

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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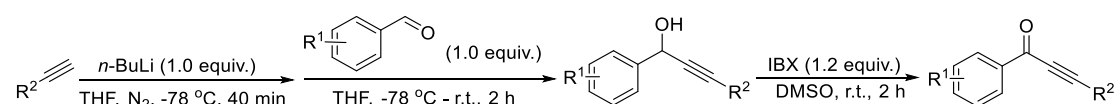
1. General Methods

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). ^1H NMR spectra were recorded at 400 500 MHz, ^{13}C NMR spectra were recorded at 125 MHz, and in CDCl_3 or $\text{d}^6\text{-DMSO}$ (containing 0.03% TMS) solutions. ^1H NMR spectra were recorded with tetramethylsilane ($\delta = 0.00$ ppm) as internal reference; ^{13}C NMR spectra were recorded with CDCl_3 ($\delta = 77.00$ ppm) or $\text{d}^6\text{-DMSO}$ ($\delta = 39.52$ 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 diffractometers with molybdenum cathodes.

2. Synthesis of Materials

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

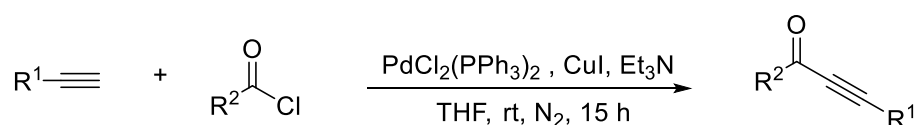
General Procedure (A) for the Preparation of Alkynyl Ketones:



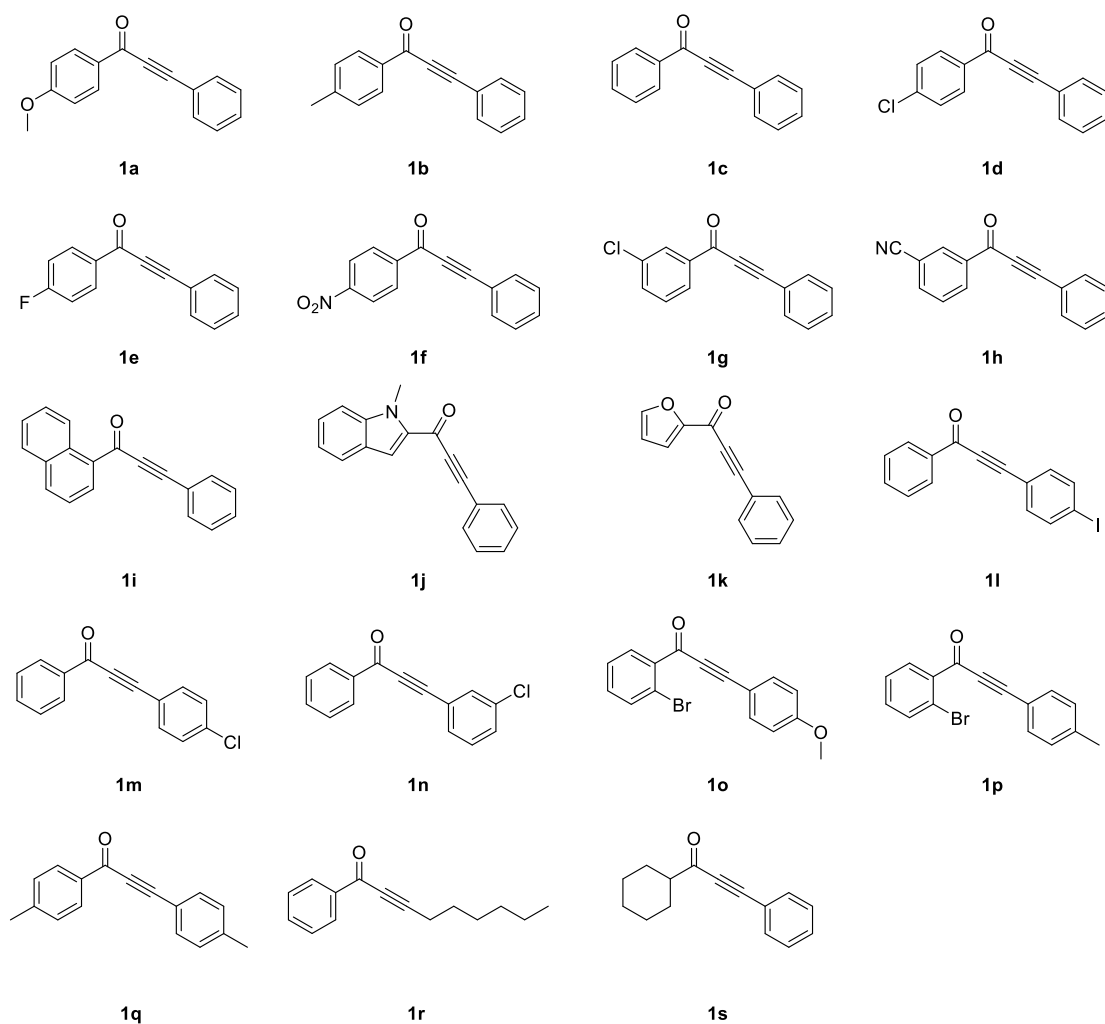
To a solution of alkyne (12 mmol) in anhydrous THF (30 mL), *n*-BuLi (10 mmol, 2.5 M, 4 mL) was added at $-78\text{ }^{\circ}\text{C}$. The resulting mixture was stirred at $-78\text{ }^{\circ}\text{C}$ for 1 h, then the aldehyde (10 mmol) was added and the reaction temperature was raised to room temperature 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 \times 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 \times 3). The organic layers were combined, washed with brine, dried over anhydrous Na₂SO₄, 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:

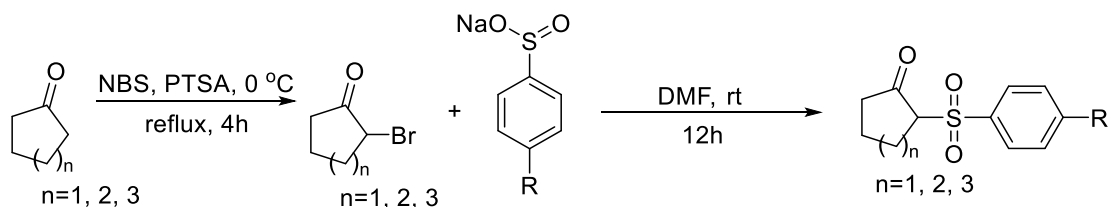


A mixture of acylchloride (1.2 equiv), PdCl₂(PPh₃)₂ (0.02 equiv) and Et₃N (1.2 equiv) in anhydrous THF were stirred for 10 min at room atmosphere under N₂. CuI (0.04 equiv) was then added and the reaction mixture was stirred for another 10 min. Terminal alkyne (1.0 equiv) was then added in one portion, 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 Na₂SO₄ 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 CH₂Cl₂ (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 CH₂Cl₂ (10 mL) at 0 °C. The reaction mixture was then brought to

reflux for 4 h. After addition of H₂O (20 mL), the organic layer was separated, and the aqueous layer was extracted with CH₂Cl₂ (2 × 15 mL). The combined organic layers were washed with saturated aqueous NaHCO₃ (15 mL) and brine (20 mL), dried over anhydrous Na₂SO₄, 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 N₂ 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.

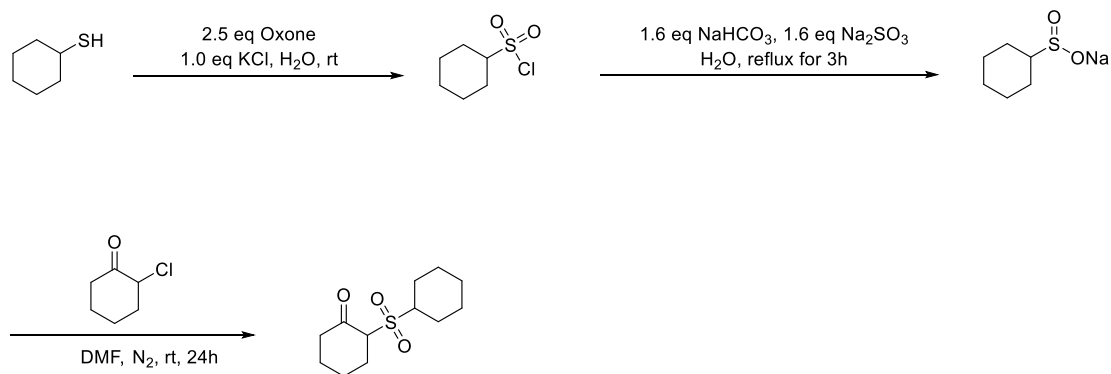
General Procedure (B) for the Preparation of Cyclic β -keto Sulfones:



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 CH₂Cl₂ (3 × 15 mL), washed with brine, dried with MgSO₄ 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:

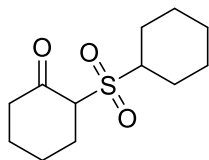
A mixture of thiol (2 mmol, 1 equiv.), Oxone (5 mmol, 2.5 equiv.), KCl (2 mmol, 1 equiv.) and water (6 mL) was vigorously stirred at room temperature for 2 hours. The aqueous phase was extracted with ethyl acetate (4 × 10 mL). The combined organic layer was dried over anhydrous sodium sulfate and concentrated 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.

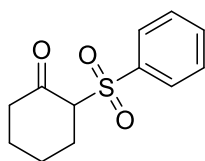
Step 3:

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 CH₂Cl₂ (3 × 15 mL), washed with brine, dried with MgSO₄ 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).

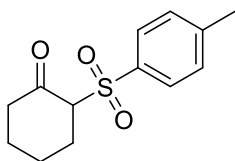


2aa

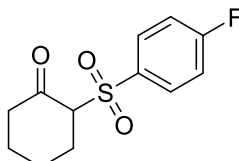
2-(cyclohexylsulfonyl)cyclohexan-1-one (2aa), white solid, petroleum ether/ethyl acetate = 5:1, 57 %). m.p. 126-128 °C. ^1H NMR (500 MHz, CDCl_3) δ 3.83 (t, J = 5.0 Hz, 1H), 3.23-3.12 (m, 1H), 2.85-2.75 (m, 1H), 2.67-2.59 (m, 1H), 2.51-2.43 (m, 1H), 2.23-2.00 (m, 5H), 1.97-1.86 (m, 2H), 1.85-1.68 (m, 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 $\text{C}_{12}\text{H}_{20}\text{O}_3\text{S}$ $[\text{M}+\text{Na}]^+$: 267.1025, found: 267.1022.



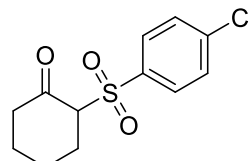
2a



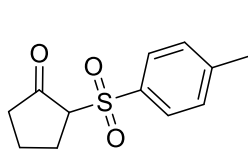
2t



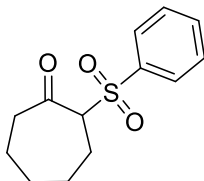
2u



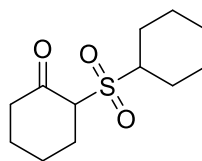
2v



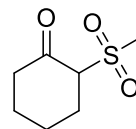
2w



2z

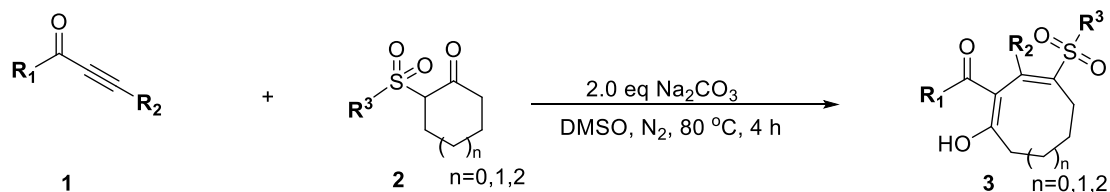


2aa

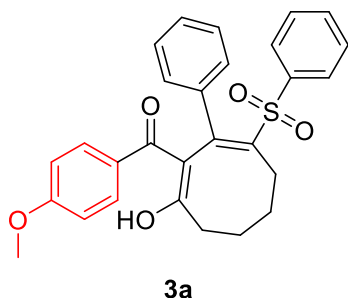


2ab

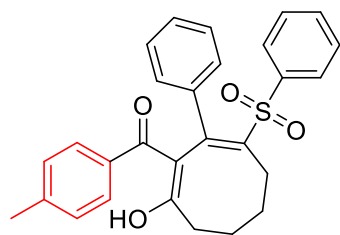
3. Synthesis of 3



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 stirred 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 \times 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**.

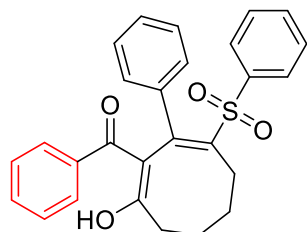


((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(4-methoxyphenyl)methanone (3a), white solid, petroleum ether/ethyl acetate = 5:1, 78.7 mg, 83 %. m.p. 209-211 °C. ^1H NMR (500 MHz, CDCl_3) δ 16.95 (s, 1H), 7.33 (t, J = 7.5 Hz, 1H), 7.26-7.23 (m, 4H), 7.15 (t, J = 7.5 Hz, 2H), 6.94 (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 $\text{C}_{28}\text{H}_{26}\text{O}_5\text{S}$ $[\text{M}+\text{H}]^+$: 475.1574, found: 475.1573.



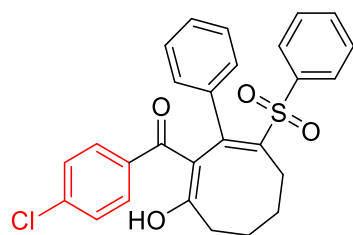
3b

((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. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₈H₂₆O₄S [M+Na]⁺: 481.1444, found: 481.1435.



3c

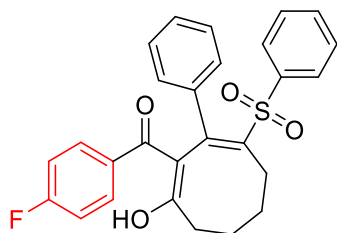
((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone (3c,
white solid, petroleum ether/ethyl acetate = 5:1, 74.6 mg, 84 %). m.p. 180-182 °C. ¹H NMR (500 MHz, CDCl₃) δ 16.87 (s, 1H), 7.41-7.38 (m, 1H), 7.31-7.25 (m, 3H), 7.22-7.20 (m, 2H), 7.14-7.11 (m, 4H), 6.92-6.89 (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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₇H₂₄O₄S [M+Na]⁺: 467.1395, found: 467.1286.



3d

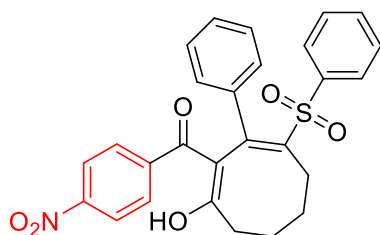
(4-chlorophenyl)((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)methanone

(**3d**, white solid, petroleum ether/ethyl acetate = 5:1, 59.3 mg, 62 %). m.p. 224-226 °C. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₇H₂₃ClO₄S [M+Na]⁺: 501.0898, found: 501.0897.



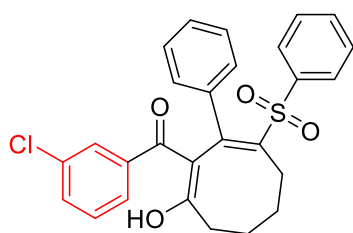
3e

((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)methanone (4-fluorophenyl) (**3e**, white solid, petroleum ether/ethyl acetate = 5:1, 80.4 mg, 87 %). m.p. 212-214 °C. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₇H₂₃FO₄S [M+Na]⁺: 485.1193, found: 485.1187.



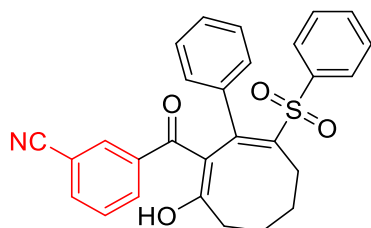
3f

((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 °C. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₇H₂₃NO₆S [M+Na]⁺: 512.1246, found: 512.1142.



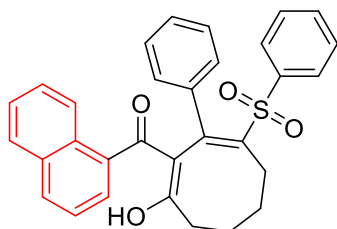
3g

(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. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₇H₂₃ClO₄S [M+H]⁺: 479.1006, found: 479.1074.



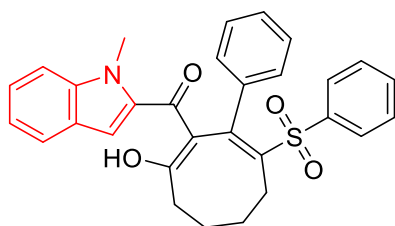
3h

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. ¹H 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); ¹³C 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 C₂₈H₂₃NO₄S [M+Na]⁺: 492.1240, found: 492.1233.



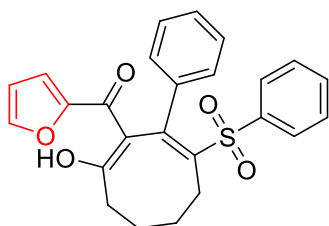
3i

((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. ¹H 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); ¹³C 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 C₃₁H₂₆O₄S [M+Na]⁺: 517.1444, found: 517.1441.



3j

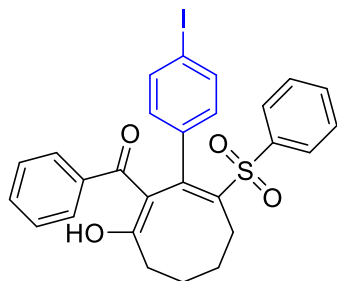
((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(1-methyl-1H-indol-2-yl)methanone (3j), yellow solid, petroleum ether/ethyl acetate = 5:1, 56.7 mg, 57 %). m.p. 240-242 °C. ¹H NMR (500 MHz, CDCl₃) δ 16.38 (s, 1H), 7.67 (d, *J* = 7.9 Hz, 1H), 7.35-7.30 (m, 2H), 7.29-7.26 (m, 2H), 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* = 12.5 Hz, 1H), 2.27-2.15 (m, 2H), 2.10-2.02 (m, 1H), 1.69-1.61 (m, 1H); ¹³C NMR (125 MHz, CDCl₃) 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 C₃₀H₂₇NO₄S2 [M+H]⁺: 498.1734, found: 498.1736.



3k

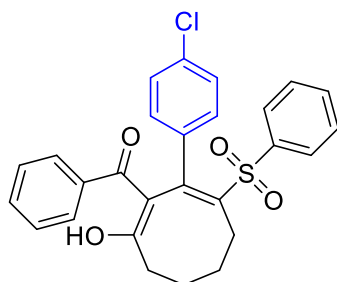
furan-2-yl((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)methanone (3k), white solid, petroleum ether/ethyl acetate = 8:1, 76.4 mg, 88 %). m.p. 160-162 °C. ¹H NMR (500 MHz, CDCl₃) δ 16.31 (s, 1H), 7.57 (d, *J* = 2.0 Hz, 1H), 7.35-7.31 (m, 3H), 7.19-7.15 (m, 2H), 7.08 (d, *J* = 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); ¹³C NMR (125 MHz, CDCl₃) 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.



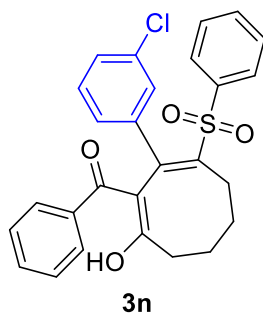
3l

((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. 1H 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 = 12 Hz, 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.

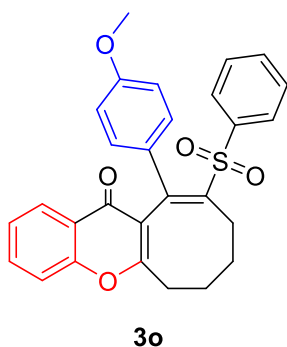


3m

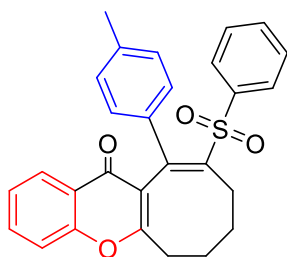
((1Z,7E)-8-(4-chlorophenyl)-2-hydroxy-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone (**3m**, white solid, petroleum ether/ethyl acetate = 5:1, 75.5 mg, 79 %). m.p. 201-203 °C. 1H NMR (500 MHz, $CDCl_3$) δ 16.86 (s, 1H), 7.44-7.40 (m, 1H), 7.38-7.34 (m, 1H), 7.30-7.24 (m, 4H), 7.21-7.18 (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.



((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 °C. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₇H₂₃ClO₄S [M+H]⁺: 479.1006, found: 479.1014.

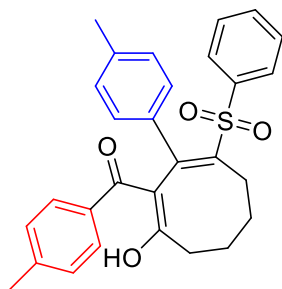


(E)-11-(4-methoxyphenyl)-10-(phenylsulfonyl)-6,7,8,9-tetrahydro-12H-cycloocta[b]chromen-12-one (3o, yellow oil, petroleum ether/ethyl acetate = 5:1, 88.8 mg, 94 %). ¹H NMR (500 MHz, CDCl₃) δ 8.01-8.00 (m, 2H), 7.62-7.59 (m, 2H), 7.43-7.38 (m, 4H), 7.31-7.25 (m, 3H), 7.03 (d, *J* = 10.0 Hz, 2H), 3.74 (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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₈H₂₄O₅S [M+Na]⁺: 495.1344, found: 495.1247.



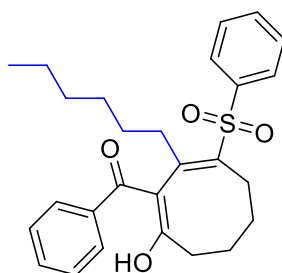
3p

(E)-10-(phenylsulfonyl)-11-(*p*-tolyl)-6,7,8,9-tetrahydro-12*H*-cycloocta[*b*]chromen-12-one (**3p**, yellow oil, petroleum ether/ethyl acetate = 5:1, 85.8 mg, 94 %). ^1H 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 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 $\text{C}_{28}\text{H}_{24}\text{O}_4\text{S}$ $[\text{M}+\text{Na}]^+$: 479.1395, found: 479.1294.



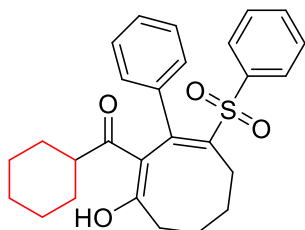
3q

((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. ^1H 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 $\text{C}_{29}\text{H}_{28}\text{O}_4\text{S}$ $[\text{M}+\text{Na}]^+$: 495.1600, found: 495.1590.



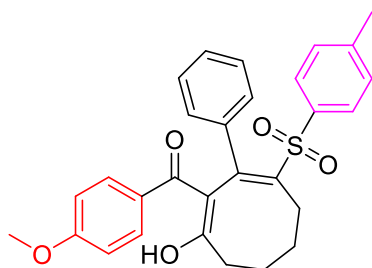
3r

((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 %). ^1H 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 $\text{C}_{27}\text{H}_{32}\text{O}_4\text{S}$ $[\text{M}+\text{Na}]^+$: 475.2178, found: 475.1927.



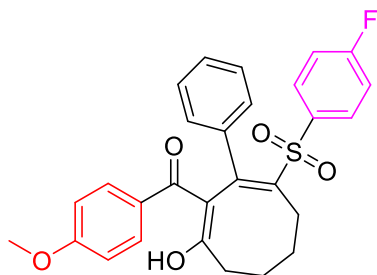
3s

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 %). ^1H 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 $\text{C}_{27}\text{H}_{30}\text{O}_4\text{S}$ $[\text{M}+\text{H}]^+$: 473.1865, found: 473.1750.



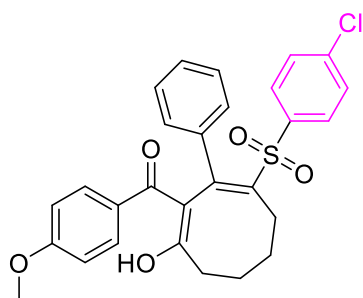
3t

((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. ^1H 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 $\text{C}_{29}\text{H}_{28}\text{O}_5\text{S}$ $[\text{M}+\text{Na}]^+$: 511.1657, found: 511.1550.



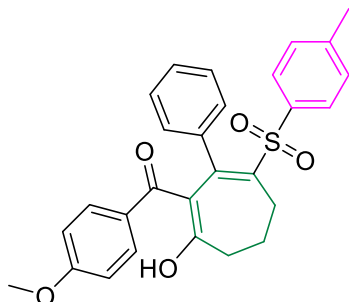
3u

((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. ^1H 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 $\text{C}_{28}\text{H}_{25}\text{FO}_5\text{S}$ $[\text{M}+\text{Na}]^+$: 515.1407, found: 515.1295.



3v

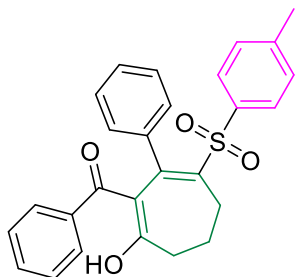
((1Z,7E)-7-((4-chlorophenyl)sulfonyl)-2-hydroxy-8-phenylcycloocta-1,7-dien-1-yl)(4-methoxyphenyl)methanone (3v, white solid, petroleum ether/ethyl acetate = 5:1, 99.6 mg, 98 %). m.p. 178-180 °C. ^1H NMR (500 MHz, CDCl_3) δ 16.93 (s, 1H), 7.22-7.19 (m, 2H), 7.12-7.06 (m, 4H), 6.98-6.95 (m, 1H), 6.81-6.76 (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 $\text{C}_{28}\text{H}_{25}\text{ClO}_5\text{S}$ $[\text{M}+\text{H}]^+$: 509.1111, found: 509.1183.



3w

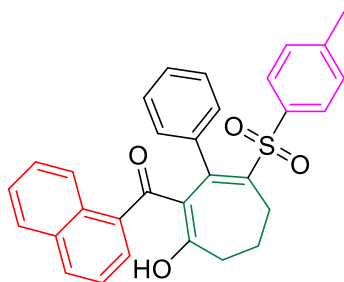
(2-hydroxy-7-phenyl-6-tosylcyclohepta-1,6-dien-1-yl)(4-methoxyphenyl)methanone (3w, white solid,

petroleum ether/ethyl acetate = 5:1, 86.3 mg, 91 %). m.p. 210-212 °C. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₈H₂₆O₅S [M+Na]⁺: 497.1501, found: 497.1389.



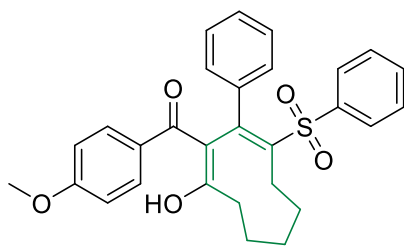
3x

(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. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₇H₂₄O₄S [M+Na]⁺: 467.1395, found: 467.1278.



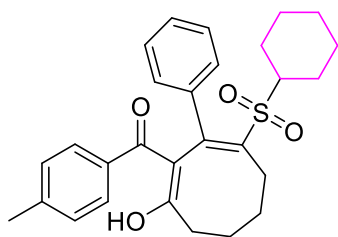
3y

(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. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₃₁H₂₆O₄S [M+Na]⁺: 517.1552, found: 517.1443.



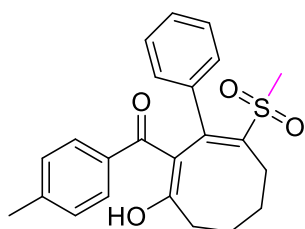
3z

((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. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₉H₂₈O₅S [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. ¹H NMR (500 MHz, CDCl₃) 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); ¹³C NMR (125 MHz, CDCl₃) 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 C₂₈H₃₂O₄S [M+Na]⁺: 487.1914, found:487.1910.

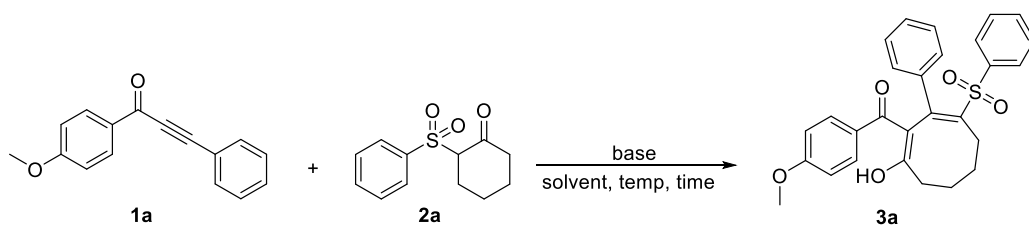


3ab

((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 °C. ^1H 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 $\text{C}_{23}\text{H}_{24}\text{O}_4\text{S}$ $[\text{M}+\text{Na}]^+$: 419.1287, found:419.1284.

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

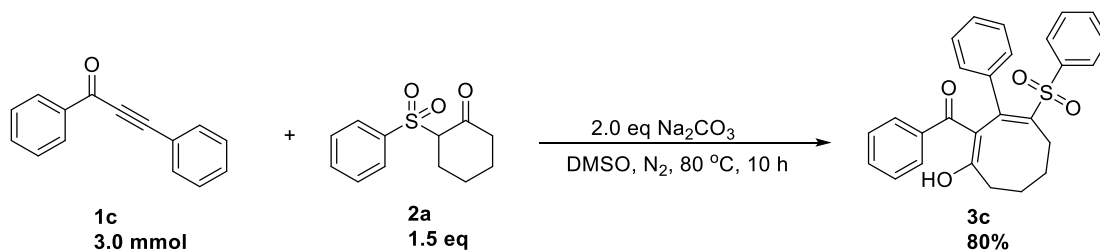


entry	2a(equiv)	base(equiv)	solvent	T (°C)	time (h)	yield ^b (%)
1	1.0	^t BuOK(2.0)	DMSO	60	8	trace ^c
2	1.0	K ₂ CO ₃ (2.0)	DMSO	60	8	41 ^c
3	1.0	^t BuONa(2.0)	DMSO	60	8	trace ^c
4	1.0	Na ₂ CO ₃ (2.0)	DMSO	60	8	56 ^c
5	1.0	Cs ₂ CO ₃ (2.0)	DMSO	60	8	43 ^c
6	1.0	Na ₂ CO ₃ (2.0)	DMSO	60	8	63
7	1.0	Cs ₂ CO ₃ (2.0)	DMSO	60	8	59
8	1.2	Na ₂ CO ₃ (2.0)	DMSO	60	8	60
9	1.5	Na ₂ CO ₃ (2.0)	DMSO	60	8	80
10	1.5	Na₂CO₃(2.0)	DMSO	80	4	83
11	1.5	Na ₂ CO ₃ (2.0)	DMSO	80	4	58 ^c
12	1.2	Na ₂ CO ₃ (2.0)	DMSO	80	4	69
13	1.5	Na ₂ CO ₃ (2.0)	DMSO	100	1.5	74
14	1.2	Na ₂ CO ₃ (2.0)	DMSO	100	1.5	64
15	1.5	Na ₂ CO ₃ (1.5)	DMSO	80	4	80
16	1.5	Na ₂ CO ₃ (3.0)	DMSO	80	4	49
17	1.5	Na ₂ CO ₃ (2.0)	DMF	80	4	28
18	1.5	Na ₂ CO ₃ (2.0)	DMAC	80	4	48
19	1.5	Na ₂ CO ₃ (2.0)	Toluene	80	4	NR

^aUnless otherwise noted, all reactions were carried out under N₂ on a 0.3 mmol scale.

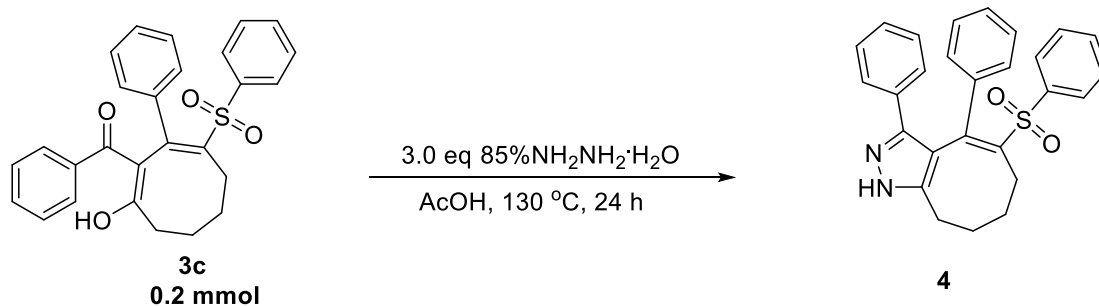
^bIsolated yields. ^cThe reaction was carried out under air.

5. Gram Scales



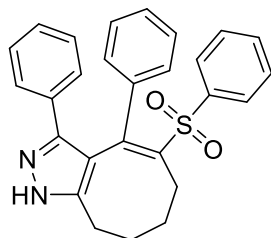
In a schlenk tube 1,3-diphenylprop-2-yn-1-one **1c** (3.0 mmol), The 2-(phenylsulfonyl)cyclohexan-1-one **2a** (4.5 mmol), Na_2CO_3 (6.0 mmol) and DMSO (30.0 ml) were stirred at 80 °C under nitrogen atmosphere. After the reaction was completed as monitored by thin-layer chromatography, the reaction mixture was then quenched by water, and the water layers were extracted with ethyl acetate (20 mL \times 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



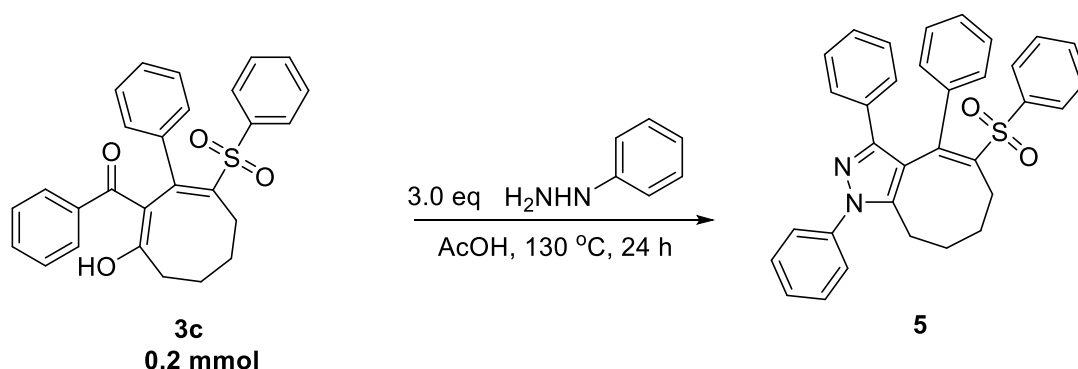
In a sealed tube, ((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone **3c**, 85% $\text{NH}_2\text{NH}_2\cdot\text{H}_2\text{O}$ (0.6 mmol, 0.04 ml, 3.0 equiv), AcOH (1 ml) were stirred at 130 °C for 24 h. After the reaction was completed as monitored by thin-layer chromatography, the reaction mixture was then quenched by saturated sodium bicarbonate, and the water layers were extracted with ethyl acetate (10 mL \times 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%).

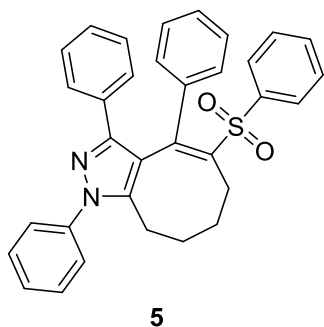


4

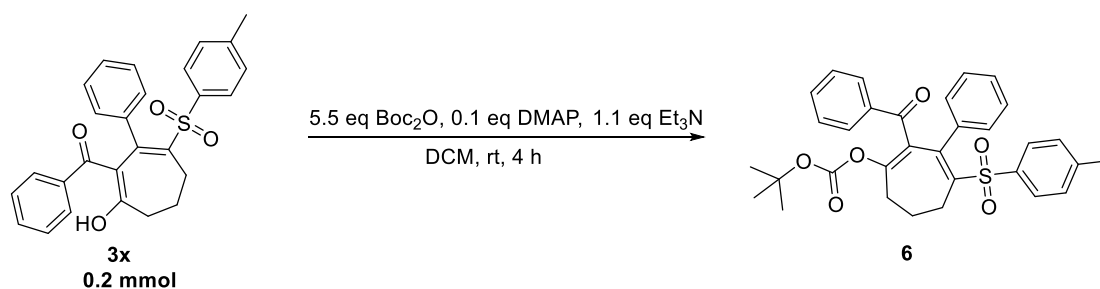
(E)-3,4-diphenyl-5-(phenylsulfonyl)-6,7,8,9-tetrahydro-1H-cycloocta[c]pyrazole (**4**, white solid, petroleum ether/ethyl acetate = 10:1, 66.7 mg, 76 %). m.p. 258-260 °C. ¹H NMR (500 MHz, *d*⁶-DMSO) δ 12.96 (s, 1H), 7.46-7.40 (m, 1H), 7.30-7.24 (m, 4H), 7.22-7.05 (m, 5H), 6.88 (t, *J* = 7.5 Hz, 1H), 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).; ¹³C 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 C₂₇H₂₄N₂O₂S [M+Na]⁺: 463.1558, found: 463.1451.



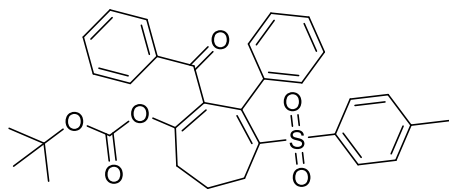
In a sealed tube, ((1Z,7E)-2-hydroxy-8-phenyl-7-(phenylsulfonyl)cycloocta-1,7-dien-1-yl)(phenyl)methanone **3c**, phenylhydrazine (0.6 mmol, 0.06 ml, 3.0 equiv), AcOH (1 ml) were stirred at 130 °C for 24 h. After the reaction was completed as monitored by thin-layer chromatography, the reaction mixture 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 Na₂SO₄, 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%).



(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 °C. ¹H 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).; ¹³C 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 C₃₃H₂₈N₂O₂S [M+H]⁺: 517.1871, found: 517.1940.



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), CH₂Cl₂ (2 ml) were stirred at room temperature, and NEt₃ (0.22 mmol, 0.03 ml, 1.1 equiv), Boc₂O (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 CH₂Cl₂ (10 ml × 3). The combined organic layers were washed with brine (10 ml), dried over Na₂SO₄, 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

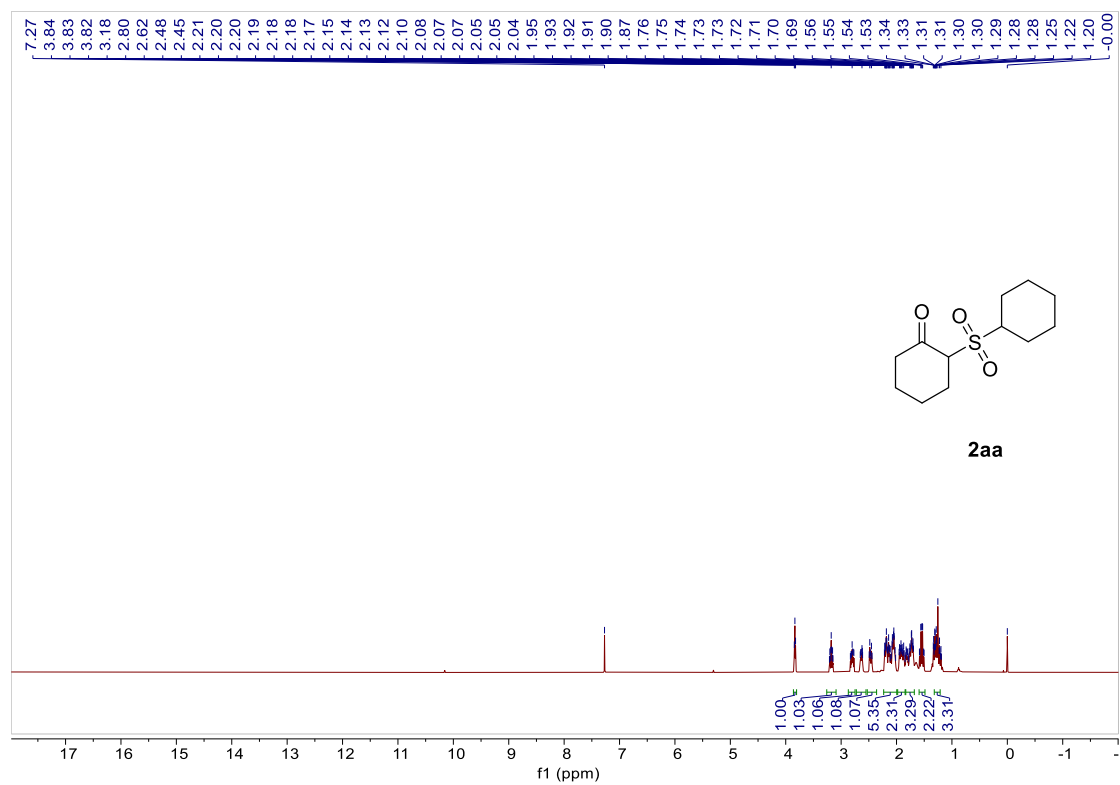
2-benzoyl-3-phenyl-4-tosylcyclohepta-1,3-dien-1-yl tert-butyl carbonate (6, white solid, petroleum ether/ethyl acetate = 10:1, 91.6 mg, 84 %). m.p. 206-208 °C. ¹H NMR (500 MHz, CDCl₃) δ 7.53-7.47 (m, 2H), 7.44-7.34 (m, 3H), 7.28 (t, *J* = 7.5 Hz, 2H), 7.13-7.05 (m, 3H), 7.01 (t, *J* = 7.5 Hz, 2H), 6.87 (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); ¹³C NMR (125 MHz, CDCl₃) 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 C₃₂H₃₂O₆S [M+Na]⁺: 567.1920, found: 567.1826.

7. References

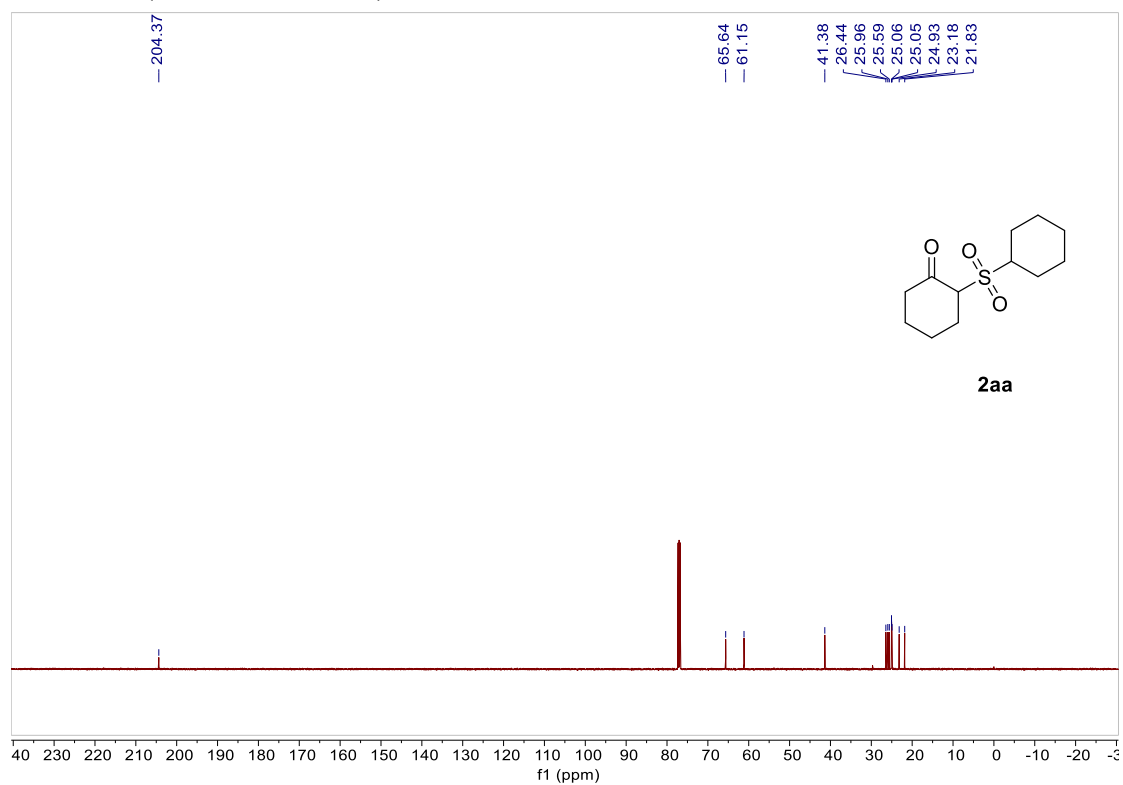
- (1) (a) Cheng, X.; Zhou, Y.; Zhang, F.; Zhu, K.; Liu, Y.; Li, Y. Base-Promoted Tandem Reaction Involving Insertion into Carbon-Carbon α -Bonds: Synthesis of Xanthone and Chromone Derivatives. *Chemistry* **2016**, *22*, 12655-12659. (b) Tan, H.; Li, H.; Ji, W.; Wang, L. Sunlight-Driven Decarboxylative Alkynylation of α -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

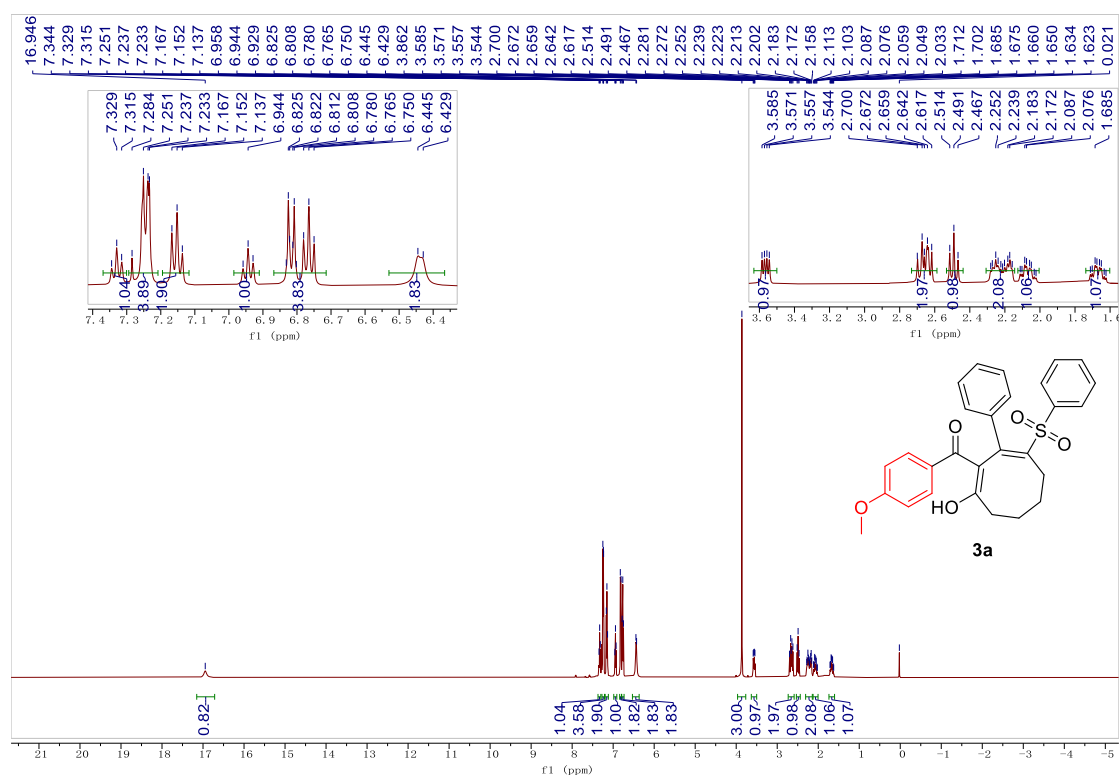
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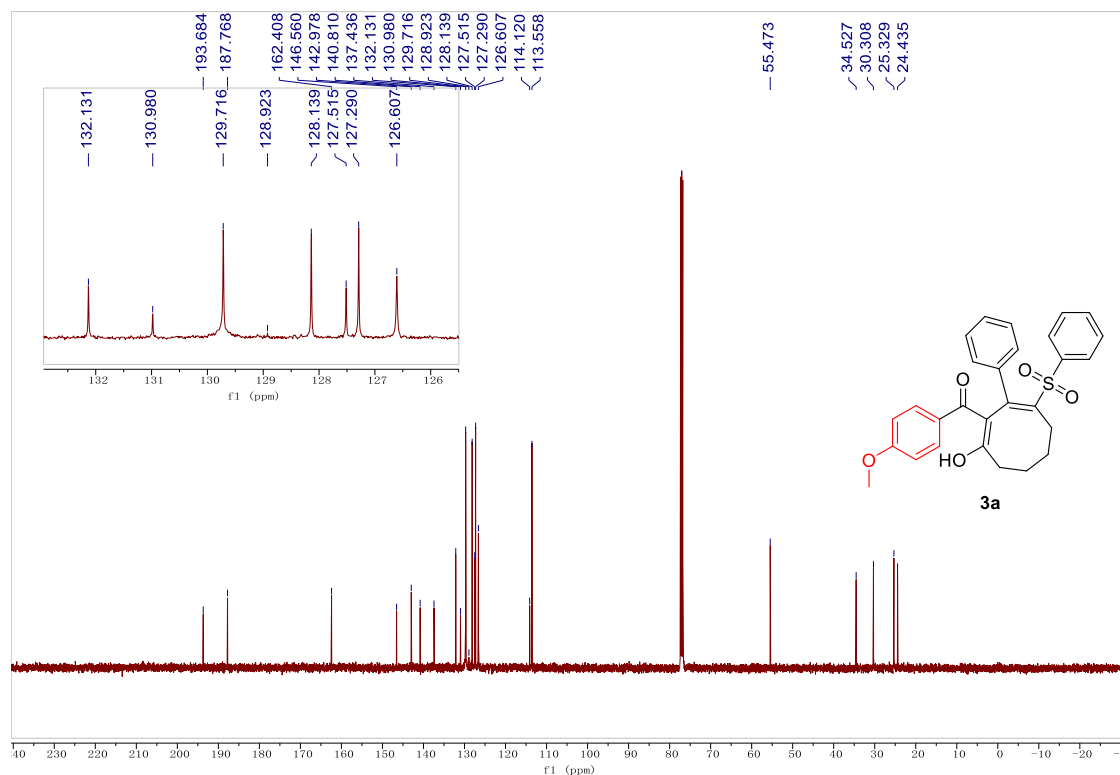
^{13}C NMR (125 MHz, CDCl_3)



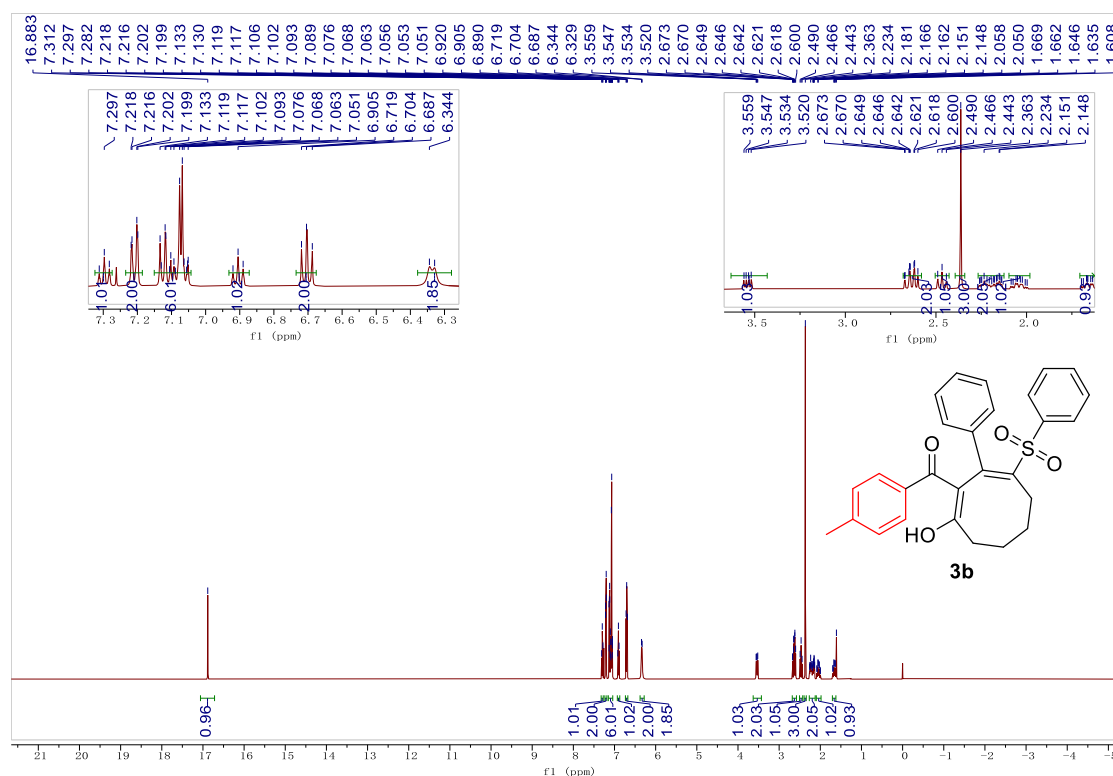
^1H NMR (500 MHz, CDCl_3)



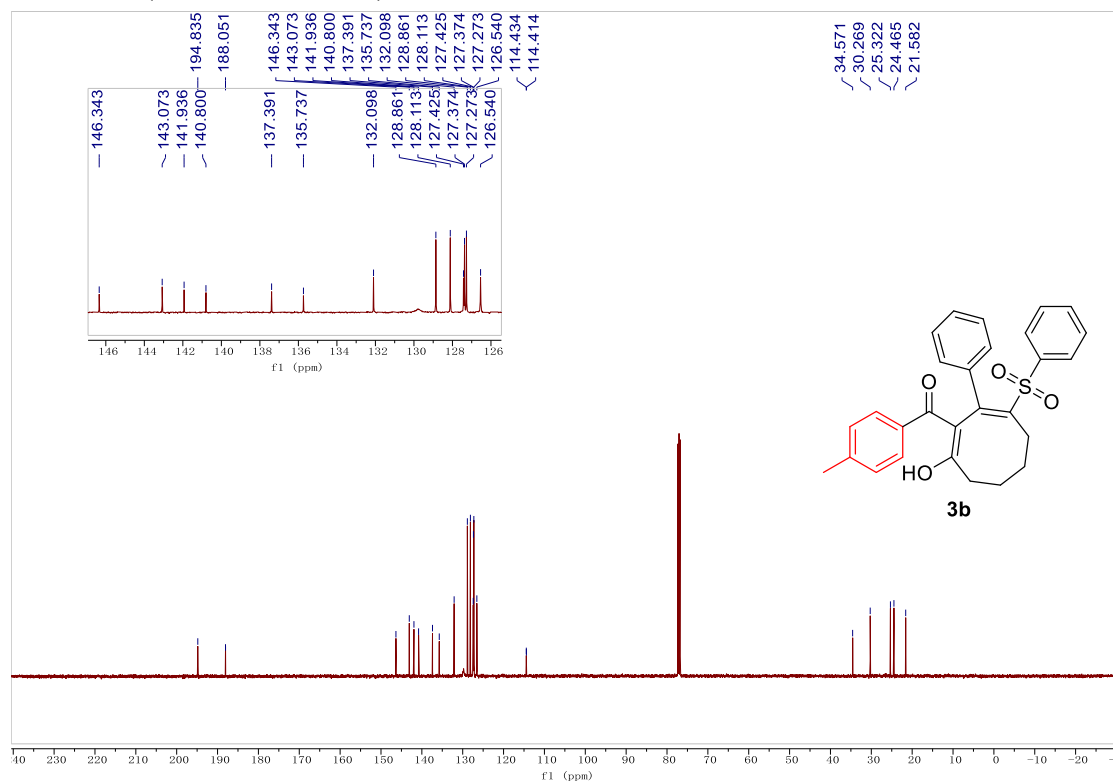
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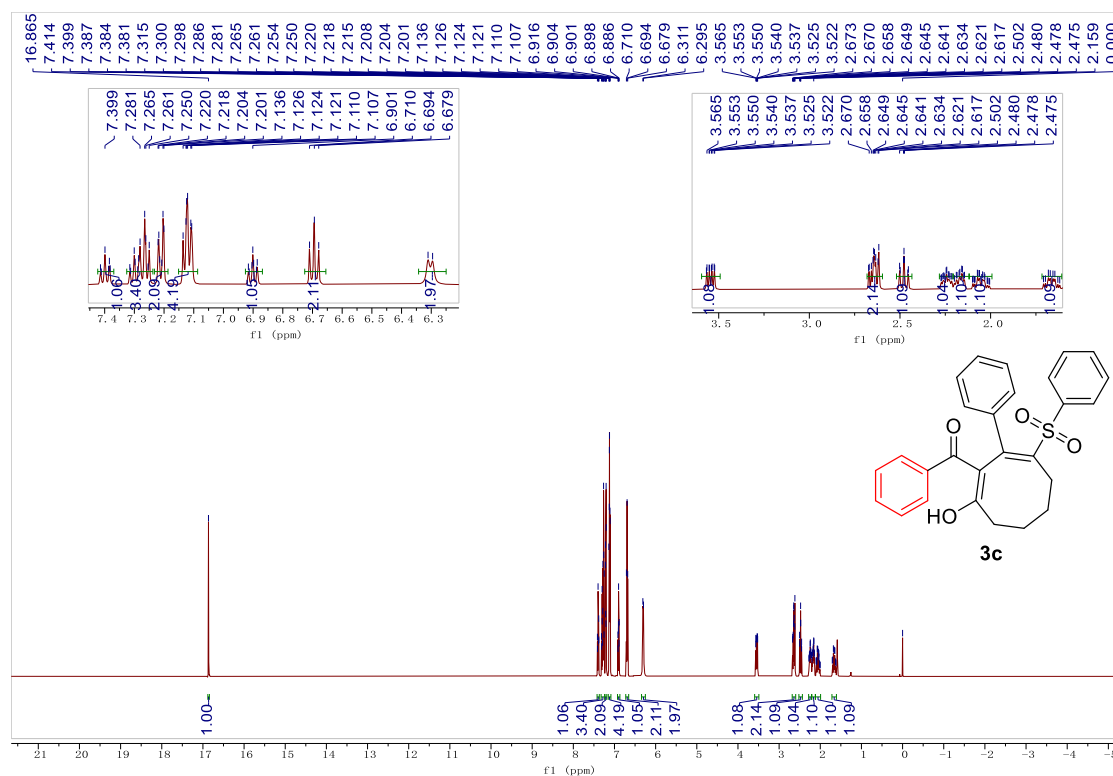
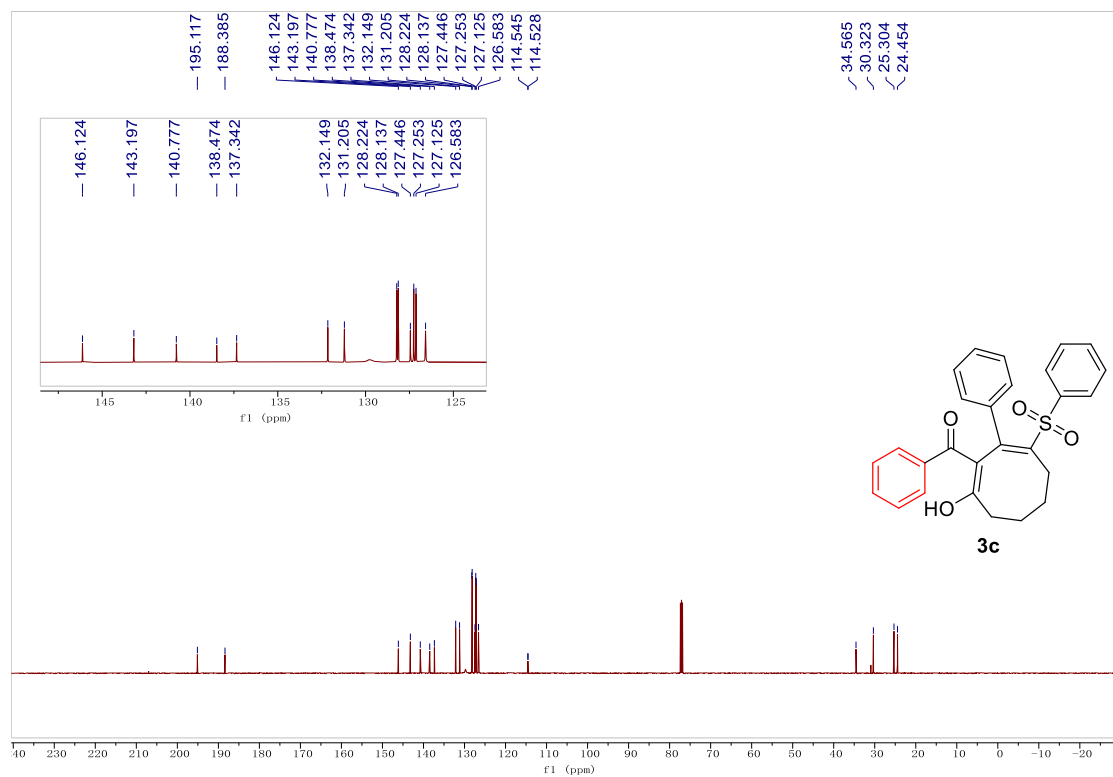


^1H NMR (500 MHz, CDCl_3)

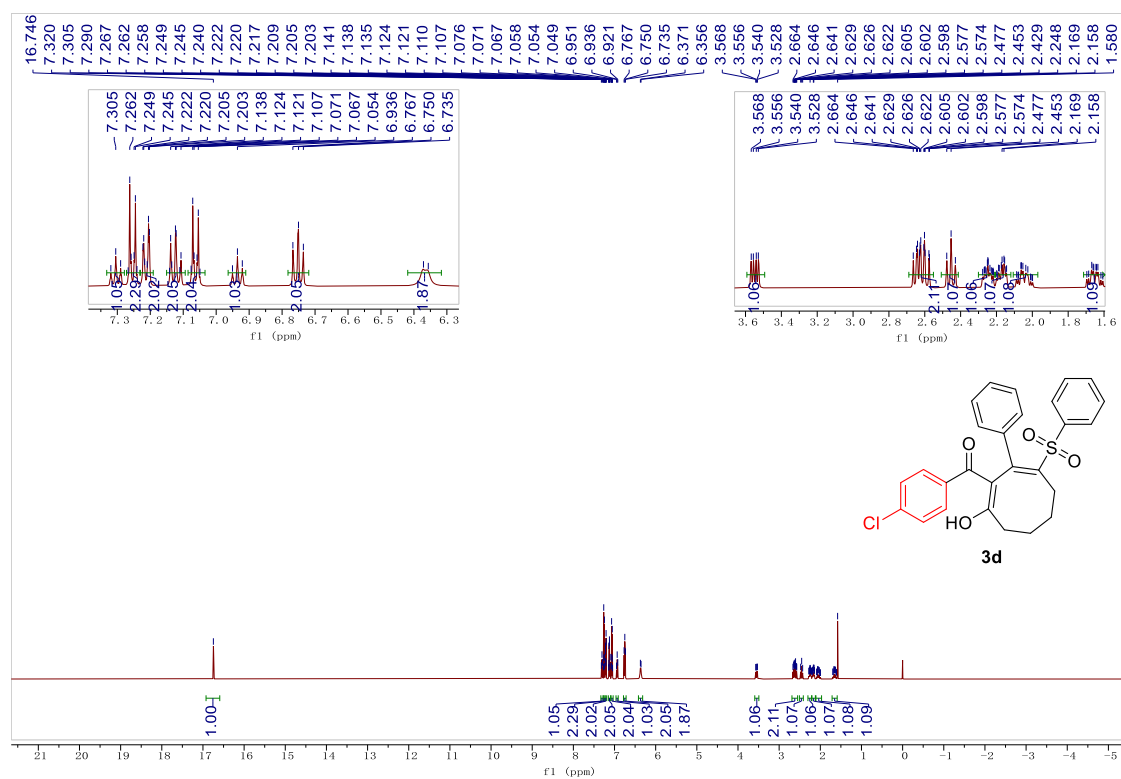


^{13}C NMR (125 MHz, CDCl_3)

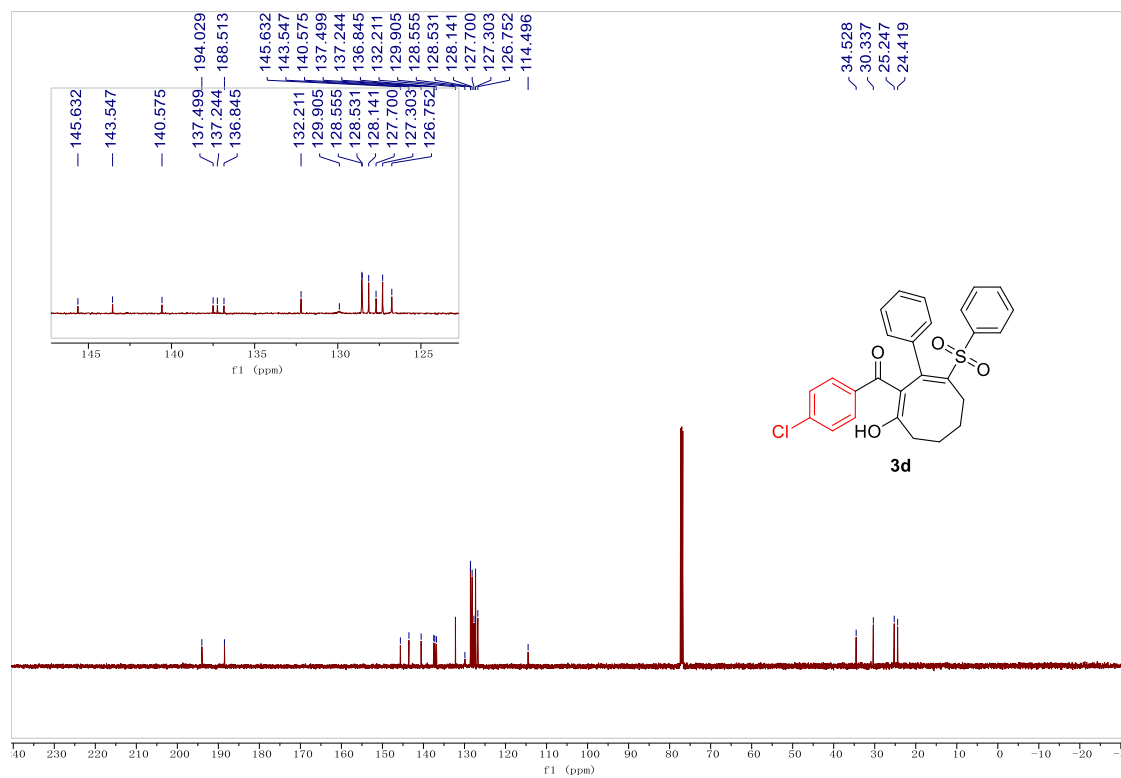


¹H NMR (500 MHz, CDCl₃) ^{13}C NMR (125 MHz, CDCl_3)

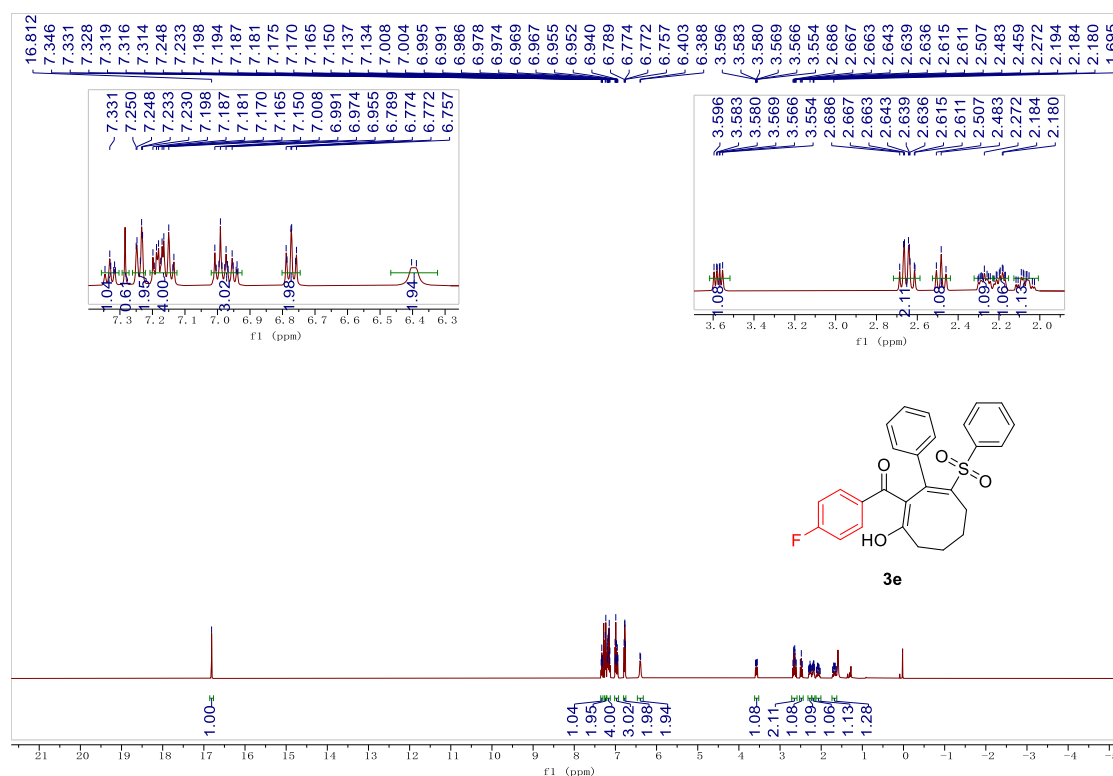
^1H NMR (500 MHz, CDCl_3)



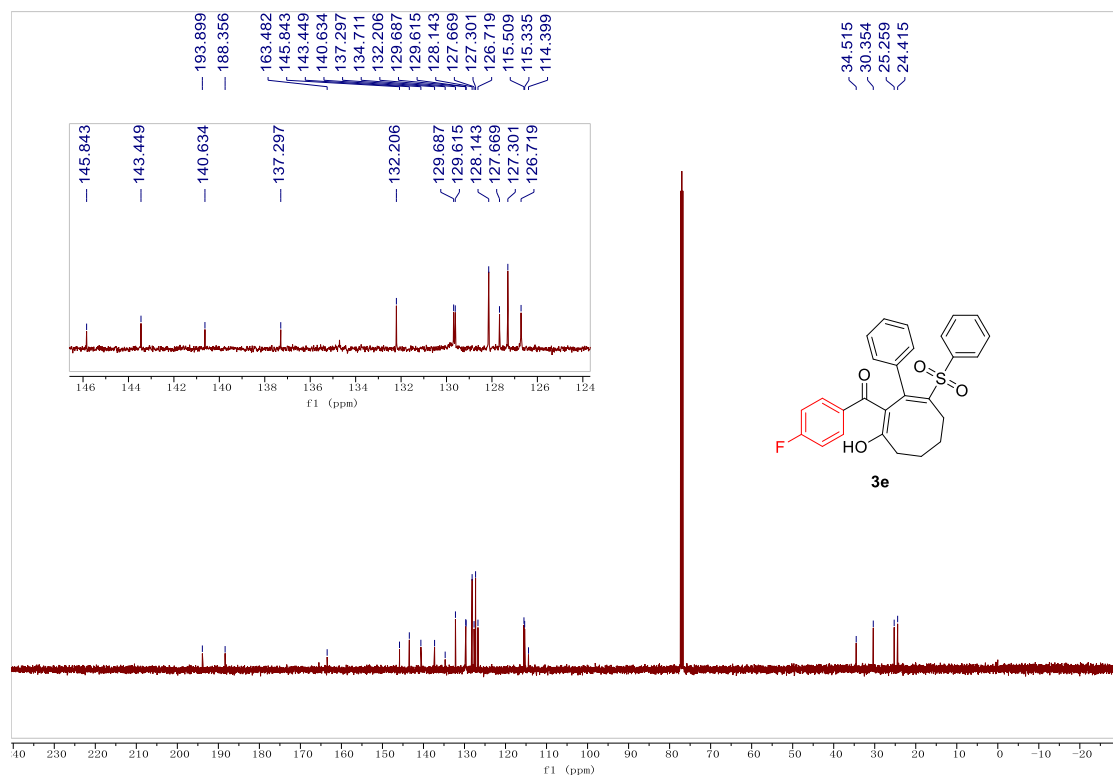
^{13}C NMR (125 MHz, CDCl_3)



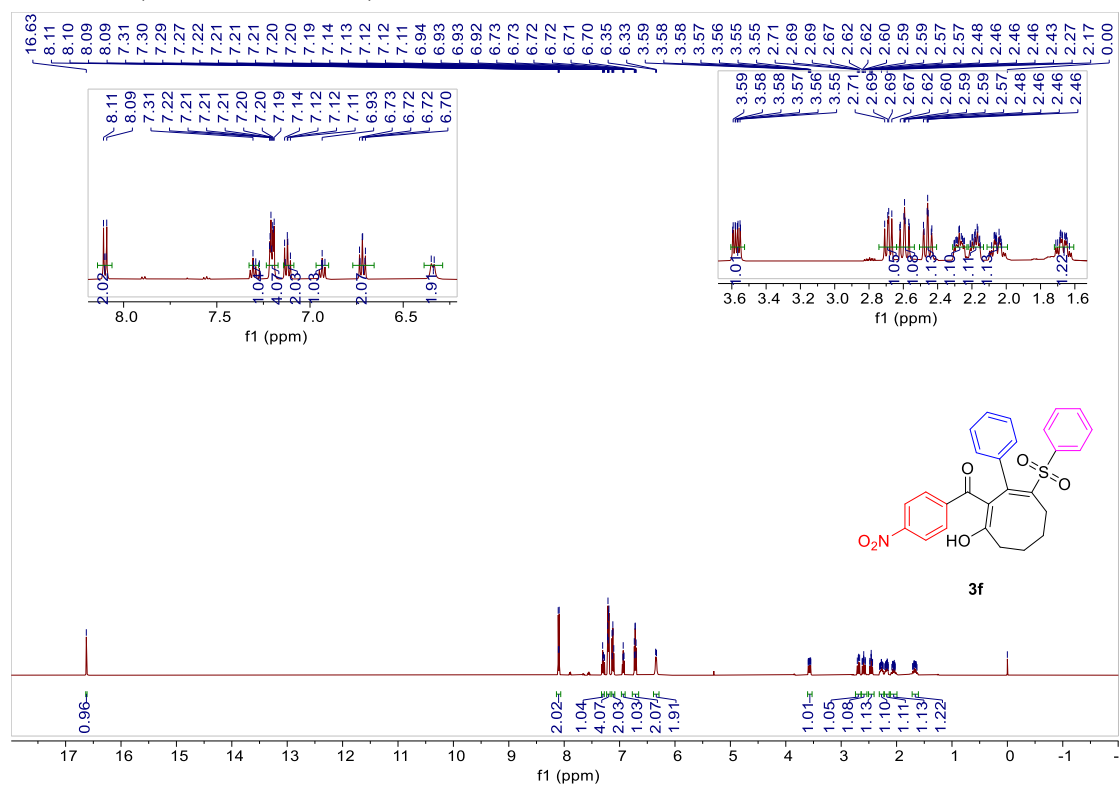
^1H NMR (500 MHz, CDCl_3)



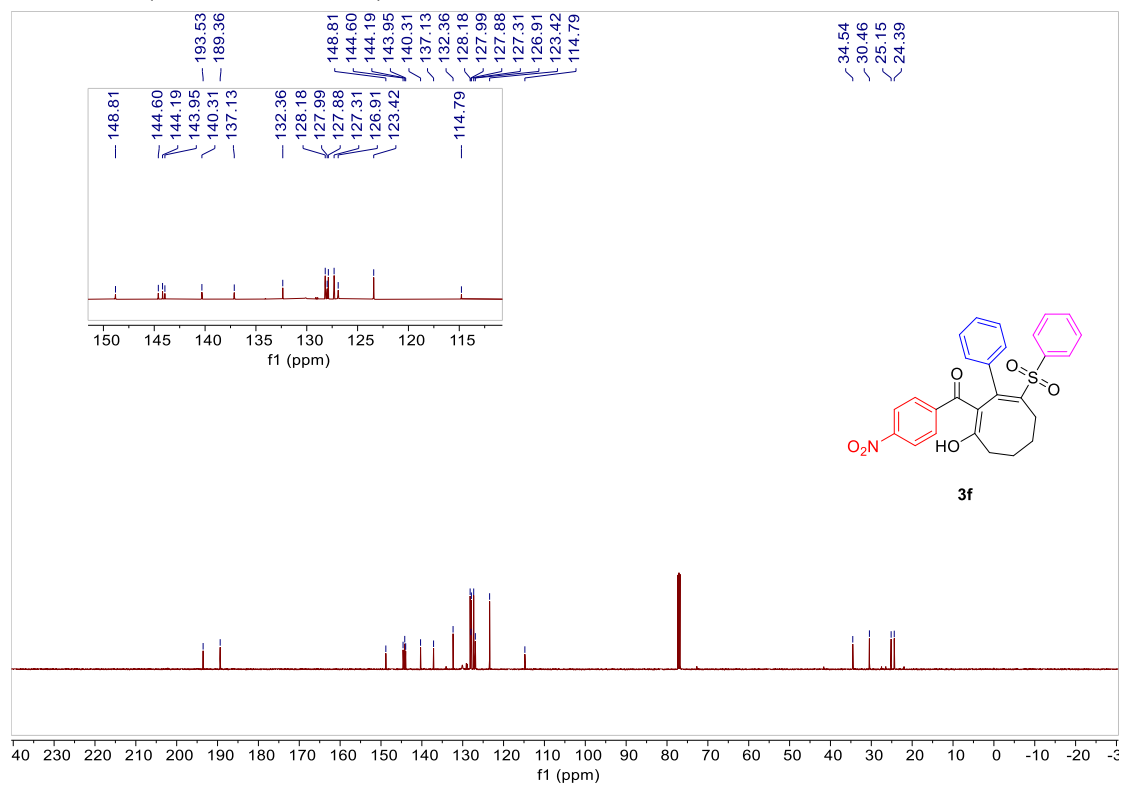
^{13}C NMR (125 MHz, CDCl_3)

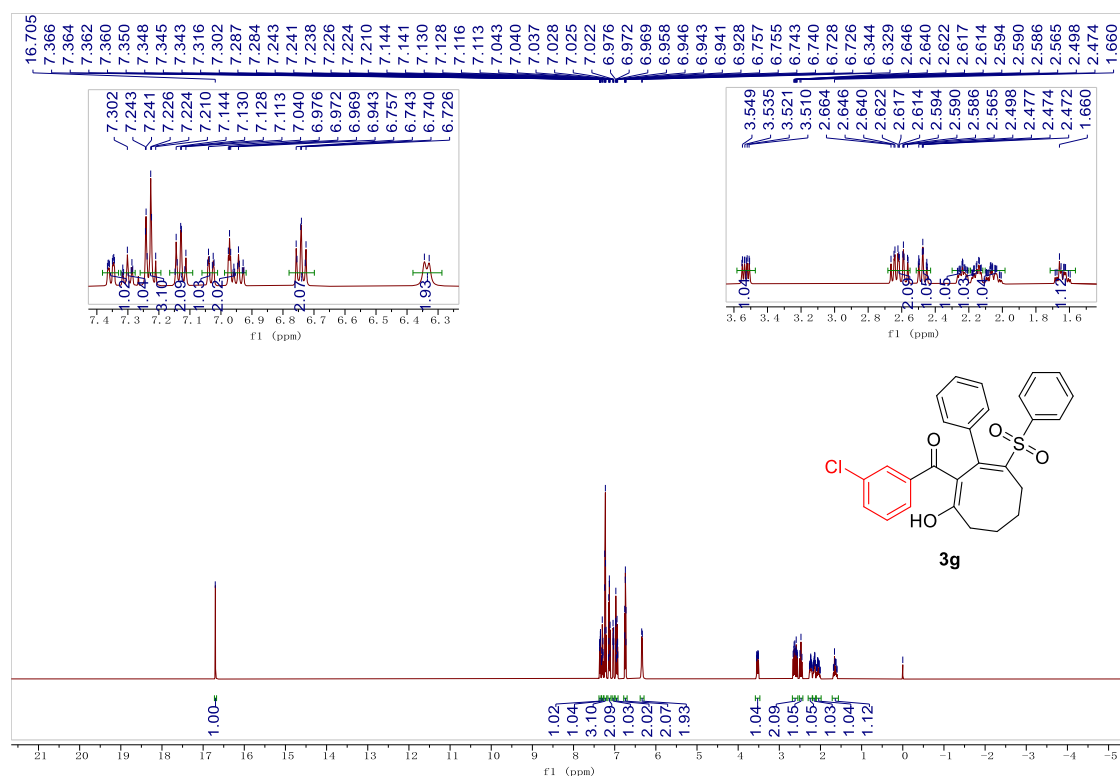
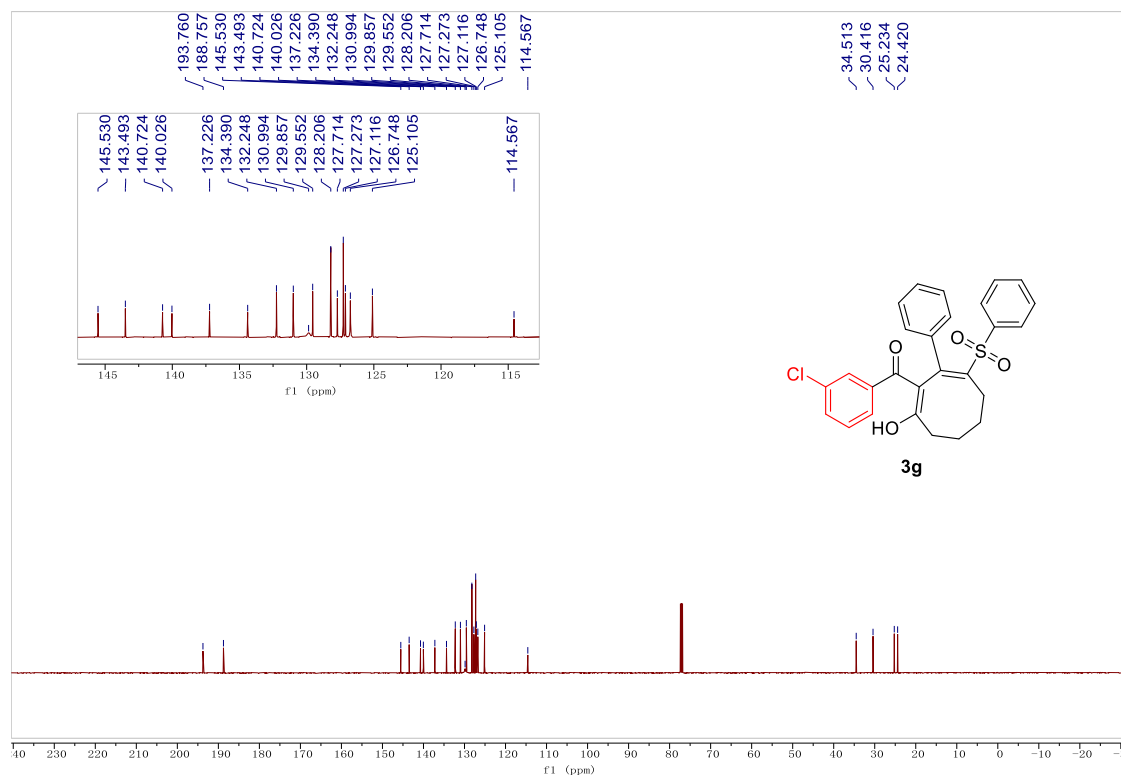


^1H NMR (500 MHz, CDCl_3)

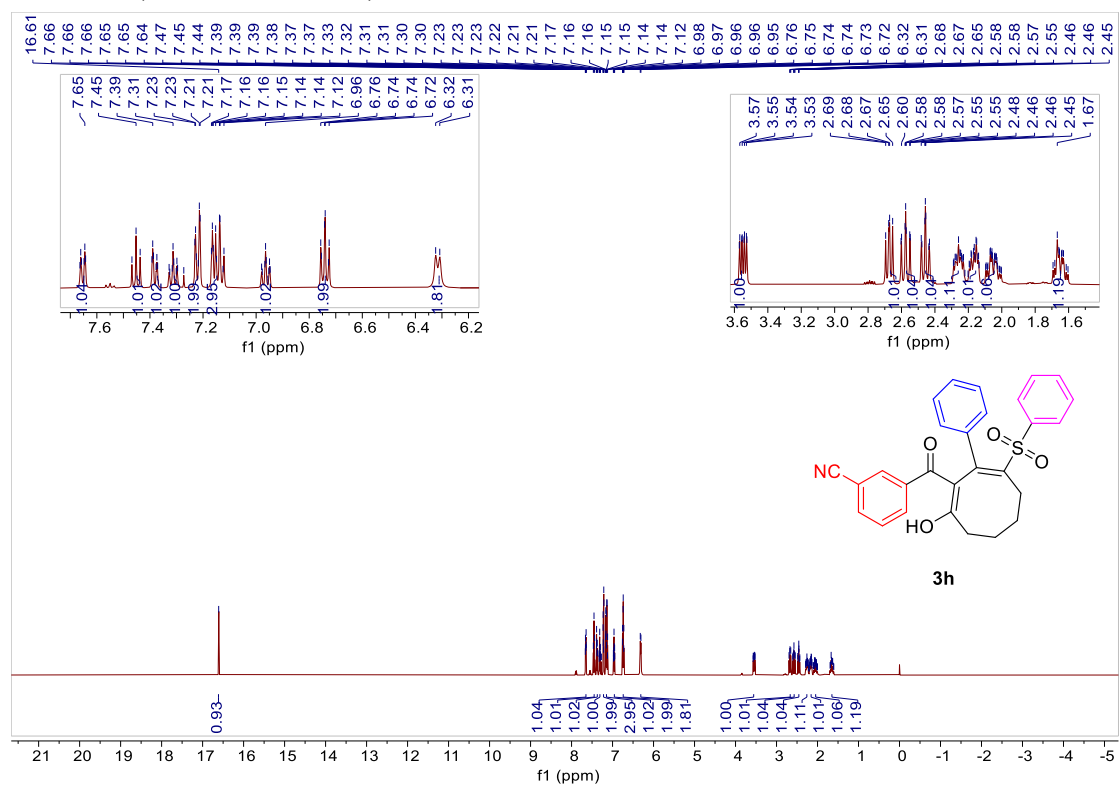


^{13}C NMR (125 MHz, CDCl_3)

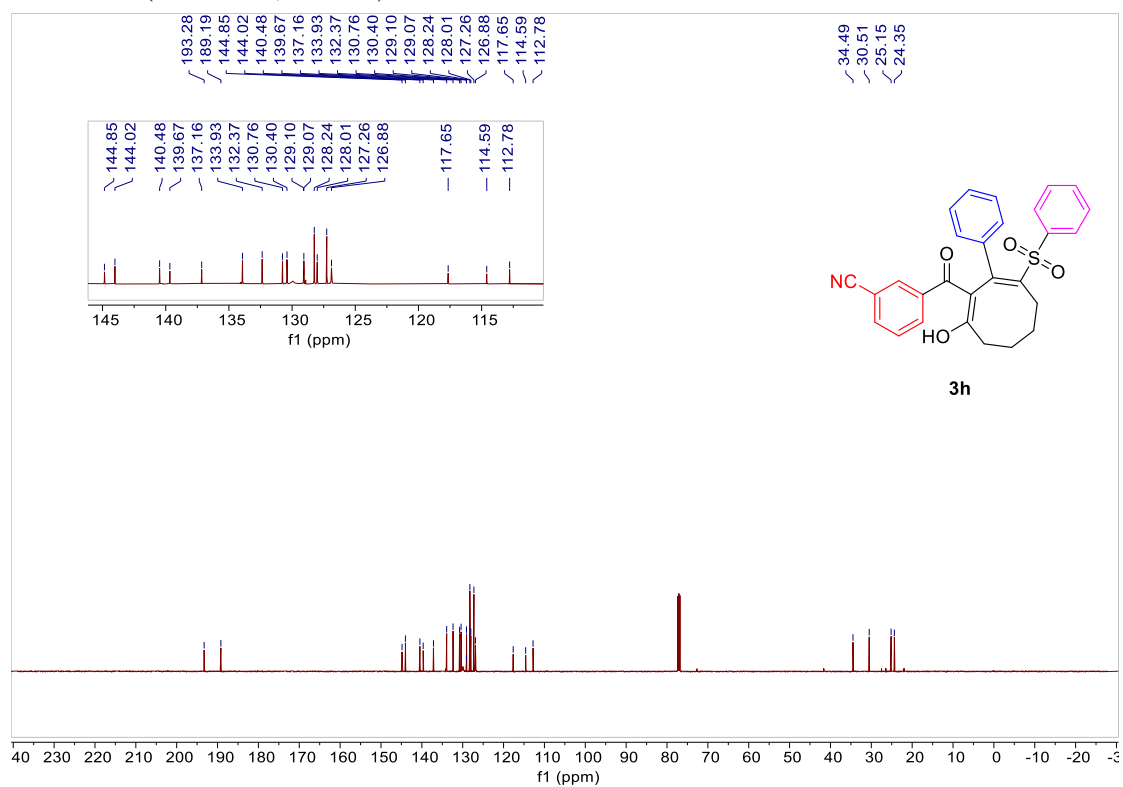


¹H NMR (500 MHz, CDCl₃) ^{13}C NMR (125 MHz, CDCl_3)

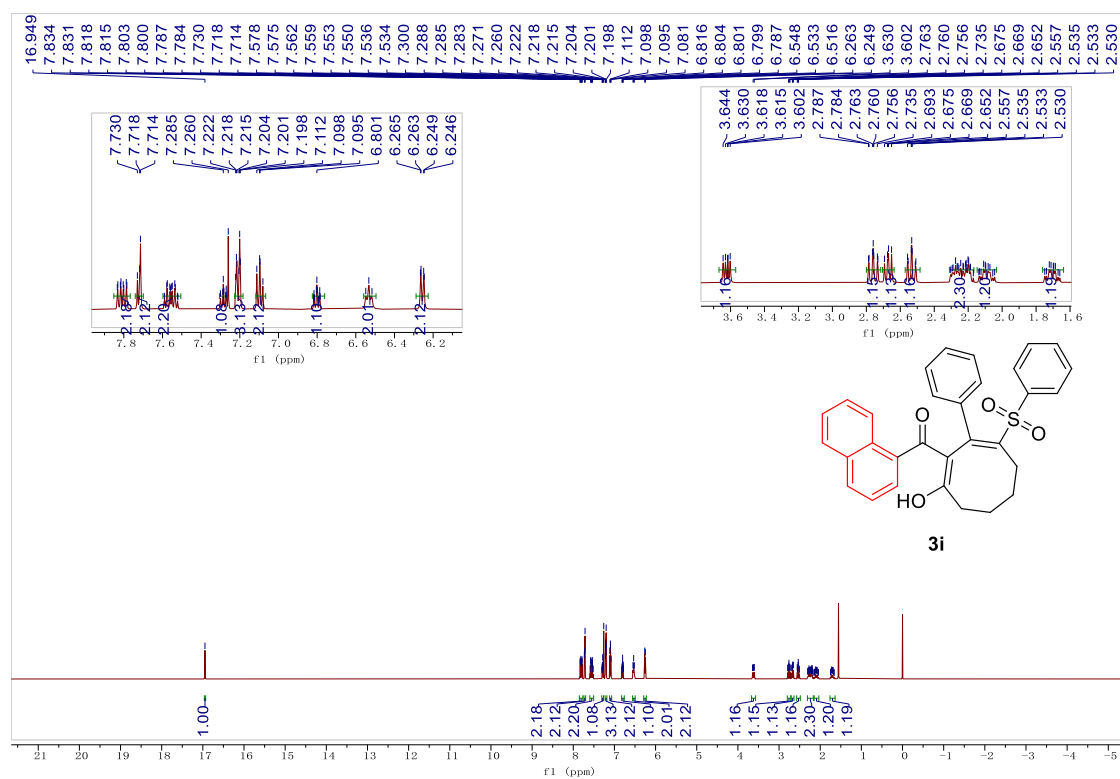
^1H NMR (500 MHz, CDCl_3)



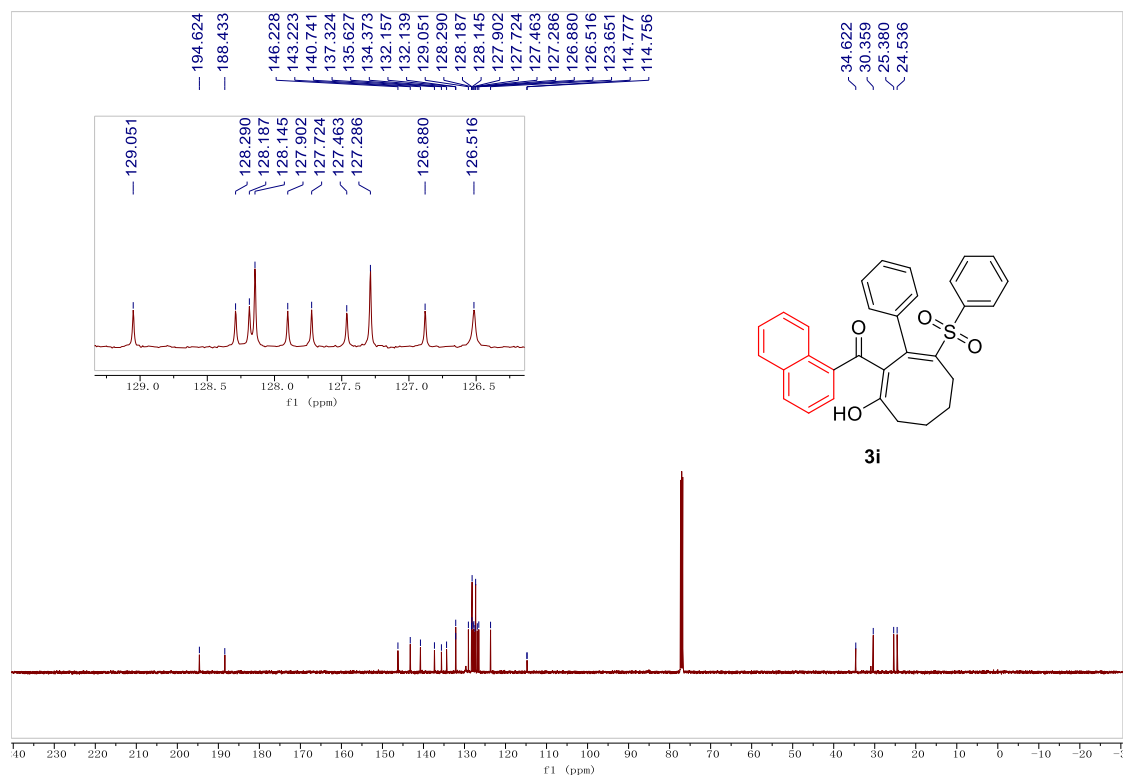
^{13}C NMR (125 MHz, CDCl_3)



^1H NMR (500 MHz, CDCl_3)



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



The figure displays the ¹H and ¹³C NMR spectra of compound 3j, along with its chemical structure.

Chemical Structure of 3j: The structure is a 10-membered ring containing a ketone, a hydroxyl group, and a sulfonamide group. It is substituted with a 1-methyl-1H-indol-3-yl group and a phenyl group.

¹H NMR Spectrum (CDCl₃): The spectrum shows peaks in the aromatic region (6.410–7.681 ppm) and aliphatic region (2.043–3.571 ppm). Integration values are provided below the peaks.

¹³C NMR Spectrum (CDCl₃): The spectrum shows peaks in the aromatic region (116.63–163.79 ppm) and aliphatic region (25.14–28.53 ppm). Integration values are provided below the peaks.

Chemical Shift Data (ppm):

- ¹H NMR (CDCl₃): 7.681, 7.665, 7.334, 7.337, 7.331, 7.322, 7.316, 7.319, 7.308, 7.305, 7.303, 7.291, 7.289, 7.285, 7.283, 7.280, 7.272, 7.268, 7.265, 7.258, 7.183, 7.181, 7.177, 7.175, 7.171, 7.166, 7.163, 7.158, 7.154, 7.147, 7.145, 7.143, 6.935, 6.920, 6.905, 6.796, 6.708, 6.692, 6.676, 6.410, 3.571, 3.559, 3.556, 3.546, 3.543, 3.531, 3.559, 3.543, 3.217, 3.543, 2.680, 3.531, 2.677, 3.217, 2.663, 2.680, 2.656, 2.653, 2.663, 2.649, 2.656, 2.639, 2.628, 2.649, 2.625, 2.539, 2.514, 2.539, 2.514, 2.043, 0.000.
- ¹³C NMR (CDCl₃): 163.79, 163.81, 163.85, 163.91, 163.93, 163.95, 163.97, 163.99, 164.01, 164.03, 164.05, 164.07, 164.09, 164.11, 164.13, 164.15, 164.17, 164.19, 164.21, 164.23, 164.25, 164.27, 164.29, 164.31, 164.33, 164.35, 164.37, 164.39, 164.41, 164.43, 164.45, 164.47, 164.49, 164.51, 164.53, 164.55, 164.57, 164.59, 164.61, 164.63, 164.65, 164.67, 164.69, 164.71, 164.73, 164.75, 164.77, 164.79, 164.81, 164.83, 164.85, 164.87, 164.89, 164.91, 164.93, 164.95, 164.97, 164.99, 165.01, 165.03, 165.05, 165.07, 165.09, 165.11, 165.13, 165.15, 165.17, 165.19, 165.21, 165.23, 165.25, 165.27, 165.29, 165.31, 165.33, 165.35, 165.37, 165.39, 165.41, 165.43, 165.45, 165.47, 165.49, 165.51, 165.53, 165.55, 165.57, 165.59, 165.61, 165.63, 165.65, 165.67, 165.69, 165.71, 165.73, 165.75, 165.77, 165.79, 165.81, 165.83, 165.85, 165.87, 165.89, 165.91, 165.93, 165.95, 165.97, 165.99, 166.01, 166.03, 166.05, 166.07, 166.09, 166.11, 166.13, 166.15, 166.17, 166.19, 166.21, 166.23, 166.25, 166.27, 166.29, 166.31, 166.33, 166.35, 166.37, 166.39, 166.41, 166.43, 166.45, 166.47, 166.49, 166.51, 166.53, 166.55, 166.57, 166.59, 166.61, 166.63, 166.65, 166.67, 166.69, 166.71, 166.73, 166.75, 166.77, 166.79, 166.81, 166.83, 166.85, 166.87, 166.89, 166.91, 166.93, 166.95, 166.97, 166.99, 167.01, 167.03, 167.05, 167.07, 167.09, 167.11, 167.13, 167.15, 167.17, 167.19, 167.21, 167.23, 167.25, 167.27, 167.29, 167.31, 167.33, 167.35, 167.37, 167.39, 167.41, 167.43, 167.45, 167.47, 167.49, 167.51, 167.53, 167.55, 167.57, 167.59, 167.61, 167.63, 167.65, 167.67, 167.69, 167.71, 167.73, 167.75, 167.77, 167.79, 167.81, 167.83, 167.85, 167.87, 167.89, 167.91, 167.93, 167.95, 167.97, 167.99, 168.01, 168.03, 168.05, 168.07, 168.09, 168.11, 168.13, 168.15, 168.17, 168.19, 168.21, 168.23, 168.25, 168.27, 168.29, 168.31, 168.33, 168.35, 168.37, 168.39, 168.41, 168.43, 168.45, 168.47, 168.49, 168.51, 168.53, 168.55, 168.57, 168.59, 168.61, 168.63, 168.65, 168.67, 168.69, 168.71, 168.73, 168.75, 168.77, 168.79, 168.81, 168.83, 168.85, 168.87, 168.89, 168.91, 168.93, 168.95, 168.97, 168.99, 169.01, 169.03, 169.05, 169.07, 169.09, 169.11, 169.13, 169.15, 169.17, 169.19, 169.21, 169.23, 169.25, 169.27, 169.29, 169.31, 169.33, 169.35, 169.37, 169.39, 169.41, 169.43, 169.45, 169.47, 169.49, 169.51, 169.53, 169.55, 169.57, 169.59, 169.61, 169.63, 169.65, 169.67, 169.69, 169.71, 169.73, 169.75, 169.77, 169.79, 169.81, 169.83, 169.85, 169.87, 169.89, 169.91, 169.93, 169.95, 169.97, 169.99, 170.01, 170.03, 170.05, 170.07, 170.09, 170.11, 170.13, 170.15, 170.17, 170.19, 170.21, 170.23, 170.25, 170.27, 170.29, 170.31, 170.33, 170.35, 170.37, 170.39, 170.41, 170.43, 170.45, 170.47, 170.49, 170.51, 170.53, 170.55, 170.57, 170.59, 170.61, 170.63, 170.65, 170.67, 170.69, 170.71, 170.73, 170.75, 170.77, 170.79, 170.81, 170.83, 170.85, 170.87, 170.89, 170.91, 170.93, 170.95, 170.97, 170.99, 171.01, 171.03, 171.05, 171.07, 171.09, 171.11, 171.13, 171.15, 171.17, 171.19, 171.21, 171.23, 171.25, 171.27, 171.29, 171.31, 171.33, 171.35, 171.37, 171.39, 171.41, 171.43, 171.45, 171.47, 171.49, 171.51, 171.53, 171.55, 171.57, 171.59, 171.61, 171.63, 171.65, 171.67, 171.69, 171.71, 171.73, 171.75, 171.77, 171.79, 171.81, 171.83, 171.85, 171.87, 171.89, 171.91, 171.93, 171.95, 171.97,

Chemical structure of 3j: O=C1C(=C(C(=C1)C(=O)c2c[nH]c3ccccc23)C(=C(C=C1)S(=O)(=O)c4ccccc4)O

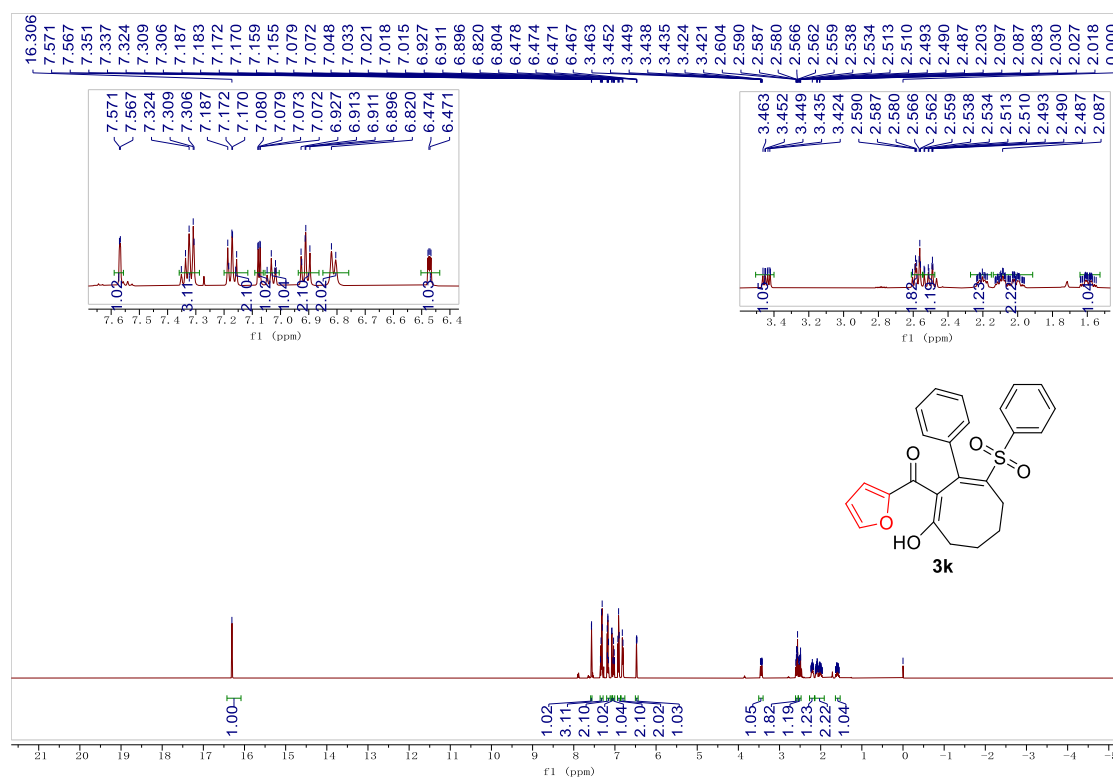
¹³C NMR peaks (ppm):

- 186.987, 186.634
- 146.269, 142.243, 140.964, 138.893, 137.981, 135.460, 132.226, 128.237, 127.462, 127.352, 126.624, 126.334, 124.928
- 122.534, 120.525
- 115.827, 115.810
- 34.564, 30.564, 30.253, 25.384, 24.357
- 0.001

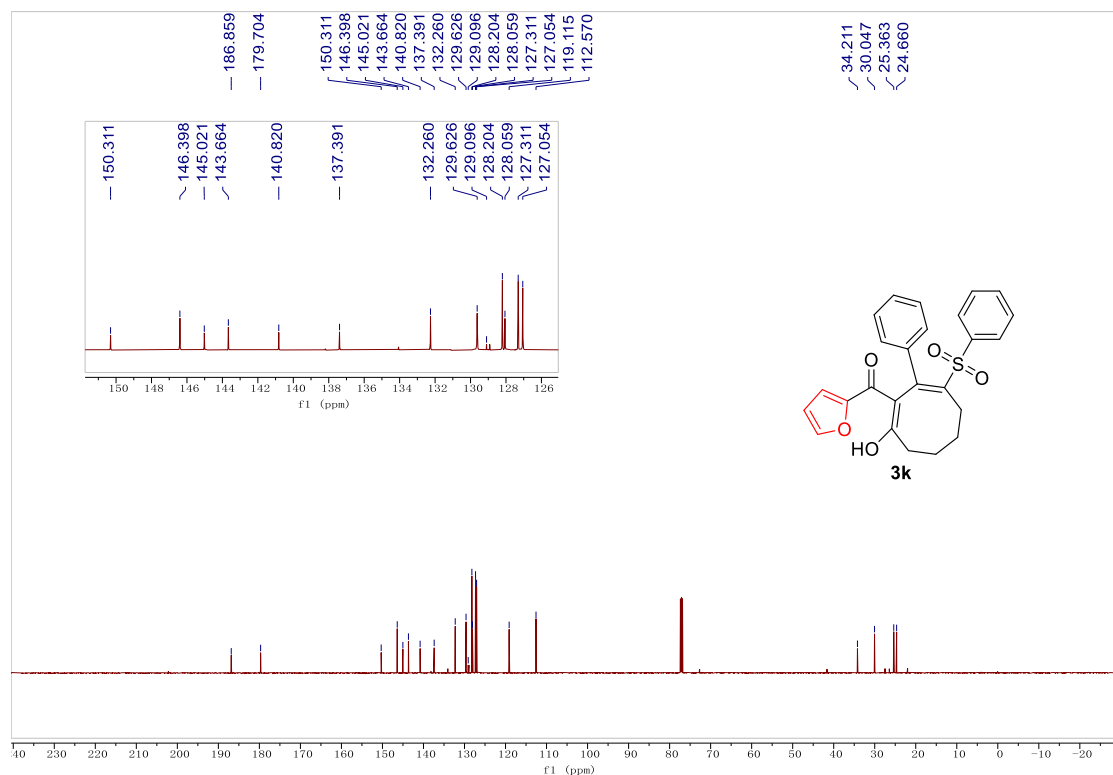
Inset peaks (ppm):

- 128.237, 127.462, 127.352, 126.624, 126.334, 124.928
- 122.534, 120.525
- 115.827, 115.810

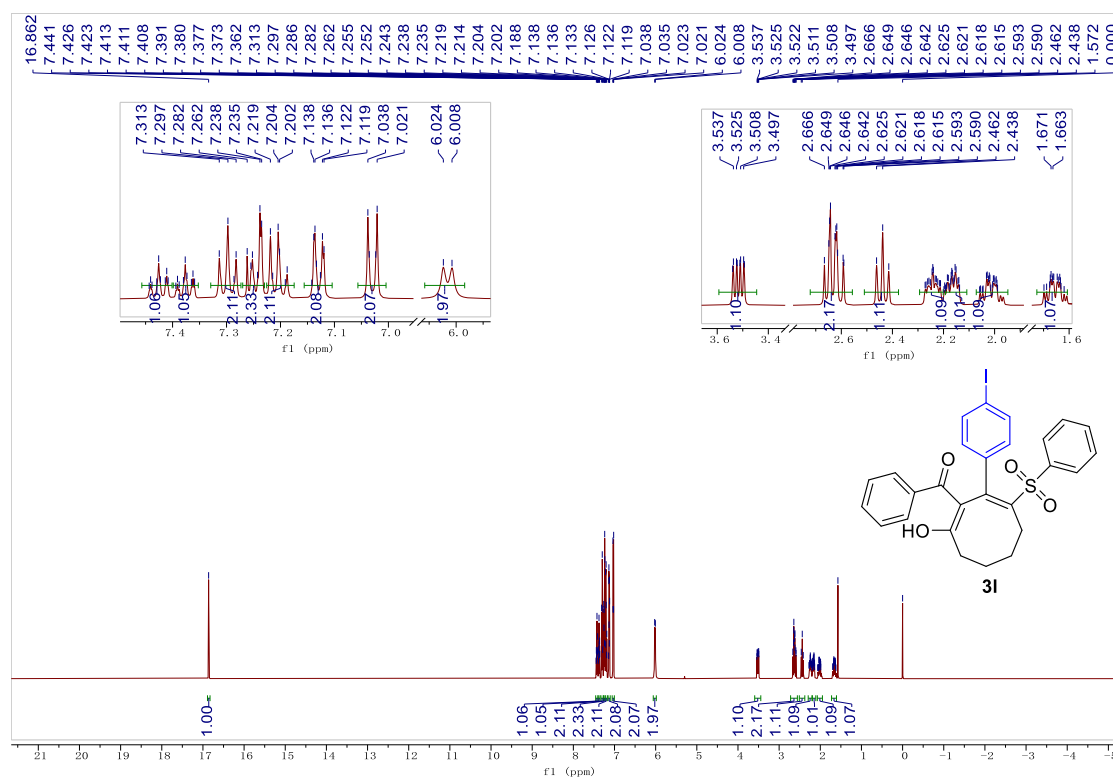
¹H NMR (500 MHz, CDCl₃)



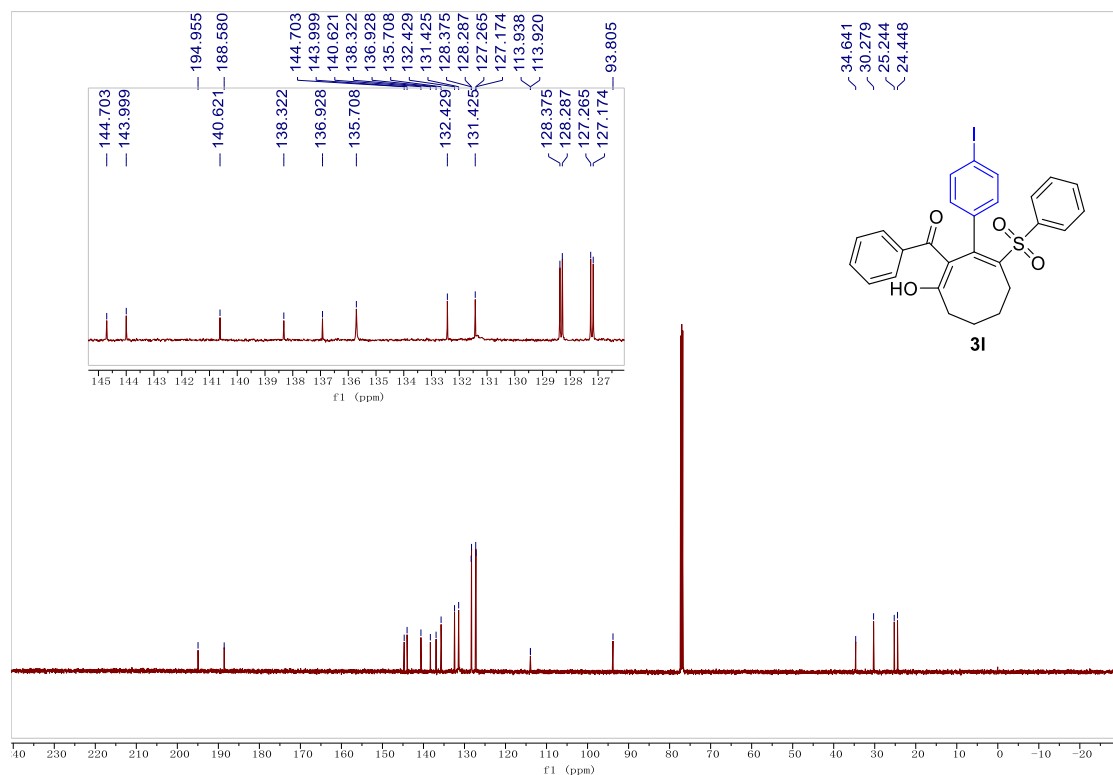
¹³C NMR (125 MHz, CDCl₃)



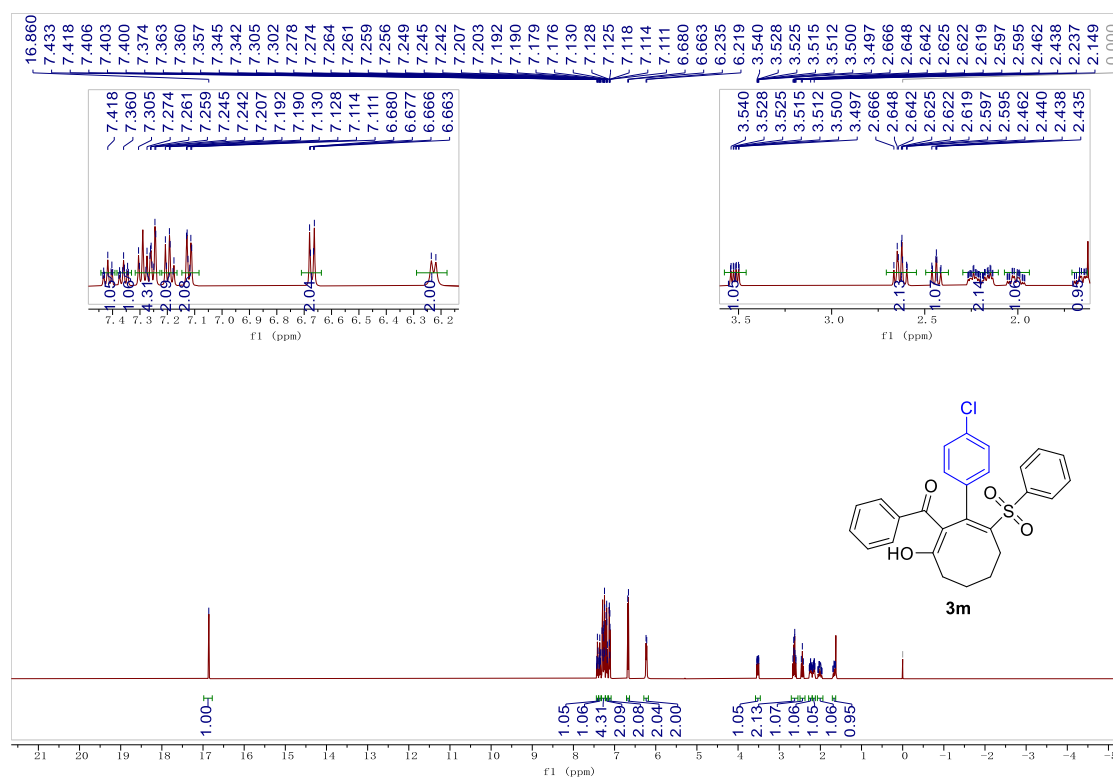
¹H NMR (500 MHz, CDCl₃)



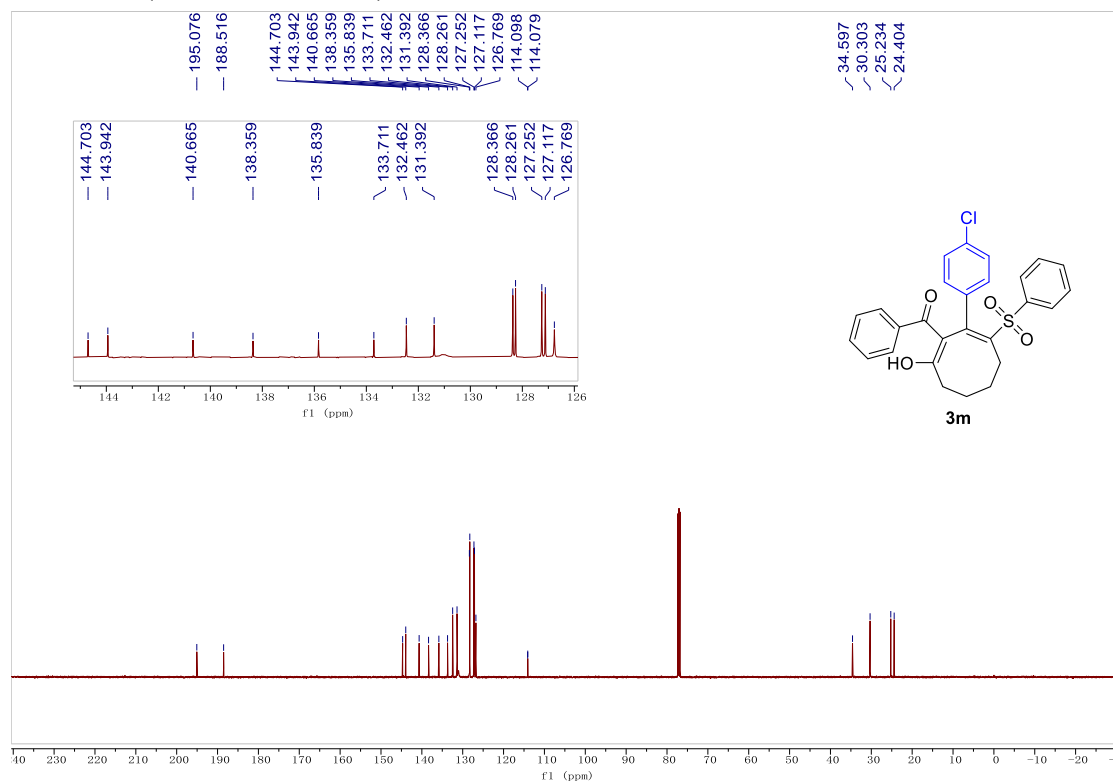
¹³C NMR (125 MHz, CDCl₃)



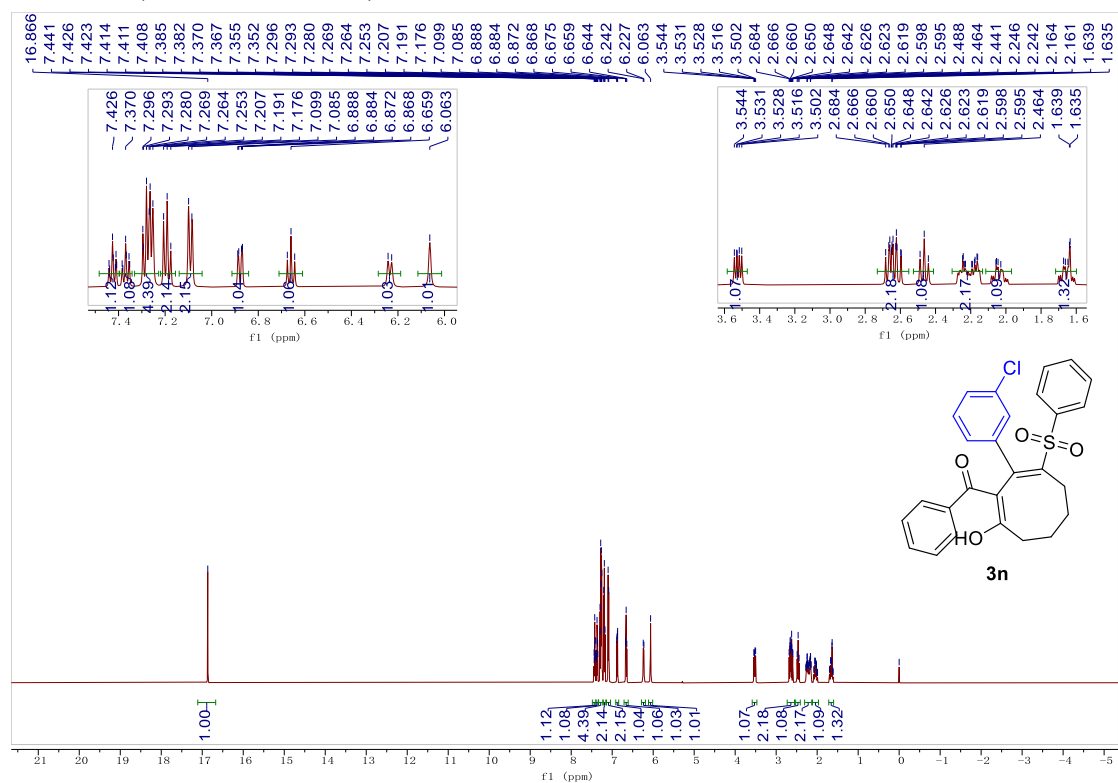
^1H NMR (500 MHz, CDCl_3)



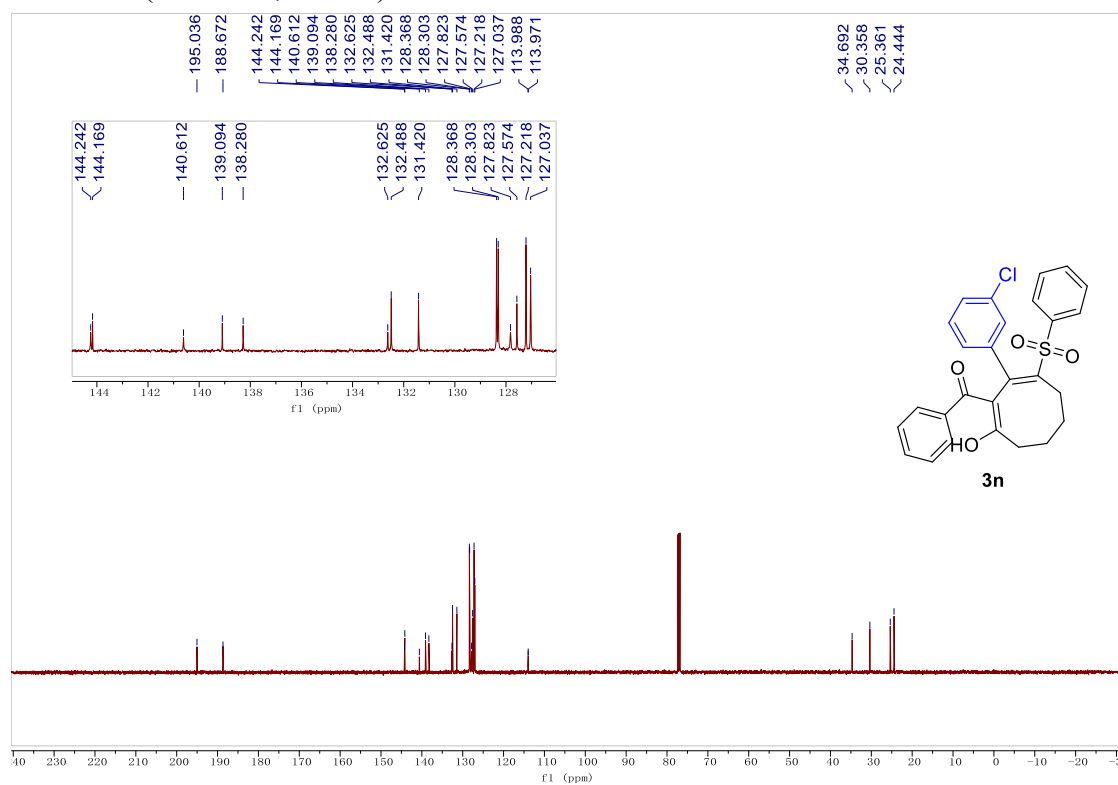
^{13}C NMR (125 MHz, CDCl_3)



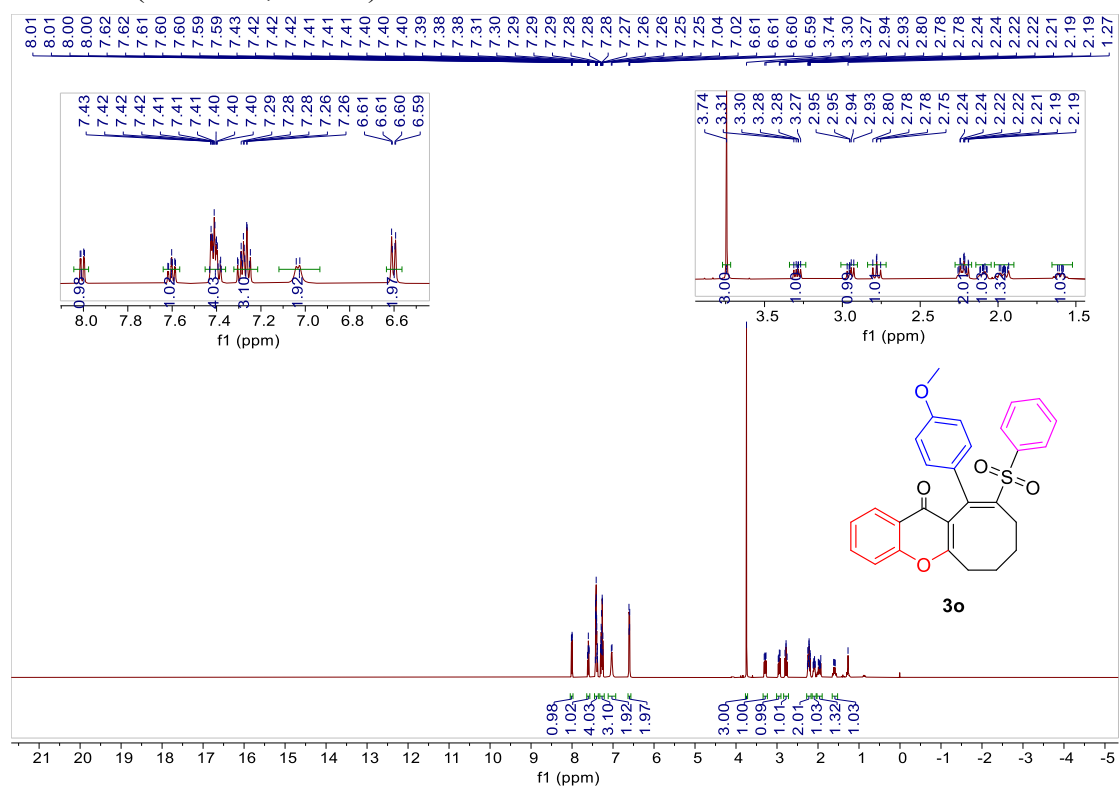
¹H NMR (500 MHz, CDCl₃)



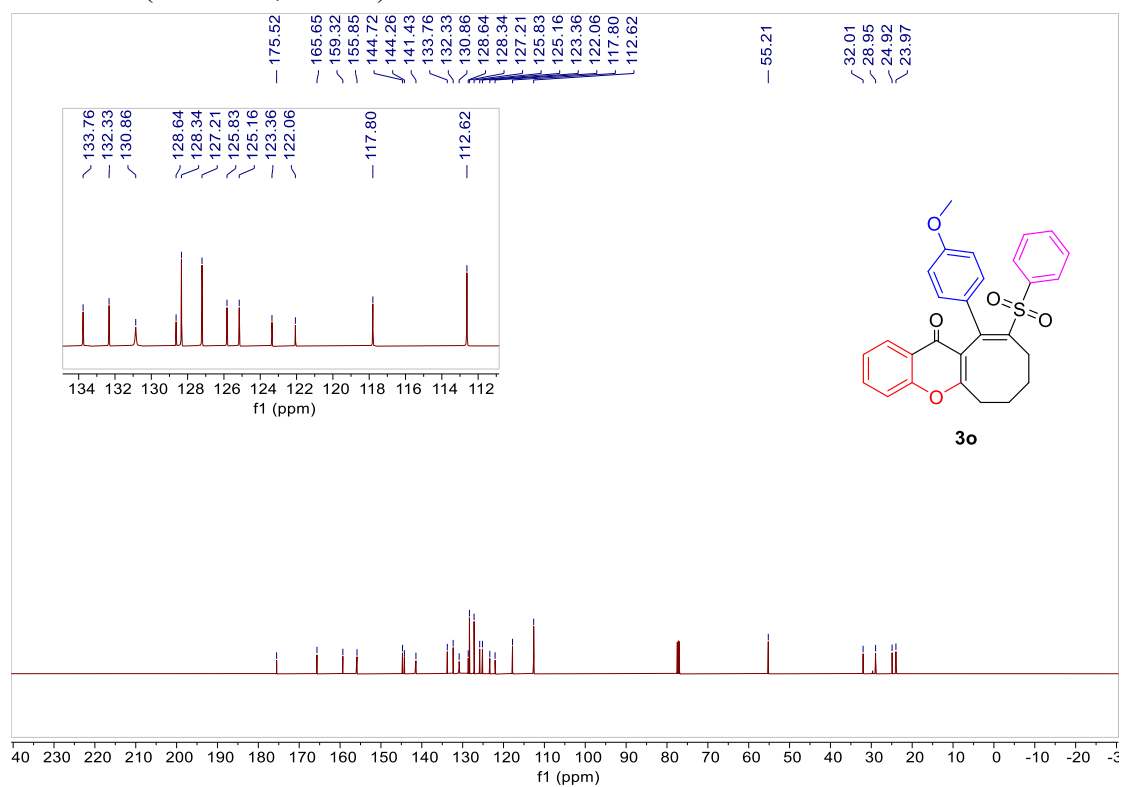
¹³C NMR (125 MHz, CDCl₃)



^1H NMR (500 MHz, CDCl_3)



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



[illegible]

13C NMR spectrum of compound 3p

The spectrum displays the following chemical shifts (ppm): 175.497, 165.683, 144.578, 141.374, 137.685, 133.750, 133.525, 132.338, 129.366, 128.870, 128.315, 127.802, 144.578, 127.373, 141.374, 125.878, 137.685, 125.151, 133.750, 123.382, 122.114, 129.366, 128.315, 127.802, 127.373, 125.878, 125.151, 123.382, 122.114, 117.787, 32.057, 29.026, 24.974, 24.043, 21.335.

Chemical structure of 3p:

Cc1ccc(cc1)c2c3ccccc3c(=O)c4ccccc4O2S(=O)(=O)c5ccccc5

The figure displays the chemical structure of compound **3q** and its corresponding ¹H and ¹³C NMR spectra.

Chemical Structure of 3q: The structure is a 10-membered ring containing a ketone and a hydroxyl group. It is substituted with a 4-methylphenyl group, a 4-methoxyphenyl group, and a benzoylsulfonyl group.

¹H NMR Spectrum (CDCl₃): The spectrum shows peaks in the aromatic region (7.3–7.4 ppm) and aliphatic region (2.1–2.3 ppm). Integration values are provided below the peaks.

Chemical Shift (ppm)	Integration
7.324, 7.326, 7.356, 7.358, 7.359, 7.360, 7.361, 7.362, 7.363, 7.364, 7.365, 7.366, 7.367, 7.368, 7.369, 7.370, 7.371, 7.372, 7.373, 7.374, 7.375, 7.376, 7.377, 7.378, 7.379, 7.380, 7.381, 7.382, 7.383, 7.384, 7.385, 7.386, 7.387, 7.388, 7.389, 7.390, 7.391, 7.392, 7.393, 7.394, 7.395, 7.396, 7.397, 7.398, 7.399, 7.400, 7.401, 7.402, 7.403, 7.404, 7.405, 7.406, 7.407, 7.408, 7.409, 7.410, 7.411, 7.412, 7.413, 7.414, 7.415, 7.416, 7.417, 7.418, 7.419, 7.420, 7.421, 7.422, 7.423, 7.424, 7.425, 7.426, 7.427, 7.428, 7.429, 7.430, 7.431, 7.432, 7.433, 7.434, 7.435, 7.436, 7.437, 7.438, 7.439, 7.440, 7.441, 7.442, 7.443, 7.444, 7.445, 7.446, 7.447, 7.448, 7.449, 7.450, 7.451, 7.452, 7.453, 7.454, 7.455, 7.456, 7.457, 7.458, 7.459, 7.460, 7.461, 7.462, 7.463, 7.464, 7.465, 7.466, 7.467, 7.468, 7.469, 7.470, 7.471, 7.472, 7.473, 7.474, 7.475, 7.476, 7.477, 7.478, 7.479, 7.480, 7.481, 7.482, 7.483, 7.484, 7.485, 7.486, 7.487, 7.488, 7.489, 7.490, 7.491, 7.492, 7.493, 7.494, 7.495, 7.496, 7.497, 7.498, 7.499, 7.500, 7.501, 7.502, 7.503, 7.504, 7.505, 7.506, 7.507, 7.508, 7.509, 7.510, 7.511, 7.512, 7.513, 7.514, 7.515, 7.516, 7.517, 7.518, 7.519, 7.520, 7.521, 7.522, 7.523, 7.524, 7.525, 7.526, 7.527, 7.528, 7.529, 7.530, 7.531, 7.532, 7.533, 7.534, 7.535, 7.536, 7.537, 7.538, 7.539, 7.540, 7.541, 7.542, 7.543, 7.544, 7.545, 7.546, 7.547, 7.548, 7.549, 7.550, 7.551, 7.552, 7.553, 7.554, 7.555, 7.556, 7.557, 7.558, 7.559, 7.560, 7.561, 7.562, 7.563, 7.564, 7.565, 7.566, 7.567, 7.568, 7.569, 7.570, 7.571, 7.572, 7.573, 7.574, 7.575, 7.576, 7.577, 7.578, 7.579, 7.580, 7.581, 7.582, 7.583, 7.584, 7.585, 7.586, 7.587, 7.588, 7.589, 7.590, 7.591, 7.592, 7.593, 7.594, 7.595, 7.596, 7.597, 7.598, 7.599, 7.600, 7.601, 7.602, 7.603, 7.604, 7.605, 7.606, 7.607, 7.608, 7.609, 7.610, 7.611, 7.612, 7.613, 7.614, 7.615, 7.616, 7.617, 7.618, 7.619, 7.620, 7.621, 7.622, 7.623, 7.624, 7.625, 7.626, 7.627, 7.628, 7.629, 7.630, 7.631, 7.632, 7.633, 7.634, 7.635, 7.636, 7.637, 7.638, 7.639, 7.640, 7.641, 7.642, 7.643, 7.644, 7.645, 7.646, 7.647, 7.648, 7.649, 7.650, 7.651, 7.652, 7.653, 7.654, 7.655, 7.656, 7.657, 7.658, 7.659, 7.660, 7.661, 7.662, 7.663, 7.664, 7.665, 7.666, 7.667, 7.668, 7.669, 7.670, 7.671, 7.672, 7.673, 7.674, 7.675, 7.676, 7.677, 7.678, 7.679, 7.680, 7.681, 7.682, 7.683, 7.684, 7.685, 7.686, 7.687, 7.688, 7.689, 7.690, 7.691, 7.692, 7.693, 7.694, 7.695, 7.696, 7.697, 7.698, 7.699, 7.700, 7.701, 7.702, 7.703, 7.704, 7.705, 7.706, 7.707, 7.708, 7.709, 7.710, 7.711, 7.712, 7.713, 7.714, 7.715, 7.716, 7.717, 7.718, 7.719, 7.720, 7.721, 7.722, 7.723, 7.724, 7.725, 7.726, 7.727, 7.728, 7.729, 7.730, 7.731, 7.732, 7.733, 7.734, 7.735, 7.736, 7.737, 7.738, 7.739, 7.740, 7.741, 7.742, 7.743, 7.744, 7.745, 7.746, 7.747, 7.748, 7.749, 7.750, 7.751, 7.752, 7.753, 7.754, 7.755, 7.756, 7.757, 7.758, 7.759, 7.760, 7.761, 7.762, 7.763, 7.764, 7.765, 7.766, 7.767, 7.768, 7.769, 7.770, 7.771, 7.772, 7.773, 7.774, 7.775, 7.776, 7.777, 7.778, 7.779, 7.780, 7.781, 7.782, 7.783, 7.784, 7.785, 7.786, 7.787, 7.788, 7.789, 7.790, 7.791, 7.792, 7.793, 7.794, 7.795, 7.796, 7.797, 7.798, 7.799, 7.800, 7.801, 7.802, 7.803, 7.804, 7.805, 7.806, 7.807, 7.808, 7.809, 7.810, 7.811, 7.812, 7.813, 7.814, 7.815, 7.816, 7.817, 7.818, 7.819, 7.820, 7.821, 7.822, 7.823, 7.824, 7.825, 7.826, 7.827, 7.828, 7.829, 7.830, 7.831, 7.832, 7.833, 7.834, 7.835, 7.836, 7.837, 7.838, 7.839, 7.840, 7.841, 7.842, 7.843, 7.844, 7.845, 7.846, 7.847, 7.848, 7.849, 7.850, 7.851, 7.852, 7.853, 7.854, 7.855, 7.856, 7.857, 7.858, 7.859, 7.860, 7.861, 7.862, 7.863, 7.864, 7.865, 7.866, 7.867, 7.868, 7.869, 7.870, 7.871, 7.872, 7.873, 7.874, 7.875, 7.876, 7.877, 7.878, 7.879, 7.880, 7.881, 7.882, 7.883, 7.884, 7.885, 7.886, 7.887, 7.888, 7.889, 7.890, 7.891, 7.892, 7.893, 7.894, 7.895, 7.896, 7.897, 7.898, 7.899, 7.900, 7.901, 7.902, 7.903, 7.904, 7.905, 7.906,	

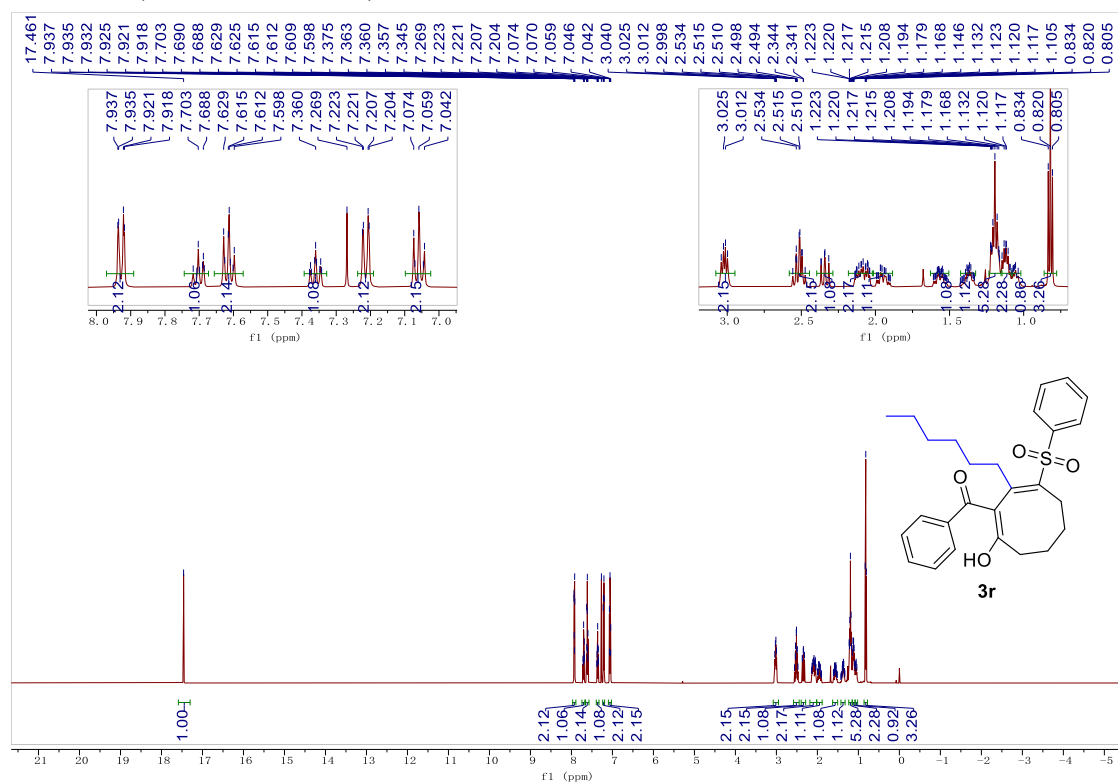
13C NMR spectrum of compound 3q.

Chemical structure of 3q: O=C1C(=C(C(=O)c2ccc(O)cc2)C(=O)c3ccc(S(=O)(=O)c4ccccc4)cc3)CCCC1

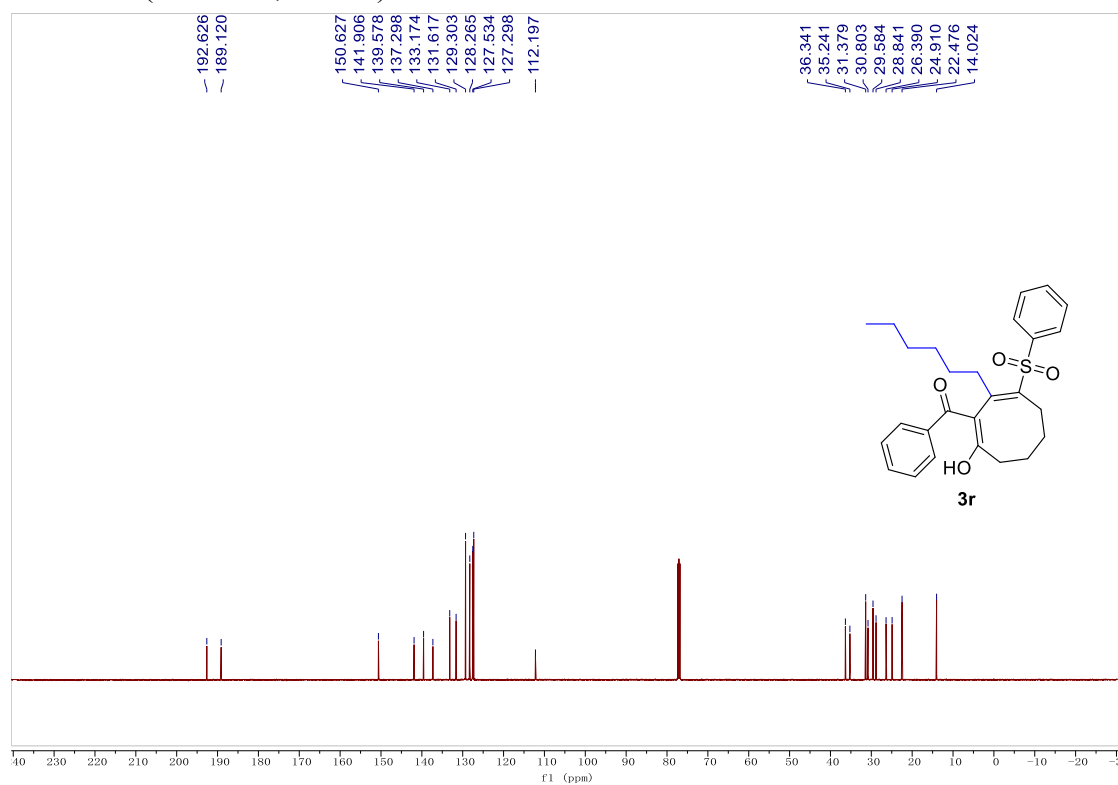
13C NMR peaks (ppm):

- 146.568
- 142.757
- 141.924
- 140.941
- 142.757
- 141.924
- 140.941
- 137.350
- 135.747
- 134.518
- 132.060
- 129.613
- 128.820
- 127.968
- 127.497
- 127.468
- 127.310
- 127.219
- 127.219
- 114.387
- 114.371
- 34.518
- 30.225
- 25.355
- 24.465
- 21.597
- 21.104

¹H NMR (500 MHz, CDCl₃)



¹³C NMR (125 MHz, CDCl₃)



The figure displays the chemical structure of compound **3s** and its corresponding ¹H and ¹³C NMR spectra.

Chemical Structure of 3s: The structure is a complex polycyclic molecule. It features a cyclohexane ring (highlighted in red) fused to a bicyclic system. Key functional groups include a carboxylic acid (HO-C=O), a ketone (C=O), and a sulfonamide group (SO₂-NH₂). The molecule also contains several aromatic rings and a complex ring system with multiple stereocenters.

¹H NMR Spectrum (Top): The spectrum shows peaks in the aromatic region (7.00-7.35 ppm) and the aliphatic region (1.00-2.50 ppm). Integration values are provided for several peaks: 1.14, 2.35, 3.20, 2.49, and 1.38.

¹³C NMR Spectrum (Bottom): The spectrum shows peaks in the aliphatic region (1.00-2.50 ppm) and the carbonyl region (17.00-17.35 ppm). Integration values are provided for several peaks: 1.14, 2.35, 3.20, 2.49, and 1.38.

Chemical Shifts (ppm):

- ¹H NMR: 7.366, 7.334, 7.319, 7.316, 7.304, 7.284, 7.282, 7.271, 7.268, 7.165, 7.161, 7.157, 7.150, 7.149, 7.137, 7.134, 7.097, 7.082, 7.067, 2.501, 2.507, 2.501, 2.483, 2.391, 2.370, 2.367, 2.364, 2.358, 2.353, 2.348, 2.341, 2.335, 2.329, 2.325, 2.261, 2.056, 1.644, 1.628, 1.617, 1.614, 1.609, 1.604, 1.590, 1.586, 1.580, 1.576, 1.566, 1.561, 1.558, 1.553, 1.548, 1.543, 1.538, 1.533, 1.528, 1.523, 1.518, 1.513, 1.508, 1.503, 1.498, 1.493, 1.488, 1.483, 1.478, 1.473, 1.468, 1.463, 1.458, 1.453, 1.448, 1.443, 1.438, 1.433, 1.428, 1.423, 1.418, 1.413, 1.408, 1.403, 1.398, 1.393, 1.388, 1.383, 1.378, 1.373, 1.368, 1.363, 1.358, 1.353, 1.348, 1.343, 1.338, 1.333, 1.328, 1.323, 1.318, 1.313, 1.308, 1.303, 1.298, 1.293, 1.288, 1.283, 1.278, 1.273, 1.268, 1.263, 1.258, 1.253, 1.248, 1.243, 1.238, 1.233, 1.228, 1.223, 1.218, 1.213, 1.208, 1.203, 1.198, 1.193, 1.188, 1.183, 1.178, 1.173, 1.168, 1.163, 1.158, 1.153, 1.148, 1.143, 1.138, 1.133, 1.128, 1.123, 1.118, 1.113, 1.108, 1.103, 1.098, 1.093, 1.088, 1.083, 1.078, 1.073, 1.068, 1.063, 1.058, 1.053, 1.048, 1.043, 1.038, 1.033, 1.028, 1.023, 1.018, 1.013, 1.008, 1.003, 0.998, 0.993, 0.988, 0.983, 0.978, 0.973, 0.968, 0.963, 0.958, 0.953, 0.948, 0.943, 0.938, 0.933, 0.928, 0.923, 0.918, 0.913, 0.908, 0.903, 0.898, 0.893, 0.888, 0.883, 0.878, 0.873, 0.868, 0.863, 0.858, 0.853, 0.848, 0.843, 0.838, 0.833, 0.828, 0.823, 0.818, 0.813, 0.808, 0.803, 0.798, 0.793, 0.788, 0.783, 0.778, 0.773, 0.768, 0.763, 0.758, 0.753, 0.748, 0.743, 0.738, 0.733, 0.728, 0.723, 0.718, 0.713, 0.708, 0.703, 0.698, 0.693, 0.688, 0.683, 0.678, 0.673, 0.668, 0.663, 0.658, 0.653, 0.648, 0.643, 0.638, 0.633, 0.628, 0.623, 0.618, 0.613, 0.608, 0.603, 0.598, 0.593, 0.588, 0.583, 0.578, 0.573, 0.568, 0.563, 0.558, 0.553, 0.548, 0.543, 0.538, 0.533, 0.528, 0.523, 0.518, 0.513, 0.508, 0.503, 0.498, 0.493, 0.488, 0.483, 0.478, 0.473, 0.468, 0.463, 0.458, 0.453, 0.448, 0.443, 0.438, 0.433, 0.428, 0.423, 0.418, 0.413, 0.408, 0.403, 0.398, 0.393, 0.388, 0.383, 0.378, 0.373, 0.368, 0.363, 0.358, 0.353, 0.348, 0.343, 0.338, 0.333, 0.328, 0.323, 0.318, 0.313, 0.308, 0.303, 0.298, 0.293, 0.288, 0.283, 0.278, 0.273, 0.268, 0.263, 0.258, 0.253, 0.248, 0.243, 0.238, 0.233, 0.228, 0.223, 0.218, 0.213, 0.208, 0.203, 0.198, 0.193, 0.188, 0.183, 0.178, 0.173, 0.168, 0.163, 0.158, 0.153, 0.148, 0.143, 0.138, 0.133, 0.128, 0.123, 0.118, 0.113, 0.108, 0.103, 0.098, 0.093, 0.088, 0.083, 0.078, 0.073, 0.068, 0.063, 0.058, 0.053, 0.048, 0.043, 0.038, 0.033, 0.028, 0.023, 0.018, 0.013, 0.008, 0.003, 0.000.

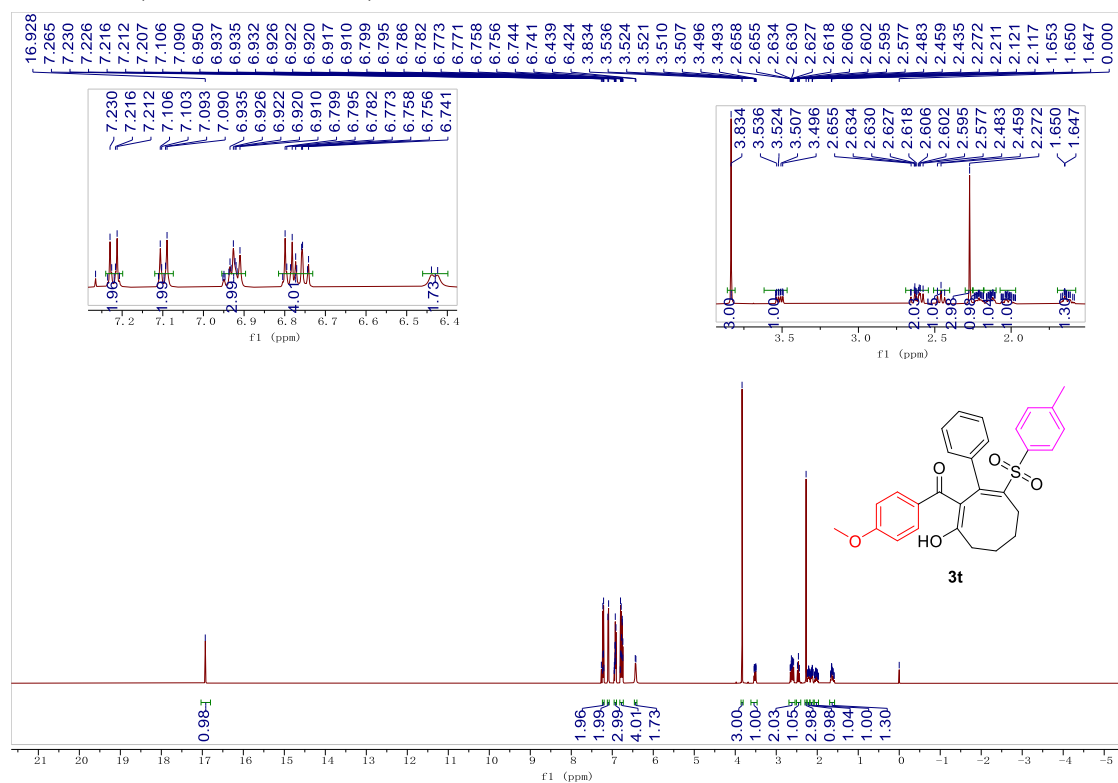
Chemical structure of **3s** is shown above the spectrum.

3s

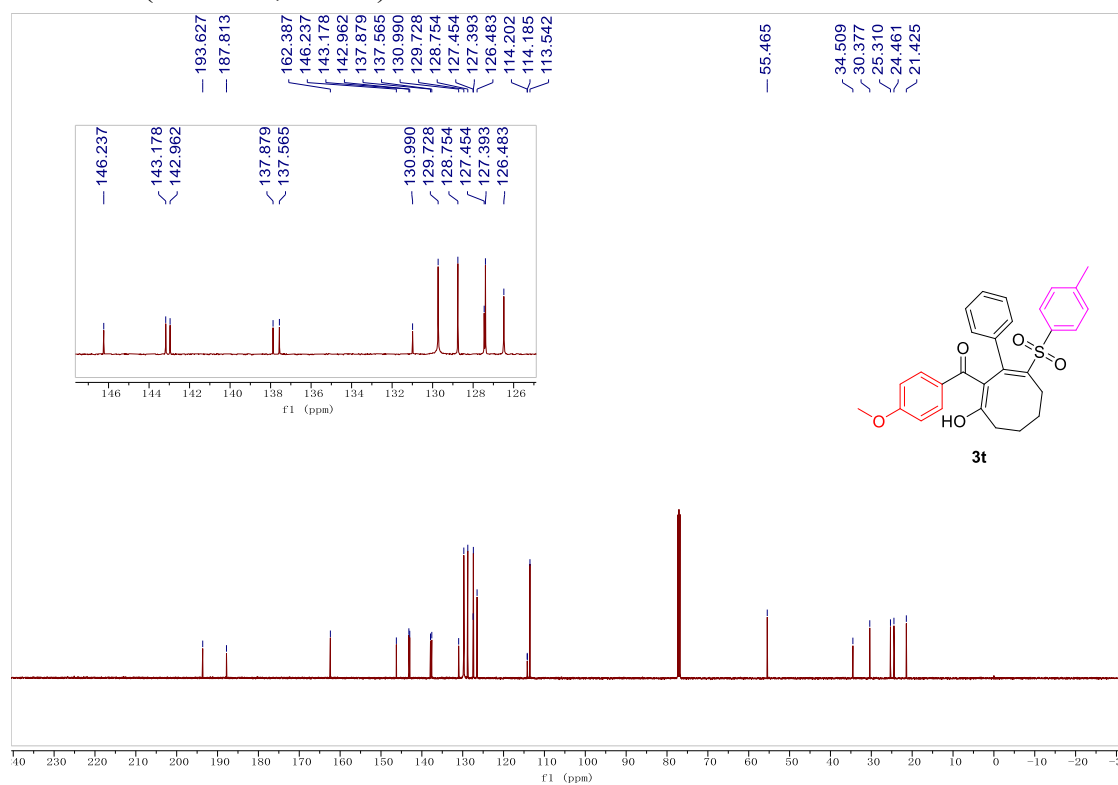
The spectrum displays the following chemical shifts (ppm):

- 204.312
- 188.319
- 145.092
- 144.429
- 140.672
- 138.020
- 132.128
- 130.566
- 128.461
- 128.124
- 127.392
- 127.244
- 113.620
- 46.289
- 34.456
- 30.006
- 29.175
- 28.184
- 25.655
- 25.473
- 25.188
- 25.093
- 24.538

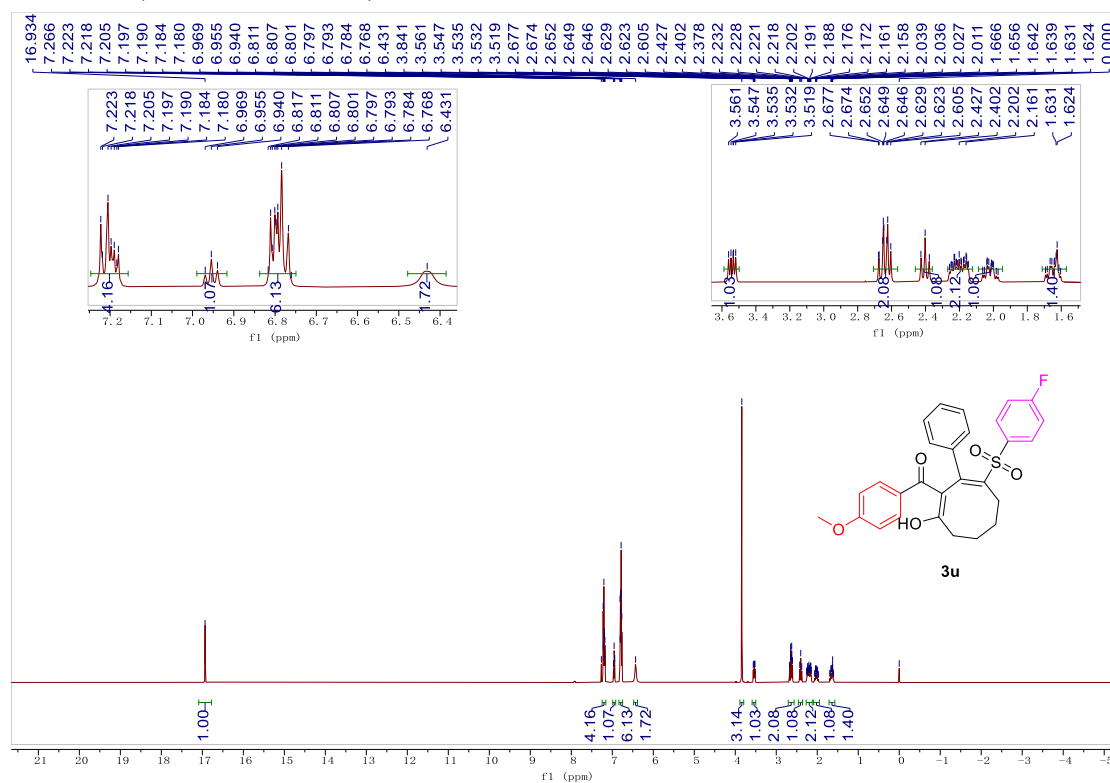
^1H NMR (500 MHz, CDCl_3)



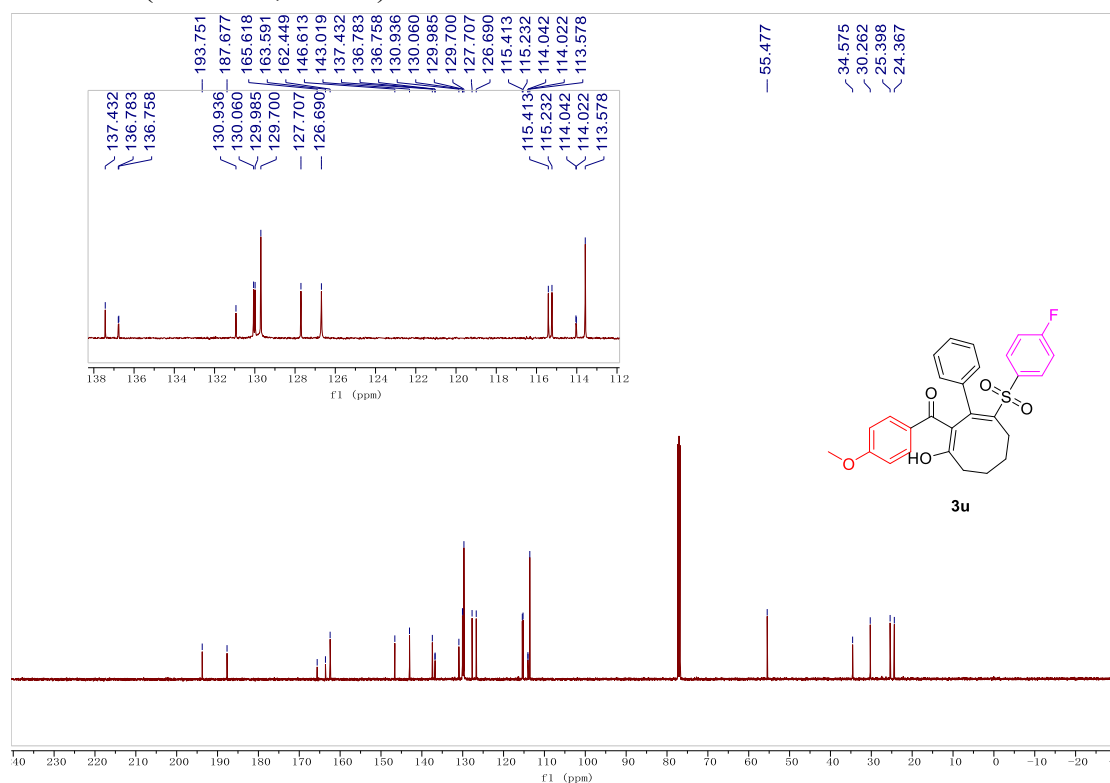
^{13}C NMR (125 MHz, CDCl_3)



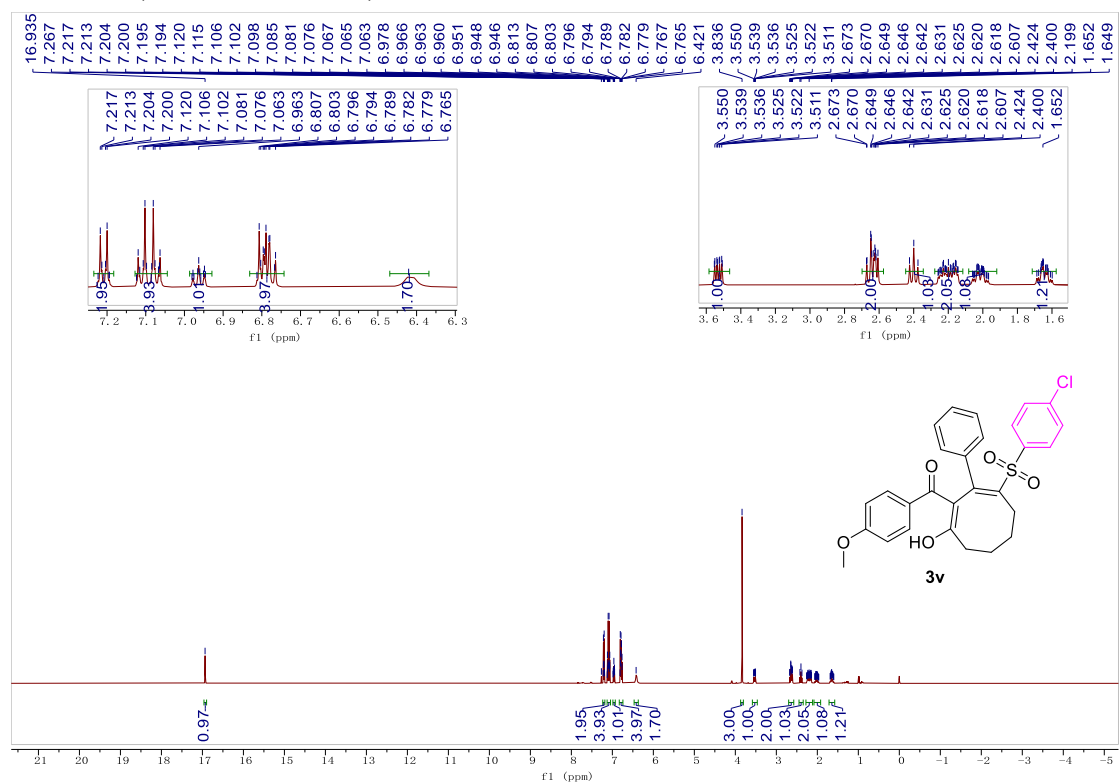
¹H NMR (500 MHz, CDCl₃)



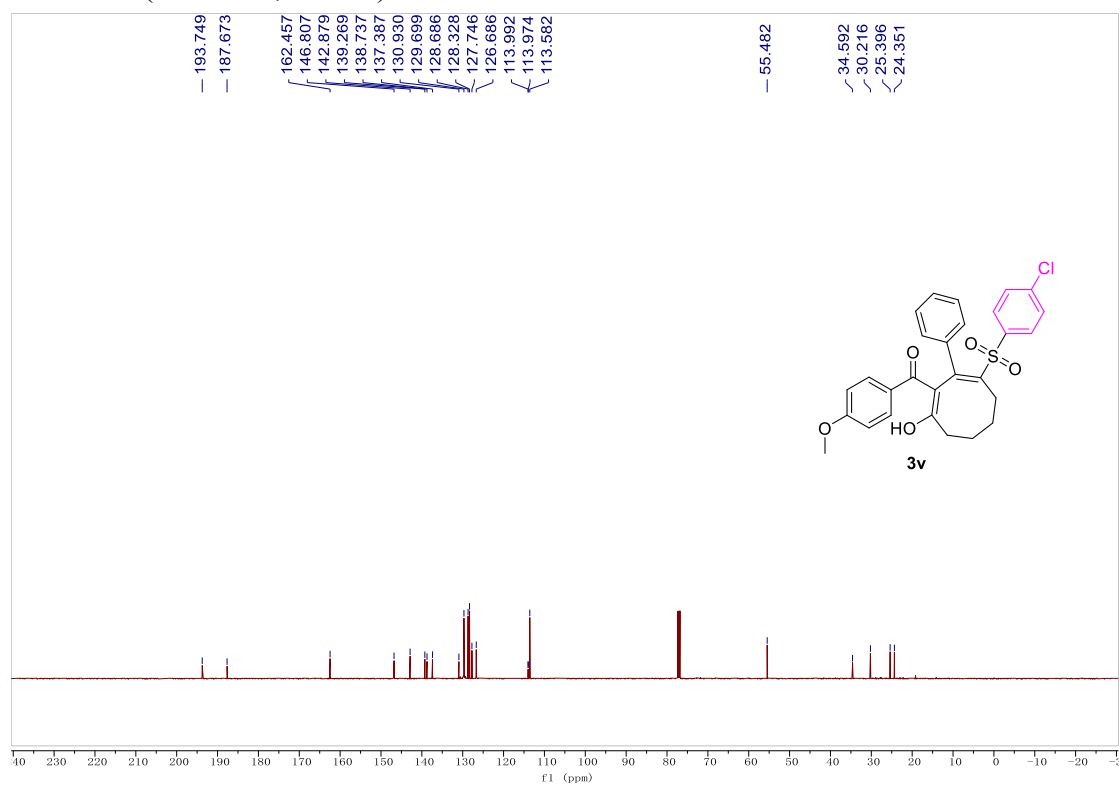
¹³C NMR (125 MHz, CDCl₃)



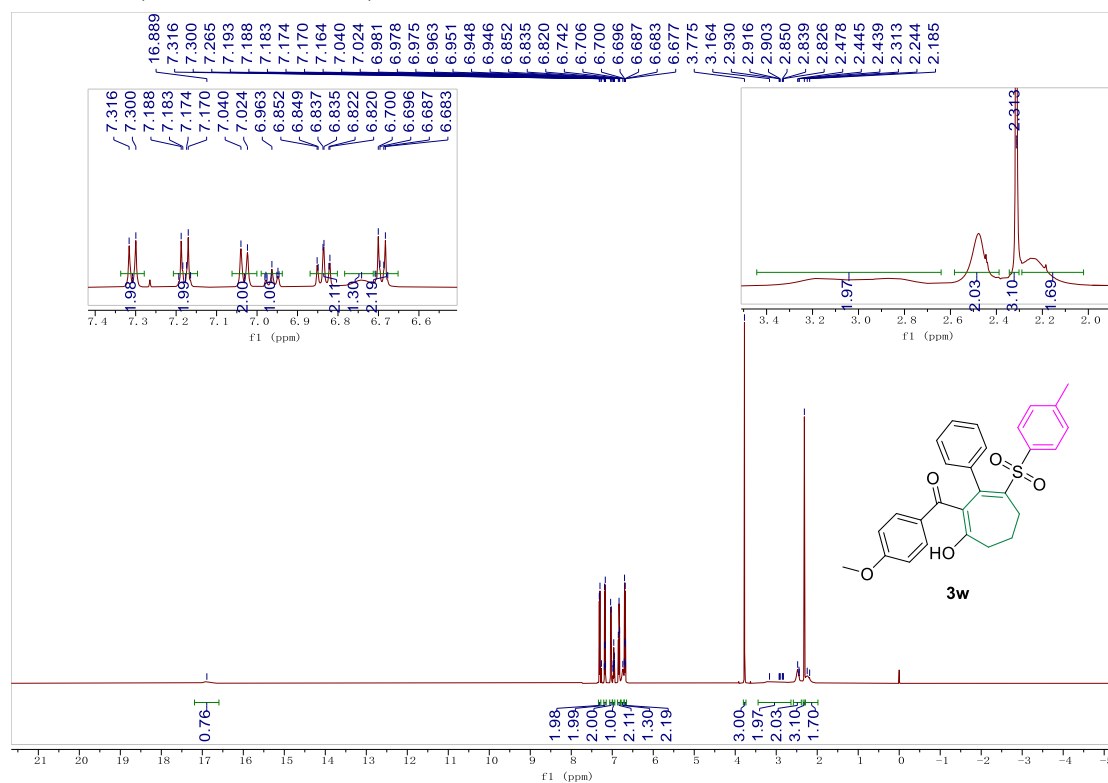
¹H NMR (500 MHz, CDCl₃)



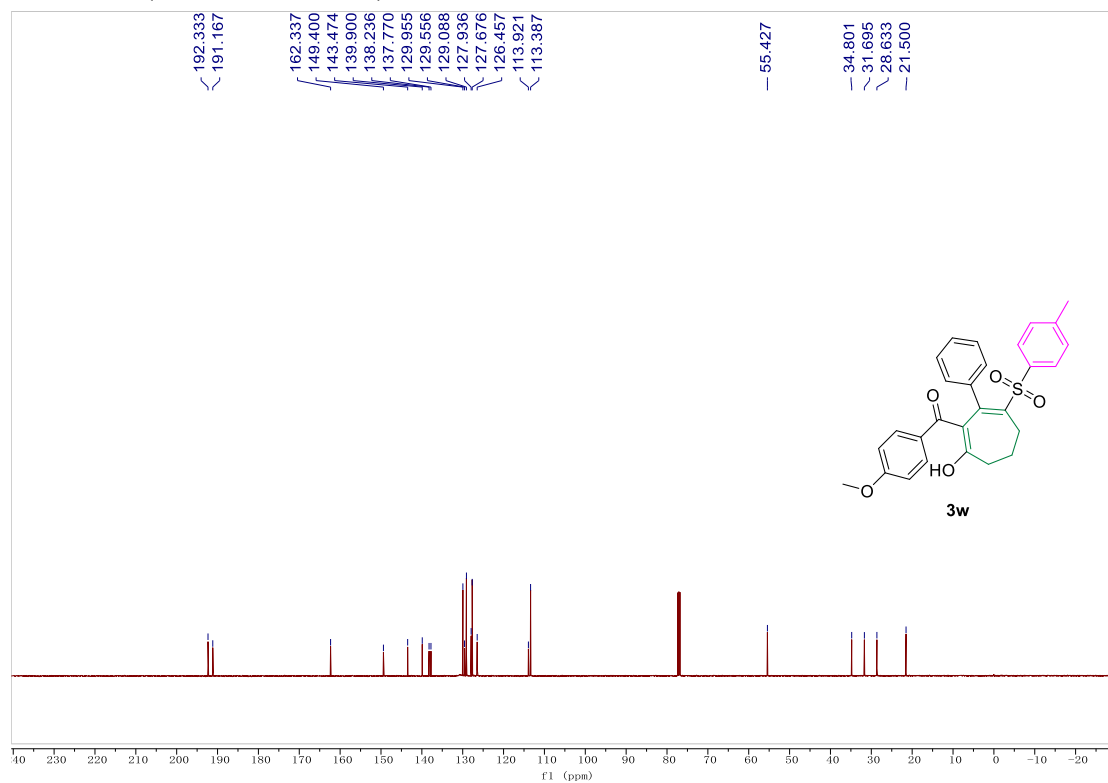
¹³C NMR (125 MHz, CDCl₃)



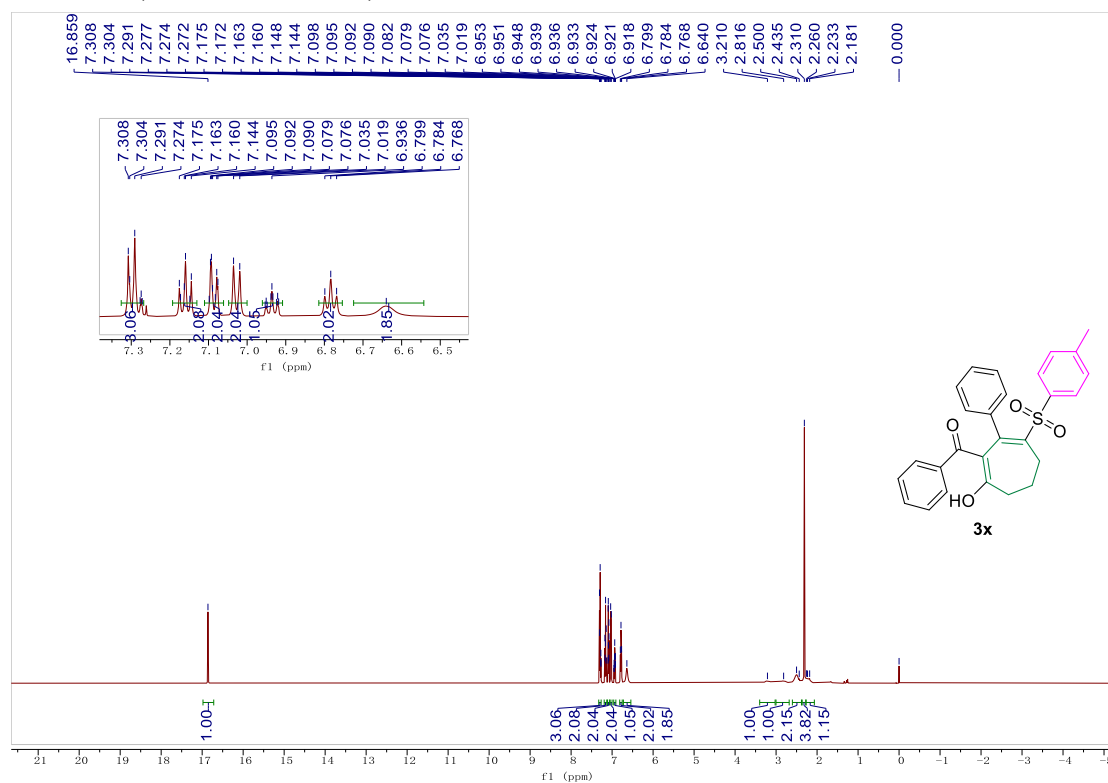
¹H NMR (500 MHz, CDCl₃)



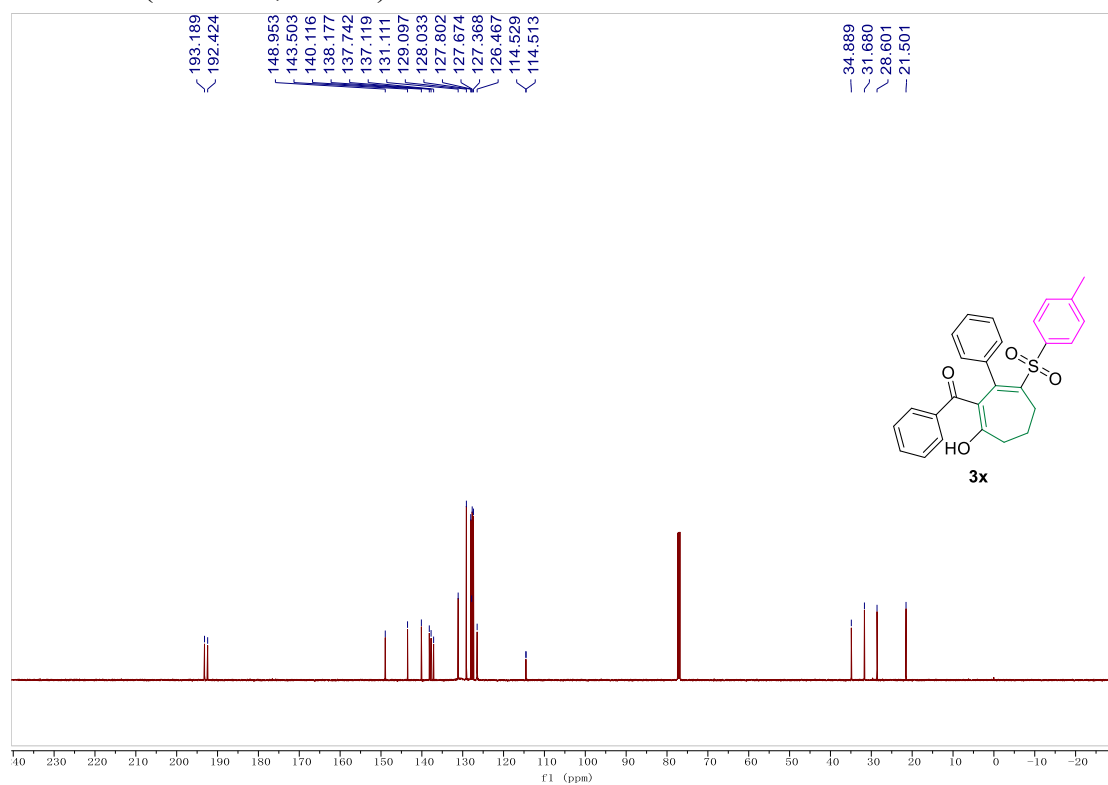
¹³C NMR (125 MHz, CDCl₃)



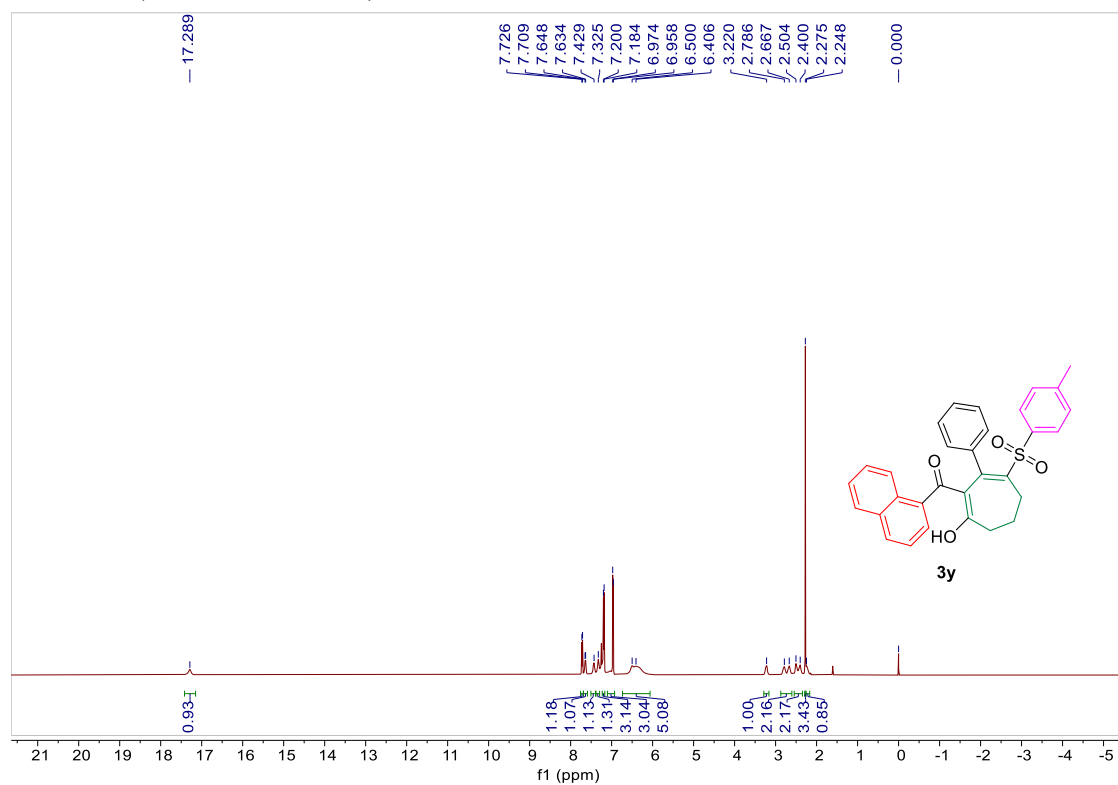
^1H NMR (500 MHz, CDCl_3)



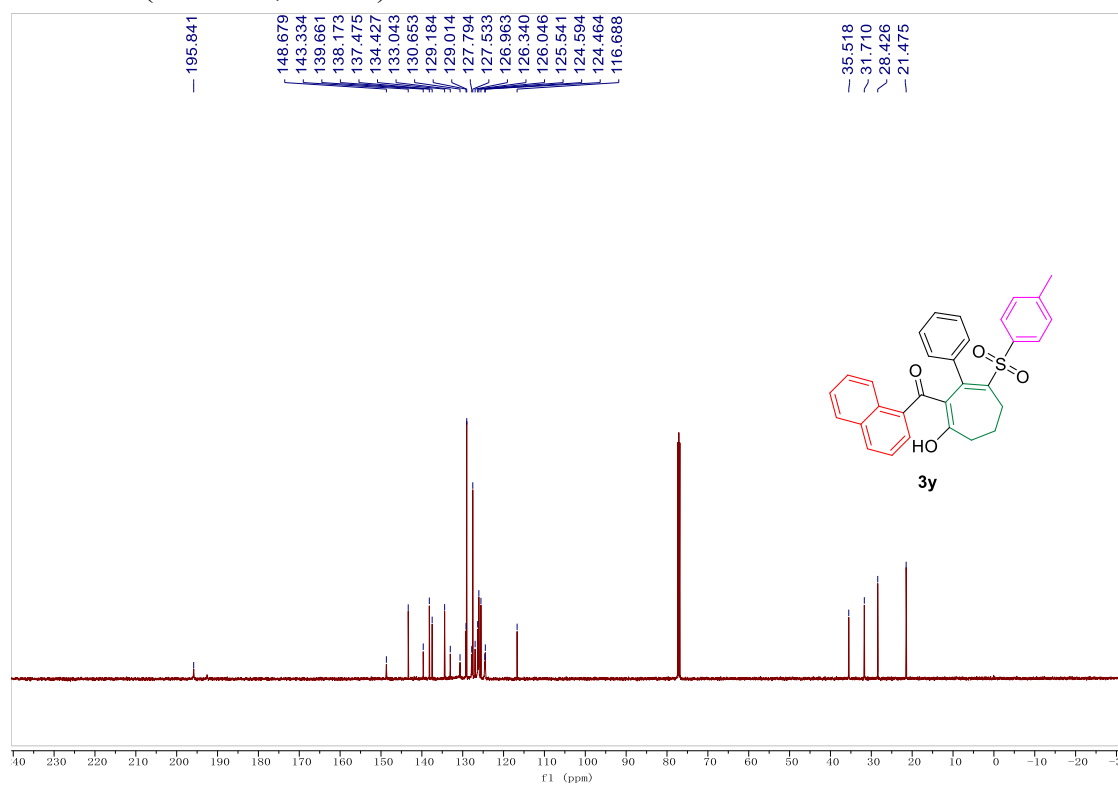
^{13}C NMR (125 MHz, CDCl_3)



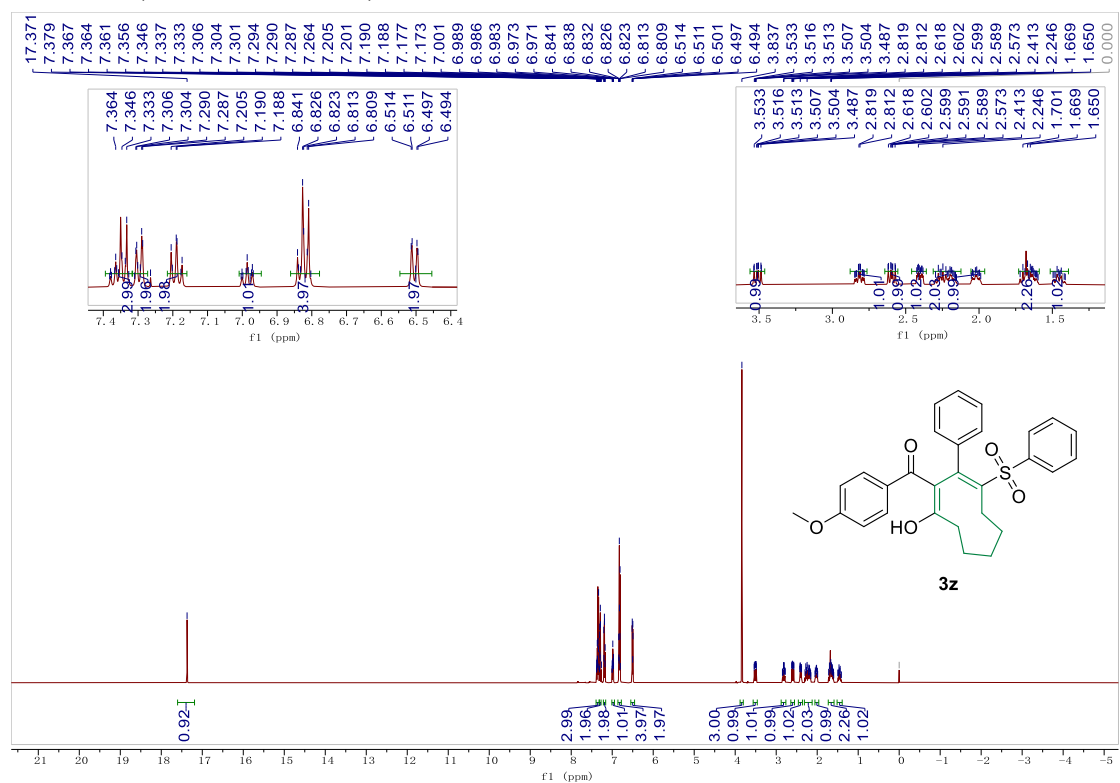
^1H NMR (500 MHz, CDCl_3)



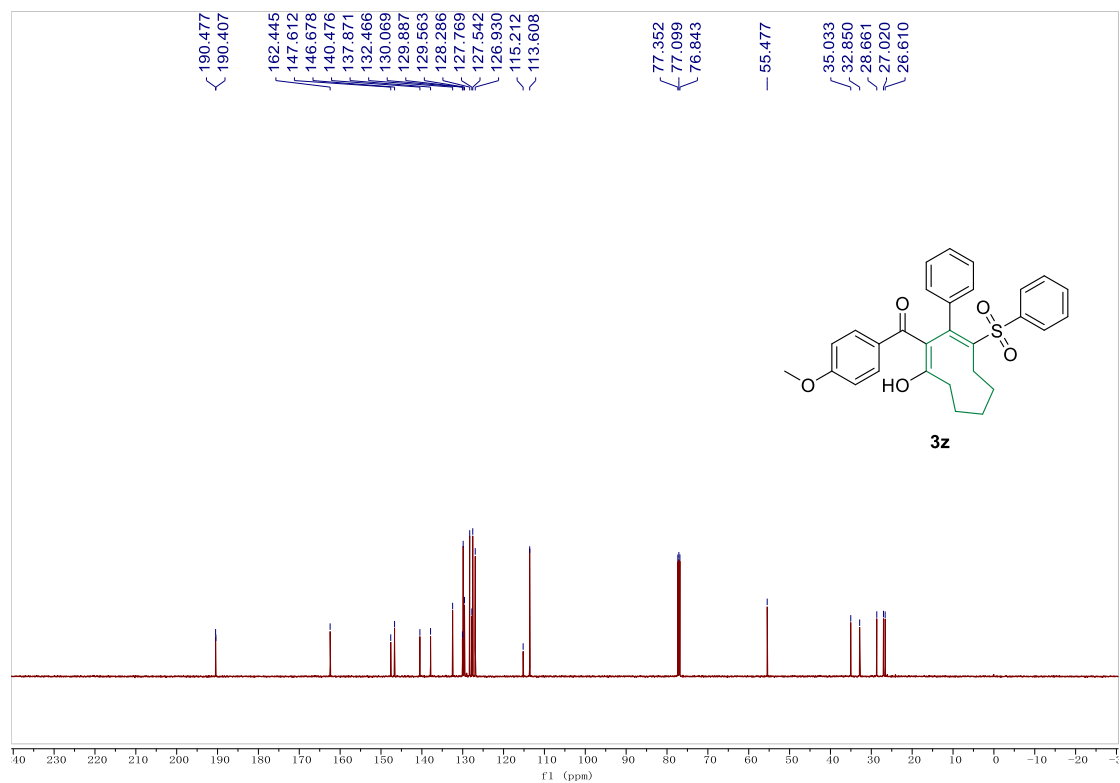
^{13}C NMR (125 MHz, CDCl_3)



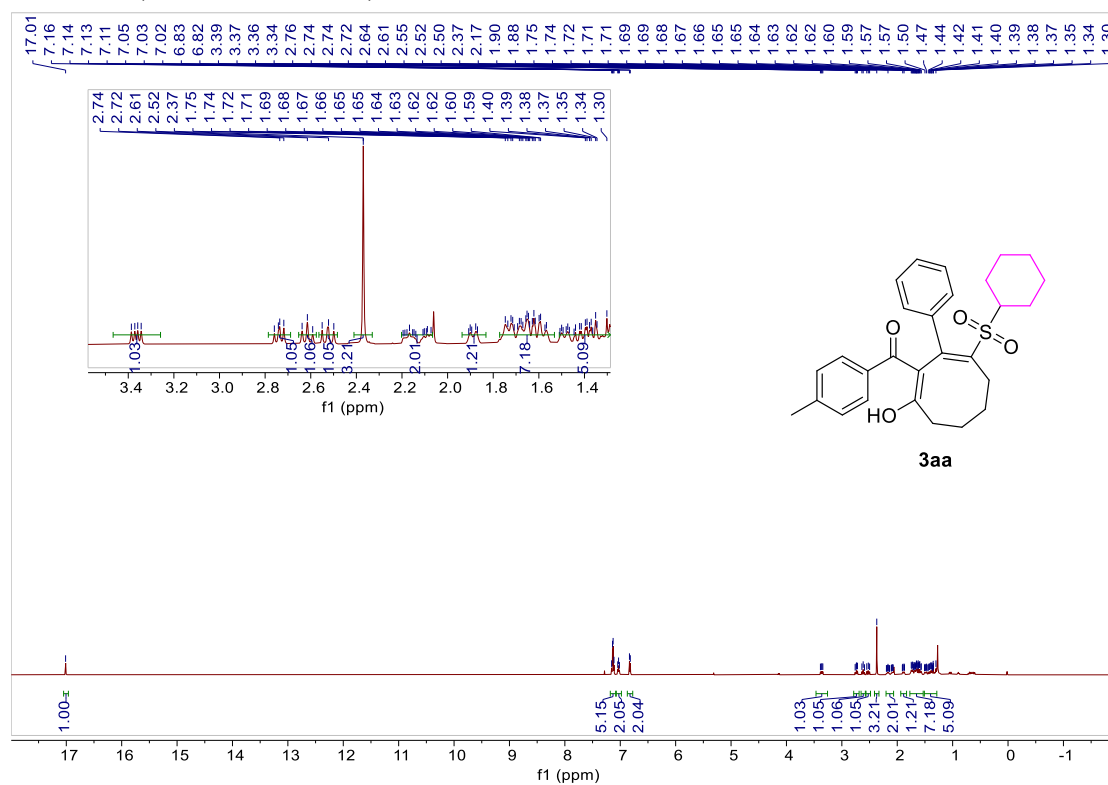
¹H NMR (500 MHz, CDCl₃)



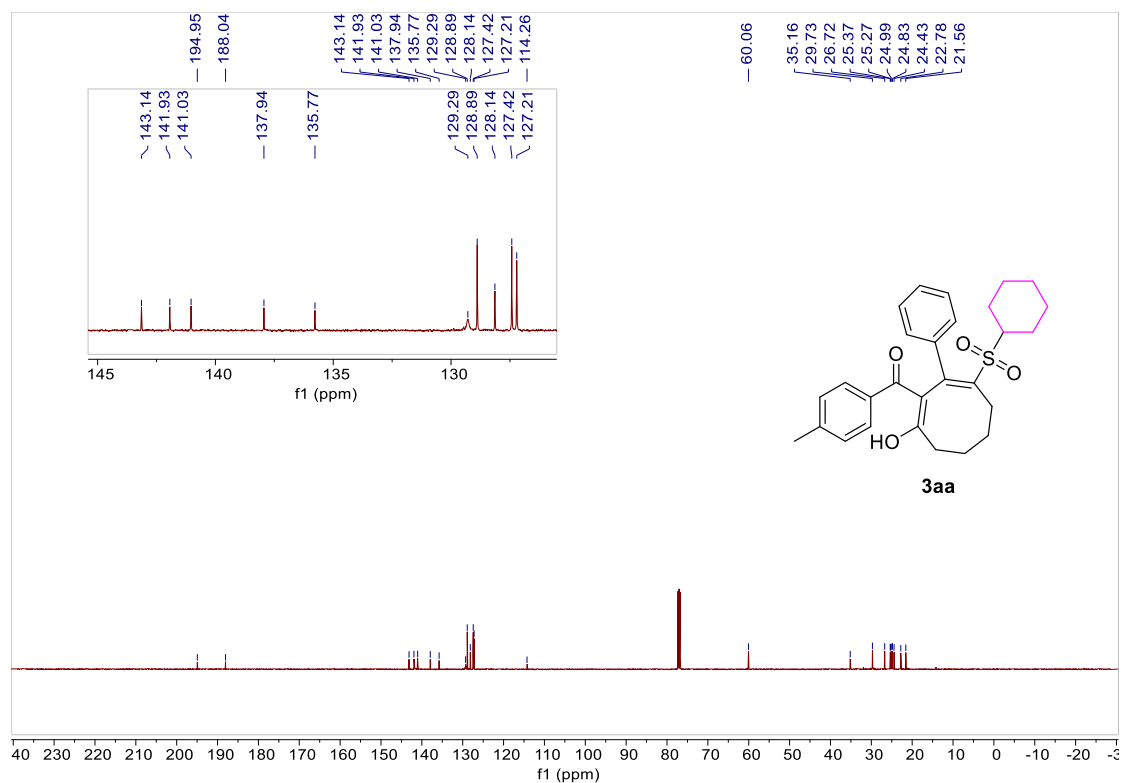
¹³C NMR (125 MHz, CDCl₃)



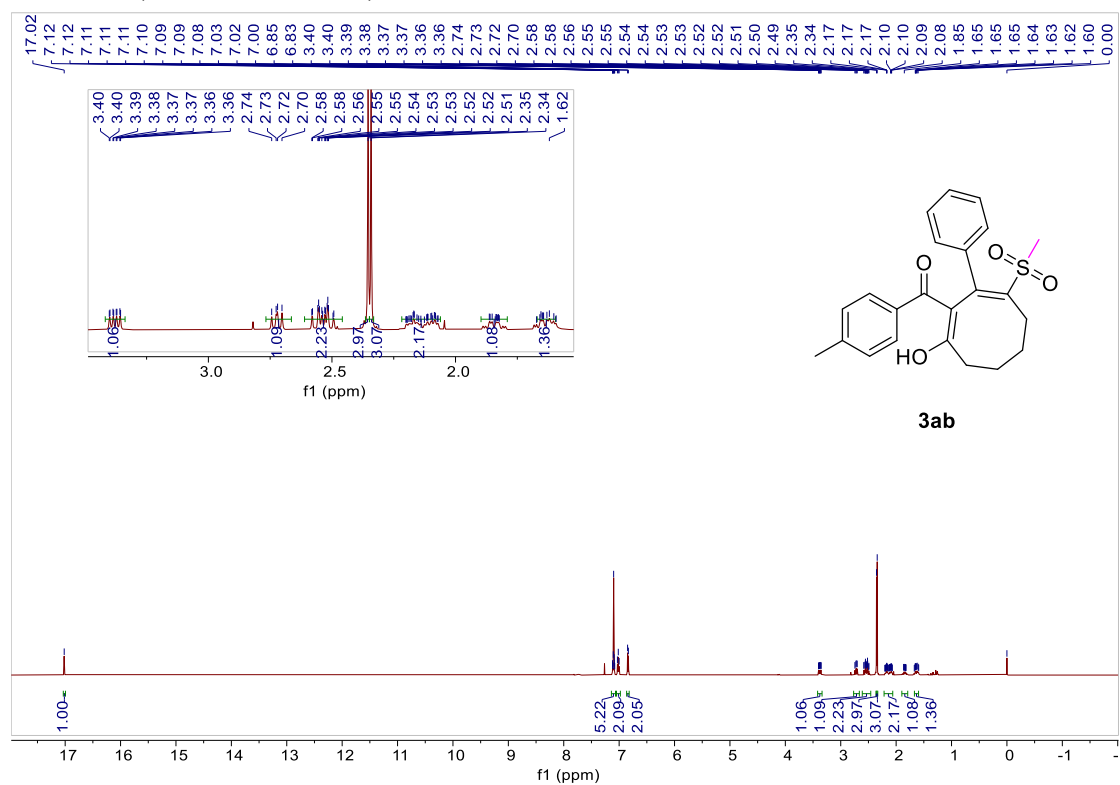
^1H NMR (500 MHz, CDCl_3)



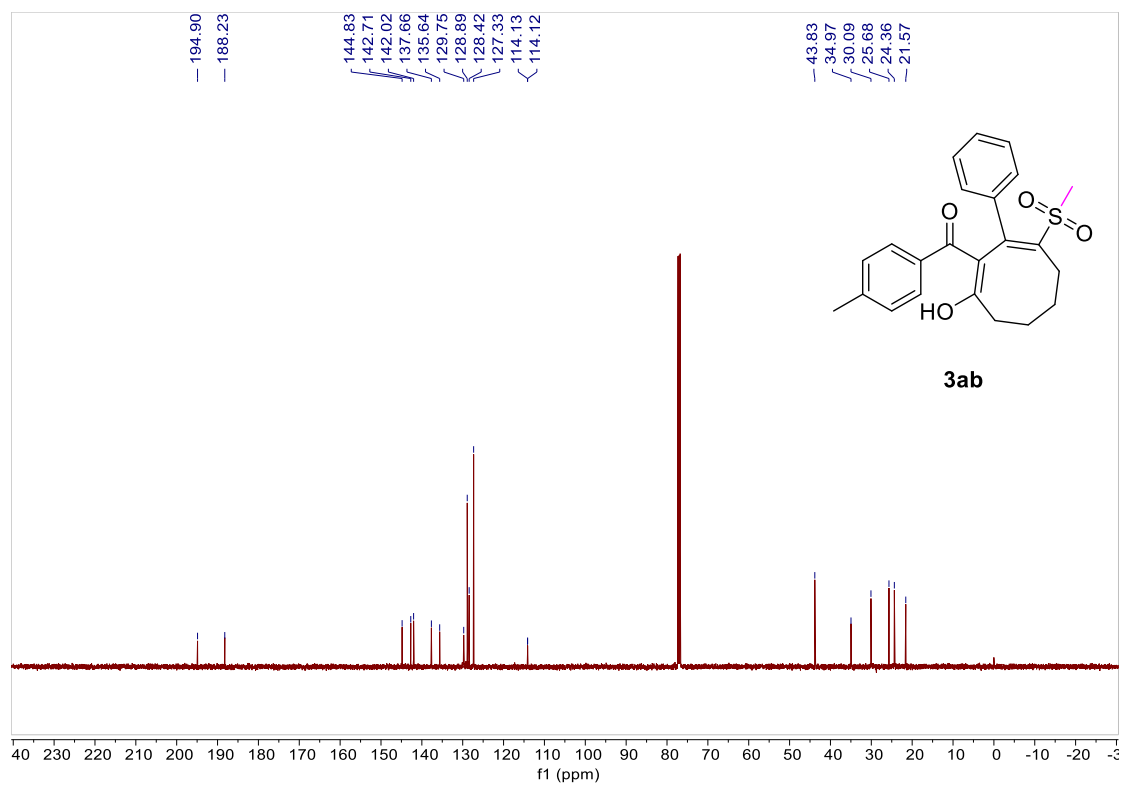
^{13}C NMR (125 MHz, CDCl_3)



^1H NMR (500 MHz, CDCl_3)



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



Chemical structure of compound **4** is shown above the spectrum.

¹H NMR spectrum (CDCl₃) of compound **4** shows peaks at the following chemical shifts (ppm): 1.236, 1.256, 1.791, 1.816, 2.032, 2.051, 2.071, 2.193, 2.244, 2.244, 2.244, 2.365, 2.369, 2.377, 2.403, 2.406, 3.106, 3.119, 3.211, 3.227, 3.239, 3.255, 6.608, 6.725, 6.740, 6.755, 6.868, 6.888, 7.120, 7.136, 7.146, 7.218, 7.255, 7.258, 7.268, 7.272, 7.285, 7.288, 7.292, 7.302, 7.305, 7.309, 7.416, 7.423, 7.429, 7.433, 7.437, 7.443, 7.447, 7.450.

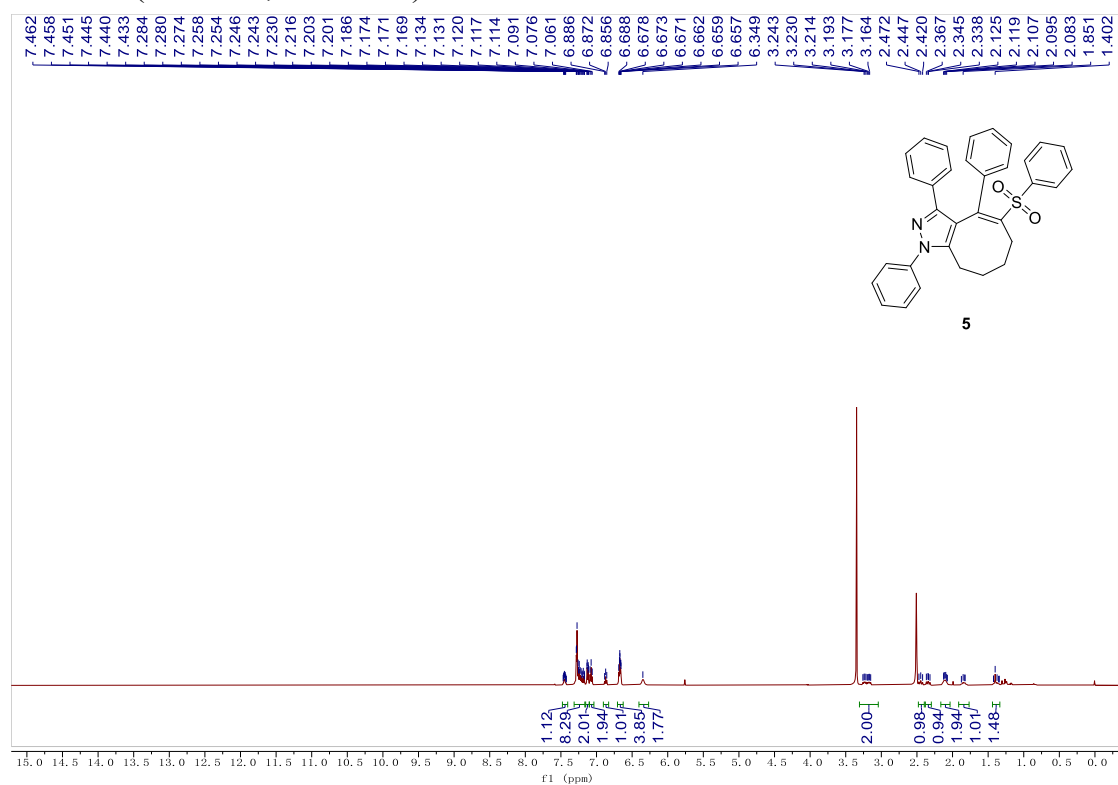
Integration values are provided below the peaks: 0.94, 1.04, 4.15, 4.87, 1.04, 2.06, 1.77, 1.05, 1.01, 1.04, 1.02, 2.00, 1.02, 1.08.

Chemical structure of compound **4** is shown in the top right corner. The structure is a complex molecule featuring a central ring system with a sulfonamide group and a phenyl ring.

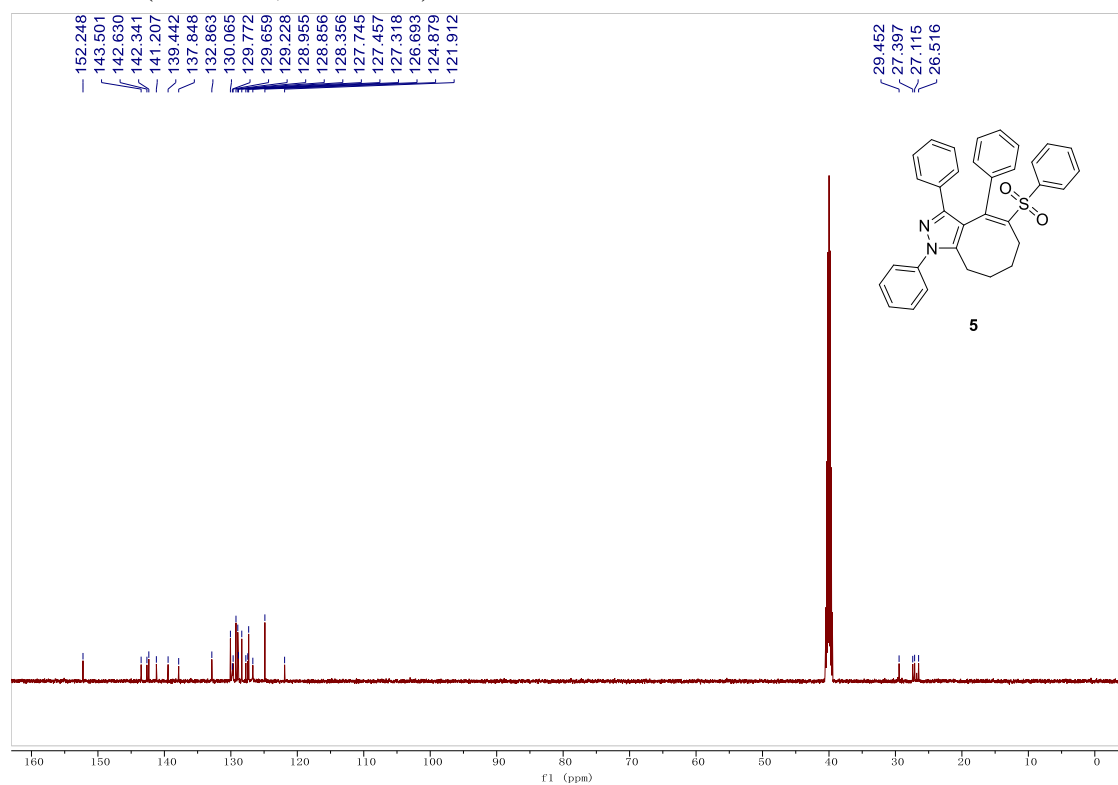
The ¹³C NMR spectrum displays the following chemical shifts (ppm):

- 150.435
- 144.226
- 143.710
- 141.344
- 140.957
- 137.524
- 133.611
- 132.756
- 130.711
- 128.912
- 128.280
- 127.972
- 127.819
- 127.675
- 127.292
- 126.612
- 117.343
- 29.509
- 27.150
- 25.031
- 24.502

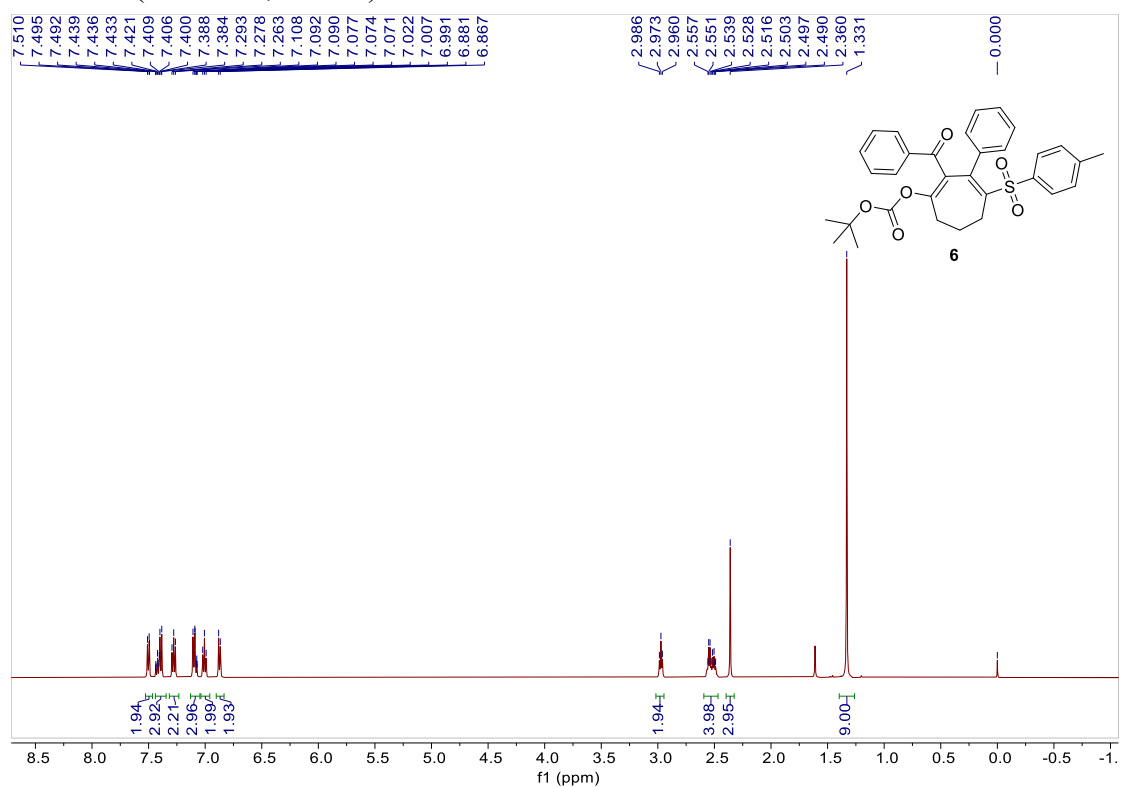
^1H NMR (500 MHz, d^6 -DMSO)



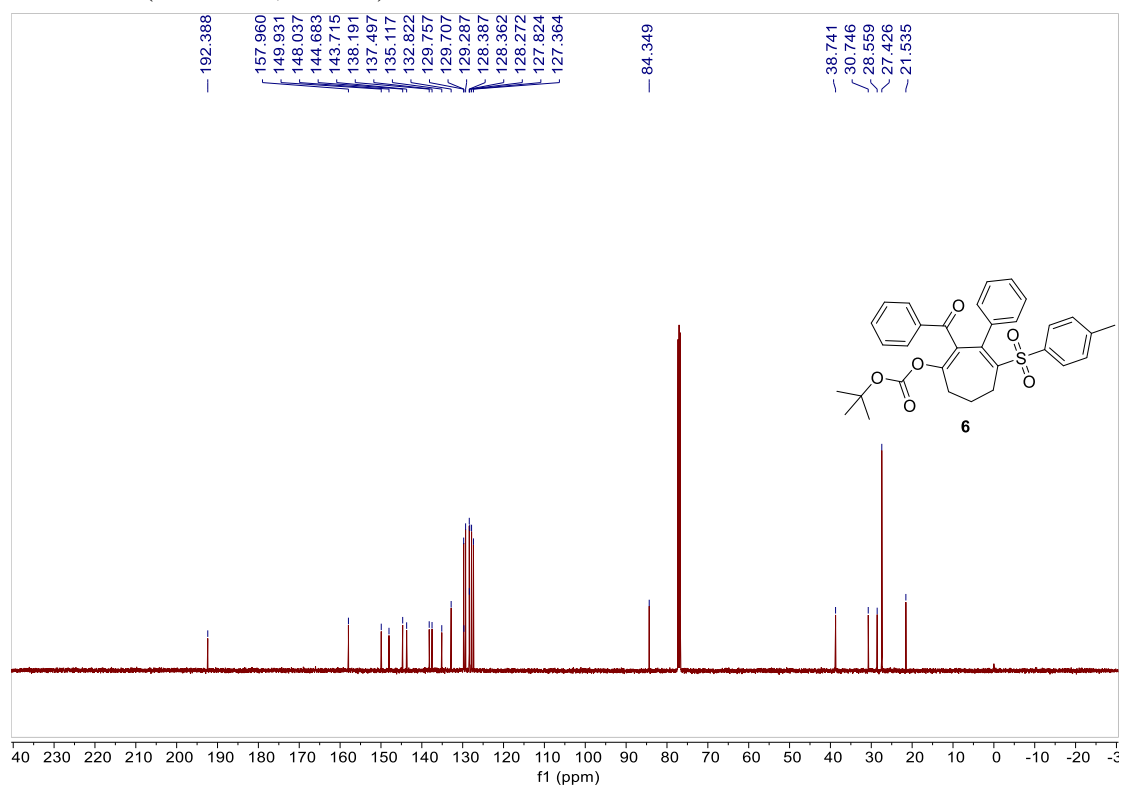
^{13}C NMR (125 MHz, d^6 -DMSO)



^1H NMR (500 MHz, CDCl_3)



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

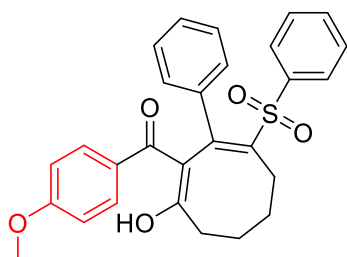


9. X-ray Crystallography of Compound 3a.

((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 ₅ S
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 > 2σ(I)]	R1 = 0.0530, wR2 = 0.1153
R indices (all data)	R1 = 0.0899, wR2 = 0.1301

