Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Asymmetric synthesis of cyclopenta[*b*]indoles via organocatalytic formal (3+2) cyclization of β-keto ester with azonaphthalene

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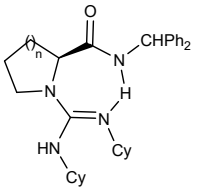
1. General Information

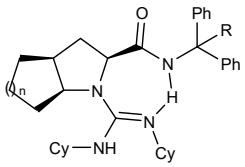
Unless otherwise noted, all catalytic reactions were run under air conditions, column chromatography was generally performed on silica gel (300–400 mesh) and reactions were monitored with thin layer chromatography (TLC) using 254 nm UV light and basic $KMnO_4$ aqueous. NMR characterization data were collected on bruker ASCENDTM operating at 400 MHz and 600 MHz for ^1H NMR, 101MHz and 151 MHz for $^{13}C\{1H\}$ NMR (with complete proton decoupling), and 565 MHz for $^{19}F\{1H\}$ NMR (with complete proton decoupling). ^1H NMR chemical shifts were reported in ppm from tetramethylsilane with the TMS resonance as the internal standard ($\delta = 0.00$). ^{13}C NMR spectra chemical shifts are reported in ppm from thetetramethylsilane with the solvent resonance as internal standard ($CDCl_3$, $\delta = 77.0$, $(CD_3)_2CO$, $\delta = 206.4$, C_6D_6, $\delta = 128.0$). Spectra were reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (Hz), integration and assignment. High-resolution mass spectra (HRMS) were recorded on a Thermo Q-Exactive Focus (FTMS+c ESI). Enantiomeric excesses were determined by chiral SFC analysis using the corresponding commercial chiral column as stated in the experimental procedures at 25 °C with UV detector. Optical rotations were measured on Rudolph Research Analytic Automatic Polarimeter and reported as follows: $[\alpha]^T_D$ (c: g/100 mL, in CH_2Cl_2). Infrared spectra (IR) were recorded on Bruker Tensor II spectrometer with Plantium ATR accessory and the peaks are reported as absorption maxima (ν, cm^{-1}). Circular dichroism (CD) spectra were recorded on Applied Photophysics Chirascan. Melting point ranges were determined on OptiMelt. X-ray crystallographic data were collected by a Bruker D8 Venture Photon II. All the solvents were purified by usual methods before use and reagents obtained from commercial sources were used without further purification. Substrates azonaphthalene[1], β-keto ester and β-keto amide[2] were synthesized according to the literature methods.

2. General procedure for the synthesis of the chiral guanidines

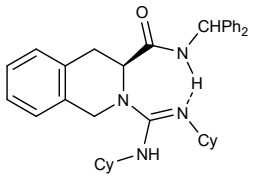
The chiral guanidines were prepared by the similar procedure in the literatures.[3, 4]



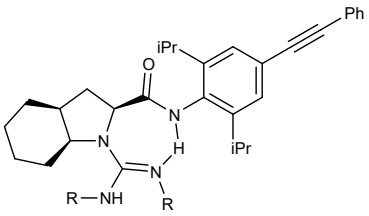
G1: n=1
G2: n=2



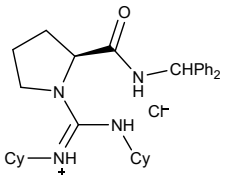
G3: n = 1, R = H
G4: n = 2, R = H
G6: n = 1, R = Ph



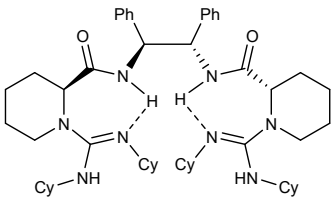
G5



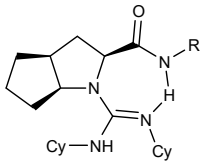
G7: R=Cy
G8: R=iPr



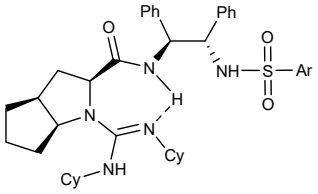
G9



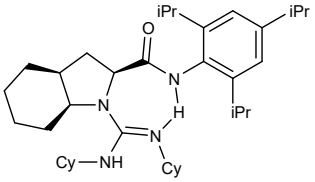
G10



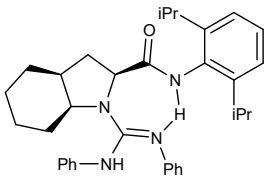
G11: R=2,4,6-iPrC_6H_2
G12: R=2,6-iPr-4-AdC_6H_2
G13: R=2,6-iPr-4-$CPh_3C_6H_2$
G14: R=tBu
G15: R=adamantyl



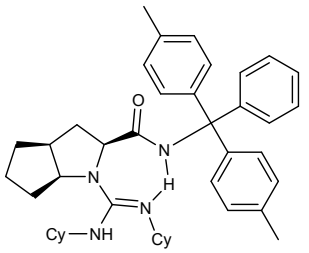
G16: Ar = 4-MeC_6H_4



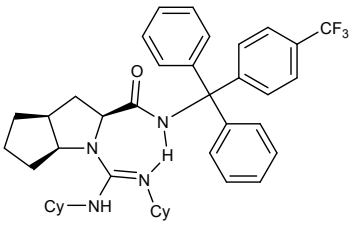
G17



G18



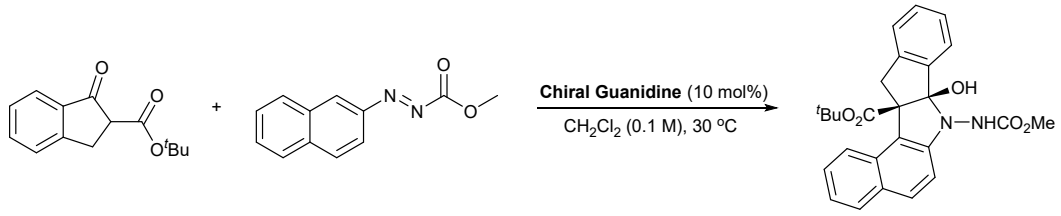
G19



G20

3. Optimization of the reaction conditions

Table S1. Screening of the chiral guanidines.

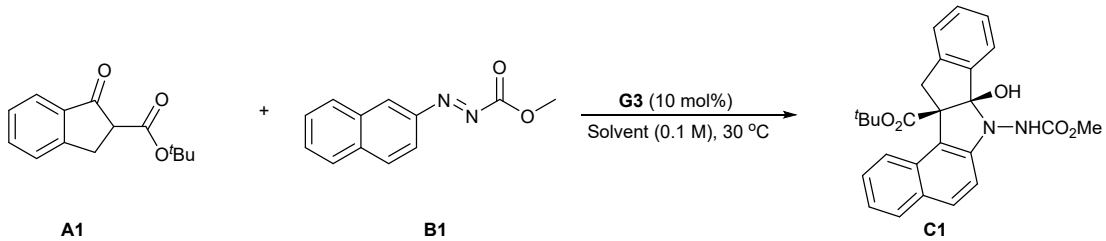


A1 B1 C1

Entry[a]	**Guanidine**	Yield (%)[b]	ee (%)[c]	dr[c]
1	**G1**	19	14	>19:1
2	**G2**	trace	0	>19:1
3	**G3**	31	32	93:7
4	**G4**	42	27	92:8
5	**G5**	13	9	>19:1
6	**G9**	N.R.	-	-
7	**G10**	12	0	>19:1
8	**G16**	29	13	53:47

[a] Unless otherwise noted, the reactions were carried out with **A1** (0.10 mmol), **B1** (0.10 mmol) and the catalyst (10 mol%) in CH_2Cl_2 (0.1 M) at 30 °C for 12 h. [b] Yield of the isolated products. [c] Determined by chiral SFC.

Table S2. Screening of solvents.



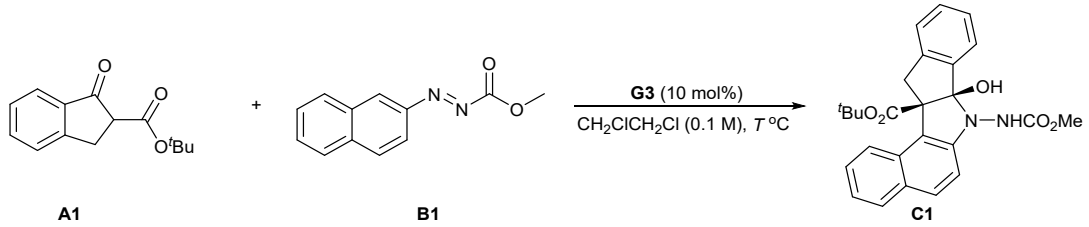
A1 B1 C1

Entry[a]	Solvent	Yield (%)[b]	ee (%)[c]	dr[c]
1	CH_2Cl_2	31	32	93:7
2	THF	59	0	>19:1
3	Toluene	34	20	87:13
4	MeCN	90	24	>19:1
5	DMF	87	3	95:5
6	CH_2ClCH_2Cl	69	34	87:13
7	EtOAc	60	4	>19:1

8	$CHCl_3$	35	24	88:12

[a] Unless otherwise noted, the reactions were carried out with **A1** (0.10 mmol), **B1** (0.10 mmol) and the **G3** (10 mol%) in solvent (0.1 M) at 30 °C for 12 h. [b] Yield of the isolated products. [c] Determined by chiral SFC.

Table S3. Screening of temperature.

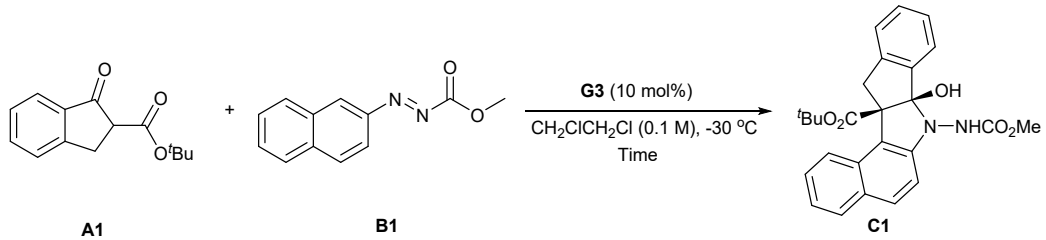


A1 **B1** **C1**

Entry[a]	*T* °C	Yield (%)[b]	ee (%)[c]	dr[c]
1	10	49	38	>19:1
2	0	51	57	>19:1
3	-10	56	65	>19:1
4	-20	46	72	>19:1
5	-30	39	74	>19:1

[a] Unless otherwise noted, the reactions were carried out with **A1** (0.10 mmol), **B1** (0.10 mmol) and the **G3** (10 mol%) in CH_2ClCH_2Cl (0.1 M) at *T* °C for 12 h. [b] Yield of the isolated products. [c] Determined by chiral SFC.

Table S4. Screening of the reaction time.

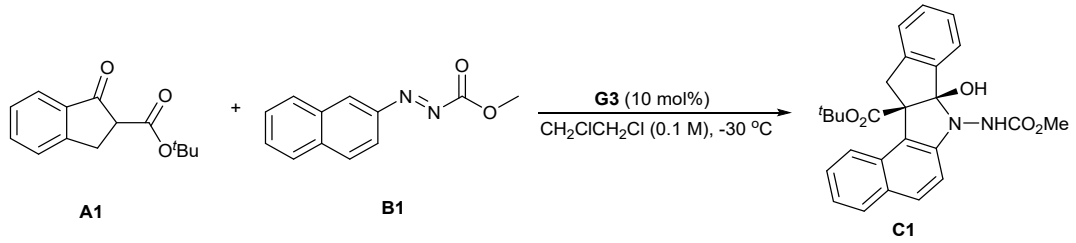


A1 **B1** **C1**

Entry[a]	Time (h)	Yield (%)[b]	ee (%)[c]	dr[c]
1	24	49	77	>19:1
2	36	56	78	>19:1
3	48	66	78	>19:1

[a] Unless otherwise noted, the reactions were carried out with **A1** (0.10 mmol), **B1** (0.10 mmol) and the **G3** (10 mol%) in CH_2ClCH_2Cl (0.1 M) at -30 °C for different times (h). [b] Yield of the isolated products. [c] Determined by chiral SFC.

Table S5. Screening of the substrate ratio.

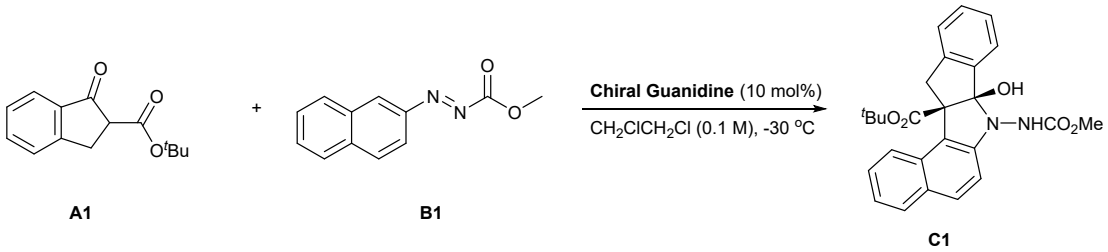


A1 B1 C1

Entry[a]	**A1**:**B1**	Yield (%)[b]	ee (%)[c]	dr[c]
1	1:1.1	66	78	>19:1
2	1:1.2	71	78	>19:1
3	1:1.5	72	78	>19:1
4	1.5:1	75	78	>19:1
5	1.2:1	72	78	>19:1
6	1.1:1	68	78	>19:1

[a] Unless otherwise noted, the reactions were carried out with **A1**, **B1** and **G3** (10 mol%) in CH_2ClCH_2Cl (0.1 M) at -30 °C for 48 h. [b] Yield of the isolated products. [c] Determined by chiral SFC.

Table S6. Rescreening of the chiral guanidines.

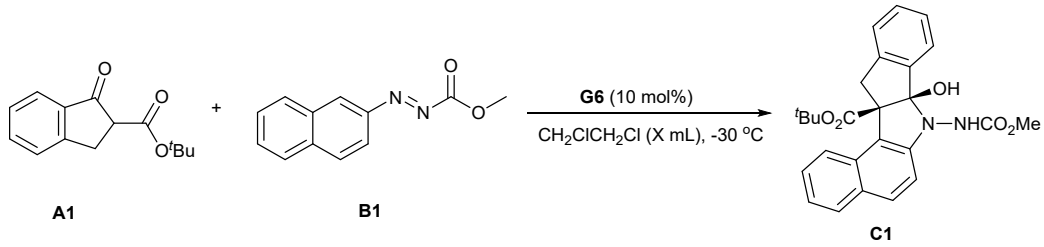


A1 B1 C1

Entry[a]	**Guanidine**	Yield (%)[b]	ee (%)[c]	dr[c]
1	**G6**	79	87	>19:1
2	**G11**	52	77	>19:1
3	**G12**	48	73	>19:1
4	**G13**	77	75	>19:1
5	**G14**	72	60	>19:1
6	**G15**	55	45	>19:1

[a] Unless otherwise noted, the reactions were carried out with **A1** (0.15 mmol), **B1** (0.10 mmol) and **chiral guanidine** (10 mol%) in CH_2ClCH_2Cl (0.5 mL) at -30 °C for 48 h. [b] Yield of the isolated products. [c] Determined by chiral SFC.

Table S7. Screening of the amount of solvent.

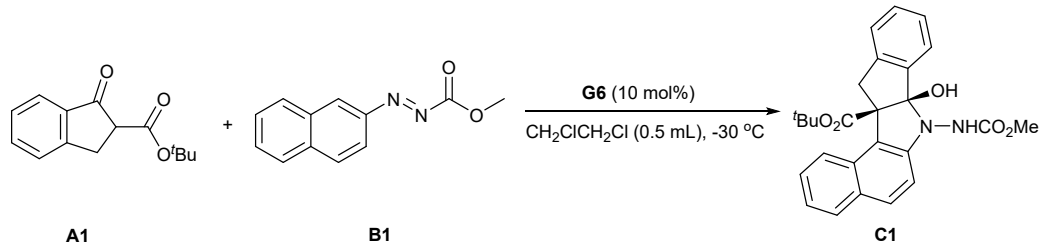


A1 B1 C1

Entry[a]	X	Yield (%)[b]	ee (%)[c]	dr[c]
1	0.5	99	92	>19:1
2	1.0	79	87	>19:1
3	1.5	73	85	>19:1

[a] Unless otherwise noted, the reactions were carried out with **A1** (0.15 mmol), **B1** (0.10 mmol) and **G6** (10 mol%) in CH_2ClCH_2Cl (X mL) at -30 °C for 48 h. [b] Yield of the isolated products. [c] Determined by chiral SFC.

Table S8. Screening of the additives.

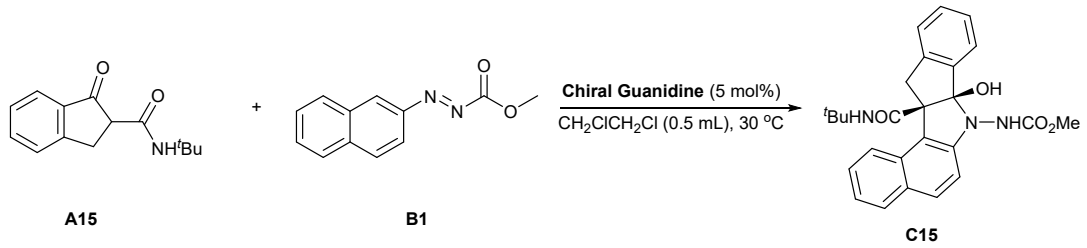


A1 B1 C1

Entry[a]	Additives	Yield (%)[b]	ee (%)[c]	dr[c]
1	3 Å MS (20 mg)	99	89	>19:1
2	4 Å MS (20 mg)	99	90	>19:1
3	5 Å MS (20 mg)	99	91	>19:1
4	Na_2SO_4 (20 mol%)	99	89	>19:1
5	TMG (10 mol%)	98	9	>19:1
6	$NaBAr^F{}_4$ (10 mol%)	94	16	>19:1
7	NEt_3 (10 mol%)	86	88	>19:1
8	--	99	92	>19:1
9[d]	--	97	91	>19:1
10[e]	--	77	89	>19:1
11[f]	--	68	90	>19:1

[a] Unless otherwise noted, the reactions were carried out with **A1** (0.15 mmol), **B1** (0.10 mmol) and **G6** (10 mol%) in CH_2ClCH_2Cl (0.5 mL) at -30 °C for 48 h. [b] Yield of the isolated products. [c] Determined by chiral SFC. [d] 5 mol% **G6** were used. [e] 5 mol% **G19** were used. [f] 5 mol% **G20** were used.

Table S9. Screening of the chiral guanidines for **A15**.

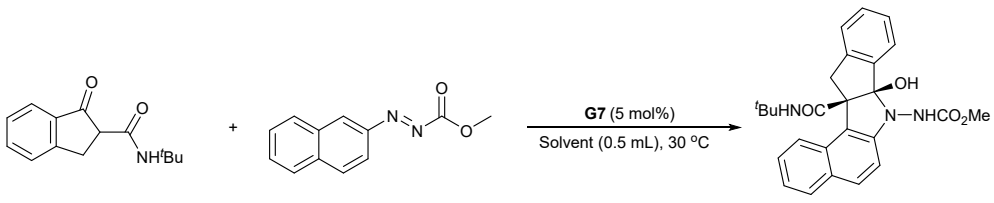


A15 B1 C15

Entry[a]	**Guanidine**	Yield (%)[b]	ee (%)[c]	dr[c]
1	**G1**	83	-2	54:46
2	**G2**	98	4	61:39
3	**G3**	95	10	55:45
4	**G4**	86	19	73:27
5	**G5**	trace	-	-
6	**G6**	99	18	83:17
7	**G7**	95	22	71:29
8	**G8**	87	16	71:29
9	**G17**	90	21	74:26
10	**G18**	trace	-	-

[a] Unless otherwise noted, the reactions were carried out with **A15** (0.15 mmol), **B1** (0.10 mmol) and **chiral guanidine** (5 mol%) in CH_2ClCH_2Cl (0.5 mL) at 30 °C for 24 h. [b] Yield of the isolated products. [c] Determined by chiral SFC.

Table S10. Screening of solvents.



A15 B1 C15

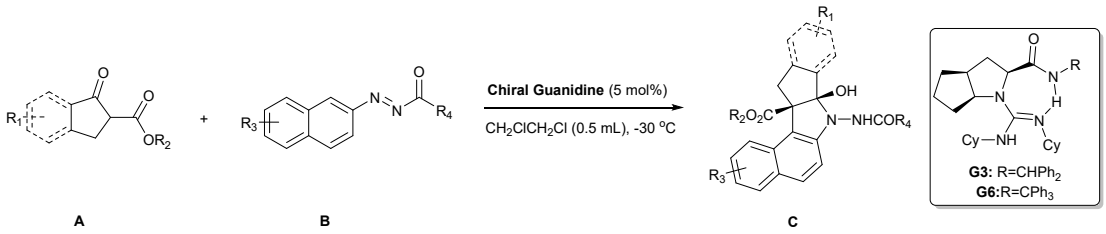
Entry[a]	Solvent	Yield (%)[b]	ee (%)[c]	dr[c]
1	THF	89	8	74:26
2	Toluene	92	34	81:19
3	MeCN	63	0	58:42
4	*i*PrOH	78	5	89:11

5	EtOAc	66	30	69:31
6	DMF	98	0	93:7
7	Mesitylene	71	34	75:25

[a] Unless otherwise noted, the reactions were carried out with **A15** (0.15 mmol), **B1** (0.10 mmol) and **G7** (5 mol%) in solvent (0.5 mL) at 30 °C for 24 h. [b] Yield of the isolated products. [c] Determined by chiral SFC.

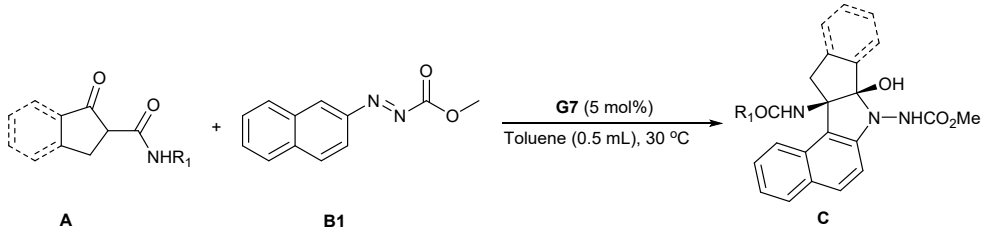
4. Typical procedure for the catalytic asymmetric reaction.

1. Typical procedure for the catalytic asymmetric reaction with β-keto ester.



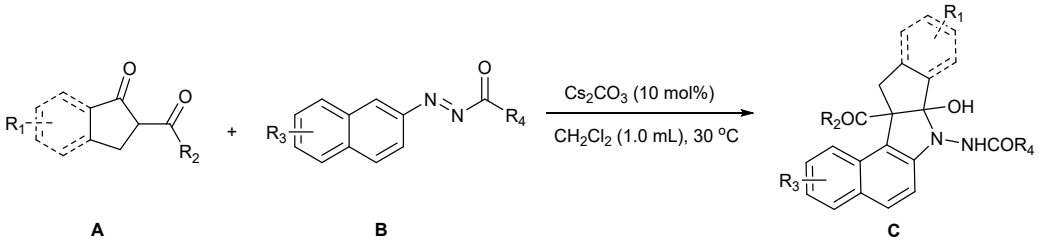
An oven-dried test tube was charged with **A** (0.15 mmol), **B** (0.10 mmol), **chiral guanidine** (5 mol%) and CH_2ClCH_2Cl (0.5 mL), the reaction mixture was stirred at -30 °C and detected by TLC. After the reaction was completed, the residue was subjected to column chromatography (silica gel, eluent: petroleum ether/ethyl acetate = 5:1 to 1:1) to afford the desired products. (**G6** were used for **C1-C14, G3** were used for **C16-C19, C21-C31**)

2. Typical procedure for the catalytic asymmetric reaction with β-keto amide.



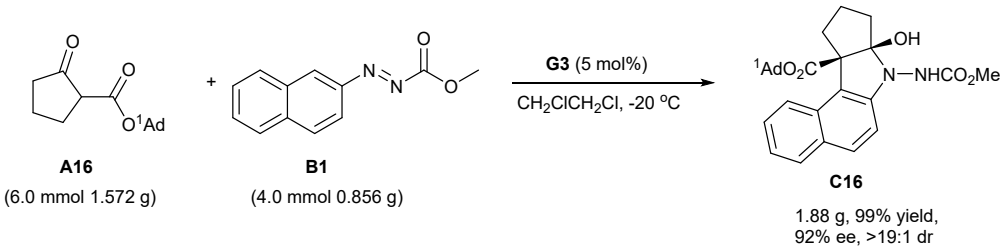
An oven-dried test tube was charged with **A** (0.15 mmol), **B1** (0.10 mmol), **G7** (5 mol%) and toluene (0.5 mL), the reaction mixture was stirred at 30 °C and detected by TLC. After the reaction was completed, the residue was subjected to column chromatography (silica gel, eluent: petroleum ether/ethyl acetate = 5:1 to 1:1) to afford the desired products **C15, C20**.

5. General procedure for the preparation of the racemic products.

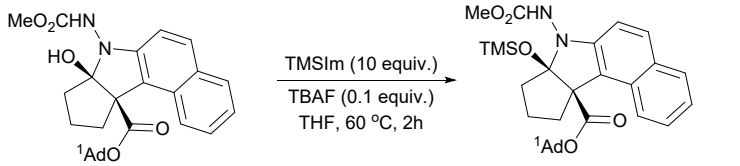


An oven-dried test tube was charged with **A** (0.10 mmol), **B** (0.10 mmol), Cs_2CO_3 (10 mol%) and CH_2Cl_2 (1.0 mL), the reaction mixture was stirred at 30 °C about 2 h and detected by TLC. After the reaction was completed, the residue was subjected to column chromatography (silica gel, eluent: petroleum ether/ethyl acetate = 5:1 to 1:1) to afford the racemic products **C**.

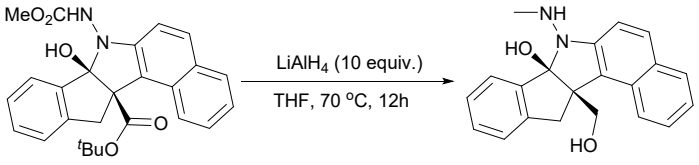
6. Gram-scale synthesis of C16 and the transformations of the products.



An over dried test tube was charged with **A16** (6.0 mmol), **B1** (4.0 mmol), **G3** (0.2 mmol, 5 mol%), and CH_2ClCH_2Cl (20.0 mL). Then, the reaction mixture was stirred at -20 °C and detected by TLC. After the reaction was completed, remove the solvent by the vacuum evaporator, and the residue was subjected to the silica gel column chromatography (eluent: petroleum ether/ethyl acetate = 3:1) to afford the product **C16** (1.88 g, 99% yield, 92% ee, >19:1 dr).

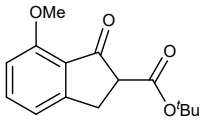


An oven-dried test tube was charged with **C16** (0.1 mmol, 47.6 mg, 92% ee, >19:1 dr) and THF (2.0 mL) followed by adding TMSIm (140 μL, 1.0 mmol, 10.0 equiv.), and TBAF (2.6 mg, 0.01 mmol, 0.1 equiv.). After stirred for 2 h at 60 °C and detected by TLC. After the reaction was completed, the reaction was quenched with saturated aqueous $NaHCO_3$ (5 mL) and extracted with ethyl acetate (3×5 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered and concentrated in vacuo and the crude residue was purified by flash-column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 4:1) to afford the desired product **D1** (47.1 mg, 86% yield, 92% ee, >19:1 dr).

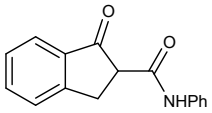


Compound **C1** (44.6 mg, 0.1 mmol, 90% ee, >19:1 dr) was treated with $LiAlH_4$ (38.0 mg, 1.0 mmol, 10 eq) in THF (1.0 mL) at 70 °C for 12 h. After finished, the reaction was quenched with H_2O (5 mL). The solution was extracted with CH_2Cl_2 (3×5 mL). The combined extracts were washed with brine (8.0 mL), dried (Na_2SO_4), filtered and concentrated in vacuo. The crude product was purified by flash-column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 2:1) gave **D2** (12.6 mg, 38% yield, 88% ee, >19:1 dr).

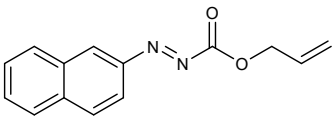
7. Unsuccessful substrates.



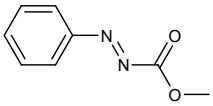
46% yield, 25% ee



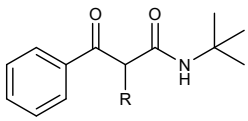
39% yield, 36% ee



37% yield, race

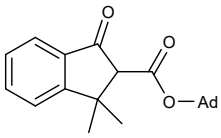


trace, 28% ee

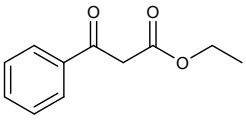


R = F, Ph, *i*Bu, Et

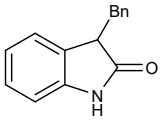
N.R.



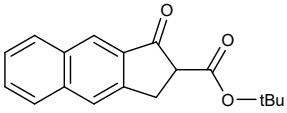
N.R.



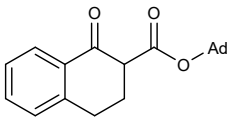
N.R.



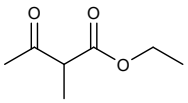
only first step



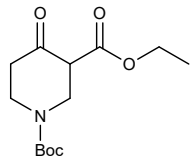
trace



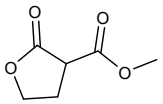
N.R.



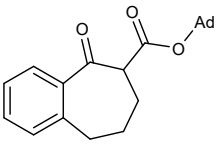
N.R.



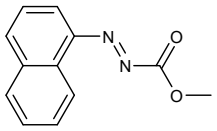
N.R.



trace



N.R.

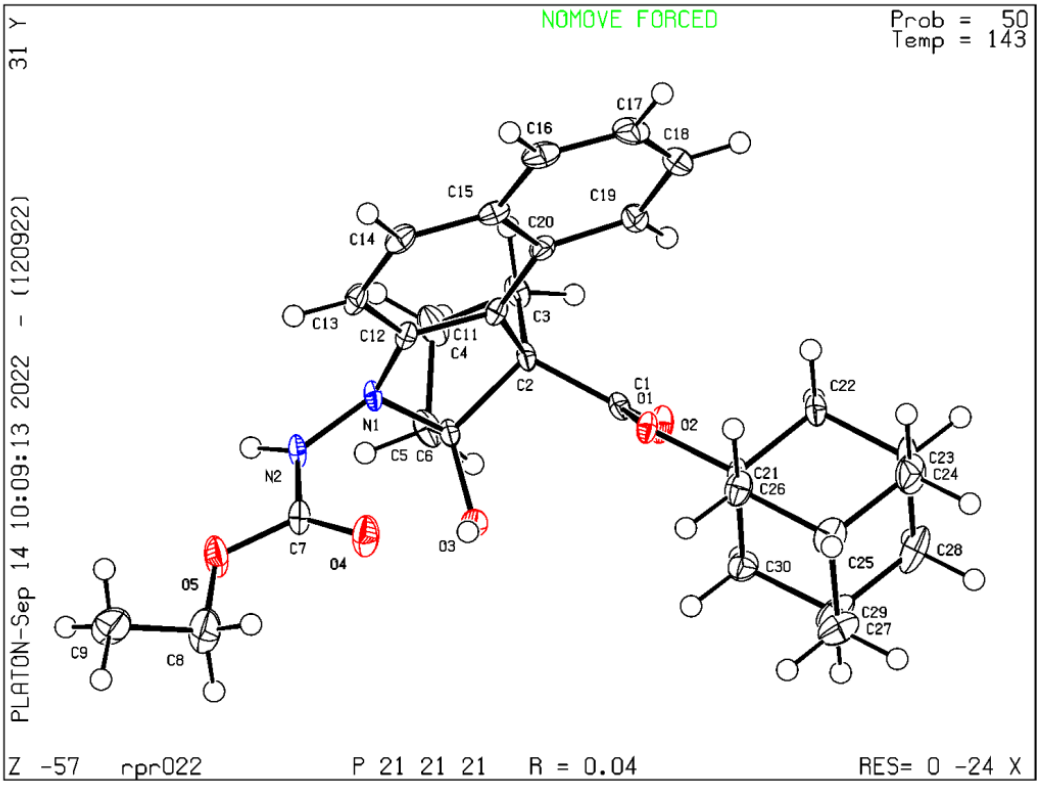


complex

8. X-ray crystal data

Crystals suitable for the X-ray crystal structure analysis were obtained from a solution of compound **C21** in CH_2Cl_2 and petroleum ether at rt. CCDC 2212549 contains the supplementary crystallographic data for this paper. These data are provided free of charge by The Cambridge Crystallographic Data Centre.

The colourless crystal in rod-shape, with approximate dimensions of 0.074 × 0.113 × 0.468 mm^3, was selected and mounted for the single-crystal X-ray diffraction. The data set was collected by Bruker D8 Venture Photon II diffractometer at 143(2) K equipped with micro-focus Cu radiation source (K_α = 1.54178Å). Applied with face-indexed numerical absorption correction, the structure solution was solved and refinement was processed by SHELXTL (version 6.14) and OLEX 2.3 program package[a, b, c, d]. The structure was analyzed by ADDSYM routine implemented in PLATON suite and no higher symmetry was suggested.[e]



Crystallographic Data for **C21**.

Formula	$C_{29}H_{34}N_2O_5$(**C21**)
Formula mass (amu)	490.58
Space group	P 21 21 21
a (Å)	10.5032(4)
b (Å)	12.2302(5)
c (Å)	19.6985(7)
α (deg)	90

β (deg)	90
γ (deg)	90
V (Å^3)	2530.40(17)
Z	4
λ (Å)	1.54178
T (K)	143 K
ρ_{calcd} (g cm^{-3})	1.288
μ (mm^{-1})	0.711
Transmission factors	0.604-1.000
θ_{max} (deg)	68.342
No. of unique data, including $F_o^2 < 0$	4512
No. of unique data, with $F_o^2 > 2\sigma(F_o^2)$	4278
No. of variables	334
$R(F)$ for $F_o^2 > 2\sigma(F_o^2)$ [a]	0.0381
$R_w(F_o^2)$ [b]	0.0968
Goodness of fit	1.045

[a] $R(F) = \sum||F_o| - |F_c|| / \sum|F_o|$.

[b] $R_w(F_o^2) = [\sum[w(F_o^2 - F_c^2)^2] / \sum wF_o^4]^{1/2}$; $w^{-1} = [\sigma^2(F_o^2) + (Ap)^2 + Bp]$, where $p = [\max(F_o^2,0) + 2F_c^2] / 3$.

References:
[a] G. M. Sheldrick, *Acta Cryst.,* 2008, **A64**, 112–122.
[b] G. M. Sheldrick, *Acta Cryst.,* 2015, **A71**, 3–8.
[c] G. M. Sheldrick, *Acta Cryst.,* 2015, **C71**, 3–8.
[d] O. V. Dolomanov, L. J. Bourhis, R. J. Gildea, J. A. K. Howard and H. Puschmann, *J. Appl. Cryst.,* 2009, **42**, 339-341.
[e] A. L. Spek, *J. Appl. Cryst.,* 2003, **36**, 7–13.

9. The NMR study of substrates with G3.

We performed NMR spectra analysis to probe the interaction between chiral guanidine and two substrates separately. In **Fig. S1**, the chemical shift of diphenylmethyl aliphatic H of **G3** shift from 6.225 ppm to 6.231 ppm when mixing with azonaphthalene (**B1**). In **Fig. S2**, the results showed that the α-H (δ=3.15 ppm) of β-ketoester was disappeared when mixing with the catalyst **G3**. These results manifested that the chiral guanidine might playing two roles in this reaction, which promoting enolization of β-ketoester by guanidine group and bonding with the azonaphthalene by hydrogen bond of amide group.

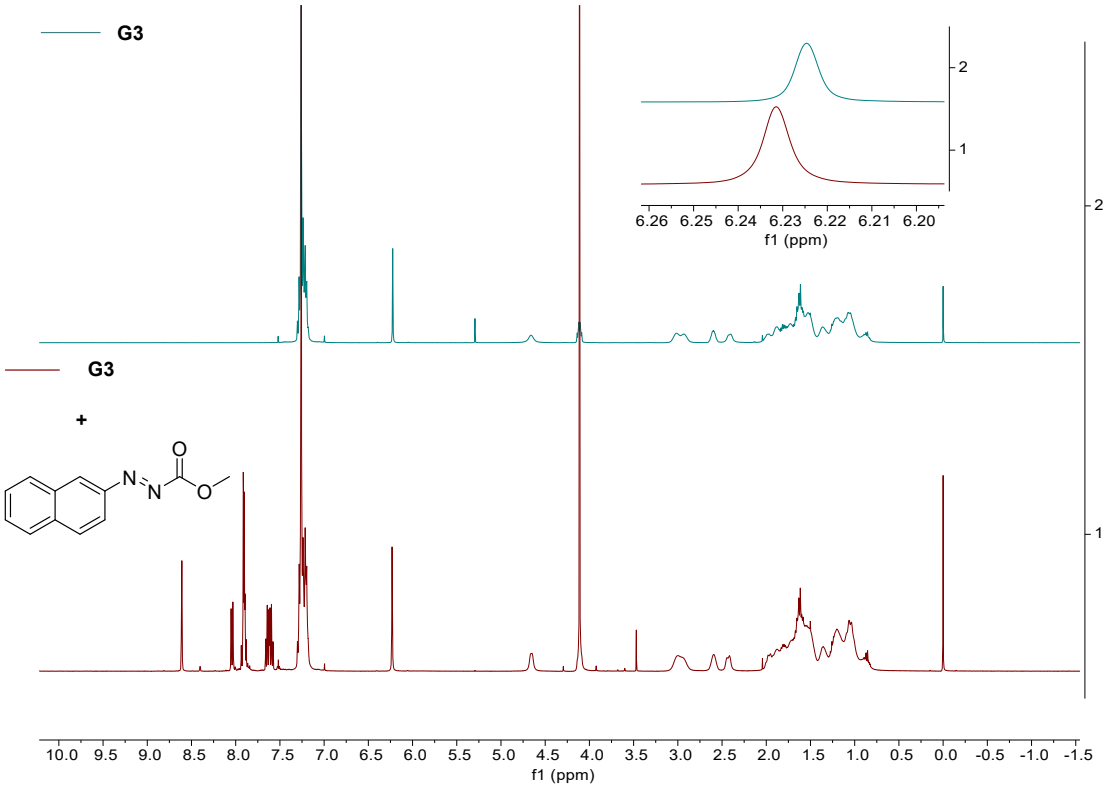


Fig. S1

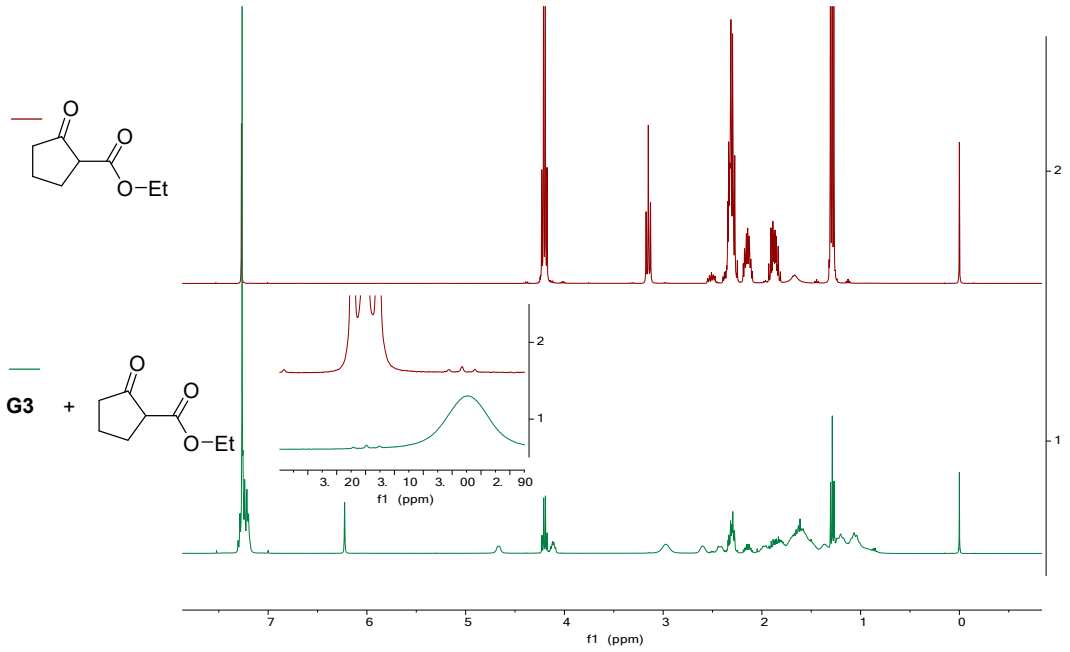
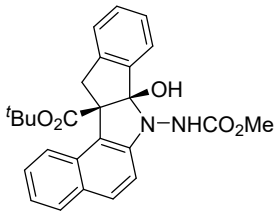


Fig. S2

10. Spectral characterization data for products

Tert-butyl (7aR,12aR)-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[e]indeno[1,2-b]indole-12a(7H)-carboxylate (C1):



White solid, 97% yield, 91% ee, >19:1 dr, m.p. 118-123 °C, $[\alpha]^{20}_{D}$ = -448.4 (c = 1.65, in CH_2Cl_2).

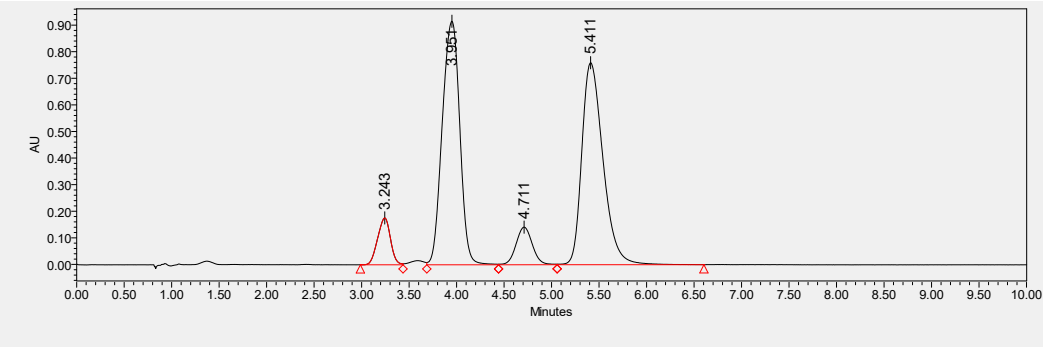
SFC Daicel Chiralpak OD-3, CO_2/MeOH = 90/10, 1.5 mL/min, λ = 240 nm, t_1 = 4.00 min, t_2 = 5.52 min.

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.57 (d, J = 7.2 Hz, 1H), 7.33 (m, 2H), 7.17 (d, J = 8.3 Hz, 1H), 7.06 (t, J = 7.5 Hz, 1H), 6.86 (s, 1H), 6.77 (s, 2H), 6.66 – 6.59 (m, 1H), 6.41 – 6.24 (m, 1H), 5.71 (s, 1H), 4.70 (s, 1H), 4.35 (d, J = 15.9 Hz, 1H), 3.08 (s, 3H), 2.90 (d, J = 16.4 Hz, 1H), 0.92 (s, 9H).

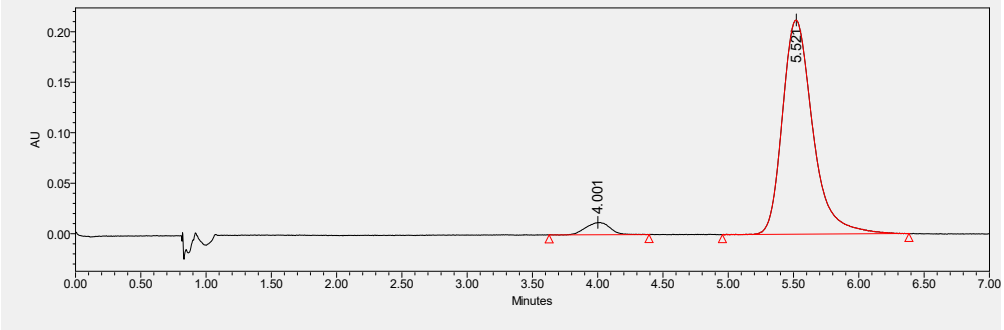
^{13}C NMR (101 MHz, Benzene-d_6) δ 170.3, 158.8, 145.4, 142.3, 140.2, 130.4, 129.9, 129.7, 129.6, 127.3, 127.0, 125.5, 124.6, 122.9, 122.3, 120.5, 110.5, 108.9, 81.9, 65.5, 52.9, 41.4, 30.1, 27.8.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{26}N_2O_5Na^+]$: 469.1734 found 469.1736.

IR (neat) 3302, 2977, 1714, 1627, 1518, 1249, 1149, 928, 842, 811, 733, 702 cm^{-1}.

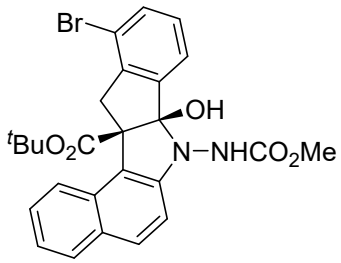


	Retention Time	Area	% Area
1	3.243	1658752	6.17
2	3.951	11748415	43.69
3	4.711	1691511	6.29
4	5.411	11794216	43.86



	Retention Time	Area	% Area
1	4.001	157915	4.41
2	5.521	3421493	95.59

Tert-butyl (7a*R*,12a*R*)-11-bromo-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[e]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C2):



White solid, 77% yield, 86% ee, >19:1 dr, m.p. 122-123 °C, $[\alpha]^{20}_{D}$ = -336.2 (c = 0.81, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 3.20 min, t_2 = 3.55 min.

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.49 (d, *J* = 7.2 Hz, 1H), 7.33 (d, *J* = 8.0 Hz, 1H), 7.16 (m, 2H), 7.01 (d, *J* = 7.4 Hz, 1H), 6.93 (d, *J* = 6.9 Hz, 1H), 6.83 (s, 1H),6.42 (t, *J* = 7.2 Hz, 1H), 6.30 (d, *J* = 7.5 Hz, 1H), 5.53 (s, 1H), 4.77 (s, 1H), 4.54 (d, *J* = 15.7 Hz, 1H), 3.04 (m, 4H), 0.90 (s, 9H).

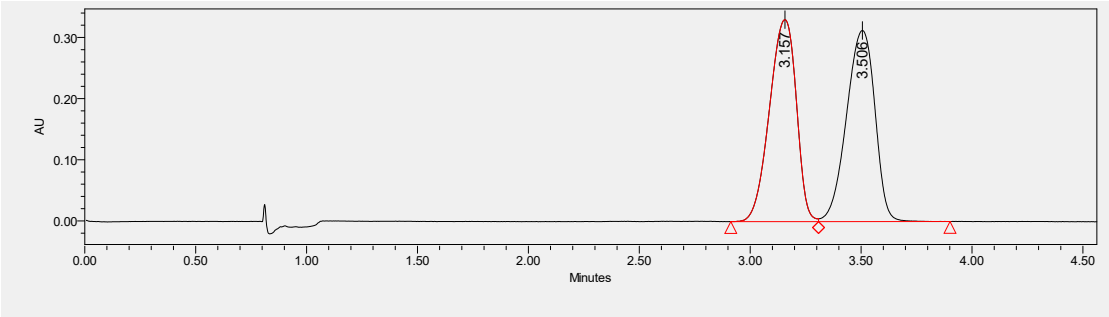
^{13}C NMR (101 MHz, Benzene-d_6) δ 169.8, 158.9, 145.2, 142.8, 142.4, 132.7, 130.5, 130.4, 130.1, 129.5, 129.0, 127.6, 123.3, 123.1, 122.3, 120.7, 120.1, 110.2, 109.1, 82.0, 65.1, 52.9, 43.2, 30.2, 27.7.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{79}BrN_2O_5Na^+]$: 547.0839 found 547.0839.

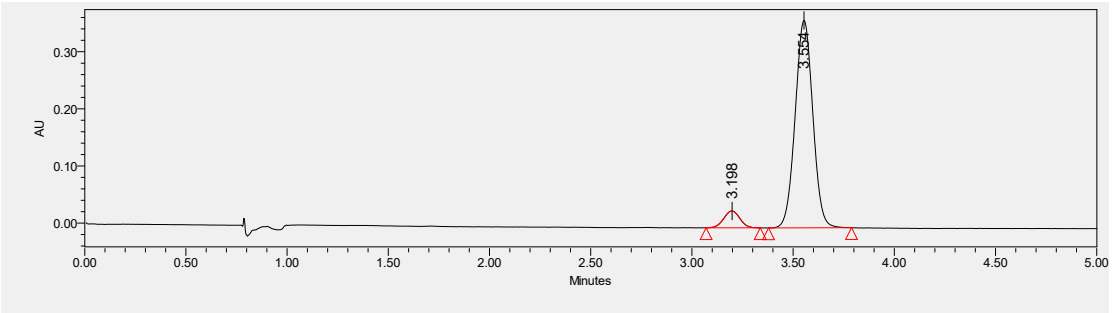
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{81}Br\ N_2O_5Na^+]$: 549.0819 found 549.0819.

IR (neat) 3299, 2976, 1722, 1628, 1578, 1519, 1368, 1255, 1175, 1061, 783, 738 cm^{-1}.

Racemate: 15:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

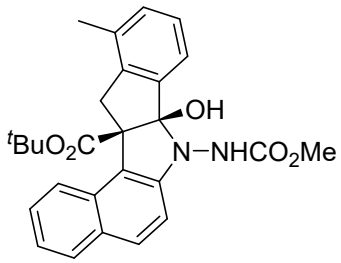


	Retention Time	Area	% Area
1	3.157	2782691	49.97
2	3.506	2785893	50.03



	Retention Time	Area	% Area
1	3.198	162472	6.87
2	3.554	2201297	93.13

Tert-butyl (7a*R*,12a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-11-methyl-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C3):



White solid, 99% yield, 88% ee, >19:1 dr, m.p. 120-122 °C, $[\alpha]^{23}_{D}$ = -618.5 (c = 0.80, in CH_2Cl_2).

SFC Daicel Chiralpak IA-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 11.81 min, t_2 = 14.58 min.

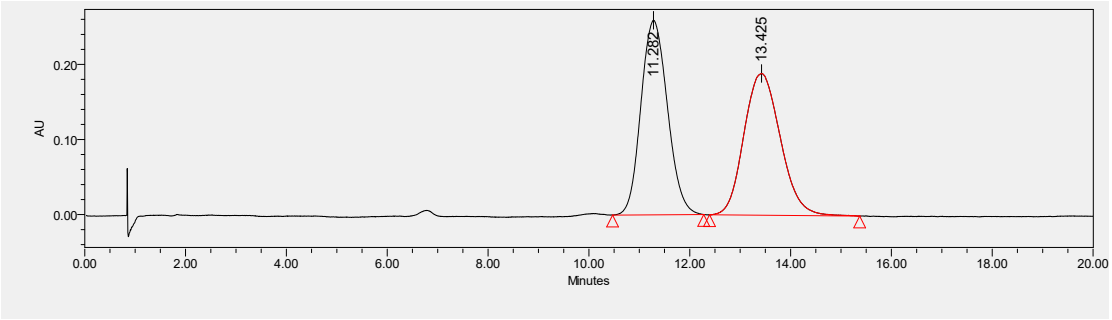
^{1}H NMR (400 MHz, Benzene-d_6) δ 7.63 (d, *J* = 7.5 Hz, 1H), 7.35 (d, *J* = 8.1 Hz, 1H), 7.24 (d, *J* = 7.4 Hz, 1H), 7.19 (d, *J* = 8.5 Hz, 1H), 7.07 (t, *J* = 7.4 Hz, 1H), 6.86 (s, 1H),6.82 – 6.76 (m, 1H), 6.62 (d, *J* = 6.7 Hz, 1H), 6.36 (d, *J* = 8.0 Hz, 1H), 5.64 (s, 1H), 4.66 (s, 1H), 4.34 (d, *J* = 16.9 Hz, 1H), 3.08 (s, 3H), 2.88 (d, *J* = 16.9 Hz, 1H), 1.56 (s, 3H), 0.93 (s, 9H).

^{13}C NMR (101 MHz, Benzene-d_6) δ 170.4, 145.5, 141.0, 140.0, 134.9, 130.5, 130.4, 129.9, 129.6, 127.5, 127.4, 122.9, 122.3, 122.0, 120.7, 110.4,109.0, 81.8, 65.3, 52.8, 40.4, 30.2, 27.8, 18.4.

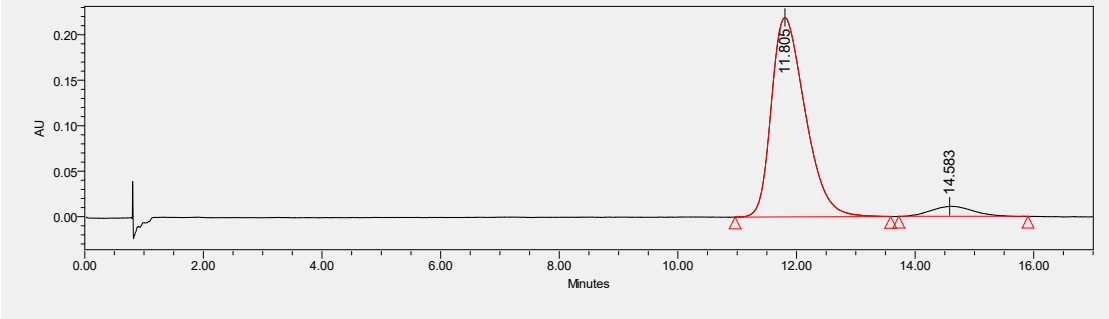
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{27}H_{28}N_2O_5Na^+]$: 483.1890 found 483.1891.

IR (neat) 3303, 2976, 1720, 1627, 1519, 1368, 1254, 1150, 1056, 848, 739 cm^{-1}.

Racemate: 3.2:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

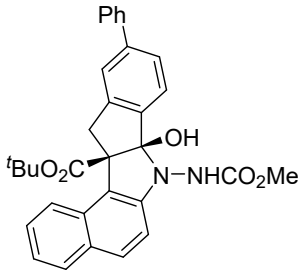


	Retention Time	Area	% Area
1	11.282	9480547	50.01
2	13.425	9476135	49.99



	Retention Time	Area	% Area
1	11.805	8638724	94.14
2	14.583	537299	5.86

Tert-butyl (7a*R*,12a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-10-phenyl-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C4):



White solid, 59% yield, 81% ee, >19:1 dr, m.p. 130-133 °C, $[\alpha]_D^{25}$ = -717.8 (c = 0.57, in CH_2Cl_2).

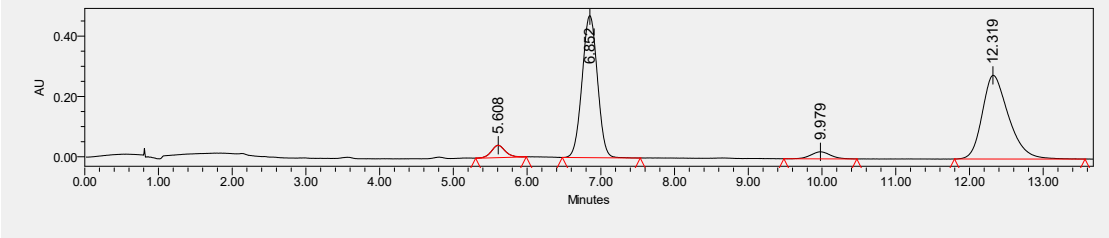
SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 6.85 min, t_2 = 12.17 min.

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.92 (d, *J* = 7.0 Hz, 1H), 7.72 – 7.61 (m, 2H), 7.50 (d, *J* = 8.4 Hz, 1H), 7.44 – 7.34 (m, 4H), 7.21 (q, *J* = 6.4, 5.5 Hz, 3H), 7.13 (m, 2H),6.70 (d, *J* = 8.0 Hz, 1H), 6.03 (s, 1H), 5.01 (s, 1H), 4.72 (d, *J* = 16.4 Hz, 1H), 3.42 (s, 3H), 3.27 (d, *J* = 16.5 Hz, 1H), 1.25 (s, 9H).

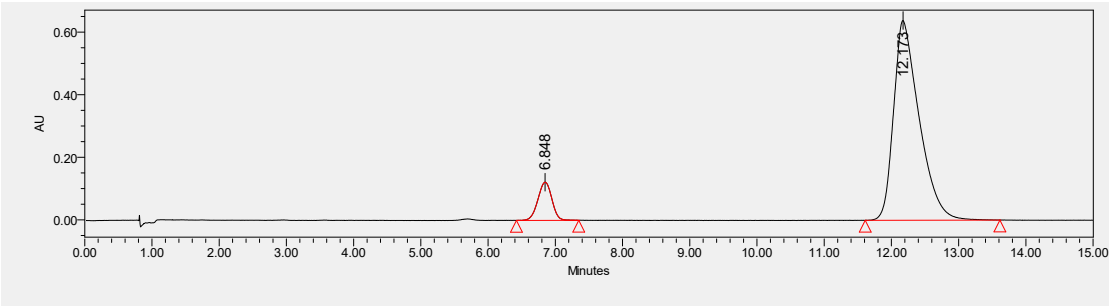
^{13}C NMR (101 MHz, Benzene-d_6) δ 170.3, 158.8, 145.4, 143.3, 143.0, 141.5, 139.2, 130.5, 130.4, 130.0, 129.6, 129.0, 127.6, 127.4, 126.4, 124.9, 124.4, 123.0, 122.3, 120.6, 110.4, 81.9, 65.8, 52.8, 41.3, 30.2, 27.8.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{32}H_{30}N_2O_5Na^+]$: 545.2047 found 545.2049.

IR (neat) 3313, 2977, 1718, 1600, 1368, 1251, 1150, 842, 765, 736 cm^{-1}.

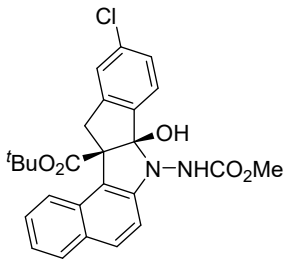


	Retention Time	Area	% Area
1	5.608	533712	3.64
2	6.852	6810955	46.43
3	9.979	442728	3.02
4	12.319	6881453	46.91



	Retention Time	Area	% Area
1	6.848	1768701	9.52
2	12.173	16814574	90.48

Tert-butyl (7a*R*, 12a*R*)-10-chloro-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C5):



White solid, 90% yield, 89% ee, >19:1 dr, m.p. 118-121 °C, $[\alpha]^{20}_{D}$ = -400.1 (c = 0.86, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 3.04 min, t_2 = 4.53 min.

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.79 (d, *J* = 6.5 Hz, 1H), 7.63 (d, *J* = 8.0 Hz, 1H), 7.48 (d, *J* = 8.3 Hz, 1H), 7.36 (m, 2H), 7.16 (s, 1H),7.05 (d, *J* = 6.9 Hz, 1H), 6.87 (s, 1H), 6.65 (d, *J* = 7.5 Hz, 1H), 5.97 (s, 1H), 5.00 (s, 1H), 4.45 (d, *J* = 14.8 Hz, 1H), 3.38 (s, 3H), 2.97 (d, *J* = 16.6 Hz, 1H), 1.21 (s, 9H).

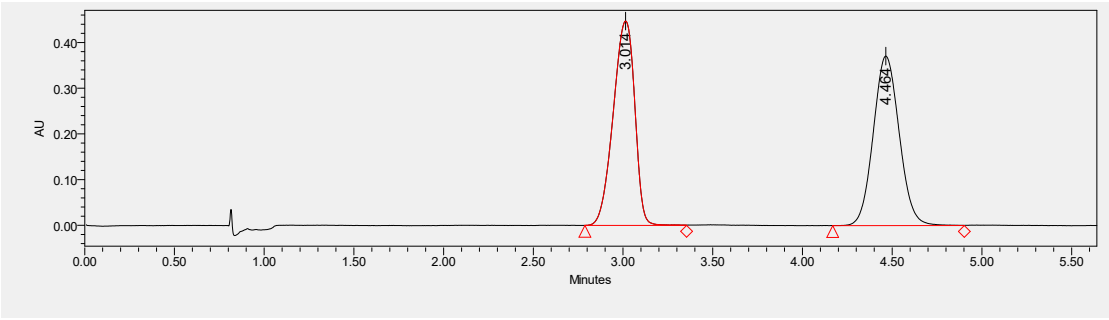
^{13}C NMR (101 MHz, Benzene-d_6) δ 170.0, 158.8, 145.3, 144.3, 138.8, 135.6, 130.4, 130.3, 130.1, 129.6, 127.4, 125.7, 125.6, 123.1, 122.2, 120.2, 110.3, 108.1, 82.0, 65.7, 52.5, 40.9, 30.2, 27.7.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{35}ClN_2O_5Na^+]$: 503.1344 found 503.1344.

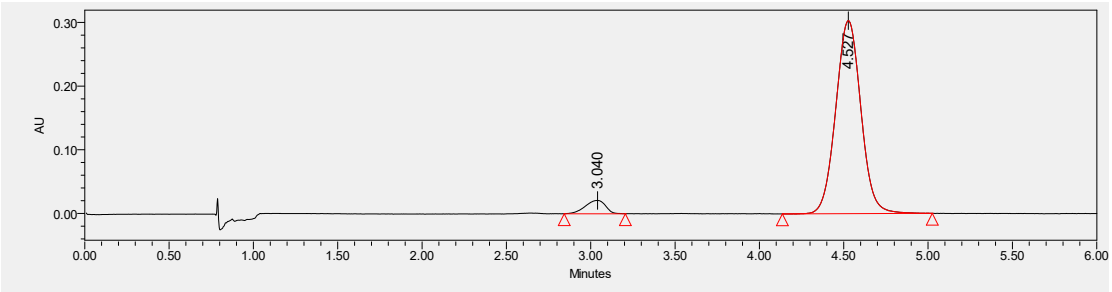
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{37}ClN_2O_5Na^+]$: 505.1315 found 505.1315.

IR (neat) 3298, 2977, 1720, 1628, 1600, 1519, 1475, 1368, 1252, 1150, 812, 701 cm^{-1}.

Racemate: 12.5:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

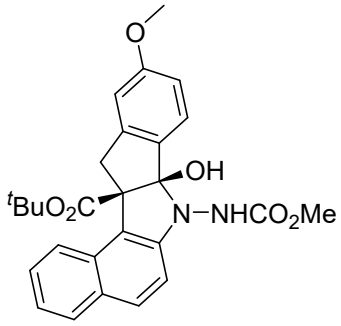


	Retention Time	Area	% Area
1	3.014	3730623	50.02
2	4.464	3727718	49.98



	Retention Time	Area	% Area
1	3.040	176534	5.32
2	4.527	3139221	94.68

Tert-butyl (7a*R*,12a*R*)-7a-hydroxy-10-methoxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C6):



White solid, 99% yield, 84% ee, >19:1 dr, m.p. 120-121 °C, $[\alpha]^{25}_{D}$ = -733.3 (c = 0.44, in CH_2Cl_2).

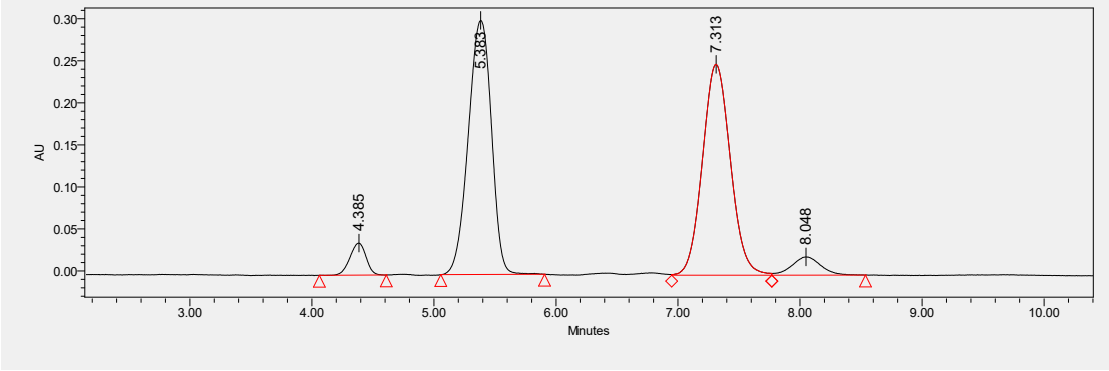
SFC Daicel Chiralpak IB-3, CO_2/MeOH = 90/10, 1.5 mL/min, λ = 240 nm, t_1 = 5.47 min, t_2 = 7.39 min.

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.92 (d, *J* = 6.8 Hz, 1H), 7.64 (d, *J* = 8.0 Hz, 1H), 7.55 (d, *J* = 8.2 Hz, 1H), 7.48 (d, *J* = 8.0 Hz, 1H), 7.37 (t, *J* = 7.5 Hz, 1H), 7.16 (s, 1H),6.79 (d, *J* = 6.7 Hz, 1H), 6.69 (d, *J* = 8.2 Hz, 1H), 6.48 (s, 1H), 6.04 (s, 1H), 4.90 (s, 1H), 4.64 (d, *J* = 15.4 Hz, 1H), 3.42 (s, 3H), 3.25 (s, 4H), 1.23 (s, 9H).

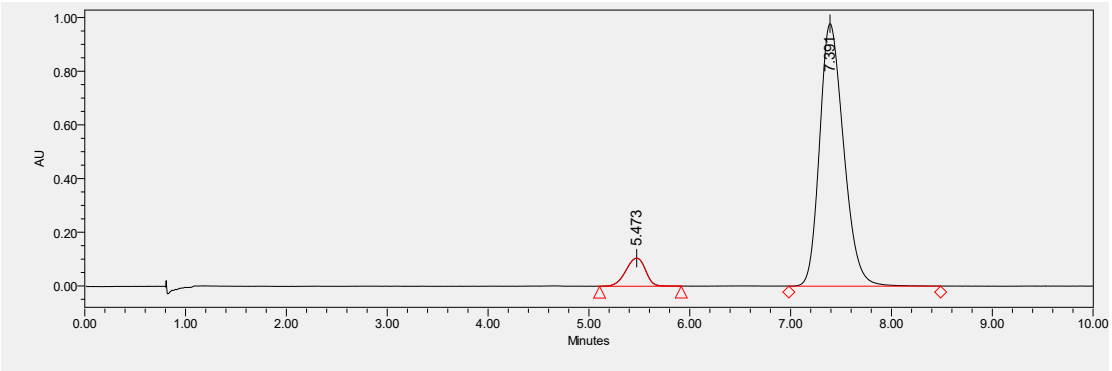
^{13}C NMR (101 MHz, Benzene-d_6) δ 170.4, 161.6, 158.7, 145.5, 144.1, 130.4, 130.4, 130.0, 129.6, 127.3, 125.6, 122.9, 122.3, 120.6, 114.4, 110.6, 109.5, 108.5, 81.8, 65.8, 54.9, 52.7, 41.2, 30.1, 27.8.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{27}H_{28}N_2O_6Na^+]$: 499.1840 found 499.1840.

IR (neat) 3291, 2975, 1720, 1608, 1497, 1251, 1149, 834, 737, 702 cm^{-1}.

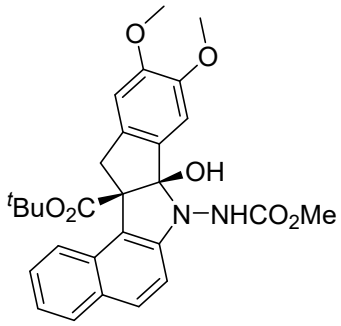


	Retention Time	Area	% Area
1	4.385	350469	4.04
2	5.383	3978451	45.85
3	7.313	3990265	45.99
4	8.048	357124	4.12



	Retention Time	Area	% Area
1	5.473	1423042	8.07
2	7.391	16203427	91.93

Tert-butyl (7a*R*,12a*R*)-7a-hydroxy-9,10-dimethoxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C7):



White solid, 99% yield, 79% ee, >19:1 dr, m.p. 126-128 °C, $[\alpha]^{25}_{D}$ = -512.2 (c = 0.80, in CH_2Cl_2).

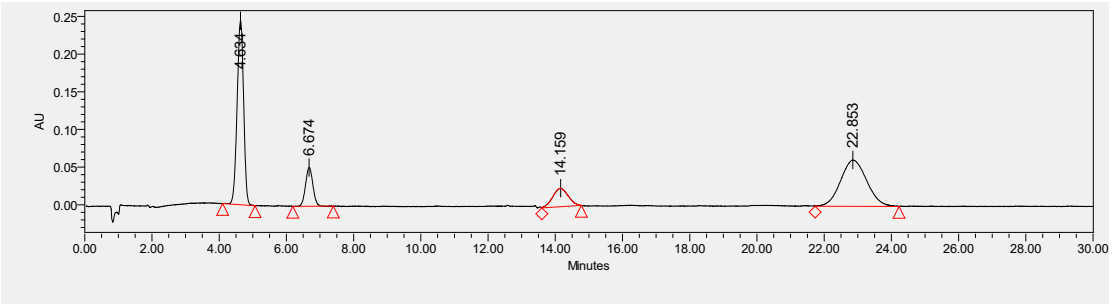
SFC Daicel Chiralpak IC-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 4.62 min, t_2 = 22.64 min.

^{1}H NMR (600 MHz, Benzene-d_6) δ 7.94 (d, *J* = 6.5 Hz, 1H), 7.65 (d, *J* = 7.6 Hz, 1H), 7.51 (d, *J* = 8.0 Hz, 1H), 7.38 (t, *J* = 7.3 Hz, 1H), 7.09 (m, 2H), 6.80 (d, *J* = 8.1 Hz, 1H), 6.56 (s, 1H), 6.31 (s, 1H), 4.98 (s, 1H), 4.68 (d, *J* = 16.0 Hz, 1H), 3.38 (d, *J* = 26.0 Hz, 6H), 3.17 (m, 4H), 1.25 (s, 9H).

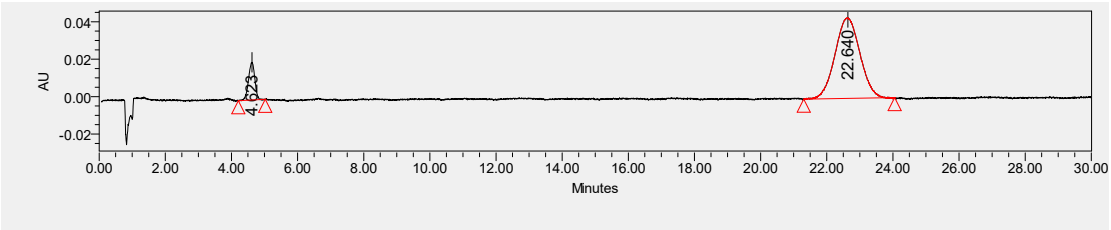
^{13}C NMR (151 MHz, Benzene-d_6) δ 170.3, 158.7, 151.4, 149.2, 145.4, 133.9, 131.3, 130.2, 129.7, 129.4, 128.3, 127.1, 122.6, 122.0, 120.6, 110.4, 108.9, 107.7, 81.5, 65.8, 55.3, 55.1, 52.4, 40.9, 29.9, 27.5.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{28}H_{30}N_2O_7Na^+]$: 529.1945 found 529.1946.

IR (neat) 3293, 2960, 1721, 1627, 1504, 1366, 1247, 1149, 1118, 811, 735 cm^{-1}.

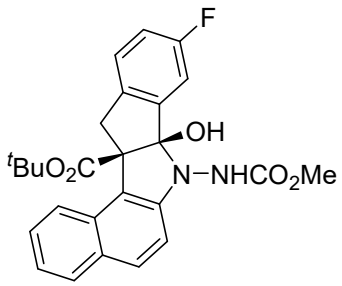


	Retention Time	Area	% Area
1	4.634	3292552	40.27
2	6.674	784462	9.59
3	14.159	779565	9.53
4	22.853	3319289	40.60



	Retention Time	Area	% Area
1	4.623	267086	10.63
2	22.640	2245161	89.37

Tert-butyl (7a*R*,12a*R*)-9-fluoro-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C8):



White solid, 91% yield, 92% ee, >19:1 dr, m.p. 108-110 °C, $[\alpha]^{20}_{D}$ = -406.3 (c = 0.84, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 2.22 min, t_2 = 2.64 min.

^{1}H NMR (600 MHz, Benzene-d_6) δ 7.81 (d, J = 6.7 Hz, 1H), 7.63 (d, J = 8.0 Hz, 1H), 7.48 (d, J = 8.4 Hz, 1H), 7.41 – 7.31 (m, 2H), 7.17 (s, 1H), 6.75 (t, J = 7.5 Hz, 1H), 6.66 (s, 1H), 6.63 – 6.56 (m, 1H), 5.85 (s, 1H), 5.12 (s, 1H), 4.53 (d, J = 14.7 Hz, 1H), 3.33 (s, 3H), 3.02 (d, J = 16.3 Hz, 1H), 1.22 (s, 9H).

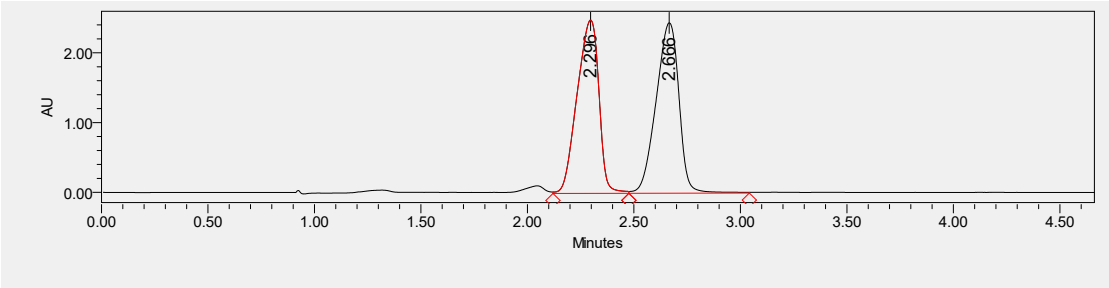
^{13}C NMR (151 MHz, Benzene- d_6) δ 170.2, 163.5, 161.9, 159.0, 145.3, 142.5, 137.5, 130.5, 130.4, 130.0, 129.6, 127.4, 126.7, 126.7, 123.0, 122.3, 120.4, 116.9, 116.8, 111.4, 111.3 110.3, 108.2, 82.0, 66.3, 52.8, 40.7, 27.8.

^{19}F NMR (565 MHz, Benzene-d_6) δ -116.01.

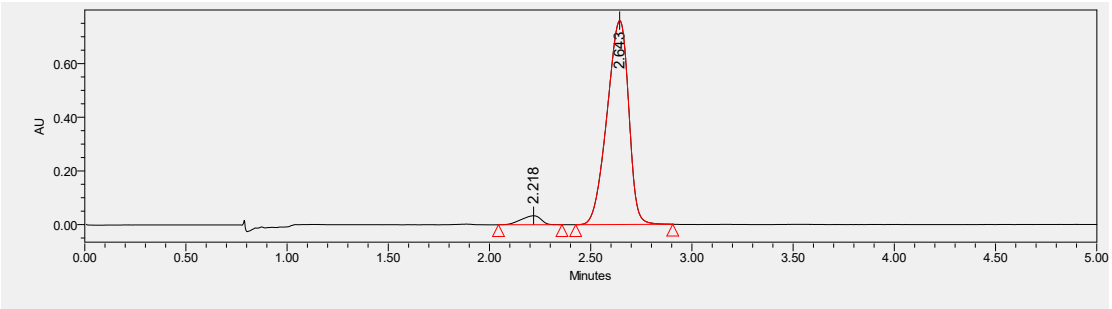
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}FN_2O_5Na^+]$: 487.1460 found 487.1460.

IR (neat) 3302, 2977, 1724, 1628, 1520, 1491, 1369, 1290, 1151, 965, 868, 843, 778, 744 cm^{-1}.

Racemate: 6:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

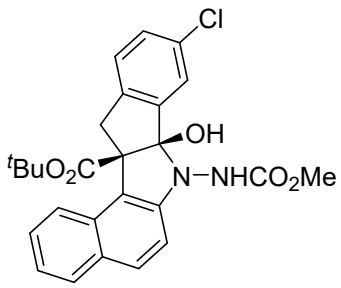


	Retention Time	Area	% Area
1	2.296	17688932	49.18
2	2.666	18282137	50.82



	Retention Time	Area	% Area
1	2.218	227114	3.88
2	2.643	5628411	96.12

Tert-butyl (7a*R*,12a*R*)-9-chloro-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C9):



White solid, 76% yield, 86% ee, >19:1 dr, m.p. 130-131 °C, $[\alpha]^{25}_{D}$ = -561.9 (c = 1.07, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 2.69 min, t_2 = 3.19 min.

^{1}H NMR (600 MHz, Benzene-d_6) δ 7.52 – 7.46 (m, 1H), 7.42 (s, 1H), 7.33 (d, *J* = 7.9 Hz, 1H), 7.18 (d, *J* = 8.4 Hz, 1H), 7.05 (t, *J* = 7.4 Hz, 1H), 6.87 (s, 1H), 6.74 (d, *J* = 7.9 Hz, 1H), 6.32 (d, *J* = 6.8 Hz, 2H), 5.58 (s, 1H), 4.77 (s, 1H), 4.21 (d, *J* = 15.5 Hz, 1H), 3.02 (s, 3H), 2.67 (d, *J* = 16.6 Hz, 1H), 0.91 (s, 9H).

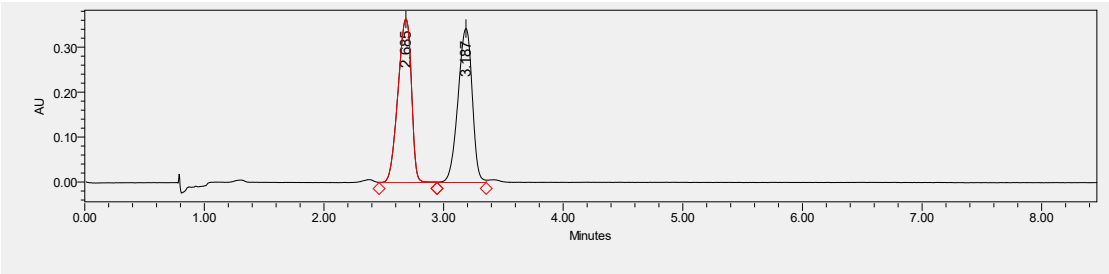
^{13}C NMR (151 MHz, Benzene-d_6) δ 170.1, 159.0, 145.3, 142.6, 140.7, 132.9, 130.4, 130.4, 130.1, 129.8, 129.7, 127.4, 126.8, 124.7, 123.1, 122.3, 120.3, 110.3, 108.3, 82.1, 66.0, 52.9, 40.9, 27.8.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{35}ClN_2O_5Na^+]$: 503.1344 found 503.1343.

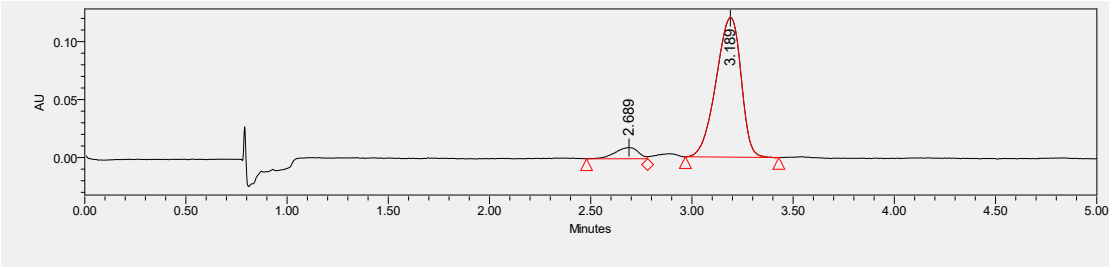
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{37}ClN_2O_5Na^+]$: 505.1315 found 505.1317.

IR (neat) 3307, 2977, 1722, 1628, 1519, 1368, 1255, 1152, 844, 690 cm^{-1}.

Racemate: 16:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

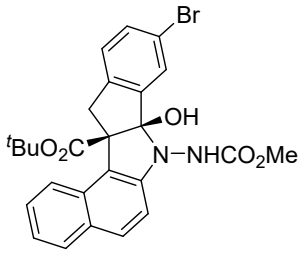


	Retention Time	Area	% Area
1	2.685	2833466	50.03
2	3.187	2830201	49.97



	Retention Time	Area	% Area
1	2.689	77543	7.00
2	3.189	1030138	93.00

Tert-butyl (7a*R*,12a*R*)-9-bromo-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C10):



White solid, 93% yield, 92% ee, >19:1 dr, m.p. 129-133 °C, $[\alpha]^{20}_{D}$ = -389.6 (c = 0.98, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 2.98 min, t_2 = 3.52 min.

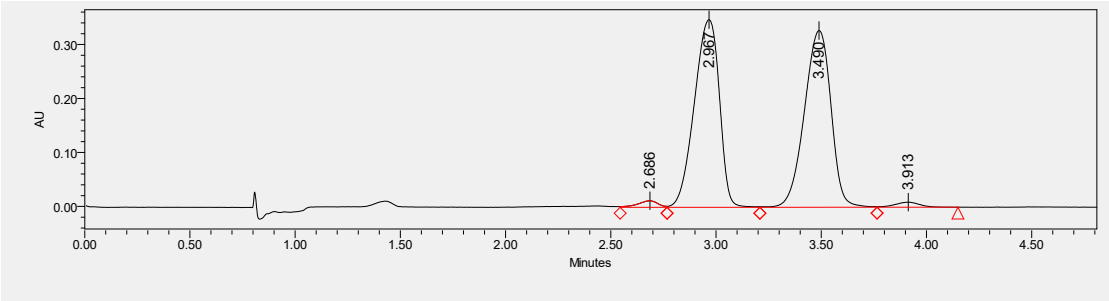
^{1}H NMR (400 MHz, Benzene-d_6) δ 7.89 (s, 1H), 7.79 (d, *J* = 7.7 Hz, 1H), 7.64 (d, *J* = 8.2 Hz, 1H), 7.49 (d, *J* = 8.6 Hz, 1H), 7.35 (t, *J* = 7.4 Hz, 1H), 7.18 (m, 2H),6.59 (m, 2H), 5.80 (s, 1H), 5.09 (s, 1H), 4.49 (d, *J* = 16.3 Hz, 1H), 3.32 (s, 3H), 2.94 (d, *J* = 16.8 Hz, 1H), 1.21 (s, 9H).

^{13}C NMR (101 MHz, Benzene-d_6) δ 170.1, 159.0, 145.2, 142.9, 141.2, 132.6, 130.4, 130.4, 130.0, 129.6, 127.4, 127.1, 123.0, 122.2, 120.8, 120.2, 110.2, 108.3, 82.0, 65.9, 52.9, 40.9, 30.2, 27.7.

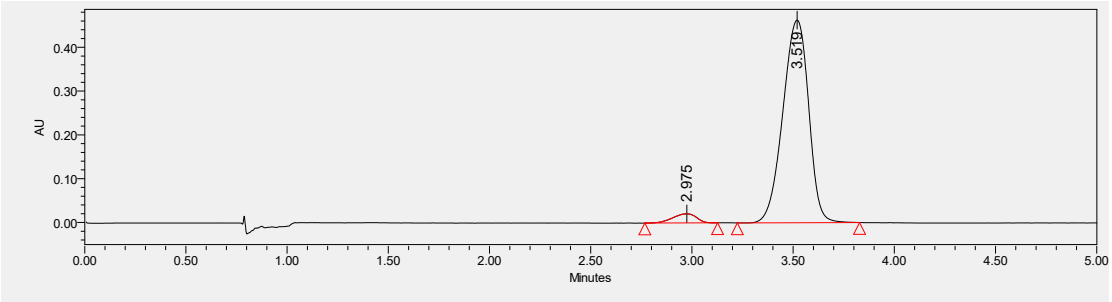
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{79}BrN_2O_5Na^+]$: 547.0839 found 547.0840.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{81}BrN_2O_5Na^+]$: 549.0819 found 549.0819.

IR (neat) 3309, 2977, 1718, 1519, 1368, 1256, 1151, 843, 810, 777, 738, 702 cm^{-1}.

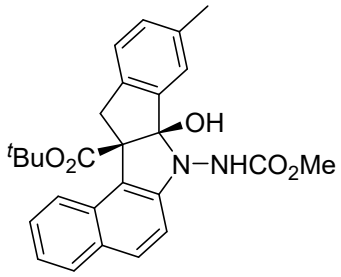


	Retention Time	Area	% Area	Height
1	2.686	80623	1.37	12236
2	2.967	2870329	48.61	347518
3	3.490	2876168	48.71	327446
4	3.913	77366	1.31	9419



	Retention Time	Area	% Area
1	2.975	169316	3.97
2	3.519	4092862	96.03

Tert-butyl (7a*R*,12a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-9-methyl-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7H)-carboxylate (C11):



White solid, 99% yield, 89% ee, >19:1 dr, m.p. 115-118 °C, $[\alpha]^{25}_{D}$ = -613.1 (c = 1.12, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 2.42 min, t_2 = 2.80 min.

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.58 (d, *J* = 7.1 Hz, 1H), 7.34 (d, *J* = 8.0 Hz, 1H), 7.19 (d, *J* = 13.2 Hz, 2H), 7.06 (t, *J* = 7.5 Hz, 1H), 6.86 (s, 1H),6.66 – 6.56 (m, 2H), 6.38 (d, *J* = 7.2 Hz, 1H), 5.81 (s, 1H), 4.69 (s, 1H), 4.34 (d, *J* = 16.0 Hz, 1H), 3.08 (s, 3H), 2.90 (d, *J* = 16.3 Hz, 1H), 1.86 (s, 3H), 0.93 (s, 9H).

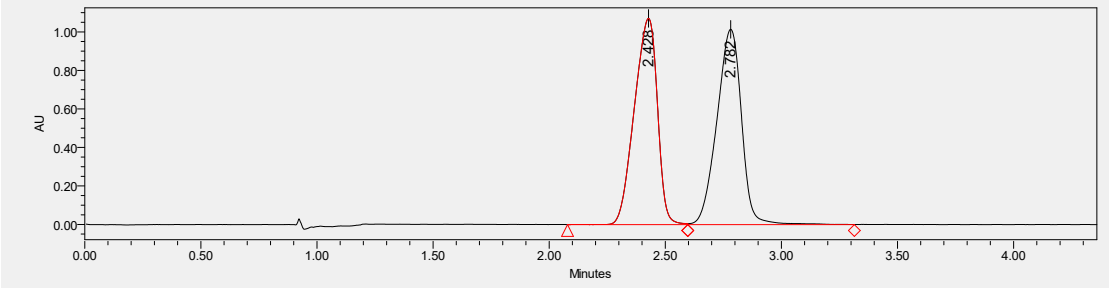
^{13}C NMR (101 MHz, Benzene-d_6) δ 170.5, 158.9, 145.5, 140.5, 139.4, 136.4, 130.7, 130.4, 129.9, 129.6, 127.3, 125.3, 125.1, 122.9, 122.4, 120.6, 110.4, 108.8, 81.8, 65.9, 60.0, 52.8, 41.0, 27.8, 21.2.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{27}H_{28}N_2O_5Na^+]$: 483.1890 found 483.1894.

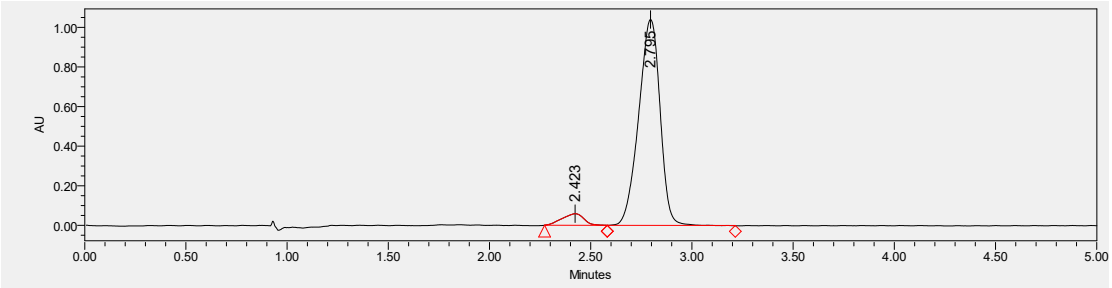
minor isomer **^{1}H NMR** (400 MHz, Benzene-d_6) δ 7.27 (s, 1H), 7.18 – 7.09 (m, 4H), 7.03 (d, *J* = 7.9 Hz, 1H), 6.89 (s, 1H), 6.81 (t, *J* = 7.1 Hz, 1H), 6.73 (m, 1H), 6.41 (d, *J* = 7.8 Hz, 1H), 6.34 (d, *J* = 7.8 Hz, 1H), 3.73 (d, *J* = 16.8 Hz, 1H), 3.28 (d, *J* = 16.9 Hz, 1H), 2.92 (s, 3H), 1.40 (s, 3H), 0.73 (s, 9H).

IR (neat) 3312, 2976, 1724, 1628, 1595, 1519, 1368, 1254, 1150, 1062, 952, 844, 778, 743 cm^{-1}.

Racemate: 3.8:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

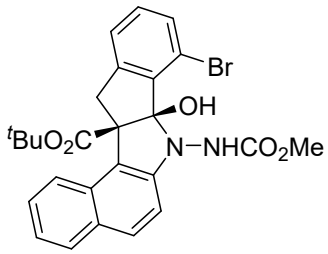


	Retention Time	Area	% Area
1	2.428	7384150	49.68
2	2.782	7477943	50.32



	Retention Time	Area	% Area
1	2.423	436529	5.42
2	2.795	7624368	94.58

Tert-butyl (7a*S*,12a*R*)-8-bromo-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C12):



White solid, 83% yield, 6% ee, >19:1 dr, m.p. 138-141 °C, $[\alpha]^{21}_{D}$ =-42.9 (c = 0.47, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 2.98 min, t_2 = 3.61 min, t_3 = 4.26 min, t_4 = 6.05 min.

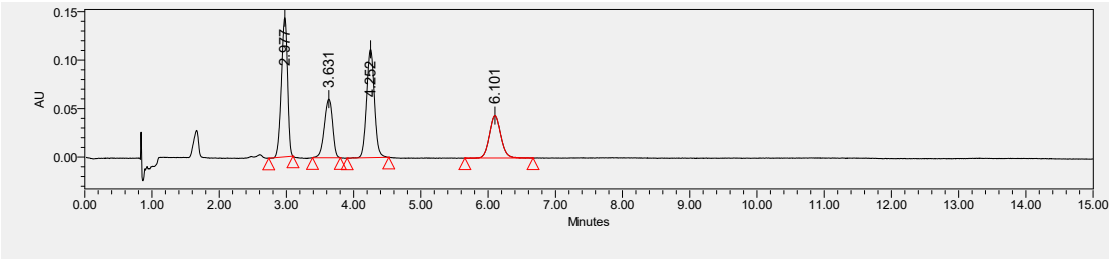
^{1}H NMR (400 MHz, Benzene-d_6) δ 7.45 (d, *J* = 7.7 Hz, 1H), 7.36 (d, *J* = 8.2 Hz, 1H), 7.22 (d, *J* = 8.7 Hz, 1H), 7.06 (t, *J* = 7.5 Hz, 1H), 6.99 (d, *J* = 6.7 Hz, 1H), 6.90 (m, 1H), 6.42 (m, 2H), 6.35 (t, *J* = 7.5 Hz, 1H), 5.94 (s, 1H), 5.14 (s, 1H), 4.25 (d, *J* = 17.4 Hz, 1H), 3.05 (s, 3H), 2.56 (d, *J* = 16.8 Hz, 1H), 0.93 (s, 9H).

^{13}C NMR (101 MHz, Benzene-d_6) δ 170.0, 159.3, 146.1, 132.6, 130.6, 130.4, 129.9, 129.6, 127.2, 124.5, 123.0, 122.5, 120.4, 119.4, 110.7, 82.0, 66.6, 52.9, 41.4, 30.2, 27.7.

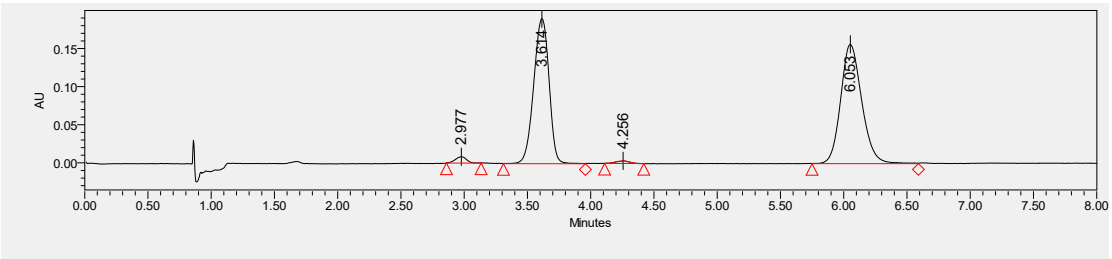
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{79}BrN_2O_5Na^+]$: 547.0839 found 547.0839.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{25}{}^{81}BrN_2O_5Na^+]$: 549.0819 found 549.0819.

IR (neat) 3339, 2976, 1721, 1629, 1454, 1368, 1258, 1154, 1061, 871, 843, 770, 745 cm^{-1}.

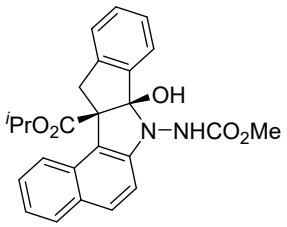


	Retention Time	Area	% Area
1	2.977	910697	32.09
2	3.631	513989	18.11
3	4.252	900103	31.72
4	6.101	513283	18.09



	Retention Time	Area	% Area
1	2.977	50677	1.45
2	3.614	1604467	45.98
3	4.256	24737	0.71
4	6.053	1809644	51.86

Isopropyl (7aR,12aR)-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[e]indeno[1,2-b]indole-12a(7H)-carboxylate (C13):



White solid, 68% yield, 73% ee, >19:1 dr, m.p. 100-102 °C, $[\alpha]^{25}_{D}$ = -521.6 (c = 0.82, in CH_2Cl_2).

SFC Daicel Chiralpak IC-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 3.89 min, t_2 = 6.59 min.

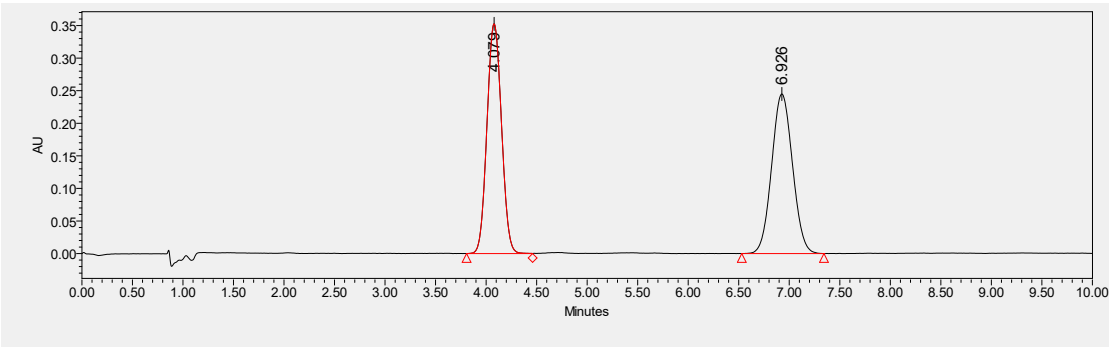
^{1}H NMR (400 MHz, Benzene-d_6) δ 7.81 (d, *J* = 6.7 Hz, 1H), 7.64 (m, 2H), 7.44 (d, *J* = 7.4 Hz, 1H), 7.34 (t, *J* = 7.4 Hz, 1H), 7.16 (s, 1H),7.07 (m, 2H), 6.95 (s, 1H), 6.64 (s, 1H), 6.16 (s, 1H), 5.08 (s, 2H), 4.68 (d, *J* = 15.6 Hz, 1H), 3.38 (s, 3H), 3.20 (d, *J* = 16.5 Hz, 1H), 0.92 (d, *J* = 6.0 Hz, 3H), 0.75 (d, *J* = 6.2 Hz, 3H).

^{13}C NMR (101 MHz, Benzene-d_6) δ 170.9, 158.8, 145.5, 142.3, 140.2, 130.5, 130.1, 129.8, 129.6, 127.4, 127.0, 125.5, 124.7, 123.0 122.3, 120.1, 110.5, 109.1, 69.4, 65.1, 52.9, 41.7, 21.5, 21.3.

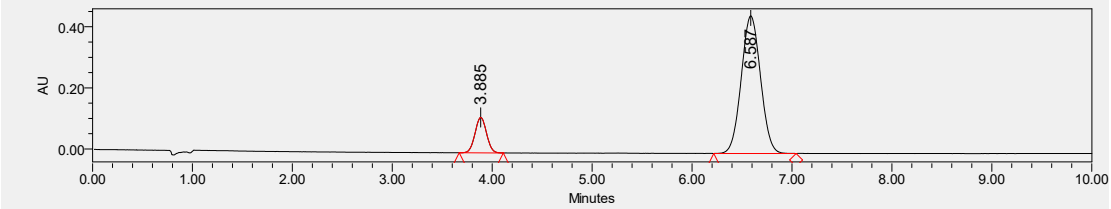
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{25}H_{24}N_2O_5Na^+]$: 455.1577 found 455.1577.

IR (neat) 3300, 2980, 1717, 1627, 1519, 1464, 1374, 1257, 1106, 925, 812, 735 cm^{-1}.

Racemate: 5:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

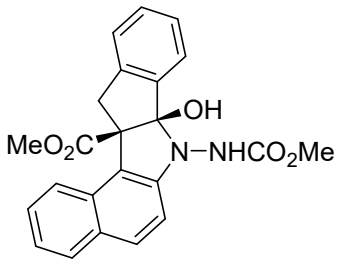


	Retention Time	Area	% Area
1	4.079	3526476	50.06
2	6.926	3518107	49.94



	Retention Time	Area	% Area
1	3.885	927020	13.32
2	6.587	6032857	86.68

Methyl (7a*R*,12a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,12-dihydrobenzo[*e*]indeno[1,2-*b*]indole-12a(7*H*)-carboxylate (C14):



White solid, 89% yield, 55% ee, >19:1 dr, m.p. 134-135 °C, $[\alpha]^{21}_{D}$ = -341.5 (c = 0.35, in CH_2Cl_2).

SFC Daicel Chiralpak IA-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 4.10 min, t_2 = 4.80 min.

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.75 (d, *J* = 7.7 Hz, 1H), 7.62 (d, *J* = 8.1 Hz, 2H), 7.47 (d, *J* = 8.6 Hz, 1H), 7.33 (t, *J* = 7.4 Hz, 1H), 7.13 (s, 1H), 7.07 (s, 2H), 6.97 – 6.92 (m, 1H), 6.65 (d, *J* = 7.6 Hz, 1H), 5.90 (s, 1H), 4.98 (s, 1H), 4.65 (d, *J* = 16.1 Hz, 1H), 3.37 (s, 3H), 3.23 (s, 1H), 3.16 (s, 3H).

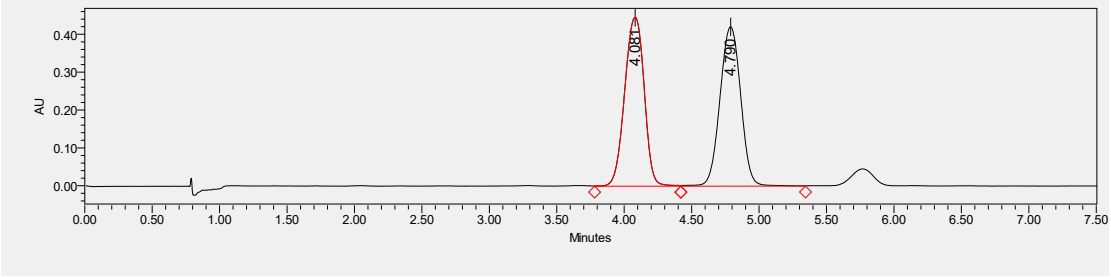
^{13}C NMR (101 MHz, Benzene-d_6) δ 171.9, 145.4, 142.3, 130.6, 130.5, 130.2, 129.9, 129.7, 127.1, 125.5, 123.1, 122.0, 110.6, 65.4, 52.8, 52.2, 41.8, 30.2.

minor isomer **^{1}H NMR** (400 MHz, Benzene-d_6) δ 7.75 (d, *J* = 7.6 Hz, 1H), 7.62 (s, 1H), 7.57 – 7.50 (m, 3H), 7.40 (d, *J* = 9.3 Hz, 1H), 7.27 (s, 1H), 7.20 (m, 2H), 6.98 (t, *J* = 7.5 Hz, 1H), 6.80 (t, *J* = 7.1 Hz, 2H), 4.05 (d, *J* = 17.1 Hz, 1H), 3.73 (d, *J* = 17.1 Hz, 1H), 3.32 (s, 3H), 3.13 (s, 3H).

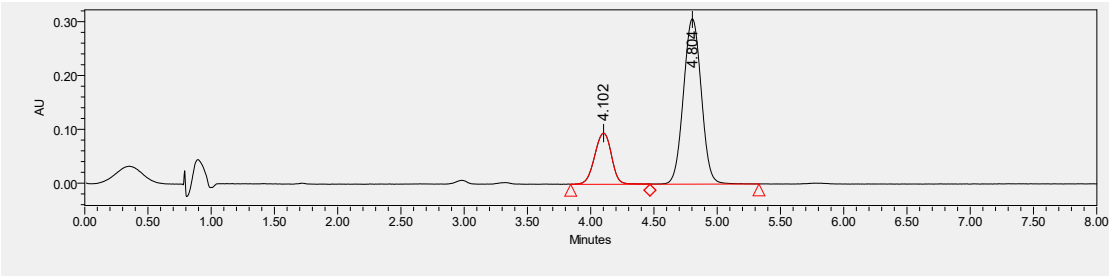
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{23}H_{20}N_2O_5Na^+]$: 427.1264 found 427.1263.

IR (neat) 3302, 2953, 1727, 1628, 1519, 1259, 1158, 1080, 860, 734 cm^{-1}.

Racemate: 3.6:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

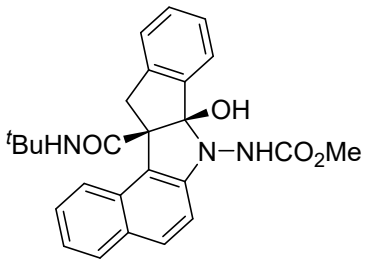


	Retention Time	Area	% Area
1	4.081	4477613	49.84
2	4.790	4506314	50.16



	Retention Time	Area	% Area
1	4.102	879922	22.62
2	4.804	3009417	77.38

Methyl ((7a*R*,12a*R*)-12a-(tert-butylcarbamoyl)-7a-hydroxy-12,12a-dihydrobenzo[*e*]indeno[1,2-*b*]indol-7(7a*H*)-yl)carbamate (C15):



White solid, 92% yield, 34% ee, 81:19 dr, m.p. 139-141 °C, $[\alpha]_D^{24}$ = -152.1 (c = 0.82, in CH_2Cl_2).

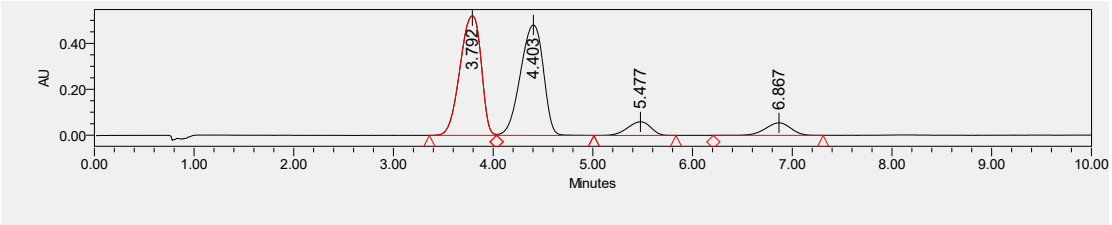
SFC Daicel Chiralcel OX-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 3.80 min, t_2 = 4.43 min, t_3 = 5.47 min, t_2 = 6.88 min.

^{1}H NMR (400 MHz, Acetone-d_6) δ 9.01 (s, 1H), 7.83 (d, *J* = 8.2 Hz, 1H), 7.78 (d, *J* = 8.7 Hz, 1H), 7.62 (d, *J* = 8.6 Hz, 1H), 7.56–7.48 (m, 2H), 7.33–7.28 (m, 1H), 7.23 (q, *J* = 7.0, 6.2 Hz, 3H), 6.95 (d, *J* = 8.7 Hz, 1H), 6.08 (s, 1H), 5.15 (s, 1H), 4.65 (d, *J* = 15.8 Hz, 1H), 3.81 (s, 3H), 3.11 (d, *J* = 15.8 Hz, 1H), 1.17 (s, 9H).

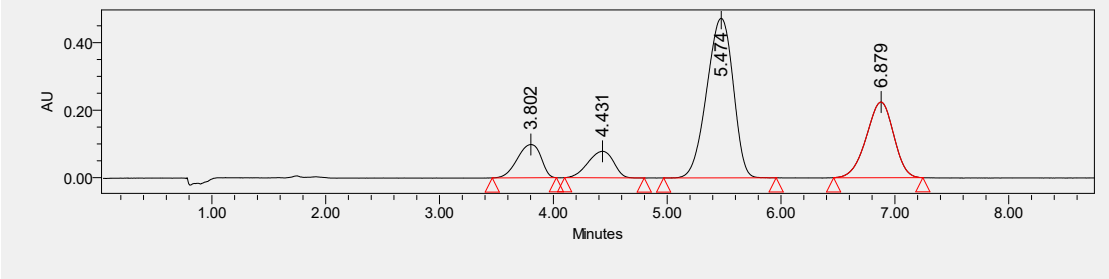
^{13}C NMR (101 MHz, Acetone-d_6) δ 169.4, 160.6, 143.0, 131.2, 131.0, 130.8, 128.1, 127.6, 125.7, 124.9, 123.7, 123.0, 111.9, 108.5, 60.7, 66.3, 53.4, 51.8, 40.9, 28.7, 21.0, 14.6.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{26}H_{27}N_3O_4Na^+]$: 468.1894 found 468.1895.

IR (neat) 3267, 2964, 1714, 1664, 1626, 1518, 1455, 1364, 1224, 813, 747 cm^{-1}.

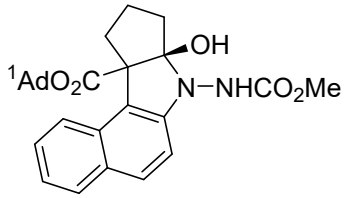


	Retention Time	Area	% Area
1	3.792	7640007	44.25
2	4.403	7683900	44.50
3	5.477	964613	5.59
4	6.867	977218	5.66



	Retention Time	Area	% Area
1	3.802	1422648	10.15
2	4.431	1227002	8.76
3	5.474	7620989	54.39
4	6.879	3740644	26.70

(3*S*,5*S*,7*S*)-adamantan-1-yl (7a*R*,10a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C16):



White solid, 98% yield, 95% ee, >19:1 dr, m.p. 136-138 °C, $[\alpha]_D^{28}$ = -59.4 (c = 0.86, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 4.10 min, t_2 = 4.73 min

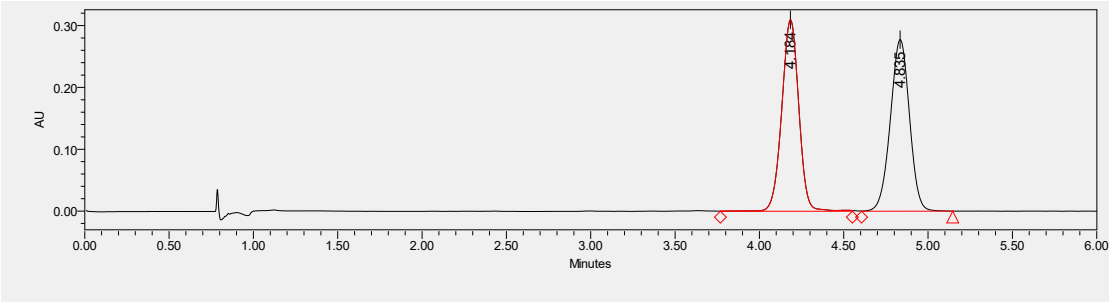
^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.75 (d, *J* = 8.2 Hz, 1H), 7.68 (d, *J* = 8.6 Hz, 1H), 7.54 (d, *J* = 8.1 Hz, 1H), 7.40 (t, *J* = 7.3 Hz, 1H), 7.28 – 7.20 (m, 1H), 6.89 (s, 1H), 6.87 (s, 1H), 4.14 (s, 1H), 3.79 (s, 3H), 2.99 (q, *J* = 11.7 Hz, 1H), 2.20 (s, 1H), 2.07 (s, 4H), 1.98 (s, 7H), 1.81 (s, 1H), 1.74 (s, 1H), 1.57 (s, 6H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 170.8, 158.3, 145.9, 129.8, 129.1, 126.8, 122.4, 121.9, 119.1, 109.6, 107.4, 82.1, 64.6, 60.4, 53.1, 41.1, 37.0, 36.0, 35.3, 30.7, 23.1.

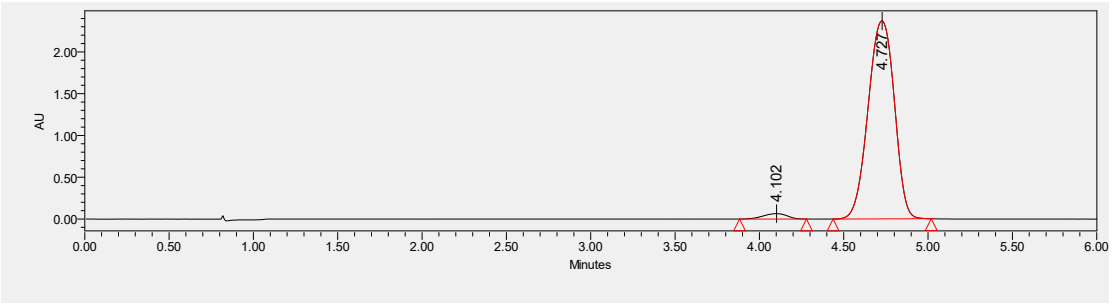
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{28}H_{32}N_2O_5Na^+]$: 499.2203 found 499.2204.

IR (neat) 3302, 2911, 1723, 1628, 1520, 1257, 1054, 810, 741 cm^{-1}.

Racemate: 17:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

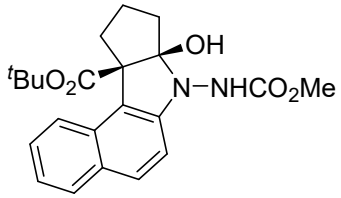


	Retention Time	Area	% Area
1	4.184	2176698	49.90
2	4.835	2185092	50.10



	Retention Time	Area	% Area
1	4.102	634155	2.42
2	4.727	25615884	97.58

Tert-butyl (7a*R*,10a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C17):



White solid, 89% yield, 96% ee, >19:1 dr, m.p. 90-91 °C, $[\alpha]^{24}_{D}$ = -407.7 (c = 1.19, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 3.02 min, t_2 = 3.39 min.

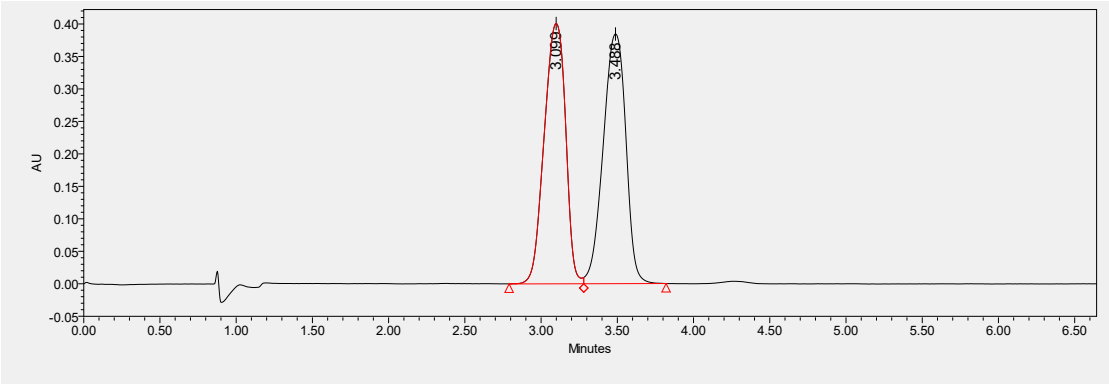
^{1}H NMR (600 MHz, Benzene-d_6) δ 7.78 (d, *J* = 7.5 Hz, 1H), 7.63 (d, *J* = 8.0 Hz, 1H), 7.51 (d, *J* = 8.5 Hz, 1H), 7.29 (t, *J* = 7.5 Hz, 1H), 7.14 – 7.09 (m, 1H), 6.71 (d, 1H), 6.03 (s, 1H), 4.60 (s, 1H), 3.31 (s, 4H), 2.26 – 1.88 (m, 3H), 1.59 (s, 1H), 1.25 (s, 9H), 1.18 (s, 1H).

^{13}C NMR (151 MHz, Benzene-d_6) δ 171.1, 158.9, 146.7, 130.5, 130.3, 129.8, 129.6, 127.1, 122.6, 122.3, 110.0, 108.3, 81.5, 64.9, 52.6, 37.6, 35.8, 27.8, 23.3.

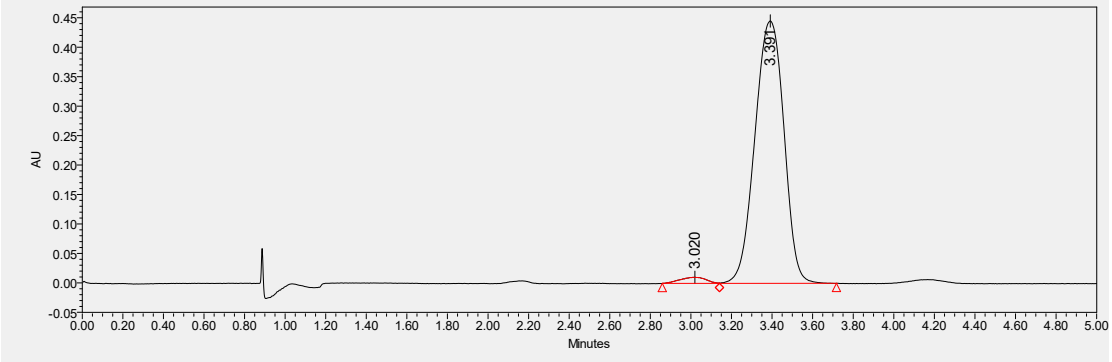
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{22}H_{26}N_2O_5Na^+]$: 421.1734 found 421.1734.

IR (neat) 3297, 2972, 1723, 1520, 1368, 1257, 1159, 810, 740 cm^{-1}.

Racemate: 8.6:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

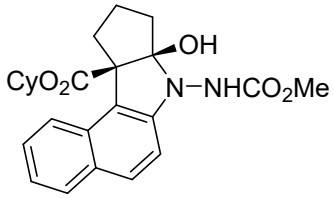


	Retention Time	Area	% Area
1	3.099	3911659	49.68
2	3.488	3961818	50.32



	Retention Time	Area	% Area
1	3.020	92594	2.05
2	3.391	4428784	97.95

Cyclohexyl (7a*R*,10a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C18):



White solid, 77% yield, 90% ee, >19:1 dr, m.p. 90-95 °C, $[\alpha]^{24}_{D}$ = -201.6 (c = 0.96, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 2.93 min, t_2 = 3.37 min

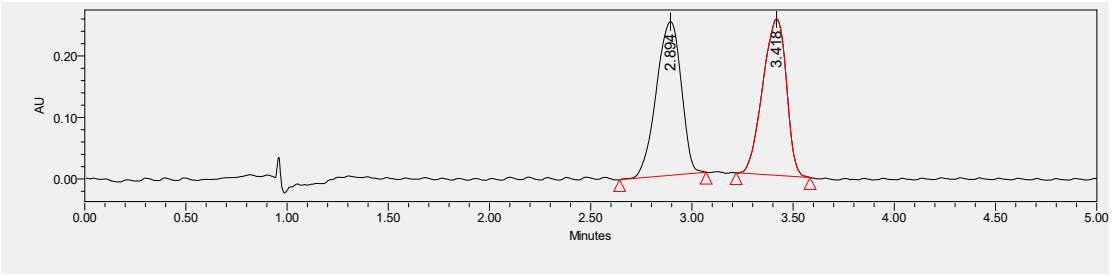
^{1}H NMR (600 MHz, Benzene-d_6) δ 7.76 (d, *J* = 7.8 Hz, 1H), 7.63 (d, *J* = 8.1 Hz, 1H), 7.51 (d, *J* = 8.5 Hz, 1H), 7.28 (t, *J* = 7.5 Hz, 1H), 7.12 (t, *J* = 7.3 Hz, 1H), 6.82 – 6.62 (m, 1H), 6.02 (s, 1H), 5.02 (s, 1H), 3.40 (s, 1H), 3.31 (s, 3H), 2.23 – 1.94 (m, 3H), 1.58 (m, 4H), 1.30 (m, 3H), 1.15 – 0.89 (m, 5H), 0.73 (s, 1H).

^{13}C NMR (151 MHz, Benzene-d_6) δ 171.5, 158.9, 146.7, 130.6, 130.3, 130.0, 129.6, 127.2, 122.7, 122.2, 119.5, 109.9, 108.5, 73.7, 64.4, 52.7, 37.5, 36.0, 31.7, 31.4, 25.2, 23.6, 23.4.

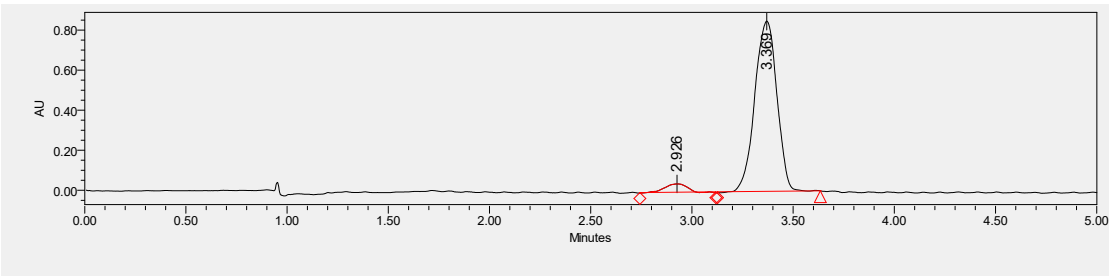
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{24}H_{28}N_2O_5Na^+]$: 447.1890 found 447.1890.

IR (neat) 3293, 2937, 2858, 1720, 1628, 1520, 1449, 1374, 1236, 1156, 810, 738 cm^{-1}.

Racemate: 12.5:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

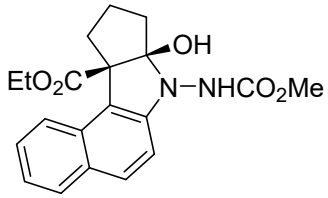


	Retention Time	Area	% Area
1	2.894	2137618	50.91
2	3.418	2061304	49.09



	Retention Time	Area	% Area
1	2.926	322754	4.76
2	3.369	6459431	95.24

Ethyl (7a*R*,10a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,8,9,10tetrahydrobenzo [*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C19):



White solid, 94% yield, 86% ee, >19:1 dr, m.p. 85-89 °C, $[\alpha]^{24}_{D}$ = -407.7 (c = 1.15, in CH_2Cl_2).

SFC Daicel Chiralpak IA-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 2.45 min, t_2 = 2.87 min.

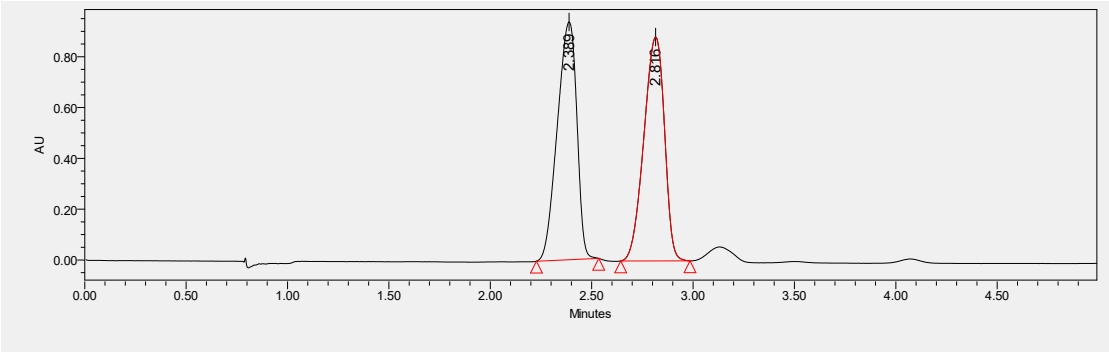
^{1}H NMR (600 MHz, Benzene-d_6) δ 7.69 (d, *J* = 6.3 Hz, 1H), 7.60 (d, *J* = 8.1 Hz, 1H), 7.48 (d, *J* = 8.5 Hz, 1H), 7.26 (t, *J* = 7.5 Hz, 1H), 7.11 (t, *J* = 7.3 Hz, 1H), 6.71 (s, 1H), 6.15 (s, 1H), 4.62 (s, 1H)3.95 (p, *J* = 7.1 Hz, 1H), 3.86 (s, 1H), 3.31 (s, 4H), 2.09 (m, 3H), 1.61 (s, 1H), 0.74-0.79 (m, 4H).

^{13}C NMR (151 MHz, Benzene-d_6) δ 172.3, 158.8, 146.8, 130.5, 130.4, 130.1, 129.6, 127.3, 122.7, 122.1, 119.3, 110.0, 108.5, 64.4, 61.5, 52.7, 37.4, 36.2, 23.4, 14.1.

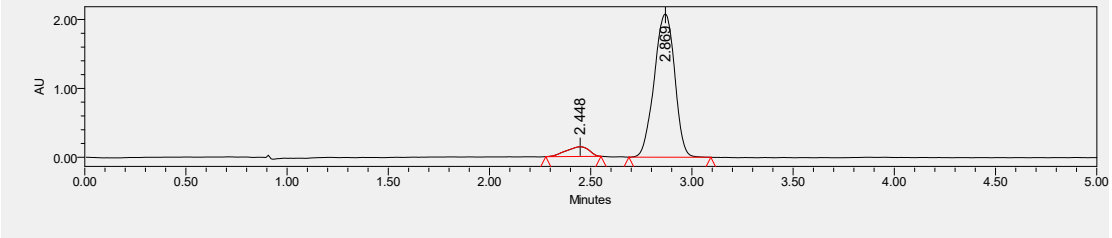
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{20}H_{22}N_2O_5Na^+]$: 393.1421 found 393.1421.

IR (neat) 3293, 2960, 1714, 1628, 1596, 1520, 1444, 1235, 1097, 810, 777, 736 cm^{-1}.

Racemate: 5.5:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

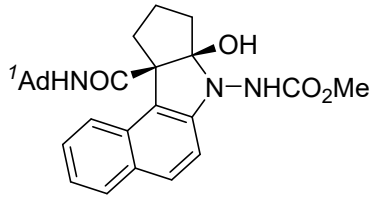


	Retention Time	Area	% Area
1	2.389	6251229	50.14
2	2.816	6216539	49.86



	Retention Time	Area	% Area
1	2.448	1102783	7.01
2	2.869	14621167	92.99

Methyl ((7a*R*,10a*R*)-10a-(((3*S*,5*S*,7*S*)-adamantan-1-yl)carbamoyl)-7a-hydroxy-8,9,10,10a-tetrahydrobenzo[*e*]cyclopenta[*b*]indol-7(7a*H*)-yl)carbamate (C20):



White solid, 99% yield, 56% ee, 87:13 dr, m.p. 142-146 °C, $[\alpha]_D^{20}$ = -57.3 (c = 0.98, in CH_2Cl_2).

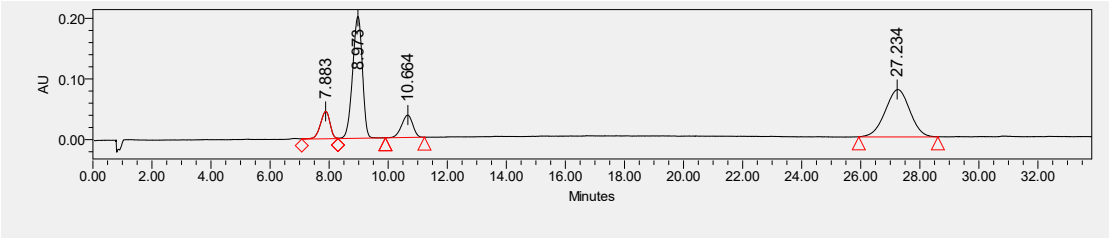
SFC Daicel Chiralcel OX-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 7.90 min, t_2 = 9.03 min, t_3 = 10.70 min, t_2 = 27.21 min.

^{1}H NMR (400 MHz, Acetone-d_6) δ 7.81 (d, *J* = 8.2 Hz, 1H), 7.77 (d, *J* = 8.7 Hz, 1H), 7.51 (d, *J* = 8.4 Hz, 1H), 7.45 (t, *J* = 7.5 Hz, 1H), 7.26 (t, *J* = 7.4 Hz, 1H), 6.95 (d, *J* = 8.7 Hz, 1H), 5.50 (s, 1H), 3.74 (s, 3H), 3.17 (q, *J* = 11.4 Hz, 1H), 2.22–2.20 (m, 1H), 1.92 (s, 3H), 1.85 (d, *J* = 11.9 Hz, 5H), 1.77 (d, *J* = 11.8 Hz, 4H), 1.56 (t, *J* = 10.7 Hz, 6H).

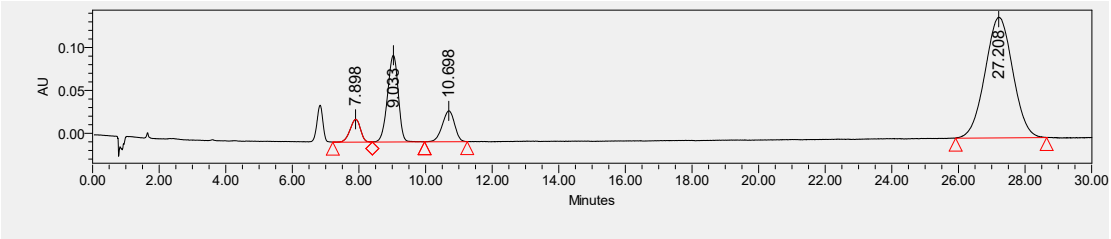
^{13}C NMR (101 MHz, Acetone-d_6) δ 169.8, 148.9, 131.1, 130.8, 130.7, 130.1, 127.8, 123.3, 123.1, 119.5, 111.3, 108.2, 65.5, 60.7, 53.3, 52.3, 42.0, 37.2, 23.8, 21.0, 14.6.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{28}H_{33}N_3O_4Na^+]$: 498.2363 found 498.2364.

IR (neat) 3267, 2908, 1730, 1657, 1518, 1359, 1261, 1122, 810, 739 cm^{-1}.

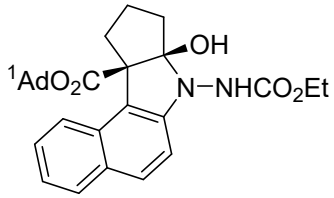


	Retention Time	Area	% Area
1	7.883	1021367	9.16
2	8.973	4626064	41.48
3	10.664	977415	8.76
4	27.234	4528593	40.60



	Retention Time	Area	% Area
1	7.898	576924	4.85
2	9.033	2263363	19.03
3	10.698	928155	7.81
4	27.208	8122189	68.31

(3*S*,5*S*,7*S*)-adamantan-1-yl (7a*R*,10a*R*)-7-((ethoxycarbonyl)amino)-7a-hydroxy-7a,8,9,10 tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C21):



White solid, 88% yield, 96% ee, >19:1 dr, m.p. 98-101 °C, $[\alpha]^{24}_{D}$ = -235.4 (c = 0.75, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 3.72 min, t_2 = 4.21 min.

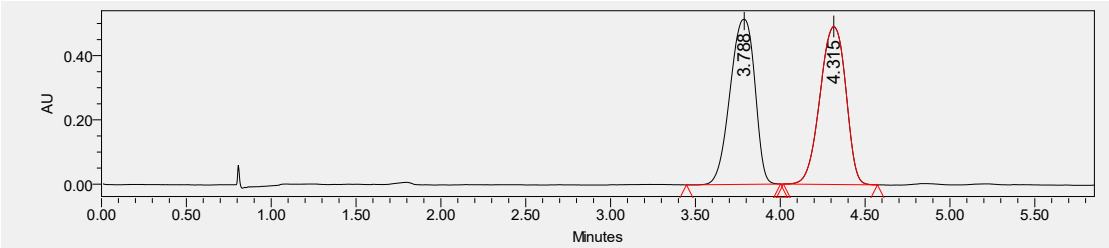
^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.75 (d, *J* = 8.2 Hz, 1H), 7.68 (d, *J* = 8.6 Hz, 1H), 7.54 (d, *J* = 8.3 Hz, 1H), 7.40 (t, *J* = 8.0 Hz, 1H), 7.26 – 7.19 (m, 1H), 6.89 (d, *J* = 8.5 Hz, 1H), 6.79 (s, 1H), 4.24 (q, *J* = 7.0 Hz, 2H), 4.15 (s, 1H), 2.99 (q, *J* = 12.0 Hz, 1H), 2.22 (s, 1H), 2.09 (d, *J* = 20.1 Hz, 4H), 1.98 (s, 7H), 1.86 – 1.76 (m, 1H), 1.75 – 1.63 (m, 1H), 1.57 (s, 6H), 1.32 (s, 3H).

^{13}C NMR (101 MHz, Chloroform-*d*) δ 170.9, 157.8, 146.0, 129.7, 129.1, 126.7, 122.4, 121.9, 119.0, 109.6, 107.4, 82.0, 64.5, 62.2, 41.1, 37.0, 36.0, 35.3, 30.7, 29.7, 23.0, 14.5.

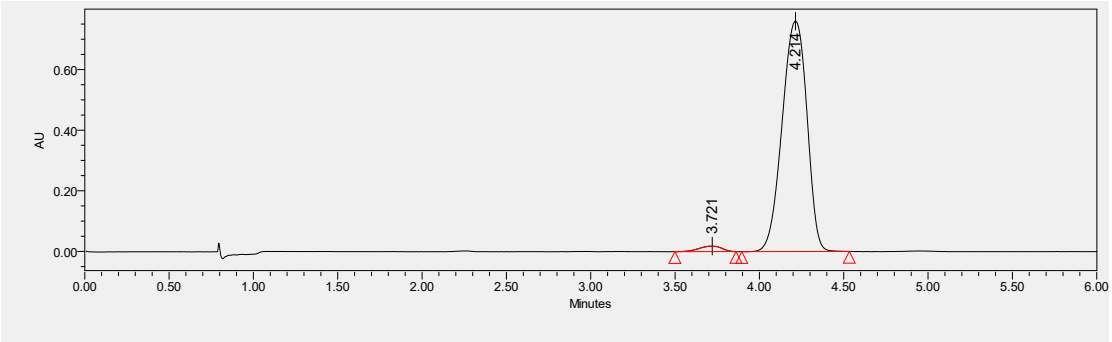
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{29}H_{34}N_2O_5Na^+]$: 513.2360 found 513.2364.

IR (neat) 3299, 2911, 1720, 1628, 1520, 1321, 1236, 1054, 809, 741 cm^{-1}.

Racemate: 7:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

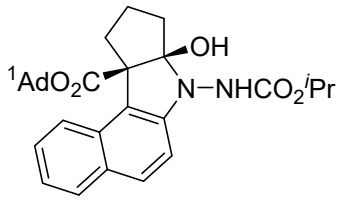


	Retention Time	Area	% Area
1	3.788	12803867	50.05
2	4.315	12801796	49.95



	Retention Time	Area	% Area
1	3.721	167975	2.12
2	4.214	7771404	97.88

(3*R*)-adamantan-1-yl (7a*R*,10a*R*)-7a-hydroxy-7-((isopropoxycarbonyl)amino)-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C22):



White solid, 86% yield, 96% ee, >19:1 dr, m.p. 101-105 °C, $[\alpha]^{24}_{D}$ = -276.0 (c = 0.87, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 3.16 min, t_2 = 3.56 min.

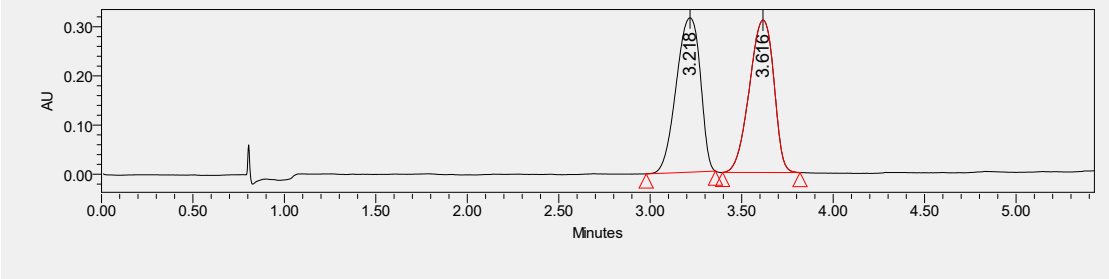
^{1}H NMR (400 MHz, Acetone-d_6) δ 7.65 (d, J = 8.2 Hz, 1H), 7.59 (d, J = 8.6 Hz, 1H), 7.30 (dt, J = 15.8, 8.3 Hz, 2H), 7.08 (ddd, J = 8.0, 6.6, 1.3 Hz, 1H), 6.74 (d, J = 8.6 Hz, 1H), 4.81 (p, J = 6.2 Hz, 1H), 2.87 (q, J = 12.1 Hz, 1H), 2.11 (d, 1H), 1.93 (m, 2H), 1.85 (m, 8H), 1.77 – 1.69 (m, 1H), 1.67 – 1.58 (m, 1H), 1.51 – 1.42 (m, 6H), 1.15 (d, J = 5.0 Hz, 6H).

^{13}C NMR (101 MHz, Acetone- d_6) 171.4, 157.9, 148.1, 131.0, 130.6, 130.3, 130.1, 127.5, 122.9, 120.0, 110.7, 108.7, 81.5, 70.0, 65.4, 42.1, 38.1, 37.0, 31.8, 23.8, 22.5, 22.4, 14.7.

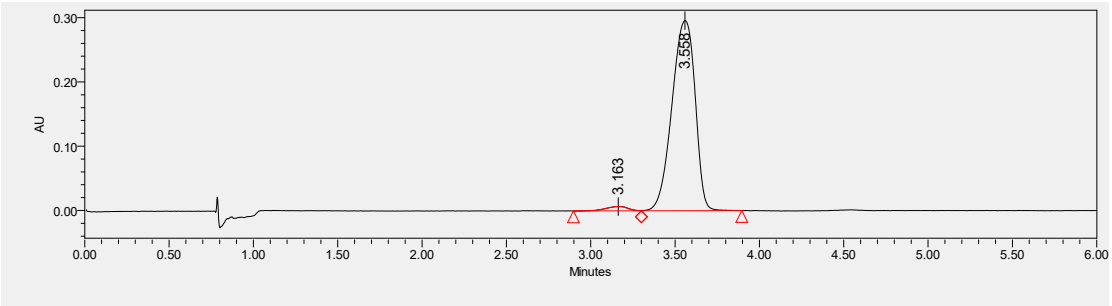
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{30}H_{36}N_2O_5Na^+]$: 527.2516 found 527.2518.

IR (neat) 3303, 2912, 1722, 1628, 1520, 1256, 1108, 809, 743 cm^{-1}.

Racemate: 18:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

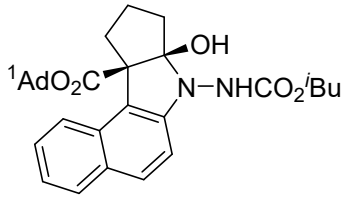


	Retention Time	Area	% Area
1	3.218	10366053	49.96
2	3.616	10380843	50.04



	Retention Time	Area	% Area
1	3.163	60389	2.09
2	3.558	2826624	97.91

(3*R*)-adamantan-1-yl (7a*R*,10a*R*)-7a-hydroxy-7-((isobutoxycarbonyl)amino)-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C23):



White solid, 84% yield, 96% ee, >19:1 dr, m.p. 103-107 °C, $[\alpha]_D^{26}$ = -69.4 (c = 0.50, in CH_2Cl_2).

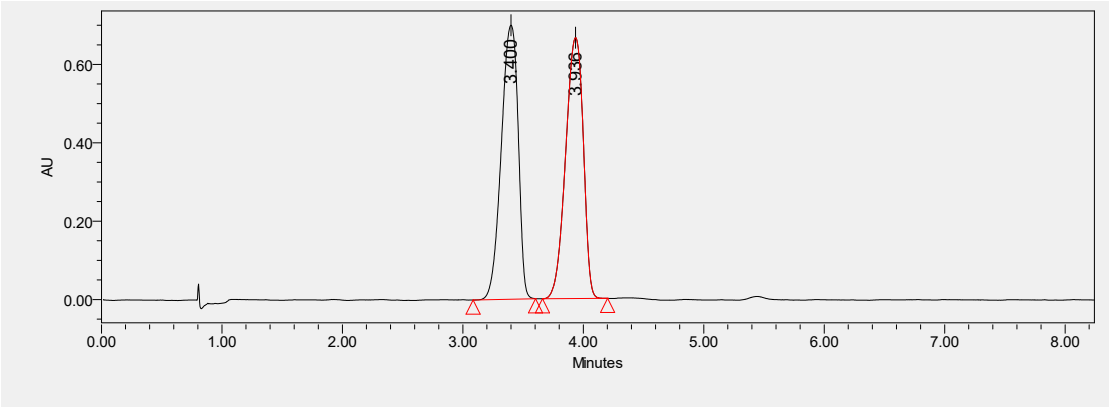
SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 3.34 min, t_2 = 3.83 min

^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.75 (d, *J* = 8.2 Hz, 1H), 7.69 (d, *J* = 8.6 Hz, 1H), 7.53 (d, *J* = 8.2 Hz, 1H), 7.39 (t, *J* = 7.6 Hz, 1H), 7.26 – 7.19 (t, 1H), 6.88 (d, *J* = 8.4 Hz, 1H), 6.83 (s, 1H), 4.15 (s, 1H), 3.97 (d, *J* = 5.4 Hz, 2H), 3.05 – 2.91 (m, 1H), 2.22 (s, 1H), 2.07 (s, 4H), 1.97 (s, 8H), 1.79 (s, 1H), 1.70 (s, 1H), 1.57 (s, 6H), 0.92 (d, *J* = 43.0 Hz, 6H).

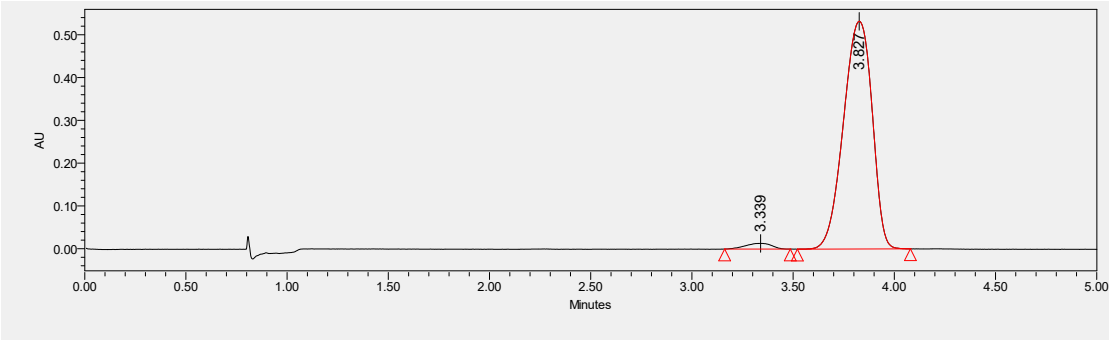
^{13}C NMR (101 MHz, Chloroform-*d*) δ 171.0, 158.1, 146.1, 129.7, 129.1, 126.7, 122.3, 121.9, 119.2, 109.6, 107.4, 82.1, 77.4, 77.0, 76.7, 72.2, 64.5, 45.3, 41.1, 37.0, 36.0, 35.4, 30.7, 29.7, 28.0, 23.1, 19.0.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{31}H_{38}N_2O_5Na^+]$: 541.2673 found 541.2673.

IR (neat) 3306, 2912, 1724, 1257, 1236, 1055, 809 cm^{-1}.

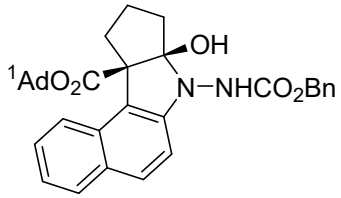


	Retention Time	Area	% Area
1	3.400	6802121	50.10
2	3.936	6775297	49.90



	Retention Time	Area	% Area
1	3.339	119340	2.22
2	3.827	5245045	97.78

(3*R*)-adamantan-1-yl (7a*R*,10a*R*)-7-(((benzyloxy)carbonyl)amino)-7a-hydroxy-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[b]indole-10a(7*H*)-carboxylate (C24):



White solid, 98% yield, 95% ee, >19:1 dr, m.p. 101-105 °C, $[\alpha]_D^{23}$ = -190.2 (c = 0.96, in CH_2Cl_2).

SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 9.36 min, t_2 = 10.43 min.

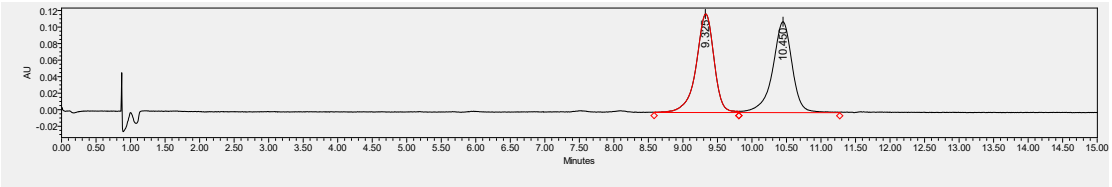
^{1}H NMR (400 MHz, Acetone-d_6) δ 7.66 (d, *J* = 8.2 Hz, 1H), 7.59 (d, *J* = 8.6 Hz, 1H), 7.28 (m, 7H), 7.09 (t, *J* = 8.0 Hz, 1H), 6.75 (d, *J* = 8.5 Hz, 1H), 5.10 (s, 2H), 2.95 – 2.80 (m, 1H), 2.14 (d, *J* = 7.5 Hz, 1H), 1.93 (s, 2H), 1.91 (m, 2H), 1.90 – 1.80 (m, 7H), 1.78 – 1.71 (m, 1H), 1.62 (s, 1H), 1.46 (m, 6H).

^{13}C NMR (101 MHz, Acetone-d_6) δ 171.4, 147.9, 137.8, 131.0, 130.7, 130.3, 130.1, 129.6, 129.2, 129.1, 127.5, 123.0, 110.8, 81.6, 67.9, 65.5, 46.5, 42.1, 38.1, 37.0, 36.8, 31.8, 23.9.

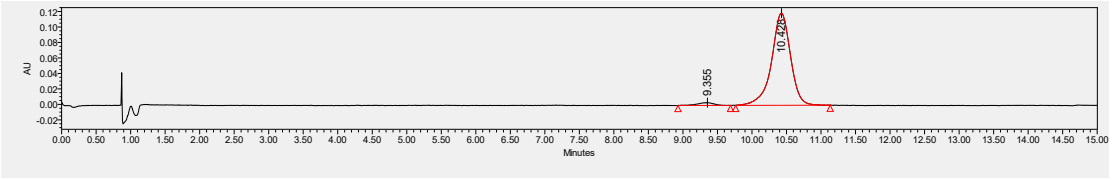
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{34}H_{36}N_2O_5Na^+]$: 575.2516 found 575.2512.

IR (neat) 3296, 2911, 1721, 1258, 1052, 808, 739 cm^{-1}.

Racemate: 8.6:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

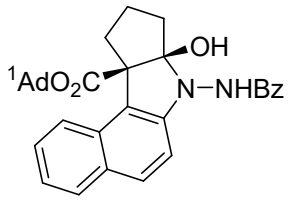


	Retention Time	Area	% Area
1	9.325	2146687	49.83
2	10.450	2161288	50.17



	Retention Time	Area	% Area
1	9.355	57604	2.47
2	10.428	2270051	97.53

(3*R*)-adamantan-1-yl (7a*R*,10a*R*)-7a-hydroxy-7-((phenoxycarbonyl)amino)-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C25):



Red solid, 69% yield, 82% ee, >19:1 dr, m.p. 112-114 °C, $[\alpha]\ ^{25}_{D}$ = -123.0 (c = 0.27, in CH_2Cl_2).

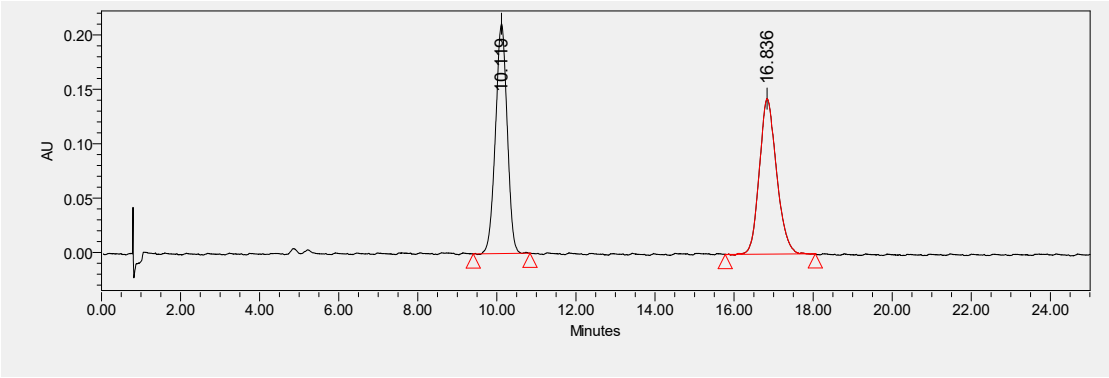
SFC Daicel Chiralpak IB-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 9.77 min, t_2 = 15.67 min

^{1}H NMR (400 MHz, Acetone-d_6) δ 9.81 (s, 1H), 8.00 – 7.90 (m, 2H), 7.66 (d, *J* = 8.2 Hz, 1H), 7.57 (d, *J* = 8.6 Hz, 1H), 7.55 – 7.49 (m, 1H), 7.43 (t, *J* = 7.5 Hz, 2H), 7.37 – 7.27 (m, 2H), 7.13 – 7.06 (m, 1H), 6.81 (d, *J* = 8.6 Hz, 1H), 4.75 (s, 1H), 2.91 (td, *J* = 12.4, 7.0 Hz, 1H), 2.19 (dd, *J* = 12.6, 5.8 Hz, 1H), 1.96 – 1.94 (m, 1H), 1.90 – 1.82 (m, 6H), 1.80 – 1.71 (m, 1H), 1.70 – 1.61 (m, 1H), 1.49 (m,, 7H), 1.16 (s, 3H).

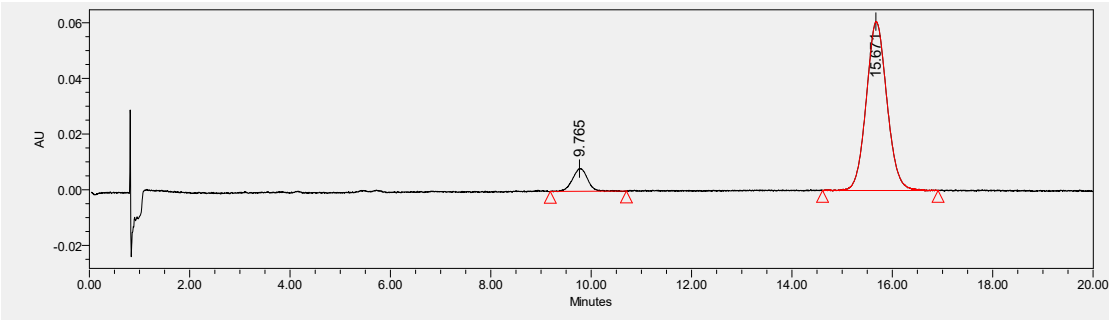
^{13}C NMR (101 MHz, Acetone-d_6) δ 171.3, 147.8, 133.7, 133.3, 131.0, 130.6, 130.2, 130.1, 129.7, 128.7, 127.4, 122.9, 120.5, 110.9, 109.5, 81.3, 65.6, 60.7, 42.1, 38.3, 37.0, 36.7, 31.7, 23.9.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{33}H_{34}N_2O_4Na^+]$: 545.2411 found 545.2413.

IR (neat) 3300, 2911, 2852, 1722, 1520, 1257, 1103, 809 cm^{-1}.

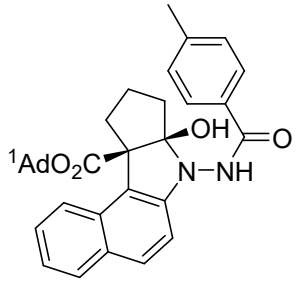


	Retention Time	Area	% Area
1	10.119	4342967	50.06
2	16.836	4333111	49.94



	Retention Time	Area	% Area
1	9.765	170895	8.99
2	15.671	1730639	91.01

(3S,5S,7S)-adamantan-1-yl (7aR,10aR)-7a-hydroxy-7-(4-methylbenzamido)-7a,8,9,10-tetrahydrobenzo[e]cyclopenta[b]indole-10a(7H)-carboxylate (C26):



White solid, 90% yield, 93% ee, >19:1 dr, m.p. 142-145 °C, $[\alpha]$ $^{13}_{D}$ = 32.1 (c = 0.20, in CH_2Cl_2).

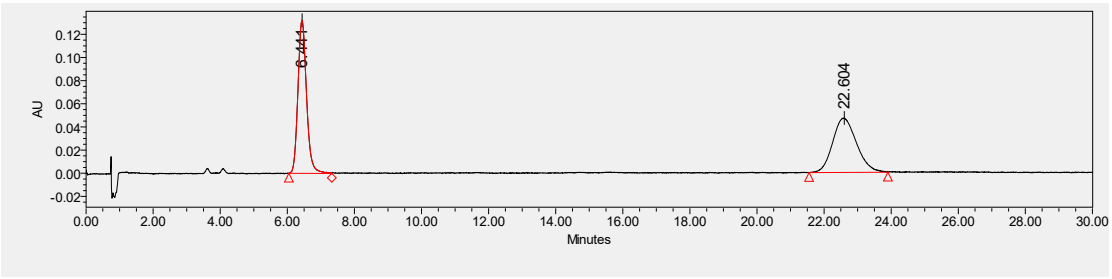
SFC Daicel Chiralcel OD-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 6.43 min, t_2 = 22.52 min

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.90 (d, J = 8.4 Hz, 1H), 7.86 (s, 1H), 7.67 (d, J = 8.1 Hz, 1H), 7.54 (m, 3H), 7.38 (t, J = 7.6 Hz, 1H), 7.18 (m, 1H), 6.80 (m, 3H), 5.18 (s, 1H), 3.40 (q, J = 12.1 Hz, 1H), 2.38 – 2.27 (m, 1H), 2.18 (m, 8H), 1.97 (s, 3H), 1.79 (s, 3H), 1.73 – 1.63 (m, 2H), 1.29 (q, J = 12.2 Hz, 6H).

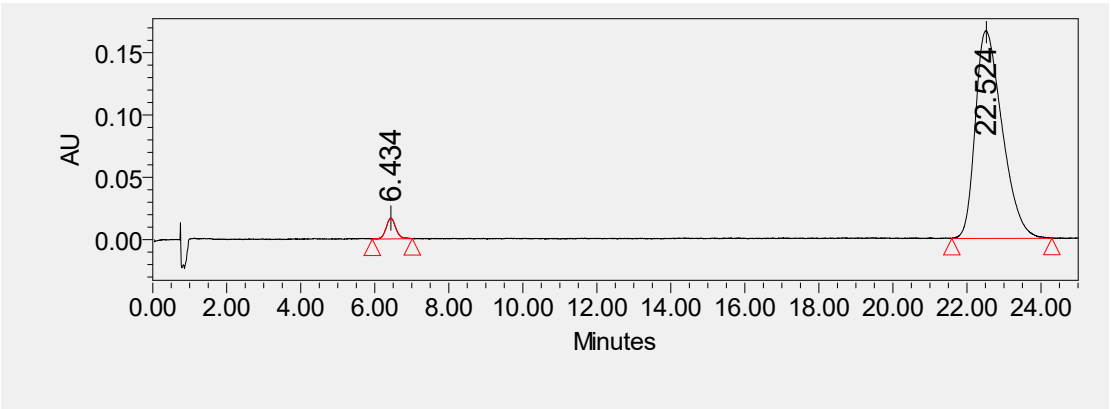
^{13}C NMR (101 MHz, Benzene-d_6) δ 171.1, 169.3, 147.0, 142.7, 130.7, 130.3, 129.8, 129.7, 129.6, 129.4, 127.0, 122.5, 122.5, 120.3, 110.2, 109.0, 81.6, 65.3, 45.6, 41.4, 38.1, 36.1, 35.9, 31.0, 23.4, 21.2.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{34}H_{36}N_2O_4Na^+]$: 559.2567 found 559.2567.

IR (neat) 3293, 2912, 2852, 1722, 1659, 1520, 1278, 1258, 1104, 833, 748 cm^{-1}.

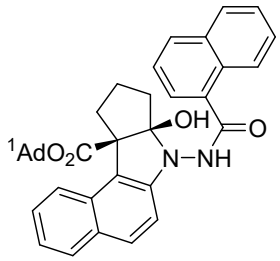


	Retention Time	Area	% Area
1	6.441	2346092	50.23
2	22.604	2325019	49.77



	Retention Time	Area	% Area
1	6.434	304735	3.50
2	22.524	8406697	96.50

(3S,5S,7S)-adamantan-1-yl (7aR,10aR)-7-(1-naphthamido)-7a-hydroxy-7a,8,9,10-tetrahydrobenzo[e]cyclopenta[b]indole-10a(7H)-carboxylate (C27):



Red solid, 91% yield, 92% ee, >19:1 dr, m.p. 164-167 °C, $[\alpha]_D^{13}$ = 52.1 (c = 1.0, in CH_2Cl_2).

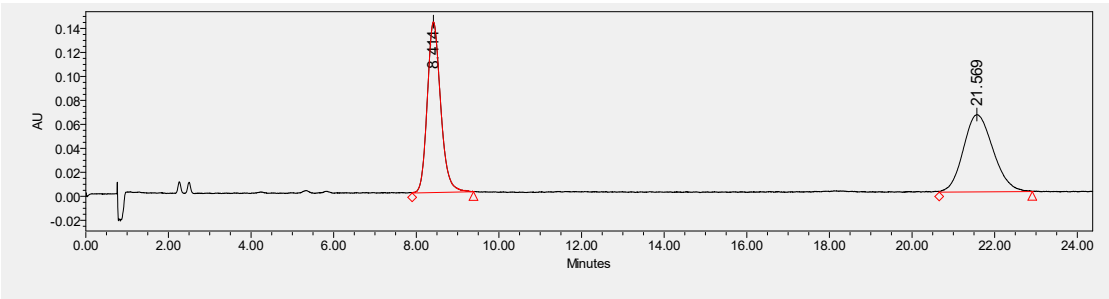
SFC Daicel Chiralcel OD-3, CO_2/MeOH = 70/30, 1.5 mL/min, λ = 240 nm, t_1 = 8.41 min, t_2 = 21.43 min

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.76 (s, 1H), 7.65 (d, *J* = 8.4 Hz, 1H), 7.44 – 7.37 (m, 2H), 7.29 (d, *J* = 8.5 Hz, 2H), 7.26 – 7.17 (m, 3H), 7.10 (t, *J* = 7.6 Hz, 1H), 6.98 – 6.93 (m, 2H), 6.90 (m, 1H), 6.53 (d, *J* = 8.6 Hz, 1H), 4.85 (s, 1H), 3.15 (dq, *J* = 12.4, 7.1 Hz, 1H), 2.05 – 1.82 (m, 9H), 1.51 (s, 3H), 1.01 (q, *J* = 12.2 Hz, 8H).

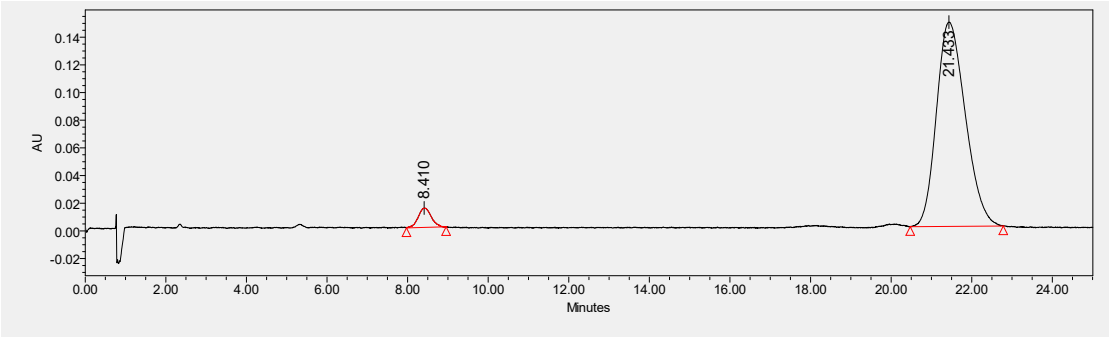
^{13}C NMR (101 MHz, Benzene-d_6) δ 170.9, 169.5, 146.9, 135.4, 132.8, 130.8, 130.4, 130.0, 129.7, 129.6, 129.2, 128.8, 127.1, 126.9, 124.3, 122.7, 122.5, 120.4, 110.1, 109.1, 81.6, 65.3, 41.5, 38.2, 36.2, 35.9, 31.0, 23.4, 20.5.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{37}H_{36}N_2O_4Na^+]$: 595.2567 found 595.2567.

IR (neat) 3291, 2911, 2852, 1721, 1661, 1520, 1291, 1258, 1237, 1103, 808, 760 cm^{-1}.

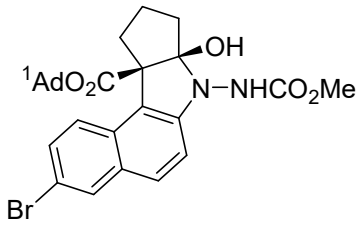


	Retention Time	Area	% Area
1	8.414	3192299	49.79
2	21.569	3219238	50.21



	Retention Time	Area	% Area
1	8.410	312258	4.07
2	21.433	7353561	95.93

(3*R*)-adamantan-1-yl (7a*R*,10a*R*)-3-bromo-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C28):



White solid, 98% yield, 95% ee, >19:1 dr, m.p. 137-141 °C, $[\alpha]_D^{23}$ = -334.9 (c = 0.48, in CH_2Cl_2).

SFC Daicel Chiralpak IA-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 8.19 min, t_2 = 9.99 min.

^{1}H NMR (600 MHz, Benzene-d_6) δ 7.79 (s, 1H), 7.60 (d, *J* = 8.3 Hz, 1H), 7.43 (d, *J* = 8.8 Hz, 1H), 7.24 (d, *J* = 8.5 Hz, 1H), 6.64 (d, *J* = 6.8 Hz, 1H), 5.97 (s, 1H), 4.63 (s, 1H), 3.31 (s, 3H), 3.25 (s, 1H), 2.15 – 1.89 (m, 9H), 1.76 (s, 3H), 1.59 (s, 1H), 1.26 (m, 7H).

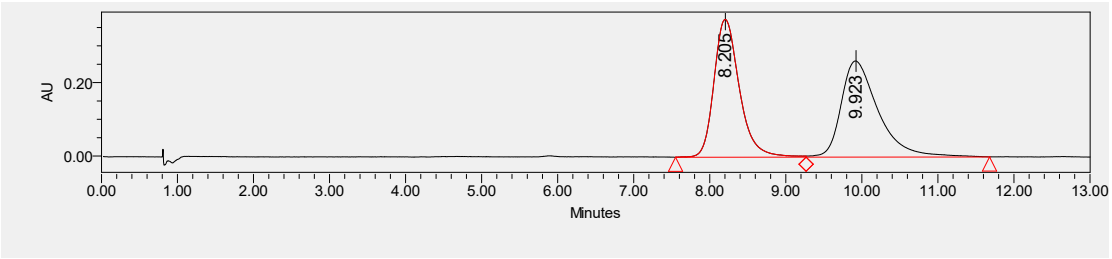
^{13}C NMR (151 MHz, Benzene-d_6) δ 170.5, 158.5, 147.0, 131.6, 131.3, 130.3, 129.0, 128.9, 124.0, 119.9, 116.1, 110.7, 108.2, 81.9, 64.8, 52.7, 41.4, 37.6, 36.1, 35.9, 31.0, 23.2.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{28}H_{31}{}^{79}BrN_2O_5Na^+]$: 577.1309 found 577.1310.

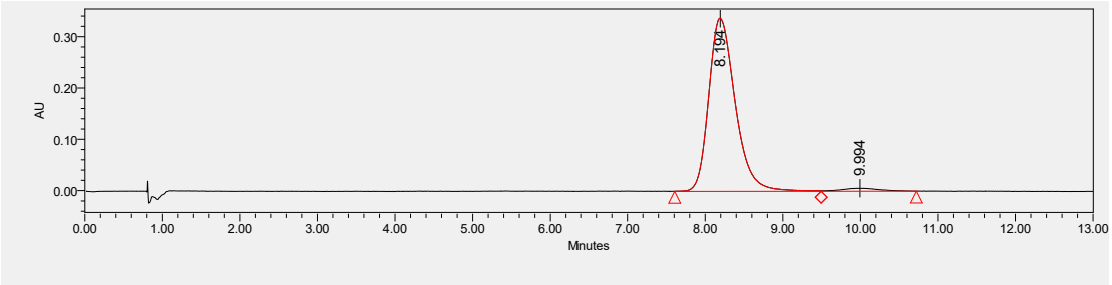
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{28}H_{31}{}^{81}BrN_2O_5Na^+]$: 579.1288 found 579.1287.

IR (neat) 3298, 2911, 1723, 1623, 1584, 1507, 1356, 1255, 1053, 813, 735 cm^{-1}.

Racemate: 5.5:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

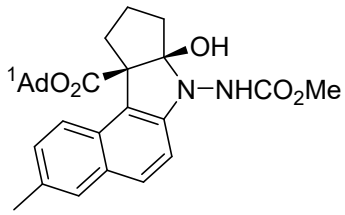


	Retention Time	Area	% Area
1	8.205	8682624	49.92
2	9.923	8709380	50.08



	Retention Time	Area	% Area
1	8.194	7984846	97.60
2	9.994	196220	2.40

(3*R*)-adamantan-1-yl (7a*R*,10a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-3-methyl-7a,8,9,10-tetrahydrobenzo[e]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C29):



White solid, 52% yield, 76% ee, >19:1 dr, m.p. 122-124 °C, $[\alpha]_D^{23}$ = -310 (c = 0.53, in CH_2Cl_2).

SFC Daicel Chiralpak IA-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 5.75 min, t_2 = 6.67 min.

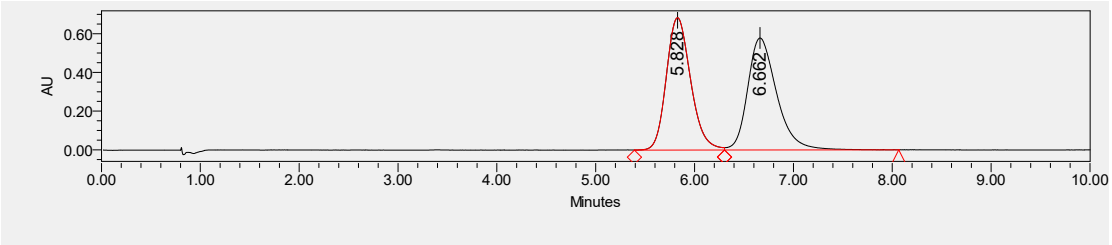
^{1}H NMR (600 MHz, Benzene-d_6) δ 7.82 (d, *J* = 7.3 Hz, 1H), 7.52 (d, *J* = 8.4 Hz, 1H), 7.42 (s, 1H), 7.20 (d, *J* = 8.7 Hz, 1H), 6.78 – 6.77 (d, 1H), 6.10 (s, 1H), 4.64 (s, 1H), 3.34 (s, 4H), 2.24 (s, 3H), 2.20 (d, *J* = 11.4 Hz, 1H), 2.16 – 2.04 (m, 7H), 2.00 (s, 1H), 1.76 (s, 3H), 1.63 (s, 1H), 1.34 – 1.18 (m, 7H).

^{13}C NMR (151 MHz, Benzene-d_6) δ 170.9, 158.7, 146.1, 131.7, 130.7, 129.3, 129.1, 128.8, 128.7, 122.3, 119.9, 110.0, 108.0, 81.7, 65.1, 52.6, 41.4, 37.6, 36.1, 35.9, 31.0, 23.3, 21.4.

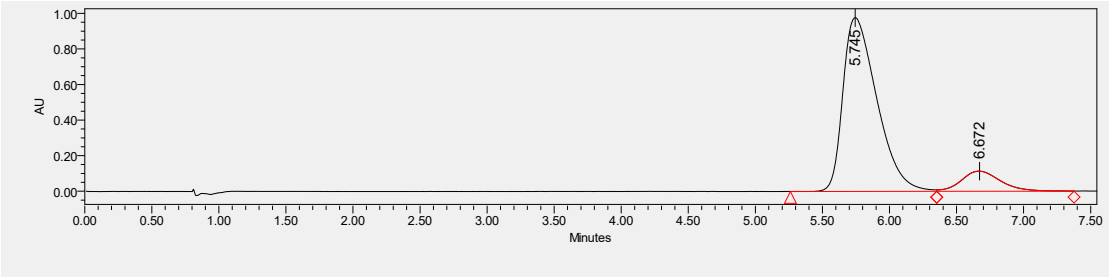
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{29}H_{34}N_2O_5Na^+]$: 513.2360 found 513.2361.

IR (neat) 3297, 2912, 1724, 1603, 1580, 1237, 1054, 815 cm^{-1}.

Racemate: 11:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

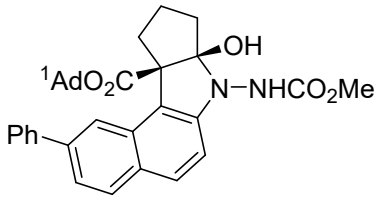


	Retention Time	Area	% Area
1	5.828	11693415	49.76
2	6.662	11804386	50.24



	Retention Time	Area	% Area
1	5.745	17167014	88.16
2	6.672	2306161	11.84

(3*R*)-adamantan-1-yl (7a*R*,10a*R*)-7a-hydroxy-7-((methoxycarbonyl)amino)-2-phenyl-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C30):



White solid, 94% yield, 84% ee, >19:1 dr, m.p. 128-133 °C, [α] $^{25}_{D}$ = -99.5 (c = 1.15, in CH_2Cl_2).

SFC Daicel Chiralpak IA-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 10.92 min, t_2 = 12.73 min.

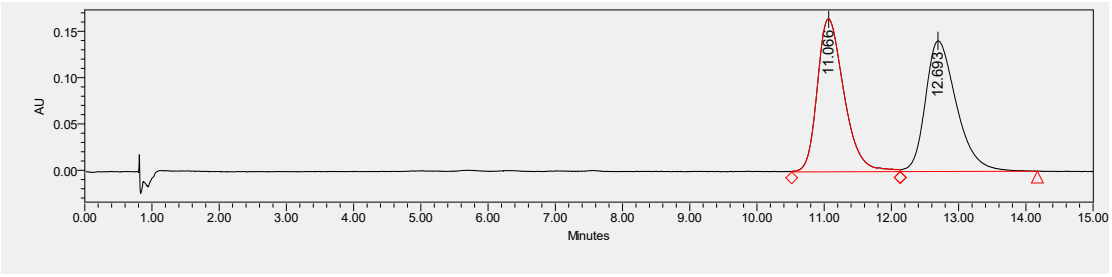
^{1}H NMR (400 MHz, Acetone-d_6) δ 7.75 (d, *J* = 8.5 Hz, 1H), 7.67 – 7.55 (m, 4H), 7.41 (dd, *J* = 8.5, 1.7 Hz, 1H), 7.37 (t, *J* = 7.7 Hz, 2H), 7.25 (t, *J* = 7.4 Hz, 1H), 6.77 (d, *J* = 8.6 Hz, 1H), 3.62 (s, 3H), 2.89 (q, *J* = 11.7 Hz, 1H), 2.23 – 2.10 (m, 1H), 1.95 (s, 1H), 1.87 (m, 9H), 1.75 (m, 1H), 1.62 (s, 1H), 1.42 (q, *J* = 12.3 Hz, 6H), 1.15 (s, 1H).

^{13}C NMR (101 MHz, Acetone-d_6) δ 171.4, 148.3, 142.2, 139.8, 131.1, 130.7, 130.0, 129.9, 128.4, 128.0, 122.3, 122.3, 120.5, 120.2, 110.8, 108.5, 81.6, 65.4, 53.1, 42.0, 38.0, 36.8, 31.6, 23.8.

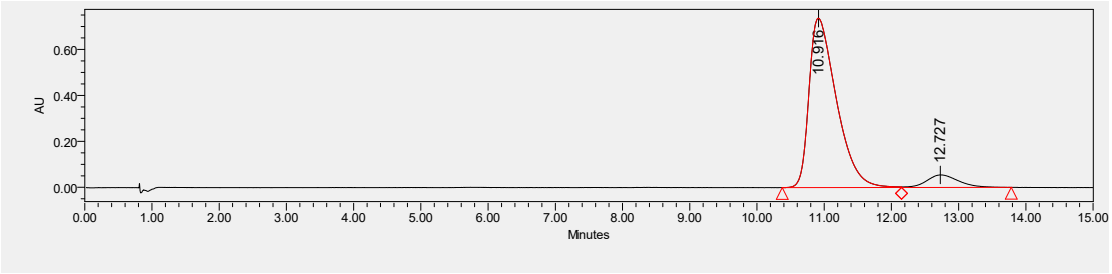
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{34}H_{36}N_2O_5Na^+]$: 575.2516 found 575.2518.

IR (neat) 3298, 2911, 2853, 1724, 1627, 1516, 1457, 1371, 1247, 1104, 879, 758, 698 cm^{-1}.

Racemate: 11:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

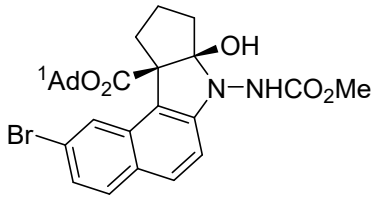


	Retention Time	Area	% Area
1	11.066	4557569	50.20
2	12.693	4520778	49.80



	Retention Time	Area	% Area
1	10.916	20860056	92.06
2	12.727	1798158	7.94

(3*R*)-adamantan-1-yl (7a*R*,10a*R*)-2-bromo-7a-hydroxy-7-((methoxycarbonyl)amino)-7a,8,9,10-tetrahydrobenzo[*e*]cyclopenta[*b*]indole-10a(7*H*)-carboxylate (C31):



White solid, 92% yield, 87% ee, >19:1 dr, m.p. 230-235 °C, $[\alpha]_D^{20}$ = -90.0 (c = 0.69, in CH_2Cl_2).

SFC Daicel Chiralpak IA-3, CO_2/MeOH = 85/15, 1.5 mL/min, λ = 240 nm, t_1 = 8.30 min, t_2 = 9.49 min.

^{1}H NMR (400 MHz, Acetone-d_6) δ 7.63 (d, *J* = 8.7 Hz, 2H), 7.50 (s, 1H), 7.19 (dd, *J* = 8.7, 1.9 Hz, 1H), 6.80 (d, *J* = 8.7 Hz, 1H), 3.62 (s, 3H), 2.94 – 2.80 (m, 1H), 2.14 (d, *J* = 8.2 Hz, 1H), 1.96 (s, 3H), 1.88 (d, *J* = 10.7 Hz, 8H), 1.76 (m, 1H), 1.68 – 1.60 (m, 1H), 1.47 (d, *J* = 14.8 Hz, 6H).

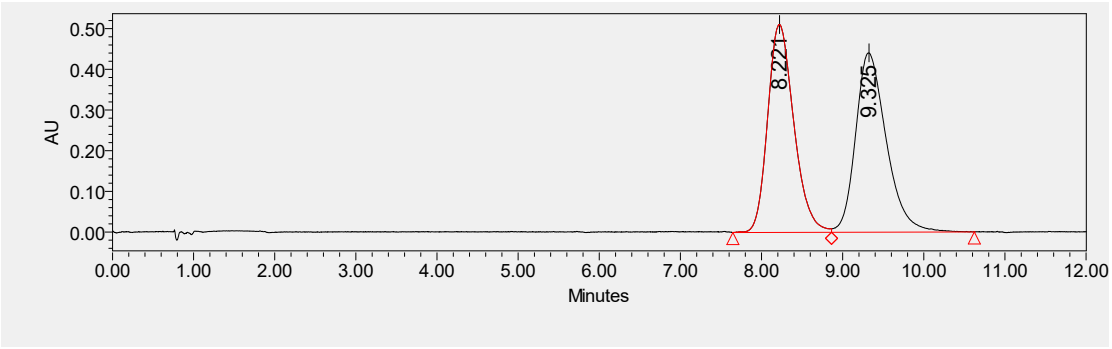
^{13}C NMR (101 MHz, Acetone-d_6) δ 171.3, 149.0, 132.3, 132.2, 130.7, 129.0, 125.2, 121.6, 111.4, 108.9, 82.0, 65.3, 53.3, 42.2, 38.0, 37.1, 31.9, 23.9, 18.4.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{28}H_{31}{}^{79}BrN_2O_5Na^+]$: 577.1309 found 577.1306.

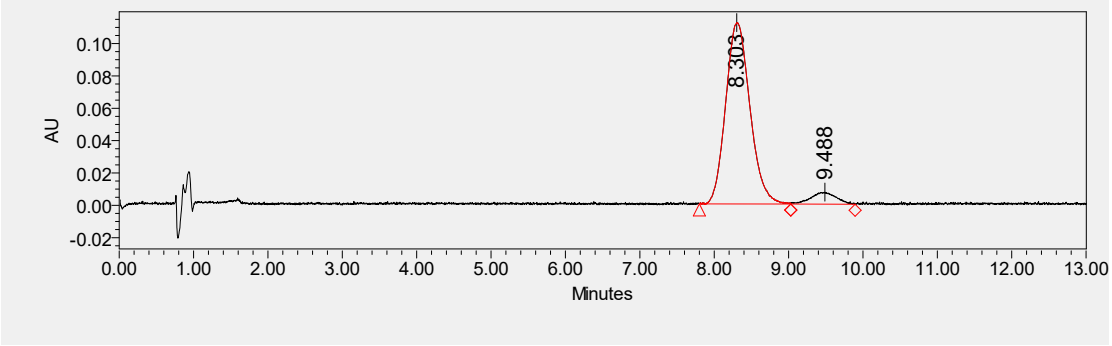
HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{28}H_{31}{}^{81}BrN_2O_5Na^+]$: 579.1288 found 579.1285.

IR (neat) 3283, 2916, 1719, 1621, 1509, 1455, 1378, 1262, 1055, 828, 797 cm^{-1}.

Racemate: 7:1 dr determined by isolate yield. The HPLC of the cis-isomer as below:

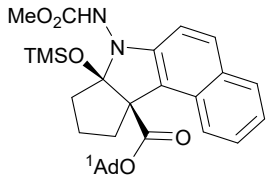


	Retention Time	Area	% Area
1	8.221	11447276	49.70
2	9.325	11583308	50.30



	Retention Time	Area	% Area
1	8.303	2539424	93.56
2	9.488	174698	6.44

(3S,5S,7S)-adamantan-1-yl (7aR,10aR)-7-((methoxycarbonyl)amino)-7a-((trimethylsilyl)oxy)-7a,8,9,10-tetrahydrobenzo[e]cyclopenta[b]indole-10a(7H)-carboxylate (D1):



White solid, 86% yield, 92% ee, >19:1 dr, m.p. 187-189 °C, $[\alpha]_D^{13}$ = 51.0 (c = 0.70, in CH_2Cl_2).

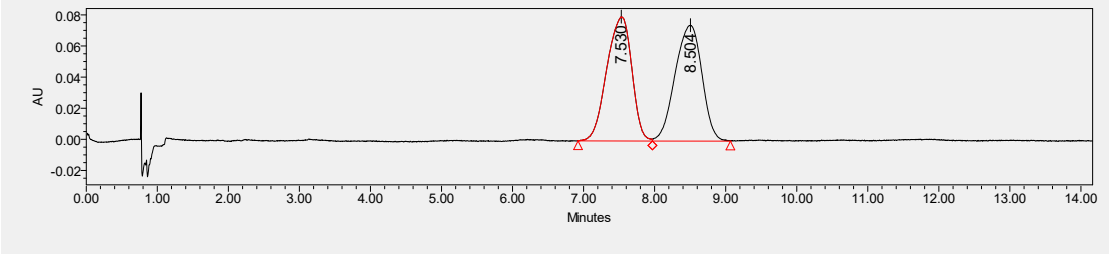
SFC Daicel Chiralcel OD-3, CO_2/MeOH = 95/5, 1.5 mL/min, λ = 240 nm, t_1 = 7.46 min, t_2 = 8.47 min.

^{1}H NMR (400 MHz, Benzene-d_6) δ 7.66 (dd, *J* = 11.6, 8.5 Hz, 2H), 7.52 (d, *J* = 8.6 Hz, 1H), 7.33 (t, *J* = 7.6 Hz, 1H), 7.19 (m, 1H), 6.90 (d, *J* = 7.9 Hz, 1H), 6.42 (s, 1H), 3.47 (s, 3H), 3.19 (s, 1H), 2.66 (s, 1H), 2.14 – 1.98 (m, 8H), 1.83 (s, 3H), 1.66 (m, 1H), 1.34 (q, *J* = 12.0 Hz, 7H), 0.32 (s, 9H).

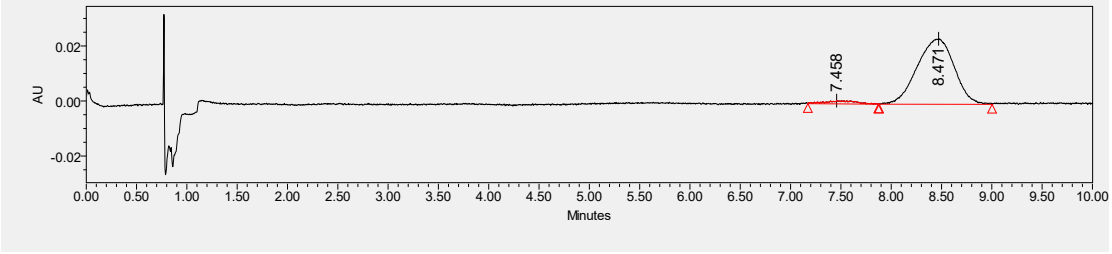
^{13}C NMR (101 MHz, Benzene-d_6) δ 168.9, 145.6, 127.7, 127.6, 126.7, 124.4, 121.9, 120.8, 119.1, 109.7, 108.3, 78.7, 64.7, 50.5, 39.6, 34.6, 34.4, 29.1, 22.5, 0.2.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{31}H_{40}N_2O_5SiNa^+]$: 571.2599 found 571.2601.

IR (neat) 3287, 2912, 2852, 1716, 1520, 1354, 1317, 1259, 1238, 1149, 897, 843 cm^{-1}.

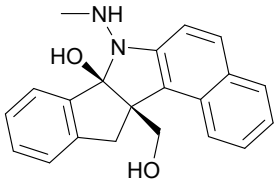


	Retention Time	Area	% Area
1	7.530	1946010	49.91
2	8.504	1953312	50.09



	Retention Time	Area	% Area
1	7.458	24544	3.87
2	8.471	609340	96.13

(7aR,12aS)-12a-(hydroxymethyl)-7-(methylamino)-12,12a-dihydrobenzo[e]indeno[1,2-b]indol-7a(7H)-ol (D2):



Pale yellow solid, 38% yield, 88% ee, >19:1 dr, m.p. 98-101 °C, $[\alpha]_D^{13}$ = -295.7 (c = 0.08, in CH_2Cl_2).

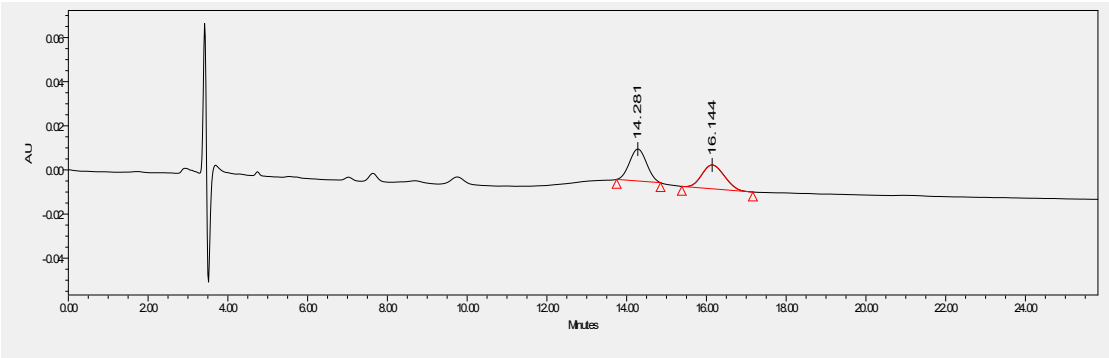
HPLC Daicel Chiralpak AZH, hexane/isopropanol= 70/30, 1.0 mL/min, λ = 254 nm, t_1 = 14.32 min, t_2 = 16.25 min.

^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.86 (d, *J* = 8.4 Hz, 1H), 7.78 (d, *J* = 8.2 Hz, 1H), 7.69 (d, *J* = 8.7 Hz, 1H), 7.54 (d, *J* = 7.5 Hz, 1H), 7.46 (t, *J* = 7.5 Hz, 1H), 7.32 – 7.27 (m, 2H), 7.22 (m, 3H), 5.17 (s, 1H), 4.49 (d, *J* = 11.2 Hz, 1H), 3.76 – 3.63 (m, 2H), 3.34 (d, *J* = 16.4 Hz, 1H), 2.96 (s, 3H), 2.27 (s, 2H).

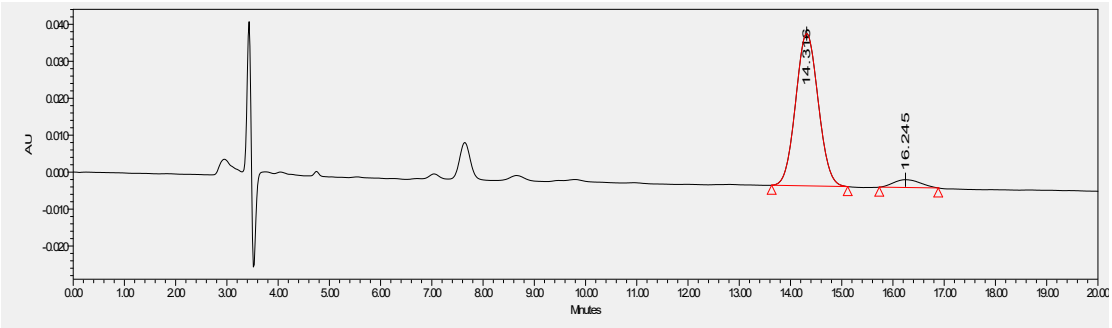
^{13}C NMR (151 MHz, Chloroform-*d*) δ 150.8, 141.9, 141.8, 130.8, 130.3, 129.6, 128.4, 127.6, 126.6, 125.8, 125.3, 122.8, 121.6, 120.7, 78.8, 67.2, 59.6, 40.5, 37.1.

HRMS (ESI) m/z: $[M + Na]^+$ Calculated for $[C_{21}H_{20}N_2O_2Na^+]$: 355.1417 found 355.1414.

IR (neat) 3334, 2924, 1720, 1622, 1518, 1467, 1375, 1209, 1027, 815, 746 cm^{-1}.



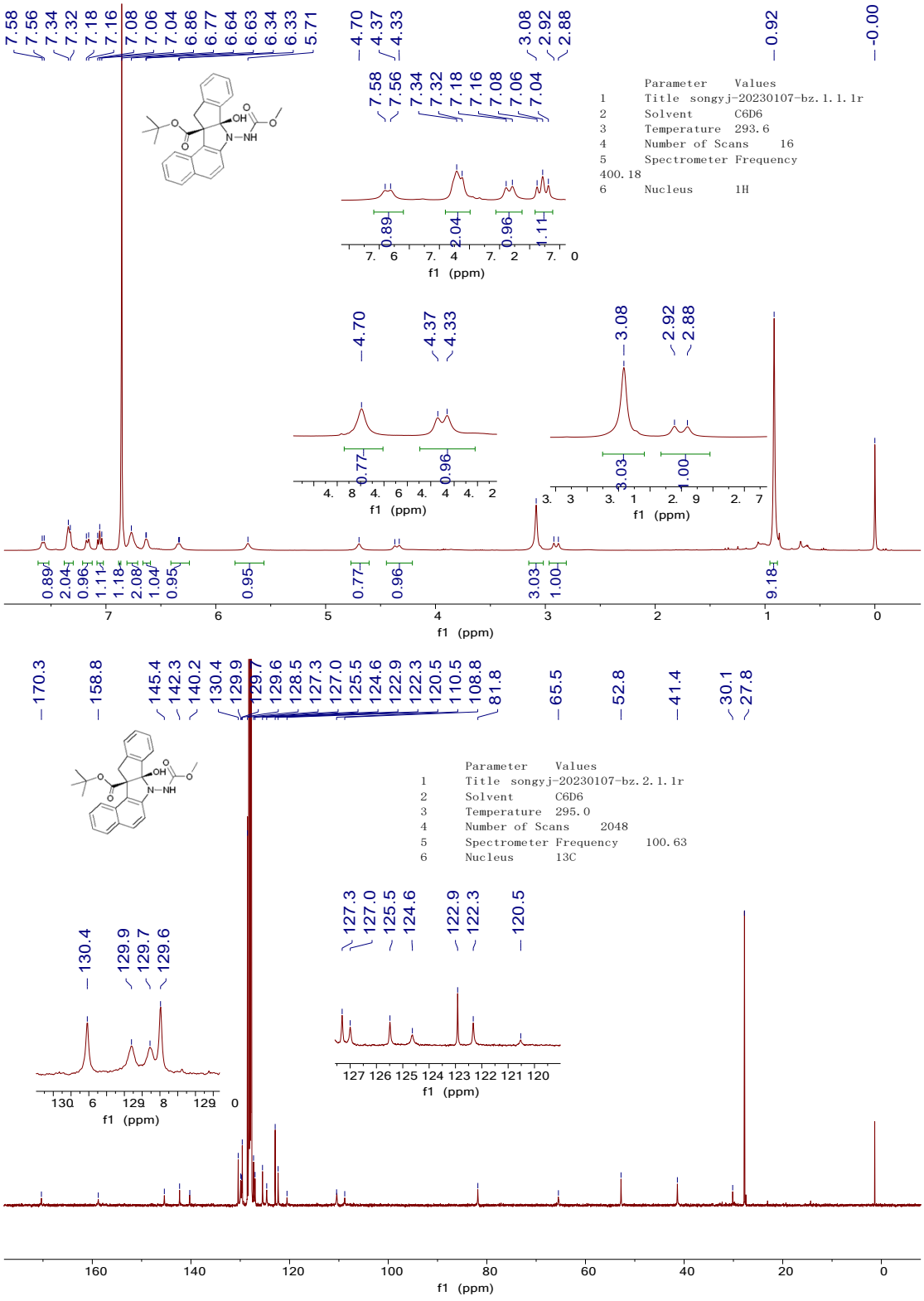
	Retention Time	Area	% Area
1	14.281	431109	50.39
2	16.144	424405	49.61



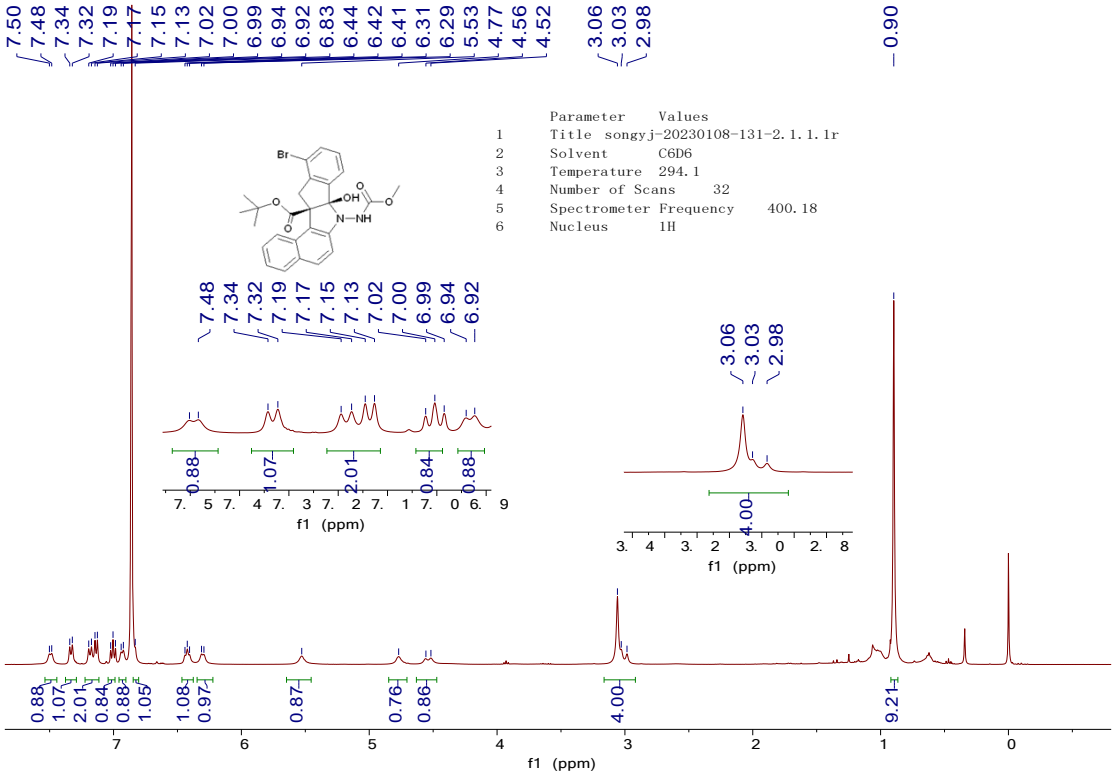
	Retention Time	Area	% Area
1	14.316	1259195	94.23
2	16.245	77071	5.77

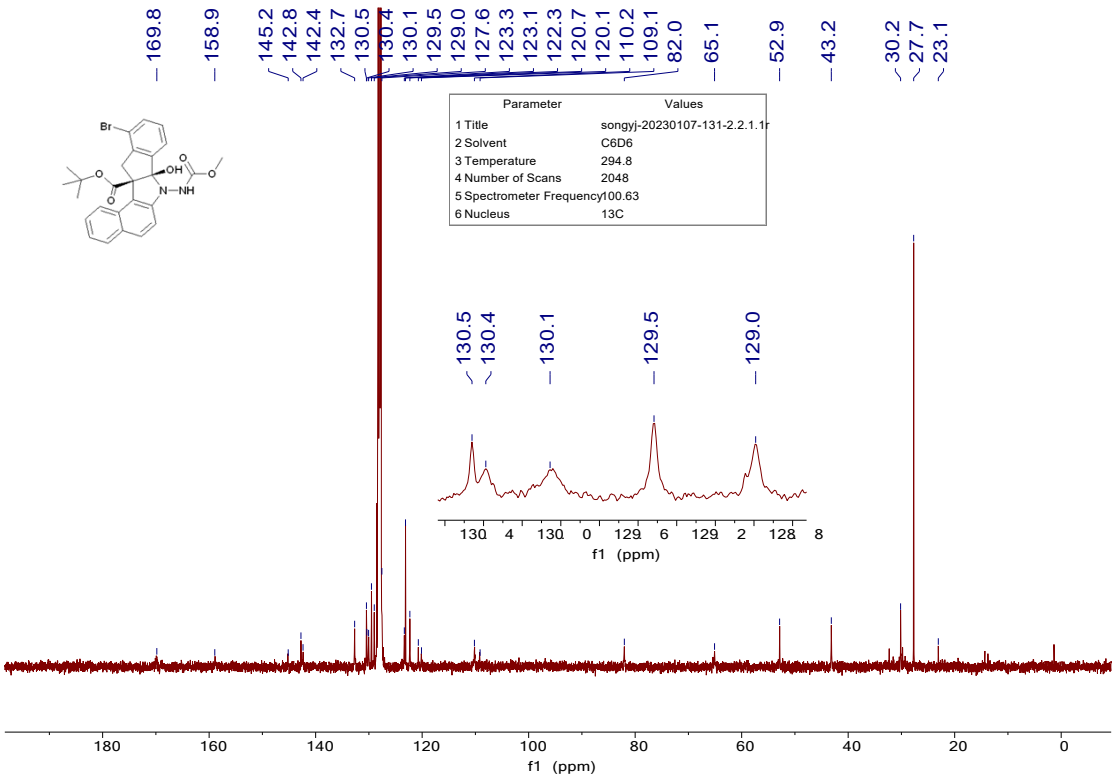
11. Copies of ^{1}H, ^{13}C and ^{19}F NMR spectra of the products

C1:

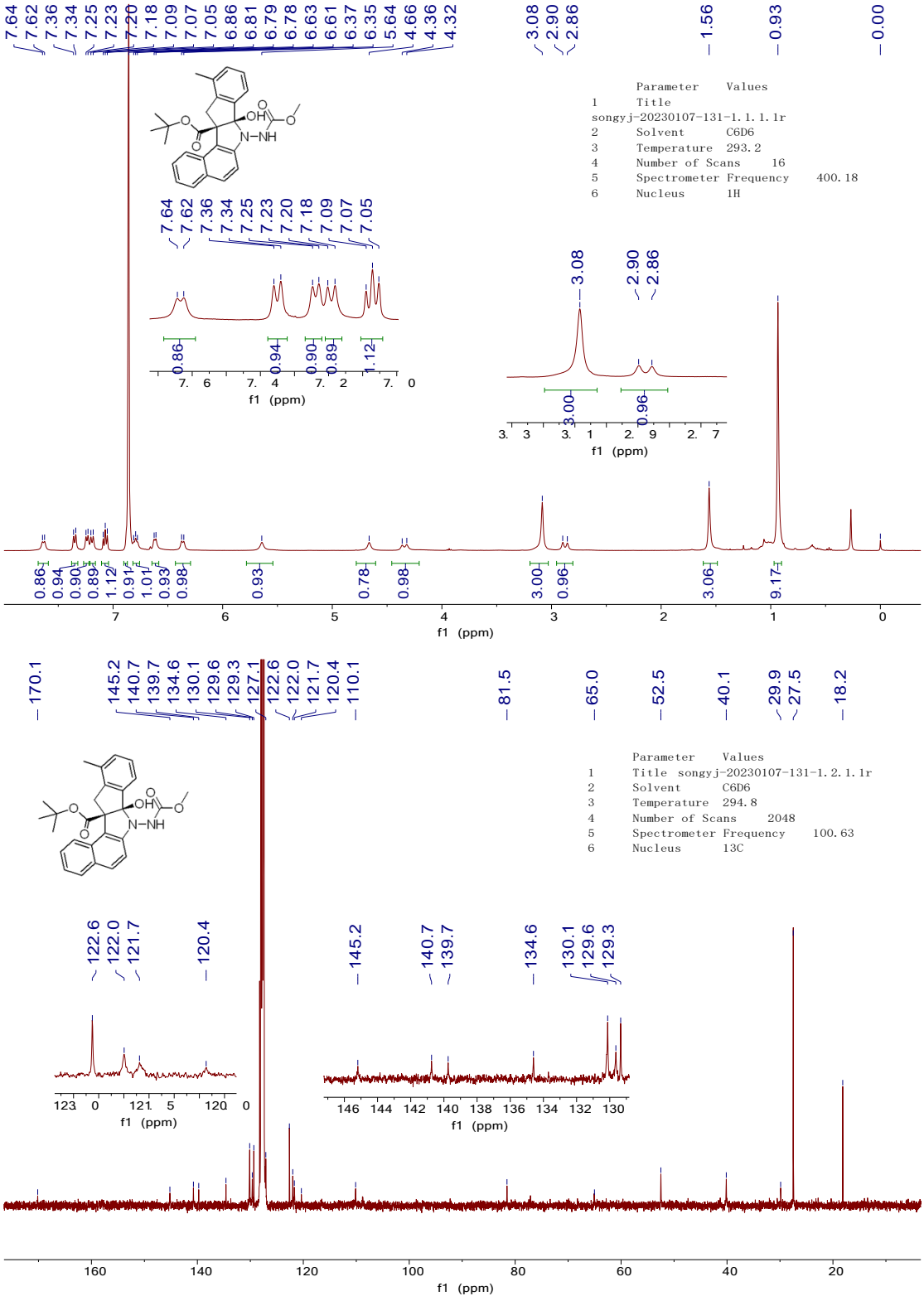


C2:

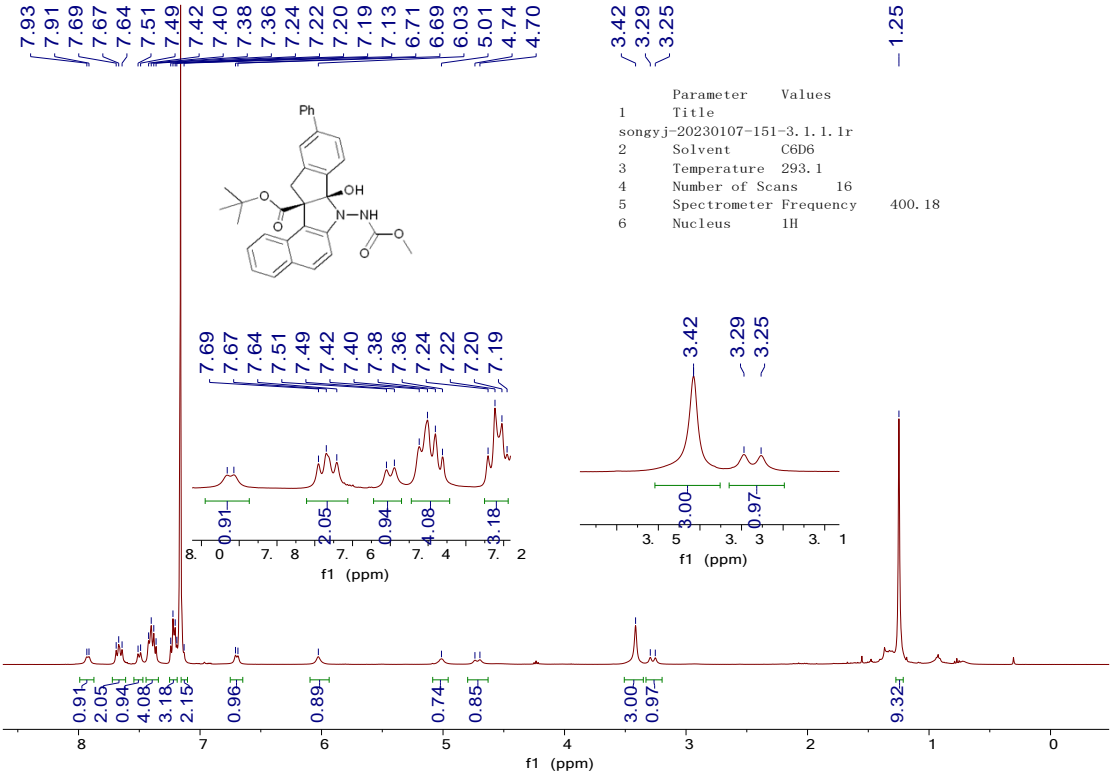

7.50 7.48 7.34 7.32 7.19 7.17 7.15 7.13 7.02 7.00 6.99 6.94 6.92 6.83 6.44 6.42 6.41 6.31 6.29 5.53 4.77 4.56 4.52 3.06 3.03 2.98 0.90
Parameter Values
1 Title songyj-20230108-131-2.1.1.1r
2 Solvent C6D6
3 Temperature 294.1
4 Number of Scans 32
5 Spectrometer Frequency 400.18
6 Nucleus 1H
Br
OH
N—NH
0.88 1.07 2.01 0.84 0.88 1.05 1.08 0.97 0.87 0.76 0.86 4.00 9.21
f1 (ppm)

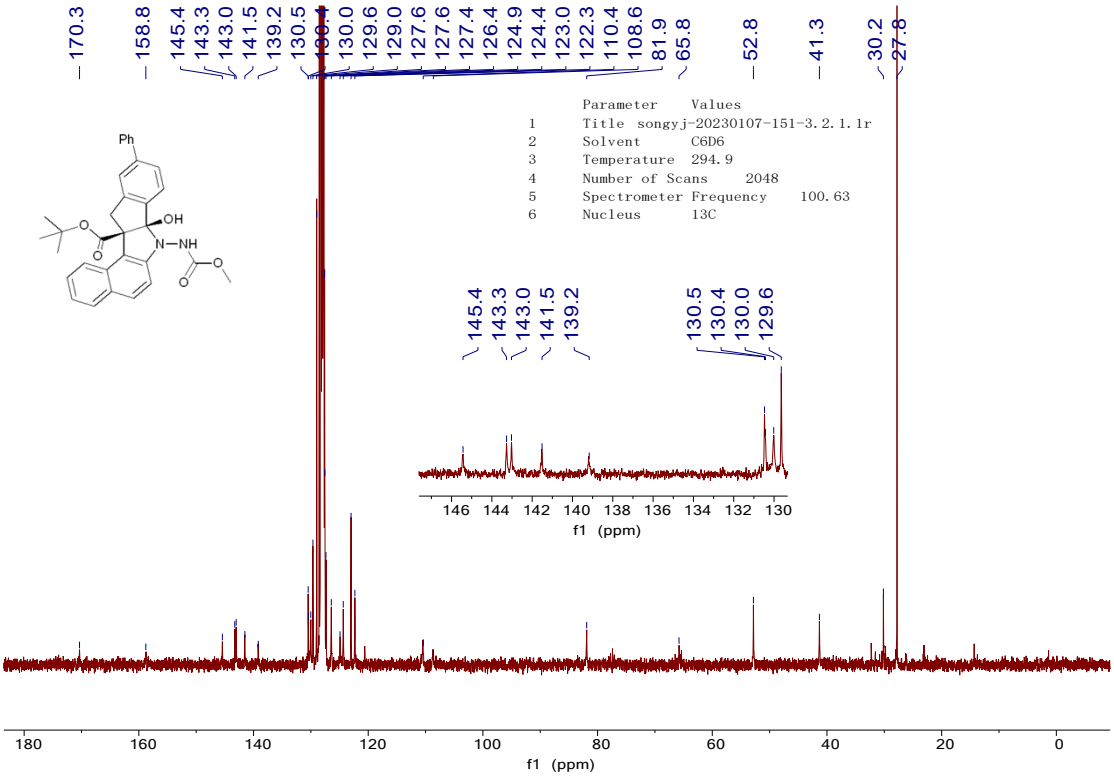

169.8 158.9 145.2 142.8 142.4 132.7 130.5 130.4 130.1 129.5 129.0 127.6 123.3 123.1 122.3 120.7 120.1 110.2 109.1 82.0 65.1 52.9 43.2 30.2 27.7 23.1
Parameter Values
1 Title songyj-20230107-131-2.2.1.1r
2 Solvent C6D6
3 Temperature 294.8
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
Br
OH
N—NH
f1 (ppm)

C3:

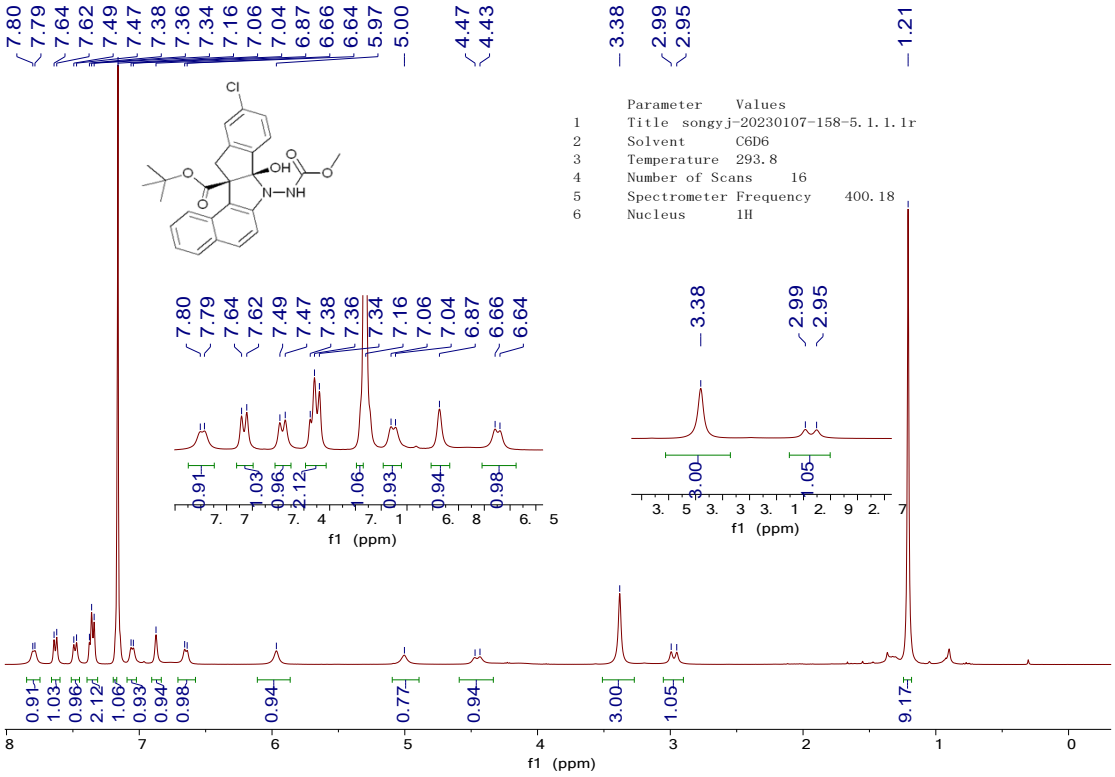

Parameter Values
1 Title songyj-20230107-131-1.1.1.1r
2 Solvent C6D6
3 Temperature 293.2
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
f1 (ppm)
Parameter Values
1 Title songyj-20230107-131-1.2.1.1r
2 Solvent C6D6
3 Temperature 294.8
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

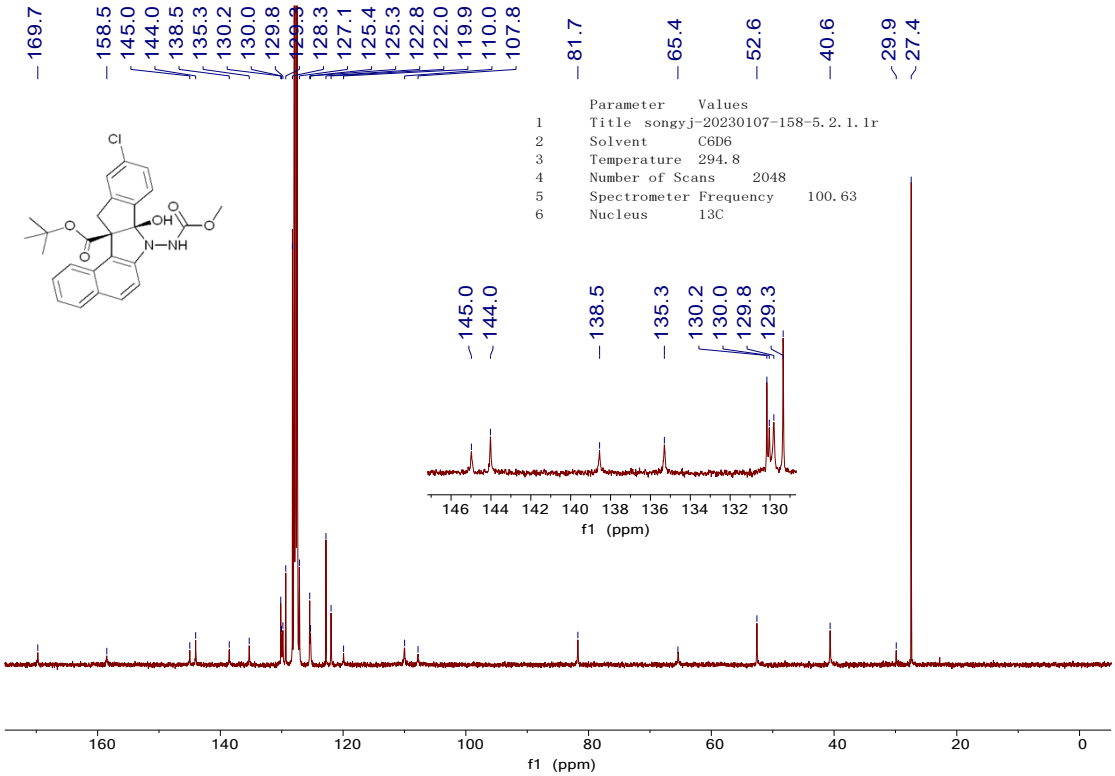
C4:


7.93 7.91 7.69 7.67 7.64 7.51 7.49 7.42 7.40 7.38 7.36 7.24 7.22 7.20 7.19 7.13 6.71 6.69 6.03 5.01 4.74 4.70
3.42 3.29 3.25
1.25
Parameter Values
1 Title songyj-20230107-151-3.1.1.1r
2 Solvent C6D6
3 Temperature 293.1
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
Ph
OH
N—NH
O
O
O
O
0.91 2.05 0.94 4.08 3.18 2.15 0.96 0.89 0.74 0.85 3.00 0.97 9.32
f1 (ppm)

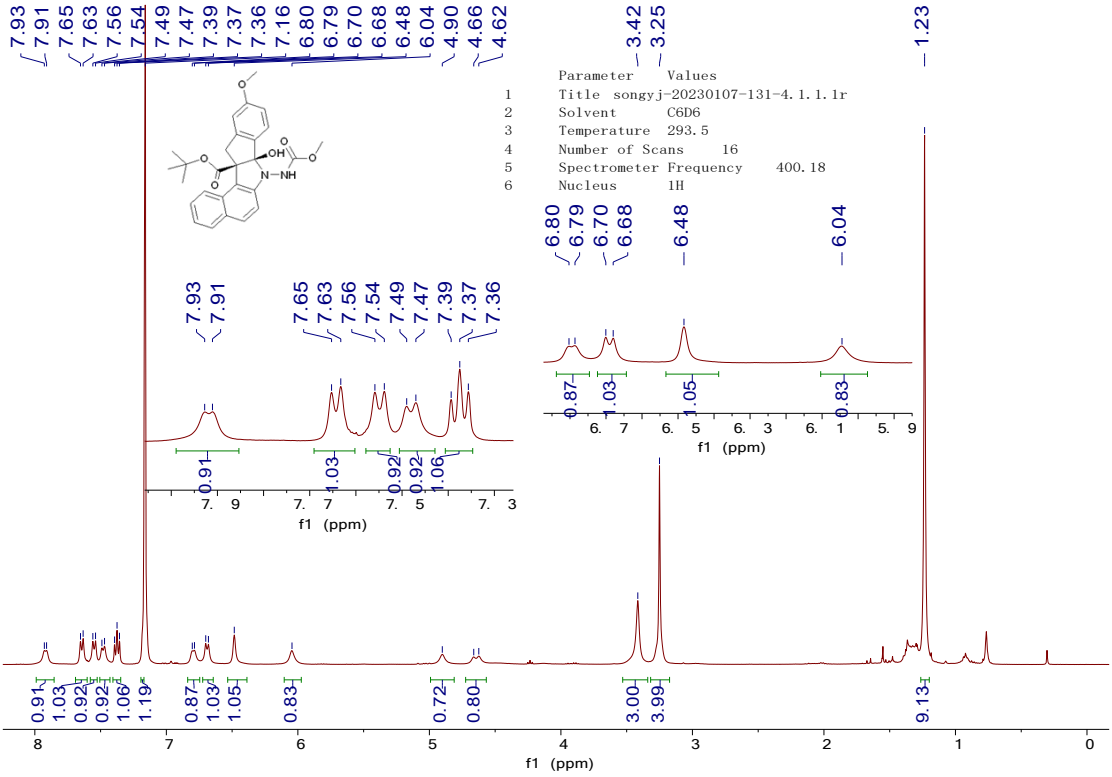

170.3 158.8 145.4 143.3 143.0 141.5 139.2 130.5 130.4 130.0 129.6 129.0 127.6 127.6 127.4 126.4 124.9 124.4 123.0 122.3 110.4 108.6 81.9 65.8 52.8 41.3 30.2 27.8
Parameter Values
1 Title songyj-20230107-151-3.2.1.1r
2 Solvent C6D6
3 Temperature 294.9
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
Ph
OH
N—NH
O
O
O
O
f1 (ppm)

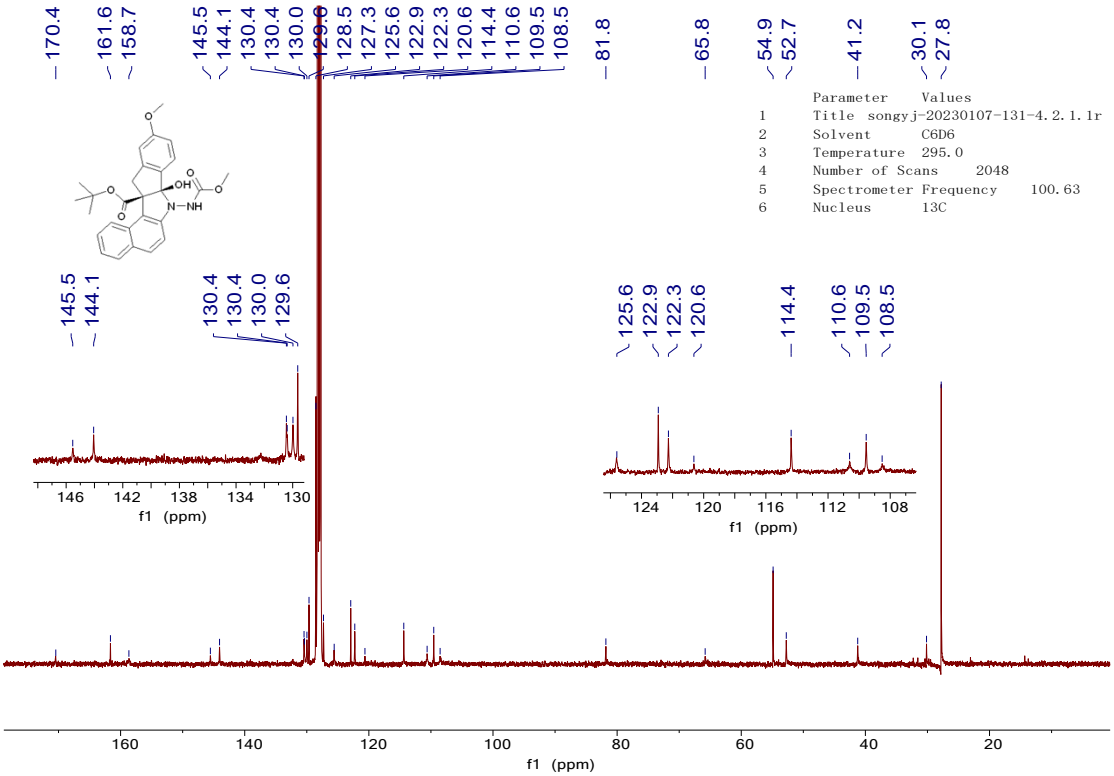
C5:


7.80 7.79 7.64 7.62 7.49 7.47 7.38 7.36 7.34 7.16 7.06 7.04 6.87 6.66 6.64 5.97 5.00 4.47 4.43 3.38 2.99 2.95 1.21
Cl
OH
N—NH
Parameter Values
1 Title songyj-20230107-158-5.1.1.1r
2 Solvent C6D6
3 Temperature 293.8
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
0.91 1.03 0.96 2.12 1.06 0.93 0.94 0.98
3.00 1.05
0.91 1.03 0.96 2.12 1.06 0.93 0.94 0.98 0.94 0.77 0.94 3.00 1.05 9.17
f1 (ppm)

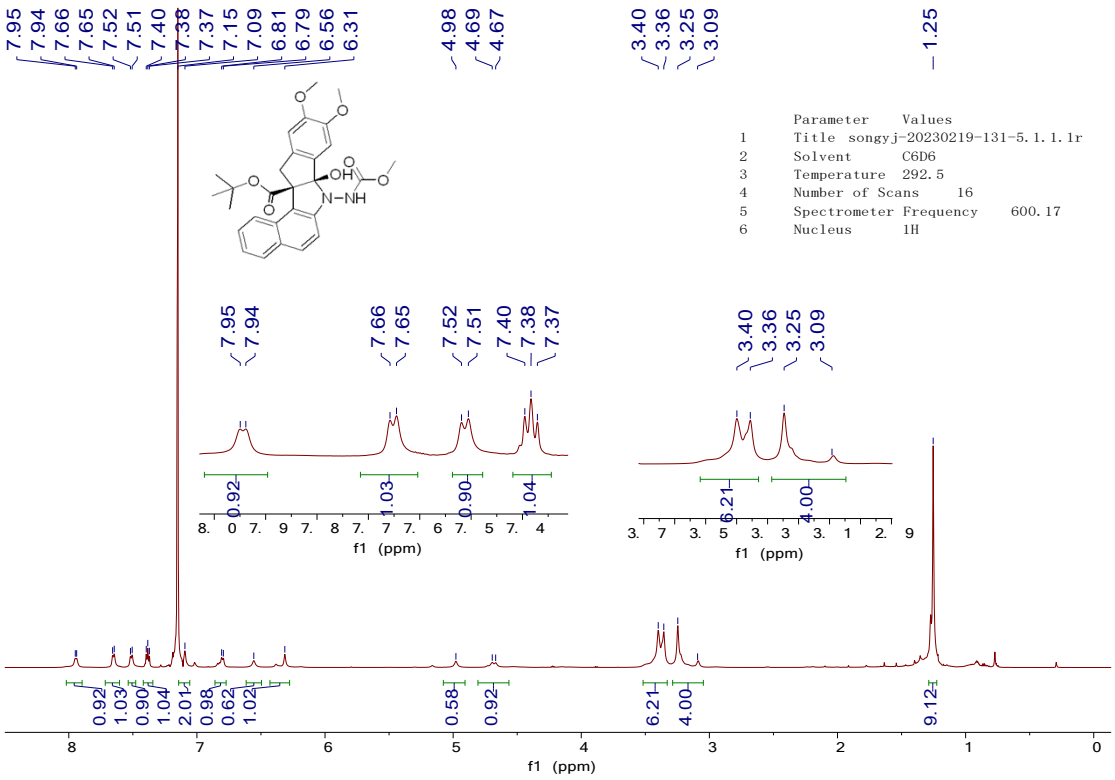

169.7 158.5 145.0 144.0 138.5 135.3 130.2 130.0 129.8 129.3 128.3 127.1 125.4 125.3 122.8 122.0 119.9 110.0 107.8 81.7 65.4 52.6 40.6 29.9 27.4
Cl
OH
N—NH
Parameter Values
1 Title songyj-20230107-158-5.2.1.1r
2 Solvent C6D6
3 Temperature 294.8
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
145.0 144.0 138.5 135.3 130.2 130.0 129.8 129.3
f1 (ppm)

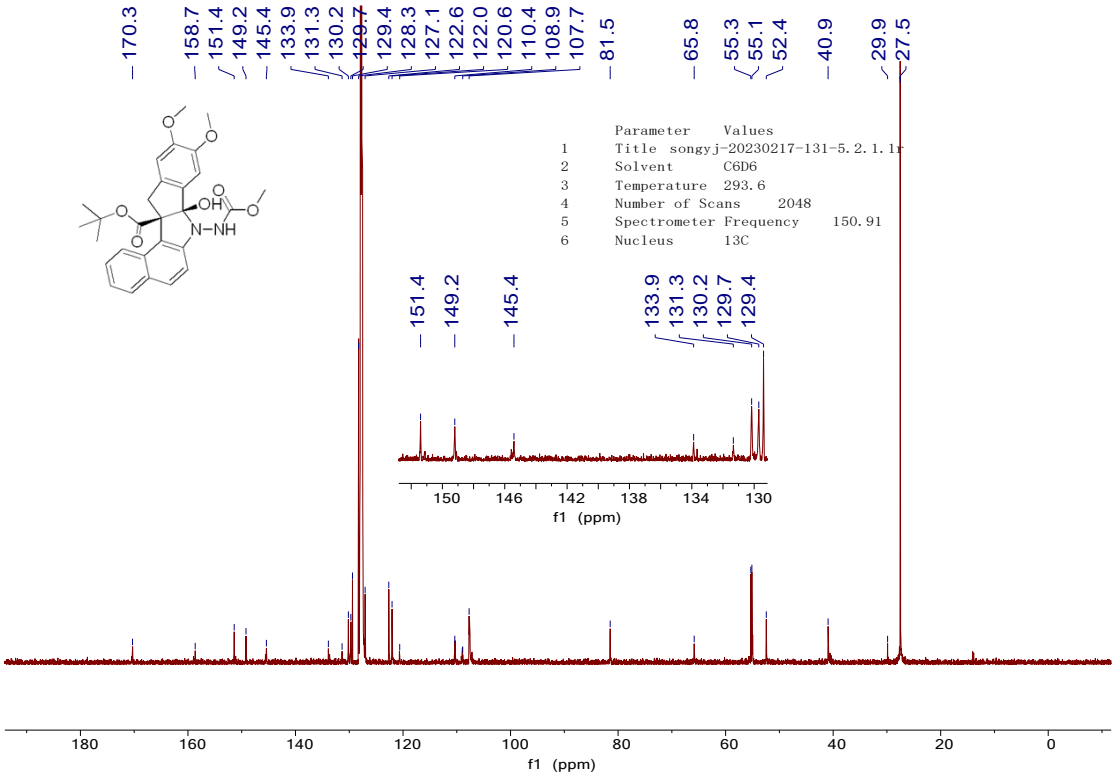
C6:


7.93 7.91 7.65 7.63 7.56 7.54 7.49 7.47 7.39 7.37 7.36 7.16 6.80 6.79 6.70 6.68 6.48 6.04 4.90 4.66 4.62
3.42 3.25
1.23
Parameter Values
1 Title songyj-20230107-131-4.1.1.1r
2 Solvent C6D6
3 Temperature 293.5
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
f1 (ppm)

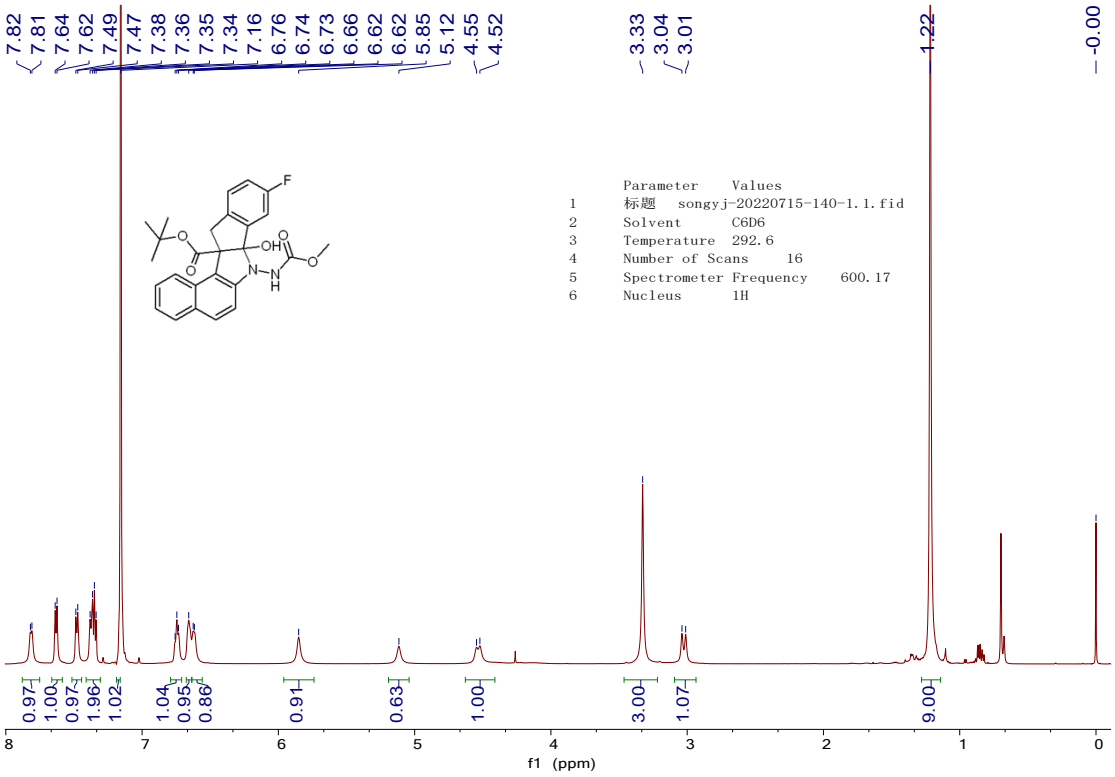

170.4 161.6 158.7 145.5 144.1 130.4 130.4 130.0 129.6 128.5 127.3 125.6 122.9 122.3 120.6 114.4 110.6 109.5 108.5 81.8 65.8 54.9 52.7 41.2 30.1 27.8
Parameter Values
1 Title songyj-20230107-131-4.2.1.1r
2 Solvent C6D6
3 Temperature 295.0
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

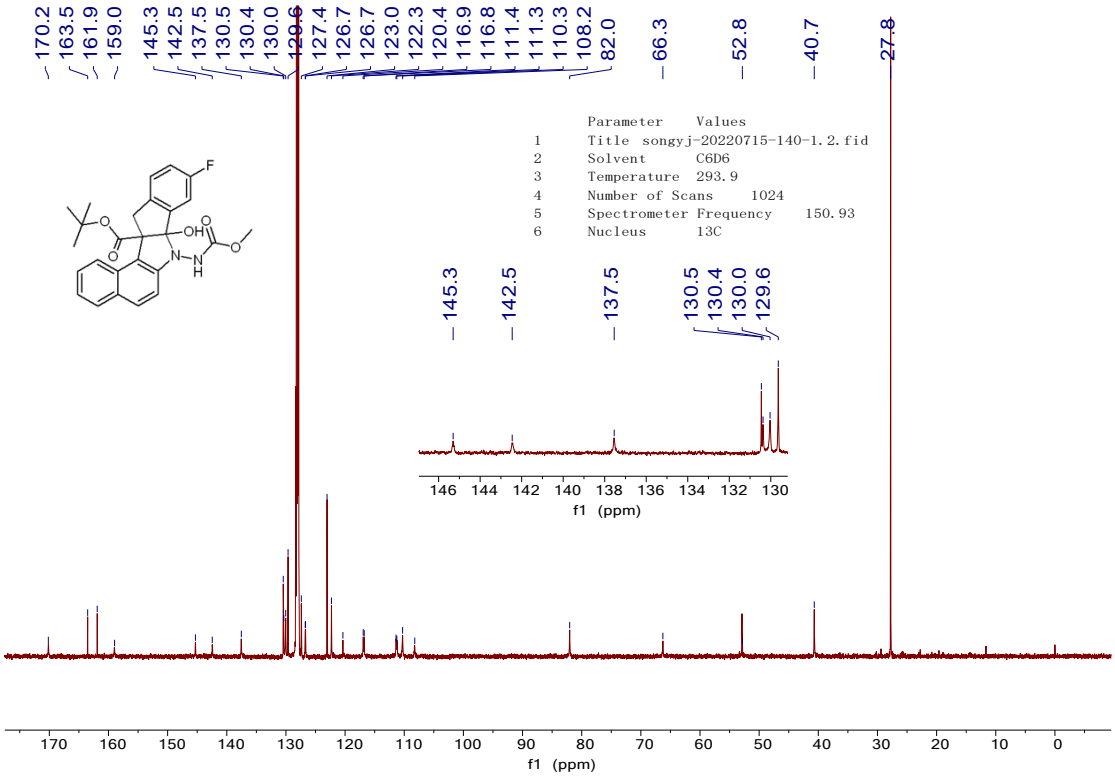
C7:

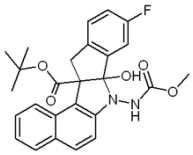

7.95 7.94 7.66 7.65 7.52 7.51 7.40 7.38 7.37 7.15 7.09 6.81 6.79 6.56 6.31
4.98 4.69 4.67
3.40 3.36 3.25 3.09
1.25
Parameter Values
1 Title songyj-20230219-131-5.1.1.1r
2 Solvent C6D6
3 Temperature 292.5
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
0.92 1.03 0.90 1.04
6.21 4.00
f1 (ppm)
0.92 1.03 0.90 2.01 0.98 0.62 1.02 0.58 0.92 6.21 4.00 9.12
f1 (ppm)


170.3 158.7 151.4 149.2 145.4 133.9 131.3 130.2 129.7 129.4 128.3 127.1 122.6 122.0 120.6 110.4 108.9 107.7 81.5 65.8 55.3 55.1 52.4 40.9 29.9 27.5
Parameter Values
1 Title songyj-20230217-131-5.2.1.1r
2 Solvent C6D6
3 Temperature 293.6
4 Number of Scans 2048
5 Spectrometer Frequency 150.91
6 Nucleus 13C
151.4 149.2 145.4 133.9 131.3 130.2 129.7 129.4
f1 (ppm)
f1 (ppm)

C8:

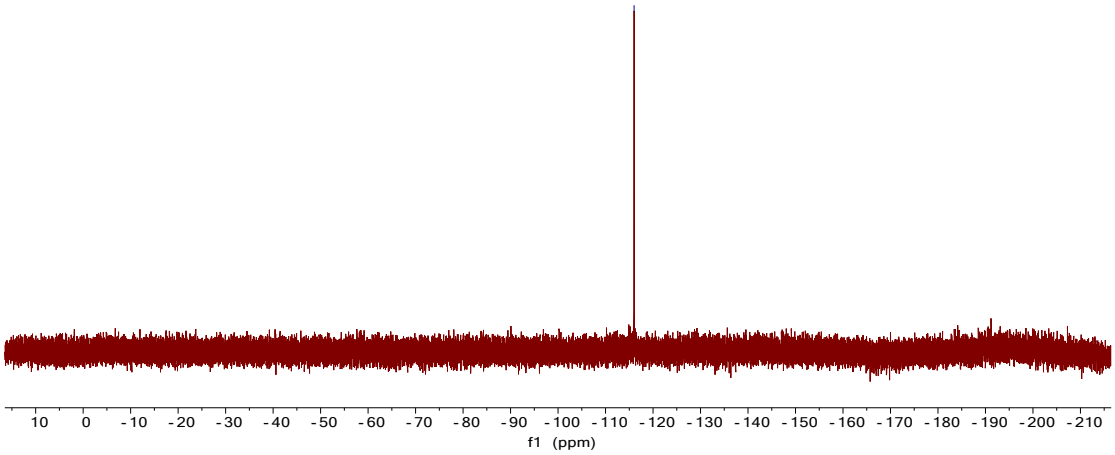

7.82
7.81
7.64
7.62
7.49
7.47
7.38
7.36
7.35
7.34
7.16
6.76
6.74
6.73
6.66
6.62
6.62
5.85
5.12
4.55
4.52
3.33
3.04
3.01
1.22
-0.00
Parameter Values
1 标题 songyj-20220715-140-1.1.fid
2 Solvent C6D6
3 Temperature 292.6
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
0.97
1.00
0.97
1.96
1.02
1.04
0.95
0.86
0.91
0.63
1.00
3.00
1.07
9.00
f1 (ppm)


170.2
163.5
161.9
159.0
145.3
142.5
137.5
130.5
130.4
130.0
129.6
127.4
126.7
126.7
123.0
122.3
120.4
116.9
116.8
111.4
111.3
110.3
108.2
82.0
66.3
52.8
40.7
27.8
Parameter Values
1 Title songyj-20220715-140-1.2.fid
2 Solvent C6D6
3 Temperature 293.9
4 Number of Scans 1024
5 Spectrometer Frequency 150.93
6 Nucleus 13C
145.3
142.5
137.5
130.5
130.4
130.0
129.6
f1 (ppm)
f1 (ppm)

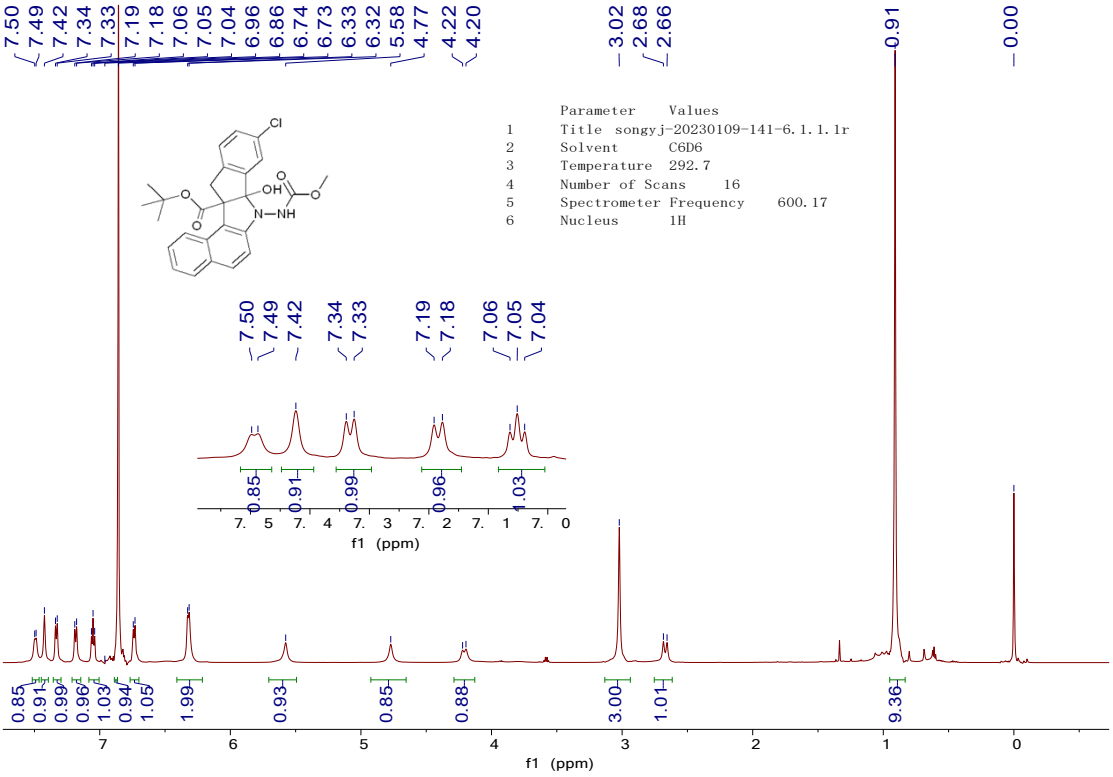


-116.01

	Parameter	Values
1	Title	as-20220716-SYJ-140-1.2.1.1r
2	Solvent	C6D6
3	Temperature	293.0
4	Number of Scans	32
5	Spectrometer Frequency	564.72
6	Nucleus	19F



C9:


7.50 7.49 7.42 7.34 7.33 7.19 7.18 7.06 7.05 7.04 6.96 6.86 6.74 6.73 6.33 6.32 5.58 4.77 4.22 4.20
3.02 2.68 2.66
0.91
0.00
Parameter Values
1 Title songyj-20230109-141-6.1.1.1r
2 Solvent C6D6
3 Temperature 292.7
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
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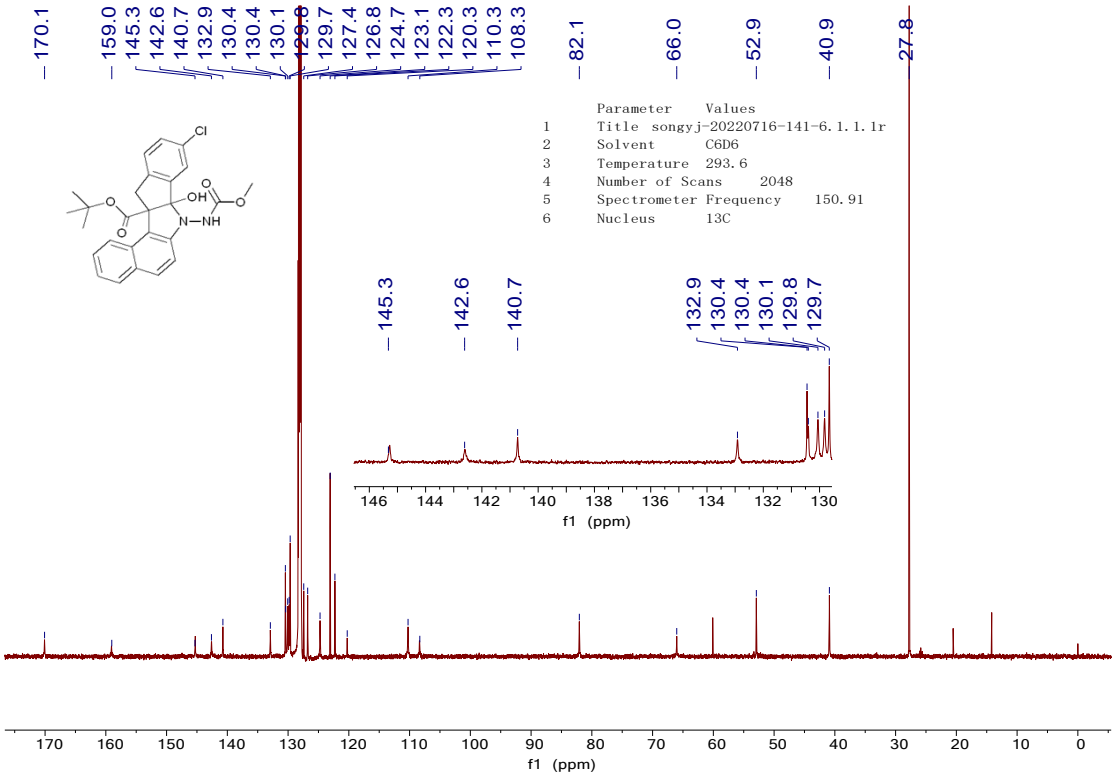
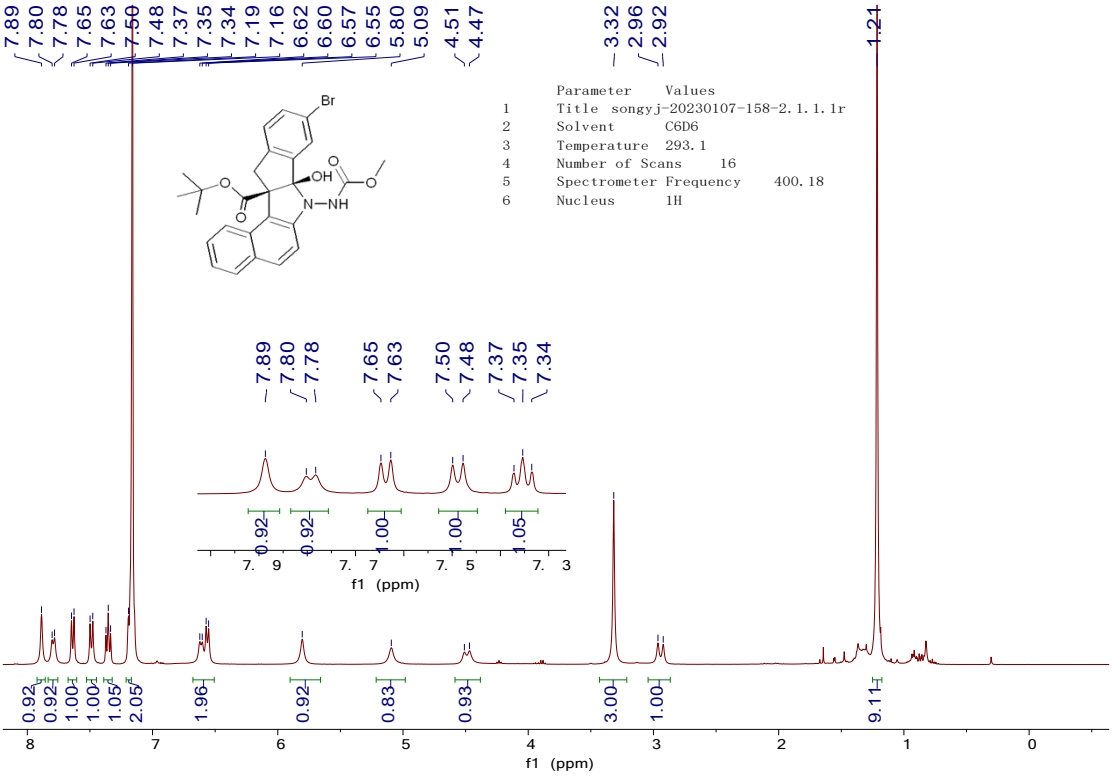
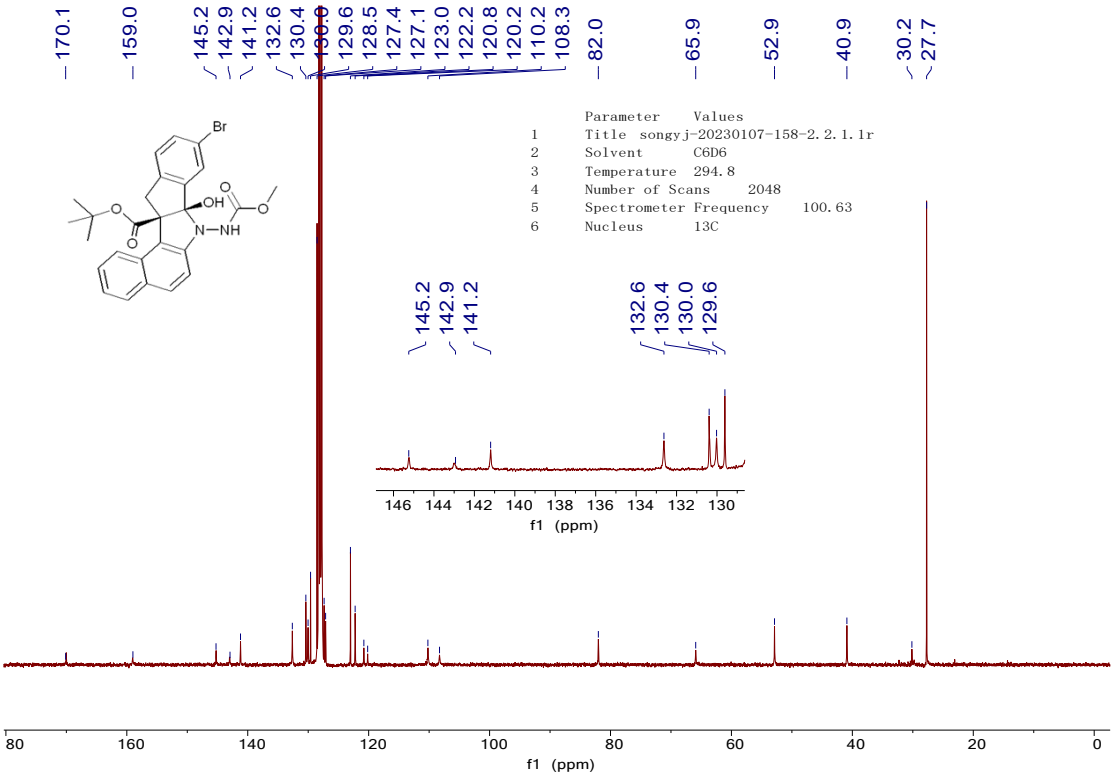
f1 (ppm)

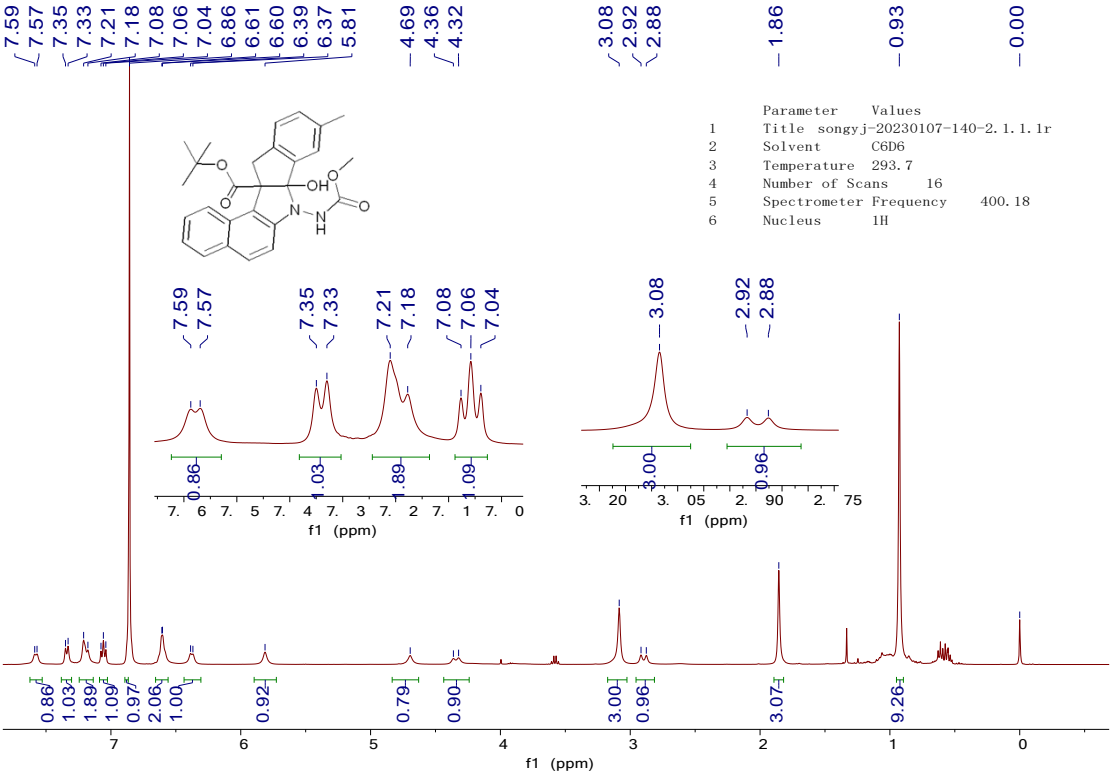

170.1 159.0 145.3 142.6 140.7 132.9 130.4 130.4 130.1 129.8 129.7 127.4 126.8 124.7 123.1 122.3 120.3 110.3 108.3
82.1 66.0 52.9 40.9 27.8
Parameter Values
1 Title songyj-20220716-141-6.1.1.1r
2 Solvent C6D6
3 Temperature 293.6
4 Number of Scans 2048
5 Spectrometer Frequency 150.91
6 Nucleus 13C
145.3 142.6 140.7 132.9 130.4 130.4 130.1 129.8 129.7
f1 (ppm)

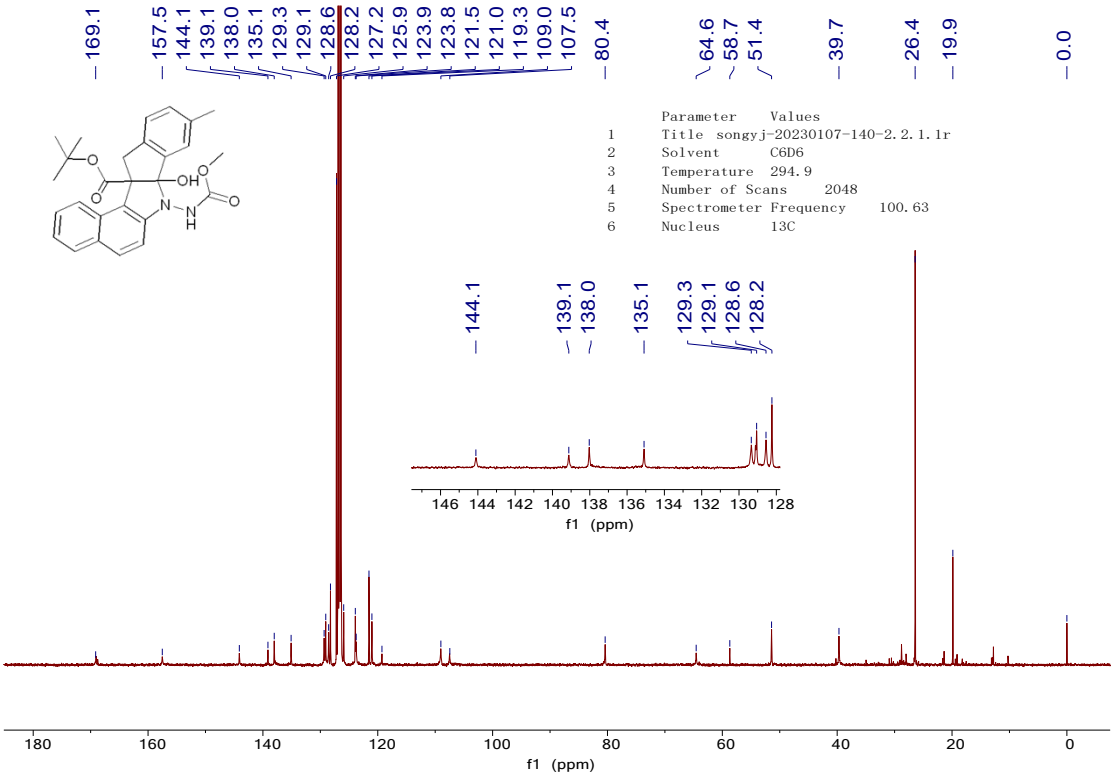
C10:


7.89 7.80 7.78 7.65 7.63 7.50 7.48 7.37 7.35 7.34 7.19 7.16 6.62 6.60 6.57 6.55 5.80 5.09 4.51 4.47
3.32 2.96 2.92
1.21
Br
OH
N—NH
Parameter Values
1 Title songyj-20230107-158-2.1.1.1r
2 Solvent C6D6
3 Temperature 293.1
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
0.92 0.92 1.00 1.00 1.05 2.05 1.96 0.92 0.83 0.93 3.00 1.00 9.11
f1 (ppm)

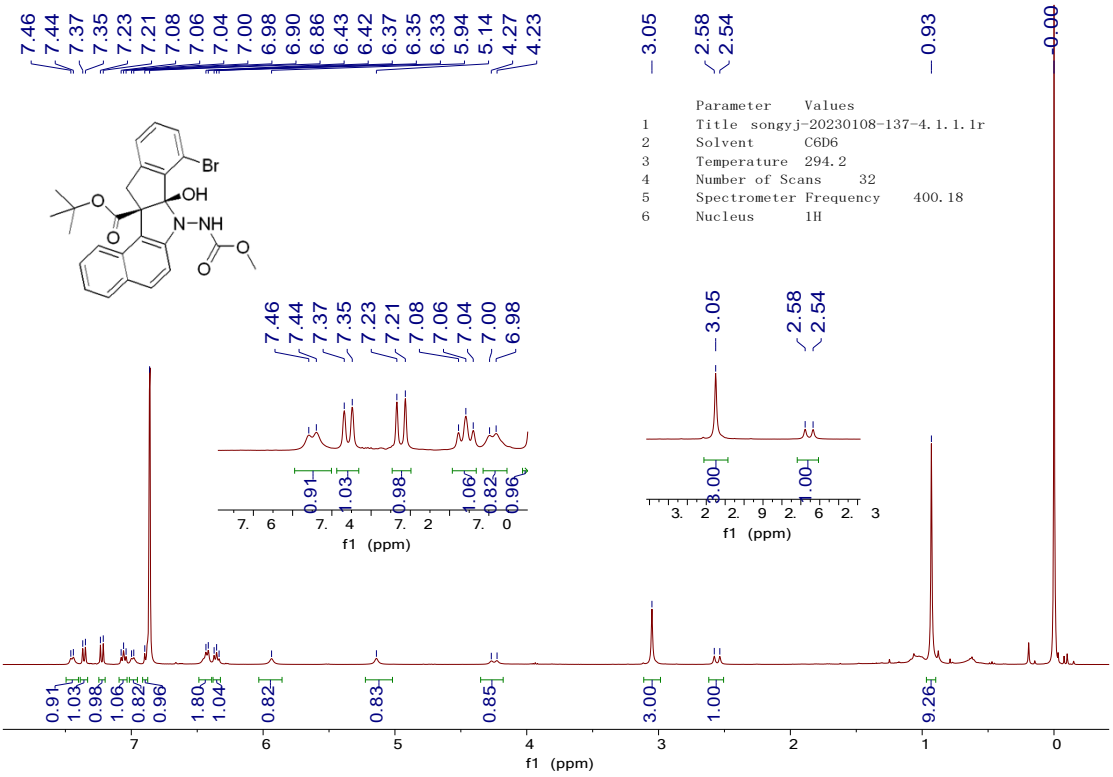

170.1 159.0 145.2 142.9 141.2 132.6 130.4 130.0 129.6 128.5 127.4 127.1 123.0 122.2 120.8 120.2 110.2 108.3
82.0 65.9 52.9 40.9 30.2 27.7
Br
OH
N—NH
Parameter Values
1 Title songyj-20230107-158-2.2.1.1r
2 Solvent C6D6
3 Temperature 294.8
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

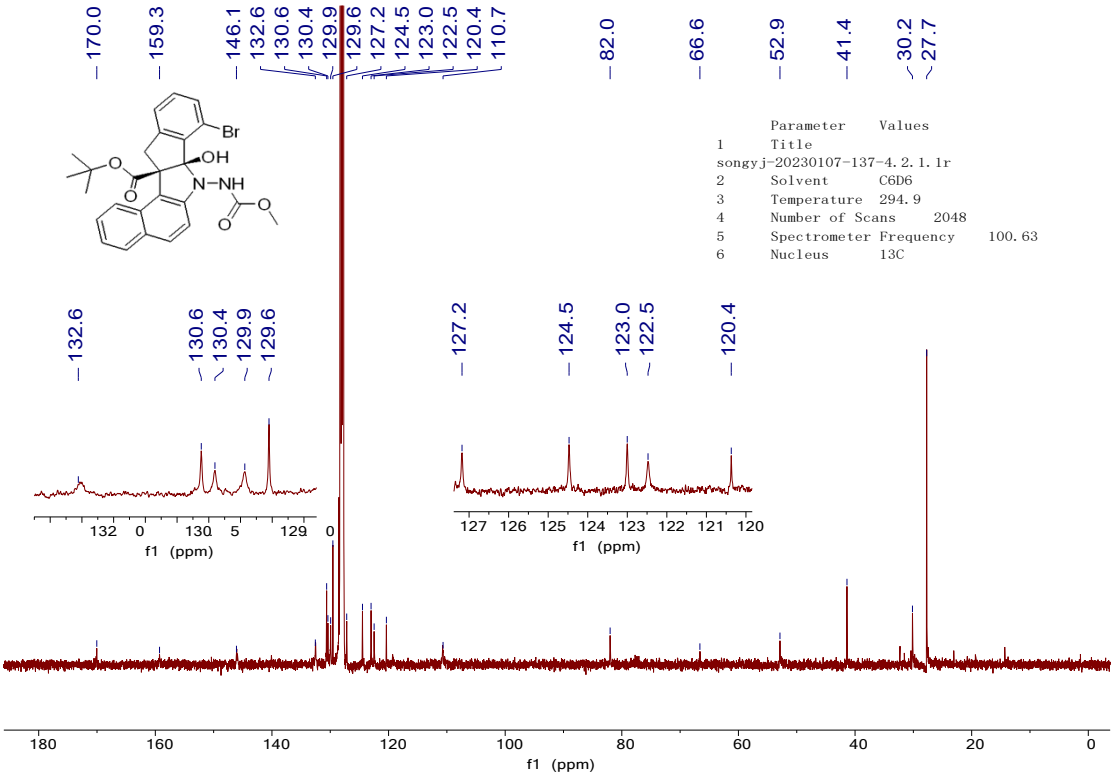
C11:


7.59 7.57 7.35 7.33 7.21 7.18 7.08 7.06 7.04 6.86 6.61 6.60 6.39 6.37 5.81 4.69 4.36 4.32 3.08 2.92 2.88 1.86 0.93 0.00
Parameter Values
1 Title songyj-20230107-140-2.1.1.1r
2 Solvent C6D6
3 Temperature 293.7
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
f1 (ppm)

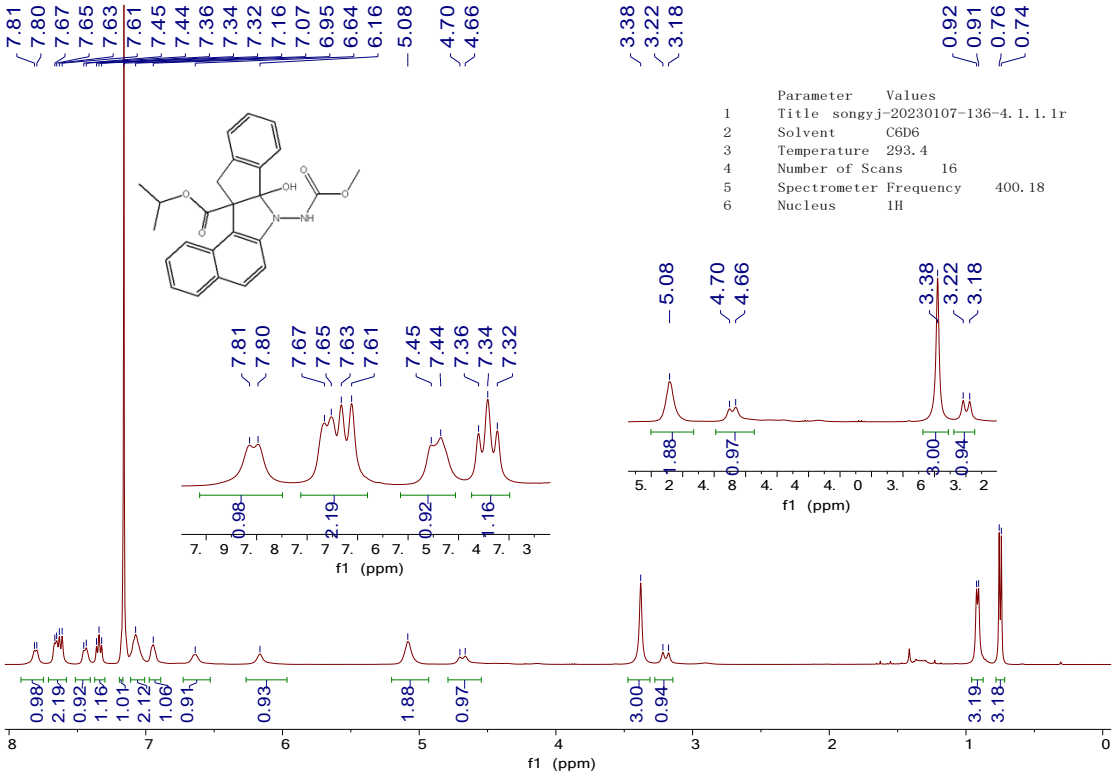

169.1 157.5 144.1 139.1 138.0 135.1 129.3 129.1 128.6 128.2 127.2 125.9 123.9 123.8 121.5 121.0 119.3 109.0 107.5 80.4 64.6 58.7 51.4 39.7 26.4 19.9 0.0
Parameter Values
1 Title songyj-20230107-140-2.2.1.1r
2 Solvent C6D6
3 Temperature 294.9
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

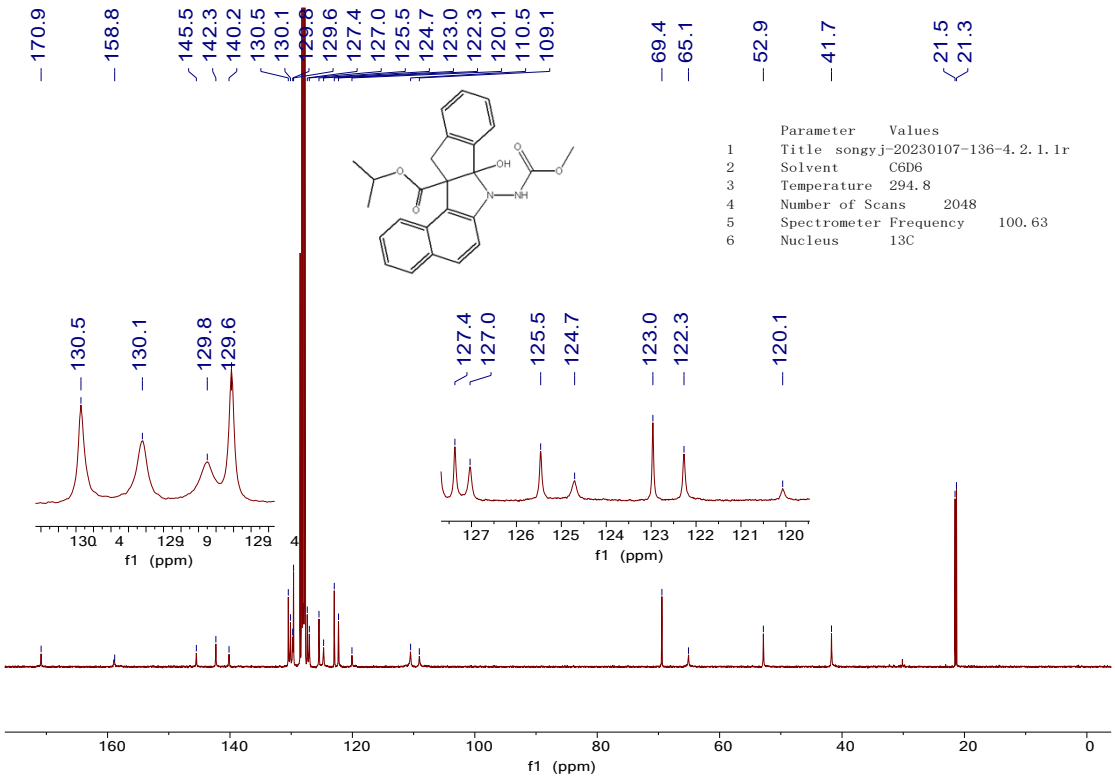
C12:


7.46 7.44 7.37 7.35 7.23 7.21 7.08 7.06 7.04 7.00 6.98 6.90 6.86 6.43 6.42 6.37 6.35 6.33 5.94 5.14 4.27 4.23
3.05 2.58 2.54 0.93 0.00
Parameter Values
1 Title songyj-20230108-137-4.1.1.1r
2 Solvent C6D6
3 Temperature 294.2
4 Number of Scans 32
5 Spectrometer Frequency 400.18
6 Nucleus 1H
Br
OH
N-NH
O
O
O
O
0.91 1.03 0.98 1.06 0.82 0.96 1.80 1.04 0.82 0.83 0.85 3.00 1.00 9.26
f1 (ppm)

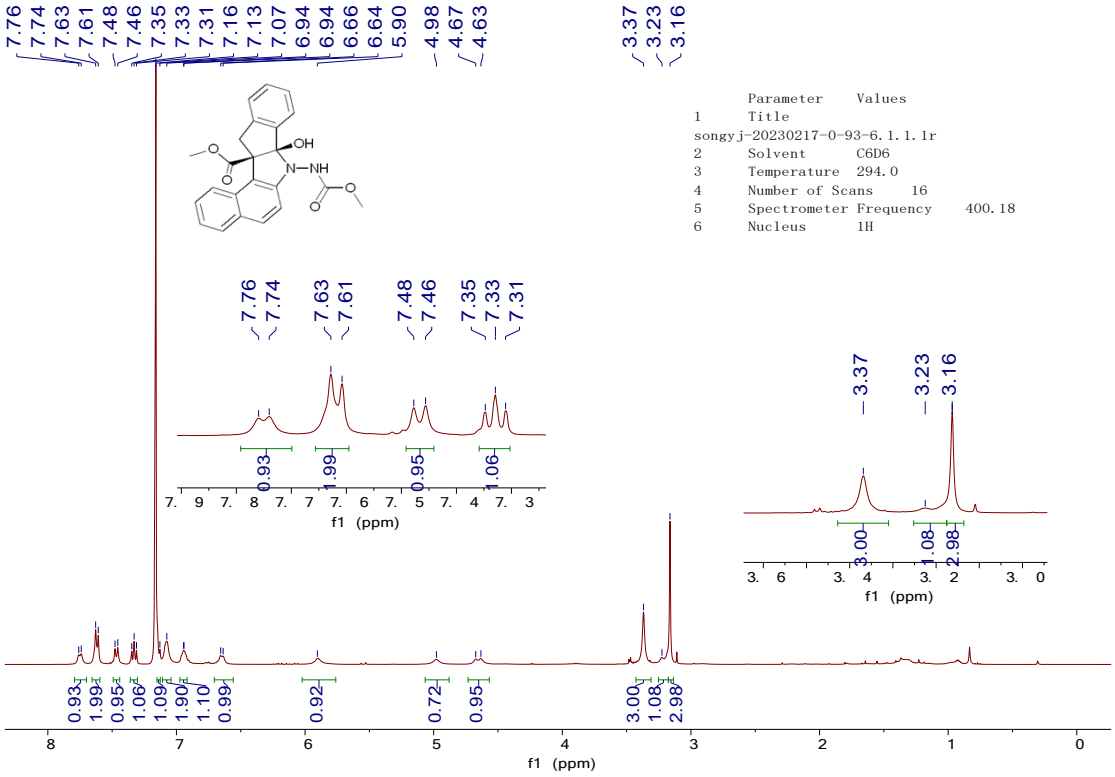

170.0 159.3 146.1 132.6 130.6 130.4 129.9 129.6 127.2 124.5 123.0 122.5 120.4 110.7 82.0 66.6 52.9 41.4 30.2 27.7
Parameter Values
1 Title songyj-20230107-137-4.2.1.1r
2 Solvent C6D6
3 Temperature 294.9
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
Br
OH
N-NH
O
O
O
O
f1 (ppm)

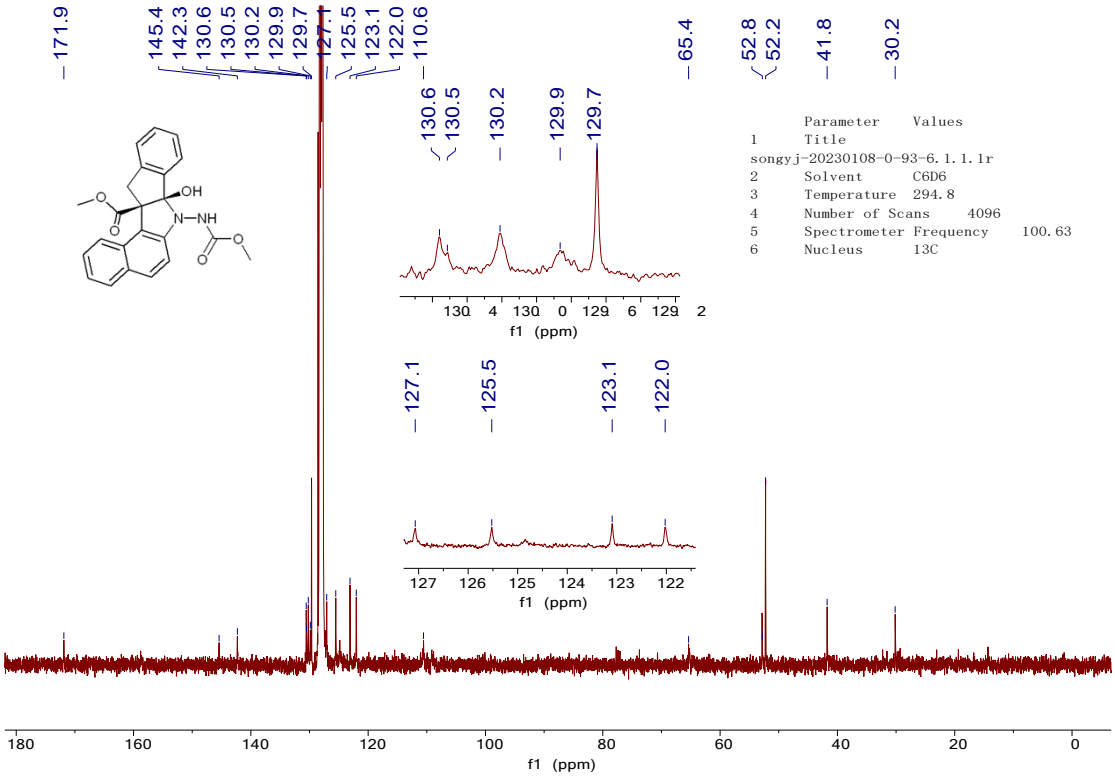
C13:


7.81 7.80 7.67 7.65 7.63 7.61 7.45 7.44 7.36 7.34 7.32 7.16 7.07 6.95 6.64 6.16 5.08 4.70 4.66 3.38 3.22 3.18 0.92 0.91 0.76 0.74
Parameter Values
1 Title songyj-20230107-136-4.1.1.1r
2 Solvent C6D6
3 Temperature 293.4
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
f1 (ppm)

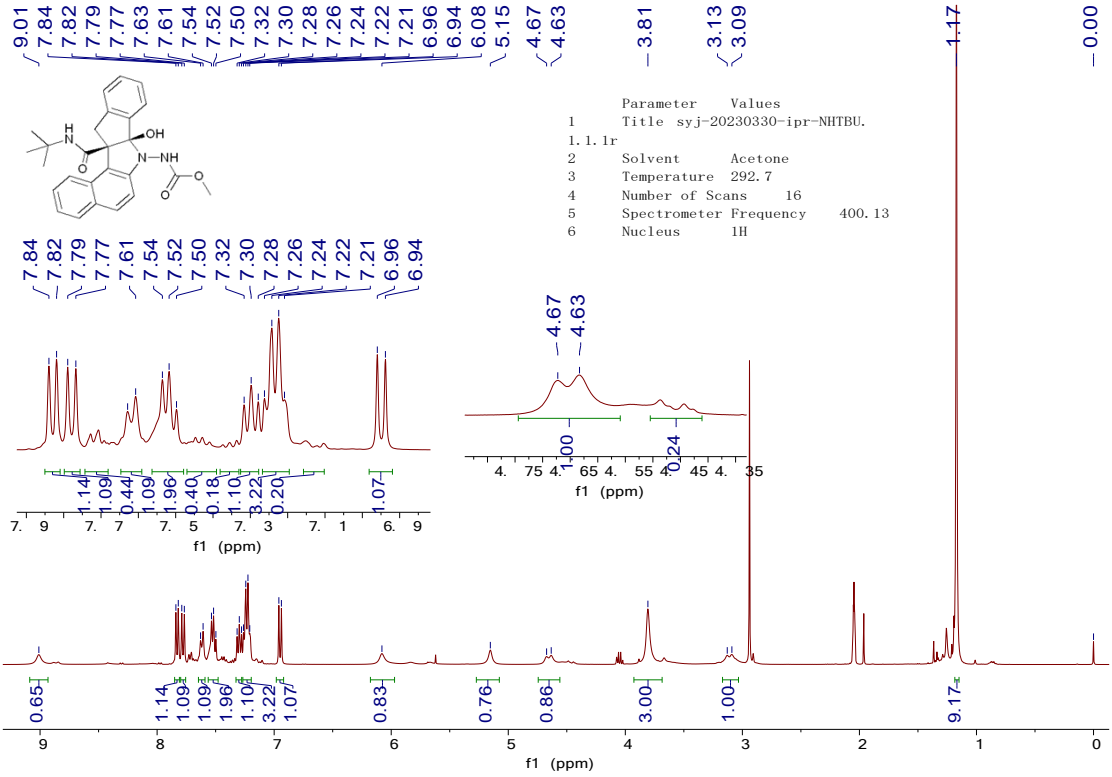

170.9 158.8 145.5 142.3 140.2 130.5 130.1 129.8 129.6 127.4 127.0 125.5 124.7 123.0 122.3 120.1 110.5 109.1 69.4 65.1 52.9 41.7 21.5 21.3
Parameter Values
1 Title songyj-20230107-136-4.2.1.1r
2 Solvent C6D6
3 Temperature 294.8
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

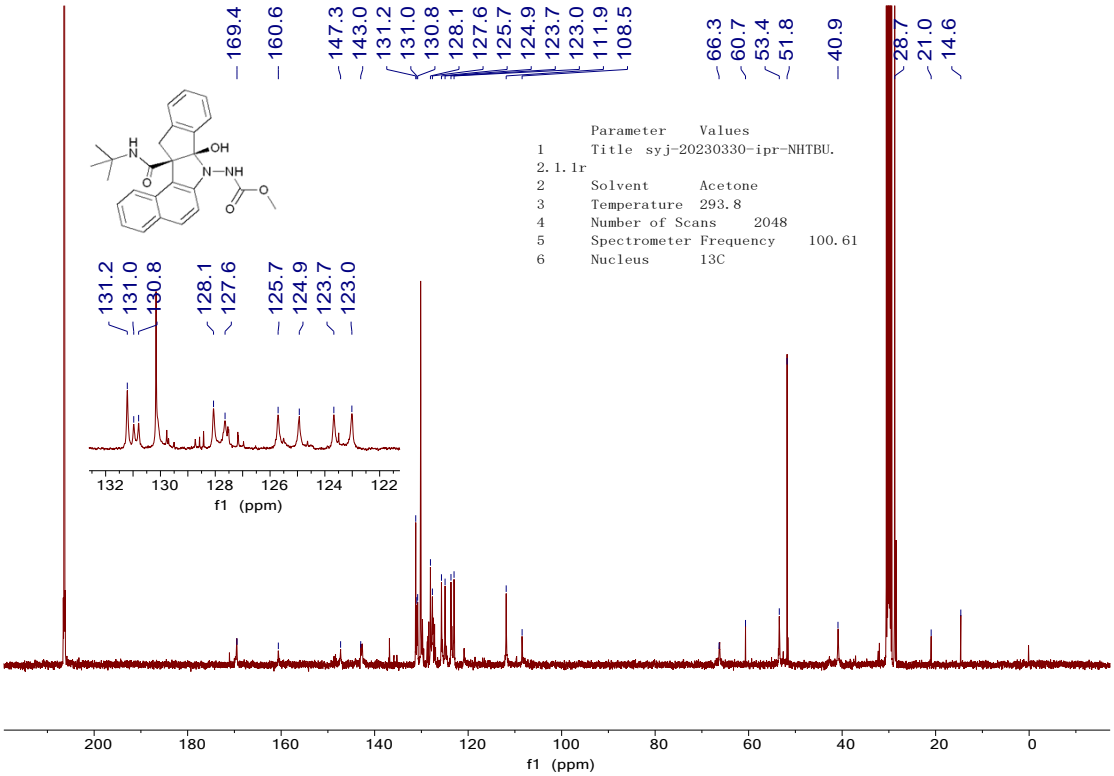
C14:


7.76 7.74 7.63 7.61 7.48 7.46 7.35 7.33 7.31 7.16 7.13 7.07 6.94 6.94 6.66 6.64 5.90 4.98 4.67 4.63 3.37 3.23 3.16
OH
N—NH
Parameter Values
1 Title songyj-20230217-0-93-6.1.1.1r
2 Solvent C6D6
3 Temperature 294.0
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
0.93 1.99 0.95 1.06 1.09 1.90 1.10 0.99 0.92 0.72 0.95 3.00 1.08 2.98
f1 (ppm)

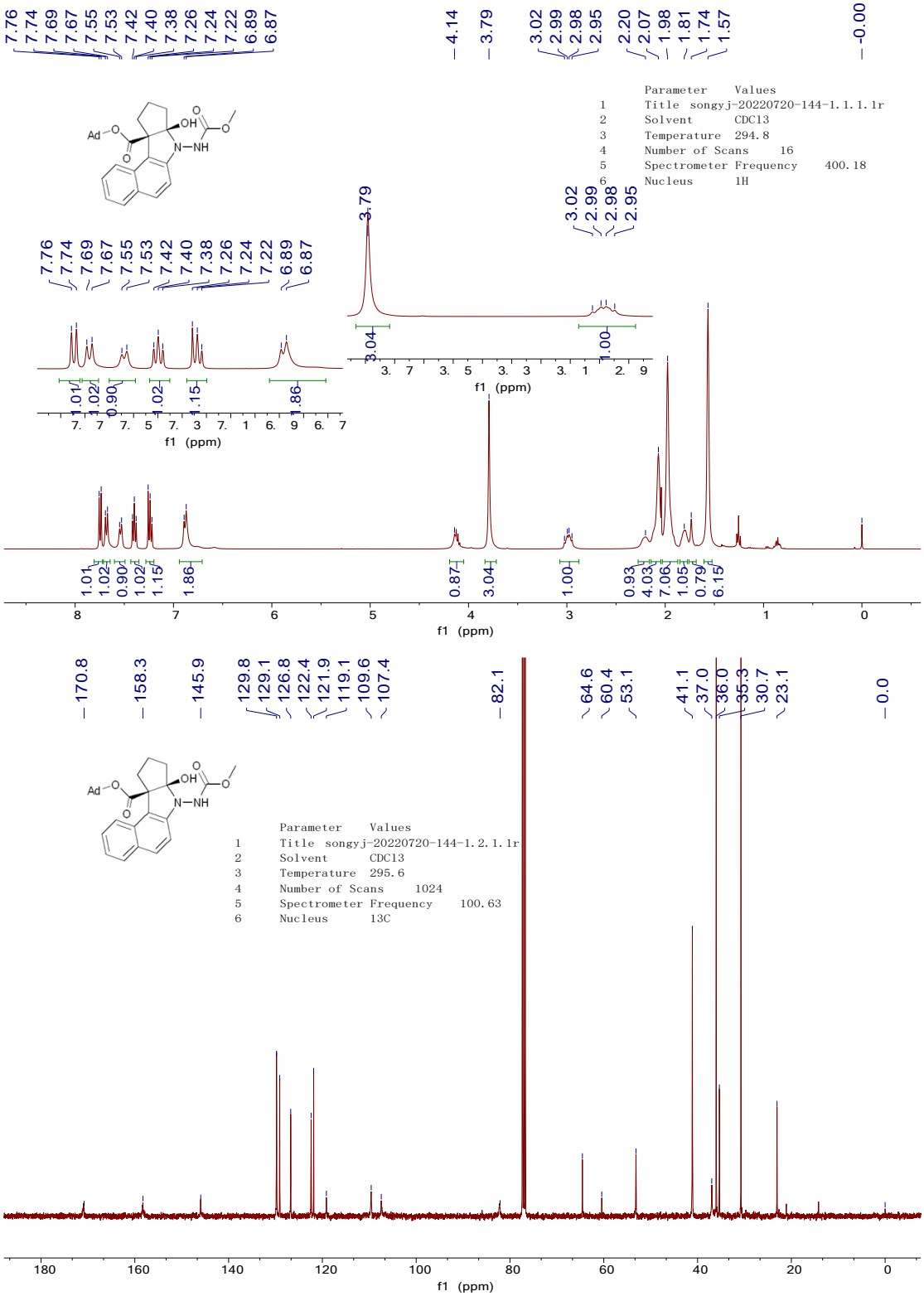

171.9 145.4 142.3 130.6 130.5 130.2 129.9 129.7 127.1 125.5 123.1 122.0 110.6 65.4 52.8 52.2 41.8 30.2
OH
N—NH
Parameter Values
1 Title songyj-20230108-0-93-6.1.1.1r
2 Solvent C6D6
3 Temperature 294.8
4 Number of Scans 4096
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

C15:

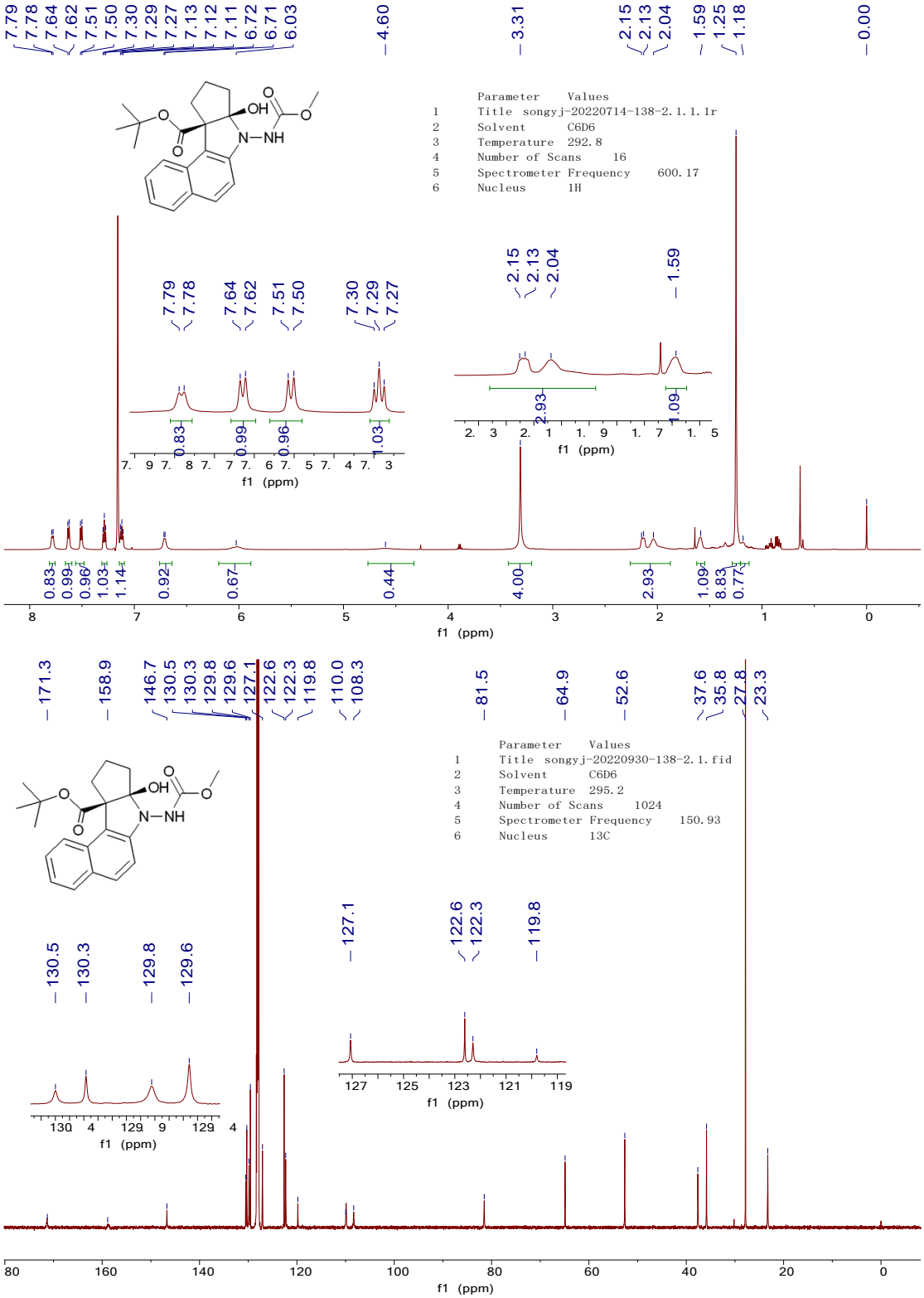

9.01 7.84 7.82 7.79 7.77 7.63 7.61 7.54 7.52 7.50 7.32 7.30 7.28 7.26 7.24 7.22 7.21 6.96 6.94 6.08 5.15 4.67 4.63 3.81 3.13 3.09 1.17 0.00
Parameter Values
1 Title syj-20230330-ipr-NHTBU.
1.1.1r
2 Solvent Acetone
3 Temperature 292.7
4 Number of Scans 16
5 Spectrometer Frequency 400.13
6 Nucleus 1H
f1 (ppm)


169.4 160.6 147.3 143.0 131.2 131.0 130.8 128.1 127.6 125.7 124.9 123.7 123.0 111.9 108.5 66.3 60.7 53.4 51.8 40.9 28.7 21.0 14.6
Parameter Values
1 Title syj-20230330-ipr-NHTBU.
2.1.1r
2 Solvent Acetone
3 Temperature 293.8
4 Number of Scans 2048
5 Spectrometer Frequency 100.61
6 Nucleus 13C
f1 (ppm)

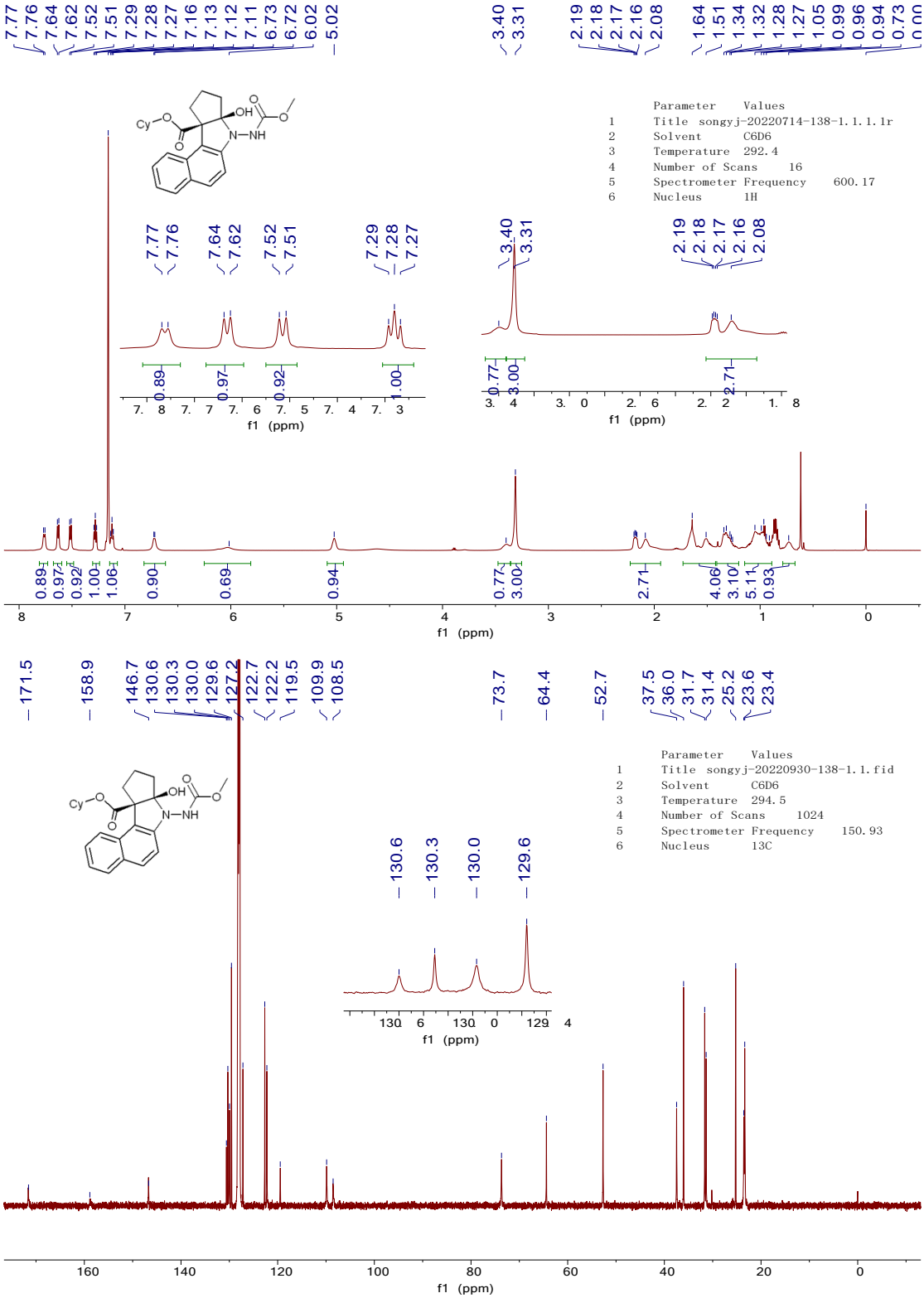
C16:


Parameter Values
1 Title songyj-20220720-144-1.1.1.1r
2 Solvent CDCl3
3 Temperature 294.8
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
f1 (ppm)
Parameter Values
1 Title songyj-20220720-144-1.2.1.1r
2 Solvent CDCl3
3 Temperature 295.6
4 Number of Scans 1024
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

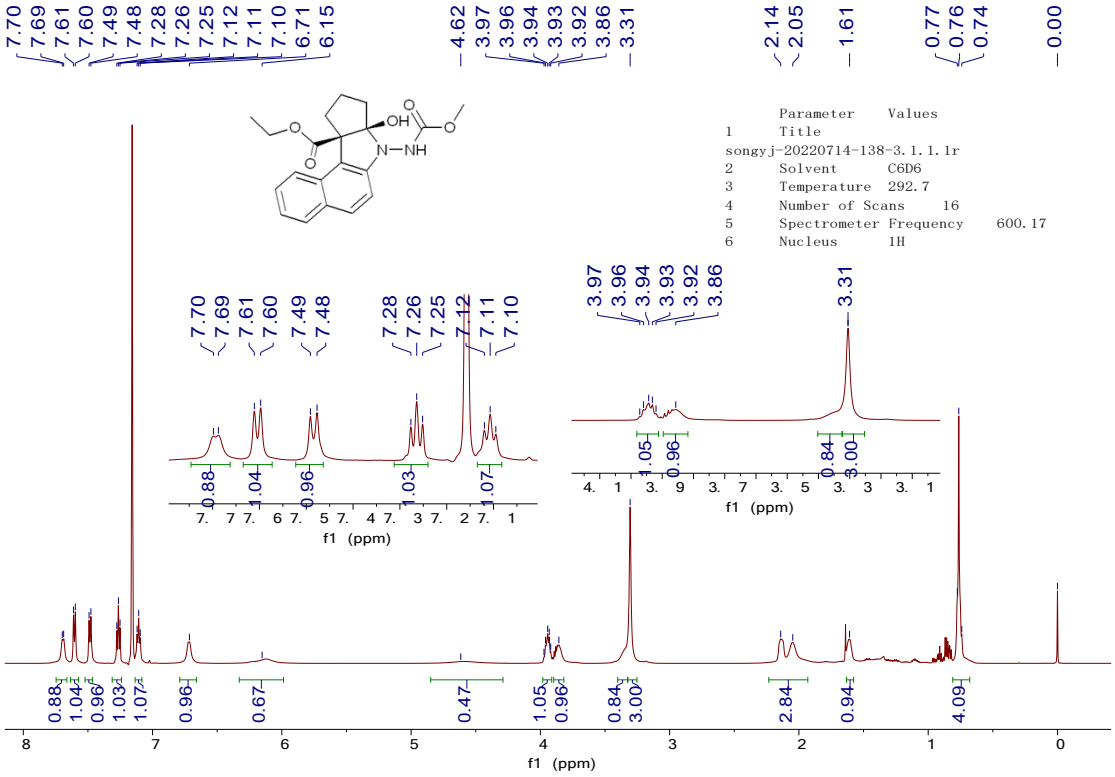
C17:

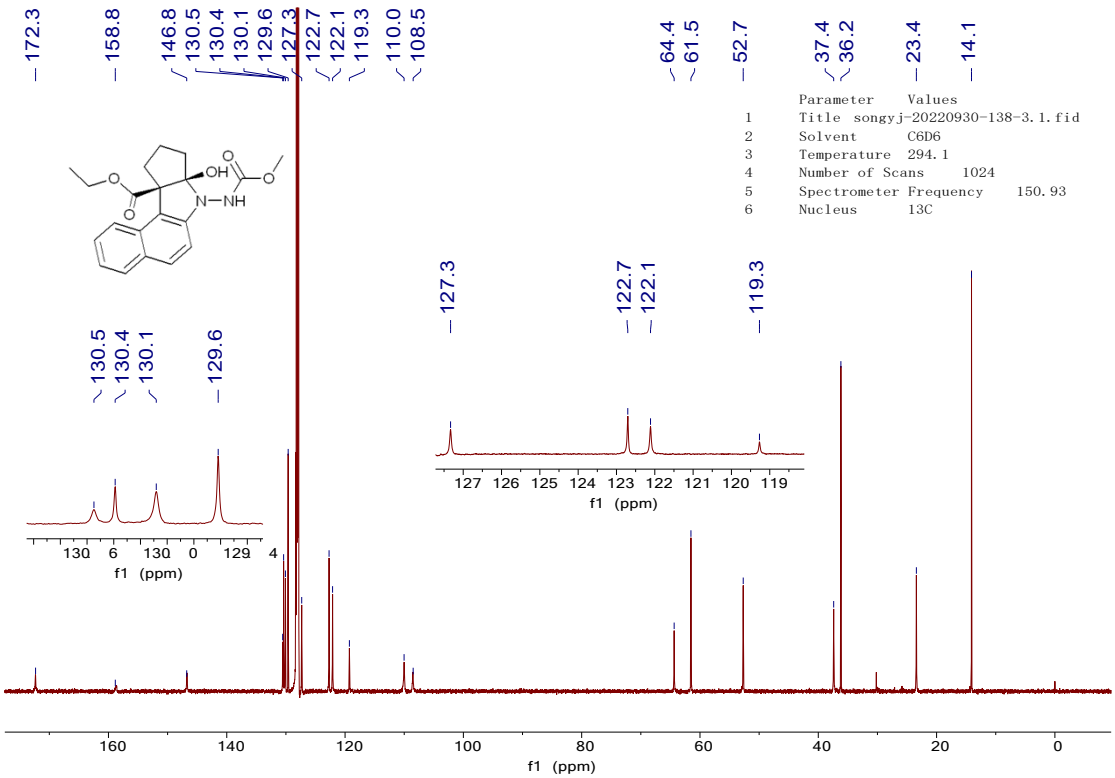

7.79 7.78 7.64 7.62 7.51 7.50 7.30 7.29 7.27 7.13 7.12 7.11 6.72 6.71 6.03
4.60
3.31
2.15 2.13 2.04
1.59 1.25 1.18
0.00
OH
N—NH
Parameter Values
1 Title songyj-20220714-138-2.1.1.1r
2 Solvent C6D6
3 Temperature 292.8
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
f1 (ppm)
0.83 0.99 0.96 1.03 1.14 0.92 0.67 0.44 4.00 2.93 1.09 8.83 0.77
171.3 158.9 146.7 130.5 130.3 129.8 129.6 127.1 122.6 122.3 119.8 110.0 108.3
81.5 64.9 52.6 37.6 35.8 27.8 23.3
Parameter Values
1 Title songyj-20220930-138-2.1.fid
2 Solvent C6D6
3 Temperature 295.2
4 Number of Scans 1024
5 Spectrometer Frequency 150.93
6 Nucleus 13C
f1 (ppm)

C18:

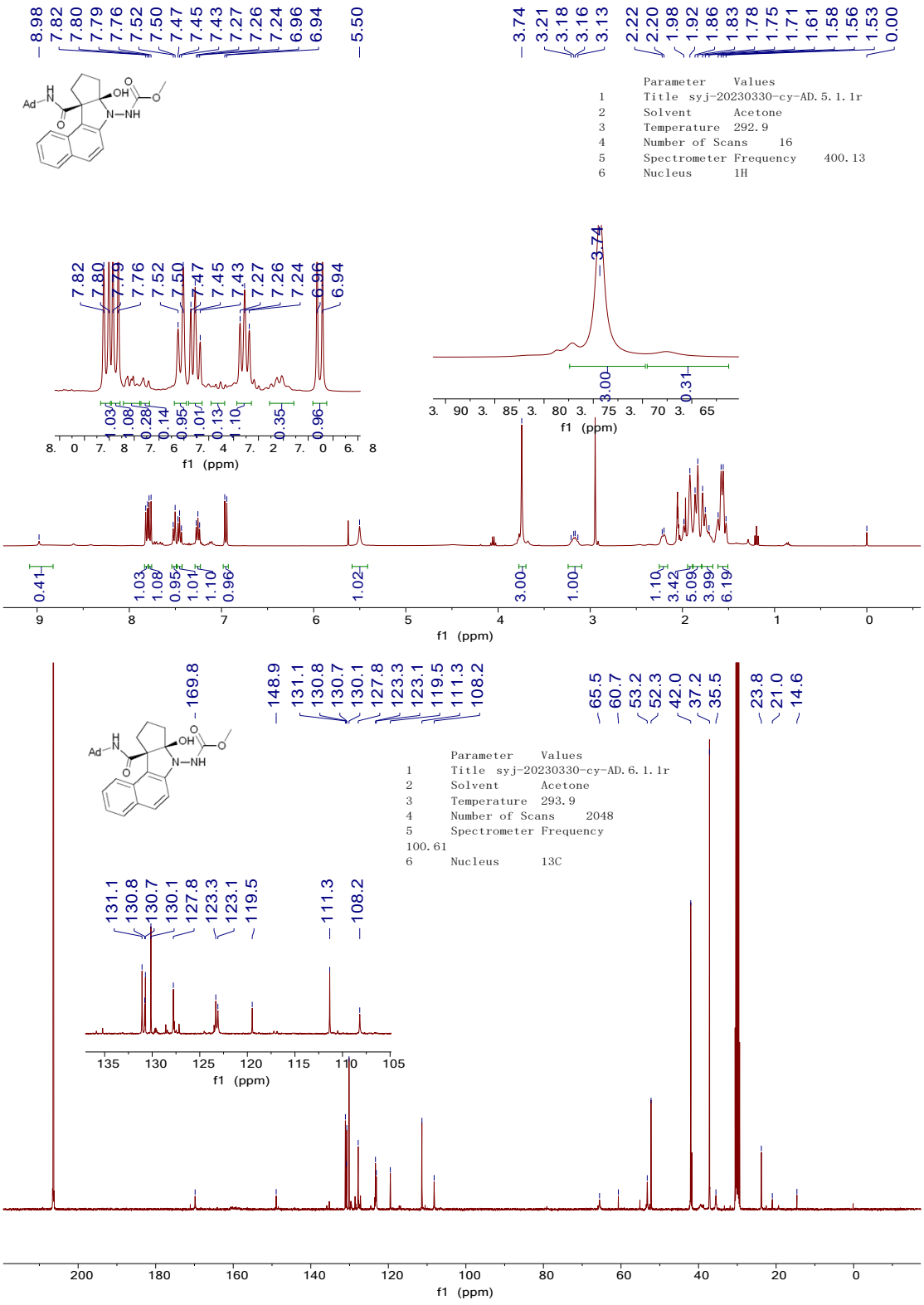

Parameter Values
1 Title songyj-20220714-138-1.1.1.1r
2 Solvent C6D6
3 Temperature 292.4
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
f1 (ppm)
Parameter Values
1 Title songyj-20220930-138-1.1.fid
2 Solvent C6D6
3 Temperature 294.5
4 Number of Scans 1024
5 Spectrometer Frequency 150.93
6 Nucleus 13C
f1 (ppm)

C19:

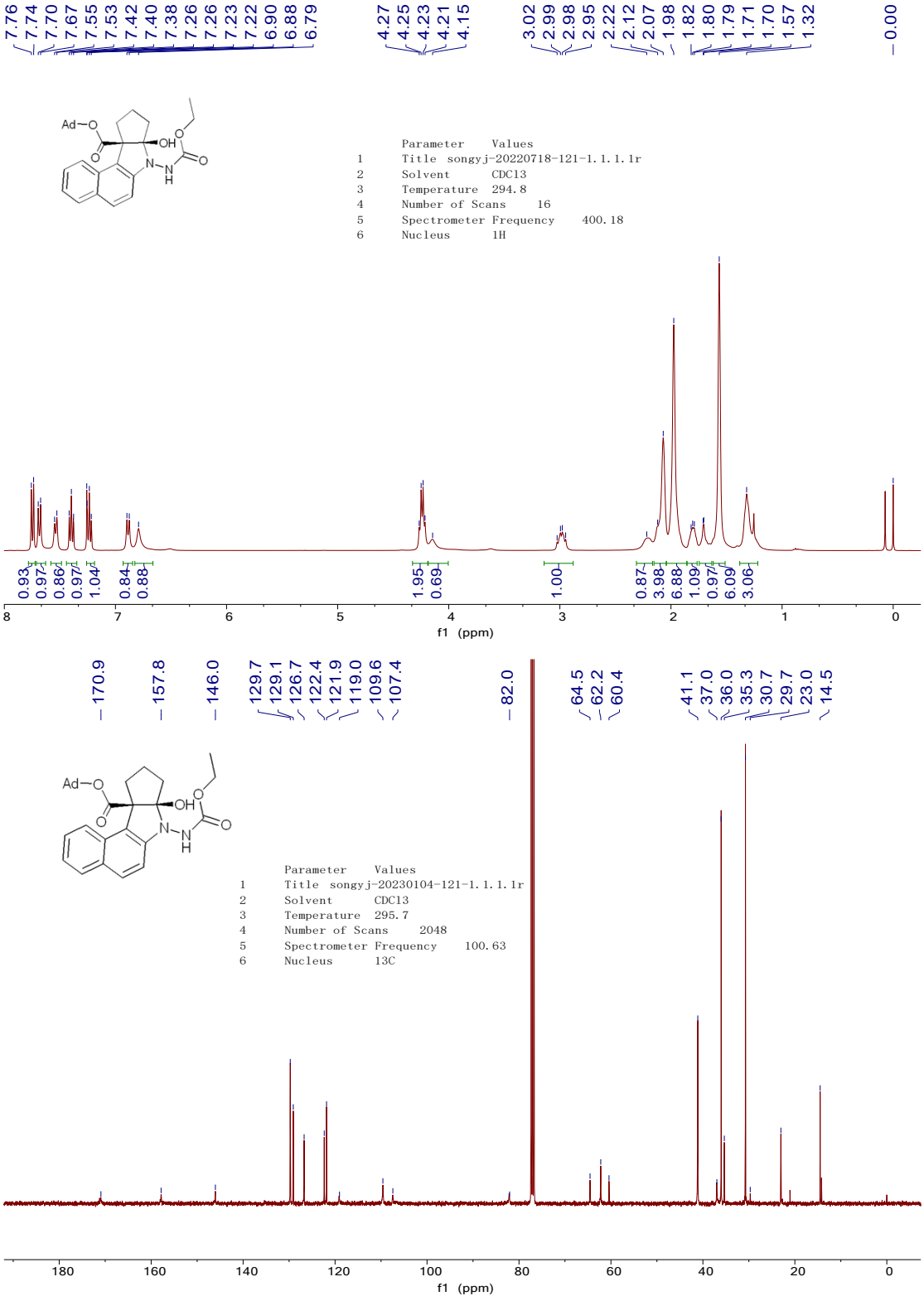

7.70 7.69 7.61 7.60 7.49 7.48 7.28 7.26 7.25 7.12 7.11 7.10 6.71 6.15
4.62 3.97 3.96 3.94 3.93 3.92 3.86 3.31
2.14 2.05 1.61 0.77 0.76 0.74 0.00
OH
N–NH
Parameter Values
1 Title songyj-20220714-138-3.1.1.1r
2 Solvent C6D6
3 Temperature 292.7
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
f1 (ppm)


172.3 158.8 146.8 130.5 130.4 130.1 129.6 127.3 122.7 122.1 119.3 110.0 108.5
64.4 61.5 52.7 37.4 36.2 23.4 14.1
OH
N–NH
Parameter Values
1 Title songyj-20220930-138-3.1.fid
2 Solvent C6D6
3 Temperature 294.1
4 Number of Scans 1024
5 Spectrometer Frequency 150.93
6 Nucleus 13C
f1 (ppm)

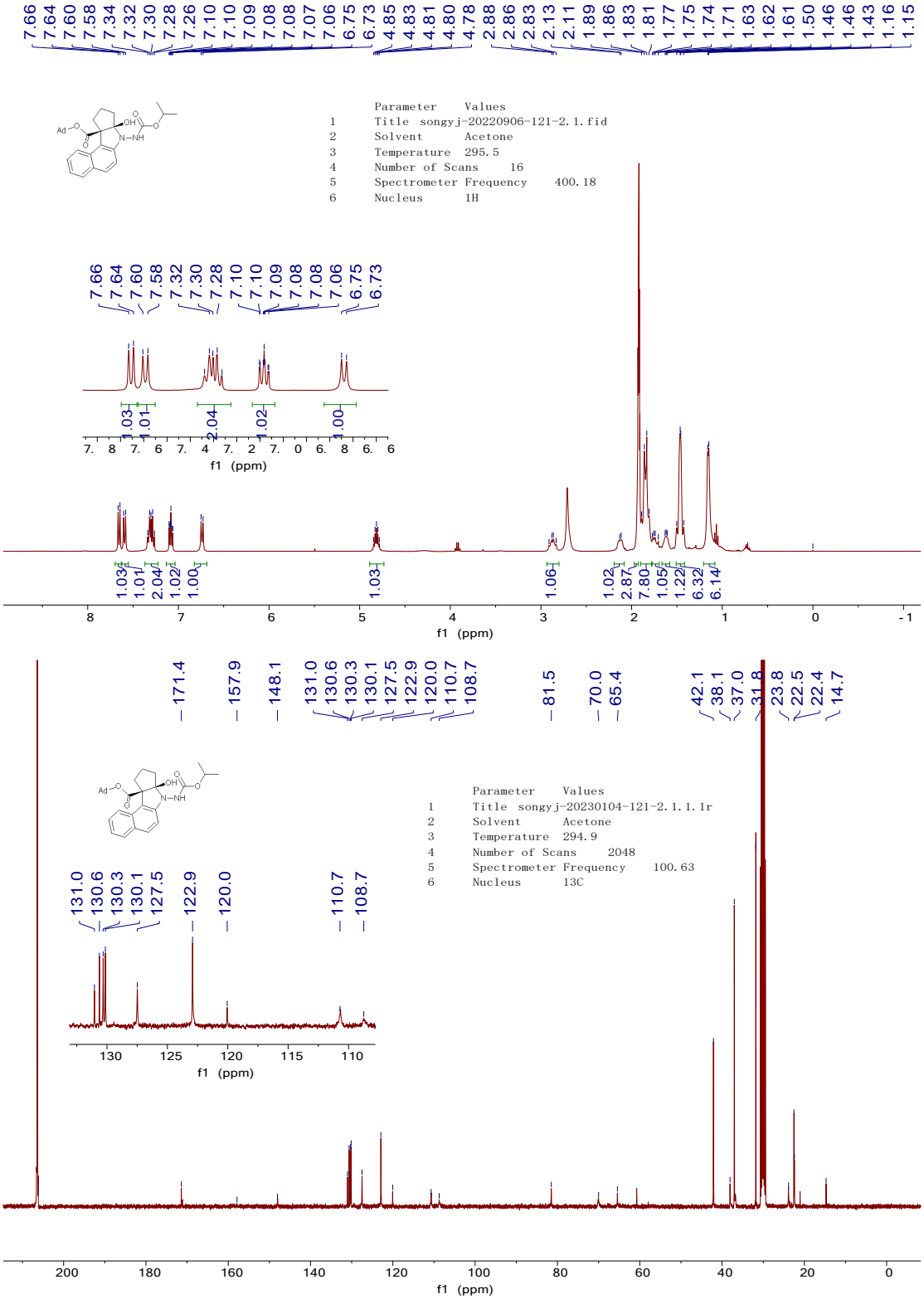
C20:


8.98 7.82 7.80 7.79 7.76 7.52 7.50 7.47 7.45 7.43 7.27 7.26 7.24 6.96 6.94 5.50
3.74 3.21 3.18 3.16 3.13 2.22 2.20 1.98 1.92 1.86 1.83 1.78 1.75 1.71 1.61 1.58 1.56 1.53 0.00
Parameter Values
1 Title syj-20230330-cy-AD.5.1.1r
2 Solvent Acetone
3 Temperature 292.9
4 Number of Scans 16
5 Spectrometer Frequency 400.13
6 Nucleus 1H
f1 (ppm)
0.41 1.03 1.08 0.95 1.01 1.10 0.96 1.02 3.00 1.00 1.10 3.42 5.09 3.99 6.19
169.8 148.9 131.1 130.8 130.7 130.1 127.8 123.3 123.1 119.5 111.3 108.2 65.5 60.7 53.2 52.3 42.0 37.2 35.5 23.8 21.0 14.6
Parameter Values
1 Title syj-20230330-cy-AD.6.1.1r
2 Solvent Acetone
3 Temperature 293.9
4 Number of Scans 2048
5 Spectrometer Frequency 100.61
6 Nucleus 13C
f1 (ppm)

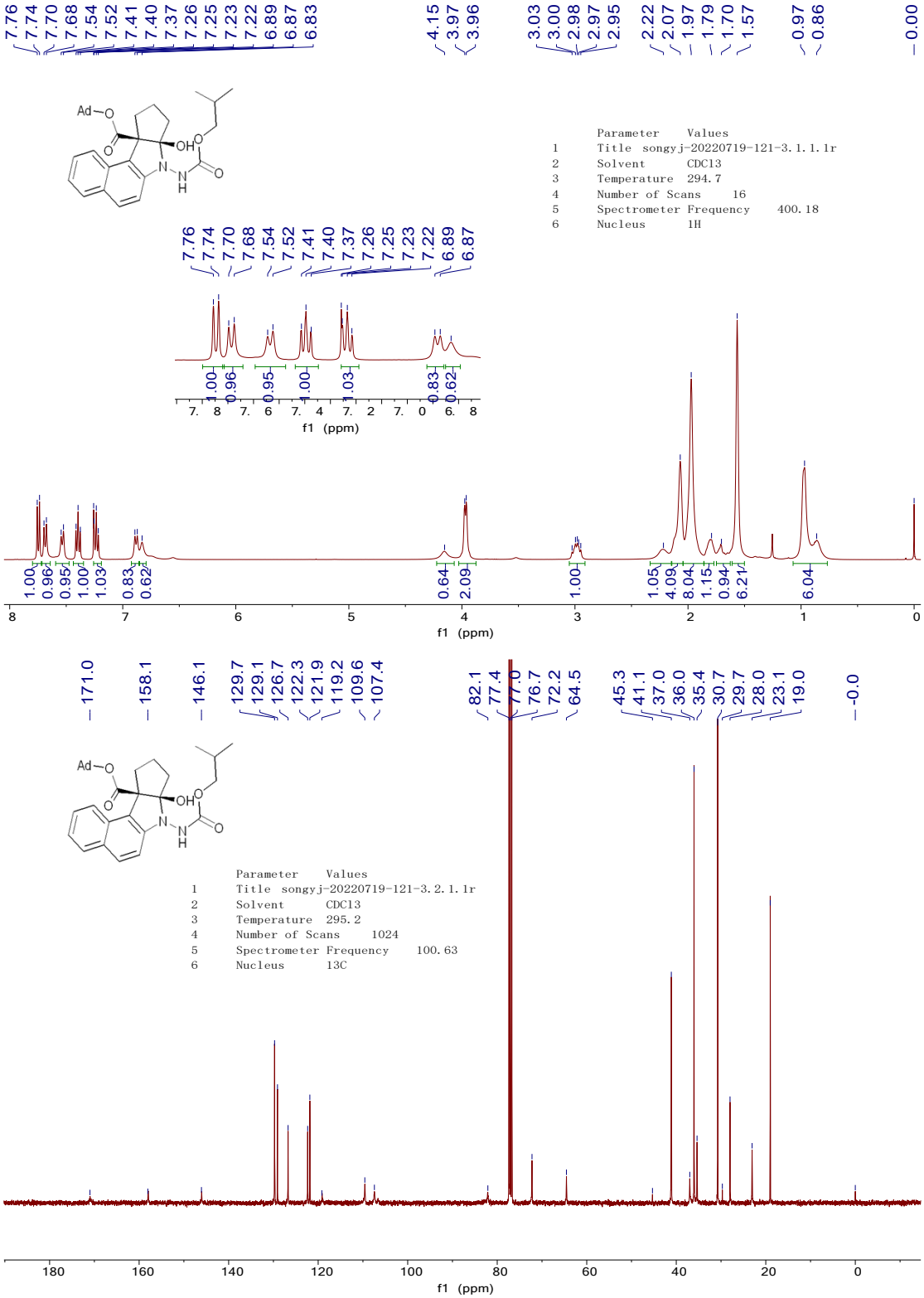
C21:


7.76 7.74 7.70 7.67 7.55 7.53 7.42 7.40 7.38 7.26 7.26 7.23 7.22 6.90 6.88 6.79
4.27 4.25 4.23 4.21 4.15
3.02 2.99 2.98 2.95 2.22 2.12 2.07 1.98 1.82 1.80 1.79 1.71 1.70 1.57 1.32
0.00
Ad—O
OH
O
N
N
H
Parameter Values
1 Title songyj-20220718-121-1.1.1.1r
2 Solvent CDCl3
3 Temperature 294.8
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
0.93 0.97 0.86 0.97 1.04 0.84 0.88 1.95 0.69 1.00 0.87 3.98 6.88 1.09 0.97 6.09 3.06
f1 (ppm)
170.9 157.8 146.0 129.7 129.1 126.7 122.4 121.9 119.0 109.6 107.4 82.0 64.5 62.2 60.4 41.1 37.0 36.0 35.3 30.7 29.7 23.0 14.5
Parameter Values
1 Title songyj-20230104-121-1.1.1.1r
2 Solvent CDCl3
3 Temperature 295.7
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

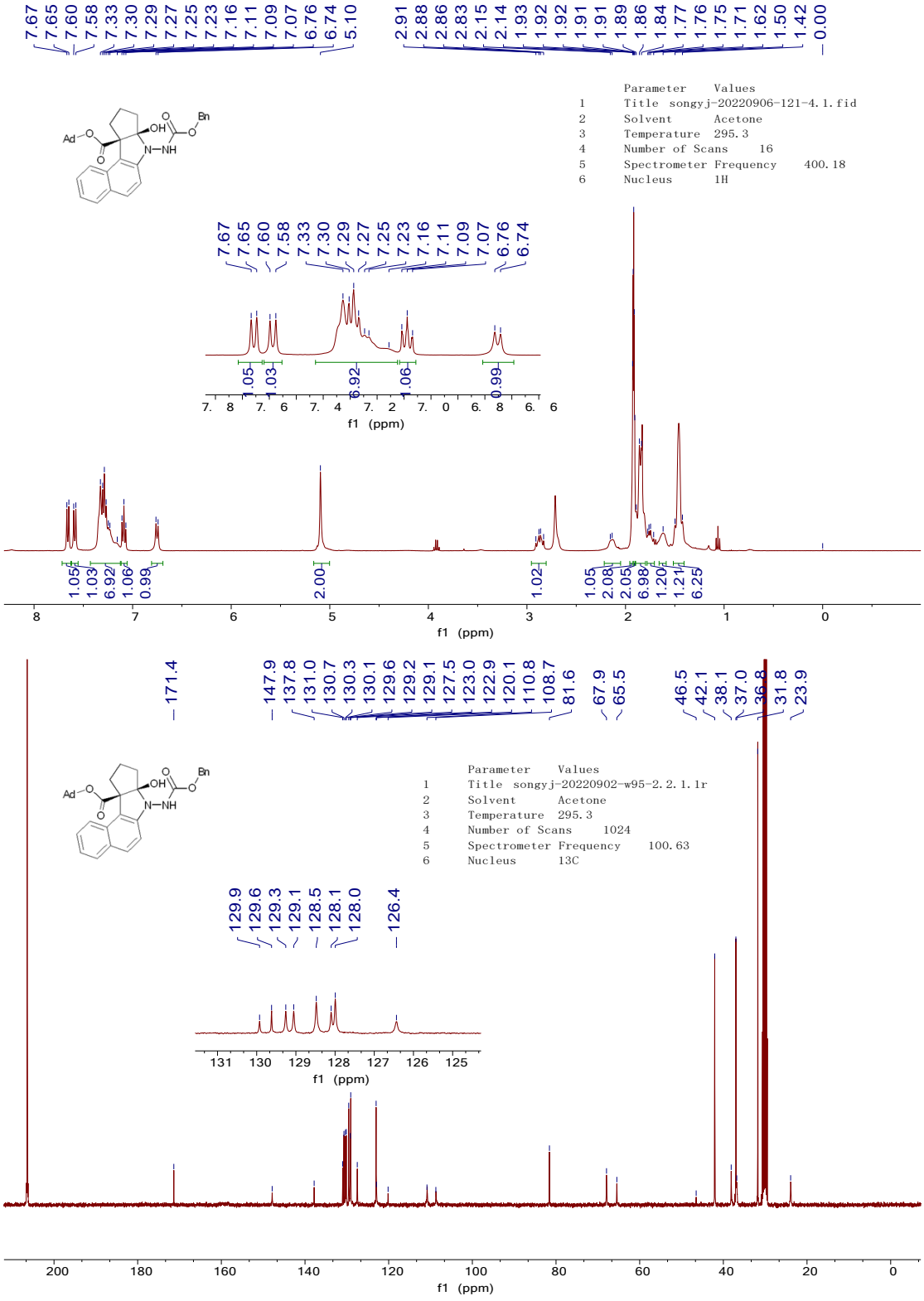
C22:


7.66 7.64 7.60 7.58 7.34 7.32 7.30 7.28 7.26 7.10 7.10 7.09 7.08 7.08 7.07 7.06 6.75 6.73 4.85 4.83 4.81 4.80 4.78 2.88 2.86 2.83 2.13 2.11 1.89 1.86 1.83 1.81 1.77 1.75 1.74 1.71 1.63 1.62 1.61 1.50 1.46 1.46 1.43 1.16 1.15
Parameter Values
1 Title songyj-20220906-121-2.1.fid
2 Solvent Acetone
3 Temperature 295.5
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
f1 (ppm)
Parameter Values
1 Title songyj-20230104-121-2.1.1.1r
2 Solvent Acetone
3 Temperature 294.9
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

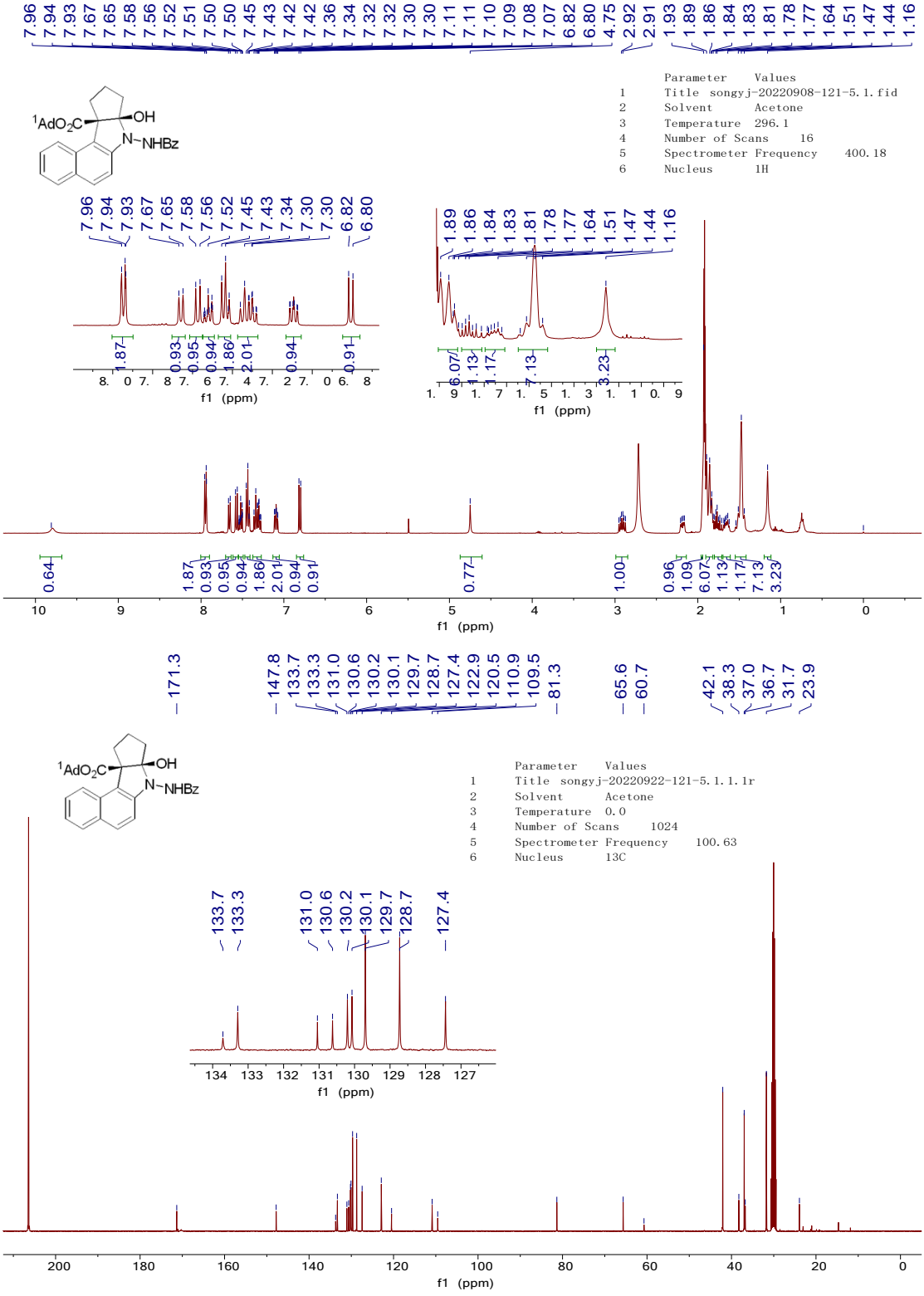
C23:


7.76 7.74 7.70 7.68 7.54 7.52 7.41 7.40 7.37 7.26 7.25 7.23 7.22 6.89 6.87 6.83
4.15 3.97 3.96
3.03 3.00 2.98 2.97 2.95
2.22 2.07 1.97 1.79 1.70 1.57
0.97 0.86
0.00
Ad
O
OH
N
N
H
O
Parameter Values
1 Title songyj-20220719-121-3.1.1.1r
2 Solvent CDCl3
3 Temperature 294.7
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
1.00 0.96 0.95 1.00 1.03 0.83 0.62
f1 (ppm)
0.64 2.09 1.00 1.05 4.09 8.04 1.15 0.94 6.21 6.04
171.0 158.1 146.1 129.7 129.1 126.7 122.3 121.9 119.2 109.6 107.4
82.1 77.4 77.0 76.7 72.2 64.5
45.3 41.1 37.0 36.0 35.4 30.7 29.7 28.0 23.1 19.0
-0.0
Parameter Values
1 Title songyj-20220719-121-3.2.1.1r
2 Solvent CDCl3
3 Temperature 295.2
4 Number of Scans 1024
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

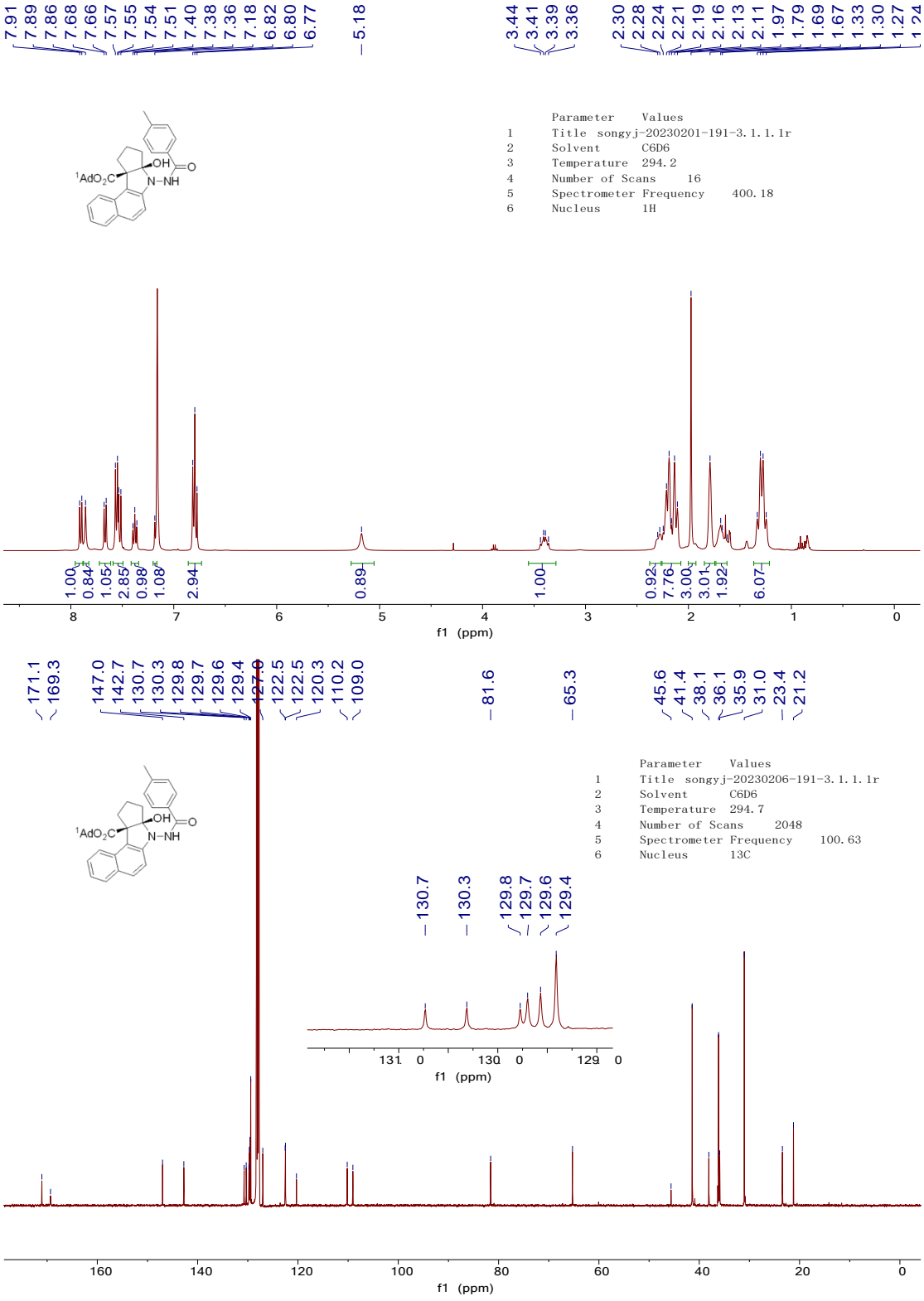
C24:


7.67 7.65 7.60 7.58 7.33 7.30 7.29 7.27 7.25 7.23 7.16 7.11 7.09 7.07 6.76 6.74 5.10
2.91 2.88 2.86 2.83 2.15 2.14 1.93 1.92 1.92 1.91 1.91 1.89 1.86 1.84 1.77 1.76 1.75 1.71 1.62 1.50 1.42 0.00
Parameter Values
1 Title songyj-20220906-121-4.1.fid
2 Solvent Acetone
3 Temperature 295.3
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
Ad
OH
N–NH
Bn
1.05 1.03 6.92 1.06 0.99 2.00 1.02 1.05 2.08 2.05 6.98 1.20 1.21 6.25
f1 (ppm)
171.4 147.9 137.8 131.0 130.7 130.3 130.1 129.6 129.2 129.1 127.5 123.0 122.9 120.1 110.8 108.7 81.6 67.9 65.5 46.5 42.1 38.1 37.0 36.8 31.8 23.9
Parameter Values
1 Title songyj-20220902-w95-2.2.1.1r
2 Solvent Acetone
3 Temperature 295.3
4 Number of Scans 1024
5 Spectrometer Frequency 100.63
6 Nucleus 13C
129.9 129.6 129.3 129.1 128.5 128.1 128.0 126.4
f1 (ppm)

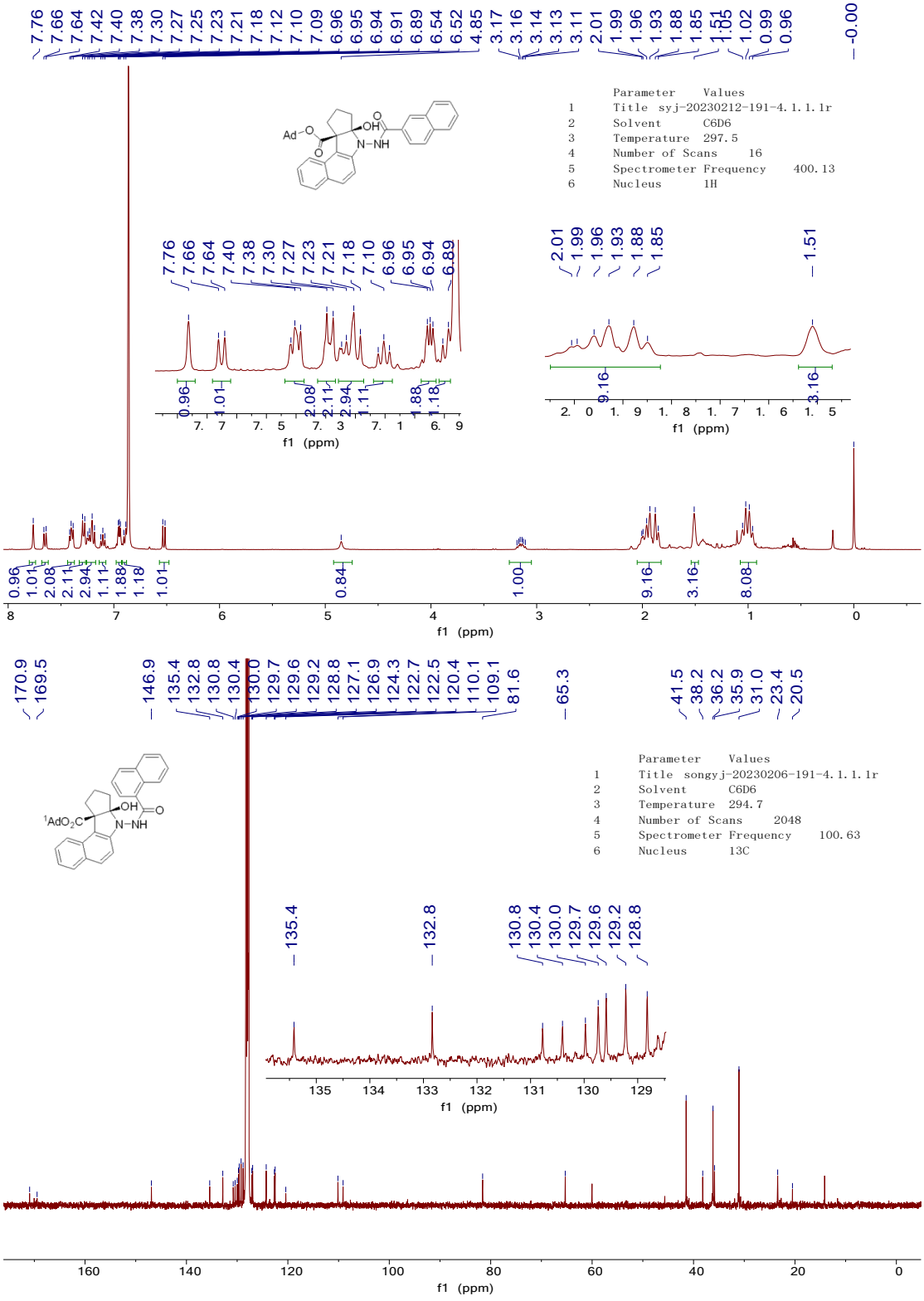
C25:


Parameter Values
1 Title songyj-20220908-121-5.1.fid
2 Solvent Acetone
3 Temperature 296.1
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
f1 (ppm)
Parameter Values
1 Title songyj-20220922-121-5.1.1.1r
2 Solvent Acetone
3 Temperature 0.0
4 Number of Scans 1024
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

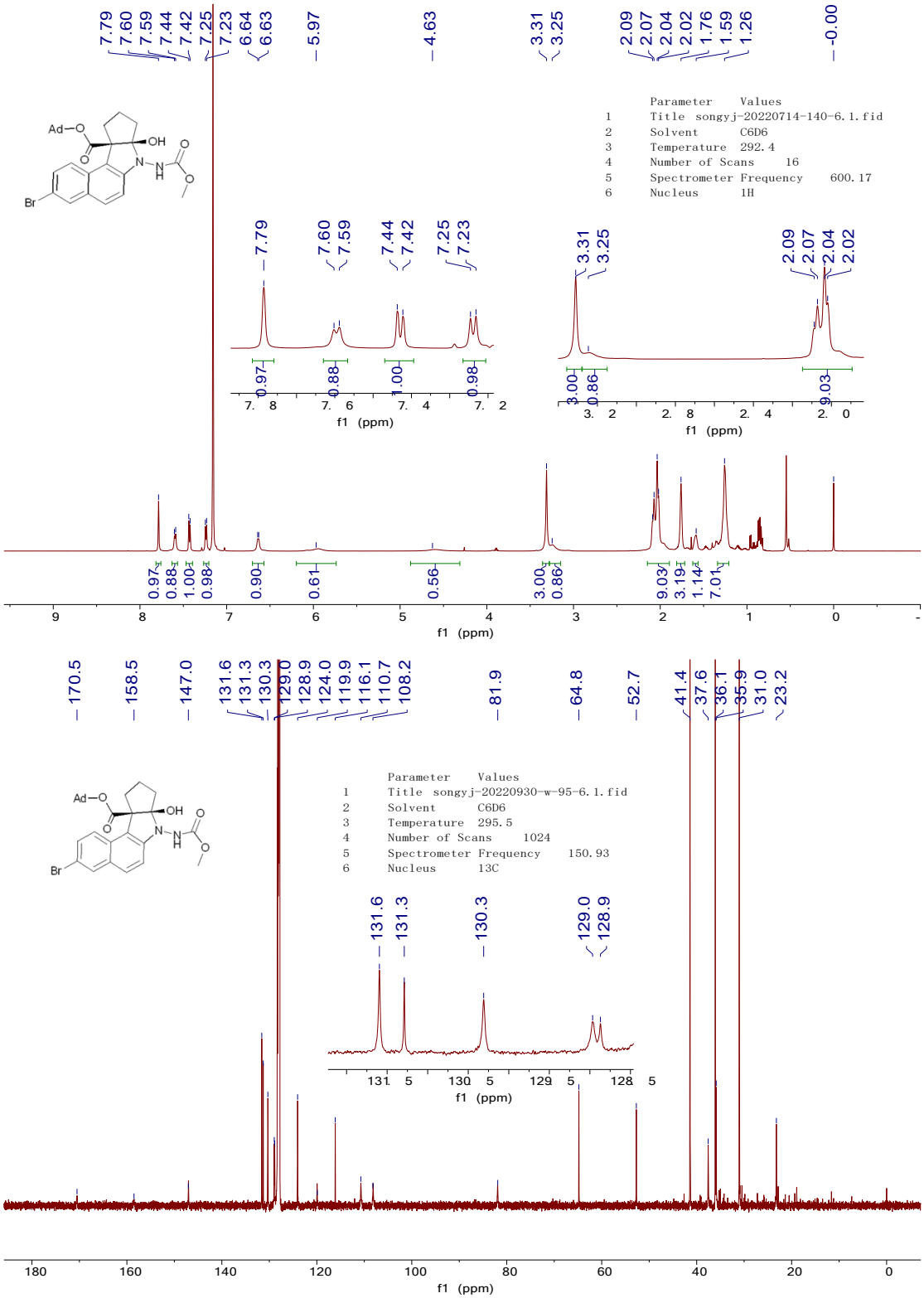
C26:


7.91 7.89 7.86 7.68 7.66 7.57 7.55 7.54 7.51 7.40 7.38 7.36 7.18 6.82 6.80 6.77
5.18
3.44 3.41 3.39 3.36
2.30 2.28 2.24 2.21 2.19 2.16 2.13 2.11 1.97 1.79 1.69 1.67 1.33 1.30 1.27
OH
O
N-NH
1AdO2C
Parameter Values
1 Title songyj-20230201-191-3.1.1.1r
2 Solvent C6D6
3 Temperature 294.2
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
1.00 0.84 1.05 2.85 0.98 1.08 2.94 0.89 1.00 0.92 7.76 3.00 3.01 1.92 6.07
f1 (ppm)
171.1 169.3 147.0 142.7 130.7 130.3 129.8 129.7 129.6 129.4 127.0 122.5 122.5 120.3 110.2 109.0
81.6
65.3
45.6 41.4 38.1 36.1 35.9 31.0 23.4 21.2
Parameter Values
1 Title songyj-20230206-191-3.1.1.1r
2 Solvent C6D6
3 Temperature 294.7
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
130.7 130.3 129.8 129.7 129.6 129.4
f1 (ppm)
f1 (ppm)

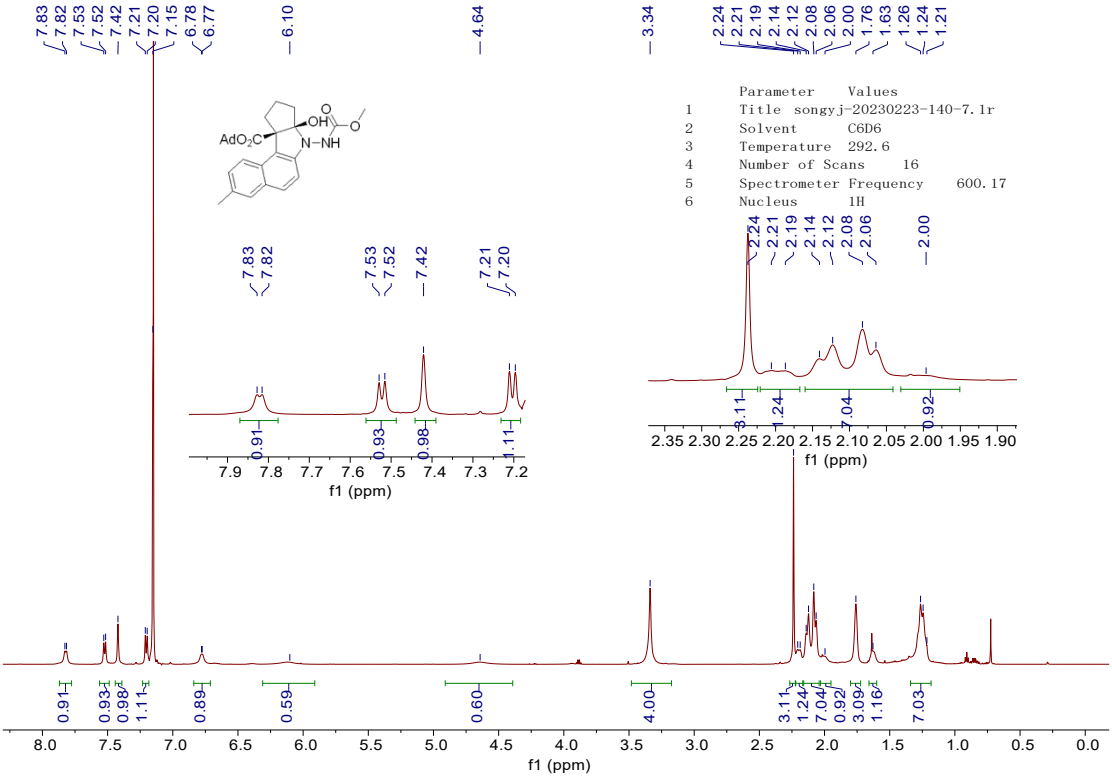
C27:

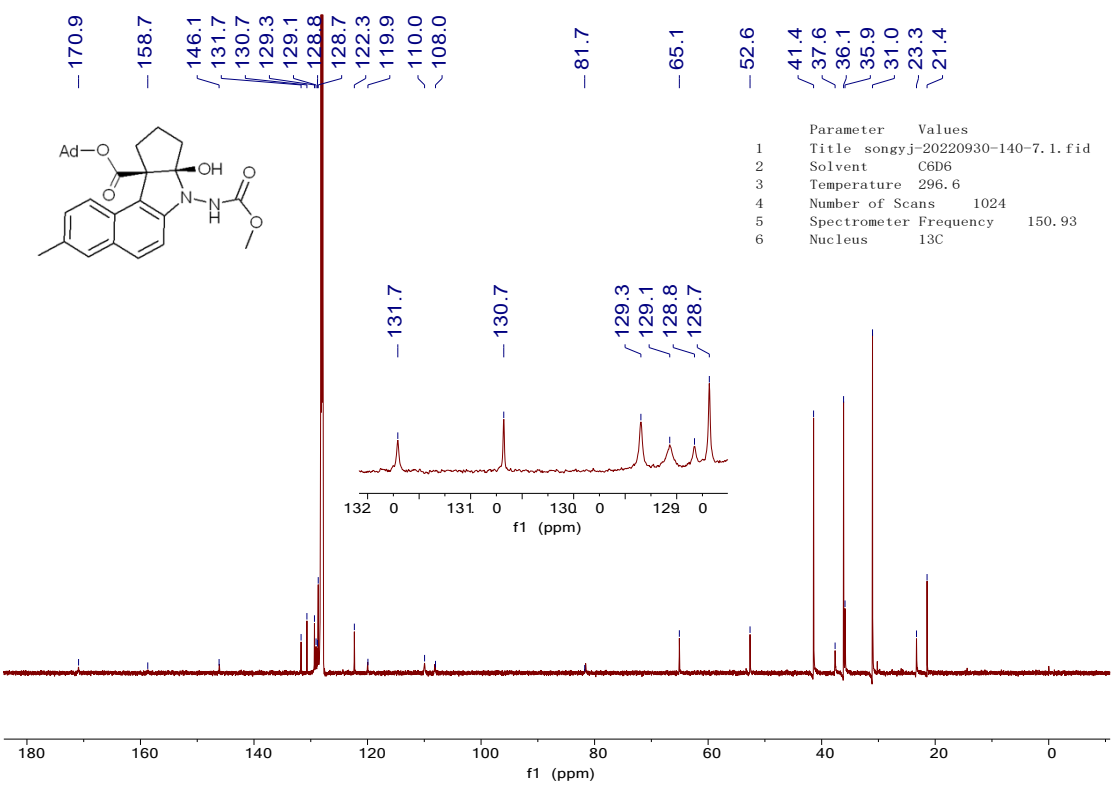

Parameter Values
1 Title syj-20230212-191-4.1.1.1r
2 Solvent C6D6
3 Temperature 297.5
4 Number of Scans 16
5 Spectrometer Frequency 400.13
6 Nucleus 1H
f1 (ppm)
Parameter Values
1 Title songyj-20230206-191-4.1.1.1r
2 Solvent C6D6
3 Temperature 294.7
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
f1 (ppm)

C28:

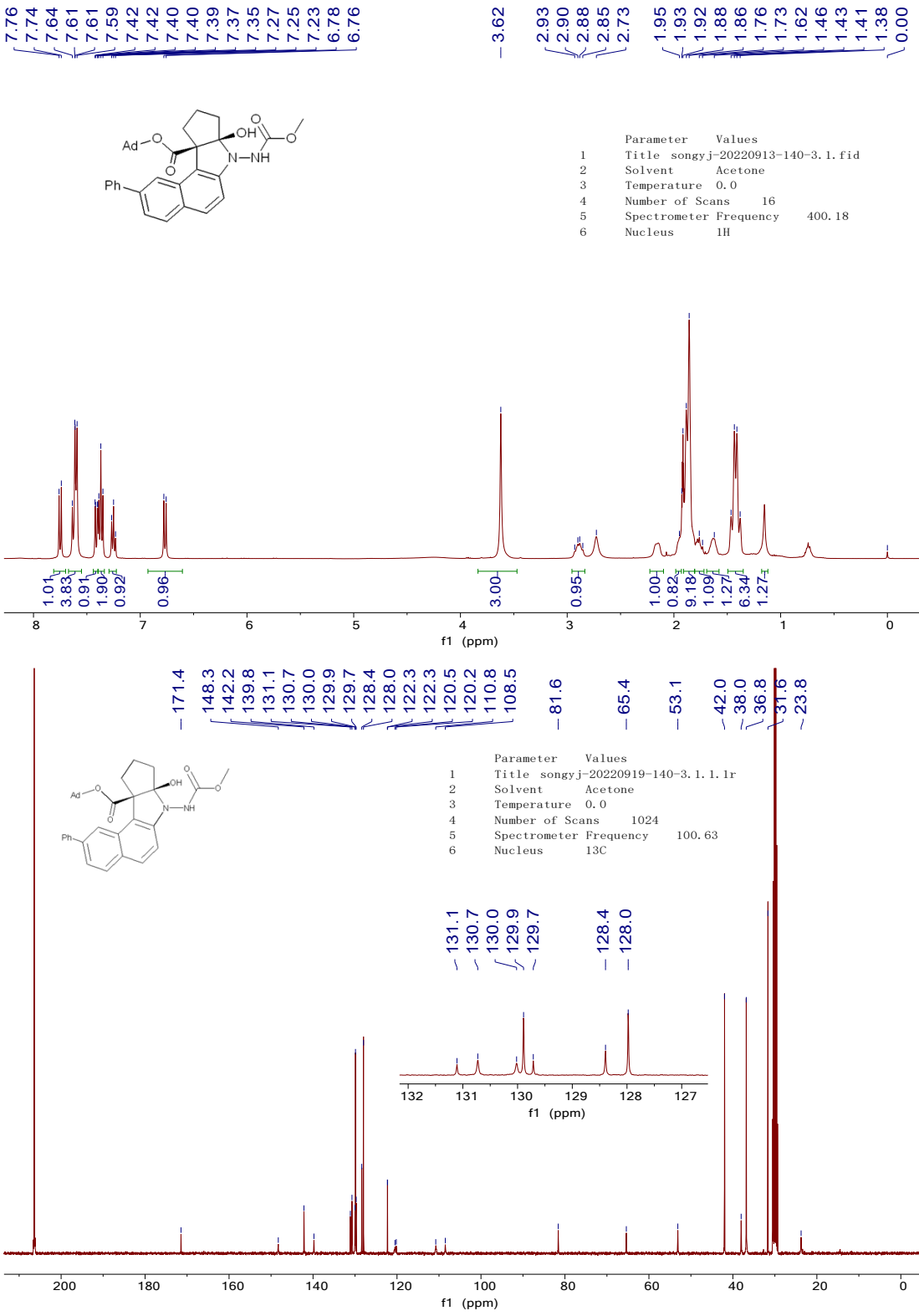

7.79
7.60
7.59
7.44
7.42
7.25
7.23
6.64
6.63
5.97
4.63
3.31
3.25
2.09
2.07
2.04
2.02
1.76
1.59
1.26
0.00
Parameter Values
1 Title songyj-20220714-140-6.1.fid
2 Solvent C6D6
3 Temperature 292.4
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
Ad—O
OH
N
N
H
O
O
Br
0.97
0.88
1.00
0.98
0.90
0.61
0.56
3.00
0.86
9.03
3.19
1.14
7.01
f1 (ppm)
170.5
158.5
147.0
131.6
131.3
130.3
129.0
128.9
124.0
119.9
116.1
110.7
108.2
81.9
64.8
52.7
41.4
37.6
36.1
35.9
31.0
23.2
Parameter Values
1 Title songyj-20220930-w-95-6.1.fid
2 Solvent C6D6
3 Temperature 295.5
4 Number of Scans 1024
5 Spectrometer Frequency 150.93
6 Nucleus 13C
f1 (ppm)

C29:

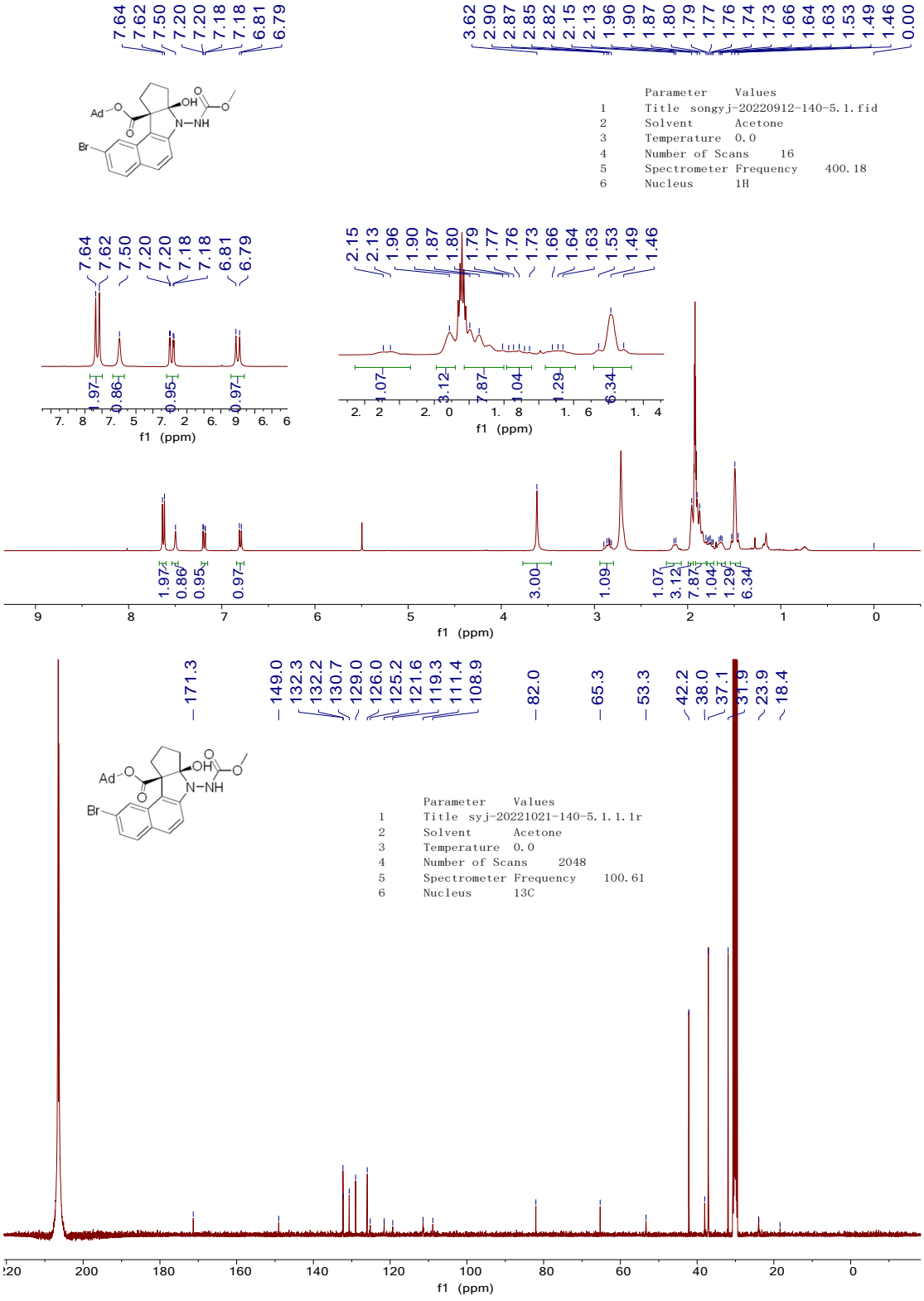

7.83 7.82 7.53 7.52 7.42 7.21 7.20 7.15 6.78 6.77 6.10 4.64 3.34 2.24 2.21 2.19 2.14 2.12 2.08 2.06 2.00 1.76 1.63 1.26 1.24 1.21
Parameter Values
1 Title songyj-20230223-140-7.1r
2 Solvent C6D6
3 Temperature 292.6
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
f1 (ppm)


170.9 158.7 146.1 131.7 130.7 129.3 129.1 128.8 128.7 122.3 119.9 110.0 108.0 81.7 65.1 52.6 41.4 37.6 36.1 35.9 31.0 23.3 21.4
Parameter Values
1 Title songyj-20220930-140-7.1.fid
2 Solvent C6D6
3 Temperature 296.6
4 Number of Scans 1024
5 Spectrometer Frequency 150.93
6 Nucleus 13C
f1 (ppm)

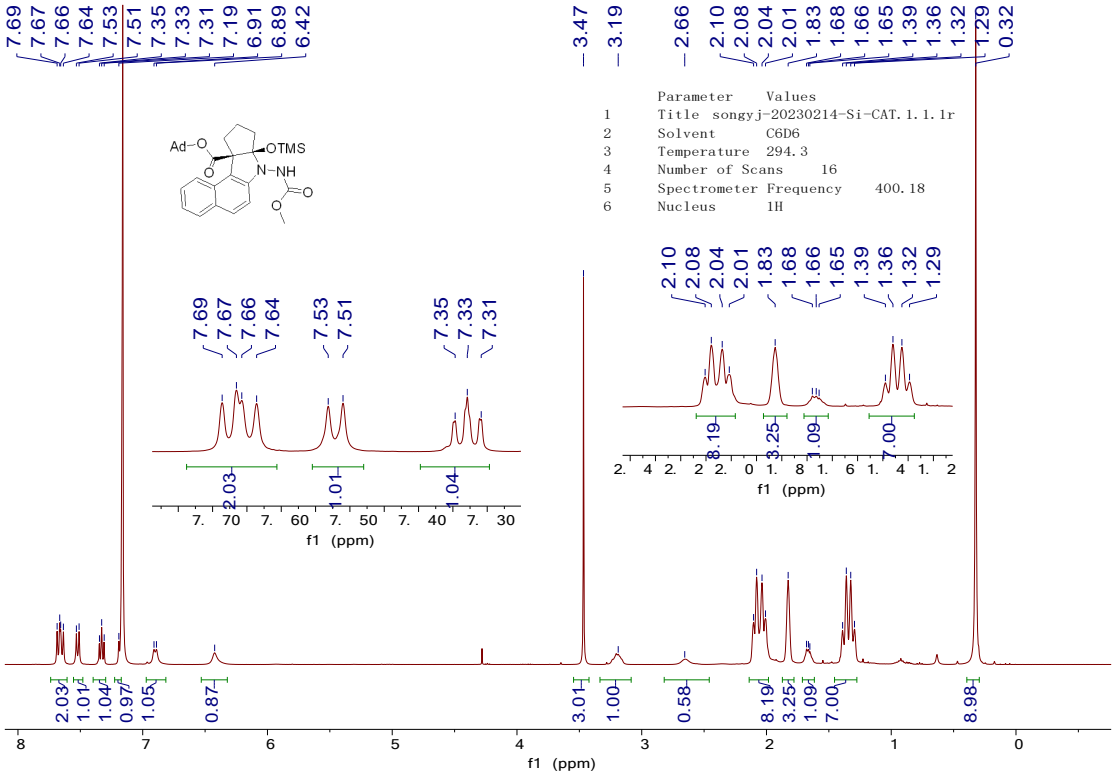
C30:

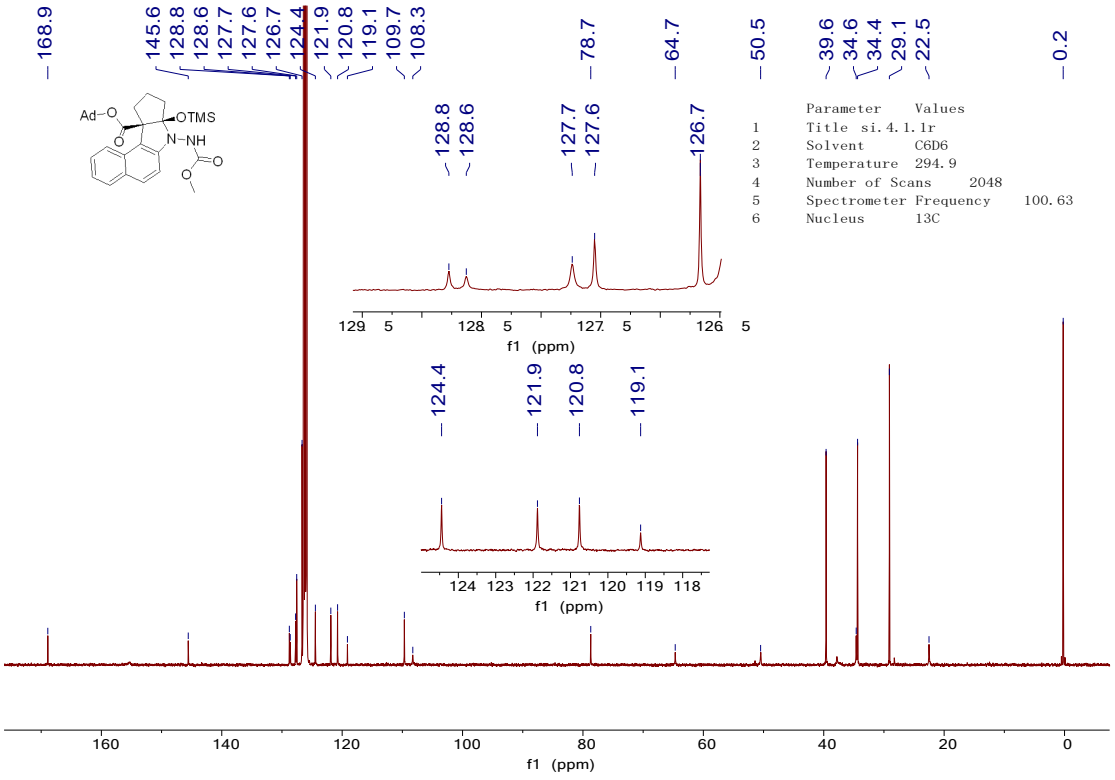

7.76 7.74 7.64 7.61 7.61 7.59 7.42 7.42 7.40 7.40 7.39 7.37 7.35 7.27 7.25 7.23 6.78 6.76
3.62
2.93 2.90 2.88 2.85 2.73
1.95 1.93 1.92 1.88 1.86 1.76 1.73 1.62 1.46 1.43 1.41 1.38 0.00
Ad
OH
O
N—NH
Ph
Parameter Values
1 Title songyj-20220913-140-3.1.fid
2 Solvent Acetone
3 Temperature 0.0
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
1.01 3.83 0.91 1.90 0.92 0.96 3.00 0.95 1.00 0.82 9.18 1.09 1.27 6.34 1.27
f1 (ppm)
171.4 148.3 142.2 139.8 131.1 130.7 130.0 129.9 129.7 128.4 128.0 122.3 122.3 120.5 120.2 110.8 108.5
81.6 65.4 53.1 42.0 38.0 36.8 31.6 23.8
Parameter Values
1 Title songyj-20220919-140-3.1.1.1r
2 Solvent Acetone
3 Temperature 0.0
4 Number of Scans 1024
5 Spectrometer Frequency 100.63
6 Nucleus 13C
131.1 130.7 130.0 129.9 129.7 128.4 128.0
f1 (ppm)

C31:

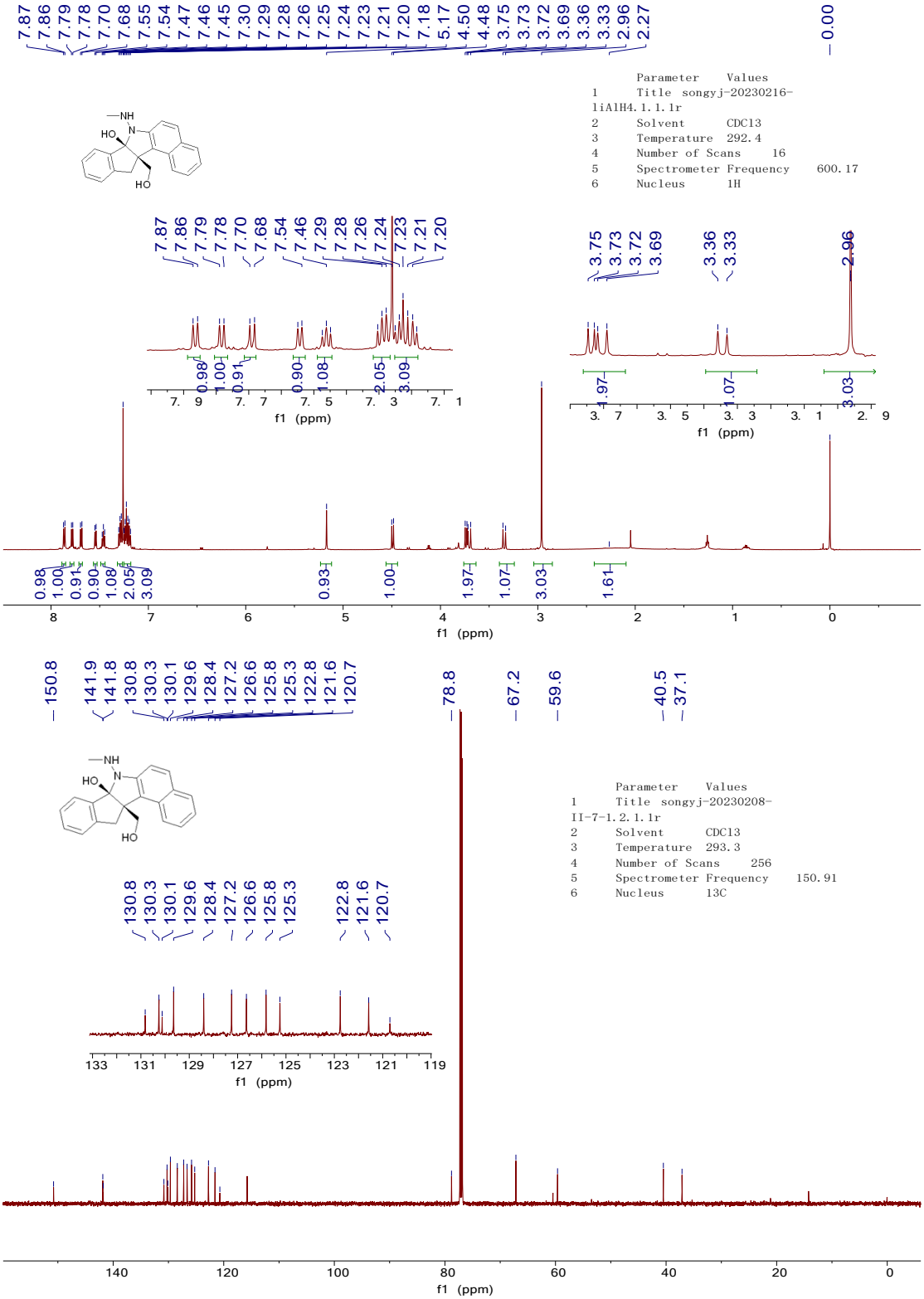

7.64 7.62 7.50 7.20 7.20 7.18 7.18 6.81 6.79
3.62 2.90 2.87 2.85 2.82 2.15 2.13 1.96 1.90 1.87 1.80 1.79 1.77 1.76 1.74 1.73 1.66 1.64 1.63 1.53 1.49 1.46 0.00
Ad
OH
N–NH
Br
Parameter Values
1 Title songyj-20220912-140-5.1.fid
2 Solvent Acetone
3 Temperature 0.0
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
1.97 0.86 0.95 0.97
1.07 3.12 7.87 1.04 1.29 6.34
f1 (ppm)
1.97 0.86 0.95 0.97 3.00 1.09 1.07 3.12 7.87 1.04 1.29 6.34
f1 (ppm)
171.3 149.0 132.3 132.2 130.7 129.0 126.0 125.2 121.6 119.3 111.4 108.9 82.0 65.3 53.3 42.2 38.0 37.1 31.9 23.9 18.4
Parameter Values
1 Title syj-20221021-140-5.1.1.1r
2 Solvent Acetone
3 Temperature 0.0
4 Number of Scans 2048
5 Spectrometer Frequency 100.61
6 Nucleus 13C
f1 (ppm)

D1:

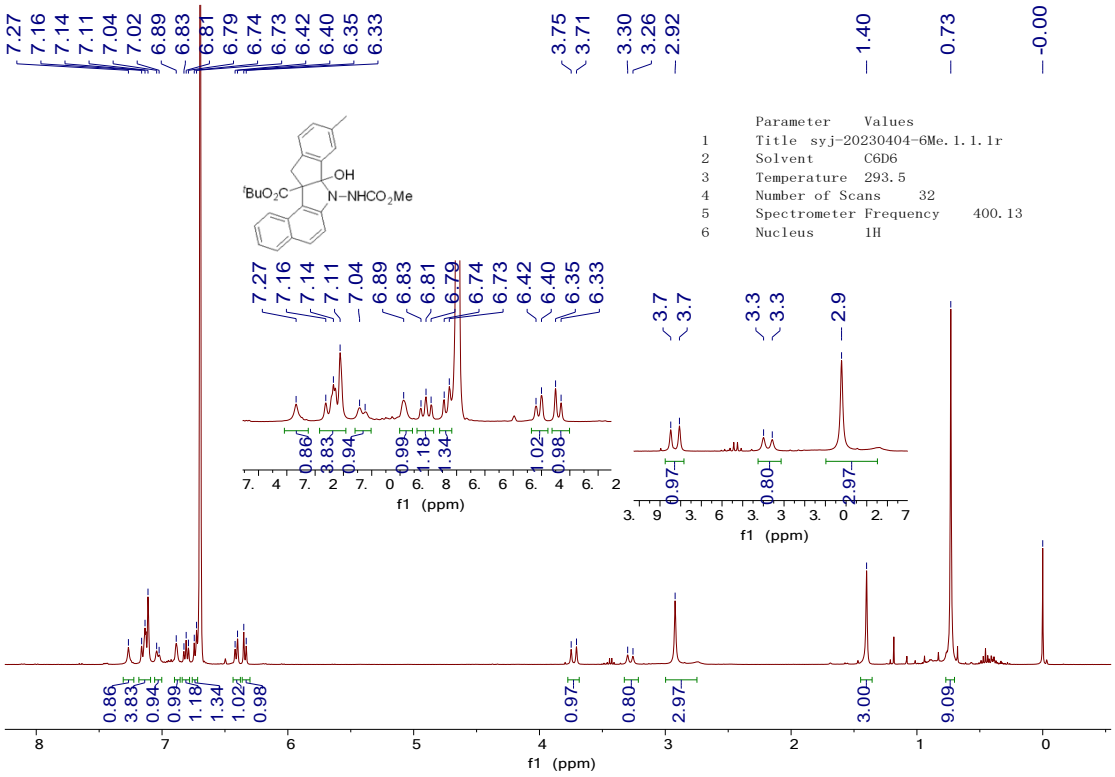

7.69 7.67 7.66 7.64 7.53 7.51 7.35 7.33 7.31 7.19 6.91 6.89 6.42
3.47 3.19 2.66 2.10 2.08 2.04 2.01 1.83 1.68 1.66 1.65 1.39 1.36 1.32 1.29 0.32
Parameter Values
1 Title songyj-20230214-Si-CAT.1.1.1r
2 Solvent C6D6
3 Temperature 294.3
4 Number of Scans 16
5 Spectrometer Frequency 400.18
6 Nucleus 1H
Ad–O
OTMS
N–NH
O
O
O
2.03 1.01 1.04 0.97 1.05 0.87 3.01 1.00 0.58 8.19 3.25 1.09 7.00 8.98
f1 (ppm)

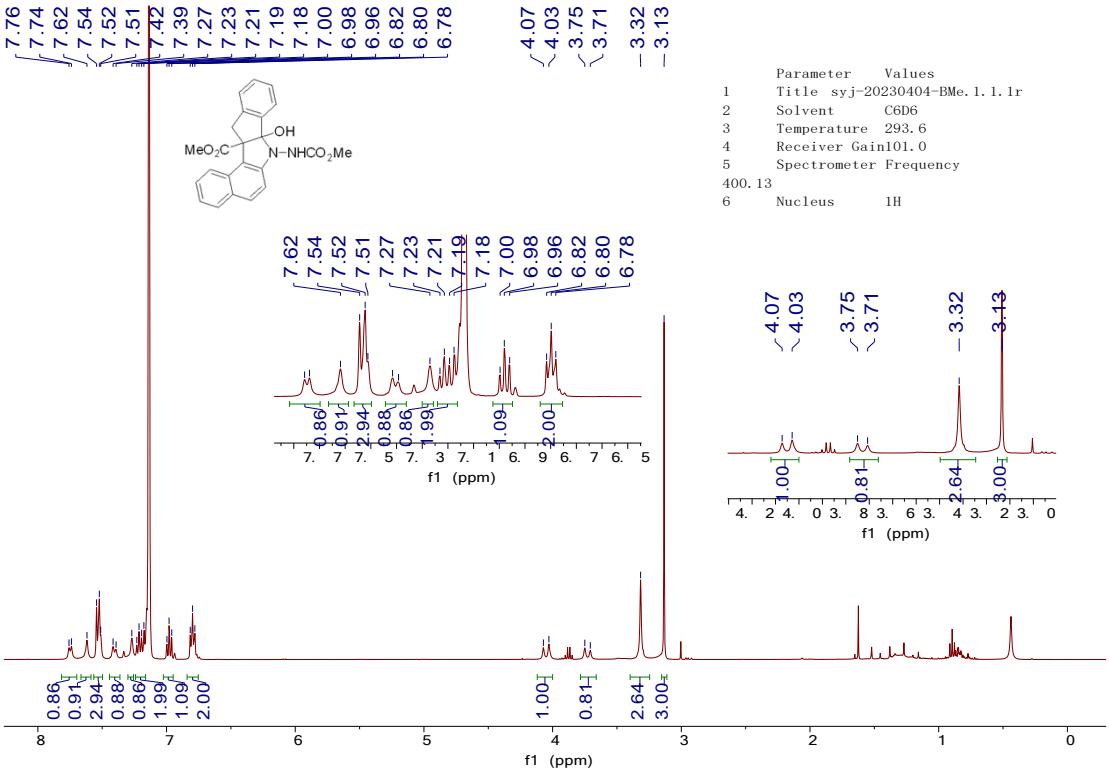

168.9 145.6 128.8 128.6 127.7 127.6 126.7 124.4 121.9 120.8 119.1 109.7 108.3 78.7 64.7 50.5 39.6 34.6 34.4 29.1 22.5 0.2
Parameter Values
1 Title si.4.1.1r
2 Solvent C6D6
3 Temperature 294.9
4 Number of Scans 2048
5 Spectrometer Frequency 100.63
6 Nucleus 13C
Ad–O
OTMS
N–NH
O
O
O
f1 (ppm)

D2:

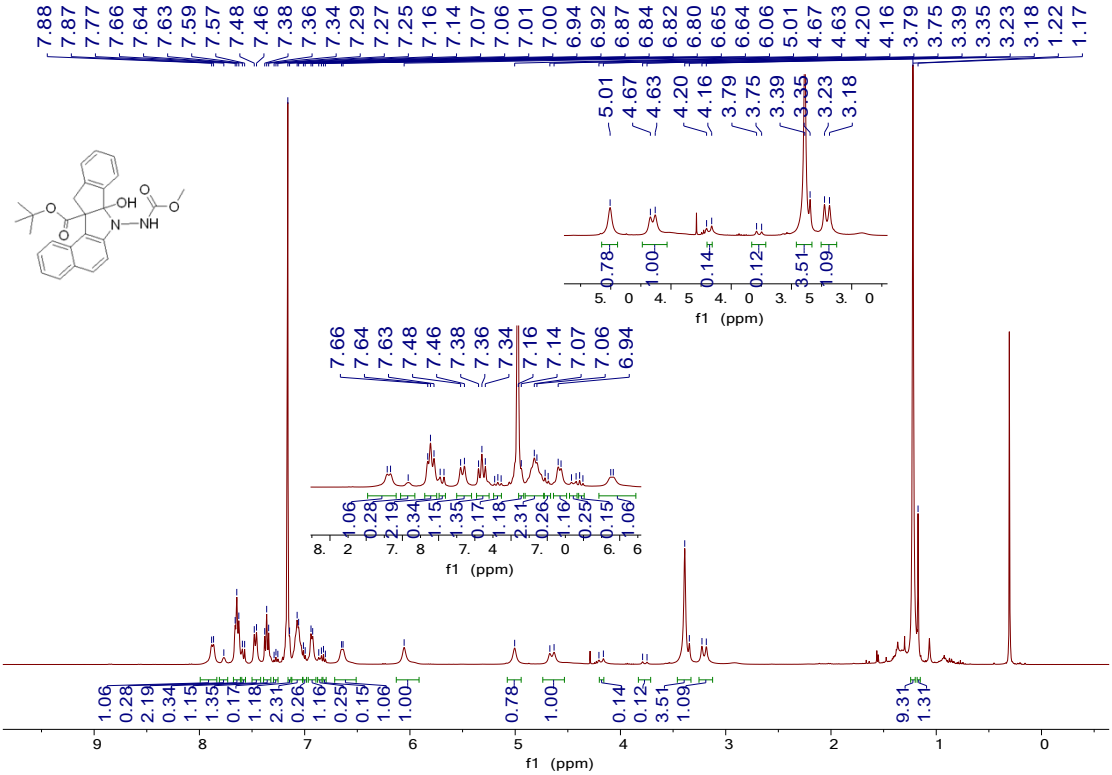

7.87 7.86 7.79 7.78 7.70 7.68 7.55 7.54 7.47 7.46 7.45 7.30 7.29 7.28 7.26 7.25 7.24 7.23 7.21 7.20 7.18 5.17 4.50 4.48 3.75 3.73 3.72 3.69 3.36 3.33 2.96 2.27 0.00
Parameter Values
1 Title songyj-20230216-liAlH4.1.1.1r
2 Solvent CDCl3
3 Temperature 292.4
4 Number of Scans 16
5 Spectrometer Frequency 600.17
6 Nucleus 1H
NH
HO
N
HO
f1 (ppm)
0.98 1.00 0.91 0.90 1.08 2.05 3.09 0.93 1.00 1.97 1.07 3.03 1.61
150.8 141.9 141.8 130.8 130.3 130.1 129.6 128.4 127.2 126.6 125.8 125.3 122.8 121.6 120.7 78.8 67.2 59.6 40.5 37.1
Parameter Values
1 Title songyj-20230208-II-7-1.2.1.1r
2 Solvent CDCl3
3 Temperature 293.3
4 Number of Scans 256
5 Spectrometer Frequency 150.91
6 Nucleus 13C

The 1H NMR of the trans-isomers:

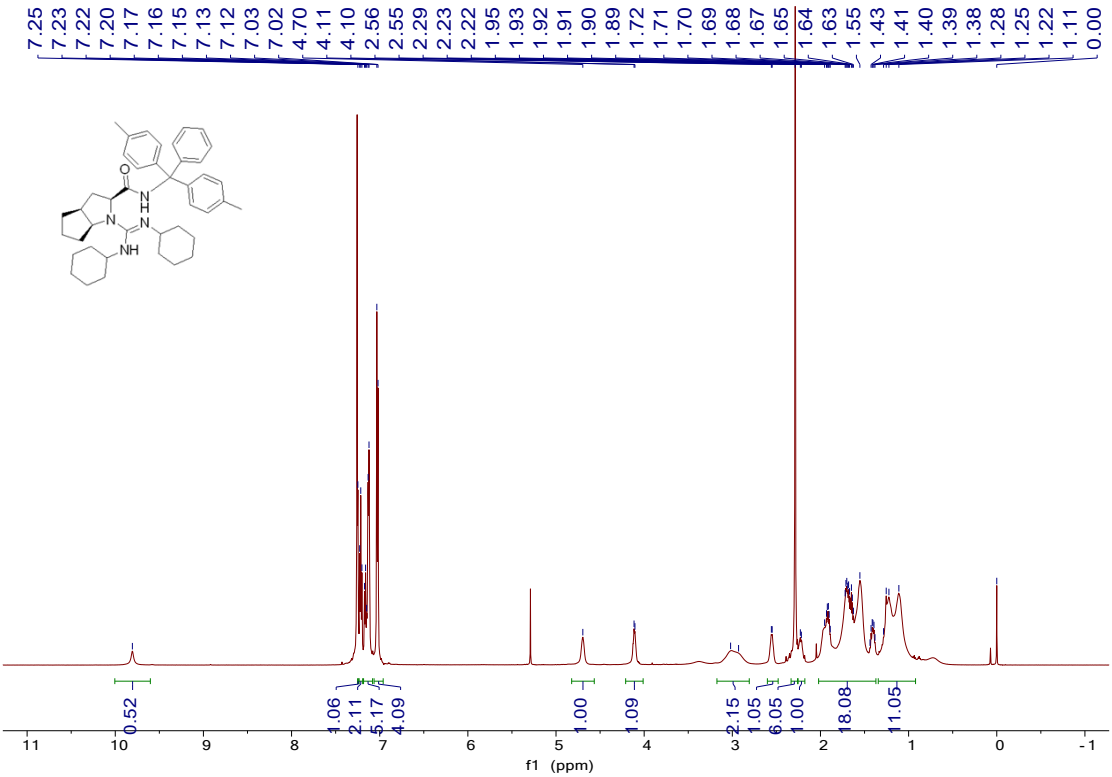


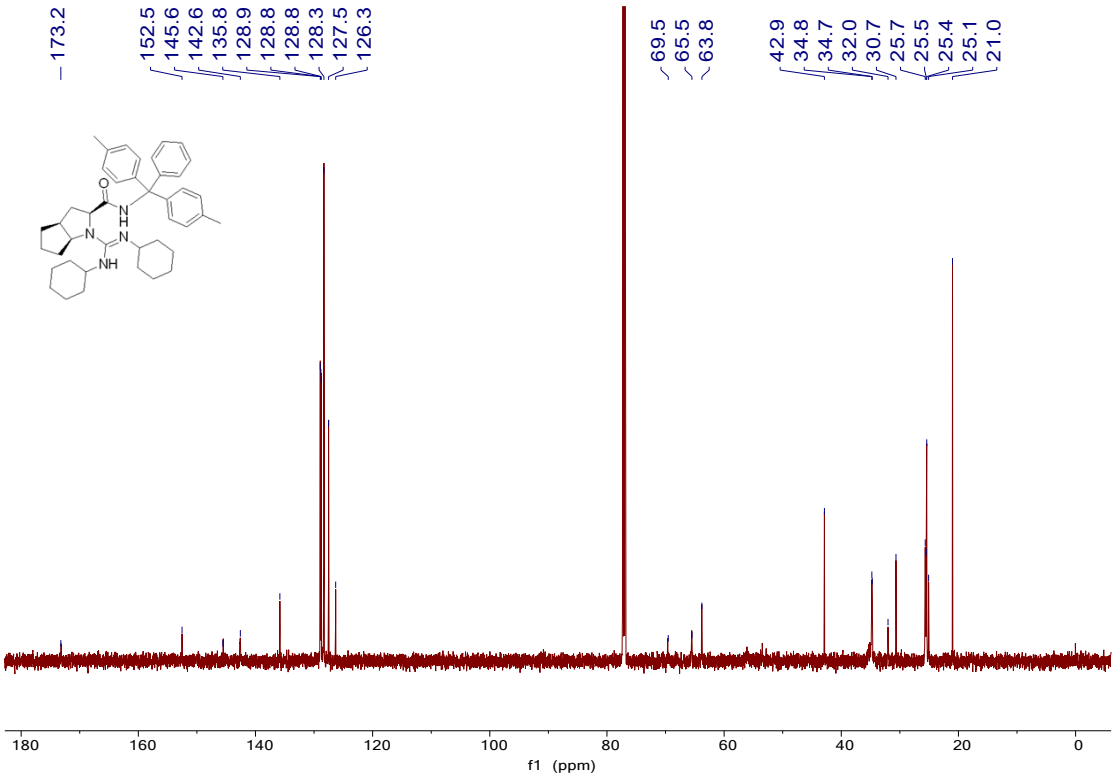


The 1H NMR of racemic C1:

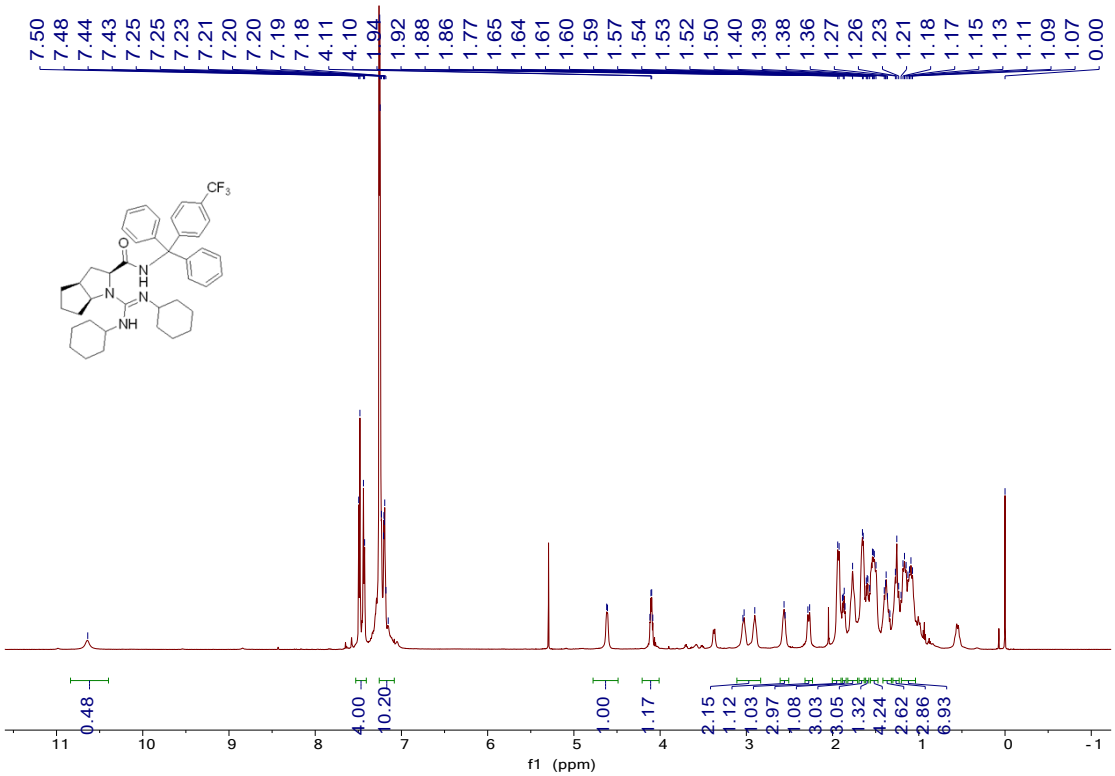


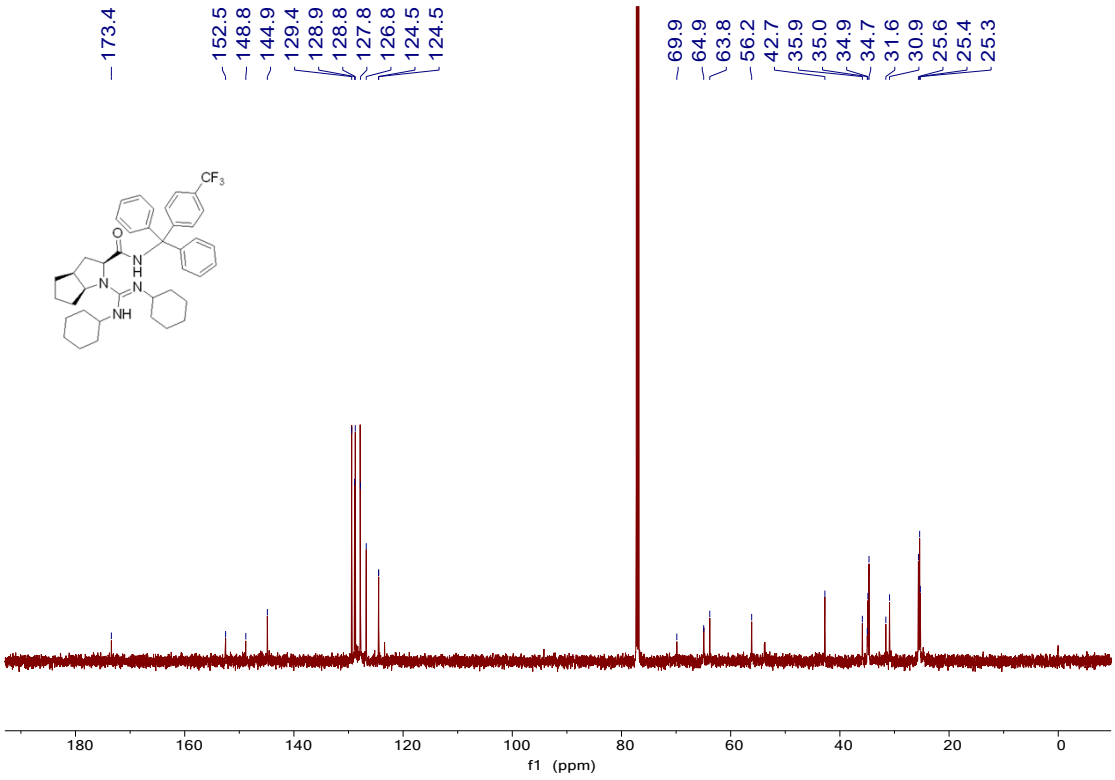
G19:

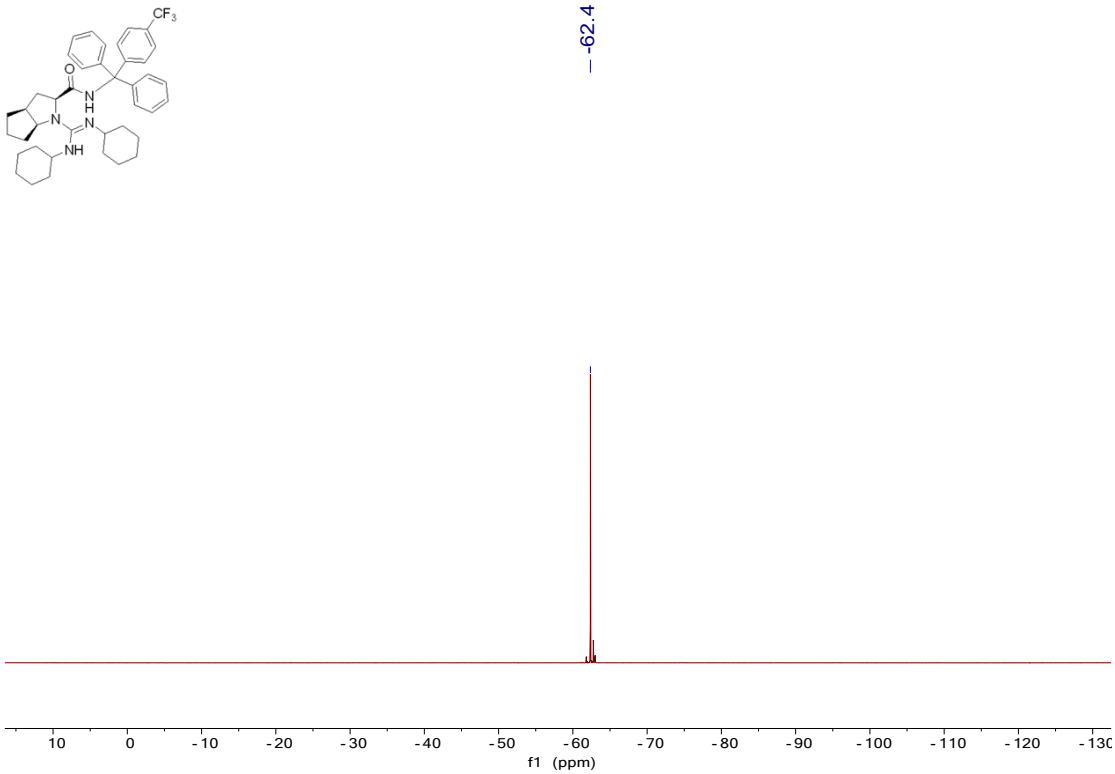



173.2
152.5
145.6
142.6
135.8
128.9
128.8
128.8
128.3
127.5
126.3
69.5
65.5
63.8
42.9
34.8
34.7
32.0
30.7
25.7
25.5
25.4
25.1
21.0
O
N
H
N
N
NH
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

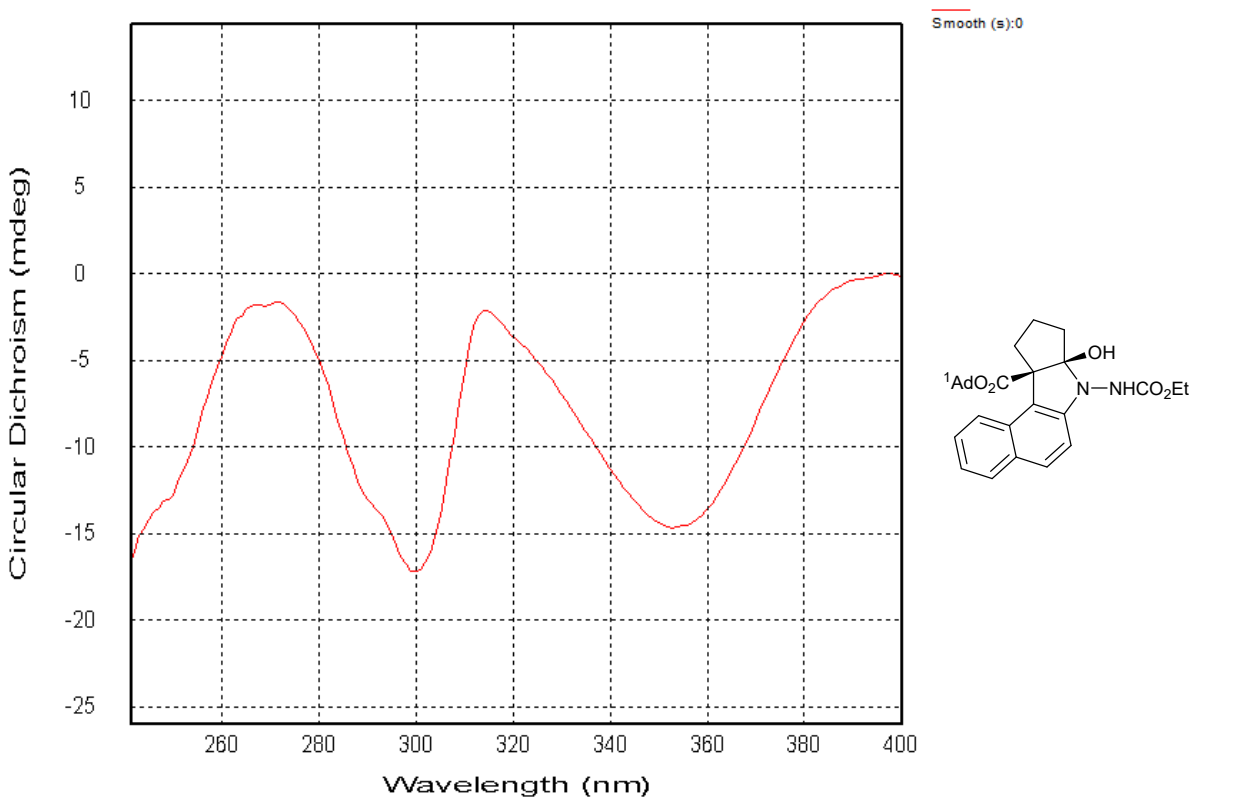
G20:

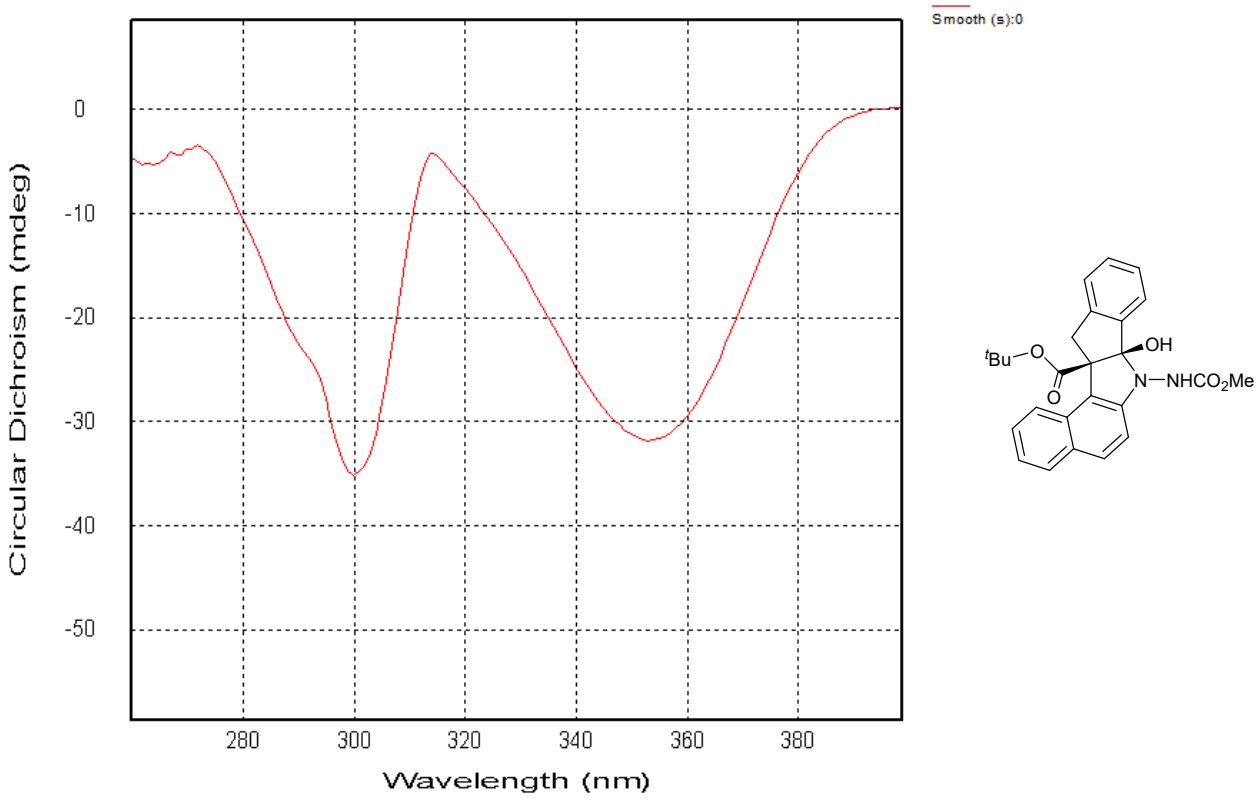

7.50
7.48
7.44
7.43
7.25
7.25
7.23
7.21
7.20
7.20
7.19
7.18
4.11
4.10
1.94
1.92
1.88
1.86
1.77
1.65
1.64
1.61
1.60
1.59
1.57
1.54
1.53
1.52
1.50
1.40
1.39
1.38
1.36
1.27
1.26
1.23
1.21
1.18
1.17
1.15
1.13
1.11
1.09
1.07
0.00
CF3
O
N
H
N
N
NH
0.48
4.00
10.20
1.00
1.17
2.15
1.12
1.03
2.97
1.08
3.03
3.05
1.32
4.24
2.62
2.86
6.93
11
10
9
8
7
6
5
4
3
2
1
0
-1
f1 (ppm)

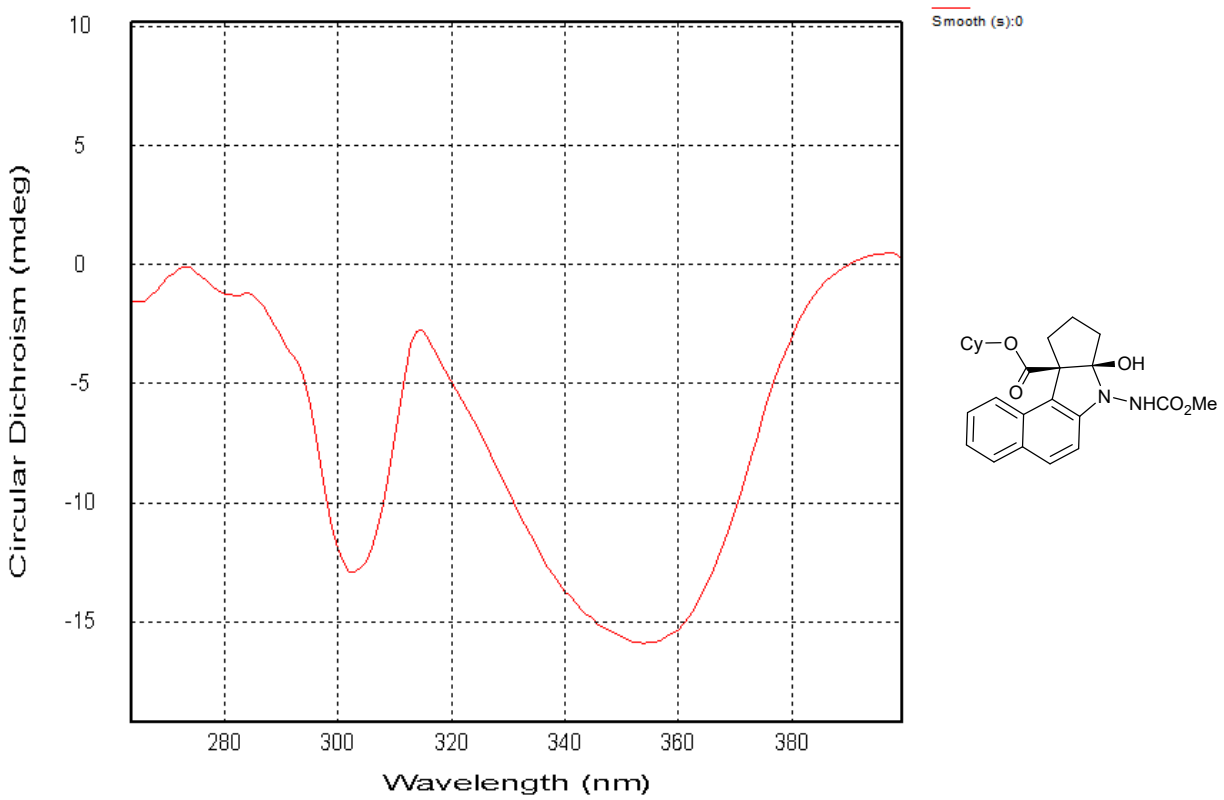

173.4
152.5
148.8
144.9
129.4
128.9
128.8
127.8
126.8
124.5
124.5
69.9
64.9
63.8
56.2
42.7
35.9
35.0
34.9
34.7
31.6
30.9
25.6
25.4
25.3
CF3
O
N
H
N
N
NH
180
160
140
120
100
80
60
40
20
0
f1 (ppm)

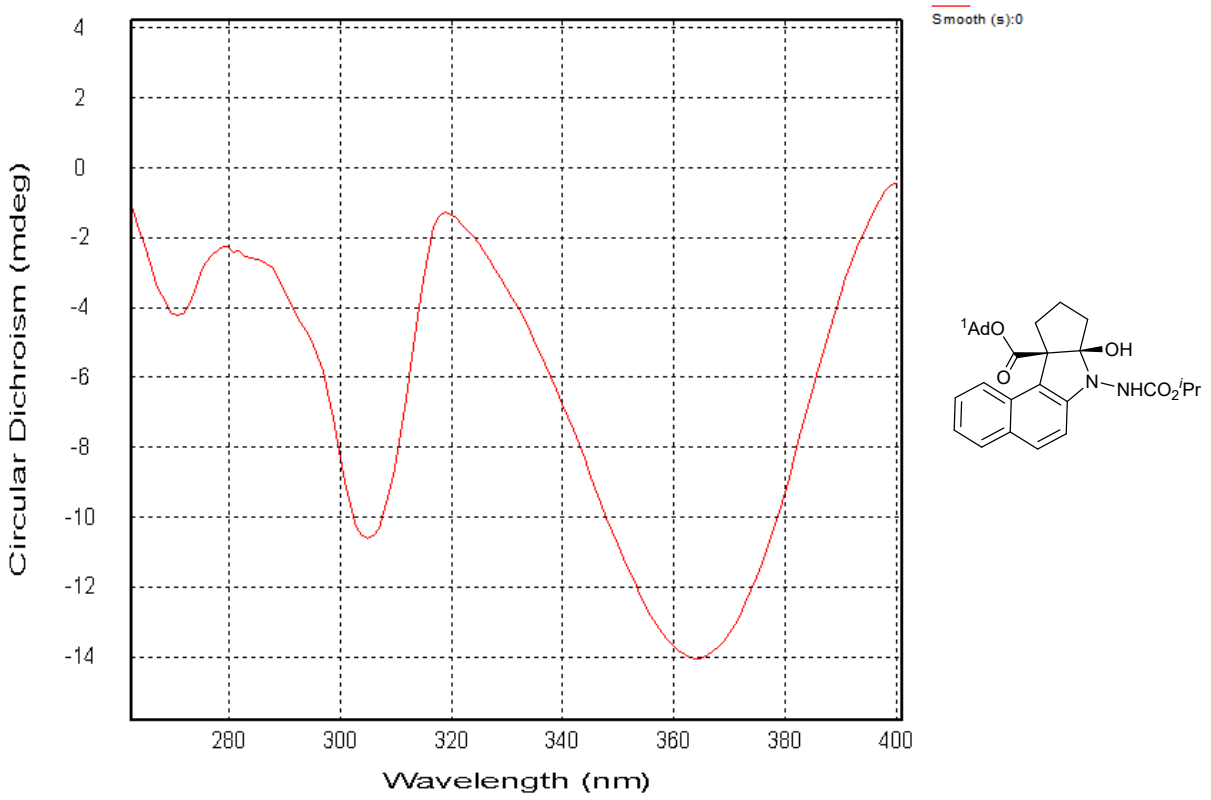

CF3
O
N
H
N
N
NH
-62.4
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
f1 (ppm)

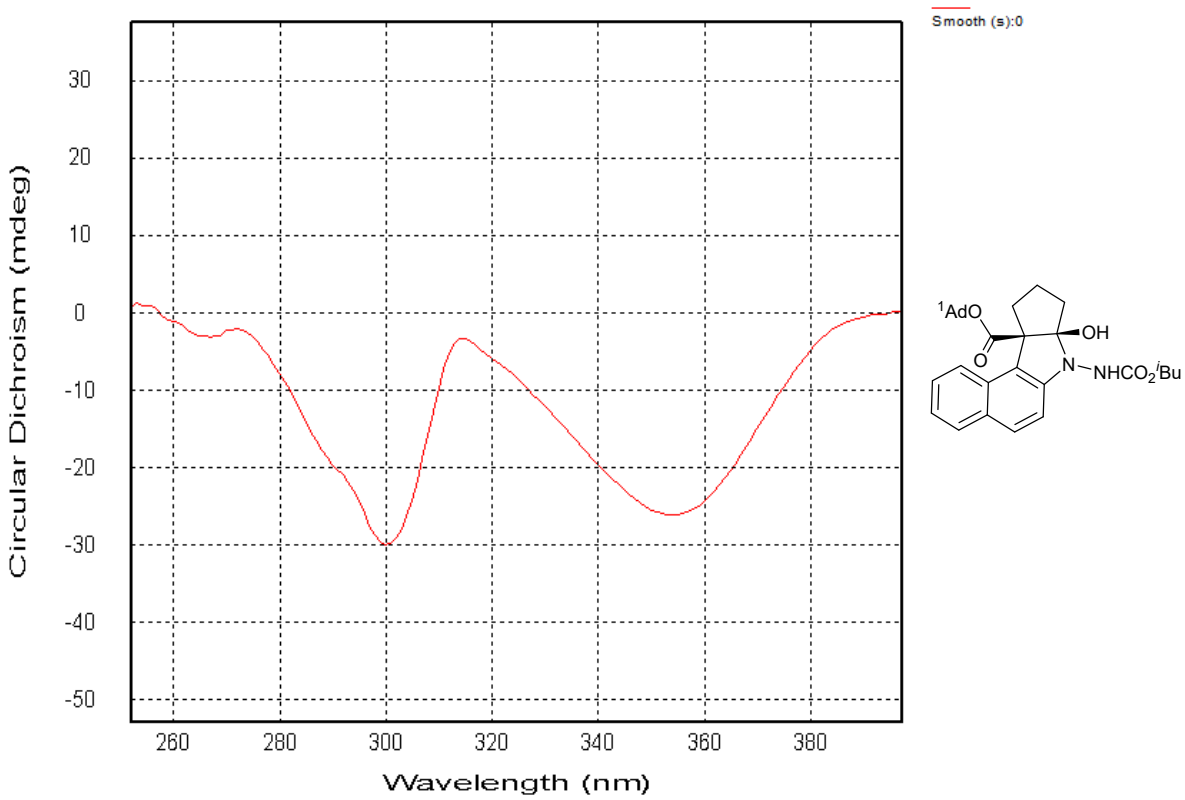
12. Copies of CD spectra of the products

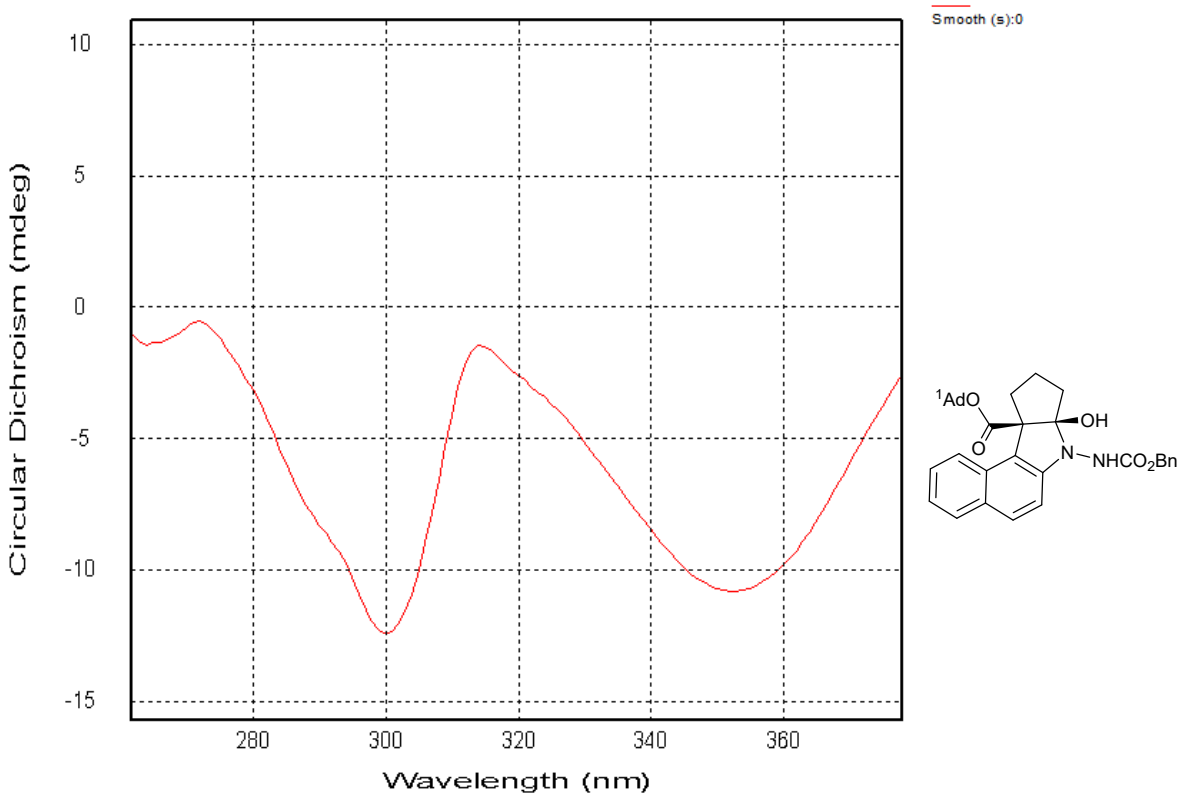


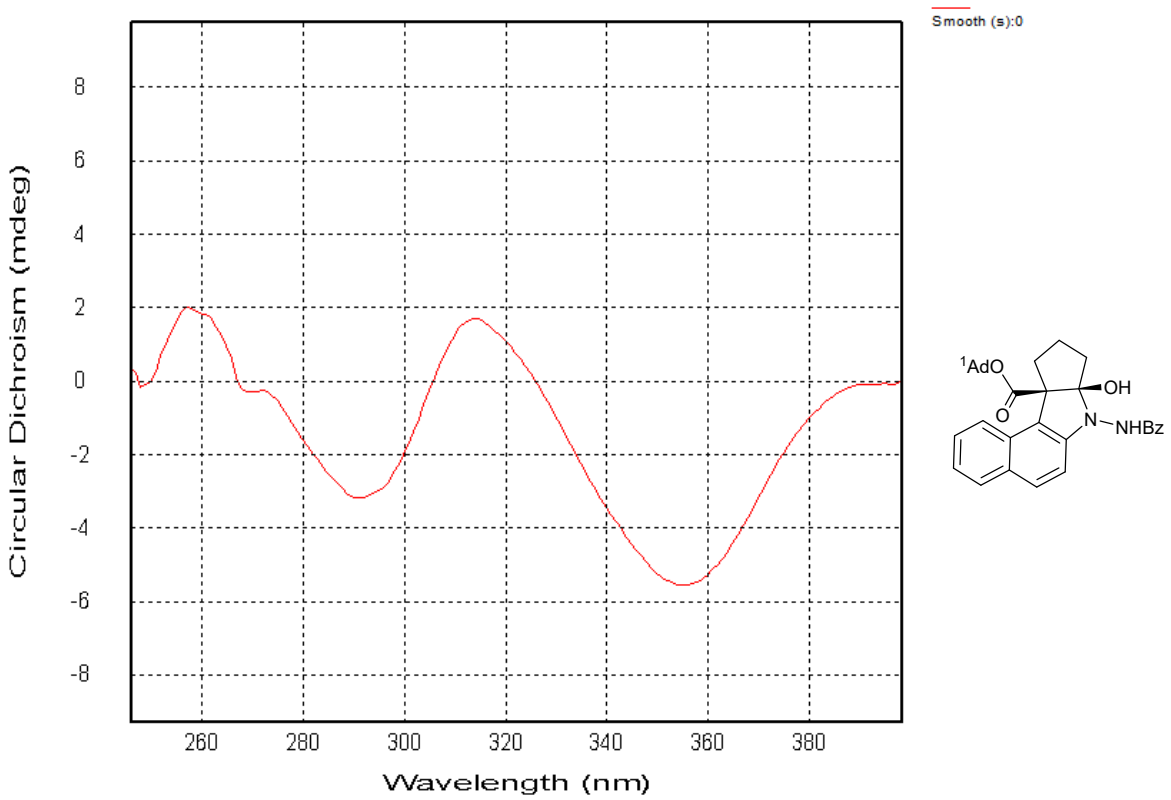


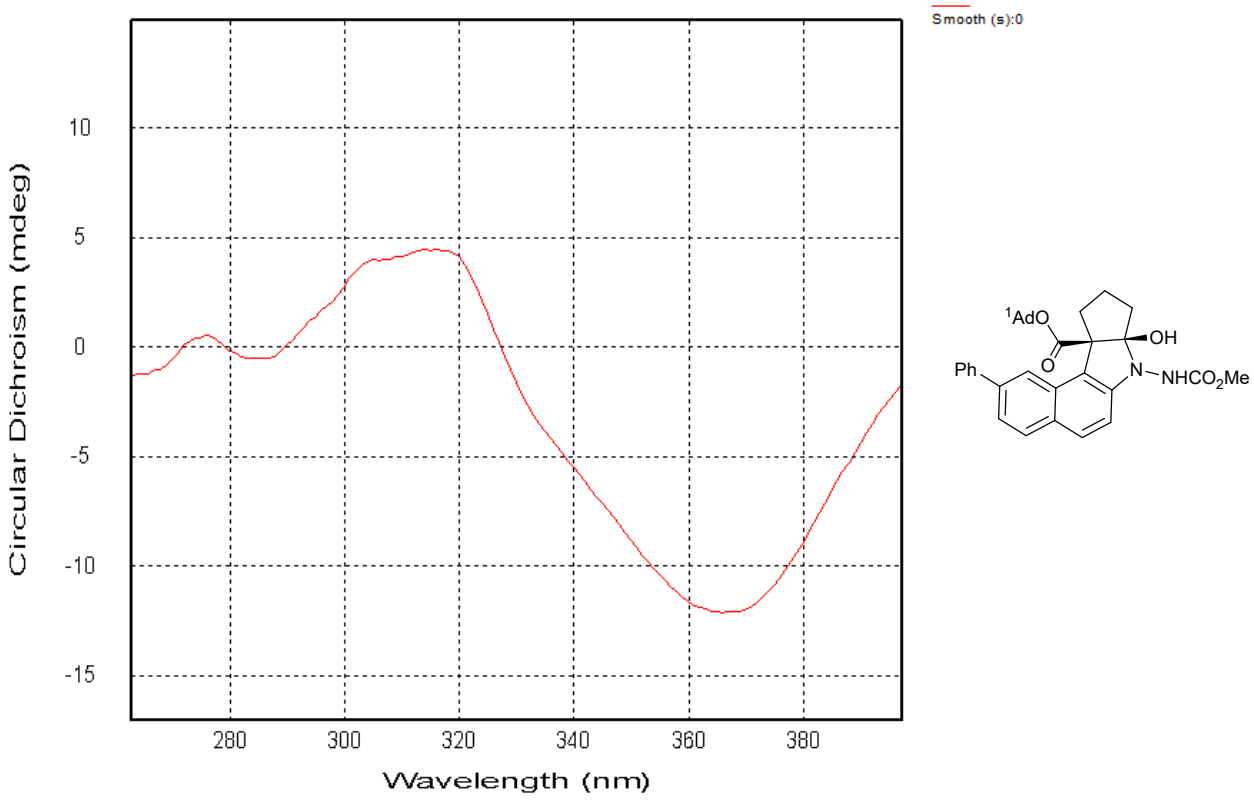

Smooth (s):0
Circular Dichroism (mdeg)
10
5
0
-5
-10
-15
280
300
320
340
360
380
Wavelength (nm)
Cy—O
O
OH
N
NHCO2Me

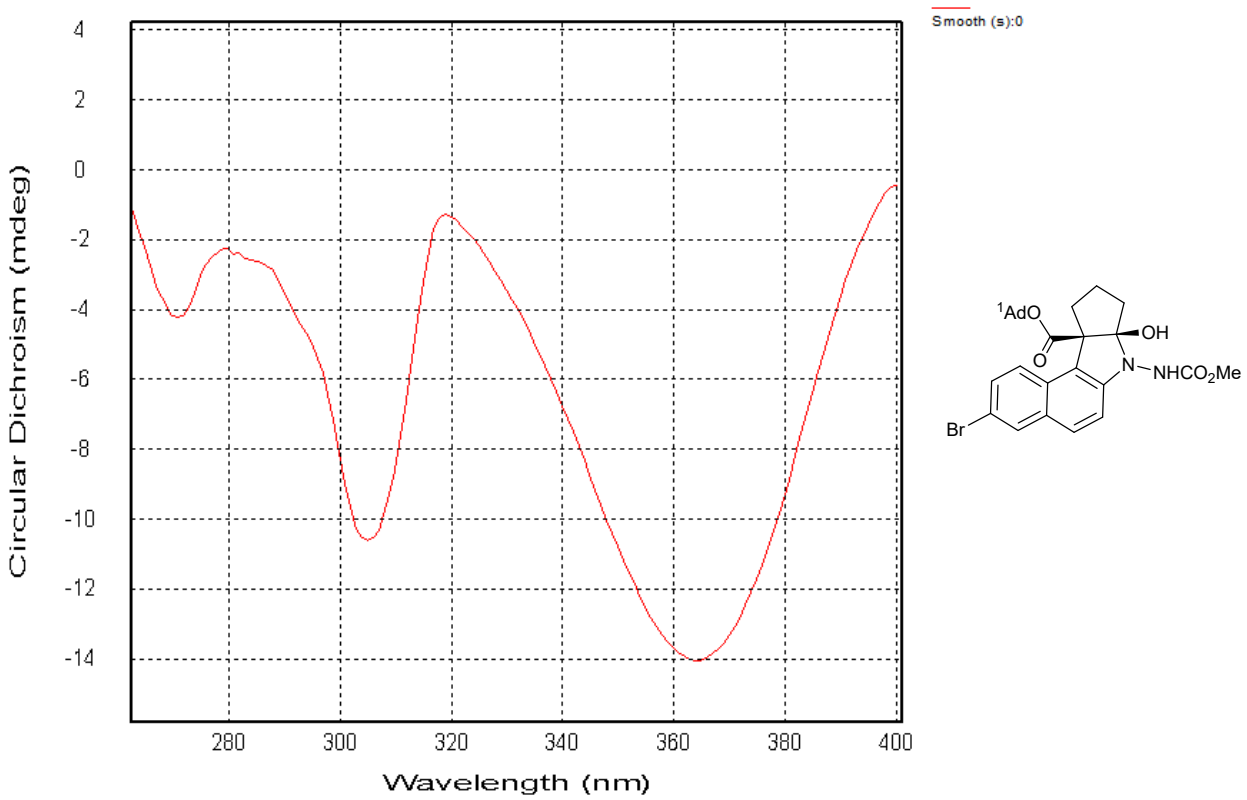

Smooth (s):0
Circular Dichroism (mdeg)
4
2
0
-2
-4
-6
-8
-10
-12
-14
280
300
320
340
360
380
400
Wavelength (nm)
1AdO
O
OH
N
NHCO2iPr

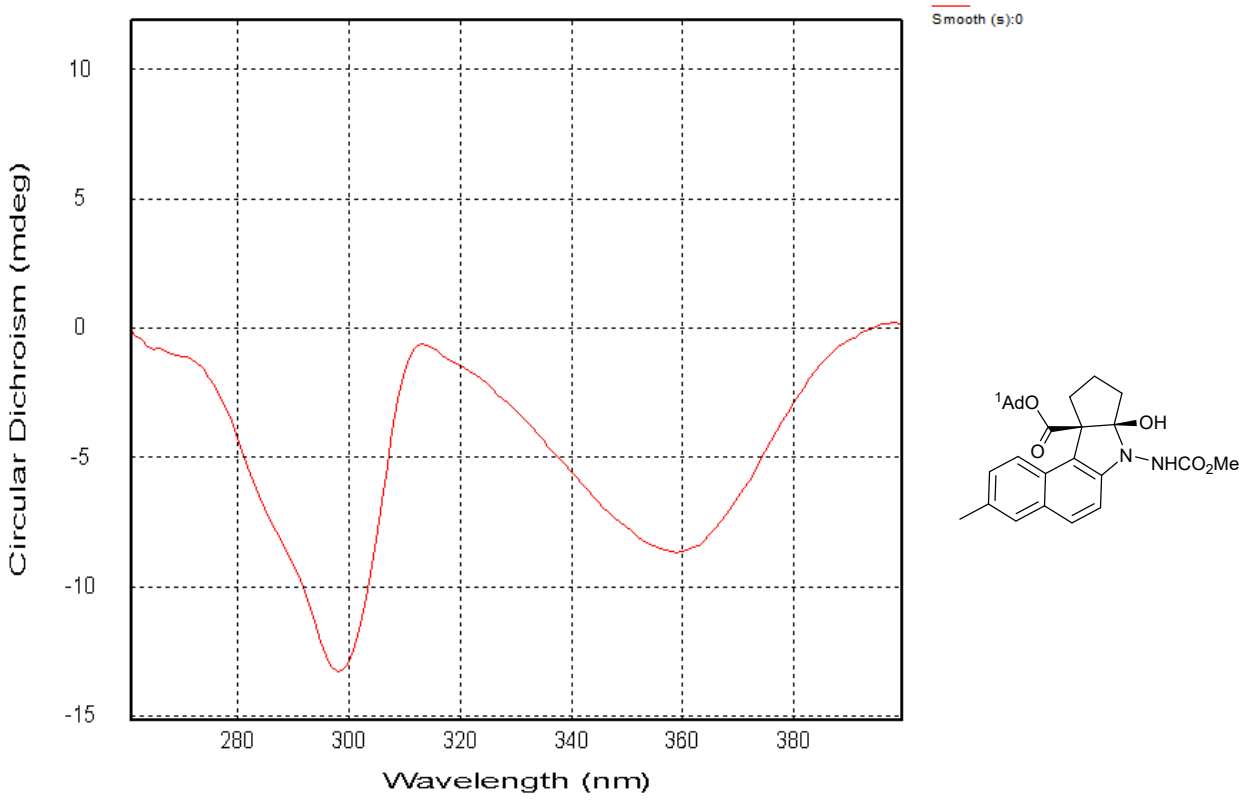

Smooth (s):0
Circular Dichroism (mdeg)
30
20
10
0
-10
-20
-30
-40
-50
260
280
300
320
340
360
380
Wavelength (nm)
1AdO
OH
O
N
NHCO2iBu

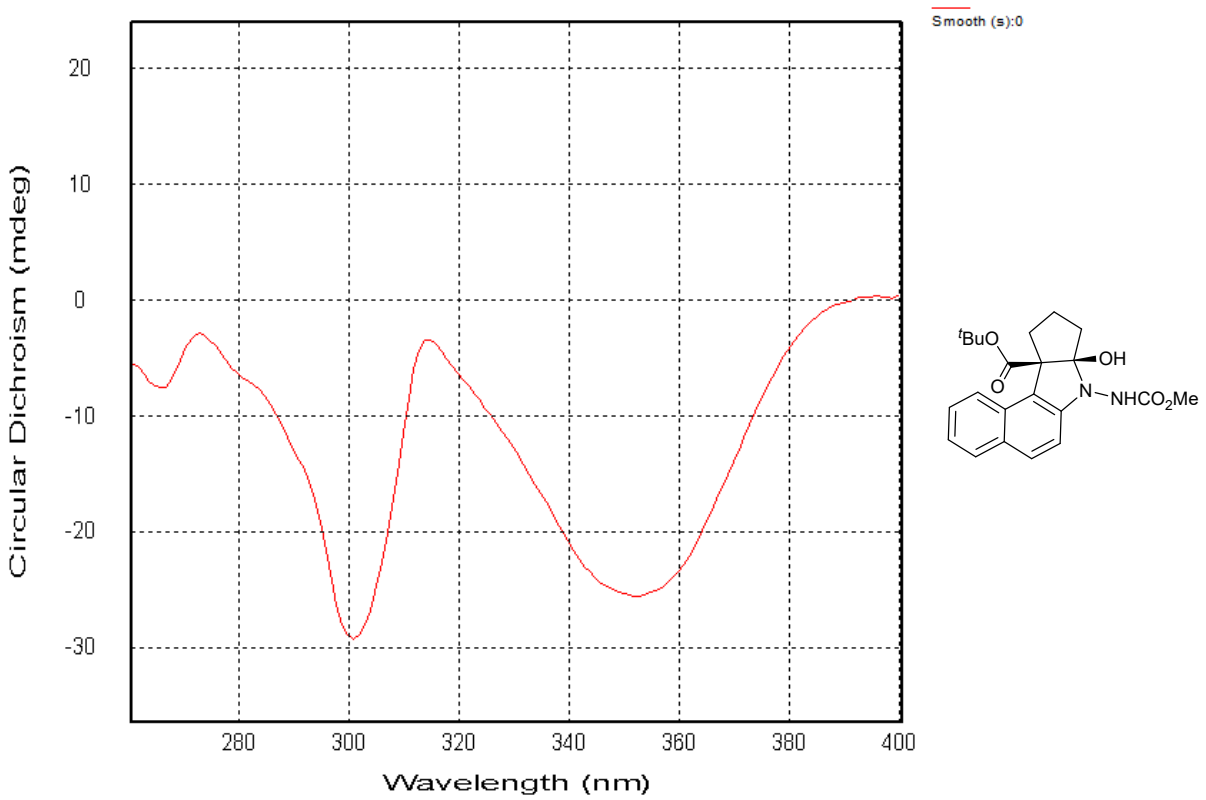

Smooth (s):0
Circular Dichroism (mdeg)
10
5
0
-5
-10
-15
280
300
320
340
360
Wavelength (nm)
1AdO
OH
O
N
NHCO2Bn

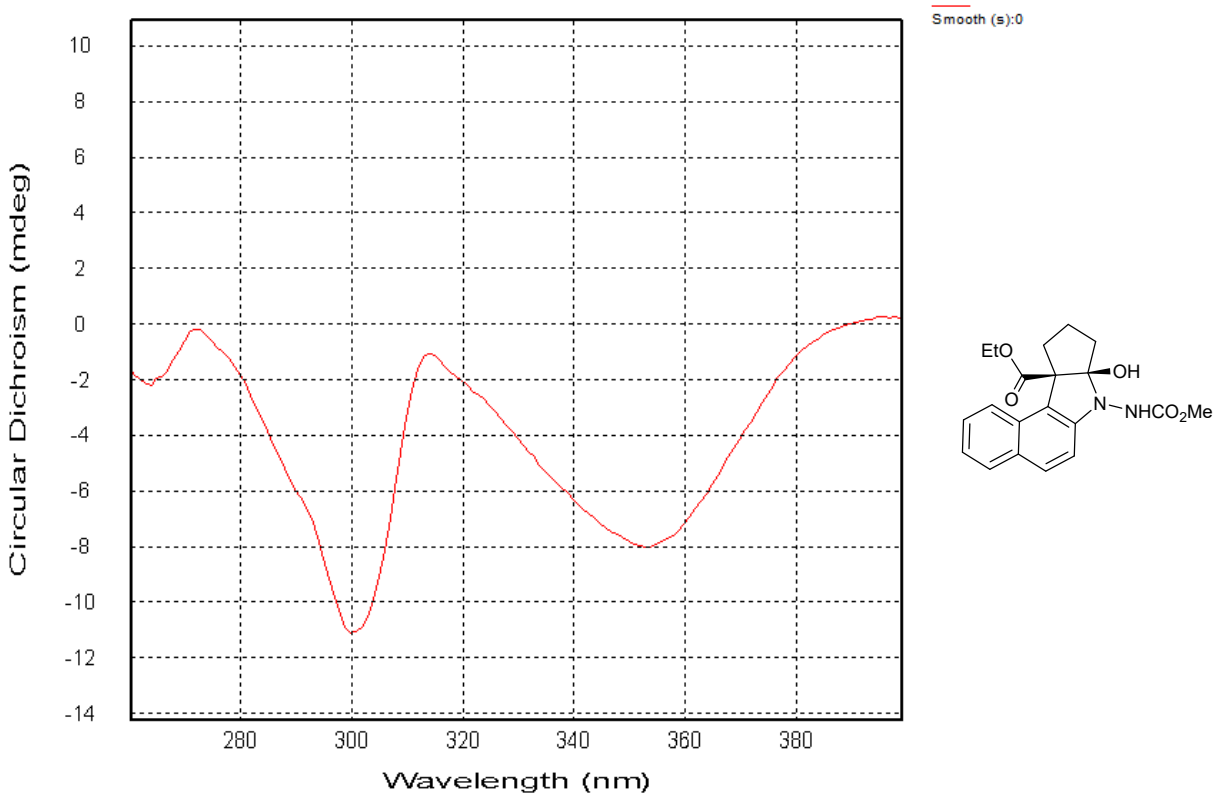

Smooth (s):0
Circular Dichroism (mdeg)
8
6
4
2
0
-2
-4
-6
-8
260
280
300
320
340
360
380
Wavelength (nm)
1AdO
OH
O
N
NHBz

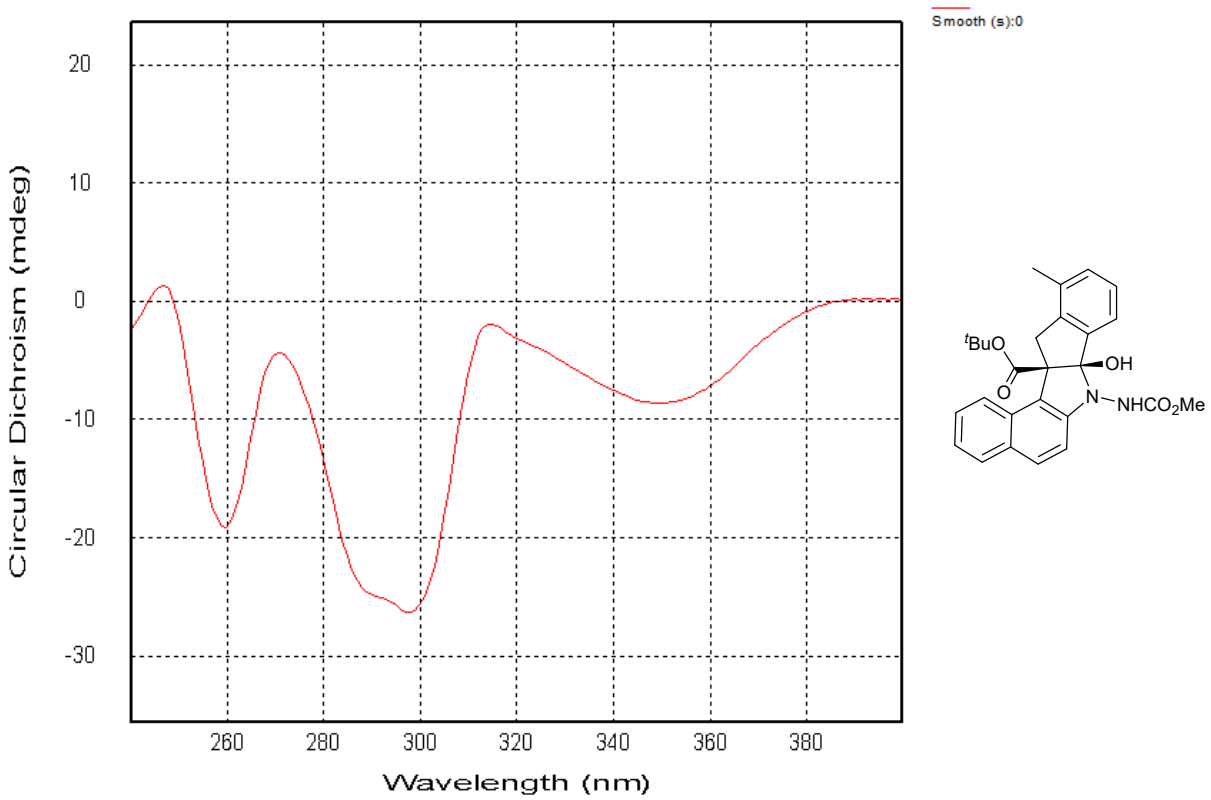

Smooth (s):0
Circular Dichroism (mdeg)
10
5
0
-5
-10
-15
280
300
320
340
360
380
Wavelength (nm)
1AdO
OH
O
Ph
N
NHCO2Me

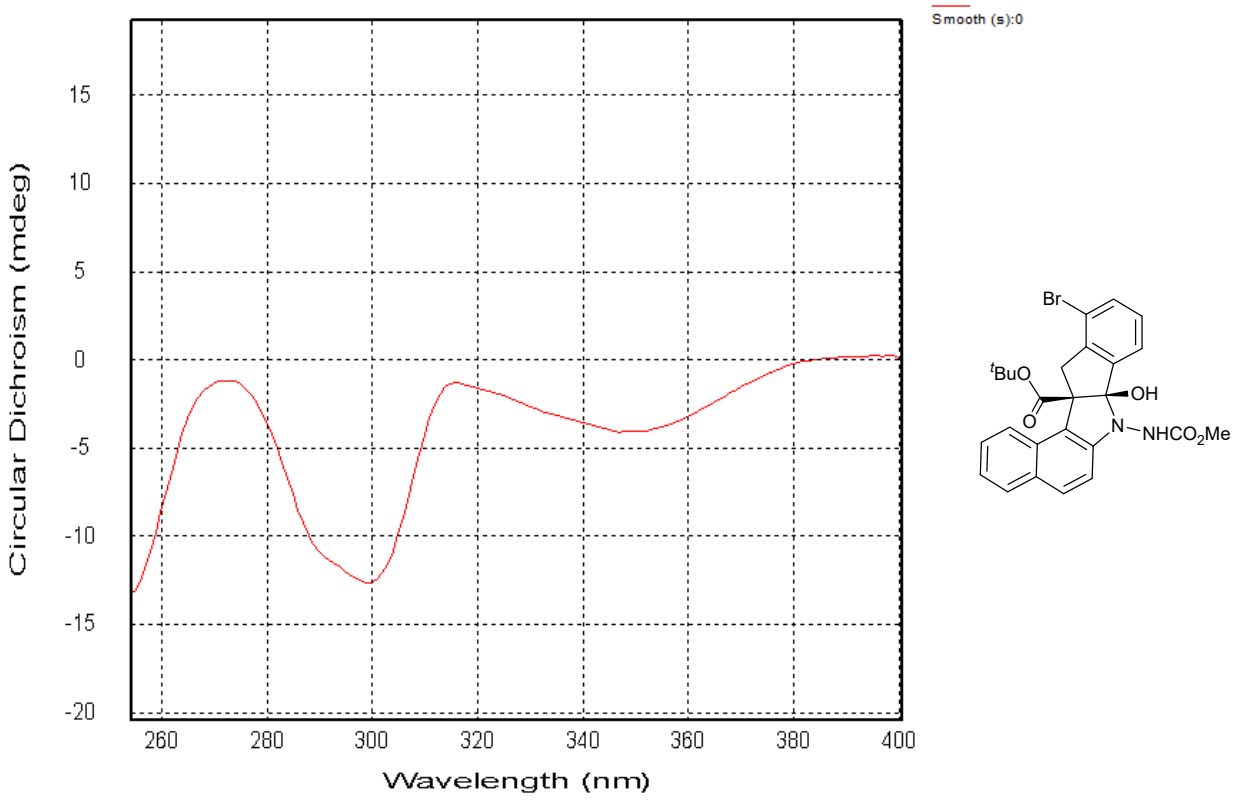

Smooth (s):0
Circular Dichroism (mdeg)
4
2
0
-2
-4
-6
-8
-10
-12
-14
280
300
320
340
360
380
400
Wavelength (nm)
1AdO
OH
O
N
NHCO2Me
Br

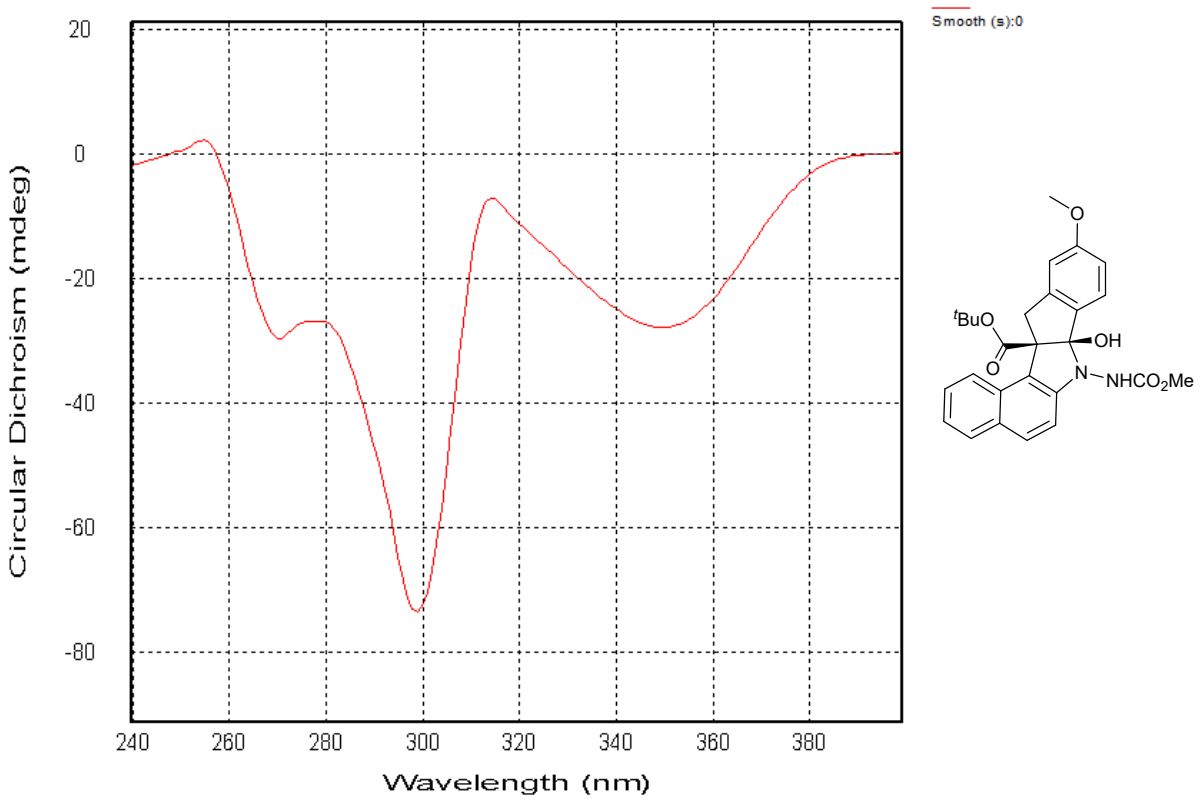

Smooth (s):0
Circular Dichroism (mdeg)
10
5
0
-5
-10
-15
280
300
320
340
360
380
Wavelength (nm)
1AdO
OH
O
N
NHCO2Me

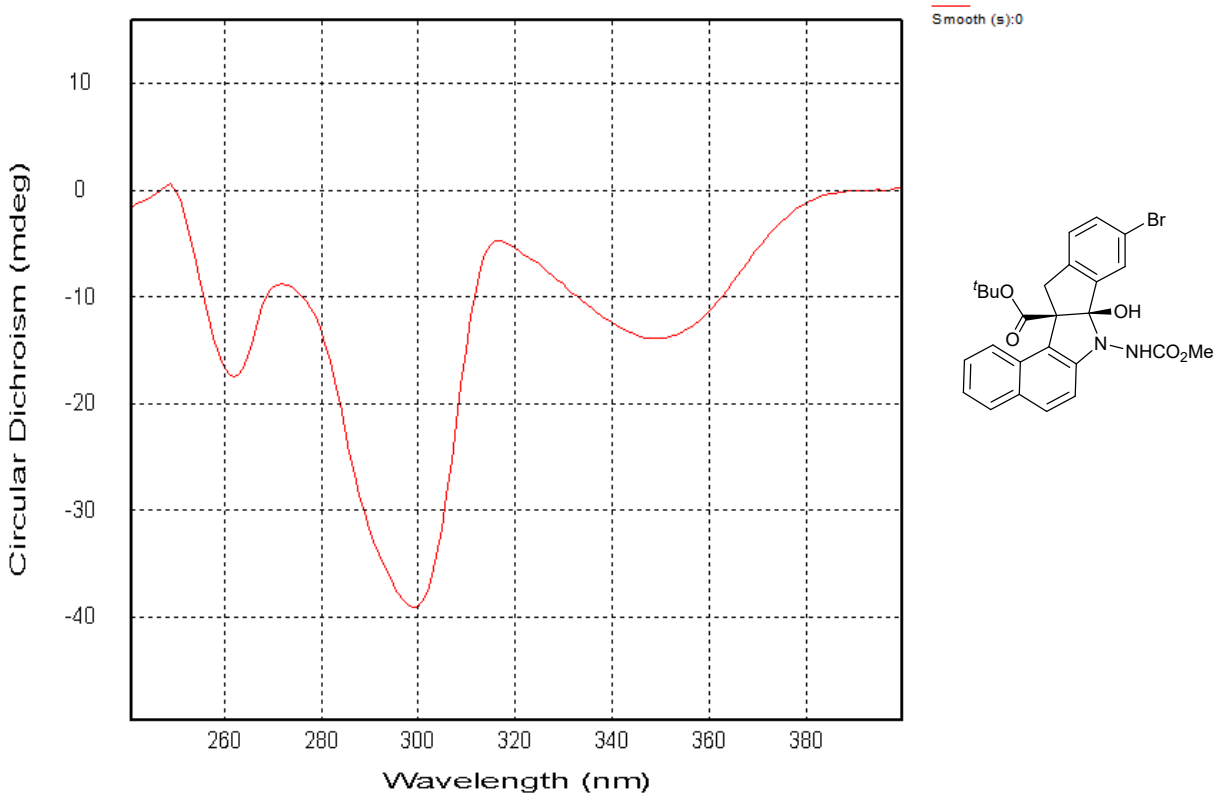

Smooth (s):0
Circular Dichroism (mdeg)
20
10
0
-10
-20
-30
280
300
320
340
360
380
400
Wavelength (nm)
tBuO
O
OH
N
NHCO2Me

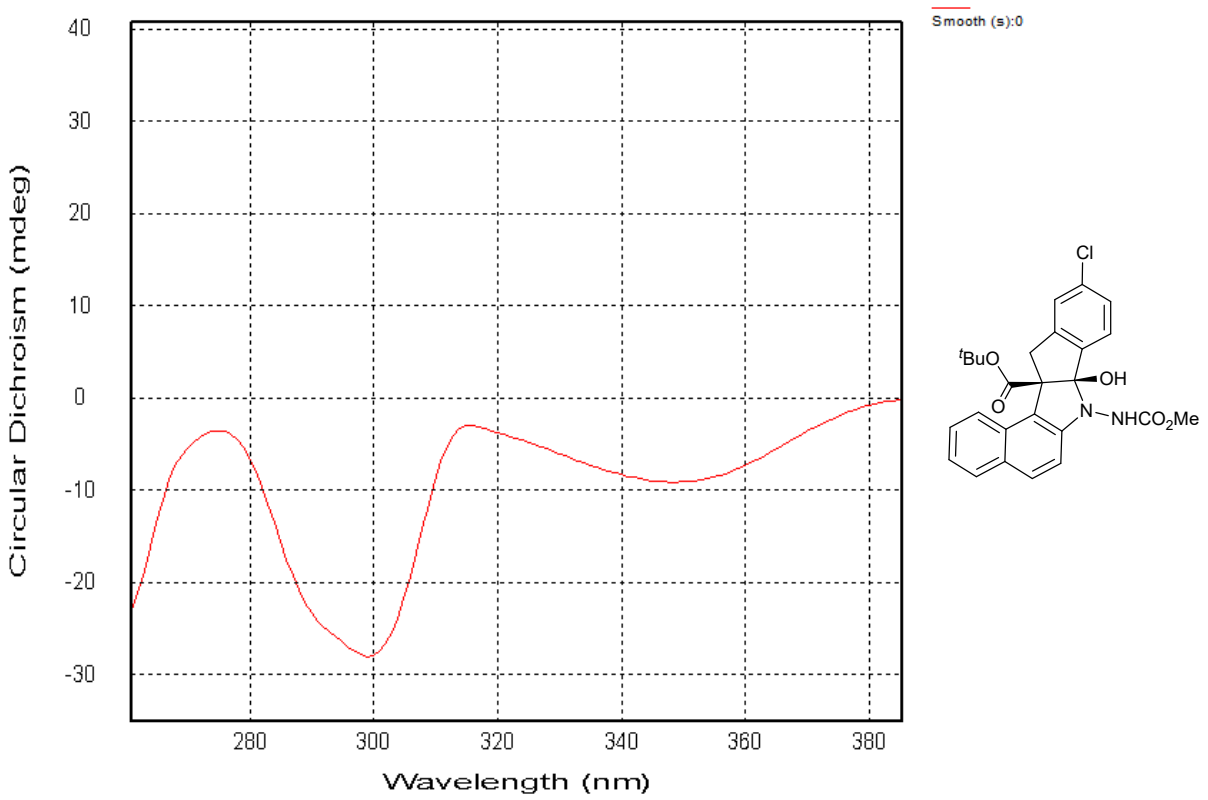

Smooth (s):0
Circular Dichroism (mdeg)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
280
300
320
340
360
380
Wavelength (nm)
EtO
O
OH
N
NHCO2Me

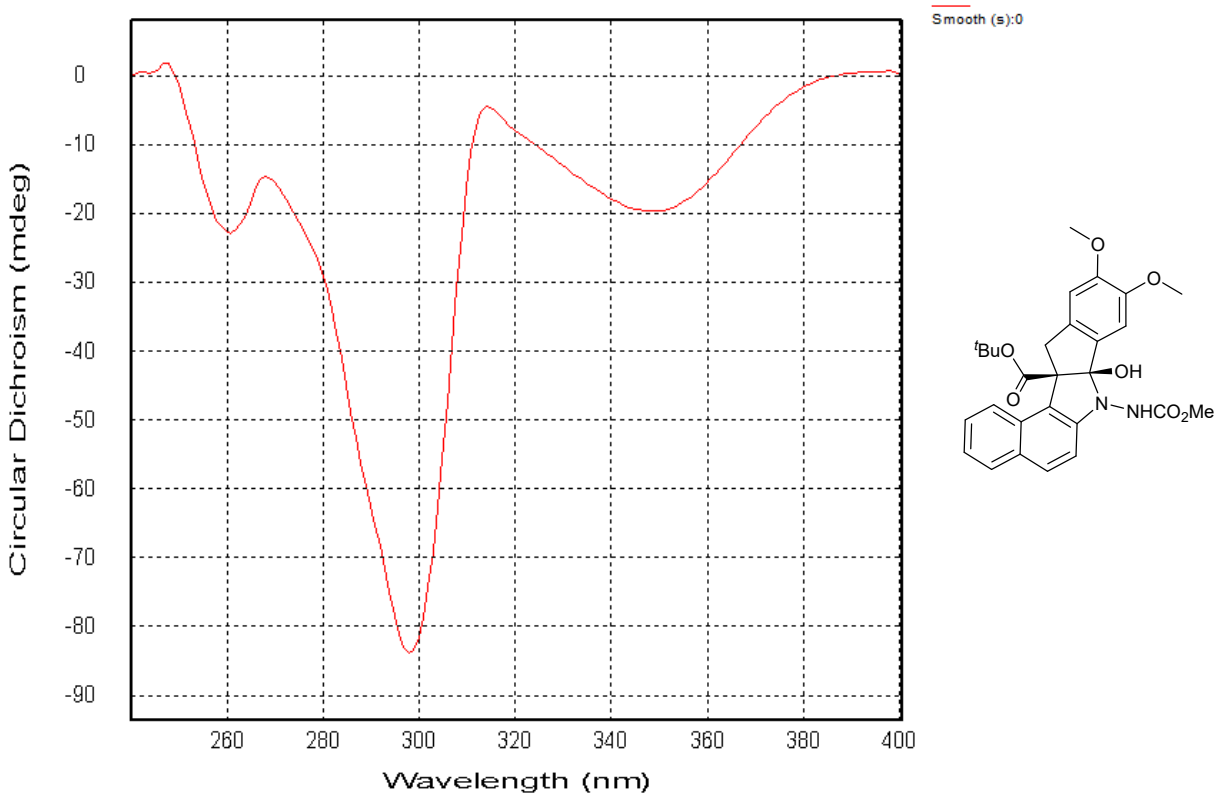

Smooth (s):0
Circular Dichroism (mdeg)
20
10
0
-10
-20
-30
260
280
300
320
340
360
380
Wavelength (nm)
tBuO
O
OH
N
NHCO2Me

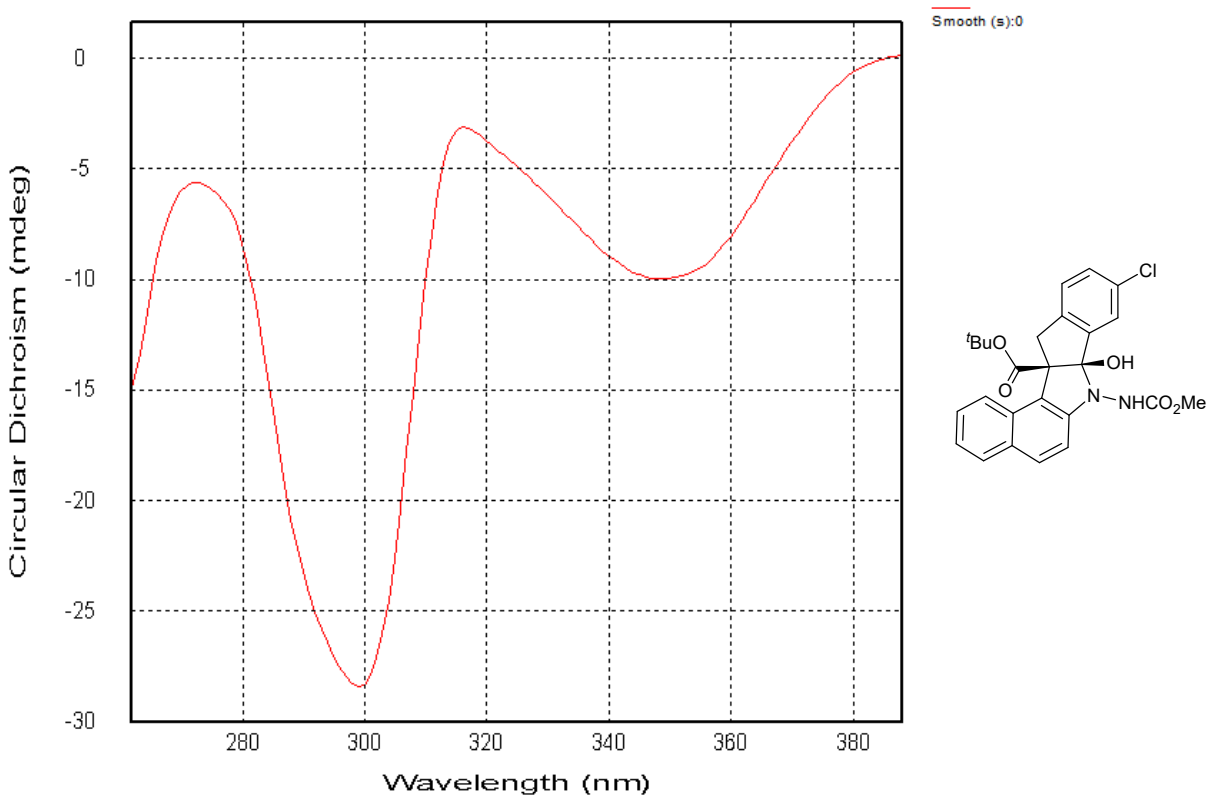

Smooth (s):0
Circular Dichroism (mdeg)
15
10
5
0
-5
-10
-15
-20
260
280
300
320
340
360
380
400
Wavelength (nm)
Br
tBuO
O
OH
N
NHCO2Me

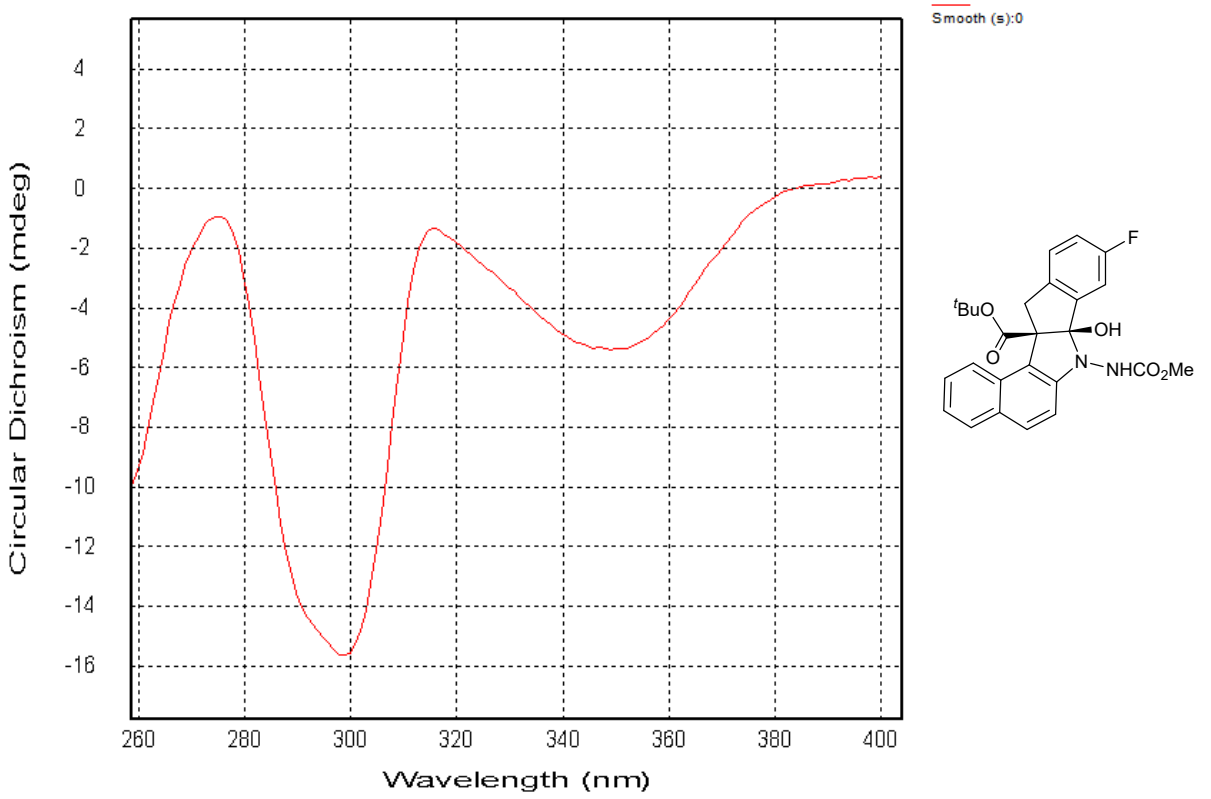

Smooth (s):0
Circular Dichroism (mdeg)
20
0
-20
-40
-60
-80
240
260
280
300
320
340
360
380
Wavelength (nm)
O
tBuO
O
OH
N
NHCO2Me

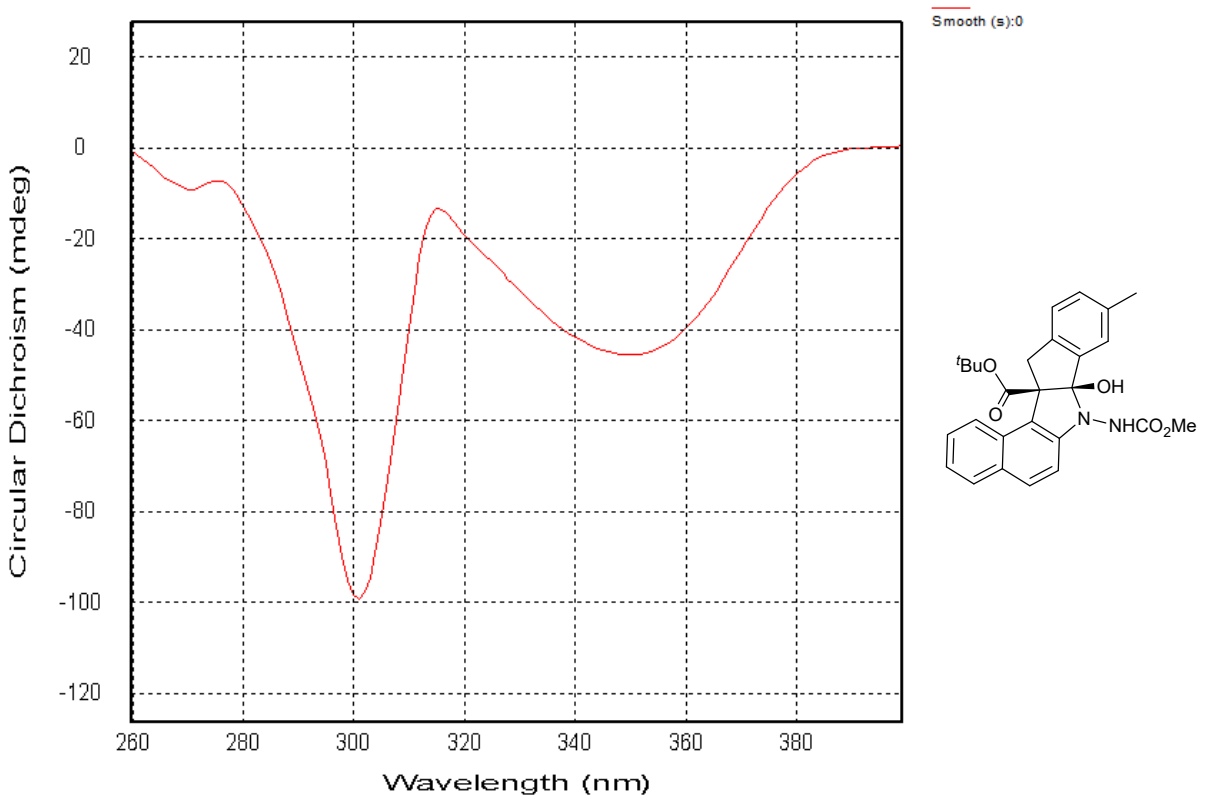

Smooth (s):0
Circular Dichroism (mdeg)
10
0
-10
-20
-30
-40
260
280
300
320
340
360
380
Wavelength (nm)
Br
tBuO
O
OH
N
NHCO2Me


Smooth (s):0
Circular Dichroism (mdeg)
40
30
20
10
0
-10
-20
-30
280
300
320
340
360
380
Wavelength (nm)
Cl
tBuO
O
OH
N
NHCO2Me


Smooth (s):0
Circular Dichroism (mdeg)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
260
280
300
320
340
360
380
400
Wavelength (nm)
O
O
tBuO
O
OH
N
NHCO2Me


Smooth (s):0
Circular Dichroism (mdeg)
0
-5
-10
-15
-20
-25
-30
280
300
320
340
360
380
Wavelength (nm)
Cl
tBuO
O
OH
N
NHCO2Me


Smooth (s):0
Circular Dichroism (mdeg)
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
260
280
300
320
340
360
380
400
Wavelength (nm)
F
tBuO
O
OH
N
NHCO2Me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Circular Dichroism (mdeg)
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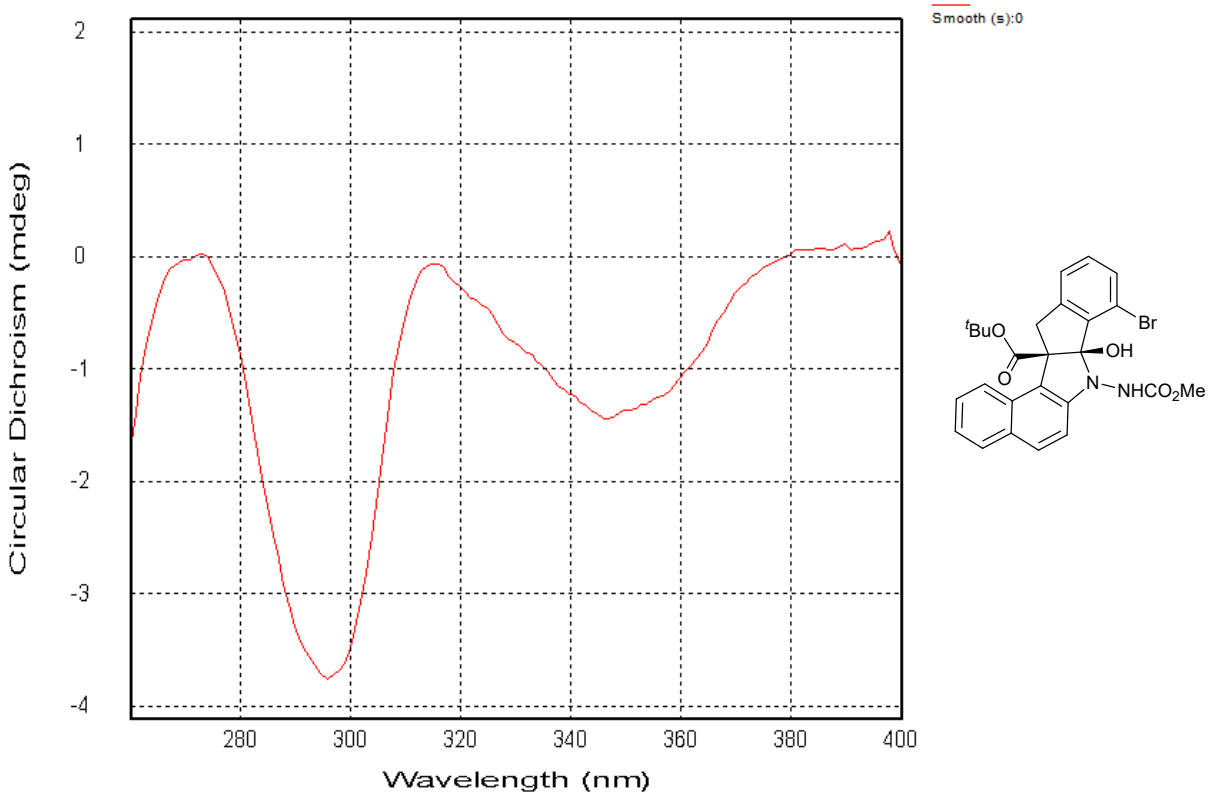
0
-20
-40
-60
-80
-100
-120
260
280
300
320
340
360
380
Wavelength (nm)
tBuO
O
OH
N
NHCO2Me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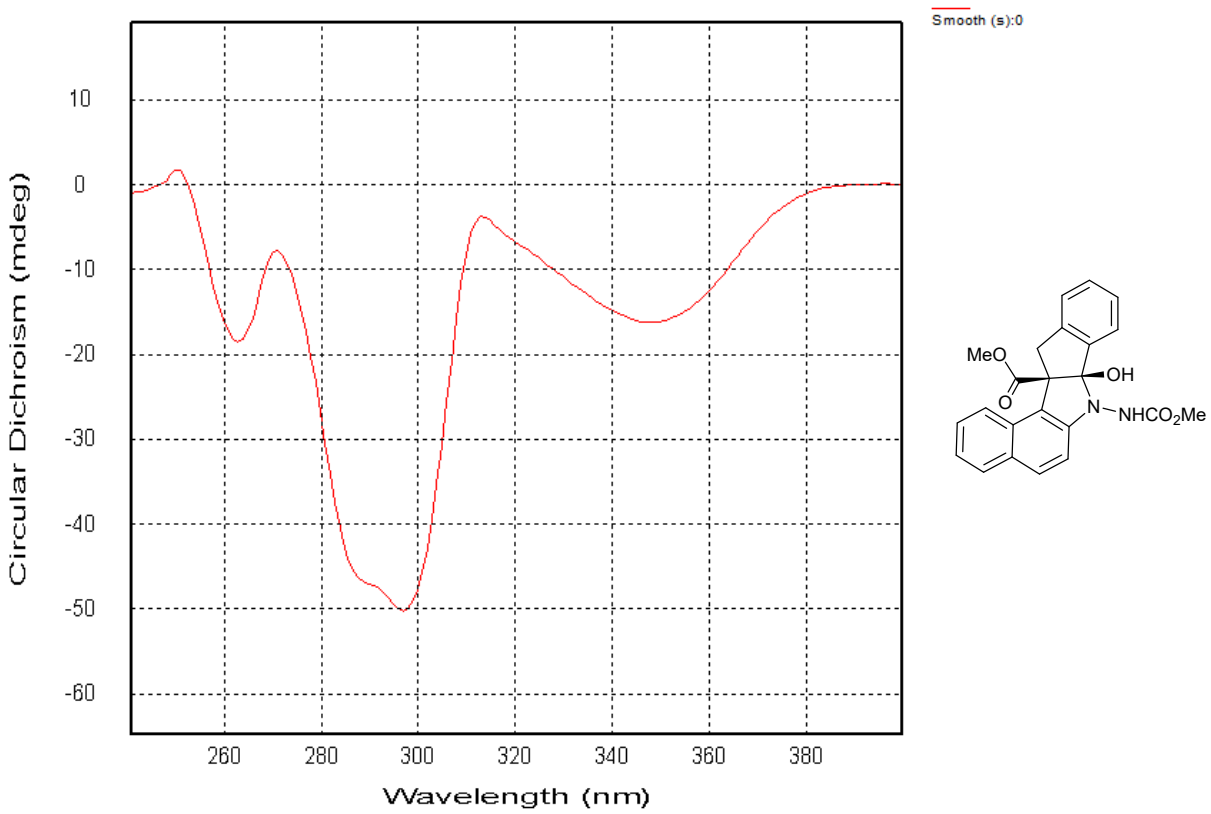
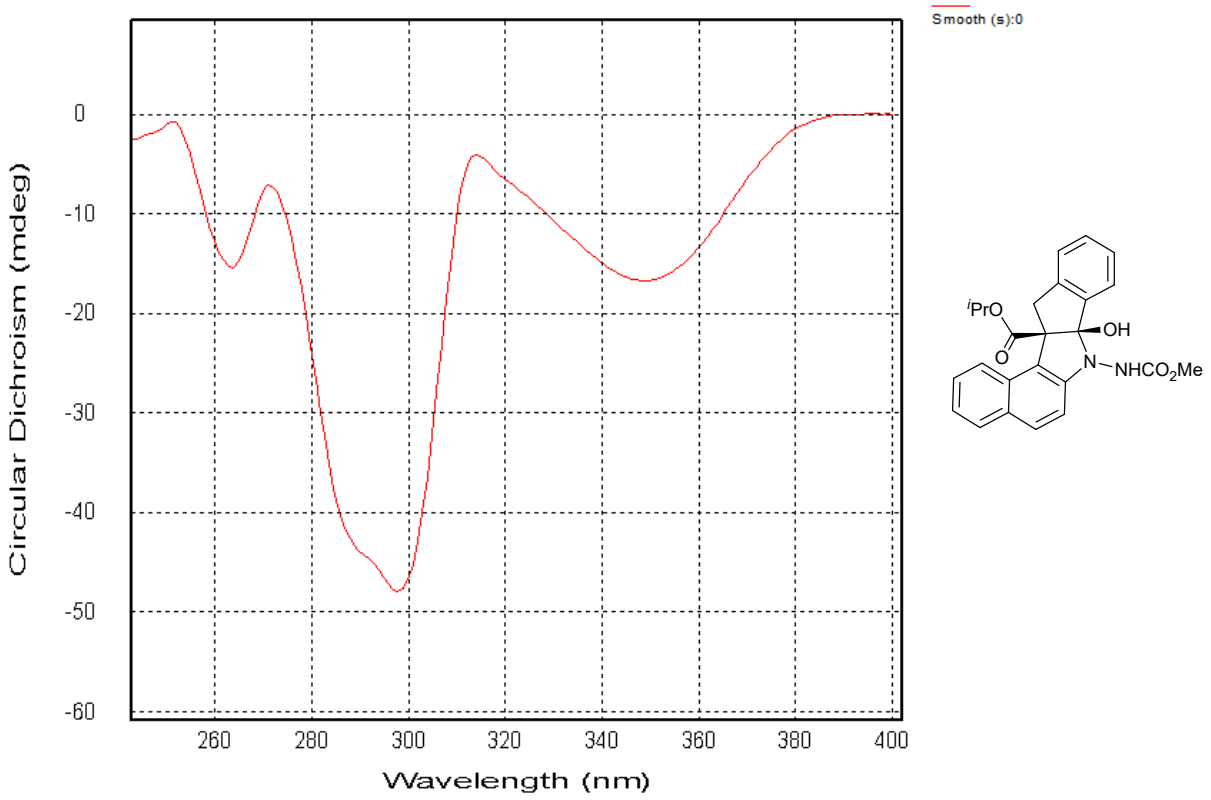
Circular Dichroism (mdeg)
2
1
0
-1
-2
-3
-4
280
300
320
340
360
380
400
Wavelength (nm)
tBuO
O
OH
Br
N
NHCO2Me


Smooth (s):0
Circular Dichroism (mdeg)
10
0
-10
-20
-30
-40
-50
-60
260
280
300
320
340
360
380
Wavelength (nm)
MeO
O
OH
N
NHCO2Me


Smooth (s):0
Circular Dichroism (mdeg)
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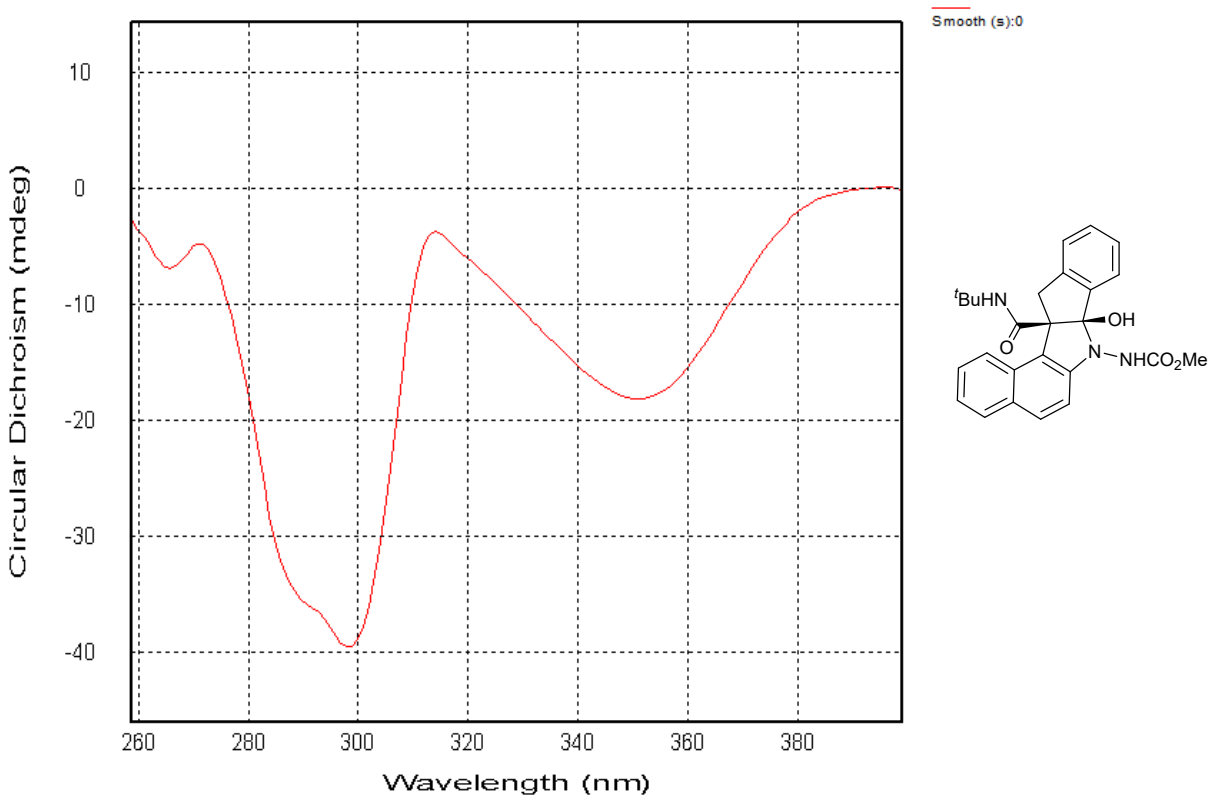
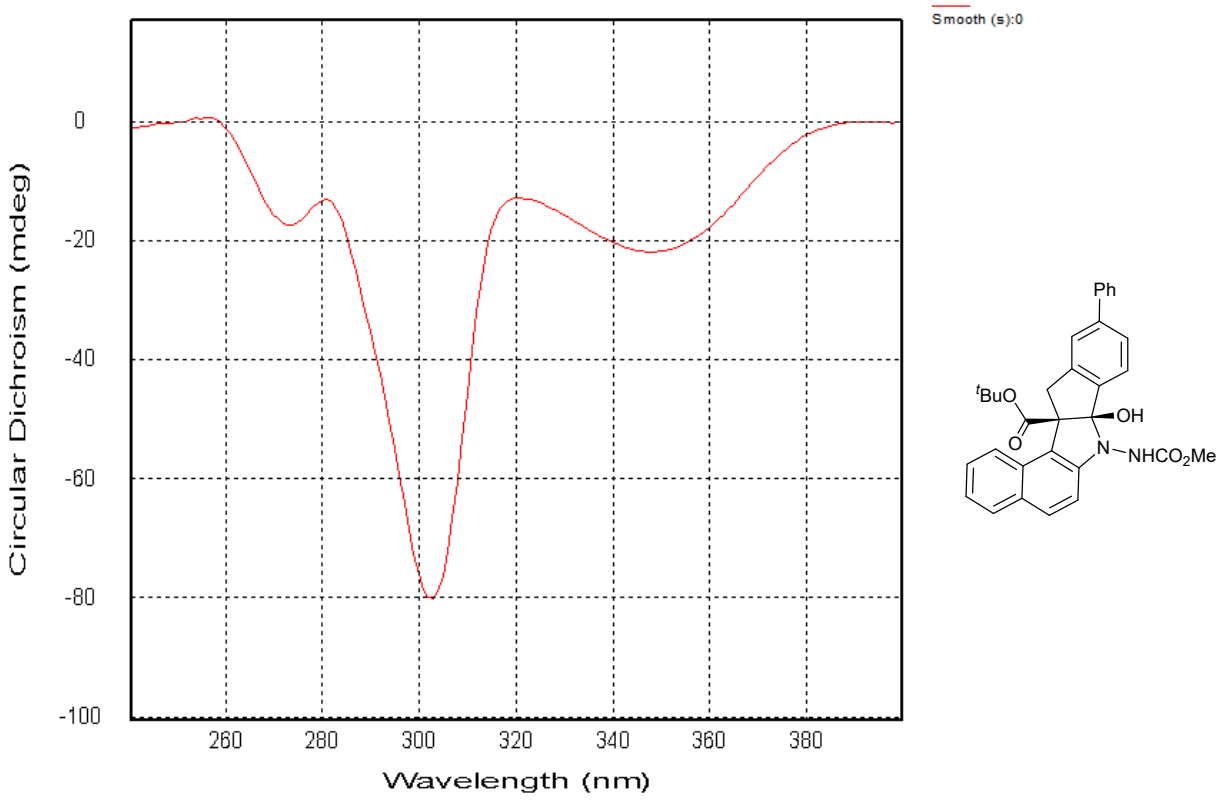
-10
-20
-30
-40
-50
-60
260
280
300
320
340
360
380
400
Wavelength (nm)
iPrO
O
OH
N
NHCO2Me


Smooth (s):0
Circular Dichroism (mdeg)
10
0
-10
-20
-30
-40
260
280
300
320
340
360
380
Wavelength (nm)
tBuHN
O
OH
N
NHCO2Me


Smooth (s):0
Circular Dichroism (mdeg)
0
-20
-40
-60
-80
-100
260
280
300
320
340
360
380
Wavelength (nm)
Ph
tBuO
O
OH
N
NHCO2Me

13. Reference.

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