Supporting Information

Access to Quaternary Stereogenic Centers via Rhodium(III)-Catalyzed Annulations between 2-Phenylindoles and Ketenes

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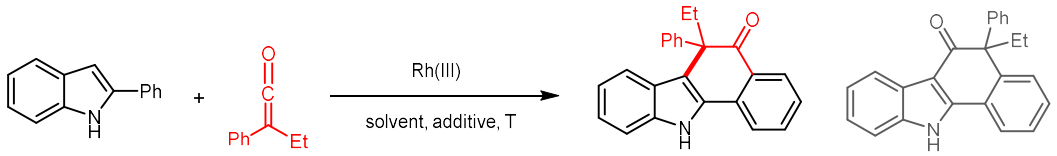
Contents

1. General Information

Unless otherwise noted, all the coupling reactions and were carried out in flame-dried pressure tubes with a Teflon screw cap under nitrogen atmosphere. Solvents were purified and dried by standard procedures. All chemicals were obtained from commercial sources and were used as received unless otherwise noted. 2-Phenylindoles[1-3] and ketenes[4] were prepared by following literature reports. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AV 400 spectrometer (400 MHz for ^{1}H, 101 MHz for ^{13}C, and 376 MHz for ^{19}F). All coupling constants were reported in Hz. The residual solvent signals were used as references for ^{1}H and ^{13}C NMR spectra and the chemical shifts were converted to the TMS scale {$CDCl_3$: δ ^{1}H = 7.26 ppm, δ ^{13}C = 77.16 ppm; CD_2Cl_2: δ ^{1}H = 5.32 ppm, δ ^{13}C = 53.84 ppm; $(CD_3)_2SO$: δ ^{1}H = 2.50 ppm, δ ^{13}C = 39.52 ppm; CD_3CN: δ ^{1}H = 1.94 ppm, δ ^{13}C = 1.32, 118.26}. HRMS data were obtained using a TOF mode. Column chromatography was performed on silica gel (300-400 mesh) using ethyl acetate (EA)/petroleum ether (PE).

2. Optimization Studies

Table S1. Optimization Studies of Coupling of 2-Phenylindoles with Ketenes.[a]



1a **2a** **3aa** **4aa**

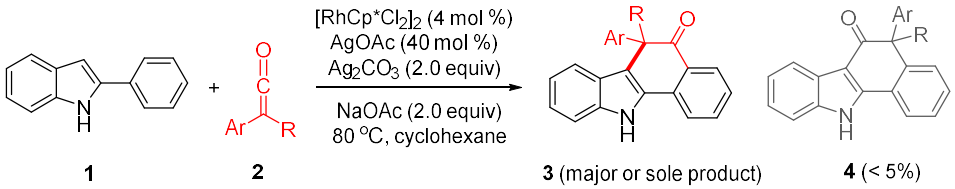
entry	oxidant (equiv)	base	solvent	yield (%) **3aa**	yield (%) **4aa**
1	AgOAc (2.2)	Na_2CO_3	DCE	ND	36
2	AgOAc (2.2)	K_2CO_3	DCE	ND	28
3	**AgOAc (2.2)**	**LiOAc**	**DCE**	**ND**	**45**
4	AgOAc (2.2)	KOAc	DCE	trace	ND
5	AgOAc (2.2)	Li_2CO_3	DCE	ND	41
6	Ag_2CO_3 (2.0)	CS_2CO_3	DCE	NR	
7[b]	AgOAc (2.2)	K_2CO_3	EtOH	ND	<5
8[b]	AgOAc (2.2)	NaOAc	MeOH	ND	<5
9[b]	AgOAc (2.2)	Li_2CO_3	MeOH	ND	<5
10	AgOAc (2.2)	Li_2CO_3	DCE	ND	17
11	AgOAc (2.2)	Na_2CO_3	CF_3Ph	8	10
12[c]	AgOAc (2.2)	Na_2CO_3	DCE	15	5
13	AgOAc (2.2)	Na_2CO_3	cyclohexane	17	ND
14	AgOAc (2.2)	Na_2CO_3	THF	22	ND
15	AgOAc (2.2)	Na_2CO_3	*σ*-xylene	18	ND
16	AgOAc (2.2)	CS_2CO_3	DCE	20	ND
17	$Cu(OAc)_2$ (2.0)	Na_2CO_3	CH_3Ph	ND	ND
18[d]	Ag_2CO_3 (2.2)	NaOAc	DCE	43	ND
19	Ag_2CO_3 (2.0)	KOAc	DCE	NR	
20	Ag_2CO_3 (2.0)	CsOAc	DCE	NR	
21	Ag_2CO_3 (2.0)	NaOAc	DCE	45	ND
22[b]	Ag_2CO_3 (2.0)	NaOAc	DCE	38	ND
23[e]	Ag_2CO_3 (2.0)	NaOAc	DCE	NR	
24[f]	Ag_2CO_3 (2.0)	NaOAc	DCE	trace	ND
25	Ag_2CO_3 (2.0)	NaOAc	CF_3Ph	50	ND
26	Ag_2CO_3 (2.0)	NaOAc	PhCl	50	ND
27	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	53	ND
28	Ag_2CO_3 (2.0)	NaOAc	*n*-hexane	NR	
29[g]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	35	ND
30[h]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	57	ND
31[h]	Ag_2O	NaOAc	cyclohexane	39	ND
32[i]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	43	ND
33[h,j]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	38	ND
34[k]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	57	ND
35[l]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	39	ND
36[m]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	10	ND

37[n,o]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	10	ND
38[h]	$Cu(OAc)_2$	NaOAc	cyclohexane	NR	
39[n]	MesCOOAg (2.2)	NaOAc	cyclohexane	ND	20
40[p]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	56	ND
41[q]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	66	ND
42[n]	Ag_2CO_3 (2.0)	NaOAc (3.0)	cyclohexane	61	ND
43[n]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	67	ND
44[n,r]	**Ag_2CO_3 (2.0)**	**NaOAc**	**cyclohexane**	**70**	**ND**
45[n]	Ag_2CO_3 (2.0)	NaOAc (1.5)	cyclohexane	22	ND
46[n]	Ag_2CO_3 (2.0)	HCOONa	cyclohexane	41	ND
47[n]	Ag_2CO_3 (2.0)	C_2H_5COONa	cyclohexane	43	ND
48[n]	Ag_2CO_3 (2.0)	CF_3COONa	cyclohexane	55	ND
49[n]	Ag_2CO_3 (2.0)	TsONa	cyclohexane	44	ND
50[s]	Ag_2CO_3 (2.0)	NaOAc	cyclohexane	62	ND
51[h,q]	Ag_2CO_3 (2.0)	$Ba(OAc)_2$ (0.1)	cyclohexane	64	ND
52[n,s]	Ag_2CO_3 (2.0)	C_2H_5COONa	cyclohexane	58	ND

[a]Reaction conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), $[RhCp^*Cl_2]_2$ (4 mol %), $AgSbF_6$ (16 mol %), base (2.0 equiv) unless otherwise noted, solvent (2.0 mL) under N_2 for 10 h, 80 °C, isolated yield after column chromatography. [b]$[RhCp^*(MeCN)_3]_2(SbF_6)_2$ (8 mol %) was used instead of $[RhCp^*Cl_2]_2/AgSbF_6$. [c]PivOH (1.0 equiv), 60 °C. [d]HOAc (0.2 mmol). [e]$Zn(NTf)_2$ 20 mol % [f]$Zn(OAc)_2$ 20 mol%. [g]$Fe(OAc)_2$ 20 mol %. [h]AgOAc was used instead of $AgSbF_6$. [i]$AgPF_6$ 16 mol %. [j]$Cp^*Rh(OAc)_2$. [k]$AgNO_3$ 40 mol %. [l]AgOTf 40 mol %. [m]$AgBF_4$ 40 mol %. [n]AgOAc 40 mol % instead of $AgSbF_6$, 15 h. [o]TBAA (0.4 mmol). [P]silver cyclohexanebutyrate (40 mol %).[q]AgOAc (0.2 mmol), 15 h. [r]Solvent (3.0 mL). [s]Ag_2WO_4 (20 mol %).

3 The Synthesis Products

3.1 General Procedure for Synthesis of 3.



2-Phenylindole (**1**, 0.2 mmol), ketene (**2**, 0.4 mmol), $[RhCp^*Cl_2]_2$ (4 mol %), AgOAc (0.08 mmol), Ag_2CO_3 (0.4 mmol), NaOAc (0.4 mmol), and cyclohexane (3.0 mL) were charged into a pressure tube. The reaction mixture was stirred at 80 °C for 15 h. After the solvent was removed under reduced pressure, the residue was purified by silica gel chromatography using PE/EA (8:1) to afford product **3.**

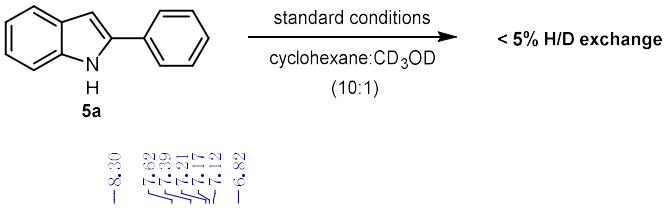
3.2 Synthesis of 3aa at a 1 mmol scale

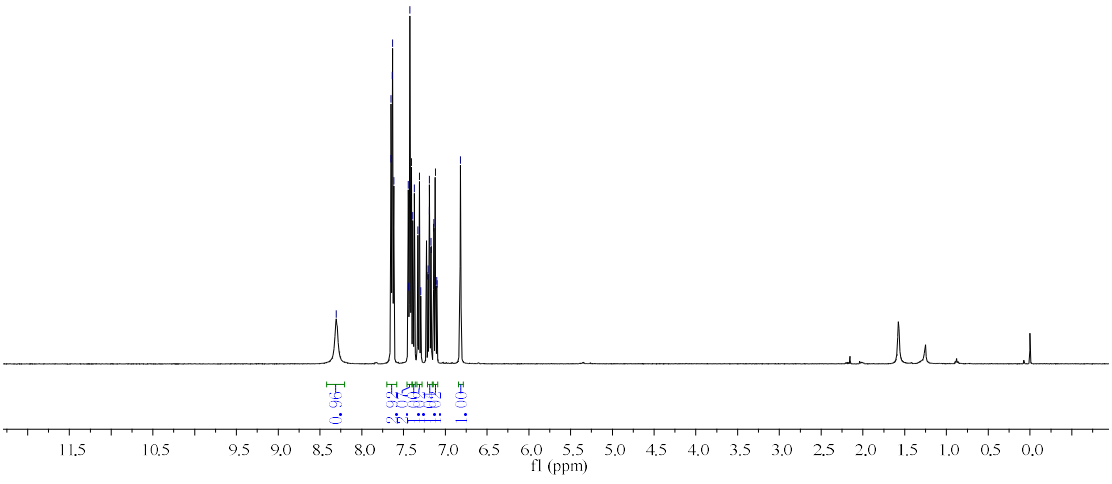
2-Phenylindole (**1a**, 193 mg, 1 mmol), phenyl ethyl ketene (**2a**, 292 mg, 2 mmol), $[RhCp^*Cl_2]_2$ (4 mol %), AgOAc (0.08 mmol), Ag_2CO_3 (2 mmol), NaOAc (2 mmol), and cyclohexane (15.0 mL) were charged into a pressure tube. The reaction mixture was stirred at 80 °C for 15 h. After the solvent was removed under reduced pressure, the residue was purified by silica gel chromatography using PE/EA (8:1) to afford product **3aa** (229 mg, 68%).

4. Mechanistic Studies on Annulation between 2-Phenylindoles and Ketenes

4.1 H/D Exchange of 2-Phenylindole

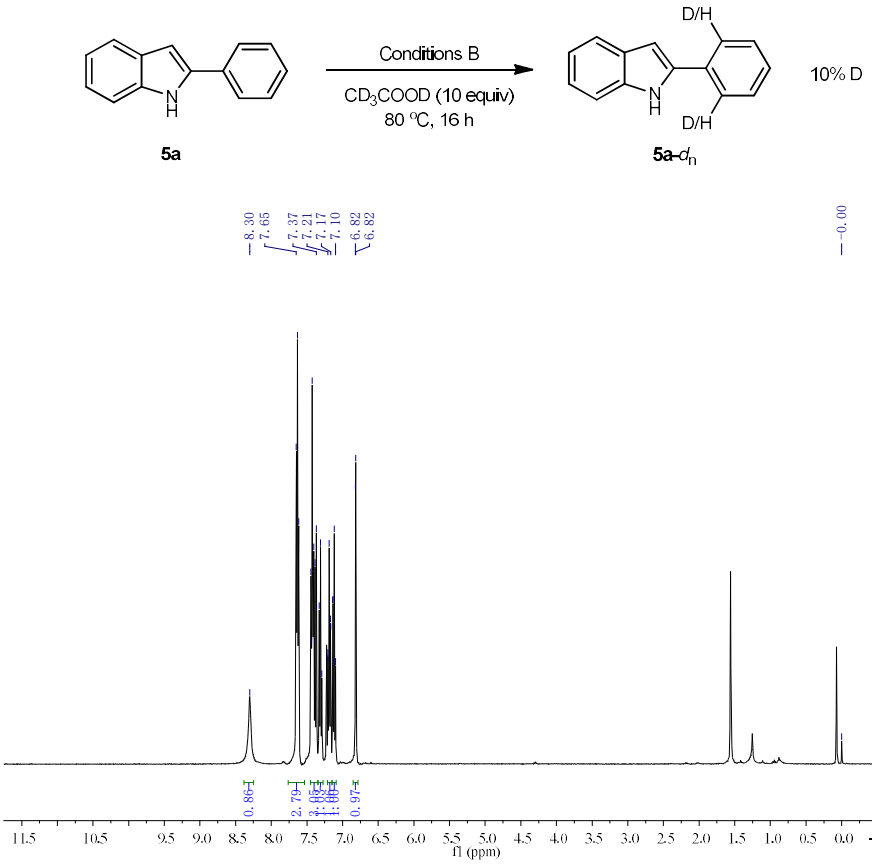
2-Phenyl-1*H*-indole (0.2 mmol), $[RhCp^*Cl_2]_2$ (4 mol%), AgOAc (0.08 mmol), Ag_2CO_3 (0.4 mmol), NaOAc (0.4 mmol), and cyclohexane/CD_3OD (10:1) were charged into a pressure tube. The reaction mixture was stirred at 80 °C for 15 h. The 2-phenylindole was isolated after chromatography using EA/PE (1:10), and only slight H/D exchange (< 5%) was observed on the basis of ^1H NMR analysis.





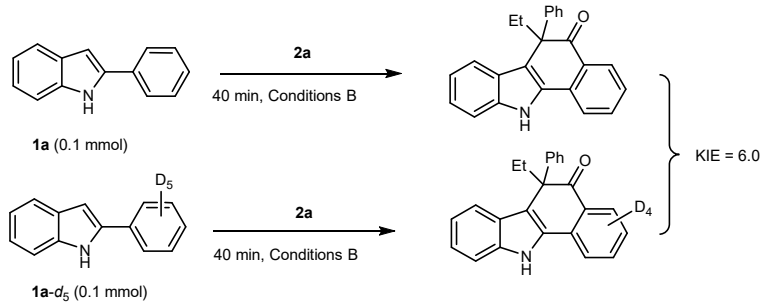
2-Phenylindole (0.2 mmol), $[RhCp^*Cl_2]_2$ (4 mol%), AgOAc (0.08 mmol), Ag_2CO_3 (0.4 mmol), NaOAc (0.4 mmol), CD_3COOD (2 mmol), and cyclohexane were charged into a pressure tube. The mixture was

stirred at 80 ºC for 15 h. The recovered 2-phenylindole was isolated after chromatography using EA/PE (1:10). Only slight H/D exchange was observed on the basis of ^{1}H NMR analysis.



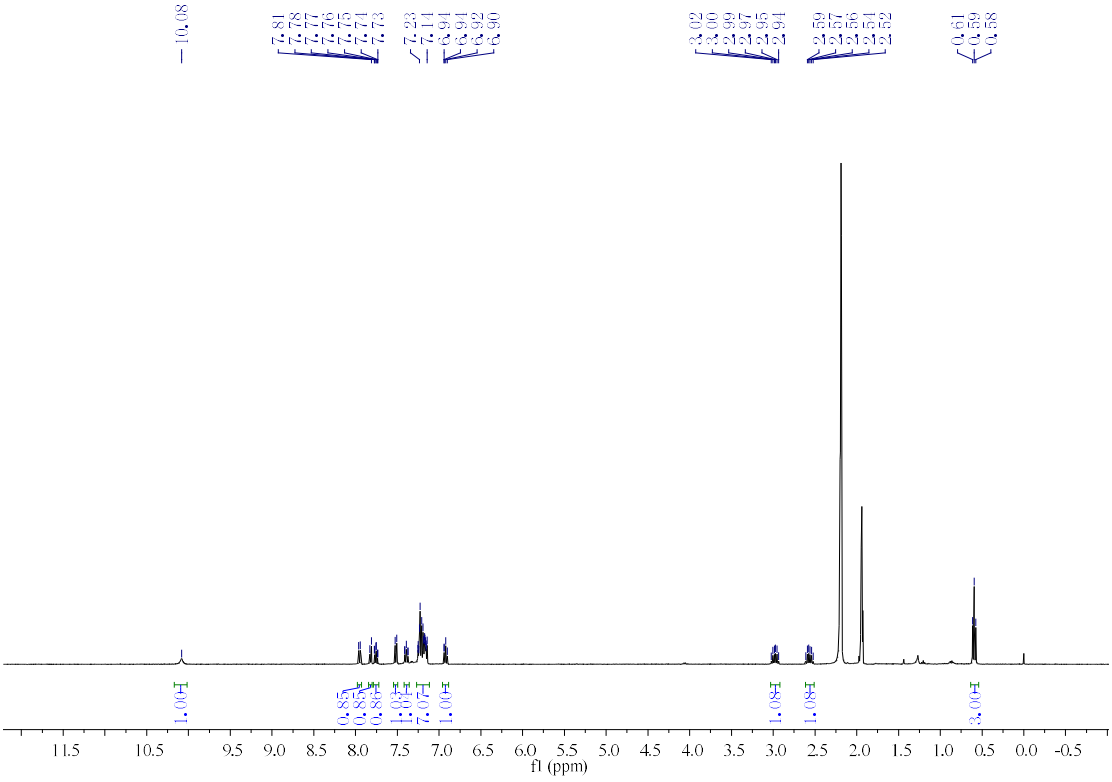
4.2 KIE Experiments

Two independent reactions with **1a** or deuterated substrate **1a-*d*$_5$** were performed under the standard conditions. Suspensions of **1a** (0.1 mmol) or **1a-*d*$_5$** (0.1 mmol), $[RhCp^*(MeCN)_3]_2(SbF_6)_2$ (8 mol%), ketene **2a** (0.2 mmol), Ag_2CO_3 (0.2 mmol), AgOAc (0.04 mmol), NaOAc (0.2 mmol), and cyclohexane (2 mL) were stirred side-by-side in an oil bath at 80 °C for 40 min under nitrogen. Both reactions were quenched and the two reactions mixtures were rapidly combined, and the volatiles were removed under reduced pressure. The residue was purified by silica gel chromatography. KIE value (k_H/k_D = 6.0) was determined on the basis of ^{1}H NMR analysis.



1a (0.1 mmol)

1a-d_5 (0.1 mmol)



5. Crystal Structure of 3aa

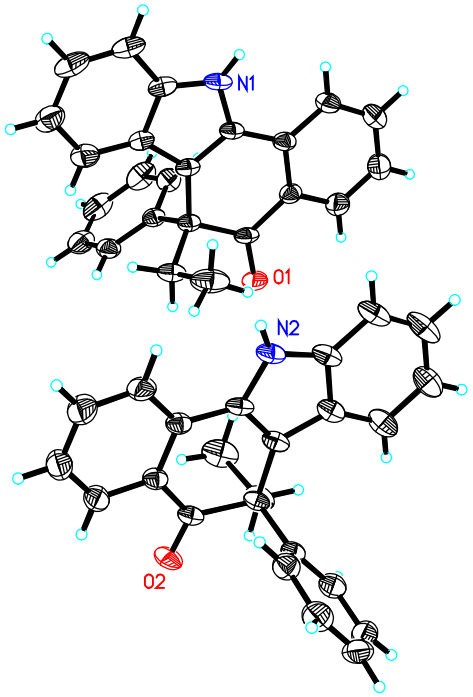


Table S3. Crystal data and structure refinement for cd17084.

Identification code	cd17084	
Empirical formula	C24 H19 N O	
Formula weight	337.40	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	Pna21	
Unit cell dimensions	a = 15.9550(15) Å	α= 90°.
	b = 8.8361(9) Å	β= 90°.
	c = 25.229(2) Å	γ = 90°.
Volume	3556.8(6) $Å^3$	
Z	8	
Density (calculated)	1.260 Mg/m^3	
Absorption coefficient	0.076 mm^{-1}	

F(000)	1424
Crystal size	0.200 x 0.170 x 0.140 mm^3
Theta range for data collection	2.442 to 25.498°.
Index ranges	-19<=h<=19, -8<=k<=10, -30<=l<=30
Reflections collected	19259
Independent reflections	6605 [R(int) = 0.0373]
Completeness to theta = 25.242°	100.0 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7456 and 0.6554
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	6605 / 3 / 480
Goodness-of-fit on F^2	1.016
Final R indices [I>2sigma(I)]	R1 = 0.0431, wR2 = 0.0989
R indices (all data)	R1 = 0.0622, wR2 = 0.1083
Absolute structure parameter	0.2(10)
Largest diff. peak and hole	0.135 and -0.120 $e.Å^{-3}$

6. References

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4. (a) Douglas, J.; Taylor, J. E.; Churchill, G.; Slawin, A. M.; Smith, A. D. *J. Org. Chem*. **2013**, *78*, 3925. (b) Lv, H.; Zhang, Y. R.; Huang, X. L.; Ye, S. *Adv. Synth. Catal.* **2008**, *350*, 2715.

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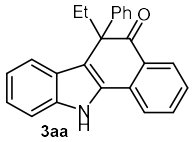
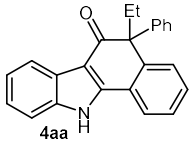
7. Characterization Data



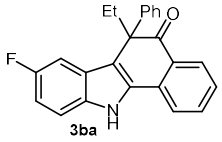
3aa

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 70% (47.2 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (s, 1H), 8.06 (d, J = 7.8 Hz, 1H), 7.63 – 7.56 (m, 2H), 7.43 (d, J = 8.0 Hz, 1H), 7.33 – 7.31 (m, 3H), 7.22 – 7.13 (m, 5H), 6.99 – 6.96 (m, 1H), 3.09 (dq, J = 14.3, 7.2 Hz, 1H), 2.56 (dq, J = 14.8, 7.4 Hz, 1H), 0.66 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 202.0, 142.5, 137.9, 134.6, 132.4, 130.5, 129.2, 128.7, 128.6, 127.6, 127.6, 127.1, 126.9, 123.6, 120.8, 120. 5, 120.4, 117.8, 111.7, 58.5, 32.4, 10.1. HRMS: $[M + H]^+$ calculated for $C_{24}H_{20}NO^+$: 338.1539, found: 338.1547.



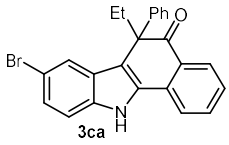
4aa

Purified by column chromatography using ethyl acetate/petroleum ether, Gray solid, 45% (30. 3 mg). ^{1}H NMR {400 MHz, $(CD_3)_2SO$)} δ 12.7 (s, 1H), 8.19 (d, J = 6.7 Hz, 1H), 8.03 (d, J = 8.7 Hz, 1H), 7.58 (d, J = 9.8 Hz, 1H), 7.50 – 7.4 (m, 1H), 7.43 – 7.40 (m, 1H), 7.34 – 7.30 (m, 1H), 7.23 – 7.10 (m, 7H), 2.91 – 2.86 (m, 1H), 2.37 – 2.32 (m, 1H), 0.48 (bs, 3H). ^{13}C NMR {400 MHz, $(CD_3)_2SO$)} δ 193.3, 146.1, 145.5, 145.0, 137.7, 129.8, 129.4, 128.3, 127.1, 127.0, 126.4, 125.5, 124.6, 124.1, 122.6, 122.6, 120.9, 112.2, 110.4, 60.2, 31.4, 8.8. HRMS: $[M + H]^+$ calculated for $C_{24}H_{20}NO^+$: 338.1539, found: 338.1545.



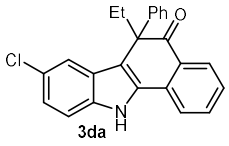
3ba

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 69% (49.0 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.18 (s, 1H), 7.96 (d, J = 7.8 Hz, 1H), 7.82 (d, J = 7.6 Hz, 1H), 7.77 – 7.73 (m, 1H), 7.49 (dd, J = 8.8, 4.5 Hz, 1H), 7.43 – 7.39 (m, 1H), 7.26 – 7.14 (m, 5H), 6.98 – 6.93 (m, 1H), 6.80 (dd, J = 10.0, 2.0 Hz, 1H), 2.94 (dq, J = 14.5, 7.2 Hz, 1H), 2.56 – 2.47 (m, 1H), 0.60 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 202.0, 158.4 (d, J = 233.3 Hz), 143.8, 136.0, 135.7, 133.5, 133.1, 129.4, 129.4, 129.1, 128.9, 128.1, 128.0, 127.3 (d, J = 10.1 Hz), 122.4, 117.6 (d, J = 8.1 Hz), 113.9 (d, J = 9.8 Hz), 112.2 (d, J = 26.4 Hz), 105.3 (d, J = 24.2 Hz), 58.6, 31.7, 9.9. HRMS: $[M + H]^+$ calculated for $C_{24}H_{19}FNO^+$: 356.1445, found: 356.1451.



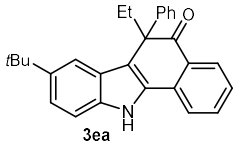
3ca

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 52% (43.3 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.06 (d, J = 7.8 Hz, 1H), 7.67 – 7.63 (m, 1H), 7.58 (d, J = 7.7 Hz, 1H), 7.42 – 7.15 (m, 9H), 3.09 (dq, J = 13.7, 6.9 Hz, 1H), 2.49 (dq, J = 14.7, 7.4 Hz, 1H), 0.65 (t, J = 7.3 Hz, 3H). ^{13}C NMR {101 MHz, $(CD_3)_2SO$} δ 200.4, 142.4, 136.7, 135.2, 132.0, 128.5, 128.2, 128.0, 127.9, 127.5, 127.0, 126.9, 125.3, 124.4, 122.2, 121.4, 115.1, 114.1, 112.1, 57.4, 30.6, 9.7. HRMS: $[M + H]^+$ calculated for $C_{24}H_{19}BrNO^+$: 416.0645, 416.0638.



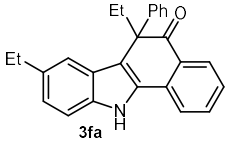
3da

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 67% (49.7 mg). ^{1}H NMR{400 MHz, $(CD_3)_2SO$} δ 12.21 (s, 1H), 8.07 (d, J = 7.8 Hz, 1H), 7.91 (d, J = 7.7 Hz, 1H), 7.85 – 7.81 (m, 1H), 7.53 (d, J = 8.6 Hz, 1H), 7.47 – 7.43 (m, 1H), 7.26 – 7.22 (m, 2H), 7.20 – 7.15 (m, 4H), 7.08 (d, J = 1.7 Hz, 1H), 2.91 (dq, J = 13.9, 7.0 Hz, 1H), 2.51 – 2.44(m, 1H), 0.54 (t, J = 7.2 Hz, 3H). ^{13}C NMR {101 MHz, $(CD_3)_2SO$} δ 200.5, 142.5, 136.5, 135.3, 132.2, 132.1, 128.6, 128.2, 128.1, 127.9, 127. 0, 127.0, 126.8, 124.1, 122.8, 122.2, 118.4, 115.3, 113.7, 57.4, 30.6, 9.7. HRMS: $[M + H]^+$ calculated for $C_{24}H_{19}ClNO^+$:372.1150, found: 372.1147.



3ea

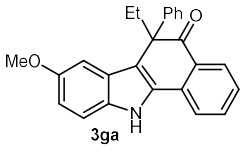
Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 50% (39.3 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.53 (s, 1H), 8.05 (d, J = 8.5 Hz, 1H), 7.65 – 7.61 (m, 1H), 7.55 (d, J = 7.7 Hz, 1H), 7.39 – 7.25 (m, 5H), 7.23 – 7.13 (m, 4H), 3.15 – 2.92 (m, 1H), 2.60 – 2.51 (m, 1H), 1.23 (s, 9H), 0.69 (t, J = 6.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 202.3, 143.2, 142.7, 136.1, 134.6, 132.6, 13054, 129.1, 128.8, 128.5, 127.7, 127.4, 127.0, 126.8, 121.9, 120.3, 118.0, 116.6, 111.0, 58.5, 34.6, 32.4, 31.8, 10.0. HRMS: $[M + H]^+$ calculated for $C_{28}H_{28}NO^+$:394.2165, found: 394.2167.



3fa

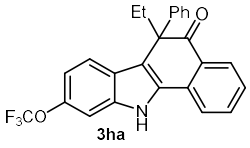
Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 50% (36.5 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.56 (s, 1H), 7.97 (d, J = 7.8 Hz, 1H), 7.55

– 7.47 (m, 2H), 7.30 – 7.21 (m, 4H), 7.14 – 7.06 (m, 3H), 7.01 – 6.98 (d, J = 8.4 Hz, 1H), 6.93 (s, 1H), 3.01 (dq, J = 14.3, 7.2 Hz, 1H), 2.55 – 2.44 (m, 3H), 1.09 (t, J = 7.6 Hz, 3H), 0.60 (t, J = 7.3 Hz, 3H).^{13}C NMR (101 MHz, $CDCl_3$) δ 202.0, 142.5, 136.5, 136.4, 134.6, 132.5, 130.6, 129.2, 128.7, 128.5, 127.6, 127.4, 127.2, 127.0, 124.2, 120.3, 119.3, 117.4, 111.5, 58.6, 32.3, 29.1, 16.4, 10.1. HRMS: $[M + H]^+$ calculated for $C_{26}H_{24}NO^+$:366.1852, found: 366.1860.



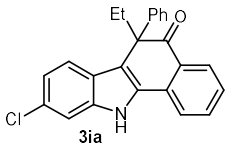
3ga

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 54% (42.4 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 9.96 (s, 1H), 7.94 (dd, J = 7.8, 0.8 Hz, 1H), 7.81 – 7.77 (m, 1H), 7.76 – 7.71 (m, 1H), 7.42 – 7.36 (m, 2H), 7.27 – 7.15 (m, 5H), 6.83 (dd, J = 8.9, 2.5 Hz, 1H), 6.56 (d, J = 2.4 Hz, 1H), 3.62 (s, 3H), 2.93 (dq, J = 13.3, 7.2 Hz, 1H), 2.58 (dq, J = 13.0, 7.4 Hz, 1H), 0.61 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, CD_2Cl_2) δ 201.9, 154.7, 143.2, 135.0, 133.5, 132.7, 131.6, 129.1, 129.0, 128.8, 127.8, 127.8, 127.6, 127.3, 120.8, 117.6, 113.5, 112.7, 102.7, 58.5, 56.0, 31.9, 10.0. HRMS: $[M + H]^+$ calculated for $C_{25}H_{22}NO_2^+$:394.1645, found: 394.1646.



3ha

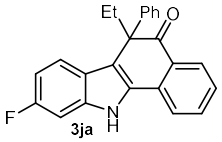
Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 38% (32.0 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.30 (s, 1H), 7.98 (d, J = 7.8 Hz, 1H), 7.84 (d, J = 7.7 Hz, 1H), 7.79 –7.75 (m, 1H), 7.56 (d, J = 8.8 Hz, 1H), 7.45 – 7.41 (m, 1H), 7.25 – 7.17 (m, 5H), 7.10 (d, J = 8.8 Hz, 1H), 7.00 (s, 1H), 2.95 (dq, J = 14.4, 7.2 Hz, 1H), 2.50 (dq, J = 14.8, 7.4 Hz, 1H), 0.60 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 202.0, 143.8, 143.6, 143.5, 137.5, 136.0, 133.9, 132.9, 129.5, 129.4, 129.2, 128.2, 128.0, 127.2, 122.7, 121.6, (q, J = 260.3 Hz), 117.9, 117.7, 113.9, 113.0, 58.7, 31.9, 9.9. HRMS: $[M + H]^+$ calculated for $C_{25}H_{19}F_3NO_2^+$: 422. 1362, found: 422.1363.



3ia

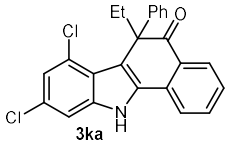
Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 60% (44.5 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.19 (s, 1H), 7.95 (d, J = 6.6 Hz, 1H), 7.80 (d, J = 9.5 Hz, 1H), 7.76 – 7.68 (m, 1H), 7.53 (s, 1H), 7.45 – 7.34 (m, 1H), 7.26 – 7.13 (m, 5H), 7.07 (d, J = 9.8 Hz, 1H), 6.89 (d, J = 9.9 Hz, 1H), 3.00 – 2.91 (m, 1H), 2.51 – 2.46 (m, 1H), 0.56 (t, J =

6.4 Hz, 3H). ^{13}C NMR {101 MHz, $(CD_3)_2SO$} δ 200.5, 142.5, 138.4, 135.2, 132.1, 131.6, 128.4, 128.0, 127.9, 127.8, 127.4, 126.9, 126.9, 124.6, 122.0, 120.9, 120.0, 115.8, 111.6, 57.4, 30.7, 9.6. HRMS: [M + H]$^+$ calculated for $C_{24}H_{19}ClNO^+$:372.1150, found: 372.1147.



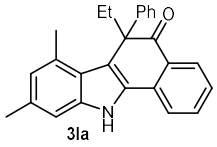
3ja

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 68% (48.2 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 (s, 1H), 8.05 (d, J = 7.7 Hz, 1H), 7.66 – 7.62 (m, 1H), 7.56 (d, J = 7.6 Hz, 1H), 7.35 – 7.08 (m, 8H), 6.77 – 6.72 (m, 1H), 3.12 – 3.04 (m, 1H), 2.54 – 2.45 (m, 1H), 0.66 (t, J = 7.1 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 202.1, 161.3 (d, J = 237.7 Hz), 144.1, 139.4 (d, J = 12.6 Hz), 136.0, 133.4, 132.4 (d, J = 3.4 Hz), 129.4, 129. 2, 129.1, 128.6, 128.1, 127.9, 123.9, 122.3, 121.9 (d, J = 10.3 Hz), 117.9, 109.3 (d, J = 24.7 Hz), 99.0 (d, J = 26.1 Hz), 58.7, 32.0, 9.9. HRMS: [M + H]$^+$ calculated for $C_{24}H_{19}FNO^+$:356.1445, found: 356.1447.



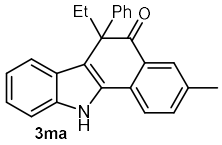
3ka

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 43% (34.8 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.55 (s, 1H), 7.97 (d, J = 7.7 Hz, 1H), 7.87 (d, J = 7.4 Hz, 1H), 7.82 – 7.78 (m, 1H), 7.53 (s, 1H), 7.48 – 7.44 (m, 1H), 7.25 – 7.18 (m, 5H), 7.01 (bs, 1H), 3.06 (dq, J = 14.0, 7.3 Hz, 1H), 2.87 (dq, J = 14.0, 7.1 Hz, 1H), 0.51 (t, J = 7.1 Hz, 1H). ^{13}C NMR {101 MHz, $(CD_3)_2SO$} δ 199.8, 143.5, 140.1, 135.5, 133.1, 131.7, 128.6, 128.2, 128.0, 127.3, 127.3, 127.2, 126.6, 125.1, 122.5, 122.3, 121.0, 115.4, 110.7, 57.6, 33.0, 9.2. HRMS: [M + H]$^+$ calculated for $C_{24}H_{18}Cl_2NO^+$:406.0760, found: 406.0760.



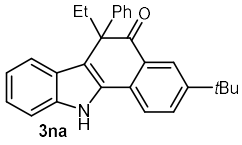
3la

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 45% (32.9 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 9.99 (s, 1H), 7.91 (d, J = 7.7 Hz, 1H), 7.82 (d, J = 7.7 Hz, 1H), 7.75 – 7.71 (m, 1H), 7.34 – 7.17 (m, 7H), 6.56 (s, 1H), 3.11 – 3.02 (m, 1H), 2.45 – 2.42 (m, 1H), 2.34 (s, 3H), 1.78 (s, 3H), 0.49 (t, J = 7.0 Hz, 3H).^{13}C NMR (101 MHz, CD_3CN) δ 202.1, 145.3, 140.8, 136.1, 134.3, 134.1, 131.1, 131.0, 129.3, 128.9, 128.6, 128.1, 127.8, 125.3, 124. 5, 122.3, 110.4, 59.3, 34.5, 22.4, 21.3, 9.5. (two signals are missing due to overlap). HRMS: [M + H]$^+$ calculated for $C_{26}H_{24}NO^+$: 366.1852, found: 366.1854.



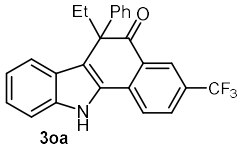
3ma

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 54% (37.9 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.60 (s, 1H), 7.87 (s, 1H), 7.50 – 7.44 (m, 3H), 7.30 (d, J = 7.8 Hz, 2H), 7.22 – 7.13 (m, 5H), 7.00 – 6.96 (m, 1H), 3.08 (dq, J = 14.3, 7.1 Hz, 1H), 2.54 (dq, J = 14.7, 7.3 Hz, 1H), 2.38 (s, 3H), 0.65 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 202.0, 142.6, 137.7, 135.4, 130.8, 129.8, 129.5, 128.7, 128.5, 127.6, 127.1, 127.0, 123.3, 120.6, 120.4, 120.4, 120.3, 117.0, 111.6, 58.5, 32.2, 21.4, 10.0. HRMS: $[M + H]^+$ calculated for $C_{25}H_{22}NO^+$:352.1696, found: 352.1699.



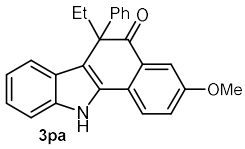
3na

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 46% (36.2 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.62 (s, 1H), 8.10 (s, 1H), 7.69 – 7.66 (m, 1H), 7.53 (d, J = 8.1 Hz, 1H), 7.44 (d, J = 8.1 Hz, 1H), 7.34 – 7.32 (m, 2H), 7.22 – 7.15 (m, 5H), 6.99 – 6.69 (t = 1H), 3.15 – 3.06 (m, 1H), 2.55 (dq, J = 14.8, 7.4 Hz, 1H), 1.32 (s, 9H), 0.66 (t, J = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 202.2, 151.0, 142.7, 137.8, 132.0, 130.8, 129.8, 128.5, 128.4, 127.7, 127.0, 127.0, 125.9, 123.3, 120.7, 120.4, 120.3, 117.2, 111.6, 58.5, 35.1, 32.5, 31.2, 10.1. HRMS: [M + H]+ calculated for $C_{28}H_{28}NO^+$:394.2167, found: 394.2168.



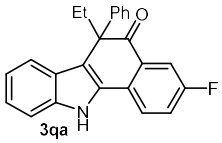
3oa

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 60% (48.6 mg). ^{1}H NMR (400 MHz, $(CD_3)_2SO$) δ 10.78 (s, 1H), 8.79 (s, 1H), 8.60 – 8.54 (m, 1H), 8.13 (d, J = 8.2 Hz, 1H), 7.95 – 7.72 (m, 7H), 7.54 – 7.50 (m, 1H), 3.58 (dq, J = 14.3, 7.2 Hz, 1H), 3.17 (dq, J = 14.7, 7.4 Hz, 1H), 1.18 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 201.5, 143.7, 139.7, 136.8, 132.22 (q, J = 3.7 Hz), 130.4, 129.9, 129.5, 129.4 (d, J = 32.9 Hz), 129.3, 128.2, 128.1, 126.9, 126.2 (q, 3.9 Hz), 125.1, 125.0 (q, J = 271.3 Hz) 123.4, 121.2 (d, J = 2.6 Hz), 119.9, 113.2, 59.2, 32.2, 10.0. HRMS: [M + H]+ calculated for $C_{25}H_{19}F_3NO^+$:406.1413, found: 406.1417.



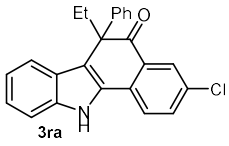
3pa

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 35% (25.7 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 9.99 (s, 1H), 7.77 (d, J = 8.6 Hz, 1H), 7.53 – 7.45 (m, 2H), 7.33 (dd, J = 8.6, 2.8 Hz, 1H), 7.25 – 7.11 (m, 7H), 6.92 – 6.88 (m, 1H), 3.85 (s, 3H), 2.97 (dq, J = 14.4, 7.2 Hz, 1H), 2.64 – 2.46 (m, 1H), 0.58 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 201.9, 159.3, 142.6, 137.7, 130.8, 130.2, 128.6, 127.6, 127.1, 127.1, 125.8, 123.0, 122.5, 122.0, 120.4, 120.4, 115.9, 111.7, 111.5, 58.5, 55.7, 32.4, 10.0. HRMS: $[M + H]^+$ calculated for $C_{25}H_{22}NO_2^+$:368.1645, found: 368.1648.



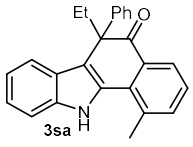
3qa

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 61% (43.3 mg). ^{1}H NMR {400 MHz, $(CD_3)_2SO$} δ 10.63 (s, 1H), 8.43 (dd, J = 8.6, 5.0 Hz, 1H), 8.24 (dd, J = 9.3, 2.7 Hz, 1H), 8.11 – 8.06 (m, 2H), 7.84 – 7.71 (m, 7H), 7.52 – 7.48 (m 1H), 3.56 (dq, J = 14.4, 7.2 Hz, 1H), 3.15 (dq, J = 14.5, 7.4 Hz, 1H), 1.17 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN). δ 201.6, 162.8 (d, J = 246.5 Hz), 143.8, 139.1, 131.2, 131.2, 131.0, 130.3 (d, J = 2.9 Hz), 129.3, 128.1, 128.0, 127.0, 124.8 (d, J = 7.5 Hz), 123.1, 122.9 (d, J = 23.1 Hz), 120.8 (d, J = 18.2 Hz), 117.0, 115.21 (d, J = 23.0 Hz), 112.9, 58.9, 32.1, 9.9. HRMS: $[M + H]^+$ calculated for $C_{24}H_{19}FNO^+$:356.1445, found: 356.1446.



3ra

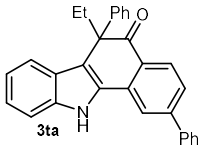
Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 63% (46.7 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 (s, 1H), 8.01 (s, 1H), 7.55 – 6.99 (m, 11H), 3.07 (bs, 1H), 2.56 (bs, 1H), 0.67 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 201.0, 142.1, 138.0, 134.5, 133.5, 130.8, 129.9, 129.7, 129.1, 128.7, 127.6, 127.3, 126.8, 123.9, 121.9, 120.8, 120.7, 118.0, 111.8, 58.7, 32.3, 10.0. HRMS: $[M + H]^+$ calculated for $C_{24}H_{19}ClNO^+$:372.1150, found: 372.1147.



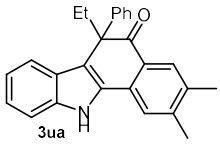
3sa

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 44% (30.9 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.18 (s, 1H), 7.96 (d, J = 7.8 Hz, 1H),

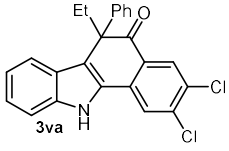
7.82 (d, J = 7.6 Hz, 1H), 7.77 – 7.73 (m, 1H), 7.49 (dd, J = 8.8, 4.5 Hz, 1H), 7.41 (t, J = 7.5 Hz, 1H), 7.23 – 7.17 (m, 5H), 6.98 – 6.93 (m, 1H), 6.80 (dd, J = 10.0, 2.0 Hz, 1H), 2.94 (dq, J = 14.3, 7.2 Hz, 1H), 2.51 (m, 2.47 – 2.56, 1H), 2.2 (s, 3H), 0.60 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 202.0, 142.7, 138.0, 137.5, 131.6, 131.2, 131.2, 130.1, 128.5, 127.9, 127.6, 127.3, 127.0, 125.9, 123.4, 120.9, 120.5, 118.0, 111.7, 58.0, 32.4, 23.0, 10.1. HRMS: $[M + H]^+$ calculated for $C_{25}H_{22}NO^+$:352.1696, found: 352.1692.



3ta Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 51% (42.1 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.73 (s, 1H), 8.12 (d, J = 8.1 Hz, 1H), 7.77 (s, 1H), 7.69 (d, J = 7.3 Hz, 2H), 7.55 – 7.44 (m, 5H), 7.33 (d, J = 7.0 Hz, 2H), 7.28 – 7.16 (m, 5H), 7.00 – 6.97 (m, 1H), 3.15 – 3.06 (m, 1H), 2.61 – 2.53 (m, 1H), 0.68 (t, J = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 201.5, 147.5, 142.6, 140.0, 138.0, 132.8, 130.5, 129.9, 129.2, 128.7, 128.6, 127.6, 127.5, 127.4, 127.1, 126.9, 126.5, 123.7, 120.9, 120.5, 119.0, 118.3, 111.7, 58.5, 32.4, 10.1. HRMS: $[M + H]^+$ calculated for $C_{30}H_{24}NO^+$:414.1852, found: 414.1853.

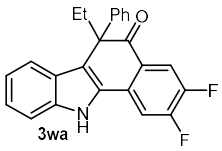


3ua Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 63% (46.0 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.61 (s, 1H), 7.83 (s, 1H), 7.43 (d, J = 8.5 Hz, 1H), 7.38 (s, 1H), 7.30 (d, J = 7.1 Hz, 2H), 7.22 – 7.10 (m, 5H), 6.98 – 6.94 (m, 1H), 3.07 (dq, J = 14.3, 7.1 Hz, 1H), 2.53 (dq, J = 14.8, 7.4 Hz, 1H), 2.38 (s, 3H), 2.29 (s, 3H), 0.64 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 201.9, 144.4, 142.8, 137.8, 136.6, 130.8, 130.3, 130.0, 128.5, 127.6, 127.0, 126.9, 126.8, 123.2, 121.7, 120.6, 120.3, 117.3, 111.6, 58.3, 32.2, 20.6, 19.8, 10.0. HRMS: $[M + H]^+$ calculated for $C_{26}H_{24}NO^+$:366.1852, found: 366.1854.

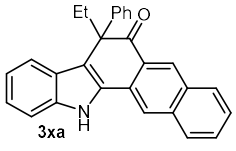


3va Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 82% (66.4 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.01 (s, 1H), 7.99 (d, J = 8.7 Hz, 2H), 7.51 (d, J = 8.2 Hz, 1H), 7.29 – 7.04 (m, 7H), 6.94 – 6.91 (m, 1H), 3.00 – 2.91 (m, 1H), 2.60 – 2.52 (m,

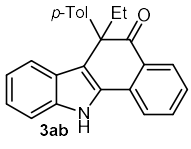
1H), 0.58 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 200.7, 143.6, 139.6, 139.4, 133.4, 131.7, 131.1, 129.7, 129.5, 128.9, 128.2, 128.1, 126.8, 124.9, 124.7, 121.2, 121.1, 119.4, 113.1, 59.1, 32.2, 9.9. HRMS: $[M + H]^+$ calculated for $C_{24}H_{18}Cl_2NO^+$: 406.0760, found: 406.0758.



3wa Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 54% (42.3 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.01 (s, 1H), 7.99 (d, J = 8.7 Hz, 2H), 7.51 (d, J = 8.2 Hz, 1H), 7.22 – 7.13 (m, 7H), 6.95 – 6.91 (t, J = 7.5 Hz, 1H), 3.00 – 2.91 (m, 1H), 2.60 – 2.52 (m, 1H), 0.58 (m, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 200.6, 155.7 (dd, J = 255.5, 13.9 Hz), 150.4 (dd, J = 248.8, 13.6 Hz), 143.7, 139.3, 132.0 (dd, J = 8.5, 3.3 Hz), 130.0, 129.5, 128.2, 128.1, 126.9, 126.7 (dd, J = 4.0, 3.5 Hz), 124.7, 121.1, 121.1, 118.6 (dd, J = 15.0, 1.9 Hz), 113.8, 111.7, 111.5, 58.8, 32.3, 9.9. HRMS: $[M + H]^+$ calculated for $C_{24}H_{18}F_2NO^+$: 374.1351, found: 374.1352.

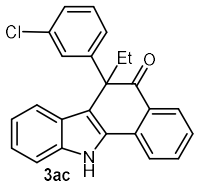


3xa Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 50% (38.6 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.20 (s, 1H), 8.57 (s, 1H), 8.24 (s, 1H), 8.05 – 7.92 (m, 2H), 7.64 (t, J = 7.5 Hz, 1H), 7.56 (d, J = 8.1 Hz, 1H), 7.50 (d, J = 7.3 Hz, 1H), 7.30 (d, J = 7.2 Hz, 2H), 7.19 (dd, J = 15.8, 7.4 Hz, 5H), 6.93 (t, J = 7.4 Hz, 1H), 3.04 (dq, J = 14.0, 7.0 Hz, 1H), 2.66 – 2.51 (m, 1H), 0.64 (t, J = 7.2 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 201.8, 144.5, 139.4, 137.3, 133.0, 132.3, 131.3, 131.1, 130.4, 129.3, 129.0, 128.7, 128.2, 128.2, 127.8, 127.6, 127.2, 124.2, 120.9, 120.8, 120.5, 117.1, 112.8, 58.7, 31.6, 10.1. HRMS: $[M + H]^+$ calculated for $C_{28}H_{22}NO^+$: 388.1696, found: 388.1704.



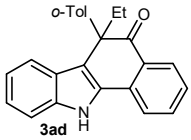
3ab Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 50% (35.3 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.01 (s, 1H), 8.06 (d, J = 7.9 Hz, 1H), 7.57 – 7.53 (m, 2H), 7.39 (d, J = 8.2 Hz, 1H), 7.31 – 7.26 (m, 1H), 7.24 – 7.16 (m, 4H), 6.99 – 6.95 (m, 3H), 3.08 (dq, J = 14.3, 7.2 Hz, 1H), 2.55 (dq, J = 14.8, 7.4 Hz, 1H), 2.19 (s, 3H), 0.67 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 202.5, 139.5, 138.0, 136.7, 134.6, 132.6, 130.5, 129.3, 129.1, 128.7, 127.5, 127.4, 126.9, 123.5, 120.7, 120.6, 120.3, 117.8, 111.8, 58.2, 32.3, 21.0, 10.0. HRMS: $[M + H]^+$ calculated

for $C_{25}H_{22}NO^+$: 352.1696, found: 352.1701.



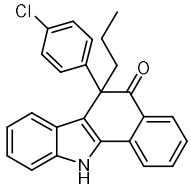
3ac

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 44% (32.5 mg). ^{1}H NMR (400 MHz, CD_3CN) δ 10.13 (s, 1H), 7.97 (d, J = 7.5 Hz, 1H), 7.84 – 7.82 (d, J = 7.6 Hz, 1H), 7.78 – 7.74 m, 1H), 7.53 (d, J = 8.2 Hz, 1H), 7.42 – 7.38 (m, 1H), 7.25 – 7.12 (m, 6H), 6.96 – 6.92 (m, 1H), 3.04 – 2.85 (m, 1H), 2.58 – 2.49 (td, J = 14.1, 8.0 Hz, 1H), 0.57 (t, J = 7.0 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 201.8, 146.6, 139.2, 136.2, 134.7, 134.5, 133.5, 131.8, 130.9, 129.2, 129.1, 128.7, 128.2, 127.9, 126.9, 124.3, 122.5, 121.0, 120.6, 116.8, 113.0, 58.6, 32.3, 9.9. HRMS: $[M + H]^+$ calculated for $C_{24}H_{19}ClNO^+$:372.1150, found: 372.1147.



3ad

Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 38% (26.5 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.69 (s, 1H), 8.20 (d, J = 7.7 Hz, 1H), 7.94 (d, J = 7.8 Hz, 1H), 7.69 – 7.66 (m, 1H), 7.61 (d, J = 7.5 Hz, 1H), 7.42 – 7.35 (m, 3H), 7.20 – 7.16 (m, 1H), 7.20 – 7.10 (m, 1H), 6.98 (d, J = 7.2 Hz, 1H), 6.85 – 6.79 (m, 2H), 2.58 (qd, J = 12.4, 7.2 Hz, 2H), 1.60 (s, 3H), 0.67 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, CD_3CN) δ 203.6, 144.2, 139.0, 137.9, 135.7, 133.4, 132.3, 131.1, 130.9, 128.5, 128.4, 128.2, 127.9, 126.5, 126.5, 124.0, 122.6, 120.4, 120.0, 117.9, 112.7, 57.7, 35.1, 20.2, 8.8. HRMS: $[M + H]^+$ calculated for $C_{25}H_{22}NO^+$:352.1696, found: 352.1697.

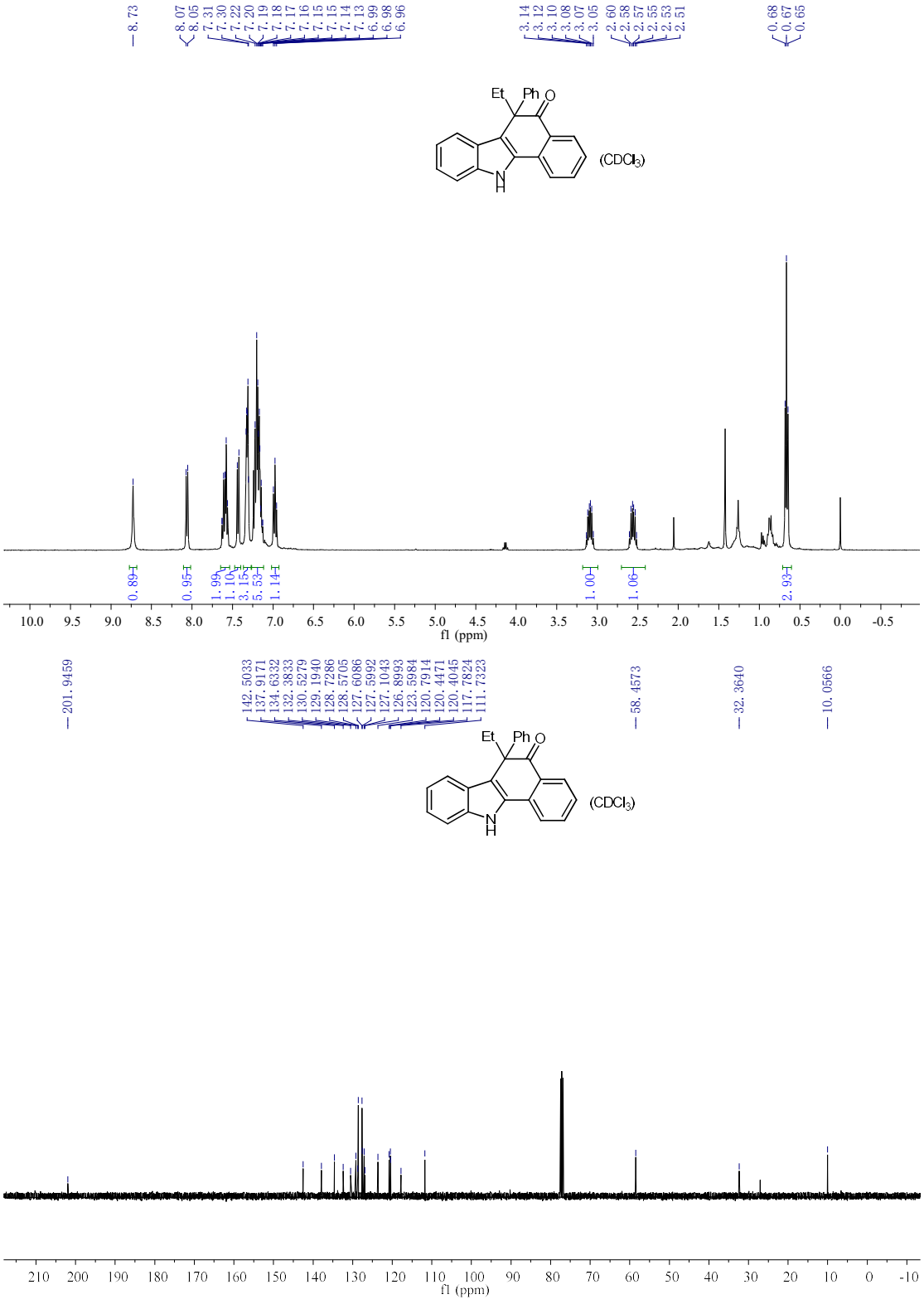


3ae

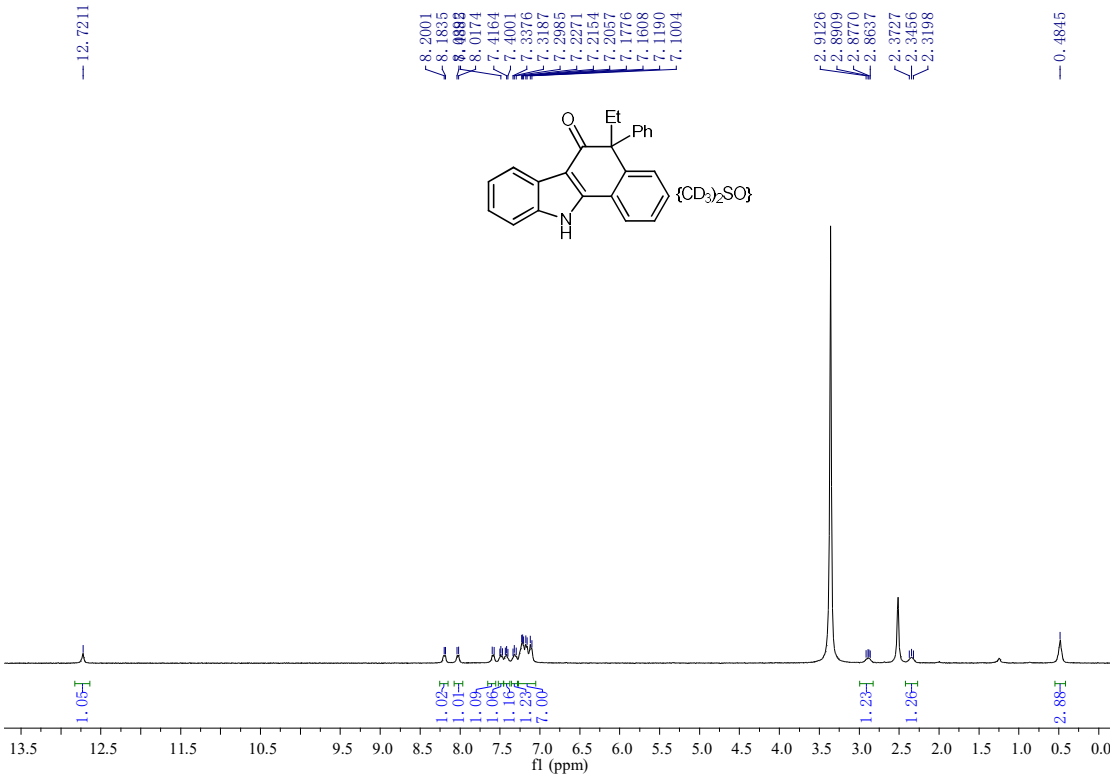
Purified by column chromatography using ethyl acetate/petroleum ether, Yellow solid, 61% (47.1 mg). ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.88 (s, 1H), 8.07 (d, J = 7.1 Hz, 1H), 7.62 – 7.57 (m, 2H), 7.41 (d, J = 8.2 Hz, 1H), 7.34 – 7.30 (m, 1H), 7.27 – 7.14 (m, 6H), 7.00 – 6.97 (m, 1H), 2.98 – 2.91 (m, 1H), 2.51 – 2.44 (m,1H), 1.03 – 0.98 (m, 2H), 0.76 (t, J = 7.3 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 201.9, 141.2, 137.9, 134.9, 133.0, 132.4, 130.2, 129.2, 129.1, 128.7, 127.7, 126.7, 123.7, 120.6, 120.5, 117.6, 111.8, 57.4, 42.0, 18.8, 14.6. (one signal is missing due to overlap). HRMS: $[M + H]^+$ calculated for $C_{25}H_{21}ClNO^+$:386.1306, found: 386.1304.

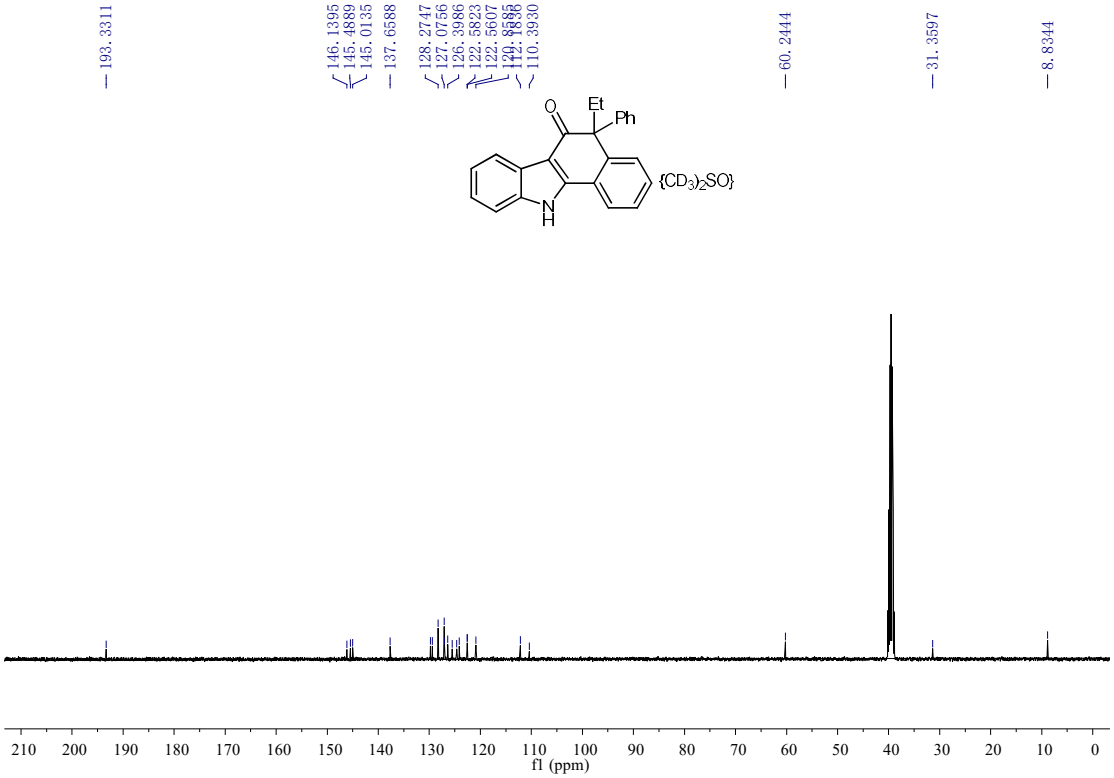
8. NMR Spectra of Coupled Products

^{1}H and ^{13}C NMR Spectra of compound **3aa**

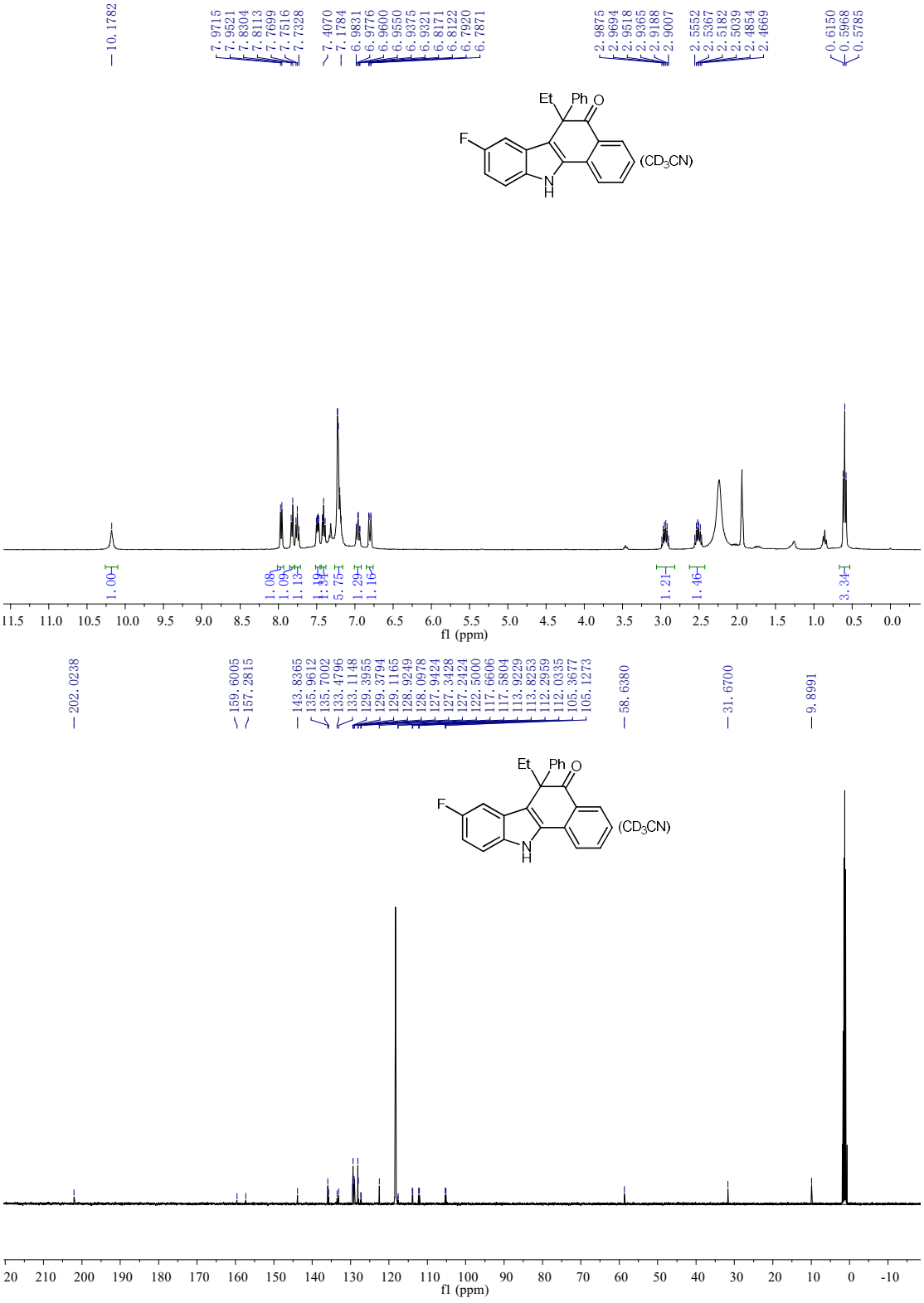


^{1}H and ^{13}C NMR Spectra of compound **4aa**

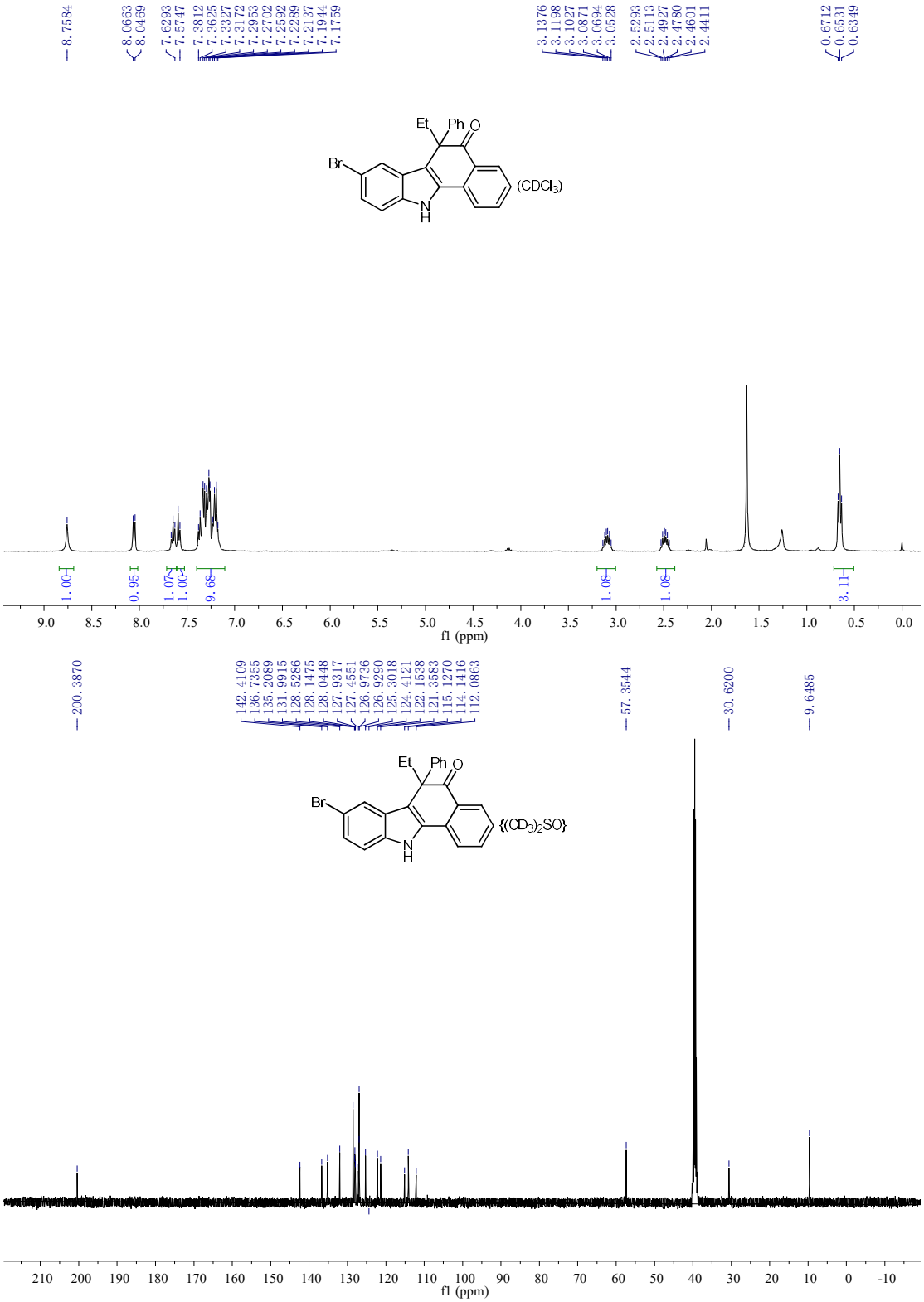




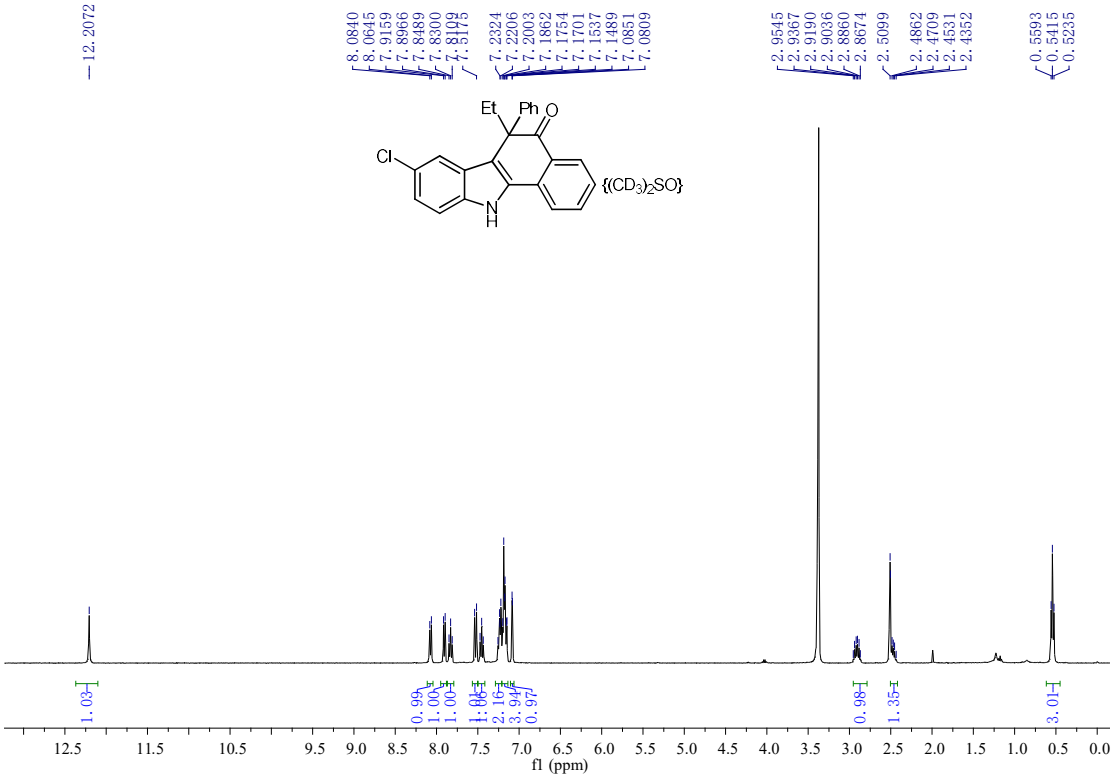
^{1}H and ^{13}C NMR Spectra of compound **3ba**

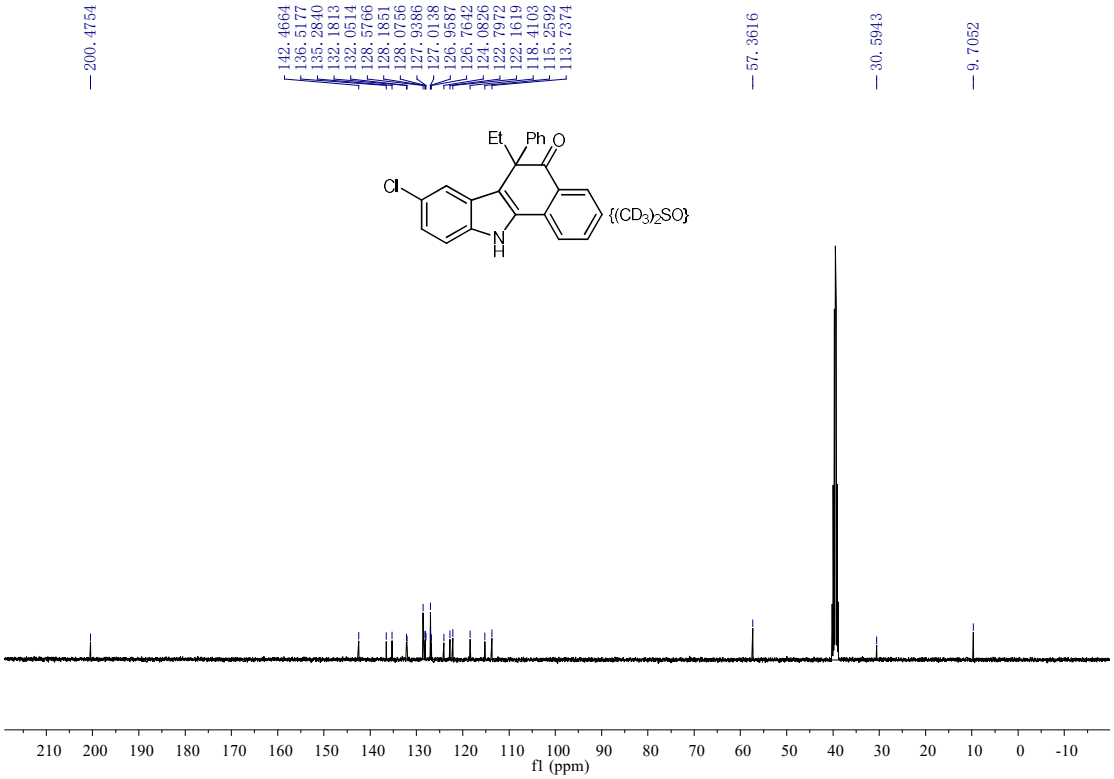


^{1}H and ^{13}C NMR Spectra of compound **3ca**

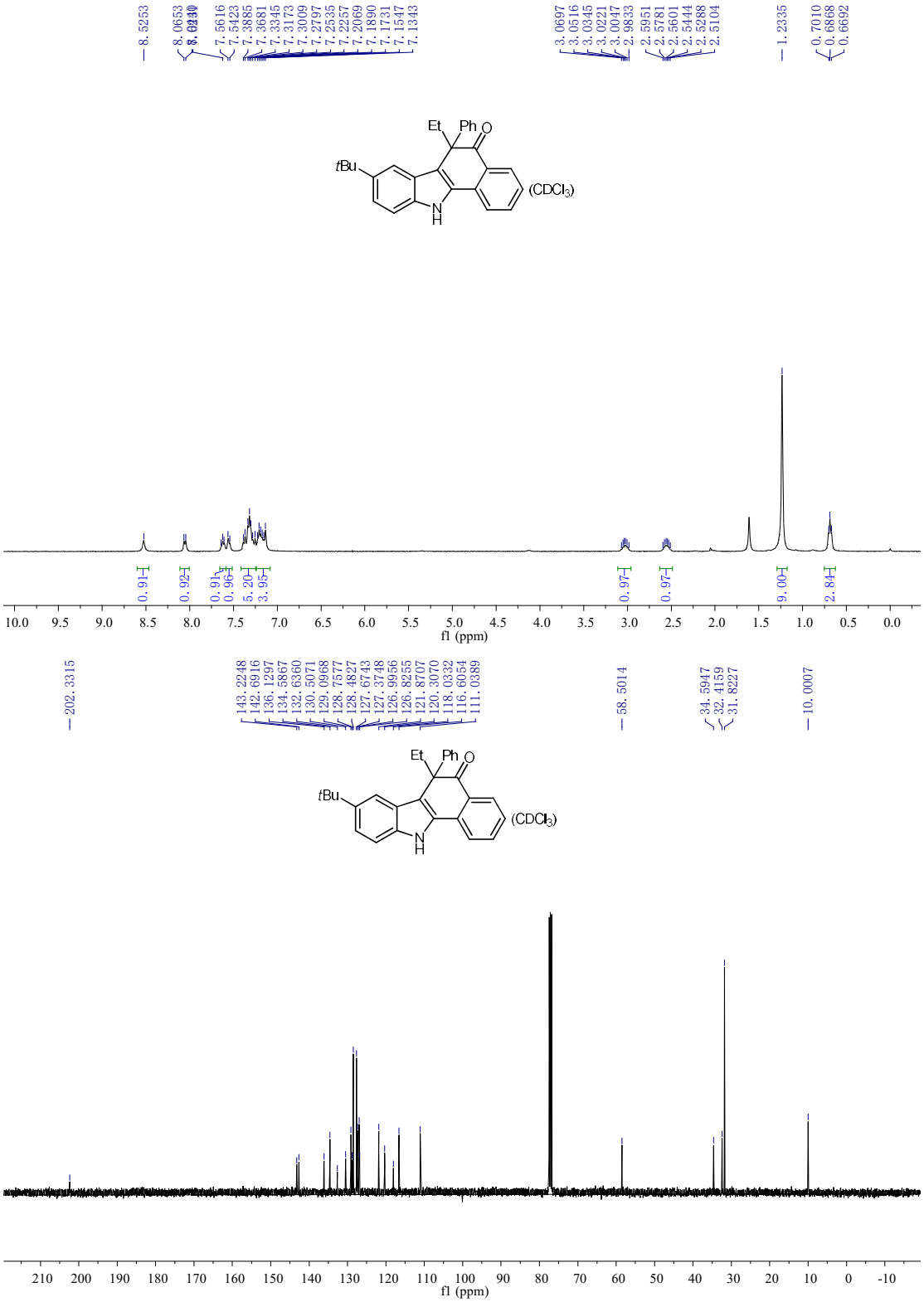


^{1}H and ^{13}C NMR Spectra of compound **3da**

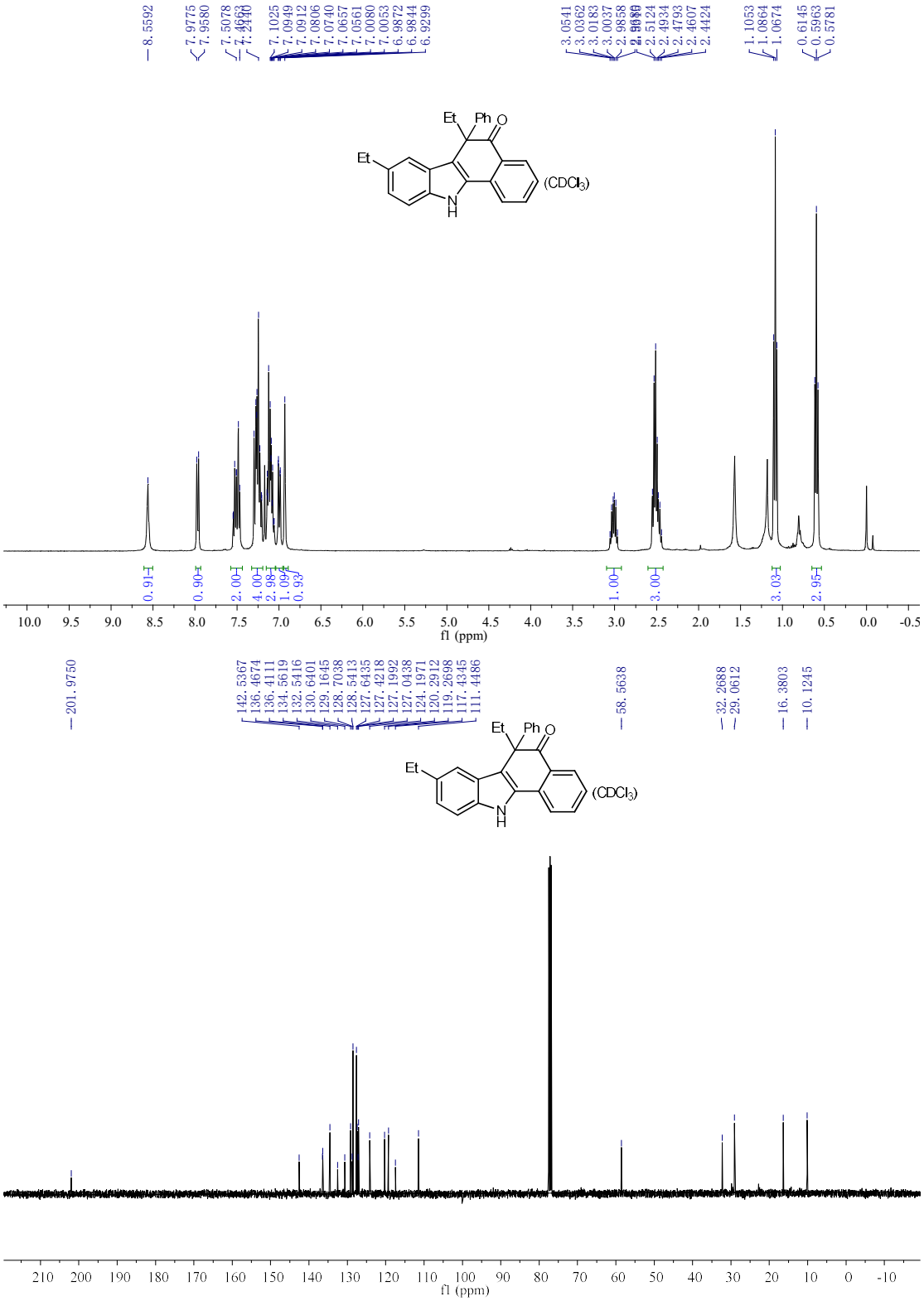




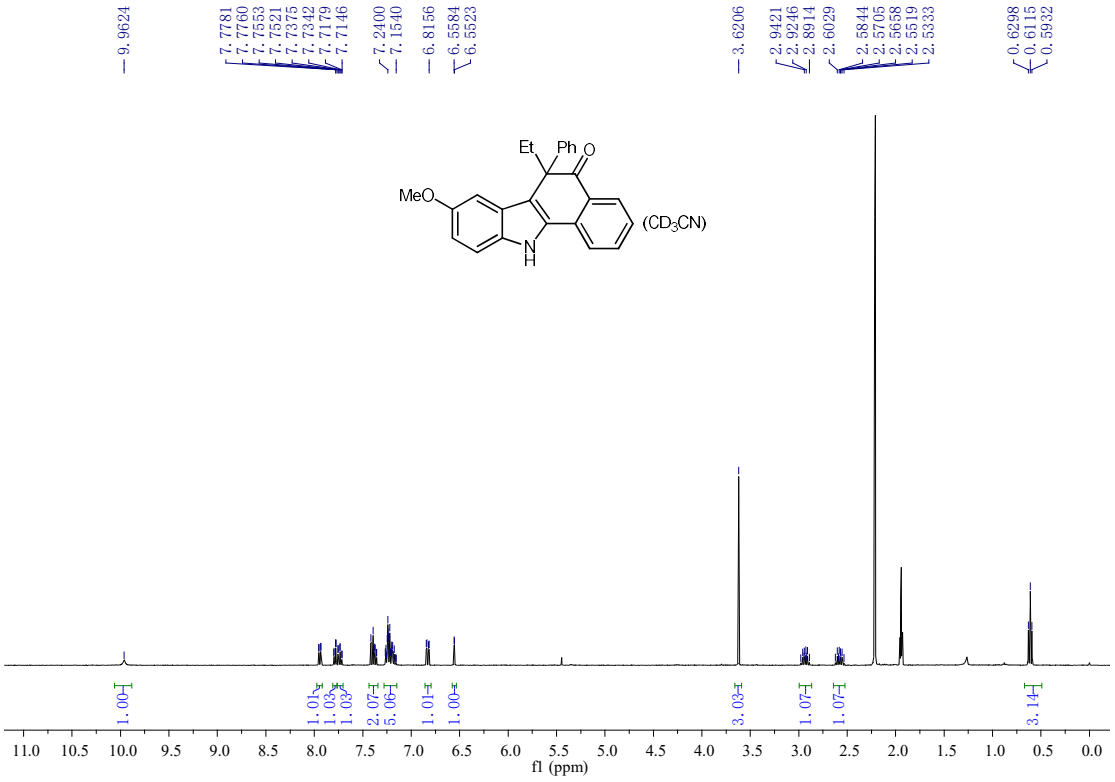
^{1}H and ^{13}C NMR Spectra of compound **3ea**

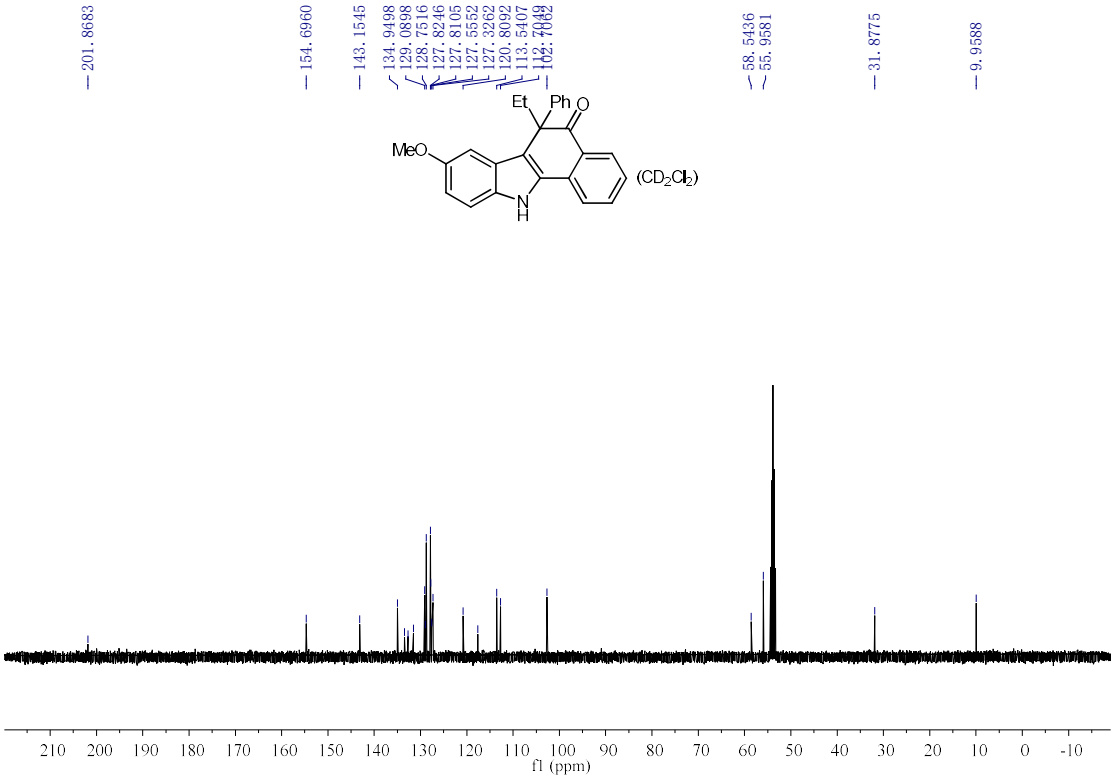


^{1}H and ^{13}C NMR Spectra of compound **3fa**

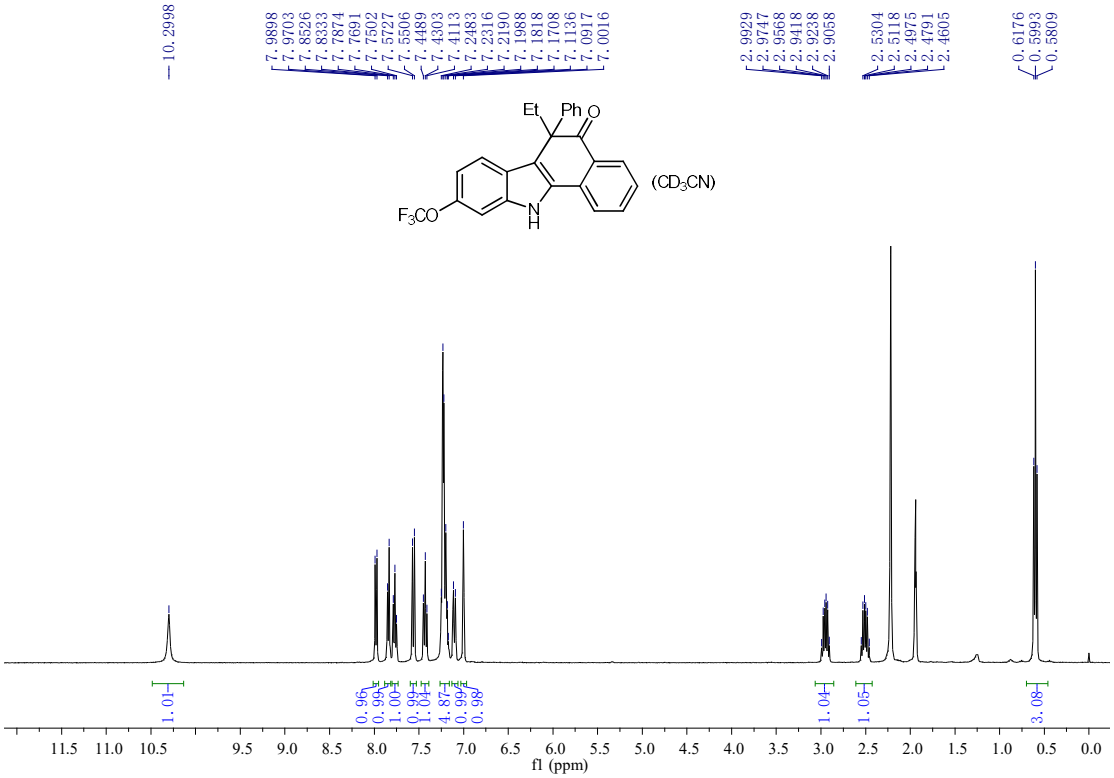


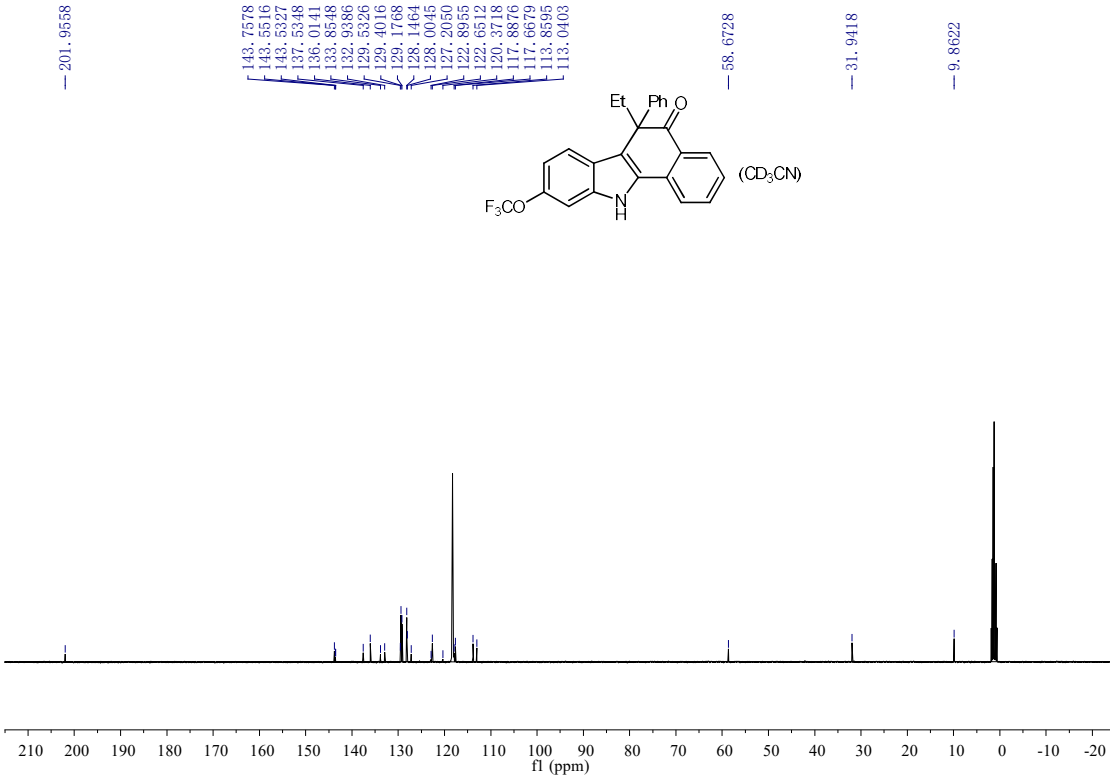
^{1}H and ^{13}C NMR Spectra of compound **3ga**



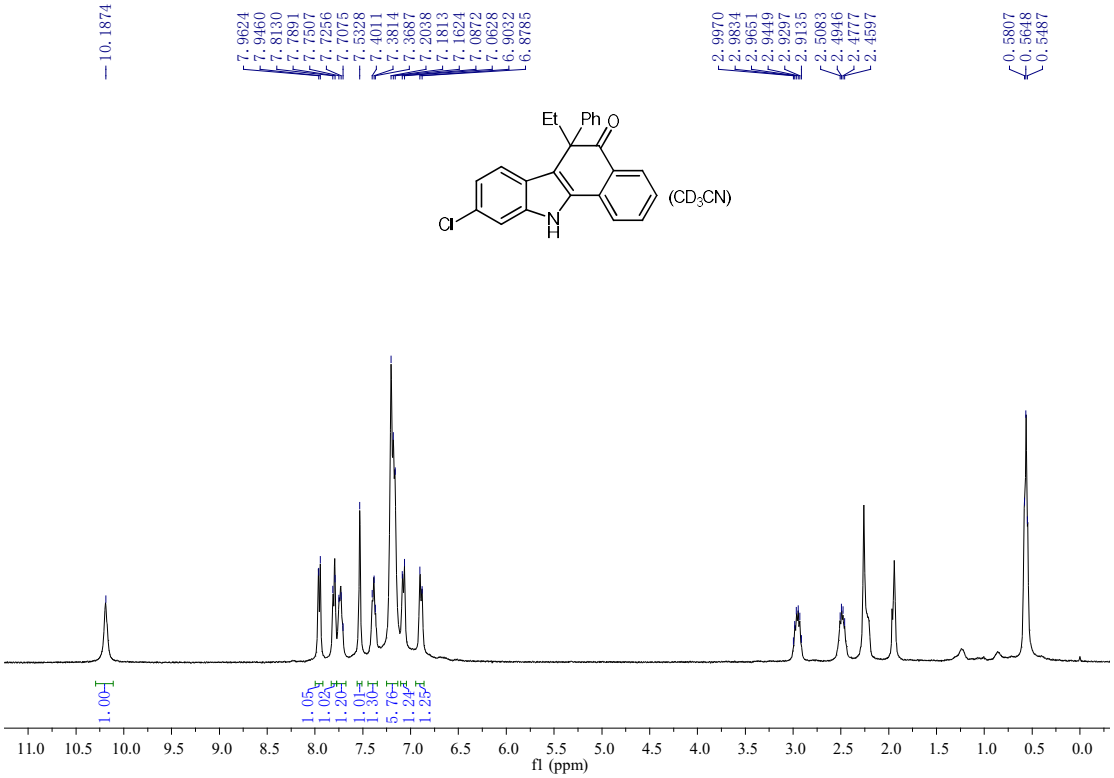


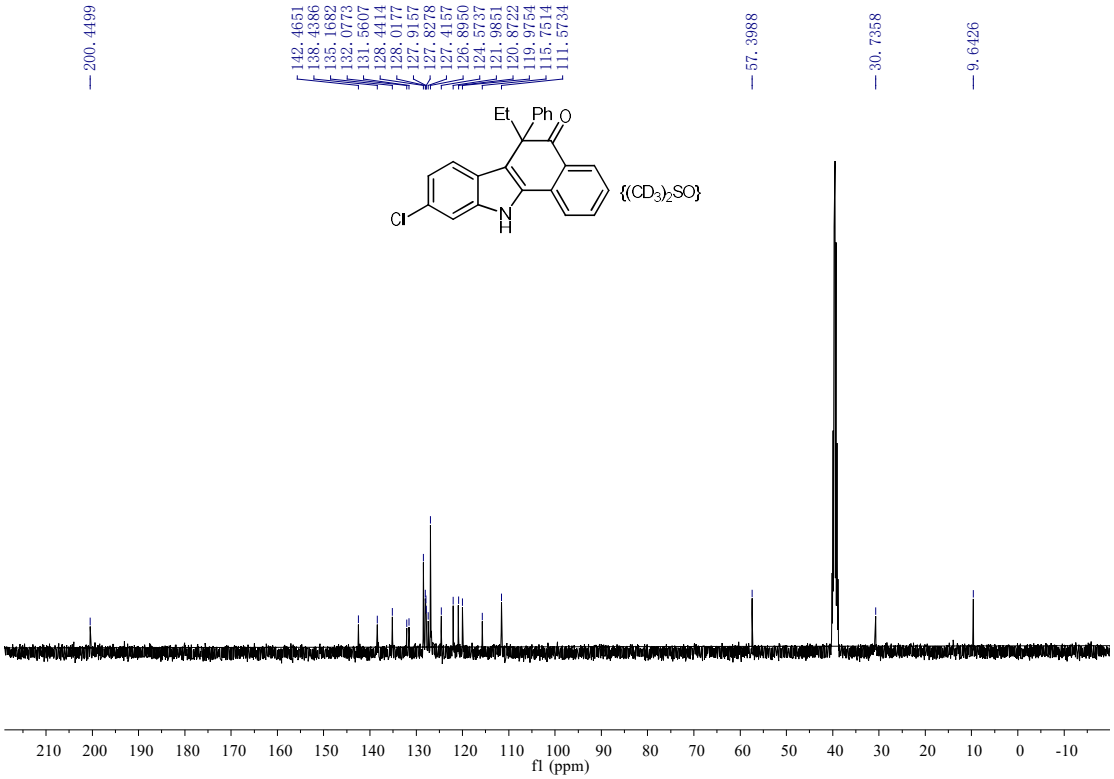
^{1}H and ^{13}C NMR Spectra of compound **3ha**



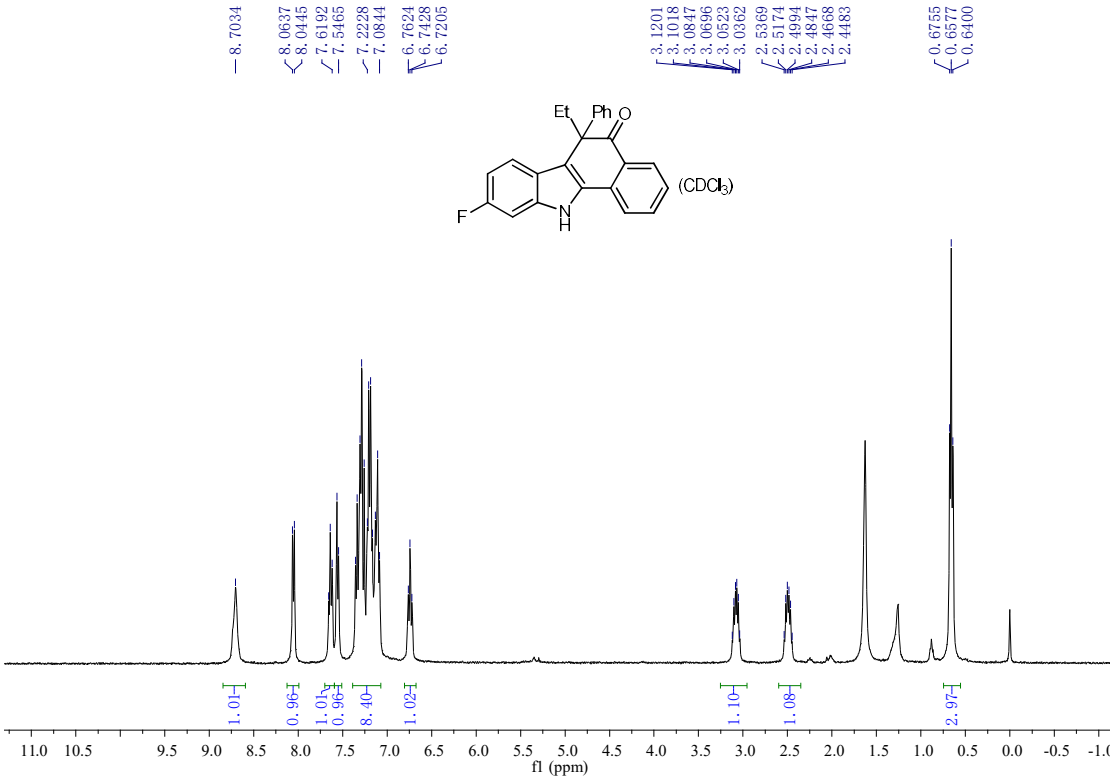


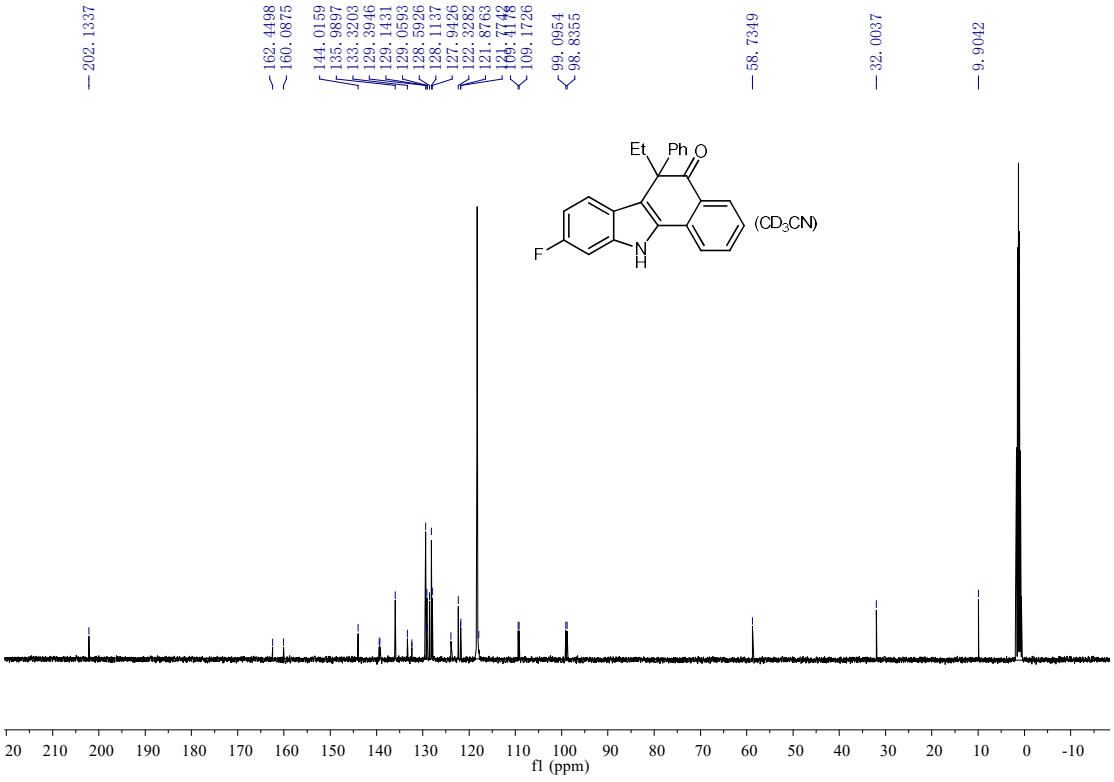
^{1}H and ^{13}C NMR Spectra of compound **3ia**



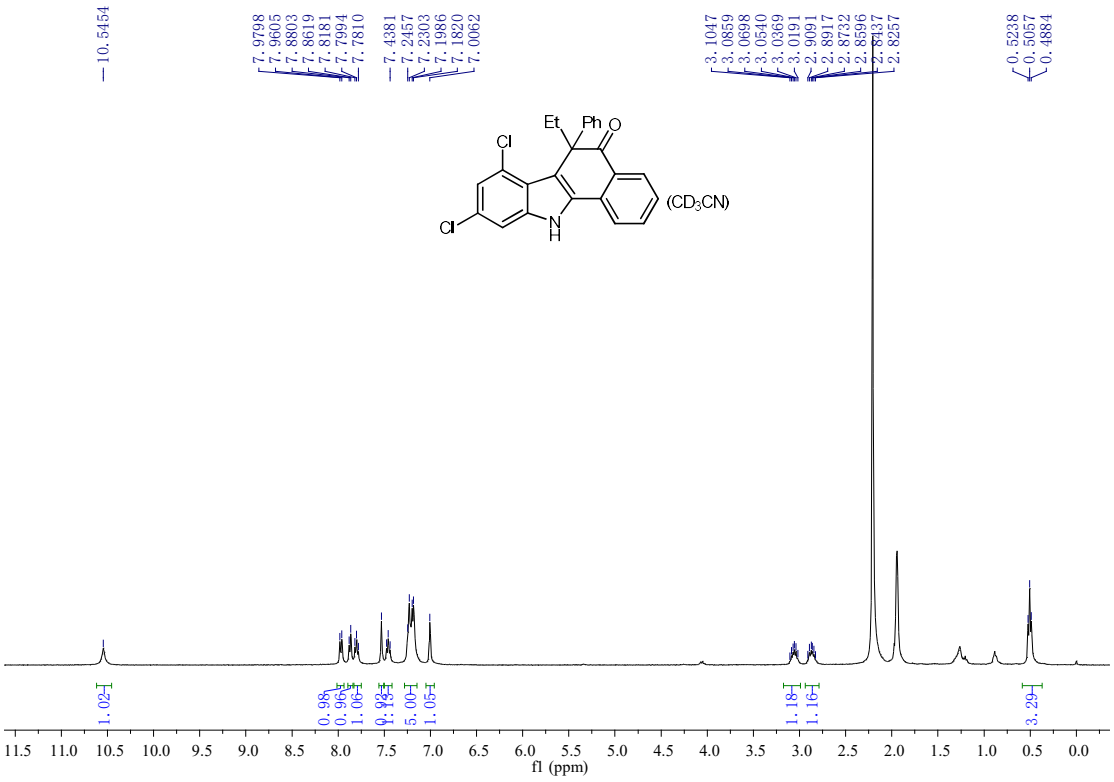


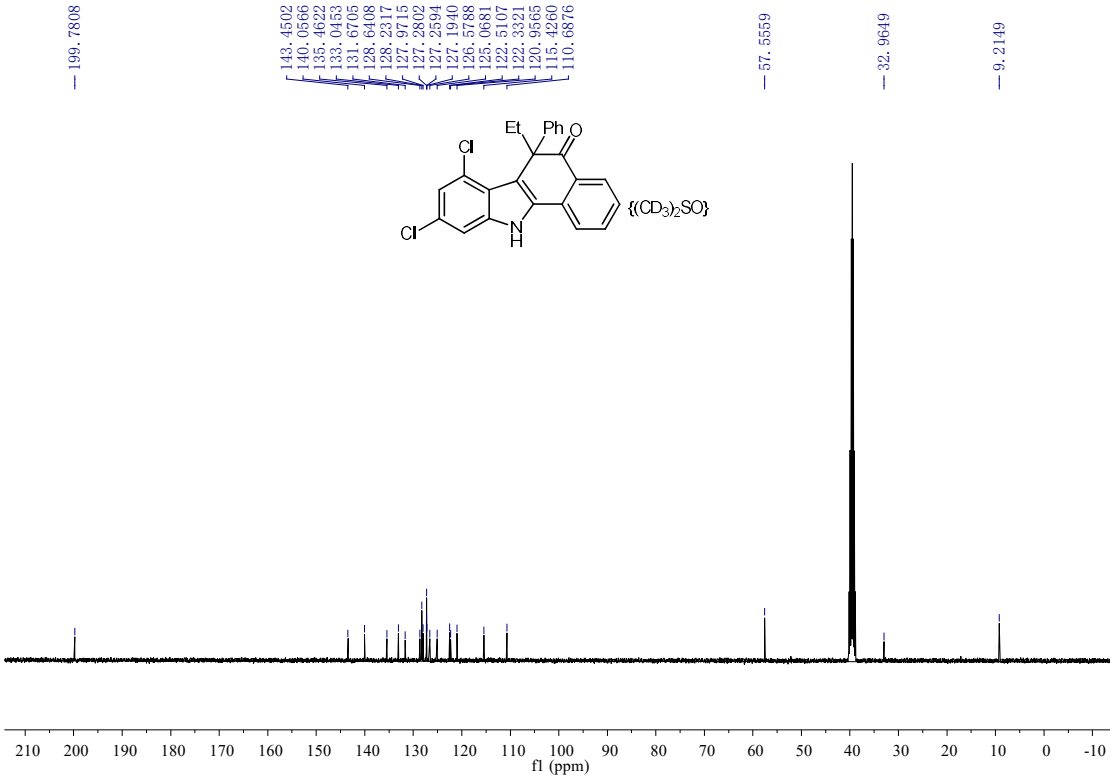
^{1}H and ^{13}C NMR Spectra of compound **3ja**



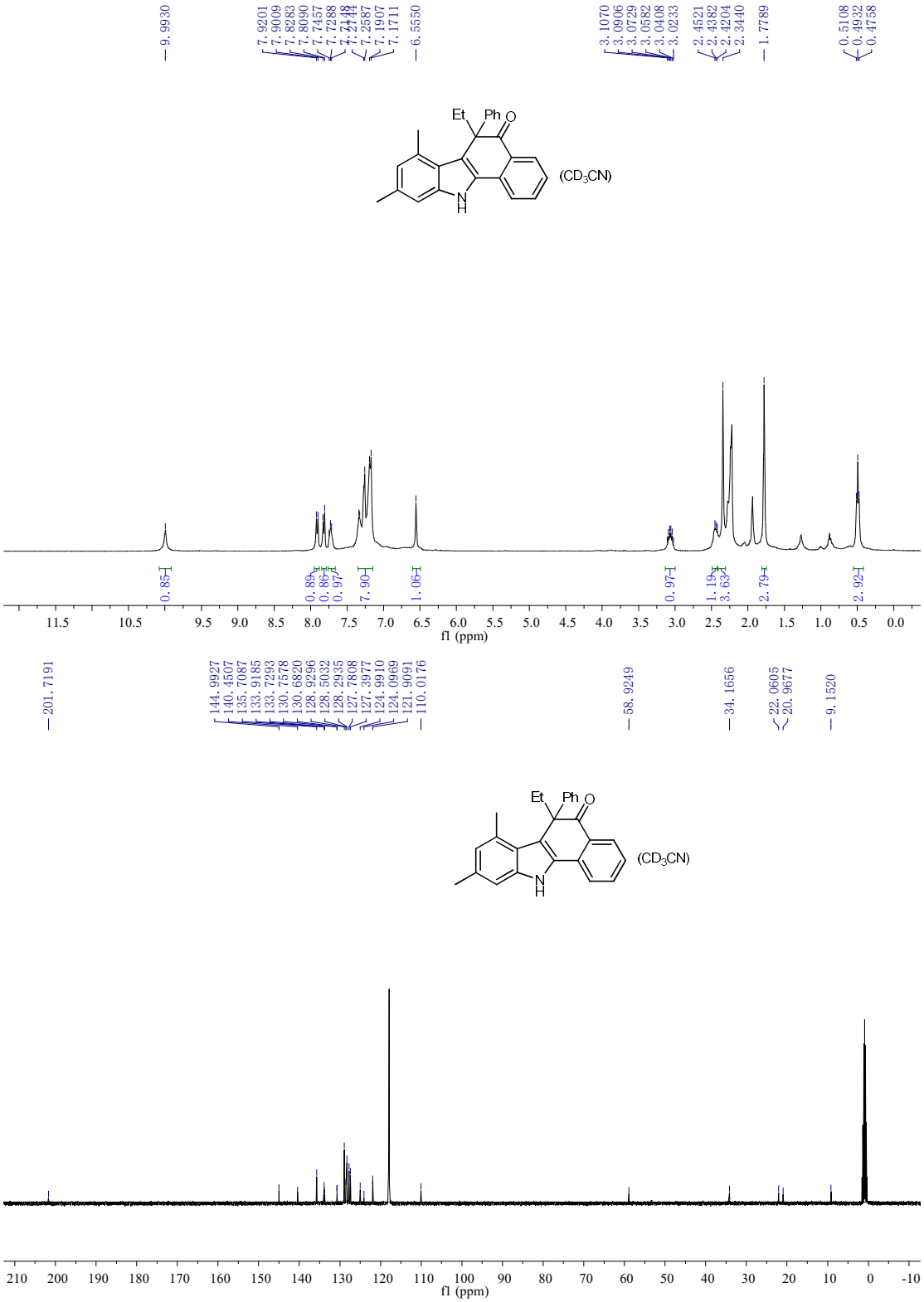


^{1}H and ^{13}C NMR Spectra of compound **3ka**

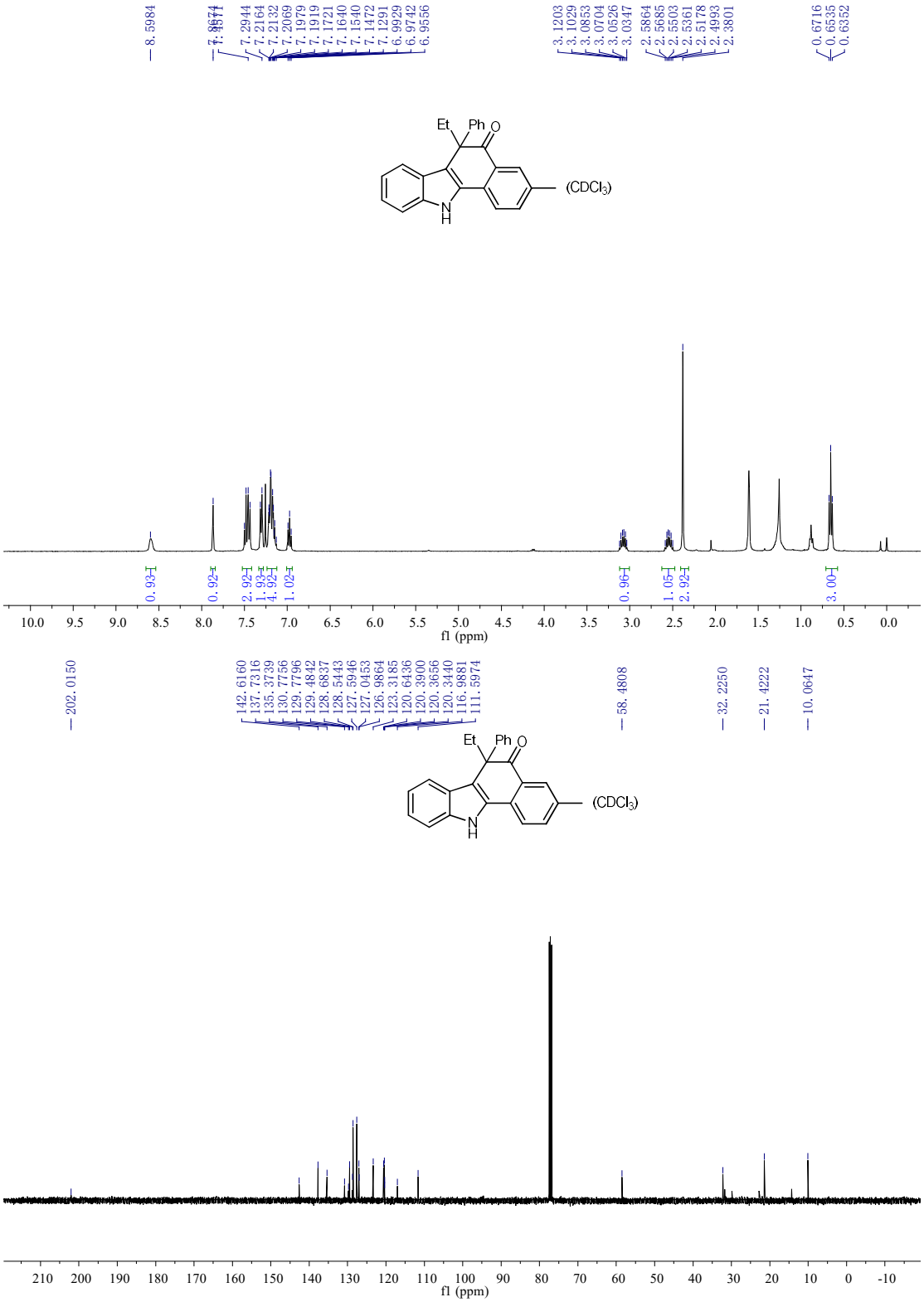




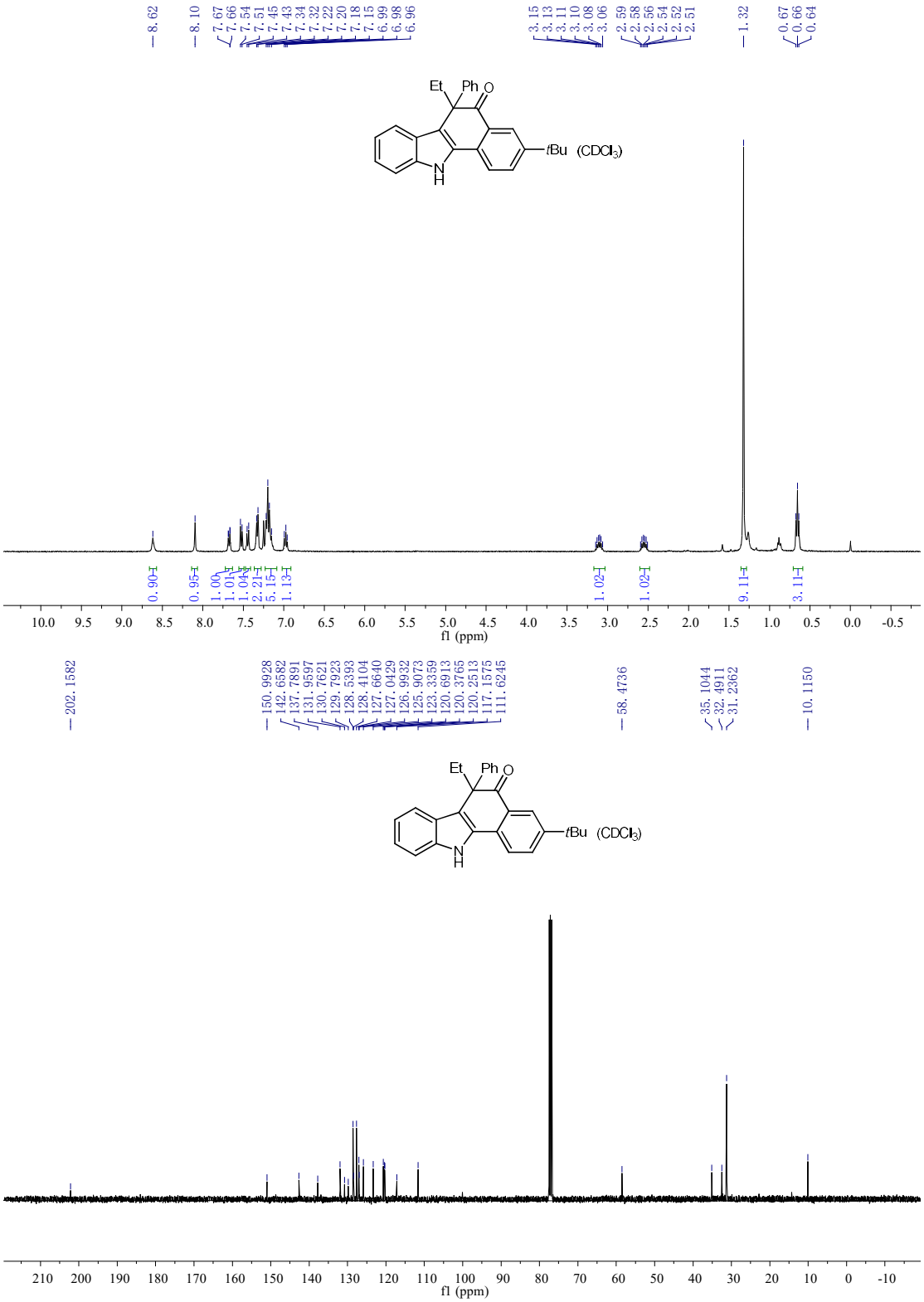
^{1}H and ^{13}C NMR Spectra of compound **3la**



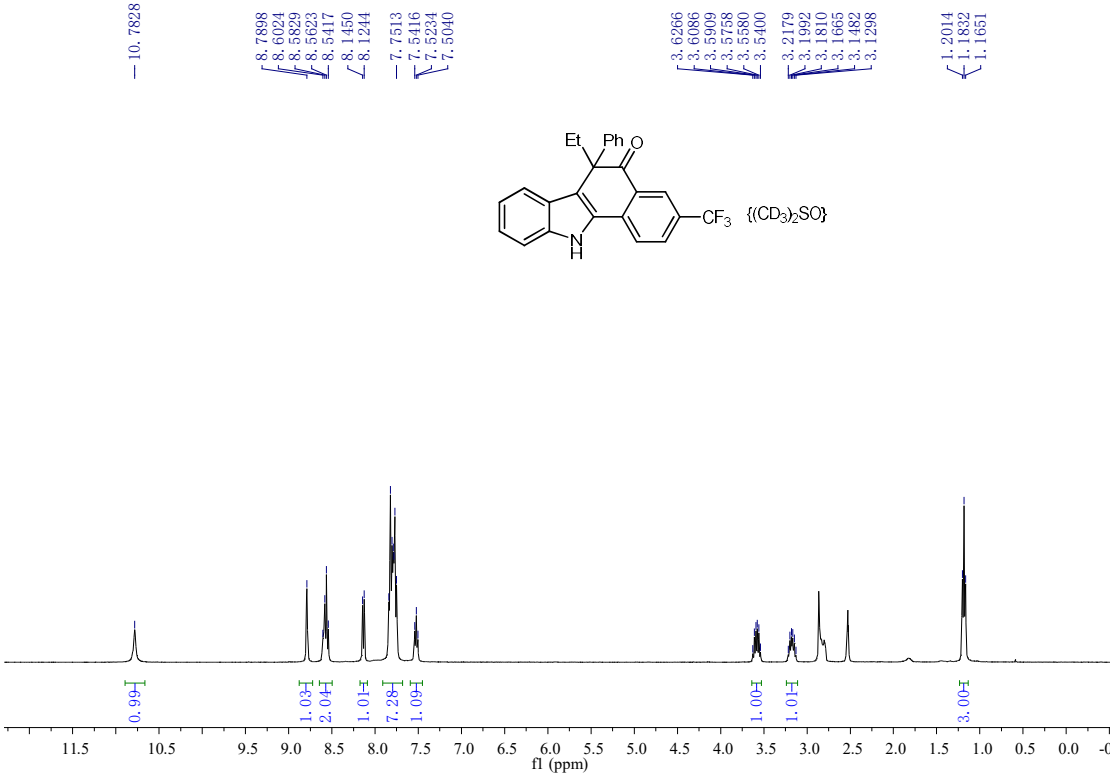
^{1}H and ^{13}C NMR Spectra of compound **3ma**

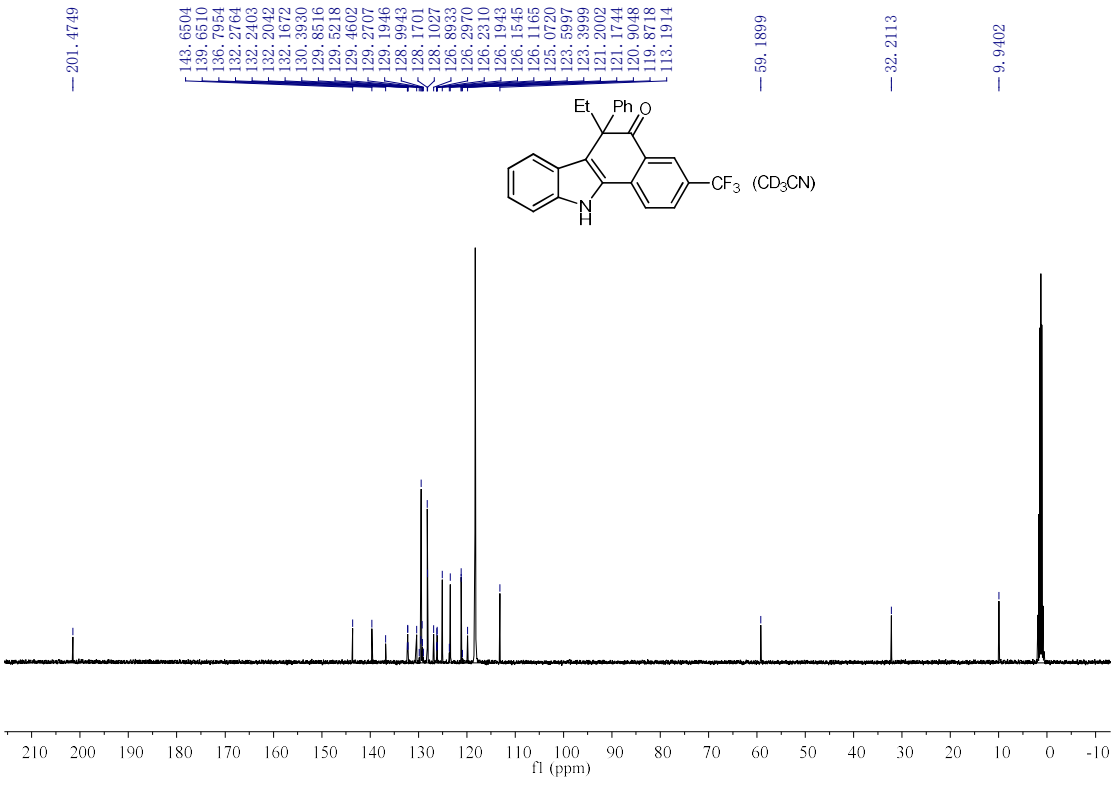


^{1}H and ^{13}C NMR Spectra of compound **3na**

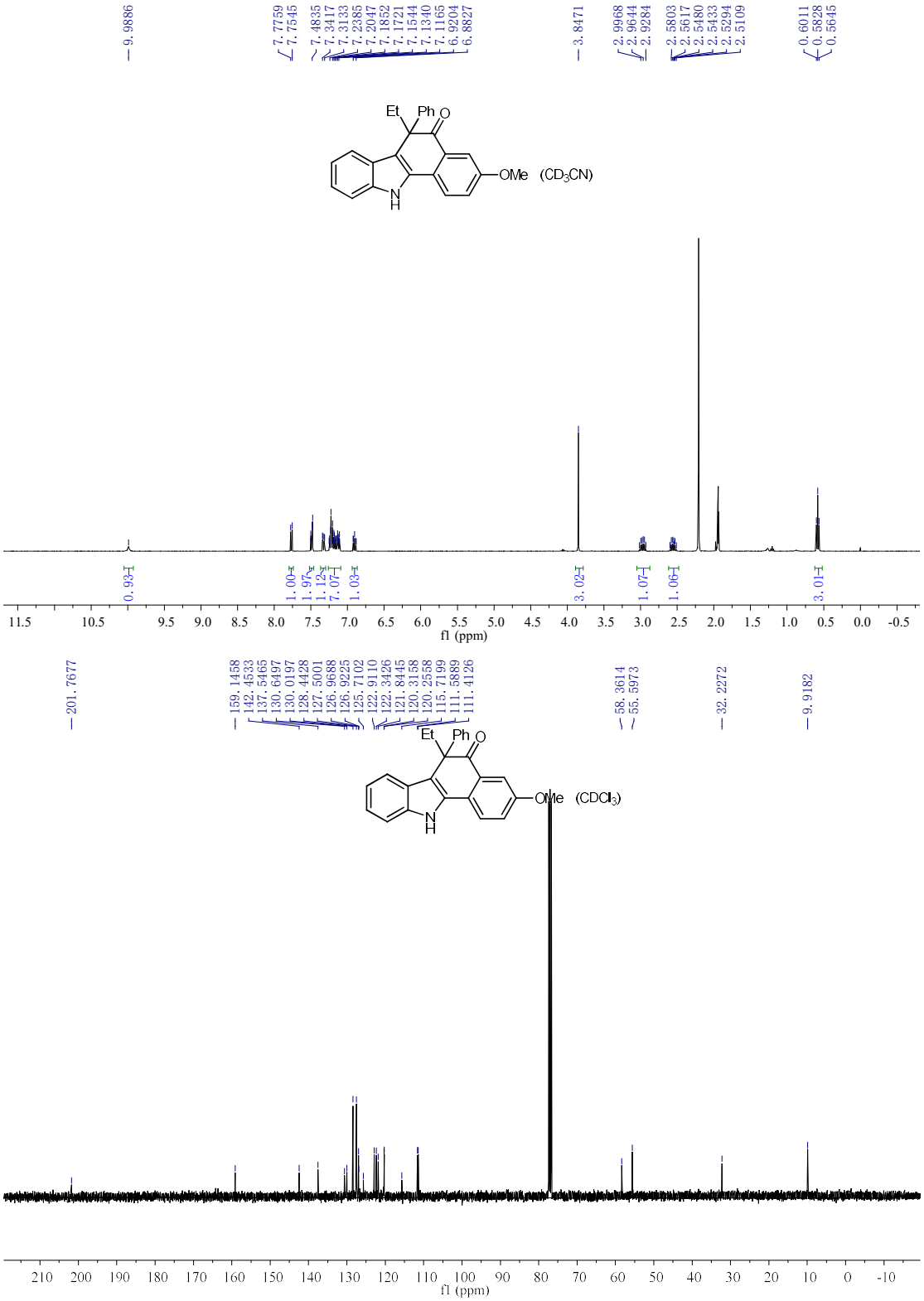


^{1}H and ^{13}C NMR Spectra of compound **3oa**

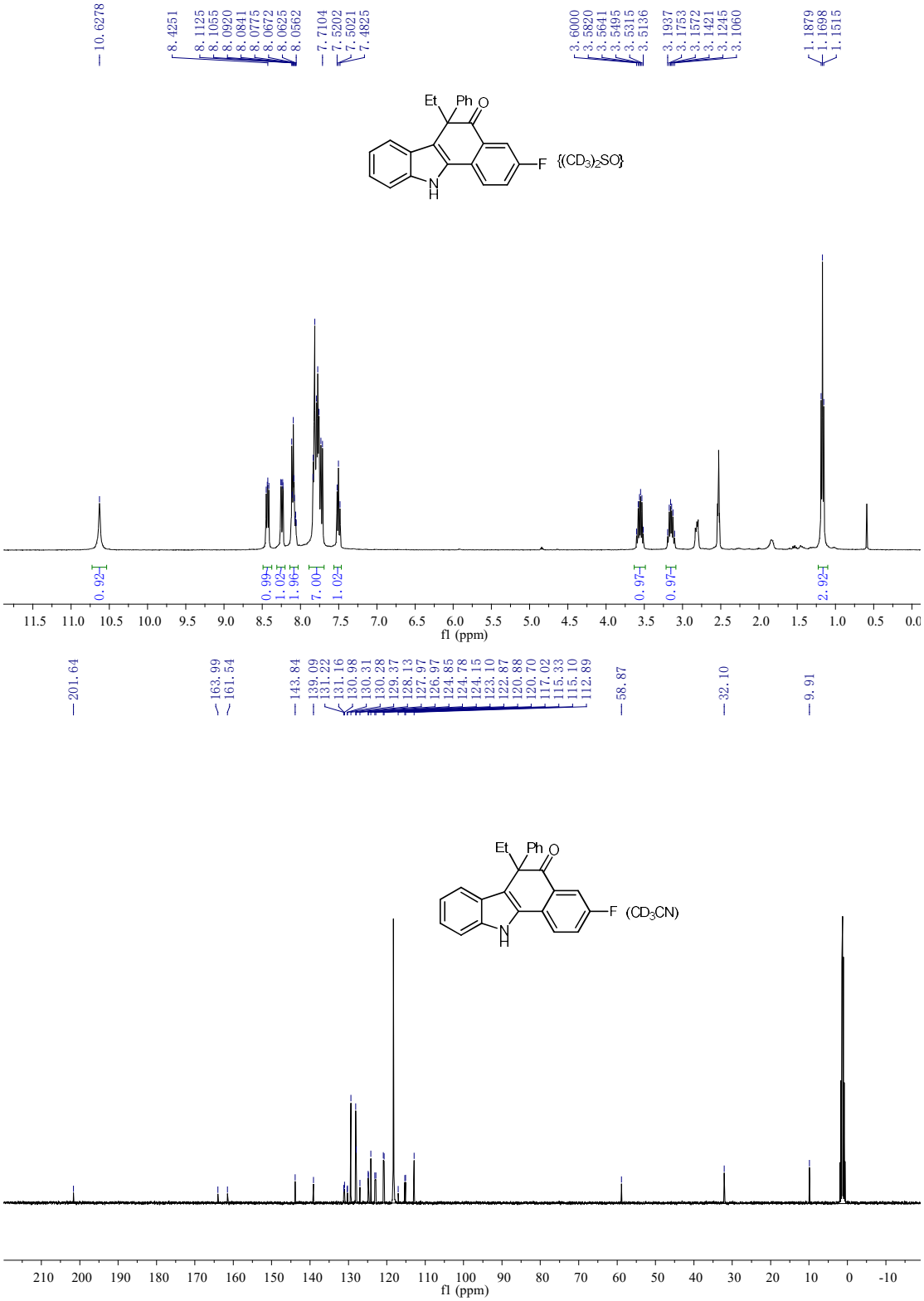




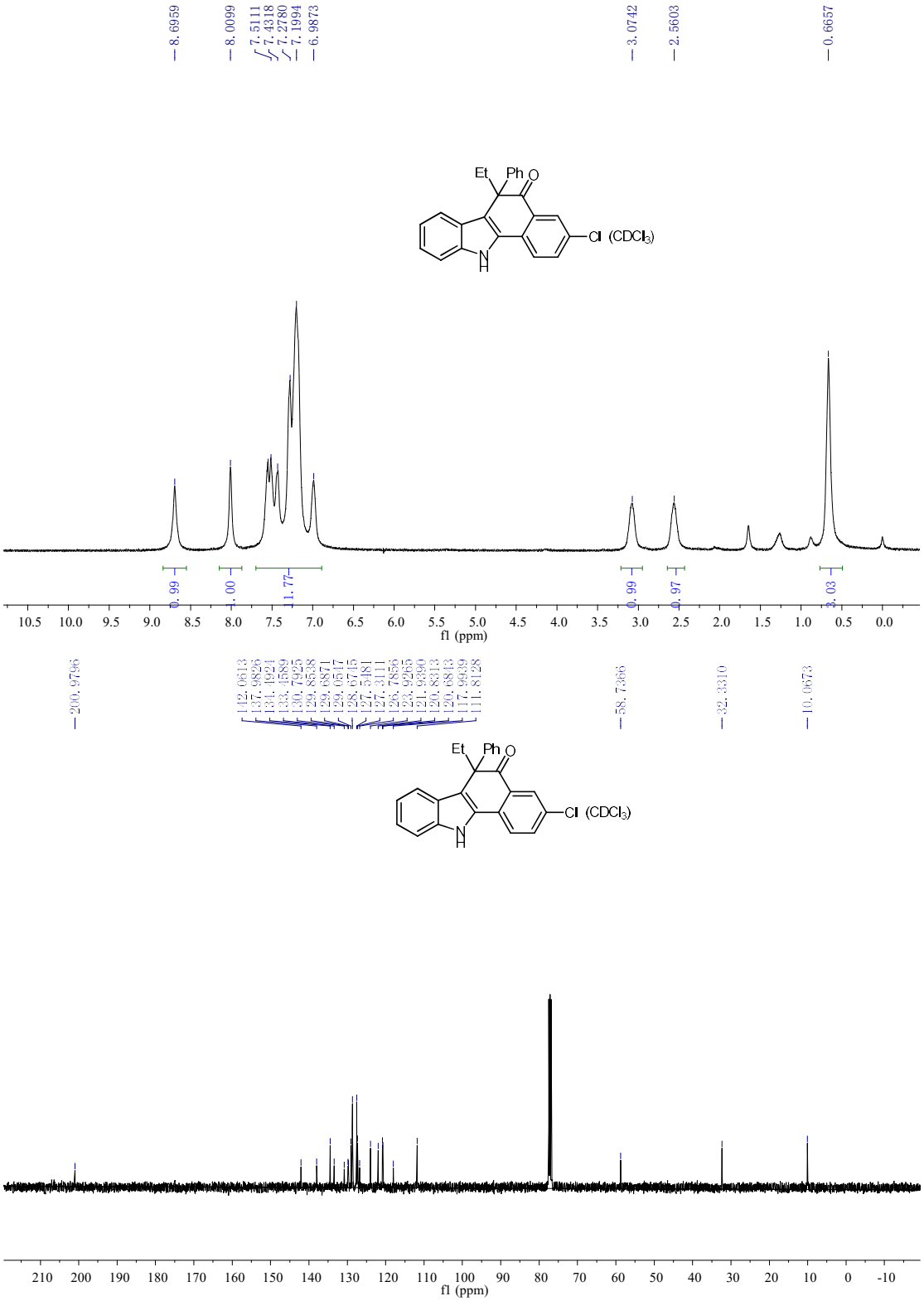
^{1}H and ^{13}C NMR Spectra of compound **3pa**



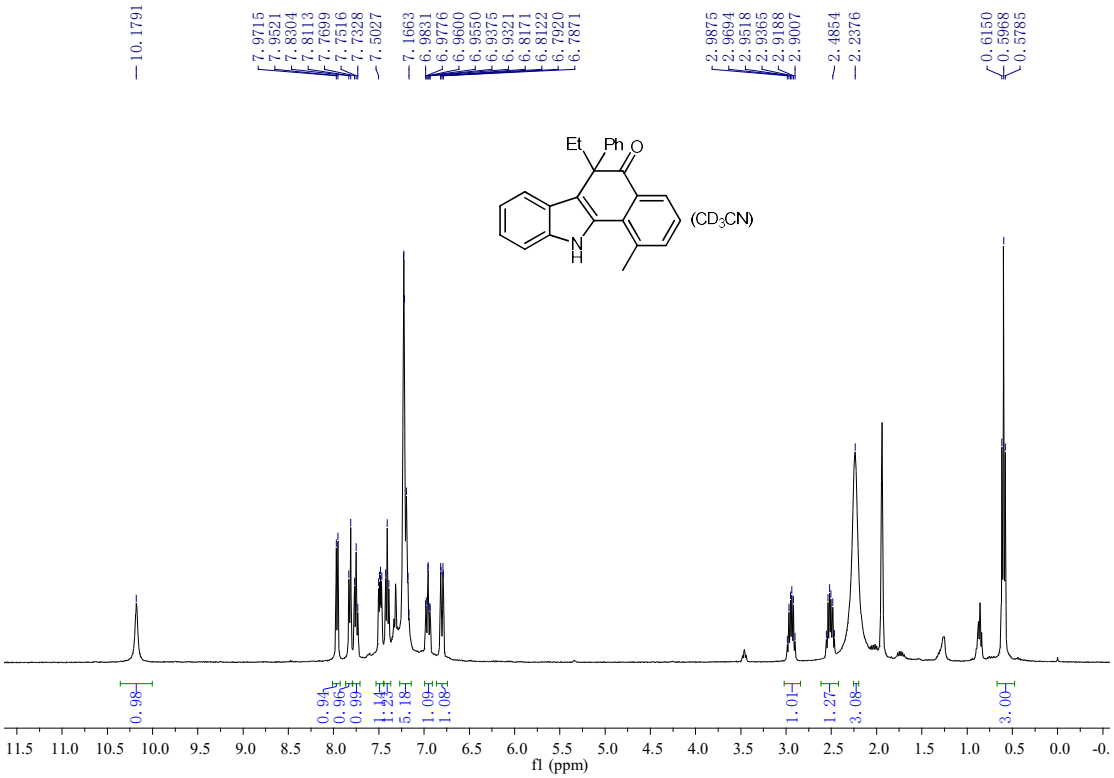
^{1}H and ^{13}C NMR Spectra of compound **3qa**

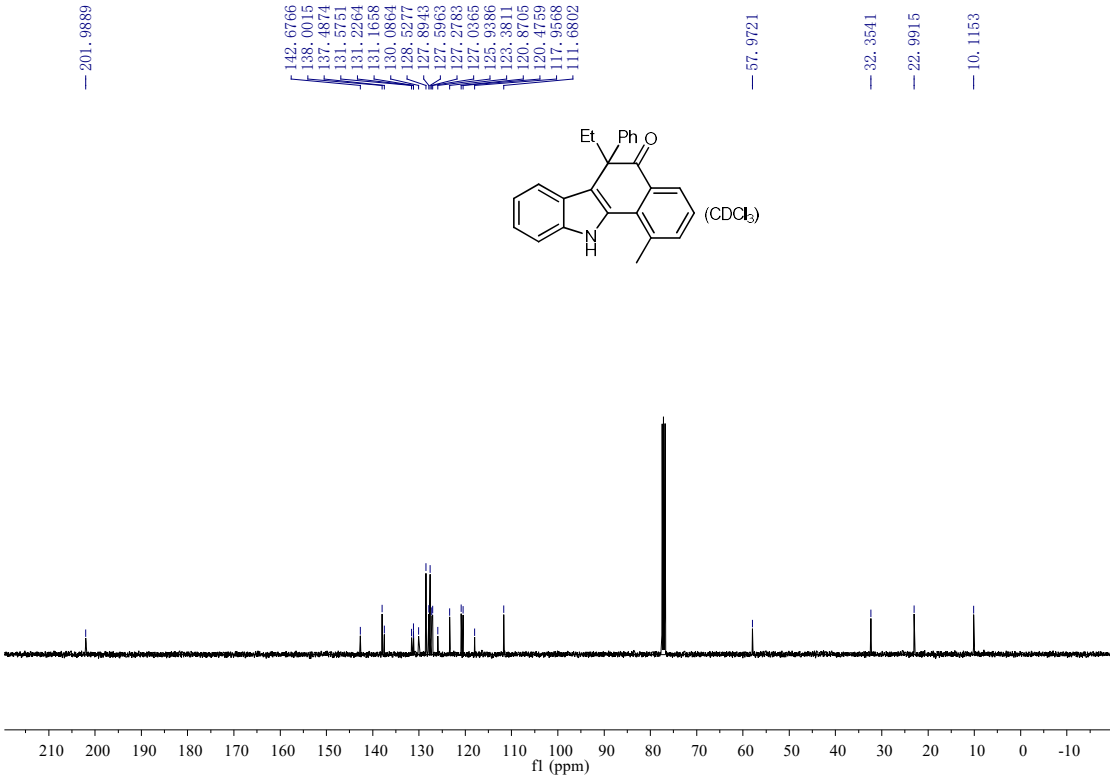


^{1}H and ^{13}C NMR Spectra of compound **3ra**

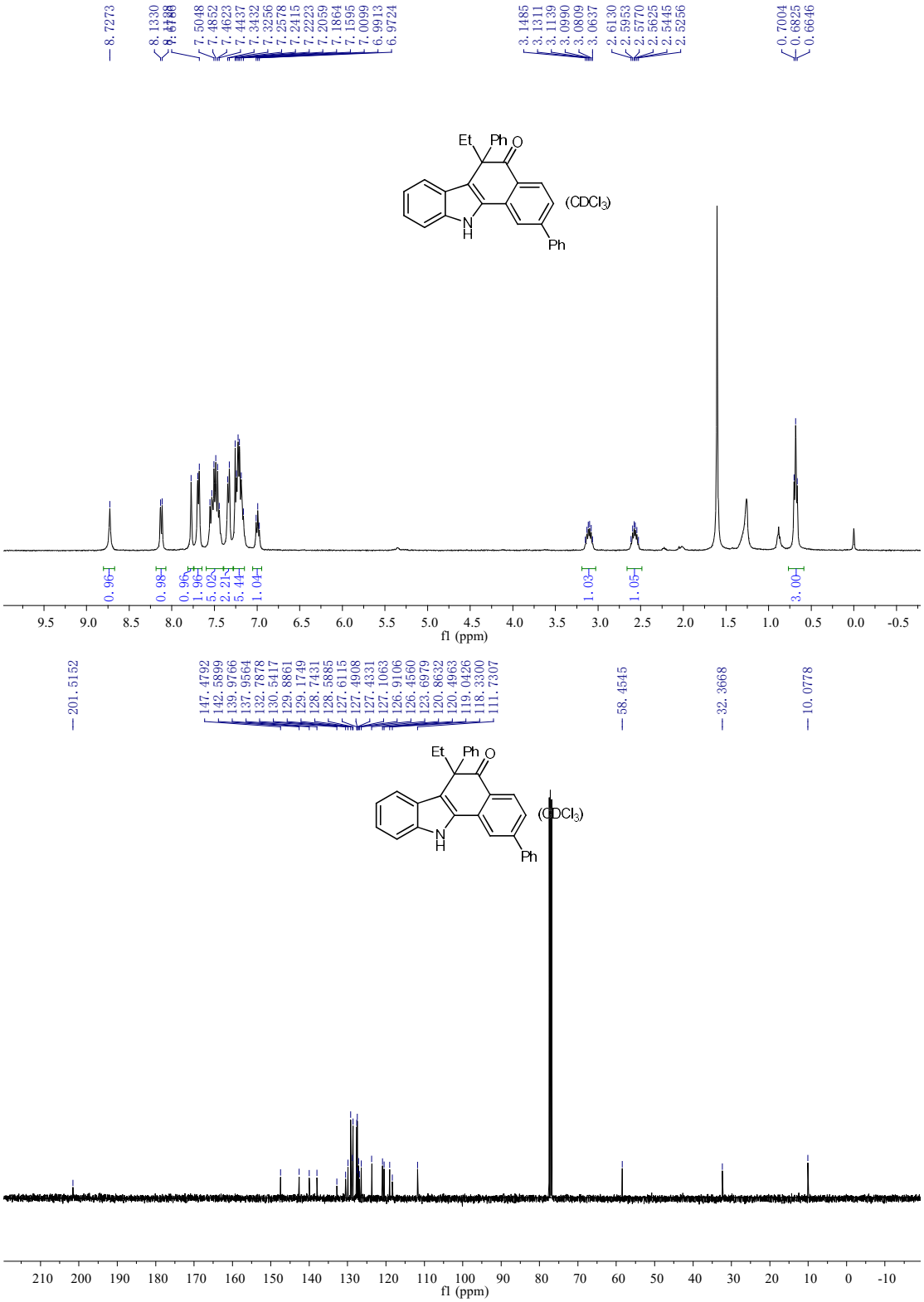


^{1}H and ^{13}C NMR Spectra of compound **3sa**

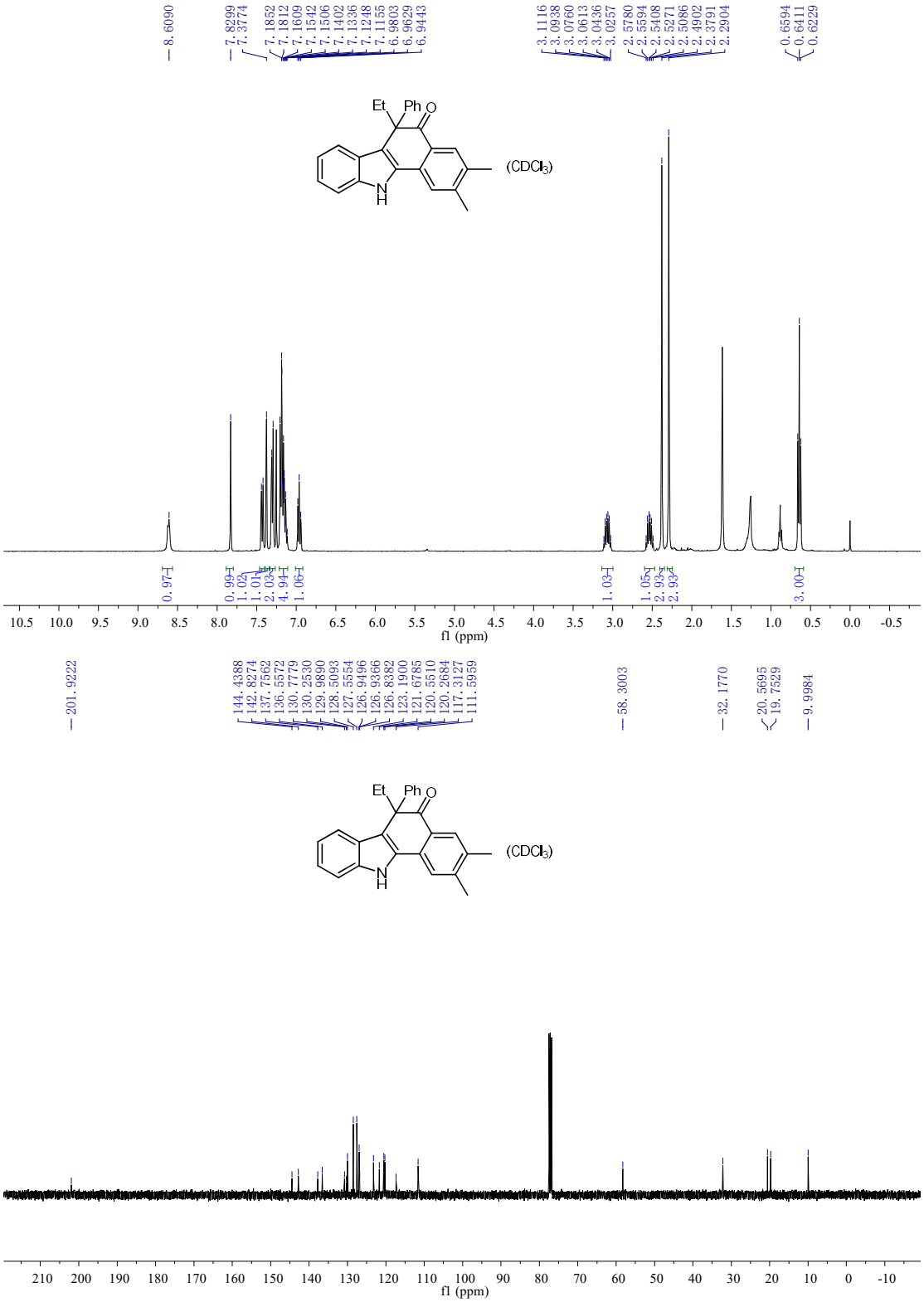




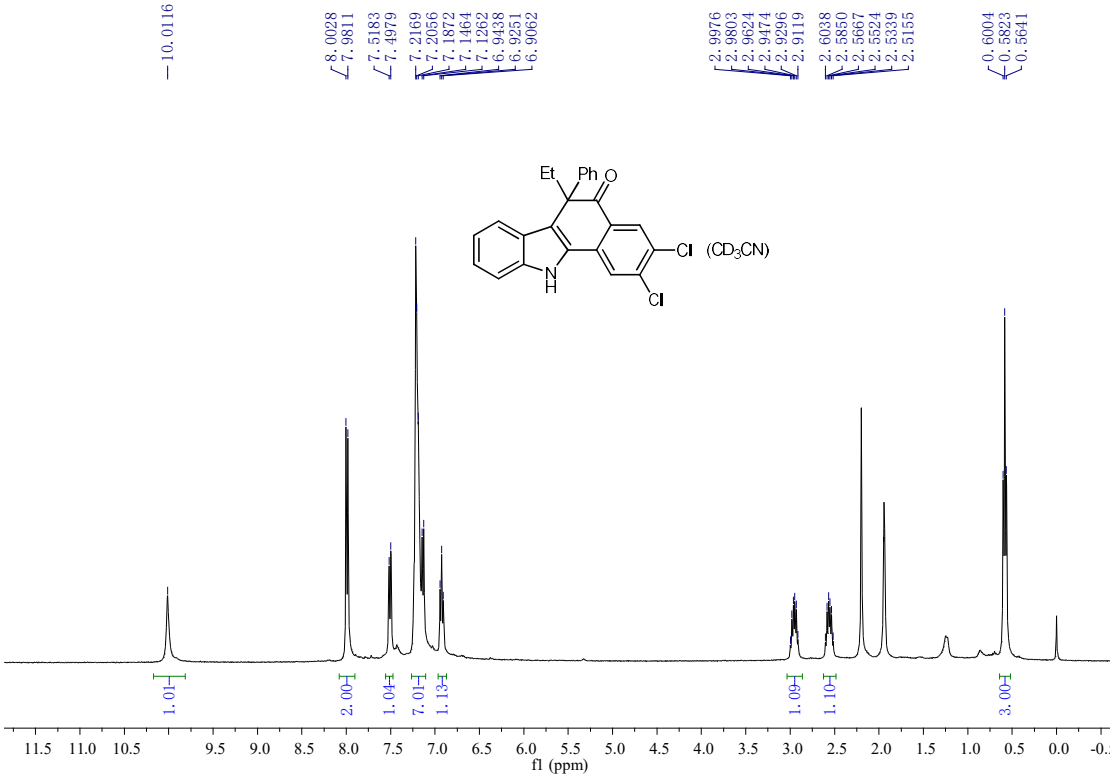
^{1}H and ^{13}C NMR Spectra of compound **3ta**

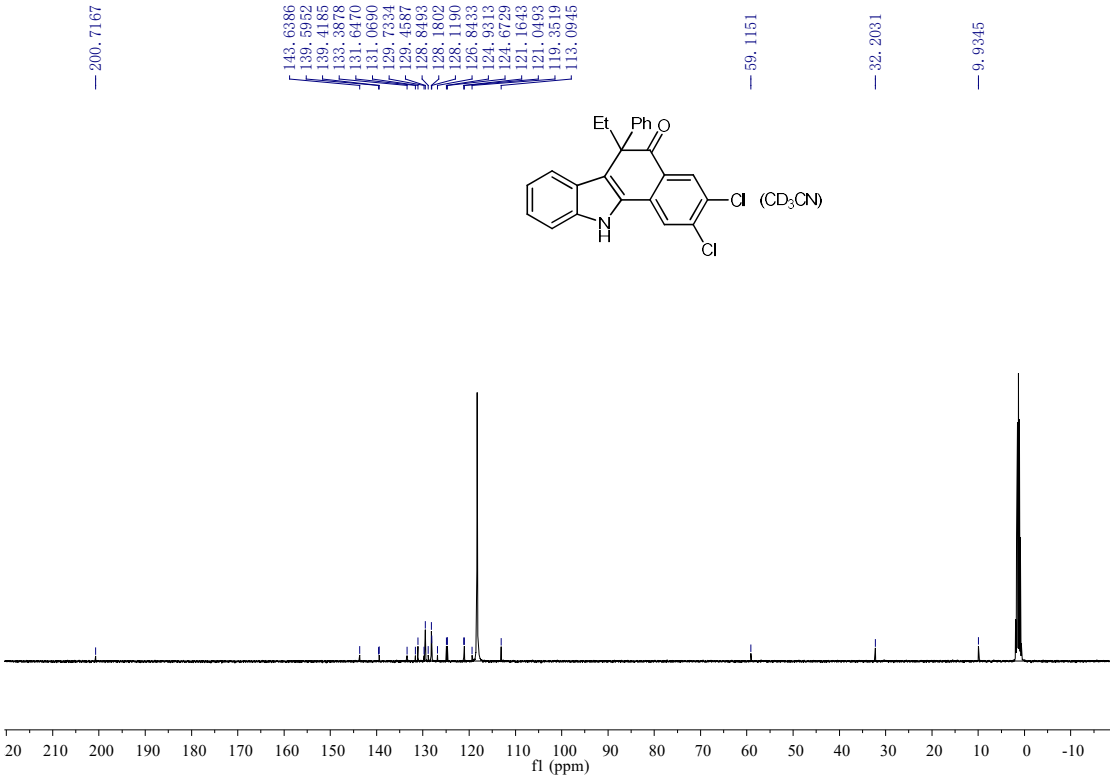


^{1}H and ^{13}C NMR Spectra of compound **3ua**

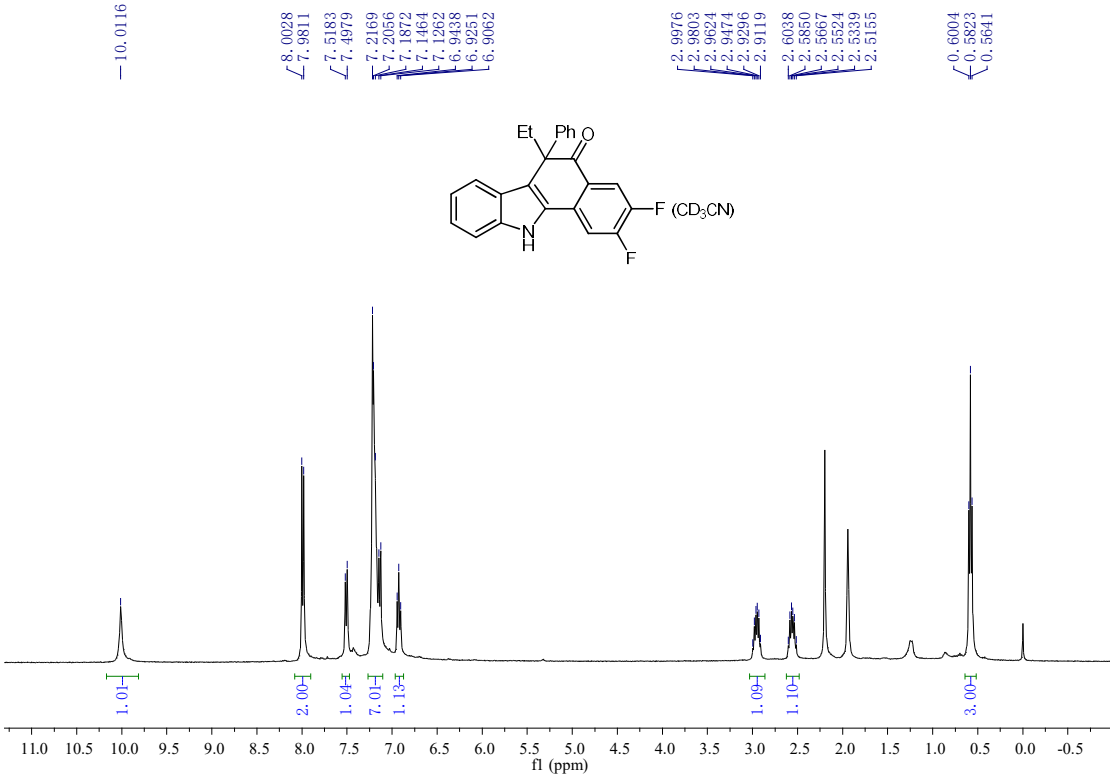


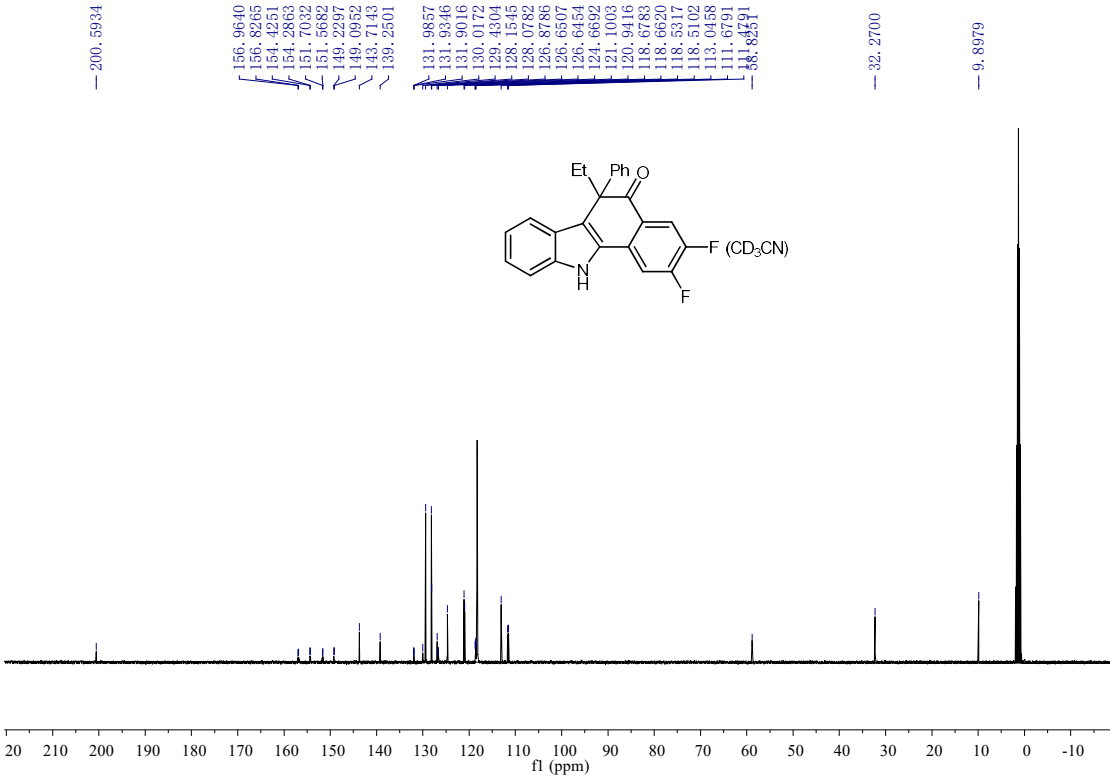
^{1}H and ^{13}C NMR Spectra of compound **3va**



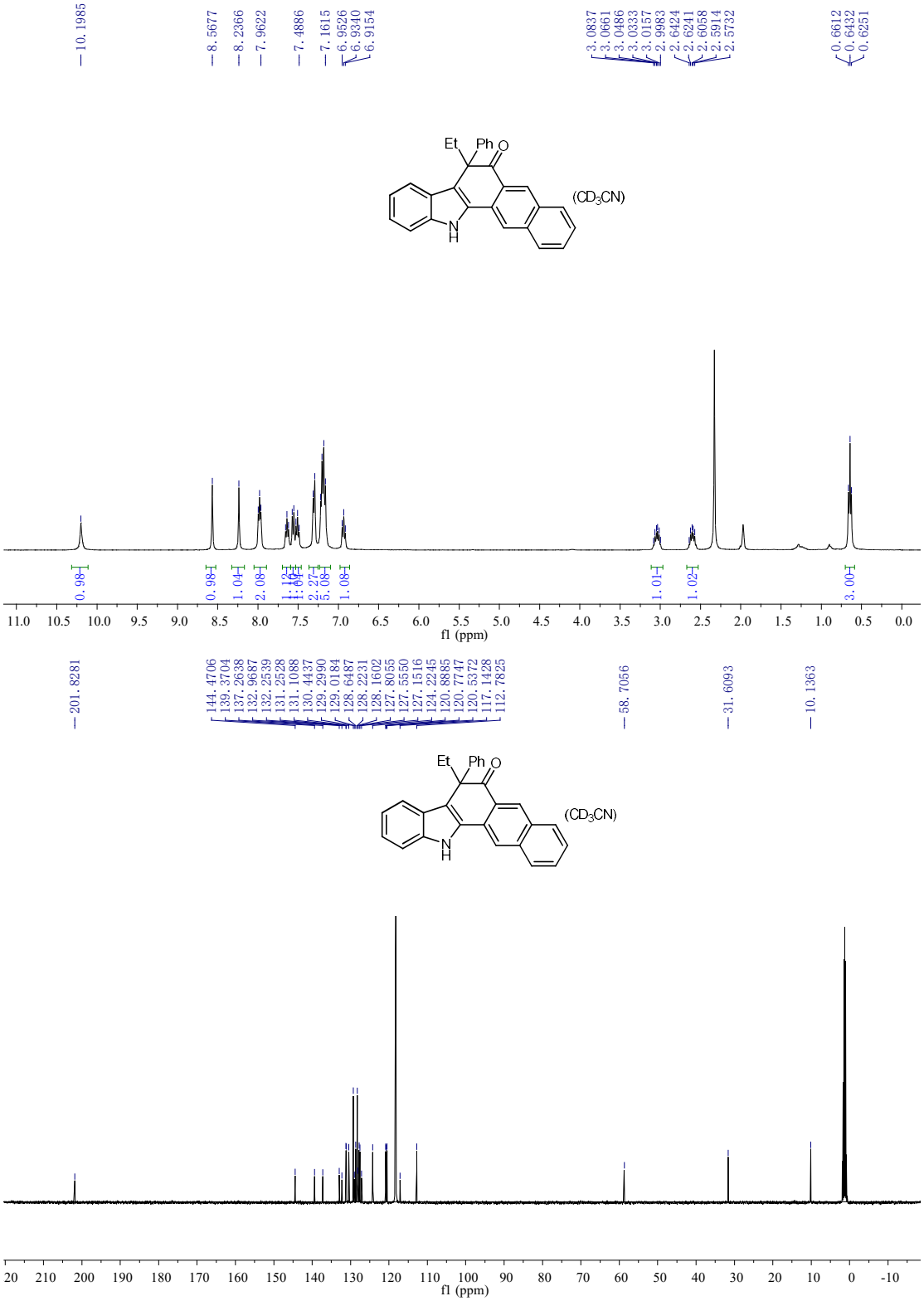


^{1}H and ^{13}C NMR Spectra of compound **3wa**

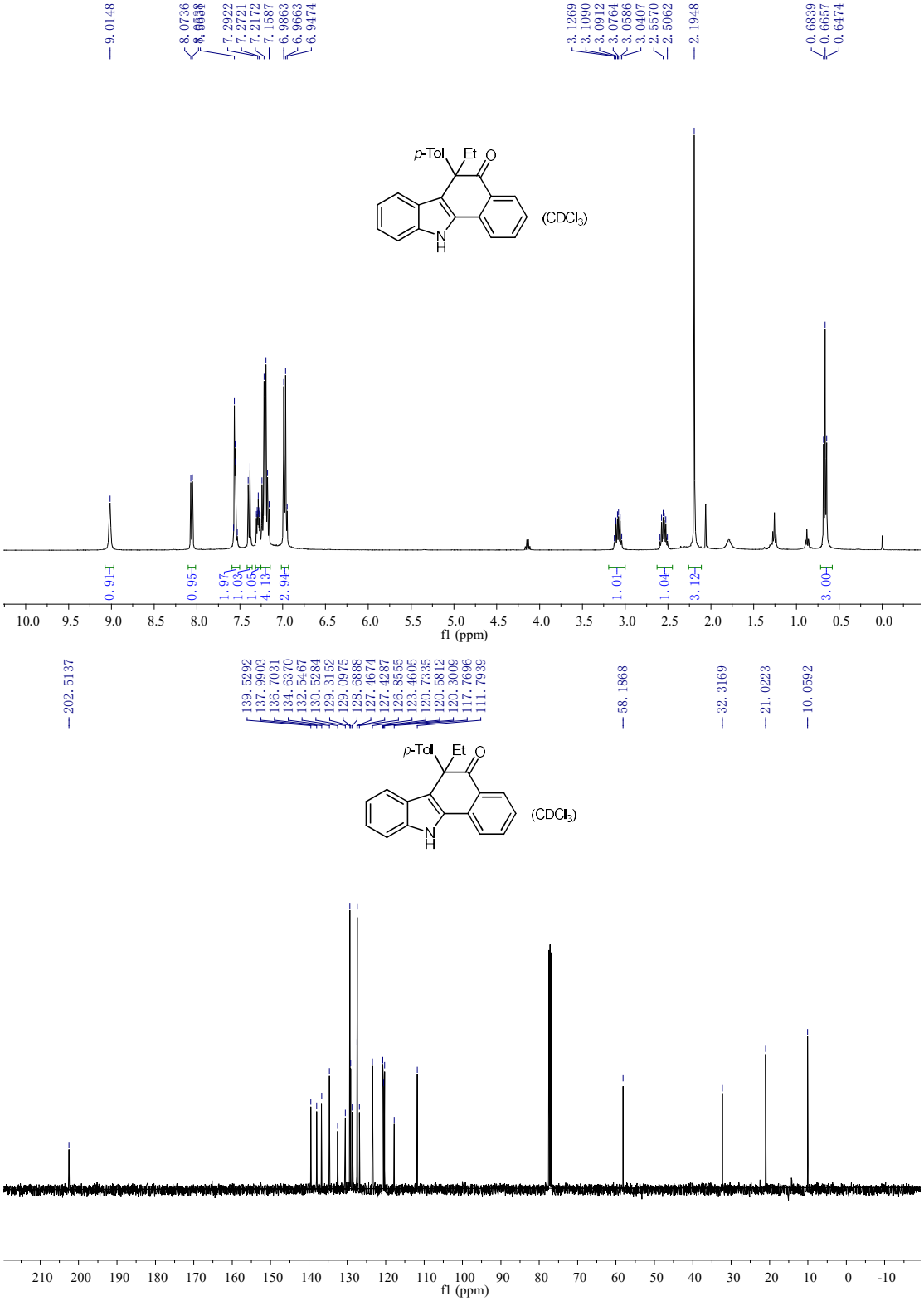




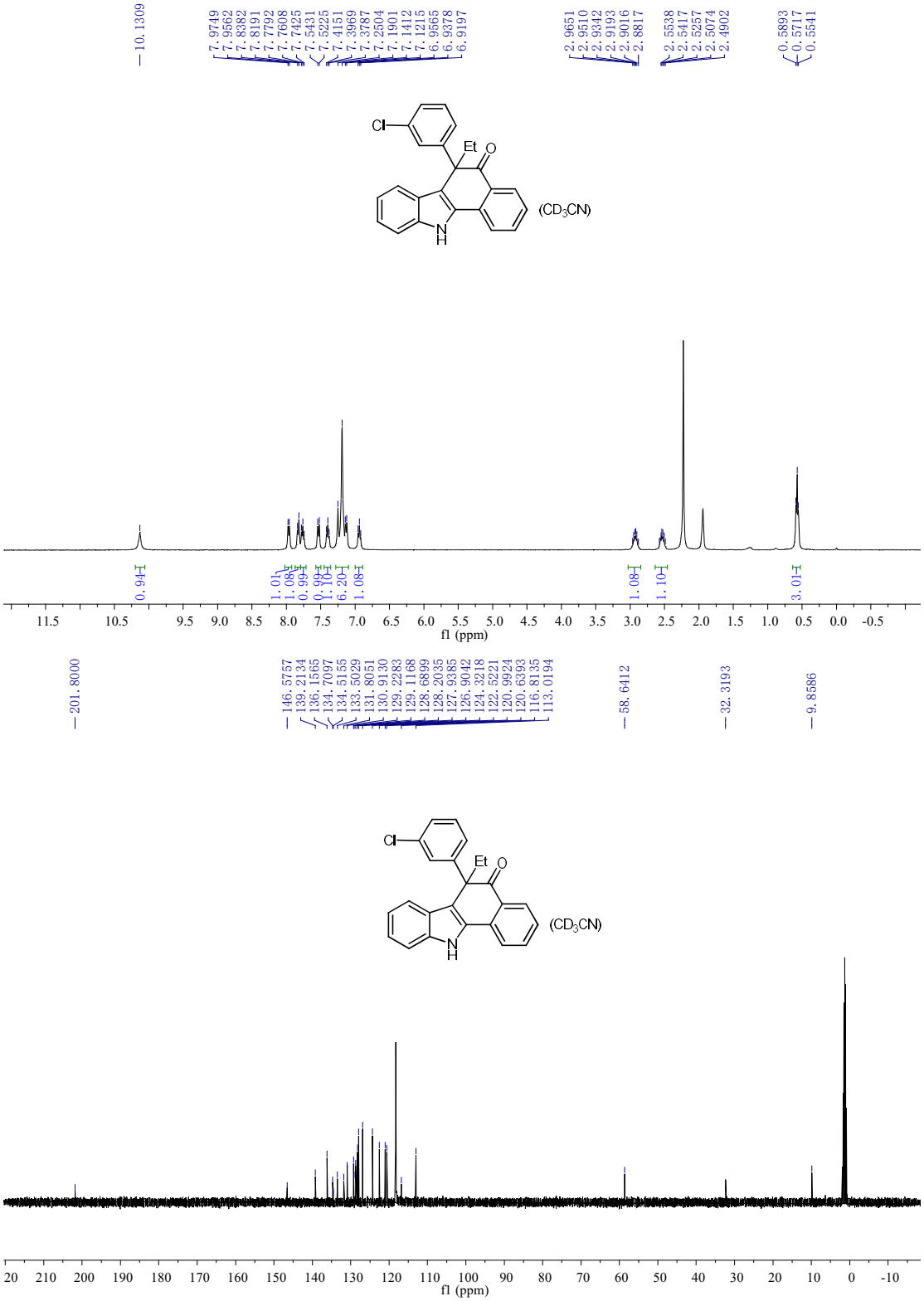
^{1}H and ^{13}C NMR Spectra of compound **3xa**



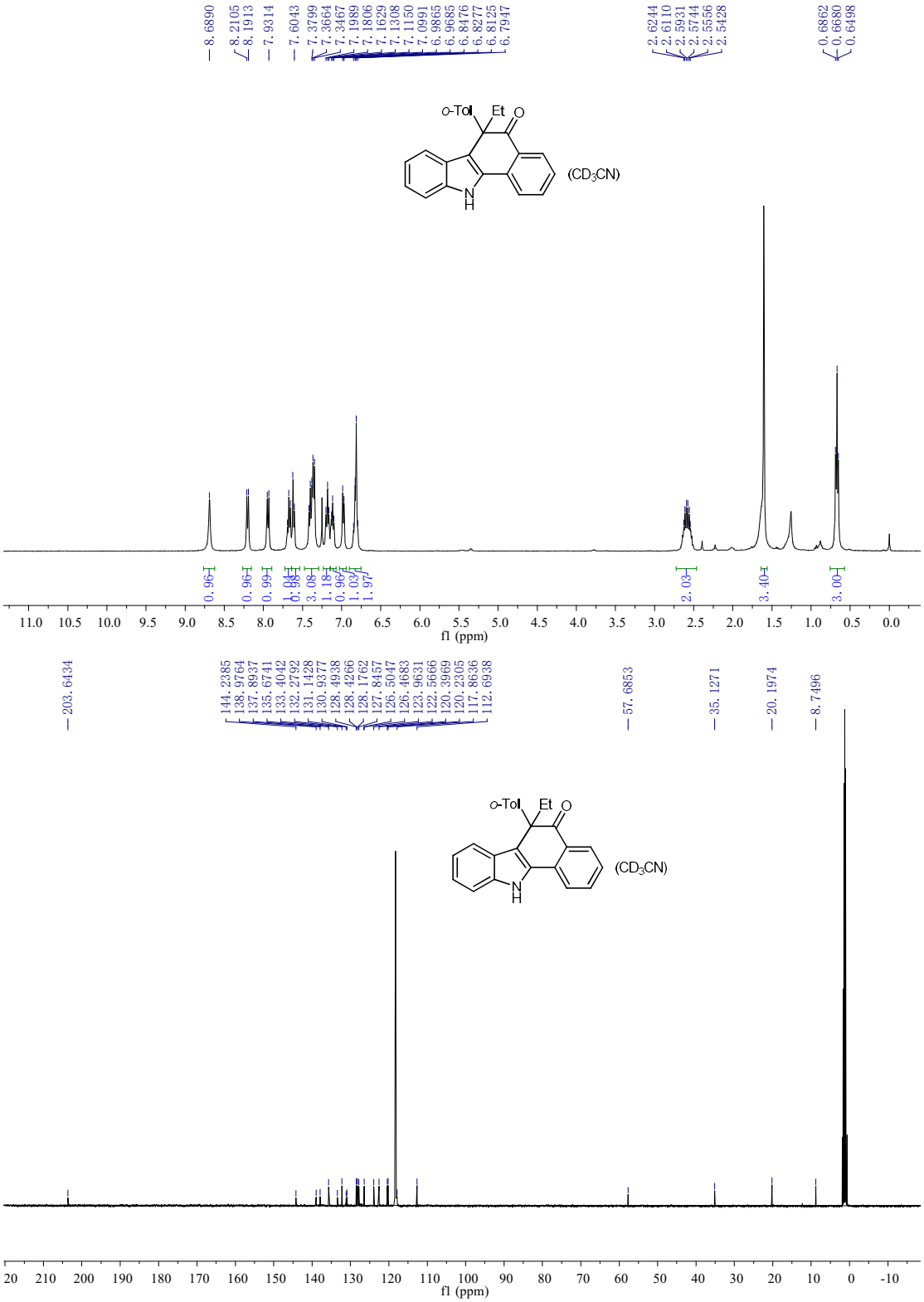
^{1}H and ^{13}C NMR Spectra of compound **3ab**



^{1}H and ^{13}C NMR Spectra of compound **3ac**



^{1}H and ^{13}C NMR Spectra of compound **3ad**



^{1}H and ^{13}C NMR Spectra of compound **3ae**