

Silver-Mediated Radical Oxytrifluoromethylation of Unstaurated Carboxylic Acids for the Synthesis of γ -Trifluoromethylthio Lactones

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1. General information

Reagents and solvents. All starting materials, which were purchased from commercial sources, were used without further purification. Solvents for column chromatography were technical standard. Column chromatography was performed with silica gel 200-400 mesh. ^1H , ^{13}C and ^{19}F NMR spectra were recorded on Bruker Avance 400 Mhz or 500 Mhz spectrometer. Chemical shifts in ^1H NMR spectra were reported in parts per million (ppm) downfield from the internal standard Me_4Si (TMS). Chemical shifts in ^{13}C NMR spectra were reported relative to the central line of the chloroform signal ($\delta = 77.0$ ppm). Peaks were labelled as singlet (s), doublet (d), triplet (t), quarter (q), and multiplet (m). High resolution mass spectra were obtained with a Shimadzu LCMS-IT-TOF mass spectrometer. Analytical TLC was performed using EM separations percolated silica gel 0.2 mm layer UV 254 fluorescent sheets.

2. Experiment Section

2.1 General procedures for preparation of 3.

Into an oven-dried sealed tube was added 4-phenylpent-4-enoic acid **1** (0.05 mmol), AgSCF_3 **2** (0.06 mmol), $\text{K}_2\text{S}_2\text{O}_8$ (40.5 mg, 0.15 mmol), and CH_3CN (0.5 mL). The mixture was stirred at 80 °C for 12 hours until the complete consumption of **1** as monitored by TLC analysis. The reaction mixture was then diluted with water and extracted with ethyl acetate. After the combined organic layers were washed with brine, dried

over Na₂SO₄, and concentrated under reduced pressure, the residue was purified by flash column chromatography on silica gel using petroleum ether/ethyl acetate as the eluent (10:1, V/V) to afford the pure product **3**.

2.2 Mechanism investigation

Procedures for the radical trapping and control experiment

Into an oven-dried sealed tube was added 4-phenylpent-4-enoic acid **1** (0.05 mmol), AgSCF₃ **2** (0.06 mmol), K₂S₂O₈ (40.5 mg, 0.15 mmol), and CH₃CN (0.5 mL). The mixture was stirred at 80 °C for 12 hours under N₂ protect, until the complete consumption of **1** as monitored by TLC analysis. The reaction mixture was then diluted with water and extracted with ethyl acetate. After the combined organic layers were washed with brine, dried over Na₂SO₄, and concentrated under reduced pressure, the residue was purified by flash column chromatography on silica gel using petroleum ether/ethyl acetate as the eluent (10:1, V/V) to afford the pure product **3**.

Into an oven-dried sealed tube was added 4-phenylpent-4-enoic acid **1** (0.05 mmol), AgSCF₃ **2** (0.06 mmol), K₂S₂O₈ (40.5 mg, 0.15 mmol), 2,2,6,6-tetramethylpiperidineoxy (TEMPO, 23.4 mg, 0.15 mmol) and CH₃CN (0.5 mL), No special precautions were taken to exclude moisture and air, The mixture was stirred at 80 °C for 12 hours.

Into an oven-dried sealed tube was added 4-phenylpent-4-enoic acid **1** (0.05 mmol), AgSCF₃ **2** (0.06 mmol), K₂S₂O₈ (40.5 mg, 0.15 mmol),

2,6-di-*tert*-butyl-4-methylphenol (BHT, 33.0 mg, 0.15 mmol) and CH₃CN (0.5 mL), No special precautions were taken to exclude moisture and air, The mixture was stirred at 80 °C for 12 hours.

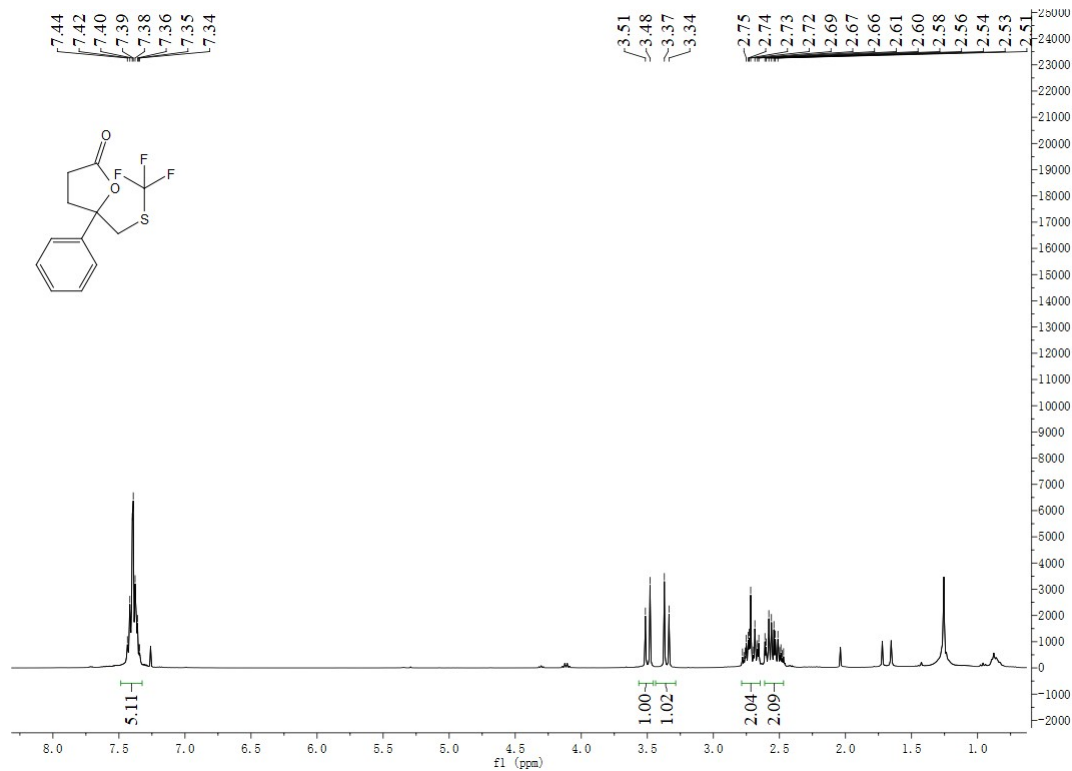
Procedures of 1a reacted with 5

To a solution of AgSCF₃ (0.1 mmol), TABI (0.5 mmol), K₂S₂O₈ (0.3 mmol) and 1 mL MeCN was added, the mixture was exchange with N₂ three times and stirred at 80 °C for 2 hours. The mixture **5** without purification and directed used for the next reaction, one tube was added K₂S₂O₈ (0.3 mmol) and AgNO₃ (0.01 mmol), No special precautions were taken to exclude moisture and air, The mixture was stirred at 80 °C for 12 hours. The other ube was added K₂S₂O₈ (0.3 mmol), No special precautions were taken to exclude moisture and air, The mixture was stirred at 80 °C for 12 hours.

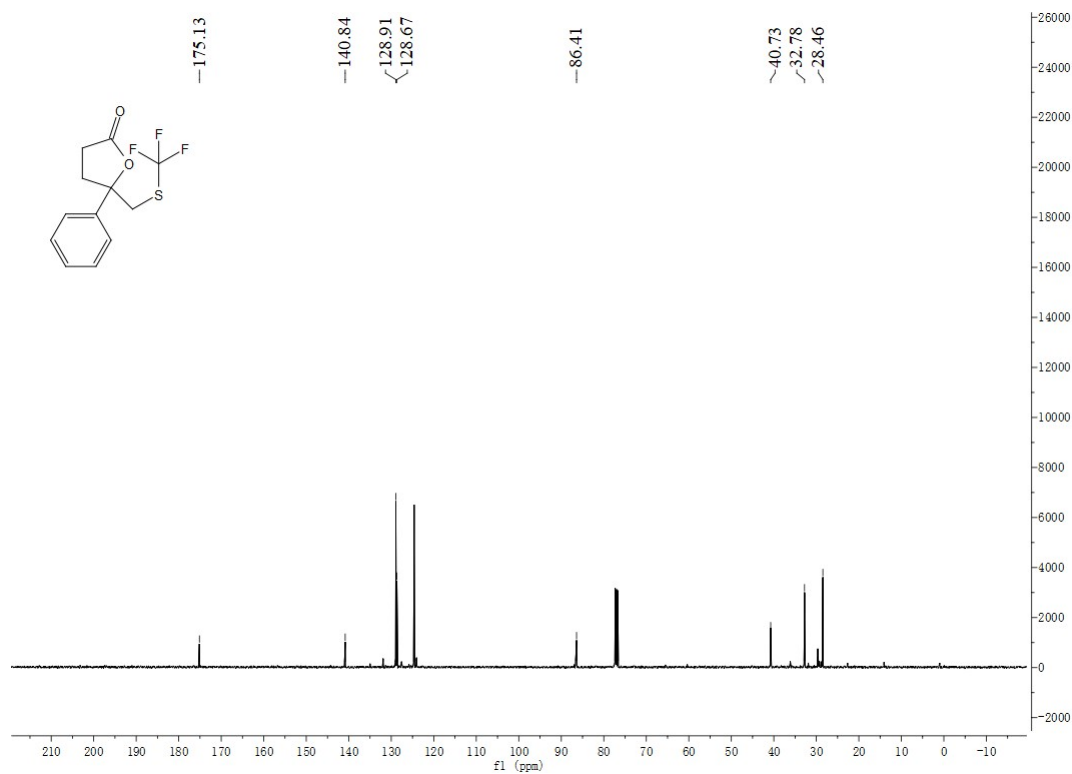
3. NMR Spectra

Compound 3a

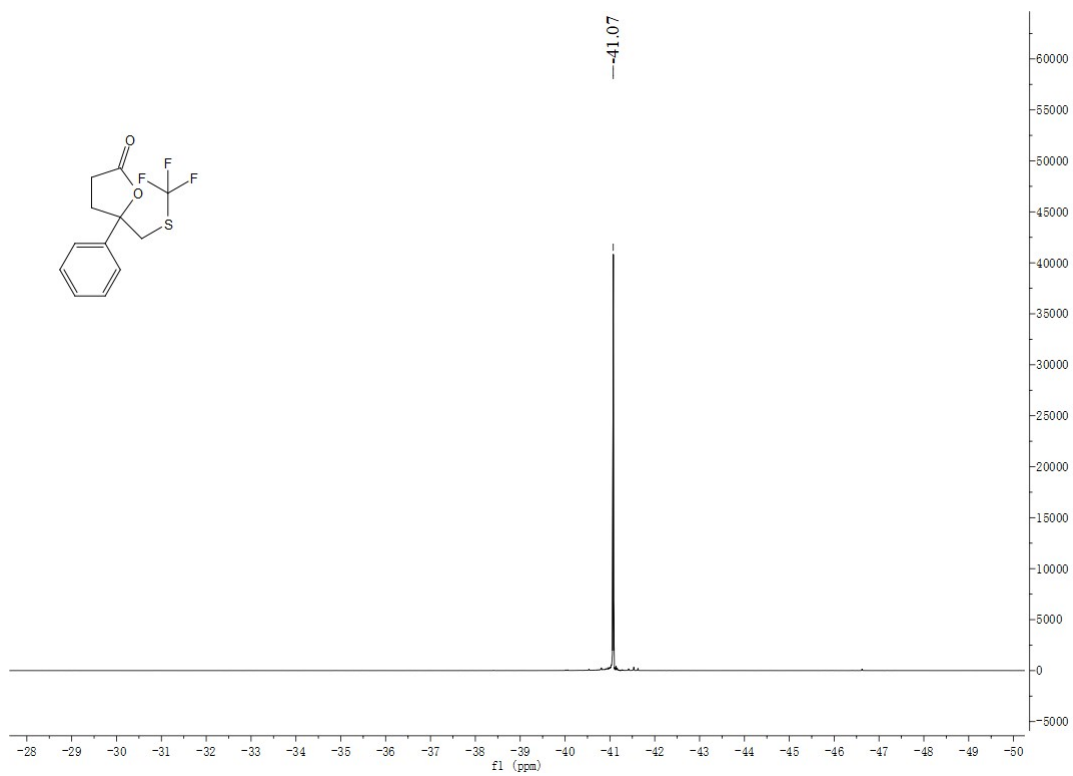
¹H NMR



¹³C NMR

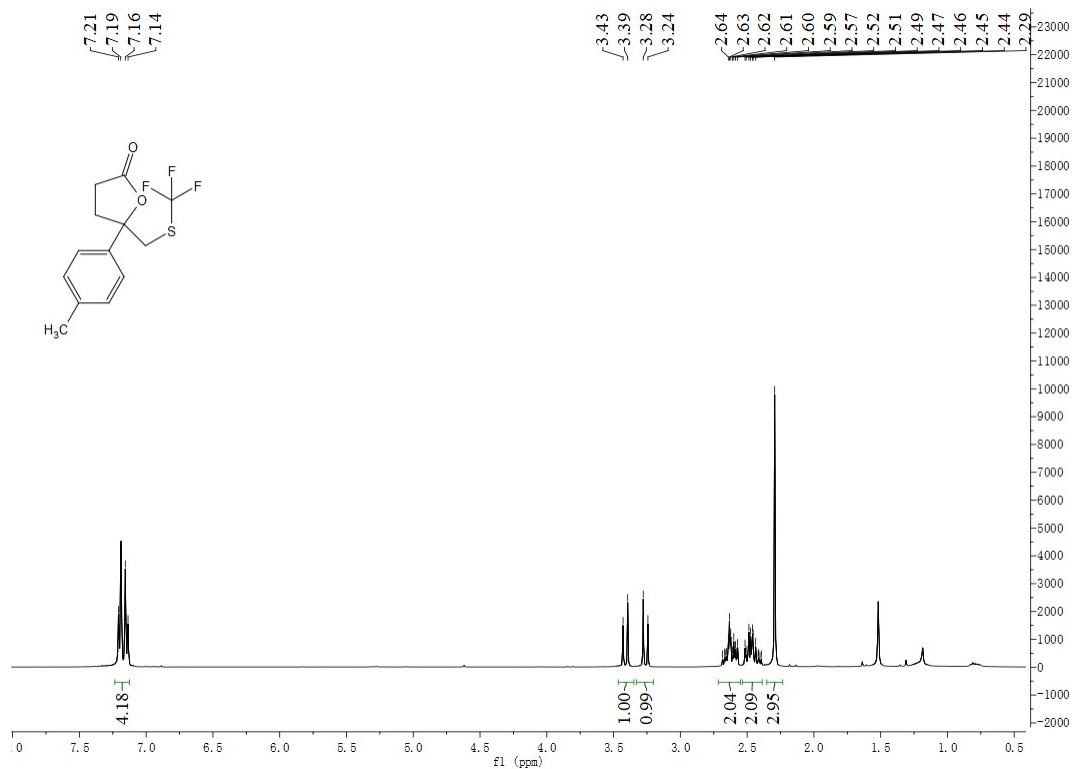


¹⁹F NMR

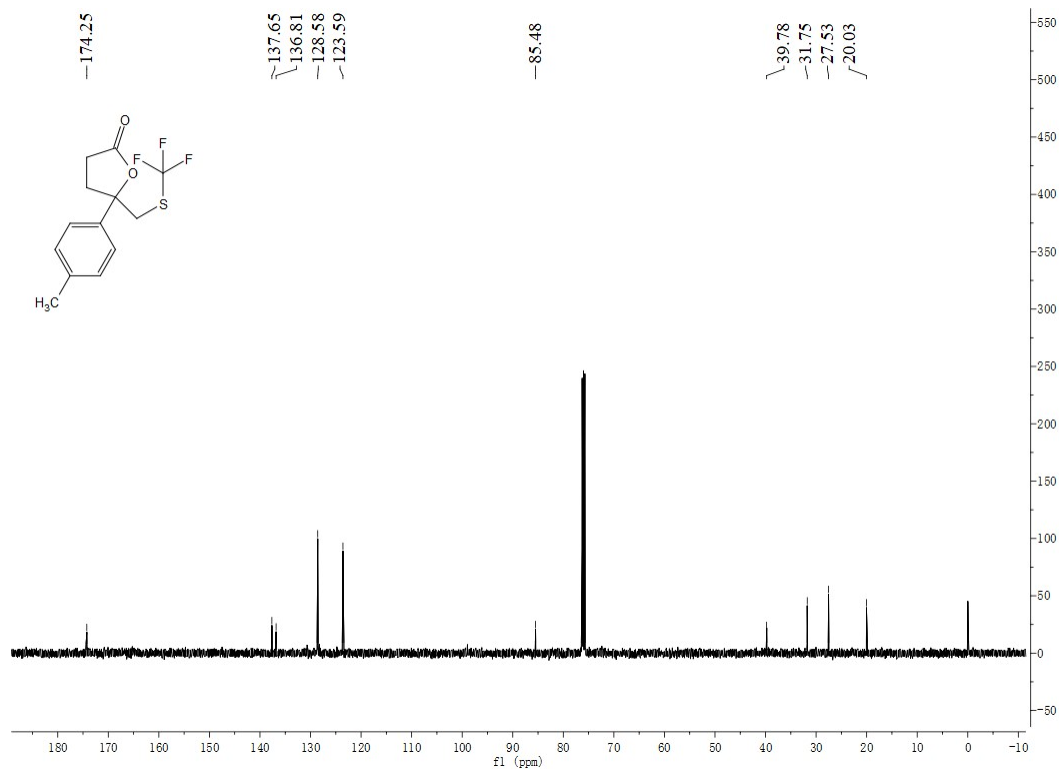


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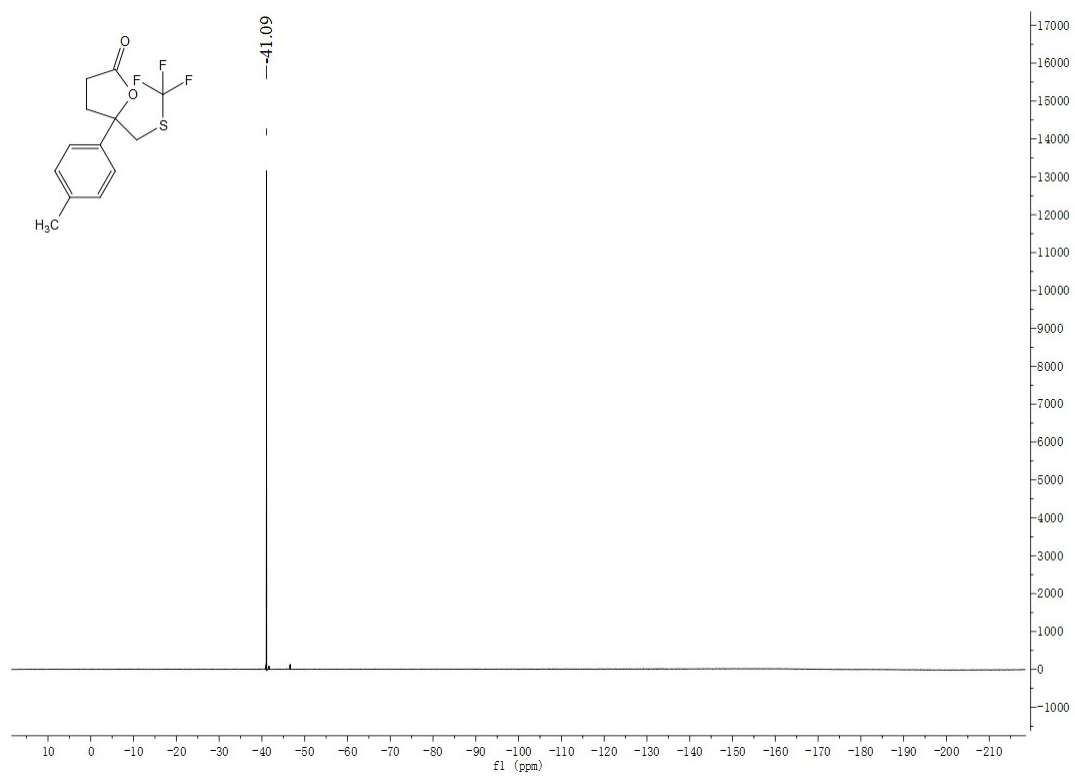
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¹³C NMR

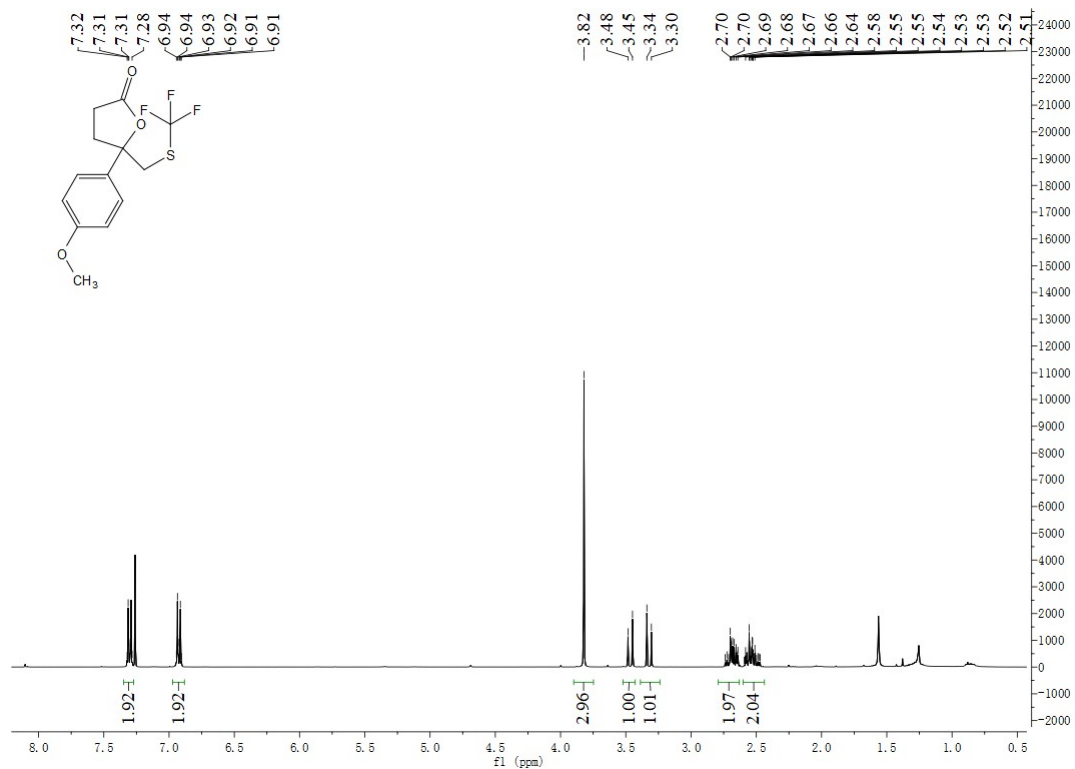


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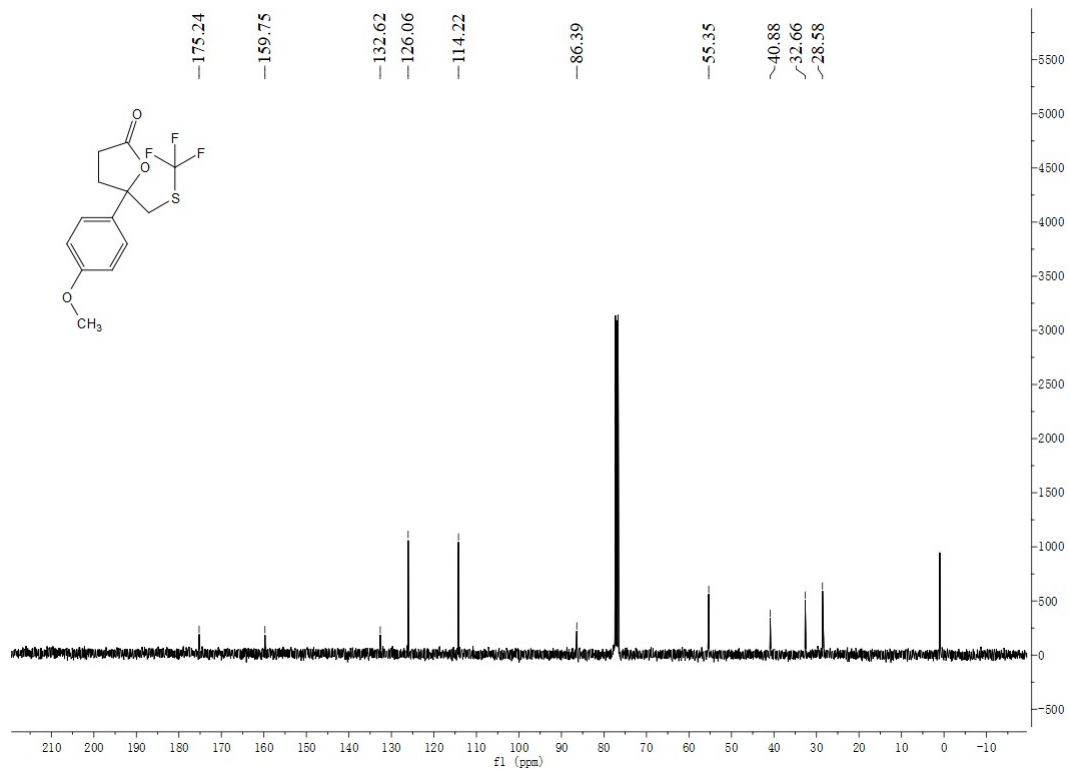


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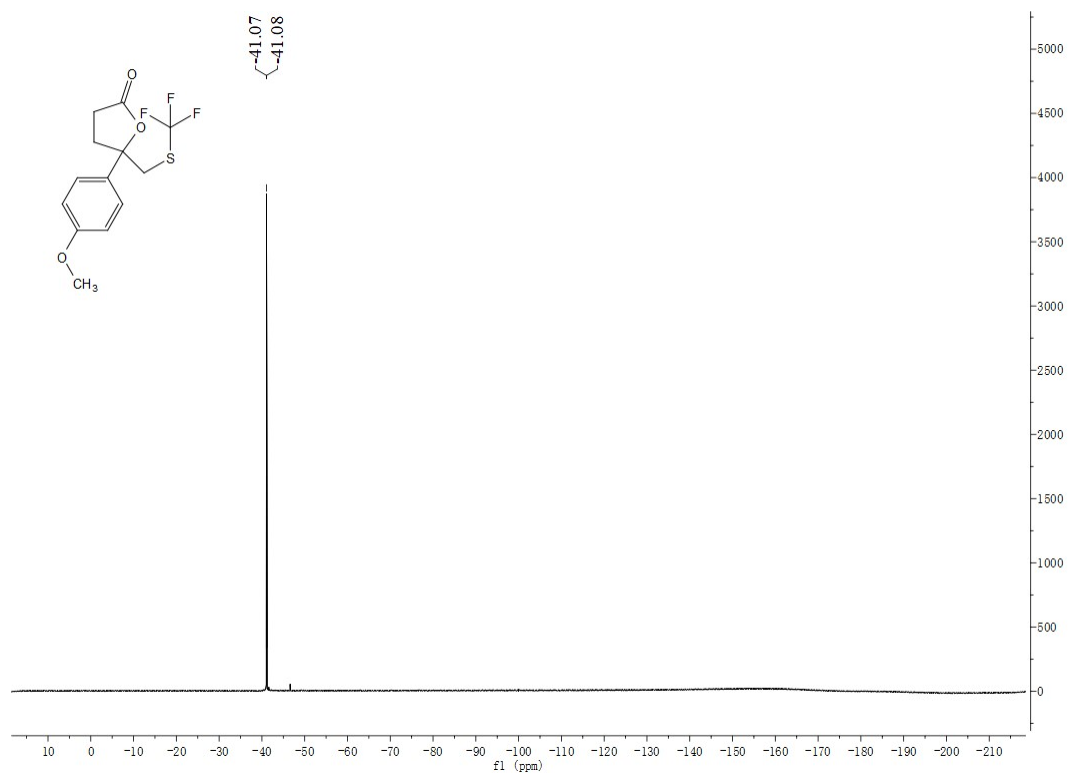
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¹³C NMR

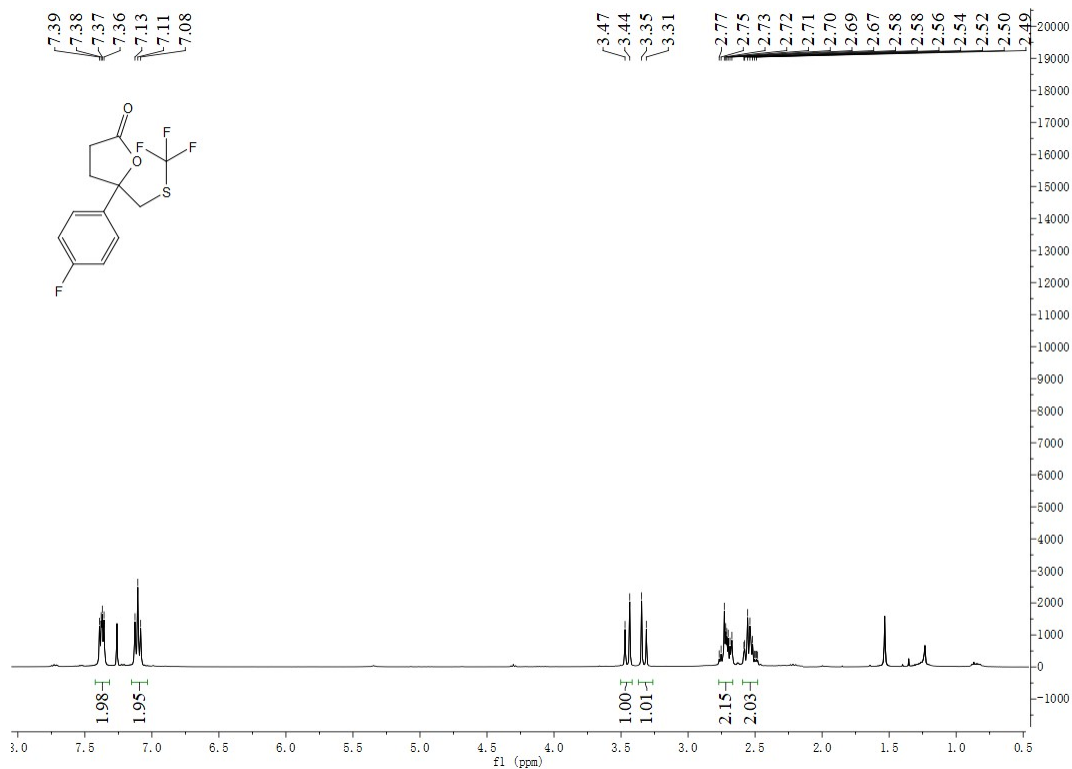


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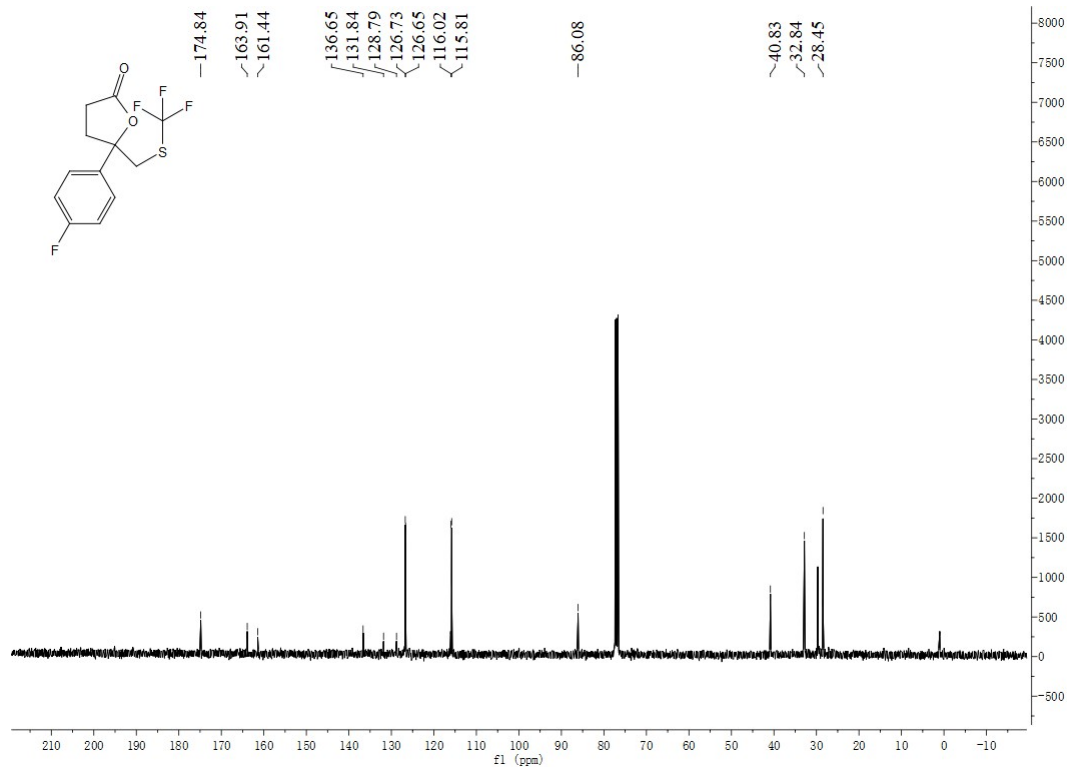


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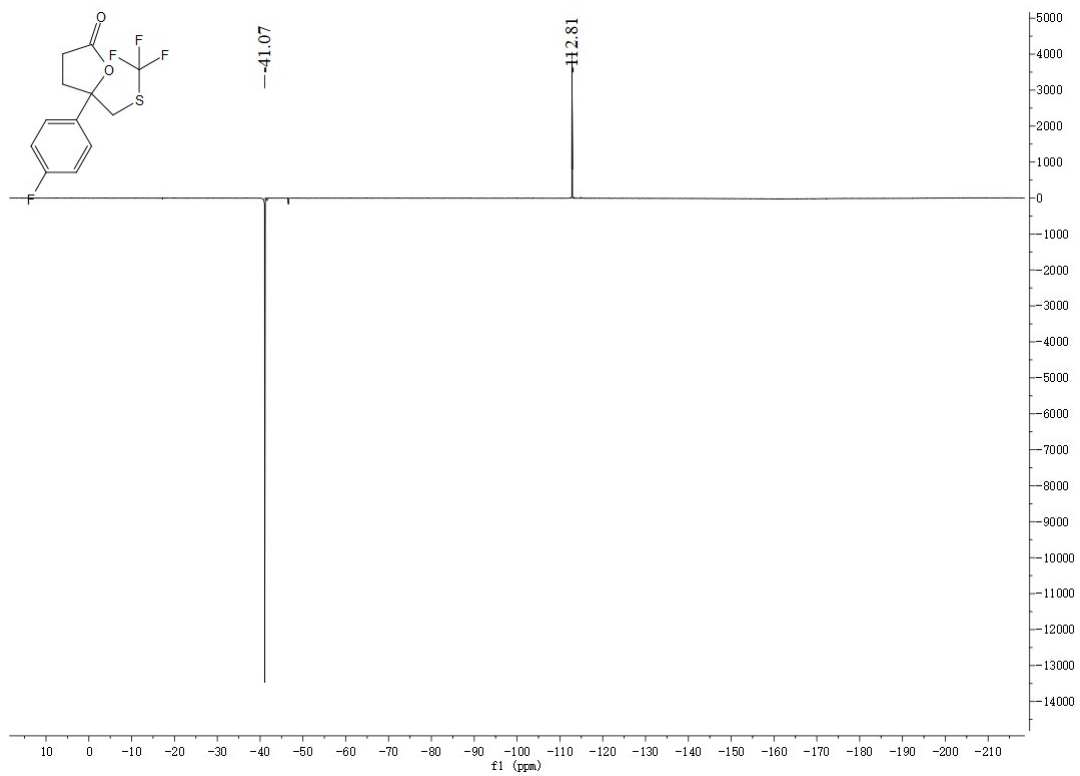
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¹³C NMR

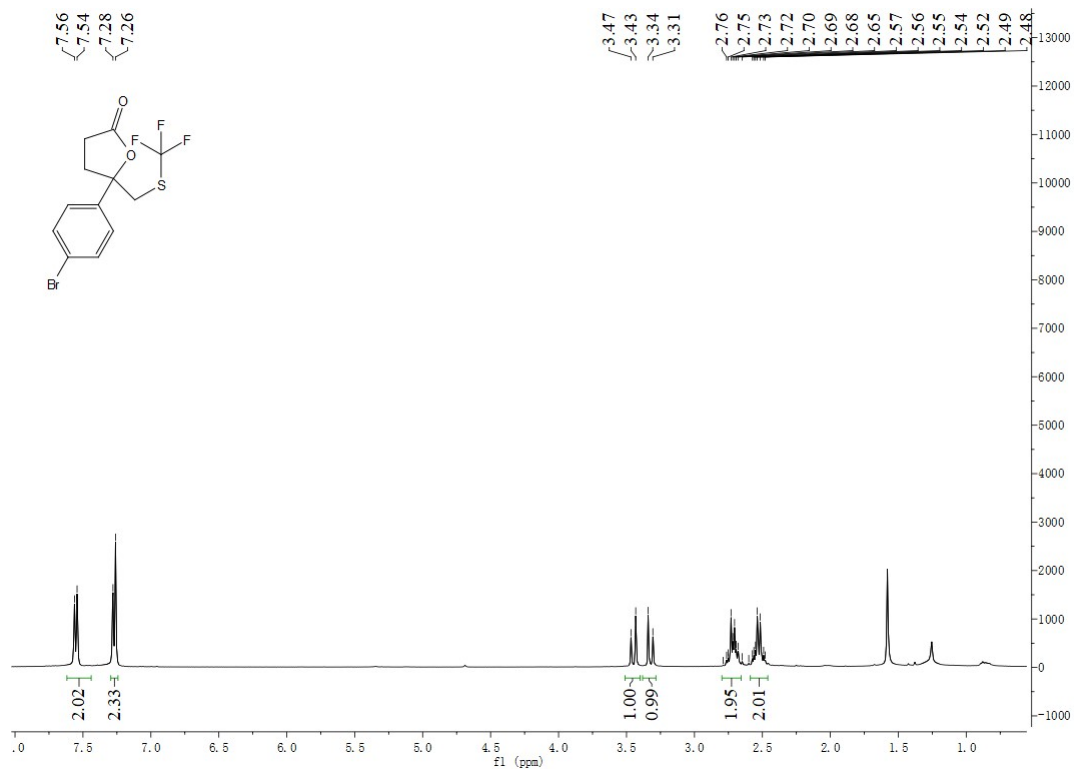


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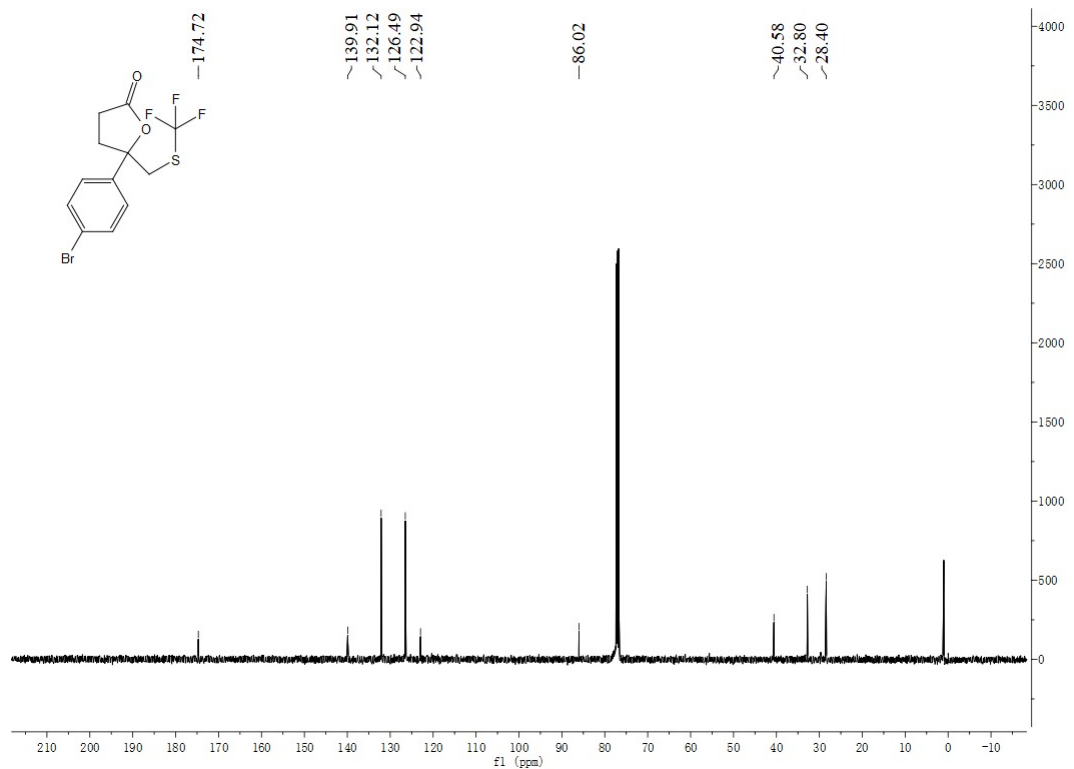


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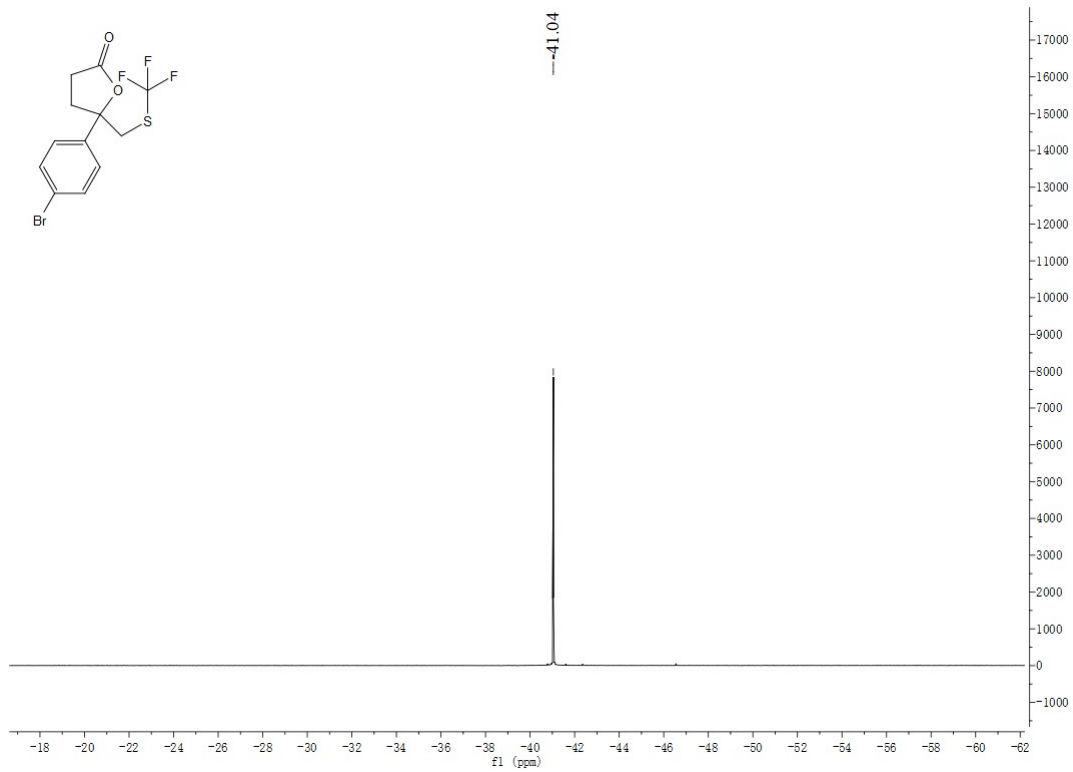
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¹³C NMR

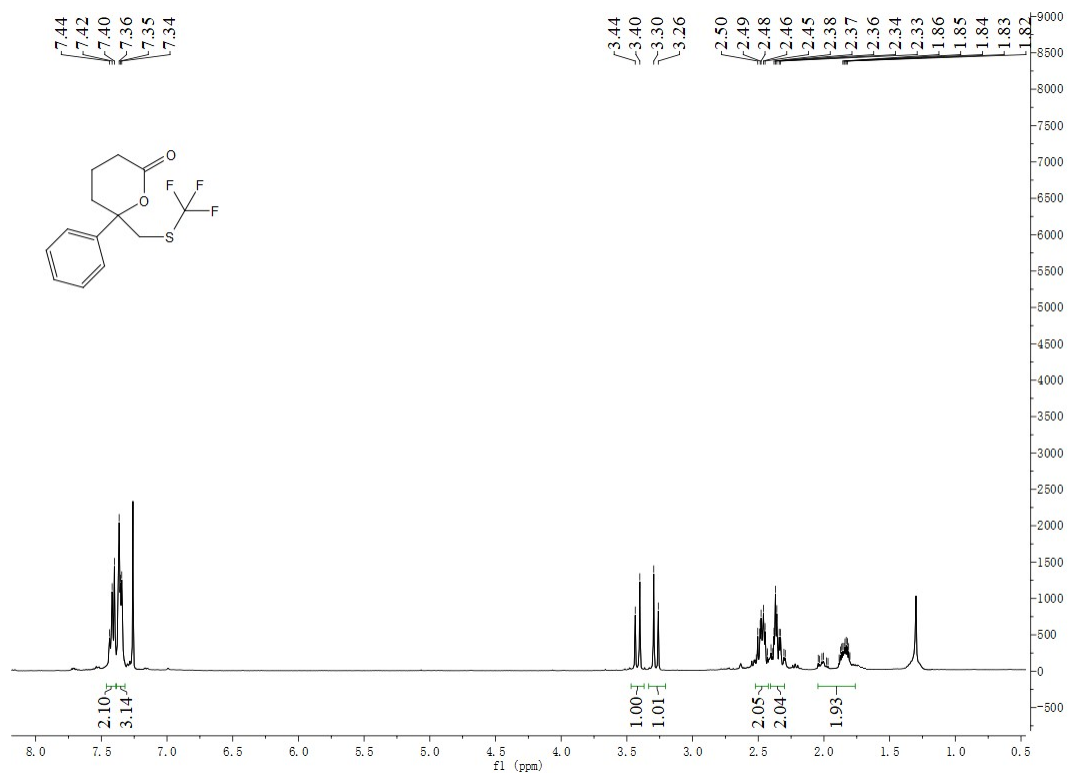


¹⁹F NMR

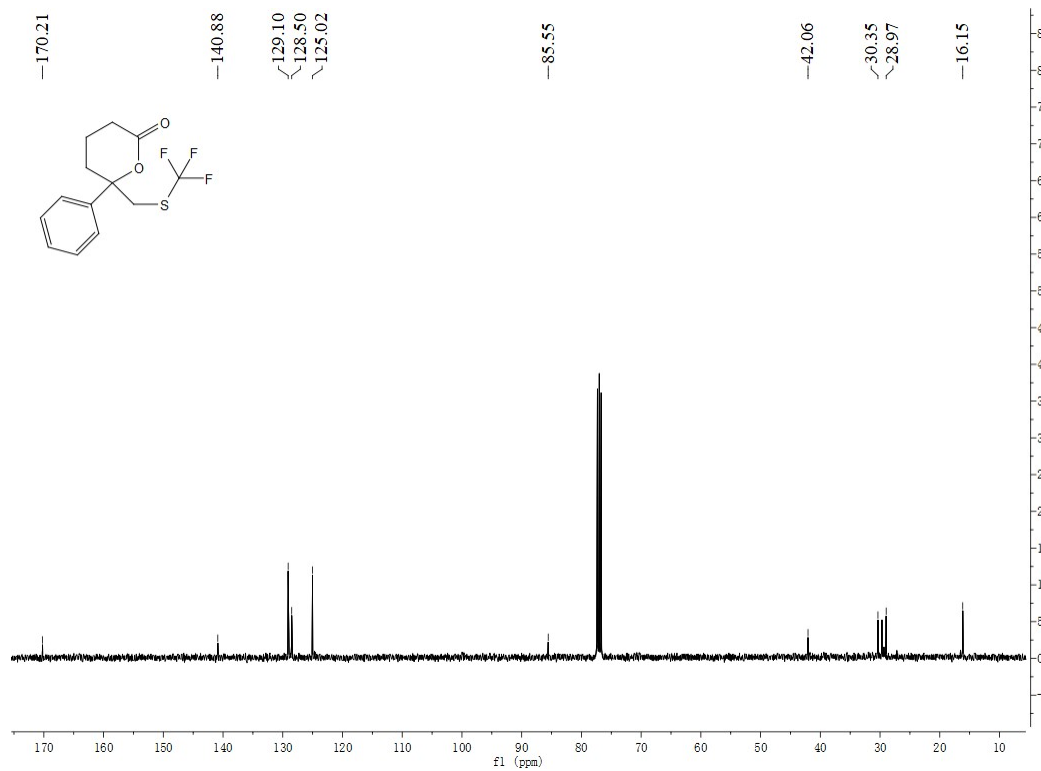


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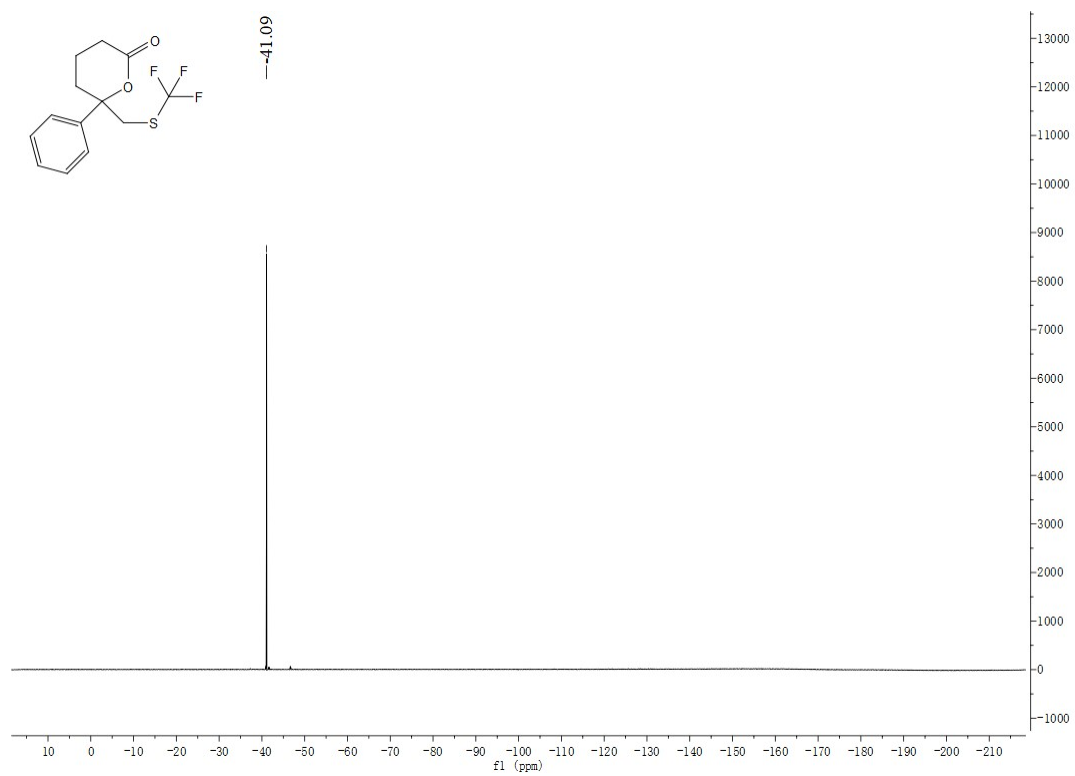
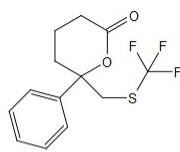
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¹³C NMR

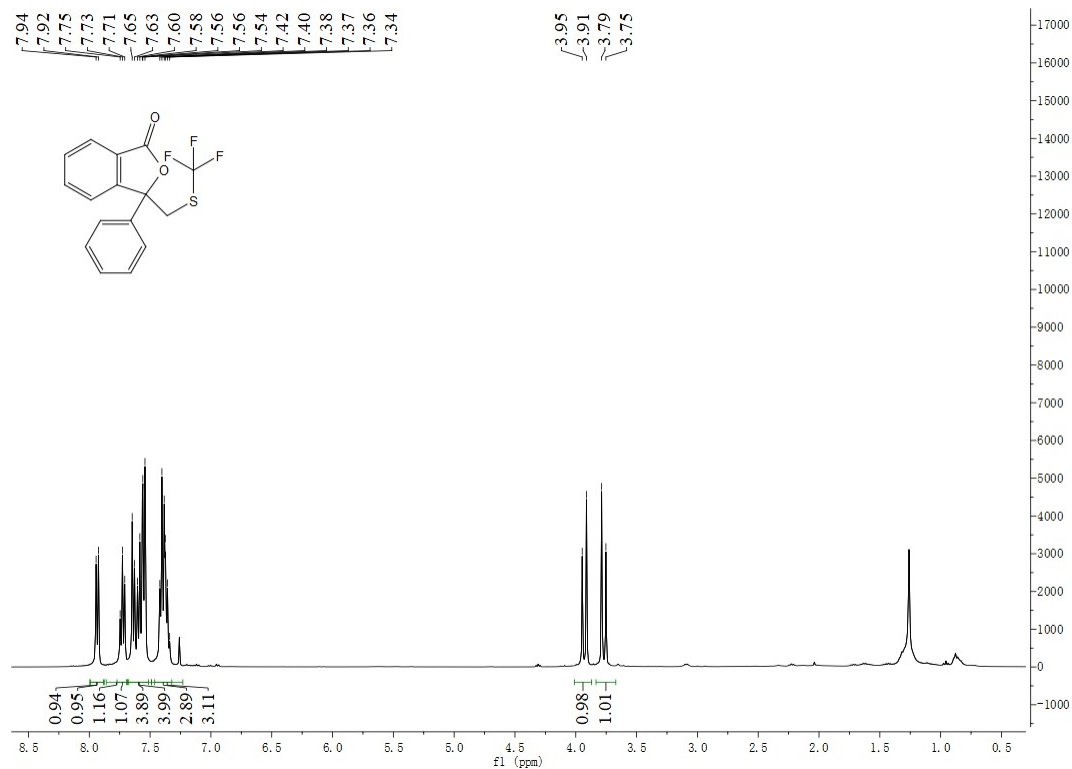


¹⁹F NMR

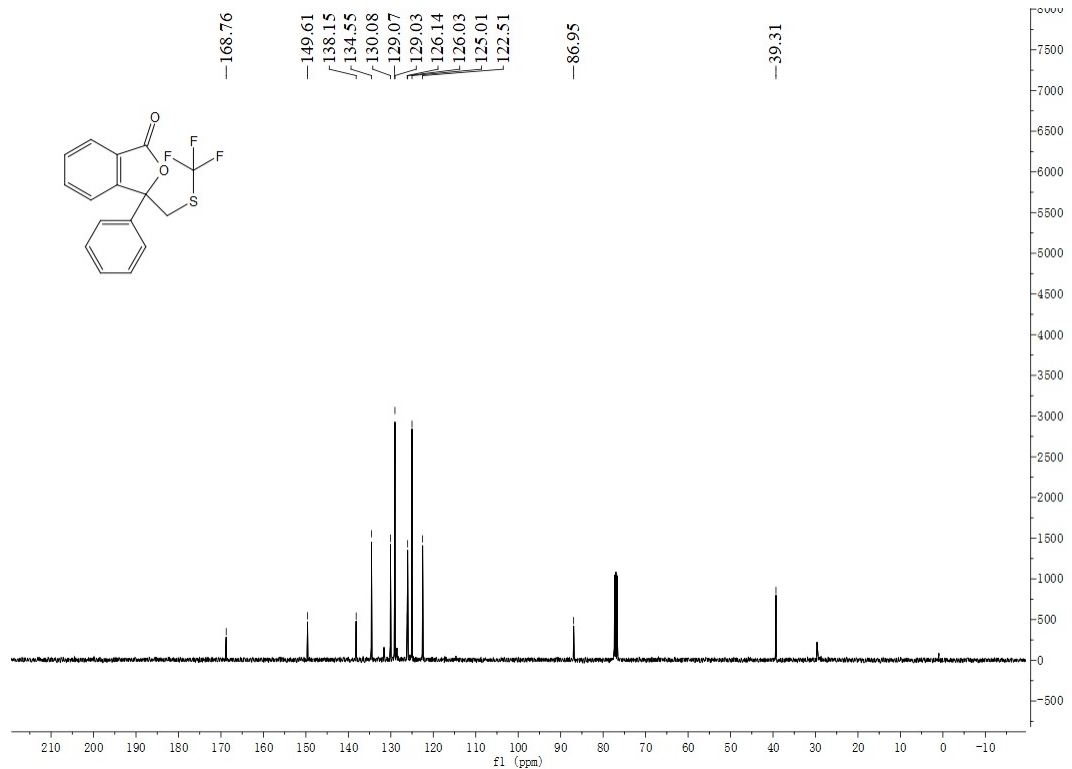


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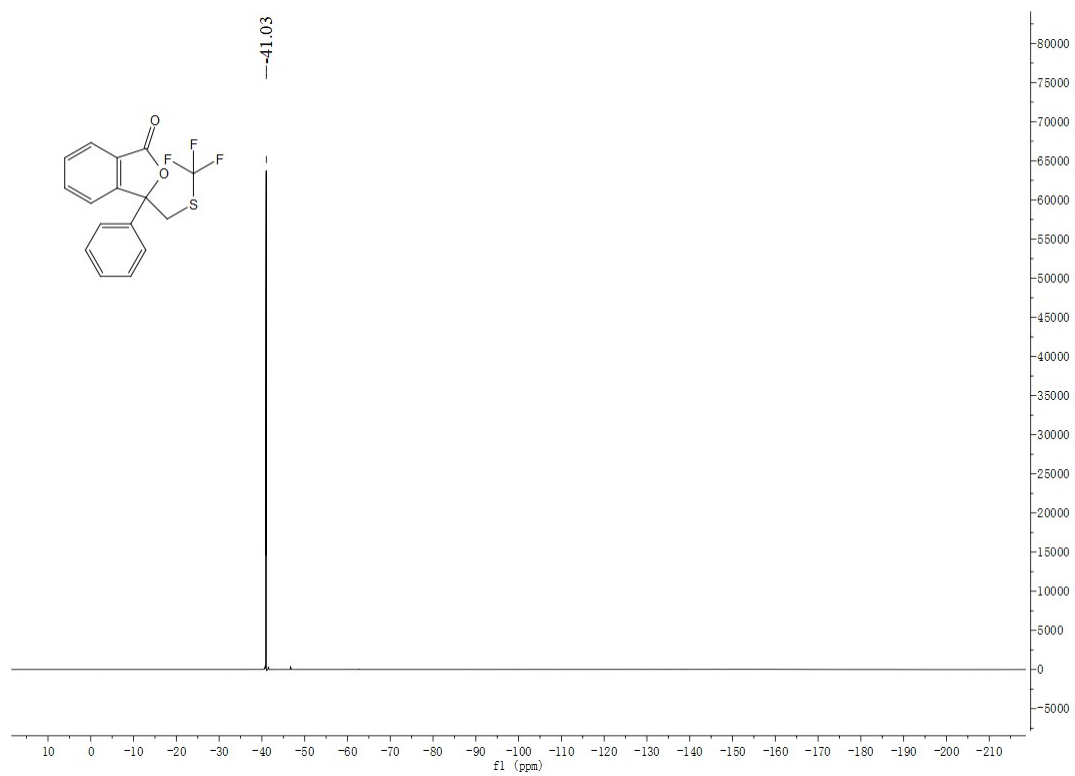
¹H NMR



¹³C NMR

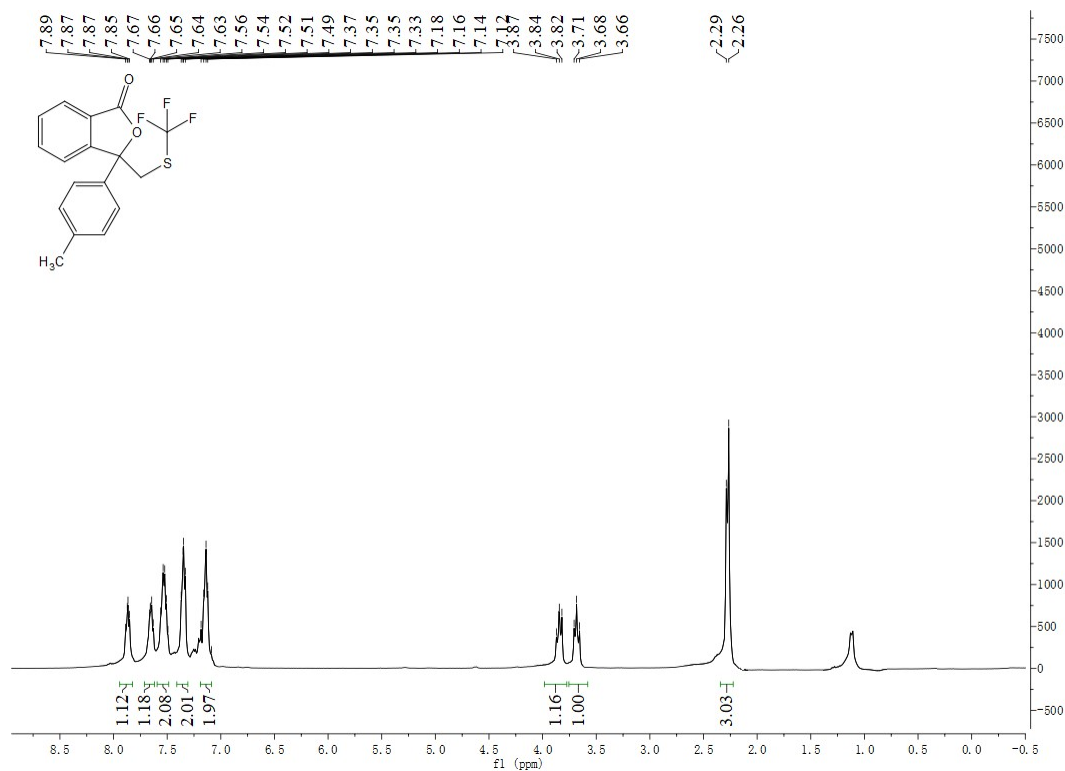


¹⁹F NMR

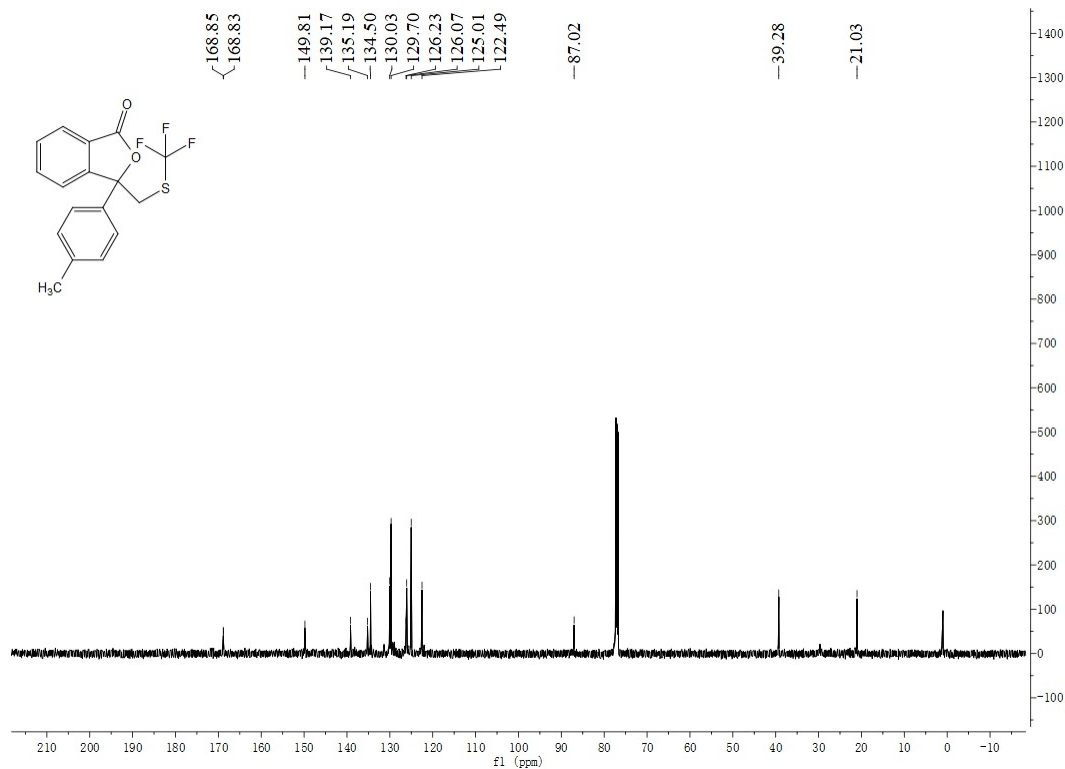


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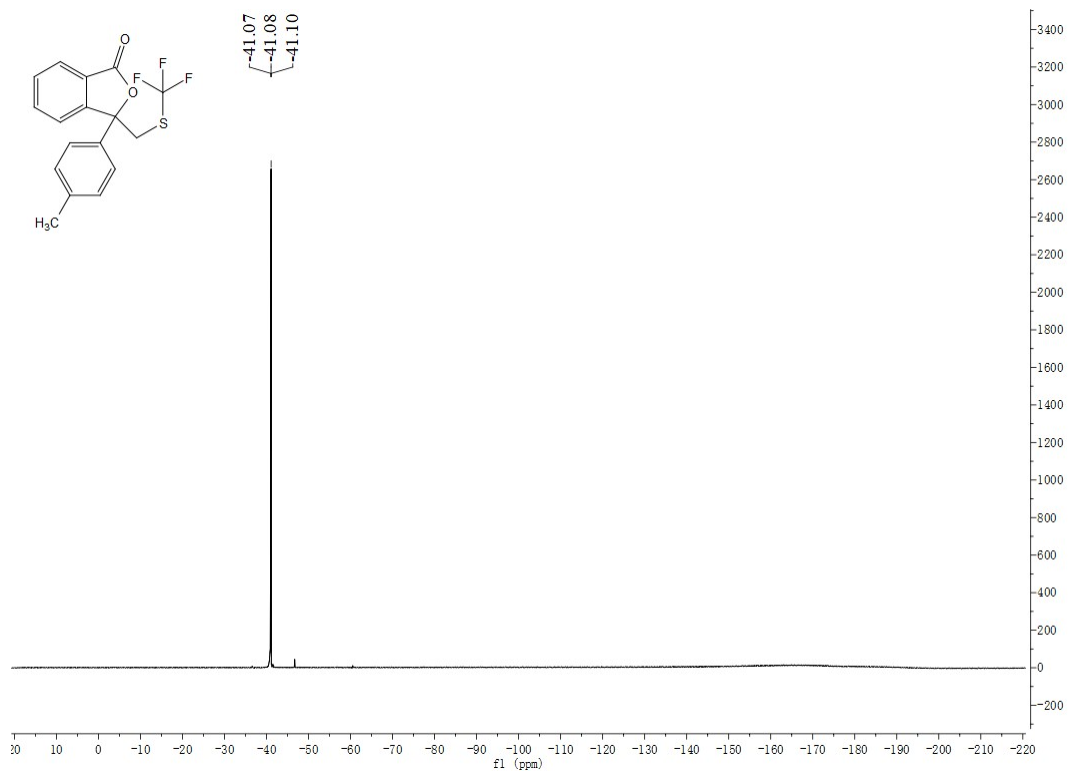
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¹³C NMR

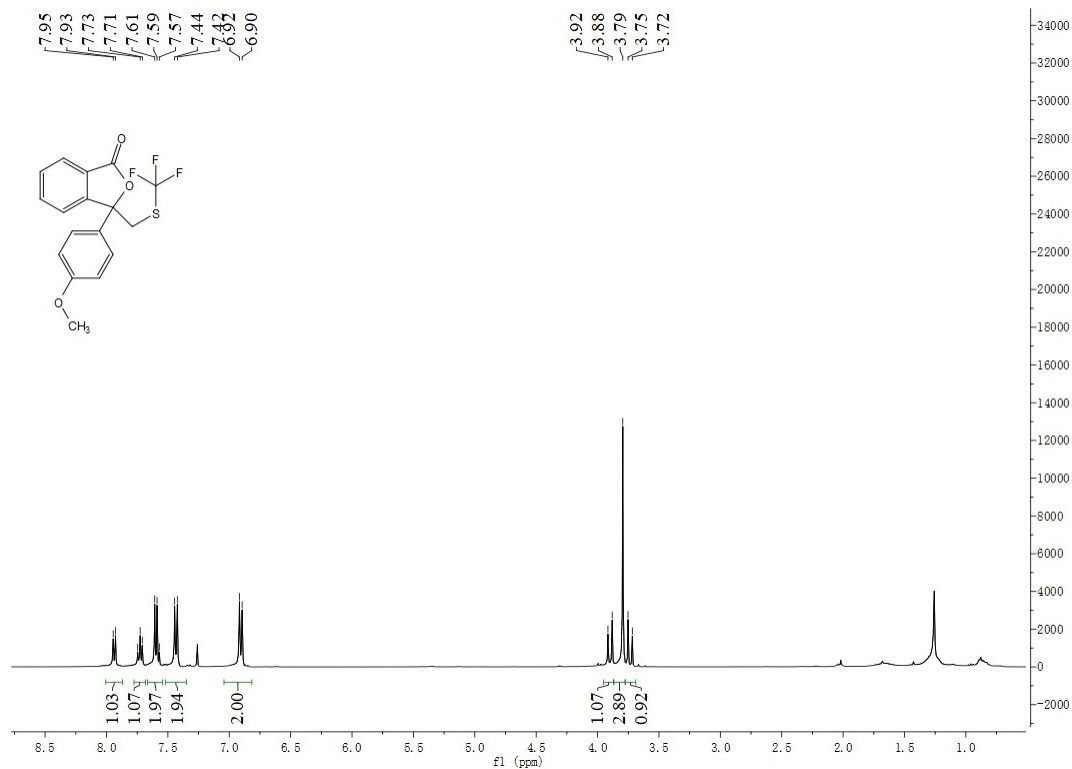


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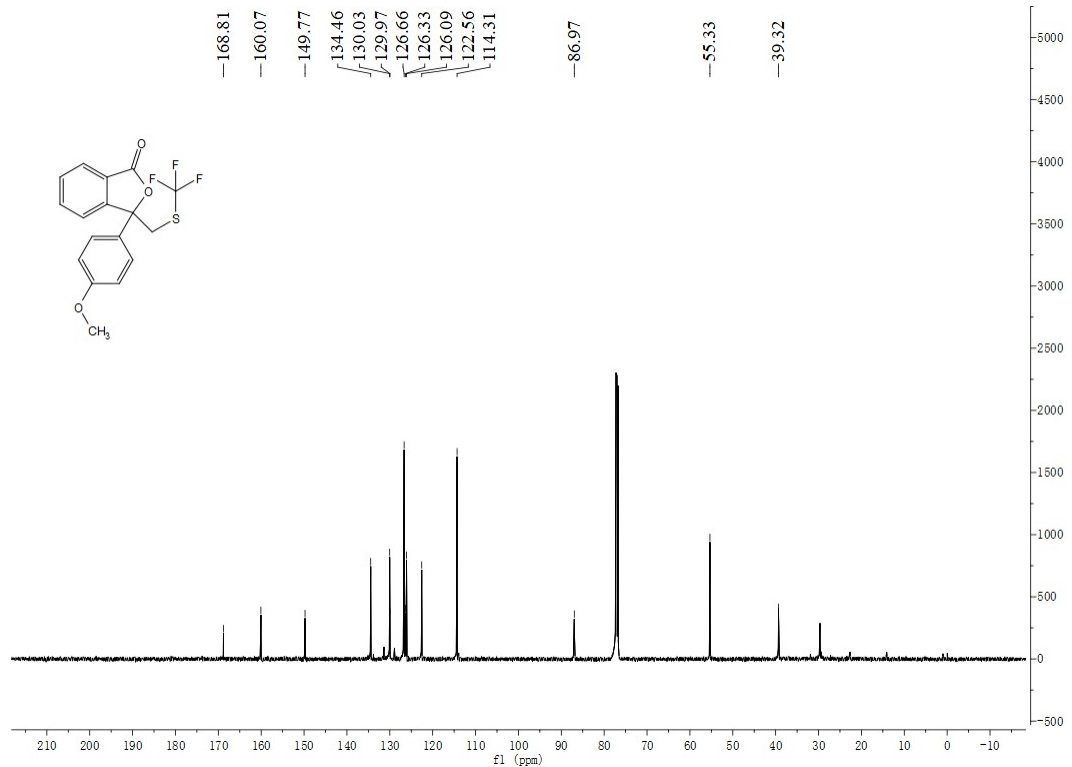


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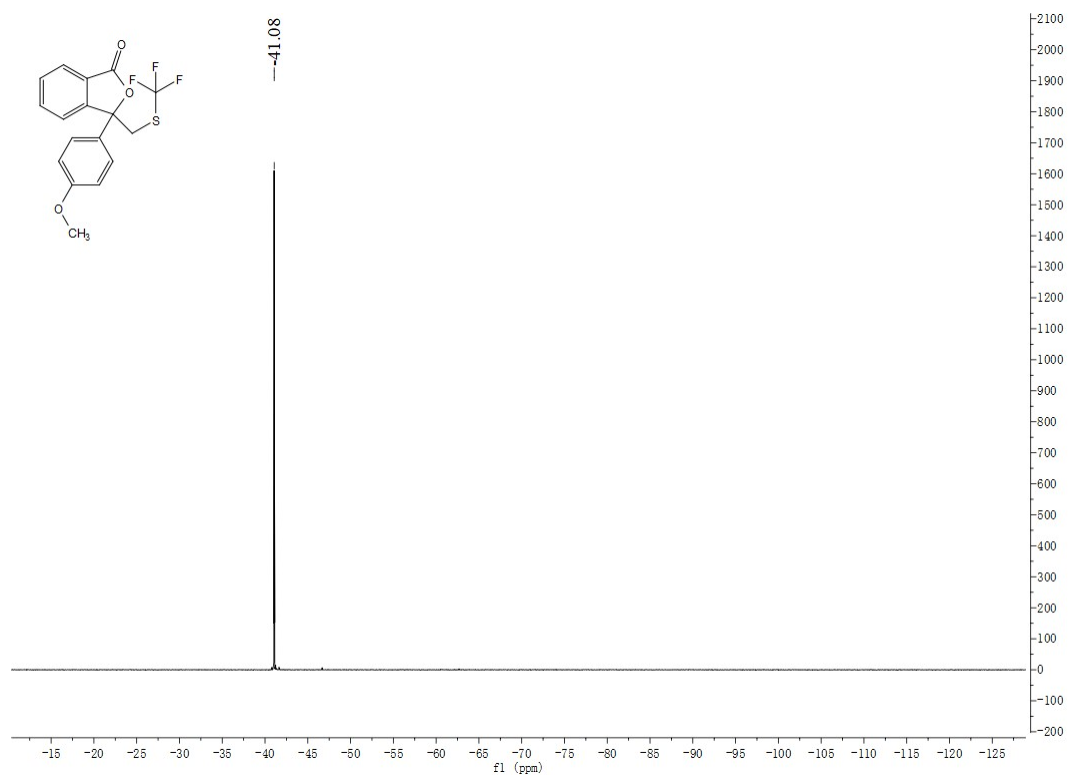
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¹³C NMR

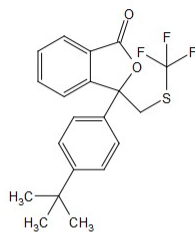
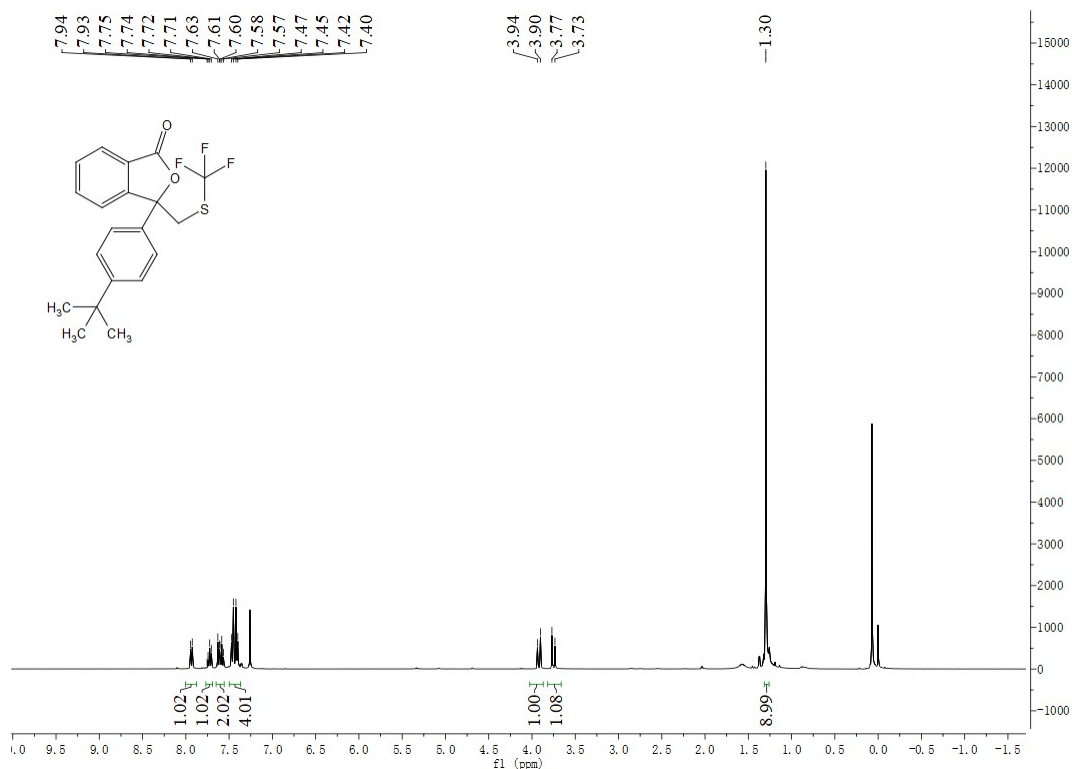


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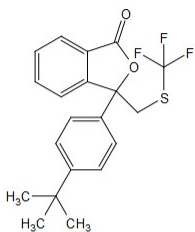
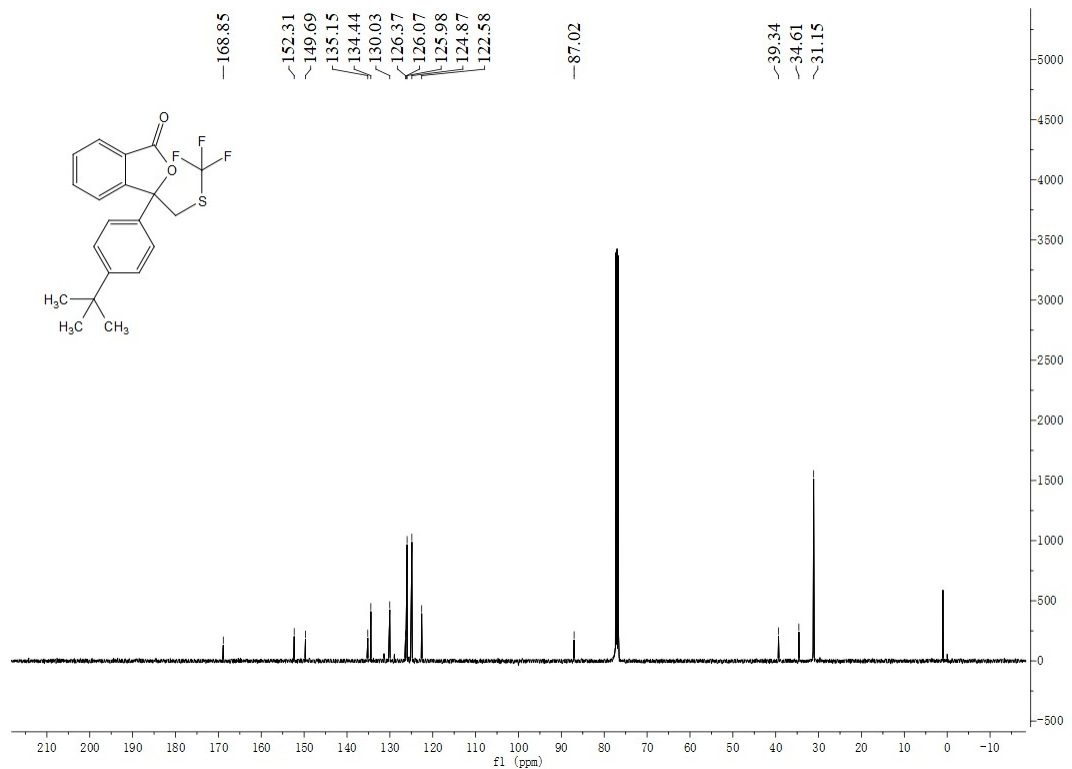


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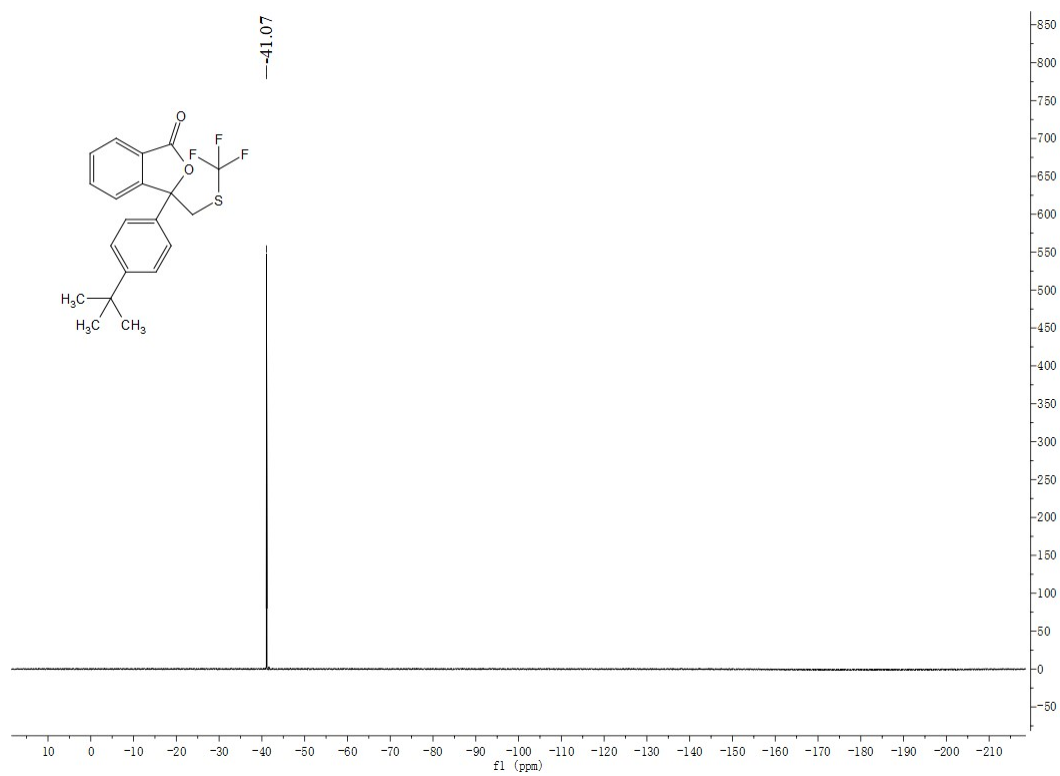
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¹³C NMR

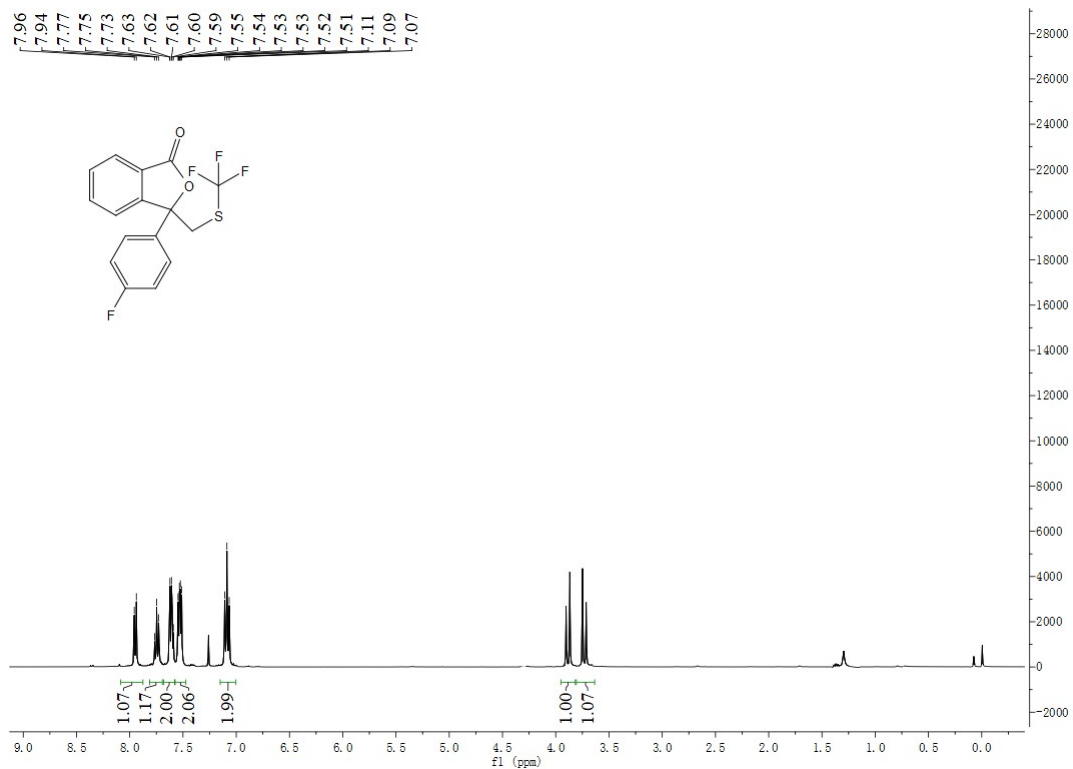


¹⁹F NMR

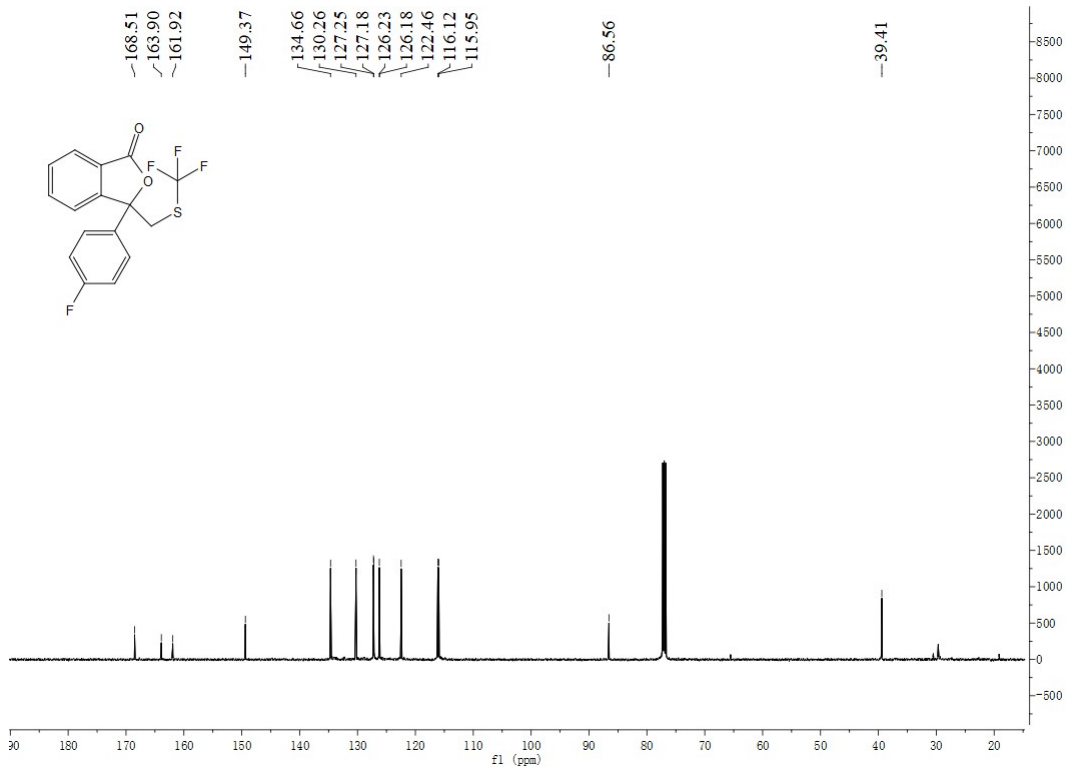


Compound 3k

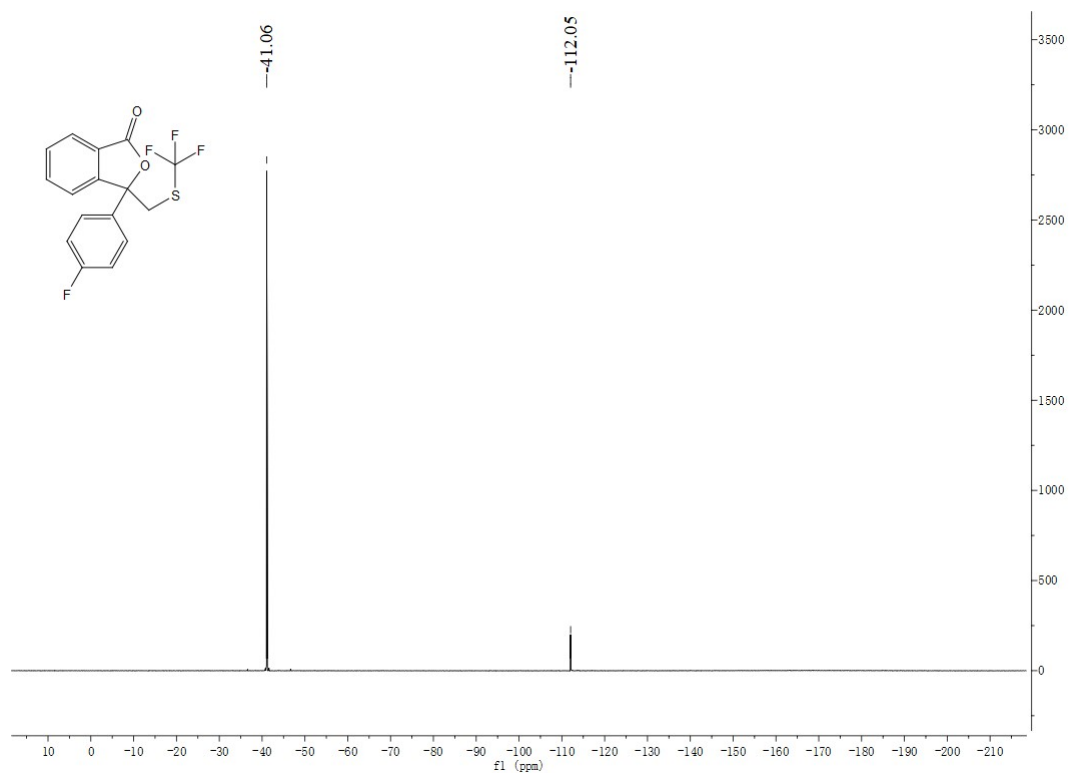
¹H NMR



¹³C NMR

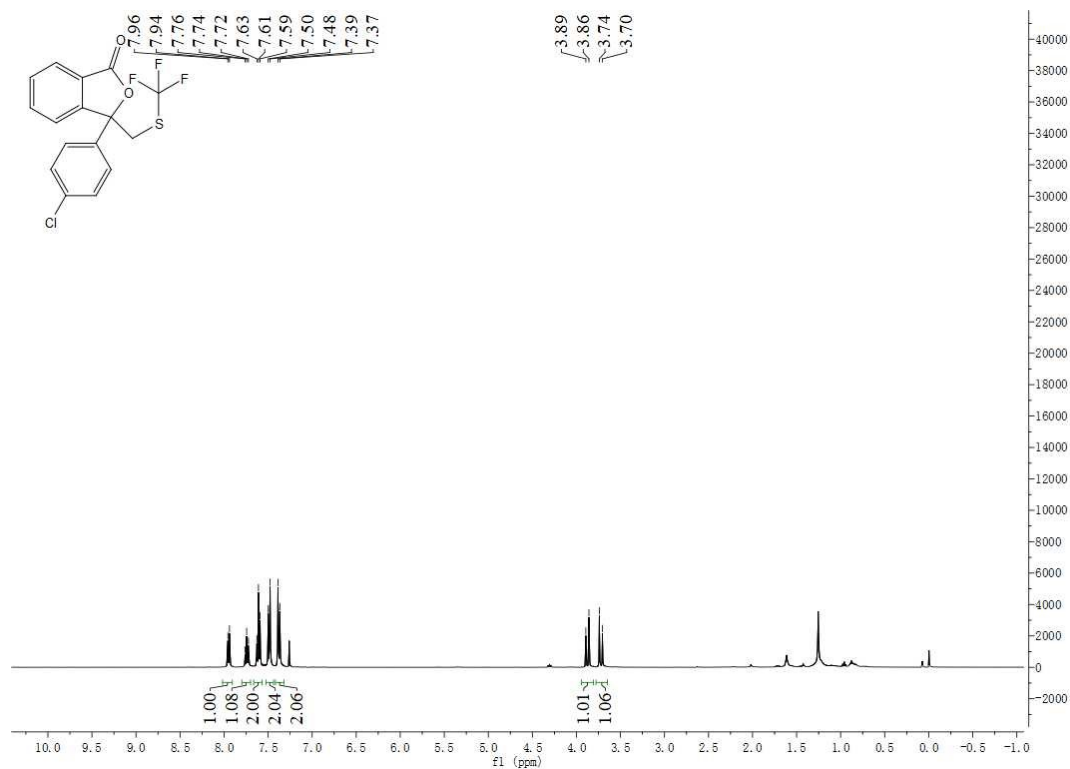


¹⁹F NMR

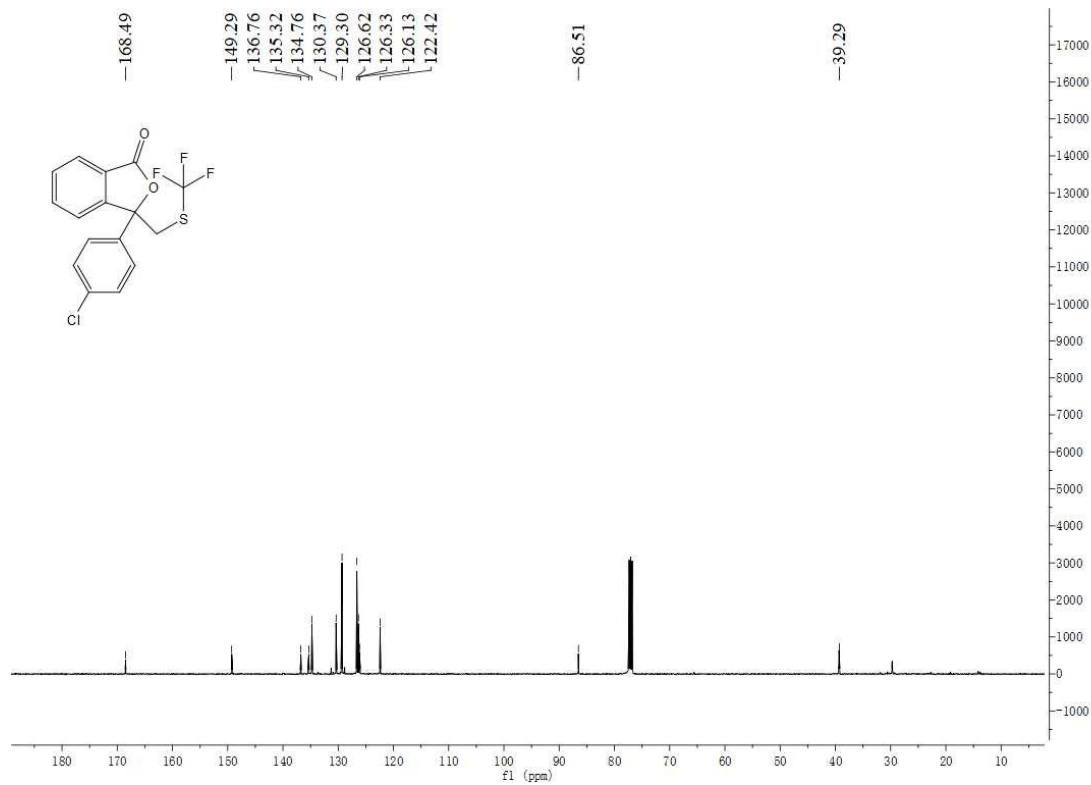


Compound 31

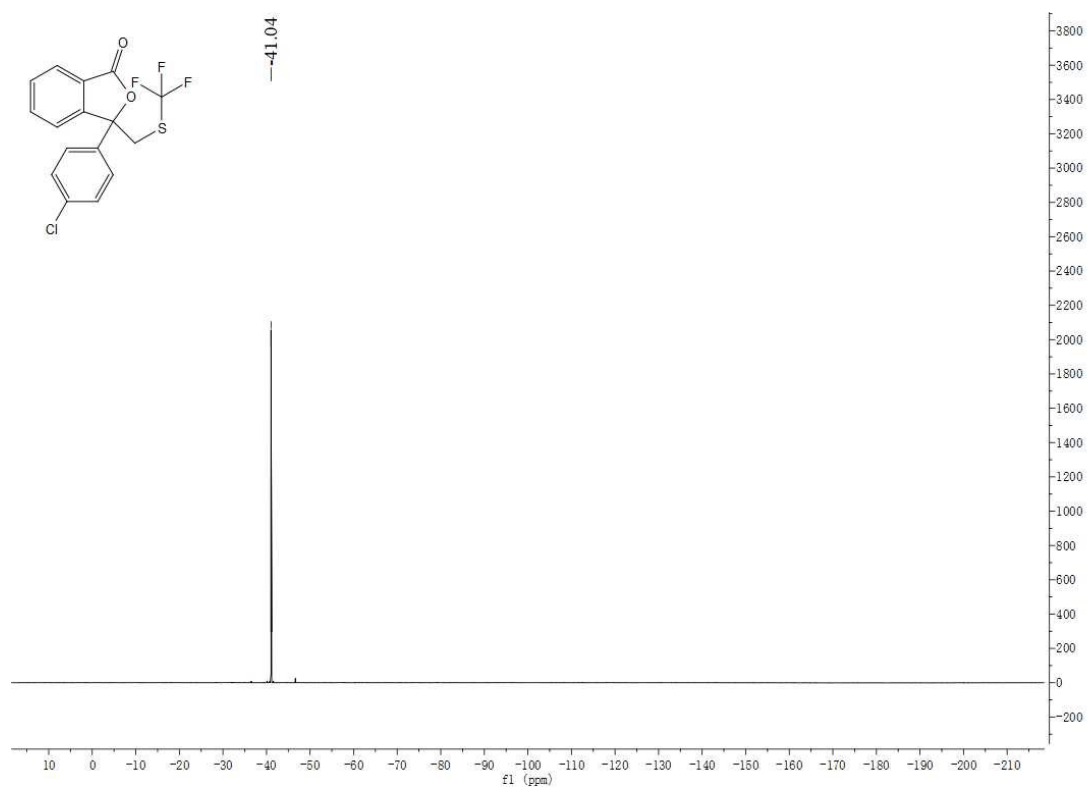
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¹³C NMR

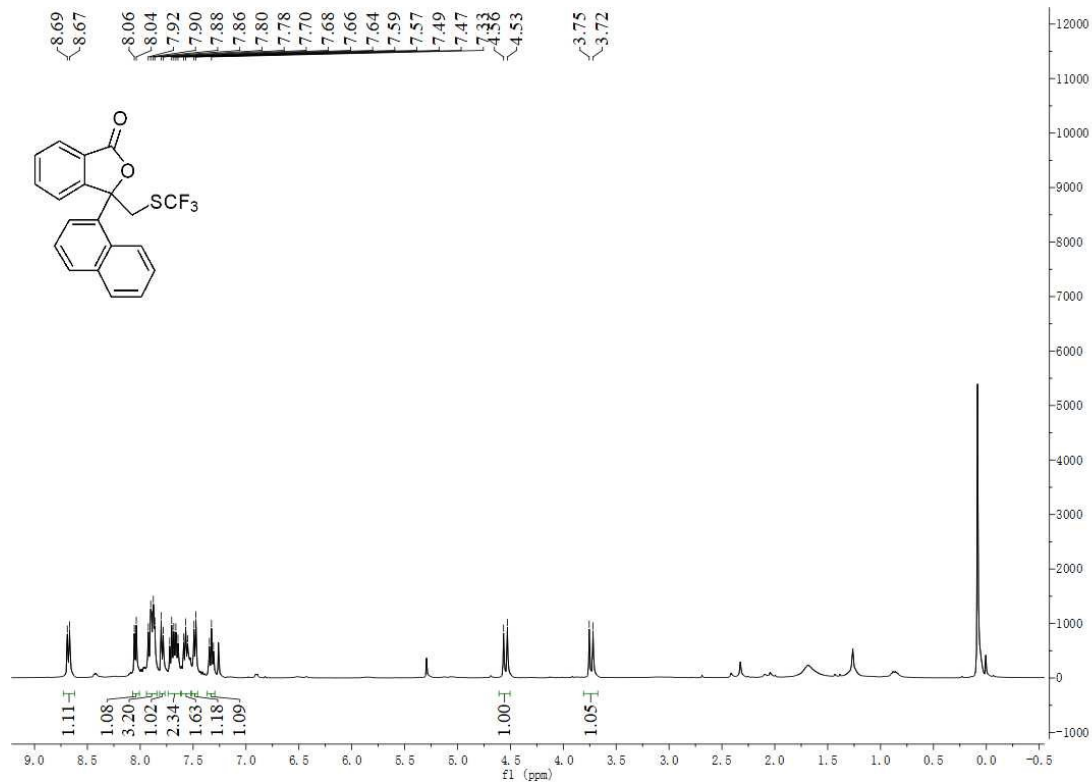


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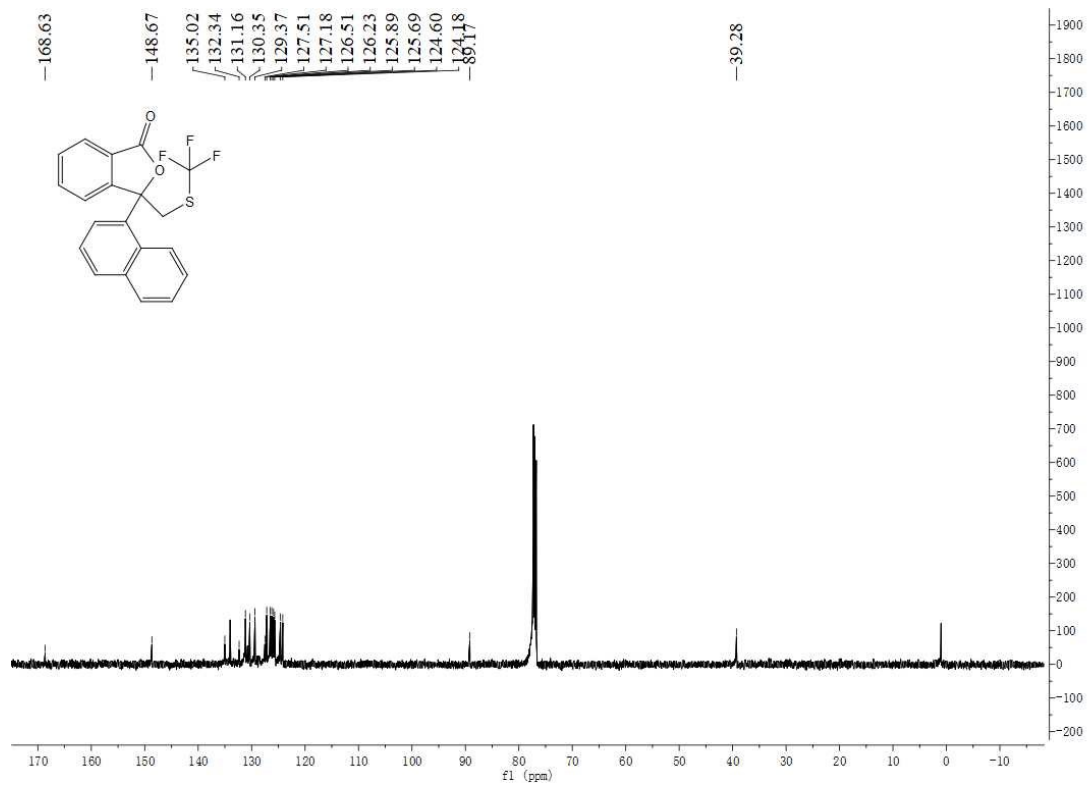


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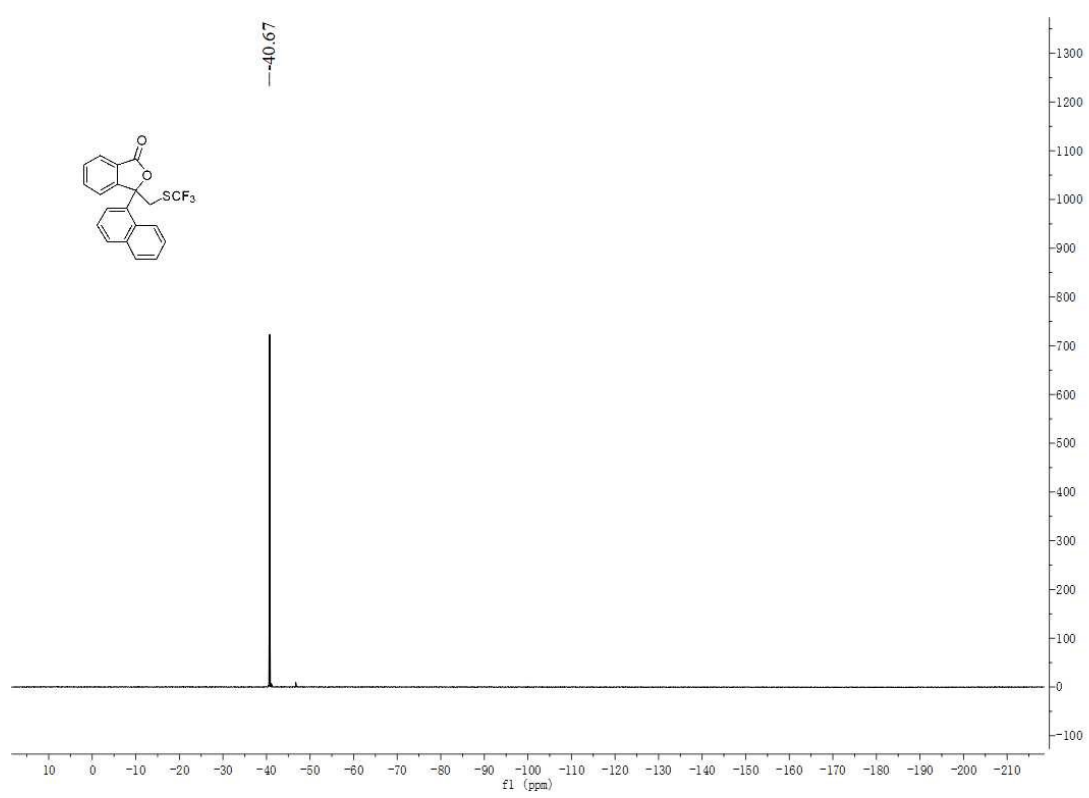
¹H NMR



¹³C NMR

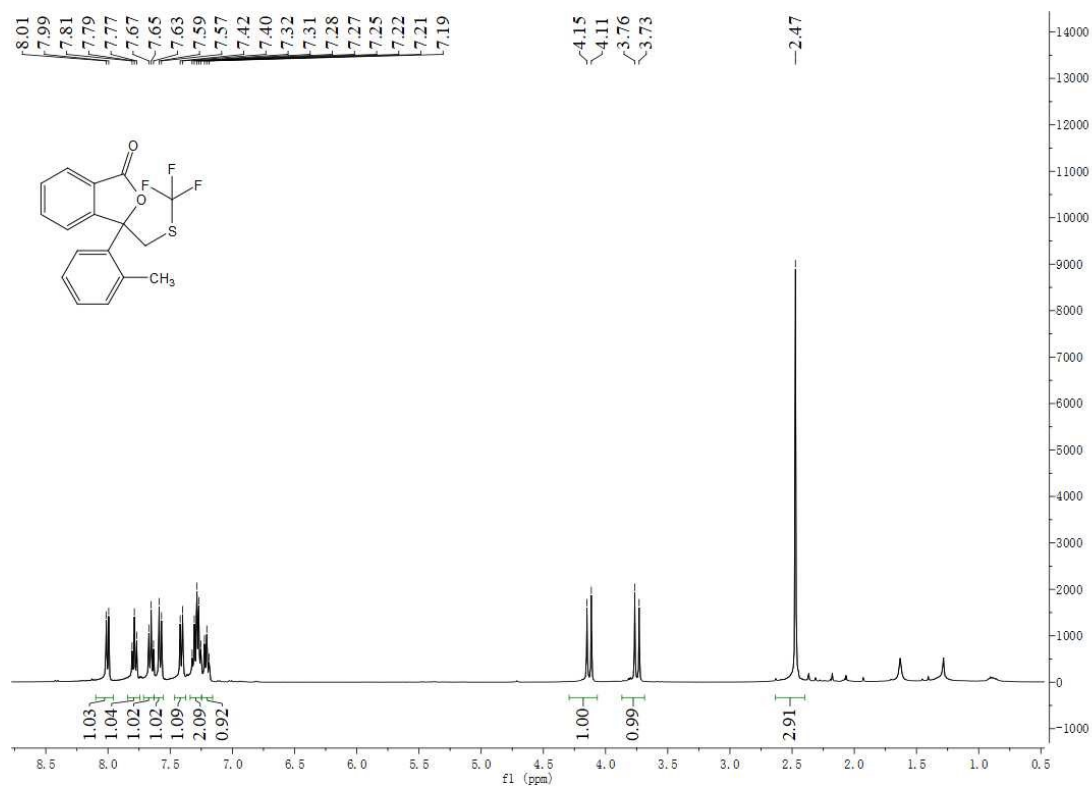


¹⁹F NMR

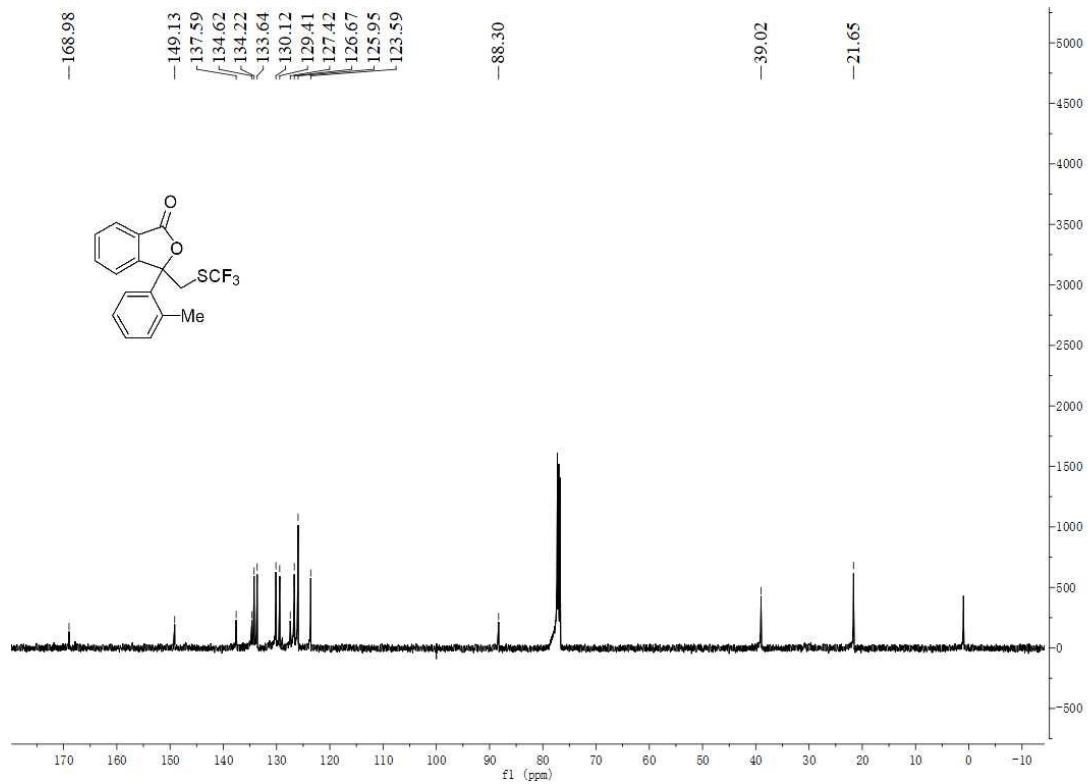


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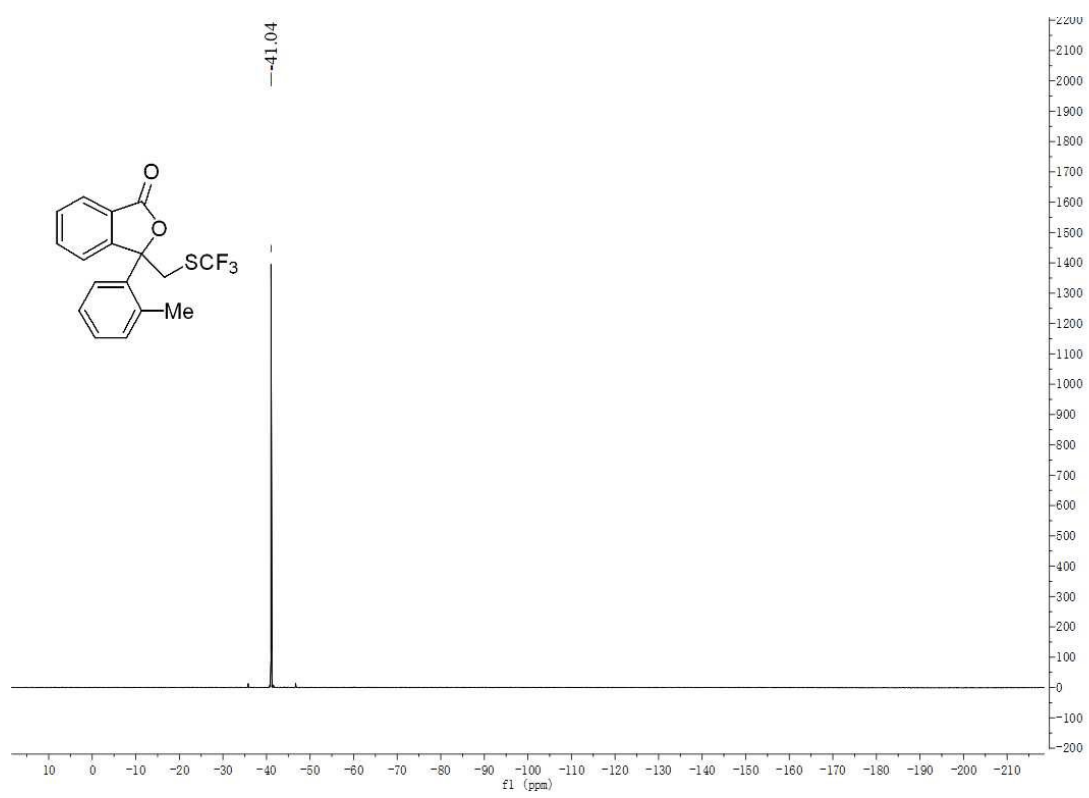
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¹³C NMR

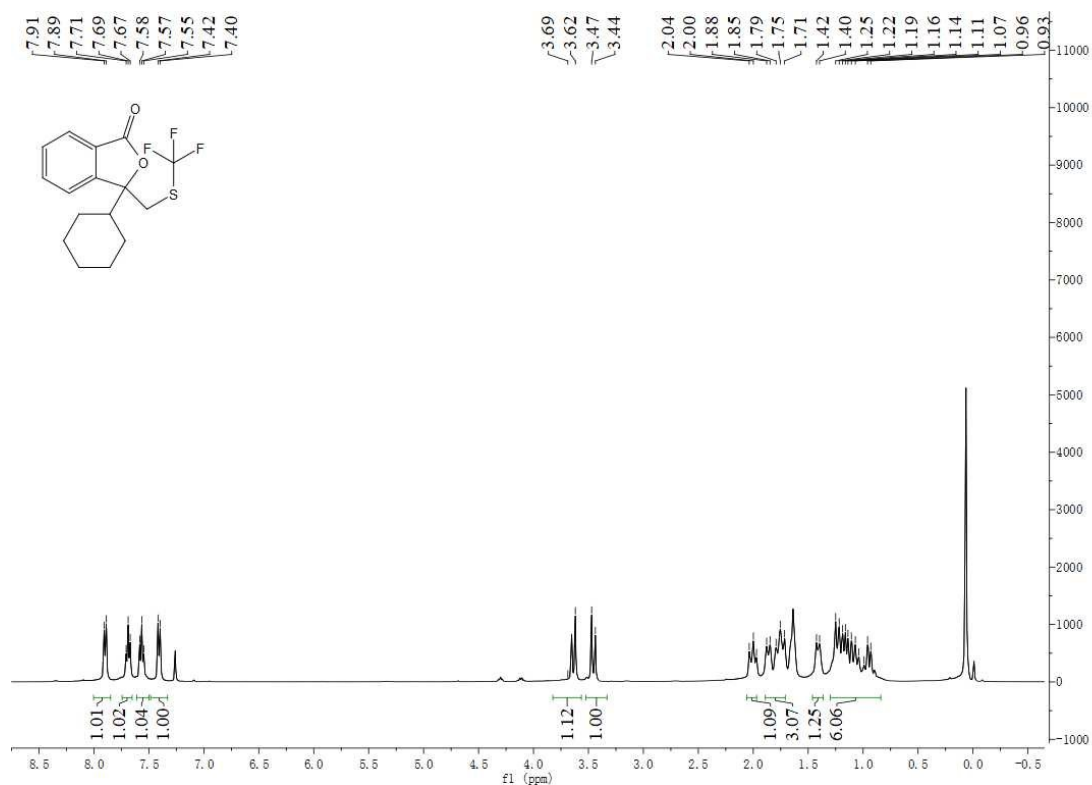


¹⁹F NMR

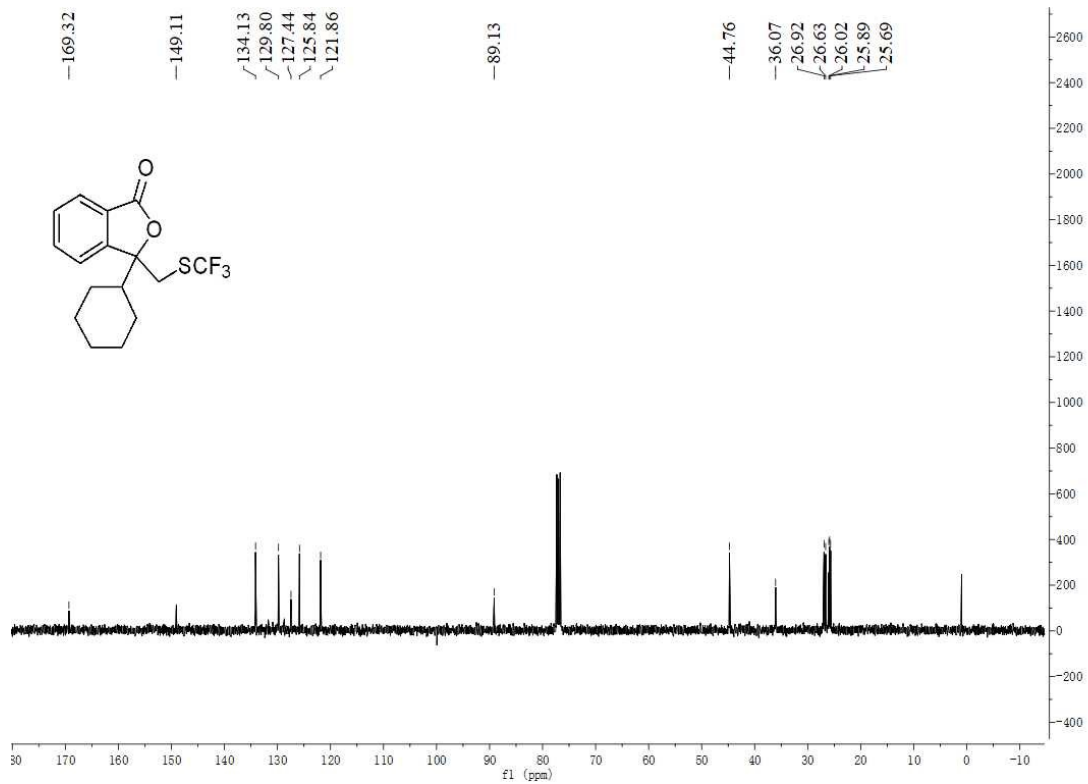


Compound 3o

¹H NMR



¹³C NMR

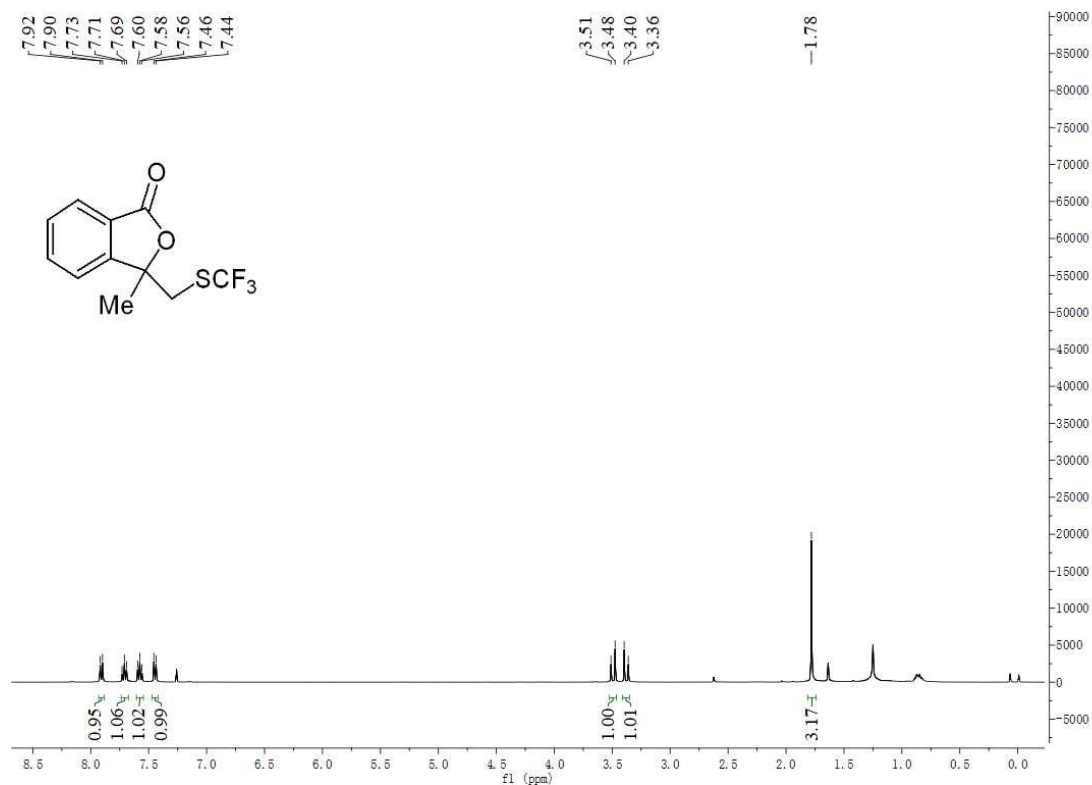


^{19}F NMR

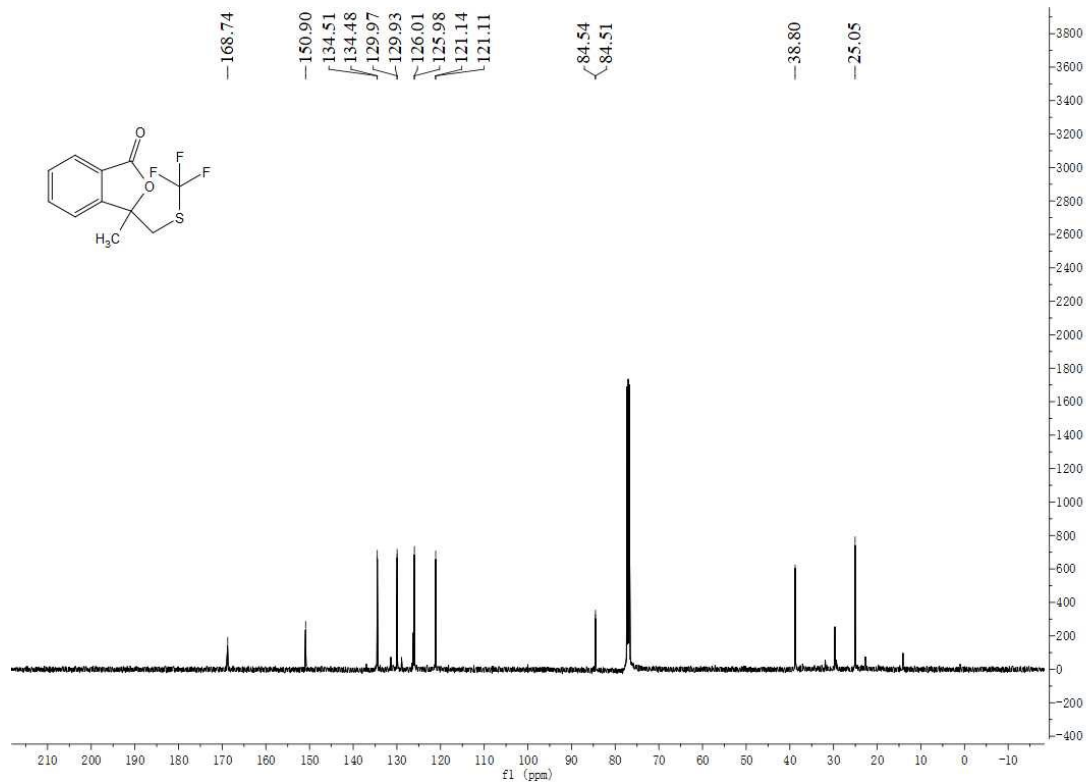


Compound 3p

¹H NMR



¹³C NMR



¹⁹F NMR

