Supporting Information

A Bio-inspired Synthesis of Hybrid Flavonoids from 2-Hydroxychalcone Driven by Visible Light

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Table of Contents

1. General Information……………………………………………………………………………...........…..........S1

2. Preparation of the Substrates………………………………………………………………….......................S2

3. Optimization of Reaction Conditions………………………………......………………….......................S6

4. Substrate Scope of the Bio-inspired Synthesis of Hybrid Flavonoids…….........….........…......S8

5. Chiral Phosphoric Acid Catalyzed Enantioselective Coupling of 2-Hydroxychalcone.............S27

6. Sunlight powered reactions...S29

7. Mechanistic Studies…………………………………………………………………………........…………...S31

8. References…………………………………………………………………………………….........................S33

9. HPLC Data……………………………………………………………………………………..........................S34

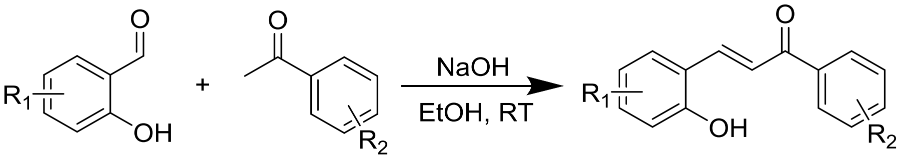
10. NMR Spectra……..……………………………………………………………………….........................S37

1.General Information

Unless otherwise noted, all reagents were obtained from commercial sources and used directly without further purification. Non-aqueous reaction was conducted under inert atmosphere of argon in flame-dried glassware. Anhydrous solvents were treated as follow: chloroform was distilled from phosphorus pentoxide under argon atmosphere; tetrahydrofurwas distilled from sodium under argon atmosphere; dichloromethane and toluene were distilled from calcium hydride under argon atmosphere; ethyl acetate was distilled from magnesium sulfate under argon atmosphere. Anhydrous 2-methyltetrahydrofurand acetonitrile (Adamas-beta, SafeDry, with molecular sieves) were commercial available. Thin layer chromatography was conducted on Merck 60 F254 pre-coated silica gel plates. Column chromatography was carried out by normal silica gel (40-60 µm, 200-400 mesh, Silicycle P60). NMR data including ^{1}H NMR or ^{13}C NMR spectra were recorded on Bruker AVANCE III 500MHz. All of the ^{13}C NMR spectra were broad band proton-decoupled. ^{1}H NMR Chemical shifts were reported in ppm relative to residual signals of the solvents ($CDCl_3$: 7.26 ppm; acetone-d_6: 2.09 ppm; (CD3CN: 1.96 ppm). ^{13}C NMR chemical shifts were reported in ppm relative to the solvent ($CDCl_3$:77.36 ppm; acetone-d_6: 30.6 ppm; CD3CN: 1.79 ppm). Multiplicities are reported using the following abbreviations: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad resonance. High resolution mass spectra were obtained from IonSpec 4.7 Tesla FTMS mass spectrometer (MALDI), Bruker APEXIII 7.0 TESLA FTMS (ESI).

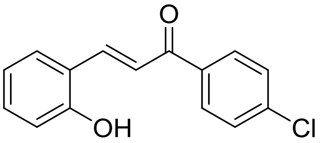
2. Preparation of Substrates

General Procedure for Synthesis of 2-Hydroxylchalcone 1a-1k[1].



To a vigorously stirred mixture of the salicylaldehyde (1.2 equiv) and acetophenone (1.0 equiv) in absolute ethanol (20 mL) was added dropwise aqueous potassium hydroxide 40% (3 equiv) at room temperature, and using aluminium foil to wrap up the reaction flask. After stirring for 24 h, distilled H_2O (50 mL) was added and the resulting red mixture was acidified with 1M HCl. The mixture was extracted with ethyl acetate, washed with H_2O and brine. The residue was purified by column chromatography using petroleum ether /ethyl acetate (12:1) as eluent to afford pure chalcones.

The spectrum data of **1a**[2] were consistent with the reference.



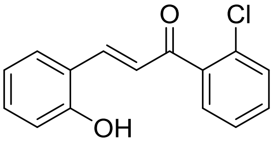
1b

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1b** was isolated as yellow solid in 78% yield (2.02 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.16 (s, 1H), 8.19 (d, *J* = 15.8 Hz, 1H), 8.15-8.10 (m, 2H), 7.86 (d, *J* = 15.7 Hz, 1H), 7.81 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.61-7.55 (m, 2H), 7.29 (ddd, *J* = 8.3, 7.3, 1.7 Hz, 1H), 7.00 (dd, *J* = 8.2, 1.2 Hz, 1H), 6.93 (td, *J* = 7.6, 1.1 Hz, 1H).

^{13}C NMR (126 MHz, acetone-d$_6$): ^{13}C NMR (126 MHz, Acetone) δ 189.22, 157.98, 140.98, 139.12, 138.07, 132.79, 130.97, 129.88, 129.67, 122.86, 122.09, 120.92, 117.14.

HRMS (ESI): exact mass calcd for $C_{15}H_{11}ClO_2$: m/z 259.0526 $[M+H]^+$, found: m/z 259.0527.



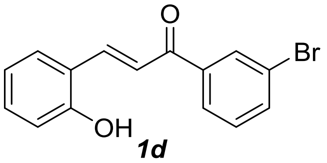
1c

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1c** was isolated as yellow solid in 74% yield (1.91 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.15 (s, 1H), 7.79 (d, *J* = 16.3 Hz, 1H), 7.68 (dd, *J* = 7.9, 1.7 Hz, 1H), 7.55-7.45 (m, 4H), 7.31-7.24 (m, 2H), 6.97 (dd, *J* = 8.2, 1.1 Hz, 1H), 6.92 (td, *J* = 7.7, 1.1 Hz, 1H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 194.26, 157.80, 142.55, 140.62, 133.09, 132.14, 131.38, 130.90, 130.06, 129.84, 127.97, 127.02, 122.36, 121.01, 117.11.

HRMS (ESI): exact mass calcd for $C_{15}H_{11}ClO_2$: m/z 259.0526 $[M+H]^+$, found: m/z 259.0524.



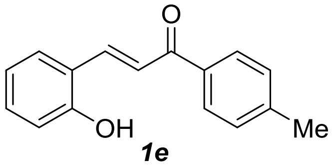
1d

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1d** was isolated as yellow solid in 81% yield (2.46 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.13 (s, 1H), 7.76 (d, *J* = 16.3 Hz, 1H), 7.71 (dd, *J* = 8.0, 0.8 Hz, 1H), 7.68 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.54-7.47 (m, 2H), 7.44 (ddd, *J* = 8.0, 7.0, 2.2 Hz, 1H), 7.31-7.27 (m, 1H), 7.23 (d, *J* = 16.3 Hz, 1H), 6.97 (dd, *J* = 8.2, 1.0 Hz, 1H), 6.92 (td, *J* = 7.6, 0.9 Hz, 1H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 195.12, 157.80, 142.80, 142.72, 134.08, 133.10, 132.14, 129.94, 129.83, 128.47, 126.85, 122.39, 121.02, 119.69, 117.14.

HRMS (ESI): exact mass calcd for $C_{15}H_{11}BrO_2$: m/z 303.0020 [M+H]$^+$, found: m/z 303.0022.



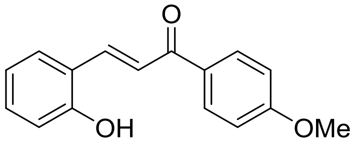
1e

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1e** was isolated as yellow solid in 69% yield (1.64 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.12 (s, 1H), 8.17 (d, *J* = 15.8 Hz, 1H), 8.02 (d, *J* = 8.3 Hz, 2H), 7.87 (d, *J* = 15.8 Hz, 1H), 7.80 (dd, *J* = 7.9, 1.6 Hz, 1H), 7.36 (d, *J* = 8.0 Hz, 2H), 7.30-7.26 (m, 1H), 7.00 (dd, *J* = 8.2, 1.1 Hz, 1H), 6.93 (td, *J* = 7.6, 1.1 Hz, 1H), 2.42 (s, 3H).

^{13}C NMR (126 MHz, acetone-d$_6$): ^{13}C NMR (126 MHz, Acetone) δ 189.83, 157.83, 144.11, 140.05, 136.97, 132.48, 130.11, 129.76, 129.34, 123.08, 122.58, 120.89, 117.10, 21.55.

HRMS (ESI): exact mass calcd for $C_{16}H_{14}O_2$: m/z 239.1072 [M+H]$^+$, found: m/z 239.1071.



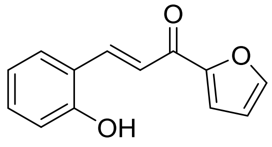
1f

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1f** was isolated as yellow solid in 60% yield (1.53 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.11 (s, 1H), 8.21-8.06 (m, 3H), 7.89 (d, *J* = 15.7 Hz, 1H), 7.80 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.27 (ddd, *J* = 8.2, 7.2, 1.6 Hz, 1H), 7.09-7.04 (m, 2H), 6.99 (dd, *J* = 8.2, 1.2 Hz, 1H), 6.92 (td, *J* = 7.5, 1.1 Hz, 1H), 3.90 (s, 3H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 188.57, 164.31, 157.75, 139.54, 132.35, 132.30, 131.46, 129.70, 123.16, 122.42, 120.86, 117.06, 114.68, 55.93.

HRMS (ESI): exact mass calcd for $C_{16}H_{14}O_3$: m/z 255.1021 [M+H]$^+$, found: m/z 255.1019.



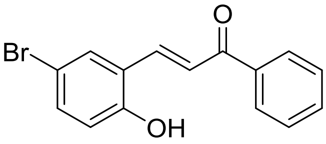
1g

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1g** was isolated as yellow solid in 64% yield (1.37 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.18 (s, 1H), 8.18 (d, *J* = 15.9 Hz, 1H), 7.91-7.84 (m, 1H), 7.76 (dd, *J* = 7.8, 1.6 Hz, 1H), 7.72 (d, *J* = 15.8 Hz, 1H), 7.50 (d, *J* = 3.5 Hz, 1H), 7.28 (ddd, *J* = 8.6, 7.3, 1.7 Hz, 1H), 7.00 (dd, *J* = 8.2, 1.2 Hz, 1H), 6.92 (td, *J* = 7.6, 1.2 Hz, 1H), 6.71 (dd, *J* = 3.5, 1.7 Hz, 1H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 178.21, 157.90, 154.86, 147.88, 139.37, 132.67, 129.76, 122.73, 122.10, 120.89, 118.19, 117.11, 113.24.

HRMS (ESI): exact mass calcd for $C_{13}H_{10}O_3$: m/z 215.0708 [M+H]$^+$, found: m/z 215.0710.



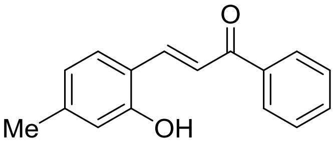
1h

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1h** was isolated as yellow solid in 85% yield (2.58 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.44 (s, 1H), 8.17-8.08 (m, 3H), 8.01 (d, *J* = 2.5 Hz, 1H), 7.96 (d, *J* = 15.8 Hz, 1H), 7.66-7.62 (m, 1H), 7.55 (t, *J* = 7.7 Hz, 2H), 7.40 (dd, *J* = 8.7, 2.5 Hz, 1H), 6.97 (d, *J* = 8.7 Hz, 1H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 190.11, 156.97, 139.24, 138.55, 134.93, 133.67, 131.70, 129.57, 129.36, 125.31, 123.65, 119.13, 112.55.

HRMS (ESI): exact mass calcd for $C_{15}H_{11}BrO_2$: m/z 303.0020 [M+H]$^+$, found: m/z 303.0019.



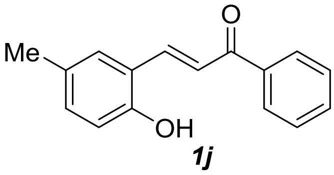
1i

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1i** was isolated as yellow solid in 77% yield (1.83 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.06 (s, 1H), 8.15 (d, *J* = 15.7 Hz, 1H), 8.11-8.08 (m, 2H), 7.83 (d, *J* = 15.8 Hz, 1H), 7.69 (d, *J* = 7.9 Hz, 1H), 7.62 (t, *J* = 7.3 Hz, 1H), 7.54 (t, *J* = 7.5 Hz, 2H), 6.83 (s, 1H), 6.76 (dd, *J* = 7.5, 1.2 Hz, 1H), 2.29 (s, 3H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 190.37, 157.92, 143.39, 140.64, 139.65, 133.29, 129.81, 129.46, 129.12, 121.96, 121.46, 120.35, 117.60, 21.51.

HRMS (ESI): exact mass calcd for $C_{16}H_{14}O_2$: m/z 239.1072 [M+H]$^+$, found: m/z 239.1070.



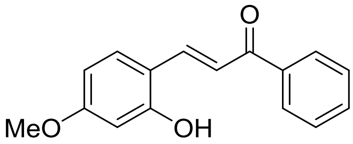
1j

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1j** was isolated as yellow solid in 71% yield (1.69 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.96 (s, 1H), 8.20 (d, *J* = 15.8 Hz, 1H), 8.15-8.12 (m, 2H), 7.91 (d, *J* = 15.8 Hz, 1H), 7.70-7.65 (m, 2H), 7.62-7.56 (m, 2H), 7.14 (dd, *J* = 8.3, 2.2 Hz, 1H), 6.93 (d, *J* = 8.3 Hz, 1H), 2.32 (s, 3H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 191.10, 156.57, 141.36, 140.31, 134.13, 134.10, 130.59, 130.57, 130.24, 129.92, 123.37, 122.95, 117.77, 21.18.

HRMS (ESI): exact mass calcd for $C_{16}H_{14}O_2$: m/z 239.1072 $[M+H]^+$, found: m/z 239.1072.



1k

Following the general procedure for the synthesis of 2-hydroxylchalcone, compound **1k** was isolated as yellow solid in 73% yield (1.86 g).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 9.27 (s, 1H), 8.18 (d, *J* = 15.7 Hz, 1H), 8.13-8.10 (m, 2H), 7.83-7.77 (m, 2H), 7.66-7.64 (m, 1H), 7.60-7.56 (m, 2H), 6.60-6.58 (d, 2H), 3.85 (s, 3H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 190.99, 164.72, 160.23, 141.35, 140.58, 133.91, 132.05, 130.18, 129.82, 120.64, 116.96, 108.23, 103.00, 56.47.

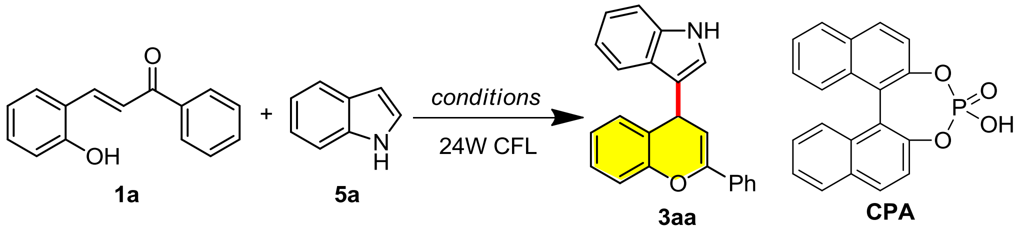
HRMS (ESI): exact mass calcd for $C_{16}H_{14}O_3$: m/z 255.1021 $[M+H]^+$, found: m/z 255.1023.

3. Optimization of Reaction Conditions.

General Procedure

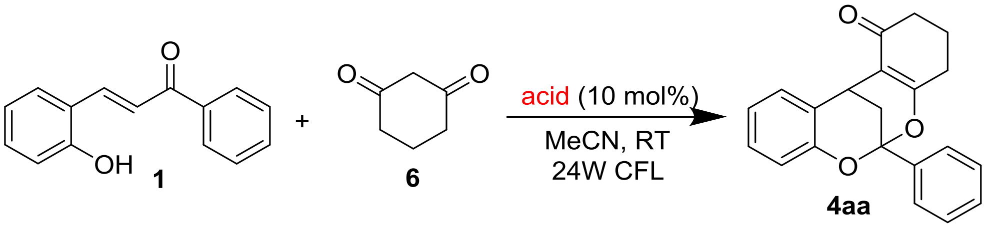
2-Hydroxylchalcone (0.1 mmol), nucleophile (0.12 mmol), acid (10 mol%) and acetonitrile (3.0 mL) were added to a reaction tube equipped with a magnetic stir bar. The mixture was stirred with irradiation by 24W CFL at room temperature under argon and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel to yield **4aa**, **4ba** or **4ca**.

Table S1. The Screening of Solvent for the Reaction of Indole with 2-Hydroxylchalcone



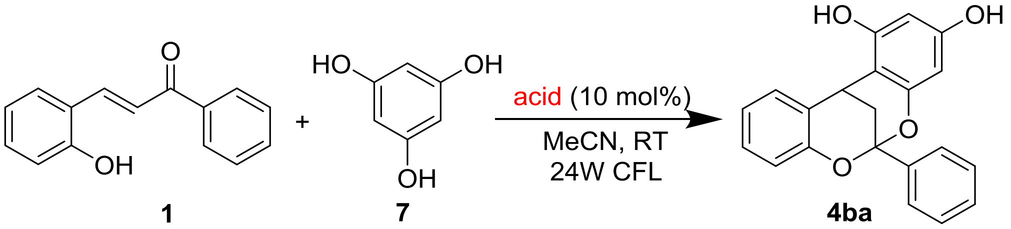
entry	catalyst	solvent	time (h)	yield (%)
1	biphenyl phosphate	MeCN	30	98
2	biphenyl phosphate	THF	19	98
3	biphenyl phosphate	DCM	72	61
4	biphenyl phosphate	toluene	69	60
5	biphenyl phosphate	EA	40	85
6	biphenyl phosphate	EtOH	40	90

Table S2. The Screening of Acid for the Model Reaction of 1, 3-Cyclohexanedione with 2-Hydroxylchalcone



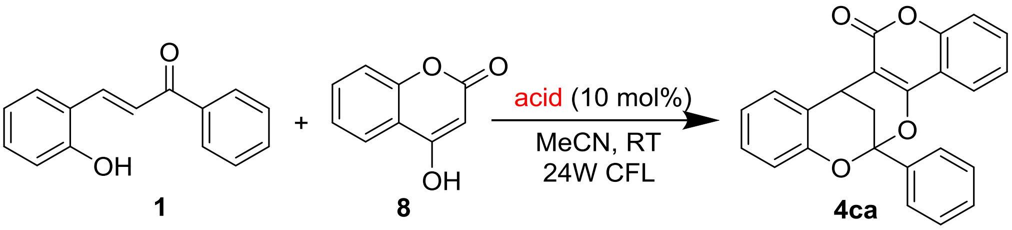
Entry	Acid	Time (h)	Yield (%)
1	None	24	trace
2	HCl	10	96
3	TsOH	10	80
4	Diphenyl phosphate	34	93
5	（±）CSA	10	62
6	HBF_4	17	53
7	HOTf	15	47
8	$HNTf_2$	12	41
9	Benzoic acid	24	trace
10	（±）CPA	18	75

Table S3. The Screening of Acid for the Model Reaction of Phloroglucinol with 2-Hydroxylchalcone



Entry	Acid	Time (h)	Yield (%)
1	None	21	39
2	HCl	20	44
3	TsOH	24	80
4	TFA	35	0
5	（±）CPA	15	63

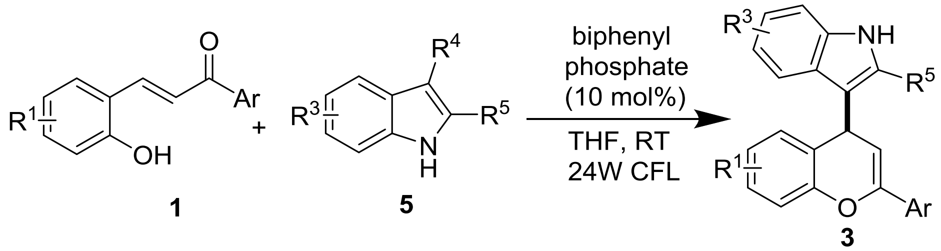
Table S4. The Screening of Acid for the Model Reaction of 4-Hydroxycoumarin with 2-Hydroxylchalcone



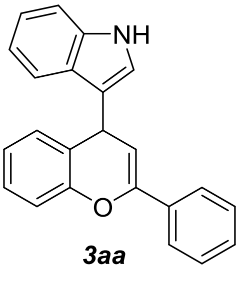
Entry	Acid	Time (h)	Yield (%)
1	None	24	trace
2	HCl	25	75
3	TsOH	33	65
4	Diphenyl phosphate	35	68
5	（±）CSA	35	55
6	（±）CPA	15	75

4. Substrate Scope of the Synthesis of Hybrid Flavonoids

4.1 General Procedure for the Synthesis of Flavonoids 3aa-3ax.



2-Hydroxylchalcone (0.1 mmol), indole (0.12 mmol), biphenyl phosphate (0.01 mmol) and THF (3.0 mL) were added to a reaction tube equipped with a magnetic stir bar. The mixture was stirred under the irradiation of 24W CFL at room temperature under argon overnight and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (EtOAc/petroleum ether = 1: 15) to yield the desired products.



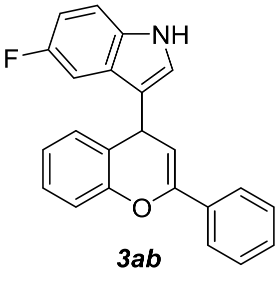
3aa

Following the general procedure, compound **3aa** was isolated as red oil in 98% yield (31.7 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.94 (s, 1H), 7.79 – 7.72 (m, 2H), 7.66 (d, *J* = 8.0 Hz, 1H), 7.43 – 7.32 (m, 4H), 7.22 – 7.12 (m, 4H), 7.08 (t, *J* = 7.5 Hz, 1H), 7.04 (d, *J* = 2.4 Hz, 1H), 6.97 – 6.92 (m, 1H), 5.71 (d, *J* = 4.0 Hz, 1H), 5.19 (d, *J* = 3.9 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.47, 148.09, 136.98, 134.74, 129.82, 128.69, 128.63, 127.86, 126.68, 125.06, 123.72, 122.47, 122.41, 121.90, 119.97, 119.72, 116.83, 111.56, 101.38, 32.46.

HRMS (ESI): exact mass calcd for $C_{23}H_{17}NO$: m/z 324.1388 $[M+H]^+$, found: m/z 324.1385.



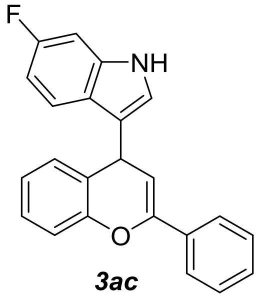
3ab

Following the general procedure, compound **3ab** was isolated as red oil in 85% yield (29.0 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.03 (s, 1H), 7.77-7.69 (m, 2H), 7.41-7.31 (m, 3H), 7.27-7.22 (m, 2H), 7.21-7.12 (m, 2H), 7.12-7.05 (m, 2H), 6.97-6.88 (m, 2H), 5.65 (d, *J* = 4.1 Hz, 1H), 5.11 (d, *J* = 4.0 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 158.02 (d, *J* = 234.7 Hz), 151.46, 148.33, 134.62, 133.52, 129.68, 128.79, 128.66, 128.02, 126.97 (d, *J* = 8.9 Hz),, 125.08, 124.11, 123.79, 123.34, 122.03 (d, *J* = 4.7 Hz), 116.98, 112.16 (d, *J* = 9.6 Hz), 110.94 (d, *J* = 26.5 Hz), 104.68 (d, *J* = 23.6 Hz), 100.92, 32.49.

HRMS (ESI): exact mass calcd for $C_{23}H_{16}FNO$: m/z 340.1138 $[M-H]^-$, found: m/z 340.1133.



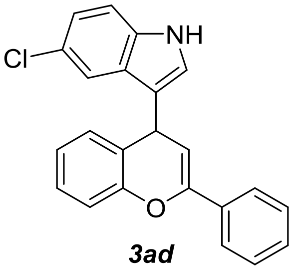
3ac

Following the general procedure, compound **3ac** was isolated as red oil in 78% yield (26.6 mg).

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.99 (s, 1H), 7.76-7.68 (m, 2H), 7.51-7.47 (m, 1H), 7.42-7.32 (m, 3H), 7.21-7.13 (m, 2H), 7.09 (d, *J* = 7.6 Hz, 1H), 7.05 (d, *J* = 2.4 Hz, 1H), 7.02 (dd, *J* = 9.6, 2.3 Hz, 1H), 6.97-6.92 (m, 1H), 6.85-6.77 (m, 1H), 5.66 (d, *J* = 4.0 Hz, 1H), 5.13 (d, *J* = 3.9 Hz, 1H).

^{13}C NMR (126 MHz, $CDCl_3$): δ 160.30 (d, *J* = 237.9 Hz), 151.43, 148.22, 136.97 (d, *J* = 12.4 Hz), 134.62, 129.71, 128.79, 128.67, 127.98, 125.05, 123.78, 123.45, 123.22, 122.52 (d, *J* = 3.5 Hz), 121.79, 120.48 (d, *J* = 10.0 Hz), 116.89, 108.74 (d, *J* = 24.4 Hz), 101.16, 97.84 (d, *J* = 26.1 Hz), 32.52.

HRMS (ESI): exact mass calcd for $C_{23}H_{16}FNO$: m/z 340.1138 $[M-H]^-$, found: m/z 340.1134.



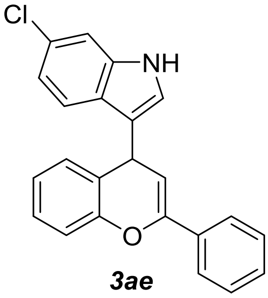
3ad

Following the general procedure, compound **3ad** was isolated as red oil in 79% yield (28.3 mg).

^{1}H NMR (500 MHz, $CDCl_3$): δ 8.05 (s, 1H), 7.77-7.71 (m, 2H), 7.59 (d, *J* = 1.9 Hz, 1H), 7.42-7.32 (m, 3H), 7.27-7.24 (m, 1H), 7.22-7.18 (m, 1H), 7.17-7.07 (m, 3H), 7.04 (d, *J* = 2.4 Hz, 1H), 6.95 (td, *J* = 7.4, 1.5 Hz, 1H), 5.65 (d, *J* = 4.0 Hz, 1H), 5.13 (d, *J* = 4.0 Hz, 1H).

^{13}C NMR (126 MHz, $CDCl_3$): δ 151.45, 148.37, 135.29, 134.62, 129.64, 128.80, 128.67, 128.05, 127.72, 125.71, 125.09, 123.96, 123.81, 123.35, 122.86, 121.78, 119.09, 117.00, 112.58, 100.93, 32.28.

HRMS (ESI): exact mass calcd for $C_{23}H_{16}ClNO$: m/z 358.0998 $[M+H]^+$, found: m/z 358.0994.

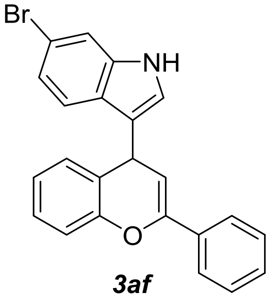


3ae

Following the general procedure, compound **3ae** was isolated as red oil in 77% yield (27.6 mg).

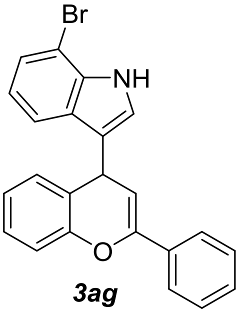
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.97 (s, 1H), 7.78-7.71 (m, 2H), 7.51 (d, *J* = 8.5 Hz, 1H), 7.43-7.34 (m, 3H), 7.32 (d, *J* = 1.6 Hz, 1H), 7.23-7.15 (m, 2H), 7.11-7.07 (m, 1H), 7.04-6.99 (m, 2H), 6.99-6.92 (m, 1H), 5.66 (d, *J* = 4.0 Hz, 1H), 5.13 (d, *J* = 4.0 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.41, 148.27, 137.36, 134.58, 129.68, 128.81, 128.67, 128.43, 128.02, 125.22, 125.06, 123.80, 123.37, 122.90, 121.92, 120.71, 120.59, 116.92, 111.50, 101.03, 32.44.
HRMS (ESI): exact mass calcd for $C_{23}H_{16}ClNO$: m/z 358.0998 $[M+H]^+$, found: m/z 358.0995.



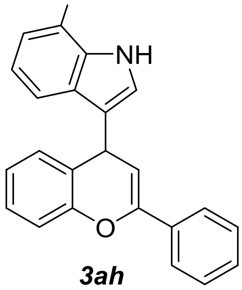
3af

Following the general procedure, compound **3af** was isolated as red oil in 86% yield (34.6 mg).
^{1}H NMR (500 MHz, CDCl$_3$): δ 8.01 (s, 1H), 7.78-7.68 (m, 2H), 7.49 (d, *J* = 1.7 Hz, 1H), 7.45 (d, *J* = 8.5 Hz, 1H), 7.41-7.32 (m, 3H), 7.21-7.12 (m, 3H), 7.09-7.02 (m, 2H), 6.96-6.91 (m, 1H), 5.64 (d, *J* = 4.0 Hz, 1H), 5.13 (d, *J* = 3.9 Hz, 1H).
^{13}C NMR (126 MHz, CDCl$_3$): δ 151.40, 148.29, 137.81, 134.58, 129.68, 128.81, 128.67, 128.02, 125.54, 125.06, 123.80, 123.35, 123.28, 122.85, 121.99, 120.98, 116.92, 116.08, 114.50, 101.00, 32.44.
HRMS (ESI): exact mass calcd for $C_{23}H_{16}BrNO$: m/z 402.0493 $[M+H]^+$, found: m/z 402.0488.



3ag

Following the general procedure, compound **3ag** was isolated as red oil in 78% yield (31.4 mg).
^{1}H NMR (500 MHz, CDCl$_3$): δ 8.19 (s, 1H), 7.77-7.70 (m, 2H), 7.55 (d, *J* = 8.0 Hz, 1H), 7.42-7.31 (m, 4H), 7.22-7.13 (m, 3H), 7.11-7.07 (m, 1H), 6.97-6.91 (m, 2H), 5.66 (d, *J* = 4.0 Hz, 1H), 5.15 (d, *J* = 3.9 Hz, 1H).
^{13}C NMR (126 MHz, CDCl$_3$): δ 151.41, 148.30, 135.67, 134.59, 129.73, 128.81, 128.66, 128.04, 127.85, 125.07, 124.81, 123.81, 123.27, 123.03, 122.86, 121.18, 119.04, 116.93, 105.19, 100.94, 32.72.
HRMS (ESI): exact mass calcd for $C_{23}H_{16}BrNO$: m/z 402.0493 $[M+H]^+$, found: m/z 402.0491.



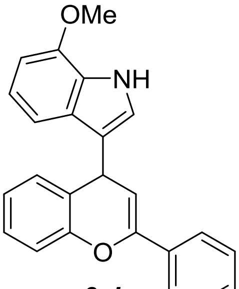
3ah

Following the general procedure, compound **3ah** was isolated as red oil in 83% yield (28.0 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.94 (s, 1H), 7.77-7.72 (m, 2H), 7.53-7.49 (m, 1H), 7.42-7.32 (m, 3H), 7.21-7.13 (m, 3H), 7.05 (d, *J* = 2.4 Hz, 1H), 7.03-6.98 (m, 2H), 6.96-6.92 (m, 1H), 5.70 (d, *J* = 4.0 Hz, 1H), 5.18 (d, *J* = 3.9 Hz, 1H), 2.48 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.44, 148.01, 136.51, 134.74, 129.83, 128.66, 128.61, 127.82, 126.19, 125.03, 123.76, 123.71, 123.00, 122.39, 122.15, 120.72, 120.20, 117.44, 116.81, 101.41, 32.52, 16.91.

HRMS (ESI): exact mass calcd for $C_{24}H_{19}NO$: m/z 336.1389 $[M-H]^-$, found: m/z 336.1392.



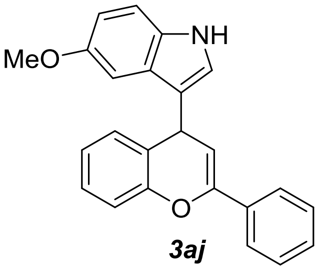
3ai

Following the general procedure, compound **3ai** was isolated as red oil in 88% yield (31.1 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.23 (s, 1H), 7.78-7.68 (m, 2H), 7.42-7.31 (m, 3H), 7.24 (d, *J* = 8.0 Hz, 1H), 7.20-7.09 (m, 3H), 7.04 (d, *J* = 2.4 Hz, 1H), 6.98 (t, *J* = 7.9 Hz, 1H), 6.96-6.91 (m, 1H), 6.63 (d, *J* = 7.7 Hz, 1H), 5.69 (d, *J* = 4.0 Hz, 1H), 5.16 (d, *J* = 3.9 Hz, 1H), 3.94 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.45, 148.05, 146.54, 134.79, 129.86, 128.65, 128.61, 128.02, 127.82, 127.52, 125.07, 123.80, 123.70, 122.37, 121.98, 120.37, 116.81, 112.47, 102.33, 101.44, 55.65, 32.55.

HRMS (ESI): exact mass calcd for $C_{24}H_{19}NO_2$: m/z 352.1338 $[M-H]^-$, found: m/z 352.1334.



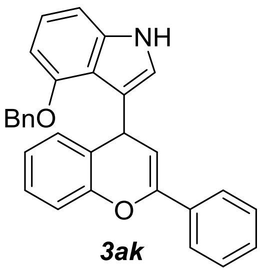
3aj

Following the general procedure, compound **3aj** was isolated as red oil in 84% yield (29.7 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.92 (s, 1H), 7.76-7.71 (m, 2H), 7.41-7.31 (m, 3H), 7.23 (d, *J* = 8.8 Hz, 1H), 7.20-7.12 (m, 3H), 7.08 (d, *J* = 2.2 Hz, 1H), 7.03 (d, *J* = 2.3 Hz, 1H), 6.97-6.93 (m, 1H), 6.84 (dd, *J* = 8.8, 2.4 Hz, 1H), 5.68 (d, *J* = 4.0 Hz, 1H), 5.13 (d, *J* = 3.9 Hz, 1H), 3.75 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 154.27, 151.52, 148.18, 134.76, 132.14, 129.84, 128.68, 128.62, 127.86, 127.10, 125.04, 123.76, 123.72, 123.09, 121.60, 116.77, 112.57, 112.25, 101.54, 101.35, 56.10, 32.49.

HRMS (ESI): exact mass calcd for $C_{24}H_{19}NO_2$: m/z 354.1494 $[M+H]^+$, found: m/z 354.1489.



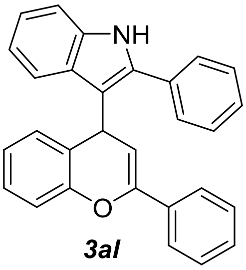
3ak

Following the general procedure, compound **3ak** was isolated as red oil in 79% yield (34.0 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.89 (s, 1H), 7.71-7.65 (m, 2H), 7.50 (d, *J* = 7.0 Hz, 2H), 7.39-7.28 (m, 7H), 7.23-7.18 (m, 1H), 7.14-7.09 (m, 2H), 7.01-6.95 (m, 2H), 6.70-6.60 (m, 2H), 5.90 (d, *J* = 4.4 Hz, 1H), 5.62 (d, *J* = 4.1 Hz, 1H), 5.34-5.26 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 153.93, 151.66, 147.04, 138.33, 137.62, 134.99, 130.38, 128.89, 128.50, 128.37, 128.09, 127.60, 127.54, 124.88, 124.77, 123.39, 123.13, 122.37, 116.78, 116.70, 105.13, 102.76, 101.17, 70.26, 32.56.

HRMS (ESI): exact mass calcd for $C_{30}H_{23}NO_2$: m/z 430.1807 $[M+H]^+$, found: m/z 430.1805.



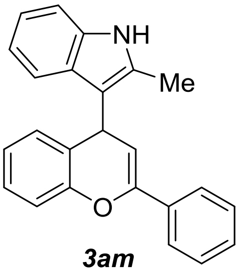
3al

Following the general procedure, compound **3al** was isolated as red oil in 84% yield (33.5 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.07 (s, 1H), 7.77-7.71 (m, 2H), 7.67-7.62 (m, 2H), 7.53-7.32 (m, 8H), 7.20-7.13 (m, 3H), 7.01-6.94 (m, 2H), 6.91-6.86 (m, 1H), 5.64 (d, *J* = 3.5 Hz, 1H), 5.41 (d, *J* = 3.4 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.39, 148.00, 136.30, 135.08, 134.41, 132.84, 129.30, 129.01, 128.60, 128.36, 128.30, 128.24, 127.83, 127.60, 124.78, 123.51, 123.34, 122.36, 120.48, 119.87, 116.40, 116.38, 110.82, 101.32, 31.45.

HRMS (ESI): exact mass calcd for $C_{29}H_{21}NO$: m/z 400.1701 $[M+H]^+$, found: m/z 400.1697.



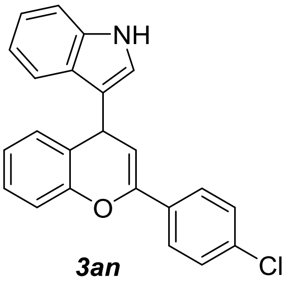
3am

Following the general procedure, compound **3am** was isolated as red oil in 83% yield (27.9 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.79-7.75 (m, 2H), 7.73 (s, 1H), 7.50 (d, *J* = 7.9 Hz, 1H), 7.44-7.34 (m, 3H), 7.28-7.25 (m, 1H), 7.22-7.15 (m, 2H), 7.14-7.09 (m, 1H), 7.04-6.98 (m, 2H), 6.95-6.90 (m, 1H), 5.61 (d, *J* = 3.8 Hz, 1H), 5.23 (d, *J* = 3.7 Hz, 1H), 2.40 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.55, 148.00, 135.47, 134.73, 131.76, 129.74, 128.62, 128.17, 127.76, 124.98, 123.75, 123.64, 121.38, 119.76, 118.90, 116.64, 116.31, 110.52, 101.23, 31.32, 12.22.

HRMS (ESI): exact mass calcd for $C_{24}H_{19}NO$: m/z 336.1389 $[M-H]^-$, found: m/z 336.1385.



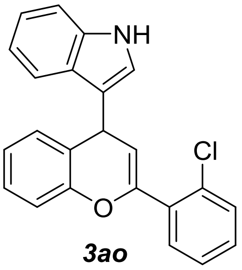
3an

Following the general procedure, compound **3an** was isolated as red oil in 88% yield (31.5 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.00 (s, 1H), 7.69-7.64 (m, 2H), 7.62 (d, *J* = 8.0 Hz, 1H), 7.38-7.33 (m, 3H), 7.22-7.11 (m, 4H), 7.10-7.05 (m, 1H), 7.03 (d, *J* = 1.7 Hz, 1H), 6.97-6.93 (m, 1H), 5.68 (d, *J* = 4.0 Hz, 1H), 5.17 (d, *J* = 3.9 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.27, 147.11, 136.96, 134.42, 133.15, 129.85, 128.78, 127.94, 126.58, 126.31, 123.88, 123.49, 122.52, 122.41, 121.61, 119.99, 119.61, 116.78, 111.62, 101.80, 32.42.

HRMS (ESI): exact mass calcd for $C_{23}H_{16}ClNO$: m/z 356.0842 [M-H]$^-$, found: m/z 356.0839.



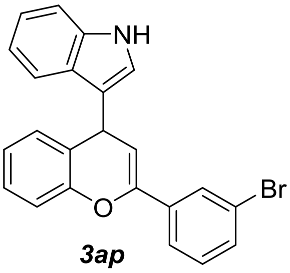
3ao

Following the general procedure, compound **3ao** was isolated as red oil in 88% yield (31.6 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.99 (s, 1H), 7.75 (d, *J* = 7.9 Hz, 1H), 7.58-7.52 (m, 1H), 7.46-7.41 (m, 1H), 7.36 (d, *J* = 8.1 Hz, 1H), 7.32-7.27 (m, 2H), 7.22-7.07 (m, 6H), 6.97-6.92 (m, 1H), 5.45 (d, *J* = 3.9 Hz, 1H), 5.19 (d, *J* = 4.5 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.52, 147.44, 136.98, 134.79, 133.45, 131.07, 130.44, 130.10, 129.81, 127.87, 126.96, 126.65, 123.83, 123.67, 122.51, 122.45, 121.63, 119.92, 119.81, 116.80, 111.57, 106.31, 32.59.

HRMS (ESI): exact mass calcd for $C_{23}H_{16}ClNO$: m/z 358.0998 [M+H]$^+$, found: m/z 358.0994.



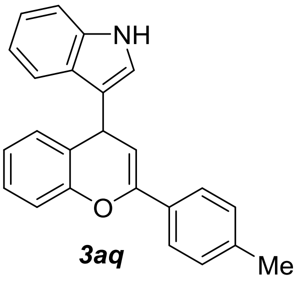
3ap

Following the general procedure, compound **3ap** was isolated as red oil in 87% yield (35.1 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.00 (s, 1H), 7.76 (d, *J* = 8.0 Hz, 1H), 7.65 (dd, *J* = 8.0, 1.3 Hz, 1H), 7.49 (dd, *J* = 7.6, 1.8 Hz, 1H), 7.38-7.30 (m, 2H), 7.25-7.08 (m, 7H), 6.98-6.91 (m, 1H), 5.38 (d, *J* = 3.8 Hz, 1H), 5.19 (d, *J* = 3.7 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.50, 148.80, 136.96, 136.87, 133.61, 131.41, 130.38, 129.80, 127.87, 127.55, 126.64, 123.85, 123.70, 122.99, 122.56, 122.45, 121.61, 119.90, 119.86, 116.83, 111.57, 106.04, 32.59.

HRMS (ESI): exact mass calcd for $C_{23}H_{16}BrNO$: m/z 402.0493 [M+H]$^+$, found: m/z 402.0491.



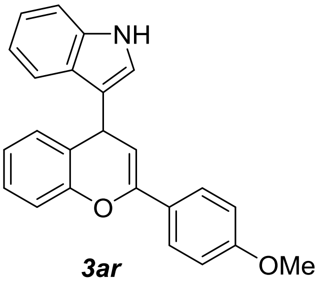
3aq

Following the general procedure, compound **3aq** was isolated as red oil in 85% yield (28.6 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.99 (s, 1H), 7.68-7.61 (m, 3H), 7.35 (d, *J* = 8.2 Hz, 1H), 7.22-7.12 (m, 6H), 7.09-7.03 (m, 2H), 6.96-6.91 (m, 1H), 5.65 (d, *J* = 4.0 Hz, 1H), 5.17 (d, *J* = 3.9 Hz, 1H), 2.39 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.47, 148.10, 138.55, 136.94, 131.93, 129.80, 129.31, 127.79, 126.66, 124.95, 123.79, 123.61, 122.41, 122.39, 121.94, 119.90, 119.74, 116.82, 111.54, 100.51, 32.41, 21.58.

HRMS (ESI): exact mass calcd for $C_{24}H_{19}NO$: m/z 336.1389 $[M-H]^-$, found: m/z 336.1385.



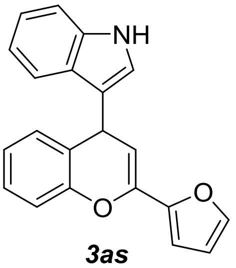
3ar

Following the general procedure, compound **3ar** was isolated as red oil in 69% yield (24.4 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.01 (s, 1H), 7.72-7.60 (m, 3H), 7.35 (d, *J* = 8.1 Hz, 1H), 7.20-7.03 (m, 6H), 6.95-6.87 (m, 3H), 5.57 (d, *J* = 3.9 Hz, 1H), 5.16 (d, *J* = 3.8 Hz, 1H), 3.83 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 160.10, 151.51, 147.89, 136.98, 129.81, 127.78, 127.46, 126.69, 126.41, 123.84, 123.61, 122.42, 122.37, 122.06, 119.91, 119.76, 116.79, 114.00, 111.55, 99.71, 55.66, 32.43.

HRMS (ESI): exact mass calcd for $C_{24}H_{19}NO_2$: m/z 352.1338 $[M-H]^-$, found: m/z 352.1339.



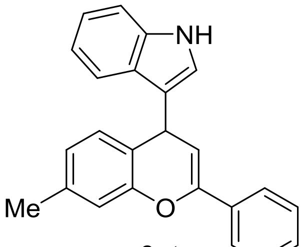
3as

Following the general procedure, compound **3as** was isolated as red oil in 85% yield (26.6 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.00 (s, 1H), 7.61 (d, *J* = 7.9 Hz, 1H), 7.39-7.33 (m, 2H), 7.20-7.05 (m, 5H), 7.03 (d, *J* = 2.3 Hz, 1H), 6.95-6.90 (m, 1H), 6.67 (d, *J* = 3.3 Hz, 1H), 6.45 (dd, *J* = 3.3, 1.8 Hz, 1H), 5.71 (d, *J* = 4.1 Hz, 1H), 5.15 (d, *J* = 4.0 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.04, 149.12, 142.58, 141.36, 136.96, 129.98, 127.90, 126.63, 123.81, 123.69, 122.47, 121.67, 119.95, 119.66, 116.78, 111.56, 111.49, 106.75, 100.33, 31.76.

HRMS (ESI): exact mass calcd for $C_{21}H_{15}NO_2$: m/z 312.1025 $[M-H]^-$, found: m/z 312.1022.



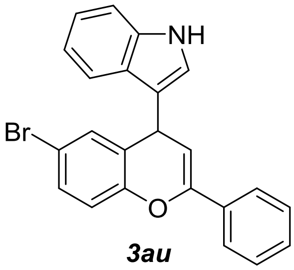
3at

Following the general procedure, compound **3at** was isolated as red oil in 83% yield (27.9 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.99 (s, 1H), 7.77-7.71 (m, 2H), 7.65 (d, *J* = 7.9 Hz, 1H), 7.41-7.33 (m, 4H), 7.20-7.16 (m, 1H), 7.09-6.99 (m, 4H), 6.78-6.74 (m, 1H), 5.69 (d, *J* = 4.0 Hz, 1H), 5.14 (d, *J* = 3.9 Hz, 1H), 2.33 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 151.22, 148.01, 137.80, 136.96, 134.82, 129.52, 128.60, 126.67, 125.02, 124.64, 122.41, 122.33, 121.99, 120.67, 119.89, 119.73, 117.16, 111.54, 101.45, 32.17, 21.38.

HRMS (ESI): exact mass calcd for $C_{24}H_{19}NO$: m/z 336.1389 [M-H]$^-$, found: m/z 336.1386.



3au

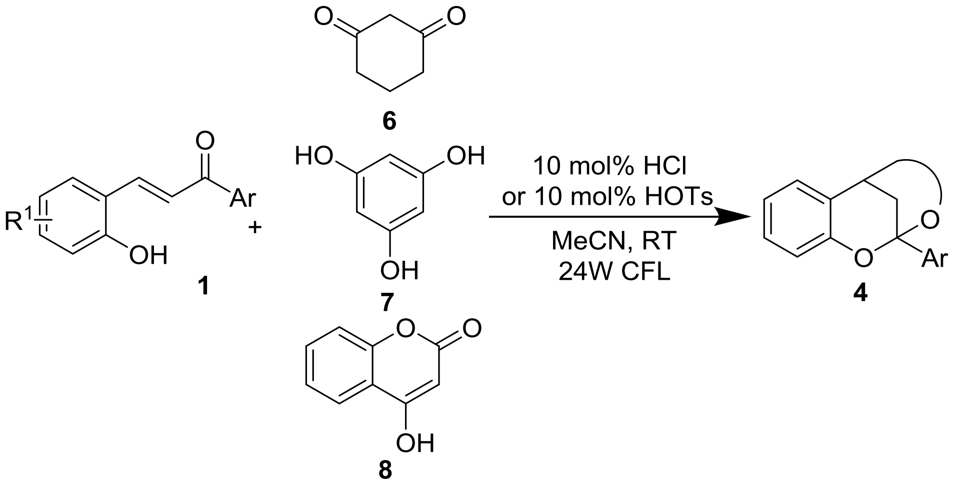
Following the general procedure, compound **3au** was isolated as red oil in 83% yield (33.3 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.98 (s, 1H), 7.69 (d, *J* = 7.5 Hz, 2H), 7.58 (d, *J* = 8.0 Hz, 1H), 7.41-7.30 (m, 4H), 7.27-7.15 (m, 3H), 7.07-6.95 (m, 3H), 5.64 (d, *J* = 3.7 Hz, 1H), 5.09 (d, *J* = 2.9 Hz, 1H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 152.09, 149.12, 139.11, 135.67, 133.82, 132.18, 130.31, 130.19, 128.33, 127.99, 126.25, 124.58, 123.31, 121.40, 120.74, 120.58, 120.28, 116.74, 113.41, 102.83, 33.80.

HRMS (ESI): exact mass calcd for $C_{23}H_{16}BrNO$: m/z 402.0493 [M+H]$^+$, found: m/z 402.0491.

4.2 General Procedure for the Bio-inspired Synthesis of Hybrid Flavonoids 4aa-4cj.

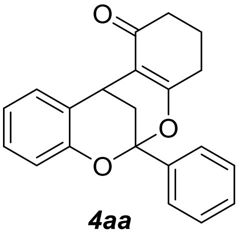


General Proceduer A

To a reaction tube equipped with a magnetic stir bar was added 2-hydroxylchalcone (0.1 mmol), nucleophile (0.12 mmol), HCl (0.01 mmol, 1M) and acetonitrile (3.0 mL). The mixture was stirred under the irradiation of 24W CFL at room temperature under argon overnight and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (EtOAc/petroleum ether = 1: 8) to yield the desired products.

General Proceduer B

To a reaction tube equipped with a magnetic stir bar was added 2-hydroxylchalcone (0.1 mmol), nucleophile (0.12 mmol), HOTs (0.01 mmol) and acetonitrile (3.0 mL). The mixture was stirred under the irradiation of 24W CFL at room temperature under argon overnight and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (Acetone/DCM = 1: 20) to yield the desired products.



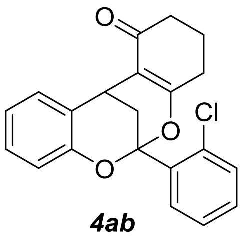
4aa

Following the **general procedure A**, compound **4aa** was isolated as white solid in 96% yield (30.5 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.75-7.58 (m, 2H), 7.50-7.36 (m, 4H), 7.16 (td, *J* = 8.3, 1.7 Hz, 1H), 7.02 (d, *J* = 8.1 Hz, 1H), 6.93 (td, *J* = 7.4, 1.3 Hz, 1H), 4.24 (t, *J* = 3.1 Hz, 1H), 2.61-2.46 (m, 2H), 2.45-2.28 (m, 2H), 2.25 (dd, *J* = 3.0, 13.0 Hz, 1H), 2.17 (dd, *J* = 3.0, 13.0 Hz, 1H), 2.06-1.92 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.31, 169.43, 151.85, 140.55, 129.39, 128.74, 128.53, 127.92, 126.90, 125.92, 121.88, 116.91, 116.30, 100.00, 36.78, 33.35, 28.16, 25.57, 21.08.

HRMS (ESI): exact mass calcd for $C_{21}H_{18}O_3$: m/z 319.1334 [M+H]$^+$, found: m/z 319.1334.



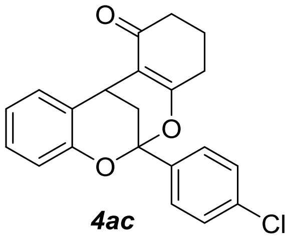
4ab

Following the **general procedure A**, compound **4ab** was isolated as white solid in 99% yield (34.9 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.05-7.96 (m, 1H), 7.50-7.43 (m, 1H), 7.41-7.33 (m, 3H), 7.17 (td, *J* = 7.7, 1.7 Hz, 1H), 7.03 (d, *J* = 8.0 Hz, 1H), 6.94 (td, *J* = 7.4, 1.2 Hz, 1H), 4.25 (t, *J* = 3.1 Hz, 1H), 2.65-2.53 (m, 1H), 2.54-2.28 (m, 5H), 2.08-1.91 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.31, 169.18, 151.35, 136.83, 132.78, 132.07, 130.72, 128.76, 128.55, 127.99, 127.24, 127.01, 122.03, 117.17, 116.52, 99.63, 36.79, 29.62, 27.92, 25.04, 21.04.

HRMS (ESI): exact mass calcd for $C_{21}H_{17}ClO_3$: m/z 353.0944 [M+H]$^+$, found: m/z 353.0942.



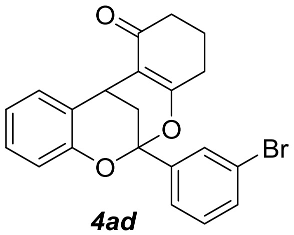
4ac

Following the **general procedure A**, compound **4ac** was isolated as white solid in 95% yield (33.4 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.64-7.56 (m, 2H), 7.46-7.36 (m, 3H), 7.16 (td, *J* = 7.8, 1.6 Hz, 1H), 7.00 (d, *J* = 8.1 Hz, 1H), 6.93 (td, *J* = 7.4, 1.1 Hz, 1H), 4.23 (t, *J* = 3.1 Hz, 1H), 2.59-2.45 (m, 2H), 2.44-2.28 (m, 2H), 2.21 (dd, *J* = 13.3, 2.9 Hz, 1H), 2.13 (dd, *J* = 13.3, 3.2 Hz, 1H),, 2.05-1.92 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.29, 169.18, 151.67, 139.17, 135.44, 128.96, 128.58, 128.02, 127.51, 126.74, 122.07, 116.93, 116.28, 99.63, 36.77, 33.30, 28.12, 25.51, 21.06.

HRMS (ESI): exact mass calcd for $C_{21}H_{17}ClO_3$: m/z 375.0764 [M+Na]$^+$, found: m/z 375.0754.



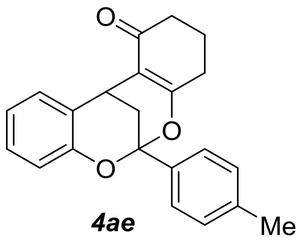
4ad

Following the **general procedure A**, compound **4ad** was isolated as white solid in 99% yield (39.2 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.06 (dd, *J* = 8.0, 1.7 Hz, 1H), 7.73 (dd, *J* = 7.9, 1.2 Hz, 1H), 7.50-7.43 (m, 2H), 7.31 (td, *J* = 7.7, 1.7 Hz, 1H), 7.22 (td, *J* = 7.8, 1.7 Hz, 1H), 7.09 (dd, *J* = 8.1, 1.1 Hz, 1H), 6.98 (td, *J* = 7.4, 1.2 Hz, 1H), 4.31-4.28 (m, 1H), 2.71-2.63 (m, 1H), 2.60 (dd, *J* = 13.4, 3.2 Hz, 1H), 2.57-2.43 (m, 2H), 2.43-2.35 (m, 2H), 2.11-1.97 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.26, 169.20, 151.35, 138.17, 135.62, 130.88, 129.00, 128.50, 127.96, 127.83, 126.99, 122.01, 121.38, 117.19, 116.58, 99.95, 36.77, 29.55, 27.92, 25.01, 21.03.

HRMS (ESI): exact mass calcd for $C_{21}H_{17}BrO_3$: m/z 419.0259 [M+Na]$^+$, found: m/z 419.0261.



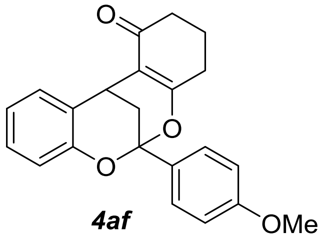
4ae

Following the **general procedure A**, compound **4ae** was isolated as white solid in 88% yield (29.3 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.58-7.53 (m, 2H), 7.40 (dd, *J* = 7.5, 1.7 Hz, 1H), 7.26 (d, *J* = 8.0 Hz, 2H), 7.15 (td, *J* = 7.7, 1.7 Hz, 1H), 7.01 (dd, *J* = 8.2, 1.1 Hz, 1H), 6.92 (td, *J* = 7.4, 1.2 Hz, 1H), 4.22 (t, *J* = 3.0 Hz, 1H), 2.59-2.46 (m, 2H), 2.44-2.37 (m, 1H, overlapped), 2.40(s, 3H,overlapped), 2.36-2.28 (m, 1H), 2.24 (dd, *J* = 13.4, 2.9 Hz, 1H), 2.16 (dd, *J* = 13.4, 3.2 Hz, 1H), 2.05-1.92 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.39, 169.56, 151.90, 139.31, 137.69, 129.40, 128.52, 127.89, 126.93, 125.82, 121.81, 116.87, 116.32, 100.06, 36.79, 33.30, 28.19, 25.60, 21.54, 21.09.

HRMS (ESI): exact mass calcd for $C_{22}H_{20}O_3$: m/z 333.1490 $[M+H]^+$, found: m/z 333.1487.



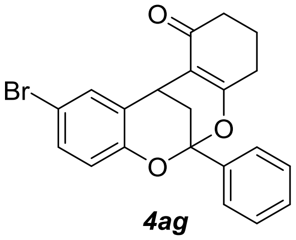
4af

Following the **general procedure A**, compound **4af** was isolated as white solid in 95% yield (33.0 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.62-7.56 (m, 2H), 7.40 (dd, *J* = 7.5, 1.7 Hz, 1H), 7.15 (ddd, *J* = 8.2, 7.4, 1.7 Hz, 1H), 7.00 (dd, *J* = 8.2, 1.1 Hz, 1H), 6.98 – 6.94 (m, 2H), 6.92 (td, *J* = 7.4, 1.2 Hz, 1H), 4.22 (t, *J* = 3.1 Hz, 1H), 3.85 (s, 3H), 2.58-2.45 (m, 2H), 2.44-2.27 (m, 2H), 2.23 (dd, *J* = 13.3, 2.9 Hz, 1H), 2.16 (dd, *J* = 13.4, 3.2 Hz, 1H), 2.05-1.91 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.36, 169.53, 160.42, 151.90, 132.81, 128.51, 127.88, 127.27, 126.92, 121.81, 116.86, 116.29, 114.02, 100.01, 55.70, 36.78, 33.35, 28.18, 25.65, 21.08.

HRMS (ESI): exact mass calcd for $C_{22}H_{20}O_4$: m/z 349.1440 $[M+H]^+$, found: m/z 349.1440.



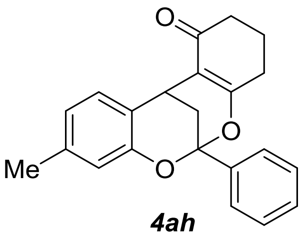
4ag

Following the **general procedure A**, compound **4ag** was isolated as white solid in 49% yield (19.5 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.66-7.61 (m, 2H), 7.54 (d, *J* = 2.4 Hz, 1H), 7.49-7.41 (m, 3H), 7.26-7.22 (m, 1H), 6.89 (d, *J* = 8.6 Hz, 1H), 4.19 (t, *J* = 3.1 Hz, 1H), 2.60-2.47 (m, 2H), 2.45-2.31 (m, 2H), 2.21 (dd, *J* = 13.5, 2.9 Hz, 1H), 2.17 (dd, *J* = 13.4, 3.2 Hz, 1H), 2.06-1.93 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.09, 169.51, 151.07, 140.10, 131.05, 130.85, 129.58, 128.96, 128.82, 125.85, 118.10, 116.38, 114.11, 100.00, 36.74, 32.96, 28.14, 25.46, 21.05.

HRMS (ESI): exact mass calcd for $C_{21}H_{17}BrO_3$: m/z 397.0439 $[M+H]^+$, found: m/z 397.0436.



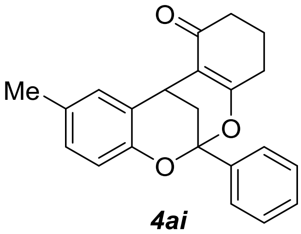
4ah

Following the **general procedure A**, compound **4ah** was isolated as white solid in 82% yield (27.3 mg).

^{1}H NMR (500 MHz, CDCl$_3$):δ 7.69-7.64 (m, 2H), 7.48-7.40 (m, 3H), 7.29 (d, *J* = 7.7 Hz, 1H), 6.86 (s, 1H), 6.77-6.72 (m, 1H), 4.20 (t, *J* = 2.6 Hz, 1H), 2.59-2.45 (m, 2H), 2.44-2.37 (m, 1H), 2.36-2.28 (m, 1H), 2.30 (s, 3H), 2.22 (dd, *J* = 13.3, 2.9 Hz, 1H), 2.15 (dd, *J* = 13.3, 3.2 Hz, 1H), 2.05-1.93 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.37, 169.37, 151.67, 140.66, 138.03, 129.36, 128.73, 128.23, 125.93, 123.97, 122.66, 117.14, 116.81, 100.00, 36.79, 33.60, 28.17, 25.22, 21.50, 21.09.

HRMS (ESI): exact mass calcd for $C_{22}H_{20}O_3$: m/z 333.1490 [M+H]$^+$, found: m/z 333.1488.



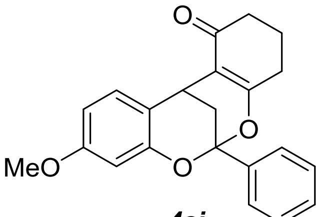
4ai

Following the **general procedure A**, compound **4ai** was isolated as white solid in 82% yield (27.1 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.66 (d, *J* = 7.1 Hz, 2H), 7.48-7.39 (m, 3H), 7.22 (s, 1H), 6.99-6.89 (m, 2H), 4.21-4.16 (m, 1H), 2.60-2.46 (m, 2H), 2.45-2.30 (m, 2H), 2.28 (s, 3H), 2.26-2.11 (m, 2H), 2.06-1.94 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 196.38, 169.56, 149.61, 140.65, 131.23, 129.34, 128.87, 128.71, 128.48, 126.57, 125.91, 116.91, 116.02, 100.01, 36.82, 33.48, 28.19, 25.53, 21.08, 20.85.

HRMS (ESI): exact mass calcd for $C_{22}H_{20}O_3$: m/z 333.1490 [M+H]$^+$, found: m/z 333.1487.



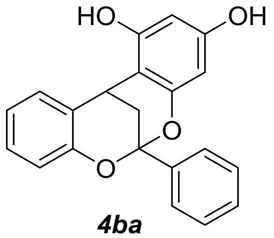
4aj

Following the **general procedure A**, compound **4aj** was isolated as white solid in 99% yield (34.4 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.68-7.64 (m, 2H), 7.48-7.40 (m, 3H), 7.29 (d, *J* = 8.4 Hz, 1H), 6.59 (d, *J* = 2.5 Hz, 1H), 6.50 (dd, *J* = 8.4, 2.5 Hz, 1H), 4.18 (t, *J* = 3.1 Hz, 1H), 3.76 (s, 3H), 2.59-2.46 (m, 2H), 2.44-2.29 (m, 2H), 2.24 (dd, *J* = 13.3, 2.9 Hz, 1H), 2.15 (dd, *J* = 13.3, 3.3 Hz, 1H), 2.05-1.93 (m, 2H).

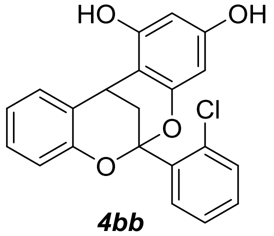
^{13}C NMR (126 MHz, CDCl$_3$): δ 196.37, 169.17, 159.66, 152.63, 140.57, 129.39, 128.86, 128.74, 125.90, 119.31, 117.37, 107.97, 101.98, 99.97, 55.72, 36.78, 33.69, 28.11, 24.90, 21.09.

HRMS (ESI): exact mass calcd for $C_{22}H_{20}O_4$: m/z 349.1440 [M+H]$^+$, found: m/z 349.1438.



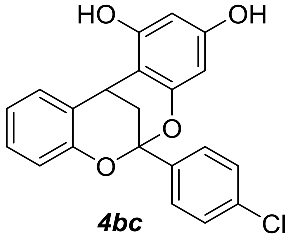
4ba

Following the **general procedure B**, compound **4ba** was isolated as brown oil in 80% yield (26.6 mg).
^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.66 (s, 1H), 8.19 (s, 1H), 7.82-7.75 (m, 2H), 7.55-7.43 (m, 4H), 7.18-7.12 (m, 1H), 6.99 (d, *J* = 8.0 Hz, 1H), 6.95-6.88 (m, 1H), 6.10 (d, *J* = 2.3 Hz, 1H), 6.08 (d, *J* = 2.2 Hz, 1H), 4.48 (t, *J* = 3.1 Hz, 1H), 2.40-2.31 (m, 2H).
^{13}C NMR (126 MHz, acetone-d$_6$): δ 158.74, 156.33, 155.03, 154.00, 143.87, 130.13, 129.80, 129.56, 129.37, 128.91, 127.36, 122.47, 117.48, 107.46, 100.22, 97.60, 96.63, 34.89, 28.28.
HRMS (ESI): exact mass calcd for $C_{21}H_{16}O_4$: m/z 331.0971 [M-H]$^-$, found: m/z 331.0969.



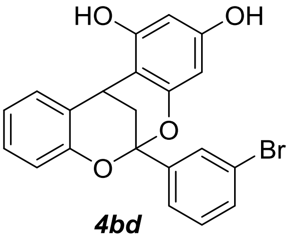
4bb

Following the **general procedure B**, compound **4bb** was isolated as brown oil in 81% yield (29.8 mg).
^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.64 (s, 1H), 8.17 (s, 1H), 8.15 (dd, *J* = 7.5, 2.1 Hz, 1H), 7.58-7.43 (m, 4H), 7.20-7.13 (m, 1H), 6.99 (d, *J* = 8.0 Hz, 1H), 6.97-6.90 (m, 1H), 6.12 (d, *J* = 2.2 Hz, 1H), 6.10 (d, *J* = 2.3 Hz, 1H), 4.51 (t, *J* = 3.1 Hz, 1H), 2.57 (dd, *J* = 13.2, 3.0 Hz, 1H), 2.53 (dd, *J* = 13.2, 3.2 Hz, 1H).
^{13}C NMR (126 MHz, acetone-d$_6$): δ158.78, 156.27, 154.49, 153.60, 139.88, 133.93, 133.14, 131.90, 130.27, 129.51, 129.34, 128.98, 128.65, 122.57, 117.68, 107.57, 100.04, 97.71, 96.74, 31.19, 27.82.
HRMS (ESI): exact mass calcd for $C_{21}H_{15}ClO_4$: m/z 365.0581 [M-H]$^-$, found: m/z 365.0583.



4bc

Following the **general procedure B**, compound **4bc** was isolated as brown oil in 63% yield (23.1 mg).
^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.66 (s, 1H), 8.19 (s, 1H), 7.83-7.78 (m, 2H), 7.57-7.52 (m, 2H), 7.47 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.19-7.11 (m, 1H), 6.98 (d, *J* = 8.0 Hz, 1H), 6.95-6.90 (m, 1H), 6.11 (d, *J* = 2.2 Hz, 1H), 6.07 (d, *J* = 2.3 Hz, 1H), 4.49 (t, *J* = 3.1 Hz, 1H), 2.39-2.32 (m, 2H).
^{13}C NMR (126 MHz, acetone-d$_6$): δ 158.77, 156.33, 154.82, 153.79, 142.78, 135.62, 129.90, 129.44, 129.38, 129.33, 128.96, 122.62, 117.49, 107.37, 99.91, 97.71, 96.62, 34.66, 28.18.
HRMS (ESI): exact mass calcd for $C_{21}H_{15}ClO_4$: m/z 365.0581 [M-H]$^-$, found: m/z 365.0579.



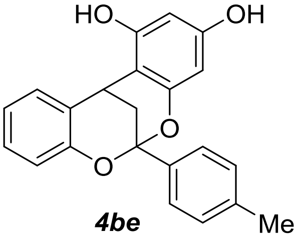
4bd

Following the **general procedure B**, compound **4bd** was isolated as brown oil in 66% yield (27.2 mg).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.66 (s, 1H), 8.19 (s, 1H), 8.02-7.93 (m, 1H), 7.83-7.76 (m, 1H), 7.69-7.61 (m, 1H), 7.51-7.45 (m, 2H), 7.20-7.12 (m, 1H), 7.01 (d, *J* = 8.0 Hz, 1H), 6.98-6.88 (m, 1H), 6.11 (d, *J* = 2.3 Hz, 1H), 6.08 (d, *J* = 2.2 Hz, 1H), 4.50 (t, *J* = 3.1 Hz, 1H), 2.44-2.34 (m, 2H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 158.79, 156.32, 154.74, 153.72, 146.31, 133.24, 131.95, 130.54, 129.43, 129.39, 128.99, 126.51, 123.42, 122.69, 117.52, 107.37, 99.67, 97.77, 96.64, 34.57, 28.15.

HRMS (ESI): exact mass calcd for $C_{21}H_{15}BrO_4$: m/z 409.0076 $[M-H]^-$, found: m/z 409.0072.



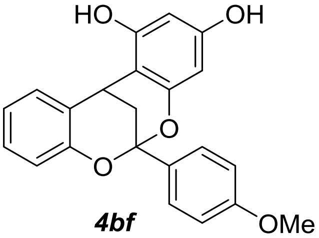
4be

Following the **general procedure B**, compound **4be** was isolated as brown oil in 68% yield (23.6 mg).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.60 (s, 1H), 8.14 (s, 1H), 7.71-7.62 (m, 2H), 7.46 (dd, *J* = 7.5, 1.7 Hz, 1H), 7.32 (d, *J* = 7.9 Hz, 2H), 7.17-7.11 (m, 1H), 6.97 (d, *J* = 8.0 Hz, 1H), 6.94-6.88 (m, 1H), 6.10 (d, *J* = 2.2 Hz, 1H), 6.06 (d, *J* = 2.2 Hz, 1H), 4.47 (t, *J* = 3.1 Hz, 1H), 2.42 (s, 3H), 2.37-2.30 (m, 2H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 158.72, 156.31, 155.11, 154.06, 141.06, 139.76, 130.37, 129.59, 129.36, 128.88, 127.30, 122.40, 117.47, 107.50, 100.25, 97.55, 96.64, 34.94, 28.32, 21.91.

HRMS (ESI): exact mass calcd for $C_{22}H_{18}O_4$: m/z 345.1972 $[M-H]^-$, found: m/z 345.1968.



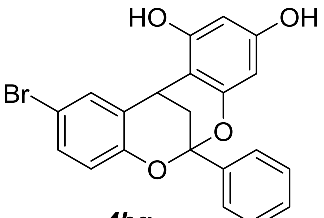
4bf

Following the **general procedure B**, compound **4bf** was isolated as brown oil in 71% yield (25.7 mg).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.61 (s, 1H), 8.15 (s, 1H), 7.74-7.67 (m, 2H), 7.46 (dd, *J* = 7.5, 1.7 Hz, 1H), 7.17-7.10 (m, 2H), 7.08-7.01 (m, 2H), 6.97 (d, *J* = 8.0 Hz, 1H), 6.94-6.87 (m, 1H), 6.10 (d, *J* = 2.2 Hz, 1H), 6.06 (d, *J* = 2.3 Hz, 1H), 4.47 (t, *J* = 3.1 Hz, 1H), 3.88 (s, 3H), 2.39-2.28 (m, 2H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 161.61, 158.70, 156.30, 155.13, 154.08, 136.04, 129.58, 129.35, 128.86, 128.67, 122.37, 117.46, 115.04, 107.49, 100.20, 97.52, 96.62, 56.39, 34.96, 28.38.

HRMS (ESI): exact mass calcd for $C_{22}H_{18}O_5$: m/z 361.1076 $[M-H]^-$, found: m/z 361.1079.



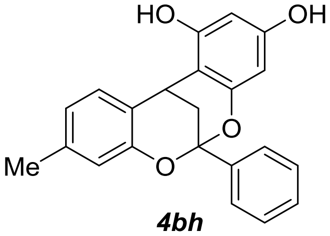
4bg

Following the **general procedure B**, compound **4bg** was isolated as brown oil in 78% yield (32.1 mg).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.76 (s, 1H), 8.25 (s, 1H), 7.81-7.74 (m, 2H), 7.60 (d, *J* = 2.5 Hz, 1H), 7.56-7.42 (m, 3H), 7.30 (dd, *J* = 8.6, 2.5 Hz, 1H), 6.96 (d, *J* = 8.6 Hz, 1H), 6.13 (d, *J* = 2.3 Hz, 1H), 6.09 (d, *J* = 2.2 Hz, 1H), 4.48 (t, *J* = 3.1 Hz, 1H), 2.42-2.35 (m, 2H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 159.02, 156.32, 154.86, 153.43, 143.34, 132.05, 131.68, 131.62, 130.28, 129.85, 127.32, 119.64, 113.99, 106.68, 100.46, 97.74, 96.73, 34.30, 28.19.

HRMS (ESI): exact mass calcd for $C_{21}H_{15}BrO_4$: m/z 409.0076 [M-H]$^-$, found: m/z 409.0079.



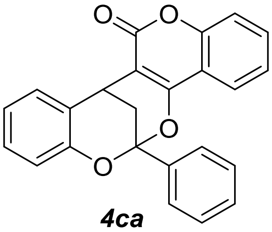
4bh

Following the **general procedure B**, compound **4bh** was isolated as brown oil in 50% yield (17.4 mg).

^{1}H NMR (500 MHz, acetone-d$_6$): δ 8.63 (s, 1H), 8.17 (s, 1H), 7.81-7.75 (m, 2H), 7.54-7.43 (m, 3H), 7.28 (d, *J* = 2.1 Hz, 1H), 6.95 (dd, *J* = 8.2, 2.1 Hz, 1H), 6.87 (d, *J* = 8.2 Hz, 1H), 6.10 (d, *J* = 2.2 Hz, 1H), 6.07 (d, *J* = 2.2 Hz, 1H), 4.43 (t, *J* = 3.1 Hz, 1H), 2.36-2.29 (m, 2H), 2.27 (s, 3H).

^{13}C NMR (126 MHz, acetone-d$_6$): δ 158.68, 156.24, 155.14, 151.77, 143.98, 131.41, 130.07, 129.77, 129.71, 129.39, 129.19, 127.35, 117.24, 107.56, 100.14, 97.54, 96.61, 34.99, 28.26, 21.40.

HRMS (ESI): exact mass calcd for $C_{22}H_{18}O_4$: m/z 345.1972 [M-H]$^-$, found: m/z 345.1971.



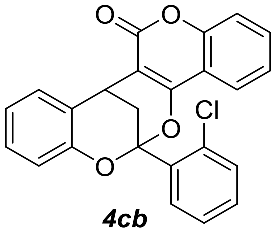
4ca

Following the **general procedure A**, compound **4ca** was isolated as white solid in 75% yield (27.5 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.88 (dd, *J* = 7.9, 1.6 Hz, 1H), 7.82-7.72 (m, 2H), 7.57-7.46 (m, 5H), 7.33-7.25 (m, 2H), 7.23-7.18 (m, 1H), 7.07 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.02-6.96 (m, 1H), 4.40 (t, *J* = 3.0 Hz, 1H), 2.50-2.40 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 161.89, 158.57, 152.75, 151.66, 140.05, 132.33, 129.75, 128.97, 128.70, 128.55, 126.00, 125.48, 124.40, 123.10, 122.45, 117.03, 116.69, 115.43, 106.38, 100.62, 33.29, 27.53.

HRMS (ESI): exact mass calcd for $C_{24}H_{16}O_4$: m/z 369.1127 [M+H]$^+$, found: m/z 369.1127.



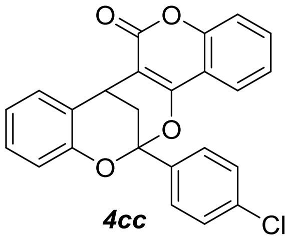
4cb

Following the **general procedure A**, compound **4cb** was isolated as white solid in 22% yield (8.9 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.13-8.09 (m, 1H), 7.87 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.55 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.53-7.49 (m, 2H), 7.47-7.40 (m, 2H), 7.31 (dd, *J* = 8.4, 1.0 Hz, 1H), 7.28-7.25 (m, 1H, overlapped), 7.24-7.20 (m, 1H), 7.08 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.02-6.98 (m, 1H), 4.42 (t, *J* = 3.0 Hz, 1H), 2.79 (dd, *J* = 13.6, 3.2 Hz, 1H), 2.54 (dd, *J* = 13.6, 2.9 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 161.90, 158.24, 152.80, 151.18, 136.40, 132.91, 132.29, 132.23, 131.08, 128.80, 128.75, 128.56, 127.39, 125.64, 124.40, 123.32, 122.58, 117.03, 116.84, 115.33, 106.59, 100.24, 29.61, 26.99.

HRMS (ESI): exact mass calcd for $C_{24}H_{15}ClO_4$: m/z 403.0737 $[M+H]^+$, found: m/z 403.0736.



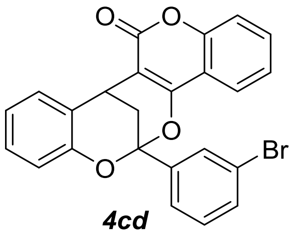
4cc

Following the **general procedure A**, compound **4cc** was isolated as white solid in 42% yield (17.0 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.84 (dd, *J* = 7.9, 1.6 Hz, 1H), 7.73-7.68 (m, 2H), 7.57-7.47 (m, 4H), 7.31 (d, *J* = 8.1 Hz, 1H), 7.29-7.25 (m, 1H), 7.23-7.18 (m, 1H), 7.05 (d, *J* = 7.9 Hz, 1H), 7.02-6.98 (m, 1H), 4.40 (t, *J* = 3.0 Hz, 1H), 2.47-2.38 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 161.77, 158.37, 152.74, 151.46, 138.64, 135.84, 132.43, 129.20, 128.78, 128.59, 127.56, 125.33, 124.46, 122.99, 122.63, 117.09, 116.65, 115.29, 106.40, 100.25, 33.20, 27.46.

HRMS (ESI): exact mass calcd for $C_{24}H_{15}ClO_4$: m/z 403.0737 $[M+H]^+$, found: m/z 403.0733.



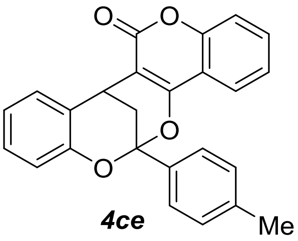
4cd

Following the **general procedure A**, compound **4cd** was isolated as white solid in 16% yield (7.1 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 8.12 (dd, *J* = 8.0, 1.7 Hz, 1H), 7.89 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.74 (dd, *J* = 7.9, 1.3 Hz, 1H), 7.56-7.48 (m, 3H), 7.36-7.30 (m, 2H), 7.29-7.25 (m, 1H, overlapped), 7.24-7.20 (m, 1H), 7.08 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.02-6.98 (m, 1H), 4.42 (t, *J* = 3.0 Hz, 1H), 2.84 (dd, *J* = 13.6, 3.2 Hz, 1H), 2.54 (dd, *J* = 13.6, 2.9 Hz, 1H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 161.90, 158.28, 152.80, 151.19, 137.80, 135.81, 132.29, 131.25, 129.05, 128.74, 128.53, 127.99, 125.65, 124.39, 123.49, 122.58, 121.47, 117.03, 116.91, 115.30, 106.63, 100.58, 29.57, 26.96.

HRMS (ESI): exact mass calcd for $C_{24}H_{15}BrO_4$: m/z 447.0232 [M+H]$^+$, found: m/z 447.0228.



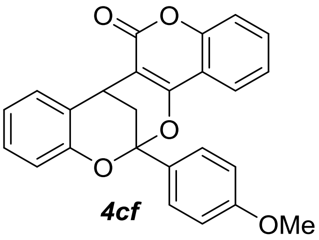
4ce

Following the **general procedure A**, compound **4ce** was isolated as white solid in 76% yield (29.1 mg).

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.87 (dd, *J* = 7.9, 1.6 Hz, 1H), 7.68-7.63 (m, 2H), 7.55 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.53-7.48 (m, 1H), 7.34-7.29 (m, 3H), 7.28-7.24 (m, 1H, overlapped), 7.22-7.17 (m, 1H), 7.06 (dd, *J* = 8.2, 1.1 Hz, 1H), 7.01-6.96 (m, 1H), 4.40 (t, *J* = 3.0 Hz, 1H), 2.49-2.40 (m, 5H).

^{13}C NMR (126 MHz, $CDCl_3$): δ 161.91, 158.62, 152.73, 151.71, 139.70, 137.18, 132.28, 129.60, 128.64, 128.53, 125.90, 125.50, 124.35, 123.11, 122.37, 117.00, 116.69, 115.45, 106.34, 100.69, 33.25, 27.56, 21.59.

HRMS (ESI): exact mass calcd for $C_{25}H_{18}O_4$: m/z 383.1283 [M+H]$^+$, found: m/z 383.1286.



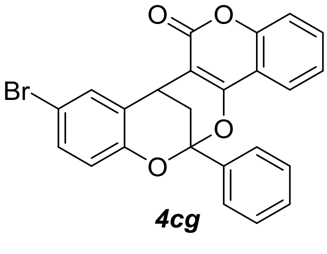
4cf

Following the **general procedure A**, compound **4cf** was isolated as white solid in 85% yield (33.8 mg).

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.86 (dd, *J* = 7.9, 1.6 Hz, 1H), 7.72-7.67 (m, 2H), 7.55 (dd, *J* = 7.5, 1.6 Hz, 1H), 7.52-7.47 (m, 1H), 7.30 (dd, *J* = 8.4, 1.0 Hz, 1H), 7.27-7.23 (m, 1H, overlapped), 7.22-7.17 (m, 1H), 7.07-6.96 (m, 4H), 4.39 (t, *J* = 3.0 Hz, 1H), 3.88 (s, 3H), 2.49-2.39 (m, 2H).

^{13}C NMR (126 MHz, $CDCl_3$): δ 161.88, 160.67, 158.61, 152.72, 151.71, 132.26, 128.63, 128.52, 127.36, 125.50, 124.34, 123.08, 122.36, 116.99, 116.66, 115.44, 114.22, 106.33, 100.65, 55.74, 33.30, 27.62.

HRMS (ESI): exact mass calcd for $C_{25}H_{18}O_5$: m/z 399.1232 [M+H]$^+$, found: m/z 399.1234.



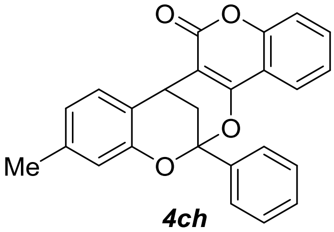
4cg

Following the **general procedure A**, compound **4cg** was isolated as white solid in 47% yield (21.1 mg).

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.86 (d, *J* = 7.9 Hz, 1H), 7.76-7.70 (m, 2H), 7.70-7.65 (m, 1H), 7.56-7.47 (m, 4H), 7.33-7.25 (m, 3H, overlapped), 6.93 (d, *J* = 8.6 Hz, 1H), 4.36 (t, *J* = 2.9 Hz, 1H), 2.45-2.40 (m, 2H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 161.65, 158.61, 152.77, 150.85, 139.56, 132.54, 131.58, 130.97, 129.90, 129.02, 127.49, 125.90, 124.48, 123.08, 118.43, 117.09, 115.19, 114.61, 105.75, 100.58, 32.89, 27.36.

HRMS (ESI): exact mass calcd for $C_{24}H_{15}BrO_4$: m/z 447.0232 [M+H]$^+$, found: m/z 447.0230.



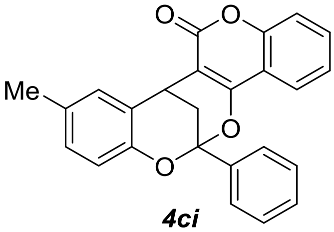
4ch

Following the **general procedure A**, compound **4ch** was isolated as white solid in 58% yield (22.1 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.87 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.78-7.74 (m, 2H), 7.54-7.46 (m, 4H), 7.43 (d, *J* = 7.6 Hz, 1H), 7.32-7.24 (m, 2H, overlapped), 6.90 (s, 1H), 6.82 (dd, *J* = 7.8, 1.6 Hz, 1H), 4.37 (t, *J* = 3.0 Hz, 1H), 2.48-2.39 (m, 2H), 2.31 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 161.91, 158.50, 152.72, 151.48, 140.16, 138.91, 132.26, 129.70, 128.94, 128.23, 126.00, 124.36, 123.22, 123.07, 122.56, 117.17, 117.00, 115.48, 106.63, 100.61, 33.52, 27.20, 21.52.

HRMS (ESI): exact mass calcd for $C_{25}H_{18}O_4$: m/z 383.1283 [M+H]$^+$, found: m/z 383.1284.



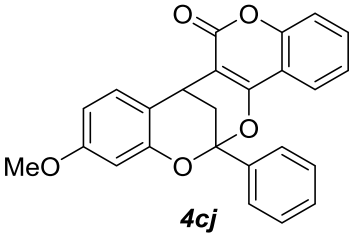
4ci

Following the **general procedure A**, compound **4ci** was isolated as white solid in 58% yield (22.0 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.88 (d, *J* = 8.0 Hz, 1H), 7.79-7.72 (m, 2H), 7.54-7.45 (m, 4H), 7.36 (s, 1H), 7.33-7.24 (m, 2H), 7.03-6.93 (m, 2H), 4.35 (t, *J* = 3.8 Hz, 1H), 2.48-2.37 (m, 2H), 2.31 (s, 3H).

^{13}C NMR (126 MHz, CDCl$_3$): δ 161.93, 158.66, 152.74, 149.41, 140.17, 132.28, 131.93, 129.69, 129.25, 128.94, 128.83, 126.00, 125.16, 124.37, 123.11, 117.00, 116.43, 115.48, 106.42, 100.66, 33.41, 27.53, 20.85.

HRMS (ESI): exact mass calcd for $C_{25}H_{18}O_4$: m/z 383.1283 [M+H]$^+$, found: m/z 383.1281.



4cj

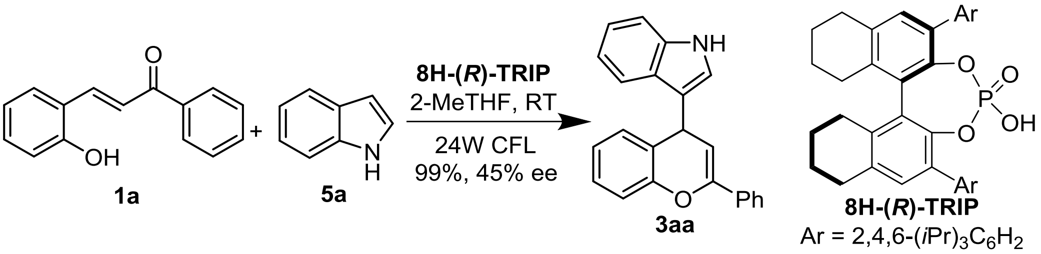
Following the **general procedure A**, compound **4cj** was isolated as white solid in 33% yield (13.2 mg).

^{1}H NMR (500 MHz, CDCl$_3$): δ 7.88 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.80-7.74 (m, 2H), 7.56-7.46 (m, 4H), 7.44 (d, *J* = 8.4 Hz, 1H), 7.33-7.24 (m, 2H, overlapped), 6.63 (d, *J* = 2.5 Hz, 1H), 6.56 (dd, *J* = 8.4, 2.5 Hz, 1H), 4.35 (t, *J* = 3.0 Hz, 1H), 3.76 (s, 3H), 2.50-2.38 (m, 2H).

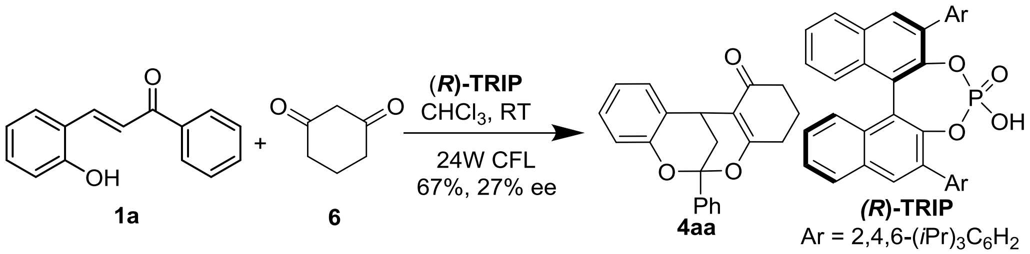
^{13}C NMR (126 MHz, CDCl$_3$): δ 161.91, 160.20, 158.30, 152.71, 152.48, 140.06, 132.24, 129.73, 128.96, 128.92, 125.98, 124.37, 123.04, 117.82, 117.01, 115.45, 108.55, 106.84, 102.33, 100.57, 55.80, 33.62, 26.88.

HRMS (ESI): exact mass calcd for $C_{25}H_{18}O_5$: m/z 399.1232 $[M+H]^+$, found: m/z 399.1230.

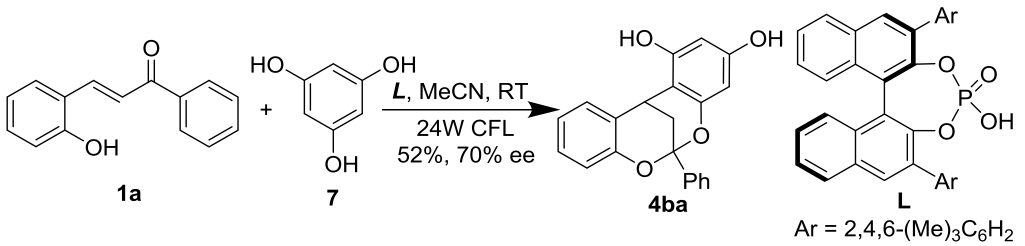
5. Chiral Phosphoric Acid Catalyzed Enantioselective Coupling of 2-Hydroxychalcone.



2-Hydroxylchalcone (0.1 mmol, 22.4 mg), indole (0.12 mmol, 14.1 mg), 8H-(*R*)-TRIP (10 mol%, 7.6 mg) and 2-methyltetrahydrofur(3.0 mL) were added to a reaction tube equipped with a magnetic stir bar. The mixture was stirred under the irradiation of 24W CFL at room temperature under argon overnight and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (EtOAc/petroleum ether = 1: 15) to afford **3aa** in 99% yield (31.9 mg). Enantiomeric excess was found to be 45% by chiral HPLC (ChiralPak OD column, hexane/i-PrOH = 85: 15, 210 nm, 1.0 mL/min, t_{major} = 11.49 min, t_{minor} = 13.79 min).



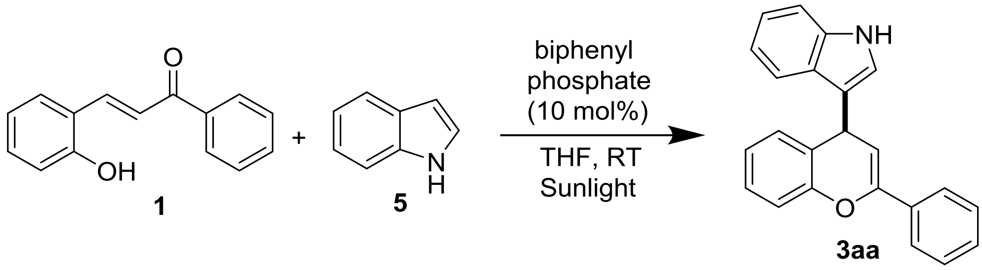
2-Hydroxylchalcone (0.1 mmol, 22.4 mg), 1, 3-cyclohexanedione (0.12 mmol, 13.5 mg), (*R*)-TRIP (10 mol%, 7.5 mg) and chloroform (3.0 mL) were added to a reaction tube equipped with a magnetic stir bar. The mixture was stirred under the irradiation of 24W CFL at room temperature under argon overnight and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (EtOAc/petroleum ether = 1: 8) to afford **4aa** in 67% yield (21.3 mg). Enantiomeric excess was found to be 27% by chiral HPLC (ChiralPak IC column, hexane/i-PrOH = 8: 2, 214 nm, 1.0 mL/min, t_{major} = 11.34 min, t_{minor} = 12.16 min).



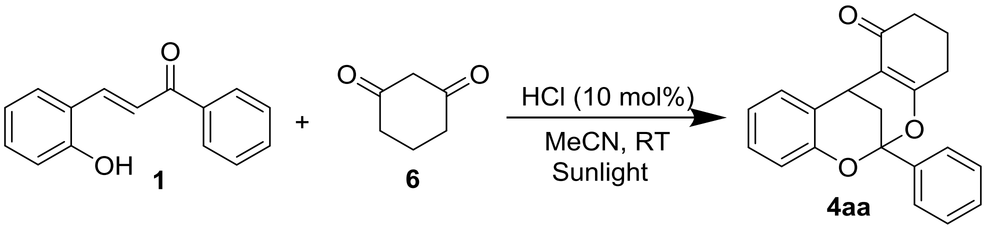
2-Hydroxylchalcone(0.1 mmol, 22.4 mg), pholoroglucinol (0.12 mmol, 15.1 mg), chiral phosphoric acid L (10 mol%, 5.8 mg) and acetonitrile (3.0 mL) were added to a reaction tube equipped with a magnetic stir bar. The mixture was stirred under the irradiation of 24W CFL at room temperature under argon overnight and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (Acetone/DCM = 1: 20) to afford **4ba** in 52% yield (17.3 mg).

Enantiomeric excess was found to be 70% by chiral HPLC (ChiralPak IC column, hexane/i-PrOH = 95: 5, 214 nm, 1.0 mL/min, t_{major} = 12.26 min, t_{minor} = 31.06 min).

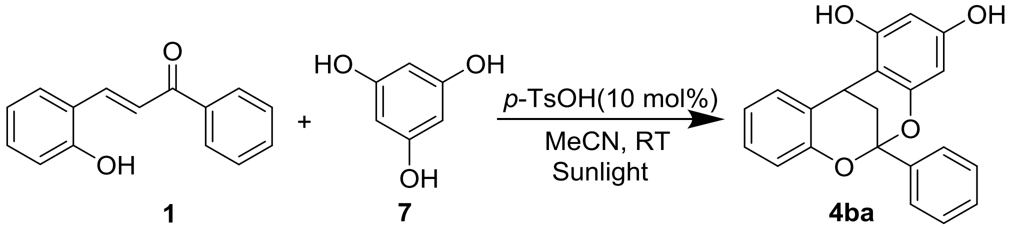
6. Sunlight powered reactions



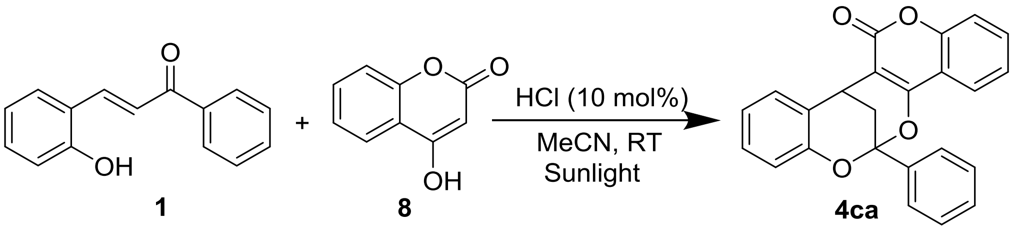
2-Hydroxylchalcone (0.1 mmol, 22.4 mg), indole (0.12 mmol, 14.1 mg), biphenyl phosphate (0.01 mmol, 2.5 mg) and THF (3.0 mL) were added to a reaction tube equipped with a magnetic stir bar. The mixture was exposed to sunlight and stirred under air and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (EtOAc/petroleum ether = 1: 15) to yield **3aa** in 94% yield (30.4 mg).



To a reaction tube equipped with a magnetic stir bar was added 2-hydroxylchalcone (0.1 mmol, 22.4 mg), 1, 3-cyclohexanedione (0.12 mmol, 13.5 mg), HCl (0.01 mmol, 1M) and acetonitrile (3.0 mL). The mixture exposed to sunlight and stirred under air and monitored by TLC.. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (EtOAc/petroleum ether = 1: 8) to yield **4aa** in 91% yield (28.9 mg).



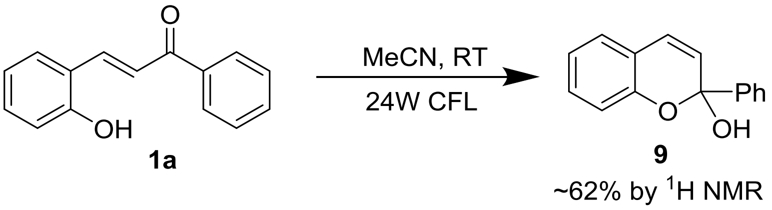
To a reaction tube equipped with a magnetic stir bar was added 2-hydroxylchalcone (0.1 mmol, 22.4 mg), phloroglucinol (0.12 mmol, 15.1 mg), HOTs (0.01 mmol, 1.7 mg) and acetonitrile (3.0 mL). The mixture was exposed to sunlight and stirred under air and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (Acetone/DCM = 1: 20) to yield **4ba** in 69% yield (23.0 mg).



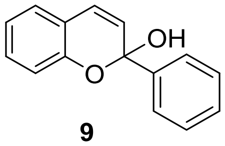
To a reaction tube equipped with a magnetic stir bar was added 2-hydroxylchalcone (0.1 mmol, 22.4 mg), 4-hydroxycoumarin (0.12 mmol, 19.5 mg), HCl (0.01 mmol, 1M) and acetonitrile (3.0 mL). The mixture was exposed to sunlight and stirred under air and monitored by TLC. After 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (EtOAc/petroleum ether = 1: 8) to yield **4ca** in 66% yield (24.3 mg).

7. Mechanistic Studies

The Synthesis of Flav-3-en-2-ol (9)



2-Hydroxylchalcone(0.1 mmol, 22.4 mg) and acetonitrile (1.0 mL) were added to a reaction tube equipped with a magnetic stir bar. The mixture was stirred under the irradiation of 24W CFL at room temperature under argon for 24h and monitored by TLC. After the 2-hydroxylchalcone was consumed completely, the solvent was removed by rotary evaporator. The residue was flav-3-en-2-ol (**9**) in 62% yield by ^{1}H NMR through adding dimethyl sulfone as the interior label.

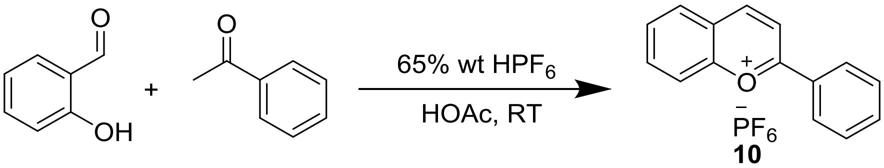


9

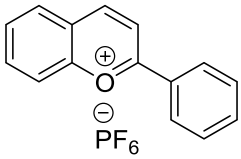
The spectrum data of **9** were consistent with the reference[3].

^{1}H NMR (500 MHz, CD$_3$CN): δ 7.62 (d, *J* = 7.0 Hz, 2H), 7.47-7.36 (m, 3H), 7.31-7.25 (m, 2H), 7.02 (t, *J* = 7.1 Hz, 1H), 6.97 (d, *J* = 7.8 Hz, 1H), 6.74 (d, *J* = 9.5 Hz, 1H), 5.89 (d, *J* = 9.6 Hz, 1H), 5.09 (s, 1H).

The Synthesis of Benzopyrylium Salts[4]



To a solution of 2-hydroxybenzaldehyde (5 mmol, 0.5 ml) and acetophenone (5 mmol, 0.6 mL) in a minimum of acetic acid was added excess of aqueous hexafluorophosphoric acid (5.61 g, 65 % in water). After stirred for 48h at room temperature under argon, the mixture was pluned into diethyl ether (20 mL per mmol). The resulting powder was collected through filtration and washed with diethyl ether to afford the desired benzopyrylium salt **10** in 59% yield (1.04 g).



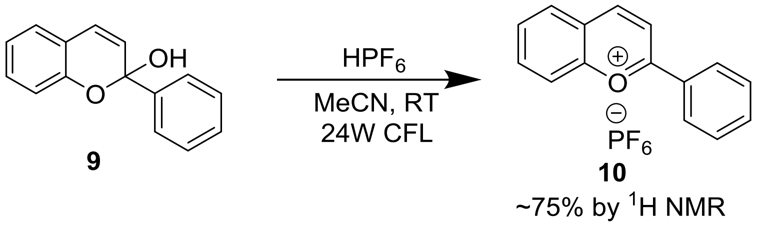
10

The spectrum data of **10** were consistent with the reference[5].

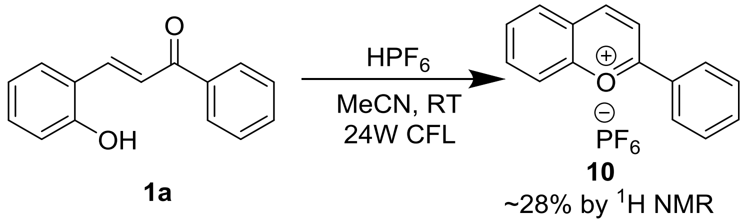
^{1}H NMR (500 MHz, CD$_3$CN): δ 9.51 (d, *J* = 8.9 Hz, 1H), 8.74 (d, *J* = 8.9 Hz, 1H), 8.62-8.56 (m, 2H), 8.44-8.37 (m, 3H), 8.09-8.03 (m, 1H), 7.99 (t, *J* = 7.5 Hz, 1H), 7.84 (t, *J* = 7.9 Hz, 2H).

^{13}C NMR (126 MHz, CD$_3$CN): δ 177.06, 159.05, 157.86, 141.43, 138.93, 131.86, 131.79, 131.61, 131.46, 129.85, 125.92, 120.49, 119.11.

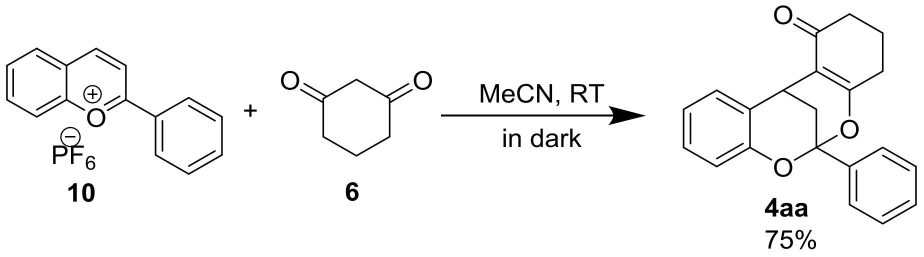
HRMS (ESI): exact mass calcd for C15H11O$^+$: m/z 207.0804 [M]$^+$, found: m/z 207.0801.



To a solvent of Flav-3-en-2-ol(**9**) (0.1 mmol, 22.4 mg) in acetonitrile (1.0 mL) was added aqueous hexafluorophosphoric acid 65% (0.1 mmol, 23.0 mg) at room temperature under argon, and irradiated by LED bulb. After stirring for 48 h, the solvent was removed by rotary evaporator. The crude was identified directly by the NMR spectrum and contained **10**, and the yield of **10** was confirmed to be 75% through adding dimethyl sulfone as the interior label.



To a solvent of **1a** (0.1 mmol, 22.4 mg) in acetonitrile (1.0 mL) was added aqueous hexafluorophosphoric acid 65%(0.1 mmol, 23.0 mg) at room temperature under argon, and irradiated by LED bulb. After stirring for 48 h, the solvent was removed by rotary evaporator. The crude was identified directly by the NMR spectrum and contained **10**, and the yield of **10** was confirmed to be 28% through adding dimethyl sulfone as the interior label.



To a reaction tube equipped with a magnetic stir bar was added the benzopyrylium salt (0.12 mmol, 42.2 mg), 1,3-cyclohexanedione (0.1 mmol, 11.2 mg) and acetonitrile (3.0 mL). The mixture was stirred in dark, using aluminium foil to wrap up the reaction flask, at room temperature under argon overnight and monitored by TLC. After 1,3-cyclohexanedione was consumed, the solvent was removed by rotary evaporator. The residue was directly purified by column chromatography on silica gel (EtOAc/petroleum ether = 1: 8) to afford **4aa** in 75% yield (23.9 mg).

8. Reference

[1] Rouh H., Liu Y., Katakam N., Pham L. Zhu Y. L..*J. Org. Chem*. **2018**, 83, 15372.

[2] Antúnez D. J. B., Greenhalgh M. D., FallC., Slawin A. M. Z., Andrew D. Smith A. D..

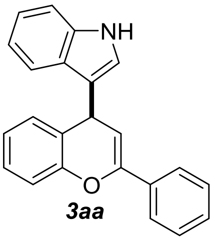
Org. Biomol. Chem.. **2016**, 14, 7268.

[3] Horiuchi H., Yokawa A., Okutsu T., Hiratsuka H.. *Bull. Chem. Soc. Jpn*. **1999**, 71, 2429.

[4] Yang Z, He Y., Toste F. D.. *J. A. Chem. Soc*. **2016**, 138, 9775.

[5] Fichtner C., Remennikov G., Mayr H.. *Eur. J. Org. Chem*. **2001**, 23, 4451.

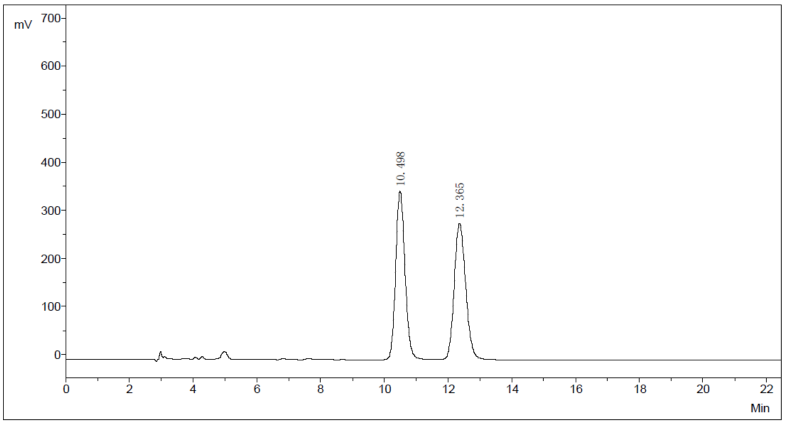
9. HPLC Data



3aa

HPLC Report

Sample Name:GYQ-I-33-2 OD-H 8515 210 1.0　　Recording Time:2016.05.04　22:46



No.	PeakNo	ID.Name	R.Time	PeakHeight	PeakArea	Conc
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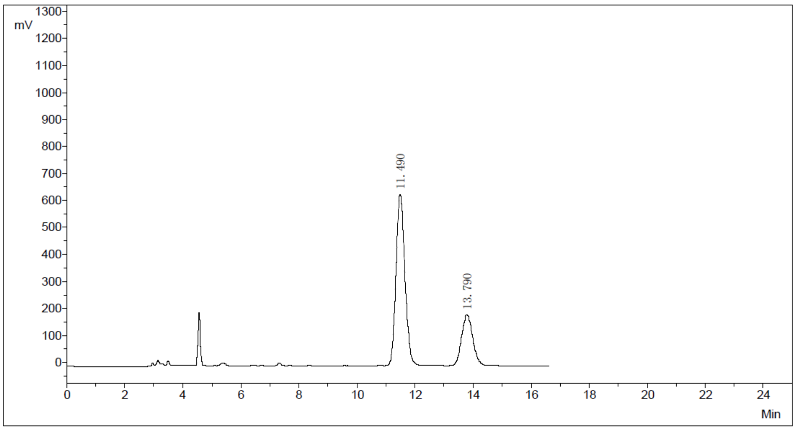
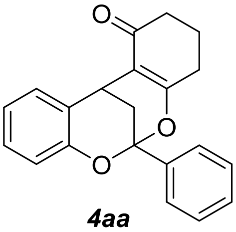
2	2		12.365	282440.0	7061978.4	49.9010
Total				631519.4	14151973.0	100.0000

HPLC Report

Sample Name:GYQ-I-37-2 OD-H 8515 210 1.0　　Recording Time:2016.05.11　11:11



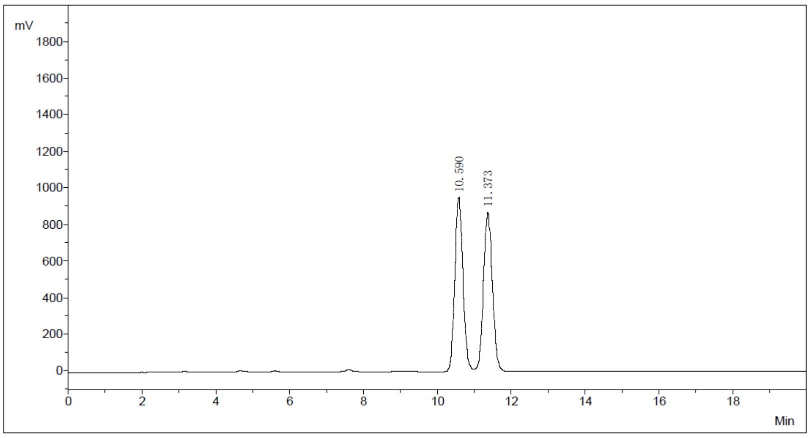
No.	PeakNo	ID.Name	R.Time	PeakHeight	PeakArea	Conc
1	1		11.490	634597.0	13634076.1	72.7437
2	2		13.790	191024.1	5108557.8	27.2563
Total				825621.1	18742634.0	100.0000



4aa

HPLC Report

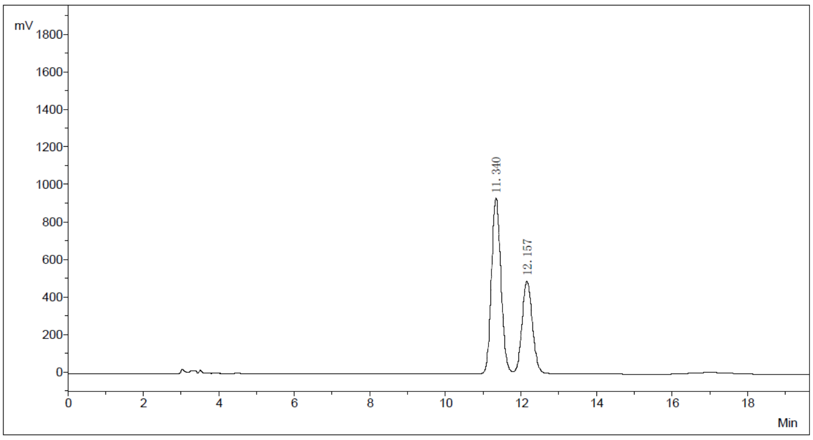
Sample Name:GYQ-II-29 IC 8020 214 1.0   Recording Time:2016.12.03   15:52



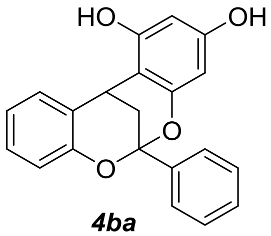
No.	PeakNo	ID.Name	R.Time	PeakHeight	PeakArea	Conc
1	1		10.590	952712.0	14765126.7	50.0107
2	2		11.373	872709.2	14758792.1	49.9893
Total				1825421.2	29523918.8	100.0000

HPLC Report

Sample Name:GYQ-IV-79-2 IC 8020 214 1.0   Recording Time:2017.12.08   11:10



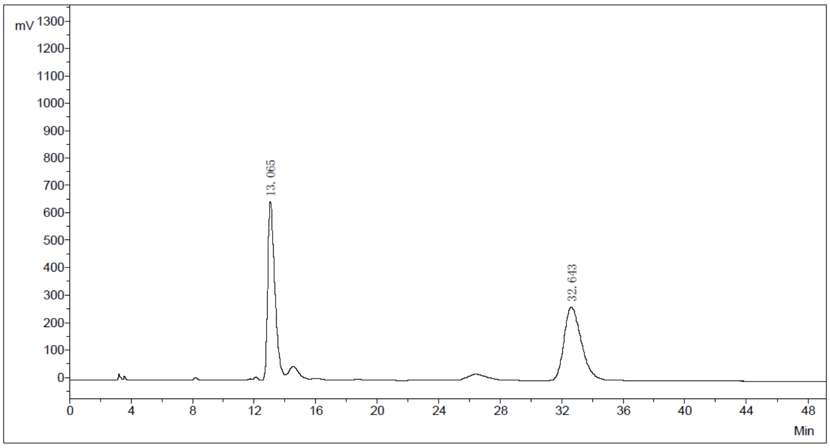
No.	PeakNo	ID.Name	R.Time	PeakHeight	PeakArea	Conc
1	1		11.340	934845.3	16385771.0	63.3001
2	2		12.157	494817.7	9500061.9	36.6999
Total				1429662.9	25885832.9	100.0000



4ba

HPLC Report

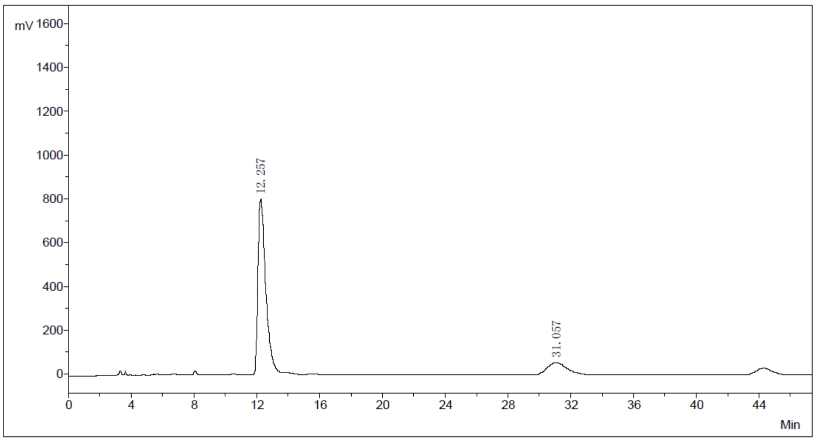
Sample Name:GYQ-I-45 IC 9505 214 1.0   Recording Time:2016.05.24 17:36



No.	PeakNo	ID. Name	R. Time	PeakHeight	PeakArea	Conc
1	1		13.065	642351.3	19992812.6	50.4016
2	2		32.643	262489.7	19674187.0	49.5984
Total				904840.9	39666999.6	100.0000

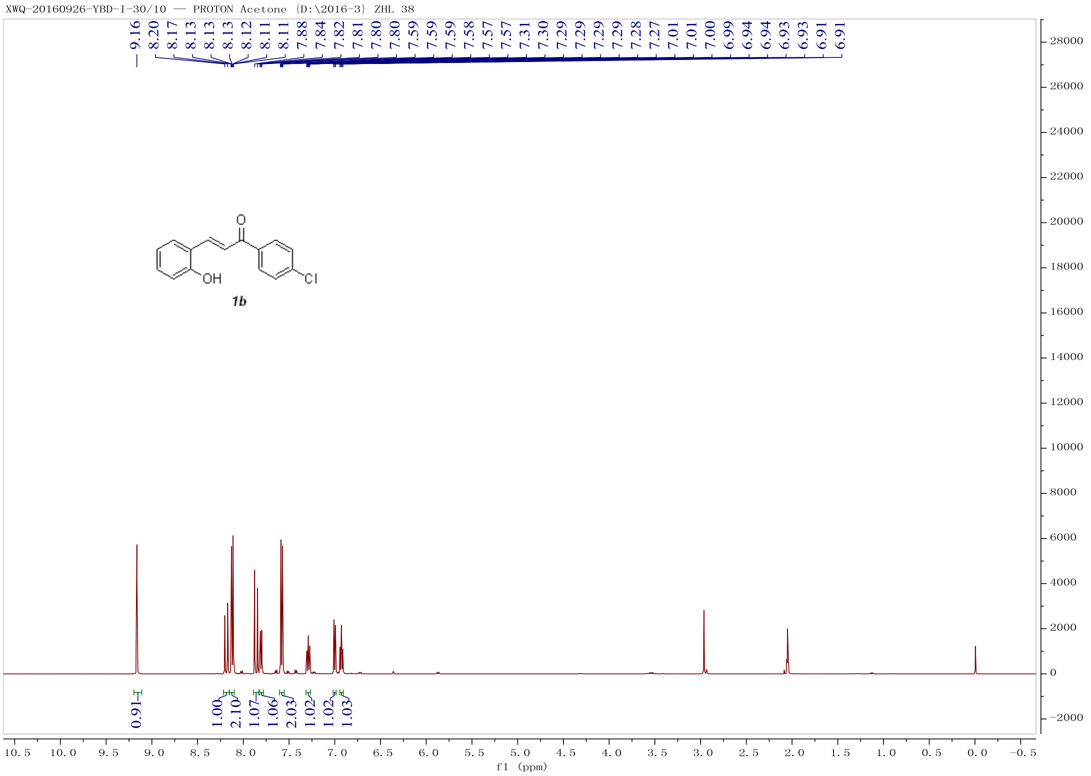
HPLC Report

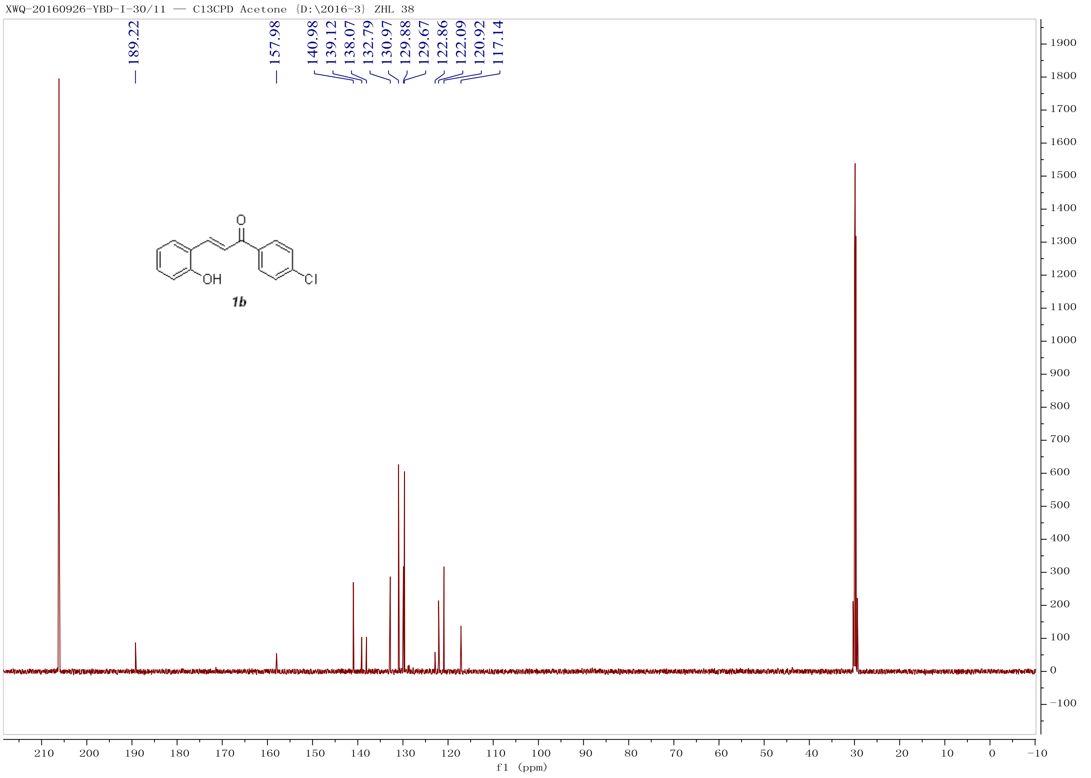
Sample Name:GYQ-II-95-1-2 IC 9505 214 1.0   Recording Time:2017.04.06 10:47

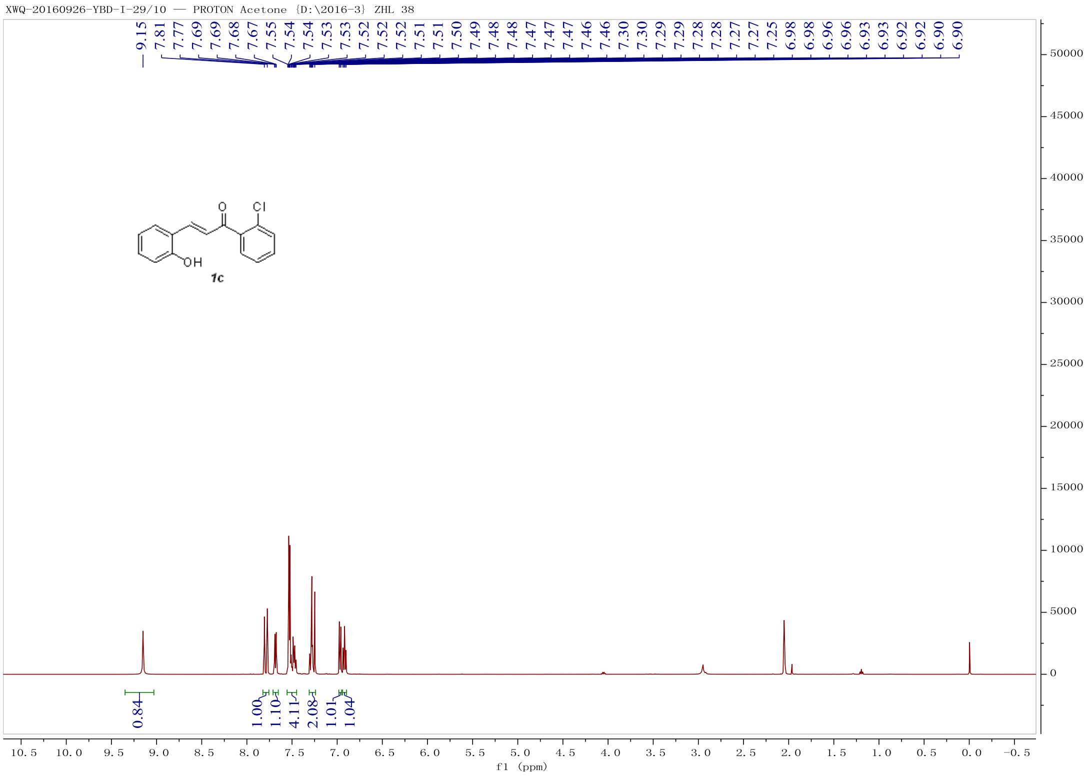


No.	PeakNo	ID. Name	R. Time	PeakHeight	PeakArea	Conc
1	1		12.257	800458.3	27578446.3	84.8554
2	2		31.057	56359.5	4922067.0	15.1446
Total				856817.8	32500513.3	100.0000

10. NMR Spectra



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7.54
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7.52
7.51
7.51
7.50
7.49
7.48
7.48
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7.46
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7.30
7.29
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6.98
6.98
6.96
6.96
6.93
6.93
6.92
6.90
6.90
O
Cl
OH
1c
0.84
1.00
1.10
4.11
2.08
1.01
1.04
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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2.5
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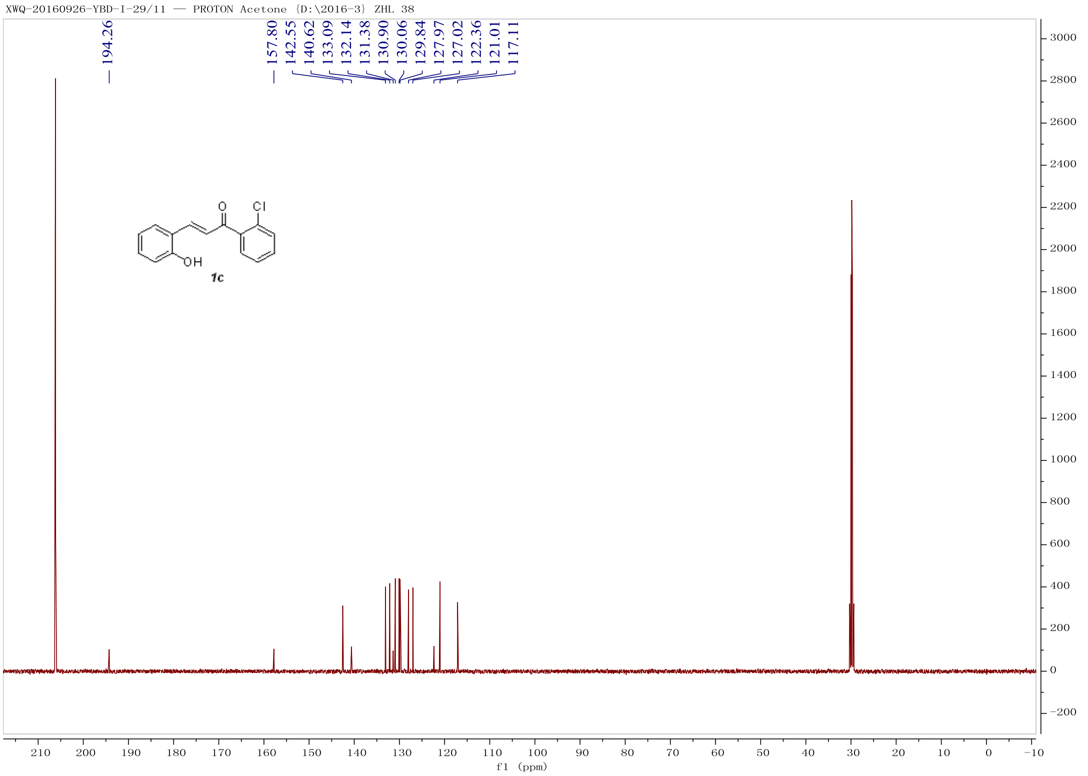
f1 (ppm)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133.09
132.14
131.38
130.90
130.06
129.84
127.97
127.02
122.36
121.01
117.11
O
Cl
OH
1c
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
210
200
190
180
170
160
150
140
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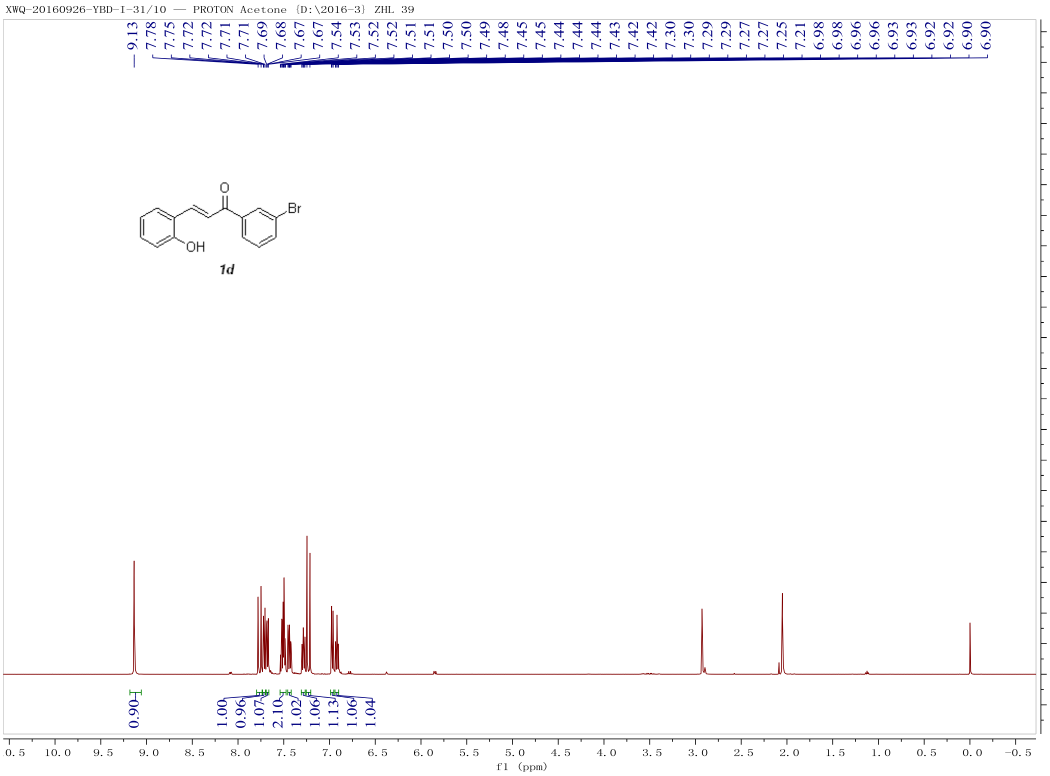
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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7.69
7.68
7.67
7.67
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7.53
7.52
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7.51
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7.48
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7.45
7.44
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6.98
6.96
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6.92
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6.90
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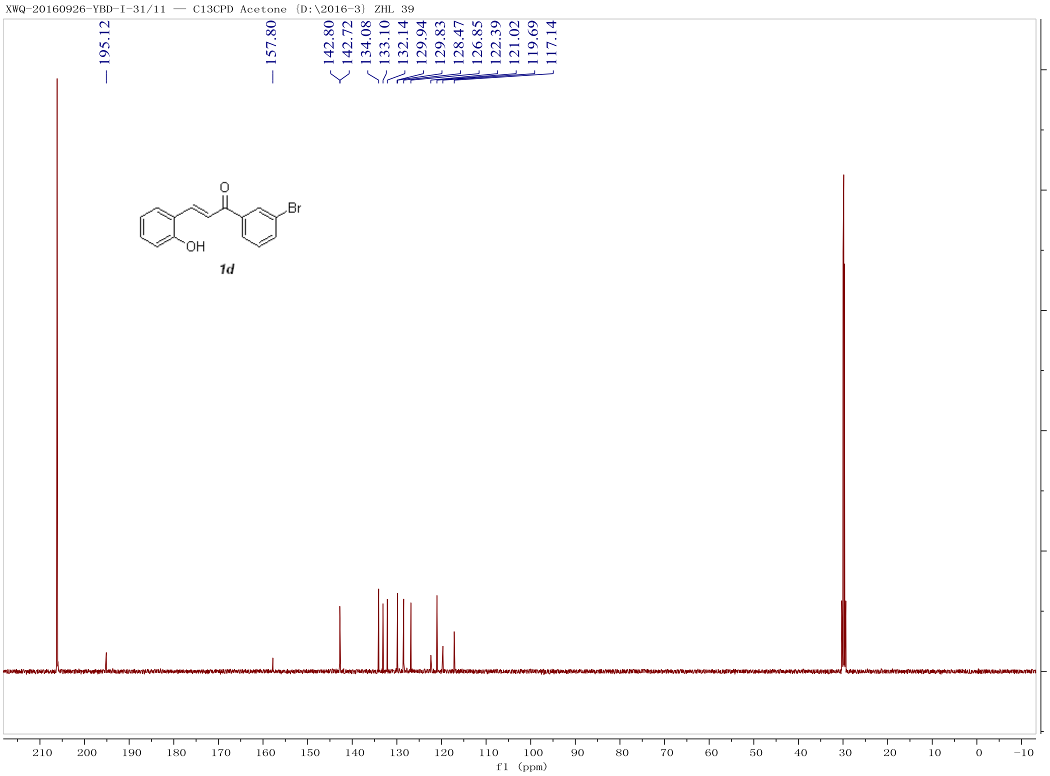
f1 (ppm)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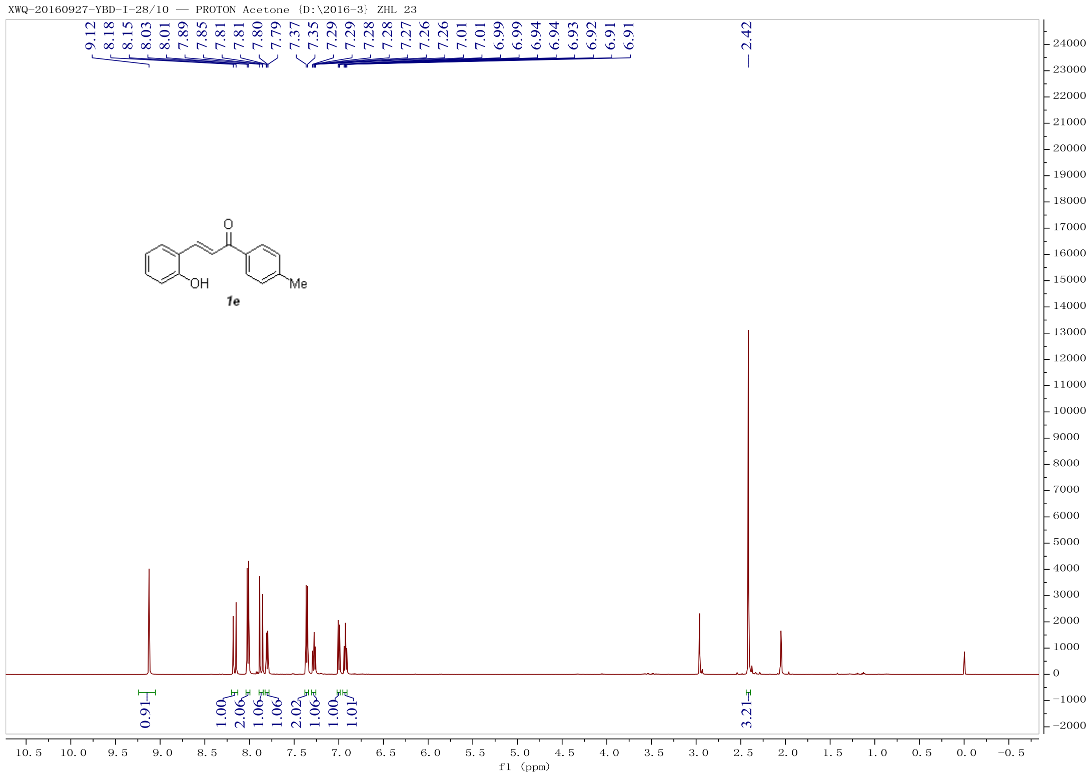
OH
1d
f1 (ppm)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7.35
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7.28
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7.26
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7.01
6.99
6.99
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6.93
6.92
6.91
6.91
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OH
Me
1e
0.91
1.00
2.06
1.06
1.06
2.02
1.06
1.00
1.01
3.21
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)
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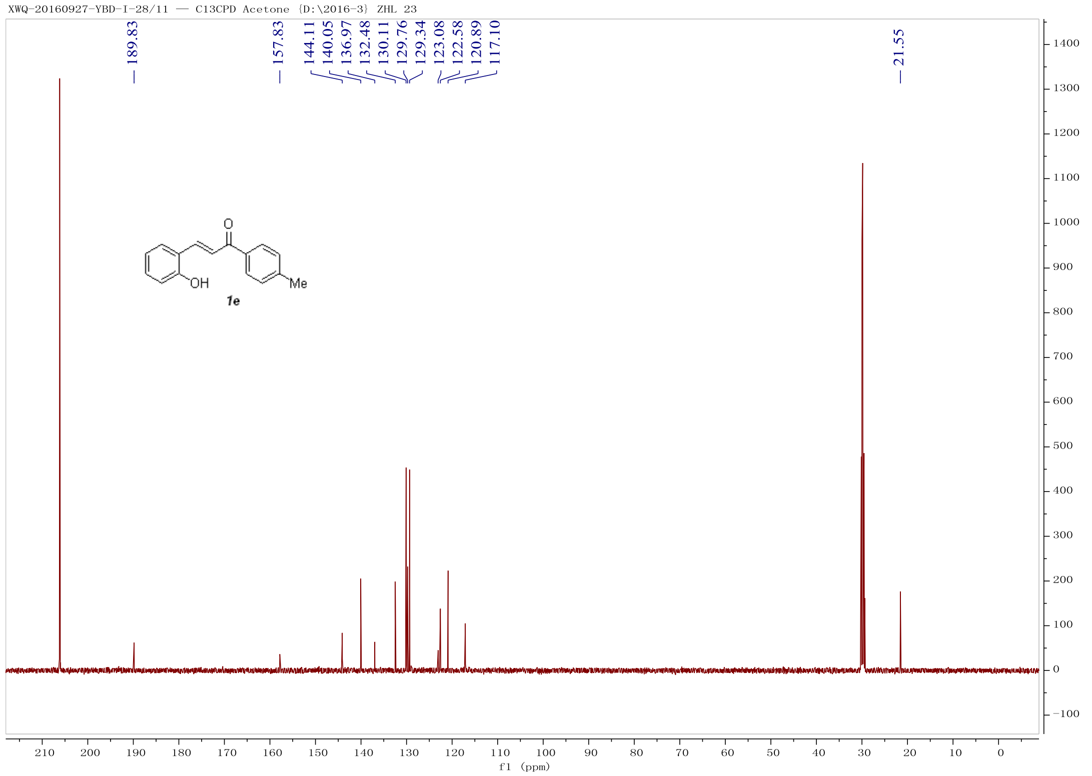
XWQ-20160927-YBD-I-28/11 — C13CPD Acetone {D:\2016-3} ZHL 23
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157.83
144.11
140.05
136.97
132.48
130.11
129.76
129.34
123.08
122.58
120.89
117.10
21.55
O
OH
Me
1e
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
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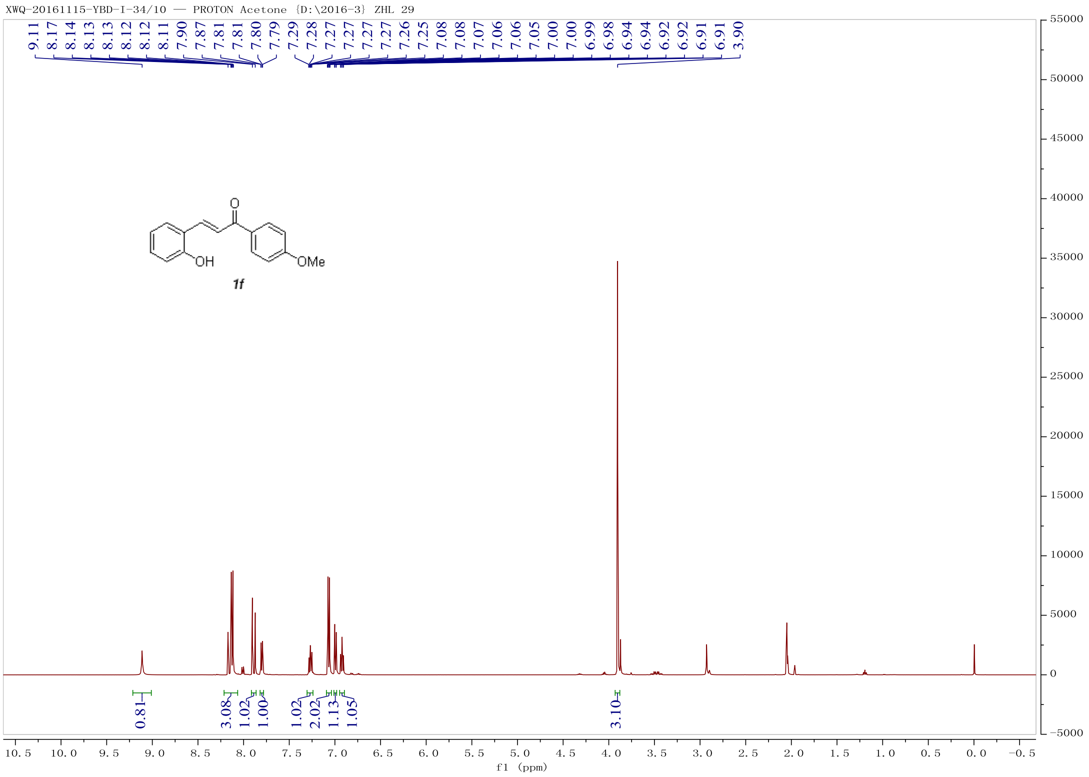
XWQ-20161115-YBD-I-34/10 — PROTON Acetone {D:\2016-3} ZHL 29
9.11 8.17 8.14 8.13 8.13 8.12 8.12 8.11 7.90 7.87 7.81 7.81 7.80 7.79 7.29 7.28 7.27 7.27 7.27 7.27 7.26 7.25 7.08 7.08 7.07 7.06 7.06 7.05 7.00 7.00 6.99 6.98 6.94 6.94 6.92 6.92 6.91 6.91 3.90
O
OH
OMe
1f
0.81
3.08
1.02
1.00
1.02
2.02
1.13
1.05
3.10
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)
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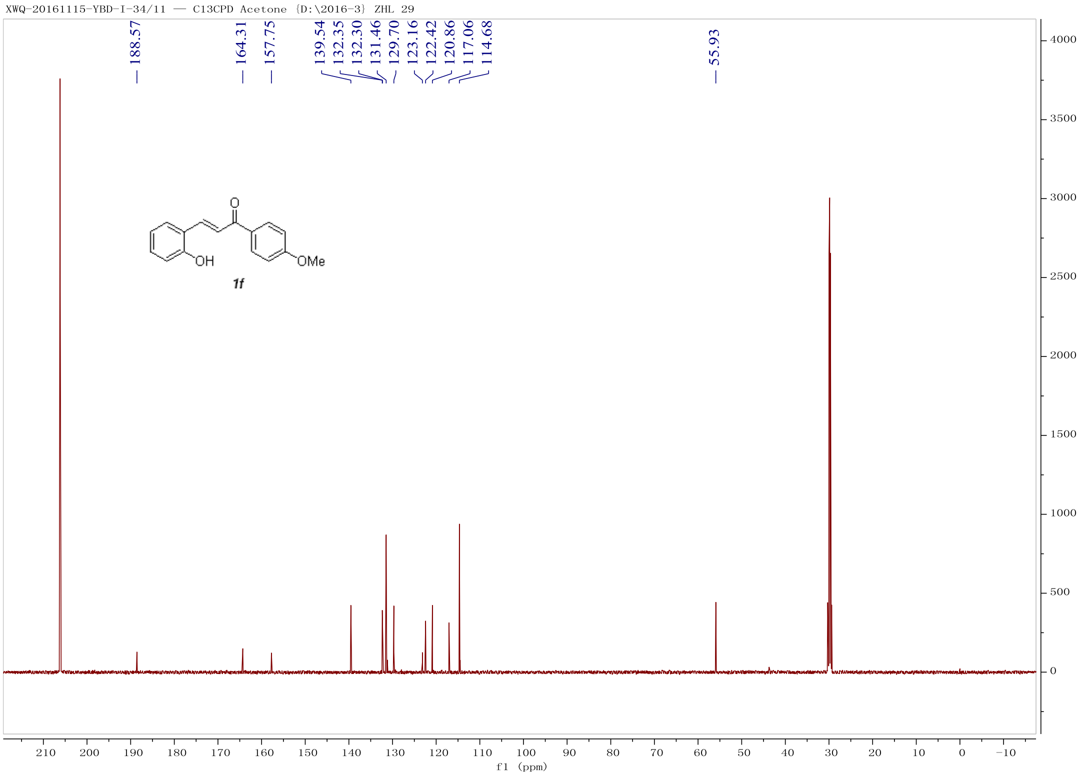
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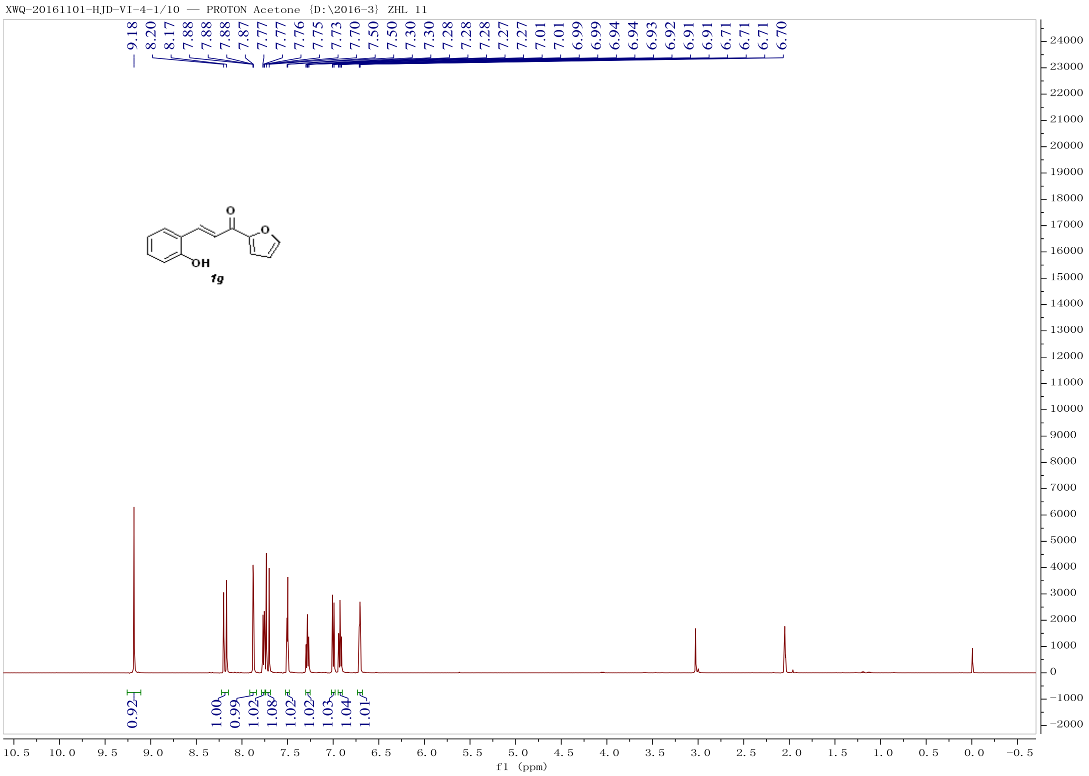
157.75
139.54 132.35 132.30 131.46 129.70 123.16 122.42 120.86 117.06 114.68
55.93
O
OH
OMe
1f
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)
4000 3500 3000 2500 2000 1500 1000 500 0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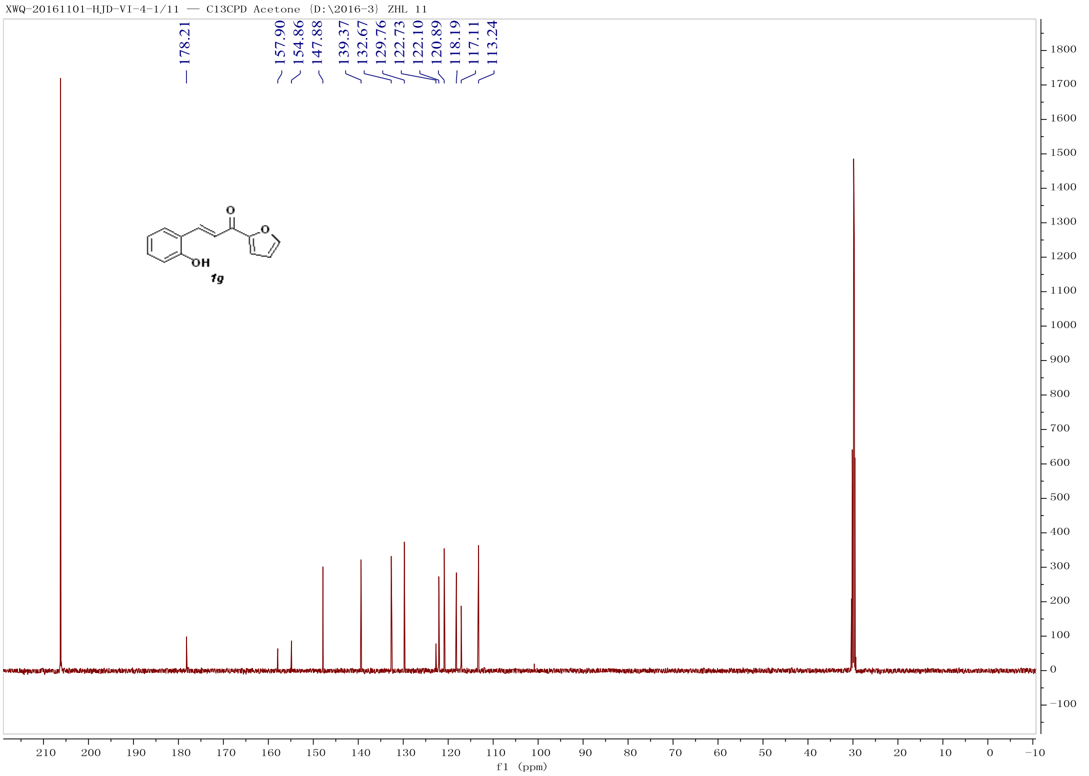
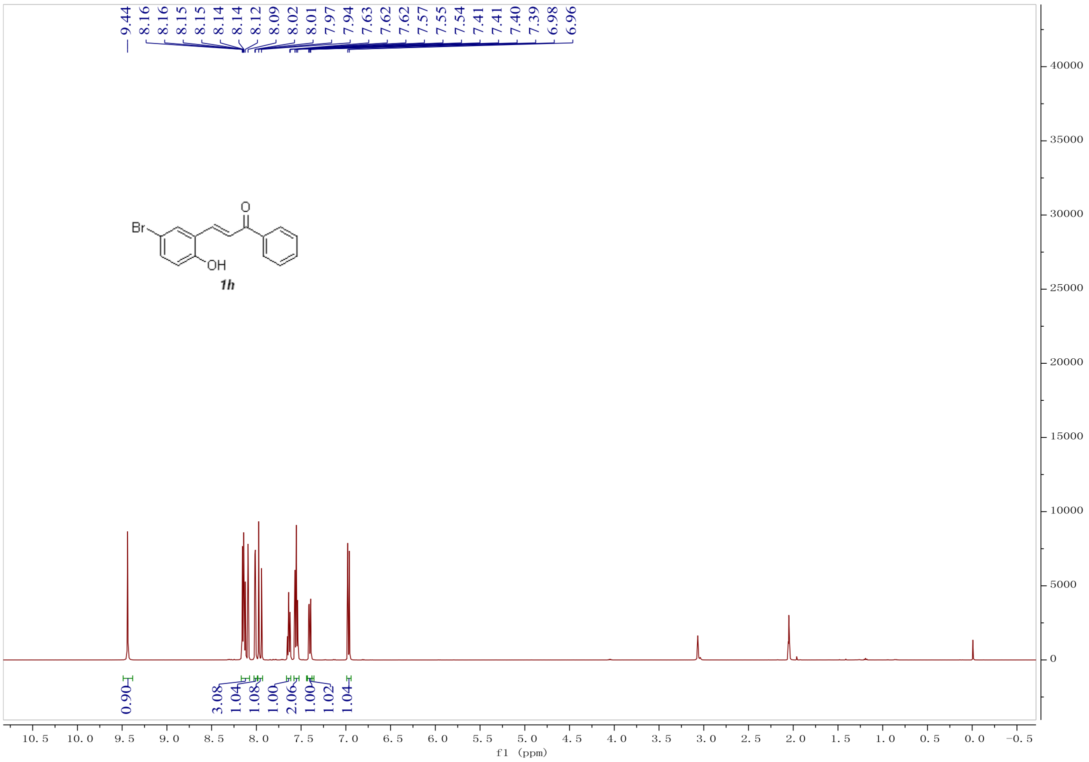
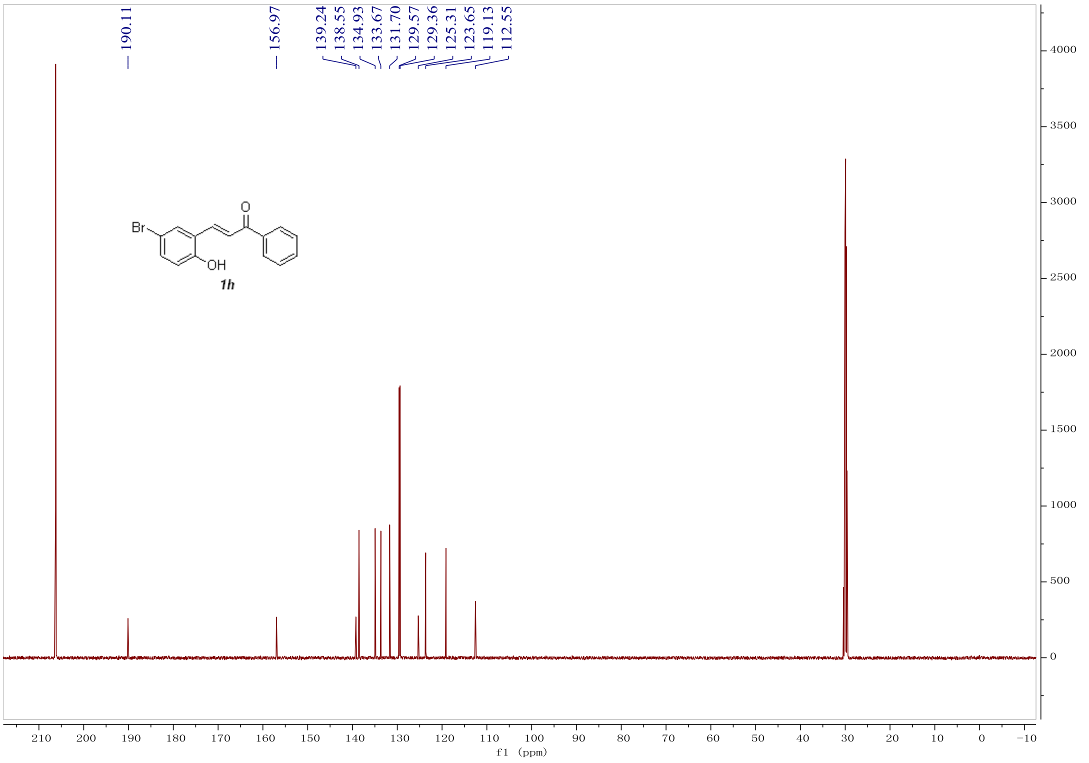
7.88
7.88
7.87
7.77
7.77
7.76
7.75
7.73
7.70
7.50
7.50
7.30
7.30
7.28
7.28
7.28
7.27
7.27
7.01
7.01
6.99
6.99
6.94
6.93
6.92
6.91
6.91
6.71
6.71
6.71
6.70
O
O
OH
1g
0.92
1.00
0.99
1.02
1.08
1.02
1.02
1.03
1.04
1.01
f1 (ppm)

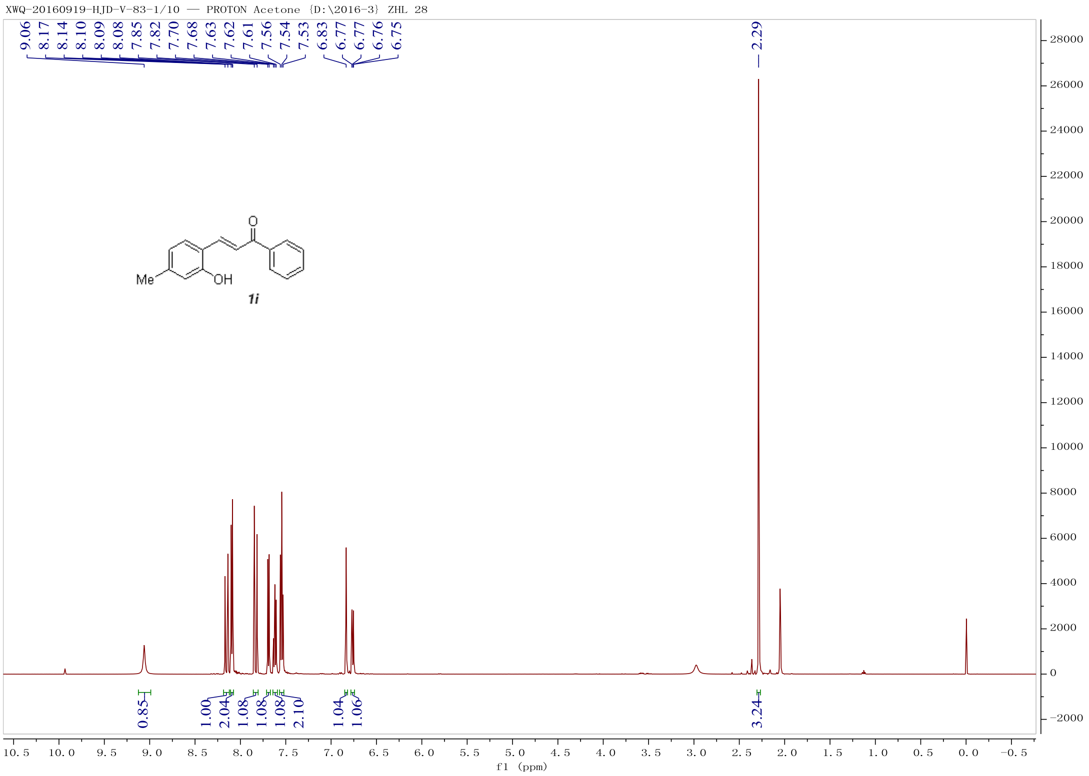

XWQ-20161101-HJD-VI-4-1/11 — C13CPD Acetone {D:\2016-3} ZHL 11
178.21
157.90
154.86
147.88
139.37
132.67
129.76
122.73
122.10
120.89
118.19
117.11
113.24
O
O
OH
1g
f1 (ppm)

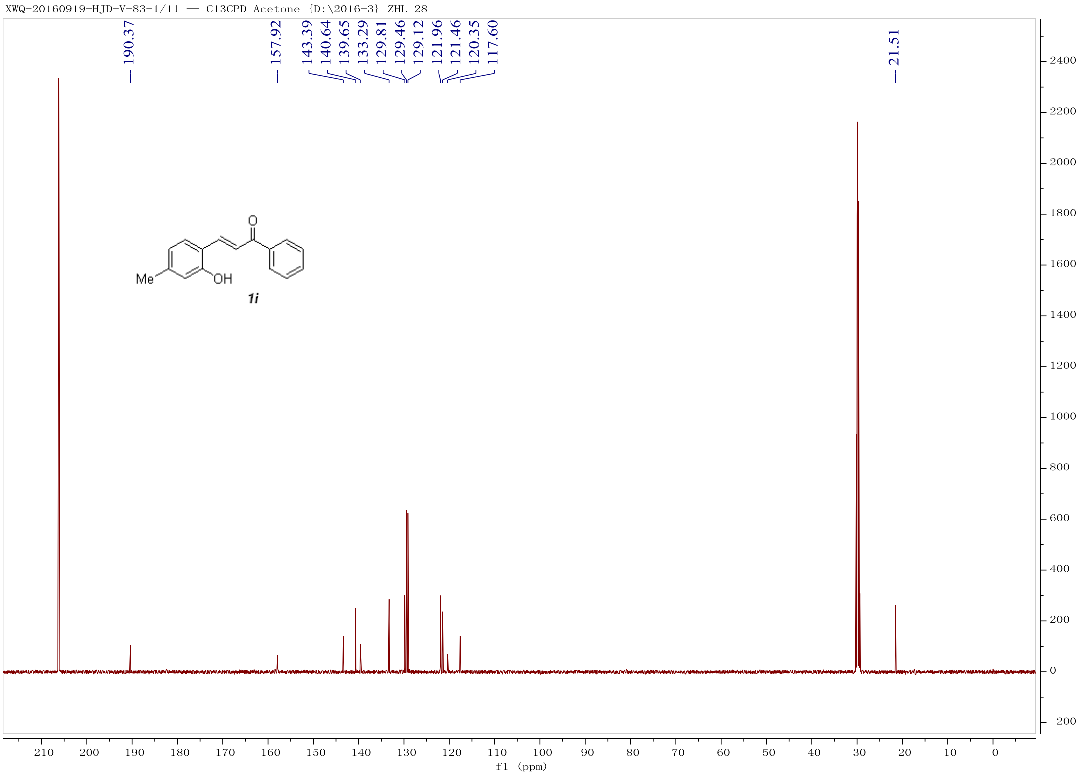
XWQ-20170308-HJD-VI-34-1/10 — PROTON Acetone {D:\2017-1} ZHL 34



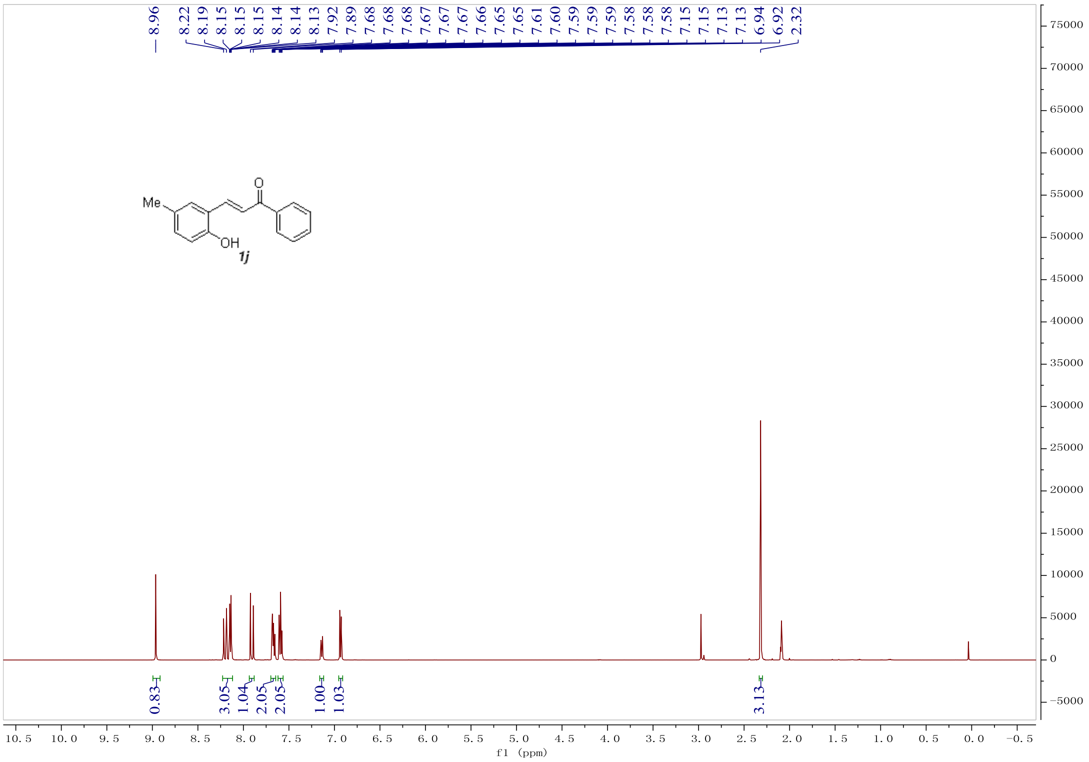
XWQ-20170308-HJD-VI-34-1/11 — C13CPD Acetone {D:\2017-1} ZHL 34



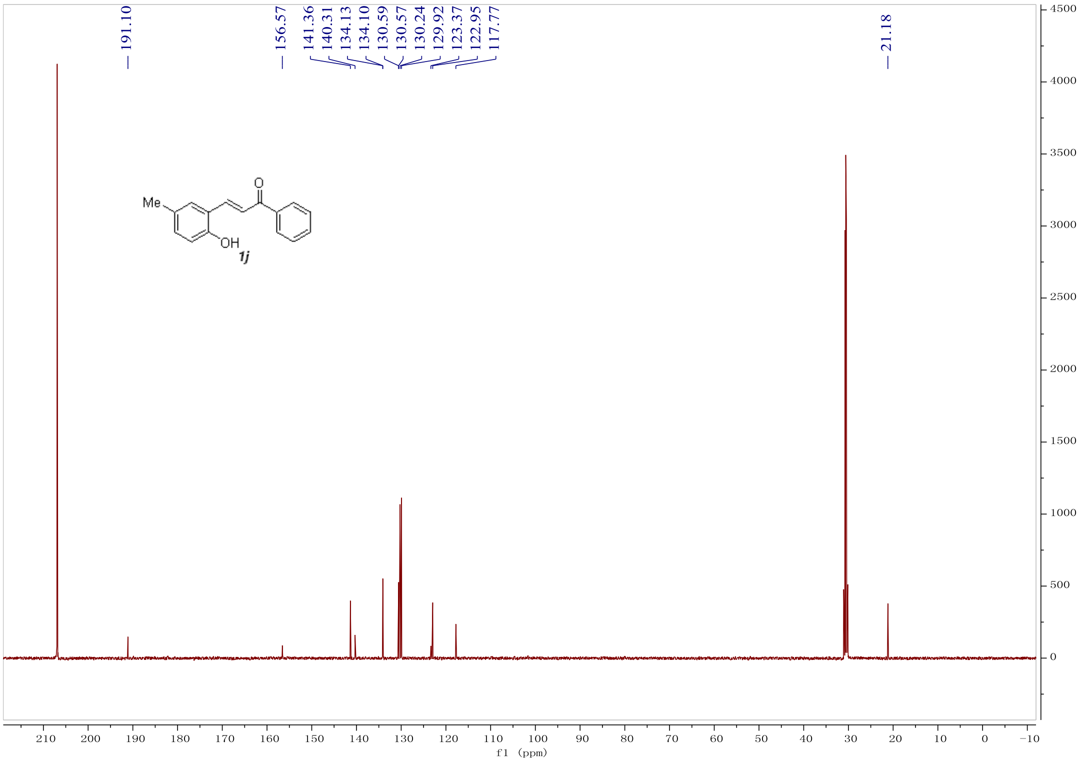

XWQ-20160919-HJD-V-83-1/10 — PROTON Acetone {D:\2016-3} ZHL 28
9.06
8.17
8.14
8.10
8.09
8.08
7.85
7.82
7.70
7.68
7.63
7.62
7.61
7.56
7.54
7.53
6.83
6.77
6.77
6.76
6.75
2.29
O
Me
OH
1i
0.85
1.00
2.04
1.08
1.08
1.08
2.10
1.04
1.06
3.24
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−2000
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

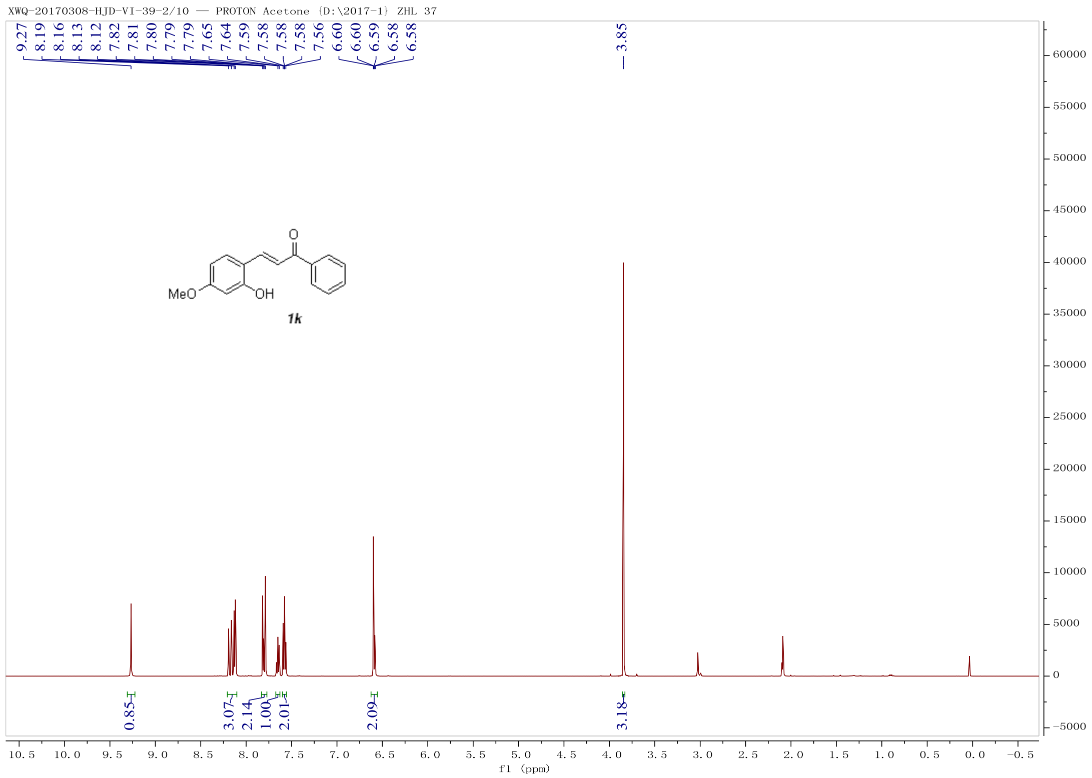

XWQ-20160919-HJD-V-83-1/11 — C13CPD Acetone {D:\2016-3} ZHL 28
190.37
157.92
143.39
140.64
139.65
133.29
129.81
129.46
129.12
121.96
121.46
120.35
117.60
21.51
O
Me
OH
1i
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−200
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

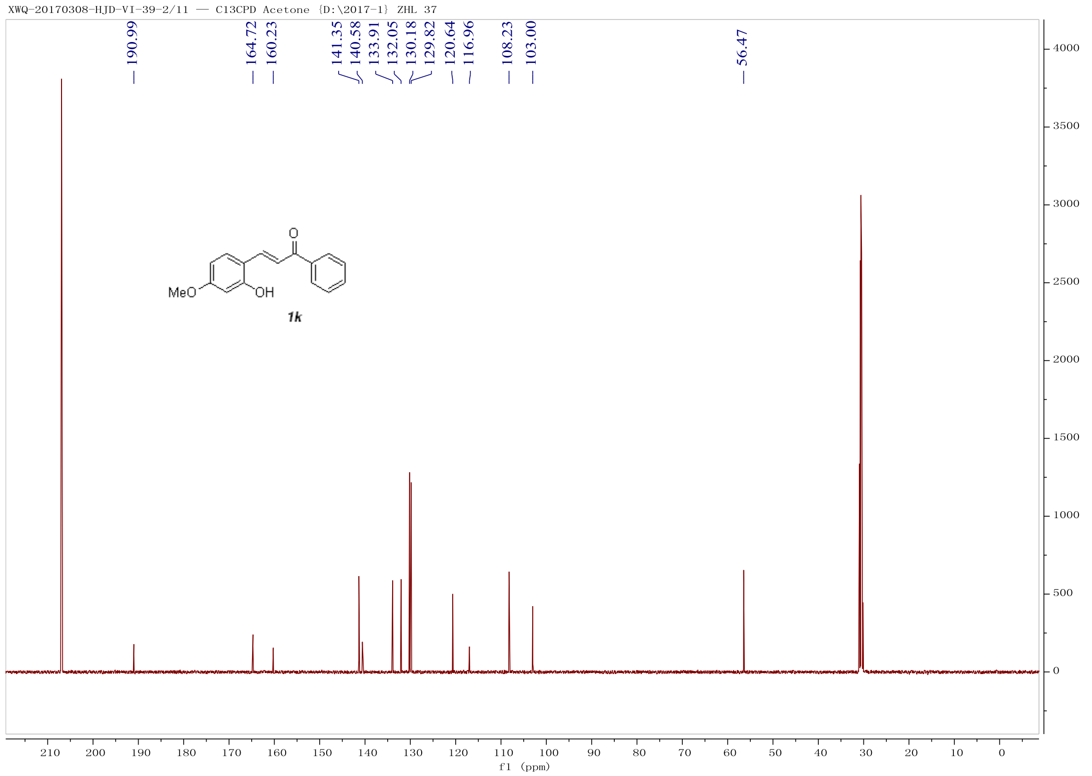
XWQ-20170308-HJD-VI-34-2/10 — PROTON Acetone {D:\2017-1} ZHL 36

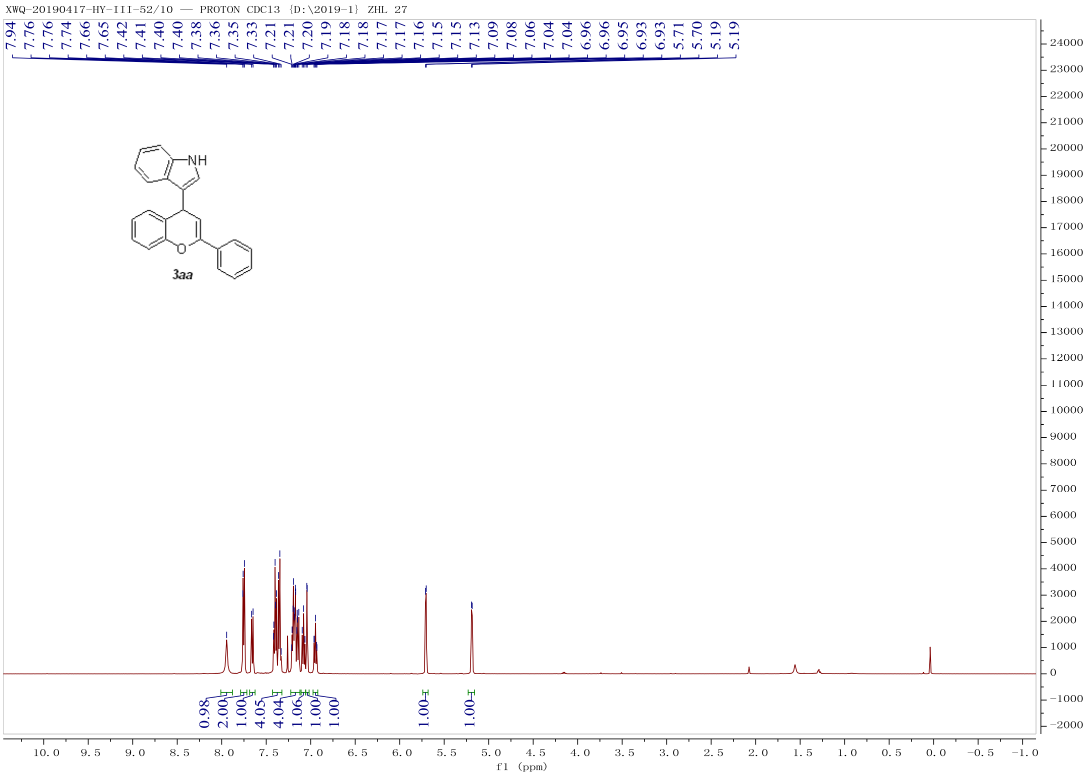


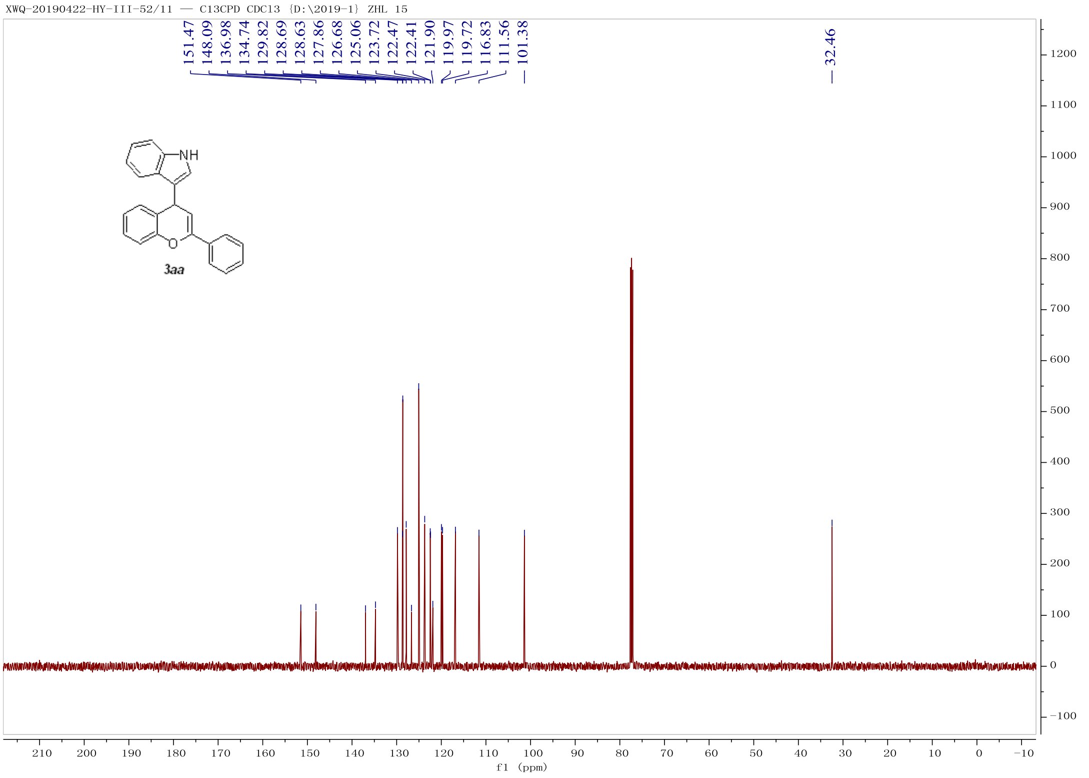
XWQ-20170308-HJD-VI-34-2/11 — C13CPD Acetone {D:\2017-1} ZHL 36



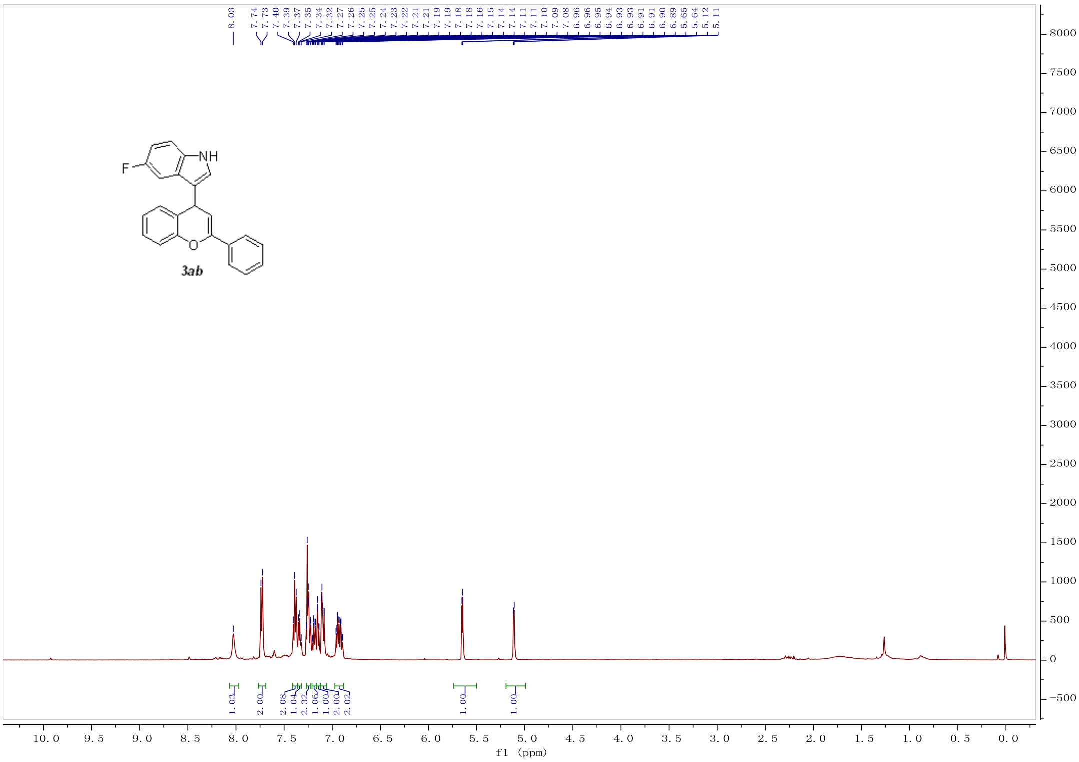

XWQ-20170308-HJD-VI-39-2/10 — PROTON Acetone {D:\2017-1} ZHL 37
9.27
8.19
8.16
8.13
8.12
7.82
7.81
7.80
7.79
7.79
7.65
7.64
7.59
7.58
7.58
7.58
7.56
6.60
6.60
6.59
6.58
6.58
3.85
MeO
OH
O
1k
0.85
3.07
2.14
1.00
2.01
2.09
3.18
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


XWQ-20170308-HJD-VI-39-2/11 — C13CPD Acetone {D:\2017-1} ZHL 37
190.99
164.72
160.23
141.35
140.58
133.91
132.05
130.18
129.82
120.64
116.96
108.23
103.00
56.47
MeO
OH
O
1k
4000
3500
3000
2500
2000
1500
1000
500
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

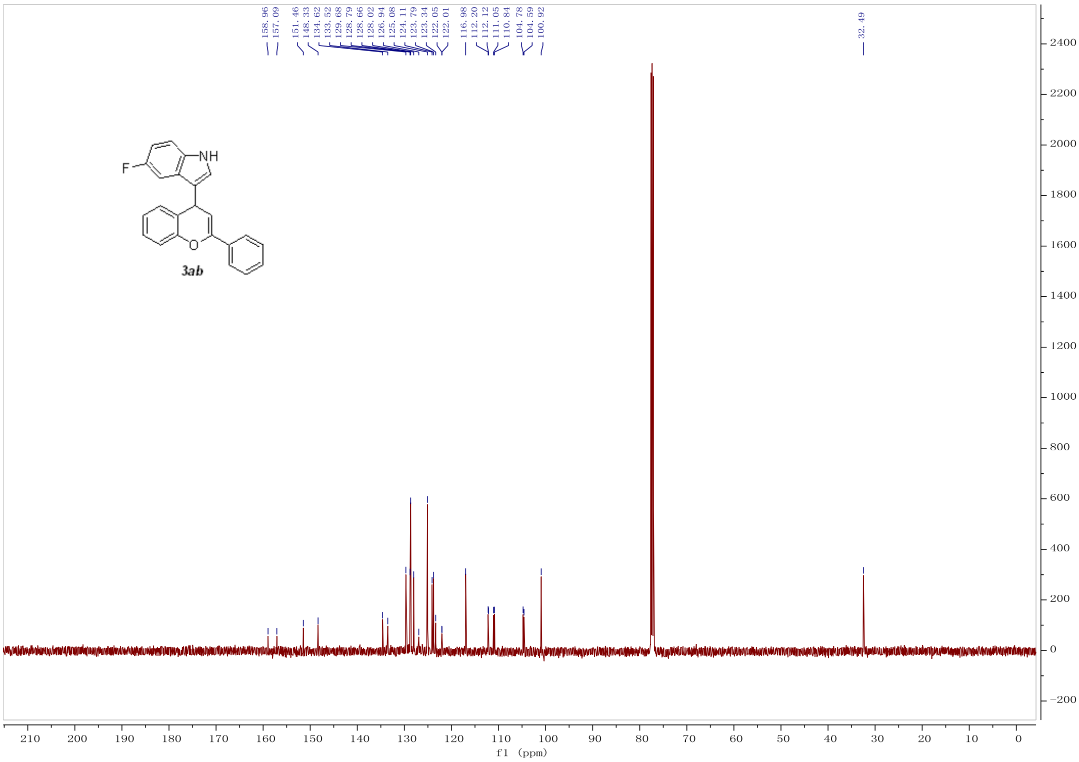

XWQ-20190417-HY-III-52/10 — PROTON CDCl3 {D:\2019-1} ZHL 27
7.94
7.76
7.76
7.74
7.66
7.65
7.42
7.41
7.40
7.40
7.38
7.36
7.35
7.33
7.21
7.21
7.20
7.19
7.18
7.18
7.17
7.17
7.16
7.15
7.15
7.13
7.09
7.08
7.06
7.04
7.04
6.96
6.96
6.95
6.93
6.93
5.71
5.70
5.19
5.19
NH
O
3aa
0.98
2.00
1.00
4.05
4.04
1.06
1.00
1.00
1.00
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
f1 (ppm)
24000
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000

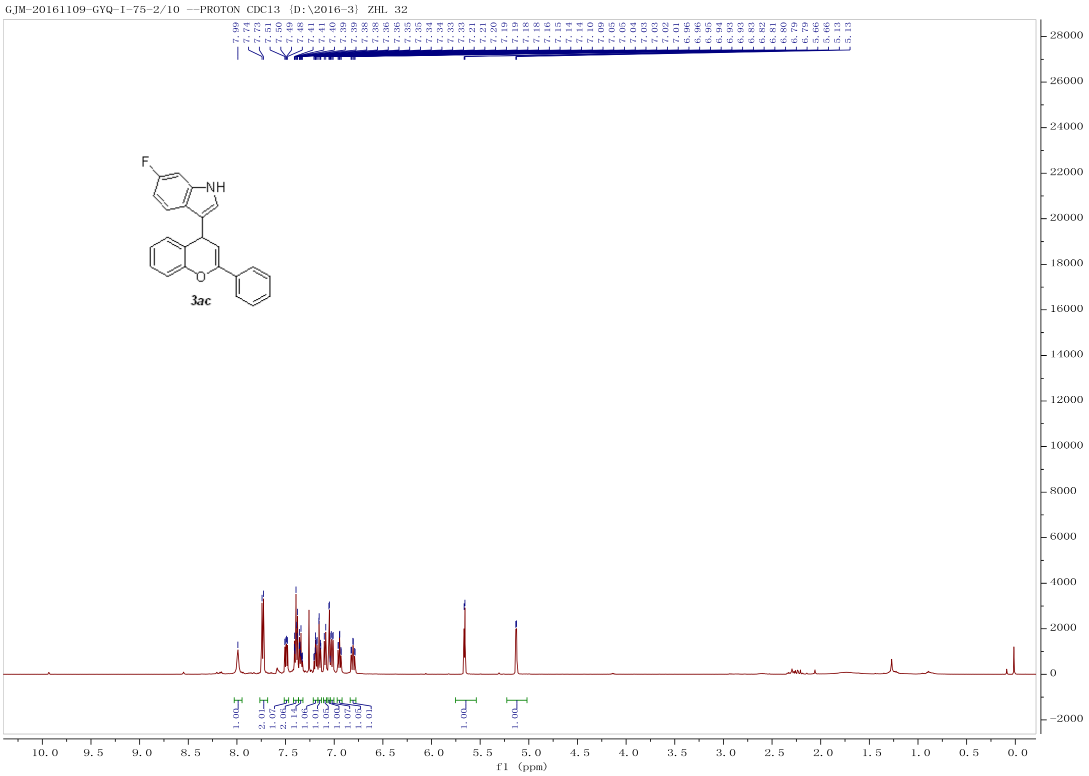

XWQ-20190422-HY-III-52/11 — C13CPD CDCl3 {D:\2019-1} ZHL 15
151.47
148.09
136.98
134.74
129.82
128.69
128.63
127.86
126.68
125.06
123.72
122.47
122.41
121.90
119.97
119.72
116.83
111.56
101.38
32.46
NH
O
3aa
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100

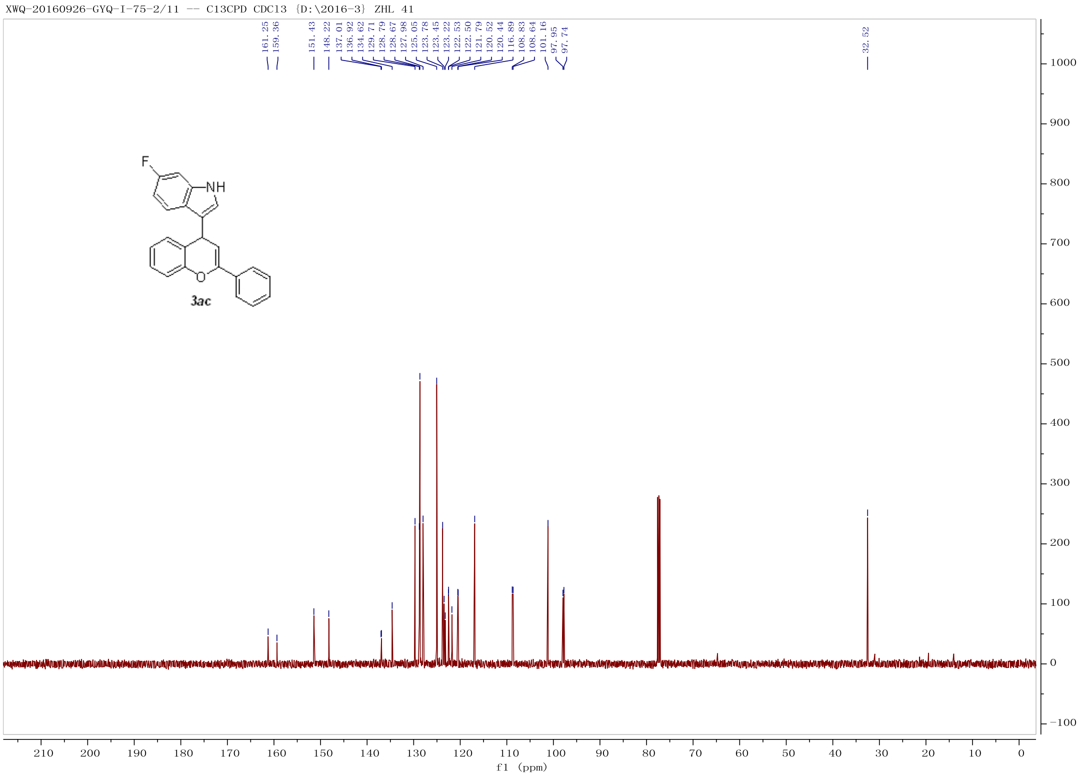
GJM-20161110-GYQ-I-71-1/10 -- PROTON CDCl3 {D:\2016-3} ZHL 51

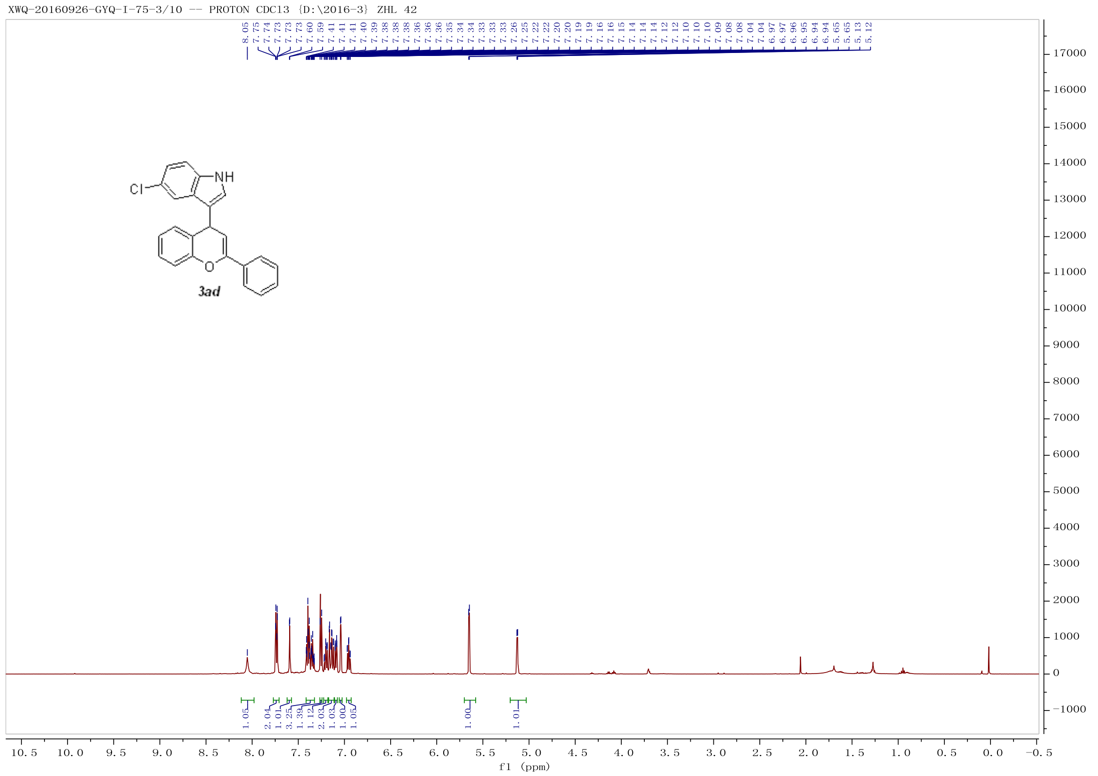


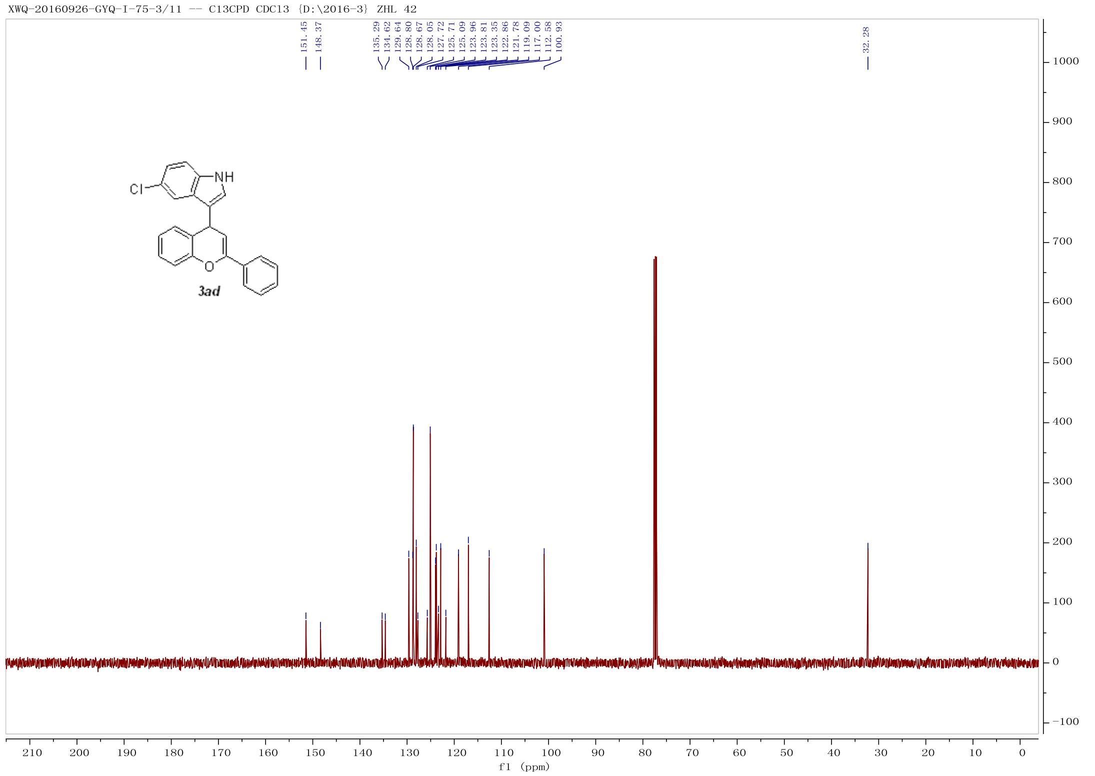
GJM-20161110-GYQ-I-71-1/11 C13CPD CDCl3 {D:\2016-3} ZHL 51



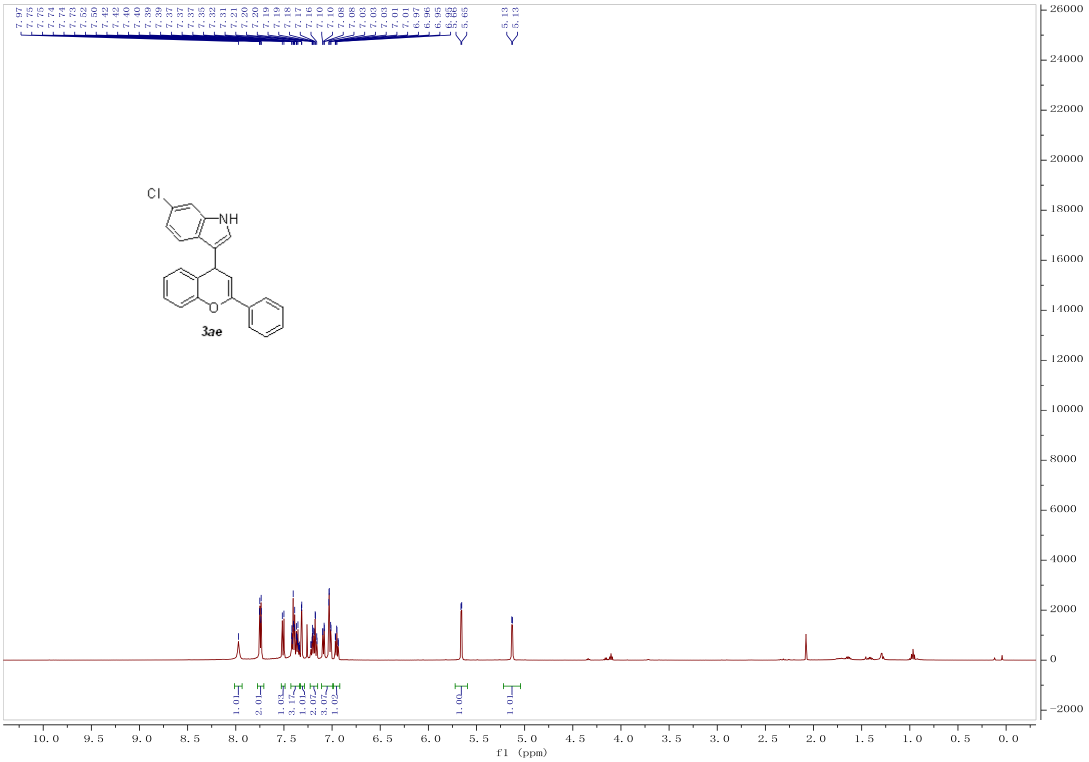

GJM-20161109-GYQ-I-75-2/10 --PROTON CDCl3 {D:\2016-3} ZHL 32
7.99
7.74
7.73
7.51
7.50
7.49
7.48
7.41
7.40
7.39
7.39
7.38
7.38
7.36
7.36
7.35
7.35
7.34
7.34
7.33
7.33
7.21
7.21
7.20
7.19
7.19
7.18
7.18
7.16
7.15
7.14
7.14
7.10
7.09
7.05
7.05
7.04
7.03
7.03
7.02
7.01
6.96
6.96
6.95
6.94
6.93
6.93
6.83
6.82
6.81
6.80
6.79
6.79
5.66
5.66
5.13
5.13
F
NH
O
3ac
1.00
2.01
1.07
2.06
1.14
1.06
1.01
1.05
1.00
1.07
1.05
1.01
1.00
1.00
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


XWQ-20160926-GYQ-I-75-2/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 41
161.25
159.36
151.43
148.22
137.01
136.92
134.62
129.71
128.79
128.67
127.98
125.05
123.78
123.45
123.22
122.53
122.50
121.79
120.52
120.44
116.89
108.83
108.64
101.16
97.95
97.74
32.52
F
NH
O
3ac
1000
900
800
700
600
500
400
300
200
100
0
-100
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

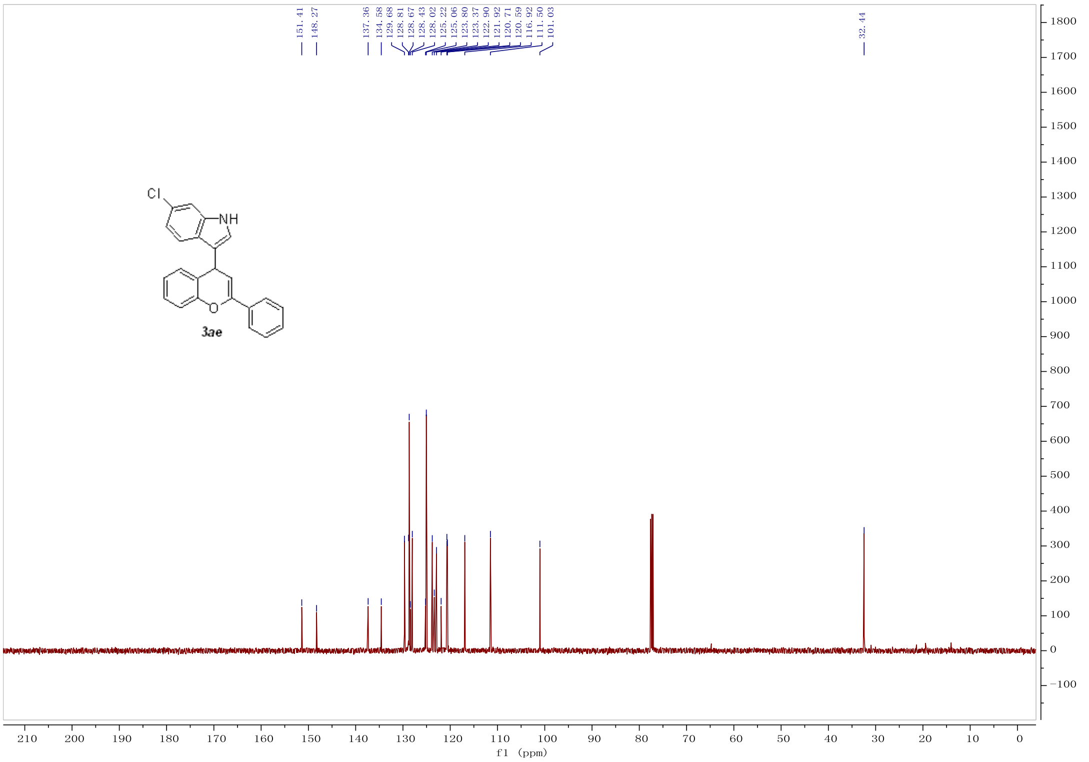

XWQ-20160926-GYQ-I-75-3/10 -- PROTON CDCl3 {D:\2016-3} ZHL 42
8.05 7.75 7.74 7.73 7.73 7.73 7.60 7.59 7.41 7.41 7.41 7.40 7.39 7.38 7.38 7.38 7.36 7.36 7.36 7.35 7.34 7.34 7.33 7.33 7.33 7.26 7.25 7.22 7.22 7.20 7.20 7.19 7.19 7.16 7.16 7.15 7.14 7.14 7.14 7.12 7.12 7.10 7.10 7.10 7.09 7.08 7.08 7.04 7.04 6.97 6.97 6.96 6.95 6.94 6.94 5.65 5.65 5.13 5.12
Cl
NH
O
3ad
1.05 2.04 1.01 3.25 1.39 1.12 2.03 1.03 1.00 1.05 1.00 1.01
17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0 −1000
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)


XWQ-20160926-GYQ-I-75-3/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 42
151.45 148.37 135.29 134.62 129.64 128.80 128.67 128.05 127.72 125.71 125.09 123.96 123.81 123.35 122.86 121.78 119.09 117.00 112.58 100.93 32.28
Cl
NH
O
3ad
1000 900 800 700 600 500 400 300 200 100 0 −100
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

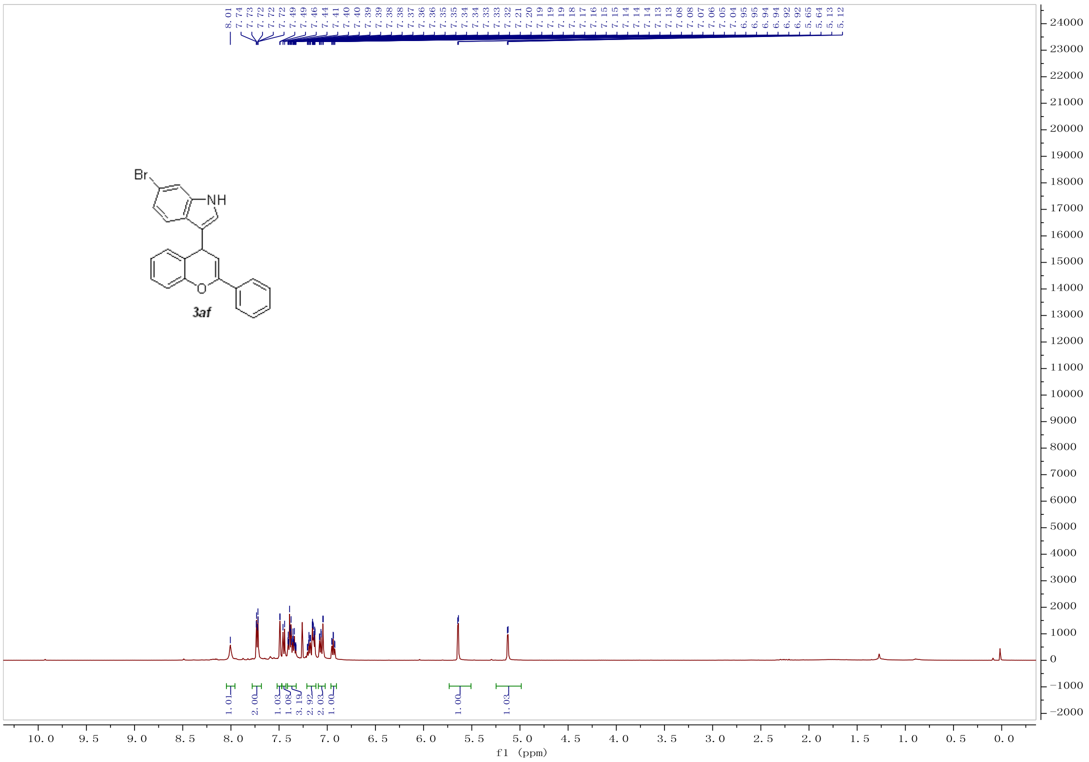
XWQ-20160926-GYQ-I-75-1/10 -- PROTON CDCl3 {D:\2016-3} ZHL 40



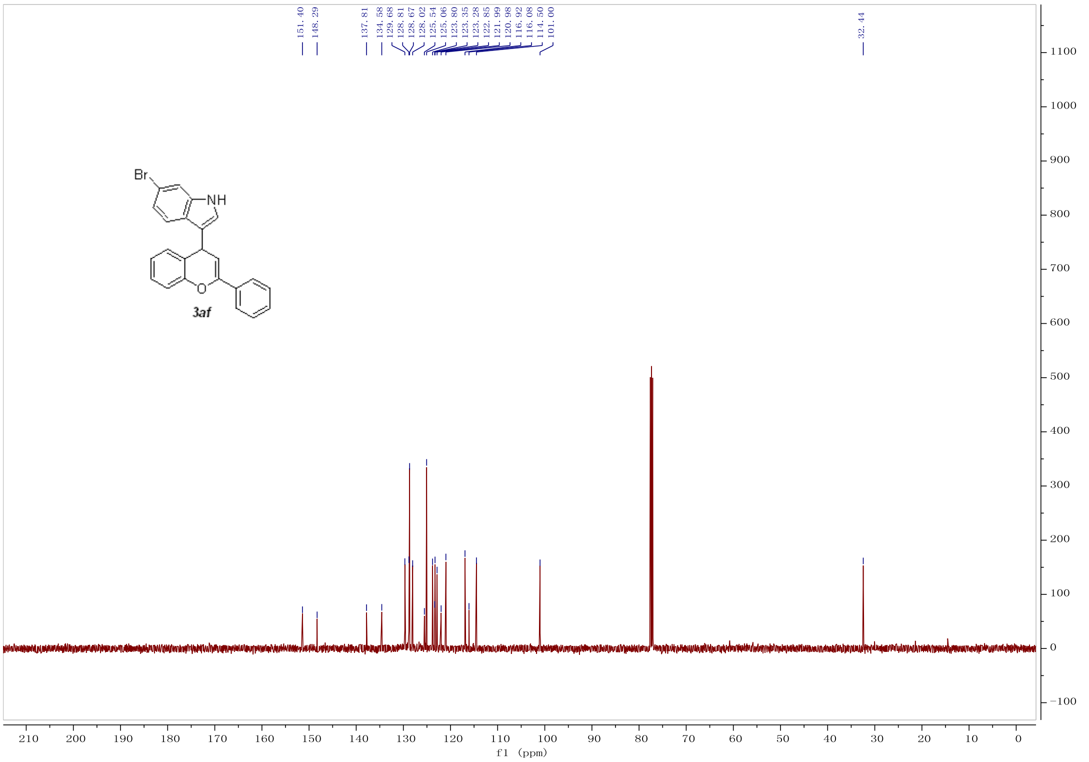
XWQ-20160926-GYQ-I-75-1/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 40

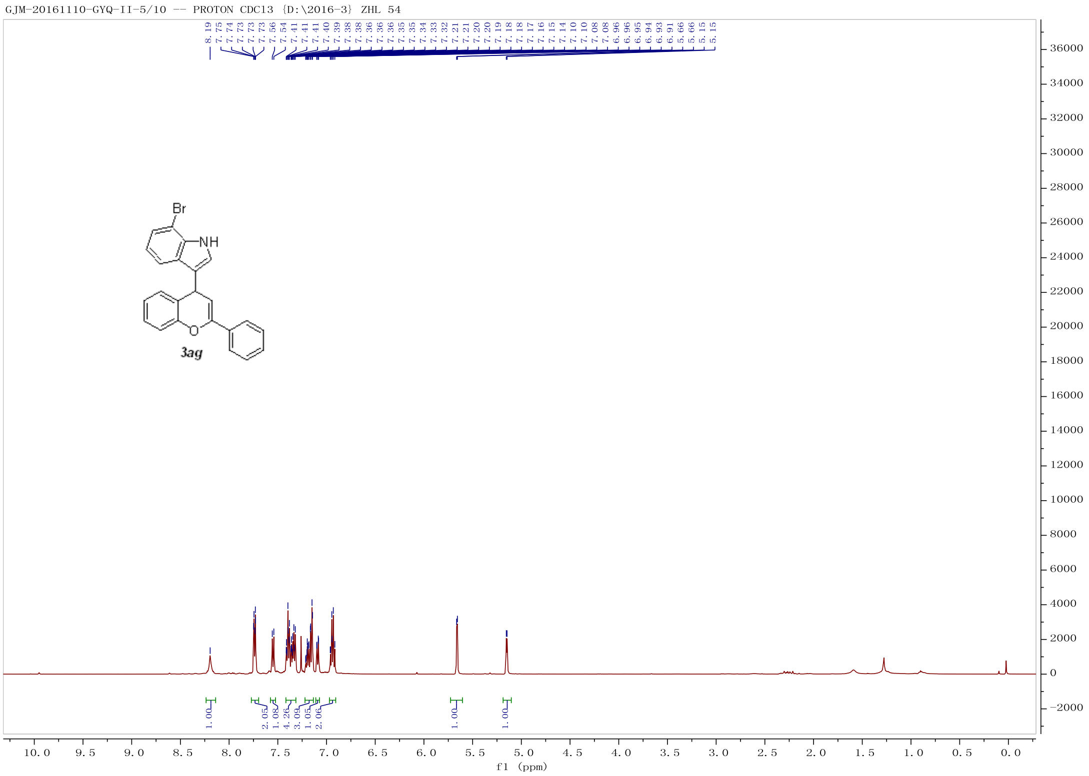


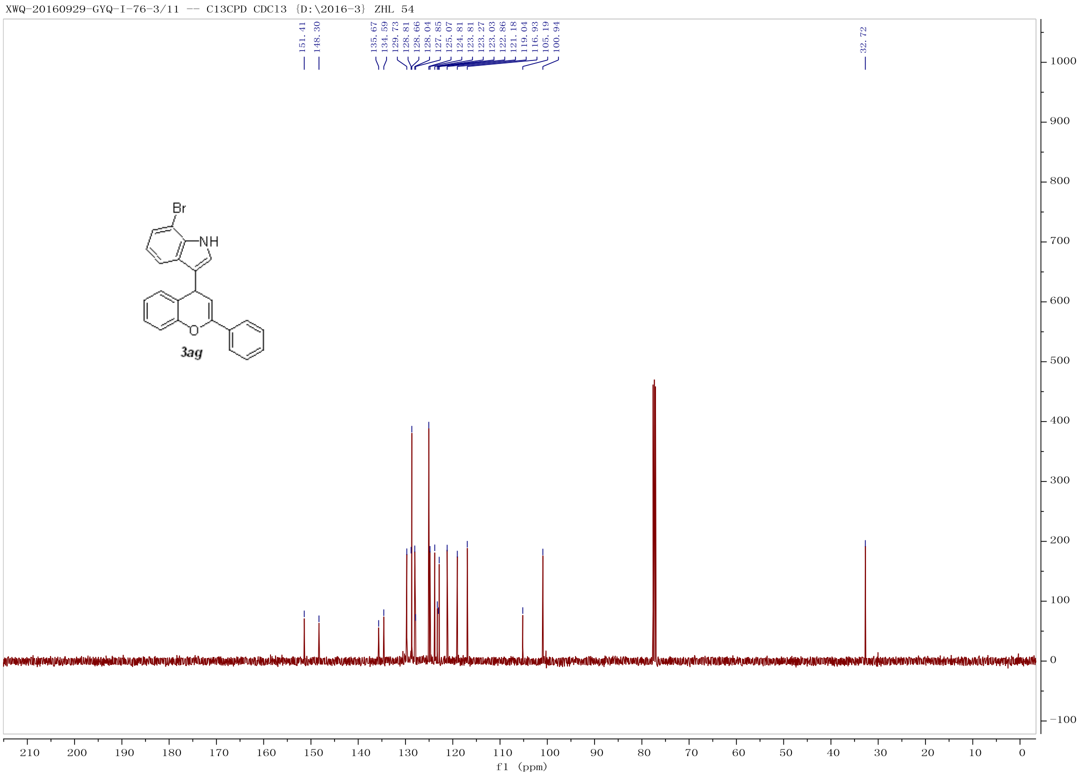
GJM-20161110-GYQ-II-3-2/10 -- PROTON CDCl3 {D:\2016-3} ZHL 53



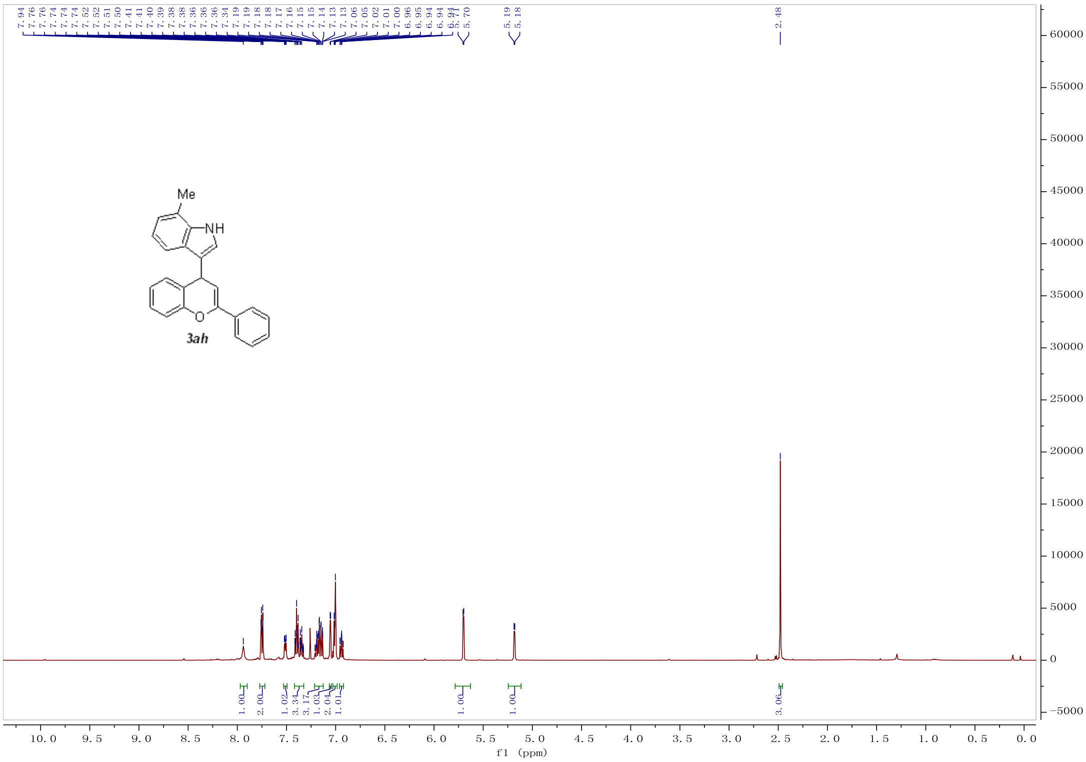
XWQ-20160929-GYQ-I-76-4/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 55



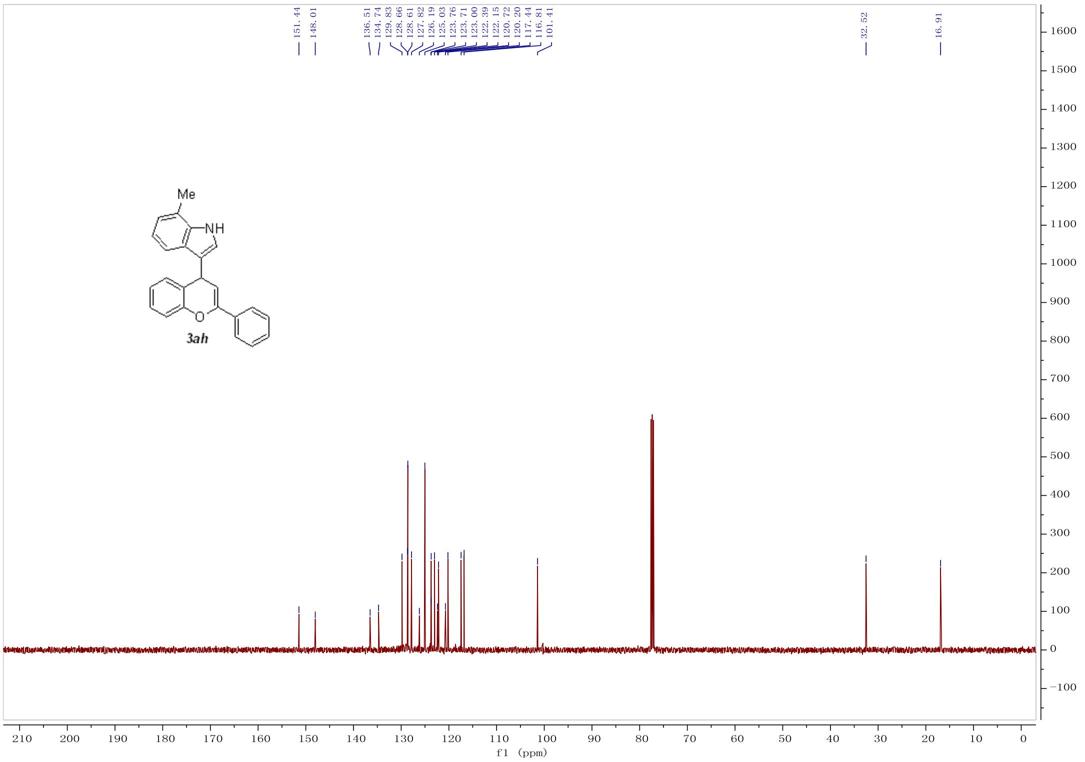

GJM-20161110-GYQ-II-5/10 -- PROTON CDCl3 {D:\2016-3} ZHL 54
8.19
7.75
7.74
7.73
7.73
7.73
7.56
7.54
7.41
7.41
7.41
7.40
7.39
7.38
7.38
7.36
7.36
7.36
7.35
7.35
7.34
7.33
7.32
7.21
7.21
7.20
7.20
7.19
7.18
7.18
7.17
7.16
7.15
7.14
7.10
7.10
7.08
7.08
6.96
6.96
6.95
6.94
6.93
6.91
5.66
5.66
5.15
5.15
Br
NH
O
3ag
1.00
2.05
1.08
4.26
3.09
1.05
2.06
1.00
1.00
36000
34000
32000
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

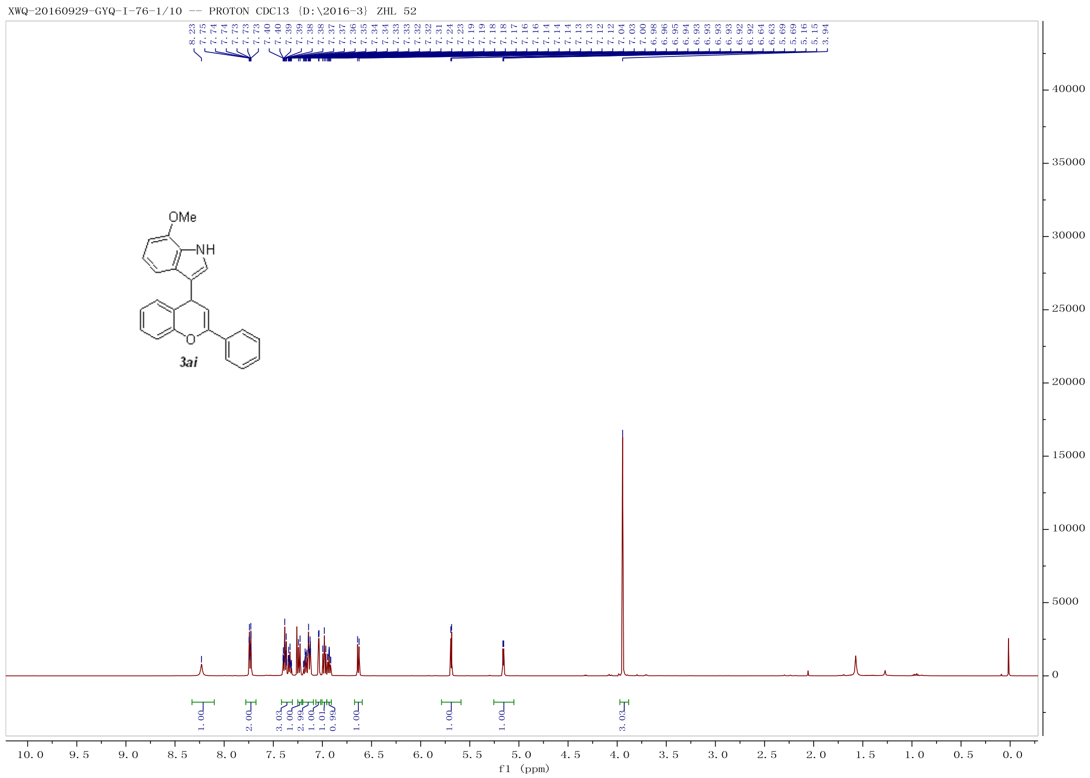

XWQ-20160929-GYQ-I-76-3/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 54
151.41
148.30
135.67
134.59
129.73
128.81
128.66
128.04
127.85
125.07
124.81
123.81
123.27
123.03
122.86
121.18
119.04
116.93
105.19
100.94
32.72
Br
NH
O
3ag
1000
900
800
700
600
500
400
300
200
100
0
-100
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

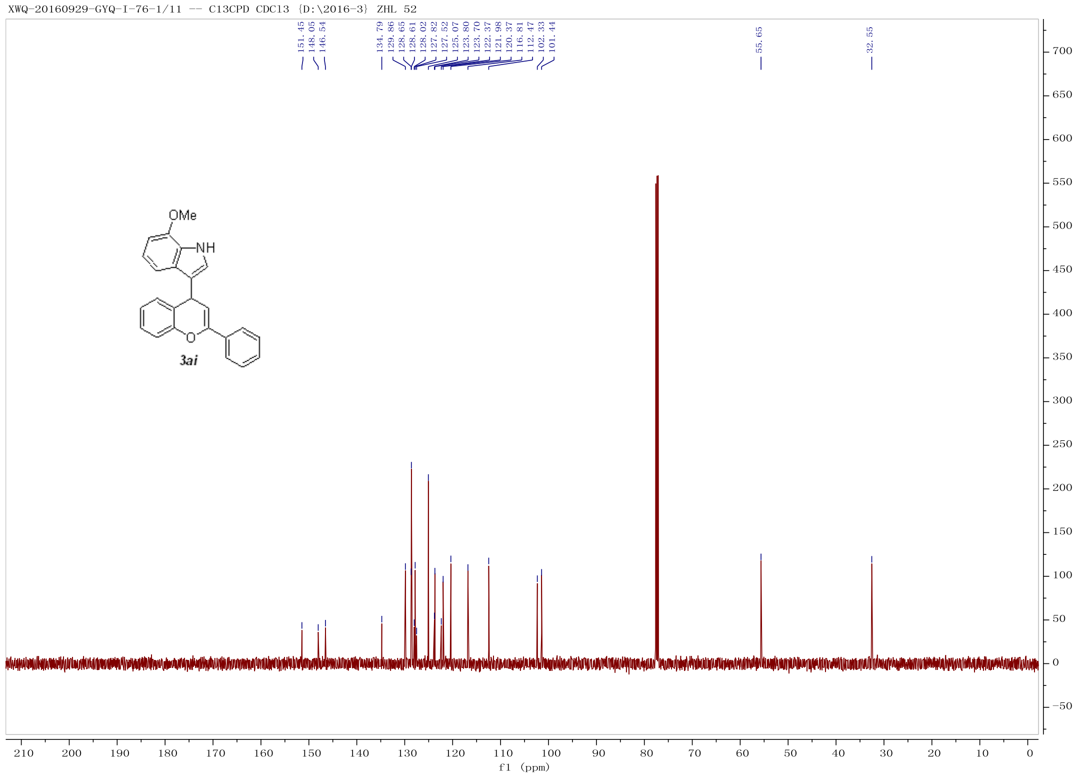
XWQ-20161118-GYQ-II-7/10 -- PROTON CDCl3 {D:\2016-3} ZHL 31

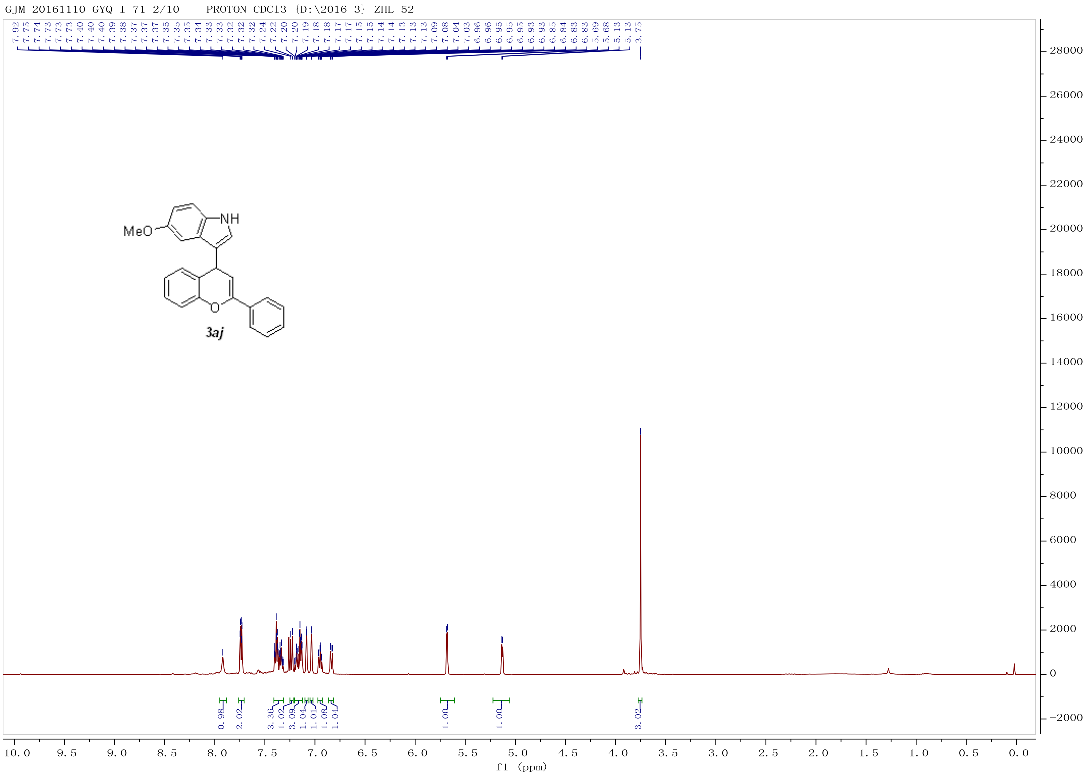


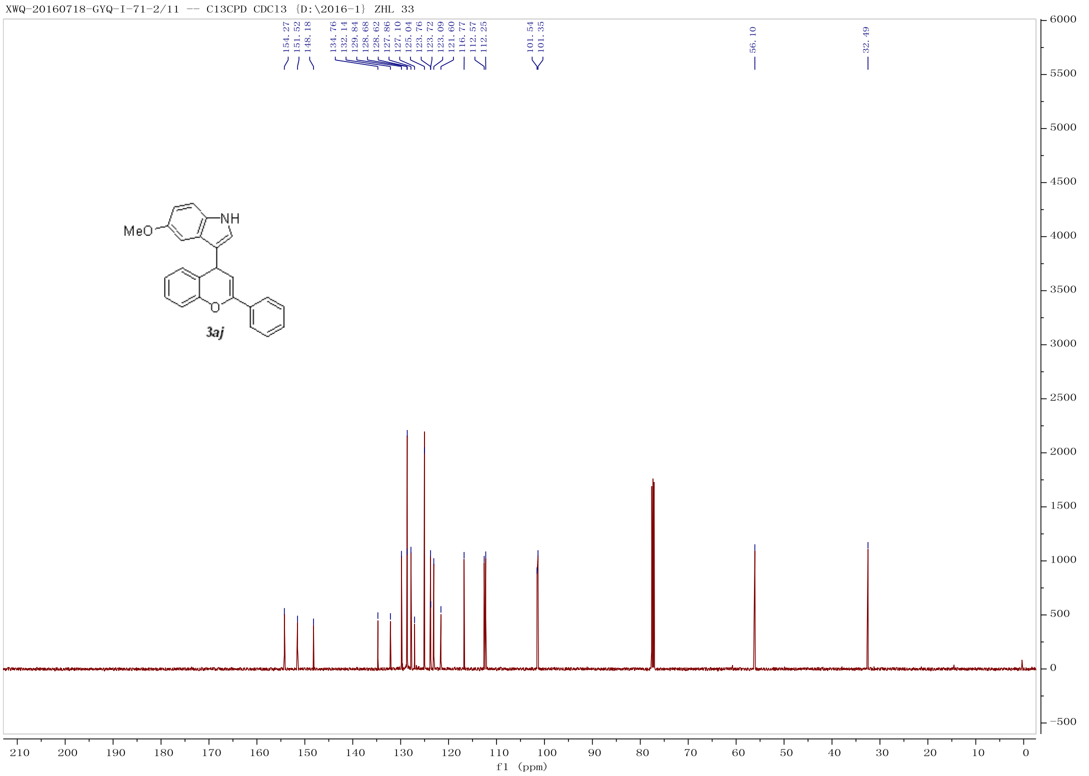
XWQ-20161118-GYQ-II-7/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 31

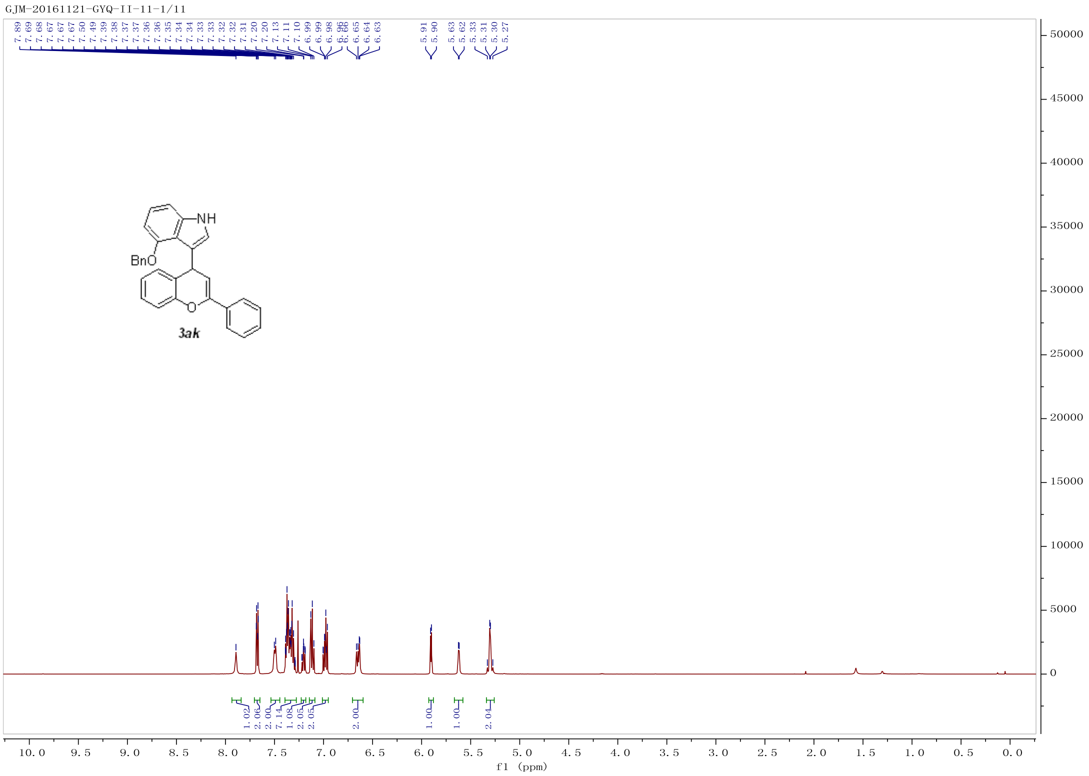


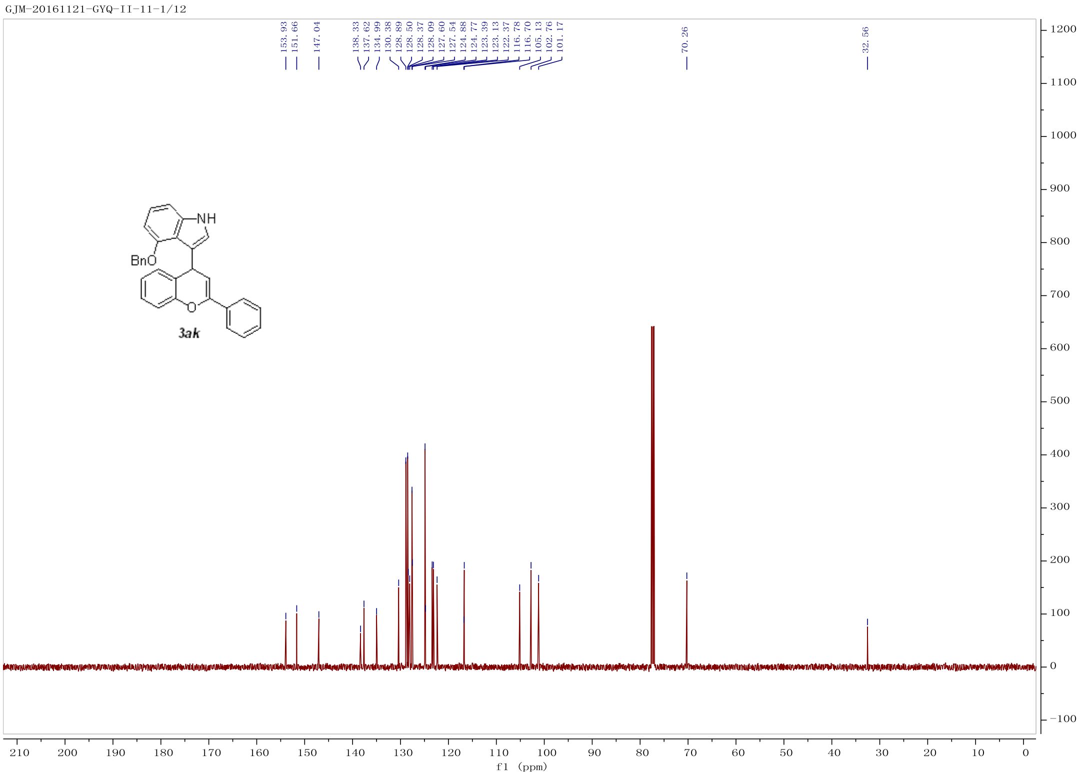

XWQ-20160929-GYQ-I-76-1/10 -- PROTON CDCl3 {D:\2016-3} ZHL 52
8.23 7.75 7.74 7.74 7.73 7.73 7.73 7.40 7.40 7.39 7.39 7.38 7.38 7.37 7.37 7.36 7.35 7.34 7.34 7.33 7.33 7.32 7.32 7.31 7.24 7.23 7.19 7.19 7.18 7.18 7.17 7.16 7.16 7.14 7.14 7.14 7.13 7.13 7.12 7.12 7.04 7.03 7.00 6.98 6.96 6.95 6.94 6.93 6.93 6.93 6.93 6.92 6.92 6.64 6.63 5.69 5.69 5.16 5.15 3.94
OMe
NH
O
3ai
1.00 2.00 3.03 1.00 2.99 1.00 1.01 0.99 1.00 1.00 1.00 3.03
40000
35000
30000
25000
20000
15000
10000
5000
0
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


XWQ-20160929-GYQ-I-76-1/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 52
151.45 148.05 146.54 134.79 129.86 128.65 128.61 128.02 127.82 127.52 125.07 123.80 123.70 122.37 121.98 120.37 116.81 112.47 102.33 101.44 55.65 32.55
OMe
NH
O
3ai
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
−50
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

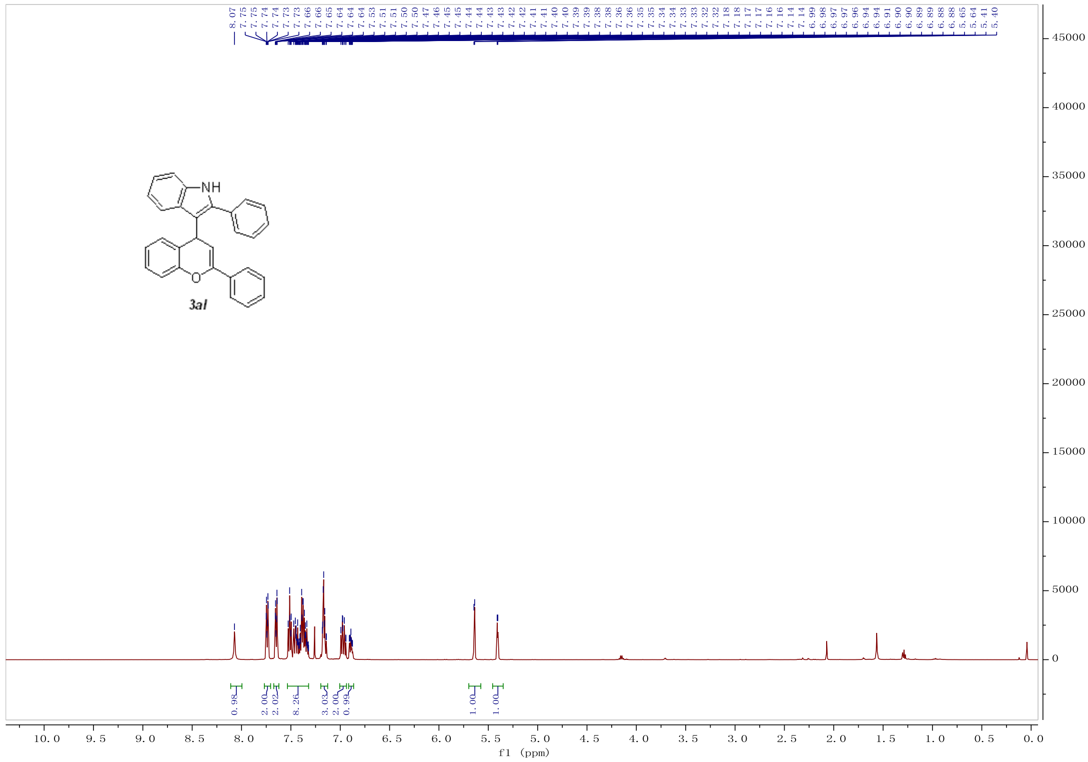

GJM-20161110-GYQ-I-71-2/10 -- PROTON CDCl3 {D:\2016-3} ZHL 52
7.92 7.75 7.74 7.73 7.73 7.73 7.40 7.40 7.40 7.39 7.38 7.37 7.37 7.37 7.35 7.35 7.35 7.34 7.33 7.33 7.32 7.32 7.32 7.24 7.22 7.20 7.20 7.19 7.18 7.18 7.17 7.17 7.15 7.15 7.14 7.14 7.13 7.13 7.13 7.09 7.08 7.04 7.03 6.96 6.96 6.95 6.95 6.95 6.93 6.93 6.85 6.84 6.83 6.83 5.69 5.68 5.13 5.13 3.75
MeO
NH
O
3aj
0.98 2.02 3.36 1.02 3.09 1.04 1.01 1.06 1.04 1.00 1.00 3.02
28000 26000 24000 22000 20000 18000 16000 14000 12000 10000 8000 6000 4000 2000 0 −2000
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


XWQ-20160718-GYQ-I-71-2/11 -- C13CPD CDCl3 {D:\2016-1} ZHL 33
154.27 151.52 148.18 134.76 132.14 129.84 128.68 128.62 127.86 127.10 125.04 123.76 123.72 123.09 121.60 116.77 112.57 112.25 101.54 101.35 56.10 32.49
MeO
NH
O
3aj
6000 5500 5000 4500 4000 3500 3000 2500 2000 1500 1000 500 0 −500
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

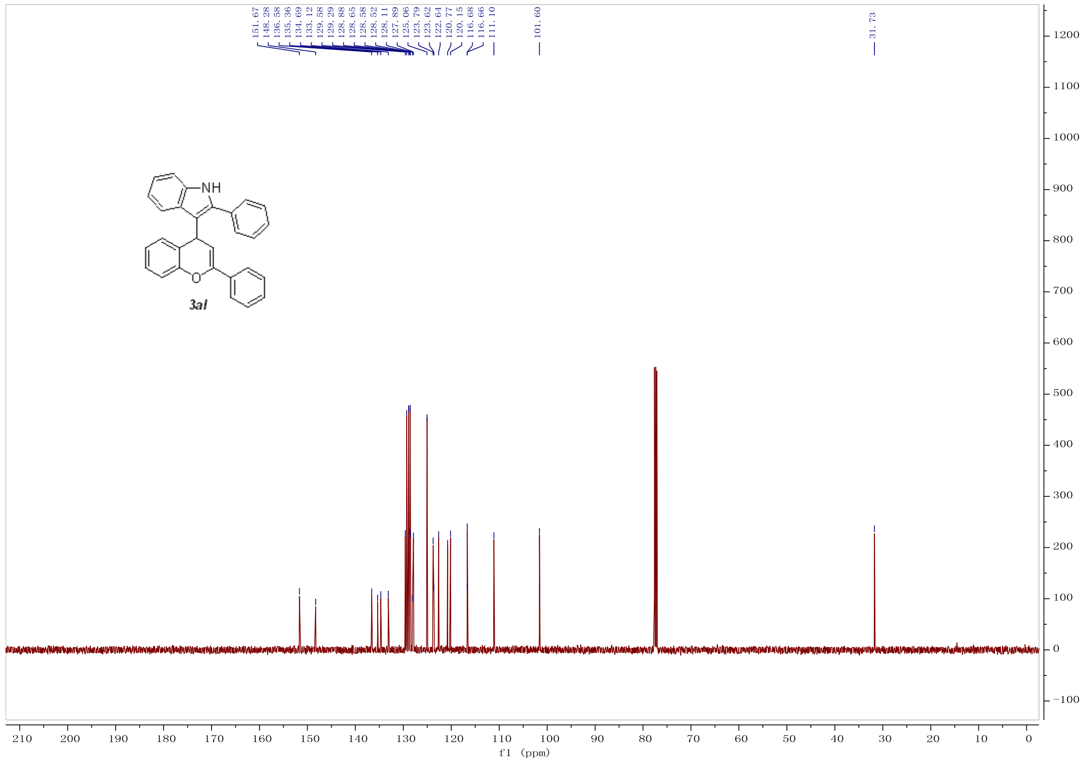

GJM-20161121-GYQ-II-11-1/11
7.89
7.69
7.68
7.67
7.67
7.67
7.50
7.49
7.39
7.38
7.37
7.37
7.36
7.36
7.35
7.34
7.34
7.33
7.33
7.32
7.32
7.31
7.20
7.20
7.13
7.11
7.10
6.99
6.99
6.98
6.96
6.66
6.65
6.64
6.63
5.91
5.90
5.63
5.62
5.33
5.31
5.30
5.27
NH
BnO
O
3ak
1.02
2.06
2.00
7.14
1.08
2.05
2.05
2.00
1.00
1.00
2.04
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0


GJM-20161121-GYQ-II-11-1/12
153.93
151.66
147.04
138.33
137.62
134.99
130.38
128.89
128.50
128.37
128.09
127.60
127.54
124.88
124.77
123.39
123.13
122.37
116.78
116.70
105.13
102.76
101.17
70.26
32.56
NH
BnO
O
3ak
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100

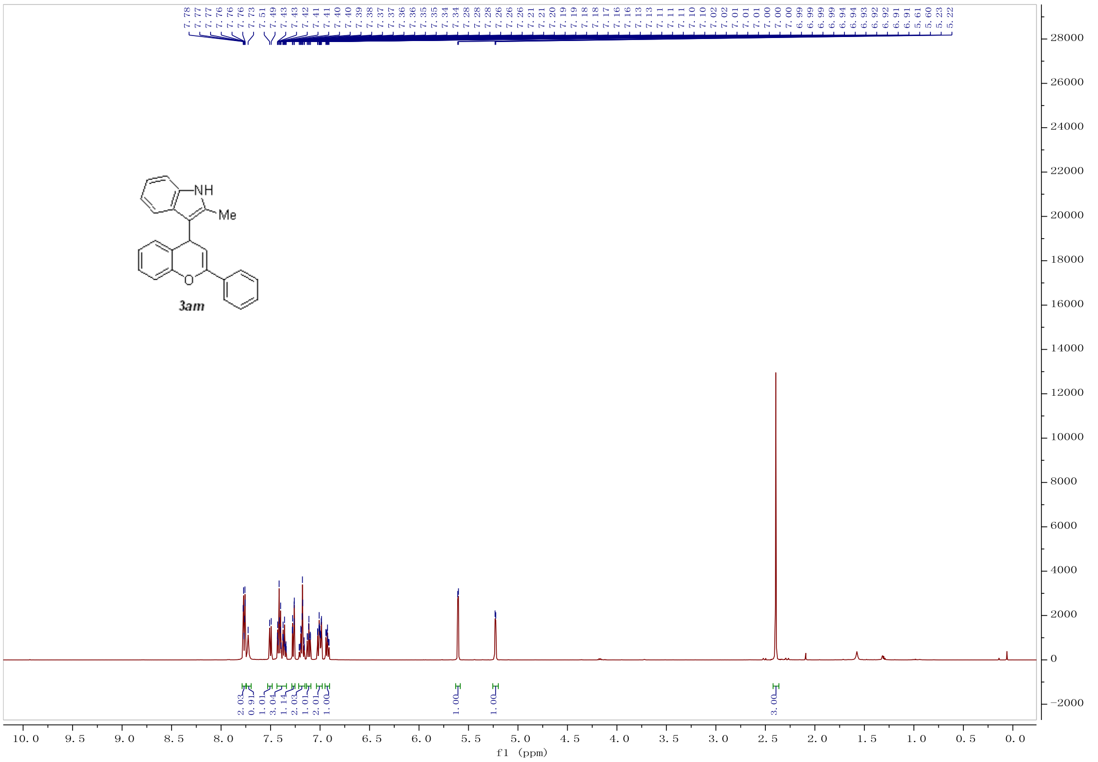
XWQ-20160929-GYQ-I-76-2/10 -- PROTON CDCl3 {D:\2016-3} ZHL 53



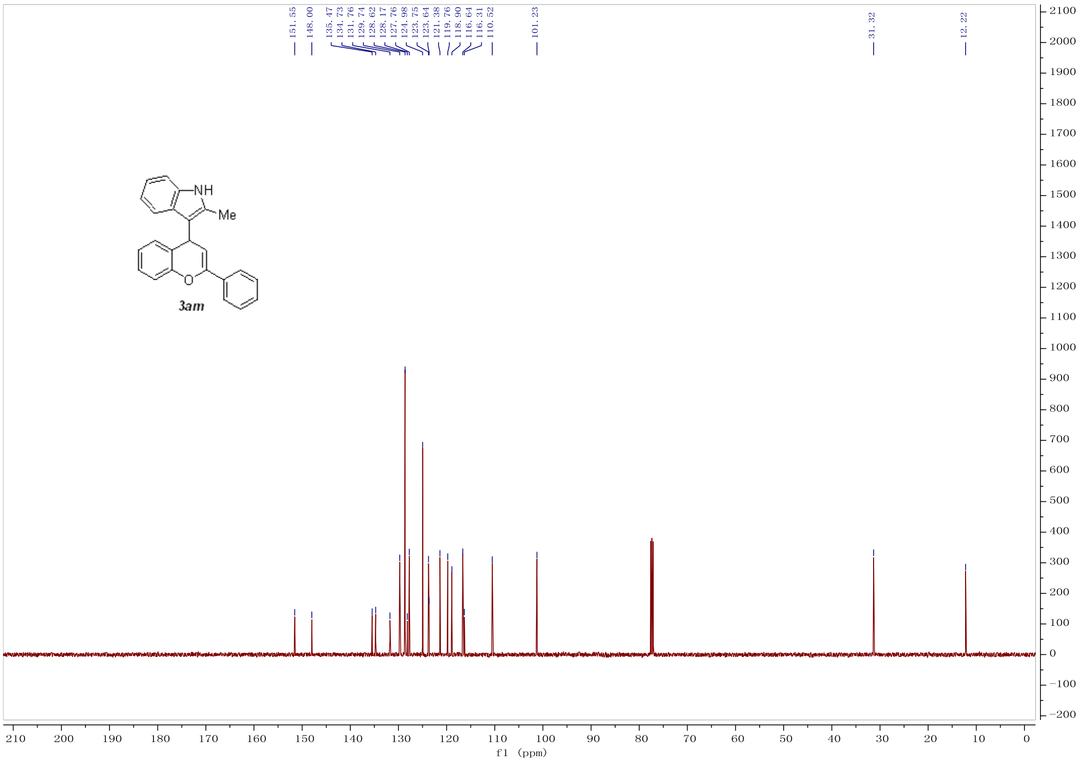
XWQ-20160929-GYQ-I-76-2/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 53

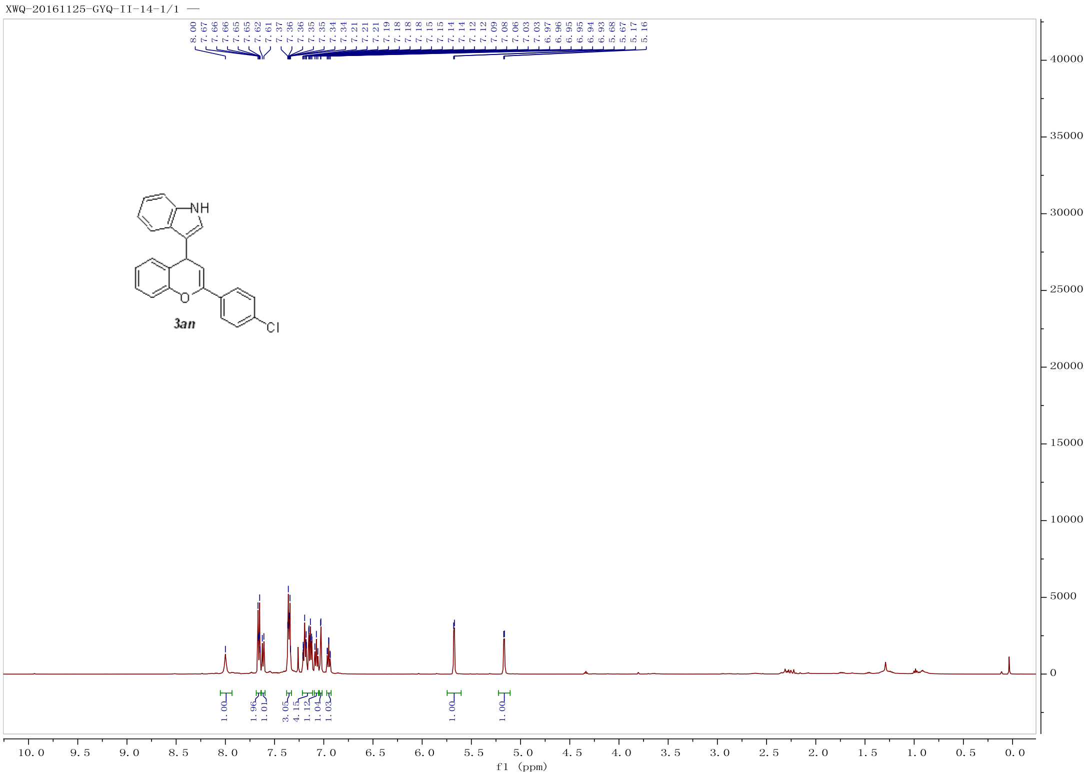


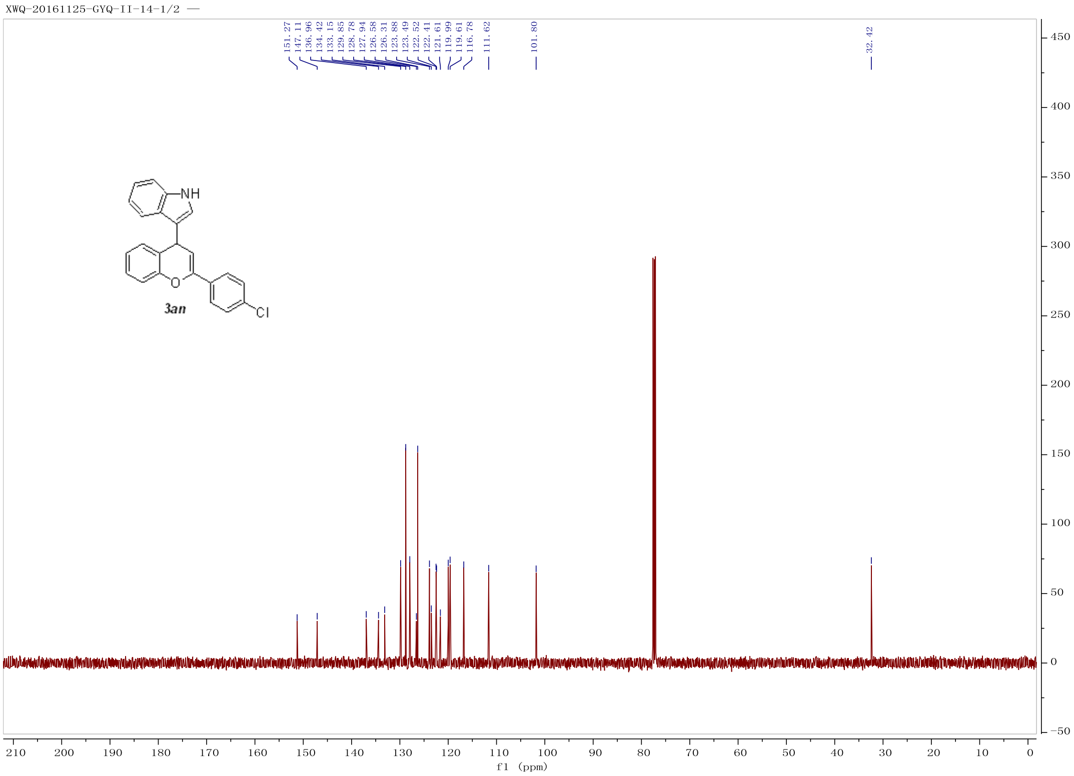
XWQ-20160926-GYQ-I-75-4/10 -- PROTON CDCl3 {D:\2016-3} ZHL 43

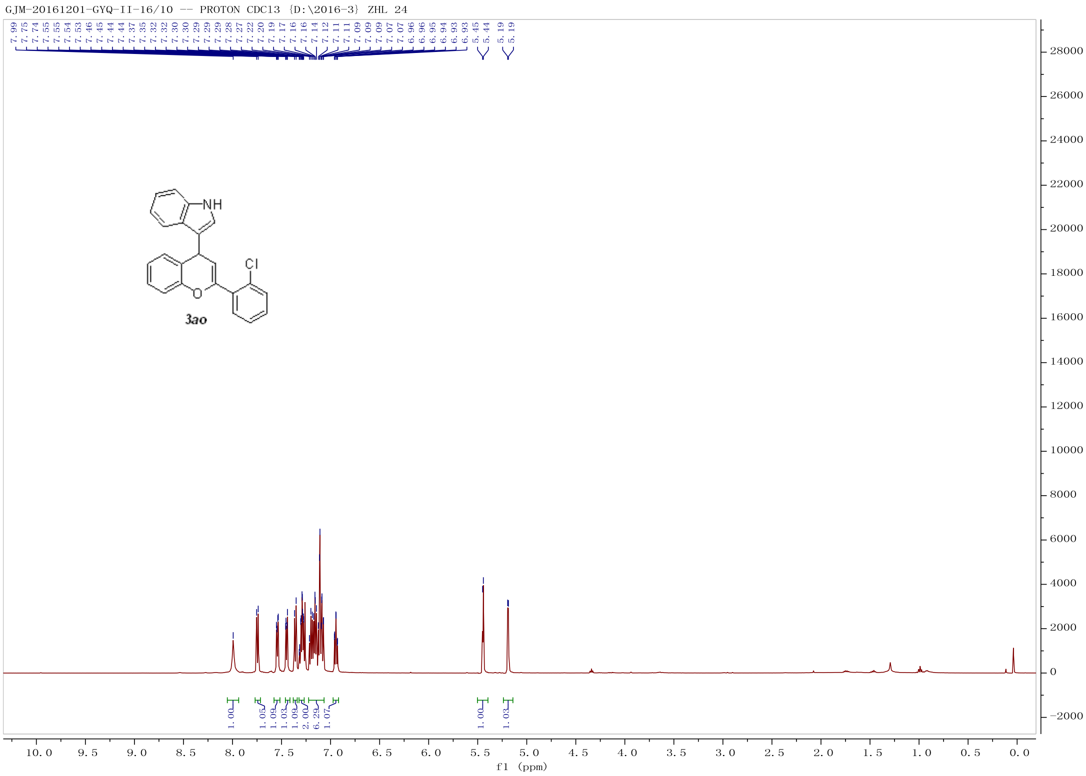


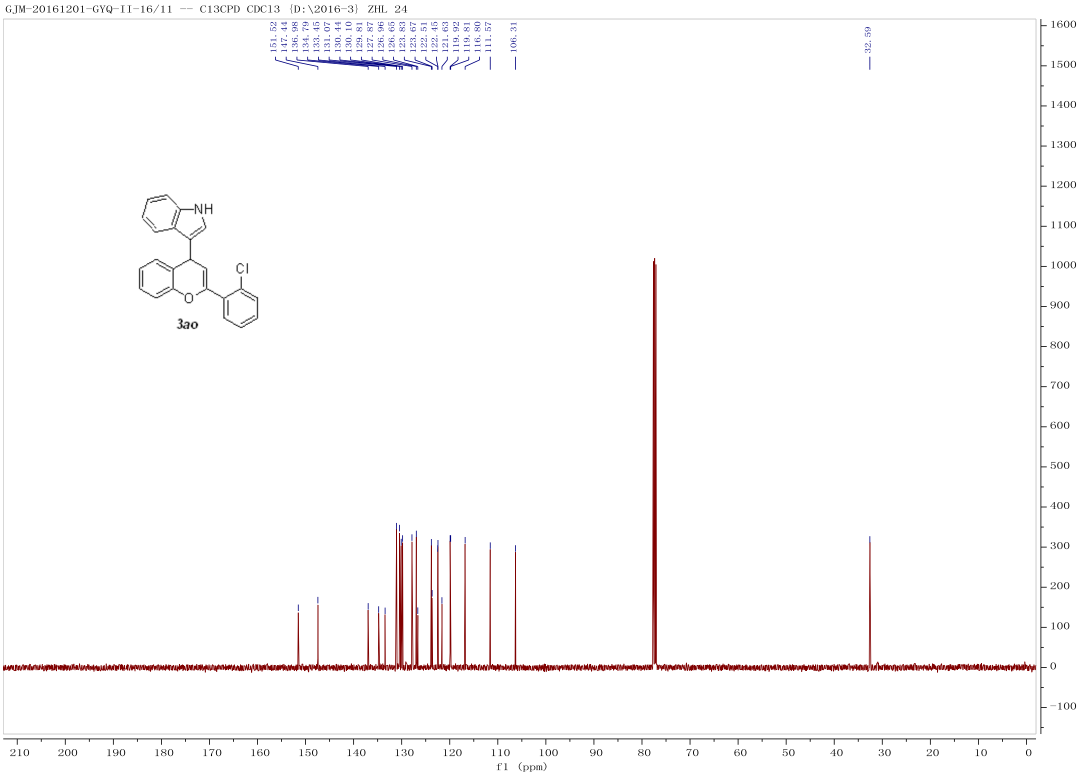
XWQ-20160926-GYQ-I-75-4/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 43

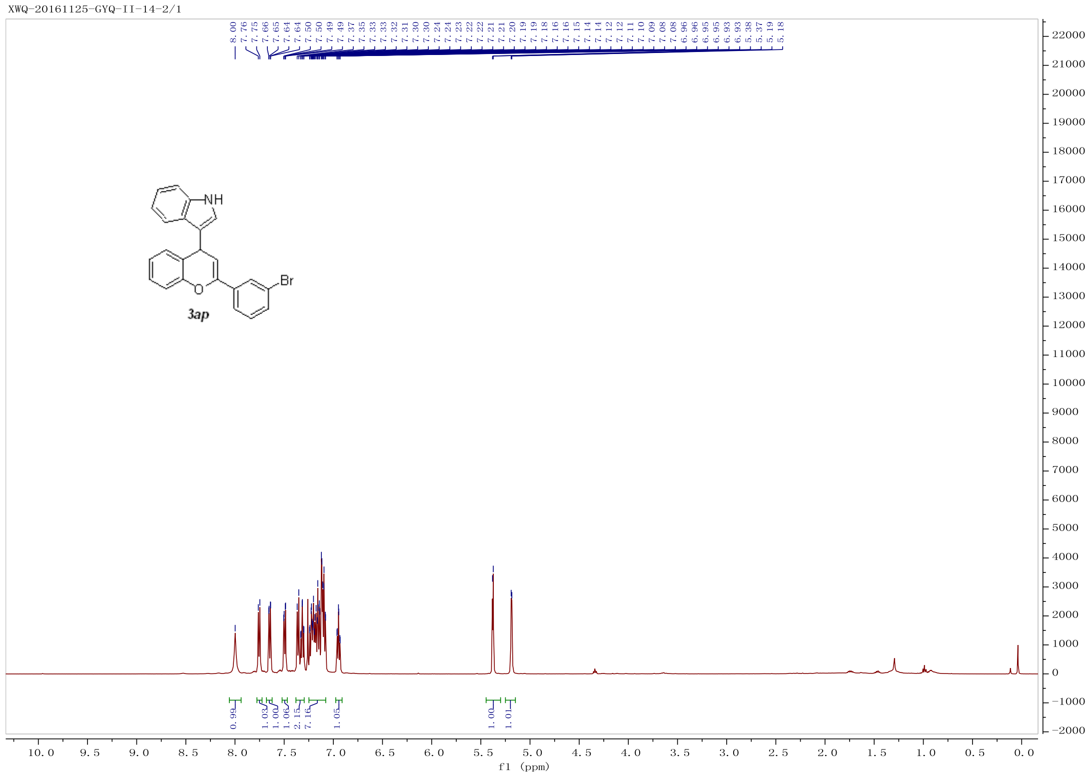


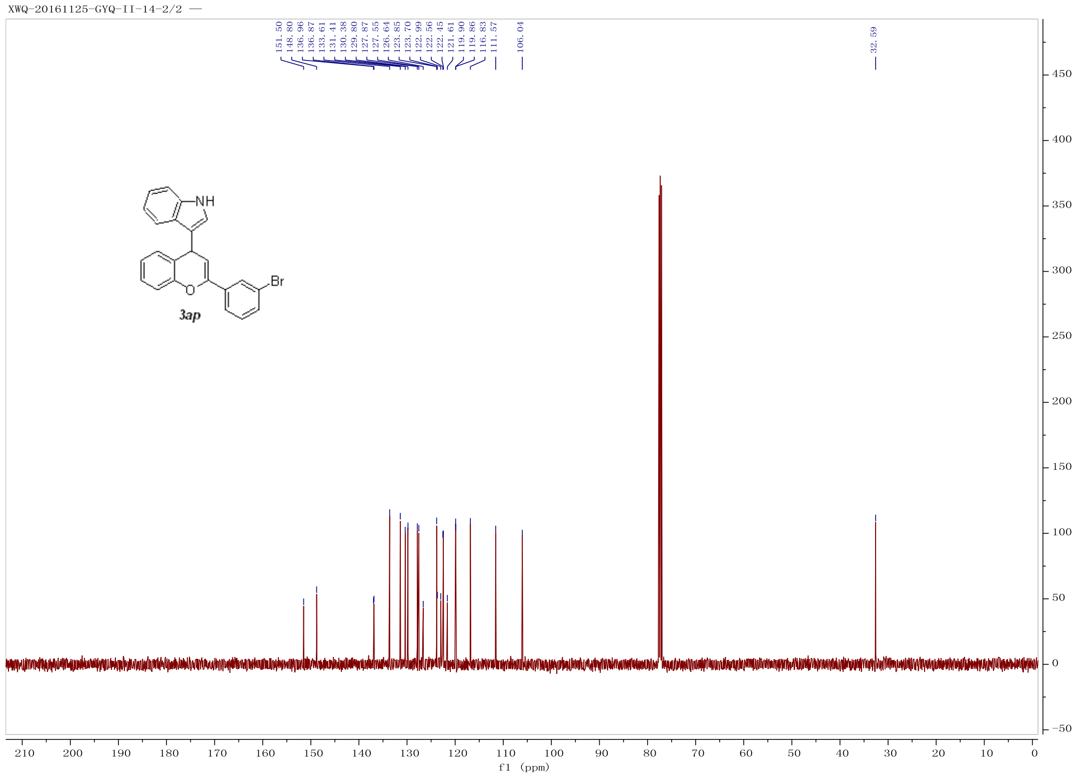

XWQ-20161125-GYQ-II-14-1/1
8.00
7.67
7.66
7.66
7.65
7.65
7.62
7.61
7.37
7.36
7.36
7.35
7.35
7.34
7.34
7.21
7.21
7.21
7.19
7.18
7.18
7.18
7.15
7.15
7.14
7.14
7.12
7.12
7.09
7.08
7.06
7.03
7.03
6.97
6.96
6.95
6.95
6.94
6.93
5.68
5.67
5.17
5.16
NH
O
Cl
3an
1.00
1.96
1.01
3.05
4.15
1.12
1.04
1.03
1.00
1.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)
40000
35000
30000
25000
20000
15000
10000
5000
0

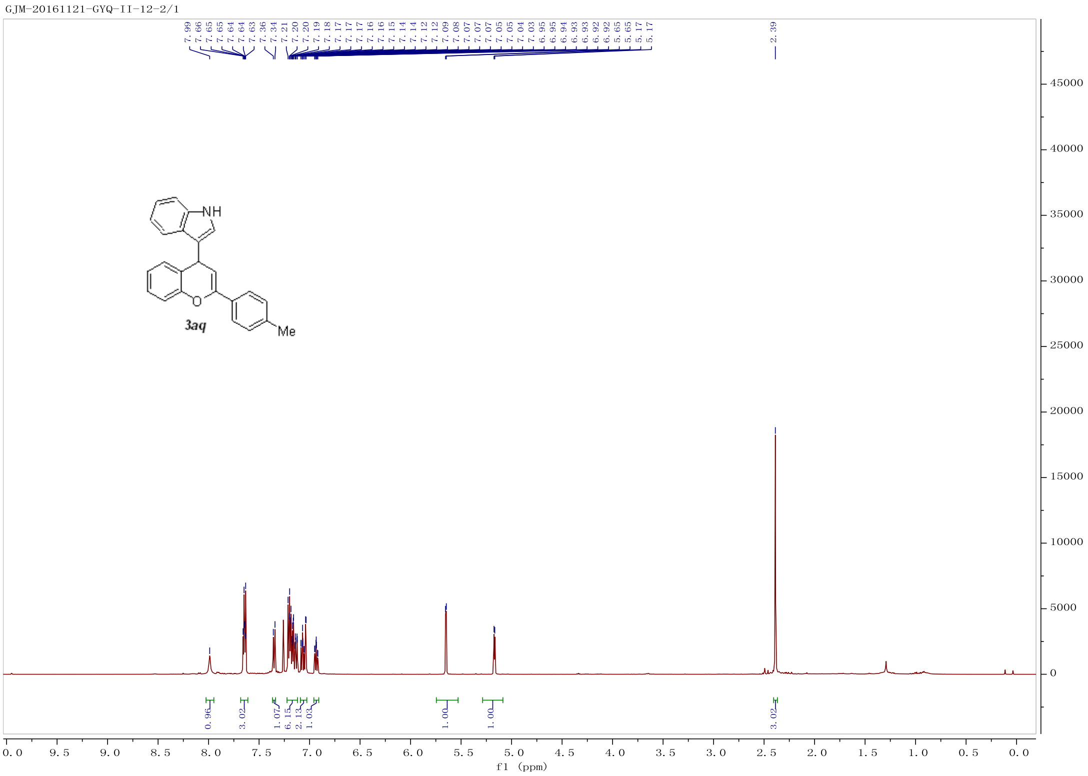

XWQ-20161125-GYQ-II-14-1/2
151.27
147.11
136.96
134.42
133.15
129.85
128.78
127.94
126.58
126.31
123.88
123.49
122.52
122.41
121.61
119.99
119.61
116.78
111.62
101.80
32.42
NH
O
Cl
3an
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)
450
400
350
300
250
200
150
100
50
0
-50

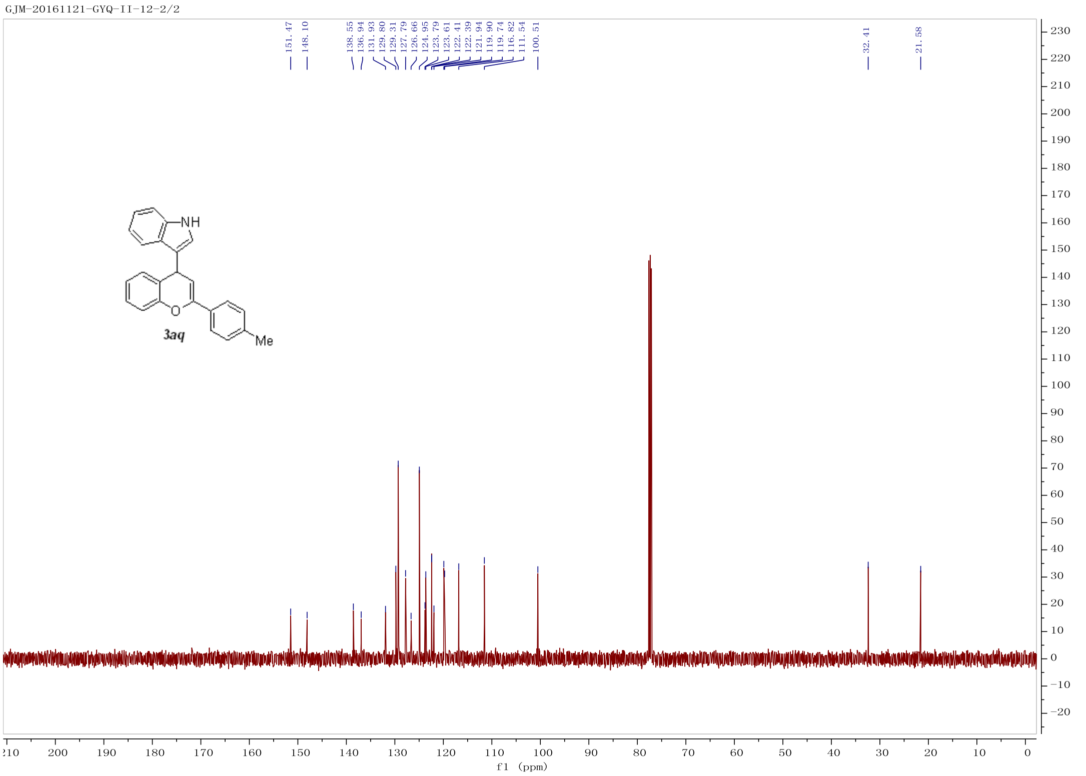

GJM-20161201-GYQ-II-16/10 -- PROTON CDCl3 {D:\2016-3} ZHL 24
7.99
7.75
7.74
7.55
7.54
7.53
7.46
7.45
7.44
7.37
7.35
7.32
7.32
7.30
7.30
7.29
7.29
7.29
7.28
7.27
7.22
7.20
7.19
7.17
7.16
7.16
7.14
7.12
7.11
7.09
7.09
7.09
7.07
7.07
6.96
6.96
6.95
6.94
6.93
6.93
5.45
5.44
5.19
5.19
NH
Cl
O
3ao
1.00
1.05
1.09
1.02
1.04
2.00
6.29
1.07
1.00
1.03
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
−2000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

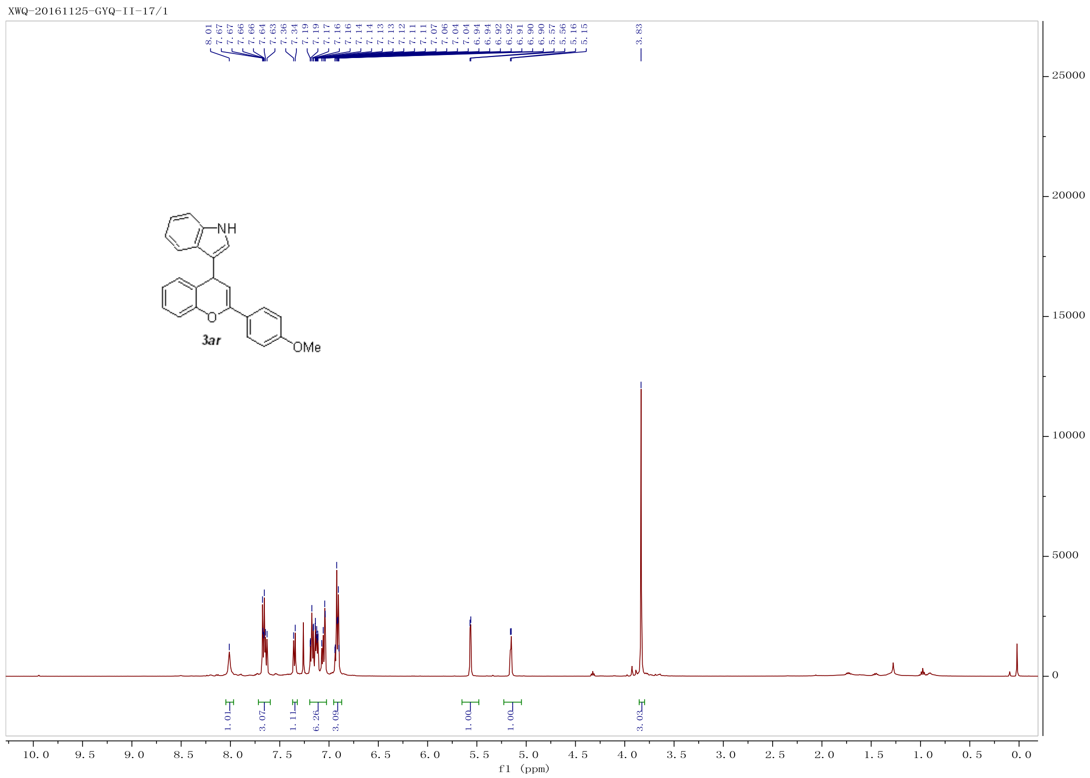

GJM-20161201-GYQ-II-16/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 24
151.52
147.44
136.98
134.79
133.45
131.07
130.44
130.10
129.81
127.87
126.96
126.65
123.83
123.67
122.51
122.45
121.63
119.92
119.81
116.80
111.57
106.31
32.59
NH
Cl
O
3ao
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
−100
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

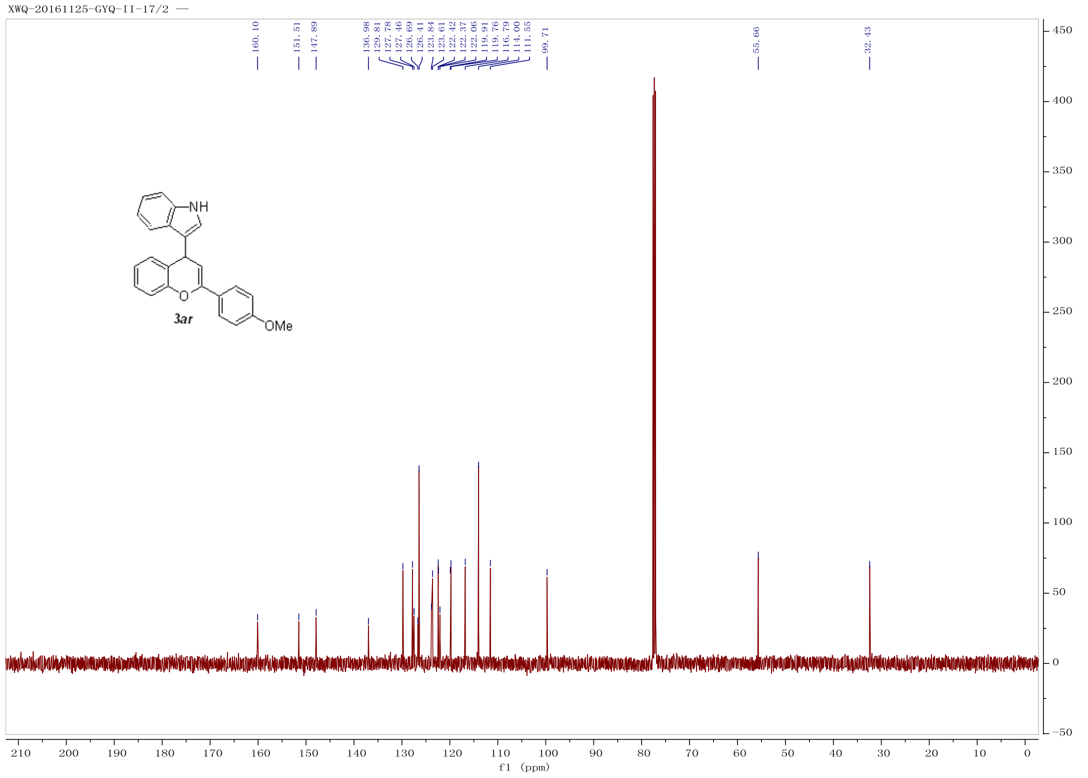

XWQ-20161125-GYQ-II-14-2/1
8.00 7.76 7.75 7.66 7.65 7.64 7.64 7.50 7.50 7.49 7.49 7.37 7.35 7.33 7.33 7.32 7.31 7.30 7.30 7.24 7.24 7.23 7.22 7.22 7.21 7.21 7.20 7.19 7.19 7.18 7.16 7.16 7.15 7.14 7.14 7.12 7.11 7.10 7.09 7.08 7.08 6.96 6.96 6.95 6.95 6.93 5.38 5.37 5.19 5.18
NH
O
Br
3ap
0.99 1.03 1.00 1.00 2.15 7.16 1.05 1.00 1.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
22000 21000 20000 19000 18000 17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0 −1000 −2000


XWQ-20161125-GYQ-II-14-2/2 —
151.50 148.80 136.96 136.87 133.61 131.41 130.38 129.80 127.87 127.55 126.64 123.85 123.70 122.99 122.56 122.45 121.61 119.90 119.86 116.83 111.57 106.04 32.59
NH
O
Br
3ap
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
450 400 350 300 250 200 150 100 50 0 −50

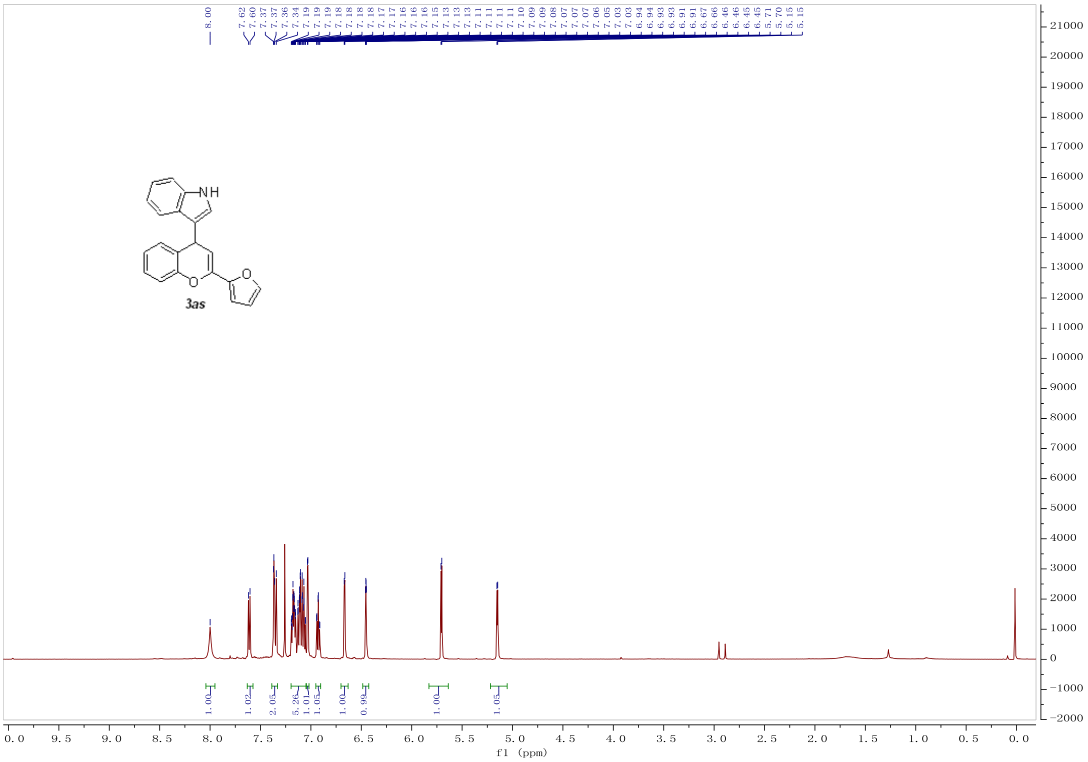

GJM-20161121-GYQ-II-12-2/1
7.99
7.66
7.65
7.65
7.64
7.64
7.63
7.36
7.34
7.21
7.20
7.20
7.19
7.18
7.17
7.17
7.17
7.16
7.16
7.15
7.14
7.14
7.12
7.12
7.09
7.08
7.07
7.07
7.07
7.05
7.05
7.04
7.03
6.95
6.95
6.94
6.93
6.93
6.92
6.92
5.65
5.65
5.17
5.17
2.39
NH
O
Me
3aq
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0.96
3.02
1.07
6.15
2.13
1.03
1.00
1.00
3.02
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


GJM-20161121-GYQ-II-12-2/2
151.47
148.10
138.55
136.94
131.93
129.80
129.31
127.79
126.66
124.95
123.79
123.41
122.41
122.39
121.94
119.90
119.74
116.82
111.54
100.51
32.41
21.58
NH
O
Me
3aq
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

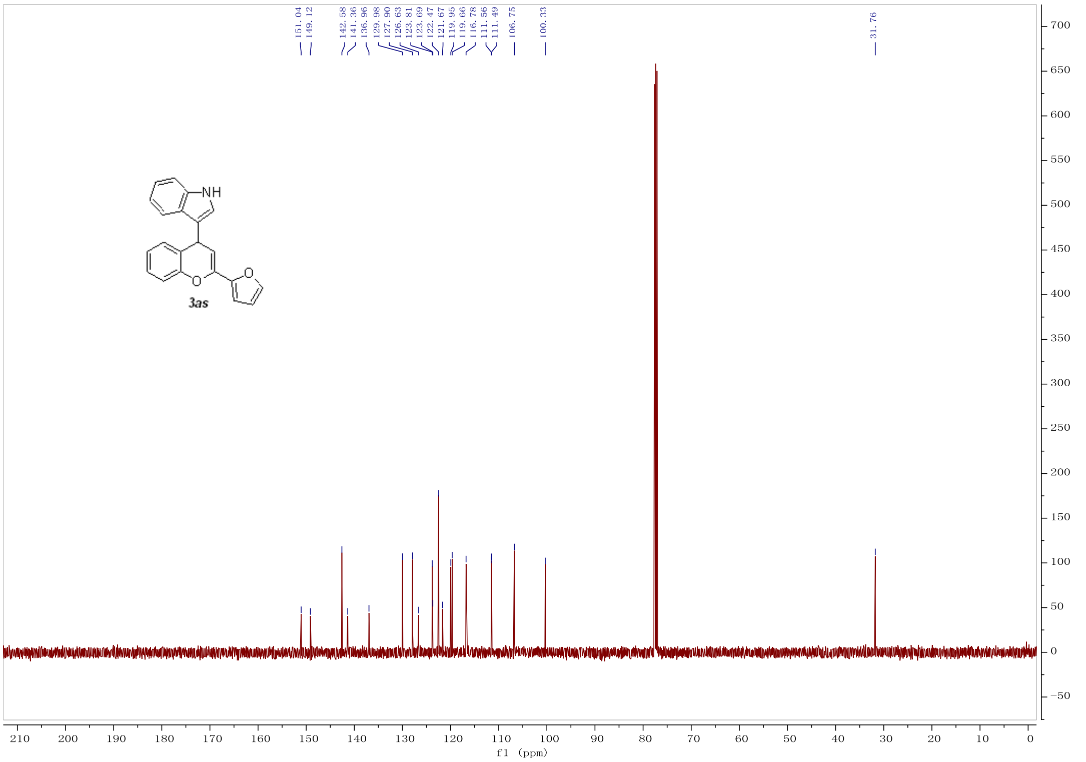

XWQ-20161125-GYQ-II-17/1
8.01
7.67
7.67
7.66
7.64
7.63
7.36
7.34
7.19
7.19
7.17
7.16
7.16
7.14
7.14
7.13
7.13
7.12
7.11
7.11
7.07
7.06
7.04
7.04
6.94
6.94
6.92
6.91
6.90
6.90
5.57
5.56
5.16
5.15
3.83
NH
O
OMe
3ar
1.01
3.07
1.11
6.26
3.09
1.00
1.00
3.03
25000
20000
15000
10000
5000
0
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

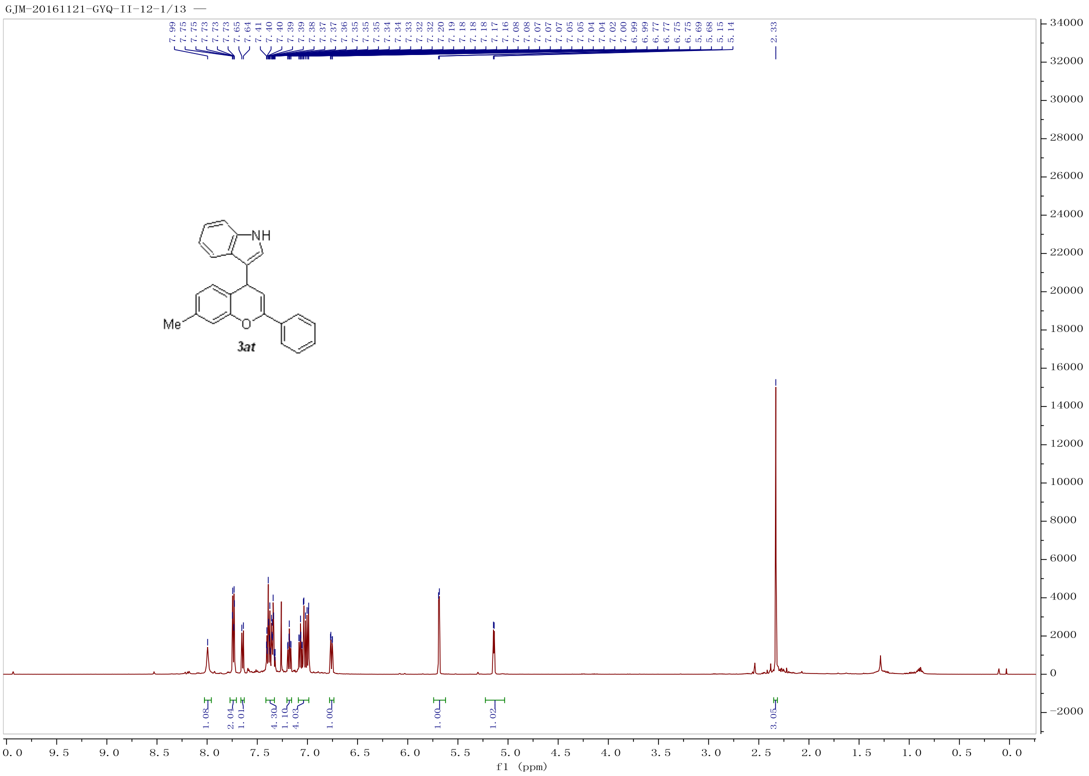

XWQ-20161125-GYQ-II-17/2
160.10
151.51
147.89
136.98
129.81
127.78
127.46
126.69
126.41
123.84
123.61
122.42
122.37
122.06
119.91
119.76
116.79
114.00
111.55
99.71
55.66
32.43
NH
O
OMe
3ar
450
400
350
300
250
200
150
100
50
0
-50
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

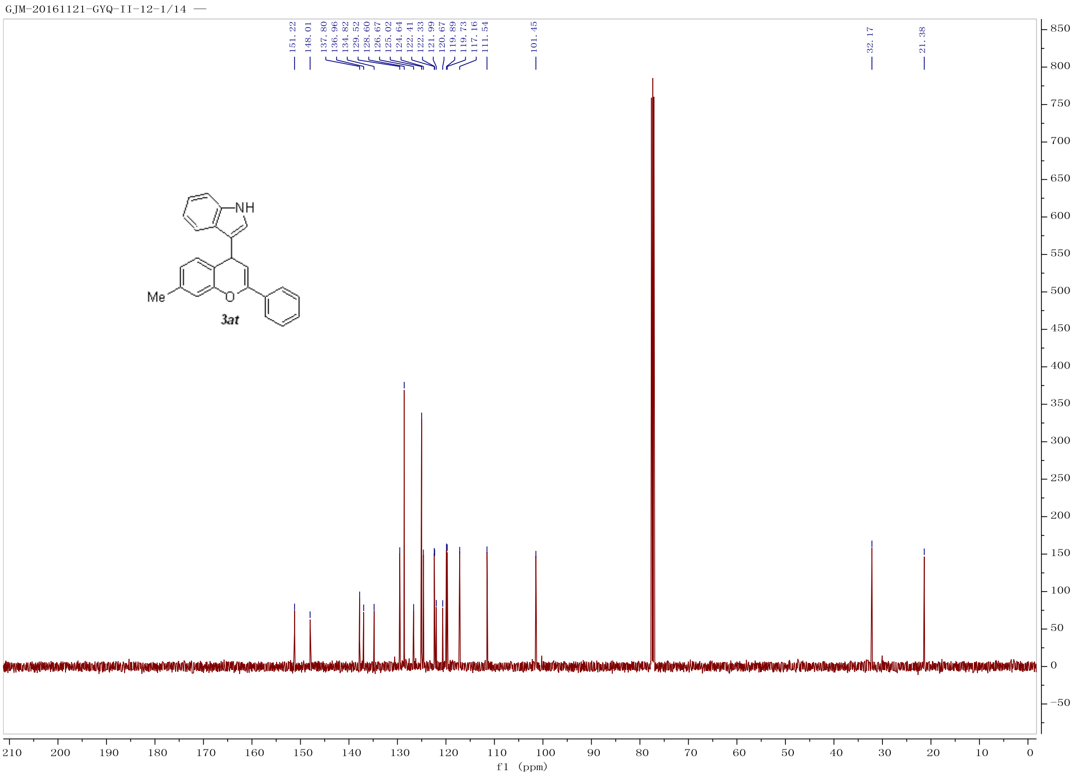
GJM-20161201-GYQ-II-20/10 -- PROTON CDCl3 {D:\2016-3} ZHL 25



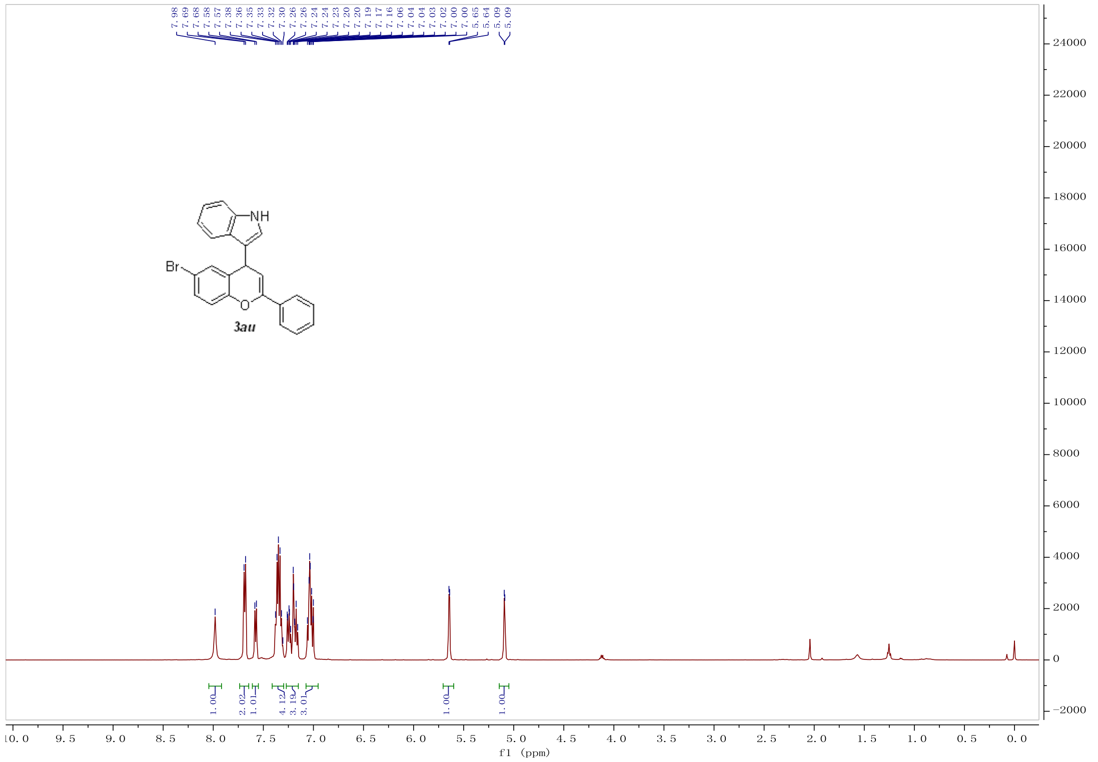
GJM-20161201-GYQ-II-20/11 -- C13CPD CDCl3 {D:\2016-3} ZHL 25



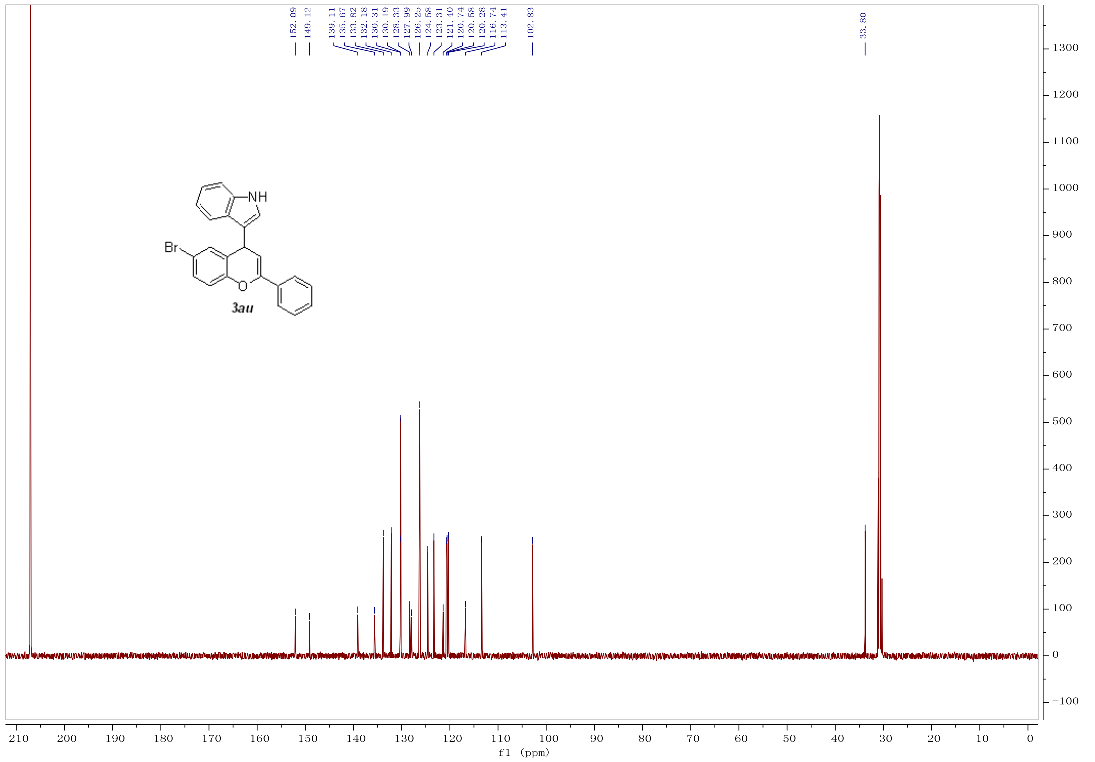

GJM-20161121-GYQ-II-12-1/13 —
7.99 7.75 7.75 7.73 7.73 7.73 7.65 7.64 7.41 7.40 7.40 7.39 7.39 7.38 7.37 7.37 7.36 7.35 7.35 7.35 7.34 7.34 7.33 7.32 7.32 7.20 7.19 7.18 7.18 7.18 7.17 7.16 7.08 7.08 7.07 7.07 7.07 7.05 7.05 7.04 7.04 7.02 7.00 6.99 6.99 6.77 6.77 6.75 6.75 5.69 5.68 5.15 5.14
2.33
NH
Me
O
3at
1.08 2.04 1.01 4.30 1.10 4.03 1.00 1.00 1.02 3.05
f1 (ppm)

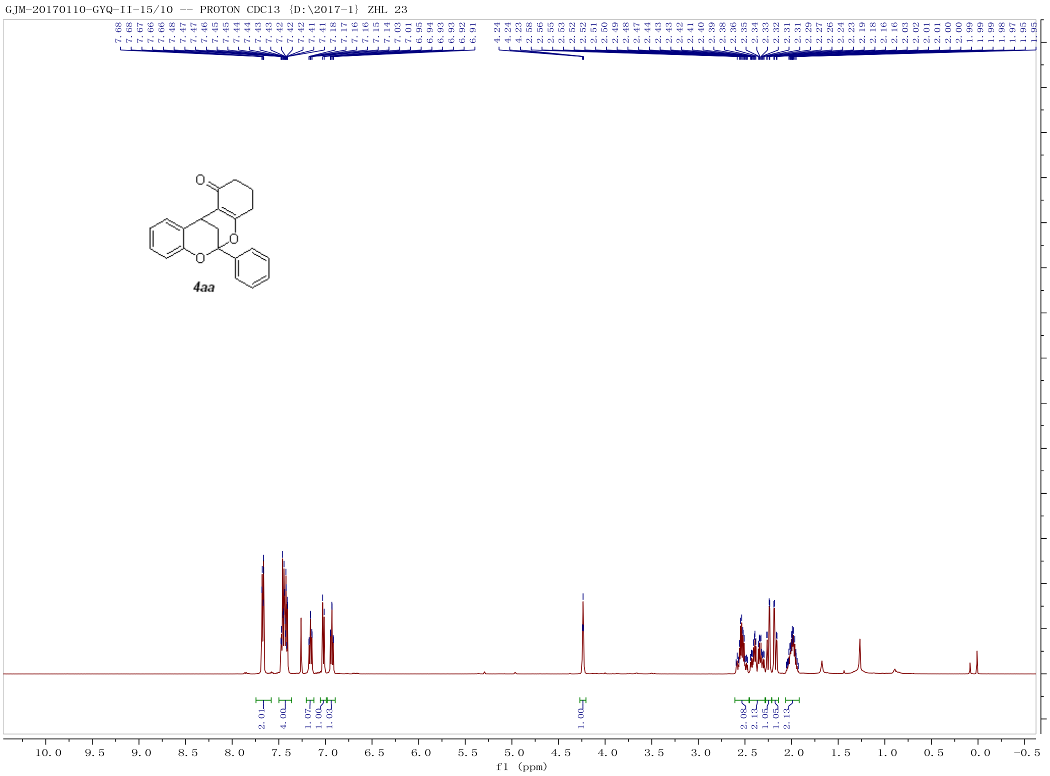

GJM-20161121-GYQ-II-12-1/14 —
151.22 148.01 137.80 136.96 134.82 129.52 128.60 126.67 125.02 124.64 122.41 122.33 121.99 120.67 119.89 119.73 117.16 111.54
101.45
32.17
21.38
NH
Me
O
3at
f1 (ppm)

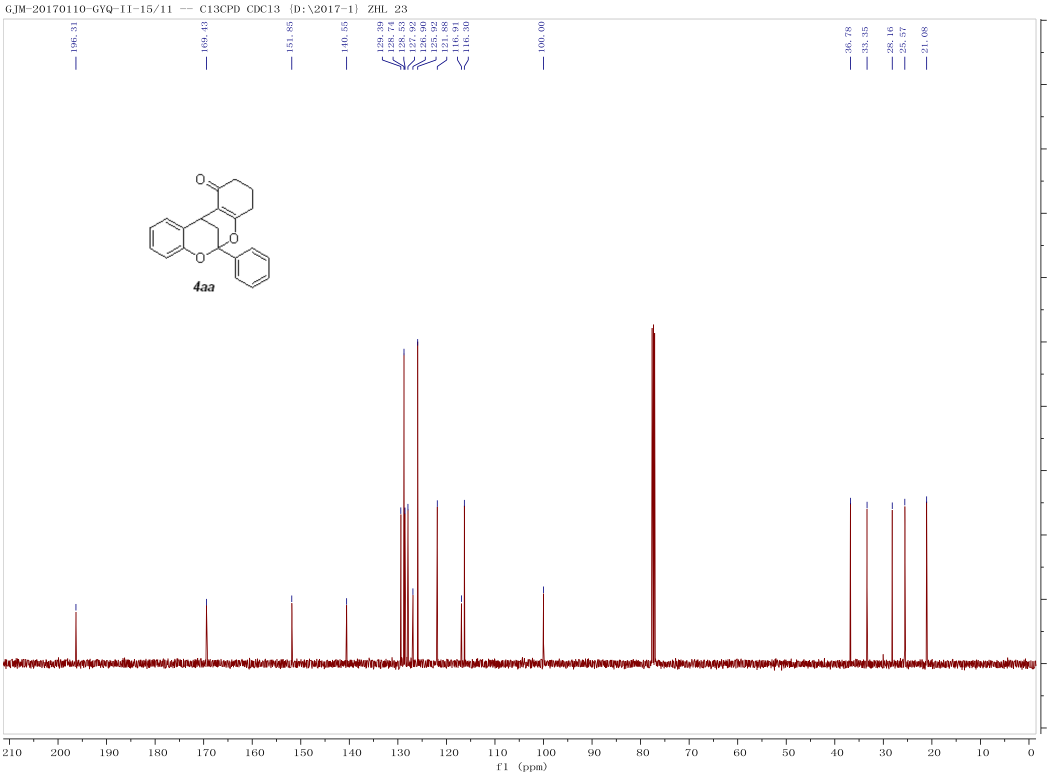
XWQ-20180305-HY-I-31/10 -- PROTON CDC13 {D:\2018-1} ZHL 26

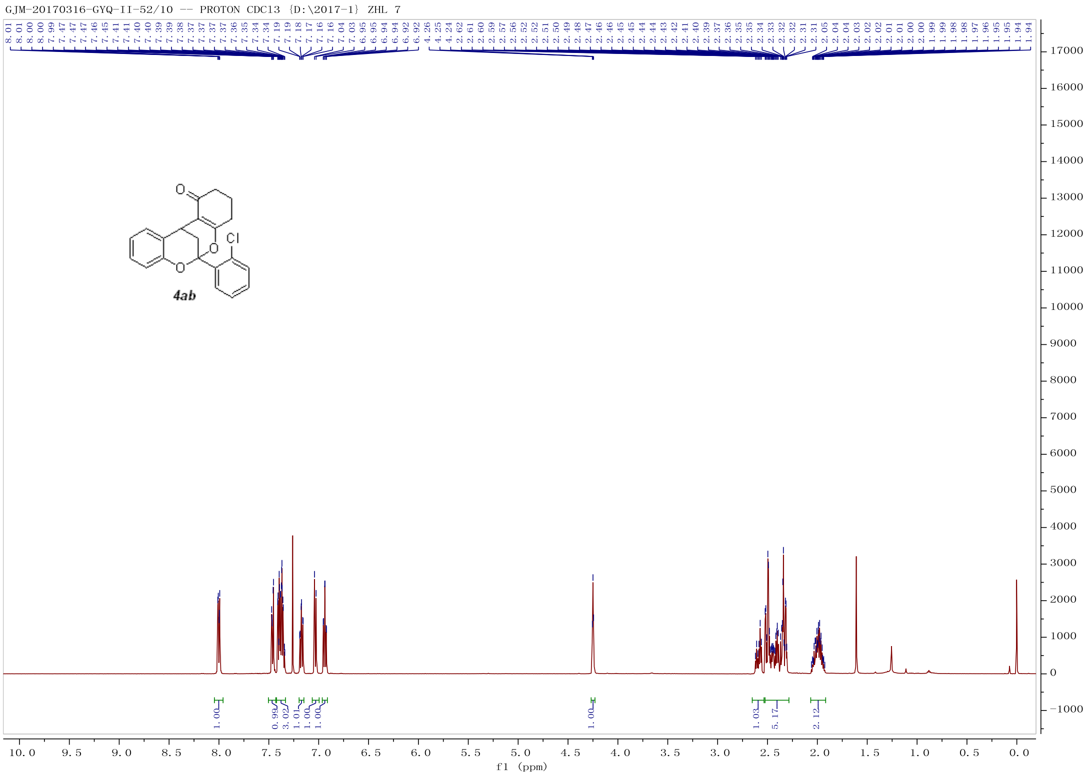


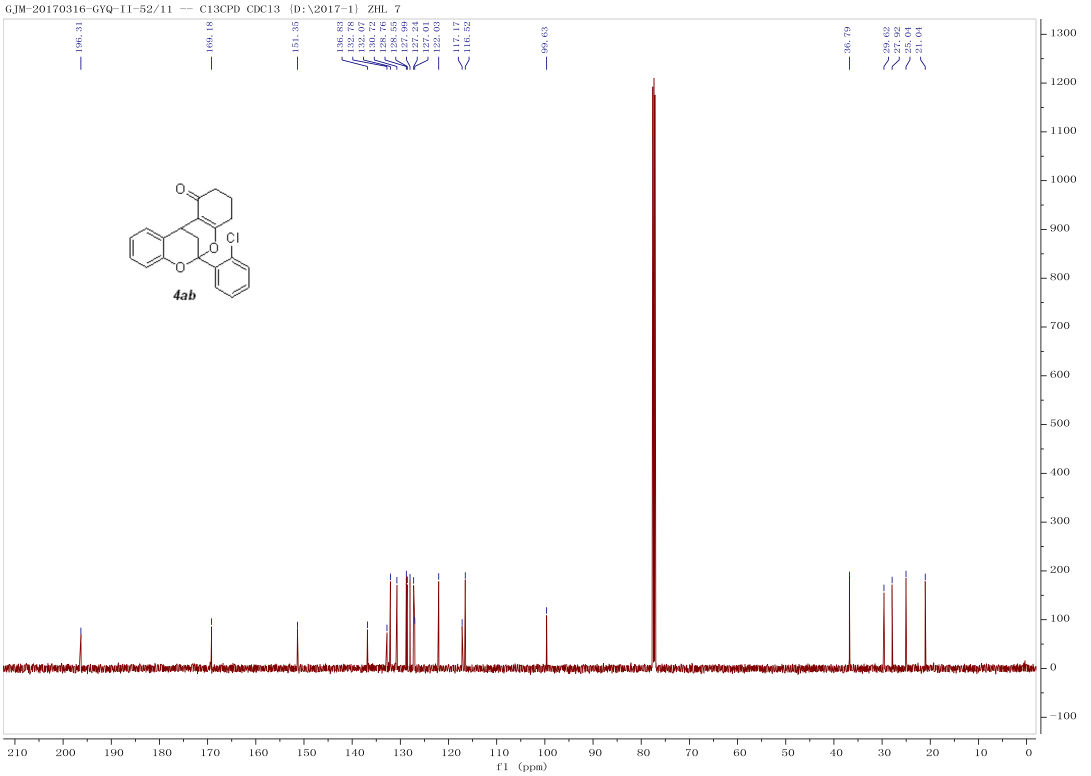
XWQ-20180305-HY-I-31/11 -- C13CPD Acetone {D:\2018-1} ZHL 24

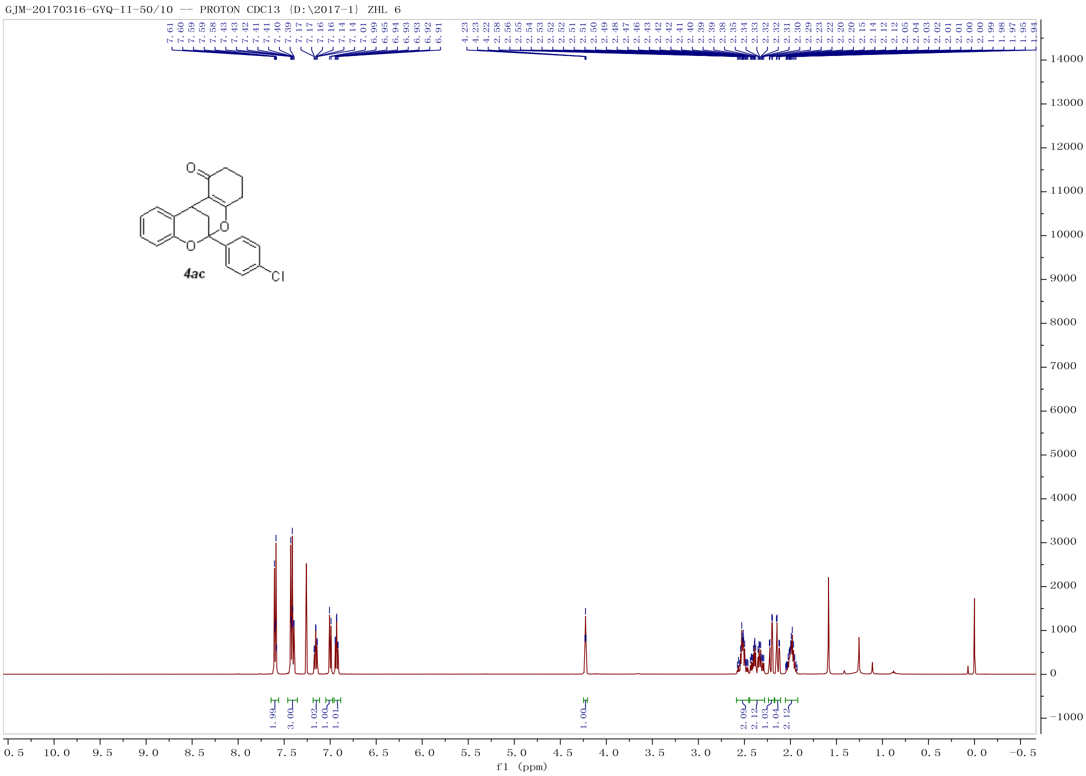


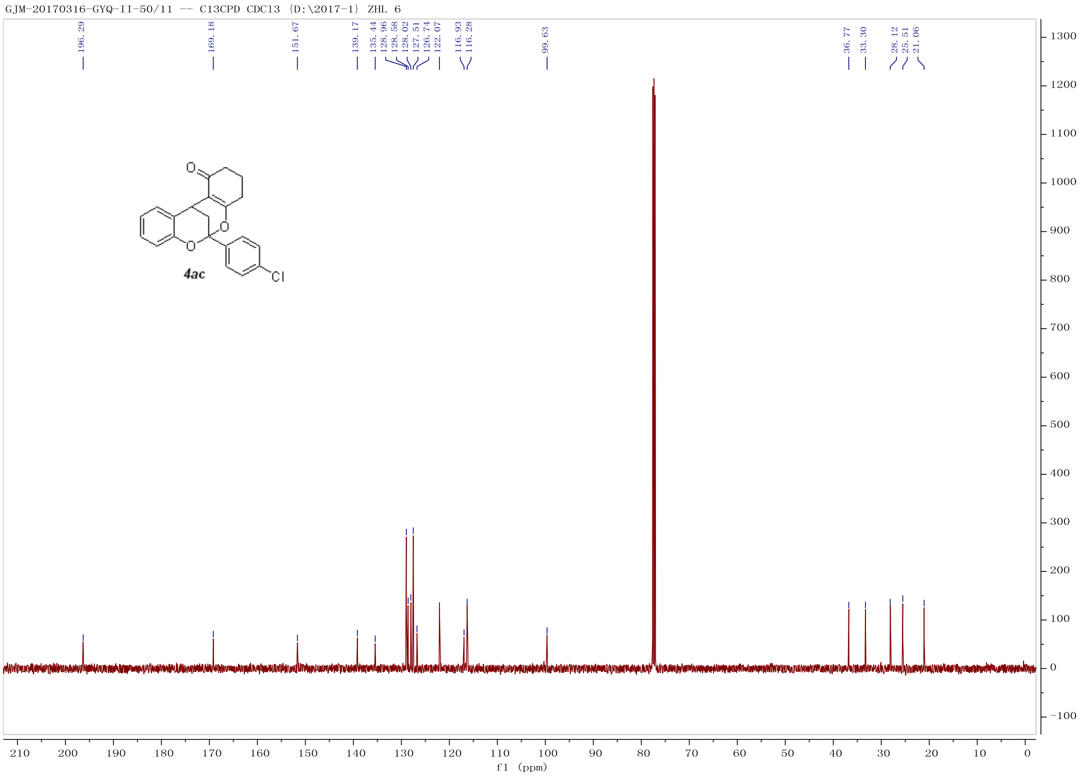

GJM-20170110-GYQ-II-15/10 -- PROTON CDCl3 {D:\2017-1} ZHL 23
7.68 7.68 7.67 7.66 7.48 7.47 7.47 7.46 7.45 7.45 7.44 7.44 7.43 7.43 7.42 7.42 7.42 7.41 7.41 7.18 7.17 7.16 7.16 7.15 7.14 7.03 7.01 6.95 6.94 6.93 6.93 6.92 6.91
4.24 4.24 4.23 2.58 2.56 2.55 2.53 2.52 2.52 2.51 2.50 2.49 2.48 2.47 2.44 2.43 2.43 2.42 2.41 2.40 2.39 2.38 2.36 2.35 2.34 2.33 2.33 2.32 2.31 2.29 2.27 2.26 2.24 2.23 2.19 2.18 2.16 2.16 2.03 2.02 2.01 2.01 2.00 2.00 1.99 1.99 1.98 1.97 1.95 1.95
O
O
O
4aa
2.01 4.00 1.07 1.00 1.03 1.00 2.08 2.13 1.05 2.32 2.13
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)
28000 26000 24000 22000 20000 18000 16000 14000 12000 10000 8000 6000 4000 2000 0 -2000

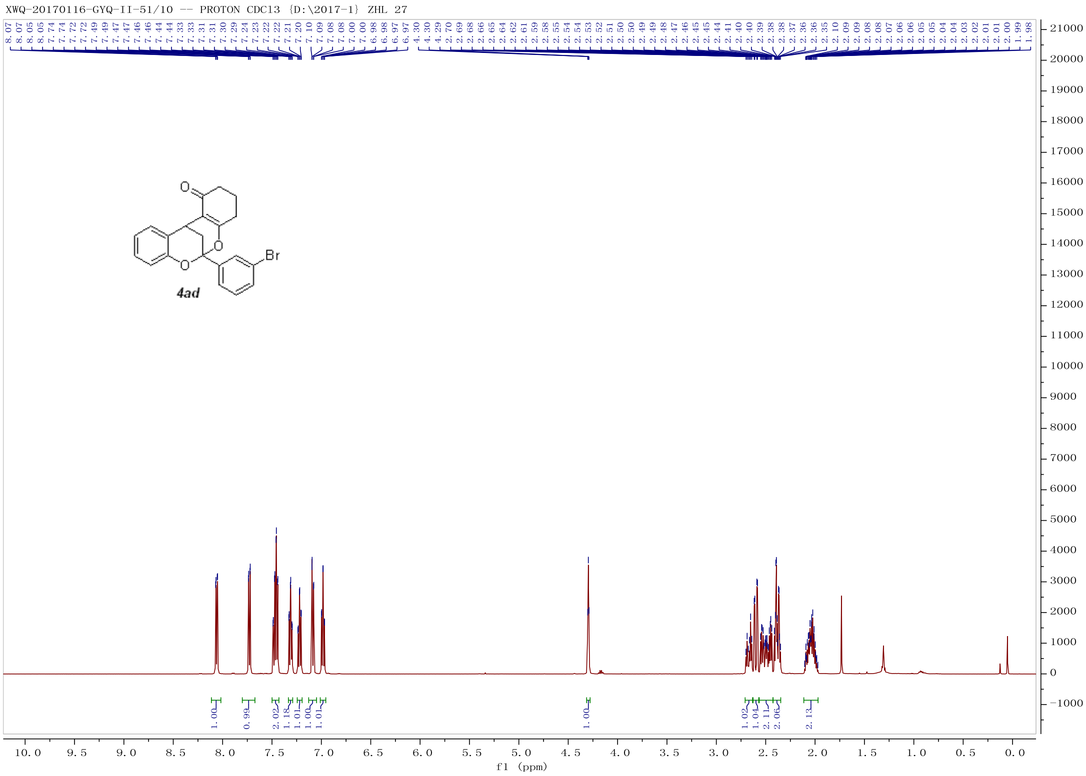

GJM-20170110-GYQ-II-15/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 23
196.31
169.43
151.85
140.55
129.39 128.74 128.53 127.92 126.90 125.92 121.88 116.91 116.30
100.00
36.78 33.35 28.16 25.57 21.08
O
O
O
4aa
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
1000 900 800 700 600 500 400 300 200 100 0 -100

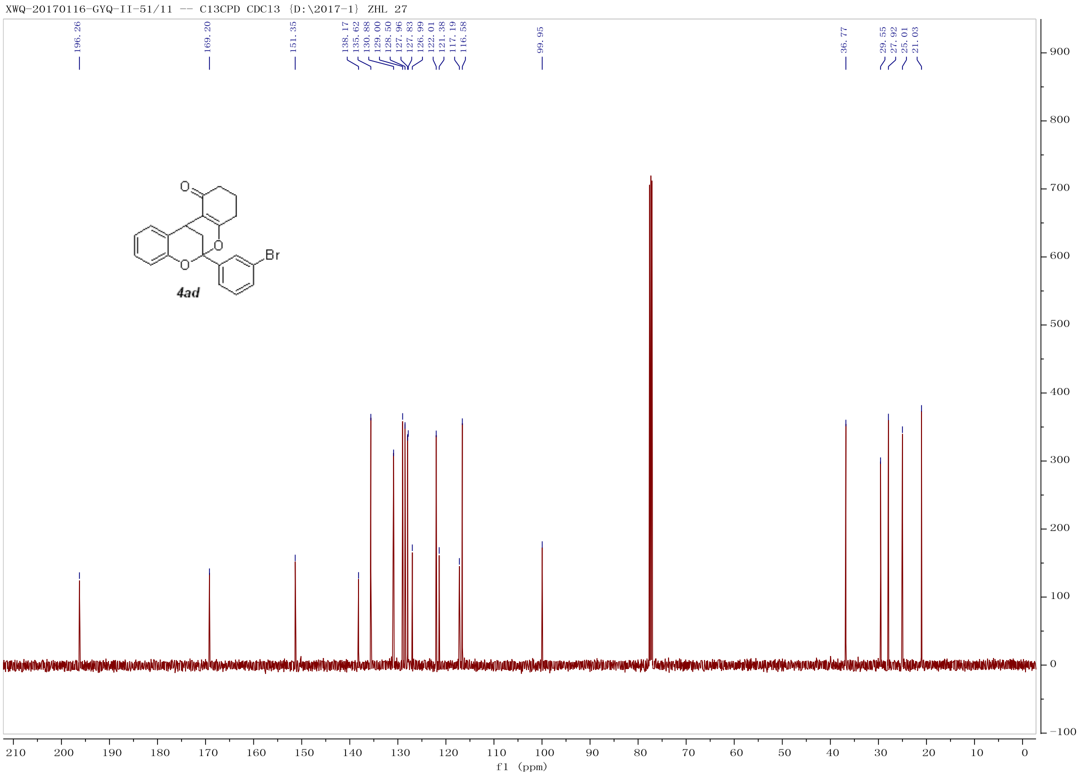

GJM-20170316-GYQ-II-52/10 -- PROTON CDCl3 {D:\2017-1} ZHL 7
8.01 8.01 8.00 8.00 7.99 7.47 7.47 7.47 7.46 7.45 7.41 7.41 7.40 7.40 7.39 7.39 7.38 7.37 7.37 7.37 7.37 7.36 7.35 7.34 7.34 7.19 7.19 7.18 7.17 7.16 7.16 7.04 7.03 6.95 6.95 6.94 6.94 6.92 6.92 4.26 4.25 4.24 2.62 2.61 2.60 2.59 2.57 2.56 2.52 2.52 2.51 2.50 2.49 2.48 2.47 2.46 2.46 2.45 2.45 2.44 2.44 2.43 2.42 2.41 2.40 2.39 2.37 2.36 2.35 2.35 2.34 2.33 2.32 2.32 2.31 2.31 2.05 2.04 2.04 2.03 2.02 2.02 2.01 2.01 2.00 2.00 1.99 1.99 1.98 1.98 1.97 1.96 1.95 1.95 1.94 1.94
O
Cl
O
O
4ab
1.00
0.99
3.02
1.01
1.00
1.00
1.00
1.03
5.17
2.12
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0 −1000


GJM-20170316-GYQ-II-52/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 7
196.31
169.18
151.35
136.83 132.78 132.07 130.72 128.76 128.55 127.99 127.24 127.01 122.03
117.17 116.52
99.63
36.79
29.62 27.92 25.04 21.04
O
Cl
O
O
4ab
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0 −100

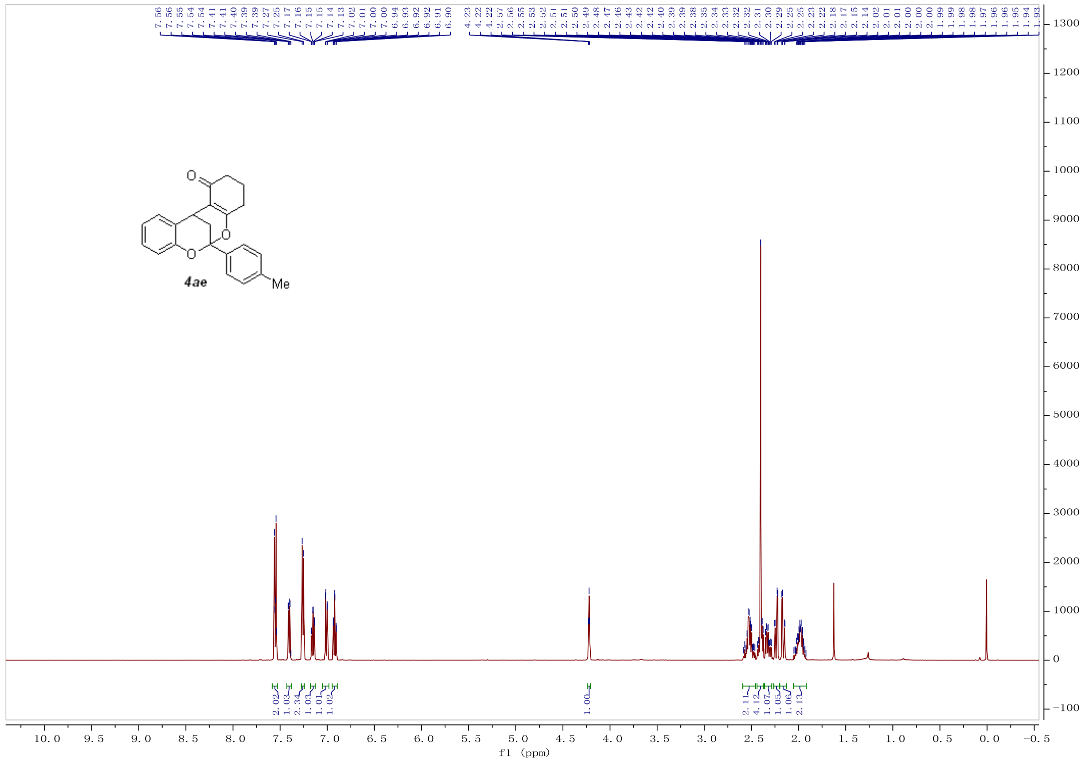

GJM-20170316-GYQ-II-50/10 -- PROTON CDCl3 {D:\2017-1} ZHL 6
7.61
7.60
7.59
7.59
7.58
7.43
7.43
7.42
7.41
7.41
7.40
7.39
7.17
7.17
7.16
7.16
7.14
7.14
7.01
6.99
6.95
6.94
6.93
6.93
6.92
6.91
4.23
4.23
4.22
2.58
2.56
2.55
2.54
2.53
2.52
2.52
2.51
2.51
2.50
2.49
2.48
2.47
2.46
2.43
2.42
2.42
2.41
2.40
2.39
2.39
2.38
2.35
2.34
2.33
2.32
2.32
2.31
2.30
2.29
2.23
2.22
2.20
2.20
2.15
2.14
2.12
2.12
2.05
2.04
2.03
2.02
2.01
2.01
2.00
2.00
1.99
1.98
1.97
1.95
1.94
O
O
O
Cl
4ac
1.99
3.00
1.02
1.00
1.01
1.00
2.09
2.12
1.03
1.04
2.12
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
0.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)


GJM-20170316-GYQ-II-50/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 6
196.29
169.18
151.67
139.17
135.44
128.96
128.58
128.02
127.51
126.74
122.07
116.93
116.28
99.63
36.77
33.30
28.12
25.51
21.06
O
O
O
Cl
4ac
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
−100
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

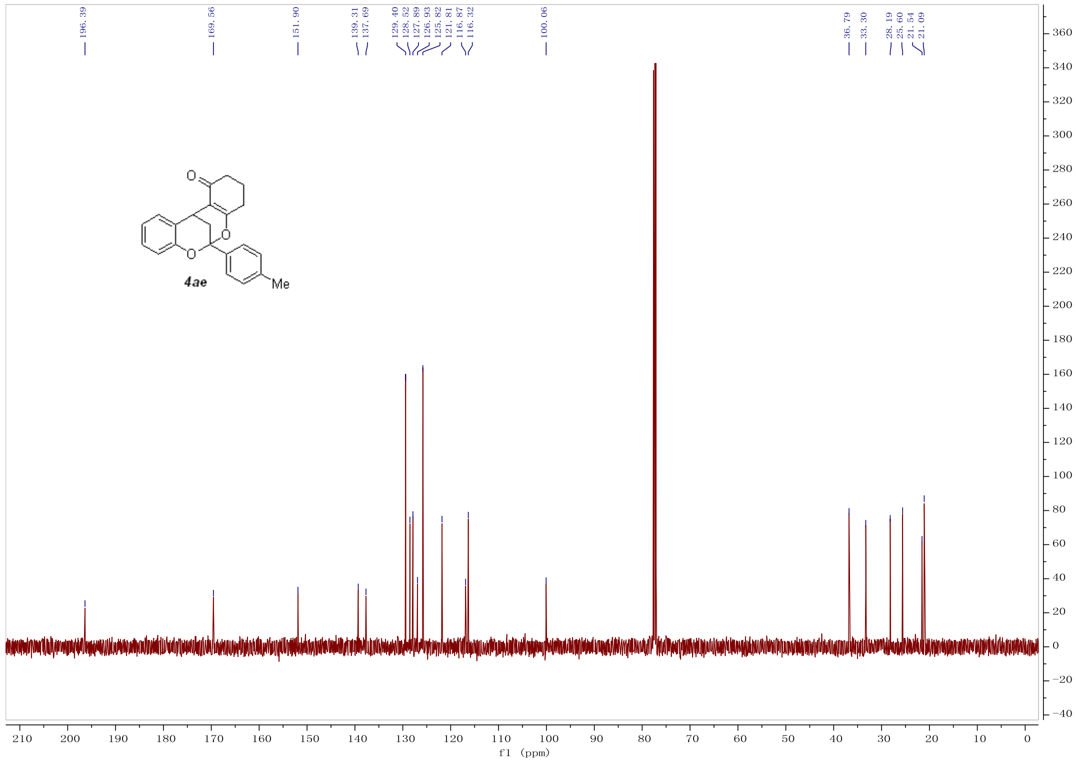

XWQ-20170116-GYQ-II-51/10 -- PROTON CDCl3 {D:\2017-1} ZHL 27
8.07 8.07 8.05 8.05 7.74 7.74 7.72 7.72 7.49 7.49 7.47 7.47 7.46 7.46 7.44 7.44 7.33 7.33 7.31 7.31 7.30 7.29 7.24 7.23 7.22 7.22 7.21 7.20 7.10 7.09 7.08 7.08 7.00 7.00 6.98 6.98 6.97 6.97 4.30 4.30 4.29 2.70 2.69 2.68 2.66 2.65 2.64 2.62 2.61 2.59 2.58 2.55 2.54 2.54 2.53 2.52 2.51 2.50 2.50 2.49 2.49 2.48 2.47 2.46 2.45 2.45 2.44 2.41 2.40 2.40 2.39 2.38 2.38 2.37 2.36 2.36 2.35 2.10 2.09 2.09 2.08 2.08 2.07 2.06 2.06 2.05 2.05 2.04 2.04 2.03 2.02 2.01 2.00 1.99 1.98
O
O
O
Br
4ad
1.00 0.99 2.02 1.18 1.01 1.00 1.01 1.00 1.02 1.04 2.11 2.06 2.13
21000 20000 19000 18000 17000 16000 15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0 −1000
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

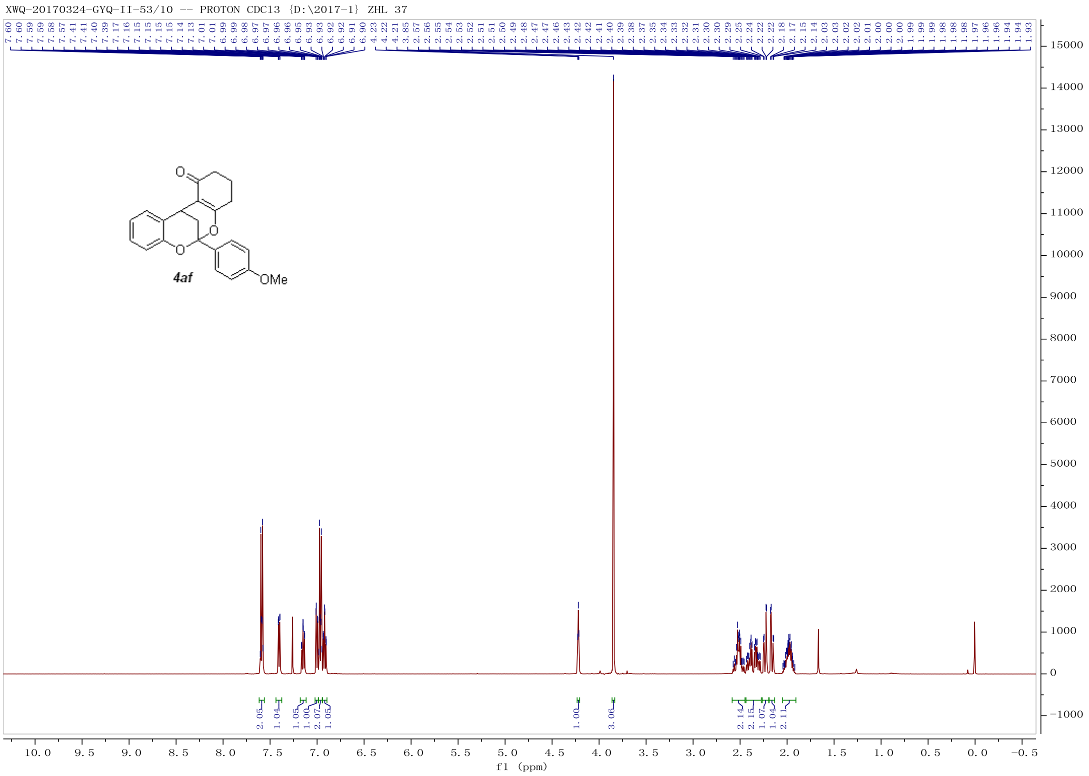

XWQ-20170116-GYQ-II-51/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 27
196.26
169.20
151.35
138.17 135.62 130.88 129.00 128.50 127.96 127.83 126.99 122.01 121.38 117.19 116.58
99.95
36.77
29.55 27.92 25.01 21.03
O
O
O
Br
4ad
900 800 700 600 500 400 300 200 100 0 −100
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

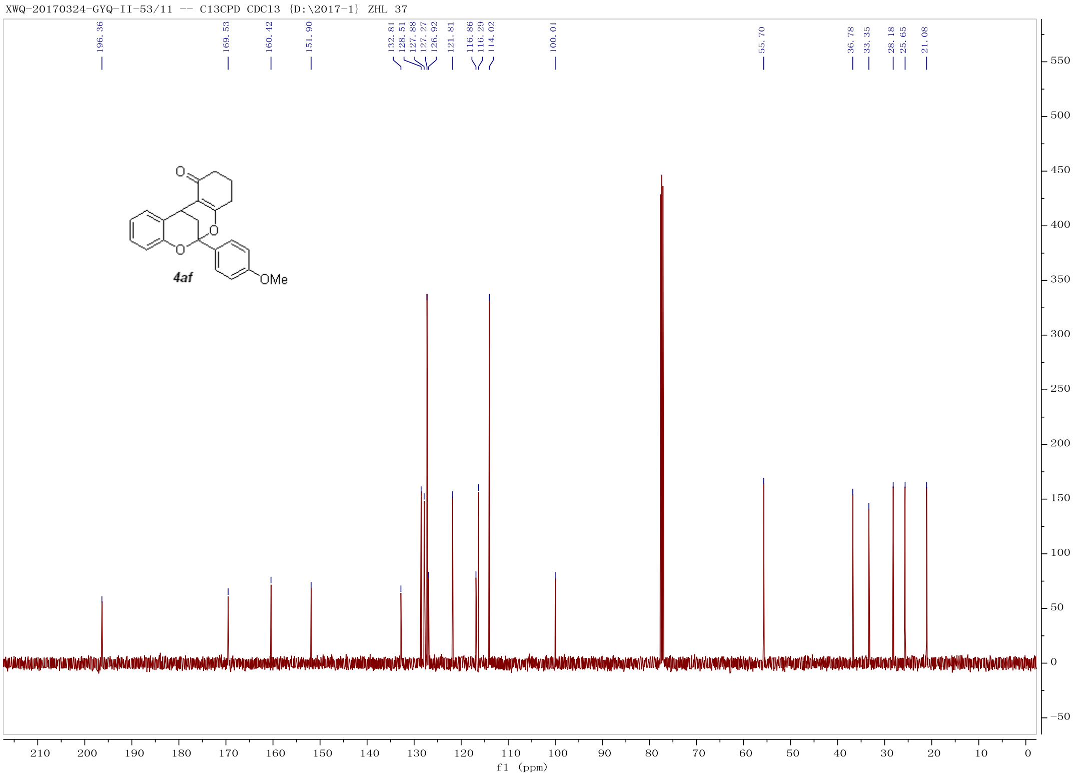
XWQ-20170324-GYQ-II-45/10 -- PROTON CDCl3 {D:\2017-1} ZHL 36

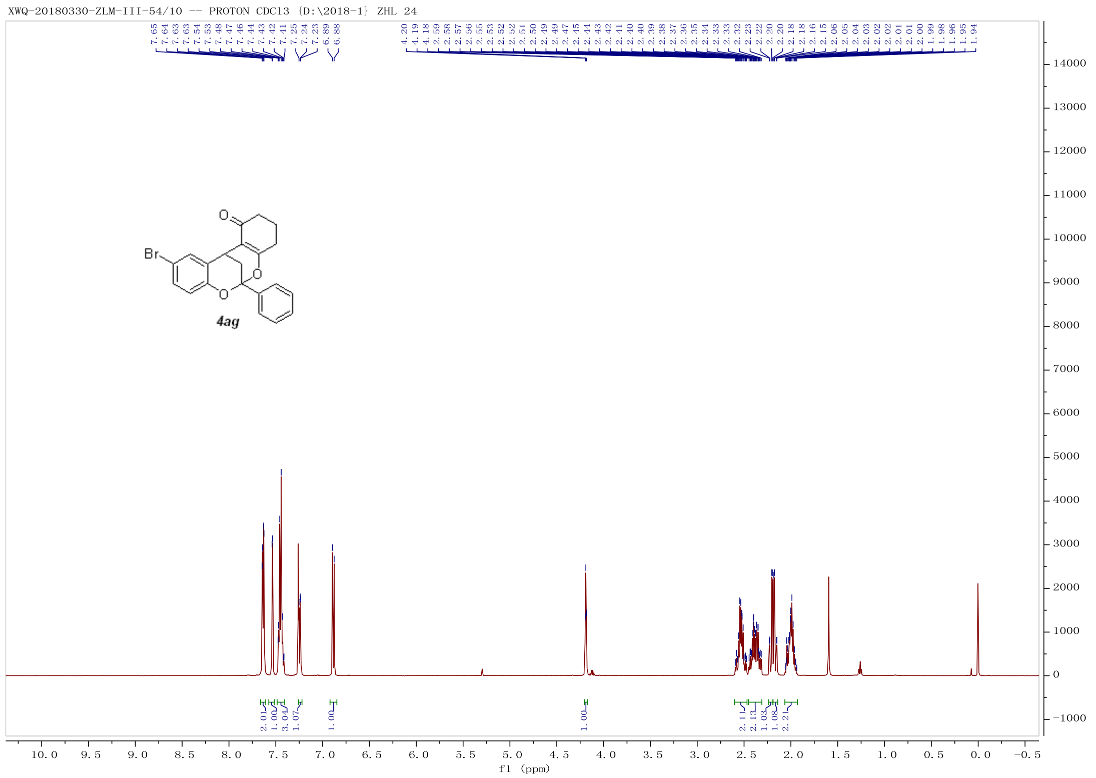


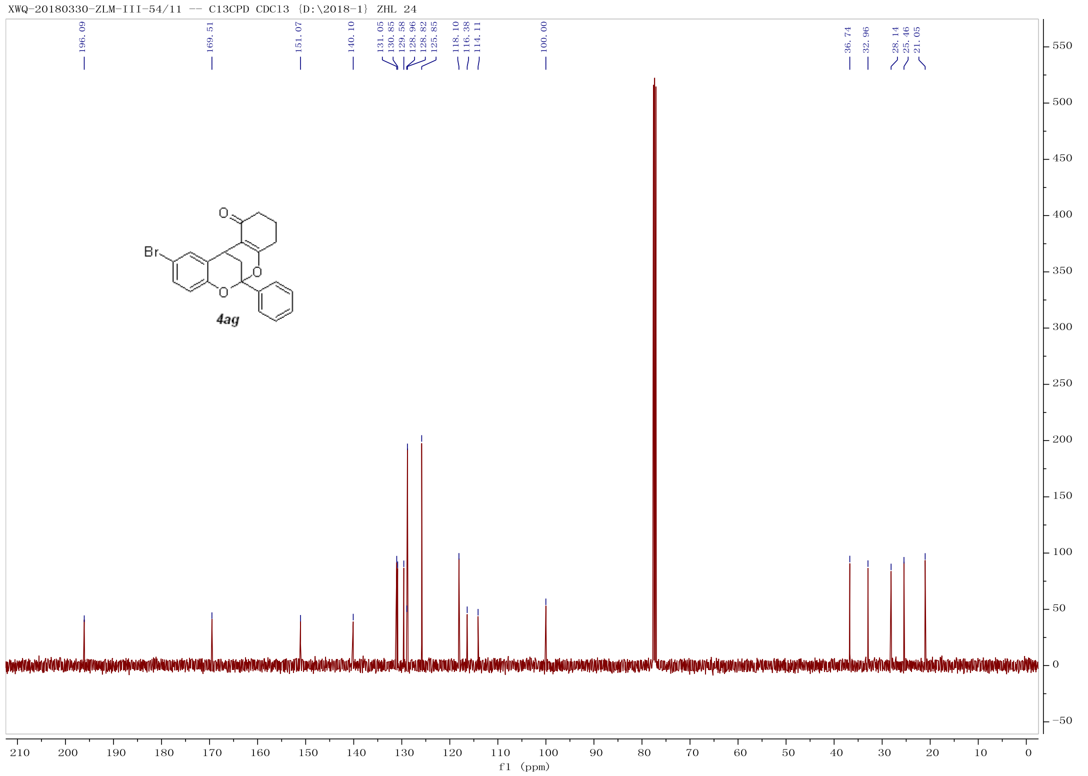
XWQ-20170324-GYQ-II-45/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 36

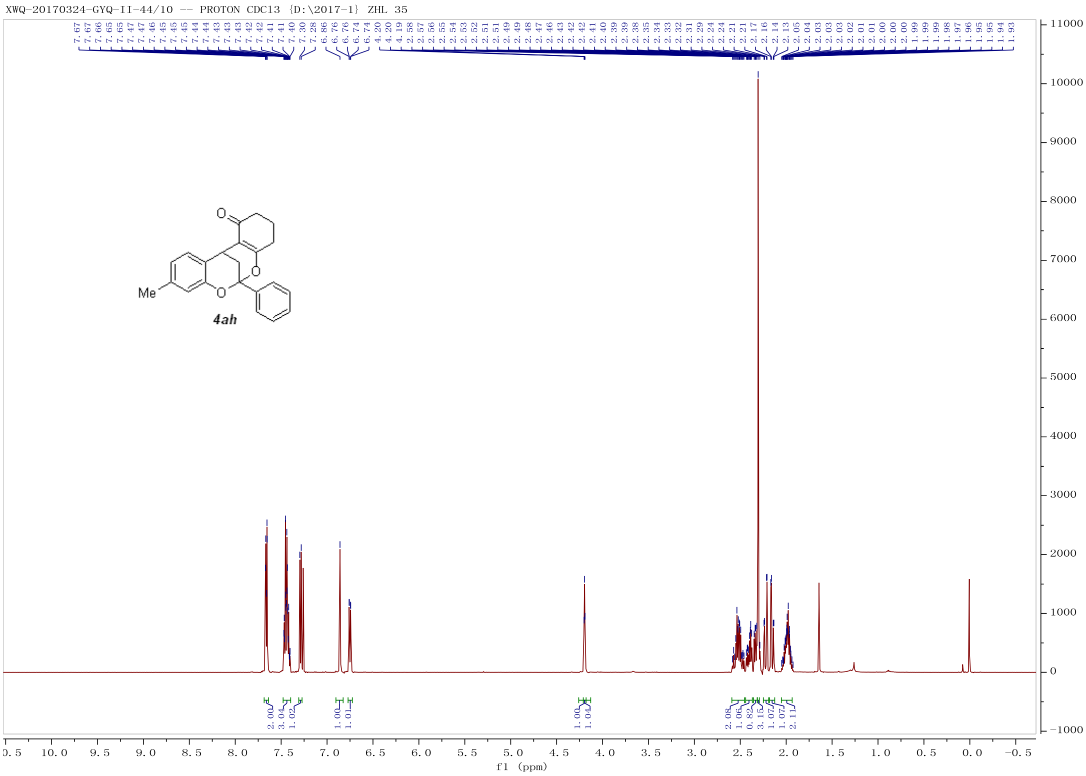


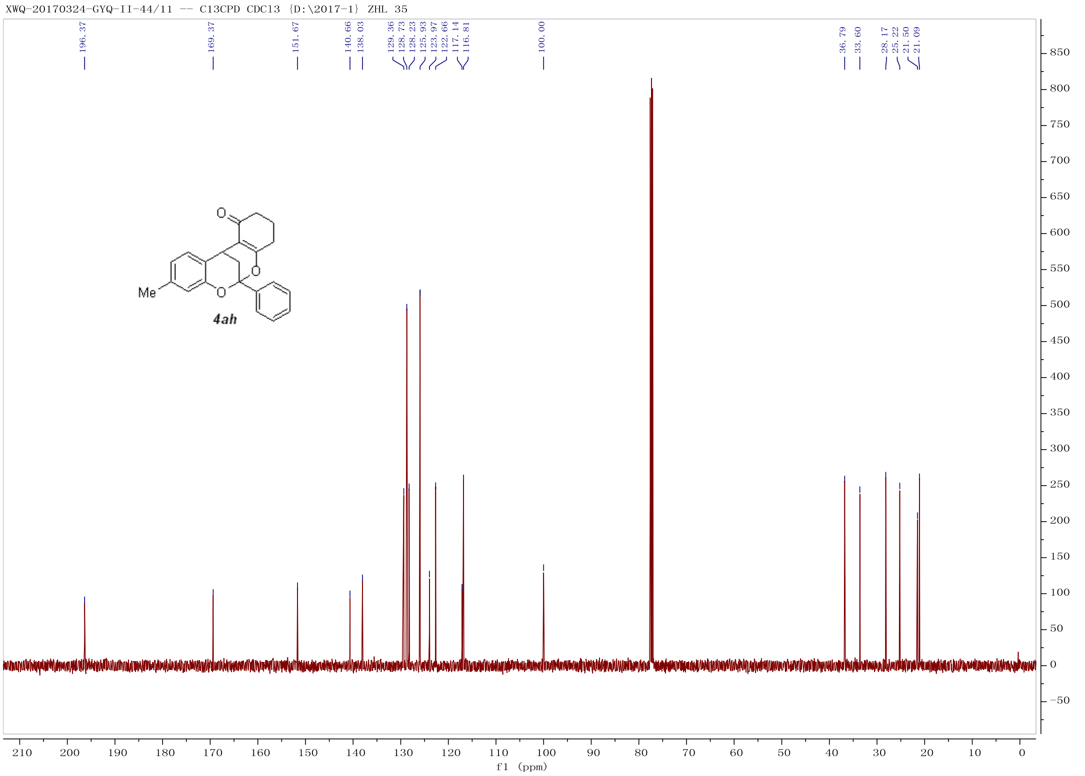

XWQ-20170324-GYQ-II-53/10 -- PROTON CDCl3 {D:\2017-1} ZHL 37
7.60
7.60
7.59
7.59
7.58
7.57
7.41
7.41
7.40
7.39
7.17
7.16
7.15
7.15
7.15
7.15
7.14
7.13
7.01
7.01
6.99
6.99
6.98
6.97
6.97
6.96
6.96
6.95
6.93
6.93
6.92
6.92
6.91
6.90
4.23
4.22
4.21
3.85
2.57
2.56
2.55
2.54
2.53
2.52
2.51
2.51
2.50
2.49
2.48
2.47
2.47
2.46
2.43
2.42
2.42
2.41
2.40
2.39
2.38
2.37
2.35
2.34
2.33
2.32
2.31
2.30
2.30
2.29
2.25
2.24
2.22
2.22
2.18
2.17
2.15
2.14
2.03
2.03
2.02
2.02
2.01
2.00
2.00
2.00
1.99
1.99
1.99
1.98
1.98
1.98
1.97
1.96
1.96
1.94
1.94
1.93
O
O
O
OMe
4af
2.05
1.04
1.05
1.00
2.07
1.05
1.00
3.06
2.14
2.15
1.07
1.04
2.11
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
−1000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
f1 (ppm)

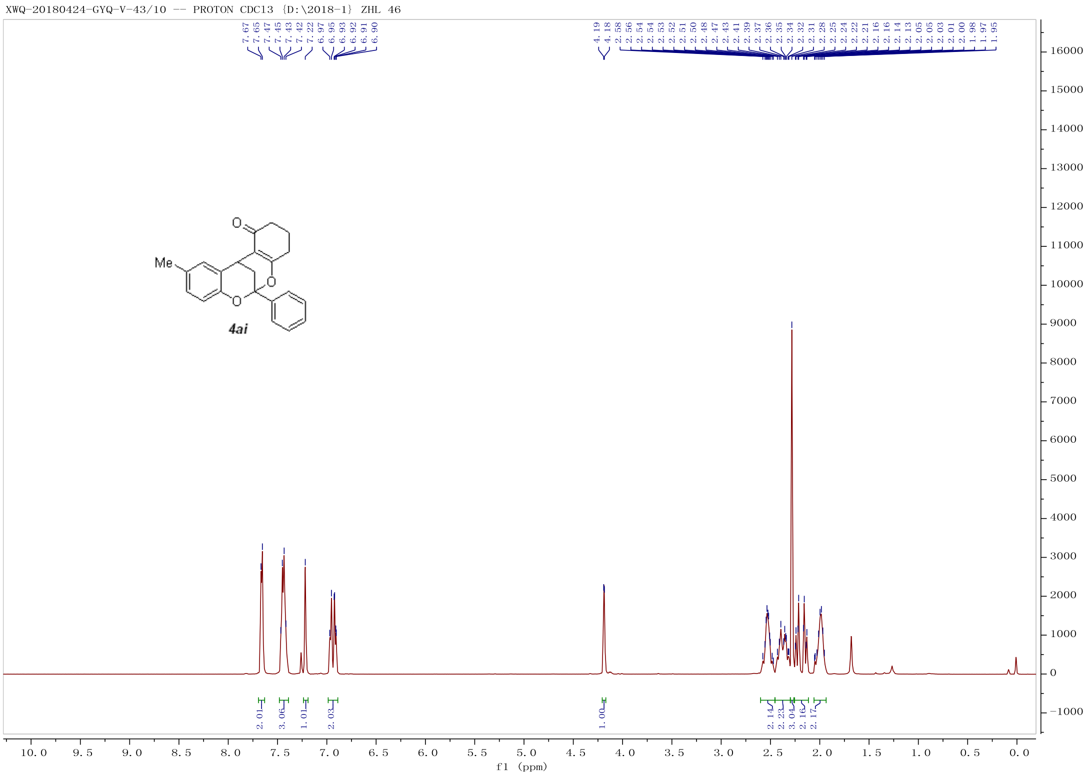

XWQ-20170324-GYQ-II-53/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 37
196.36
169.53
160.42
151.90
132.81
128.51
127.88
127.27
126.92
121.81
116.86
116.29
114.02
100.01
55.70
36.78
33.35
28.18
25.65
21.08
O
O
O
OMe
4af
550
500
450
400
350
300
250
200
150
100
50
0
−50
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

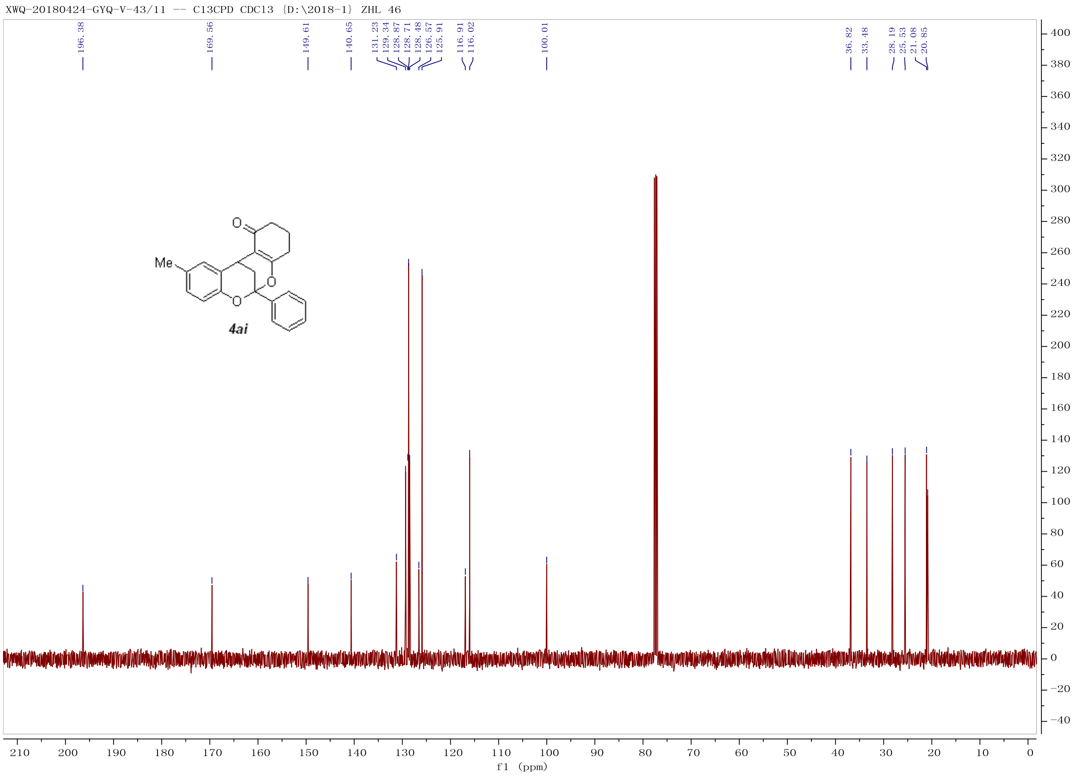

XWQ-20180330-ZLM-III-54/10 -- PROTON CDCl3 {D:\2018-1} ZHL 24
7.65 7.64 7.63 7.54 7.53 7.48 7.47 7.46 7.44 7.43 7.42 7.41 7.25 7.24 7.23 6.89 6.88
4.20 4.19 4.18 2.59 2.58 2.57 2.56 2.55 2.53 2.52 2.51 2.50 2.49 2.47 2.45 2.44 2.43 2.42 2.41 2.40 2.40 2.39 2.38 2.37 2.36 2.35 2.34 2.33 2.33 2.32 2.32 2.23 2.22 2.20 2.20 2.18 2.16 2.15 2.06 2.05 2.04 2.03 2.02 2.02 2.01 2.01 2.00 1.99 1.98 1.96 1.95 1.94
Br
O
O
O
4ag
2.01 1.00 3.04 1.07 1.00 1.00 2.11 2.13 1.03 1.08 2.21
f1 (ppm)


XWQ-20180330-ZLM-III-54/11 -- C13CPD CDCl3 {D:\2018-1} ZHL 24
196.09 169.51 151.07 140.10 131.05 130.85 129.58 128.96 128.82 125.85 118.10 116.38 114.11 100.00 36.74 32.96 28.14 25.46 21.05
Br
O
O
O
4ag
f1 (ppm)

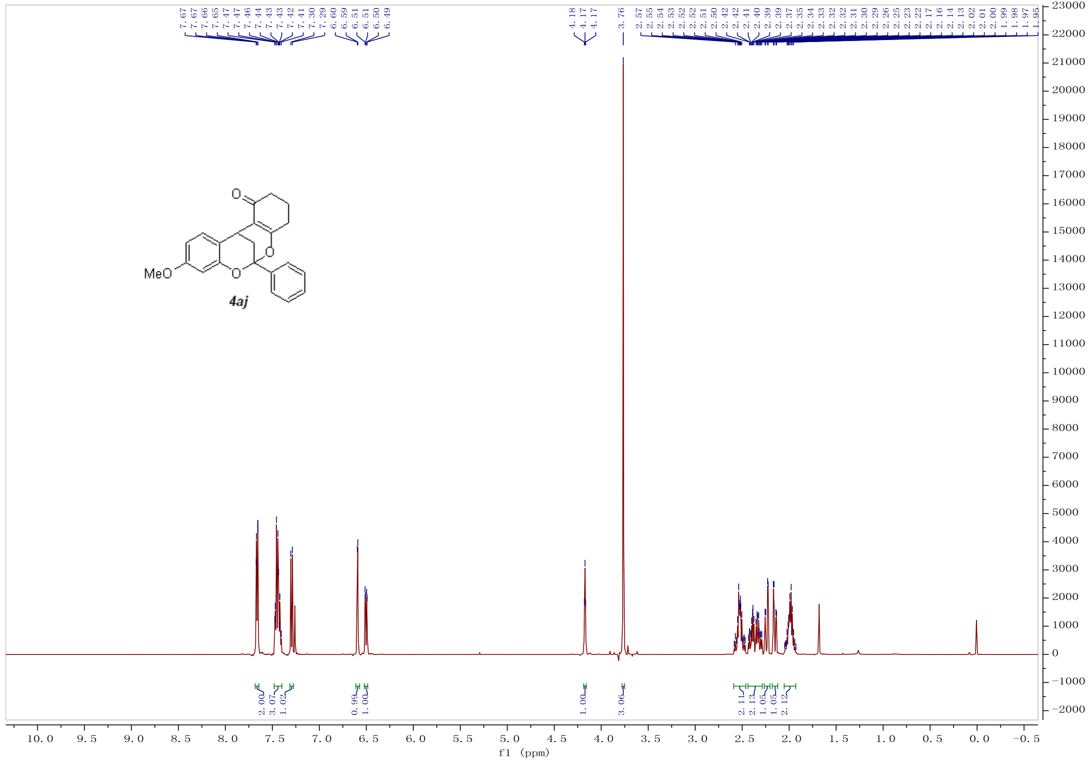

XWQ-20170324-GYQ-II-44/10 -- PROTON CDCl3 {D:\2017-1} ZHL 35
7.67 7.67 7.66 7.65 7.65 7.47 7.47 7.46 7.45 7.45 7.45 7.44 7.44 7.43 7.43 7.43 7.42 7.42 7.41 7.41 7.40 7.30 7.28 6.86 6.76 6.76 6.74 6.74 4.20 4.20 4.19 2.58 2.57 2.56 2.55 2.54 2.53 2.52 2.51 2.51 2.49 2.49 2.48 2.47 2.46 2.43 2.42 2.42 2.41 2.40 2.39 2.39 2.38 2.35 2.34 2.33 2.32 2.31 2.29 2.24 2.24 2.21 2.21 2.17 2.16 2.14 2.13 2.05 2.04 2.03 2.03 2.03 2.02 2.01 2.01 2.00 2.00 2.00 1.99 1.99 1.99 1.98 1.97 1.96 1.95 1.95 1.94 1.93
O
O
Me
O
4ah
2.00 3.04 1.02 1.00 1.01 1.00 1.04 2.08 1.06 0.82 3.15 1.07 1.07 2.11
f1 (ppm)


XWQ-20170324-GYQ-II-44/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 35
196.37 169.37 151.67 140.66 138.03 129.36 128.73 128.23 125.93 123.97 122.66 117.14 116.81 100.00 36.79 33.60 28.17 25.22 21.50 21.09
O
O
Me
O
4ah
f1 (ppm)

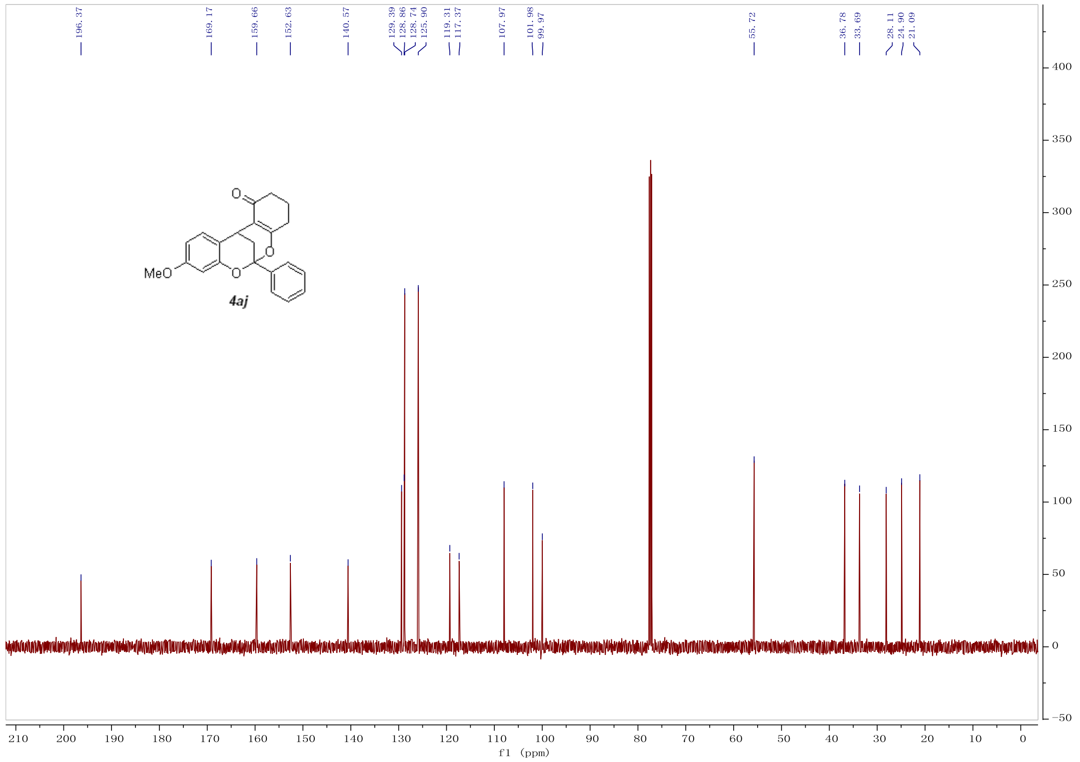

XWQ-20180424-GYQ-V-43/10 -- PROTON CDCl3 {D:\2018-1} ZHL 46
7.67
7.65
7.47
7.45
7.43
7.42
7.22
6.97
6.95
6.93
6.92
6.91
6.90
4.19
4.18
2.58
2.56
2.54
2.53
2.52
2.51
2.50
2.48
2.47
2.43
2.41
2.39
2.37
2.36
2.35
2.34
2.32
2.31
2.28
2.25
2.24
2.22
2.21
2.16
2.14
2.13
2.05
2.03
2.01
2.00
1.98
1.97
1.95
O
Me
O
O
4ai
2.01
3.06
1.01
2.03
1.00
2.14
2.23
3.04
2.16
2.17
f1 (ppm)


XWQ-20180424-GYQ-V-43/11 -- C13CPD CDCl3 {D:\2018-1} ZHL 46
196.38
169.56
149.61
140.65
131.23
129.34
128.87
128.71
128.48
126.57
125.91
116.91
116.02
100.01
36.82
33.48
28.19
25.53
21.08
20.85
O
Me
O
O
4ai
f1 (ppm)

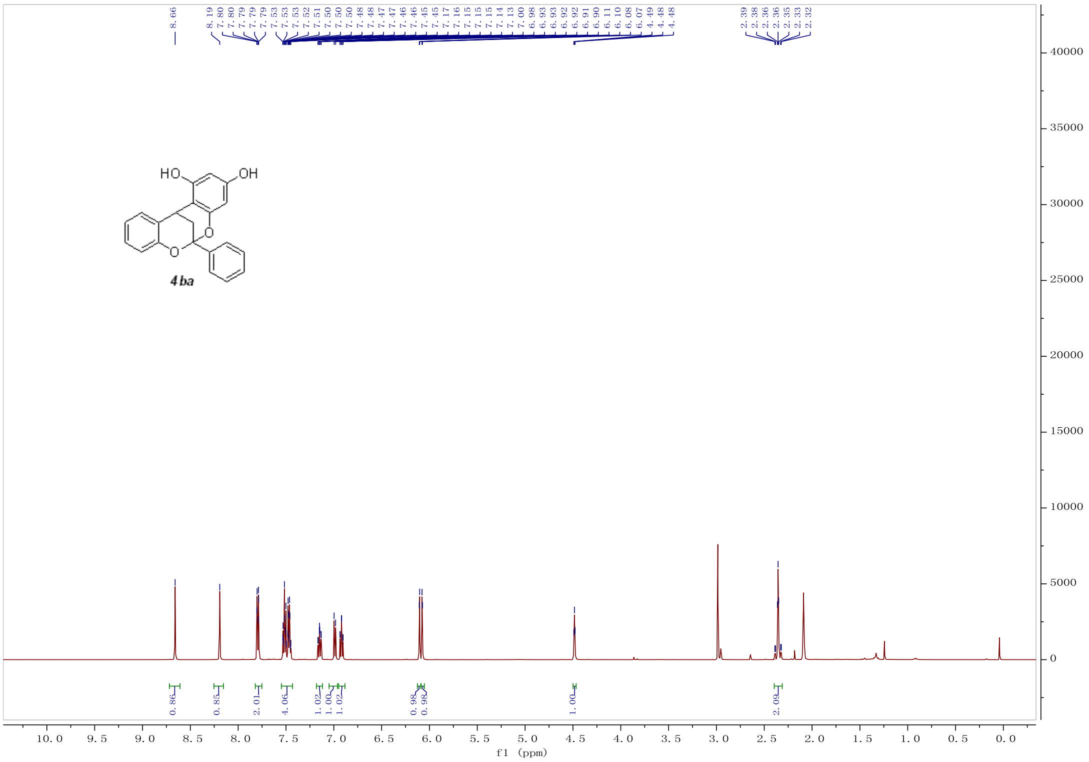
XWQ-20180330-ZLM-III-55/10 -- PROTON CDCl3 {D:\2018-1} ZHL 25



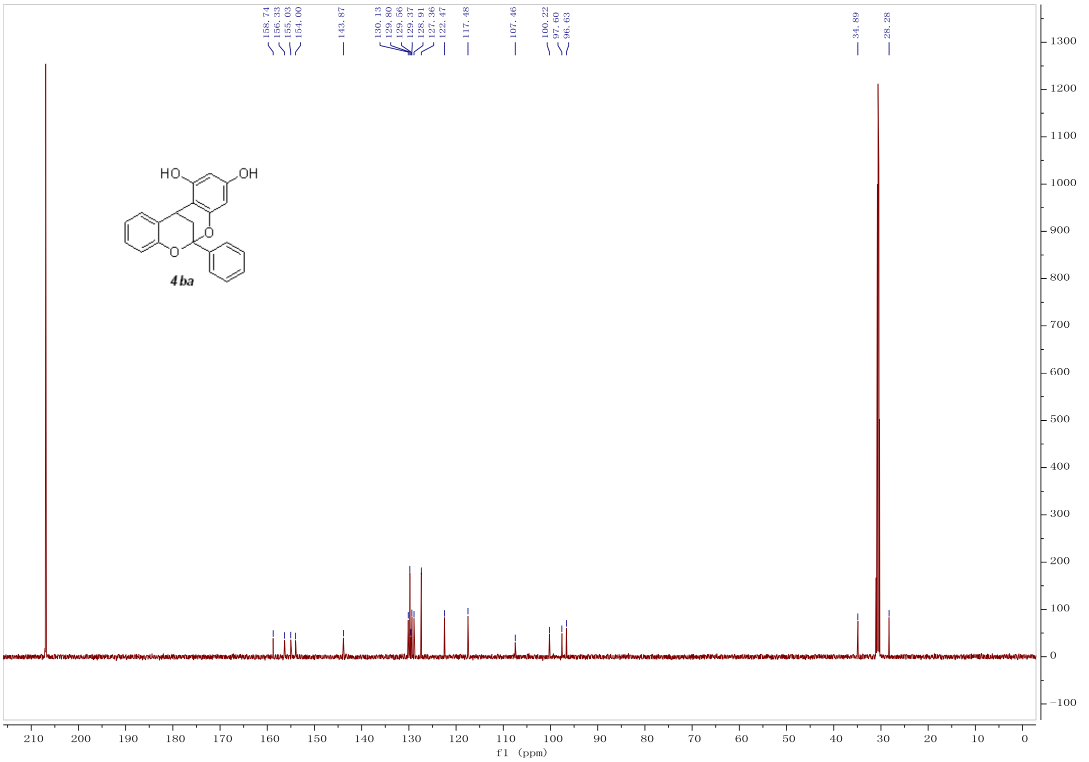
XWQ-20180330-ZLM-III-55/11 -- C13CPD CDCl3 {D:\2018-1} ZHL 25



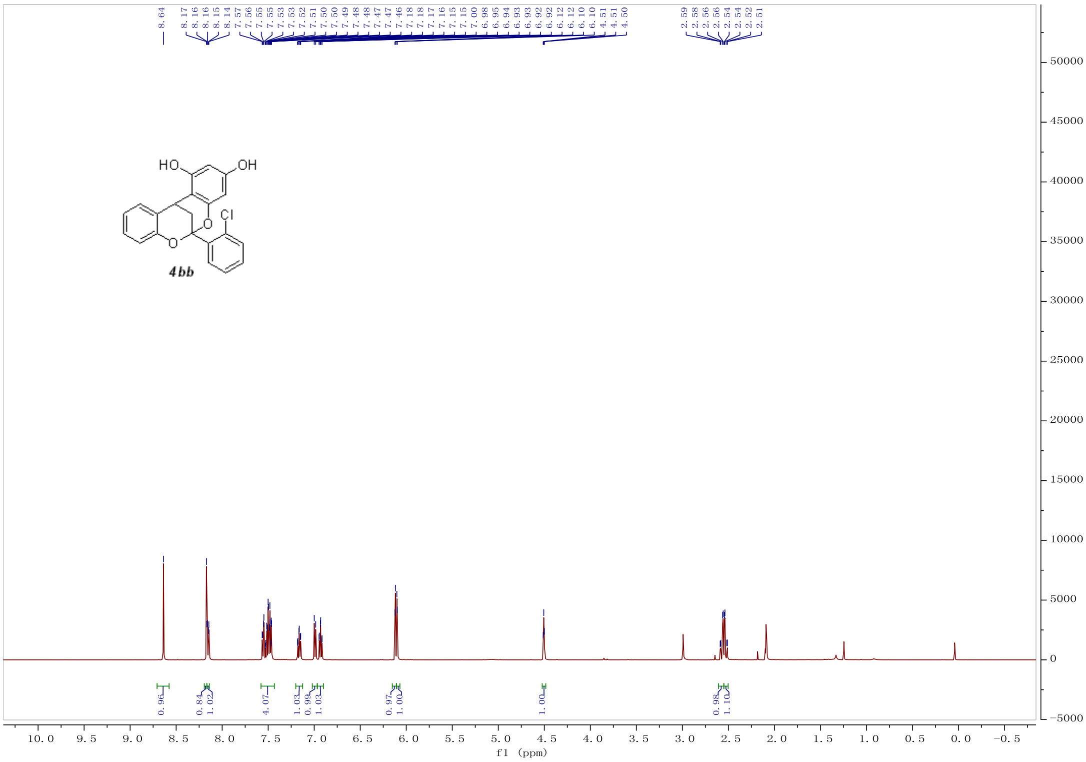
XWQ-20181101-GYQ-VI-45-2/10 -- PROTON Acetone {D:\2018-3} ZHL 50



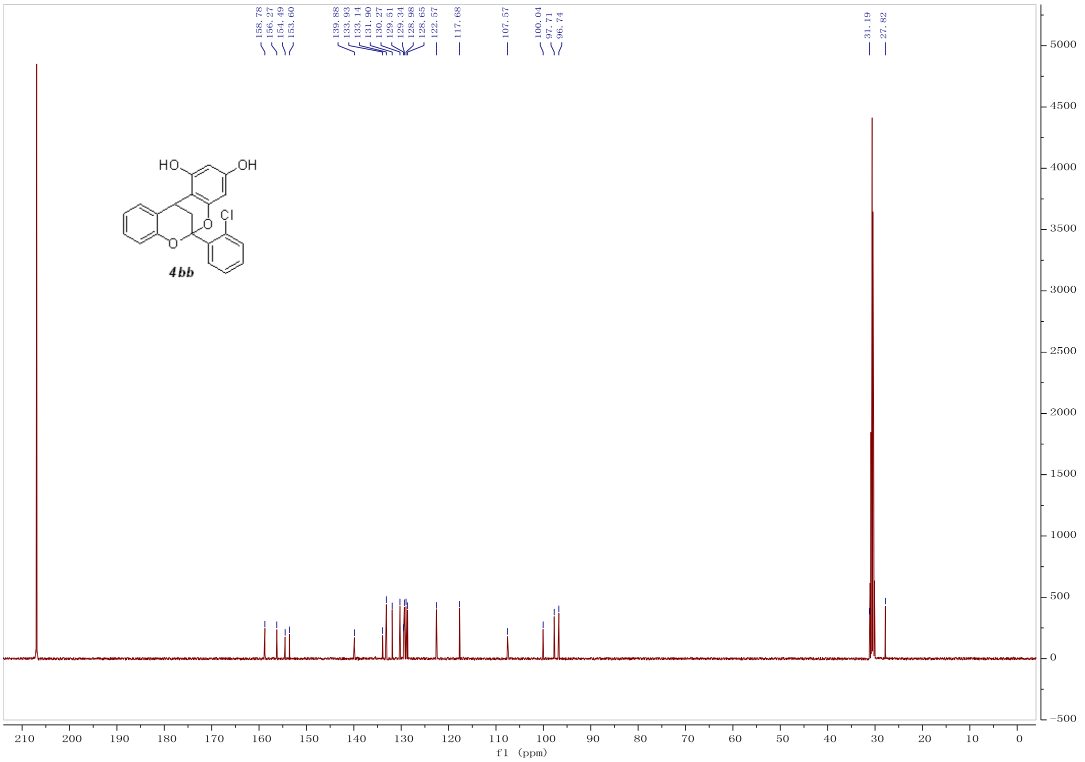
XWQ-20181102-GYQ-VI-45-2/11 -- C13CPD Acetone {D:\2018-3} ZHL 26

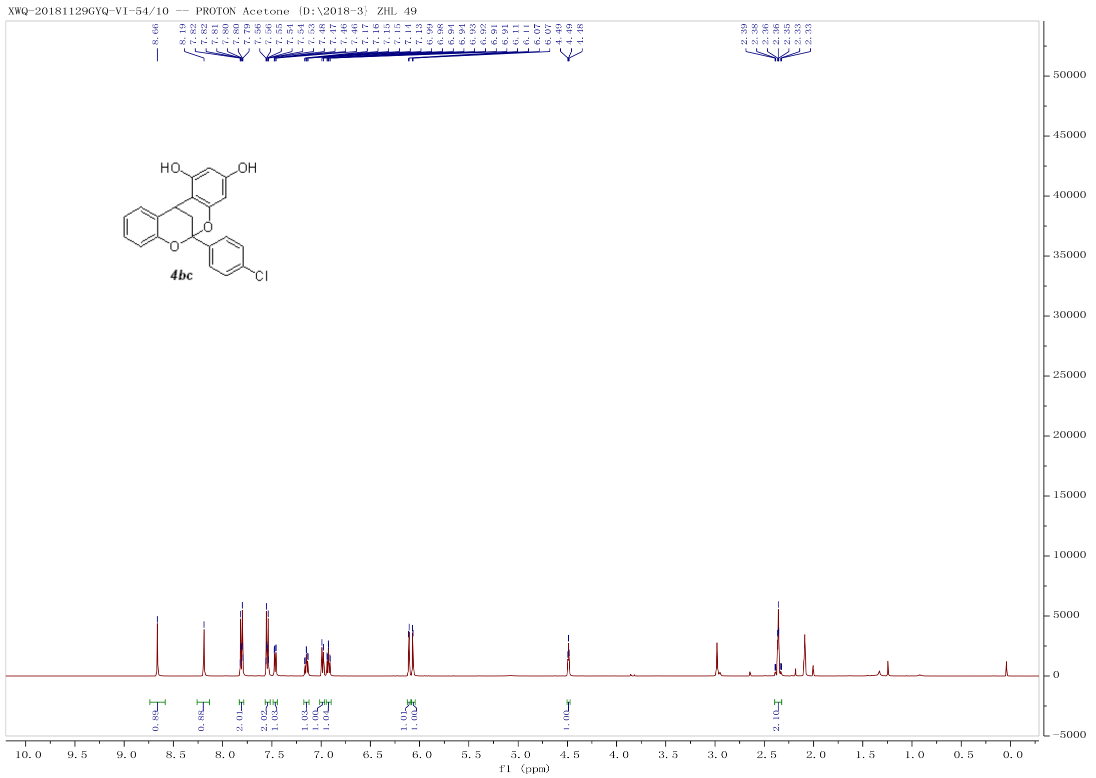


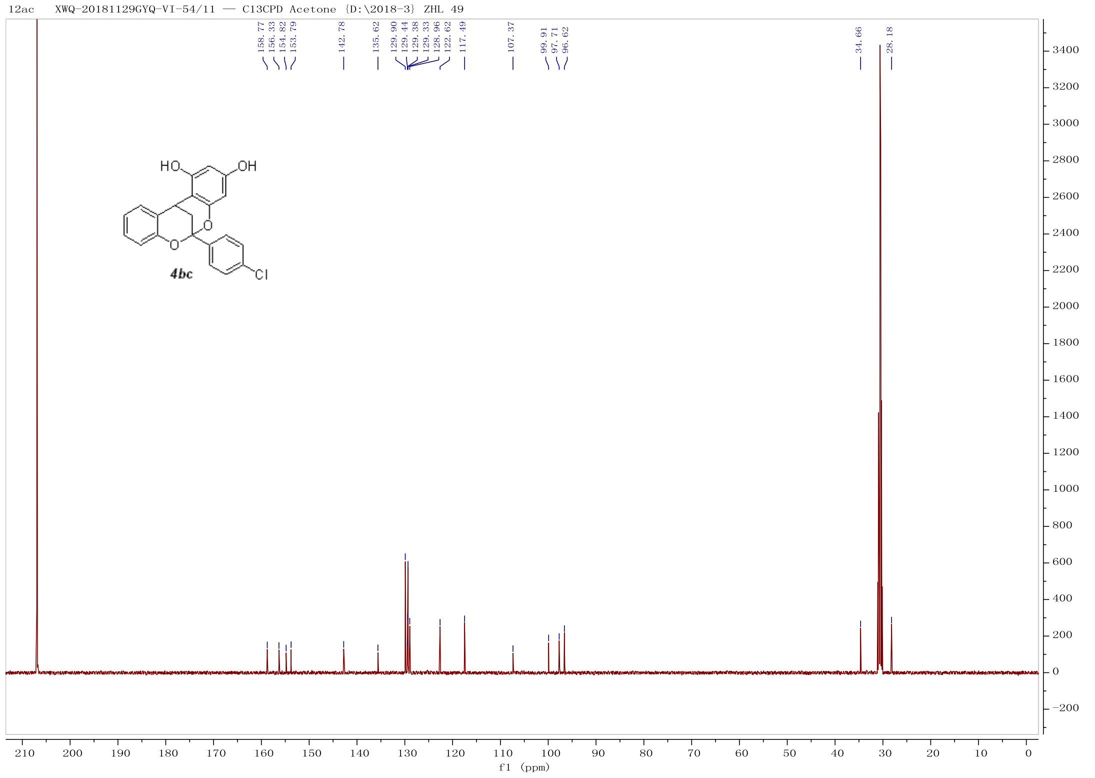
XWQ-20181211-GYQ-VI-57/10 -- PROTON Acetone {D:\2018-3} ZHL 43

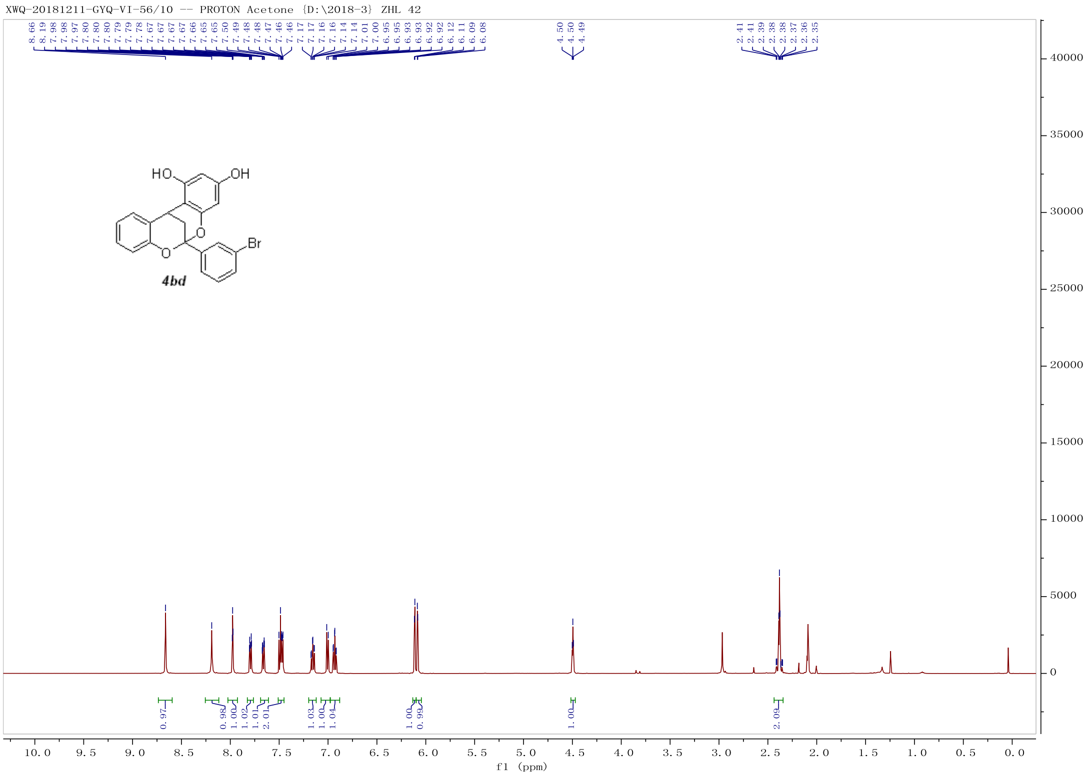


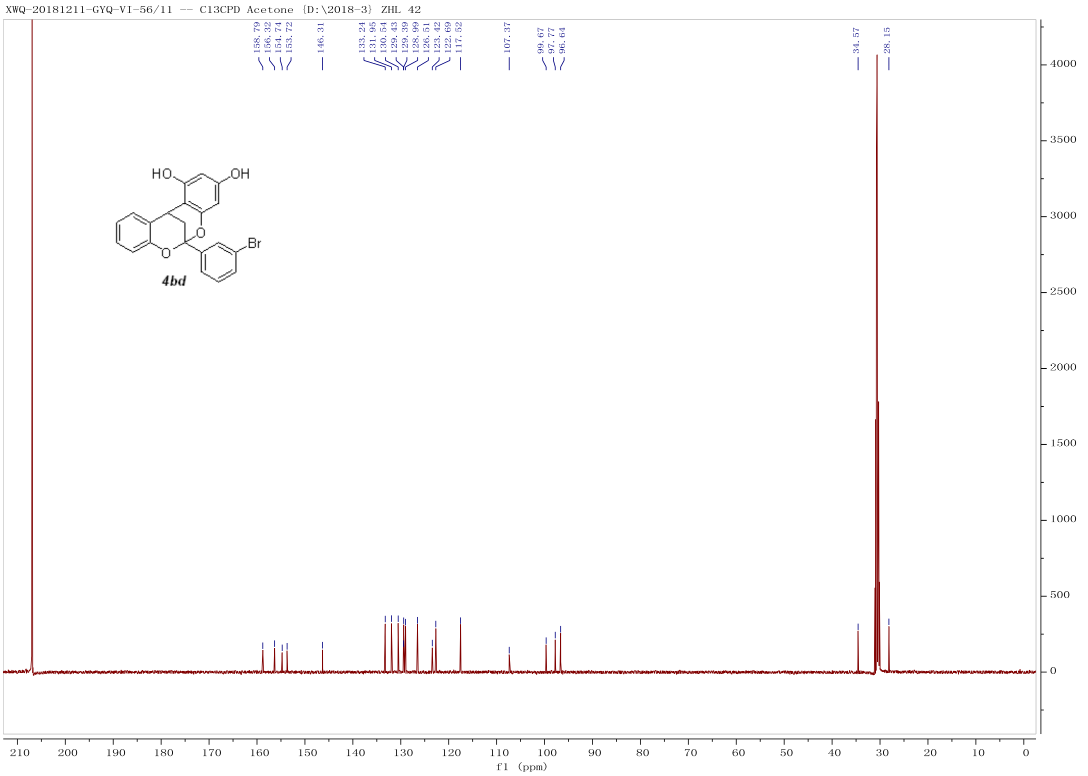
XWQ-20181211-GYQ-VI-57/11 -- C13CPD Acetone {D:\2018-3} ZHL 43



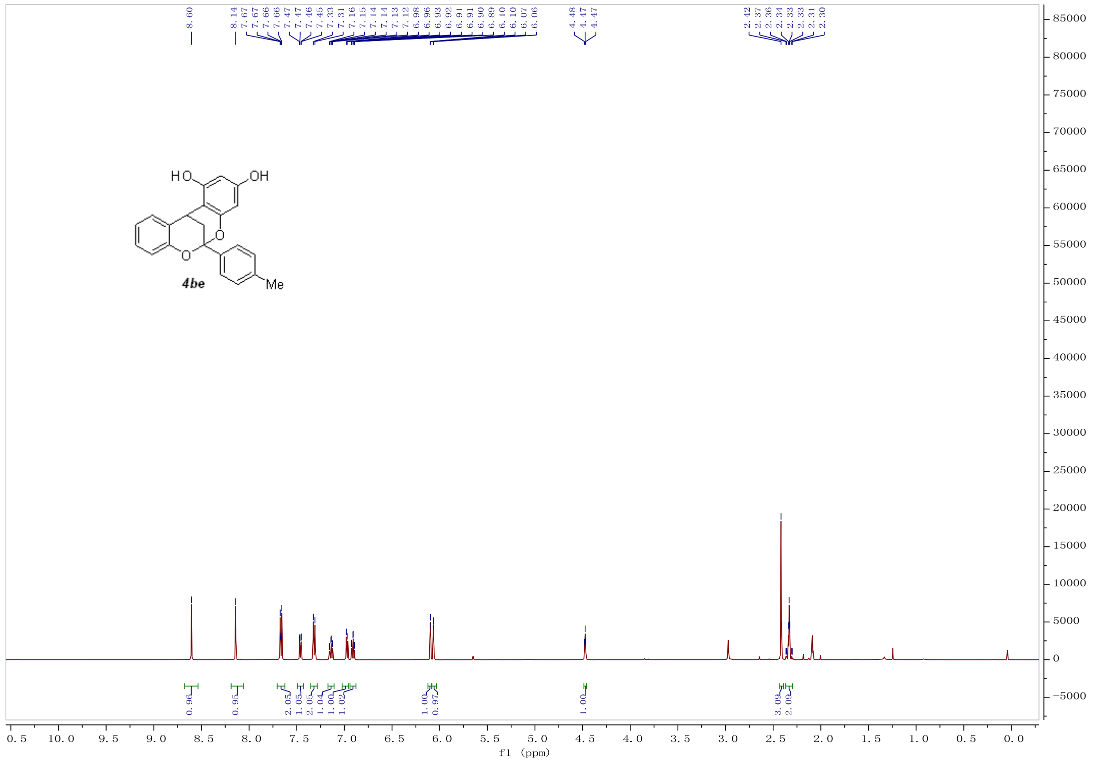

XWQ-20181129GYQ-VI-54/10 -- PROTON Acetone {D:\2018-3} ZHL 49
8.66
8.19
7.82
7.82
7.81
7.80
7.80
7.79
7.56
7.56
7.55
7.54
7.54
7.53
7.48
7.47
7.46
7.46
7.17
7.16
7.15
7.15
7.14
7.13
6.99
6.98
6.94
6.94
6.93
6.92
6.91
6.91
6.11
6.11
6.07
6.07
4.49
4.49
4.48
2.39
2.38
2.36
2.36
2.35
2.33
2.33
HO
OH
O
O
Cl
4bc
0.89
0.88
2.01
2.02
1.03
1.03
1.00
1.04
1.01
1.00
1.00
2.10
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
-5000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


12ac XWQ-20181129GYQ-VI-54/11 — C13CPD Acetone {D:\2018-3} ZHL 49
158.77
156.33
154.82
153.79
142.78
135.62
129.90
129.44
129.38
129.33
128.96
122.62
117.49
107.37
99.91
97.71
96.62
34.66
28.18
HO
OH
O
O
Cl
4bc
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

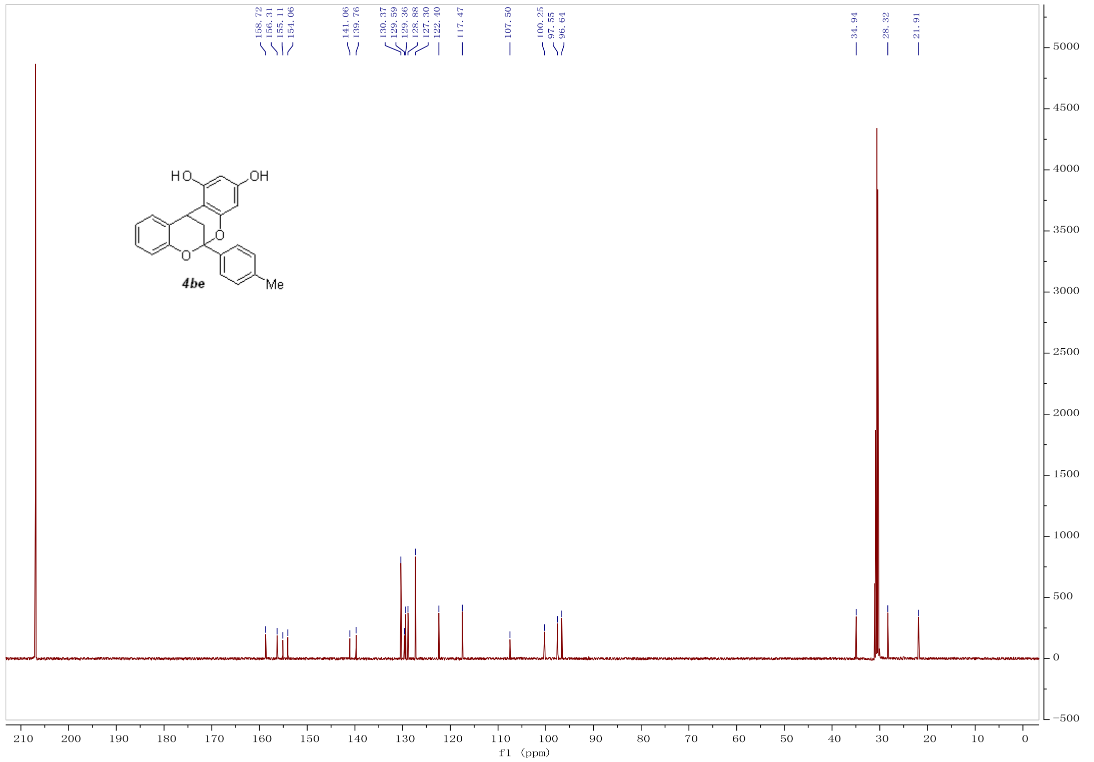

XWQ-20181211-GYQ-VI-56/10 -- PROTON Acetone {D:\2018-3} ZHL 42
8.66
8.19
7.98
7.98
7.97
7.80
7.80
7.80
7.79
7.79
7.78
7.67
7.67
7.67
7.66
7.65
7.65
7.50
7.49
7.48
7.48
7.47
7.46
7.46
7.17
7.17
7.16
7.16
7.14
7.14
7.01
7.00
6.95
6.95
6.93
6.93
6.92
6.92
6.12
6.11
6.09
6.08
4.50
4.50
4.49
2.41
2.41
2.39
2.38
2.38
2.37
2.36
2.35
HO
OH
O
O
Br
4bd
0.97
0.98
1.00
1.02
1.01
2.01
1.03
1.00
1.04
1.00
0.99
1.00
2.09
40000
35000
30000
25000
20000
15000
10000
5000
0
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


XWQ-20181211-GYQ-VI-56/11 -- C13CPD Acetone {D:\2018-3} ZHL 42
158.79
156.32
154.74
153.72
146.31
133.24
131.95
130.54
129.43
129.39
128.99
126.51
123.42
122.69
117.52
107.37
99.67
97.77
96.64
34.57
28.15
HO
OH
O
O
Br
4bd
4000
3500
3000
2500
2000
1500
1000
500
0
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

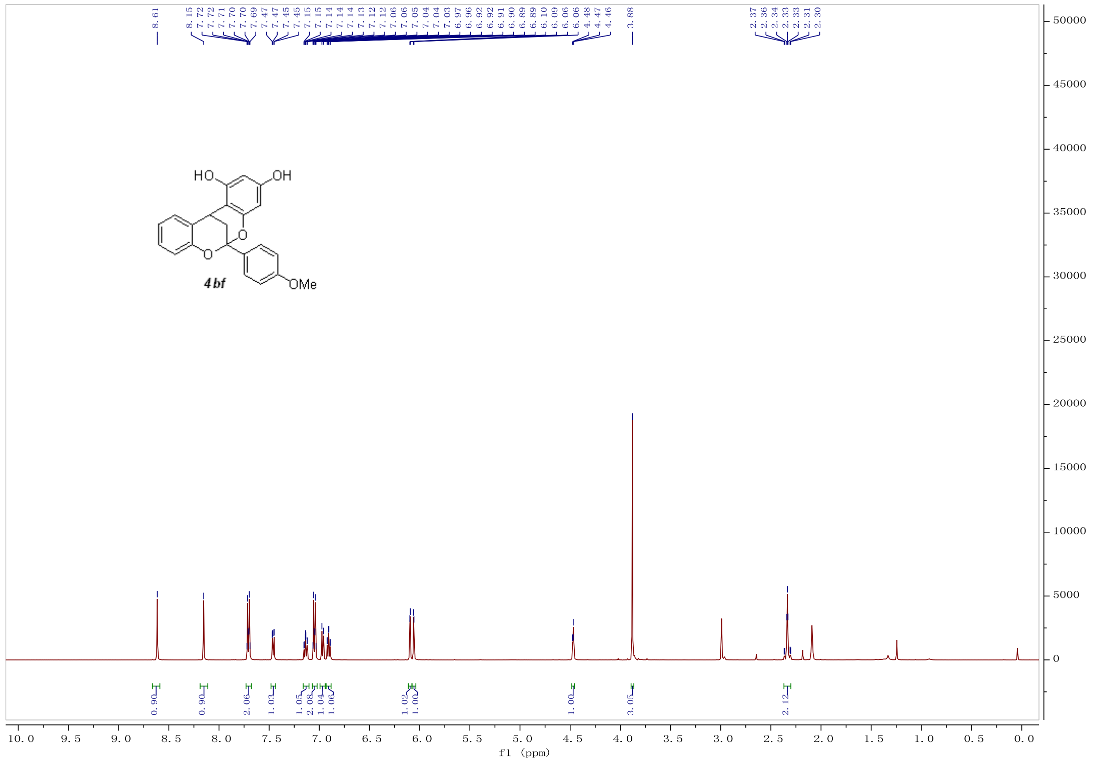
XWQ-20181211-GYQ-VI-58/10 -- PROTON Acetone {D:\2018-3} ZHL 44



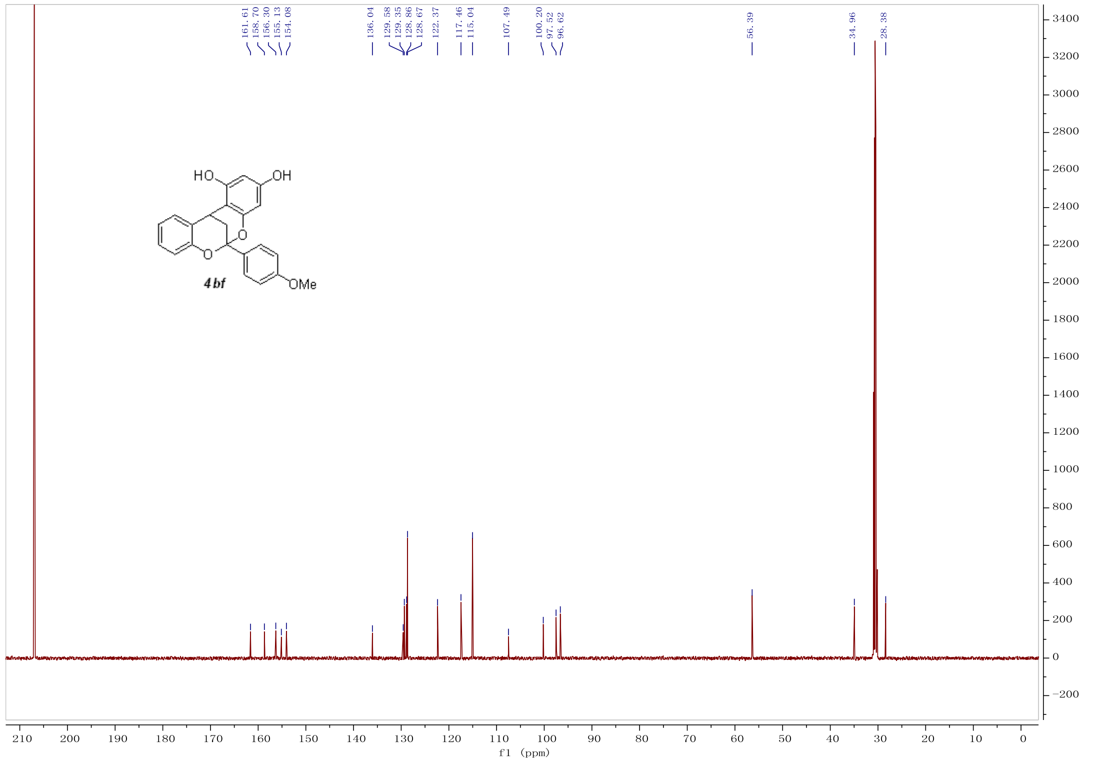
12ae XWQ-20181211-GYQ-VI-58/11 — C13CPD Acetone {D:\2018-3} ZHL 44



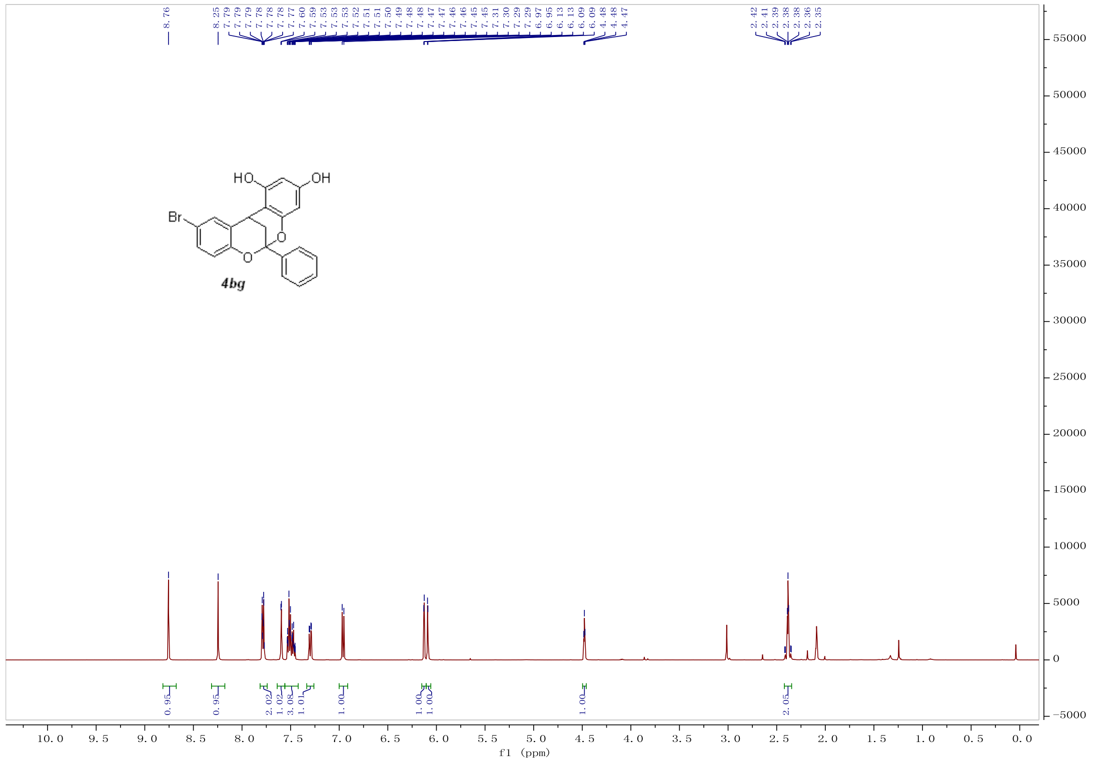
XWQ-20181129GYQ-VI-53/10 -- PROTON Acetone {D:\2018-3} ZHL 48



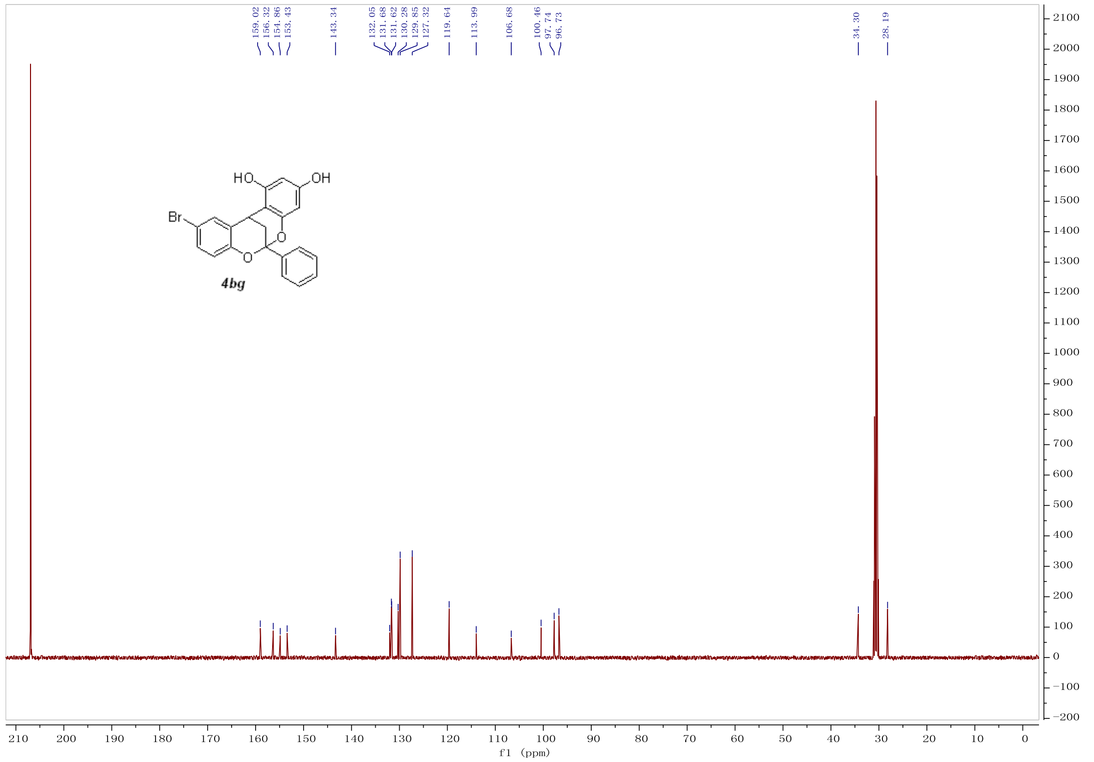
XWQ-20181129GYQ-VI-53/22 -- C13CPD Acetone {D:\2018-3} ZHL 48

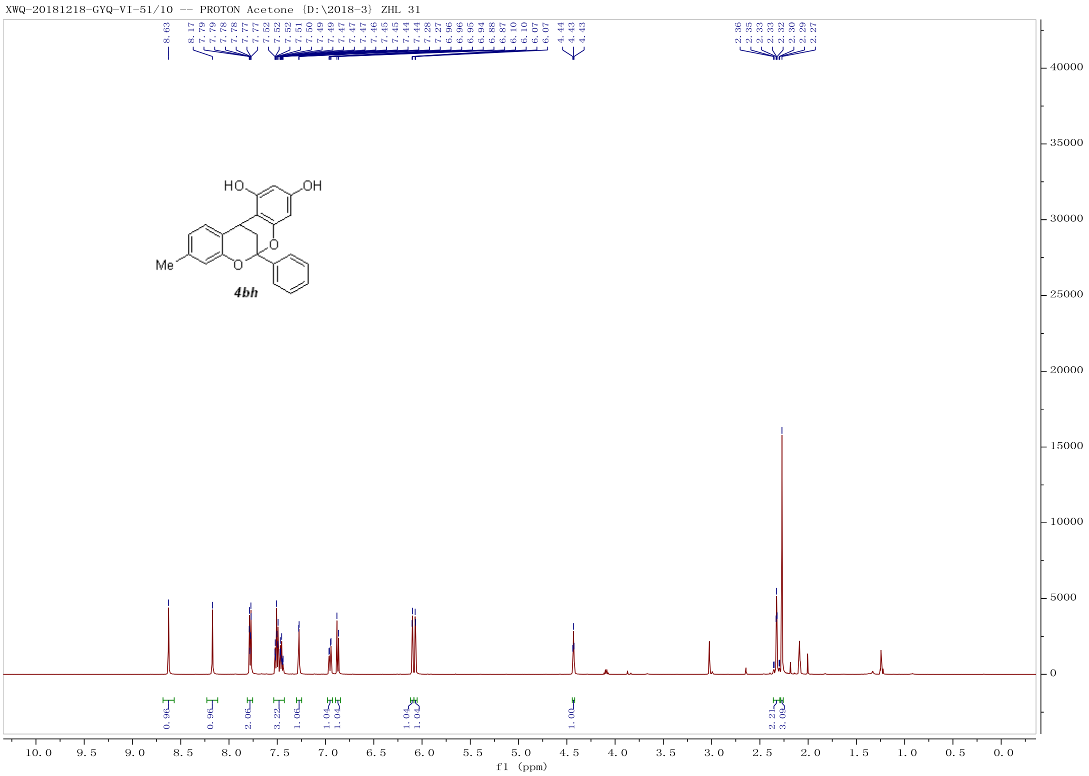


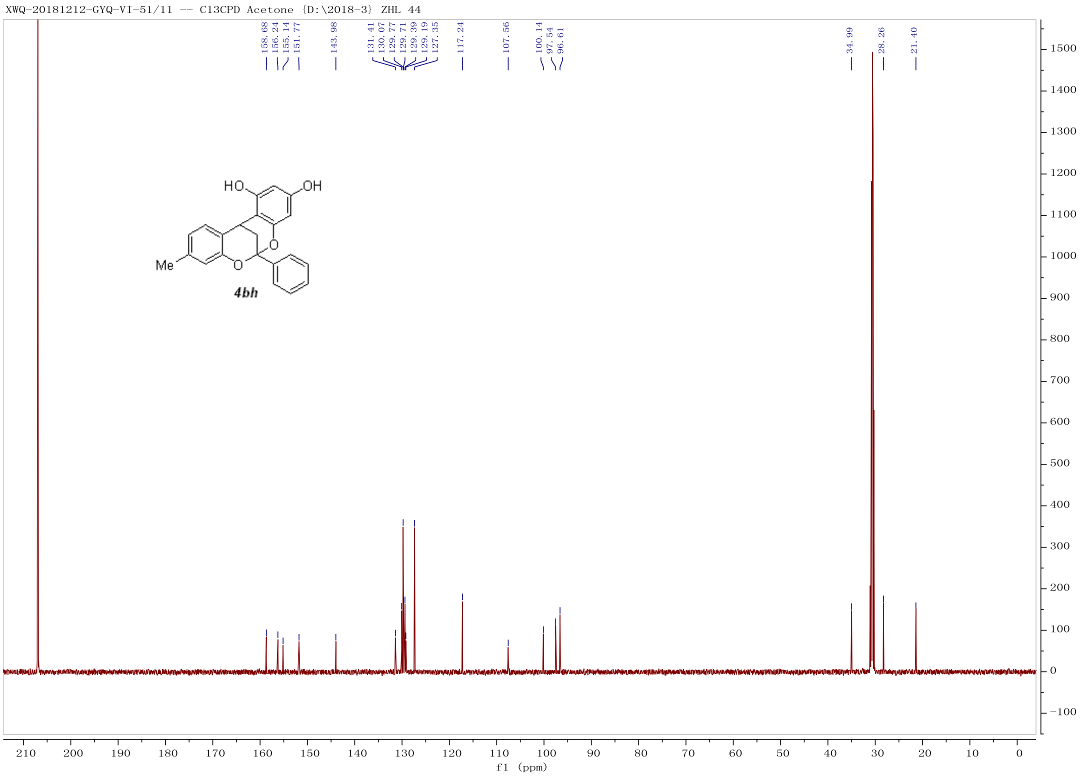
XWQ-20181212-GYQ-VI-60/10 -- PROTON Acetone {D:\2018-3} ZHL 45



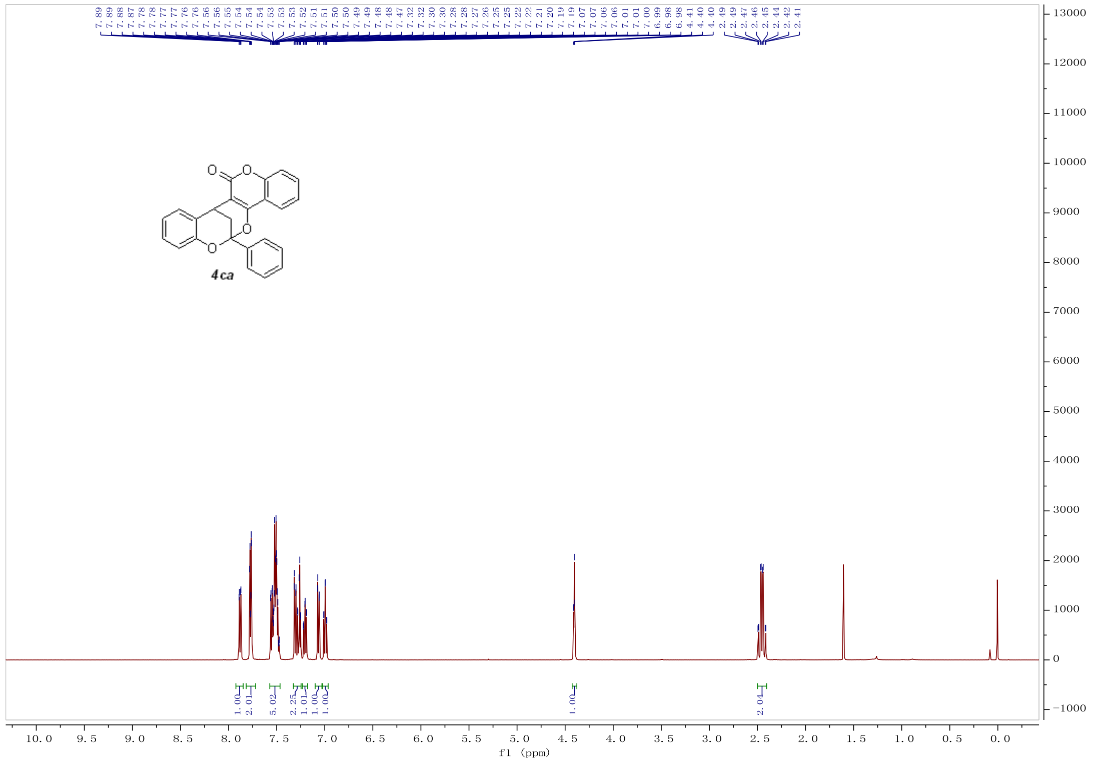
XWQ-20181212-GYQ-VI-60/11 -- C13CPD Acetone {D:\2018-3} ZHL 45



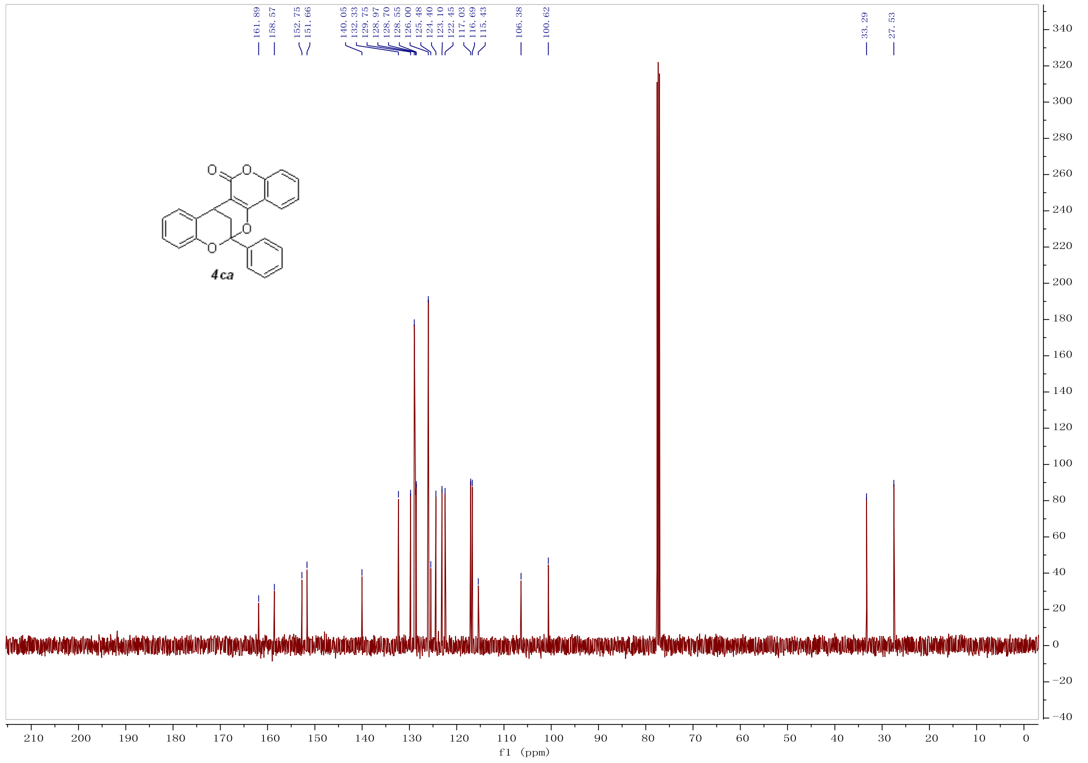

XWQ-20181218-GYQ-VI-51/10 -- PROTON Acetone {D:\2018-3} ZHL 31
8.63
8.17
7.79
7.78
7.78
7.77
7.77
7.52
7.52
7.52
7.51
7.50
7.49
7.49
7.47
7.47
7.46
7.45
7.45
7.44
7.44
7.28
7.27
6.96
6.96
6.95
6.94
6.88
6.87
6.10
6.10
6.07
6.07
4.44
4.43
4.43
2.36
2.35
2.33
2.33
2.32
2.30
2.29
2.27
HO
OH
O
Me
O
4bh
0.96
0.96
2.06
3.22
1.06
1.04
1.01
1.04
1.04
1.00
2.21
3.09
f1 (ppm)


XWQ-20181212-GYQ-VI-51/11 -- C13CPD Acetone {D:\2018-3} ZHL 44
158.68
156.24
155.14
151.77
143.98
131.41
130.07
129.77
129.71
129.39
129.19
127.35
117.24
107.56
100.14
97.54
96.61
34.99
28.26
21.40
HO
OH
O
Me
O
4bh
f1 (ppm)

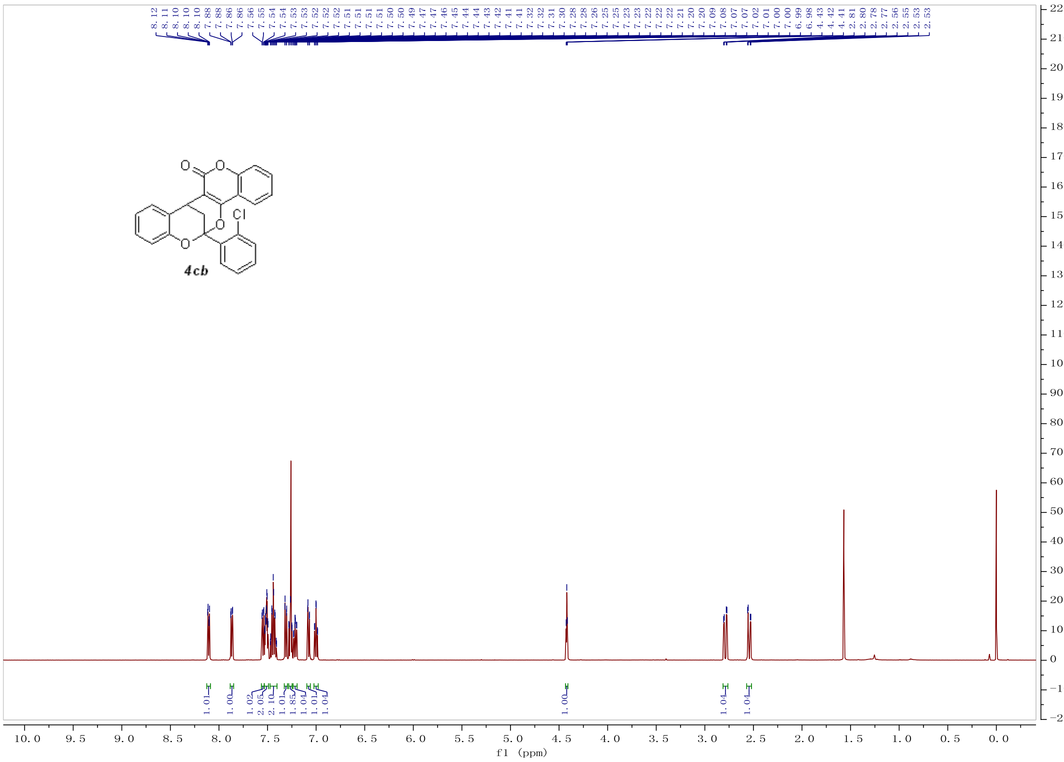
XWQ-20170324-GYQ-II-56-1/10 -- PROTON CDCl3 {D:\2017-1} ZHL 38



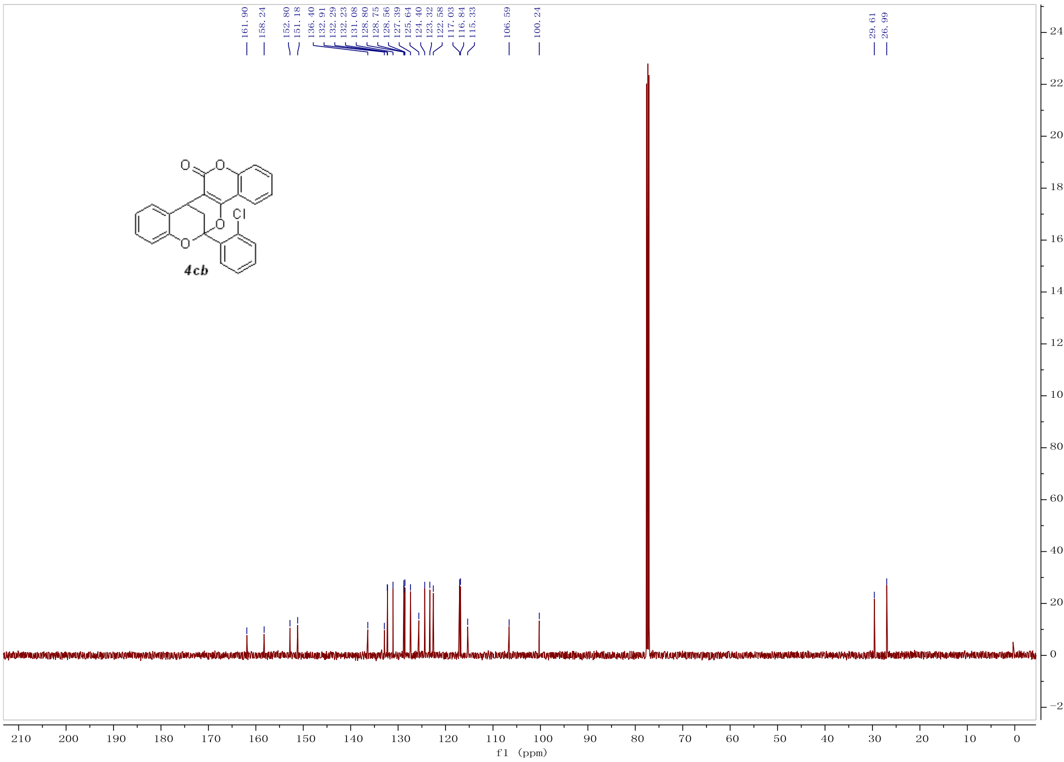
XWQ-20170324-GYQ-II-56-1/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 38

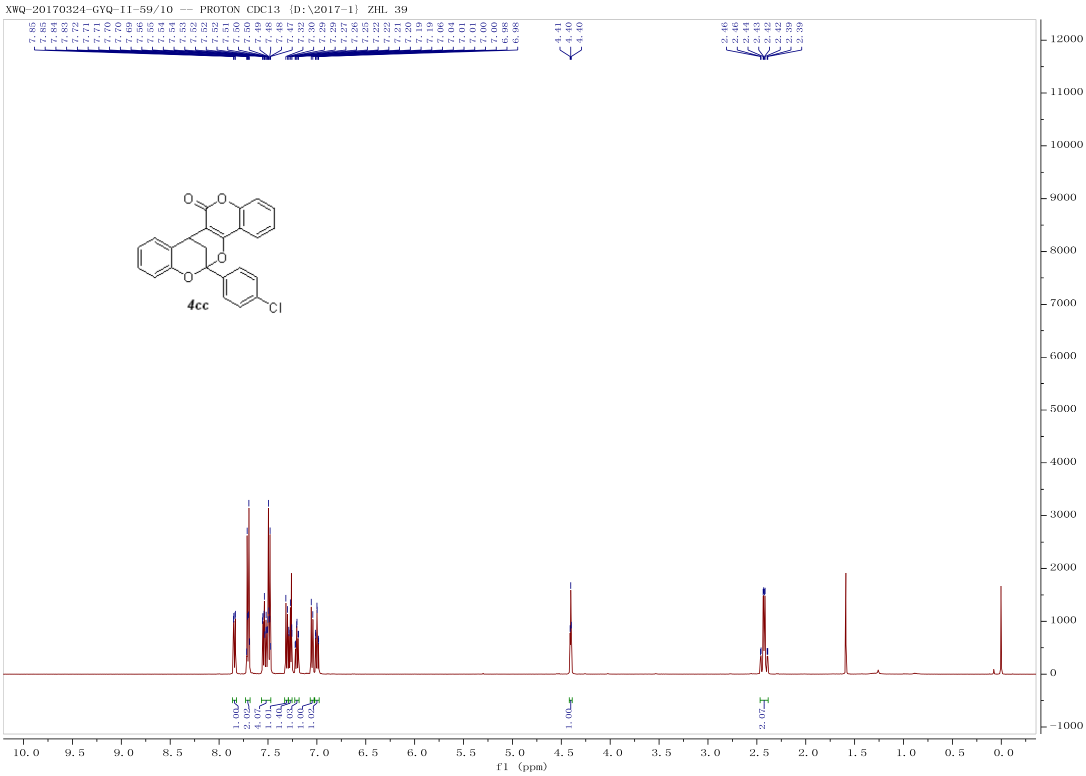


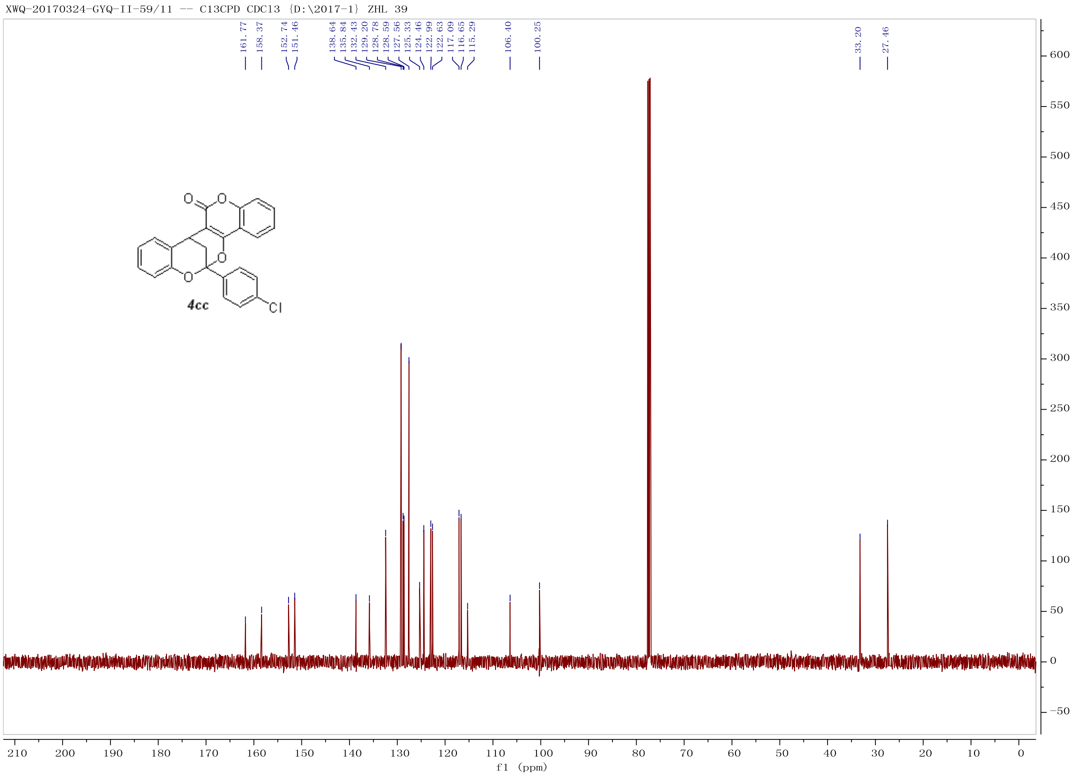
XWQ-20170329-GYQ-II-61-2/10 -- PROTON CDCl3 {D:\2017-1} ZHL 28

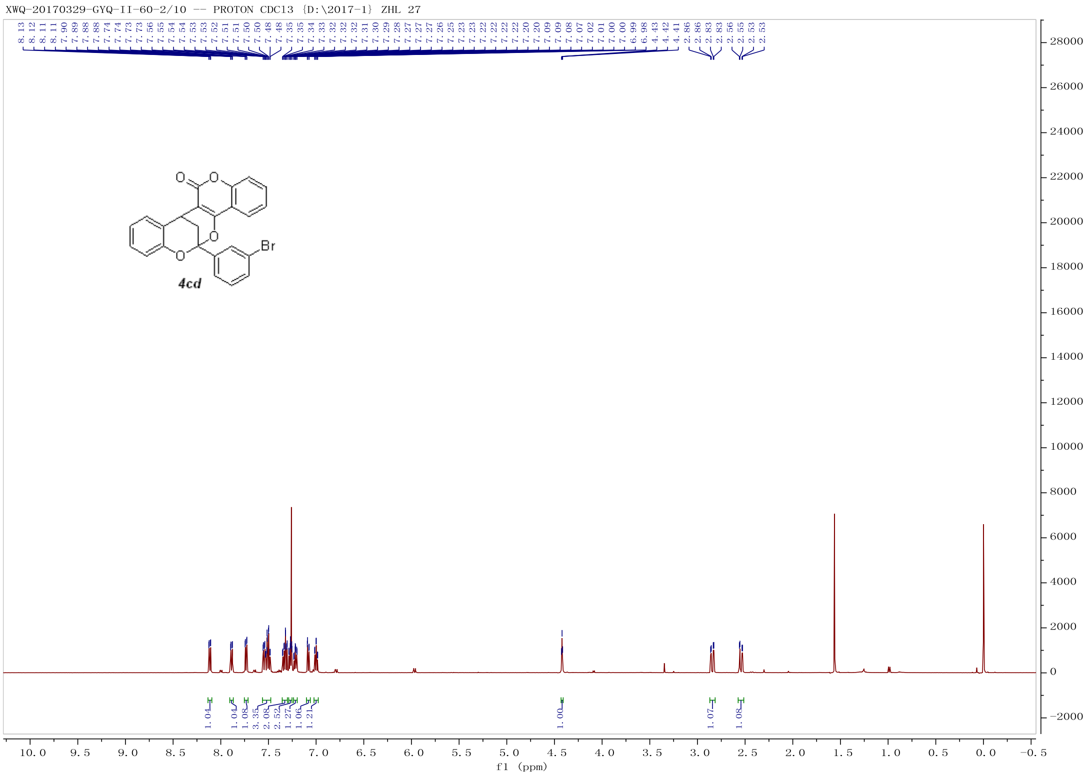


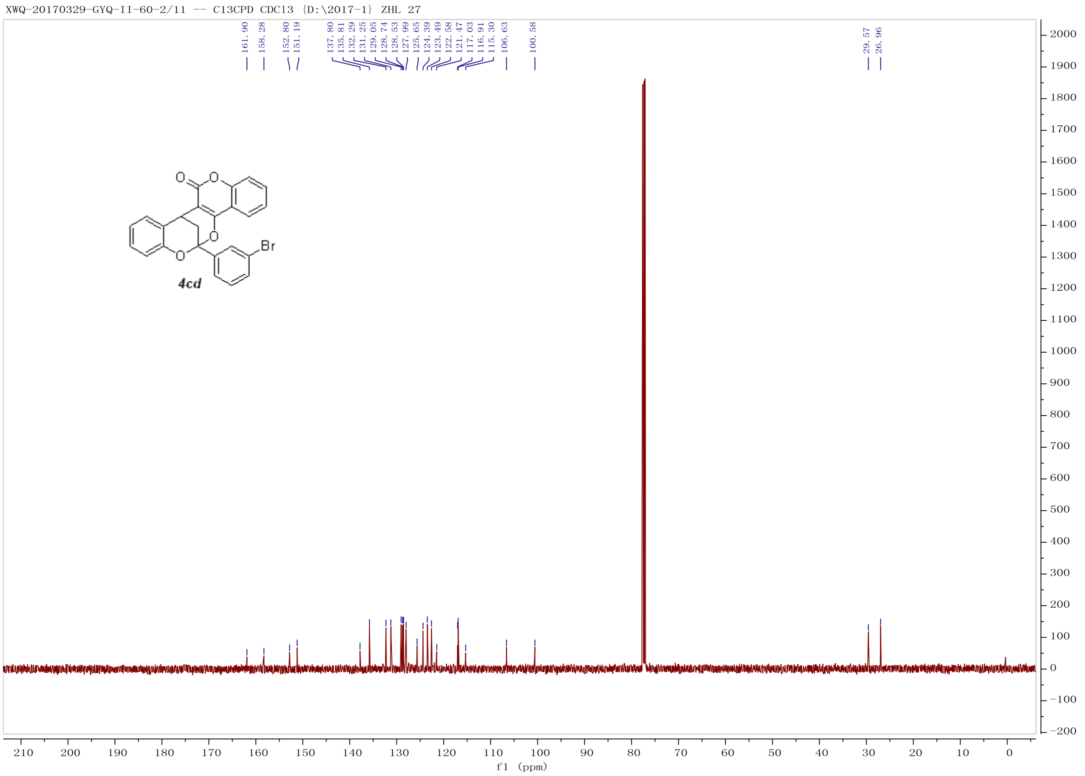
XWQ-20170329-GYQ-II-61-2/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 28

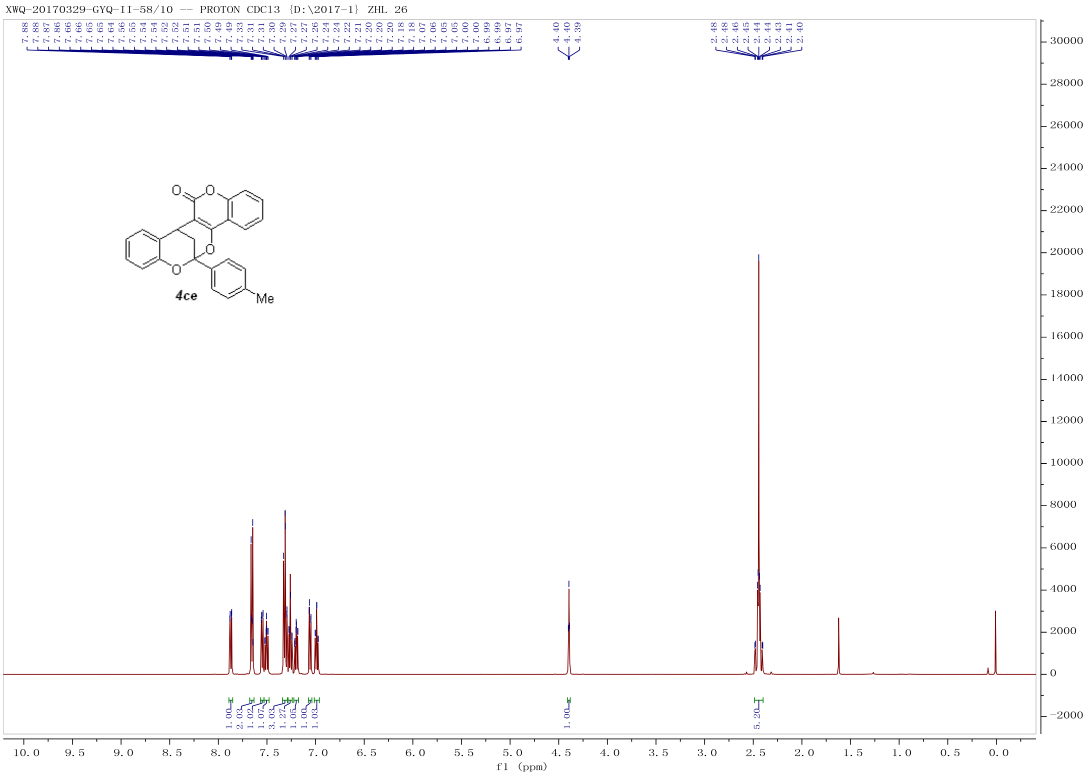


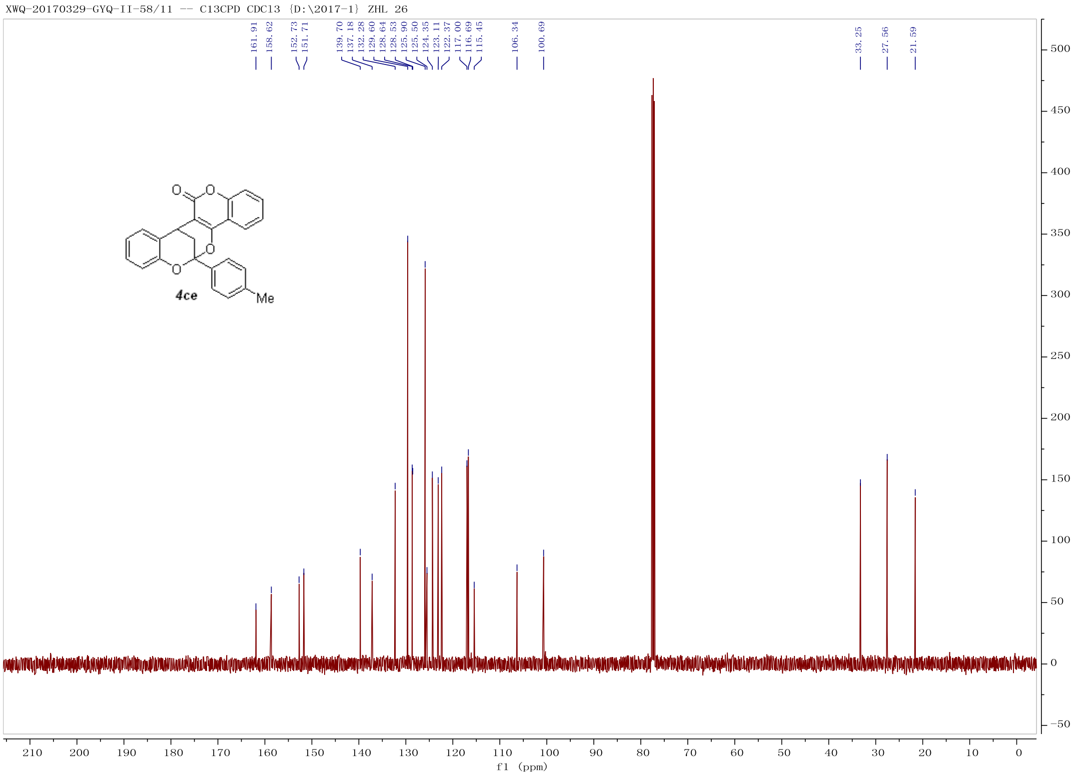

XWQ-20170324-GYQ-II-59/10 -- PROTON CDC13 {D:\2017-1} ZHL 39
7.85 7.85 7.84 7.83 7.72 7.71 7.71 7.70 7.70 7.69 7.56 7.55 7.54 7.54 7.53 7.52 7.52 7.52 7.51 7.50 7.50 7.49 7.48 7.48 7.47 7.32 7.30 7.29 7.29 7.27 7.26 7.25 7.22 7.22 7.21 7.20 7.19 7.19 7.06 7.04 7.01 7.01 7.00 7.00 6.98 6.98
4.41 4.40 4.40
2.46 2.46 2.44 2.43 2.42 2.42 2.39 2.39
O
O
O
O
Cl
4cc
1.00 2.02 4.07 1.01 1.40 1.03 1.00 1.02
1.00
2.07
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)
12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0 −1000


XWQ-20170324-GYQ-II-59/11 -- C13CPD CDC13 {D:\2017-1} ZHL 39
161.77 158.37 152.74 151.46
138.64 135.84 132.43 129.20 128.78 128.59 127.56 125.33 124.46 122.99 122.63 117.09 116.65 115.29
106.40 100.25
33.20 27.46
O
O
O
O
Cl
4cc
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)
600 550 500 450 400 350 300 250 200 150 100 50 0 −50

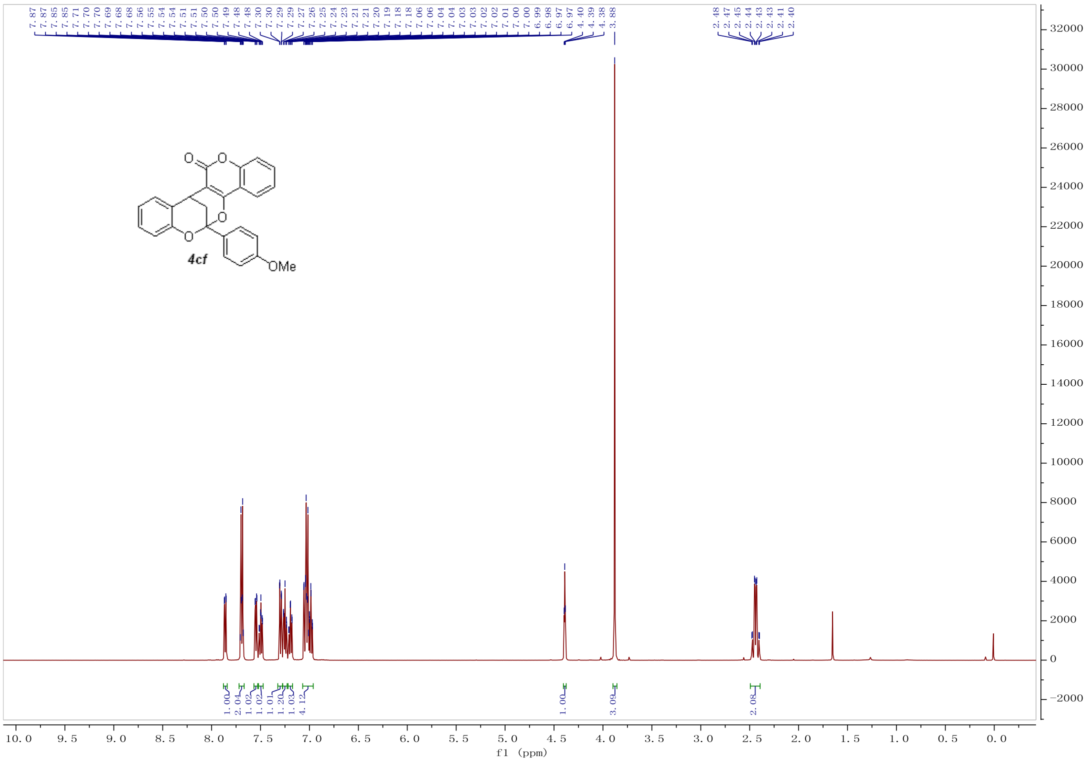

XWQ-20170329-GYQ-II-60-2/10 -- PROTON CDCl3 {D:\2017-1} ZHL 27
8.13 8.12 8.11 8.11 7.90 7.89 7.88 7.88 7.74 7.74 7.73 7.73 7.56 7.55 7.54 7.54 7.53 7.53 7.52 7.51 7.51 7.50 7.50 7.48 7.48 7.35 7.35 7.34 7.33 7.32 7.32 7.32 7.31 7.30 7.29 7.28 7.27 7.27 7.27 7.26 7.25 7.23 7.23 7.22 7.22 7.22 7.22 7.20 7.20 7.09 7.09 7.08 7.07 7.02 7.01 7.00 7.00 6.99 6.98 4.43 4.42 4.41 2.86 2.86 2.83 2.83 2.56 2.55 2.53 2.53
O
O
O
O
Br
4cd
1.04 1.04 1.08 3.35 2.08 2.52 1.27 1.06 1.21 1.00 1.07 1.08
28000 26000 24000 22000 20000 18000 16000 14000 12000 10000 8000 6000 4000 2000 0 −2000
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)


XWQ-20170329-GYQ-II-60-2/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 27
161.90 158.28 152.80 151.19 137.80 135.81 132.29 131.25 129.05 128.74 128.53 127.99 125.65 124.39 123.49 122.58 121.47 117.03 116.91 115.30 106.63 100.58 29.57 26.96
O
O
O
O
Br
4cd
2000 1900 1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 100 0 −100 −200
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

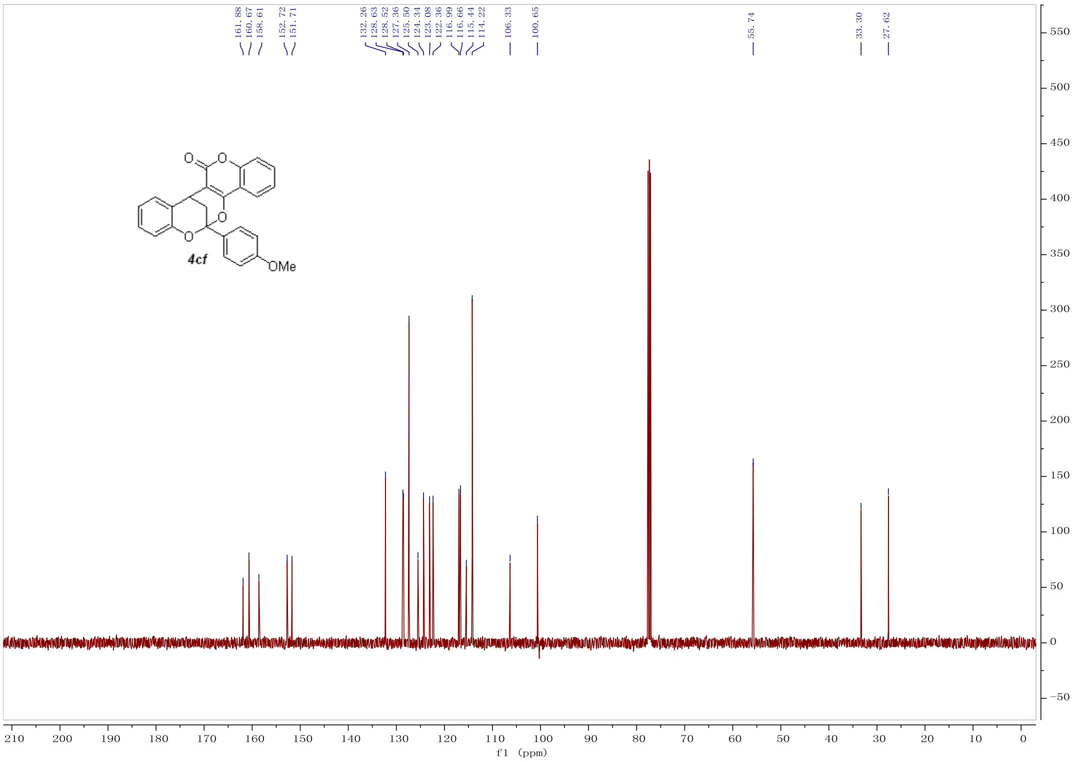

XWQ-20170329-GYQ-II-58/10 -- PROTON CDCl3 {D:\2017-1} ZHL 26
7.88 7.88 7.87 7.86 7.66 7.66 7.65 7.65 7.64 7.56 7.55 7.54 7.54 7.52 7.52 7.51 7.51 7.50 7.49 7.49 7.33 7.31 7.31 7.30 7.29 7.27 7.27 7.26 7.24 7.22 7.21 7.20 7.20 7.20 7.18 7.18 7.07 7.06 7.05 7.05 7.00 7.00 6.99 6.97 6.97
4.40 4.40 4.39
2.48 2.48 2.46 2.45 2.44 2.44 2.43 2.41 2.40
4ce
Me
1.00 2.03 1.02 1.07 3.04 1.27 1.05 1.00 1.03
1.00
5.20
f1 (ppm)

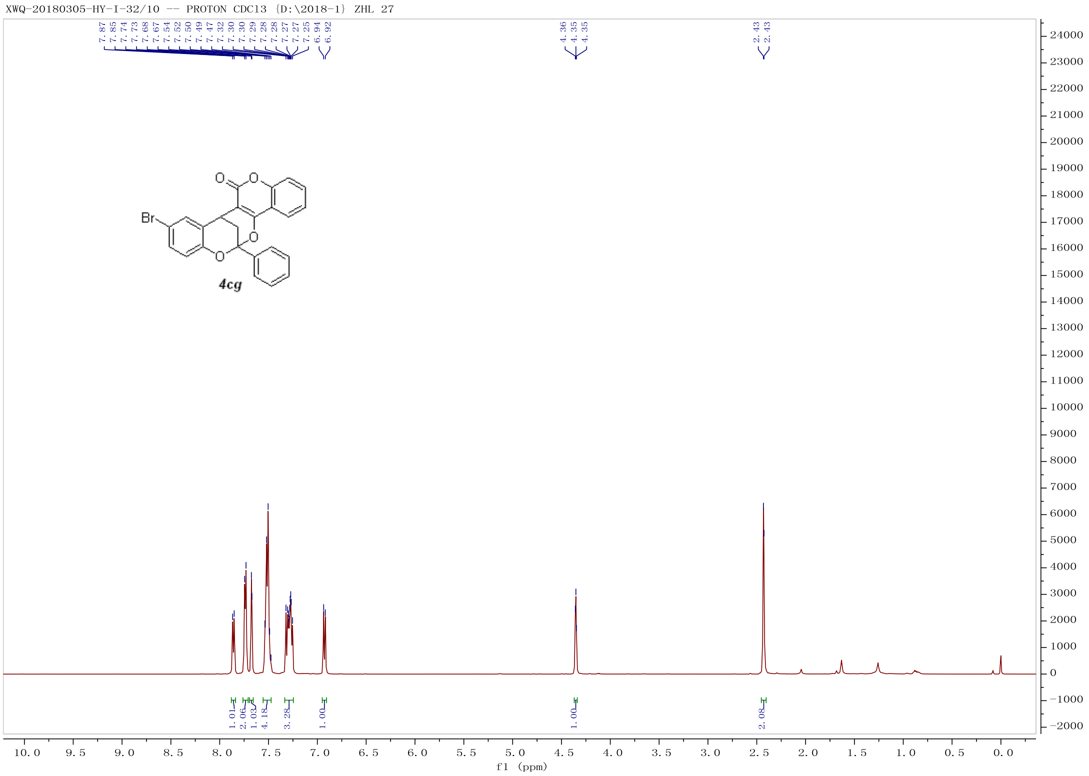

XWQ-20170329-GYQ-II-58/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 26
161.91 158.62 152.73 151.71
139.70 137.18 132.28 129.60 128.64 128.53 125.90 125.50 124.35 123.11 122.37 117.00 116.69 115.45
106.34 100.69
33.25 27.56 21.59
4ce
Me
f1 (ppm)

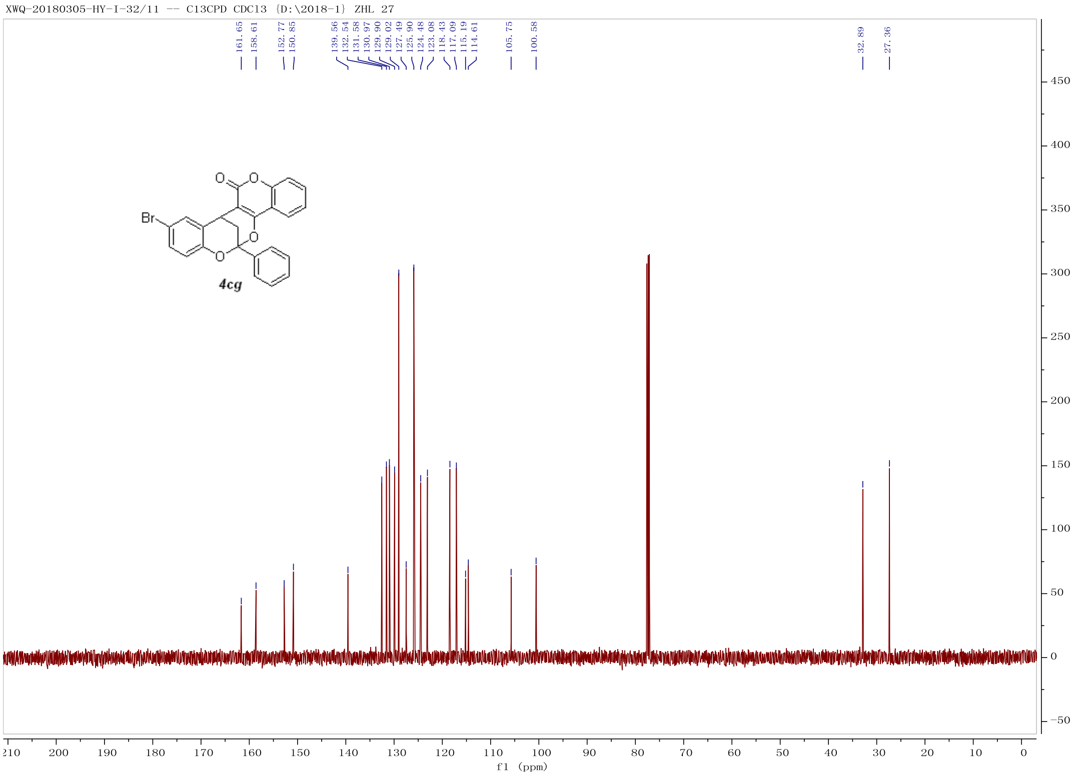
GJM-20170316-GYQ-II-62/10 -- PROTON CDCl3 {D:\2017-1} ZHL 8



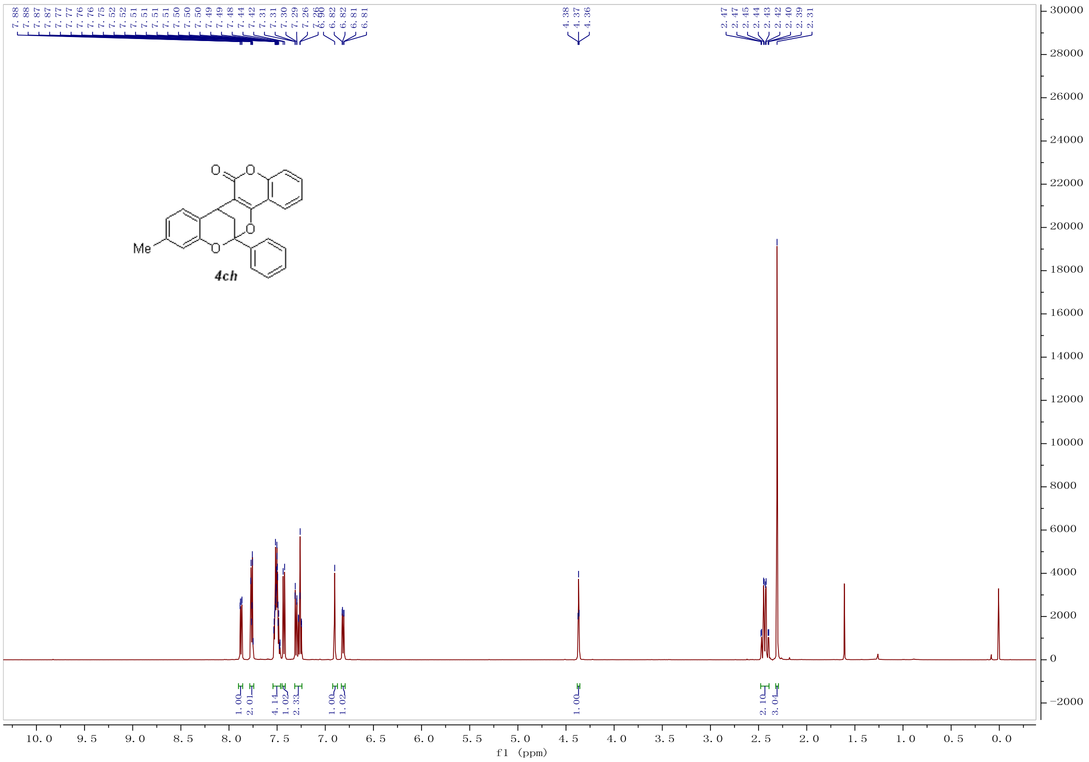
GJM-20170316-GYQ-II-62/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 8



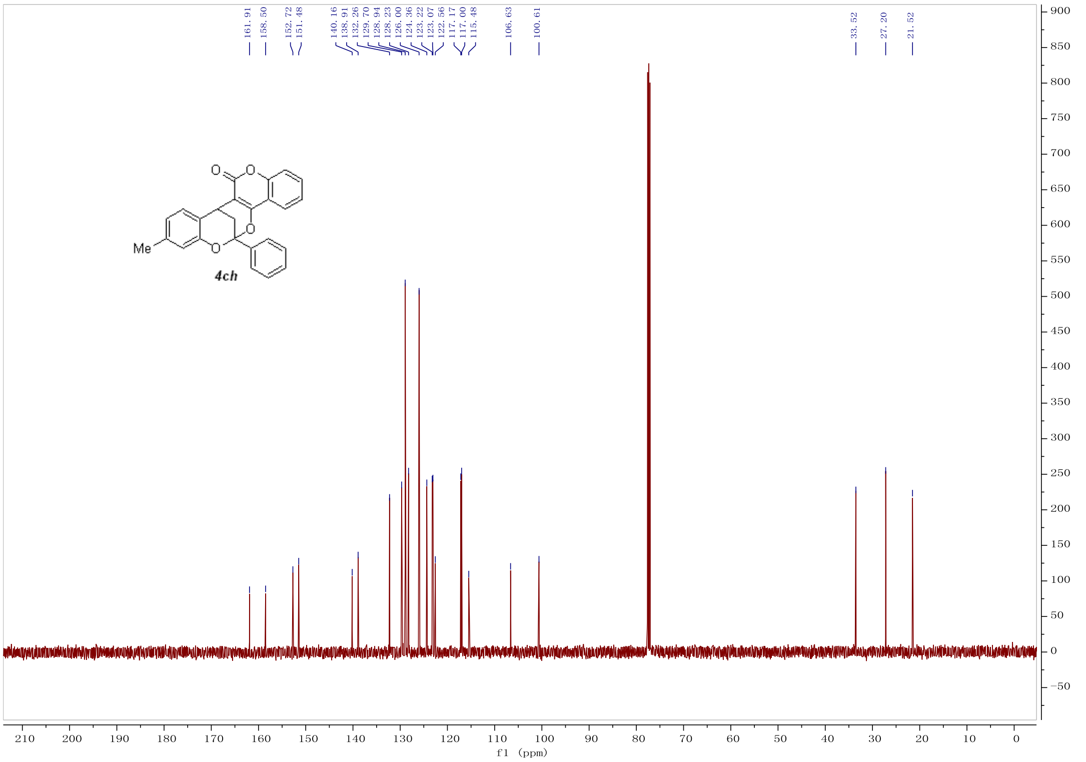

XWQ-20180305-HY-I-32/10 -- PROTON CDCl3 {D:\2018-1} ZHL 27
7.87 7.85 7.74 7.73 7.68 7.67 7.54 7.52 7.50 7.49 7.47 7.32 7.30 7.30 7.29 7.28 7.28 7.27 7.27 7.25 6.94 6.92
4.36 4.35 4.35
2.43 2.43
Br
O
O
O
O
4cg
1.01
2.06
1.03
4.18
3.28
1.00
1.00
2.08
f1 (ppm)

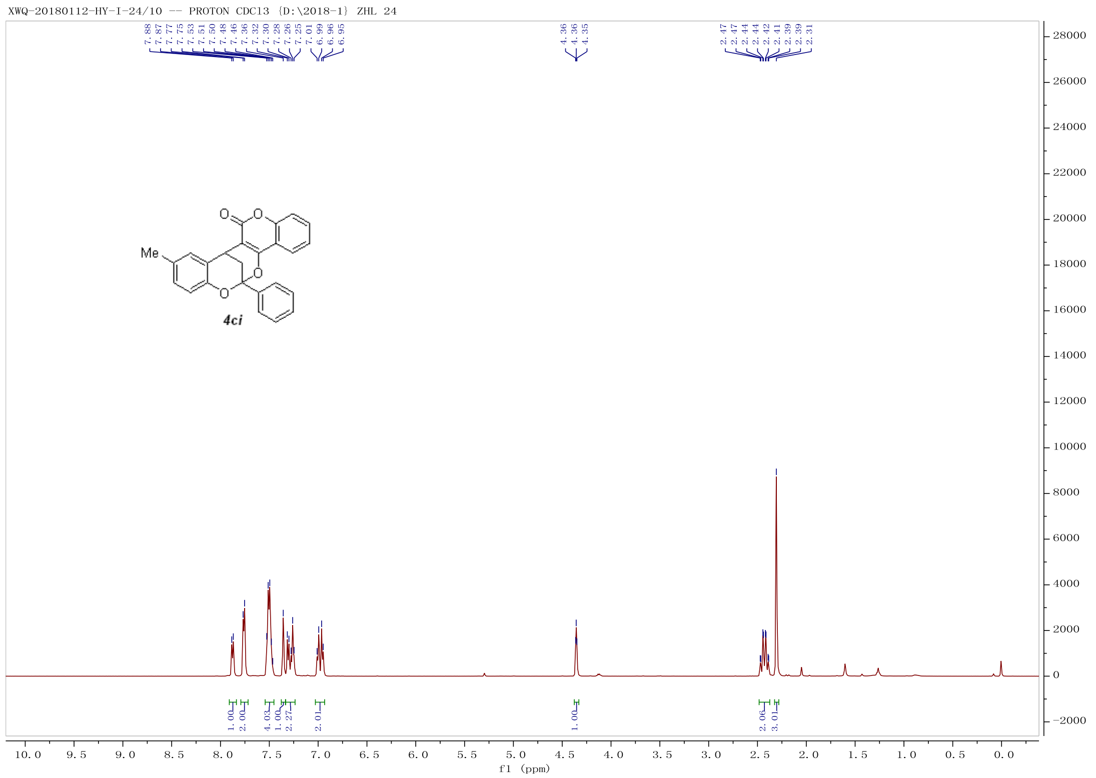

XWQ-20180305-HY-I-32/11 -- C13CPD CDCl3 {D:\2018-1} ZHL 27
161.65 158.61 152.77 150.85 139.56 132.54 131.58 130.97 129.90 129.02 127.49 125.90 124.08 123.08 118.43 117.09 115.19 114.61 105.75 100.58
32.89 27.36
Br
O
O
O
O
4cg
f1 (ppm)

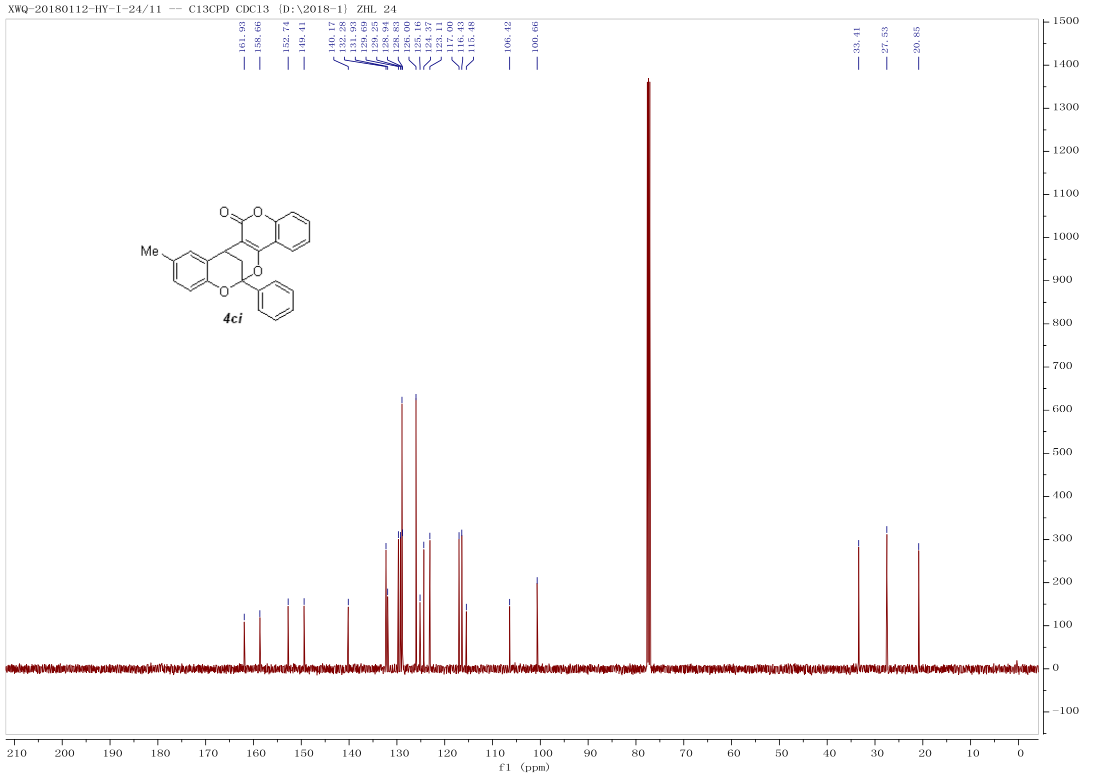
XWQ-20170329-GYQ-II-57/10 -- PROTON CDCl3 {D:\2017-1} ZHL 25

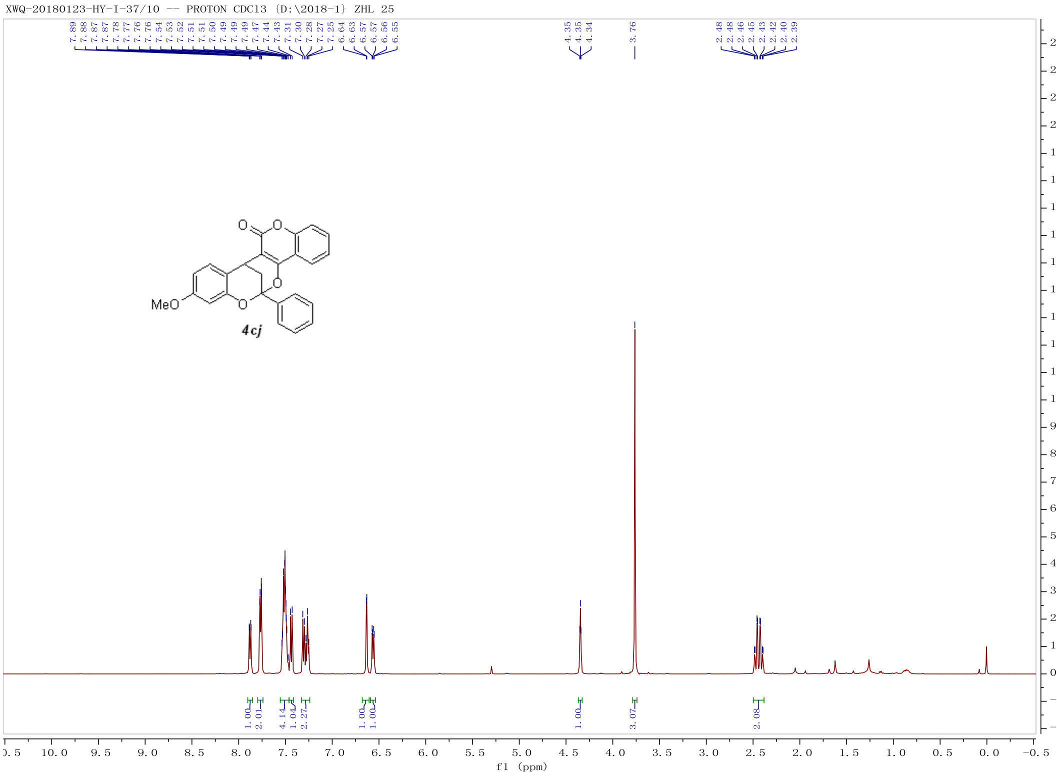


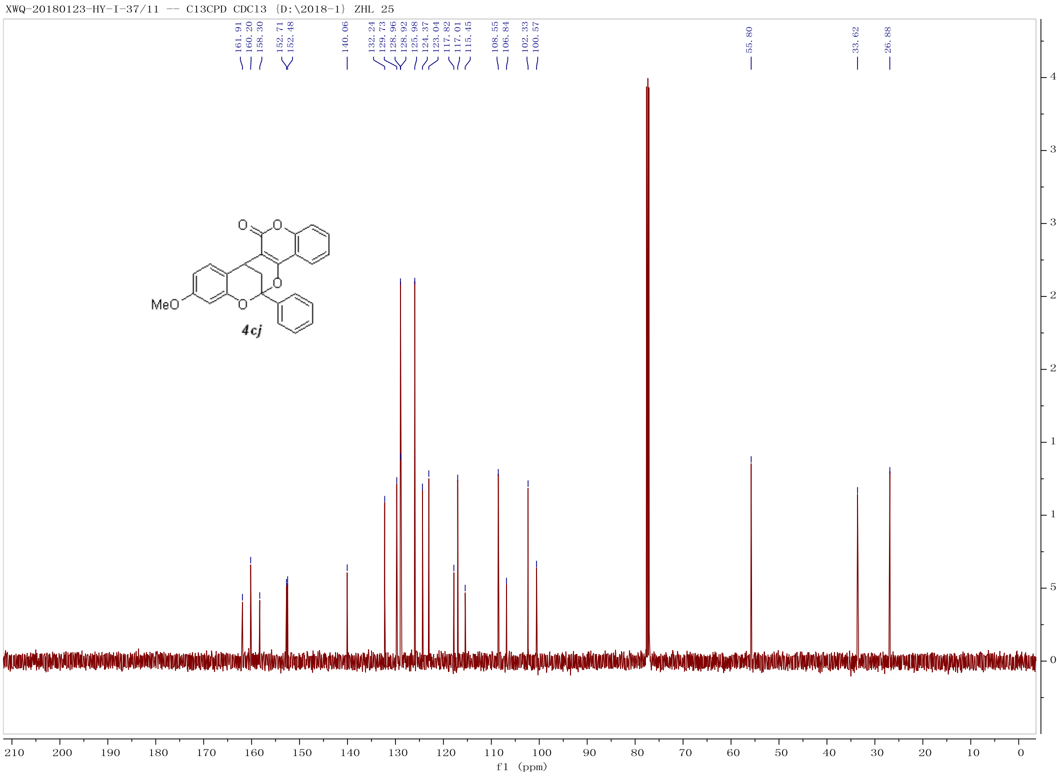
XWQ-20170329-GYQ-II-57/11 -- C13CPD CDCl3 {D:\2017-1} ZHL 25

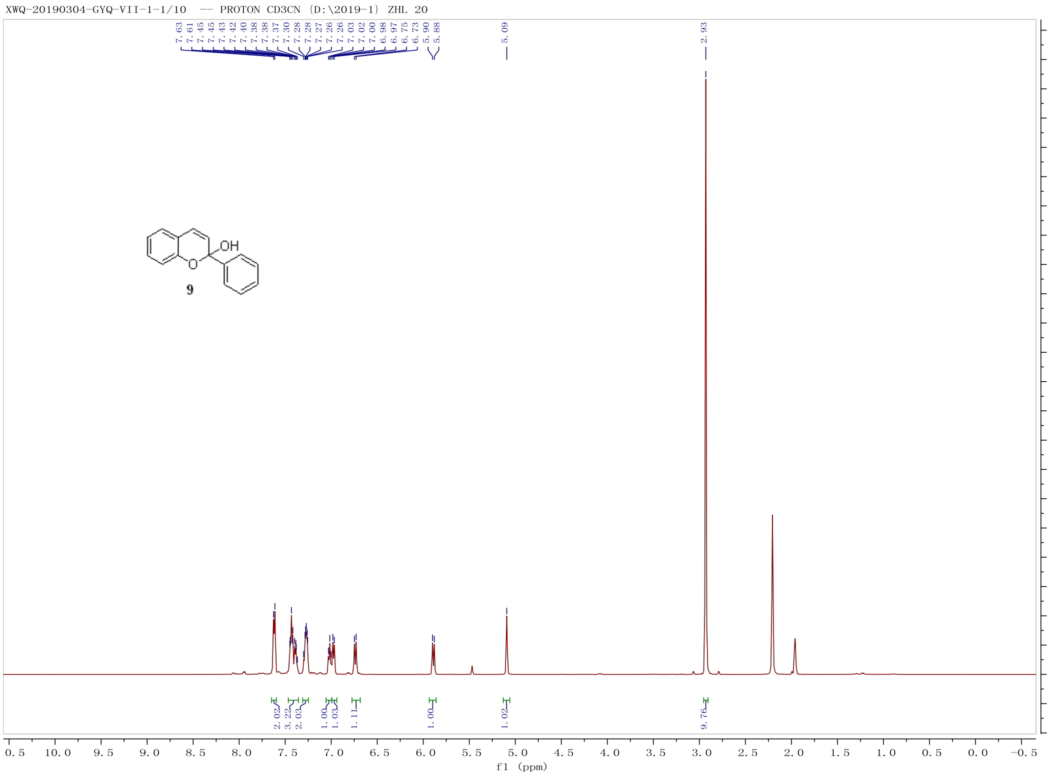


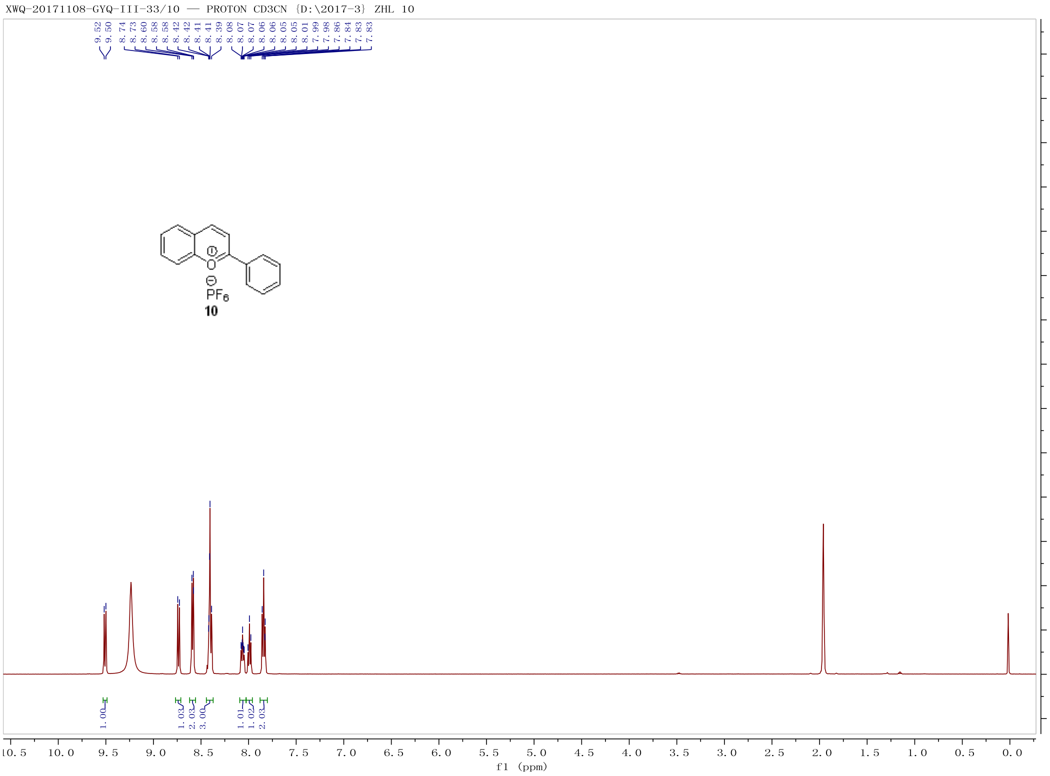

XWQ-20180112-HY-I-24/10 -- PROTON CDCl3 {D:\2018-1} ZHL 24
7.88
7.87
7.77
7.75
7.53
7.51
7.50
7.48
7.46
7.36
7.32
7.30
7.28
7.26
7.25
7.01
6.99
6.96
6.95
4.36
4.36
4.35
2.47
2.47
2.44
2.44
2.42
2.41
2.39
2.39
2.31
Me
O
O
O
O
4ci
1.00
2.00
4.03
1.00
2.27
2.01
1.00
2.06
3.01
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

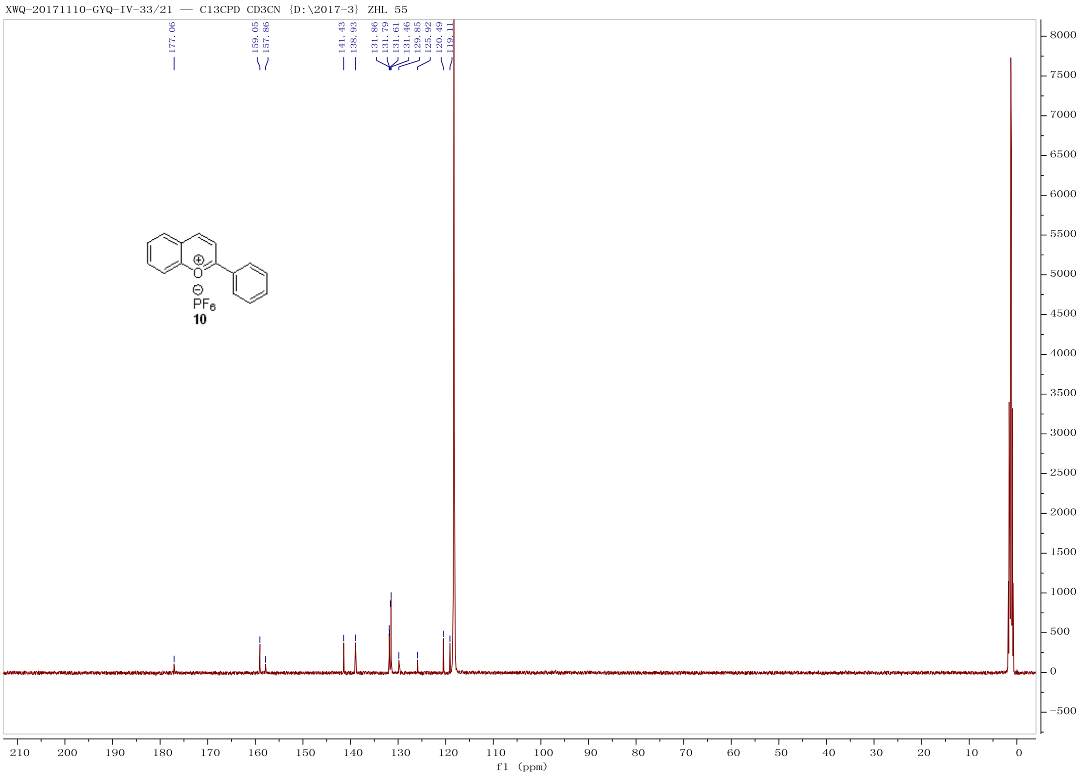

XWQ-20180112-HY-I-24/11 -- C13CPD CDCl3 {D:\2018-1} ZHL 24
161.93
158.66
152.74
149.41
140.17
132.28
131.93
129.69
129.25
128.94
128.83
126.00
125.16
124.37
123.11
117.00
116.43
115.48
106.42
100.66
33.41
27.53
20.85
Me
O
O
O
O
4ci
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

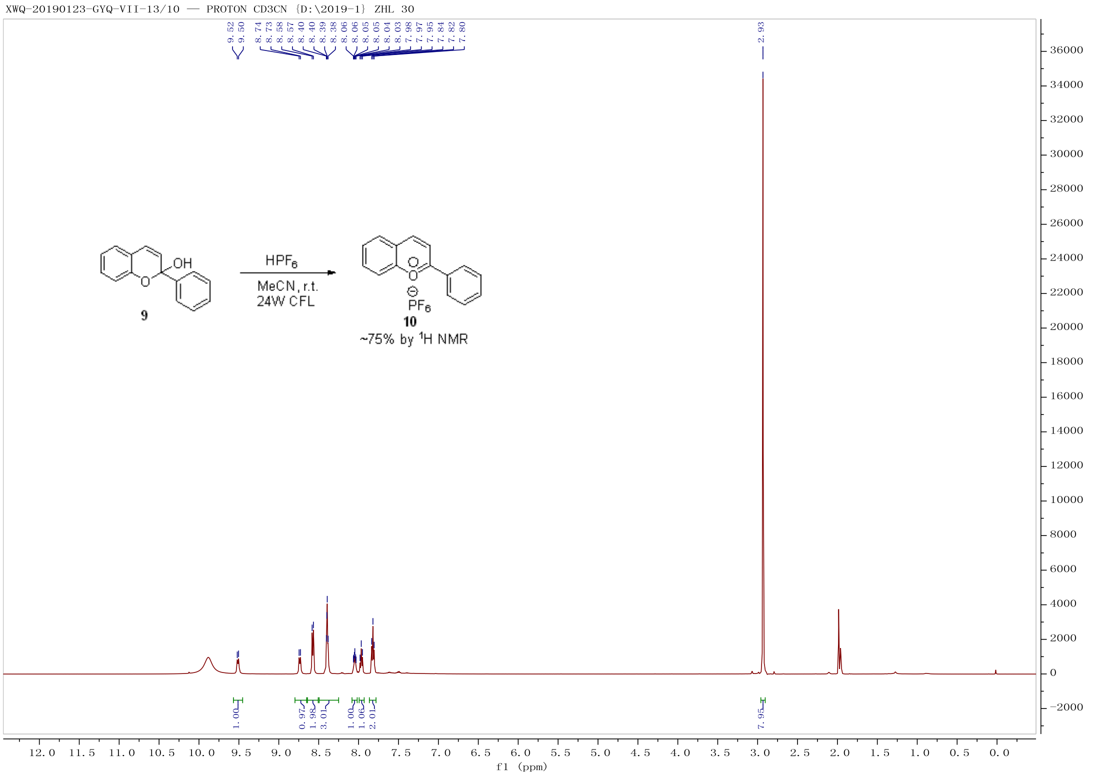

XWQ-20180123-HY-I-37/10 -- PROTON CDCl3 {D:\2018-1} ZHL 25
7.89
7.88
7.87
7.87
7.78
7.77
7.76
7.76
7.54
7.53
7.52
7.51
7.51
7.50
7.49
7.49
7.49
7.47
7.44
7.43
7.31
7.30
7.28
7.27
7.25
6.64
6.63
6.57
6.57
6.56
6.55
4.35
4.35
4.34
3.76
2.48
2.48
2.46
2.45
2.43
2.42
2.40
2.39
O
O
O
O
MeO
4cj
1.00
2.01
4.14
1.04
2.27
1.00
1.00
1.00
3.07
2.08
f1 (ppm)

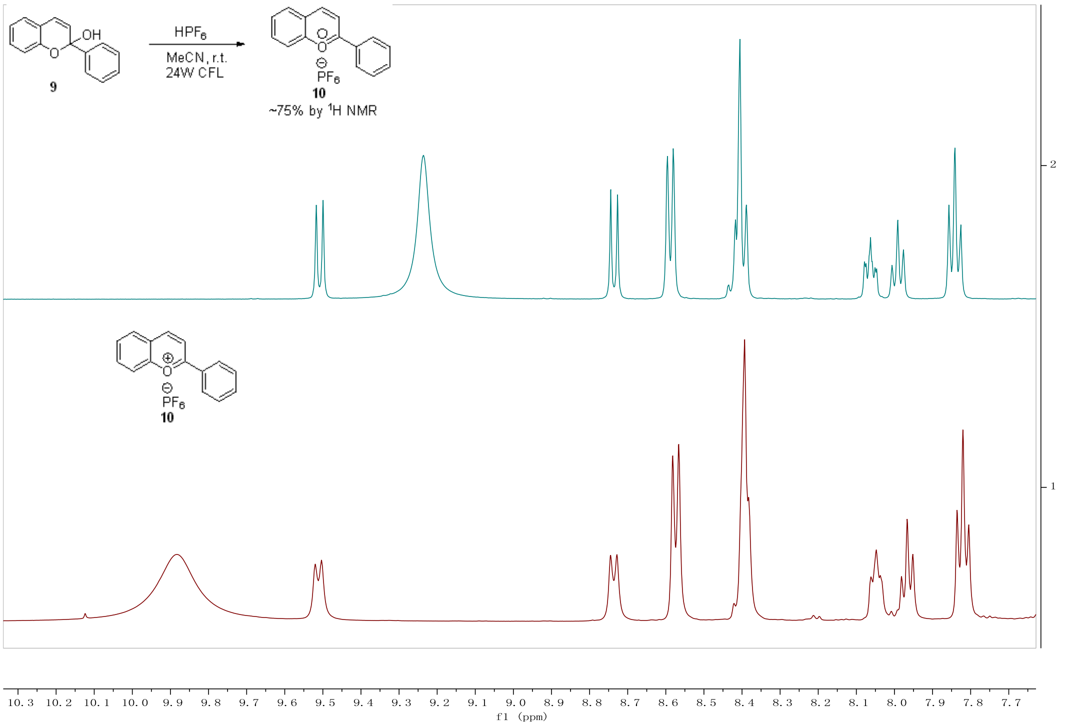

XWQ-20180123-HY-I-37/11 -- C13CPD CDCl3 {D:\2018-1} ZHL 25
161.91
160.20
158.30
152.71
152.48
140.06
132.24
129.73
128.96
128.92
125.98
124.37
123.04
117.82
117.01
115.45
108.55
106.84
102.33
100.57
55.80
33.62
26.88
O
O
O
O
MeO
4cj
f1 (ppm)


XWQ-20190304-GYQ-VII-1-1/10 -- PROTON CD3CN {D:\2019-1} ZHL 20
7.63 7.61 7.45 7.43 7.42 7.40 7.38 7.37 7.30 7.28 7.28 7.27 7.26 7.26 7.03 7.02 7.00 6.98 6.97 6.75 6.73 5.90 5.88
5.09
2.93
OH
O
9
2.02 3.22 2.03 1.00 1.03 1.11 1.00 1.02 9.76
f1 (ppm)

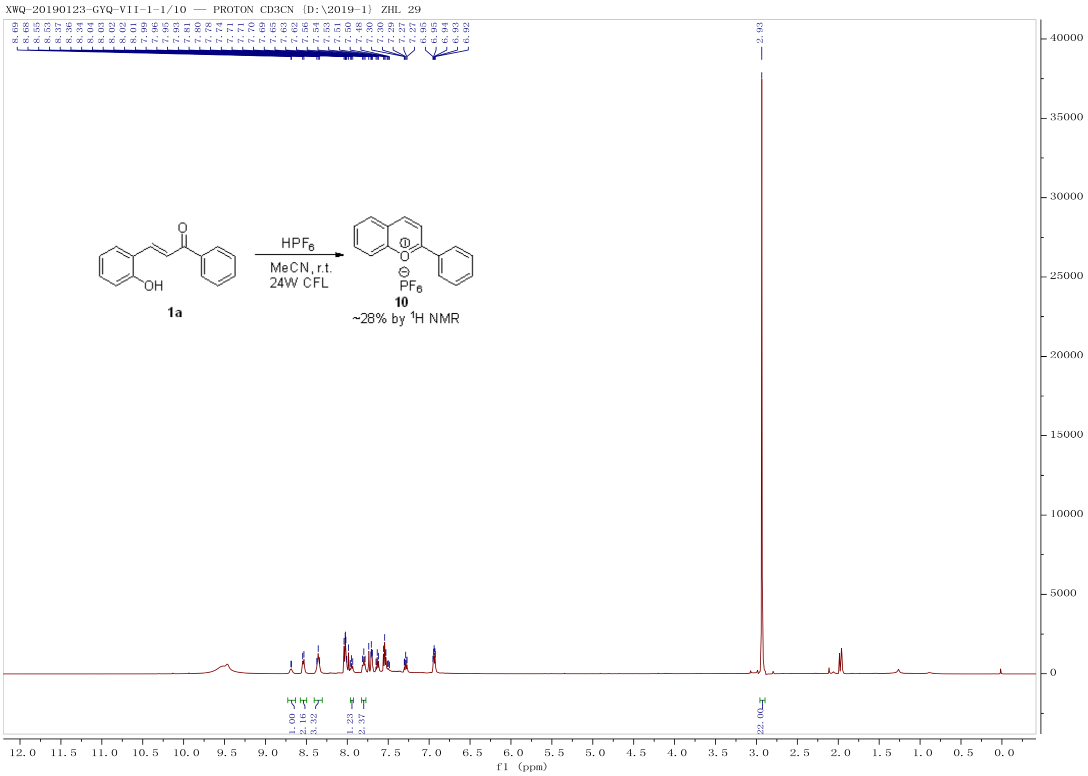

XWQ-20171108-GYQ-III-33/10 — PROTON CD3CN {D:\2017-3} ZHL 10
9.52 9.50 8.74 8.73 8.60 8.58 8.58 8.42 8.42 8.41 8.39 8.08 8.07 8.06 8.06 8.05 8.01 7.99 7.98 7.86 7.84 7.83 7.83
O
PF6
10
1.00 1.03 2.03 3.00 1.01 1.02 2.03
f1 (ppm)


XWQ-20171110-GYQ-IV-33/21 — C13CPD CD3CN {D:\2017-3} ZHL 55
177.06
159.05
157.86
141.43
138.93
131.86
131.79
131.61
131.46
129.85
125.92
120.49
119.11
PF6
10
f1 (ppm)

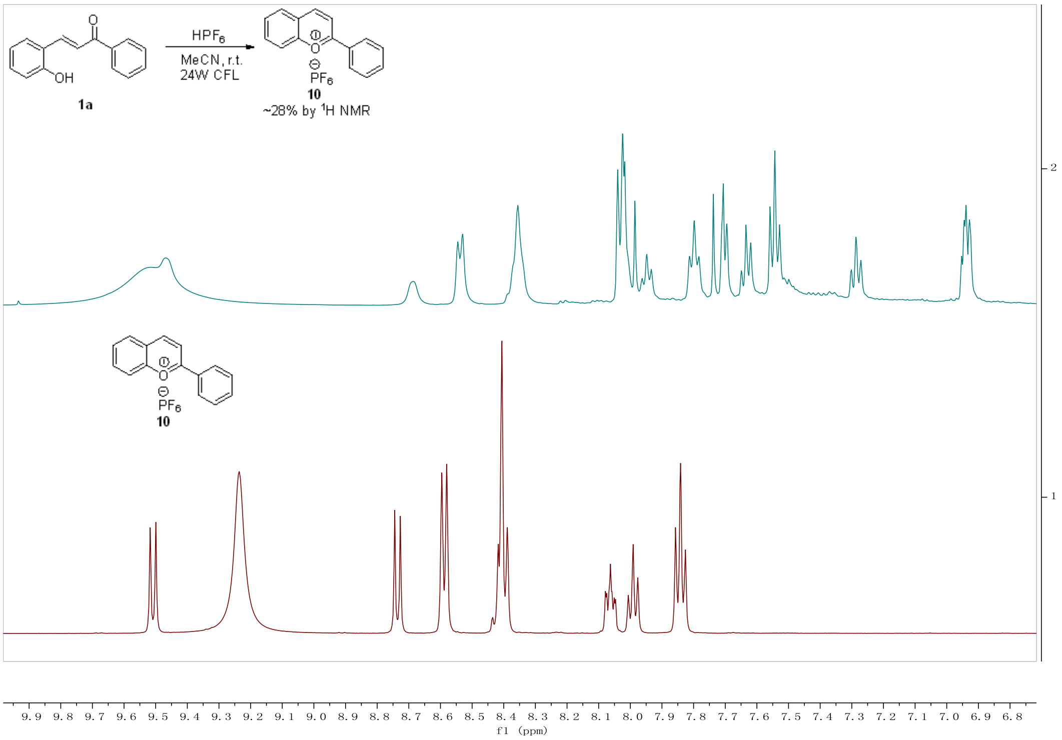

XWQ-20190123-GYQ-VII-13/10 — PROTON CD3CN {D:\2019-1} ZHL 30
9.52
9.50
8.74
8.73
8.58
8.57
8.40
8.40
8.39
8.38
8.06
8.06
8.05
8.05
8.04
8.03
7.98
7.97
7.95
7.84
7.82
7.80
2.93
OH
9
HPF6
MeCN, r.t.
24W CFL
PF6
10
~75% by 1H NMR
1.00
0.97
1.98
3.01
1.00
1.06
2.01
7.95
f1 (ppm)



HPF6
MeCN, r.t.
24W CFL
9
10
~75% by 1H NMR
10
2
1
10.3 10.2 10.1 10.0 9.9 9.8 9.7 9.6 9.5 9.4 9.3 9.2 9.1 9.0 8.9 8.8 8.7 8.6 8.5 8.4 8.3 8.2 8.1 8.0 7.9 7.8 7.7
f1 (ppm)



XWQ-20190123-GYQ-VII-1-1/10 — PROTON CD3CN {D:\2019-1} ZHL 29
8.69 8.68 8.55 8.53 8.37 8.36 8.34 8.04 8.03 8.02 8.01 7.99 7.96 7.95 7.93 7.81 7.80 7.78 7.74 7.74 7.71 7.71 7.70 7.69 7.65 7.63 7.62 7.56 7.54 7.53 7.51 7.50 7.48 7.30 7.29 7.27 7.27 6.95 6.94 6.93 6.92
2.93
HPF6
MeCN, r.t.
24W CFL
1a
10
~28% by 1H NMR
40000
35000
30000
25000
20000
15000
10000
5000
0
1.00
2.16
3.32
1.23
2.37
22.00
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)



HPF6
MeCN, r.t.
24W CFL
1a
10
~28% by 1H NMR
10
2
1
9.9 9.8 9.7 9.6 9.5 9.4 9.3 9.2 9.1 9.0 8.9 8.8 8.7 8.6 8.5 8.4 8.3 8.2 8.1 8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8
f1 (ppm)