Supporting Information

Chrysomycin A Derivatives for the Treatment of Multi-Drug-Resistant Tuberculosis

Fan Wu[1†], Jing Zhang[1†], Fuhang Song[2†], Sanshan Wang[1], Hui Guo[2], Qi Wei[2], Huanqin Dai[2], Xiangyin Chen[3], Xuekui Xia[3,5], Xueting Liu[3], Lixin Zhang[2,3,5], Jin-Quan Yu[4] and Xiaoguang Lei[1]*

[1]Beijing National Laboratory for Molecular Sciences, Key Laboratory of Bioorganic Chemistry and Molecular Engineering of Ministry of Education, Department of Chemical Biology, College of Chemistry and Molecular Engineering, and Peking-Tsinghua Center for Life Sciences, Peking University, Beijing 100871, China

[2]CAS Key Laboratory of Pathogenic Microbiology & Immunology, Chinese Academy of Sciences, Institute of Microbiology, Beijing, 100101, China

[3]State Key Laboratory of Bioreactor Engineering, East China University of Science and Technology, Shanghai, 200237, China

[4]The Scripps Research Institute, 10550 North Torrey Pines Road, La Jolla, CA 92037, USA

[5]Key Biosensor Laboratory of Shandong Province, Biology Institute, Qilu University of Technology (Shandong Academy of Sciences), Jinan, 250013, China

[†]These authors contributed equally to this work.

*e-mail: xglei@pku.edu.cn

Table of Contents

I) General Information

^{1}H NMR spectra were recorded on Brucker ARX 400 MHz, DRX 500 MHz or AVANCE III HD 600 MHz, spectrometer at ambient temperature with $CDCl_3$, CD_3OD or DMSO-*d6* as the solvent unless otherwise stated. ^{13}C NMR spectra were recorded on Brucker ARX 100 MHz, DRX 125 MHz or AVANCE III HD 600 MHz spectrometer (with complete proton decoupling) at ambient temperature. Chemical shifts are reported in parts per million relative to chloroform, methanol or DMSO (^{1}H, δ 7.26 for $CDCl_3$, 3.31 for CD_3OD, 2.50 for DMSO-*d6*; ^{13}C, δ 77.00 for $CDCl_3$, 49.00 for 39.50 for CD_3OD, DMSO-*d6*). Data for ^{1}H NMR are reported as follows: chemical shift, integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet) and coupling constants. Infrared spectra were recorded on a Thermo Fisher FT-IR200 spectrophotometer. High-resolution mass spectra were obtained at Peking University Mass Spectrometry Laboratory using a Bruker APEX Flash chromatography. Optical rotations were recorded on an AUTOPOL III digital polarimeter at 589 nm and are recorded as $[\alpha]_D$ (concentration in grams/100 mL solvent). Analytical thin layer chromatography was performed using 0.25 mm silica gel 60-F plates. Flash chromatography was performed using 200-300 mesh silica gel. Yields refer to chromatographically and spectroscopically pure materials unless otherwise stated. Dichloromethane, dichloroethane, acetonitrile and dimethyl formamide were distilled from calcium hydride; tetrahydrofuran was distilled from sodium/benzophenone ketyl prior to use. Reagents were purchased at the highest commercial quality and used without further purification unless otherwise stated. All reactions were carried out in oven-dried glassware under an argon atmosphere with dry solvents unless otherwise noted. No unexpected or unusually high safety hazards were encountered.

II) Supplementary Tables and Schemes

Table S1. Minimum inhibitory concentrations (μg/mL) against *M.tb* strains

Species	Strain	1	2	26	71	55	10	8	(-)-64	(+)-64	68	41	46a
M. bovis	BCG	0.4	——	5	>10	>10	0.32	>10	0.32	0.08	>10	5	>10
M.tb	H37Rv	0.4	5	5	>10	>10	0.16	>10	0.16	0.08	>10	>10	>10
	Hr1	0.4	>10	5	>10	>10	0.16	>10	0.16	0.08	>10	>10	>10
M.tb	Hr2	0.4	2.5	5	>10	>10	0.16	>10	0.32	0.32	>10	>10	>10
Clinical	Hr3	0.4	5	5	>10	>10	0.16	>10	0.16	0.16	>10	>10	>10
isolates	Hr4	0.4	5	5	>10	>10	0.16	>10	0.16	0.16	>10	>10	>10
	Hr5	0.4	>10	5	>10	>10	0.16	>10	0.32	0.32	>10	>10	>10

Species	Strain	46b	40	39	36	37	38	51a	51b	31a	31b	32a	32b
M. bovis	BCG	>10	0.64	2.5	0.16	>10	>10	>10	>10	>10	>10	>10	>10
M.tb	H37Rv	>10	0.64	0.32	0.16	>10	>10	>10	>10	>10	>10	>10	>10
	Hr1	>10	0.32	0.16	0.16	>10	>10	>10	>10	>10	>10	>10	>10
M.tb	Hr2	>10	>10	0.16	0.16	>10	>10	>10	>10	>10	>10	>10	>10
Clinical	Hr3	>10	0.64	0.32	0.16	>10	>10	>10	>10	>10	>10	>10	>10
isolates	Hr4	>10	0.64	0.32	0.16	>10	>10	>10	>10	>10	>10	>10	>10
	Hr5	>10	0.64	0.32	0.16	>10	>10	>10	>10	>10	>10	>10	>10

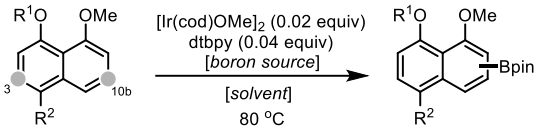
Species	Strain	70a	70b	ent-70a	ent-70b	20	50	45	30	24	35	rifampicin	bedaquiline
M. bovis	BCG	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	0.02	——
M.tb	H37Rv	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	0.02	0.04
	Hr1	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	1	0.04
M.tb	Hr2	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	2	0.08
Clinical	Hr3	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	0.5	0.08
isolates	Hr4	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	1	0.64
	Hr5	>10	>10	>10	>10	>10	>10	>10	>10	>10	>10	2	0.08

MIC colour scale (µg/mL)	>10	5	2.5	2	1	0.64	0.5	0.4	0.32	0.16	0.08	0.04	0.02

Table S2. Minimum inhibitory concentrations (μg/mL) against non-*tb* strains

Compound	Non-tb				
	M.chelonae	*M.abscessus*	*M.terrae*	*M.scrofulaceum*	*M.xenopi*
Chrysomycin A (**1**)	10	10	20	10	10
Chrysomycin B (**2**)	20	20	>20	>20	>20
C2-glycosyl isomer of chrysomycin A (**36**)	10	10	20	20	10
Defucogilvocarcin V (**26**)	>20	>20	>20	>20	>20

Table S3. Optimization of the C–H borylation reaction

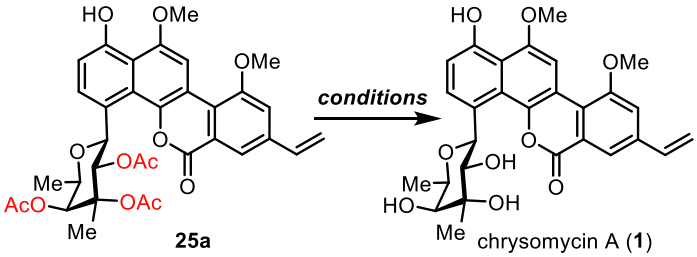


R^1 = *i*-Pr, R^2 = Br: **15**
R^1 = *i*-Pr, R^2 = H: **15a**
R^1 = Ac, R^2 = H: **15b**

entry	substrate	boron source (equiv)	solvent	regioselectivity (C3/C10b/bis)	yield (%)
1	**15**	B_2pin_2 (0.55)	THF	---	0
2	**15**	HBpin (2.5)	THF	0/100/0	4
3	**15**	HBpin (2.5)	hexane	0/100/0	76, 87 brsm[a]
4	**15a**	HBpin (1.1)	hexane	44/44/12[b]	< 50[b]
5	**15b**	HBpin (1.1)	hexane	59/35/6[b]	< 15[b]

[a]Reaction run on 1.6 g scale. [b]Determined by ^{1}H-NMR and LC-MS of the crude reaction mixture.

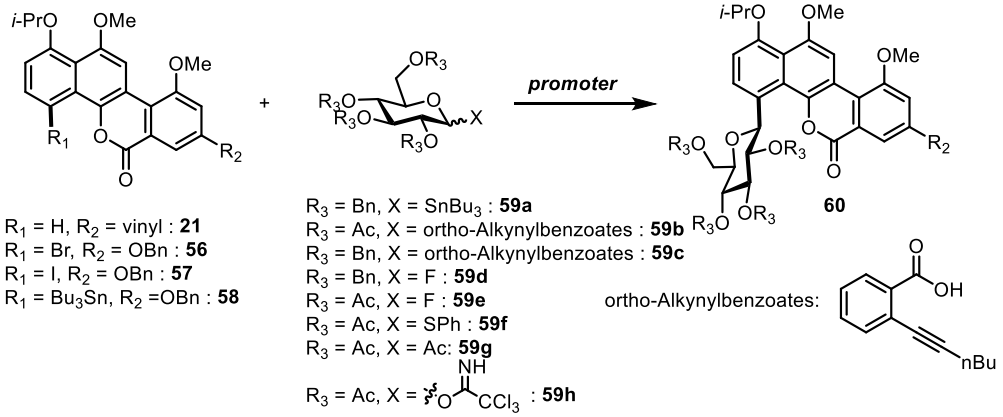
Table S4. Screening of conditions for the deacetylation of **25a**



entry	conditions	result
1	K_2CO_3, MeOH, r.t.	complex, no **1**
2	NaCN, MeOH, r.t.	complex, no **1**
3	NaOMe, MeOH, r.t.	complex, **1** (trace)
4	$La(OTf)_3$, NaOMe, MeOH, r.t. to 50 °C	complex, no **1**
5	NH_3, MeOH, r.t.	decomposition
6	N_2H_4•H_2O, EtOH, 44 °C to 60 °C	NR
7	N_2H_4•H_2O, Pyr/AcOH (4/1), r.t.	NR
8[a]	3 M H_2SO_4 (aq)/MeOH (1/1), 80~85 °C	**1**/**25a** = 1/2.3[b]
9[a]	12 M HCl (aq) / 3 M H_2SO_4 (aq) / MeOH (0.1/1/1), 80~85 °C	**1** (trace)
10[a]	3 M H_2SO_4 (aq) / MeOH (1/1), 100 °C	**1** (trace)
11[a]	**1.5 M H_2SO_4 in MeOH, 70 °C**	**1 (65%[c])**

[a] Reaction run in a sealed tube. [b] Ratio determined by ^{1}H-NMR of the crude reaction mixture. [c] Isolated yield.

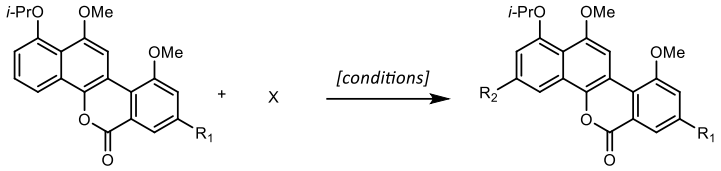
Table S5. Attempts of the *C*-glycosylation reaction



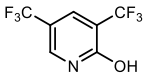
entry[a]	A/D	promoter	additive	T (°C)	solution	result
1[a]	**56**/**59a**	$Pd_2(dba)_3$	CuCl	110	Dioxane	N.R.
2[a]	**56**/**59a**	$Pd_2(dba)_3$	CuI	110	Dioxane	N.R.
3[a]	**57**/**59a**	$Pd_2(dba)_3$	CuCl	110	Dioxane	N.R.
4[a]	**57**/**59a**	$Pd_2(dba)_3$	CuI	110	Dioxane	N.R.
5[b]	**21**/**59b**	$Ph_3PAuNTf_2$	4 Å MS	25	DCM	N.R.
6[b]	**21**/**59c**	$Ph_3PAuNTf_2$	4 Å MS	25	DCM	N.R.
7[c]	**58**/**59d**	$BF_3 \bullet Et_2O$	-	25	DCM	N.R
8[c]	**58**/**59d**	TMSOTf	-	25	DCM	N.R
9[c]	**58**/**59e**	$BF_3 \bullet Et_2O$	-	25	DCM	N.R
10[c]	**58**/**59e**	TMSOTf	-	25	DCM	N.R
11[d]	**21**/**59f**	AgOTf, NIS	4 Å MS	0	DCM	N.R
12[e]	**21**/**59g**	$SnCl_4$	4 Å MS	25	DCE	N.R.
13[f]	**21**/**59g**	$SnCl_4$, AgOTfa	4 Å MS	25	DCE	N.R.
14[e]	**21**/**59h**	$SnCl_4$	4 Å MS	25	DCE	N.R.

[a]Conditions: **56** (1.0 equiv), **59a** (2.0 equiv), Jackiephos (0.2 equiv), $Pd_2(dba)_3$(0.05 equiv), CuI((3.0 equiv),KF (2.0 equiv), 110 °C, 58h. [b]Conditions: **57** (1.25 equiv), **59b** (1.0 equiv), 4 Å MS (20 wt), $Ph_3PAuNTf_2$ (0.02 equiv), 25 °C, 2h [c]Conditions: **58** (2.0 equiv), glycol donor (1.0 equiv), promoter (2.0 equiv), 4 Å MS (30 wt), 25 °C, 2h. [d]Conditions: **21** (1.0 equiv), **59g** (1.5 equiv), AgOTf (0.11 equiv), NIS (1.33 equiv) 4 Å MS (20 wt), 0 °C, 30 min. [e]Conditions: **21** (3.0 equiv), **59g** (1.0 equiv), $SnCl_4$ (3.0 equiv), 4 Å MS (20 wt), 25 °C, 32 h. [f]Conditions: **21** (3.0 equiv), **59g** (1.0 equiv), $SnCl_4$ (3.0 equiv), AgOTfa (1.5 equiv), 4 Å MS (20 wt), 25 °C, 32 h.

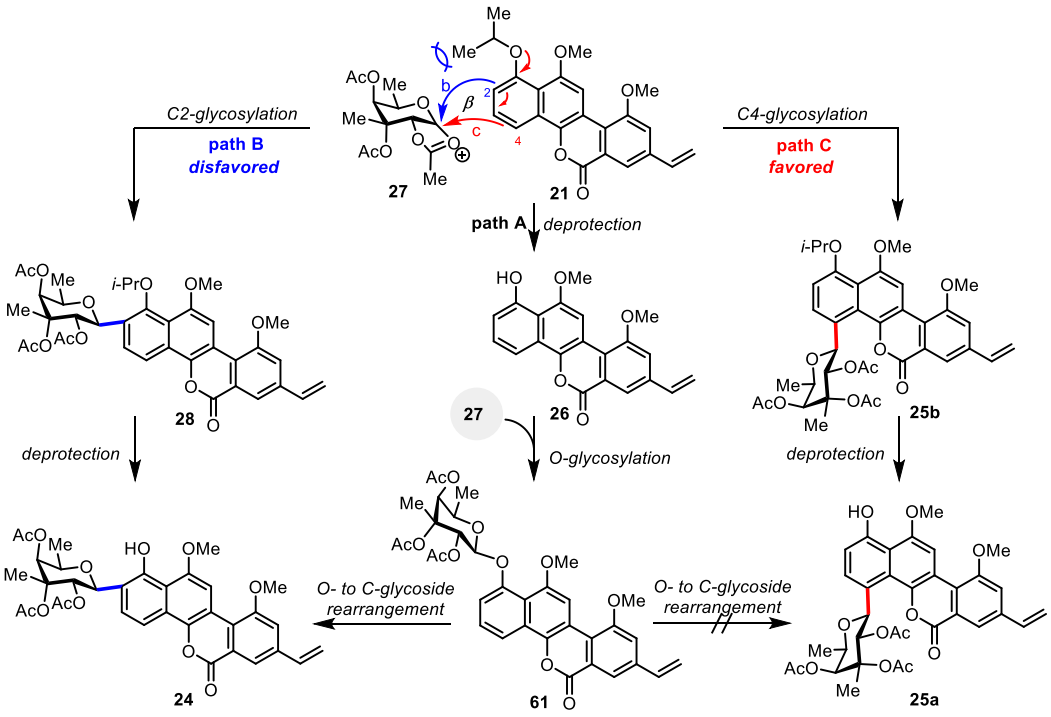
Table S6. Attempts of the *meta* functionalization



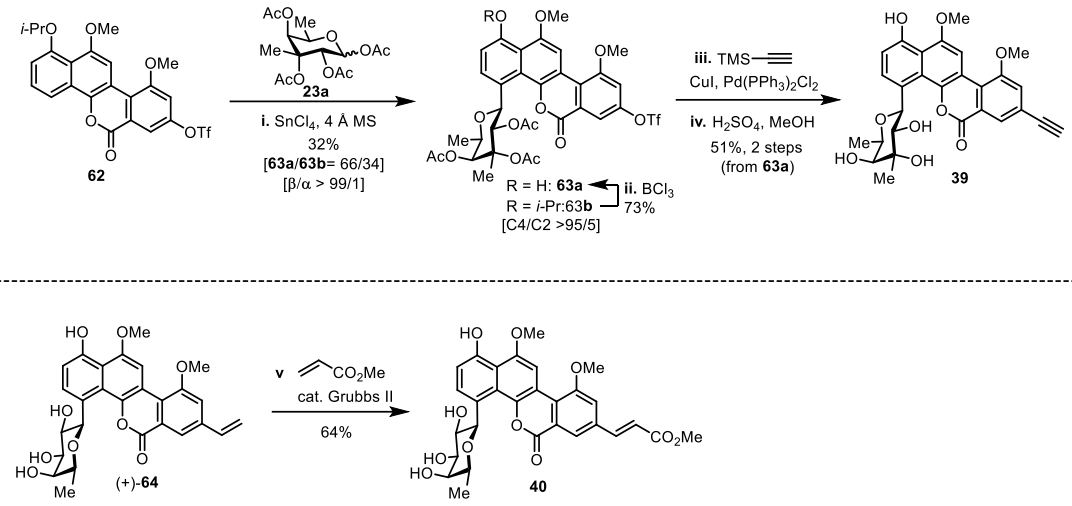
entry	R_1	R_2	X	conditions	result
1	OBn	COO*n*-Bu	COO*n*-Bu	V_2O_5, PCy_3, $Rh_2(OAc)_4$,$Cu(TFA)_2$, 5A Ms, 140°C,24h	N.R.[a]
2		COO*n*-Bu	COO*n*-Bu	V_2O_5, PCy_3, $Rh_2(OAc)_4$,$Cu(TFA)_2$, 5A Ms, 140°C,24h	N.R.[a]
3	OBn	COOEt	COOEt	$Pd(OAc)_2$, AgOAc, Ligand,$CHCl_3$,80°C, 24h	N.R.
4	OBn	COOEt	COOEt	$Pd(OAc)_2$, AgOAc, Ligand,HFIP,80°C, 24h	N.D.
5	OBn	BPin	HBPin	$[Ir(cod)OMe]_2$, dtbpy, n-hexane, 80°C, 60h	N.R.[a]
6	OBn	BPin	HBPin	$[Ir(cod)OMe]_2$, dtbpy, THF, 80°C, 60h	N.R.[a]
7		BPin	HBPin	$[Ir(cod)OMe]_2$, dtbpy, n-hexane, 80°C, 60h	N.D.[a]
8		BPin	HBPin	$[Ir(cod)OMe]_2$, dtbpy, THF, 80°C, 60h	N.D.[a]

[a] Reaction was operated in a glove-box, Ligand: 

Scheme S1. Proposed reaction pathways for the *C*-glycosylation reaction

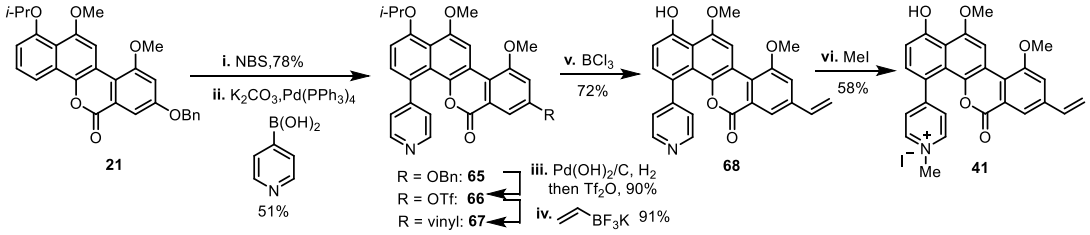


Scheme S2. Synthesis of C8 analogues.



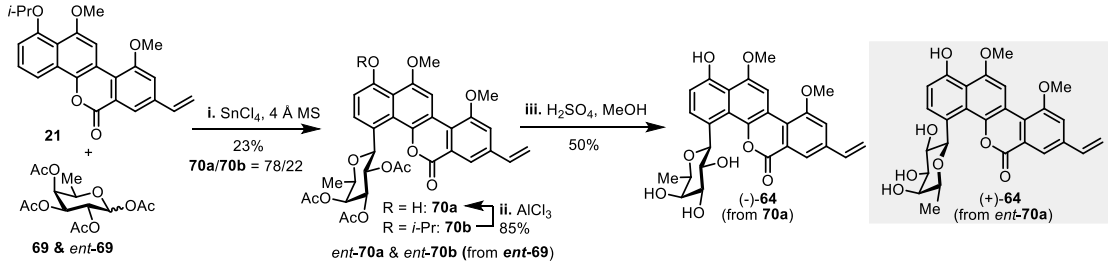
Reagents and conditions: (i) $SnCl_4$, 4 Å MS, DCE, r.t. (ii) $BlCl_3$, CH_2Cl_2, 0 °C. (iii) Trimethylsilylacetylene, CuI, $Pd(PPh_3)_2Cl_2$, Et_3N, DMF, r.t.(iv) 1.5 M H_2SO_4 in MeOH, 70 °C. (v) Methyl acrylate, cat. Grubbs II, CH_2Cl_2, reflux.

Scheme S3. Synthesis of C4 pyridinium analogues.



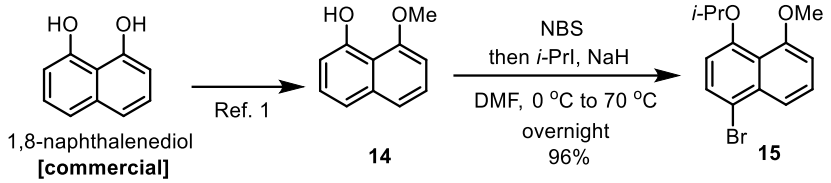
Reagents and conditions: (i) NBS, DMF, r.t. (ii) $Pd(PPh_3)_4$, K_2CO_3, Pyridine-4-boronic acid, DMF, r.t. (iii)$Pd(OH)_2/C,H_2$, MeOH, r.t.; Tf_2O, Et_3N, CH_2Cl_2, -78°C. (iv)Potassium vinyltrifluoroborate, $[Pd(dppf)Cl_2]\cdot CH_2Cl_2$, Et_3N, *n*-PrOH, reflux.(v) BCl_3, CH_2Cl_2, 0°C.(vi) MeI, CH_3CN, 80°C.

Scheme S4. Synthesis of C4 analogues using direct C-glcosylation



Reagents and conditions: (i) $SnCl_4$, 4 Å MS, DCE, r.t. (ii) $AlCl_3$, CH_2Cl_2, 0 °C. (iii) 1.5 M H_2SO_4 in MeOH, 70 °C.

III) Detailed Experimental Procedures



Compound 15. NBS (21.85 g, 120.3 mmol) was added to a solution of **14** (20.96 g, 120.3 mmol) in 400 mL DMF at r.t. The reaction was stirred at r.t. for 1h. Then sodium hydride (60% dispersion in mineral oil, 8.67 g, 216.5 mmol) was added carefully at 0 ^{o}C. After stirring for 30 min, isopropyl iodide (24.5 mL, 240.6 mmol) was added and the reaction mixture was heated at 70 ^{o}C overnight. The reaction was cooled to r.t. and then poured into ice-cold water (1000 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by silica gel column chromatography (PE/EtOAc = 97/3) to afford compound **15** (34.09 g, 96%) as a white solid.

Mp 66-68 ^{o}C;

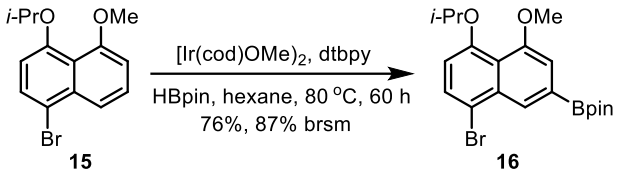
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (d, *J* = 8.3 Hz, 1H), 7.66 (d, *J* = 8.3 Hz, 1H), 7.46 (t, *J* = 8.2 Hz, 1H), 6.90 (d, *J* = 7.8 Hz, 1H), 6.79 (d, *J* = 8.3 Hz, 1H), 4.53 (hept, *J* = 6.1 Hz, 1H), 3.95 (s, 3H), 1.40 (d, *J* = 6.1 Hz, 6H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 157.3, 154.9, 135.0, 130.3, 127.5, 120.6, 120.2, 114.3, 112.9, 107.3, 73.2, 56.5, 22.0;

IR (neat) ν_{max} 2977, 2930, 1609, 1578, 1455, 1272, 1091 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{14}H_{16}BrO_2$: 295.0328, found: 295.0326;

TLC: R_f = 0.62 (PE/EtOAc = 9/1).



Compound 16. To a reaction flask charged with a stir bar were added $[Ir(cod)OMe]_2$ (887.0 mg, 1.34 mmol) and 4,4'-di-*tert*-butyl-2,2'-dipyridyl (734.0 mg, 2.68 mmol) in the glove box. Then the flask was sealed and taken out of the glove box. **15** (24.70 g, 83.67 mmol). Hexane (330 mL) and pinacolborane (31.3 mL, 184.1 mmol) were added sequentially to the reaction mixture at r.t. under argon. The resulting reaction mixture was heated to 80 °C and stirred at this temperature for 60 h. Then it was cooled to r.t. and directly loaded on a silica gel column. Flash chromatography (PE/EtOAc = 97/3) provided boronate ester **16** (26.78 g, 76%, 87% based on recovered starting material) and **15** (3.12 g) each as a white foam.

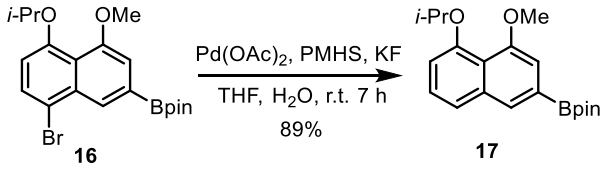
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.30 (s, 1H), 7.65 (d, *J* = 8.3 Hz, 1H), 7.23 (s, 1H), 6.83 (d, *J* = 8.3 Hz, 1H), 4.49 (hept, *J* = 6.1 Hz, 1H), 3.99 (s, 3H), 1.40-1.37 (m, 18H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 156.4, 154.8, 134.5, 130.2, 128.1, 122.3, 115.4, 114.7, 111.3, 84.1, 73.6, 56.5, 24.9, 22.0;

IR (neat) ν_{max} 2976, 2930, 1588, 1562, 1449, 1364, 1256, 1110 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{20}H_{27}BBrO_4$: 421.1184, found: 421.1184;

TLC: R_f = 0.48 (PE/EtOAc = 9/1).



Boronate 17. A round bottom flask charged with **16** (27.50 g, 65.3 mmol), $Pd(OAc)_2$ (777.0 mg, 3.27 mmol) and anhydrous THF (323 mL) was flushed with argon. While being flushed, KF (7.67 g, 130.6 mmol) in 130 mL of degassed water was added by syringe. A balloon filled with argon was attached to the flask. Polymethylhydrosiloxane (15.65 mL, 261.2 mmol) was then added to the reaction mixture dropwise. The reaction was stirred at r.t. for 7 h and then diluted with Et_2O (500 mL). The layers were separated

and the ether layer as filtered through a short pad of Celite with EtOAc as the eluent. The filtrate was concentrated *in vacuo* and then purified by silica gel column chromatography (PE to PE/EtOAc = 95/5) to afford boronate **17** (19.89 g, 89%) as a white foam.

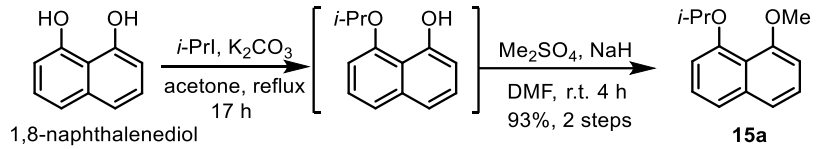
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (s, 1H), 7.49 (d, *J* = 7.6 Hz, 1H), 7.34 (t, *J* = 7.6 Hz, 1H), 7.16 (s, 1H), 6.99 (d, *J* = 7.6 Hz, 1H), 4.52 (hept, *J* = 6.1 Hz, 1H), 4.00 (s, 3H), 1.41-1.37 (m, 18H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 156.2, 154.7, 137.0, 129.4, 126.1, 122.7, 121.2, 115.1, 110.1, 83.9, 73.5, 56.3, 24.9, 22.1;

IR (neat) ν_{max} 2976, 2930, 1594, 1572, 1460, 1371, 1264, 1107 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{20}H_{28}BO_4$: 343.2079, found: 343.2080;

TLC: R_f = 0.48 (PE/EtOAc = 9/1).



1-Isopropoxy-8-methoxynaphthalene 15a. A mixture of 1,8-naphthalenediol (1.0 g, 6.06 mmol) and K_2CO_3 (0.94 g, 6.72 mmol) in 25 mL of acetone was treated with 2-iodopropane (0.9 mL, 9.08 mmol) at r.t. The reaction mixture was heated at reflux for 17 h and cooled to r.t. It was filtered and washed with EtOAc. The filtrate was concentrated *in vacuo* to afford a crude oil, which was redissolved in 25 mL of DMF. To the solution was added portion wise NaH (60% dispersion in mineral oil, 0.33 g, 8.18 mmol) followed by dimethyl sulfate (0.77 mL, 8.18 mmol). The reaction mixture was stirred at r.t. for 4 h and then quenched by careful addition of water (50 mL). The mixture was extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by silica gel column chromatography (PE/EtOAc = 98/2) to afford **15a** (1.22 g, 93% for two steps) as a white solid.

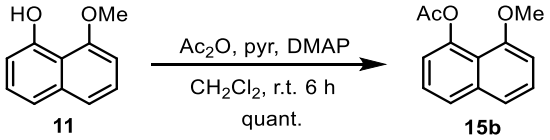
Mp 54-56 ^{o}C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.41 (dd, *J* = 8.3, 1.2 Hz, 1H), 7.38 – 7.32 (m, 2H), 6.95 (dd, *J* = 7.6, 1.2 Hz, 1H), 6.84 (dd, *J* = 7.6, 1.2 Hz, 1H), 4.56 (hept, *J* = 6.1 Hz, 1H), 3.96 (s, 3H), 1.43 (d, *J* = 6.1 Hz, 6H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 156.9, 154.8, 137.5, 126.2, 126.0, 121.6, 120.9, 119.5, 113.1, 106.4, 73.0, 56.3, 22.1;

HRMS (ESI) $[M + H]^+$ calculated for $C_{14}H_{17}O_2$: 217.1223, found: 217.1217;

TLC: R_f = 0.60 (PE/EtOAc = 9/1).

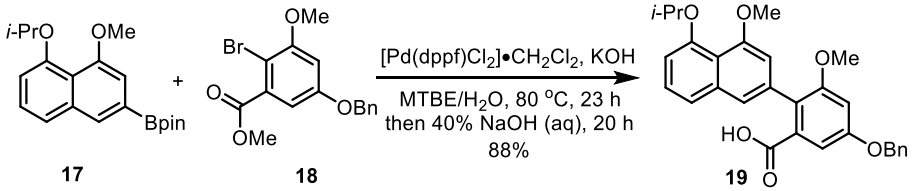


1-Acetoxy-8-methoxynaphthalene 15b. To a solution of **11**[1] (20.4 mg, 0.117 mmol) in 2.3 mL of CH_2Cl_2 were added pyridine (95 μL, 1.17 mmol), 4-dimethylaminopyridine (2.9 mg, 0.023 mmol) and acetic anhydride (55 μL, 0.586 mmol) sequentially. The reaction was stirred at r.t. for 6 h, followed by concentration *in vacuo*. The residue was dissolved in Et_2O (20 mL), and washed with water and brine. The organic phase was dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo* to give a crude oil, which was purified by silica gel column chromatography (PE/EtOAc = 9/1) to afford 1-acetoxy-8-methoxynaphthalene **15b**[1] (25.3 mg, quant.) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, *J* = 8.2 Hz, 1H), 7.49 – 7.36 (m, 3H), 7.08 (d, *J* = 7.4 Hz, 1H), 6.85 (d, *J* = 7.7 Hz, 1H), 3.93 (s, 3H), 2.39 (s, 3H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.3, 155.1, 146.4, 136.9, 126.4, 126.3, 126.0, 120.9, 119.2, 119.0, 106.0, 56.0, 21.0;

TLC: R_f = 0.34 (PE/EtOAc = 4/1).



Acid 19. To a mixture of **18** (17.56 g, 57.3 mmol) and **17** (13.86 g, 39.47 mmol) in methyl *tert*-butyl ether (292 mL) and water (31 mL) were added $[Pd(dppf)Cl_2]$ CH_2Cl_2 (0.99 g, 1.18 mmol) and KOH (13.10 g 197.4 mmol) sequentially under argon. The

1. Matsuzaka, H.; Hiroe, Y.; Iwasaki, M.; Ishii, Y.; Koyasu, Y.; Hidai, M. *J. Org. Chem.* **1988**, *53*, 3832.

mixture was heated to 80 °C and stirred at this temperature for 23 h, followed by addition of 40% NaOH aqueous solution (159 mL). The mixture was stirred for further 20 h. It was cooled to r.t. and acidified by 1 M HCl (aq). The mixture was extracted with EtOAc three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by silica gel column chromatography (PE/EtOAc = 85/15) to afford acid **19** (16.41 g, 88%) as a light yellow foam.

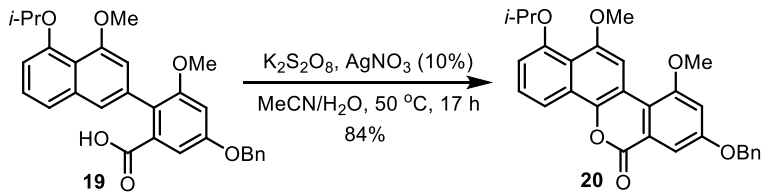
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48-7.27 (m, 7H), 7.24 (s, 1H), 7.08 (d, *J* = 2.2 Hz, 1H), 6.89 (d, *J* = 7.4 Hz, 1H), 6.76 (d, *J* = 2.2 Hz, 1H), 6.72 (s, 1H), 5.10 (s, 2H), 4.55 (hept, *J* = 6.1 Hz, 1H), 3.87 (s, 3H), 3.67 (s, 3H), 1.41 (d, *J* = 6.0 Hz, 6H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 172.5, 158.8, 158.3, 156.2, 154.7, 137.2, 136.4, 134.1, 132.3, 128.6, 128.2, 127.7, 126.0, 124.7, 121.9, 121.9, 118.6, 112.8, 109.5, 106.1, 103.5, 72.9, 70.4, 56.4, 56.0, 22.1;

IR (neat) ν_{max} 2974, 2933, 1696, 1600, 1573, 1378, 1208 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{29}H_{29}O_6$: 473.1959, found: 473.1964;

TLC: R_f = 0.22 (PE/EtOAc = 4/1).



Lactone 20. To a reaction flask charged with acid **19** (10.40 g, 22.01 mmol), potassium persulfate (17.94 g, 66.03 mmol) and silver nitrate (374.0 mg, 2.20 mmol) were added acetonitrile (494 mL) and water (494 mL) at r.t. under air. The reaction mixture was heated under magnetic stirring at 50 °C for 17 h. It was cooled to r.t. and quenched with saturated aqueous $NaHCO_3$ (1000 mL). The mixture was extracted with CH_2Cl_2 three times and the combined organic layers were dried over anhydrous Na_2SO_4. After filtration and concentration, the residue was purified by flash chromatography on silica gel (PE/EtOAc/CH_2Cl_2 = 7/2/1) to afford lactone **20** (8.70 g, 84%) as a yellow solid.

Mp 164-166 °C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.37 (s, 1H), 8.24 (dd, *J* = 8.5, 0.8 Hz, 1H), 7.70 (d, *J* =

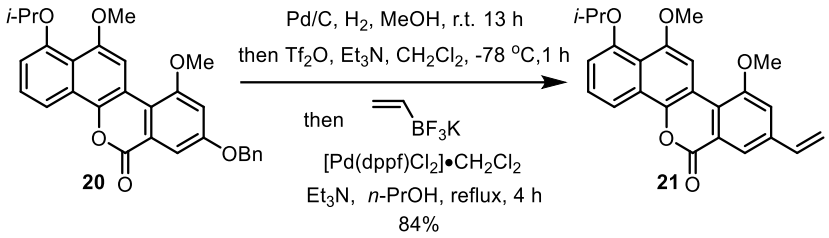
2.5 Hz, 1H), 7.53-7.34 (m, 6H), 7.06 (d, *J* = 7.3 Hz, 1H), 7.01 (d, *J* = 2.5 Hz, 1H), 5.21 (s, 2H), 4.60 (hept, *J* = 6.1 Hz, 1H, 1H), 4.06 (s, 3H), 4.01 (s, 3H), 1.44 (d, *J* = 6.1 Hz, 6H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 161.4, 159.3, 158.7, 154.5, 152.8, 140.0, 136.0, 128.7, 128.4, 127.8, 127.0, 126.9, 124.2, 119.2, 119.0, 115.4, 114.3, 113.4, 106.9, 104.6, 104.3, 73.1, 70.5, 56.8, 56.2, 22.1;

IR (neat) ν_{max} 2974, 2931, 1715, 1605, 1585, 1451, 1343, 1130 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{29}H_{27}O_6$: 471.1802, found: 471.1802;

TLC: R_f = 0.31 (PE/EtOAc = 4/1).



1-*O*-isopropyldefucogilvocarcin V (21). To a mixture of **20** (8.10 g, 17.22 mmol) and 5% Pd/C (1.62 g) was added 450 mL of MeOH. The resulting mixture was degassed at -78 °C and backfilled with H_2 three times and equipped with an H_2-filled balloon. Then the reaction was stirred at r.t. for 13 h followed by concentration *in vacuo*. The residue was redissolved in 324 mL of CH_2Cl_2. To the solution was added triethyl amine (13.8 mL, 100.8 mmol) at r.t. and the resulting solution was cooled to -78 °C and treated with trifluoromethanesulfonic anhydride (4.38 mL, 26.04 mmol) dropwise. The reaction mixture was allowed to stir for 1 h, quenched with saturated aqueous $NaHCO_3$ (150 mL) and warmed to r.t. The mixture was extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo* to afford crude triflate product. To a suspension of the crude product, potassium vinyltrifluoroborate (4.70 g, 34.44 mmol), $[Pd(dppf)Cl_2]$ CH_2Cl_2 (430.8 mg, 0.52 mmol) in 420 mL of *n*-PrOH was added triethyl amine (3.78 mL, 27.54 mmol) under argon. The resulting reaction mixture was heated at reflux for 4 h. The reaction was cooled and diluted with water (450 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4,

filtered and concentrated *in vacuo* to afford a crude solid which was purified by silica gel column chromatography (PE/CH_2Cl_2 = 1/1 to 1/2) to afford 1-*O*-propyldefucogilvocarcin V (**21**) (5.64 g, 84%) as a yellow solid.

Mp 204-206 ^oC;

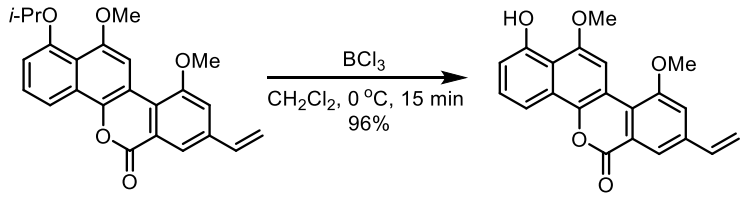
^1H NMR (400 MHz, $CDCl_3$) δ 8.30 (s, 1H), 8.20 (d, *J* = 8.5 Hz, 1H), 8.08 (s, 1H), 7.47 (t, *J* = 8.1 Hz, 1H), 7.27 (s, 1H), 7.05 (d, *J* = 8.0 Hz, 1H), 6.75 (dd, *J* = 17.5, 10.8 Hz, 1H), 5.90 (d, *J* = 17.5 Hz, 1H), 5.40 (d, *J* = 10.8 Hz, 1H), 4.58 (hept, *J* = 6.0 Hz, 1H), 4.05 (s, 3H), 3.97 (s, 3H), 1.44 (d, *J* = 6.0 Hz, 6H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 161.3, 157.4, 154.6, 152.8, 140.9, 138.4, 135.3, 127.0, 126.8, 123.8, 123.3, 120.5, 119.6, 116.2, 115.6, 114.6, 113.9, 113.2, 104.6, 73.1, 56.6, 56.1, 22.1;

IR (neat) ν_{max} 2972, 2927, 1716, 1586, 1450, 1386, 1332, 1293 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{24}H_{23}O_5$: 391.1540, found: 391.1545;

TLC: R_f = 0.36 (PE/EtOAc = 4/1).



21 defucogilvocarcin V (**26**)

Defucogilvocarcin V (26). To a solution of **21** (17.3 mg, 0.044 mmol) in 2.6 mL of CH_2Cl_2 at 0 ^oC was added BCl_3 (1.0 M in CH_2Cl_2, 0.21 mL, 0.21 mmol) dropwise. The resulting solution was stirred for 15 min and quenched with water (5 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Flash chromatography (CH_2Cl_2) provided defucogilvocarcin V (**26**) (14.8 mg, 96%) as a yellow solid. Spectroscopic data are in accordance with the literature reported values.[2]

Mp 245-247 ^oC;

2. (a) James, C. A.; Snieckus, V. *J. Org. Chem.* **2009**, *74*, 4080. (b) Nandaluru, P. R.; Bodwell, G. J. *J. Org. Chem.* **2012**, *77*, 8028.

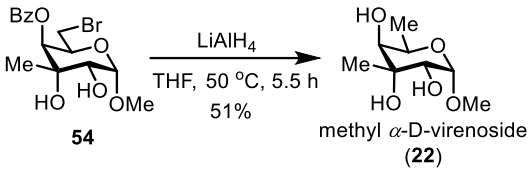
^{1}H NMR (400 MHz, $CDCl_3$) δ 9.35 (s, 1H), 8.30 (s, 1H), 8.13 (d, *J* = 1.5 Hz, 1H), 8.07 (d, *J* = 7.8 Hz, 1H), 7.49 (t, *J* = 8.1 Hz, 1H), 7.32 (d, *J* = 1.3 Hz, 1H), 7.01 (d, *J* = 7.8 Hz, 1H), 6.79 (dd, *J* = 17.6, 10.9 Hz, 1H), 5.95 (d, *J* = 17.5 Hz, 1H), 5.46 (d, *J* = 10.9 Hz, 1H), 4.11 (s, 6H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 161.1, 157.3, 154.2, 151.9, 141.7, 138.7, 135.4, 128.6, 126.2, 123.7, 123.4, 120.7, 116.5, 114.9, 114.1, 113.5, 112.8, 101.7, 56.3, 56.0;

IR (neat) ν_{max} 3378, 1716, 1625, 1604, 1586, 1446, 1383, 1361, 1333, 1297, 1062 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{21}H_{17}O_5$: 349.1071, found: 349.1072;

TLC: R_f = 0.14 (PE/EtOAc = 4/1).



Methyl *α*-D-virenoside (22). To a solution of **54**[3] (352 mg, 0.94 mmol) in 4.9 mL of THF was added lithium aluminium hydride (184 mg, 4.69 mmol) in portions. After stirring at 50 °C for 5.5 h, the reaction was quenched with EtOAc (4.9 mL) at 0 °C, followed by successively addition of water (60 *μ*L), 15% aqueous NaOH (60 *μ*L), and water (180 *μ*L). The suspension was stirred at 50 °C for further 1 h and filtered. The filtrate was concentrated and purified by silica gel column chromatography (CH_2Cl_2/MeOH = 50/1 to 19/1) to afford methyl *α*-D-virenoside (**22**) (91.6 mg, 51%) as a white foam. Spectroscopic data are in accordance with literature reported values.[4b]

^{1}H NMR (400 MHz, CD_3OD) δ 4.64 (d, *J* = 4.0 Hz, 1H), 4.28 (q, *J* = 6.6 Hz, 1H), 3.62 (d, *J* = 4.0 Hz, 1H), 3.42 (s, 3H), 3.18 (s, 1H), 1.28 (d, *J* = 4.9 Hz, 3H), 1.20 (d, *J* = 6.6 Hz, 3H);

^{13}C NMR (100 MHz, CD_3OD) δ 102.2, 77.3, 74.9, 69.4, 63.9, 56.1, 22.8, 16.6;

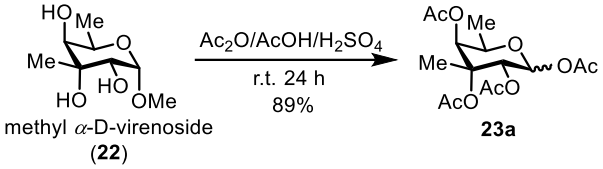
IR (neat) ν_{max} 3404, 2978, 2935, 1456, 1374, 1266, 1194, 1078, 1039 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_8H_{16}NaO_5$: 215.0890, found: 215.0891;

$[\alpha]_D^{27}$ +137.3 (*c* 0.34, MeOH);

3. For the five-step synthesis of compound **27** from methyl *α*-D-galactopyranoside, see: (a) Yoshimura, J.; Hong, N.; Sato, K. *Chem. Lett.* **1980**, 1131. b) Hong, N.; Sato, K.; Yoshimura, J. *Bull. Chern. Soc. Jpn.* **1981**, *54*, 2379. c) Wang, H.; She, J.; Zhang, L.-H.; Ye, X.-S. *J. Org. Chem.* **2004**, *69***,** 5774.

TLC: R_f = 0.44 (CH_2Cl_2/MeOH = 9/1).



Tetraacetate 23a. To a solution of **22** (81.5 mg, 0.424 mmol) in Ac_2O/AcOH (105/45, 3.29 mL in total) was added conc. H_2SO_4 (22 μL) dropwise at 0 °C. The resulting reaction mixture was stirred at r.t. for 24 h, and then diluted with CH_2Cl_2 (15 mL) and washed with water, saturated aqueous $NaHCO_3$, and brine sequentially. The organic phase was dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Flash chromatography (PE/EtOAc = 4/1) provided a mixture of two anomers **23a** (130.7 mg, 89%, α/β = 1/4) as a white solid.

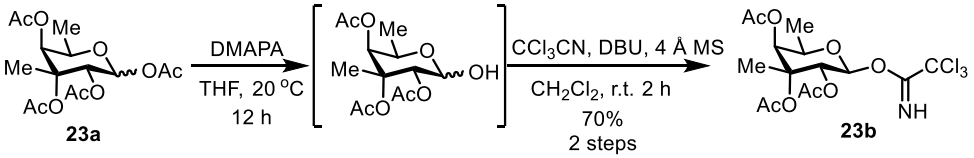
^{1}H NMR (400 MHz, $CDCl_3$) δ 6.21 (d, *J* = 4.2 Hz, 0.2H), 5.97 (d, *J* = 8.4 Hz, 0.8H), 5.80 (s, 0.8H), 5.79 (s, 0.2H) 5.18-5.11 (m, 1H), 4.35 (q, *J* = 6.8 Hz, 1H), 4.13 (q, *J* = 6.8 Hz, 1H), 2.17 (s, 3H), 2.11 (s, 6H), 2.09 (s, 3H), 1.49 – 1.45 (m, 3H), 1.14 (d, *J* = 6.5 Hz, 2.4H), 1.09 (d, *J* = 6.6 Hz, 0.6H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.2, 169.9, 169.8, 169.7, 169.4, 169.2, 169.1, 90.4, 89.3, 81.9, 79.2, 71.3, 70.9, 70.6, 69.3, 68.9, 64.5, 22.2, 22.0, 20.9, 20.9, 20.6, 20.6, 20.5, 18.2, 18.0, 16.2, 16.1;

IR (neat) ν_{max} 2990, 1747, 1434, 1370, 1212, 1143, 1079, 1065, 1047, 1018 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_{15}H_{22}NaO_9$: 369.1156, found: 369.1158;

TLC: R_f = 0.56 (PE/EtOAc = 2/1).



Glycosyl trichloroacetimidate 23b. A solution of **23a** (8.0 mg, 0.023 mmol) and 3-(dimethylamino)-1-propylamine (23 μL, 0.184 mmol) in 0.5 mL of THF was stirred at 20 °C for 12 h.[4] Then it was diluted with CH_2Cl_2 (10 mL) and washed with 1 N HCl followed by brine. The organic phase was dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was dissolved in anhydrous CH_2Cl_2 (0.5 mL). To

4. Andersen, S. M.; Heuckendorff, M.; Jensen, H. H. *Org. Lett.* **2015**, *17*, 944.

the solution were added 4 Å molecular sieves (8.0 mg) and trichloroacetonitrile (48 μL, 0.46 mmol). The resulting mixture was stirred at r.t. for 0.5 h, and then cooled to 0 °C. 1,8-Diazabicyclo[5.4.0]undec-7-ene (2.8 μL, 0.018 mmol) was added. The reaction was warmed to r.t. and stirred for 2 h followed by concentration *in vacuo*. Flash chromatography (PE/EtOAc = 7/3) provided glycosyl trichloroacetimidate **23b** (7.3 mg, 70% for two steps) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.63 (s, 1H), 6.08 (d, *J* = 8.4 Hz, 1H), 5.85 (s, 1H), 5.30 (d, *J* = 8.2 Hz, 1H), 4.23 – 4.17 (m, 1H), 2.21 (s, 3H), 2.14 (s, 3H), 2.10 (s, 3H), 1.50 (s, 3H), 1.19 (d, *J* = 6.4 Hz, 3H);

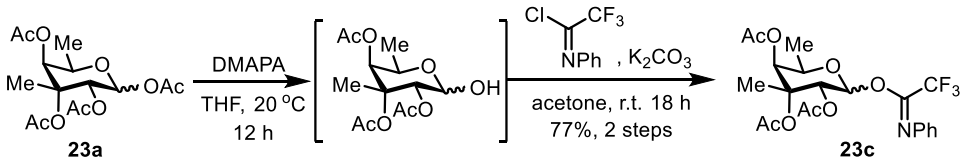
^{13}C NMR (100 MHz, $CDCl_3$) δ 169.9, 169.7, 169.2, 161.4, 94.6, 90.7, 82.0, 71.3, 70.4, 69.1, 22.1, 20.7, 18.0, 16.2;

IR (neat) ν_{max} 2952, 2924, 2854, 1753, 1728, 1679, 1465, 1378, 1220, 1066, 794 cm^{-1};

HRMS (ESI) $[M - H]^-$ calculated for $C_{15}H_{19}Cl_3NO_8$: 446.0182, found: 446.0178;

$[\alpha]_D^{19}$ +13.4 (*c* 0.09, $CHCl_3$);

TLC: R_f = 0.59 (PE/EtOAc = 1/1).



Glycosyl *N*-phenyltrifluoroacetimidate 23c. A solution of **23a** (8.5 mg, 0.0245 mmol) and 3-(dimethylamino)-1-propylamine (23 μL, 0.184 mmol) in 0.5 mL of THF was stirred at 20 °C for 12 h.[5] Then it was diluted with CH_2Cl_2 (10 mL) and washed with 1 N HCl followed by brine. The organic phase was dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was dissolved in acetone (0.5 mL). To the solution were added K_2CO_3 (6.8 mg, 0.049 mmol) and *N*-phenyltrifluoroacetimidoyl chloride (10.2 mg, 0.049 mmol). The resulting reaction mixture was stirred at r.t. for 2 h, followed by addition of K_2CO_3 (3.4 mg, 0.025 mmol) and trifluoroacetimidoyl chloride (10.2 mg, 0.049 mmol). After stirring for additional 16 h, the reaction was concentrated *in vacuo* and purified by flash chromatography on silica gel (PE/EtOAc = 9/1) to afford glycosyl *N*-phenyltrifluoroacetimidate **23c** (8.9 mg, 77%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 (t, *J* = 7.8 Hz, 2H), 7.13 (t, *J* = 7.4 Hz, 1H), 6.88

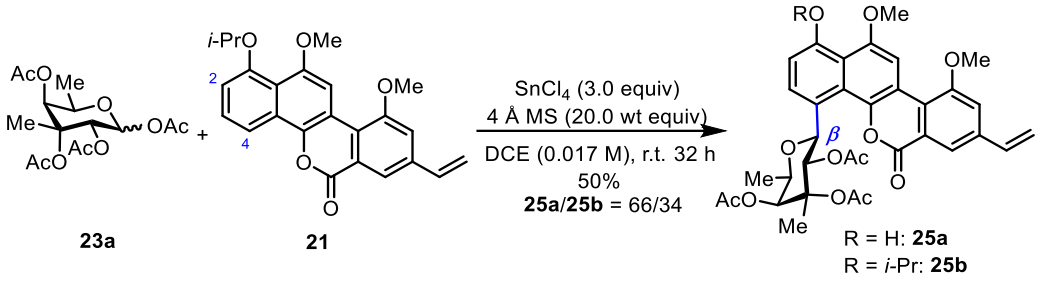
(d, *J* = 6.4 Hz, 2H), 5.97 (br s, 1H), 5.79 (br s, 1H), 5.24 (br s, 1H), 4.11 (br s, 1H), 2.20 (s, 3H), 2.16 (s, 3H), 2.04 (br s, 3H), 1.48 (s, 3H), 1.13 (br s, 3H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 169.8, 169.7, 169.1, 143.4, 128.7, 124.4, 119.3, 93.6, 82.0, 71.3, 70.3, 69.1, 22.1, 20.7, 20.5, 17.9, 16.1;

IR (neat) ν_{max} 1755, 1726, 1597, 1377, 1320, 1213, 1146, 1082, 914 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_{21}H_{24}F_3NNaO_8$: 498.1346, found: 498.1341;

TLC: R_f = 0.48 (PE/EtOAc = 2/1).



4-Glycosylation products 25. To a round bottom flask charged with **23a** (80.5 mg, 0.232 mmol), **21** (272.0 mg, 0.697 mmol) and 4 Å molecular sieves (1.61 g) and a stir bar was added 13.7 mL of anhydrous dichloroethane under argon. The resulting mixture was stirred at r.t. for 2 h. Then it was cooled to 0 °C and $SnCl_4$ (1.0 M in CH_2Cl_2, 0.70 mL, 0.70 mmol) was added dropwise. After kept at 0 °C for 30 min, the reaction was warmed to r.t. and stirred for 38 h. It was then quenched with saturated aqueous $NaHCO_3$ (15 mL), and extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. ^{1}H-NMR analysis of the residue showed a ratio of >95/5 (**25**/**24**). Silica gel column chromatography (PE/CH_2Cl_2/EtOAc = 0/100/0 to 75/10/15 to 65/20/15) afforded **25a** (48.8 mg, 33%) and **25b** (26.2 mg, 17%) each as a yellow solid. The structure of **25a** was determined by 2D-NMR analysis.

For 1-OH-4-glycosylated product **25a**:

Mp 268-270 °C;

^{1}H NMR (500 MHz, $CDCl_3$) δ 9.83 (s, 1H), 8.51 (s, 1H), 8.15 (d, *J* = 1.5 Hz, 1H), 7.83 (d, *J* = 8.4 Hz, 1H), 7.40 (d, *J* = 1.5 Hz, 1H), 7.03 (d, *J* = 8.4 Hz, 1H), 6.83 (dd, *J* = 17.5, 10.5 Hz, 1H), 6.81 (d, *J* = 10.0 Hz, 1H), 5.98 (d, *J* = 17.5 Hz, 1H), 5.98 (d, *J* = 0.5 Hz, 1H), 5.48 (d, *J* = 10.5 Hz, 1H), 5.44 (d, *J* = 10.0 Hz, 1H), 4.64 (q, *J* = 6.5 Hz,

1H), 4.15 (s, 3H), 4.14 (s, 3H), 2.31 (s, 3H), 2.23 (s, 3H), 1.57 (s, 3H), 1.53 (s, 3H), 1.17 (d, *J* = 6.5 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 170.3, 170.2, 170.0, 160.2, 157.5, 154.7, 152.2, 143.2, 139.0, 135.3, 129.7, 125.0, 123.8, 123.0, 120.3, 116.8, 116.1, 114.3, 113.9, 113.1, 102.4, 81.5, 74.5, 72.6, 72.0, 70.2, 56.4, 56.4, 22.3, 20.9, 20.4, 18.7, 16.8;

IR (neat) ν_{max} 2955, 2925, 2855, 1749, 1742, 1727, 1464, 1374, 1258, 1223 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_{34}H_{34}NaO_{12}$: 657.1943, found: 657.1938;

$[\alpha]_D^{20}$ +75.7 (*c* 0.21, $CHCl_3$);

TLC: R_f = 0.30 (PE/EtOAc = 1/1).

For 1-*O*-isopropyl-4-glycosylated product **25b**:

Mp 188-190 ^oC;

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (s, 1H), 8.15 (d, *J* = 1.6 Hz, 1H), 7.84 (d, *J* = 8.4 Hz, 1H), 7.40 (d, *J* = 1.5 Hz, 1H), 7.06 (d, *J* = 8.5 Hz, 1H), 6.84 (d, *J* = 10.0 Hz, 1H) 6.83 (dd, *J* = 17.6, 10.8 Hz, 1H), 5.99 (s, 1H), 5.97 (d, *J* = 17.2 Hz, 1H), 5.46 (d, *J* = 10.8 Hz, 1H), 5.43 (d, *J* = 10.0 Hz, 1H), 4.68 (q, *J* = 6.5 Hz, 1H), 4.61 (hept, *J* = 6.0 Hz, 1H), 4.14 (s, 3H), 3.99 (s, 3H), 2.30 (s, 3H), 2.23 (s, 3H), 1.53 (s, 3H), 1.52 (s, 3H), 1.42 (d, *J* = 6.0 Hz, 3H), 1.39 (d, *J* = 6.0 Hz, 3H), 1.18 (d, *J* = 6.5 Hz, 3H);

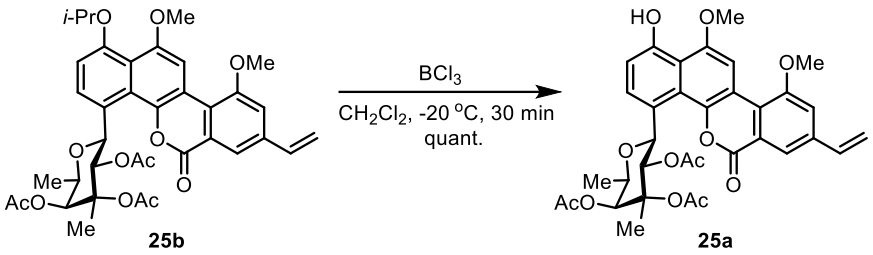
^{13}C NMR (100 Hz, $CDCl_3$) δ 170.4, 170.1, 170.0, 160.4, 157.7, 154.8, 153.3, 142.5, 138.8, 135.3, 128.2, 126.5, 125.7, 124.1, 123.0, 120.9, 120.1, 116.5, 114.4, 114.1, 113.5, 105.7, 81.4, 74.6, 72.8, 72.7, 72.0, 70.2, 57.2, 56.4, 22.3, 22.1, 21.8, 20.9, 20.3, 18.6, 16.8;

IR (neat) ν_{max} 2926, 2856, 1750, 1727, 1589, 1450, 1371, 1224, 1066 cm^{-1};

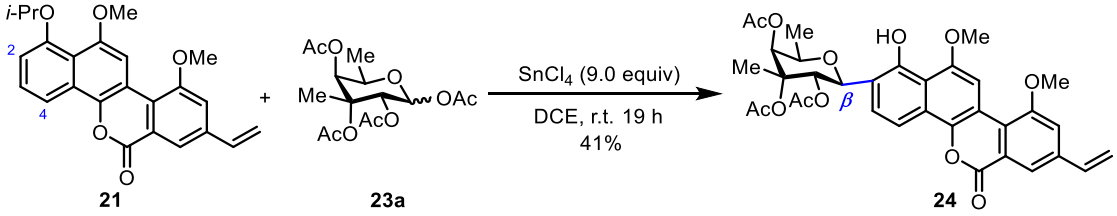
HRMS (ESI) $[M + Na]^+$ calculated for $C_{37}H_{40}NaO_{12}$: 699.2412, found: 699.2403;

$[\alpha]_D^{20}$ +92.2 (*c* 0.58, $CHCl_3$);

TLC: R_f = 0.57 (PE/EtOAc = 1/1).



Naphthol 25a. To a solution of **25b** (9.2 mg, 0.0136 mmol) in 0.8 mL of CH_2Cl_2 at -20 °C was added BCl_3 (1.0 M in hexane, 54.4 μL, 0.0544 mmol) dropwise. The resulting solution was stirred for 30 min and quenched with water (5 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo* to afford naphthol **25a** (8.6 mg, quant.) as a yellow solid.



C2-glycosylation product 24. To a stirred solution of **21** (3.0 mg, 0.0077 mmol), and **23a** (10.1 mg, 0.029 mmol) in 0.6 mL of anhydrous dichloroethane was added $SnCl_4$ (1.0 M in dichloroethane, 69.2 μL, 0.0692 mmol) at r.t. The reaction mixture was stirred at r.t. for 19 h, followed by addition of CH_2Cl_2 (10 mL) and saturated aqueous $NaHCO_3$ (10 mL). The organic layer was separated, washed with water and then concentrated *in vacuo*. The residue was purified by preparative TLC (CH_2Cl_2/acetone = 30/1) to afford **24** (2.0 mg, 41%) as a yellow solid. The structure of **24** was determined by 2D-NMR analysis.

Mp 280-282 °C;

^{1}H NMR (500 MHz, $CDCl_3$) δ 9.79 (s, 1H), 8.36 (s, 1H), 8.14 (d, *J* = 1.5 Hz, 1H), 8.10 (d, *J* = 8.8 Hz, 1H), 7.70 (d, *J* = 8.8 Hz, 1H), 7.36 (d, *J* = 1.4 Hz, 1H), 6.80 (dd, *J* = 17.5, 10.9 Hz, 1H), 5.96 (d, *J* = 16.5 Hz, 1H), 5.94 (d, *J* = 1.2 Hz, 1H), 5.54-5.45 (m, 3H), 4.18 (q, *J* = 6.5 Hz, 1H), 4.12 (s, 3H), 4.11 (s, 3H), 2.28 (s, 3H), 2.22 (s, 3H), 1.78 (s, 3H), 1.54 (s, 3H), 1.19 (d, *J* = 6.5 Hz, 3H);

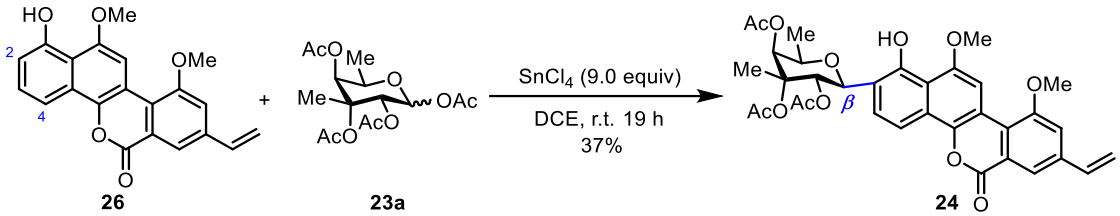
^{13}C NMR (125 MHz, $CDCl_3$) δ 170.1, 169.8, 169.6, 161.0, 157.3, 152.0, 151.9, 141.7, 138.8, 135.3, 127.7, 126.0, 123.6, 123.5, 120.8, 116.6, 114.4, 114.1, 113.7, 113.1, 102.3, 81.4, 73.4, 73.4, 71.5, 70.5, 56.3, 56.2, 22.3, 20.9, 20.5, 18.8, 16.8;

IR (neat) ν_{max} 2956, 2929, 2854, 1750, 1727, 1462, 1378, 1226 cm^{-1};

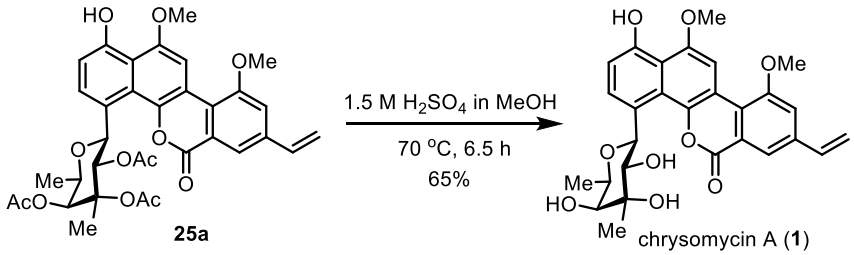
HRMS (ESI) $[M + Na]^+$ calculated for $C_{34}H_{34}NaO_{12}$: 657.1943, found: 657.1948;

$[\alpha]_D^{20}$ -4.8 (*c* 0.13, $CHCl_3$);

TLC: R_f = 0.20 (PE/EtOAc = 1/1).



C2-glycosylation product 24. To a stirred solution of **26** (3.0 mg, 0.0086 mmol), and **23a** (11.3 mg, 0.033 mmol) in 0.67 mL of anhydrous dichloroethane was added $SnCl_4$ (1.0 M in dichloroethane, 77.5 μL, 0.0775 mmol) at r.t. The reaction mixture was stirred at r.t. for 19 h, followed by addition of CH_2Cl_2 (10 mL) and saturated aqueous $NaHCO_3$ (10 mL). The organic layer was separated, washed with water and then concentrated *in vacuo*. The residue was purified by preparative TLC (CH_2Cl_2/acetone = 30/1) to provide **24** (2.0 mg, 37%) as a yellow solid.



Chrysomycin A (1). To a suspension of **25a** (32.6 mg, 0.051 mmol) in 5.7 mL of MeOH was added 5.7 mL of 3.0 M H_2SO_4 in MeOH. The resulting reaction solution was stirred at 70 °C for 6.5 h and then cooled to r.t. The reaction was diluted with water (20 mL), and extracted with CH_2Cl_2 three times. The organic phases were washed with saturated aqueous $NaHCO_3$ and then dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (CH_2Cl_2/MeOH = 100/1 to 30/1) to afford chrysomycin A (**1**) (17.0 mg, 65%) as a

yellow solid. Spectroscopic data are in accordance with the naturally obtained material.

Mp 234-236 °C;

^{1}H NMR (400 MHz, DMSO-*d6*) δ 9.82 (s, 1H), 8.49 (s, 1H), 8.01 (s, 1H), 7.84 (d, *J* = 8.4 Hz, 1H), 7.76 (s, 1H), 6.97 (d, *J* = 8.6 Hz, 1H), 6.95 (dd, *J* = 17.6, 11.2 Hz, 1H), 6.16 (d, *J* = 17.6 Hz, 1H), 6.02 (d, *J* = 9.6 Hz, 1H), 5.51 (d, *J* = 11.0 Hz, 1H), 4.59 (d, *J* = 7.7 Hz, 1H), 4.52 (q, *J* = 6.6 Hz, 1H), 4.20 (s, 1H), 4.19 (d, *J* = 8.0 Hz, 1H), 4.18 (s, 3H), 4.13 (s, 3H), 3.68 (dd, *J* = 9.2, 8.8 Hz, 1H), 3.14 (d, *J* = 7.9 Hz, 1H), 1.25 (s, 3H), 1.02 (d, *J* = 6.5 Hz, 3H);

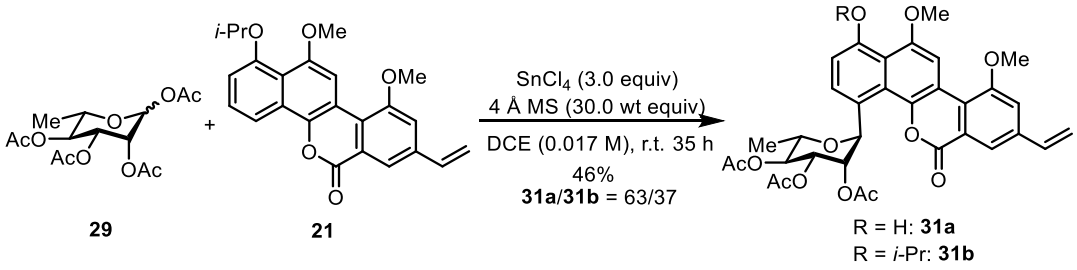
^{13}C NMR (100 MHz, DMSO-*d6*) δ 159.8, 157.4, 153.2, 151.9, 142.5, 138.8, 135.2, 129.4, 128.1, 125.2, 123.0, 122.1, 119.1, 117.3, 115.2, 114.8, 113.2, 112.2, 101.5, 75.8, 74.6, 73.2, 72.5, 70.7, 56.8, 56.3, 23.9, 17.1;

IR (neat) ν_{max} 3362, 3334, 2955, 2924, 2855, 1716, 1698, 1456, 1372, 1259, 1062 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{28}H_{29}O_9$: 509.1806, found: 509.1806;

$[\alpha]_D^{22}$ -13.3 (*c* 0.06, $CHCl_3$);

TLC: R_f = 0.32 (CH_2Cl_2/MeOH = 19/1).



Compound 31a and 31b. To a round bottom flask charged with **29** (10 mg, 0.03 mmol), **21** (35.2 mg, 0.09 mmol) and 4 Å molecular sieves (300 mg) and a stir bar was added 1.75 mL of anhydrous dichloroethane under argon. The resulting mixture was stirred at r.t. for 2 h. Then it was cooled to 0 °C and $SnCl_4$ (1.0 M in CH_2Cl_2, 90 μL, 0.09 mmol) was added dropwise. After kept at 0 °C for 30 min, the reaction was warmed to r.t. and stirred for 35 h. It was then quenched with saturated aqueous $NaHCO_3$ (5 mL), and extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Silica gel column chromatography (PE/CH_2Cl_2/EtOAc = 0/100/0 to 75/10/15 to 65/20/15) afforded compound **31a** (5.3 mg, 29%) and compound **31b** (3.4 mg, 17%) each as a yellow solid.

For 1-OH-4-glycosylated product **31a**:
Mp 270-272 °C;
^{1}H NMR (400 MHz, $CDCl_3$) δ 9.77 (s, 1H), 8.44 (s, 1H), 8.20 (d, *J* = 1.5 Hz, 1H), 7.87 (d, *J* = 8.4 Hz, 1H), 7.36 (d, *J* = 1.4 Hz, 1H), 6.99 (d, *J* = 8.4 Hz, 1H), 6.80 (dd, *J* = 17.6, 10.9 Hz, 1H), 6.32 (s, 1H), 5.94 (d, *J* = 17.6 Hz, 1H), 5.93 (d, *J* = 3.2 Hz, 1H), 5.71 (dd, *J* = 9.9, 3.4 Hz, 1H), 5.46 (d, *J* = 10.9 Hz, 1H), 5.22 (t, *J* = 9.8 Hz, 1H), 4.11 (s, 3H), 4.11 (s, 3H), 3.91 (dd, *J* = 9.6, 6.1 Hz, 1H), 2.10 (s, 3H), 1.95 (s, 3H), 1.88 (s, 3H), 1.38 (d, *J* = 6.1 Hz, 3H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.4, 170.0, 169.8, 159.8, 157.4, 154.2, 152.2, 142.5, 138.9, 135.3, 129.2, 124.0, 123.7, 123.1, 122.7, 120.6, 116.6, 115.6, 114.3, 114.0, 112.2, 102.5, 74.7, 72.5, 72.1, 71.5, 56.4, 56.3, 21.0, 20.7, 20.6, 18.1;
IR (neat) ν_{max} 3375, 2926, 2853, 1741, 1622, 1589, 1450, 1369, 1228, 1129, 1054 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{33}H_{33}O_{12}$: 621.1967, found: 621.1951;
$[\alpha]_D^{20}$ -94.3 (*c* 0.14, $CHCl_3$);

TLC: R_f = 0.34 (PE/EtOAc = 1/1).

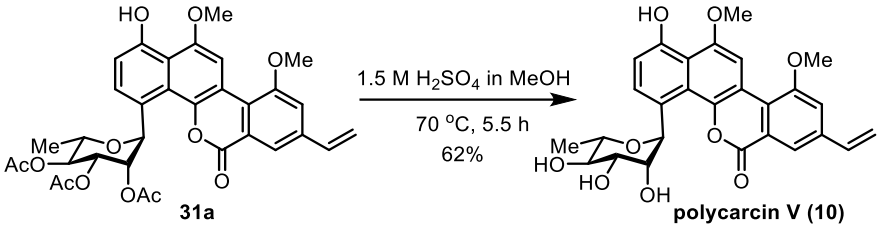
For 1-*O*-isopropyl-4-glycosylated product **31b**:
Mp 106-108 °C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (s, 1H), 8.20 (d, *J* = 1.5 Hz, 1H), 7.87 (d, *J* = 8.4 Hz, 1H), 7.37 (d, *J* = 1.5 Hz, 1H), 7.04 (d, *J* = 8.5 Hz, 1H), 6.81 (dd, *J* = 17.6, 10.9 Hz, 1H), 6.36 (s, 1H), 5.97 (d, *J* = 2.8 Hz, 1H), 5.95 (d, *J* = 17.2 Hz, 1H), 5.73 (dd, *J* = 9.9, 3.4 Hz, 1H), 5.44 (d, *J* = 10.9 Hz, 1H), 5.22 (t, *J* = 9.8 Hz, 1H), 4.57 (hept, *J* = 6.0 Hz, 1H), 4.11 (s, 3H), 3.98 (s, 3H), 3.92 (dd, *J* = 9.8, 6.3 Hz, 1H), 2.10 (s, 3H), 1.95 (s, 3H), 1.86 (s, 3H), 1.42 (d, *J* = 6.0 Hz, 3H), 1.39 (d, *J* = 6.0 Hz, 3H), 1.37 (d, *J* = 5.1 Hz, 3H);
^{13}C NMR (100 MHz, $CDCl_3$) δ 170.5, 169.9, 169.8, 160.1, 157.6, 154.3, 153.3, 141.8, 138.7, 135.4, 127.8, 126.0, 123.9, 122.7, 120.5, 116.4, 114.6, 114.4, 113.6, 108.0, 105.8, 74.6, 72.9, 72.5, 72.1, 71.5, 57.1, 56.4, 22.1, 21.9, 21.0, 20.7, 20.6, 18.0;
IR (neat) ν_{max} 2922, 2851, 1745, 1729, 1589, 1370, 1240, 1135, 1053 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{36}H_{39}O_{12}$: 663.2436, found: 663.2463;

$[\alpha]_D^{24}$ -87.1 (*c* 0.27, $CHCl_3$);

TLC: R_f = 0.52 (PE/EtOAc = 1/1).



Polycarcin V (10). To a suspension of **31a** (5.3 mg, 0.0085 mmol) in 0.8 mL of MeOH was added 0.8 mL of 3.0 M H_2SO_4 in MeOH. The resulting reaction solution was stirred at 70 °C for 5.5 h and then cooled to r.t. The reaction was diluted with water (5 mL), and extracted with $CHCl_3$/*i*-PrOH (3/1) three times. The organic phases were washed with saturated aqueous $NaHCO_3$ and then dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (CH_2Cl_2/MeOH = 9/1) to afford polycarcin V (**10**) (2.6 mg, 62%) as a yellow solid.

Mp >330 °C;

^{1}H NMR (500 MHz, DMSO-*d6*) δ 9.73 (s, 1H), 8.45 (s, 1H), 7.97 (d, *J* = 1.2 Hz, 1H), 7.81 (d, *J* = 8.4 Hz, 1H), 7.73 (d, *J* = 1.2 Hz, 1H), 6.96 (d, *J* = 8.5 Hz, 1H), 6.94 (dd, *J* = 17.6, 11.0 Hz, 1H), 6.14 (d, *J* = 17.6 Hz, 1H), 5.84 (s, 1H), 5.50 (d, *J* = 11.0 Hz, 1H), 4.81 (d, *J* = 5.1 Hz, 1H), 4.47 (d, *J* = 5.3 Hz, 1H), 4.16 (s, 3H), 4.11 (s, 3H), 4.07 (dd, *J* = 5.6, 3.1 Hz, 1H), 4.01 (m, 1H), 3.78 (m, 1H), 3.36 (m, 1H) 3.31 (m, 1H), 1.29 (d, *J* = 5.9 Hz, 3H);

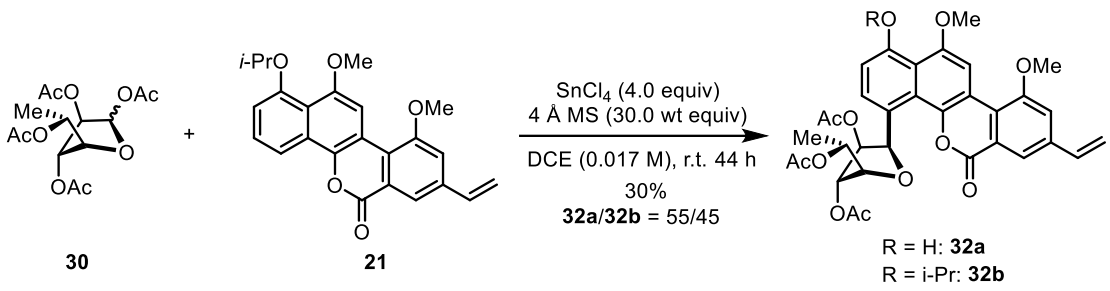
^{13}C NMR (125 MHz, DMSO-*d6*) δ 159.4, 157.5, 152.8, 152.1, 141.8, 138.9, 135.2, 130.0, 126.7, 122.9, 122.5, 121.9, 119.2, 117.3, 114.9, 114.7, 113.3, 112.1, 101.4, 77.5, 76.4, 74.7, 72.8, 71.6, 56.8, 56.3, 18.5;

IR (neat) ν_{max} 3375, 2923, 2852, 1712, 1619, 1606, 1589, 1450, 1371, 1246, 1131, 1085 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{27}H_{27}O_9$: 495.1650, found: 495.1646;

$[\alpha]_D^{22}$ -83.6 (*c* 0.2, MeOH);

TLC: R_f = 0.21 (CH_2Cl_2/MeOH = 19/1).



Compound 32a and 32b. To a round bottom flask charged with **30** (25.3 mg, 0.0762 mmol), **21** (89.4 mg, 0.229 mmol) and 4 Å molecular sieves (759 mg) and a stir bar was added 4.4 mL of anhydrous dichloroethane under argon. The resulting mixture was stirred at r.t. for 2 h. Then it was cooled to 0 °C and $SnCl_4$ (1.0 M in CH_2Cl_2, 0.31mL, 0.305 mmol) was added dropwise. After kept at 0 °C for 30 min, the reaction was warmed to r.t. and stirred for 44 h. It was then quenched with saturated aqueous $NaHCO_3$ (5 mL), and extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Silica gel column chromatography (PE/CH_2Cl_2/EtOAc = 0/100/0 to 75/10/15 to 65/20/15) afforded compound **32a** (7.8 mg, 16%) and compound **32b** (6.8 mg, 14%) each as a yellow solid.

For 1-OH-4-glycosylated product **32a**:

Mp 141-143 °C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.75 (s, 1H), 8.42 (s, 1H), 8.09 (d, J = 1.3 Hz, 1H), 7.92 (d, J = 8.4 Hz, 1H), 7.35 (d, J = 1.2 Hz, 1H), 6.99 (d, J = 8.4 Hz, 1H), 6.80 (dd, J = 17.6, 10.9 Hz, 1H), 6.46 (d, J = 3.0 Hz, 1H), 6.08 (d, J = 3.1 Hz, 1H), 5.94 (d, J = 17.6 Hz, 1H), 5.45 (d, J = 10.9 Hz, 1H), 5.40 – 5.35 (m, 1H), 5.19 (d, J = 3.7 Hz, 1H), 4.18 (dd, J = 6.3, 3.8 Hz, 1H), 4.11 (s, 3H), 4.09 (s, 3H), 2.32 (s, 3H), 2.15 (s, 5H), 1.57 (s, 3H), 1.43 (d, J = 6.5 Hz, 3H)

^{13}C NMR (125 MHz, $CDCl_3$) δ 170.7, 170.5, 168.6, 160.1, 157.4, 154.1, 151.9, 142.8, 138.8, 135.3, 129.2, 124.1, 123.8, 122.7, 122.1, 120.4, 116.5, 115.4, 114.0, 113.6, 112.1, 102.4, 83.3, 81.5, 78.9, 77.9, 69.8, 56.3, 56.2, 21.3, 21.1, 20.3, 16.4.

IR (neat) ν_{max} 3357, 2987, 2936, 1740, 1589, 1449, 1371, 1236, 1129, 1069, 1043, 783 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{33}H_{33}O_{12}$: 621.1967, found: 621.1961;

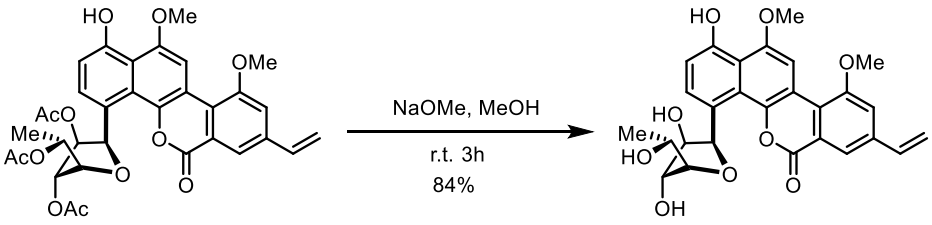
$[\alpha]_D^{26}$ -90.5 (*c* 0.25, $CHCl_3$);

TLC: R_f = 0.34 (PE/EtOAc = 1/1).

For 1-*O*-isopropyl-4-glycosylated product **32b**:
Mp 90-92 °C;
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (s, 1H), 8.12 (d, J = 1.6 Hz, 1H), 7.94 (d, J = 8.4 Hz, 1H), 7.38 (d, J = 1.6 Hz, 1H), 7.06 (d, J = 8.5 Hz, 1H), 6.82 (dd, J = 17.5, 10.9 Hz, 1H), 6.54 (d, J = 3.2 Hz, 1H), 6.17 (dd, J = 3.3, 0.9 Hz, 1H), 5.95 (d, J = 17.5 Hz, 1H), 5.44 (d, J = 10.9 Hz, 1H), 5.38 (t, J = 6.5 Hz, 1H), 5.20 (dd, J = 3.9, 0.8 Hz, 1H), 4.61 – 4.58 (hept, J = 6.0 Hz,1H), 4.18 (dd, J = 6.5, 3.9 Hz, 1H), 4.11 (s, 3H), 3.99 (s, 3H), 2.32 (s, 3H), 2.15 (s, 3H), 1.54 (s, 3H), 1.44 – 1.37 (m, 9H)
^{13}C NMR (125 MHz, $CDCl_3$) δ 170.6, 170.5, 168.5, 160.4, 157.7, 154.2, 153.1, 142.2, 138.7, 135.4, 127.9, 124.9, 124.2, 124.2, 122.8, 120.4, 120.3, 116.4, 114.2, 114.1, 113.9, 105.7, 83.3, 81.7, 78.9, 78.0, 73.0, 69.9, 57.0, 56.4, 22.1, 21.9, 21.4, 21.1, 20.2, 16.4.
IR(neat)ν_{max} 2978, 2921, 2850, 1741, 1589, 1451, 1370, 1335, 1301, 1235, 1135, 1044, 925, 783 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{36}H_{39}O_{12}$: 663.2436, found: 663.2451;
$[\alpha]_D^{26}$ -86.7 (*c* 0.25, $CHCl_3$);

TLC: R_f = 0.45 (PE/EtOAc = 1/1).



32a **gilvocarcin V (8)**

Gilvocarcin V (8). To a suspension of **32a** (4.7 mg, 0.00757 mmol) in MeOH (0.5 mL) was added a 1.0 M solution of NaOMe in MeOH (15 μL) at room temperature. Stirring was continued for 3 h, The suspension was treated with AcOH (0.2 mL) and concentrated in vacuo. The residue was purified by PTLC (/CH_2C1_2/MeOH = 90/10) to afford **gilvocarcin V (8)** (3.1 mg, 84%) as a yellow crystalline solid. Spectroscopic data are in accordance with the naturally obtained material.

Mp 230 - 233 °C;

^{1}H NMR (400 MHz, DMSO-d6) δ 9.71 (s, 1H), 8.48 (s, 1H), 8.07 (d, J = 8.2 Hz, 1H), 7.99 (s, 1H), 7.76 (s, 1H), 6.96 (dd, J = 17.6, 10.9 Hz, 1H), 6.95 (d, J = 8.2 Hz, 1H),6.20 (d, J = 5.5 Hz, 1H), 6.16 (d, J = 17.6 Hz, 1H), 5.51 (d, J = 11.0 Hz, 1H), 5.10 (d, J = 4.8 Hz, 1H), 4.83 (d, J = 4.8 Hz, 1H), 4.66-4.71 (m, 1H), 4.51 (d, J = 6.6 Hz, 1H), 4.18 (s, 3H), 4.13 (s, 3H), 3.82-3.90(m, 2H),3.51(dd, J = 5.9, 4.4 Hz, 1H)， 1.24 (d, J = 6.5 Hz, 3H)

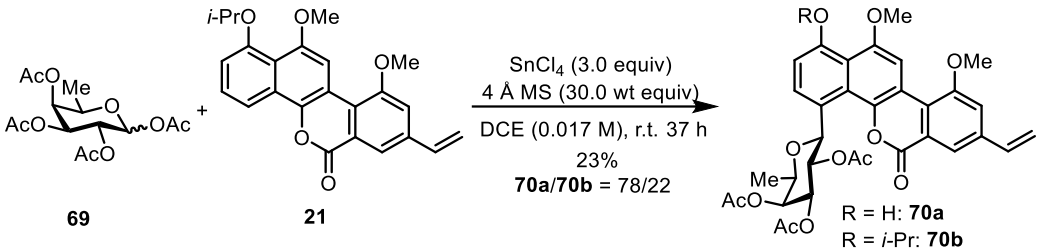
^{13}C NMR (125 MHz, DMSO-d6) δ 159.6, 157.3, 152.6, 151.8, 142.3, 138.7, 135.2, 129.1, 126.2, 123.6, 122.9, 122.2, 119.0, 117.0, 114.8, 114.4, 112.5, 112.0, 101.4, 85.7, 80.7, 78.9, 78.6, 66.4, 56.7, 56.2, 20.0.

IR (neat) ν_{max} 3361, 2981, 2944, 1720, 1589, 1449, 1365, 1236, 1129, 1069, 1043, 743 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{27}H_{27}O_9$: 495.1649, found: 495.1641;

$[\alpha]_D^{25}$ -221.0 (*c* 0.22, DMSO);

TLC: R_f = 0.39 (DCM/MeOH = 19/1).



Compound 70a and 70b. To a round bottom flask charged with **69** (50 mg, 0.15 mmol), **21** (175.9 mg, 0.45 mmol) and 4 Å molecular sieves (1.5 g) and a stir bar was added 8.8 mL of anhydrous dichloroethane under argon. The resulting mixture was stirred at r.t. for 2 h. Then it was cooled to 0 °C and $SnCl_4$ (1.0 M in CH_2Cl_2, 0.45 mL, 0.45 mmol) was added dropwise. After kept at 0 °C for 30 min, the reaction was warmed to r.t. and stirred for 37 h. It was then quenched with saturated aqueous $NaHCO_3$ (25 mL), and extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Silica gel column chromatography (PE/CH_2Cl_2/EtOAc = 0/100/0 to 75/10/15 to 60/25/15) afforded compound **70a** (4.2 mg, 18%) and compound **70b** (3.4 mg, 5%) each as a yellow solid.

For 1-OH-4-glycosylated product **70a**:

Mp 306-308 °C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.87 (s, 1H), 8.53 (s, 1H), 8.16 (d, *J* = 1.5 Hz, 1H), 7.77 (d, *J* = 8.4 Hz, 1H), 7.40 (d, *J* = 1.5 Hz, 1H), 7.02 (d, *J* = 8.4 Hz, 1H), 6.83 (dd, *J* = 17.5, 10.9 Hz, 1H), 6.21 (d, *J* = 10.1 Hz, 1H), 5.98 (d, *J* = 17.5 Hz, 1H), 5.78 (t, *J* = 9.8 Hz, 1H), 5.49 (d, *J* = 10.8 Hz, 1H), 5.47 (d, *J* = 4.4 Hz, 1H), 5.41 (dd, *J* = 9.6, 3.4 Hz, 1H), 4.64 (q, *J* = 6.6 Hz, 1H), 4.15 (s, 3H), 4.14 (s, 3H), 2.23 (s, 3H), 2.01 (s, 3H), 1.65 (s, 3H), 1.23 (d, *J* = 6.4 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 171.0, 170.3, 169.6, 160.3, 157.5, 155.0, 152.2, 142.9, 139.1, 135.2, 129.4, 125.2, 123.6, 123.1, 122.8, 120.3, 116.8, 116.3, 114.3, 114.2, 112.7, 102.6, 76.9, 74.0, 73.1, 71.8, 69.3, 56.4, 56.4, 20.9, 20.8, 20.6, 16.5;

IR (neat) ν_{max} 2917, 1849, 1749, 1719, 1464, 1371, 1221, 1137 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_{33}H_{32}NaO_{12}$: 643.1786, found: 643.1795;

$[\alpha]_D^{26}$ +68.6 (*c* 0.2, $CHCl_3$);

TLC: R_f = 0.33 (PE/EtOAc = 1/1).

For 1-*O*-isopropyl-4-glycosylated product **70b**:

Mp 84-86 °C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.55 (s, 1H), 8.17 (d, *J* = 1.5 Hz, 1H), 7.77 (d, *J* = 8.5 Hz, 1H), 7.41 (d, *J* = 1.2 Hz, 1H), 7.04 (d, *J* = 8.4 Hz, 1H), 6.84 (dd, *J* = 17.6, 10.9 Hz, 1H), 6.22 (d, *J* = 10.1 Hz, 1H), 5.98 (d, *J* = 17.5 Hz, 1H), 5.80 (t, *J* = 9.8 Hz, 1H), 5.47 (d, *J* = 10.8 Hz, 1H), 5.47 (d, *J* = 4.0 Hz, 1H), 5.40 (dd, *J* = 9.6, 3.2 Hz, 1H), 4.68 (q, *J* = 6.4 Hz, 1H), 4.62 (hept, *J* = 6.1 Hz, 1H), 4.14 (s, 3H), 3.99 (s, 3H), 2.23 (s, 3H), 2.01 (s, 3H), 1.64 (s, 3H), 1.43 (d, *J* = 6.0 Hz, 3H), 1.40 (d, *J* = 6.0 Hz, 3H), 1.24 (d, *J* = 6.4 Hz, 3H);

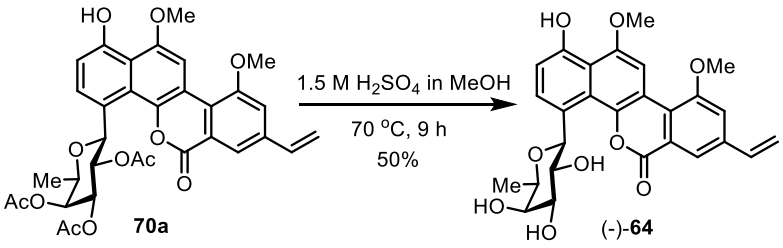
^{13}C NMR (100 MHz, $CDCl_3$) δ 170.9, 170.2, 169.7, 160.6, 157.7, 155.2, 153.4, 142.2, 138.9, 135.3, 128.0, 125.9, 124.4, 124.0, 122.8, 121.0, 120.2, 116.6, 114.8, 114.2, 112.7, 106.1, 77.1, 74.0, 73.1, 72.5, 71.8, 69.3, 57.2, 56.4, 29.7, 22.2, 21.8, 20.9, 20.8, 20.6, 16.6;

IR (neat) ν_{max} 2922, 2852, 1741, 1589, 1463, 1376, 1260, 1091, 803 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{33}H_{33}O_{12}$: 621.1967, found: 621.1951;

$[\alpha]_D^{26}$ +38.7 (*c* 0.25, $CHCl_3$);

TLC: R_f = 0.52 (PE/EtOAc = 1/1).



Compound (-)-64. To a suspension of **70a** (6.8 mg, 0.011 mmol) in 1.2 mL of MeOH was added 1.2 mL of 3.0 M H_2SO_4 in MeOH. The resulting reaction solution was stirred at 70 °C for 9 h and then cooled to r.t. The reaction was diluted with water (5 mL), and extracted with $CHCl_3$/*i*-PrOH (3/1) three times. The organic phases were washed with saturated aqueous $NaHCO_3$ and then dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (CH_2Cl_2/MeOH = 50/1 to 20/1) to afford (-)-**70** (2.7 mg, 50%) as a yellow solid.

Mp >330 °C;

^{1}H NMR (500 MHz, DMSO-*d6*) δ 9.86 (s, 1H), 8.50 (s, 1H), 8.00 (d, *J* = 1.5 Hz, 1H), 7.76 (s, 1H), 7.75 (d, *J* = 8.5 Hz, 1H), 6.97 (d, *J* = 8.5 Hz, 1H), 6.94 (dd, *J* = 17.5, 11.0 Hz, 1H), 6.16 (d, *J* = 17.6 Hz, 1H), 5.63 (d, *J* = 9.4 Hz, 1H), 5.50 (d, *J* = 11.0 Hz, 1H), 4.84 (s, 1H), 4.55 (d, *J* = 5.3 Hz, 1H), 4.41 (d, *J* = 4.7 Hz, 1H), 4.17 (s, 3H), 4.12 (s, 3H), 4.06 (q, *J* = 6.5 Hz, 1H), 3.85 – 3.83 (m, 1H), 3.62 (t, *J* = 3.5 Hz, 1H), 3.57 – 3.54 (m, 1H), 1.05 (d, *J* = 6.4 Hz, 3H);

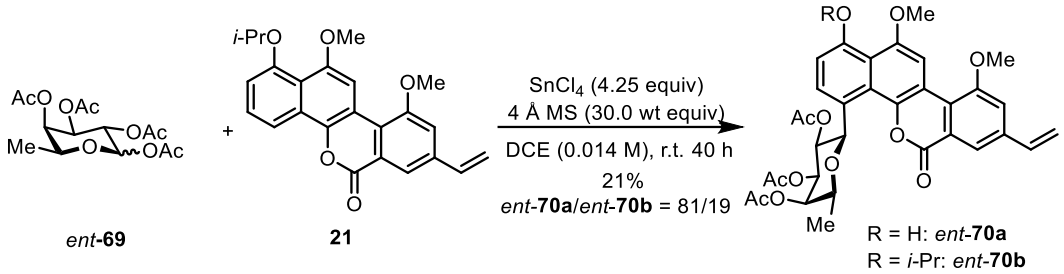
^{13}C NMR (125 MHz, DMSO-*d6*) δ 159.7, 157.5, 153.5, 152.0, 142.4, 138.9, 135.2, 129.5, 126.6, 125.1, 122.9, 122.1, 119.1, 117.4, 115.4, 114.9, 113.4, 112.1, 101.7, 77.9, 76.1, 74.0, 71.9, 70.4, 56.8, 56.4, 17.13;

HRMS (ESI) $[M + Na]^+$ calculated for $C_{27}H_{27}O_9$: 495.1650, found: 495.1667;

$[\alpha]_D^{22}$ -15.7 (*c* 0.17, MeOH);

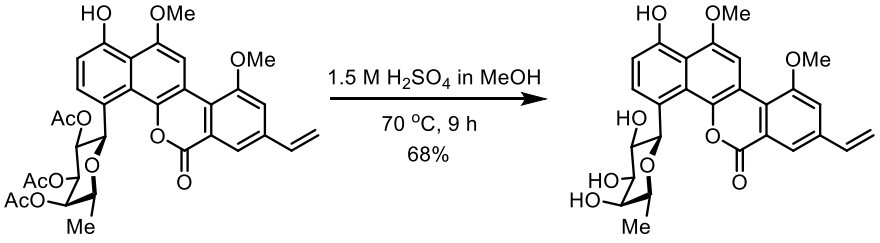
TLC: R_f = 0.20 (CH_2Cl_2/MeOH = 19/1).

Large scale preparation of (+)-64



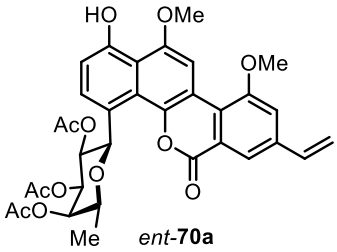
ent-**69** **21**

Compound *ent*-70a and *ent*-70b. To a round bottom flask charged with *ent*-**69** (1.36 g, 4.10 mmol), **21** (4.80 g, 12.30 mmol) and 4 Å molecular sieves (40.8 g) and a stir bar was added 300 mL of anhydrous dichloroethane under argon. The resulting mixture was stirred at r.t. for 2 h. Then it was cooled to 0 °C and $SnCl_4$ (1.0 M in CH_2Cl_2, 17.4 mL, 17.4 mmol) was added dropwise. After kept at 0 °C for 30 min, the reaction was warmed to r.t. and stirred for 40 h. It was then quenched with saturated aqueous $NaHCO_3$ (300 mL), and extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Silica gel column chromatography (PE/CH_2Cl_2/EtOAc = 0/100/0 to 75/10/15 to 60/25/15) afforded compound *ent*-**70a** (432.1 mg, 17%) and compound *ent*-**70b** (108.6 mg, 4%) each as a yellow solid, as well as the recovered **21** (2.18 g).



ent-**70a** (+)-**64**

Compound (+)-64. To a suspension of *ent*-**70a** (432.1 mg, 0.70 mmol) in 76 mL of MeOH was added 76 mL of 3.0 M H_2SO_4 in MeOH. The resulting reaction solution was stirred at 70 °C for 9 h and then cooled to r.t. The reaction was diluted with water (250 mL), and extracted with $CHCl_3$/*i*-PrOH (3/1) three times. The organic phases were washed with saturated aqueous $NaHCO_3$ and then dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (CH_2Cl_2/MeOH = 50/1 to 20/1) to afford (+)-**64** (235.1 mg, 68%) as a yellow solid.



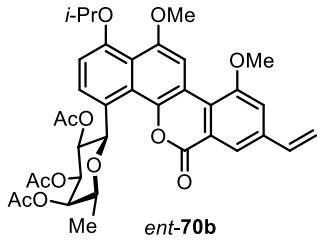
ent-**70a**

Mp 285-287 ^{o}C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.85 (s, 1H), 8.52 (s, 1H), 8.15 (d, *J* = 1.5 Hz, 1H), 7.77 (d, *J* = 8.4 Hz, 1H), 7.39 (d, *J* = 1.5 Hz, 1H), 7.02 (d, *J* = 8.4 Hz, 1H), 6.83 (dd, *J* = 17.5, 10.9 Hz, 1H), 6.21 (d, *J* = 10.1 Hz, 1H), 5.97 (d, *J* = 17.5 Hz, 1H), 5.76 (t, *J* = 9.8 Hz, 1H), 5.47 (d, *J* = 10.8 Hz, 1H), 5.45 (d, *J* = 4.4 Hz, 1H), 5.41 (dd, *J* = 9.6, 3.4 Hz, 1H), 4.64 (q, *J* = 6.6 Hz, 1H), 4.15 (s, 3H), 4.14 (s, 3H), 2.23 (s, 3H), 2.01 (s, 3H), 1.65 (s, 3H), 1.23 (d, *J* = 6.4 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 171.0, 170.3, 169.6, 160.3, 157.5, 155.0, 152.2, 142.9, 139.1, 135.2, 129.4, 125.2, 123.6, 123.1, 122.8, 120.3, 116.8, 116.3, 114.3, 114.2, 112.7, 102.6, 76.9, 74.0, 73.1, 71.8, 69.3, 56.4, 56.4, 20.9, 20.8, 20.6, 16.5;

HRMS (ESI) $[M + Na]^+$ calculated for $C_{33}H_{32}NaO_{12}$: 643.1786, found: 643.1801;
$[\alpha]_D^{24}$ -66.0 (*c* 0.2, $CHCl_3$).



ent-**70b**

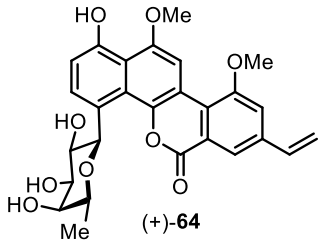
Mp 90-92 ^{o}C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.56 (s, 1H), 8.17 (d, *J* = 1.5 Hz, 1H), 7.76 (d, *J* = 8.5 Hz, 1H), 7.40 (d, *J* = 1.2 Hz, 1H), 7.03 (d, *J* = 8.4 Hz, 1H), 6.84 (dd, *J* = 17.6, 10.9 Hz, 1H), 6.22 (d, *J* = 10.1 Hz, 1H), 5.98 (d, *J* = 17.5 Hz, 1H), 5.80 (t, *J* = 9.8 Hz, 1H), 5.47 (d, *J* = 10.8 Hz, 1H), 5.48 (d, *J* = 4.0 Hz, 1H), 5.41 (dd, *J* = 9.6, 3.2 Hz, 1H), 4.69 (q, *J* = 6.4 Hz, 1H), 4.62 (hept, *J* = 6.1 Hz, 1H), 4.14 (s, 3H), 3.99 (s, 3H), 2.24 (s, 3H), 2.01

(s, 3H), 1.64 (s, 3H), 1.43 (d, *J* = 6.0 Hz, 3H), 1.40 (d, *J* = 6.0 Hz, 3H), 1.24 (d, *J* = 6.4 Hz, 3H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.9, 170.2, 169.7, 160.6, 157.7, 155.2, 153.4, 142.2, 138.9, 135.3, 128.0, 125.9, 124.4, 124.0, 122.8, 121.0, 120.2, 116.6, 114.8, 114.2, 112.7, 106.1, 77.1, 74.0, 73.1, 72.5, 71.8, 69.3, 57.2, 56.4, 29.7, 22.2, 21.8, 20.9, 20.8, 20.6, 16.6;

HRMS (ESI) $[M + H]^+$ calculated for $C_{36}H_{39}O_{12}$: 663.2436, found: 663.2455;
$[\alpha]_D^{25}$ -39.8 (*c* 0.25, $CHCl_3$).



(+)-**64**

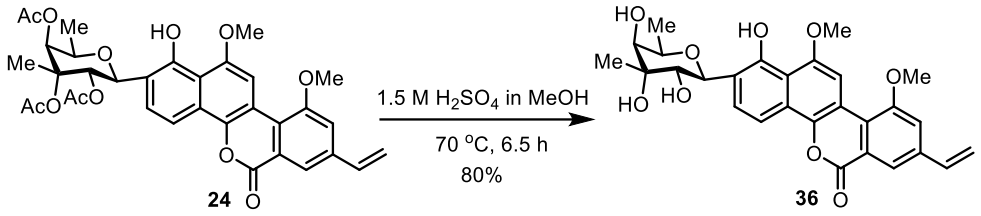
Mp >330 ºC;

^{1}H NMR (500 MHz, DMSO-*d6*) δ 9.85 (s, 1H), 8.50 (s, 1H), 8.00 (d, *J* = 1.5 Hz, 1H), 7.76 (s, 1H), 7.75 (d, *J* = 8.5 Hz, 1H), 6.97 (d, *J* = 8.5 Hz, 1H), 6.93 (dd, *J* = 17.5, 11.0 Hz, 1H), 6.16 (d, *J* = 17.6 Hz, 1H), 5.63 (d, *J* = 9.4 Hz, 1H), 5.50 (d, *J* = 11.0 Hz, 1H), 4.84 (s, 1H), 4.55 (d, *J* = 5.3 Hz, 1H), 4.41 (d, *J* = 4.7 Hz, 1H), 4.17 (s, 3H), 4.12 (s, 3H), 4.06 (q, *J* = 6.5 Hz, 1H), 3.85 – 3.83 (m, 1H), 3.62 (t, *J* = 3.5 Hz, 1H), 3.57 – 3.54 (m, 1H), 1.05 (d, *J* = 6.4 Hz, 3H);

^{13}C NMR (125 MHz, DMSO-*d6*) δ 159.7, 157.5, 153.5, 152.0, 142.4, 138.9, 135.2, 129.5, 126.6, 125.1, 122.9, 122.1, 119.1, 117.4, 115.4, 114.9, 113.4, 112.1, 101.7, 77.9, 76.1, 74.0, 71.9, 70.4, 56.8, 56.4, 17.13;

IR (neat) ν_{max} 3368, 2918, 2850, 1724, 1606, 1589, 1451, 1370, 1245, 1131, 1059 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_{27}H_{26}NaO_9$: 517.1469, found: 517.1485;
$[\alpha]_D^{22}$ +15.4 (*c* 0.14, MeOH).



C2-glycosyl isomer of chrysomycin A (36). To a suspension of **24** (2.2 mg, 0.0035 mmol) in 0.38 mL of MeOH was added 0.38 mL of 3.0 M H_2SO_4 in MeOH. The resulting reaction solution was stirred at 70 °C for 6.5 h and then cooled to r.t. The reaction was diluted with water (5 mL), and extracted with $CHCl_3$/*i*-PrOH (3/1) three times. The organic phases were washed with saturated aqueous $NaHCO_3$ and then dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (CH_2Cl_2/MeOH = 80/1 to 20/1) to afford C2-glycosyl isomer of chrysomycin A (**36**) (1.4 mg, 80%) as a yellow solid.

Mp 245-247 °C;

^{1}H NMR (500 MHz, $CDCl_3$) δ 9.89 (s, 1H), 8.29 (s, 1H), 8.11 (s, 1H), 8.08 (d, *J* = 8.7 Hz, 1H), 7.67 (d, *J* = 8.7 Hz, 1H), 7.33 (s, 1H), 6.79 (dd, *J* = 17.6, 10.9 Hz, 1H), 5.95 (d, *J* = 17.5 Hz, 1H), 5.46 (d, *J* = 10.9 Hz, 1H), 5.09 (d, *J* = 9.8 Hz, 1H), 4.44 (q, *J* = 6.4 Hz, 1H), 4.11 (s, 3H), 4.08 (s, 3H), 3.87 (d, *J* = 9.4 Hz, 1H), 3.44 (d, *J* = 4.2 Hz, 1H), 2.74 (s, 1H), 2.45 (s, 1H), 2.13 (s, 1H), 1.49 (s, 3H), 1.33 (d, *J* = 6.6 Hz, 3H);

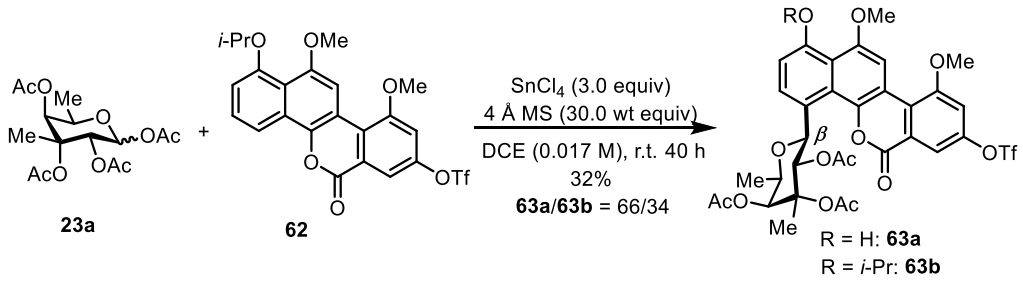
^{13}C NMR (125 MHz, $CDCl_3$) δ 161.0, 157.3, 151.7, 151.0, 141.5, 138.9, 135.3, 127.3, 125.6, 123.4, 123.0, 120.7, 116.6, 114.6, 114.5, 114.2, 114.1, 102.3, 76.0, 73.9, 73.5, 72.8, 71.5, 56.3, 56.2, 23.8, 16.7;

IR (neat) ν_{max} 3410, 3375, 2925, 2854, 1726, 1712, 1591, 1461, 1380 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{28}H_{29}O_9$: 509.1806, found: 509.1812;

$[\alpha]_D^{20}$ +5.0 (*c* 0.1, $CHCl_3$);

TLC: R_f = 0.35 (CH_2Cl_2/MeOH = 19/1).



Compound 63a and 63b. To a round bottom flask charged with **23a** (110 mg, 0.318 mmol), **62** (488.4 mg, 0.953 mmol) and 4 Å molecular sieves (3.3 g) and a stir bar was added 18.3 mL of anhydrous dichloroethane under argon. The resulting mixture was stirred at r.t. for 2 h. Then it was cooled to 0 °C and $SnCl_4$ (1.0 M in CH_2Cl_2, 0.96 mL, 0.96 mmol) was added dropwise. After kept at 0 °C for 30 min, the reaction was warmed to r.t. and stirred for 40 h. It was then quenched with saturated aqueous $NaHCO_3$ (40 mL), and extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Silica gel column chromatography (PE/CH_2Cl_2/EtOAc = 0/100/0 to 75/10/15 to 60/25/15) afforded **63a** (50.5 mg, 21%) and **63b** (26.9 mg, 11%) each as a yellow solid.

For 1-OH-4-glycosylated product **63a**:
Mp 323-325 °C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.80 (s, 1H), 8.40 (s, 1H), 8.01 (d, *J* = 2.5 Hz, 1H), 7.87 (d, *J* = 8.5 Hz, 1H), 7.25 (d, *J* = 2.5 Hz, 1H), 7.07 (d, *J* = 8.4 Hz, 1H), 6.74 (d, *J* = 10.0 Hz, 1H), 5.99 (s, 1H), 5.44 (d, *J* = 10.0 Hz, 1H), 4.60 (q, *J* = 6.4 Hz, 1H), 4.16 (s, 3H), 4.14 (s, 3H), 2.29 (s, 3H), 2.24 (s, 3H), 1.58 (s, 3H), 1.53 (s, 3H), 1.17 (d, *J* = 6.5 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.3, 170.1, 169.9, 158.8, 158.7, 154.7, 152.5, 148.9, 143.5, 130.0, 125.1, 125.0, 124.8, 123.9, 118.7 (q, *J* = 319 Hz), 116.4, 114.1, 113.7, 112.7, 110.4, 101.5, 81.4, 74.4, 72.5, 71.8, 70.2, 57.1, 56.3, 22.3, 20.9, 20.4, 18.6, 16.8.
IR (neat) ν_{max} 3375, 2925, 2853, 1736, 1594, 1428, 1370, 1219, 1140, 981 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{33}H_{32}F_3O_{15}S$: 757.1409, found: 757.1410;

$[\alpha]_D^{18}$ +71.6 (*c* 1.0, $CHCl_3$);

TLC: R_f = 0.40 (PE/EtOAc = 1/1).

For 1-*O*-isopropyl-4-glycosylated product **63b**:
Mp 103-105 °C;

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (s, 1H), 8.01 (d, *J* = 2.5 Hz, 1H), 7.87 (d, *J* = 8.5 Hz, 1H), 7.25 (d, *J* = 2.6 Hz, 1H), 7.10 (d, *J* = 8.5 Hz, 1H), 6.77 (d, *J* = 10.0 Hz, 1H), 5.99 (d, *J* = 0.7 Hz, 1H), 5.44 (d, *J* = 10.0 Hz, 1H), 4.68 – 4.59 (m, 2H), 4.16 (s, 3H),

3.99 (s, 3H), 2.29 (s, 3H), 2.24 (s, 3H), 1.54 (s, 3H), 1.53 (s, 3H), 1.44 (d, *J* = 6.0 Hz, 3H), 1.40 (d, *J* = 6.0 Hz, 3H), 1.18 (d, *J* = 6.5 Hz, 3H);

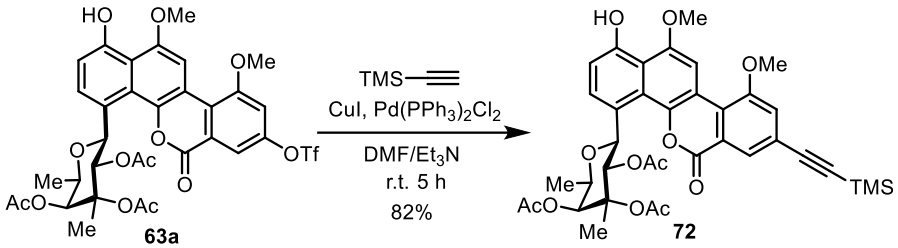
^{13}C NMR (100 MHz, $CDCl_3$) δ 170.3, 170.1, 169.9, 159.0, 158.9, 154.9, 153.7, 148.8, 142.7, 128.6, 126.5, 125.6, 125.2, 123.9, 121.2, 118.7 (q, *J* = 319 Hz), 113.9, 113.5, 113.3, 110.2, 104.9, 81.3, 74.5, 72.7, 72.6, 71.8, 70.2, 57.1, 57.0, 22.2, 22.1, 21.8, 20.9, 20.3, 18.6, 16.8;

IR (neat) ν_{max} 2924, 2854, 1750, 1731, 1593, 1370, 1218, 1052, 798 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{36}H_{38}F_3O_{15}S$: 799.1878, found: 799.1882;

$[\alpha]_D^{18}$ +89.9 (*c* 0.34, $CHCl_3$);

TLC: R_f = 0.58 (PE/EtOAc = 1/1).



Compound 72. To a mixture of **63a** (27 mg, 0.0357 mmol), CuI (0.7 mg, 0.00357 mmol), and $Pd(PPh_3)_2Cl_2$ (2.5 mg, 0.0357 mmol) was added DMF (4 mL) under argon. The resulting mixture was cooled to 0 °C, and then degassed and refilled with argon three times. It was treated with trimethylamine (49.6 μL, 0.357 mmol), followed by trimethylsilylacetylene (20 μL, 0.143 mmol). The reaction was warmed to r.t. and stirred for 5 h. The reaction was diluted with 20 mL of CH_2Cl_2/EtOAc (1/1) and filtered through a short pad of Celite. The filtrated was concentrated *in vacuo* and purified by silica gel chromatography (CH_2Cl_2/acetone = 50/1) to afford compound **72** (20.5 mg, 82%) as a yellow solid.

Mp 316-318 °C;

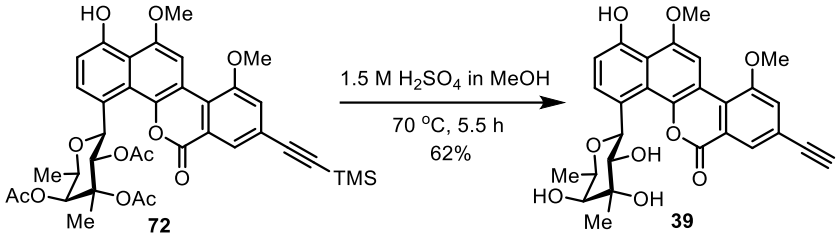
^{1}H NMR (400 MHz, $CDCl_3$) δ 9.84 (s, 1H), 8.49 (s, 1H), 8.23 (s, 1H), 7.84 (d, *J* = 8.5 Hz, 1H), 7.41 (s, 1H), 7.04 (d, *J* = 8.4 Hz, 1H), 6.79 (d, *J* = 10.0 Hz, 1H), 5.99 (s, 1H), 5.43 (d, *J* = 9.9 Hz, 1H), 4.63 (q, *J* = 6.0 Hz, 1H), 4.15 (s, 3H), 4.13 (s, 3H), 2.30 (s, 3H), 2.24 (s, 3H), 1.57 (s, 3H), 1.53 (s, 3H), 1.16 (d, *J* = 6.4 Hz, 3H), 0.30 (s, 9H);

^{13}C NMR (100 MHz, $CDCl_3$) δ 170.3, 170.1, 169.9, 159.3, 156.9, 154.6, 152.1, 143.4, 129.7, 126.1, 125.0, 124.8, 124.4, 124.4, 122.7, 119.2, 116.1, 113.5, 113.3, 103.1, 102.1, 97.7, 81.4, 74.5, 72.5, 71.9, 70.1, 56.5, 56.3, 29.7, 22.2, 20.9, 20.4, 18.6, 16.8, -0.2;
IR (neat) ν_{max} 3376, 2925, 2853, 1751, 1729, 1625, 1451, 1370, 1220, 1053, 857 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{37}H_{41}O_{12}Si$: 705.2362, found: 705.2357;

$[\alpha]_D^{17}$ +100.3 (*c* 0.2, $CHCl_3$);

TLC: R_f = 0.63 (PE/EtOAc = 1/1).



Compound 39. To a suspension of **72** (2.7 mg, 0.0038 mmol) in 0.5 mL of MeOH was added 0.5 mL of 3.0 M H_2SO_4 in MeOH. The resulting reaction solution was stirred at 70 °C for 5.5 h and then cooled to r.t. The reaction was diluted with water (5 mL), and extracted with $CHCl_3$/*i*-PrOH (3/1) three times. The organic phases were washed with saturated aqueous $NaHCO_3$ and then dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel (CH_2Cl_2/MeOH = 80/1 to 20/1) to afford **39** (1.2 mg, 62%) as a yellow solid.
Mp 150-152 °C;

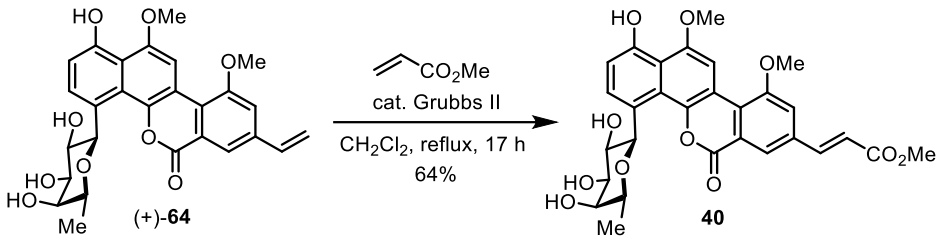
^{1}H NMR (500 MHz, $CDCl_3$) δ 9.76 (s, 1H), 8.40 (s, 1H), 8.19 (d, *J* = 1.2 Hz, 1H), 7.90 (d, *J* = 8.4 Hz, 1H), 7.41 (d, *J* = 1.4 Hz, 1H), 7.07 (d, *J* = 8.4 Hz, 1H), 6.26 (d, *J* = 9.7 Hz, 1H), 4.65 (q, *J* = 6.4 Hz, 1H), 4.13 (s, 3H), 4.11 (s, 3H), 3.89 (dd, *J* = 9.1, 5.0 Hz, 1H), 3.48 (d, *J* = 7.1 Hz, 1H), 3.27 (s, 1H), 3.17 (s, 1H), 2.18 (d, *J* = 5.4 Hz, 1H), 1.93 (d, *J* = 8.1 Hz, 1H), 1.54 (s, 3H), 1.25 (d, *J* = 6.5 Hz, 3H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 160.1, 157.0, 154.4, 152.4, 143.1, 129.3, 127.1, 126.2, 125.1, 125.0, 123.4, 122.5, 119.7, 116.0, 113.5, 113.5, 102.1, 81.9, 80.0, 76.9, 75.7, 75.7, 73.8, 72.2, 56.6, 56.4, 23.5, 16.7;
IR (neat) ν_{max} 3381, 3301, 2925, 2852, 1713, 1624, 1588, 1452, 1359, 1245, 1128, 1052 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{28}H_{27}O_9$: 507.1650, found: 507.1642;

$[\alpha]_D^{17}$ -8.9(*c* 0.2, $CHCl_3$);

TLC: R_f = 0.24 (CH_2Cl_2/MeOH = 19/1).



Compound 40. To a sealed tube were added (+)-**64** (2.8 mg, 0.0057 mmol), Grubbs's second-generation Ru-alkylidene catalyst (0.2 mg, 0.00024 mmol) and 0.2 mL of CH_2Cl_2 sequentially under argon. Then a solution of methyl acrylate (0.8 μL, 0.0085 mmol) in CH_2Cl_2 (0.1 mL) was added. The tube was then sealed and stirred at 40 ^oC for 13 h. A second batch of Grubbs's second-generation Ru-alkylidene catalyst (0.2 mg, 0.00024 mmol) and methyl acrylate (0.8 μL, 0.0085 mmol) were added. The reaction mixture was further stirred at 40 ^oC for 4 h. The mixture was concentrated *in vacuo* and the residue was purified by preparative TLC (CH_2Cl_2/MeOH = 93/7) to afford **40** (2.0 mg, 64%) as a yellow solid.

Mp >280 ^oC (decomposed);

^1H NMR (400 MHz, DMSO-*d6*) δ 9.86 (s, 1H), 8.52 (s, 1H), 8.23 (s, 1H), 8.00 (s, 1H), 7.85 (d, *J* = 16.1 Hz, 1H), 7.77 (d, *J* = 8.5 Hz, 1H), 7.00 (d, *J* = 8.4 Hz, 1H), 6.98 (d, *J* = 16.0 Hz, 1H), 5.64 (d, *J* = 9.4 Hz, 1H), 4.75 (d, *J* = 5.2 Hz, 1H), 4.51 (d, *J* = 5.4 Hz, 1H), 4.39 (d, *J* = 4.7 Hz, 1H), 4.20 (s, 3H), 4.13 (s, 3H), 4.06 (q, *J* = 6.3 Hz, 1H), 3.85 – 3.79 (m, 1H), 3.78 (s, 3H), 3.64 – 3.59 (m, 1H), 3.59 – 3.52 (m, 1H), 1.06 (d, *J* = 6.5 Hz, 3H);

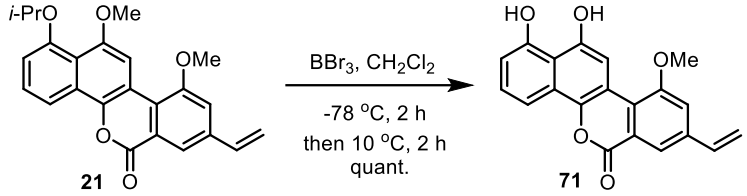
^{13}C NMR (200 MHz, DMSO-*d6*) δ 166.5, 159.4, 157.5, 153.5, 152.0, 143.0, 142.6, 135.6, 129.5, 126.8, 125.0, 122.2, 122.0, 120.4, 116.0, 115.7, 113.1, 112.4, 101.6, 77.9, 76.0, 74.1, 72.0, 70.5, 57.1, 56.4, 51.7, 17.1;

IR (neat) ν_{max} 3369, 2923, 2851, 1721, 1637, 1589, 1436, 1372, 1275, 1170, 1130;

HRMS (ESI) $[M + H]^+$ calculated for $C_{29}H_{29}O_{11}$: 553.1704, found: 553.1721;

$[\alpha]_D^{17}$ +18.4 (*c* 0.05, $CHCl_3$);

TLC: R_f = 0.19 (CH_2Cl_2/MeOH = 19/1).



Compound 71. To a stirred solution of **21** (5.0 mg, 0.0128 mmol) in 0.7 mL of CH_2Cl_2 at -78 °C was added BBr_3 (1.0 M in CH_2Cl_2, 64 μL, 0.064 mmol) dropwise. The resulting solution was stirred -78 °C for 2 h and then warmed to 10 °C over 2 h. The reaction was quenched with water (5 mL). The mixture was extracted with EtOAc three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo* to provide compound **71** (4.3 mg, quant.) as a yellow solid. The structure of **71** was determined by 2D-NMR analysis.

Mp >330 °C;

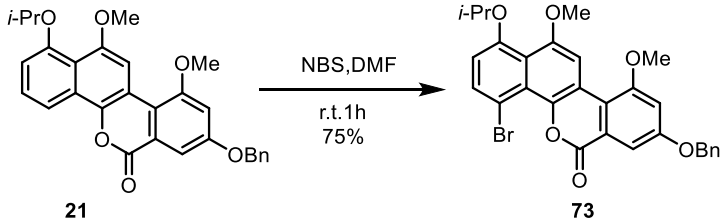
^{1}H NMR (400 MHz, Pyr) δ 8.38 (s, 1H), 8.16 (d, *J* = 1.4 Hz, 1H), 7.96 (d, *J* = 8.4 Hz, 1H), 7.27 (t, *J* = 8.0 Hz, 1H), 7.21 (s, 1H), 6.94 (d, *J* = 7.7 Hz, 1H), 6.60 (dd, *J* = 17.6, 10.9 Hz, 1H), 5.74 (d, *J* = 17.6 Hz, 1H), 5.13 (d, *J* = 10.9 Hz, 1H), 3.46 (s, 3H);

^{13}C NMR (100 MHz, Pyr) δ 161.6, 158.5, 156.4, 152.0, 141.0, 139.5, 128.9, 127.2, 121.0, 117.0, 116.5, 115.1, 115.0, 114.0, 112.0, 106.7, 56.4;

IR (neat) ν_{max} 3347, 3134, 2924, 2852, 1723, 1672, 1585, 1458, 1391, 1368, 1300, 1249, 1067 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{20}H_{15}O_5$: 335.0914, found: 335.0913;

TLC: R_f = 0.31 (PE/EtOAc = 2/1).



Compound 73. A solution of NBS (105mg,0,459mmol) in DMF (4.6 mL) was added to a solution of **21** (200mg,0,425mmol) in DMF at r.t. The reaction was stirred at r.t.

for 1h and then quenched with saturated aqueous $NaHCO_3$. The mixture was extracted with CH_2Cl_2 three times and the combined organic layers were dried over anhydrous Na_2SO_4. After filtration and concentration, the residue was purified by flash chromatography on silica gel (PE/EtOAc = 85/15) to afford **73** (175.1mg, 75%) as a yellow solid.

Mp 80-82 °C;

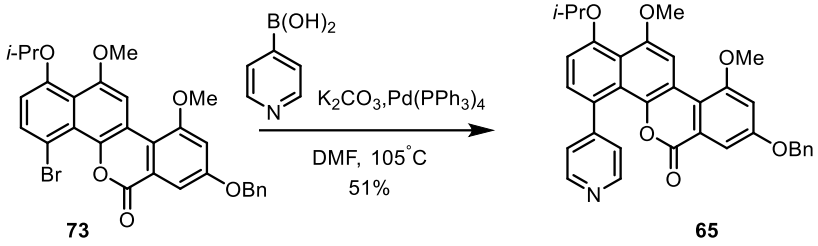
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.48 (s, 1H), 7.82 (d, J = 8.5 Hz, 1H), 7.68 (d, J = 4.5 Hz, 1H), 7.50 (d, J = 7.2 Hz, 2H), 7.46 – 7.33 (m, 3H), 7.00 (d, J = 2.5 Hz, 1H), 6.83 (d, J = 8.5 Hz, 1H), 5.21 (s, 2H), 4.55 (hept, J = 6.1 Hz, 1H), 4.05 (s, 3H), 3.98 (s, 3H), 1.41 (d, J = 6.1 Hz, 6H);

^{13}C NMR (125 MHz, $CDCl_3$) δ 160.2, 159.6, 158.8, 154.3, 152.8, 139.5, 135.9, 134.9, 128.73, 128.4, 127.9, 124.2, 121.4, 118.6, 115.1, 114.1, 107.9, 106.9, 106.4, 104.1, 99.9, 73.2, 70.6, 57.2, 56.3, 22.0.

IR (neat) ν_{max} 2977, 2837, 1718, 1605, 1586, 1368, 1351, 1314,1134,1029 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{29}H_{26}BrO_6$: 549.0907, found: 549.0910;

TLC: R_f = 0.41 (PE/EtOAc = 3/1)



Compound 65. K_2CO_3 (26.7 mg, 0.193 mmol), Pyridine-4-boronic acid (18mg, 0.145mmol) were dried in a tube, then **73** (53 mg, 0.0965 mmol) and $Pd(PPh)_4$ (22.3mg,0.0193mmol) was added. The mixture were evacuated and backfilled with argon 3 times, then DMF（0.9ml） was added. The reaction was stirred at 103 ° C for 12h and then diluted with EtOAc, after filtration and concentration, the residue was purified by flash chromatography on silica gel (Acetone/CH_2Cl_2 = 4/96 to 8/92) to afford **65**（53.9 mg, 51%）as a yellow solid.

Mp 185-187 °C;

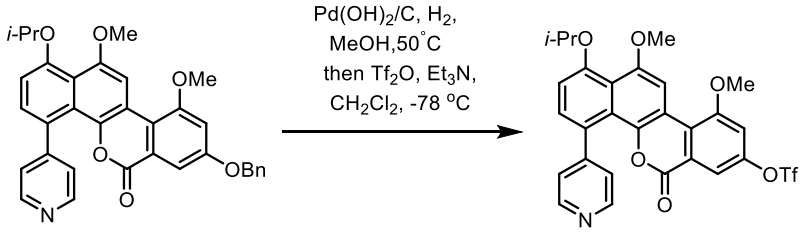
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.64 (s, 2H), 8.47 (s, 1H), 7.51 – 7.22 (m, 9H), 7.03 (d, J = 8.1 Hz, 1H), 6.96 (d, J = 1.6 Hz, 1H), 5.11 (s, 2H), 4.66 (hept, J = 6.0 Hz, 1H), 4.04 (s, 3H), 4.02 (s, 3H), 1.48 (d, J = 6.0 Hz, 6H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 159.5, 159.4, 158.8, 155.1, 153.3, 148.8, 140.2, 135.9, 130.7, 128.7, 128.4, 127.8, 124.2 – 122.9 (m), 119.9, 118.5, 114.7, 112.2, 106.9, 106.3, 104.1, 72.9, 70.5, 57.3, 56.3, 22.1.

IR(neat)ν_{max} 3360, 3170 2921, 2850, 1721, 1604, 1585, 1438, 1381, 1351, 1305, 1133, 1119 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{34}H_{30}NO_6$: 548.2068, found: 548.2062;

TLC: R_f = 0.55 (DCM/MeOH = 9/1)



65 **66**

Compound 66. To a mixture of **65** (36.3mg, 0.0663 mmol) and 5% $Pd(OH)_2/C$ (7.3 mg) was added 6 mL of MeOH. The resulting mixture was degassed at -78 °C and backfilled with H_2 three times and equipped with an H_2-filled balloon. Then the reaction was stirred at 50 ° C for 6 h followed by concentration *in vacuo*. The residue was redissolved in 1.3 mL of CH_2Cl_2. To the solution was added triethyl amine (54 μL, 0.391 mmol) at r.t. and the resulting solution was cooled to -78 °C and treated with trifluoromethanesulfonic anhydride (20 μL, 0.119 mmol) dropwise. The whole was allowed to stir for 1 h, quenched with saturated aqueous $NaHCO_3$ (5 mL) and warmed to r.t. The mixture was extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The residue was purified by silica gel column chromatography (Acetone/CH_2Cl_2 = 10/90) to afford compound **66** (35.3mg) as a yellow solid.

Mp 120-122 °C;

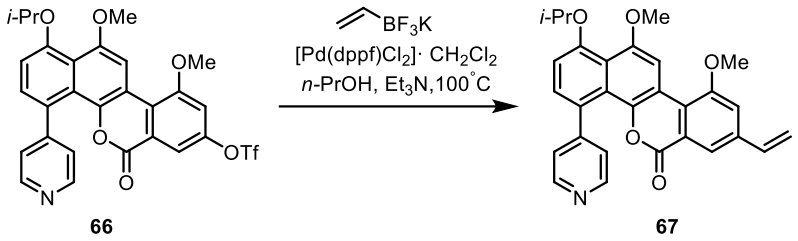
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.65 (d, J = 4.7 Hz, 2H), 8.44 (s, 1H), 7.81 (d, J = 2.5 Hz, 1H), 7.34 – 7.28 (m, 3H), 7.20 (d, J = 2.5 Hz, 1H), 7.09 (d, J = 8.2 Hz, 1H), 4.69 (hept, J = 6.0 Hz,1H), 4.15 (s, 3H), 4.03 (s, 3H), 1.49 (d, J = 6.0 Hz, 6H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 158.9, 157.9, 155.3, 153.7, 148.9, 148.2, 141.5, 135.7, 131.1, 128.5, 127.8, 124.8, 124.3, 123.8, 120.7, 119.9, 117.4, 114.1, 113.4, 112.5, 110.3, 105.7, 72.8, 57.3, 56.9, 22.0.

IR(neat)ν_{max} 3362, 3193, 2923, 2850, 1735, 1646, 1593, 1470, 1377, 1247, 1216, 1141 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{28}H_{23}F_3NO_8S$: 590.1091, found: 590.1094;

TLC: R_f = 0.55 (DCM/MeOH = 9/1)



66 **67**

Compound 67. To a suspension of **66** (35.3mg, 0.0599 mmol), potassium vinyltrifluoroborate (12.5 mg, 0.0899 mmol), $[Pd(dppf)Cl_2]\cdot CH_2Cl_2$ (1.5 mg, 0.0018mmol) in 2.5 mL of *n*-PrOH was added triethyl amine (13.3 μL, 0.0958 mmol) under argon. The resulting reaction mixture was heated at reflux for 4 h. The reaction was cooled and diluted with water (5 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo* to afford a crude solid which was purified by silica gel column chromatography (Acetone/CH_2Cl_2 = 10/90) to afford **67** (24.4 mg) as a yellow solid.

Mp 67-69 °C;

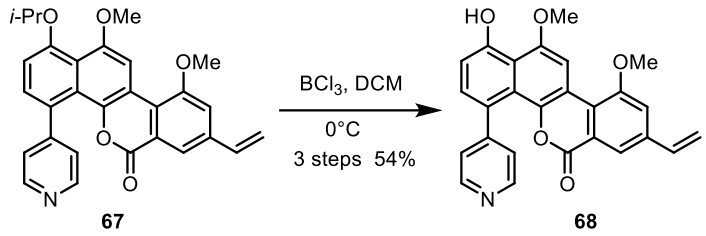
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.65 (s, 2H), 8.53 (s, 1H), 7.97 (s, 1H), 7.35 (s, 3H), 7.28 (s, 1H), 7.06 (d, J = 8.1 Hz, 1H), 6.76 (dd, J = 17.5, 10.8 Hz, 1H), 5.90 (d, J = 17.5 Hz, 1H), 5.42 (d, J = 10.9 Hz, 1H), 4.68 (hept, J = 6.1 Hz, 1H), 4.12 (s, 3H), 4.04 (s, 3H), 1.48 (d, J = 6.0 Hz, 6H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 159.4, 157.6, 155.3, 153.3, 141.1, 138.9, 135.3, 130.8, 124.0, 123.4, 120.4, 116.5, 114.6, 114.0, 112.4, 106.5, 99.9, 72.9, 57.3, 56.4, 22.1.

IR (neat) ν_{max} 3360, 2919, 2850, 1726, 1659, 1633, 1470,1377,1261, 1119 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{29}H_{26}NO_5$: 468.1805, found: 468.1803;

TLC: R_f = 0.57 (DCM/MeOH = 9/1)



67 68

Compound 68. To a solution of **67** (24.4 mg, mmol) in 1 mL of CH_2Cl_2 at 0 °C was added BCl_3 (1.0 M in CH_2Cl_2, 0.26 mL, 0.26 mmol) dropwise. The resulting solution was stirred for 15 min and quenched with water (5 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Flash chromatography (Acetone/CH_2Cl_2 = 10/90) provided **68** (15.2 mg, 54% from **65**) as a yellow solid.

Mp 85-87 °C;

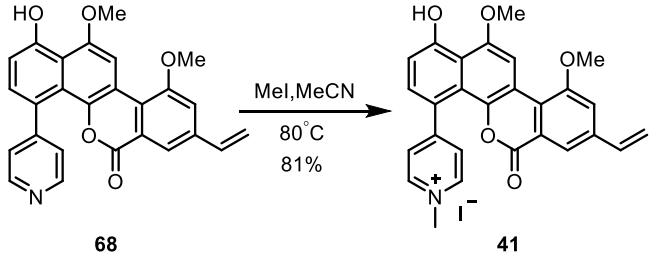
^{1}H NMR (400 MHz, $CDCl_3$) δ 9.78 (s, 1H), 8.64 (d, J = 4.5, 1.5 Hz, 2H), 8.49 (s, 1H), 7.96 (s, 1H), 7.32 (s, 1H), 7.28 (m, 3H), 7.04 (d, J = 8.1 Hz, 1H), 6.75 (dd, J = 17.5, 10.9 Hz, 1H), 5.89 (d, J = 17.5 Hz, 1H), 5.42 (d, J = 10.9 Hz, 1H), 4.18 (s, 3H), 4.11 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 159.2, 157.3, 154.7, 152.0, 148.9, 141.9, 138.9, 135.2, 132.20 127.4, 123.9, 123.3, 123.2, 123.1, 120.4, 116.6, 115.6, 113.9, 113.8, 112.2, 102.9, 56.4, 56.3.

IR (neat) ν_{max} 3363, 2920, 2851, 1728, 1646, 1633, 1470, 1377, 1334, 1245, 1170, 1130 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{26}H_{20}NO_5$: 426.1336, found: 426.1341;

TLC: R_f = 0.55 (DCM/MeOH = 9/1)



68 41

Compound 41. 68 (1.5 mg, 0.00352 mmol) was taken in dry acetonitrile (0.5 mL) and

methyl iodide (1.1 μl, 0.0176 mmol) was added to it and then refluxed for 8 h. Then the reaction was allowed to come to room temperature and the solvent was evaporated. The crude product was purified by PTLC (CH_2C1_2/MeOH = 90/10) to afford **41** (1.6mg, 81%) as a yellow crystalline solid.

Mp 172-174 ^oC;

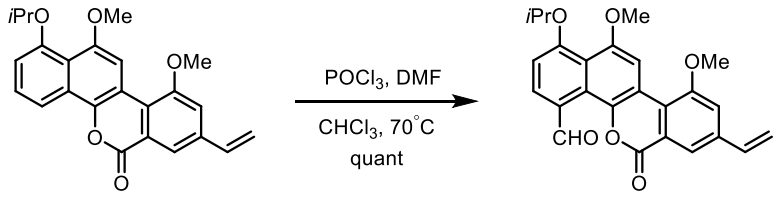
^1H NMR (400 MHz, CD_3OD) δ 8.79 (d, J = 6.3 Hz, 2H), 8.49 (s, 1H), 7.98 (d, J = 6.1 Hz, 2H), 7.83 (s, 1H), 7.52 (s, 1H), 7.44 (d, J = 8.2 Hz, 1H), 7.02 (d, J = 8.1 Hz, 1H), 6.83 (dd, J = 17.5, 10.9 Hz, 1H), 6.00 (d, J = 17.6 Hz, 1H), 5.48 (d, J = 10.9 Hz, 1H), 4.46 (s, 3H), 4.15 (s, 3H), 4.11 (s, 3H).

^{13}C NMR (125 MHz, CD_3OD) δ 163.1, 161.1, 159.3, 158.4, 153.8, 145.0, 141.6, 141.3, 136.4, 134.4, 128.8, 123.9, 123.9, 123.8, 123.6, 120.5, 117.6, 116.7, 116.4, 115.8, 113.2, 104.5, 57.1, 57.1, 48.0.

IR (neat) ν_{max} 3405, 1717, 1615, 1578, 1428, 1379, 1333,1308,1226, 1137 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{27}H_{22}NO_5$: 440.1492, found: 440.1492;

TLC: R_f = 0.29 (DCM/MeOH = 9/1)



21 42

Compound 42. 21 (150mg, 0.384mmol) was dissolved in $CHCl_3$ (7.5ml) and treated with DMF(0.6ml), to this mixture $POCl_3$ (0.7ml) was added dropwise at 0 ^oC. The reaction was refluxed at 70 ^oC under argon for 6h. The reaction mixture was then cooled to 0 ^oC and diluted with CH_2Cl_2. 1N aqueous sodium hydroxide solution was slowly added until the aqueous layer became basic. The organic layer was separated, dried over Na_2SO_4, and concentrated in vacuo. purified by silica gel column chromatography (PE/EtOAc=20/80) to afford **42** (160.6 mg, quant) as a yellow solid.

Mp 226-229 ^oC;

^1H NMR (400 MHz, $CDCl_3$) δ 11.16 (s, 1H), 8.48 (s, 1H), 8.12 (d, J = 1.5 Hz, 1H), 8.09 (d, J = 8.4 Hz, 1H), 7.36 (d, J = 1.5 Hz, 1H), 7.00 (d, J = 8.4 Hz, 1H), 6.79 (dd, J = 17.5, 10.9 Hz, 1H), 5.96 (d, J = 17.6 Hz, 1H), 5.46 (d, J = 10.9 Hz, 1H), 4.81 – 4.73 (m, 1H),

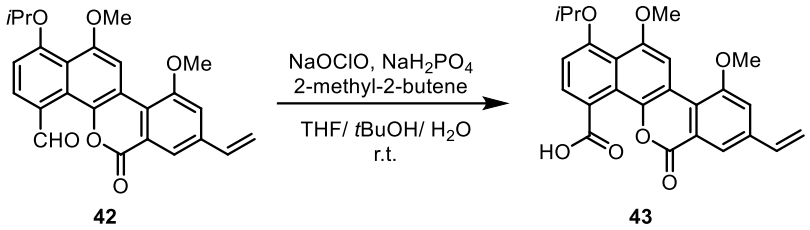
4.13 (s, 3H), 4.00 (s, 3H), 1.49 (d, J = 6.0 Hz, 6H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 193.1, 160.4, 159.5, 157.8, 154.1, 141.5, 139.4, 135.4, 131.6, 127.2, 125.4, 123.4, 123.3, 120.6, 119.2, 116.9, 115.9, 114.4, 110.0, 106.4, 72.3, 57.3, 56.5, 22.1.

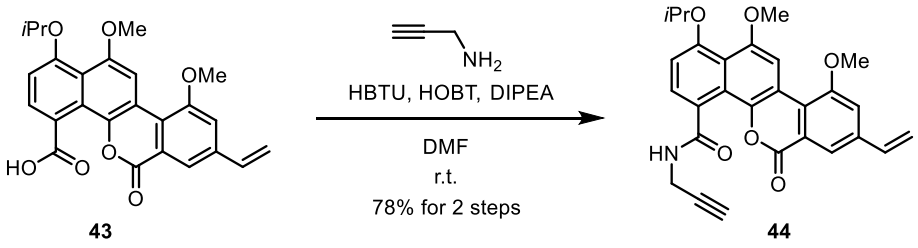
IR (neat) ν_{max} 2928, 1724, 1673, 1581, 1452, 1318, 1133, 995 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{25}H_{22}O_6$: 419.1489, found: 419.1494;

TLC: R_f = 0.31 (PE/EtOAc = 3/1)



Compound 43. To a solution of **42** (200 mg, 0.478 mmol), NaH_2PO_4 (745.7 mg, 4.78 mmol), and 2-methyl-2-butene (1.52 mL, 14.34 mmol) in THF, tBuOH and water (4:4:1, 0.04M) at room temperature was added sodium chlorite (432.3 mg, 4.78 mmol), and the mixture was allowed to stir for 12 h, A saturated aqueous Na_2CO_3 solution (200 mL) was added. After 5min, the crude was extracted with EtOAc (100 mL). The organic layer was then dried with Na_2SO_4 and concentrated in vacuo to afford a yellow solid which was used directly in the next step.



Compound 44. To a stirring solution of crude **43** and propargylamine (153 μL, 2.39 mmol) in dry DMF (5 mL) was successively added N-hydroxybenzotriazole monohydrate (64.6 mg, 0.478mmol), diisopropylethylamine (395 μL, 2.39 mmol), and HBTU (217.5 mg, 0.574 mmol). The mixture was stirred at room temperature under nitrogen for 12 h. then concentrated under reduced pressure to yield a crude yellow solid which was purified by silica gel column chromatography (PE/EtOAc = 1/1) to

afford **44** (162.0 mg, 78% for 2 steps) as a yellow solid.

Mp 308-311 ^{o}C;

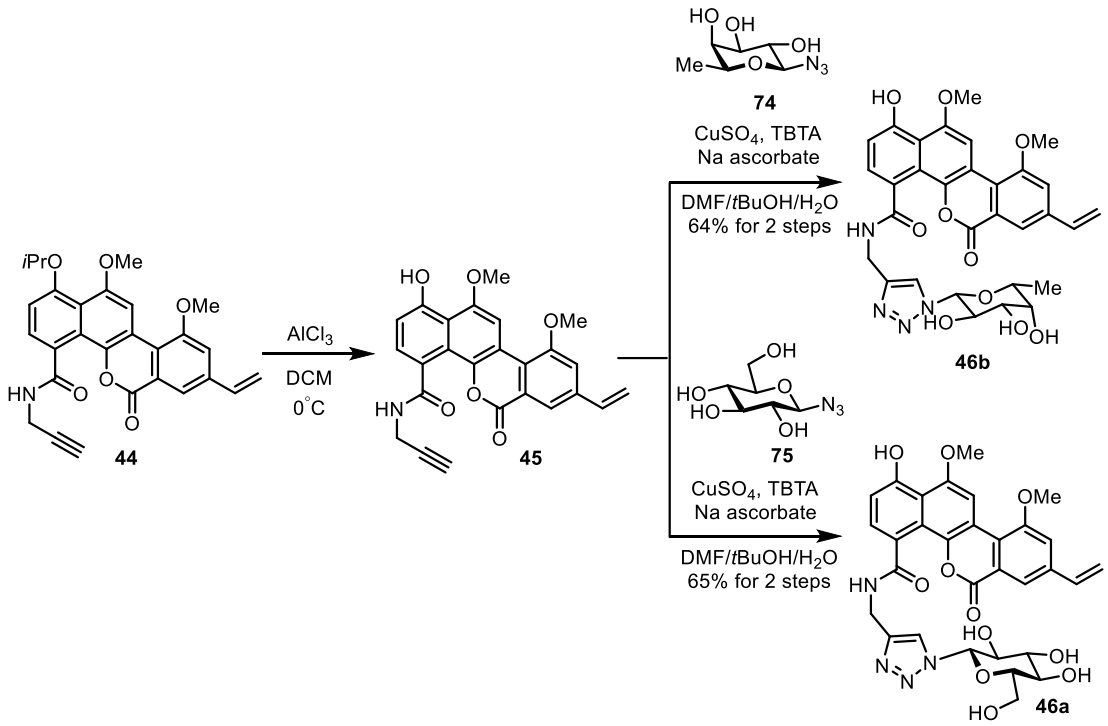
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 (s, 1H), 8.00 (s, 1H), 7.29 (d, J = 8.0 Hz, 1H), 7.03 (s, 1H), 6.97 (s, 1H), 6.76 (dd, J = 17.6, 10.9 Hz, 1H), 6.70 (d, J = 8.0 Hz, 1H), 5.91 (d, J = 17.5 Hz, 1H), 5.46 (d, J = 10.9 Hz, 1H), 4.57 (m, 3H), 4.02 (s, 3H), 3.91 (s, 3H), 2.36 (t, J = 2.5 Hz, 1H), 1.49 (d, J = 6.0 Hz, 6H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 171.7, 159.9, 157.2, 155.3, 152.7, 140.0, 138.4, 135.6, 127.2, 125.7, 123.4, 123.3, 122.8, 120.0, 119.2, 116.5, 114.0, 113.2, 111.8, 105.3, 80.6, 73.2, 71.9, 56.9, 55.9, 30.6, 22.3.

IR (neat) ν_{max} 3361, 3234, 1713, 1656, 1527, 1387, 1339, 1322, 1251cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{28}H_{26}NO_6$: 472.1760, found: 472.1761;

TLC: R_f = 0.67 (DCM / MeOH = 19/1)



Compound 45. To a solution of **44** (18.7 mg, 0.0396 mmol) in 2mL of CH_2Cl_2 at 0 ^{o}C was added $AlCl_3$ (26.4 mg, 0.198 mmol) dropwise. The resulting solution was stirred for 30 min and quenched with water (5 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated to afford a yellow solid which was used directly in the next

step.

Compound 46a/46b Azido glycan **75/74** (2.0 eq.) and $CuSO_4$ (2.0 mg, 0.0125 mmol) were dissolved in water (200 μL). To the mixture were added sodium ascorbate (14.0 mg, 0.0707 mmol), TBTA (Tris[(1-benzyl-1,2,3-triazol-4-yl)methyl]amine (4 mg, 0.0755mmol), DMF (200 μL), t-BuOH (200 μL) and the mixture was kept at room temperature. Crude **45** was added to the reaction mixture and stirred at room temperature for 3h and the reaction was lyophilized. The residues were purified by prepare HPLC to afford **46b** (15.7 mg, 64% for 2 steps) / **46a** (16.3 mg, 65% for 2 steps) as a yellow solid.

For **46b**

Mp >330 ºC;

^{1}H NMR (400 MHz, DMSO) δ 8.58 (t, J = 5.4 Hz, 1H), 8.51 (s, 1H), 8.15 (s, 1H), 8.05 (d, J = 1.4 Hz, 1H), 7.78 (s, 1H), 7.44 (d, J = 8.0 Hz, 1H), 7.01 – 6.91 (m, 2H), 6.18 (d, J = 17.6 Hz, 1H), 5.52 (d, J = 11.1 Hz, 1H), 5.44 (d, J = 9.2 Hz, 1H), 5.19 (d, J = 6.0 Hz, 1H), 4.98 (d, J = 5.4 Hz, 1H), 4.65 (d, J = 5.6 Hz, 1H), 4.19 (s, 3H), 4.14 (s, 3H), 4.00 (d, J = 7.1 Hz, 2H), 3.87 (d, J = 6.5 Hz, 1H), 3.54 (d, J = 4.3 Hz, 2H), 3.17 (d, J = 5.2 Hz, 1H), 1.12 (d, J = 6.4 Hz, 3H).

^{13}C NMR (150 MHz, DMSO) δ 170.6, 159.3, 157.6, 154.5, 152.0, 145.1, 140.3, 139.2, 135.3, 129.0, 125.4, 122.7, 122.5, 122.1, 121.6, 119.6, 117.6, 114.9, 114.6, 113.6, 111.8, 102.2, 88.0, 73.9, 73.2, 71.2, 68.9, 56.8, 56.4, 54.9, 16.4.

IR (neat) ν_{max} 3010, 2673, 1677, 1595, 1376, 1317, 1281, 1023 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{31}H_{31}N_4O_{10}$: 619.2035, found: 619.2037;

TLC: R_f = 0.40 (DCM / MeOH = 19/1)

$[\alpha]_D^{25}$ -15.99 (*c* 0.05, DMSO);

For **46a**

Mp >330 ºC;

^{1}H NMR (400 MHz, DMSO) δ 9.84 (s, 1H), 8.59 (s, 1H), 8.50 (s, 1H), 8.26 (s, 1H),

8.03 (s, 1H), 7.77 (s, 1H), 7.46 (d, J = 7.9 Hz, 1H), 6.95 (m, 2H), 6.17 (d, J = 17.6 Hz, 1H), 5.53 (s, 1H), 5.51 (d, J = 3.2 Hz, 1H), 5.35 (d, J = 6.0 Hz, 1H), 5.27 (d, J = 4.9 Hz, 1H), 5.14 (d, J = 5.5 Hz, 1H), 4.64 (d, J = 5.6 Hz, 1H), 4.18 (s, 3H), 4.13 (s, 3H), 3.80 (d, J = 6.1 Hz, 1H), 3.68 (dd, J = 9.8, 5.7 Hz, 1H), 3.48 – 3.35 (m, 4H), 3.23 (d, J = 5.5 Hz, 1H).

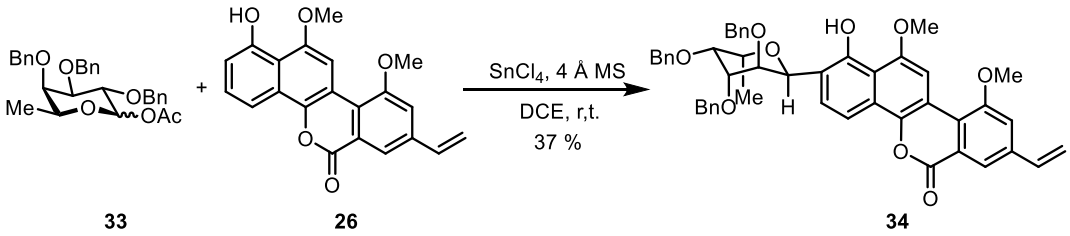
^{13}C NMR (125 MHz, DMSO) δ 170.9, 159.7, 158.0, 154.9, 152.4, 140.7, 139.6, 135.7, 129.6, 125.8, 123.1, 122.9, 122.5, 119.9, 118.0, 115.4, 115.0, 114.0, 112.2, 102.6, 87.9, 80.4, 77.5, 72.5, 70.1, 61.2, 60.2, 57.3, 56.8, 55.4, 40.6, 40.5, 40.4, 40.35, 40.3, 40.2, 40.0, 39.8, 39.7, 39.5, 36.01, 21.2, 14.6.

IR (neat) ν_{max} 3001, 2513, 1659, 1437, 1407, 1317, 1023 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{31}H_{31}N_4O_{11}$: 635.1989, found: 635.1987;

TLC: R_f = 0.36 (DCM / MeOH = 19/1)

$[\alpha]_D^{25}$ 2.9 (*c* 0.19, DMSO);



33 26 34

Compound 34. To a round bottom flask charged with **33** (49.8 mg, 0.105 mmol), **26** (43.7 mg, 0.125 mmol), 4 Å molecular sieves (1.00 g) and a stir bar was added 4.8 mL of anhydrous dichloroethane under argon. Then $SnCl_4$ (1.0 M in CH_2Cl_2, 0.31mL, 0.305 mmol) was added to the mixture dropwise. The reaction was stirred for 18 h. It was then quenched with saturated aqueous $NaHCO_3$ (10 mL), and extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Silica gel column chromatography (CH_2Cl_2/EtOAc = 100/0 to 98/2) afforded compound **34** (29.7 mg, 37%) as a yellow solid.

For **34**:

Mp 103-106 ^{o}C;

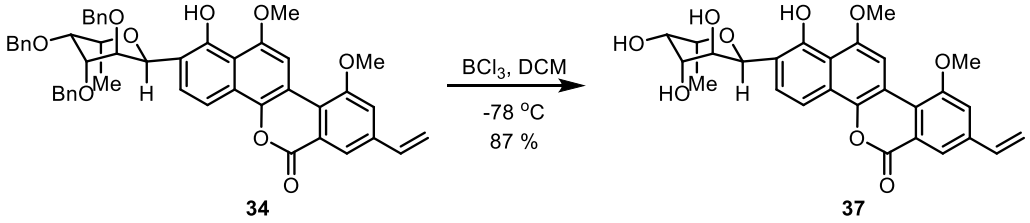
^{1}H NMR (400 MHz, $CDCl_3$) δ 9.71 (s, 1H), 8.22 (s, 1H), 8.11 – 8.01 (m, 2H), 7.75 (d, *J* = 8.8 Hz, 1H), 7.47 (d, *J* = 7.2 Hz, 2H), 7.42 (d, *J* = 7.3 Hz, 2H), 7.34 (ddd, *J* = 17.0, 9.4, 4.2 Hz, 7H), 7.03 (t, *J* = 7.3 Hz, 1H), 6.96 (t, *J* = 7.3 Hz, 2H), 6.84 (d, *J* = 7.1 Hz, 2H), 6.76 (dd, *J* = 17.5, 11.0 Hz, 1H), 5.93 (d, *J* = 17.5 Hz, 1H), 5.44 (d, *J* = 10.8 Hz, 1H), 5.12 (d, *J* = 11.8 Hz, 1H), 5.04 (d, *J* = 9.5 Hz, 1H), 4.87 (d, *J* = 11.8 Hz, 1H), 4.82 (d, *J* = 4.9 Hz, 1H), 4.79 (d, *J* = 4.9 Hz, 1H), 4.55 (d, *J* = 10.7 Hz, 1H), 4.14 (t, *J* = 9.5 Hz, 1H), 4.09 (s, 3H), 4.05 – 4.01 (m, 1H), 3.99 (s, 3H), 3.83 (dd, *J* = 9.5, 2.6 Hz, 1H), 3.77 – 3.72 (m, 2H), 1.28 (d, *J* = 6.3 Hz, 3H).

^{13}C NMR (101 MHz, CDCl3) δ 161.3, 157.3, 152.1, 151.9, 141.6, 140.8, 139.2, 139.0, 138.7, 138.2, 135.4, 128.5, 128.4, 128.2, 127.9, 127.7, 127.6, 127.3, 125.7, 123.6, 123.4, 123.2, 120.7, 116.6, 114.6, 114.0, 113.6, 112.9, 102.0, 100.1, 85.2, 80.5, 77.74, 77.4, 75.3, 75.1, 74.7, 73.2, 56.3, 56.2, 17.7.

IR (neat) ν_{max} 2924, 1727, 1582, 1454, 1380, 1300, 1133, 1068 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_{48}H_{44}NaO_9$: 787.2877, found 787.2882;

$[\alpha]_D^{26}$ +2.445 (*c* 0.11, $CHCl_3$);



Compound 37. To a solution of **34** (5.0 mg, 0.00654 mmol) in 0.8 mL of CH_2Cl_2 at -78 °C was added BCl_3 (1.0 M in hexane, 39.0 μL, 0.0392 mmol) dropwise. The resulting solution was stirred for 2 hours and quenched with water. The mixture was warmed to room temperature and extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Flash chromatography (CH_2Cl_2/MeOH = 100/0 to 97/3) provided compound **37** (2.8 mg, 87%) as a yellow solid.

For **37**:

Mp 280-284 °C;

^{1}H NMR (600 MHz, DMSO) δ 9.75 (s, 1H), 8.40 (d, *J* = 5.7 Hz, 1H), 8.02 (s, 1H), 7.86 (d, *J* = 8.7 Hz, 1H), 7.74 (s, 1H), 7.67 (d, *J* = 8.8 Hz, 1H), 6.94 (dd, *J* = 17.6, 11.0 Hz, 1H), 6.16 (d, *J* = 17.6 Hz, 1H), 5.50 (d, *J* = 11.0 Hz, 1H), 4.68 (d, *J* = 3.4 Hz, 1H), 4.67

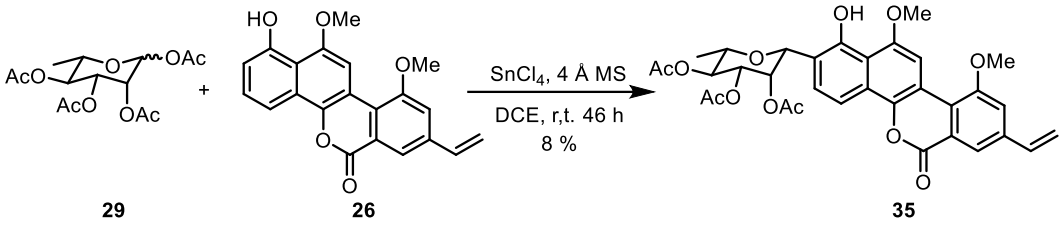
(s, 1H), 4.53 (d, *J* = 5.4 Hz, 1H), 4.47 (d, *J* = 5.2 Hz, 1H), 4.17 (s, 3H), 4.13 (s, 3H), 3.76 (td, *J* = 9.3, 5.3 Hz, 1H), 3.68 (q, *J* = 6.3 Hz, 1H), 3.59 – 3.56 (t, 1H), 3.49 (m, *J* = 9.1, 5.8, 3.4 Hz, 1H), 1.15 (d, *J* = 6.4 Hz, 3H).

^{13}C NMR (151 MHz, DMSO) δ 160.2, 157.5, 151.9, 151.7, 140.5, 138.8, 135.3, 128.4, 124.6, 123.8, 122.8, 122.7, 119.7, 117.3, 114.8, 114.1, 112.6, 111.9, 101.6, 75.4, 74.5, 74.4, 71.8, 70.4, 56.7, 56.3, 17.1.

IR (neat) ν_{max} 2960, 2922, 2852, 1723, 1632, 1456, 1379, 1259, 1088 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_{27}H_{26}NaO_9$: 517.1469, found 517.1471;

$[\alpha]_D^{26}$ +0.288 (*c* 0.05, $CHCl_3$);



29 **26** **35**

Compound 35. To a round bottom flask charged with **26** (400 mg, 1.204 mmol), **29** (105.0 mg, 0.301 mmol) and a stir bar was added 17.7 mL of anhydrous dichloroethane under argon. Then $SnCl_4$ (1.0 M in CH_2Cl_2, 2.7 mL, 2.709 mmol) was added to the mixture dropwise. The reaction was stirred for 46 h. It was then quenched with saturated aqueous $NaHCO_3$ (30 mL), and extracted with CH_2Cl_2 three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. Silica gel column chromatography (CH_2Cl_2/EtOAc = 100/0 to 98/2) afforded compound **35** (15.1 mg, 8%) as a yellow solid.

For **35**:

Mp 292-294 ^{o}C;

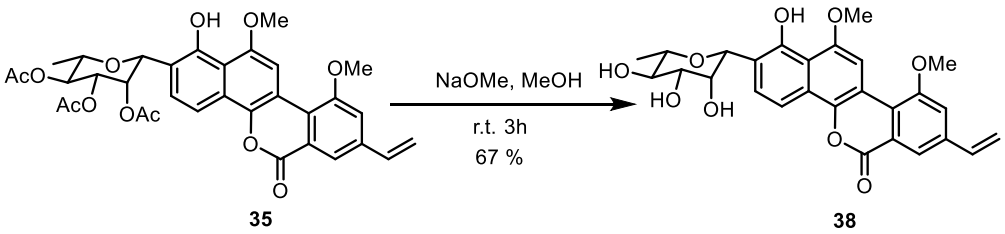
^{1}H NMR (400 MHz, $CDCl_3$) δ 9.52 (s, 1H), 8.01 – 7.95 (m, 3H), 7.68 (d, *J* = 8.8 Hz, 1H), 7.15 (s, 1H), 6.68 (dd, *J* = 17.5, 10.9 Hz, 1H), 5.88 (d, *J* = 17.5 Hz, 1H), 5.70 (d, *J* = 2.5 Hz, 1H), 5.40 (d, *J* = 10.8 Hz, 1H), 5.33 (dd, *J* = 10.1, 3.2 Hz, 1H), 5.23 (d, *J* = 7.1 Hz, 2H), 3.98 (s, 3H), 3.93 (s, 3H), 3.80 (dd, *J* = 9.3, 6.2 Hz, 1H), 2.11 (s, 3H), 1.99 (s, 3H), 1.87 (s, 3H), 1.41 (d, *J* = 6.1 Hz, 3H).

^{13}C NMR (126 MHz, $CDCl_3$) δ 170.3, 170.1, 170.1, 161.1, 157.0, 151.7, 149.6, 141.2, 138.5, 135.2, 126.8, 125.2, 123.2, 123.0, 120.3, 120.1, 116.3, 113.8, 113.8, 112.7, 112.5, 101.4, 74.8, 73.2, 72.4, 71.3, 69.6, 56.0, 55.7, 20.9, 20.7, 20.6, 17.9.

IR (neat) ν_{max} 2962, 1746, 1591, 1382, 1259, 1226, 1093, 1016 cm^{-1};

HRMS (ESI) $[M + Na]^+$ calculated for $C_{33}H_{32}NaO_{12}$: 643.1786, found 643.1792;

$[\alpha]_D^{26}$ +9.678 (*c* 0.2, $CHCl_3$);



Compound 38. To a suspension of **35** (9.5 mg, 0.0153 mmol) in MeOH (0.5 mL) was added a 1.0 M solution of NaOMe in MeOH (34 μL) at room temperature. Stirring was continued for 3 h, The suspension was treated with AcOH (0.2 mL) and concentrated in vacuo. The residue was purified by PTLC (CH_2C1_2/MeOH = 90/10) to afford compound **38** (5.1 mg, 67%) as a yellow crystalline solid.

For **38**:

Mp > 330 ^oC;

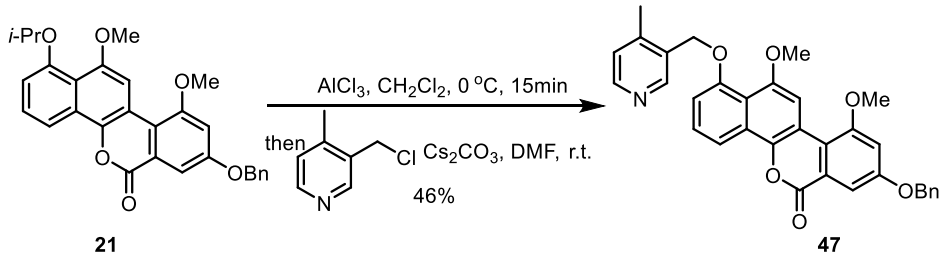
^1H NMR (500 MHz, DMSO) δ 9.73 (s, 1H), 8.30 (s, 1H), 7.97 (d, *J* = 1.4 Hz, 1H), 7.81 (d, *J* = 8.7 Hz, 1H), 7.71 (d, *J* = 8.7 Hz, 1H), 7.67 (d, *J* = 1.3 Hz, 1H), 6.90 (dd, *J* = 17.6, 11.0 Hz, 1H), 6.13 (d, *J* = 17.6 Hz, 1H), 5.48 (d, *J* = 11.0 Hz, 1H), 4.87 (s, 1H), 4.83 (br, 1H), 4.68 (br, 1H), 4.27 (d, *J* = 4.9 Hz, 1H), 4.13 (s, 3H), 4.09 (s, 3H), 3.96 (br, 1H), 3.45 (br, 1H), 1.30 (d, *J* = 5.4 Hz, 3H).

^{13}C NMR (126 MHz, DMSO) δ 160.1, 157.3, 151.6, 148.7, 140.5, 138.6, 135.2, 128.7, 124.2, 123.7, 122.7, 122.6, 119.6, 117.1, 114.6, 113.5, 112.0, 111.2, 101.1, 76.4, 74.9, 74.5, 72.1, 69.9, 56.6, 56.1, 18.4.

IR (neat) ν_{max} 2927, 2850, 1727, 1645, 1469, 1261, 1096 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{27}H_{27}O_9$: 495.1649, found: 495.1649;

$[\alpha]_D^{26}$ -1.166 (*c* 0.21, DMSO);



Compound 47. To a solution of **21** (175 mg, 0.372 mmol) in 35 mL of CH_2Cl_2 at 0 °C was added $AlCl_3$ (245 mg, 1.83 mmol). The resulting solution was monitored by TLC and stirred for 15 min at 0 °C and quenched with water (5 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*. The crude product was dissolved in DMF (30ml) with Cs_2CO_3 (606 mg, 1.86 mmol), then the pyridine (158 mg, 1.12 mmol) part was added to the solution at 0 °C. The mixture was allowed to stirred at r.t. for 8h. Then the mixture was diluted with EA (60 ml), and washed by statured $NaHCO_3$ solution (30 ml) for two times, and then washed by brine (30 mL). Then the combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*, The crude product was purified by silica gel column chromatography (CH_2Cl_2/MeOH = 200/1) to afford **47** (91.4 mg, 46%) as a yellow solid.

Mp 245-247 °C;

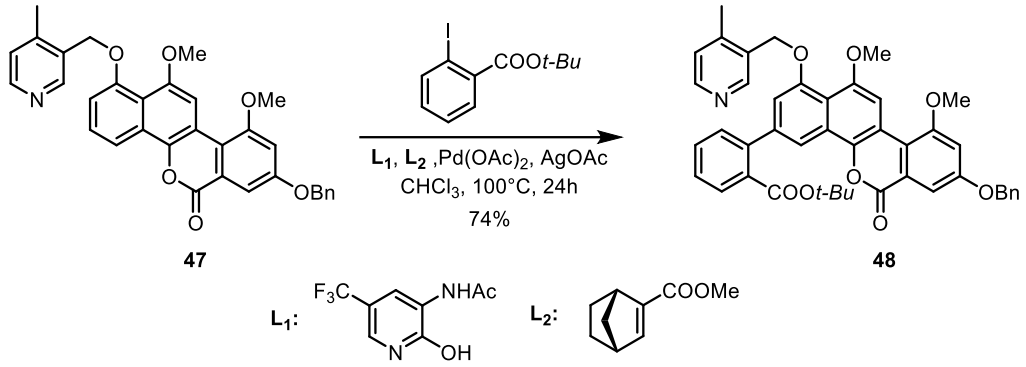
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (d, J = 4.2 Hz, 1H), 8.32 (s, 1H), 8.20 (d, J = 8.4 Hz, 1H), 7.66 (d, J = 2.0 Hz, 1H), 7.56 (d, J = 7.5 Hz, 1H), 7.43 (ddd, J = 30.7, 16.4, 7.3 Hz, 6H), 7.25 – 7.14 (m, 2H), 6.97 (d, J = 1.9 Hz, 1H), 5.40 (s, 2H), 5.18 (s, 2H), 4.02 (s, 3H), 3.90 (s, 3H), 2.55 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 161.5, 159.5, 158.9, 155.6, 154.6, 153.0, 146.2, 140.0, 138.7, 136.2, 134.0, 128.9, 128.5, 128.0, 127.3, 126.9, 124.4, 123.6, 119.1, 117.9, 115.3, 113.8, 110.6, 107.1, 104.5, 104.2, 72.6, 70.7, 56.6, 56.4, 18.2.

IR (neat) ν_{max} 2936, 2360, 1722, 1446, 1375, 1300 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{33}H_{28}NO_6$: 534.1911, found: 534.1912;

TLC: R_f = 0.14 (PE/EtOAc = 4/1).



Compound 48. 47 (90 mg, 0.169 mmol), Ar-I (205 mg, 0.676 mmol), $Pd(OAc)_2$ (7.6 mg, 20 mol%), L_1 (7.5 mg, 20 mol%), AgOAc (112.0 mg, 0.676 mmol), NBE-COOMe (51 μL, 0.34 mmol) and $CHCl_3$ (5.0 mL) were added to a 45 mL sealed tube. The tube was capped and closed tightly. The reaction mixture was then stirred at 100 ℃ for 18 hours. After cooling to room temperature, the mixture was passed through a pad of Celite with EtOAc as the eluent to remove the insoluble precipitate. The resulting solution was concentrated and then purified by silica gel column chromatography (CH_2Cl_2/MeOH = 200/1) to afford **48** (89 mg, 74%) as a yellow solid.

Mp 115-119 ^oC;

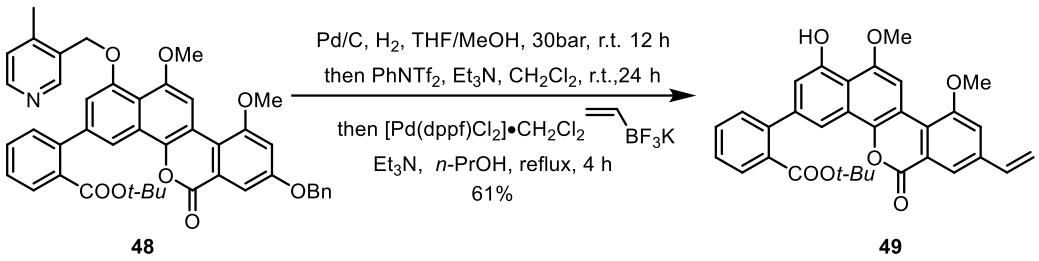
^1H NMR (400 MHz, $CDCl_3$) δ 9.35 (s, 1H), 8.29 (s, 1H), 8.12 (s, 1H), 8.06 (s, 1H), 7.84 (d, J = 7.6 Hz, 1H), 7.49 (qd, J = 14.8, 7.2 Hz, 3H), 7.31 (s, 1H), 7.02 (s, 1H), 6.77 (dd, J = 17.5, 10.9 Hz, 1H), 5.93 (d, J = 17.5 Hz, 1H), 5.44 (d, J = 10.8 Hz, 1H), 4.11 (s, 3H), 4.10 (s, 3H), 1.30 (s, 9H).

^{13}C NMR (101 MHz, CDCl3) δ 167.6, 161.2, 159.4, 158.8, 155.2, 154.4, 152.9, 146.3, 141.9, 141.2, 140.0, 138.4, 136.0, 133.8, 132.8, 130.9, 130.8, 129.9, 128.8, 128.8, 128.4, 127.9, 127.8, 127.5, 127.5, 126.4, 124.4, 123.5, 118.9, 116.7, 114.9, 114.0, 111.9, 107.0, 104.4, 104.1, 81.3, 77.4, 77.0, 76.7, 72.8, 70.6, 56.5, 56.3, 27.7, 18.1.

IR (neat) ν_{max} 2925, 2854, 2375, 2397, 1720, 1605, 1588, 1432, 1347 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{44}H_{40}NO_8$: 710.2748, found: 710.2744;

TLC: R_f = 0.72 (DCM/MeOH = 20/1).



48 49

Compound 49. To a mixture of **48** (33 mg, 0.047 mmol) and 10% Pd/C (66 mg) was added 4 mL of MeOH and 4ml THF. The resulting mixture was degassed in a high pressure reactor and backfilled with H_2 under 30 bar. Then the reaction was stirred at r.t. for 12 h followed by filtration and filtrate was concentrated *in vacuo*. The residue was redissolved in 10 mL of CH_2Cl_2. Triethyl amine (32 μL, 0.225 mmol) and $PhNTf_2$ (18 mg, 0.05 mmol) was added to the solution and at r.t. The resulting solution was allowed to stir for 24 h, quenched with saturated NH_4Cl solution (10 mL). The mixture was extracted with CH_2Cl_2 for three times. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*.

To a suspension of the mixture, potassium vinyltrifluoroborate (9.3 mg, 0.070 mmol), [Pd(dppf)Cl_2] CH_2Cl_2 (2.3 mg, 0.0028 mmol) in 2mL of n-PrOH was added triethyl amine (12 μL, 0.084 mmol) under argon. The resulting reaction mixture was heated at reflux for 4 h. The reaction was cooled and diluted with water (4 mL). The mixture was extracted with CH_2Cl_2 three times, and the combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated in vacuo to give a crude solid which was purified by silica gel column chromatography (PE/EA/CH_2Cl_2 = 5/1/1) to afford **49** (15 mg, 61% for 3 steps) as a yellow solid.

Mp 216-219 ^oC;

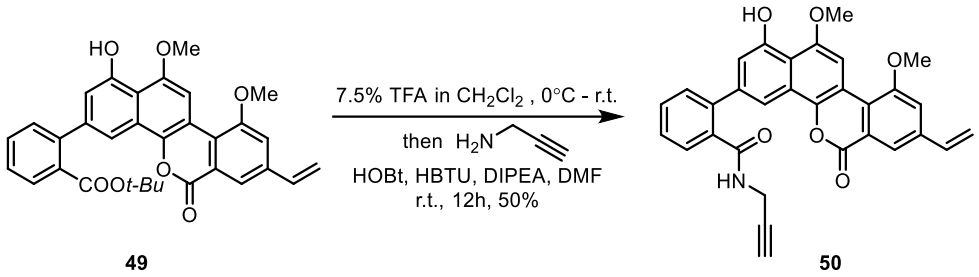
^1H NMR (400 MHz, $CDCl_3$) δ 9.35 (s, 1H), 8.29 (s, 1H), 8.09 (d, J = 24.2 Hz, 2H), 7.84 (d, J = 7.6 Hz, 1H), 7.49 (qd, J = 14.8, 7.2 Hz, 3H), 7.31 (s, 1H), 7.02 (s, 1H), 6.77 (dd, J = 17.5, 10.9 Hz, 1H), 5.93 (d, J = 17.5 Hz, 1H), 5.44 (d, J = 10.8 Hz, 1H), 4.10 (d, J = 6.9 Hz, 6H), 1.30 (s, 9H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 167.6, 161.0, 157.3, 153.7, 151.9, 142.4, 141.8, 141.6, 138.7, 135.3, 132.9, 130.8, 130.7, 129.8, 127.5, 125.9, 123.6, 123.4, 120.7, 116.5, 114.2, 114.1, 113.7, 113.1, 101.6, 81.4, 56.3, 56.1, 27.7.

IR (neat) ν_{max} 2934, 2923, 2852, 1722, 1459, 1378, 1300 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{32}H_{29}O_7$: 525.1910, found: 525.1913;

TLC: R_f = 0.62 (PE/EtOAc = 2/1).



49 **50**

Compound 50. To a suspension of **49** (12.0 mg, 0.023 mmol) in 6 mL of CH_2Cl_2 was added 0.45 mL TFA at 0 ^oC. The resulting reaction solution was slowly warmed to r.t. and stirred for 6h. The solution was concentrated *in vacuo* to yield the acid and was directly used for next step. The mixture of crude acid, HOBt (3.1 mg, 0.023 mmol) and HBTU (10.6 mg, 0.028 mmol) were added DMF (2 ml) followed by the addition of the propargyl amine (7.5 μL, 0.115 mmol) under argon, DIPEA (19.5 μL, 0.115 mmol) was added after 10 minutes and the reaction was allowed to stirred for 12h at r.t. The mixture was diluted with EA (20 ml) and washed by brime (10 ml) for three times. Then combined organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated *in vacuo*, The crude product was purified by silica gel column chromatography (CH_2Cl_2/MeOH = 200/1) to afford **50** (6.8 mg, 50%) as a yellow solid.

Mp >330 ^oC;

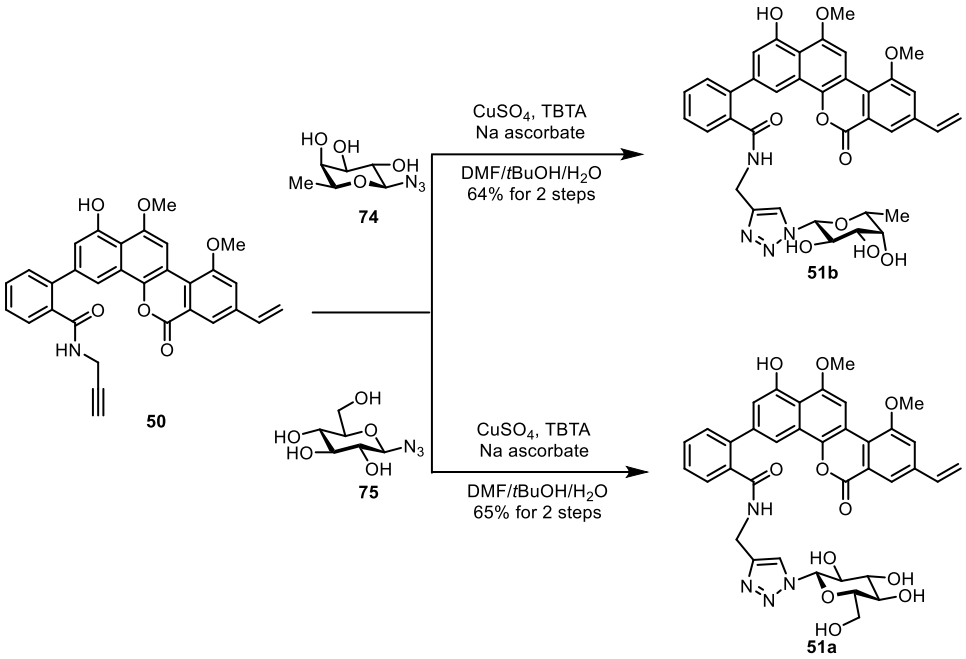
^1H NMR (400 MHz, DMSO-*d6*) δ 9.55 (s, 1H), 8.75 (t, *J* = 5.6 Hz, 1H), 8.37 (s, 1H), 8.00 (d, *J* = 1.4 Hz, 1H), 7.86 (d, *J* = 1.6 Hz, 1H), 7.72 (d, *J* = 1.4 Hz, 1H), 7.59 – 7.54 (m, 2H), 7.51 – 7.45 (m, 2H), 6.97 (d, *J* = 1.6 Hz, 1H), 6.92 (dd, *J* = 17.6, 11.0 Hz, 1H), 6.14 (d, *J* = 17.6 Hz, 1H), 5.49 (d, *J* = 11.1 Hz, 1H), 4.16 (s, 3H), 4.10 (s, 3H), 3.87 (dd, *J* = 5.5, 2.4 Hz, 2H), 2.89 (t, *J* = 2.5 Hz, 1H).

^{13}C NMR (126 MHz, DMSO) δ 168.7, 160.0, 157.5, 153.7, 151.8, 140.6, 140.4, 138.9, 138.6, 136.6, 135.2, 123.0, 129.8, 129.6, 127.8, 127.6, 125.4, 122.9, 122.7, 119.7, 117.3, 114.9, 113.6, 113.1, 113.1, 112.1, 101.6, 80.6, 72.7, 56.8, 56.2, 35.1.

IR (neat) ν_{max} 2986, 1813, 1739, 1691, 1261, 1136, 753cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{31}H_{24}NO_6$: 506.1598, found: 506.1597;

TLC: R_f = 0.61 (CH_2Cl_2/MeOH = 19/1).



Compound 51a/51b. Azido glycan **75/74** (2.0 eq.) and $CuSO_4$ (2.0 mg, 0.0125 mmol) were dissolved in water (200 µl). To the mixture were added sodium ascorbate (12.3 mg, 0.0623 mmol), TBTA (Tris[(1-benzyl-1,2,3-triazol-4-yl)methyl]amine (5 mg, 0.089mmol), DMF (200 µl), t-BuOH (200 µl) and the mixture was kept at room temperature. **50** (4.2mg, 0.0083 mmol) was added to the reaction mixture and stirred at room temperature for 3h and the reaction was lyophilized. The residues were purified by HPLC to afford the desired product **51b** (3.6 mg, 64%)/ **51a** (3.8 mg, 65%)

For **51b**

Mp >330 ^oC;

^1H NMR (600 MHz, DMSO) δ 9.61 (s, 1H), 8.92 (t, *J* = 5.5 Hz, 1H), 8.43 (s, 1H), 8.04 (s, 1H), 7.93 (s, 1H), 7.78 (d, *J* = 15.1 Hz, 2H), 7.57 (s, 2H), 7.54 – 7.47 (m, 2H), 7.04 (s, 1H), 6.94 (dd, *J* = 17.5, 11.0 Hz, 1H), 6.17 (d, *J* = 17.6 Hz, 1H), 5.50 (d, *J* = 10.9 Hz, 1H), 5.23 (d, *J* = 9.1 Hz, 1H), 5.14 (d, *J* = 5.6 Hz, 1H), 4.96 (d, *J* = 4.8 Hz, 1H), 4.70 (d, *J* = 5.2 Hz, 1H), 4.43 – 4.36 (m, 2H), 4.19 (s, 3H), 4.14 (s, 3H), 4.03 –

3.98 (m, 1H), 3.77 (dd, *J* = 12.5, 6.1 Hz, 1H), 3.54 – 3.47 (m, 2H), 1.08 (d, *J* = 6.6 Hz, 3H).

^{13}C NMR (151 MHz, DMSO) δ 169.1, 160.0, 157.5, 153.7, 151.9, 144.7, 140.7, 140.5, 138.9, 138.6, 136.9, 135.2, 129.9, 129.6, 127.9, 127.6, 125.4, 122.9, 122.6, 117.4, 114.9, 113.6, 113.2, 112.0, 88.0, 73.9, 73.1, 71.1, 68.7, 56.8, 56.2, 34.8, 16.4.

IR (neat) ν_{max} 2919, 1663, 1436, 1410, 1312, 1015, 953cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{37}H_{35}N_4O_{10}$: 695.2349, found: 695.2348;

$[\alpha]_D^{25}$ -2.222 (*c* 0.15, DMSO);

For **51a**

Mp >330 ºC;

^{1}H NMR (400 MHz, DMSO) δ 9.61 (s, 1H), 8.94 (s, 1H), 8.44 (s, 1H), 8.04 (s, 1H), 7.94 (s, 1H), 7.83 (s, 1H), 7.77 (s, 1H), 7.58 – 7.49 (m, 4H), 7.04 (s, 1H), 6.95 (dd, *J* = 17.2, 10.8 Hz, 1H), 6.17 (d, *J* = 17.6 Hz, 1H), 5.51 (d, *J* = 11.1 Hz, 1H), 5.33 (d, *J* = 5.7 Hz, 4H), 5.24 (d, *J* = 4.6 Hz, 1H), 5.13 (d, *J* = 5.2 Hz, 1H), 4.61 (s, 1H), 4.40 (d, *J* = 5.6 Hz, 2H), 4.19 (s, 3H), 4.14 (s, 3H), 3.76 (d, *J* = 6.4 Hz, 1H), 3.61 (d, *J* = 4.6 Hz, 1H), 3.40 (s, 1H), 3.21 (d, *J* = 5.0 Hz, 1H).

^{13}C NMR (126 MHz, Acetone) δ161.3, 158.8, 154.9, 153.2, 140.1, 136.4, 136.0, 130.6, 130.2, 129.9, 128.8, 126.3, 124.6, 123.6, 120.3, 117.1, 116.3, 115.5, 115.2, 114.5, 113.3, 113.2, 105.5, 102.8, 100.9, 77.5, 76.3, 76.2, 74.6, 72.6, 57.1, 56.9, 36.2.

IR (neat) ν_{max} 2920, 2857, 1754, 1662, 1470, 1275, 1047, 764 cm^{-1};

HRMS (ESI) $[M + H]^+$ calculated for $C_{37}H_{35}N_4O_{11}$: 711.2287, found: 711.2297;

$[\alpha]_D^{25}$ 9.512 (*c* 0.2, DMSO);

IV) Comparison of Natural and Synthetic Chrysomycin A

^{1}H NMR (Hz) data (in DMSO-*d6*) comparison of natural and synthetic chrysomycin A:

Natural (500 MHz)	Synthetic + Natural (400 MHz)	Synthetic (400 MHz)
9.80 (s, 1H)	9.82 (s, 1H)	9.82 (s, 1H)
8.43 (s, 1H)	8.50 (s, 1H)	8.49 (s, 1H)
7.97 (d, 1.5, 1H)	8.02 (s, 1H)	8.01 (s, 1H)
7.84 (d, 8.5, 1H)	7.84 (d, 8.4, 1H)	7.84 (d, 8.4, 1H)
7.69 (d,1.5, 1H)	7.77 (s, 1H)	7.76 (s, 1H)
6.97 (d, 8.5, 1H)	6.97 (d, 8.5, 1H)	6.97 (d, 8.6, 1H)
6.91(dd,17.5, 11.0, 1H)	6.96 (dd, 17.5, 11.2, 1H)	6.95 (dd, 17.6, 11.2, 1H)
6.13 (d, 17.5, 1H)	6.16 (d, 17.5, 1H)	6.16 (d, 17.6, 1H)
6.03 (d, 9.5, 1H)	6.02 (d, 9.5, 1H)	6.02 (d, 9.6, 1H)
5.49 (d, 11.0, 1H)	5.51 (d, 11.0, 1H)	5.51 (d, 11.0, 1H)
4.59 (d, 7.5, 1H)	4.59 (d, 7.7, 1H)	4.59 (d, 7.7, 1H)
4.53 (q, 6.5, 1H)	4.52 (q, 6.5, 1H)	4.52 (q, 6.6, 1H)
4.20 (s, 1H)	4.20 (s, 1H)	4.20 (s, 1H)
4.19 (d, 8.5, 1H)	4.19 (d, 8.4, 1H)	4.19 (d, 8.0, 1H)
4.14(s, 3H)	4.18 (s, 3H)	4.18 (s, 3H)
4.09 (s, 3H)	4.13 (s, 3H)	4.13 (s, 3H)
3.69 (dd, 9.5, 8.5, 1H)	3.68 (dd, 9.2, 8.8, 1H)	3.68 (dd, 9.2, 8.8, 1H)
3.16 (d, 7.5, 1H)	3.15 (d, 7.6, 1H)	3.14 (d, 7.9, 1H)
1.26 (s, 3H	1.25 (s, 3H)	1.25 (s, 3H),
1.03 (d, 6.5, 3H)	1.02 (d, 6.5, 3H)	1.02 (d, 6.5, 3H)

^{13}C NMR data (in DMSO-*d6*) comparison of natural and synthetic chrysomycin A:

Natural (125 MHz)	Synthetic (100 MHz)
159.8	159.8
157.4	157.4
153.2	153.2
151.8	151.9
142.4	142.5
138.7	138.8
135.2	135.2
129.3	129.4
128.1	128.1
125.2	125.2
122.9	123.0
122.0	122.1
119.1	119.1
117.2	117.3
115.2	115.2
114.6	114.8
113.2	113.2
112.1	112.2
101.4	101.5
75.8	75.8
74.6	74.6
73.2	73.2
72.6	72.5
70.7	70.7
56.7	56.8
56.2	56.3
23.9	23.9
17.1	17.1

$[\alpha]_D$ Comparison of natural and synthetic chrysomycin A:

Natural chrysomycin A	Synthetic chrysomycin A
$[\alpha]_D^{22}$ -12.0 (*c* 0.06, $CHCl_3$)	$[\alpha]_D^{22}$ -13.3 (*c* 0.06, $CHCl_3$)

V) Comparison of Natural and Synthetic Polycarcin V

NMR data (in DMSO-d_6) comparison of natural and synthetic polycarcin V:

^{1}H NMR (Hz)		^{13}C NMR (Hz)	
Natural (500 MHz)	Synthetic (500 MHz)	Natural (125 MHz)	Synthetic (125 MHz)
9.72 (s, 1H)	9.73 (s, 1H)	159.4	159.4
8.45 (s, 1H)	8.45 (s, 1H)	157.4	157.5
7.97 (d, 1.5, 1H)	7.97 (d, 1.2, 1H)	152.8	152.8
7.78 (d, 8.4, 1H)	7.81 (d, 8.4, 1H)	152.0	152.1
7.73 (d, 1.5, 1H)	7.73 (d, 1.2, 1H)	141.8	141.8
6.96 (d, 8.4, 1H)	6.96 (d, 8.5, 1H)	138.8	138.9
6.94 (dd, 17.6, 11.0, 1H)	6.94 (dd, 17.6, 11.0, 1H)	135.2	135.2
6.13 (d, 17.6, 1H)	6.14 (d, 17.6, 1H)	129.9	130.0
5.84 (br s, 1H)	5.84 (s, 1H)	126.7	126.7
5.50 (d, 11.0, 1H)	5.50 (d, 11.0, 1H)	122.8	122.9
4.77 (d, 5.1, 1H)[a]	4.81 (d, 5.1, 1H)[a]	122.4	122.5
4.42 (d, 5.9, 1H)[a]	4.47 (d, 5.3, 1H)[a]	121.8	121.9
4.16 (s, 3H)	4.16 (s, 3H)	119.1	119.2
4.11 (s, 3H)	4.11 (s, 3H)	117.3	117.3
4.06 (dd, 5.9, 3.7, 1H)	4.07 (dd, 5.6, 3.1, 1H)	114.9	114.9
3.98 (d, 5.9, 1H)[a]	4.01 (m, 1H)[a]	114.6	114.7
3.78 (m, 1H)	3.78 (m, 1H)	113.2	113.3
3.36 (m, 1H)	3.36 (m, ,1H)	112.0	112.1
3.31 (m, 1H)	3.31 (m, 1H)	101.4	101.4
1.28 (d, 6.4, 3H)	1.29 (d, 5.9, 3H)	77.5	77.5
		76.4	76.4
		74.7	74.7
		72.8	72.8
		71.6	71.6
		56.7	56.8
		56.5	56.3
		18.5	18.5

[a] Protons of the hydroxyl groups on the sugar moiety

$[\alpha]_D$ Comparison of natural and synthetic polycarcin V:

Natural polycarcin V	Synthetic polycarcin V
$[\alpha]_D^{22}$ -79 (*c* 0.4, MeOH)	$[\alpha]_D^{22}$ -83.6 (*c* 0.2, MeOH)

VI) Comparison of Natural and Synthetic Gilvocarcin V

NMR data (in DMSO-d_6) comparison of natural and synthetic gilvocarcin V:

^{1}H NMR (Hz)		^{13}C NMR (Hz)	
Natural (400 MHz)	Synthetic (400 MHz)	Natural (125 MHz)	Synthetic (125 MHz)
9.72 (s, 1H)	9.71 (s, 1H)	159.5	159.6
8.48 (s, 1H)	8.48 (s, 1H)	157.3	157.3
8.07 (d, 8.4, 1H)	8.07 (d, 8.2, 1H)	152.6	152.6
7.99 (s, 1H)	7.99 (s, 1H)	151.8	151.8
7.76 (s, 1H)	7.76 (s, 1H)	142.3	142.3
6.96 (dd, 17.6, 11.0, 1H)	6.96 (dd, 17.6, 10.9, 1H)	138.6	138.7
6.95 (d, 8.4, 1H)	6.95 (d, 8.2, 1H)	135.2	135.2
6.20 (d, 5.5, 1H)	6.20 (d, 5.5, 1H)	129.0	129.1
6.16 (d, 17.6, 1H)	6.16 (d, 17.6, 1H)	126.1	126.2
5.51 (d, 11.0, 1H)	5.51 (d, 11.0, 1H)	123.6	123.6
5.10 (d, 4.8, 1H)	5.10 (d, 4.8, 1H)	122.9	122.9
4.83 (d, 4.8, 1H)	4.83 (d, 4.8, 1H)	122.2	122.2
4.66 – 4.71 (m, 1H)	4.66 – 4.71 (m, 1H)	119.0	119.0
4.51 (d, 6.6, 1H)	4.51 (d, 6.6, 1H)	117.0	117.0
4.18 (s, 3H)	4.18 (s, 3H)	114.8	114.8
4.13 (s, 3H)	4.13 (s, 3H)	114.5	114.4
3.82 – 3.90 (m, 2H)	3.82 – 3.90 (m, 2H)	112.8	112.5
3.51 (dd, 5.9, 4.4, 1H)	3.51 (dd, 5.9, 4.4, 1H)	112.0	112.0
1.24 (d, 6.6, 3H)	1.24 (d, 6.5, 3H)	101.4	101.4
		85.7	85.7
		80.7	80.7
		78.8	78.9
		78.6	78.6
		66.4	66.4
		56.7	56.7
		56.3	56.2
		20.1	20.0

$[\alpha]_D$ Comparison of natural and synthetic gilvocarcin V:

Natural gilvocarcin V	Synthetic gilvocarcin V
$[\alpha]_D^{22}$ -220.0 (*c* 0.22, DMSO)	$[\alpha]_D^{22}$ -221.0 (*c* 0.22, DMSO)

VI) Biological Evaluation

Anti- BCG and MTB assays

BCG Antimicrobial Assay

The Anti-BCG assay was carried out in 96-well microplates by using a strain with constitutive GFP expression **(**pUV3583c-GFP) through direct readout of fluorescence as a measure of bacterial growth[5].

Anti- MTB and NTM (nontuberculous mycobacteria) assays

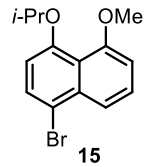
MICs were determined by the Microplate Alamar Blue Assay (MABA) by using a wild type strain H37Rv and clinic isolates (Hr1, Hr2, Hr3, Hr4, Hr5). Rifampicin and bedaquiline were included as positive controls.

The test strain *M. tuberculosis* was inoculated on a Lowenstein-Jensen medium plate and incubated at 37 ℃ for about 21 days until the colonies was visible. Then the colonies were picked into by 2 ml 0.05%Tween-80/physiological saline solution by an inoculating loop and vortex 2 min into suspension, keeping stationary about 5-10 min. The supernatant was taken out and diluted into 1 MCF by physiological saline solution. Then this solution were diluted by fresh medium (7H9+10%OADC) to final bacterial titers of 1.0×10^6. The wells of 96 well plates were filled by using 198 μl bacterial solution, then 2 μl 2-fold diluted test compounds, positive controls, and negative control (DMSO) were added into the wells, respectively.

The plates were incubated at 37 ℃; on day 7 of incubation, 50 μL of 20% Tween 80 and 20 μL of Alamar blue were added to all wells. After incubation at 37℃ for 16-24 h, the MICs were identified as the concentrations of the wells which the colors do not change.

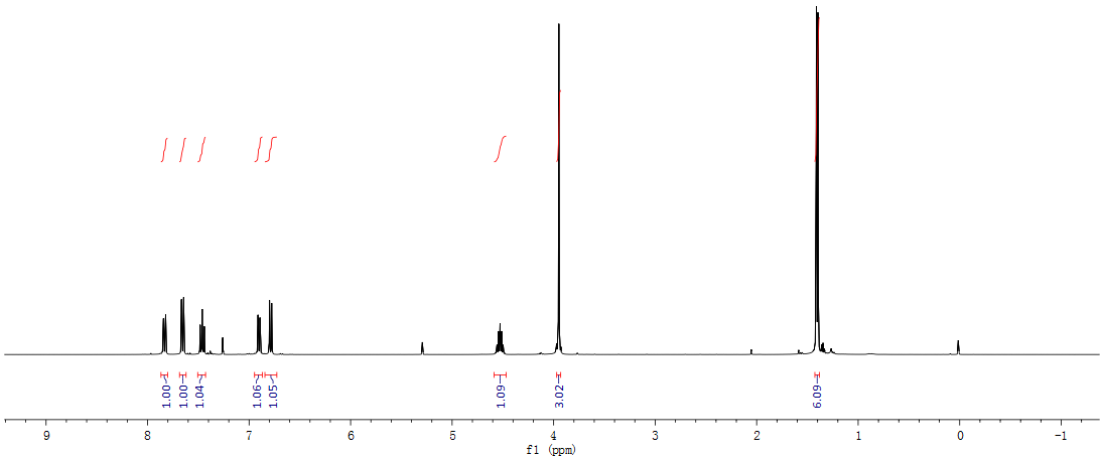
5. Song, F.; Liu, X.; Guo, H.; Ren, B.; Chen, C.; Piggott, A. M. *Org. Lett.* **2012**, *14*, 4770.

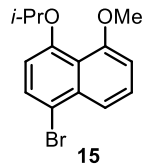
VII) NMR Spectra



15

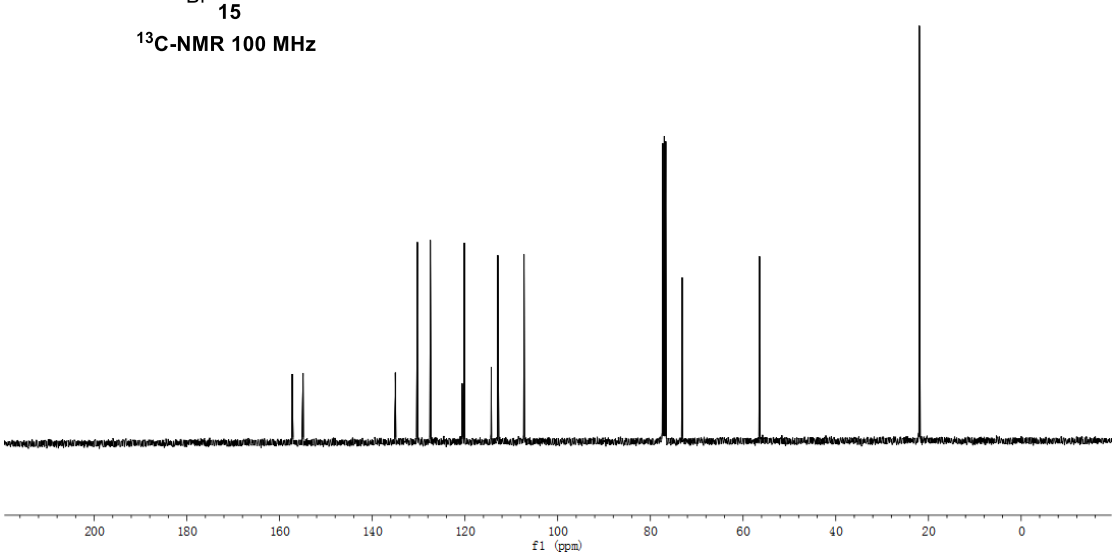
^{1}H-NMR 400 MHz

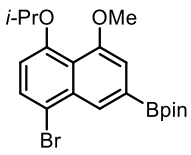




15

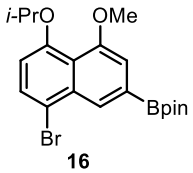
^{13}C-NMR 100 MHz





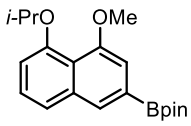
16

^{1}H-NMR 400 MHz



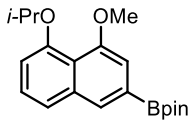
16

^{13}C-NMR 100 MHz



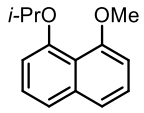
17

^{1}H-NMR 400 MHz



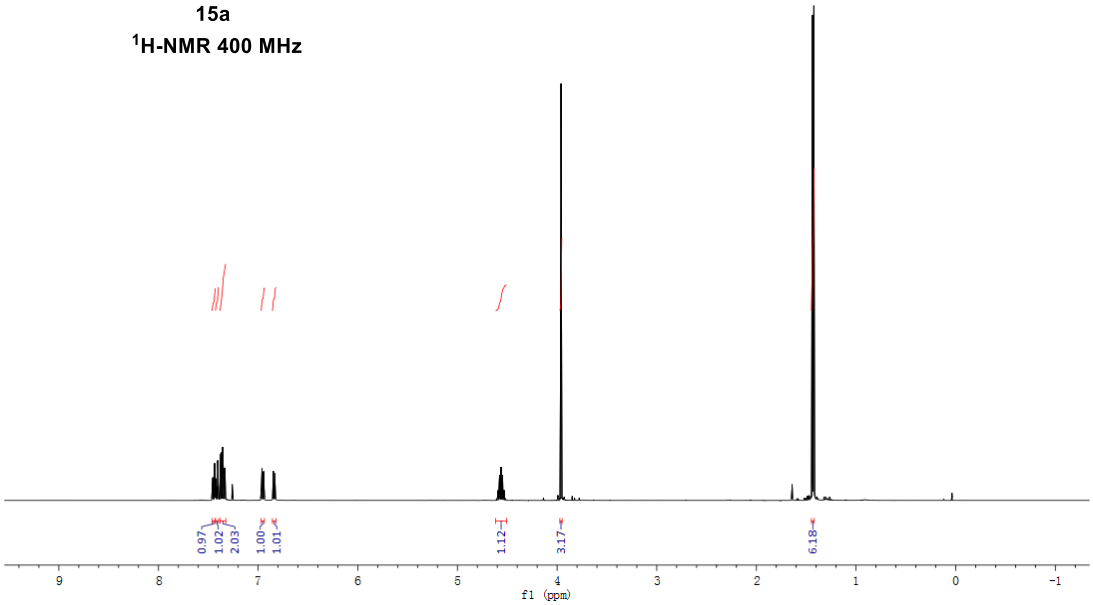
17

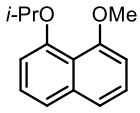
^{13}C-NMR 100 MHz



15a

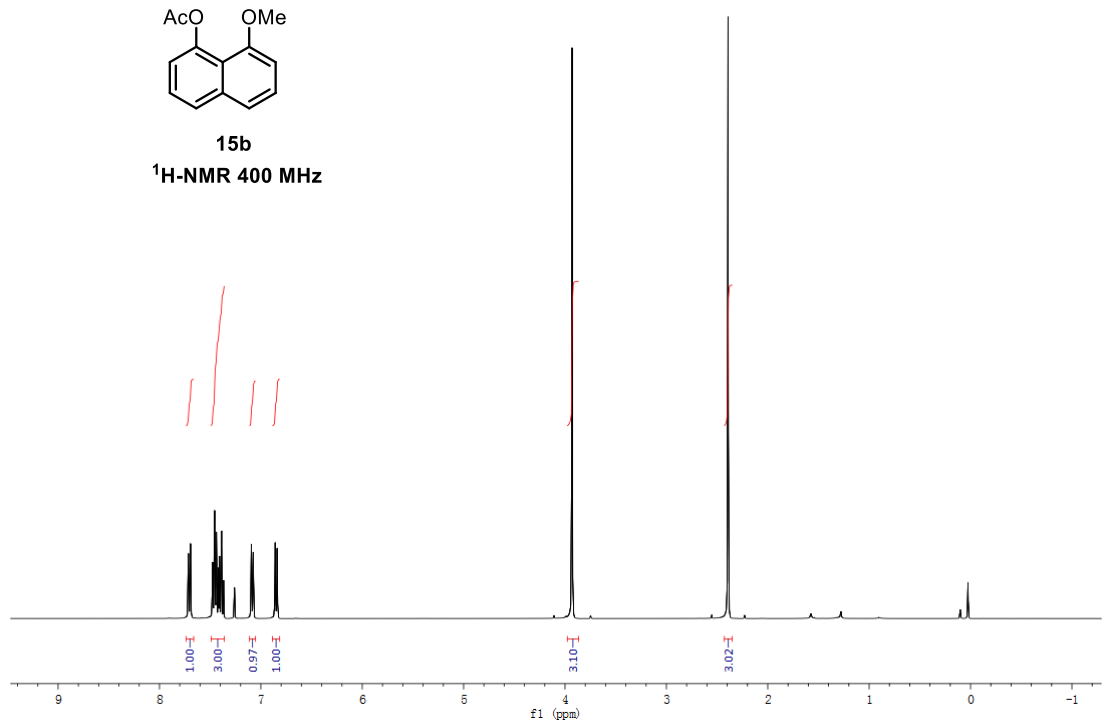
^{1}H-NMR 400 MHz

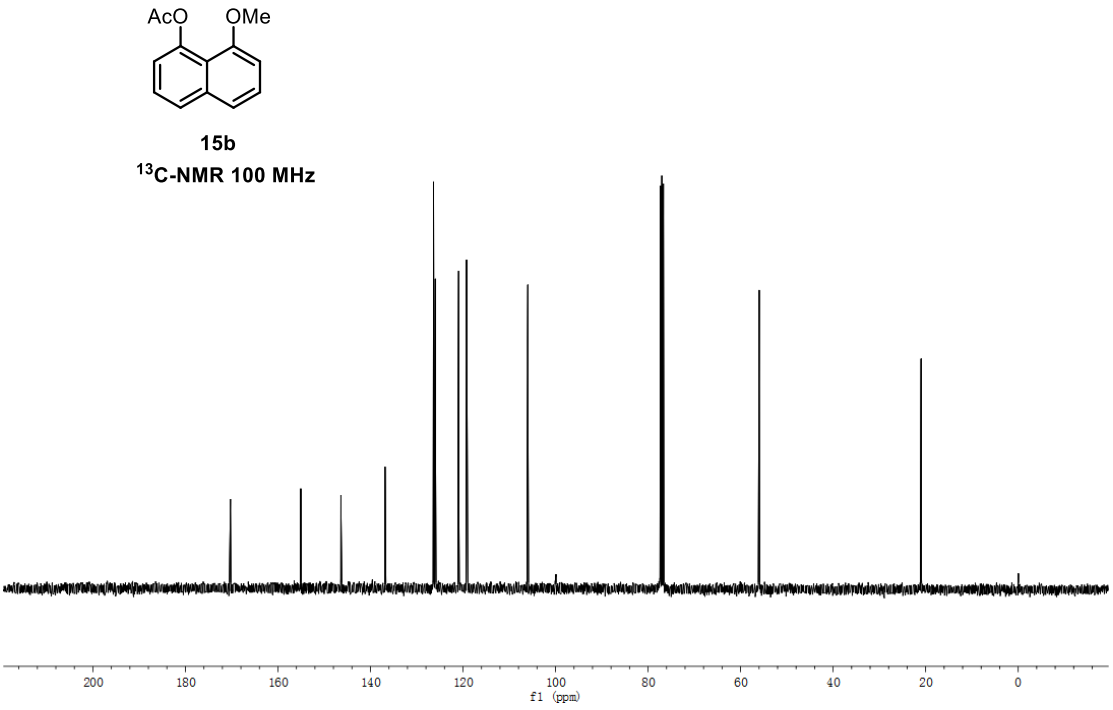


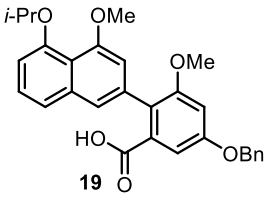


15a

^{13}C-NMR 100 MHz

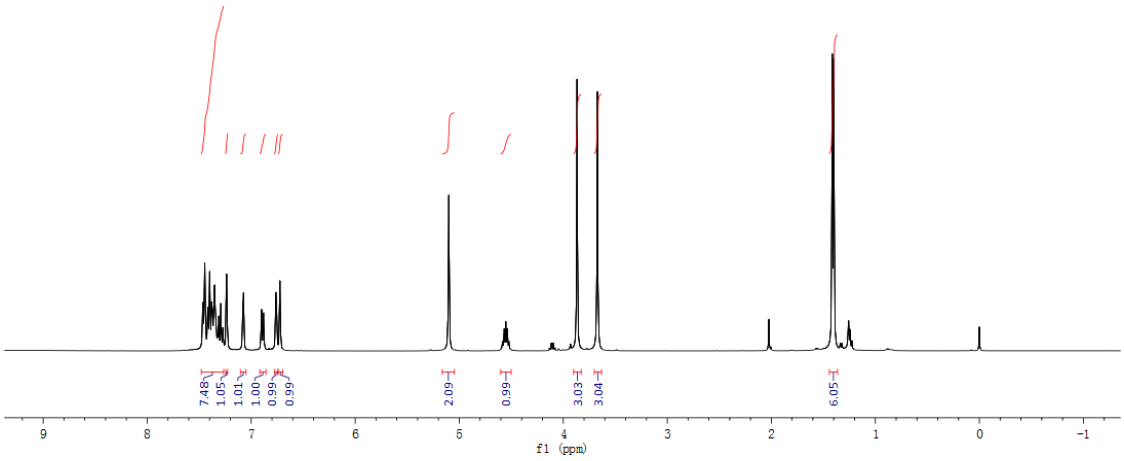

AcO
OMe
15b
1H-NMR 400 MHz
1.00
3.00
0.97
1.00
3.10
3.02
9
8
7
6
5
4
3
2
1
0
-1
f1 (ppm)

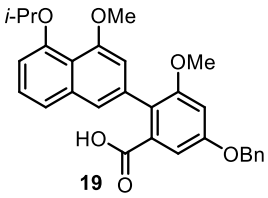

AcO
OMe
15b
13C-NMR 100 MHz
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)



19

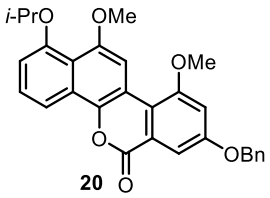
^{1}H-NMR 400 MHz





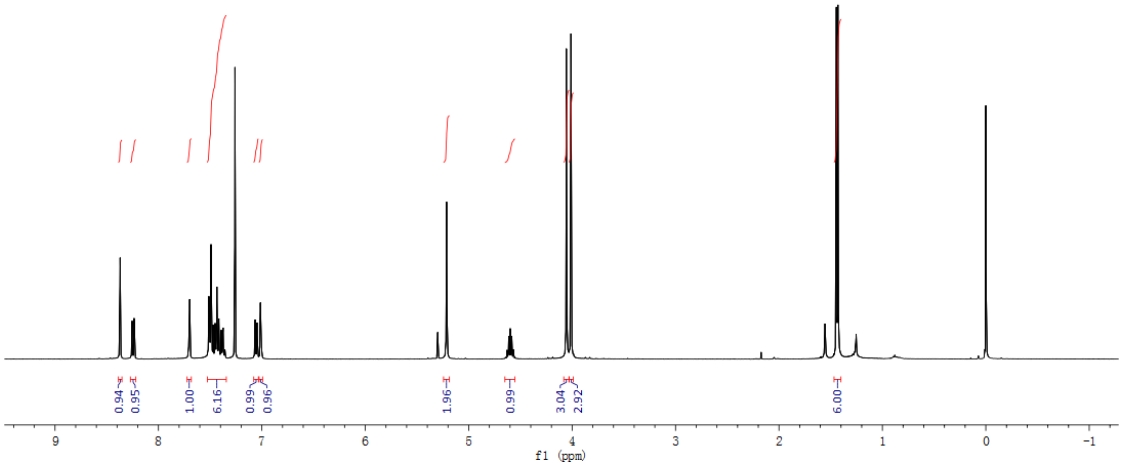
19

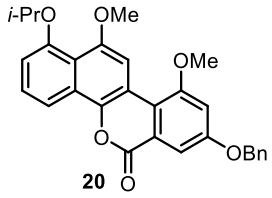
^{13}C-NMR 100 MHz



20

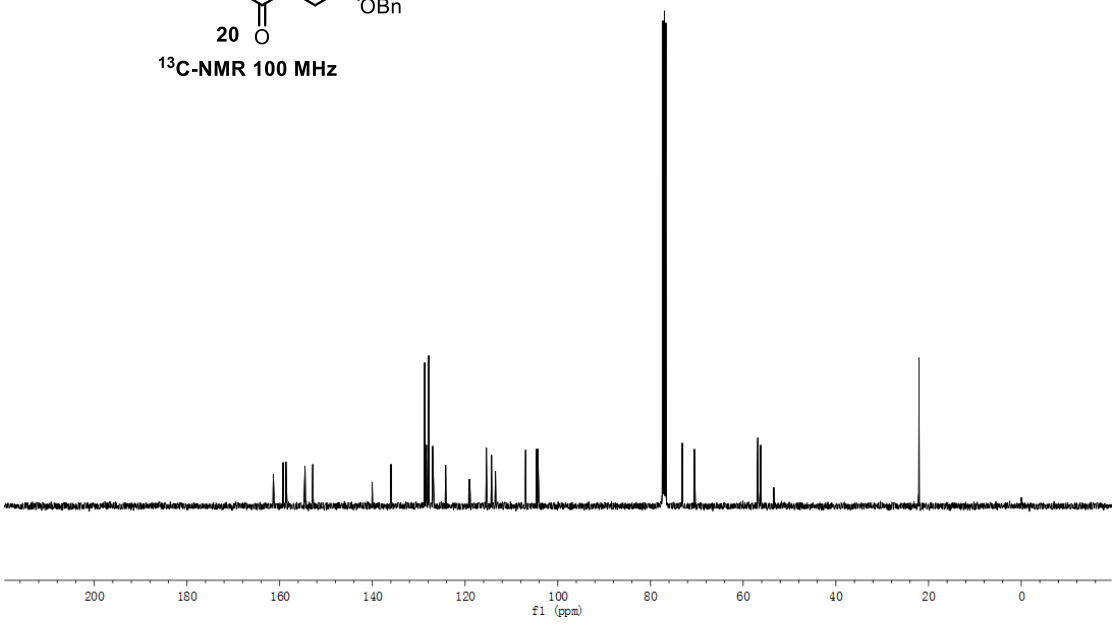
^{1}H-NMR 400 MHz

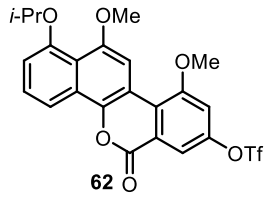




20

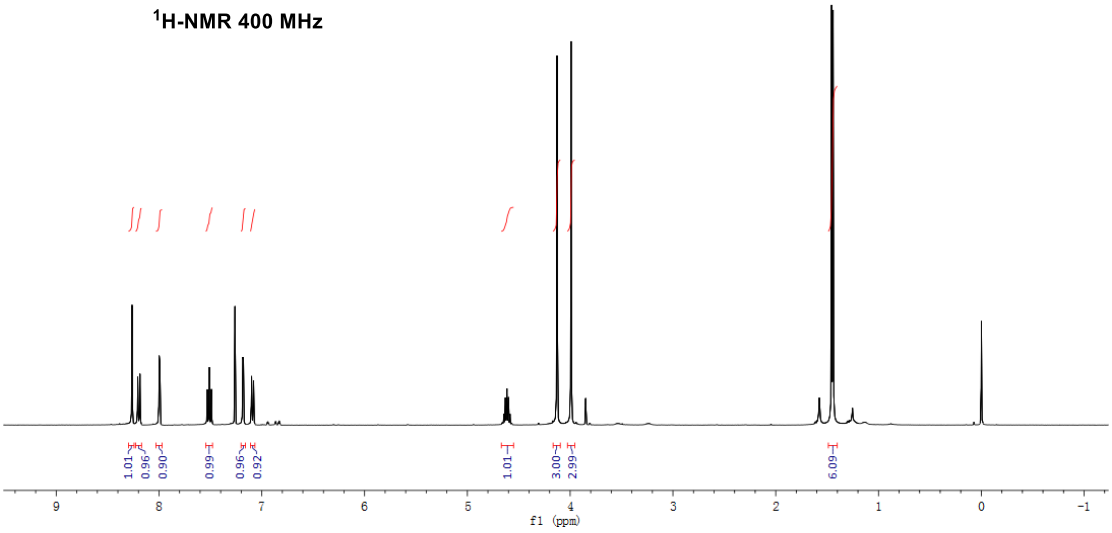
^{13}C-NMR 100 MHz

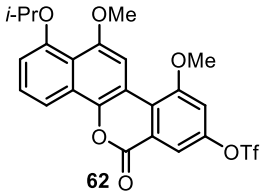




62

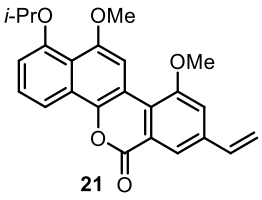
^{1}H-NMR 400 MHz





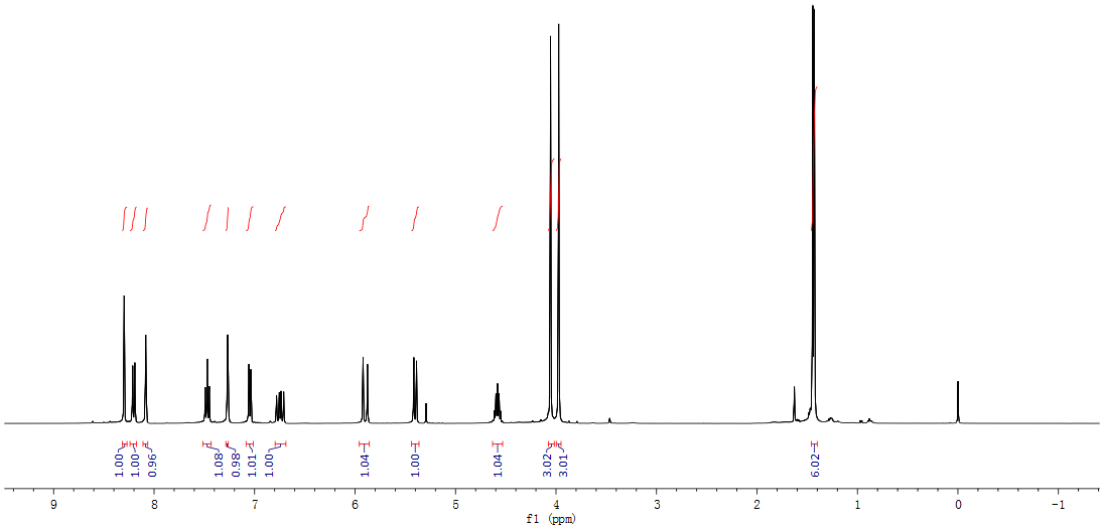
62

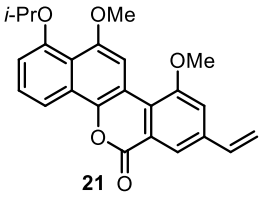
^{13}C-NMR 100 MHz



21

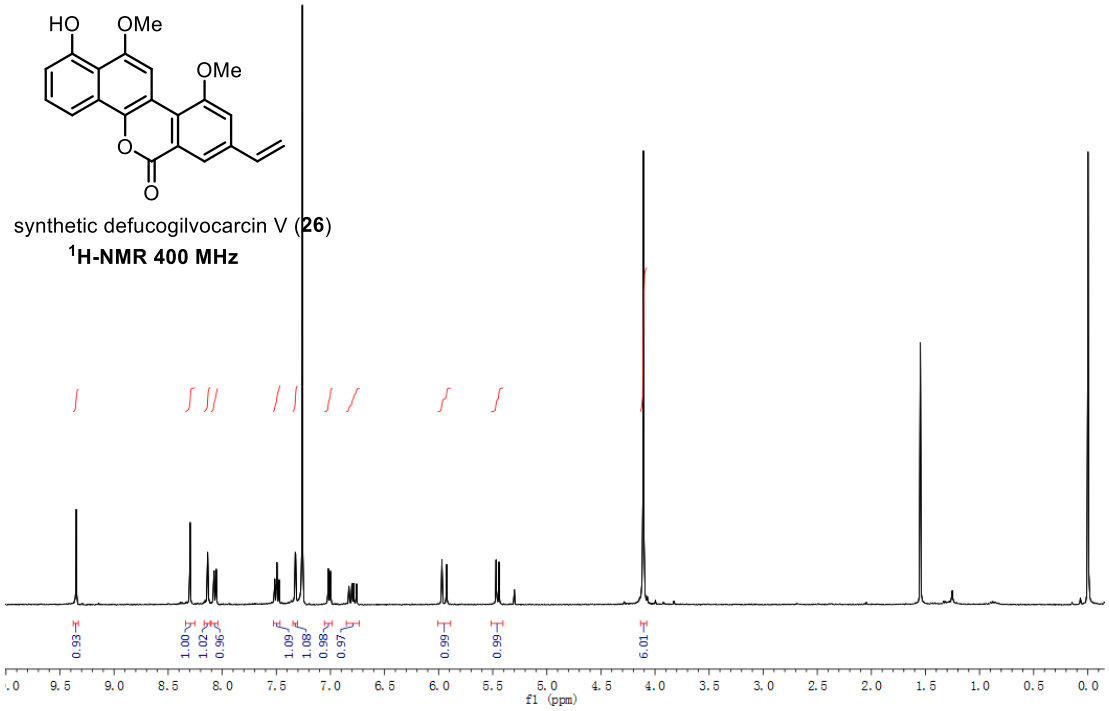
^{1}H-NMR 400 MHz





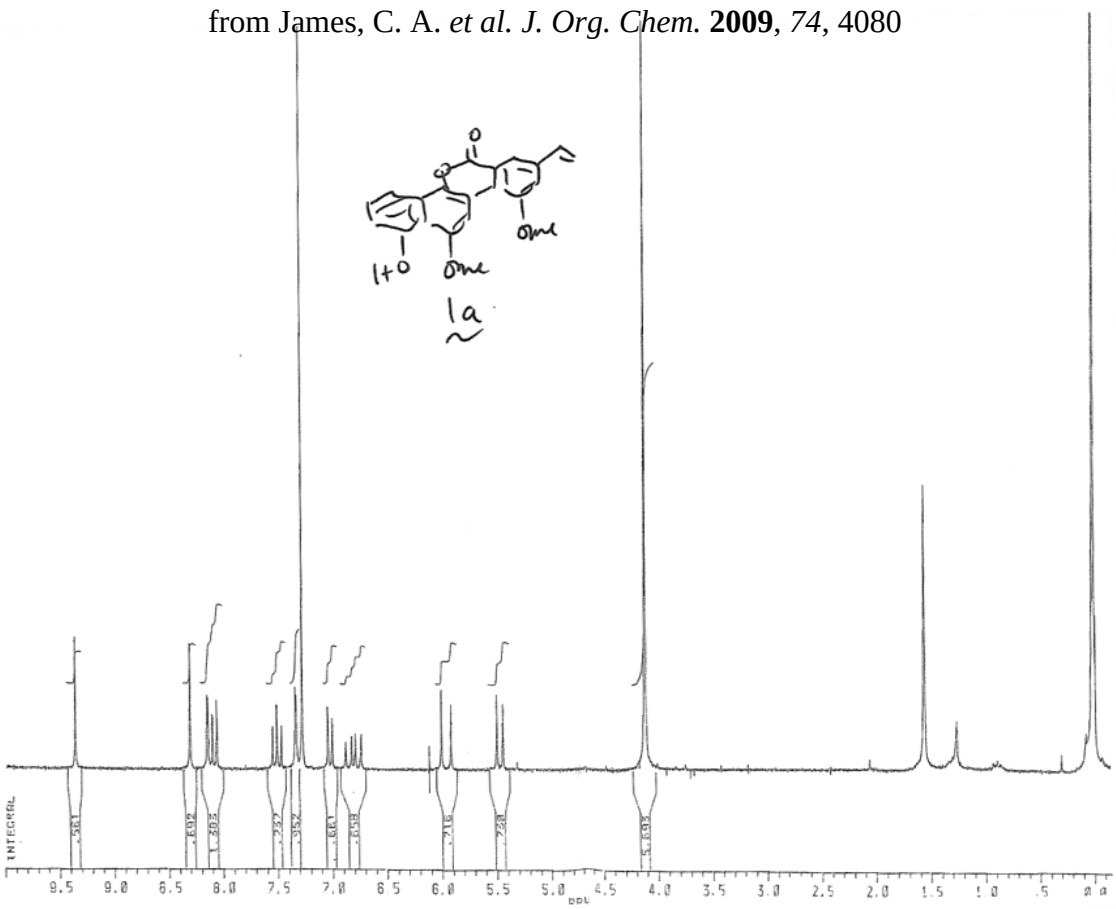
21

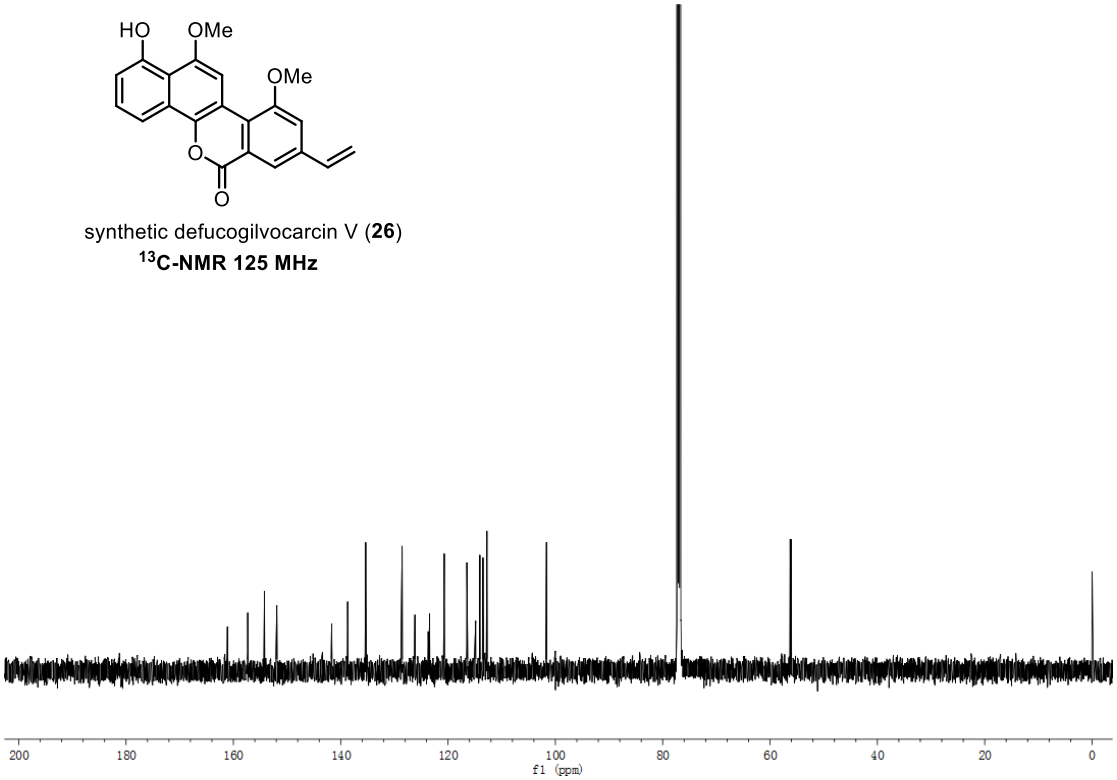
^{13}C-NMR 100 MHz



^{1}H-NMR of Synthetic Defucogilvocarcin V

from James, C. A. *et al. J. Org. Chem.* **2009**, *74*, 4080



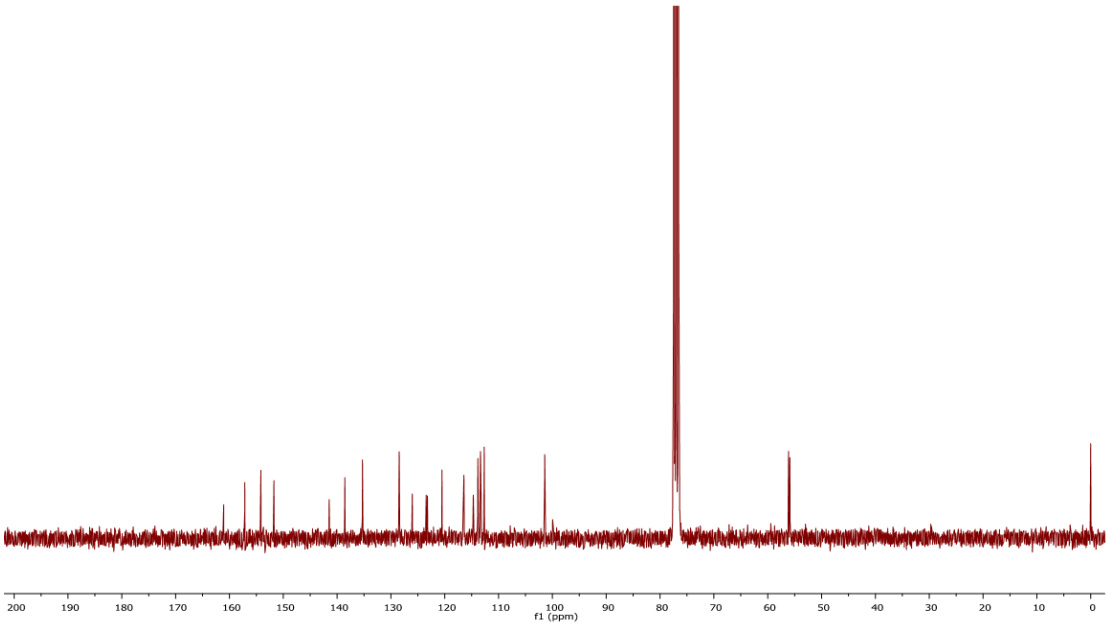


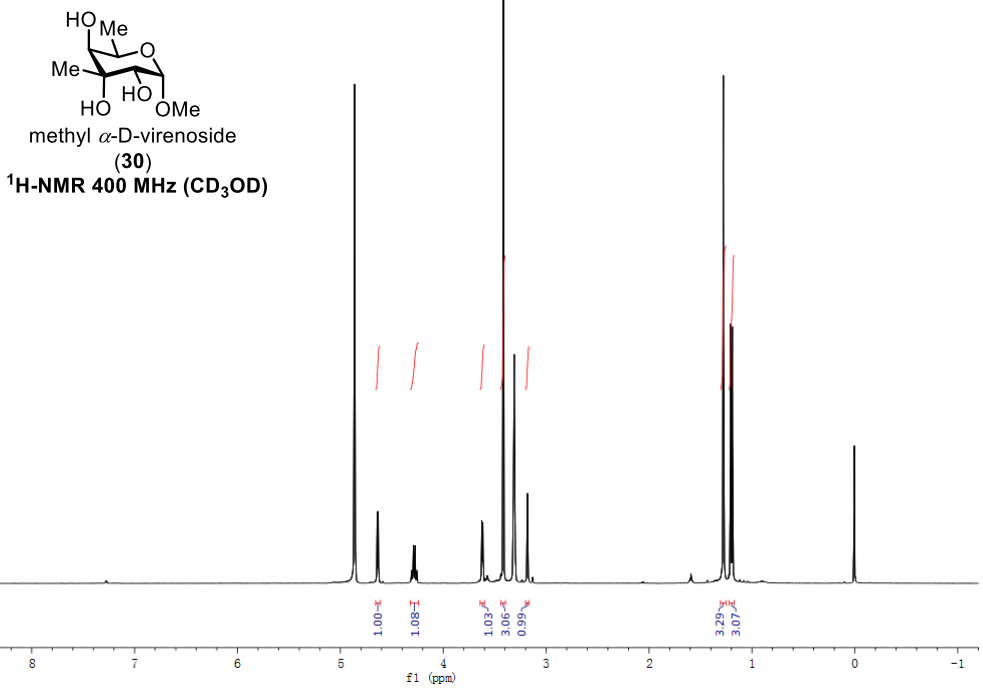
synthetic defucogilvocarcin V (**26**)

^{13}C-NMR 125 MHz

^{1}H-NMR of Synthetic Defucogilvocarcin V

from Nandaluru, P. R. *et al. J. Org. Chem.* **2012**, *77*, 8028

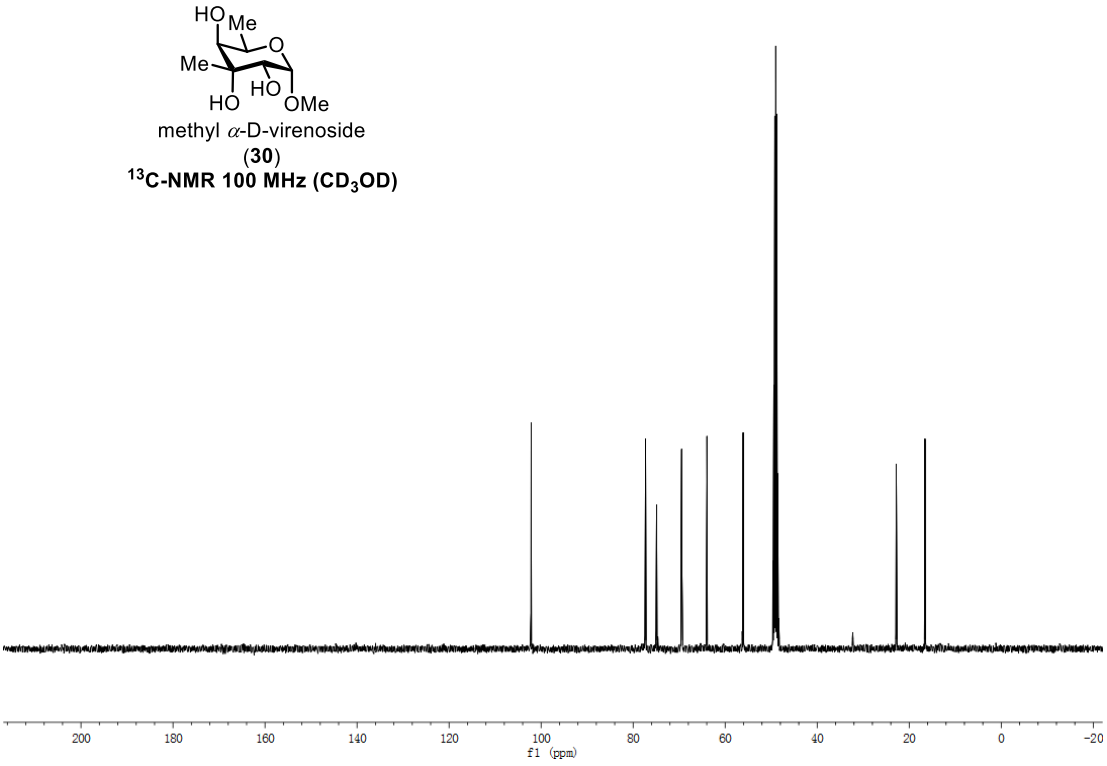




methyl α-D-virenoside

(**30**)

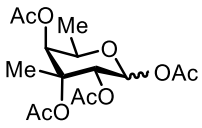
^{1}H-NMR 400 MHz (CD_3OD)



methyl α-D-virenoside

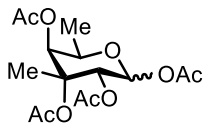
(**30**)

^{13}C-NMR 100 MHz (CD_3OD)



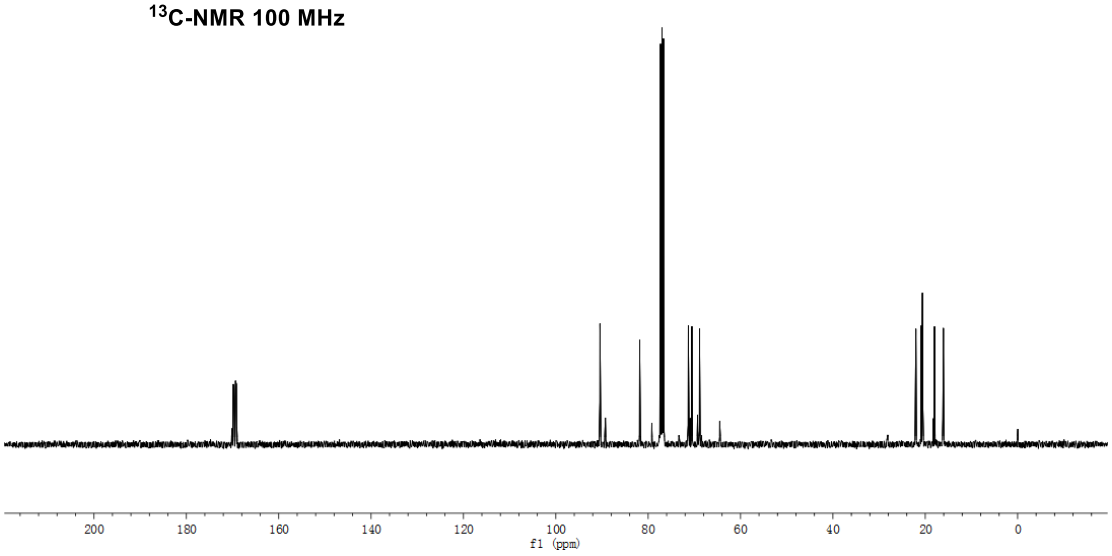
23a

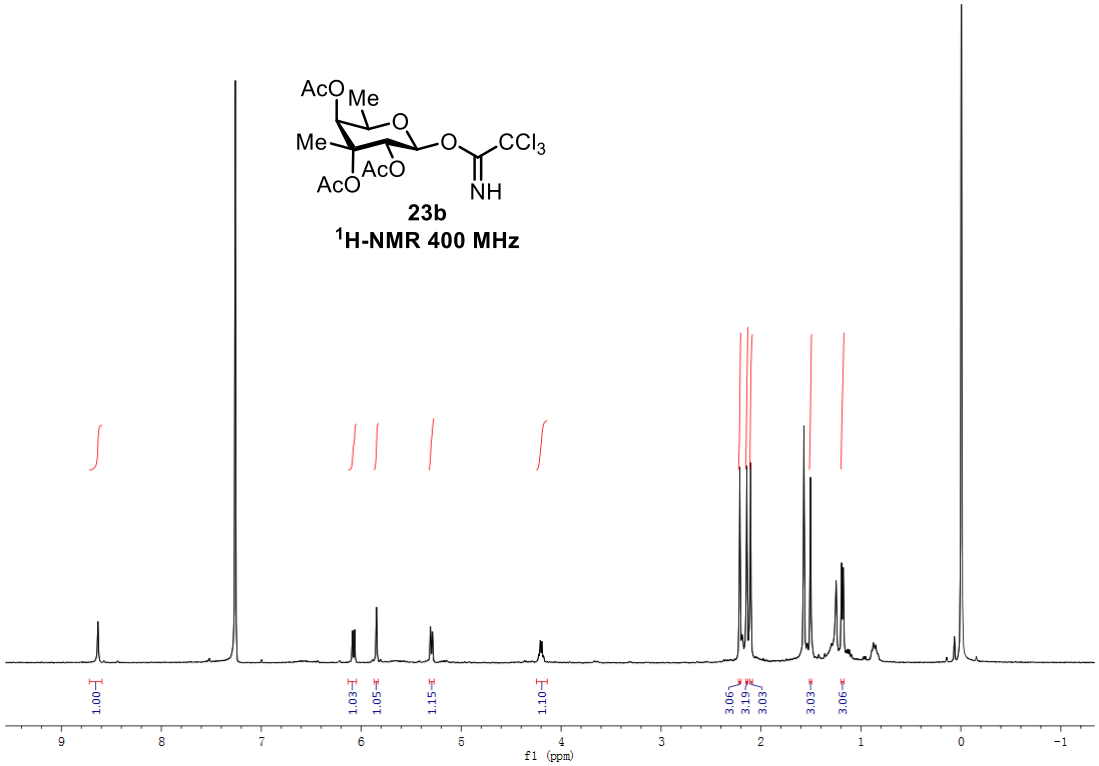
^{1}H-NMR 400 MHz



23a

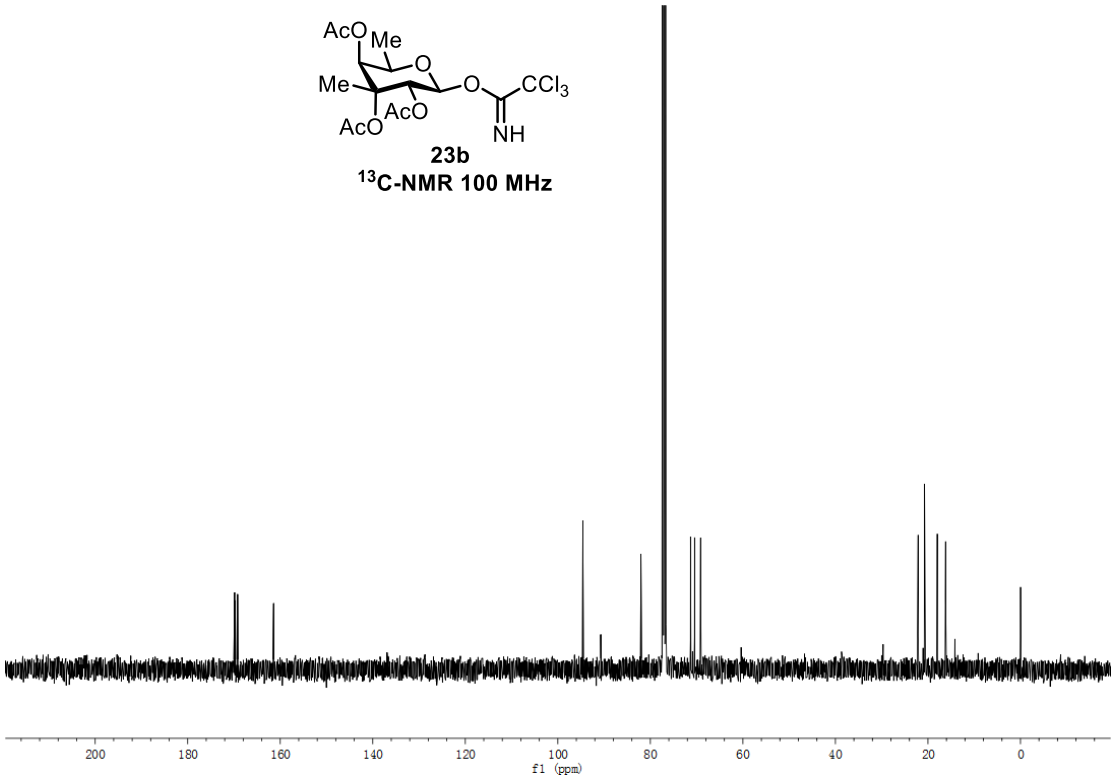
^{13}C-NMR 100 MHz





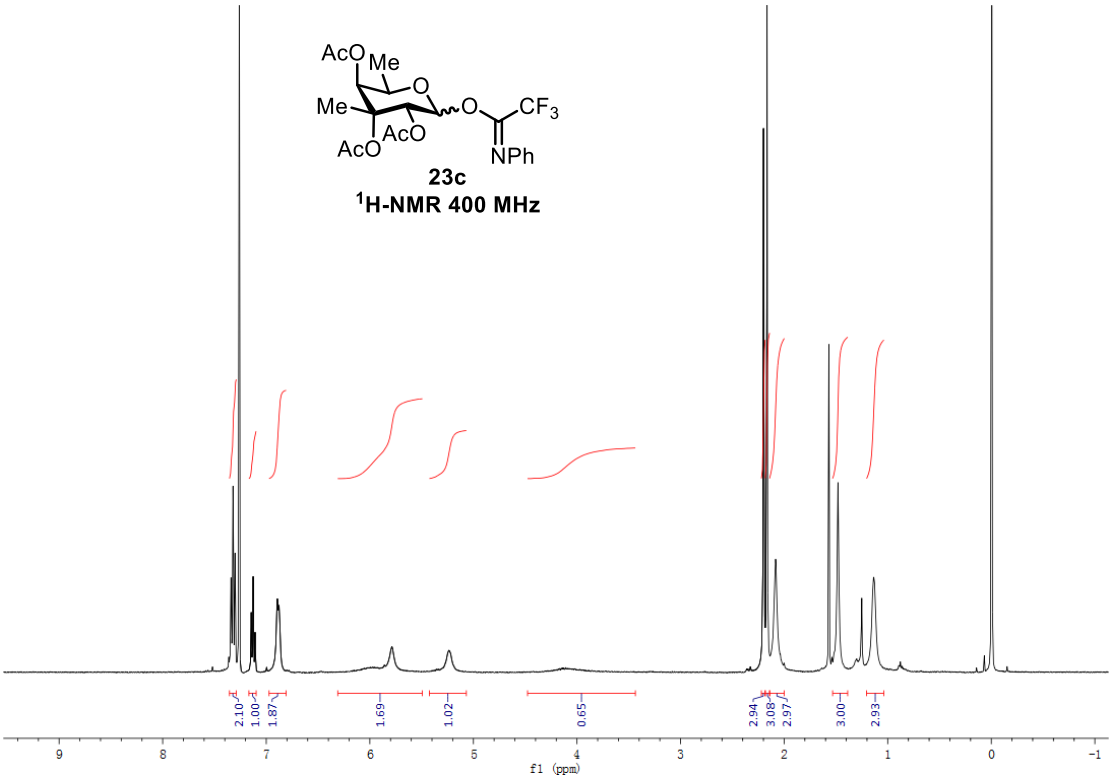
23b

^{1}H-NMR 400 MHz



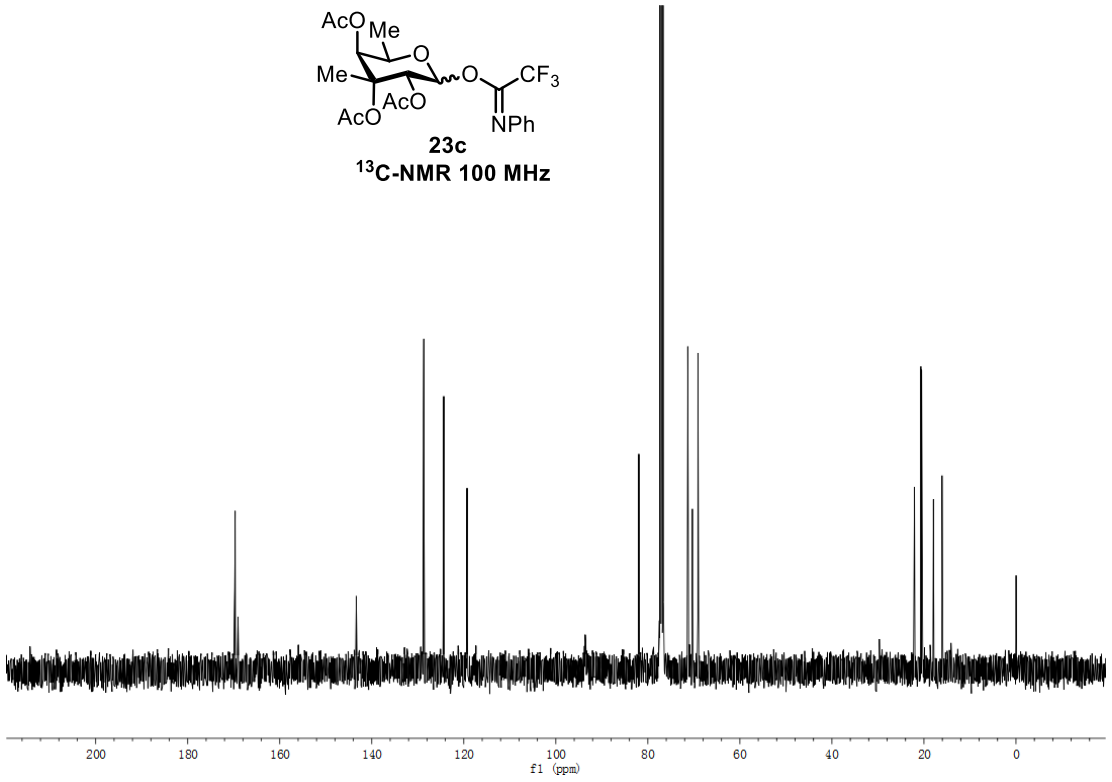
23b

^{13}C-NMR 100 MHz



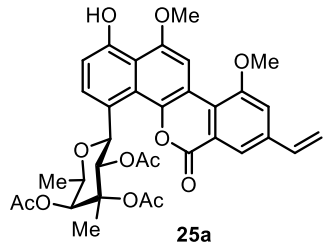
23c

^{1}H-NMR 400 MHz



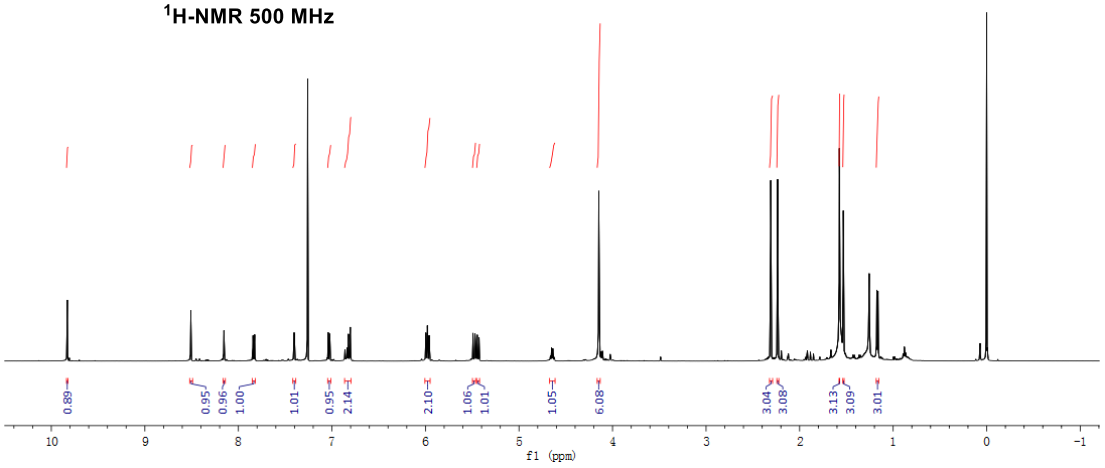
23c

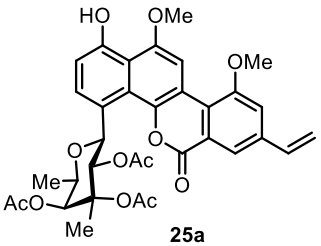
^{13}C-NMR 100 MHz



25a

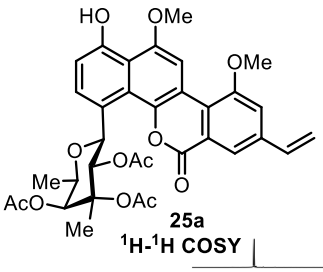
^{1}H-NMR 500 MHz





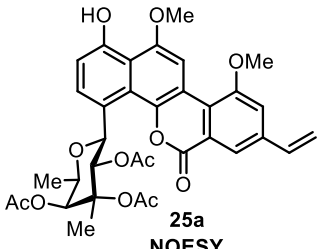
25a

^{13}C-NMR 125 MHz



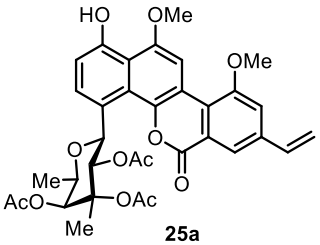
25a

^{1}H-^{1}H COSY

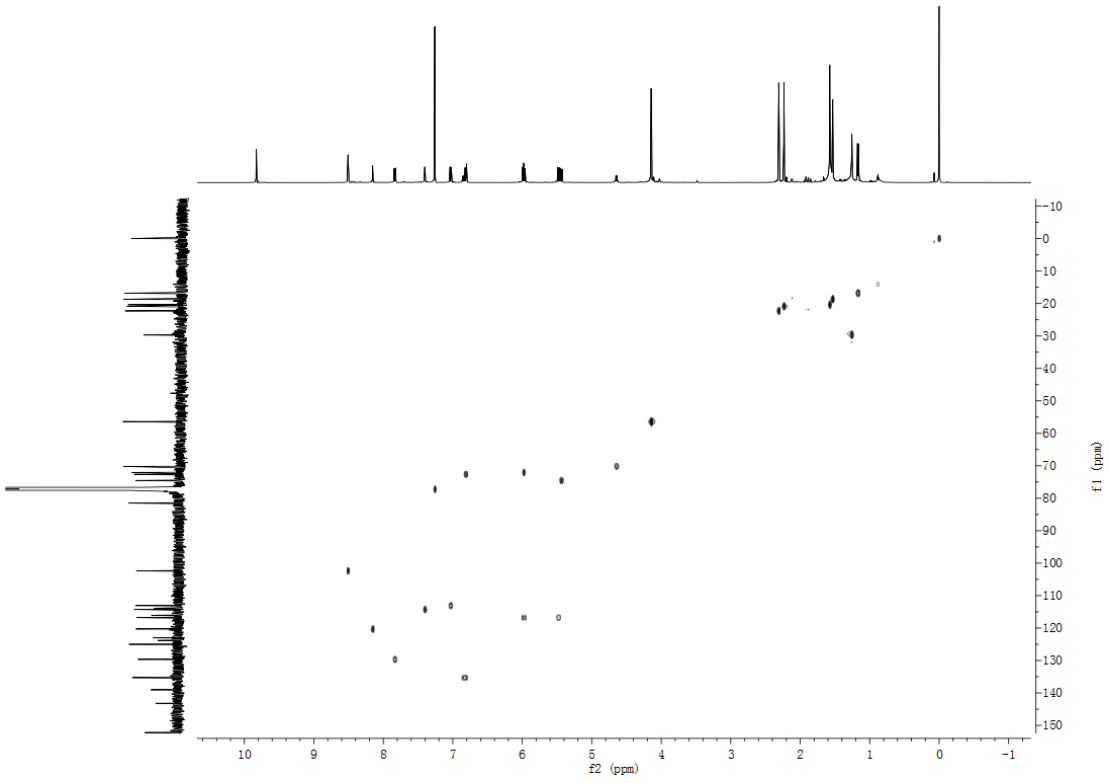


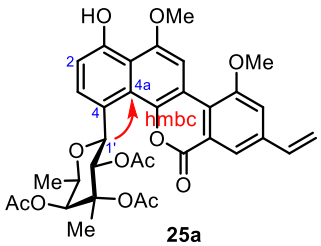
25a

NOESY

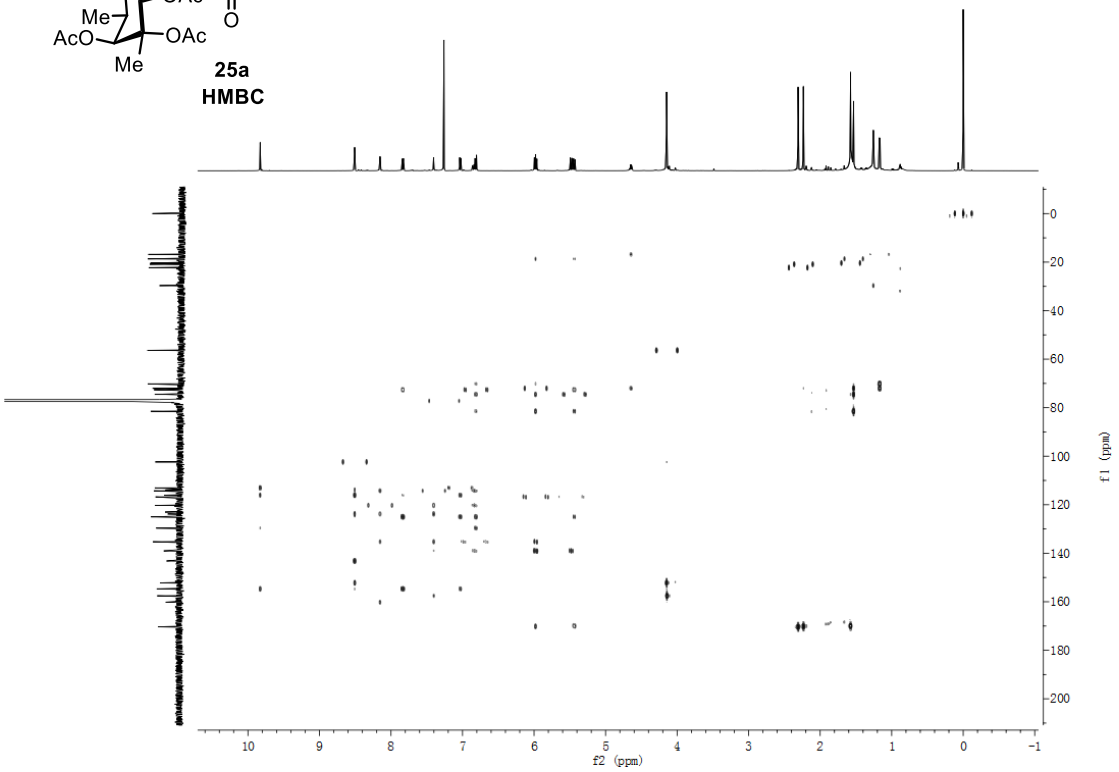


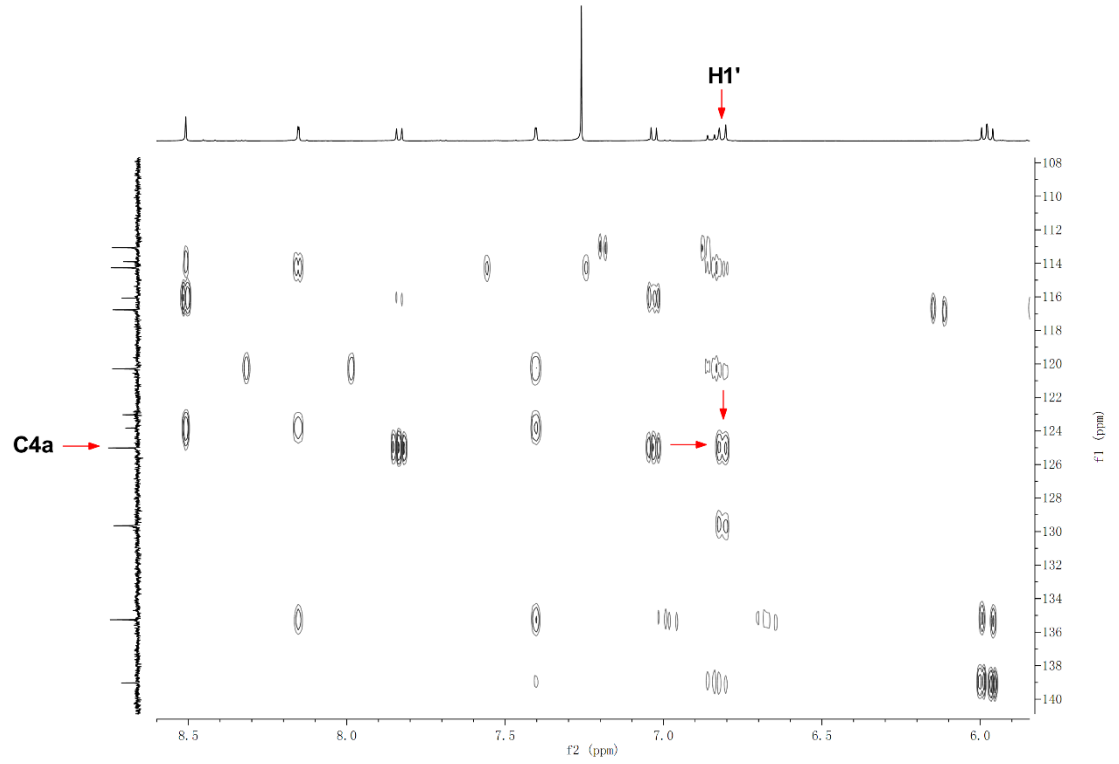
25a
HSQC

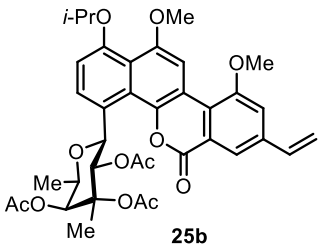



HO
OMe
OMe
2
4a
4
hmbc
1'
O
O
OAc
Me
AcO
OAc
Me
O
O

25a
HMBC

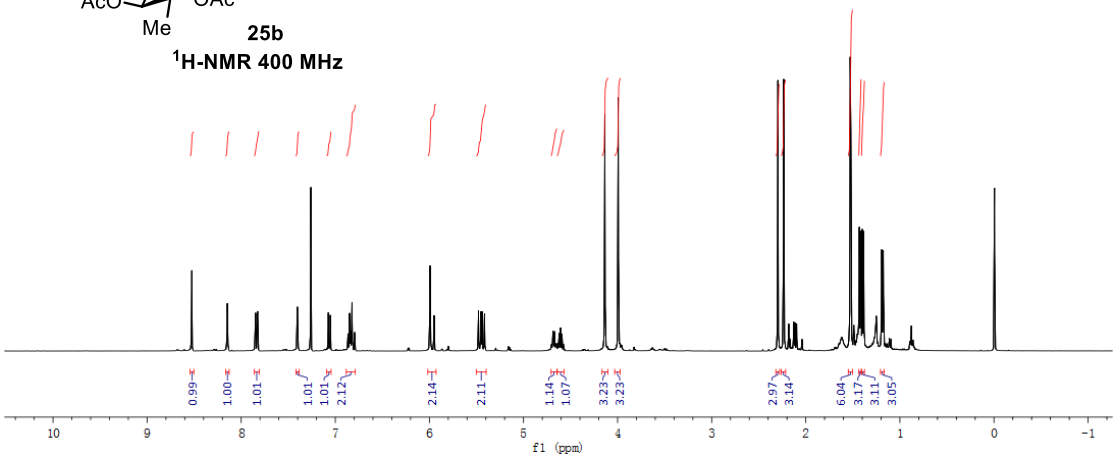

0
20
40
60
80
100
120
140
160
180
200
f1 (ppm)
10
9
8
7
6
5
4
3
2
1
0
−1
f2 (ppm)

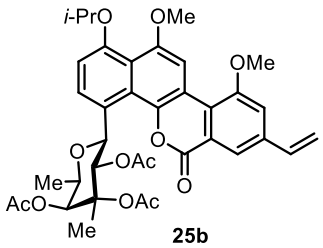

H1'
C4a
108
110
112
114
116
118
120
122
124
126
128
130
132
134
136
138
140
f1 (ppm)
8.5
8.0
7.5
7.0
6.5
6.0
f2 (ppm)



25b

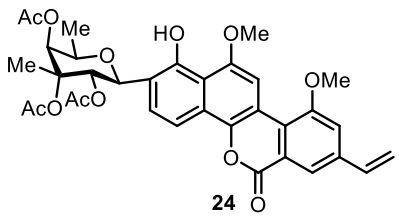
^{1}H-NMR 400 MHz





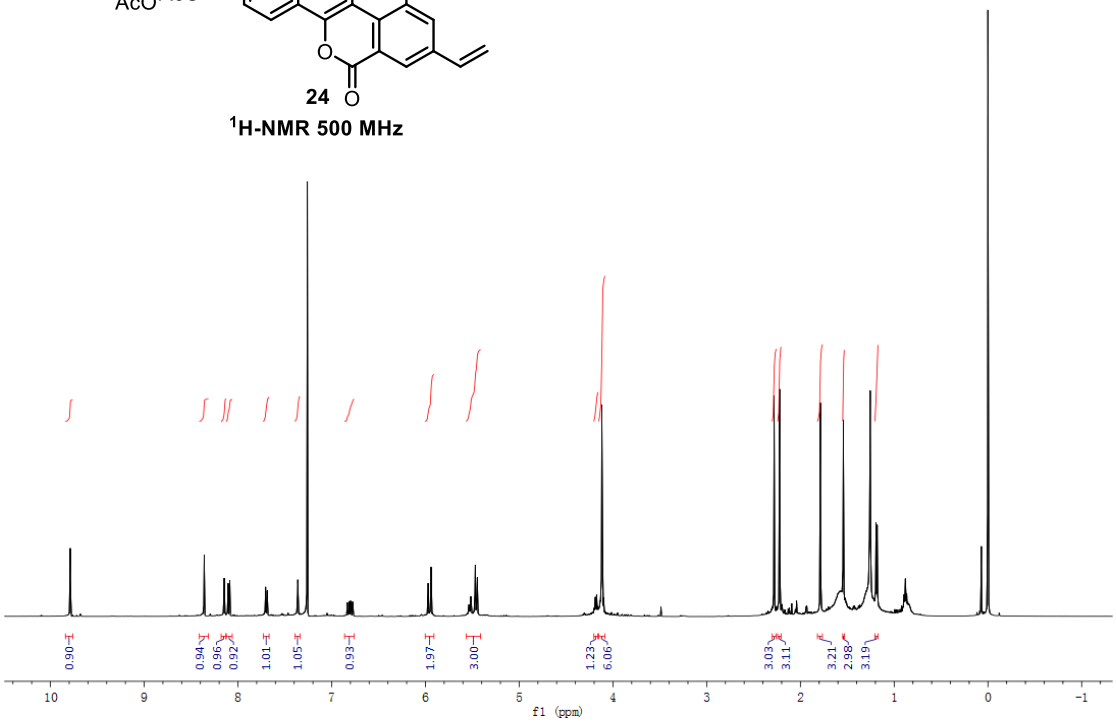
25b

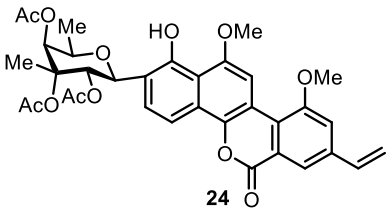
^{13}C-NMR 100 MHz



24

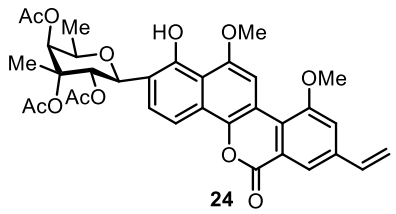
^{1}H-NMR 500 MHz





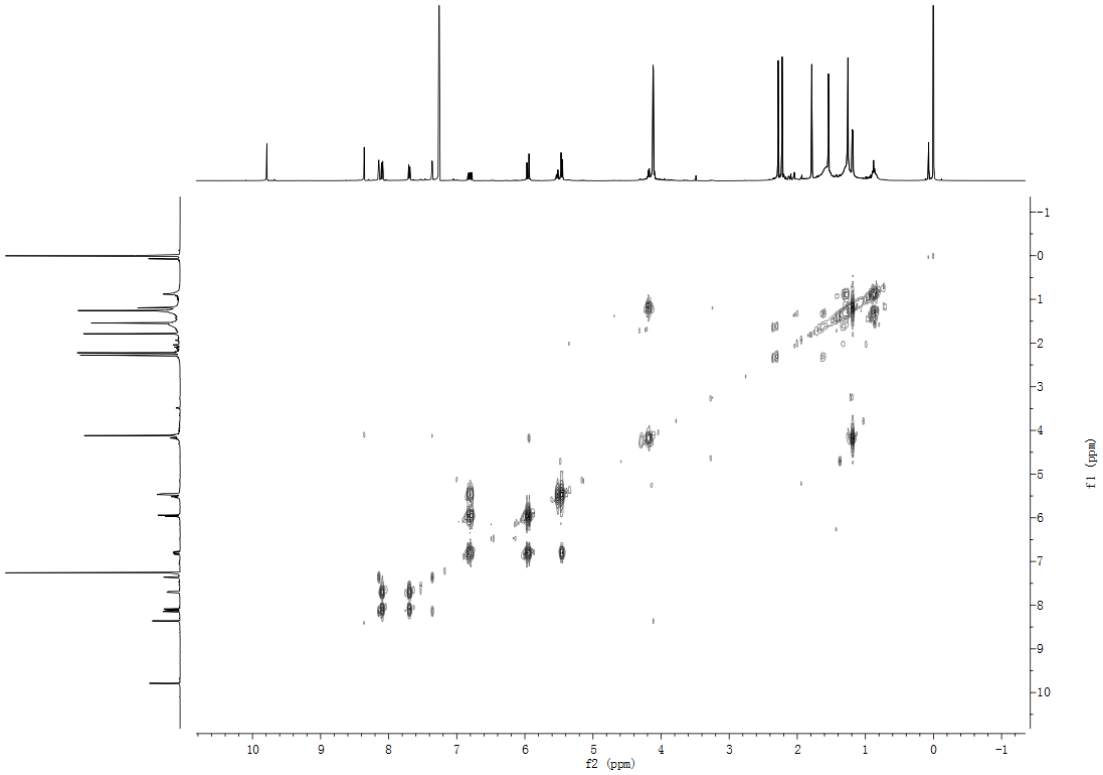
24

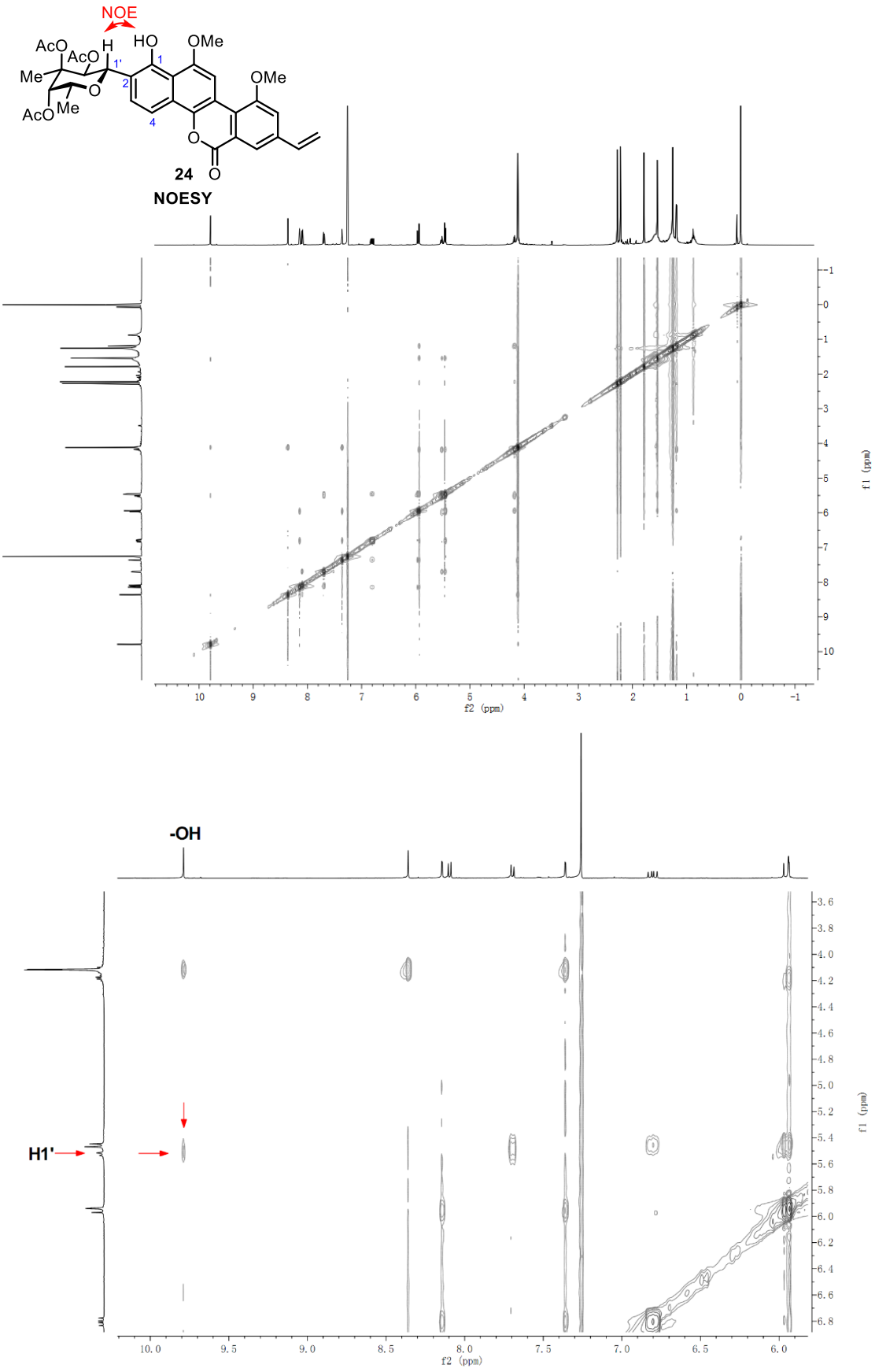
^{13}C-NMR 125 MHz

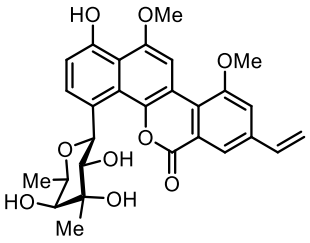


24

^{1}H-^{1}H COSY

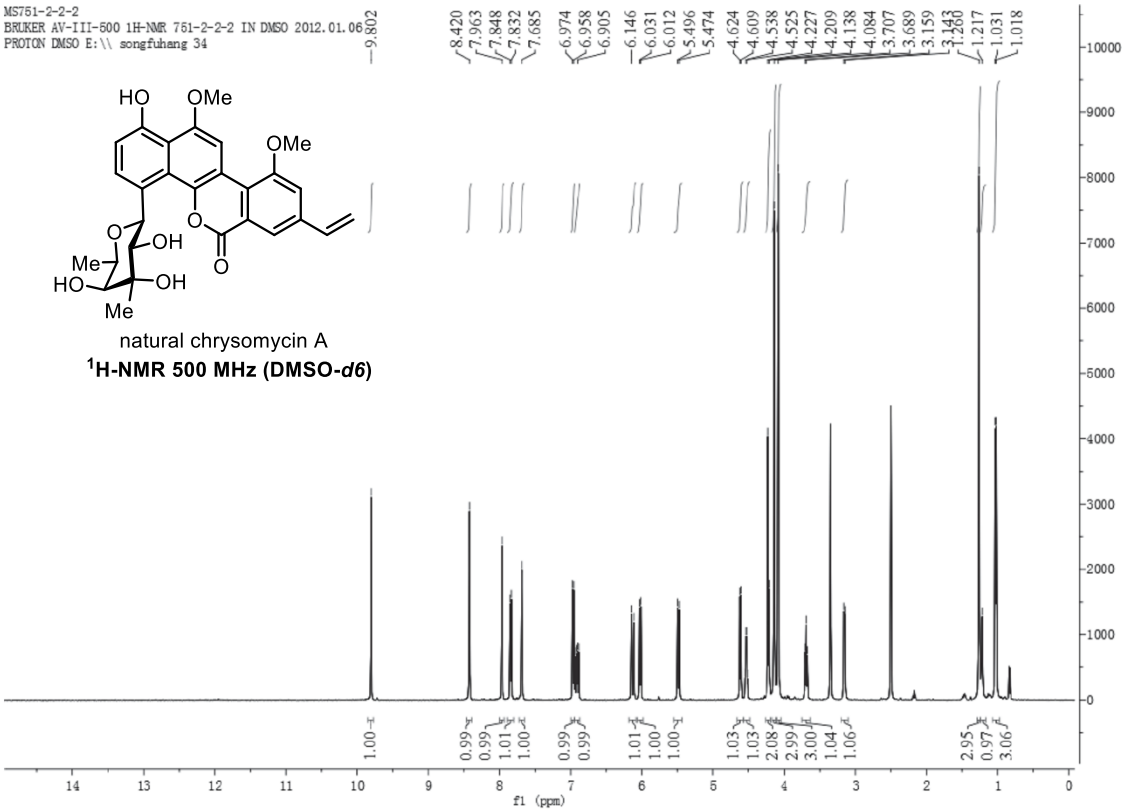



NOE
AcO
AcO
H
HO
OMe
Me
1'
1
2
OMe
O
AcO
Me
4
O
O
24
NOESY
f2 (ppm)
f1 (ppm)
-OH
H1'
f2 (ppm)
f1 (ppm)



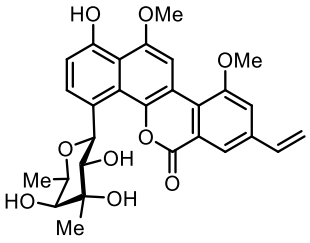
synthetic chrysomycin A

^{1}H-NMR 400 MHz (DMSO-*d6*)



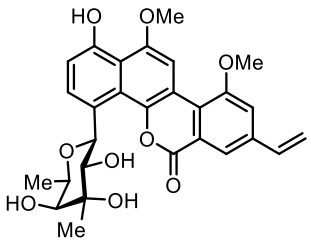
natural chrysomycin A

^{1}H-NMR 500 MHz (DMSO-*d6*)



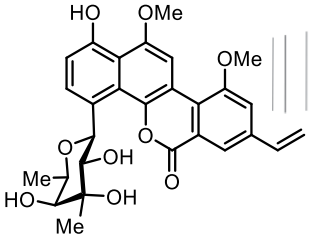
"synthetic + natural" chrysomycin A

^{1}H-NMR 400 MHz (DMSO-*d6*)



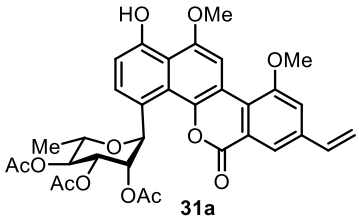
synthetic chrysomycin A

^{13}C-NMR 100 MHz (DMSO-*d6*)



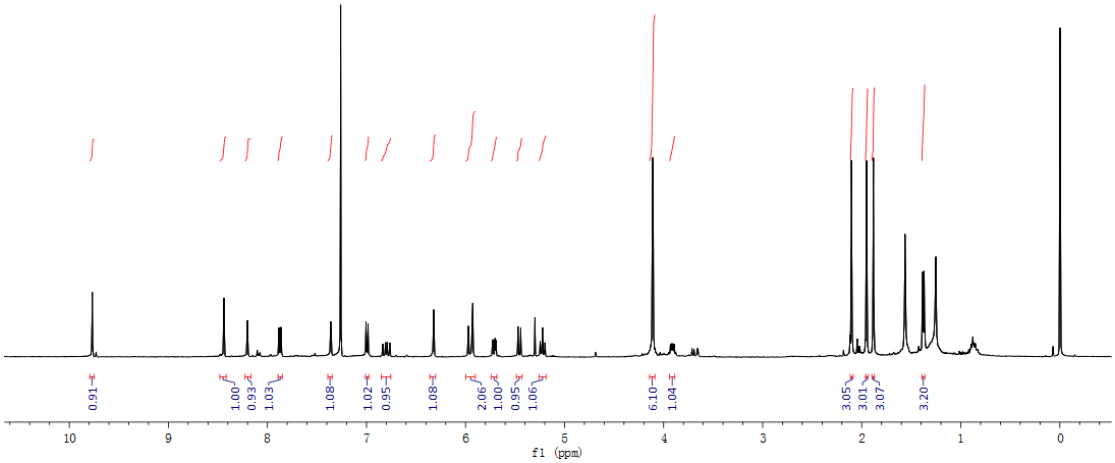
natural chrysomycin A

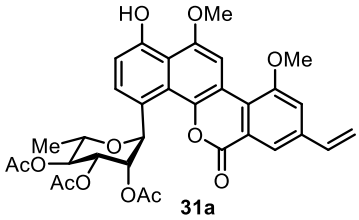
^{13}C-NMR 125 MHz (DMSO-*d6*)



31a

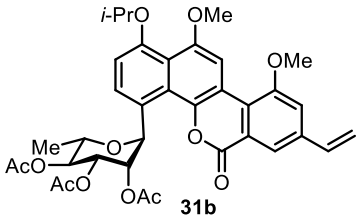
^{1}H-NMR 400 MHz





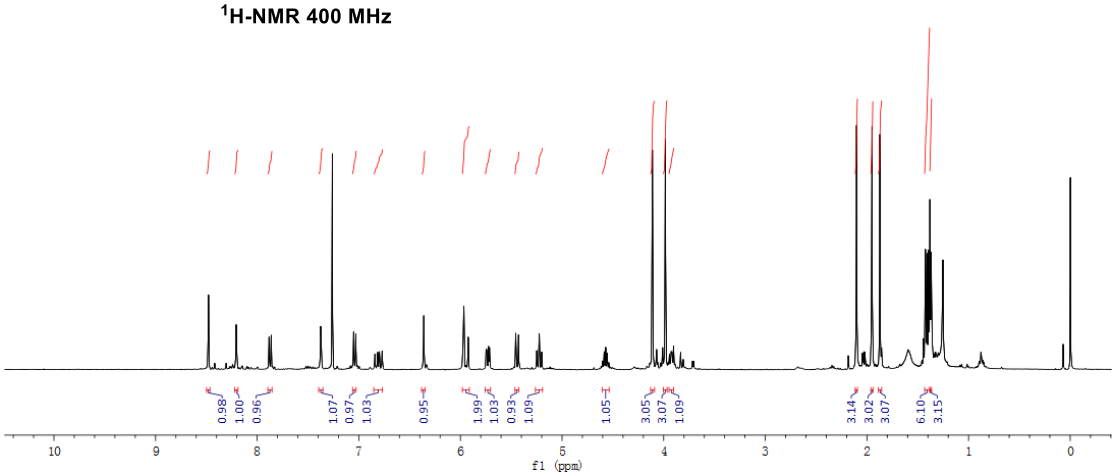
31a

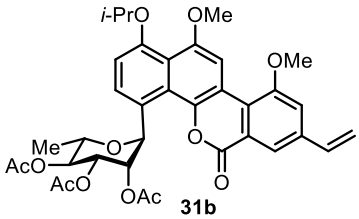
^{13}C-NMR 100 MHz



31b

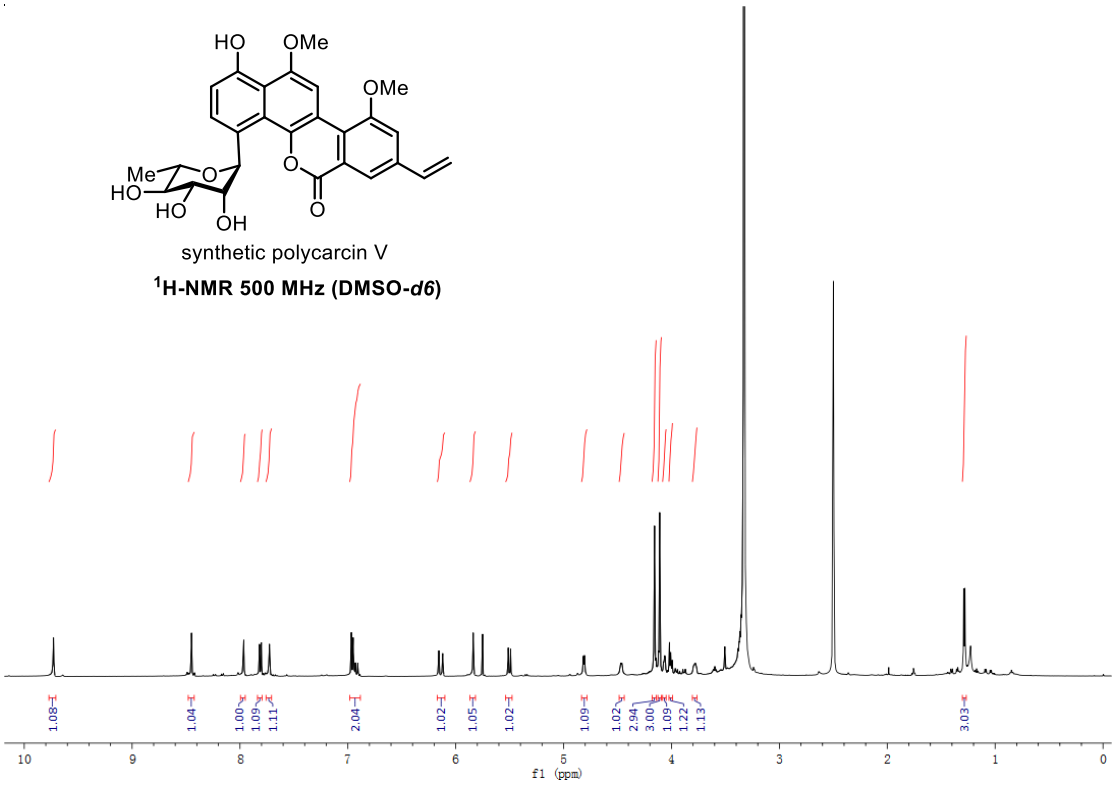
^{1}H-NMR 400 MHz





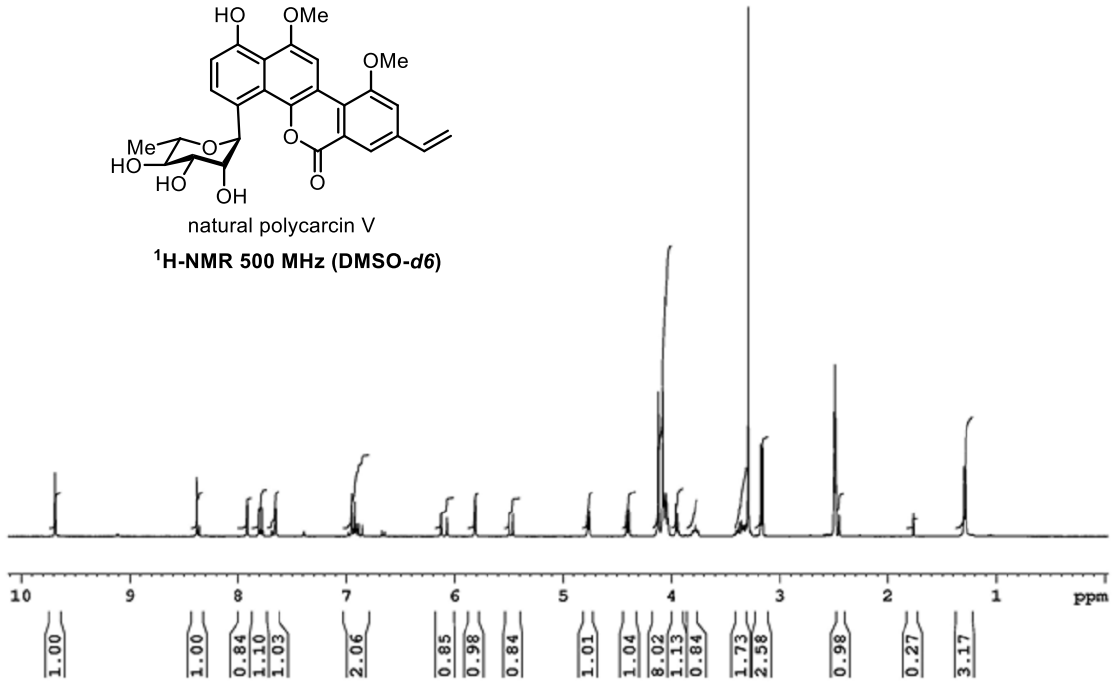
31b

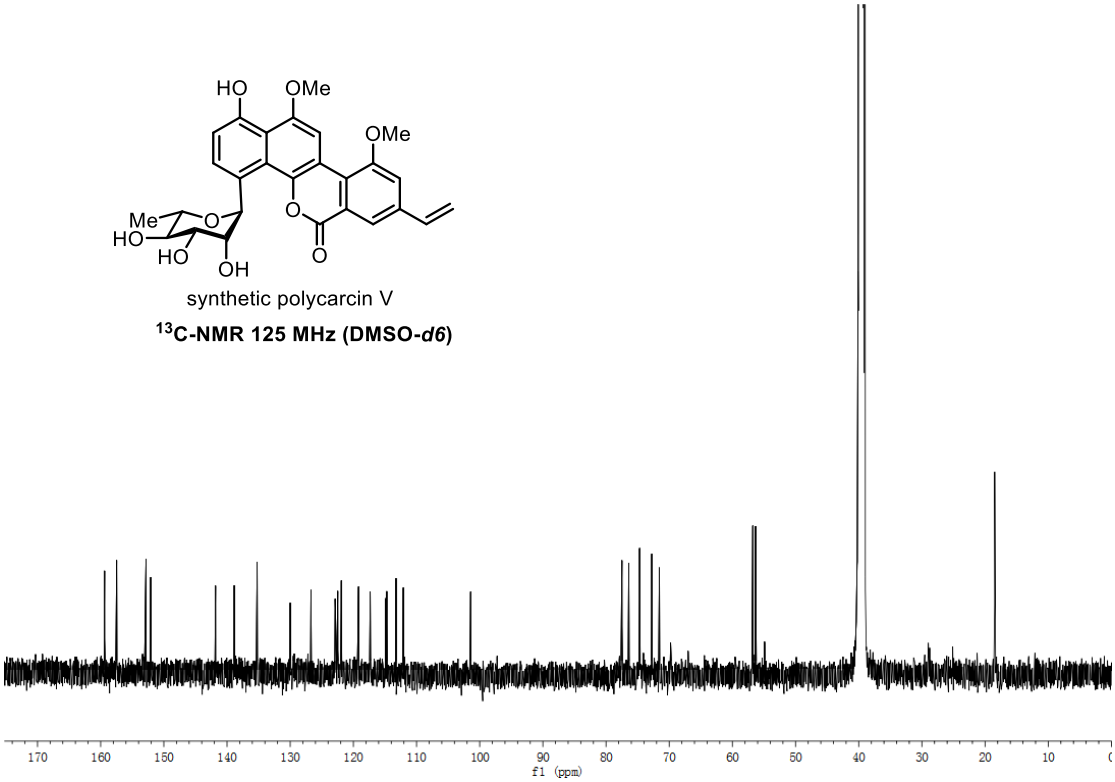
^{13}C-NMR 100 MHz



^{1}H NMR of Natural Polycarcin V

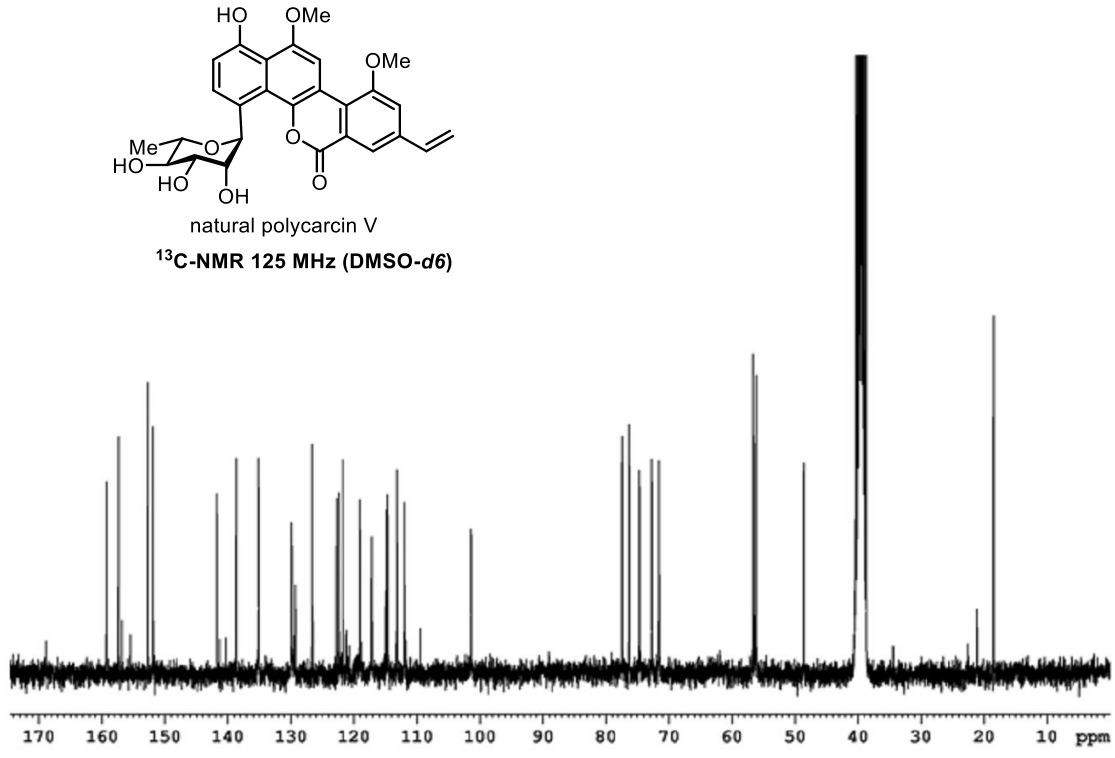
from Li, Y. *et al. Org. & Biomol. Chem.* **2008**, *6*, 3601

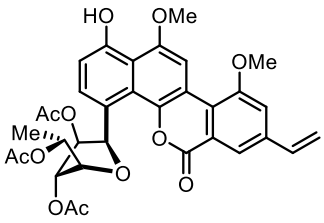




^{13}C NMR of Natural Polycarcin V

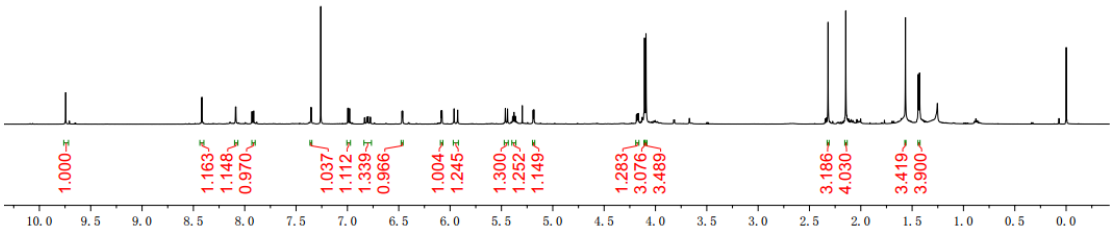
from Li, Y. *et al. Org. & Biomol. Chem.* **2008**, *6*, 3601

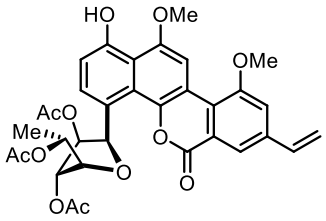




32a

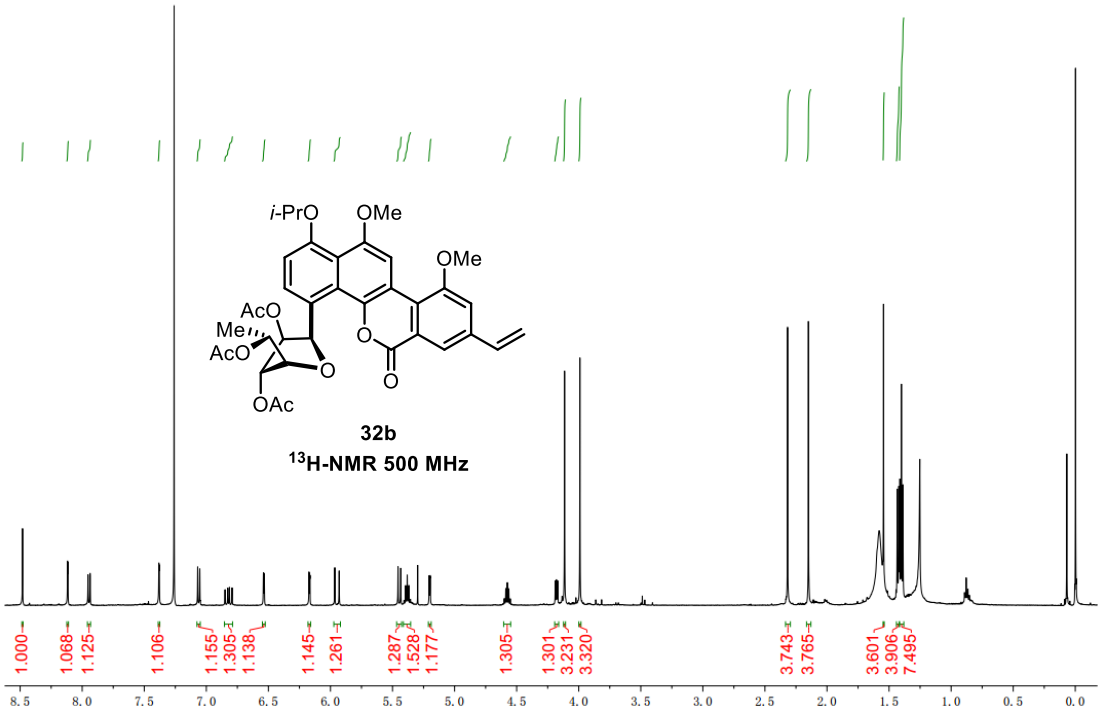
^{1}H-NMR 500 MHz





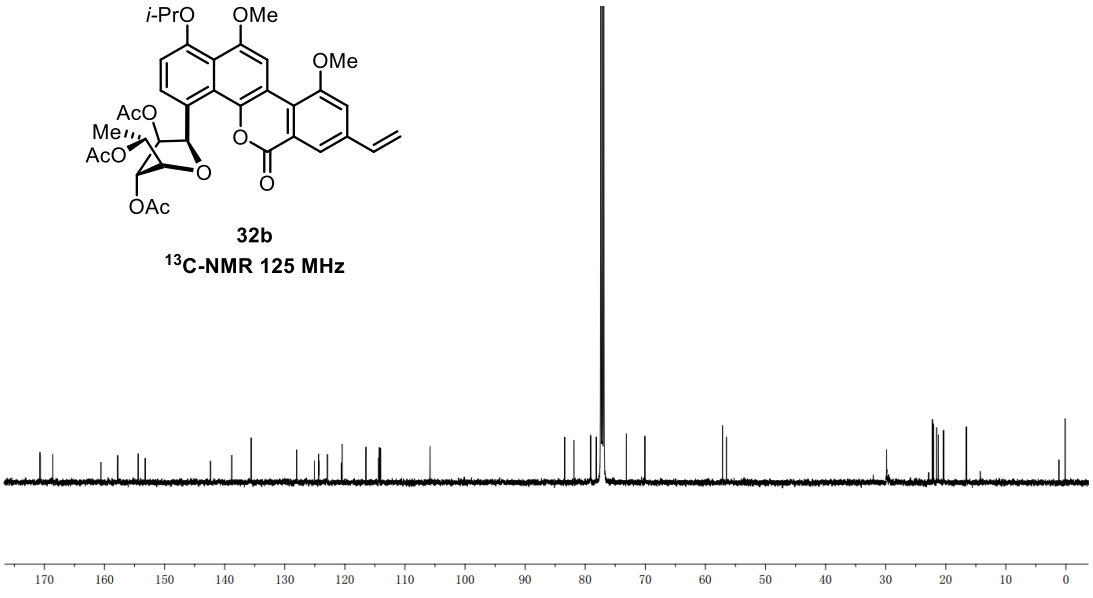
32a

^{13}C-NMR 125 MHz



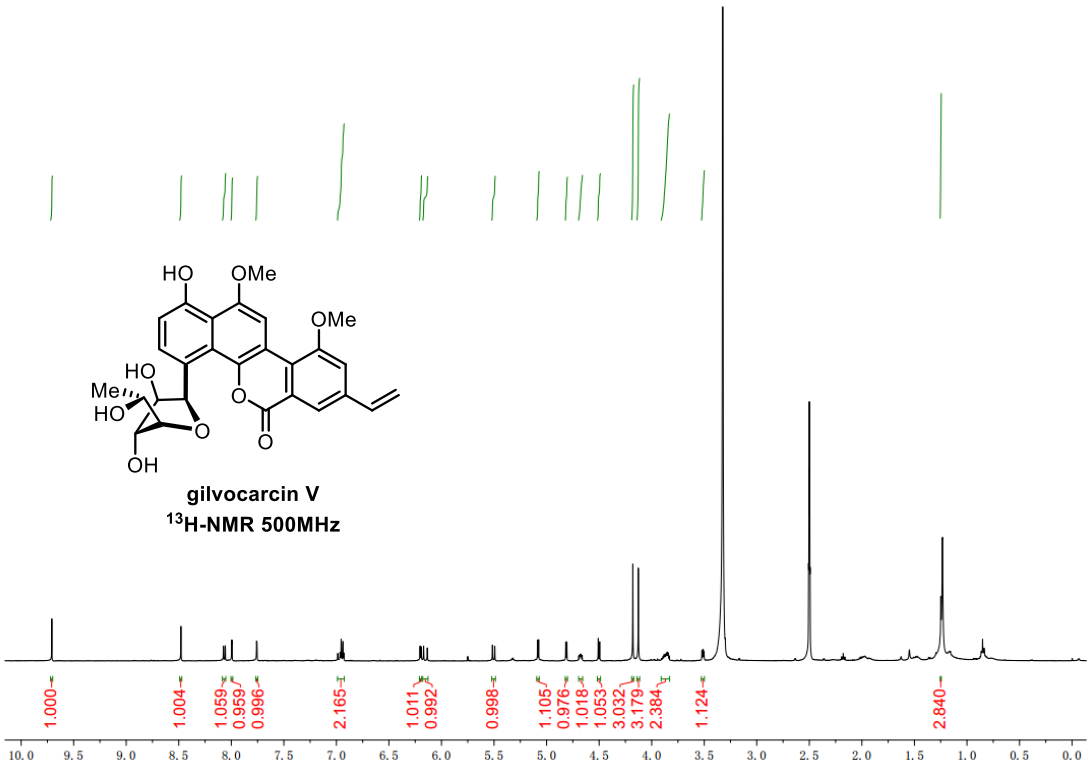
32b

^{13}H-NMR 500 MHz

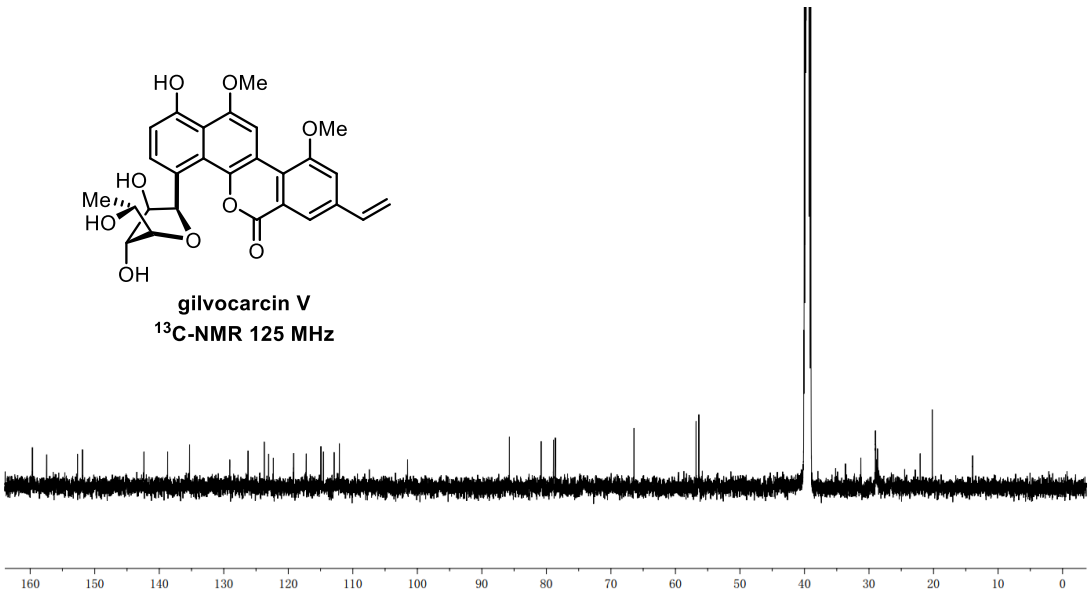


32b

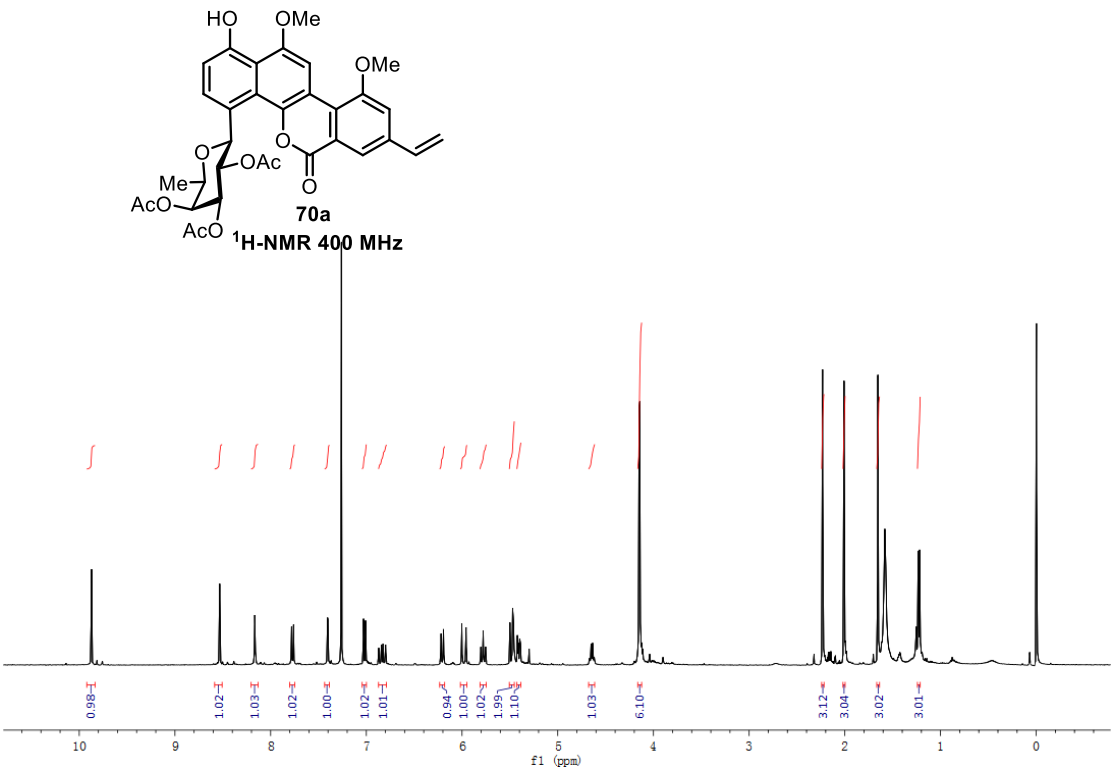
^{13}C-NMR 125 MHz

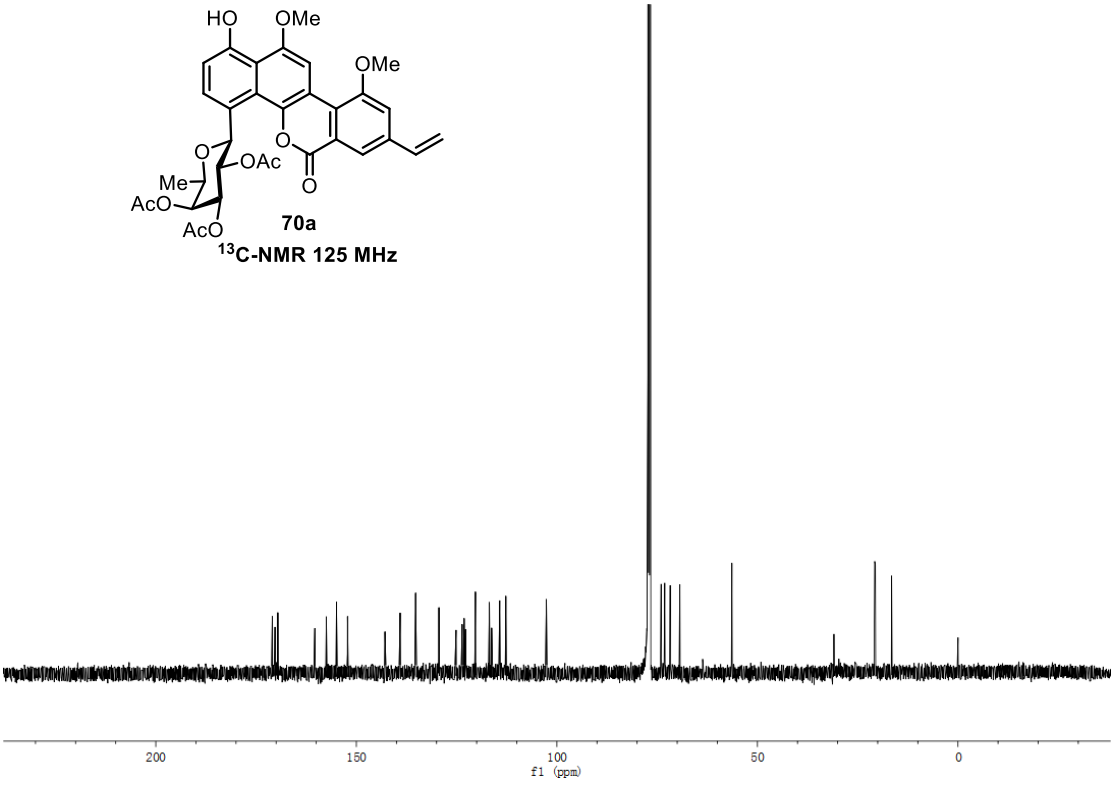


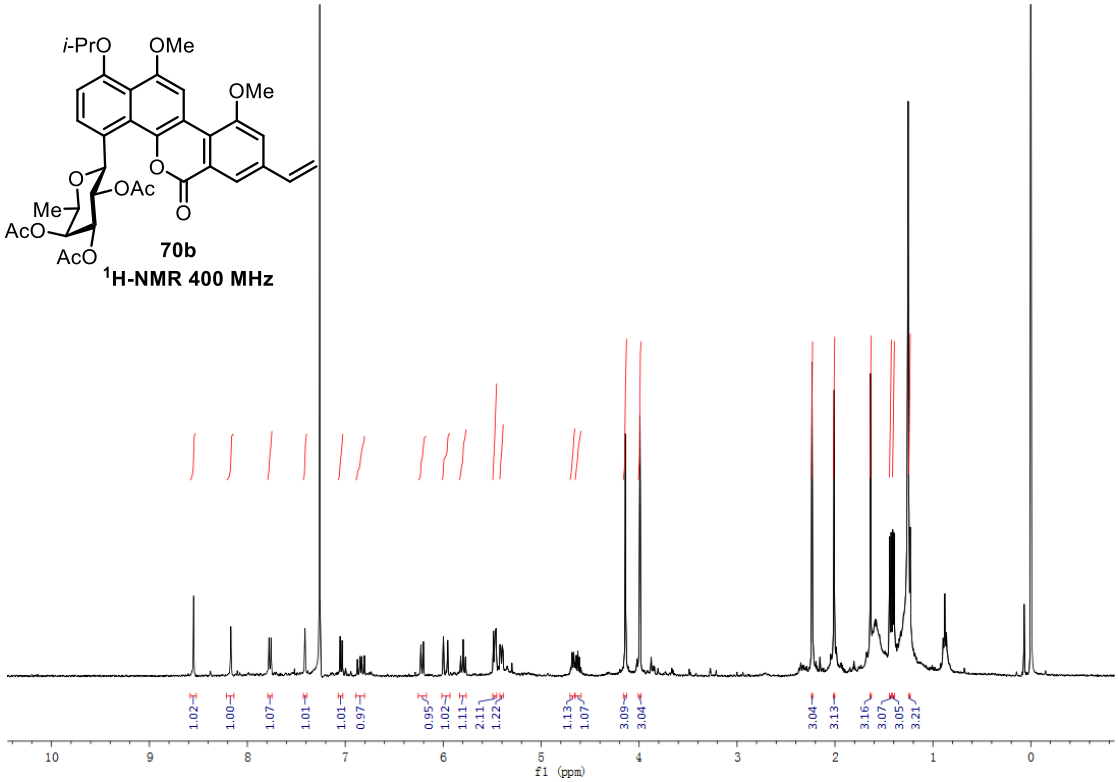
gilvocarcin V
^{13}H-NMR 500MHz

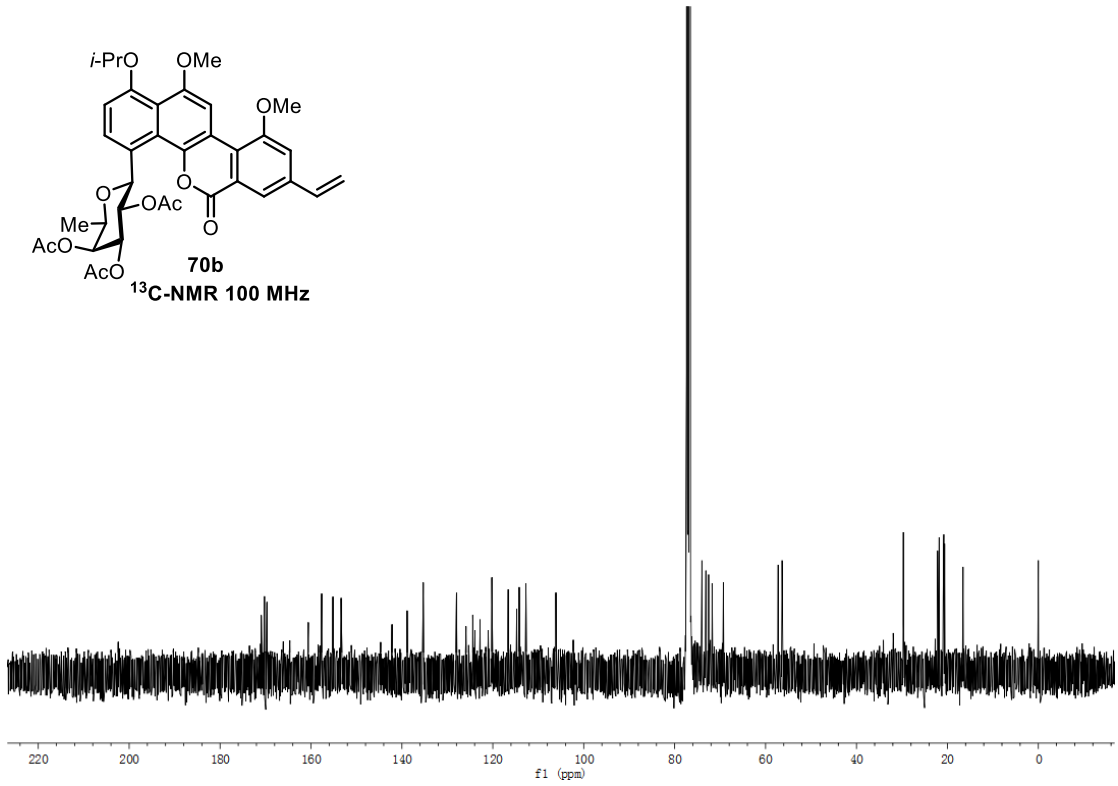


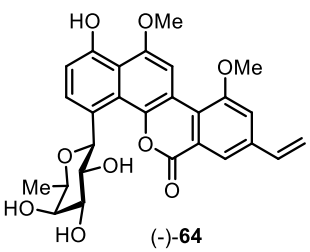
gilvocarcin V
^{13}C-NMR 125 MHz


HO
OMe
OMe
O
OAc
O
O
Me
AcO
AcO
70a
1H-NMR 400 MHz
0.98
1.02
1.03
1.02
1.00
1.02
1.01
0.94
1.00
1.02
1.99
1.10
1.03
6.10
3.12
3.04
3.02
3.01
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


HO
OMe
OMe
O
OAc
O
O
Me
AcO
AcO
70a
13C-NMR 125 MHz
200
150
100
50
0
f1 (ppm)

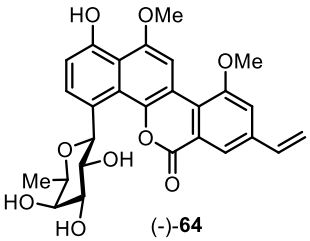

i-PrO
OMe
OMe
O
O
OAc
O
Me
AcO
AcO
70b
1H-NMR 400 MHz
1.02
1.00
1.07
1.01
1.01
0.97
0.95
1.02
1.11
2.11
1.22
1.13
1.07
3.09
3.04
3.04
3.13
3.16
3.07
3.05
3.21
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)


i-PrO
OMe
OMe
O
O
OAc
O
Me
AcO
AcO
70b
13C-NMR 100 MHz
220
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)



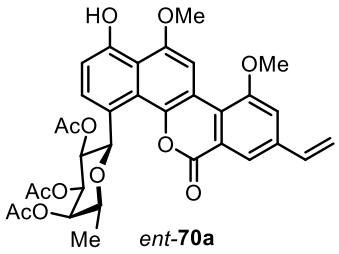
(-)-**64**

^{1}H-NMR 500 MHz (DMSO-*d6*)



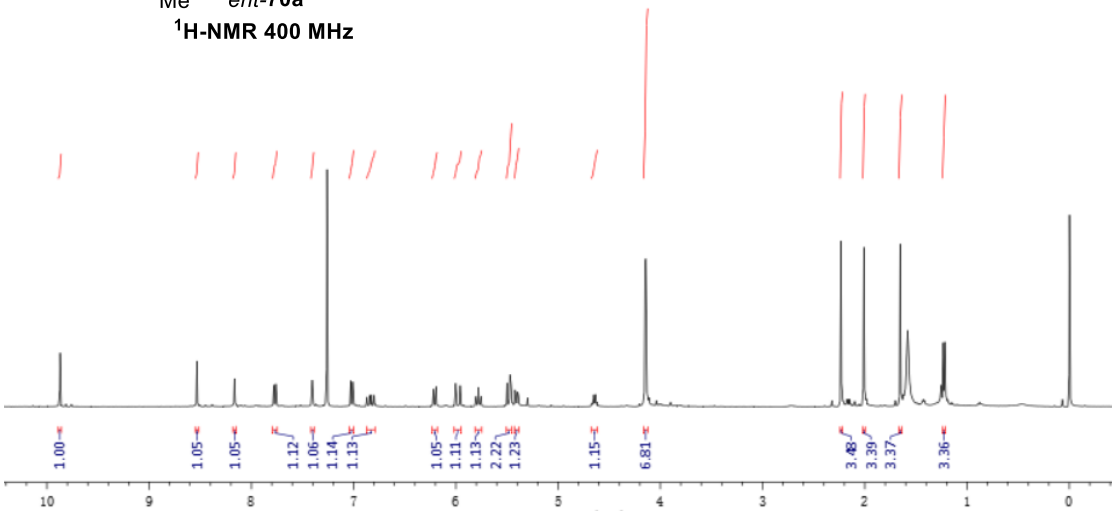
(-)-**64**

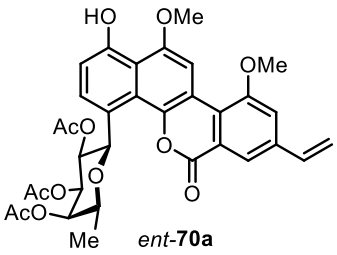
^{13}C-NMR 125 MHz (DMSO-*d6*)



ent-**70a**

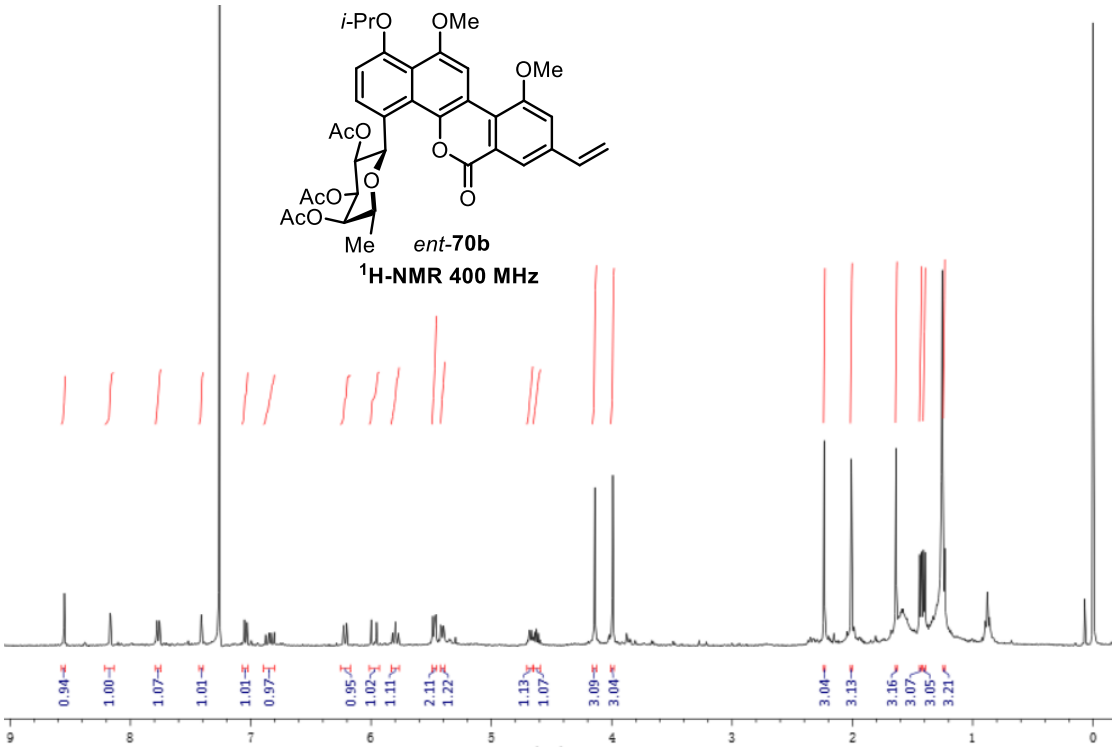
^{1}H-NMR 400 MHz

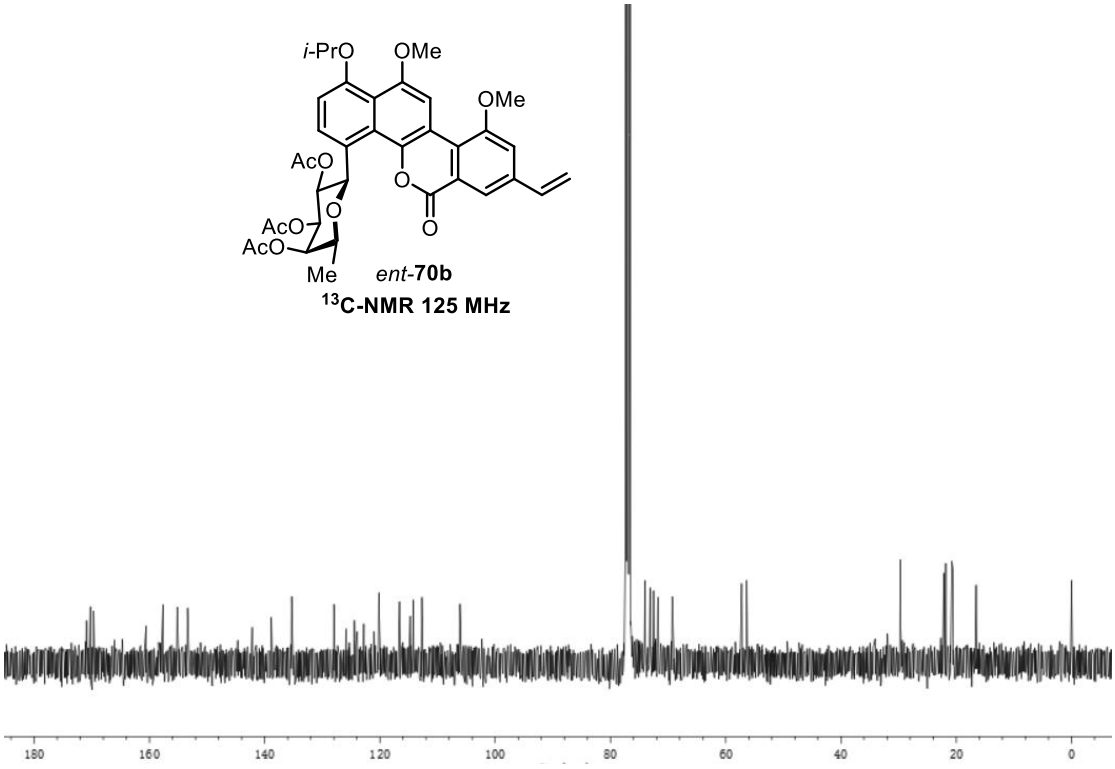


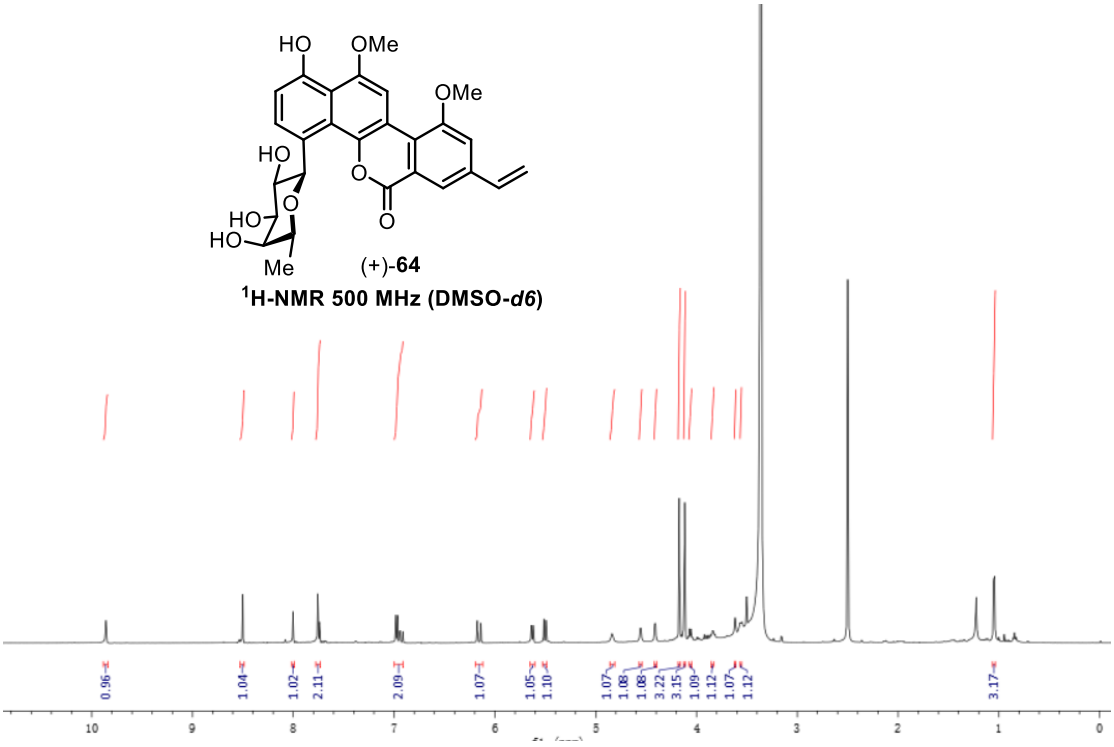


ent-**70a**

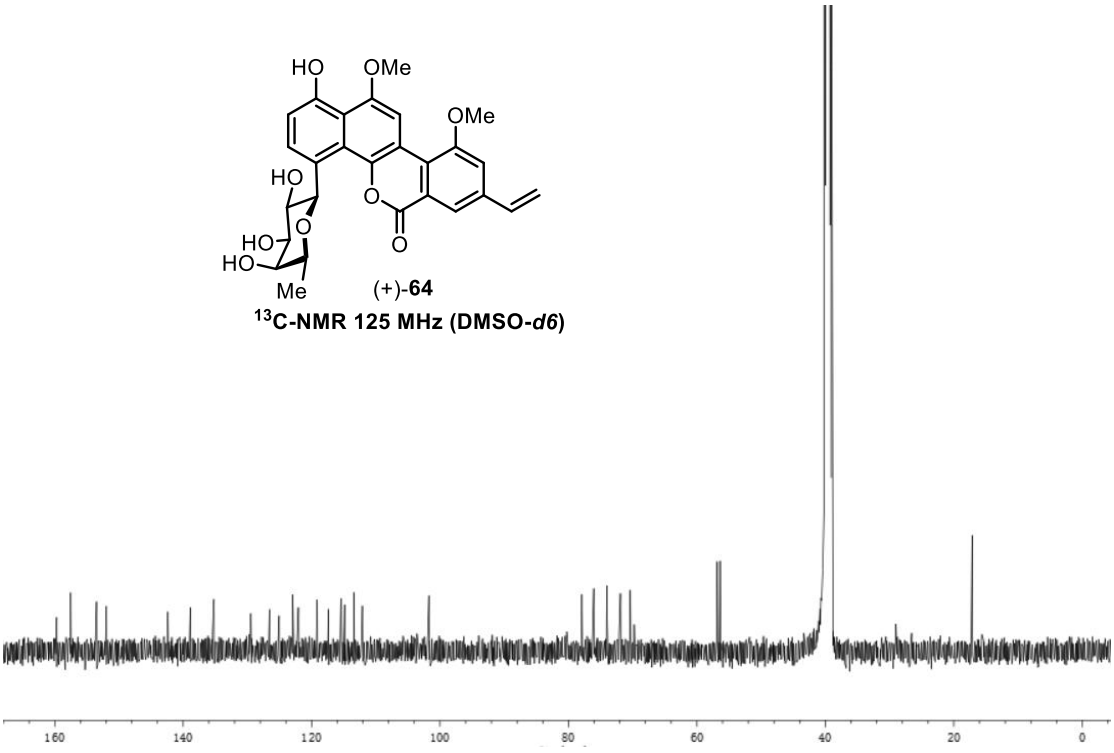
^{13}C-NMR 125 MHz


i-PrO
OMe
OMe
AcO
AcO
AcO
Me
ent-70b
1H-NMR 400 MHz

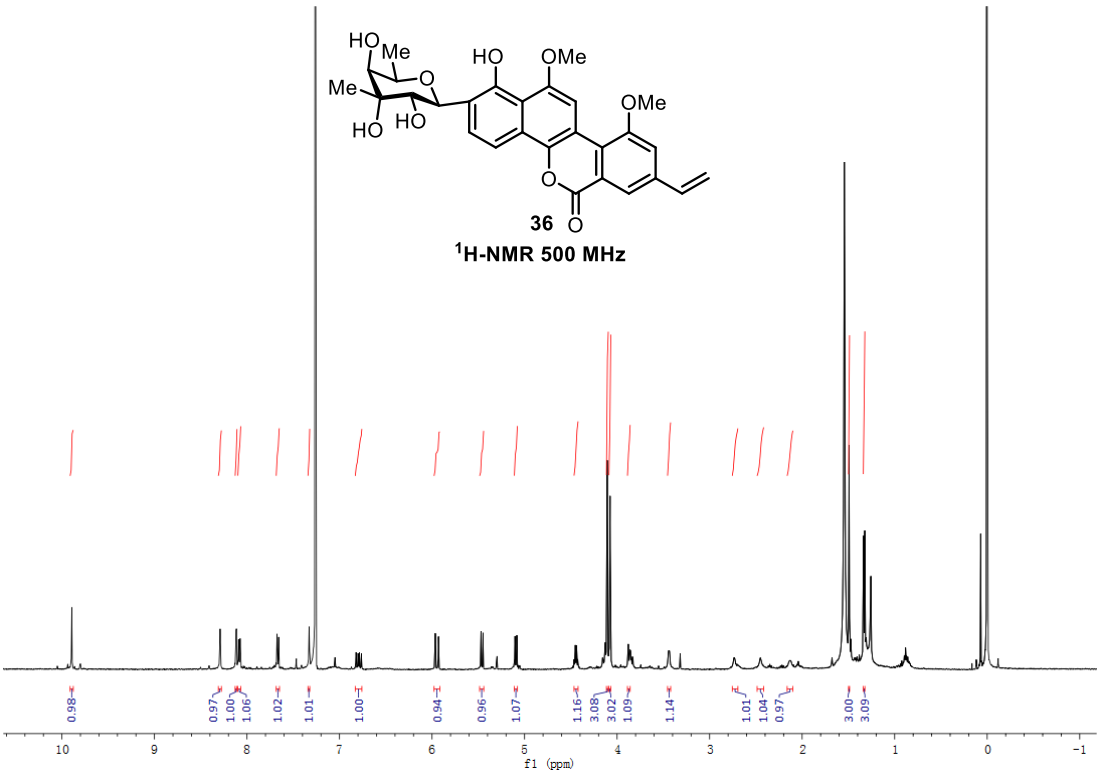

i-PrO
OMe
OMe
AcO
AcO
AcO
Me
ent-70b
13C-NMR 125 MHz

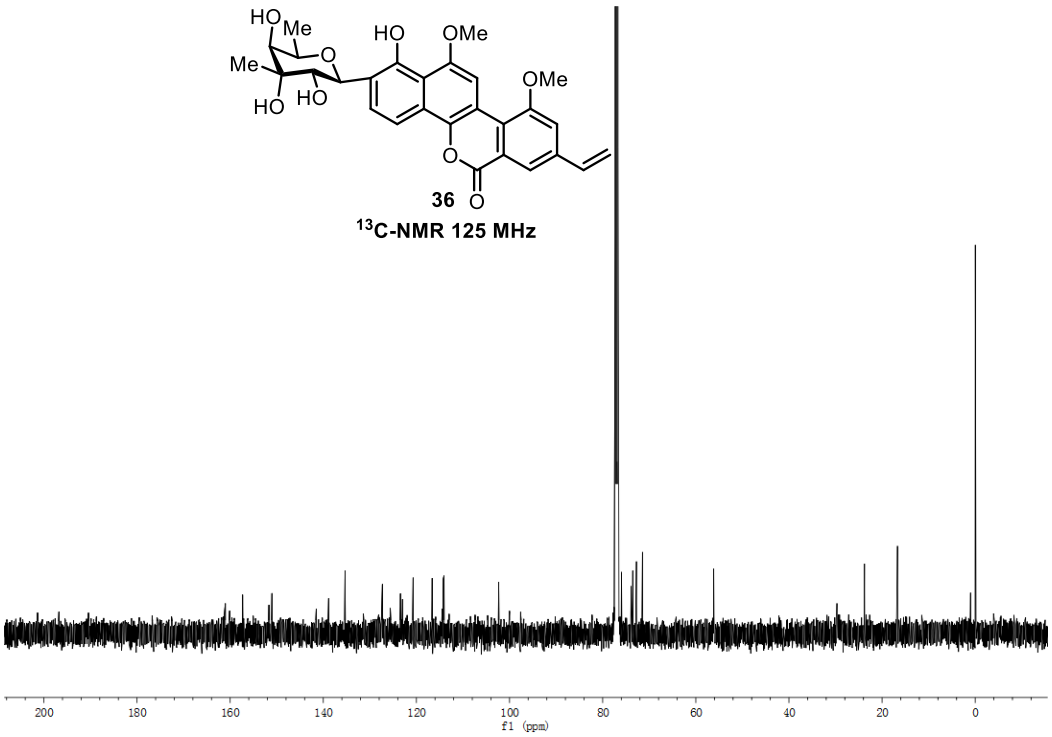


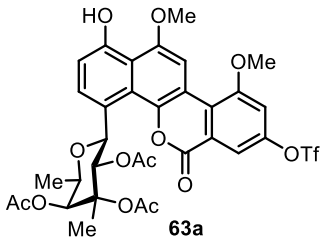
^{1}H-NMR 500 MHz (DMSO-*d6*)



^{13}C-NMR 125 MHz (DMSO-*d6*)

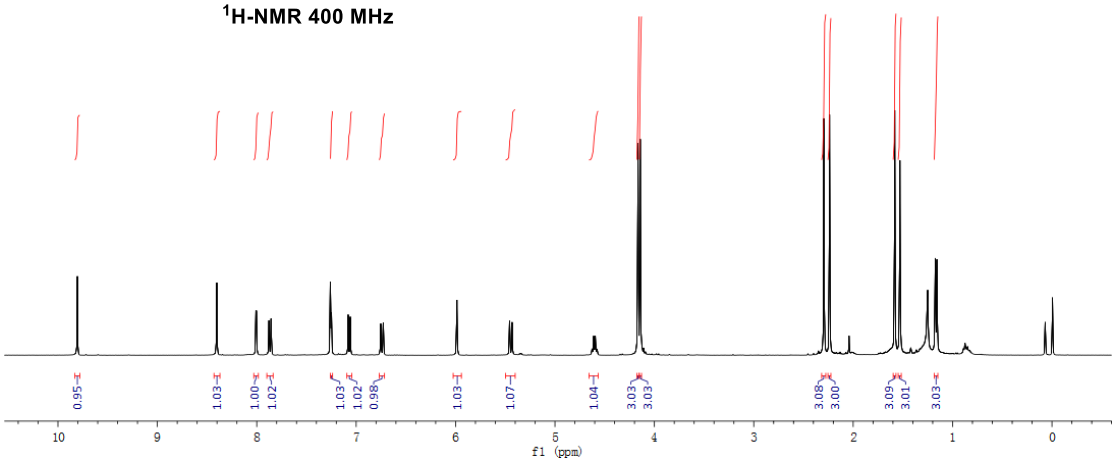

HO
Me
Me
HO
HO
O
HO
OMe
OMe
O
O
36
1H-NMR 500 MHz
0.98
0.97
1.00
1.06
1.02
1.01
1.00
0.94
0.96
1.07
1.16
3.08
3.02
1.09
1.14
1.01
1.04
0.97
3.00
3.09
10
9
8
7
6
5
4
3
2
1
0
-1
f1 (ppm)

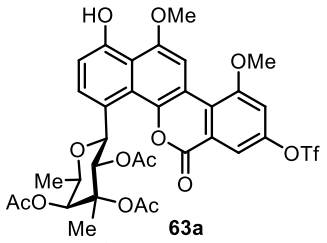

HO
Me
Me
HO
HO
O
HO
OMe
OMe
O
O
36
13C-NMR 125 MHz
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)



63a

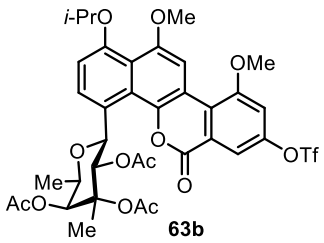
^{1}H-NMR 400 MHz





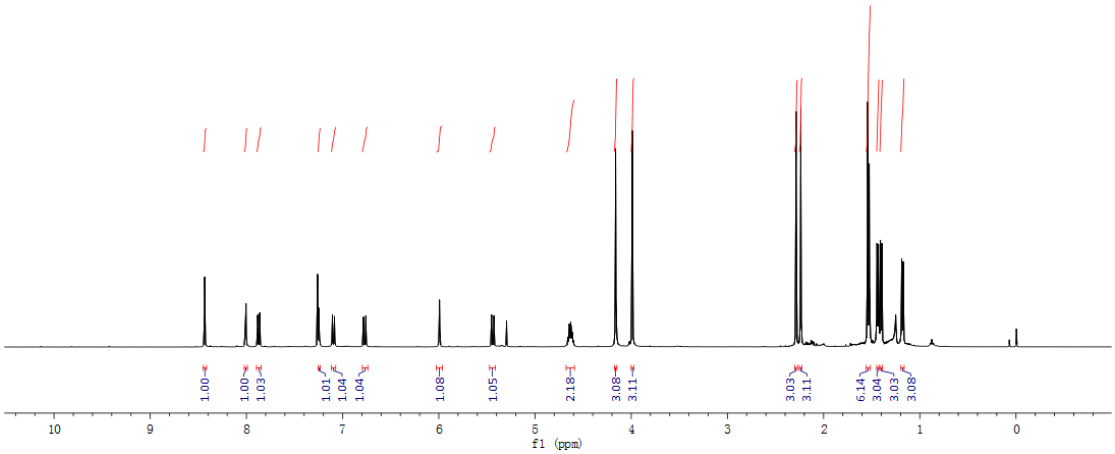
63a

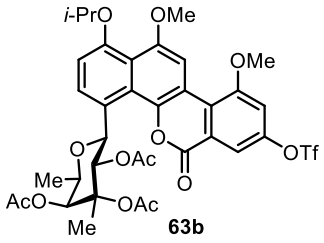
^{13}C-NMR 100 MHz



63b

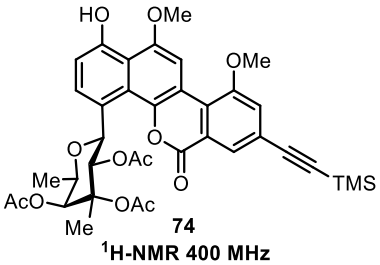
^{1}H-NMR 400 MHz





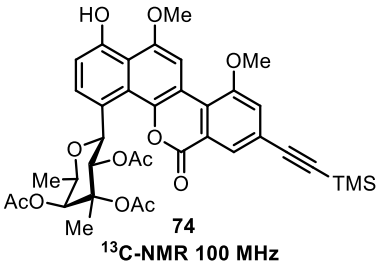
63b

^{13}C-NMR 100 MHz



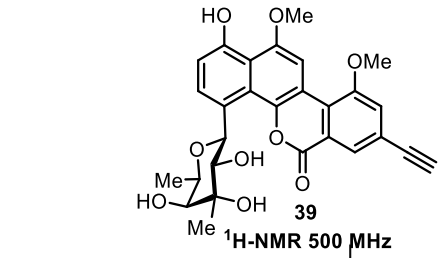
74

^{1}H-NMR 400 MHz



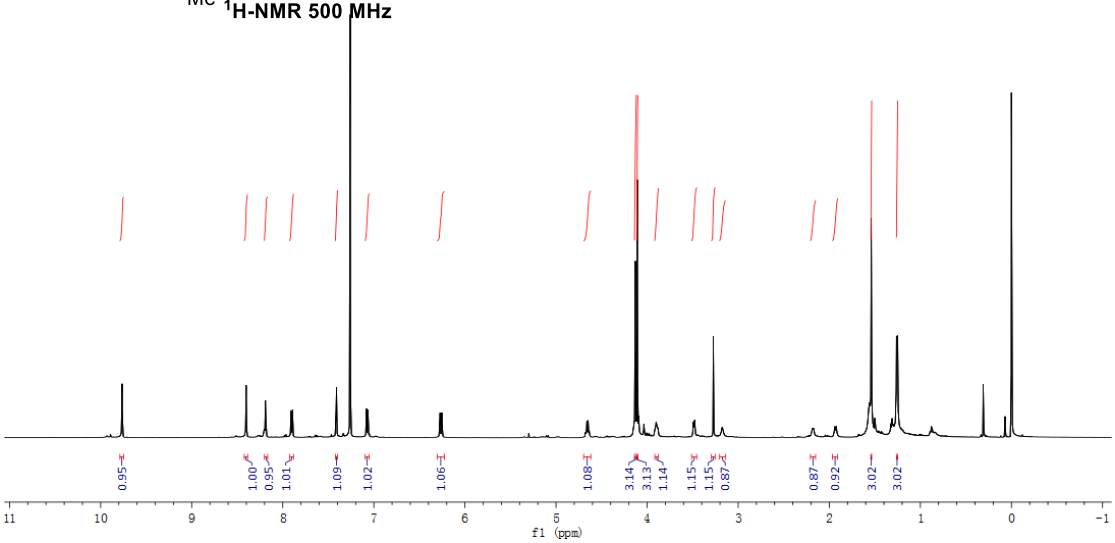
74

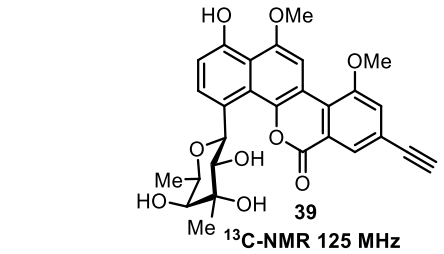
^{13}C-NMR 100 MHz



39

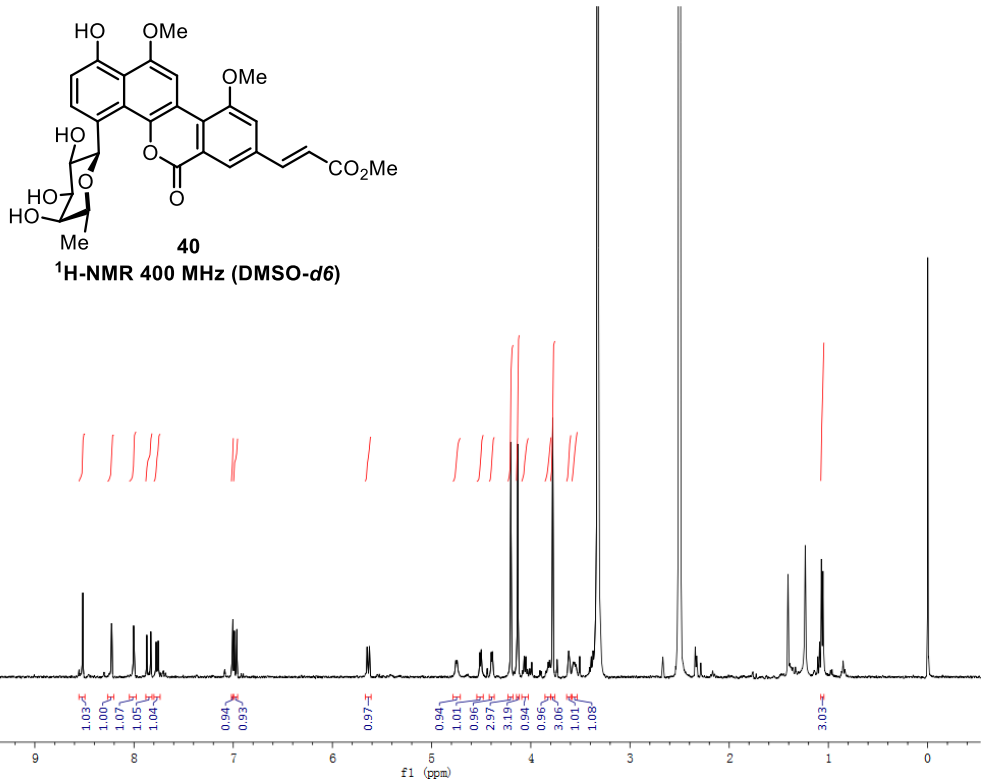
^{1}H-NMR 500 MHz

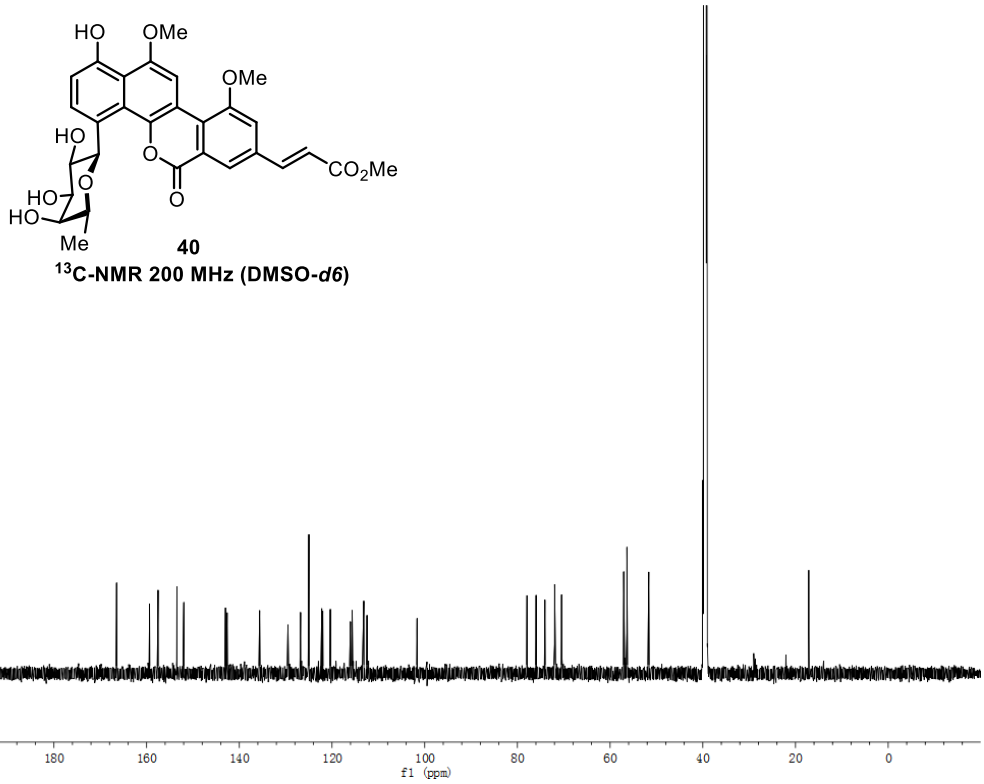


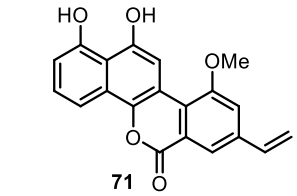


39

^{13}C-NMR 125 MHz

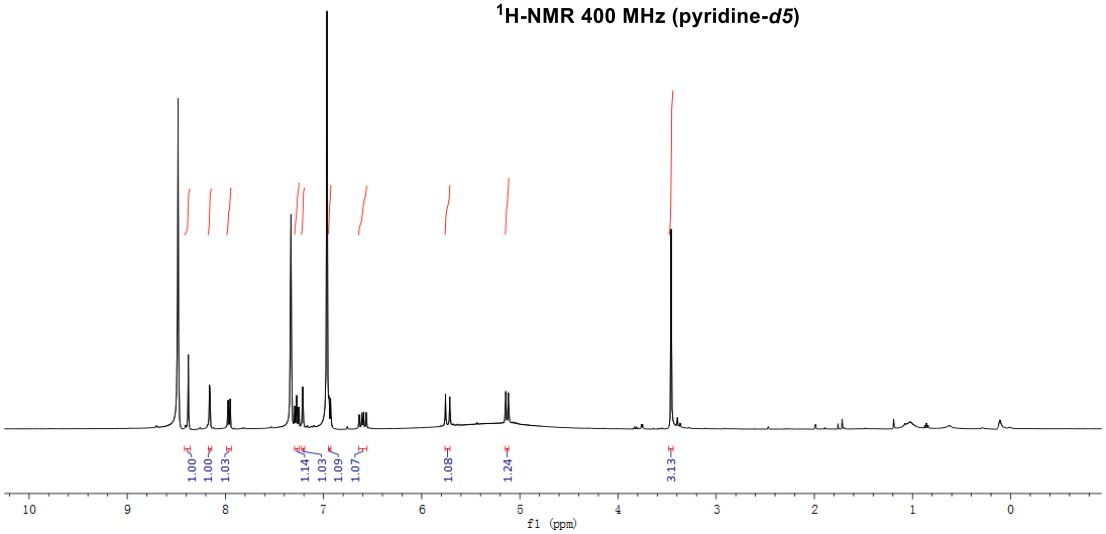

HO
OMe
OMe
HO
O
HO
HO
O
O
CO2Me
Me
40
1H-NMR 400 MHz (DMSO-d6)
0.96
1.03
1.00
1.07
1.05
1.04
0.94
0.93
0.97
0.94
1.01
0.96
2.97
3.19
0.94
0.96
3.06
1.01
1.08
3.03
10
9
8
7
6
5
4
3
2
1
0
f1 (ppm)

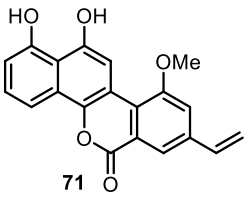

HO
OMe
OMe
HO
O
HO
HO
O
O
CO2Me
Me
40
13C-NMR 200 MHz (DMSO-d6)
200
180
160
140
120
100
80
60
40
20
0
f1 (ppm)



71

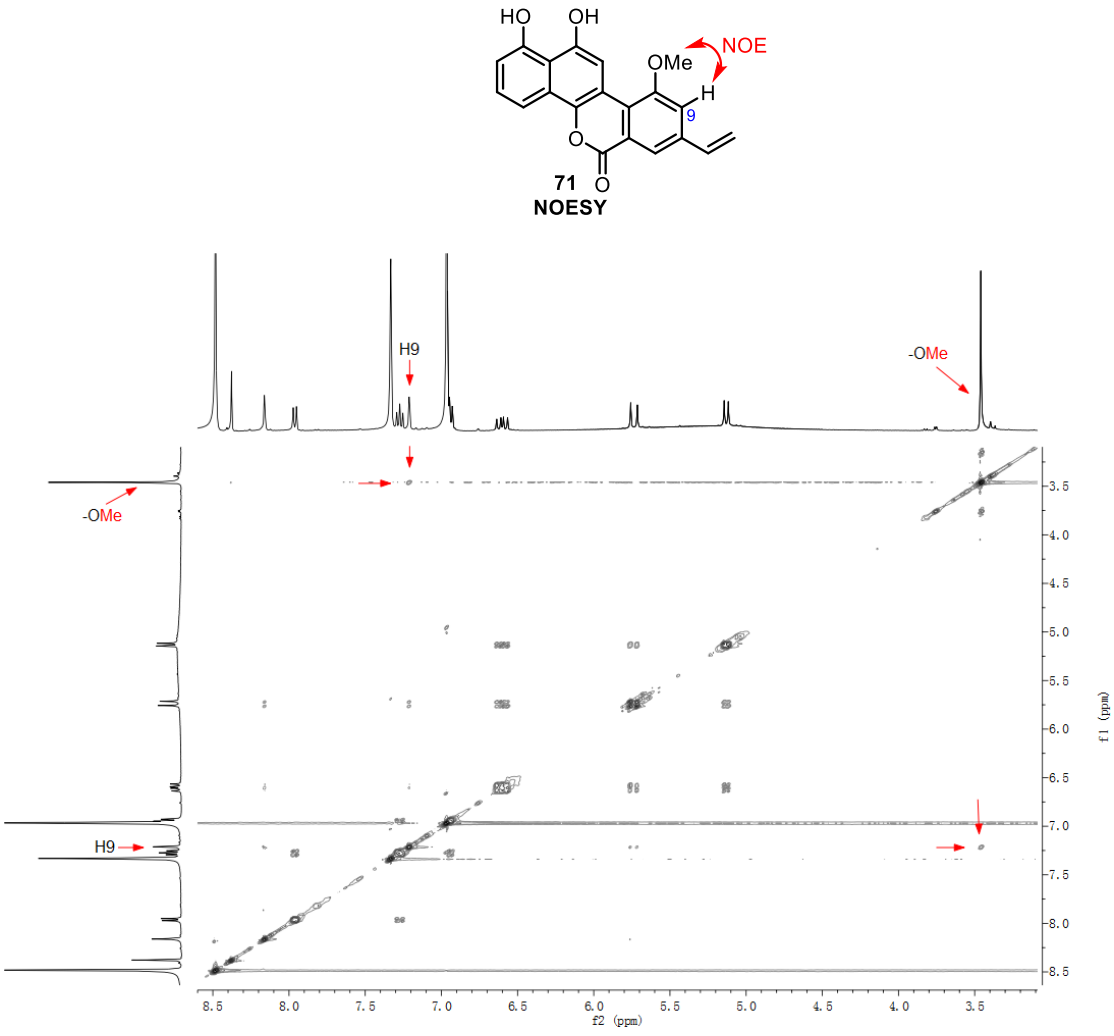
^{1}H-NMR 400 MHz (pyridine-*d5*)

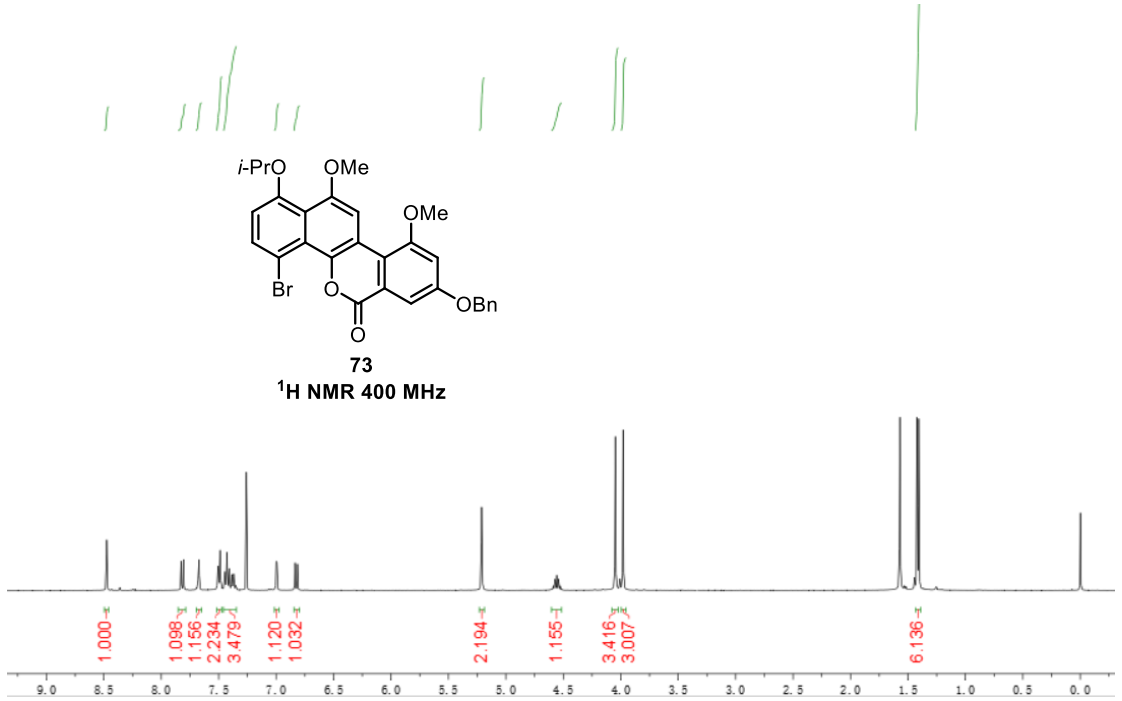




71

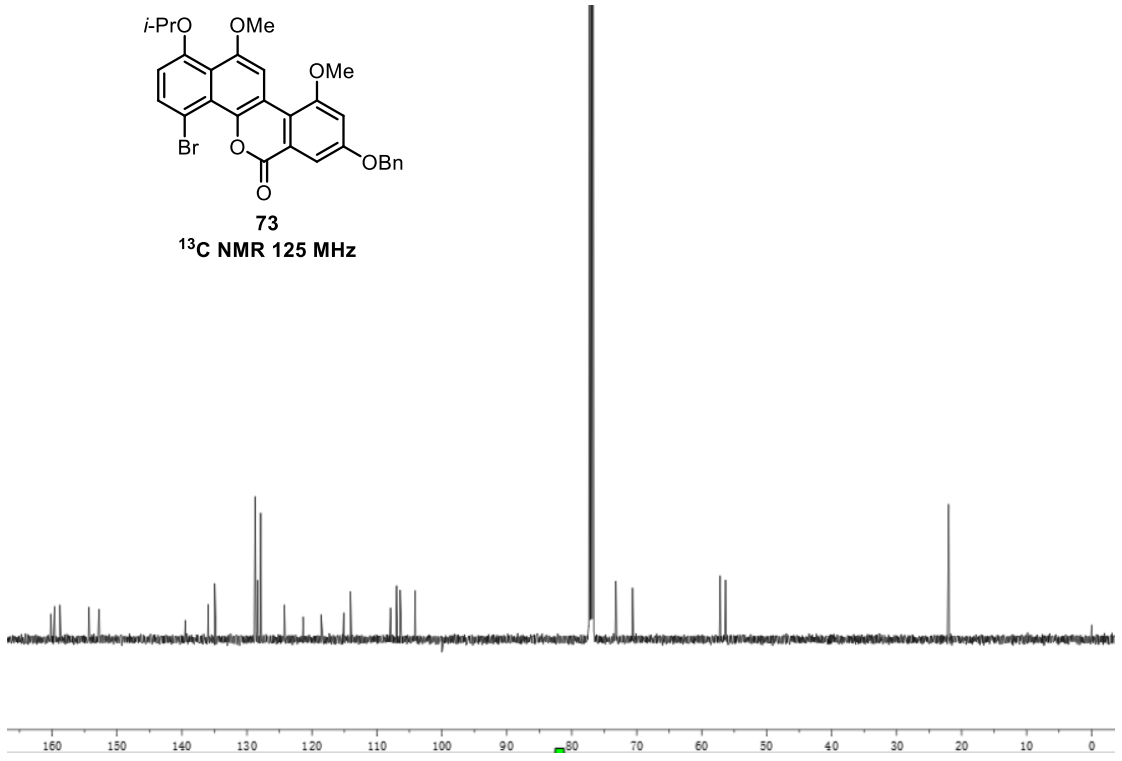
^{13}C-NMR 100 MHz (pyridine-*d5*)


HO
OH
OMe
NOE
H
9
O
O
71
NOESY
H9
-OMe
-OMe
H9
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
f2 (ppm)
f1 (ppm)



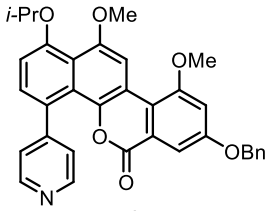
73

^{1}H NMR 400 MHz



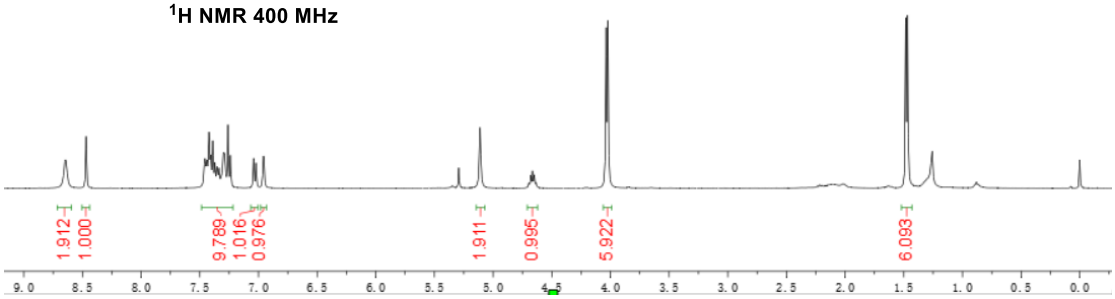
73

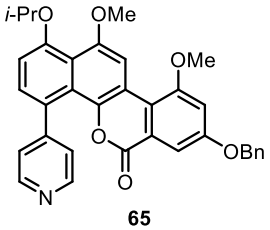
^{13}C NMR 125 MHz



65

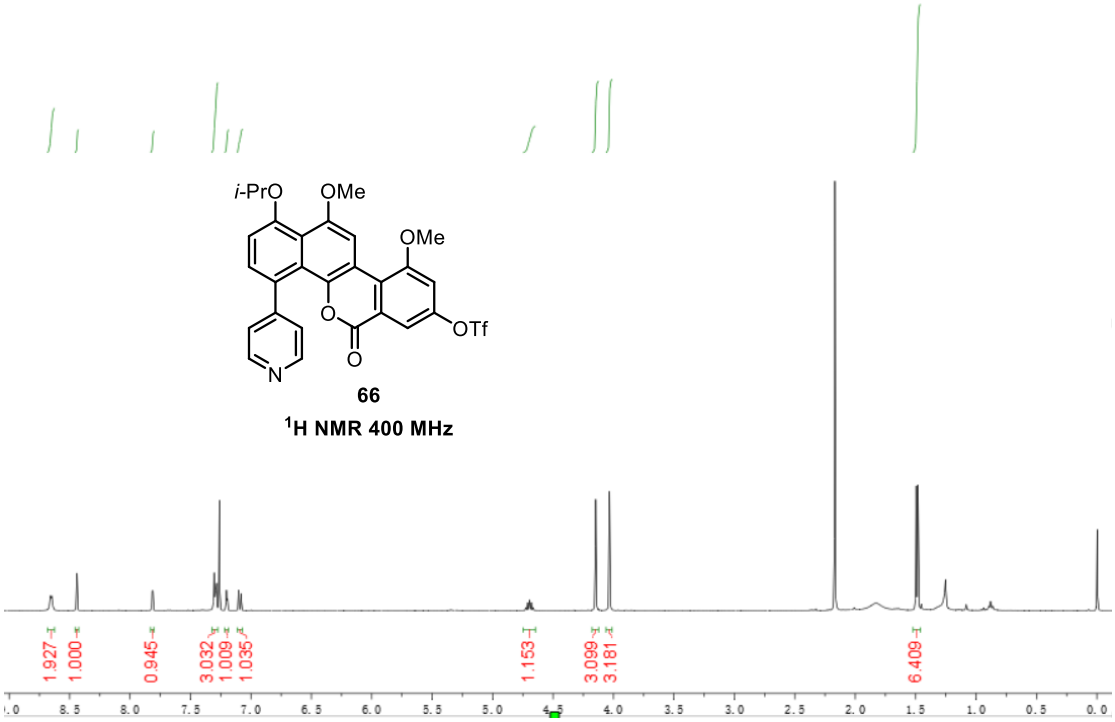
^{1}H NMR 400 MHz





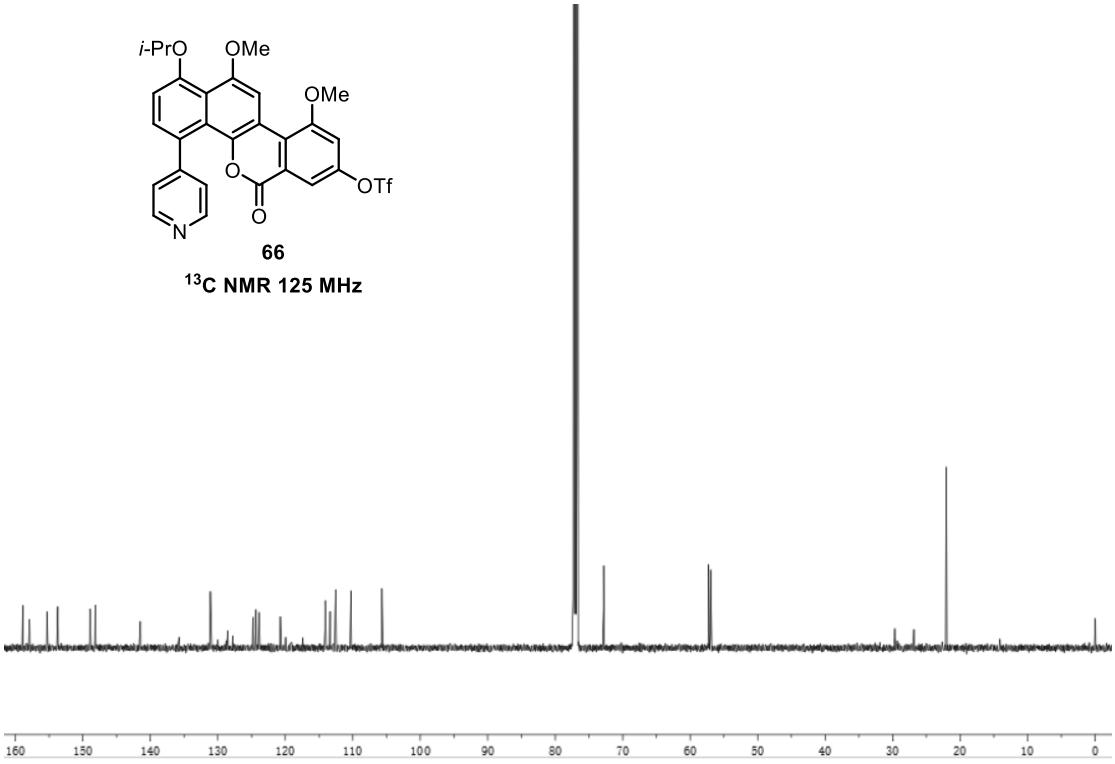
65

^{13}C NMR 125 MHz



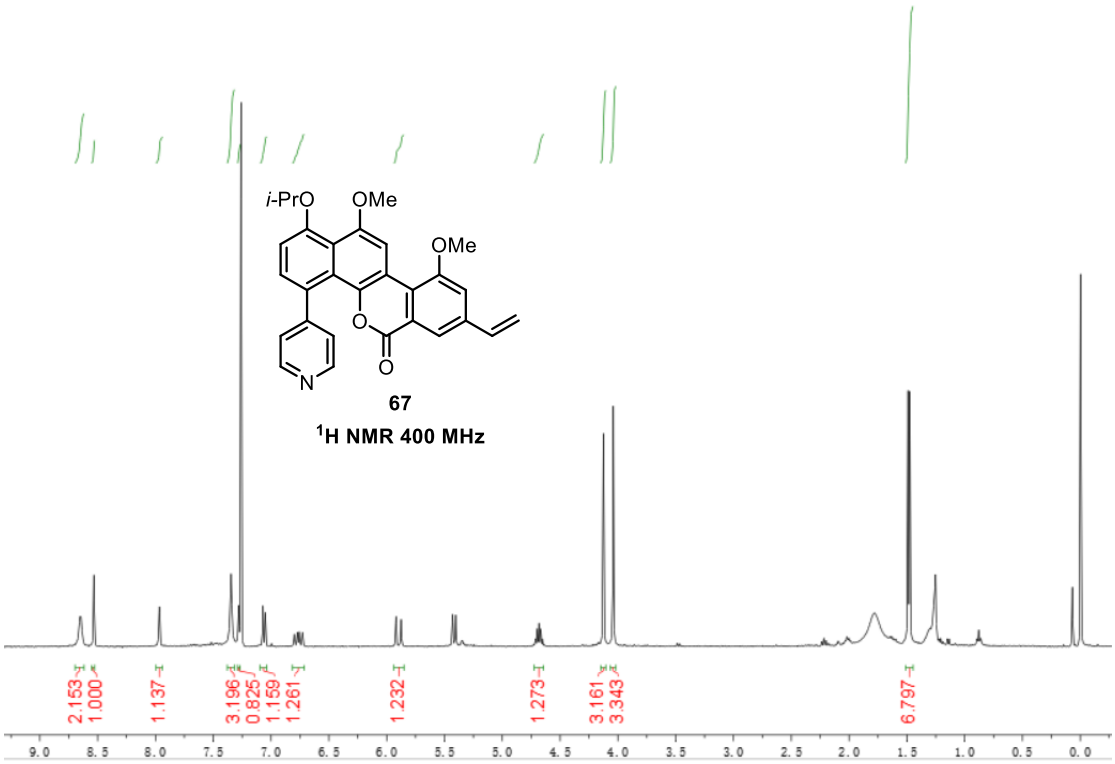
66

^{1}H NMR 400 MHz



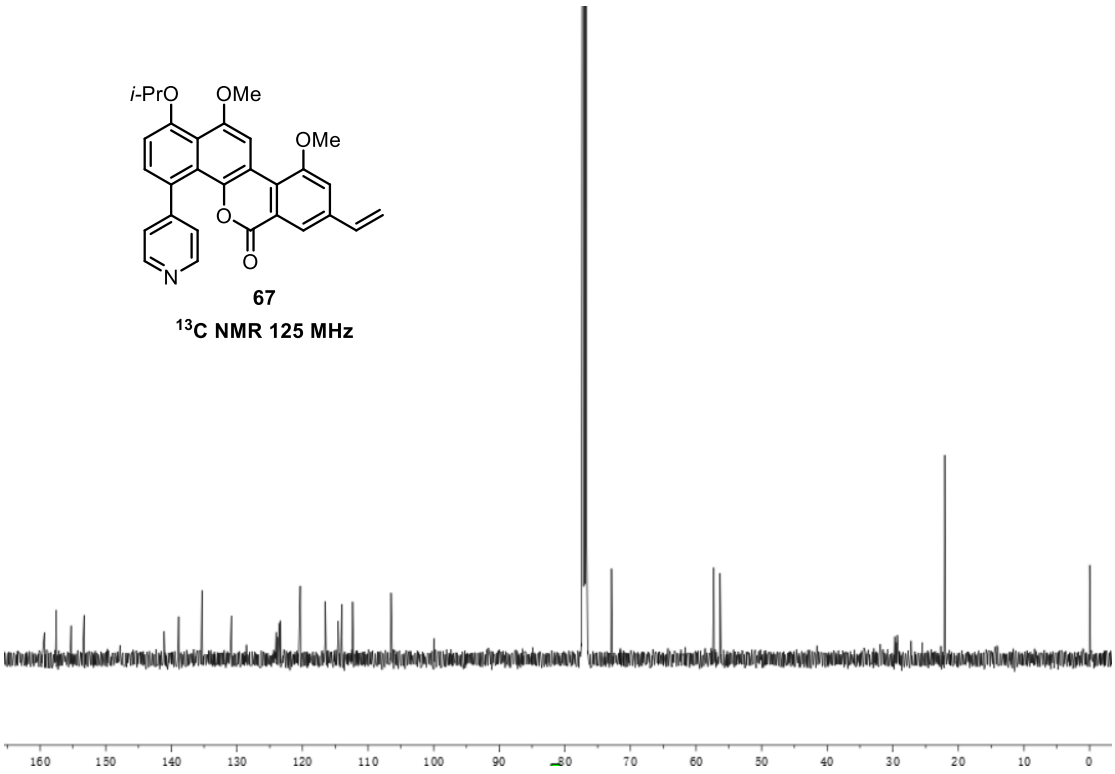
66

^{13}C NMR 125 MHz



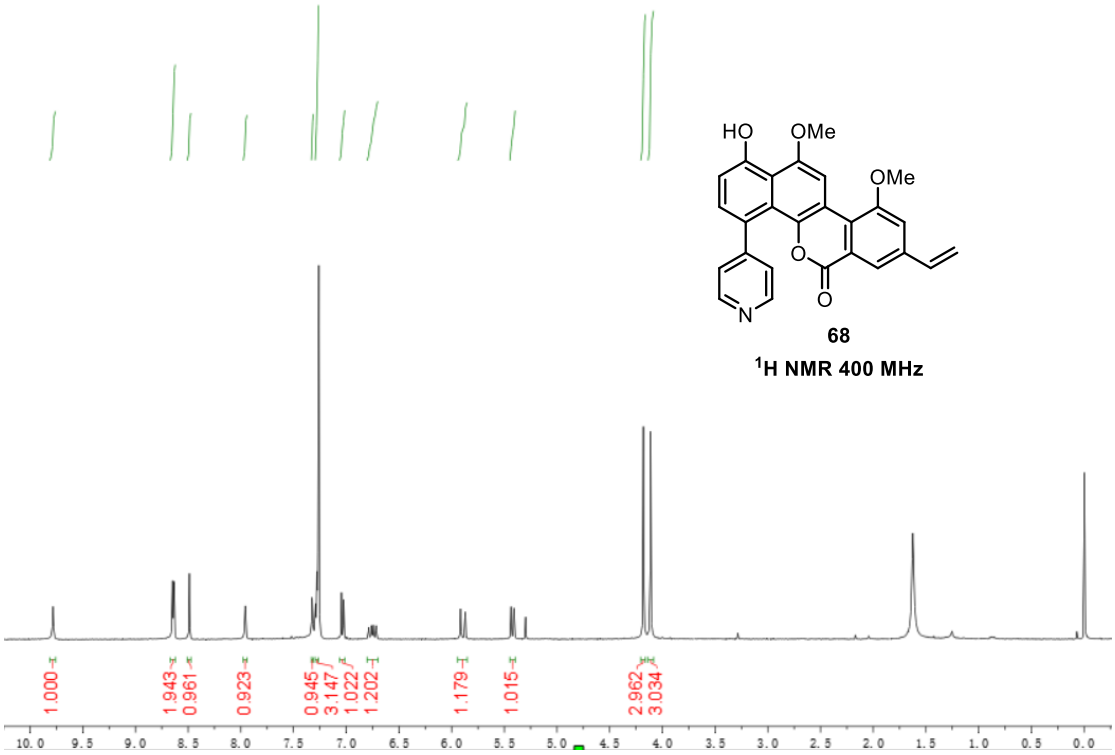
67

^{1}H NMR 400 MHz



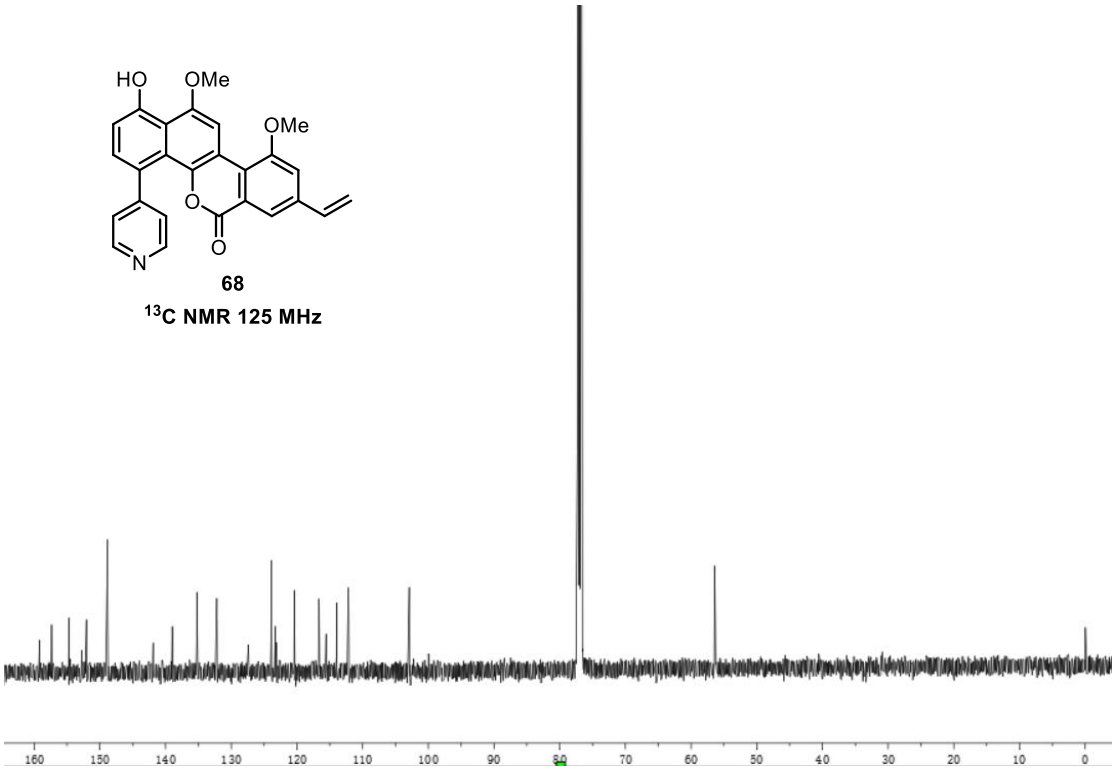
67

^{13}C NMR 125 MHz



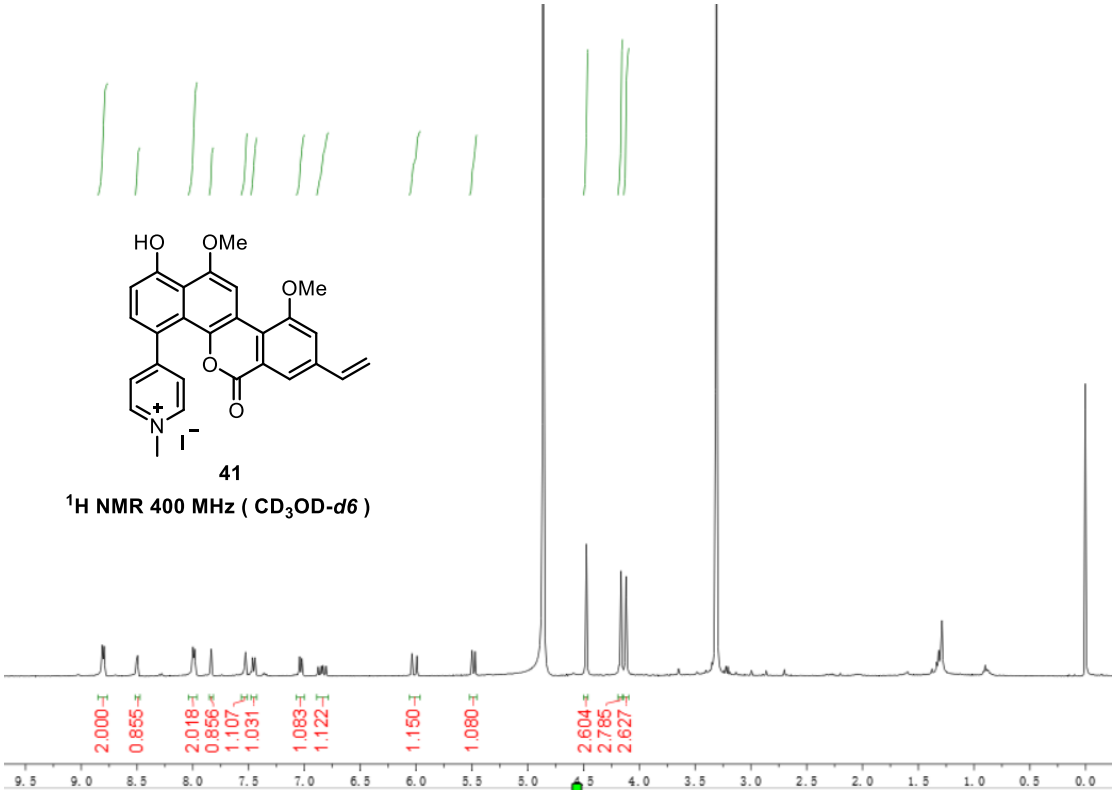
68

^{1}H NMR 400 MHz



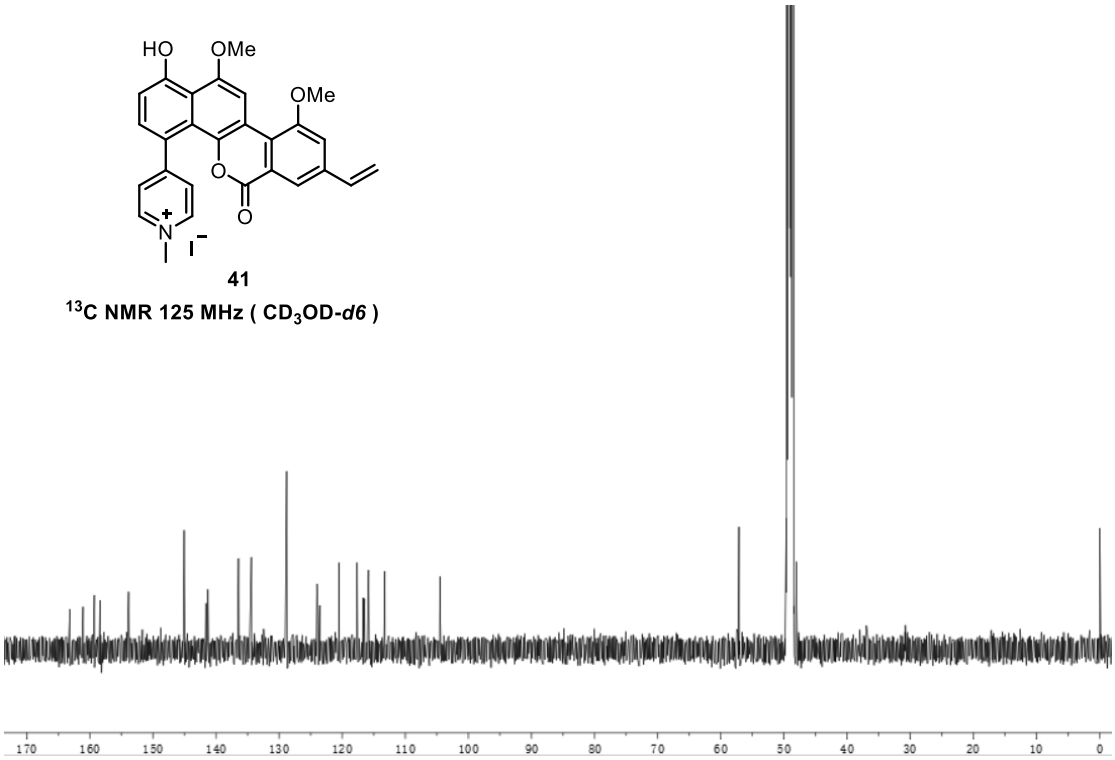
68

^{13}C NMR 125 MHz



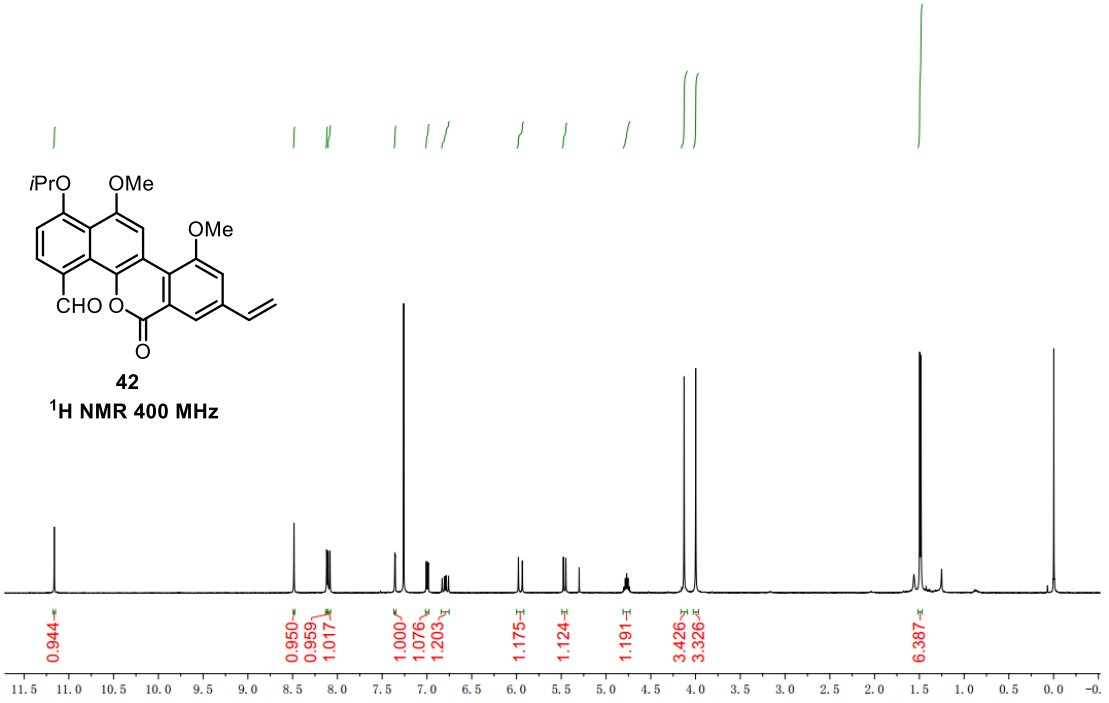
41

^{1}H NMR 400 MHz (CD_3OD-*d6*)



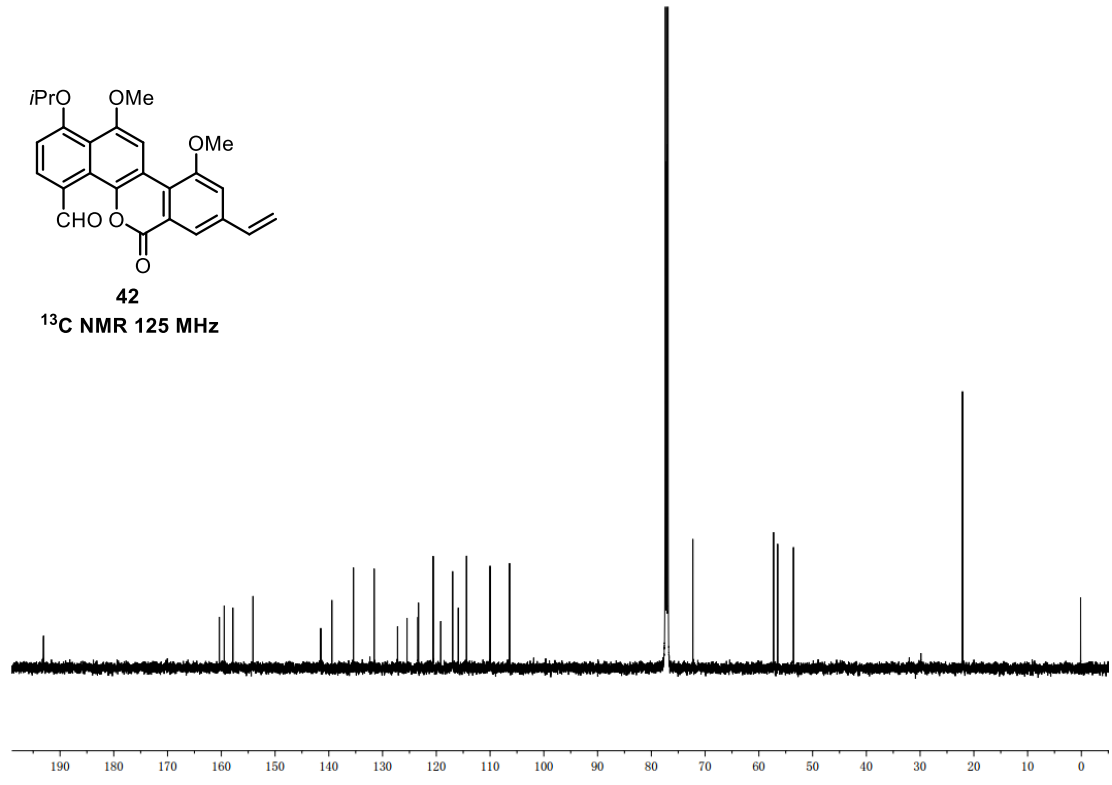
41

^{13}C NMR 125 MHz (CD_3OD-*d6*)



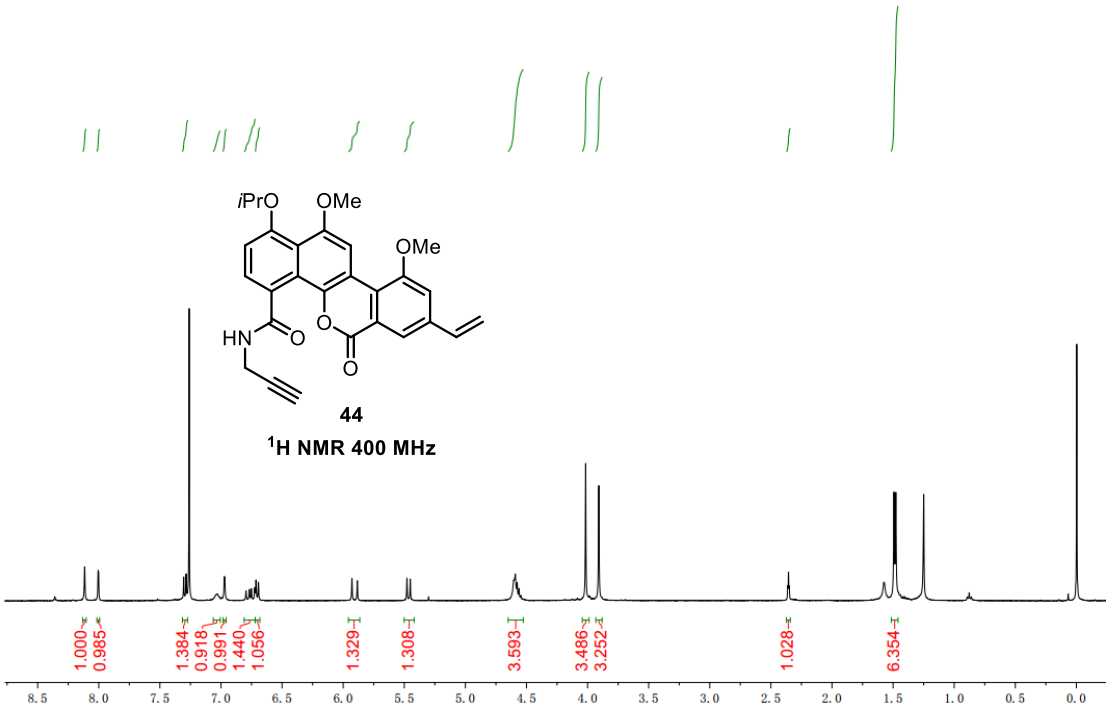
42

^{1}H NMR 400 MHz



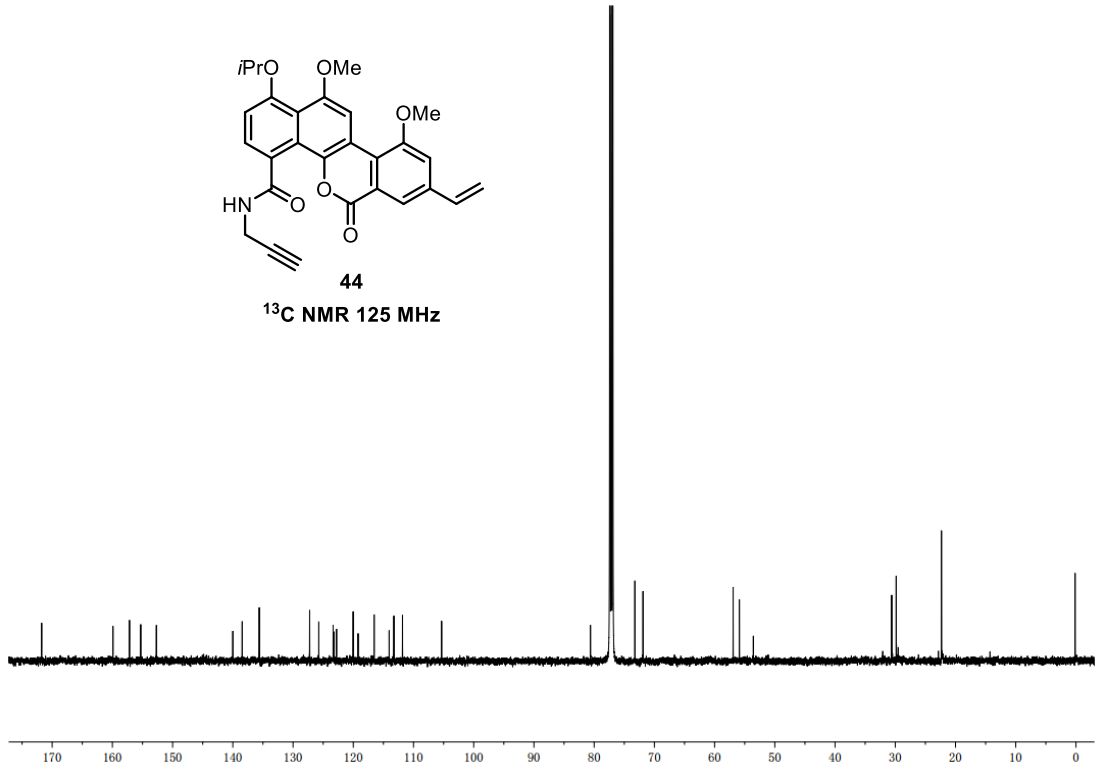
42

^{13}C NMR 125 MHz



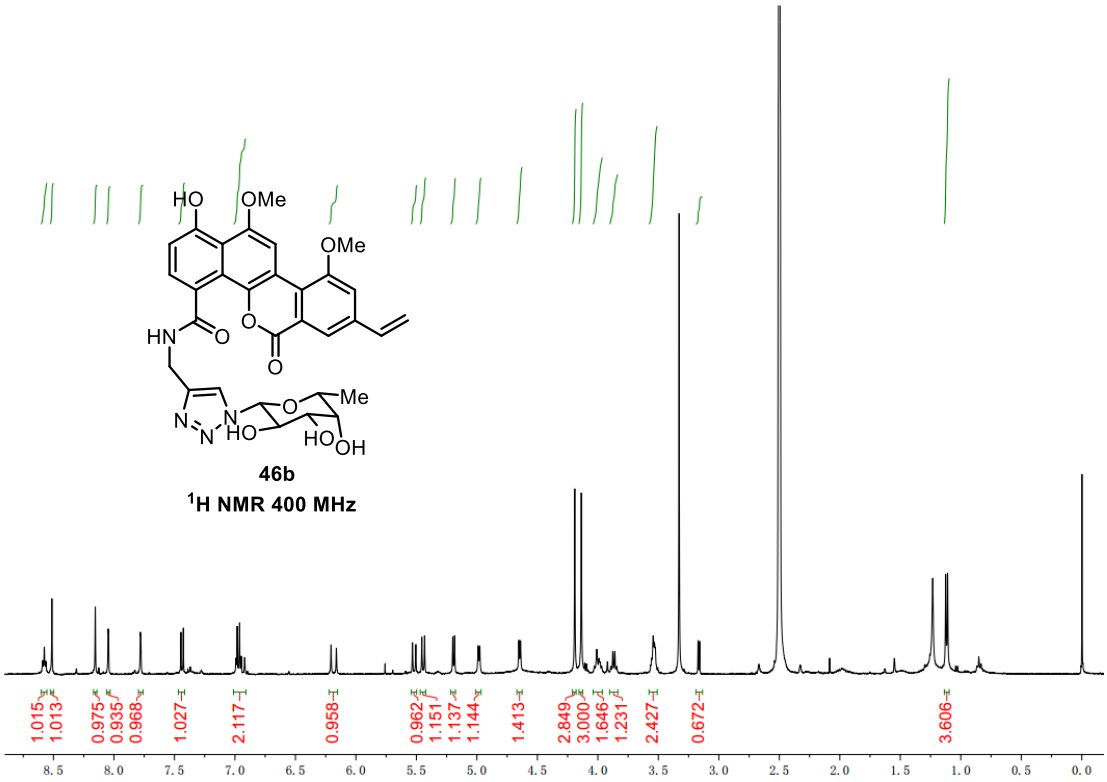
44

^{1}H NMR 400 MHz



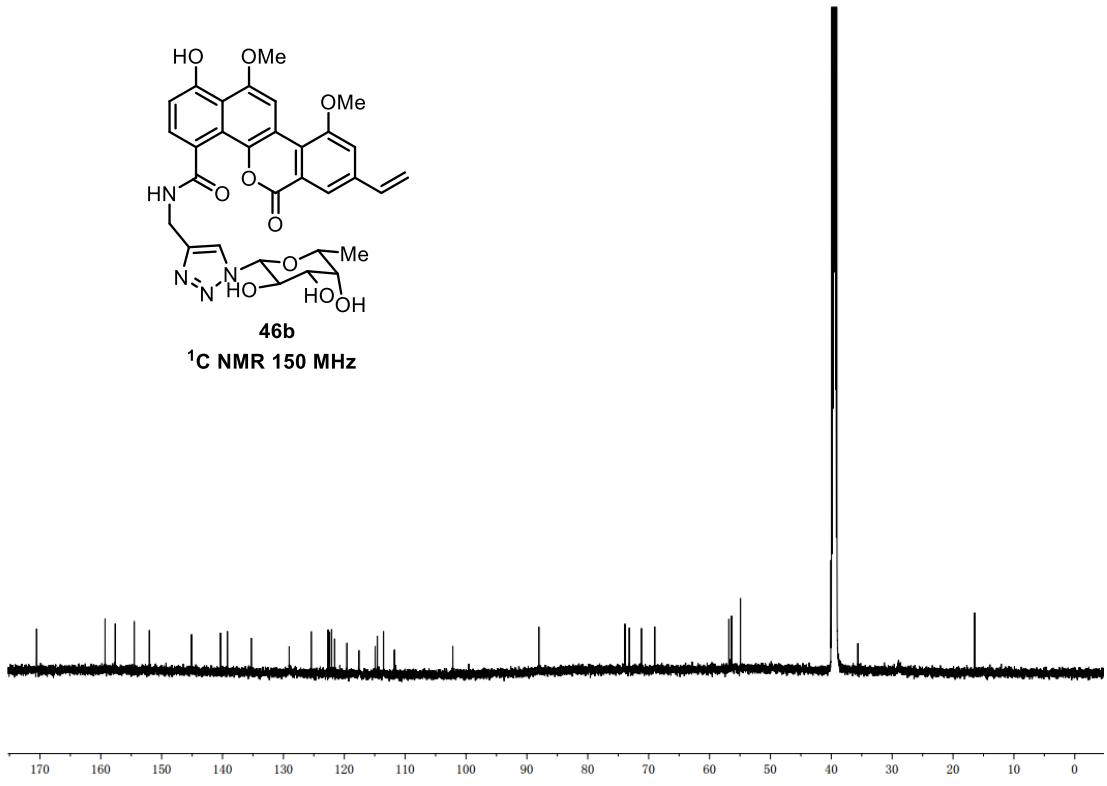
44

^{13}C NMR 125 MHz



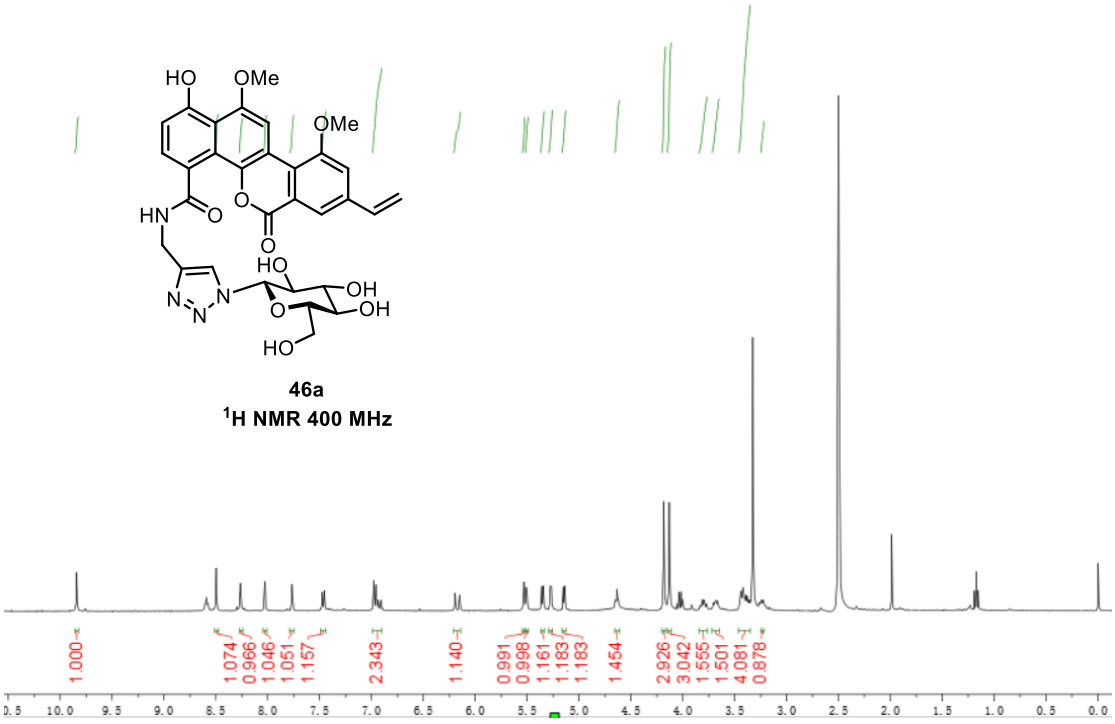
46b

^{1}H NMR 400 MHz



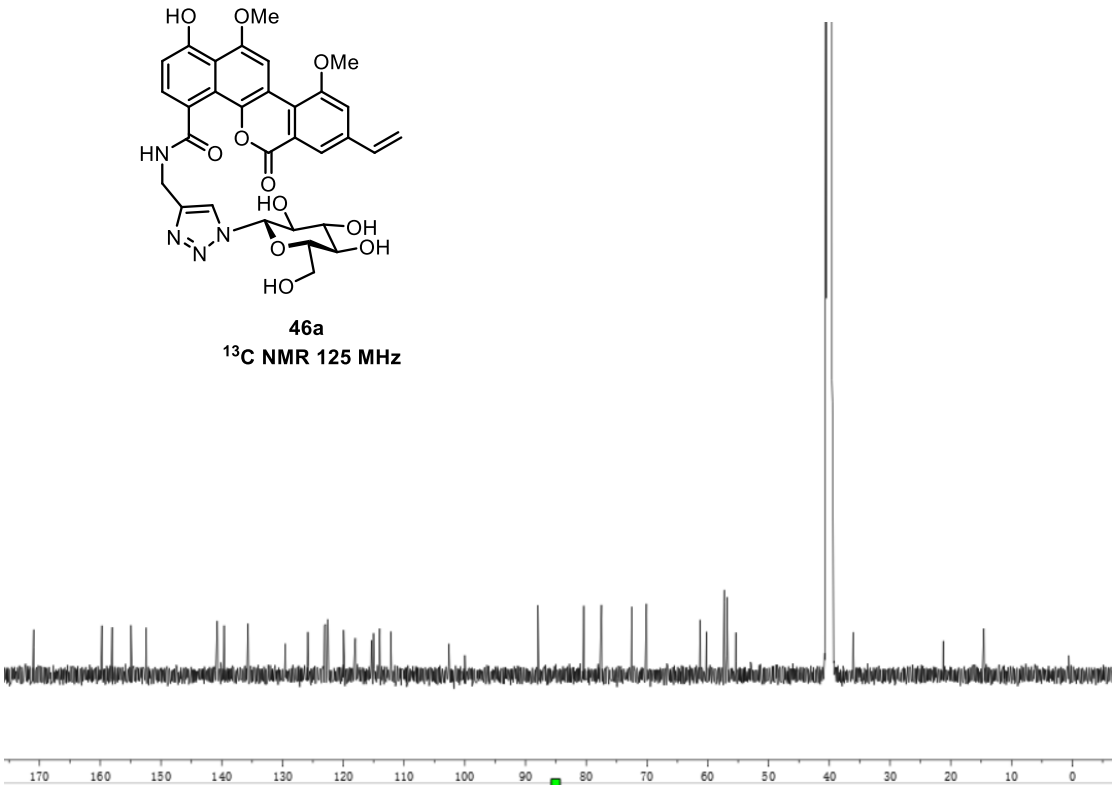
46b

^{1}C NMR 150 MHz



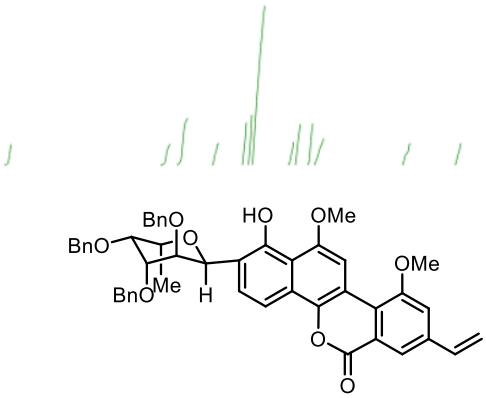
46a

^{1}H NMR 400 MHz



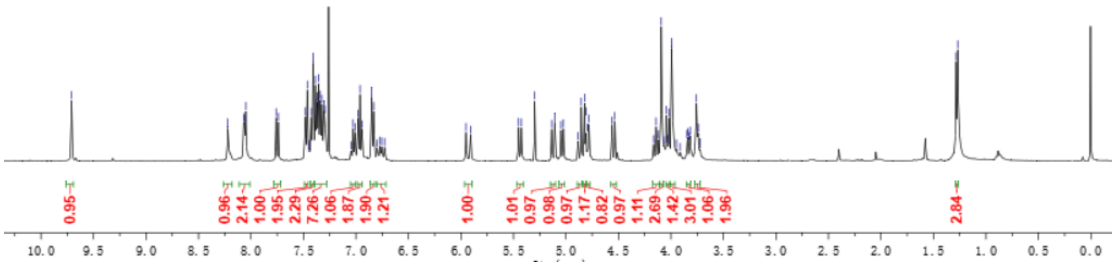
46a

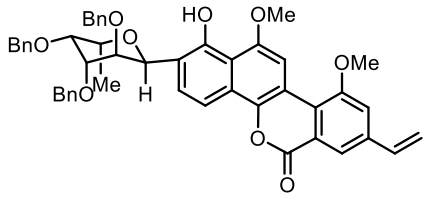
^{13}C NMR 125 MHz



34

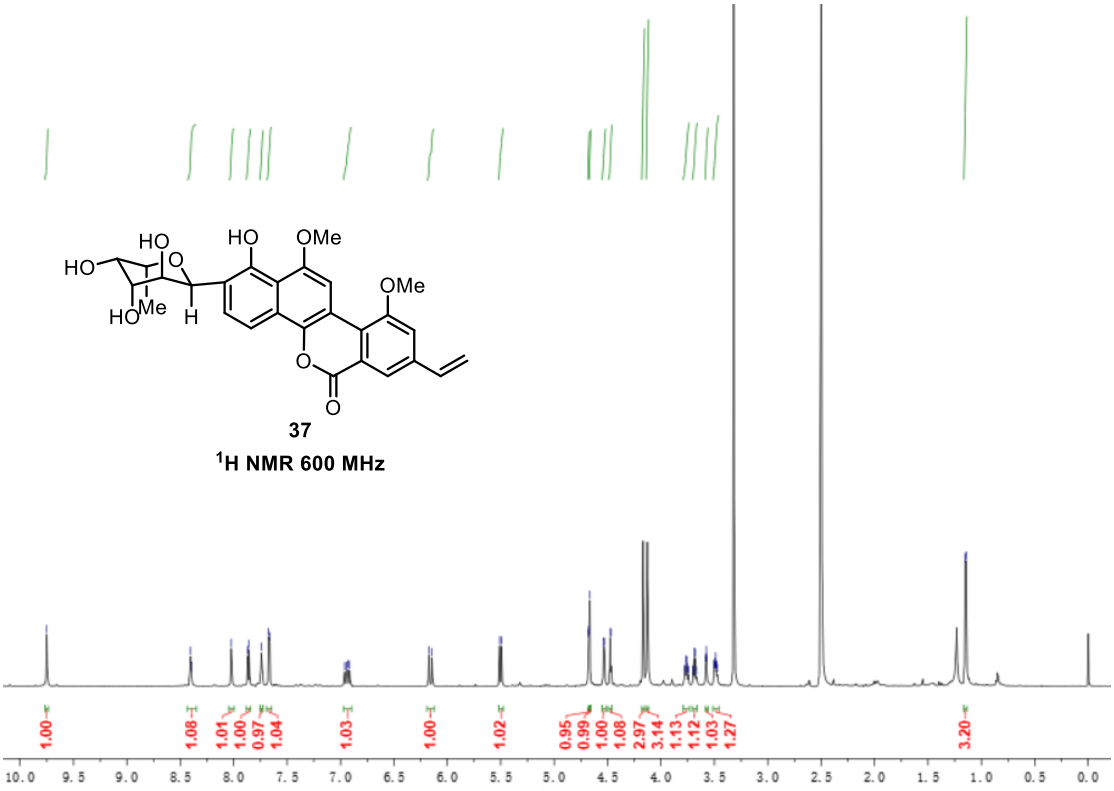
^{1}H NMR 400 MHz





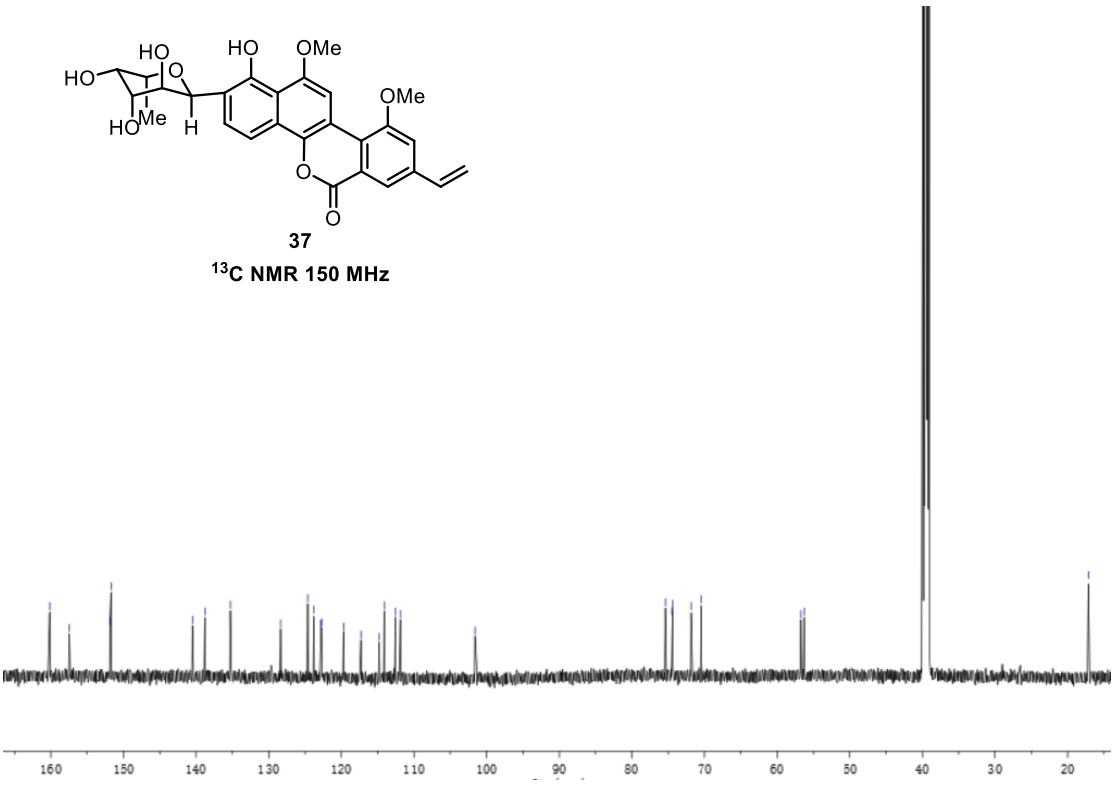
34

^{13}C NMR 100 MHz



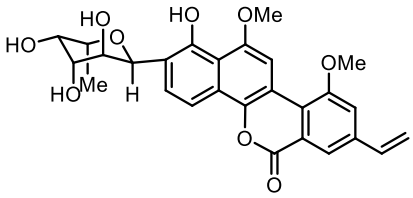
37

^{1}H NMR 600 MHz



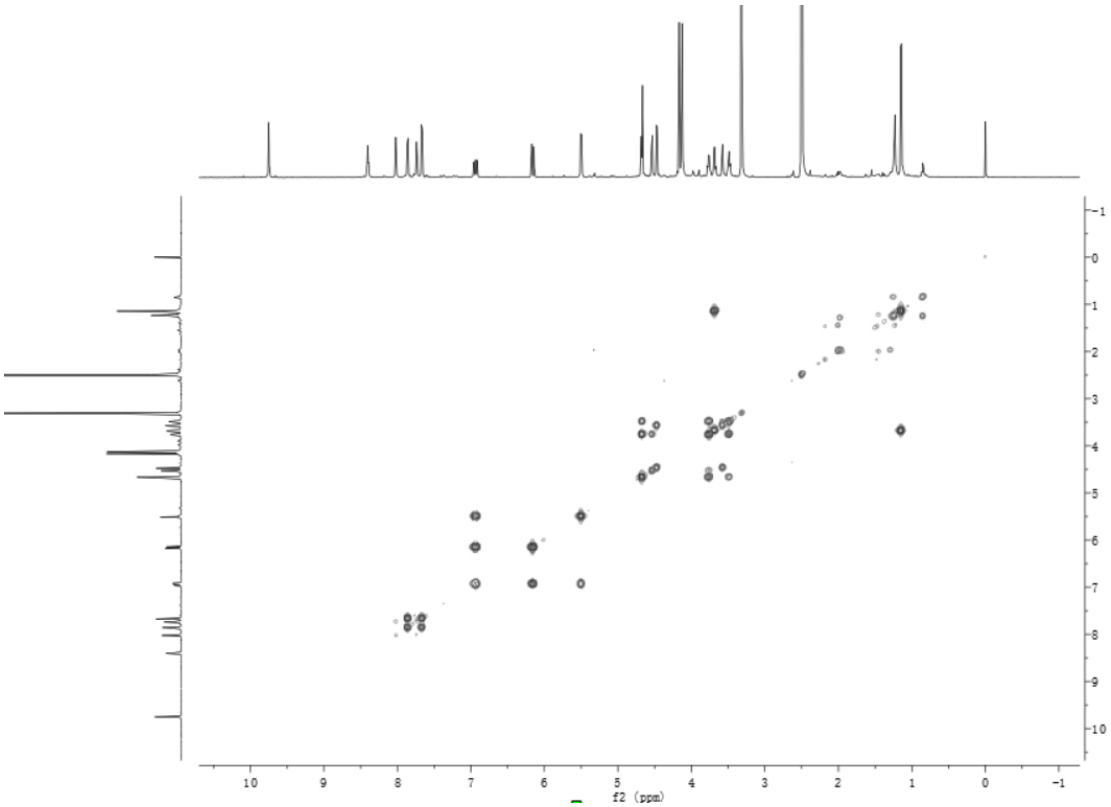
37

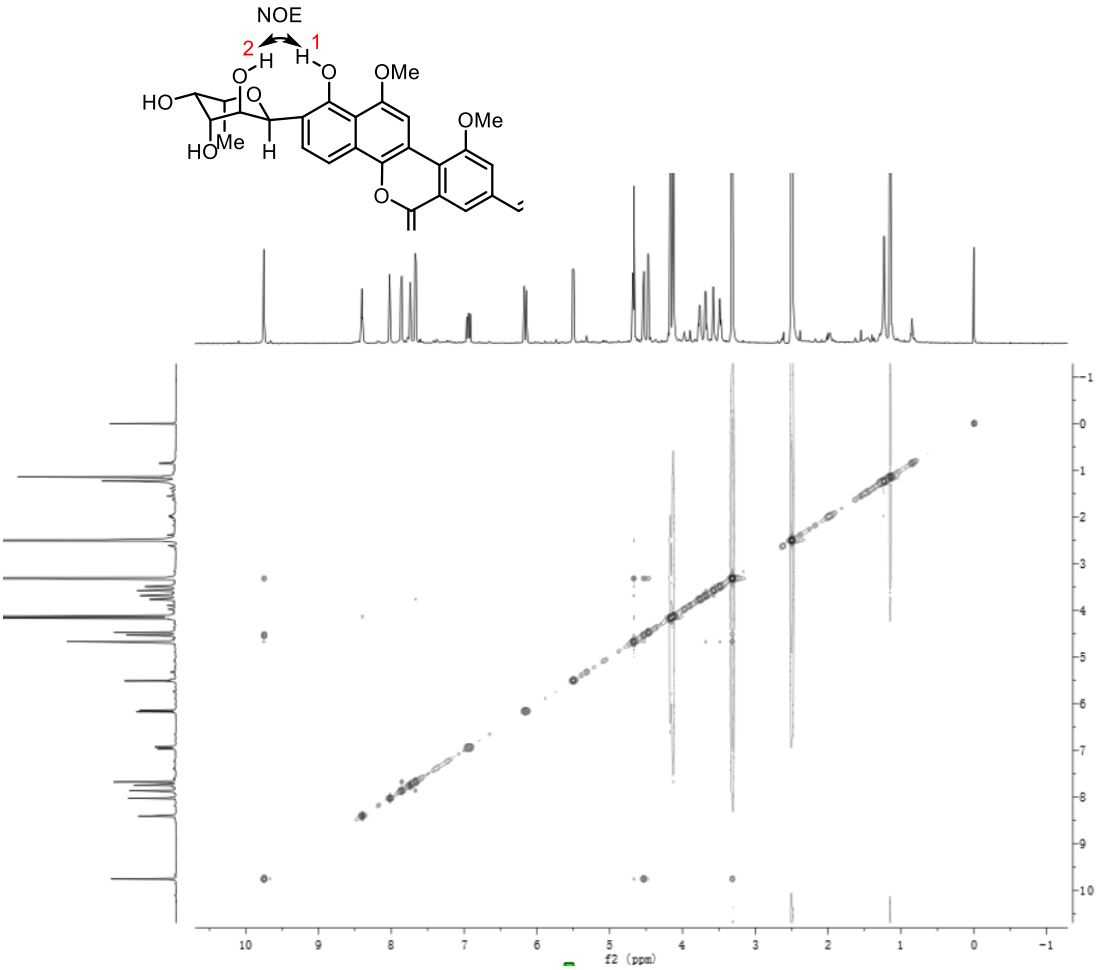
^{13}C NMR 150 MHz

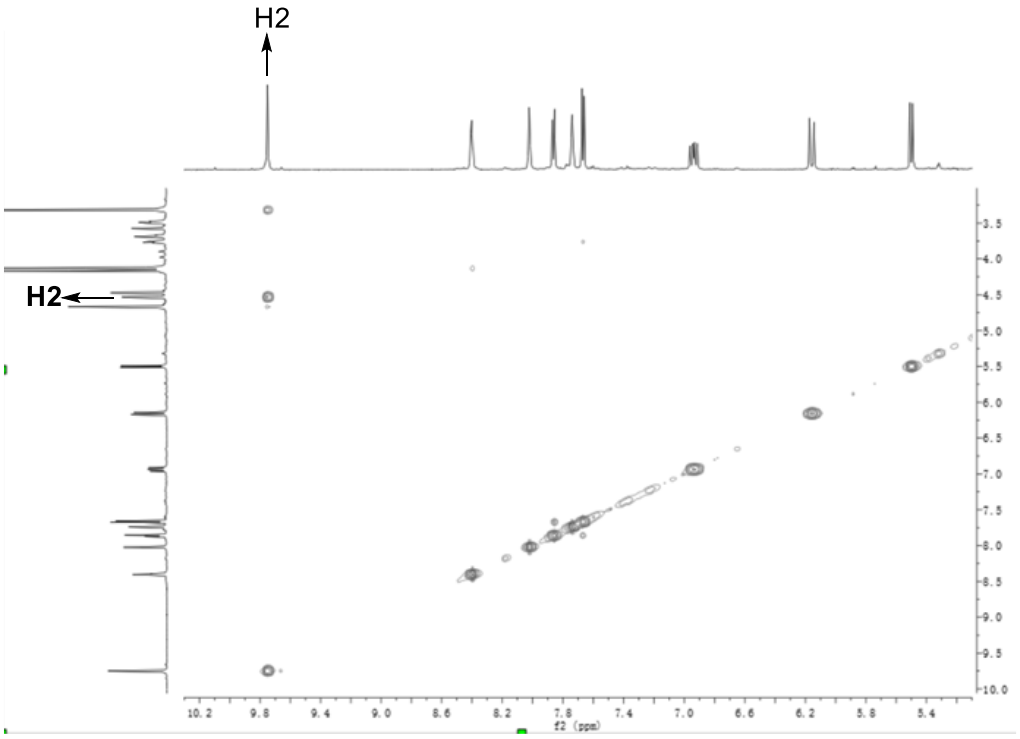

HO
HO
O
HO
OMe
OMe
HO
Me
H
O
O

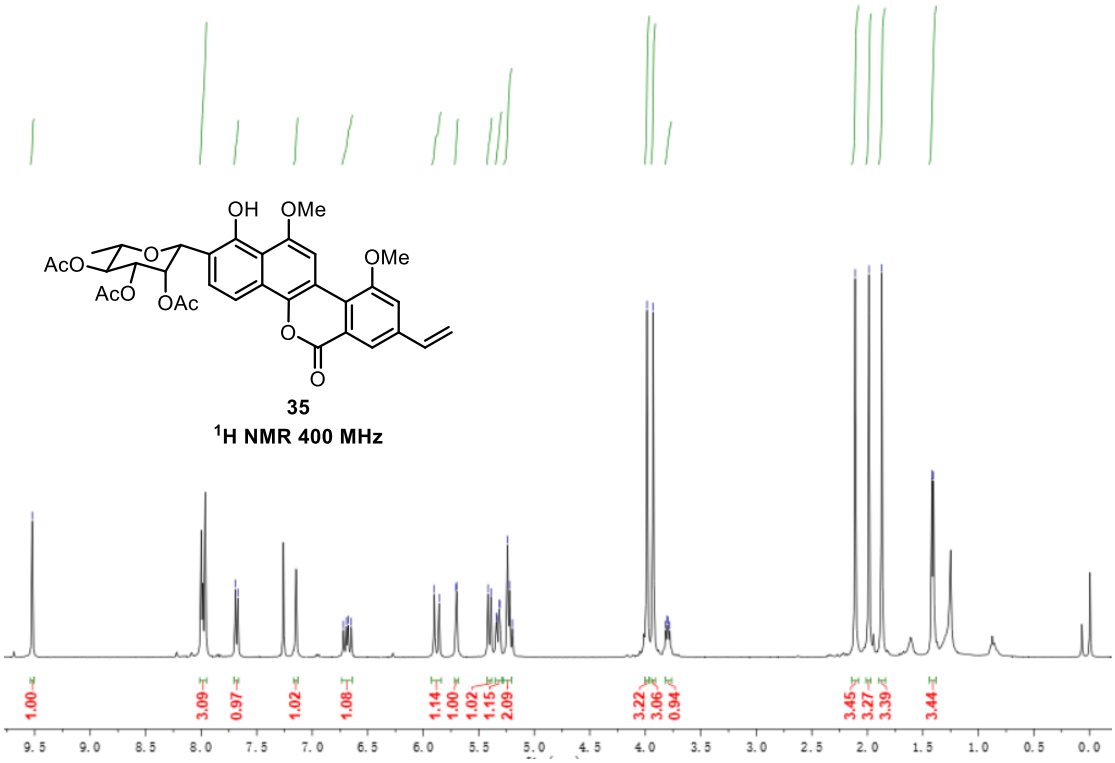
51

^{1}H-^{1}H COSY


10
9
8
7
6
5
4
3
2
1
0
-1
f2 (ppm)
-1
0
1
2
3
4
5
6
7
8
9
10

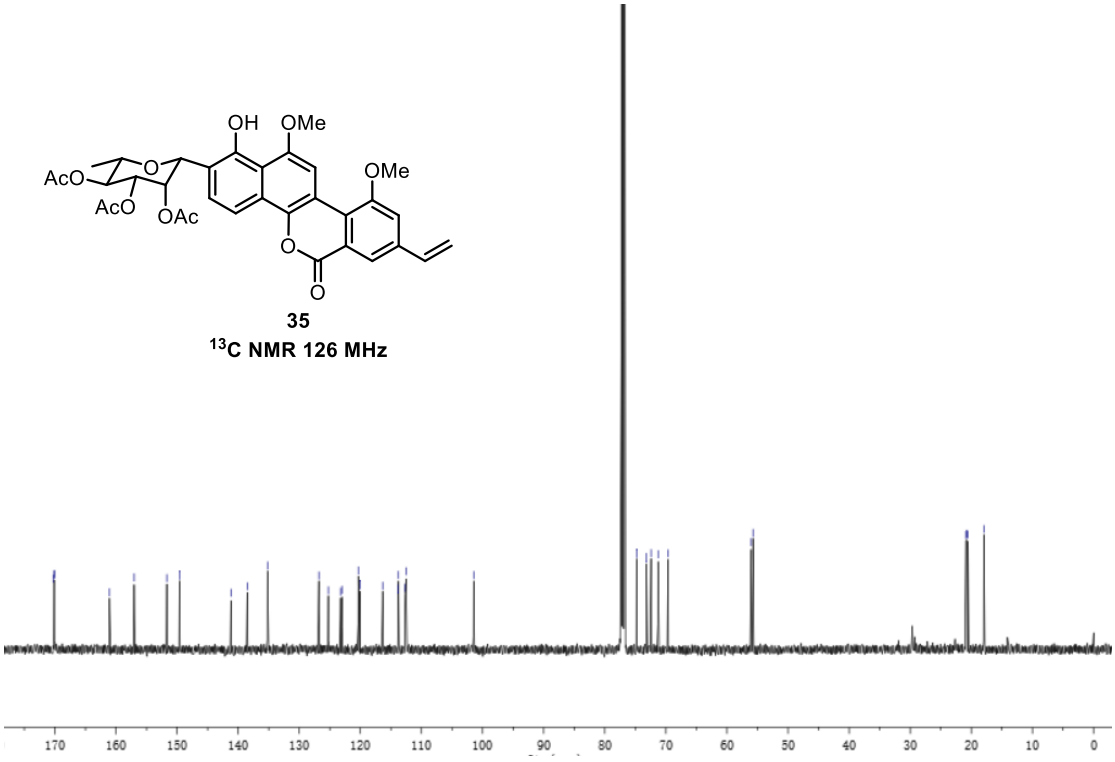

NOE
2
H
H
1
O
OMe
HO
O
OMe
HO
Me
H
O
f2 (ppm)


H2
H2
f2 (ppm)



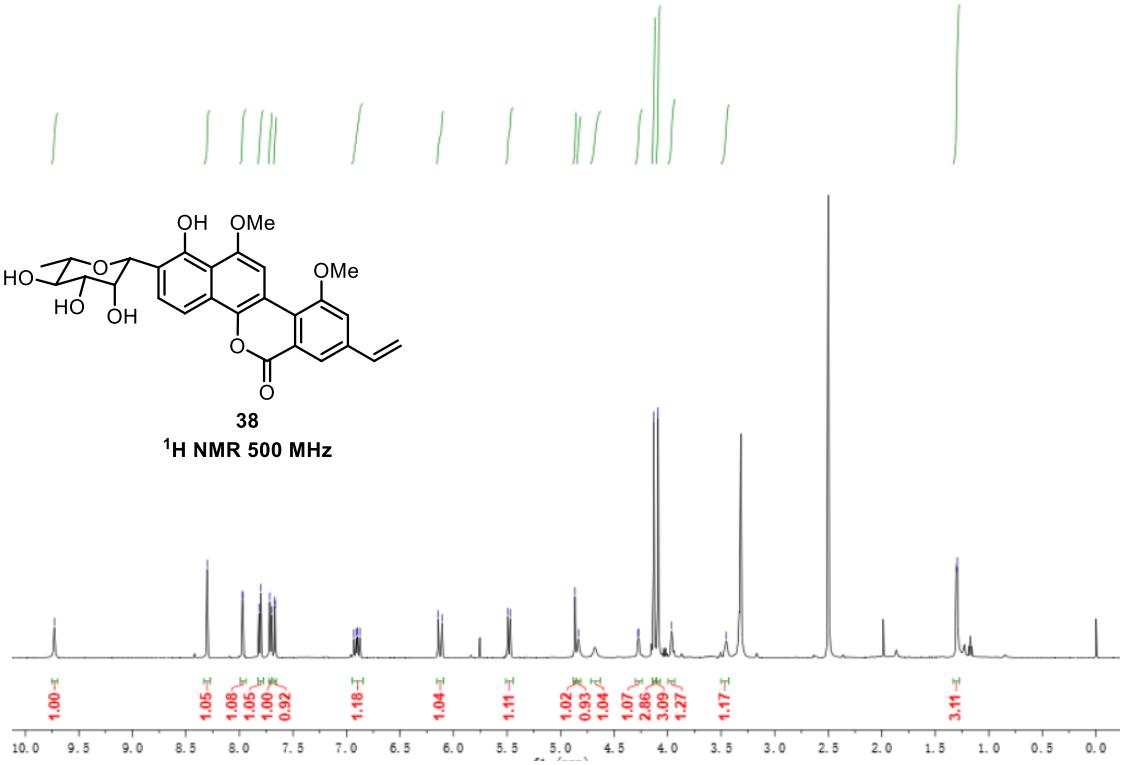
35

^{1}H NMR 400 MHz



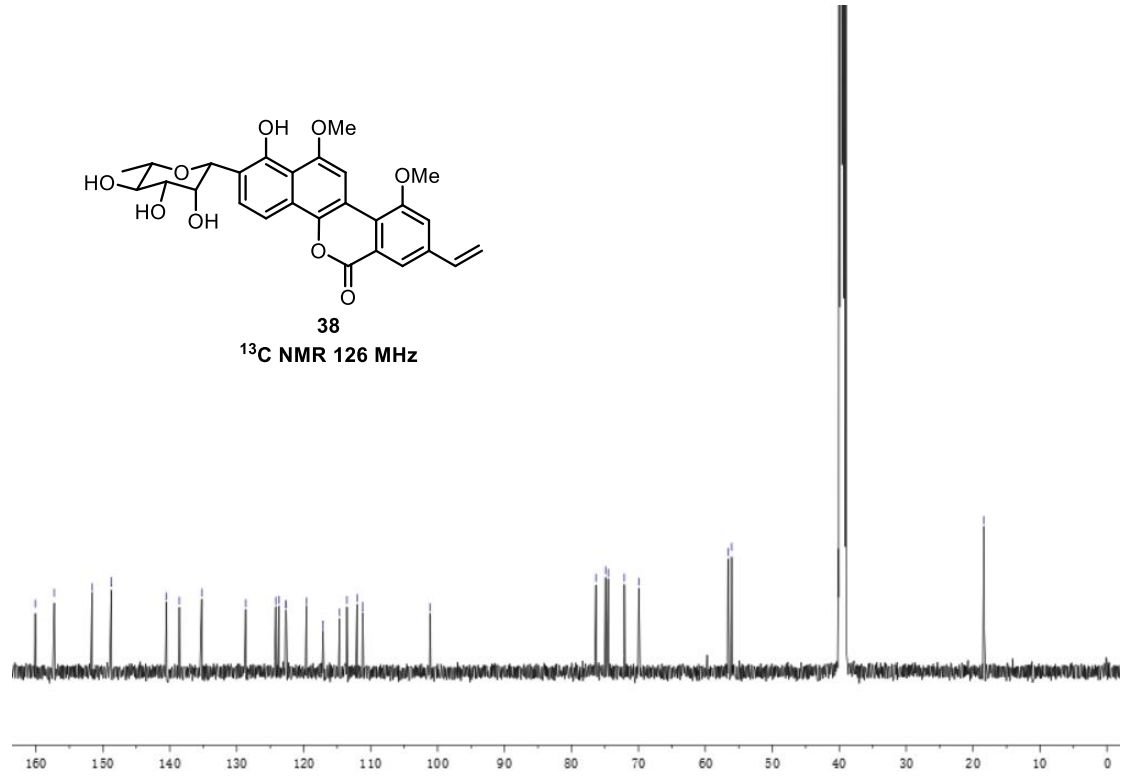
35

^{13}C NMR 126 MHz



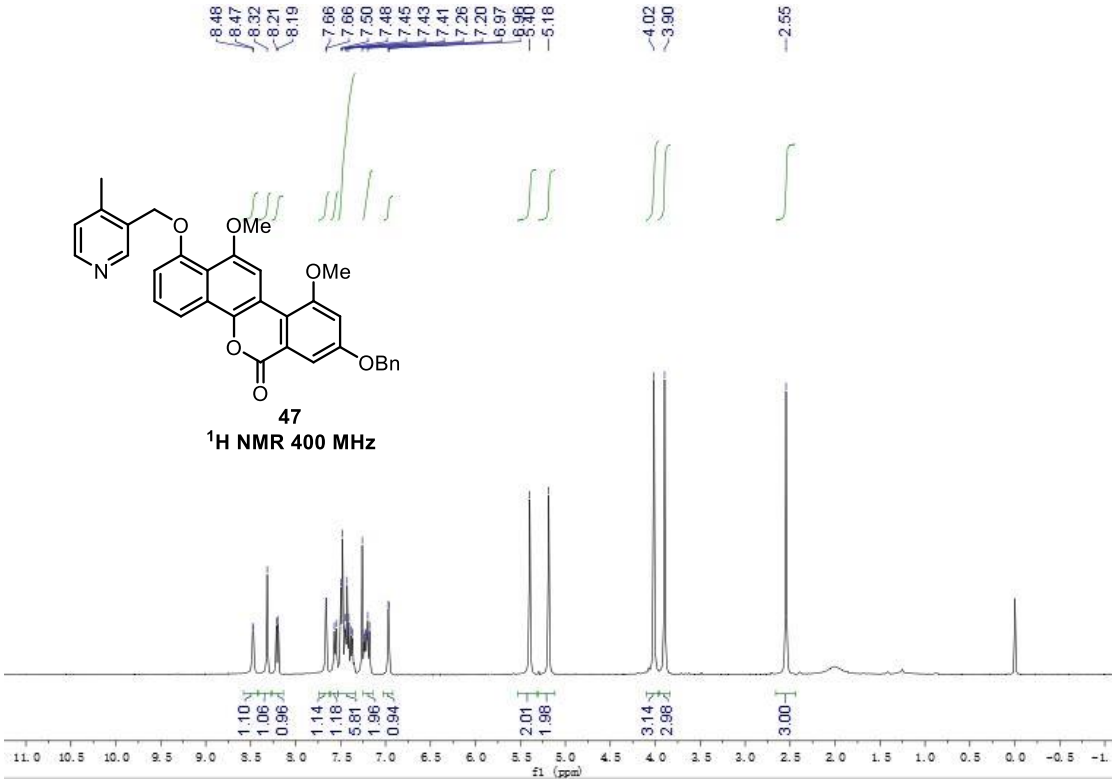
38

^{1}H NMR 500 MHz



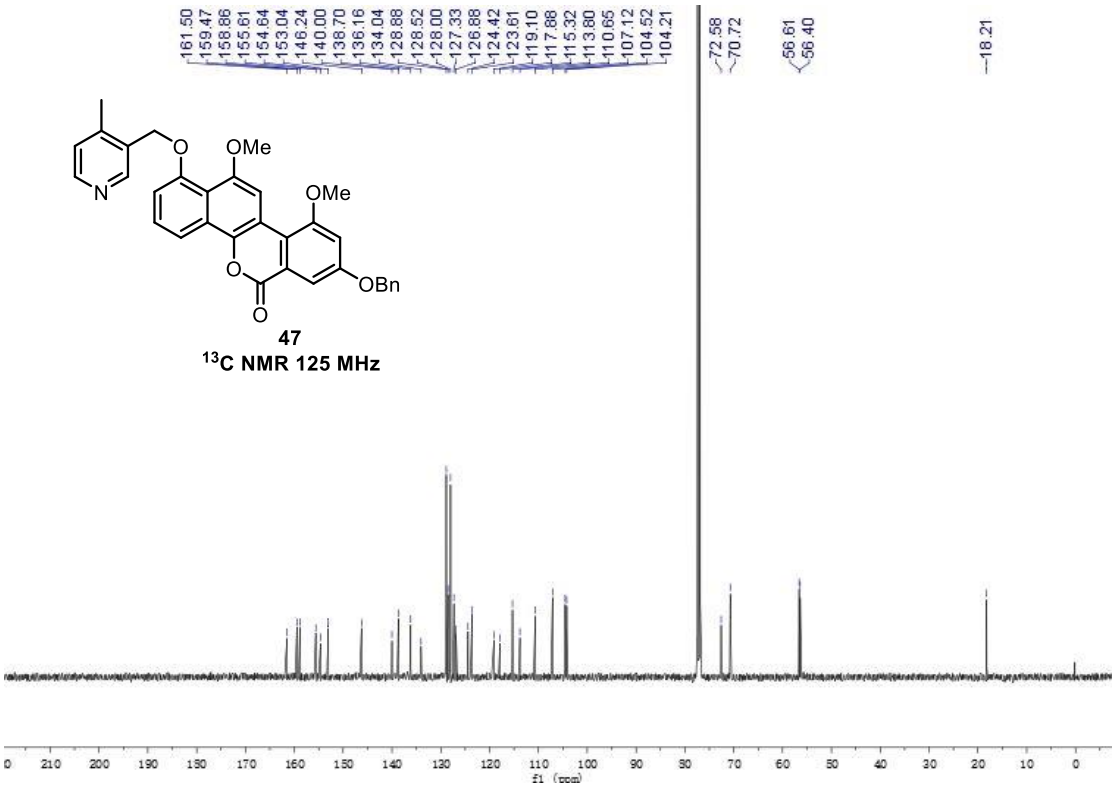
38

^{13}C NMR 126 MHz



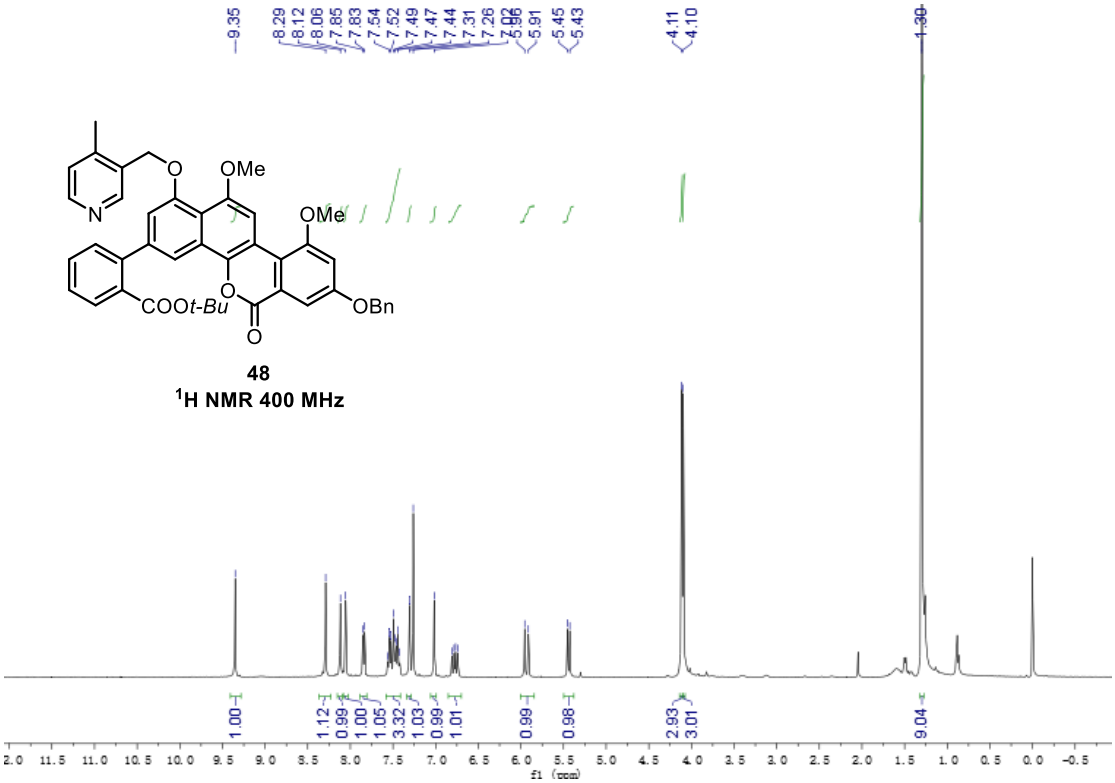
47

^{1}H NMR 400 MHz



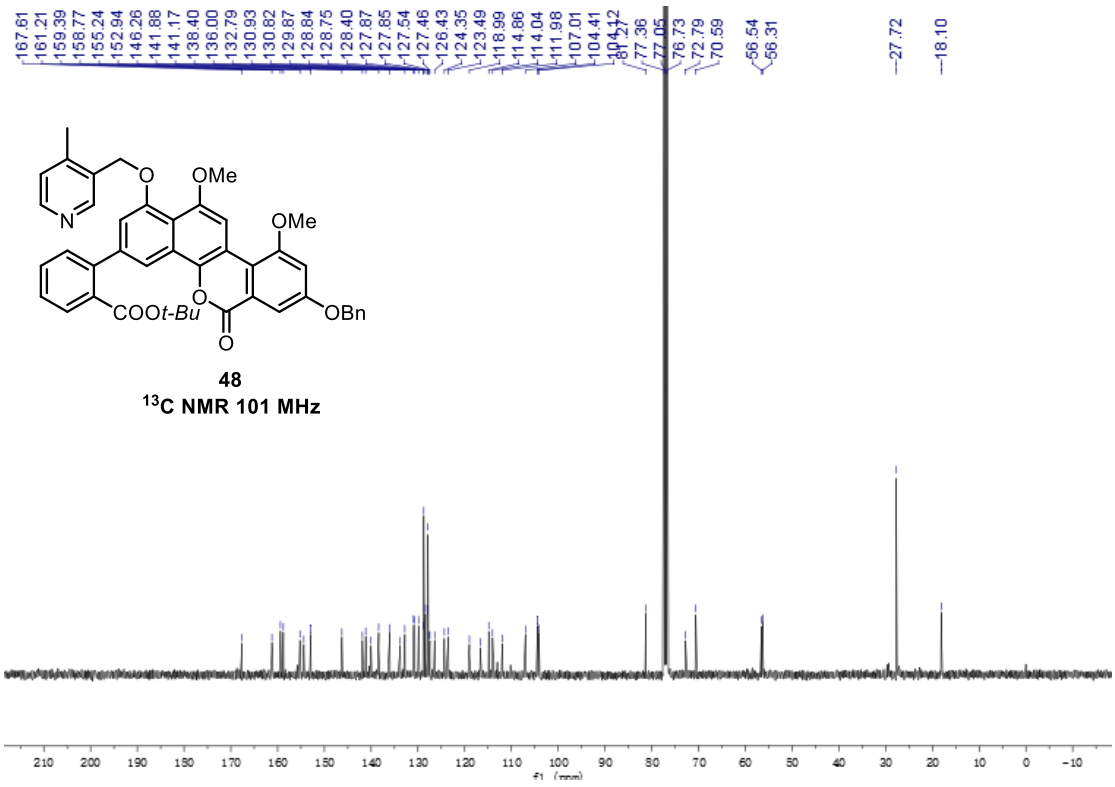
47

^{13}C NMR 125 MHz



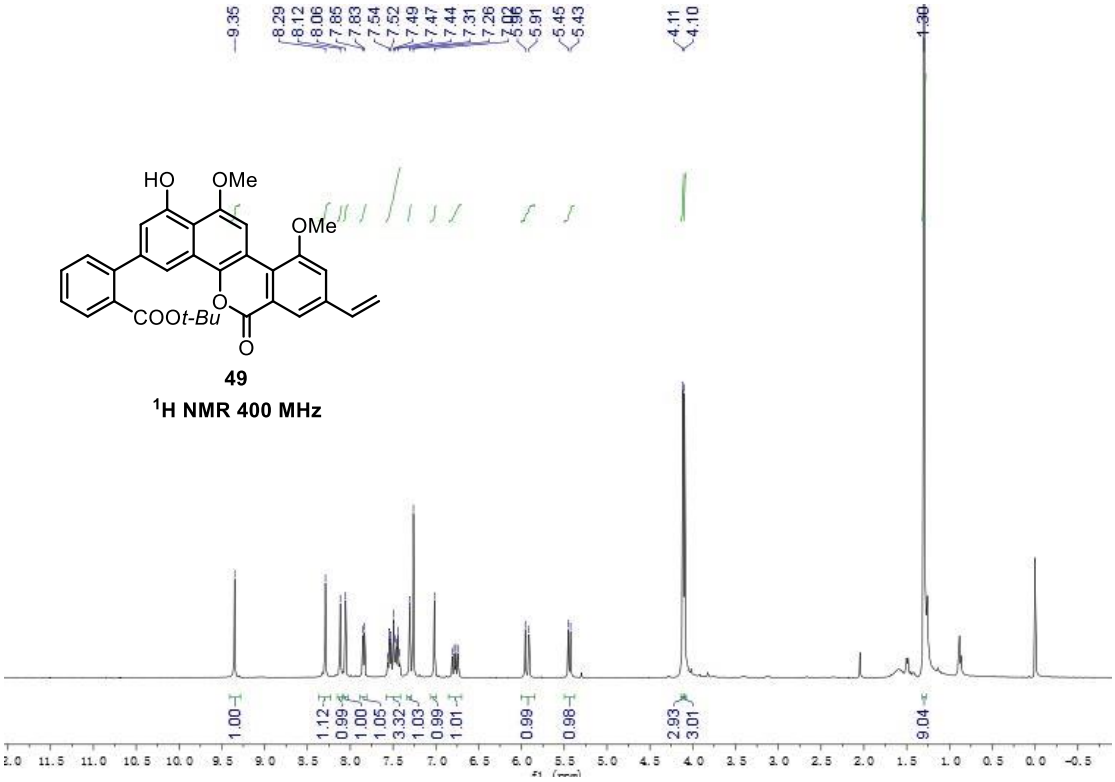
48

^{1}H NMR 400 MHz



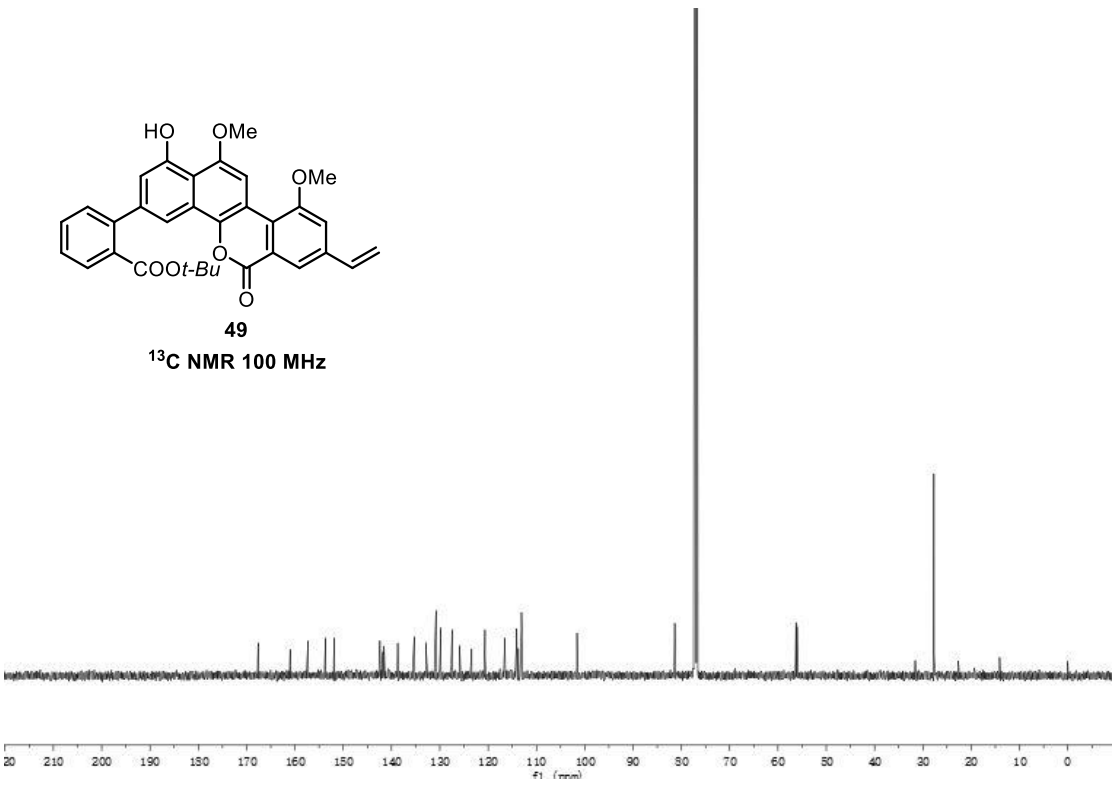
48

^{13}C NMR 101 MHz



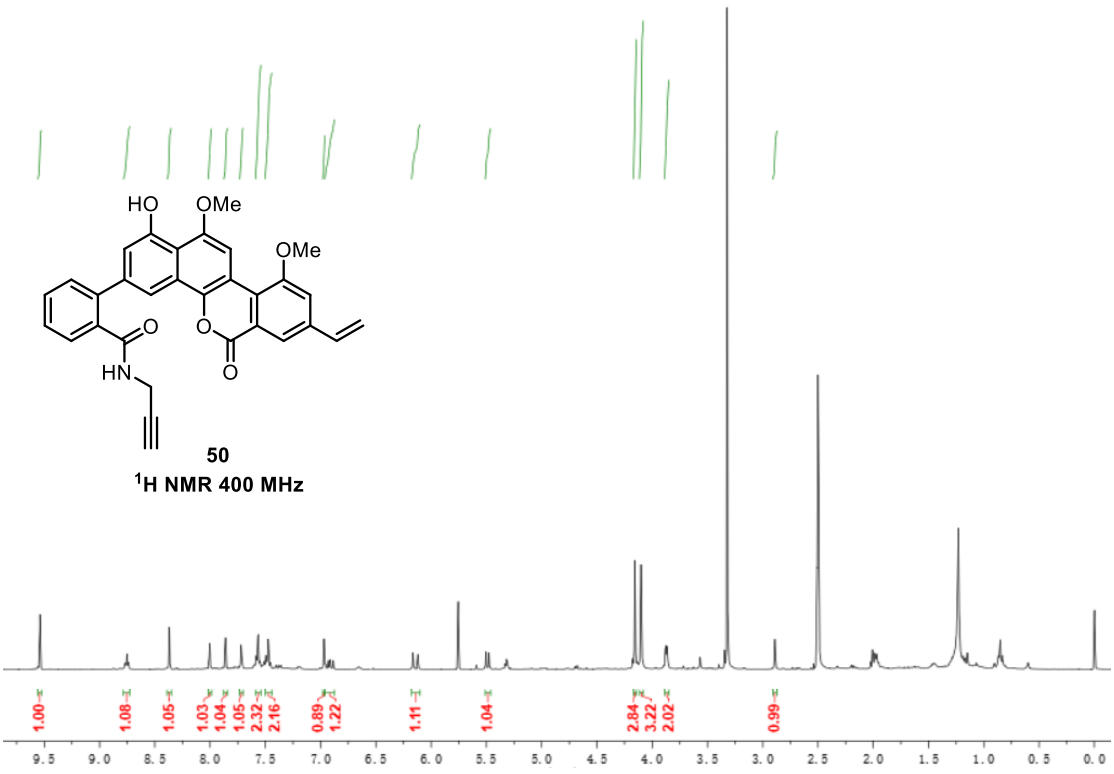
49

^{1}H NMR 400 MHz



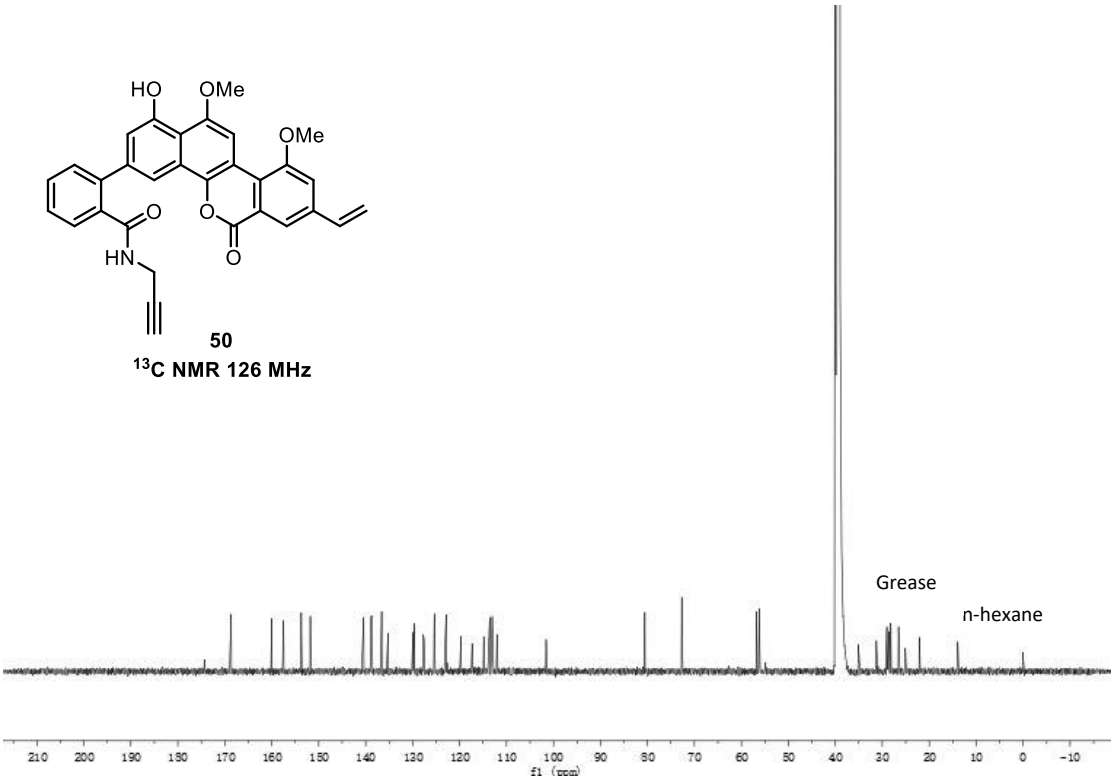
49

^{13}C NMR 100 MHz



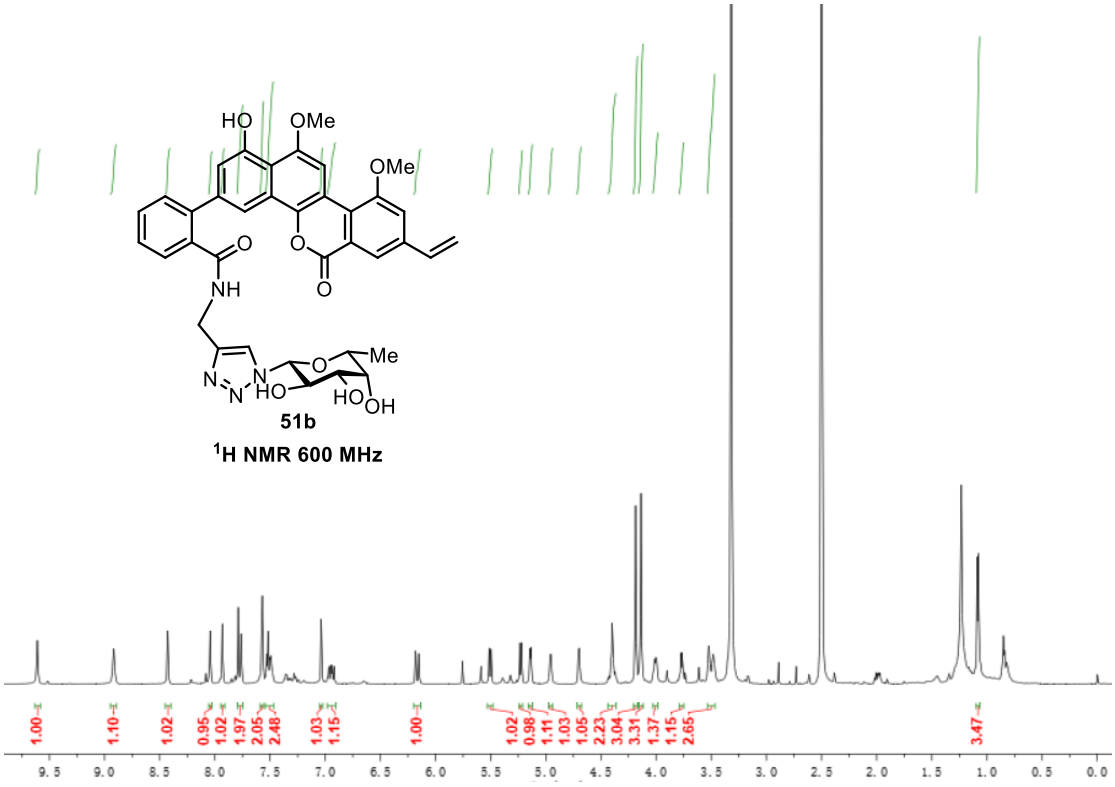
50

^{1}H NMR 400 MHz



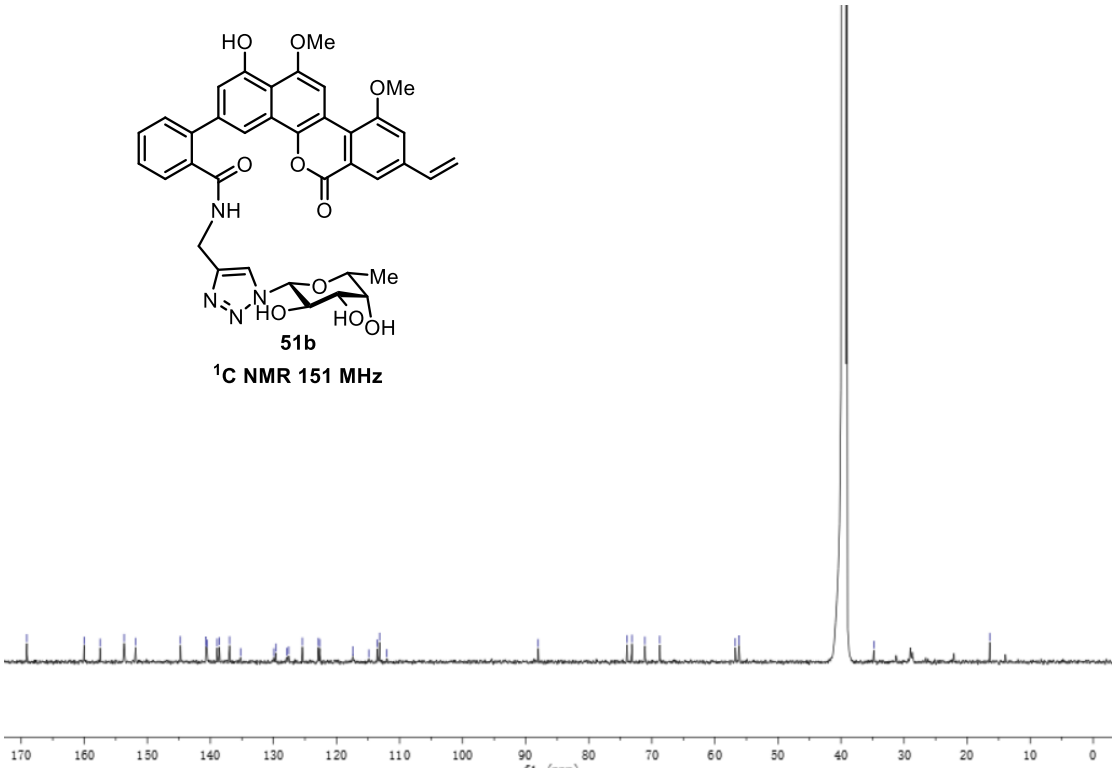
50

^{13}C NMR 126 MHz



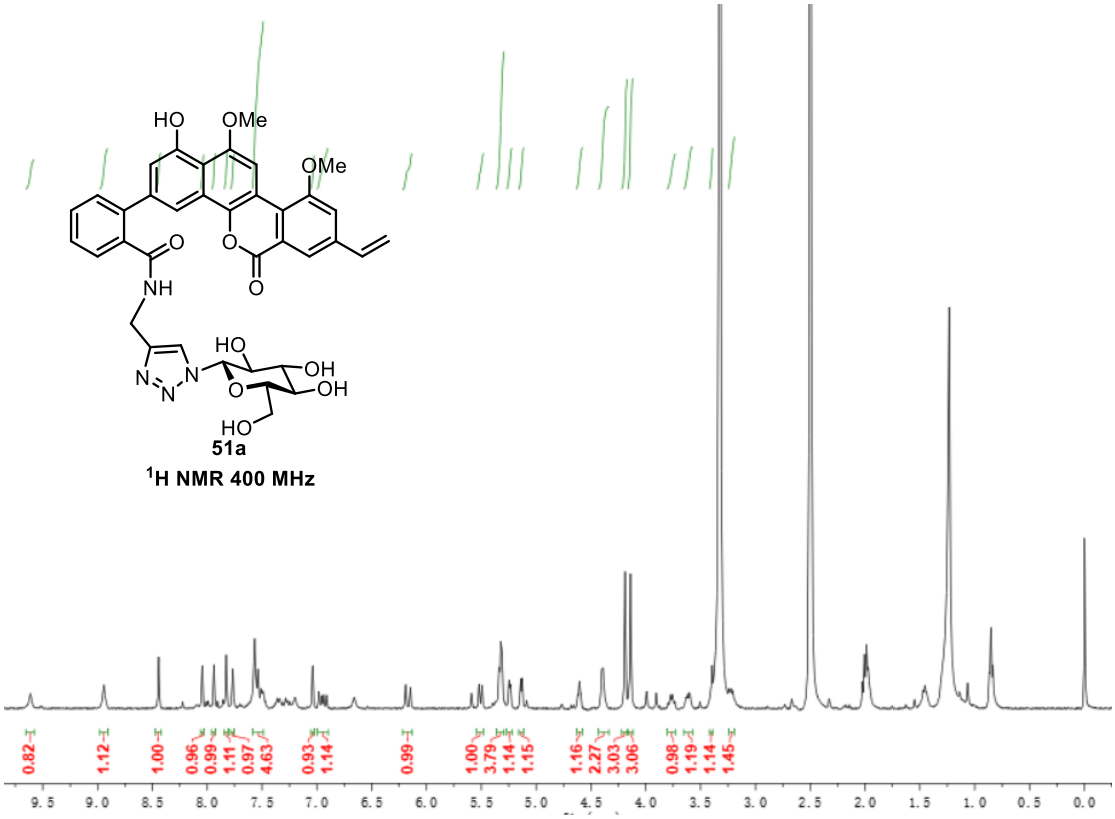
51b

^{1}H NMR 600 MHz



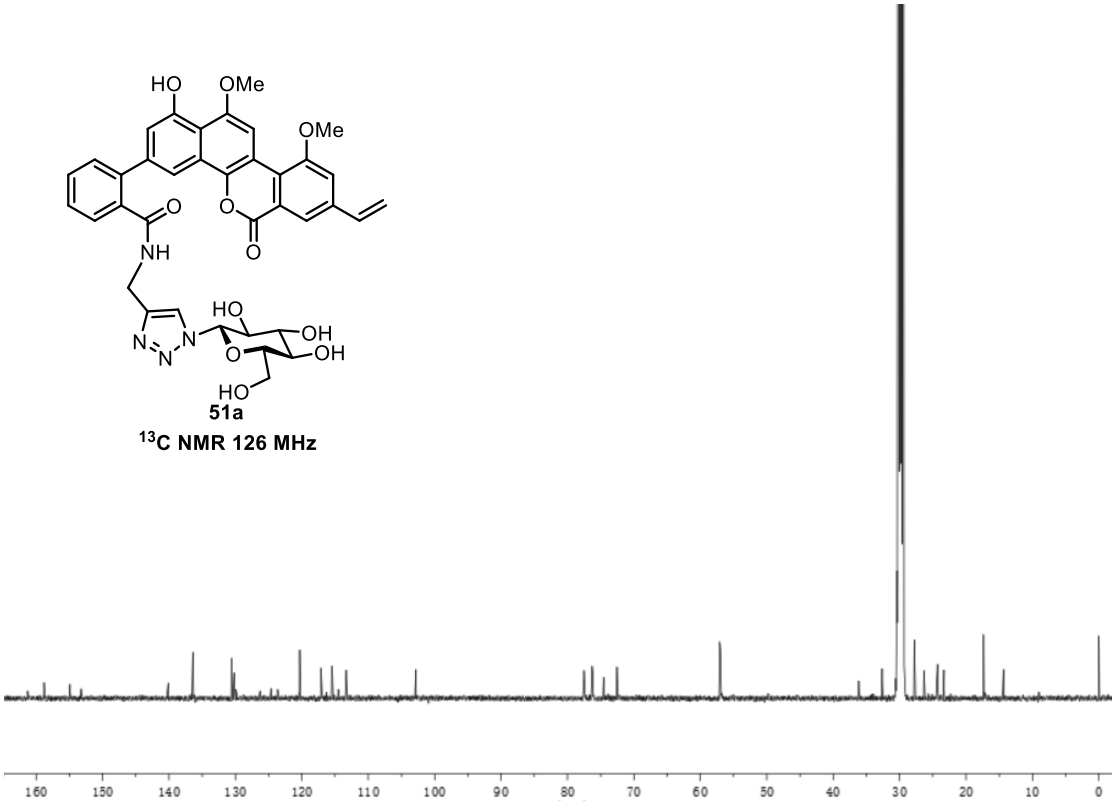
51b

^{1}C NMR 151 MHz



51a

^{1}H NMR 400 MHz



51a

^{13}C NMR 126 MHz