

Enantioselective Synthesis of Eight-Membered Lactone Derivatives via Organocatalytic Cascade Reactions

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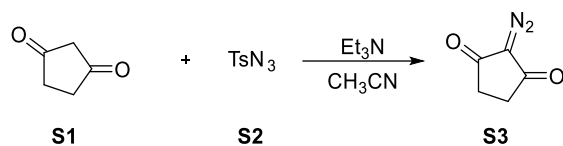
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1. General Information

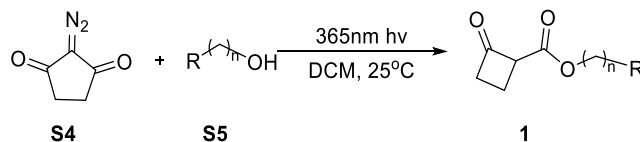
Chemicals and solvents were either purchased from commercial suppliers or purified by standard techniques. Analytical thin-layer chromatography (TLC) was performed on silicycle silica gel plates with F-254 indicator and compounds were visualized by irradiation with UV light. Flash chromatography was carried out utilizing silica gel 200-300 mesh. ^1H NMR, ^{13}C NMR spectra were recorded on a Bruker AM-400 or AM-600 spectrometer (400 MHz ^1H , 100 MHz ^{13}C , 600 MHz ^1H , 150 MHz ^{13}C). The spectra were recorded in CDCl_3 as the solvent at room temperature, ^1H and ^{13}C NMR chemical shifts are reported in ppm relative to either the residual solvent peak (^{13}C) ($\delta = 77.00$ ppm) or TMS (^1H) ($\delta = 0$ ppm) as an internal standard. Data for ^1H NMR are reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet, dd = double doublet, br = broad), integration, coupling constant (Hz) and assignment. Data for ^{13}C NMR are reported as chemical shift. HRMS were performed on Thermo Scientific LTQ-Orbitrap Elite-ETD MS with ESI. Enantiomeric excess values were determined by HPLC with a Daicel Chirapak IA/IC-3/IF-3/OD-H column on Agilent 1260 series with *i*-PrOH and *n*-hexane. Optical rotation was measured on the Perkin Elmer 341 polarimeter with $[\alpha]_{\text{D}}$ values reported in degrees. Concentration (c) is in g/100 mL. The crystal measurement is performed on XtaLAB Synergy-DW. All the catalysts mentioned in this work are known compounds, Cat-7 was purchased from Daicel. Cat-1, Cat-4, Cat-5 were derived from quinine and hydrogenquinine, which were synthesized according to the methods in *J. Am. Chem. Soc.* **2008**, *130*, 14416. Cat-2 was derived from quinine, which was synthesized according to the methods in *Organic Letters* **2005**, *7*, 1967 and *Chem. Commun.*, **2005**, 4481. Cat-3 was derived from (*R, R*)-*N, N*-dimethyl-*trans*-diaminocyclohexane according to the methods in *J. Am. Chem. Soc.* **2003**, *125*, 12672. Cat-6 was derived from quinine and (*1R, 2S*)-1-Amino-2-indanol (*Chem. Eur.J.* **2017**, *23*, 6752). Cat-8 was derived from (*1R, 2R*)-1,2-diaminocyclohexane according to the methods in *Org. Lett.* **2016**, *18*, 260. Cat-9 was derived from *L*-Phenylalaninol according to the method in *Tetrahedron: Asymmetry*, **2013**, *24*, 953. Cat-10 was derived from (*1R, 2R*)-1,2-diphenyl-2-(piperidin-1-yl)ethan-1-amine according to the methods in *Eur. J. Org. Chem.*, **2013**, *22*, 4844. Cat-11 was derived from (*1R, 2R*)-diaminocyclohexane according to the method in *Chem. Commun.*, **2010**, *46*, 3004; Cat-12 was derived from (*1R, 2R*)-diaminocyclohexane according to the method in *Org. Lett.* **2010**, *12*, 2028.

2 General Procedures for the synthesis of substrates

2.1 The general procedures for synthesis cyclobutanone carbonxester 1

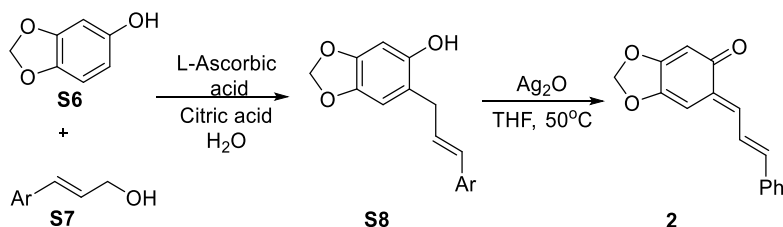


A 50 mL round-bottomed flask, protected from sunlight with aluminum foil, equipped with an adequate stirring bar was charged with cyclopentane-1,3-dione (**S3** 1.47 g, 15 mmol) and MeCN (5 mL). Tosyl azide (3.2 mL, 15 mmol (75 % wt in EtOAc)) and Et₃N (2.30 mL, 16.5 mmol) were successively added and the mixture was stirred for 4 h at r.t. The mixture was concentrated under vacuum to give the crude product. Purification of this material by flash chromatography (neutral Al₂O₃, eluent: 4:6 EtOAc–PE) afforded 1.59 g (86%) of **S5** as a yellowish solid, which should be protected from light and stored at ca. –25 °C for next step¹.



S5 (2.4 mmol, 298 mg) and alcohol (amine) **S6** (2.5 mmol) were added in 10 mL DCM under argon atmosphere in 50 mL reaction tube and stirred under **photoreactor** (10 W, 365 nm) for about 8-20 h (monitored by TLC, iodine vapor). Then the solution was concentrated in vacuo, and the crude residue was purified by column chromatography on silica gel to give the compound **1**² as known compound.

2.2 The general procedures for synthesis ortho-quinone methides



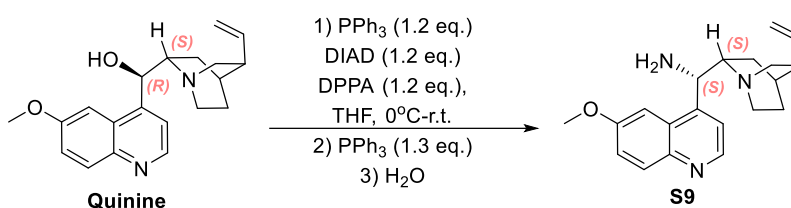
A suspension of sesame phenol **S6** (2.76 g, 20.0 mmol) and (E)-3-argioprop-2-en-1-ol **S7** (1 eq. 20 mmol) in 2% aqueous citric acid (100 mL) containing ascorbic acid (1.0 g, 5.6 mmol) was refluxed for 17 hours, then cooling to room temperature, the oily

¹ Presset M, Mailhol D, Coquerel Y, et al. *Synthesis*, 2011, 2011(16): 2549-2552.

² Zhang M M, Chen P, Xiong W, et al. *CCS Chemistry*, 2022, 4(8): 2620-2629.

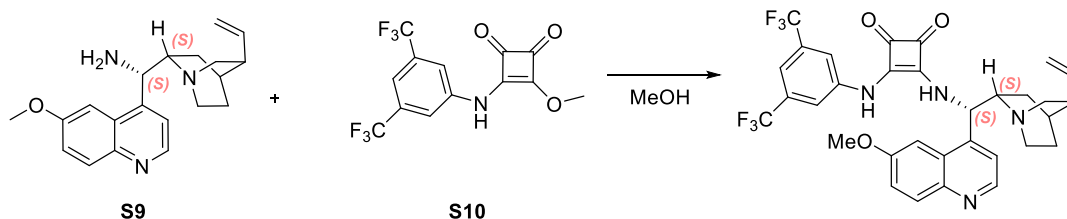
product was crystallized. After filtration, the crude product was recrystallized from toluene and afforded **S8**, which was directly used in the next step. The solid **S8** (1g) was dissolved in THF (50 mL), followed by addition of silver oxide (1.5 g), and stirred for 12 h at room temperature (RT). The solution was filtered, the residue was washed with dichloromethane until the liquid flowing down became colorless. Then the solution was concentrated to 10 mL, and red crystals were collected³ as known compound.

2.3 The procedure of synthesis Cat-1



Quinine (3.26 g, 10.0 mmol) and **triphenylphosphine** (3.15 g, 12.0 mmol) were dissolved in 50 mL of dry THF and the solution was cooled to 0 °C. **Diisopropyl azodicarboxylate** (2.43 g, 12.0 mmol) was added all at once. Then solution of **diphenyl phosphoryl azide** (3.30 g, 12.0 mmol) in 20 mL of dry THF was added dropwise at 0 °C. The mixture was allowed to warm to room temperature. After being stirred for 12 h, the solution was heated to 50 °C for 2 h. Then **triphenylphosphine** (3.41 g, 13.0 mmol) was added and heating was maintained until the gas evolution has ceased (2 h). The solution was cooled to room temperature, and 1 mL of water was added and the solution was stirred for 3 h. Solvents were removed in vacuo and the residue was dissolved in CH₂Cl₂ and 10% hydrochloric acid (1:1, 100 mL). The aqueous phase was washed with CH₂Cl₂ (4 × 50 mL). Then the aqueous phase was made alkaline with excess cc. aqueous ammonia and was washed with CH₂Cl₂ (4 × 50 mL). The combined organic phases was dried over Na₂SO₄ and concentrated. The residue was purified by column chromatography on silica gel (EtOAc/EtOH/Et₃N = 70/30/1 as eluant) affording the **S9** as a yellowish viscous oil. (65-70% yield).

³ Yu X, Lan W, Li J, et al.. RSC advances, 2020, 10(72): 44437-44441.



To a solution of **S10** (372 mg, 1.1 mmol) in MeOH (10 mL) was added a solution of **quinine amine S9** (323 mg, 1 mmol) in MeOH (5 mL). After 24 h, The residue was concentrated and purified by column chromatography on silica gel with EtOH to afford squaramide **Cat-1** (0.49 g, 71 %) as a yellow solid.

3 The optimization of reaction conditions

Table S1 The screen of different bifunctional catalyst:

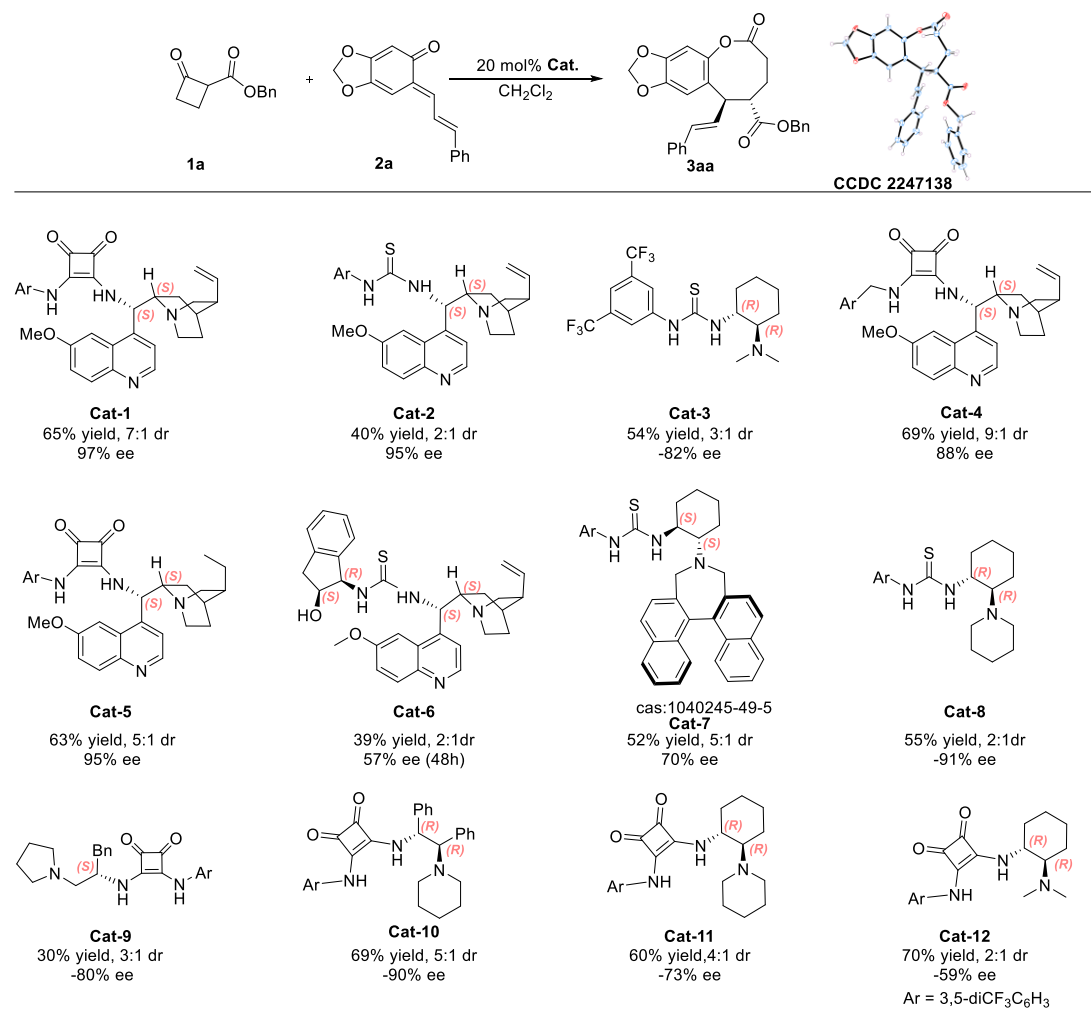
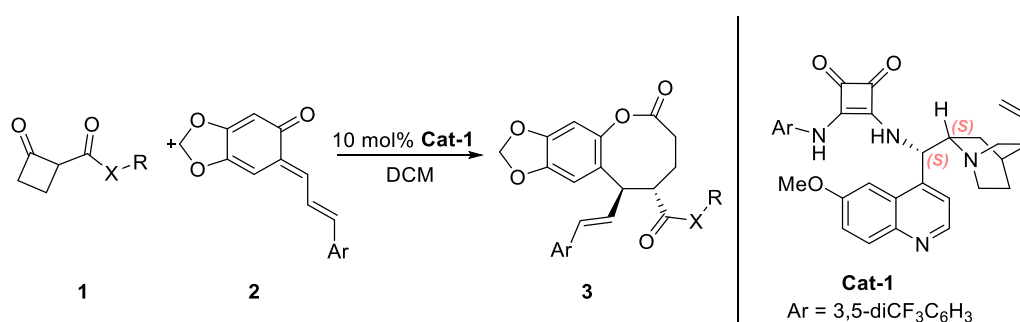


Table S2 The optimization of others paraments

Entry ^a	cat/ mol%	solvent	t/ °C	dr ^b	Yield/% ^c	Ee/% ^d
1	20	DCM	25	7:1	65	97
2	20	DCE	25	7:1	66	95
3	20	Toluene	25	7:1	60	90
4	20	CHCl ₃	25	5:1	69	89
5	20	CH ₃ CN	25	7:1	63	75
6	20	THF	25	4:1	56	87
7	15	DCM	25	7:1	66	97
8	10	DCM	25	8:1	66	98
9	5	DCM	25	8:1	59	96
10	10	DCM	0	8:1	69	97
11	10	DCM	-10	8:1	61	96
12 ^e	10	DCM	25	8:1	70	98
13 ^f	10	DCM	25	7:1	72	97
14 ^g	10	DCM	25	8:1	75	98
15 ^h	10	DCM	25	8:1	78	98
16 ⁱ	10	DCM	25	7:1	79	98

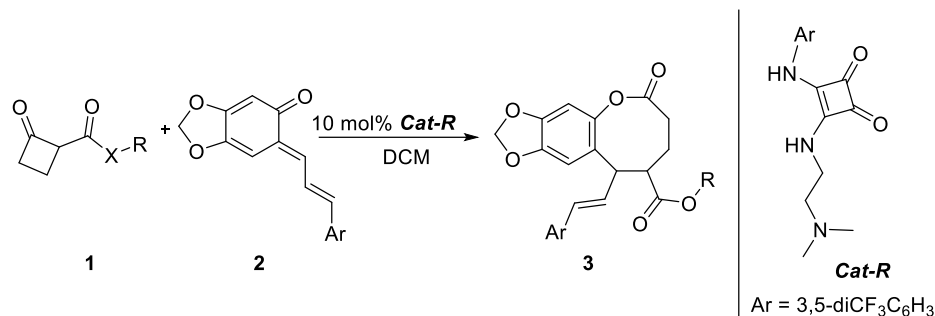
[a] Unless others specified, the reactions were performed with 0.1 mmol **1a**, 0.1 mmol **2a**, catalyst (10 mol%) in 1 mL solvent at 20°C for 4 hours (determined by the disappear of **2a**). [b] Isolated yield. [c] Determined by chiral HPLC. [d] Determined by the curde ¹HNMR. [e] 0.11 mmol **1a**. [f] 0.11 mmol **2a**. [g] 0.12 mmol **1a**. [h] 0.13 mmol **1a**. [i] 0.15 mmol **2a**

4 The general procedure for the synthesis of 8-membered lactone

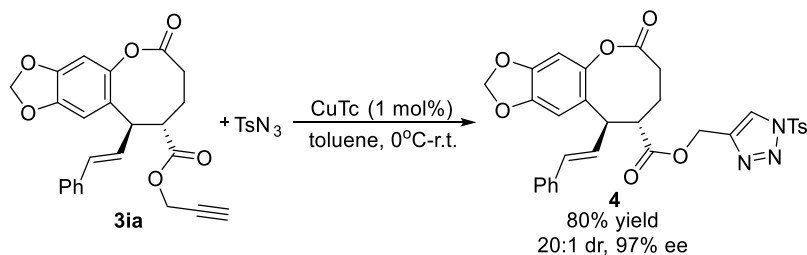


To a 10 ml vessel were successively added **Cat-1** (0.01 mmol), **cyclobutanone carbonxester 1** (0.13 mmol), **ortho-quinone methides 2** (0.10 mmol), then 1 mL dry DCM (CH₂Cl₂) added by syringe and the reaction mixture was stirred at 20 °C for approximately 2-4 h and monitored by thin layer chromatography, when TLC analysis showed **ortho-quinone methides 2** was mainly consumed, the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography

on silica gel (petroleum ether/ethyl acetate = 10:1-5:1-4:1) to give the corresponding enantioenriched **8-membered lactone** as a colourless oil or solid.

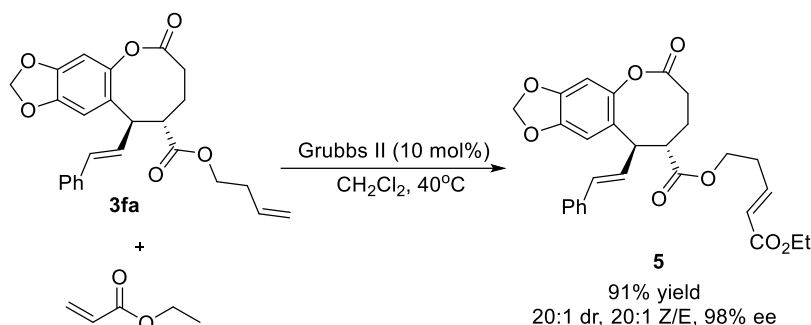


To a 10 ml vessel were successively added **Cat-R** (0.02 mmol), **cyclobutanone carbonxester 1** (0.13 mmol), **ortho-quinone methides 2** (0.10 mmol), then 1 mL dry DCM(CH₂Cl₂) added by syringe and the reaction mixture was stirred at 20 °C for approximately 24 h and monitored by thin layer chromatography, when TLC analysis showed **ortho-quinone methides 2** was mainly consumed, the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to give the corresponding racemic **8-membered lactone** as a colourless oil or solid.



A toluene solution of **3ia** (55.0 mg, 0.1 mmol, 1 mL toluene) was transferred into a 10 mL sealed tube, then **CuTc** (CAS: 68986-76-5) (2 mg, 0.005 mmol), **TsN₃** (20 mg, 0.1 mmol) were added at 0°C under Ar. This mixture solution was stirred at 0 °C for 1 hour and 10 hours at 20°C. After the completion of the reaction which was indicated by TLC (**3ia** was totally consumed), the reaction mixture was transferred into a 10 mL flask and added a small spoon silica gel, that the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) to give the **enantioenriched product 4** as a colorless oil (49

mg, 80% yield). The **racemic product 4** was synthesized from the **racemic 3ia** by the same procedure.



A DCM solution of **3fa** (42.0 mg, 0.1 mmol, 1 mL DCM) was transferred into a 10 mL sealed tube, then **Grubbs II catalyst** (13 mg, 0.01 mmol), **Ethyl Acrylate** (108 μL) were added under Ar. The mixture solution was stirred at 40 $^\circ\text{C}$ (oil bath) for 12 hours, when TLC analysis showed the **3fa** was consumed. The stirring was stopped and cooled to room temperature, the reaction mixture was transferred into a 10 mL flask and added a small spoon silica gel, that the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) to give the **enantioenriched product 5** as a colorless oil (48 mg, 91% yield). The **racemic product 5** was synthesized from the **racemic 3fa** by the same procedure.

5 The epimerization experiments

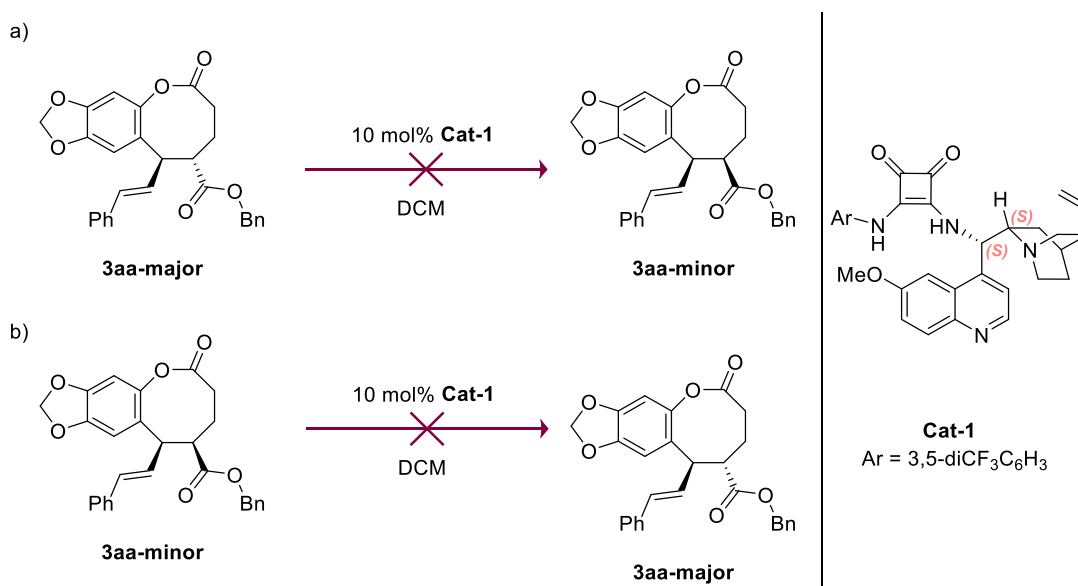


Fig. S1 Epimerization experiments

In a 10 mL reaction tube, 0.1 mmol **3aa-major** and 0.01 mmol **Cat-1** were added

with 1 mL DCM, stirred 72 hours at 25 °C, after that we couldn't observe any epimerization product (**3aa-minor**). Respectively, when the **3aa-minor** was used as starting material, any **3aa-major** was detected (Fig. S1). **These results implied the diastereoselectivity was not originated from the process of epimerization.**

6 Reaction mechanism and DFT calculations

Based on our experiments and previous reports, a proposed mechanism was outlined as below Fig. S2: the quinine-squaramide (Cat-1) as a bifunctional catalyst synergistic activated ortho-quinone methides **2** and cyclobutone carbonester **1**, the racemic cyclobutone carbonester **1** was transformed into pre-chiral enolate via a deprotonation with the help of catalyst-1, which underwent a stereospecific Michael addition with quinone methides **2** and afforded the proposed **Int-1**, then the electron-rich oxygen anion on **Int-1** attacked the carbonyl of cyclobutone and yielded **Int-2**, next the **Int-2** underwent fragmentation reaction which driven by the tension release of cyclobutanone and produced the enolate **Int-3**, at last a selective protonation of **Int-3** afforded the 8-membered lactone product **3**. In order to get some insights to diastereoselectivity, some DFT-calculations were conducted. First, the energy barriers (Cat-4 showed superior diastereoselectivity than Cat-1, so we calculated the energy barrier that Cat-4 mediated for the formation TS1 and TS2). of protonation of **Int-3** were calculated, the results showed the formation of trans-lactone from **Int-3** need to overcome 2.3 kcal energy barrier (TS1), respectively the energy barrier of cis-product from **Int-3** was 15.4 kcal (TS2). Moreover, the calculated Gibbs free energy of product **3aa** indicated that the **trans-lactone-3aa** was lower 6.9 kcal/mol than the **cis-product-3aa**, it implied the trans-product as thermodynamic product is more stable than cis-product. These two calculated results implied the formation of trans-lactone was favorable process in our protocol, it was consistent with our experiments results that the trans-lactones were obtained as the major products.

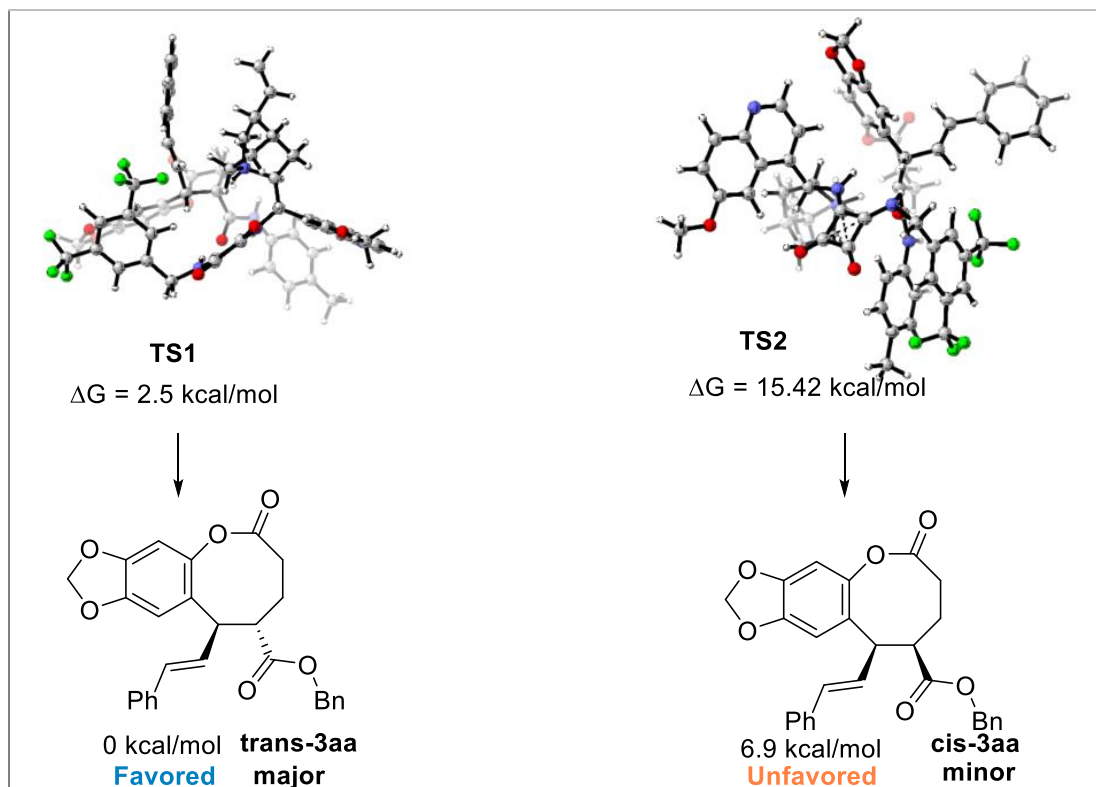
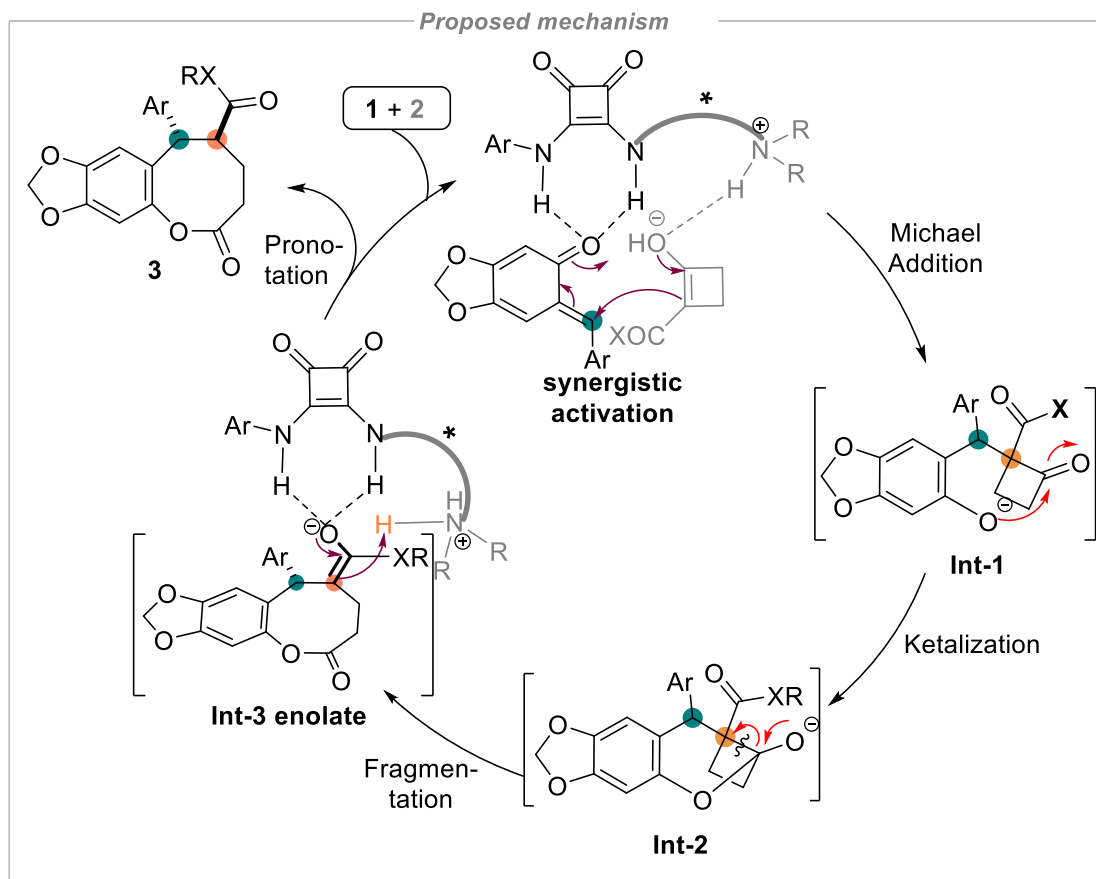


Figure S2 Proposed mechanism and DFT-calculations

DFT calculations¹ were performed with the Gaussian16² software package. All geometries were optimized using B3LYP/6-31G (d) with GD3³. Vibration frequencies were computed at the same level of theory to obtain thermal corrections. Single point energies were calculated by using M062X^{4,5}-D3/6-311G(2d,p), with inclusion of the IEFPCM⁶ implicit solvent model (solvent =Dichloromethane). All structures were generated using GaussView5.0.9 and CYLview. The Cartesian coordinates were listed below.

Enolate intermediate for the formation of trans-3aa

M062X/6-311g(2d,p) EmpiricalDispersion=GD3 scrf=(pcm,solvent=Dichloromethane)

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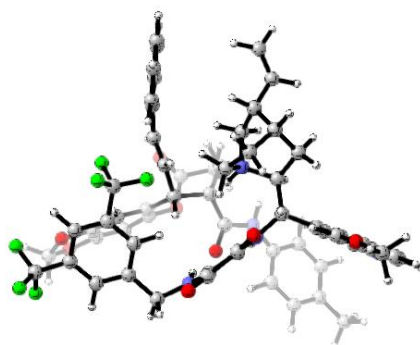
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H	-0.15988100	5.02676200	0.81174500
H	-0.90003900	5.10048200	2.43808000
H	1.49537700	3.74397000	0.44992100
H	1.76834300	2.31845600	-2.97956100
H	3.51373300	3.09829300	-4.53322700
H	4.94839000	5.85075800	-1.57340400
H	3.22610000	5.06459500	-0.01107500
H	5.16160000	4.90201600	-5.16058600
H	5.80544900	5.98138200	-3.91197500
H	6.36794900	4.30956500	-4.01536400
H	0.75235500	0.63597600	1.32802200

C	-6.40321700	1.26568900	-3.14486000
H	-7.33643800	1.36460300	-2.57147100
O	-5.73741900	2.53595300	-3.19821600
O	-5.53290200	0.34237100	-2.48343300
H	-6.59980900	0.91115800	-4.15967400
C	-3.85157200	0.95304800	3.71000800
C	-3.63756000	-0.29815300	4.31681100
C	-4.58096900	1.92350500	4.41948600
C	-4.11350600	-0.55547800	5.60099800
H	-3.12990600	-1.08183400	3.76321500
C	-5.05460800	1.66498700	5.70478400
H	-4.75489100	2.89178200	3.95591300
C	-4.81959700	0.42513300	6.30339700
H	-3.94721600	-1.53156100	6.05035100
H	-5.60996100	2.43160500	6.23908400
H	-5.19405300	0.21943600	7.30266100



TS1 for the formation of **trans-3aa**

M062X/6-311g(2d,p) EmpiricalDispersion=GD3 scrf=(pcm,solvent=Dichloromethane)

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C	0.78459600	-0.87370500	3.85359500
C	0.57930700	-1.46622300	2.50023000
C	1.65303800	-0.74350600	1.95609800
C	1.89967900	-0.02100300	3.22562800
O	0.23606900	-1.00399800	4.93082600
O	2.61100300	0.92273300	3.54690400
N	-0.34761000	-2.29315200	1.99732900
N	2.18045400	-0.63582000	0.72345400
C	3.21938400	0.34494700	0.43070200
C	4.55920500	-0.31879300	0.11769800
C	2.84765700	1.33453600	-0.70971900
C	5.68513200	-0.21976200	0.99848600

C	6.89015100	-0.89066700	0.58480000
N	6.99189100	-1.62761000	-0.55982900
C	5.92289600	-1.71176100	-1.32278600
C	4.69905600	-1.06398700	-1.03174600
C	5.68389900	0.48802800	2.22405000
C	6.82839500	0.55798500	3.00217300
C	8.02306600	-0.08554300	2.58593300
C	8.03963300	-0.79489800	1.40669100
N	1.39591000	1.76039500	-0.70585200
C	0.99005800	2.31544700	0.63428600
C	2.05157000	3.33319400	1.11650500
C	2.86378500	3.79336200	-0.11071800
C	3.72924700	2.61489100	-0.61211100
C	1.83788400	4.18797000	-1.20452500
C	1.23030600	2.86189600	-1.72324100
C	2.38795300	4.99725000	-2.34678100
C	1.77160100	6.05676800	-2.87199900
H	-0.39792800	-2.35514900	0.97502700
H	1.87127300	-1.30865800	0.02744900
C	-1.51105700	-2.66942400	2.79159800
C	-2.65467400	-1.66540400	2.74522900
C	-2.40851800	-0.29320300	2.62973400
C	-3.46355400	0.61477400	2.62719700
C	-4.78392900	0.17930400	2.76027100
C	-5.03004400	-1.18527300	2.87889200
C	-3.97534900	-2.10069500	2.86407000
O	6.71618400	1.26825900	4.15909400
C	7.82508000	1.32137100	5.04414400
C	-6.43996100	-1.67595100	3.07797800
F	-6.74939600	-1.73874900	4.39461200
F	-7.34889200	-0.87029300	2.49582700
F	-6.61589800	-2.92540500	2.58035900
C	-3.21191000	2.08323300	2.42517200
F	-1.90043800	2.35599700	2.17803700
F	-3.91229300	2.55228400	1.36472900
F	-3.57695100	2.81767200	3.49399900
H	3.31911700	0.92668000	1.34209300
H	2.97803900	0.83609400	-1.67339400
H	6.00075300	-2.31731300	-2.22377900
H	3.87357800	-1.18324100	-1.72220600
H	4.78737900	0.94976100	2.62264600
H	8.91996700	-0.03219200	3.19196300
H	8.93658900	-1.30590400	1.07137500
H	0.84438800	1.49371800	1.32966400

H	0.02639200	2.80066000	0.48812400
H	2.69198800	2.88806000	1.88327400
H	3.50124600	4.64519000	0.14441200
H	4.55988200	2.43721000	0.07830300
H	4.17709700	2.84889800	-1.58314200
H	1.03725800	4.77287800	-0.73513200
H	1.54609800	4.18676600	1.58030600
H	1.72617700	2.53130900	-2.63806000
H	0.16600100	2.96403100	-1.93260400
H	3.33112000	4.65457400	-2.77574200
H	0.81732700	6.41006600	-2.48533000
H	2.18997600	6.60141700	-3.71405100
H	-1.86161500	-3.64764800	2.44809600
H	-1.18524300	-2.77620400	3.83158300
H	-1.39758000	0.07428200	2.51808900
H	-5.60597100	0.88577900	2.73637200
H	-4.19350100	-3.16211600	2.93301500
H	8.12242000	0.31982800	5.38292900
H	8.68990200	1.81948000	4.58469200
H	7.48991300	1.90564400	5.90289300
O	-2.91148500	-0.01635700	-4.75841300
C	-5.10013000	-2.50102100	-1.86965500
C	-4.96992700	-1.63002200	-0.79030500
C	-3.86248300	-0.83433200	-0.62192800
C	-2.82158300	-0.89861200	-1.57723400
C	-3.00394500	-1.75138900	-2.66547400
C	-4.12950200	-2.57291800	-2.84459200
O	-2.00902300	-1.79408100	-3.64430500
C	-1.57101600	-0.04732600	-1.25951700
C	-0.22293100	-0.20084700	-2.02666000
C	-1.90081800	1.42645400	-1.14960100
C	-2.53262700	2.18420700	-2.05864000
C	-0.03855500	0.42402100	-3.41713900
C	-0.51876400	-0.34939100	-4.69718800
C	-1.95345200	-0.68440900	-4.45209000
C	0.43781300	-1.45757400	-1.76018000
O	0.23412000	-2.16993900	-0.74196600
N	1.46786500	-1.83511500	-2.62488800
C	2.32979600	-2.94868700	-2.58467200
C	2.39413600	-3.87724900	-1.53304700
C	3.35555000	-4.88656300	-1.56137900
C	4.27299200	-5.02194700	-2.60911600
C	4.17817500	-4.10716900	-3.66546200
C	3.22861100	-3.09043000	-3.65695300

C	5.34329600	-6.08672100	-2.58560900
H	-3.79443100	-0.15287000	0.21425400
H	-4.21393800	-3.20707400	-3.71821400
H	-1.31295600	-0.37149400	-0.24397400
H	-1.47108400	1.91361600	-0.28233600
H	-2.96429900	1.70906900	-2.93899800
H	1.02208600	0.66420400	-3.58622800
H	-0.55231900	1.38816200	-3.43552800
H	0.05176200	-1.26932600	-4.85249300
H	-0.42434800	0.29545500	-5.57434900
H	1.56666400	-1.28154400	-3.46072100
H	1.69621500	-3.80280100	-0.71308700
H	3.39096100	-5.58903800	-0.73156600
H	4.85965300	-4.18732400	-4.50958200
H	3.18725400	-2.38988400	-4.48992700
H	6.24393600	-5.73094300	-2.06723700
H	5.00239000	-6.98691500	-2.06263900
H	5.64372800	-6.37820700	-3.59806400
H	0.71060900	0.84722000	-1.13066200
C	-2.54049700	3.65708600	-2.03705800
C	-2.68161700	4.34905500	-3.25301500
C	-2.30615600	4.41079100	-0.86914500
C	-2.55278300	5.73667800	-3.31159800
H	-2.87300900	3.78330800	-4.16192800
C	-2.17783000	5.79668700	-0.92881300
H	-2.25676700	3.91163800	0.09242700
C	-2.29084100	6.46781300	-2.15124100
H	-2.65660000	6.24696200	-4.26558500
H	-2.00521200	6.35861400	-0.01425800
H	-2.19509800	7.54942800	-2.19350800
O	-6.09791500	-1.70090000	-0.00340000
O	-6.30397200	-3.15899800	-1.79430600
C	-6.83754100	-2.81982300	-0.50526700
H	-6.71834000	-3.67031700	0.17915700
H	-7.88919800	-2.54117200	-0.60859300

Enolate intermediate for the formation of cis-3aa

M062X/6-311g(2d,p) EmpiricalDispersion=GD3 scrf=(pcm,solvent=Dichloromethane)

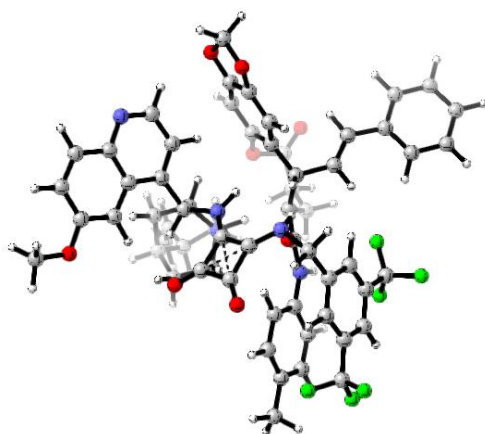
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C	0.27482000	-3.31240000	-2.87184500
C	-0.04218700	-1.87026500	-2.67680200
C	1.18709700	-1.61751200	-2.05565400
C	1.58971500	-3.03802500	-2.10442200

O	-0.31183100	-4.26544800	-3.34993300
O	2.49432000	-3.67823500	-1.58689500
N	-1.11386000	-1.08301800	-2.89039500
N	1.74440600	-0.50496300	-1.53968400
C	2.90976100	-0.58030100	-0.65642900
C	4.12388200	0.13435500	-1.23482100
C	2.52688200	0.01637200	0.72197100
C	5.43138600	-0.44909500	-1.18596400
C	6.52103200	0.35664200	-1.66564000
N	6.35853500	1.60448500	-2.19447500
C	5.13075200	2.07433400	-2.27100900
C	3.98982800	1.38257300	-1.79652900
C	5.70860100	-1.74987100	-0.70087000
C	7.00654100	-2.23119000	-0.65464000
C	8.08619700	-1.42446300	-1.10074900
C	7.83633300	-0.16588100	-1.59868400
N	1.34776400	-0.74318100	1.30933000
C	1.66912600	-2.19486000	1.55813800
C	2.97077800	-2.27637200	2.38824400
C	3.28988300	-0.87974200	2.95671300
C	3.66133100	0.04164000	1.77956700
C	2.02628200	-0.35251200	3.68910800
C	0.93891200	-0.10304500	2.61066500
C	2.27561100	0.88647800	4.50503800
C	2.09098900	0.97662800	5.82179700
H	-1.19398900	-0.33811700	-2.19213100
H	1.09062800	0.25727400	-1.36485500
C	-2.37207800	-1.63751900	-3.40657600
C	-3.26345000	-2.21961400	-2.32300000
C	-3.27224900	-3.59355300	-2.07753600
C	-4.04520100	-4.11534400	-1.03698500
C	-4.82264400	-3.27997100	-0.24243900
C	-4.81475000	-1.90617900	-0.49101500
C	-4.03819800	-1.37479600	-1.51829200
O	7.15392800	-3.49376900	-0.16563600
C	8.44580800	-4.08615700	-0.16952200
C	-5.64745900	-1.01707600	0.38954200
F	-6.89878400	-1.50128200	0.54336500
F	-5.12954600	-0.90984600	1.64694400
F	-5.75065300	0.23934200	-0.09542000
C	-4.04031700	-5.60073800	-0.79572400
F	-4.83968600	-6.25135600	-1.67177400
F	-2.80150100	-6.12469600	-0.93173400
F	-4.47757700	-5.91369100	0.44781800

H	3.14952600	-1.63578800	-0.54727800
H	2.14280700	1.02733600	0.54979800
H	5.00566000	3.06188400	-2.70923100
H	3.01520700	1.84860000	-1.87968500
H	4.91882800	-2.43069800	-0.40426000
H	9.10398400	-1.79487800	-1.06542600
H	8.64255500	0.46345500	-1.96197800
H	1.74340700	-2.71311200	0.60301900
H	0.80750600	-2.60679400	2.08297400
H	3.80374500	-2.62352400	1.76743700
H	4.12535400	-0.93662100	3.66070500
H	4.59999500	-0.30135500	1.33895200
H	3.82851000	1.06968200	2.11396000
H	2.84562900	-3.00465100	3.19589700
H	1.68113900	-1.14497000	4.36495500
H	0.78403100	0.95531700	2.40777900
H	-0.02688100	-0.53131800	2.88185200
H	2.62579100	1.75824800	3.95276000
H	-2.89424200	-0.82956500	-3.92989100
H	-2.11702900	-2.40524900	-4.14006400
H	-2.63396600	-4.24795000	-2.66432500
H	-5.41359000	-3.68759700	0.56913800
H	-4.01718800	-0.30005800	-1.67261500
H	8.86059000	-4.14524100	-1.18436100
H	9.14528100	-3.53985400	0.47760100
H	8.30909300	-5.09556600	0.22210400
O	-1.76210400	4.84032100	2.36475300
C	2.55661200	4.00818400	0.95273600
C	2.28422800	3.99288100	-0.41234200
C	1.06200100	3.59194900	-0.90744100
C	0.04220500	3.21126400	-0.00206200
C	0.33244200	3.29204000	1.36615000
C	1.58727600	3.67771600	1.87464200
O	-0.60788200	2.87573100	2.30181900
C	-1.29787800	2.73836500	-0.60196500
C	-2.13715300	1.77651600	0.24514700
C	-2.12728400	3.88791700	-1.13557600
C	-2.00870800	5.17728900	-0.79022900
C	-3.29186300	2.29029600	1.07422000
C	-2.93387500	2.71878900	2.54937900
C	-1.75862300	3.63869400	2.44667700
C	-1.64719600	0.50050000	0.36459700
O	-0.59965800	0.05680200	-0.29309600
N	-2.23996200	-0.40308400	1.27375600

C	-2.02036400	-1.77283000	1.44130300
C	-1.39909500	-2.59739200	0.48898400
C	-1.22886800	-3.95934500	0.72677800
C	-1.67330000	-4.56752400	1.90577500
C	-2.29527100	-3.74080000	2.85314000
C	-2.46176100	-2.37602900	2.63670900
C	-1.54555100	-6.05638600	2.11978600
H	0.87171100	3.58133500	-1.97625600
H	1.75049200	3.72093900	2.94426100
H	-0.99168600	2.15864200	-1.48530800
H	-2.92610000	3.57742400	-1.80977200
H	-1.25713300	5.44786800	-0.05218400
H	-4.10676900	1.56084800	1.13663900
H	-3.72302400	3.17404000	0.59405800
H	-2.66046100	1.84163500	3.14453000
H	-3.77786600	3.23439700	3.01389300
H	-2.97177100	-0.02671200	1.85519400
H	-1.06999200	-2.16833900	-0.44029600
H	-0.76298200	-4.56469400	-0.04723000
H	-2.65879400	-4.17394700	3.78280900
H	-2.95181800	-1.76595800	3.39253600
H	-1.44217900	-6.30428000	3.18230100
H	-2.43162400	-6.57921200	1.74128300
H	-0.67862100	-6.46393800	1.58889900
H	0.50990300	-0.60170300	0.64006100
H	1.73167800	0.13291500	6.40794200
O	3.40463700	4.38062100	-1.11053300
O	3.85990000	4.37697800	1.17048900
C	4.39696600	4.70027400	-0.12315400
H	4.61946200	5.77352800	-0.16749100
H	5.29328900	4.09881000	-0.30443500
C	-2.85422800	6.28378200	-1.26141000
C	-3.56677300	6.24144500	-2.47335200
C	-2.96331100	7.43903200	-0.46728800
C	-4.37432300	7.30676100	-2.86454400
H	-3.46955300	5.37442000	-3.12117300
C	-3.77206800	8.50505700	-0.85798900
H	-2.42076400	7.48222400	0.47412100
C	-4.48306900	8.44345000	-2.05821800
H	-4.91339000	7.25540900	-3.80726600
H	-3.84734500	9.38512000	-0.22433600
H	-5.11003700	9.27551200	-2.36748900
H	2.28896500	1.89630900	6.36508700



TS2 for the formation of cis-3aa

M062X/6-311g(2d,p) EmpiricalDispersion=GD3 scrf=(pcm,solvent=Dichloromethane)

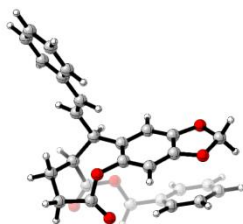
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C	-0.24937900	-3.35922700	-2.10984000
C	-0.15225700	-1.88269900	-2.24535300
C	0.88803200	-1.79509300	-1.30965300
C	0.86415800	-3.25484500	-1.05113600
O	-0.97167500	-4.21936100	-2.57910000
O	1.42344900	-3.98546300	-0.24412800
N	-0.84060500	-0.96686300	-2.95728900
N	1.57636100	-0.79297700	-0.72989400
C	2.71898800	-1.07079700	0.13567200
C	4.04281300	-0.79644600	-0.57740400
C	2.70417500	-0.30858200	1.48644100
C	4.92521400	-1.84480900	-0.99305800
C	6.14323400	-1.44172200	-1.64747100
N	6.47524300	-0.14105800	-1.89524700
C	5.62153500	0.78521300	-1.51370200
C	4.40252900	0.50321600	-0.85404600
C	4.67724500	-3.22423100	-0.79864900
C	5.59551100	-4.17402500	-1.21733800
C	6.80226400	-3.77829200	-1.85175400
C	7.05743900	-2.44201700	-2.05956900
N	1.34539000	-0.24491600	2.14566200
C	0.72991000	-1.61016700	2.27711200
C	1.75766700	-2.56355800	2.93328300
C	2.87956900	-1.72102600	3.57644600
C	3.68659700	-1.00705900	2.47260600
C	2.19862100	-0.65940500	4.47942700
C	1.50236900	0.33922000	3.52194000
C	3.13311400	0.05339000	5.41802100
C	3.03522300	0.02739800	6.74727000

H	-0.87093300	-0.06713900	-2.48331300
H	1.38965900	0.16432600	-1.00070300
C	-2.12188500	-1.34921600	-3.57667700
C	-3.27527700	-1.39901400	-2.58851900
C	-3.92080400	-2.59879600	-2.29998500
C	-4.95936600	-2.63151100	-1.36209800
C	-5.33065400	-1.48334200	-0.67342600
C	-4.66493500	-0.28516500	-0.94577700
C	-3.66521500	-0.23719300	-1.91030000
O	5.25677700	-5.47103000	-0.97964500
C	6.11600400	-6.50334900	-1.44114600
C	-5.05071700	0.95141900	-0.18414500
F	-6.17954900	1.51819200	-0.66697100
F	-5.27903800	0.68583200	1.12458500
F	-4.08494900	1.90746300	-0.22913500
C	-5.68289400	-3.92834800	-1.12805900
F	-6.54017800	-4.20280600	-2.14093100
F	-4.82992100	-4.97478500	-1.05071300
F	-6.41332700	-3.91080600	0.01146200
H	2.64652700	-2.13134200	0.36067100
H	2.97316100	0.73681600	1.32698800
H	5.89412600	1.82137800	-1.70654000
H	3.76067400	1.32614400	-0.56832400
H	3.75370100	-3.58881600	-0.36281000
H	7.52250400	-4.51864500	-2.17983600
H	7.96957400	-2.11401300	-2.54789200
H	0.41783500	-1.94526700	1.29380500
H	-0.17478700	-1.48349400	2.87347500
H	2.15859700	-3.25421600	2.18527900
H	3.54084500	-2.35427800	4.17513600
H	4.29984500	-1.73296800	1.93005600
H	4.37982300	-0.27960200	2.90522400
H	1.25881000	-3.17299700	3.69383100
H	1.43728700	-1.17133400	5.08114500
H	2.06550900	1.26639900	3.40345000
H	0.49818000	0.59747000	3.86271400
H	3.93484300	0.62988100	4.95434800
H	-2.32783400	-0.61695100	-4.36505900
H	-1.98406300	-2.32370000	-4.04846300
H	-3.58607700	-3.51849700	-2.76981700
H	-6.09553200	-1.52609000	0.09196900
H	-3.15356100	0.69973100	-2.09737300
H	6.24405800	-6.46744900	-2.53130100
H	7.10202000	-6.45842200	-0.95881800

H	5.62575500	-7.43935000	-1.16811100
O	0.80071900	5.25708400	2.01417100
C	3.88054400	3.90768900	-0.91995100
C	3.02586200	3.51698400	-1.95009600
C	1.76168600	3.02812000	-1.70054300
C	1.31645300	2.92973300	-0.35844900
C	2.20394400	3.32981700	0.64546400
C	3.49823200	3.82164200	0.40173500
O	1.79329000	3.20534100	1.96909900
C	-0.12499500	2.45900400	-0.14469400
C	-0.56859500	1.67848200	1.13646500
C	-1.14717900	3.52752100	-0.47896800
C	-0.97216600	4.85315000	-0.56471700
C	-1.14262700	2.52370200	2.29262400
C	-0.19773600	3.38288400	3.19708600
C	0.81330600	4.11012500	2.37270200
C	-1.35674000	0.52349300	0.72988200
O	-1.19977400	-0.05056900	-0.37508000
N	-2.23707300	-0.06449900	1.65013600
C	-2.75630800	-1.37264800	1.65174500
C	-2.27674300	-2.40873300	0.83758600
C	-2.78100900	-3.70119300	0.97040600
C	-3.77639900	-4.01646300	1.90036500
C	-4.26480400	-2.96937200	2.69484800
C	-3.76948600	-1.67467300	2.57902600
C	-4.33275400	-5.41438900	2.02654400
H	1.10740100	2.74172300	-2.51778400
H	4.14038600	4.11687200	1.22222100
H	-0.26436600	1.70483100	-0.92557000
H	-2.14070400	3.10663600	-0.61436500
H	0.02543800	5.26050000	-0.41508300
H	-1.66082800	1.87954000	3.01055700
H	-1.89970000	3.22035800	1.90674100
H	0.32901800	2.74903000	3.91417700
H	-0.79610600	4.11144500	3.74936800
H	-2.64882500	0.54468700	2.33905100
H	-1.53878200	-2.19044400	0.08444000
H	-2.39306800	-4.47318400	0.31053900
H	-5.04925600	-3.17040800	3.42168800
H	-4.17535900	-0.88455900	3.20775800
H	-4.39905400	-5.72615000	3.07593800
H	-5.33959700	-5.47575800	1.59913200
H	-3.70788800	-6.13970500	1.49638100
H	0.63815600	0.50805000	1.62720200

H	2.24607600	-0.52707400	7.25156300
O	3.67335600	3.64156600	-3.15622300
O	5.09453200	4.28388700	-1.44353900
C	4.87715400	4.35944800	-2.86271100
H	4.76043100	5.41270300	-3.15573200
H	5.71577700	3.88947900	-3.38056300
C	-2.02264700	5.84653200	-0.83591100
C	-3.39241100	5.52363000	-0.91175000
C	-1.65278000	7.19012000	-1.02099900
C	-4.34263500	6.50548700	-1.17609800
H	-3.72109600	4.50056600	-0.75174300
C	-2.60495000	8.17408900	-1.28481800
H	-0.60153600	7.46079300	-0.95352300
C	-3.95611600	7.83616900	-1.36664100
H	-5.39369700	6.23260800	-1.22862600
H	-2.29032100	9.20526600	-1.42423800
H	-4.70219400	8.59956500	-1.57056900
H	3.73961500	0.55619900	7.38318100



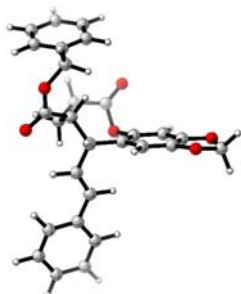
Trans-3aa major

M062X/6-311g(2d,p) EmpiricalDispersion=GD3 scrf=(pcm,solvent=Dichloromethane)

0 1			
C	-0.12575100	1.85116600	2.09331500
C	0.71255600	3.08348700	1.89798600
C	1.48205600	2.98989300	0.55775500
C	0.71224300	2.39294400	-0.66287300
O	-1.31485700	1.81113300	2.29413900
C	-0.73474700	2.88418300	-0.67609600
C	-1.26414600	-2.26001800	1.06024700
C	-1.18880900	-2.22071500	-0.32905300
C	-0.51382700	-1.22328900	-0.99605300
C	0.11182500	-0.20954600	-0.23725500
C	0.02261700	-0.28620500	1.15330300

C	-0.66432100	-1.29673600	1.84208100
O	-2.02590500	-3.33000600	1.45817000
C	-2.43182000	-3.99392500	0.25003400
O	-1.88661000	-3.27682700	-0.86208100
O	0.64845200	0.72996900	1.88193700
C	0.90428700	0.85899200	-0.98851700
C	2.39023100	0.56283800	-1.05202000
C	3.04826400	-0.38425400	-0.36972800
C	4.48940500	-0.67276500	-0.42502900
C	5.03914100	-1.54631400	0.52985000
C	6.40053900	-1.84679600	0.53663900
C	7.24611500	-1.28314500	-0.41957700
C	6.71449800	-0.42044500	-1.38317900
C	5.35515800	-0.12139800	-1.38826700
O	-1.60422400	1.92016100	-1.01778600
O	-1.05059800	4.02298900	-0.39781900
C	-3.01860500	2.22155500	-0.85152000
C	-3.74666900	0.91018100	-0.74269300
C	-3.68630200	0.18102000	0.45207700
C	-4.34187400	-1.04498400	0.55928800
C	-5.05852100	-1.55536200	-0.52673300
C	-5.11567900	-0.83732000	-1.72239100
C	-4.46062600	0.39094700	-1.82742400
H	0.04343700	3.94401900	1.91962900
H	1.43430300	3.17405400	2.71845400
H	2.38216600	2.38701100	0.69887800
H	1.80092200	4.00356500	0.29865900
H	1.16009100	2.88911500	-1.53558900
H	-0.48348300	-1.20636200	-2.07983500
H	-0.72867700	-1.28714800	2.92256300
H	-2.04194400	-5.01914100	0.25197100
H	-3.52528100	-3.98603200	0.18555800
H	0.53768500	0.78745400	-2.02183300
H	2.94156300	1.22305900	-1.72295400
H	2.48118600	-1.01128700	0.31531600
H	4.38600200	-1.98797000	1.27913600
H	6.79980700	-2.52263300	1.28838500
H	8.30727900	-1.51682800	-0.42001100
H	7.36296700	0.01581600	-2.13864700
H	4.95980800	0.53681500	-2.15667600
H	-3.12619600	2.82984200	0.05010600
H	-3.35104500	2.81235600	-1.71091200
H	-3.10628100	0.56793900	1.28457300
H	-4.27992400	-1.60817000	1.48626800

H	-5.57557200	-2.50807100	-0.44066100
H	-5.66896700	-1.23129400	-2.57064100
H	-4.50335400	0.95063000	-2.75922300



Cis-3aa minor

M062X/6-311g(2d,p) EmpiricalDispersion=GD3 scrf=(pcm,solvent=Dichloromethane)

0 1			
C	-1.21961900	0.36456800	-1.97611600
C	-1.53865700	-1.10936900	-1.96868600
C	-0.85656200	-1.78570200	-0.75925600
C	-0.93893000	-0.94294200	0.55348400
O	-1.99207200	1.28145900	-2.09093400
C	-1.37654600	-1.85455900	1.69440200
C	0.99531300	3.80720200	-0.35572200
C	1.14496200	3.47833000	0.98955200
C	0.94723000	2.19525400	1.45520600
C	0.58550000	1.19361500	0.52722100
C	0.45364500	1.55774000	-0.81811200
C	0.64107100	2.86216900	-1.29623600
O	1.21819700	5.14925900	-0.53499700
C	1.70168000	5.62679700	0.72877300
O	1.46955800	4.60608700	1.70714700
O	0.12863300	0.53877700	-1.71300200
C	0.41067700	-0.23849800	1.02217800
C	1.60671200	-1.13502100	0.79031500
C	2.72046400	-0.80712500	0.12156700
C	3.89178400	-1.66500400	-0.11287200
C	4.95957700	-1.15634000	-0.87298000
C	6.09398600	-1.92423400	-1.13317900
C	6.18699700	-3.22433100	-0.63566700
C	5.13446300	-3.74581700	0.12360800
C	4.00289600	-2.97832500	0.38245400
O	-2.47316600	-1.54085200	2.44031000

O	-0.75491100	-2.84844600	1.99636200
C	-3.36781300	-0.46909600	2.08040600
C	-4.10998600	-0.72323700	0.78621800
C	-4.36422100	0.32541600	-0.10254300
C	-5.05024600	0.09133000	-1.29559400
C	-5.48195400	-1.19765700	-1.61062700
C	-5.22266200	-2.25229600	-0.72933000
C	-4.54177700	-2.01676100	0.46459700
H	-2.62605400	-1.20891500	-1.94198400
H	-1.17763000	-1.56759100	-2.89802800
H	0.19449300	-1.96984400	-0.99033800
H	-1.31988900	-2.76330400	-0.60116500
H	1.07457600	1.96098000	2.50693400
H	0.50274600	3.09443600	-2.34409300
H	2.78050200	5.82612600	0.65463600
H	1.15301500	6.53060700	1.00816700
H	0.31099700	-0.14900100	2.11406500
H	1.48621900	-2.12440700	1.22562200
H	2.79240500	0.19081000	-0.30761800
H	4.89336100	-0.14376800	-1.26510900
H	6.90456300	-1.50601100	-1.72440500
H	7.06912300	-3.82675300	-0.83509500
H	5.19749300	-4.75718700	0.51695400
H	3.19848800	-3.40260300	0.97598100
H	-4.06039500	-0.43086200	2.92687400
H	-2.83382300	0.48836200	2.05065000
H	-3.99485900	1.32399600	0.11571500
H	-5.21375000	0.91090900	-1.98833700
H	-6.00695700	-1.38408600	-2.54353600
H	-5.54932100	-3.25944800	-0.97391200
H	-4.32730200	-2.83511700	1.14598500
H	-1.66582800	-0.14425400	0.41457600

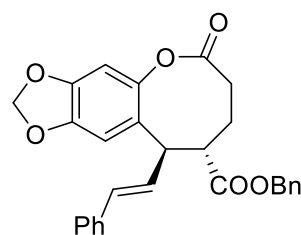
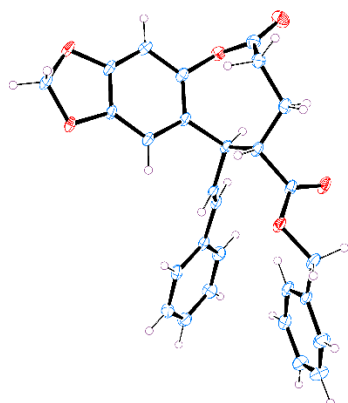
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7 X-ray Crystallographic Data

X-ray Crystallographic Data of Compound 3aa



CCDC 2247138

Bond precision: C-C = 0.0041 Å

Wavelength=1.54184

Cell: a=5.75373 (14)
alpha=90

b=13.0355 (3)
beta=90

c=30.5621 (8)
gamma=90

Temperature: 150 K

	Calculated	Reported
Volume	2292.24 (10)	2292.25 (9)
Space group	P 21 21 21	P 21 21 21
Hall group	P 2ac 2ab	P 2ac 2ab
Moiety formula	C ₂₈ H ₂₄ O ₆	C ₂₈ H ₂₄ O ₆
Sum formula	C ₂₈ H ₂₄ O ₆	C ₂₈ H ₂₄ O ₆
Mr	456.47	456.47
Dx, g cm ⁻³	1.323	1.323
Z	4	4
Mu (mm ⁻¹)	0.760	0.760
F000	960.0	960.0
F000'	963.10	
h, k, lmax	7, 16, 38	6, 15, 38
Nref	4808 [2795]	4441
Tmin, Tmax	0.886, 0.913	0.586, 1.000
Tmin'	0.886	

Correction method= # Reported T Limits: Tmin=0.586 Tmax=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.59/0.92

Theta(max)= 76.329

R(reflections)= 0.0483 (4019)

wR2(reflections)=
0.1229 (4441)

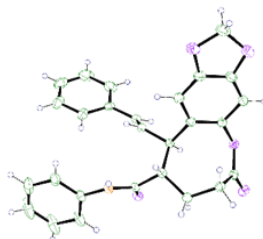
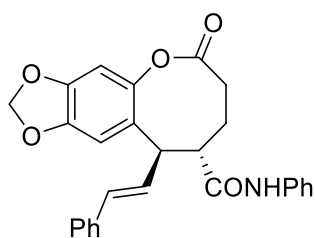
S = 1.035

Npar= 307

Displacement ellipsoids are drawn at 50% probability level.

The formation of single crystal (In a 10 mL glass bottle was added 100mg 3aa product, 2 mL petroleum ether, followed by adding about 0.5 mL ethyl acetate, ultrasound for about 2 minutes to obtain a supersaturated solution. After filtration, two drops of ethyl acetate were added to the filtrate and placed in a fume hood. About 48-72 hours, a small amount of crystals were obtained for single crystal testing).

X-ray Crystallographic Data of Compound 3na



CCDC 2170067

Bond precision: C-C = 0.0042 Å Wavelength=1.54184
Cell: a=12.8629(1) b=18.0002(2) c=19.3080(1)
alpha=90 beta=98.593(1) gamma=90
Temperature: 150 K

	Calculated	Reported
Volume	4420.29(7)	4420.29(7)
Space group	P 21	P 1 21 1
Hall group	P 2yb	P 2yb
Moiety formula	C ₂₇ H ₂₃ N O ₅	4(C ₂₇ H ₂₃ N O ₅)
Sum formula	C ₂₇ H ₂₃ N O ₅	C ₁₀₈ H ₉₂ N ₄ O ₂₀
Mr	441.46	1765.85
D _x , g cm ⁻³	1.327	1.327
Z	8	2
Mu (mm ⁻¹)	0.748	0.748
F ₀₀₀	1856.0	1856.0
F ₀₀₀ '	1861.88	
h, k, l _{max}	16, 22, 24	16, 22, 23
N _{ref}	18839[9731]	16150
T _{min} , T _{max}	0.874, 0.914	0.400, 1.000
T _{min} '	0.874	

Correction method= # Reported T Limits: T_{min}=0.400 T_{max}=1.000
AbsCorr = MULTI-SCAN

Data completeness= 1.66/0.86 Theta(max)= 77.601

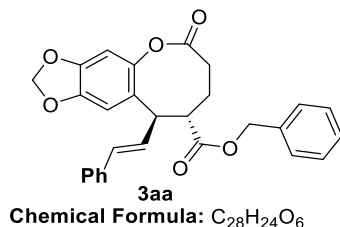
R(reflections)= 0.0379(15443) wR₂(reflections)=
0.0994(16150)
S = 1.028 N_{par}= 1190

Displacement ellipsoids are drawn at 50% probability level.

The formation of single crystal (0.5g 3na product added to 10 ml petroleum ether, followed by adding 2 ml ethyl acetate, ultrasound for about 2 minutes, to obtain a supersaturated solution, after filtration, add a few drops of ethyl acetate to the filtrate, placed in a fume hood, about 12 hours to obtain crystals for single crystal testing)

8 The characterization of data

benzyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3aa)



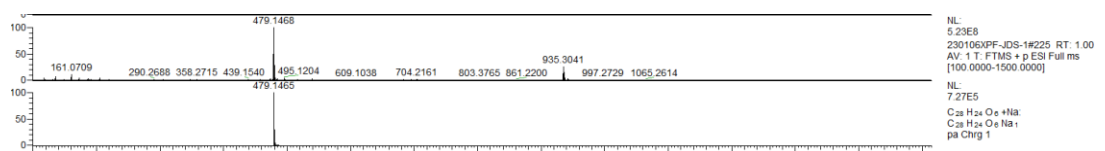
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1-5:1-4:1) as a colourless oil at room temperature, 78% yield (35mg). $[\alpha]_D^{24} = +50$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 98 % ee). **CCDC 2247138**

¹H NMR (400 MHz, Chloroform-*d*) δ 7.30 – 7.21 (m, 10H), 6.82 (s, 1H), 6.58 (s, 1H), 6.45 – 6.34 (m, 2H), 6.00 – 5.95 (m, 2H), 5.02 (s, 2H), 3.78 (t, *J* = 8.3 Hz, 1H), 2.86 (d, *J* = 12.8 Hz, 1H), 2.61 – 2.47 (m, 1H), 2.41 – 2.08 (m, 3H).

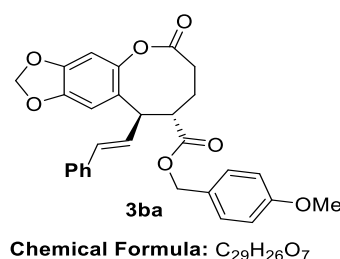
¹³C NMR (101 MHz, Chloroform-*d*) δ 173.0, 172.9, 147.4, 146.5, 144.4, 136.5, 135.2, 132.6, 128.55, 128.51, 128.50, 128.4, 127.72, 127.70, 126.4, 108.0, 102.0, 67.6, 44.9, 50.7, 28.9, 26.8.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; $t_{\text{Retention-major}} = 24.99$ min, $t_{\text{Retention-minor}} = 15.54$ min.

HRMS (ESI): $[M+Na]^+$ calcd for [C₂₈H₂₄O₆Na]:479.1465, found:479.1468.



4-methoxybenzyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate(3ba)



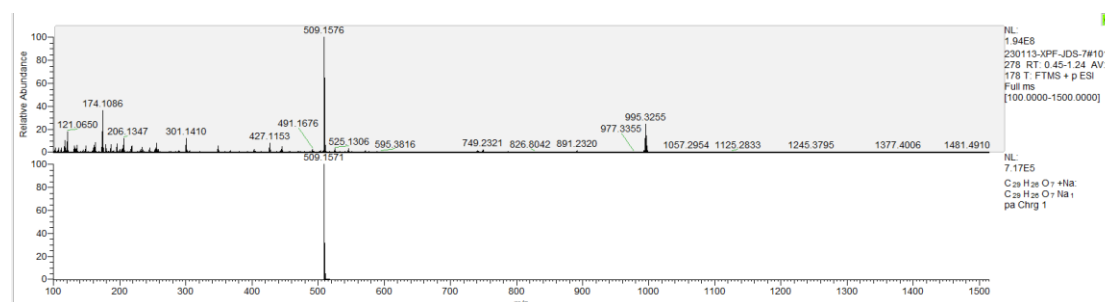
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1-5:1-4:1) as a colourless oil at room temperature, 80% yield (39mg). $[\alpha]_D^{19} = +43$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 98 % ee).

¹H NMR (400 MHz, Chloroform-*d*) δ 7.31 – 7.20 (m, 5H), 7.19 – 7.13 (m, 2H), 6.81 – 6.75 (m, 3H), 6.57 (s, 1H), 6.38 (d, *J* = 7.2 Hz, 2H), 5.98 (q, *J* = 1.3 Hz, 2H), 4.96 (d, *J* = 2.9 Hz, 2H), 3.77 (s, 4H), 2.82 (s, 1H), 2.53 (td, *J* = 8.7, 4.0 Hz, 1H), 2.35 – 2.08 (m, 3H).

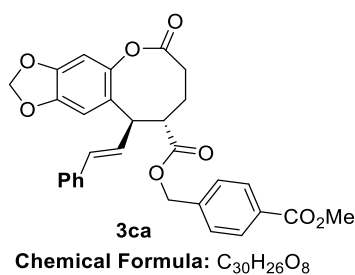
¹³C NMR (101 MHz, CDCl₃) δ 173.1, 172.9, 159.6, 147.3, 146.4, 144.3, 136.5, 132.5, 130.4, 128.5, 127.7, 127.6, 127.3, 126.6, 126.4, 113.8, 107.72, 102.3, 102.0, 66.6, 55.2, 51.1, 44.3, 28.9, 26.4.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; *t*_{Retention-major} = 33.19 min, *t*_{Retention-minor} = 20.55 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₉H₂₆O₇Na]:509.1571, found:509.1576.



4-(methoxycarbonyl)benzyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ca)



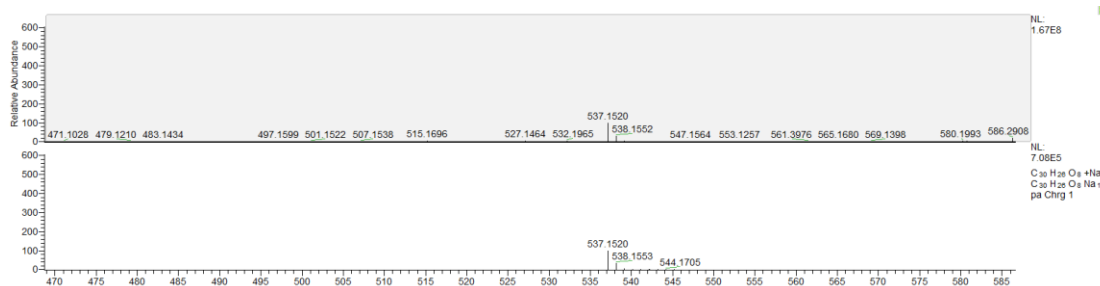
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1-5:1-4:1) as a colourless oil at room temperature, 63% yield (32mg). [α]_D¹⁹ = +56 (*c* 1.0 (10mg/mL), CH₂Cl₂, 97 % ee).

¹H NMR (600 MHz, Chloroform-*d*) δ 7.92 – 7.86 (m, 2H), 7.29 (d, *J* = 8.3 Hz, 2H), 7.27 – 7.23 (m, 2H), 7.21 (d, *J* = 7.3 Hz, 3H), 6.79 (s, 1H), 6.58 (s, 1H), 6.45 – 6.30 (m, 2H), 5.97 (q, *J* = 1.4 Hz, 2H), 5.07 (d, *J* = 3.1 Hz, 2H), 3.91 (s, 3H), 3.78 (dd, *J* = 11.0, 6.3 Hz, 1H), 2.87 (q, *J* = 8.9, 8.1 Hz, 1H), 2.55 (ddd, *J* = 12.4, 8.7, 3.5 Hz, 1H), 2.33 (ddd, *J* = 12.9, 9.8, 3.5 Hz, 1H), 2.25 (dtd, *J* = 13.6, 9.9, 3.4 Hz, 1H), 2.19 – 2.11 (m, 1H).

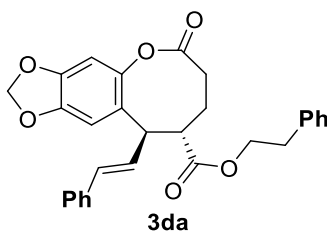
^{13}C NMR (151 MHz, CDCl_3) δ 172.9, 172.7, 166.6, 147.5, 146.5, 144.5, 140.2, 136.3, 132.7, 130.0, 129.8, 128.5, 128.2, 127.8, 127.6, 126.5, 126.3, 107.2, 102.4, 102.1, 66.1, 52.1, 50.6, 44.5, 28.9, 25.8.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; $t_{\text{Reten-major}} = 57.26$ min, $t_{\text{Reten-minor}} = 31.63$ min.

HRMS (LTQ-ORBITRAP ESI): $[\text{M}+\text{Na}]^+$ calcd for $[\text{C}_{30}\text{H}_{26}\text{O}_8\text{Na}]$:537.1520, found:537.1520.



Phenethyl (9*S*,10*R*)-6-oxo-10-((*E*)-styryl)-7,8,9,10-tetrahydro-6*H*-[1,3]dioxolo[4',5':4,5]benzo[1,2-*b*]oxocine-9-carboxylate (**3da**)



Chemical Formula: $\text{C}_{29}\text{H}_{26}\text{O}_6$

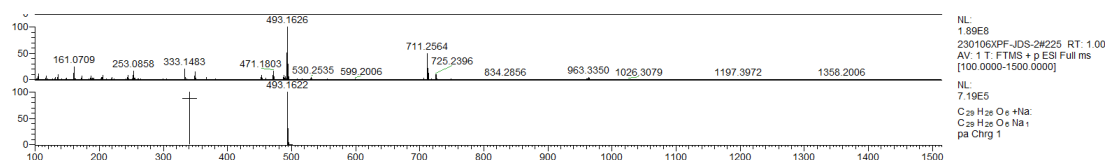
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1-5:1-4:1) as a white solid, M. P. = 139-141°C, 84% yield (39mg), $[\alpha]_{\text{D}}^{24.3} = +79$ (*c* 1.0 (10mg/mL), CH_2Cl_2 , 98 % ee).

^1H NMR (400 MHz, Chloroform-*d*) δ 7.31 – 7.19 (m, 8H), 7.13 (d, $J = 7.0$ Hz, 2H), 6.75 (s, 1H), 6.58 (s, 1H), 6.33 (d, $J = 4.0$ Hz, 2H), 5.98 (d, $J = 3.9$ Hz, 2H), 4.18 (t, $J = 6.2$ Hz, 2H), 3.79 – 3.61 (m, 1H), 2.86 (t, $J = 7.0$ Hz, 2H), 2.82 – 2.71 (m, 1H), 2.52 (td, $J = 10.3, 8.5, 2.9$ Hz, 1H), 2.34 – 2.14 (m, 2H), 2.08 (dt, $J = 14.7, 5.3$ Hz, 1H).

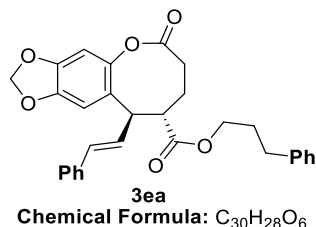
^{13}C NMR (101 MHz, CDCl_3) δ 173.0, 172.8, 147.4, 146.4, 144.4, 137.5, 136.5, 132.5, 128.9, 128.5, 128.48, 127.7, 127.6, 126.6, 126.55, 126.3, 107.9, 102.3, 102.0, 65.4, 50.4, 44.6, 34.9, 28.9, 26.4.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; $t_{\text{Reten-major}} = 22.30$ min, $t_{\text{Reten-minor}} = 14.28$ min.

HRMS (ESI): $[\text{M}+\text{Na}]^+$ calcd for $[\text{C}_{29}\text{H}_{26}\text{O}_6\text{Na}]$:493.1622, found:493.1626.



3-phenylpropyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ea)



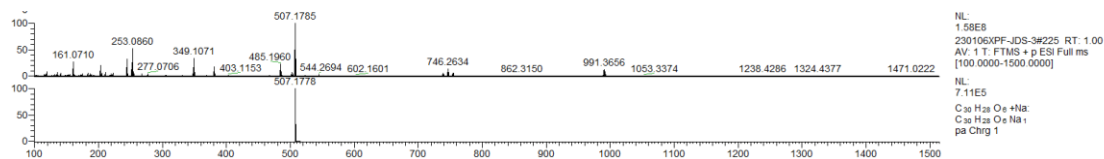
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1-5:1-4:1) as a pale-yellow oil at room temperature, 72% yield (35mg). $[\alpha]_D^{19} = +41$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 97 % ee)

¹H NMR (400 MHz, Chloroform-d) δ 7.33 – 7.13 (m, 8H), 7.08 – 7.04 (m, 2H), 6.84 (s, 1H), 6.58 (s, 1H), 6.48 – 6.36 (m, 2H), 5.96 (dd, *J* = 8.4, 1.4 Hz, 2H), 4.02 (t, *J* = 6.6 Hz, 2H), 3.77 (t, *J* = 8.5 Hz, 1H), 2.79 (dt, *J* = 9.4, 3.9 Hz, 1H), 2.62 – 2.50 (m, 3H), 2.37 – 2.08 (m, 3H), 1.92 – 1.82 (m, 2H).

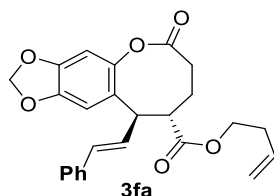
¹³C NMR (101 MHz, Chloroform-d) δ 173.1, 172.8, 147.3, 146.4, 144.4, 140.8, 136.4, 132.4, 128.5, 128.3, 128.2, 127.8, 127.7, 126.6, 126.3, 125.9, 107.9, 102.3, 102.0, 64.3, 50.7, 32.0, 29.9, 28.9, 26.5.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; *t*_{Retention-major} = 24.30 min, *t*_{Retention-minor} = 15.35 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₃₀H₂₈O₆Na]: 507.1778, found: 507.1785.



but-3-en-1-yl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate(3fa)



Chemical Formula: C₂₅H₂₄O₆

The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1-5:1) as a colorless oil at room temperature, 77% yield (32mg).

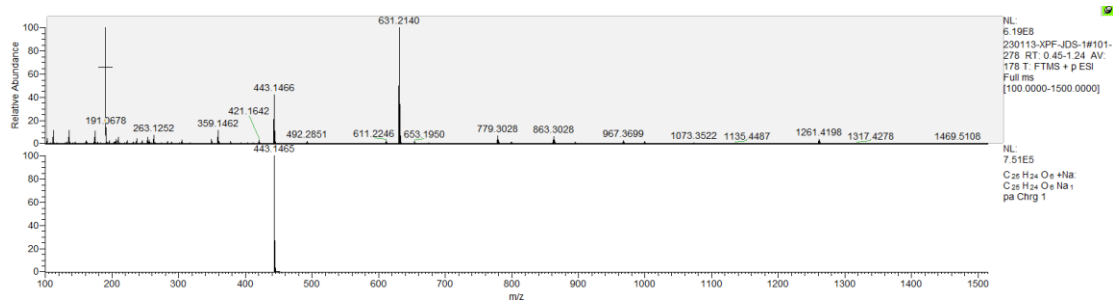
$[\alpha]_D^{24} = +93$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 98 % ee)

¹H NMR (400 MHz, Chloroform-*d*) δ 7.35 – 7.26 (m, 4H), 7.25 – 7.19 (m, 1H), 6.85 (s, 1H), 6.59 (s, 1H), 6.48 – 6.34 (m, 2H), 6.01 – 5.97 (m, 2H), 5.68 (ddt, *J* = 17.0, 10.3, 6.7 Hz, 1H), 5.08 – 4.99 (m, 2H), 4.05 (t, *J* = 6.7 Hz, 2H), 3.82 – 3.70 (m, 1H), 2.80 (s, 1H), 2.55 (ddd, *J* = 12.2, 8.6, 3.3 Hz, 1H), 2.38 – 2.27 (m, 3H), 2.25 – 2.07 (m, 2H).

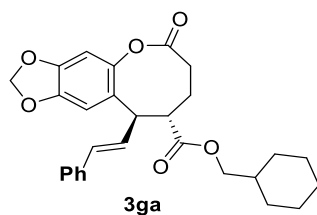
¹³C NMR (101 MHz, Chloroform-*d*) δ 173.1, 172.9, 147.4, 146.4, 144.4, 136.5, 133.7, 132.5, 128.5, 127.8, 127.7, 126.6, 126.3, 117.3, 107.9, 102.4, 102.0, 63.9, 50.8, 44.5, 32.9, 28.9, 26.5.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 254 nm; *t*_{Retention-major} = min, *t*_{Retention-minor} = 11.74 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₅H₂₄O₆Na]: 443.1465, found:443.1466.



cyclohexylmethyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ga)



Chemical Formula: C₂₈H₃₀O₆

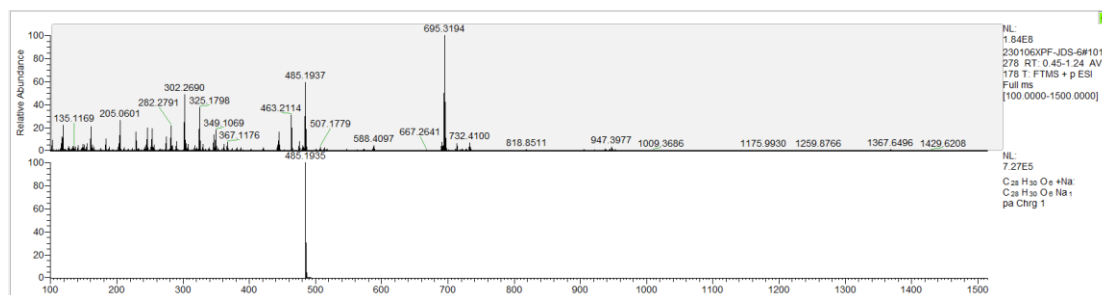
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 69% yield (34mg). $[\alpha]_D^{19} = +74$ (c 1.0 (10mg/mL), CH₂Cl₂, 95 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.34 – 7.26 (m, 1H), 7.24 – 7.19 (m, 1H), 6.85 (s, 1H), 6.59 (s, 1H), 6.47 – 6.36 (m, 1H), 6.01 – 5.98 (m, 2H), 3.84 – 3.73 (m, 3H), 2.81 (s, 1H), 2.56 (ddd, $J = 12.2, 8.5, 3.4$ Hz, 1H), 2.33 (ddd, $J = 12.6, 9.6, 3.5$ Hz, 1H), 2.27 – 2.10 (m, 2H), 1.68 – 1.50 (m, 7H), 1.19 – 1.06 (m, 3H), 0.92 – 0.80 (m, 2H).

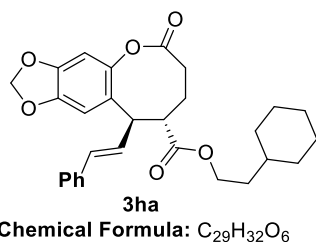
¹³C NMR (101 MHz, CDCl₃) δ 173.3, 173.0, 147.3, 146.4, 144.4, 136.5, 132.5, 128.5, 127.8, 127.7, 126.7, 126.3, 108.2, 102.3, 102.0, 70.2, 49.5, 44.3, 36.8, 29.64, 29.59, 28.9, 27.4, 26.2, 25.5.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; $t_{\text{Retention-major}} = 17.45$ min, $t_{\text{Retention-minor}} = 11.93$ min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₈H₃₀O₆Na]: 485.1935, found: 485.1937.



2-cyclohexylethyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ha)



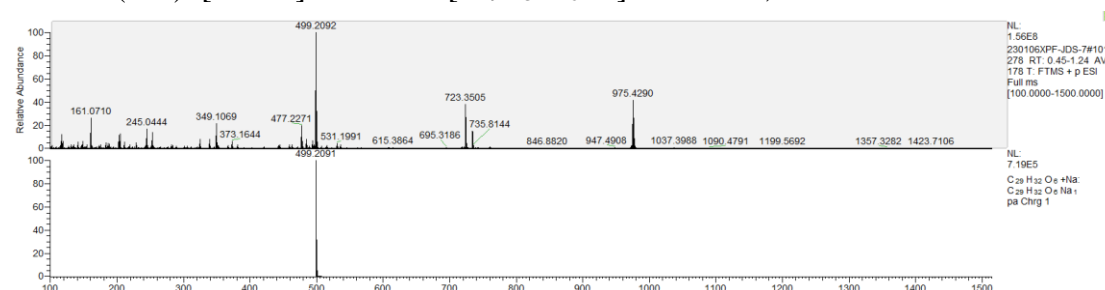
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1-5:1) as a white solid, at room temperature, M. P. = 126-128 °C, 74% yield (35mg). $[\alpha]_D^{19} = +63$ (c 1.0 (10mg/mL), CH₂Cl₂, 96 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.39 – 7.25 (m, 4H), 7.21 (t, $J = 7.0$ Hz, 1H), 6.85 (s, 1H), 6.59 (s, 1H), 6.41 (d, $J = 9.4$ Hz, 2H), 5.99 (d, $J = 3.3$ Hz, 2H), 4.03 (t, $J = 7.0$ Hz, 2H), 3.78 (d, $J = 8.2$ Hz, 1H), 2.80 (s, 1H), 2.61 – 2.49 (m, 1H), 2.41 – 2.07 (m, 3H), 1.59 (d, $J = 15.5$ Hz, 5H), 1.41 (d, $J = 7.0$ Hz, 2H), 1.25 (s, 1H), 1.14 (t, $J = 13.9$ Hz, 3H), 0.90 – 0.74 (m, 2H).

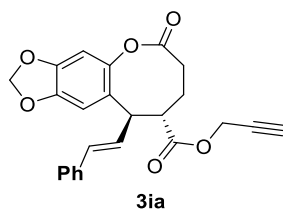
¹³C NMR (101 MHz, CDCl₃) δ 173.2, 172.9, 147.3, 146.4, 144.4, 136.5, 132.5, 128.5, 127.8, 127.7, 126.7, 126.3, 107.9, 102.3, 102.0, 63.3, 51.3, 44.9, 35.9, 34.4, 32.95, 32.91, 29.6, 28.9, 26.8, 26.3, 26.03, 26.00.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 290 nm; $t_{\text{Retention-major}} = 16.15$ min, $t_{\text{Retention-minor}} = 10.71$ min.

HRMS (ESI): $[M+Na]^+$ calcd for [C₂₉H₃₂O₆Na]: 499.2091, found:499.2092.



prop-2-yn-1-yl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ia)



3ia
Chemical Formula: C₂₄H₂₀O₆

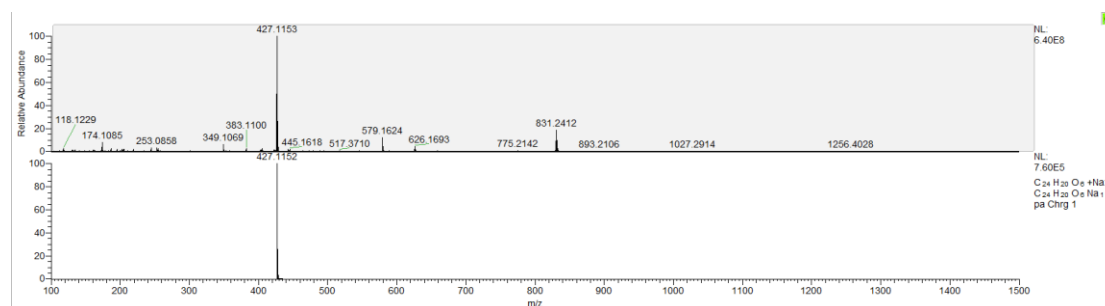
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 80% yield (34mg). $[\alpha]_D^{19} = +39$ (c 1.0 (10mg/mL), CH₂Cl₂, 99 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.36 – 7.26 (m, 4H), 7.21 (t, *J* = 7.1 Hz, 1H), 6.88 (s, 1H), 6.59 (s, 1H), 6.51 – 6.38 (m, 2H), 5.99 (d, *J* = 3.8 Hz, 2H), 4.61 (t, *J* = 2.9 Hz, 2H), 3.80 (t, *J* = 8.6 Hz, 1H), 2.86 (t, *J* = 8.1 Hz, 1H), 2.56 (dd, *J* = 11.0, 7.7 Hz, 1H), 2.39 – 2.20 (m, 3H), 2.16 (q, *J* = 5.6 Hz, 1H).

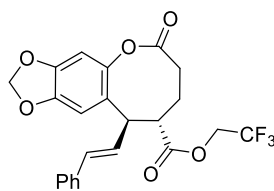
¹³C NMR (101 MHz, CDCl₃) δ 172.8, 172.3, 147.5, 146.5, 144.4, 136.5, 132.9, 128.5, 127.7, 127.3, 126.5, 126.3, 107.8, 102.4, 102.1, 77.2, 75.3, 52.2, 50.3, 45.0, 28.7, 27.3.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; *t*_{Retention-major} = 24.22 min, *t*_{Retention-minor} = 15.03 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₄H₂₀O₆Na]: 427.1152, found:427.1153.



2,2,2-trifluoroethyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ja)



3ja
Chemical Formula: C₂₃H₁₉F₃O₆

The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 80% yield (36mg). $[\alpha]_D^{19} = +36$ (c 1.0 (10mg/mL), CH₂Cl₂, 95 % ee).

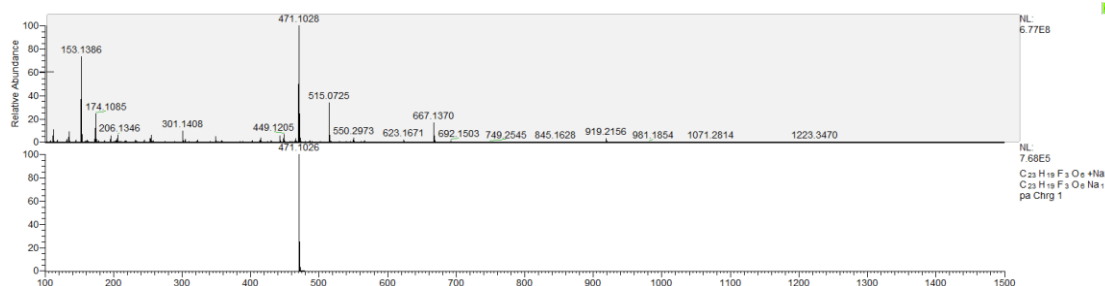
¹H NMR (400 MHz, Chloroform-*d*) δ 7.35 – 7.27 (m, 4H), 7.26 – 7.21 (m, 1H), 6.86 (s, 1H), 6.61 (s, 1H), 6.51 – 6.36 (m, 2H), 6.03 – 5.99 (m, 2H), 4.36 (qq, *J* = 8.3, 4.3

Hz, 2H), 3.79 (t, $J = 9.0$ Hz, 1H), 2.92 (s, 1H), 2.57 (ddd, $J = 12.0, 8.4, 3.2$ Hz, 1H), 2.42 – 2.29 (m, 1H), 2.29 – 2.13 (m, 2H).

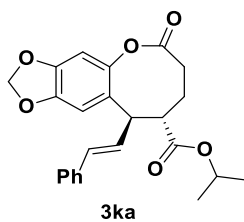
^{13}C NMR (101 MHz, Chloroform- d) δ 172.5, 171.6, 147.6, 146.6, 144.5, 136.2, 133.1, 128.6, 127.9, 126.9, 126.4, 126.1, 124.1, 121.4, 107.7, 102.5, 102.1, 60.7 (q, $J_{\text{C-F}} = 36.2$ Hz), 50.3, 44.6, 28.8, 26.7.

HPLC: Chiral Ia-3 column, (n -hexane/ i -PrOH = 80:20), flow rate 1 mL/min, $I = 250$ nm; $t_{\text{Retention-major}} = 16.34$ min, $t_{\text{Retention-minor}} = 9.45$ min.

HRMS (ESI): $[\text{M}+\text{Na}]^+$ calcd for $[\text{C}_{23}\text{H}_{19}\text{F}_3\text{O}_6\text{Na}]$: 471.1026, found: 471.1028.



isopropyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ka)



Chemical Formula: $\text{C}_{24}\text{H}_{24}\text{O}_6$

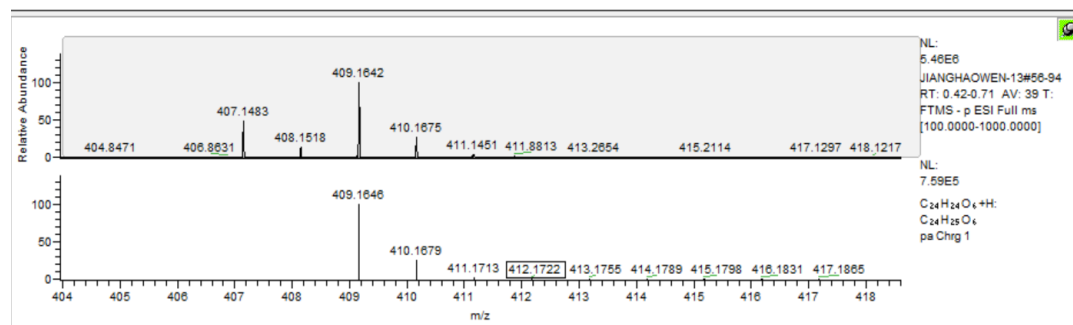
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 82% yield (34mg). $[\alpha]_{\text{D}}^{19} = +75$ (c 1.0 (10mg/mL), CH_2Cl_2 , 98 % ee).

^1H NMR (400 MHz, Chloroform- d) δ 7.34 – 7.25 (m, 4H), 7.21 (t, $J = 6.9$ Hz, 1H), 6.86 (s, 1H), 6.59 (s, 1H), 6.42 (d, $J = 8.0$ Hz, 2H), 5.99 (d, $J = 3.5$ Hz, 2H), 4.92 (hept, $J = 6.3$ Hz, 1H), 3.75 (t, $J = 8.4$ Hz, 1H), 2.74 (q, $J = 7.3$ Hz, 1H), 2.54 (ddd, $J = 12.1, 8.3, 3.3$ Hz, 1H), 2.32 (td, $J = 12.6, 11.1, 3.4$ Hz, 1H), 2.26 – 2.08 (m, 2H), 1.15 (d, $J = 6.2$ Hz, 3H), 1.12 (d, $J = 6.3$ Hz, 3H).

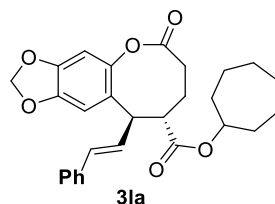
^{13}C NMR (101 MHz, CDCl_3) δ 173.0, 172.7, 147.3, 146.4, 144.3, 136.5, 132.5, 128.5, 127.9, 127.6, 126.9, 126.3, 107.9, 102.3, 102.0, 68.4, 50.8, 43.9, 29.0, 27.0, 21.8, 21.7.

HPLC: Chiral Ia-3 column, (n -hexane/ i -PrOH = 80:20), flow rate 1 mL/min, $I = 250$ nm; $t_{\text{Retention-major}} = 18.08$ min, $t_{\text{Retention-minor}} = 10.86$ min.

HRMS (ESI): [M+H]⁺ calcd for [C₂₄H₂₅O₆]: 409.1646, found: 409.1642.



cycloheptyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3la)



Chemical Formula: C₂₈H₃₀O₆

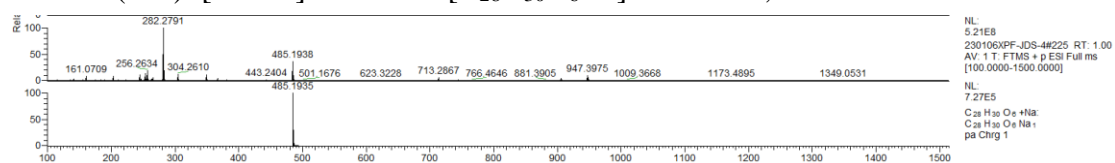
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a white solid at room temperature, M. P. = 118-119 °C, 73% yield (36.5mg) [α]_D¹⁹ = +42 (*c* 1.0 (10mg/mL), CH₂Cl₂, 97 % ee).

¹H NMR (400 MHz, Chloroform-*d*) δ 7.34 – 7.25 (m, 4H), 7.24 – 7.18 (m, 1H), 6.86 (s, 1H), 6.59 (s, 1H), 6.48 – 6.34 (m, 2H), 6.02 – 5.95 (m, 2H), 4.85 (tt, *J* = 8.3, 4.6 Hz, 1H), 3.76 (t, *J* = 8.7 Hz, 1H), 2.75 (s, 1H), 2.54 (ddd, *J* = 12.3, 8.5, 3.5 Hz, 1H), 2.32 (ddd, *J* = 12.7, 9.5, 3.6 Hz, 1H), 2.26 – 2.06 (m, 2H), 1.76 (qd, *J* = 9.2, 7.2, 3.5 Hz, 2H), 1.62 – 1.43 (m, 8H), 1.35 – 1.25 (m, 2H).

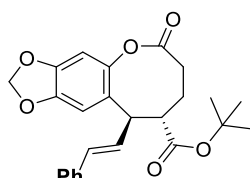
¹³C NMR (101 MHz, Chloroform-*d*) δ 173.0, 172.5, 147.3, 146.4, 144.3, 136.5, 132.5, 128.5, 127.9, 127.7, 127.0, 126.3, 107.8, 102.3, 102.0, 75.9, 50.9, 44.0, 33.8, 33.6, 29.0, 28.22, 28.21, 27.0, 22.69, 22.67.

HPLC: Chiral Ia-3 column, (n-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 254 nm; *t*_{Retention-major} = 18.31 min, *t*_{Retention-minor} = 13.95 min.

HRMS (ESI): $[M+Na]^+$ calcd for $[C_{28}H_{30}O_6Na]$: 485.1935, found:485.1938.



tert-butyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ma)



3ma
Chemical Formula: $C_{25}H_{26}O_6$

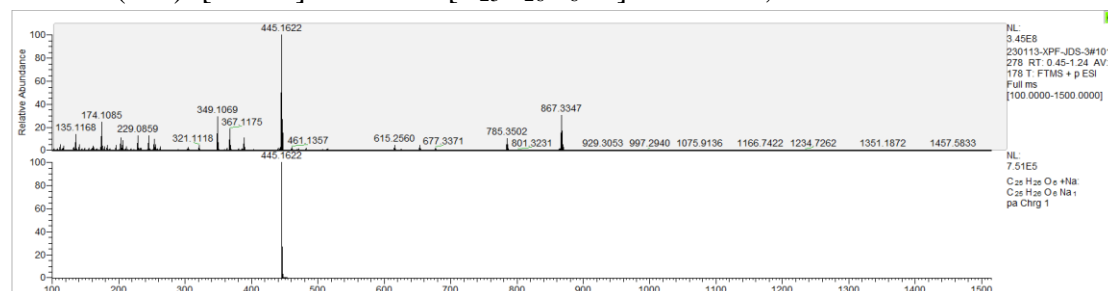
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 81% yield (34mg). $[\alpha]_D^{19} = +90$ (*c* 1.0 (10mg/mL), CH_2Cl_2 , 98 % ee).

1H NMR (400 MHz, Chloroform- d) δ 7.29 (dd, $J = 13.9, 6.7$ Hz, 4H), 7.25 – 7.17 (m, 1H), 6.85 (s, 1H), 6.58 (s, 1H), 6.43 (d, $J = 6.0$ Hz, 2H), 5.98 (d, $J = 3.9$ Hz, 2H), 3.73 (t, $J = 8.3$ Hz, 1H), 2.66 (d, $J = 8.5$ Hz, 1H), 2.53 (dd, $J = 20.2, 4.7$ Hz, 1H), 2.31 (ddd, $J = 13.0, 8.1, 4.9$ Hz, 1H), 2.14 (dq, $J = 10.3, 6.1, 5.6$ Hz, 2H), 1.35 (s, 9H).

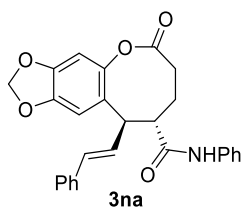
^{13}C NMR (101 MHz, $CDCl_3$) δ 173.0, 172.4, 147.2, 146.4, 144.3, 136.5, 132.3, 128.5, 128.3, 127.6, 127.1, 126.3, 108.0, 102.3, 102.0, 81.3, 51.6, 43.7, 29.0, 28.0, 26.7.

HPLC: Chiral Ia-3 column, (n-hexane/i-PrOH = 80:20), flow rate 1 mL/min, $I = 250$ nm; $t_{Reten-major} = 12.46$ min, $t_{Reten-minor} = 7.96$ min.

HRMS (ESI): $[M+Na]^+$ calcd for $[C_{25}H_{26}O_6Na]$: 445.1622, found:445.1622



(9S,10R)-6-oxo-N-phenyl-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxamide (3na)



Chemical Formula: C₂₇H₂₃NO₅

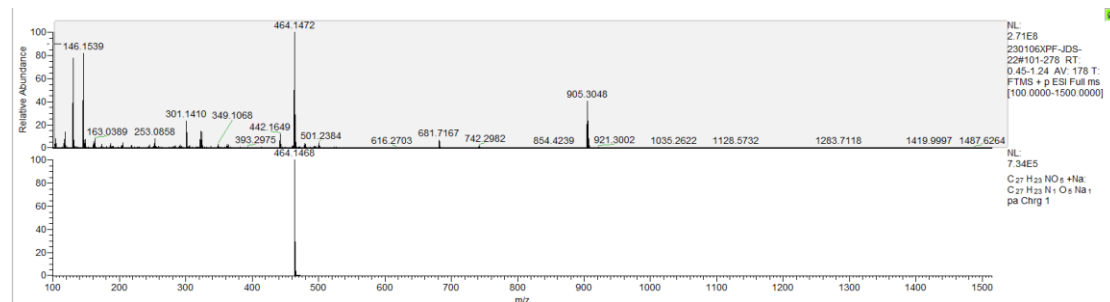
3na was obtained on a scale-up reaction: In a 50 ml round-bottomed flasks were successively added Cat-1 (0.01 mmol), cyclobutanone carbonamide 1n (3.9 mmol, 0.73g), ortho-quinone methides 2a (3 mmol, 0.75g), then 30 mL dry DCM added by syringe and the reaction mixture was stirred at 20 °C for approximately 48 h and monitored by thin layer chromatography, when TLC analysis showed ortho-quinone methides 2 was mainly consumed, the solvent was evaporated under reduced pressure and the residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 2:1 to 1:1) to give the enantioenriched 8-membered lactone 3na as yellow solid. M. P. = 130-133 °C, 82% yield (1.12 g). $[\alpha]_D^{23} = +54$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 92 % ee). **Attention:** This compound was not stable on silica gel column chromatography, so the quickly column chromatography is necessary. Moreover, the solubility of this compound in CDCl₃ was poor, the CD₂Cl₂ was used for NMR testing.

¹H NMR (600 MHz, Methylene Chloride-*d*₂) δ 7.76 (s, 1H), 7.45 (d, *J* = 7.9 Hz, 2H), 7.31 – 7.18 (m, 6H), 7.08 (t, *J* = 7.4 Hz, 1H), 6.87 (s, 1H), 6.60 (d, *J* = 32.7 Hz, 1H), 6.43 (d, *J* = 15.2 Hz, 2H), 5.99 (s, 2H), 3.92 (s, 1H), 2.79 (s, 1H), 2.59 (dt, *J* = 13.4, 7.5 Hz, 1H), 2.46 – 2.32 (m, 1H), 2.15 (p, *J* = 11.4, 8.7 Hz, 2H).

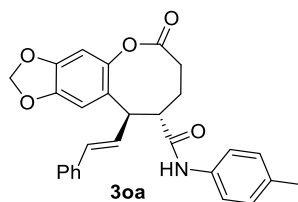
¹³C NMR (101 MHz, Methylene Chloride-*d*₂) δ 173.4, 171.9, 148.0, 146.8, 145.2, 138.1, 137.1, 132.4, 129.2, 128.8, 127.9, 127.4, 126.6, 124.8, 120.7, 108.9, 103.0, 102.7, 29.9, 27.3.

HPLC: Chiral OD-H column, (*n*-hexane/*i*-PrOH = 80:20), I = 250 nm, *t*_{Retention-major} = 19.21 min, *t*_{Retention-minor} = 13.36 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₇H₂₃NO₅Na]: 464.1468, found: 464.1472.



(9S,10R)-6-oxo-10-((E)-styryl)-N-(p-tolyl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxamide (30a)



Chemical Formula: $C_{28}H_{25}NO_5$

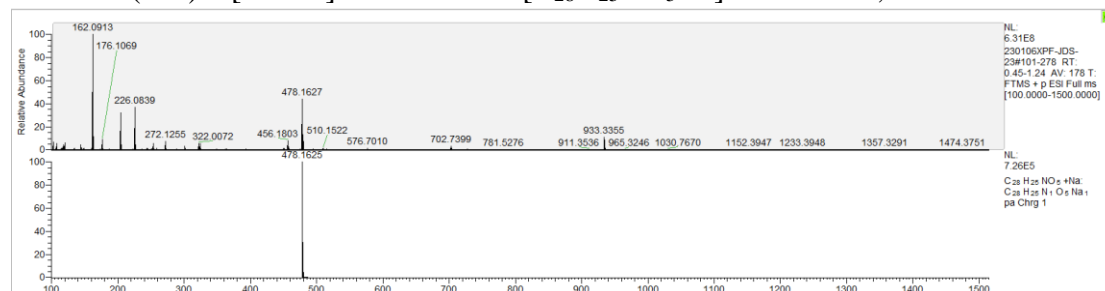
30a was synthesized according to the general procedure the synthesis of 8-membered lactone but the reaction time was prolonged to hours. 30a was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 3:1 to 2:1 to 1:1) as a yellow solid at room temperature, M. P. = 205-208 °C, 77% yield (36mg). $[\alpha]_D^{23} = +53$ (*c* 1.0 (10mg/mL), CH_2Cl_2 , 94 % ee). **Attention:** This compound was not stable on silica gel column chromatography, so the quickly column chromatography is necessary. Moreover, the solubility of this compound in $CDCl_3$ was poor, the CD_2Cl_2 was used for NMR testing.

1H NMR (400 MHz, Methylene Chloride- d_2) δ 7.49 (s, 1H), 7.34 – 7.27 (m, 2H), 7.28 – 7.19 (m, 4H), 7.19 – 7.14 (m, 1H), 7.07 (d, $J = 8.1$ Hz, 2H), 6.86 (s, 1H), 6.59 (s, 1H), 6.47 – 6.33 (m, 2H), 6.00 (s, 2H), 3.90 (t, $J = 7.9$ Hz, 1H), 2.72 (s, 1H), 2.59 (dt, $J = 13.5, 7.4$ Hz, 1H), 2.38 (dt, $J = 12.9, 6.3$ Hz, 1H), 2.27 (s, 3H), 2.20 – 2.06 (m, 2H).

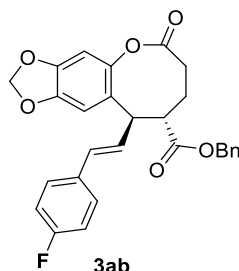
^{13}C NMR (101 MHz, Methylene Chloride- d_2) δ 173.4, 171.8, 147.9, 146.8, 145.2, 137.1, 135.4, 134.7, 132.3, 129.7, 128.8, 127.9, 127.5, 126.7, 120.8, 108.8, 103.0, 102.7, 30.1, 27.3, 20.9.

HPLC: Chiral OD-H column, (*n*-hexane/*i*-PrOH = 80:20) , $I = 250$ nm, flow rate 1 mL/min; $t_{Reten-major} = 28.85$ min, $t_{Reten-minor} = 39.22$ min.

HRMS (ESI): $[M+Na]^+$ calcd for $[C_{28}H_{25}NO_5Na]$: 478.1625, found:478.1627.



benzyl (9S,10R)-10-((E)-4-fluorostyryl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ab)



Chemical Formula: C₂₈H₂₃FO₆

The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 77% yield (34mg).

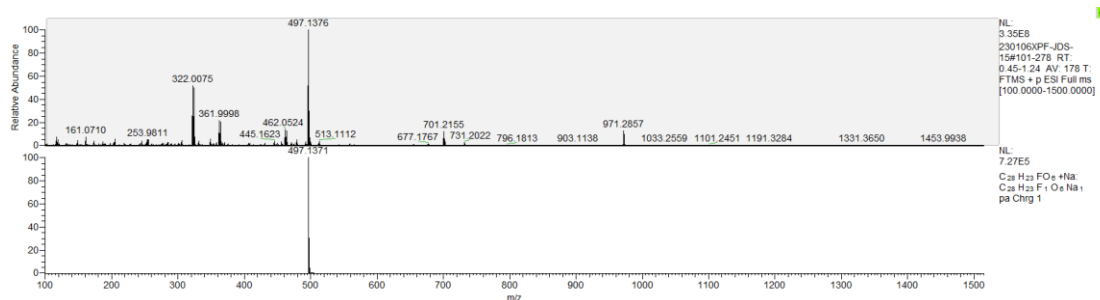
$[\alpha]_D^{19} = +47$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 96 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.32 – 7.14 (m, 7H), 6.96 (t, *J* = 8.7 Hz, 2H), 6.80 (s, 1H), 6.58 (s, 1H), 6.39 – 6.24 (m, 2H), 5.99 (d, *J* = 1.8 Hz, 2H), 5.02 (d, *J* = 2.6 Hz, 2H), 3.77 (t, *J* = 8.7 Hz, 1H), 2.85 (s, 1H), 2.55 (ddd, *J* = 11.8, 8.4, 3.0 Hz, 1H), 2.38 – 2.11 (m, 3H).

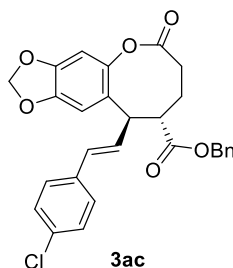
¹³C NMR (101 MHz, CDCl₃) δ 173.0, 172.8, 162.2 (d, *J*_{C-F} = 247.4 Hz), 147.4 (d, *J*_{C-F} = 3.0 Hz), 144.4, 135.2, 132.6 (d, *J*_{C-F} = 3 Hz), 131.4, 128.6, 128.5, 128.4, 127.9 (d, *J*_{C-F} = 8.1 Hz), 127.4, 126.4, 115.5, 115.3, 107.8, 102.4, 102.1, 66.8, 50.8, 43.9, 28.8, 26.2.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, $\lambda = 250$ nm; $t_{\text{Retention-major}} = 26.87$ min, $t_{\text{Retention-minor}} = 18.77$ min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₈H₂₃O₆FN]_a: 497.1371, found:497.1376.



benzyl (9S,10R)-10-((E)-4-chlorostyryl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate(3ac)



Chemical Formula: C₂₈H₂₃ClO₆

The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 79% yield (39mg).

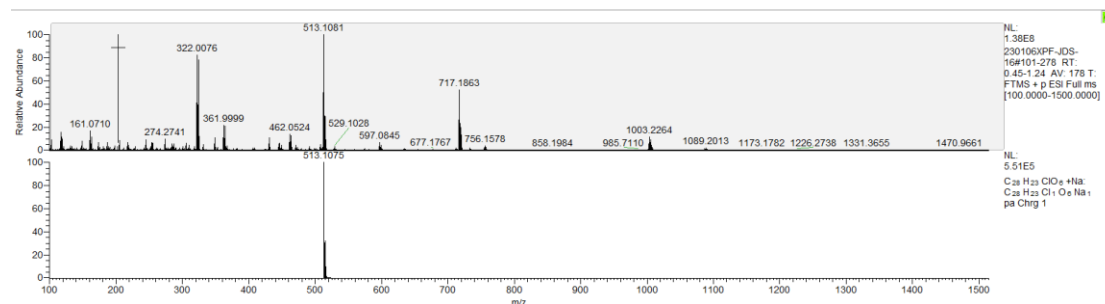
$[\alpha]_D^{19} = +28$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 96 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.31 – 7.20 (m, 7H), 7.15 (d, *J* = 8.3 Hz, 2H), 6.79 (s, 1H), 6.58 (s, 1H), 6.34 (d, *J* = 4.0 Hz, 2H), 5.99 (d, *J* = 1.6 Hz, 2H), 5.02 (d, *J* = 2.4 Hz, 2H), 3.77 (s, 1H), 2.80 (s, 1H), 2.55 (t, *J* = 9.1 Hz, 1H), 2.37 – 2.11 (m, 3H).

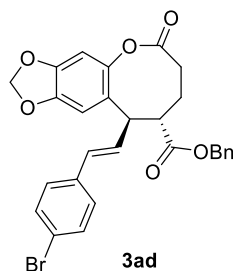
¹³C NMR (101 MHz, CDCl₃) δ 172.9, 172.8, 147.5, 146.5, 144.4, 135.1, 134.9, 133.3, 131.3, 128.6, 128.5, 128.48, 127.6, 126.2, 107.0, 102.4, 102.1, 66.9, 51.1, 43.8, 28.8, 26.7.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; *t*_{Retention-major} = 28.16 min, *t*_{Retention-minor} = 20.54 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₈H₂₃O₆ClNa]: 513.1075, found: 513.1081.



benzyl (9S,10R)-10-((E)-4-bromostyryl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ad)



Chemical Formula: C₂₈H₂₃BrO₆

The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 78% yield (41mg).

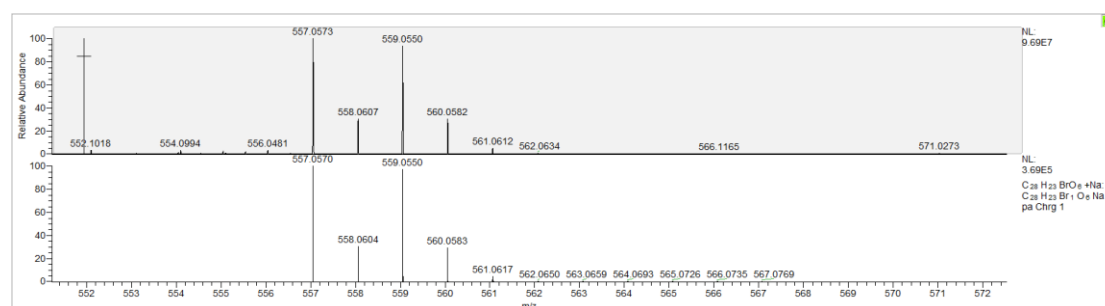
$[\alpha]_D^{19} = +35$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 97 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.38 (d, *J* = 8.1 Hz, 2H), 7.33 – 7.20 (m, 5H), 7.09 (d, *J* = 6.7 Hz, 2H), 6.79 (s, 1H), 6.58 (s, 1H), 6.34 (d, *J* = 6.9 Hz, 2H), 5.99 (s, 2H), 5.02 (s, 2H), 3.78 (d, *J* = 8.5 Hz, 1H), 2.85 (s, 1H), 2.55 (ddd, *J* = 12.0, 8.4, 3.1 Hz, 1H), 2.40 – 2.11 (m, 3H).

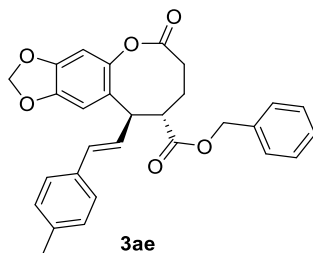
¹³C NMR (101 MHz, CDCl₃) δ 172.9, 172.8, 147.5, 146.5, 144.4, 135.4, 135.1, 131.6, 131.4, 128.6, 128.5, 128.4, 127.9, 126.2, 121.5, 107.0, 102.4, 102.1, 68.0, 50.0, 44.4, 30.2, 26.1.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; *t*_{Retention-major} = 31.39 min, *t*_{Retention-minor} = 22.57 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₈H₂₃O₆BrNa]: 557.0570, 559.0550, found: 557.0573, 559.0550.



benzyl (9S,10R)-10-((E)-4-methylstyryl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ae)



Chemical Formula: C₂₉H₂₆O₆

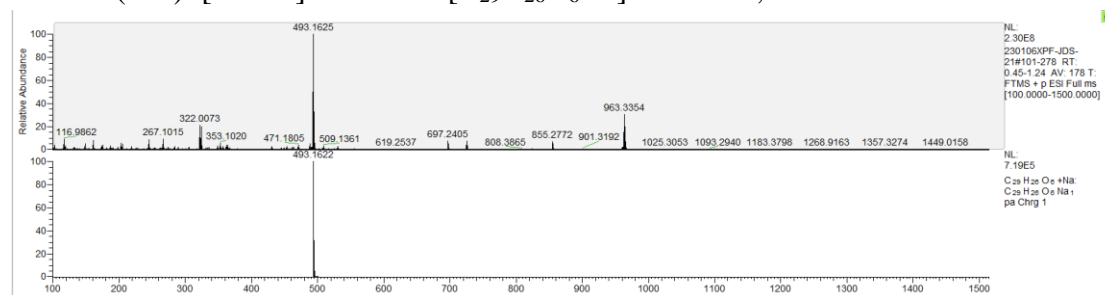
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a yellow solid at room temperature, M. P. = 52-53°C, 81% yield (38mg). $[\alpha]_D^{19} = +37$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 98 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.29 (dd, *J* = 5.1, 2.2 Hz, 3H), 7.26 – 7.22 (m, 2H), 7.17 (d, *J* = 8.2 Hz, 2H), 7.09 (d, *J* = 7.9 Hz, 2H), 6.82 (s, 1H), 6.57 (s, 1H), 6.41 – 6.30 (m, 2H), 6.01 – 5.95 (m, 2H), 5.01 (s, 2H), 3.76 (t, *J* = 8.2 Hz, 1H), 2.82 (d, *J* = 10.5 Hz, 1H), 2.54 (dd, *J* = 10.7, 7.4 Hz, 1H), 2.33 (s, 3H), 2.26 (dd, *J* = 24.0, 2.7 Hz, 2H), 2.18 – 2.11 (m, 1H).

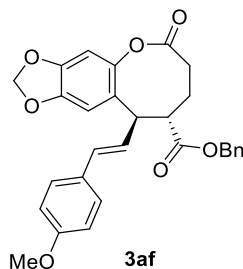
¹³C NMR (101 MHz, CDCl₃) δ 173.0, 172.9, 147.3, 146.4, 144.3, 137.6, 135.2, 133.7, 132.5, 129.2, 128.53, 128.48, 128.4, 128.3, 126.6, 126.3, 107.9, 102.3, 102.0, 66.8, 50.4, 43.7, 28.8, 26.8, 21.2.

HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; *t*_{Retention-major} = 24.65 min, *t*_{Retention-minor} = 17.37 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₉H₂₆O₆Na]:493.1622, found: 493.1625.



benzyl (9S,10R)-10-((E)-4-methoxystyryl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3af)



Chemical Formula: C₂₉H₂₆O₇

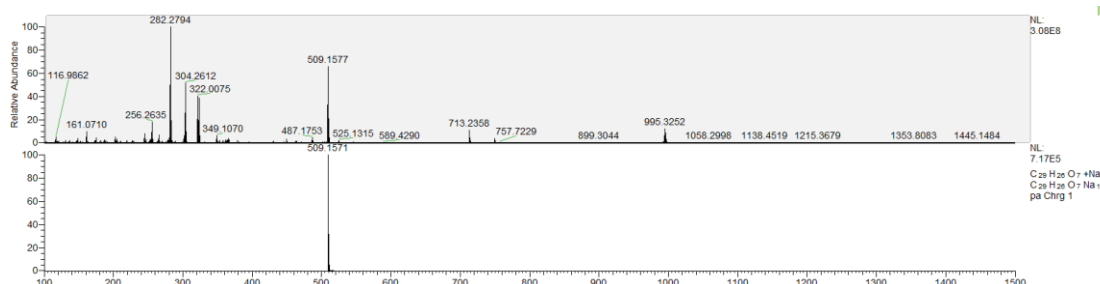
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a white solid at room temperature, M. P. = 37-38°C, 76% yield (40mg). $[\alpha]_D^{19} = 35$ (c 1.0 (10mg/mL), CH₂Cl₂, 98 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.31 – 7.18 (m, 7H), 6.84 – 6.79 (m, 3H), 6.58 (s, 1H), 6.38 – 6.21 (m, 2H), 5.98 (q, *J* = 1.4 Hz, 2H), 5.01 (s, 2H), 3.80 (s, 3H), 3.78 – 3.71 (m, 1H), 2.83 (s, 1H), 2.54 (dd, *J* = 10.9, 7.5 Hz, 1H), 2.35 – 2.11 (m, 3H).

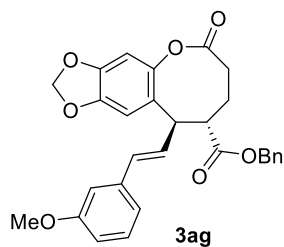
¹³C NMR (101 MHz, CDCl₃) δ 173.1, 172.9, 159.3, 147.3, 146.4, 144.3, 135.2, 132.0, 129.2, 128.6, 128.5, 128.3, 127.6, 126.8, 125.4, 113.9, 107.9, 102.3, 102.0, 66.8, 55.3, 52.0, 44.5, 28.9, 26.6.

HPLC: Chiral Ia-3 column, (n-hexane/i-PrOH = 80:20), flow rate 1 mL/min, I = 290 nm; *t*_{Retention-major} = 37.23 min, *t*_{Retention-minor} = 24.78 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₉H₂₆O₇Na]:509.1571, found: 509.1577.



benzyl (9S,10R)-10-((E)-3-methoxystyryl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ag)



Chemical Formula: C₂₉H₂₆O₇

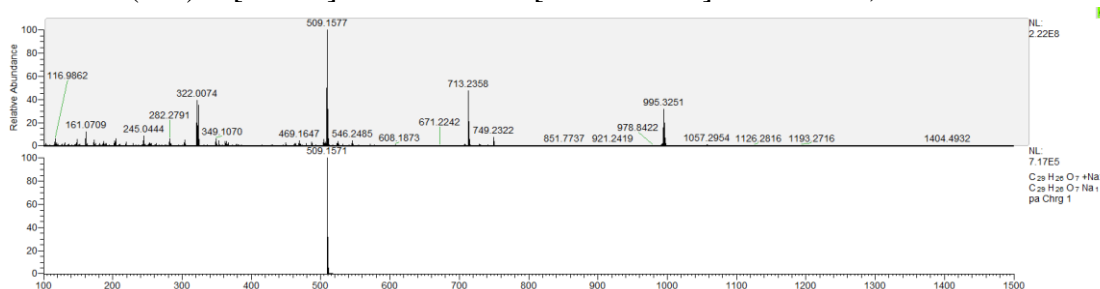
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a yellow solid at room temperature, M. P. = 36-38°C, 80% yield (39.8mg). $[\alpha]_D^{19} = +46$ (c 1.0 (10mg/mL), CH₂Cl₂, 97 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.30 – 7.17 (m, 6H), 6.87 (d, $J = 6.5$ Hz, 1H), 6.84 – 6.76 (m, 3H), 6.58 (s, 1H), 6.42 – 6.33 (m, 2H), 5.98 (q, $J = 1.4$ Hz, 2H), 5.02 (s, 2H), 3.79 (s, 4H), 2.85 (s, 1H), 2.54 (ddd, $J = 11.6, 8.4, 2.9$ Hz, 1H), 2.38 – 2.08 (m, 3H).

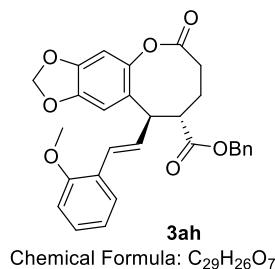
¹³C NMR (101 MHz, CDCl₃) δ 173.0, 172.8, 159.7, 147.7, 146.4, 144.4, 137.9, 135.2, 132.5, 129.5, 128.53, 128.48, 128.3, 128.0, 126.5, 119.0, 113.4, 111.0, 108.1, 102.4, 102.0, 66.9, 55.2, 50.3, 43.9, 28.9, 26.3.

HPLC: Chiral Ia-3 column, (n-hexane/i-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; $t_{\text{Reten-major}} = 32.20$ min, $t_{\text{Reten-minor}} = 18.48$ min.

HRMS (ESI): $[M+Na]^+$ calcd for [C₂₉H₂₆O₇Na]: 509.1571, found:509.1577.



benzyl (9S,10R)-10-((E)-2-methoxystyryl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3ah)



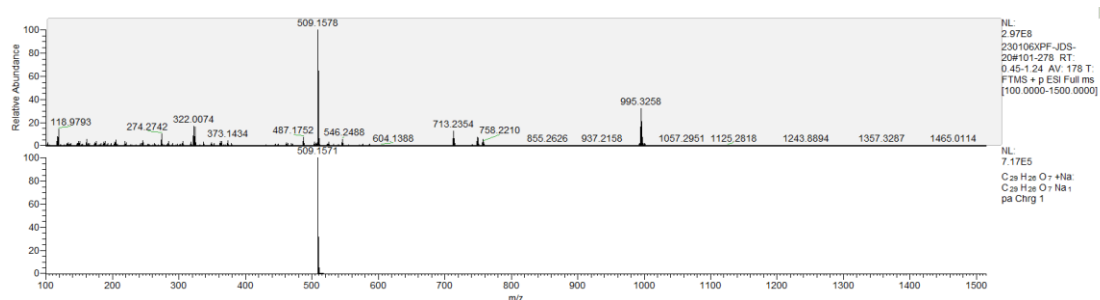
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a white solid at room temperature, M. P. = 106-107 °C, 68% yield (34mg). $[\alpha]_D^{19} = +57$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 92 % ee).

¹H NMR (400 MHz, Chloroform-d) δ 7.35 – 7.19 (m, 7H), 6.91 – 6.72 (m, 4H), 6.58 (s, 1H), 6.43 (dd, *J* = 15.8, 9.1 Hz, 1H), 6.00 – 5.96 (m, 2H), 5.07 – 4.97 (m, 2H), 3.79 (s, 4H), 2.85 (s, 1H), 2.55 (dd, *J* = 11.0, 8.3 Hz, 1H), 2.36 – 2.11 (m, 3H).

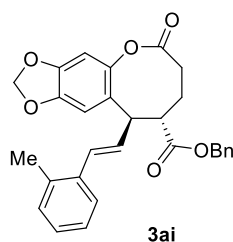
¹³C NMR (101 MHz, CDCl₃) δ 173.0, 172.9, 156.7, 147.3, 146.4, 144.5, 135.4, 128.7, 128.5, 128.4, 128.25, 128.15, 127.6, 126.9, 125.6, 120.6, 110.7, 108.1, 102.3, 102.0, 66.8, 55.3, 50.7, 45.0, 28.9, 26.7.

HPLC: Chiral Ia-3 column, (n-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; *t*_{Retention-major} = 27.24 min, *t*_{Retention-minor} = 14.82 min.

HRMS (ESI): [M+Na]⁺ calcd for [C₂₉H₂₆O₇Na]: 509.1571, found: 509.1578.



benzyl (9S,10R)-10-((E)-2-methylstyryl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate(3ai)



The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) as oil at room temperature, 72% yield (28 mg). $[\alpha]_D^{23.3} = +32$ (*c* 1.0 (10mg/mL), CH₂Cl₂, 98 % ee).

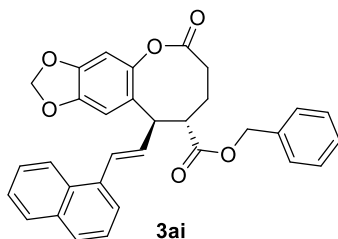
¹H NMR (600 MHz, Chloroform-*d*) δ 7.32 (d, *J* = 1.9 Hz, 1H), 7.28 – 7.23 (m, 3H), 7.21 (dd, *J* = 7.9, 1.8 Hz, 2H), 7.13 (dtd, *J* = 15.3, 7.6, 5.7 Hz, 3H), 6.83 (s, 1H), 6.62 (d, *J* = 15.5 Hz, 1H), 6.59 (s, 1H), 6.27 (dd, *J* = 15.5, 9.0 Hz, 1H), 5.98 (q, *J* = 1.4 Hz, 2H), 5.02 (d, *J* = 3.3 Hz, 2H), 3.82 (d, *J* = 9.5 Hz, 1H), 2.85 (s, 1H), 2.55 (ddd, *J* = 11.6, 8.6, 2.6 Hz, 1H), 2.35 – 2.26 (m, 2H), 2.24 (s, 3H), 2.15 (dddd, *J* = 14.5, 8.0, 6.1, 3.5 Hz, 1H).

¹³C NMR (151 MHz, CDCl₃) δ 172.99, 172.86, 147.39, 146.51, 144.44, 135.70, 135.56, 135.23, 130.61, 130.21, 129.01, 128.53, 128.44, 128.35, 127.64, 126.02, 125.69, 107.92, 102.36, 102.05, 66.87, 51.21, 44.36, 28.90, 26.87, 19.77.

HPLC: Chiral Ia-3 column, (n-hexane/i-PrOH = 80:20), flow rate 1 mL/min, $\lambda = 250$ nm; $t_{\text{Retention-major}} = 16.44$ min, $t_{\text{Retention-minor}} = 10.75$ min.

HRMS (ESI): $[M+H]^+$ calcd for [C₂₉H₂₇O₆]: 471.1802, found: 471.1804.

benzyl (9S,10R)-10-((E)-2-(naphthalen-1-yl)vinyl)-6-oxo-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (3aj)



Chemical Formula: C₃₂H₂₆O₆

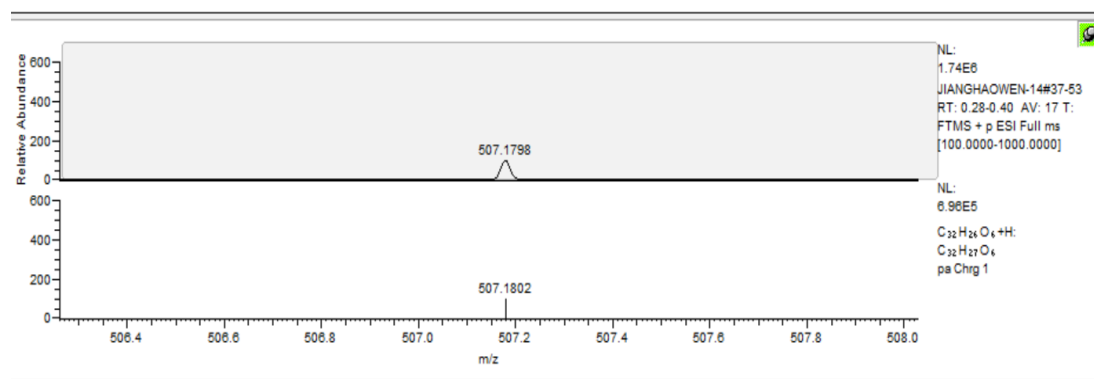
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) as a colorless oil at room temperature, 67% yield (35mg). $[\alpha]_D^{19} = +60$ (*c* 0.5 (5mg/mL), CH₂Cl₂, 96 % ee).

¹H NMR (400 MHz, Chloroform-*d*) δ 8.02 – 7.95 (m, 1H), 7.83 (dt, *J* = 7.9, 2.8 Hz, 1H), 7.77 (d, *J* = 8.1 Hz, 1H), 7.52 – 7.44 (m, 3H), 7.41 (d, *J* = 7.8 Hz, 1H), 7.22 – 7.14 (m, 6H), 6.89 (s, 1H), 6.62 (s, 1H), 6.42 (dd, *J* = 15.4, 9.0 Hz, 1H), 6.00 (q, *J* = 1.4 Hz, 2H), 5.00 (q, *J* = 12.1 Hz, 2H), 3.93 (t, *J* = 9.0 Hz, 1H), 2.90 (s, 1H), 2.58 (t, *J* = 9.2 Hz, 1H), 2.41 – 2.27 (m, 2H), 2.20 (ddd, *J* = 11.5, 8.9, 5.2 Hz, 1H).

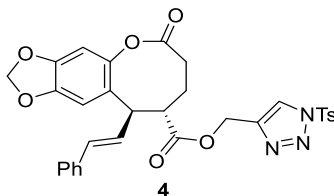
¹³C NMR (101 MHz, Chloroform-*d*) δ 173.0, 172.9, 147.4, 146.6, 145.0, 135.1, 134.3, 133.5, 131.0, 130.8, 130.1, 128.5, 128.43, 128.41, 128.3, 128.1, 126.1, 125.8, 125.5, 123.9, 123.8, 107.8, 103.2, 102.1, 66.9, 50.9, 44.1, 28.9, 26.3.

HPLC: Chiral Ia-3 column, (n-hexane/i-PrOH = 80:20), flow rate 1 mL/min, I = 290 nm; $t_{\text{Reten-major}} = 21.45$ min, $t_{\text{Reten-minor}} = 14.71$ min.

HRMS (ESI): $[M+H]^+$ calcd for $[C_{32}H_{27}O_6]$: 507.1798, found: 507.1802.



(1-tosyl-1H-1,2,3-triazol-4-yl)methyl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (4)



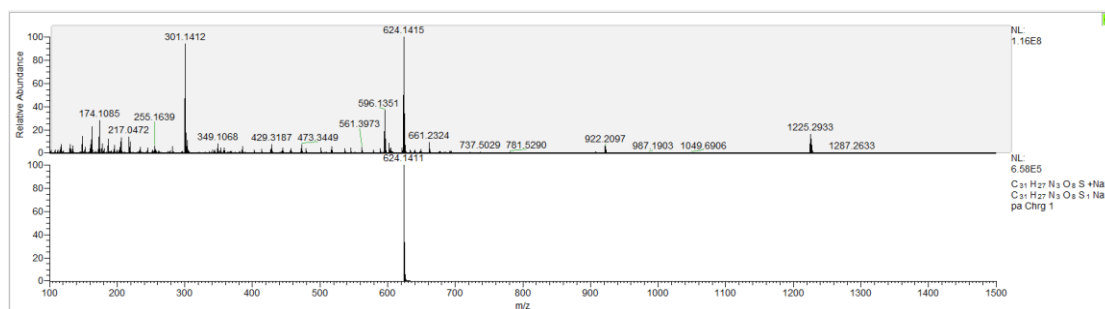
The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) as a white solid at room temperature, M. P. = 36-38°C, 80% yield (49mg). $[\alpha]_D^{19} = +36$ (c 1.0 (10mg/mL), CH_2Cl_2 , 94 % ee).

1H NMR (400 MHz, Chloroform-d) δ 8.05 – 7.92 (m, 3H), 7.39 (d, $J = 7.9$ Hz, 2H), 7.34 – 7.28 (m, 4H), 7.25 (s, 1H), 6.79 (s, 1H), 6.58 (s, 1H), 6.47 – 6.34 (m, 2H), 5.99 (q, $J = 1.6$ Hz, 2H), 5.15 – 5.05 (m, 2H), 3.85 – 3.74 (m, 1H), 2.90 – 2.79 (m, 1H), 2.53 (ddd, $J = 12.4, 9.1, 3.1$ Hz, 1H), 2.45 (s, 3H), 2.33 (ddd, $J = 12.5, 9.5, 3.2$ Hz, 1H), 2.22 (qd, $J = 9.6, 4.6$ Hz, 1H), 2.16 – 2.06 (m, 1H).

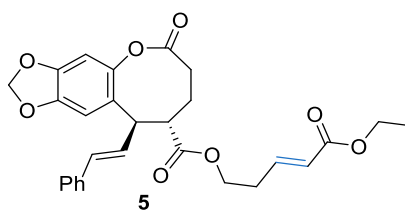
^{13}C NMR (101 MHz, $CDCl_3$) δ 172.8, 172.7, 147.5, 146.5, 144.5, 141.9, 136.3, 132.7, 132.6, 130.5, 128.8, 128.7, 127.9, 127.5, 126.3, 126.0, 123.5, 108.1, 102.4, 102.1, 57.3, 49.9, 45.2, 28.4, 26.4, 21.1.

HPLC: Chiral Ia-3 column, (n-hexane/i-PrOH = 80:20), flow rate 1 mL/min, I = 250 nm; $t_{\text{Reten-major}} = 38.44$ min, $t_{\text{Reten-minor}} = 26.78$ min.

HRMS (ESI): $[M+Na]^+$ calcd for $[C_{31}H_{27}N_3O_8SNa]$: 624.1411, found:624.1415.



(E)-5-ethoxy-5-oxopent-3-en-1-yl (9S,10R)-6-oxo-10-((E)-styryl)-7,8,9,10-tetrahydro-6H-[1,3]dioxolo[4',5':4,5]benzo[1,2-b]oxocine-9-carboxylate (5)



Chemical Formula: $C_{28}H_{28}O_8$

The product was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) as a colorless oil at room temperature, 91% yield (48mg).

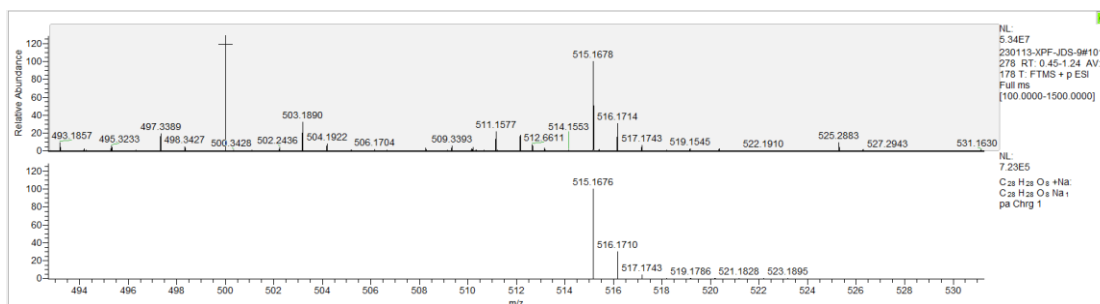
$[\alpha]_D^{24} = 70$ (c 1.0 (10mg/mL), CH_2Cl_2 , 98 % ee).

1H NMR (400 MHz, Chloroform- d) δ 7.34 – 7.27 (m, 5H), 7.25 – 7.20 (m, 1H), 6.87 – 6.79 (m, 1H), 6.60 (s, 1H), 6.47 – 6.36 (m, 2H), 6.00 (q, $J = 1.4$ Hz, 2H), 5.82 (dt, $J = 15.7, 1.6$ Hz, 1H), 4.20 (q, $J = 7.1$ Hz, 2H), 4.10 (tt, $J = 7.7, 3.9$ Hz, 2H), 3.74 (t, $J = 8.8$ Hz, 1H), 2.78 (d, $J = 13.8$ Hz, 1H), 2.54 (ddd, $J = 12.0, 8.7, 3.2$ Hz, 1H), 2.44 (qd, $J = 6.7, 1.6$ Hz, 2H), 2.32 (ddd, $J = 17.9, 10.5, 5.7$ Hz, 1H), 2.26 – 2.08 (m, 2H), 1.30 (t, $J = 7.1$ Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 172.9, 172.8, 166.0, 147.4, 146.5, 144.4, 143.5, 136.3, 132.6, 128.6, 127.8, 127.5, 126.5, 126.3, 123.7, 107.9, 102.4, 102.1, 62.7, 60.4, 50.8, 43.9, 31.2, 28.9, 27.1, 14.2.

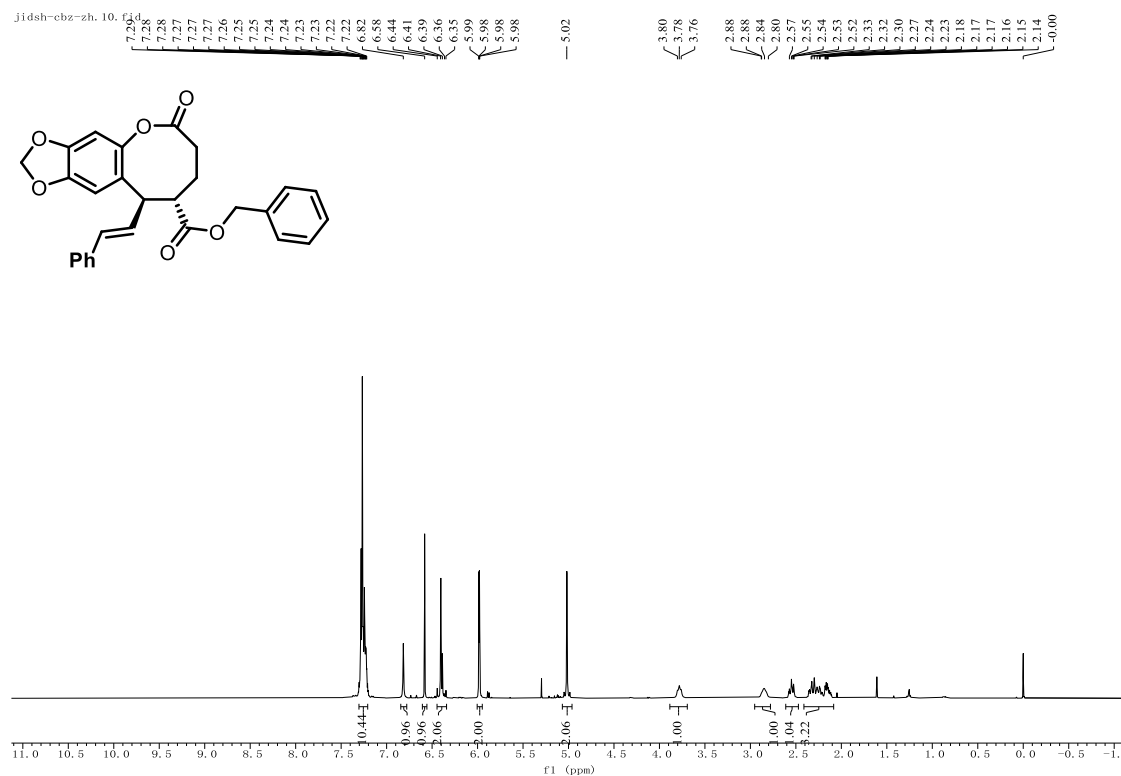
HPLC: Chiral Ia-3 column, (*n*-hexane/*i*-PrOH = 80:20), flow rate 1 mL/min, $I = 250$ nm; $t_{Reten-major} = 33.33$ min, $t_{Reten-minor} = 20.12$ min.

HRMS (ESI): $[M+Na]^+$ calcd for $[C_{28}H_{28}O_8Na]$: 515.1676, found: 515.1678.

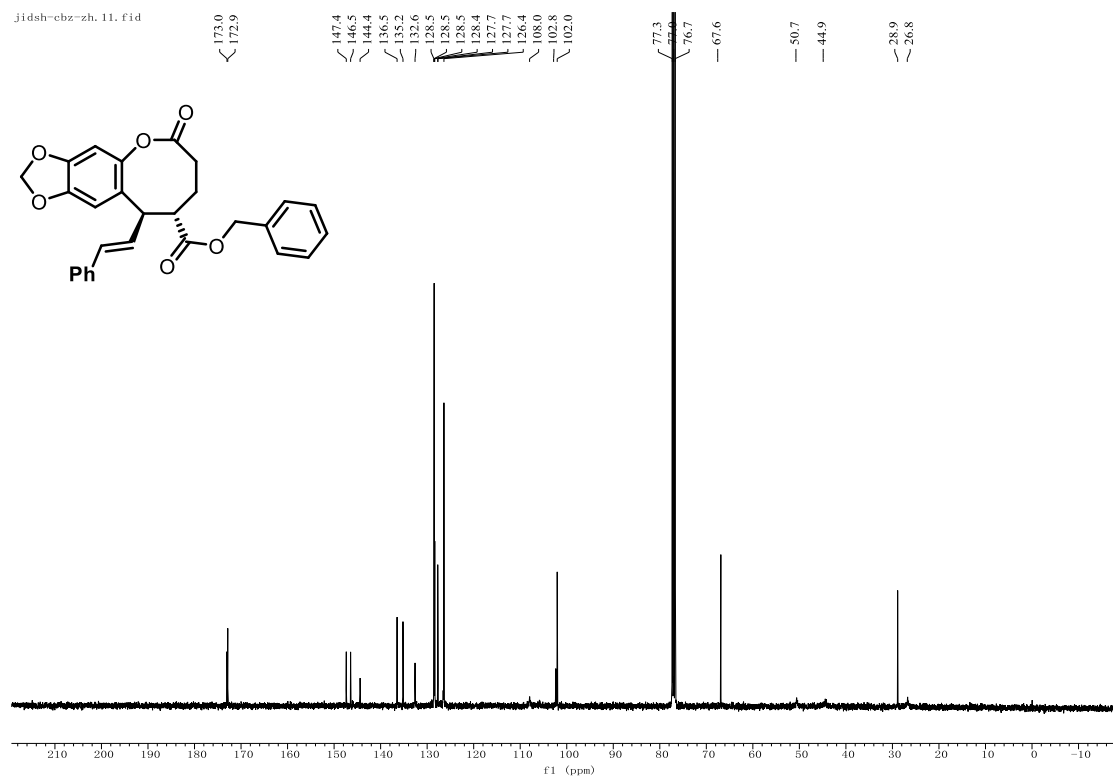


9 NMR spectra of 8-memebered lactone

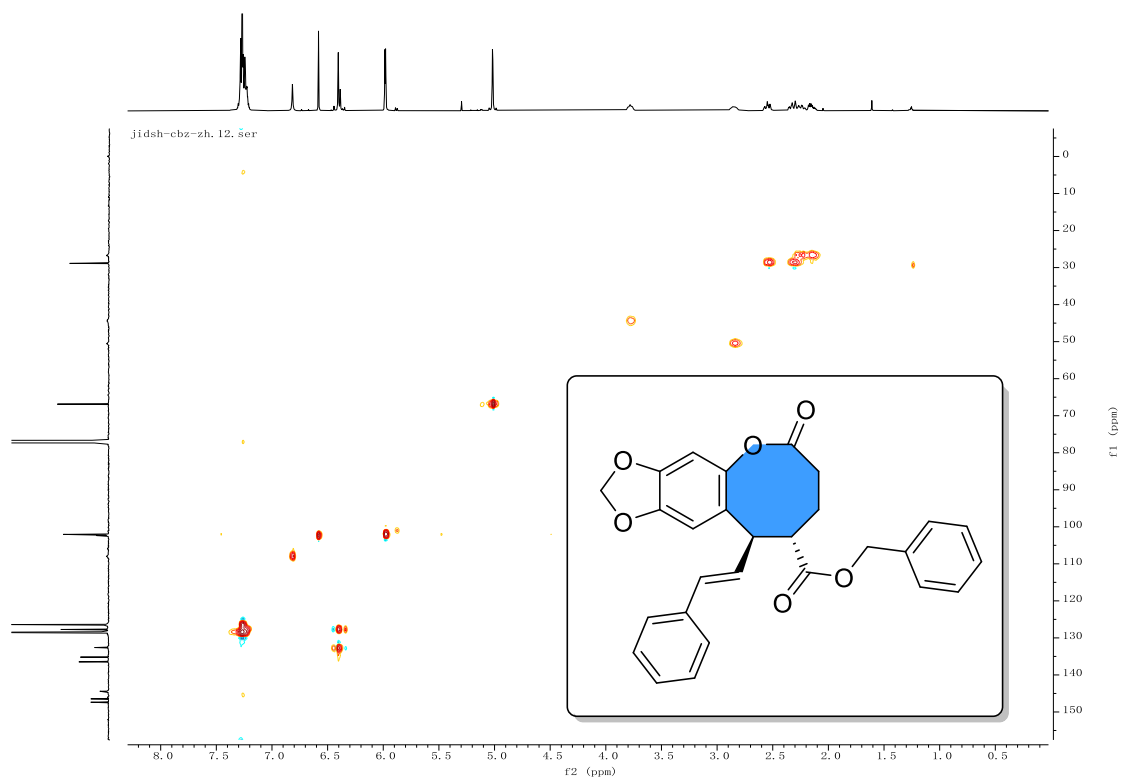
Compound-3aa (^1H NMR 400MHz, CDCl_3)



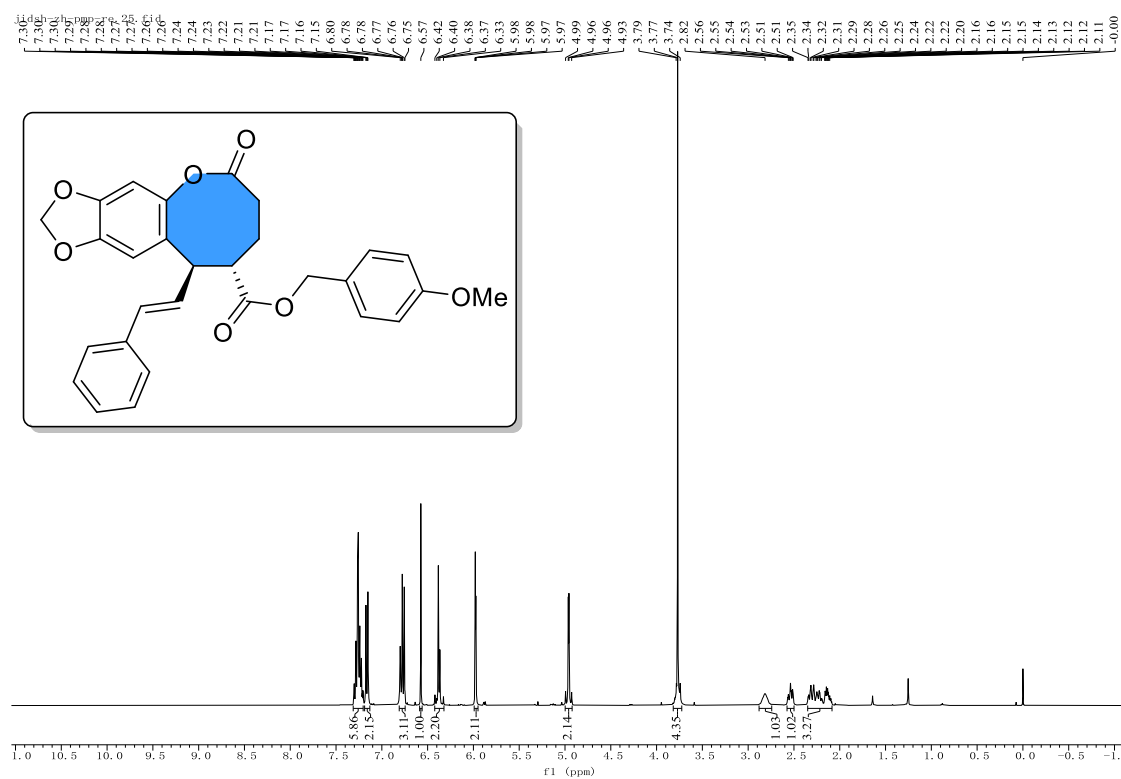
Compound-3aa (^{13}C NMR 101MHz, CDCl_3)



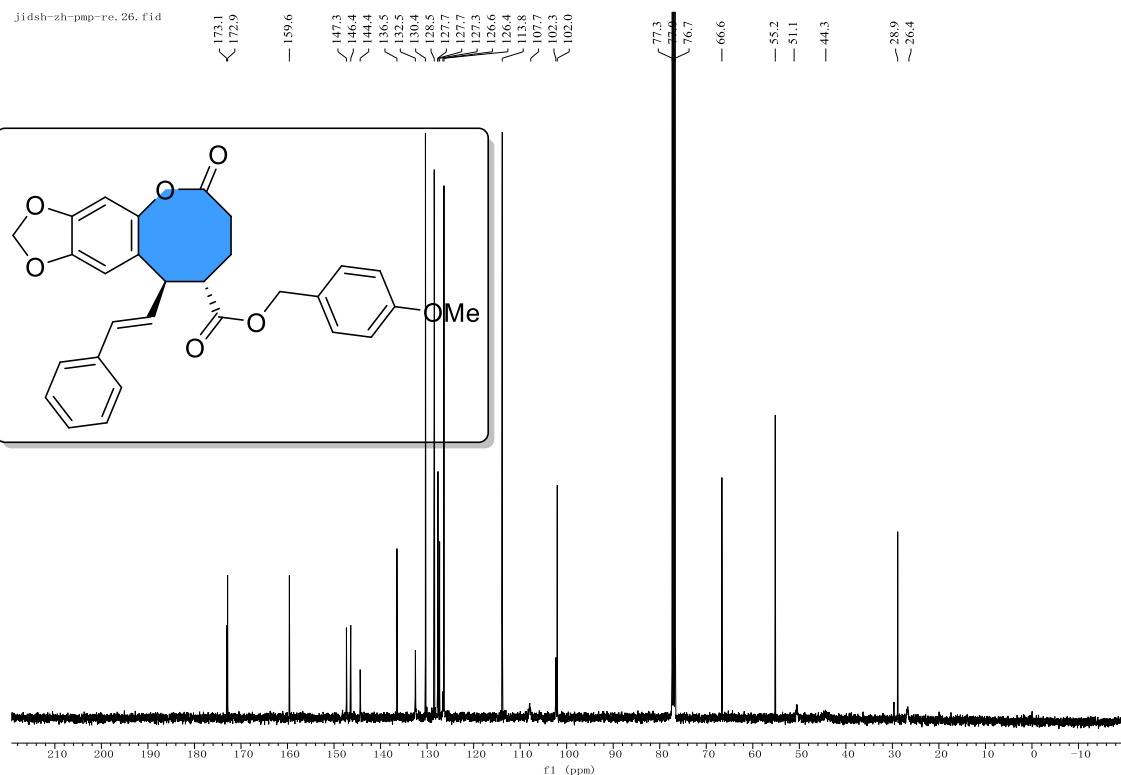
Compound-3aa (HSQC-400MHz, CDCl₃)



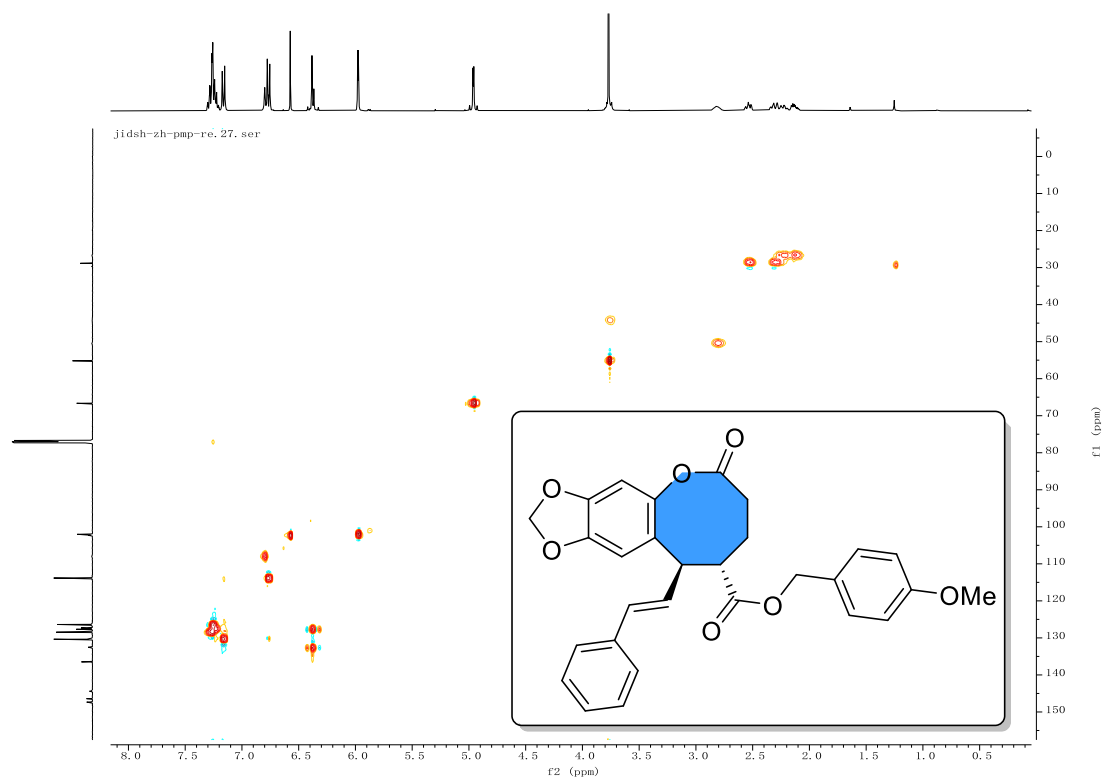
Compound-3ba (^1H NMR 400MHz, CDCl_3)



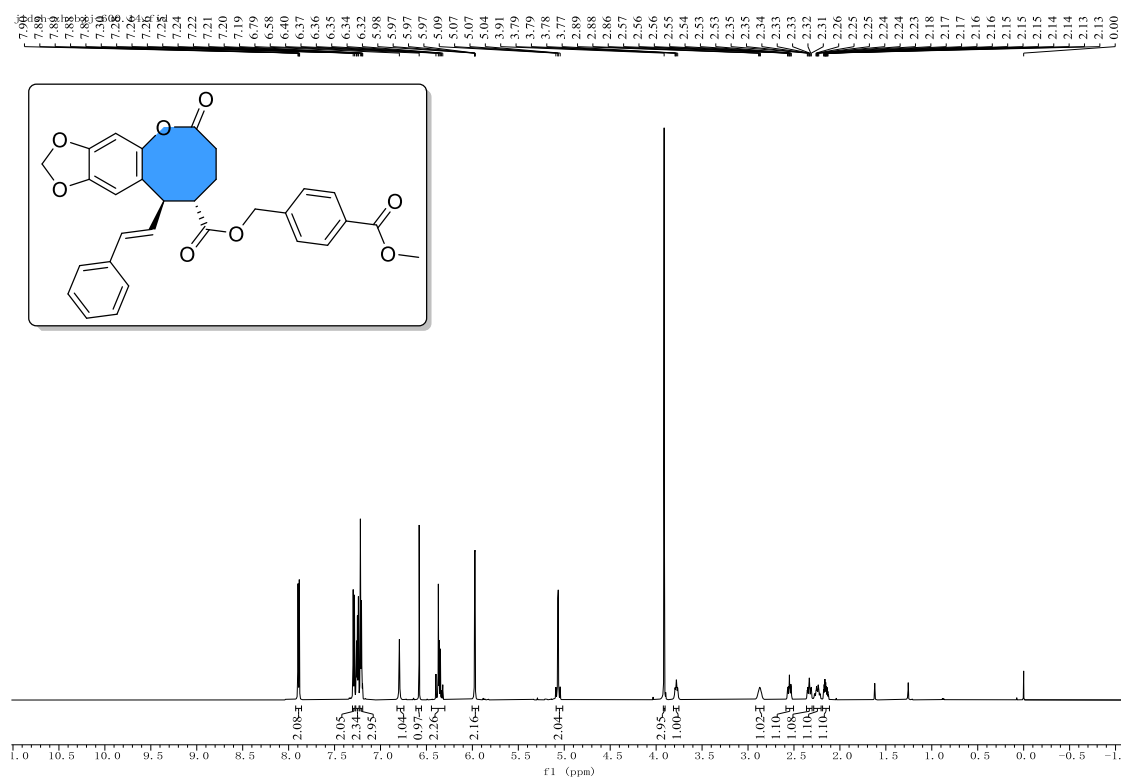
Compound-3ba (^{13}C NMR 101MHz, CDCl_3)



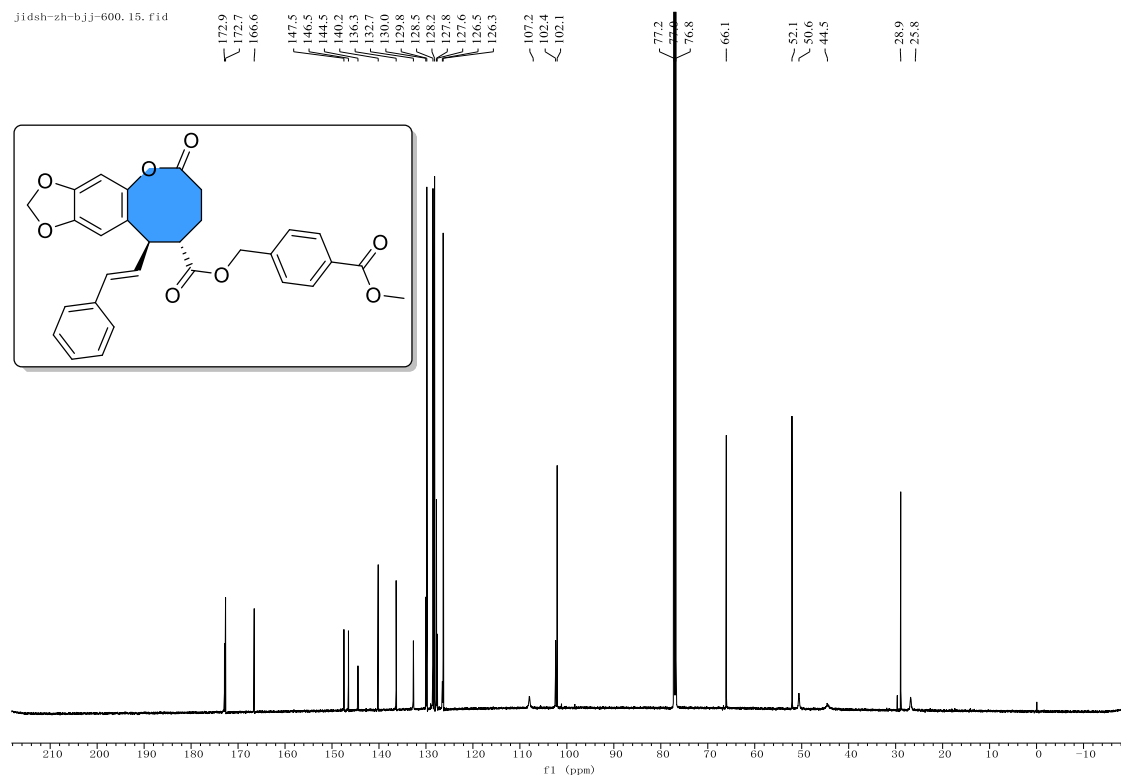
Compound-3ba HSQC, 400MHz, CDCl₃



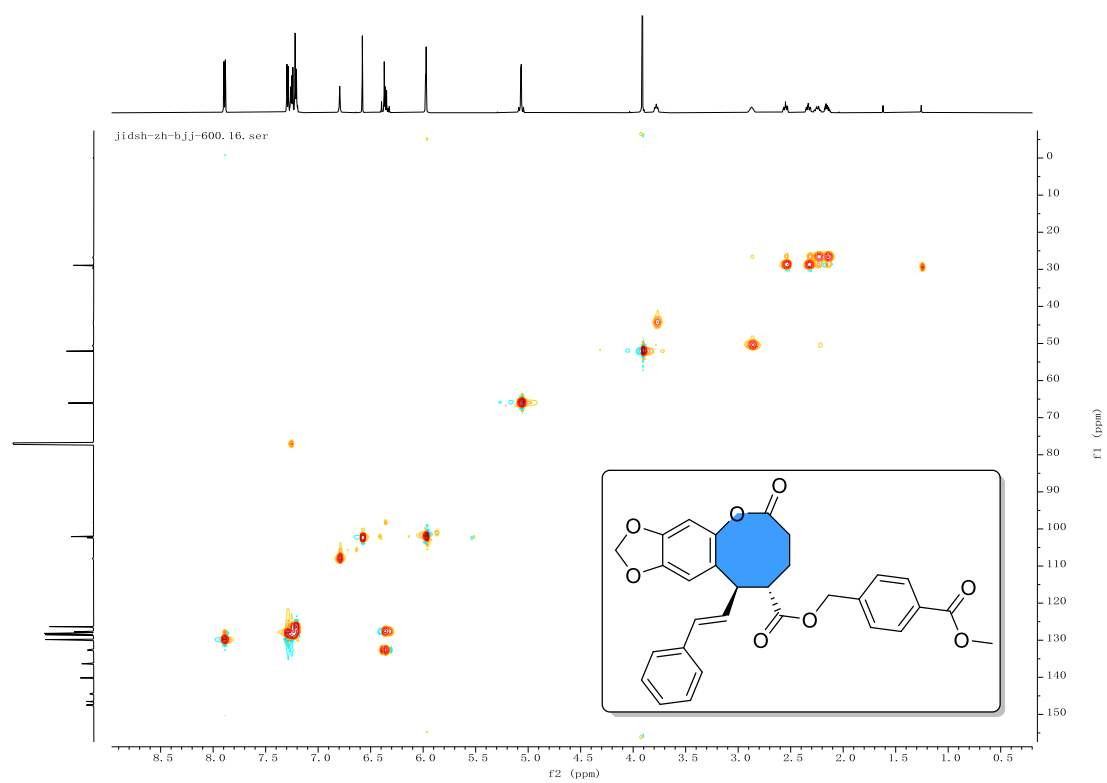
Compound-3ca ¹H NMR 400MHz, CDCl₃



Compound-3ca ¹³C NMR 101MHz, CDCl₃



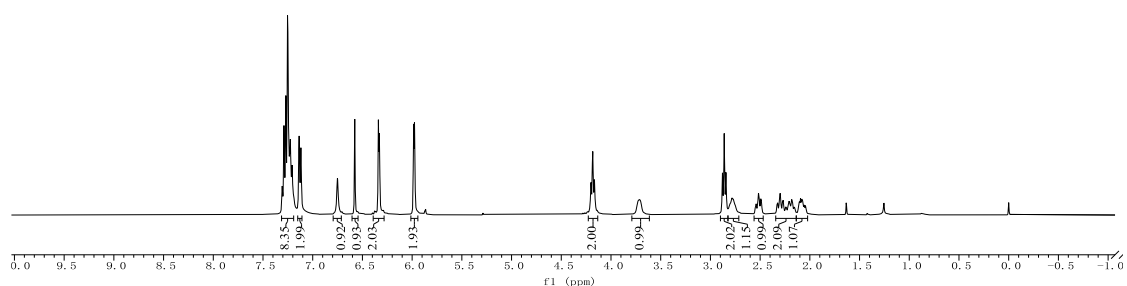
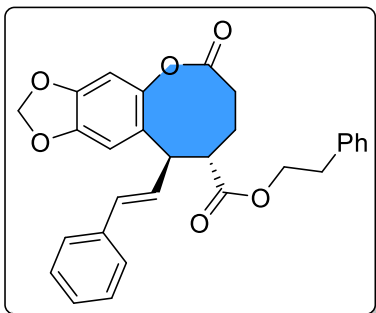
HSQC



Compound-3da (¹HNMR 400MHz, CDCl₃)

jidsh-zh-byc-re.10.fid

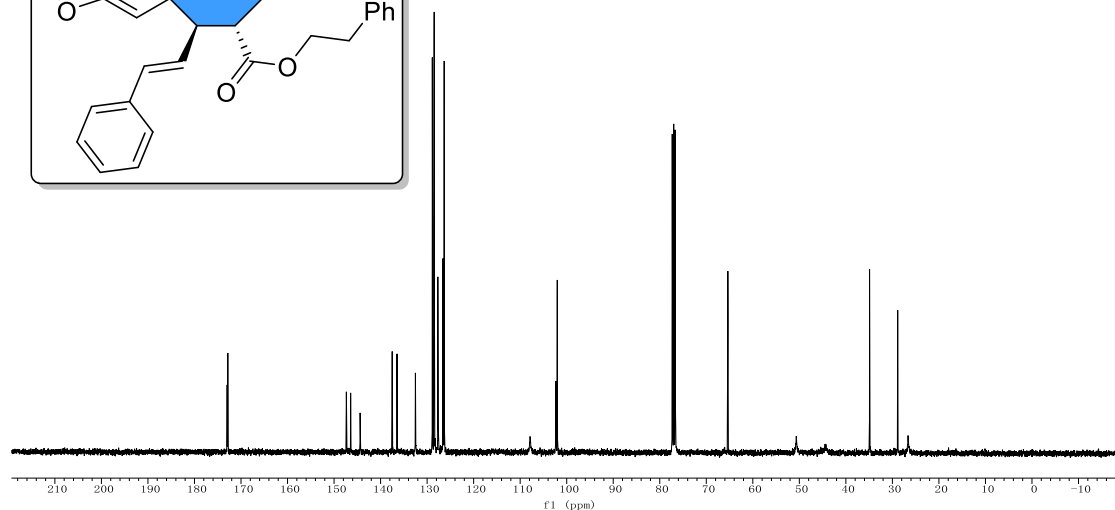
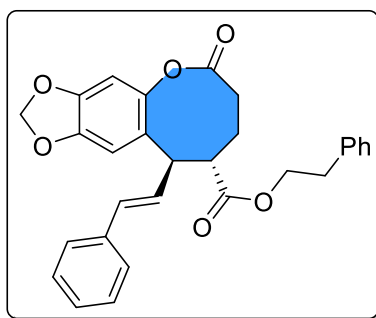
7.31, 7.29, 7.27, 7.25, 7.23, 7.11, 7.11, 7.12, 6.75, 6.58, 6.37, 6.34, 6.33, 6.29, 6.29, 5.99, 5.98, 4.20, 4.18, 4.17, 3.73, 3.72, 3.70, 2.88, 2.86, 2.84, 2.81, 2.78, 2.77, 2.55, 2.54, 2.52, 2.51, 2.49, 2.49, 2.49, 2.35, 2.32, 2.31, 2.27, 2.27, 2.24, 2.21, 2.20, 2.18, 2.11, 2.09, 2.08, 2.07, 2.06, 2.04, -0.00



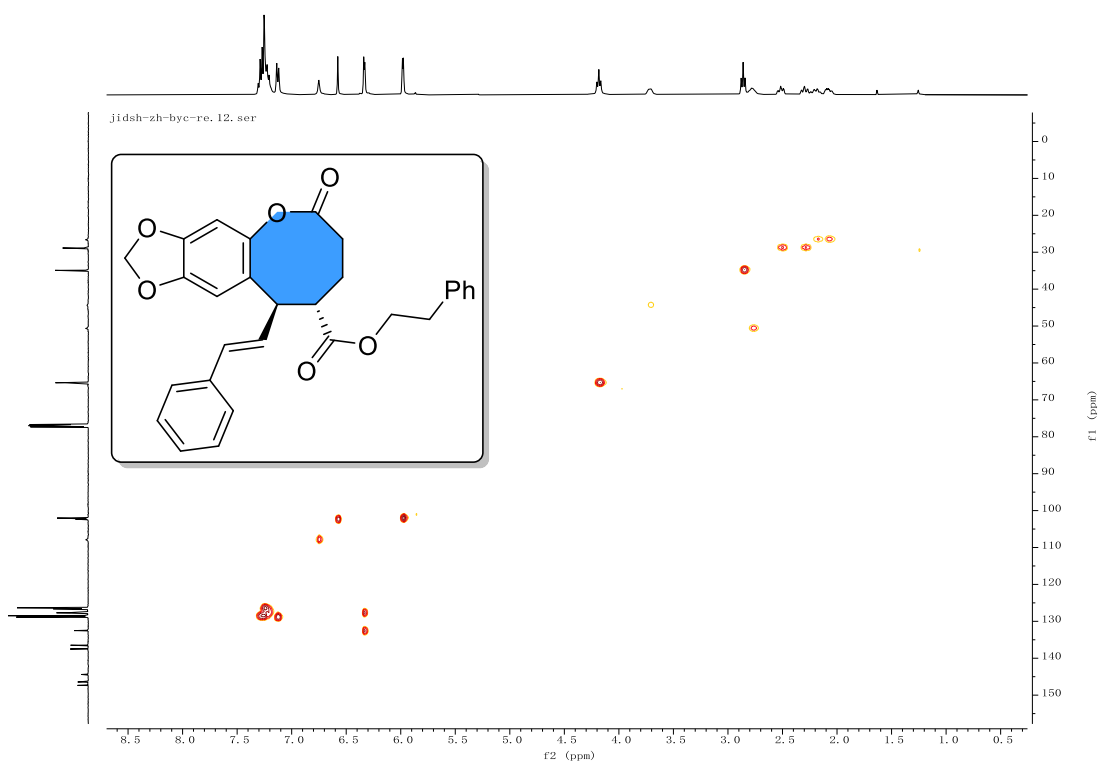
Compound-3da ¹³CNMR 101MHz, CDCl₃

jidsh-zh-byc-re.11.fid

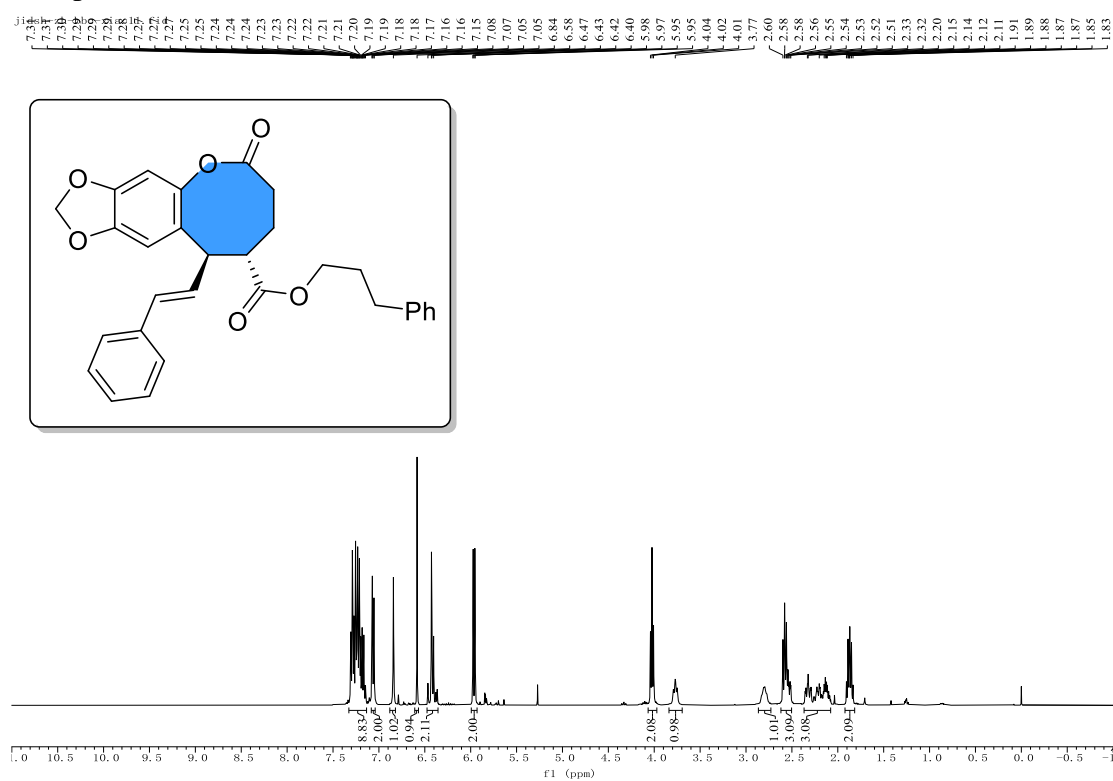
173.0, 172.8, 147.4, 146.4, 144.4, 137.5, 136.5, 132.5, 128.9, 128.5, 128.5, 127.7, 127.6, 126.6, 126.3, 107.9, 102.3, 102.0, 77.3, 77.0, 76.7, 65.4, 50.4, 44.6, 34.9, 28.9, 26.4



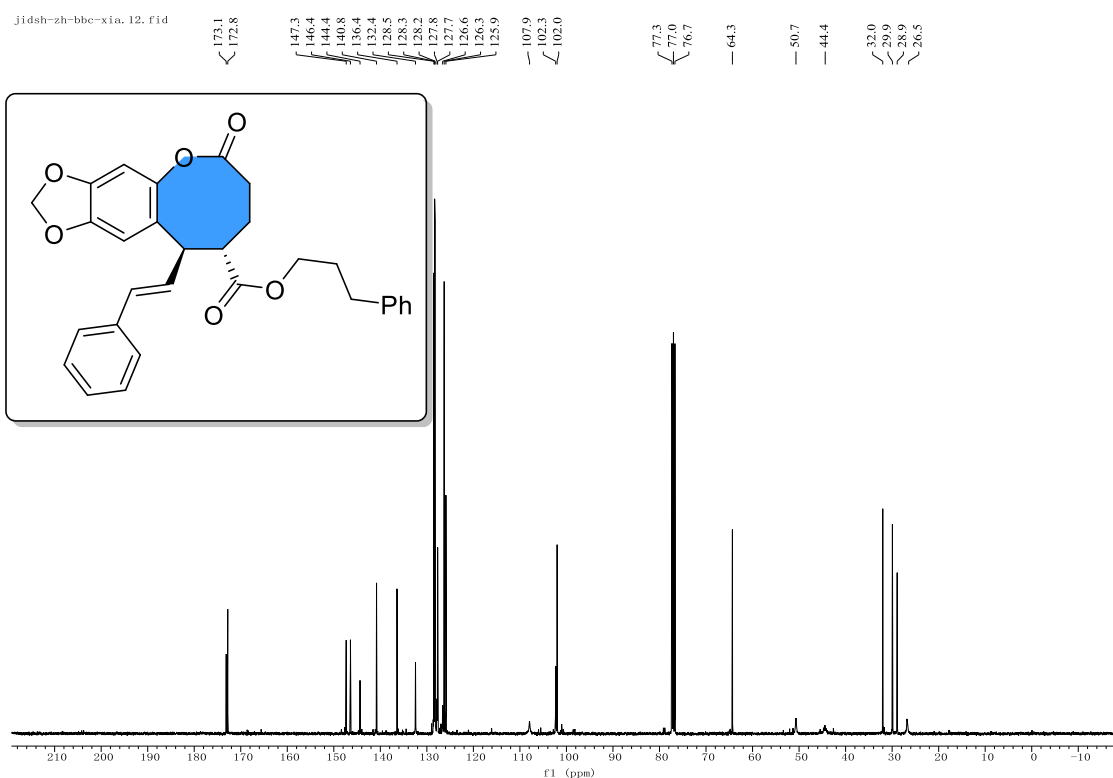
Hsqc



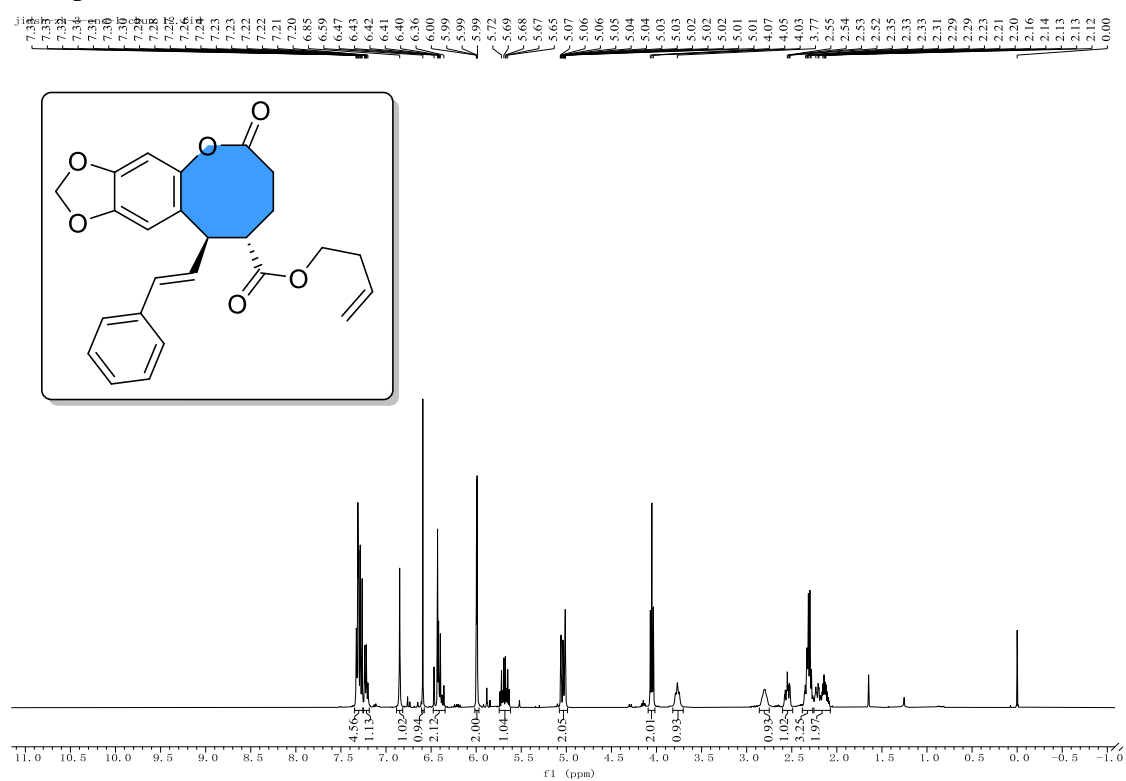
Compound-3ea (¹HNMR 400MHz, CDCl₃)



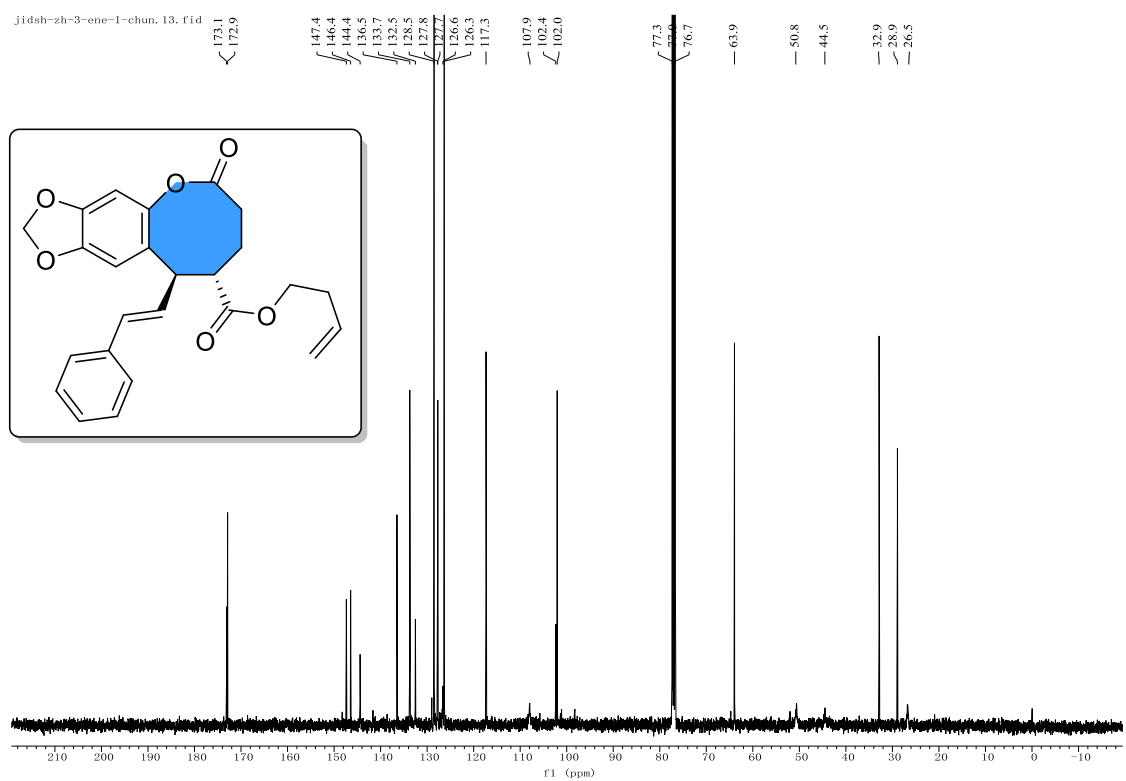
¹³CNMR 101MHz, CDCl₃



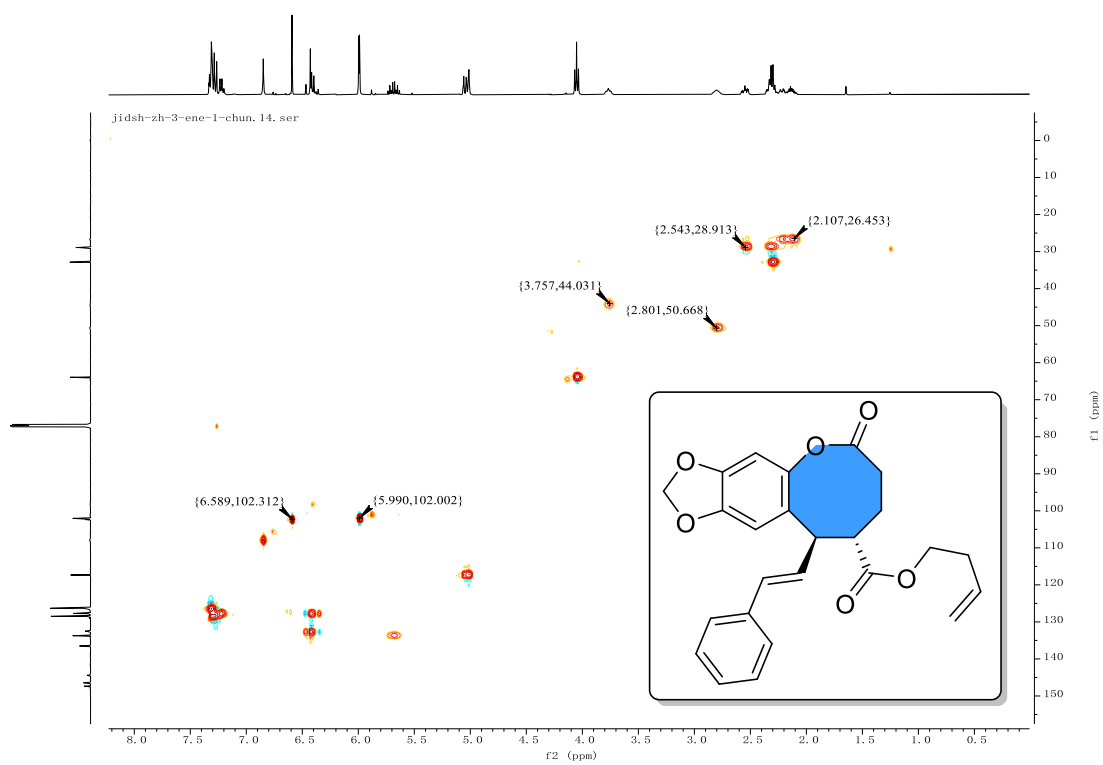
Compound-3fa (¹HNMR 400MHz, CDCl₃)



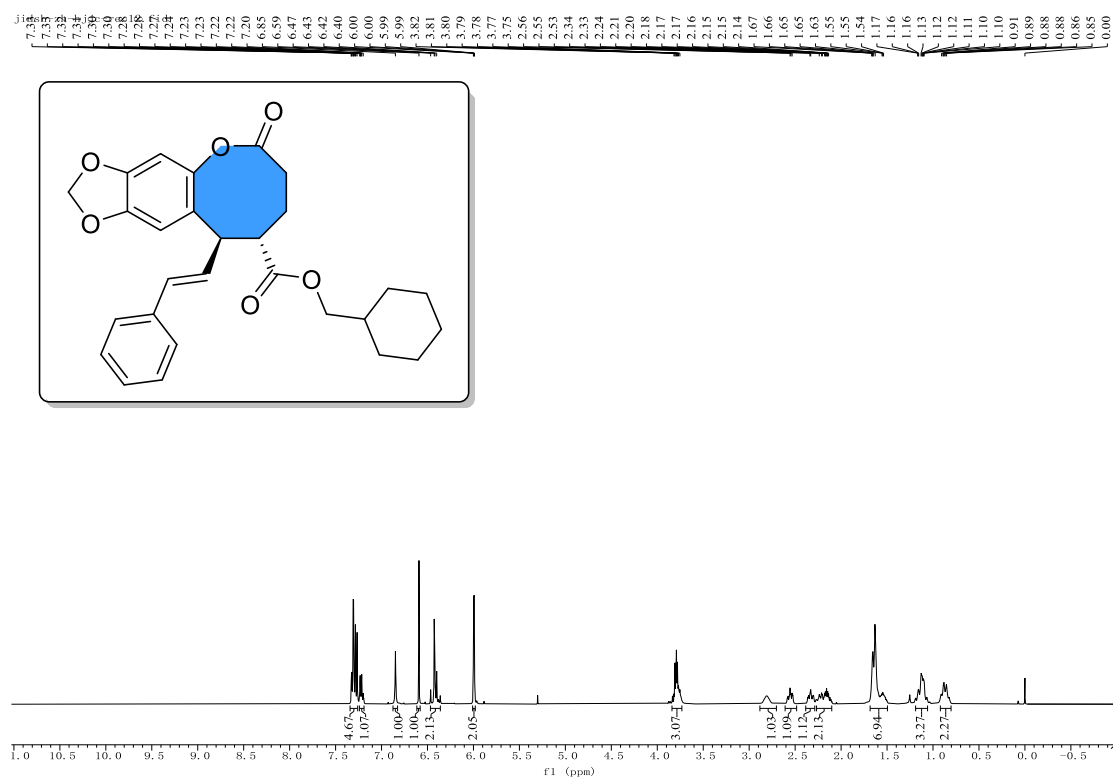
¹³CNMR 101MHz, CDCl₃



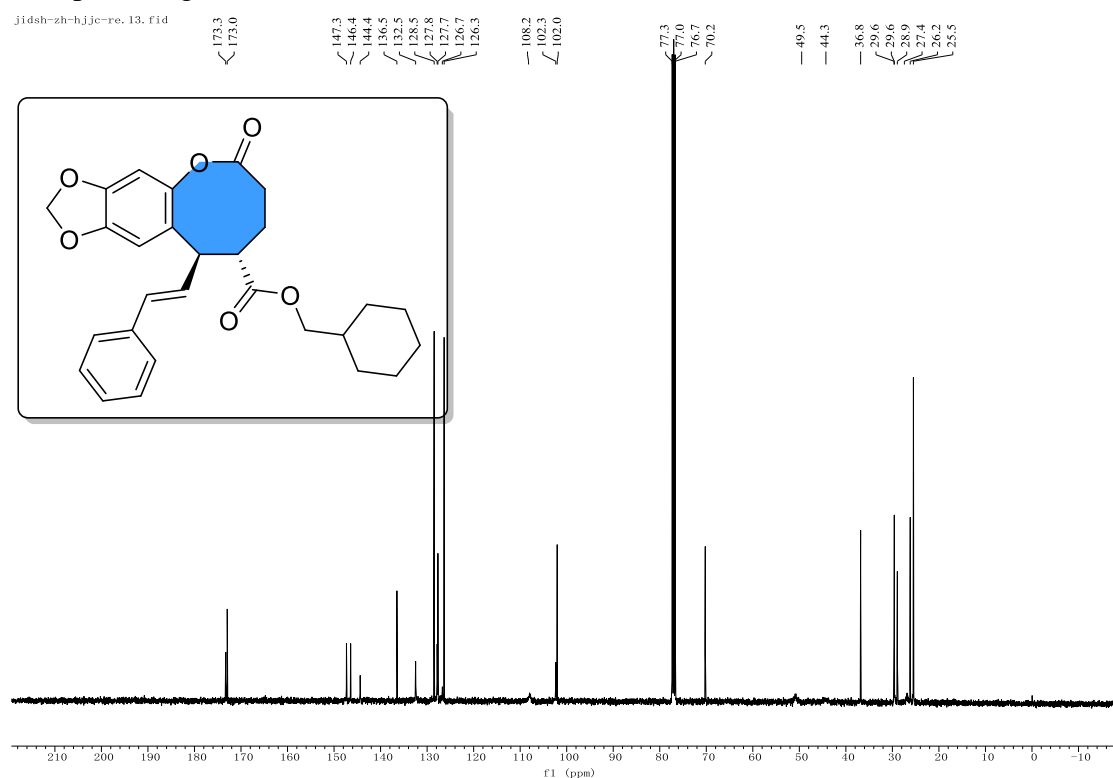
HSQC



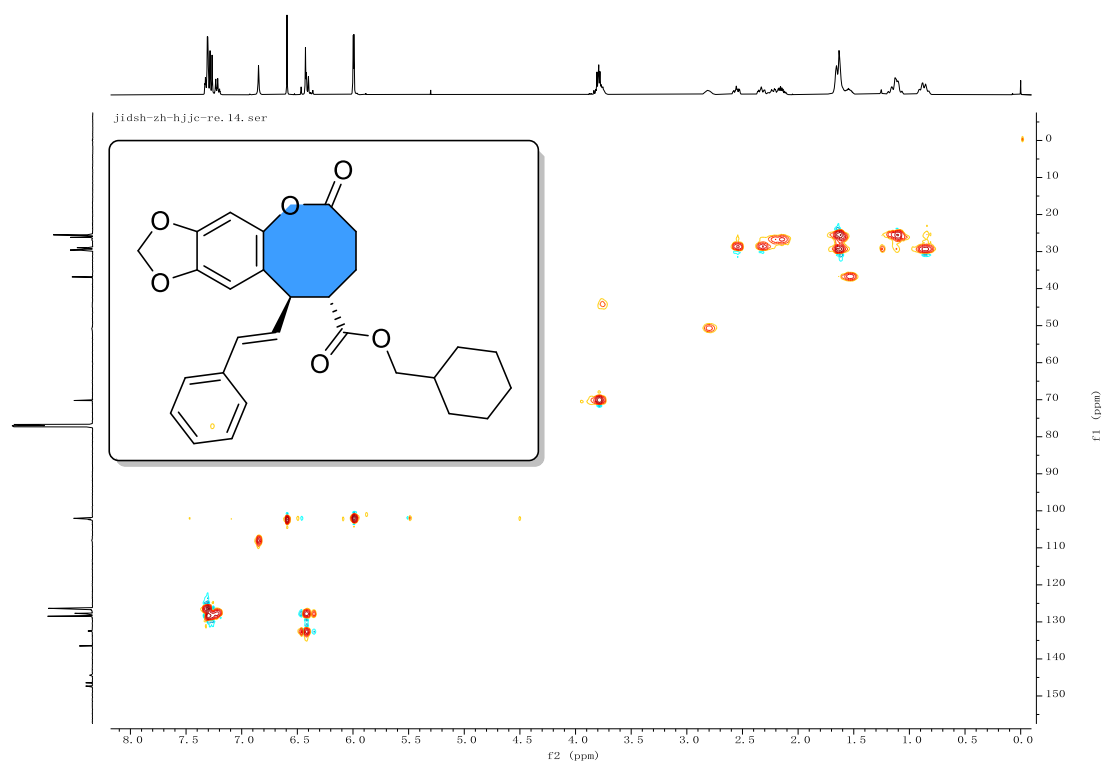
Compound-3ga (^1H NMR 400MHz, CDCl_3)



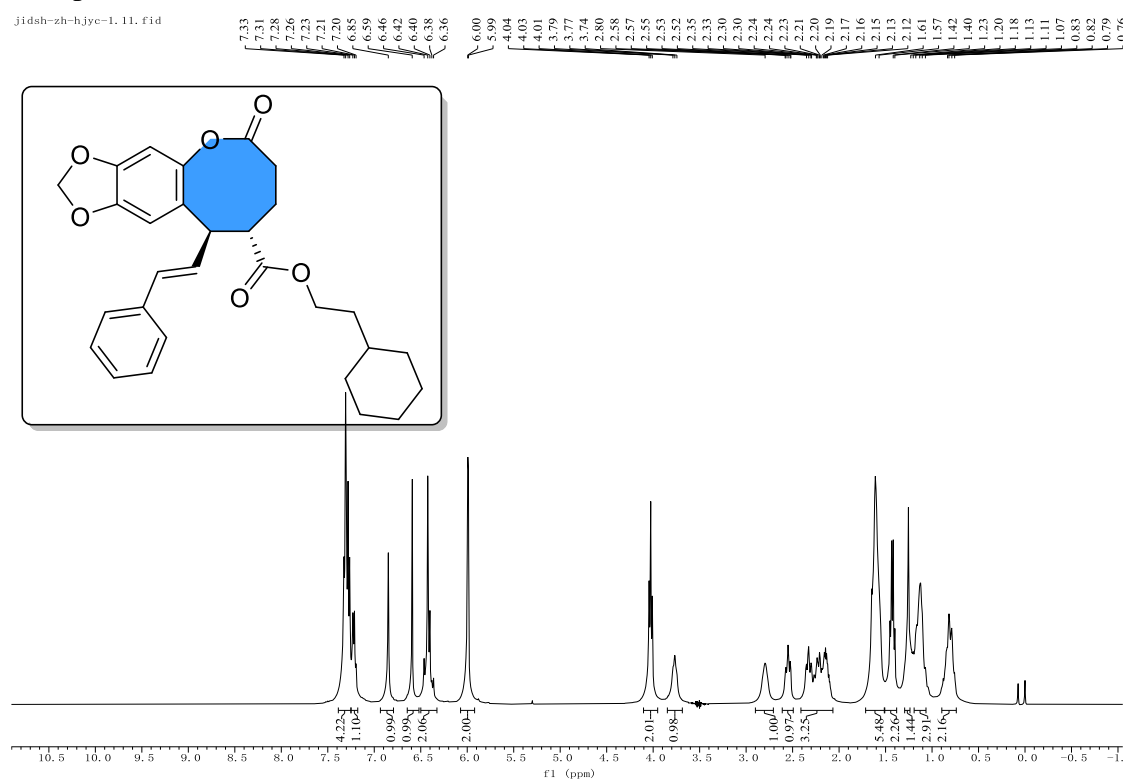
Compound-3ga (^{13}C NMR 101MHz, CDCl_3)



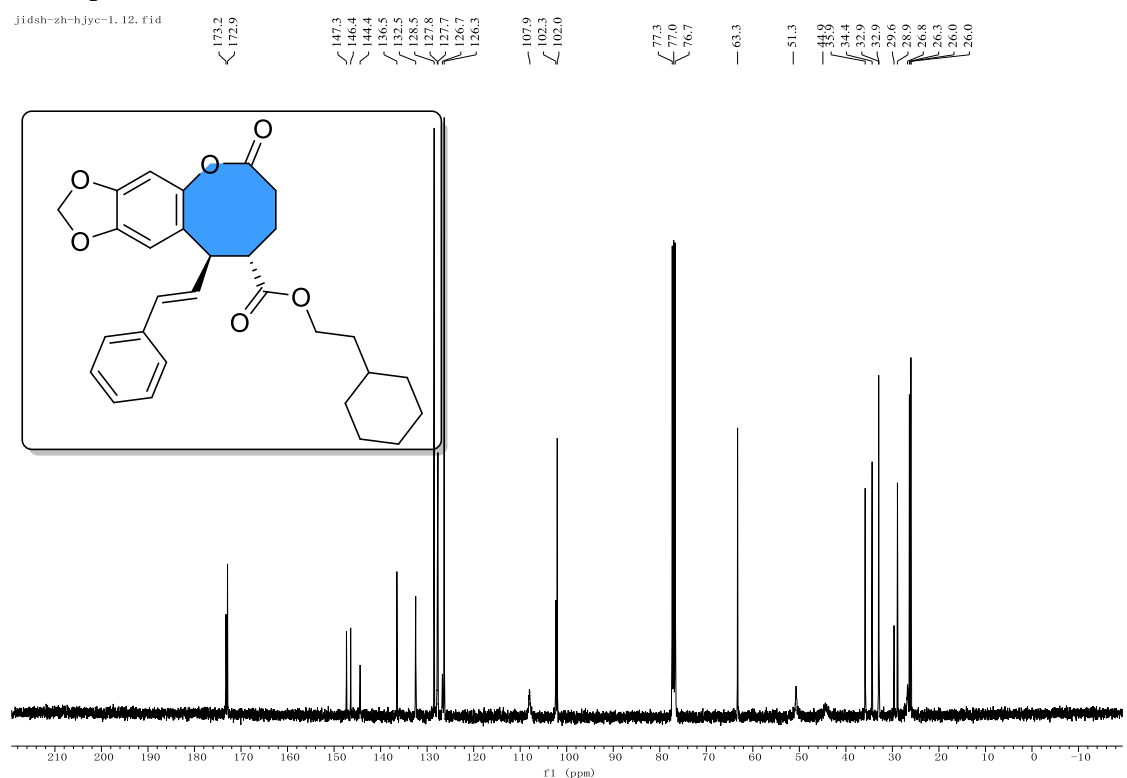
HSQC



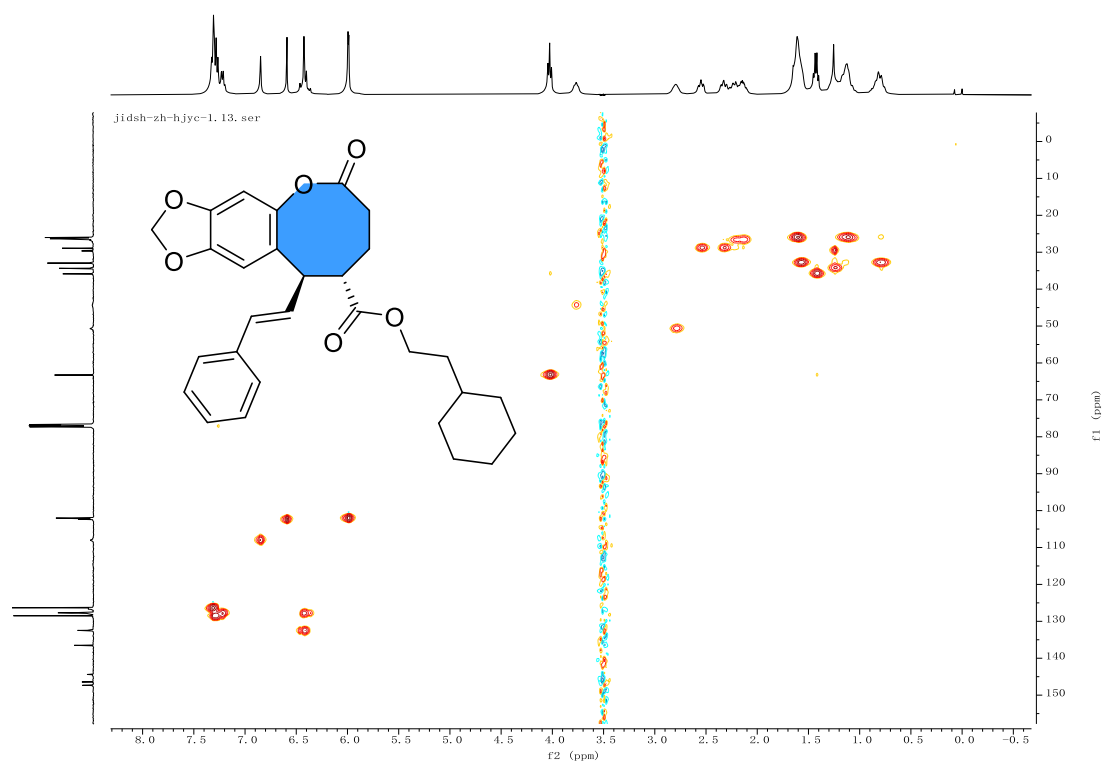
Compound-3ha (¹HNMR 400MHz, CDCl₃)



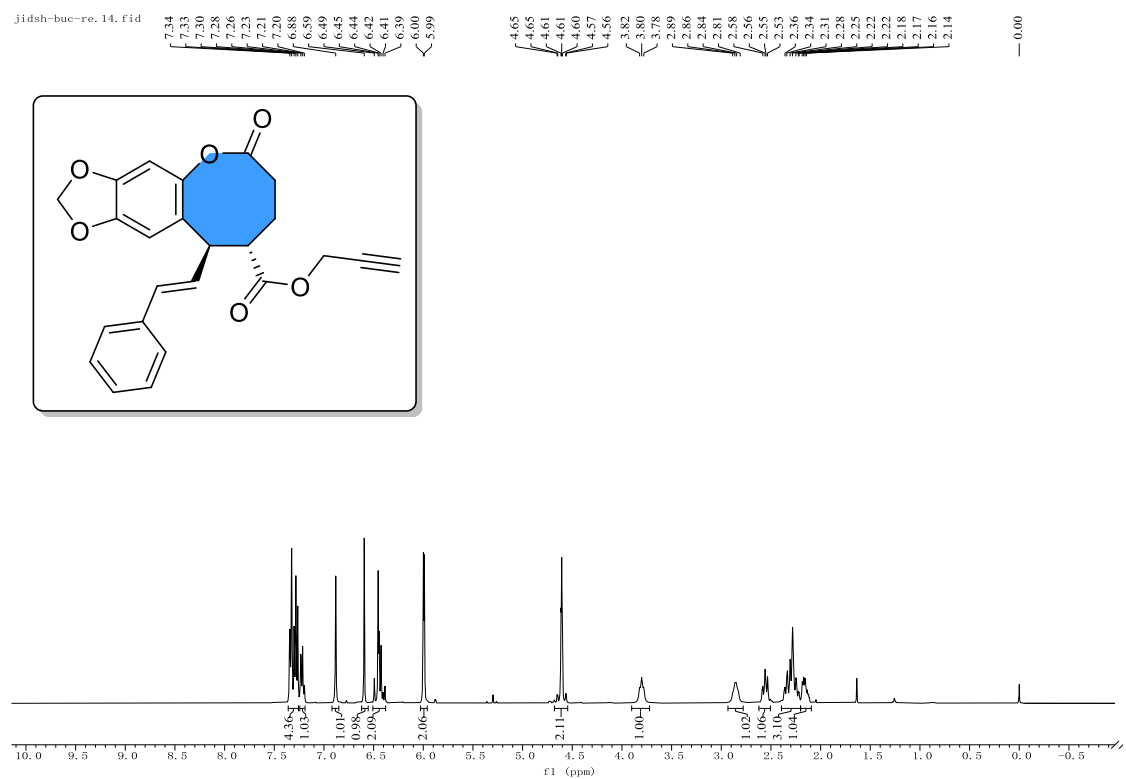
Compound-3ha (¹³CNMR 101MHz, CDCl₃)



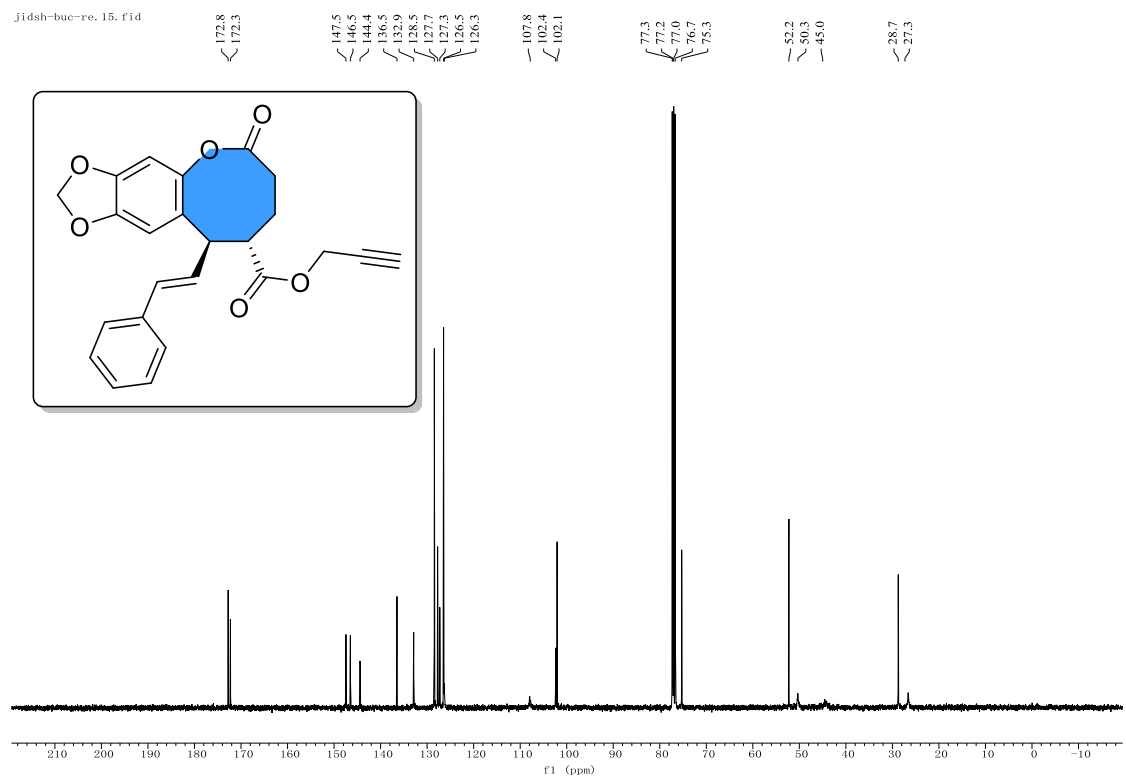
HSQC



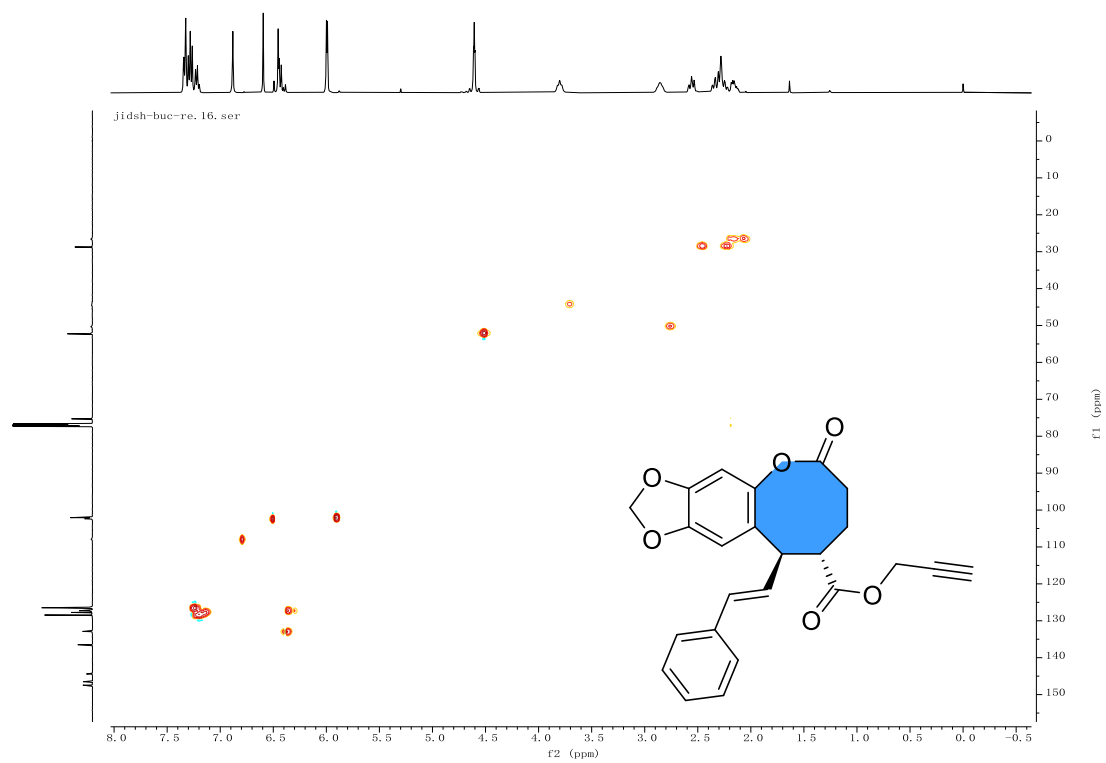
Compound-3ia (¹HNMR 400MHz, CDCl₃)



Compound-3ia (¹³CNMR 101MHz, CDCl₃)

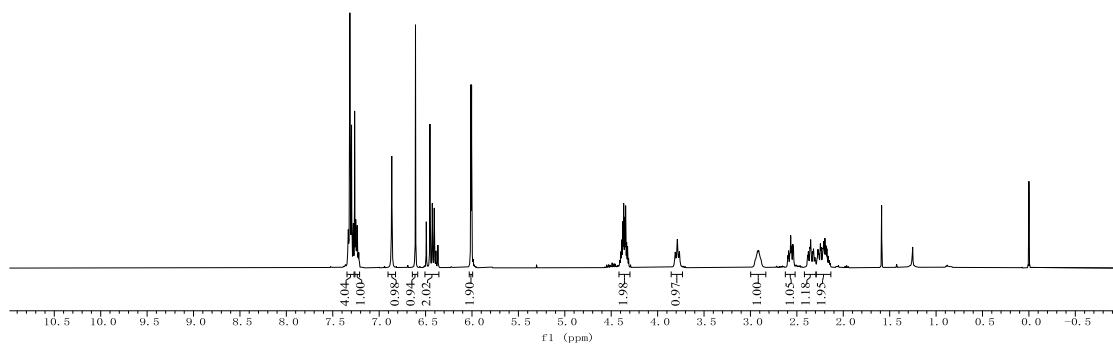
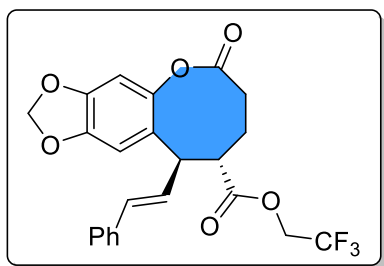


HSQC



Compound-3ja (¹H NMR 400MHz, CDCl₃)

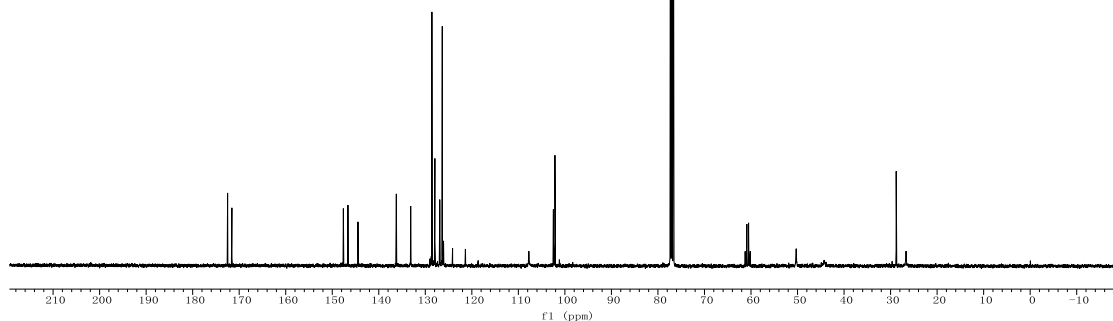
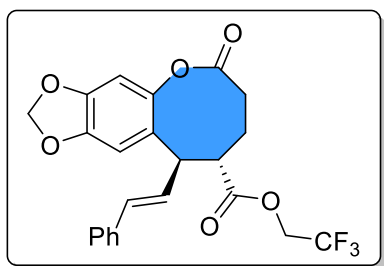
7.344, 7.335, 7.331, 7.328, 7.316, 7.293, 7.285, 7.265, 7.255, 7.24, 7.24, 7.23, 7.22, 7.22, 6.86, 6.61, 6.49, 6.45, 6.43, 6.41, 6.39, 6.37, 6.01, 6.01, 6.00, 6.00, 4.40, 4.39, 4.38, 4.37, 4.35, 4.34, 4.33, 4.32, 4.31, 3.81, 3.79, 3.77, 2.92, 2.91, 2.60, 2.59, 2.58, 2.57, 2.56, 2.54, 2.54, 2.38, 2.38, 2.36, 2.35, 2.34, 2.33, 2.32, 2.31, 2.26, 2.24, 2.22, 2.22, 2.21, 2.21, 2.20, 2.19, 2.18, 2.18, 2.16, 2.16, -0.00



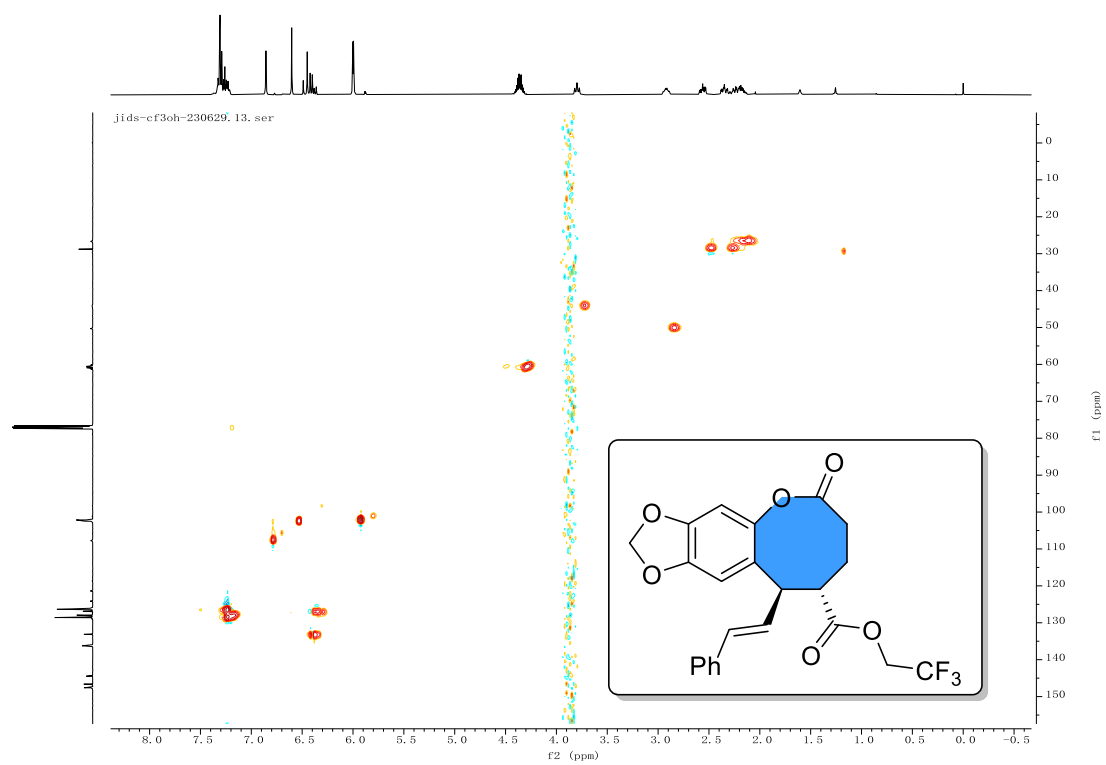
Compound-3ja (¹³C NMR 101MHz, CDCl₃)

jids-cf3oh-230629.12.fid

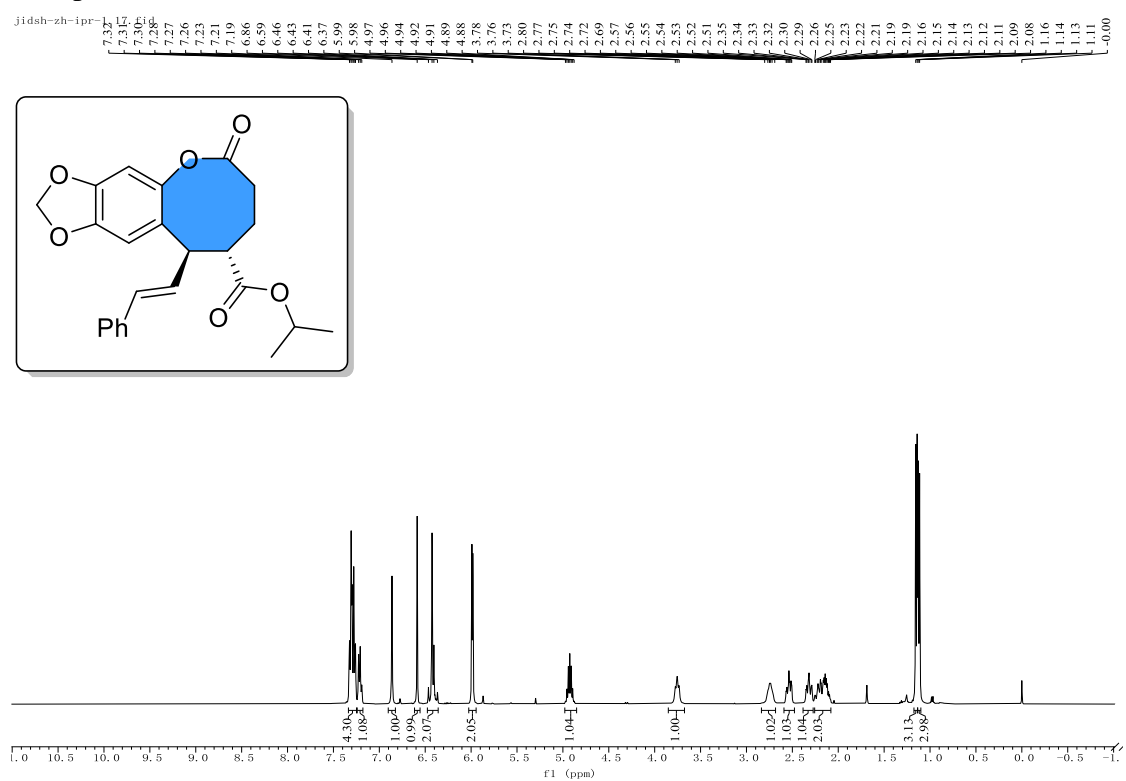
172.5, 171.6, 147.6, 146.6, 144.5, 136.2, 133.1, 128.6, 127.9, 126.9, 126.4, 126.1, 124.1, 121.4, 107.7, 102.5, 102.1, 77.3, 77.0, 76.7, 61.3, 60.9, 60.5, 60.2, 50.3, 44.6, 28.8, 26.7



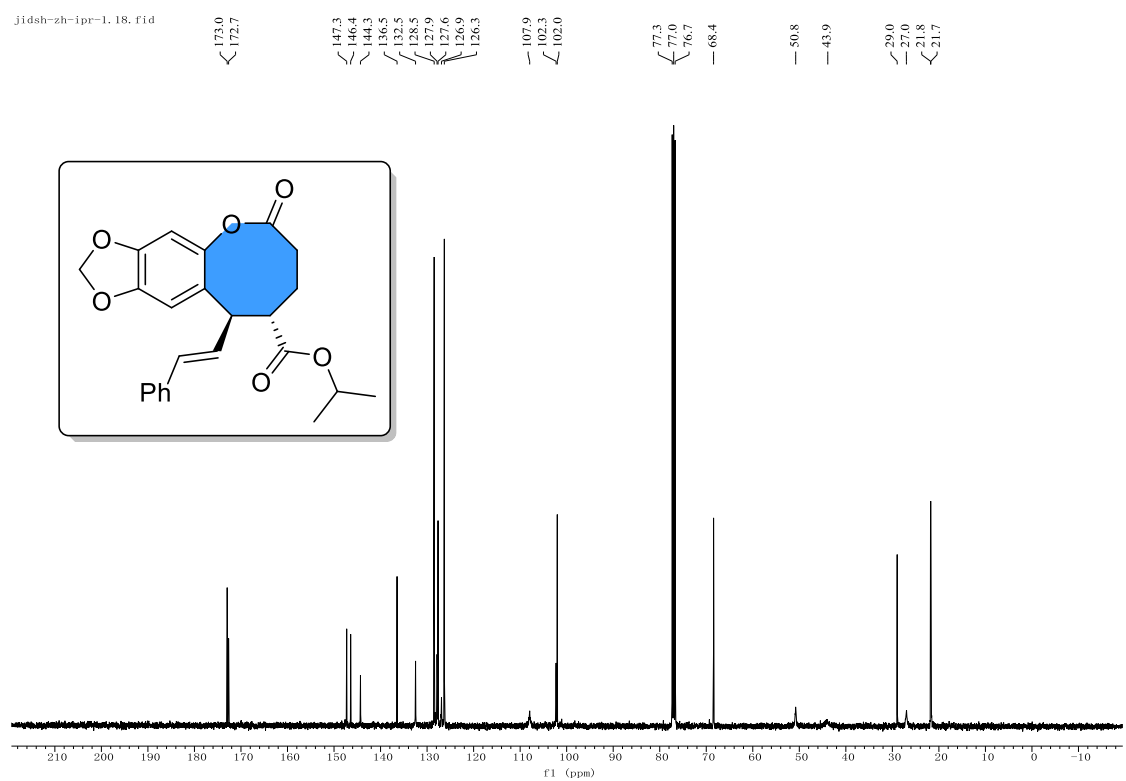
3ja-HSQC (400MHz, CDCl₃)



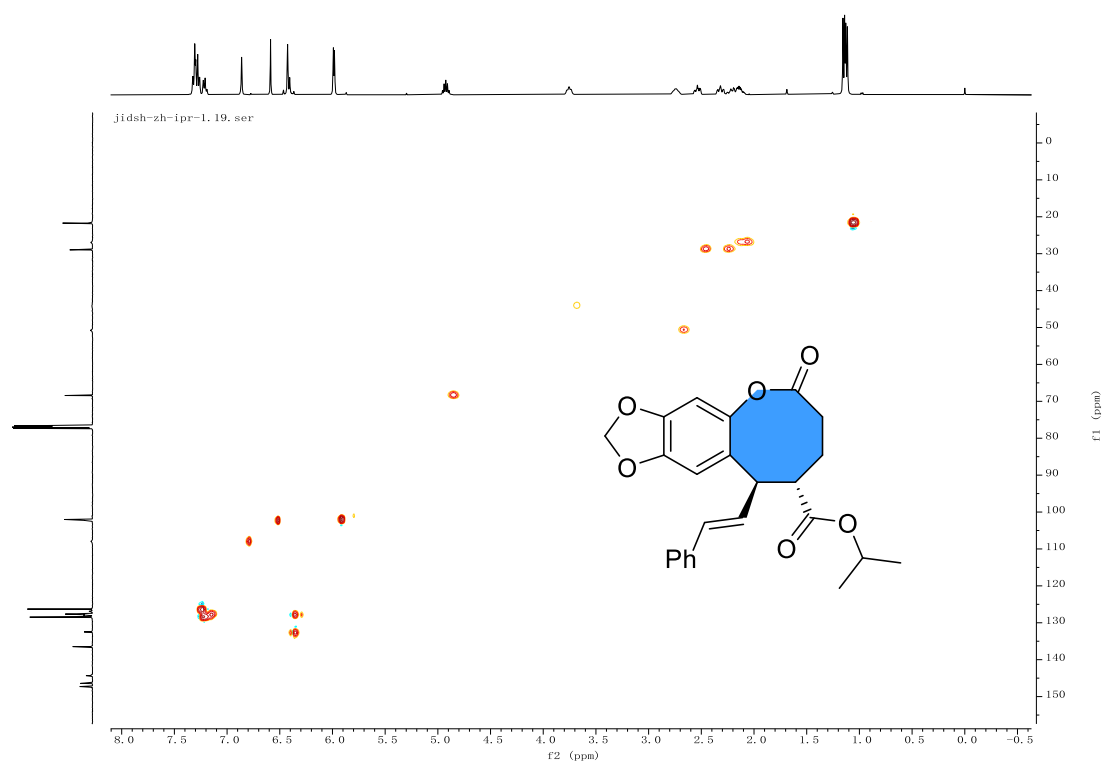
Compound-3ka (¹HNMR 400MHz, CDCl₃)



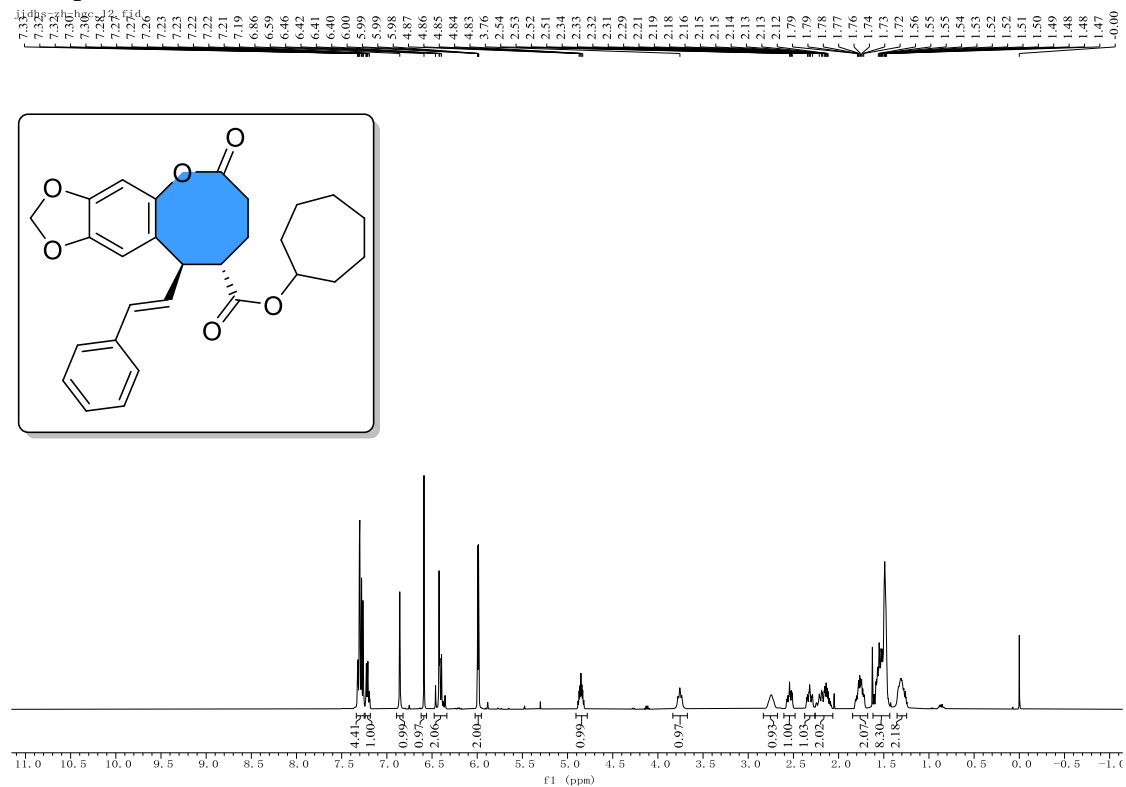
¹³CNMR 101MHz, CDCl₃



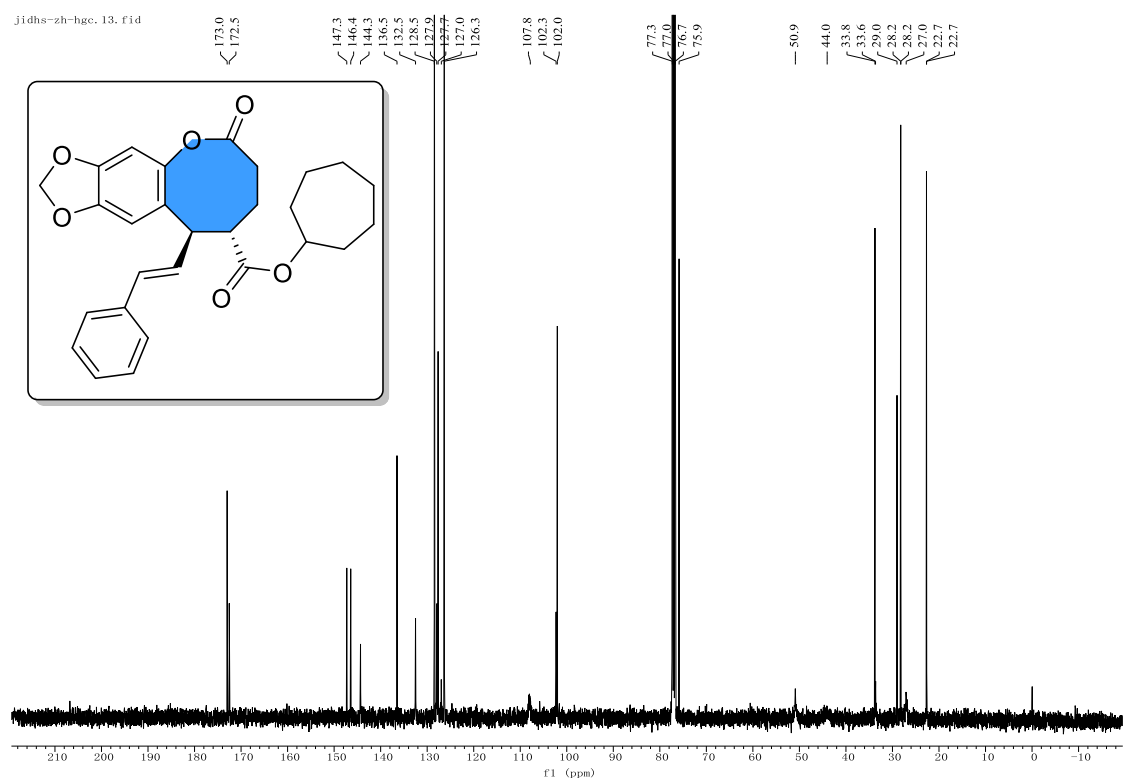
HSQC



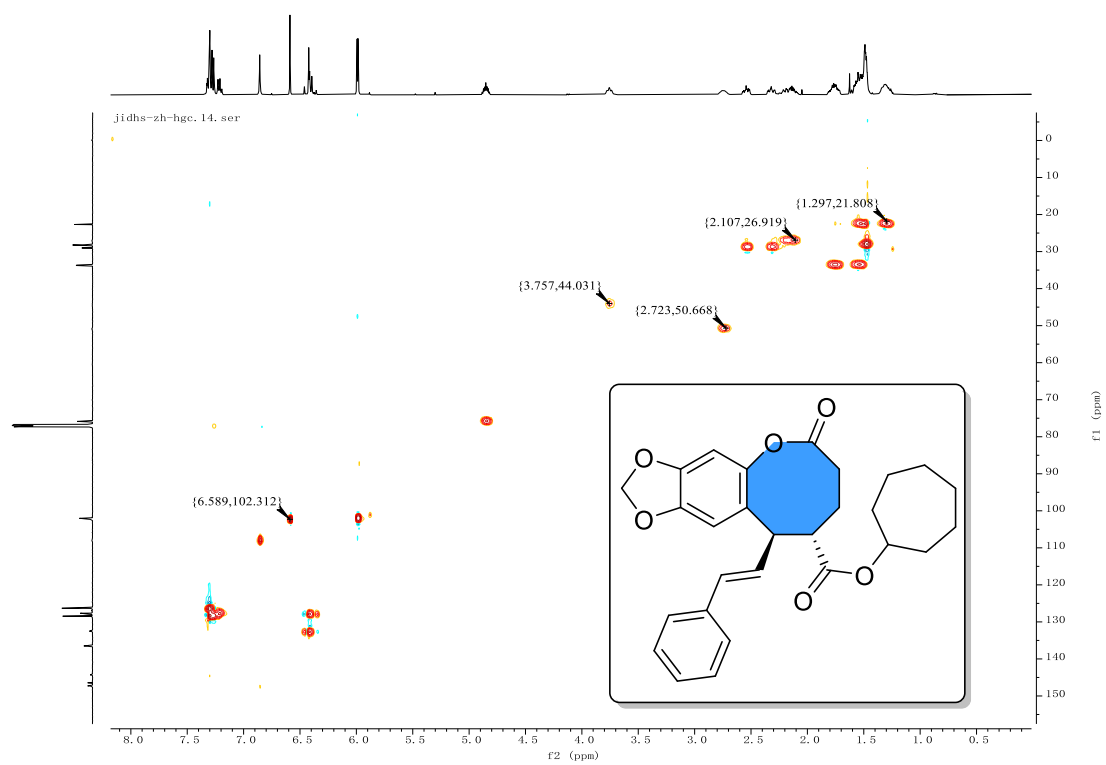
Compound-3la (¹HNMR 400MHz, CDCl₃)



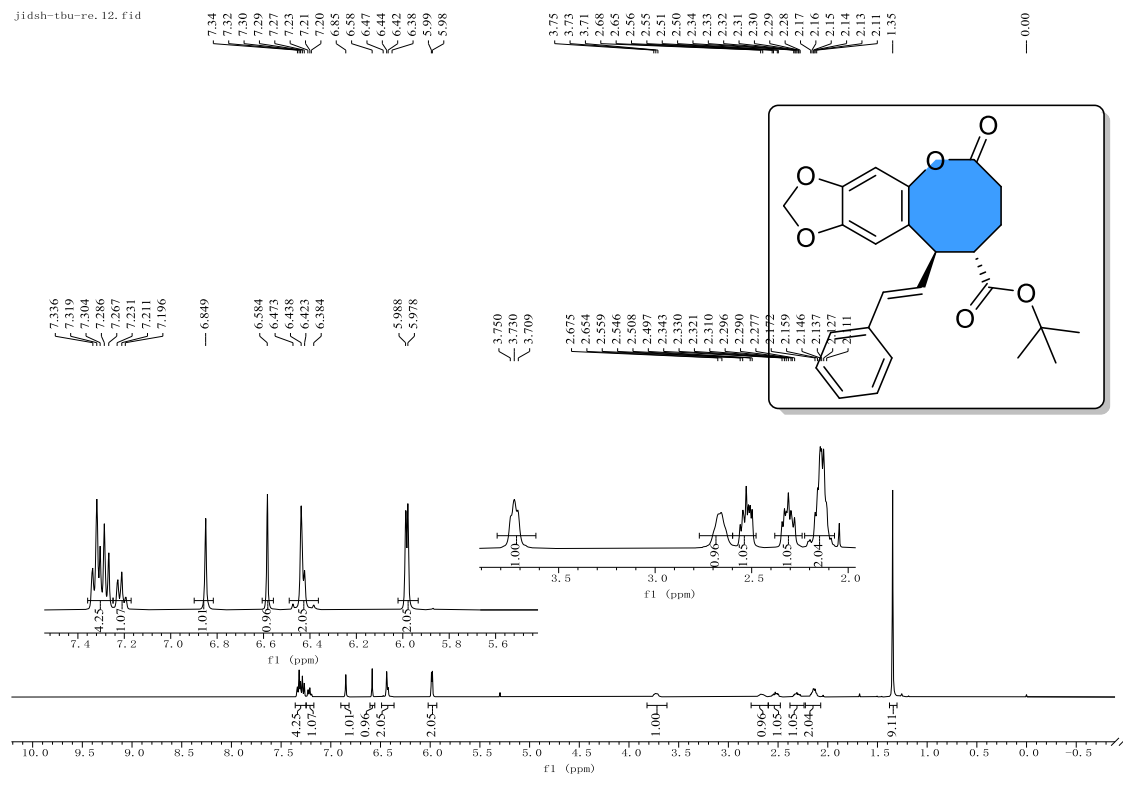
¹³CNMR 101MHz, CDCl₃



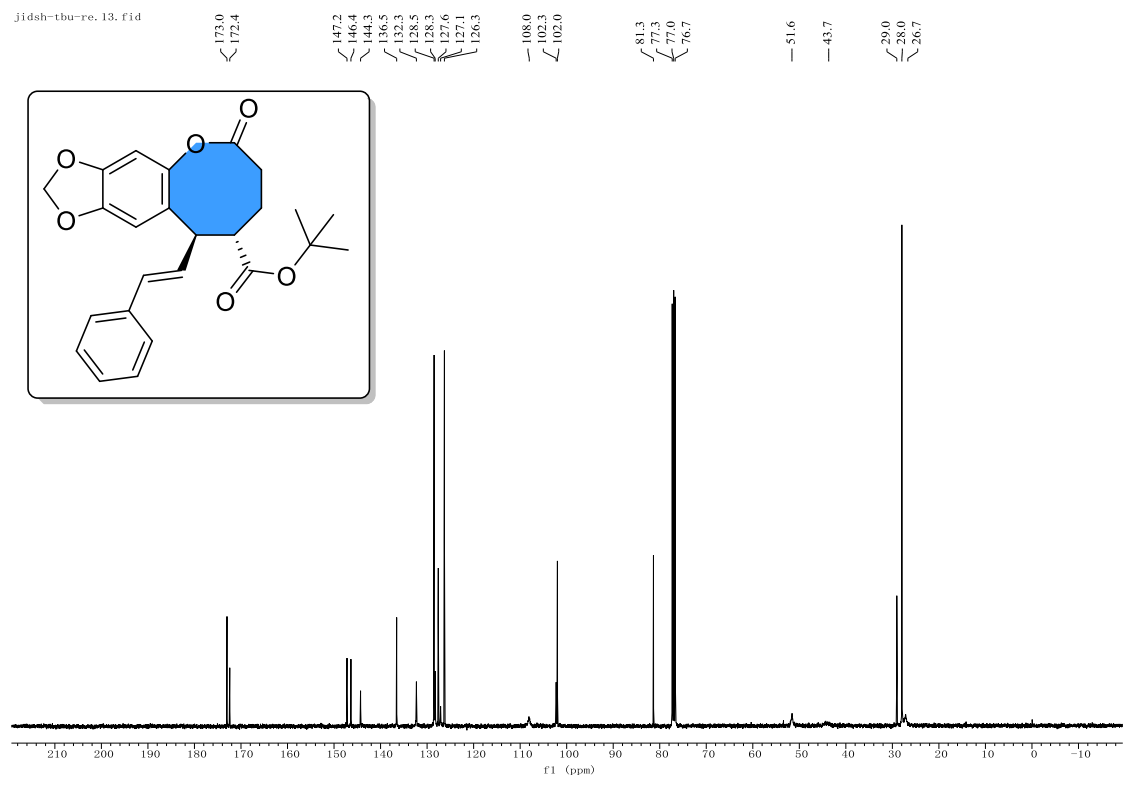
HSQC



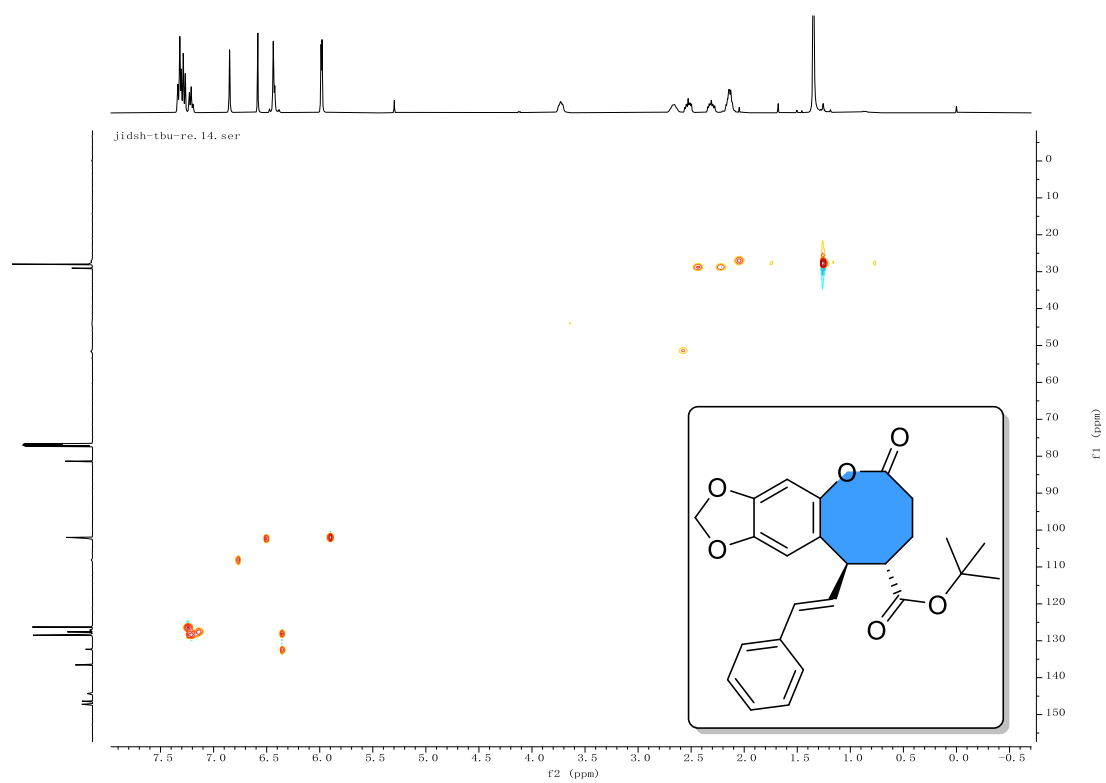
Compound-3ma (¹HNMR 400MHz, CDCl₃)



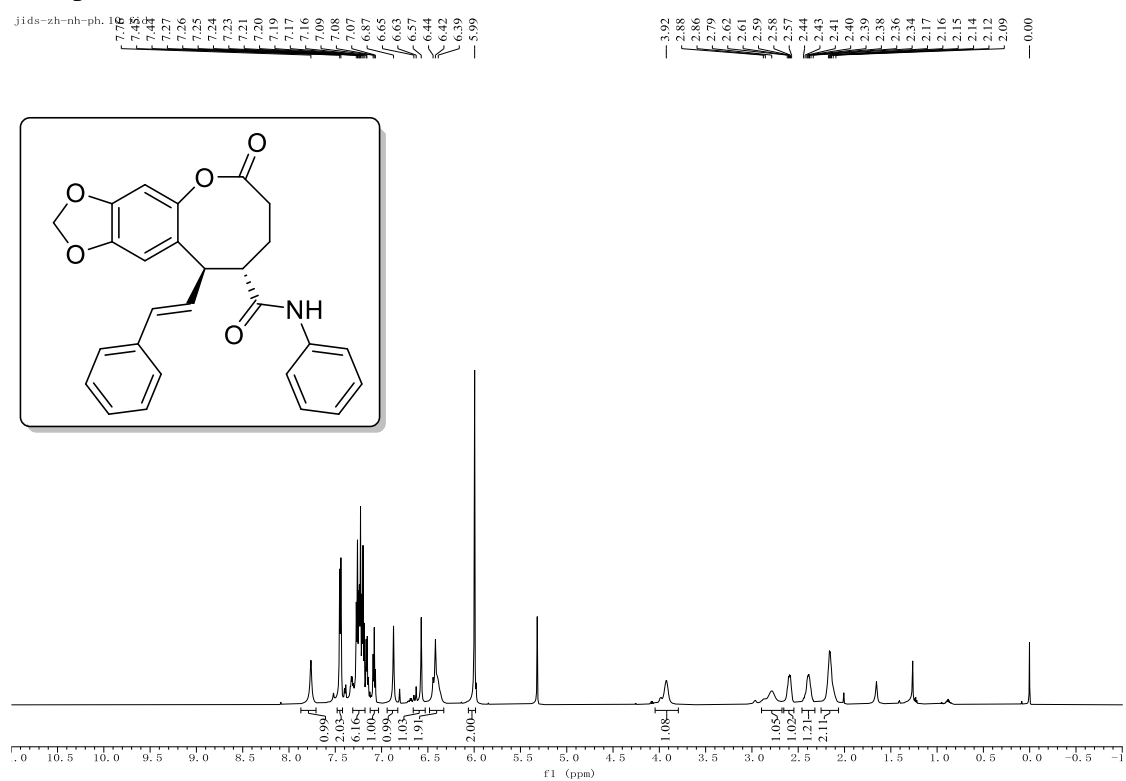
¹³CNMR 101MHz, CDCl₃



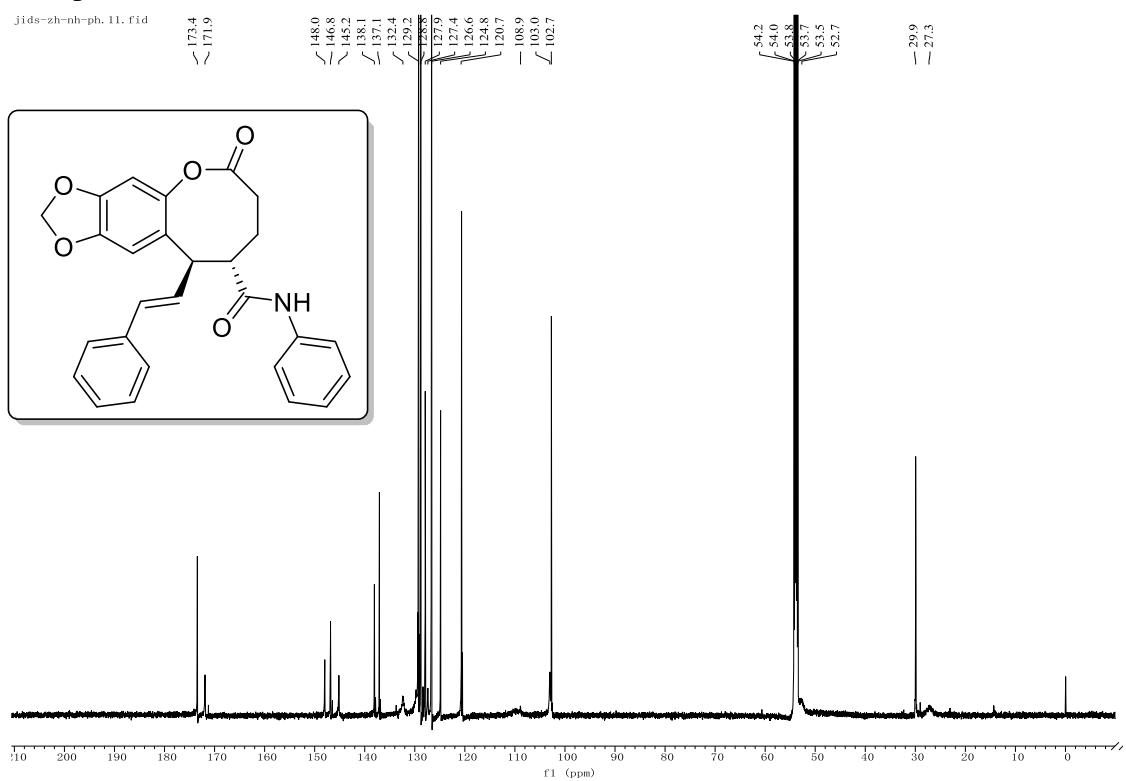
HSQC



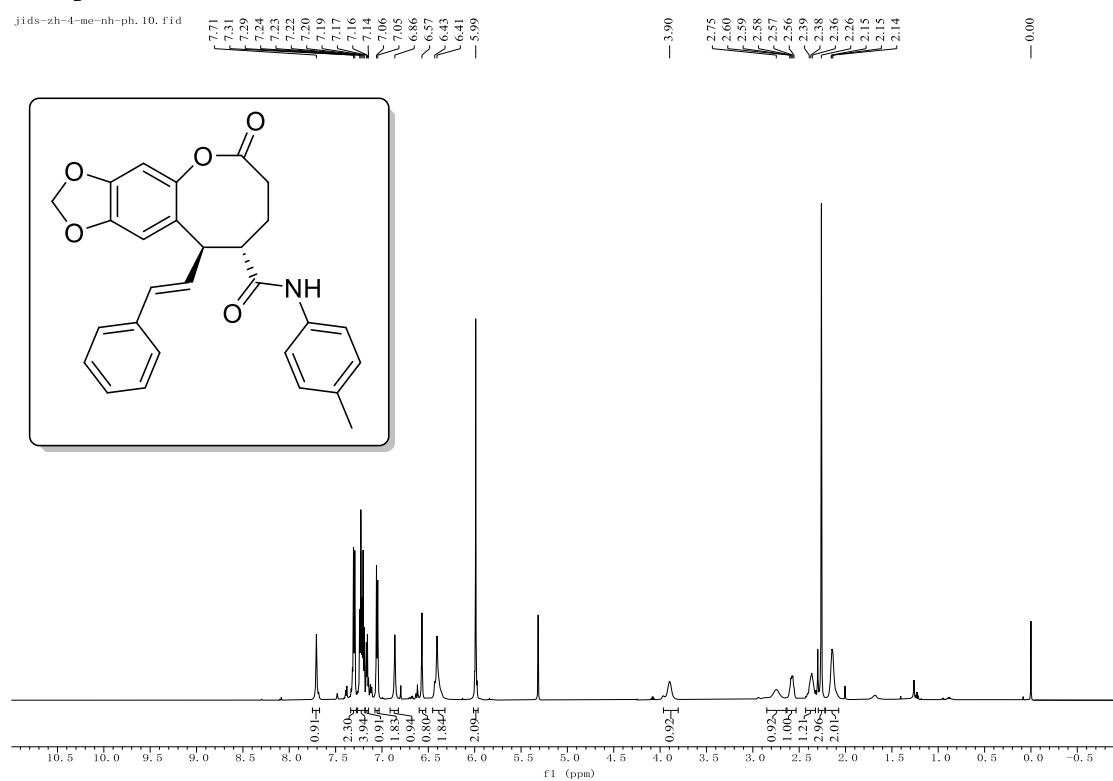
Compound-3na ¹H NMR (600 MHz, CD₂Cl₂)



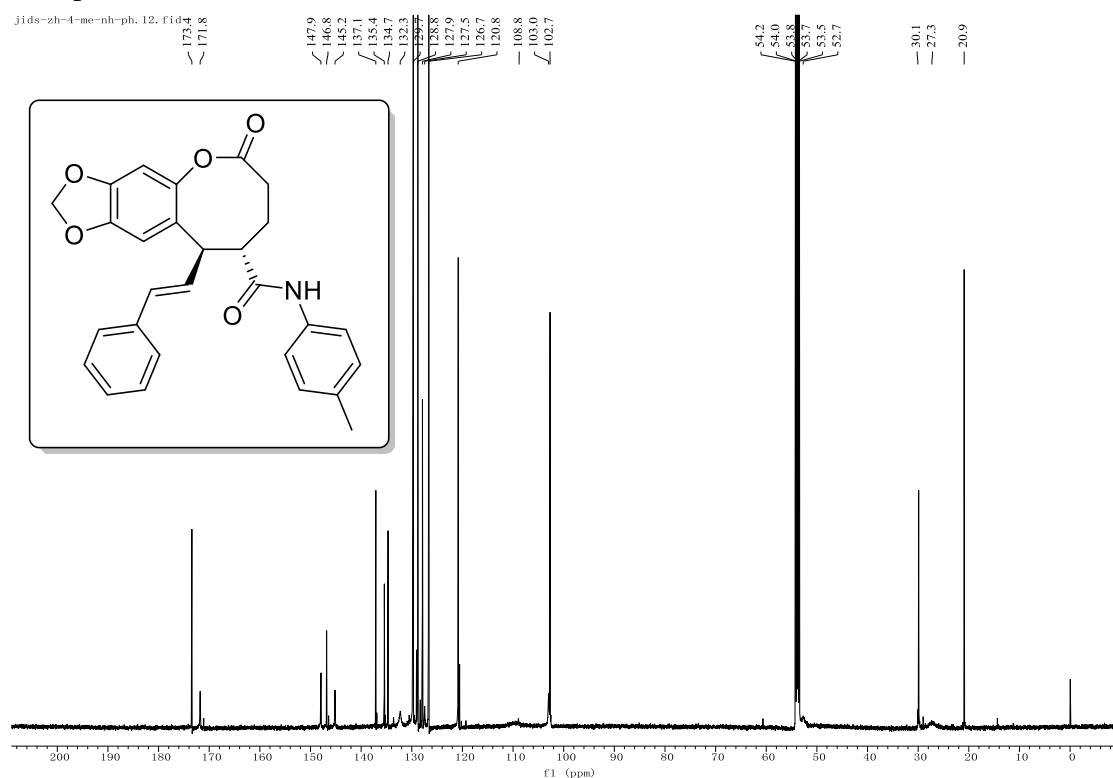
Compound-3na ¹³C NMR (150 MHz, CD₂Cl₂)



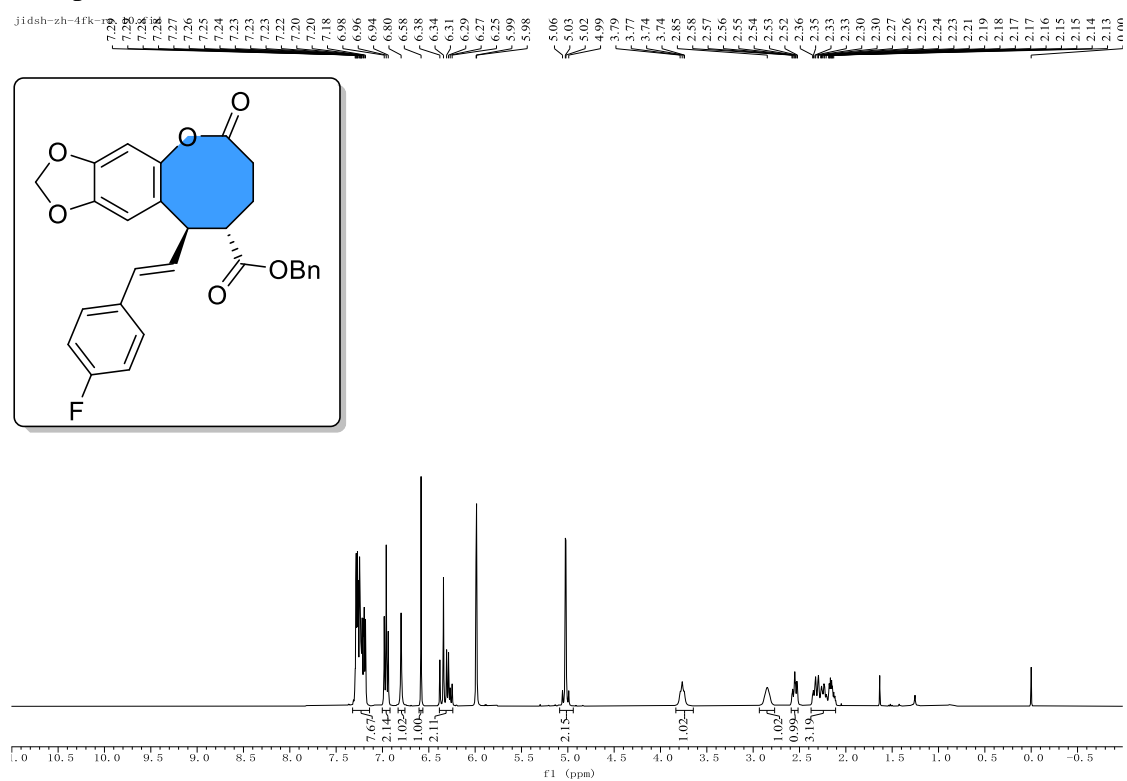
Compound-3oa ¹H NMR (600 MHz, CD₂Cl₂)



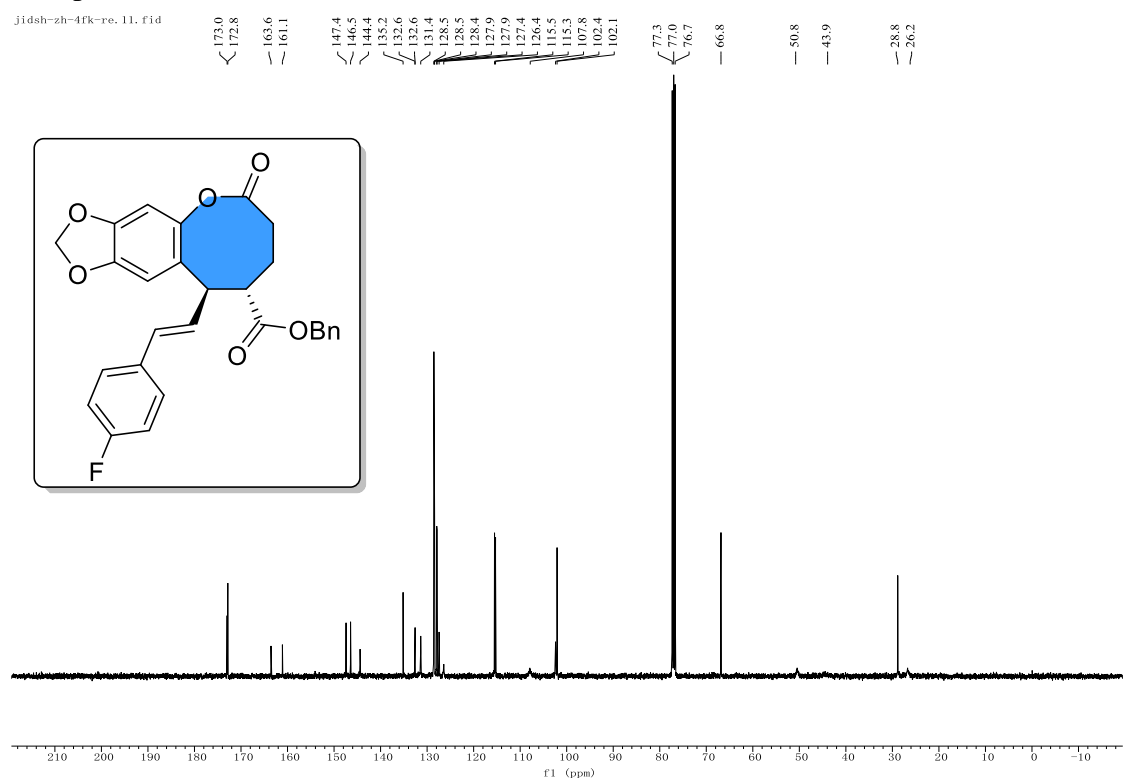
Compound-3oa ¹³C NMR (150 MHz, CD₂Cl₂)



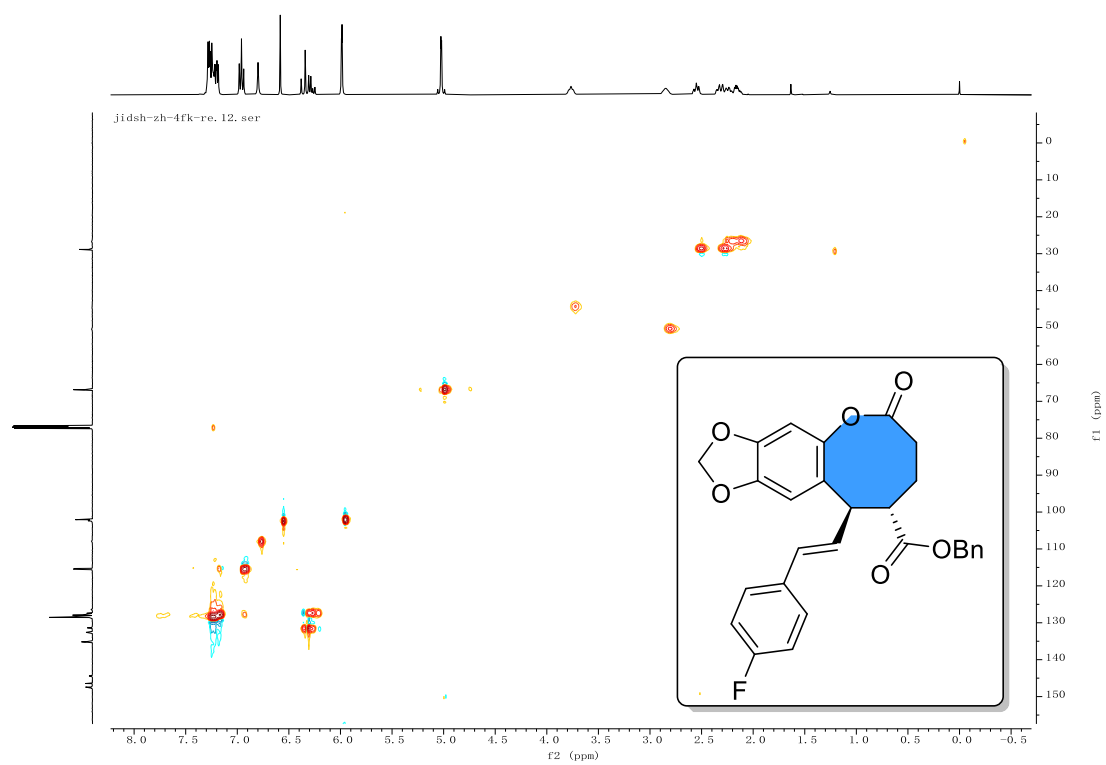
Compound-3ab (¹HNMR 400MHz, CDCl₃)



Compound-3ab (¹³CNMR 101MHz, CDCl₃)

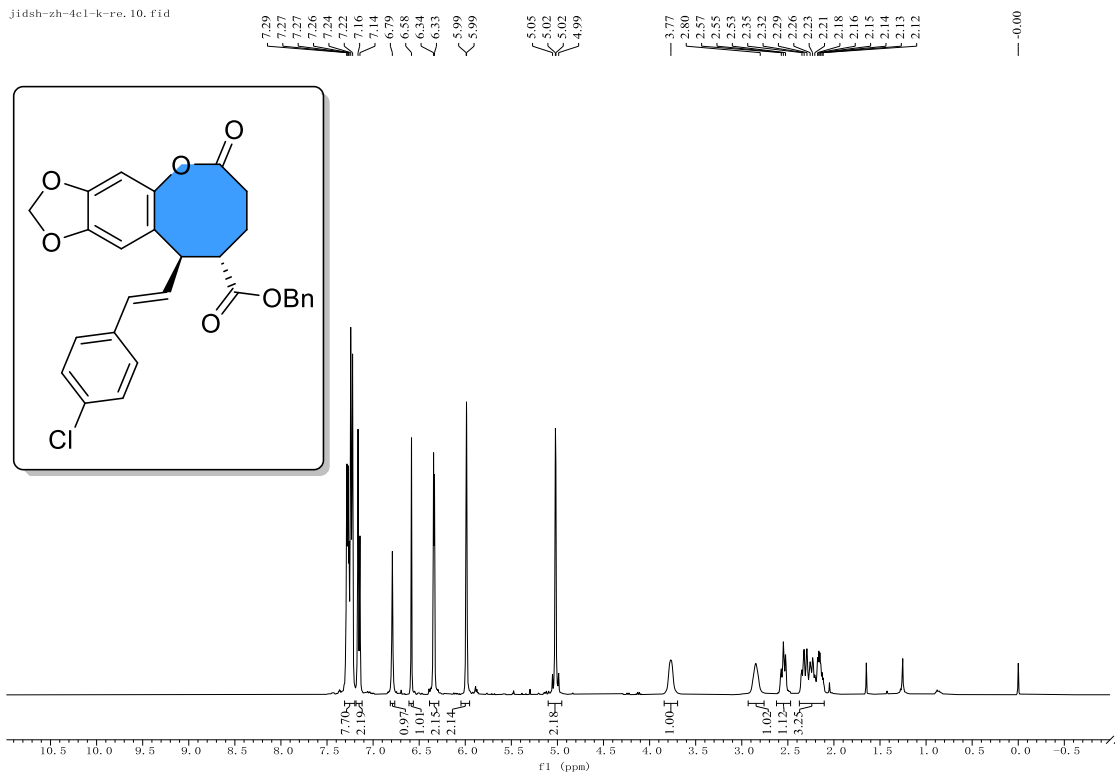


HSQC



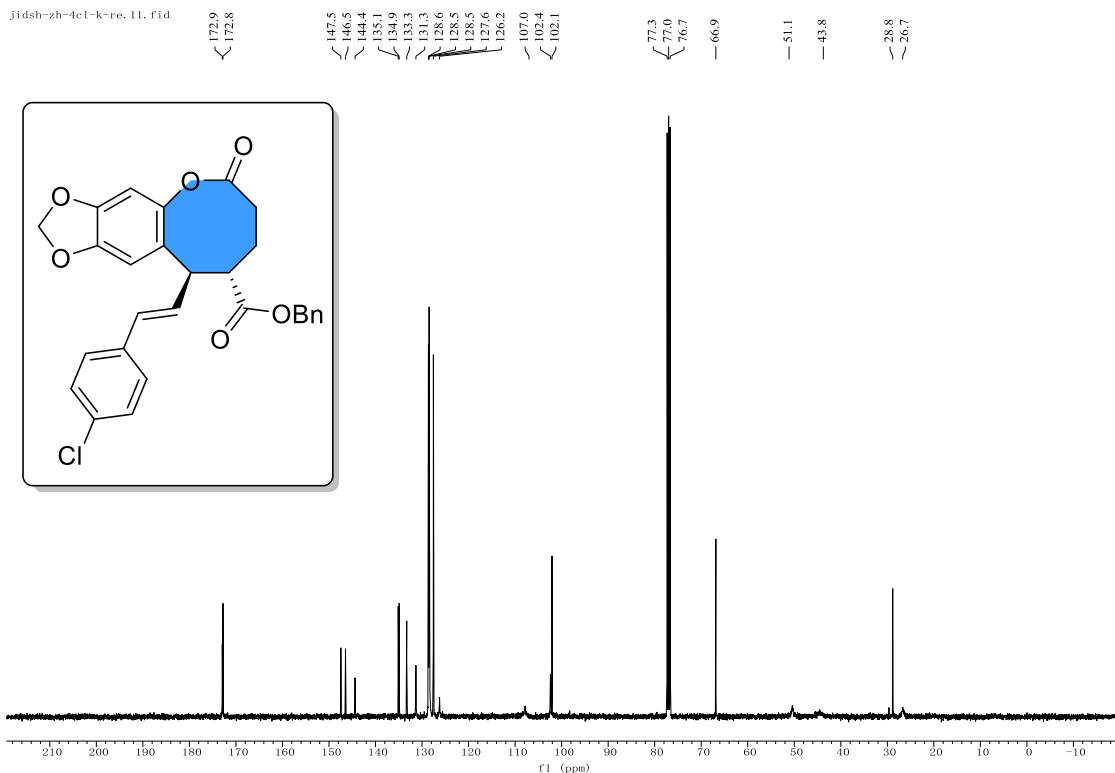
Compound-3ac (¹HNMR 400MHz, CDCl₃)

jidsh-zh-4cl-k-re, 10. fid

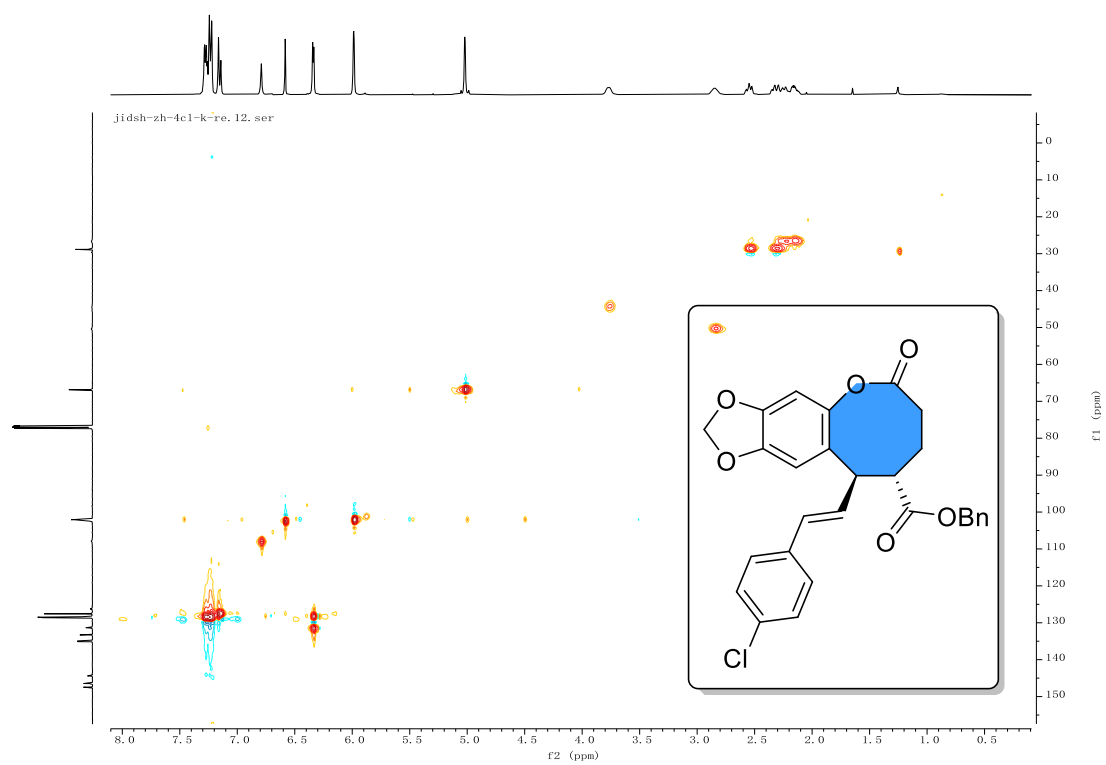


Compound-3ac (¹³CNMR 101MHz, CDCl₃)

jidsh-zh-4cl-k-re, 11. fid

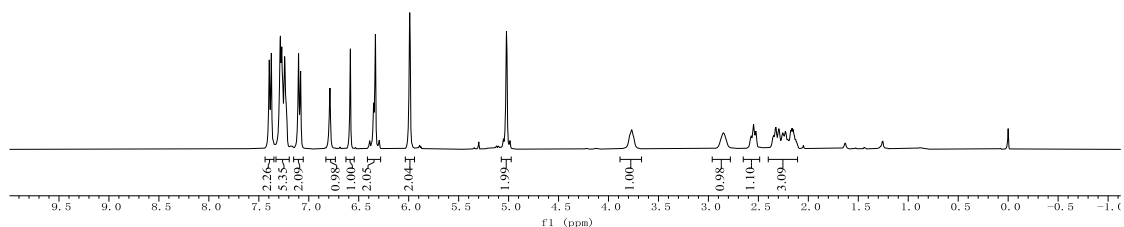
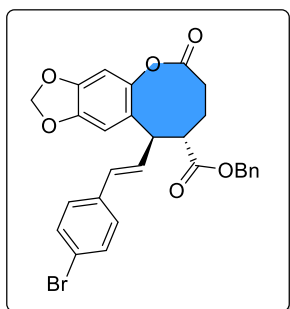
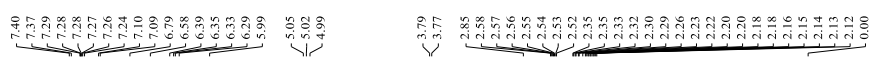


HSQC



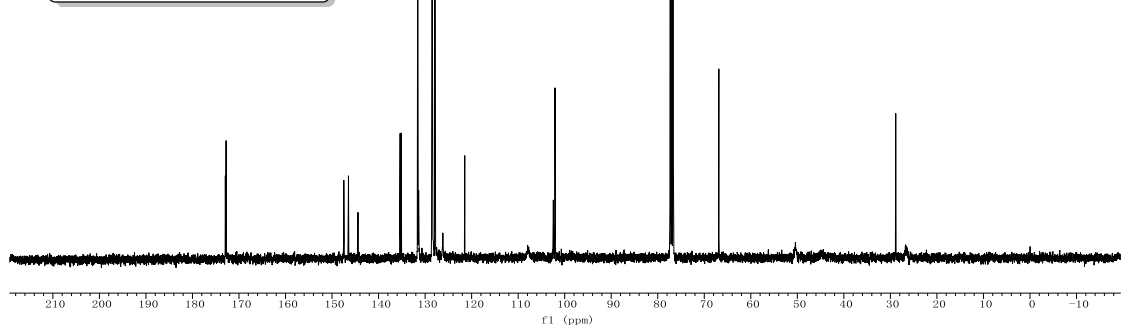
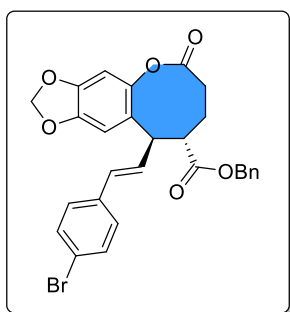
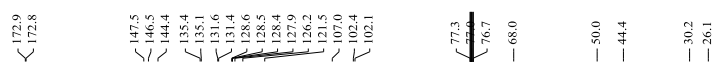
Compound-3ad (¹HNMR 400MHz, CDCl₃)

jidsh-4-br-k-cbz. 11. F1d

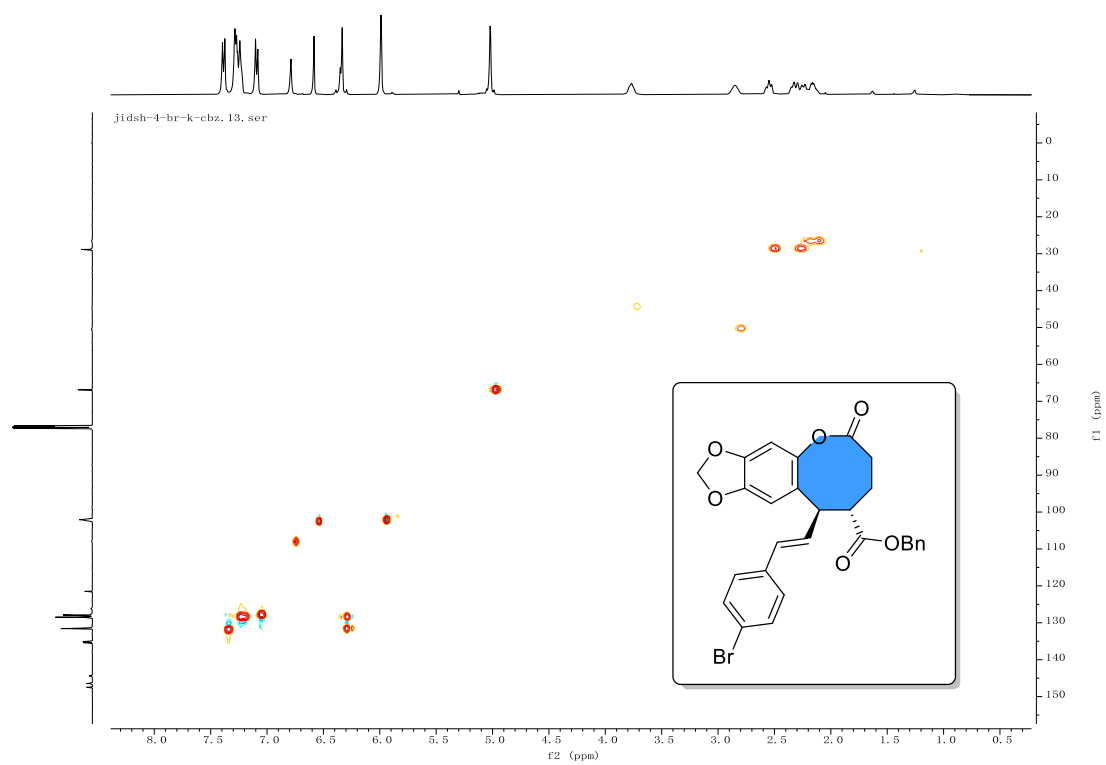


Compound-3ad ¹³CNMR 101MHz, CDCl₃

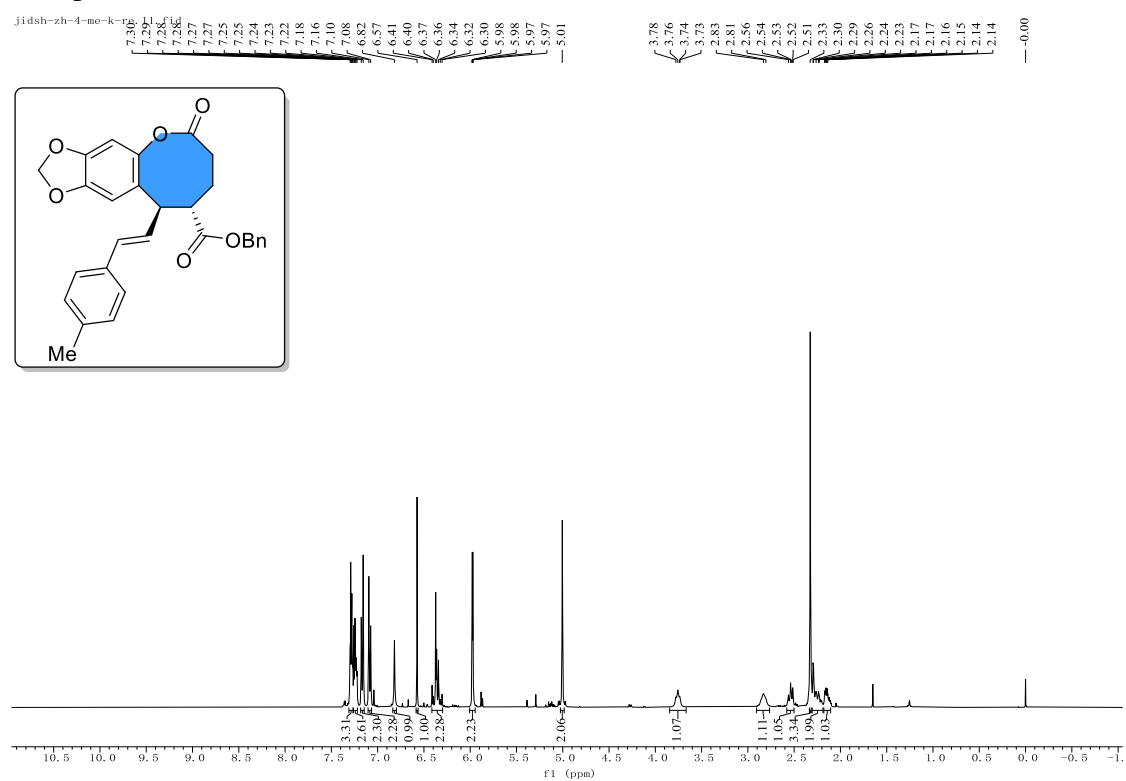
jidsh-4-br-k-cbz. 12. F1d



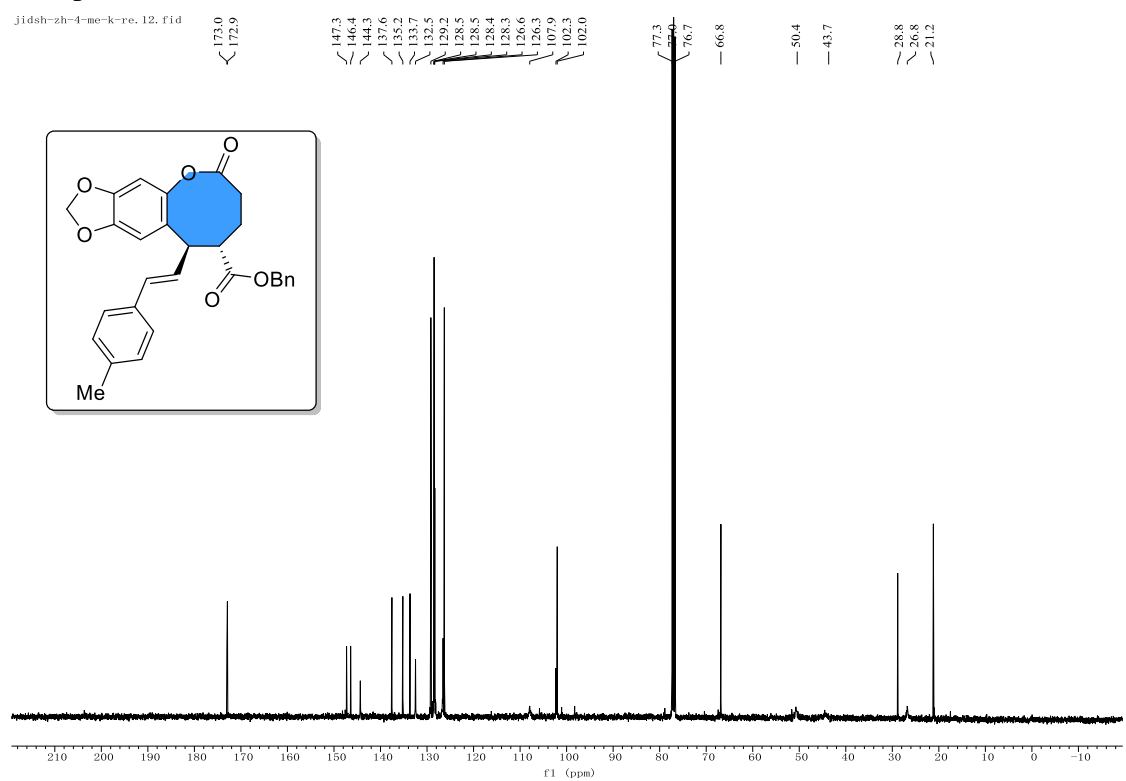
HSQC



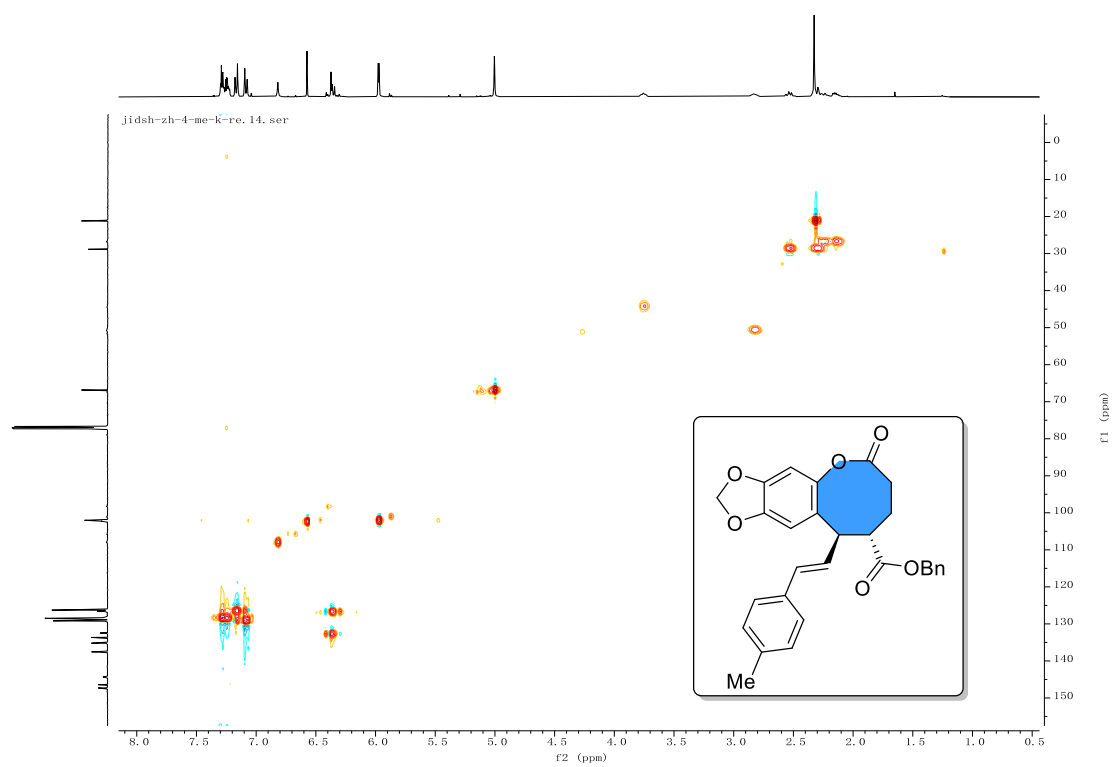
Compound-3ae (¹HNMR 400MHz, CDCl₃)



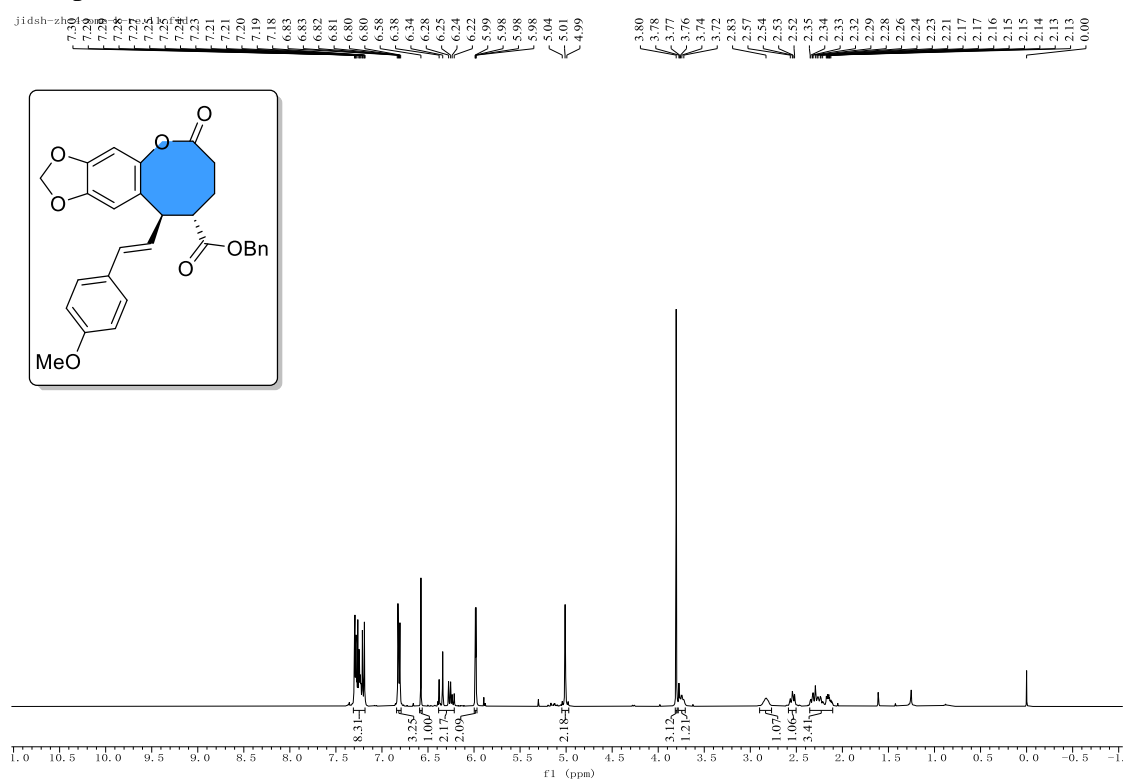
Compound-3ae (¹³CNMR 101MHz, CDCl₃)



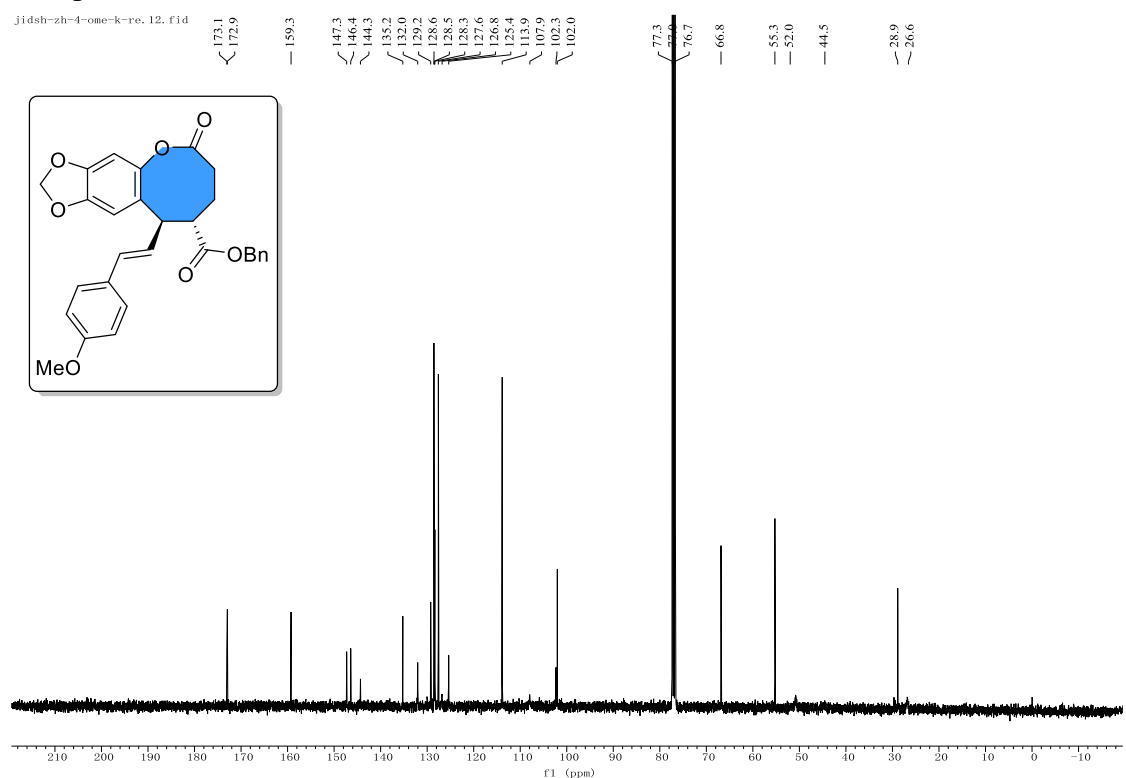
Compound-3ae HSQC (¹HNMR 400MHz, CDCl₃)



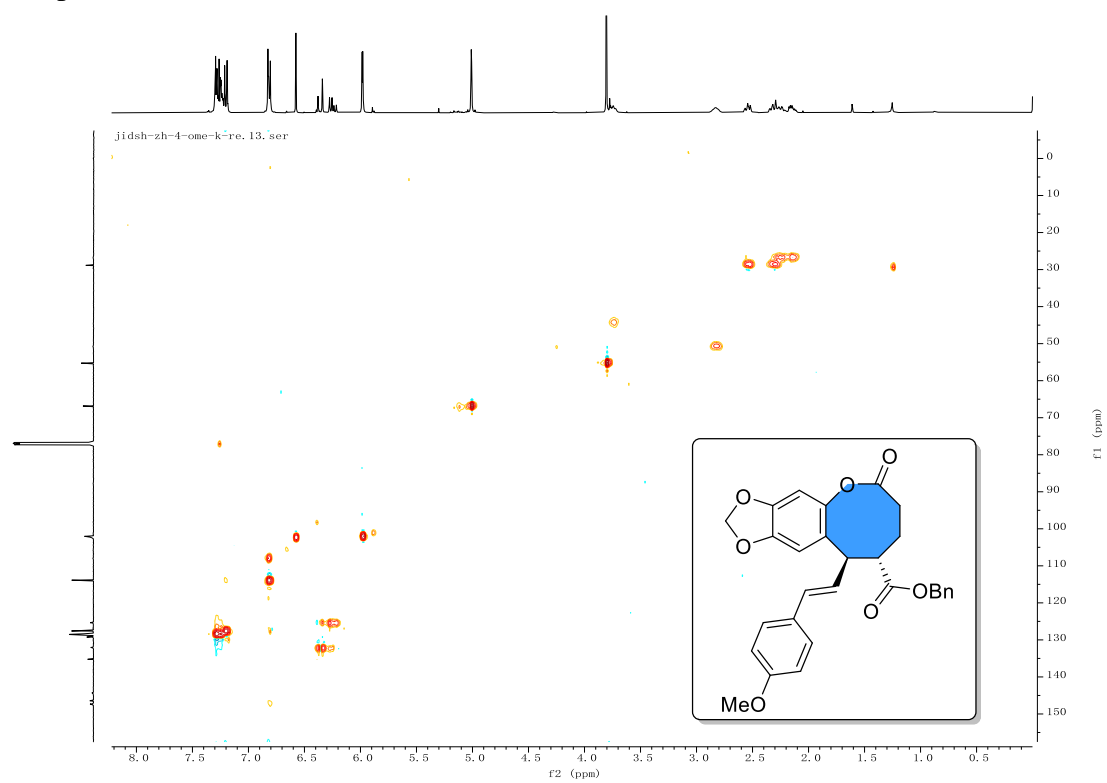
Compound-3af (^1H NMR 400MHz, CDCl_3)



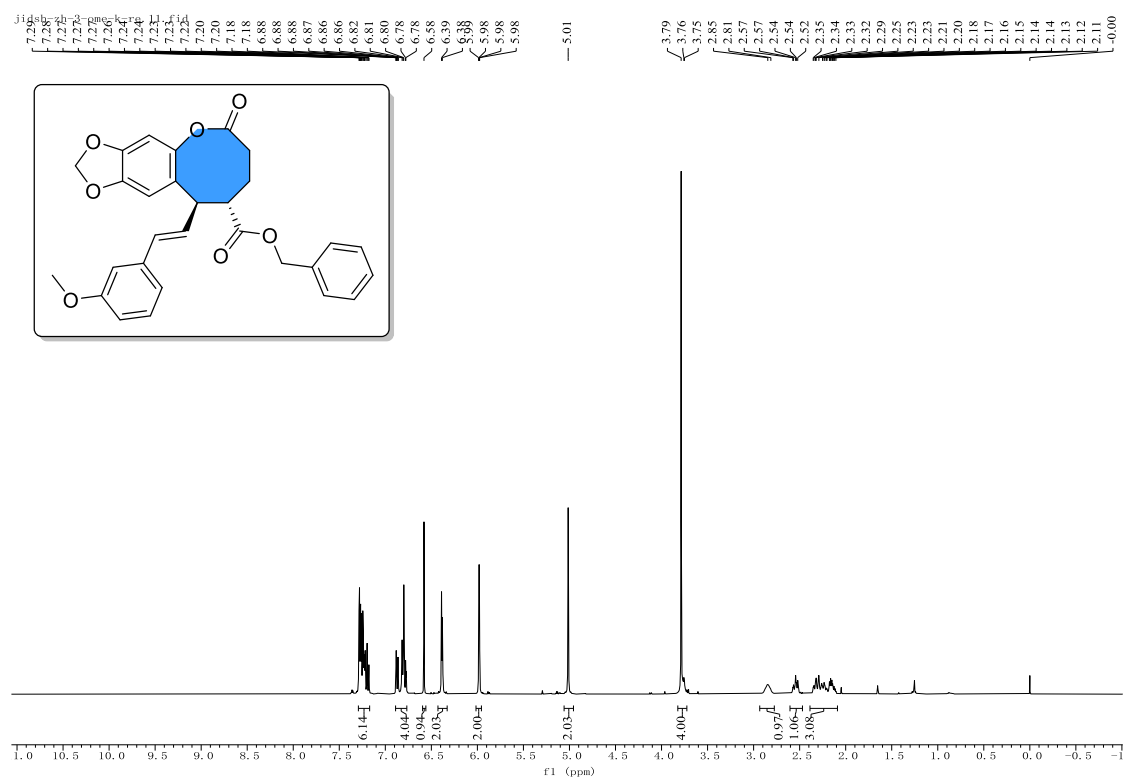
Compound-3af (^{13}C NMR 101MHz, CDCl_3)



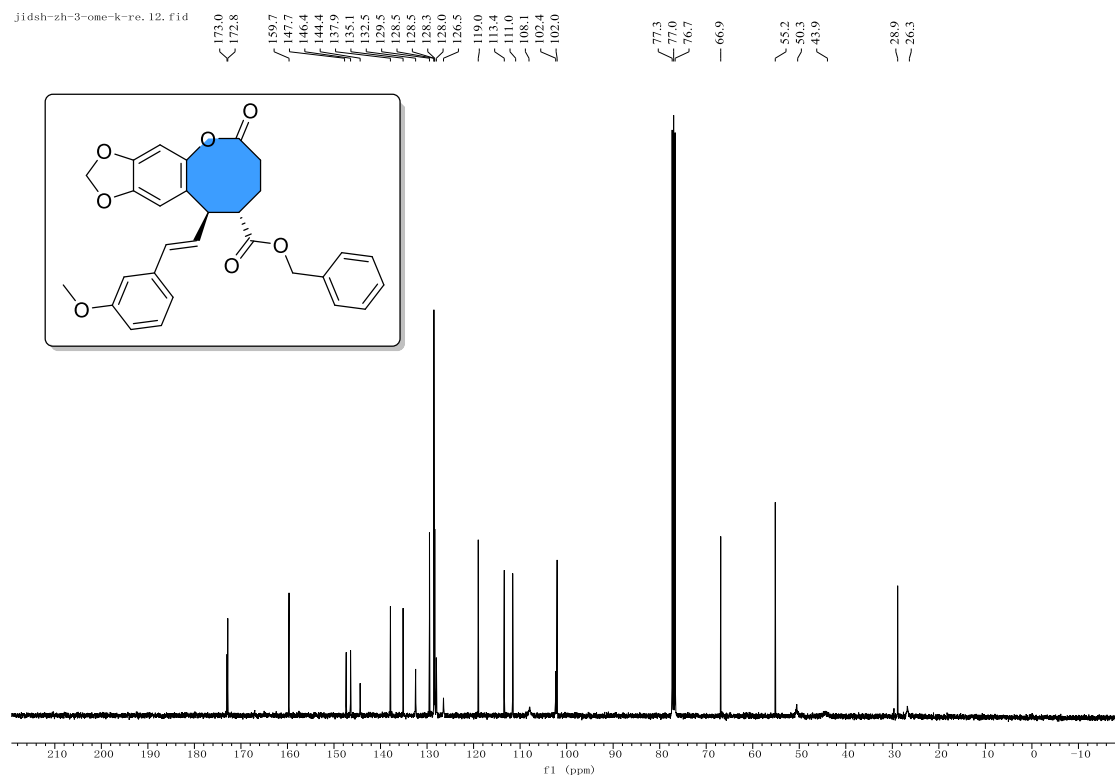
Compound-3af HSQC



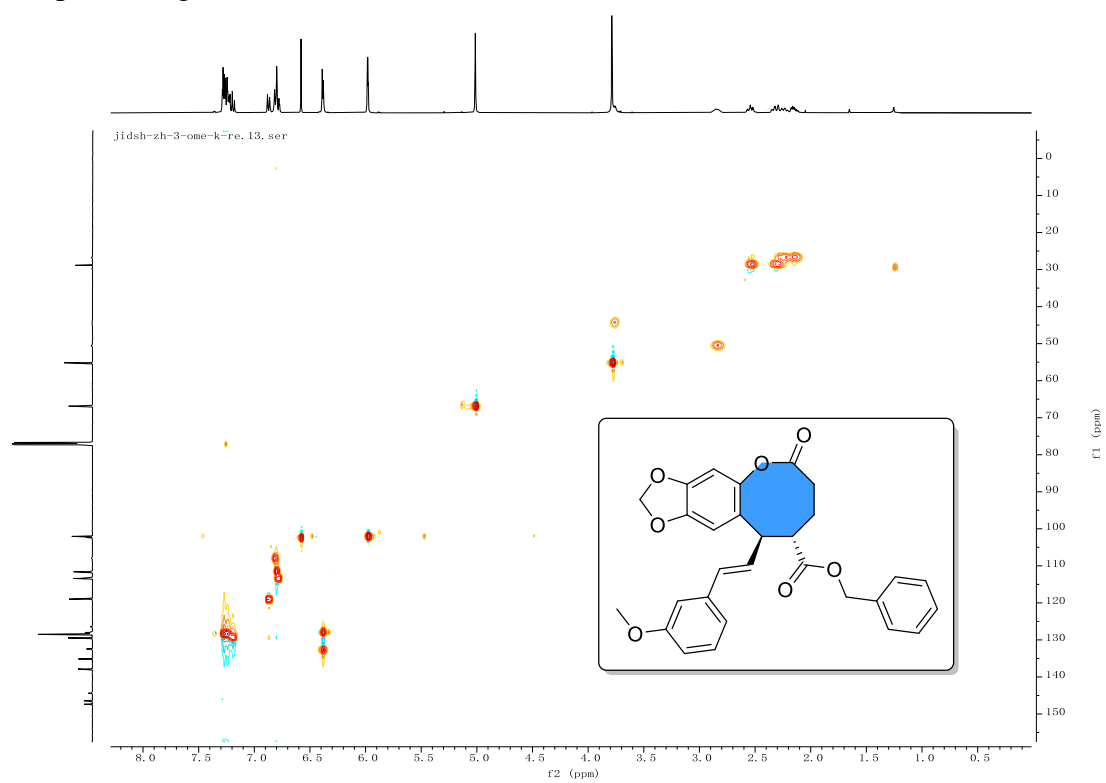
Compound-3ag (¹HNMR 400MHz, CDCl₃)



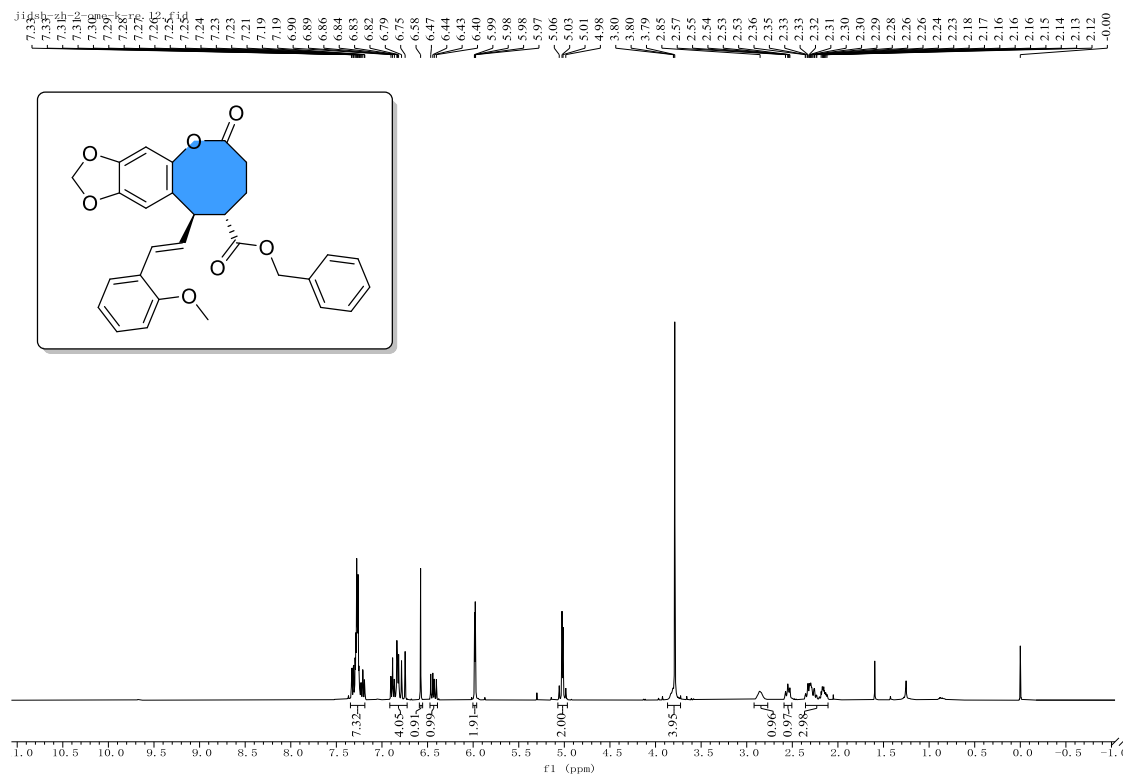
Compound-3ag (¹³CNMR 101MHz, CDCl₃)



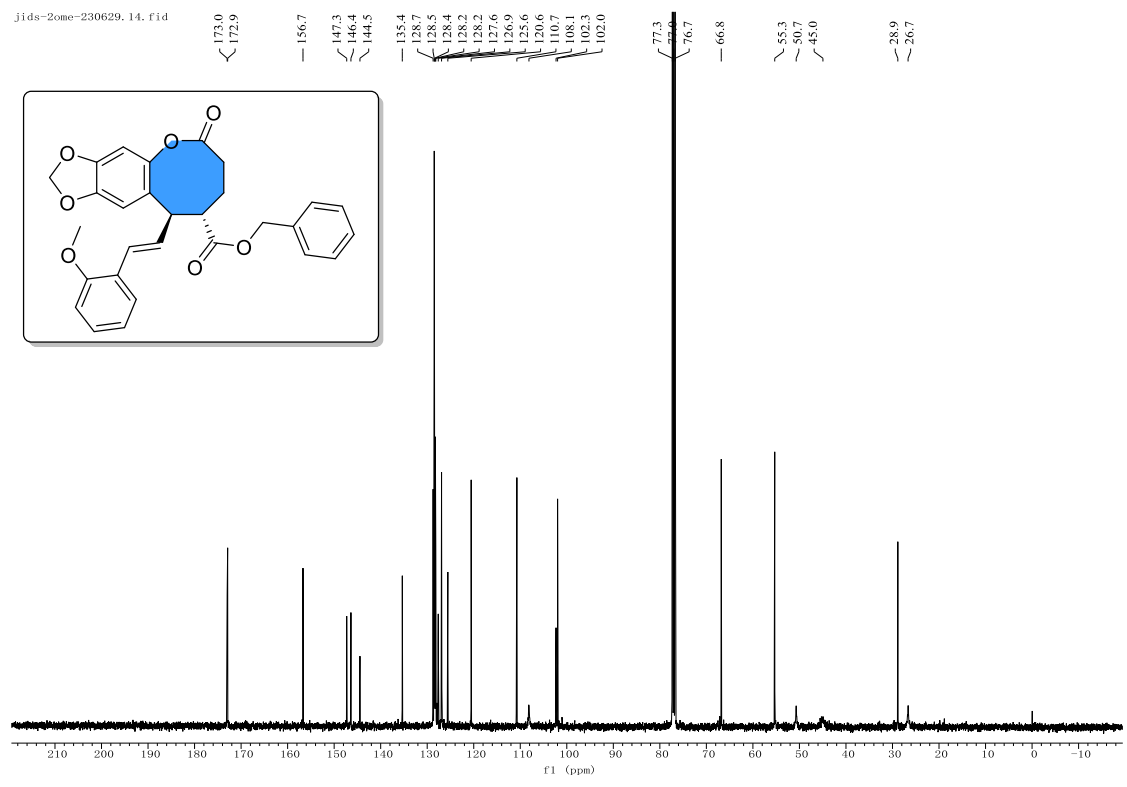
Compound-3ag HSQC



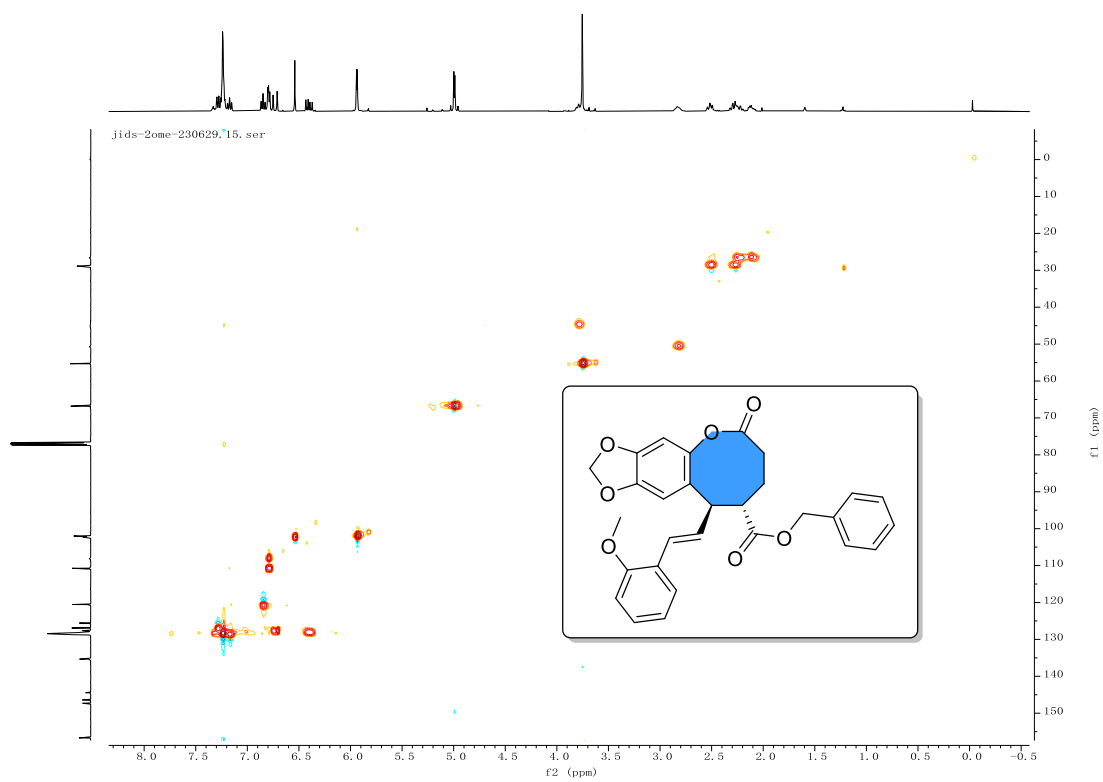
Compound-3ah (^1H NMR 400MHz, CDCl_3)



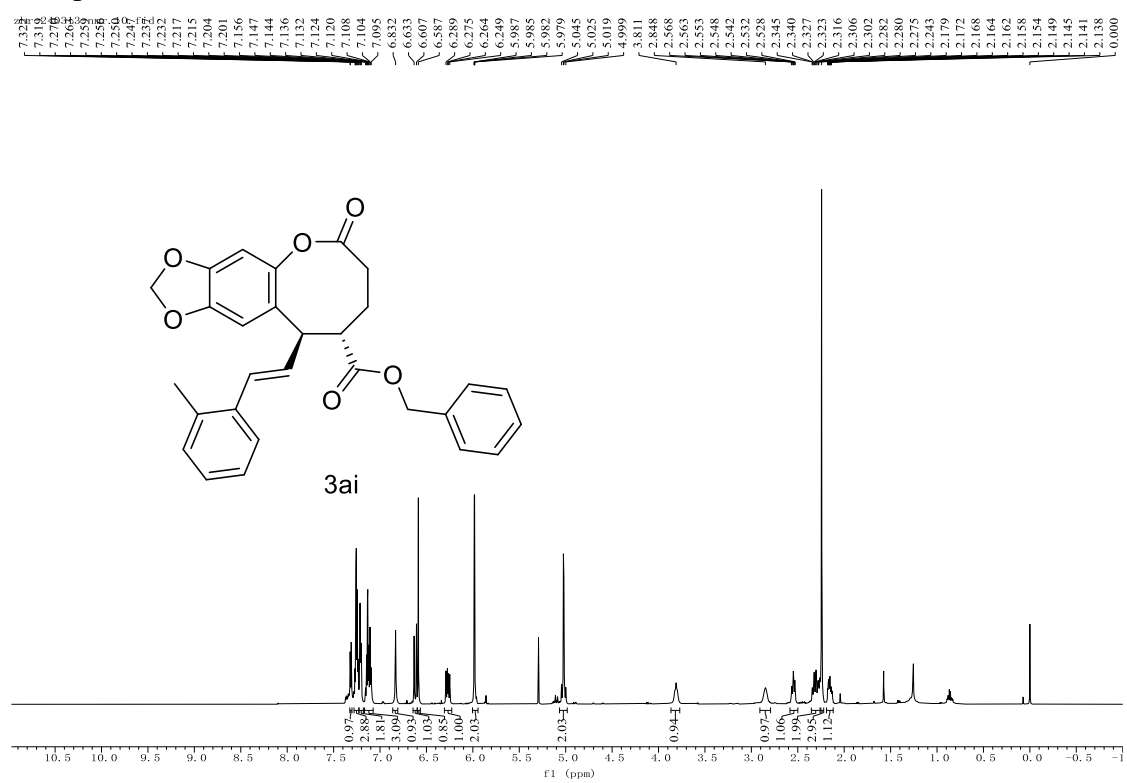
Compound-3ah ^{13}C NMR (101MHz, CDCl_3)



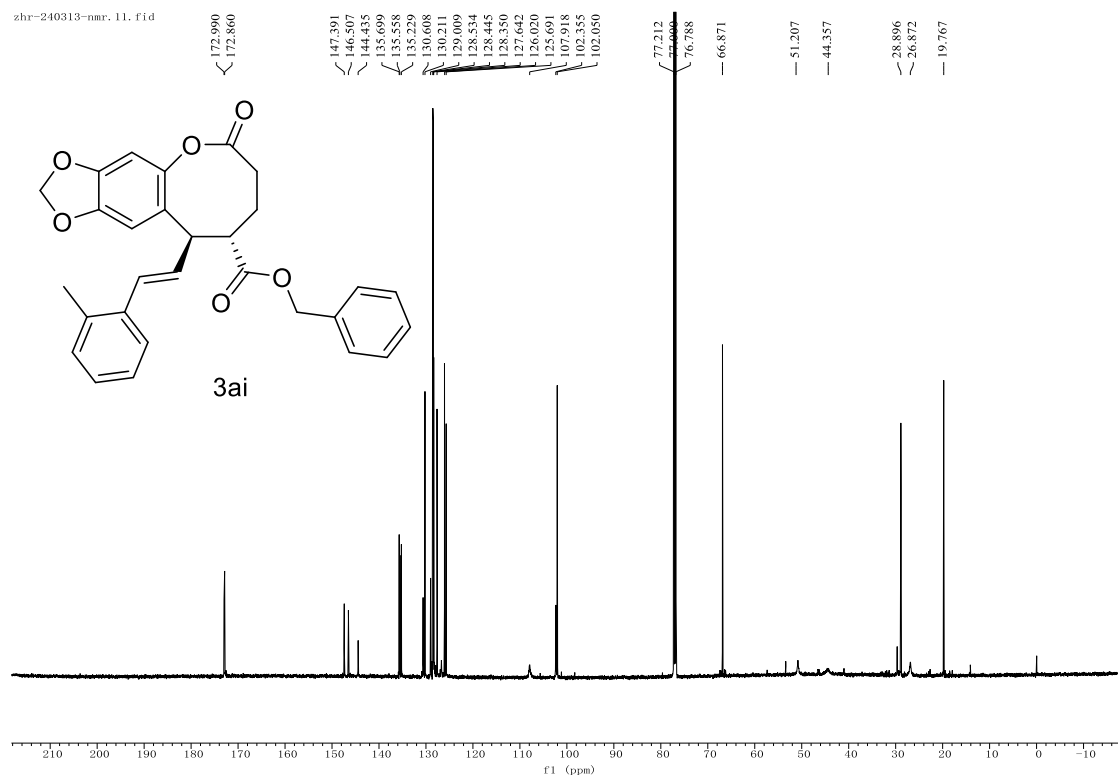
HSQC



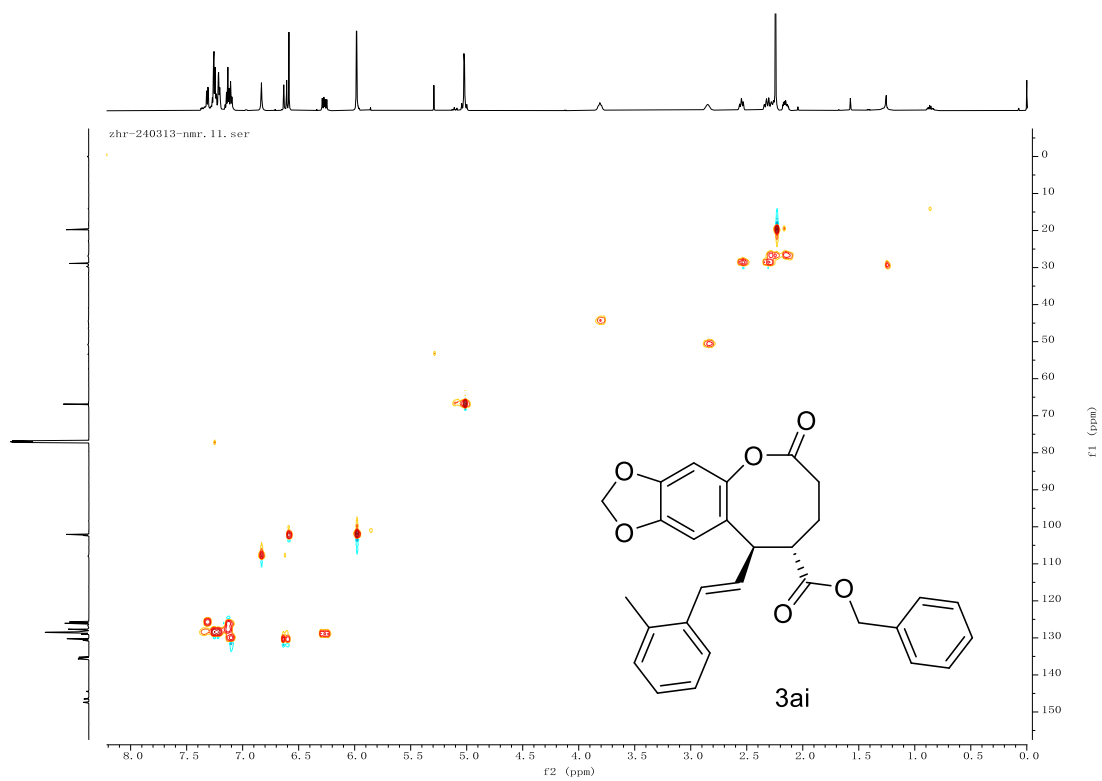
Compound-3ai ¹H NMR (600 MHz, CDCl₃)



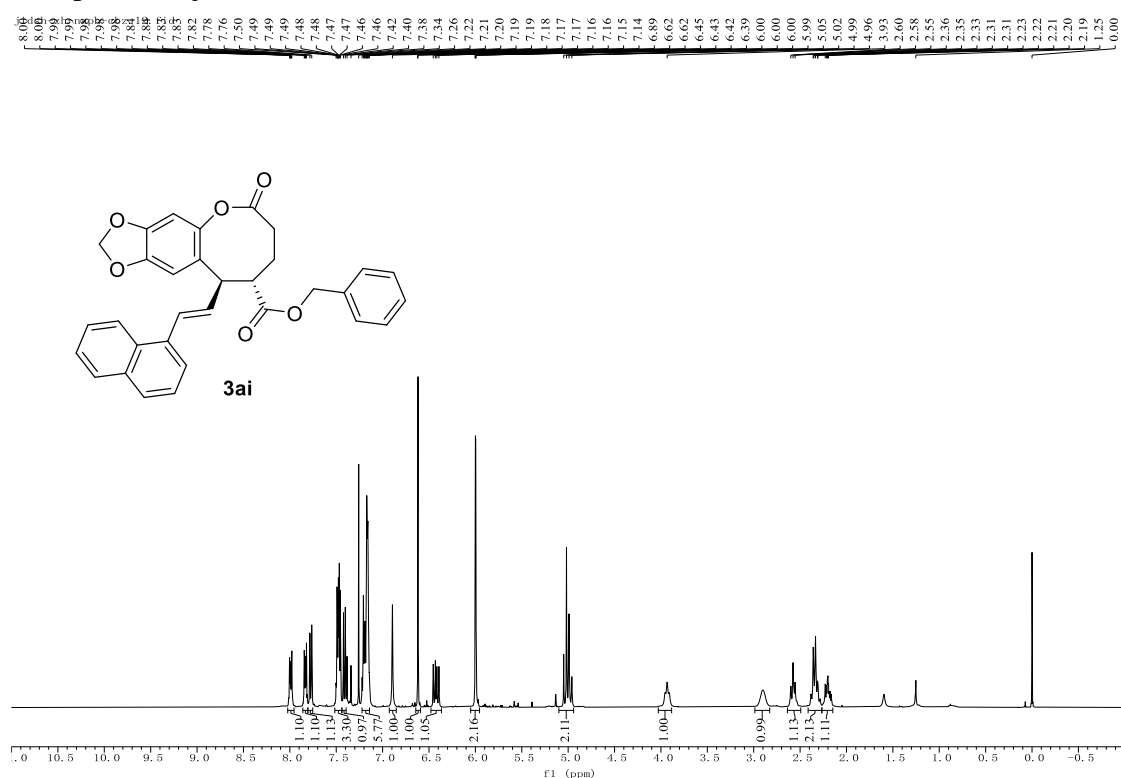
Compound-3ai ¹³C NMR (150 MHz, CDCl₃)



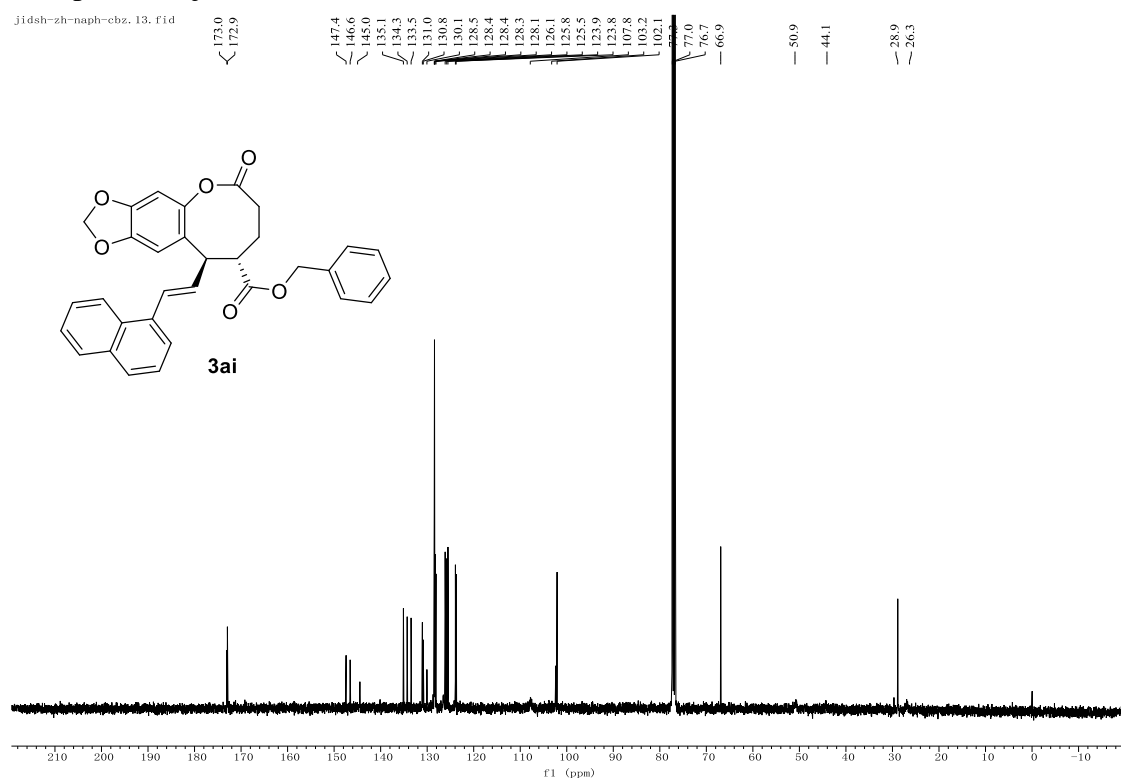
HSQC-3ai



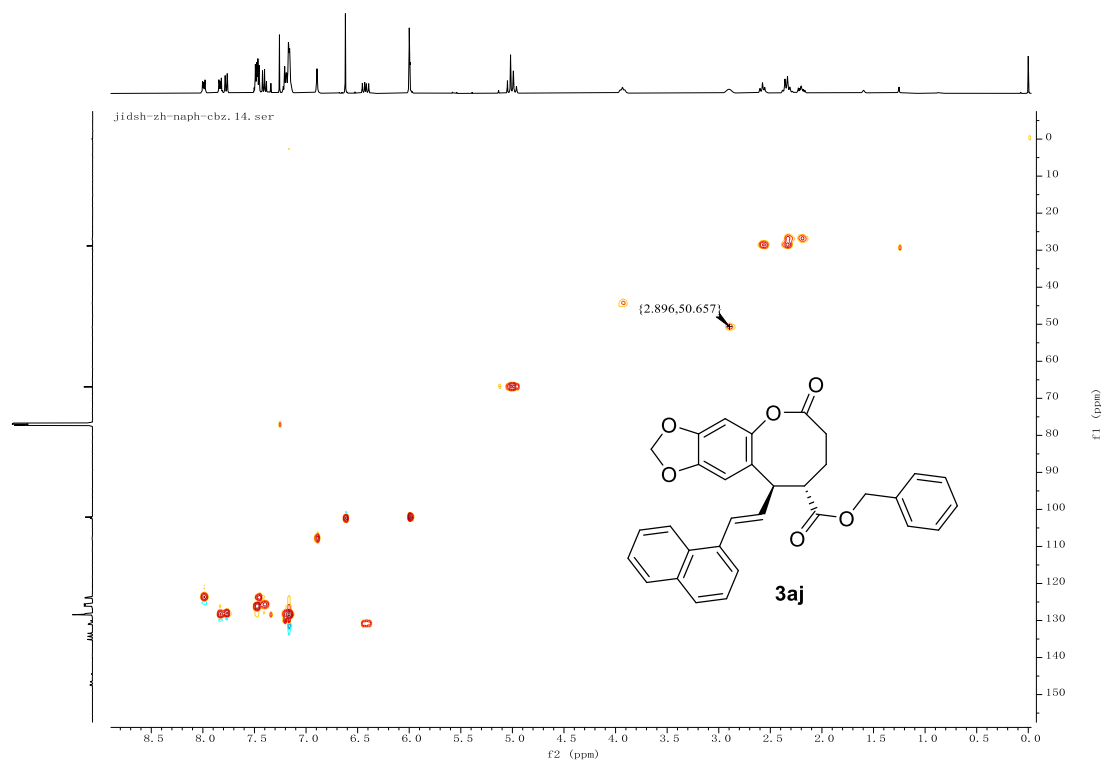
Compound-3aj (¹HNMR 400MHz, CDCl₃)



Compound-3aj ¹³CNMR (101MHz, CDCl₃)

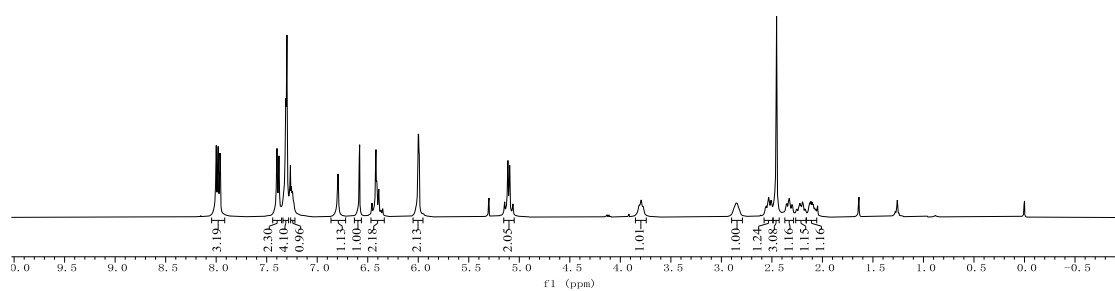
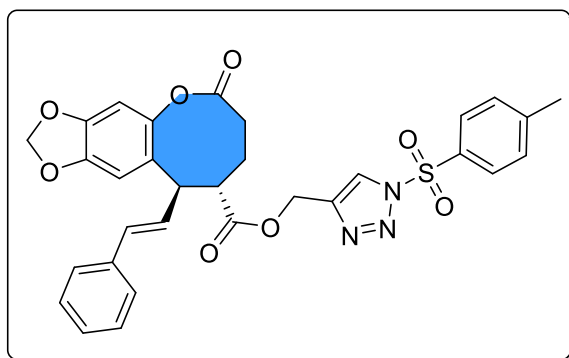


HSQC Compound-3aj



¹H NMR 400MHz, CDCl₃ Compound-4

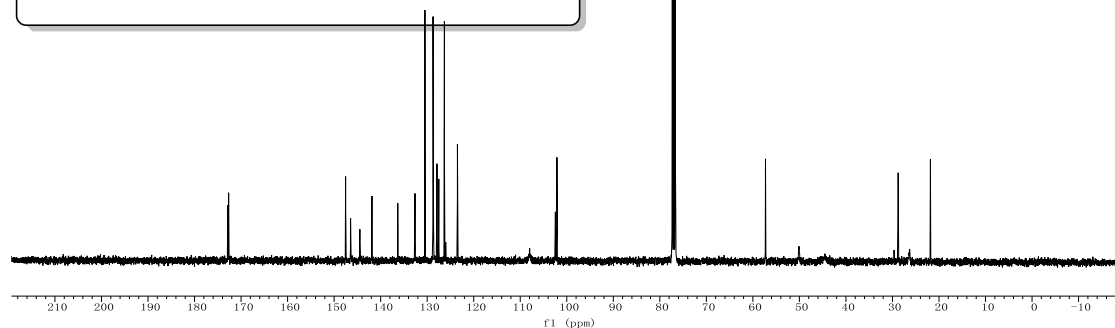
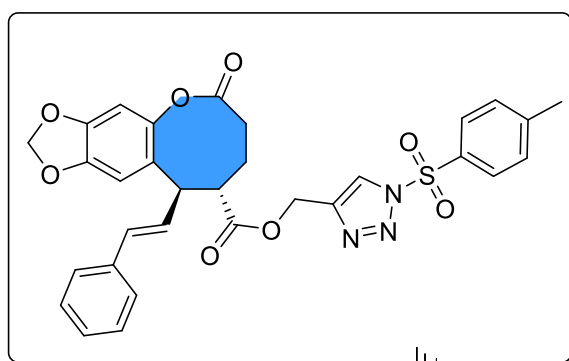
8.06, 8.04, 7.98, 7.96, 7.94, 7.44, 7.38, 7.33, 7.30, 7.30, 7.27, 7.25, 7.23, 7.22, 6.79, 6.58, 6.46, 6.42, 6.41, 6.39, 6.35, 6.00, 6.00, 5.99, 5.15, 5.15, 5.10, 5.06, 3.80, 3.79, 3.77, 2.89, 2.85, 2.85, 2.80, 2.80, 2.56, 2.56, 2.54, 2.53, 2.52, 2.51, 2.50, 2.45, 2.45, 2.36, 2.35, 2.33, 2.33, 2.30, 2.29, 2.26, 2.25, 2.25, 2.22, 2.20, 2.19, 2.17, 2.16, 2.13, 2.13, 2.11, 2.10, 2.09, 2.08, 2.06, -0.00



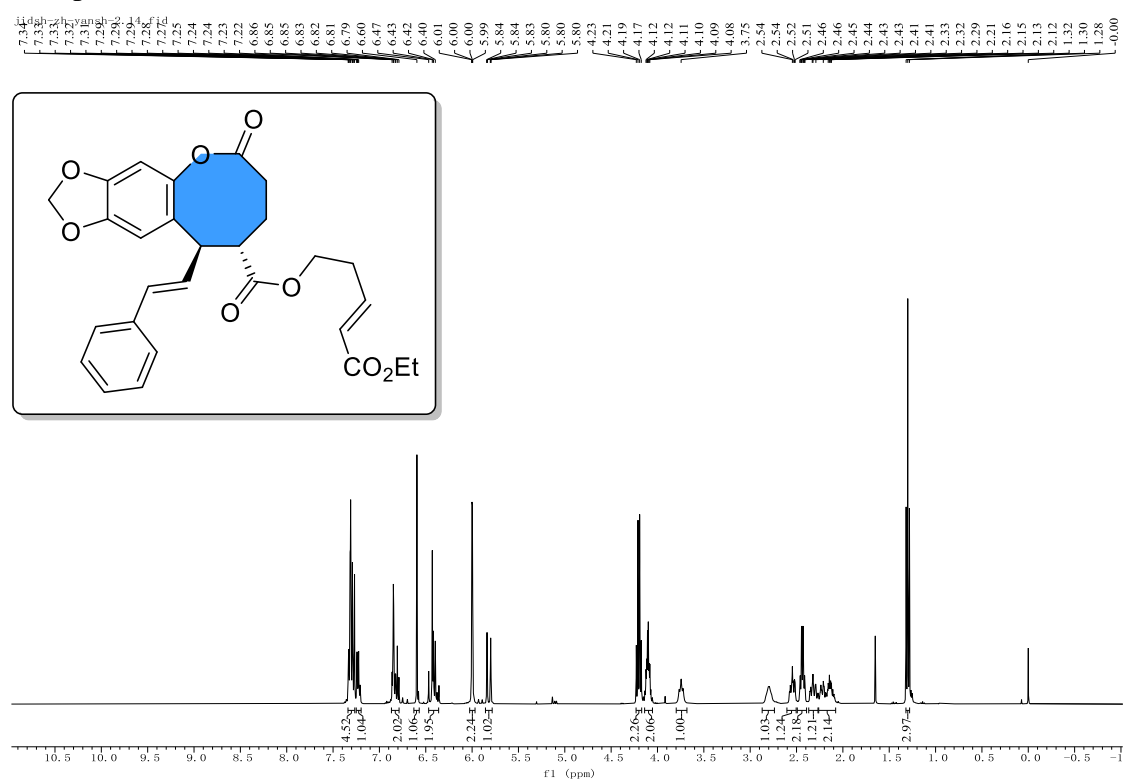
¹³C NMR 101MHz, CDCl₃

jidsh-zh-djfy.12.fid

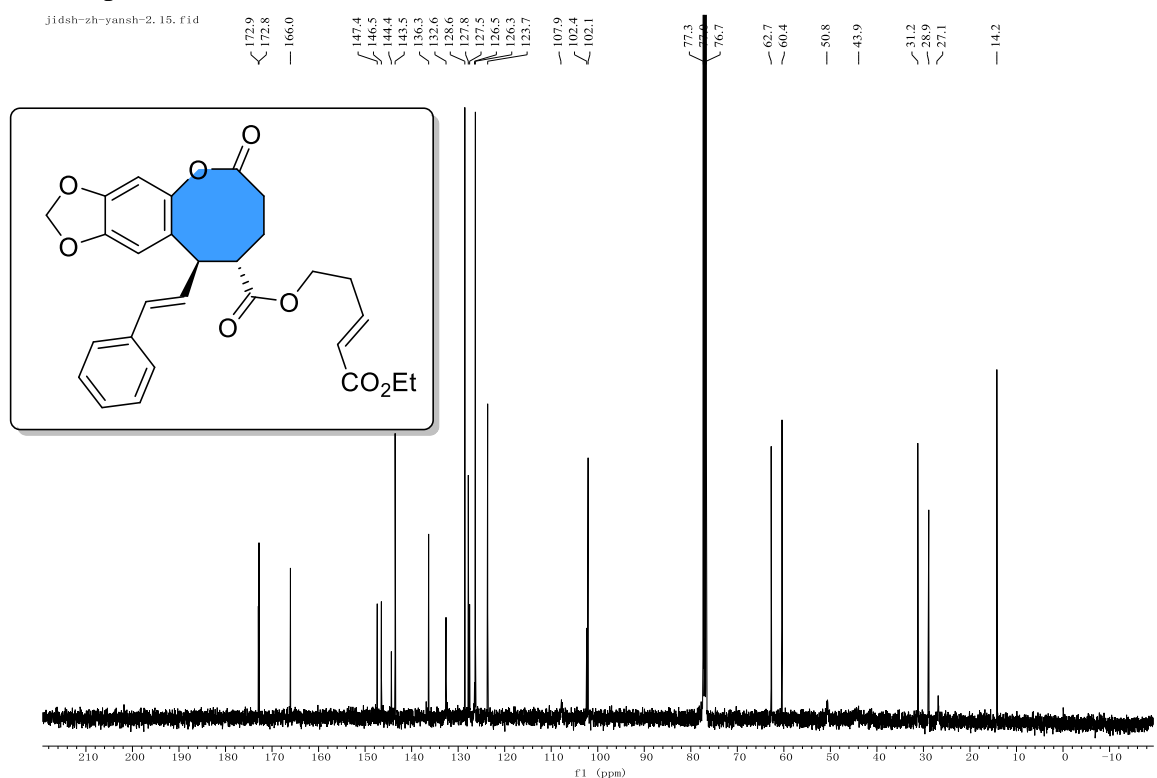
172.8, 172.7, 147.5, 146.5, 144.5, 141.9, 136.3, 132.7, 132.6, 130.5, 128.7, 127.9, 127.5, 126.3, 126.0, 123.5, 108.1, 102.4, 102.1, 77.3, 77.0, 76.7, 57.3, 49.9, 45.2, 28.4, 26.4, 21.1



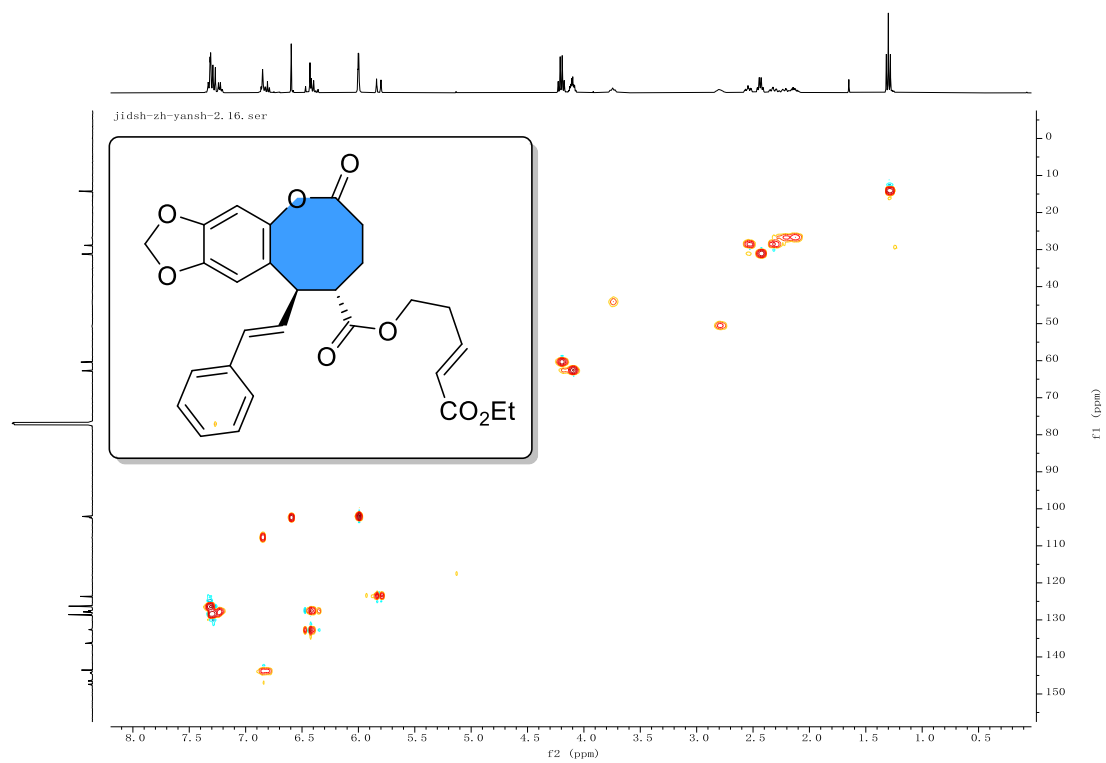
Compound-5 (^1H NMR 400MHz, CDCl_3)



Compound-5 (^{13}C NMR 400MHz, CDCl_3)

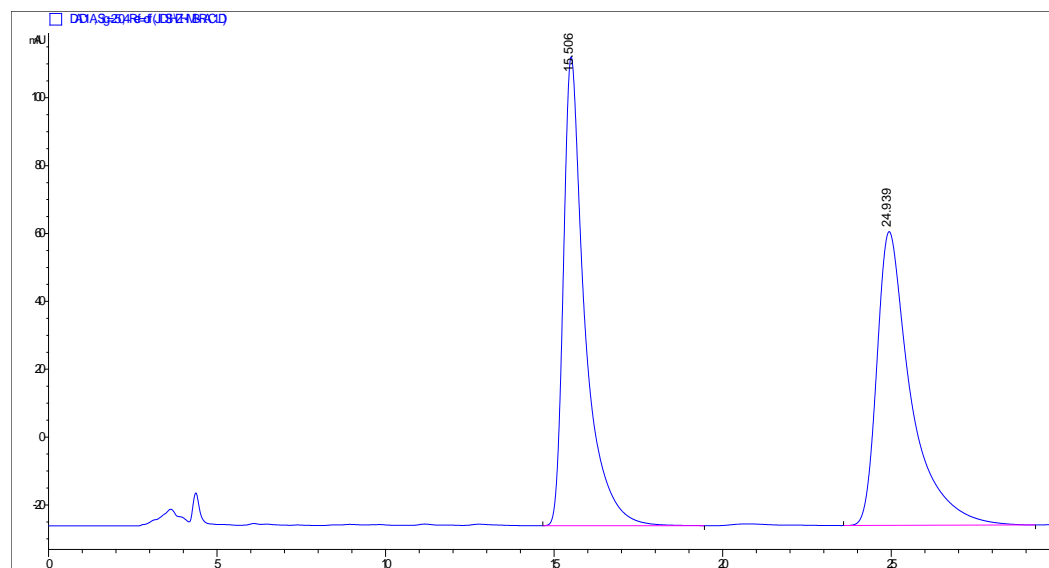


HSQC



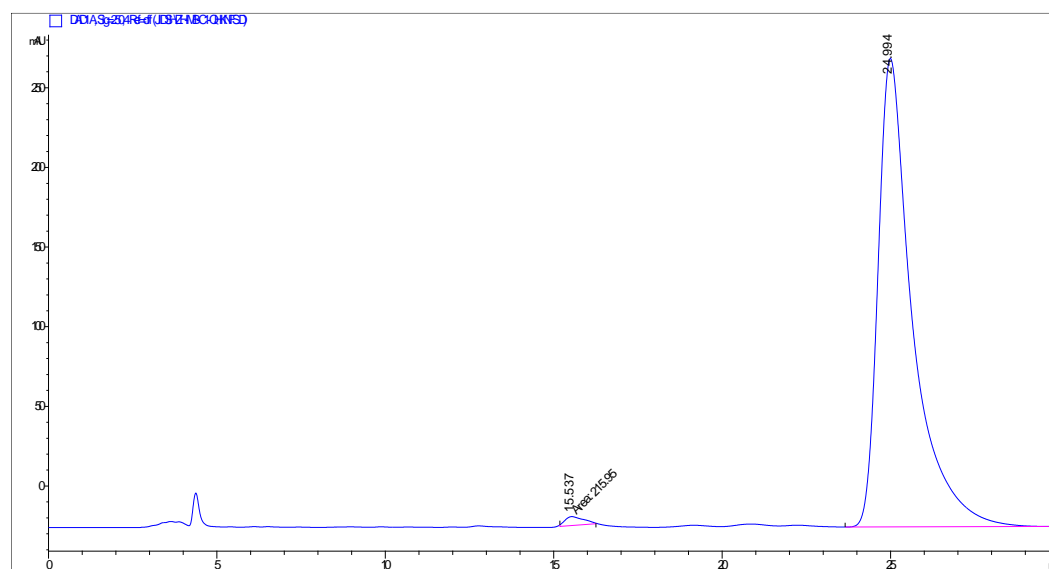
10 HPLC spectra of 8-membered lactone

HPLC of racemic **3aa**



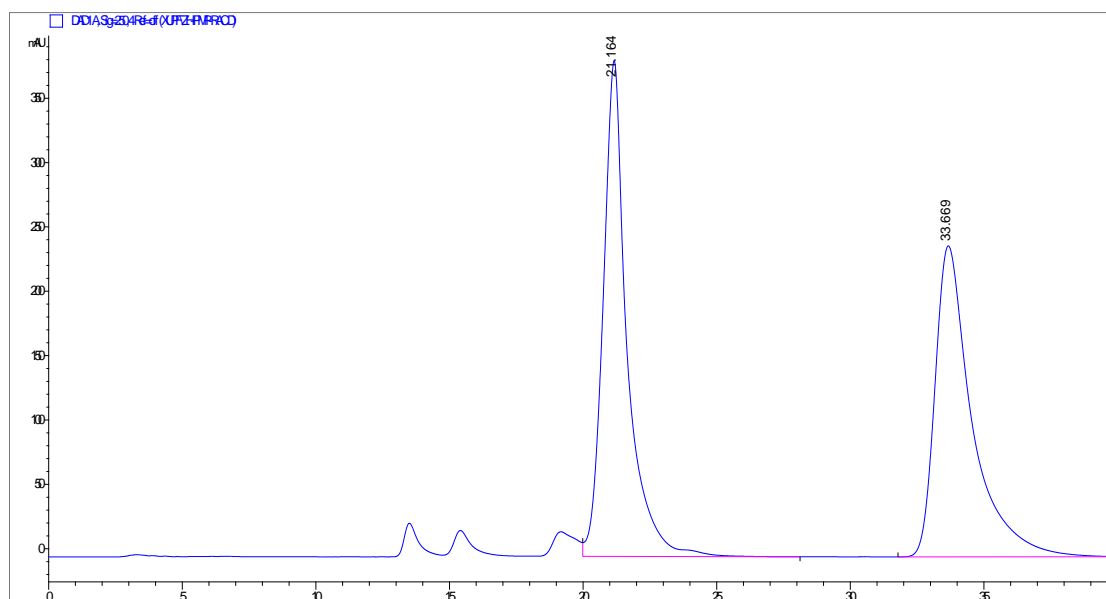
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.506	BB	0.6367	6096.41406	138.19295	50.1462
2	24.939	BB	1.0127	6060.86426	86.57984	49.8538

Enantioenriched **3aa**



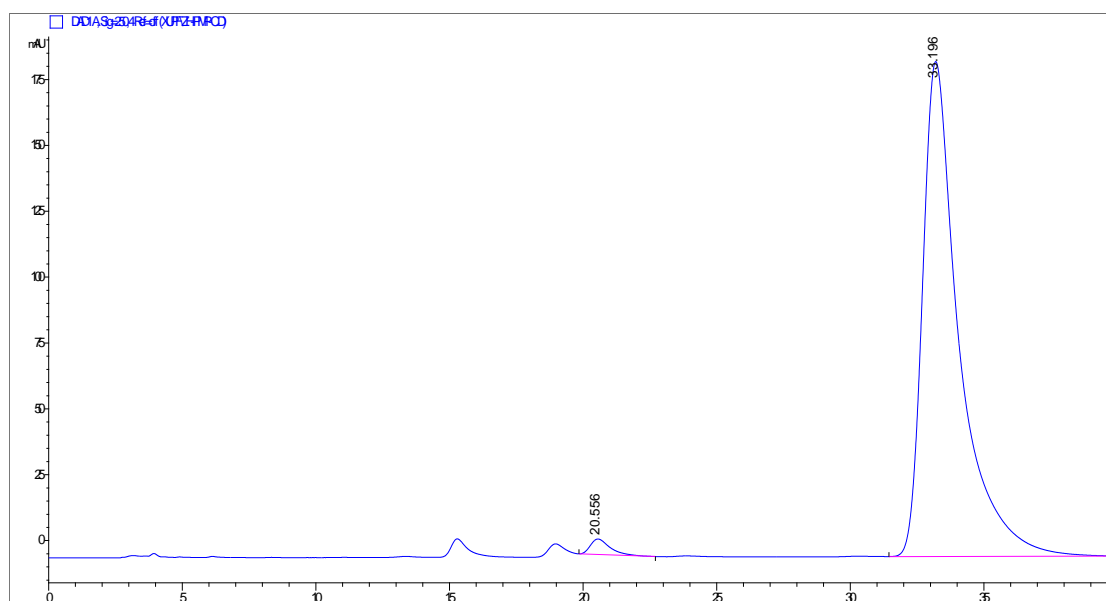
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.537	MM	0.6376	215.95013	5.64489	1.0273
2	24.994	BBA	1.0293	2.08050e4	294.11728	98.9727

Racemic-3ba



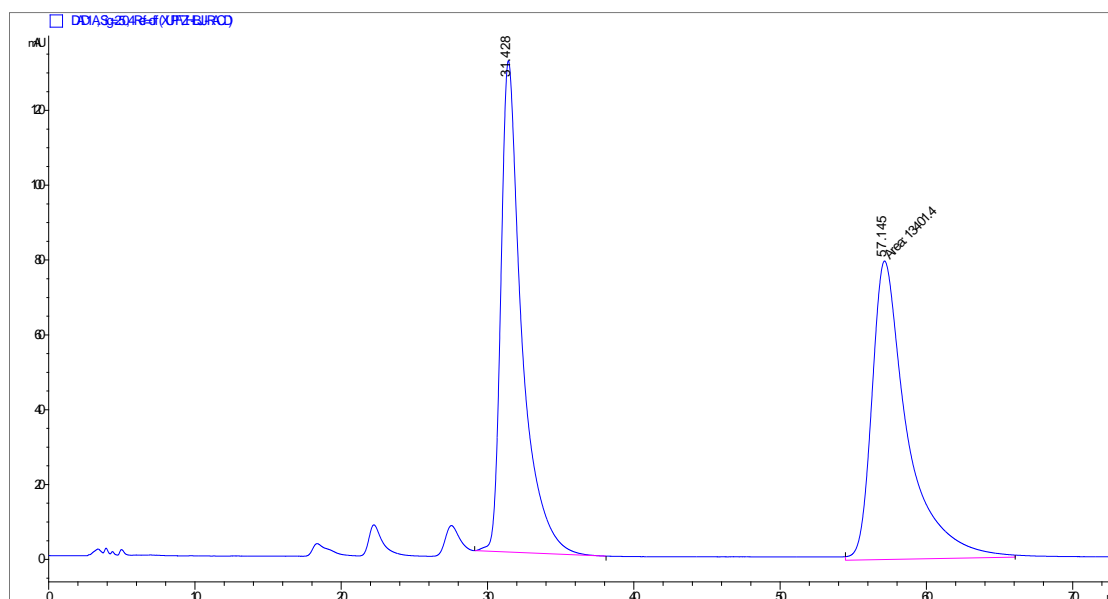
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.164	VB	0.8874	2.40141e4	385.18512	50.8534
2	33.669	BBA	1.3905	2.32082e4	241.63474	49.1466

Enantioenriched-3ba



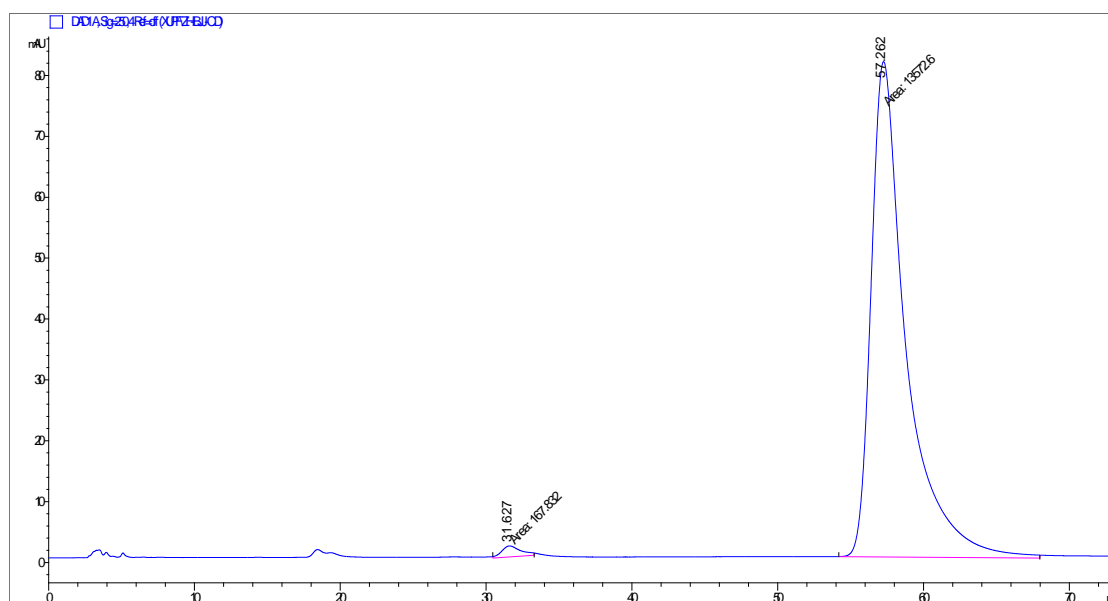
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.556	BB	0.7322	300.96606	5.88918	1.6694
2	33.196	BBA	1.3710	1.77272e4	187.84019	98.3306

Racemic-3ca



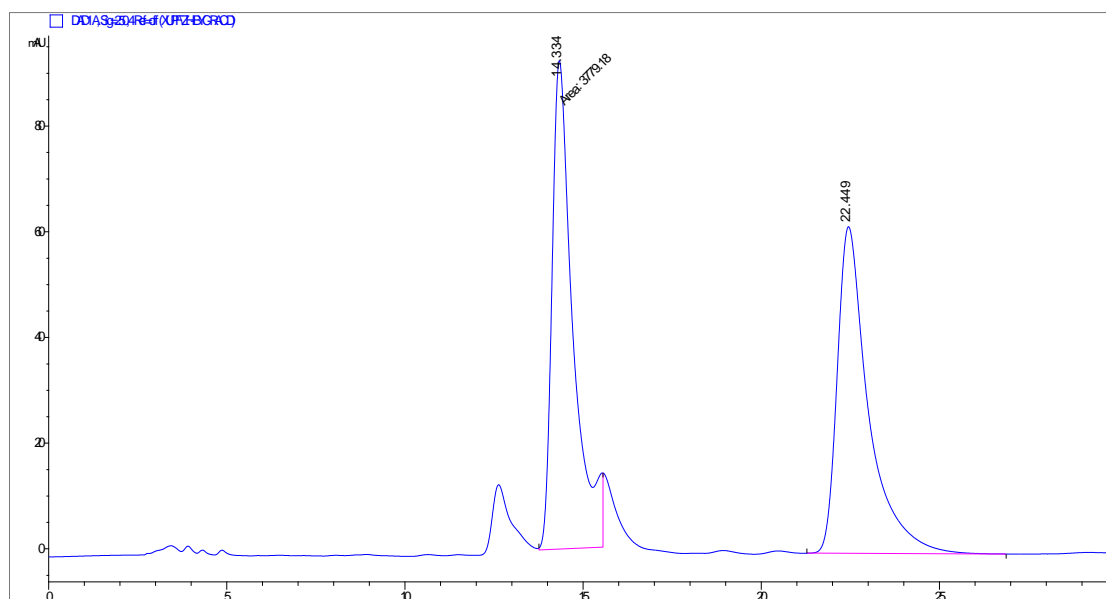
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	31.428	BB	1.4371	1.30235e4	131.31514	49.2849
2	57.145	MM	2.8004	1.34014e4	79.75992	50.7151

Enantioenriched-3ca



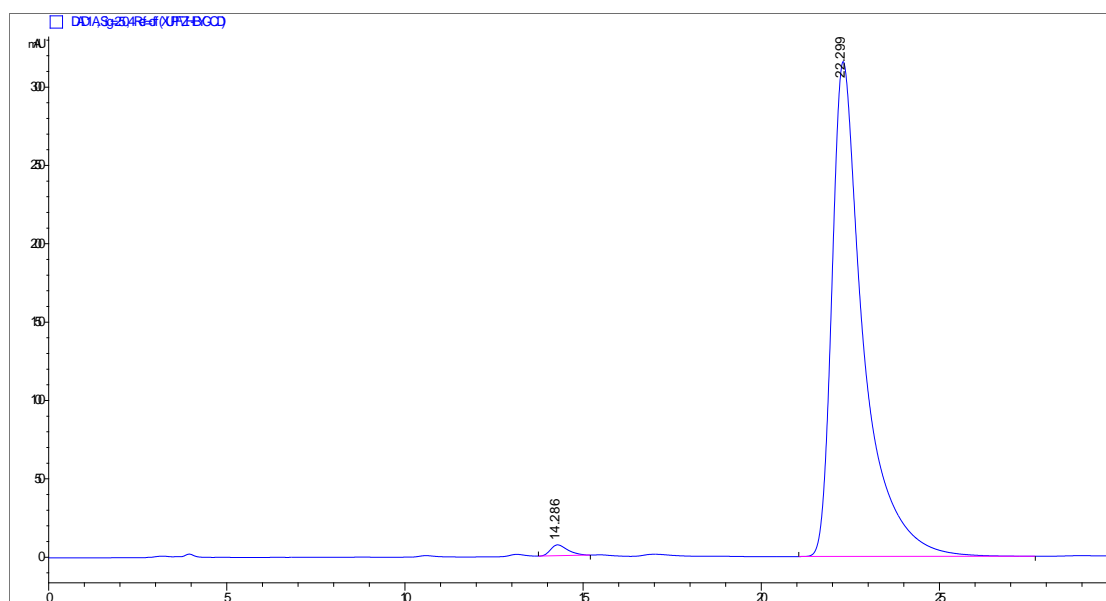
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	31.627	MM	1.5446	167.83243	1.81096	1.2215
2	57.262	MM	2.7796	1.35726e4	81.38148	98.7785

Racemic-3da



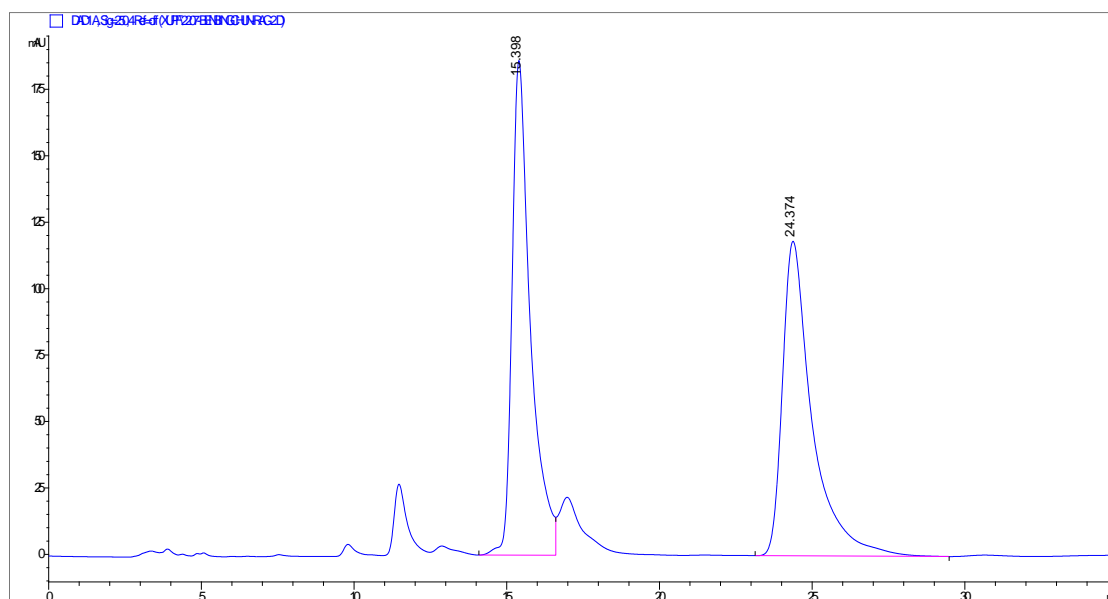
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.334	MM	0.6814	3779.18481	92.43330	50.1083
2	22.449	BB	0.8843	3762.84399	61.80508	49.8917

Enantioenriched-3da



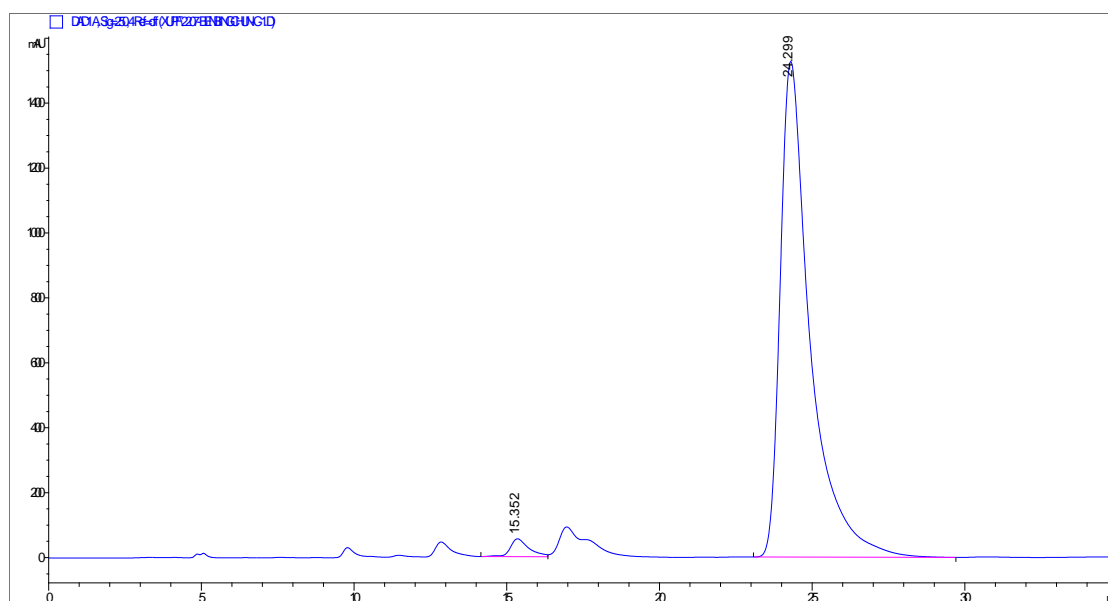
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.286	BB	0.4976	233.31847	6.95168	1.1928
2	22.299	BB	0.8900	1.93266e4	315.80740	98.8072

Racemic-3ea



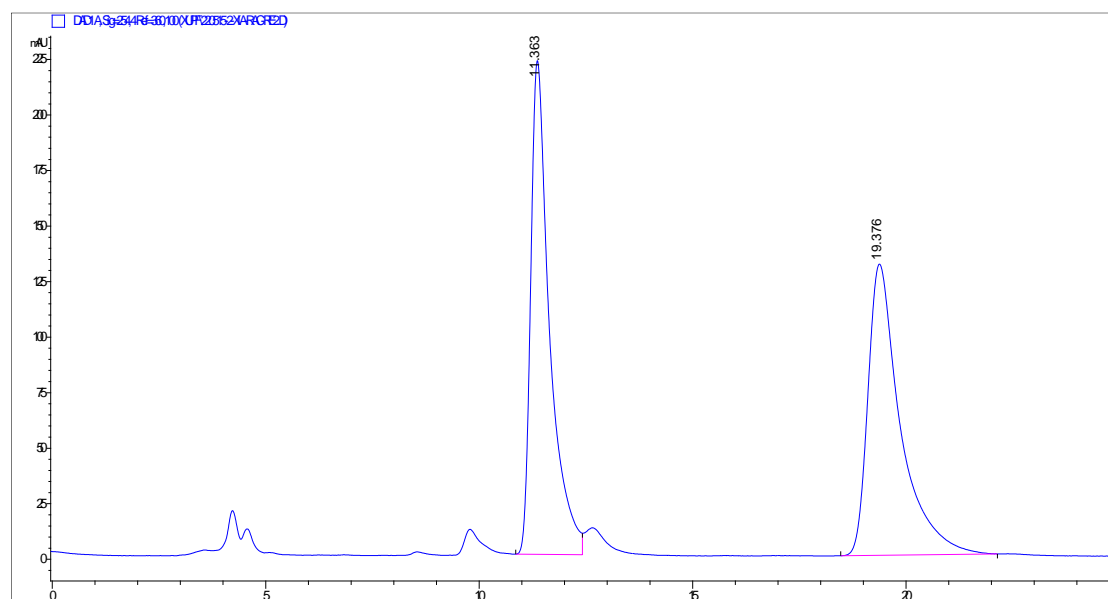
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.398	BV	0.6126	7826.03809	186.10379	49.4886
2	24.374	BB	0.9813	7987.78516	118.37040	50.5114

Enantioenriched-3ea



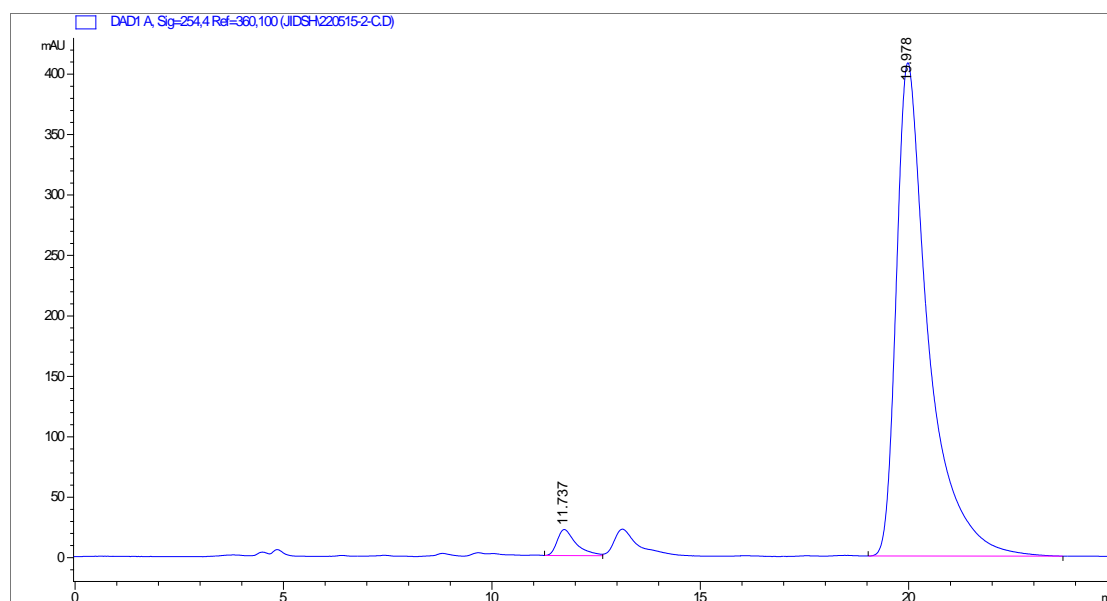
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.352	BV	0.6177	2344.76245	55.18307	2.1969
2	24.299	BB	0.9997	1.04384e5	1526.68005	97.8031

Racemic-3fa



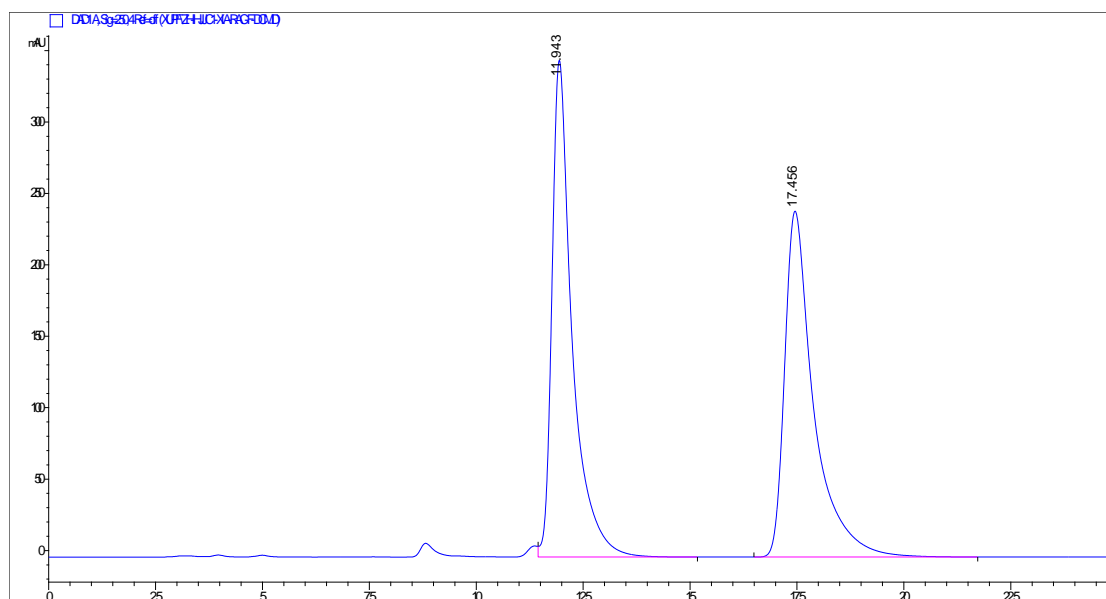
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.363	BV	0.4468	6834.97168	222.25769	49.7673
2	19.376	BB	0.7518	6898.89746	131.12804	50.2327

Enantioenriched-3fa



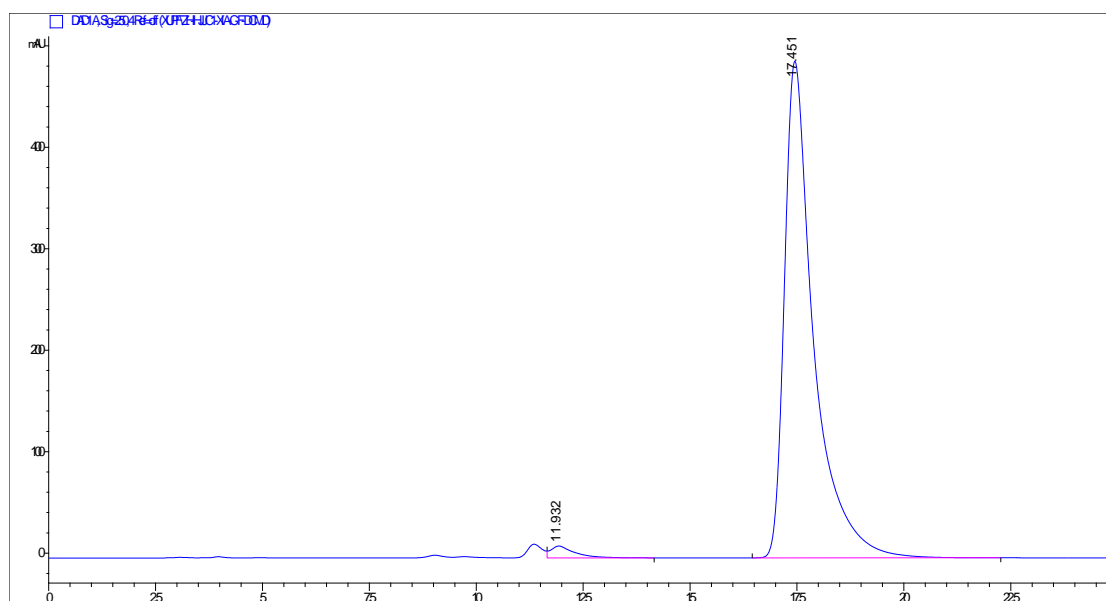
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.737	BV	0.4544	679.67218	21.52134	3.0096
2	19.978	BB	0.7842	2.19036e4	408.09927	96.9904

Racemic-3ga



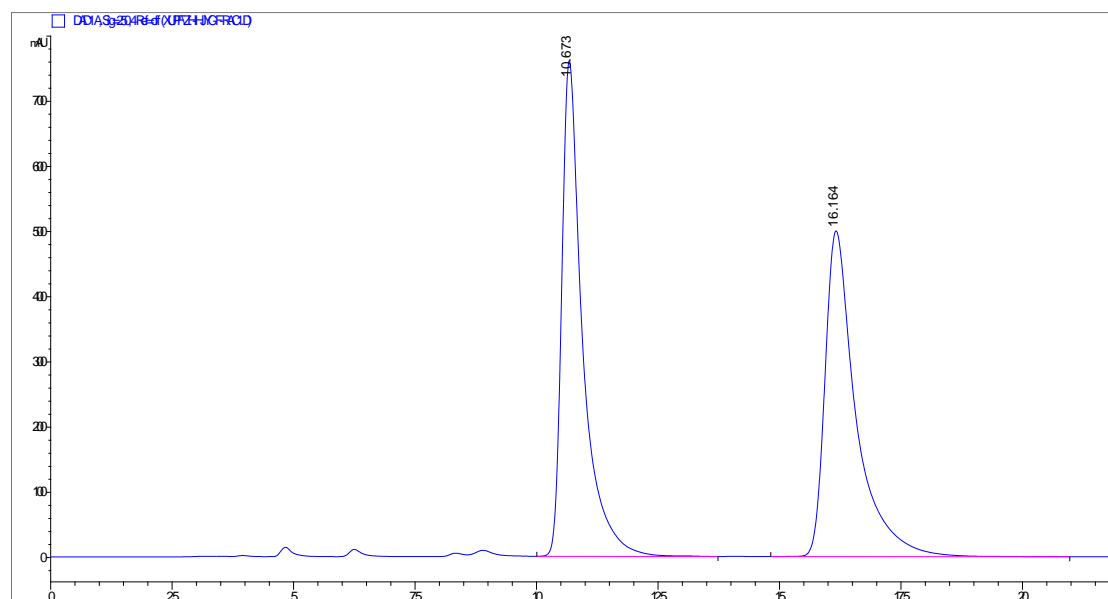
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.943	VB	0.4780	1.14427e4	347.63327	50.0213
2	17.456	BB	0.6870	1.14330e4	242.07831	49.9787

Enantiomeriched-3ga



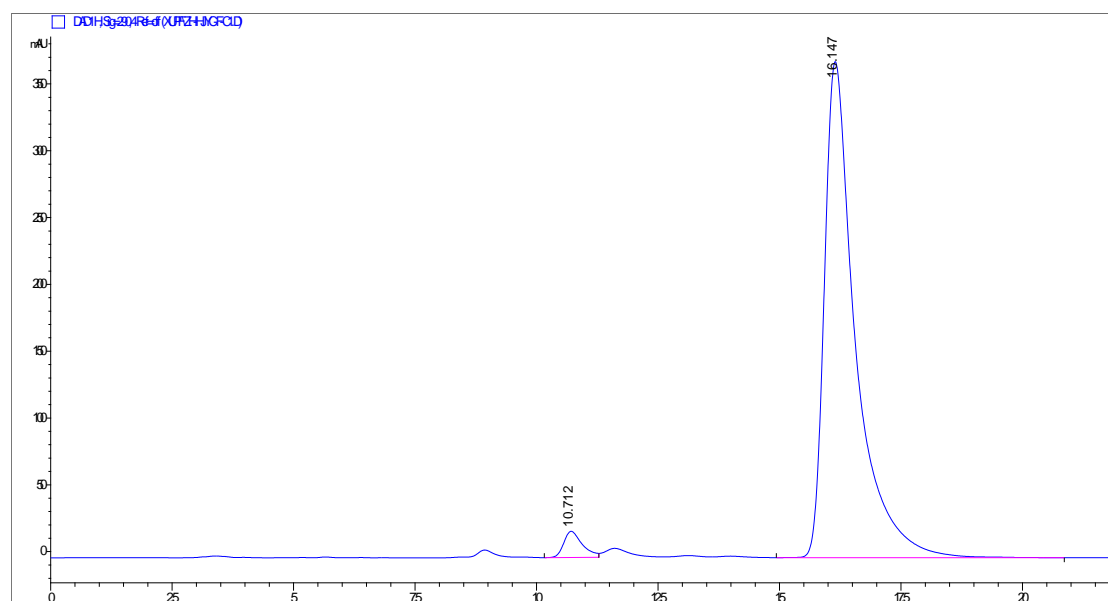
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.932	VB	0.5364	450.20132	11.61038	1.8983
2	17.451	BB	0.6928	2.32663e4	489.27783	98.1017

Racemic-3ha



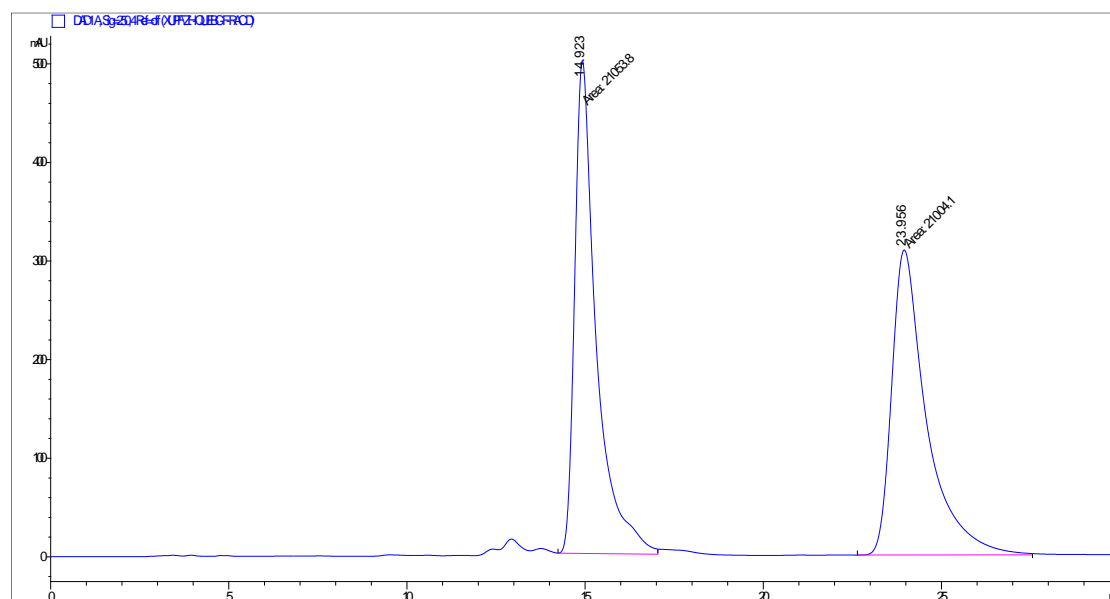
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.673	BB	0.4340	2.26801e4	760.41919	50.6060
2	16.164	BB	0.6449	2.21369e4	499.64114	49.3940

Enantioenriched-3ha



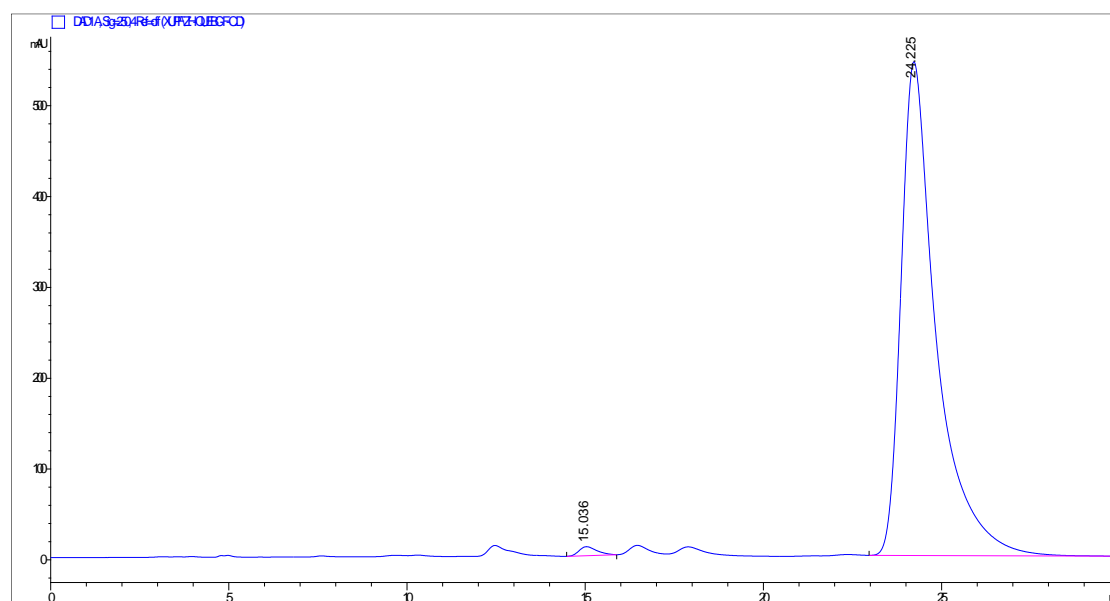
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.713	MF	0.3411	1346.02661	65.76846	2.4872
2	16.147	BB	0.6488	5.27727e4	1186.75610	97.5128

Racemic-3ia



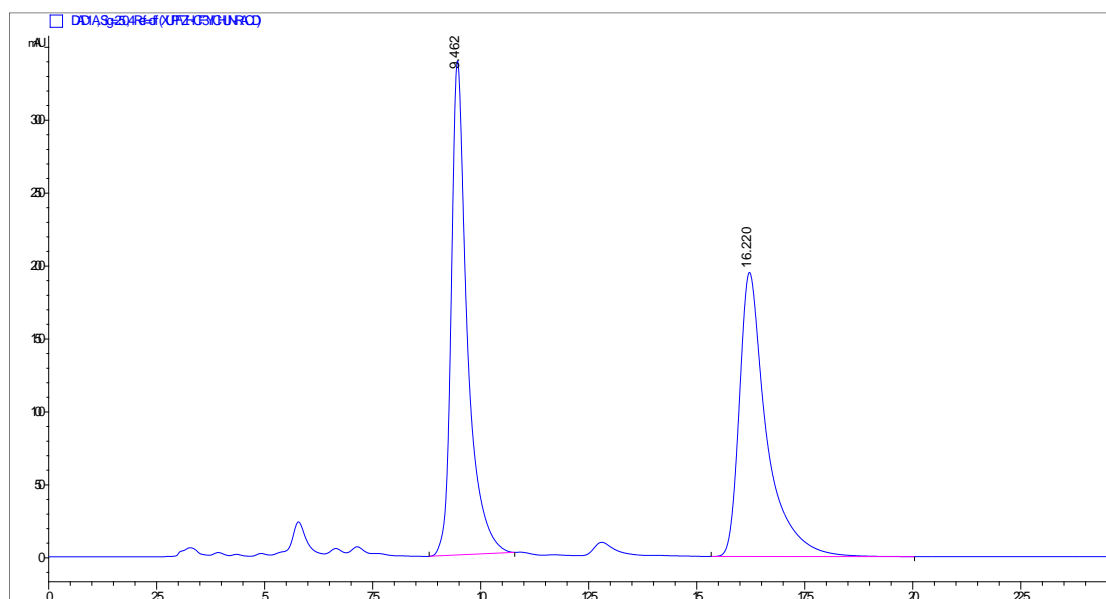
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.923	MF	0.7022	2.10538e4	499.68320	50.0591
2	23.956	MF	1.1312	2.10041e4	309.46317	49.9409

Enantioenriched-3ia



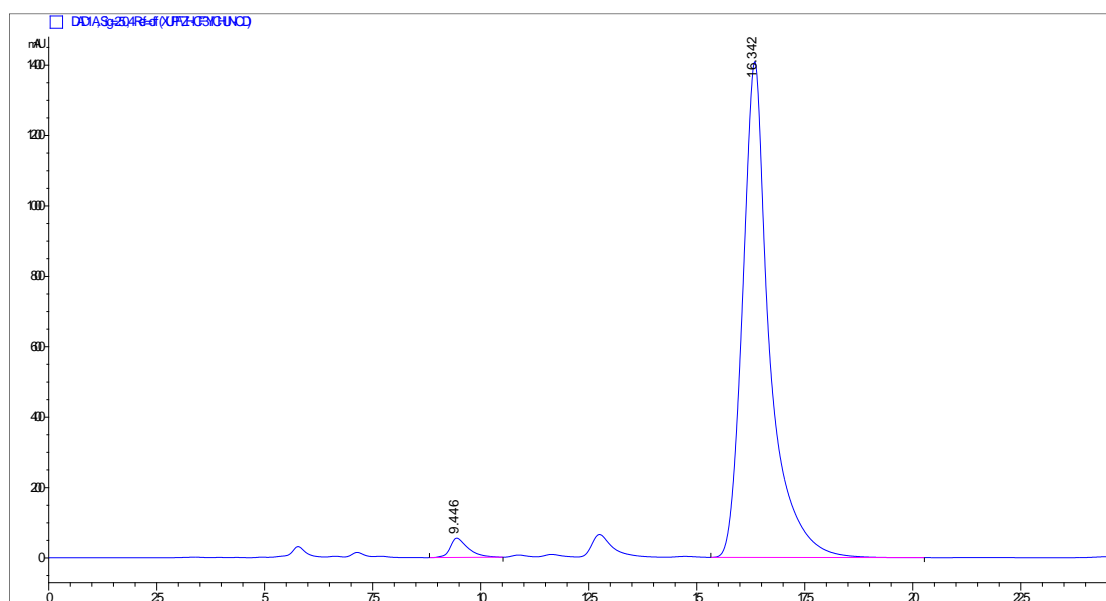
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.036	BB	0.5155	342.63486	9.90702	0.9086
2	24.225	BBA	0.9999	3.73674e4	543.64166	99.0914

Racemic-3ja



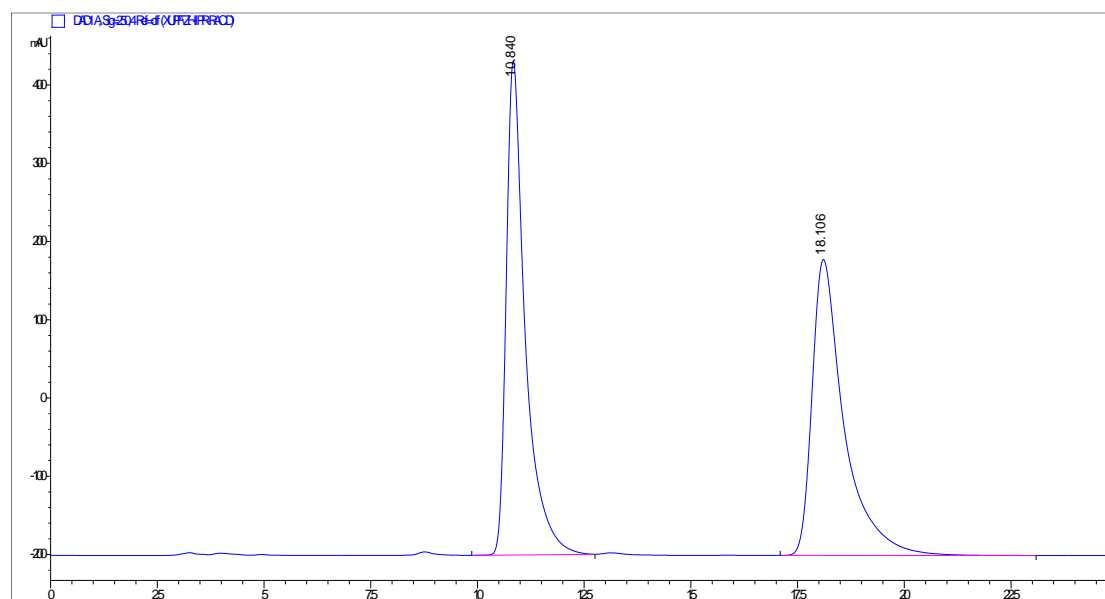
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.462	BB	0.3772	8746.53711	338.81989	50.7732
2	16.220	BB	0.6342	8480.15039	194.69583	49.2268

Enantioenriched-3ja



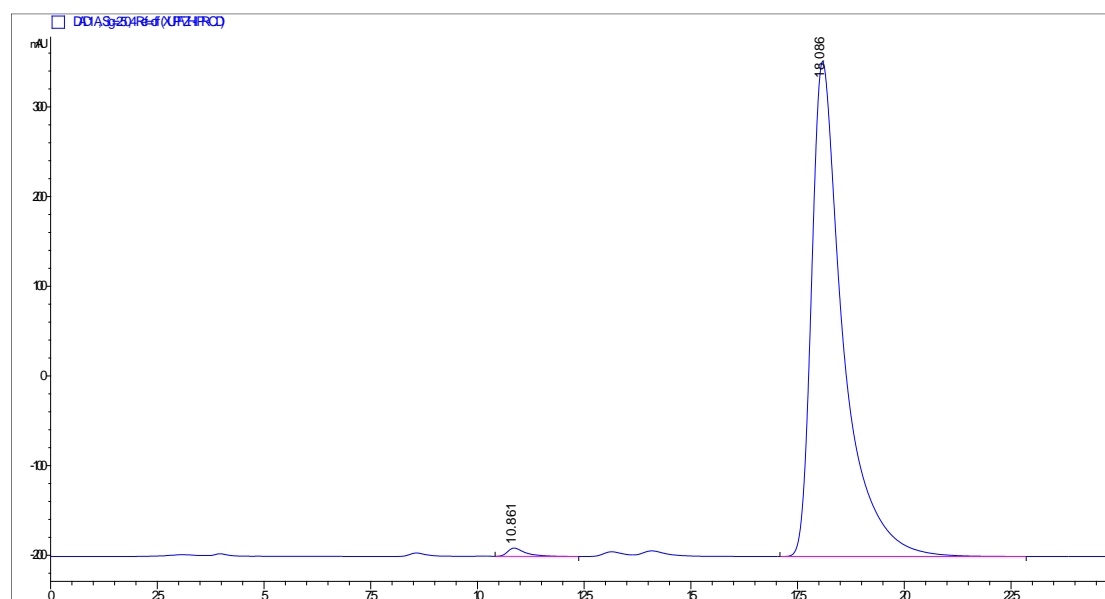
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.446	BB	0.4156	1582.29810	55.00337	2.5424
2	16.342	BB	0.6206	6.06553e4	1407.95898	97.4576

Racemic-3ka



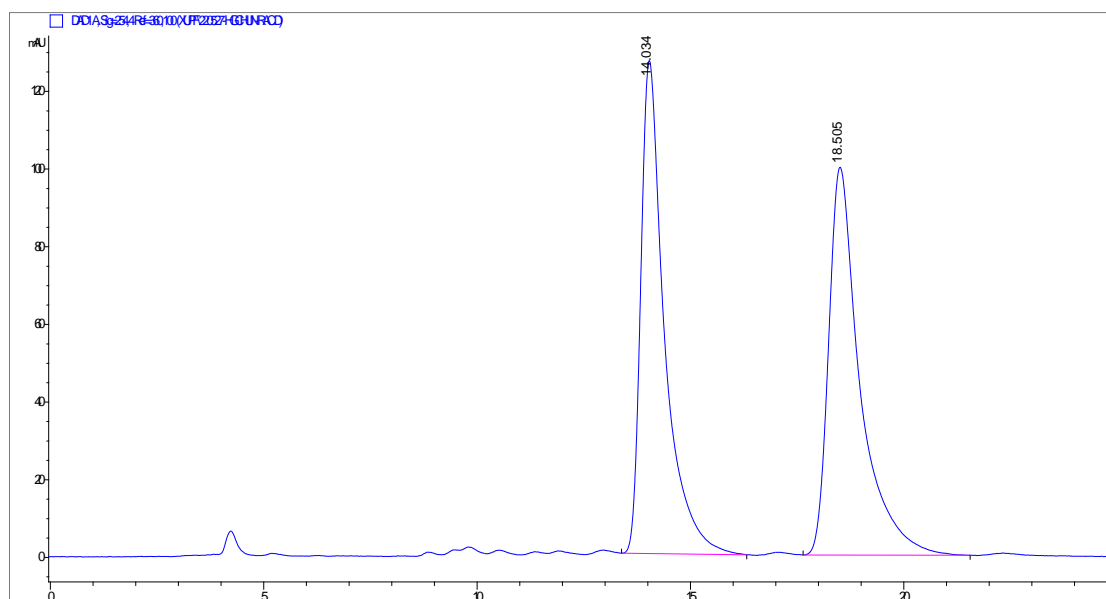
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.840	BB	0.4531	1.95498e4	631.63580	49.8342
2	18.106	BB	0.7611	1.96799e4	378.17221	50.1658

Enantioenriched-3ka



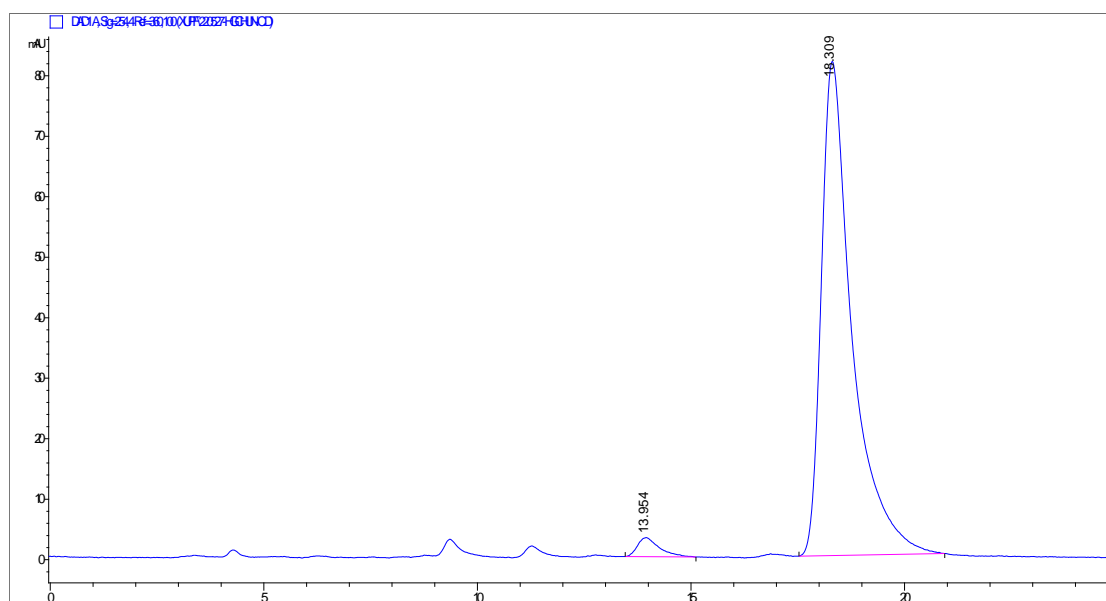
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.861	BB	0.4239	268.56650	9.21731	0.9412
2	18.086	BB	0.7476	2.82671e4	551.82098	99.0588

Racemic-3la



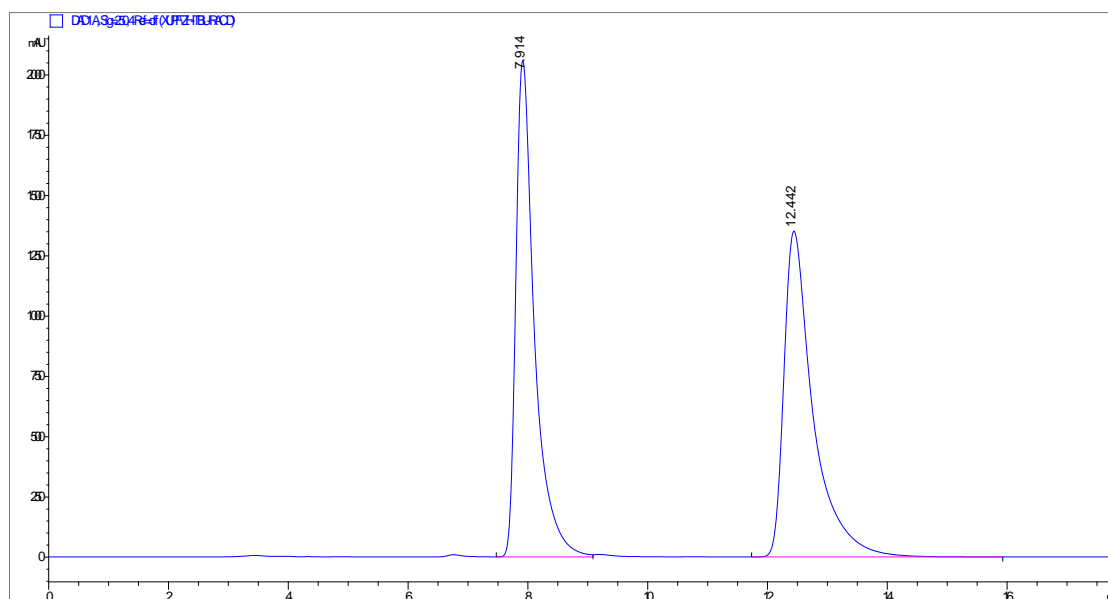
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.034	BB	0.5635	4912.62207	126.94267	49.0848
2	18.505	BB	0.7274	5095.80713	99.84973	50.9152

Enantioenriched-3la



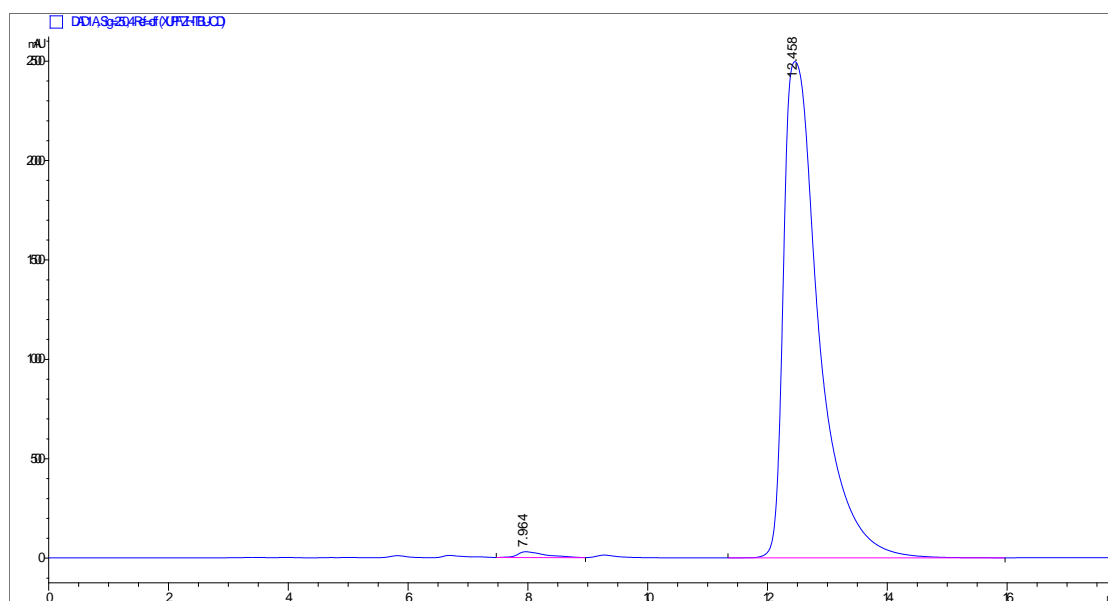
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.954	BB	0.4287	112.28943	3.14357	2.6698
2	18.309	BB	0.7228	4093.69458	81.67459	97.3302

Racemic-3ma



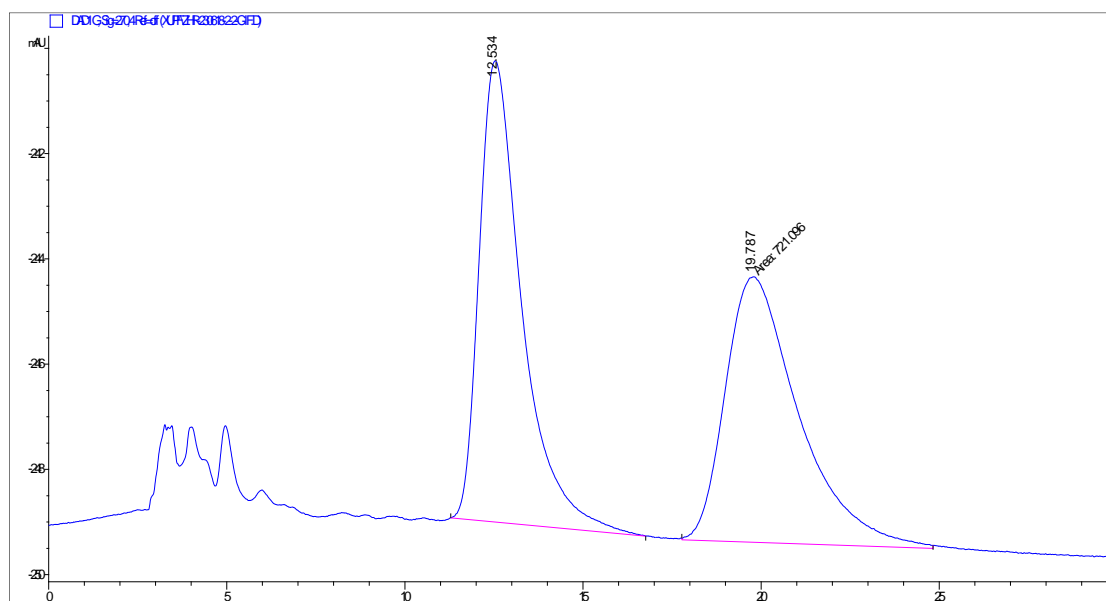
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.914	BV	0.3203	4.45172e4	2058.17529	49.3210
2	12.442	BB	0.4949	4.57429e4	1351.42236	50.6790

Enanrioenriched-3ma



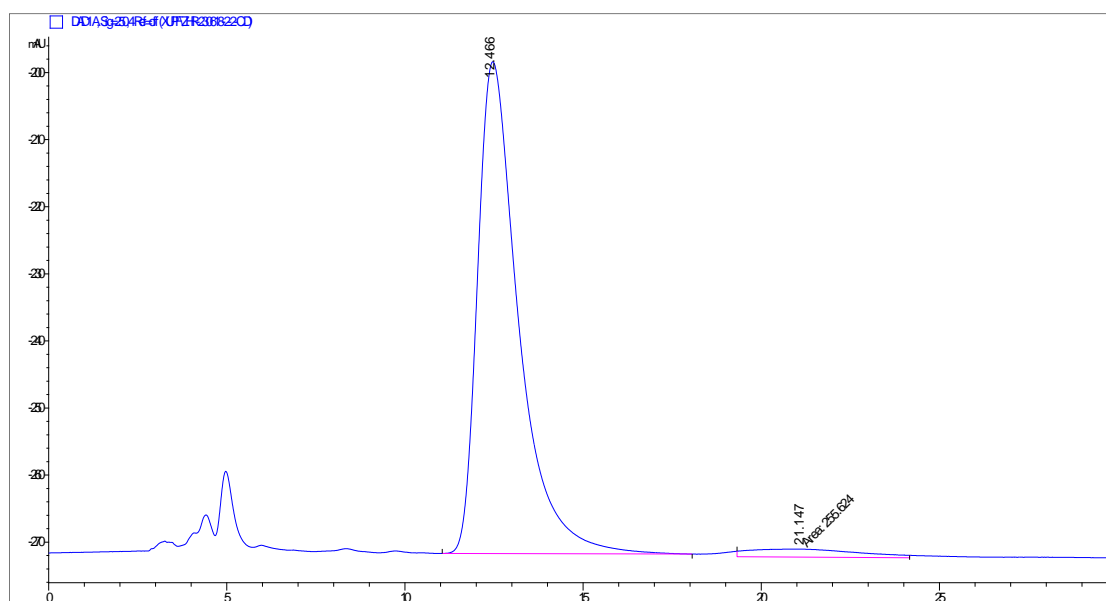
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.964	BV	0.4351	933.21216	29.02180	0.9033
2	12.458	BB	0.6145	1.02382e5	2496.16479	99.0967

Racemic-3na



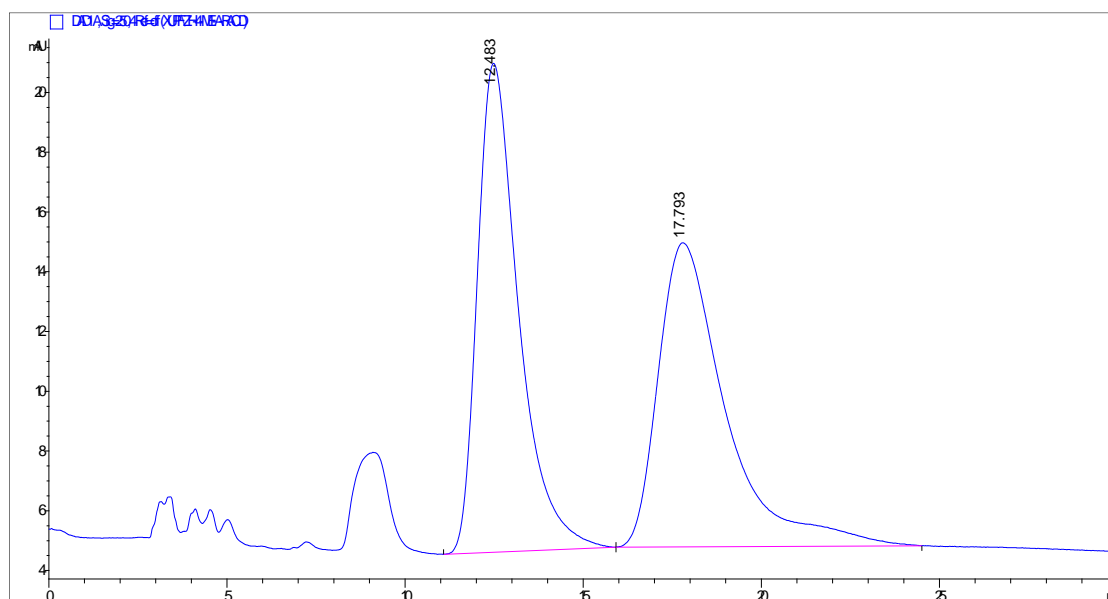
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.534	BB	0.9842	730.33984	8.76403	50.3184
2	19.787	MM	2.3833	721.09589	5.04276	49.6816

Enantioenriched-3na



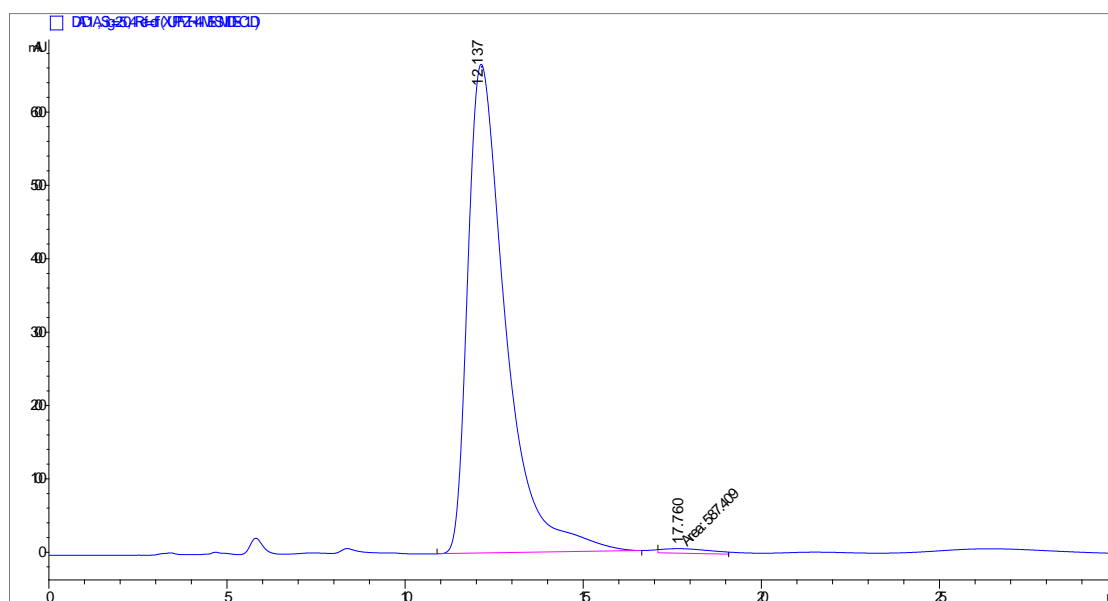
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.466	BB	1.1919	5870.66748	73.34243	95.8274
2	21.147	MF	3.5881	255.62392	1.18737	4.1726

Racemic-30a



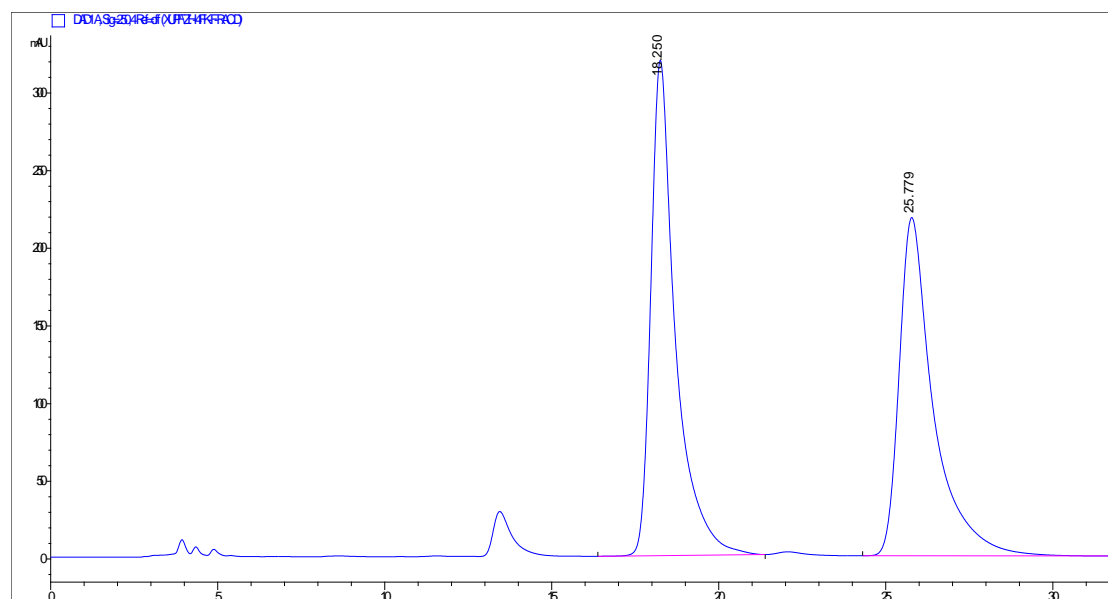
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.483	BB	1.1495	1314.98145	16.36365	49.6047
2	17.793	BB	1.5551	1335.94214	10.17956	50.3953

Enantioenriched-30a



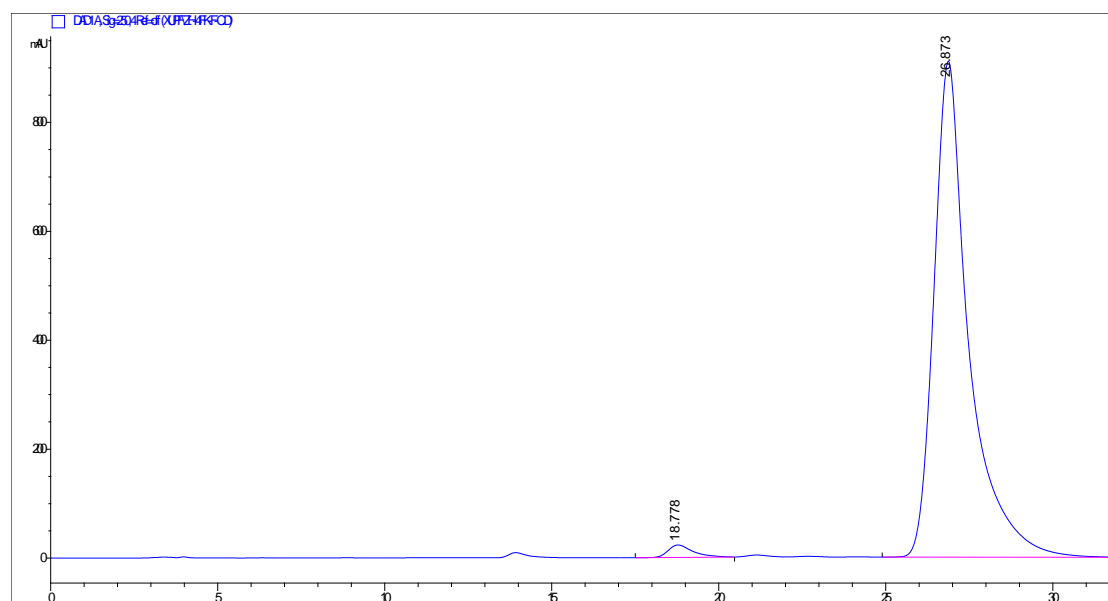
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.137	BB	1.1085	4.91484e4	666.35876	98.8189
2	17.760	MM	1.5819	587.40930	6.18883	1.1811

Racemic-3ab



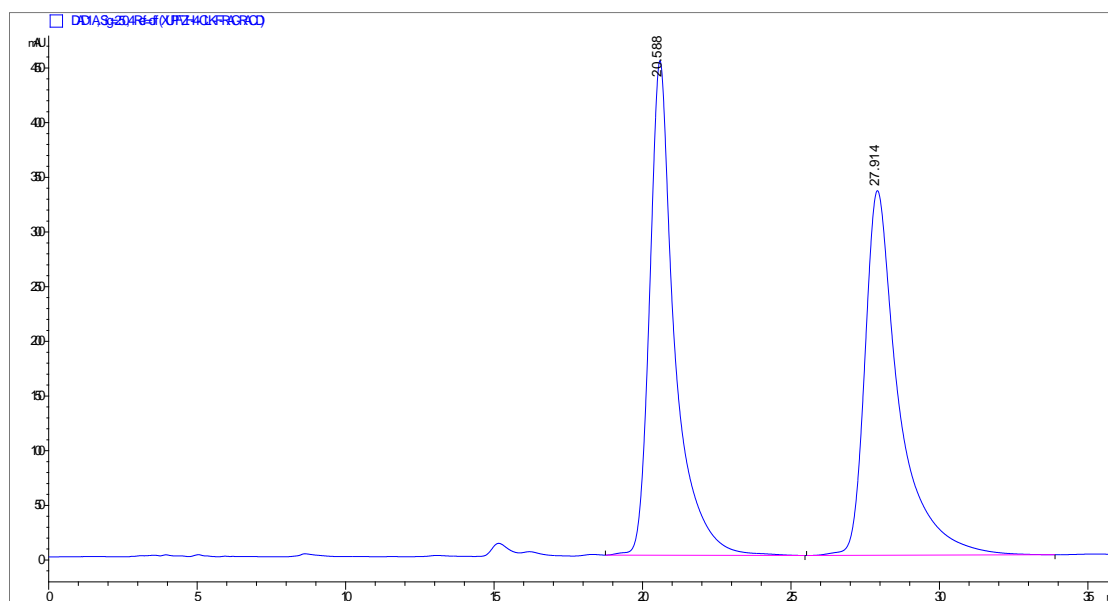
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.250	BB	0.7428	1.63649e4	318.82086	51.3964
2	25.779	BB	1.0272	1.54757e4	217.73332	48.6036

Enantioriched-3ab



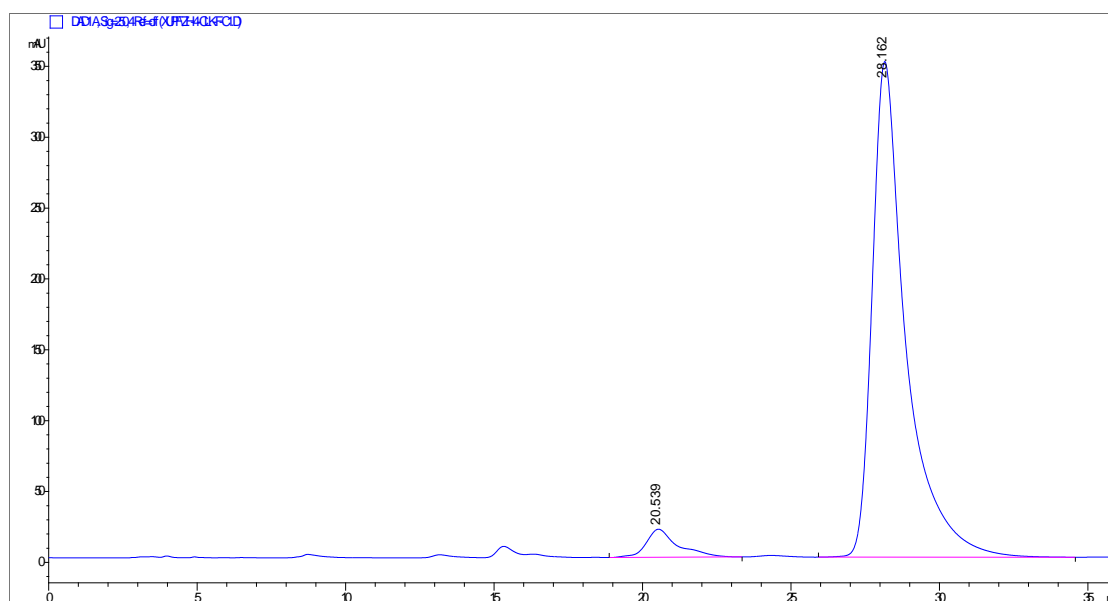
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.778	BB	0.7601	1180.94507	22.88120	1.7518
2	26.873	BBA	1.0507	6.62328e4	910.48273	98.2482

Racemic-3ac



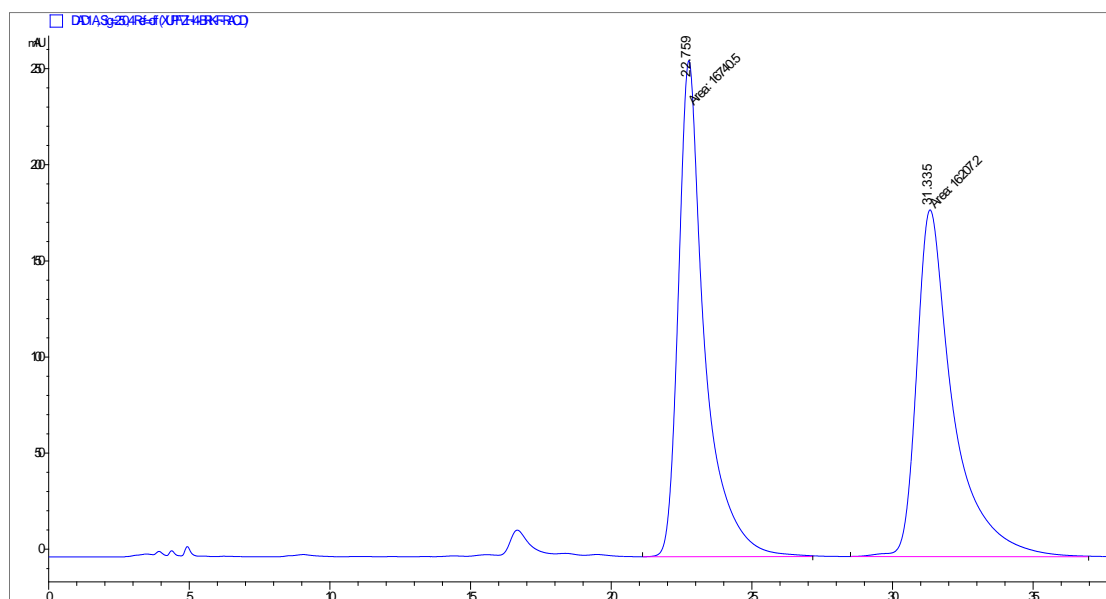
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.588	BB	0.8419	2.65136e4	452.30679	50.1559
2	27.914	BB	1.1417	2.63488e4	333.51526	49.8441

Enantioenriched-3ac



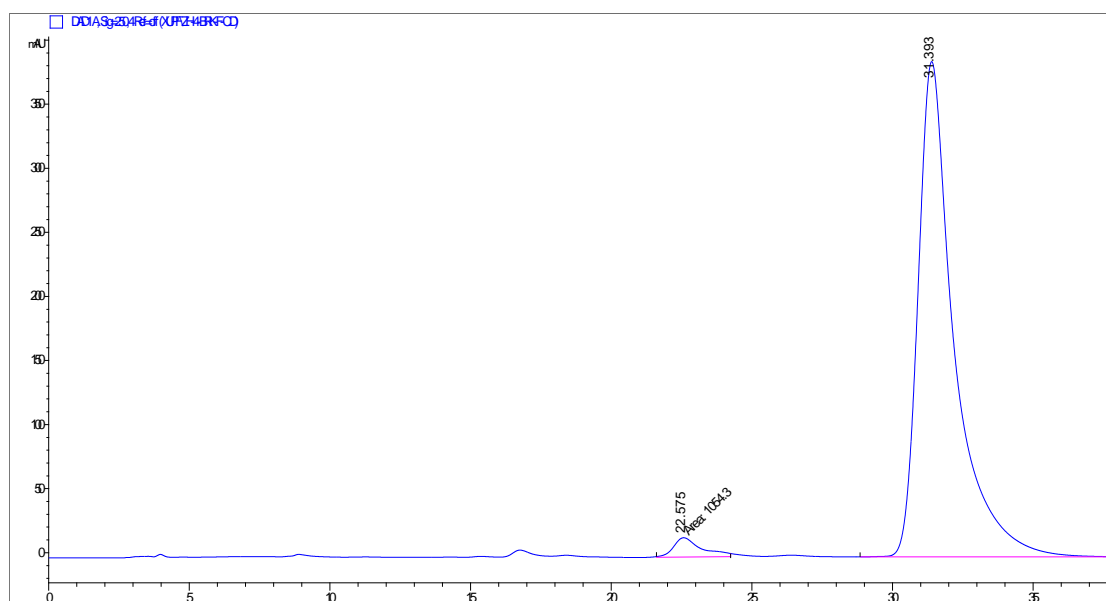
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.539	BB	1.0381	1466.12842	19.84029	5.0403
2	28.162	BB	1.1415	2.76218e4	349.69333	94.9597

Racemic-3ad



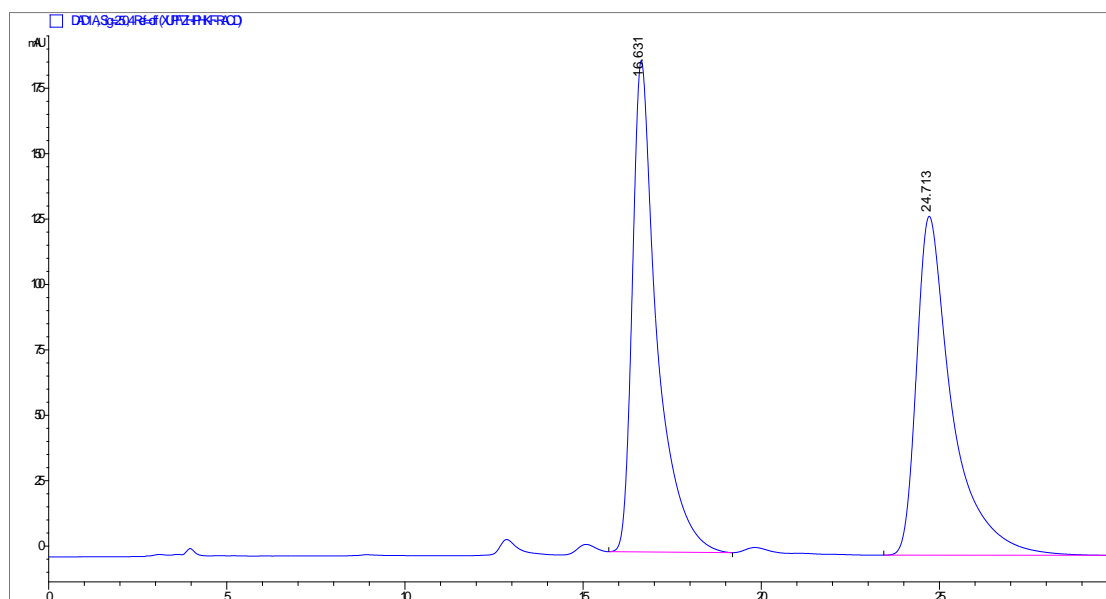
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	22.759	MF	1.0815	1.67405e4	257.97812	50.8092
2	31.335	MF	1.4982	1.62072e4	180.30193	49.1908

Enantioenriched-3ad



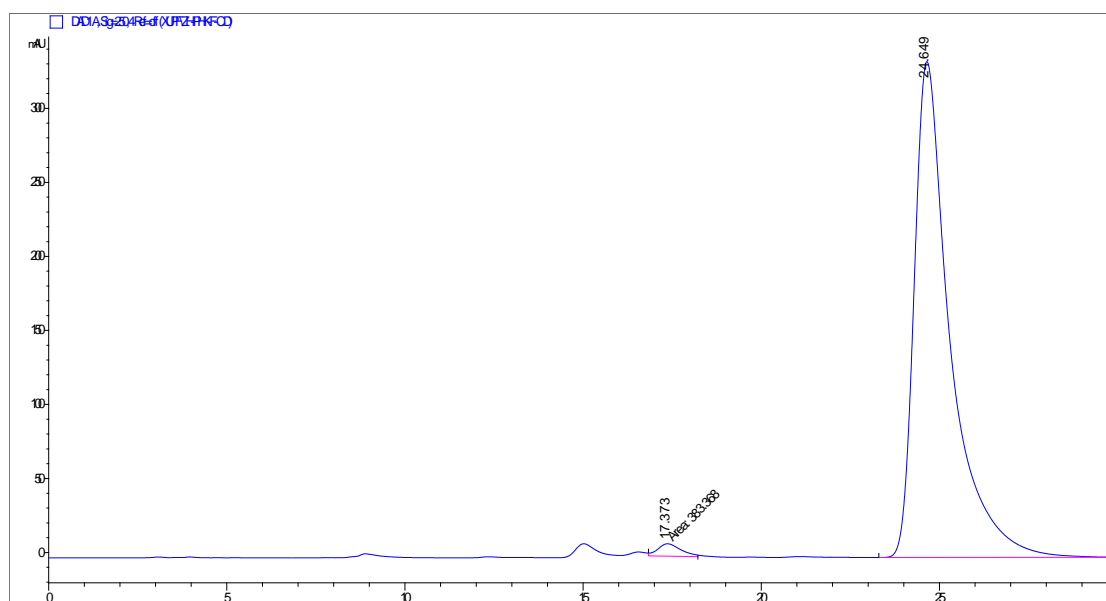
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	22.575	FM	1.1632	1034.30286	15.10623	2.9853
2	31.393	BBA	1.2822	3.42625e4	386.50055	97.0147

Racemic-3ae



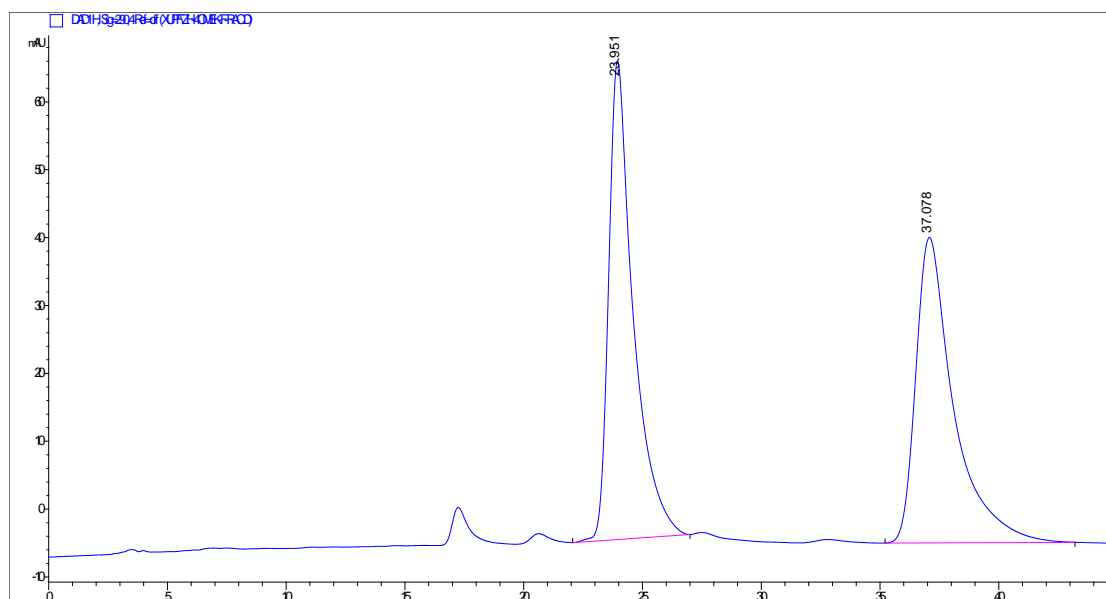
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.631	BB	0.6940	9010.86426	187.73538	50.1491
2	24.713	BB	1.0071	8957.29785	129.47745	49.8509

Enantioenriched-3ae



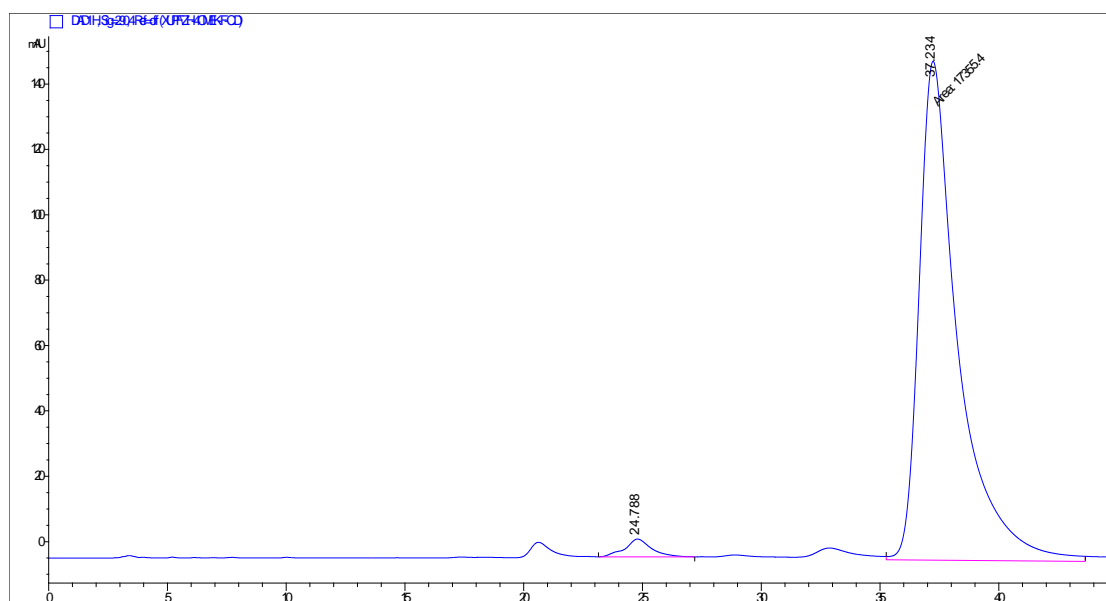
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.373	MF	0.7595	383.36829	8.41219	1.6155
2	24.649	BBA	1.0153	2.33472e4	334.91013	98.3845

Racemic-3af



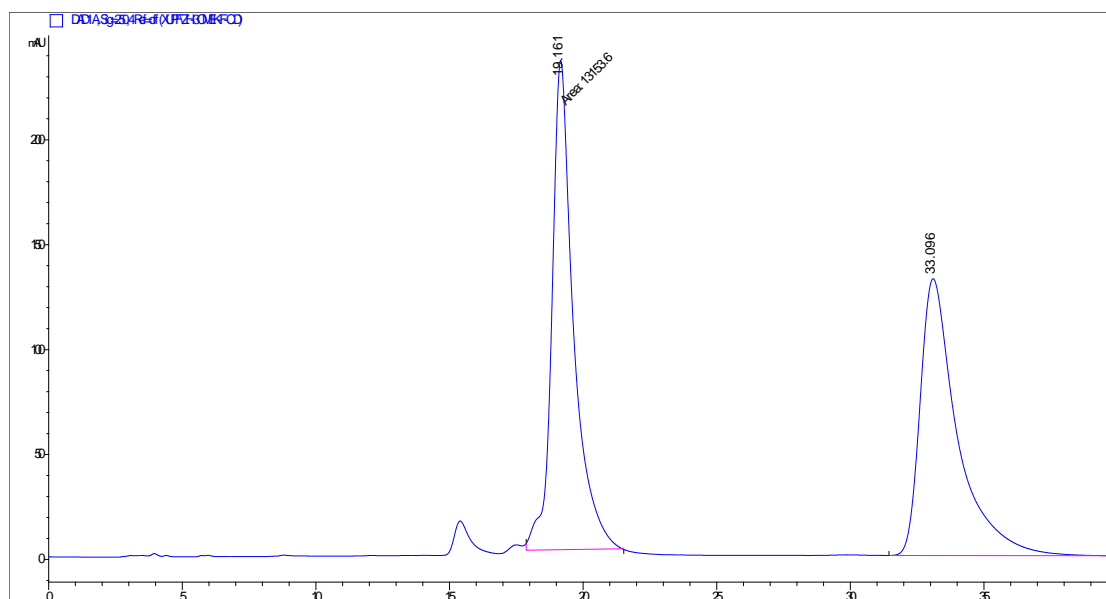
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.950	BB	1.0330	6134.52441	84.90253	50.4368
2	37.077	BB	1.5654	6028.26904	54.29262	49.5632

Enantioenriched-3af



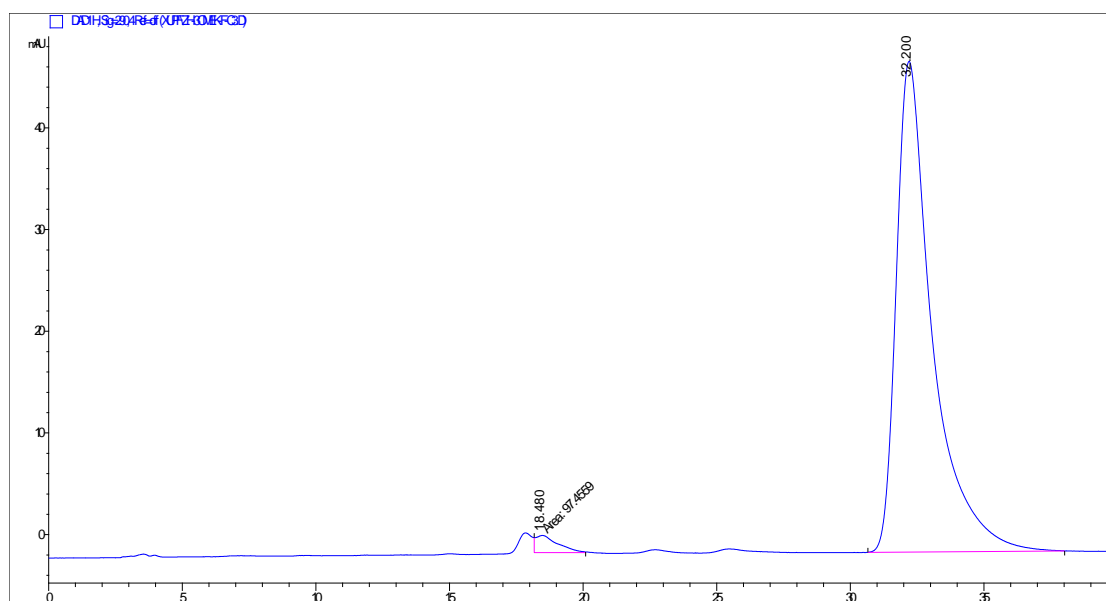
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.788	BB	0.9572	419.87085	5.42354	2.3621
2	37.234	MM	1.8954	1.73554e4	152.60648	97.6379

Racemic-3ag



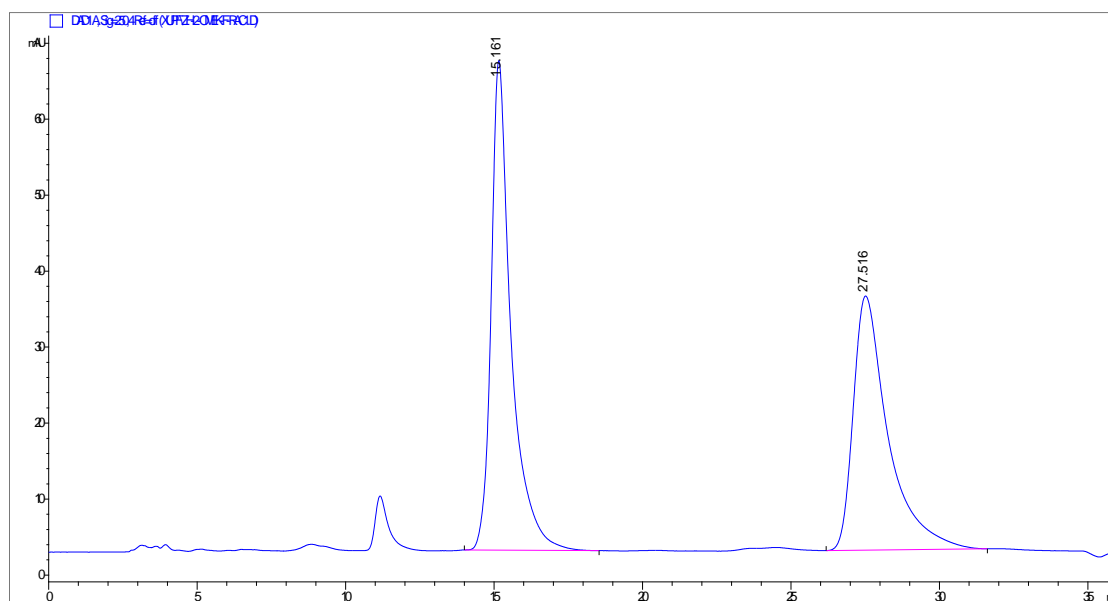
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.161	MM	0.9403	1.31536e4	233.14539	50.8037
2	33.096	BBA	1.4027	1.27374e4	131.89125	49.1963

Enantioenriched-3ag



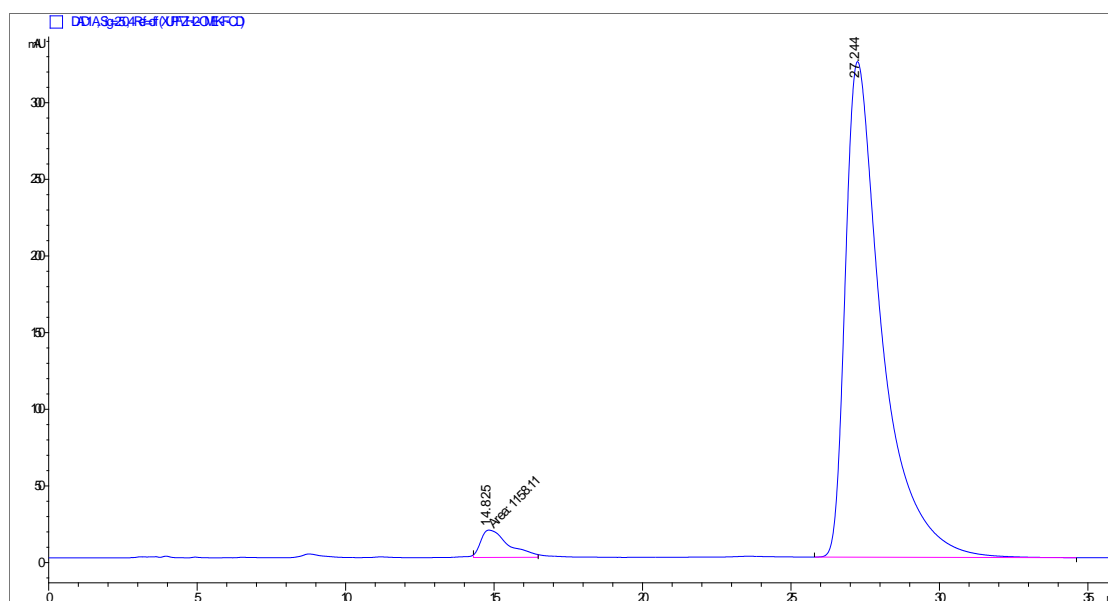
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.480	MM	0.9591	97.45587	1.69359	2.1158
2	32.200	BB	1.3241	4508.58350	48.25230	97.8842

Racemic-3ah



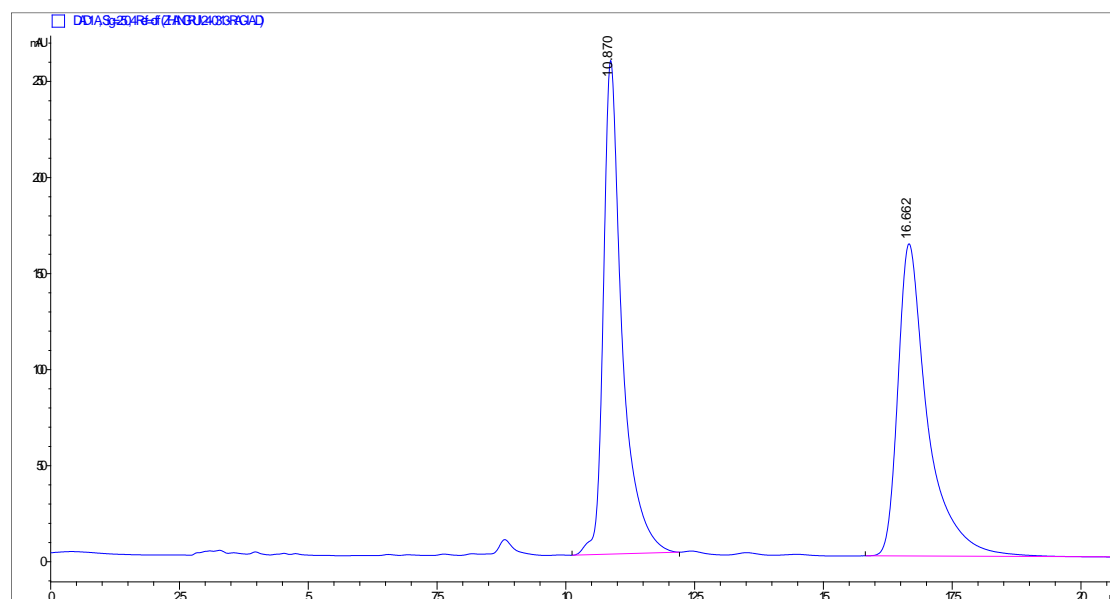
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.161	MF	0.7271	2810.91089	64.42883	50.7575
2	27.516	BB	1.1630	2727.01489	33.45532	49.2425

Enantioenriched-3ah



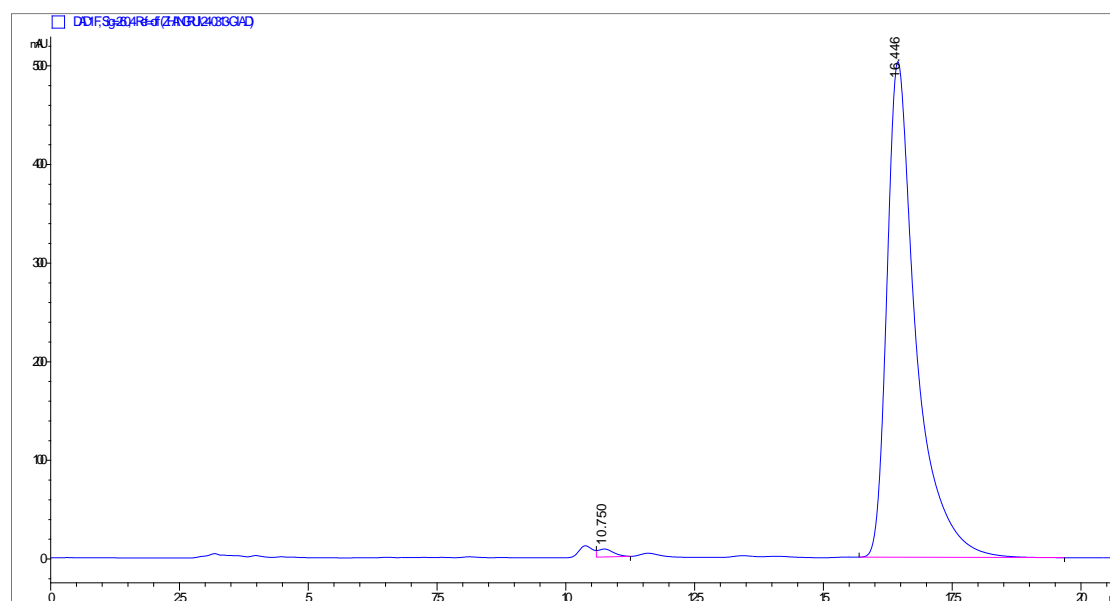
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.825	FM	1.0851	1158.11353	17.78766	4.0096
2	27.244	BB	1.2566	2.77255e4	323.26694	95.9904

Racemic-3ai



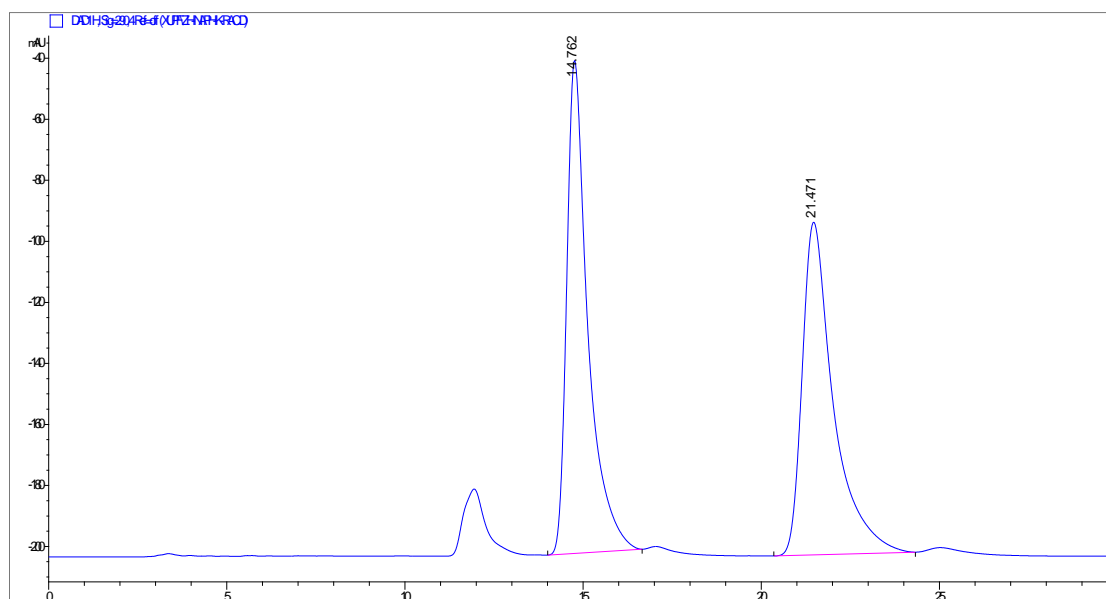
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.870	BB	0.3684	6528.97803	256.97961	50.0080
2	16.662	BB	0.5843	6526.88623	162.58836	49.9920

Enantioenriched-3ai



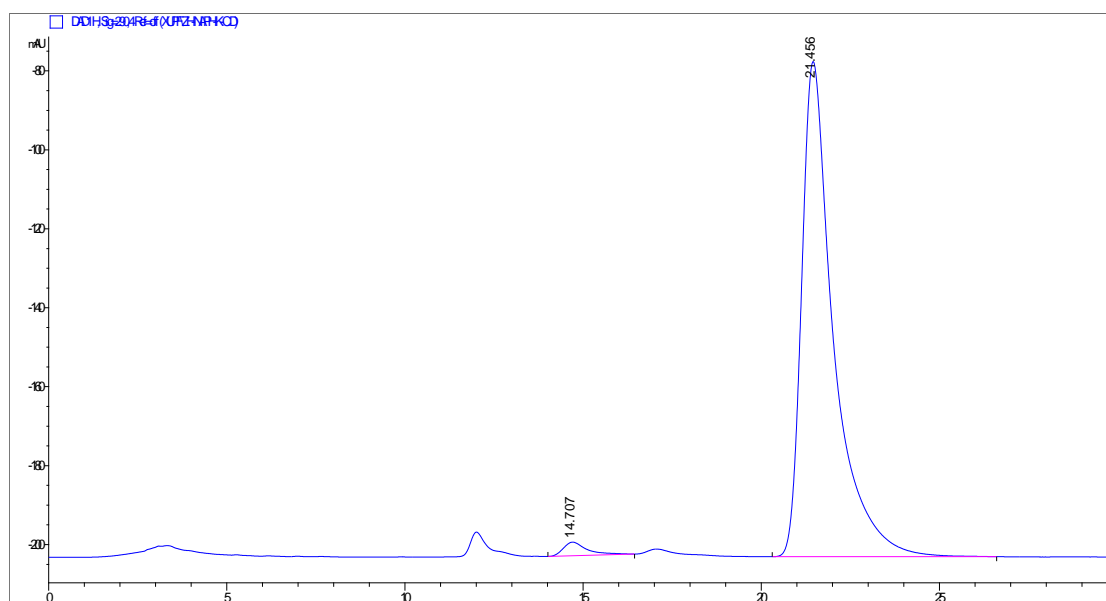
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.750	VB	0.3049	163.96147	7.94013	0.8242
2	16.446	BB	0.5740	1.97297e4	502.55795	99.1758

Racemic-3aj



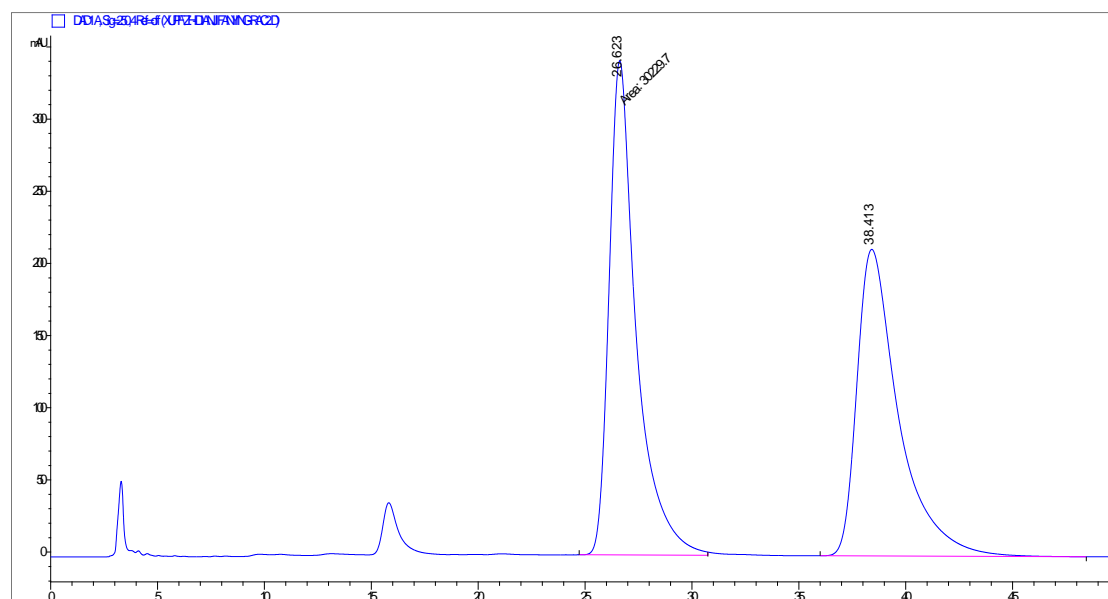
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.761	BB	0.6044	3421.49561	82.40189	50.4544
2	21.471	BB	0.8813	3359.87158	55.41794	49.5456

Enantioenriched-3aj



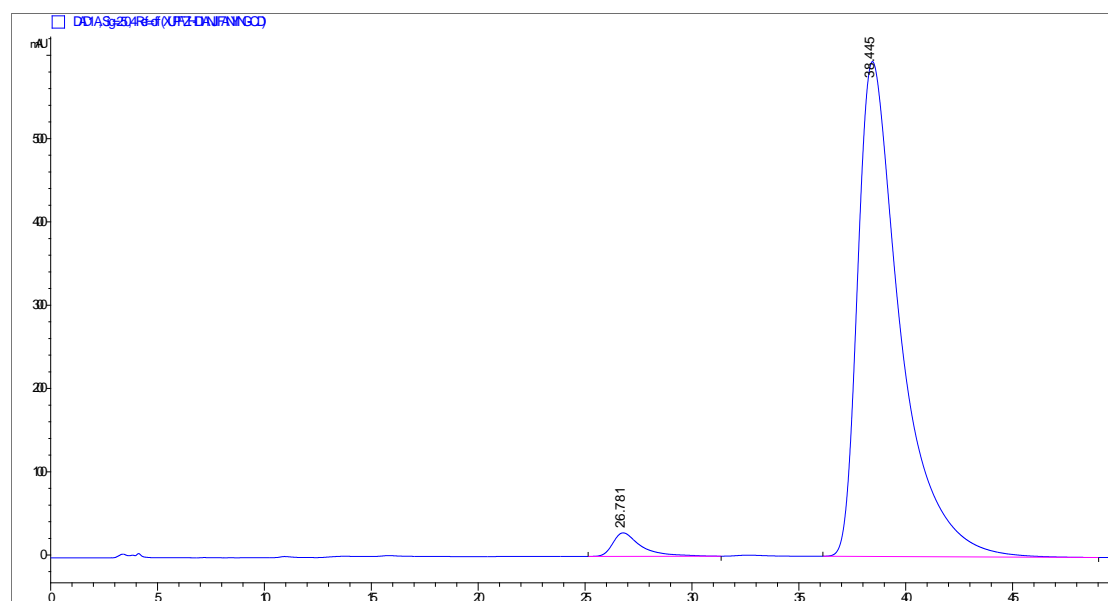
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.707	BB	0.6464	160.65355	3.45526	2.0200
2	21.456	BB	0.9048	7792.57324	125.42951	97.9800

Racemic-4



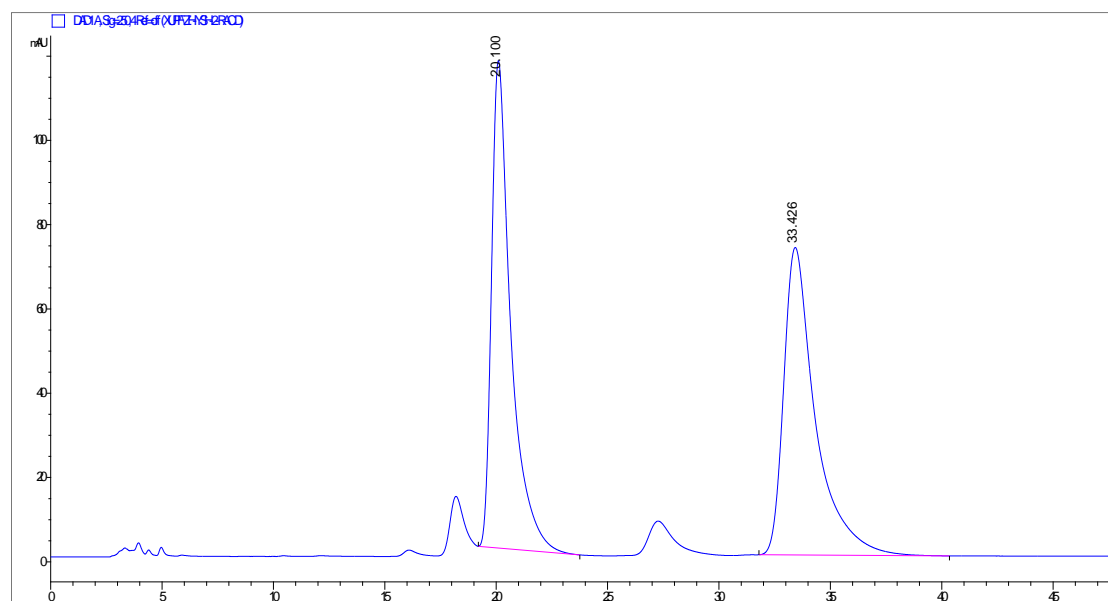
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.623	MF	1.4711	3.02297e4	342.47504	51.3059
2	38.413	BB	1.9597	2.86908e4	212.42435	48.6941

Enantioenriched-4



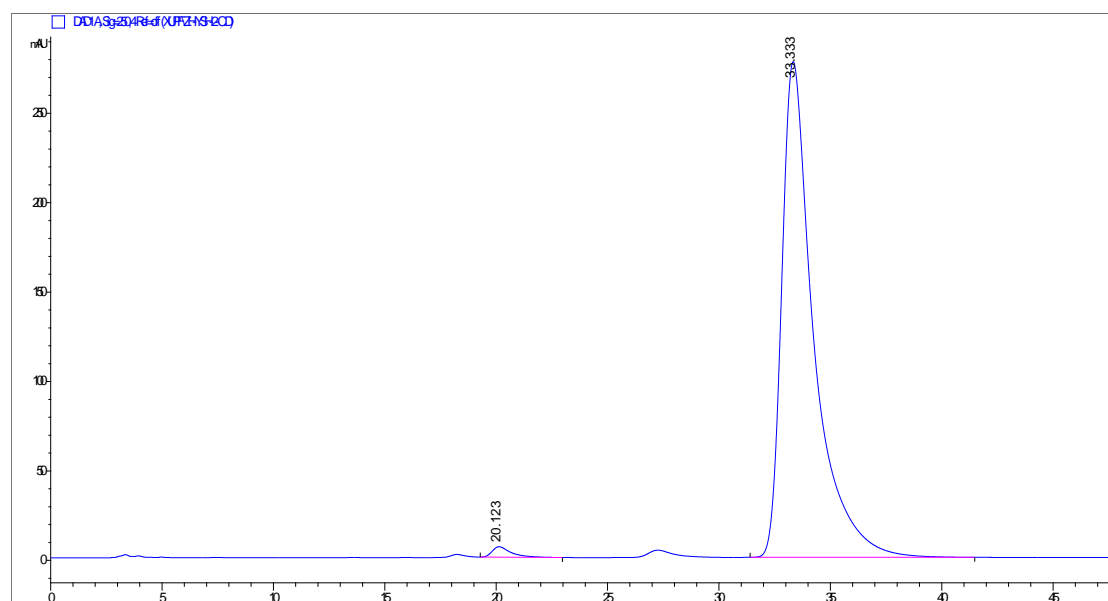
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.781	BB	1.2897	2587.52490	28.22065	3.0451
2	38.445	BB	2.0535	8.23865e4	594.24939	96.9549

Racemic-5



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.100	BB	0.8787	6945.10303	115.63970	49.0937
2	33.426	BB	1.4173	7201.51514	72.97661	50.9063

Enantioenriched-5



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.123	BB	0.8239	348.18344	5.87077	1.2433
2	33.333	BB	1.4540	2.76563e4	277.18527	98.7567