12b** was observed in the control experiment **a** by TLC and MS detections and no product **12b** was found in the control experiment **b.**

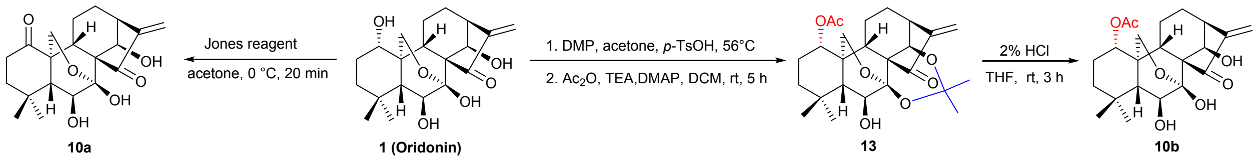


Scheme S-1 Control experiments a and b

Oxalyl chloride (0.02 mL, 0.24 mmol) and DMSO (0.03 mL, 0.48 mmol) were dissolved in dichloromethane (10 mL) under nitrogen atmosphere and the resulting mixture was stirred at -78 °C for 30 min. To the solution was added **11b** (100 mg, 0.18 mmol) and the mixture was stirred for 2 h, followed by addition of *i*-Pr_2NEt (0.03 mL, 0.18 mmol) and further stirred for 30 min. The reaction was warmed up to room temperature, poured into water, and the resulting mixture was extracted with dichloromethane (3 × 5 mL). The organic layers were combined, washed with water and brine, dried over anhydrous $MgSO_4$, filtered and concentrated in vacuo.

Compound **11b** (180 mg, 0.33 mmol), 3,4,5-trimethoxybenzoic acid (70 mg, 0.33 mmol) and Ph_3P (257 mg, 0.98 mmol) was dissolved in anhydrous THF (20 mL), then DIAD (0.19 mL, 0.98 mmol) was added at -30 °C. The mixture was stirred at room temperature for 6 h under nitrogen atmosphere. The solvent was evaporated and the residue was dissolved in EtOAc (50 mL), then the mixture was washed by diluted hydrochloric acid for two times, and brine in sequence. The organic layer was dried by anhydrous $MgSO_4$ and the solvent was evaporated.

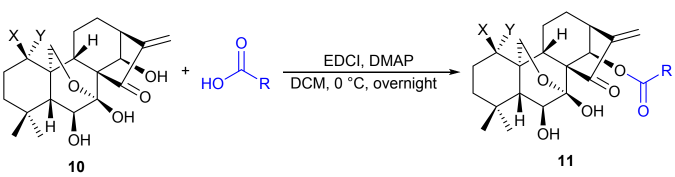
1.3 Scheme S-2 General procedure for the synthesis of compounds 10[1]



To a stirring solution of oridonin (500 mg, 1.37 mmol) in acetone (40 mL) was added Jones reagent (0.6 mL) dropwise at ice−water bath. The resulting mixture was stirred at 0 °C for 20 min, followed by addition of isopropyl alcohol to quench excess Jones reagent. Then the mixture was diluted with water and extracted with dichloromethane (3 × 10 mL). The extract was washed with brine, dried over anhydrous $MgSO_4$, filtered, and evaporated to give a solid crude product. The crude residue was recrystallized from acetone−hexane to give compound **10a** as a white solid, 440 mg, 88% yield.

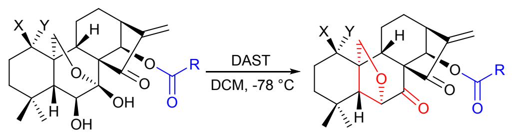
Treatment of oridonin (500 mg, 1.37 mmol) with 2,2-dimethoxypropane in the presence of *p*-TsOH in acetone afforded 7,14-(1-methylethylene)-dioxy-oridonin derivative (498 mg, 1.23 mmol) in 90% yield. 7,14-(1-methylethylene)-dioxy-oridonin derivative (200 mg, 0.50 mmol) upon reaction with Ac_2O (0.05 mL, 0.50 mmol), Et_3N (1 mL), DMAP (183 mg, 1.50 mmol) in 15 mL dichloromethane, yielded the corresponding compound **13**, 221 mg, 91% yield. Deprotection of compound **13** (200 mg, 0.44 mmol) with 2% HCl solution in 10 mL tetrahydrofuran gave the corresponding compound **10b,** 155 mg, 87% yield.[1]

1.4 Scheme S-3 General procedure for the synthesis of compounds 11a-11r[1]



Compound **10a** (100 mg, 0.25 mmol) was mixed with 4-methoxycinnamic acid (50mg, 0.25 mmol), EDCI (143 mg, 0.75 mmol) and DMAP (92 mg, 0.75 mmol) in 10 mL anhydrous dichloromethane and the resulting mixture was stirred under nitrogen atmosphere at room temperature overnight. The mixture was poured into 1 M HCl solution, and extracted with dichloromethane (3 × 5 mL). The organic layers were combined, washed with water and brine, dried over anhydrous $MgSO_4$, filtered and concentrated in vacuo. The crude product was purified by column chromatography (SiO_2, DCM / MeOH) to give the compound **11a**.[1] All of the products **11b-11r** were synthesized according to above described procedure.

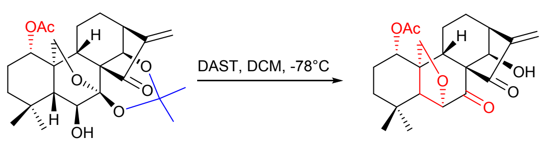
1.5 Scheme S-4 General procedure for the synthesis of compounds 12a-12j



11 12

Compound **11a** (94 mg, 0.18 mmol) was mixed with 0.24 mL DAST (diethylaminosulfur trifluoride) in anhydrous dichloromethane (10 mL) and the resulting mixture was stirred under nitrogen atmosphere at -78 °C for 10 min and then warmed up to room temperature for 2 h. The mixture was poured into water, and extracted with dichloromethane (3 × 5 mL). The organic layers were combined, washed with water and saturated NaCl solution, dried over anhydrous $MgSO_4$, filtered and concentrated in vacuo. The crude product was purified by column chromatography (petroleum ether / ethyl acetate) to give the compound **12a**. All of the products **12b-12j** were synthesized according to above described procedure.

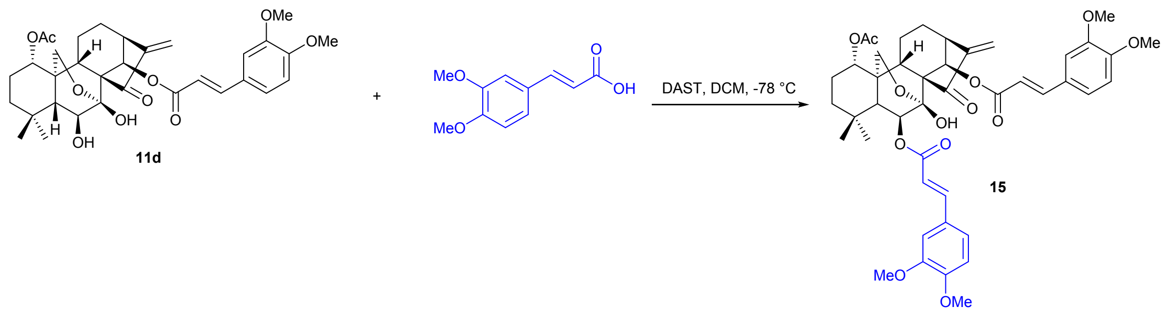
1.6 Scheme S-5 General procedure for the synthesis of compound 14



13 14

Compound **13** (100 mg, 0.22 mmol) was mixed with 0.30 mL DAST (diethylaminosulfur trifluoride) in anhydrous dichloromethane (10 mL) and the resulting mixture was stirred under nitrogen atmosphere at -78 °C for 10 min and then warmed up to room temperature for 2 h. The mixture was poured into water, and extracted with dichloromethane (3 × 5 mL). The organic layers were combined, washed with water and brine, dried over anhydrous $MgSO_4$, filtered and concentrated in vacuo. The crude product was purified by column chromatography (6:1 petroleum ether / ethyl acetate) to give the compound **14** as a white solid, 77 mg, 89% yield.

1.7 Scheme S-6 General procedure for the synthesis of compound 15



Compound **11d** (50 mg, 0.08 mmol) was mixed with (*E*)-3-(3,4-dimethoxyphenyl)acrylic acid (33 mg, 0.16 mmol), 0.11 mL DAST (diethylaminosulfur trifluoride) in anhydrous dichloromethane (10 mL) and the resulting mixture was stirred under nitrogen atmosphere at -78 °C for 10 min and warmed up to room temperature overnight. The mixture was poured into water, and extracted with dichloromethane (3 × 5 mL). The organic layers were combined, washed with water and brine, dried over anhydrous $MgSO_4$, filtered and concentrated in vacuo. The crude product was purified by column chromatography (6:1 petroleum ether / ethyl acetate) to give the compound **15** as a white solid, 52 mg, 83% yield.

1.8 In vitro cytotoxicity

The HepG2, RPMI-8226, A549, L-O2 cell lines used in this study were all purchased from EnoGene company. RPMI-8226 and A549 cells were cultured in RPMI 1640 media containing 10% heat inactivated FBS, HepG2 and L-O2 cells were cultured in DMEM media containing 10% heat inactivated FBS at 37 ℃ with 5% CO_2. In order to investigate the antitumor activity of some compounds, a commercial Paclitaxel (PTX) was used as a positive control drug.

10000 cells of HepG2, RPMI-8226, A549 or L-O2 were prepared into 200 μL cell suspension in each well of 96-well plates and the plates were incubated for 24 h at 37 ℃ with 5% CO_2. 100 μL Medium with compounds was mixed into each well of 96-well plates, respectively. And the negative control group, the solvent control group, the positive control group were established, respectively. The plates were incubated for 72 h at 37 ℃ with 5% CO_2. Then 10 μL CCK-8 solution was mixed into each well of 96-well plates and the plates were incubated for 4 h. Optical absorbance at 450 nm was determined with microplate absorbance reader (Bio-Rad). IC_{50} values were calculated from the dose–

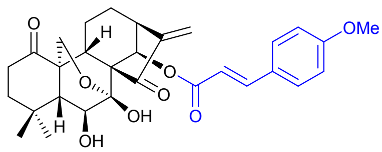
response curves of the assay (Prism 7.0).

Table S-2 IC_{50}[a] values (μM) of compounds **11e**, **11i** and **14** in human liver cancer cells HepG2 and human normal liver cells L-O2

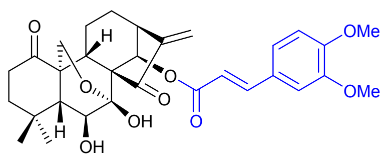
Compd.	HepG2	L-O2	SI[b]
Oridonin	7.93 ± 1.25	17.42 ± 1.06	2.20
11e	13.81 ± 2.27	11.65 ± 0.61	0.84
11i	0.98 ± 0.10	8.66 ± 0.21	8.84
14	2.07 ± 0.29	7.09 ± 0.08	3.43

[a]IC_{50}: concentration that inhibits 50% of cell growth. [b]SI: selectivity index (IC_{50} on normal cells/IC_{50} on tumor cells)

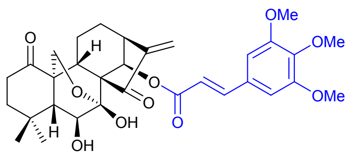
1.9 Characterization data for all products



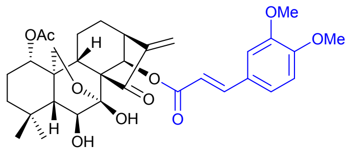
(4a*R*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-5,6-dihydroxy-4,4-dimethyl-8-methylene-1,7-dioxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*E*)-3-(4-methoxyphenyl)acrylate (11a). White solid, mp 136-137 °C. 121 mg, 83% yield. R_f = 0.35 (1 : 25 MeOH in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$) δ 7.60 (d, *J* = 15.9 Hz, 1H), 7.44 (d, *J* = 8.7 Hz, 2H), 6.88 (t, *J* = 5.8 Hz, 2H), 6.27 (s, 1H), 6.20 (d, *J* = 15.9 Hz, 1H), 5.92 (s, 1H), 5.62 (d, *J* = 0.9 Hz, 1H), 5.47 (d, *J* = 8.8 Hz, 1H), 4.32 (dd, *J* = 10.6, 1.0 Hz, 1H), 4.05 (dd, *J* = 10.6, 1.5 Hz, 1H), 3.83 (d, *J* = 6.1 Hz, 3H), 3.25 (d, *J* = 9.6 Hz, 1H), 2.62 (dt, *J* = 14.0, 8.8 Hz, 1H), 2.47 (ddd, *J* = 15.4, 10.9, 6.6 Hz, 1H), 2.38 – 2.24 (m, 3H), 2.08 – 2.01 (m, 1H), 1.99 (d, *J* = 8.6 Hz, 1H), 1.95 – 1.87 (m, 1H), 1.74 (ddd, *J* = 13.8, 8.8, 6.7 Hz, 2H), 1.68 – 1.60 (m, 1H), 1.37 – 1.30 (m, 1H), 1.21 (s, 3H), 1.01 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.78, 204.97, 165.43, 161.79, 149.32, 146.32, 130.08, 126.56, 122.20, 114.37, 114.06, 97.13, 75.54, 73.03, 64.93, 61.18, 60.35, 55.39, 50.77, 48.56, 41.32, 38.54, 35.83, 32.89, 30.53, 30.00, 29.69, 23.30, 19.05. **HRMS** (*m/z*) (ESI): calcd for $C_{30}H_{35}O_8$ 523.2326 $[M+H]^+$ found 523.2318.



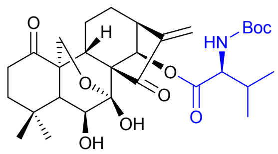
(4a*R*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-5,6-dihydroxy-4,4-dimethyl-8-methylene-1,7-dioxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*E*)-3-(3,4-dimethoxyphenyl)acrylate (11b). White solid, mp 139-141 °C. 127 mg, 82% yield. R_f = 0.49 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.57 (d, *J* = 15.9 Hz, 1H), 7.06 (dd, *J* = 8.3, 1.9 Hz, 1H), 7.00 (d, *J* = 1.9 Hz, 1H), 6.84 (d, *J* = 8.4 Hz, 1H), 6.27 (s, 1H), 6.20 (d, *J* = 15.9 Hz, 1H), 5.91 (s, 1H), 5.61 (d, *J* = 0.5 Hz, 1H), 5.44 (d, *J* = 11.5 Hz, 1H), 4.44 (s, 1H), 4.31 (d, *J* = 10.6 Hz, 1H), 4.05 (dd, *J* = 10.6, 1.3 Hz, 1H), 3.89 (s, 6H), 3.82 (dd, *J* = 11.4, 8.7 Hz, 1H), 3.24 (d, *J* = 9.5 Hz, 1H), 2.61 (dt, *J* = 14.0, 8.8 Hz, 1H), 2.46 (ddd, *J* = 15.4, 10.8, 6.6 Hz, 1H), 2.36 – 2.25 (m, 2H), 2.07 – 2.00 (m, 1H), 1.98 (d, *J* = 8.6 Hz, 1H), 1.94 – 1.87 (m, 1H), 1.76 – 1.69 (m, 2H), 1.68 – 1.59 (m, 1H), 1.37 – 1.30 (m, 1H), 1.20 (s, 3H), 1.01 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.71, 204.97, 165.31, 151.56, 149.29, 146.48, 126.81, 123.28, 122.19, 114.29, 110.95, 109.46, 97.15, 75.56, 73.05, 64.92, 61.20, 60.34, 55.95, 50.75, 48.56, 41.32, 38.54, 35.82, 32.88, 30.54, 30.01, 29.67, 23.29, 19.05. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{37}O_9$ 553.2432 [M+H]$^+$ found 553.2428.



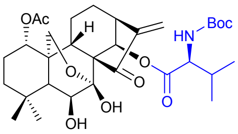
(4a*R*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-5,6-dihydroxy-4,4-dimethyl-8-methylene-1,7-dioxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*E*)-3-(3,4,5-trimethoxyphenyl)acrylate (11c). White solid, mp 113-115 °C. 137 mg, 84% yield. R_f = 0.64 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.52 (d, *J* = 15.9 Hz, 1H), 6.69 (s, 2H), 6.27 – 6.21 (m, 2H), 5.92 (s, 1H), 5.61 (s, 1H), 5.43 (d, *J* = 11.5 Hz, 1H), 4.39 (s, 1H), 4.30 (d, *J* = 10.7 Hz, 1H), 4.03 (d, *J* = 10.7 Hz, 1H), 3.88 – 3.78 (m, 10H), 3.22 (d, *J* = 9.3 Hz, 1H), 2.59 (dt, *J* = 14.0, 8.8 Hz, 1H), 2.50 – 2.41 (m, 1H), 2.36 – 2.22 (m, 2H), 2.05 – 1.98 (m, 1H), 1.96 (d, *J* = 8.7 Hz, 1H), 1.93 – 1.86 (m, 1H), 1.74 – 1.67 (m, 1H), 1.63 (td, *J* = 13.1, 7.4 Hz, 1H), 1.36 – 1.29 (m, 1H), 1.18 (s, 3H), 0.98 (d, *J* = 7.8 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.66, 204.95, 165.09, 153.37, 149.31, 146.34, 140.44, 129.28, 122.25, 116.04, 105.39, 105.18, 97.12, 75.50, 73.09, 64.92, 61.22, 60.90, 60.23, 56.17, 50.73, 48.53, 41.33, 38.48, 35.79, 32.86, 30.52, 30.01, 29.64, 23.26, 19.06. **HRMS** (*m/z*) (ESI): calcd for $C_{32}H_{39}O_{10}$ 583.2538 [M+H]$^+$ found 583.2530.



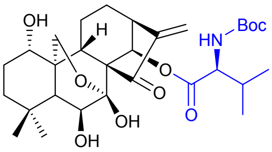
(1*S*,4a*R*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1-acetoxy-5,6-dihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[a]naphthalen-14-yl (*E*)-3-(3,4-dimethoxyphenyl)acrylate (11d). White solid, mp 144-145 °C. 122 mg, 83% yield. R_f = 0.60 (1 : 30 MeOH in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$) δ 7.55 (d, *J* = 15.8 Hz, 1H), 7.04 (d, *J* = 8.3 Hz, 1H), 6.97 (s, 1H), 6.82 (d, *J* = 8.3 Hz, 1H), 6.18 (d, *J* = 15.9 Hz, 1H), 6.16 – 6.10 (m, 2H), 5.87 (s, 1H), 5.48 (s, 1H), 4.61 (dd, *J* = 11.1, 5.5 Hz, 1H), 4.42 (s, 1H), 4.27 (d, *J* = 10.6 Hz, 1H), 4.16 (d, *J* = 10.6 Hz, 1H), 3.88 (t, *J* = 7.0 Hz, 6H), 3.78 (dd, *J* = 10.3, 6.5 Hz, 1H), 3.24 (d, *J* = 9.9 Hz, 1H), 2.61 – 2.50 (m, 1H), 2.09 – 2.00 (m, 2H), 1.98 (s, 3H), 1.73 (dd, *J* = 9.1, 5.2 Hz, 1H), 1.57 – 1.49 (m, 1H), 1.45 (t, *J* = 12.6 Hz, 2H), 1.33 (d, *J* = 6.4 Hz, 1H), 1.28 (d, *J* = 6.6 Hz, 1H), 1.22 (s, 1H), 1.10 (s, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.41, 169.88, 165.37, 151.65, 149.43, 149.24, 146.68, 126.69, 123.25, 120.54, 114.07, 110.98, 109.52, 96.20, 76.64, 75.37, 73.69, 63.50, 61.50, 60.32, 55.96, 55.92, 53.61, 41.05, 39.74, 38.10, 33.56, 32.34, 30.19, 25.17, 21.53, 21.47, 17.95. **HRMS** (*m/z*) (ESI): calcd for $C_{33}H_{41}O_{10}$ 597.2694 $[M+H]^+$ found 597.2689.



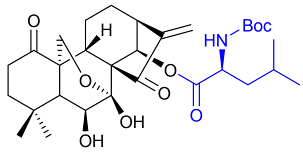
(5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-5,6-dihydroxy-4,4-dimethyl-8-methylene-1,7-dioxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-valinate (11e). White solid, mp 96-97 °C. 130 mg, 86% yield. R_f = 0.38 (1 : 25 MeOH in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$) δ 6.22 (s, 1H), 5.86 (d, *J* = 13.6 Hz, 1H), 5.58 (s, 1H), 5.35 (d, *J* = 11.7 Hz, 1H), 4.98 (d, *J* = 8.1 Hz, 1H), 4.27 (d, *J* = 10.7 Hz, 1H), 4.22 (s, 1H), 4.08 – 3.99 (m, 2H), 3.77 (dd, *J* = 11.6, 9.0 Hz, 1H), 3.10 (d, *J* = 9.3 Hz, 1H), 2.55 (dt, *J* = 14.0, 8.8 Hz, 1H), 2.48 – 2.38 (m, 1H), 2.36 – 2.28 (m, 1H), 2.21 (dd, *J* = 13.6, 4.4 Hz, 1H), 2.03 (dt, *J* = 18.1, 5.9 Hz, 1H), 1.95 (dt, *J* = 17.5, 7.1 Hz, 2H), 1.88 (dd, *J* = 10.9, 4.3 Hz, 1H), 1.71 (ddd, *J* = 18.1, 12.4, 8.1 Hz, 1H), 1.61 (td, *J* = 13.1, 7.4 Hz, 1H), 1.41 (d, *J* = 9.9 Hz, 9H), 1.33 – 1.26 (m, 1H), 1.18 (s, 3H), 0.97 (d, *J* = 12.7 Hz, 3H), 0.88 (dd, *J* = 13.8, 5.8 Hz, 3H), 0.83 (d, *J* = 6.7 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.67, 204.52, 171.19, 149.36, 121.94, 96.79, 79.92, 75.15, 73.36, 64.86, 61.31, 59.79, 59.05, 50.68, 48.48, 41.44, 38.38, 35.73, 32.84, 30.76, 30.49, 29.92, 28.24, 23.18, 19.12, 18.85, 17.75. **HRMS** (*m/z*) (ESI): calcd for $C_{30}H_{44}NO_9$ 562.3011 $[M+H]^+$ found 562.2998.



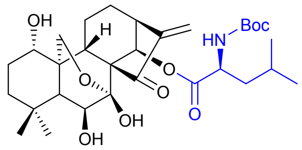
(1*S*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1-acetoxy-5,6-dihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-valinate (11f). White solid, mp 80-82 °C. 123 mg, 82% yield. R_f = 0.56 (1 : 30 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.11 (s, 1H), 6.06 (d, *J* = 10.6 Hz, 1H), 5.81 (d, *J* = 0.6 Hz, 1H), 5.46 (s, 1H), 4.98 (d, *J* = 8.1 Hz, 1H), 4.60 (dd, *J* = 11.3, 5.5 Hz, 1H), 4.23 (dd, *J* = 10.6, 1.1 Hz, 1H), 4.20 – 4.11 (m, 2H), 4.06 (dd, *J* = 8.1, 5.2 Hz, 1H), 3.74 (dt, *J* = 11.7, 5.8 Hz, 1H), 3.13 (d, *J* = 10.0 Hz, 1H), 2.56 – 2.47 (m, 1H), 2.08 – 1.94 (m, 6H), 1.74 (ddd, *J* = 12.1, 7.3, 3.1 Hz, 1H), 1.54 – 1.48 (m, 1H), 1.48 – 1.41 (m, 2H), 1.41 – 1.36 (m, 9H), 1.32 (d, *J* = 6.7 Hz, 1H), 1.27 (d, *J* = 6.7 Hz, 1H), 1.22 (s, 1H), 1.10 (s, 6H), 0.89 (d, *J* = 6.8 Hz, 3H), 0.83 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 205.95, 171.22, 169.87, 155.54, 149.35, 120.41, 95.82, 79.96, 76.53, 75.36, 74.16, 63.43, 61.62, 59.99, 59.12, 53.70, 41.07, 39.63, 38.11, 33.52, 32.39, 30.76, 30.10, 29.65, 28.21, 25.11, 21.61, 21.52, 18.91, 18.02, 17.74. **HRMS** (*m/z*) (ESI): calcd for $C_{32}H_{47}O_{10}NNa$ 628.3092 [M+H] $^+$ found 628.3082.



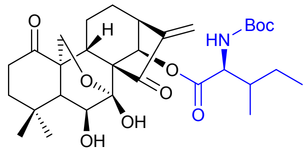
(1*S*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1,5,6-trihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-valinate (11g). White solid, mp 219-220 °C. 128 mg, 84% yield. R_f = 0.25 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.13 (s, 1H), 6.07 (t, *J* = 10.0 Hz, 1H), 5.88 (s, 1H), 5.48 (s, 1H), 5.03 (d, *J* = 8.2 Hz, 1H), 4.29 (d, *J* = 10.4 Hz, 1H), 4.21 (s, 1H), 4.08 (t, *J* = 11.7 Hz, 2H), 3.75 (dd, *J* = 10.5, 7.0 Hz, 1H), 3.52 – 3.45 (m, 1H), 3.15 (d, *J* = 9.8 Hz, 1H), 2.60 (dt, *J* = 13.9, 9.1 Hz, 1H), 2.24 (dt, *J* = 21.5, 13.4 Hz, 1H), 2.06 (dd, *J* = 12.2, 6.3 Hz, 1H), 1.95 (dd, *J* = 12.8, 5.2 Hz, 1H), 1.84 (s, 1H), 1.81 – 1.72 (m, 1H), 1.70 – 1.63 (m, 1H), 1.62 – 1.54 (m, 2H), 1.50 (s, 1H), 1.45 (t, *J* = 10.3 Hz, 1H), 1.41 (d, *J* = 9.2 Hz, 9H), 1.27 (d, *J* = 10.0 Hz, 1H), 1.11 (s, 6H), 0.90 (t, *J* = 8.5 Hz, 3H), 0.84 (t, *J* = 8.7 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.21, 171.12, 155.58, 149.87, 120.08, 96.00, 79.94, 74.37, 73.45, 63.36, 61.99, 59.51, 59.01, 54.71, 41.33, 38.70, 33.71, 32.62, 30.90, 30.44, 29.95, 29.68, 28.25, 21.76, 19.85, 18.91, 17.66. **HRMS** (*m/z*) (ESI): calcd for $C_{30}H_{46}NO_9$ 564.3167 [M+H] $^+$ found 564.3152.



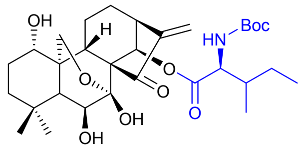
(5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-5,6-dihydroxy-4,4-dimethyl-8-methylene-1,7-dioxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-leucinate (11h). White solid, mp 128-129 ºC. 127 mg, 82% yield. R_f = 0.39 (1 : 25 MeOH in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$) δ 6.24 (s, 1H), 5.90 (s, 1H), 5.60 (s, 1H), 5.38 (d, *J* = 11.6 Hz, 1H), 4.84 (d, *J* = 7.3 Hz, 1H), 4.29 (dd, *J* = 10.7, 0.7 Hz, 1H), 4.23 (s, 1H), 4.20 – 4.14 (m, 1H), 4.03 (dd, *J* = 10.7, 1.4 Hz, 1H), 4.01 – 3.99 (m, 1H), 3.78 (dd, *J* = 11.6, 8.9 Hz, 1H), 3.10 (d, *J* = 9.3 Hz, 1H), 2.55 (dt, *J* = 13.9, 8.7 Hz, 1H), 2.46 (ddd, *J* = 15.6, 10.9, 6.5 Hz, 1H), 2.33 (ddd, *J* = 15.4, 8.9, 4.6 Hz, 1H), 2.22 (dd, *J* = 13.7, 4.3 Hz, 1H), 2.02 – 1.87 (m, 3H), 1.77 – 1.71 (m, 1H), 1.69 (s, 1H), 1.64 – 1.57 (m, 2H), 1.45 – 1.38 (m, 9H), 1.32 (dd, *J* = 13.4, 6.7 Hz, 1H), 1.20 (s, 3H), 1.00 (s, 3H), 0.88 (t, *J* = 6.5 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.67, 204.53, 171.90, 155.33, 149.42, 121.87, 96.83, 79.98, 74.99, 73.40, 64.86, 61.33, 59.80, 52.53, 50.72, 48.52, 41.42, 40.88, 38.41, 35.74, 32.85, 30.51, 29.98, 29.68, 28.25, 24.81, 23.19, 22.62, 22.07, 19.15. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{46}NO_9$ 576.3167 $[M+H]^+$ found 576.3158.



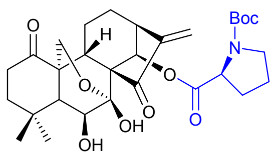
(1*S*,4a*R*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1,5,6-trihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-leucinate (18i). White solid, mp 217-218 ºC. 139 mg, 89% yield. R_f = 0.28 (1 : 25 MeOH in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$) δ 6.11 (s, 1H), 5.87 (s, 1H), 5.47 (s, 1H), 4.90 (d, *J* = 7.6 Hz, 1H), 4.28 (d, *J* = 10.4 Hz, 1H), 4.23 (s, 1H), 4.20 – 4.13 (m, 1H), 4.05 (d, *J* = 10.4 Hz, 1H), 3.73 (dd, *J* = 10.6, 6.9 Hz, 1H), 3.50 – 3.44 (m, 1H), 3.12 (d, *J* = 9.8 Hz, 1H), 2.62 – 2.54 (m, 1H), 2.24 (ddd, *J* = 21.4, 13.4, 8.4 Hz, 1H), 1.96 (d, *J* = 9.5 Hz, 1H), 1.80 – 1.72 (m, 1H), 1.71 – 1.63 (m, 2H), 1.58 (ddd, *J* = 19.7, 13.3, 6.9 Hz, 4H), 1.48 – 1.35 (m, 11H), 1.26 (dd, *J* = 18.6, 4.6 Hz, 3H), 1.10 (s, 6H), 0.87 (t, *J* = 5.9 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.25, 171.84, 155.28, 149.89, 119.99, 96.01, 79.96, 77.24, 76.52, 74.40, 73.37, 63.38, 62.01, 59.51, 54.71, 52.52, 41.30, 40.89, 38.70, 33.70, 32.62, 30.49, 29.89, 28.23, 24.77, 22.71, 21.94, 21.73, 19.84. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{48}NO_9$ 578.3324 $[M+H]^+$ found 578.3327.



(5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-5,6-dihydroxy-4,4-dimethyl-8-methylene-1,7-dioxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (2*S*)-2-((*tert*-butoxycarbonyl)amino)-3-methylpentanoate (11j). White solid, mp 88-89 ºC. 134 mg, 86% yield. R_f = 0.48 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.23 (s, 1H), 5.87 (s, 1H), 5.58 (s, 1H), 5.35 (d, *J* = 11.6 Hz, 1H), 4.99 (d, *J* = 7.8 Hz, 1H), 4.27 (d, *J* = 10.7 Hz, 1H), 4.23 (s, 1H), 4.13 – 4.08 (m, 1H), 4.02 (d, *J* = 10.6 Hz, 1H), 3.78 (dd, *J* = 11.5, 9.0 Hz, 1H), 3.10 (d, *J* = 9.3 Hz, 1H), 2.55 (dt, *J* = 14.0, 8.7 Hz, 1H), 2.48 – 2.40 (m, 1H), 2.35 – 2.28 (m, 1H), 2.21 (dd, *J* = 13.6, 4.5 Hz, 1H), 1.96 – 1.91 (m, 2H), 1.88 (dd, *J* = 10.9, 4.3 Hz, 1H), 1.75 – 1.67 (m, 1H), 1.61 (td, *J* = 13.0, 7.3 Hz, 1H), 1.40 (d, *J* = 9.8 Hz, 8H), 1.29 (dd, *J* = 13.4, 6.9 Hz, 2H), 1.18 (s, 3H), 1.14 – 1.04 (m, 1H), 0.98 (s, 3H), 0.90 – 0.80 (m, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.69, 204.48, 149.40, 121.88, 96.78, 75.21, 73.33, 64.84, 61.30, 59.78, 58.21, 50.66, 48.49, 41.44, 38.39, 37.39, 35.73, 32.84, 30.49, 29.91, 28.25, 25.08, 23.18, 19.11, 15.34, 11.45. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{46}NO_9$ 576.3167 [M+H] $^+$ found 576.3157.

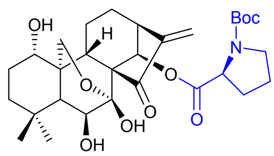


(1*S*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1,5,6-trihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (2*S*)-2-((*tert*-butoxycarbonyl)amino)-3-methylpentanoate (11k). White solid, mp 249-251 ºC. 126 mg, 81% yield. R_f = 0.24 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.14 (s, 1H), 6.05 (d, *J* = 10.7 Hz, 1H), 5.88 (s, 1H), 5.47 (s, 1H), 5.01 (d, *J* = 8.0 Hz, 1H), 4.29 (d, *J* = 10.4 Hz, 1H), 4.15 (d, *J* = 10.6 Hz, 2H), 4.07 (d, *J* = 10.4 Hz, 1H), 3.76 (dd, *J* = 10.6, 6.9 Hz, 1H), 3.53 – 3.45 (m, 1H), 3.16 (d, *J* = 9.9 Hz, 1H), 2.61 (dt, *J* = 13.9, 9.1 Hz, 1H), 2.25 (dt, *J* = 21.4, 13.3 Hz, 1H), 1.96 (dd, *J* = 12.8, 5.2 Hz, 1H), 1.77 (dd, *J* = 14.1, 7.2 Hz, 2H), 1.73 (s, 2H), 1.71 – 1.55 (m, 4H), 1.47 (d, *J* = 13.7 Hz, 1H), 1.42 (d, *J* = 9.8 Hz, 9H), 1.31 (d, *J* = 3.8 Hz, 2H), 1.12 (s, 6H), 0.91 – 0.83 (m, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.16, 171.07, 155.45, 149.89, 120.06, 96.00, 79.96, 74.34, 73.49, 63.32, 61.98, 59.52, 58.33, 54.68, 41.32, 38.68, 37.54, 33.72, 32.61, 30.44, 30.01, 29.69, 28.27, 25.01, 21.77, 19.85, 15.38, 11.56. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{47}NO_9Na$ 600.3134 [M+H] $^+$ found 600.3143.

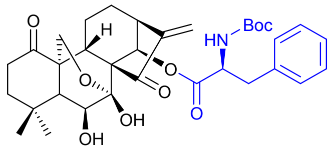


1-(*tert*-butyl) 2-((5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-5,6-dihydroxy-4,4-dimethyl-8-methylene-1,7-dioxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl) (2*S*)-pyrrolidine-

1,2-dicarboxylate (11l). White solid, mp 212-213 ºC. 131 mg, 87% yield. R_f = 0.38 (1 : 25 MeOH in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$) δ 6.22 (d, *J* = 22.1 Hz, 1H), 5.80 (d, *J* = 17.4 Hz, 1H), 5.59 (s, 1H), 5.45 – 5.31 (m, 1H), 4.58 (s, 1H), 4.23 (ddd, *J* = 26.9, 19.5, 8.4 Hz, 2H), 4.02 (dd, *J* = 10.7, 1.3 Hz, 1H), 3.80 (dt, *J* = 14.8, 7.5 Hz, 1H), 3.46 – 3.30 (m, 2H), 3.13 (dd, *J* = 39.1, 9.4 Hz, 1H), 2.56 (dt, *J* = 13.9, 8.8 Hz, 1H), 2.48 – 2.40 (m, 1H), 2.36 – 2.28 (m, 1H), 2.23 (dd, *J* = 13.5, 4.8 Hz, 1H), 2.12 (dq, *J* = 12.9, 8.2 Hz, 1H), 2.00 – 1.91 (m, 3H), 1.87 (dd, *J* = 12.3, 7.7 Hz, 2H), 1.82 (dd, *J* = 13.1, 6.1 Hz, 1H), 1.78 – 1.68 (m, 2H), 1.65 – 1.55 (m, 1H), 1.40 (s, 8H), 1.34 – 1.26 (m, 2H), 1.24 (s, 1H), 1.19 (s, 3H), 0.99 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.85, 204.71, 171.55, 149.19, 121.97, 96.88, 80.14, 75.94, 73.15 (d, *J* = 15.5 Hz), 64.83, 61.20, 60.26, 59.99, 59.23, 50.76, 48.51, 46.61, 46.30, 41.35, 41.11, 38.48 (d, *J* = 15.2 Hz), 35.82, 32.86, 30.51, 30.01, 29.71 (d, *J* = 9.1 Hz), 28.34 (d, *J* = 13.9 Hz), 24.51, 23.36 (d, *J* = 14.1 Hz), 19.05. **HRMS** (*m/z*) (ESI): calcd for $C_{30}H_{42}NO_9$ 560.2854 [M+H] $^+$ found 560.2839.

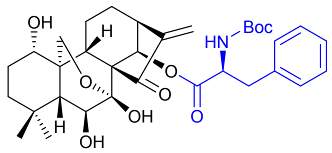


1-(*tert*-butyl) 2-((1*S*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1,5,6-trihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl) (2*S*)-pyrrolidine-1,2-dicarboxylate (11m). White solid, mp 99-100 ºC. 128 mg, 85% yield. R_f = 0.23 (1 : 25 MeOH in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$) δ 6.19 – 6.12 (m, 1H), 6.11 – 5.99 (m, 1H), 5.80 (d, *J* = 15.9 Hz, 1H), 5.49 (s, 1H), 4.48 (s, 1H), 4.28 (d, *J* = 10.3 Hz, 1H), 4.18 (d, *J* = 6.6 Hz, 1H), 4.06 (d, *J* = 9.8 Hz, 1H), 3.77 (dd, *J* = 10.3, 6.7 Hz, 1H), 3.53 – 3.31 (m, 3H), 3.21 (dd, *J* = 48.5, 9.7 Hz, 1H), 2.65 – 2.55 (m, 1H), 2.33 – 2.22 (m, 1H), 2.17 (dd, *J* = 20.5, 7.7 Hz, 1H), 1.98 (dd, *J* = 12.6, 5.5 Hz, 1H), 1.93 – 1.80 (m, 2H), 1.78 – 1.62 (m, 5H), 1.57 (dd, *J* = 26.4, 16.5 Hz, 2H), 1.46 (d, *J* = 13.5 Hz, 1H), 1.40 (d, *J* = 5.0 Hz, 8H), 1.26 (dt, *J* = 21.9, 9.2 Hz, 4H), 1.10 (d, *J* = 13.8 Hz, 5H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 171.47, 120.25, 96.18, 77.73, 73.91, 73.46, 63.34, 61.83, 59.88, 59.35, 54.55, 46.69, 41.25, 40.84, 38.64, 33.74, 32.51, 30.52, 30.03 (d, *J* = 7.1 Hz), 28.31 (d, *J* = 18.3 Hz), 24.60, 21.70, 19.70. **HRMS** (*m/z*) (ESI): calcd for $C_{30}H_{44}NO_9$ 562.3011 [M+H] $^+$ found 562.2997.

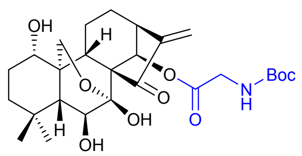


(5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-5,6-dihydroxy-4,4-dimethyl-8-methylene-1,7-dioxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-phenylalaninate (11n). White solid, mp 118-119 ºC. 126 mg, 84% yield. R_f = 0.50 (1 : 30 MeOH in CH_2Cl_2); ^1H NMR (500 MHz, $CDCl_3$)

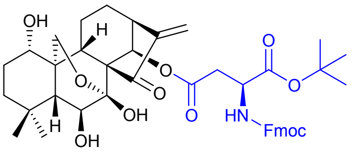
δ 7.27 (s, 1H), 7.22 (dd, *J* = 12.9, 6.5 Hz, 2H), 7.12 (d, *J* = 7.3 Hz, 2H), 6.17 (s, 1H), 5.89 (s, 1H), 5.49 (s, 1H), 5.37 (d, *J* = 11.7 Hz, 1H), 5.01 (d, *J* = 6.8 Hz, 1H), 4.43 (dd, *J* = 13.4, 6.6 Hz, 1H), 4.27 (d, *J* = 10.6 Hz, 1H), 4.17 (s, 1H), 4.01 (d, *J* = 10.6 Hz, 1H), 3.75 (dd, *J* = 11.5, 9.1 Hz, 1H), 3.04 (dd, *J* = 13.7, 7.0 Hz, 1H), 2.95 (dd, *J* = 12.5, 7.7 Hz, 1H), 2.83 (d, *J* = 9.1 Hz, 1H), 2.54 – 2.40 (m, 2H), 2.36 – 2.28 (m, 1H), 2.17 (dd, *J* = 13.5, 4.1 Hz, 1H), 1.91 (dt, *J* = 14.8, 7.9 Hz, 3H), 1.77 (s, 1H), 1.75 – 1.68 (m, 1H), 1.62 – 1.53 (m, 1H), 1.42 – 1.33 (m, 9H), 1.19 (s, 3H), 0.99 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 211.67, 204.53, 170.90, 155.10, 149.21, 136.00, 129.29, 128.47, 126.93, 122.00, 96.71, 80.12, 74.74, 73.46, 64.81, 61.37, 59.68, 54.95, 50.72, 48.50, 41.29, 38.37, 37.84, 35.72, 32.83, 30.49, 30.00, 29.68, 28.24, 23.17, 19.14.**HRMS** (*m/z*) (ESI): calcd for $C_{34}H_{44}O_9N$ 610.3011 [M+H] $^+$ found 610.2997.



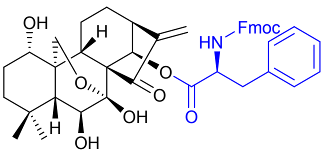
(1*S*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1,5,6-trihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-phenylalaninate (11o). White solid, mp 111-112 ºC. 147 mg, 89% yield. R_f = 0.29 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28 – 7.18 (m, 3H), 7.10 (d, *J* = 6.8 Hz, 2H), 6.20 (d, *J* = 10.7 Hz, 1H), 6.09 (s, 1H), 5.91 (s, 1H), 5.41 (s, 1H), 5.10 (d, *J* = 7.2 Hz, 1H), 4.49 (s, 1H), 4.41 (dd, *J* = 13.2, 6.4 Hz, 1H), 4.25 (d, *J* = 10.4 Hz, 1H), 4.02 (d, *J* = 10.3 Hz, 1H), 3.70 (dd, *J* = 10.1, 7.5 Hz, 1H), 3.46 – 3.38 (m, 1H), 3.07 (dd, *J* = 13.9, 6.3 Hz, 1H), 2.97 – 2.87 (m, 2H), 2.53 (dt, *J* = 13.7, 9.1 Hz, 1H), 2.25 – 2.11 (m, 2H), 2.03 (d, *J* = 4.1 Hz, 1H), 1.88 (dd, *J* = 12.9, 5.3 Hz, 1H), 1.80 – 1.71 (m, 1H), 1.71 – 1.47 (m, 4H), 1.42 (d, *J* = 13.6 Hz, 1H), 1.36 (s, 9H), 1.07 (d, *J* = 6.6 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.31, 170.64, 155.00, 149.91, 136.08, 129.33, 128.43, 126.90, 120.09, 95.94, 80.03, 75.95, 74.53, 73.35, 63.37, 62.13, 59.40, 54.93, 54.75, 41.42, 41.27, 38.76, 37.76, 33.66, 32.68, 30.55, 29.75, 28.26, 21.67, 19.85. **HRMS** (*m/z*) (ESI): calcd for $C_{34}H_{46}NO_9$ 612.3167 [M+H] $^+$ found 612.3163.



(1*S*,4a*R*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1,5,6-trihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)glycinate (11p). White solid, mp 151-152 ºC. 122 mg, 87% yield. R_f = 0.19 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.20 (d, *J* = 10.7 Hz, 1H), 6.12 (s, 1H), 5.95 (s, 1H), 5.50 (s, 1H), 5.37 (t, *J* = 5.2 Hz, 1H), 4.52 (s, 1H), 4.27 (d, *J* = 10.3 Hz, 1H), 4.02 (d, *J* = 10.3 Hz, 1H), 3.79 (ddd, *J* = 23.2, 18.2, 5.7 Hz, 2H), 3.69 (dd, *J* = 10.8, 7.0 Hz, 1H), 3.44 (dd, J = 11.3, 5.5 Hz, 1H), 3.11 (d, J = 9.7 Hz, 1H), 2.56 (dt, J = 13.8, 9.1 Hz, 1H), 2.28 – 2.13 (m, 1H), 2.05 (s, 1H), 1.89 (dd, J = 13.0, 5.6 Hz, 1H), 1.76 (dd, J = 14.0, 6.8 Hz, 1H), 1.71 – 1.62 (m, 1H), 1.57 (dt, J = 19.4, 8.7 Hz, 2H), 1.46 – 1.35 (m, 10H), 1.07 (d, J = 2.2 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.48, 169.40, 155.90, 149.84, 120.35, 95.98, 79.87, 75.67, 74.39, 73.32, 63.36, 62.09, 59.37, 54.70, 42.92, 41.36, 41.26, 38.72, 33.67, 32.65, 30.56, 29.75, 28.27, 21.67, 19.86. **HRMS** (*m/z*) (ESI): calcd for $C_{27}H_{40}NO_9$ 522.2698 [M+H] $^+$ found 522.2686.

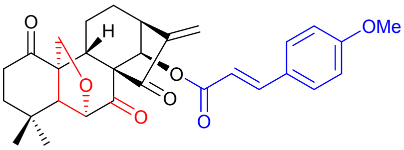


1-(*tert*-butyl) 4-((1*S*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1,5,6-trihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl) (((9*H*-fluoren-9-yl)methoxy)carbonyl)-*L*-aspartate (11q). White solid, mp 119-121 ºC. 170 mg, 83% yield. R_f = 0.27 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.77 (d, J = 7.5 Hz, 2H), 7.66 – 7.61 (m, 2H), 7.41 (t, J = 7.4 Hz, 2H), 7.33 (t, J = 7.3 Hz, 2H), 6.12 (s, 1H), 6.09 (d, J = 8.1 Hz, 1H), 6.05 (d, J = 10.9 Hz, 1H), 5.93 (s, 1H), 5.44 (s, 1H), 4.48 (dd, J = 8.2, 4.3 Hz, 1H), 4.41 (dd, J = 10.0, 7.5 Hz, 1H), 4.30 (t, J = 12.2 Hz, 2H), 4.24 (t, J = 7.2 Hz, 1H), 4.07 (d, J = 10.4 Hz, 1H), 4.03 (s, 1H), 3.74 (dd, J = 10.7, 7.2 Hz, 1H), 3.52 – 3.45 (m, 1H), 3.14 (d, J = 9.7 Hz, 1H), 2.90 (ddd, J = 42.1, 16.9, 4.6 Hz, 2H), 2.64 – 2.55 (m, 1H), 2.24 (ddd, J = 27.1, 13.4, 8.4 Hz, 1H), 1.94 (dd, J = 13.0, 5.5 Hz, 1H), 1.79 – 1.72 (m, 1H), 1.68 (s, 1H), 1.64 (dd, J = 11.5, 3.7 Hz, 1H), 1.62 – 1.53 (m, 2H), 1.47 (d, J = 11.5 Hz, 10H), 1.24 (d, J = 3.9 Hz, 1H), 1.21 (d, J = 3.9 Hz, 1H), 1.12 (d, J = 6.2 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.30, 169.37, 156.02, 149.67, 143.89, 141.25, 127.68, 127.09, 125.29, 120.63, 119.94, 95.92, 82.84, 76.34, 74.54, 73.47, 67.20, 63.32, 62.00, 59.31, 54.84, 50.73, 47.12, 41.36, 38.63, 37.24, 33.71, 32.61, 30.55, 30.02, 29.69, 27.86, 21.77, 19.87. **HRMS** (*m/z*) (ESI): calcd for $C_{43}H_{52}NO_{11}$ 758.3535 [M+H] $^+$ found 758.3542.

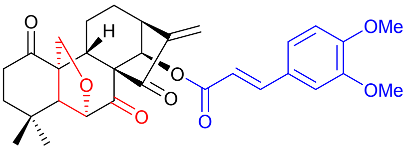


(1*S*,4a*R*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1,5,6-trihydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (((9*H*-fluoren-9-yl)methoxy)carbonyl)-*L*-phenylalaninate (11r). White solid, mp 146-147 ºC. 166 mg, 84% yield. R_f = 0.27 (1 : 25 MeOH in CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76 (d, J = 7.4 Hz, 2H), 7.55 (d, J = 7.3 Hz, 2H), 7.40 (t, J = 7.4 Hz, 2H), 7.32 (t, J = 7.4 Hz, 2H), 7.24 (d, J = 9.6 Hz, 2H), 7.12 (d, J = 6.9 Hz, 2H), 6.17 (d, J = 10.9 Hz, 1H), 6.07 (s, 1H), 5.95 (s, 1H), 5.51 – 5.45 (m, 1H), 5.40 (s, 1H), 4.53 (dd, J = 13.4, 6.6 Hz, 1H), 4.37 (dd, J = 10.2, 7.5 Hz, 1H), 4.32 (s, 1H), 4.30

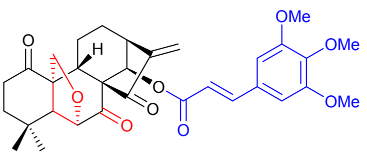
– 4.23 (m, 2H), 4.17 (t, *J* = 7.0 Hz, 1H), 4.03 (d, *J* = 10.3 Hz, 1H), 3.72 (dd, *J* = 10.8, 7.1 Hz, 1H), 3.41 (d, *J* = 5.9 Hz, 1H), 3.12 (dd, *J* = 13.9, 6.5 Hz, 1H), 2.99 (dd, *J* = 13.8, 6.3 Hz, 1H), 2.93 (d, *J* = 9.7 Hz, 1H), 2.52 (dt, *J* = 13.6, 8.9 Hz, 1H), 2.17 (dt, *J* = 21.5, 13.4 Hz, 1H), 1.92 (s, 1H), 1.87 (dd, *J* = 12.9, 5.3 Hz, 1H), 1.77 – 1.68 (m, 1H), 1.63 (d, *J* = 3.5 Hz, 2H), 1.60 – 1.48 (m, 2H), 1.42 (d, *J* = 13.5 Hz, 1H), 1.08 (d, *J* = 13.7 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 206.20, 170.35, 155.67, 149.86, 143.83, 143.75, 141.24, 135.93, 129.38, 128.56, 128.51, 127.69, 127.13, 127.10, 127.02, 125.22, 125.15, 120.22, 119.93, 95.97, 75.89, 74.71, 73.41, 67.14, 63.36, 62.14, 59.31, 55.40, 54.72, 47.08, 41.44, 41.26, 38.70, 37.74, 33.67, 32.69, 30.49, 29.82, 21.75, 19.91; **HRMS** (*m/z*) (ESI): calcd for $C_{44}H_{48}NO_9$ 734.3324 [M+H] $^+$ found 734.3319.



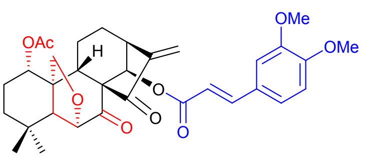
(5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-4,4-dimethyl-8-methylene-1,6,7-trioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*E*)-3-(4-methoxyphenyl)acrylate (12a). White solid, mp 119-120 ºC. 73 mg, 81% yield. R_f = 0.46 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58 (d, *J* = 15.9 Hz, 1H), 7.44 (d, *J* = 8.7 Hz, 2H), 6.86 (d, *J* = 8.7 Hz, 2H), 6.20 (d, *J* = 15.9 Hz, 1H), 6.16 (s, 1H), 5.72 (s, 1H), 5.50 (s, 1H), 4.38 (d, *J* = 9.7 Hz, 1H), 4.31 – 4.26 (m, 2H), 3.82 (s, 3H), 3.23 (d, *J* = 7.9 Hz, 1H), 2.74 (ddd, *J* = 14.6, 11.7, 6.3 Hz, 1H), 2.56 – 2.45 (m, 2H), 2.35 (dt, *J* = 14.6, 4.6 Hz, 1H), 2.18 – 2.10 (m, 2H), 1.96 – 1.81 (m, 3H), 1.77 – 1.69 (m, 1H), 1.66 (s, 1H), 1.19 (d, *J* = 15.1 Hz, 3H), 1.05 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.87, 202.56, 199.65, 166.04, 161.48, 147.69, 145.74, 129.98, 126.97, 119.22 , 114.68, 114.21, 83.31, 77.27, 77.01, 76.76, 75.61, 70.10, 64.24, 61.58, 61.31, 55.34, 47.17, 42.05, 41.18, 36.37, 31.96, 31.33, 30.17, 29.68, 23.23, 19.17. **HRMS** (*m/z*) (ESI): calcd for $C_{30}H_{33}O_7$ 505.2221 [M+H] $^+$ found 505.2218.



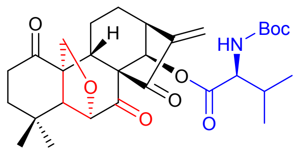
(5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-4,4-dimethyl-8-methylene-1,6,7-trioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*E*)-3-(3,4-dimethoxyphenyl)acrylate (12b). White solid, mp 144-146 ºC. 77 mg, 80% yield. R_f = 0.32 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.61 – 7.56 (m, 1H), 7.07 (dd, *J* = 8.3, 1.8 Hz, 1H), 7.03 (d, *J* = 1.8 Hz, 1H), 6.85 – 6.82 (m, 1H), 6.22 (d, *J* = 15.9 Hz, 1H), 6.18 (s, 1H), 5.74 (s, 1H), 5.51 (s, 1H), 4.38 (t, *J* = 7.7 Hz, 1H), 4.30 (dd, *J* = 14.7, 4.9 Hz, 2H), 3.91 (d, *J* = 4.0 Hz, 6H), 3.25 (d, *J* = 7.9 Hz, 1H), 2.75 (ddd, *J* = 14.6, 11.7, 6.3 Hz, 1H), 2.57 – 2.52 (m, 1H), 2.49 (ddd, *J* = 16.3, 8.1, 4.2 Hz, 1H), 2.36 (dt, J = 14.6, 4.6 Hz, 1H), 2.19 – 2.11 (m, 2H), 1.98 – 1.83 (m, 4H), 1.79 – 1.71 (m, 1H), 1.62 (s, 2H), 1.21 (d, J = 6.5 Hz, 3H), 1.06 (d, J = 9.5 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.83, 202.53, 199.76, 165.95, 151.23, 149.11, 147.63, 145.99, 127.20, 123.14, 119.28, 114.84, 110.84, 109.47, 83.31, 75.67, 70.12, 64.26, 61.63, 61.34, 55.92, 47.17, 42.06, 41.19, 36.36, 31.97, 31.34, 30.17, 23.22, 19.16. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{35}O_8$ 535.2326 $[M+H]^+$ found 535.2327.



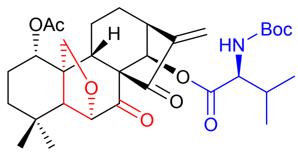
(5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-4,4-dimethyl-8-methylene-1,6,7-trioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*E*)-3-(3,4,5-trimethoxyphenyl)acrylate (12c). White solid, mp 185-186 °C. 82 mg, 81% yield. R_f = 0.28 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54 (d, J = 15.9 Hz, 1H), 6.71 (s, 2H), 6.25 (d, J = 15.9 Hz, 1H), 6.17 (s, 1H), 5.73 (s, 1H), 5.51 (s, 1H), 4.38 (d, J = 9.7 Hz, 1H), 4.33 – 4.27 (m, 2H), 3.87 (d, J = 2.1 Hz, 9H), 3.24 (d, J = 7.8 Hz, 1H), 2.75 (ddd, J = 14.6, 11.8, 6.3 Hz, 1H), 2.58 – 2.45 (m, 2H), 2.35 (ddd, J = 14.5, 9.5, 5.1 Hz, 1H), 2.19 – 2.10 (m, 2H), 1.95 – 1.85 (m, 3H), 1.79 – 1.71 (m, 1H), 1.21 (s, 3H), 1.06 (s, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.78, 202.48, 199.77, 165.66, 153.31, 147.55, 145.99, 129.67, 119.38, 116.46, 105.37, 83.31, 75.82, 70.13, 64.23, 61.64, 61.34, 60.94, 56.17, 47.16, 42.05, 41.21, 36.36, 31.98, 31.36, 30.19, 29.68, 23.22, 19.16. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{37}O_9$ 565.2432 $[M+H]^+$ found 565.2428.



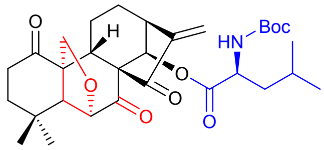
(1*S*,5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1-acetoxy-4,4-dimethyl-8-methylene-6,7-dioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*E*)-3-(3,4-dimethoxyphenyl)acrylate (12d). White solid, mp 148-150 °C. 84 mg, 85% yield. R_f = 0.46 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.55 (d, J = 15.9 Hz, 1H), 7.04 (dd, J = 8.3, 1.7 Hz, 1H), 7.00 (d, J = 1.6 Hz, 1H), 6.81 (d, J = 8.3 Hz, 1H), 6.18 (d, J = 15.9 Hz, 1H), 6.11 (s, 1H), 5.74 (s, 1H), 5.42 (s, 1H), 4.88 (dd, J = 10.9, 6.1 Hz, 1H), 4.34 (d, J = 10.1 Hz, 1H), 4.19 (d, J = 7.1 Hz, 2H), 3.88 (d, J = 7.2 Hz, 6H), 3.27 (d, J = 6.7 Hz, 1H), 2.49 – 2.38 (m, 1H), 2.22 (t, J = 7.8 Hz, 1H), 2.00 (s, 3H), 1.99 – 1.92 (m, 1H), 1.92 – 1.86 (m, 1H), 1.71 (s, 1H), 1.70 – 1.63 (m, 1H), 1.58 (d, J = 13.7 Hz, 1H), 1.46 (qd, J = 12.8, 4.2 Hz, 2H), 1.38 – 1.30 (m, 1H), 1.02 (s, 3H), 0.95 (d, J = 10.0 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 202.84, 199.89, 169.92, 165.84, 151.23, 149.12, 147.32, 145.93, 127.18, 123.11, 118.48, 114.84, 110.87, 109.47, 83.77, 75.76, 69.16, 65.22, 58.36, 55.91, 54.18, 51.90, 42.34, 41.94, 36.89, 32.29, 31.23, 29.97, 26.98, 24.50, 21.96, 21.36, 18.57. **HRMS** (*m/z*) (ESI): calcd for $C_{33}H_{39}O_9$ 579.2589 [M+H] $^+$ found 579.2596.



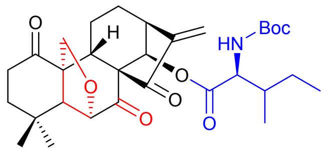
(5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-4,4-dimethyl-8-methylene-1,6,7-trioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-valinate (12e). White solid, mp 67-68 °C. 78 mg, 80% yield. R_f = 0.51 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.12 (s, 1H), 5.60 (s, 1H), 5.45 (s, 1H), 4.95 (d, *J* = 8.8 Hz, 1H), 4.33 – 4.24 (m, 3H), 4.18 – 4.12 (m, 1H), 3.16 (d, *J* = 7.6 Hz, 1H), 2.73 (ddd, *J* = 14.6, 11.8, 6.3 Hz, 1H), 2.54 – 2.49 (m, 1H), 2.48 – 2.40 (m, 1H), 2.34 (dt, *J* = 14.6, 4.6 Hz, 1H), 2.16 (d, *J* = 9.6 Hz, 1H), 2.13 – 2.05 (m, 2H), 1.92 – 1.84 (m, 3H), 1.75 – 1.67 (m, 1H), 1.41 (s, 9H), 1.21 (s, 3H), 1.05 (s, 3H), 0.88 (d, *J* = 6.8 Hz, 3H), 0.80 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.67, 170.82, 147.29, 119.21, 83.23, 76.52, 70.10, 63.98, 61.62, 61.32, 58.71, 47.19, 41.97, 41.23, 36.35, 31.97, 31.35, 30.88, 30.06, 28.29, 23.17, 19.07, 18.93, 17.42. **HRMS** (*m/z*) (ESI): calcd for $C_{30}H_{42}NO_8$ 544.2905 [M+H] $^+$ found 544.2910.



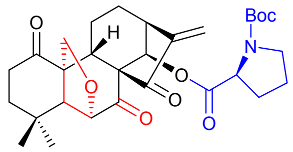
(1*S*,5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1-acetoxy-4,4-dimethyl-8-methylene-6,7-dioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-valinate (12f). Light yellow solid, mp 100-101 °C. 78 mg, 80% yield. R_f = 0.43 (3 : 2 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.07 (d, *J* = 17.0 Hz, 1H), 5.61 (s, 1H), 5.36 (s, 1H), 4.94 – 4.81 (m, 2H), 4.31 – 4.22 (m, 1H), 4.15 (d, *J* = 11.9 Hz, 2H), 4.09 (dd, *J* = 8.8, 4.7 Hz, 1H), 3.16 (d, *J* = 5.9 Hz, 1H), 2.36 (td, *J* = 13.9, 6.9 Hz, 1H), 2.19 (t, *J* = 7.7 Hz, 1H), 2.04 – 1.90 (m, 5H), 1.82 (td, *J* = 15.5, 7.8 Hz, 1H), 1.68 (s, 1H), 1.66 – 1.58 (m, 1H), 1.55 (d, *J* = 13.6 Hz, 1H), 1.52 – 1.42 (m, 2H), 1.40 – 1.35 (m, 9H), 1.33 (dd, *J* = 14.2, 2.1 Hz, 1H), 1.00 (s, 3H), 0.93 (s, 3H), 0.83 (d, *J* = 6.8 Hz, 3H), 0.75 (d, *J* = 6.9 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 202.25, 199.35, 170.65, 169.90, 155.53, 146.99, 118.41, 83.68, 79.48, 76.54, 76.36, 69.17, 64.93, 58.74, 58.33, 54.11, 51.85, 42.20, 36.84, 32.25, 31.20, 30.96, 29.83, 28.27, 24.43, 21.93, 21.35, 18.88, 18.47, 17.41. **HRMS** (*m/z*) (ESI): calcd for $C_{32}H_{46}NO_9$ 588.3167 [M+H] $^+$ found 588.3162.



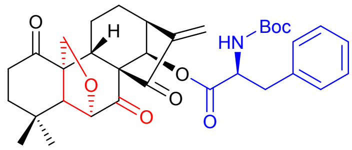
(5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-4,4-dimethyl-8-methylene-1,6,7-trioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-leucinate (12g). White solid, mp 118-120 °C. 79 mg, 79% yield. R_f = 0.46 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.12 (s, 1H), 5.62 (s, 1H), 5.46 (s, 1H), 4.84 (d, J = 8.2 Hz, 1H), 4.31 (d, J = 9.8 Hz, 1H), 4.27 – 4.17 (m, 3H), 3.12 (d, J = 8.1 Hz, 1H), 2.73 (ddd, J = 14.6, 11.9, 6.2 Hz, 1H), 2.52 – 2.40 (m, 2H), 2.33 (dt, J = 14.6, 4.6 Hz, 1H), 2.17 – 2.08 (m, 2H), 1.92 – 1.79 (m, 3H), 1.70 (d, J = 16.9 Hz, 2H), 1.67 – 1.58 (m, 1H), 1.59 – 1.50 (m, 1H), 1.39 (s, 9H), 1.22 – 1.18 (m, 3H), 1.04 (s, 3H), 0.88 (d, J = 6.4 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.75, 119.19, 83.12, 75.80, 69.96, 63.91, 61.10, 52.36, 47.01, 41.85, 41.06, 36.31, 31.90, 31.32, 30.08, 29.67, 28.29, 24.67, 23.21, 22.73, 21.80, 19.21. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{44}NO_8$ 558.3061 [M+H] $^+$ found 558.3048.



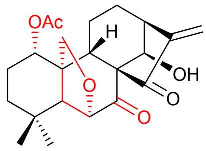
(5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-4,4-dimethyl-8-methylene-1,6,7-trioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (2*S*)-2-((*tert*-butoxycarbonyl)amino)-3-methylpentanoate(12h). White solid, mp 114-116 °C. 83 mg, 83% yield. R_f = 0.57 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.12 (s, 1H), 5.58 (s, 1H), 5.44 (s, 1H), 4.96 (d, J = 8.6 Hz, 1H), 4.32 – 4.25 (m, 3H), 4.19 (dd, J = 8.5, 4.5 Hz, 1H), 3.16 (d, J = 7.4 Hz, 1H), 2.73 (ddd, J = 14.5, 11.9, 6.3 Hz, 1H), 2.55 – 2.48 (m, 1H), 2.44 (dtd, J = 12.5, 8.0, 4.3 Hz, 1H), 2.33 (dt, J = 14.6, 4.5 Hz, 1H), 2.17 – 2.07 (m, 2H), 1.92 – 1.83 (m, 3H), 1.83 – 1.75 (m, 1H), 1.75 – 1.68 (m, 1H), 1.41 (s, 9H), 1.29 (ddd, J = 10.8, 8.0, 4.4 Hz, 1H), 1.21 (s, 3H), 1.09 (dd, J = 15.2, 6.6 Hz, 1H), 1.05 (s, 3H), 0.84 (dd, J = 9.0, 7.1 Hz, 6H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.67 , 170.78, 147.28, 119.18, 83.24, 76.59, 70.10, 63.95, 61.69, 61.35, 57.99, 47.19, 41.98, 41.25, 37.61, 36.35, 31.97, 31.35, 30.05, 28.30, 24.89, 23.16, 19.05, 15.32, 11.52. **HRMS** (*m/z*) (ESI): calcd for $C_{31}H_{44}NO_8$ 558.3061 [M+H] $^+$ found 558.3051.



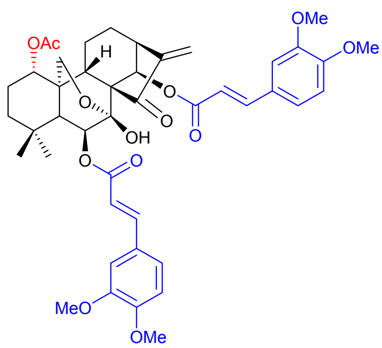
1-(*tert*-butyl) 2-((5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-4,4-dimethyl-8-methylene-1,6,7-trioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl) (2*S*)-pyrrolidine-1,2-dicarboxylate (12i). White solid, mp 84-85 °C. 82 mg, 84% yield. R_f = 0.39 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.04 (d, J = 19.2 Hz, 1H), 5.52 (d, J = 7.0 Hz, 1H), 5.40 (d, J = 15.8 Hz, 1H), 4.26 (dd, J = 9.7, 2.5 Hz, 1H), 4.23 – 4.17 (m, 2H), 4.12 (ddd, J = 29.3, 8.7, 3.0 Hz, 1H), 3.39 – 3.19 (m, 2H), 3.04 (dd, J = 24.3, 7.9 Hz, 1H), 2.73 – 2.63 (m, 1H), 2.43 (dd, J = 16.2, 7.0 Hz, 1H), 2.39 – 2.32 (m, 1H), 2.31 – 2.23 (m, 1H), 2.10 – 1.99 (m, 3H), 1.94 – 1.87 (m, 1H), 1.86 – 1.77 (m, 3H), 1.77 – 1.70 (m, 1H), 1.70 – 1.57 (m, 1H), 1.34 (d, J = 7.7 Hz, 9H), 1.18 (s, 1H), 1.15 (s, 3H), 0.97 (t, J = 8.8 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.68, 201.68, 199.19, 171.65 (d, J = 14.5 Hz), 153.60, 147.51 (d, J = 39.1 Hz), 119.15 (d, J = 29.6 Hz), 83.22, 79.58 (d, J = 54.9 Hz), 75.82 (d, J = 5.7 Hz), 69.99 (d, J = 5.7 Hz), 63.81, 61.43 (d, J = 9.9 Hz), 61.16 (d, J = 3.5 Hz), 59.21 (d, J = 14.4 Hz), 47.03, 46.30 (d, J = 31.9 Hz), 41.95 (d, J = 18.9 Hz), 41.18, 36.32, 31.90, 31.31 (d, J = 3.1 Hz), 30.36, 30.04 (d, J = 16.9 Hz), 29.65, 28.34, 24.08, 23.33, 19.18 (d, J = 5.6 Hz). **HRMS** (*m/z*) (ESI): calcd for $C_{30}H_{40}NO_8$ 542.2748 $[M+H]^+$ found 542.2742.



(5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-4,4-dimethyl-8-methylene-1,6,7-trioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-14-yl (*tert*-butoxycarbonyl)-*L*-phenylalaninate (12j). White solid, mp 74-76 °C. 86 mg, 81% yield. R_f = 0.53 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28 – 7.16 (m, 3H), 7.10 (d, J = 7.1 Hz, 2H), 6.09 (d, J = 16.6 Hz, 1H), 5.62 (d, J = 24.5 Hz, 1H), 5.43 (d, J = 13.8 Hz, 1H), 4.96 (d, J = 7.7 Hz, 1H), 4.47 (d, J = 6.5 Hz, 1H), 4.33 – 4.15 (m, 3H), 3.12 – 2.98 (m, 2H), 2.93 (dd, J = 13.7, 7.0 Hz, 1H), 2.72 (ddd, J = 14.6, 12.1, 6.1 Hz, 1H), 2.51 – 2.36 (m, 2H), 2.34 – 2.27 (m, 1H), 2.16 – 2.05 (m, 2H), 1.93 – 1.76 (m, 3H), 1.67 (dt, J = 26.0, 8.5 Hz, 1H), 1.37 (d, J = 17.9 Hz, 9H), 1.20 (d, J = 10.6 Hz, 3H), 1.01 (d, J = 17.3 Hz, 3H). ^{13}C NMR (125 MHz, $CDCl_3$) δ 209.71, 201.84, 199.43, 170.59, 154.99, 147.46, 136.37, 129.30, 128.38, 126.74, 119.44, 83.05, 79.60, 76.26, 69.92, 63.84, 61.06, 54.69, 46.99, 41.75, 41.10, 37.86, 36.30, 31.88, 31.32, 30.12, 29.65, 28.25, 23.20, 19.19. **HRMS** (*m/z*) (ESI): calcd for $C_{34}H_{42}NO_8$ 592.2905 $[M+H]^+$ found 592.2900.



(1*S*,5*R*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-14-hydroxy-4,4-dimethyl-8-methylene-6,7-dioxododecahydro-1*H*-5,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalen-1-yl acetate (14). Yellow solid, mp 115-116 °C. 77 mg, 89% yield. R_f = 0.27 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, cdcl$_3$) δ 6.13 (s, 1H), 5.53 (s, 1H), 4.88 (dd, *J* = 10.9, 6.0 Hz, 1H), 4.88 (dd, *J* = 10.9, 6.0 Hz, 1H), 4.74 (s, 2H), 4.58 (s, 1H), 4.17 (s, 1H), 4.12 (d, *J* = 10.0 Hz, 1H), 4.10 (q, *J* = 10.0 Hz, 2H), 4.09 (d, *J* = 10.0 Hz, 1H), 3.83 (dd, *J* = 43.1, 15.7 Hz, 1H), 3.11 (d, *J* = 8.7 Hz, 1H), 3.11 (d, *J* = 8.7 Hz, 1H), 2.44 – 2.35 (m, 1H), 2.45 – 2.33 (m, 1H), 2.19 (dd, *J* = 12.2, 6.1 Hz, 1H), 2.19 (dd, *J* = 12.2, 6.1 Hz, 1H), 1.99 (s, 3H), 1.89 (s, 1H), 1.64 – 1.57 (m, 2H), 1.49 (s, 1H), 1.41 (d, *J* = 8.7 Hz, 1H), 1.21 (s, 1H), 1.04 (s, 3H), 1.01 (s, 3H). ^{13}C NMR (125 MHz, CDCl$_3$) δ 205.36, 203.22, 169.94, 149.04, 120.20, 82.53, 76.74, 73.59, 68.21, 64.94, 55.04, 52.97, 51.04, 43.79, 36.97, 32.26, 30.83, 29.68, 29.37, 24.60, 22.45, 21.40, 18.95. **HRMS** (*m/z*) (ESI): calcd for $C_{22}H_{29}O_6$ 389.1959 [M+H] $^+$ found 389.1959.

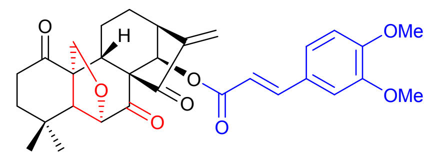


(1*S*,5*S*,6*S*,6a*R*,9*S*,11a*S*,11b*S*,14*R*)-1-acetoxy-6-hydroxy-4,4-dimethyl-8-methylene-7-oxododecahydro-1*H*-6,11b-(epoxymethano)-6a,9-methanocyclohepta[*a*]naphthalene-5,14-diyl (2*E*,2'*E*)-bis(3-(3,4-dimethoxyphenyl)acrylate) (15). White solid, mp 125-126 °C. 52 mg, 83% yield. R_f = 0.63 (1 : 1 petroleum ether / ethyl acetate); ^{1}H NMR (500 MHz, CDCl$_3$) δ 7.88 (d, *J* = 15.9 Hz, 1H), 7.59 (d, *J* = 15.9 Hz, 1H), 7.18 (d, *J* = 8.3 Hz, 1H), 7.15 (s, 1H), 7.04 (d, *J* = 8.3 Hz, 1H), 6.99 (s, 1H), 6.88 (d, *J* = 8.2 Hz, 1H), 6.81 (t, *J* = 9.1 Hz, 1H), 6.56 (d, *J* = 15.9 Hz, 1H), 6.20 (dd, *J* = 15.8, 6.4 Hz, 1H), 6.01 (d, *J* = 13.7 Hz, 2H), 5.36 – 5.31 (m, 2H), 5.02 (s, 1H), 4.73 (dd, *J* = 11.2, 5.5 Hz, 1H), 4.41 (d, *J* = 10.6 Hz, 1H), 4.28 (t, *J* = 8.9 Hz, 1H), 3.93 (d, *J* = 6.4 Hz, 6H), 3.89 (d, *J* = 5.4 Hz, 6H), 3.17 (d, *J* = 9.9 Hz, 1H), 2.61 – 2.53 (m, 1H), 2.36 – 2.31 (m, 1H), 2.04 (d, *J* = 7.4 Hz, 3H), 1.90 – 1.78 (m, 2H), 1.71 (d, *J* = 6.1 Hz, 1H), 1.56 (d, *J* = 12.9 Hz, 1H), 1.46 (t, *J* = 12.7 Hz, 1H), 1.40 – 1.30 (m, 3H), 1.21 (d, *J* = 8.9 Hz, 3H), 0.90 (d, *J* = 8.9 Hz, 3H). ^{13}C NMR (125 MHz, CDCl$_3$) δ 200.70, 169.93, 168.85, 165.90, 151.30, 151.20, 150.25, 149.16, 146.21, 146.05, 127.58, 127.10, 123.20, 117.17, 115.70, 114.89, 110.93, 110.86, 109.77, 109.31, 96.81, 75.94, 75.16, 74.05, 63.40, 60.14, 56.04, 52.18, 41.97, 40.46, 40.23, 37.70, 33.68, 31.65, 30.37, 29.68, 27.00, 25.17, 21.58, 21.38, 17.82. **HRMS** (*m/z*) (ESI): calcd for $C_{44}H_{51}NO_{13}$ 787.3324 [M+H] $^+$ found 787.3342.

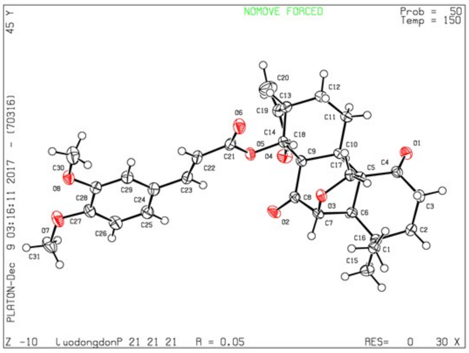
1.10 References

1. J. Y. Xu, J. Y. Yang, Q. Ran, L. Wang, J. Liu, Z. X. Wang, X. M. Wu, W. Y. Hua, S. T. Yuan, L. Y. Zhang, M. Q. Shen and Y. F. Ding, *Bioorg Med Chem Lett*, 2008, **18**, 4741-4744.

1.11 The X-ray Crystallographic Analysis for Product 12b



12b



Bond precision:	C-C = 0.0055 A	Wavelength=1.54184

Cell:	a=7.3902(4)	b=8.3748(5)	c=43.293(3)
	alpha=90	beta=90	gamma=90
Temperature:	150 K		

	Calculated	Reported
Volume	2679.5(3)	2679.5(3)
Space group	P 21 21 21	P 21 21 21
Hall group	P 2ac 2ab	P 2ac 2ab
Moiety formula	C31 H34 O8	?
Sum formula	C31 H34 O8	C31 H34 O8
Mr	534.58	534.58
Dx,g cm-3	1.325	1.325
Z	4	4
Mu (mm-1)	0.782	0.782
F000	1136.0	1136.0
F000'	1139.70	
h,k,lmax	9,10,53	8,10,52
Nref	5323[3093]	5085
Tmin,Tmax	0.894,0.932	0.839,1.000
Tmin'	0.882	

Correction method= # Reported T Limits: Tmin=0.839 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.64/0.96 Theta(max)= 72.657

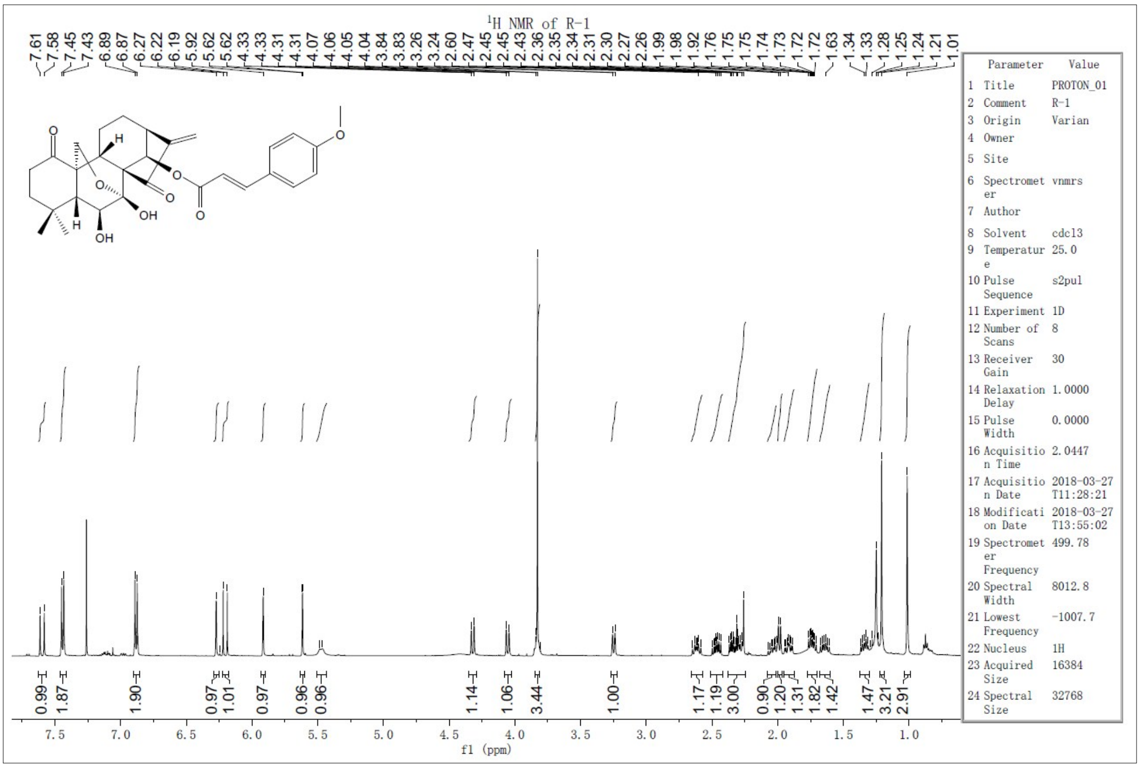
R(reflections)= 0.0506(4899) wR2(reflections)= 0.1218(5085)

S = 1.159 Npar= 364

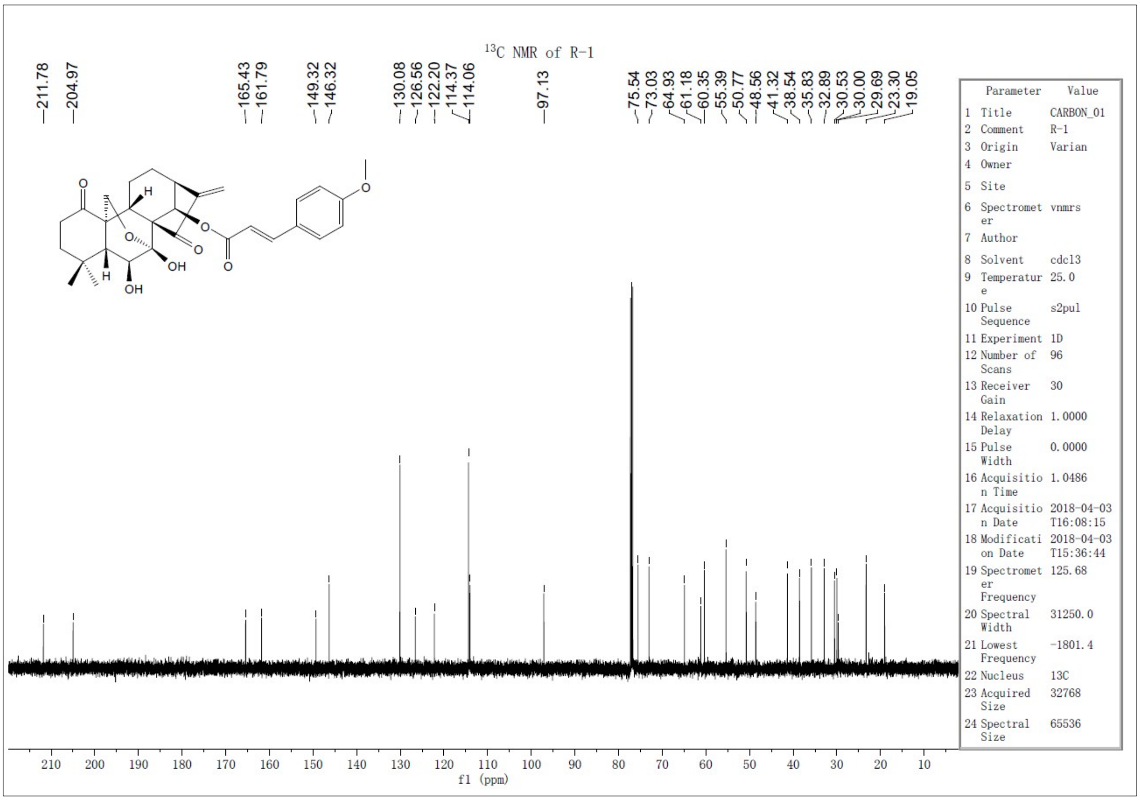
Crystal of **12b** was obtained from methanol. Thermal Ellipsoid Plot for the crystal structure of **12b** are shown at the 50% probability level.

1.12 NMR Spectra

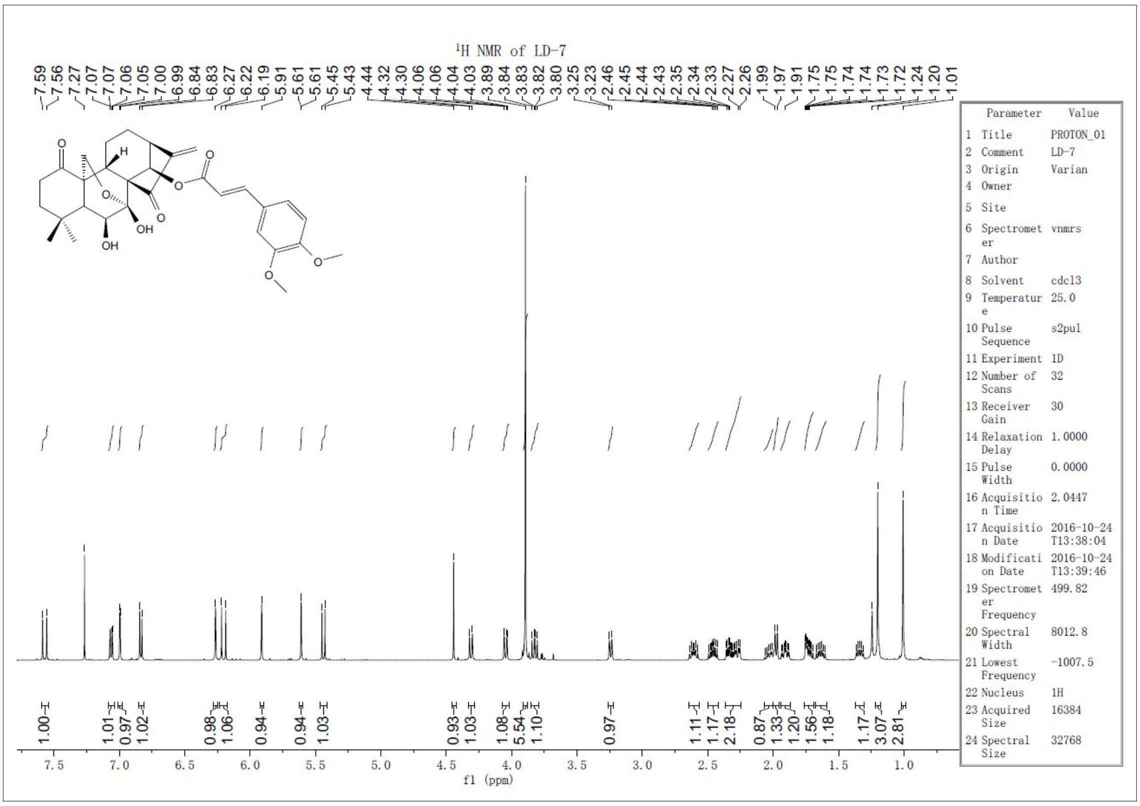
^{1}H NMR of **11a**



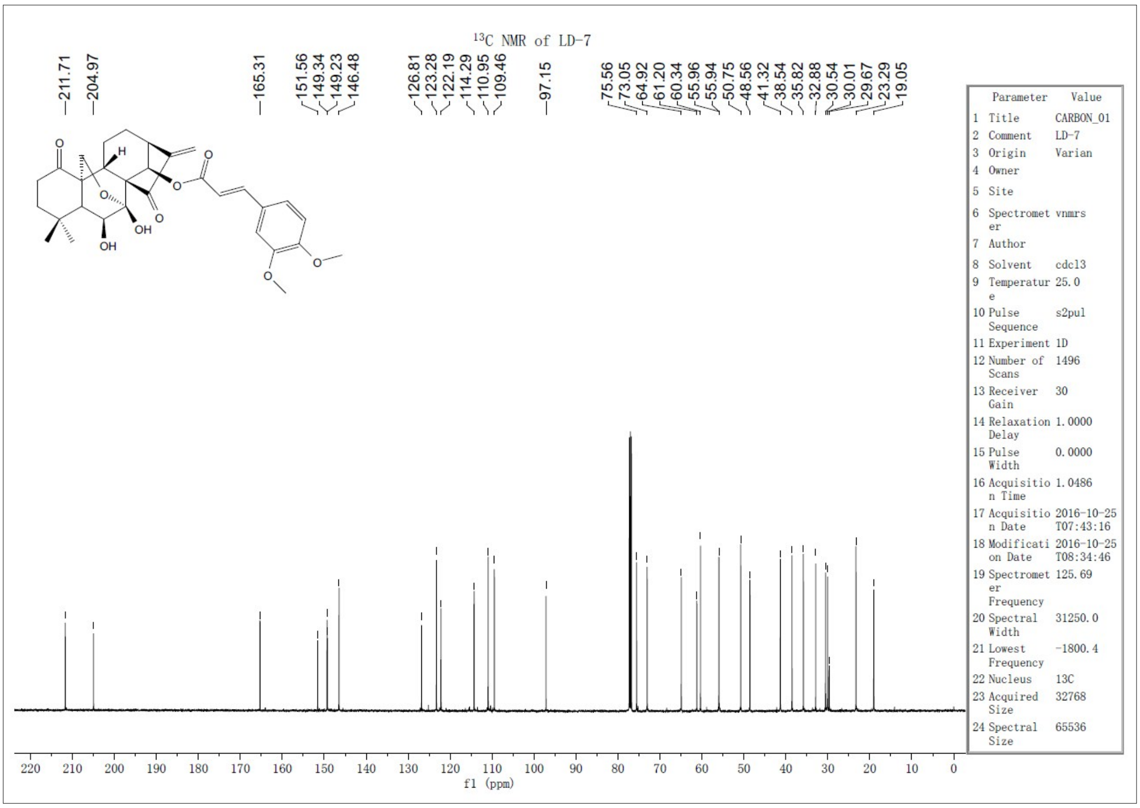
^{13}C NMR of **11a**



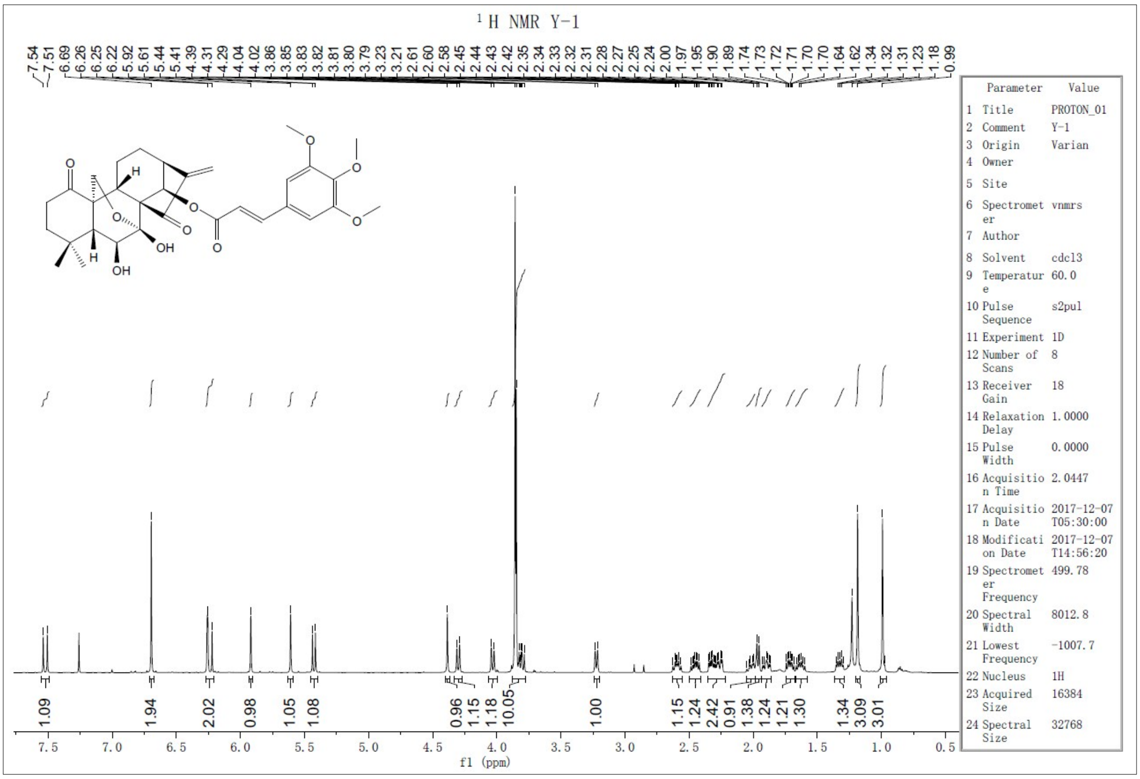
^{1}H NMR of **11b**



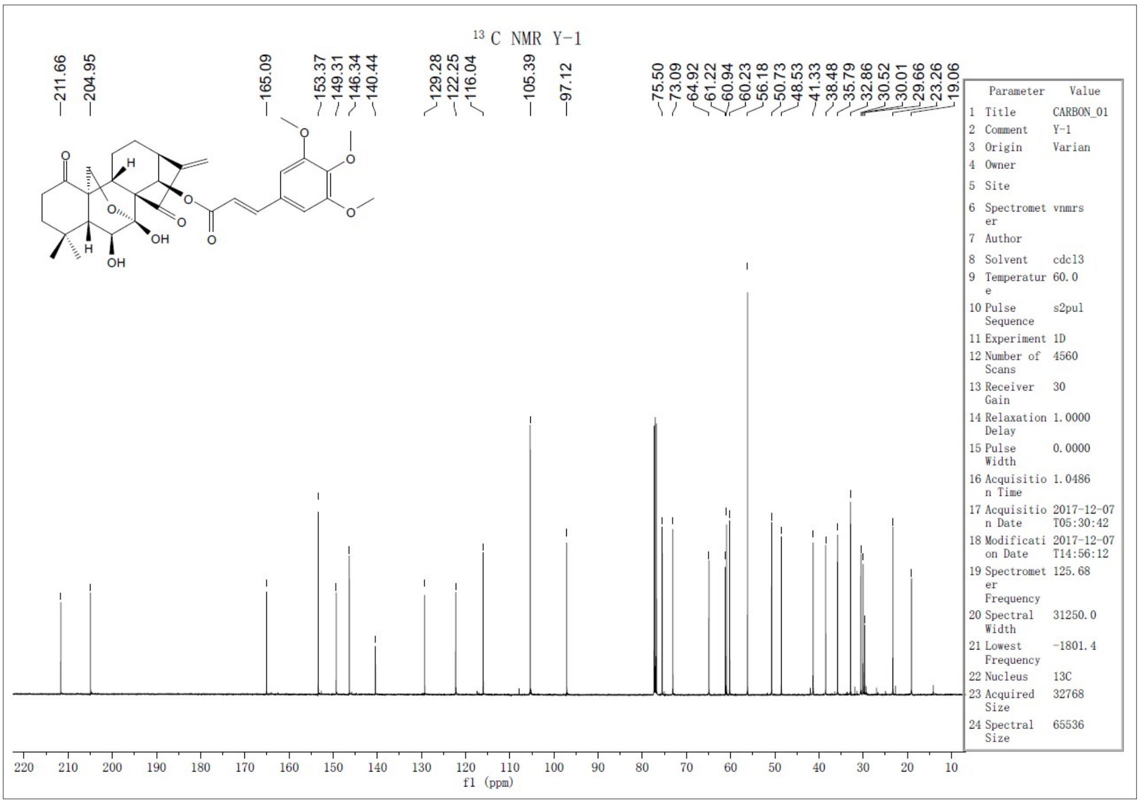
^{13}C NMR of **11b**



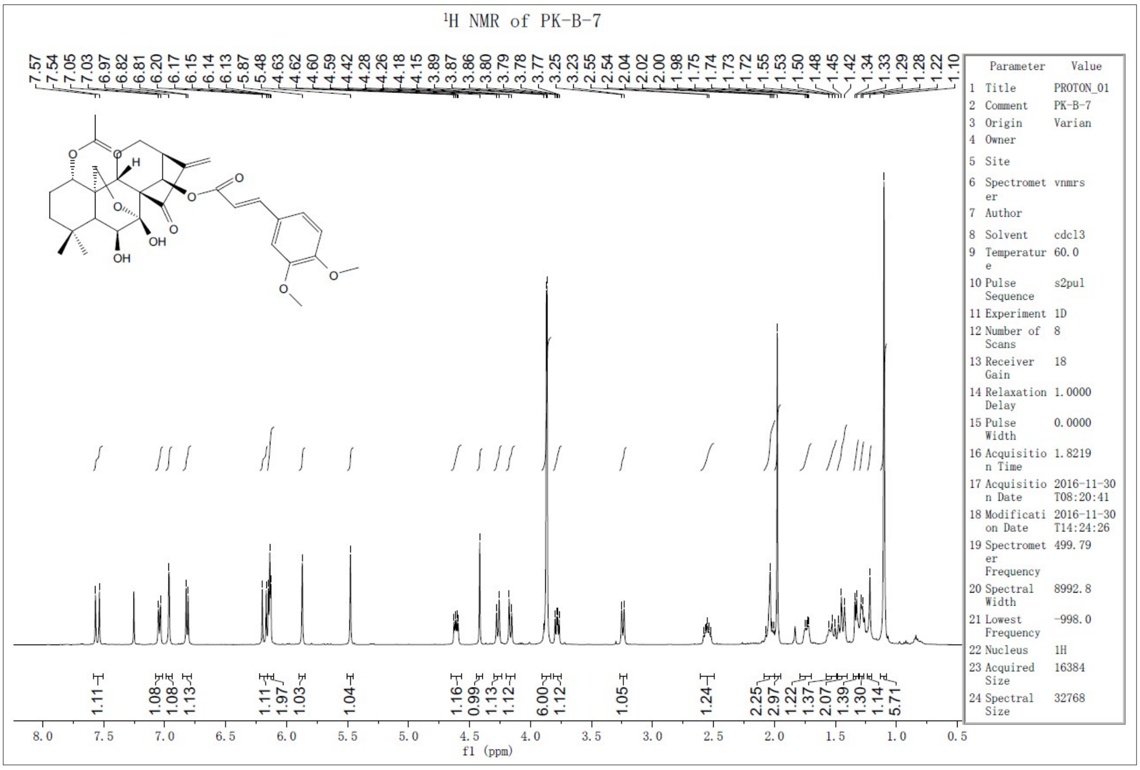
^{1}H NMR of **11c**



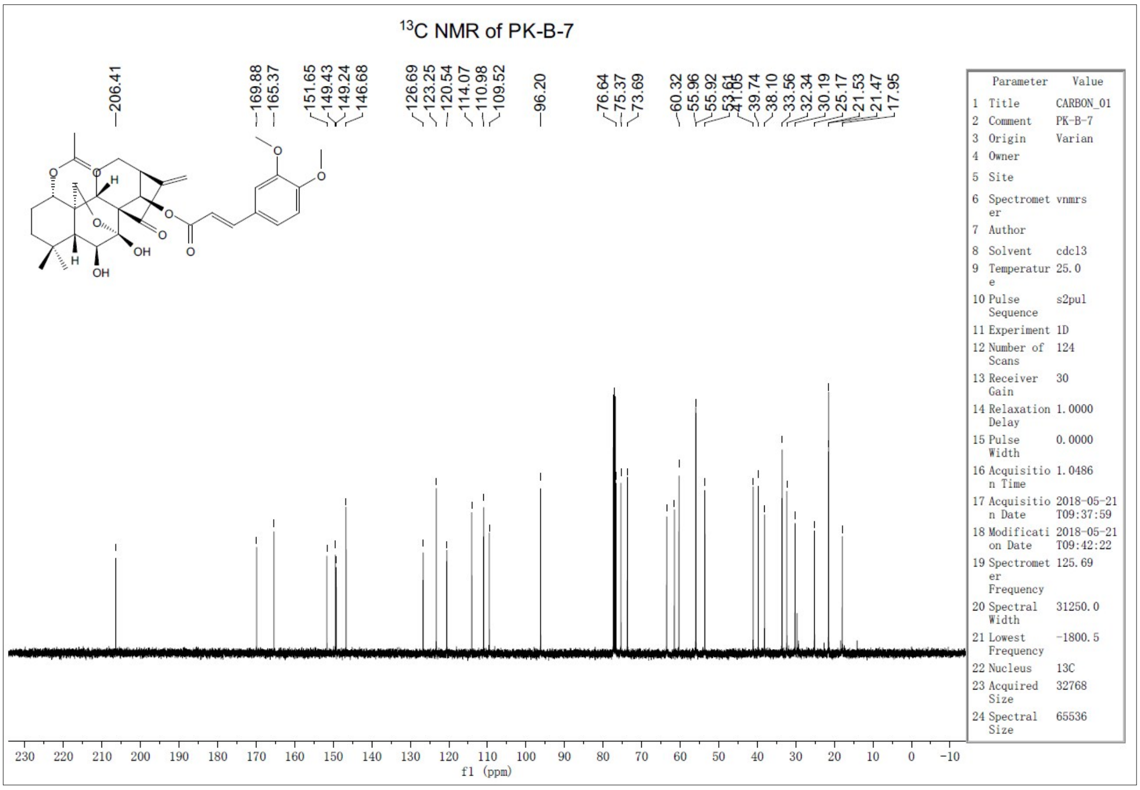
^{13}C NMR of **11c**



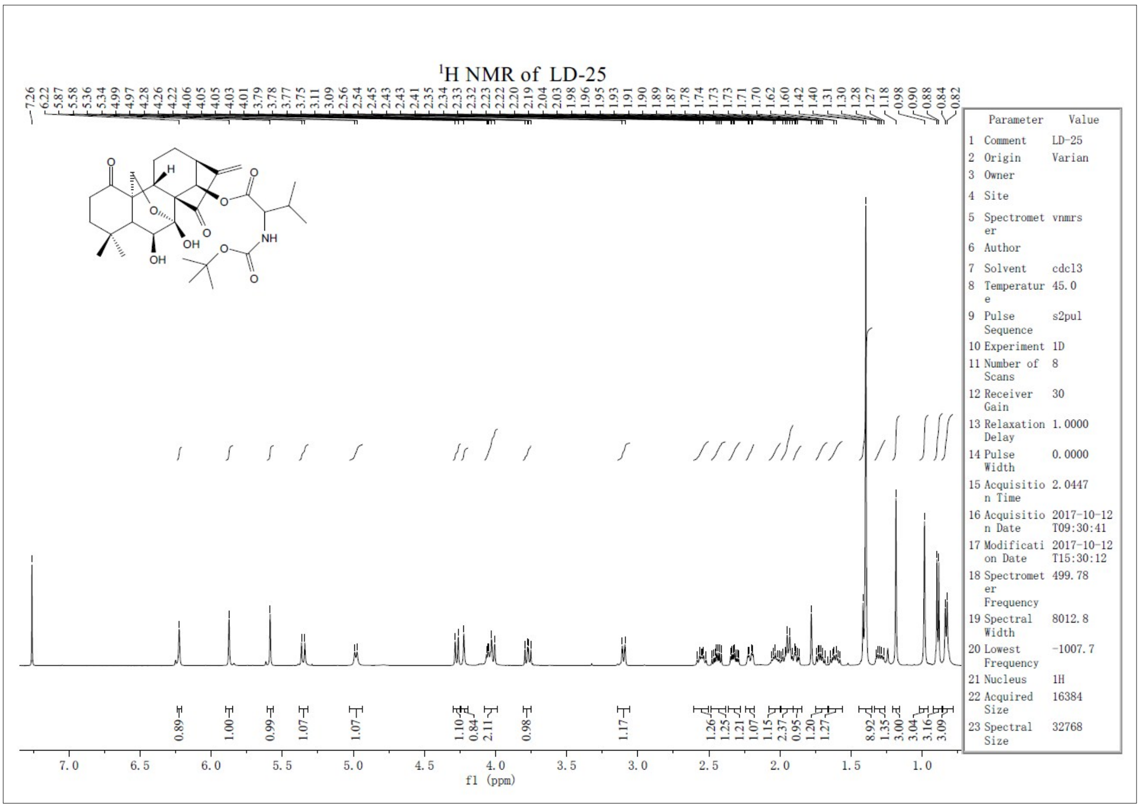
^{1}H NMR of **11d**



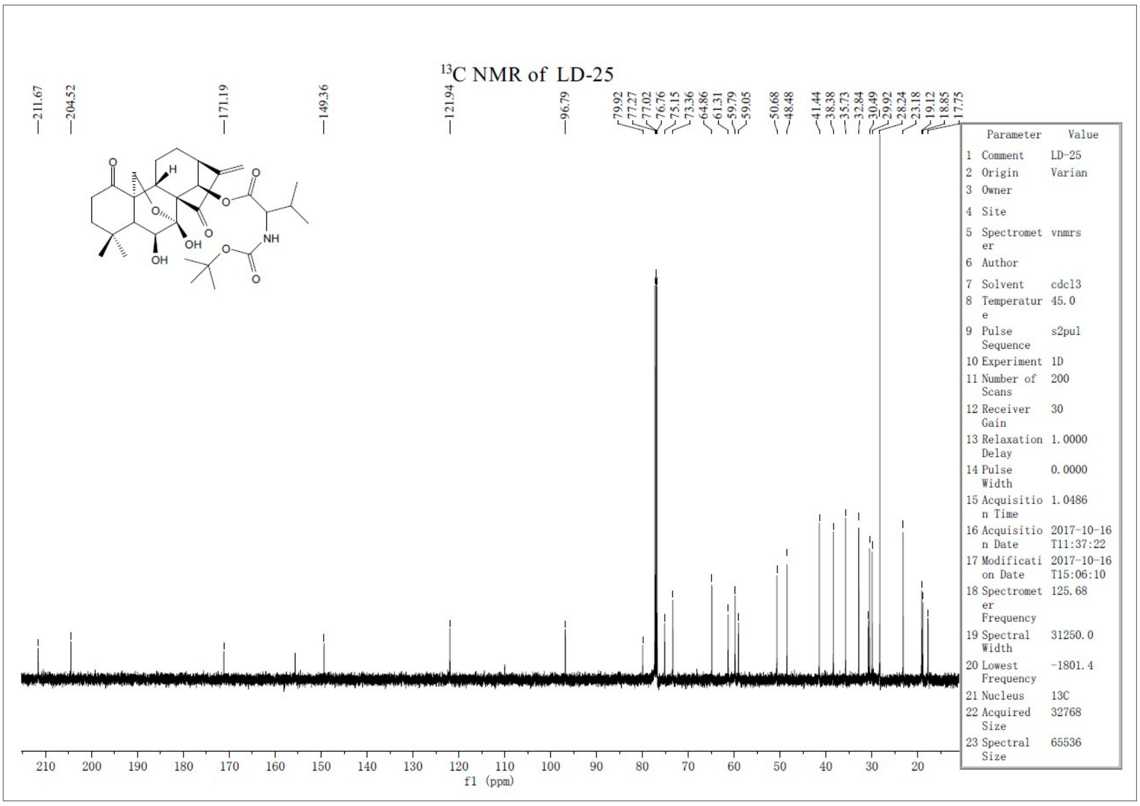
^{13}C NMR of **11d**



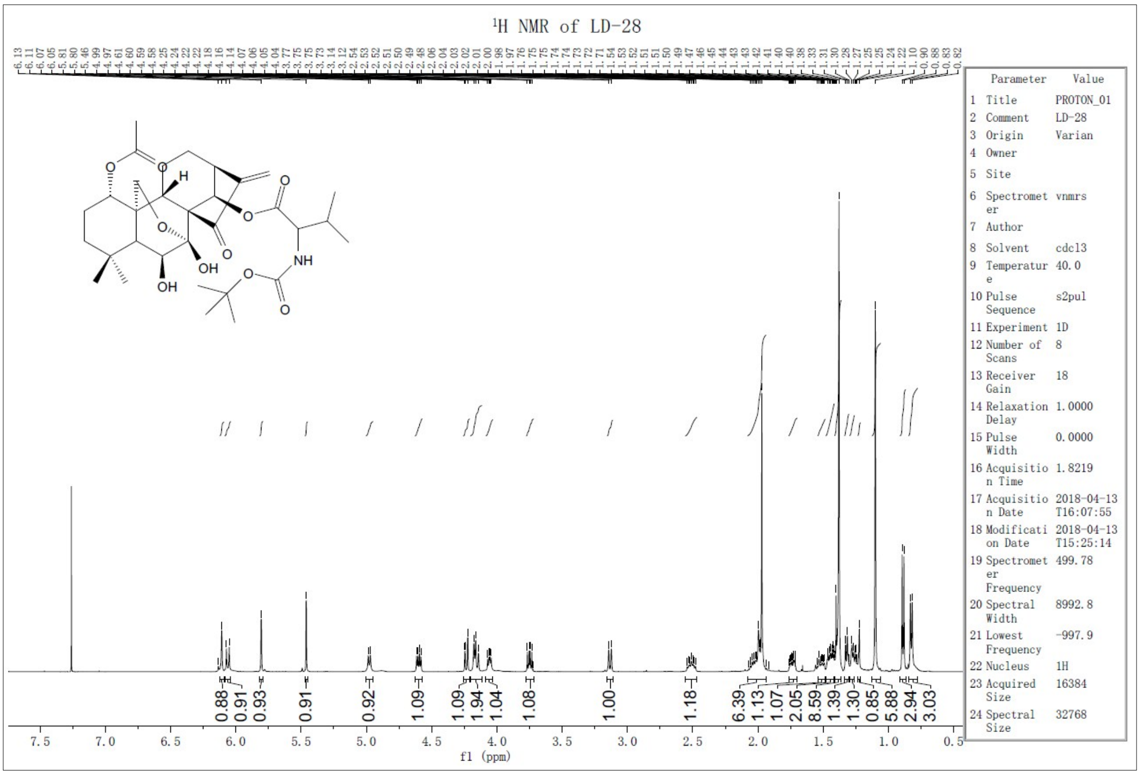
^{1}H NMR of **11e**



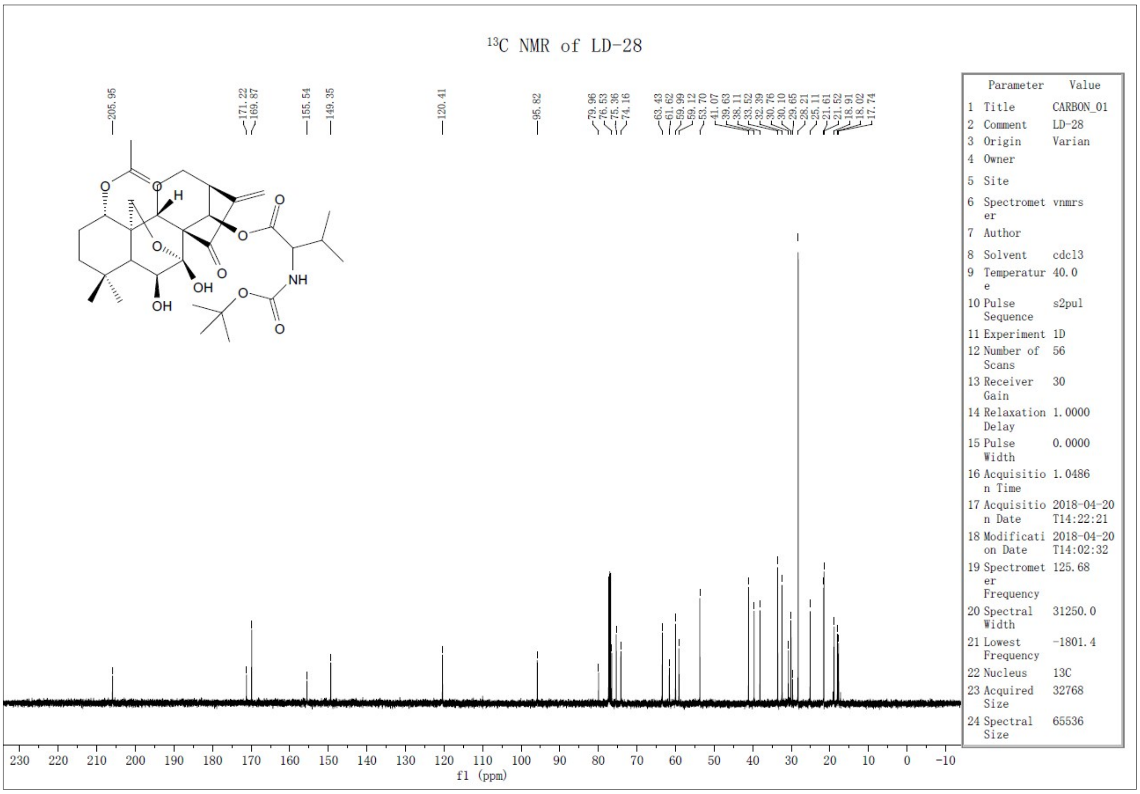
^{13}C NMR of **11e**



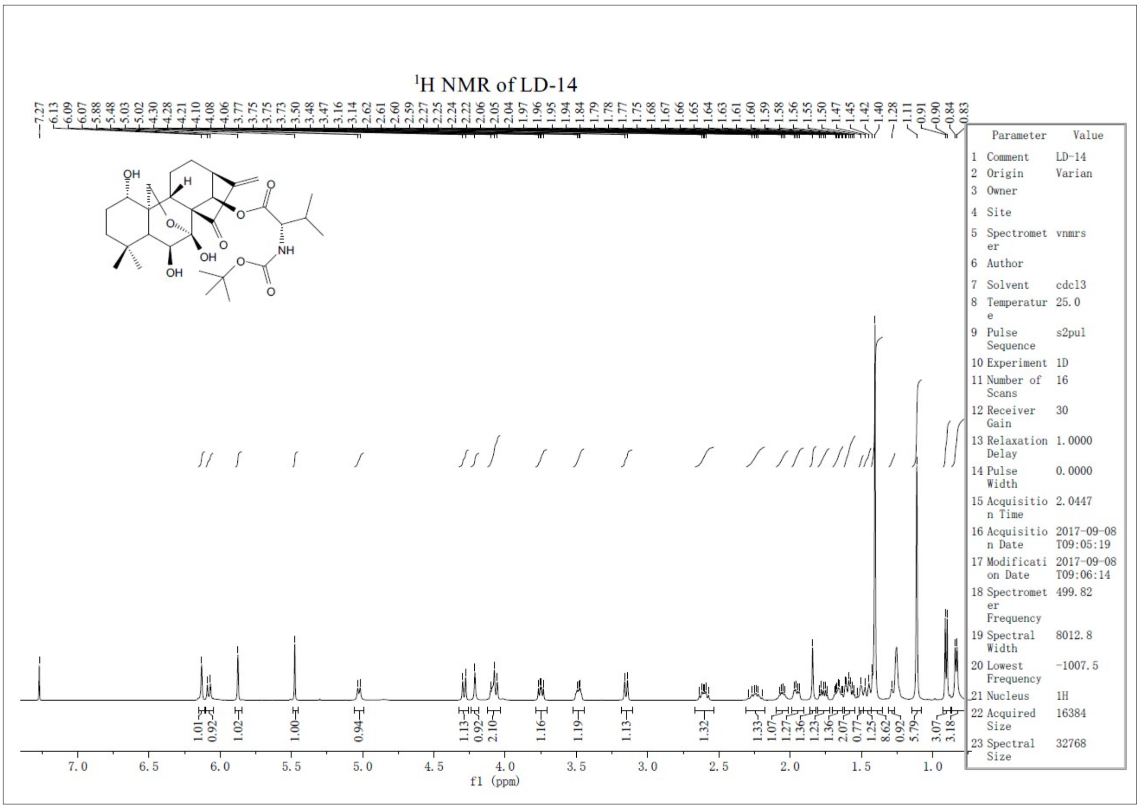
^{1}H NMR of **11f**



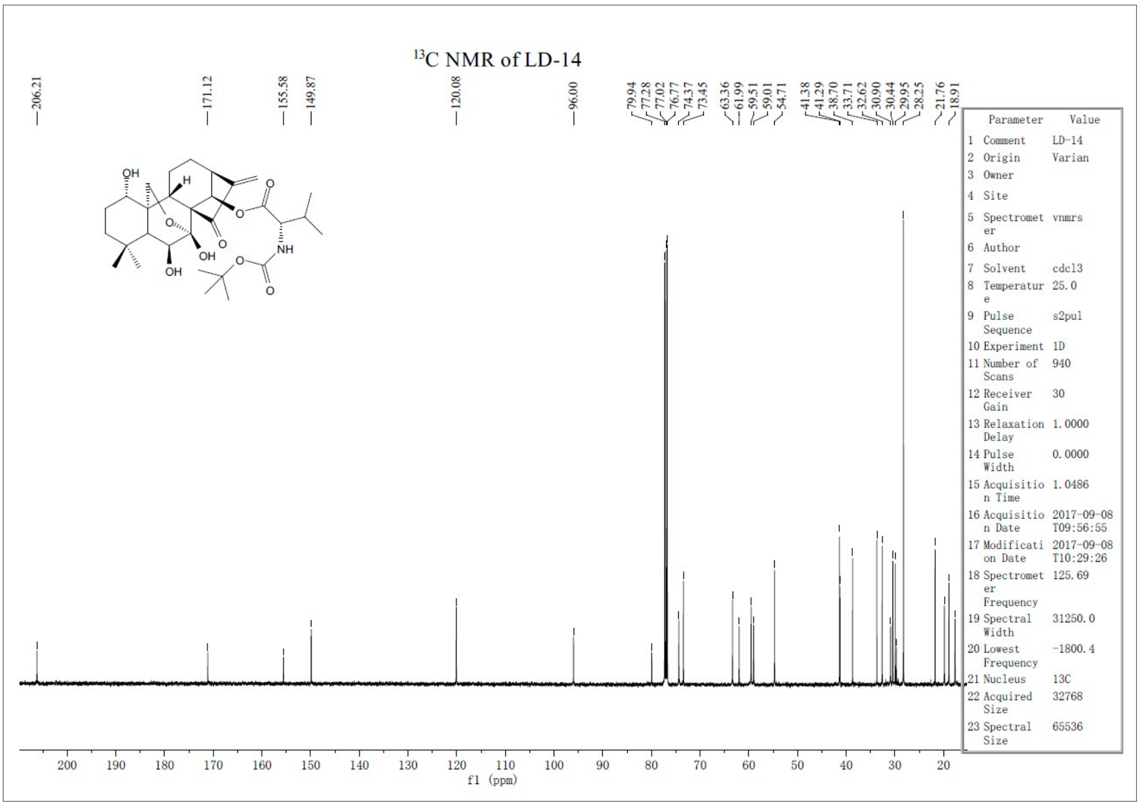
^{13}C NMR of **11f**



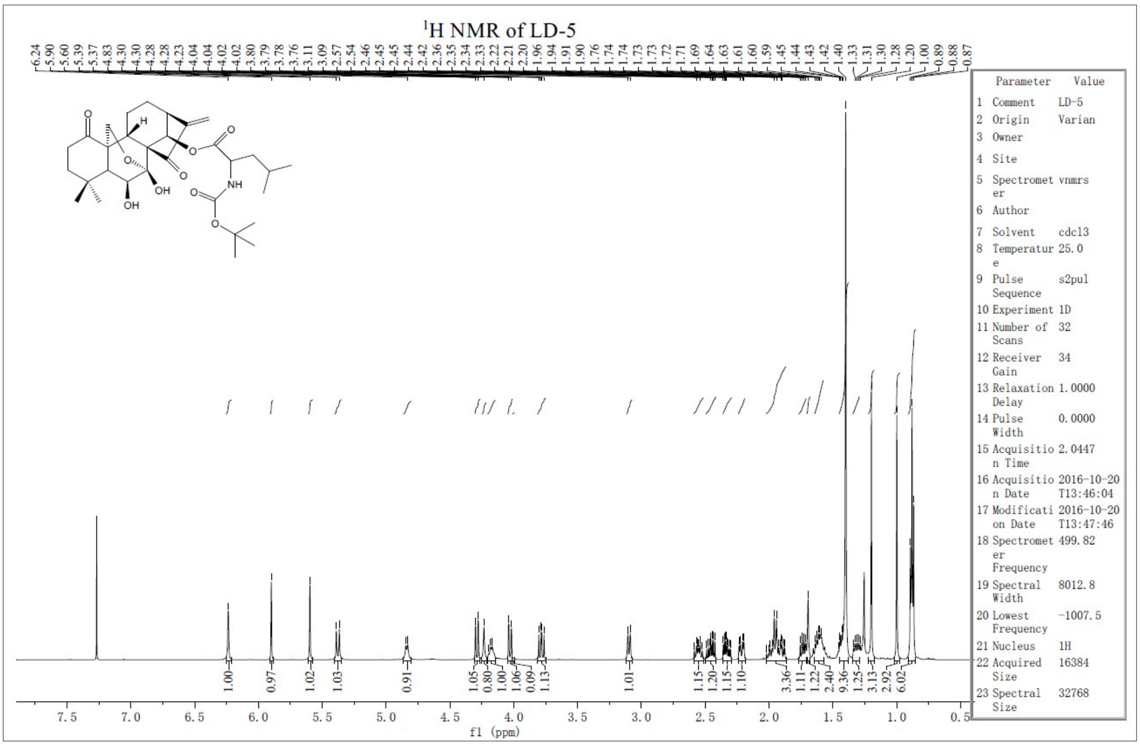
^{1}H NMR of **11g**



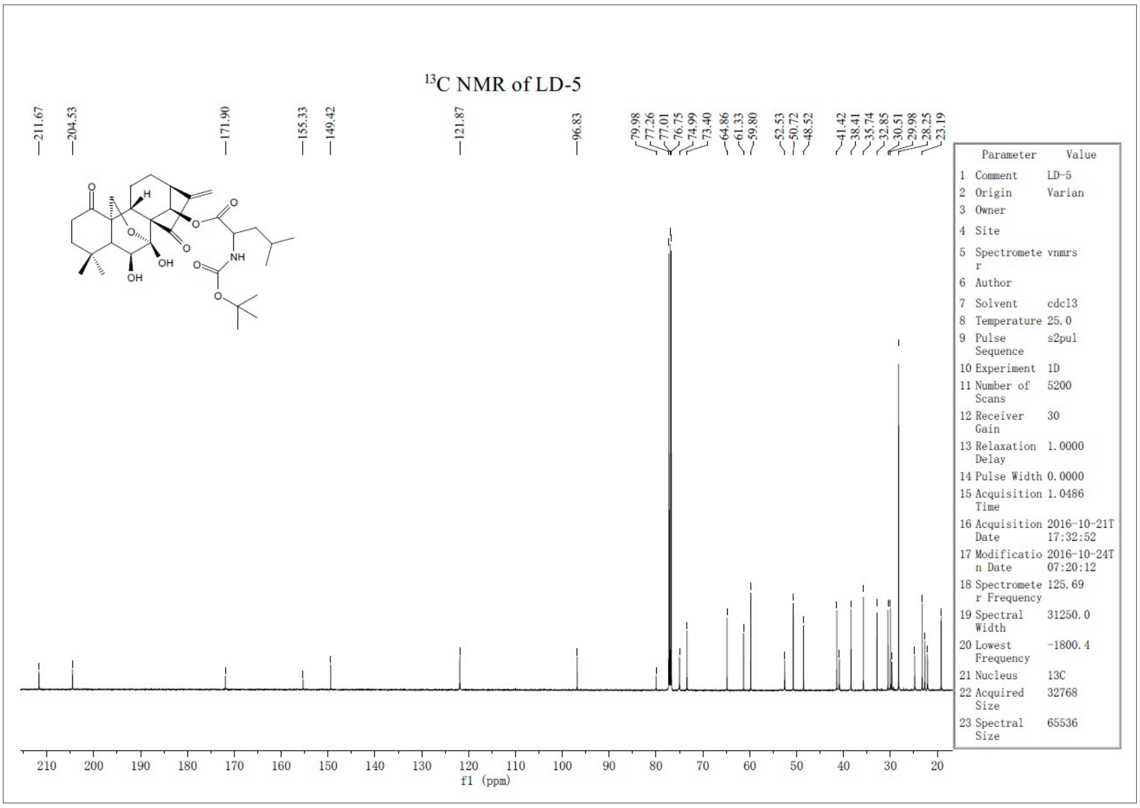
^{13}C NMR of **11g**



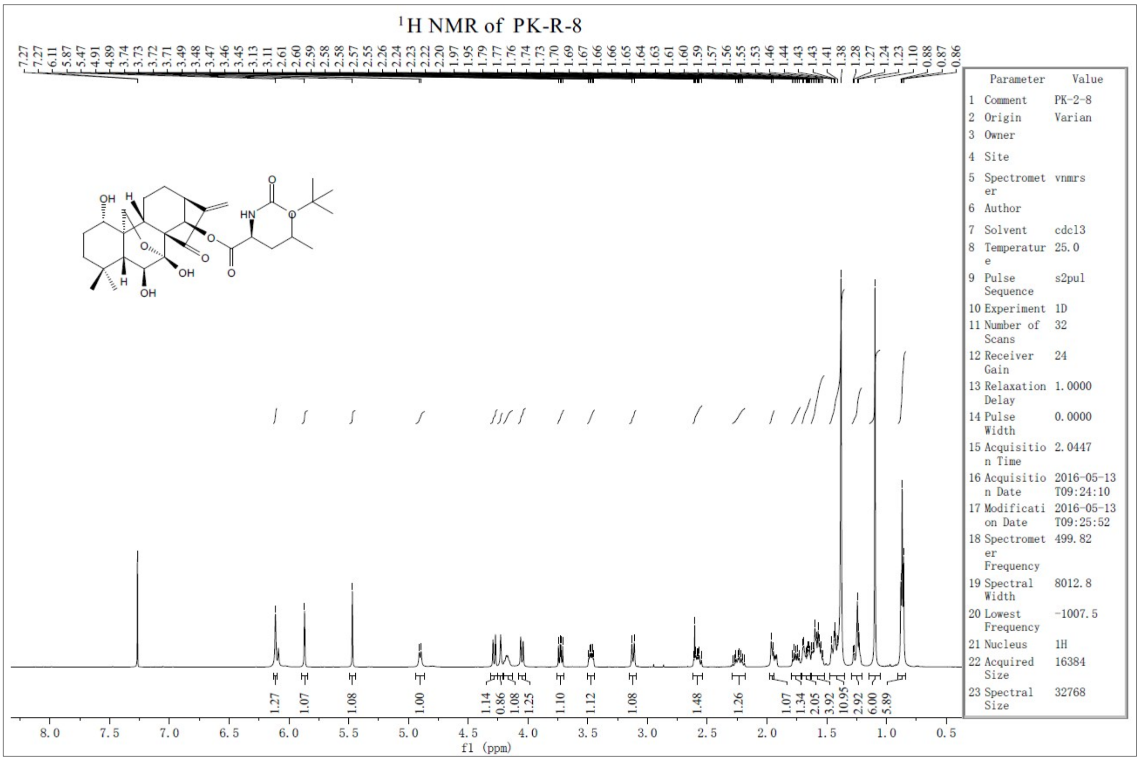
^{1}H NMR of **11h**



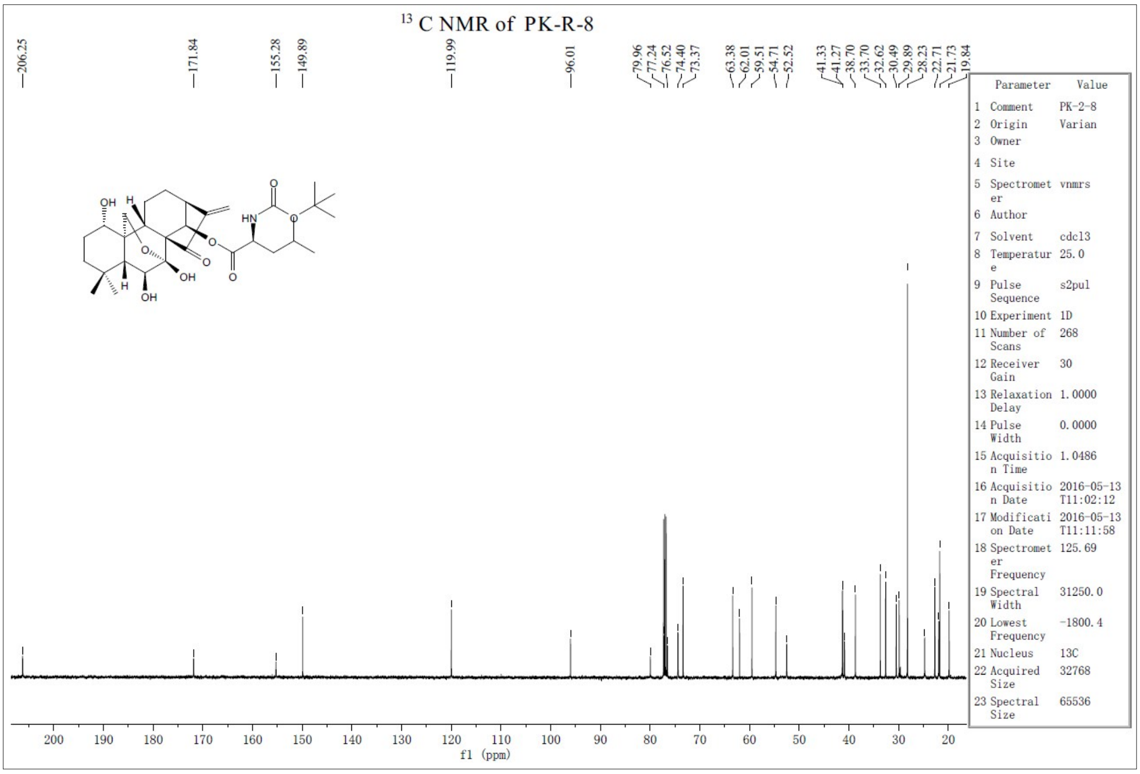
^{13}C NMR of **11h**



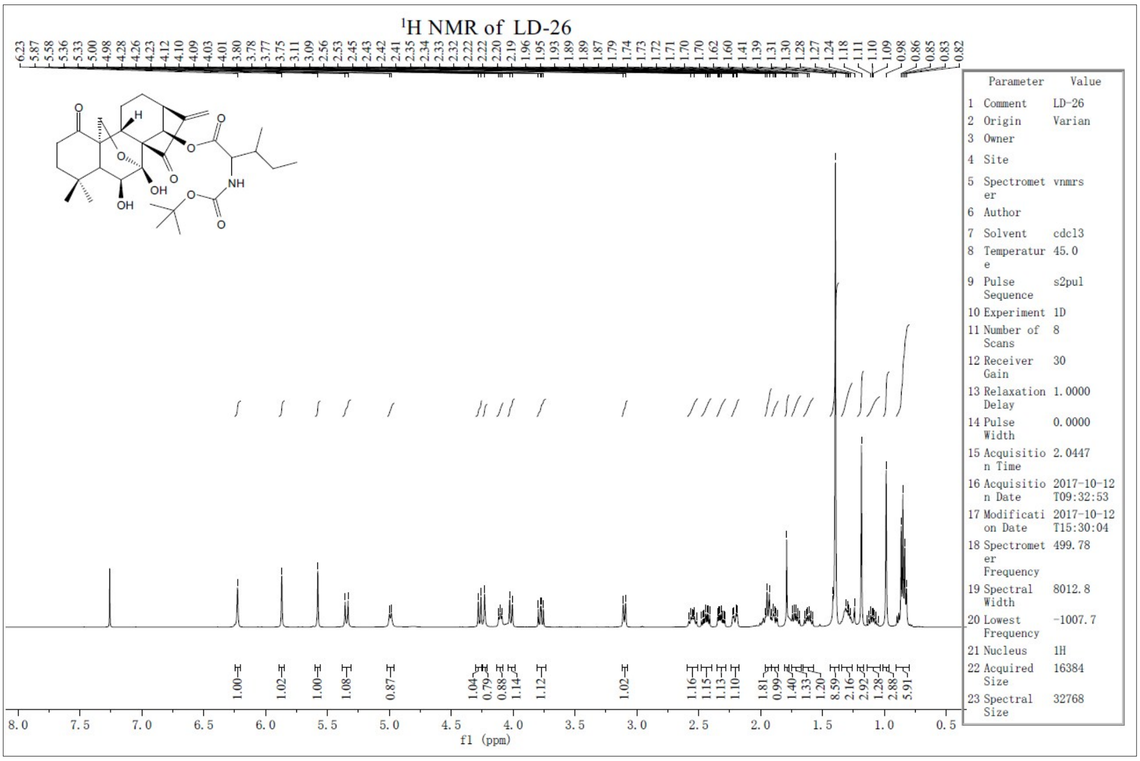
^{1}H NMR of **11i**



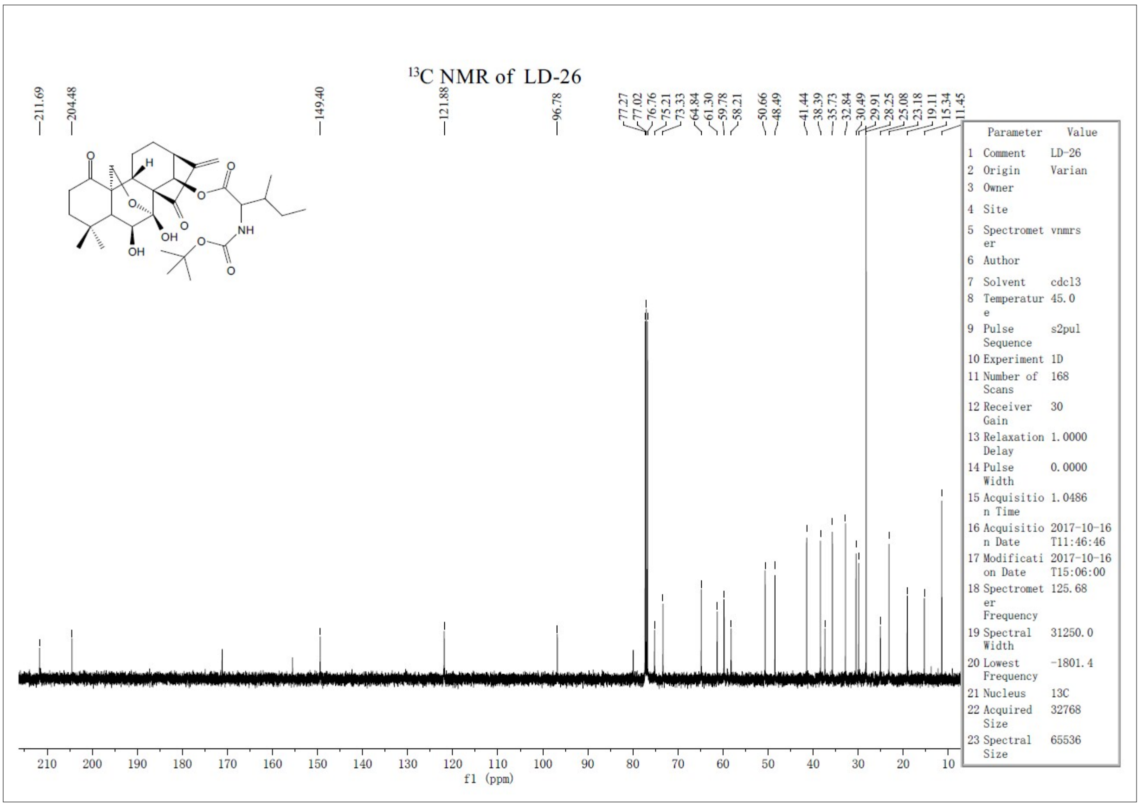
^{13}C NMR of **11i**



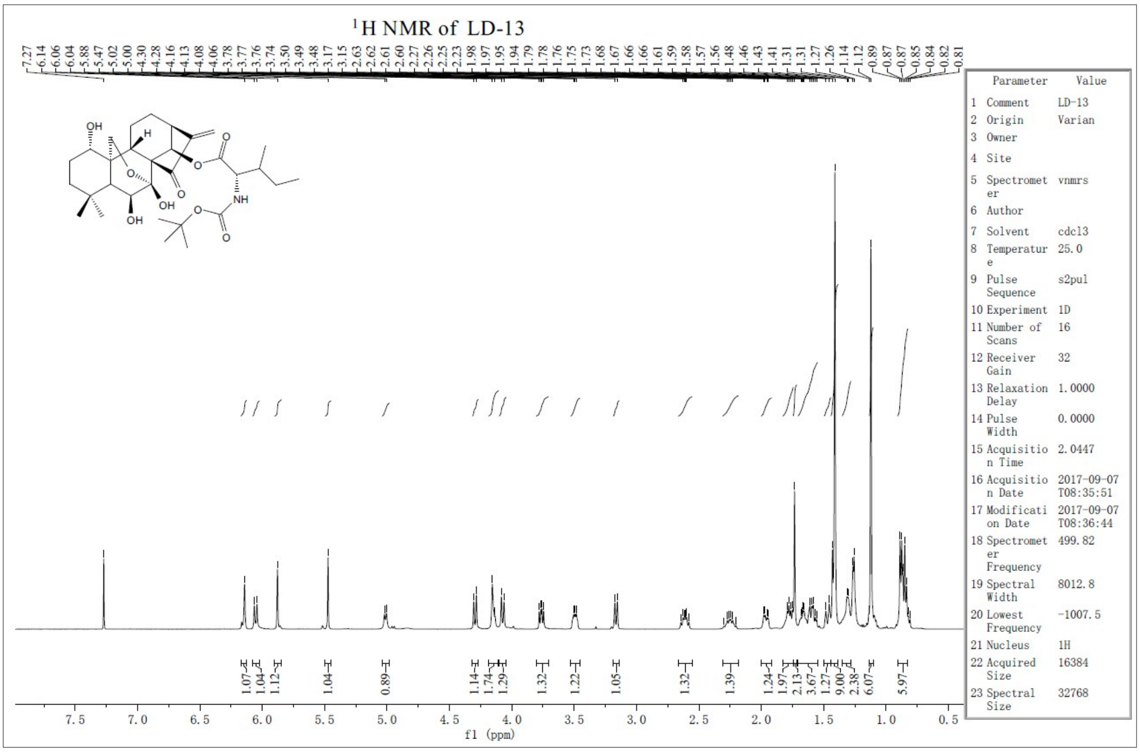
^{1}H NMR of **11j**



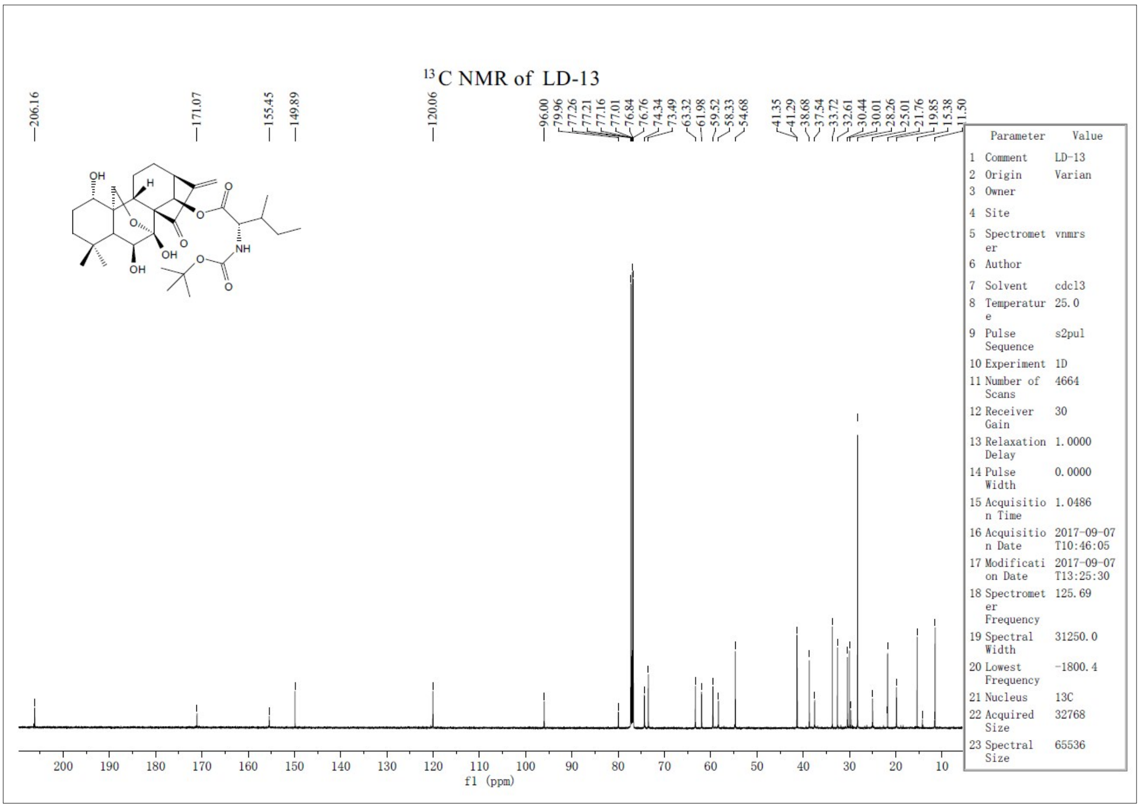
^{13}C NMR of **11j**



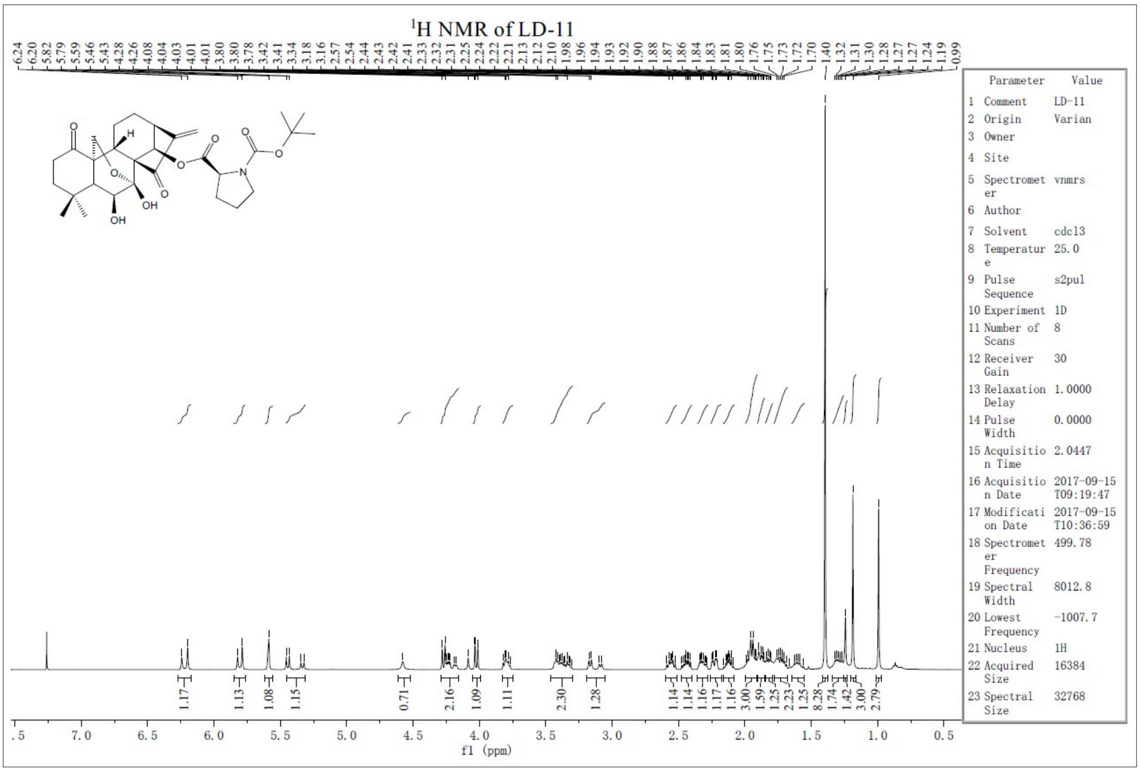
^{1}H NMR of **11k**



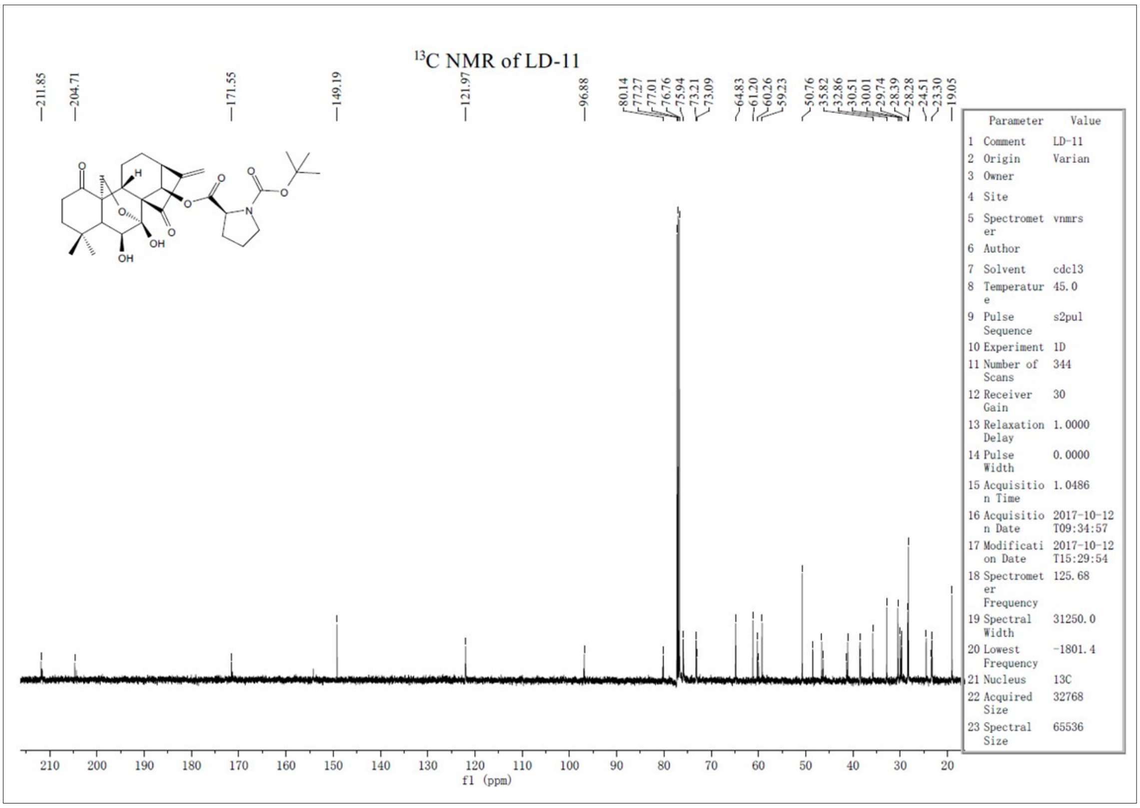
^{13}C NMR of **11k**



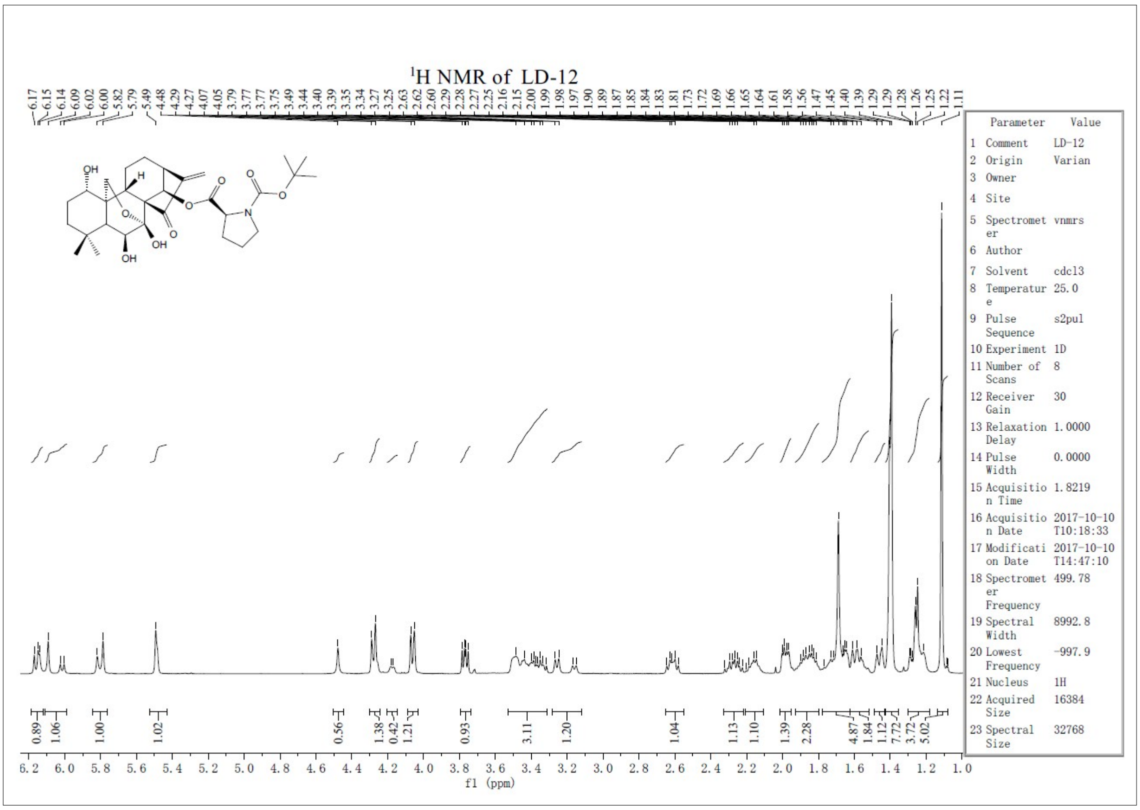
^{1}H NMR of **11l**



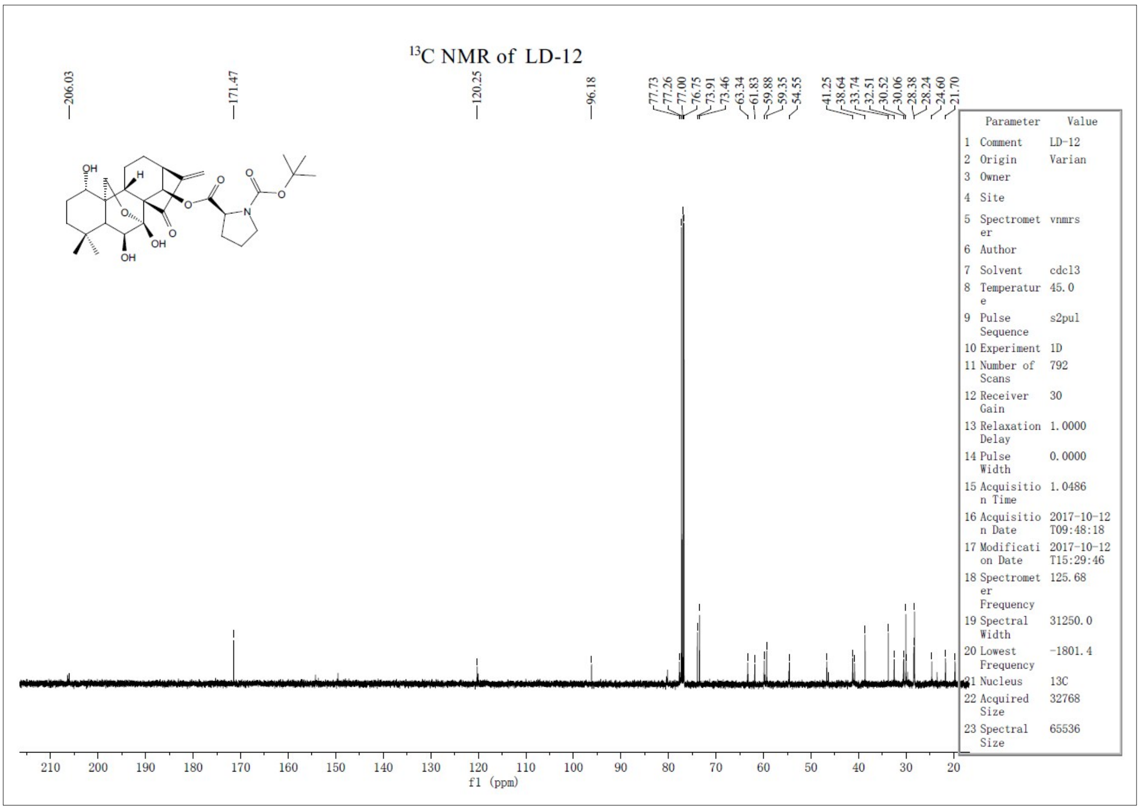
^{13}C NMR of **11l**



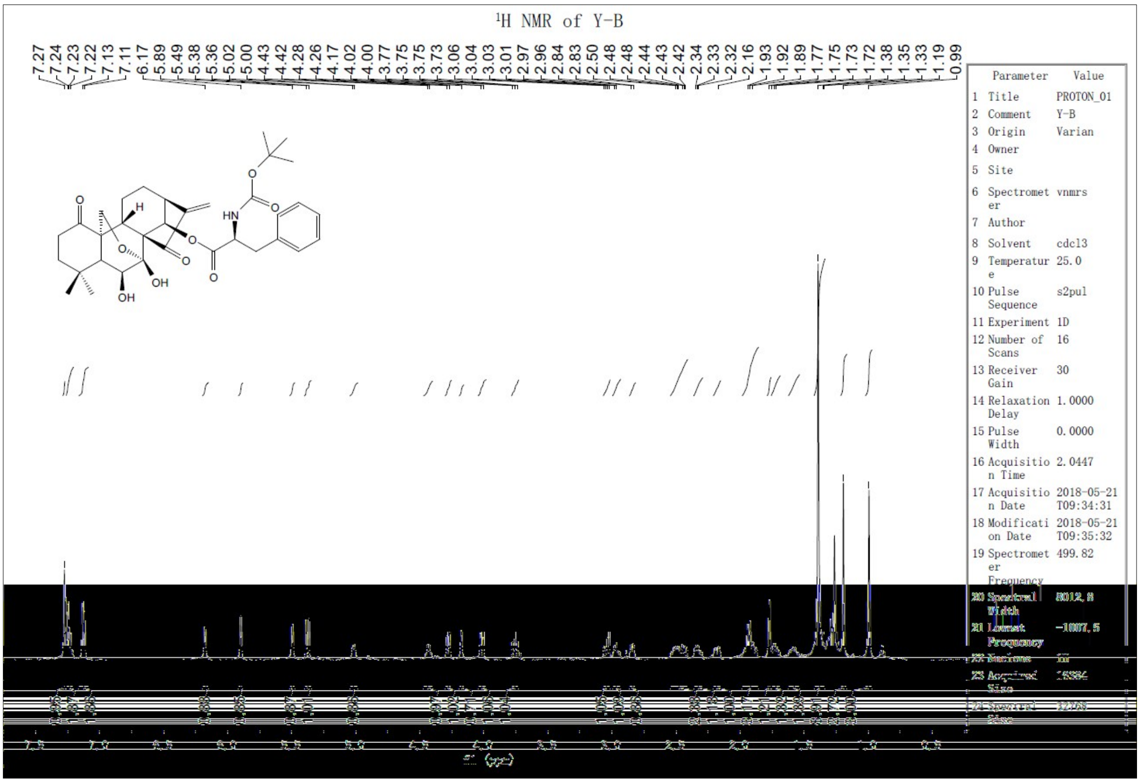
^{1}H NMR of **11m**



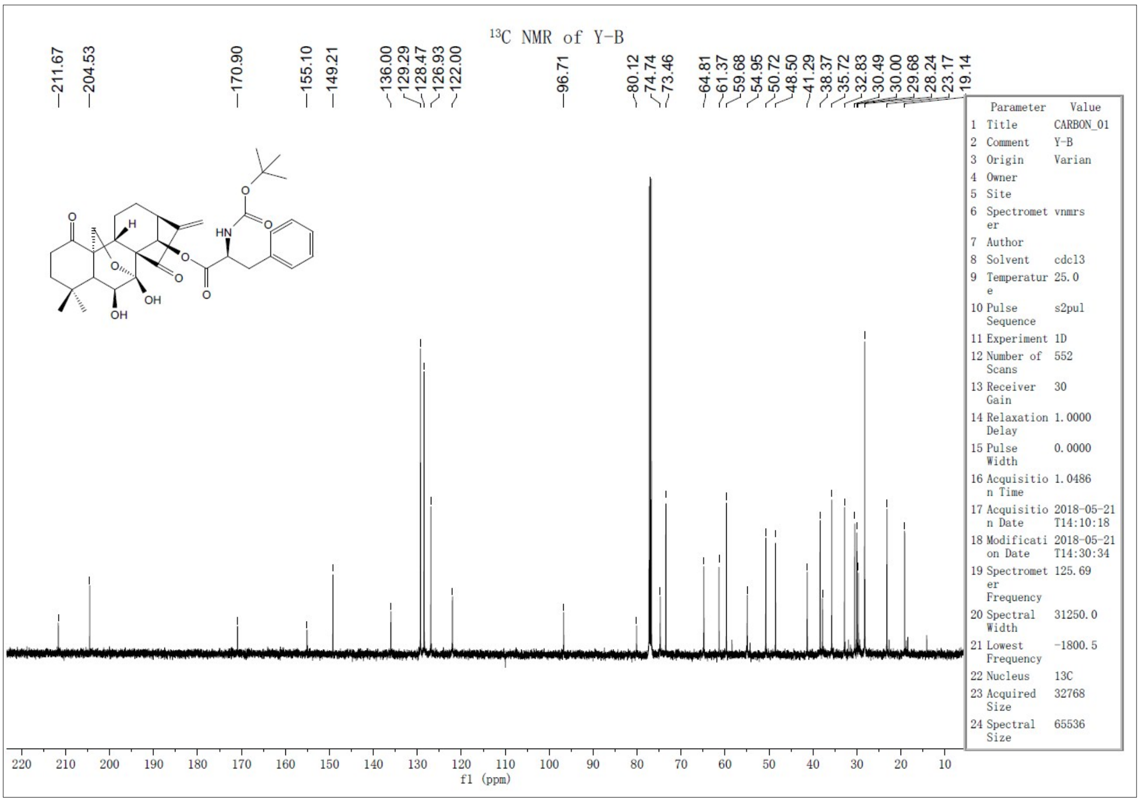
^{13}C NMR of **11m**



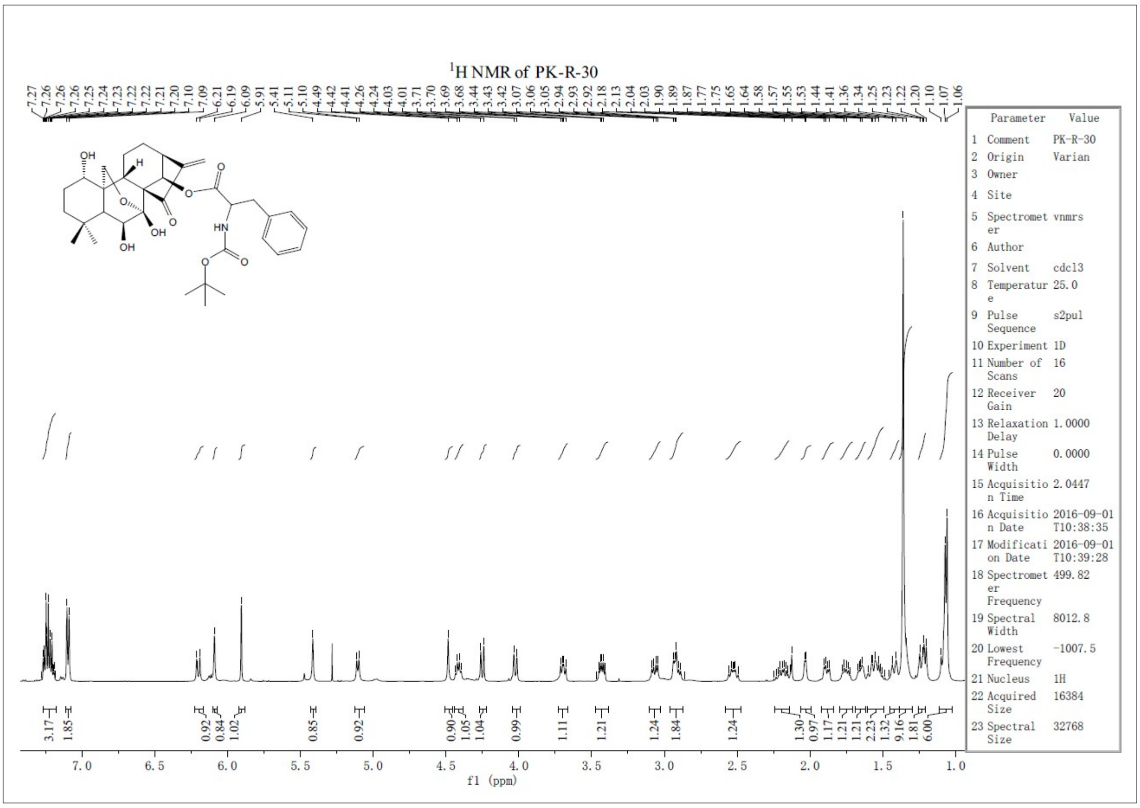
^{1}H NMR of **11n**



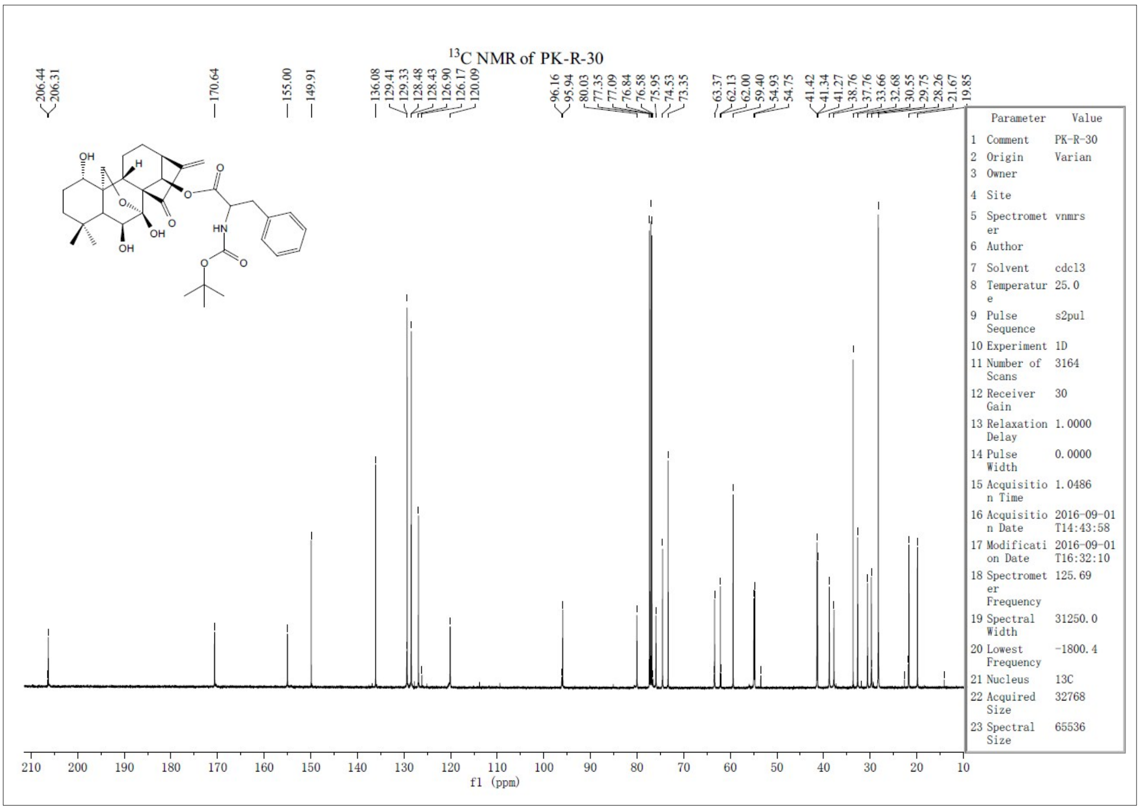
^{13}C NMR of **11n**



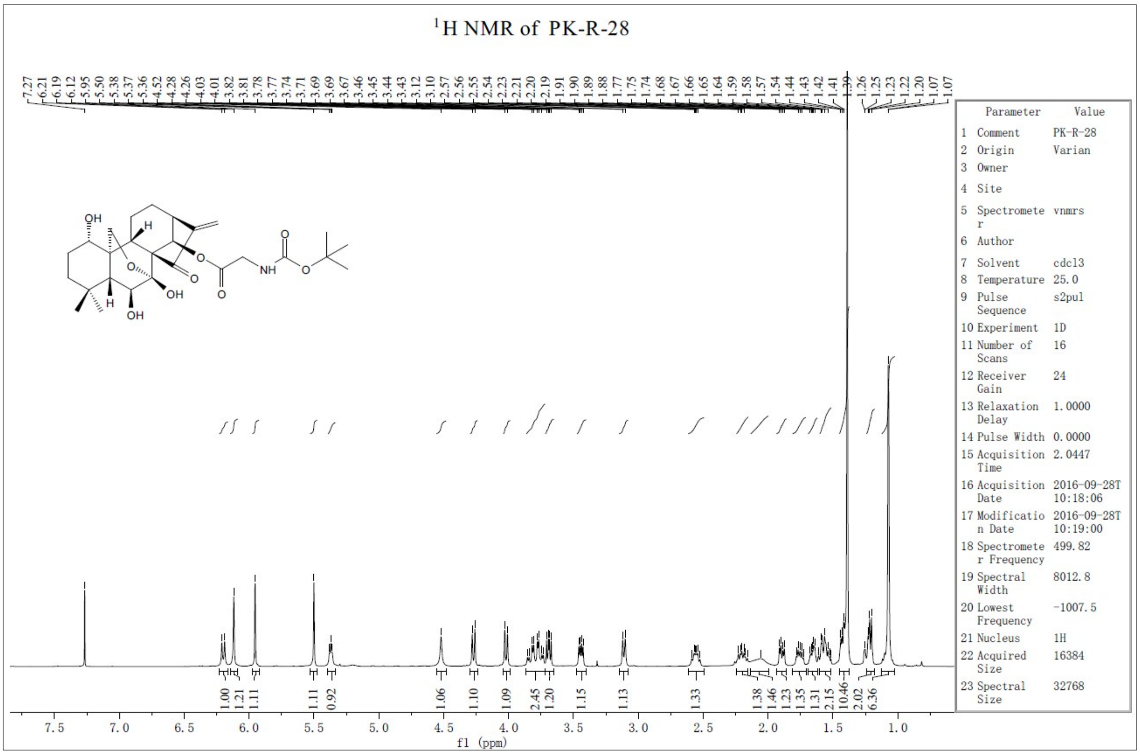
^{1}H NMR of **11o**



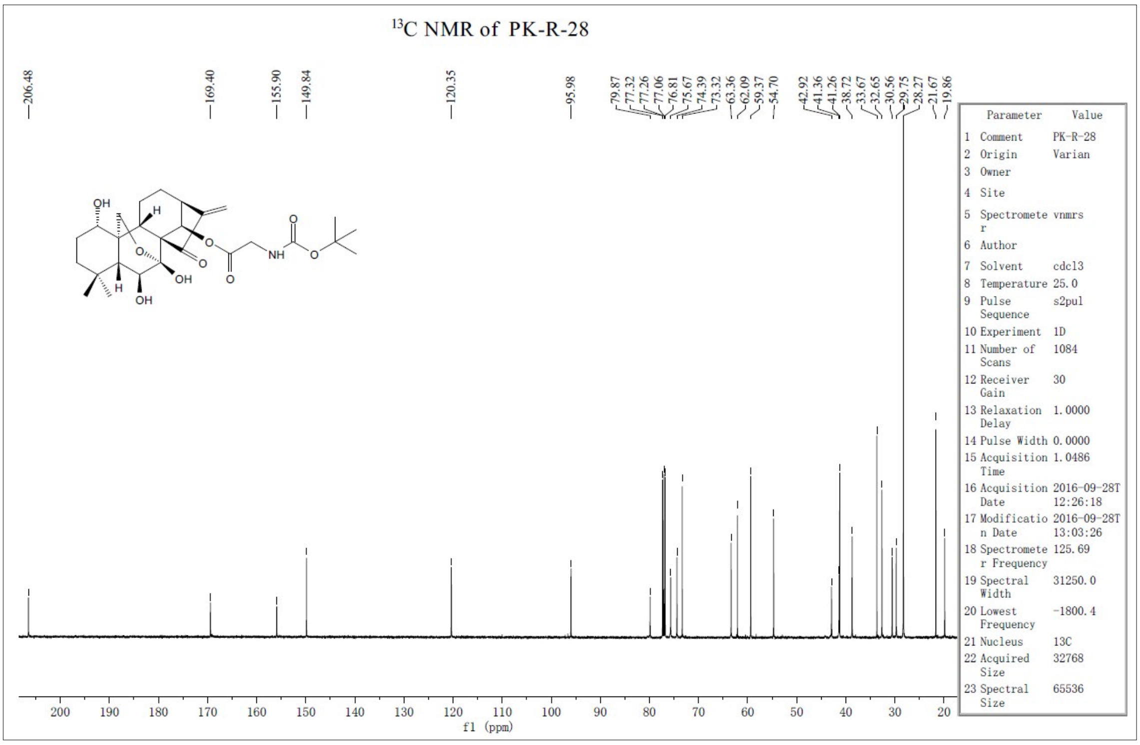
^{13}C NMR of **11o**



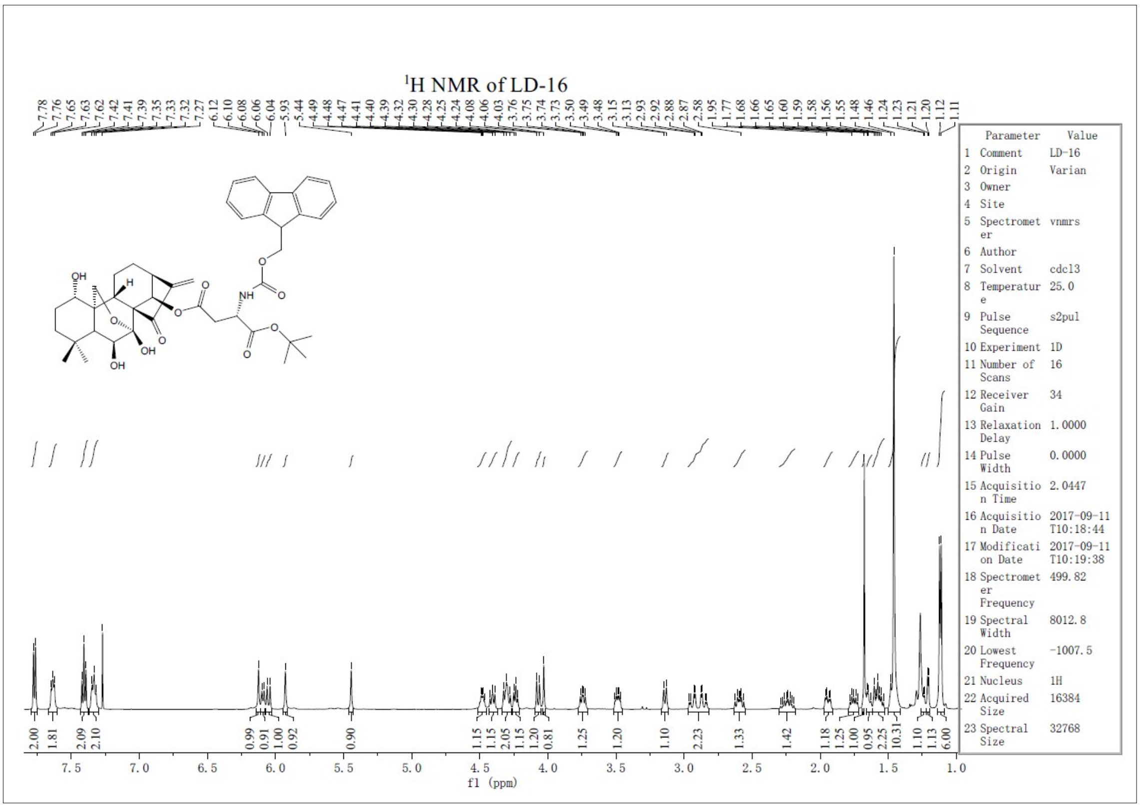
^{1}H NMR of **11p**



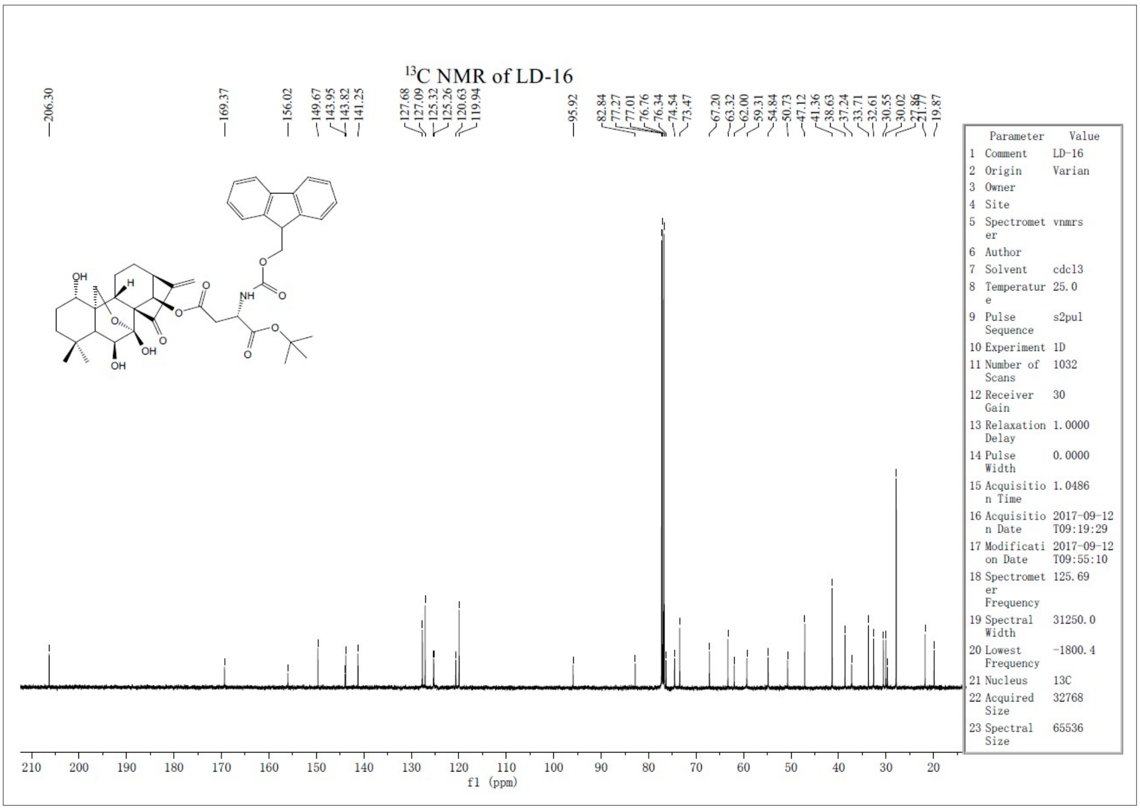
^{13}C NMR of **11p**



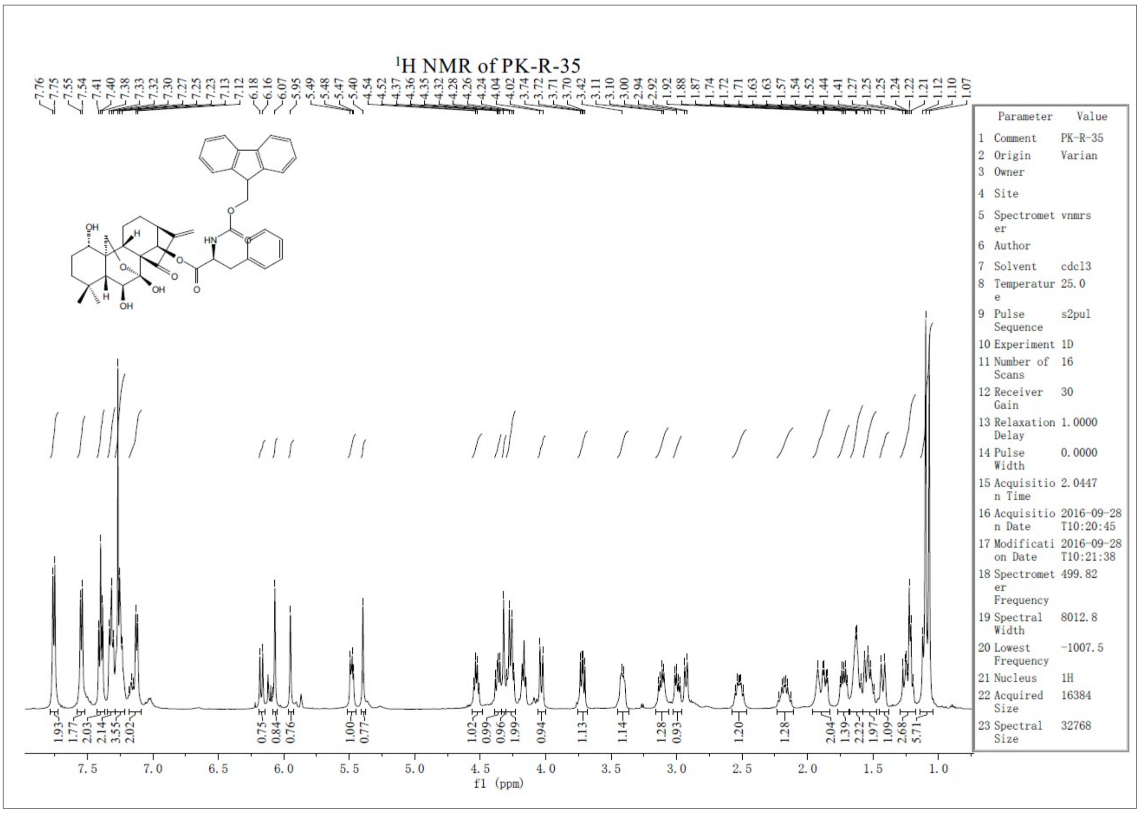
^{1}H NMR of **11q**



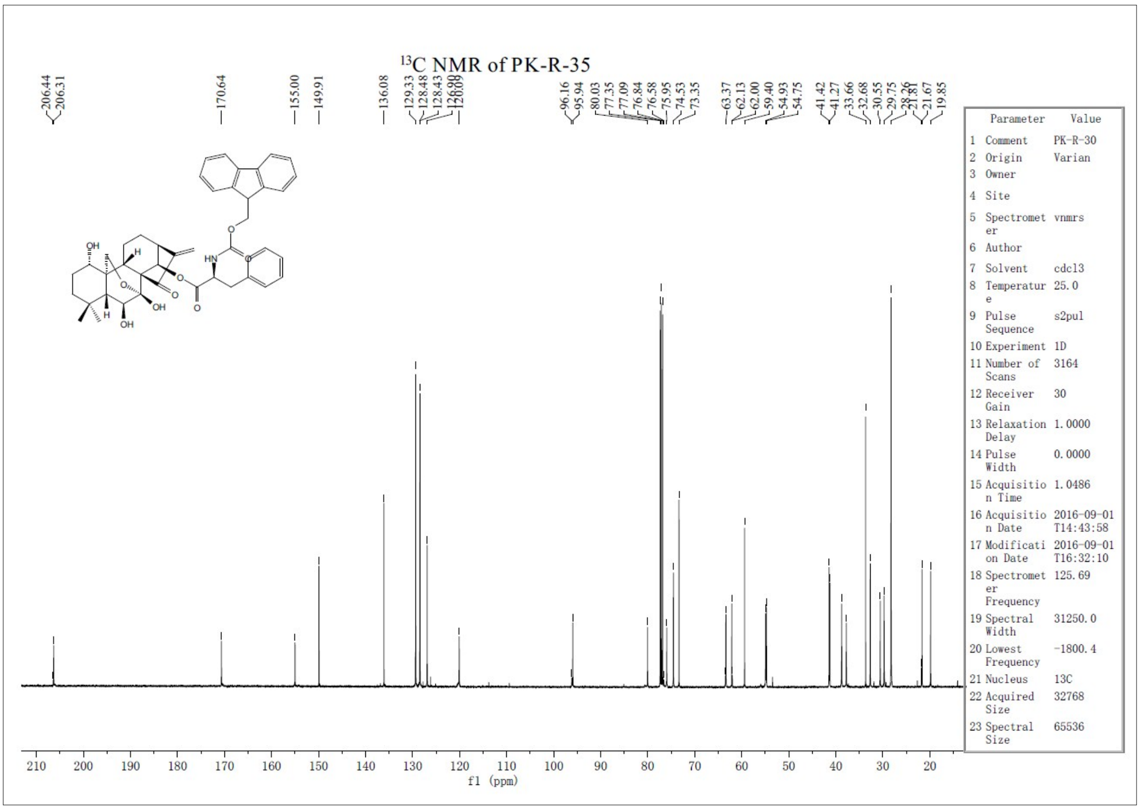
^{13}C NMR of **11q**



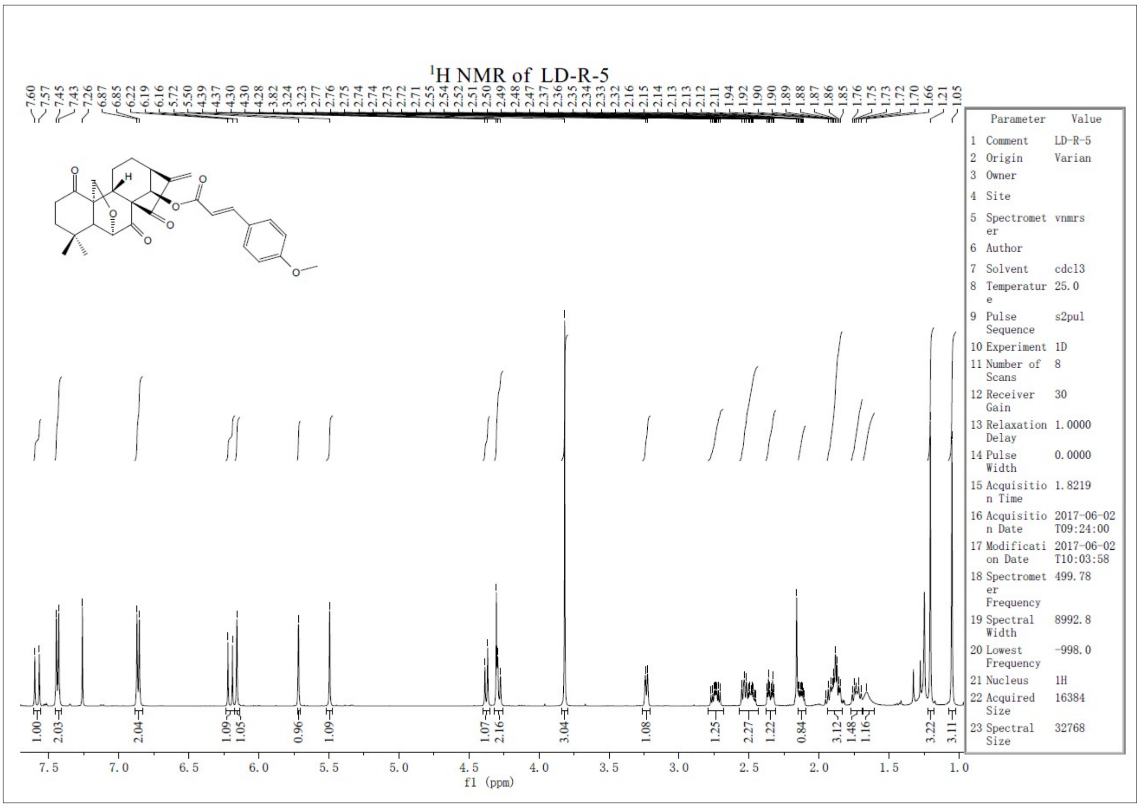
^{1}H NMR of **11r**



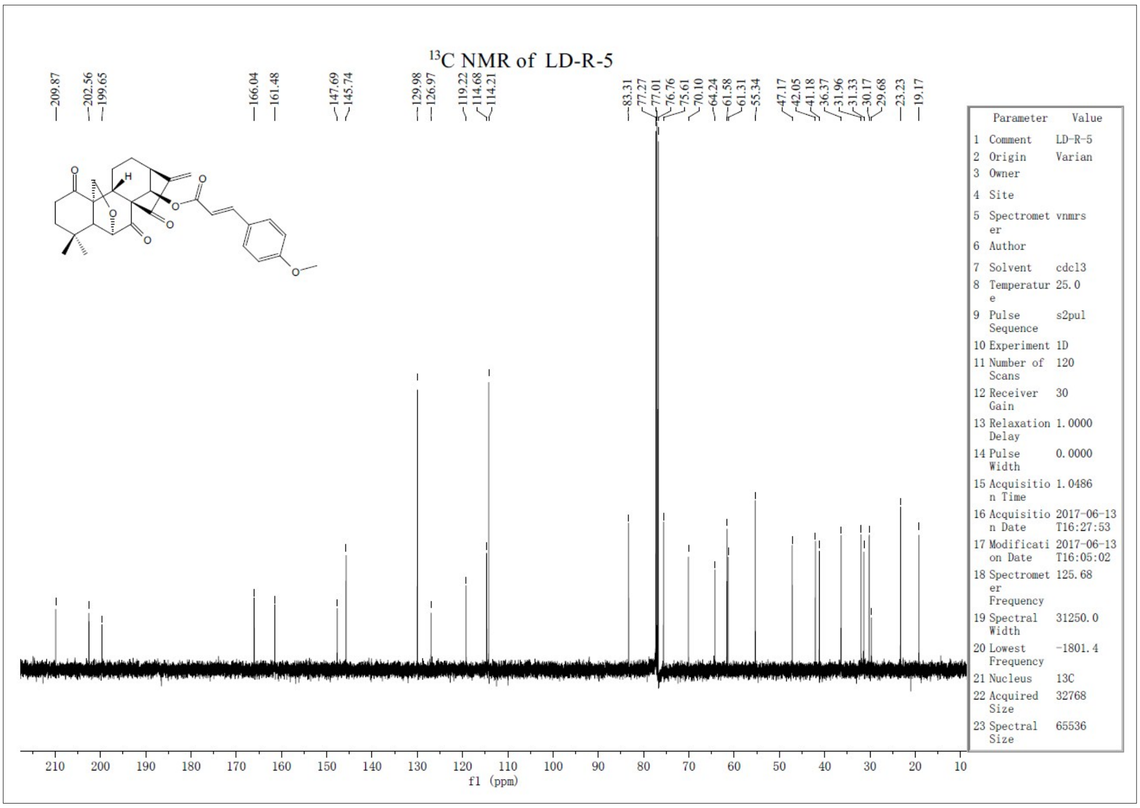
^{13}C NMR of **11r**



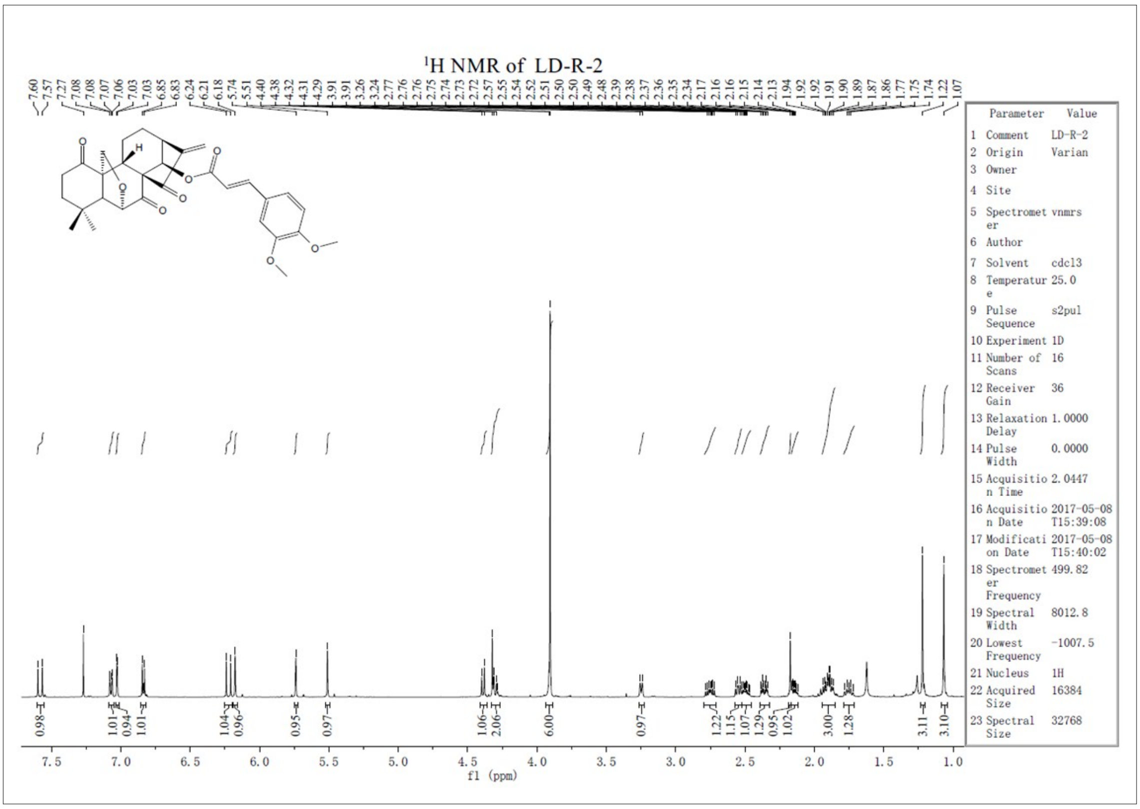
^{1}H NMR of **12a**



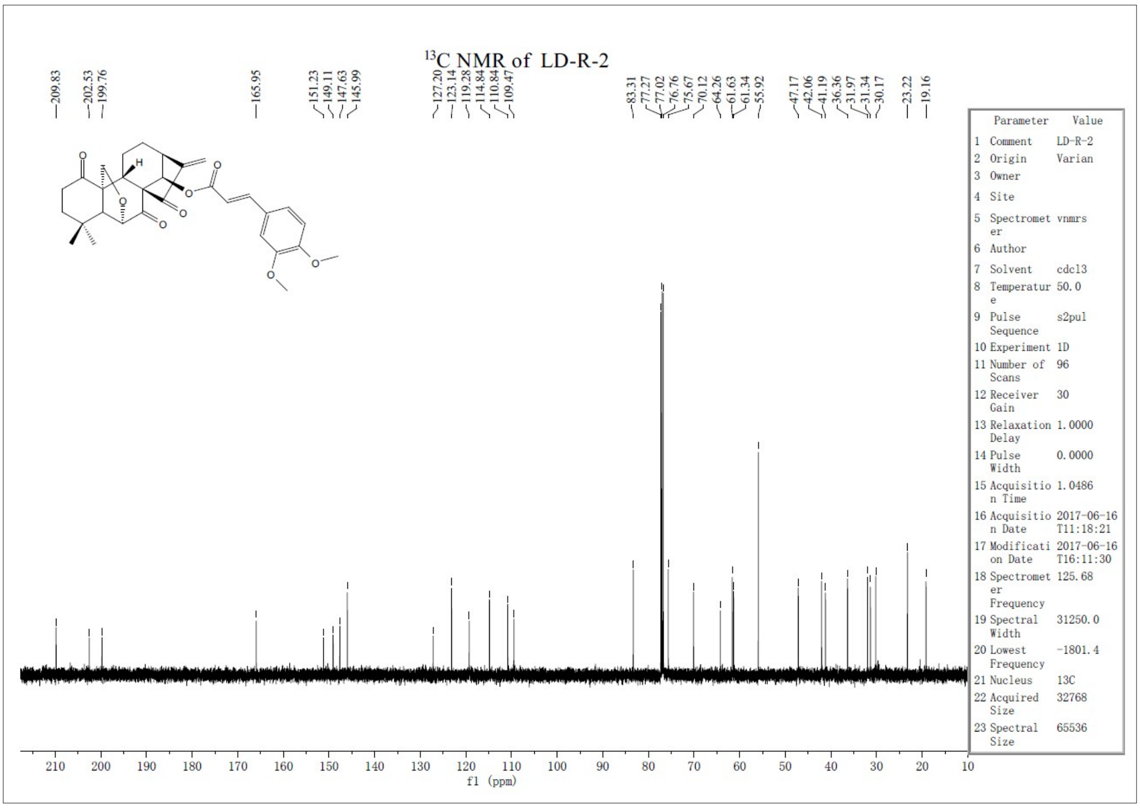
^{13}C NMR of **12a**



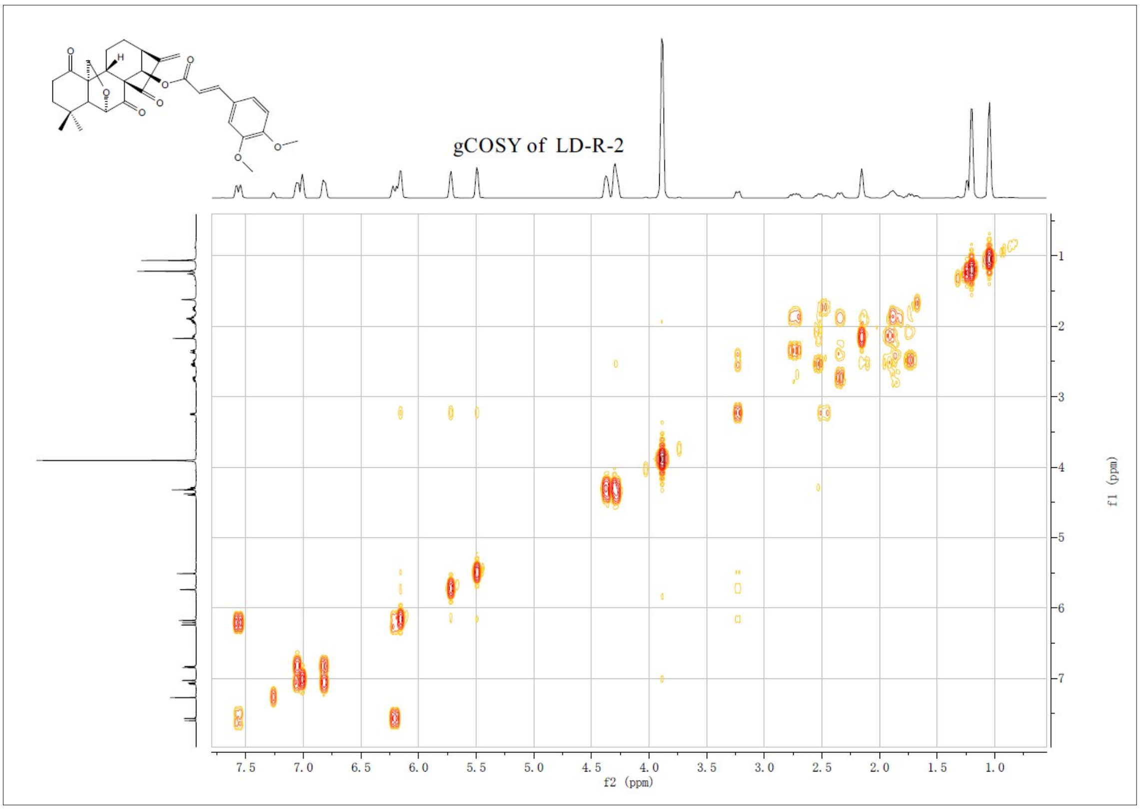
^{1}H NMR of **12b**



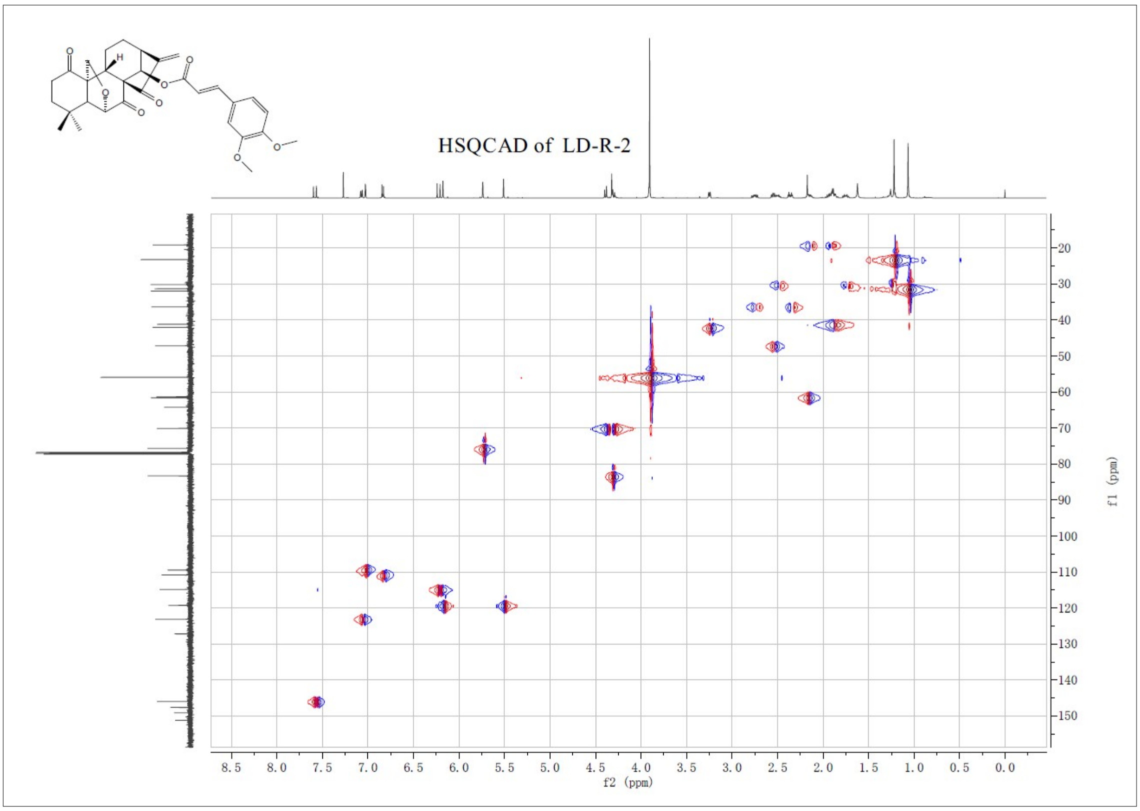
^{13}C NMR of **12b**



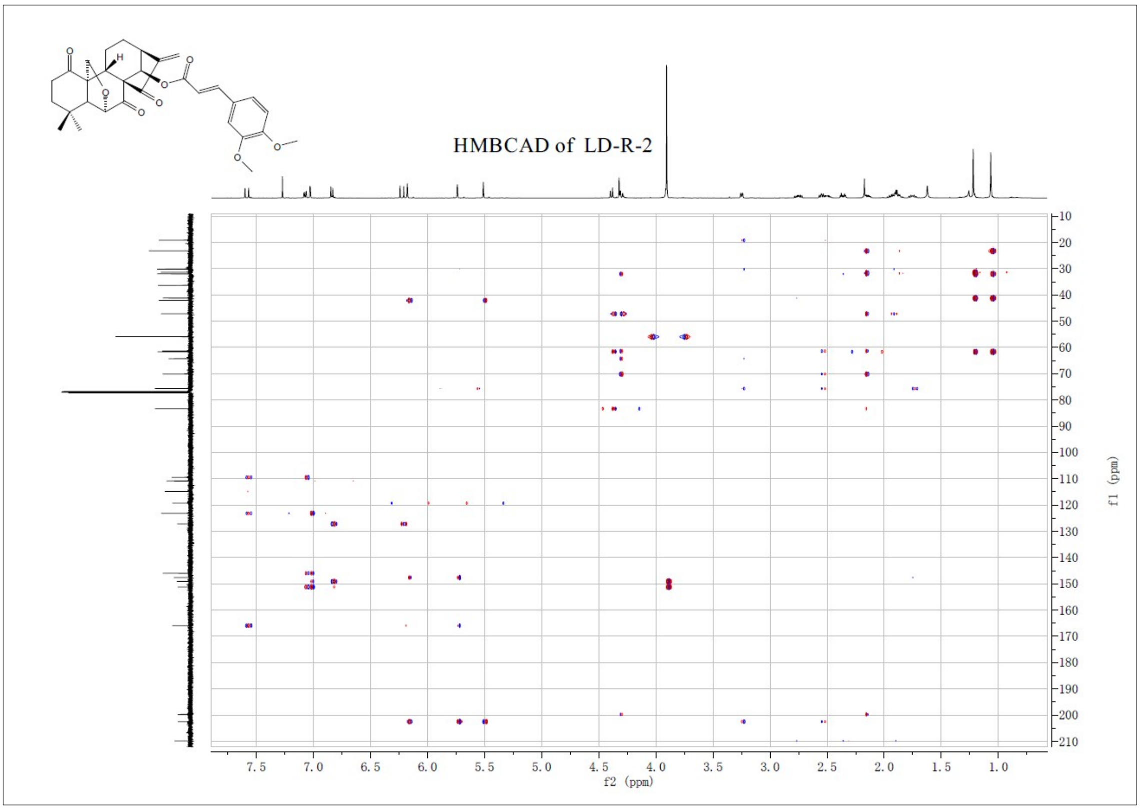
H-H COSY of **12b**



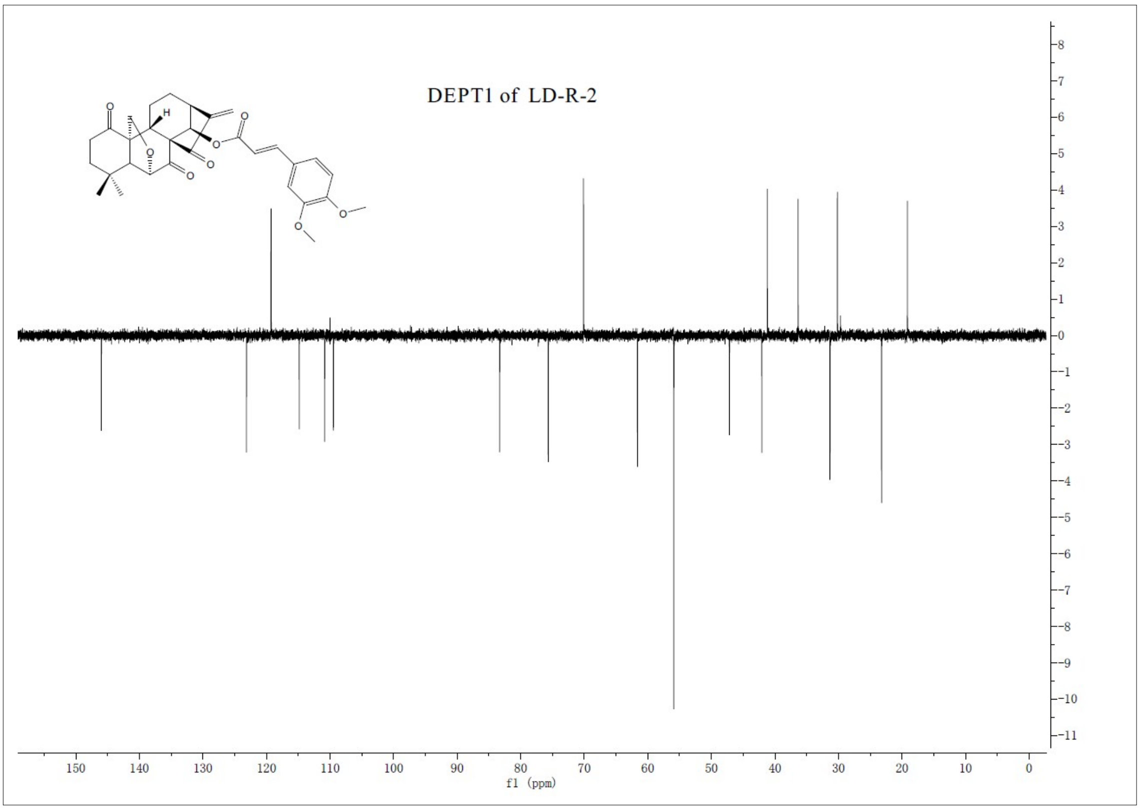
HSQC of **12b**



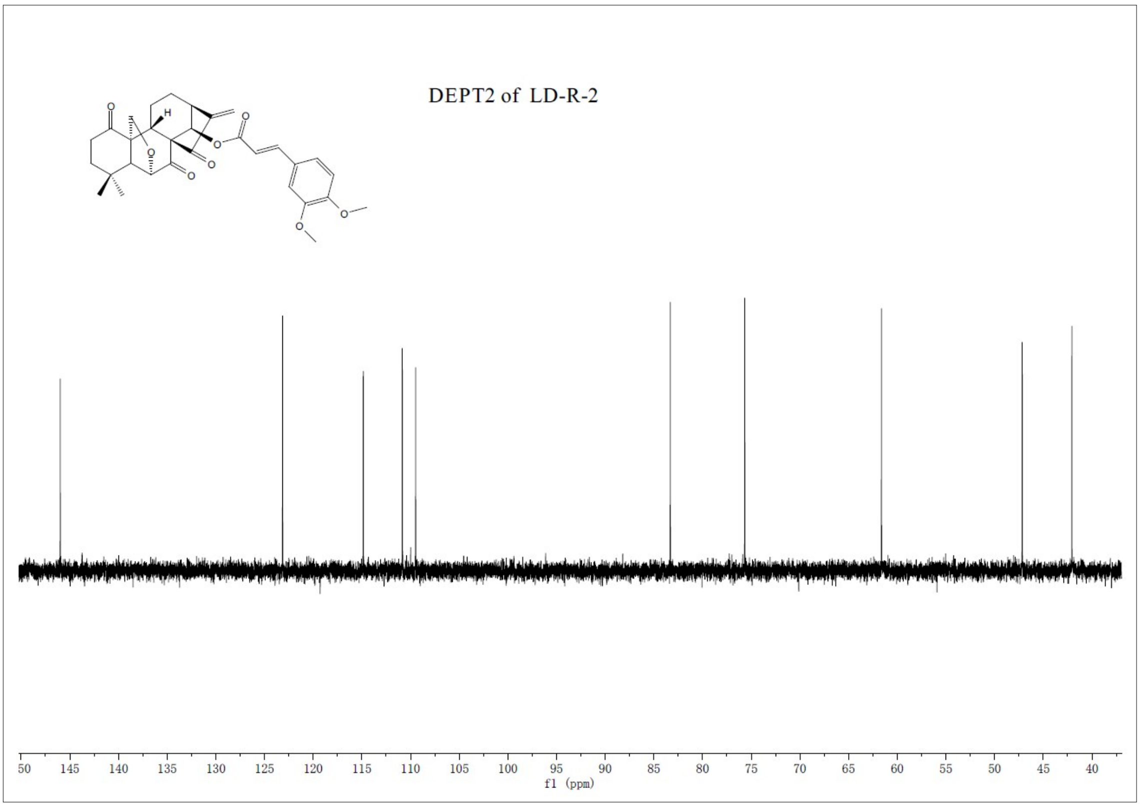
HMBC of **12b**



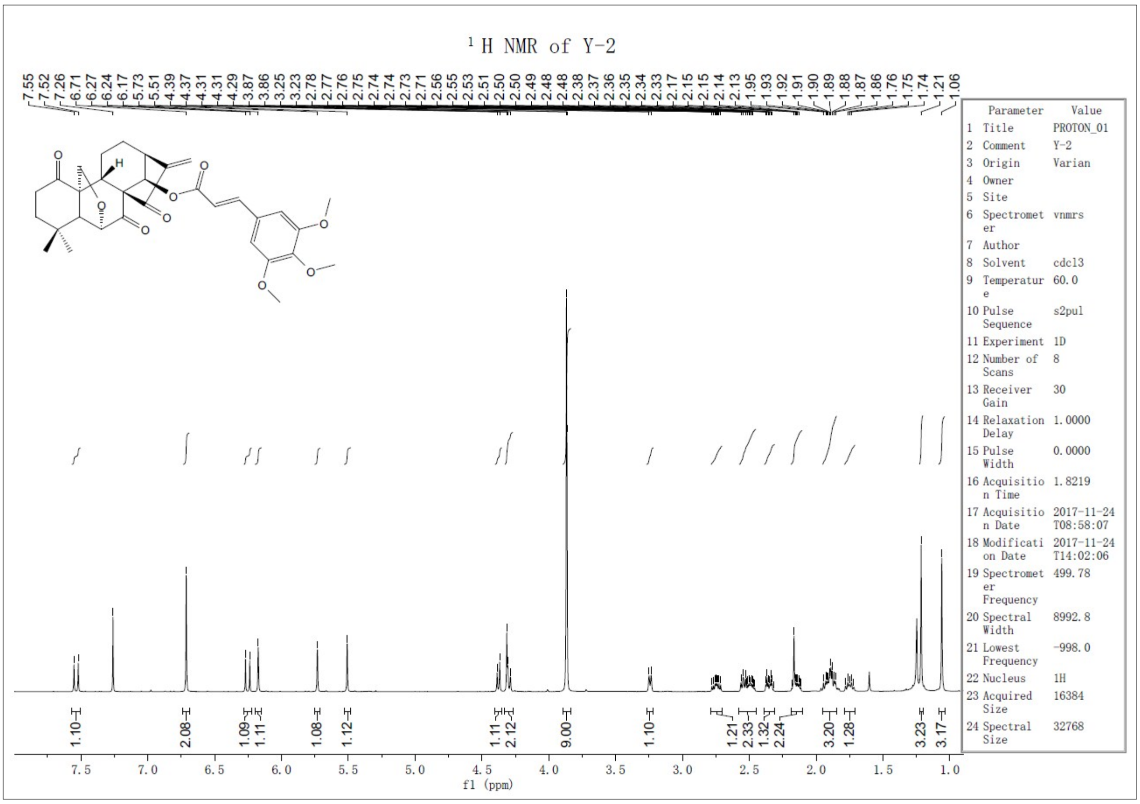
DEPT1 of **12b**



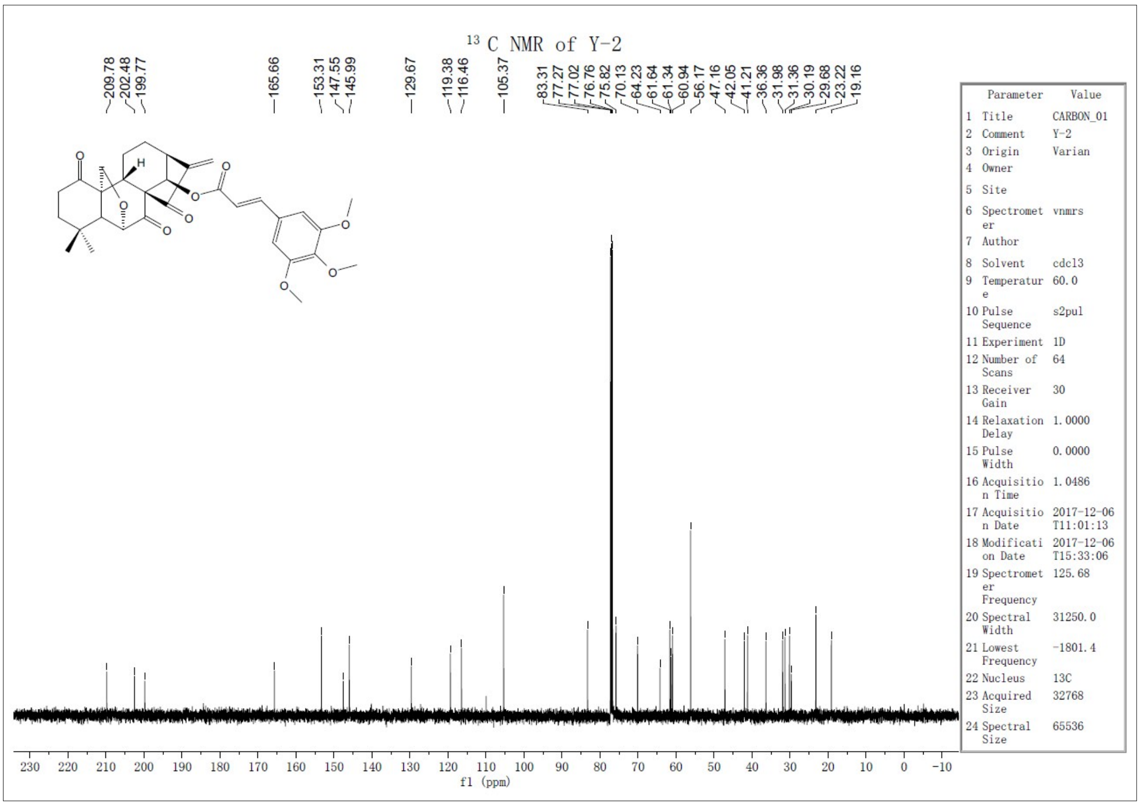
DEPT2 of **12b**



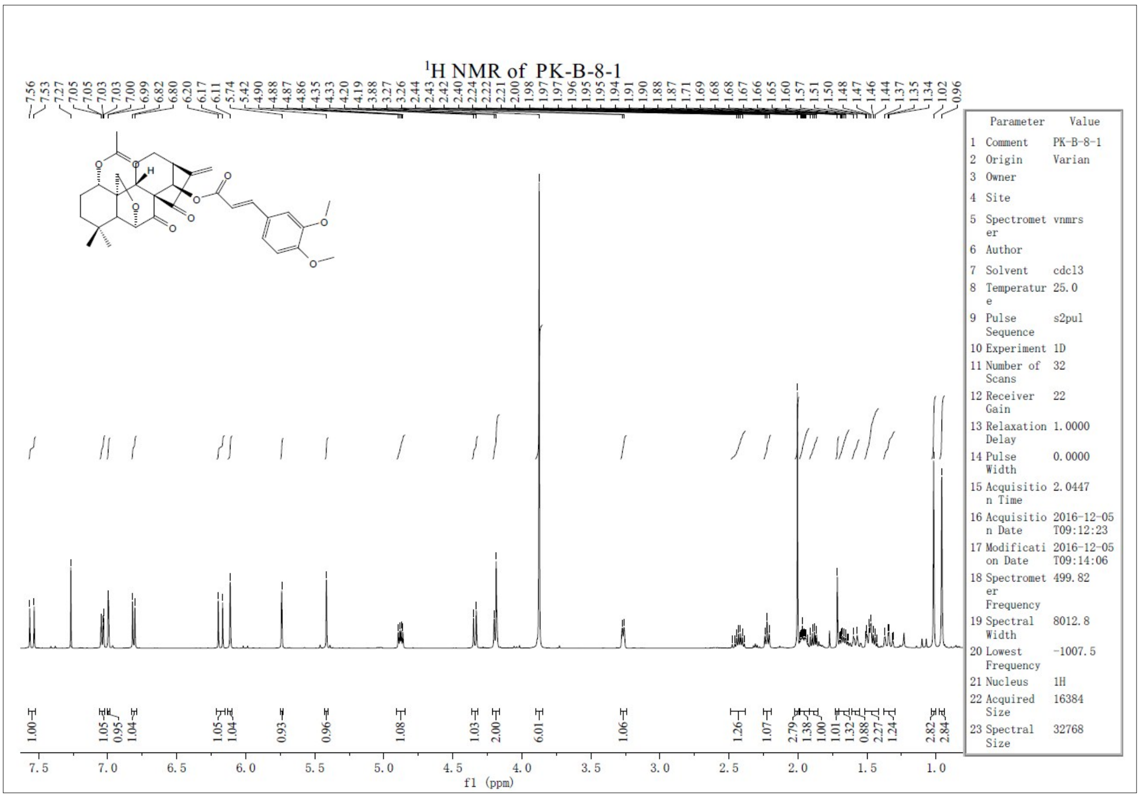
^{1}H NMR of **12c**



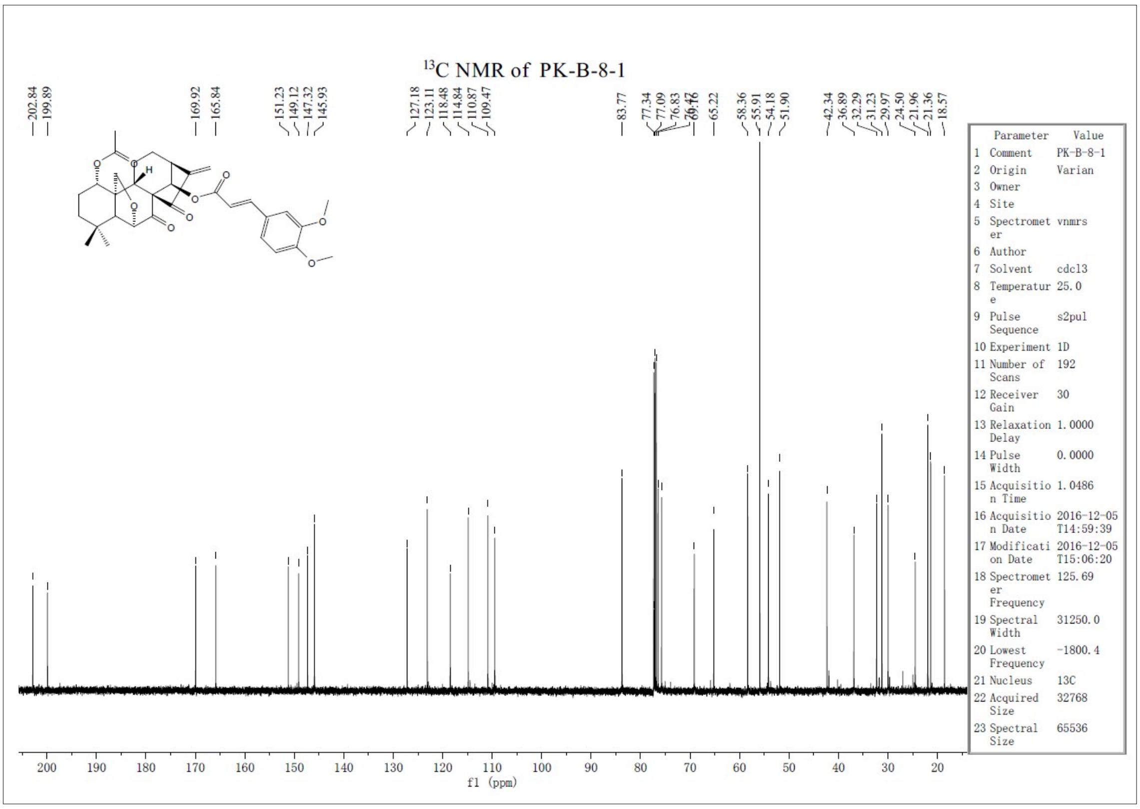
^{13}C NMR of **12c**



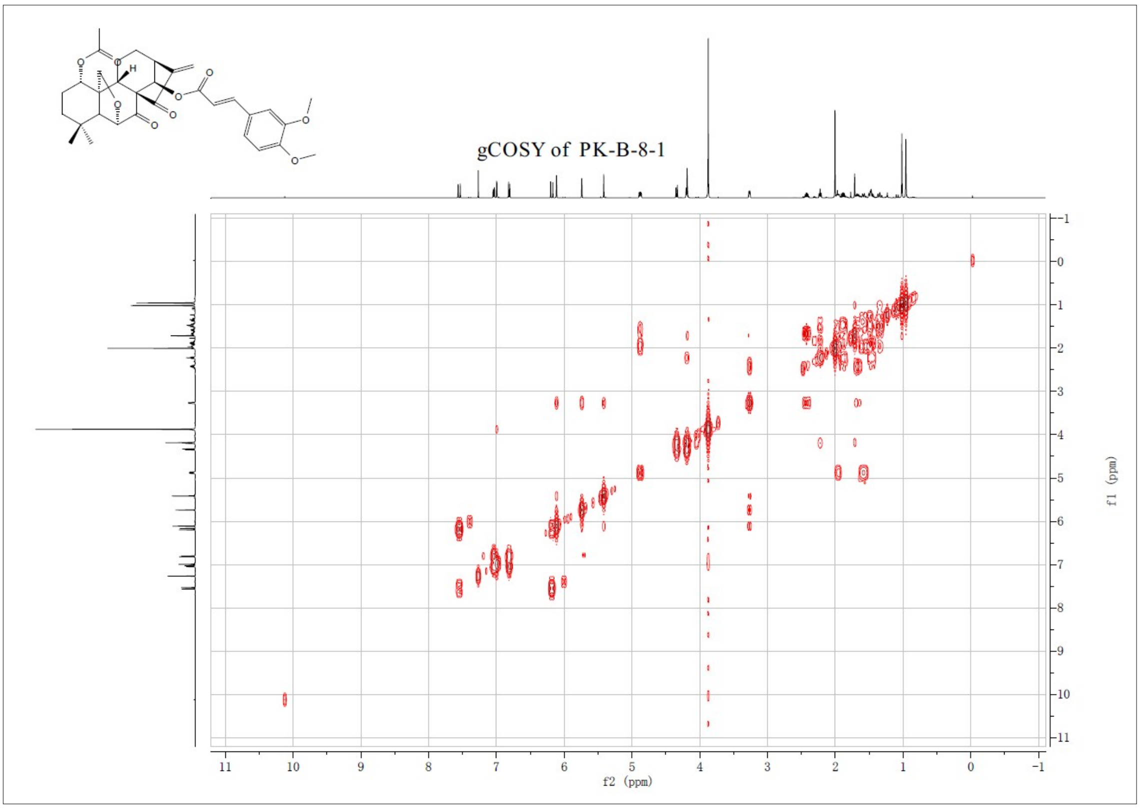
^{1}H NMR of **12d**



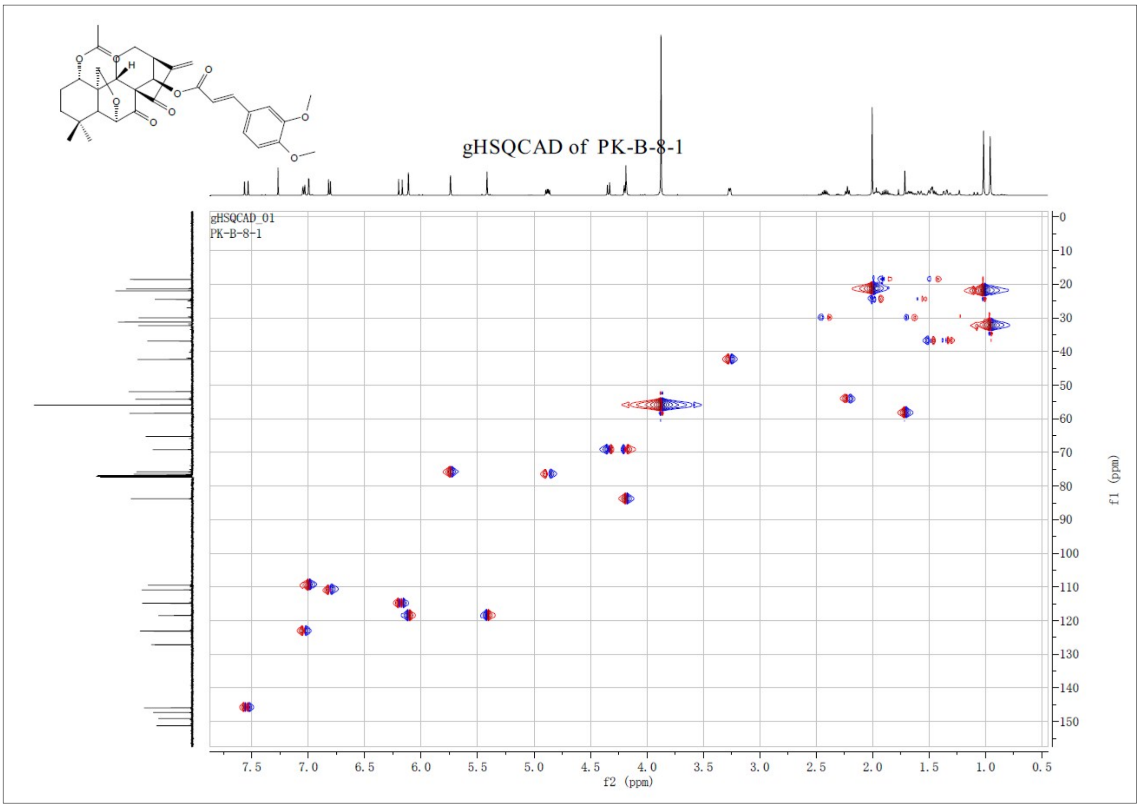
^{13}C NMR of **12d**



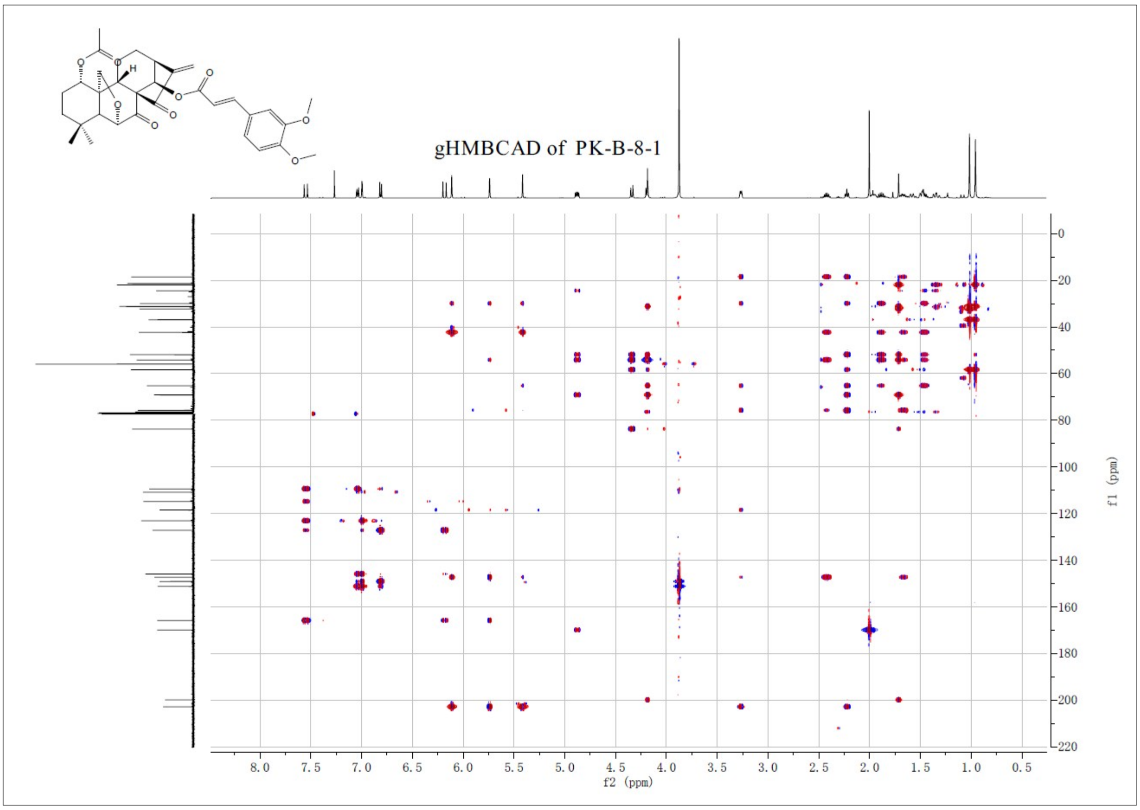
H-H COSY of **12d**



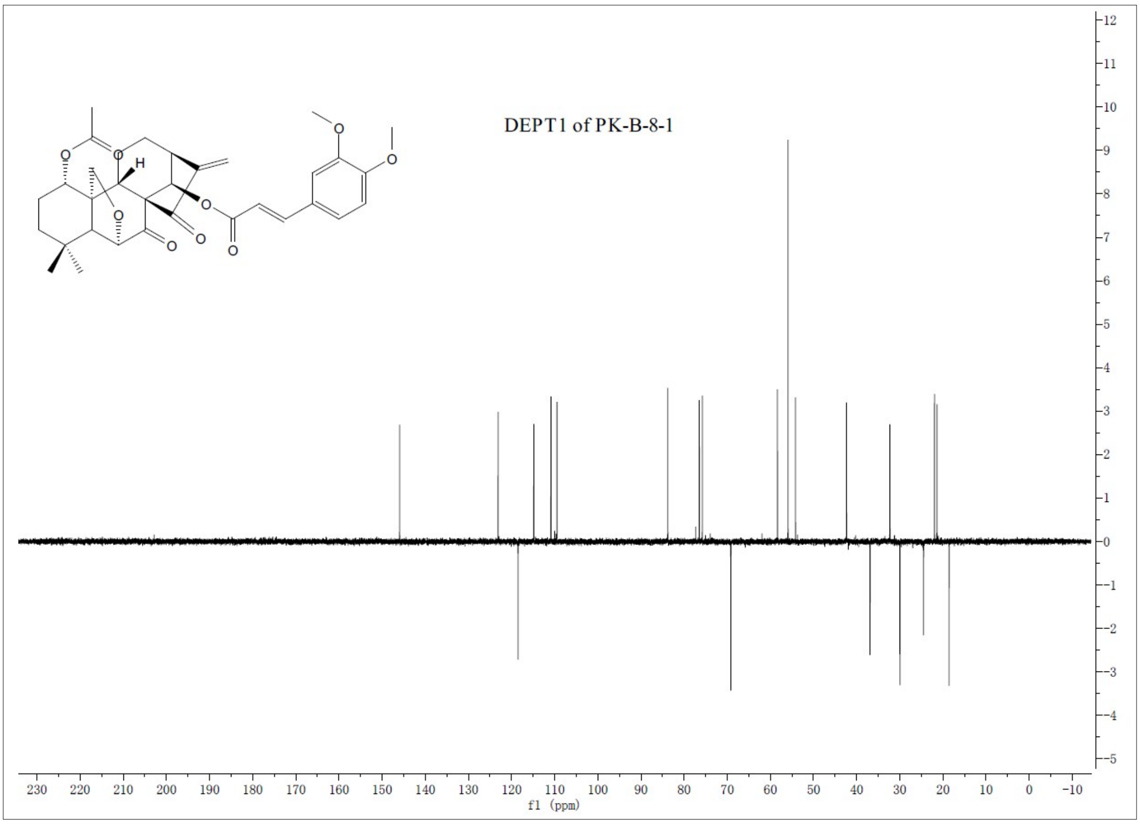
HSQC of **12d**



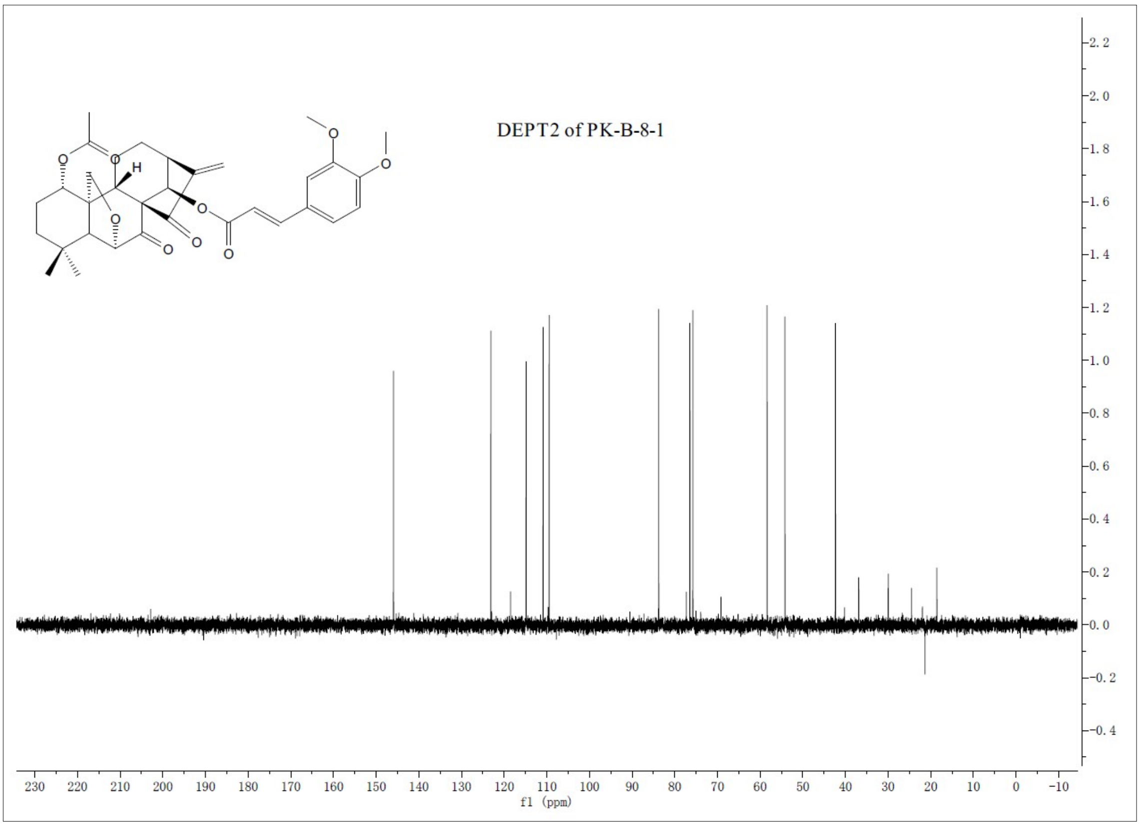
HMBC of **12d**



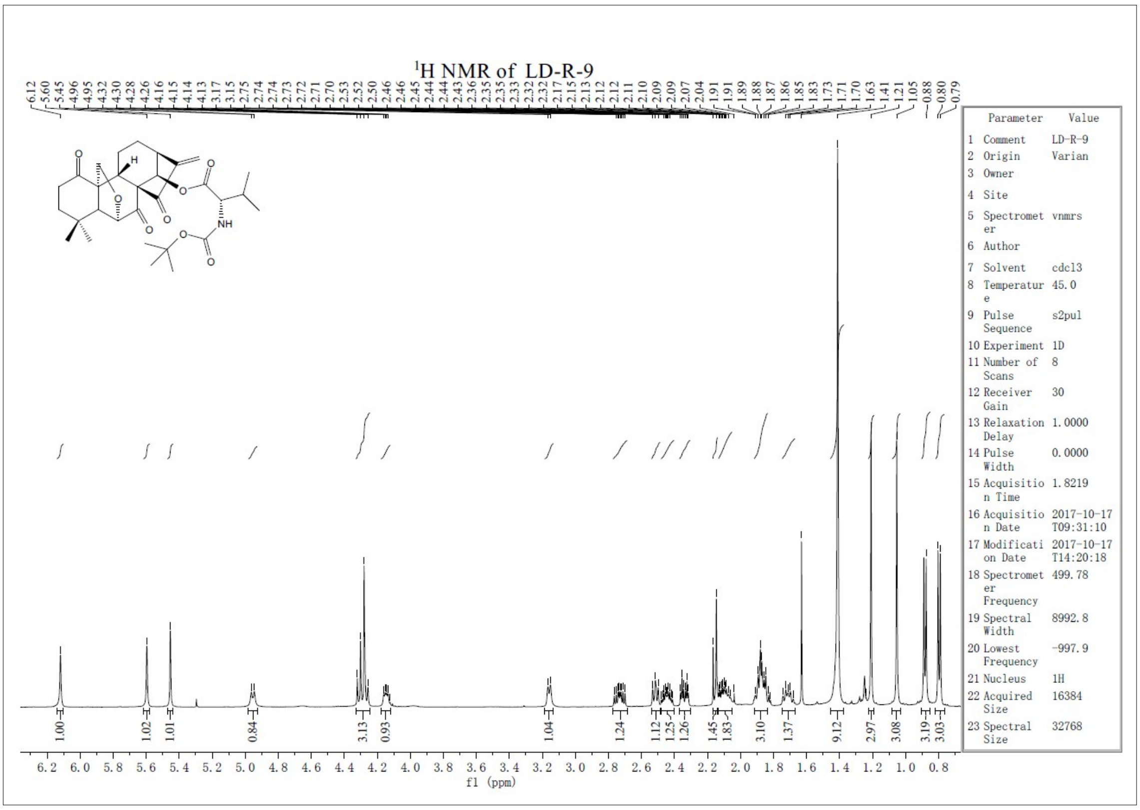
DEPT1 of **12d**



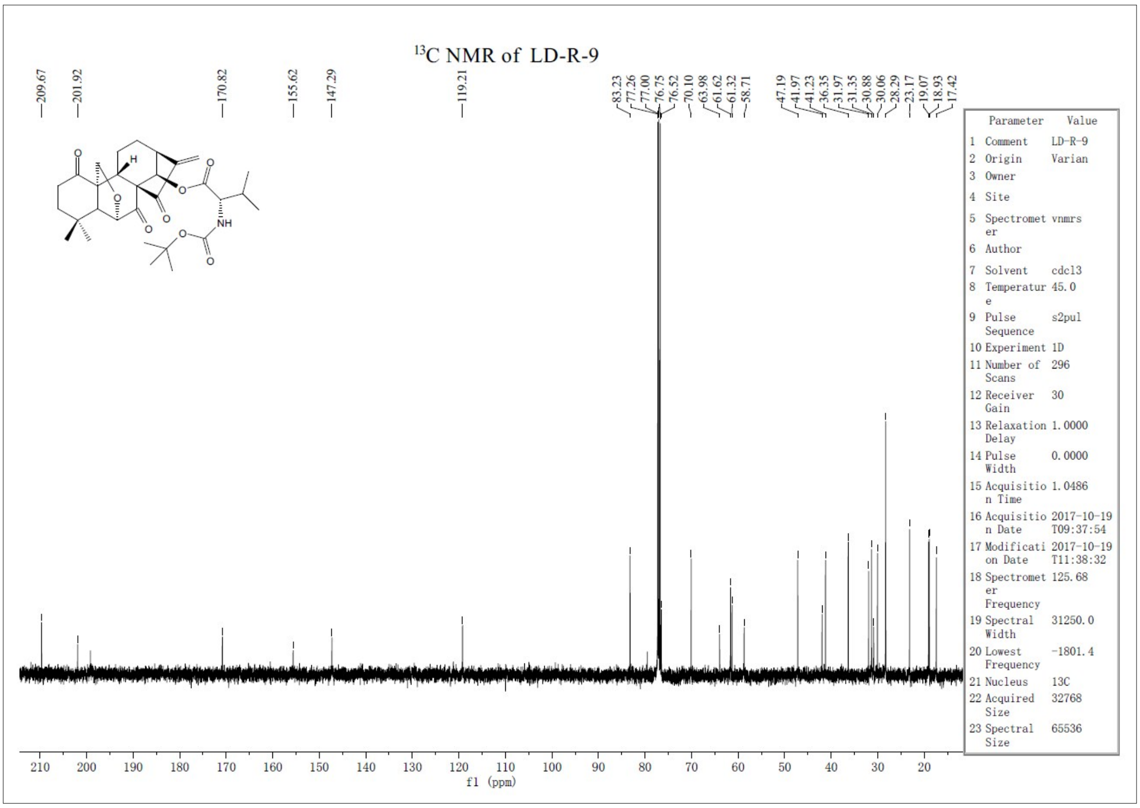
DEPT2 of **12d**



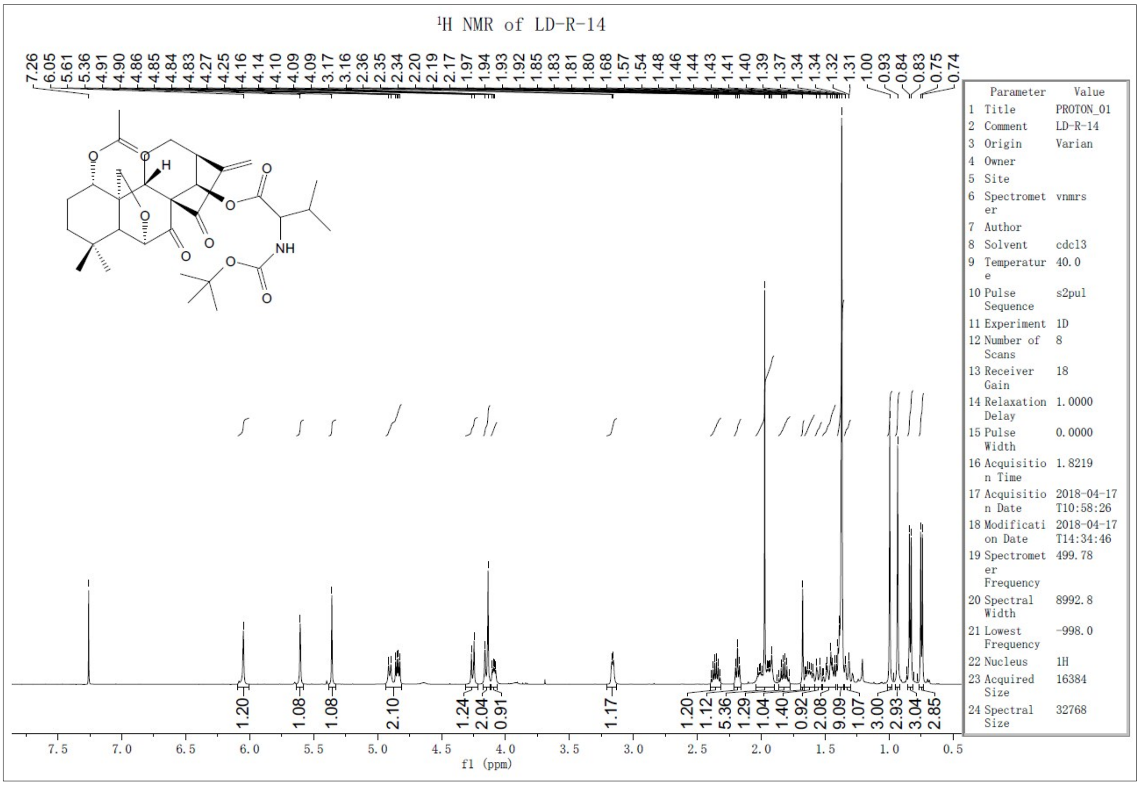
^{1}H NMR of **12e**



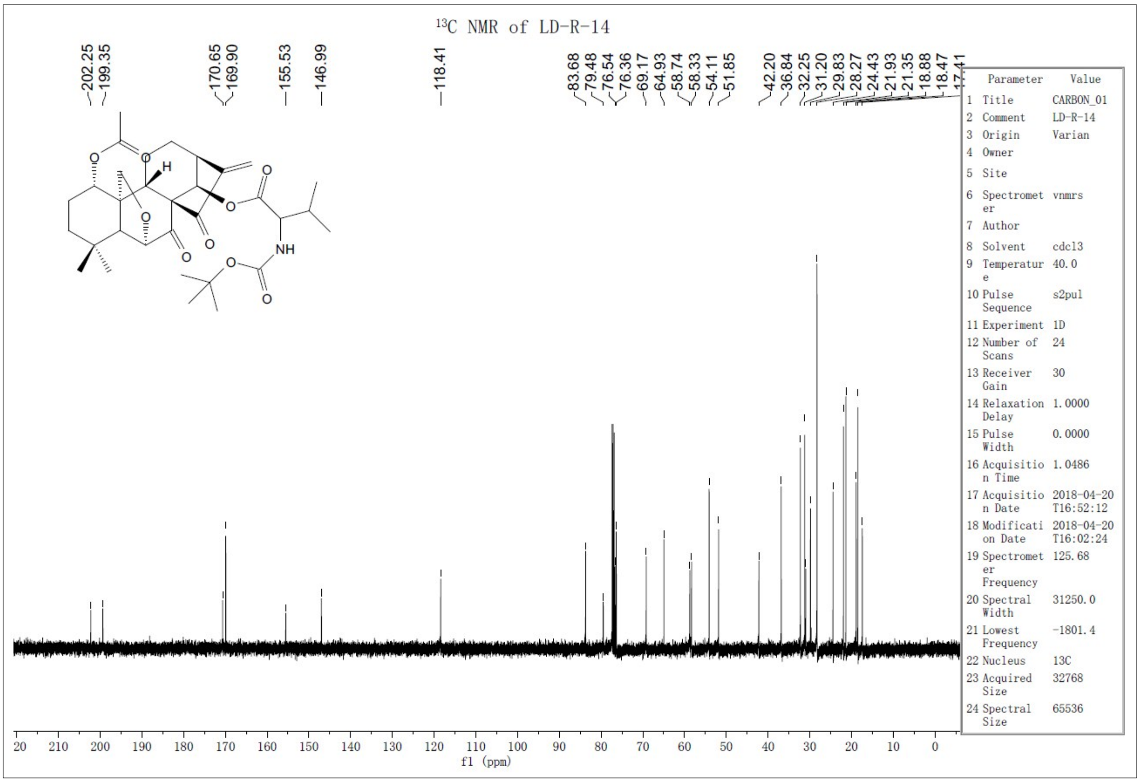
^{13}C NMR of **12e**



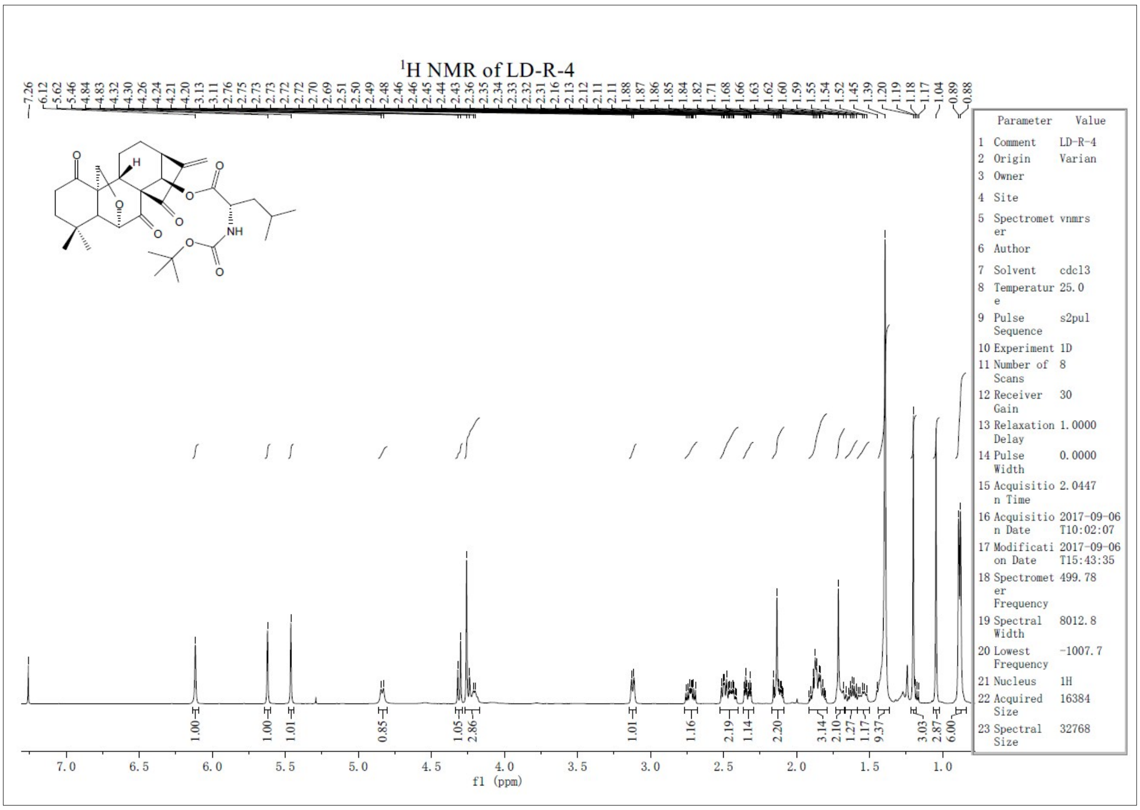
^{1}H NMR of **12f**



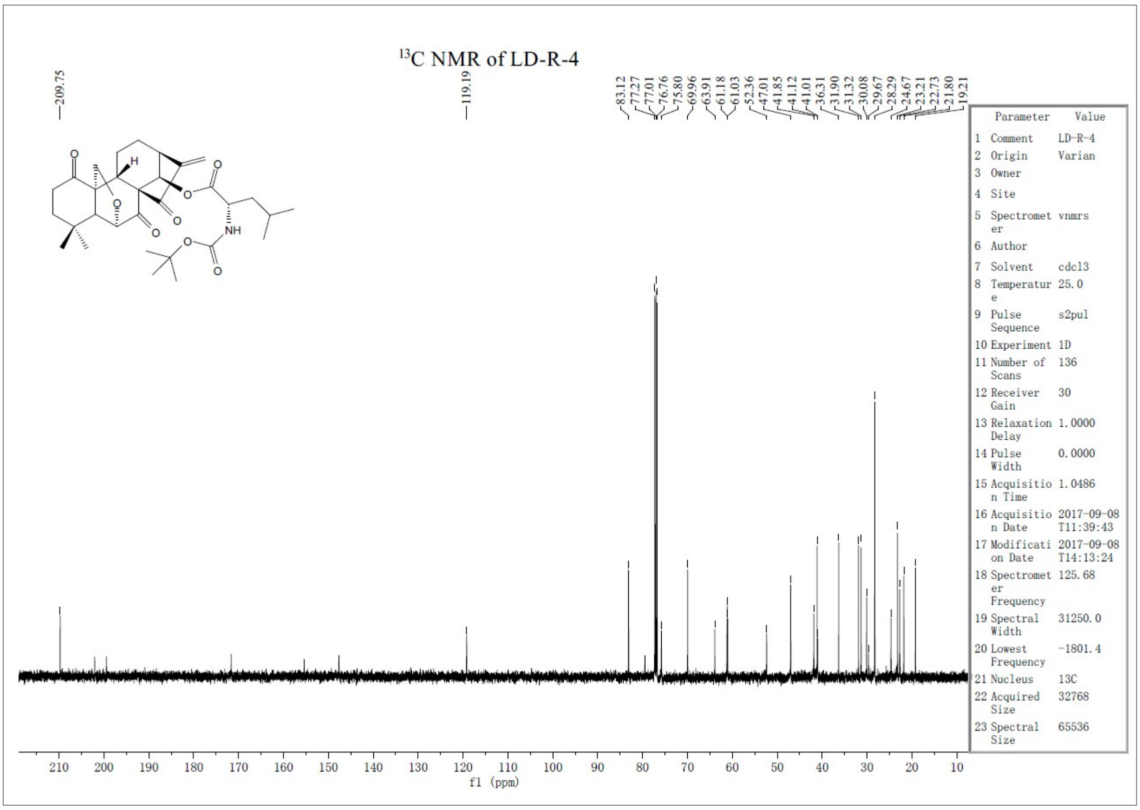
^{13}C NMR of **12f**



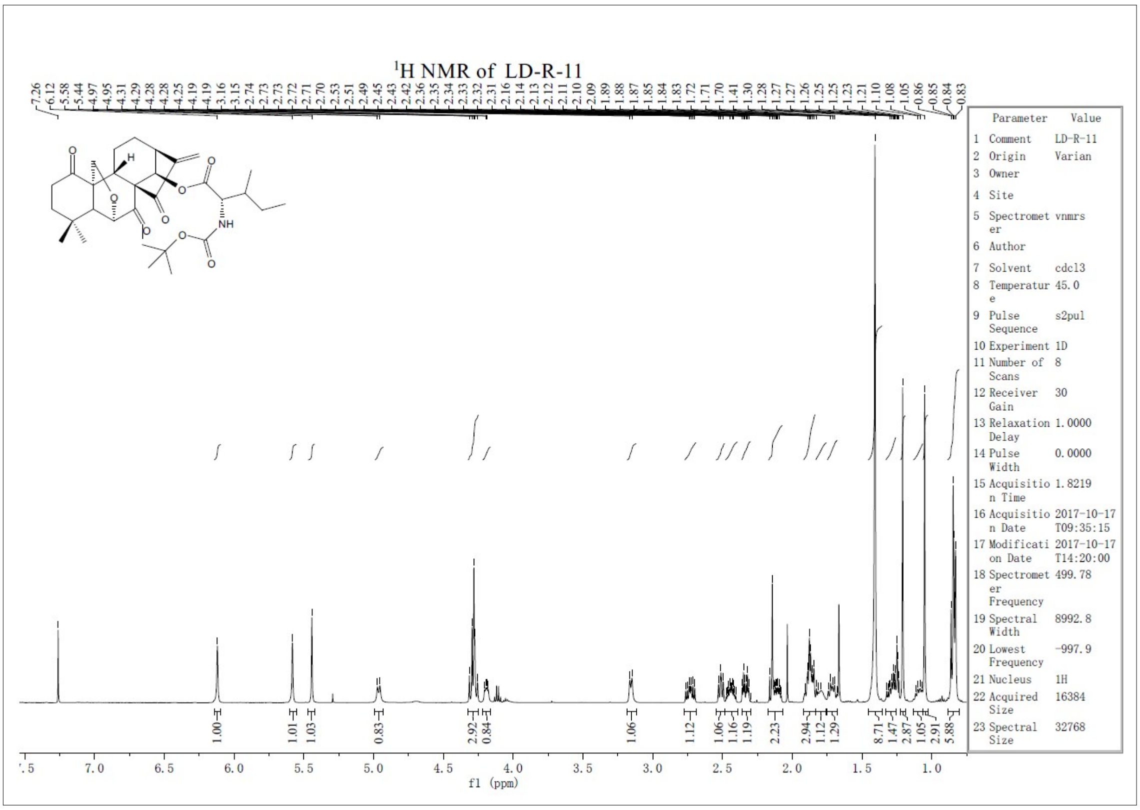
^{1}H NMR of **12g**



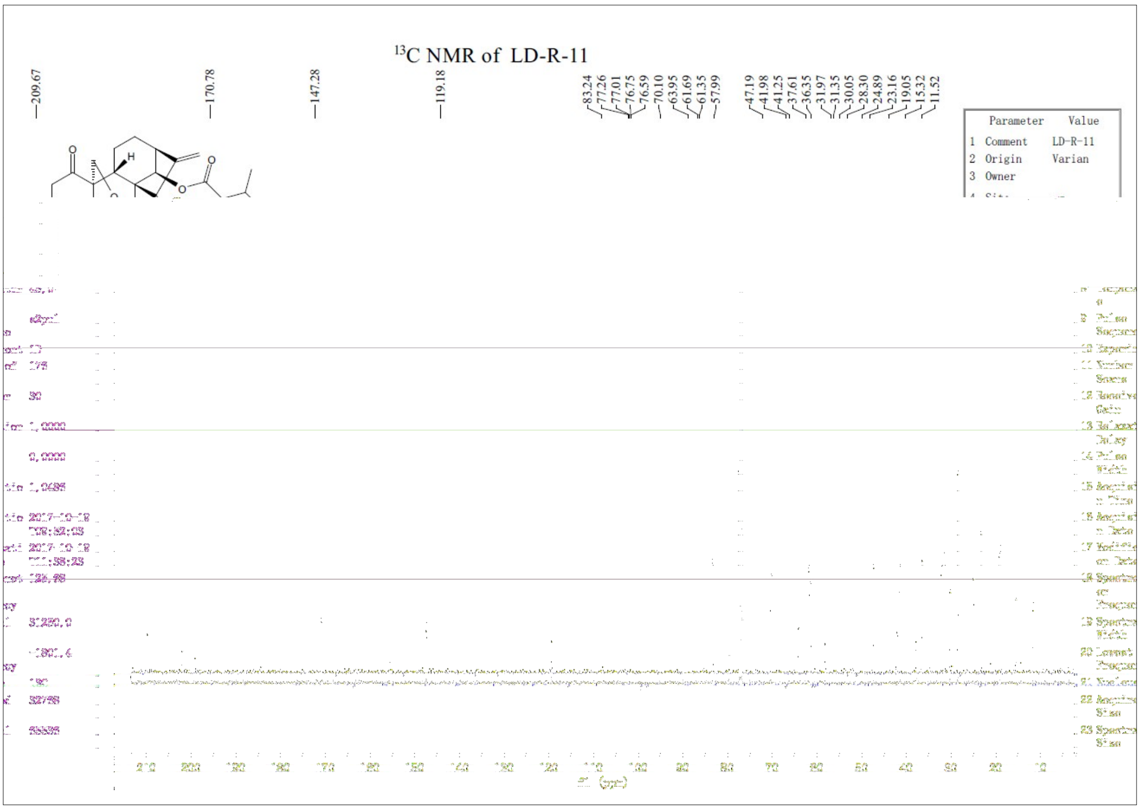
^{13}C NMR of **12g**



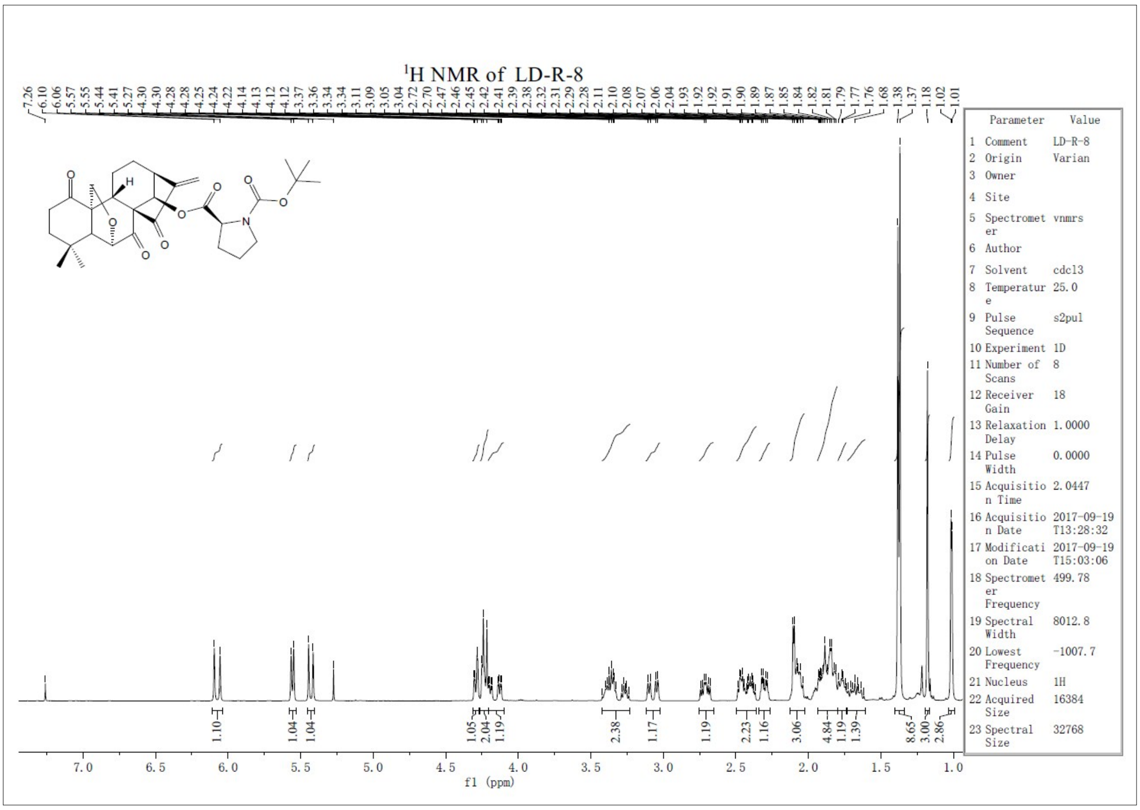
^{1}H NMR of **12h**



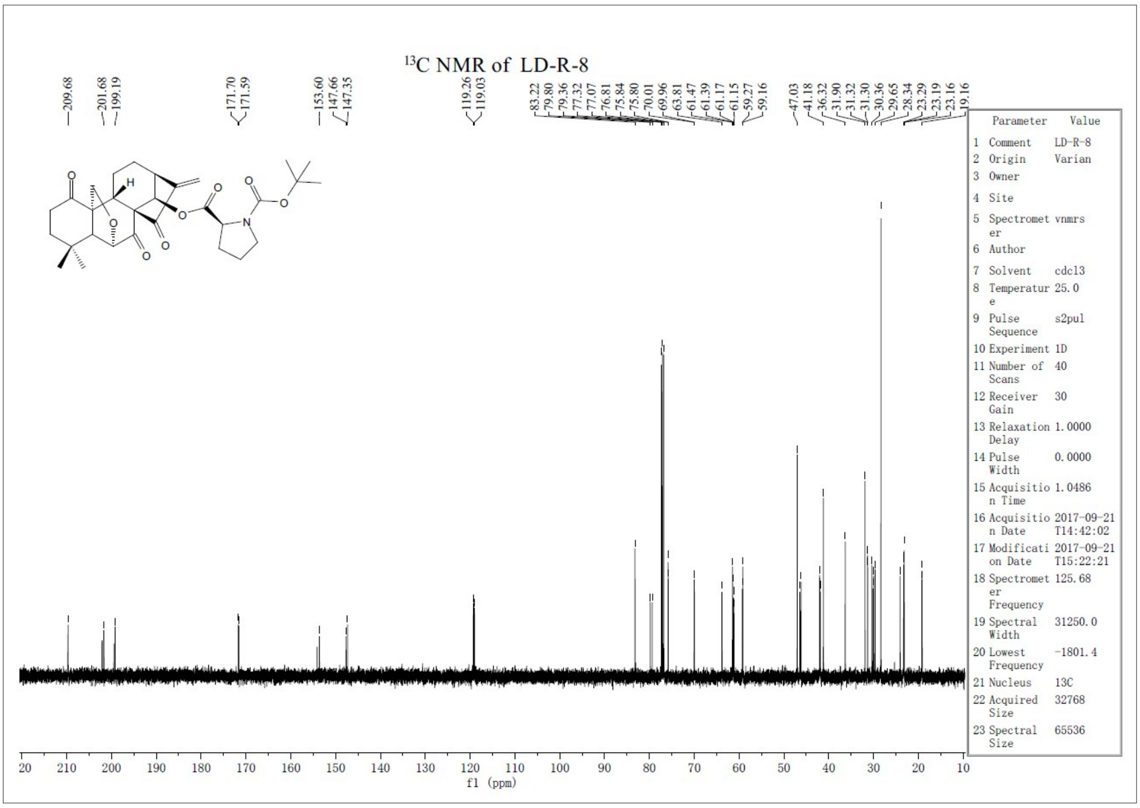
^{13}C NMR of **12h**



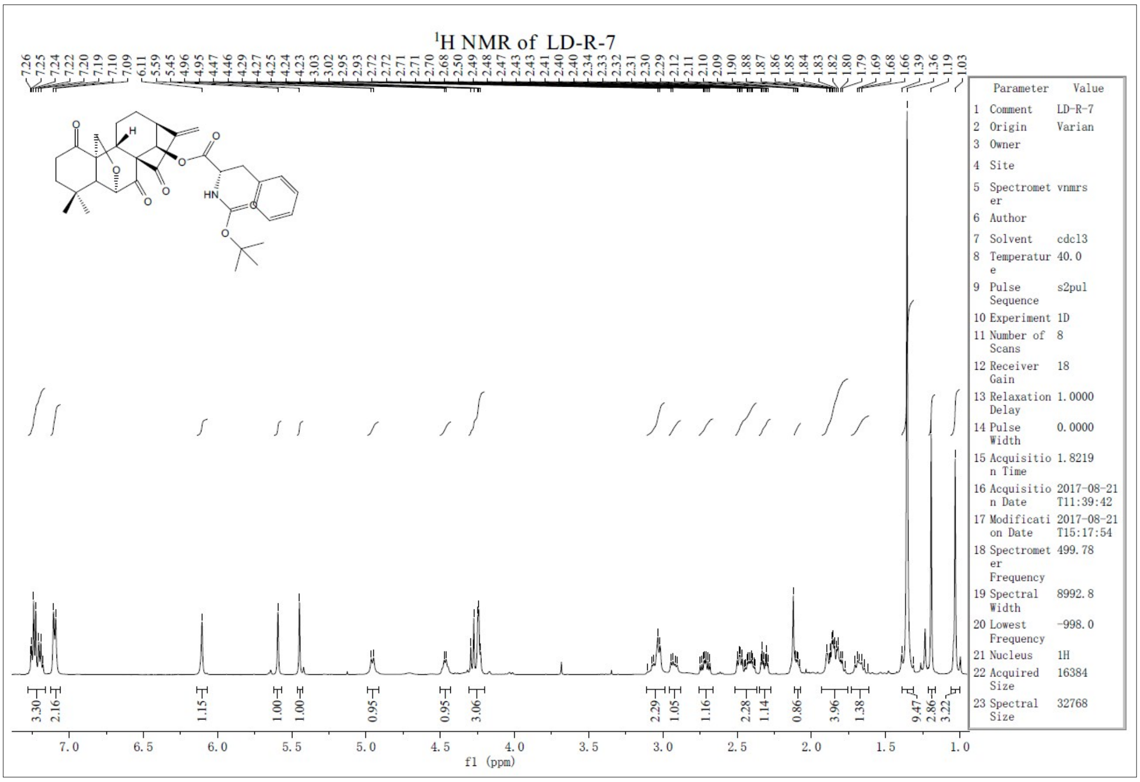
^{1}H NMR of **12i**



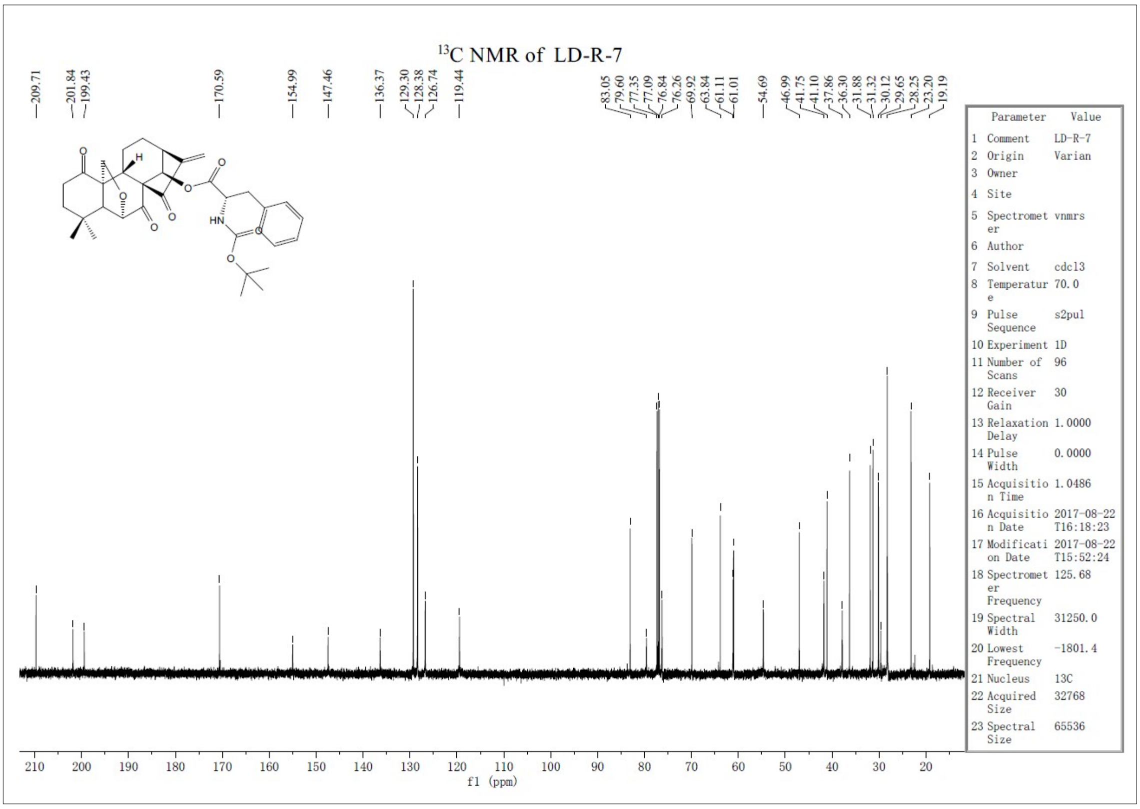
^{13}C NMR of **12i**



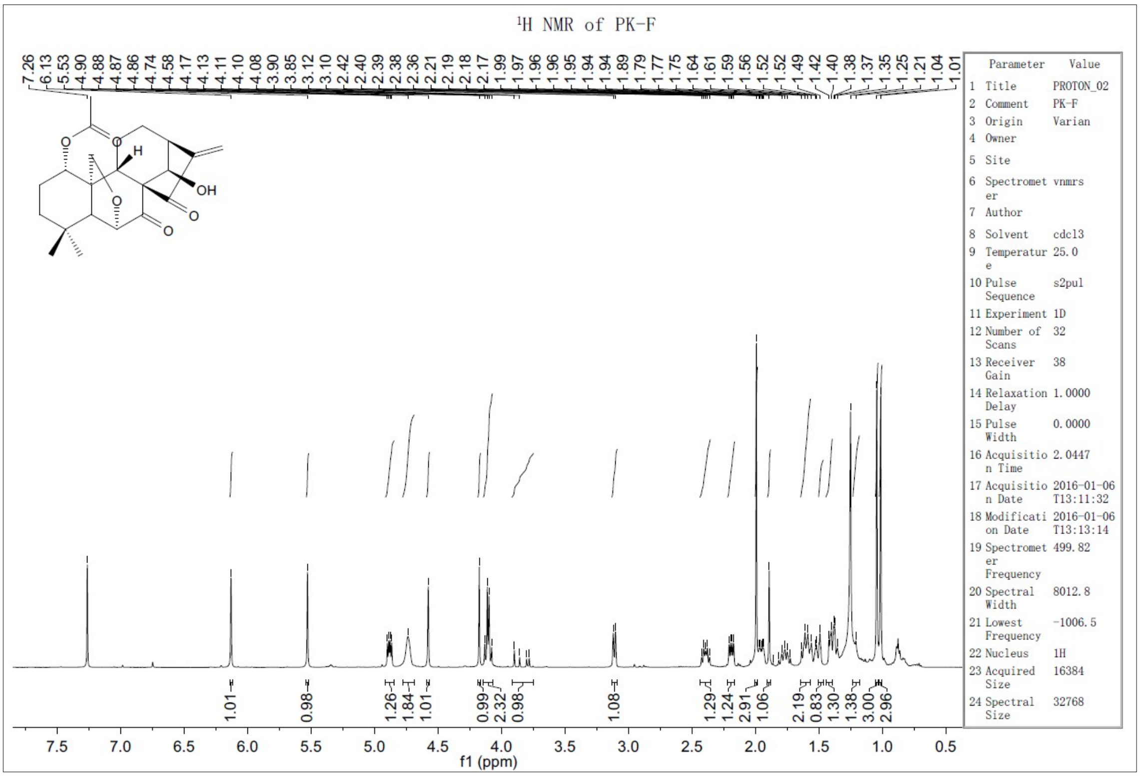
^{1}H NMR of **12j**



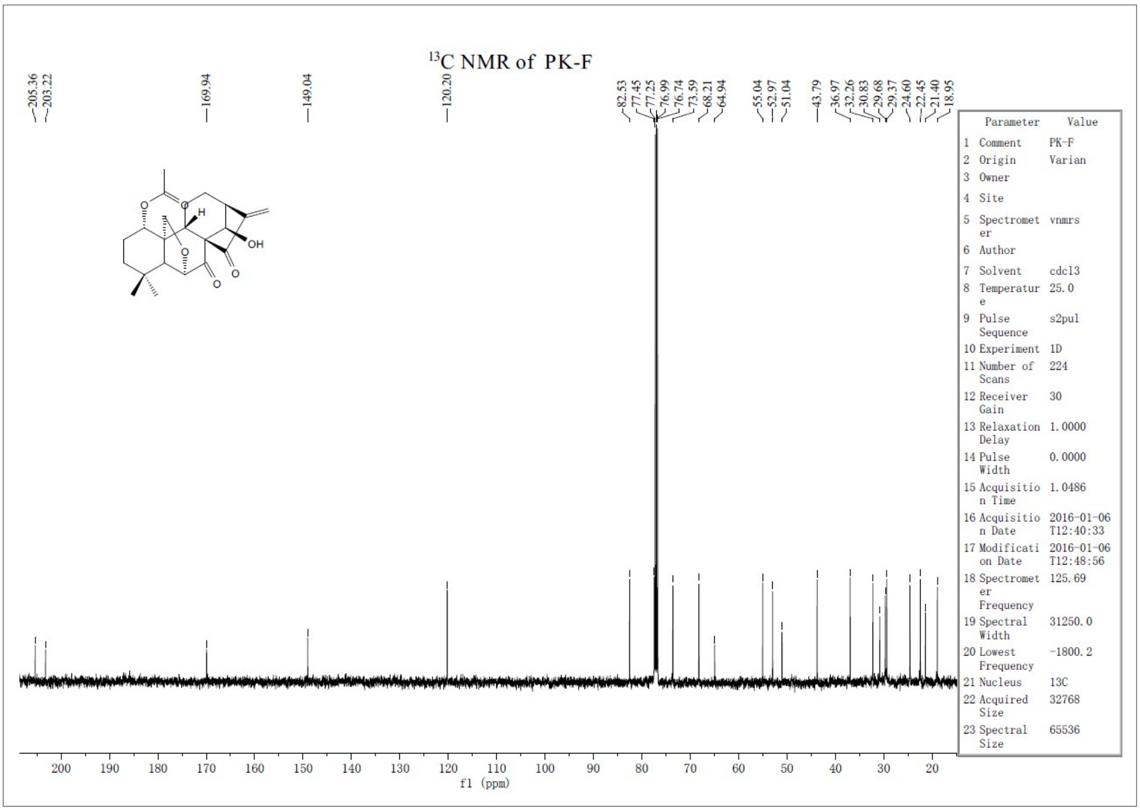
^{13}C NMR of **12j**



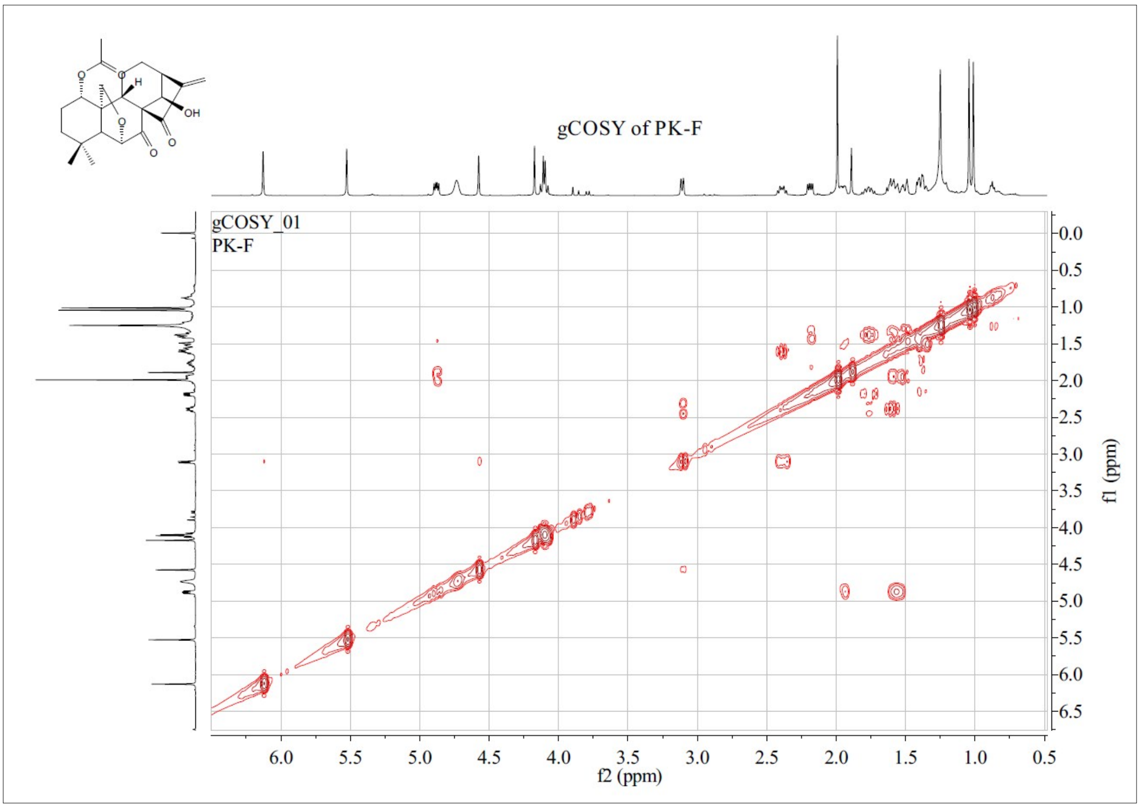
^{1}H NMR of **14**



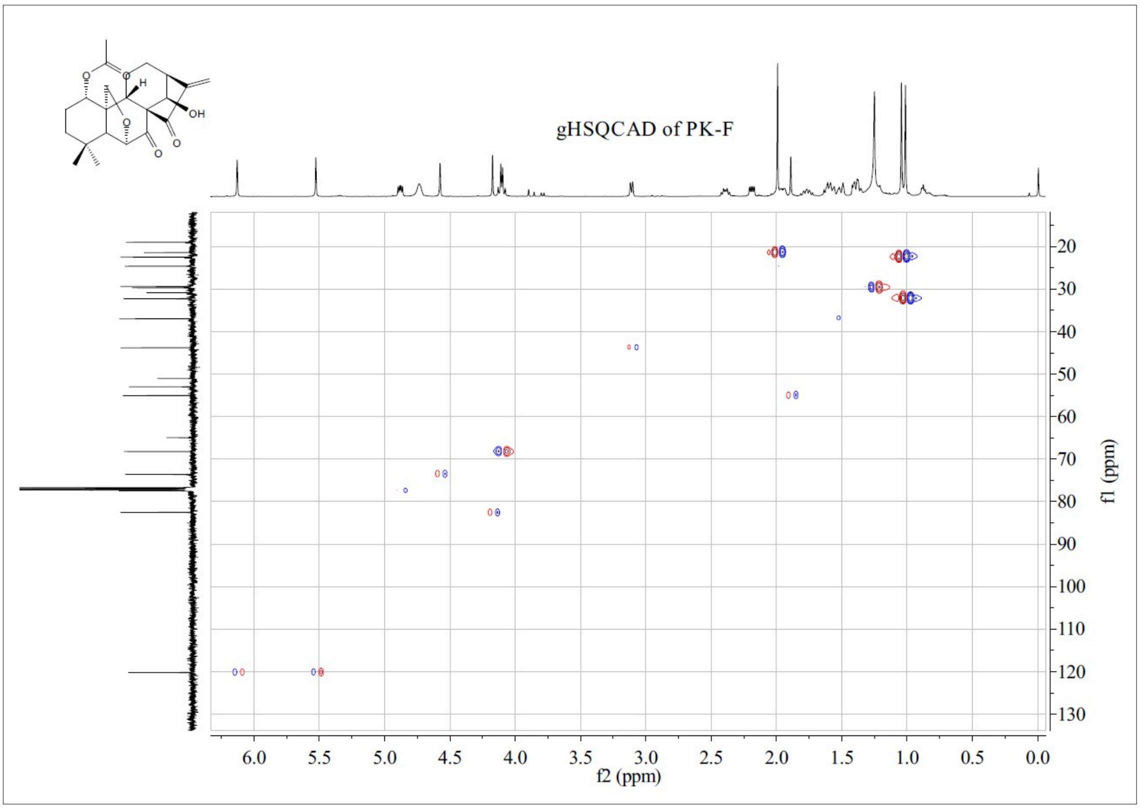
^{13}C NMR of **14**



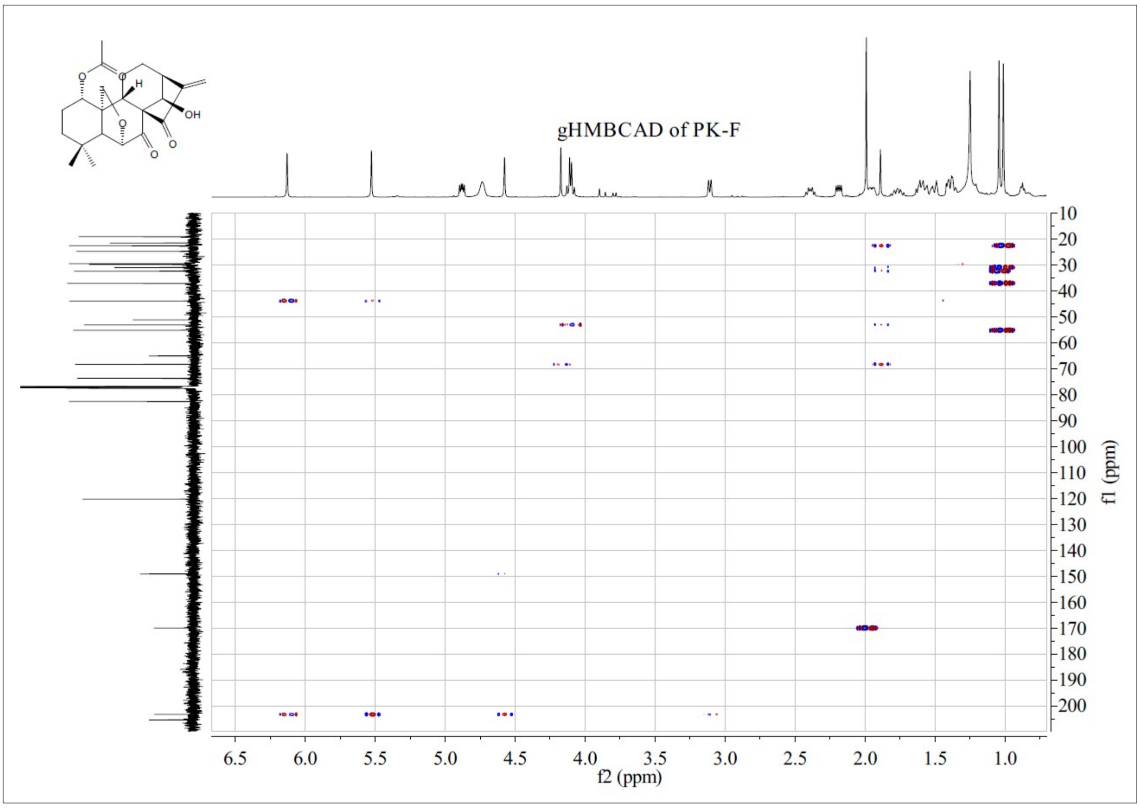
H-H COSY of **14**



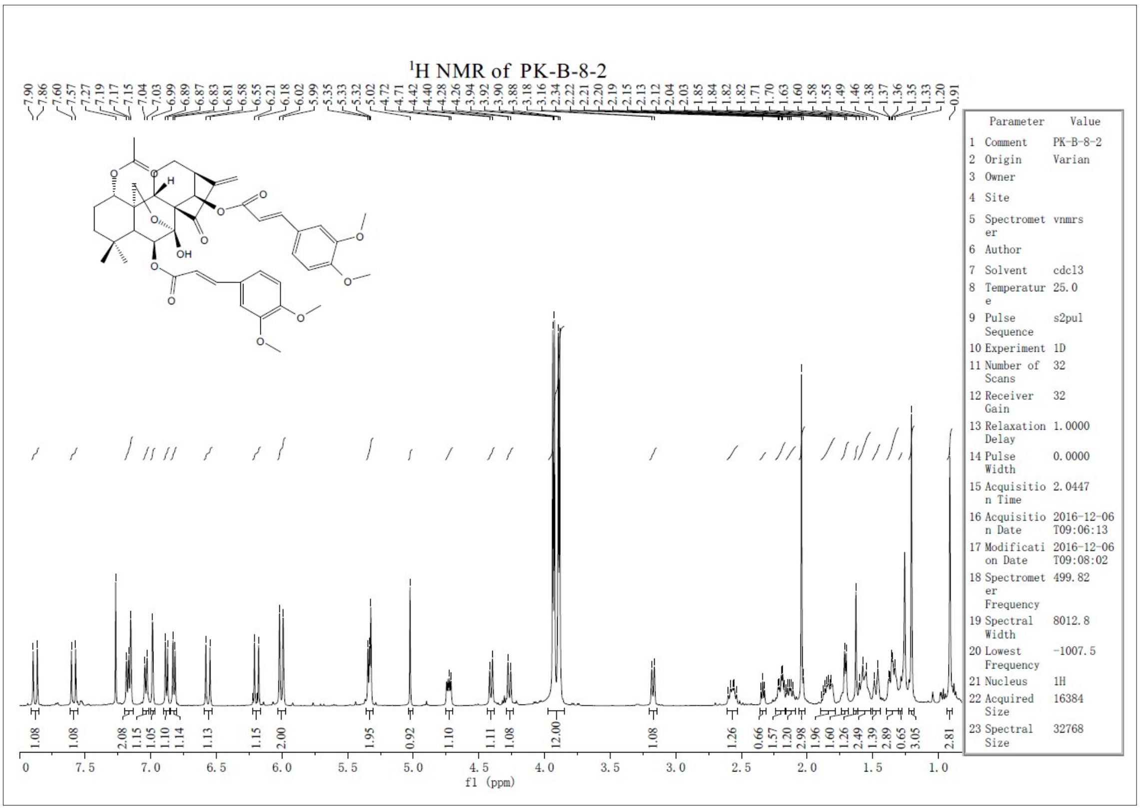
HSQC of **14**



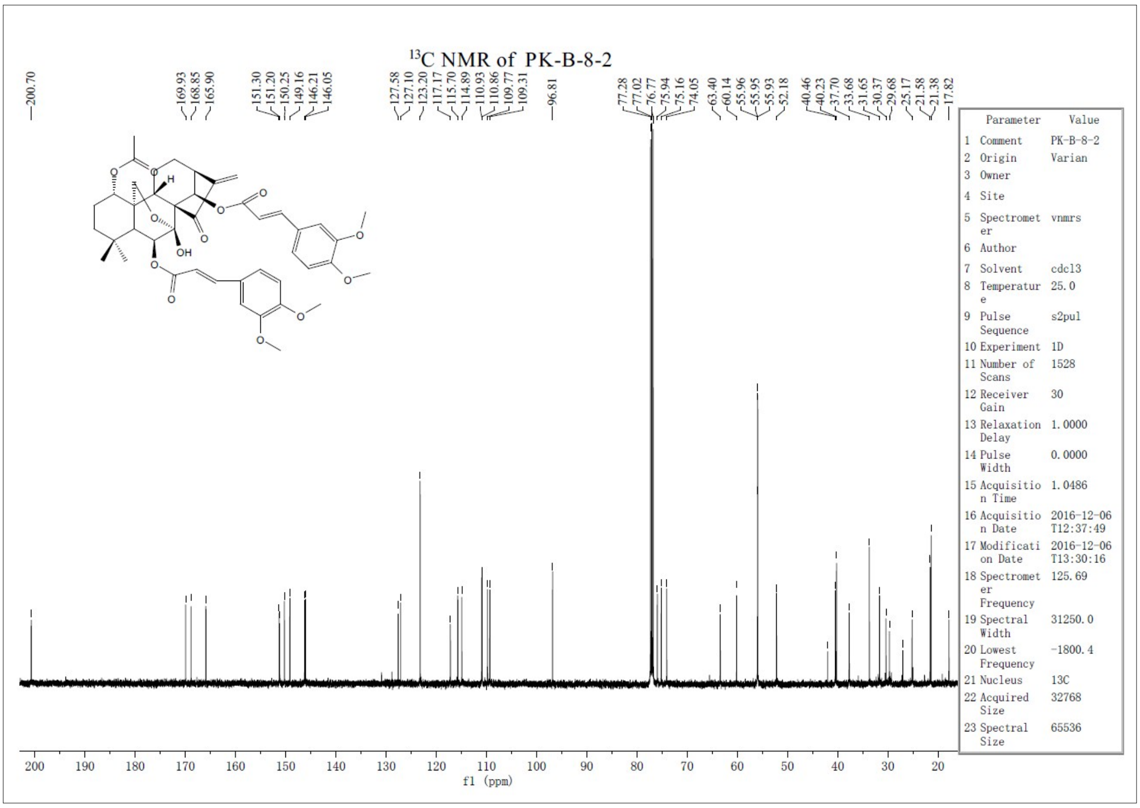
HMBC of **14**



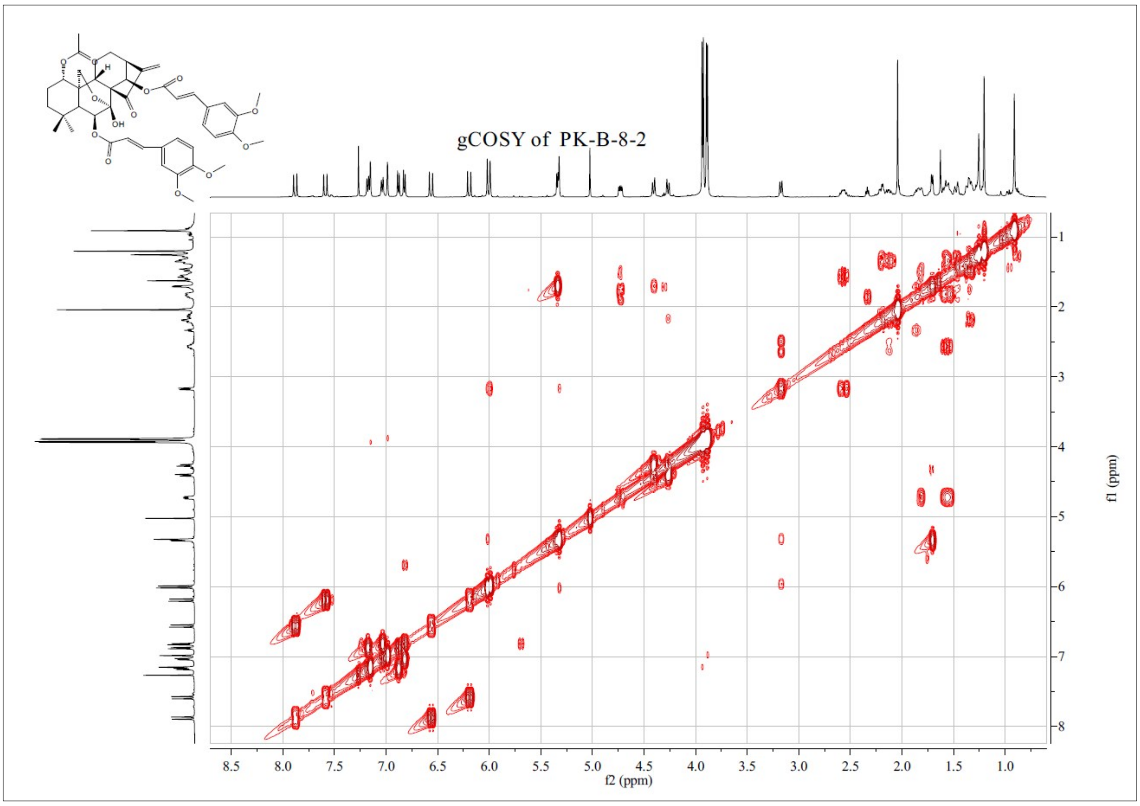
^{1}H NMR of **15**



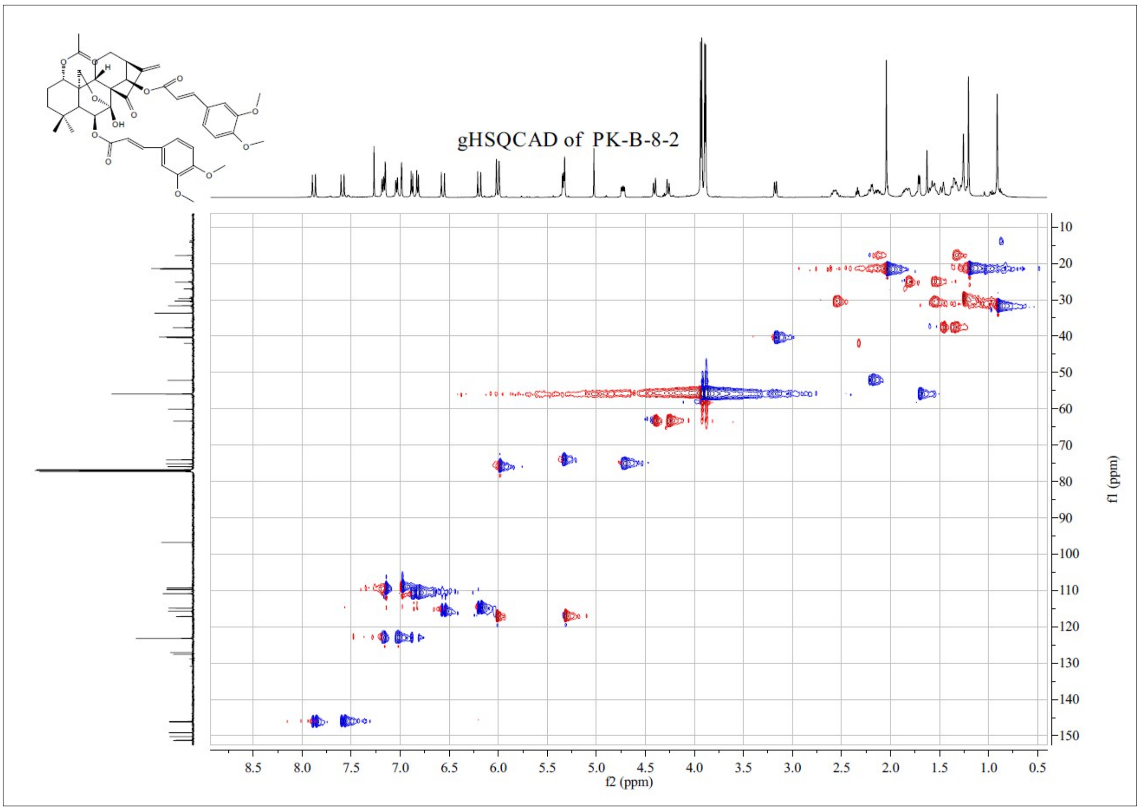
^{13}C NMR of **15**



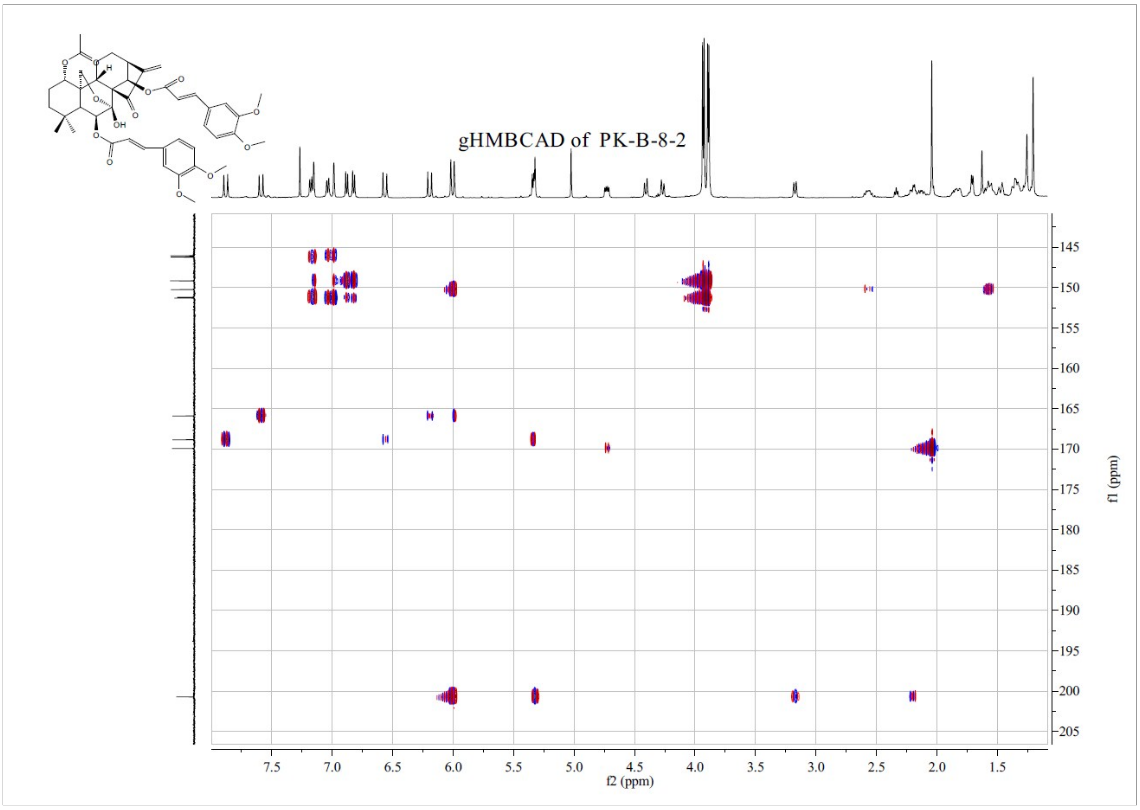
H-H COSY of **15**



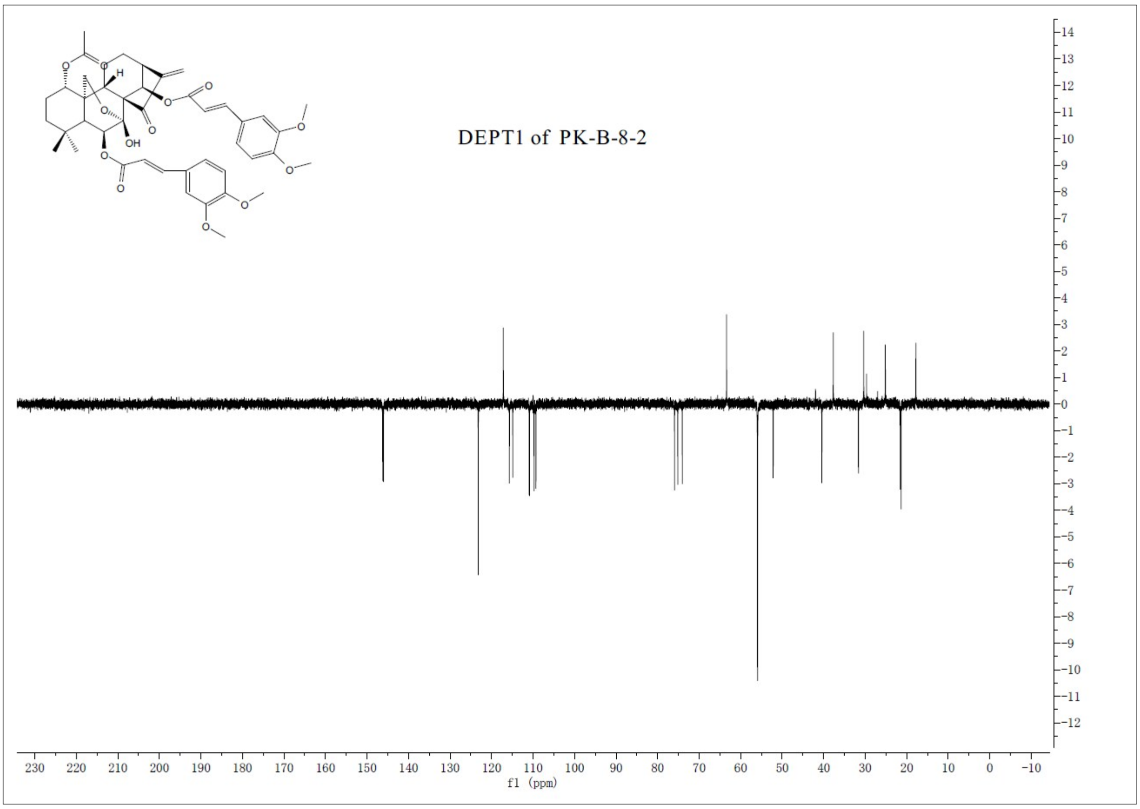
HSQC of **15**



HMBC of **15**



DEPT1 of **15**



DEPT2 of **15**