Stereoselective Skeletal Modification of Tryptanthrins to Install Chiral Piperidine-2-Ones enabled by Brønsted Acid Catalysis†

Rong Zeng,[a,b] Xiang Zhang,[b] Yuan-Yuan Lei,[b] Zhuo-Zhuo Zhang,[b] Min Jiang,[b] Qing-Zhu Li,[b] Jun-Long Li*[a,b] and Bo Han*[a]

[a] *State Key Laboratory of Southwestern Chinese Medicine Resources, School of Pharmacy, Chengdu University of Traditional Chinese Medicine, Chengdu 611137, PR China.*

[b] *Anti-infective Agent Creation Engineering Research Centre of Sichuan Province, Sichuan Industrial Institute of Antibiotics, School of Pharmacy, Chengdu University, Chengdu 610106, PR China.*

Email: hanbo@cdutcm.edu.cn; lijunlong709@hotmail.com.

Supplementary Information

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1. General Information

General Procedures.

All reactions were performed in over-dried or flame-dried reaction vessels, modified Schlenk flasks, or round-bottom flasks. The flasks were fitted with Teflon screw caps and reactions were conducted under an atmosphere of argon if needed. Gas-tight syringes with stainless steel needles were used to transfer air- and moisture-sensitive liquids. All moisture and/or air sensitive solid compounds were manipulated inside normal desiccators. Flash column chromatography was performed over silica gel (40 – 45 μm, 300 – 400 mesh).

Analytical thin layer chromatography (TLC) was performed on silica gel $HSGF_{254}$ glass plates (purchased from Jiangyou silica gel development Co., Ltd, Yantai, China) containing a 254 nm fluorescent indicator. TLC plates were visualized by exposure to short wave ultraviolet light (254 nm) or I_2 and to a solution of $KMnO_4$ (1 g of $KMnO_4$, 6 g of K_2CO_3 and 0.1 g of KOH in 100 mL of H_2O) or vanillin (2 g of vanillin and 4 mL of concentrated H_2SO_4 in 100 mL of EtOH) followed by heating.

Organic solutions were concentrated at 30 – 40 °C on rotary evaporators at ~80 mbar followed by drying on vacuum pump below 1 mbar. Reaction temperatures are reported as the temperature of the bath surrounding the vessel unless otherwise stated.

Materials.

Commercial reagents were obtained from Adamas-beta, Aldrich Chemical Co., Alfa Aesar, Leyan, Macklin and Energy Chemical and used as received. All-solvents were dried and/or distilled by standard methods.[1,2,3] Various tryptanthrins[4] and azlactones[5] was synthesized according to previous reports.

Instrumentation.

Proton nuclear magnetic resonance (^{1}H NMR) spectra were measured on a JEOL JNM-ECZ600R/S1 spectrometer at ambient temperature for ^{1}H at 600 MHz. Proton chemical shifts are reported in parts per million (δ scale), and are referenced using tetramethylsilane (TMS) as an internal standard or residual protium in the NMR solvent ($CDCl_3$: δ 7.26 ($CHCl_3$) or DMSO-d_6: δ 2.50 (CD_2HSOCD_3)). Data are reported as follows: chemical shift [multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of doublets, td = triplet of doublets, brs = broad singlet), coupling constant(s) (Hz), integration].

Carbon-13 nuclear magnetic resonance (^{13}C NMR) spectra measured on a JEOL JNM-ECZ600R/S1 spectrometer at ambient temperature for ^{13}C at 151 MHz.. Carbon

chemical shifts are reported in parts per million (δ scale), and are referenced using the carbon resonances of the solvent (δ 77.00 ($CDCl_3$) or δ 39.52 (DMSO-d_6)). Data are reported as follows: chemical shift [multiplicity (if not singlet), assignment (C_q = fully substituted carbon)].

High resolution mass spectra (HRMS) were performed on an Agilent 6230 time-of-flight (TOF) LC/MS instrument or a Waters SYNAPT G2 mass spectrometer by using an electrospray ionization (ESI) ionization source analyzed by quadrupole time-of-flight (Q-TOF). Melting points were determined on a SGW X-4 digital melting point apparatus and temperatures were not corrected.

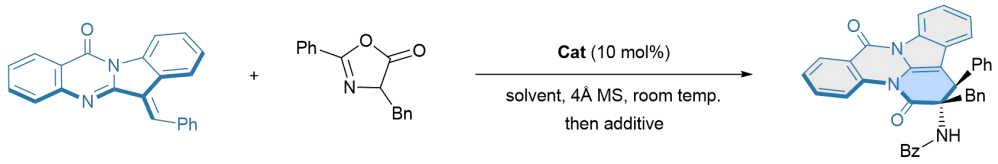
Enantiomeric ratio (er) values were determined on an Agilent 1260 Infinity II chiral HPLC, using Daicel CHIRALPAK® IA, IC, columns with hexane and 2-propanol as eluent, hexane, DCM and CH_3OH as eluent. Er values for several compounds were determined on a Waters Acquity UPC2 chiral HPLC using Daicel CHIRALPAK® IA, IG columns with CO_2 and 2-propanol as eluent.

Optical rotation was measured with a Rudolph Autopol IV automatic polarimeter at 20 °C using 100 mm cell of 2.5 mL capacity, and $[\alpha]_D^{20}$ values reported in degrees.

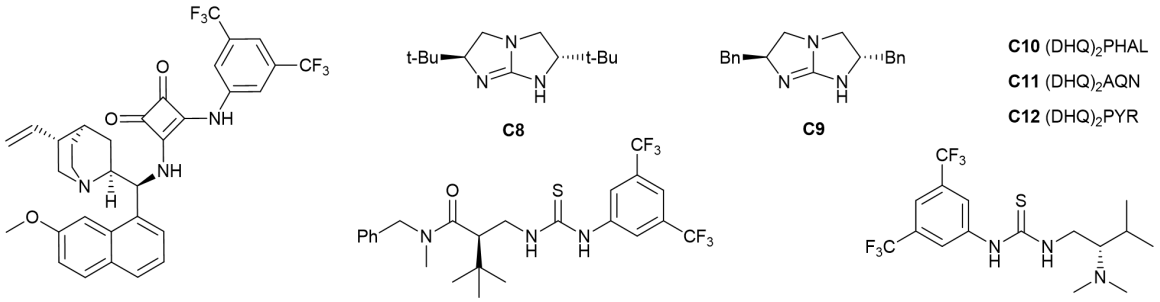
Melting points were determined on a SGW X-4 digital melting point apparatus using open glass capillaries and temperatures were not corrected, reported in degrees Celsius.

2. Further Optimisation Studies

Table S1. Optimisation this reaction conditions. [a]



1a 2a 3a

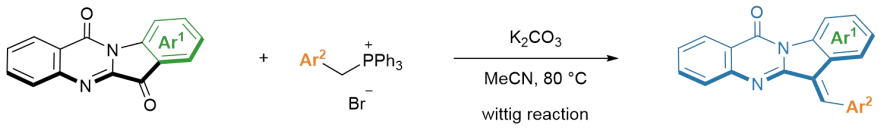


C7 C8 C9 C13 C14

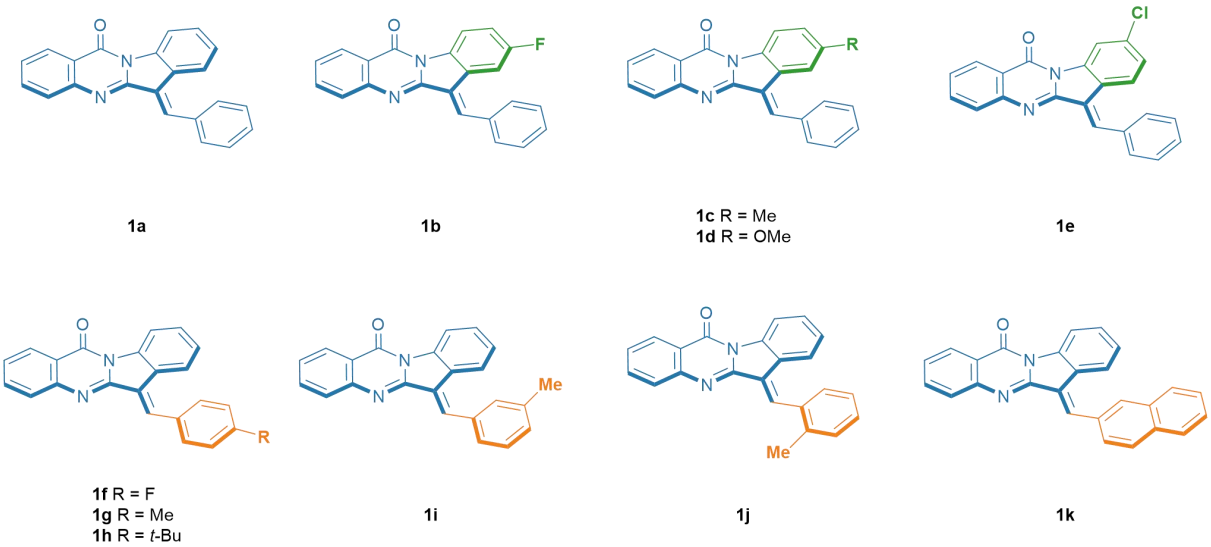
Entry	Catalyst	Additive	Solvent	Yield (%) [b]	Er
1	**C7**	-	DCM	n.r.	-
2	**C8**	-	DCM	n.r.	-
3	**C9**	-	DCM	n.r.	-
4	**C10**	-	DCM	n.r.	-
5	**C11**	-	DCM	n.r.	-
6	**C12**	-	DCM	n.r.	-
7	**C13**	-	DCM	n.r.	-
8	**C14**	-	DCM	< 5	n.d.
9[c]	**C1**	$Sc(OTf)_3$	DCM	51	90:10
10[c]	**C1**	TfOH	DCM	n.r.	-
11[c]	**C1**	DBU	DCM	n.r.	-
12[c]	**C1**	TMG	DCM	n.r.	-
13[d]	**C1**	TEA	DCM	81	95:5
14[e]	**C1**	TEA	DCM	70	95:5

[a] Unless otherwise noted, reactions were performed with 0.10 mmol of **1a**, 0.15 mmol of **2a**, and 10 mol % catalyst **C** in 1.0 mL of solvent at room temp. for 8 h, then added with 0.3 mL of TEA for 0.5 h. [b] Isolated yield. [c] Performed with 20 mol% additive. [d] preformed with 0.2 mL TEA for 0.5 h. [e] preformed with 0.1 mL TEA for 0.5 h. n.r. : no reaction. n.r. : no detected.

3. General Procedure for the synthesis of tryptanthrin derived aza-diene 1.



S-1 1

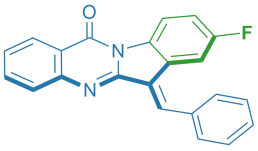


1a 1b **1c** R = Me **1d** R = OMe 1e

1f R = F **1g** R = Me **1h** R = *t*-Bu 1i 1j 1k

Tryptanthrin **S-1** were synthesized according to the reported literature procedures.[4] To an 100mL over-dried Schlenck tube was added substrates S-**1** (5.0 mmol), K_2CO_3 (6.0 mmol) and different Wittig reagents (6.0 mmol). The Schlenck tube was subjected to three cycles of pressurization/depressurization using dry Ar. After that, under the protection of Ar atmosphere, the solvent of MeCN (10 mL) was added, and the reaction mixture was stirred at 80 °C for 12 hours. Then the mixture were filtered, and the obtained green solid were washed with a small amount of cold acetonitrile until chaning to a yellow solid. After that, the crude product diluted with water and extracted by DCM three times. The combined organic phases were washed with brine, dried over with anhydrous Na_2SO_4, filtered and concentrated in vacuum to afford the corresponding tryptanthrin derived aza-diene **1**. All products were dried under vacuum and further analyzed by ^{1}H NMR, ^{13}C NMR, HRMS analysis, *etc*. Notice: **1a** was reported compund,[6] and some substrates are very difficult to dissolve in various deuterated solvents, such as **1f, 1g, 1k**.

(E)-6-benzylidene-8-fluoroindolo[2,1-b]quinazolin-12(6H)-one-1b



Prepared according to ***General Procedure*** to afford **1b** in 75% yield as a yellow solid, m. p. = 200 – 203 °C。

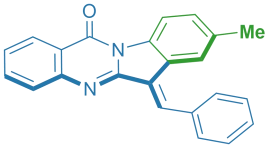
*NMR and HRMS data for the product **1b***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.67 – 8.64 (m, 1H), 8.41 (d, *J* = 8.4 Hz, 1H), 8.38 (s, 1H), 7.78 (d, *J* = 3.6 Hz, 2H), 7.67 (d, *J* = 7.8 Hz, 2H), 7.54 – 7.47 (m, 5H), 7.14 – 7.11 (m, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 160.3 (d, $J_{C\text{-}F}$ = 244.2 Hz), 159.3, 152.6, 147.4, 136.2, 134.5, 134.3, 130.0, 129.2, 129.0 127.7, 127.1 (d, $J_{C\text{-}F}$ = 2.9 Hz), 127.0, 126.8, 125.7 (d, $J_{C\text{-}F}$ = 8.7 Hz), 121.3, 118.3 (d, $J_{C\text{-}F}$ = 8.7 Hz), 116.8 (d, $J_{C\text{-}F}$ = 24.6 Hz), 110.0 (d, $J_{C\text{-}F}$ = 26.0 Hz).

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{22}H_{13}FN_2OH^+$ 341.1085, found 341.1088.

(E)-6-benzylidene-8-methylindolo[2,1-b]quinazolin-12(6H)-one-1c



Prepared according to ***General Procedure*** to afford **1c** in 48% yield as a yellow solid, m. p. = 177 – 180 °C。

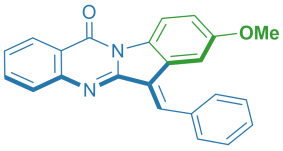
*NMR and HRMS data for the product **1c***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.54 (d, *J* = 8.4 Hz, 1H), 8.42 (d, *J* = 7.8 Hz, 1H), 8.31 (s, 1H), 7.78 – 7.70 (m, 4H), 7.62 (s, 1H), 7.52 – 7.46 (m, 4H), 7.24 (d, *J* = 8.4 Hz, 1H), 2.28 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 159.4, 153.0, 147.5, 137.9, 135.5, 135.1, 134.5, 134.1, 130.9, 129.6, 129.3, 128.7, 127.8, 127.6, 127.0, 126.6, 124.2, 123.2, 121.5, 116.9, 21.5.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{23}H_{16}N_2ONa^+$ 359.1155, found 359.1154.

(E)-6-benzylidene-8-methoxyindolo[2,1-b]quinazolin-12(6H)-one-1d



Prepared according to ***General Procedure*** to afford **1d** in 58% yield as a yellow solid, m. p. = 220 – 223 °C。

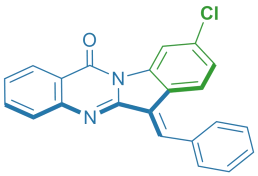
*NMR and HRMS data for the product **1d***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.61 – 8.55 (m, 3H), 8.42 (d, *J* = 7.8 Hz, 1H), 7.79 – 7.75 (m, 2H), 7.65 (s, 1H), 7.52 – 7.48 (m, 4H), 7.26 (s, 1H), 6.99 (d, *J* = 7.8 Hz, 1H), 3.91 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 159.3, 158.1, 150.6, 147.3, 135.4, 134.1, 133.8, 132.8, 132.2, 130.6, 129.0, 128.3, 128.1, 127.1, 126.7, 126.4, 121.4, 118.2, 114.8, 104.6, 55.8.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{23}H_{16}N_2O_2Na^+$ 375.1104, found 375.1106.

(E)-6-benzylidene-9-chloroindolo[2,1-b]quinazolin-12(6H)-one-1e



Prepared according to ***General Procedure*** to afford **1e** in 69% yield as a yellow solid, m. p. = 194 – 198 °C。

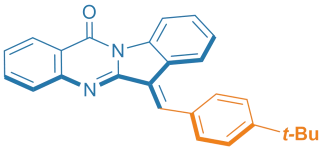
*NMR and HRMS data for the product **1e***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.72 – 8.72 (m, 1H), 8.41 (d, *J* = 8.4 Hz, 1H), 8.32 (s, 1H), 7.79 – 7.77 (m, 2H), 7.72 (d, *J* = 8.4 Hz, 1H), 7.67 (d, *J* = 7.8 Hz, 2H), 7.53 – 7.46 (m, 4H), 7.11 (d, *J* = 8.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 159.4, 152.5, 147.4, 140.6, 135.8, 135.1, 134.8, 134.5, 129.8, 129.2, 128.9, 127.7, 127.2, 126.9, 126.8, 125.9, 123.5, 122.6, 121.2, 117.6.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{22}H_{13}{}^{35}ClN_2OH^+$ 357.0789, found 357.0792; calculated for $C_{22}H_{13}{}^{37}ClN_2OH^+$ 359.0760, found 359.0763.

(E)-6-(4-(tert-butyl)benzylidene)indolo[2,1-b]quinazolin-12(6H)-one-1h



Prepared according to ***General Procedure*** to afford **1f** in 81% yield as a yellow solid, m. p. = 120 – 124 °C。

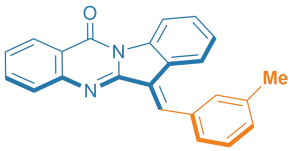
*NMR and HRMS data for the product **1f***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.68 (d, *J* = 7.8 Hz, 1H), 8.41 (d, *J* = 7.8 Hz, 1H), 8.30 (s, 1H), 7.95 (d, *J* = 8.4 Hz, 1H), 7.78 – 7.74 (m, 2H), 7.67 (d, *J* = 7.8 Hz, 2H), 7.54 – 7.41 (m, 4H), 7.16 (t, *J* = 7.8 Hz, 1H), 1.40 (s, 9H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 159.6, 153.3, 152.9, 147.5, 139.9, 135.1, 134.2, 133.0, 132.0, 129.9, 129.4, 127.5, 127.0, 126.8, 126.4, 125.6, 124.3, 122.7, 121.3, 117.2, 35.0, 31.2.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{26}H_{22}N_2OH^+$ 379.1805, found 379.1809.

(E)-6-(3-methylbenzylidene)indolo[2,1-b]quinazolin-12(6H)-one-1i



Prepared according to ***General Procedure*** to afford **1i** in 45% yield as a yellow solid, m. p. = 210 – 212 °C。

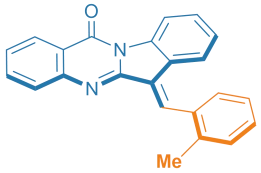
*NMR and HRMS data for the product **1i***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.69 (d, *J* = 7.2 Hz, 1H), 8.45 (d, *J* = 6.0 Hz, 1H), 8.39 (s, 1H), 7.82 – 7.79 (m, 2H), 7.60 – 7.30 (m, 7H), 7.10 (s, 1H), 2.43 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 159.6, 152.4, 147.6, 139.9, 137.3, 134.4, 134.3, 134.2, 130.6, 130.1, 129.5, 128.6, 128.4, 127.7, 127.1, 126.7, 126.0, 125.8, 124.4, 123.0, 121.5, 117.2, 20.1.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{23}H_{16}N_2OH^+$ 337.1335, found 337.1343.

(E)-6-(2-methylbenzylidene)indolo[2,1-b]quinazolin-12(6H)-one-1j



Prepared according to ***General Procedure*** to afford **1k** in 38% yield as a yellow solid, m. p. = 208 – 211 ℃。

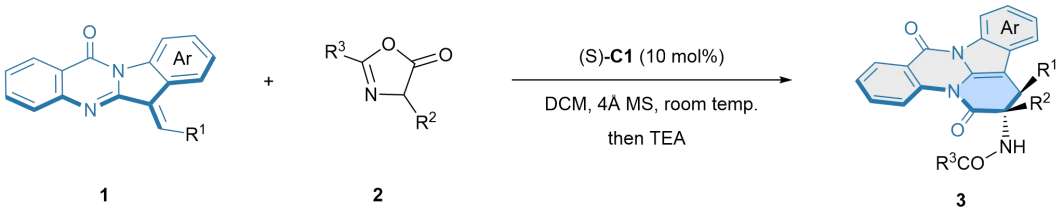
*NMR and HRMS data for the product **1k***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.64 (d, *J* = 8.4 Hz, 1H), 8.60 (s, 1H), 8.42 (d, *J* = 8.4 Hz, 1H), 8.29 (d, *J* = 7.8 Hz, 1H), 7.74 (t, *J* = 8.4 Hz, 3H), 7.64 (s, 1H), 7.53 – 7.50 (m, 1H), 7.44 (t, *J* = 7.8 Hz, 1H), 7.39 (t, *J* = 7.8 Hz, 1H), 7.34 (t, *J* = 7.2 Hz, 1H), 7.28 – 7.26 (m, 1H), 2.49 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 159.7, 150.4, 147.3, 138.0, 137.6, 135.5, 134.1, 134.0, 133.4, 131.4, 130.1, 129.2, 128.2, 128.0, 127.7, 127.1, 126.9, 126.0, 125.8, 121.3, 119.0, 117.2, 21.5.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{23}H_{16}N_2OH^+$ 337.1335, found 337.1342.

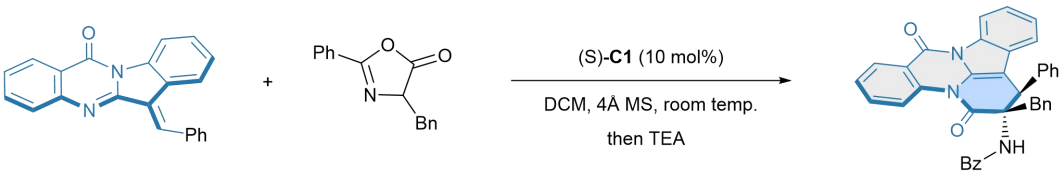
4. General Procedure for the asymmetric [4 + 2] cyclisation.



1 **2** **3**

To an over-dried Schlenck tube was added substrates **1** (0.10 mmol), (S)-**C1** (10 mol %), 4Å MS (50 mg) and substrates **2** (0.15 mmol) in dry DCM (1 mL), and the reaction mixture was stirred at room temperature for 8 hours. Then the mixture were added with 0.3 ml of TEA for 0.5 h. After that, the mixture were concentrated in vacuum, and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 30/1 to 6:1) to afford the corresponding product **3**. All products were dried under vacuum and further analyzed by ^{1}H NMR, ^{13}C NMR, HRMS, chiral HPLC analysis, *etc*.

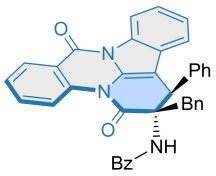
Procedure for scale-up synthesis of 3a



1, 1.0 mmol **2** **3,** 0.50 g, 87% yield

To an over-dried Schlenck tube was added substrates **1a** (1.0 mmol), (S)-**C1** (10 mol %), 4Å MS (500 mg) and substrates **2a** (1.5 mmol) in dry DCM (10 mL), and the reaction mixture was stirred at room temperature for 12 hours. Then the mixture were added with 3 ml of TEA for 1 h. After that, the mixture were concentrated in vacuum, and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 30/1 to 10:1) to afford the corresponding product **3a** in 87% yield and 95:5 er.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3a



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3a** (51.7 mg, 90% yield) as a yellow solid, m. p. = 201 – 204 °C, and the enantiomeric ratio of **3a** was determined to be 95:5 by chiral HPLC analysis on Chiralpak IG column (CO_2/*i*-PrOH = 50:50, flow rate: 1.5 mL/min), UV 270 nm, t_R (major) = 17.75 min, t_R (minor) = 13.04 min; $[\alpha]_D^{20}$ = -107.8 (*c* = 0.75 in CH_2Cl_2).

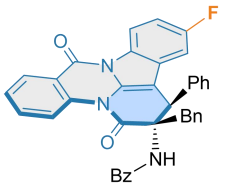
*NMR and HRMS data for the product 3**a***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.80 (d, *J* = 9.0 Hz, 1H), 8.67 (d, *J* = 7.8 Hz, 1H), 8.48 (d, *J* = 7.8 Hz, 1H), 7.75 – 7.72 (m, 1H), 7.66 (d, *J* = 8.4 Hz, 2H), 7.51 (t, *J* = 7.8 Hz, 1H), 7.44 – 7.38 (m, 8H), 7.32 – 7.17 (m, 5H), 6.92 (d, *J* = 7.2 Hz, 2H), 6.82 (d, *J* = 7.2 Hz, 1H), 6.37 (s, 1H), 5.75 (s, 1H), 3.73 (d, *J* = 14.4 Hz, 1H), 2.92 (d, *J* = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.2, 157.3, 136.8, 135.5, 135.1, 134.2, 134.0, 132.0, 131.2, 131.1, 130.9, 130.4, 129.0, 128.8, 128.7, 128.4, 128.2, 127.9, 127.3, 127.0, 124.8, 124.4, 122.8, 119.1, 118.6, 116.3, 116.2, 95.4, 65.6, 44.2, 38.2.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{38}H_{27}N_3O_3Na^+$ 596.1945, found 596.1945.

N-((1R,2S)-2-benzyl-11-fluoro-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3b



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3b** (50.9 mg, 86% yield) as a yellow solid, m. p. = 135 – 137 °C, and the enantiomeric ratio of **3b** was determined to be 96:4 by chiral HPLC analysis on Chiralpak IA column (DCM/*n*-hexane/MeOH = 75:25:0.3,

flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 6.19 min, t_R (minor) = 6.97 min; $[\alpha]_D^{20}$ = -47.6 (c = 0.63 in CH_2Cl_2).

*NMR and HRMS data for the product **3b***:

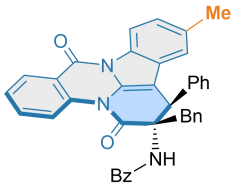
^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.78 (d, J = 8.4 Hz, 1H), 8.64 – 8.61 (m, 1H), 8.49 (d, J = 7.8 Hz, 1H), 7.74 (t, J = 7.8 Hz, 1H), 7.66 (d, J = 7.8 Hz, 2H), 7.52 (t, J = 7.2 Hz, 1H), 7.46 – 7.37 (m, 8H), 7.28 (t, J = 7.2 Hz, 1H), 7.24 – 7.22 (m, 2H), 7.00 (t, J = 9.0 Hz, 1H), 6.91 (d, J = 7.8 Hz, 2H), 6.45 (d, J = 9.6 Hz, 1H), 6.35 (s, 1H), 5.75 (s, 1H), 3.70 (d, J = 14.4 Hz, 1H), 2.90 (d, J = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.3, 168.1, 168.0 (d, $J_{C\text{-}F}$ = 241.3 Hz), 157.0, 136.7, 135.2, 134.9, 134.1, 133.8, 132.4, 132.0, 130.8, 130.3, 129.0, 128.82, 128.75, 128.5, 128.4, 127.9, 127.5, 127.0, 125.0, 118.7, 117.4 (d, $J_{C\text{-}F}$ = 10.1 Hz), 116.0, 110.4 (d, $J_{C\text{-}F}$ = 26.0 Hz), 105.2 (d, $J_{C\text{-}F}$ = 26.0 Hz), 95.3 (d, $J_{C\text{-}F}$ = 4.3 Hz), 65.6, 44.0, 38.3.

^{19}F NMR (564 MHz, $CDCl_3$) δ (ppm): -115.3.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{38}H_{26}FN_3O_3Na^+$ 614.1850, found 614.1851.

N-((1R,2S)-2-benzyl-11-methyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3c



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3c** (47.0 mg, 80% yield) as a yellow solid, m. p. = 200 – 202 °C, and the enantiomeric ratio of **3c** was determined to be 92:8 by chiral HPLC analysis on Chiralpak IC column (*n*-hexane/*i*-PrOH = 70:30, flow rate: 1.0 mL/min), UV 270 nm, t_R (major) = 17.91 min, t_R (minor) = 9.85 min; $[\alpha]_D^{20}$ = -59.4 (c = 0.80 in CH_2Cl_2).

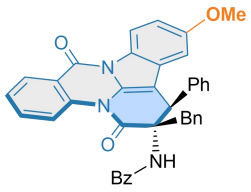
*NMR and HRMS data for the product **3c***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.80 (d, J = 8.4 Hz, 1H), 8.55 (d, J = 8.4 Hz, 1H), 8.50 – 8.49 (m, 1H), 7.74 – 7.71 (m, 1H), 7.63 (d, J = 7.8 Hz, 2H), 7.50 (t, J = 7.2 Hz, 1H), 7.44 – 7.39 (m, 8H), 7.29 – 7.22 (m, 3H), 7.13 (d, J = 8.4 Hz, 1H), 6.93 (d, J = 7.8 Hz, 2H), 6.64 (s, 1H), 6.31 (s, 1H), 5.61 (s, 1H), 3.76 (d, J = 14.4 Hz, 1H), 2.92 (d, J = 14.4 Hz, 1H), 2.31 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.4, 168.2, 157.1, 136.8, 135.6, 135.0, 134.21, 134.17, 134.1, 132.0, 131.2, 130.8, 130.4, 129.4, 129.0, 128.7, 128.4, 128.2, 127.8, 127.5, 127.0, 124.8, 124.1, 119.1, 118.6, 116.3, 116.0, 95.2, 65.5, 44.4, 38.0, 21.7.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{39}H_{29}N_3O_3Na^+$ 610.2101, found 610.2107.

N-((1R,2S)-2-benzyl-11-methoxy-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3d



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 6:1) to afford **3d** (44.7 mg, 74% yield) as a yellow solid, m. p. = 230 – 235°C, and the enantiomeric ratio of **3d** was determined to be 98:2 by chiral HPLC analysis on Chiralpak IA column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 6.43 min, t_R (minor) = 7.28 min; $[\alpha]_D^{20}$ = -146.3 (*c* = 0.53 in CH_2Cl_2).

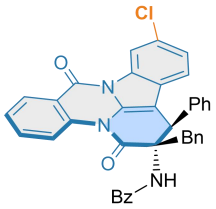
*NMR and HRMS data for the product **3d***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.80 (d, *J* = 8.4 Hz, 1H), 8.58 (d, *J* = 9.0 Hz, 1H), 8.51 (d, *J* = 7.8 Hz, 1H), 7.74 – 7.71 (m, 1H), 7.65 (d, *J* = 8.4 Hz, 2H), 7.53 – 7.50 (m, 1H), 7.46 – 7.40 (m, 8H), 7.29 – 7.26 (m, 1H), 7.25 – 7.22 (m, 2H), 6.92 – 6.89 (m, 3H), 6.33 (s, 1H), 6.25 (s, 1H), 5.75 (s, 1H), 3.73 (d, *J* = 14.4 Hz, 1H), 3.62 (s, 3H), 2.92 (d, *J* = 15.0 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.25, 168.17, 156.9, 156.8, 136.7, 135.2, 134.9, 134.2, 133.9, 132.0, 131.6, 131.0, 130.3, 128.9, 128.8, 128.7, 128.5, 128.3, 128.2, 127.9, 127.0, 125.7, 124.9, 118.6, 117.1, 116.3, 110.6, 102.8, 95.3, 65.6, 55.3, 44.1, 38.2.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{39}H_{29}N_3O_4Na^+$ 626.2050, found 626.2051.

N-((1R,2S)-2-benzyl-10-chloro-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3e



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3e** (52.9 mg, 87% yield) as a yellow solid, m. p. = 200 – 205 °C, and the enantiomeric ratio of **3e** was determined to be 97:3 by chiral HPLC analysis on Chiralpak IA column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 6.23 min, t_R (minor) = 7.09 min; $[\alpha]_D^{20}$ = -67.7 (*c* = 0.75 in CH_2Cl_2).

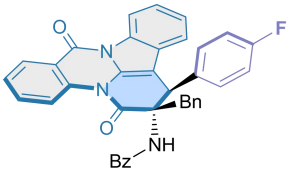
*NMR and HRMS data for the product **3e***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.79 (d, *J* = 8.4 Hz, 1H), 8.74 – 8.74 (m, 1H), 8.52 (d, *J* = 8.4 Hz, 1H), 7.80 (d, *J* = 8.4 Hz, 1H), 7.76 – 7.73 (m, 1H), 7.67 – 7.65 (m, 2H), 7.54 – 7.36 (m, 9H), 7.24 (t, *J* = 7.8 Hz, 2H), 7.16 (d, *J* = 8.4 Hz, 1H), 6.91 (d, *J* = 6.6 Hz, 2H), 6.70 (d, *J* = 9.0 Hz, 1H), 6.33 (s, 1H), 5.82 (s, 1H), 3.68 (d, *J* = 14.4 Hz, 1H), 2.89 (d, *J* = 15.0 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.3, 168.0, 157.2, 136.8, 135.4, 135.1, 134.1, 133.7, 133.3, 132.1, 130.9, 130.3, 129.7, 128.9, 128.8, 128.6, 128.4, 128.0, 127.6, 127.3, 127.0, 125.8, 125.1, 124.9, 120.0, 118.7, 116.5, 116.0, 95.2, 65.7, 43.9, 38.4.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{38}H_{26}{}^{35}ClN_3O_3Na^+$ 630.1555, found 630.1559; calculated for $C_{38}H_{26}{}^{37}ClN_3O_3Na^+$ 632.1525, found 632.1533.

N-((1R,2S)-2-benzyl-1-(4-fluorophenyl)-3,8-dioxo-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3f



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3f** (41.4 mg, 70% yield) as a yellow solid, m. p. = 130 – 133 °C, and the enantiomeric ratio of **3f** was determined to be

92:8 by chiral HPLC analysis on Chiralpak IC column (*n*-hexane/*i*-PrOH = 70:30, flow rate: 1.0 mL/min), UV 270 nm, t_R (major) = 12.12 min, t_R (minor) = 10.19 min; $[\alpha]_D^{20}$ = -42.5 (*c* = 0.76 in CH_2Cl_2).

*NMR and HRMS data for the product **3f***:

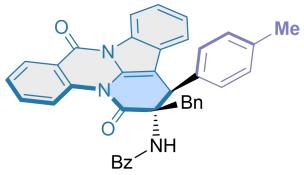
^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.78 (d, *J* = 8.4 Hz, 1H), 8.69 (d, *J* = 8.4 Hz, 1H), 8.49 (d, *J* = 7.8 Hz, 1H), 7.74 – 7.71 (m, 1H), 7.67 – 7.66 (m, 2H), 7.54 – 7.51 (m, 1H), 7.47 – 7.19 (m, 10H), 7.12 – 7.09 (m, 2H), 6.91 (d, *J* = 6.6 Hz, 2H), 6.77 (d, *J* = 7.2 Hz, 1H), 6.38 (s, 1H), 5.87 (s, 1H), 3.68 (d, *J* = 14.4 Hz, 1H), 2.85 (d, *J* = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.4, 168.0, 162.3 (d, J_{C-F} = 248.5 Hz), 157.2, 136.8, 135.1, 134.1, 133.6, 132.5 (d, J_{C-F} = 8.7 Hz), 132.1, 131.2, 131.1, 130.2, 129.1, 128.9, 128.8, 128.0, 127.1, 127.0, 124.9, 124.5, 122.9, 119.1, 118.6, 116.4, 116.2, 115.3 (d, J_{C-F} = 21.7 Hz), 95.1, 65.7, 43.2, 38.3.

^{19}F NMR (564 MHz, $CDCl_3$) δ (ppm): -109.0.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{38}H_{26}FN_3O_3Na^+$ 614.1850, found 614.1847.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-(p-tolyl)-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3g



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3g** (48.2 mg, 82% yield) as a yellow solid, m. p. = 136 – 138 °C, and the enantiomeric ratio of **3g** was determined to be 96:4 by chiral HPLC analysis on Chiralpak IC column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 9.36 min, t_R (minor) = 7.58 min; $[\alpha]_D^{20}$ = -88.1 (*c* = 0.77 in CH_2Cl_2).

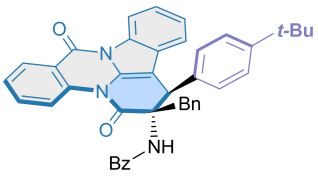
*NMR and HRMS data for the product **3g***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.72 – 8.68 (m, 1H), 8.50 – 8.49 (m, 1H), 8.36 – 8.32 (m, 2H), 7.84 – 7.81 (m, 1H), 7.58 (d, *J* = 8.4 Hz, 2H), 7.48 – 7.45 (m, 2H), 7.38 – 7.35 (m, 2H), 7.27 – 7.17 (m, 11H), 7.10 – 7.08 (m, 1H), 5.13 (s, 1H), 3.67 (d, *J* = 13.8 Hz, 1H), 2.90 (d, *J* = 15.0 Hz, 1H), 2.30 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 169.3, 167.3, 156.9, 136.9, 136.3, 135.7, 134.6, 134.0, 133.8, 131.4, 131.3, 130.8, 130.3, 129.5, 129.0, 128.1, 127.6, 127.4, 127.3, 126.5, 124.1, 124.0, 121.7, 117.9, 117.8, 115.5, 115.4, 95.8, 64.6, 44.2, 36.7, 20.6.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{39}H_{29}N_3O_3Na^+$ 610.2101, found 610.2106.

N-((1R,2S)-2-benzyl-1-(4-(tert-butyl)phenyl)-3,8-dioxo-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3h



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3h** (55.4 mg, 88% yield) as a yellow solid, m. p. = 126 – 128 °C, and the enantiomeric ratio of **3h** was determined to be 93:7 by chiral HPLC analysis on Chiralpak IA column (CO_2/*i*-PrOH = 60:40, flow rate: 1.5 mL/min), UV 270 nm, t_R (major) = 10.32 min, t_R (minor) = 8.19 min; $[\alpha]_D^{20}$ = -82.4 (*c* = 0.25 in CH_2Cl_2).

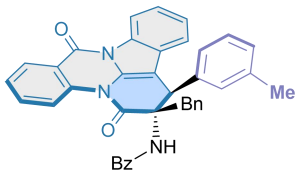
*NMR and HRMS data for the product **3h***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.80 (d, *J* = 8.4 Hz, 1H), 8.64 (d, *J* = 7.8 Hz, 1H), 8.45 (d, *J* = 7.8 Hz, 1H), 7.75 – 7.72 (m, 1H), 7.64 (d, *J* = 8.4 Hz, 2H), 7.50 (t, *J* = 7.8 Hz, 1H), 7.42 – 7.38 (m, 5H), 7.32 – 7.18 (m, 7H), 6.96 (d, *J* = 7.8 Hz, 2H), 6.88 (d, *J* = 8.4 Hz, 1H), 6.41 (d, *J* = 6.0 Hz, 1H), 5.57 (s, 1H), 3.76 (d, *J* = 14.4 Hz, 1H), 2.95 (d, *J* = 14.4 Hz, 1H), 1.37 (s, 9H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.6, 168.2, 157.3, 151.1, 136.8, 135.0, 134.3, 134.2, 132.4, 131.9, 131.2, 131.0, 130.5, 130.3, 128.9, 128.7, 128.6, 127.7, 127.4, 127.0, 125.3, 124.7, 124.3, 122.7, 119.0, 118.6, 116.3, 116.1, 95.7, 65.6, 43.9, 37.9, 34.6, 31.3.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{42}H_{35}N_3O_3Na^+$ 652.2571, found 652.2579.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-(m-tolyl)-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3i



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3i** (48.2 mg, 82% yield) as a yellow solid, m. p. = 88 – 90 °C, and the enantiomeric ratio of **3i** was determined to be 92:8 by chiral HPLC analysis on Chiralpak IC column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 10.42 min, t_R (minor) = 8.13 min; $[\alpha]_D^{20}$ = -88.9 (*c* = 0.73 in CH_2Cl_2).

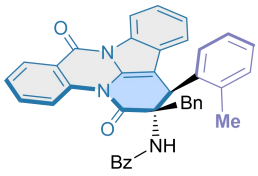
*NMR and HRMS data for the product **3i***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.80 (d, *J* = 9.0 Hz, 1H), 8.67 (d, *J* = 8.4 Hz, 1H), 8.49 – 8.47 (m, 1H), 7.73 (t, *J* = 7.8 Hz, 1H), 7.65 (d, *J* = 6.6 Hz, 2H), 7.51 (t, *J* = 7.2 Hz, 1H), 7.45 – 7.40 (m, 3H), 7.32 – 7.18 (m, 9H), 6.93 (d, *J* = 7.8 Hz, 2H), 6.85 (d, *J* = 8.4 Hz, 1H), 6.36 (s, 1H), 5.66 (s, 1H), 3.75 (d, *J* = 14.4 Hz, 1H), 2.94 (d, *J* = 14.4 Hz, 1H), 2.34 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.31, 168.27, 157.3, 138.0, 136.8, 135.3, 135.1, 134.3, 134.1, 131.9, 131.6, 131.2, 131.0, 130.4, 129.0, 128.9, 128.7, 128.1, 127.9, 127.8, 127.4, 127.0, 124.8, 124.4, 122.7, 119.1, 118.6, 116.3, 116.2, 95.5, 65.6, 44.1, 38.1, 21.5.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{39}H_{29}N_3O_3Na^+$ 610.2101, found 610.2098.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-(o-tolyl)-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3j



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3j** (37.6 mg, 64% yield) as a yellow solid, m. p. = 136 – 138 °C, and the enantiomeric ratio of **3j** was determined to be

82:18 by chiral HPLC analysis on Chiralpak IC column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 8.74 min, t_R (minor) = 7.57 min; $[\alpha]_D^{20}$ = -43.9 (*c* = 0.63 in CH_2Cl_2).

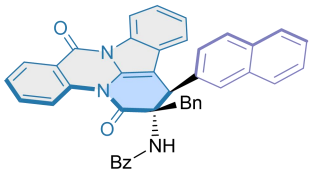
*NMR and HRMS data for the product **3j***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.80 (d, *J* = 8.4 Hz, 1H), 8.66 (d, *J* = 8.4 Hz, 1H), 8.48 (d, *J* = 7.8 Hz, 1H), 7.74 – 7.71 (m, 1H), 7.66 – 7.65 (m, 2H), 7.50 (t, *J* = 7.8 Hz, 1H), 7.44 – 7.39 (m, 3H), 7.34 – 7.24 (m, 7H), 7.15 – 7.12 (m, 2H), 6.95 (d, *J* = 7.8 Hz, 2H), 6.58 – 6.57 (m, 2H), 5.84 (s, 1H), 3.78 (d, *J* = 14.4 Hz, 1H), 3.10 (d, *J* = 14.4 Hz, 1H), 2.35 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.5, 168.2, 157.3, 138.3, 136.8, 135.0, 134.3, 134.2, 134.1, 132.0, 131.4, 131.3, 130.5, 129.7, 129.0, 128.72, 128.70, 127.9, 127.7, 127.0, 125.6, 124.8, 124.4, 122.7, 118.8, 118.7, 116.3, 116.2, 96.6, 66.0, 40.8, 38.8, 20.2.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{39}H_{29}N_3O_3Na^+$ 610.2101, found 610.2106.

<u>N-((1R,2S)-2-benzyl-1-(naphthalen-2-yl)-3,8-dioxo-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3k</u>



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 50:1 to 30:1) to afford **3k** (48.7 mg, 78% yield) as a yellow solid, m. p. = 182 – 184 °C, and the enantiomeric ratio of **3k** was determined to be 96:4 by chiral HPLC analysis on Chiralpak IC column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 10.99 min, t_R (minor) = 9.14 min; $[\alpha]_D^{20}$ = -109.7 (*c* = 0.76 in CH_2Cl_2).

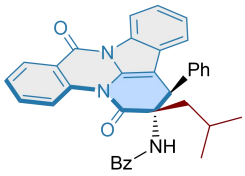
*NMR and HRMS data for the product **3k***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.82 (d, *J* = 8.4 Hz, 1H), 8.71 (d, *J* = 8.4 Hz, 1H), 8.52 – 8.51 (m, 1H), 7.92 – 7.87 (m, 3H), 7.79 (d, *J* = 8.4 Hz, 1H), 7.76-7.73 (m, 1H), 7.69 (d, *J* = 6.6 Hz, 2H), 7.57 – 7.51 (m, 4H), 7.46 – 7.41 (m, 3H), 7.33 – 7.26 (m, 2H), 7.23 – 7.20 (m, 2H), 7.14 – 7.11 (m, 1H), 6.89 (d, *J* = 6.6 Hz, 2H), 6.78 (d, *J* = 7.8 Hz, 1H), 6.39 (s, 1H), 6.03 (s, 1H), 3.81 (d, *J* = 14.4 Hz, 1H), 2.92 (d, *J* = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.6, 168.2, 157.4, 137.0, 135.2, 134.5, 133.9, 133.2, 133.1, 132.1, 131.4, 131.3, 130.5, 130.4, 129.2, 128.94, 128.90, 128.6, 128.1, 128.0, 127.9, 127.8, 127.5, 127.1, 126.5, 125.0, 124.6, 123.0, 119.4, 118.8, 116.5, 116.4, 95.5, 66.1, 44.3, 38.6.

HRMS (ESI – TOF) *m/z*: [M + Na]$^+$ calculated for $C_{42}H_{29}N_3O_3Na^+$ 646.2101, found 646.2098.

N-((1R,2S)-2-isobutyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3l



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3l** (45.4 mg, 84% yield) as a yellow solid, m. p. = 180 – 182 °C, and the enantiomeric ratio of **3l** was determined to be 98:2 by chiral HPLC analysis on Chiralpak IA column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 6.08 min, t_R (minor) = 6.96 min; $[\alpha]_D^{20}$ = -6.7 (*c* = 0.3 in CH_2Cl_2).

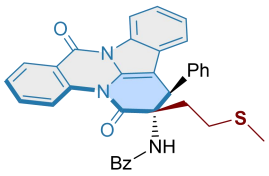
*NMR and HRMS data for the product **3l***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 9.03 (d, *J* = 9.0 Hz, 1H), 8.71 (d, *J* = 8.4 Hz, 1H), 8.51 (d, *J* = 7.8 Hz, 1H), 7.78 (d, *J* = 7.8 Hz, 2H), 7.76 – 7.73 (m, 1H), 7.55 (t, *J* = 7.8 Hz, 1H), 7.48 – 7.30 (m, 9H), 7.16 (t, *J* = 7.8 Hz, 1H), 6.70 (d, *J* = 7.2 Hz, 1H), 6.23 (s, 1H), 5.74 (s, 1H), 2.40 (dd, *J* = 15.0, 4.8 Hz, 1H), 1.80 – 1.77 (m, 1H), 1.26 – 1.21 (m, 1H), 1.01 (d, *J* = 6.0 Hz, 3H), 0.80 (d, *J* = 6.6 Hz, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.2, 167.3, 157.3, 137.0, 135.2, 134.2, 132.0, 131.23, 131.21, 131.1, 129.1, 128.8, 128.11, 128.05, 127.4, 126.9, 124.9, 124.3, 122.7, 119.4, 118.8, 116.4, 116.3, 95.6, 65.6, 44.3, 41.0, 24.7, 24.4, 24.0.

HRMS (ESI – TOF) *m/z*: [M + Na]$^+$ calculated for $C_{35}H_{29}N_3O_3Na^+$ 562.2101, found 562.2106.

N-((1R,2S)-2-((methylthio)methyl)-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3m



Prepared according to ***General Procedure*** at room temp., the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 8:1) to afford **3m** (54.1 mg, 97% yield) as a yellow solid, m. p. = 165 – 167 °C, and the enantiomeric ratio of **3m** was determined to be 95:5 by chiral HPLC analysis on Chiralpak IC column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 12.00 min, t_R (minor) = 7.86 min; $[\alpha]_D^{20}$ = -8.4 (*c* = 0.73 in CH_2Cl_2).

*NMR and HRMS data for the product **3m***:

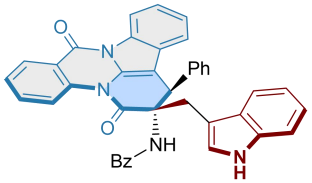
^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.98 (d, *J* = 9.0 Hz, 1H), 8.67 (d, *J* = 8.4 Hz, 1H), 8.47 (d, *J* = 7.8 Hz, 1H), 7.82 – 7.81 (m, 2H), 7.74 – 7.71 (m, 1H), 7.54 – 7.51 (m, 1H), 7.44 – 7.34 (m, 7H), 7.32 – 7.28 (m, 3H), 7.17 (t, *J* = 7.8 Hz, 1H), 6.79 (d, *J* = 7.8 Hz, 1H), 5.62 (s, 1H), 2.61 – 2.55 (m, 3H), 1.95 (s, 3H), 1.93 – 1.88 (m, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.4, 167.8, 157.2, 137.0, 135.2, 135.1, 133.8, 132.0, 131.2, 131.1, 130.6, 129.0, 128.7, 128.3, 128.2, 127.24, 127.21, 124.9, 124.4, 122.8, 119.2, 118.8, 116.4, 116.3, 95.3, 65.7, 44.5, 30.5, 28.2, 15.6.

^{19}F NMR (564 MHz, $CDCl_3$) δ (ppm): -85.2 – -85.4 (m, 3F), -118.1 (t, *J* = 17.3 Hz, 2F).

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{34}H_{27}N_3O_3SNa^+$ 580.1665, found 580.1669.

N-((1R,2S)-2-((1H-indol-3-yl)methyl)-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)benzamide-3n



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 3:1) to afford **3n** (49.7 mg, 81% yield) as a yellow solid, m. p. = 223 – 226 °C, and the enantiomeric ratio of **3n** was determined to be

99:1 by chiral HPLC analysis on Chiralpak IC column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 13.60 min, t_R (minor) = 9.18 min; $[\alpha]_D^{20}$ = -13.7 (*c* = 0.9 in CH_2Cl_2).

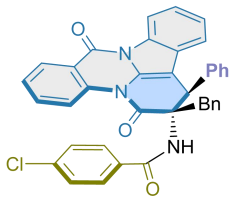
NMR and HRMS data for the product ***3n***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 10.83 (s, 1H), 8.64 (s, 1H), 8.48 – 8.47 (m, 1H), 8.29 – 8.25 (m, 2H), 7.70 (t, *J* = 8.4 Hz, 1H), 7.47 (d, *J* = 7.8 Hz, 2H), 7.40 – 7.38 (m, 2H), 7.29 – 7.20 (m, 11H), 7.09 – 7.06 (m, 2H), 6.89 (t, *J* = 7.8 Hz, 1H), 6.59 (t, *J* = 7.2 Hz, 1H), 5.28 (s, 1H), 3.87 (d, *J* = 15.0 Hz, 1H), 2.96 (d, *J* = 15.0 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 169.9, 167.5, 156.9, 137.1, 136.4, 135.6, 134.5, 133.9, 131.6, 131.2, 130.3, 129.6, 128.3, 128.2, 127.9, 127.5, 127.3, 124.5, 124.1, 123.8, 121.6, 120.6, 118.2, 118.0, 117.9, 117.6, 115.5, 115.3, 111.0, 107.3, 95.7, 64.5, 43.9, 40.1, 26.5.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{40}H_{28}N_4O_3Na^+$ 635.2054, found 635.2053.

<u>N-((1R,2S)-2-benzyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)-4-chlorobenzamide-3o</u>



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3o** (42.6 mg, 70% yield) as a yellow solid, m. p. = 216 – 219 °C, and the enantiomeric ratio of **3o** was determined to be 91:9 by chiral HPLC analysis on Chiralpak IA column (CO_2/*i*-PrOH = 60:40, flow rate: 1.5 mL/min), UV 270 nm, t_R (major) = 13.00 min, t_R (minor) = 15.42 min; $[\alpha]_D^{20}$ = -62.6 (*c* = 0.20 in CH_2Cl_2).

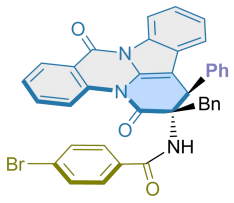
NMR and HRMS data for the product ***3o***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.79 (d, *J* = 9.0 Hz, 1H), 8.68 (d, *J* = 7.8 Hz, 1H), 8.50 (d, *J* = 7.8 Hz, 1H), 7.72 (t, *J* = 7.8 Hz, 1H), 7.57 (d, *J* = 8.4 Hz, 2H), 7.45-7.36 (m, 7H), 7.32-7.17 (m, 6H), 6.89 (d, *J* = 7.8 Hz, 2H), 6.79 (d, *J* = 7.2 Hz, 1H), 6.27 (s, 1H), 5.76 (s, 1H), 3.70 (d, *J* = 14.4 Hz, 1H), 2.91 (d, *J* = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.1, 167.3, 157.2, 138.3, 136.8, 135.3, 135.1, 133.8, 132.6, 131.2, 131.0, 130.9, 130.3, 129.1, 129.0, 128.8, 128.41, 128.39, 128.3, 128.0, 127.3, 124.9, 124.4, 122.9, 119.2, 118.6, 116.4, 116.3, 95.4, 65.7, 44.1, 38.2.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{38}H_{26}{}^{35}ClN_3O_3Na^+$ 630.1555, found 630.1545; calculated for $C_{38}H_{26}{}^{37}ClN_3O_3Na^+$ 632.1525, found 632.1519.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)-4-bromobenzamide-3p



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3p** (48.3 mg, 74% yield) as a yellow solid, m. p. = 171 – 174 °C, and the enantiomeric ratio of **3o** was determined to be 97:3 by chiral HPLC analysis on Chiralpak IA column (CO_2/*i*-PrOH = 60:40, flow rate: 1.5 mL/min), UV 270 nm, t_R (major) = 15.79 min, t_R (minor) = 19.10 min; $[\alpha]_D^{20}$ = -68.2 (*c* = 0.10 in CH_2Cl_2).

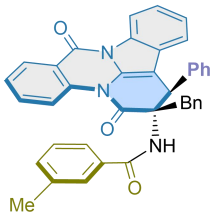
*NMR and HRMS data for the product **3p***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.79 (d, *J* = 8.4 Hz, 1H), 8.68 (d, *J* = 8.4 Hz, 1H), 8.49 (d, *J* = 7.8 Hz, 1H), 7.73 (t, *J* = 7.8 Hz, 1H), 7.55-7.50 (m, 4H), 7.45 – 7.39 (m, 5H), 7.30 – 7.16 (m, 6H), 6.90 (d, *J* = 6.6 Hz, 2H), 6.79 (d, *J* = 7.8 Hz, 1H), 6.31 (s, 1H), 5.76 (s, 1H), 3.71 (d, *J* = 14.4 Hz, 1H), 2.92 (d, *J* = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.1, 167.4, 157.2, 136.8, 135.3, 135.1, 133.8, 133.1, 132.0, 131.3, 131.0, 130.9, 130.3, 129.1, 128.8, 128.6, 128.4, 128.3, 128.0, 127.3, 126.8, 124.9, 124.4, 122.9, 119.2, 118.6, 116.4, 116.3, 95.4, 65.7, 44.1, 38.2.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{38}H_{26}Br^{79}N_3O_3Na^+$ 674.1050, found 674.1043; calculated for $C_{38}H_{26}Br^{81}N_3O_3Na^+$ 676.1029, found 676.1021.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)-3-methylbenzamide-3q



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3q** (39.4 mg, 67% yield) as a yellow solid, m. p. = 161 – 165 °C, and the enantiomeric ratio of **3o** was determined to be 92:8 by chiral HPLC analysis on Chiralpak IC column (DCM/*n*-hexane/MeOH = 75:25:0.3, flow rate: 0.6 mL/min), UV 254 nm, t_R (major) = 13.40 min, t_R (minor) = 9.56 min; $[\alpha]_D^{20}$ = -130.2 (*c* = 0.79 in CH_2Cl_2).

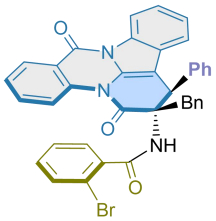
*NMR and HRMS data for the product **3q***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.81 (d, *J* = 9.0 Hz, 1H), 8.69 (d, *J* = 8.4 Hz, 1H), 8.51 – 8.50 (m, 1H), 7.75 – 7.72 (m, 1H), 7.46 – 7.38 (m, 8H), 7.33 – 7.27 (m, 4H), 7.25 – 7.18 (m, 3H), 6.92 (d, *J* = 6.6 Hz, 2H), 6.84 (d, *J* = 7.8 Hz, 1H), 6.31 (s, 1H), 5.73 (s, 1H), 3.73 (d, *J* = 14.4 Hz, 1H), 2.92 (d, *J* = 14.4 Hz, 1H), 2.36 (s, 3H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.5, 168.3, 157.3, 138.6, 136.8, 135.5, 135.1, 134.2, 134.0, 132.7, 131.2, 131.1, 130.9, 130.4, 129.0, 128.8, 128.6, 128.4, 128.2, 127.8, 127.3, 124.8, 124.4, 123.9, 122.8, 119.2, 118.6, 116.4, 116.2, 95.5, 65.6, 44.2, 38.2, 21.3.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{39}H_{29}N_3O_3Na^+$ 610.2101, found 610.2102.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)-2-bromobenzamide-3r



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3r** (42.4 mg, 65% yield) as a yellow solid, m. p. = 148 – 151 °C, and the enantiomeric ratio of **3r** was determined to be

98:2 by chiral HPLC analysis on Chiralpak IA column (CO_2/*i*-PrOH = 60:40, flow rate: 1.5 mL/min), UV 254 nm, t_R (major) = 13.86 min, t_R (minor) = 12.49 min; $[\alpha]_D^{20}$ = -38.77 (*c* = 0.57 in CH_2Cl_2).

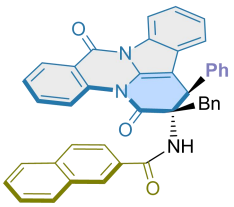
*NMR and HRMS data for the product **3r***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.83 (d, *J* = 8.4 Hz, 1H), 8.66 (d, *J* = 7.8 Hz, 1H), 8.49 (d, *J* = 7.2 Hz, 1H), 7.78 (t, *J* = 7.2 Hz, 1H), 7.49 – 7.42 (m, 8H), 7.31 – 7.23 (m, 7H), 7.04 – 6.98 (m, 3H), 6.34 (s, 1H), 5.33 (s, 1H), 3.91 (d, *J* = 14.4 Hz, 1H), 3.00 (d, *J* = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.5, 167.7, 157.3, 137.0, 136.9, 136.0, 135.1, 134.6, 133.6, 131.6, 131.4, 131.2, 130.7, 130.5, 129.7, 129.0, 128.6, 128.5, 128.3, 127.6, 127.5, 127.4, 124.7, 124.5, 122.8, 119.2, 118.5, 118.4, 116.4, 116.3, 95.8, 65.8, 45.1, 37.4.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{38}H_{26}Br^{79}N_3O_3H^+$ 652.1230, found 652.1227; calculated for $C_{38}H_{26}Br^{81}N_3O_3H^+$ 654.1210, found 654.1201.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)-2-naphthamide-3s



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 10:1) to afford **3s** (51.2 mg, 82% yield) as a yellow solid, m. p. = 200 – 203 °C, and the enantiomeric ratio of **3s** was determined to be 99:1 by chiral HPLC analysis on Chiralpak IA column (CO_2/*i*-PrOH = 60:40, flow rate: 1.5 mL/min), UV 270 nm, t_R (major) = 15.87 min, t_R (minor) = 14.13 min; $[\alpha]_D^{20}$ = -227.0 (*c* = 0.35 in CH_2Cl_2).

*NMR and HRMS data for the product **3s***:

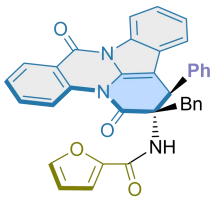
^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.81 (d, *J* = 8.4 Hz, 1H), 8.67 (d, *J* = 8.4 Hz, 1H), 8.48 – 8.46 (m, 1H), 8.13 (s, 1H), 7.85 – 7.83 (m, 3H), 7.74 – 7.69 (m, 2H), 7.57 – 7.50 (m, 2H), 7.44 – 7.40 (m, 6H), 7.32 – 7.23 (m, 4H), 7.19 (t, *J* = 7.2 Hz, 1H), 6.96 (d, *J* = 7.2 Hz, 2H), 6.83 (d, *J* = 8.4 Hz, 1H), 6.55 (s, 1H), 5.81 (s, 1H), 3.75 (d, *J* = 14.4 Hz, 1H), 2.97 (d, *J* = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.4, 168.3, 157.2, 136.8, 135.5, 135.0, 134.9, 134.0, 132.5, 131.5, 131.2, 131.1, 130.9, 130.4, 129.0, 128.9, 128.8, 128.6, 128.4, 128.2,

127.9, 127.7, 127.3, 126.8, 124.8, 124.4, 123.4, 122.8, 119.1, 118.6, 116.3, 116.2, 95.5, 65.7, 44.2, 38.2.

HRMS (ESI – TOF) *m/z*: [M + Na]$^+$ calculated for $C_{42}H_{29}N_3O_3Na^+$ 646.2101, found 646.2110.

N-((1R,2S)-2-benzyl-3,8-dioxo-1-phenyl-2,3-dihydro-1H,8H-3a,8a-diazabenzo[e]acephenanthrylen-2-yl)furan-2-carboxamide-3t



Prepared according to ***General Procedure***, the crude product was purified by silica gel chromatography (petroleum ether/ethyl acetate 30:1 to 8:1) to afford **3t** (35.0 mg, 62% yield) as a yellow solid, m. p. = 229 – 235 °C, and the enantiomeric ratio of **3t** was determined to be 95:5 by chiral HPLC analysis on Chiralpak IG column (CO_2/*i*-PrOH = 50:50, flow rate: 1.5 mL/min), UV 270 nm, t_R (major) = 15.70 min, t_R (minor) = 14.02 min; $[\alpha]_D^{20}$ = -24.5 (*c* = 0.16 in CH_2Cl_2).

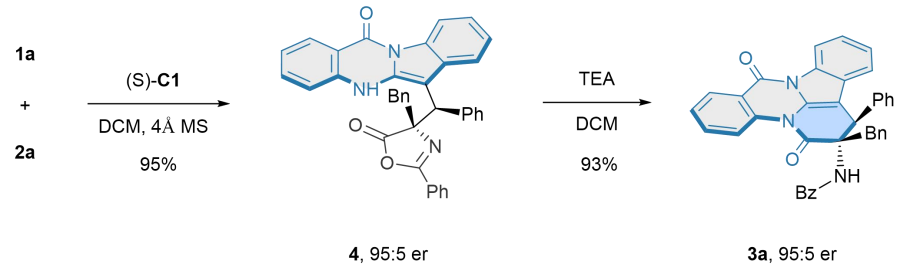
*NMR and HRMS data for the product **3t***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.74 – 8.70 (m, 2H), 8.52 (d, *J* = 7.8 Hz, 1H), 7.71 (t, *J* = 7.8 Hz, 1H), 7.46 – 7.40 (m, 7H), 7.32 (t, *J* = 7.8 Hz, 1H), 7.28 – 7.15 (m, 5H), 6.94 (d, *J* = 7.8 Hz, 2H), 6.82 (d, *J* = 8.4 Hz, 1H), 6.62 (s, 1H), 6.51 – 6.51 (m, 1H), 5.66 (s, 1H), 3.72 (d, *J* = 14.4 Hz, 1H), 2.87 (d, *J* = 14.4 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 168.0, 158.8, 157.3, 147.4, 144.4, 136.7, 135.3, 135.1, 133.8, 131.2, 131.0, 130.8, 130.3, 129.0, 128.7, 128.4, 128.2, 127.8, 127.3, 124.9, 124.4, 122.8, 119.2, 118.7, 116.3, 116.2, 115.4, 112.3, 95.5, 65.5, 44.5, 38.3.

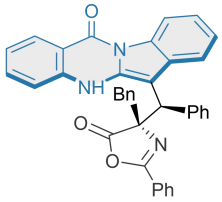
HRMS (ESI – TOF) *m/z*: [M + Na]$^+$ calculated for $C_{36}H_{25}N_3O_4Na^+$ 586.1737, found 586.1742.

5. Mechanism experiments.



To an over-dried Schlenck tube was added substrates **1a** (0.10 mmol), (S)-**C1** (10 mol %), 4Å MS (50 mg) and substrates **2a** (0.15 mmol) in dry DCM (1 mL), and the reaction mixture was stirred at room temperature for 8 hours, and monitored by TLC. After the reaction finished, the mixture were concentrated in vacuum, and purified by column chromatography on silica gel (petroleum ether/ethyl acetate = 50/1 to 20:1) to afford the aza-Michael addition product **5** in 95% yield with 95:5 er. Then the product **5** were treated with 0.3 ml of TEA in 1.0 mL DCM for 0.5 h. And the mixture were concentrated in vacuum, and purified by column chromatography to afford the corresponding product **3** in 93% yield with 95:5 er.

(S)-4-benzyl-4-((R)-(12-oxo-5,12-dihydroindolo[2,1-b]quinazolin-6-yl)(phenyl)methyl)-2-phenyloxazol-5(4H)-one-5



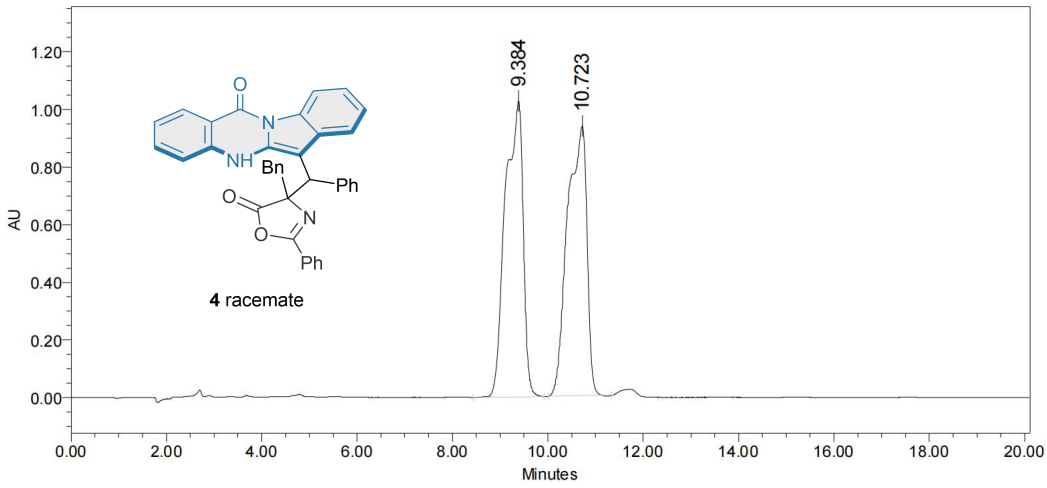
Prepared according to *General Procedure* to afford **5** (54.5 mg, 95% yield) as a yellow solid, m. p. = 191 – 195 °C, and the enantiomeric ratio of **5** was determined to be 95:5 by chiral HPLC analysis on Chiralpak IA column (CO_2/*i*-PrOH = 60:40, flow rate: 1.5 mL/min), UV 270 nm, t_R (major) = 9.47 min, t_R (minor) = 10.78 min; $[\alpha]_D^{20}$ = -163.4 (*c* = 0.50 in CH_2Cl_2).

*NMR and HRMS data for the product **5***:

^{1}H NMR (600 MHz, $CDCl_3$) δ (ppm): 8.83 (d, *J* = 8.4 Hz, 1H), 8.47-8.46 (m, 1H), 7.80 – 7.77 (m, 1H), 7.71 (d, *J* = 8.4 Hz, 2H), 7.61 – 7.58 (m, 1H), 7.53 (d, *J* = 7.8 Hz, 1H), 7.48 (t, *J* = 7.8 Hz, 2H), 7.40 – 7.37 (m, 2H), 7.31 – 7.26 (m, 4H), 7.17 – 7.03 (m, 8H), 5.04 (s, 1H), 3.54 (d, *J* = 13.8 Hz, 1H), 3.38 (d, *J* = 13.8 Hz, 1H).

^{13}C NMR (151 MHz, $CDCl_3$) δ (ppm): 177.4, 161.7, 159.5, 140.3, 138.0, 134.9, 133.8, 133.5, 133.3, 130.5, 129.9, 129.8, 129.1, 129.0, 128.9, 128.4, 128.3, 127.7, 127.6, 127.4, 124.6, 124.4, 121.1, 120.8, 116.2, 115.6, 114.3, 112.7, 91.0, 49.5, 42.4.

HRMS (ESI – TOF) *m/z*: $[M + Na]^+$ calculated for $C_{38}H_{27}N_3O_3Na^+$ 596.1945, found 596.1950.



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
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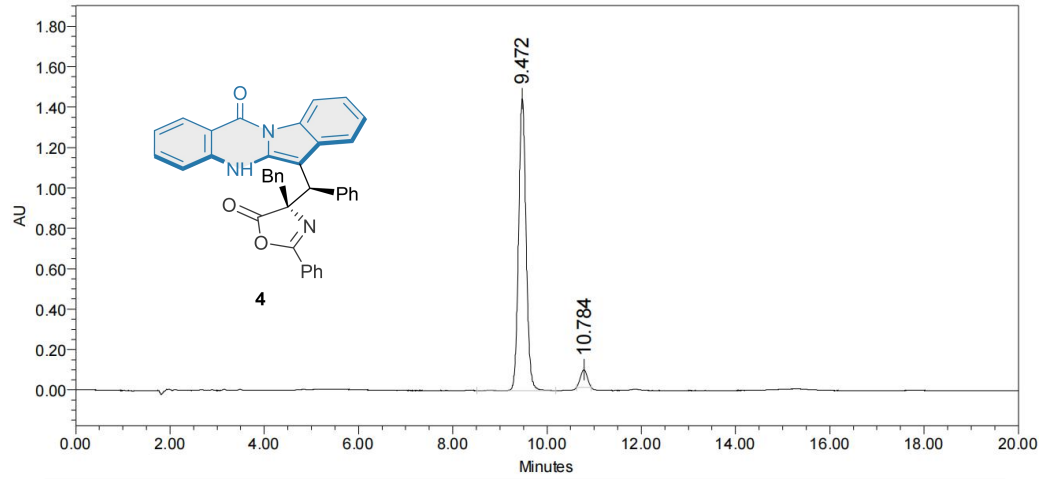
2	10.723	935804	26626685	49.88



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
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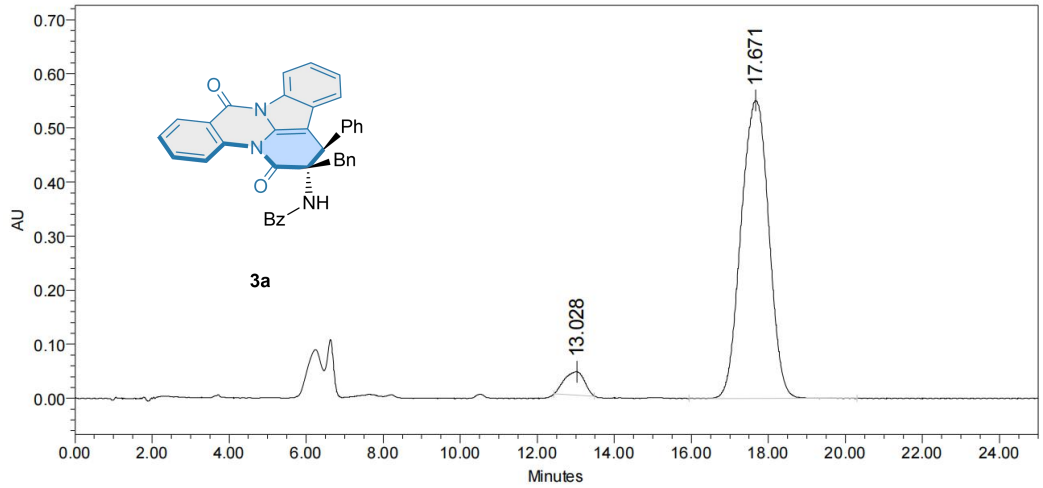
2	10.784	87387	870225	5.18



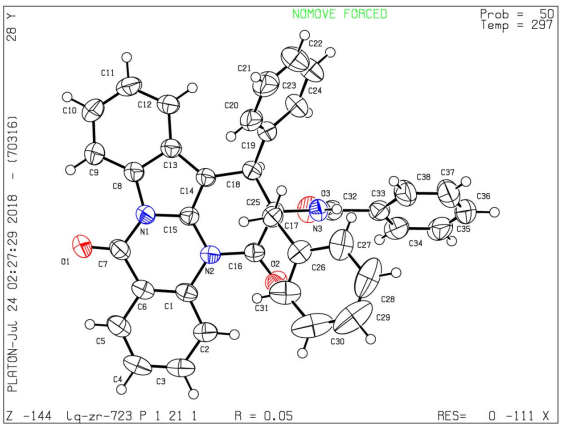
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	13.028	43154	1562636	5.35
2	17.671	550812	27664239	94.65

6. Crystal Data and Structure Refinement for 3a

Crystal preparation and measurement

To a 10 mL tube containing **3a** (98 mg) was added a 15:1 mixture of petroleum ether and ethyl acetate (about 3 mL). The mixture was kept aside for 2 days at room temperature to obtain crystals. The crystals were subjected for single crystal XRD to determine the structure of **14b**. The data were collected by an Agilent Gemini equipped with a Cu radiation source (K_α = 1.54184 Å) at 296.6 K. CCDC 2304757 (**3a**) contains the supplementary crystallographic data for this paper.

Crystal Data (at 50% probability level)



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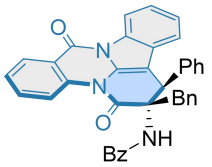


3a (CCDC 2304757)

Identification code	**3a**
Empirical formula	$C_{38}H_{27}N_3O_3$
Formula weight	573.62
Temperature/K	296.6(2)
Crystal system	monoclinic
Space group	$P2_1$
a/Å	12.3693(6)
b/Å	7.9290(4)
c/Å	16.3345(8)
α/°	90
β/°	110.272(6)
γ/°	90

Volume/Å^3	1502.80(14)
Z	2
ρ_{calc}g/cm^3	1.268
μ/mm^{-1}	0.647
F(000)	600.0
Crystal size/mm^3	0.65 × 0.3 × 0.15
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	7.62 to 145.912
Index ranges	$-15 \leq h \leq 14$, $-9 \leq k \leq 8$, $-20 \leq l \leq 14$
Reflections collected	15153
Independent reflections	5237 [R_{int} = 0.0342, R_{sigma} = 0.0325]
Data/restraints/parameters	5237/1/397
Goodness-of-fit on F^2	1.029
Final R indexes [I>=2σ (I)]	R_1 = 0.0497, wR_2 = 0.1299
Final R indexes [all data]	R_1 = 0.0548, wR_2 = 0.1361
Largest diff. peak/hole / e Å^{-3}	0.22/-0.26
Flack parameter	-0.03(15)

7. References and Notes

1 E. Krell, *Handbook of Laboratory Distillation,* Elseriver Publishing Company, Amsterdam-London-New York, 1963.

2 M. J. Rosengart, *The Technique of Distillation and Rectification in the Laboratory,* VEB Verlag Technik, Berlin, 1954.

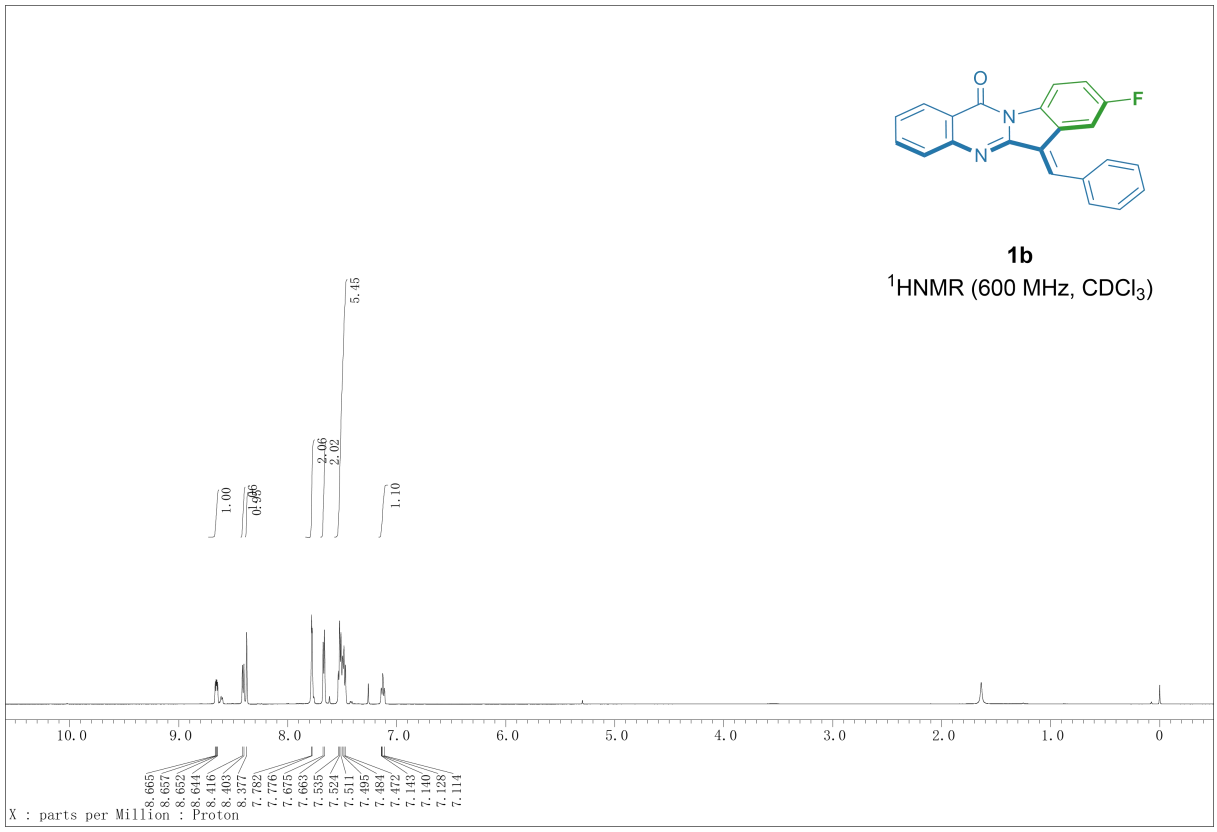
3 F. Stage, Die kolonnen zur laboratoriumsdestillation. eine ubersicht über den entwicklungsstand der kolonnen zur destillation im laboratorium, *Angew. Chem.* 1947, **19**, 175–183.

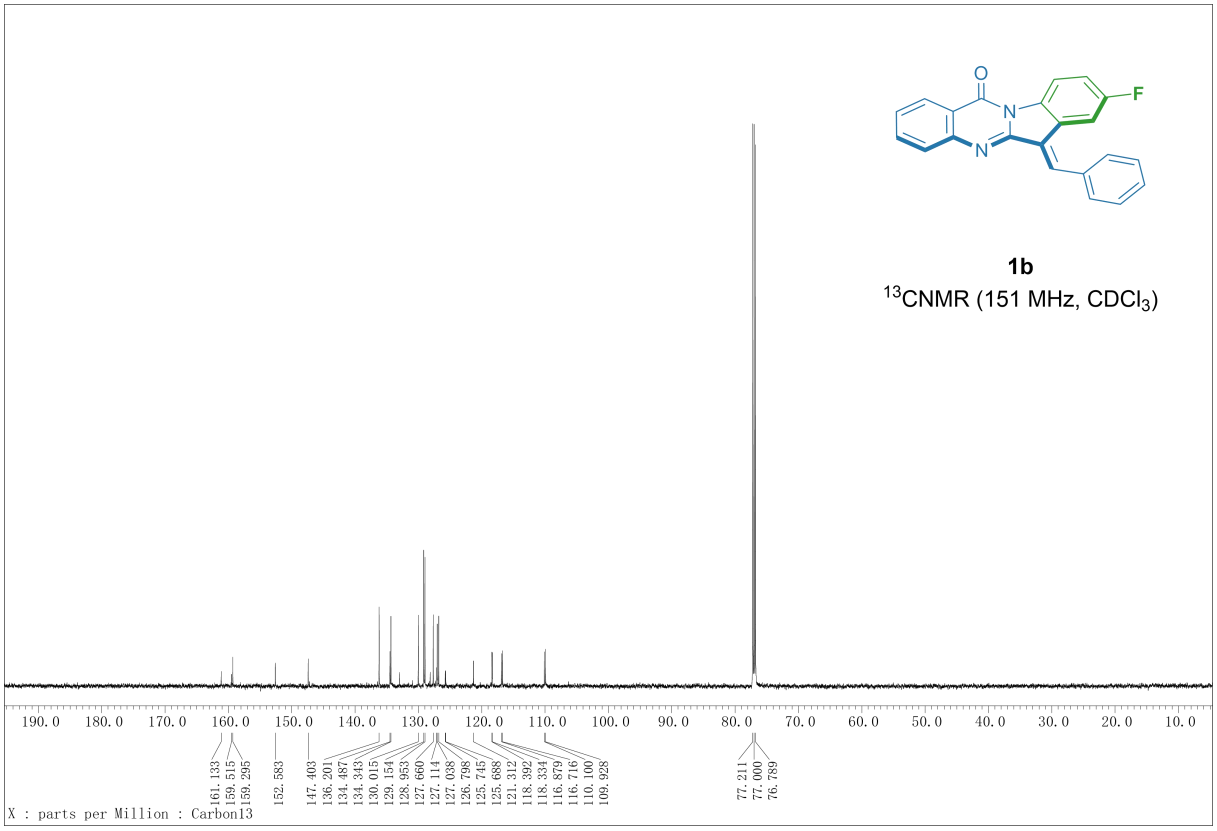
4 (a) D. Gahtory, M. Chouhan, R. Sharma, and V. A. Nair, Total synthesis of a pyrroloindoloquinazoline alkaloid, *Org. Lett.,* 2013, **15**, 3942–3945; (b) B. Rai, R. D. Shukla and A. Kumar, Zinc oxide-NP catalyzed direct indolation of in situ generated bioactive tryptanthrin, *Green Chem.,* 2018, **20**, 822–826; (c) J. Du, P, Liu , Y. Zhu, G. Wang, S. Xing, T. Liu, J. Xia, S. Dong, N. Lv and Z. Li, Novel tryptanthrin derivatives with benzenesulfonamide substituents: design, synthesis, and anti-inflammatory evaluation, *Eur. J. Med. Chem.,* 2023, **246**, 114956.

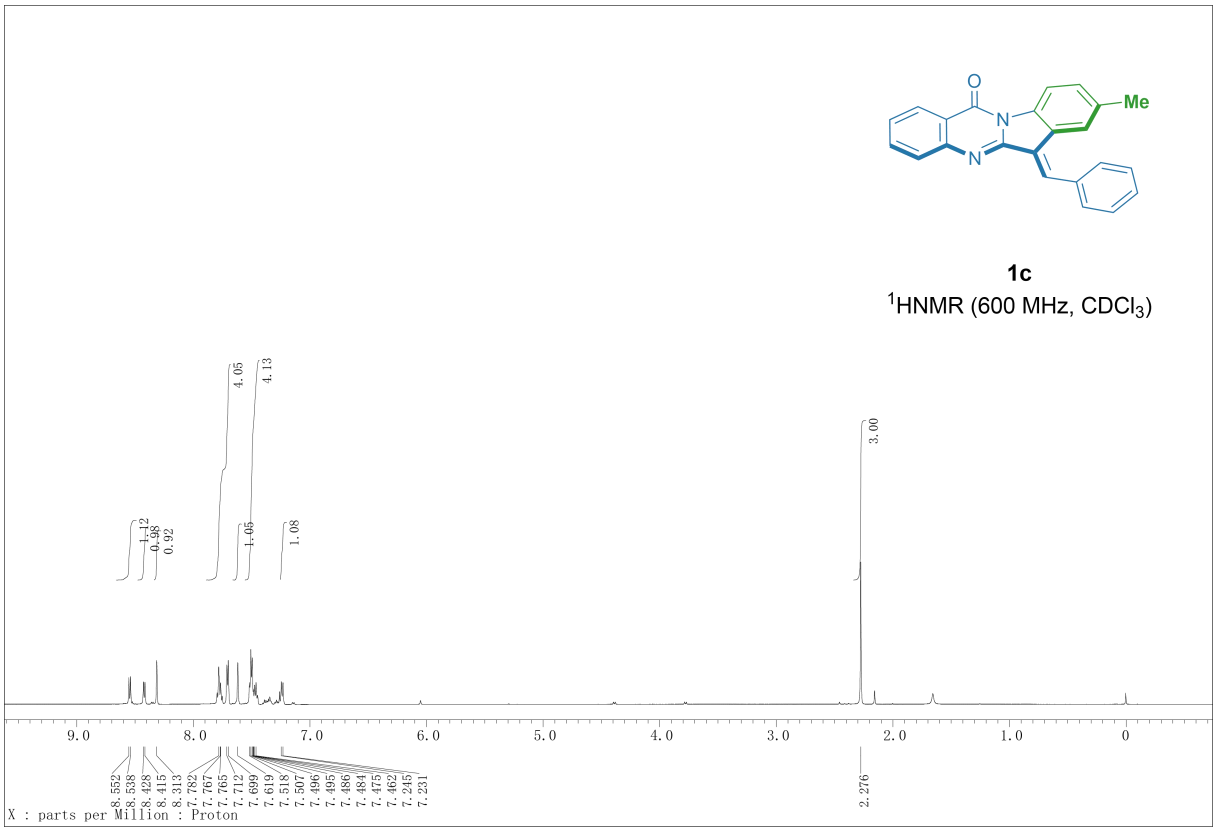
5 (a) E. Badiola, B. Fiser, E. Gómez-Bengoa, A. Mielgo, I. Olaizola, I. Urruzuno, J. M. García, J. M. Odriozola, J. Razkin, M. Oiarbide and C. Palomo, Enantioselective construction of tetrasubstituted stereogenic carbons through brønsted base catalyzed michael reactions: α-hydroxy enones as key enoate equivalent, *J. Am. Chem. Soc.,* 2014, **136**, 17869–17881; (b) S. He, H. Gu, Y. He, and X. Yang, Asymmetric Aza-Diels-Alder reactions of in situ generated β,β-disubstituted α,β-unsaturated N–H ketimines catalyzed by chiral phosphoric acids, *Org. Lett.,* 2020, **22**, 5633–5639; (c) Q. Ni, X. Wang, F. Xu, X. Chen and X. Song, Organocatalytic asymmetric [4+2] cyclization of 2-benzothiazolimines with azlactones: access to chiral benzothiazolopyrimidine derivatives, *Chem. Commun.,* 2020, **56**, 3155–3158.

6 E. S. Lee, J.-G. Park and Y. Jahng, A facile synthesis of simple alkaloids–synthesis of 2,3-polymethylene-4(3H)-quinazolinones and related alkaloids. *Tetrahedron Lett.,* 2003, **44**, 1883–1886.

8. Copies of ^{1}H, ^{13}C NMR, HPLC Spectra

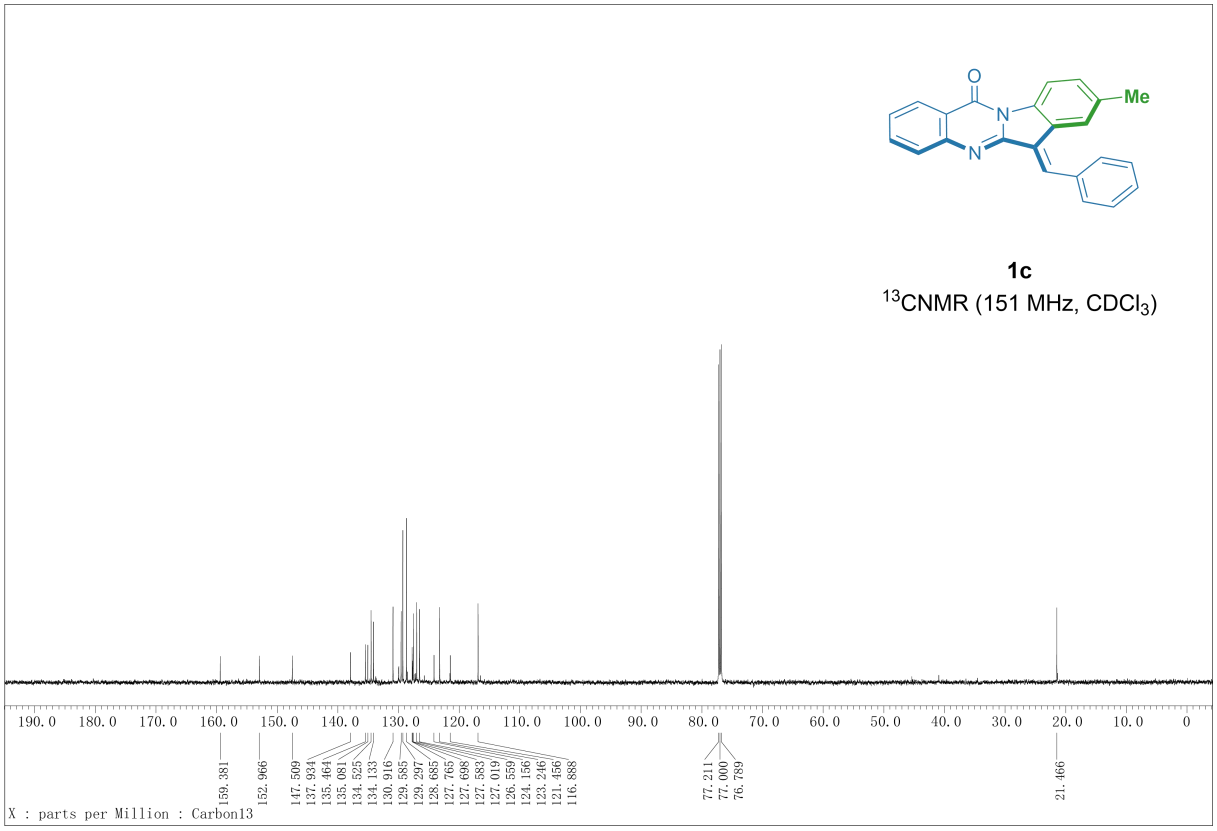






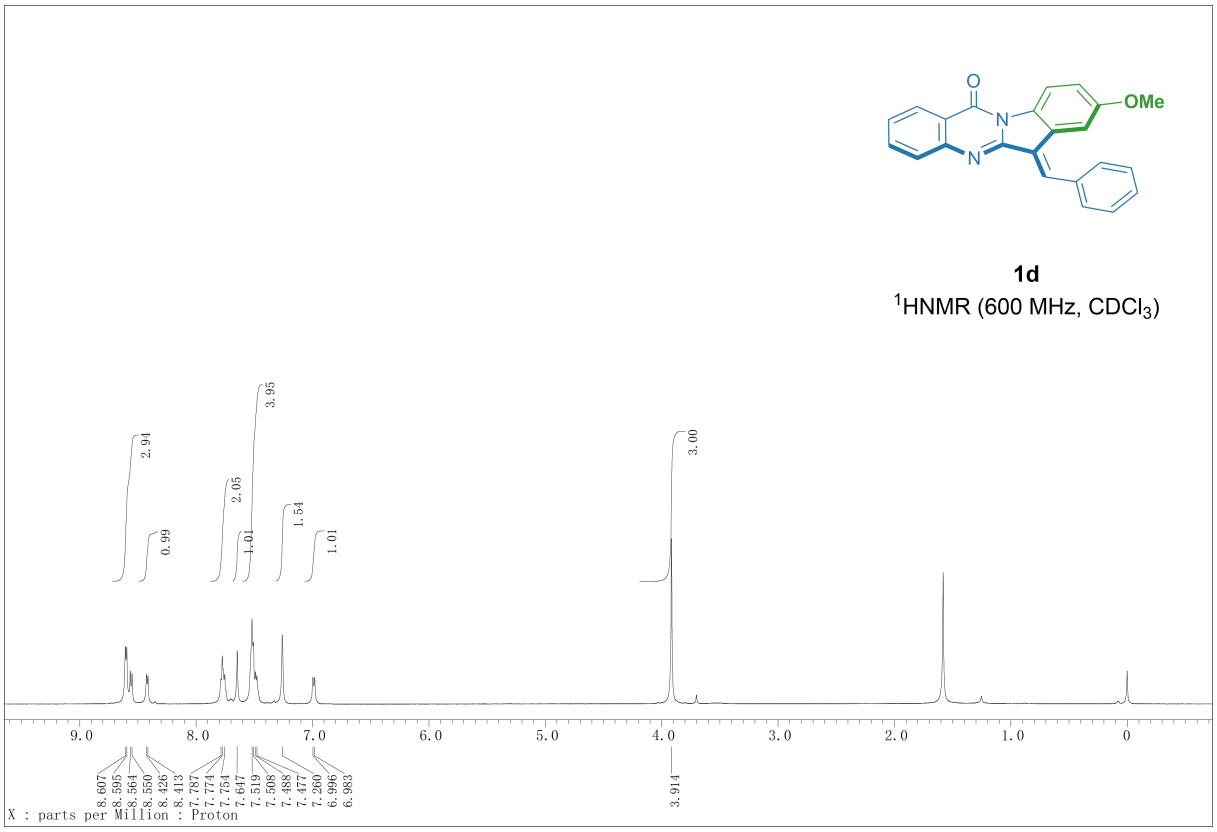
1c

^{1}HNMR (600 MHz, $CDCl_3$)



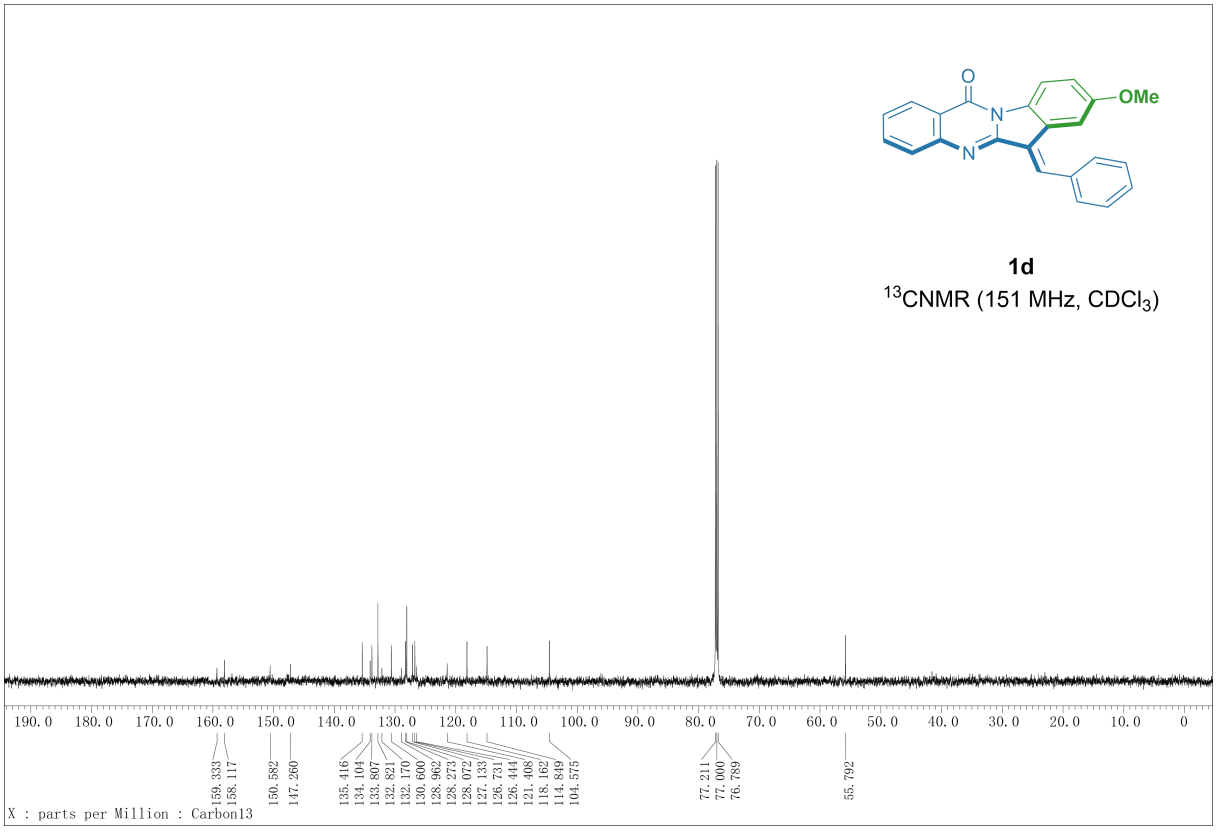
1c

^{13}CNMR (151 MHz, $CDCl_3$)



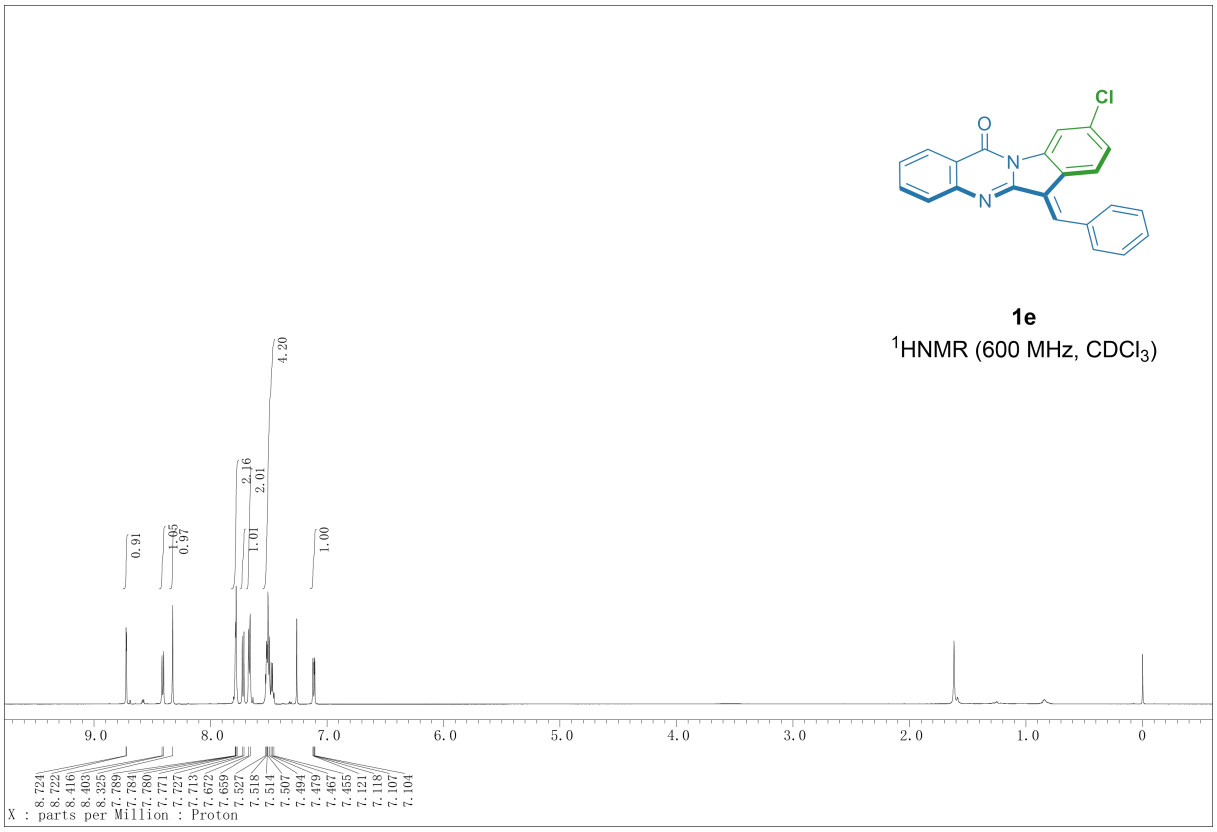
1d

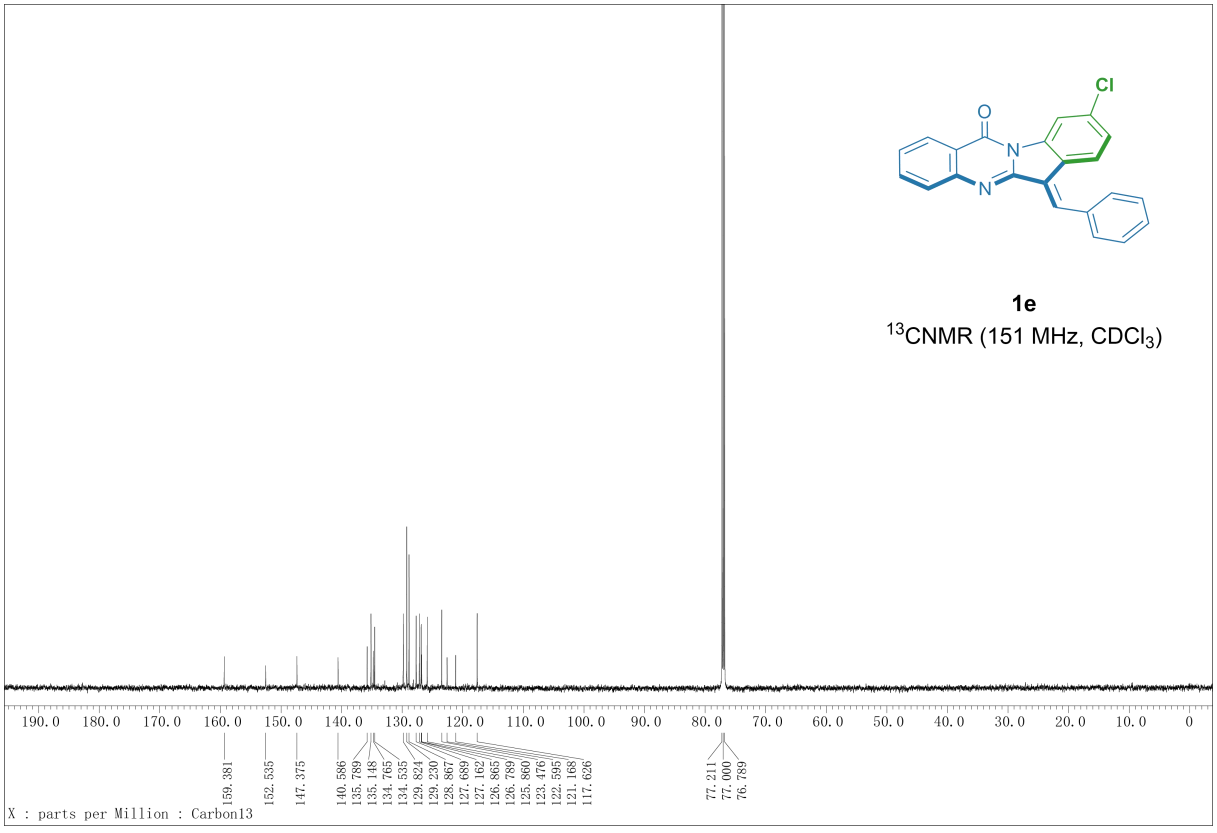
^{1}HNMR (600 MHz, $CDCl_3$)

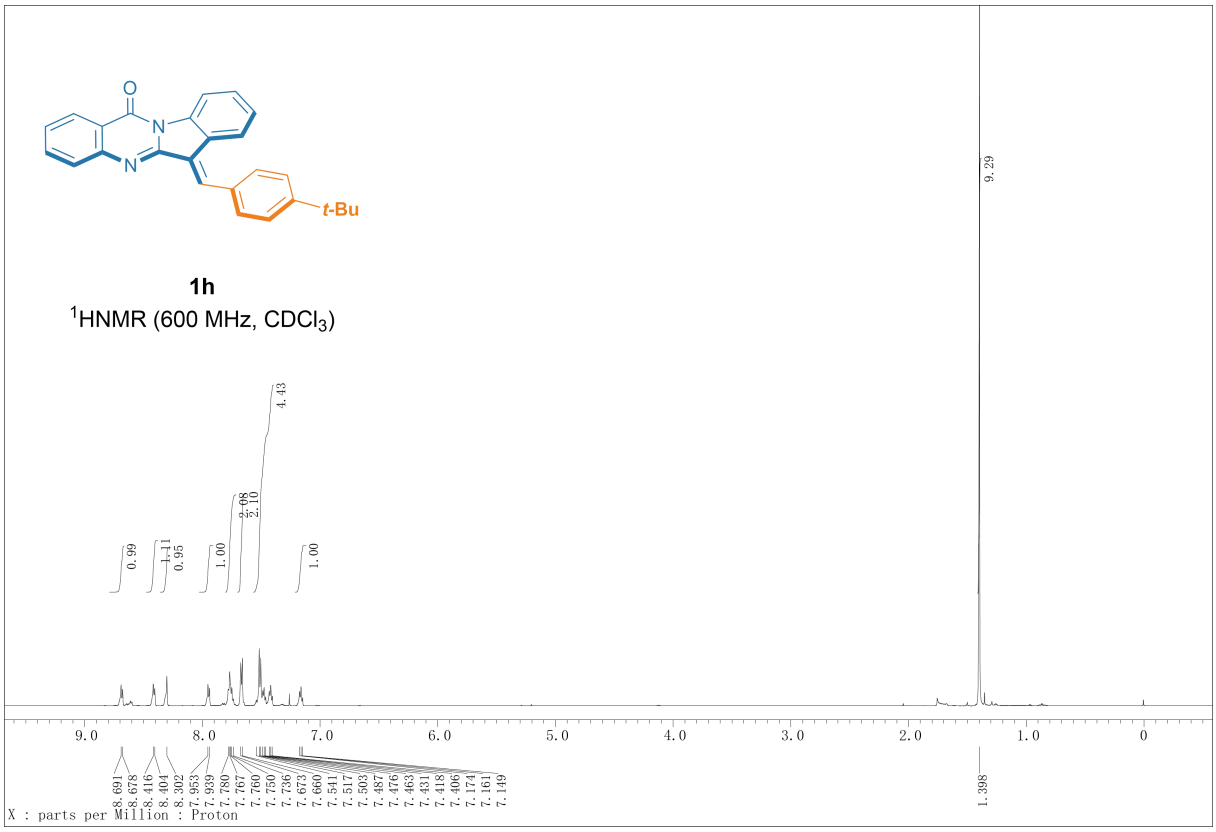


1d

^{13}CNMR (151 MHz, $CDCl_3$)

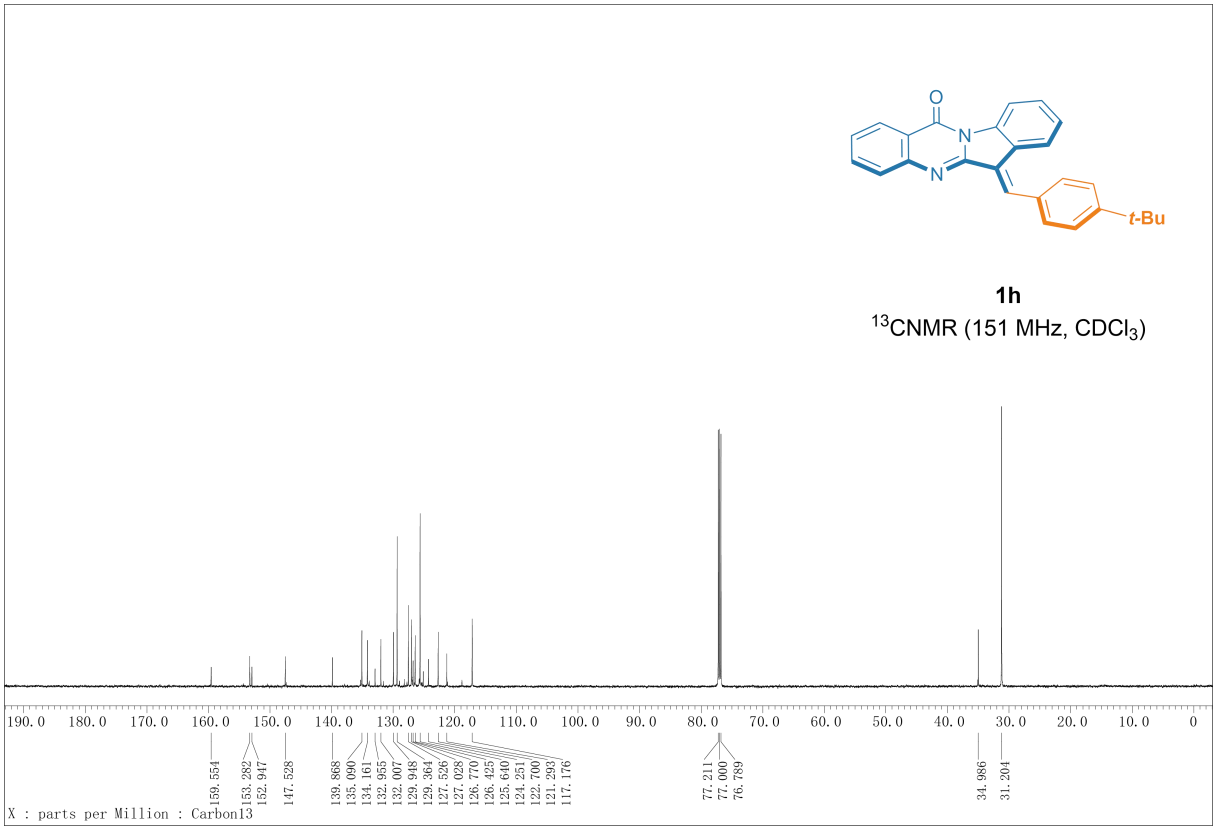

Cl
O
N
N
1e
1HNMR (600 MHz, CDCl3)
0.91
1.95
0.97
2.16
2.01
1.01
4.20
1.00
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
8.724
8.722
8.416
8.403
8.325
7.789
7.784
7.780
7.771
7.727
7.713
7.672
7.659
7.527
7.518
7.514
7.507
7.494
7.479
7.467
7.455
7.121
7.118
7.107
7.104
X : parts per Million : Proton


Cl
O
N
N
1e
13CNMR (151 MHz, CDCl3)
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
159.381
152.535
147.375
140.586
135.789
135.148
134.765
134.535
129.824
129.230
128.867
127.689
127.162
126.865
126.789
125.860
123.476
122.595
121.168
117.626
77.211
77.000
76.789
X : parts per Million : Carbon13



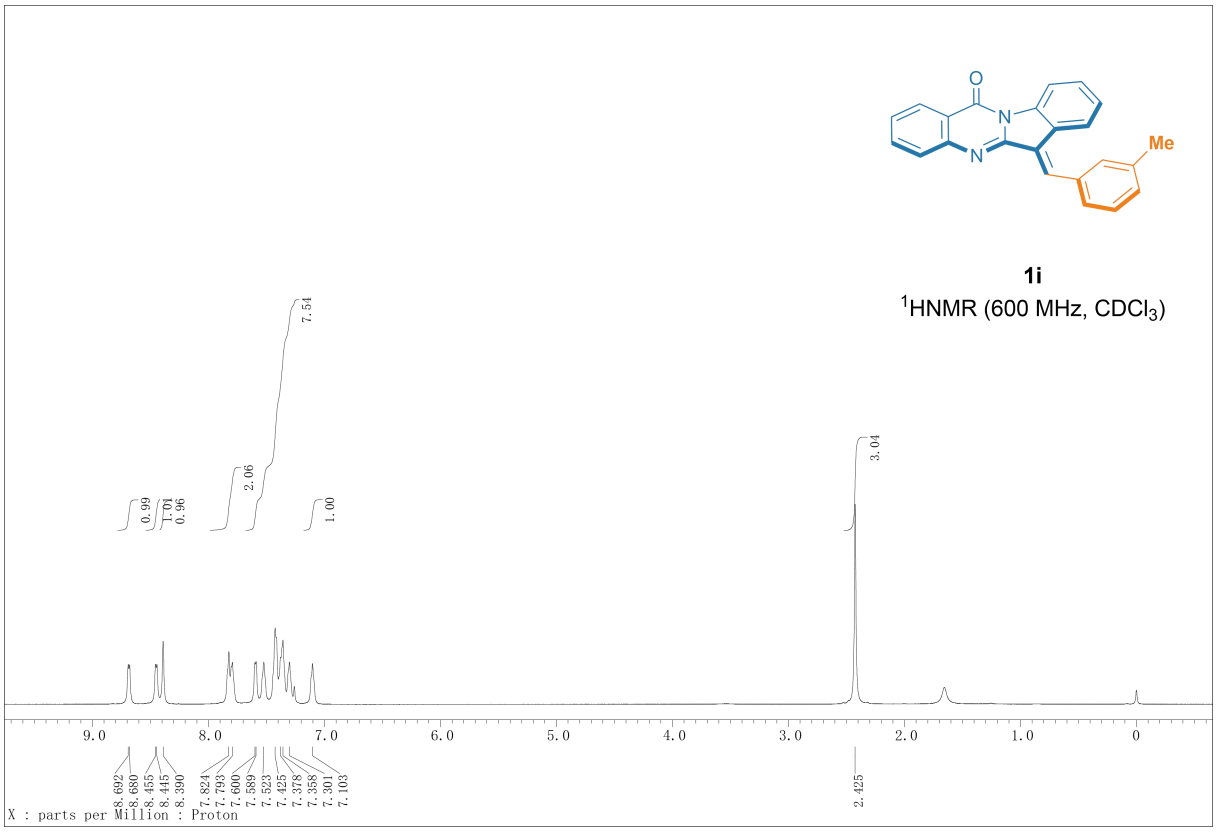
1h

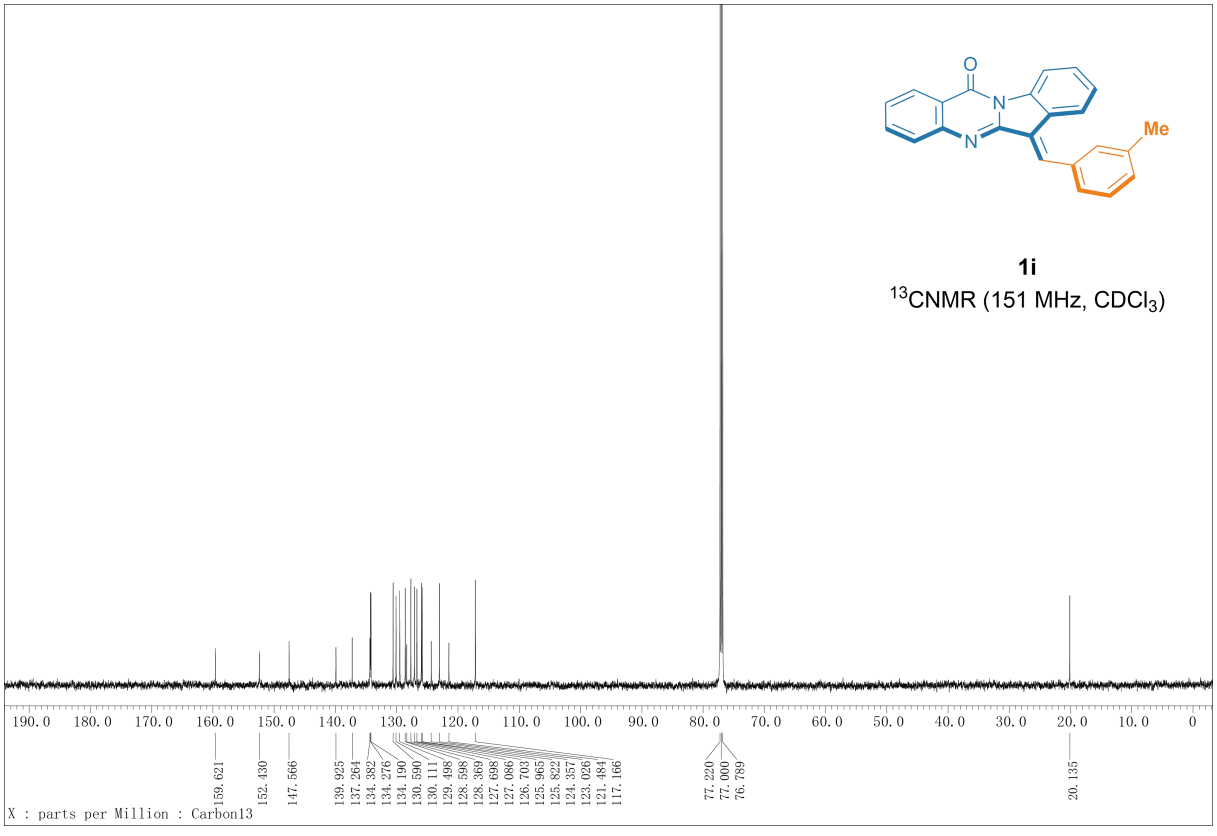
^{1}HNMR (600 MHz, $CDCl_3$)



1h

^{13}CNMR (151 MHz, $CDCl_3$)


O
N
N
Me
1i
1HNMR (600 MHz, CDCl3)
0.99
1.01
0.96
2.06
7.54
1.00
3.04
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
8.692
8.680
8.455
8.445
8.390
7.824
7.793
7.600
7.589
7.523
7.425
7.378
7.358
7.301
7.103
2.425
X : parts per Million : Proton


O
N
N
Me
1i
13CNMR (151 MHz, CDCl3)
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
159.621
152.430
147.566
139.925
137.264
134.382
134.276
134.190
130.590
130.111
129.498
128.598
128.369
127.698
127.086
126.703
125.965
125.822
124.357
123.026
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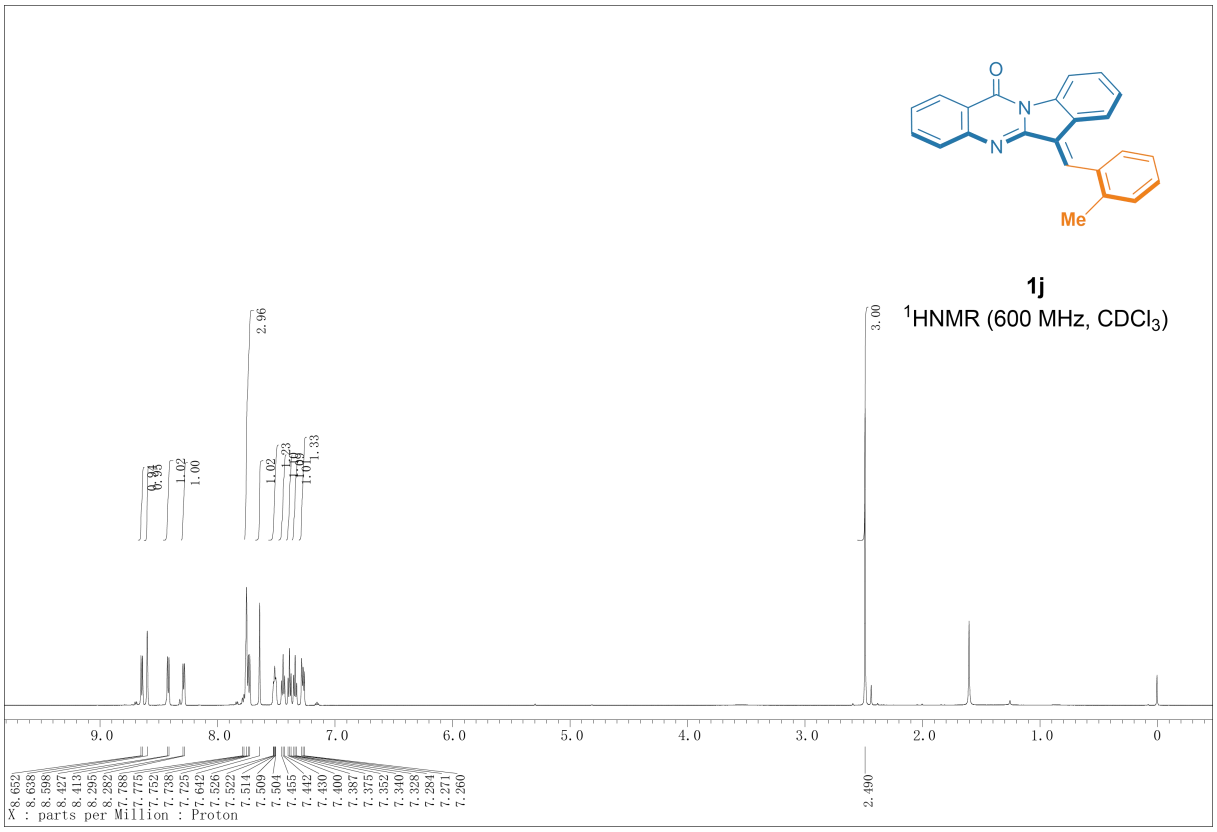
77.220
77.000
76.789
20.135
X : parts per Million : Carbon13


O
N
N
Me
1j
1HNMR (600 MHz, CDCl3)
2.96
3.00
1.02
1.00
1.02
1.23
1.09
1.33
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
8.652
8.638
8.598
8.427
8.413
8.295
8.282
7.788
7.775
7.762
7.738
7.725
7.642
7.526
7.522
7.514
7.509
7.504
7.455
7.442
7.430
7.400
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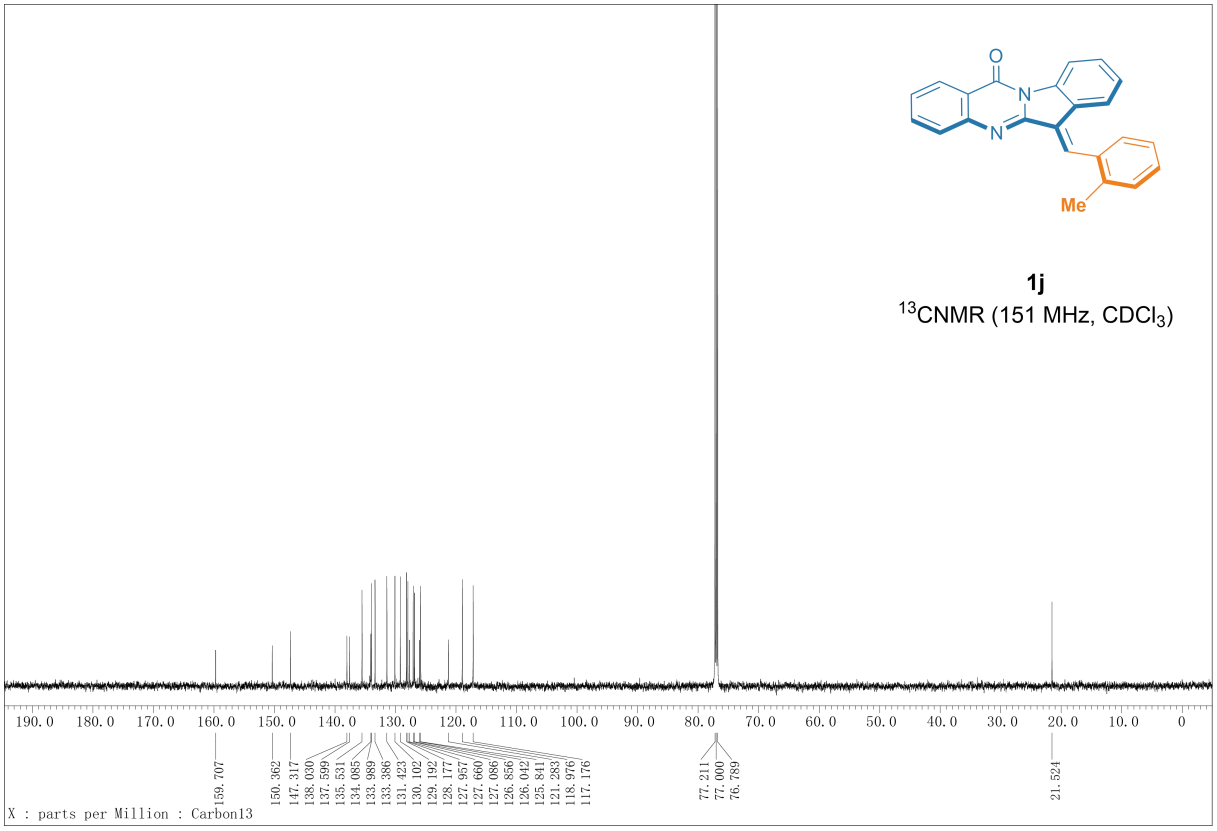
7.375
7.352
7.340
7.328
7.284
7.271
7.260
2.490
X : parts per Million : Proton


O
N
N
Me
1j
13CNMR (151 MHz, CDCl3)
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
159.707
150.362
147.317
138.030
137.599
135.531
134.085
133.989
133.386
131.423
130.102
129.192
128.177
127.957
127.660
127.086
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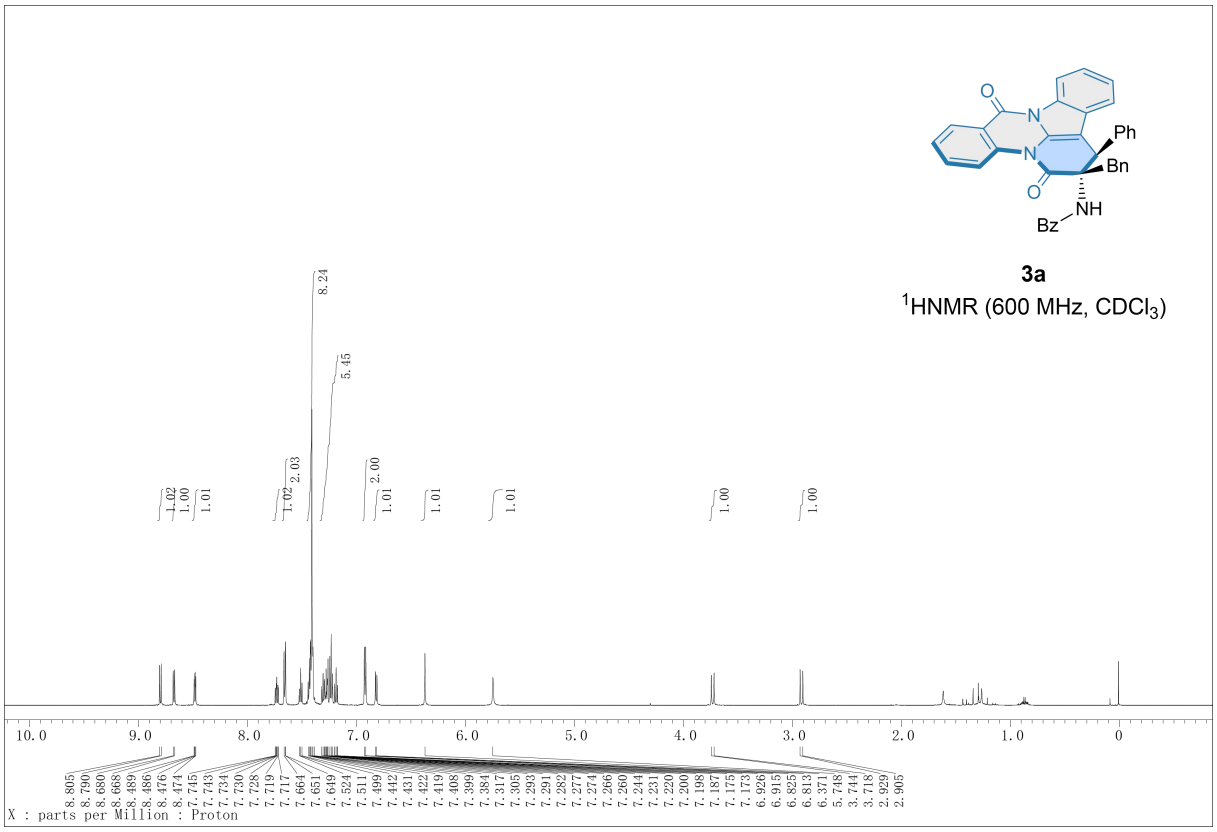
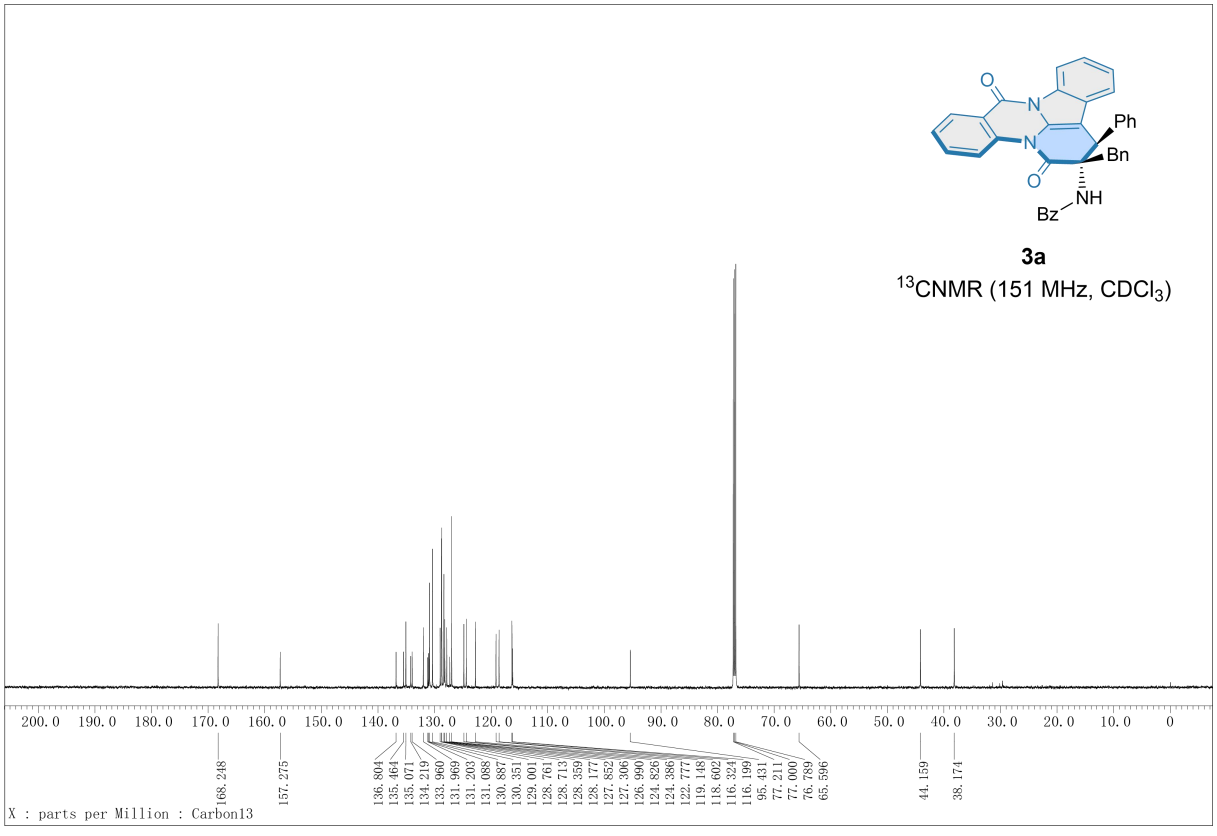
77.000
76.789
21.524
X : parts per Million : Carbon13



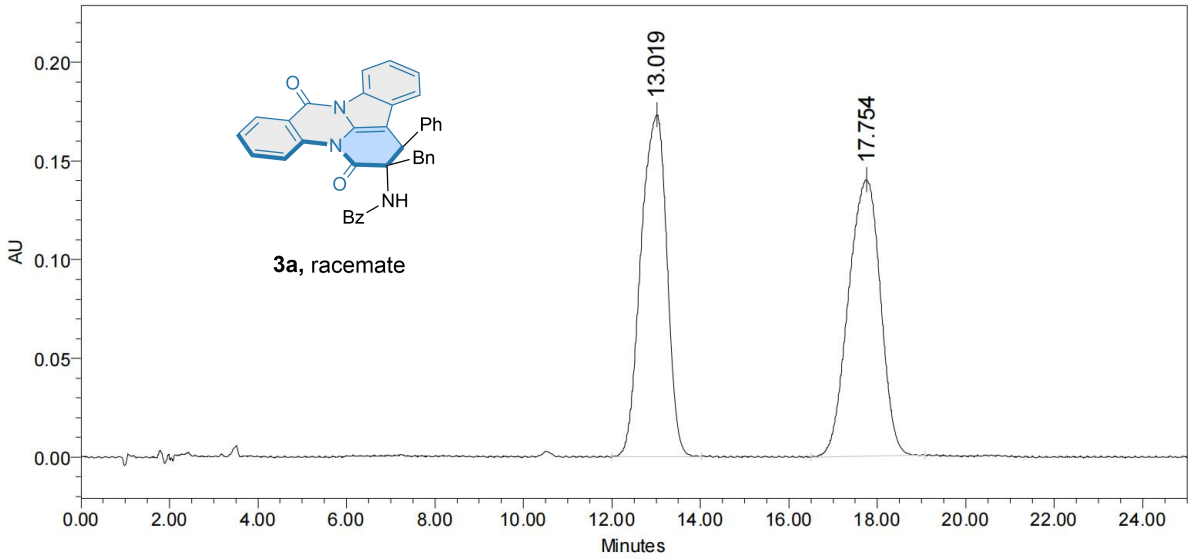
3a

^{1}HNMR (600 MHz, $CDCl_3$)



3a

^{13}CNMR (151 MHz, $CDCl_3$)



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
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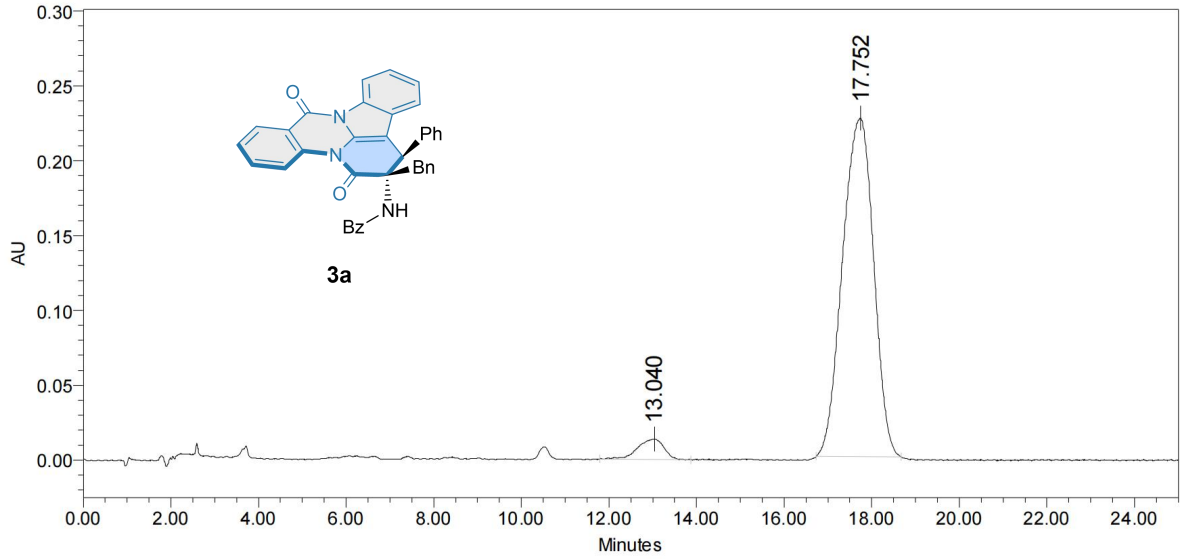
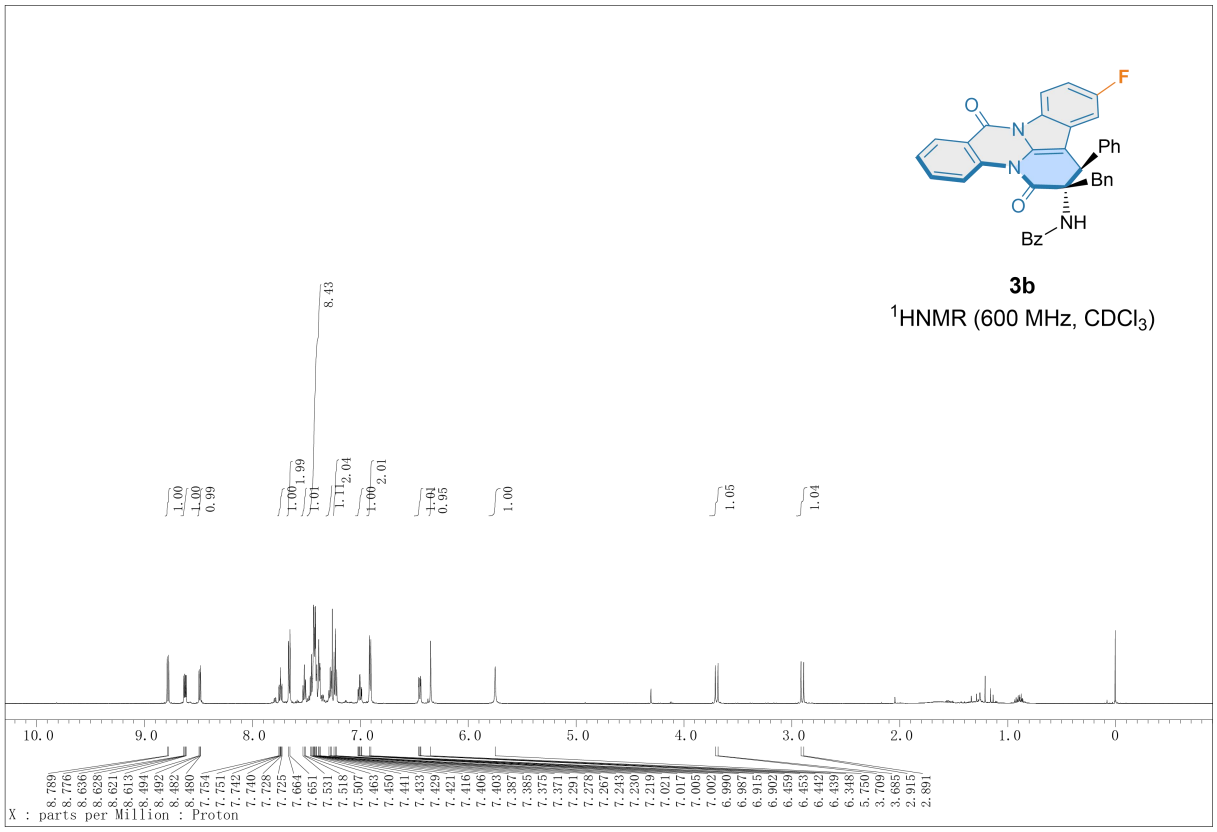
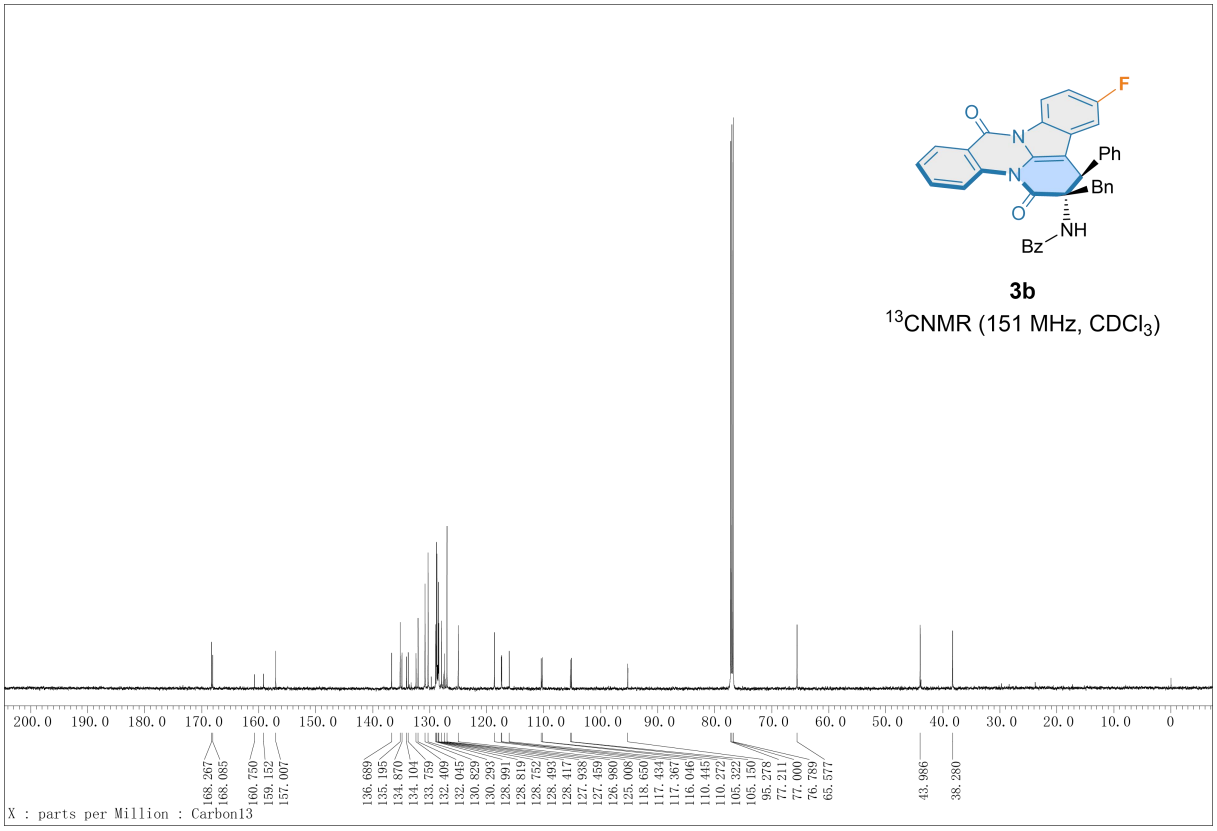
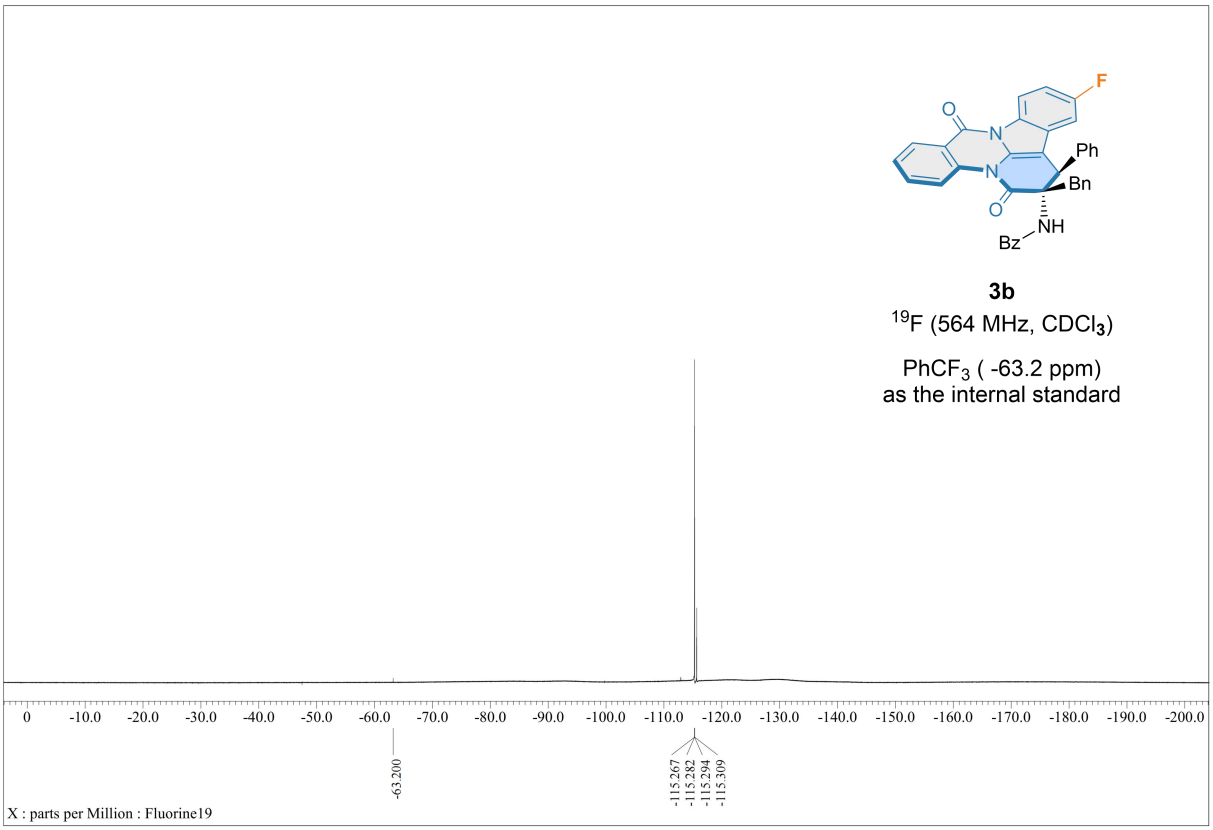
2	17.754	139859	7074470	49.94



	Ret.Time(min)	Height(mV)	Area(mV*sec)	Rel.Area(%)
1	13.040	13629	568438	4.83
2	17.752	225948	11188521	95.17


F
O
N
N
Ph
Bn
O
NH
Bz
3b
1HNMR (600 MHz, CDCl3)
8.43
1.00
1.00
0.99
1.00
1.01
1.99
1.11
2.04
1.00
2.01
1.04
0.95
1.00
1.05
1.04
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
8.789
8.776
8.636
8.628
8.621
8.613
8.494
8.492
8.482
8.480
7.754
7.751
7.742
7.740
7.728
7.725
7.664
7.651
7.531
7.518
7.507
7.465
7.460
7.441
7.433
7.429
7.421
7.416
7.406
7.403
7.387
7.385
7.375
7.371
7.291
7.278
7.267
7.243
7.230
7.219
7.021
7.017
7.005
7.002
6.990
6.987
6.915
6.902
6.459
6.453
6.442
6.439
6.348
5.760
3.709
3.685
2.915
2.891
X : parts per Million : Proton


F
O
N
N
Ph
Bn
O
NH
Bz
3b
13CNMR (151 MHz, CDCl3)
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
168.267
168.085
160.750
159.152
157.007
136.689
135.195
134.870
134.104
133.759
132.409
132.045
130.829
130.293
128.991
128.819
128.752
128.493
128.417
127.938
127.459
126.980
125.008
118.650
117.434
117.367
116.046
110.445
110.272
105.322
105.150
95.278
77.211
77.000
76.789
65.577
43.986
38.280
X : parts per Million : Carbon13


F
O
N
N
O
Ph
Bn
NH
Bz
3b
19F (564 MHz, CDCl3)
PhCF3 (-63.2 ppm)
as the internal standard
0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
-150.0
-160.0
-170.0
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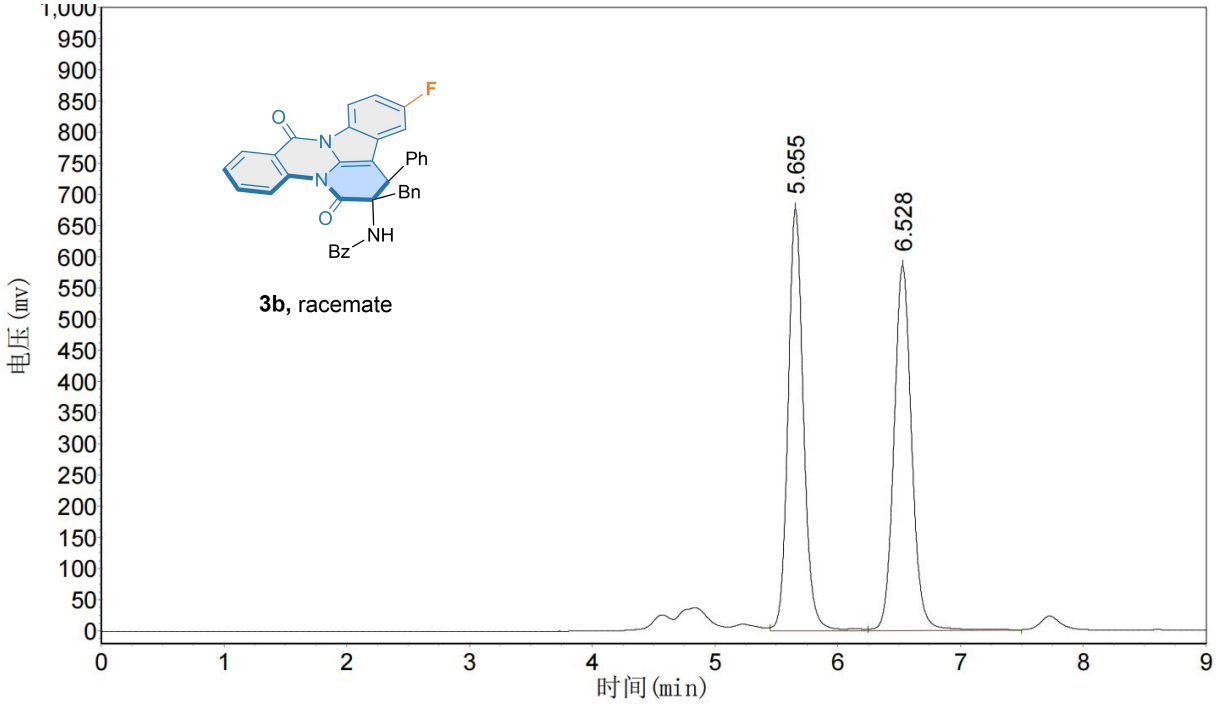
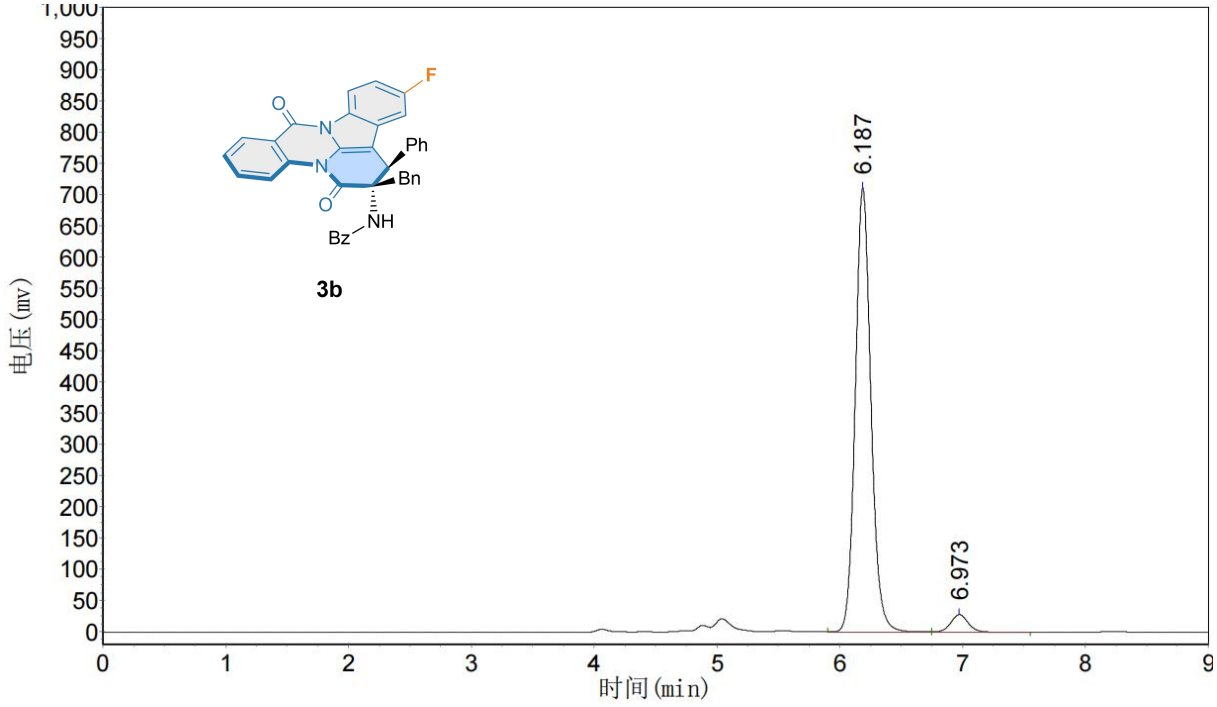
-200.0
-63.200
-115.267
-115.282
-115.294
-115.309
X : parts per Million : Fluorine19



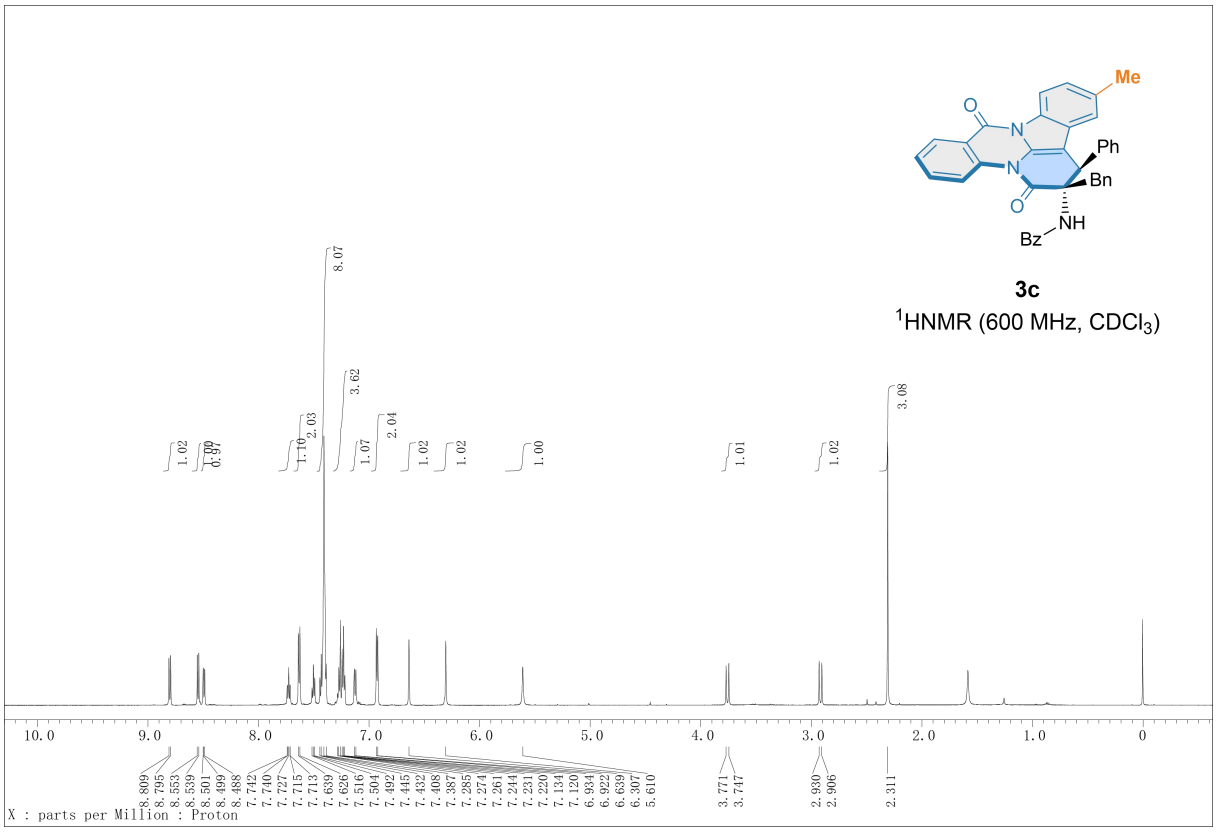
3b, racemate

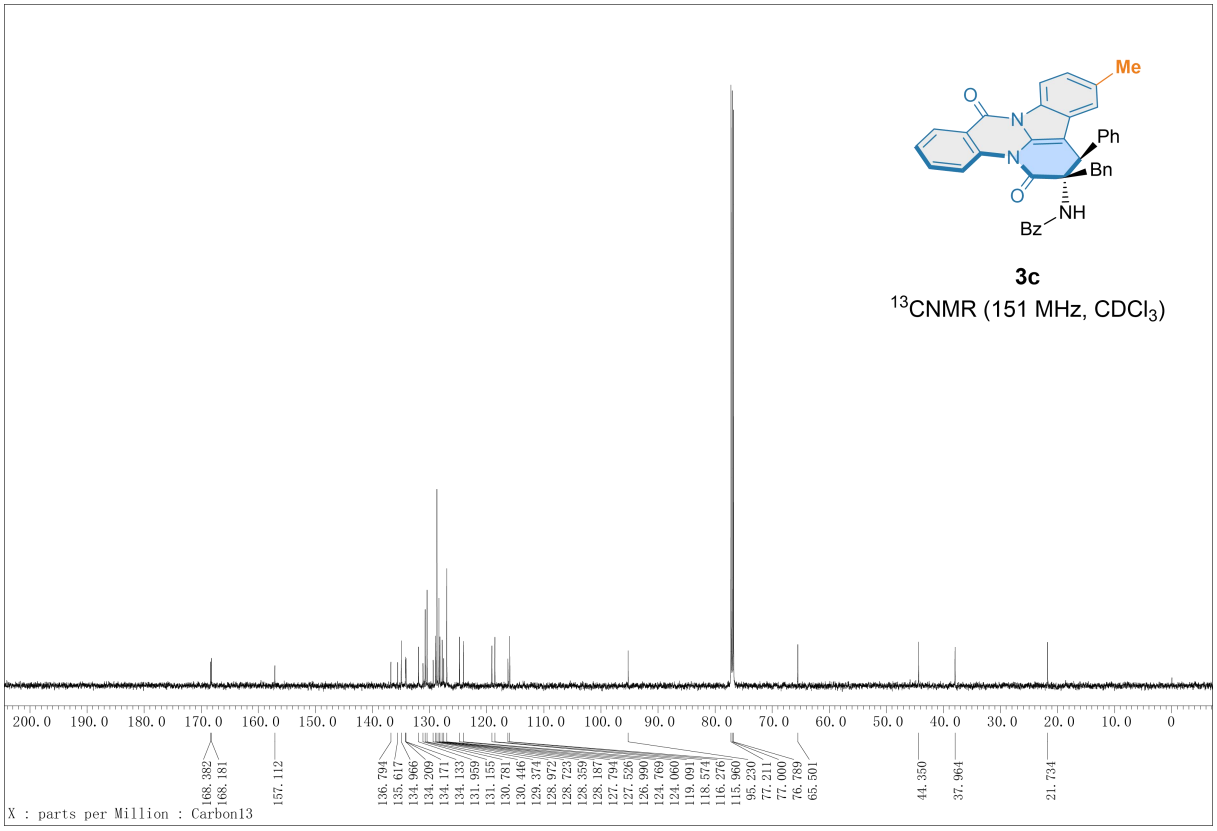
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	5.655	676628	5894318	50.02
2	6.528	585343	5889047	49.98

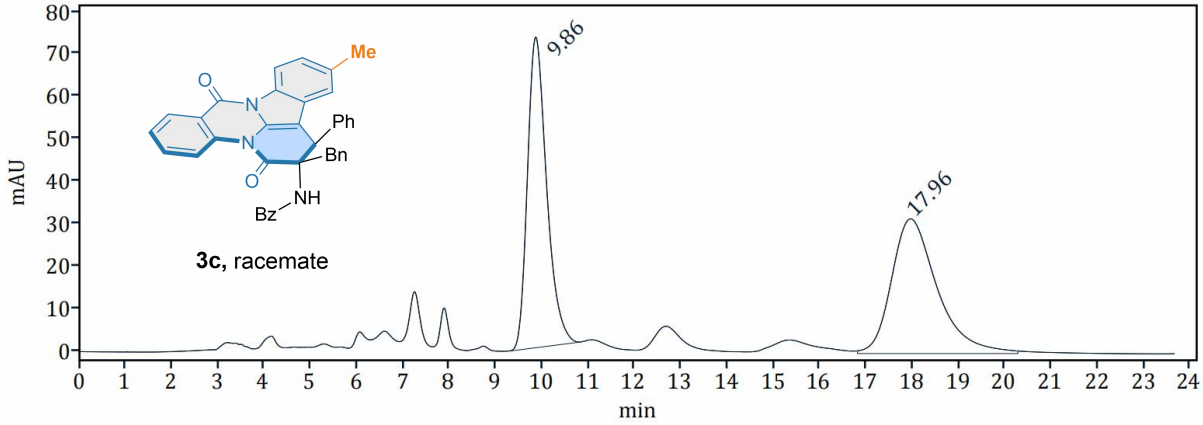


3b

	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	6.187	712007	6319438	95.72
2	6.973	28135	282389	4.28

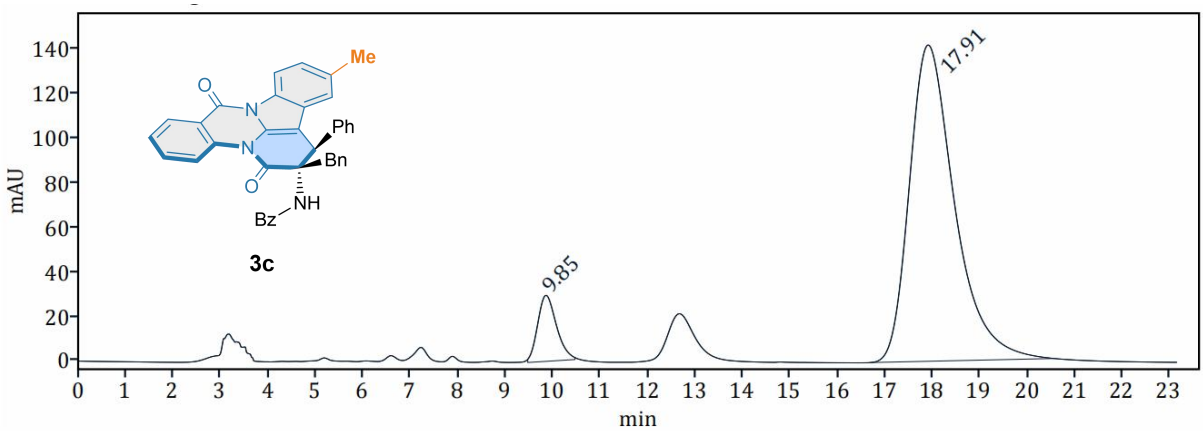

Me
O
N
N
O
Ph
Bn
NH
Bz
3c
1HNMR (600 MHz, CDCl3)
X : parts per Million : Proton


Me
O
N
N
O
Ph
Bn
NH
Bz
3c
13CNMR (151 MHz, CDCl3)
X : parts per Million : Carbon13



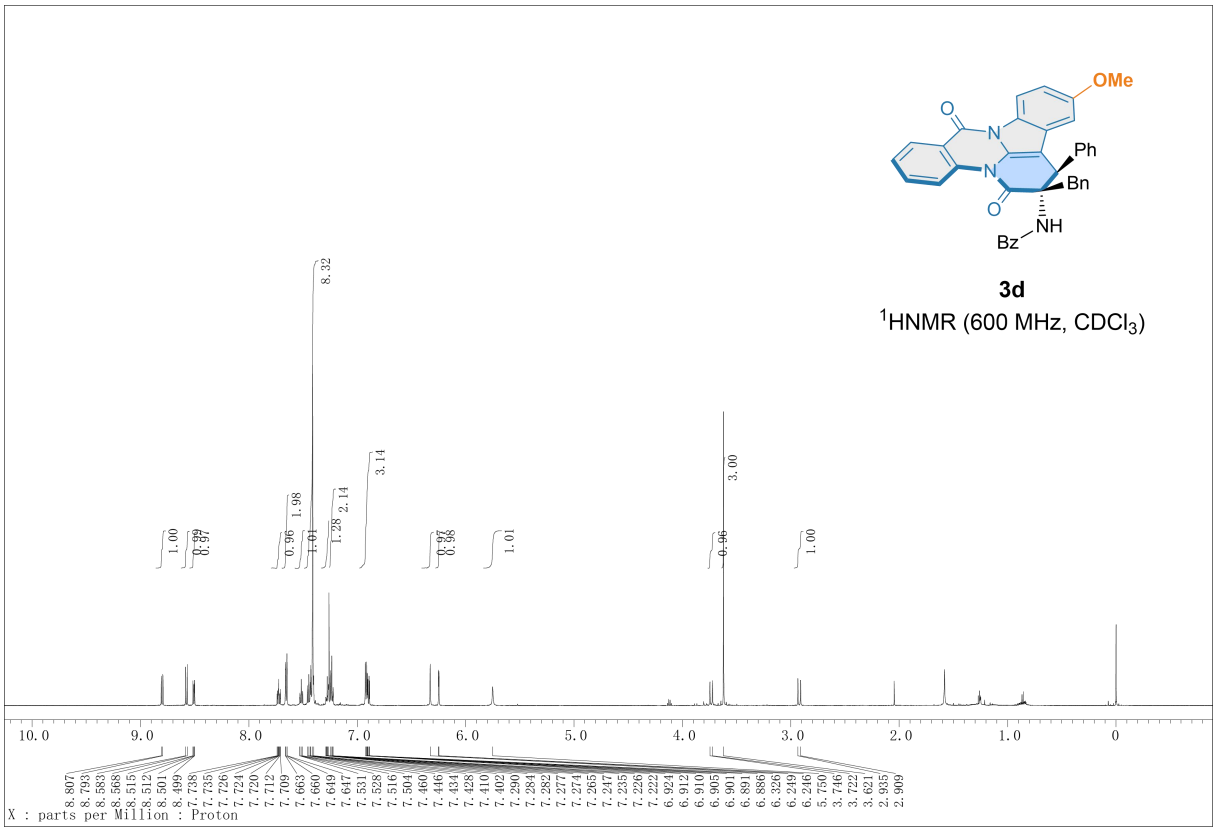
Peak Analysis Report

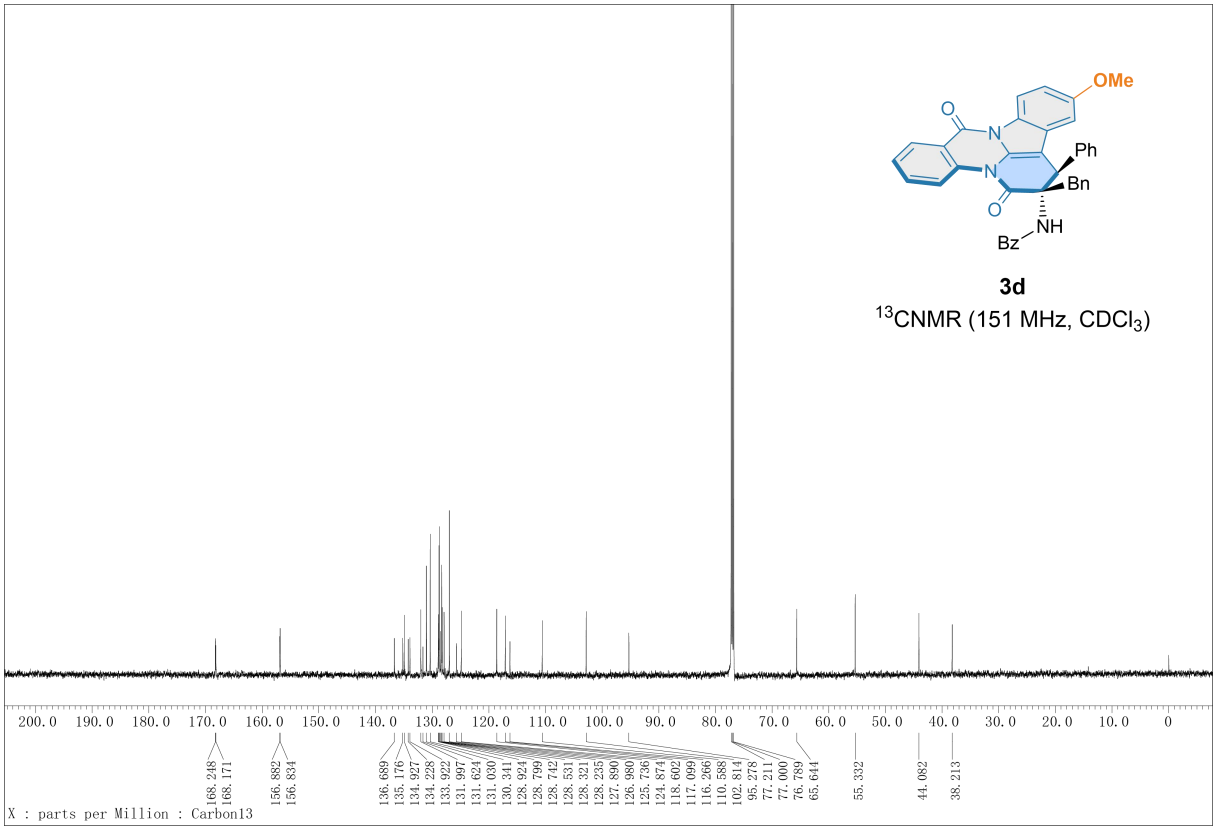
Peak #	Ret. Time [min]	Area [mAU*s]	Height [mAU]	Rel. Area [%]
1	9.86	2112.801	73.2066	49.2165
2	17.96	2180.073	31.7515	50.7835

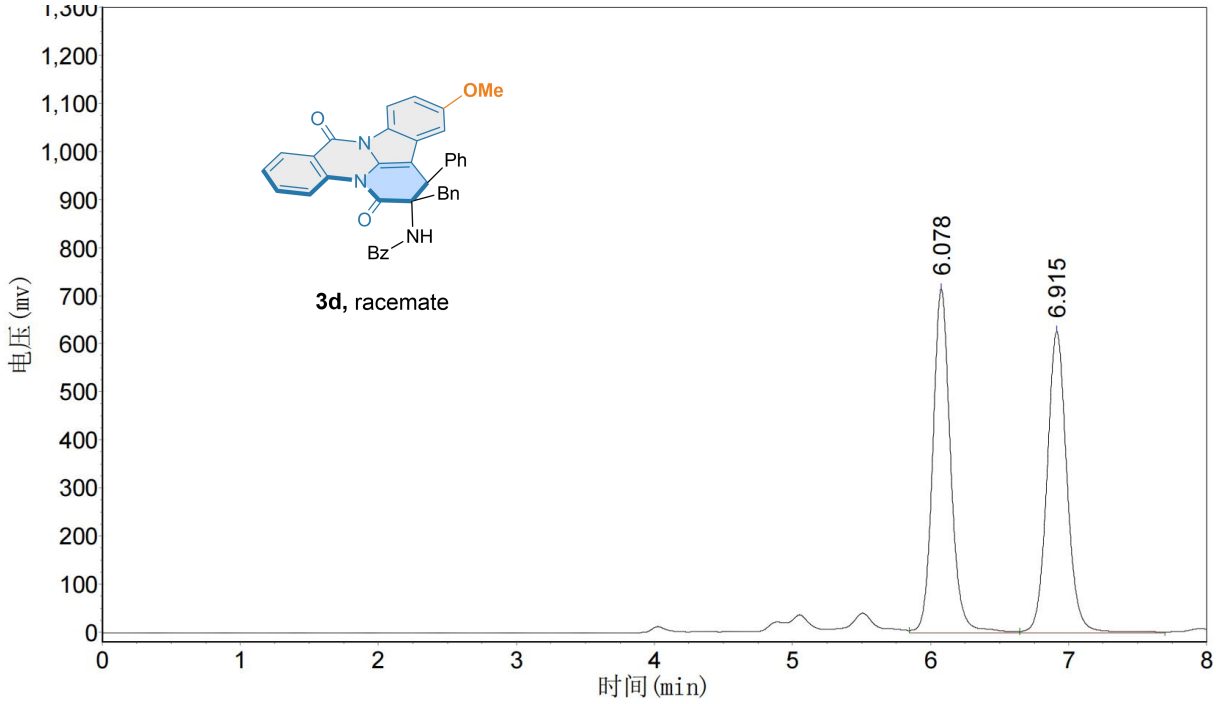


Peak Analysis Report

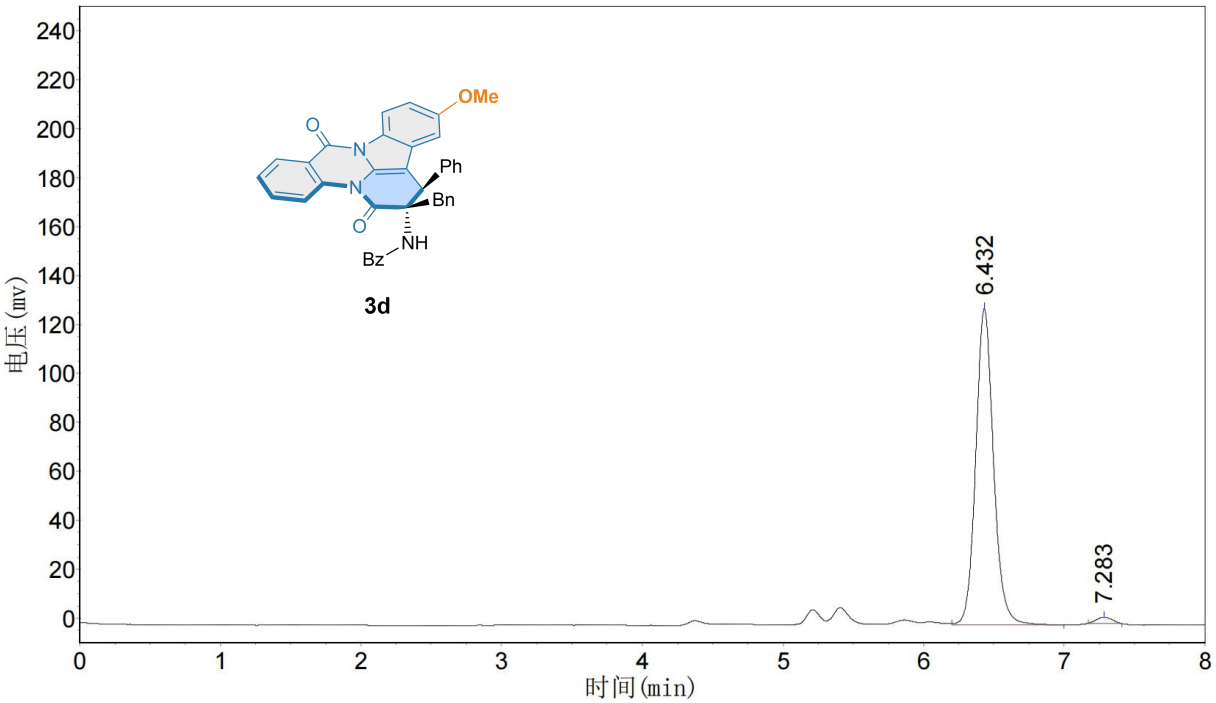
Peak #	Ret. Time [min]	Area [mAU*s]	Height [mAU]	Rel. Area [%]
1	9.85	817.163	29.6710	8.0012
2	17.91	9395.842	142.1854	91.9988


OMe
O
N
N
Ph
Bn
O
NH
Bz
3d
1HNMR (600 MHz, CDCl3)
X : parts per Million : Proton

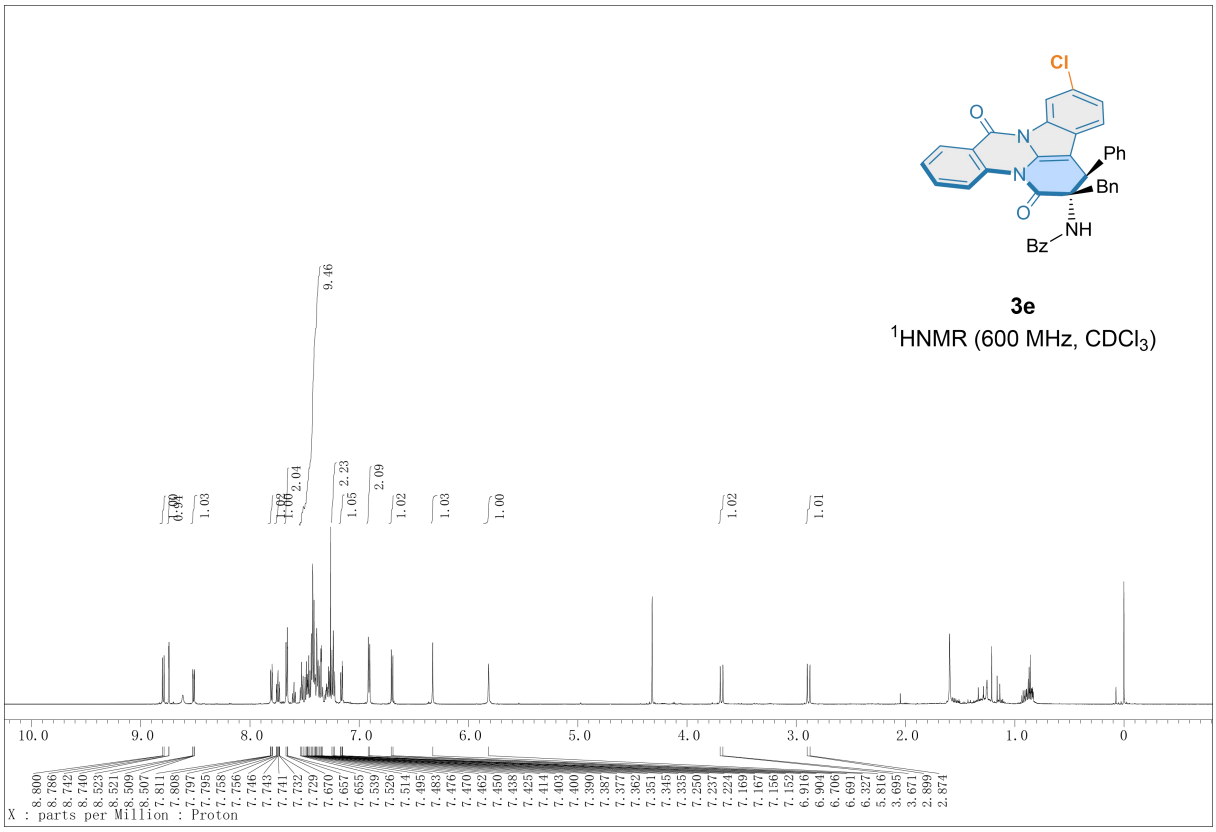

OMe
O
N
N
Ph
Bn
O
NH
Bz
3d
13CNMR (151 MHz, CDCl3)
X : parts per Million : Carbon13



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	6.078	714598	6413109	50.53
2	6.915	626452	6279747	49.47

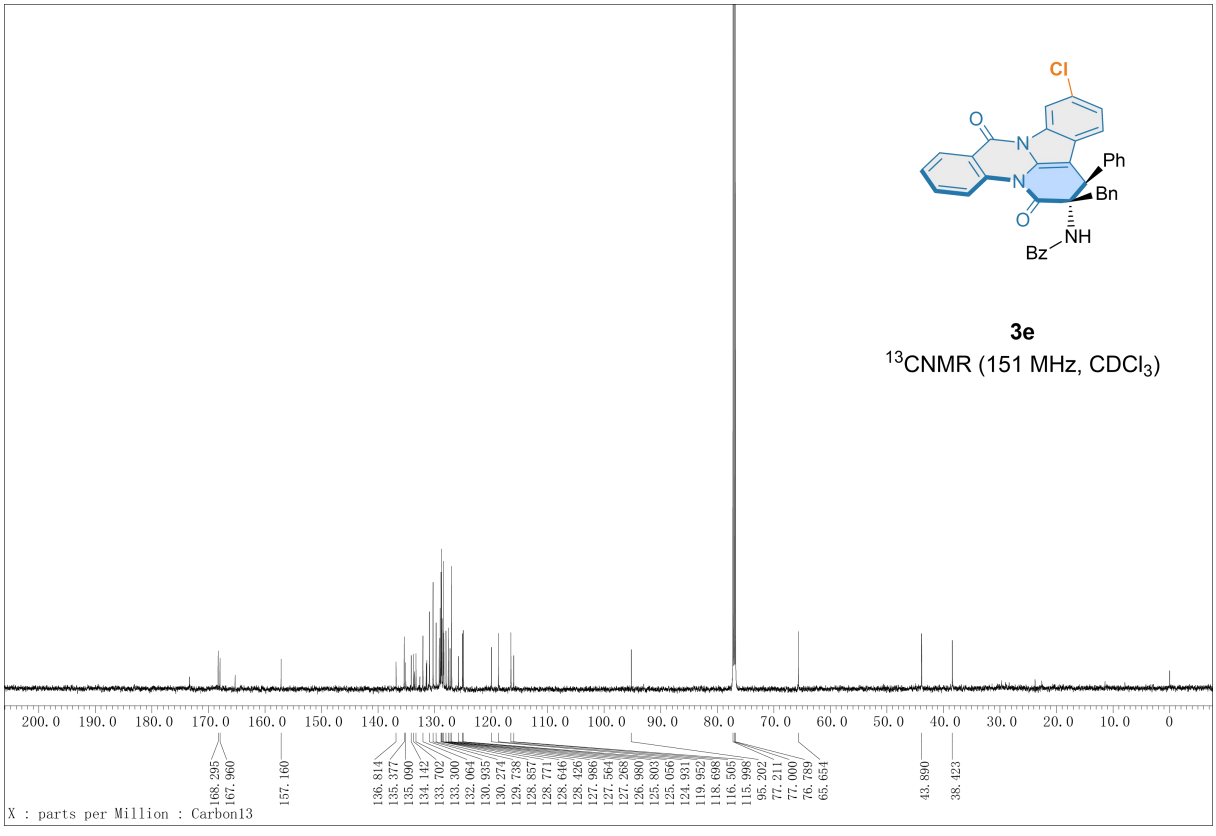


	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	6.432	129349	1141219	98.33
2	7.283	2513	19430	1.67



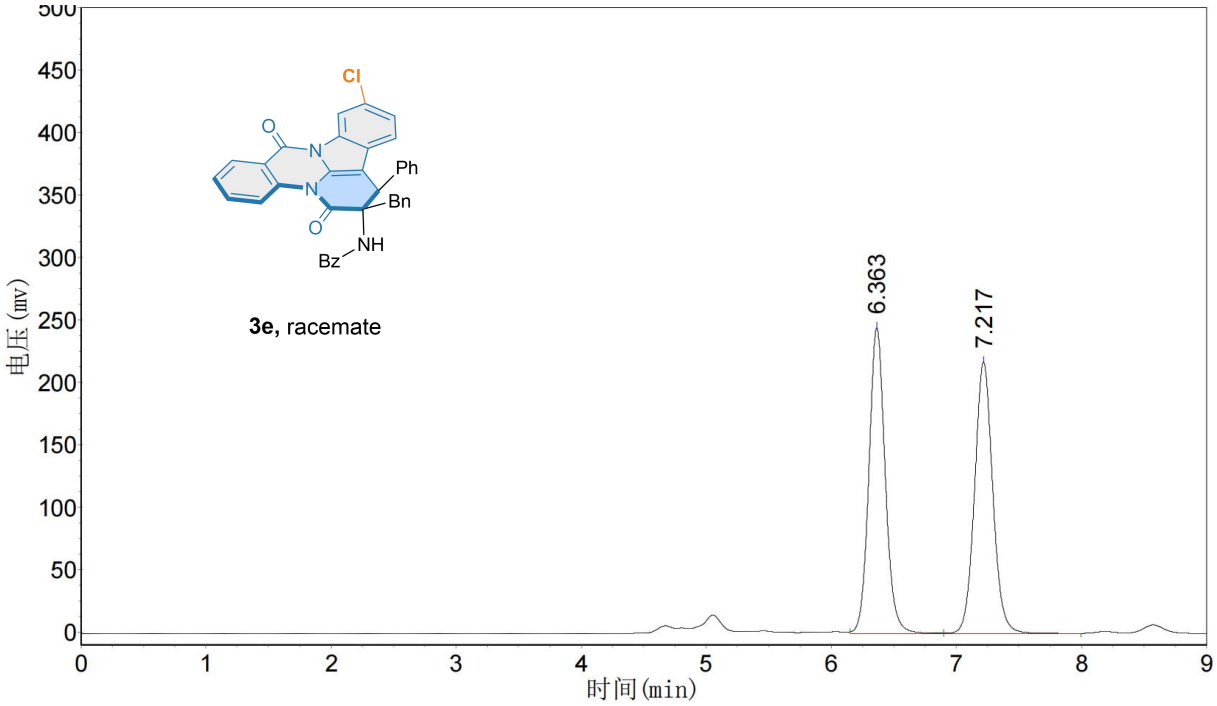
3e

^{1}HNMR (600 MHz, $CDCl_3$)

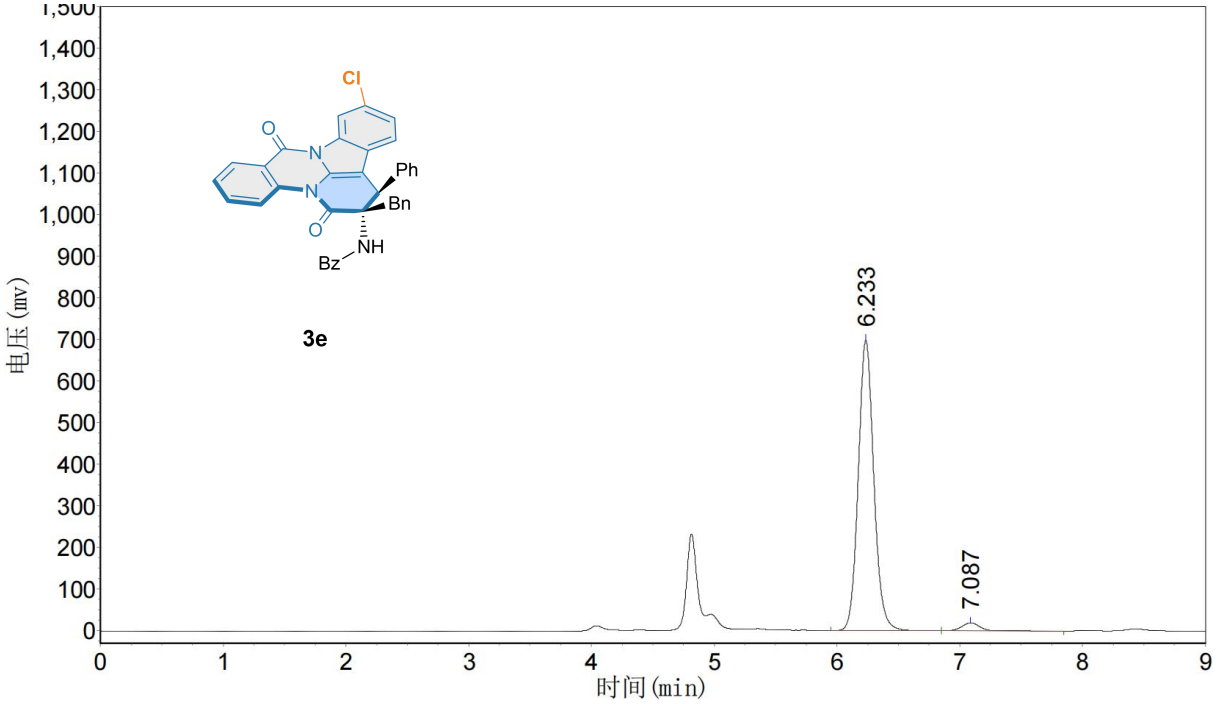


3e

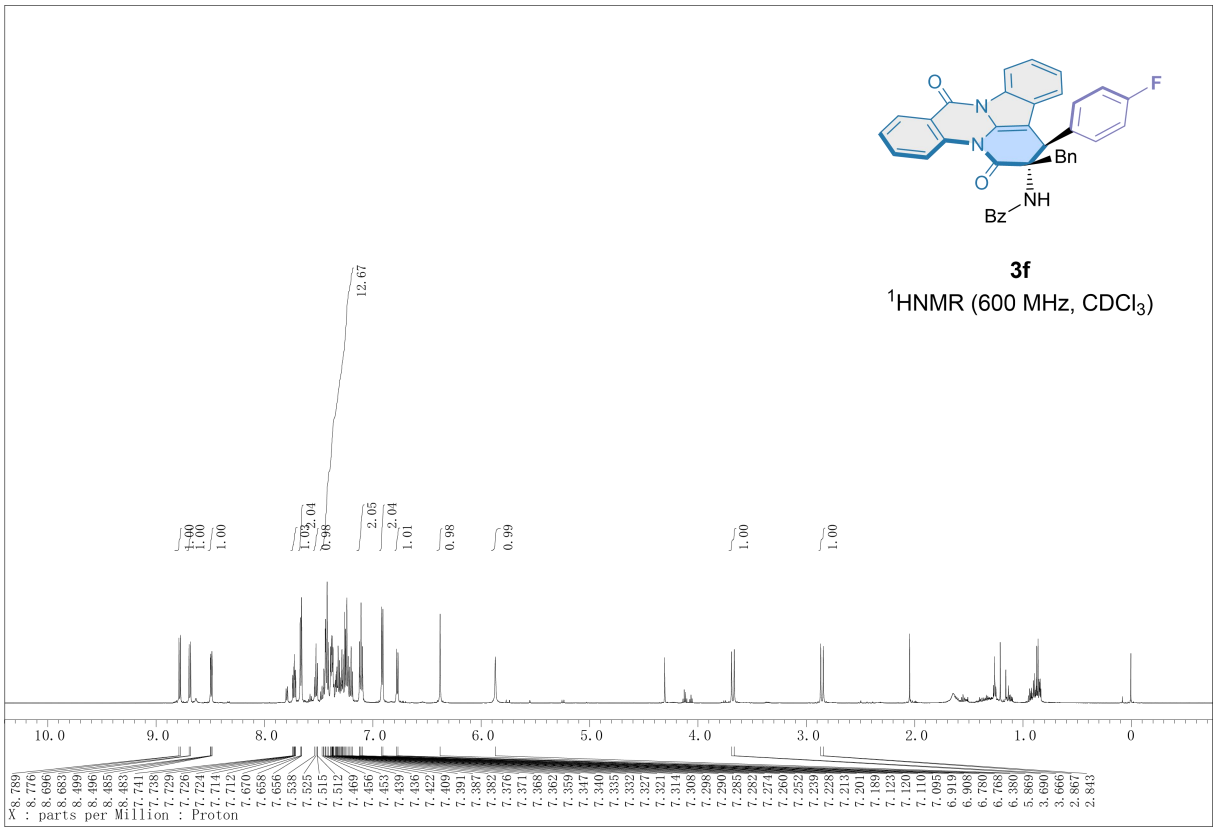
^{13}CNMR (151 MHz, $CDCl_3$)



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	6.363	244802	2225538	50.14
2	7.217	217383	2213303	49.86

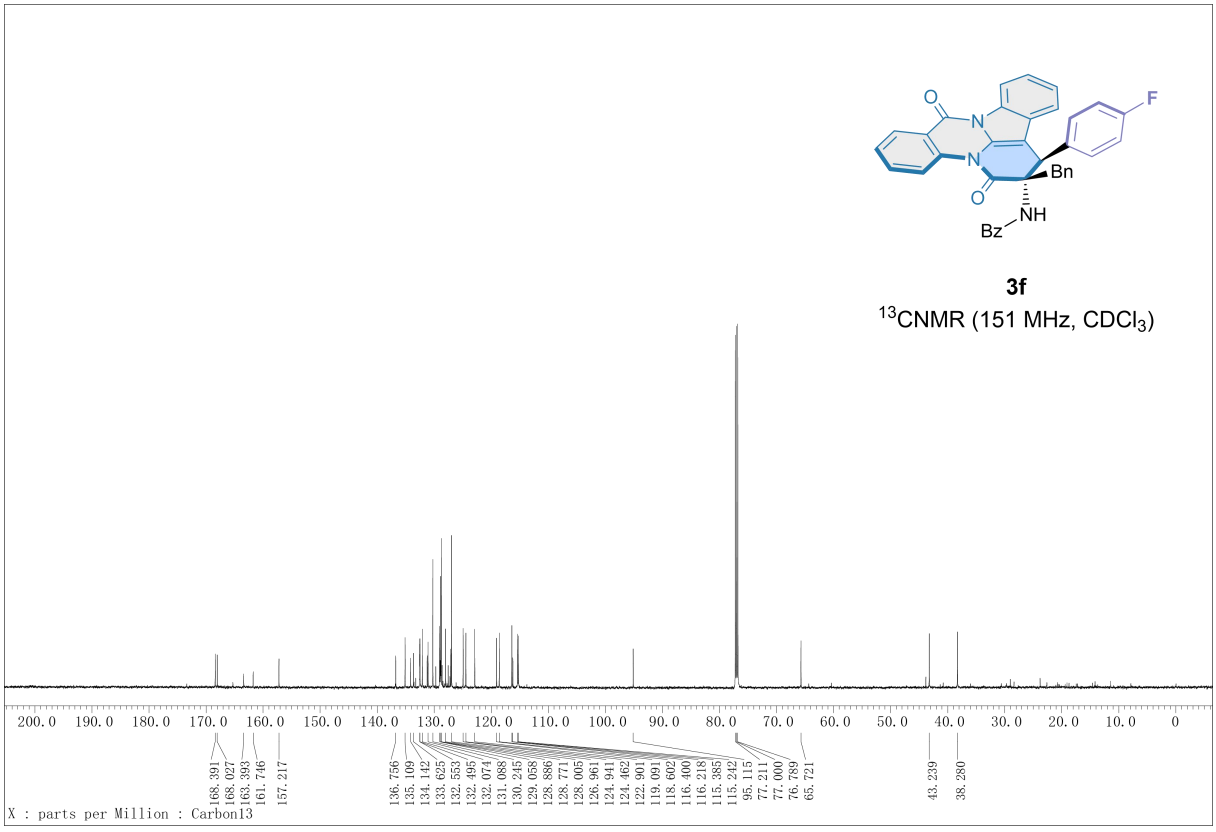


	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	6.233	698035	6142388	96.99
2	7.087	19168	190360	3.01



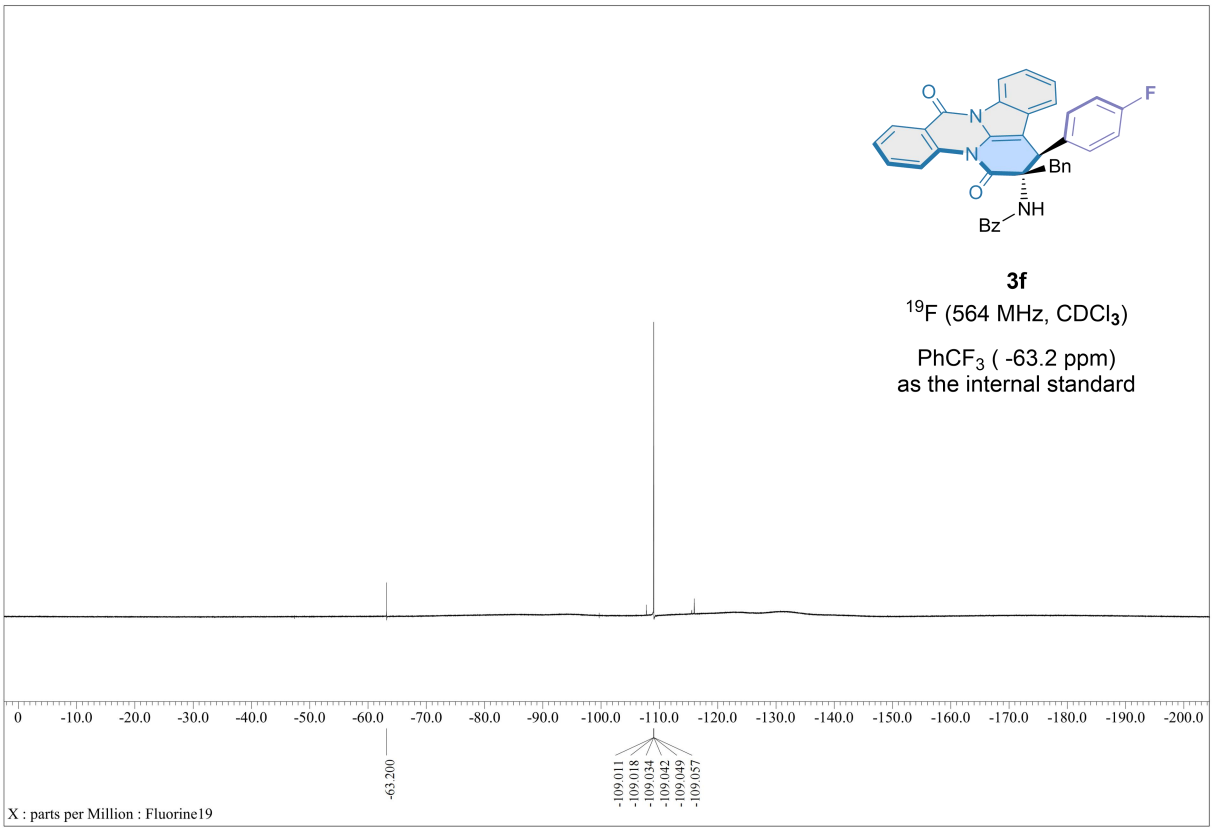
3f

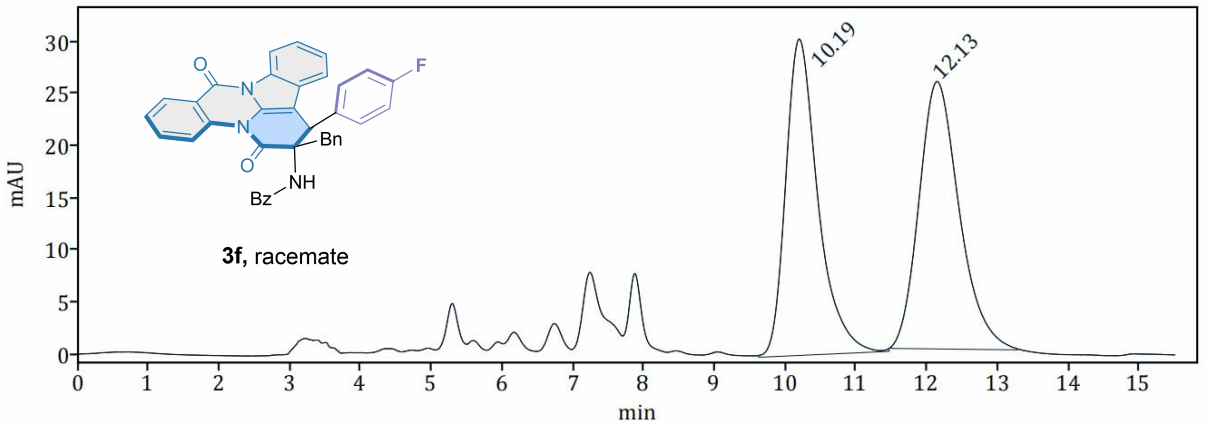
^{1}HNMR (600 MHz, $CDCl_3$)



3f

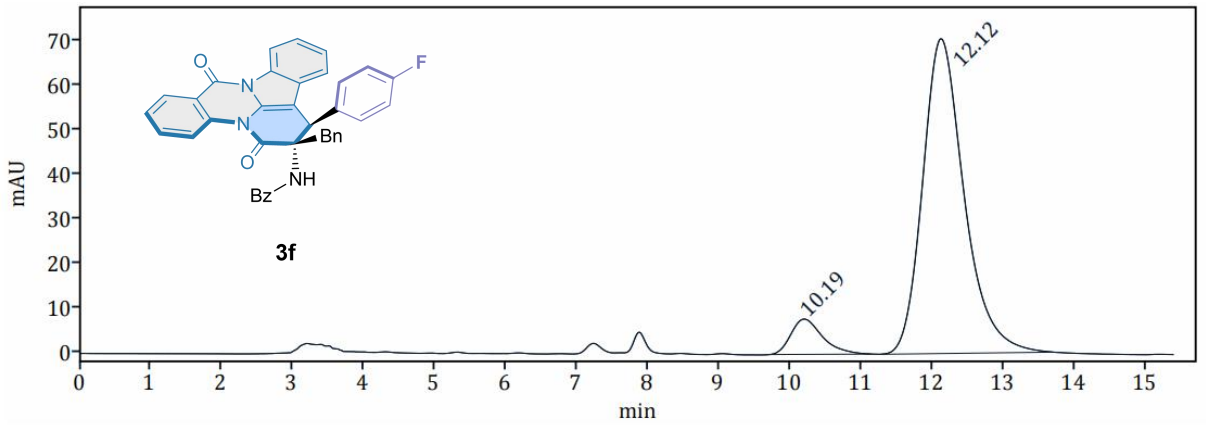
^{13}CNMR (151 MHz, $CDCl_3$)


O
N
N
O
F
Bn
NH
Bz
3f
19F (564 MHz, CDCl3)
PhCF3 (-63.2 ppm)
as the internal standard
0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
-150.0
-160.0
-170.0
-180.0
-190.0
-200.0
-63.200
-109.011
-109.018
-109.034
-109.042
-109.049
-109.057
X : parts per Million : Fluorine19



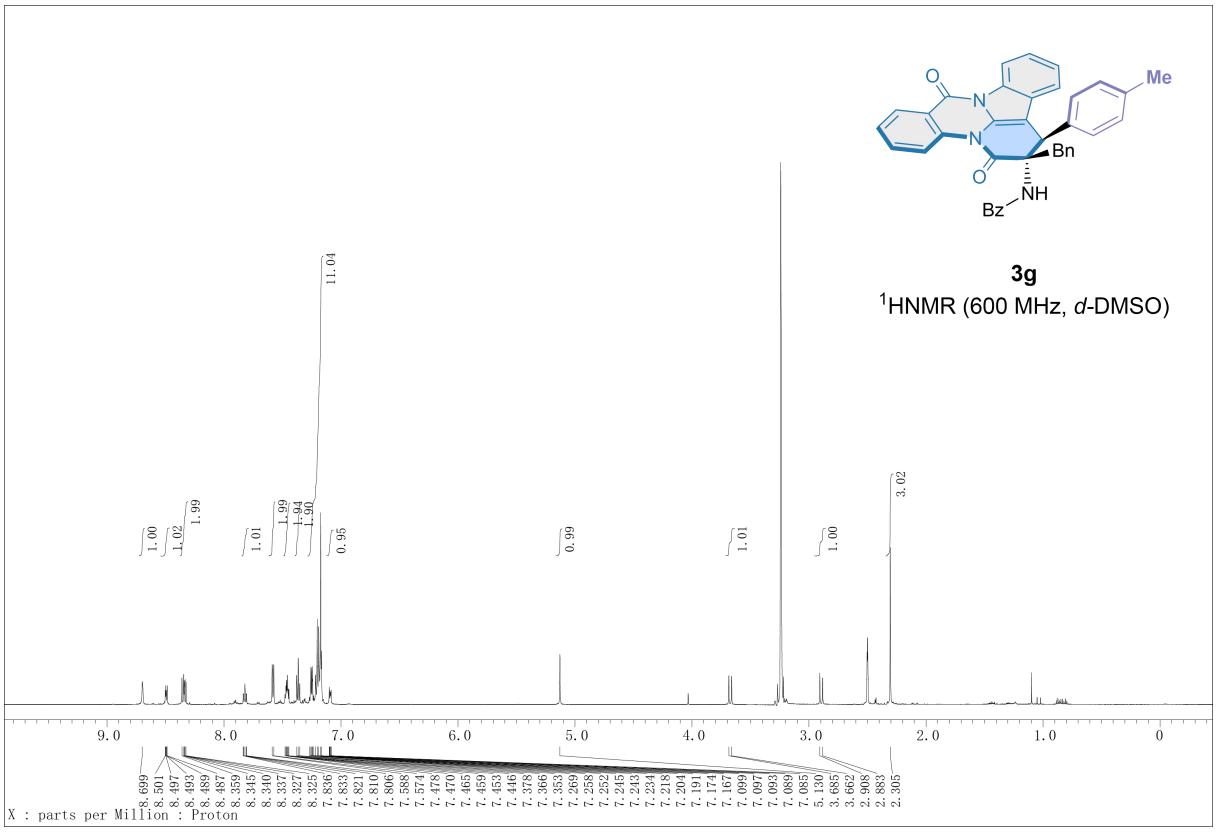
Peak Analysis Report

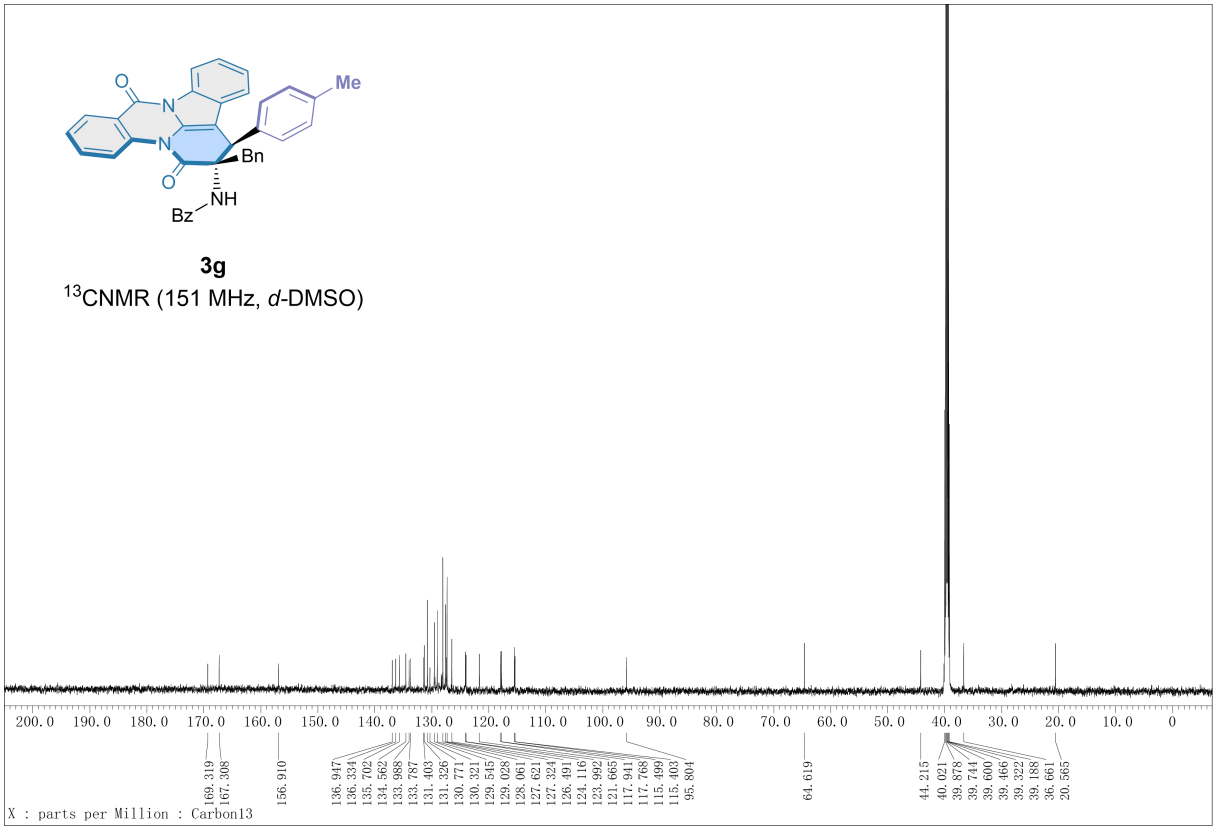
Peak #	Ret. Time [min]	Area [mAU*s]	Height [mAU]	Rel. Area [%]
1	10.19	960.684	30.3776	48.6219
2	12.13	1015.140	25.6637	51.3781

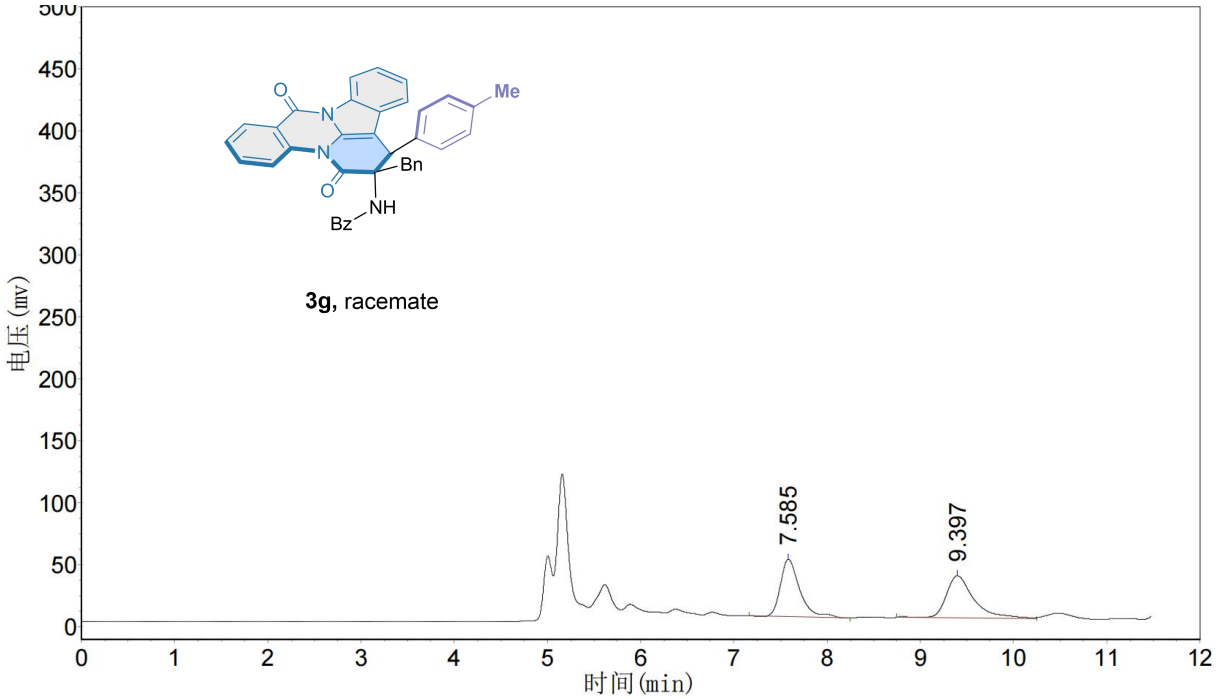


Peak Analysis Report

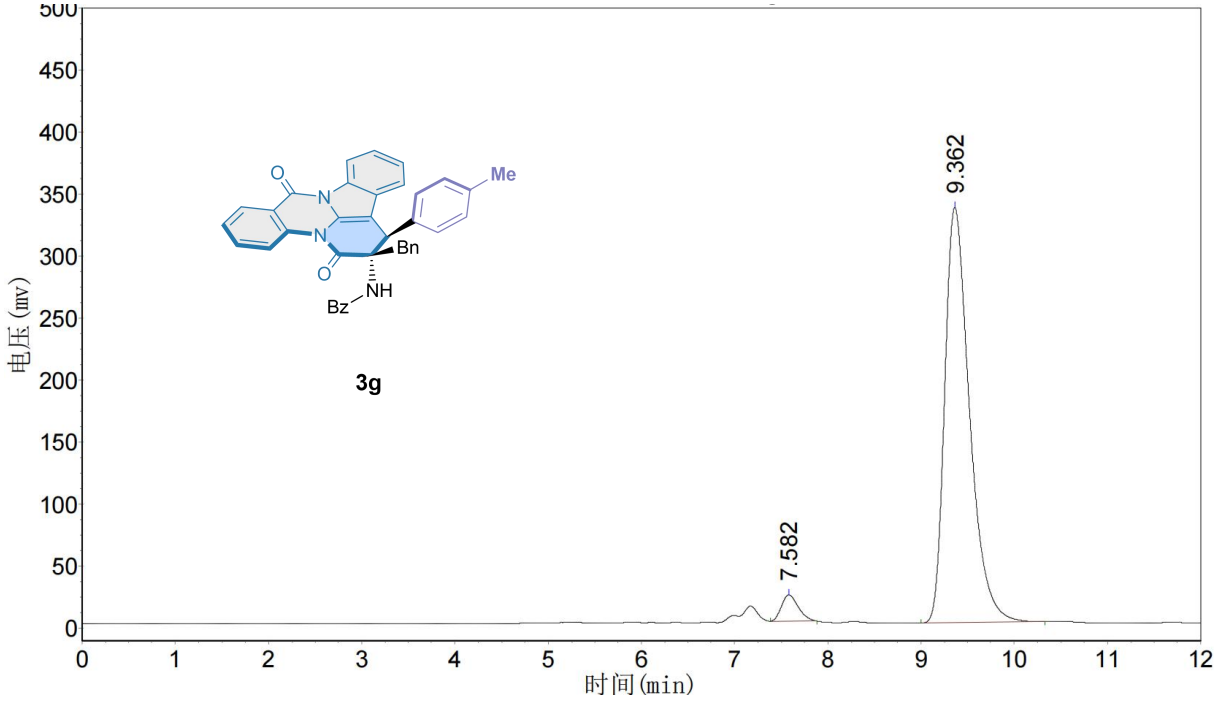
Peak #	Ret. Time [min]	Area [mAU*s]	Height [mAU]	Rel. Area [%]
1	10.19	246.097	7.9465	7.8880
2	12.12	2873.798	70.7770	92.1120


Me
Bn
NH
Bz
3g
1HNMR (600 MHz, d-DMSO)
X : parts per Million : Proton

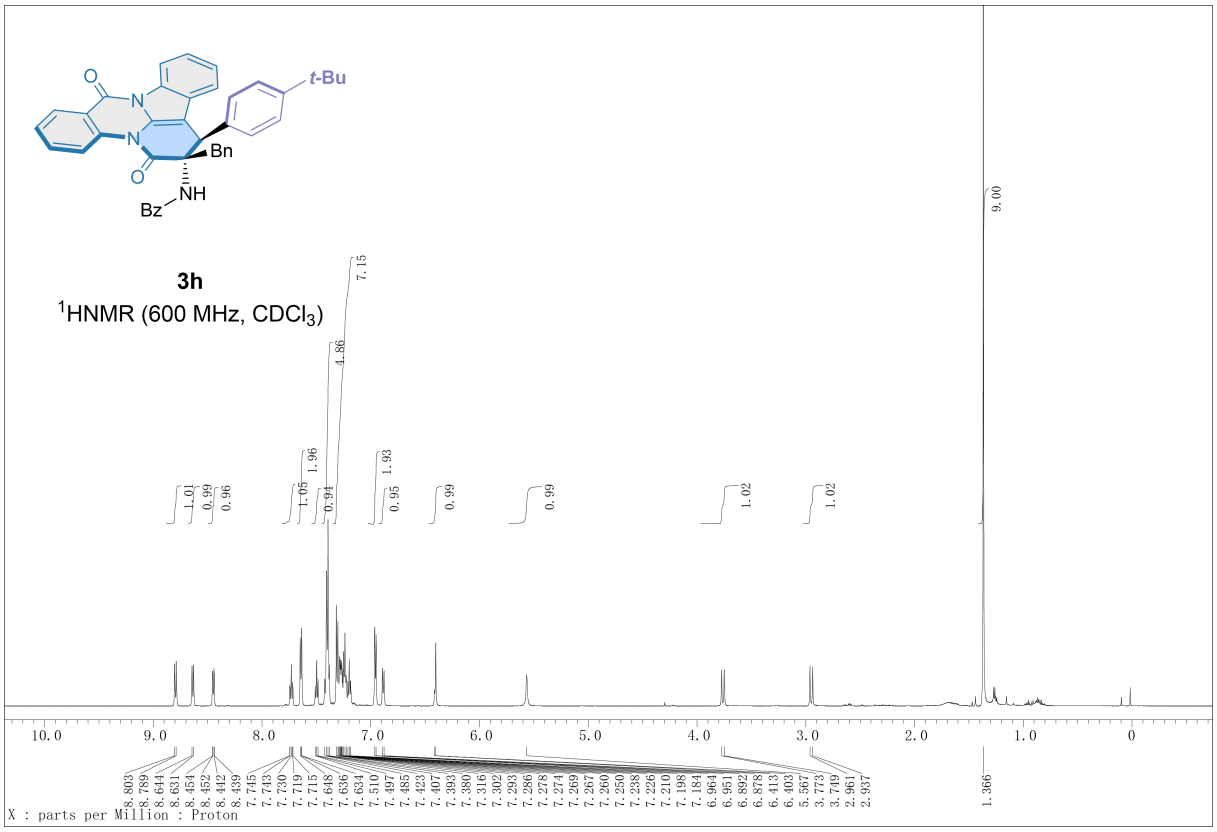

Me
Bn
NH
Bz
3g
13CNMR (151 MHz, d-DMSO)
X : parts per Million : Carbon13

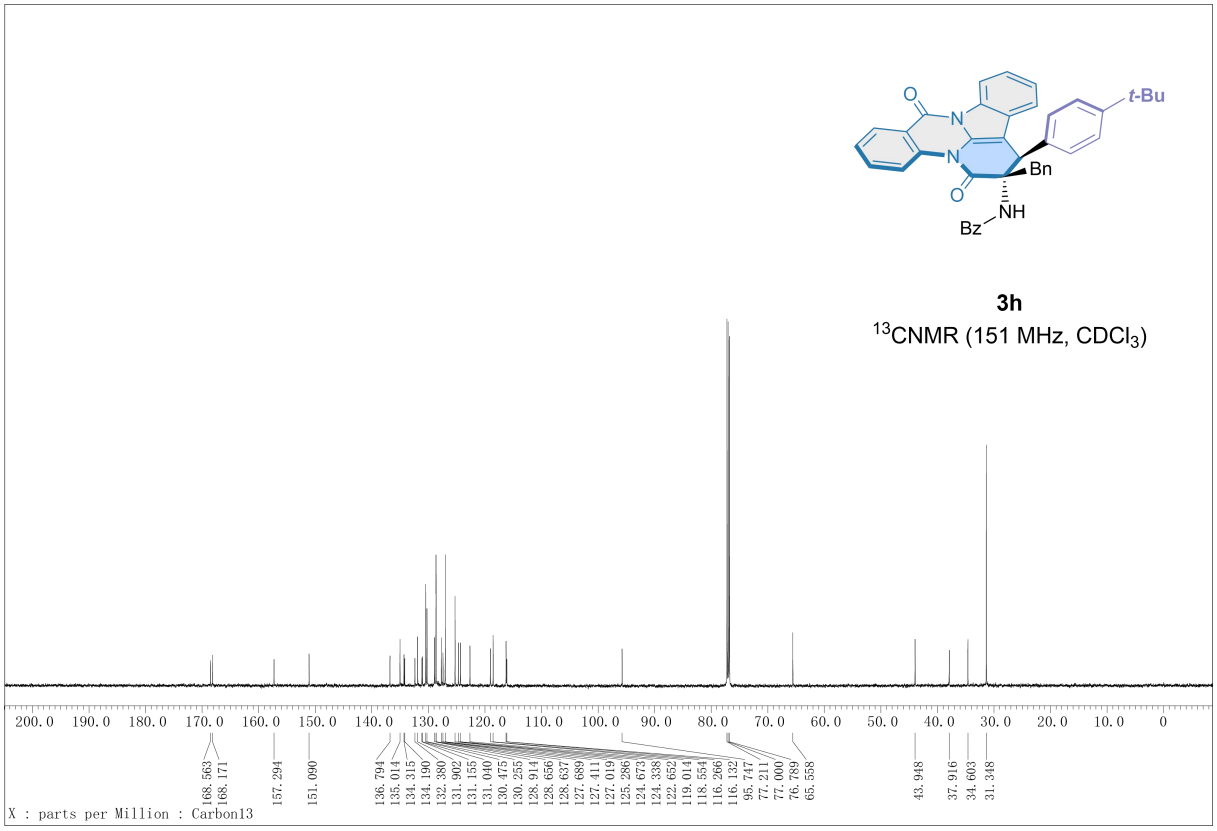


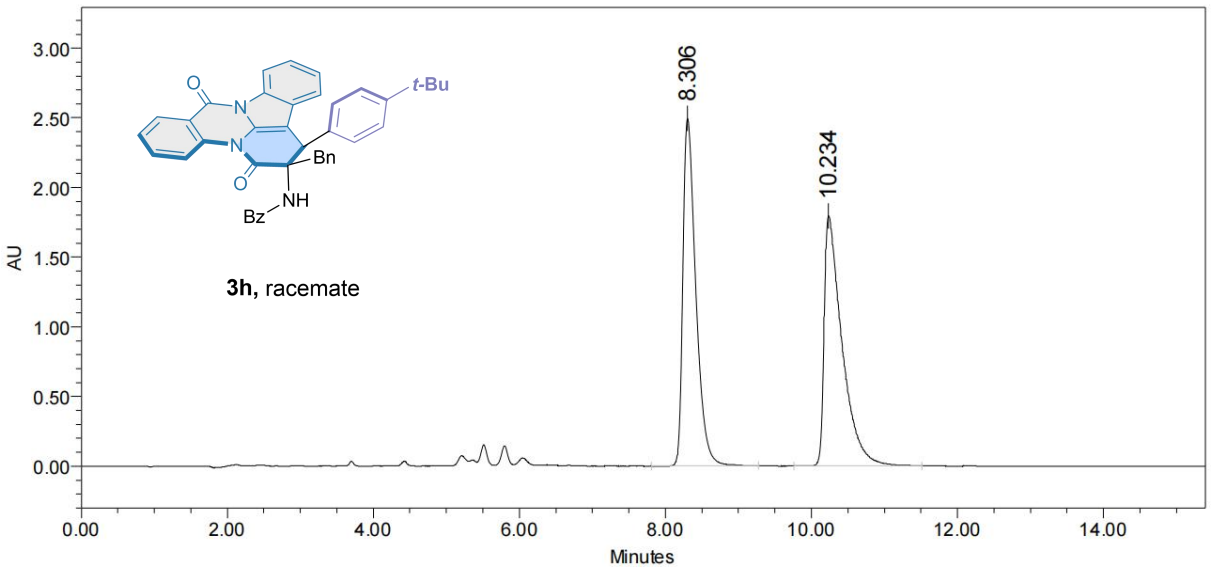
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	7.585	46392	666936	49.00
2	9.397	33821	694043	51.00



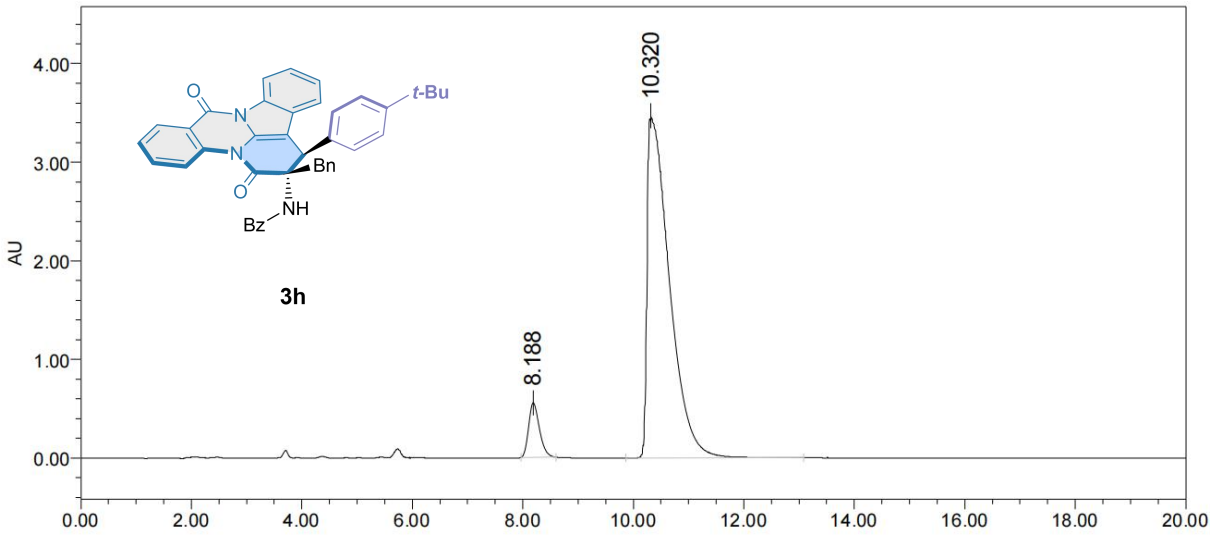
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	7.582	21107	264338	4.10
2	4.1016	334930	6180486	95.90


t-Bu
Bn
NH
Bz
3h
1HNMR (600 MHz, CDCl3)
X : parts per Million : Proton

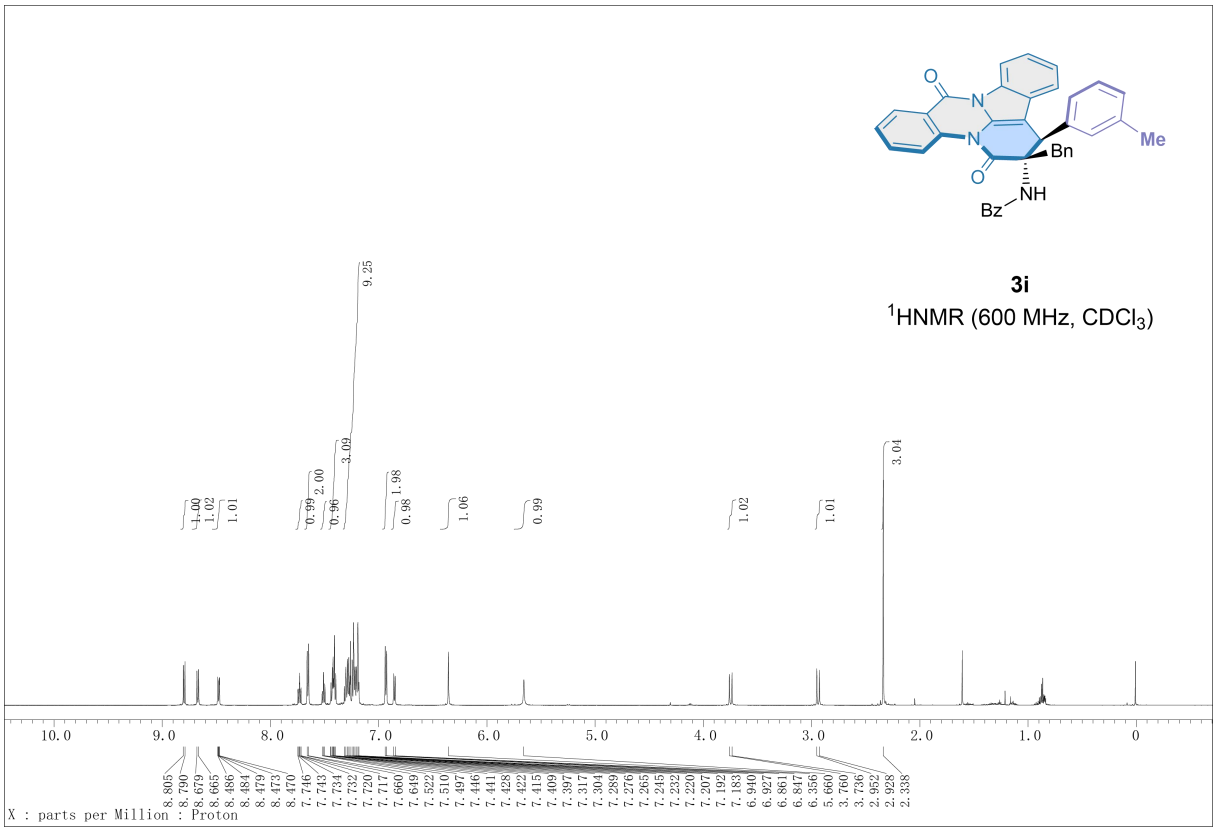

t-Bu
Bn
NH
Bz
3h
13CNMR (151 MHz, CDCl3)
X : parts per Million : Carbon13



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	8.306	30586947	2492657	50.04
2	10.234	30540258	1794065	49.96



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	8.188	7521568	555875	7.16
2	10.320	97495610	3468440	92.84


O
N
N
O
Bn
Me
NH
Bz
3i
1HNMR (600 MHz, CDCl3)
9.25
3.09
2.00
1.98
3.04
1.06
1.02
1.01
0.99
0.98
0.96
1.00
1.02
1.01
0.99
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
8.805
8.790
8.679
8.665
8.486
8.484
8.479
8.473
8.470
7.746
7.743
7.734
7.732
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7.717
7.660
7.649
7.522
7.510
7.497
7.446
7.441
7.428
7.422
7.415
7.409
7.397
7.317
7.304
7.289
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7.265
7.245
7.232
7.220
7.207
7.192
7.183
6.940
6.927
6.861
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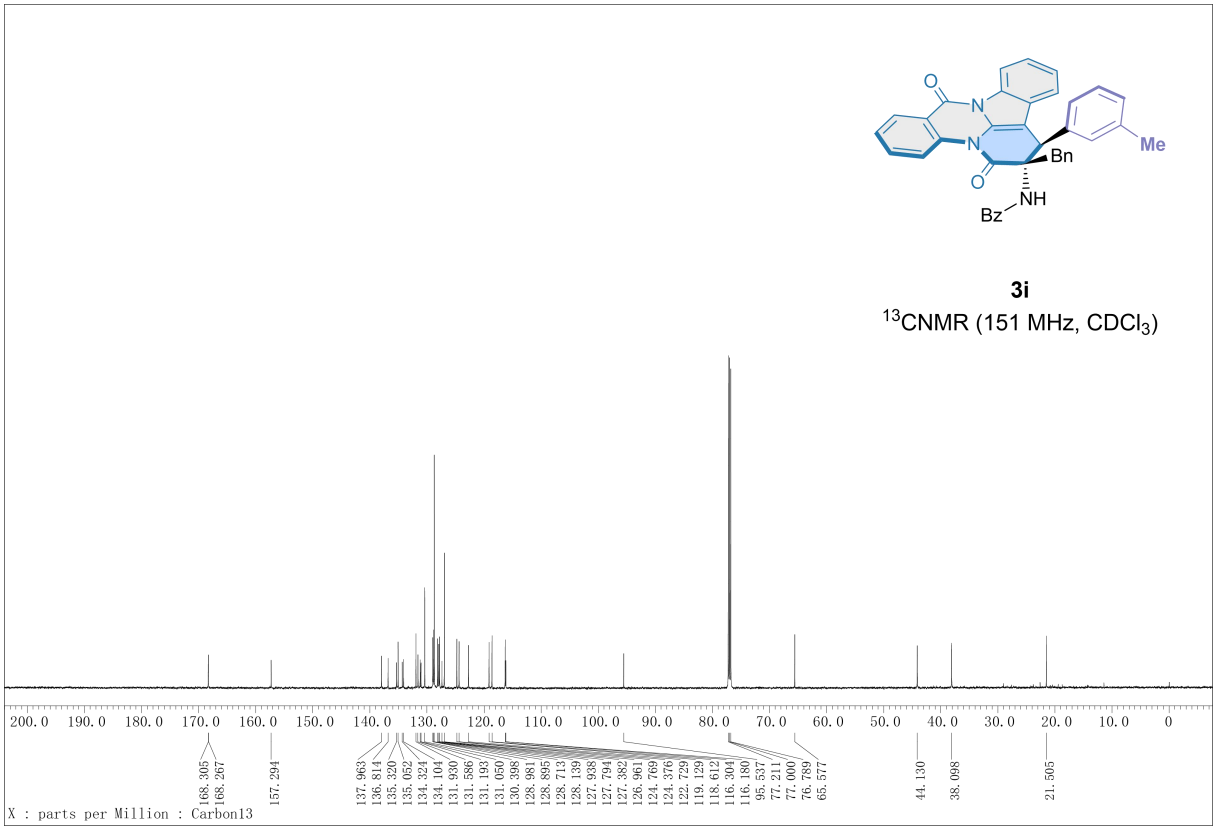
6.356
5.660
3.760
3.736
2.952
2.928
2.338
X : parts per Million : Proton


O
N
N
O
Bn
Me
NH
Bz
3i
13CNMR (151 MHz, CDCl3)
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
168.305
168.267
157.294
137.963
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135.052
134.324
134.104
131.930
131.586
131.193
131.050
130.398
128.981
128.895
128.713
128.139
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127.794
127.382
126.961
124.769
124.376
122.729
119.129
118.612
116.304
116.180
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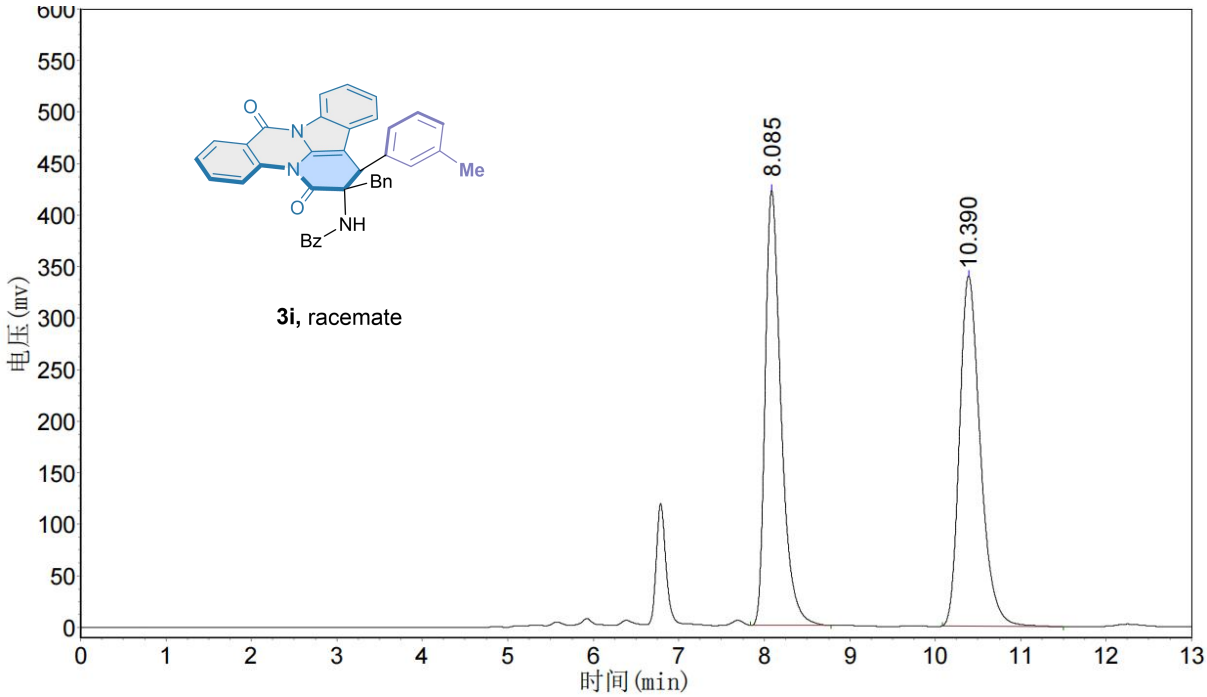
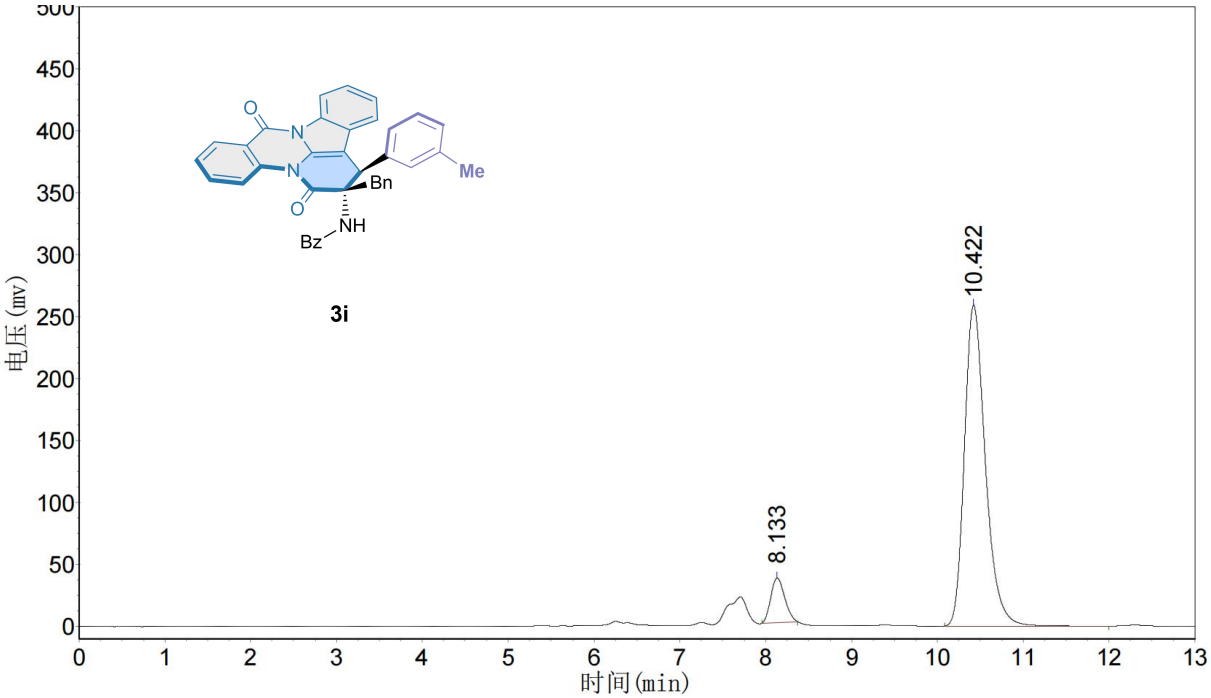
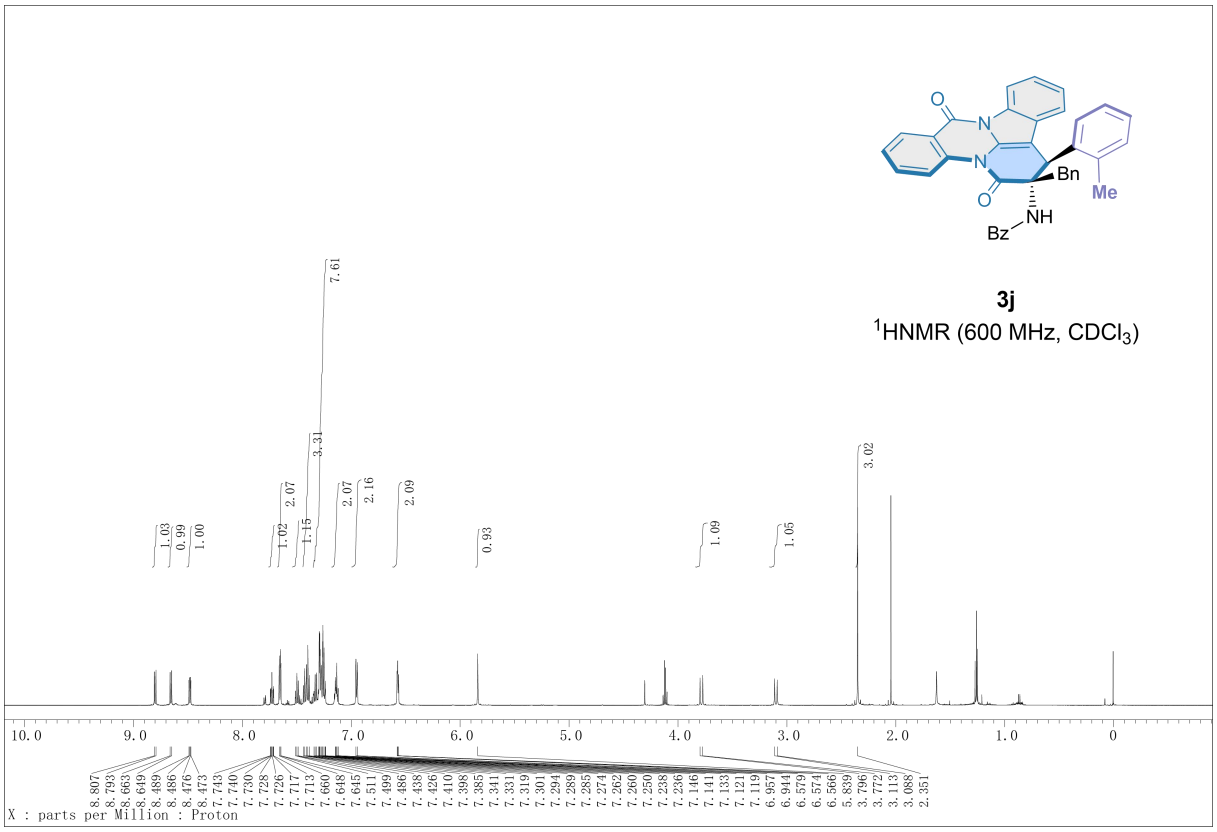
77.211
77.000
76.789
65.577
44.130
38.098
21.505
X : parts per Million : Carbon13

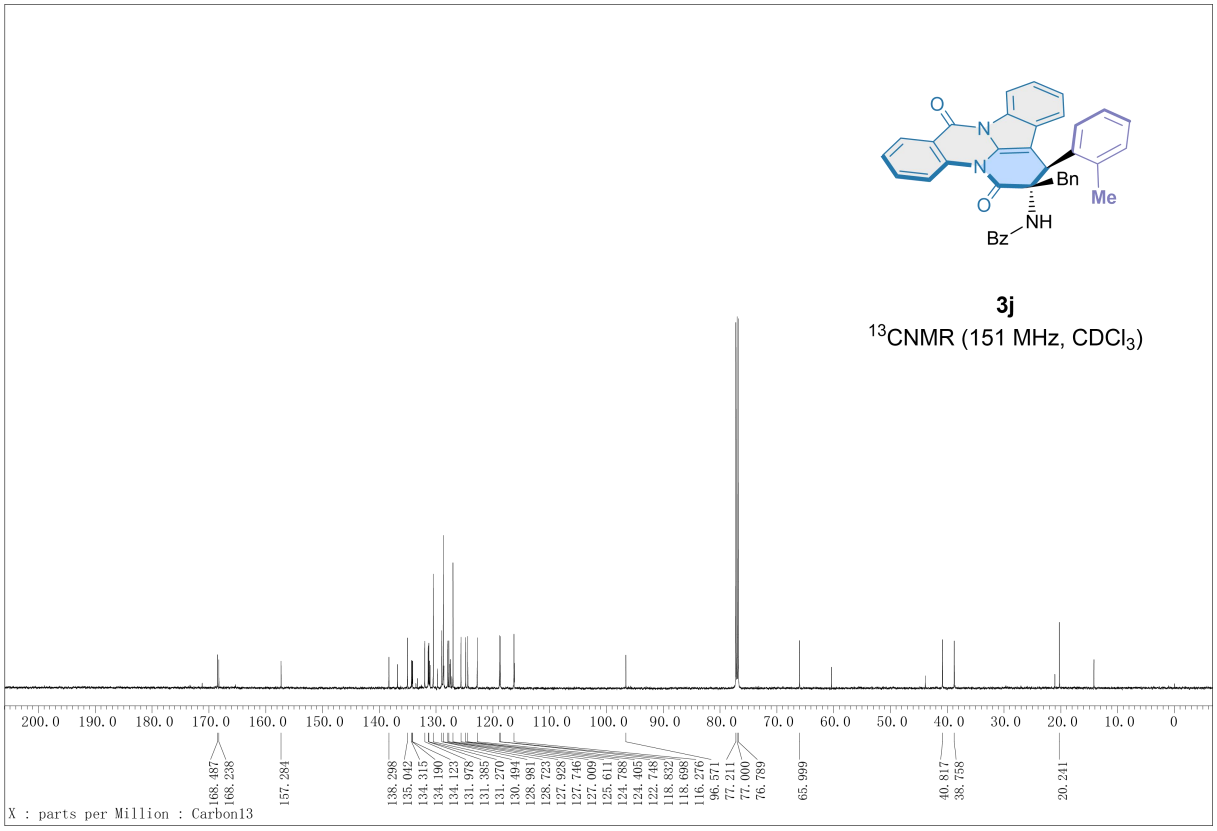


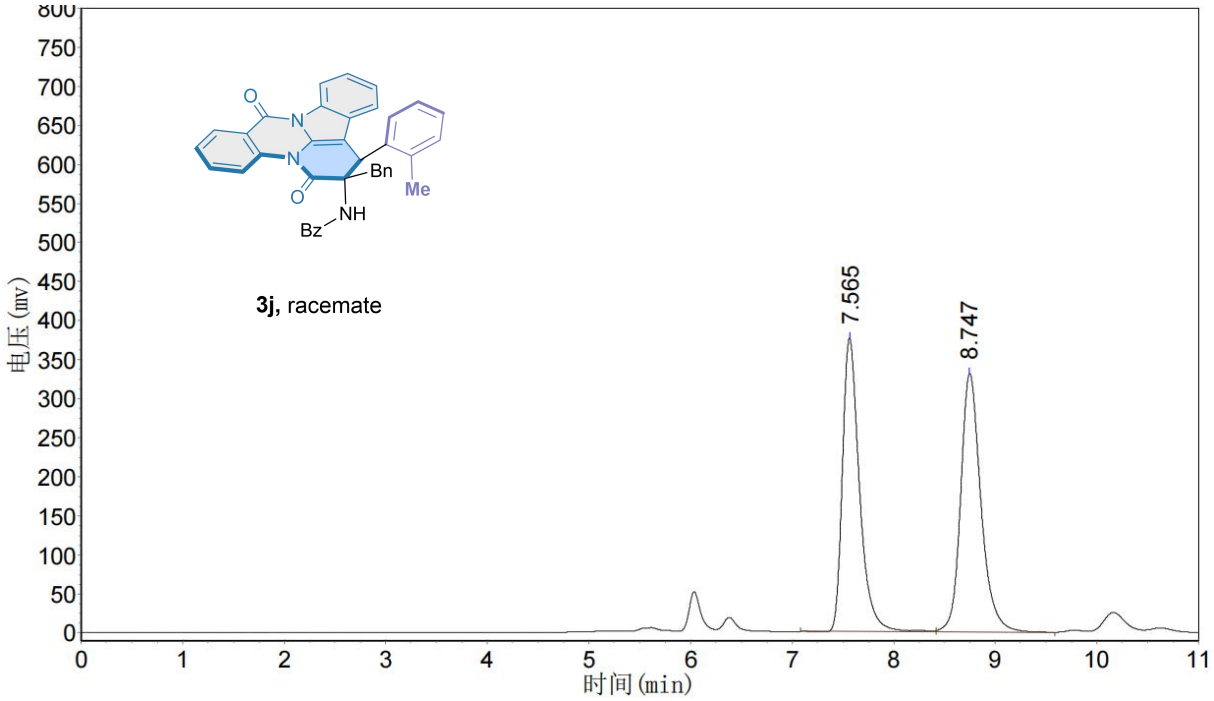
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	8.085	422061	5450228	48.72
2	10.390	339791	5736529	51.28



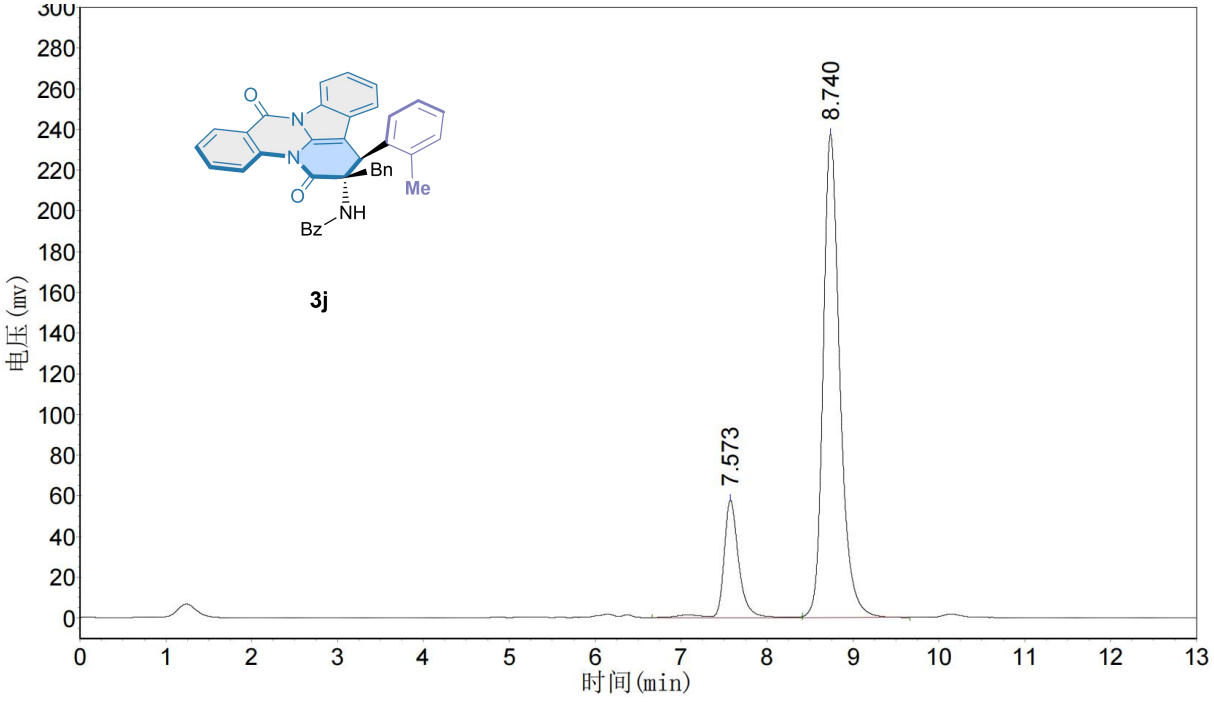
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	8.133	35953	402291	8.39
2	10.422	259065	4391447	91.61


O
N
N
O
Bn
Me
NH
Bz
3j
1HNMR (600 MHz, CDCl3)
7.61
3.31
2.07
2.07
2.16
2.09
3.02
1.03
0.99
1.00
1.02
1.15
0.93
1.09
1.05
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
X : parts per Million : Proton

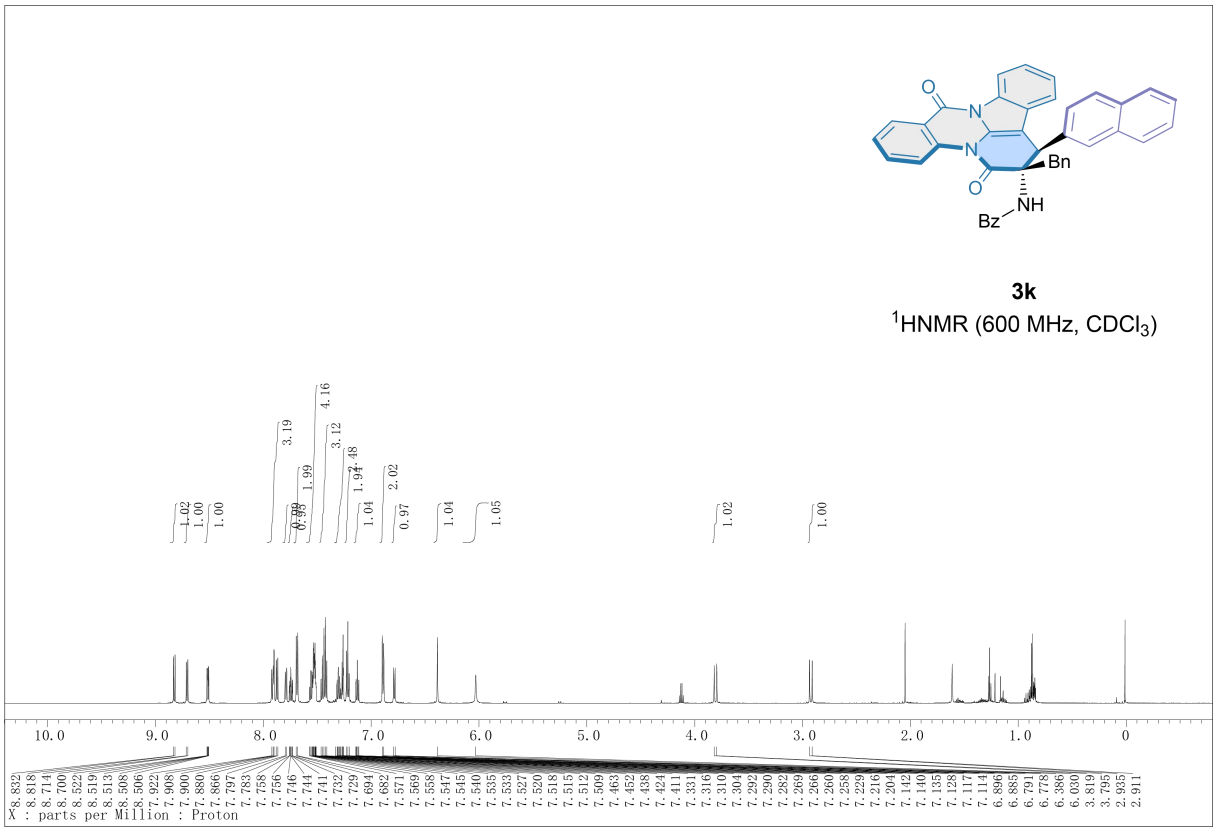

O
N
N
O
Bn
Me
NH
Bz
3j
13CNMR (151 MHz, CDCl3)
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
168.487
168.238
157.284
138.298
135.042
134.315
134.190
134.123
131.978
131.385
131.270
130.494
128.981
128.723
127.928
127.746
127.009
125.611
124.788
124.405
122.748
118.832
118.698
116.276
96.571
77.211
77.000
76.789
65.999
40.817
38.758
20.241
X : parts per Million : Carbon13

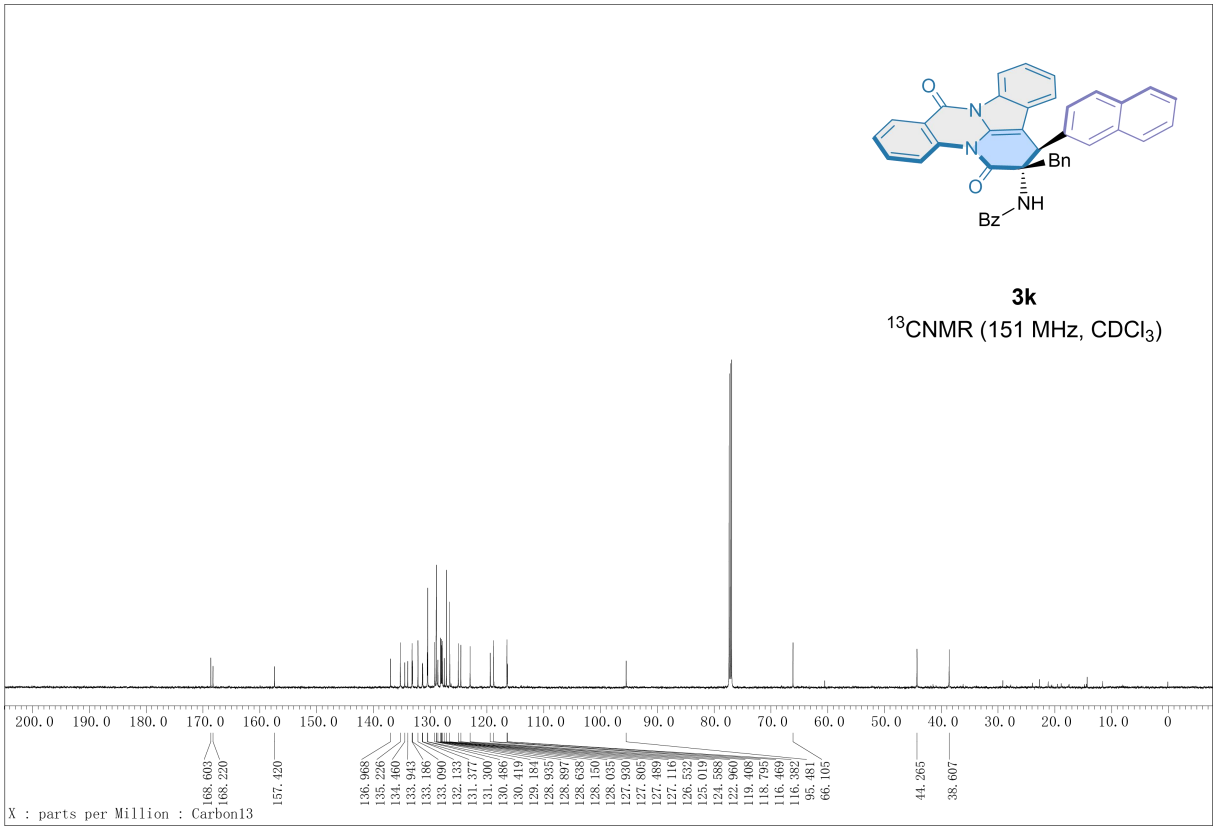


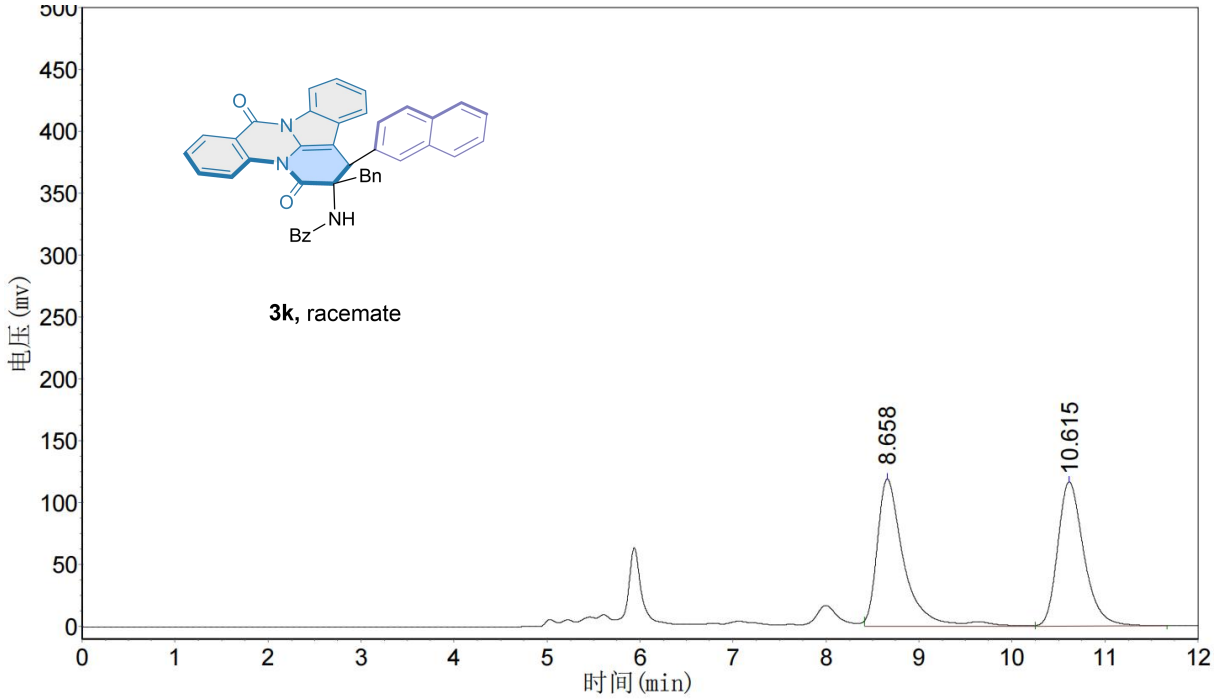
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	7.565	376257	4375635	48.75
2	8.747	331450	4599843	51.25



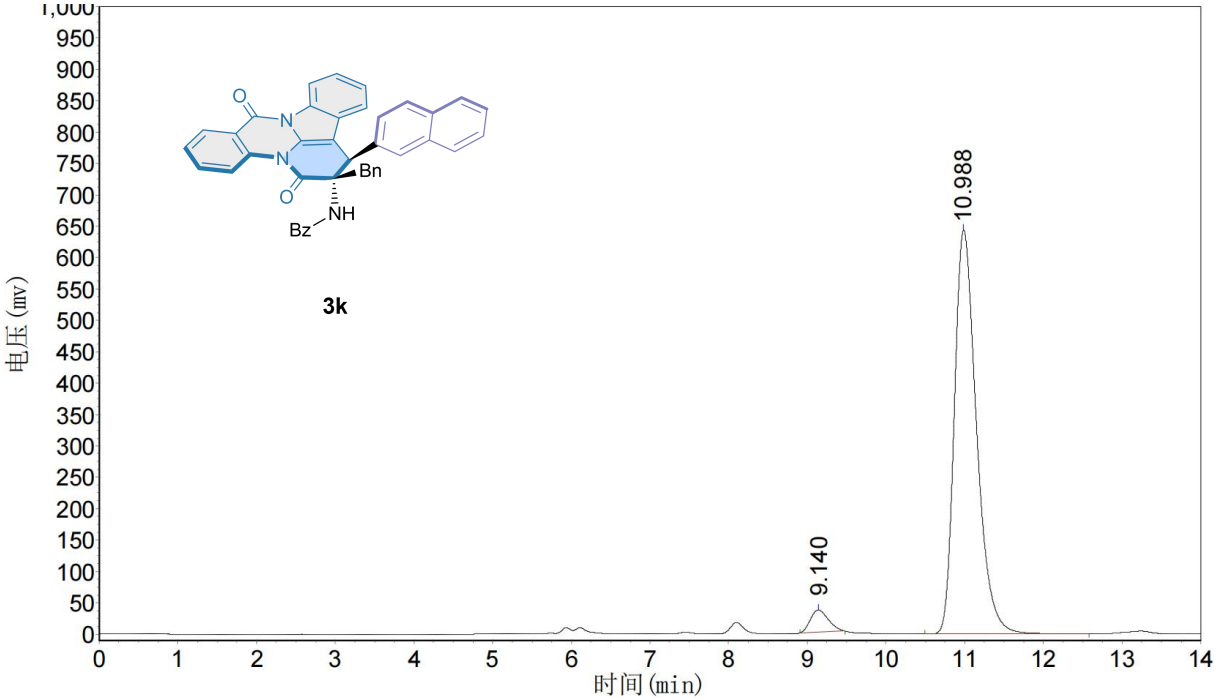
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	7.573	57644	697687	17.88
2	8.740	237331	3204504	82.12


O
N
N
O
Bn
NH
Bz
3k
1HNMR (600 MHz, CDCl3)
4.16
3.19
3.12
2.48
2.02
1.99
1.94
1.04
0.97
1.04
1.05
1.02
1.00
1.02
1.00
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
X : parts per Million : Proton

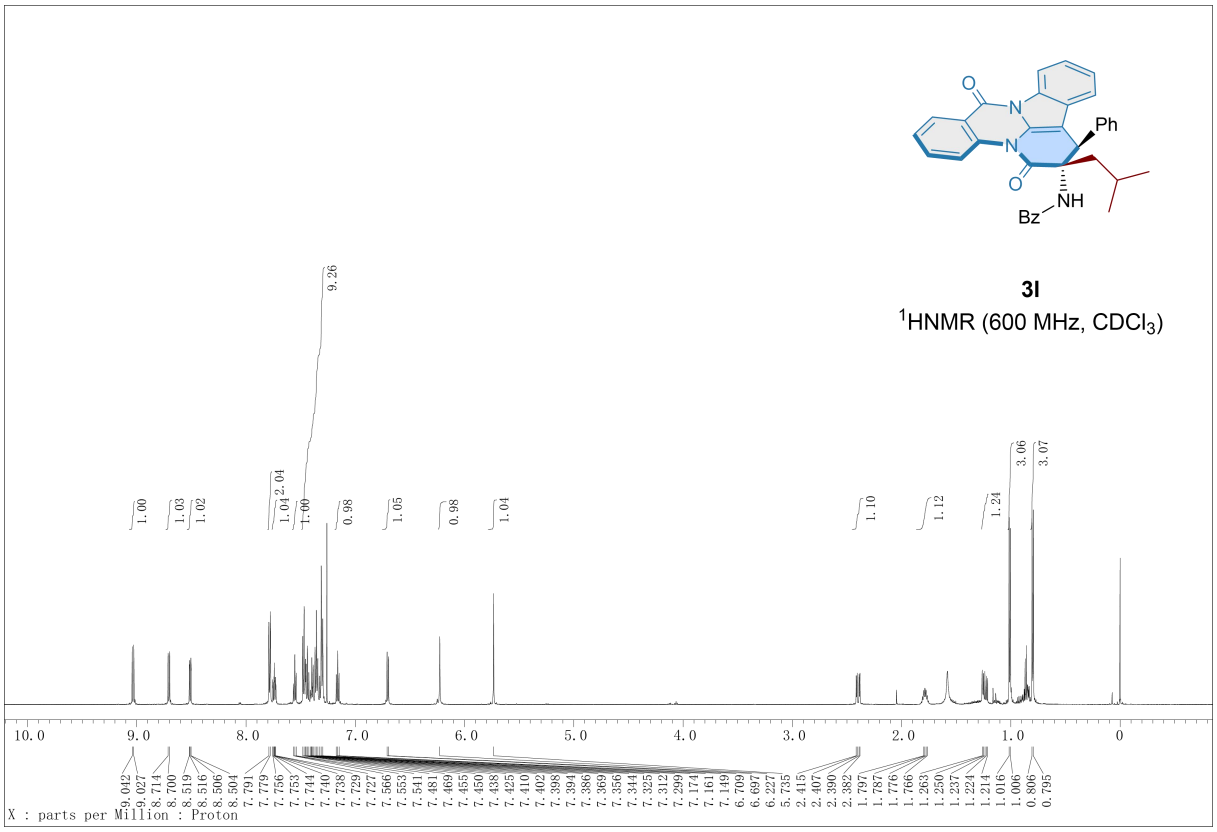

O
N
N
O
Bn
NH
Bz
3k
13CNMR (151 MHz, CDCl3)
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
168.603
168.220
157.420
136.968
135.226
134.460
133.943
133.186
133.090
132.133
131.377
131.300
130.486
130.419
129.184
128.935
128.897
128.638
128.150
128.035
127.930
127.805
127.489
127.116
126.532
125.019
124.588
122.960
119.408
118.795
116.469
116.382
95.481
66.105
44.265
38.607
X : parts per Million : Carbon13



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	8.658	119026	2371833	51.12
2	10.615	116559	2268227	48.88

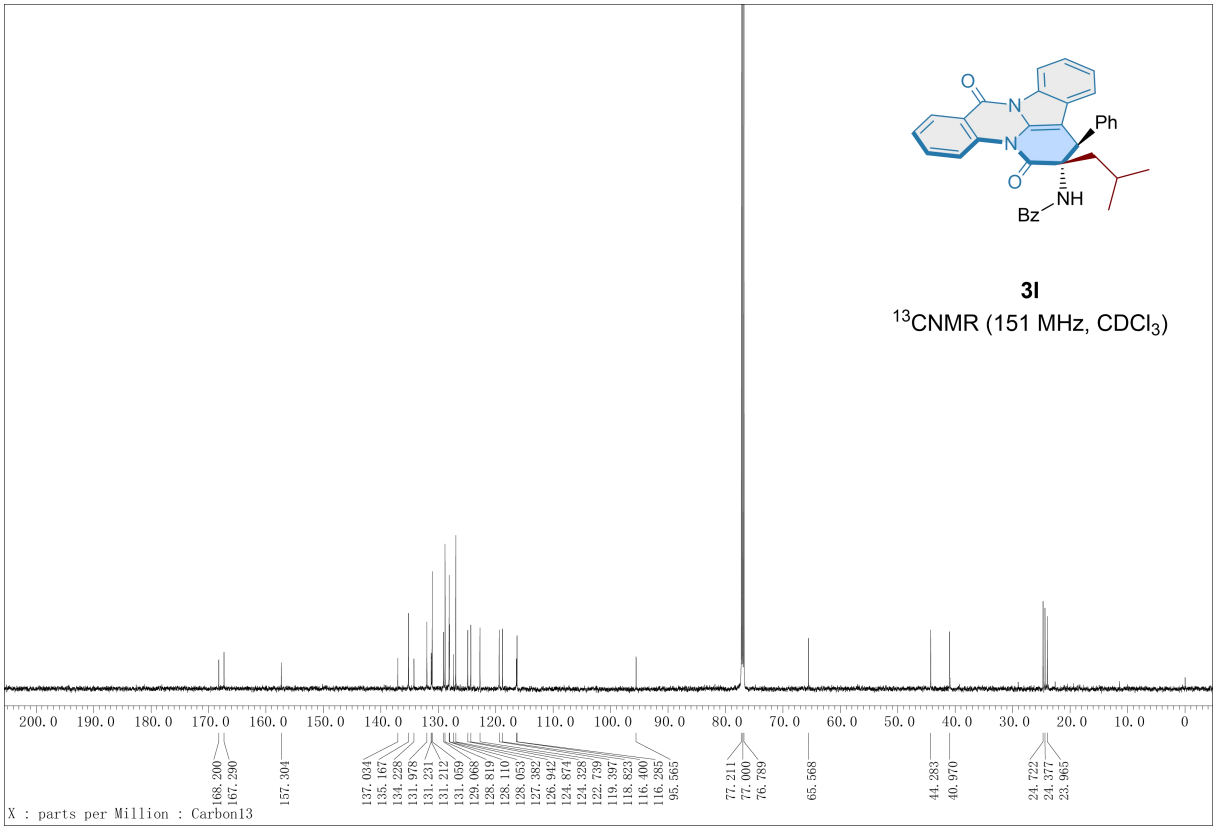


	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	9.140	35204	558754	4.25
2	10.988	644045	12583913	95.75



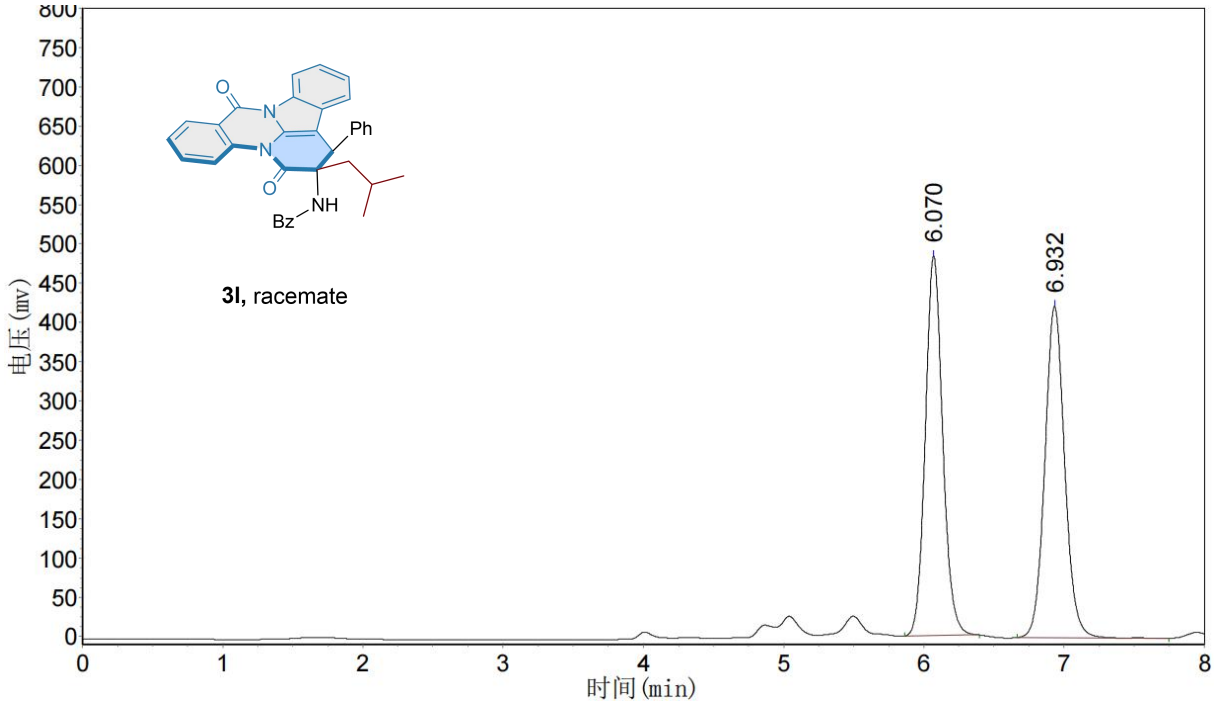
3l

^{1}HNMR (600 MHz, $CDCl_3$)

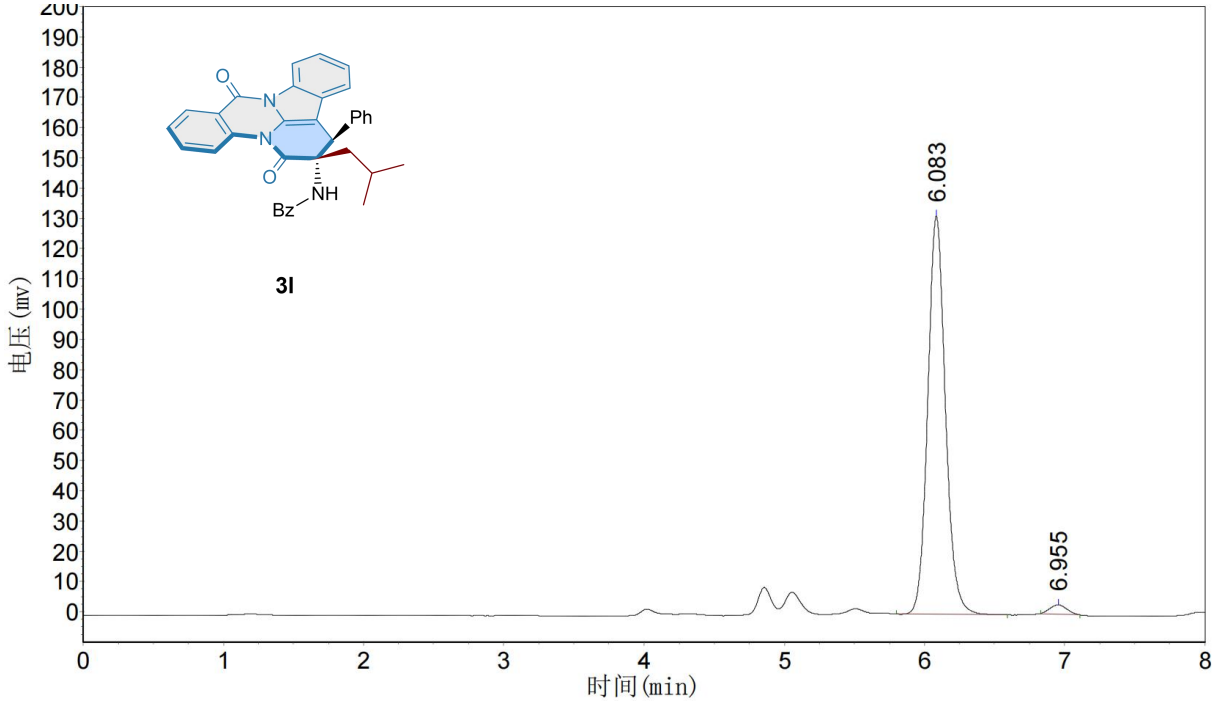


3l

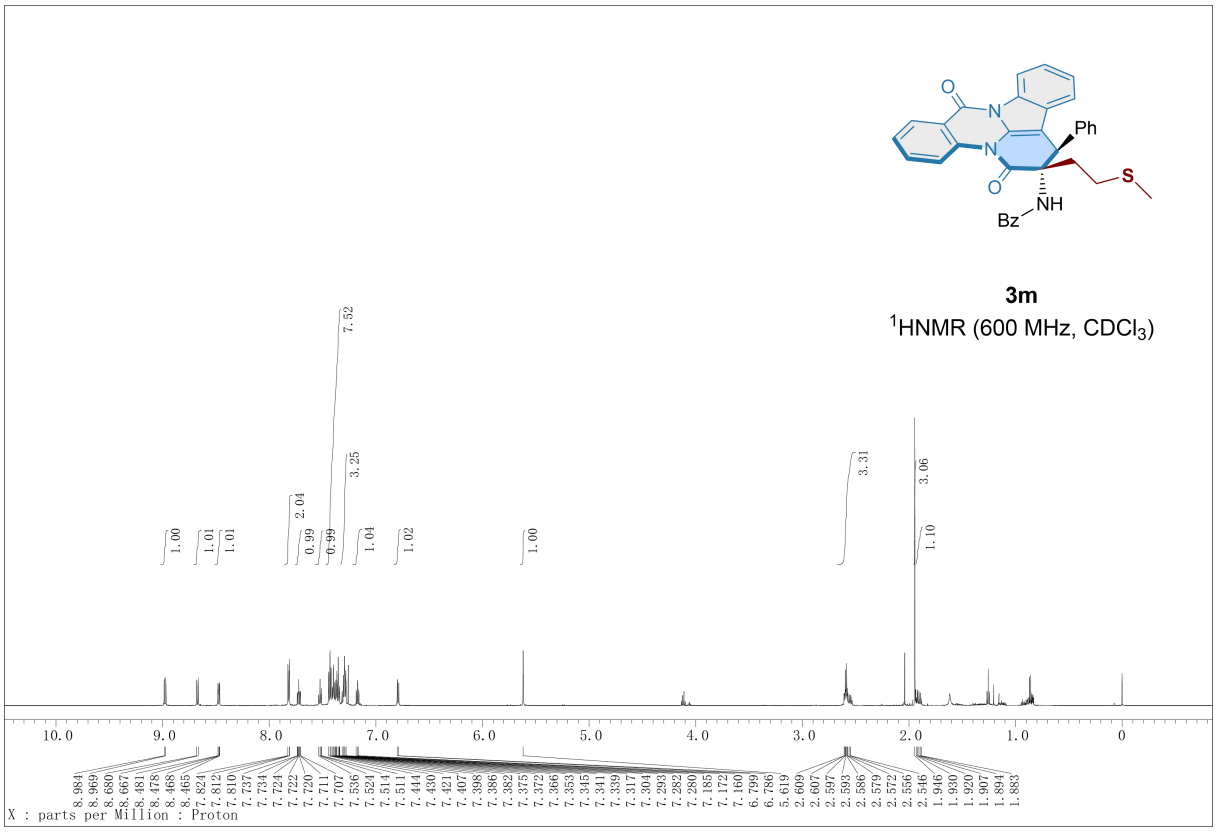
^{13}CNMR (151 MHz, $CDCl_3$)

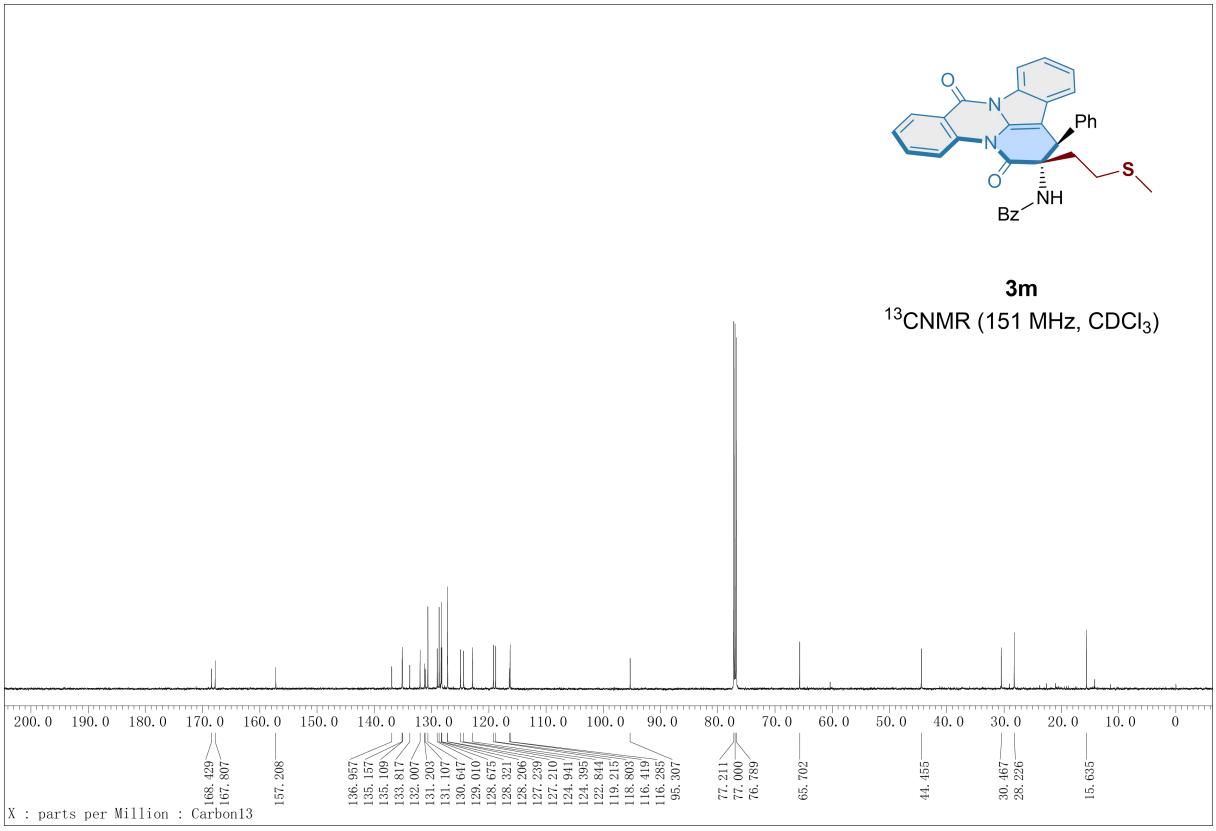


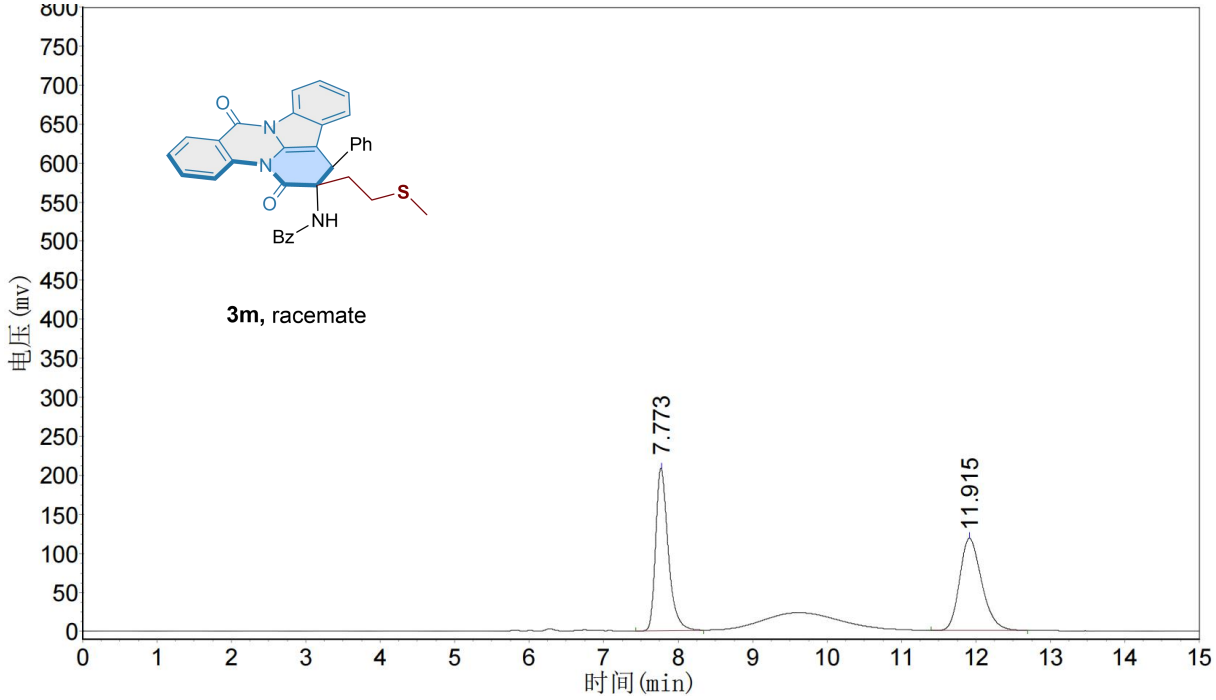
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	6.070	483897	4161412	50.05
2	6.932	422499	4152352	49.95



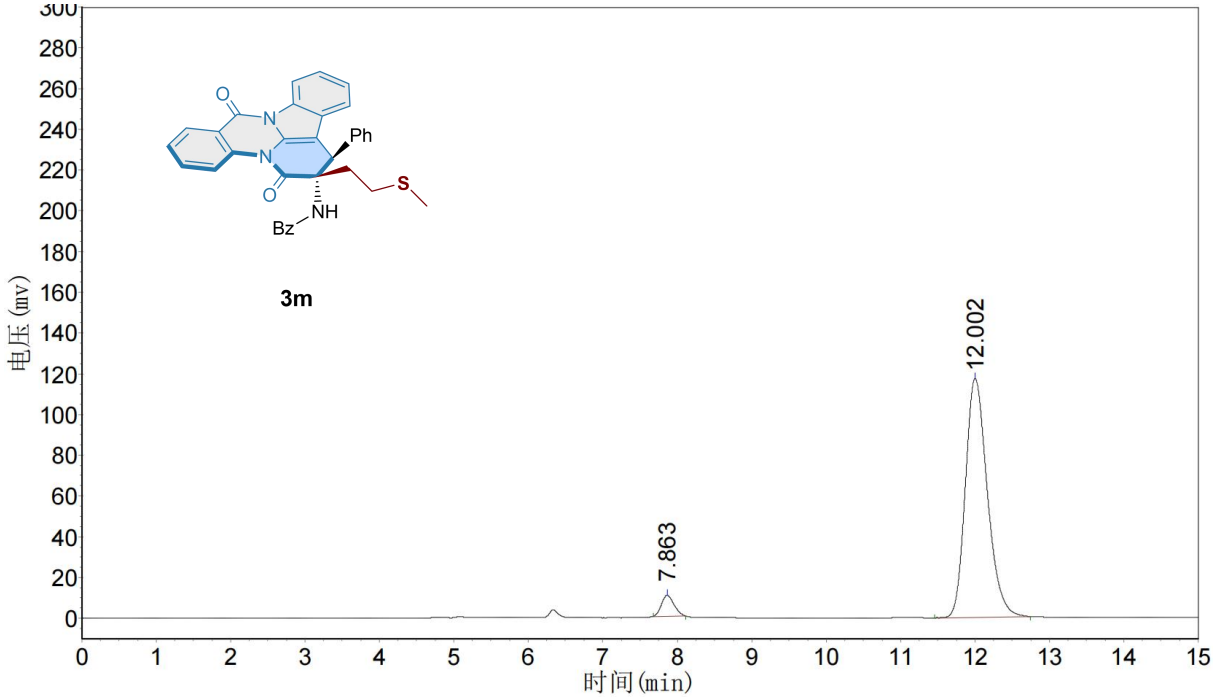
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	6.083	131660	131660	97.81
2	6.955	3089	25761	2.19


Ph
S
NH
Bz
3m
1HNMR (600 MHz, CDCl3)
X : parts per Million : Proton

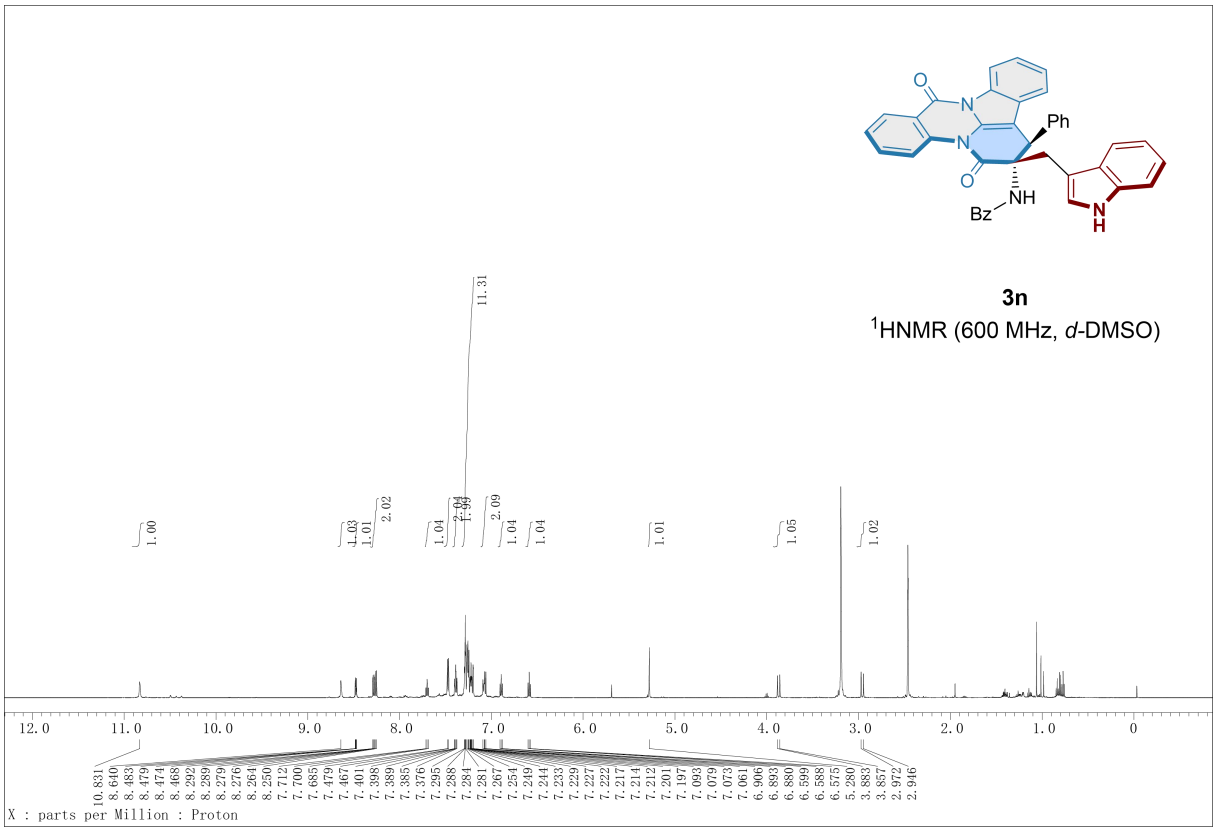

Ph
S
NH
Bz
3m
13CNMR (151 MHz, CDCl3)
X : parts per Million : Carbon13



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	7.773	208085	2429516	49.89
2	11.915	118029	2440427	50.11

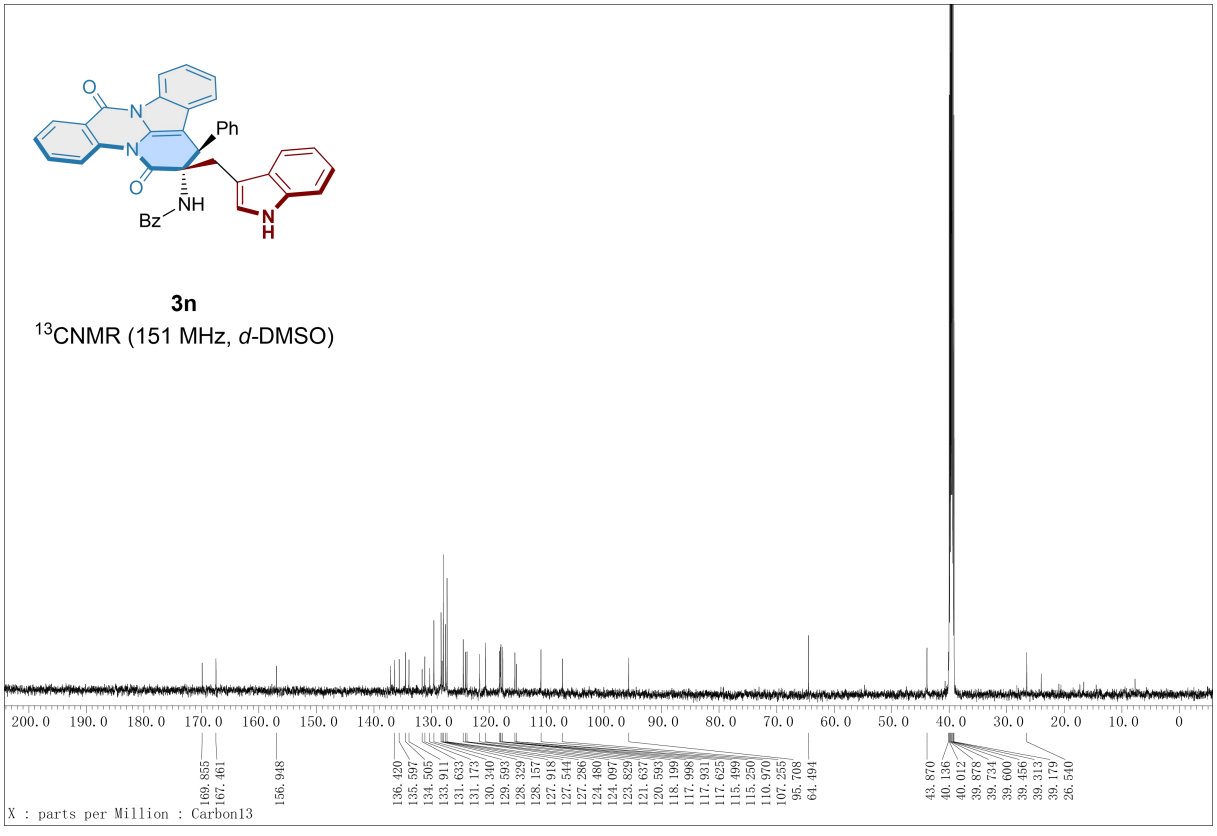


	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	7.863	10249	119332	4.73
2	12.002	117218	2402071	95.27



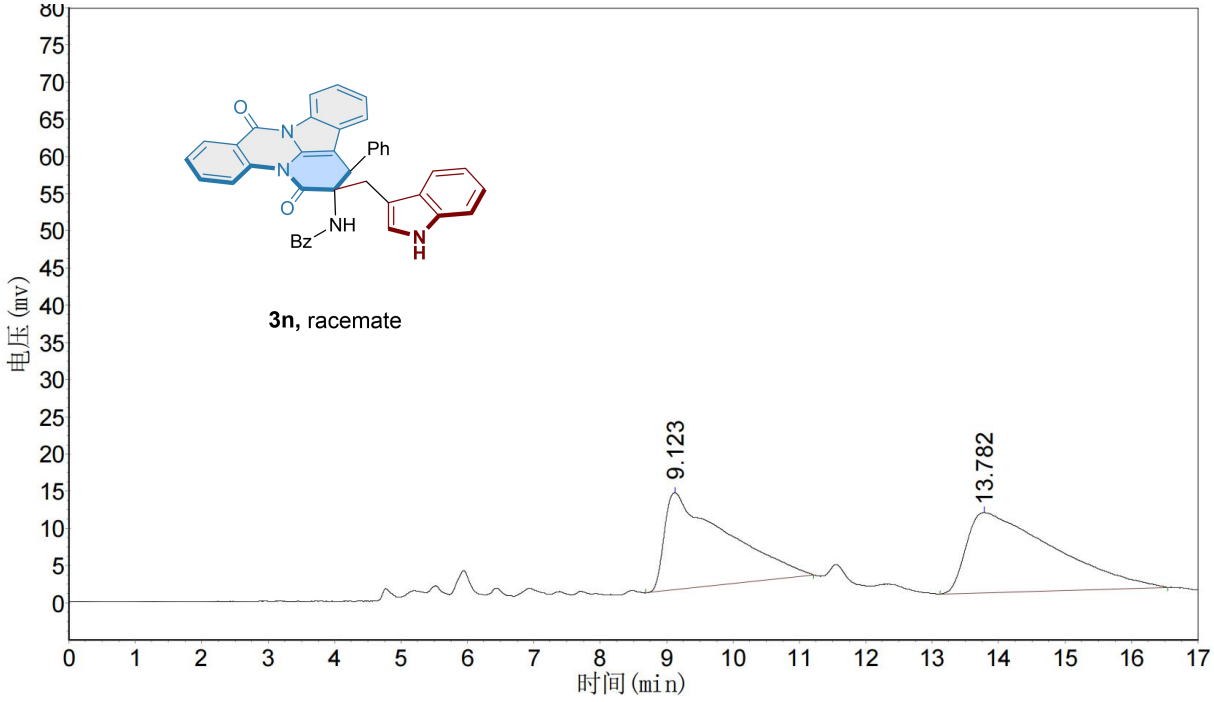
3n

^{1}HNMR (600 MHz, *d*-DMSO)



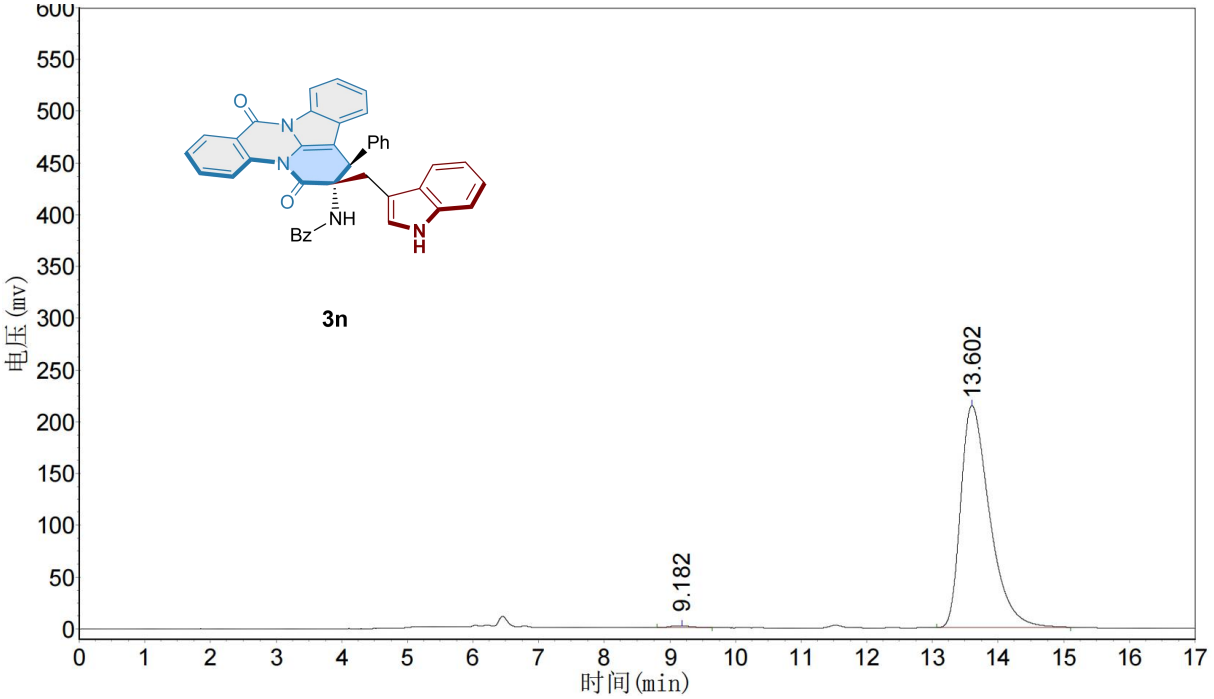
3n

^{13}CNMR (151 MHz, *d*-DMSO)



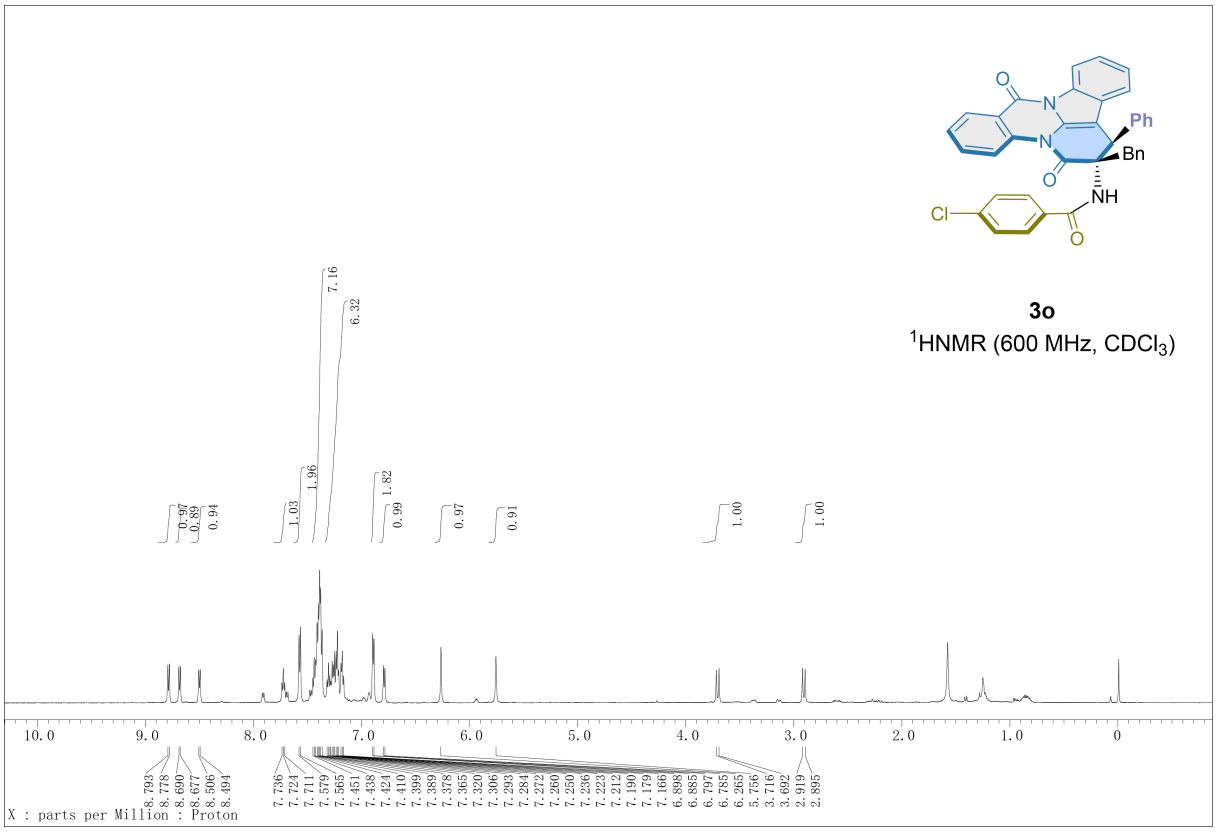
3n, racemate

	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	9.123	13063	836489	46.14
2	13.782	10773	976424	53.86



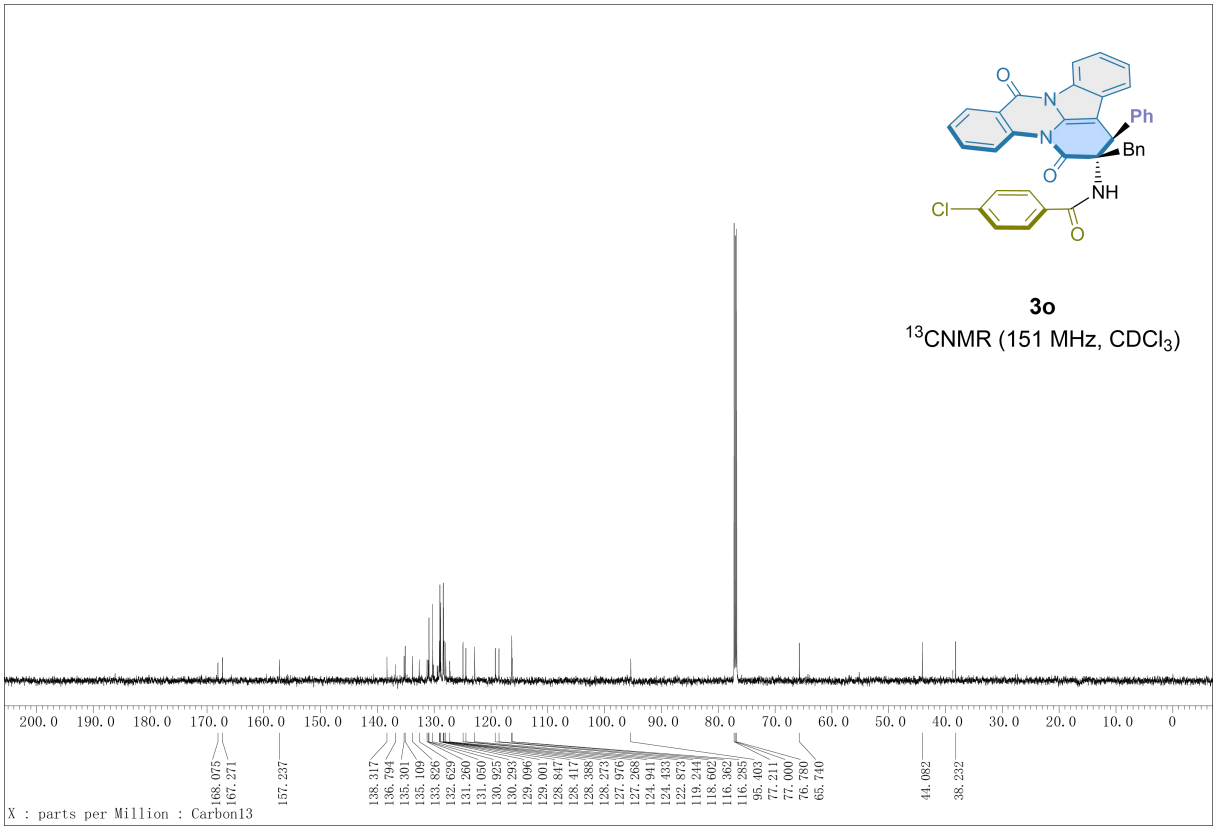
3n

	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	9.182	1709	37961	0.58
2	13.602	214478	6560855	99.42



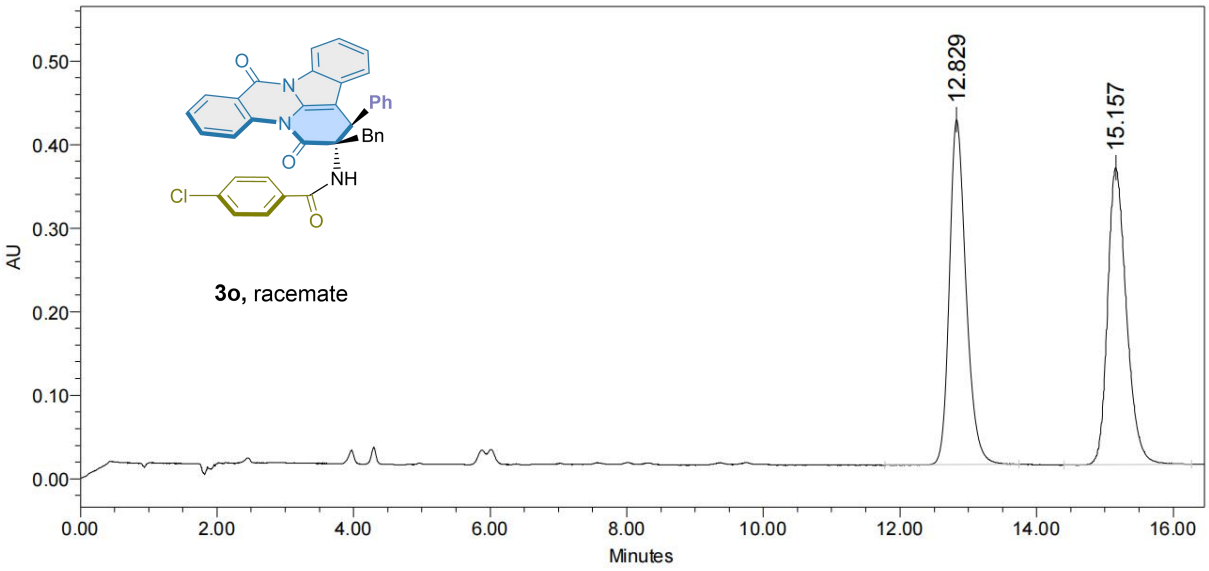
3o

^{1}HNMR (600 MHz, $CDCl_3$)

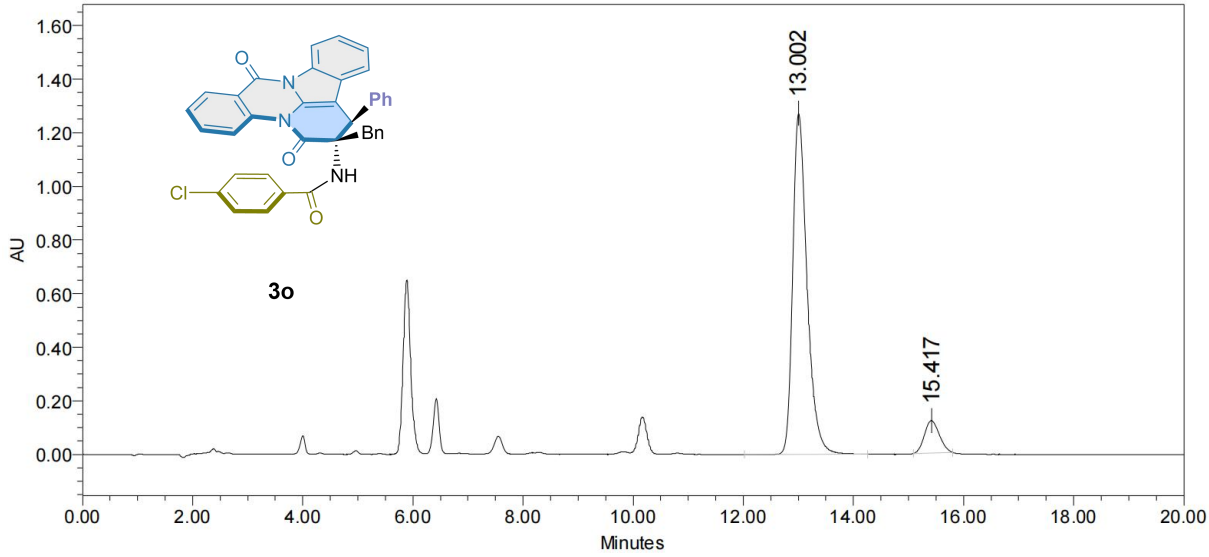


3o

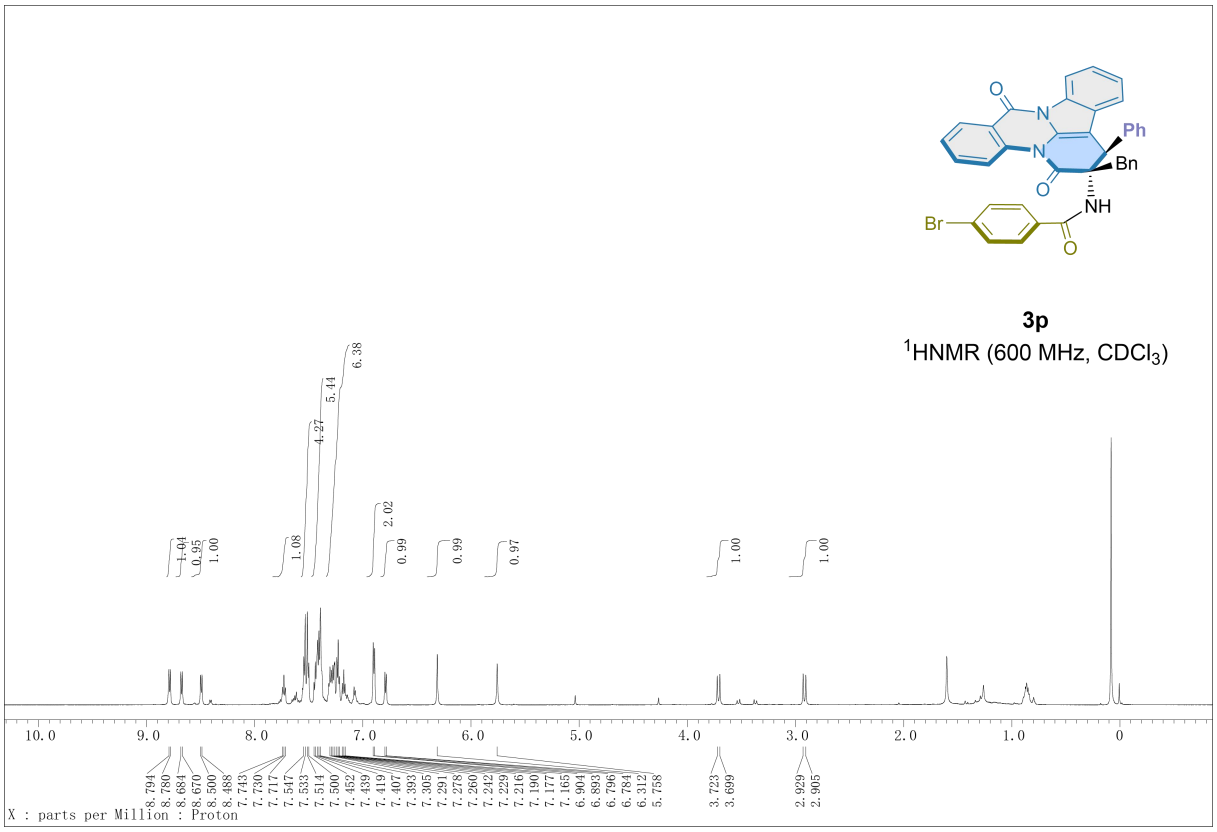
^{13}CNMR (151 MHz, $CDCl_3$)



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	12.829	412639	6977084	50.53
2	15.157	355153	6829449	49.47

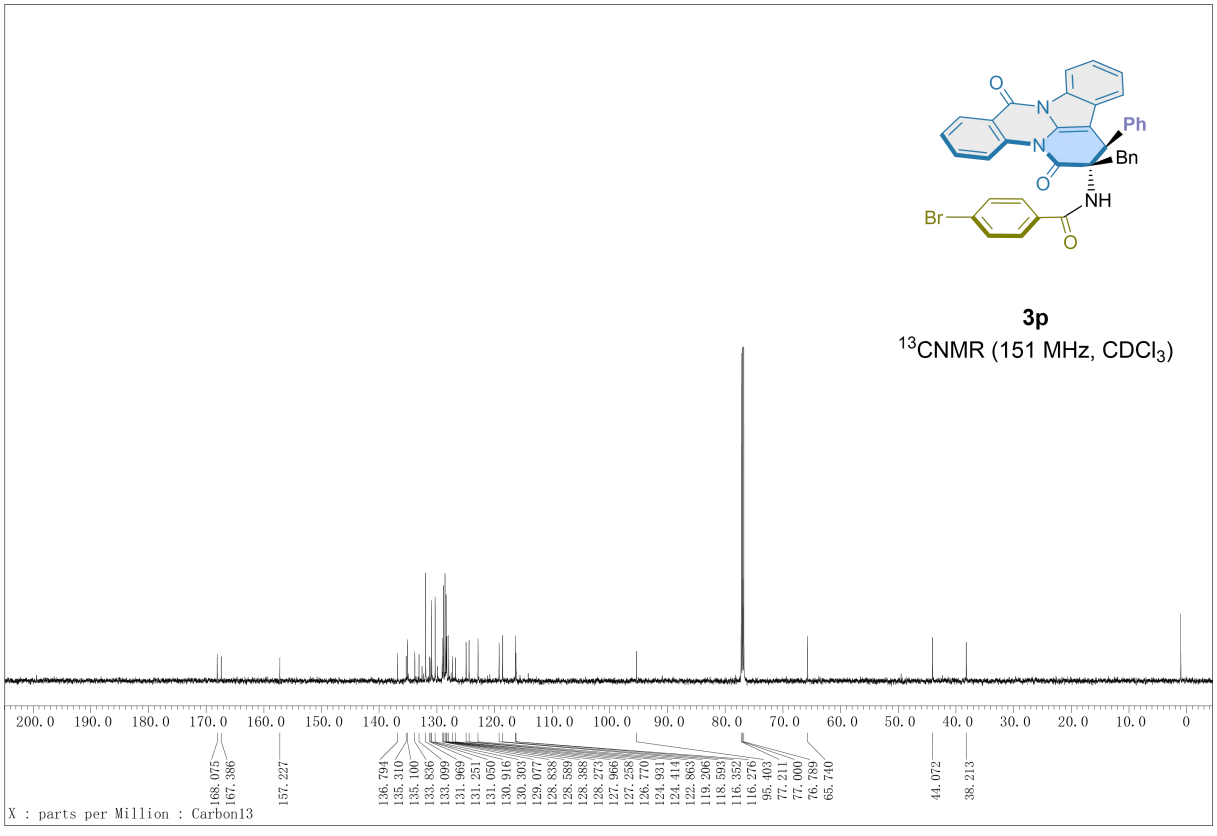


	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	13.002	1271703	22913929	91.01
2	15.417	120894	2264040	8.99



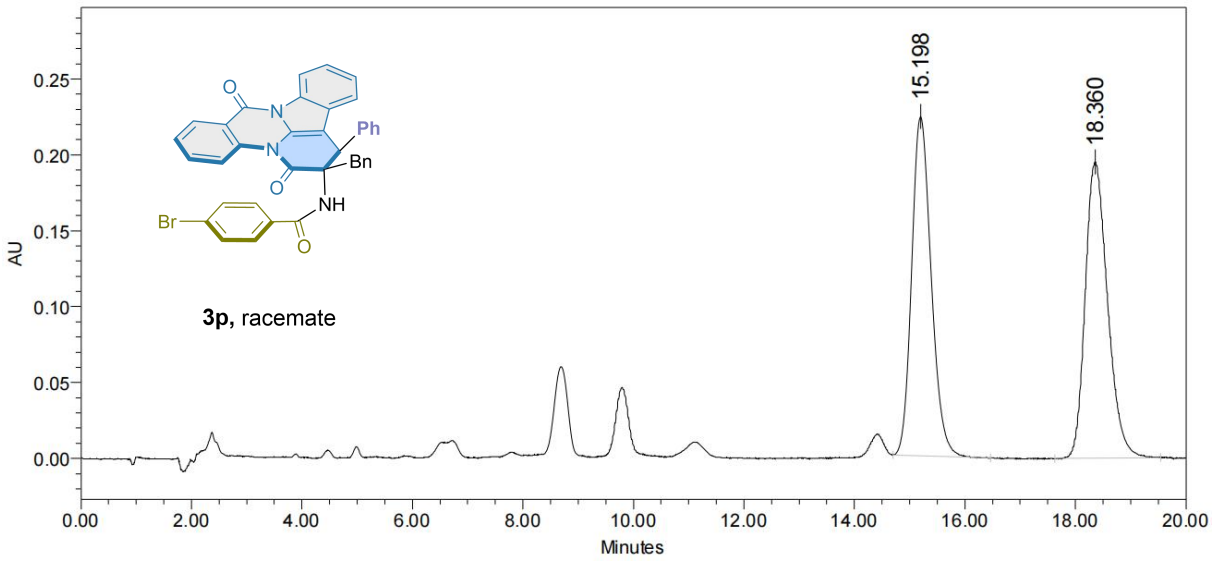
3p

^{1}HNMR (600 MHz, $CDCl_3$)



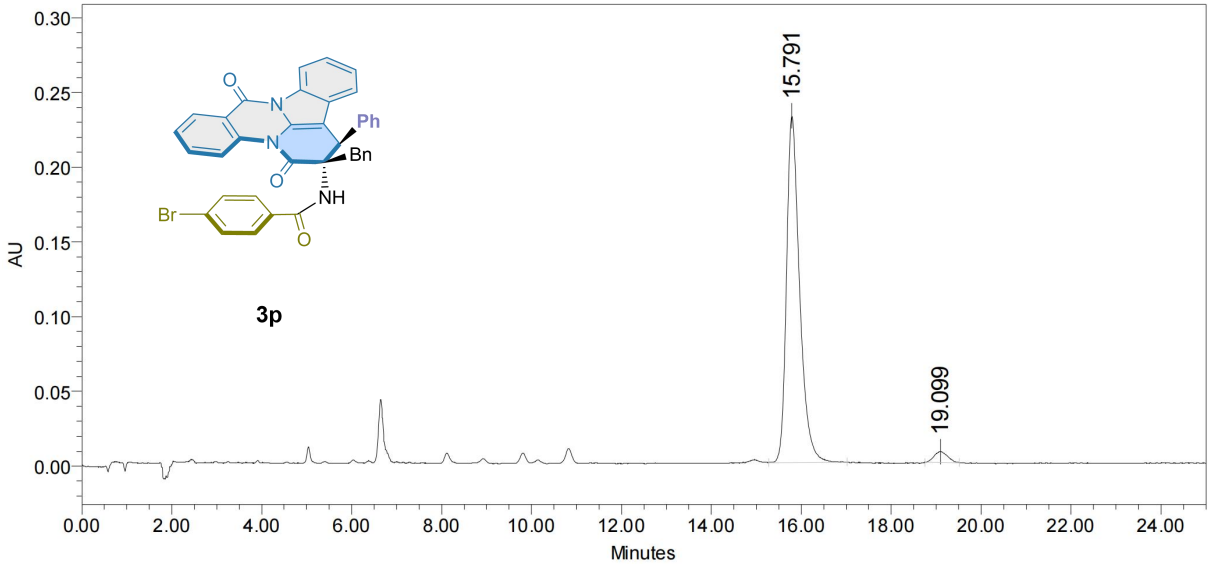
3p

^{13}CNMR (151 MHz, $CDCl_3$)



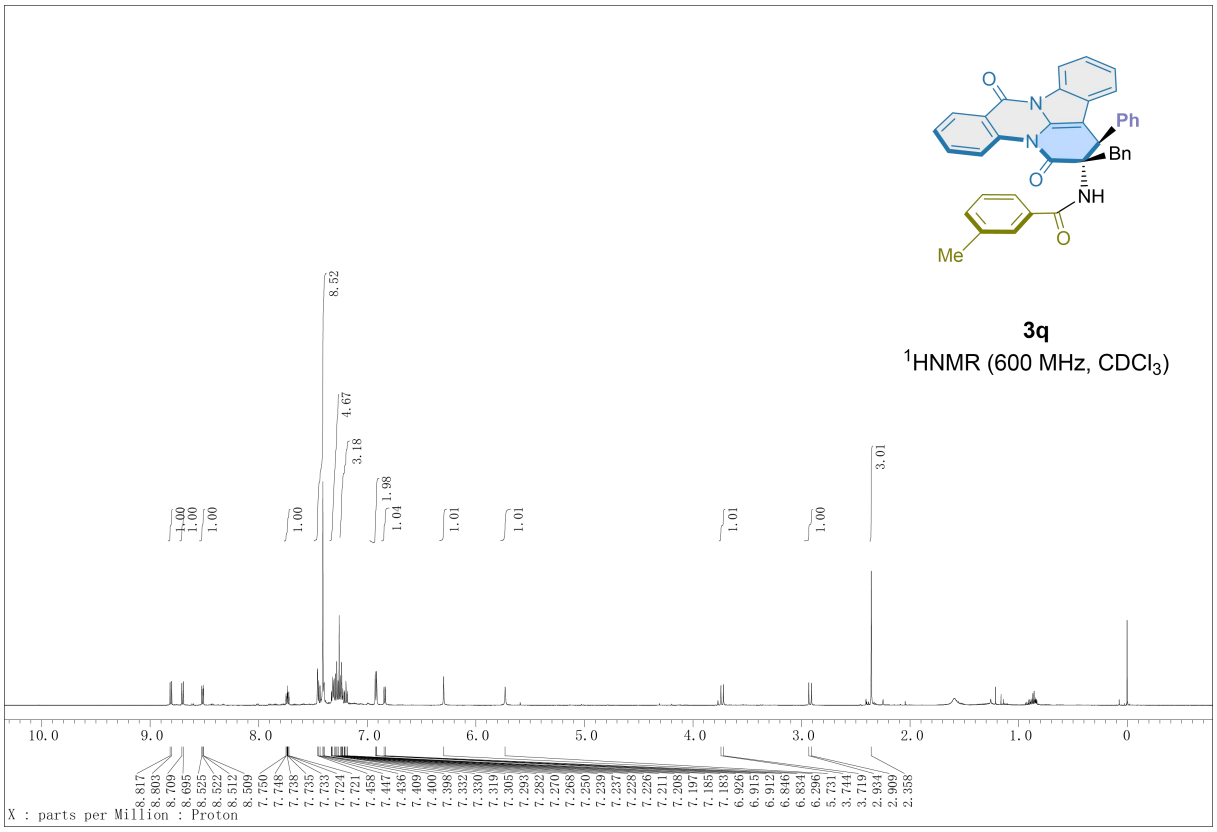
3p, racemate

	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	15.198	223489	5481260	49.91
2	18.360	195111	5500255	50.09



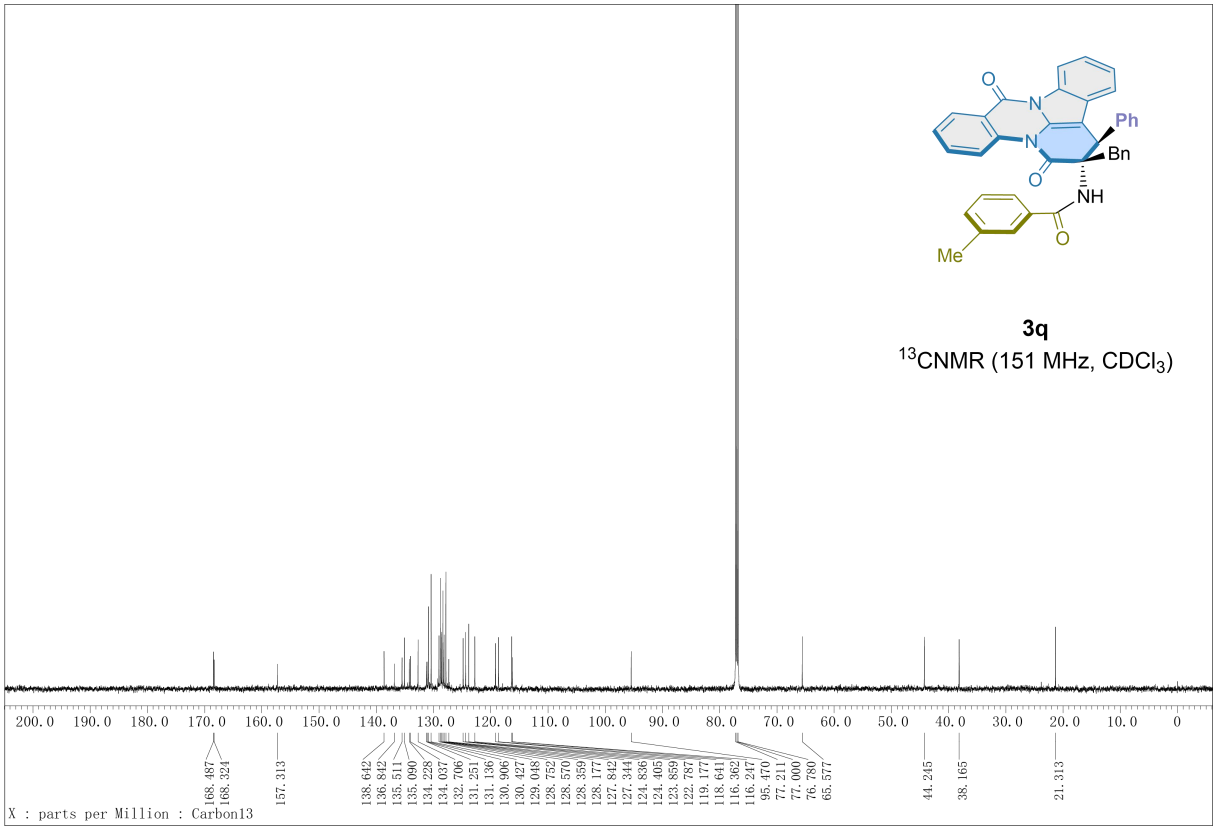
3p

	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	15.791	231856	4685489	96.87
2	19.099	7297	151191	3.13



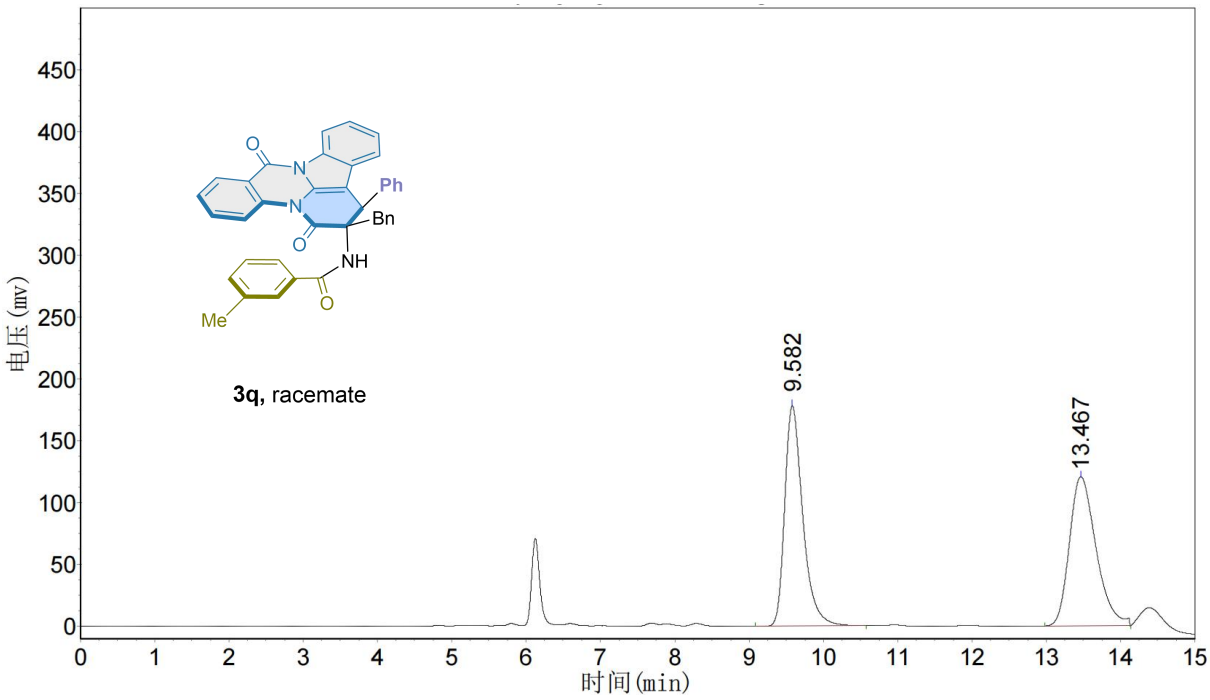
3q

^{1}HNMR (600 MHz, $CDCl_3$)

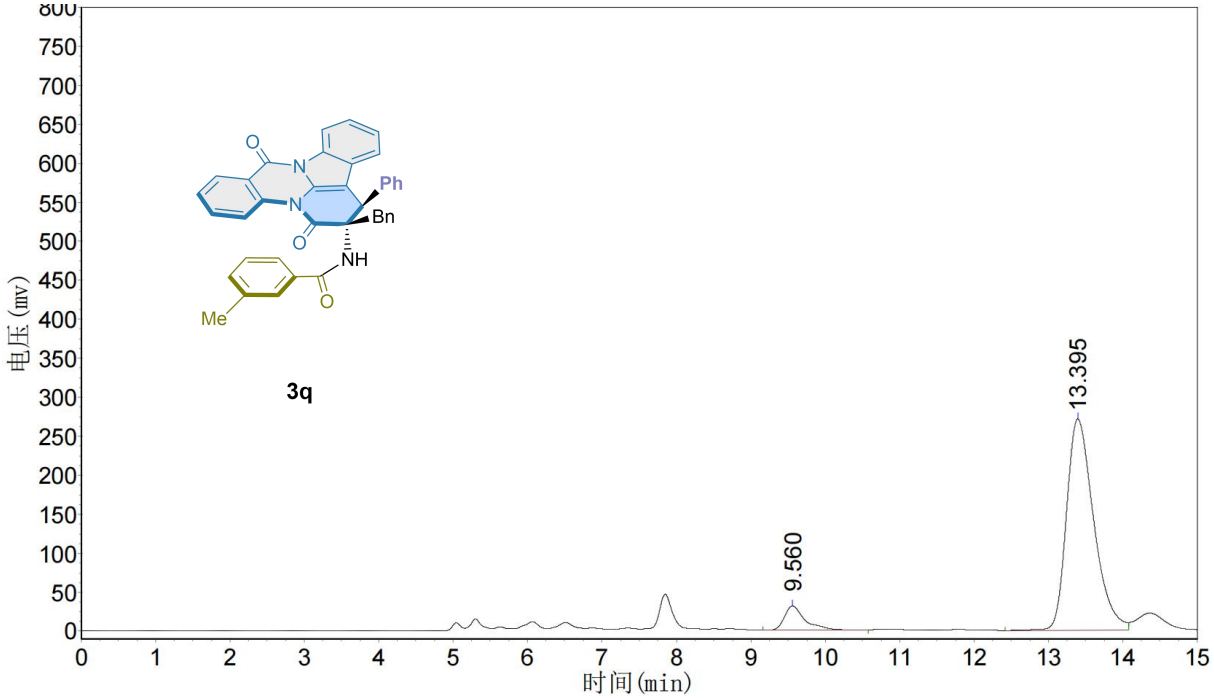


3q

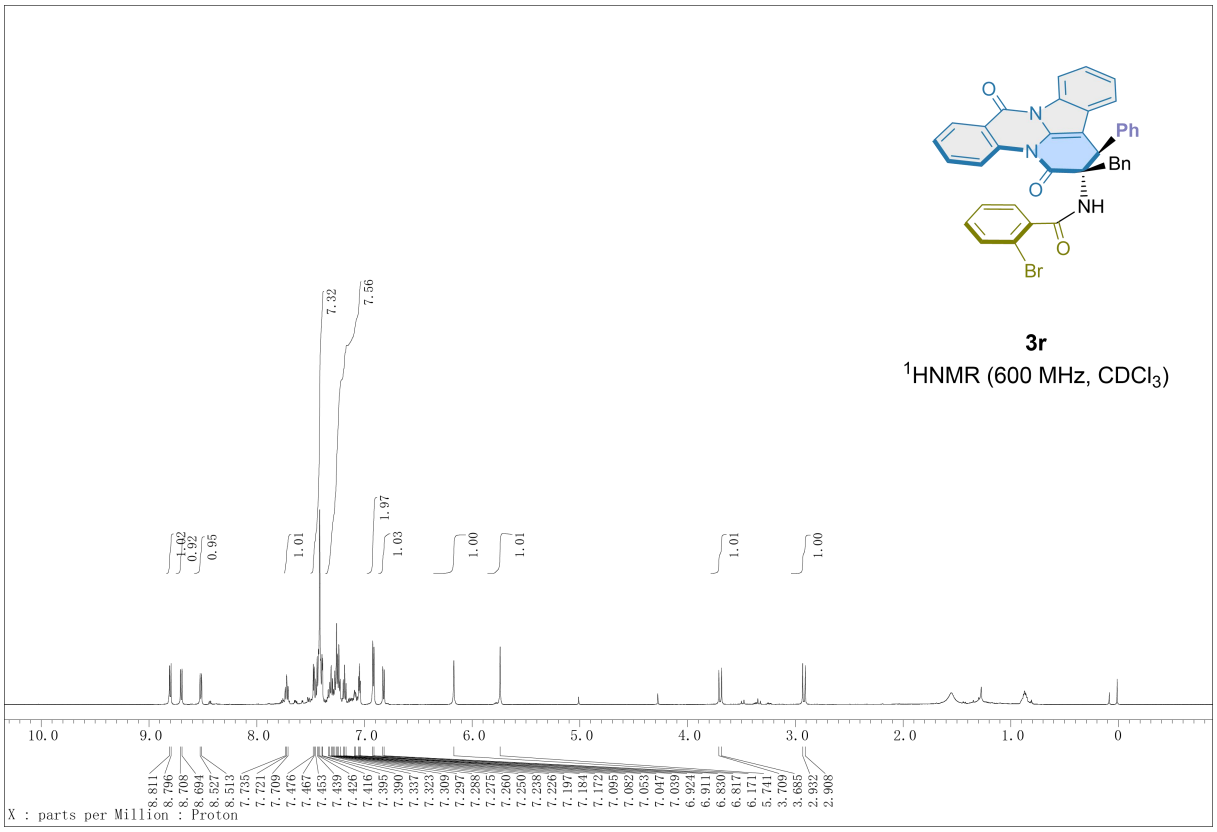
^{13}CNMR (151 MHz, $CDCl_3$)



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	9.582	178217	3014430	50.10
2	13.467	120620	3002145	49.90

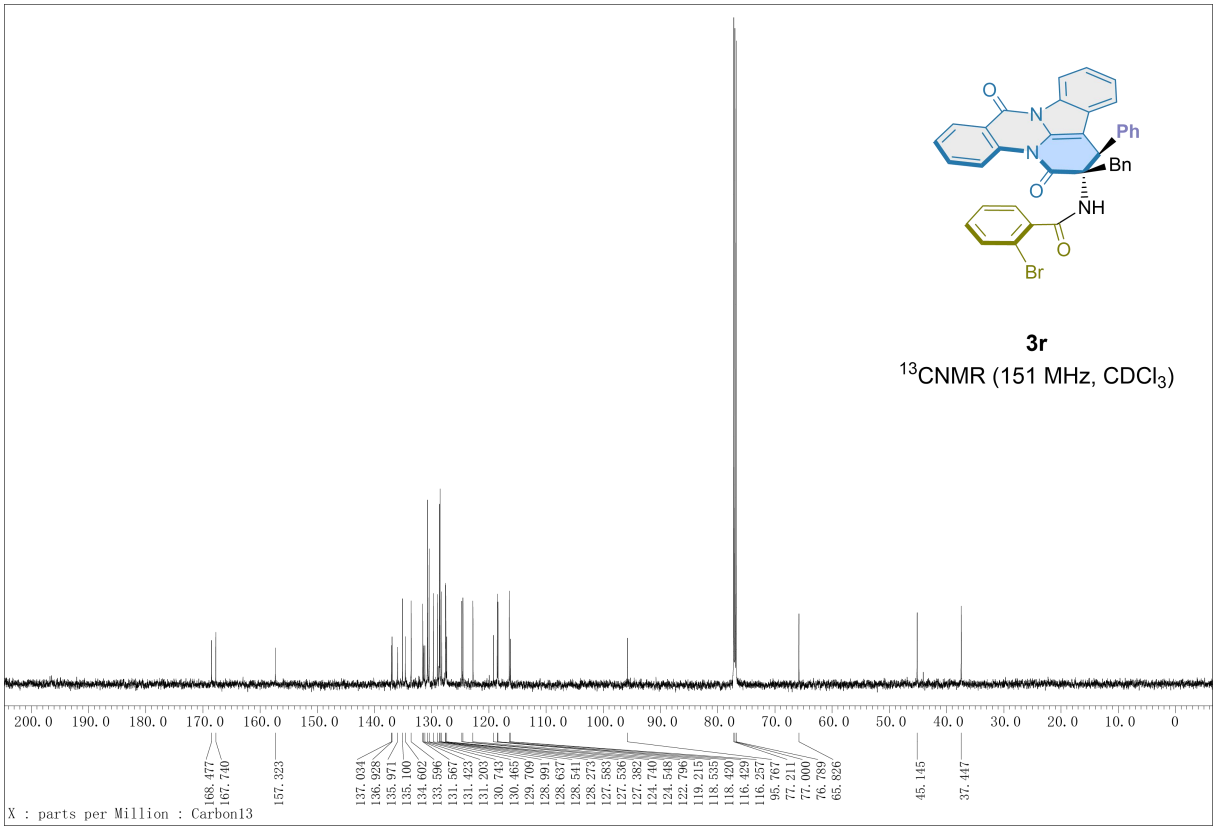


	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	9.560	30925	592500	7.94
2	13.395	271010	6872721	92.06



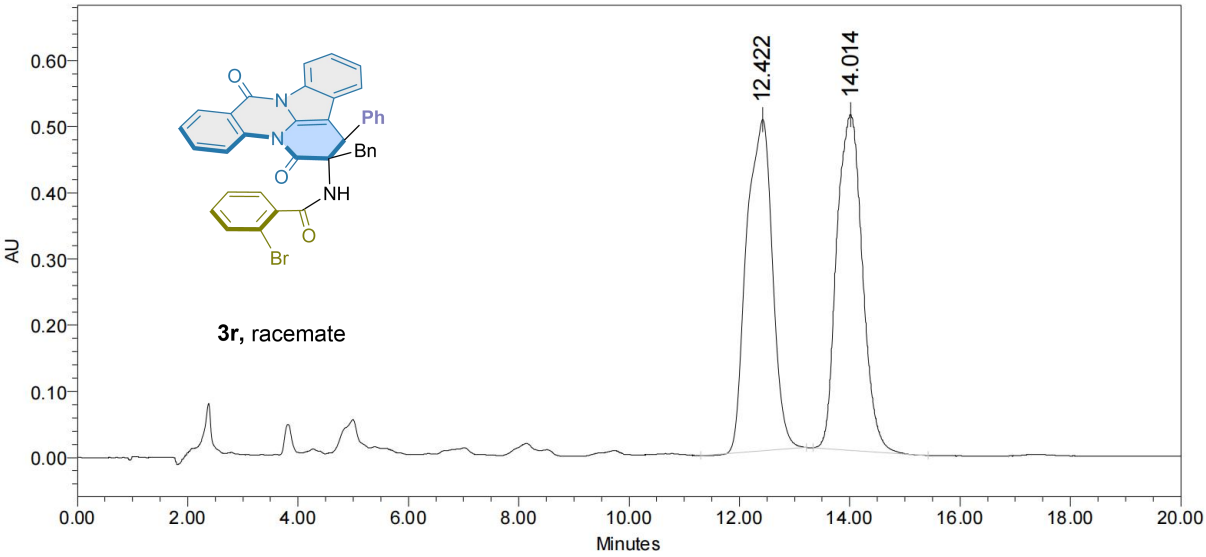
3r

^{1}HNMR (600 MHz, $CDCl_3$)

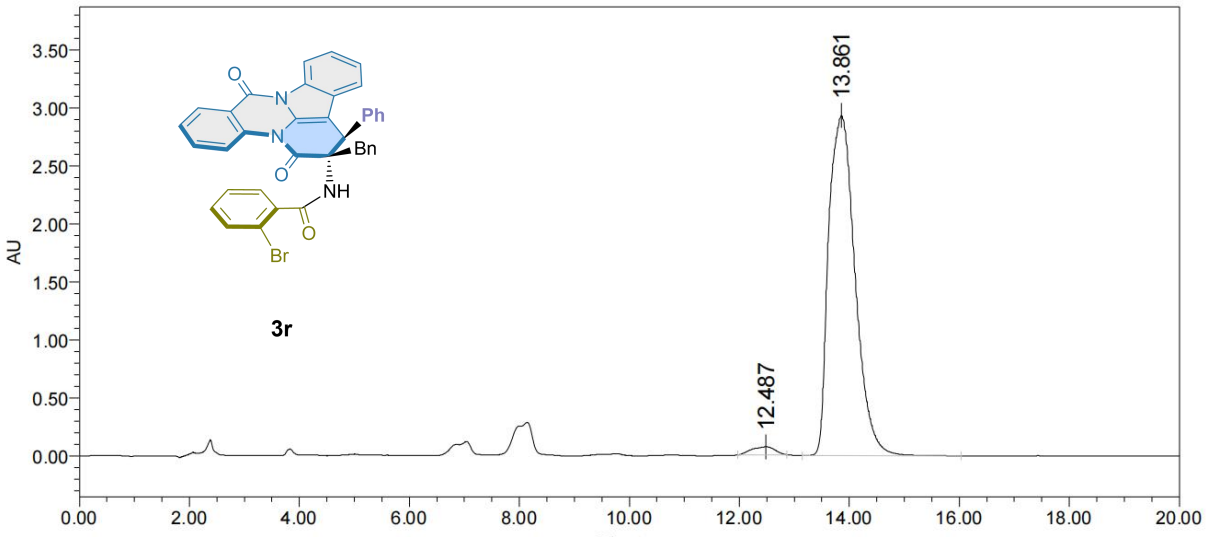


3r

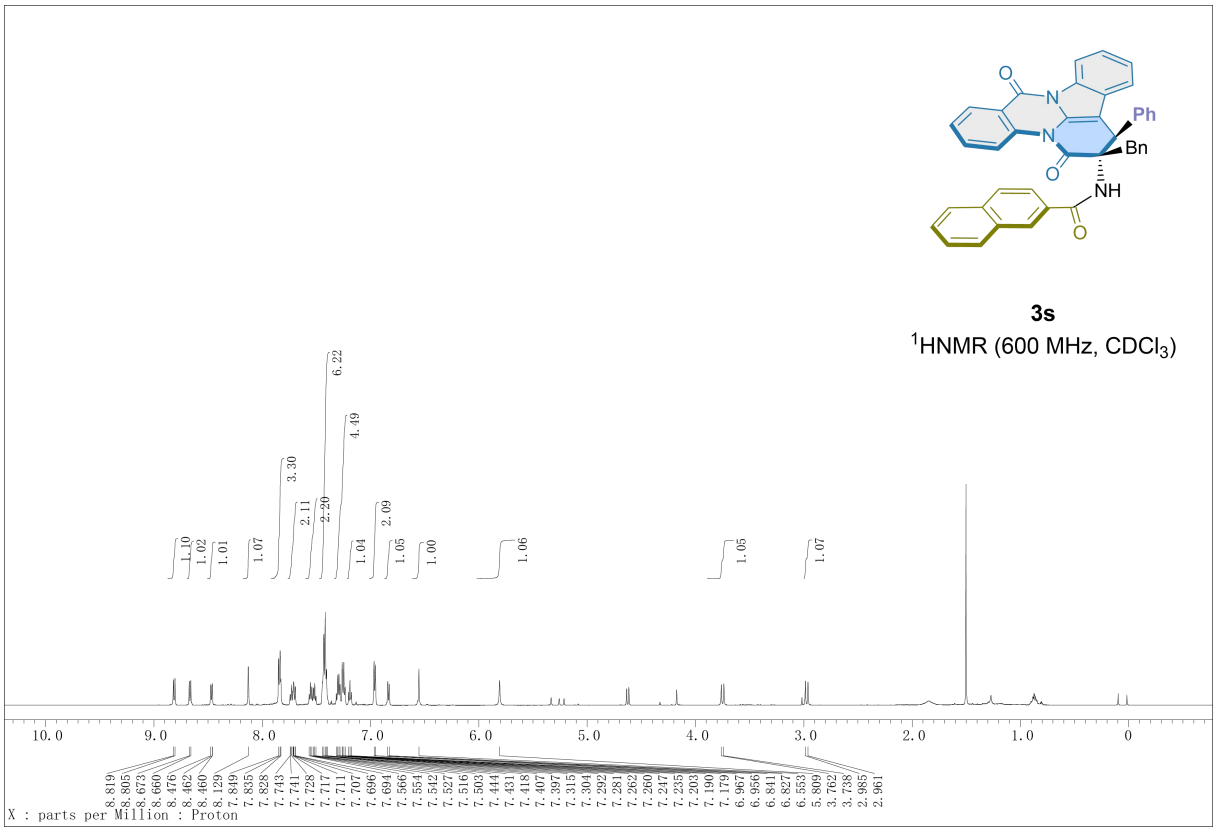
^{13}CNMR (151 MHz, $CDCl_3$)

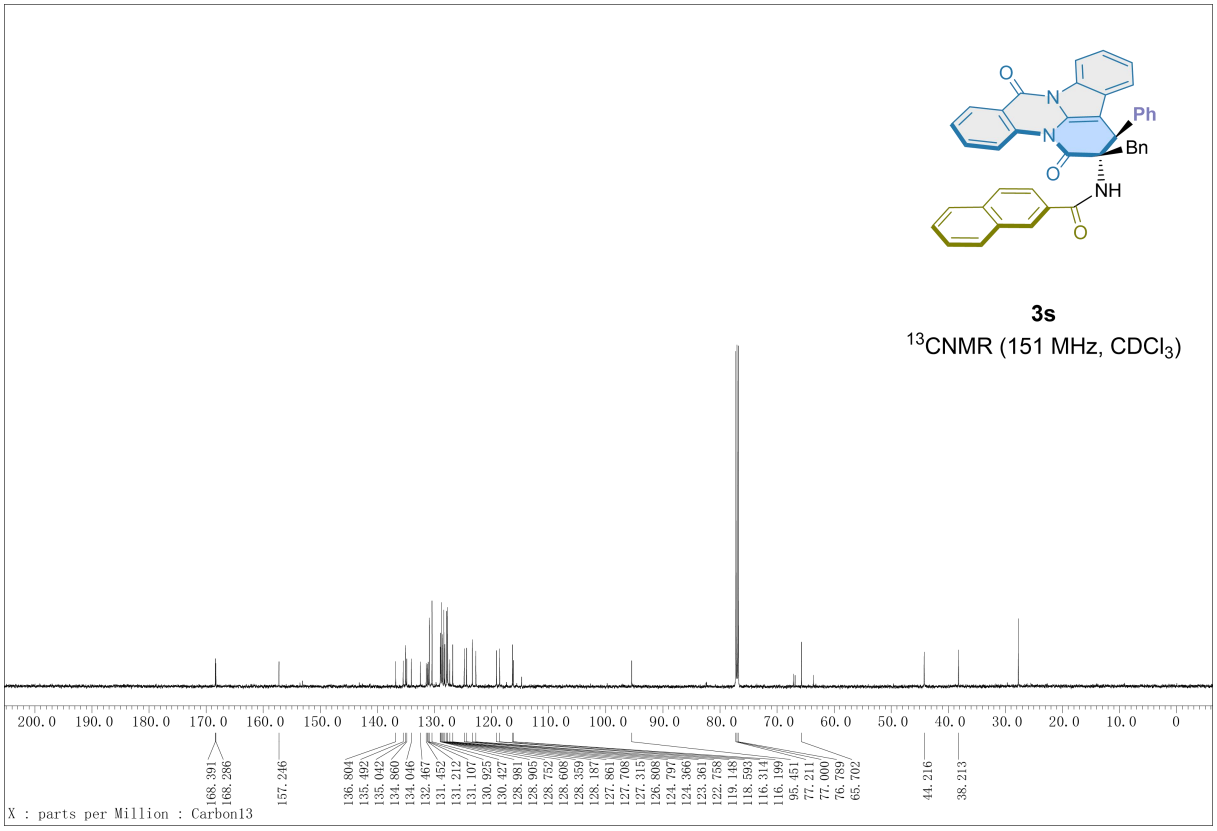


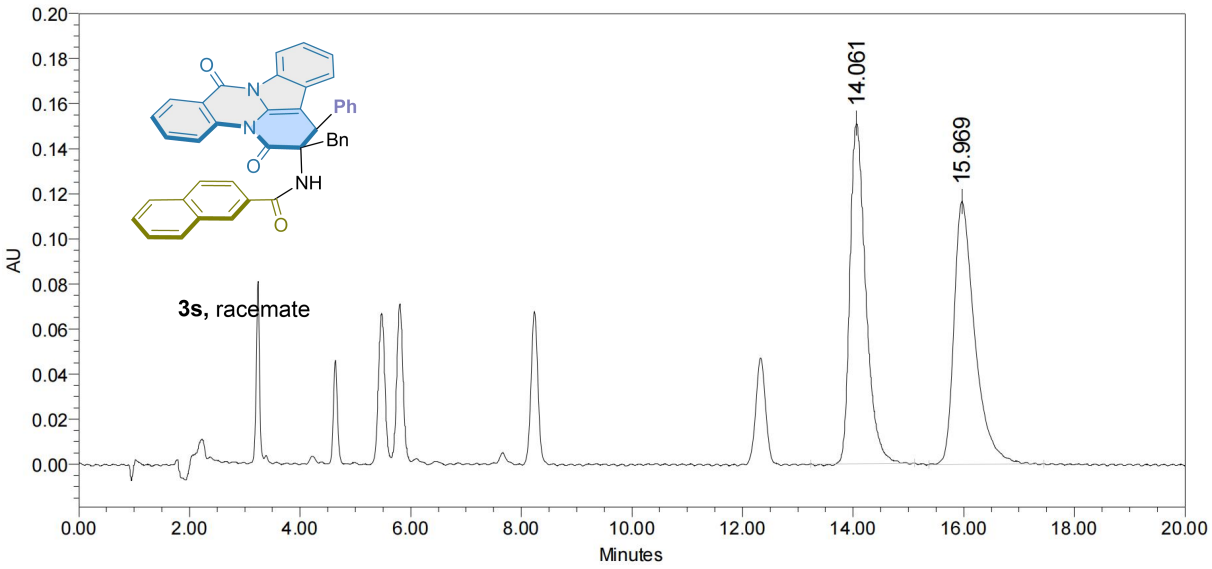
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	12.422	500774	16262955	49.68
2	14.014	507277	16475657	50.32



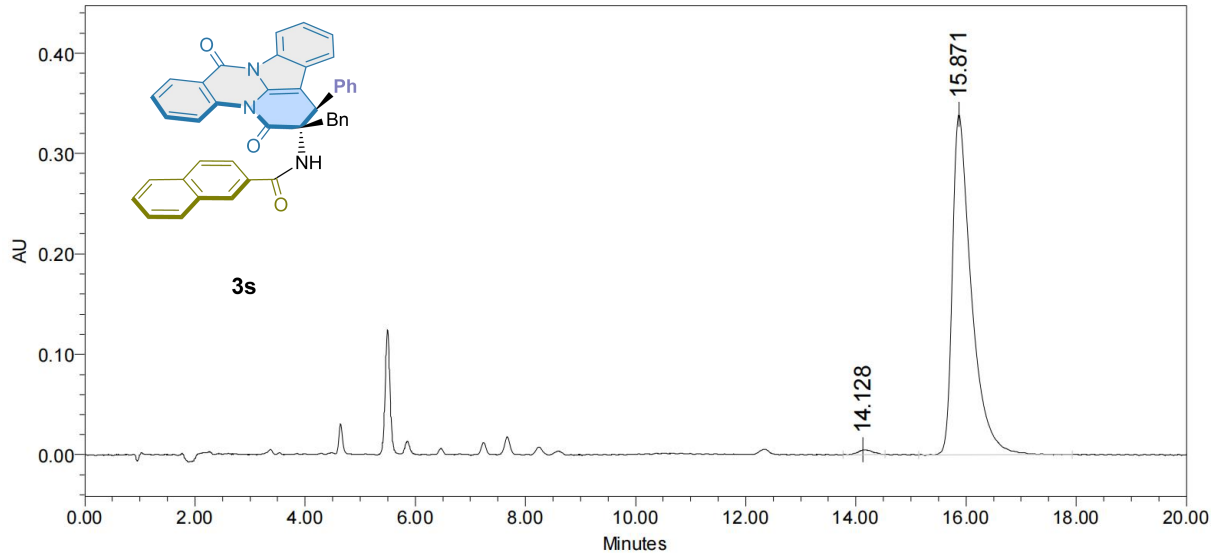
	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	12.487	68619	2037221	2.03
2	13.861	2931377	98151326	97.97


Ph
Bn
NH
O
N
3s
1HNMR (600 MHz, CDCl3)
6.22
4.49
3.30
2.11
2.20
2.09
1.10
1.02
1.01
1.07
1.04
1.05
1.00
1.06
1.05
1.07
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
X : parts per Million : Proton

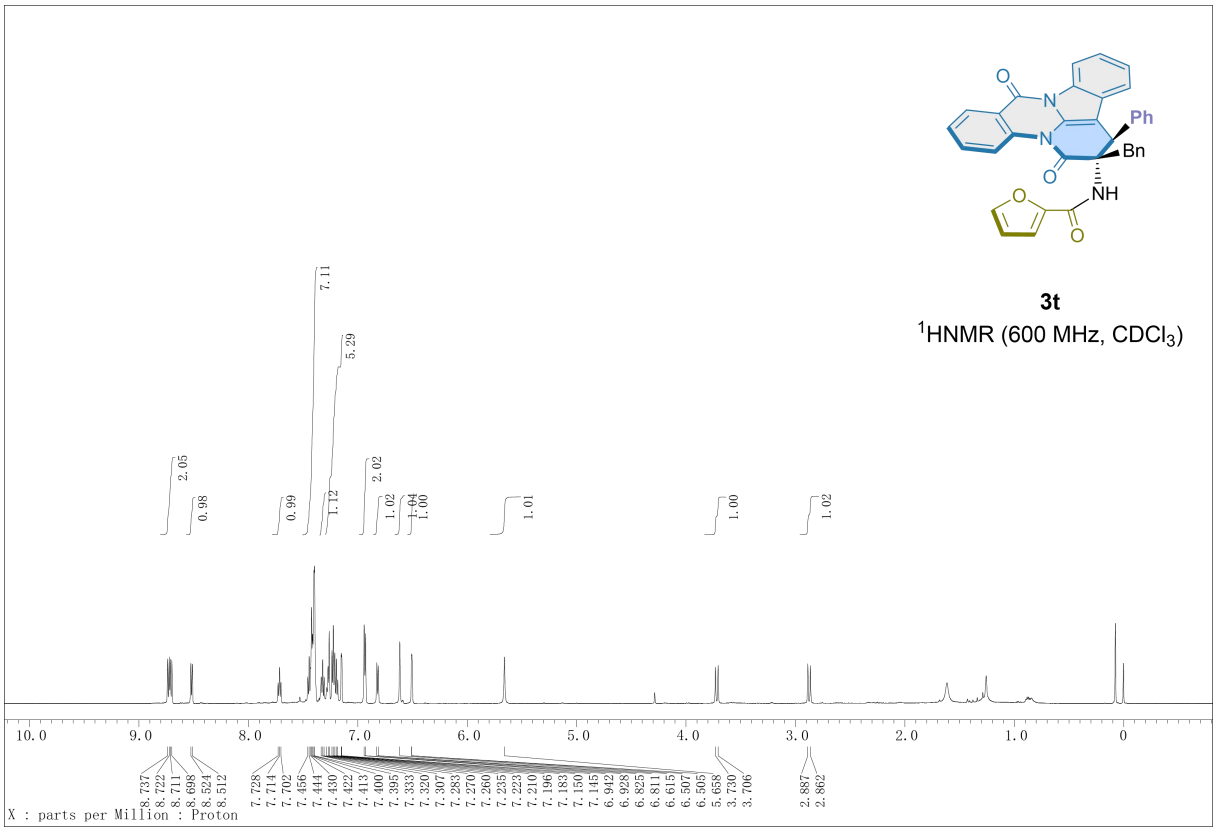

Ph
Bn
NH
O
N
3s
13CNMR (151 MHz, CDCl3)
200.0
190.0
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0
X : parts per Million : Carbon13



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	14.061	151179	3021103	49.91
2	15.969	116622	3031748	50.09

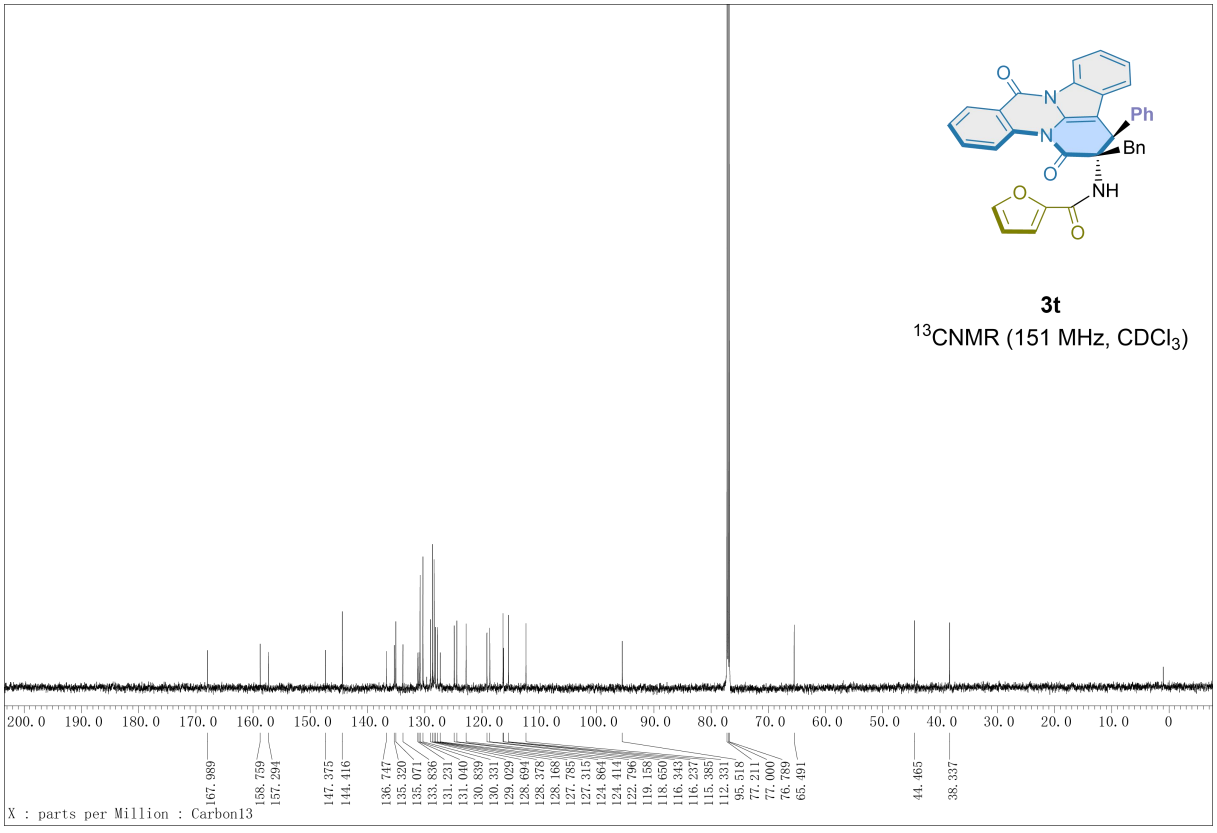


	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	14.128	4662	87081	1.07
2	15.871	339099	8088334	98.93



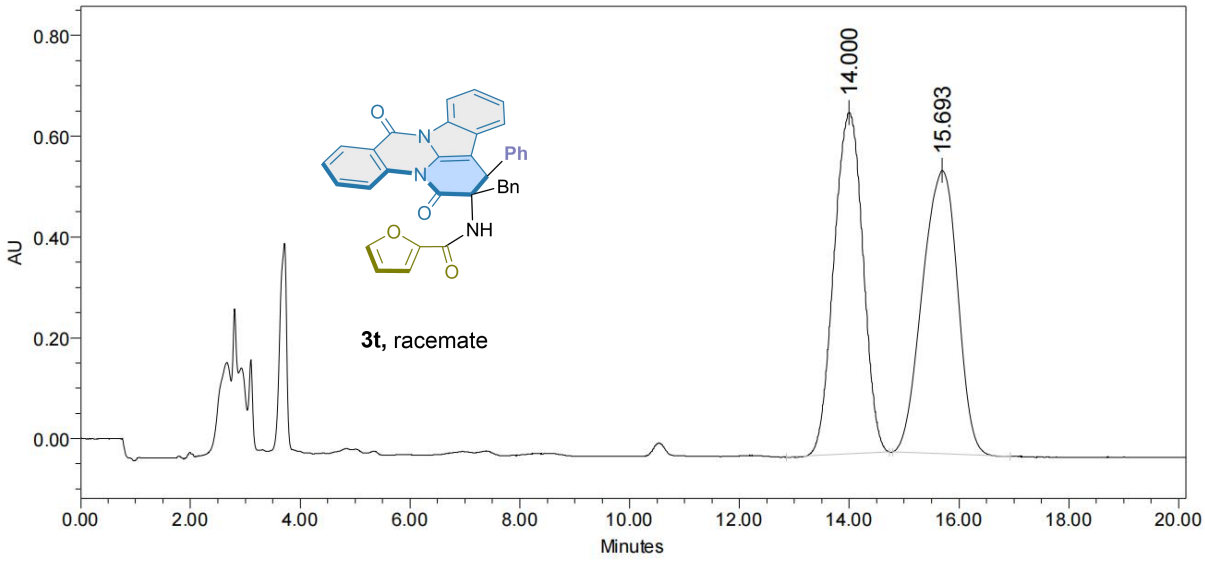
3t

^{1}HNMR (600 MHz, $CDCl_3$)

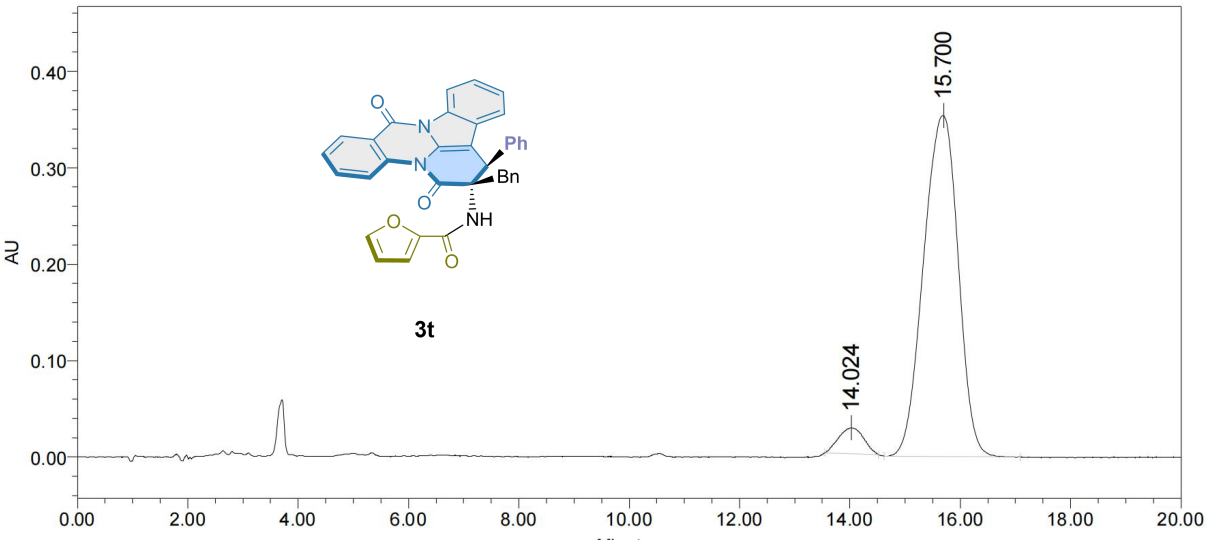


3t

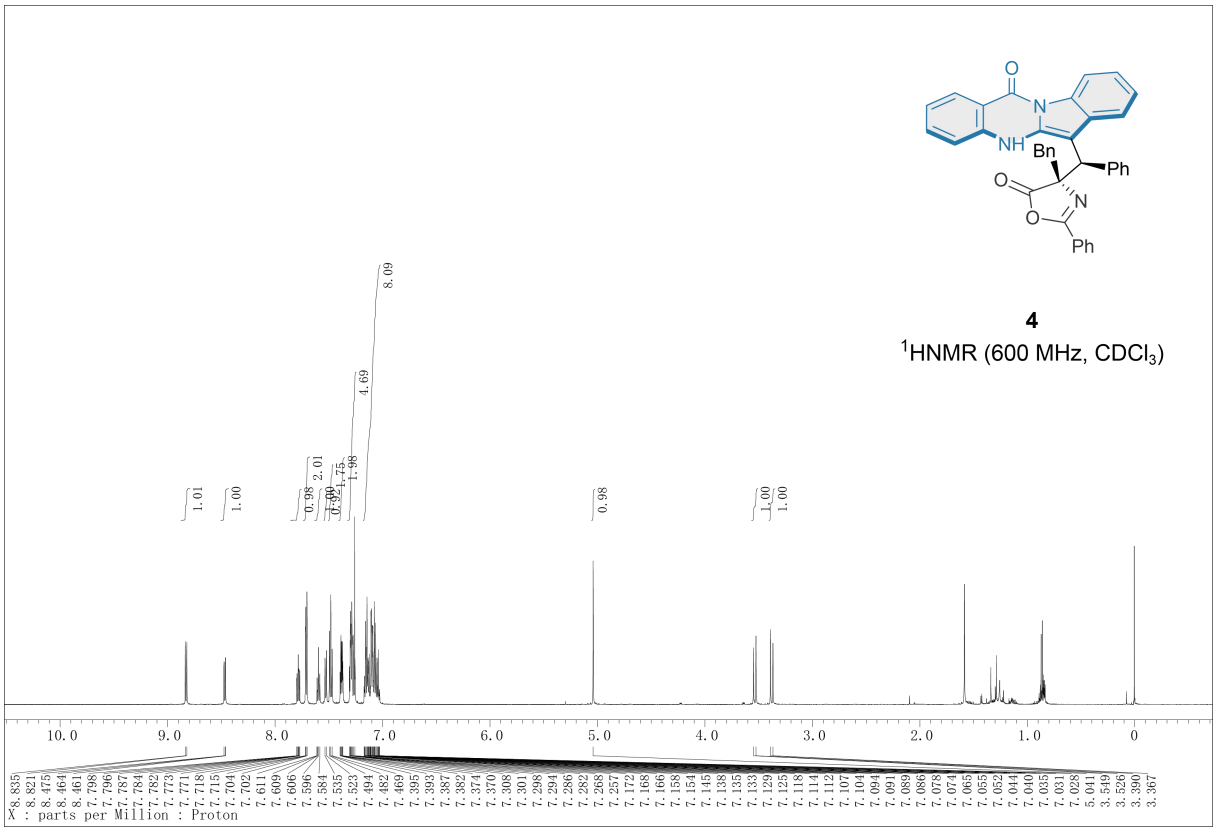
^{13}CNMR (151 MHz, $CDCl_3$)



	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	14.000	677927	24948759	50.00
2	15.693	562266	24953227	50.00

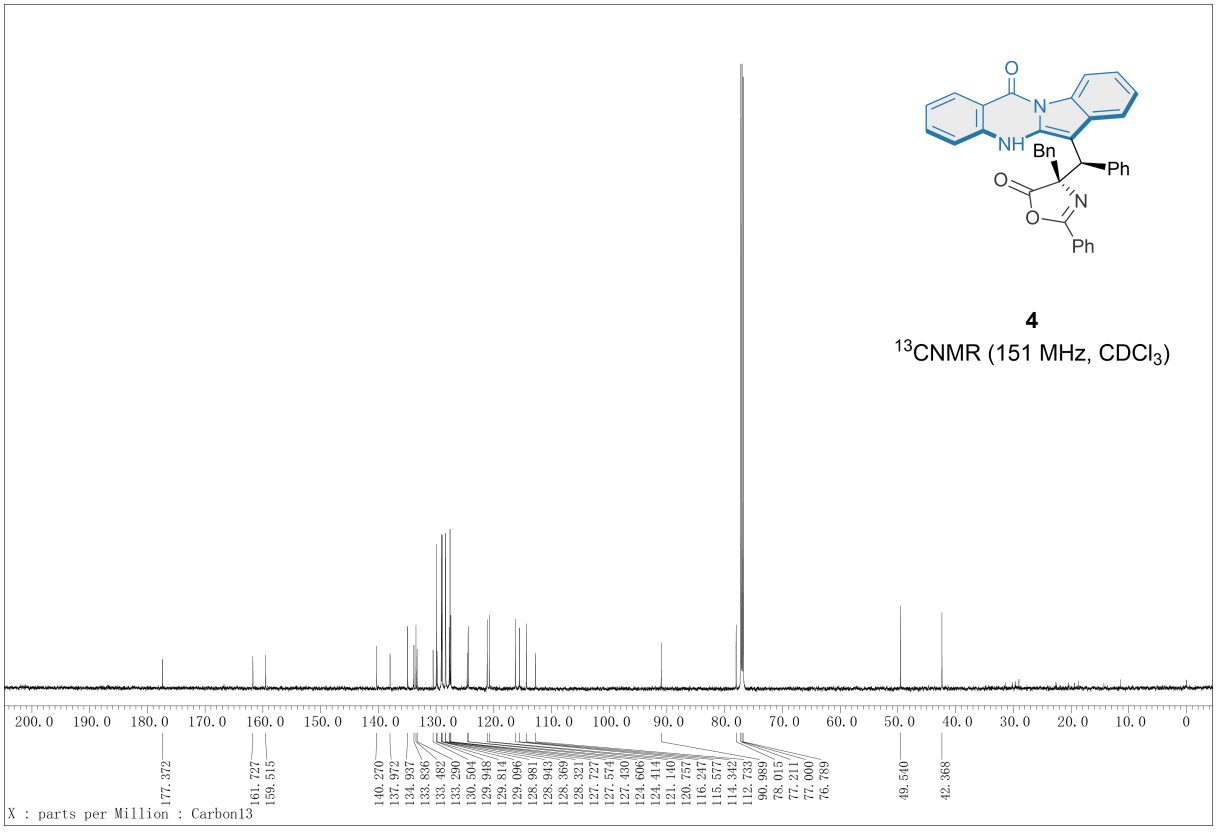


	Ret.Time(min)	Height(μV)	Area(μV*sec)	Rel.Area(%)
1	14.024	26824	851140	5.25
2	15.700	353387	15347832	94.75



4

^{1}HNMR (600 MHz, $CDCl_3$)



4

^{13}CNMR (151 MHz, $CDCl_3$)