Supporting Information

Transition-Metal-Free Insertion of Alkynes into C-C σ-bond of Cyclic β-keto Sulfones: An Atom-Economical Way to Medium-Size-Ring Sulfonyl Derivatives

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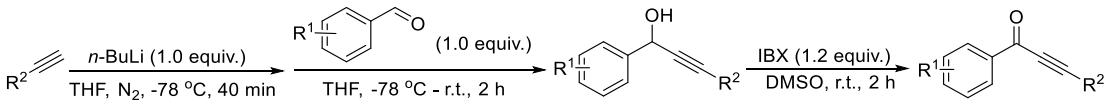
1. General Methods

All reactions were carried out under air. Unless noted, all commercial reagents were used without further purification. Reactions were monitored by thin layer chromatography. Purification of reaction products was carried out by flash chromatography on silica gel (200~300 mesh). ^{1}H NMR spectra were recorded at 400 500 MHz, ^{13}C NMR spectra were recorded at 125 MHz, and in $CDCl_3$ or d^6-DMSO (containing 0.03% TMS) solutions. ^{1}H NMR spectra were recorded with tetramethylsilane (δ= 0.00 ppm) as internal reference; ^{13}C NMR spectra were recorded with $CDCl_3$ (δ= 77.00 ppm) or d^6-DMSO (δ = 39.52 ppm) as internal reference. High-resolution mass spectra were performed on a mass spectrometer with a TOF (for EI or ESI) or FT-ICR (for MALDI) analyzer. Single crystal X-ray diffraction data was collected in Bruker SMARTAPEX diffractiometers with molybdenum cathodes.

2. Synthesis of Materials

The alkynyl ketones **1** are known compounds and were synthesized according to the previous literatures.[1]

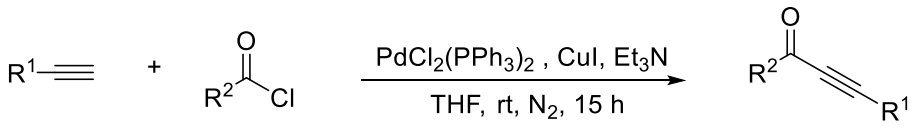
General Procedure (A) for the Preparation of Alkynyl Ketones:



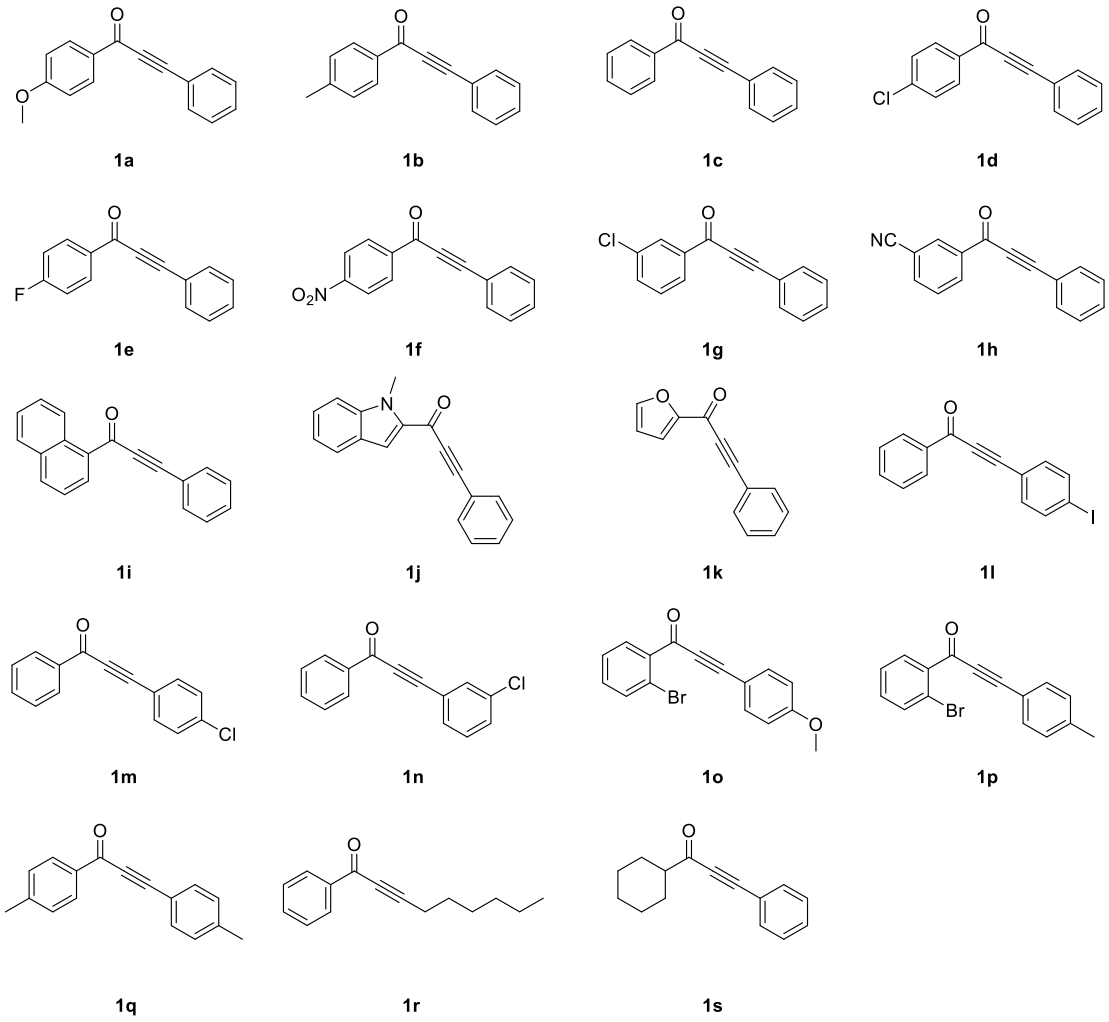
To a solution of alkyne (12 mmol) in anhydrous THF (30 mL), *n*-BuLi (10 mmol, 2.5 M, 4 mL) was added at -78 °C. The resulting mixture was stirred at -78 °C for 1 h, then the aldehyde (10 mmol) was added and the reaction temperature was raised to room temperature till aldehyde disappeared by TLC analysis. The resulting mixture was quenched with a saturated solution of NH_4Cl and extracted with ethyl acetate (20 mL × 3). The combined organic layers were washed with brine and dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by column chromatography with petroleum ether/ethyl acetate = 10:1-5:1 as the eluent afforded the substituted alkynol. To a solution of substituted alkynol (10 mmol) in DMSO (20

mL) in round-bottom flask, IBX (12 mmol, 3.36 g) was added at room temperature. The reaction was stirred in air until the full conversion of substituted alkynol monitored by thin-layer chromatography. The resulting mixture was quenched with water (20 mL) and filtered. Then the filtrate was extracted with ethyl acetate (20 mL × 3). The organic layers were combined, washed with brine, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. Purification by column chromatography with petroleum ether/ethyl acetate = 20:1-10:1 as the eluent afforded the alkynyl ketones.

General Procedure (B) for the Preparation of Alkynyl Ketones:

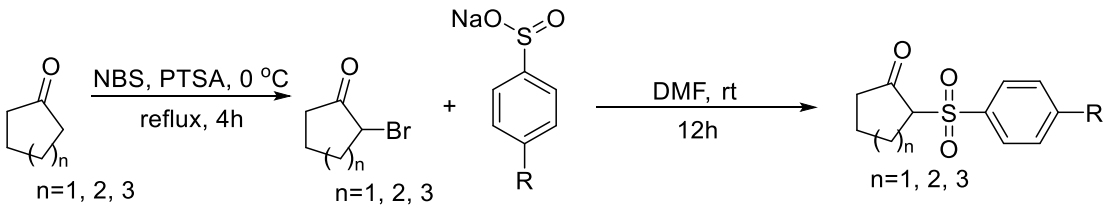


A mixture of acylchloride (1.2 equiv), $PdCl_2(PPh_3)_2$ (0.02 equiv) and Et_3N (1.2 equiv) in anhydrous THF were stirred for 10 min at room atmosphere under N_2. CuI (0.04 equiv) was then added and the reaction mixture was stirred for another 10 min. Terminal alkyne (1.0 equiv) was then added in one portion, the resulting mixture was stirred at room atmosphere for 3h. After the reaction was complete, ethyl acetate was added, and the resulting solution was washed with 0.1N HCl in a separatory funnel. After the layers were separated, the organic phase was dried over Na_2SO_4 and evaporated on a rotary evaporator to give the crude product, which was purified by flash chromatography on silica gel using hexane/ethyl acetate as the eluent to afford the corresponding alkynyl ketones.



The cyclic β-keto sulfones **2** are known compounds and were synthesized according to the previous literature.[2]

General Procedure (A) for the Preparation of Cyclic β-keto Sulfones:



Step 1:

A solution of cycloalkanones (10 mmol) in CH_2Cl_2 (5 mL) was added dropwise to a solution of *n*-bromosuccinimide (2.14 g, 1.2mmol, 1.2equiv) and *p*-TsOH (0.19 g, 1.0 mmol, 0.1 equiv) in CH_2Cl_2 (10 mL) at 0 °C. The reaction mixture was then brought to

reflux for 4 h. After addition of H_2O (20 mL), the organic layer was separated, and the aqueous layer was extracted with CH_2Cl_2 (2 × 15 mL). The combined organic layers were washed with saturated aqueous $NaHCO_3$ (15 mL) and brine (20 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. Column chromatography on silica gel using hexane/ethyl acetate as the eluent to afford the corresponding α-bromo cycloalkanones.

Step 2:

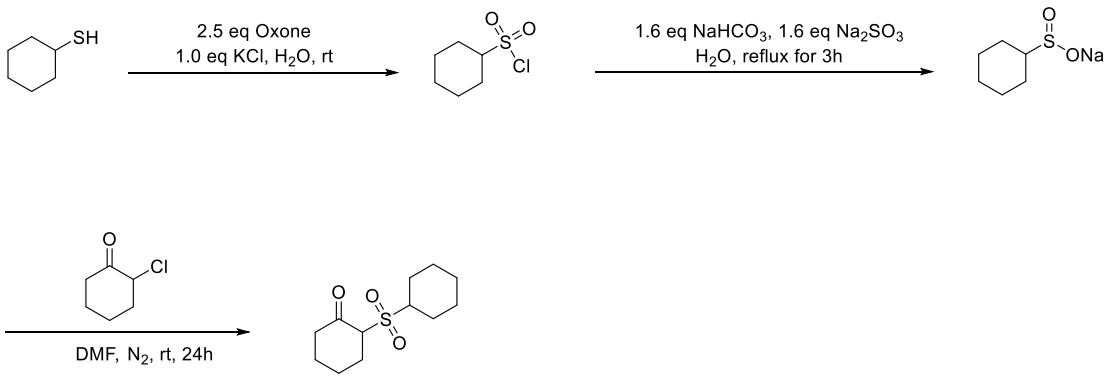
The 2-bromoketone (1 mmol) was dissolved in dimethylformamide (2 ml) under N_2 at 0 °C, then sodium benzenesulfinate (1 mmol, 1.0 equiv) was added. The mixture was stirred vigorously at room temperature until complete consumption of the substrate. The mixture was quenched with water and extracted with ethyl acetate. The organic layer was washed with water, evaporated and purified by column (ethyl acetate /Hexanes: 1/9-1/5) chromatography on silica gel to give the corresponding cyclic β-keto sulfones.

General Procedure (B) for the Preparation of Cyclic β-keto Sulfones:

To a solution of α-haloketone (1 mmol, 1 equiv.) in DMF (2 mL, 0.5 M) was added sodium sulfinate (1 mmol, 1 equiv.) in one portion and the reaction mixture was stirred at room temperature for 24 h. The reaction was stopped by the addition of water (10 mL), extracted with CH_2Cl_2 (3 × 15 mL), washed with brine, dried with $MgSO_4$ and the solvent was removed under reduced pressure. The crude product was further purified by column chromatography or re-crystallization.

The cyclic β-keto sulfone **2aa** was synthesized according to the previous literature.[2]

General Procedure (C) for the Preparation of Cyclic β-keto Sulfones (2aa):



Step 1:

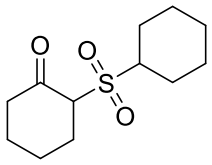
A mixture of thiol (2 mmol, 1 equiv.), Oxone (5 mmol, 2.5 equiv.), KCl (2 mmol, 1 equiv.) and water (6 mL) was vigorously stirred at room temperature for 2 hours. The aqueous phase was extracted with ethyl acetate (4 × 10 mL). The combined organic layer was dried over anhydrous sodium sulfate and concentrated under reduced pressure. The crude product was purified by flash column chromatography affording the desired product (cyclohexanesulfonyl chloride).

Step 2:

The corresponding sulfonyl chloride (1 mmol, 1 equiv.) was dissolved in water (5 mL). Sodium sulfite (1.6 mmol, 1.6 equiv.) and sodium bicarbonate (1.6 mmol, 1.6 equiv.) were added and the reaction mixture was refluxed for 3 hours in an oil bath. Water was evaporated and ethanol was added to the residue. The suspension was heated for 10 minutes, cooled and filtered. This procedure was repeated twice using the residue of the filtration. The ethanol fractions were combined and the solvent was evaporated under reduced pressure. Sodium sulfinate was used without any further purification.

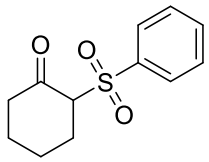
Step 3:

To a solution of α-haloketone (1 mmol, 1 equiv.) in DMF (2 mL, 0.5 M) was added sodium sulfinate (1 mmol, 1 equiv.) in one portion and the reaction mixture was stirred at room temperature for 24 h. The reaction was stopped by the addition of water (10 mL), extracted with CH_2Cl_2 (3 × 15 mL), washed with brine, dried with $MgSO_4$ and the solvent was removed under reduced pressure. The crude product was further purified by column chromatography affording the desired product (2-(cyclohexylsulfonyl)cyclohexan-1-one).

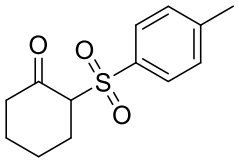


2aa

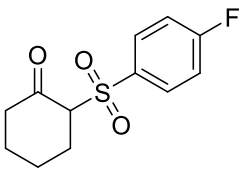
2-(cyclohexylsulfonyl)cyclohexan-1-one (**2aa**, white solid, petroleum ether/ethyl acetate = 5:1, 57 %). m.p. 126-128 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 3.83 (t, *J* = 5.0 Hz, 1H), 3.23-3.12 (m, 1H), 2.85-2.75 (m, 1H), 2.67-2.59 (m, 1H), 2.51-2.43 (m, 1H), 2.23-2.00 (m, 5H), 1.97-1.86 (m, 2H), 1.85-1.68 (m, 3H), 1.60-1.49 (m, 2H), 1.35-1.18 (m, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 204.37, 65.64, 61.15, 41.38, 26.44, 25.96, 25.59, 25.06, 25.05, 24.93, 23.18, 21.83. HRMS (ESI) calcd for $C_{12}H_{20}O_3S$ $[M+Na]^+$: 267.1025, found: 267.1022.



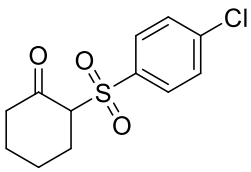
2a



2t



2u



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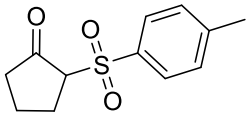
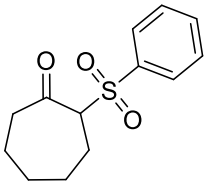
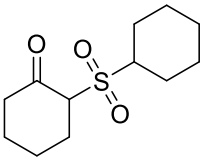


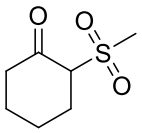
2w



2z

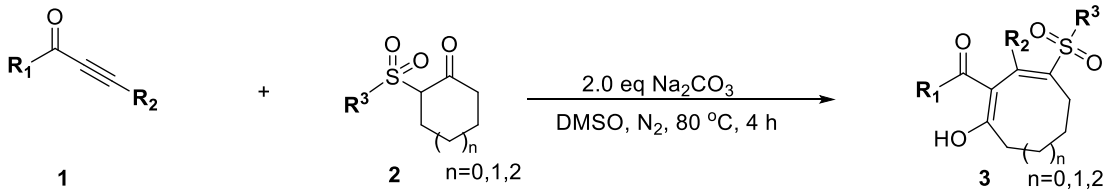


2aa

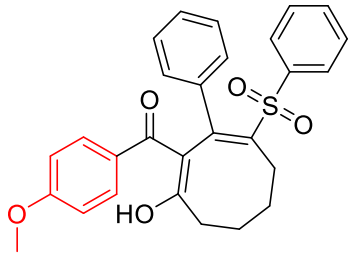


2ab

3. Synthesis of 3

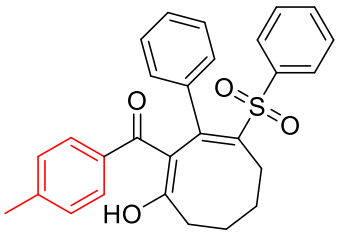


In a schlenk tube alkynyl ketones **1** (0.2 mmol), The cyclic ketone sulfones **2** (0.3 mmol, 1.5 equiv), Na_2CO_3 (0.4 mmol, 2.0 equiv) and DMSO (2.0 ml) were stired at 80 °C under nitrogen atmosphere. After the reaction was completed as monitored by thin-layer chromatography, the reaction mixture was then quenched by water, and the water layers were extracted with ethyl acetate (10 mL × 3). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by chromatography on silica gel (petroleum ether/ethyl acetate = 8:1-5:1) afforded desired compound **3**.



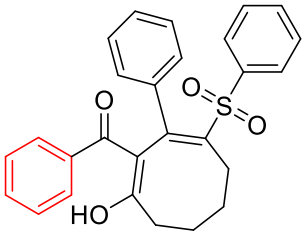
3a

((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(4-methoxyphenyl)methanone (**3a**, white solid, petroleum ether/ethyl acetate = 5:1, 78.7 mg, 83 %). m.p. 209-211 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.95 (s, 1H), 7.33 (t, J = 7.5 Hz, 1H), 7.26-7.23 (m, 4H), 7.15 (t, J = 7.5 Hz, 2H), 6.94 (t, J = 7.0 Hz, 1H), 6.82 (d, J = 8.5 Hz, 2H), 6.76 (t, J = 7.5 Hz, 2H), 6.44 (d, J = 8 Hz, 2H), 3.86 (s, 3H), 3.56 (dd, J_1 = 14.0 Hz, J_2 = 7.0 Hz, 1H), 2.75-2.61 (m, 2H), 2.49 (t, J = 11.5 Hz, 1H), 2.28-2.16 (m, 2H), 2.11-2.02 (m, 1H), 1.71-1.62 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 193.68, 187.77, 162.41, 146.56, 142.98, 140.81, 137.44, 132.13, 130.98, 129.72, 128.92, 128.14, 127.51, 127.29, 126.61, 114.12, 113.56, 55.47, 34.53, 30.31, 25.33, 24.43. HRMS (ESI) calcd for $C_{28}H_{26}O_5S$ $[M+H]^+$: 475.1574, found: 475.1573.



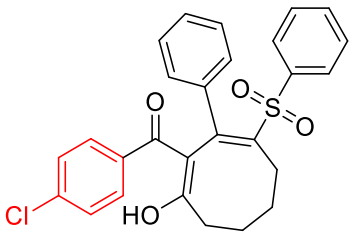
3b

((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(p-tolyl)methanone (**3b**, white solid, petroleum ether/ethyl acetate = 5:1, 69.6 mg, 76 %). m.p. 240-242 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.88 (s, 1H), 7.30 (t, J = 7.5 Hz, 1H), 7.22-7.20 (m, 2H), 7.13-7.05 (m, 6H), 6.90 (t, J = 7.5 Hz, 1H), 6.70 (t, J = 8.0 Hz, 2H), 6.34 (d, J = 7.5 Hz, 2H), 3.54 (dd, J_1 = 12.5, J_2 = 6.0 Hz, 1H), 2.67-2.60 (m, 2H), 2.47 (t, J = 12.0 Hz, 1H), 2.36 (s, 3H), 2.26-2.14 (m, 2H), 2.08-2.00 (m, 1H), 1.70-1.63 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.84, 188.05, 146.34, 143.07, 141.94, 140.80, 137.39, 135.74, 132.10, 128.86, 128.11, 127.43, 127.37, 127.27, 126.54, 114.43, 114.41, 34.57, 30.27, 25.32, 24.46, 21.58. HRMS (ESI) calcd for $C_{28}H_{26}O_4S$ $[M+Na]^+$: 481.1444, found: 481.1435.



3c

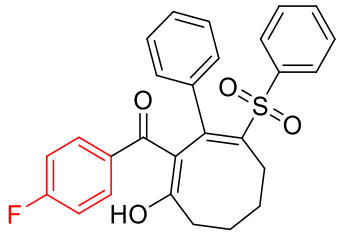
((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone (**3c**, white solid, petroleum ether/ethyl acetate = 5:1, 74.6 mg, 84 %). m.p. 180-182 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 16.87 (s, 1H), 7.41-7.38 (m, 1H), 7.31-7.25 (m, 3H), 7.22-7.20 (m, 2H), 7.14-7.11 (m, 4H), 6.92-6.89 (m, 1H), 6.69 (t, J = 8.0 Hz, 2H), 6.30 (d, J = 8.0 Hz, 2H), 3.57-3.52 (m, 1H), 2.67-2.62 (m, 2H), 2.50-2.45 (m, 1H), 2.27-2.21 (m, 1H), 2.20-2.14 (m, 1H), 2.10-2.00 (m, 1H), 1.66 (qd, J_1= 13.5 Hz, J_2= 5.5 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.12, 188.39, 146.12, 143.20, 140.78, 138.47, 137.34, 132.15, 131.20, 128.22, 128.14, 127.45, 127.25, 127.13, 126.58, 114.54, 114.53, 34.56, 30.32, 25.30, 24.45. HRMS (ESI) calcd for $C_{27}H_{24}O_4S$ $[M+Na]^+$: 467.1395, found: 467.1286.



3d

(4-chlorophenyl)((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)methanone

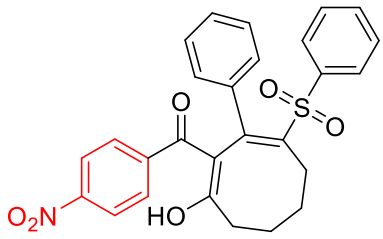
(**3d**, white solid, petroleum ether/ethyl acetate = 5:1, 59.3 mg, 62 %). m.p. 224-226 ºC.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.75 (s, 1H), 7.30 (t, *J* = 7.5 Hz, 1H), 7.27-7.24 (m, 2H), 7.22-7.20 (m, 2H), 7.14-7.11 (m, 2H), 7.08-7.05 (m, 2H), 6.94 (t, *J* = 7.5 Hz, 1H), 6.75 (t, *J* = 8.5 Hz, 2H), 6.36 (d, *J* = 7.5 Hz, 2H), 3.55 (dd, J_1= 14.0 Hz, J_2= 6.0 Hz, 1H), 2.66-2.57 (m, 2H), 2.45 (t, *J* = 12.0 Hz, 1H), 2.28-2.22 (m, 1H), 2.20 – 2.14 (m, 1H), 2.09-2.00 (m, 1H), 1.70-1.61 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.03, 188.51, 145.63, 143.55, 140.57, 137.50, 137.24, 136.85, 132.21, 129.91, 128.55, 128.53, 128.14, 127.70, 127.30, 126.75, 114.50, 34.53, 30.34, 25.25, 24.42. HRMS (ESI) calcd for $C_{27}H_{23}ClO_4S$ $[M+Na]^+$: 501.0898, found: 501.0897.



3e

(4-fluorophenyl)((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)methanone

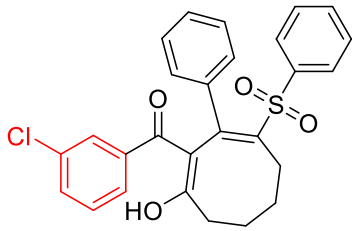
(**3e**, white solid, petroleum ether/ethyl acetate = 5:1, 80.4 mg, 87 %). m.p. 212-214 ºC.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.81 (s, 1H), 7.35-7.31 (m, 1H), 7.28 (s, 1H), 7.24 (d, *J* = 7.5 Hz, 2H), 7.20-7.13 (m, 4H), 7.01-6.94 (m, 3H), 6.77 (t, *J* = 8.0 Hz, 2H), 6.40 (d, *J* = 7.5 Hz, 2H), 3.60-3.55 (m, 1H), 2.69-2.61 (m, 2H), 2.48 (t, *J* = 12.0 Hz, 1H), 2.30-2.24 (m, 1H), 2.22-2.17 (m, 1H), 2.12-2.03 (m, 1H), 1.72-1.63 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 193.90, 188.36, 164.48 (d, *J* = 251.2 Hz), 145.84, 143.45, 140.63, 137.30, 132.21, 129.65 (d, *J* = 8.7 Hz), 128.14, 127.67, 127.30, 126.72, 115.42 (d, *J* = 22.5 Hz), 114.40, 34.51, 30.35, 25.26, 24.42. HRMS (ESI) calcd for $C_{27}H_{23}FO_4S$ $[M+Na]^+$: 485.1193, found: 485.1187.



3f

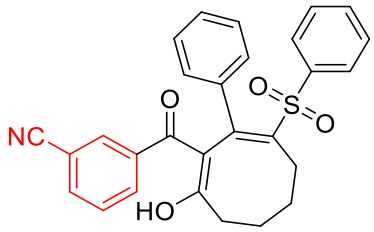
((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(4-nitrophenyl)methanone

(**3f**, yellow solid, petroleum ether/ethyl acetate = 5:1, 72.4 mg, 74 %). m.p. 256-258 ºC.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.63 (s, 1H), 8.11-8.09 (m, 2H), 7.32-7.29 (m, 1H), 7.22-7.19 (m, 4H), 7.14-7.11 (m, 2H), 6.95-6.92 (m, 1H), 6.73-6.70 (m, 2H), 6.34 (d, *J* = 10.0 Hz, 2H), 3.59-3.55 (m, 1H), 2.71-2.67 (m, 1H), 2.62-2.57 (m, 1H), 2.48-2.43 (m, 1H), 2.30-2.24 (m, 1H), 2.21-2.15 (m, 1H), 2.09-2.03 (m, 1H), 1.71-1.63 (m, 1H);^{13}C NMR (125 MHz, $CDCl_3$) δ 193.53, 189.36, 148.81, 144.60, 144.19, 143.95, 140.31, 137.13, 132.36, 128.18, 127.99, 127.88, 127.31, 126.91, 123.42, 114.79, 34.54, 30.46, 25.15, 24.39. HRMS (ESI) calcd for $C_{27}H_{23}NO_6S$ $[M+Na]^+$: 512.1246, found: 512.1142.



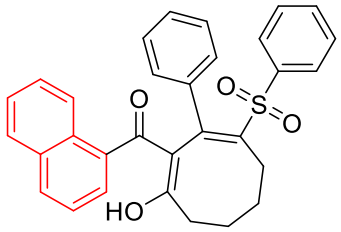
3g

(3-chlorophenyl)((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)methanone (**3g**, white solid, petroleum ether/ethyl acetate = 5:1, 69.8 mg, 73 %). m.p. 176-178 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.70 (s, 1H), 7.37-7.34 (m, 1H), 7.32-7.28 (m, 1H), 7.24-7.21 (m, 3H), 7.15-7.11 (m, 2H), 7.03 (dt, J_1= 7.5 Hz, J_2= 1.5 Hz, 1H), 6.98-6.93 (m, 2H), 6.76-6.73 (m, 2H), 6.34 (d, J = 7.5 Hz, 2H), 3.55-3.51 (m, 1H), 2.66-2.56 (m, 2H), 2.47 (t, J = 12.0 Hz, 1H), 2.27-2.21 (m, 1H), 2.18-2.13 (m, 1H), 2.10-2.01 (m, 1H), 1.68-1.60 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 193.76, 188.76, 145.53, 143.49, 140.72, 140.03, 137.23, 134.39, 132.25, 130.99, 129.86, 129.55, 128.21, 127.71, 127.27, 127.12, 126.75, 125.11, 114.57, 34.51, 30.42, 25.23, 24.42. HRMS (ESI) calcd for $C_{27}H_{23}ClO_4S$ $[M+H]^+$: 479.1006, found: 479.1074.



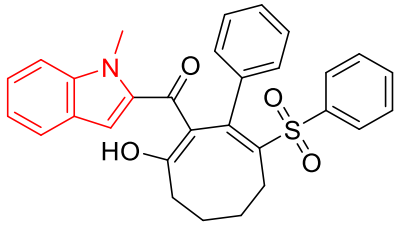
3h

3-((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-diene-1-carbonyl)benzonitrile (**3h**, white solid, petroleum ether/ethyl acetate = 7:1, 83.5 mg, 89 %). m.p. 210-212 °C. ^{1}H NMR (500 MHz, CDCl3) δ 16.61 (s, 1H), 7.66-7.64 (m, 1H), 7.45 (t, J = 10.0 Hz, 1H), 7.39-7.37 (m, 1H), 7.33-7.30 (m, 1H), 7.23-7.21 (m, 2H), 7.17-7.12 (m, 3H), 6.98-6.95 (m, 1H), 6.74 (t, J = 10.0 Hz, 2H), 6.31 (d, J = 5.0 Hz, 2H), 3.57-3.53 (m, 1H), 2.69-2.65 (m, 1H), 2.60-2.55 (m, 1H), 2.46 (t, J = 10.0 Hz, 1H), 2.29-2.22 (m, 1H), 2.20-2.14 (m, 1H), 2.10-2.00 (m, 1H), 1.69-1.60 (m, 1H); ^{13}C NMR (125 MHz, CDCl3) δ 193.28, 189.19, 144.85, 144.02, 140.48, 139.67, 137.16, 133.93, 132.37, 130.76, 130.40, 129.10, 129.07, 128.24, 128.01, 127.26, 126.88, 117.65, 114.59, 112.78, 34.49, 30.51, 25.15, 24.35. HRMS (ESI) calcd for $C_{28}H_{23}NO_4S$ $[M+Na]^+$:492.1240, found: 492.1233.



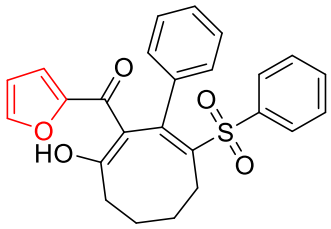
3i

((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(naphthalen-1-yl)methanone (**3i**, white solid, petroleum ether/ethyl acetate = 5:1, 61.3 mg, 62 %). m.p. 198-200 °C.^{1}H NMR (500 MHz, CDCl3) δ 16.95 (s, 1H), 7.83-7.78 (m, 2H), 7.73-7.71 (m, 2H), 7.59-7.52 (m, 2H), 7.30-7.27 (m, 1H), 7.22-7.20 (m, 3H), 7.11-7.08 (m, 2H), 6.82-6.78 (m, 1H), 6.53 (t, *J* = 7.5 Hz, 2H), 6.26 (d, *J* = 7.0 Hz, 2H), 3.64-3.60 (m, 1H), 2.79-2.73 (m, 1H), 2.69-2.65 (m, 1H), 2.56-2.51 (m, 1H), 2.30-2.17 (m, 2H), 2.14-2.04 (m, 1H), 1.75-1.66 (m, 1H); ^{13}C NMR (125 MHz, CDCl3) δ 194.62, 188.43, 146.23, 143.22, 140.74, 137.32, 135.63, 134.37, 132.16, 132.14, 129.05, 128.29, 128.19, 128.15, 127.90, 127.72, 127.46, 127.29, 126.88, 126.52, 123.65, 114.78, 114.76, 34.62, 30.36, 25.38, 24.54. HRMS (ESI) calcd for $C_{31}H_{26}O_4S$ [M+Na]$^+$: 517.1444, found: 517.1441.



3j

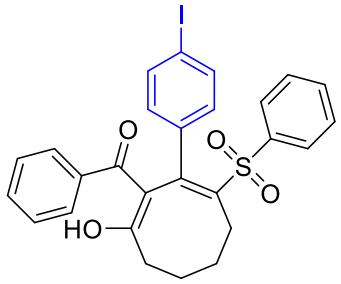
((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(1-methyl-1H-indol-2-yl)methanone (**3j**, yellow solid, petroleum ether/ethyl acetate = 5:1, 56.7 mg, 57 %). m.p. 240-242 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.38 (s, 1H), 7.67 (d, *J* = 7.9 Hz, 1H), 7.35-7.30 (m, 2H), 7.29-7.26 (m, 2H), 7.18-7.14 (m, 4H), 6.92 (t, *J* = 7.5 Hz, 1H), 6.80 (s, 1H), 6.69 (t, *J* = 7.9 Hz, 2H), 6.40 (d, *J* = 9.5 Hz, 2H), 3.57-3.53 (m, 1H), 3.22 (s, 3H), 2.68-2.62 (m, 2H), 2.51 (t, *J* = 12.5Hz, 1H), 2.27-2.15 (m, 2H), 2.10-2.02 (m, 1H), 1.69-1.61 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 186.99, 186.63, 146.27, 142.24, 140.96, 138.89, 137.98, 135.46, 132.23, 128.24, 127.46, 127.35, 126.62, 126.33, 124.93, 122.53, 120.52, 115.83, 115.81, 109.82, 109.07, 34.56, 30.56, 30.25, 25.38, 24.36. HRMS (ESI) calcd for $C_{30}H_{27}NO_4S2$ [M+H]$^+$: 498.1734, found: 498.1736.



3k

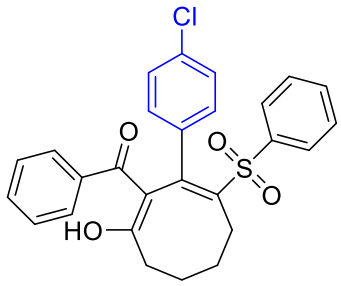
furan-2-yl((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)methanone (**3k**, white solid, petroleum ether/ethyl acetate = 8:1, 76.4 mg, 88 %). m.p. 160-162 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.31 (s, 1H), 7.57 (d, *J* = 2.0 Hz, 1H), 7.35-7.31 (m, 3H), 7.19-7.15 (m, 2H), 7.08 (d, *J* = 3.5 Hz, 1H), 7.05-7.01 (m, 1H), 6.91 (t, *J* = 8.0 Hz, 2H), 6.81 (d, *J* = 8.0 Hz, 2H), 6.47 (dd, J_1= 3.5 Hz, J_2= 2.0 Hz, 1H), 3.46-3.42 (m, 1H), 2.60-2.56 (m, 2H), 2.54-2.49 (m, 1H), 2.23-2.17 (m, 1H), 2.13-1.99 (m, 2H), 1.64-1.56 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 186.86, 179.70, 150.31, 146.40, 145.02, 143.66,

140.82, 137.39, 132.26, 129.63, 129.10, 128.20, 128.06, 127.31, 127.05, 119.11, 112.57, 34.21, 30.05, 25.36, 24.66. HRMS (ESI) calcd for $C_{25}H_{22}O_5S$ $[M+H]^+$: 435.1261, found: 435.1257.



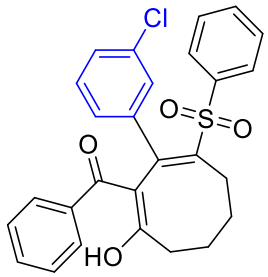
3l

((1Z,7E)-2-hydroxy-8-(4-iodophenyl)-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone (**3l**, white solid, petroleum ether/ethyl acetate = 5:1, 87.8 mg, 77 %). m.p. 216-218 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.86 (s, 1H), 7.44-7.41 (m, 1H), 7.39-7.36 (m, 1H), 7.31-7.28(m, 2H), 7.26-7.23 (m, 2H), 7.22-7.19 (m, 2H), 7.14-7.12 (m, 2H), 7.04-7.02 (m, 2H), 6.02 (d, *J* = 8.0 Hz, 2H), 3.54-3.49 (m, 1H), 2.67-2.59 (m, 2H), 2.44 (t, *J* = 12Hz, 1H), 2.27-2.21 (m, 1H), 2.20-2.14 (m, 1H), 2.06-1.99 (m, 1H), 1.70-1.62 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.95, 188.58, 144.70, 144.00, 140.62, 138.32, 136.93, 135.71, 132.43, 131.42, 128.37, 128.29, 127.27, 127.17, 113.94, 113.92, 93.80, 34.64, 30.28, 25.24, 24.45. HRMS (ESI) calcd for $C_{27}H_{23}IO_4S$ $[M+H]^+$: 571.0434, found: 571.0431.



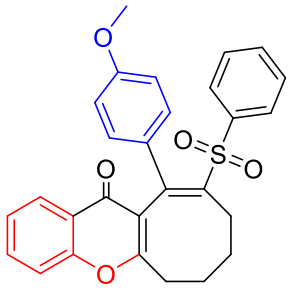
3m

((1Z,7E)-8-(4-chlorophenyl)-2-hydroxy-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone (**3m**, white solid, petroleum ether/ethyl acetate = 5:1, 75.5 mg, 79 %). m.p. 201-203 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.86 (s, 1H), 7.44-7.40 (m, 1H), 7.38-7.34 (m, 1H), 7.30-7.24 (m, 4H), 7.21-7.18 (m, 2H), 7.13-7.11 (m, 2H), 6.67 (d, *J* = 8.5 Hz, 2H), 6.23 (d, *J* = 8.0 Hz, 2H), 3.54-3.50 (m, 1H), 2.67-2.59 (m, 2H), 2.44 (t, *J* = 12.0 Hz, 1H), 2.27-2.21 (m, 1H), 2.19-2.13 (m, 1H), 2.06-1.96 (m, 1H), 1.70-1.63 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.08, 188.52, 144.70, 143.94, 140.66, 138.36, 135.84, 133.71, 132.46, 131.39, 128.37, 128.26, 127.25, 127.12, 126.77, 114.10, 114.08, 34.60, 30.30, 25.23, 24.40. HRMS (ESI) calcd for $C_{27}H_{23}ClO_4S$ $[M+H]^+$: 479.1006, found: 479.1074.



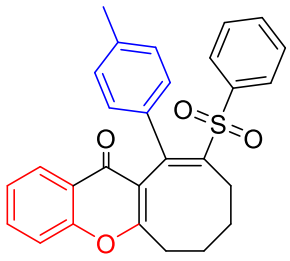
3n

((1Z,7E)-8-(3-chlorophenyl)-2-hydroxy-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone (**3n**, white solid, petroleum ether/ethyl acetate = 5:1, 60.2 mg, 63 %). m.p. 206-208 ºC.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.87 (s, 1H), 7.44-7.41 (m, 1H), 7.38-7.35 (m, 1H), 7.30-7.25 (m, 4H), 7.19 (t, *J* = 8.0 Hz, 2H), 7.09 (d, *J* = 7.0 Hz, 2H), 6.88 (dd, J_1= 8.0 Hz, J_2= 2.0 Hz, 1H), 6.66 (t, *J* = 8.0 Hz, 1H), 6.23 (d, *J* = 7.5 Hz, 1H), 6.06 (s, 1H), 3.54-3.50 (m, 1H), 2.68-2.59 (m, 2H), 2.46 (t, *J* = 12.0 Hz, 1H), 2.27-2.15 (m, 2H), 2.08-1.99 (m, 1H), 1.70-1.61 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.04, 188.67, 144.24, 144.17, 140.61, 139.09, 138.28, 132.62, 132.49, 131.42, 128.37, 128.30, 127.82, 127.57, 127.22, 127.04, 113.99, 113.97, 34.69, 30.36, 25.36, 24.44. HRMS (ESI) calcd for $C_{27}H_{23}ClO_4S$ $[M+H]^+$: 479.1006, found: 479.1014.



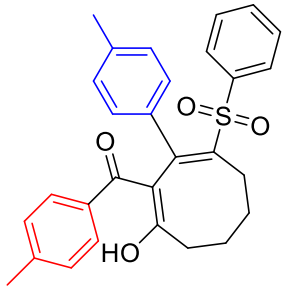
3o

(E)-11-(4-methoxyphenyl)-10-(phenylsulfonyl)-6,7,8,9-tetrahydro-12H-cycloocta[b]chromen-12-one (**3o**, yellow oil, petroleum ether/ethyl acetate = 5:1, 88.8 mg, 94 %).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.01-8.00 (m, 2H), 7.62-7.59 (m, 2H), 7.43-7.38 (m, 4H), 7.31-7.25 (m, 3H), 7.03 (d, *J* = 10.0 Hz, 2H), 3.74 (s, 3H), 3.31-3.27 (m, 1H), 2.97-2.93 (m, 1H), 2.78 (t, *J* = 10.0 Hz, 1H), 2.26-2.19 (m, 2H), 2.12-2.07 (m, 1H), 1.99-1.93 (m, 1H), 1.62-1.58 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 175.52, 165.65, 159.32, 155.85, 144.72, 144.26, 141.43, 133.76, 132.33, 130.86, 128.64, 128.34, 127.21, 125.83, 125.16, 123.36, 122.06, 117.80, 112.62, 55.21, 32.01, 28.95, 24.92, 23.97. HRMS (ESI) calcd for $C_{28}H_{24}O_5S$ $[M+Na]^+$: 495.1344, found: 495.1247.



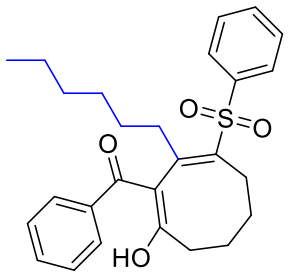
3p

(E)-10-(phenylsulfonyl)-11-(p-tolyl)-6,7,8,9-tetrahydro-12H-cycloocta[b]chromen-12-one (**3p**, yellow oil, petroleum ether/ethyl acetate = 5:1, 85.8 mg, 94 %).^{1}H NMR (500 MHz, $CDCl_3$) δ 8.00-7.99 (m, 1H), 7.60-7.57 (m, 1H), 7.43-7.38 (m, 5H), 7.29-7.22 (m, 3H), 7.00 (d, *J* = 5.0 Hz, 2H), 6.87 (d, *J* = 5.0 Hz, 2H), 3.28-3.23 (m, 1H), 2.96-2.92 (m, 1H), 2.84-2.78 (m, 1H), 2.26 (s, 3H), 2.24-2.18 (m, 2H), 2.10-2.06 (m, 1H), 1.99-1.95 (m, 1H), 1.63-1.55 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ δ 175.50, 165.68, 155.87, 144.58, 141.37, 137.68, 133.75, 133.52, 132.34, 129.37, 128.32, 127.80, 127.37, 125.88, 125.15, 123.38, 122.11, 117.79, 32.06, 29.03, 24.97, 24.04, 21.34. HRMS (ESI) calcd for $C_{28}H_{24}O_4S$ $[M+Na]^+$: 479.1395, found: 479.1294.



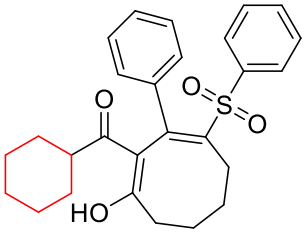
3q

((1Z,7E)-2-hydroxy-7-(phenylsulfonyl)-8-(p-tolyl)cycloocta-1,7-dien-1-yl)(p-tolyl)methanone (**3q**, white solid, petroleum ether/ethyl acetate = 5:1, 77.4 mg, 82 %). m.p. 209-211 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.87 (s, 1H), 7.34-7.31 (m, 1H), 7.26-7.24 (m, 2H), 7.15-7.10 (m, 6H), 6.53 (d, *J* = 8.0 Hz, 2H), 6.23 (d, *J* = 8.0 Hz, 2H), 3.55-3.51 (m, 1H), 2.67-2.60 (m, 2H), 2.48 (t, *J* = 13.5 Hz, 1H), 2.38 (s, 3H), 2.28-2.20 (m, 2H), 2.15 (s, 3H), 2.09-2.00 (m, 1H), 1.68-1.61 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.72, 187.81, 146.57, 142.76, 141.92, 140.94, 137.35, 135.75, 134.52, 132.06, 129.61, 128.82, 127.97, 127.50, 127.47, 127.31, 127.22, 114.39, 114.37, 34.52, 30.23, 25.35, 24.47, 21.60, 21.10. HRMS (ESI) calcd for $C_{29}H_{28}O_4S$ $[M+Na]^+$: 495.1600, found: 495.1590.



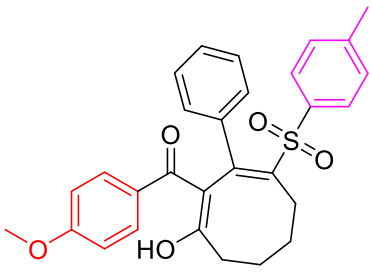
3r

((1Z,7E)-8-hexyl-2-hydroxy-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone (**3r**, yellow oil, petroleum ether/ethyl acetate = 5:1, 51.5 mg, 57 %). ^{1}H NMR (500 MHz, $CDCl_3$) δ 17.46 (s, 1H), 7.94-7.92 (m, 2H), 7.72-7.68 (m, 1H), 7.63-7.60 (m, 2H), 7.38-7.34 (m, 1H), 7.22-7.20 (m, 2H), 7.07-7.04 (m, 2H), 3.02 (dd, J_1= 14.0 Hz, J_2= 7.5 Hz, 2H), 2.56-2.47 (m, 2H), 2.37-2.31 (m, 1H), 2.14-2.04 (m, 2H), 1.99-1.90 (m, 1H), 1.61-1.52 (m, 1H), 1.43-1.33 (m, 1H), 1.22-1.17 (m, 5H), 1.15-1.09 (m, 2H), 1.08-1.04 (m, 1H), 0.82 (t, J = 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 192.63, 189.12, 150.63, 141.91, 139.58, 137.30, 133.17, 131.62, 129.30, 128.26, 127.53, 127.30, 112.20, 36.34, 35.24, 31.38, 30.80, 29.58, 28.84, 26.39, 24.91, 22.48, 14.02. HRMS (ESI) calcd for $C_{27}H_{32}O_4S$ $[M+Na]^+$: 475.2178, found: 475.1927.



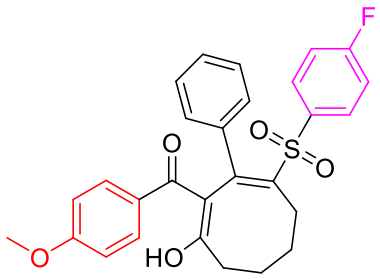
3s

cyclohexyl((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)methanone (**3s**, white oil, petroleum ether/ethyl acetate = 5:1, 38.7 mg, 43 %). ^{1}H NMR (500 MHz, $CDCl_3$) δ 17.37 (s, 1H), 7.33-7.30 (m, 1H), 7.28-7.26 (m, 2H), 7.17-7.13 (m, 3H), 7.08 (t, J = 7.5 Hz, 2H), 7.05-7.03 (m, 1H), 3.38-3.34 (m, 1H), 2.52-2.48 (m, 1H), 2.39-3.31 (m, 3H), 2.19-2.13 (m, 1H), 2.10-1.97 (m, 2H), 1.76-1.73 (m, 1H), 1.64-1.55 (m, 4H), 1.41-1.33 (m, 2H), 1.28- 1.18 (m, 1H), 1.11-1.02 (m, 1H), 0.98-0.89 (m, 1H), 0.83-0.74 (m, 1H), 0.20 (d, J = 12.5 Hz, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 204.31, 188.32, 145.09, 144.43, 140.67, 138.02, 132.13, 130.57, 128.46, 128.12, 127.39, 127.24, 113.62, 46.29, 34.46, 30.01, 29.17, 28.18, 25.66, 25.47, 25.19, 25.09, 24.54. HRMS (ESI) calcd for $C_{27}H_{30}O_4S$ $[M+H]^+$: 473.1865, found: 473.1750.



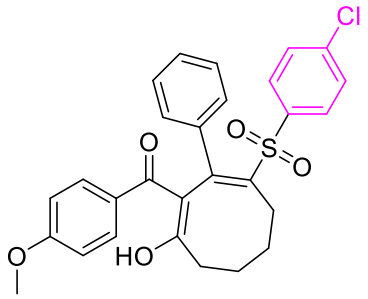
3t

((1Z,7E)-2-hydroxy-8-phenyl-7-tosylcycloocta-1,7-dien-1-yl)(4-methoxyphenyl)methanone (**3t**, white solid, petroleum ether/ethyl acetate = 5:1, 95.7 mg, 98 %). m.p. 211-213 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.93 (s, 1H), 7.26-7.21 (m, 2H), 7.10 (d, J = 8.0 Hz, 2H), 6.95-6.91 (m, 3H), 6.80-6.74 (m, 4H), 6.43 (d, J = 7.5 Hz, 2H), 3.83 (s, 3H), 3.54-3.49 (m, 1H), 2.66-2.58 (m, 2H), 2.46 (t, J = 12.0 Hz, 1H), 2.27 (s, 3H), 2.24-2.18 (m, 1H), 2.16-2.11 (m, 1H), 2.06-1.97 (m, 1H), 1.67-1.59 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 193.63, 187.81, 162.39, 146.24, 143.18, 142.96, 137.88, 137.57, 130.99, 129.73, 128.75, 127.45, 127.39, 126.48, 114.20, 114.19, 113.54, 55.46, 34.51, 30.38, 25.31, 24.46, 21.42. HRMS (ESI) calcd for $C_{29}H_{28}O_5S$ $[M+Na]^+$: 511.1657, found:511.1550.



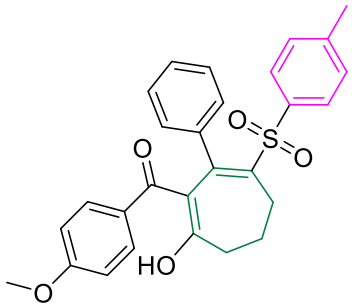
3u

((1Z,7E)-7-((4-fluorophenyl)sulfonyl)-2-hydroxy-8-phenylcycloocta-1,7-dien-1-yl)(4-methoxyphenyl)methanone (**3u**, white solid, petroleum ether/ethyl acetate = 5:1, 70.9 mg, 72 %). m.p. 230-232 °C.^{1}H NMR (500 MHz, $CDCl_3$) δ 16.93 (s, 1H), 7.22-7.18 (m, 4H), 6.95 (t, *J* = 7.0 Hz, 1H), 6.81-6.77 (m, 6H), 6.43 (s, 2H), 3.84 (s, 3H), 3.56-3.52 (m, 1H), 2.68-2.60 (m, 2H), 2.40 (t, *J* = 12.5 Hz, 1H), 2.26-2.15 (m, 2H), 2.06-1.97 (m, 1H), 1.69-1.60 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 193.75, 187.68, 164.60 (d, *J* = 253.4 Hz), 162.45, 146.61, 143.02, 137.43, 136.77 (d, *J* = 3.1 Hz), 130.94, 130.02 (d, *J* = 9.4 Hz), 129.70, 127.71, 126.69, 115.32 (d, *J* = 22.6 Hz), 114.04, 114.02, 113.58, 55.48, 34.57, 30.26, 25.40, 24.37. HRMS (ESI) calcd for $C_{28}H_{25}FO_5S$ [M+Na]$^{+}$: 515.1407, found: 515.1295.



3v

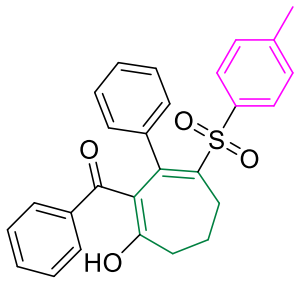
((1Z,7E)-7-((4-chlorophenyl)sulfonyl)-2-hydroxy-8-phenylcycloocta-1,7-dien-1-yl)(4-methoxyphenyl)methanone (**3v**, white solid, petroleum ether/ethyl acetate = 5:1, 99.6 mg, 98 %). m.p. 178-180 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 16.93 (s, 1H), 7.22-7.19 (m, 2H), 7.12-7.06 (m, 4H), 6.98-6.95 (m, 1H), 6.81-6.76 (m, 4H), 6.42 (s, 2H), 3.84 (s, 3H), 3.55-3.51 (m, 1H), 2.67-2.61 (m, 2H), 2.40 (t, *J* = 12.0 Hz, 1H), 2.26-2.14 (m, 2H), 2.06-1.97 (m, 1H), 1.69-1.60 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 193.75, 187.67, 162.46, 146.81, 142.88, 139.27, 138.74, 137.39, 130.93, 129.70, 128.69, 128.33, 127.75, 126.69, 113.99, 113.97, 113.58, 55.48, 34.59, 30.22, 25.40, 24.35. HRMS (ESI) calcd for $C_{28}H_{25}ClO_5S$ [M+H]$^{+}$: 509.1111, found: 509.1183.



3w

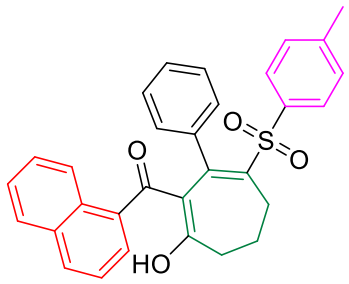
(2-hydroxy-7-phenyl-6-tosylcyclohepta-1,6-dien-1-yl)(4-methoxyphenyl)methanone (**3w**, white solid,

petroleum ether/ethyl acetate = 5:1, 86.3 mg, 91 %). m.p. 210-212 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 16.89 (s, 1H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.19-7.16 (m, 2H), 7.03 (d, *J* = 8.0 Hz, 2H), 6.98-6.95 (m, 1H), 6.83 (t, *J* = 8.5, 2H), 6.74 (s, 1H), 6.71-6.68 (m, 2H), 3.77 (s, 3H), 3.16-2.83 (m, 2H), 2.48-2.44 (m, 2H), 2.31 (s, 3H), 2.24-2.18 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 192.33, 191.17, 162.34, 149.40, 143.47, 139.90, 138.24, 137.77, 129.96, 129.56, 129.09, 127.94, 127.68, 126.46, 113.92, 113.39, 55.43, 34.80, 31.69, 28.63, 21.50. HRMS (ESI) calcd for $C_{28}H_{26}O_5S$ $[M+Na]^+$: 497.1501, found: 497.1389.



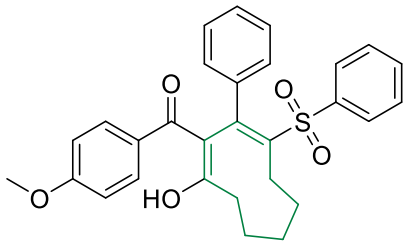
3x

(2-hydroxy-7-phenyl-6-tosylcyclohepta-1,6-dien-1-yl)(phenyl)methanone (**3x**, white solid, petroleum ether/ethyl acetate = 5:1, 79.0 mg, 89 %). m.p. 155-157 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 16.86 (s, 1H), 7.31-7.27 (m, 3H), 7.17-7.14 (m, 2H), 7.10-7.08 (m, 2H), 7.03 (d, *J* = 8.0 Hz, 2H), 6.95-6.92 (m, 1H), 6.78 (t, *J* = 7.5 Hz, 2H), 6.64 (s, 2H), 3.21 (s, 1H), 2.82 (s, 1H), 2.50-2.43 (m, 2H), 2.31 (s, 3H), 2.26-2.18 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 193.19, 192.42, 148.95, 143.50, 140.12, 138.18, 137.74, 137.12, 131.11, 129.10, 128.03, 127.80, 127.67, 127.37, 126.47, 114.53, 114.51, 34.89, 31.68, 28.60, 21.50. HRMS (ESI) calcd for $C_{27}H_{24}O_4S$ $[M+Na]^+$: 467.1395, found: 467.1278.



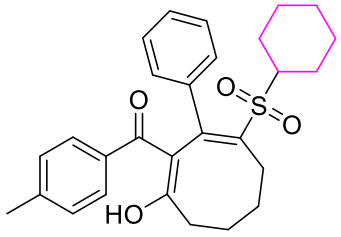
3y

(2-hydroxy-7-phenyl-6-tosylcyclohepta-1,6-dien-1-yl)(naphthalen-1-yl)methanone (**3y**, white solid, petroleum ether/ethyl acetate = 5:1, 86.0 mg, 87 %). m.p. 208-210 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 17.29 (s, 1H), 7.72 (d, *J* = 8.5 Hz, 1H), 7.64 (d, *J* = 7.0 Hz, 1H), 7.43 (s, 1H), 7.32 (s, 1H), 7.19 (d, *J* = 8.0 Hz, 3H), 6.97 (d, *J* = 8.0 Hz, 3H), 6.45 (d, *J* = 47.0 Hz, 5H), 3.22 (s, 1H), 2.73 (d, *J* = 59.5 Hz, 2H), 2.45 (d, *J* = 52.0 Hz, 2H), 2.27 (s, 3H), 2.25 (s, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 195.84, 148.68, 143.33, 139.66, 138.17, 137.47, 134.43, 133.04, 130.65, 129.18, 129.01, 127.79, 127.53, 126.96, 126.34, 126.05, 125.54, 124.59, 124.46, 116.69, 35.52, 31.71, 28.43, 21.47. HRMS (ESI) calcd for $C_{31}H_{26}O_4S$ $[M+Na]^+$:517.1552, found: 517.1443.



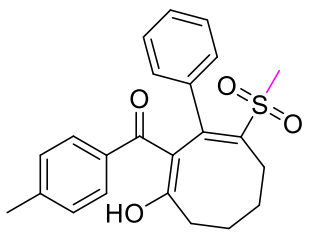
3z

((1Z,8E)-2-hydroxy-9-phenyl-8-(phenylsulfonyl)cyclonona-1,8-dien-1-yl)(4-methoxyphenyl)methanone (**3z**, white solid, petroleum ether/ethyl acetate = 5:1, 95.7 mg, 98 %). m.p. 150-152 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 17.37 (s, 1H), 7.38-7.33 (m, 3H), 7.31-7.29 (m, 2H), 7.20-7.17 (m, 2H), 7.00-6.97 (m, 1H), 6.84-6.80 (m, 4H), 6.51-6.49 (m, 2H), 3.84 (s, 3H), 3.54-3.48 (m, 1H), 2.85-2.78 (m, 1H), 2.62-2.57 (m, 1H), 2.42-2.38 (m, 1H), 2.30-2.15 (m, 2H), 2.05-1.99 (m, 1H), 1.72-1.60 (m, 2H), 1.49-1.41 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 190.48, 190.41, 162.45, 147.61, 146.68, 140.48, 137.87, 132.47, 130.07, 129.89, 129.56, 128.29, 127.77, 127.54, 126.93, 115.21, 113.61, 77.35, 77.10, 76.84, 55.48, 35.03, 32.85, 28.66, 27.02, 26.61. HRMS (ESI) calcd for $C_{29}H_{28}O_5S$ $[M+Na]^+$: 511.1657, found:511.1546.



3aa

((1Z,7E)-7-(cyclohexylsulfonyl)-2-hydroxy-8-phenylcycloocta-1,7-dien-1-yl)(p-tolyl)methanone (**3aa**, white solid, petroleum ether/ethyl acetate = 8:1, 82.6 mg, 89 %). m.p. 200-202 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 17.01 (s, 1H), 7.18-7.09 (m, 5H), 7.03 (t, *J* = 7.5 Hz, 2H), 6.82 (d, *J* = 5.0 Hz, 2H), 3.47-3.31 (m, 1H), 2.78-2.70 (m, 1H), 2.61 (t, *J* = 12.5 Hz, 1H), 2.52 (t, *J* = 12.5 Hz, 1H), 2.37 (s, 3H), 2.20-2.07 (m, 2H), 1.92-1.85 (m, 1H), 1.77-1.54 (m, 7H), 1.51-1.29 (m, 5H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.95, 188.04, 143.14, 141.93, 141.03, 137.94, 135.77, 129.29, 128.89, 128.14, 127.42, 127.21, 114.26, 60.06, 35.16, 29.73, 26.72, 25.37, 25.27, 24.99, 24.83, 24.43, 22.78, 21.56. HRMS (ESI) calcd for $C_{28}H_{32}O_4S$ $[M+Na]^+$: 487.1914, found:487.1910.

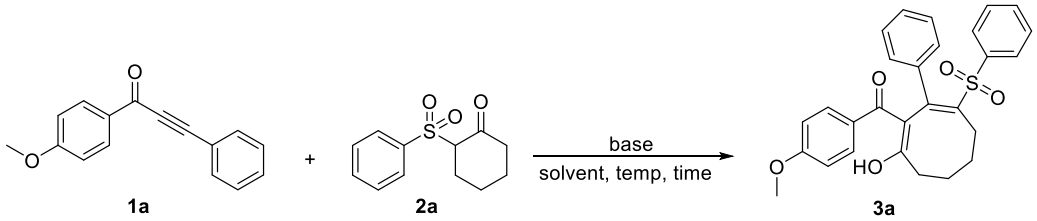


3ab

((1Z,7E)-2-hydroxy-7-(methylsulfonyl)-8-phenylcycloocta-1,7-dien-1-yl)(p-tolyl)methanone (**3ab**,

white solid, petroleum ether/ethyl acetate = 5:1, 71.3 mg, 90 %). m.p. 211-213 ^{o}C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 17.02 (s, 1H), 7.14-7.07 (m, 5H), 7.02 (t, *J* = 7.5 Hz, 2H), 6.86-6.82 (m, 2H), 3.41-3.34 (m, 1H), 2.76-2.68 (m, 1H), 2.60-2.47 (m, 2H), 2.35 (s, 3H), 2.34 (s, 3H), 2.21-2.06 (m, 2H), 1.88-1.81 (m, 1H), 1.68-1.58 (m, 1H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 194.90, 188.23, 144.83, 142.71, 142.02, 137.66, 135.64, 129.75, 128.89, 128.42, 127.33, 114.13, 114.12, 43.83, 34.97, 30.09, 25.68, 24.36, 21.57. HRMS (ESI) calcd for $C_{23}H_{24}O_4S$ $[M+Na]^+$: 419.1287, found:419.1284.

4. Table 1. Optimization Studies for the Synthesis of 3a[a]

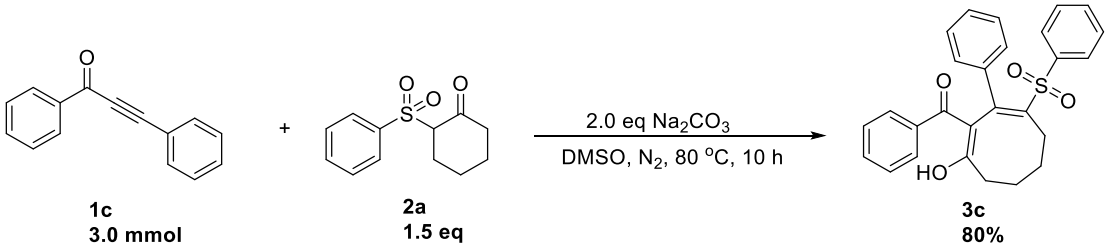


1a 2a 3a

entry	2a(equiv)	base(equiv)	solvent	T (^{o}C)	time (h)	yield[b] (%)
1	1.0	^{t}BuOK(2.0)	DMSO	60	8	trace[c]
2	1.0	K_2CO_3(2.0)	DMSO	60	8	41[c]
3	1.0	^{t}BuONa(2.0)	DMSO	60	8	trace[c]
4	1.0	Na_2CO_3(2.0)	DMSO	60	8	56[c]
5	1.0	Cs_2CO_3(2.0)	DMSO	60	8	43[c]
6	1.0	Na_2CO_3(2.0)	DMSO	60	8	63
7	1.0	Cs_2CO_3(2.0)	DMSO	60	8	59
8	1.2	Na_2CO_3(2.0)	DMSO	60	8	60
9	1.5	Na_2CO_3(2.0)	DMSO	60	8	80
10	**1.5**	**Na_2CO_3(2.0)**	**DMSO**	**80**	**4**	**83**
11	1.5	Na_2CO_3(2.0)	DMSO	80	4	58[c]
12	1.2	Na_2CO_3(2.0)	DMSO	80	4	69
13	1.5	Na_2CO_3(2.0)	DMSO	100	1.5	74
14	1.2	Na_2CO_3(2.0)	DMSO	100	1.5	64
15	1.5	Na_2CO_3(1.5)	DMSO	80	4	80
16	1.5	Na_2CO_3(3.0)	DMSO	80	4	49
17	1.5	Na_2CO_3(2.0)	DMF	80	4	28
18	1.5	Na_2CO_3(2.0)	DMAC	80	4	48
19	1.5	Na_2CO_3(2.0)	Toluene	80	4	NR

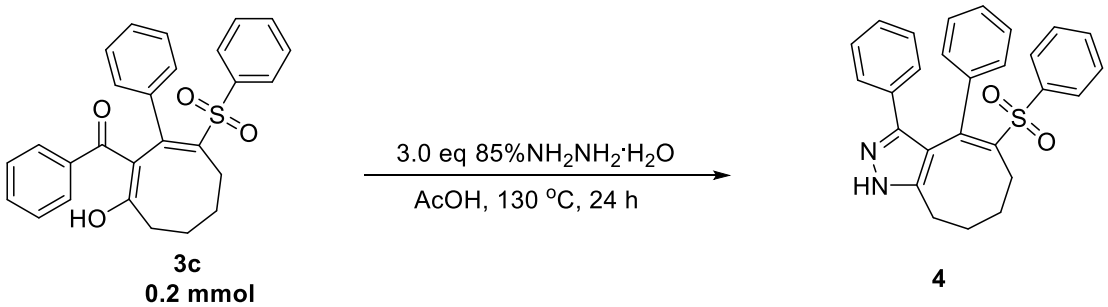
[a]Unless otherwise noted, all reactions were carried out under N_2 on a 0.3 mmol scale. [b]Isolated yields. [c]The reaction was carried out under air.

5. Gram Scales



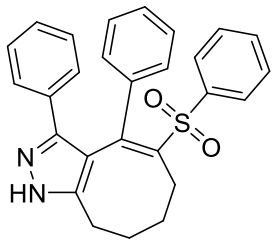
In a schlenk tube 1,3-diphenylprop-2-yn-1-one **1c** (3.0 mmol), The 2-(phenylsulfonyl)cyclohexan-1-one **2a** (4.5 mmol), Na_2CO_3 (6.0 mmol) and DMSO (30.0 ml) were stired at 80 °C under nitrogen atmosphere. After the reaction was completed as monitored by thin-layer chromatography, the reaction mixture was then quenched by water, and the water layers were extracted with ethyl acetate (20 mL × 3). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by chromatography on silica gel (petroleum ether/ethyl acetate = 5:1) afforded desired compound **3c** as a white solid. (1065.9 mg, 80%).

6. Further Transformations of 3c and 3x



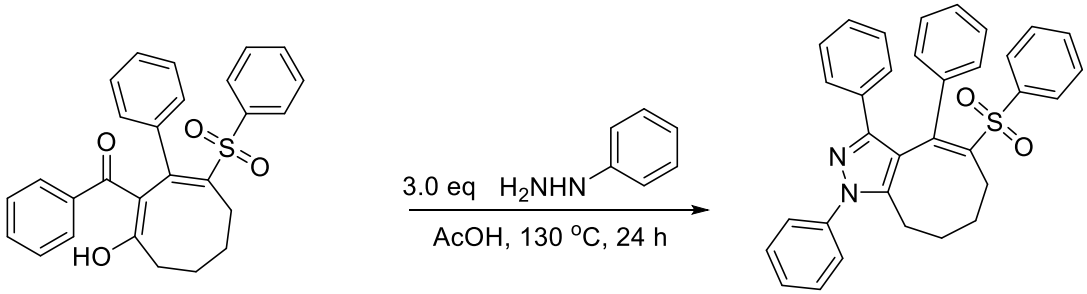
In a sealed tube, ((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone **3c**, 85% $NH_2NH_2{\cdot}H_2O$ (0.6 mmol, 0.04 ml, 3.0 equiv), AcOH (1 ml) were stirred at 130 °C for 24 h. After the reaction was completed as monitored by thin-layer chromatography, the reaction mixture was then quenched by saturated sodium bicarbonate, and the water layers were extracted with ethyl acetate (10 mL × 3). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4,

filtered, and concentrated under reduced pressure. Purification by chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) afforded desired compound **4** as a white solid. (66.7 mg, 76%).



4

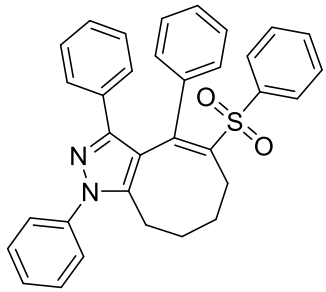
(E)-3,4-diphenyl-5-(phenylsulfonyl)-6,7,8,9-tetrahydro-1H-cycloocta[c]pyrazole (**4**, white solid, petroleum ether/ethyl acetate = 10:1, 66.7 mg, 76 %). m.p. 258-260 °C. ^{1}H NMR (500 MHz, *d*^{6}-DMSO) δ 12.96 (s, 1H), 7.46-7.40 (m, 1H), 7.30-7.24 (m, 4H), 7.22-7.05 (m, 5H), 6.88 (t, *J* = 7.5 Hz, 1H), 6.74 (t, *J* = 7.5 Hz, 2H), 6.61 (s, 2H), 3.26-3.20 (m, 1H), 3.17-3.03 (m, 1H), 2.43-2.30 (m, 1H), 2.22 (t, *J* = 12.5 Hz, 1H), 2.10-1.98 (m, 2H), 1.89-1.71 (m, 1H), 1.34-1.16 (m, 1H).; ^{13}C NMR (125 MHz, *d*^{6}-DMSO) δ 150.44, 144.23, 143.71, 141.34, 140.96, 137.52, 133.61, 132.76, 130.71, 128.91, 128.28, 127.97, 127.82, 127.68, 127.29, 126.61, 117.34, 29.51, 27.15, 25.03, 24.50. HRMS (ESI) calcd for $C_{27}H_{24}N_2O_2S$ $[M+Na]^+$: 463.1558, found: 463.1451.



3c
0.2 mmol

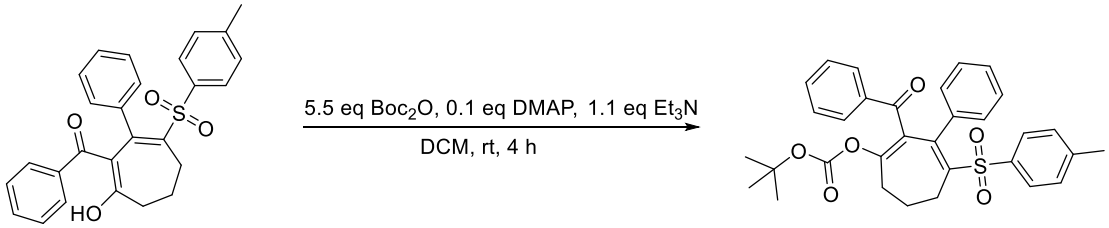
5

In a sealed tube, ((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone **3c**, phenylhydrazine (0.6 mmol, 0.06 ml, 3.0 equiv), AcOH (1 ml) were stirred at 130 °C for 24 h. After the reaction was completed as monitored by thin-layer chromatography, the reaction mixture was then quenched by saturated sodium bicarbonate, and the water layers were extracted with ethyl acetate (10 mL × 3). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by chromatography on silica gel (petroleum ether/ethyl acetate = 4:1) afforded desired compound **5** as a white solid. (90.4 mg, 80%).



5

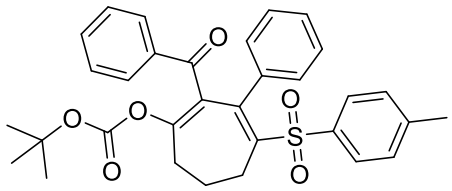
(E)-1,3,4-triphenyl-5-(phenylsulfonyl)-6,7,8,9-tetrahydro-1H-cycloocta[c]pyrazole (**5**, white solid, petroleum ether/ethyl acetate = 4:1, 90.4 mg, 80 %). m.p. 287-289 ºC. ^{1}H NMR (500 MHz, *d*^{6}-DMSO) δ 7.47-7.42 (m, 1H), 7.32-7.16 (m, 8H), 7.15-7.10 (m, 2H), 7.08 (t, *J* = 7.5 Hz, 2H), 6.87 (t, *J* = 7.0 Hz, 1H), 6.71-6.63 (m, 4H), 6.35 (s, 2H), 3.28-3.12 (m, 2H), 2.45 (t, *J* = 12.5 Hz, 1H), 2.38-2.30 (m, 1H), 2.16-2.04 (m, 2H), 1.91-1.77 (m, 1H), 1.44-1.33 (m, 1H).; ^{13}C NMR (125 MHz, *d*^{6}-DMSO) δ 152.25, 143.50, 142.63, 142.34, 141.21, 139.44, 137.85, 132.86, 130.06, 129.77, 129.66, 129.23, 128.96, 128.86, 128.36, 127.75, 127.46, 127.32, 126.69, 124.88, 121.91, 29.45, 27.40, 27.12, 26.52. HRMS (ESI) calcd for $C_{33}H_{28}N_2O_2S$ $[M+H]^+$: 517.1871, found: 517.1940.



3x
0.2 mmol

6

In a schlenk tube, the (2-hydroxy-7-phenyl-6-tosylcyclohepta-1,6-dien-1-yl) (phenyl)methanone **3x** (0.2 mmol, 88.8 mg, 1.0 equiv), DMAP (0.02 mmol, 2.4 mg, 0.1 equiv), CH_2Cl_2 (2 ml) were stirred at room temperature, and NEt_3 (0.22 mmol, 0.03 ml, 1.1 equiv), Boc_2O (1.1 mmol, 0.25 ml, 5.5 equiv) were added to the reaction vessel. The reaction was stirred for 4 h, then the reaction mixture was quenched by Saturated sodium bicarbonate solution. The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (10 ml × 3). The combined organic layers were washed with brine (10 ml), dried over Na_2SO_4, and concentrated under reduced pressure. The crude residue was purified by flash chromatography (petroleum ether/ethyl acetate = 10:1) to afford **6** as a white solid (91.6 mg, 84%).



6

2-benzoyl-3-phenyl-4-tosylcyclohepta-1,3-dien-1-yl tert-butyl carbonate (**6**, white solid, petroleum ether/ethyl acetate = 10:1, 91.6 mg, 84 %). m.p. 206-208 °C. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.53-7.47 (m, 2H), 7.44-7.34 (m, 3H), 7.28 (t, *J* = 7.5 Hz, 2H), 7.13-7.05 (m, 3H), 7.01 (t, *J* = 7.5 Hz, 2H), 6.87 (d, *J* = 7.0 Hz, 2H), 2.97 (t, *J* = 6.5 Hz, 2H), 2.59-2.47 (m, 4H), 2.36 (s, 3H), 1.33 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 192.39, 157.96, 149.93, 148.04, 144.68, 143.71, 138.19, 137.50, 135.12, 132.82, 129.76, 129.71, 129.29, 128.39, 128.36, 128.27, 127.82, 127.36, 84.35, 38.74, 30.75, 28.56, 27.43, 21.54. HRMS (ESI) calcd for $C_{32}H_{32}O_6S$ $[M+Na]^+$: 567.1920, found: 567.1826.

7. References

(1) (a) Cheng, X.; Zhou, Y.; Zhang, F.; Zhu, K.; Liu, Y.; Li, Y. Base-Promoted Tandem Reaction Involving Insertion into Carbon-Carbon α-Bonds: Synthesis of Xanthone and Chromone Derivatives. *Chemistry* **2016,** *22*, 12655-12659. (b) Tan, H.; Li, H.; Ji, W.; Wang, L. Sunlight-Driven Decarboxylative Alkynylation of alpha-Keto Acids with Bromo acetylenes by Hypervalent Iodine Reagent Catalysis: A Facile Approach to Ynones. *Angew. Chem. Int. Ed. Engl.* **2015,** *54*, 8374-8377. (c) da Silva, V. A. F.; da Silva, G. P.; Matsuo, B. T.; Ali, A.; Davis, R. L.; Zukerman-Schpector, J.; Correa, A. G.; Paixao, M. W. Synthesis of (Z)-β-Halo α, β-Unsaturated Carbonyl Systems via the Combination of Halotrimethylsilane and Tetrafluoroboric Acid. *Org. Biomol. Chem.* **2019,** *17*, 519-526.

(2) (a) Vyas, V. K.; Bhanage, B. M. Ru-Prolinamide-Catalyzed Asymmetric Transfer Hydrogenation of Racemic β-Heterosubstituted Cycloalkanones Driven by Dynamic Kinetic Resolution. *Asian J. Org. Chem.* **2018,** *7*, 346-349. (b) Enders, D.; Grossmann, A.; Huang, H.; Raabe, G. Dual Secondary Amine/N-Heterocyclic Carbene Catalysis in the Asymmetric Michael/Cross-Benzoin Cascade Reaction of β-Oxo Sulfones with Enals. *Eur. J. Org. Chem.* **2011,** *2011*, 4298-4301. (c) Filippini, G.; Silvi, M.; Melchiorre, P. Enantioselective Formal α-Methylation and α-Benzylation of Aldehydes by Means of Photo-Organocatalysis. *Angew. Chem. Int. Ed.* **2017**, *56*, 4447-4451.

8. Copies of Spectra of Products

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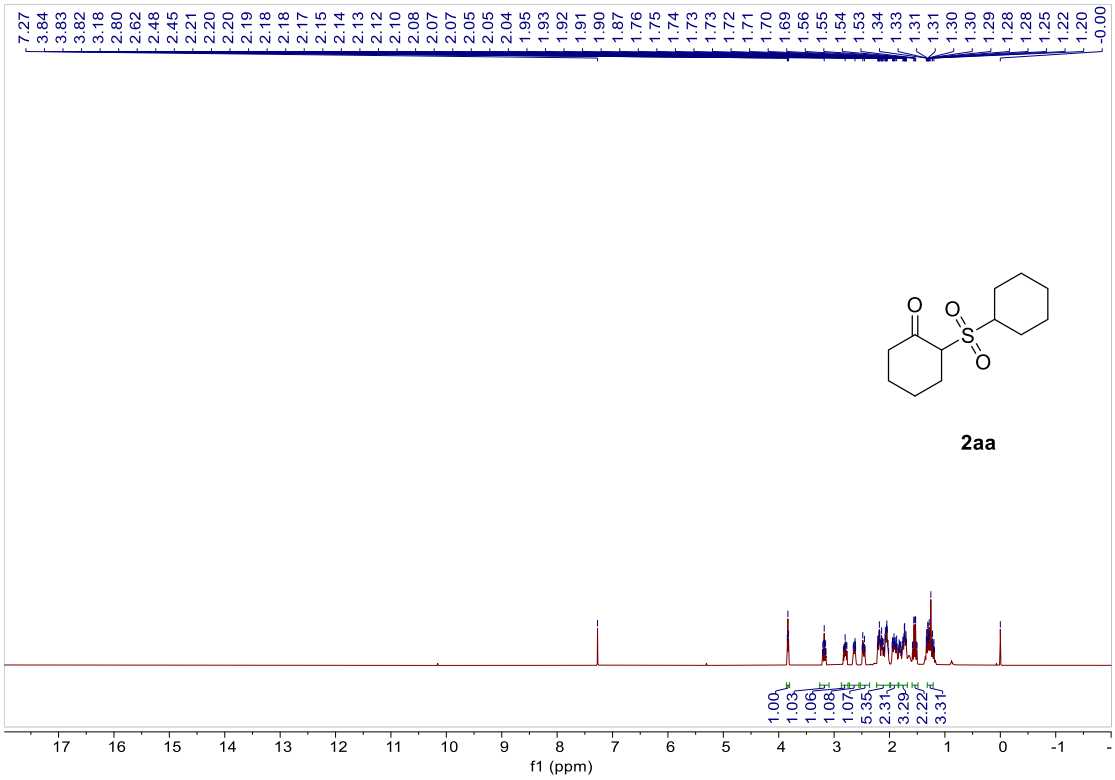

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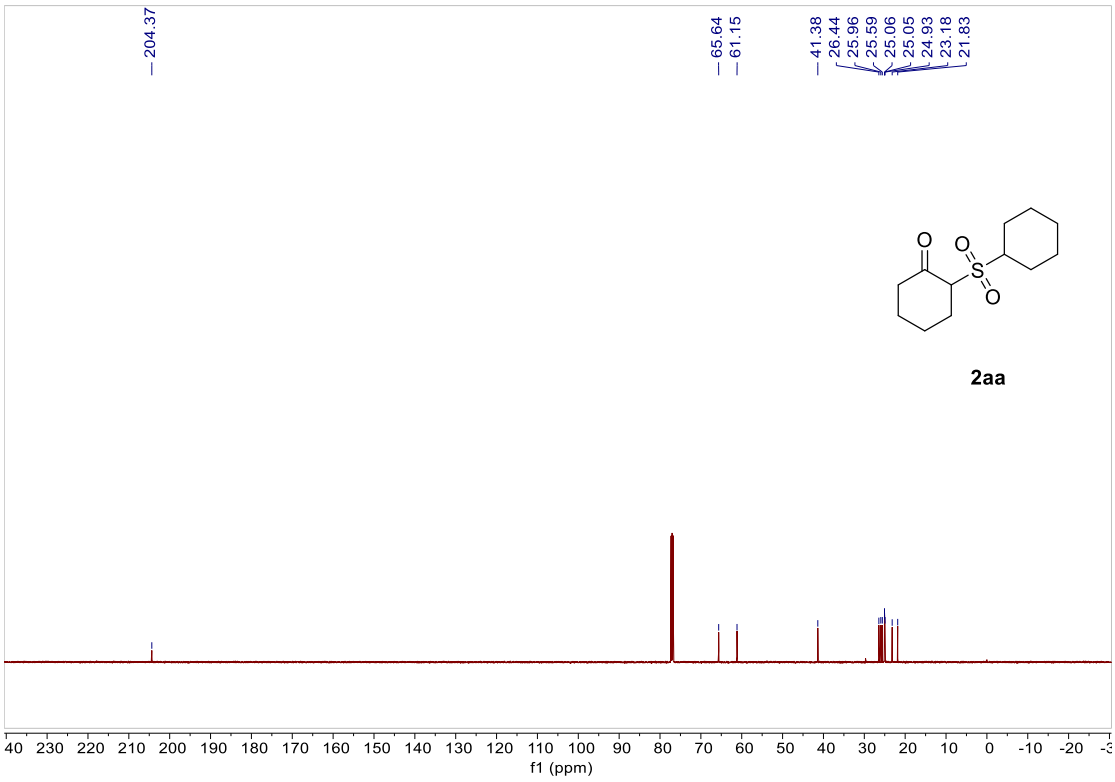

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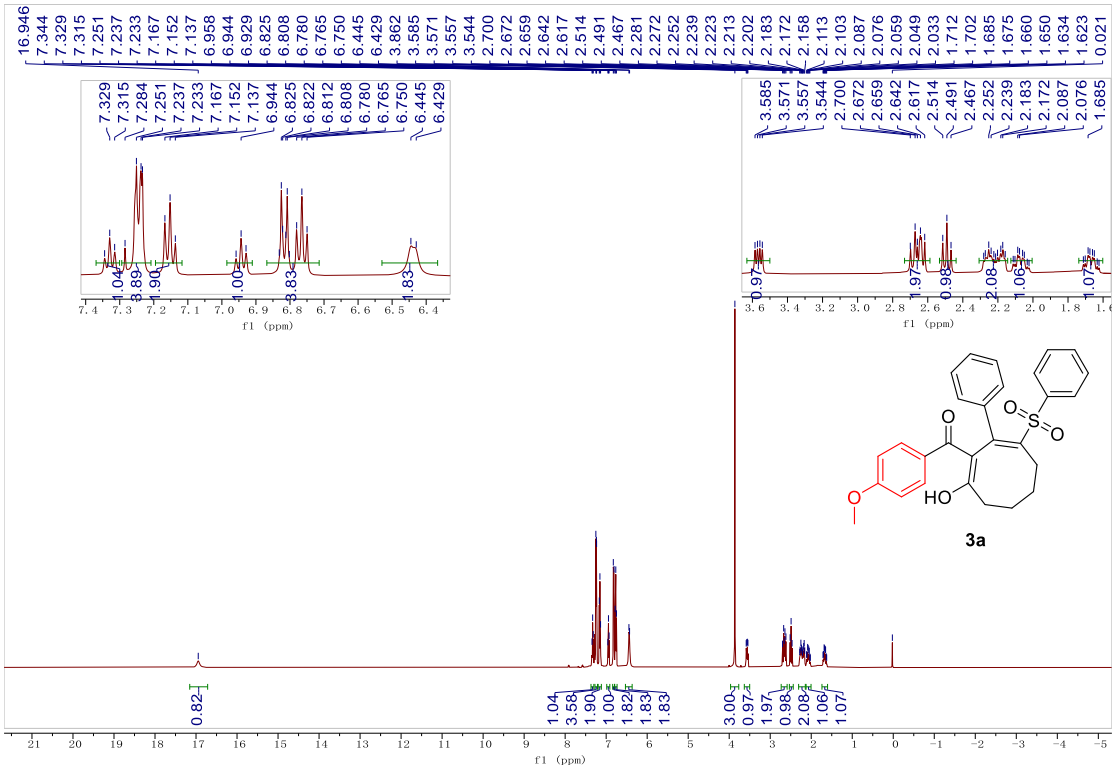

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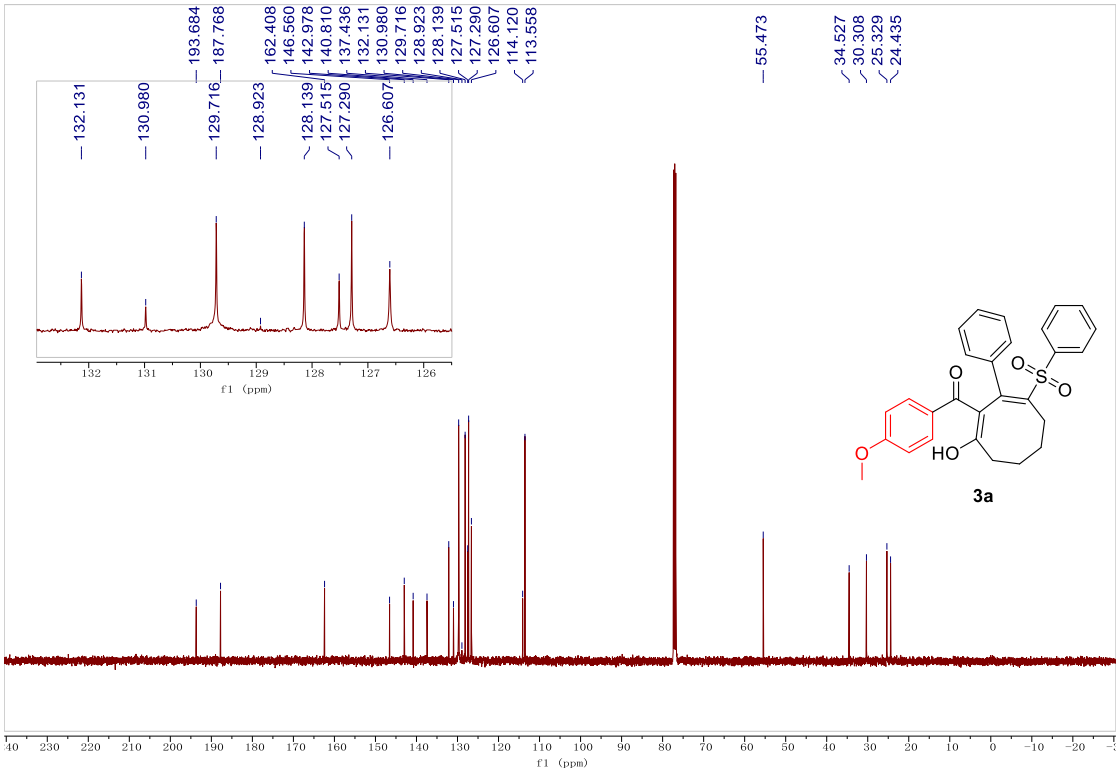

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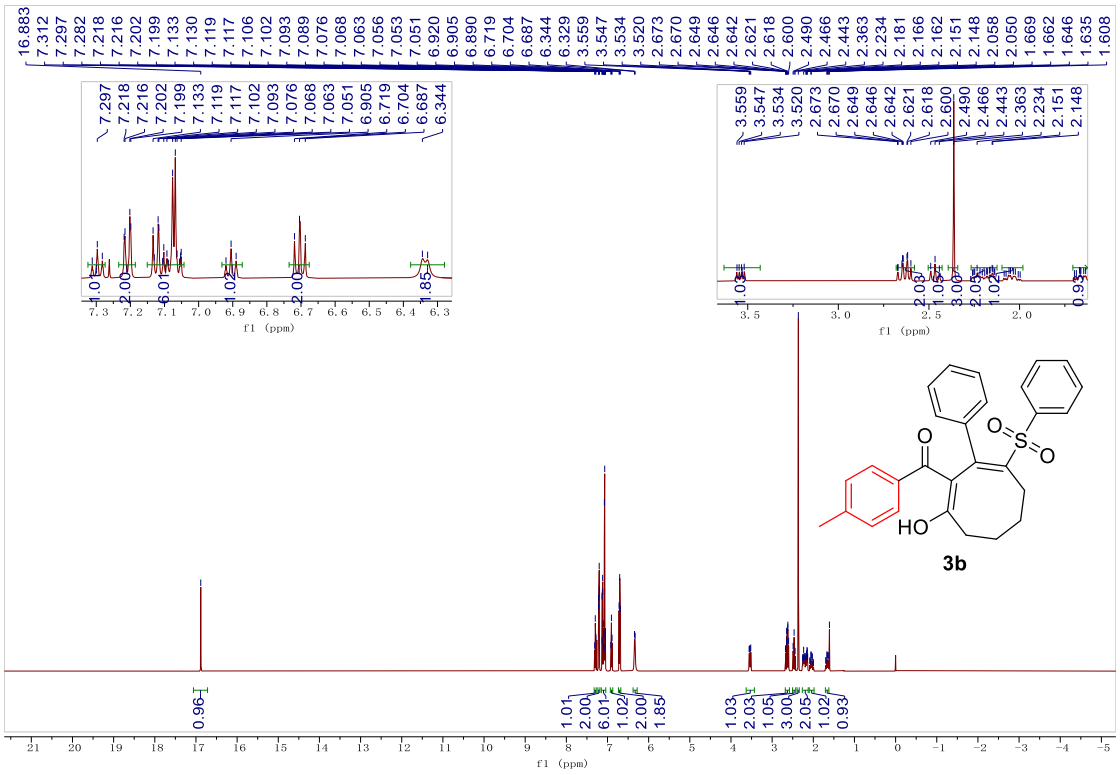

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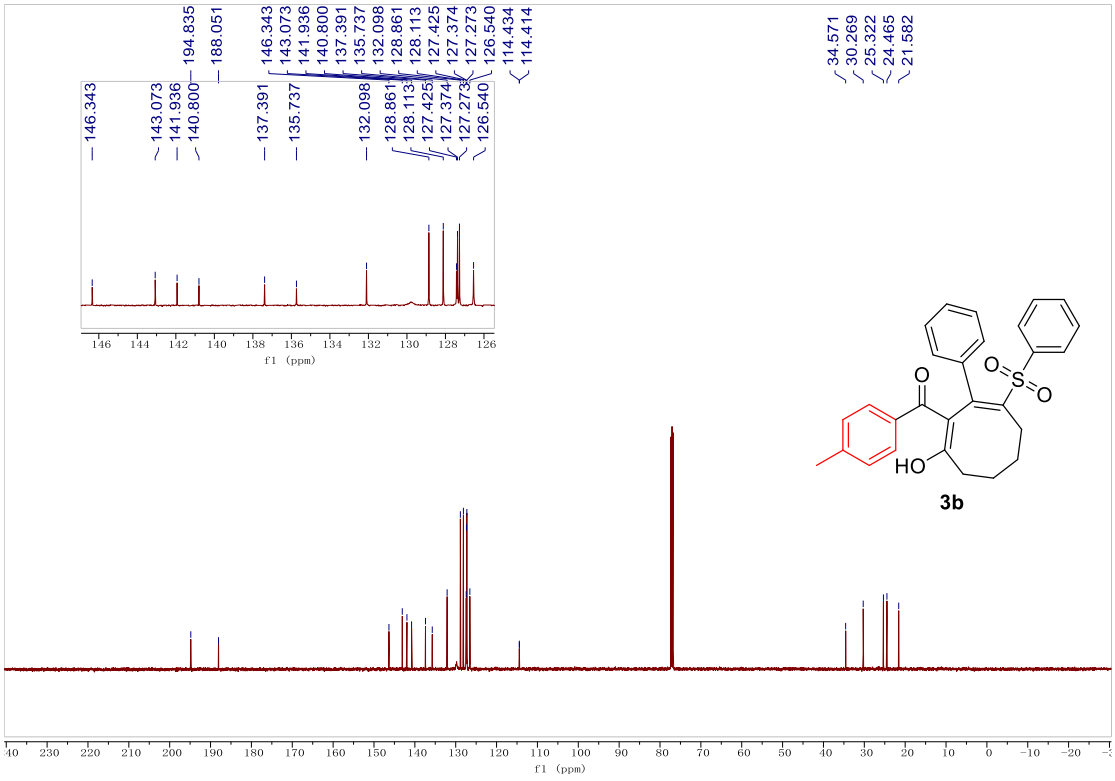

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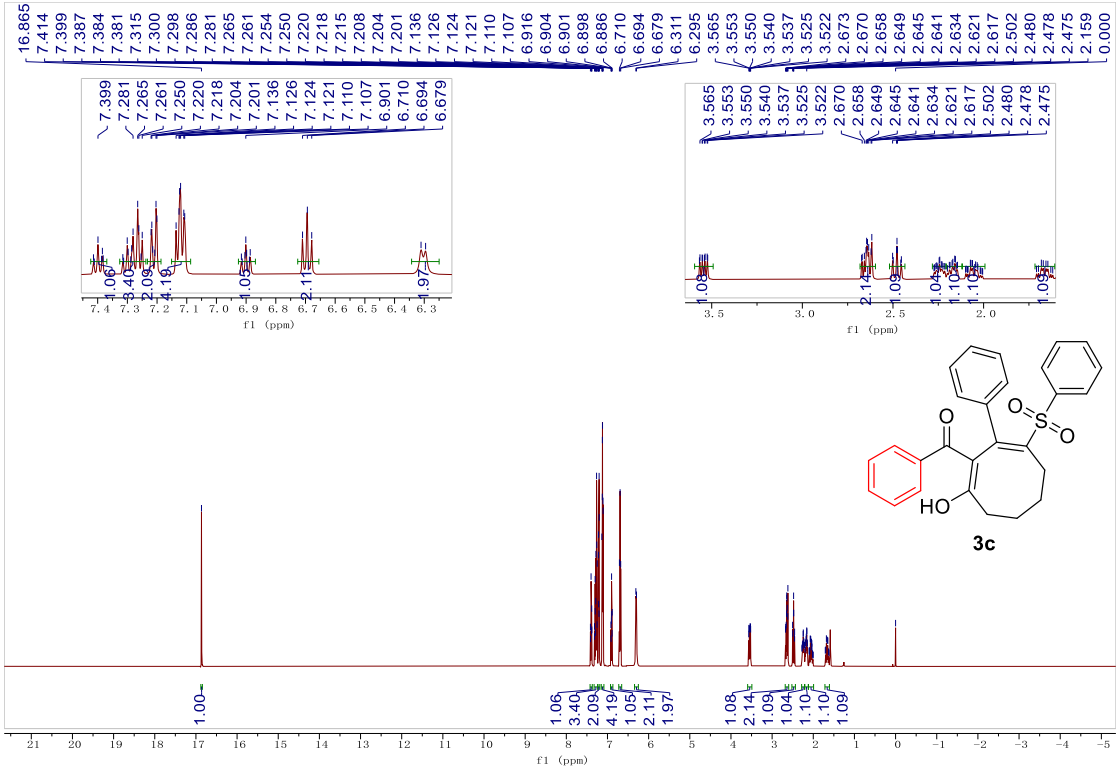

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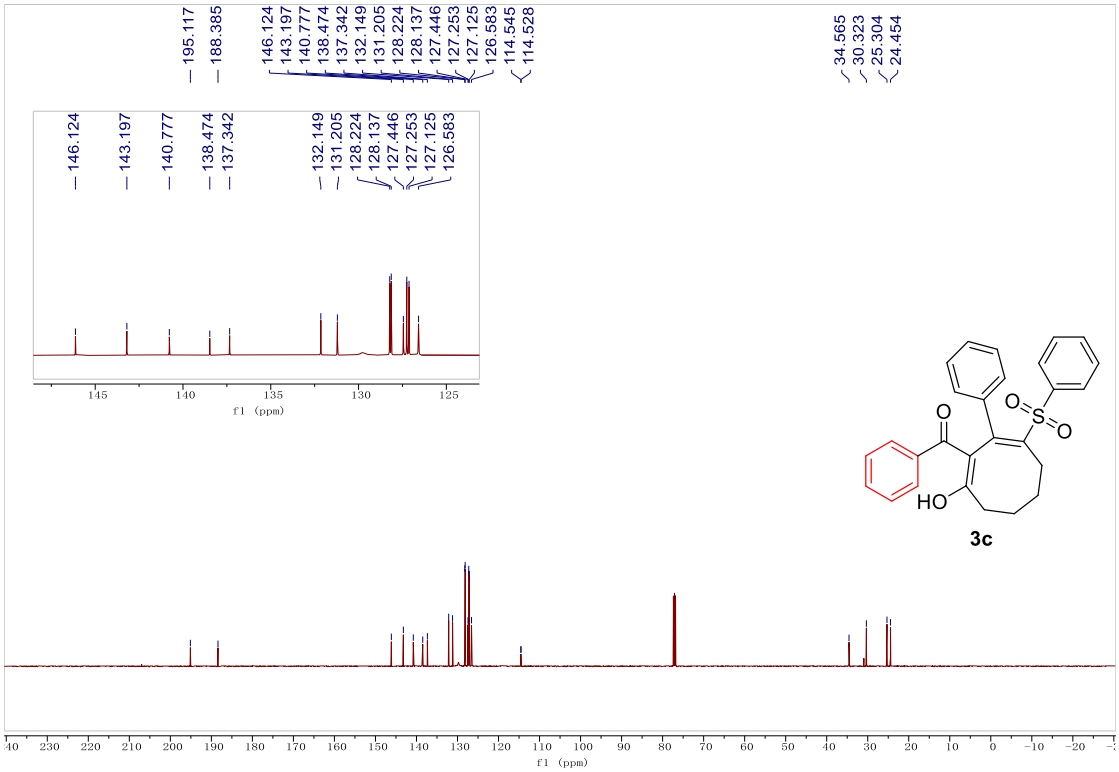

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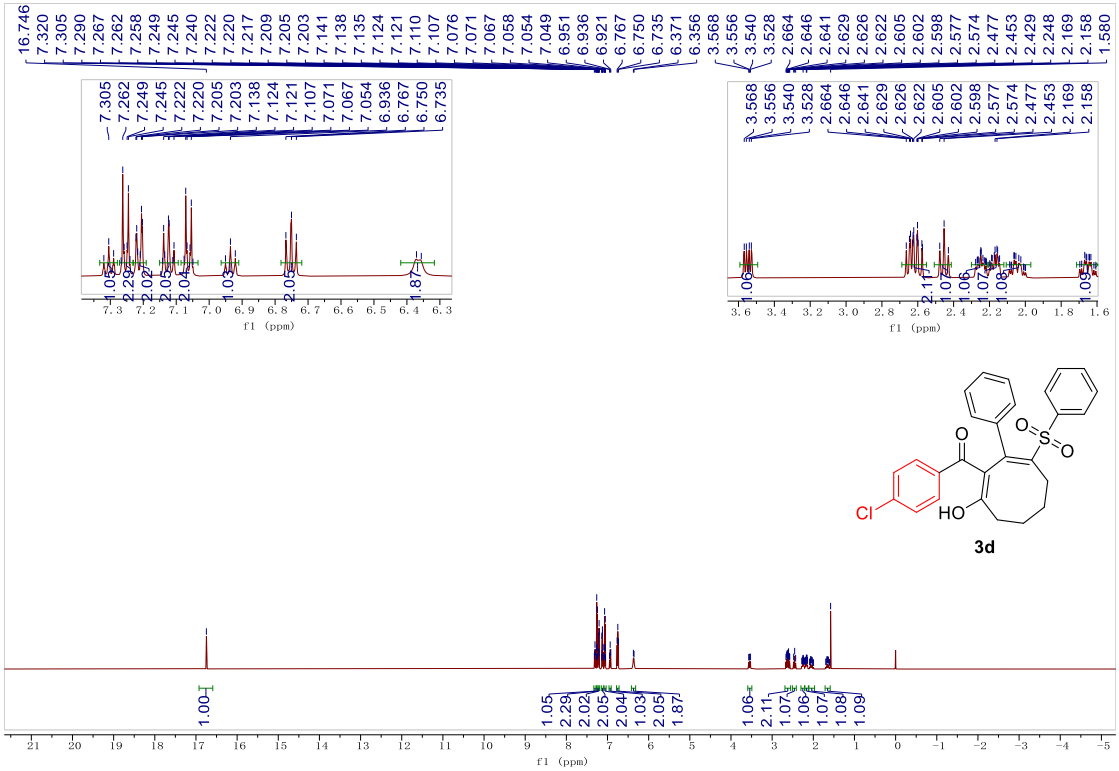

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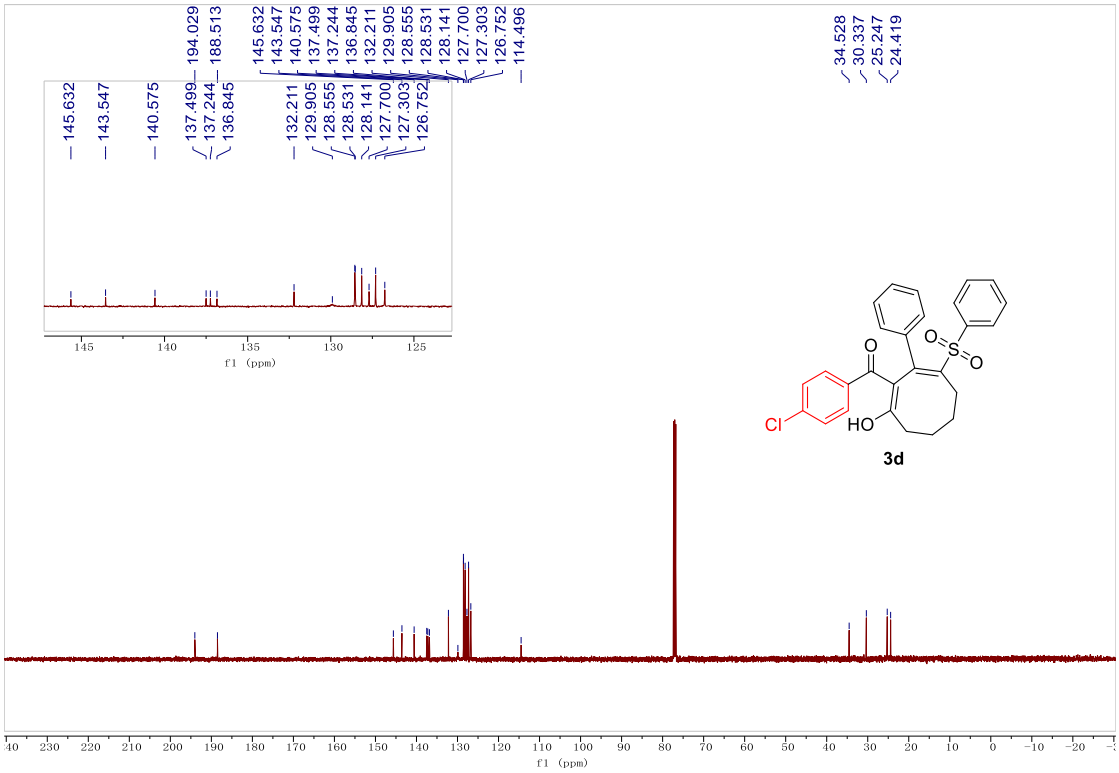

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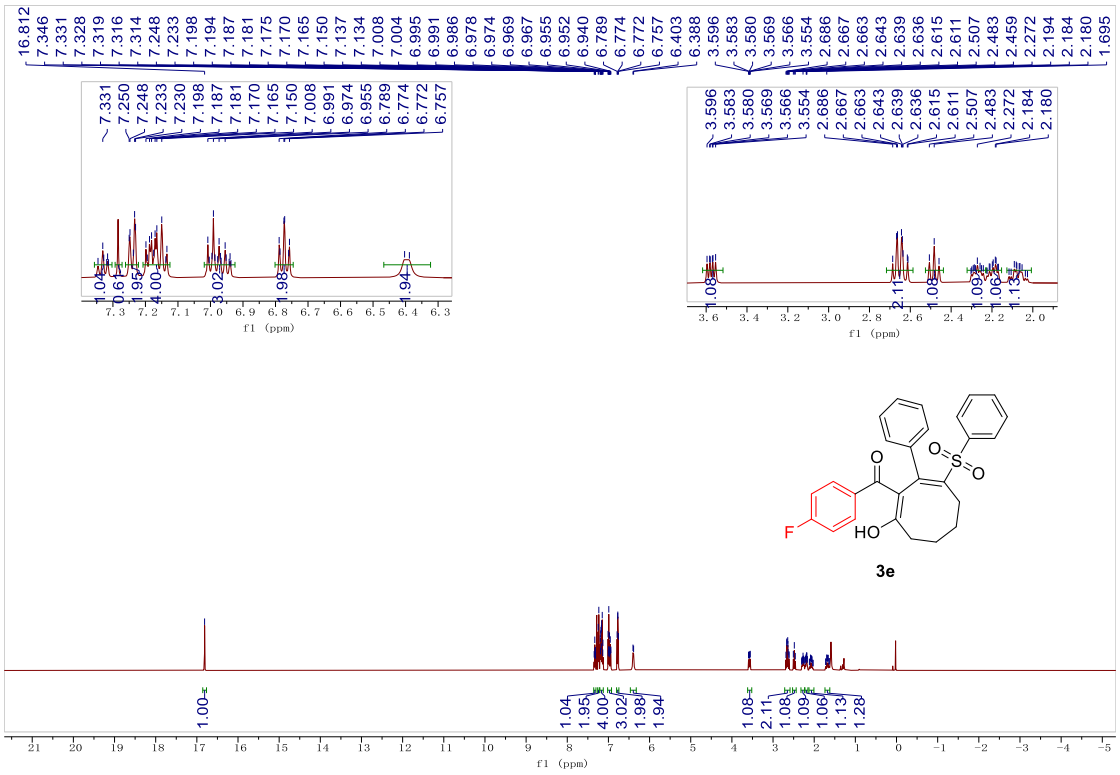

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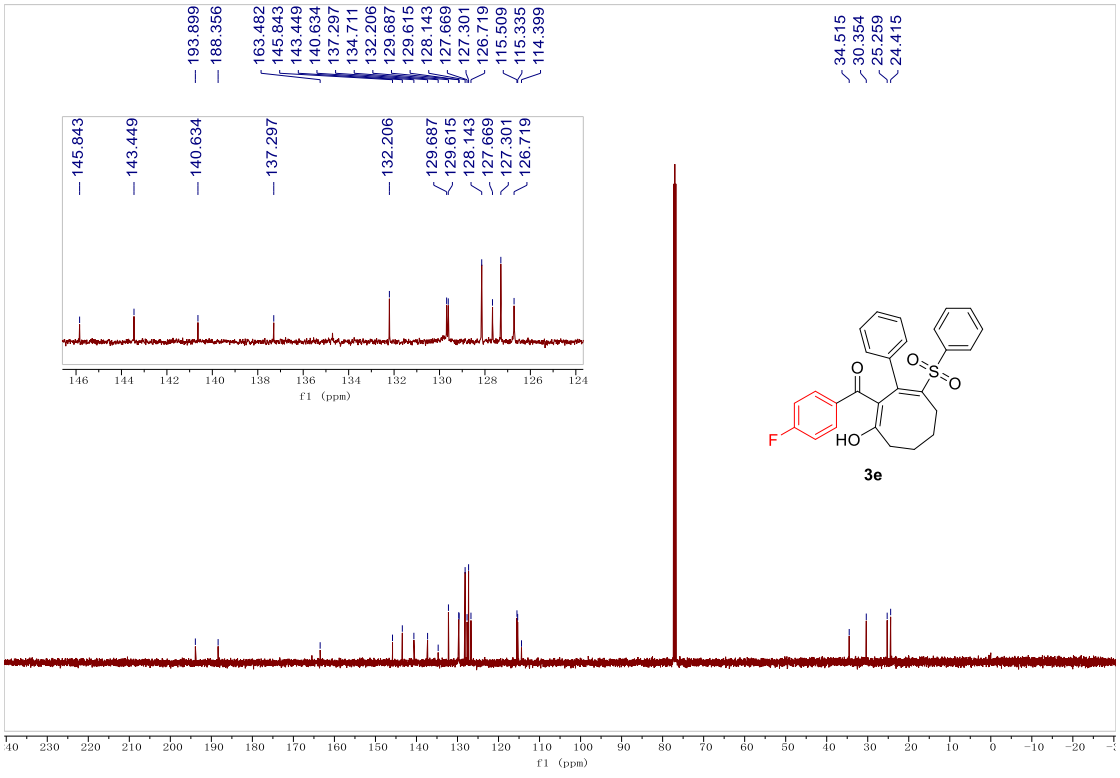

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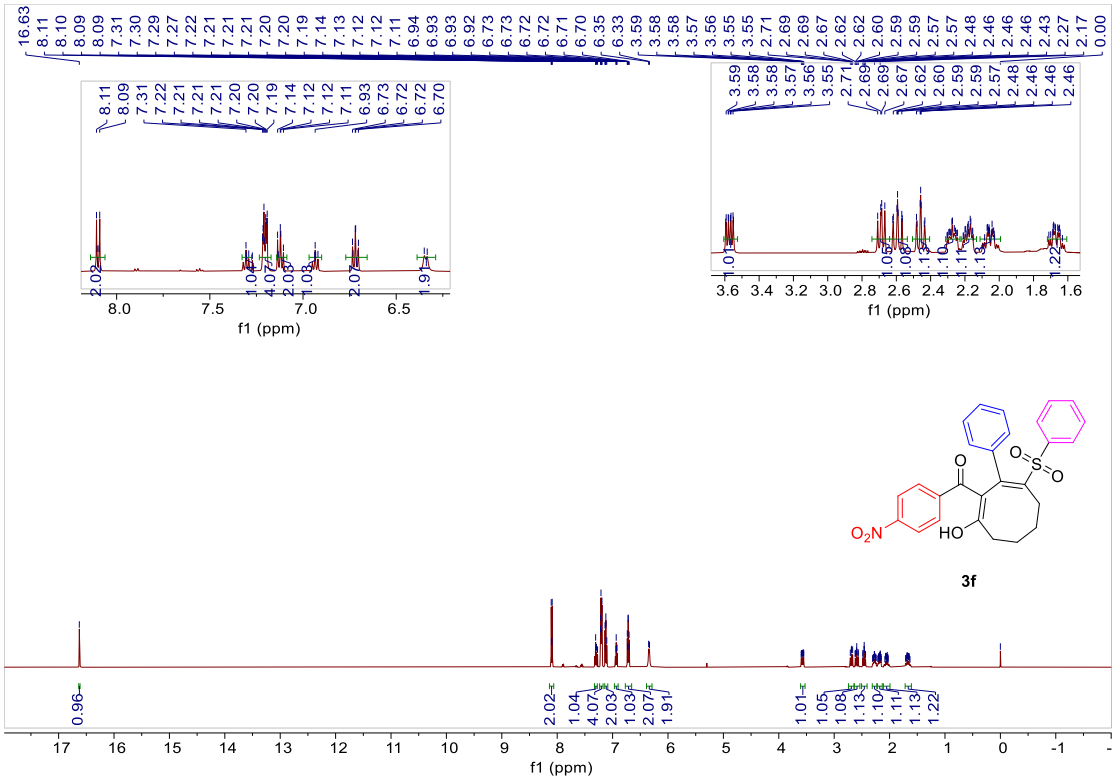

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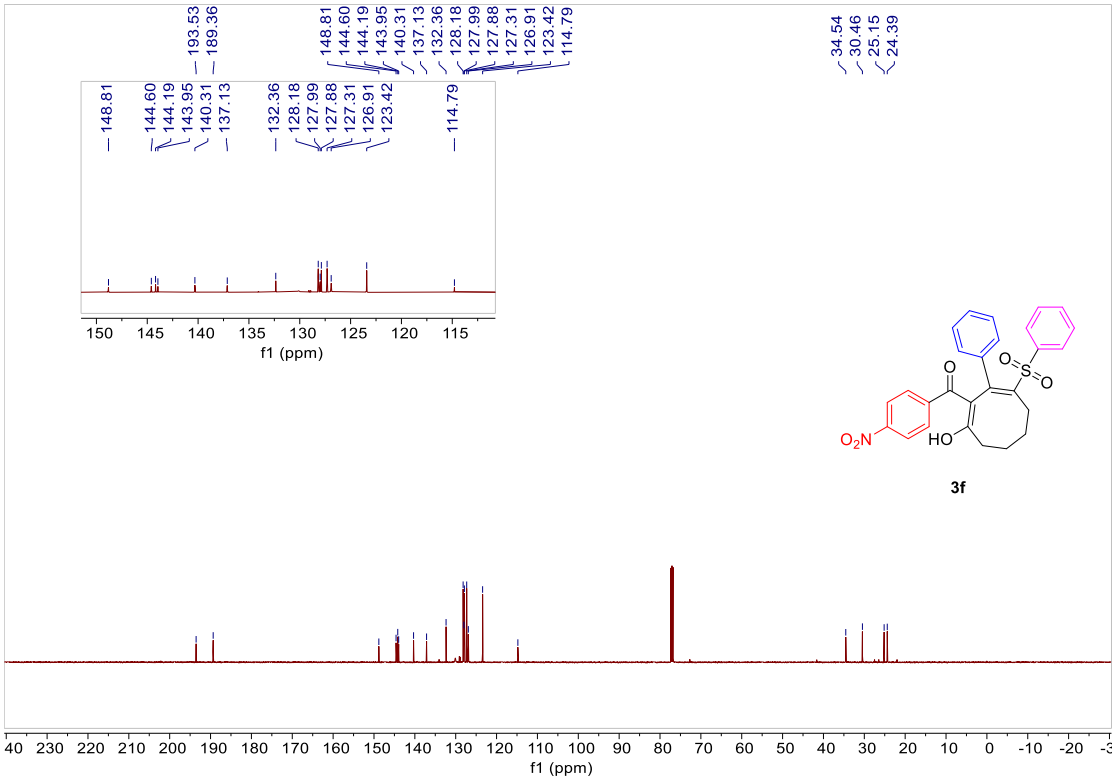

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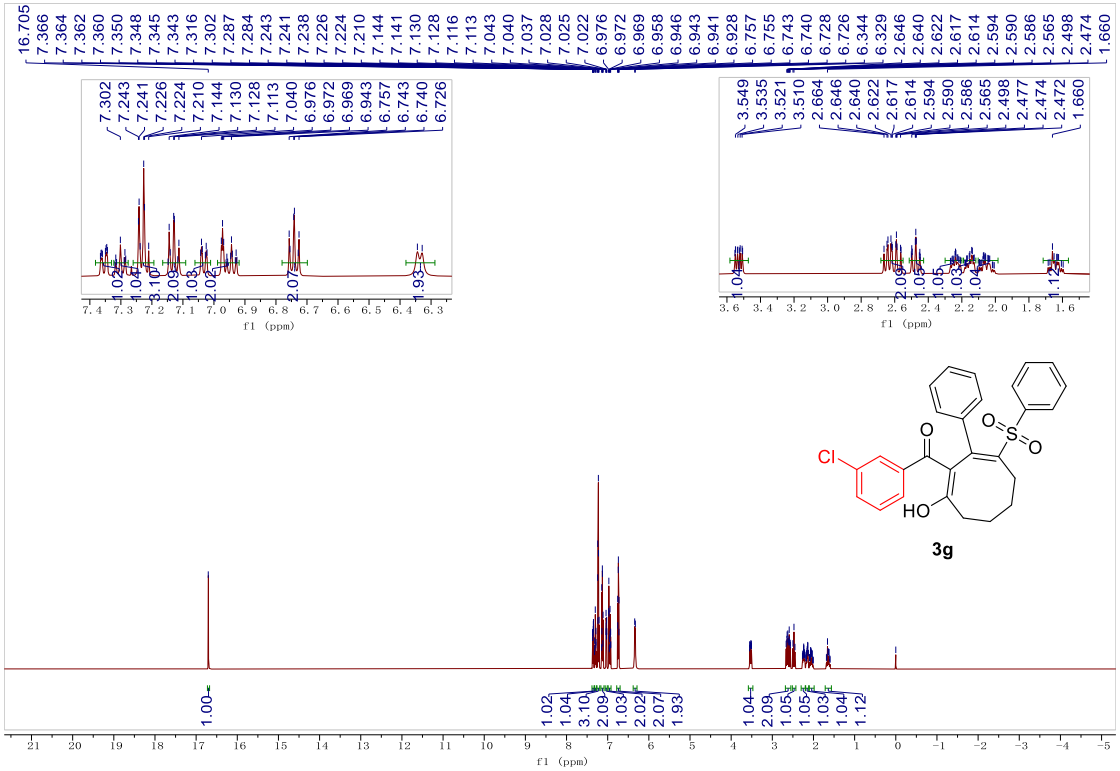

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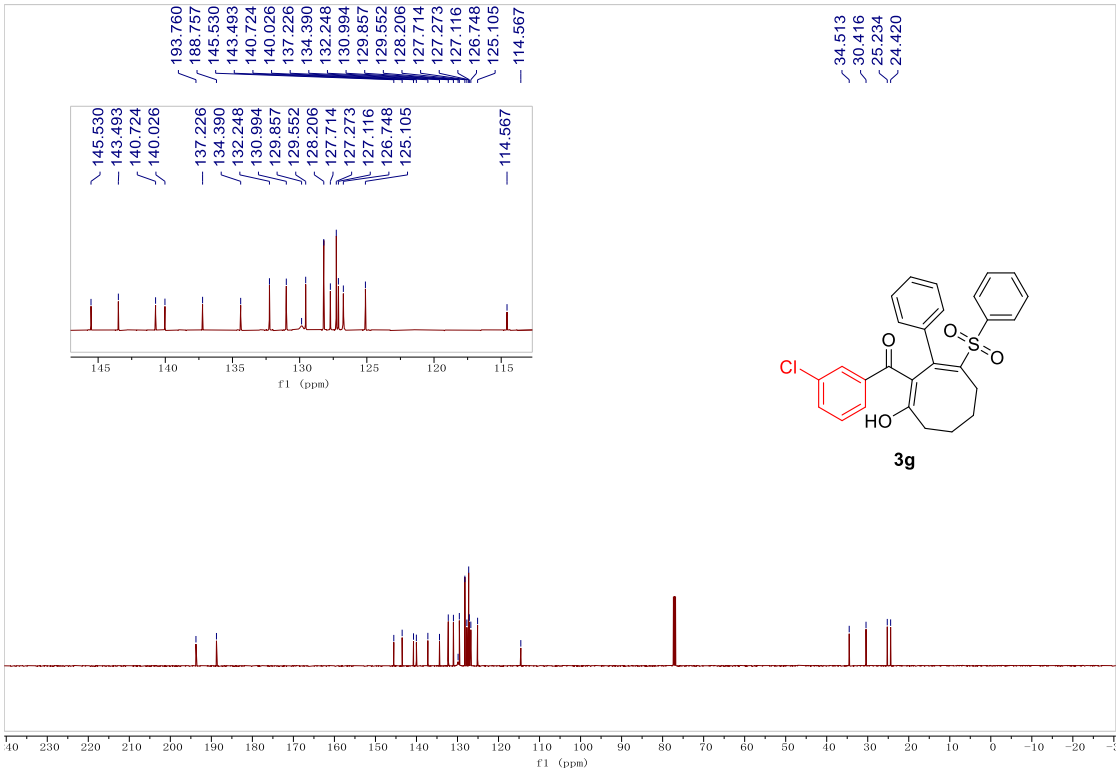

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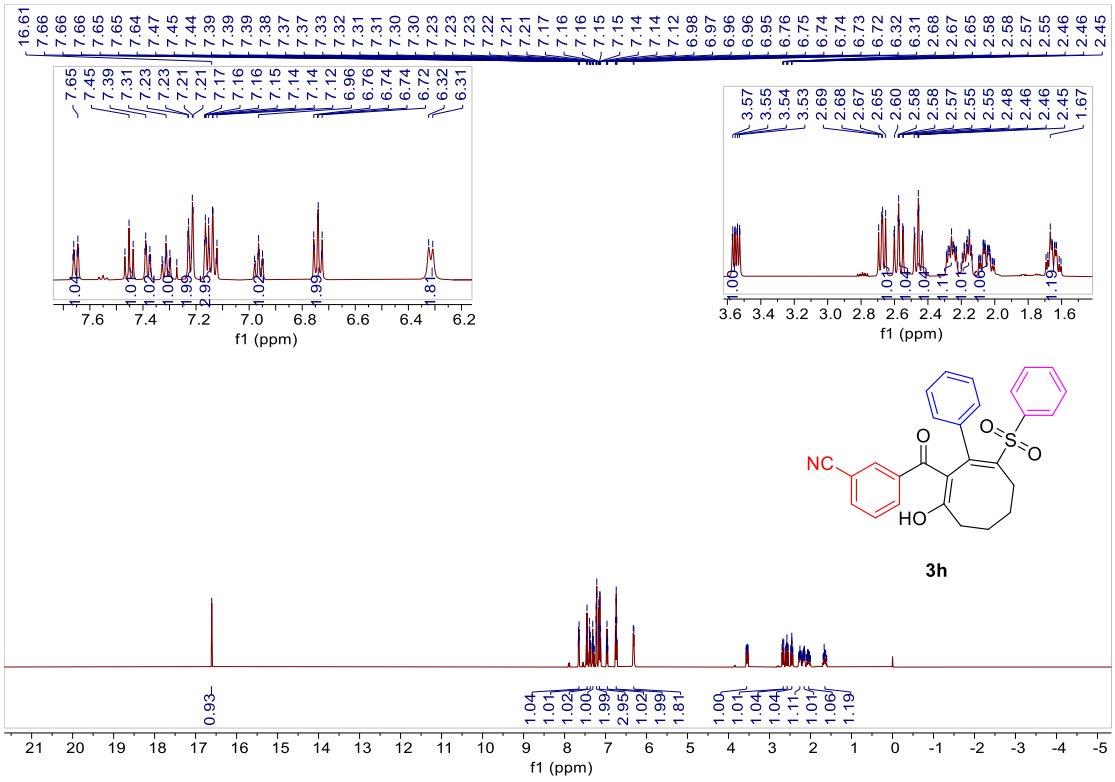

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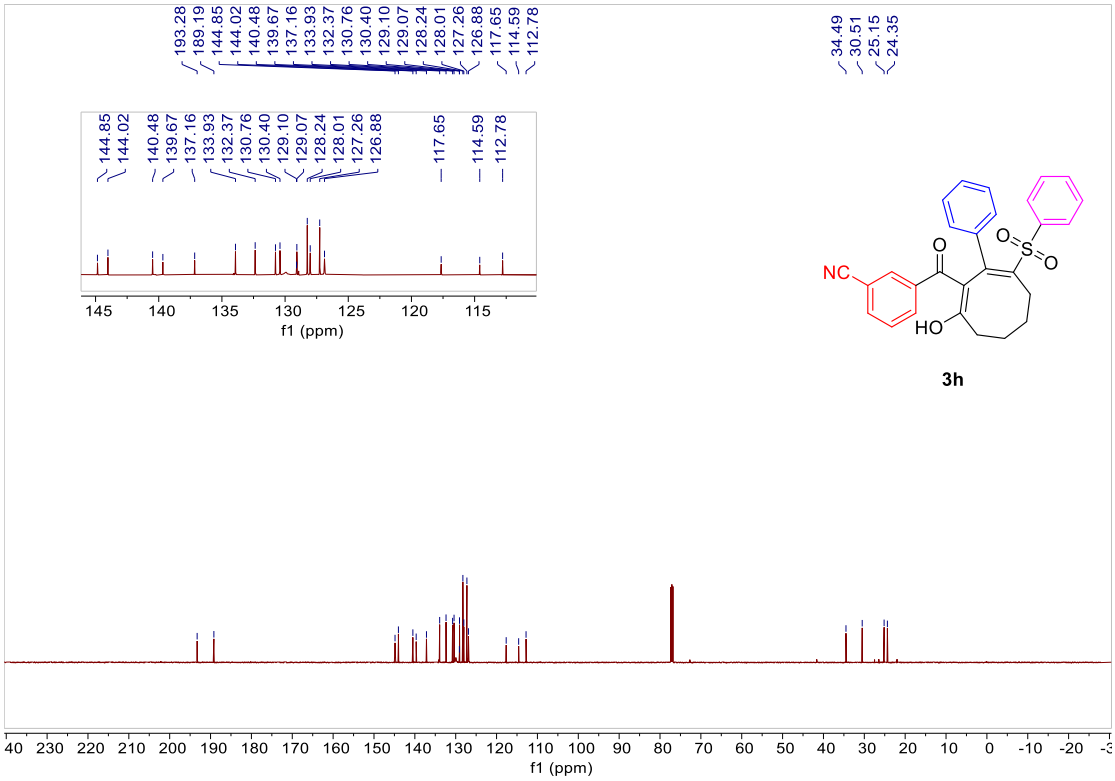

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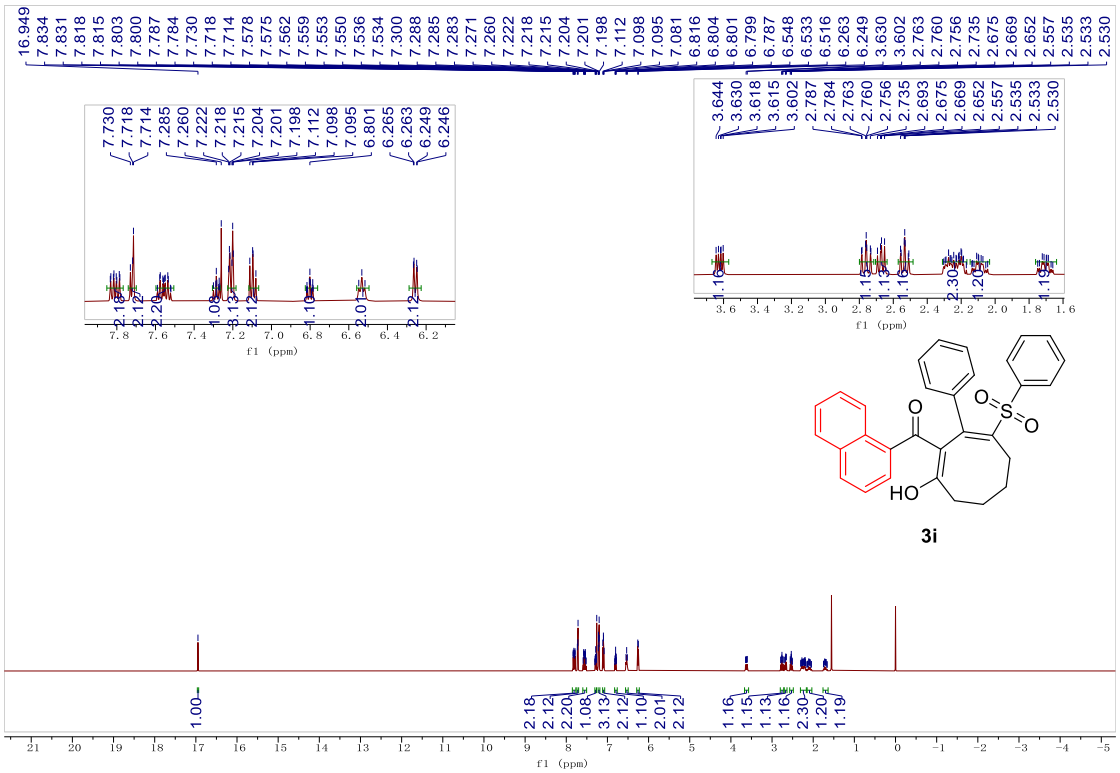

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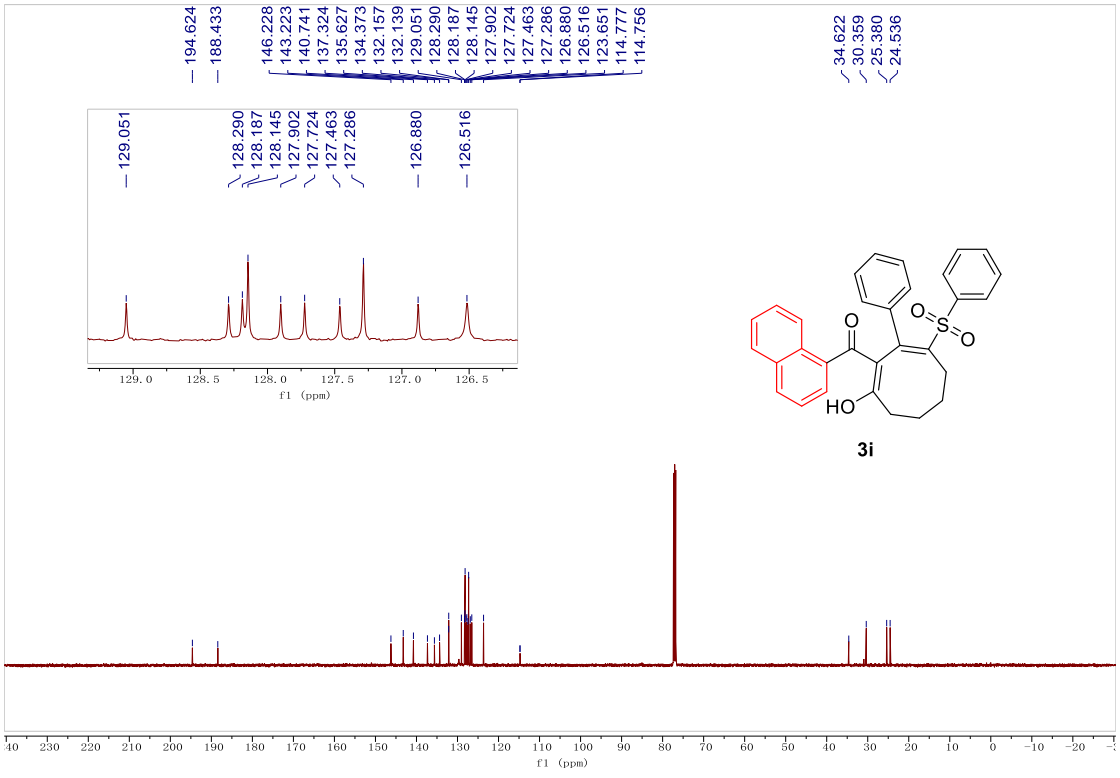

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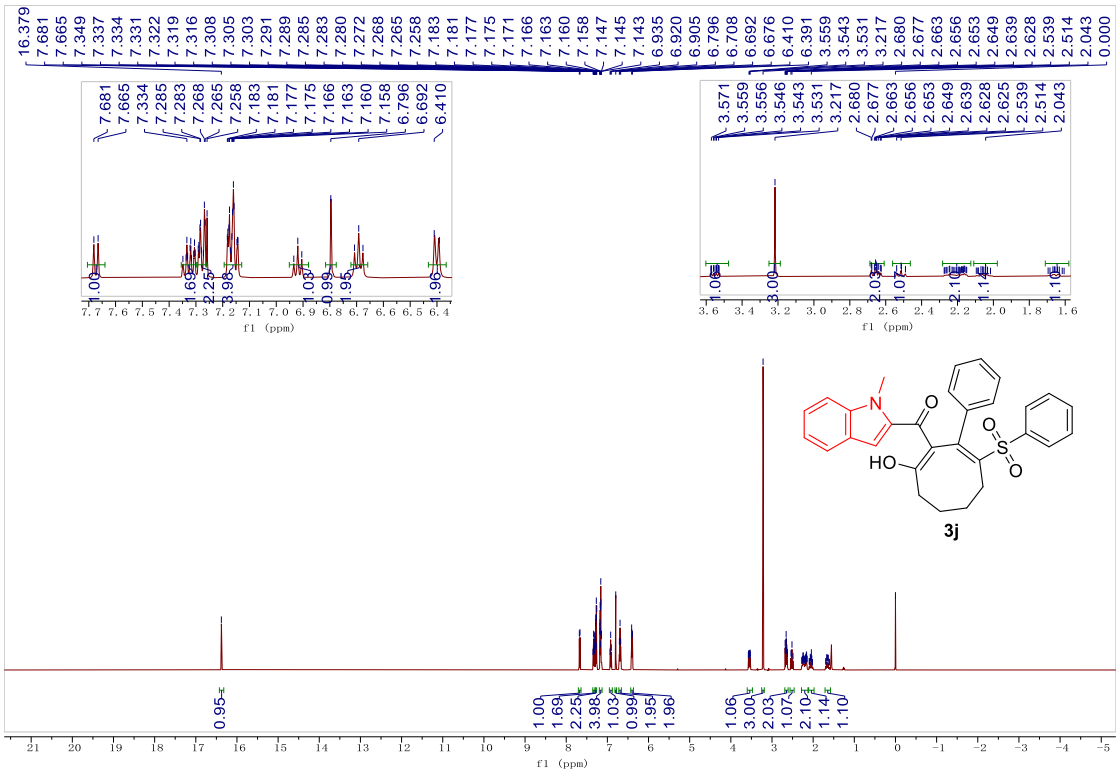

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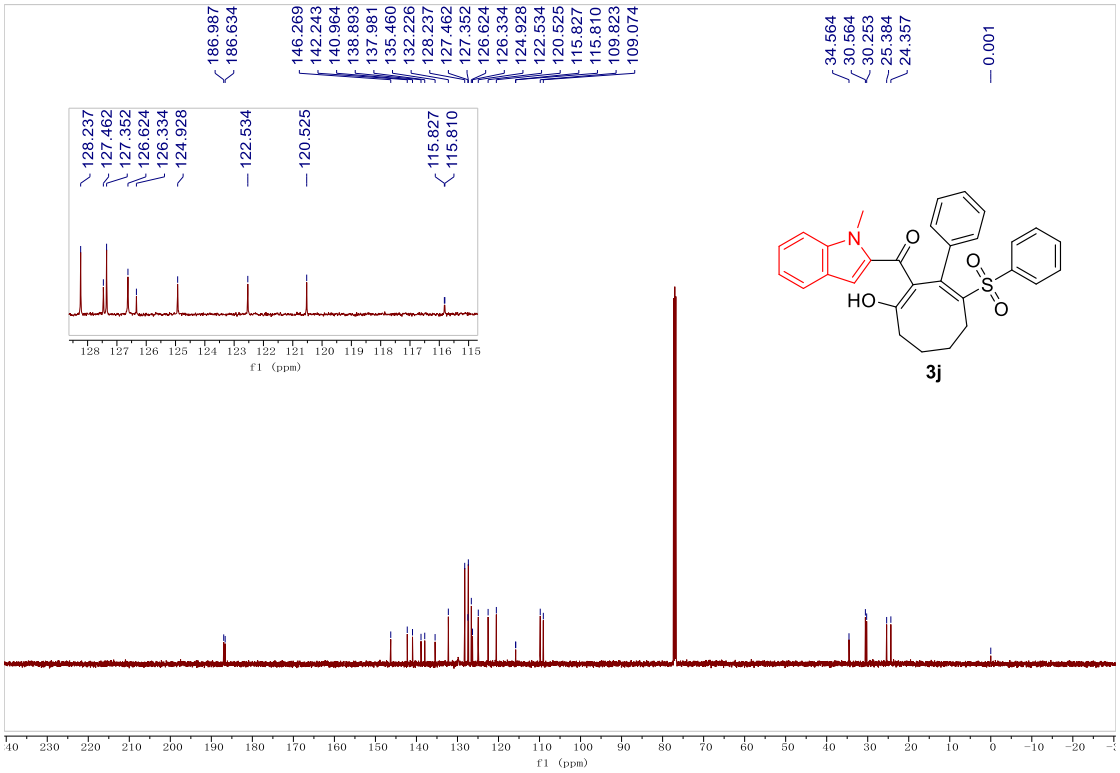

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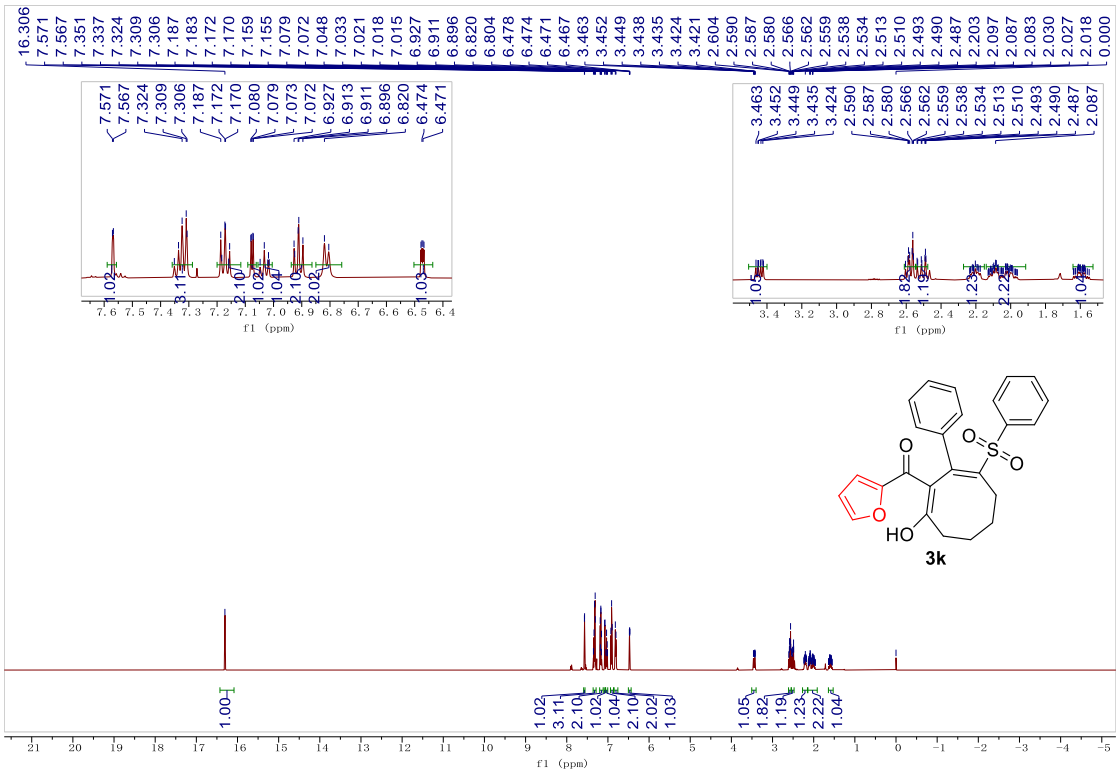

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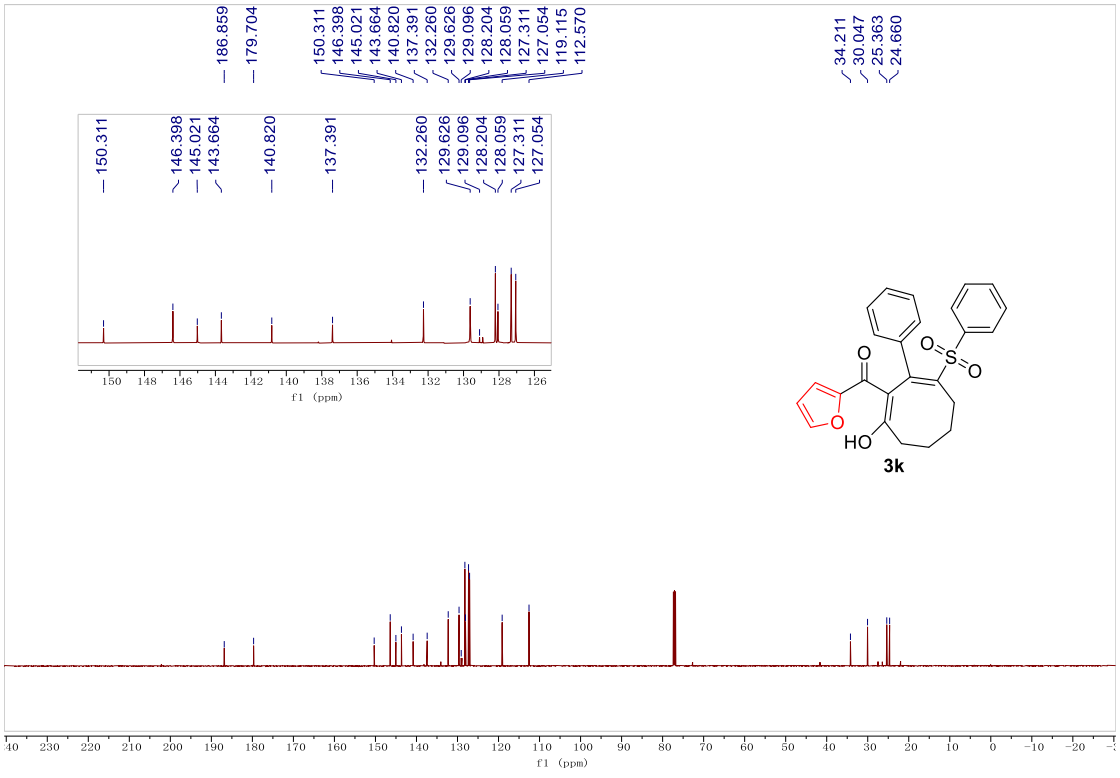

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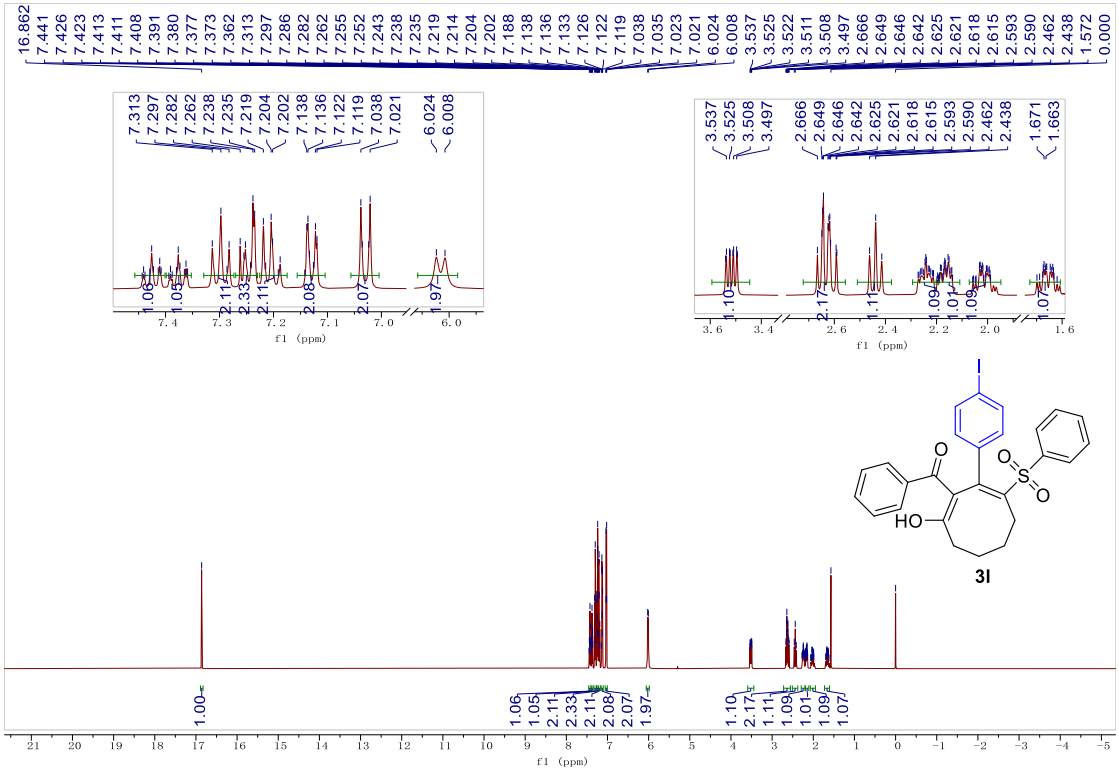

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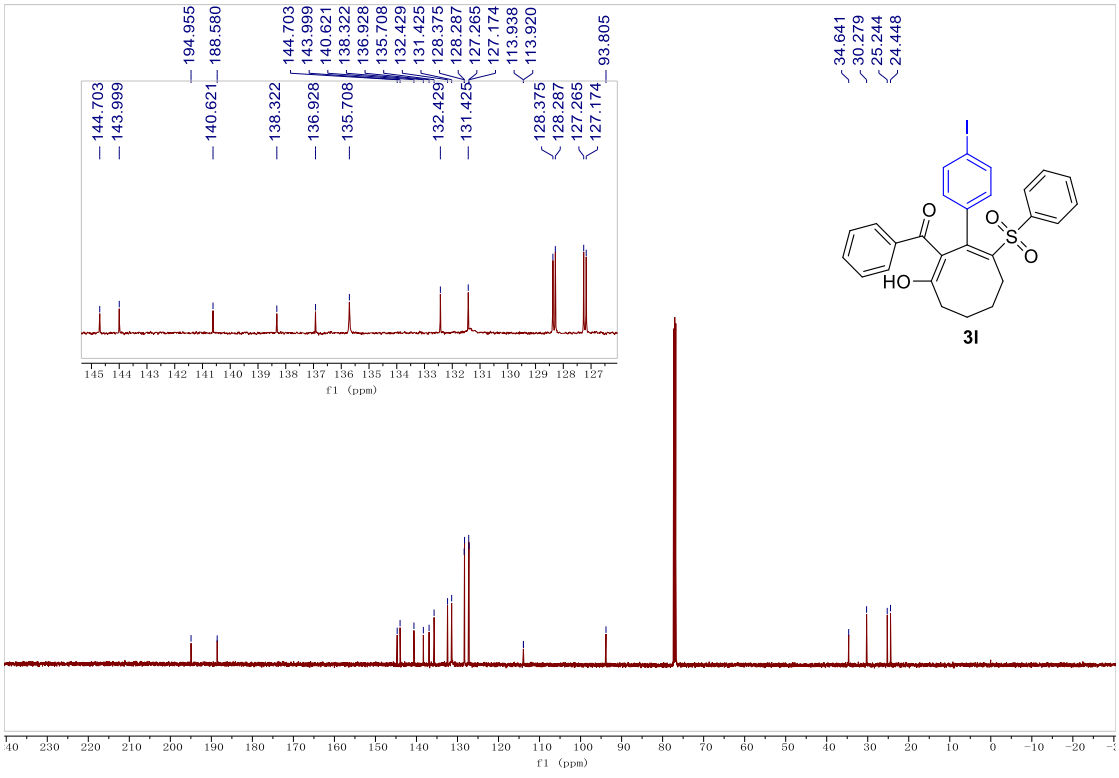

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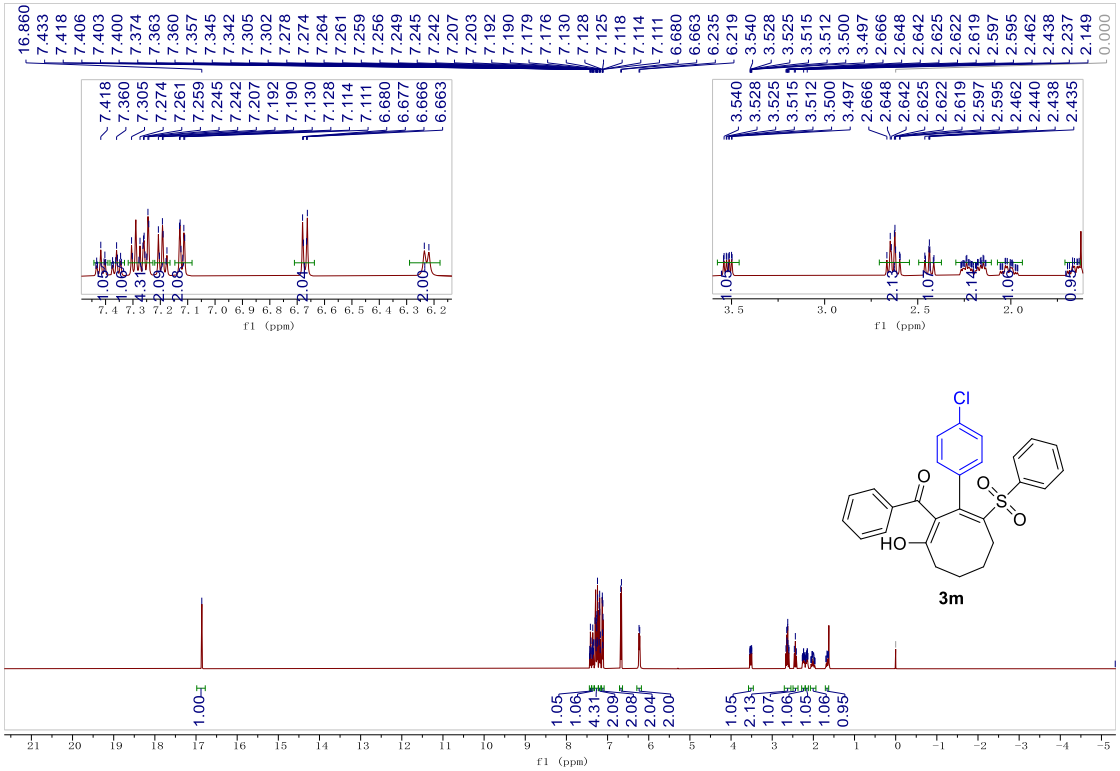

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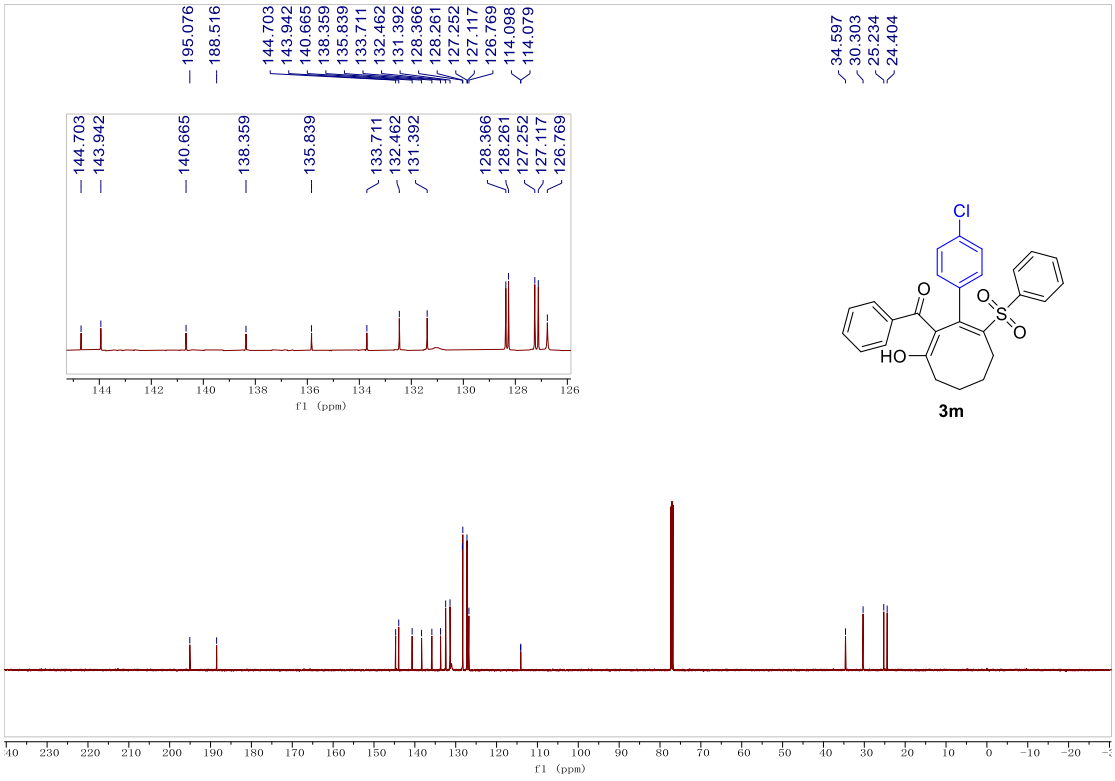

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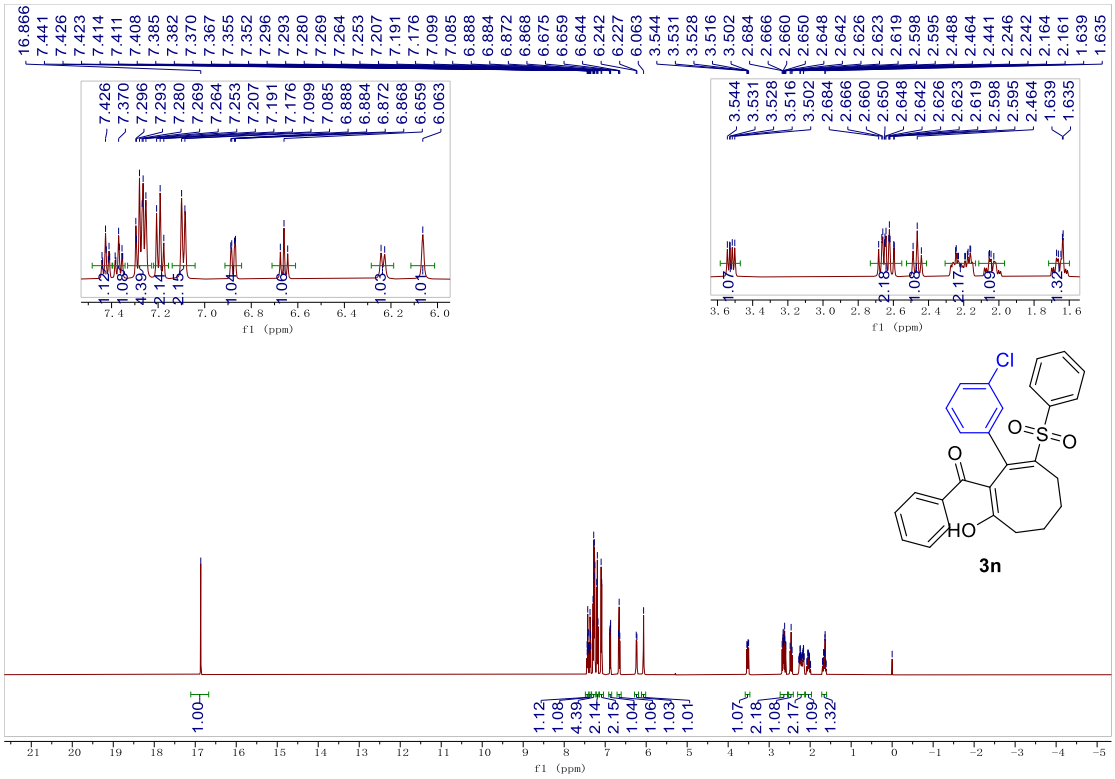

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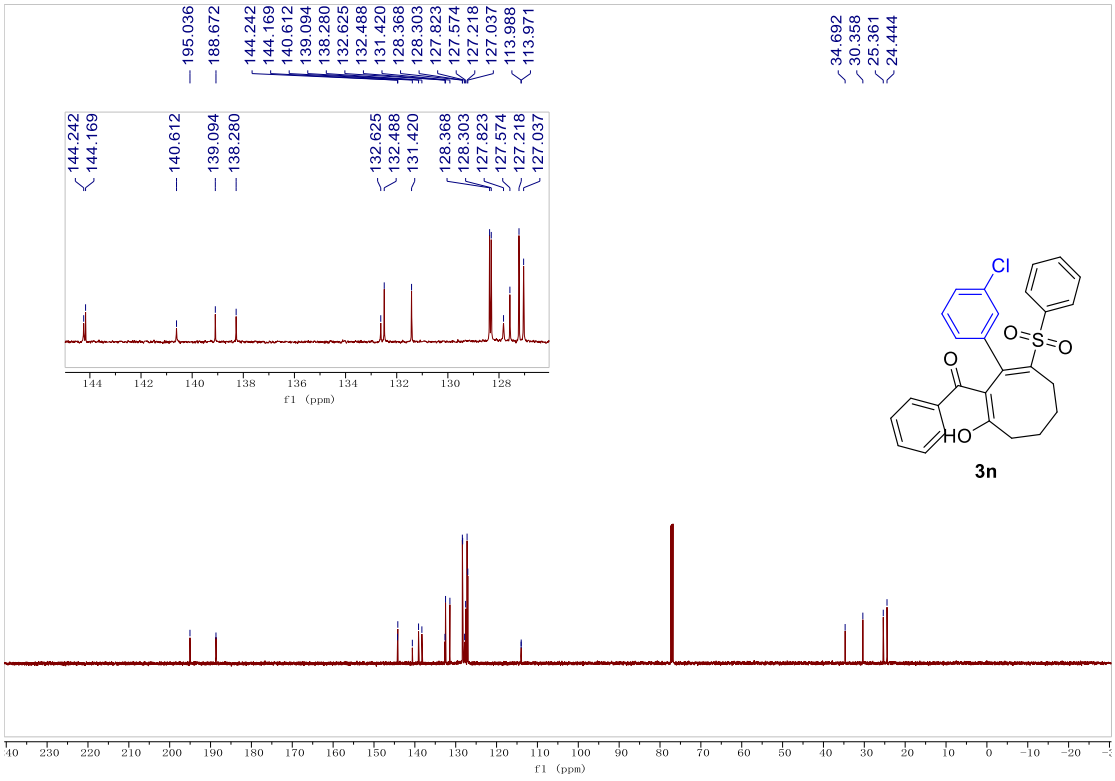

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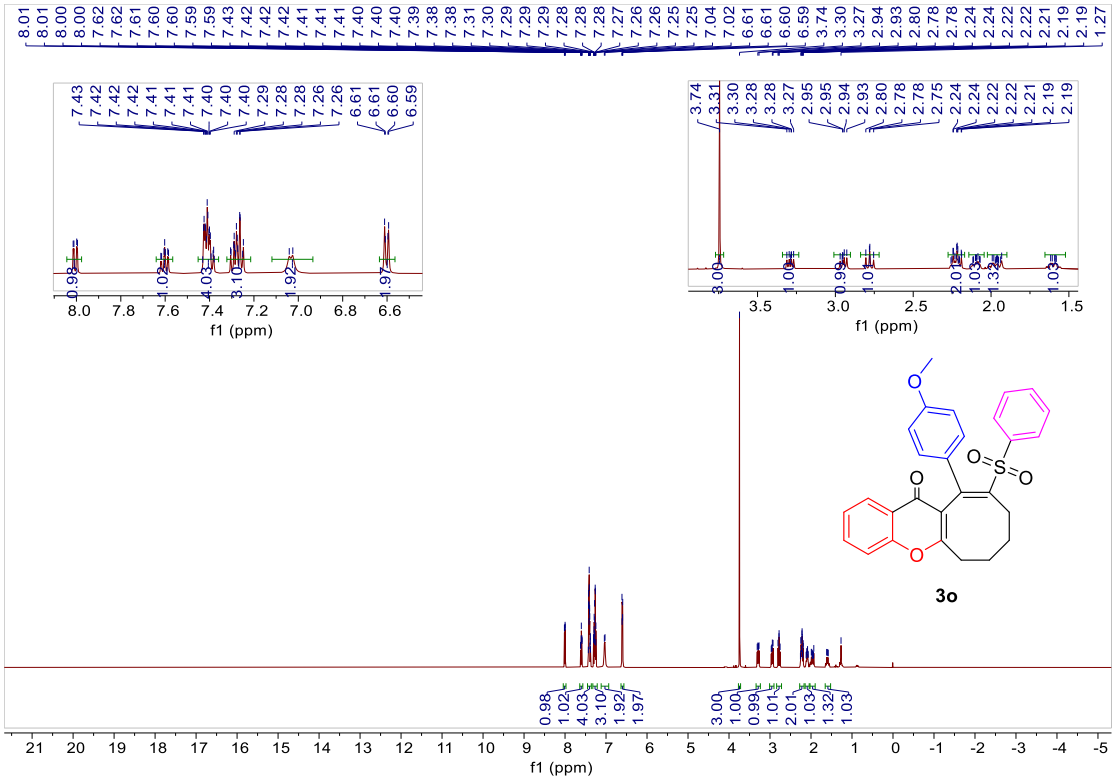

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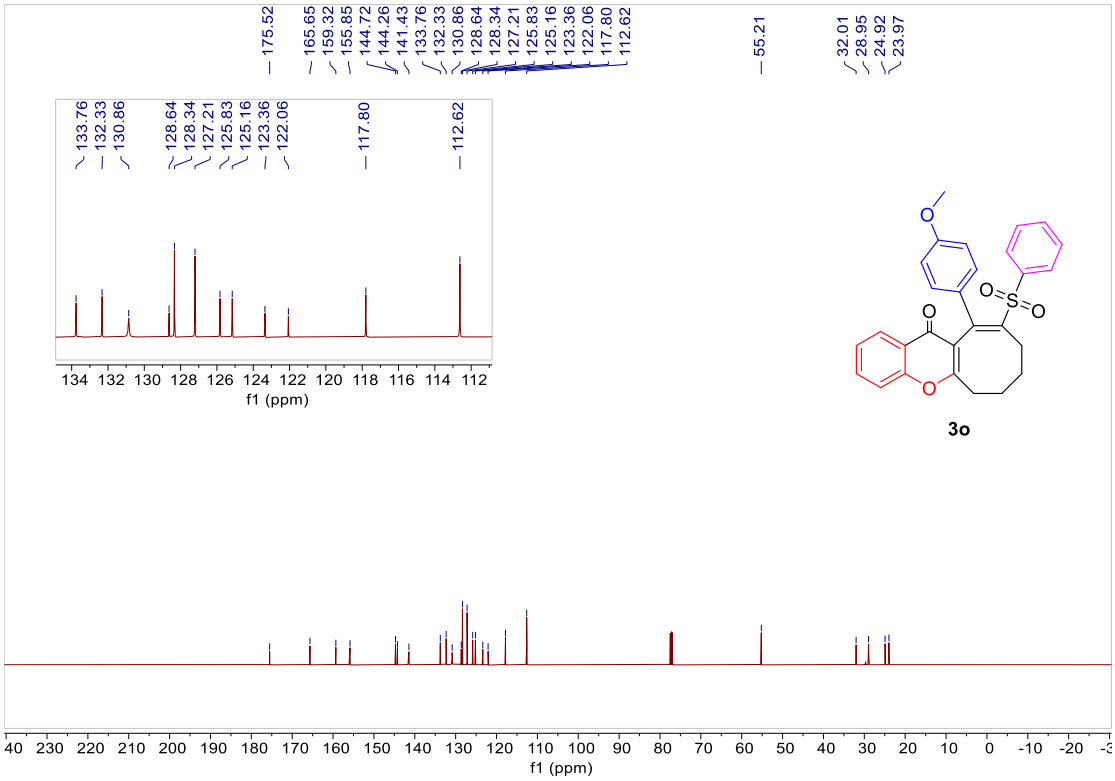

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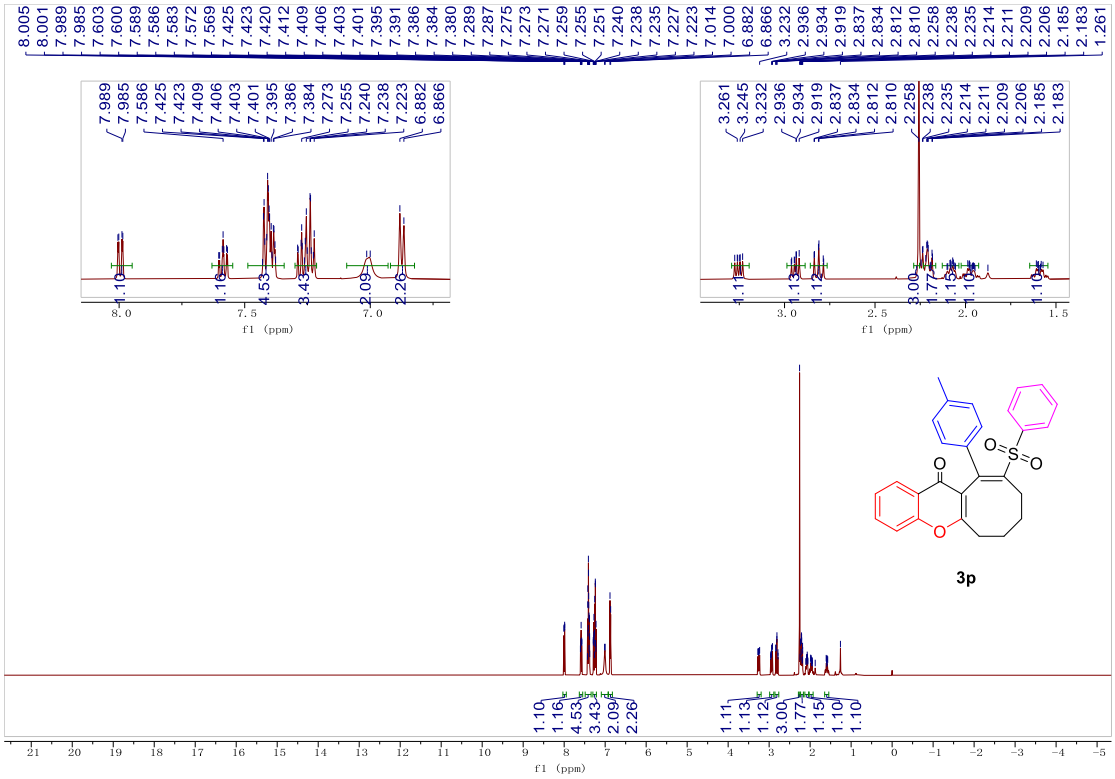

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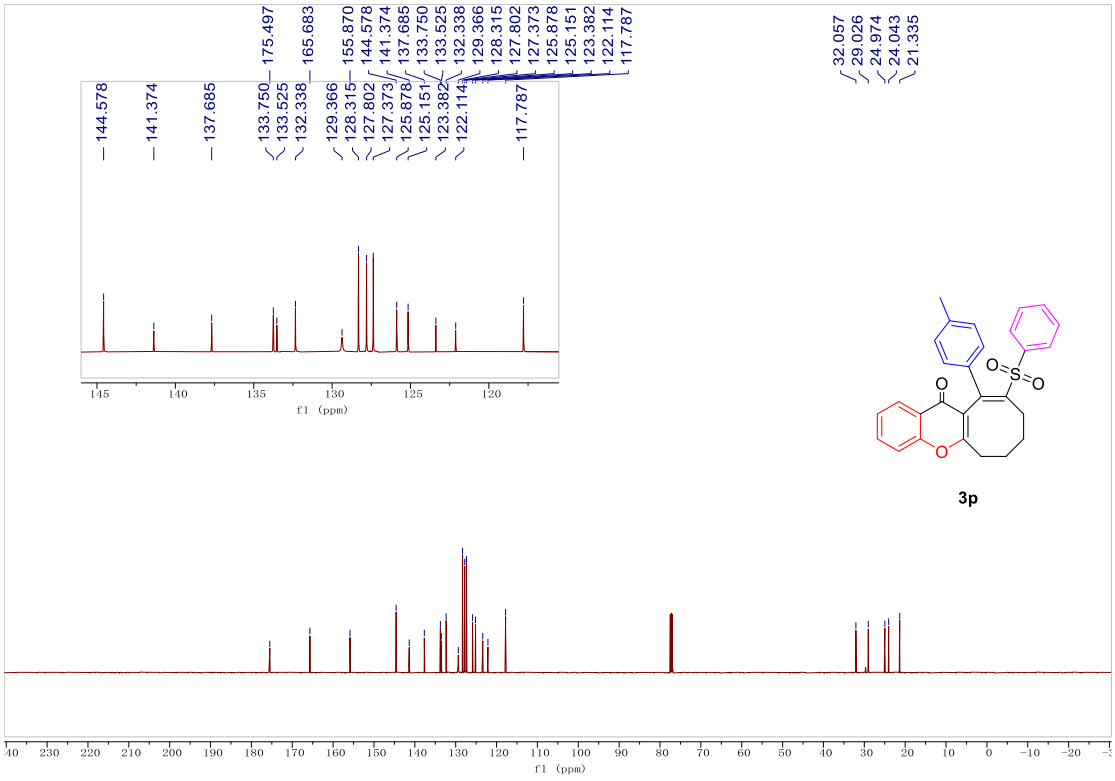

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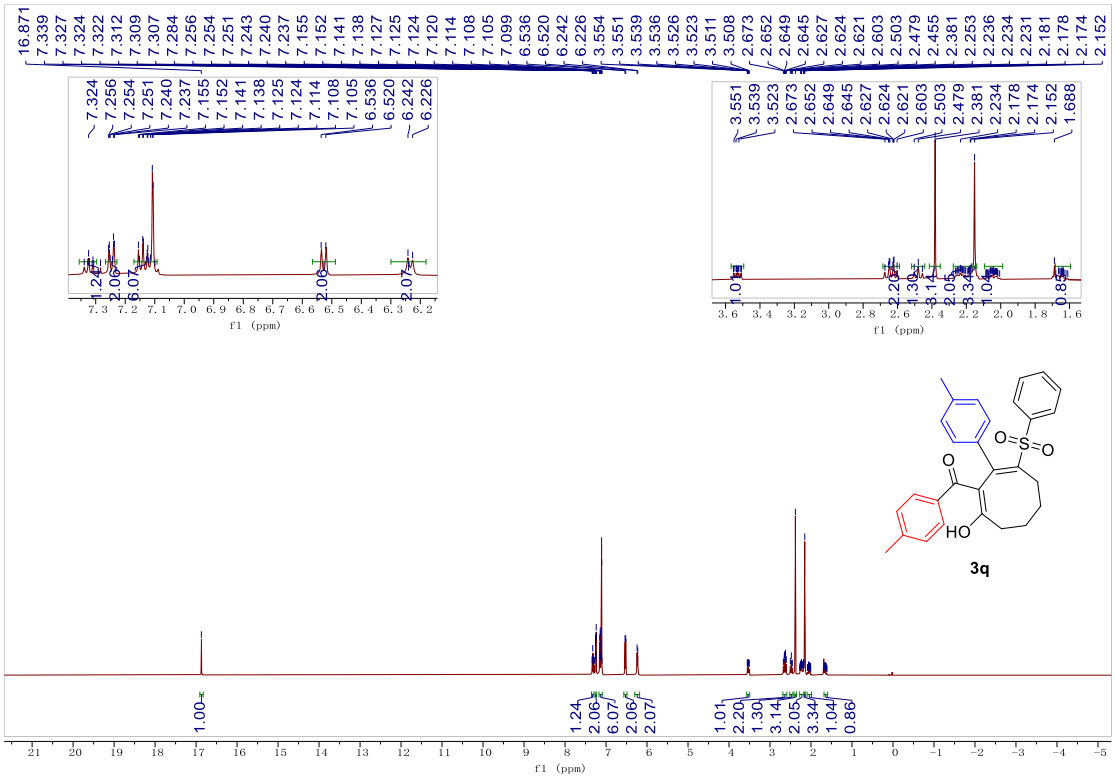

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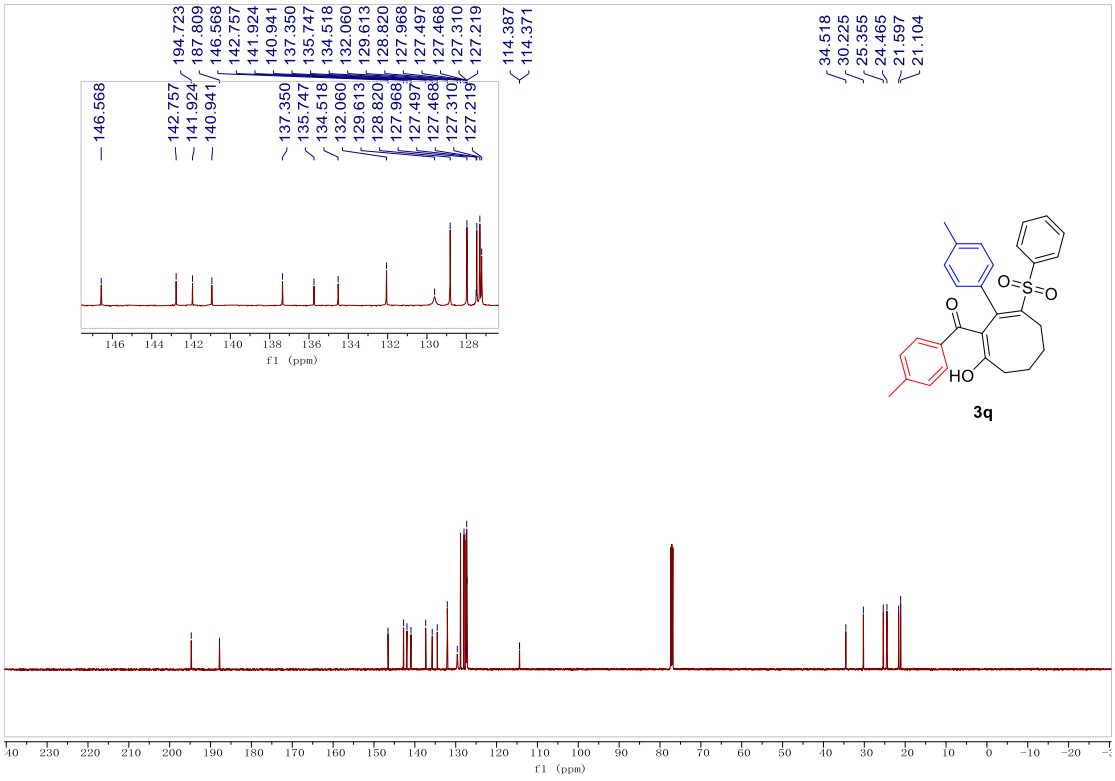

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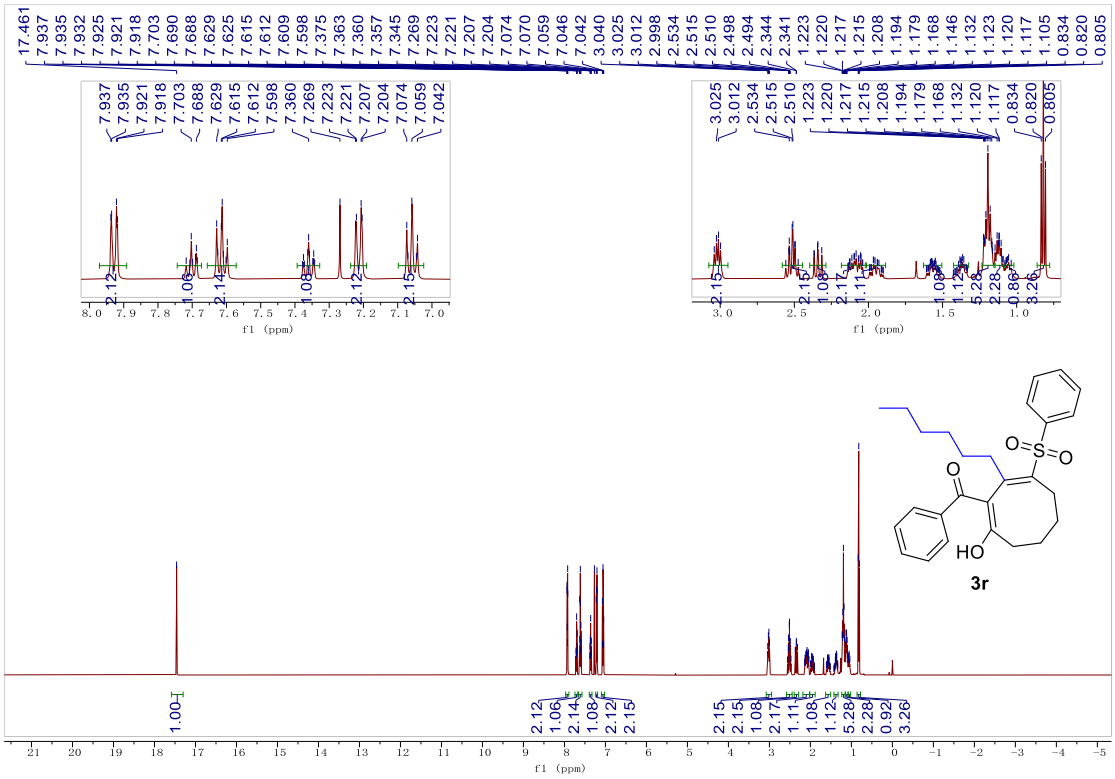

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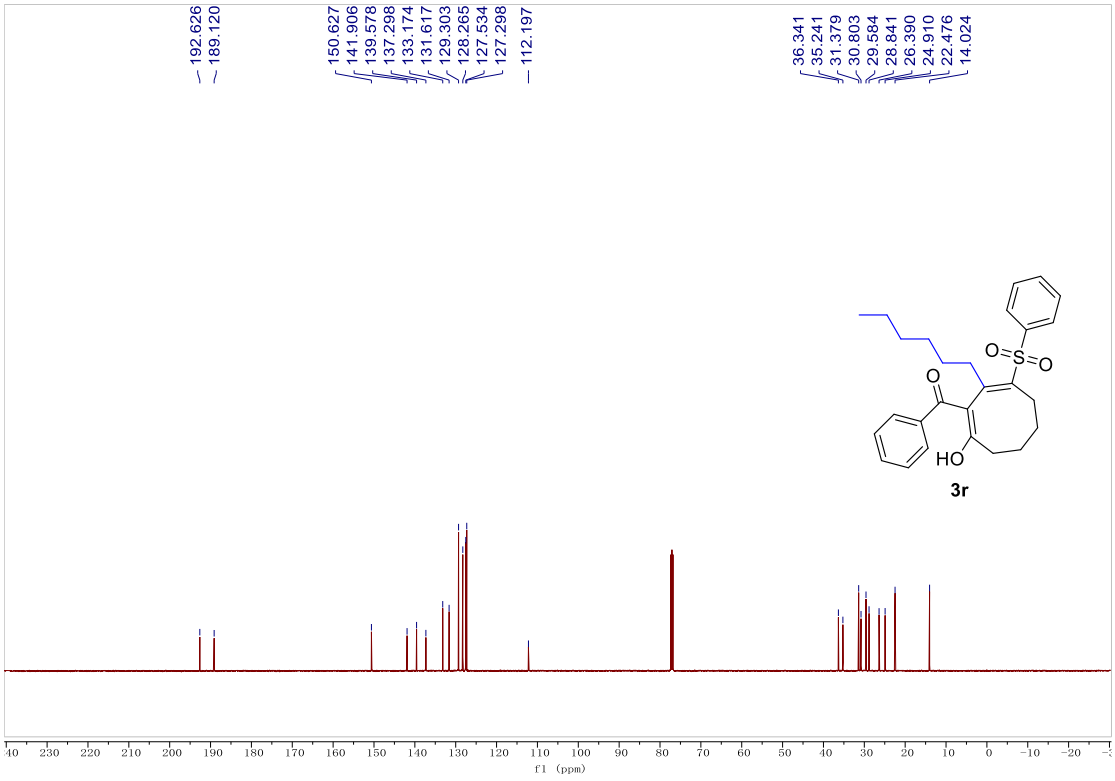

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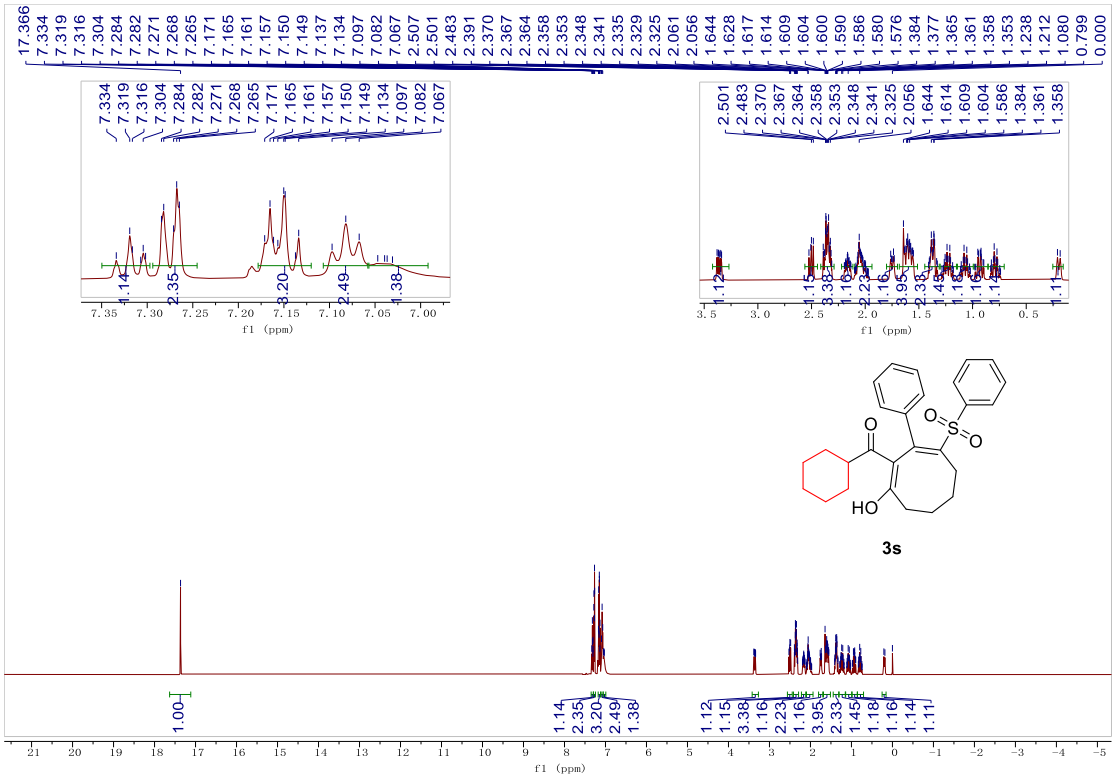
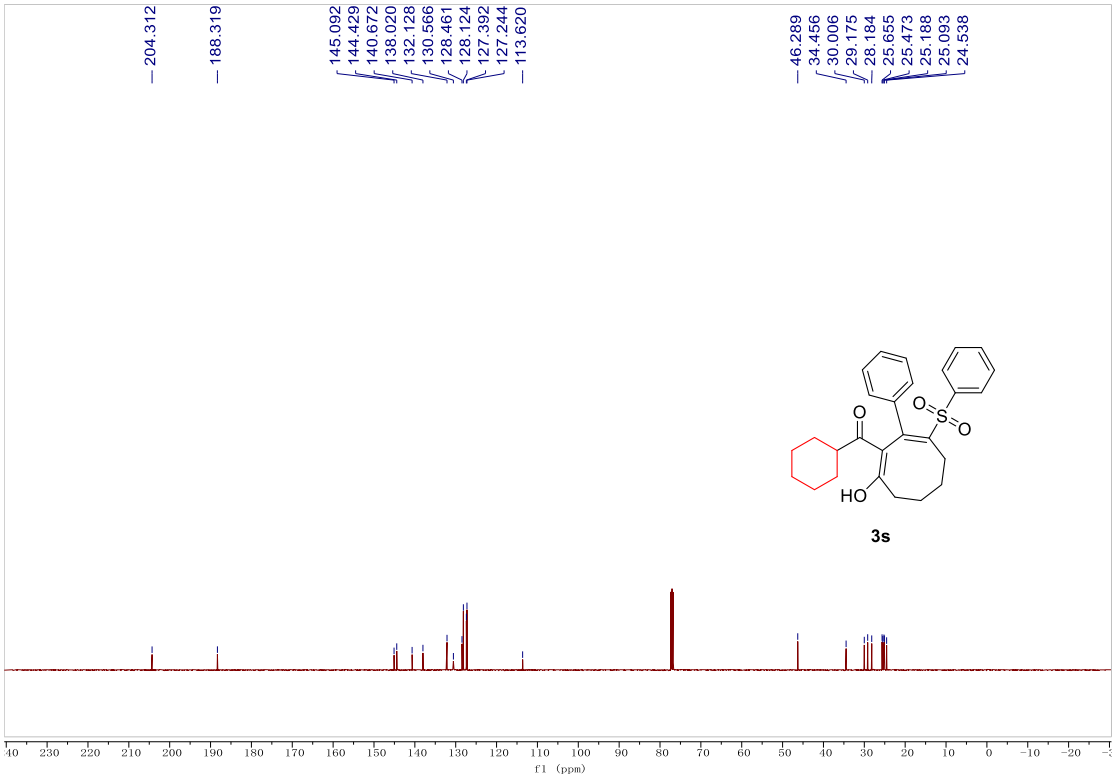
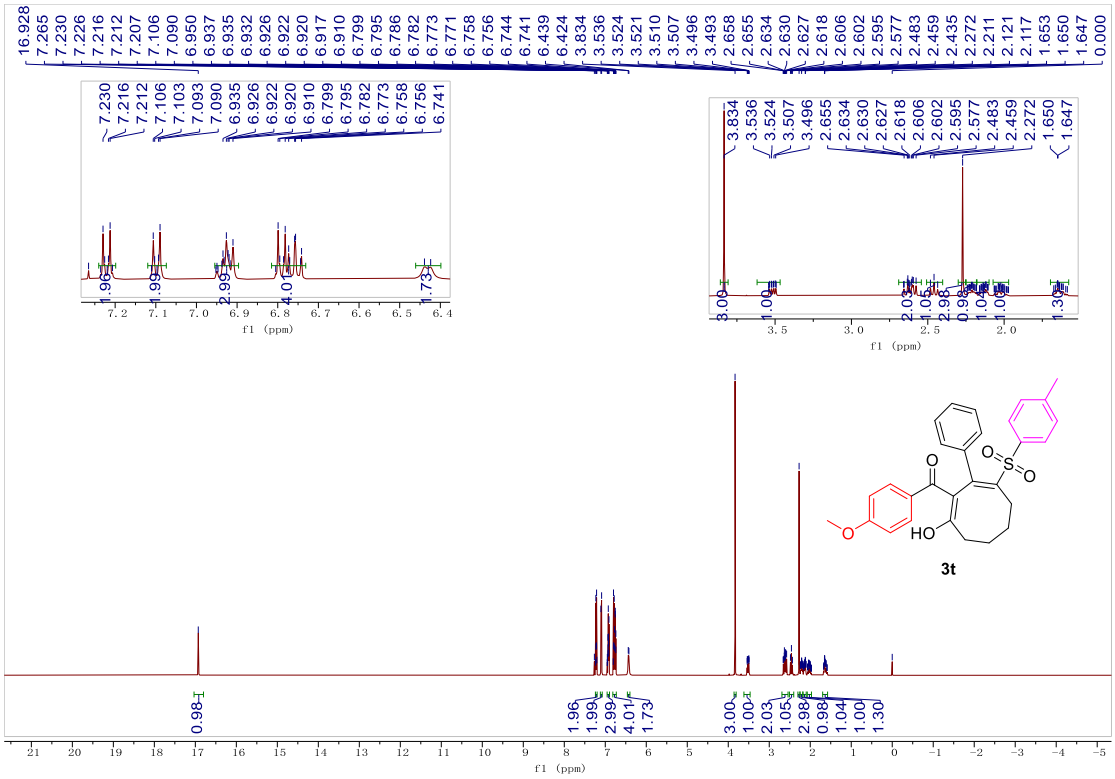


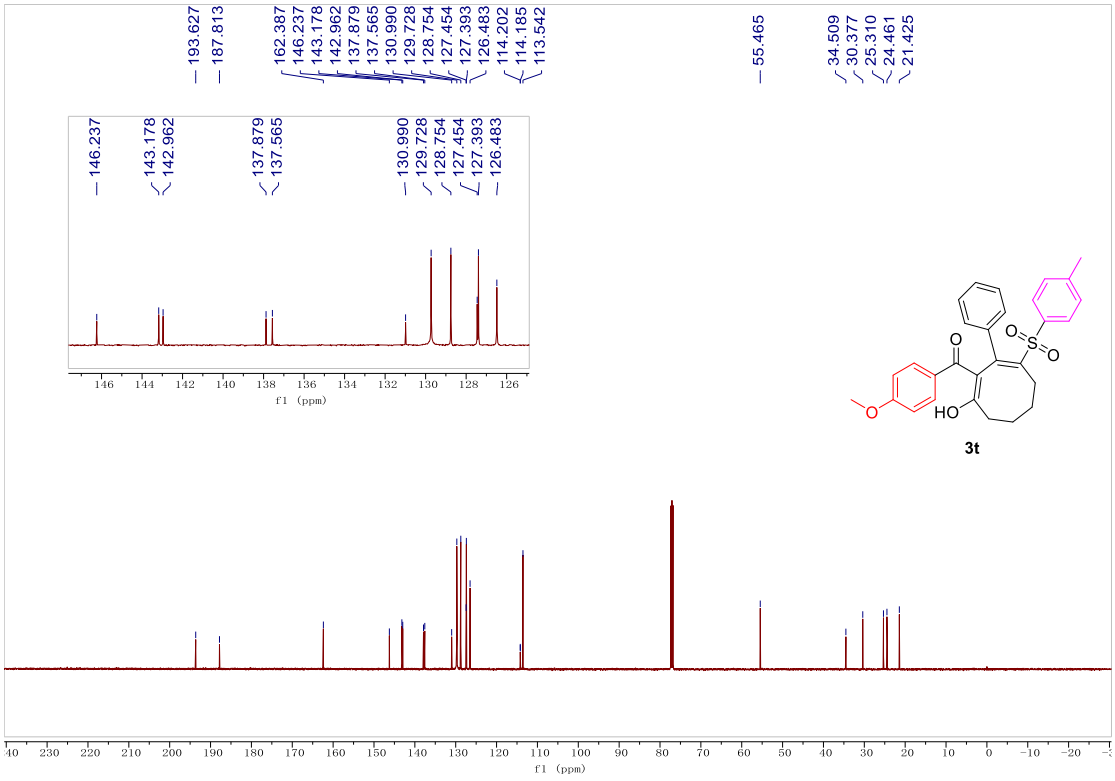
^{13}C NMR (125 MHz, $CDCl_3$)



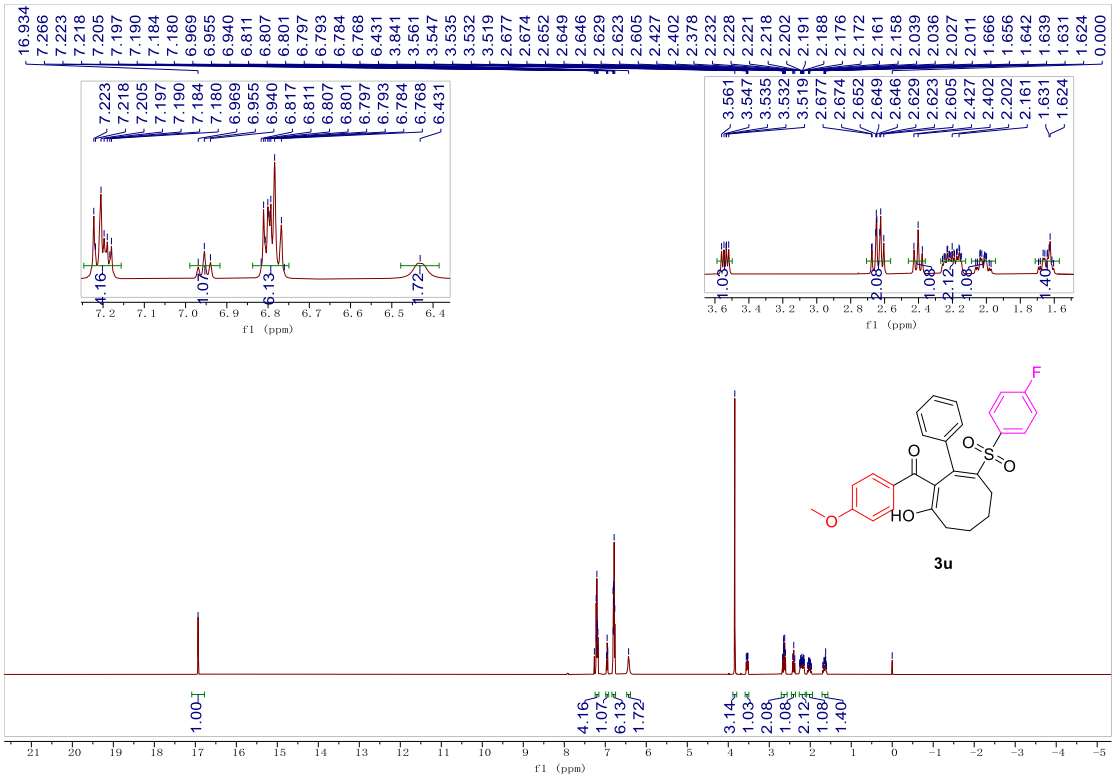
^{1}H NMR (500 MHz, $CDCl_3$)



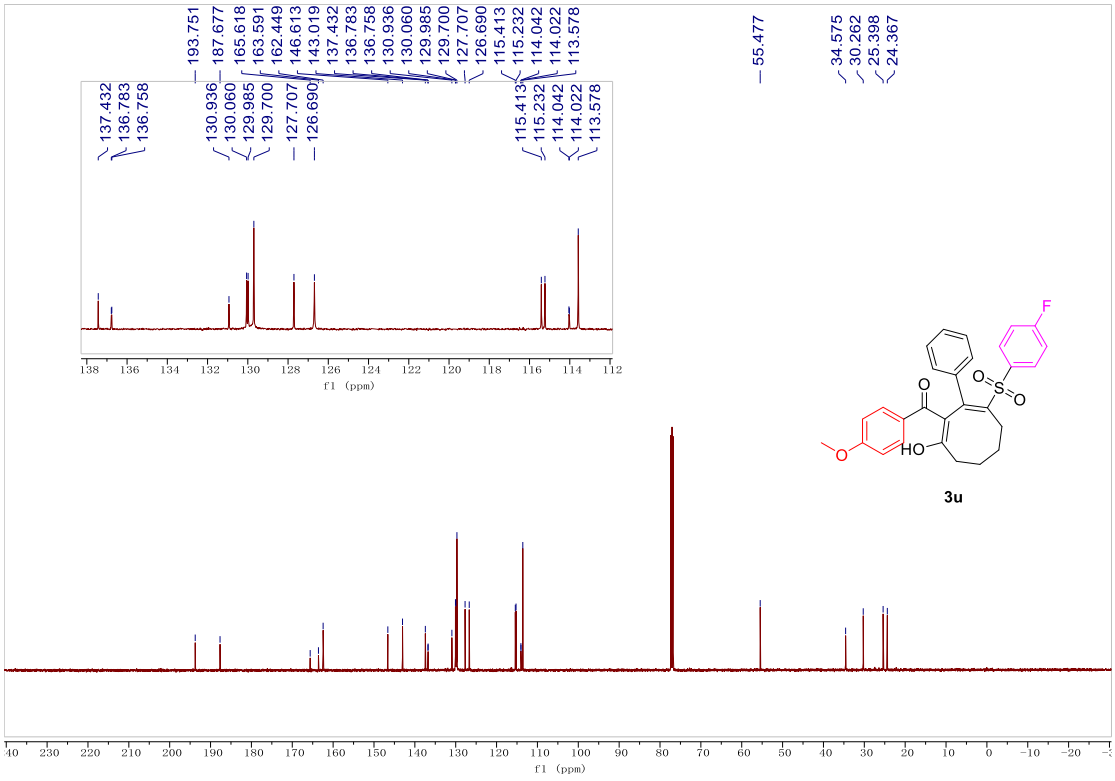
^{13}C NMR (125 MHz, $CDCl_3$)



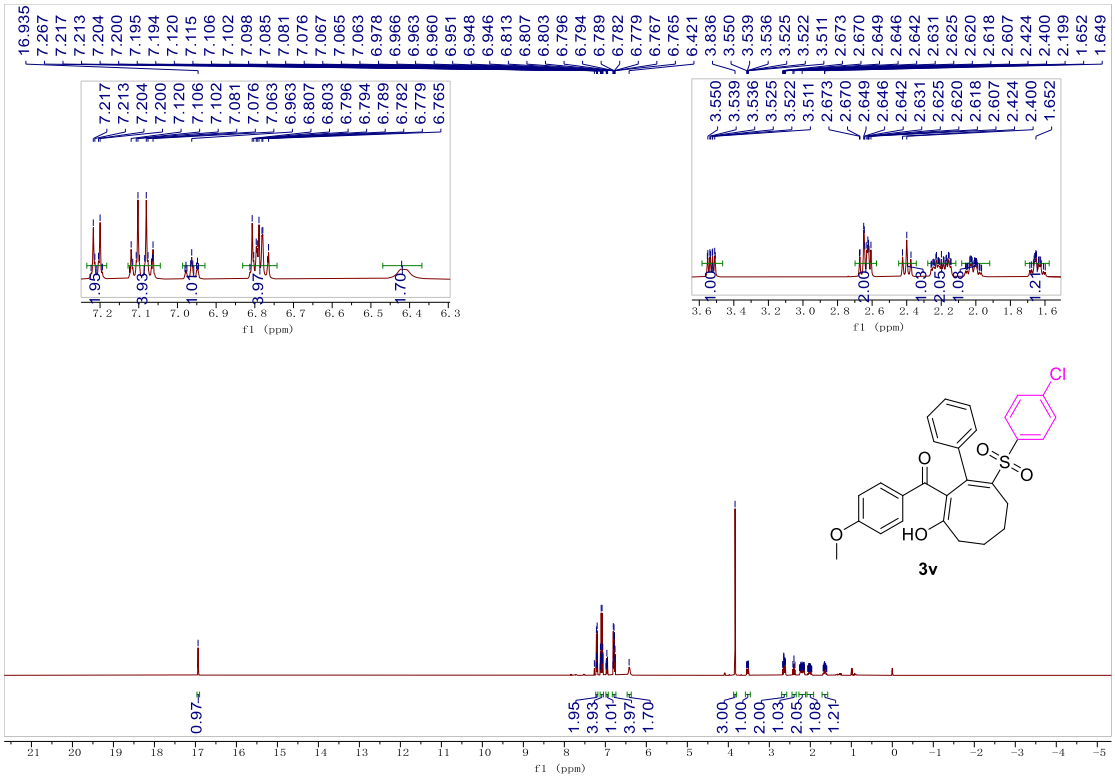
^{1}H NMR (500 MHz, $CDCl_3$)



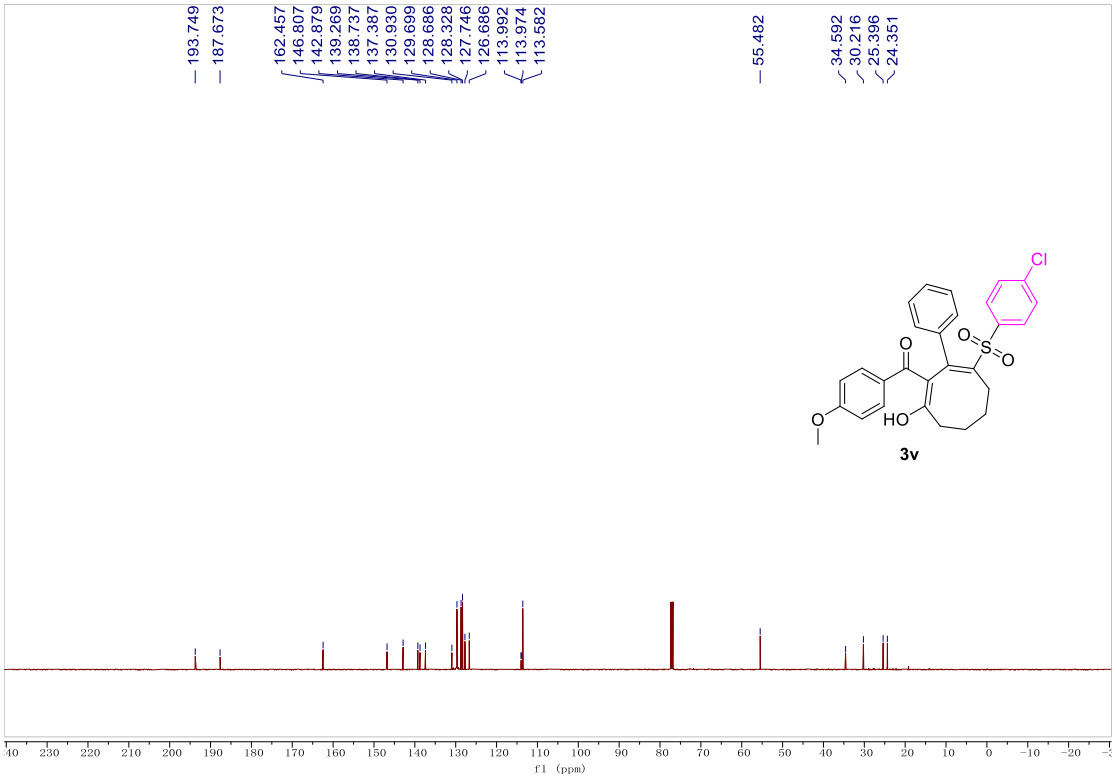
^{13}C NMR (125 MHz, $CDCl_3$)



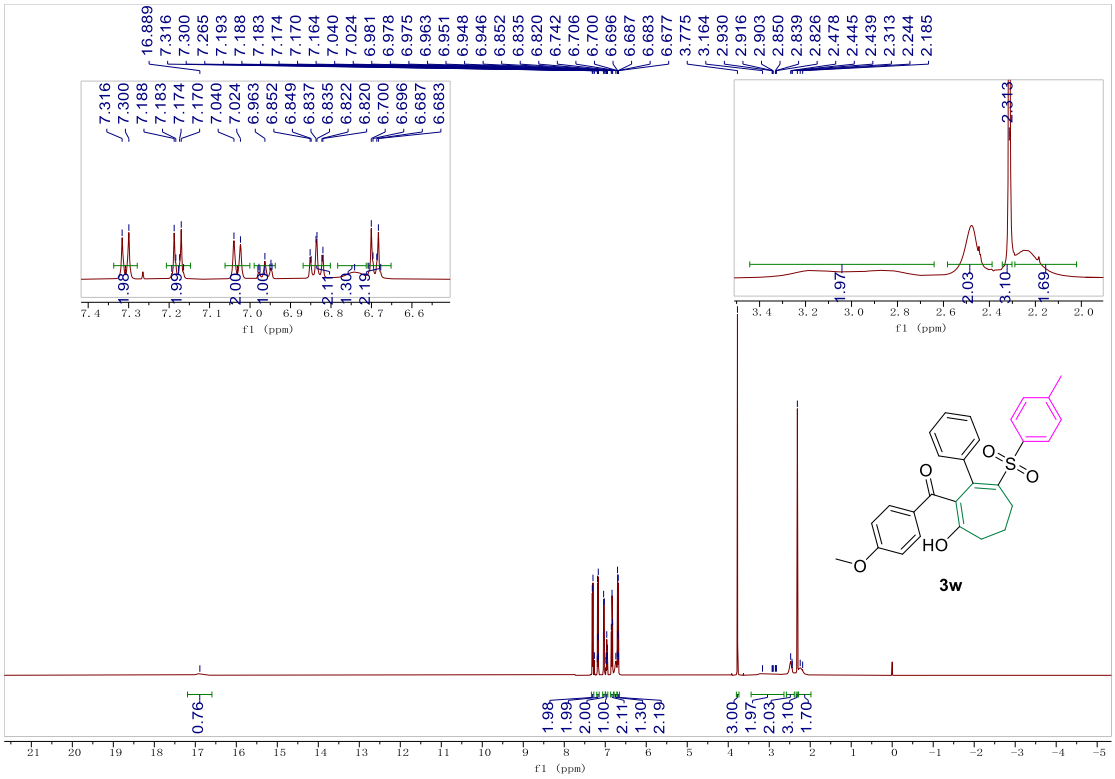
^{1}H NMR (500 MHz, $CDCl_3$)



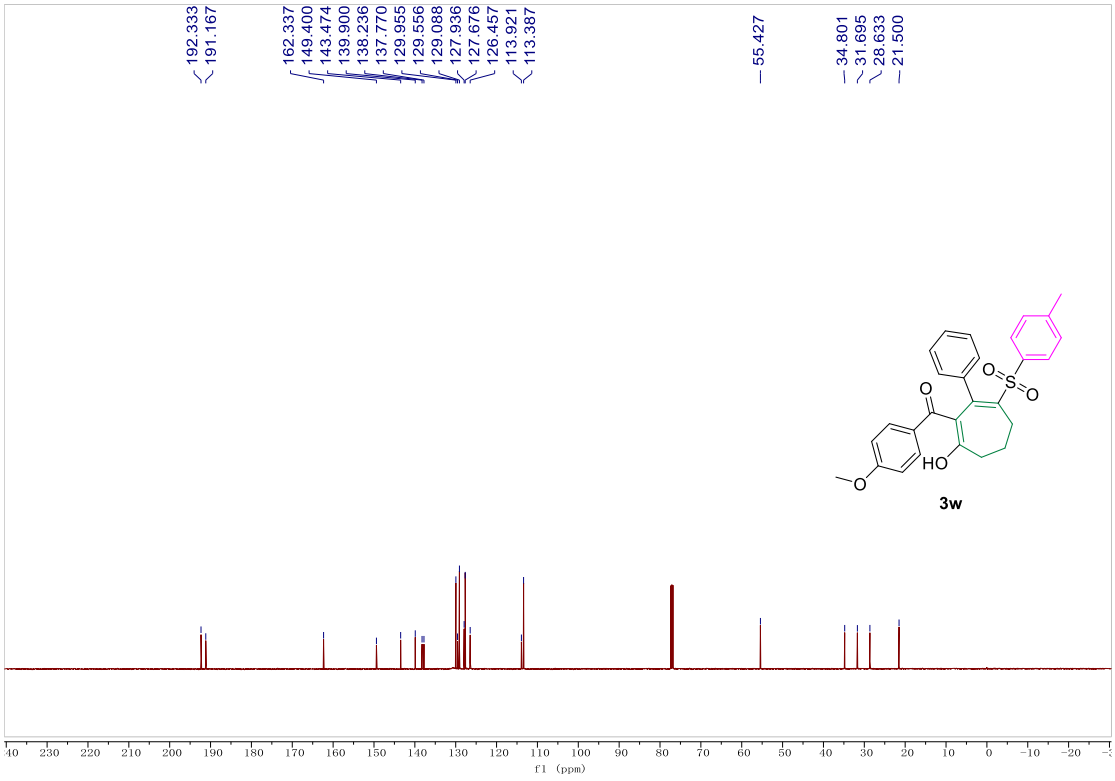
^{13}C NMR (125 MHz, $CDCl_3$)



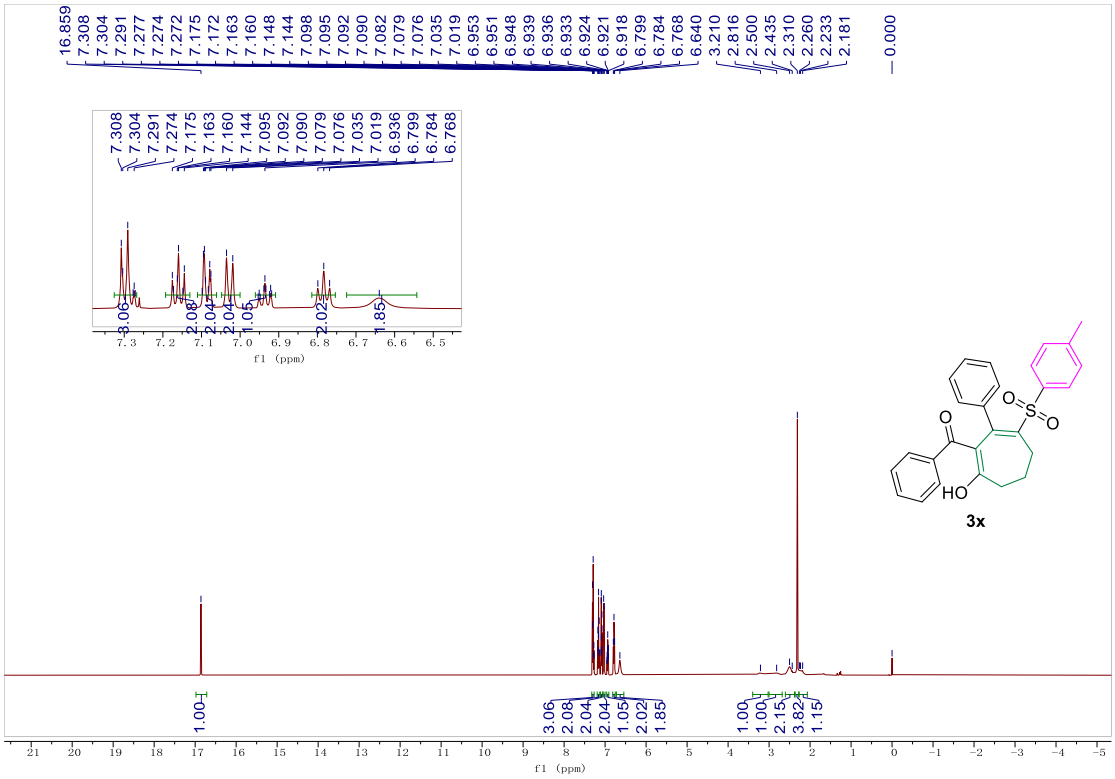
^{1}H NMR (500 MHz, $CDCl_3$)



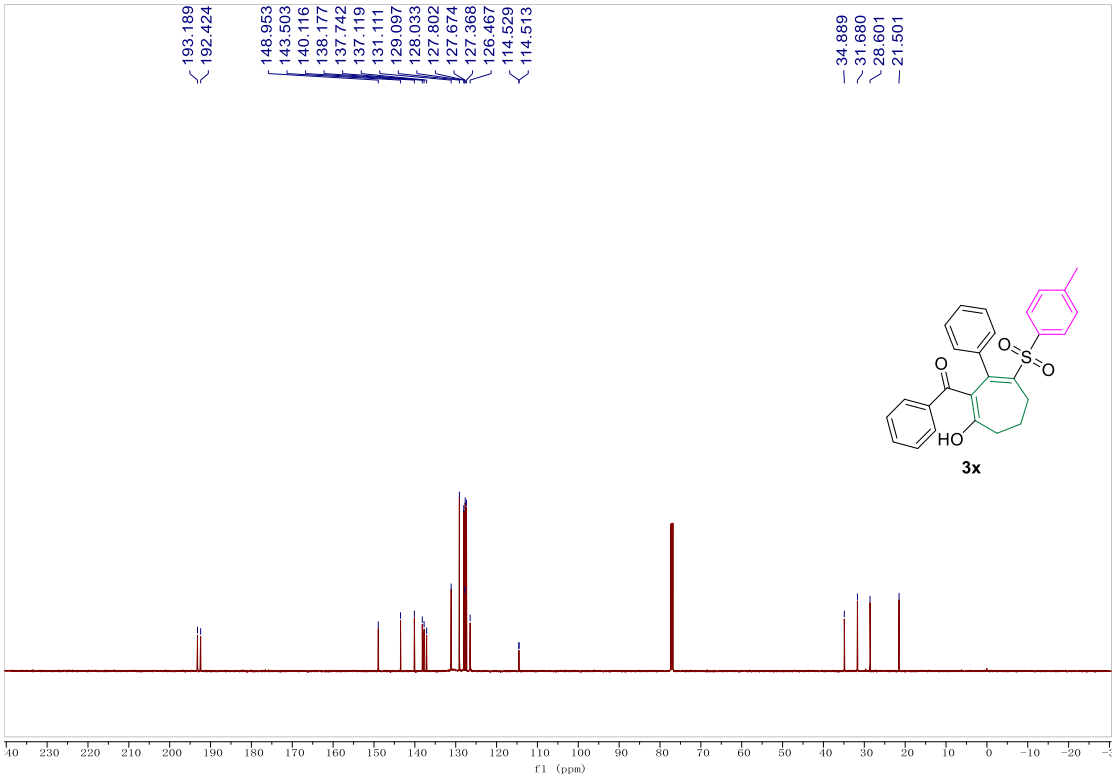
^{13}C NMR (125 MHz, $CDCl_3$)



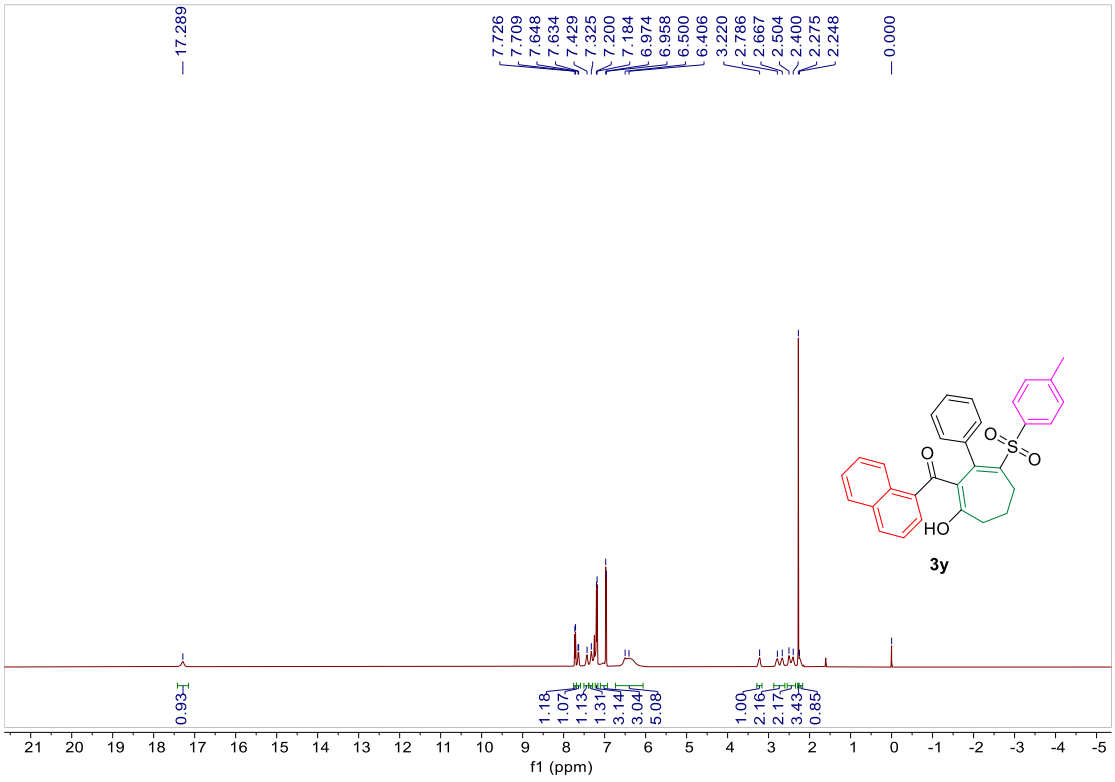
^{1}H NMR (500 MHz, $CDCl_3$)



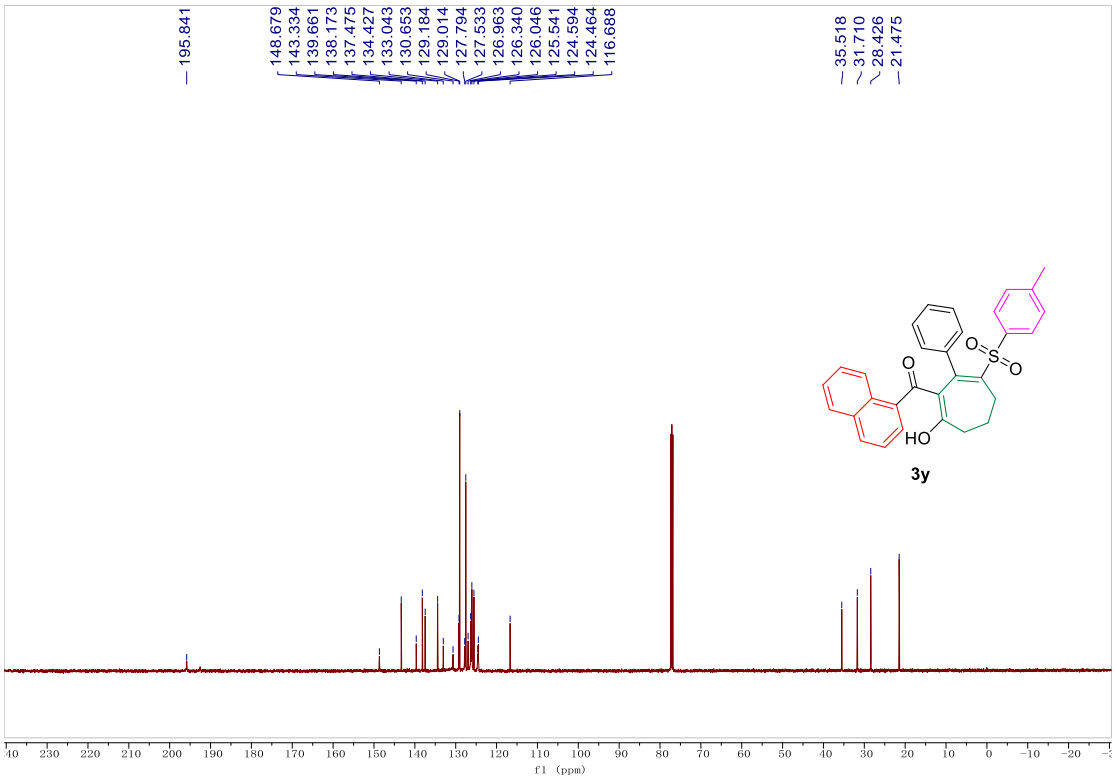
^{13}C NMR (125 MHz, $CDCl_3$)



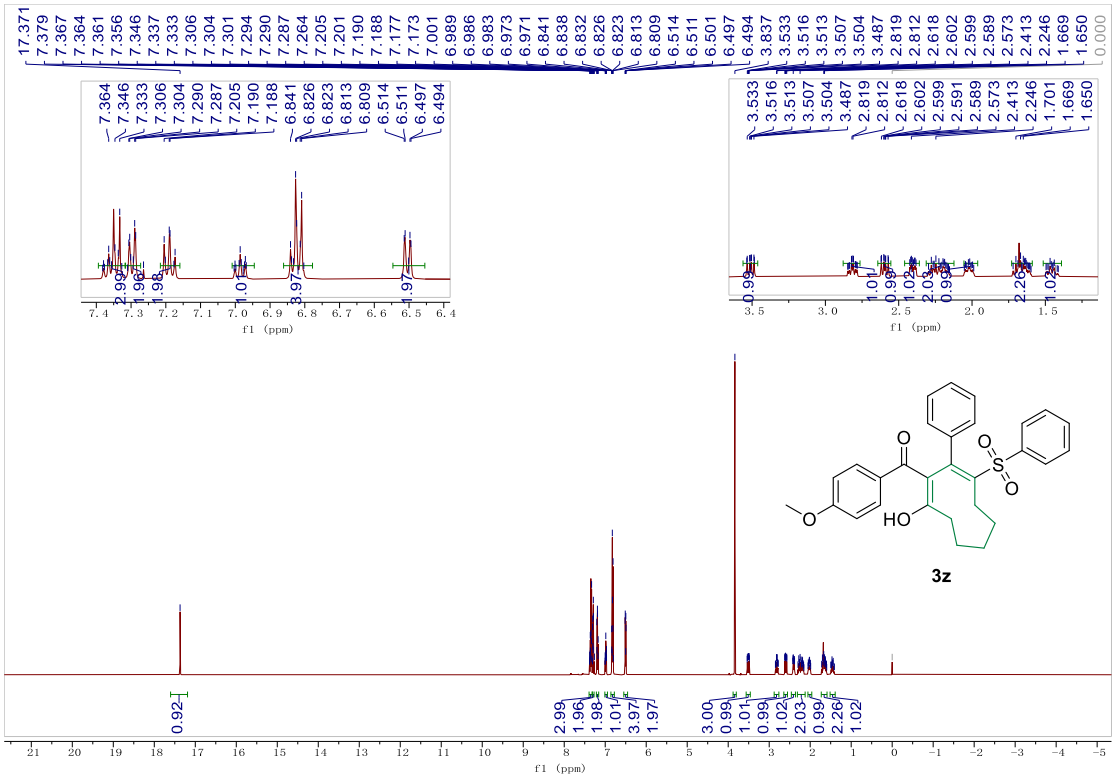
^{1}H NMR (500 MHz, $CDCl_3$)



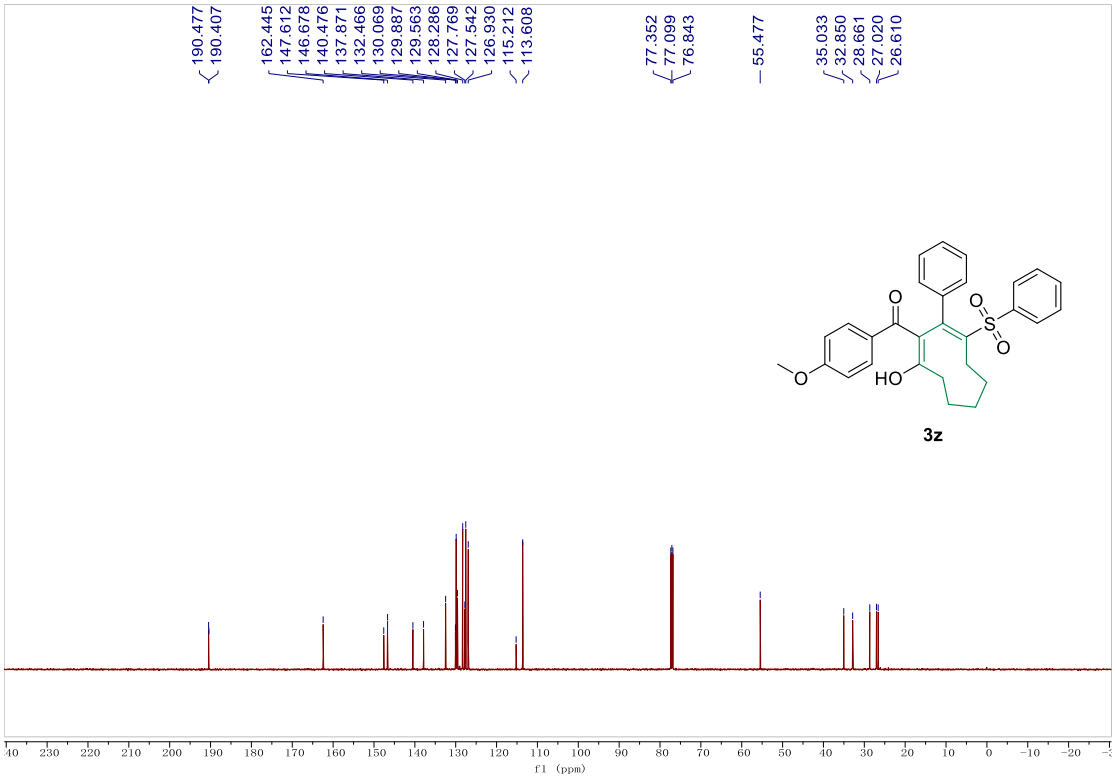
^{13}C NMR (125 MHz, $CDCl_3$)



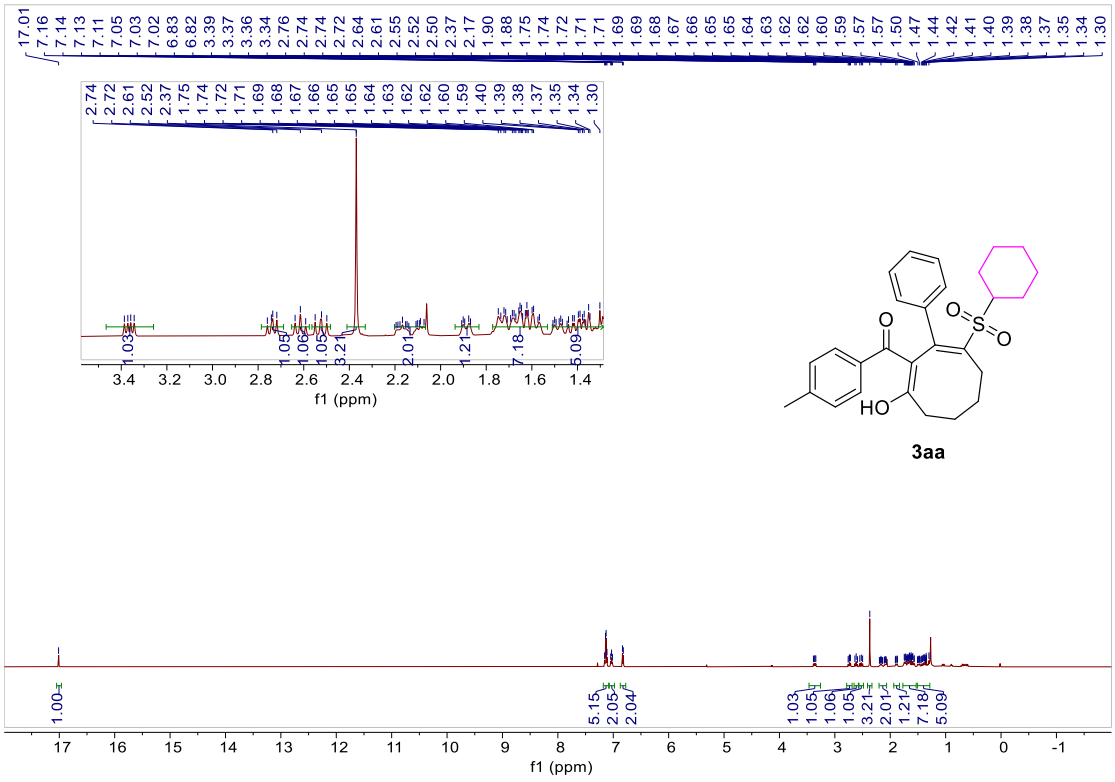
^{1}H NMR (500 MHz, $CDCl_3$)



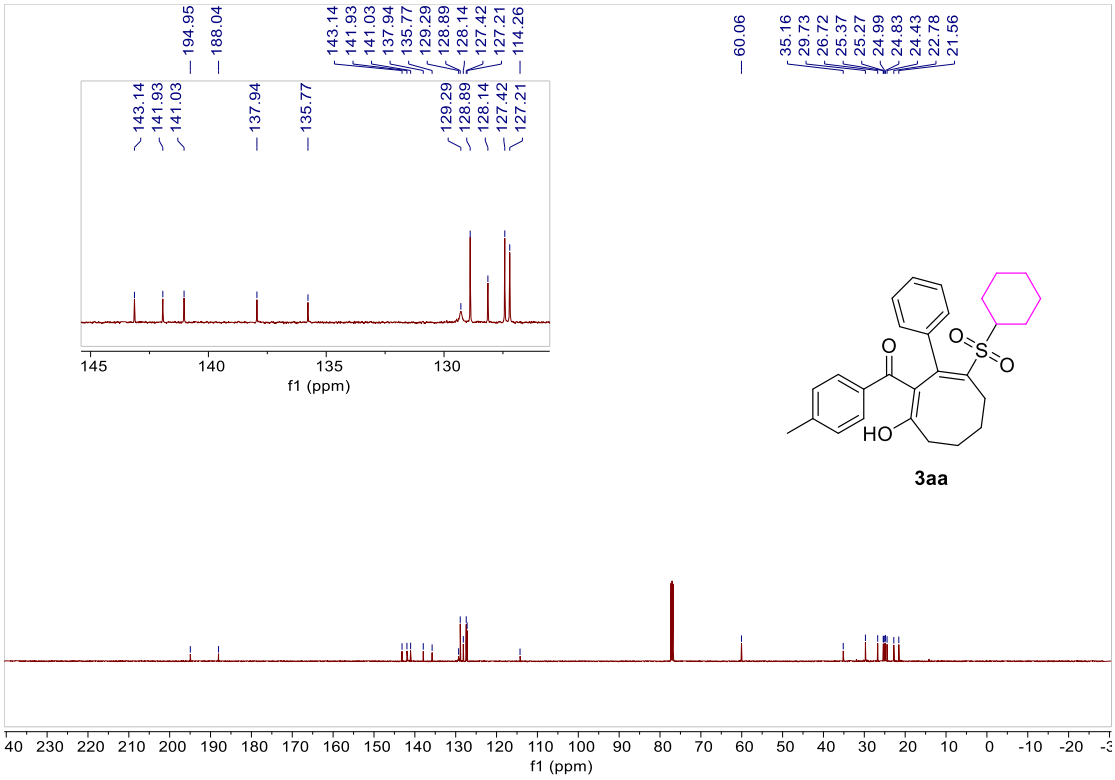
^{13}C NMR (125 MHz, $CDCl_3$)



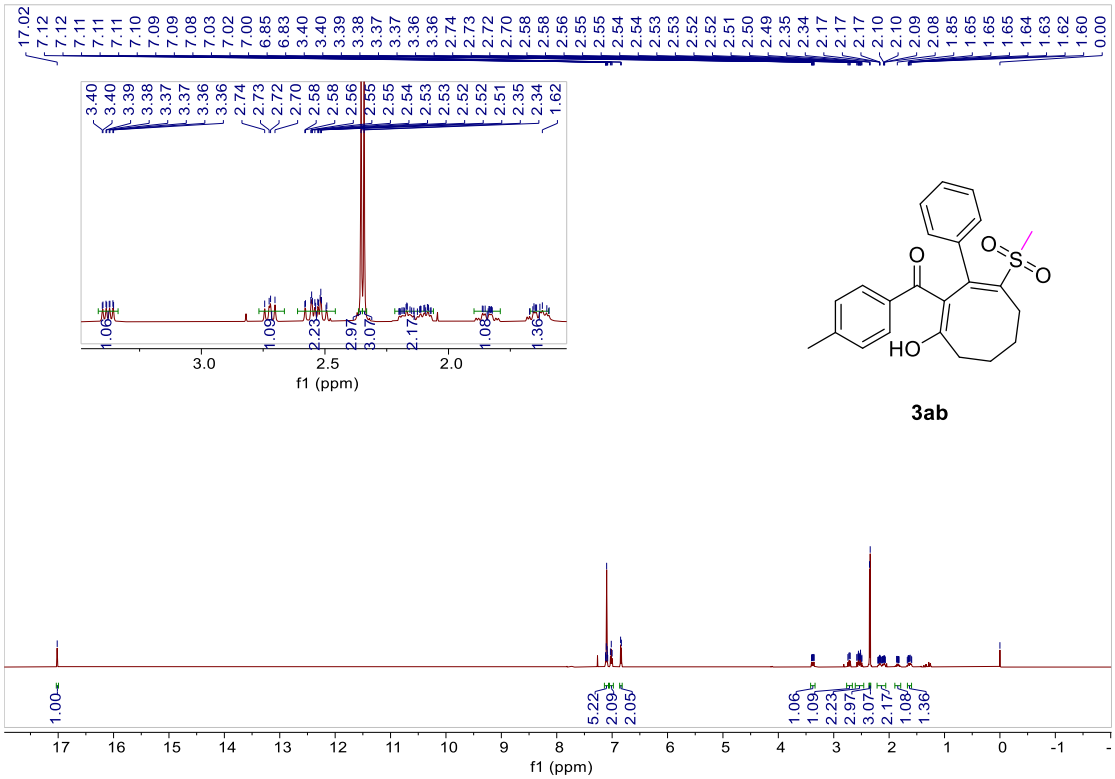
^{1}H NMR (500 MHz, $CDCl_3$)



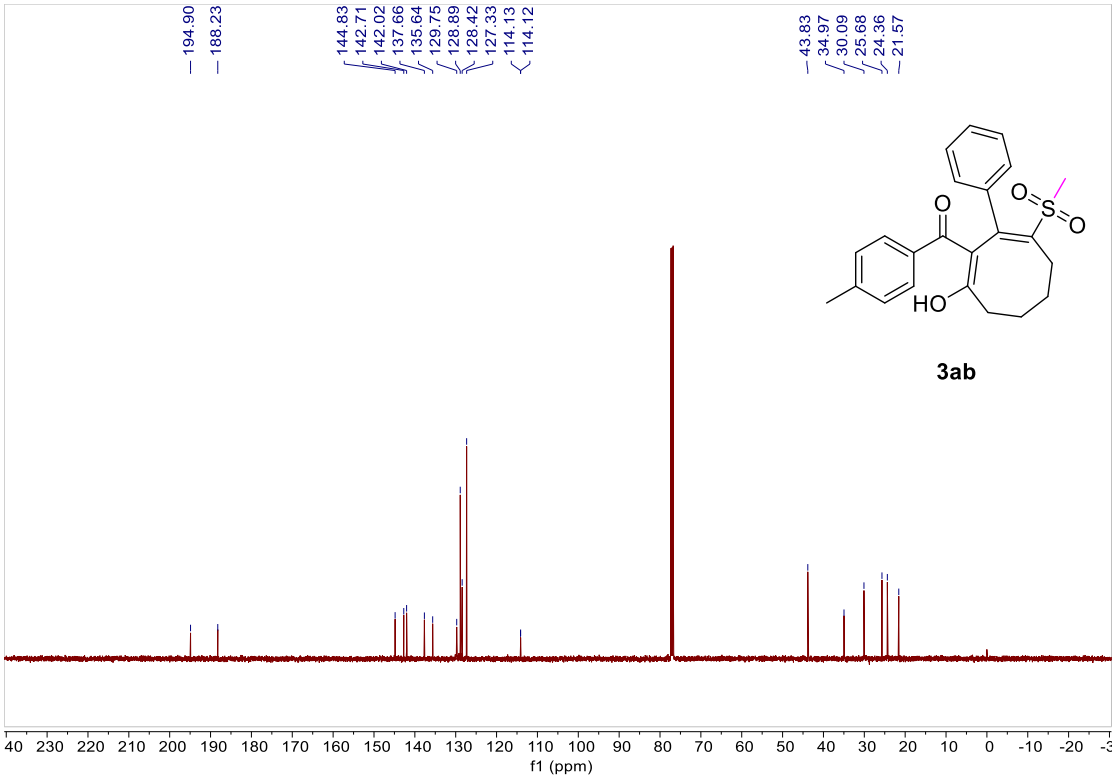
^{13}C NMR (125 MHz, $CDCl_3$)



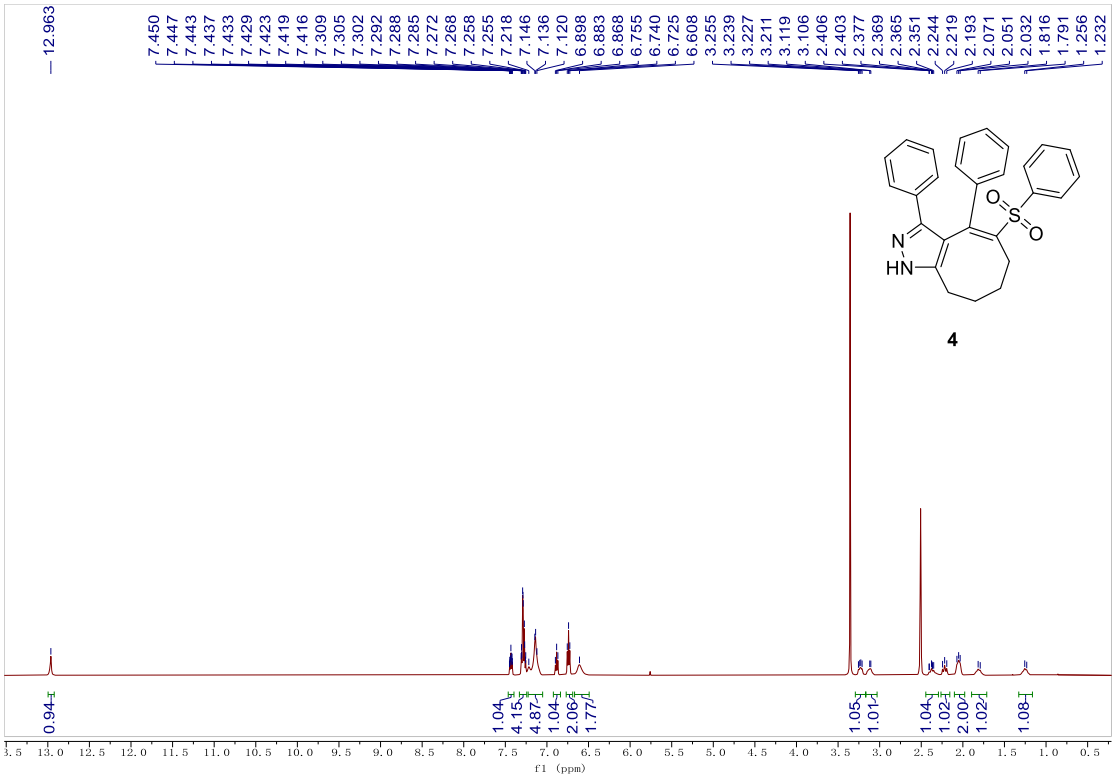
^{1}H NMR (500 MHz, $CDCl_3$)



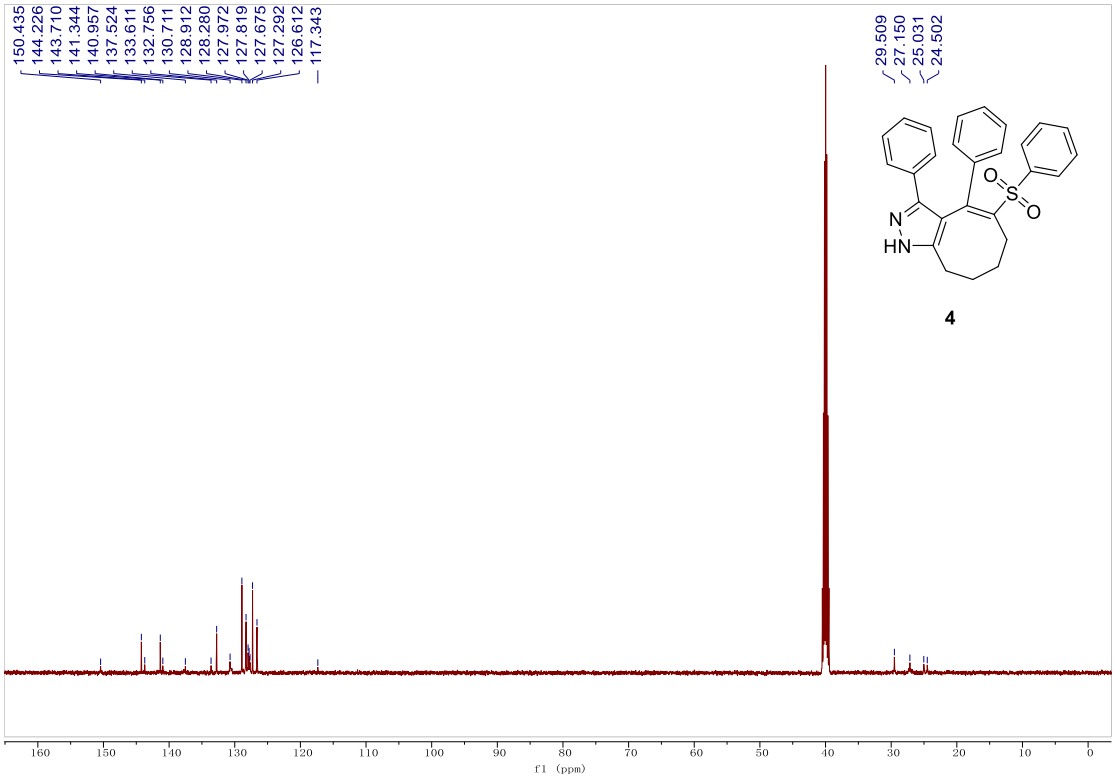
^{13}C NMR (125 MHz, $CDCl_3$)



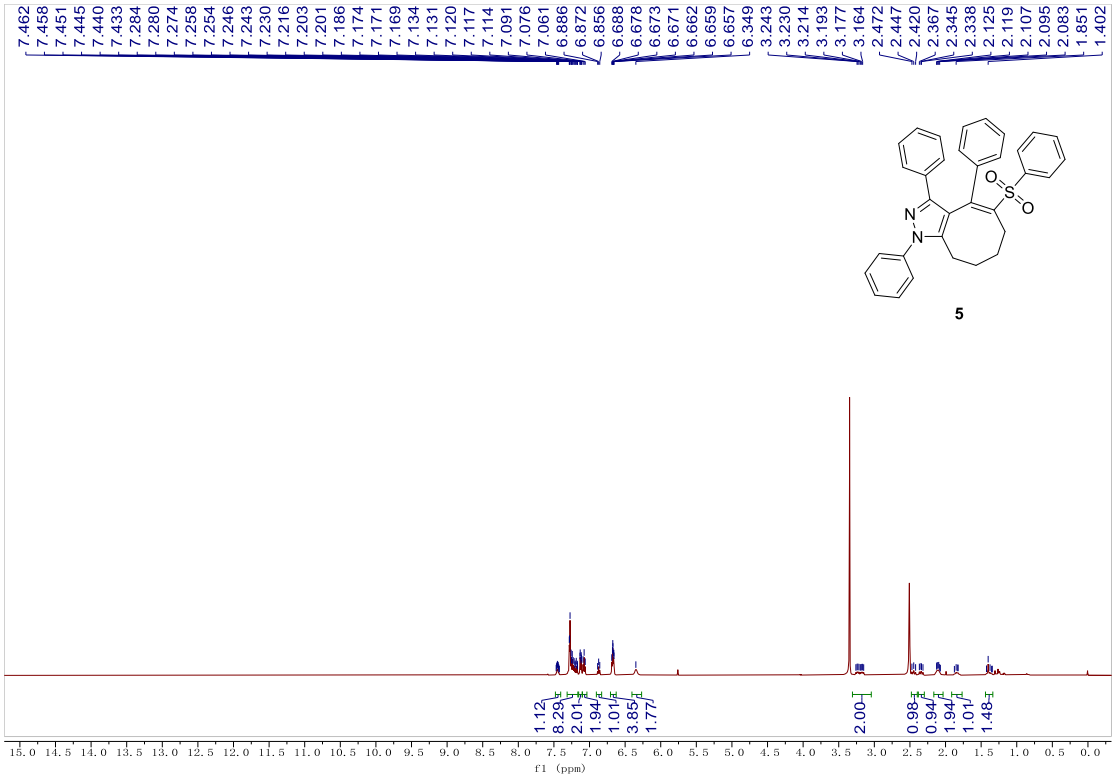
^{1}H NMR (500 MHz, d^{6}-DMSO)



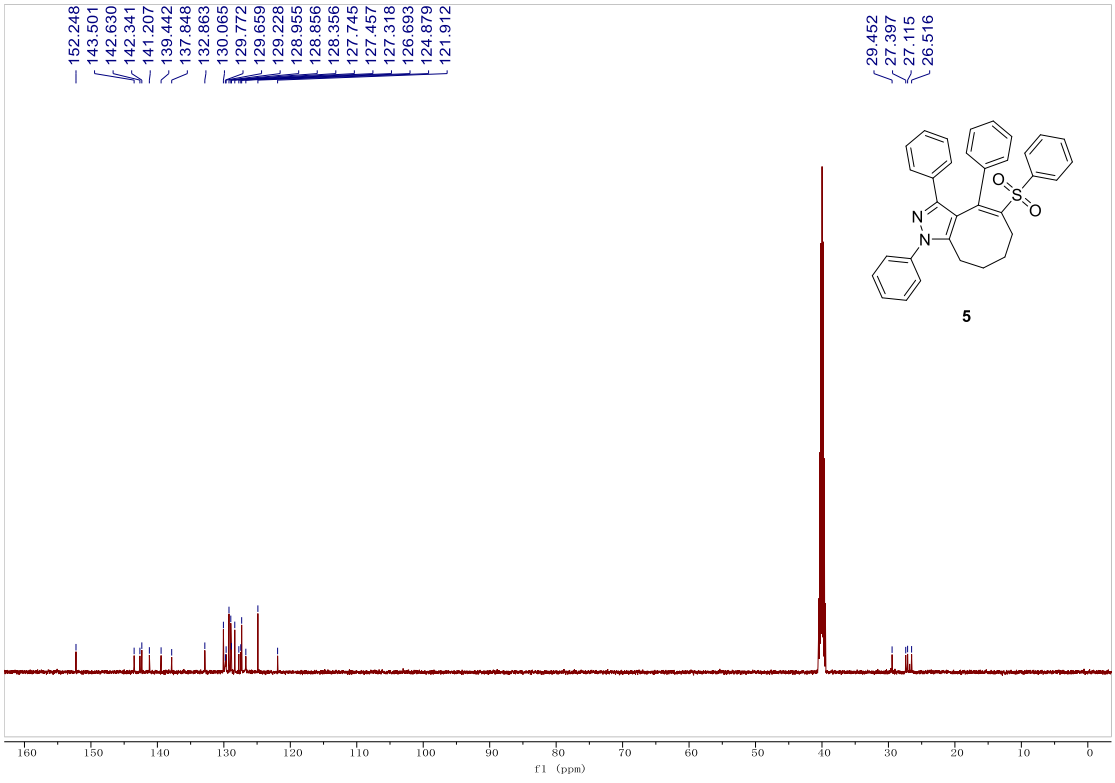
^{13}C NMR (125 MHz, d^{6}-DMSO)



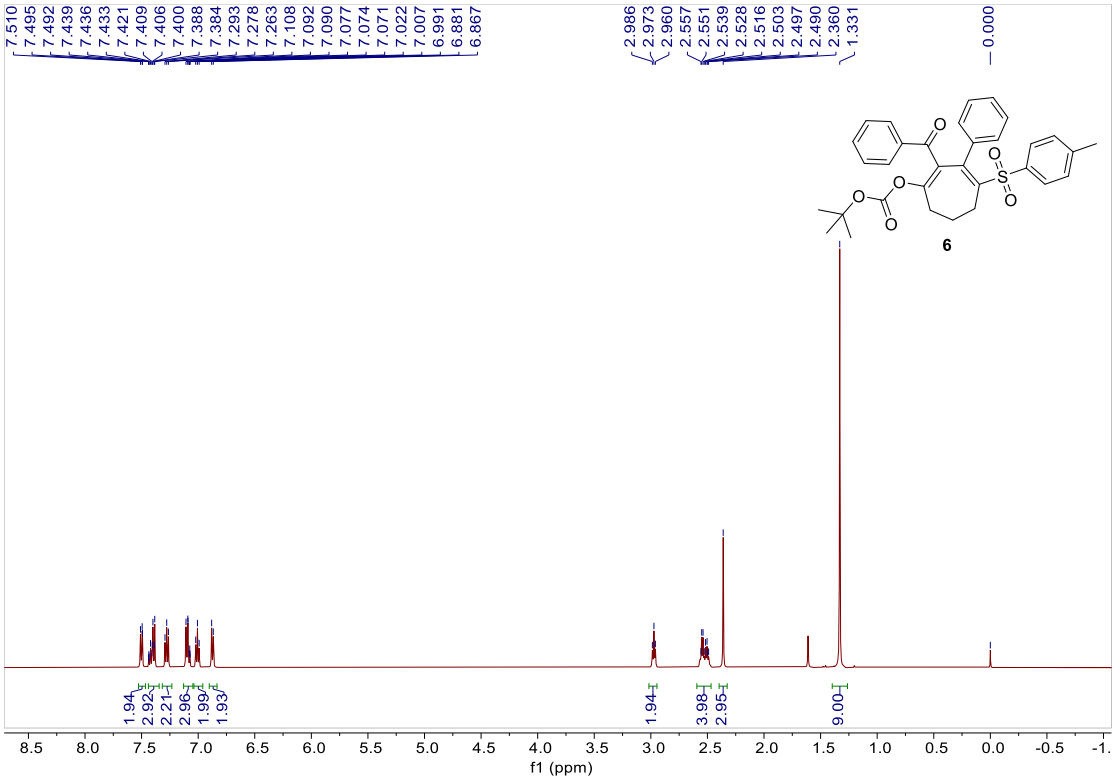
^{1}H NMR (500 MHz, d^{6}-DMSO)



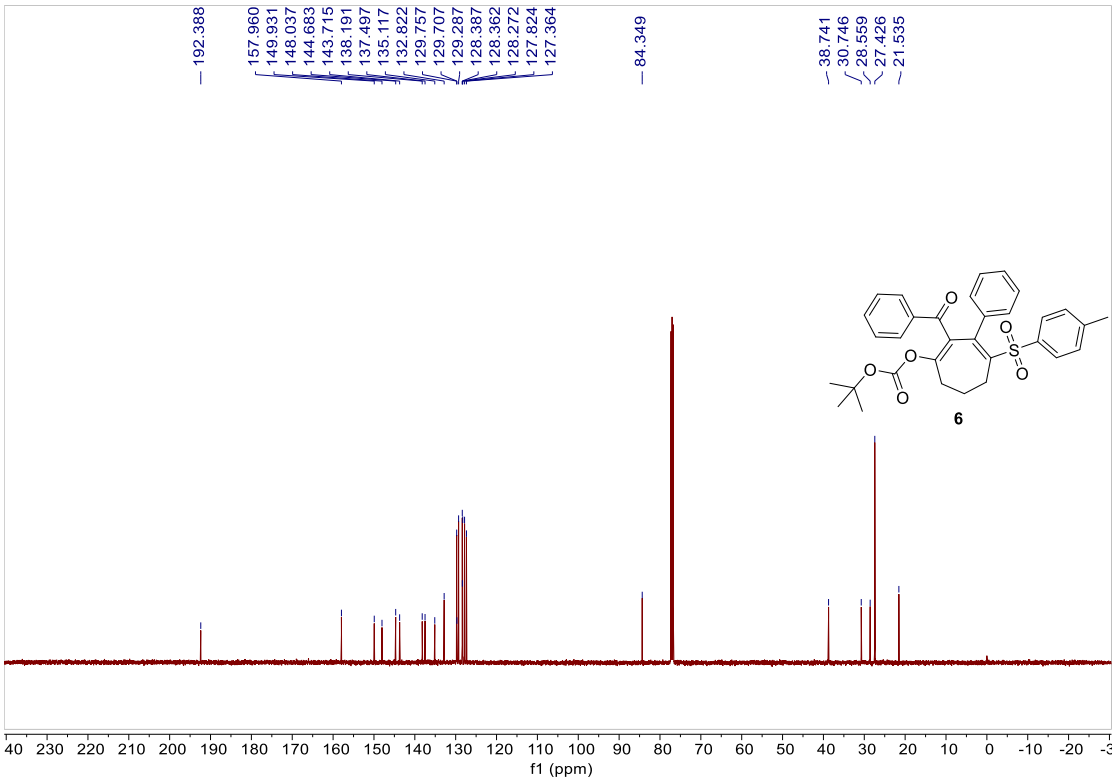
^{13}C NMR (125 MHz, d^{6}-DMSO)



^{1}H NMR (500 MHz, $CDCl_3$)



^{13}C NMR (125 MHz, $CDCl_3$)

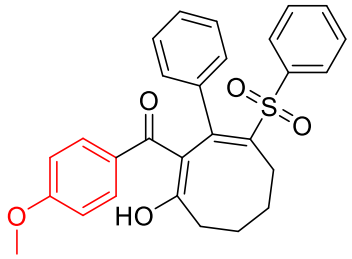


9. X-ray Crystallography of Compound 3a.

((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(4-methoxyphenyl)methanone (3a, gyc-7)

(Ortep ellipsoids are depicted at the 50% level)

Sample preparation for crystal growth: Compound **3a** (60 mg) was dissolved in the mixed solvent of dichloromethane/petroleum ether = 4 ml/8 ml in a 50 mL round-bottom flask, while slow evaporation of solvent at room temperature under the air conditions colorless square type crystals were grown.



3a

Table 2. Crystal Data and Structure Refinement for 3a.

Identification code	**3a**
Empirical formula	$C_{28}H_{26}O_5S$
Formula weight	474.55
Temperature	293(2) K
Wavelength	0.71073 Å
Crystal system	orthorhombic
Space group	Pbca
Unit cell dimensions	a = 17.5906(8) Å, α= 90°. b = 12.7342(7) Å, β= 90°. c = 21.5096(10) Å, γ = 90°.
Volume	4818.2(4) $Å^3$
Z	8
Density (calculated)	1.308 Mg/m^3
Absorption coefficient	0.171 mm^{-1}
F(000)	2000
Crystal size	0.38 x 0.27 x 0.22 mm^3
Theta range for data collection	5.472 to 59.278°.
Index ranges	-22<=h<=21, -15<=k<=16, -27<=l<=21
Reflections collected	29902
Independent reflections	5831 [R(int) = 0.0383, R(sigma) = 0.0371]
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.921 and 1.000
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	5831 / 0 / 309
Goodness-of-fit on F^2	1.018
Final R indices [I>2sigma(I)]	R1 = 0.0530, wR2 = 0.1153
R indices (all data)	R1 = 0.0899, wR2 = 0.1301

Largest diff. peak and hole	0.21 and -0.31 e.Å^{-3}