

Supporting Information

Catalyst- and additive-free cascade radical addition/cyclization of N-arylacrylamides with trifluoropyruvates

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List of Contents

1. General information	S2
2. General procedure for the cyclization reaction.....	S3
3. Mechanistic studies	S5
3.1 Radical trapping experiments.....	S5
3.2 Uv-vis absorption spectrum	S7
3.3 Fluorescence quenching.....	S7
3.4 Light on-off experiment	S9
4. Characterization of products	S10
5. References	S30
6. Copies of NMR spectra of all products	S31

1. General information

The reactions via general procedure were carried out under argon atmosphere unless otherwise noted. Column chromatography was performed using silica gel (200-300 mesh). ¹H NMR, ¹³C NMR, and ¹⁹F NMR spectra were recorded on Bruker (400, 101, and 376 MHz, respectively). ¹H NMR chemical shifts are given in ppm with respect to the residual CDCl₃ peak (δ 7.26 ppm), residual DMSO-d₆ (δ 2.50 ppm), or an internal TMS standard (δ 0.00 ppm), ¹³C NMR shifts are given in ppm with respect to CDCl₃ (δ 77.00 ppm), DMSO-d₆ (δ 39.52 ppm). Mass spectra were measured on Agilent 5977 GC-MS instrument (EI). High-resolution mass spectra (ESI) were obtained with the Thermo Scientific LTQ Orbitrap XL mass spectrometer. Melting points were measured with a YUHUA X-5 melting point instrument and were uncorrected. UV-Vis absorption was measured using Cary 100 Ultraviolet-visible. Fluorescence quenching experiments were recorded with PTI-QM40 spectrophotometer. Unless otherwise noted, all other reagents were obtained from commercial suppliers and used without further purification. The substrates of acrylamides were prepared according previous methods from literature¹⁻².

2. General procedure for the cyclization reaction

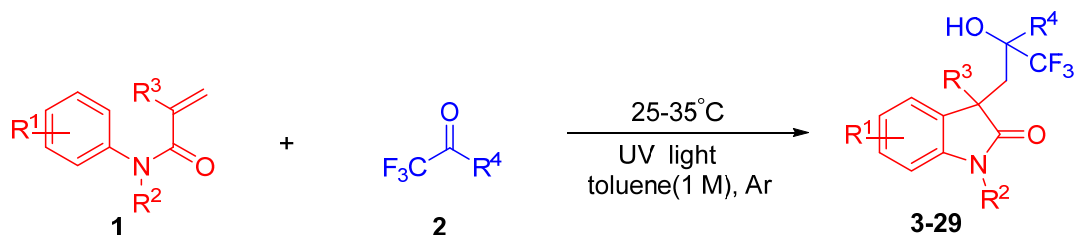


Figure S1

In a 10 mL test tube with a magnetic stirring bar, acrylamides (0.2 mmol) and trifluoropyruvate (0.6 mmol or 0.8 mmol) were dissolved in toluene (0.2 mL). The test tube was sealed with a septum. The mixture was purged with argon for three minutes. Then the mixture was irradiated with 36 W UV light (365 nm) at 25-35 °C or 35 W Blue LEDs at 40-45 °C for 48 h. The crude reaction mixture was diluted with ethyl acetate, and the crude mixture was analyzed by TLC. The solvent was removed under reduced pressure. The residue was purified with flash column chromatography (Petroleum ether:acetone = 30:1 – 8:1) to afford the desired products.



Figure S2 Reaction setup with a fan to maintain the temperature below 35 °C

Gram scale reaction

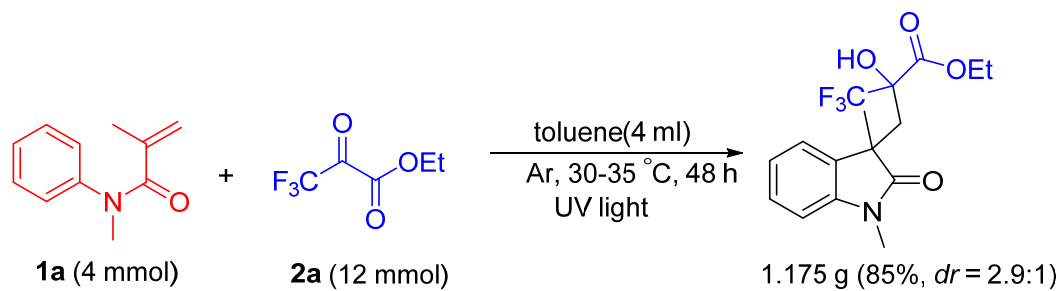


Figure S3

In a 25 mL oven-dried reaction vessel with a magnetic stirring bar, N-methyl-N-phenylmethacrylamide (4 mmol) and ethyl trifluoropyruvate (12 mmol) were dissolved in toluene (4 mL). The vessel was sealed with a septum. The mixture was purged with argon for three minutes. Then the mixture was irradiated at 30-35 °C with UV light for 48 h. The crude reaction mixture was diluted with ethyl acetate, and the crude mixture was analyzed by TLC. The solvent was removed under reduced pressure. The residue was purified with flash column chromatography (Petroleum ether:acetone = 30:1 – 10:1) to afford the desired product **3** (85% 1.175 g, *dr* (*syn/anti*) = 2.9:1).



Figure S4 Large-scale setup

3. Mechanistic studies

3.1 Radical trapping experiments

(i) In a 10 mL test tube with a magnetic stirring bar, N-methyl-N-phenylmethacrylamide (0.2 mmol), ethyl trifluoropyruvate (0.6 mmol or 0.8 mmol) and 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO) (0.2 mmol, 1 equiv) were dissolved in toluene (0.2 mL). The test tube was sealed with a septum. The mixture was purged with argon for three minutes. Then the mixture was irradiated at 30-35 °C with UV light for 48 h. The crude reaction mixture was diluted with ethyl acetate, and the crude mixture was analyzed by TLC and GC-MS. The product **3** was observed with trace yield in GC-MS and TEMPO-trapped product was not detected by GC-MS.

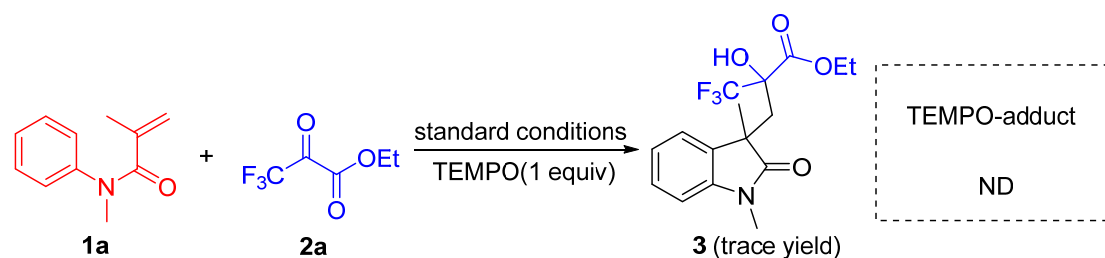
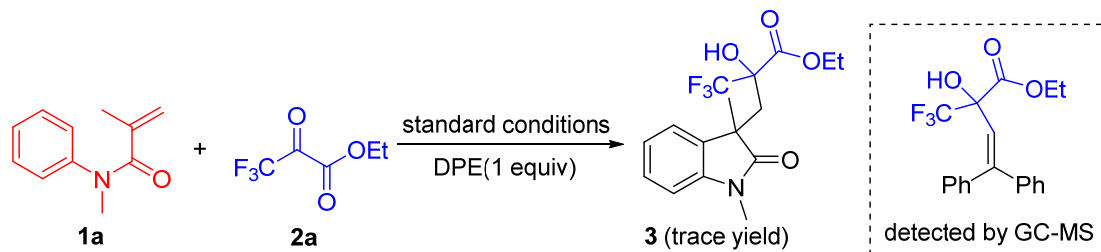


Figure S5

(ii) In a 10 mL test tube with a magnetic stirring bar, N-methyl-N-phenylmethacrylamide (0.2 mmol), ethyl trifluoropyruvate (0.6 mmol or 0.8 mmol) and 1,1-diphenylethene (DPE) (0.2 mmol, 1 equiv) were dissolved in toluene (0.2 mL). The test tube was sealed with a septum. The mixture was purged with argon for three minutes. Then the mixture was irradiated at 30-35 °C with UV light for 48 h. The crude reaction mixture was diluted with ethyl acetate, and the crude mixture was analyzed by TLC and GC-MS. The product **3** was observed with trace yield in TLC and DPE-trapped product was detected by GC-MS.



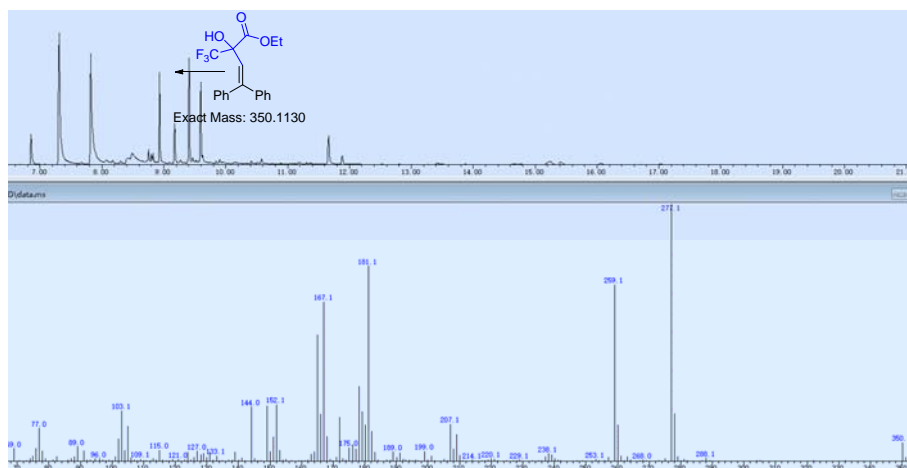


Figure S6

(iii) In a 10 mL test tube with a magnetic stirring bar, N-methyl-N-phenylmethacrylamide (0.2 mmol), ethyl trifluoropyruvate (0.6 mmol or 0.8 mmol) and butylated hydroxytoluene (BHT) (0.2 mmol) were dissolved in toluene (0.2 mL). The test tube was sealed with a septum. The mixture was purged with argon for three minutes. Then the mixture was irradiated at 30-35 °C with UV light for 48 h. The crude reaction mixture was diluted with ethyl acetate, the crude mixture was analyzed by TLC, ^{19}F NMR and GC-MS. The product **3** was observed with 55% ^{19}F NMR yield and BHT-trapped product was detected by GC-MS.

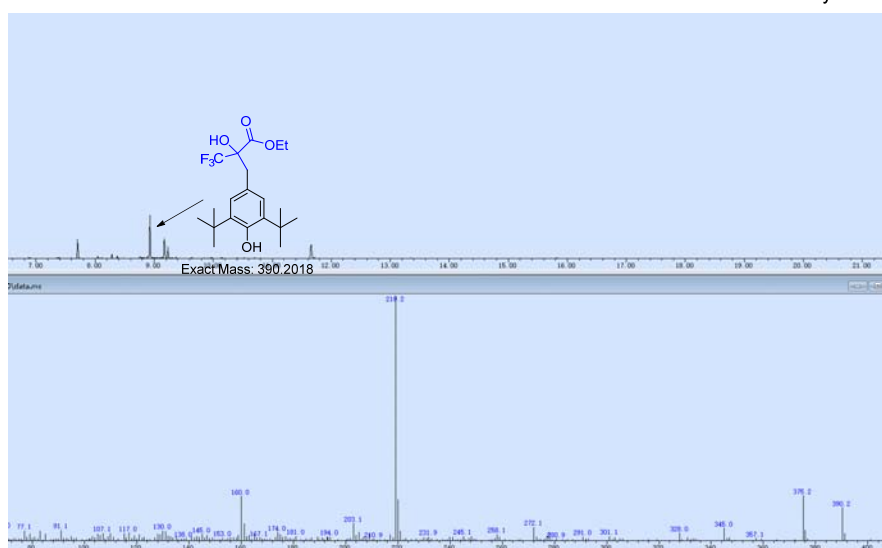
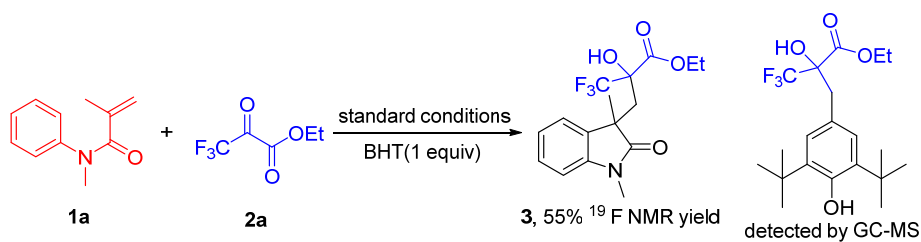


Figure S7

3.2 Uv-vis absorption spectrum

The absorption spectrum of N-methyl-N-phenylmethacrylamide **1a** (0.2 M) was measured at room temperature in toluene (2.5 mL). The absorption spectrum of ethyl trifluoropyruvate **2a** (0.2 M) was measured at room temperature in toluene (2.5 ml). The absorption spectrum of the mixture of (N-methyl-N-phenylmethacrylamide **1a** (0.2 M) and ethyl 3,3,3-trifluoropyruvate **2a** (0.2 M) was measured at room temperature in toluene (2.5 mL). The absorption spectrum of benzaldehyde (0.2 M) was measured at room temperature in toluene (2 mL). The absorption spectrum of acetophenone (0.2 M) was measured at room temperature in toluene (2 mL). The absorption spectrum of 2,2,2-trifluoroacetophenone (0.2 M) was measured at room temperature in toluene (2 mL).

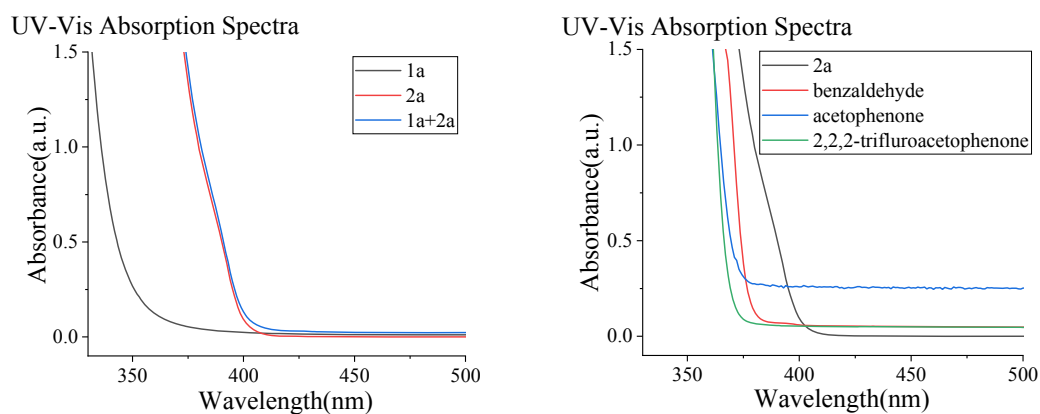


Figure S8

3.3 Fluorescence quenching

The ethyl trifluoropyruvate solution (0.2 M, 10 μ l) was added to cuvette and was then diluted to a volume of 2.0 mL by adding toluene to prepare a 1 mM solution and its fluorescence was recorded with excitation at 300 nm in the spectrometer. Quenching experiments were performed under duplicate conditions with the injection of 10 μ L, 20 μ L, 30 μ L, 40 μ L, 50 μ L, 60 μ L, 70 μ L, 80 μ L, 90 μ L and 110 μ L N-methyl-N-phenylmethacrylamide solution respectively. The results were stacked in the following figure and the Stern-Volmer relationship was plotted as below.

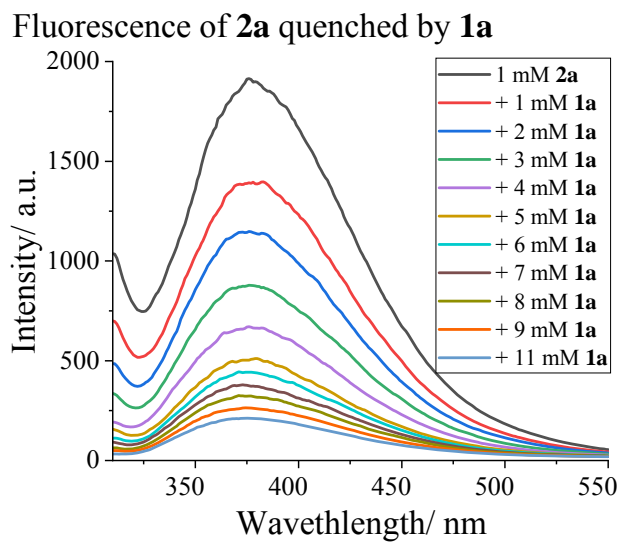


Figure S9

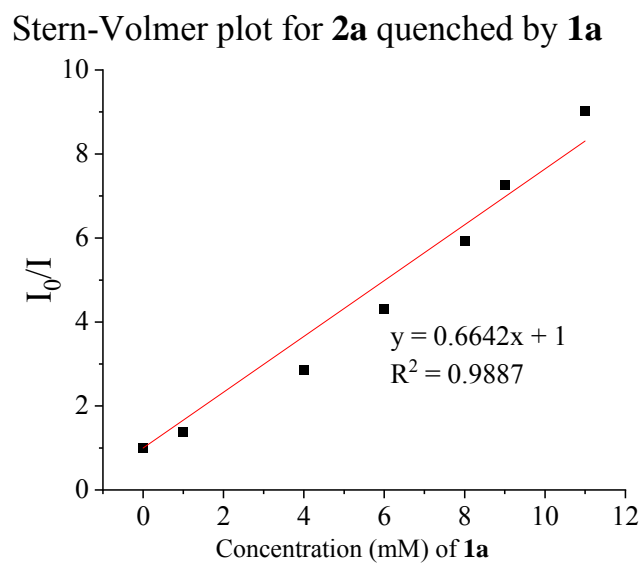


Figure S10

3.4 Light on-off experiment

To study the necessity of continuous irradiation with ultraviolet light for the progress of the reaction, we started a reaction with successive irradiation and black periods. A mixture of N-methyl-N-phenylmethacrylamide (0.2 mmol, 35 mg), ethyl trifluoropyruvate (0.6 mmol, 102 mg) and (trifluoromethyl)benzene (0.2 mmol, 29.2 mg) in toluene (1 mL) were stirred at 30-35 °C under Ar atmosphere irradiated by UV light. After being irradiated for 12 h, an aliquot (100 μ L) from the reaction mixture was transferred into a nuclear magnetic tube charged with 0.4 mL of CDCl_3 . The yield of product was determined by ^{19}F NMR. Then the reaction mixture was stirred for 12 h with light-off. All of the following yields were analyzed in the identical way after a 12 hour light on or off.

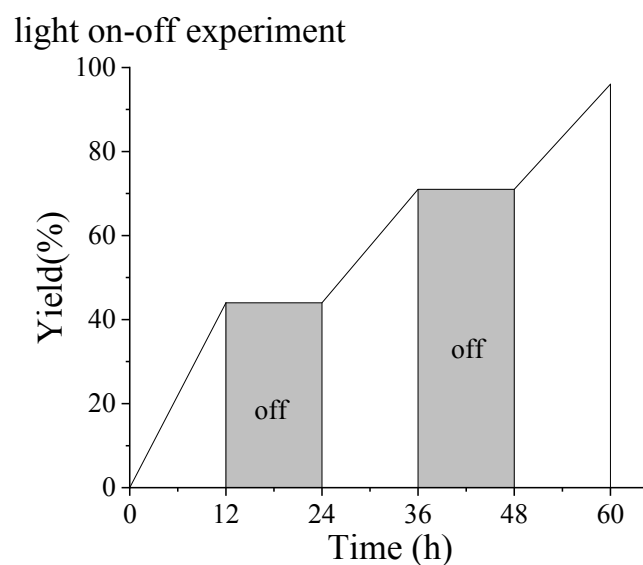
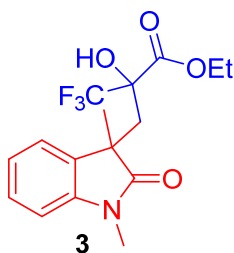


Figure S11

4. Characterization of products



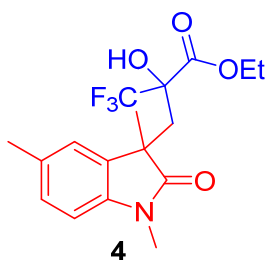
Following the general procedure, the title compound (63 mg, *dr* (*syn/anti*) = 2.5:1) was obtained in 91% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.32 – 7.22 (m, 2H), 7.10 (t, $J = 7.5$ Hz, 1H), 6.85 (d, $J = 7.8$ Hz, 1H), 4.95 (s, 1H), 4.40 – 4.20 (m, 2H), 3.20 (s, 3H), 2.83 (d, $J = 14.9$ Hz, 1H), 2.37 (d, $J = 14.9$ Hz, 1H), 1.39 (s, 3H), 1.35 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 180.30, 169.41, 142.29, 133.66, 128.20, 123.38 (q, $J = 287.2$ Hz), 123.02, 122.97, 108.38, 76.81 (q, $J = 28.7$ Hz), 63.61, 46.18, 36.86, 26.35, 24.71, 13.76. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.56. HRMS (ESI) m/z calculated for $\text{C}_{16}\text{H}_{18}\text{F}_3\text{NO}_4$ ($\text{M}+\text{Na}$) $^+$ 368.1080, found 368.1094. Colorless solid, melting point: 46-48 °C.

Anti isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.35 – 7.21 (m, 1H), 7.05 (d, $J = 7.3$ Hz, 1H), 6.98 (t, $J = 7.5$ Hz, 1H), 6.83 (d, $J = 7.8$ Hz, 1H), 4.10 – 3.85 (m, 2H), 3.48 (s, 1H), 3.21 (s, 3H), 2.84 (d, $J = 14.6$ Hz, 1H), 2.72 (d, $J = 14.6$ Hz, 1H), 1.36 (s, 3H), 1.26 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 180.02, 168.56, 144.08, 130.53, 128.70, 123.69, 123.12 (q, $J = 287.8$ Hz), 121.43, 108.29, 76.25 (q, $J = 28.9$ Hz), 63.63, 44.85, 37.83, 26.44, 25.70, 13.54. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.55. Colorless solid, melting point: 96-98 °C.



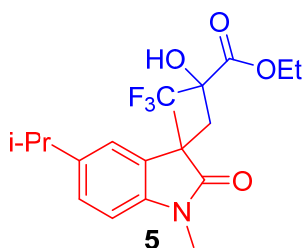
Following the general procedure, the title compound (42 mg, *dr* (*syn/anti*) = 5:1) was obtained in 59% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.08 (m, 2H), 6.74 (d, *J* = 7.7 Hz, 1H), 5.36 (s, 1H), 4.46 – 4.19 (m, 2H), 3.19 (s, 3H), 2.83 (d, *J* = 14.8 Hz, 1H), 2.35 (s, 3H), 2.31 (d, *J* = 15.7 Hz, 1H), 1.38 (s, 3H), 1.37 – 1.33 (m, 3H). ¹³C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 179.15, 168.17, 140.76, 133.70, 131.05, 128.07, 124.59, 124.48 (q, *J* = 289.3 Hz), 108.36, 76.91 (q, *J* = 27.4 Hz), 62.55, 45.52, 37.70, 26.72, 26.47, 21.30, 13.97. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.56. HRMS (ESI) *m/z* calculated for C₁₇H₂₀F₃NO₄(M+Na)⁺ 382.1237, found 382.1253. Colorless oil.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.12 – 7.05 (m, 1H), 6.89 – 6.84 (m, 1H), 6.72 (d, *J* = 7.9 Hz, 1H), 3.96 (m, 2H), 3.48 (s, 1H), 3.19 (s, 3H), 2.83 (d, *J* = 14.5 Hz, 1H), 2.69 (d, *J* = 14.5 Hz, 1H), 2.32 (s, 3H), 1.35 (s, 3H), 1.27 (t, *J* = 7.2 Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.99, 168.62, 141.73, 130.77, 130.60, 128.98, 124.55, 123.12 (q, *J* = 287.94 Hz) 108.03, 76.26 (q, *J* = 28.8 Hz), 63.46, 44.91, 37.80, 26.47, 25.82, 21.03, 13.56. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.52. Colorless solid, melting point: 96-98 °C.



Following the general procedure, the title compound (43 mg, *dr* (*syn/anti*) = 2.1:1) was obtained in 56% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

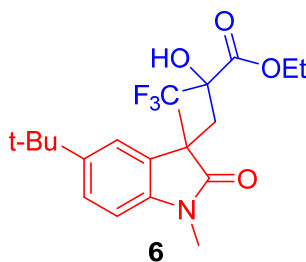
¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.14 (d, *J* = 8.0 Hz, 1H), 7.11 (s, 1H), 6.77 (d, *J* = 7.9 Hz, 1H), 5.50 (s, 1H), 4.52 – 4.01 (m, 2H), 3.19 (s, 3H), 2.91 (p, *J* = 7.0 Hz, 1H), 2.84 (d, *J* = 15.0 Hz, 1H), 2.31 (d, *J* = 15.0 Hz, 1H), 1.39 (s, 3H), 1.34 (t, *J* = 7.1 Hz, 3H), 1.25 (d, *J* = 6.9 Hz, 6H). ¹³C NMR (101

MHz, DMSO-*d*₆), δ (ppm) 179.50, 168.19, 142.45, 141.12, 133.38, 125.39, 124.46 (q, $J = 288.7$ Hz), 122.28, 108.25, 76.92 (q, $J = 27.3$ Hz), 62.47, 45.63, 37.68, 33.73, 26.50, 26.43, 24.55, 24.51, 13.87.

¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.53. HRMS (ESI) m/z calculated for C₁₉H₂₄F₃NO₄ (M+H)⁺ 388.1730, found 388.1748. Colorless oil.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.15 (d, $J = 8.0$ Hz, 1H), 6.90 (s, 1H), 6.76 (d, $J = 8.1$ Hz, 1H), 4.07 – 3.85 (m, 2H), 3.50 (s, 1H), 3.19 (s, 3H), 2.88 – 2.83 (m, 1H), 2.81 (d, $J = 11.8$ Hz, 1H), 2.71 (d, $J = 14.6$ Hz, 1H), 1.35 (s, 3H), 1.24 (t, $J = 6.9$ Hz, 3H), 1.22 (d, $J = 6.5$ Hz, 6H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 180.17, 168.38, 142.46, 141.87, 130.63, 125.95, 123.20 (q, $J = 287.6$ Hz), 122.37, 108.12, 76.34 (q, $J = 28.6$ Hz), 63.38, 45.15, 37.65, 33.90, 26.46, 26.04, 24.88, 23.68, 13.63. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.62. Colorless solid, melting point: 91-93 °C.



Following the general procedure, the title compound (64.8 mg, *dr* (*syn/anti*) = 2.1:1) was obtained in 81% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

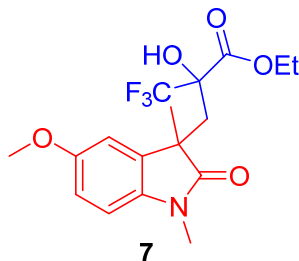
Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.31 (d, $J = 8.3$ Hz, 1H), 7.27 (s, 1H), 6.78 (d, $J = 8.1$ Hz, 1H), 5.44 (s, 1H), 4.40-4.20 (m, 2H), 3.20 (s, 3H), 2.84 (d, $J = 15.0$ Hz, 1H), 2.33 (d, $J = 14.9$ Hz, 1H), 1.40 (s, 3H), 1.38 – 1.26 (m, 12H). ¹³C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 179.65, 168.15, 144.72, 140.83, 132.95, 124.46 (q, $J = 289.1$ Hz), 124.37, 121.26, 107.88, 76.89 (q, $J = 27.1$ Hz), 62.44, 45.69, 37.70, 34.66, 31.85, 26.60, 26.45, 13.89. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.52. HRMS (ESI) m/z calculated for C₂₀H₂₆F₃NO₄ (M+Na)⁺ 424.1706, found 424.1726. Colorless oil.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.31 (dd, $J = 8.2, 2.0$ Hz, 1H), 7.10 (d, $J = 2.0$ Hz, 1H), 6.77 (d, $J = 8.2$ Hz, 1H), 4.04 – 3.87 (m, 2H), 3.51 (s, 1H), 3.20 (s, 3H), 2.80 (d, $J = 14.7$ Hz, 1H), 2.73 (d, $J = 14.6$ Hz, 1H), 1.36 (s, 3H), 1.32 (s, 9H), 1.16 (t, $J = 7.2$ Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ

(ppm) 180.30, 168.16, 144.98, 141.45, 130.45, 125.57, 123.25 (q, $J = 287.6$ Hz), 120.62, 107.77, 76.48 (q, $J = 28.3$ Hz), 63.41, 45.33, 37.66, 34.52, 31.68, 26.44, 26.13, 13.64. ^{19}F NMR (376 MHz, Chloroform- d), δ (ppm) -79.70. Colorless solid, melting point: 110-112 °C.



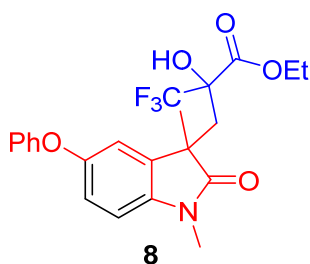
Following the general procedure, the title compound (43 mg, *dr* (*syn/anti*) = 4.4:1) was obtained in 58% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

^1H NMR (400 MHz, Chloroform- d), δ (ppm) 6.85 (d, $J = 2.5$ Hz, 1H), 6.80 (dd, $J = 8.5, 2.5$ Hz, 1H), 6.74 (d, $J = 8.4$ Hz, 1H), 5.26 (s, 1H), 4.42 – 4.21 (m, 2H), 3.80 (s, 3H), 3.18 (s, 3H), 2.82 (d, $J = 14.9$ Hz, 1H), 2.33 (d, $J = 14.9$ Hz, 1H), 1.38 (s, 3H), 1.35 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, DMSO- d_6), δ (ppm) 178.85, 168.13, 155.63, 136.58, 135.06, 124.48 (q, $J = 288.6$ Hz), 111.99, 111.59, 108.78, 76.88 (q, $J = 27.4$ Hz), 62.57, 55.83, 45.85, 37.73, 26.84, 26.50, 13.94. ^{19}F NMR (376 MHz, Chloroform- d), δ (ppm) -79.58. HRMS (ESI) m/z calculated for $\text{C}_{17}\text{H}_{20}\text{F}_3\text{NO}_5(\text{M}+\text{Na})^+$ 398.1186, found 398.1213. Colorless oil.

Anti isomer

^1H NMR (400 MHz, Chloroform- d), δ (ppm) 6.80 (dd, $J = 8.4, 2.5$ Hz, 1H), 6.72 (d, $J = 8.5$ Hz, 1H), 6.67 (d, $J = 2.5$ Hz, 1H), 4.23 – 3.86 (m, 2H), 3.79 (s, 3H), 3.49 (s, 1H), 3.18 (s, 3H), 2.83 (d, $J = 14.5$ Hz, 1H), 2.68 (d, $J = 14.6$ Hz, 1H), 1.35 (s, 3H), 1.27 (t, $J = 7.1$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform- d), δ (ppm) 179.70, 168.65, 155.38, 137.56, 132.01, 123.12 (q, $J = 287.5$ Hz), 112.51, 111.62, 108.27, 76.26 (q, $J = 28.7$ Hz), 63.72, 55.76, 45.22, 37.75, 26.52, 25.76, 13.53. ^{19}F NMR (376 MHz, Chloroform- d), δ (ppm) -79.53. Colorless solid, melting point: 95-97 °C.



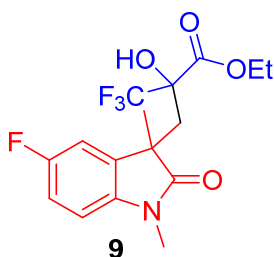
Following the general procedure, the title compound (81 mg, *dr* (*syn/anti*) = 2.5:1) was obtained in 93% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.32 (dd, *J* = 8.6, 7.3 Hz, 2H), 7.08 (tt, *J* = 7.3, 1.1 Hz, 1H), 7.00 (d, *J* = 2.4 Hz, 1H), 6.96 (ddd, *J* = 8.3, 3.6, 1.8 Hz, 3H), 6.79 (d, *J* = 8.3 Hz, 1H), 4.67 (s, 1H), 4.46 – 4.21 (m, 2H), 3.20 (s, 3H), 2.80 (d, *J* = 14.9 Hz, 1H), 2.37 (d, *J* = 14.9 Hz, 1H), 1.40 – 1.32 (m, 6H). ¹³C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 178.88, 168.09, 158.75, 151.21, 139.50, 135.67, 130.25, 124.46 (q, *J* = 288.8 Hz), 122.77, 119.01, 117.39, 117.06, 109.30, 76.79 (q, *J* = 27.4 Hz), 62.61, 45.77, 37.87, 27.01, 26.53, 13.97. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.54. HRMS (ESI) *m/z* calculated for C₂₂H₂₂F₃NO₅(M+Na)⁺ 460.1342, found 460.1353. White solid, melting point: 60-62 °C.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.36 – 7.30 (m, 2H), 7.08 (t, *J* = 7.4 Hz, 1H), 6.95 (dd, *J* = 9.9, 8.2 Hz, 3H), 6.82 (d, *J* = 2.4 Hz, 1H), 6.77 (d, *J* = 8.4 Hz, 1H), 3.90-4.20 (m, 2H), 3.52 (d, *J* = 1.4 Hz, 1H), 3.21 (s, 3H), 2.86 (d, *J* = 14.6 Hz, 1H), 2.67 (d, *J* = 14.6 Hz, 1H), 1.36 (s, 3H), 1.25 (t, *J* = 7.2 Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.85, 168.95, 158.02, 151.89, 139.92, 132.29, 129.80, 123.07 (q, *J* = 287.7 Hz), 122.93, 119.43, 117.77, 116.28, 108.77, 76.12 (q, *J* = 28.9 Hz), 63.96, 45.30, 37.52, 26.59, 25.77, 13.58. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.51. Colorless oil.



Following the general procedure, the title compound (42 mg, *dr* (*syn/anti*) = 1.8:1) was obtained in 58% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

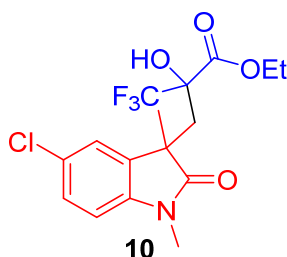
Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.02 – 6.92 (m, 2H), 6.75 (dd, *J* = 8.1, 4.1 Hz, 1H), 4.48 (s, 1H), 4.42 – 4.16 (m, 2H), 3.17 (s, 3H), 2.80 (d, *J* = 14.9 Hz, 1H), 2.40 (d, *J* = 14.9 Hz, 1H), 1.37 (s, 1H), 1.35 (t, *J* = 7.2 Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.50, 169.25, 159.45 (d, *J* =

241.0 Hz), 138.27 (d, $J = 2.1$ Hz), 135.47 (d, $J = 8.1$ Hz), 123.26 (q, $J = 287.2$ Hz), 114.22 (d, $J = 23.5$ Hz), 111.20 (d, $J = 25.0$ Hz), 108.74 (d, $J = 8.1$ Hz), 76.54 (q, $J = 28.8$ Hz), 63.84, 46.38 (d, $J = 1.8$ Hz), 36.88, 26.40, 25.24, 13.70. ^{19}F NMR (376MHz, Chloroform-*d*), δ (ppm) -79.60, -119.94. HRMS (ESI) m/z calculated for $\text{C}_{16}\text{H}_{17}\text{F}_4\text{NO}_4(\text{M}+\text{Na})^+$ 386.0986, found 386.1007. Colorless solid, melting point: 39-41 °C.

Anti isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 6.99 (td, $J = 8.9, 2.7$ Hz, 1H), 6.79 (dd, $J = 7.9, 2.6$ Hz, 1H), 6.74 (dd, $J = 8.5, 4.2$ Hz, 1H), 4.21 – 3.89 (m, 2H), 3.46 (s, 1H), 3.19 (s, 3H), 2.85 (d, $J = 14.6$ Hz, 1H), 2.68 (d, $J = 14.6$ Hz, 1H), 1.36 (s, 3H), 1.29 (t, $J = 7.1$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.62, 168.73, 158.59 (d, $J_{\text{C-F}} = 239.8$ Hz), 140.04 (d, $J_{\text{C-F}} = 1.9$ Hz), 132.14 (d, $J_{\text{C-F}} = 7.6$ Hz), 123.02 (q, $J_{\text{C-F}} = 287.7$ Hz), 114.85 (d, $J_{\text{C-F}} = 23.1$ Hz), 111.83 (d, $J_{\text{C-F}} = 24.6$ Hz), 108.70 (d, $J_{\text{C-F}} = 8.0$ Hz), 76.16 (q, $J_{\text{C-F}} = 29.1$ Hz), 63.89, 45.29 (d, $J_{\text{C-F}} = 1.7$ Hz), 37.65, 26.58, 25.56, 13.54. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.54, -121.97. White solid, melting point: 102-104 °C.



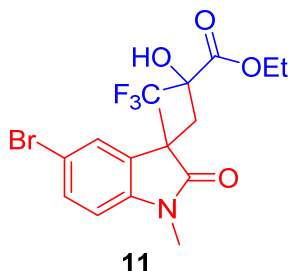
Following the general procedure, the title compound (41 mg, dr (*syn/anti*) = 2.7:1) was obtained in 54% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.29 – 7.16 (m, 2H), 6.76 (d, $J = 8.2$ Hz, 1H), 4.40 – 4.17 (m, 3H), 3.18 (s, 3H), 2.80 (d, $J = 14.9$ Hz, 1H), 2.41 (d, $J = 14.9$ Hz, 1H), 1.38 (s, 3H), 1.35 (t, $J = 7.3$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.32, 169.26, 140.96, 135.44, 128.28, 127.97, 123.53, 123.22 (q, $J = 287.0$ Hz), 109.18, 76.51 (q, $J = 28.8$ Hz), 63.91, 46.16, 36.87, 26.40, 25.33, 13.74. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.56. HRMS (ESI) m/z calculated for $\text{C}_{16}\text{H}_{17}\text{ClF}_3\text{NO}_4(\text{M}+\text{Na})^+$ 402.0690, found 402.0711. White solid, melting point: 96-98 °C.

Anti isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.29 – 7.22 (m, 1H), 7.00 (d, $J = 2.2$ Hz, 1H), 6.74 (d, $J = 8.3$ Hz, 1H), 4.20-3.95 (m, 2H), 3.45 (s, 1H), 3.19 (s, 3H), 2.85 (d, $J = 14.6$ Hz, 1H), 2.68 (d, $J = 14.6$ Hz, 1H), 1.36 (s, 3H), 1.32 (t, $J = 7.1$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.47, 168.74, 142.72, 132.18, 128.64, 124.23, 122.99 (q, $J = 287.7$ Hz), 109.22, 76.09 (q, $J = 29.0$ Hz), 64.14, 45.06, 37.66, 26.57, 25.55, 13.61. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.52. Colorless solid, melting point: 80-82 °C.



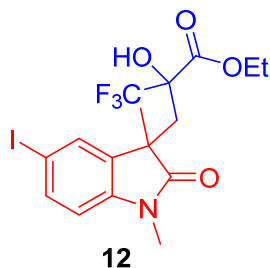
Following the general procedure, the title compound (60 mg, *dr* (*syn/anti*) = 3:1) was obtained in 71% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.40 (d, $J = 8.2$ Hz, 1H), 7.35 (s, 1H), 6.71 (d, $J = 8.1$ Hz, 1H), 4.58 – 4.03 (m, 3H), 3.17 (s, 3H), 2.79 (d, $J = 14.8$ Hz, 1H), 2.41 (d, $J = 14.9$ Hz, 1H), 1.38 (s, 3H), 1.35 (t, $J = 7.0$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.21, 169.24, 141.46, 135.78, 130.88, 126.28, 123.22 (q, $J = 287.1$ Hz), 115.55, 109.69, 76.51 (q, $J = 28.9$ Hz), 63.91, 46.11, 36.88, 26.37, 25.34, 13.73. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.58. HRMS (ESI) m/z calculated for $\text{C}_{16}\text{H}_{17}\text{BrF}_3\text{NO}_4(\text{M}+\text{Na})^+$ 446.0185, found 446.0208. White solid, melting point: 98-100 °C.

Anti isomer

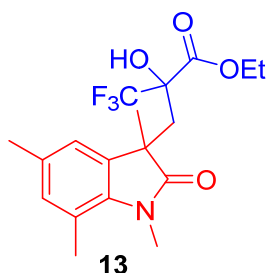
^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.40 (d, $J = 8.3$ Hz, 1H), 7.13 (s, 1H), 6.70 (d, $J = 8.3$ Hz, 1H), 4.21-4.01 (m, 2H), 3.49 (s, 1H), 3.18 (s, 3H), 2.84 (d, $J = 14.6$ Hz, 1H), 2.68 (d, $J = 14.6$ Hz, 1H), 1.35 (s, 3H), 1.31 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.33, 168.73, 143.22, 132.60, 131.53, 126.94, 122.99 (q, $J = 287.7$ Hz), 114.10, 109.73, 76.09 (q, $J = 28.9$ Hz), 64.26, 45.02, 37.67, 26.54, 25.58, 13.65. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.52. White solid, melting point: 129-131 °C.



Following the general procedure, the title compound (34 mg, *dr* (*syn/anti*) = 2.8:1) was obtained in 36% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.59 (d, J = 8.2 Hz, 1H), 7.51 (s, 1H), 6.61 (d, J = 8.2 Hz, 1H), 4.42 (s, 1H), 4.41 – 4.18 (m, 2H), 3.16 (s, 3H), 2.77 (d, J = 14.9 Hz, 1H), 2.39 (d, J = 14.9 Hz, 1H), 1.37 (s, 3H), 1.34 (t, J = 7.6 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.12, 169.24, 142.15, 136.89, 136.06, 131.83, 123.23 (q, J = 287.4 Hz), 110.30, 85.42, 76.53 (q, J = 28.8 Hz), 63.89, 45.96, 36.86, 26.34, 25.25, 13.74. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.53. HRMS (ESI) m/z calcd for $\text{C}_{16}\text{H}_{17}\text{IF}_3\text{NO}_4(\text{M}+\text{Na})^+$ 494.0047, found 494.0074. Colorless solid, melting point: 97-99 °C.



Following the general procedure, the title compound (33 mg, *dr* (*syn/anti*) = 2.3:1) was obtained in 44% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

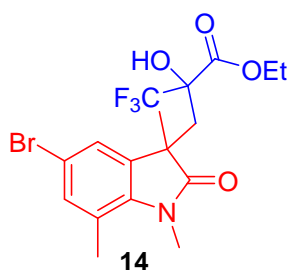
^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 6.88 (s, 1H), 6.82 (s, 1H), 5.84 (s, 1H), 4.41 – 4.28 (m, 2H), 3.46 (s, 3H), 2.82 (d, J = 14.9 Hz, 1H), 2.52 (s, 3H), 2.30 (s, 3H), 2.24 (d, J = 15.0 Hz, 1H), 1.37 (t, J = 7.2 Hz, 3H), 1.35 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 181.56, 169.64, 137.39, 134.60, 132.73, 132.50, 123.56 (q, J = 287.2 Hz), 121.43, 119.92, 77.02 (q, J = 28.3 Hz), 63.33, 45.91, 36.88, 29.77, 23.98, 20.80, 18.71, 13.83. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.58.

HRMS (ESI) m/z calculated for $C_{18}H_{22}F_3NO_4(M+Na)^+$ 396.1393, found 396.1414. White solid, melting point: 78-80 °C.

Anti isomer

1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 6.82 (s, 1H), 6.69 (s, 1H), 4.15 – 3.76 (m, 2H), 3.53 (s, 1H), 3.46 (s, 3H), 2.81 (d, $J = 14.5$ Hz, 1H), 2.65 (d, $J = 14.5$ Hz, 1H), 2.52 (s, 3H), 2.26 (s, 3H), 1.32 (s, 3H), 1.27 (t, $J = 7.1$ Hz, 3H). ^{13}C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 180.14, 168.09, 139.84, 132.45, 131.41, 129.95, 124.46 (q, $J = 289.1$ Hz), 122.89, 119.26, 76.42 (q, $J = 27.2$ Hz), 62.44, 43.99, 38.86, 29.64, 26.47, 20.76, 18.94, 13.82. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.50.

White solid, melting point: 99-101 °C.



Following the general procedure, the title compound (57 mg, *dr* (*syn/anti*) = 1.9:1) was obtained in 65% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

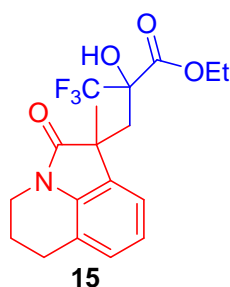
Syn isomer

1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.15 (d, $J = 5.6$ Hz, 2H), 4.78 (s, 1H), 4.44 – 4.17 (m, 2H), 3.44 (s, 1H), 2.77 (d, $J = 14.9$ Hz, 1H), 2.53 (s, 3H), 2.33 (d, $J = 14.9$ Hz, 1H), 1.37 (d, $J = 7.3$ Hz, 1H), 1.34 (s, 1H). ^{13}C NMR (101 MHz, DMSO-*d*₆) δ 179.12, 168.14, 140.26, 137.20, 133.33, 124.46, 124.42 (q, $J = 288.4$ Hz), 122.10, 114.00, 76.72 (q, $J = 27.4$ Hz), 62.65, 45.09, 37.88, 29.46, 27.19, 18.52, 14.00. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.56. HRMS (ESI) m/z calculated for $C_{17}H_{19}BrF_3NO_4(M+Na)^+$ 460.0342, found 460.0364. Colorless solid, melting point: 105-107 °C.

Anti isomer

1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.15 (d, $J = 2.0$ Hz, 1H), 6.97 (d, $J = 2.0$ Hz, 1H), 4.22-4.00 (m, 2H), 3.52 (d, $J = 1.4$ Hz, 1H), 3.46 (s, 3H), 2.84 (d, $J = 14.6$ Hz, 1H), 2.64 (d, $J = 14.6$ Hz, 1H), 2.54 (s, 3H), 1.40 – 1.27 (m, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 180.22, 168.79, 141.08, 134.71, 133.18, 124.60, 123.02 (q, $J = 287.7$ Hz), 121.99, 113.84, 76.04 (q, $J = 29.0$ Hz), 64.24, 44.42, 37.90,

29.82, 26.02, 18.85, 13.65. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.51 (d, $J = 2.4$ Hz). Colorless solid, melting point: 172-174 $^{\circ}\text{C}$.



Following the general procedure, the title compound (61 mg, *dr* (*syn/anti*) = 2.6:1) was obtained in 82% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

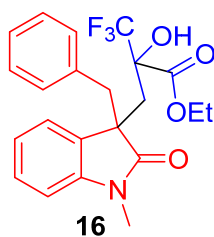
Syn isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.08 (d, $J = 7.3$ Hz, 1H), 7.04 (d, $J = 6.4$ Hz, 1H), 6.98 (t, $J = 7.4$ Hz, 1H), 5.16 (s, 1H), 4.40 – 4.20 (m, 2H), 3.75 – 3.60 (m, 2H), 2.90 – 2.75 (m, 3H), 2.35 (d, $J = 14.9$ Hz, 1H), 2.02 (p, $J = 6.0$ Hz, 2H), 1.40 (s, 3H), 1.35 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 177.98, 168.15, 138.83, 132.11, 126.67, 125.92 (q, $J = 288.4$ Hz), 121.84, 121.60, 120.07, 76.98 (q, $J = 27.2$ Hz), 62.55, 46.68, 38.81, 37.67, 26.42, 24.44, 21.11, 13.96. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.50. HRMS (ESI) m/z calculated for C₁₈H₂₀F₃NO₄(M+Na)⁺ 394.1237, found 394.1258. Colorless oil.

Anti isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.02 (t, $J = 4.4$ Hz, 1H), 6.86 (d, $J = 4.5$ Hz, 2H), 4.10-3.85 (m, 2H), 3.71 (t, $J = 5.8$ Hz, 2H), 3.50 (s, 1H), 2.85 – 2.60 (m, 4H), 2.02 – 1.90 (m, 2H), 1.36 (s, 3H), 1.25 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 178.87, 168.65, 139.85, 129.00, 127.39, 123.14 (q, $J = 287.6$ Hz), 121.51, 120.95, 120.41, 76.33 (q, $J = 28.7$ Hz), 63.62, 46.12, 39.00, 37.69, 25.44, 24.65, 21.10, 13.53. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.51.

Colorless solid, melting point: 104-106 $^{\circ}\text{C}$.



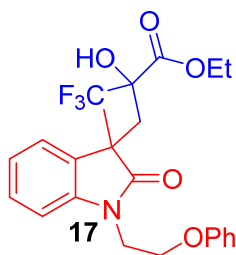
Following the general procedure, the title compound (48 mg, *dr* (*syn/anti*) = 1.7:1) was obtained in 57% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 10:1) to afford the desired product.

Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.31 (d, *J* = 7.3 Hz, 1H), 7.18 (t, *J* = 7.5 Hz, 1H), 7.09 (t, *J* = 7.4 Hz, 1H), 7.03 (d, *J* = 7.1 Hz, 1H), 6.98 (t, *J* = 7.2 Hz, 2H), 6.69 (d, *J* = 7.1 Hz, 2H), 6.50 (d, *J* = 7.7 Hz, 1H), 4.67 (s, 1H), 4.50 – 4.03 (m, 2H), 3.20 (d, *J* = 12.5 Hz, 1H), 3.00 (m, 2H), 2.85 (s, 3H), 2.56 (d, *J* = 14.9 Hz, 1H), 1.36 (t, *J* = 7.1 Hz, 3H). ¹³C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 177.54, 168.09, 143.68, 135.32, 130.76, 130.02, 127.85, 127.54, 126.85, 124.85, 124.53 (q, *J* = 288.6 Hz), 121.74, 107.96, 76.82 (q, *J* = 27.3 Hz), 62.57, 51.36, 45.81, 37.46, 25.99, 13.97. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.53. HRMS (ESI) *m/z* calculated for C₂₂H₂₂F₃NO₄ (M+Na)⁺ 444.1393, found 444.1408. Colorless oil.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.19 (td, *J* = 7.7, 1.5 Hz, 1H), 7.11 – 6.88 (m, 5H), 6.76 (d, *J* = 6.8 Hz, 2H), 6.55 (d, *J* = 7.8 Hz, 1H), 4.13 – 3.83 (m, 2H), 3.49 (s, 1H), 3.10 (d, *J* = 12.7 Hz, 1H), 3.01 (d, *J* = 5.6 Hz, 1H), 2.97 (d, *J* = 3.8 Hz, 1H), 2.92 (s, 3H), 2.86 (d, *J* = 14.5 Hz, 1H), 1.23 (t, *J* = 7.2 Hz, 3H). ¹³C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 178.06, 168.15, 145.00, 135.47, 130.18, 128.52, 127.81, 127.58, 126.82, 125.39, 124.53 (q, *J* = 289.0 Hz), 120.90, 108.16, 76.50 (q, *J* = 26.9 Hz), 62.56, 50.63, 44.44, 37.96, 26.23, 13.81. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.46. Colorless oil.



Following the general procedure, the title compound (53 mg, *dr* (*syn/anti*) = 2.5:1) was obtained in 59% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

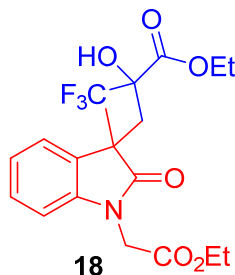
Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.31-7.25 (m, 4H), 7.08 (q, *J* = 8.7, 8.1 Hz, 2H), 6.94 (t, *J* = 7.5 Hz, 1H), 6.85 (d, *J* = 8.1 Hz, 2H), 4.65 (s, 1H), 4.40 – 4.17 (m, 4H), 4.10 (t, *J* = 6.3 Hz, 2H), 2.83 (d, *J* = 15.0 Hz, 1H), 2.43 (d, *J* = 15.0 Hz, 1H), 1.38 (s, 3H), 1.34 (t, *J* = 7.4 Hz, 3H). ¹³C NMR (101 MHz,

DMSO-*d*₆), δ (ppm) 179.54, 168.32, 158.63, 142.35, 134.10, 129.91, 127.74, 124.48 (q, $J = 288.7$ Hz), 123.67, 122.21, 121.22, 114.82, 109.17, 76.80 (q, $J = 27.4$ Hz), 64.70, 62.62, 45.38, 39.24, 37.62, 26.94, 13.90. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.64. HRMS (ESI) m/z calculated for C₂₃H₂₄F₃NO₅(M+Na)⁺ 474.1499, found 474.1509. Colorless solid, melting point: 101-103 °C.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.30 – 7.21 (m, 3H), 7.05 – 6.90 (m, 4H), 6.85 (dd, $J = 8.7, 1.1$ Hz, 2H), 4.35 – 3.84 (m, 6H), 3.46 (d, $J = 1.3$ Hz, 1H), 2.83 (d, $J = 14.5$ Hz, 1H), 2.71 (d, $J = 14.5$ Hz, 1H), 1.36 (s, 3H), 1.21 (t, $J = 7.2$ Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 180.13, 168.31, 158.19, 143.96, 130.23, 129.52, 128.50, 123.74, 123.10 (q, $J = 287.4$ Hz), 121.26, 121.16, 114.51, 109.36, 76.28 (q, $J = 28.8$ Hz), 65.22, 63.52, 44.72, 39.71, 38.33, 25.58, 13.53. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.53. Colorless solid, melting point: 100-102 °C.



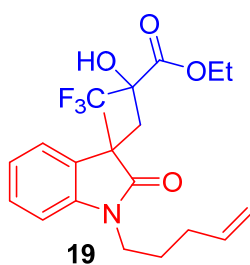
Following the general procedure, the title compound (48 mg, *dr* (*syn/anti*) = 2.2:1) was obtained in 58% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.25 (ddd, $J = 6.8, 4.7, 3.3$ Hz, 2H), 7.11 (td, $J = 7.6, 1.0$ Hz, 1H), 6.71 (d, $J = 7.3$ Hz, 1H), 4.71 (s, 1H), 4.54 – 4.16 (m, 6H), 2.84 (d, $J = 14.9$ Hz, 1H), 2.53 (d, $J = 14.9$ Hz, 1H), 1.42 (s, 3H), 1.34 (t, $J = 7.1$ Hz, 3H), 1.27 (t, $J = 7.1$ Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 180.01, 169.21, 167.58, 141.01, 134.12, 127.93, 123.33 (q, $J = 287.0$ Hz), 123.31, 122.61, 108.22, 76.40 (q, $J = 28.9$ Hz), 63.76, 61.98, 45.95, 41.20, 37.02, 25.54, 14.08, 13.79. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.85. HRMS (ESI) m/z calculated for C₁₉H₂₂F₃NO₆(M+Na)⁺ 440.1291, found 440.1320. Colorless oil.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.27 (td, $J = 7.5, 1.4$ Hz, 1H), 7.10 (dd, $J = 7.5, 1.4$ Hz, 1H), 7.01 (td, $J = 7.5, 1.0$ Hz, 1H), 6.68 (d, $J = 7.8$ Hz, 1H), 4.86 (d, $J = 17.8$ Hz, 1H), 4.39 (s, 1H), 4.25 (q, $J = 7.1$ Hz, 2H), 4.17 (d, $J = 17.9$ Hz, 1H), 3.97-3.75 (m, 2H), 2.84 (d, $J = 14.3$ Hz, 1H), 2.73 (d, $J = 14.3$ Hz, 1H), 1.40 (s, 3H), 1.30 (t, $J = 7.2$ Hz, 3H), 1.21 (t, $J = 7.2$ Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.67, 168.13 (d, $J = 13.6$ Hz), 142.60, 129.91, 128.83, 126.00 (q, $J = 287.2$ Hz), 124.06, 121.83, 108.39, 76.28 (q, $J = 28.7$ Hz), 63.40, 62.05, 44.80, 40.89, 39.41, 25.54, 14.11, 13.47. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.38. Colorless oil.



Following the general procedure, the title compound (41 mg, *dr* (*syn/anti*) = 2.4:1) was obtained in 51% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 10:1) to afford the desired product.

Syn isomer

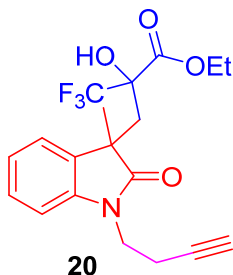
¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.33 – 7.20 (m, 2H), 7.09 (t, $J = 7.5$ Hz, 1H), 6.86 (d, $J = 7.8$ Hz, 1H), 5.89-5.78 (m, 1H), 5.15 (s, 1H), 5.12 – 4.96 (m, 2H), 4.42 – 4.22 (m, 2H), 3.69 (qt, $J = 14.2, 7.4$ Hz, 2H), 2.84 (d, $J = 14.9$ Hz, 1H), 2.37 (d, $J = 14.9$ Hz, 1H), 2.13 (q, $J = 7.2$ Hz, 2H), 1.78 (p, $J = 7.6$ Hz, 2H), 1.39 (s, 3H), 1.35 (t, $J = 7.2$ Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 180.35, 169.47, 141.59, 137.23, 134.09, 128.09, 123.42 (q, $J = 287.4$ Hz), 122.89, 122.86, 115.63, 108.67, 76.74 (q, $J = 28.6$ Hz), 63.61, 46.18, 39.64, 36.55, 30.92, 26.31, 24.87, 13.80. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.64. HRMS (ESI) m/z calculated for C₂₀H₂₄F₃NO₄(M+Na)⁺ 422.1550, found 422.1564.

Colorless oil.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.28 (d, $J = 7.4$ Hz, 1H), 7.05 (d, $J = 7.2$ Hz, 1H), 6.97 (t, $J = 7.5$ Hz, 1H), 6.83 (d, $J = 8.0$ Hz, 1H), 6.08 – 5.61 (m, 1H), 5.05 (dd, $J = 23.4, 13.6$ Hz, 2H), 3.97 (m, 2H), 3.70 (ddq, $J = 21.9, 14.4, 7.6$ Hz, 2H), 3.45 (s, 1H), 2.83 (d, $J = 14.3$ Hz, 1H), 2.71 (d, $J = 14.5$ Hz, 1H), 2.15 (p, $J = 6.7$ Hz, 2H), 1.78 (q, $J = 7.3$ Hz, 2H), 1.36 (s, 3H), 1.25 (t, $J = 7.2$ Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.74, 168.60, 143.45, 137.44, 130.65, 128.61, 123.86, 123.13 (q, J

= 287.5 Hz), 121.18, 115.52, 108.49, 76.33 (q, $J = 28.7$ Hz), 63.62, 44.77, 39.54, 37.72, 31.06, 26.12, 26.00, 13.53. ^{19}F NMR (376 MHz, Chloroform- d), δ (ppm) -79.49. Colorless solid, melting point: 52-54 °C.



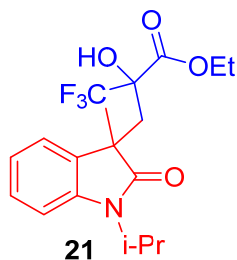
Following the general procedure, the title compound (33 mg, *dr* (*syn/anti*) = 3.7:1) was obtained in 43% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

^1H NMR (400 MHz, Chloroform- d), δ (ppm) 7.30 – 7.21 (m, 2H), 7.10 (t, $J = 7.5$ Hz, 1H), 6.92 (d, $J = 7.8$ Hz, 1H), 4.64 (s, 1H), 4.47 – 4.22 (m, 2H), 3.87 (t, $J = 7.0$ Hz, 2H), 2.83 (d, $J = 14.9$ Hz, 1H), 2.60 (tt, $J = 7.1, 2.5$ Hz, 2H), 2.45 (d, $J = 14.9$ Hz, 1H), 1.97 (t, $J = 2.7$ Hz, 1H), 1.39 (s, 3H), 1.36 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, DMSO- d_6), δ (ppm) 179.22, 168.35, 141.84, 134.26, 127.76, 124.46 (q, $J = 288.7$ Hz), 123.63, 122.25, 108.91, 81.68, 76.74 (q, $J = 27.5$ Hz), 73.14, 62.67, 45.37, 38.23, 37.58, 27.10, 16.89, 14.00. ^{19}F NMR (376 MHz, Chloroform- d), δ (ppm) -79.68. HRMS (ESI) m/z calculated for $\text{C}_{19}\text{H}_{20}\text{F}_3\text{NO}_4(\text{M}+\text{Na})^+$ 406.1237, found 406.1265. Colorless oil.

Anti isomer

^1H NMR (400 MHz, Chloroform- d), δ (ppm) 7.30 – 7.21 (m, 1H), 7.03 (d, $J = 7.4$ Hz, 1H), 6.96 (m, 2H), 4.07 – 3.86 (m, 3H), 3.80 (m, 1H), 3.66 (s, 1H), 2.83 (d, $J = 14.4$ Hz, 1H), 2.77 – 2.64 (m, 2H), 2.52 (m, 1H), 1.96 (t, $J = 2.6$ Hz, 1H), 1.35 (s, 3H), 1.23 (t, $J = 7.1$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform- d), δ (ppm) 179.84, 168.48, 143.40, 130.30, 123.89, 123.12 (q, $J = 287.3$ Hz), 121.30, 108.89, 81.43, 76.21 (q, $J = 28.7$ Hz), 70.38, 63.60, 44.71, 38.71, 38.15, 25.72, 17.12, 13.55. ^{19}F NMR (376 MHz, Chloroform- d), δ (ppm) -79.48. Colorless oil.



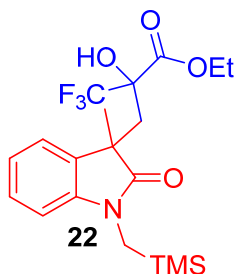
Following the general procedure, the title compound (45 mg, *dr* (*syn/anti*) = 5.4:1) was obtained in 60% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/ethyl acetate 30:1 to 8:1) to afford the desired product.

Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.24 (d, *J* = 7.6 Hz, 2H), 7.07 (t, *J* = 7.5 Hz, 1H), 7.02 (d, *J* = 7.9 Hz, 1H), 5.10 (s, 1H), 4.59 (p, *J* = 7.1 Hz, 1H), 4.43 – 4.23 (m, 2H), 2.82 (d, *J* = 14.9 Hz, 1H), 2.37 (d, *J* = 14.9 Hz, 1H), 1.51 – 1.45 (m, 6H), 1.37 (m, 6H). ¹³C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 178.72, 168.34, 141.57, 134.76, 127.52, 124.50 (q, *J* = 288.8 Hz), 123.61, 121.65, 109.94, 76.75 (q, *J* = 27.4 Hz), 62.54, 45.15, 43.43, 37.55, 27.30, 19.45, 19.07, 13.96. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.63. HRMS (ESI) *m/z* calculated for C₁₈H₂₂F₃NO₄(M+Na)⁺ 396.1393, found 396.1422. Colorless oil.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.24 (t, *J* = 7.9 Hz, 1H), 7.05 (d, *J* = 7.1 Hz, 1H), 7.01 – 6.92 (m, 2H), 4.67 (p, *J* = 6.8 Hz, 1H), 4.12 – 3.79 (m, 2H), 3.46 (s, 1H), 2.81 (d, *J* = 14.5 Hz, 1H), 2.69 (d, *J* = 14.5 Hz, 1H), 1.46 (d, *J* = 7.1 Hz, 6H), 1.34 (s, 3H), 1.25 (t, *J* = 7.1 Hz, 3H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.45, 168.60, 142.63, 131.01, 128.34, 123.95, 123.15 (q, *J* = 287.8 Hz), 120.79, 110.07, 76.34 (q, *J* = 28.8 Hz), 63.59, 44.59, 43.48, 37.82, 26.07, 19.27, 18.75, 13.51. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.47. Colorless solid, melting point: 70-72 °C.



Following the general procedure, the title compound (68 mg, *dr* (*syn/anti*) = 3.5:1) was obtained in 82% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 10:1) to afford the desired product.

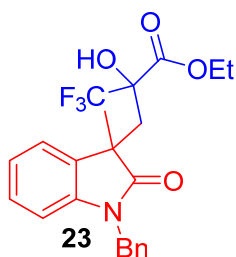
Syn isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.30 – 7.19 (m, 2H), 7.08 (q, $J = 7.5, 6.2$ Hz, 1H), 6.79 (d, $J = 7.8$ Hz, 1H), 5.98 (s, 1H), 4.41 – 4.22 (m, 2H), 3.30 (d, $J = 15.3$ Hz, 1H), 3.09 (d, $J = 15.3$ Hz, 1H), 2.84 (d, $J = 15.0$ Hz, 1H), 2.24 (d, $J = 15.1$ Hz, 1H), 1.38 (s, 3H), 1.34 (t, $J = 7.2$ Hz, 3H), 0.09 (s, 9H).

¹³C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 178.99, 168.21, 143.29, 133.65, 127.90, 124.47 (q, $J = 287.8$ Hz), 123.86, 121.93, 109.06, 77.01 (q, $J = 27.1$ Hz), 62.56, 45.45, 37.29, 30.93, 26.38, 13.94, -1.08. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.68. HRMS (ESI) m/z calculated for C₁₉H₂₆F₃NO₄Si(M+Na)⁺ 440.1475, found 440.1487. Colorless oil.

Anti isomer

¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.26 (q, $J = 7.9, 5.4$ Hz, 1H), 7.03 (d, $J = 7.3$ Hz, 1H), 6.94 (t, $J = 7.4$ Hz, 1H), 6.76 (d, $J = 7.9$ Hz, 1H), 4.09 – 3.85 (m, 2H), 3.42 (s, 1H), 3.30 (d, $J = 15.4$ Hz, 1H), 3.07 (d, $J = 15.4$ Hz, 1H), 2.81 (d, $J = 14.5$ Hz, 1H), 2.69 (d, $J = 14.6$ Hz, 1H), 1.35 (s, 3H), 1.24 (t, $J = 7.1$ Hz, 3H), 0.11 (s, 9H). ¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.29, 168.61, 144.45, 130.93, 128.43, 123.57, 123.17 (q, $J = 287.3$ Hz), 120.96, 108.63, 76.32 (q, $J = 28.6$ Hz), 63.56, 44.59, 37.47, 31.58, 26.30, 13.53, -1.42. ¹⁹F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.54. White solid, melting point: 69-71 °C.



Following the general procedure, the title compound (48 mg, *dr* (*syn/anti*) = 2.2:1) was obtained in 57% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 10:1) to afford the desired product.

Syn isomer

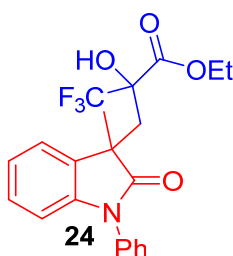
¹H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.37 – 7.21 (m, 6H), 7.16 (t, $J = 7.7$ Hz, 1H), 7.06 (t, $J = 7.5$ Hz, 1H), 6.74 (d, $J = 7.8$ Hz, 1H), 5.00 (d, $J = 15.6$ Hz, 1H), 4.88 (s, 1H), 4.78 (d, $J = 15.6$ Hz, 1H), 4.43 – 4.18 (m, 2H), 2.89 (d, $J = 14.9$ Hz, 1H), 2.46 (d, $J = 14.9$ Hz, 1H), 1.46 (s, 3H), 1.33 (t, $J = 7.2$ Hz, 3H).

¹³C NMR (101 MHz, Chloroform-*d*), δ (ppm) 180.48, 169.43, 141.44, 135.64, 133.86, 128.87, 128.05, 127.77, 127.33, 123.44 (q, $J = 287.6$ Hz), 123.00, 122.85, 109.48, 76.46 (q, $J = 28.4$ Hz), 63.72, 46.22,

43.90, 36.63, 25.30, 13.79. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.58. HRMS (ESI) *m/z* calculated for $\text{C}_{22}\text{H}_{22}\text{F}_3\text{NO}_4$ ($\text{M}+\text{Na}$) $^+$ 444.1393, found 444.1422. White solid, melting point: 71-73 $^\circ\text{C}$.

Anti isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.35 – 7.26 (m, 5H), 7.16 (t, $J = 7.5$ Hz, 1H), 7.05 (d, $J = 7.3$ Hz, 1H), 6.94 (t, $J = 7.5$ Hz, 1H), 6.74 (d, $J = 7.8$ Hz, 1H), 4.99 (d, $J = 15.6$ Hz, 1H), 4.82 (d, $J = 15.5$ Hz, 1H), 4.07 – 3.85 (m, 2H), 3.39 (s, 1H), 2.89 (d, $J = 14.5$ Hz, 1H), 2.75 (d, $J = 14.5$ Hz, 1H), 1.42 (s, 3H), 1.22 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.93, 168.52, 143.22, 136.09, 130.54, 128.73, 128.57, 127.61, 127.56, 123.19 (q, $J = 287.6$ Hz), 109.36, 76.34 (q, $J = 28.6$ Hz), 63.63, 44.92, 44.02, 37.71, 26.31, 13.51. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.43. White solid, melting point: 96-98 $^\circ\text{C}$.



Following the general procedure, the title compound (65 mg, *dr* (*syn/anti*) = 2.8:1) was obtained in 80% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 10:1) to afford the desired product.

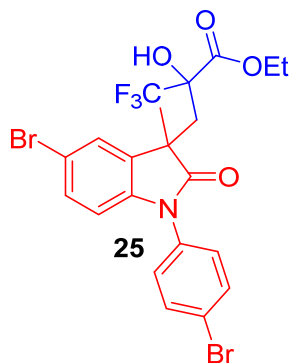
Syn isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.56 – 7.49 (m, 2H), 7.45 – 7.39 (m, 3H), 7.31 (d, $J = 6.0$ Hz, 1H), 7.20 (t, $J = 7.0$ Hz, 1H), 7.12 (t, $J = 7.5$ Hz, 1H), 6.79 (d, $J = 7.1$ Hz, 1H), 4.41 – 4.11 (m, 3H), 2.92 (d, $J = 14.8$ Hz, 1H), 2.58 (d, $J = 14.9$ Hz, 1H), 1.51 (s, 3H), 1.31 (t, $J = 7.1$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 179.11, 169.47, 142.47, 134.34, 133.66, 129.64, 128.21, 127.86, 126.59, 123.34 (q, $J = 287.1$ Hz), 123.21, 123.09, 109.59, 76.31 (q, $J = 28.9$ Hz), 63.99, 46.07, 37.14, 26.45, 13.72. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.47. HRMS (ESI) *m/z* calculated for $\text{C}_{21}\text{H}_{20}\text{F}_3\text{NO}_4$ ($\text{M}+\text{Na}$) $^+$ 430.1237, found 440.1266. Colorless solid, melting point: 61-63 $^\circ\text{C}$.

Anti isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.51 (t, $J = 7.7$ Hz, 2H), 7.44 (d, $J = 7.1$ Hz, 2H), 7.39 (t, $J = 7.3$ Hz, 1H), 7.21 (t, $J = 7.7$ Hz, 1H), 7.12 (d, $J = 7.5$ Hz, 1H), 7.05 – 6.98 (m, 1H), 6.86 (d, $J = 7.9$ Hz, 1H), 4.10-3.90 (m, 2H), 3.64 (s, 1H), 2.94 (d, $J = 14.5$ Hz, 1H), 2.81 (d, $J = 14.5$ Hz, 1H), 1.49 (s, 3H),

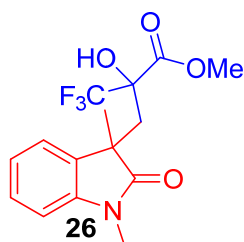
1.26(t, $J=7.4$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform- d), δ (ppm) 179.18, 168.60, 143.94, 134.74, 130.27, 129.51, 128.59, 127.83, 126.31, 124.04, 123.18 (q, $J = 287.5$ Hz), 121.86, 109.62, 76.44 (q, $J = 28.7$ Hz), 63.72, 45.01, 38.39, 25.92, 13.55. ^{19}F NMR (376 MHz, Chloroform- d), δ (ppm) -79.42. Colorless solid, melting point: 111-113 $^{\circ}\text{C}$.



Following the general procedure, the title compound (36 mg, dr (*syn/anti*) = 3.5:1) was obtained in 32% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/dichloromethane 4:1 to 1:1.5) to afford the desired product.

Syn isomer

^1H NMR (400 MHz, Chloroform- d), δ (ppm) 7.66 (d, $J = 1.9$ Hz, 1H), 7.64 (d, $J = 1.9$ Hz, 1H), 7.40 (d, $J = 1.9$ Hz, 1H), 7.31 (dd, $J = 8.4, 1.9$ Hz, 1H), 7.28 (d, $J = 1.9$ Hz, 1H), 7.26 – 7.24 (m, 1H), 6.64 (d, $J = 8.4$ Hz, 1H), 4.40-4.15 (m, 2H), 3.78 (s, 1H), 2.87 (d, $J = 14.9$ Hz, 1H), 2.59 (d, $J = 14.9$ Hz, 1H), 1.48 (s, 3H), 1.31 (t, $J = 7.2$ Hz, 3H). ^{13}C NMR (101 MHz, Chloroform- d), δ (ppm) 177.83, 169.39, 141.05, 135.86, 133.08, 132.97, 130.65, 128.12, 126.35, 123.11 (q, $J = 287.0$ Hz), 122.05, 116.00, 110.75, 76.21 (q, $J = 29.2$ Hz), 64.38, 45.95, 37.20, 27.07, 13.71. ^{19}F NMR (376 MHz, Chloroform- d), δ (ppm) -79.46. HRMS (ESI) m/z calculated for $\text{C}_{21}\text{H}_{18}\text{Br}_2\text{F}_3\text{NO}_4$ ($\text{M}+\text{Na}$) $^+$ 585.9447, found 585.9469. Colorless solid, melting point: 138-140 $^{\circ}\text{C}$.



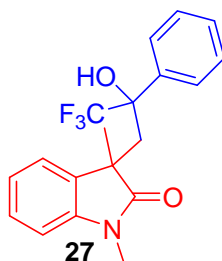
Following the general procedure, the title compound (51 mg, dr (*syn/anti*) = 2.4:1) was obtained in 77% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/acetone 30:1 to 8:1) to afford the desired product.

Syn isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.32 – 7.27 (m, 1H), 7.25 (d, $J = 7.4$ Hz, 1H), 7.11 (t, $J = 7.4$ Hz, 1H), 6.86 (d, $J = 7.8$ Hz, 1H), 5.00 (s, 1H), 3.87 (s, 3H), 3.21 (s, 3H), 2.84 (d, $J = 14.9$ Hz, 1H), 2.37 (d, $J = 14.9$ Hz, 1H), 1.39 (s, 3H). ^{13}C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 179.05, 168.68, 143.04, 133.87, 127.81, 124.43 (q, $J = 288.9$ Hz), 123.71, 122.24, 108.58, 76.89 (q, $J = 27.1$ Hz), 53.44, 45.40, 37.92, 27.08, 26.42. ^{19}F NMR (376 MHz, DMSO-*d*₆), δ (ppm) -77.93. HRMS (ESI) m/z calculated for $\text{C}_{15}\text{H}_{16}\text{F}_3\text{NO}_4$ ($\text{M}+\text{Na}$)⁺ 354.0924, found 354.0936. Colorless solid, melting point: 77-81 °C.

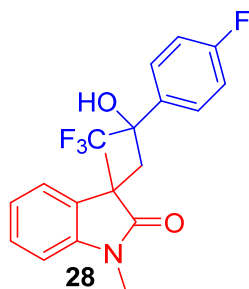
Anti isomer

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.29 (td, $J = 7.8, 1.5$ Hz, 1H), 7.02 (dt, $J = 14.7, 6.8$ Hz, 2H), 6.84 (d, $J = 7.8$ Hz, 1H), 3.59 (s, 3H), 3.51 (s, 1H), 3.21 (s, 3H), 2.85 (d, $J = 14.6$ Hz, 1H), 2.71 (d, $J = 14.5$ Hz, 1H), 1.36 (s, 3H). ^{13}C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 179.44, 168.62, 144.40, 130.68, 128.53, 124.40 (q, $J = 289.0$ Hz), 124.37, 121.42, 108.67, 76.51 (q, $J = 27.2$ Hz), 53.42, 44.54, 38.70, 26.56, 26.00. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -79.55. Colorless solid, melting point: 77-78 °C.



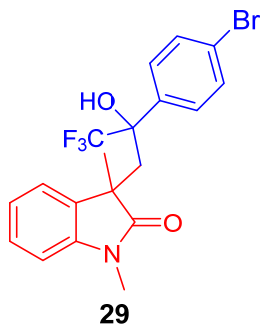
Following the general procedure, the title compound (17 mg, *dr* (*syn/anti*) = 6.2:1) was obtained in 24% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/ethyl acetate 30:1 to 7:1) to afford the desired product.

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.63 (d, $J = 7.4$ Hz, 2H), 7.36 (dt, $J = 10.6, 6.8$ Hz, 3H), 7.31 – 7.21 (m, 2H), 7.11 (t, $J = 7.3$ Hz, 1H), 6.78 (d, $J = 7.7$ Hz, 1H), 6.48 (s, 1H), 3.06 (s, 3H), 2.91 (d, $J = 15.2$ Hz, 1H), 2.46 (d, $J = 15.2$ Hz, 1H), 1.03 (s, 3H). ^{13}C NMR (101 MHz, DMSO-*d*₆), δ (ppm) 179.87, 142.84, 134.81, 132.22, 128.15, 127.74, 127.31, 127.12, 125.97, 123.41 (d, $J = 288.0$ Hz), 121.60, 107.94, 76.03 (t, $J = 26.3$ Hz), 45.53, 40.64, 27.72, 26.05. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -80.84. HRMS (ESI) m/z calculated for $\text{C}_{19}\text{H}_{18}\text{F}_3\text{NO}_2$ ($\text{M}+\text{Na}$)⁺ 372.1182, found 372.1196. Colorless solid, melting point: 178-183 °C.



Following the general procedure, the title compound (27 mg, *dr (syn/anti)* = 7:1) was obtained in 37% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/ethyl acetate 30:1 to 7:1) to afford the desired product.

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.65 (dd, J = 8.3, 5.4 Hz, 2H), 7.34 – 7.27 (m, 1H), 7.21 (d, J = 7.3 Hz, 1H), 7.10 (dt, J = 17.4, 8.2 Hz, 3H), 6.82 (d, J = 7.8 Hz, 1H), 6.40 (s, 1H), 3.11 (s, 3H), 2.84 (d, J = 15.3 Hz, 1H), 2.44 (d, J = 15.3 Hz, 1H), 1.04 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 182.08, 162.77 (d, J = 247.5 Hz), 142.04, 134.17, 134.13, 128.86 (q, J = 8.1 Hz), 128.62, 125.22 (d, J = 286.3 Hz), 123.48, 122.59, 114.91 (d, J = 21.4 Hz), 108.84, 76.17 (q, J = 27.9 Hz), 47.57, 38.94, 26.44, 23.64. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm) -81.23, -114.32. HRMS (ESI) m/z calculated for $\text{C}_{19}\text{H}_{17}\text{F}_4\text{NO}_2$ ($\text{M}+\text{Na}$) $^+$ 390.1088, found 390.1104. Colorless solid, melting point: 150-154 °C.



Following the general procedure, the title compound (18 mg, *dr (syn/anti)* = 4.6:1) was obtained in 21% yield. The reaction mixture went through flash column chromatography (silica gel, petroleum ether/ethyl acetate 30:1 to 7:1) to afford the desired product.

^1H NMR (400 MHz, Chloroform-*d*), δ (ppm) 7.55 (q, J = 8.7 Hz, 4H), 7.30 (t, J = 7.5 Hz, 1H), 7.20 (d, J = 7.0 Hz, 1H), 7.13 (t, J = 7.4 Hz, 1H), 6.83 (d, J = 7.8 Hz, 1H), 6.58 (s, 1H), 3.12 (s, 3H), 2.82 (d, J = 15.3 Hz, 1H), 2.43 (d, J = 15.3 Hz, 1H), 1.03 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*), δ (ppm) 182.13, 141.99, 137.64, 134.07, 131.25, 128.81, 128.70, 125.08 (q, J = 286.5 Hz), 123.57, 122.76, 122.60, 108.93, 76.19 (q, J = 28.0 Hz), 47.64, 38.70, 26.52, 23.61. ^{19}F NMR (376 MHz, Chloroform-*d*), δ (ppm)

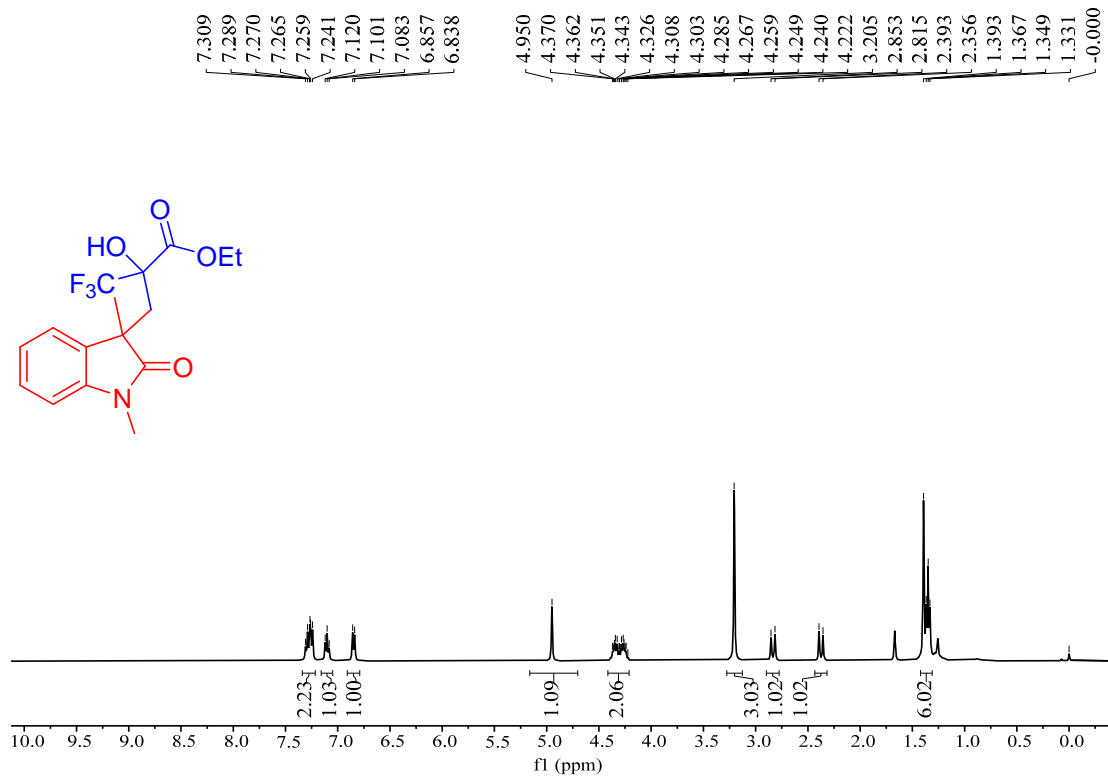
-81.09. HRMS (ESI) m/z calculated for $C_{19}H_{17}BrF_3NO_2$ ($M+Na$)⁺ 450.0287, found 450.0305. Colorless solid, melting point: 149-155 °C.

5. References

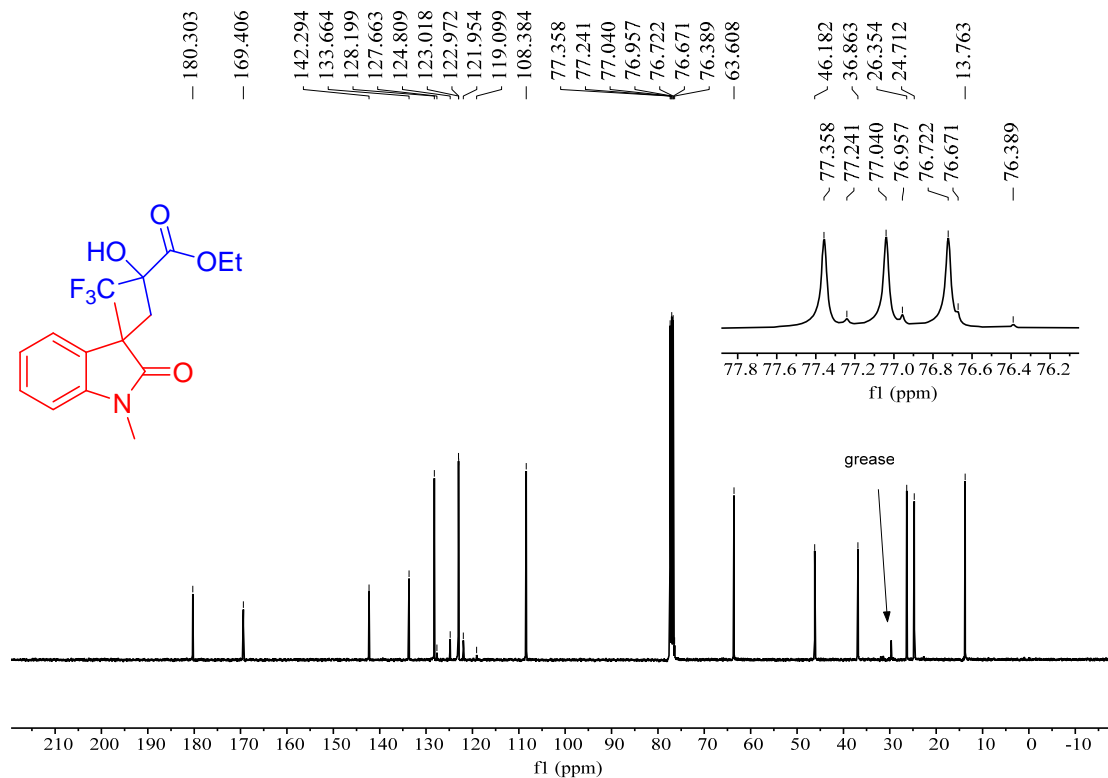
- (1) Z. Liu, S. Zhong, X. Ji, G.-J. Deng, H. Huang. *ACS Catal.* 2021, **11**, 4422-4429.
- (2) Z. Qu, T. Tian, Y. Tan, X. Ji, G.-J. Deng, H. Huang. *Green Chem.* 2022, **24**, 7403-7409.

6. Copies of NMR spectra of all products

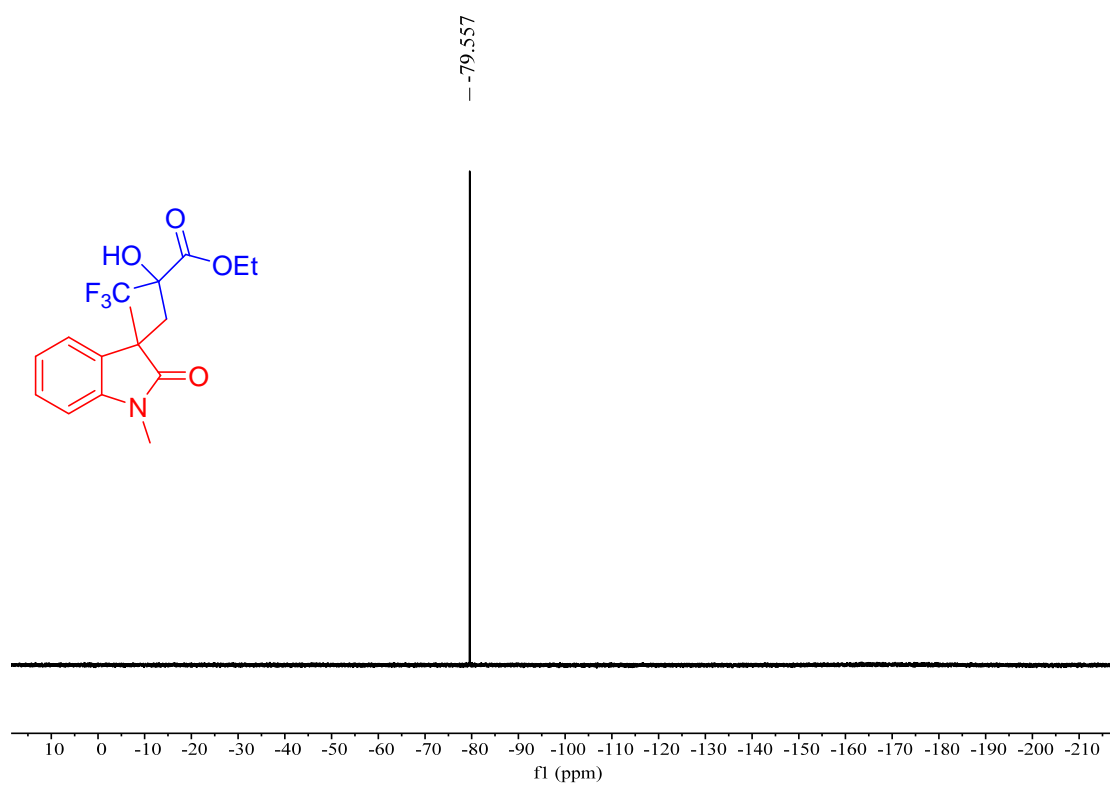
^1H NMR of **3** (syn) (400 MHz, CDCl_3)



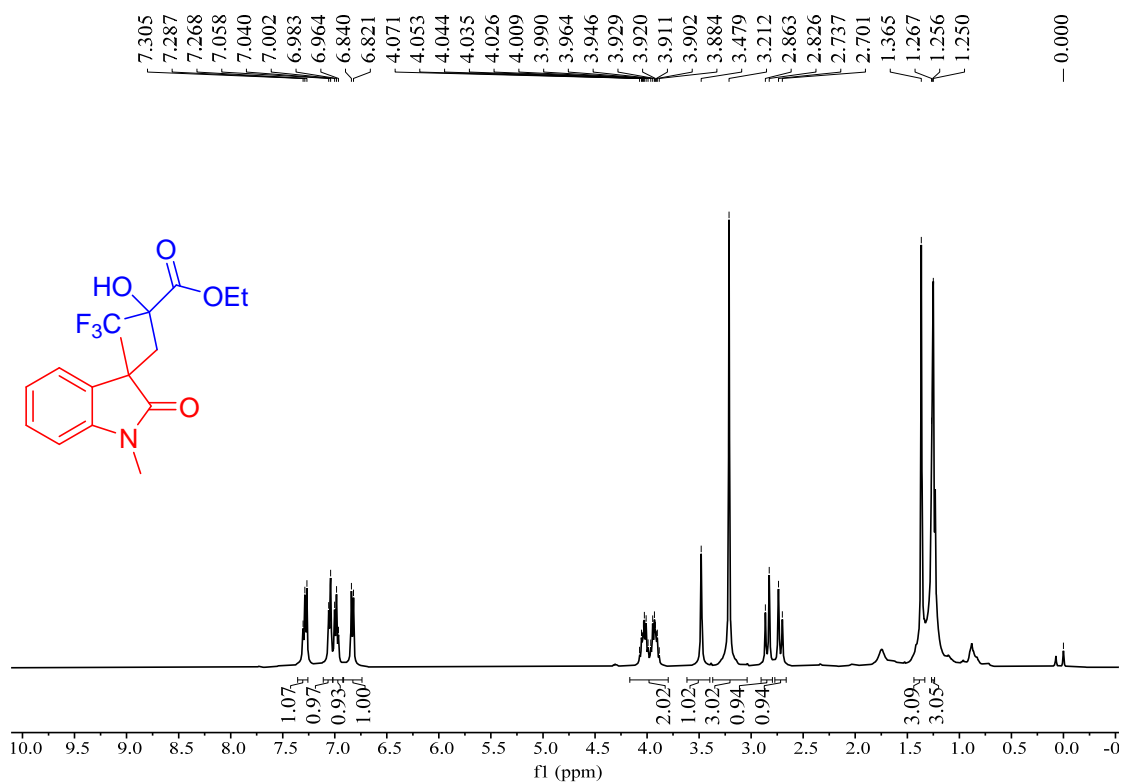
^{13}C NMR of **3** (syn) (101 MHz, CDCl_3)



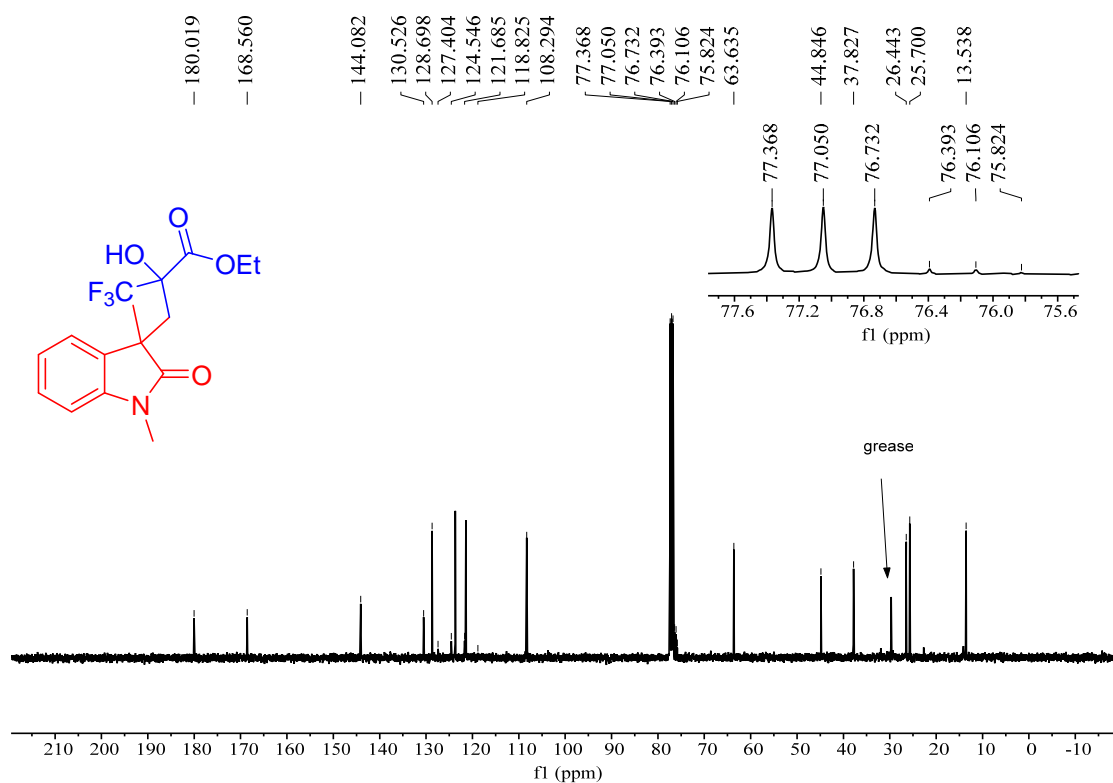
¹⁹F NMR of **3** (syn) (376 MHz, CDCl₃)



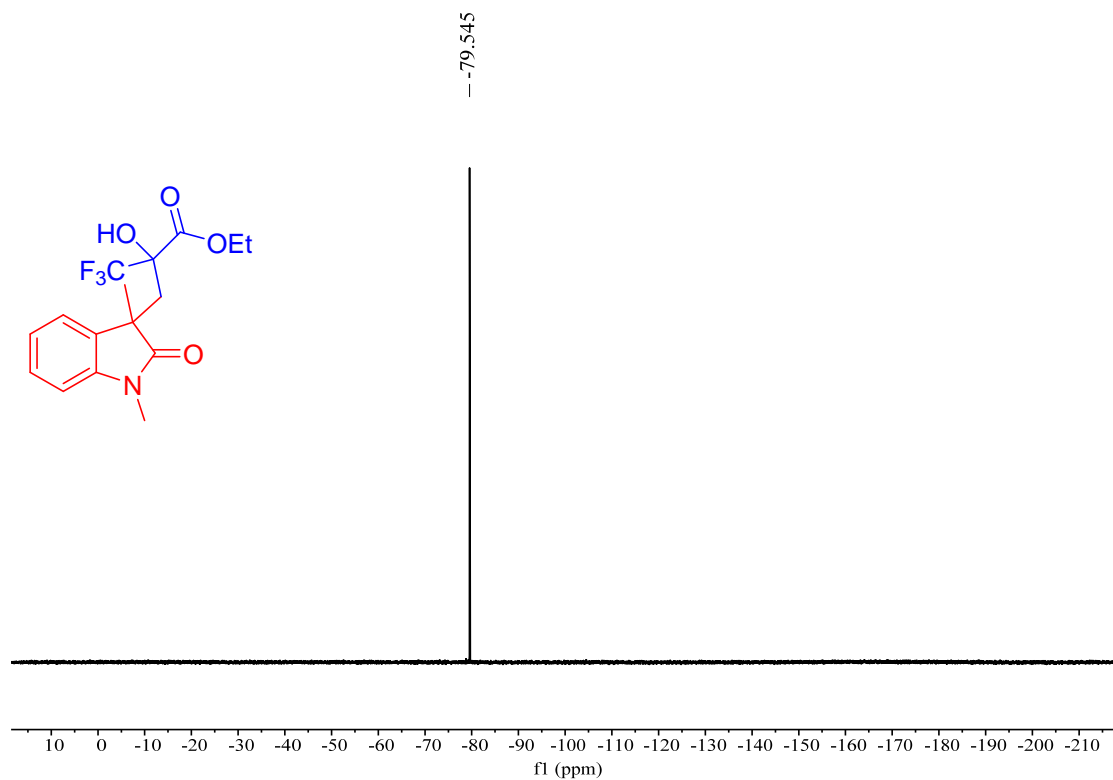
¹H NMR of **3** (anti) (400 MHz, CDCl₃)



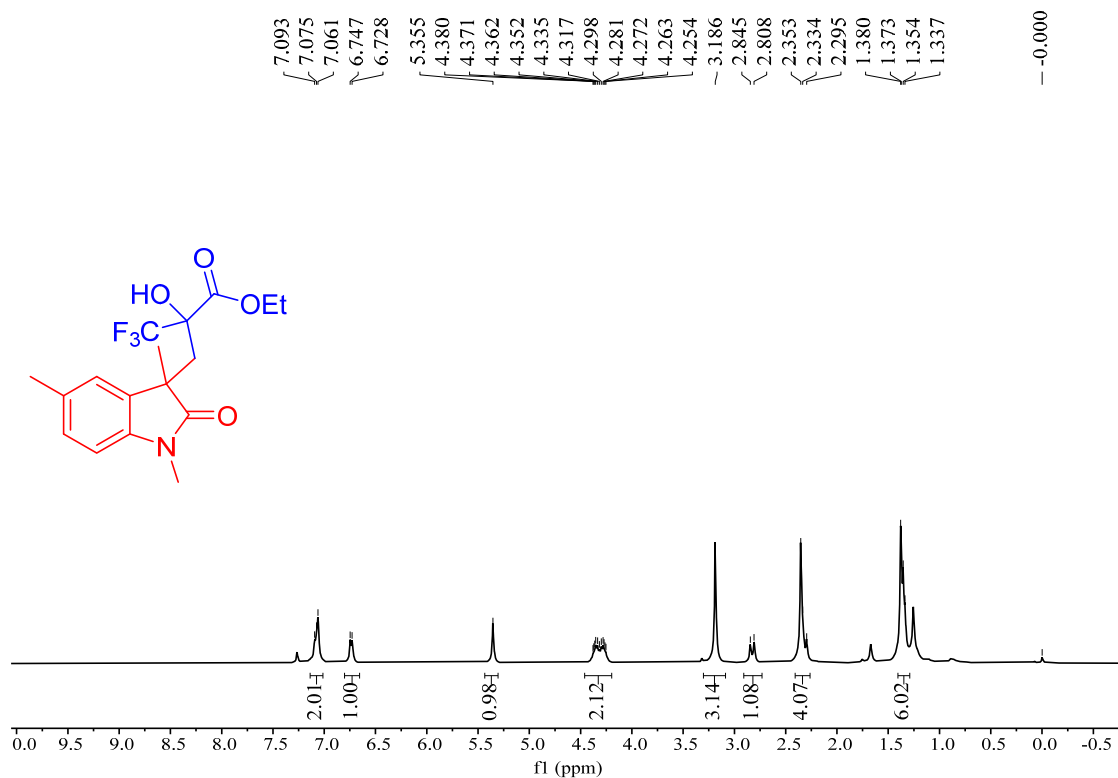
¹³C NMR of **3** (anti) (101 MHz, CDCl₃)



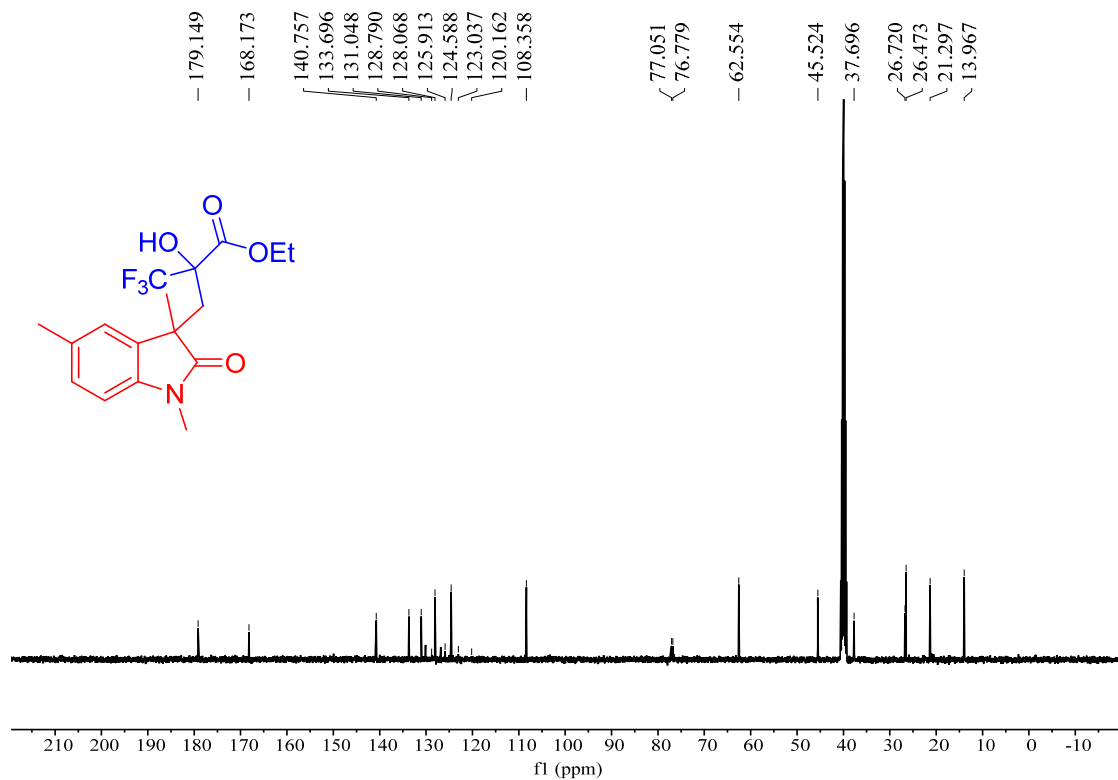
¹⁹F NMR of **3** (anti) (376 MHz, CDCl₃)



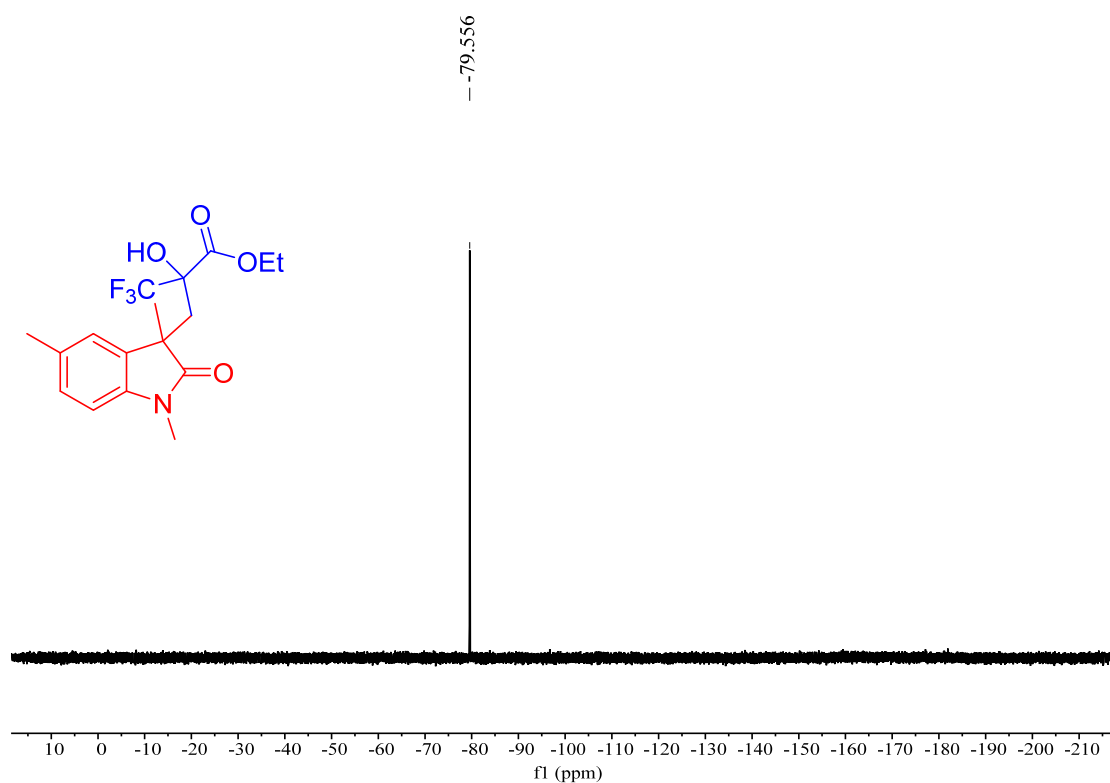
¹H NMR of **4** (syn isomer) (400 MHz, CDCl₃)



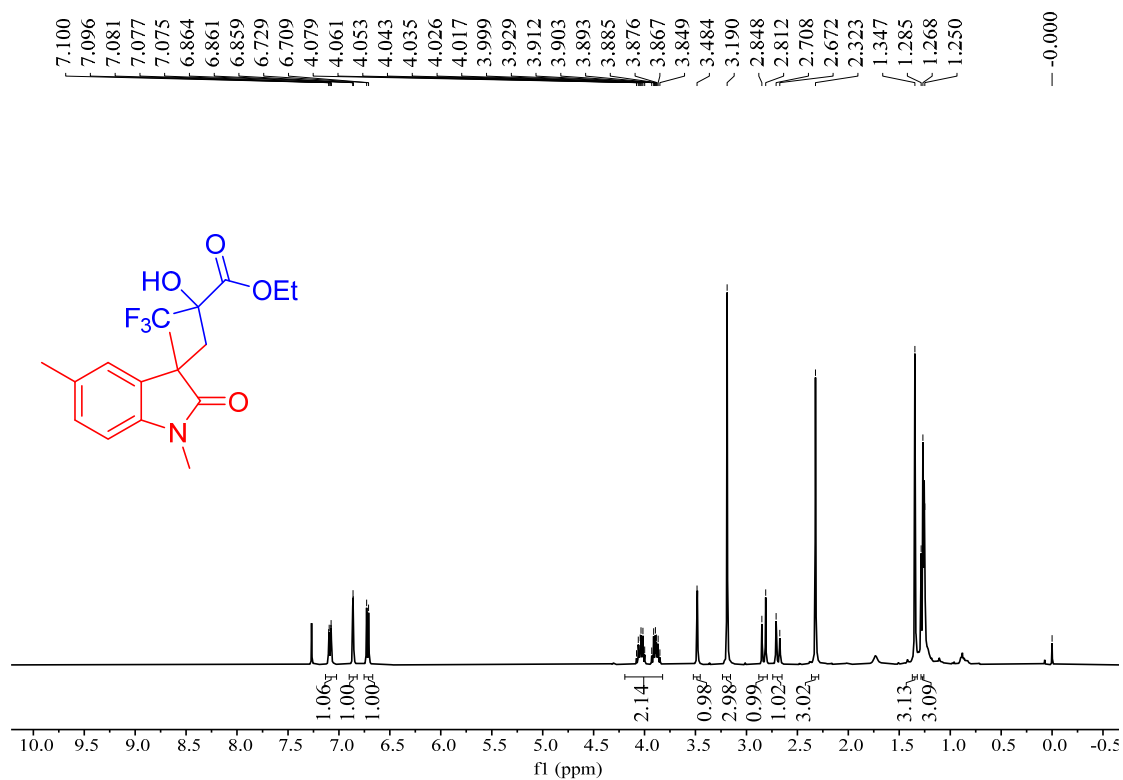
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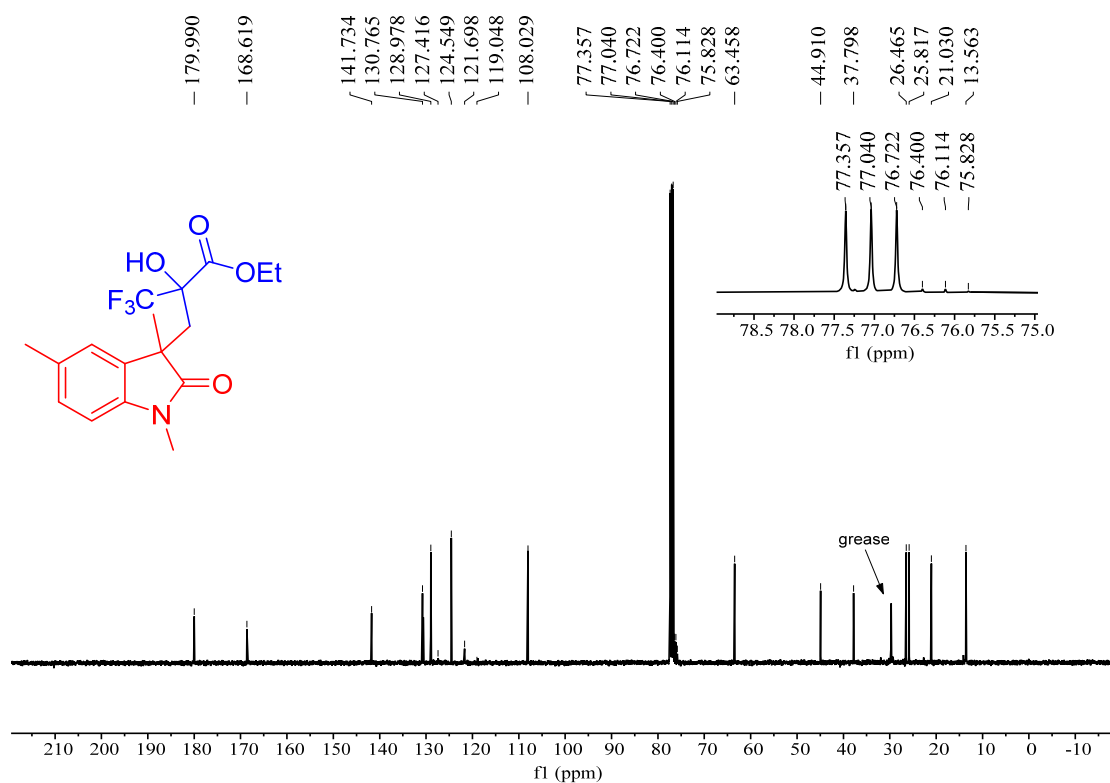
¹⁹F NMR of **4** (syn isomer) (376 MHz, CDCl₃)



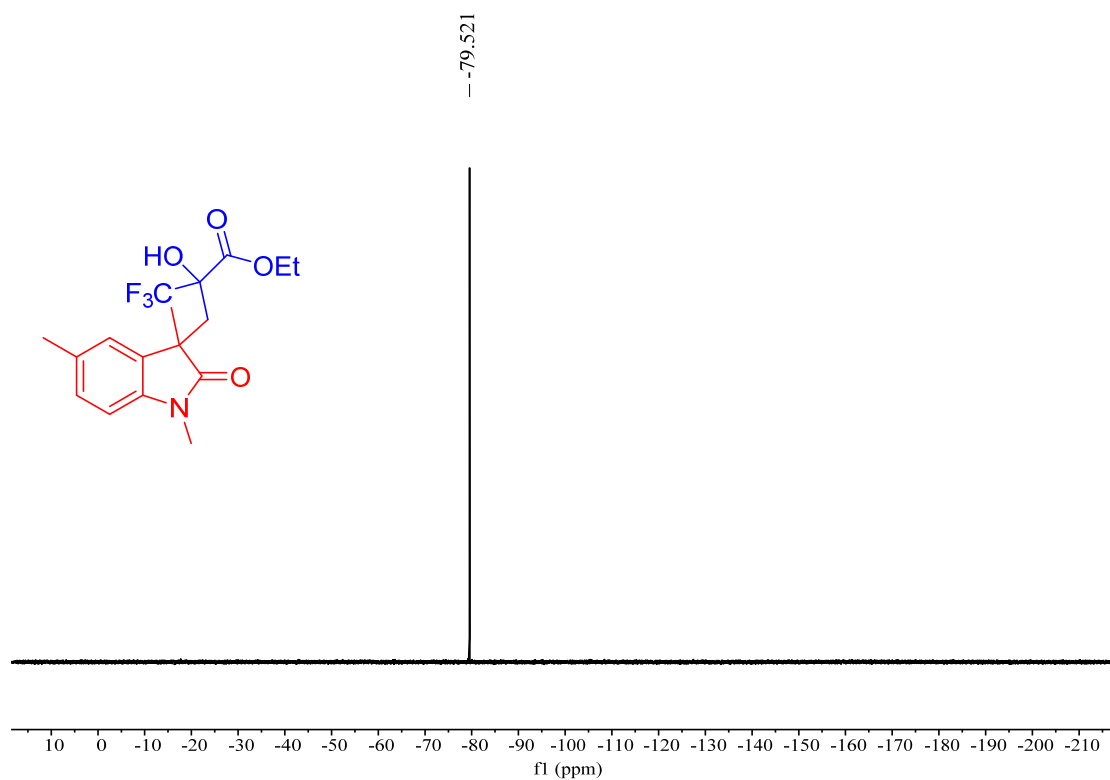
¹H NMR of **4** (anti isomer) (400 MHz, CDCl₃)



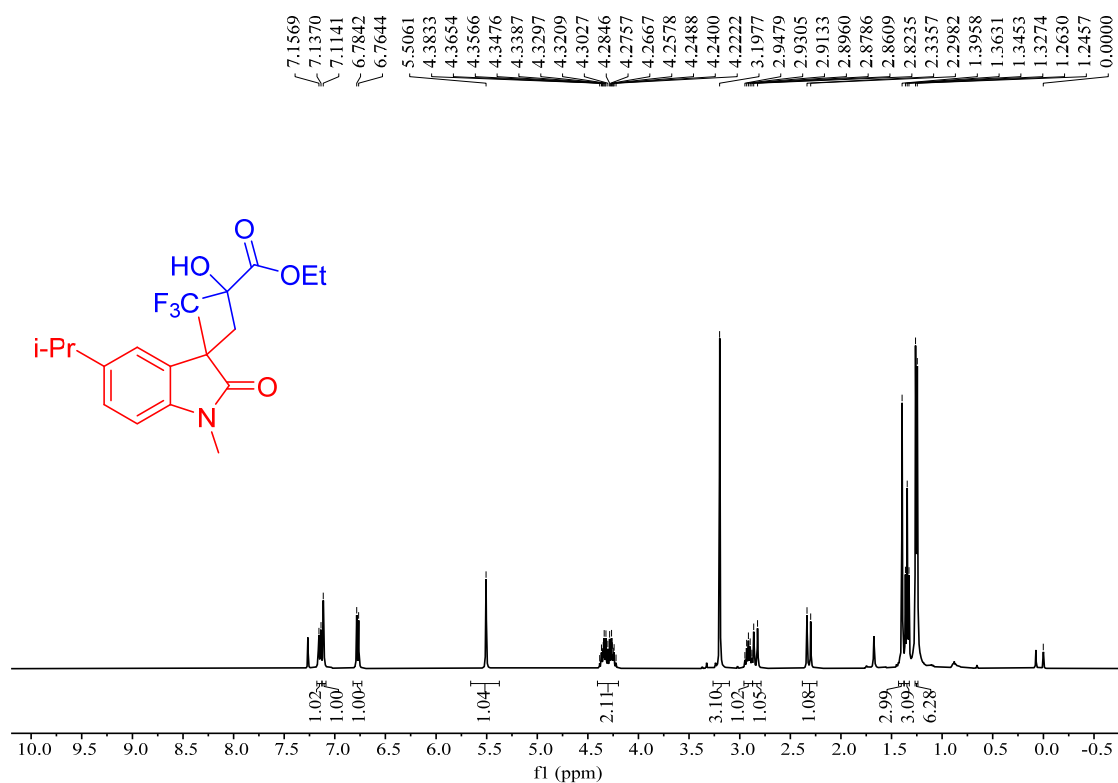
¹³C NMR of **4** (anti isomer) (101 MHz, CDCl₃)



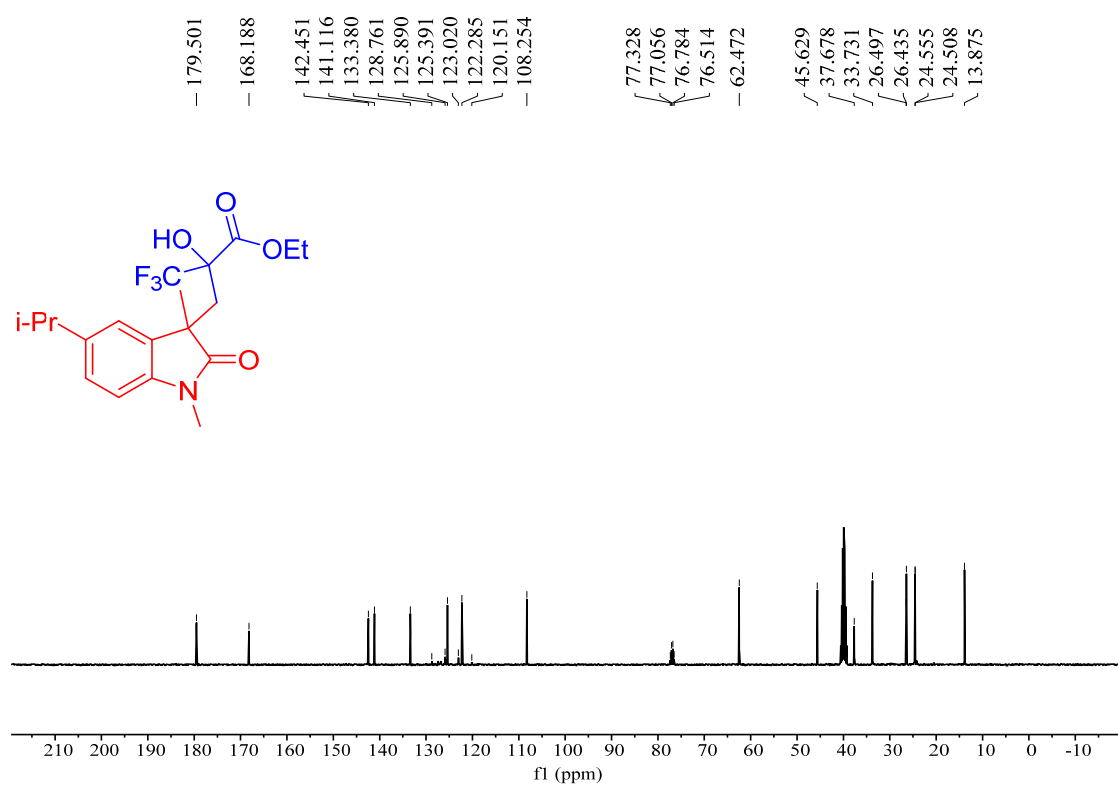
¹⁹F NMR of **4** (anti isomer) (376 MHz, CDCl₃)



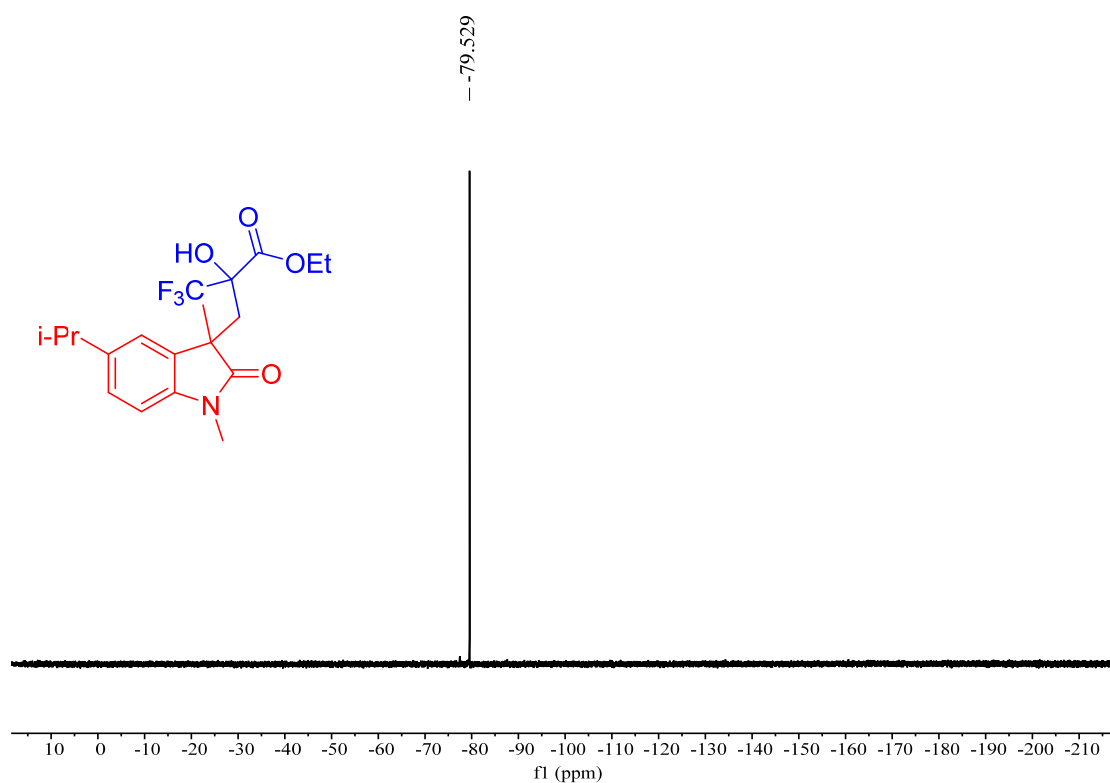
¹H NMR of **5** (syn isomer) (400 MHz, CDCl₃)



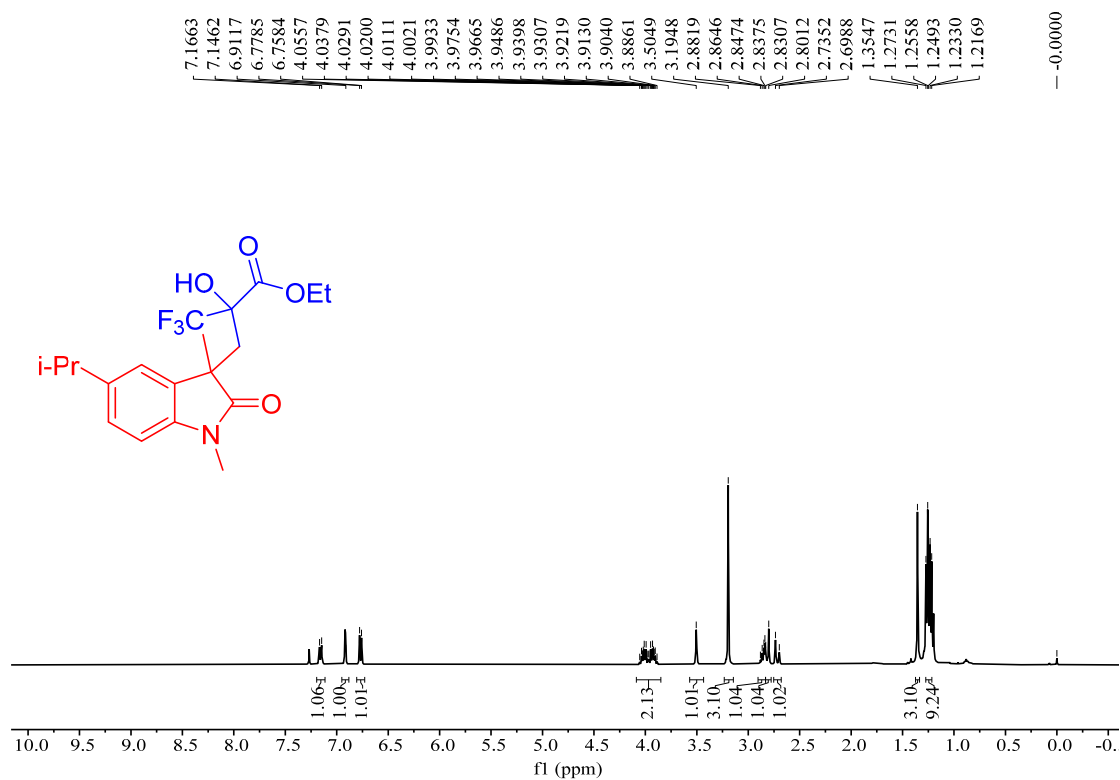
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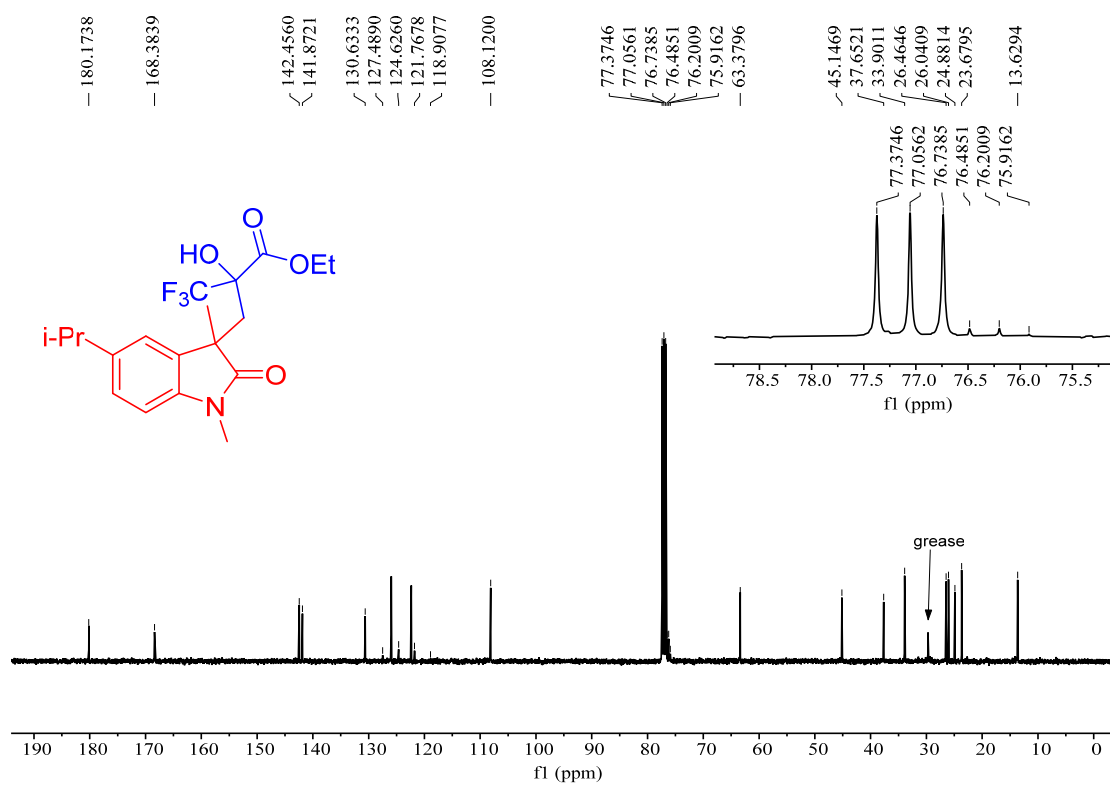
¹⁹F NMR of **5** (syn isomer) (376 MHz, CDCl₃)



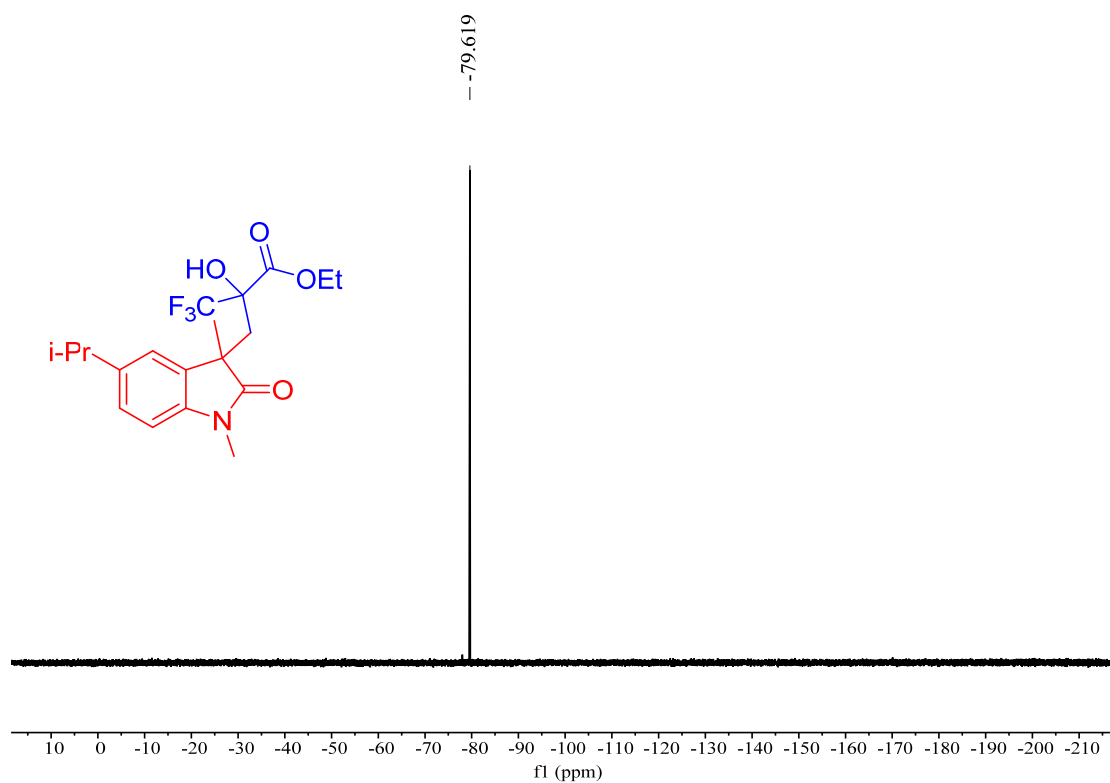
¹H NMR of **5** (anti isomer) (400 MHz, CDCl₃)



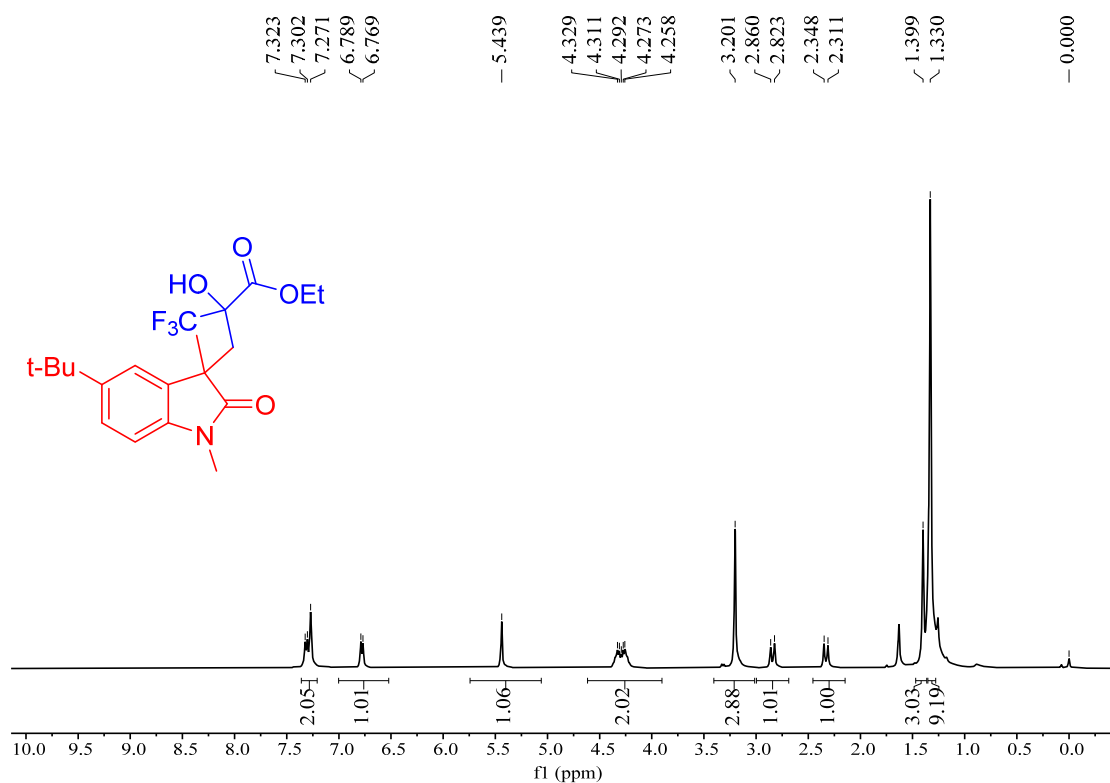
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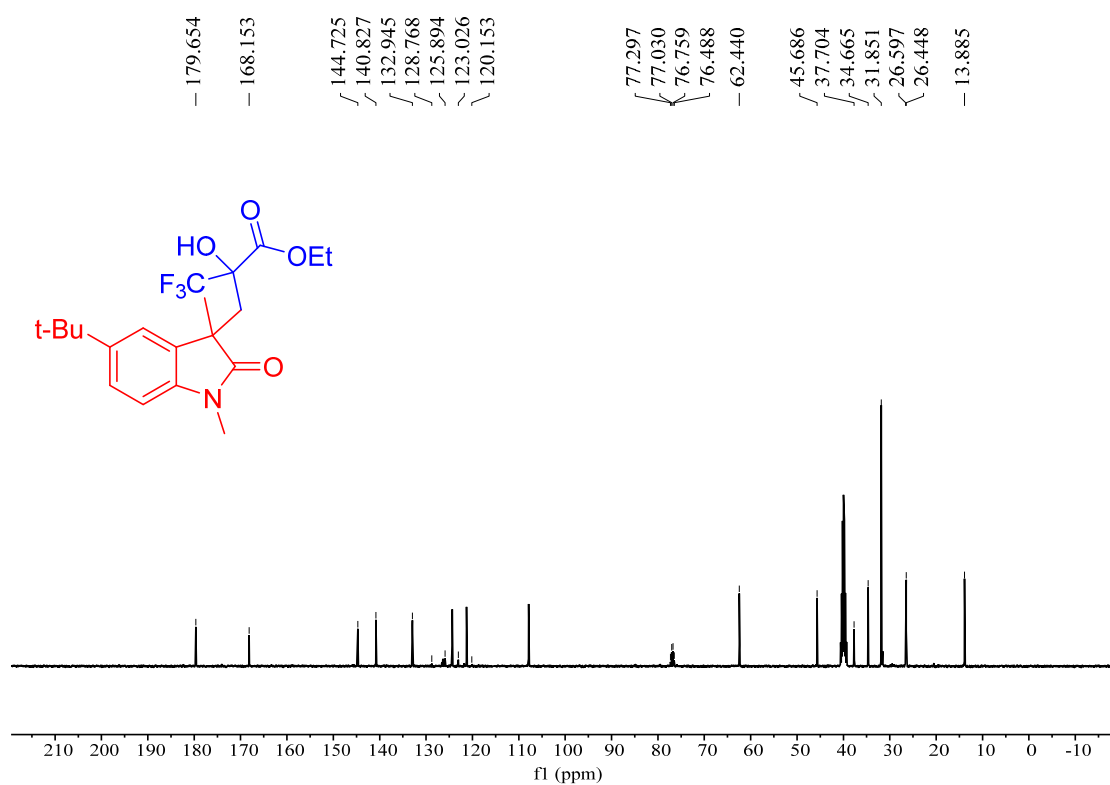
¹⁹F NMR of **5** (anti isomer) (376 MHz, CDCl₃)



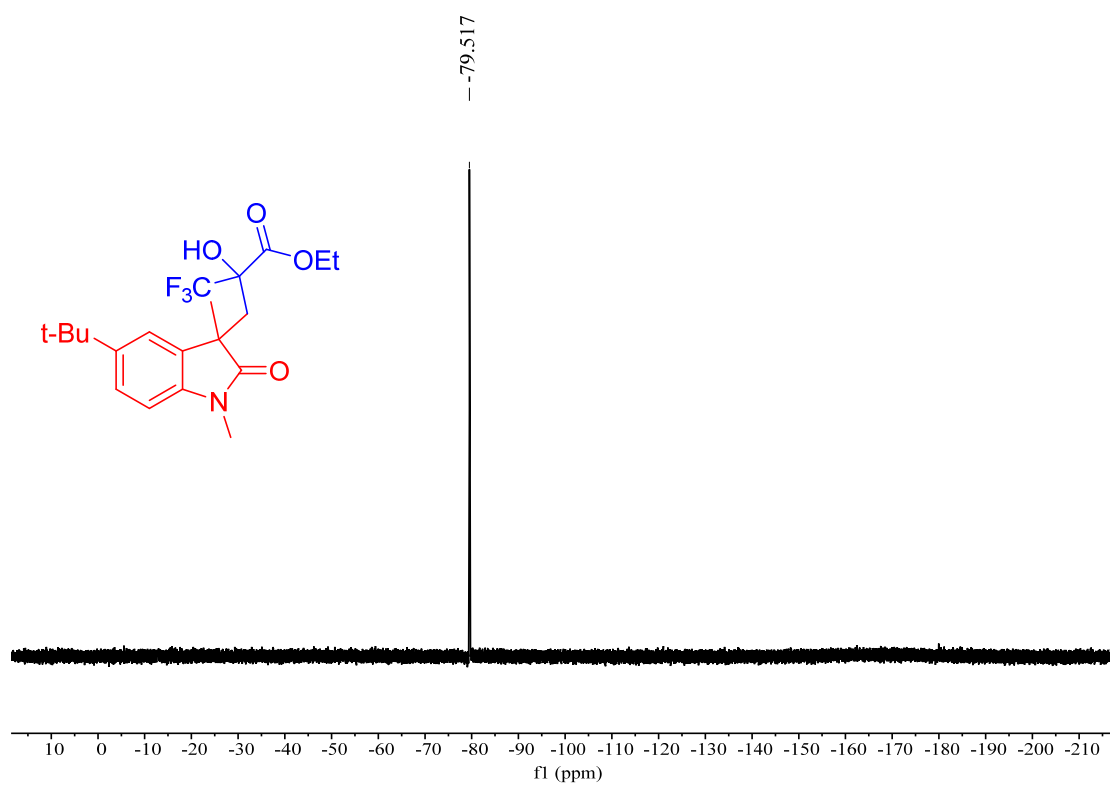
¹H NMR of **6** (syn isomer) (400 MHz, CDCl₃)



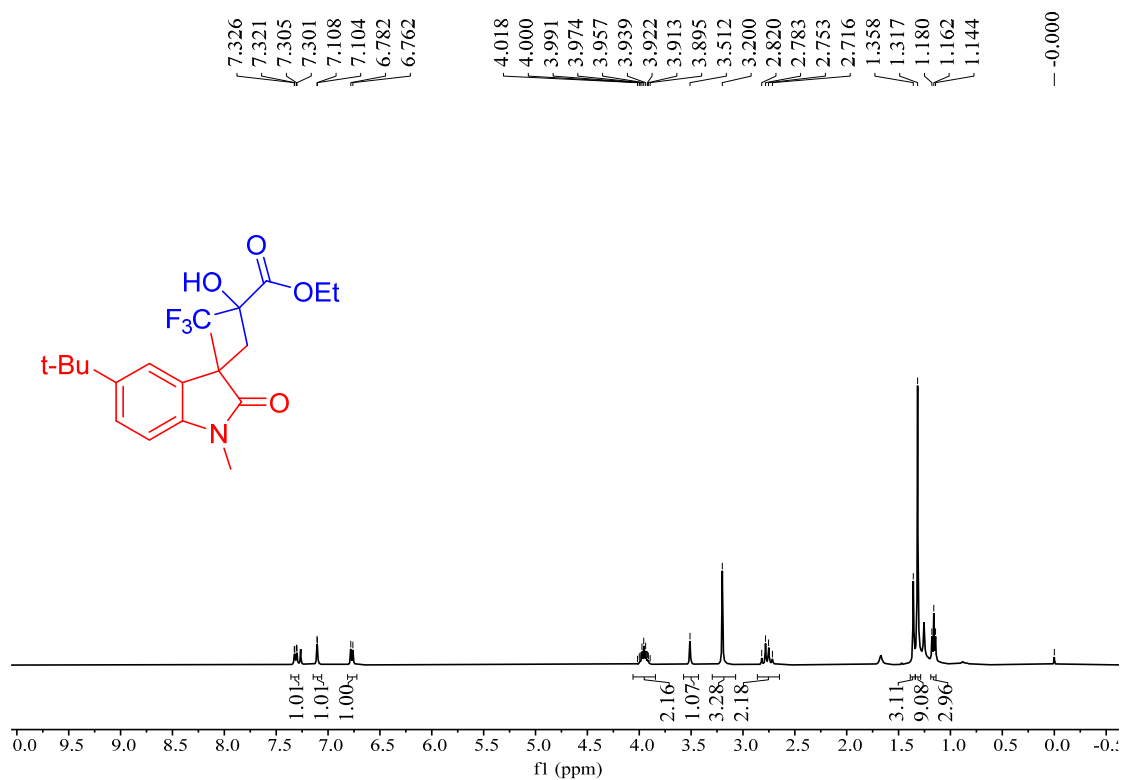
¹³C NMR of **6** (syn isomer) (101 MHz, DMSO-*d*₆)



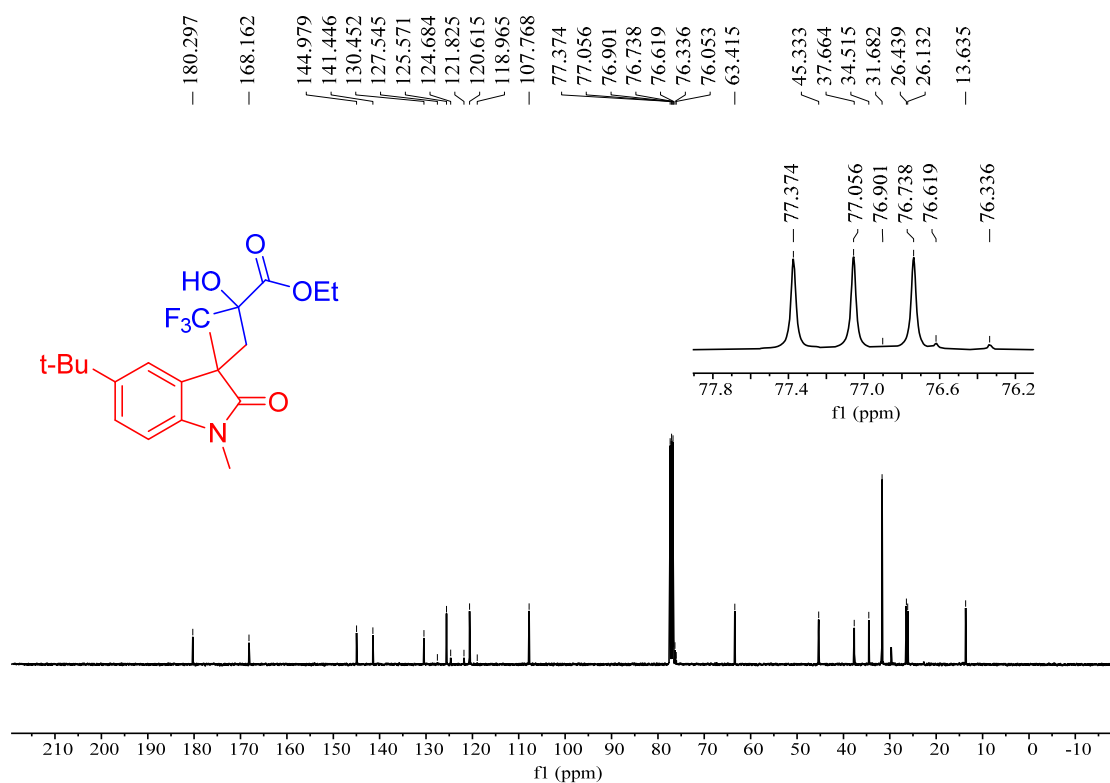
¹⁹F NMR of **6** (syn isomer) (376 MHz, CDCl₃)



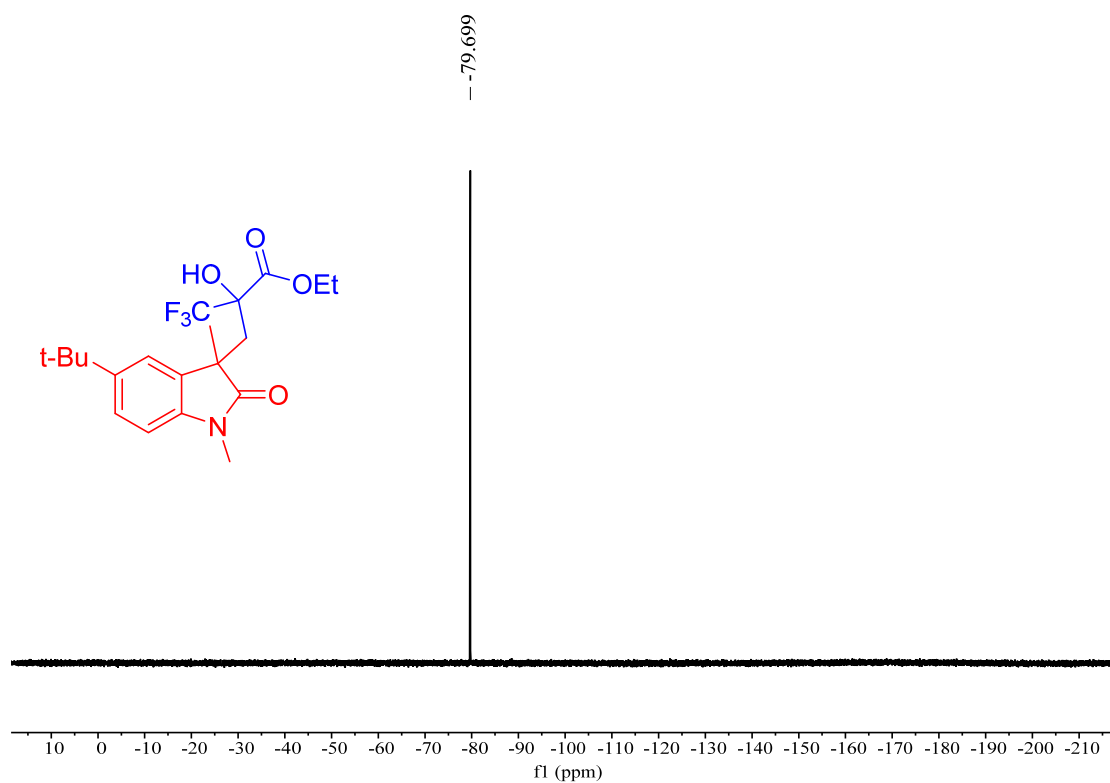
¹H NMR of **6** (anti isomer) (400 MHz, CDCl₃)



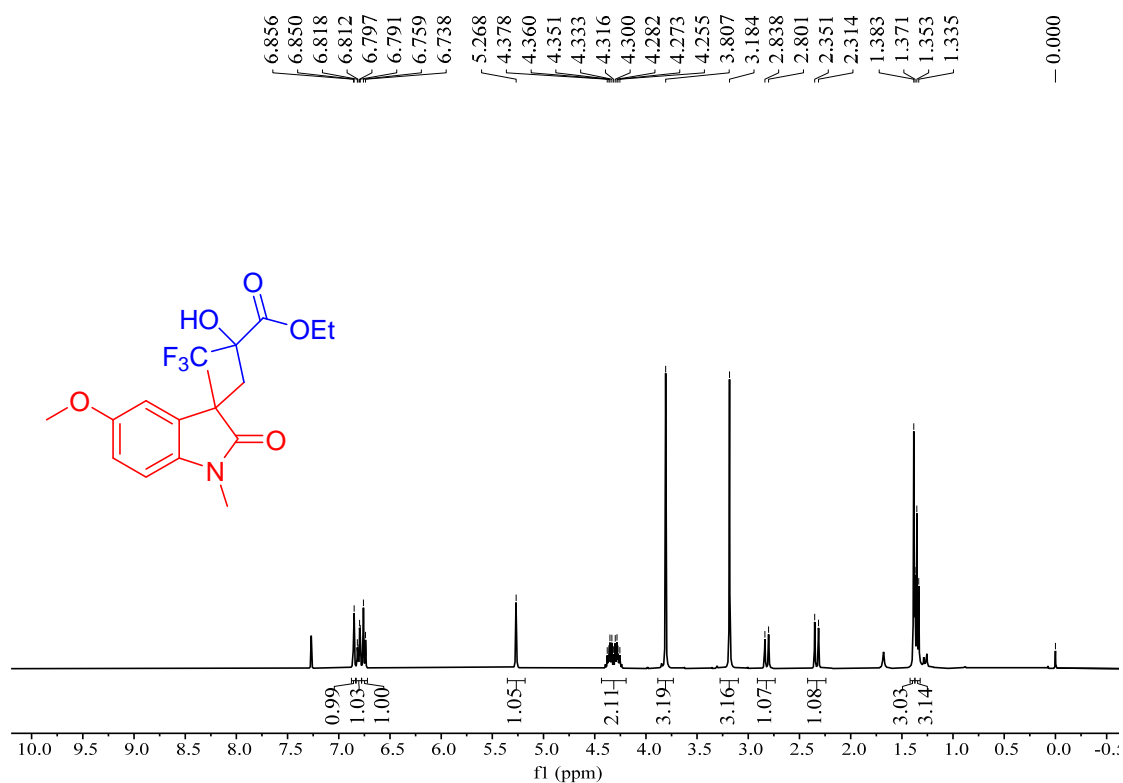
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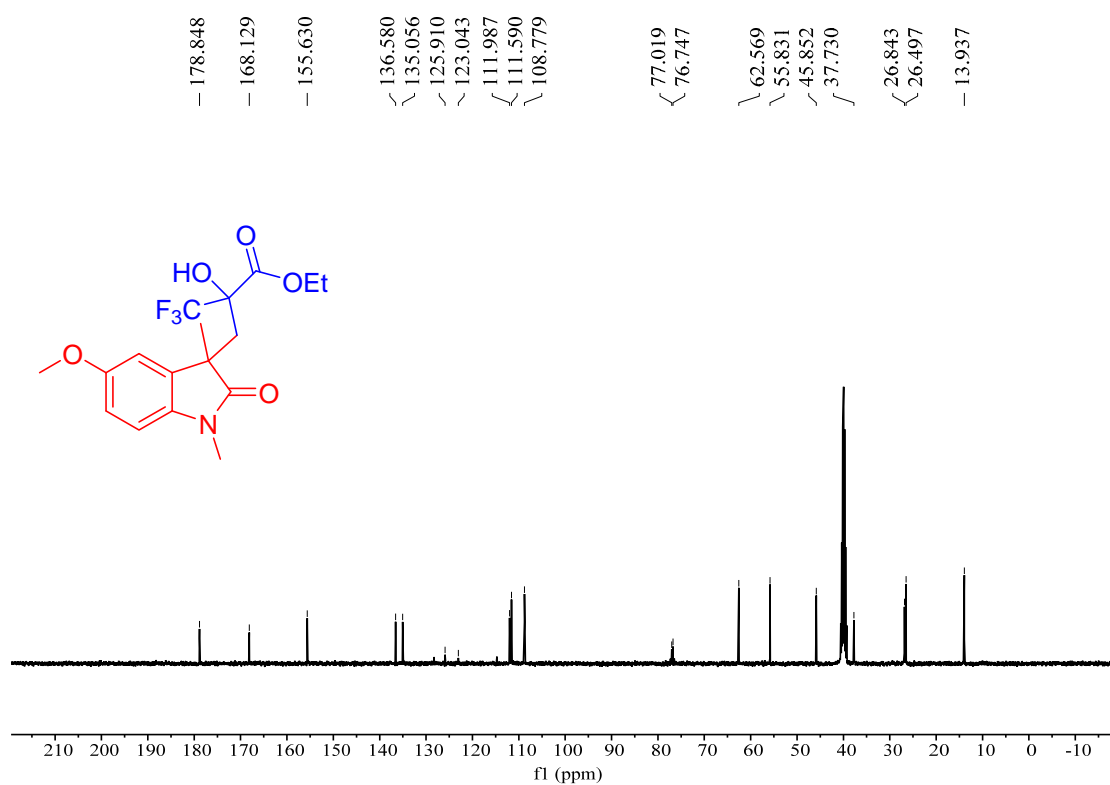
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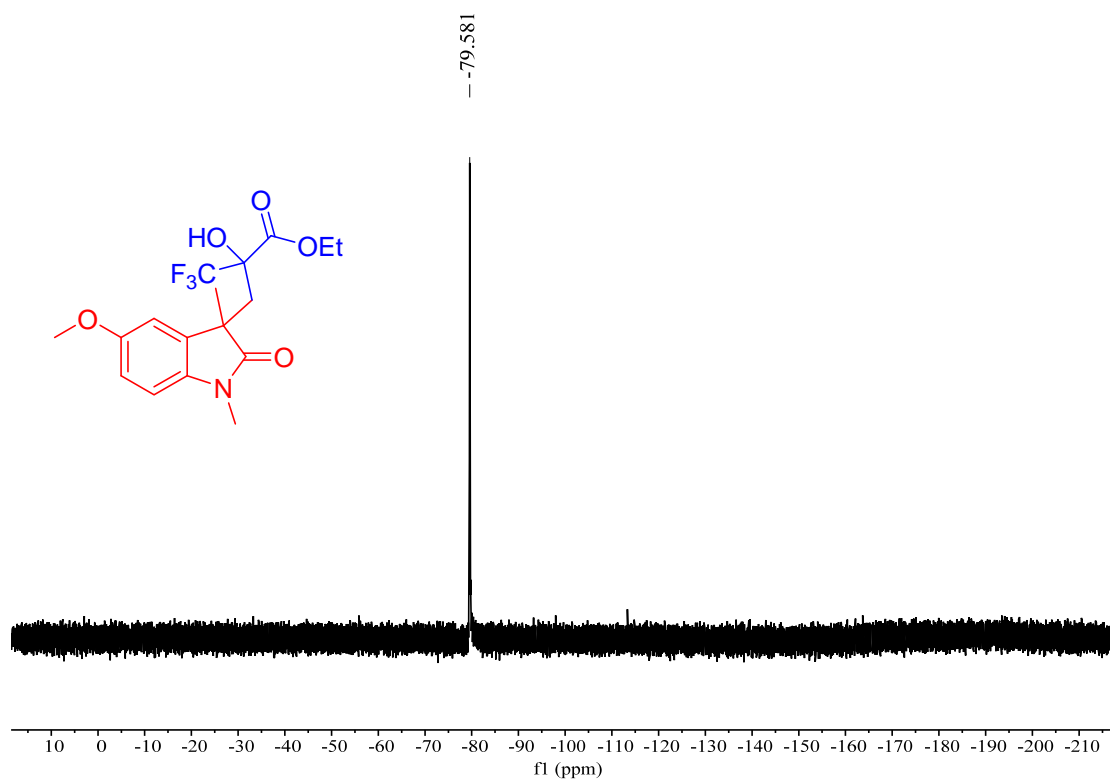
¹H NMR of **7** (syn isomer) (400 MHz, CDCl₃)



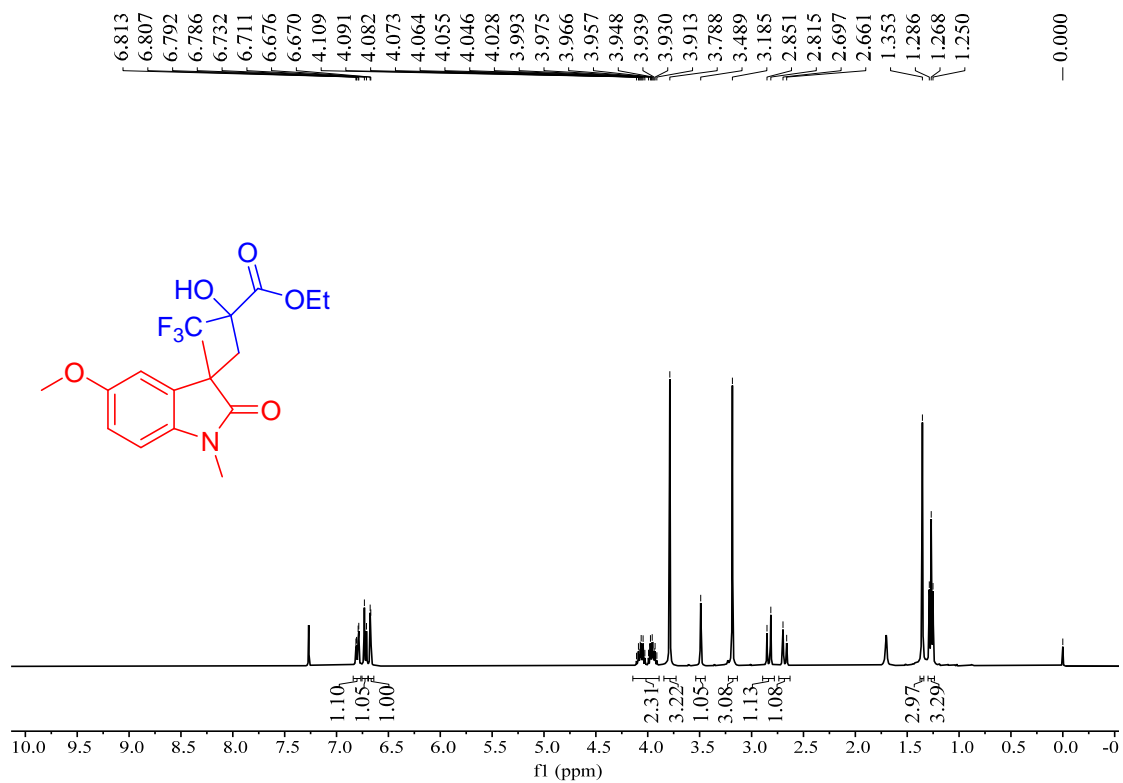
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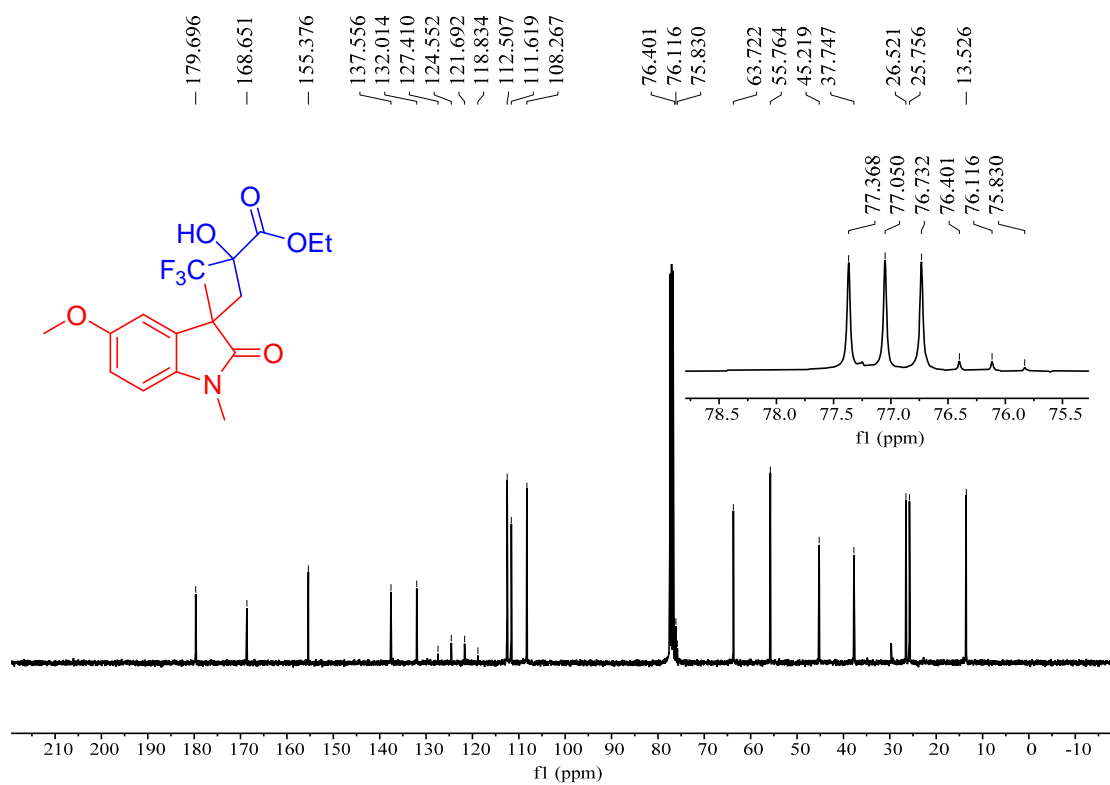
^{19}F NMR of **7** (syn isomer) (376 MHz, CDCl_3)



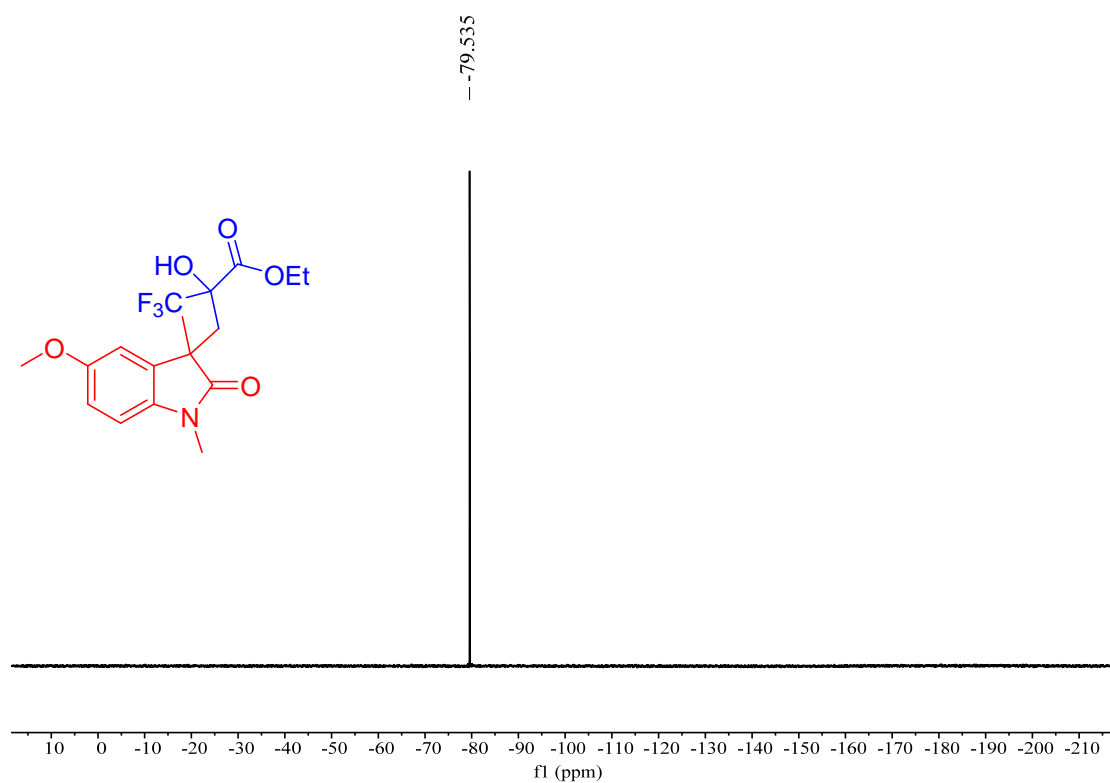
^1H NMR of **7** (anti isomer) (400 MHz, CDCl_3)



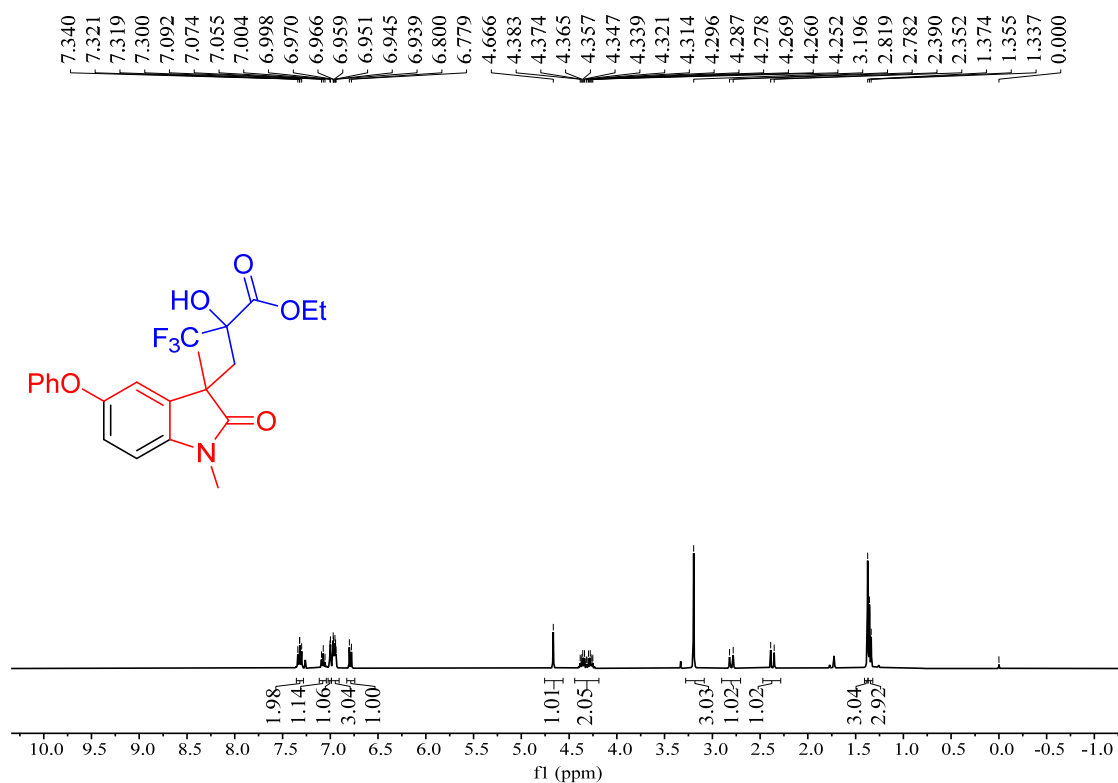
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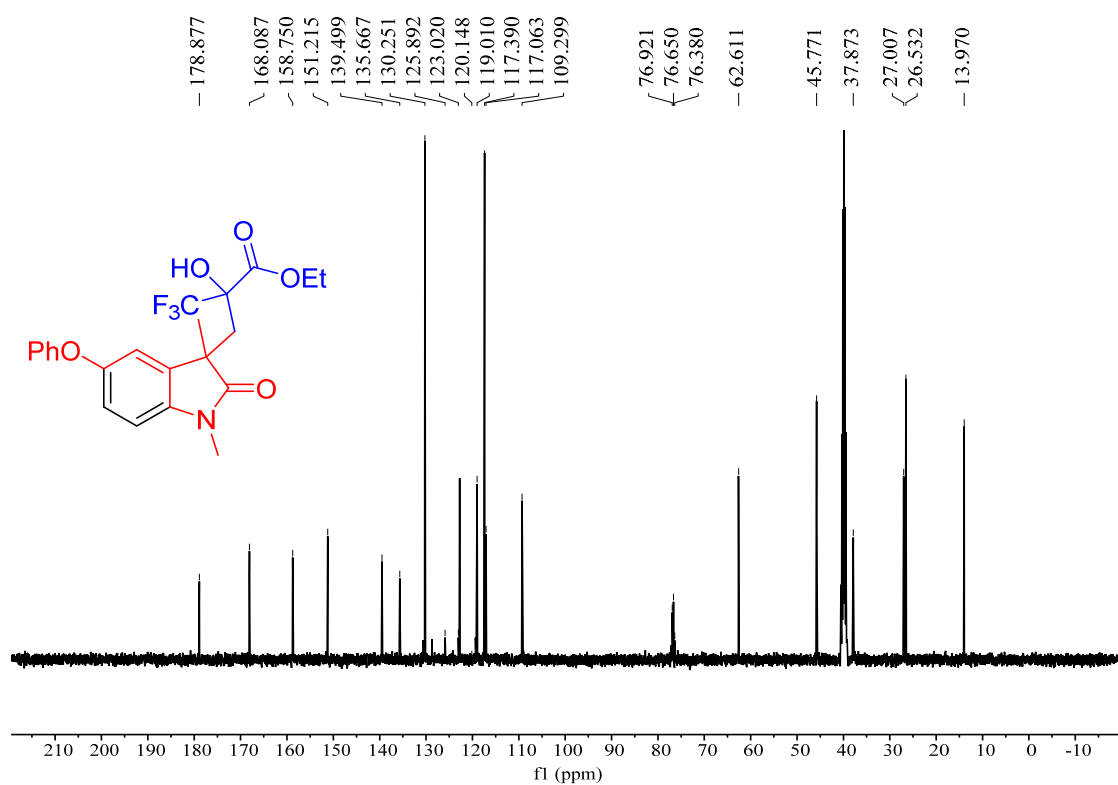
¹⁹F NMR of **7** (anti isomer) (376 MHz, CDCl₃)



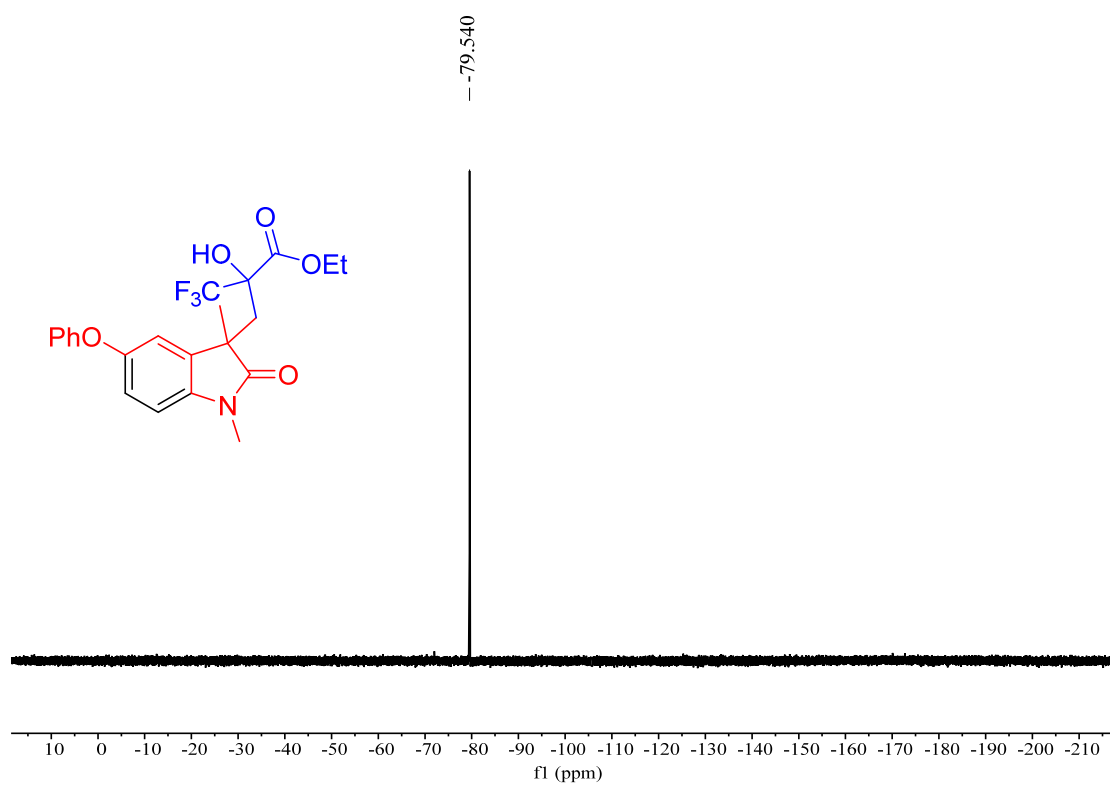
¹H NMR of **8** (syn isomer) (400 MHz, CDCl₃)



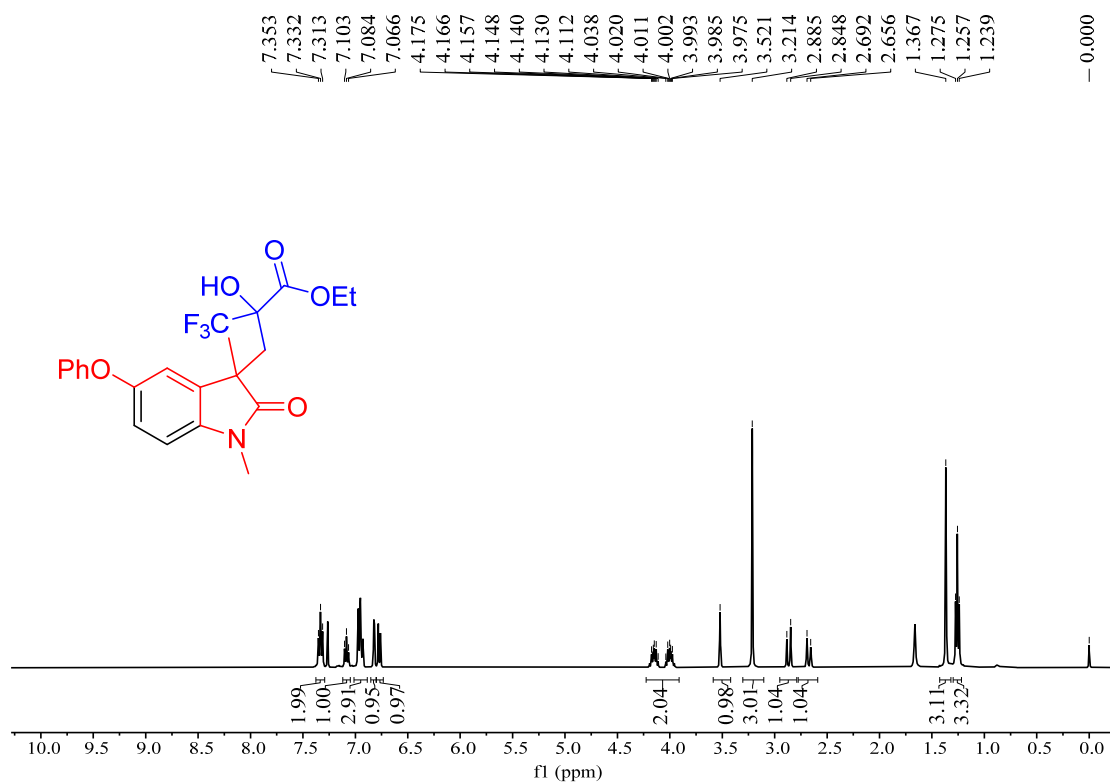
¹³C NMR of **8** (syn isomer) (101 MHz, DMSO-*d*₆)



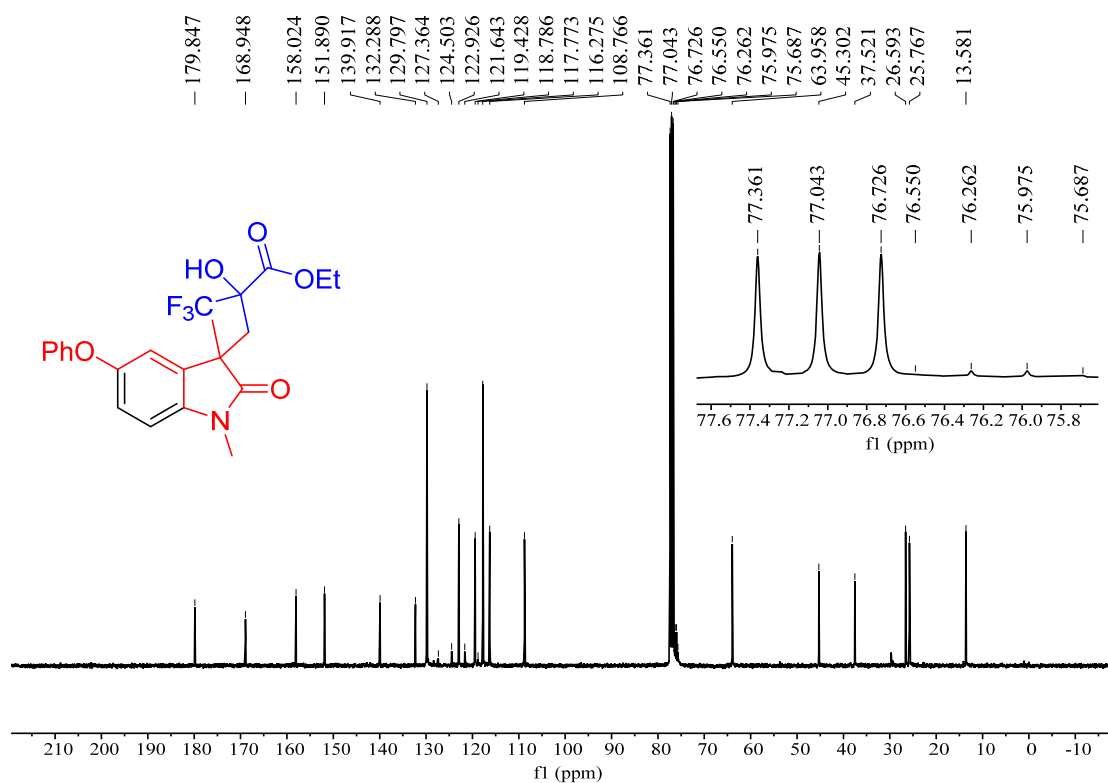
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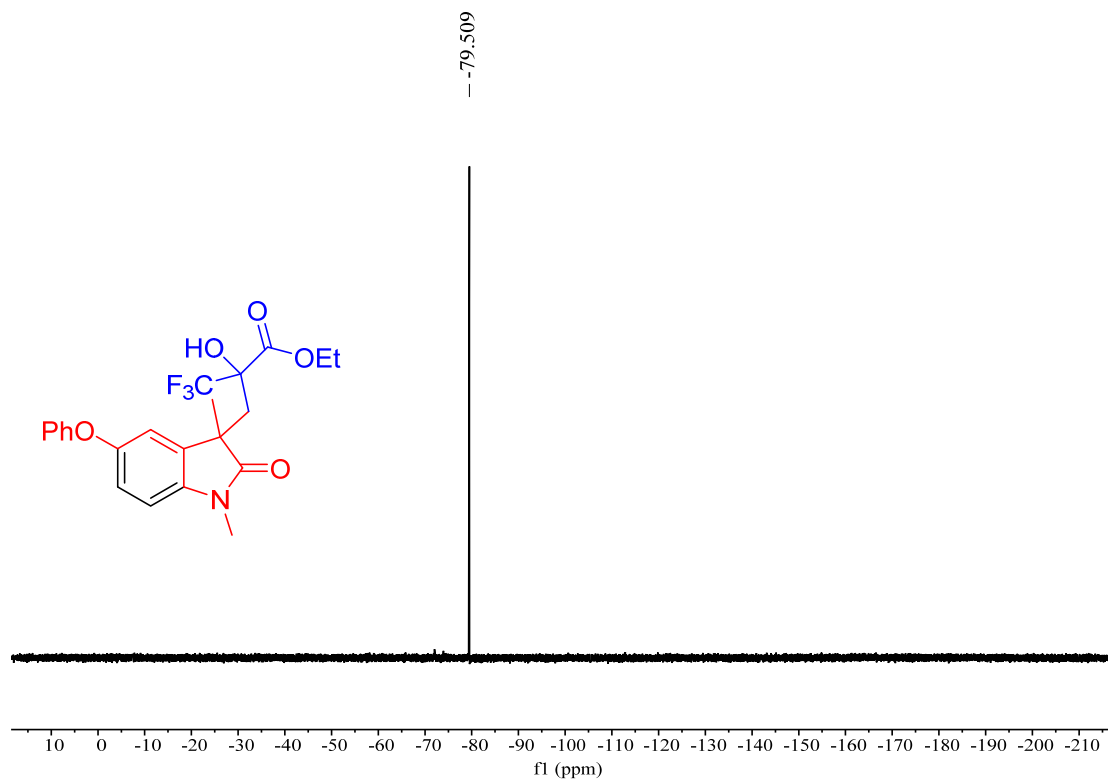
^1H NMR of **8** (anti isomer) (400 MHz, CDCl_3)



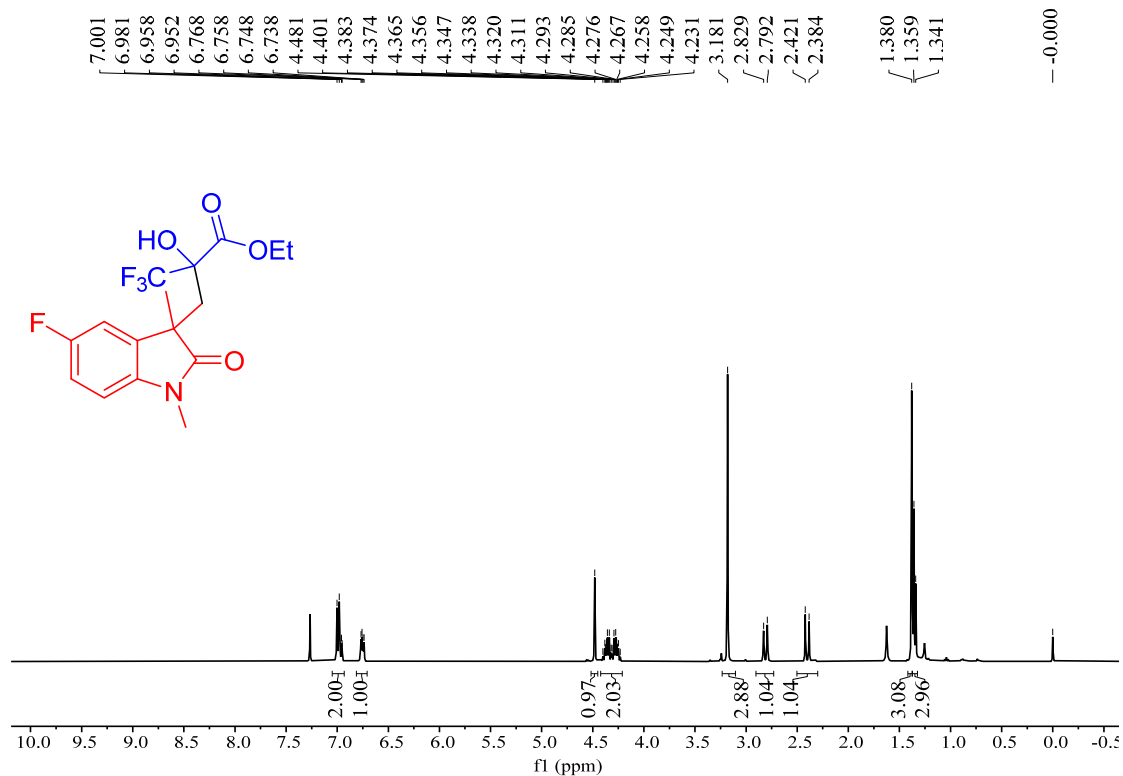
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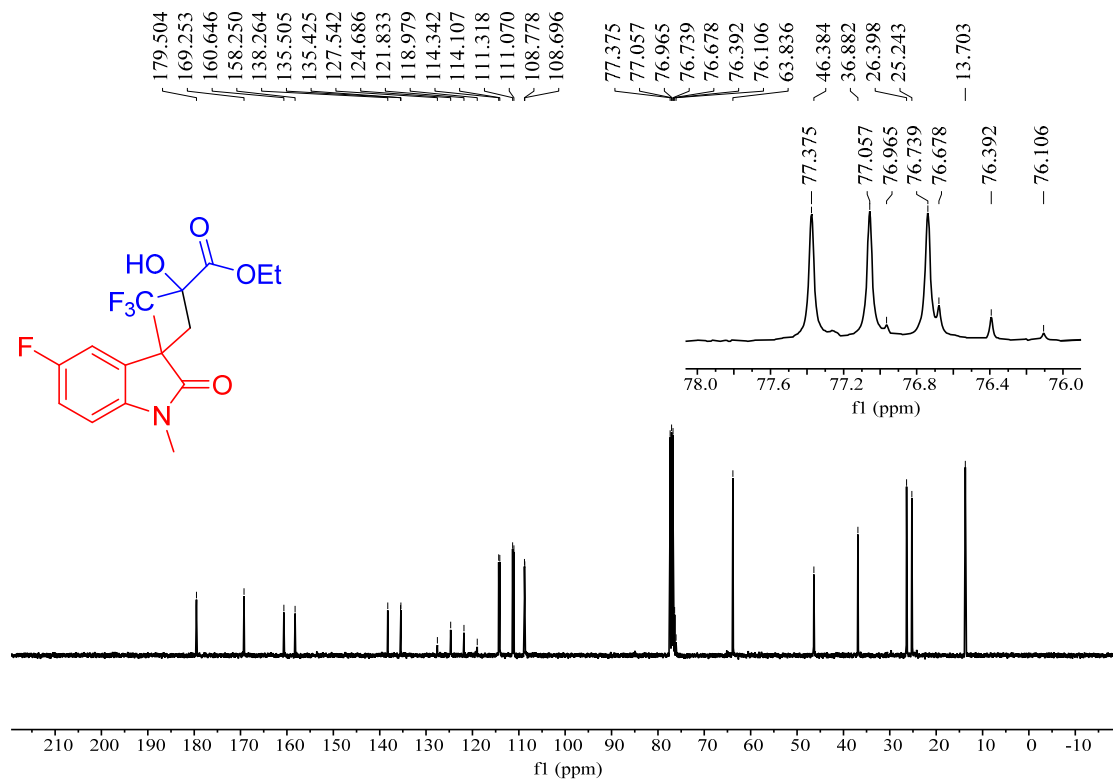
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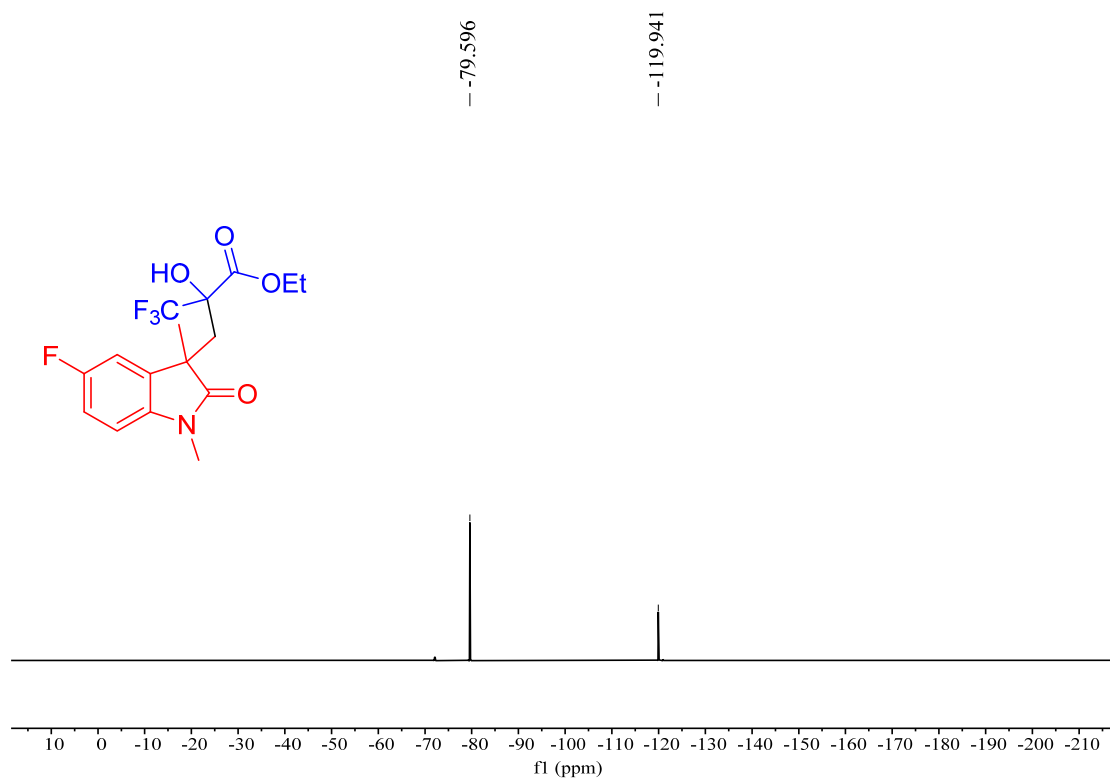
¹H NMR of **9** (syn isomer) (400 MHz, CDCl₃)



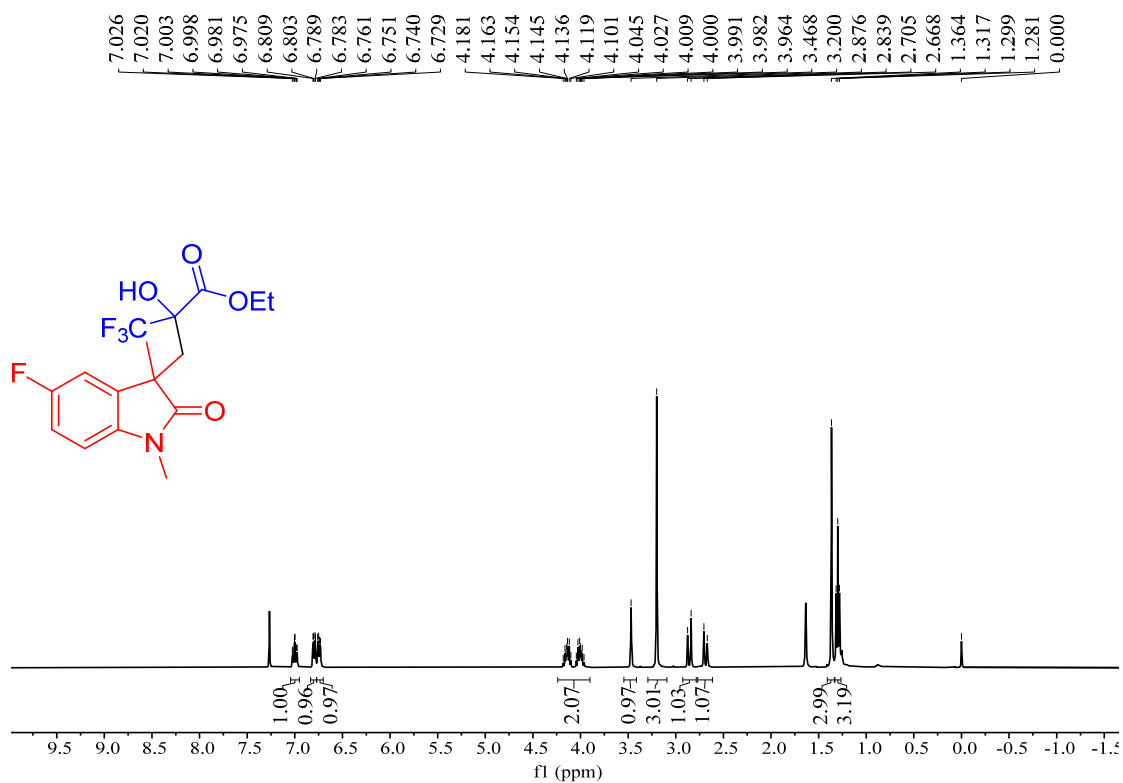
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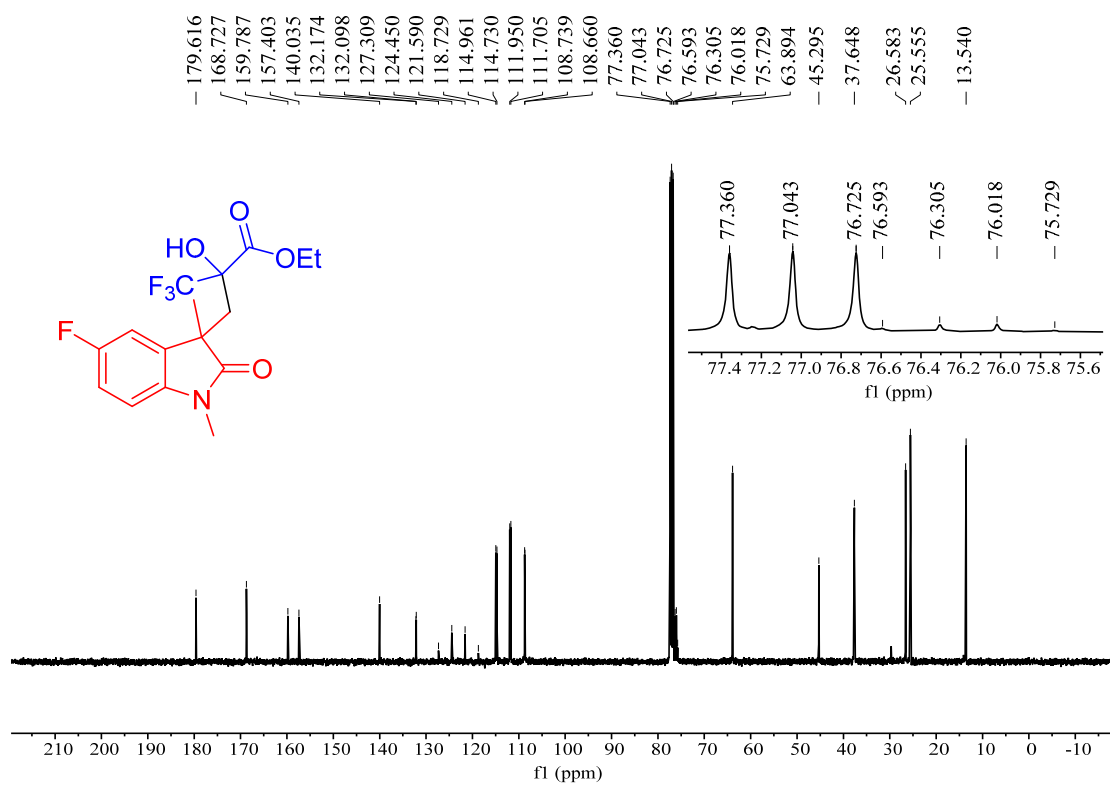
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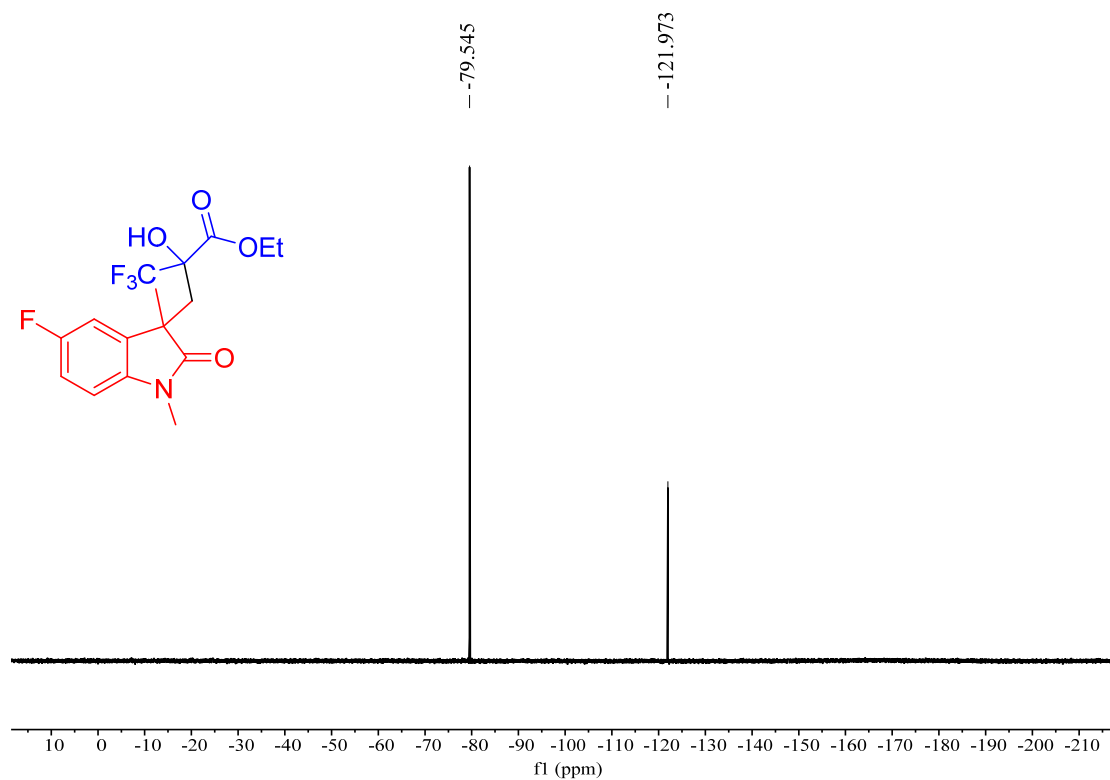
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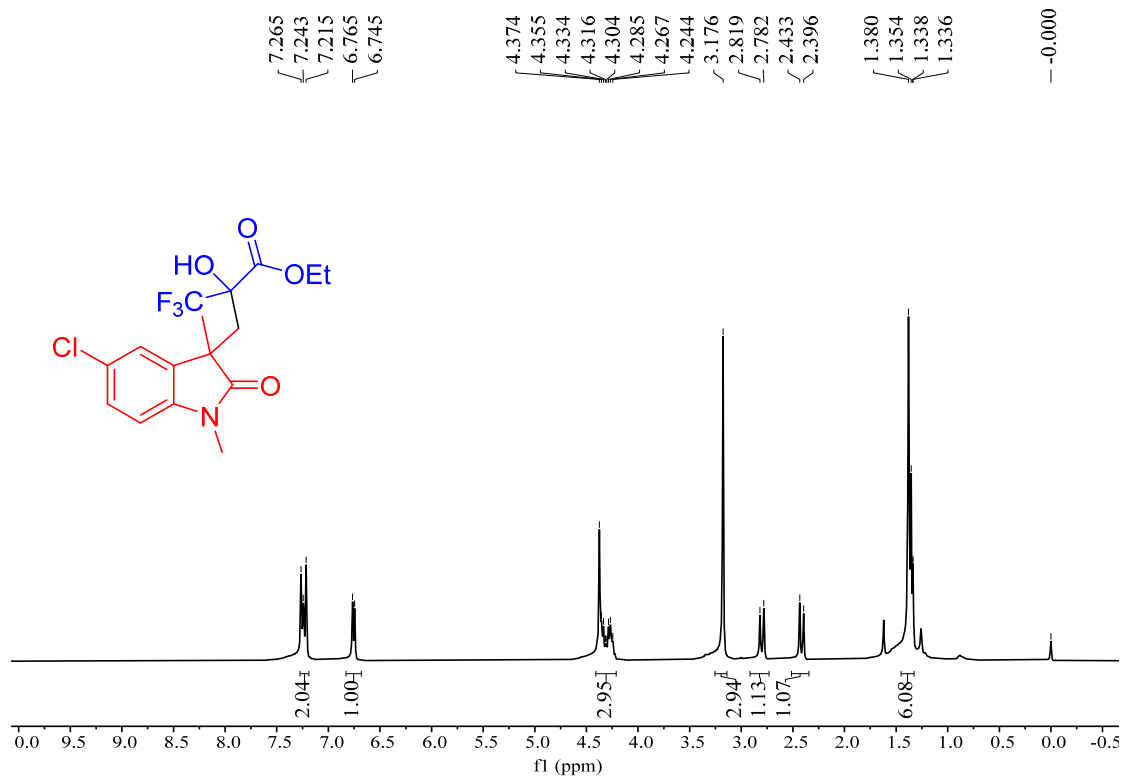
¹³C NMR of **9** (anti isomer) (101 MHz, CDCl₃)



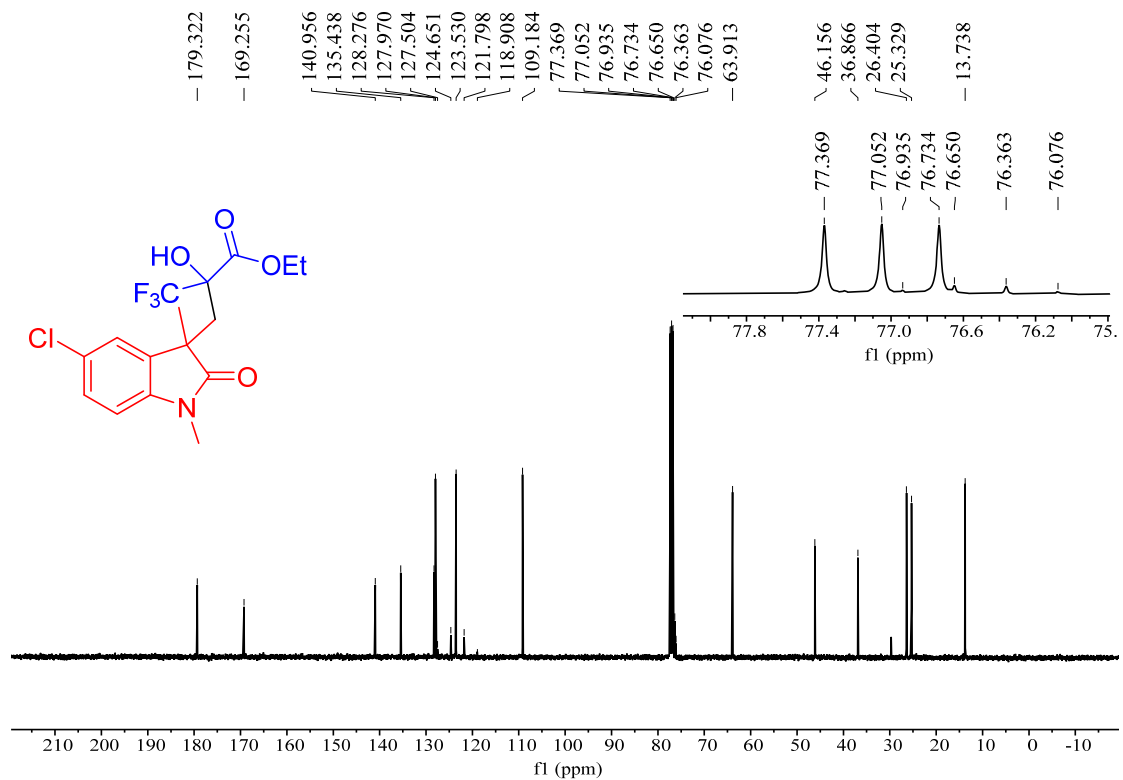
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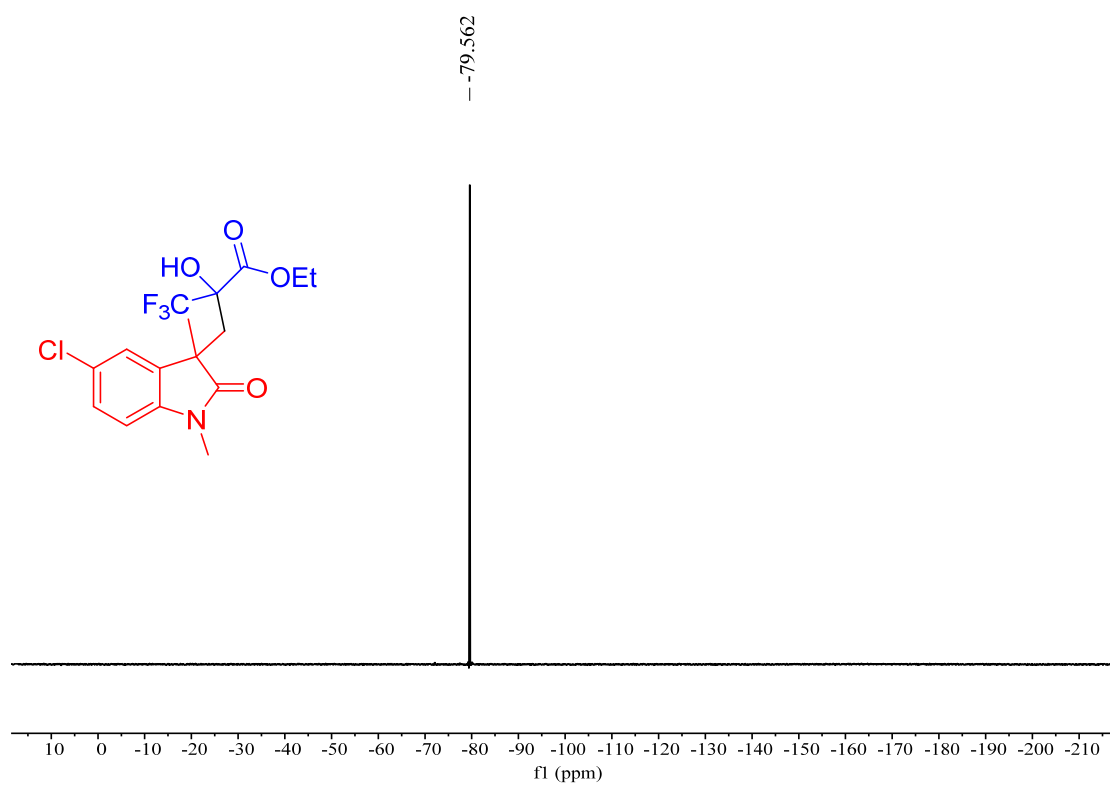
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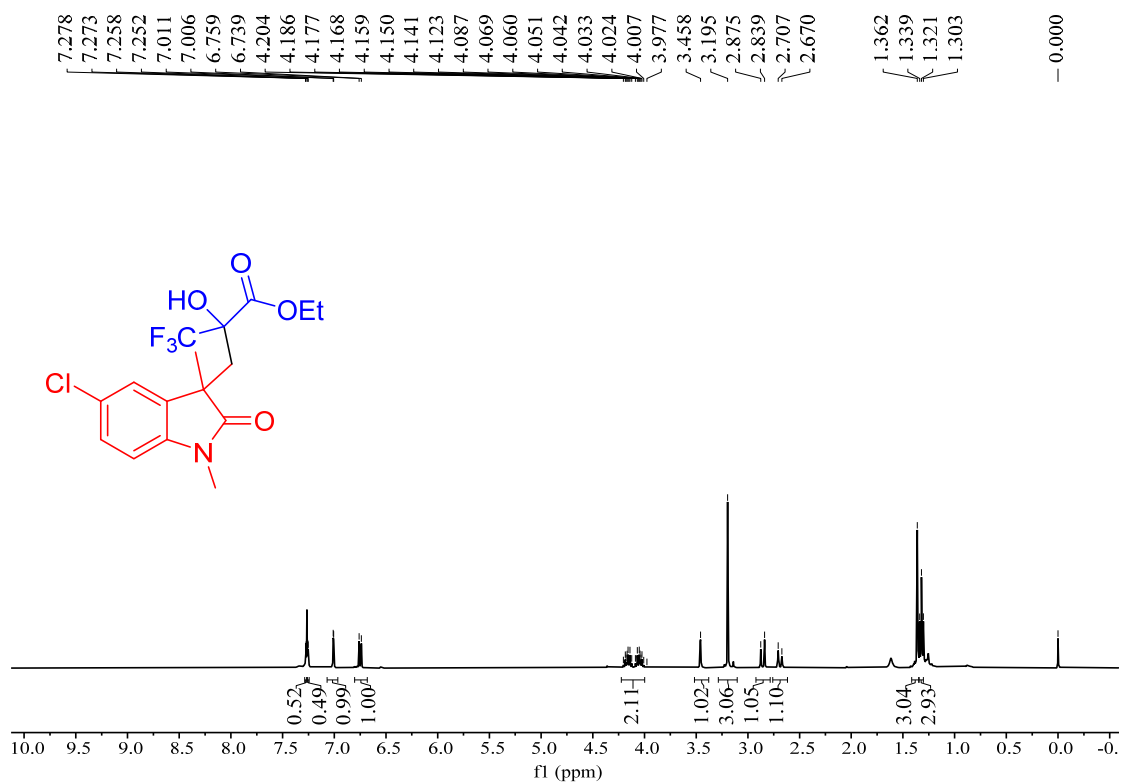
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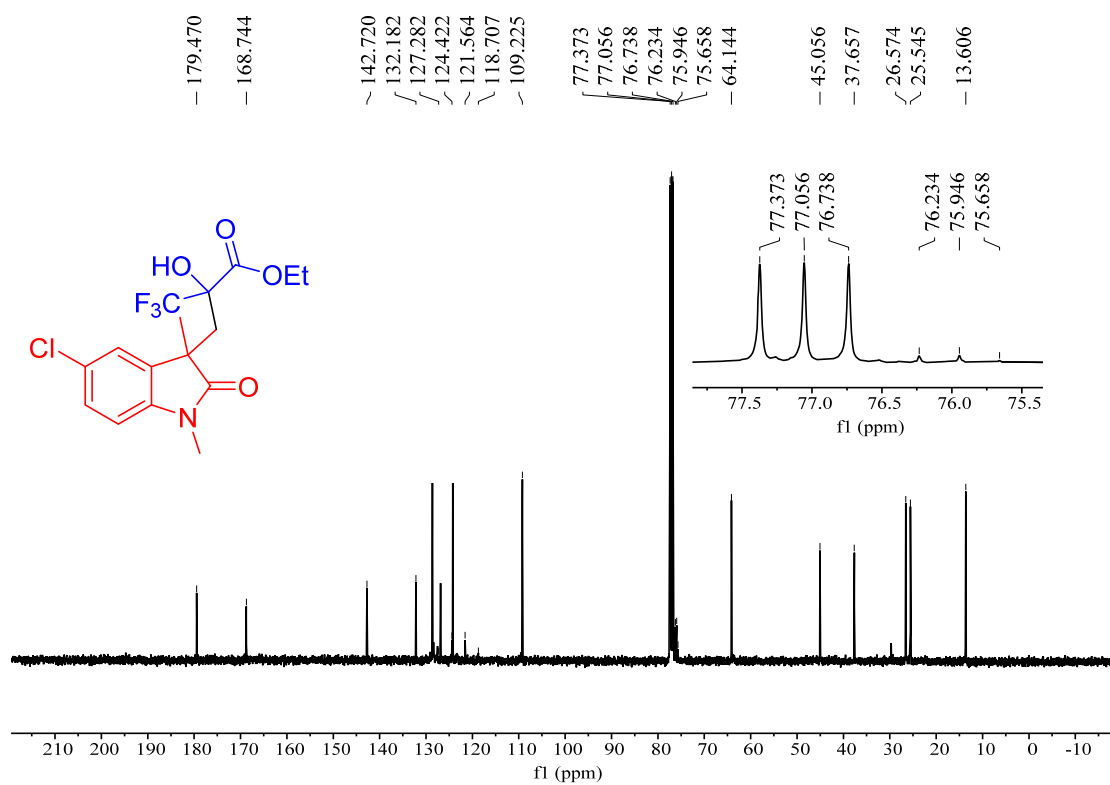
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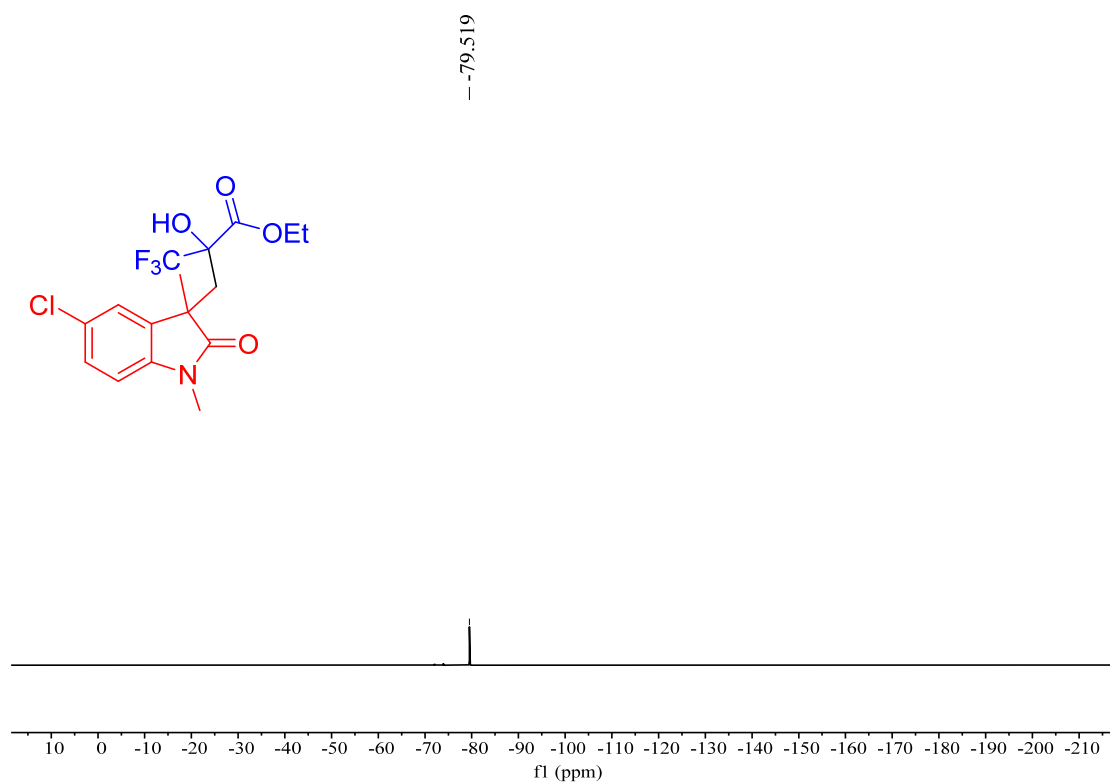
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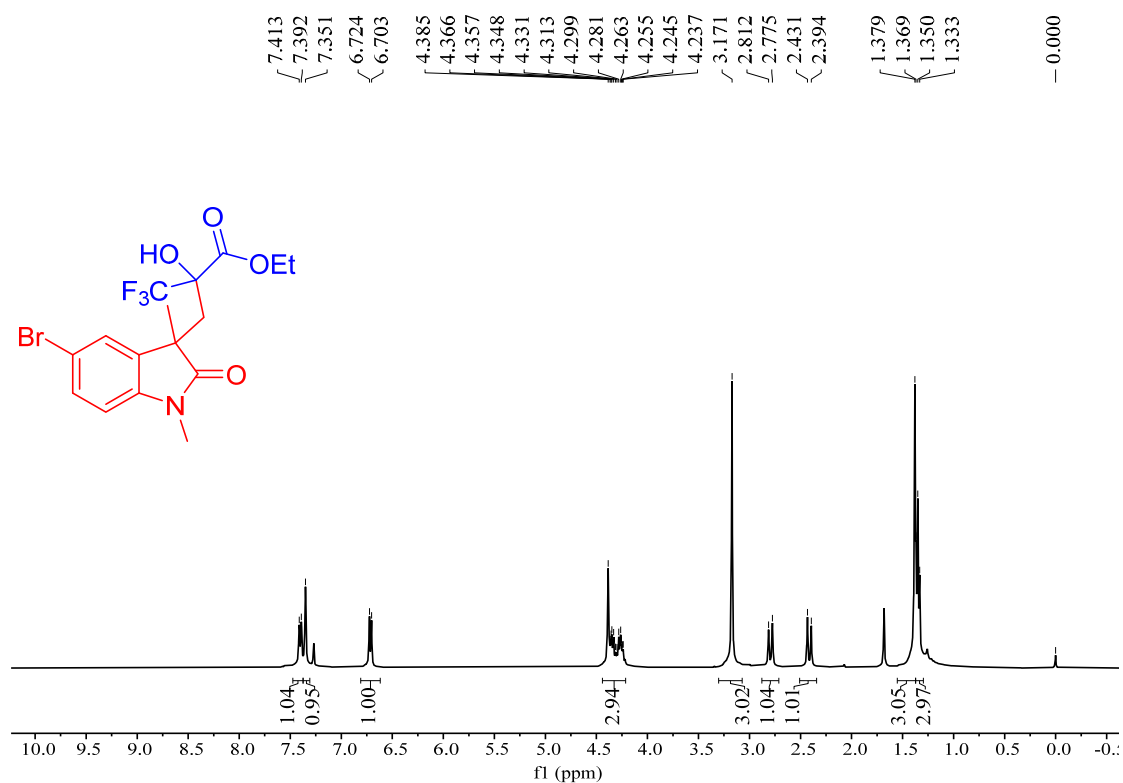
¹³C NMR of **10** (anti isomer) (101 MHz, CDCl₃)



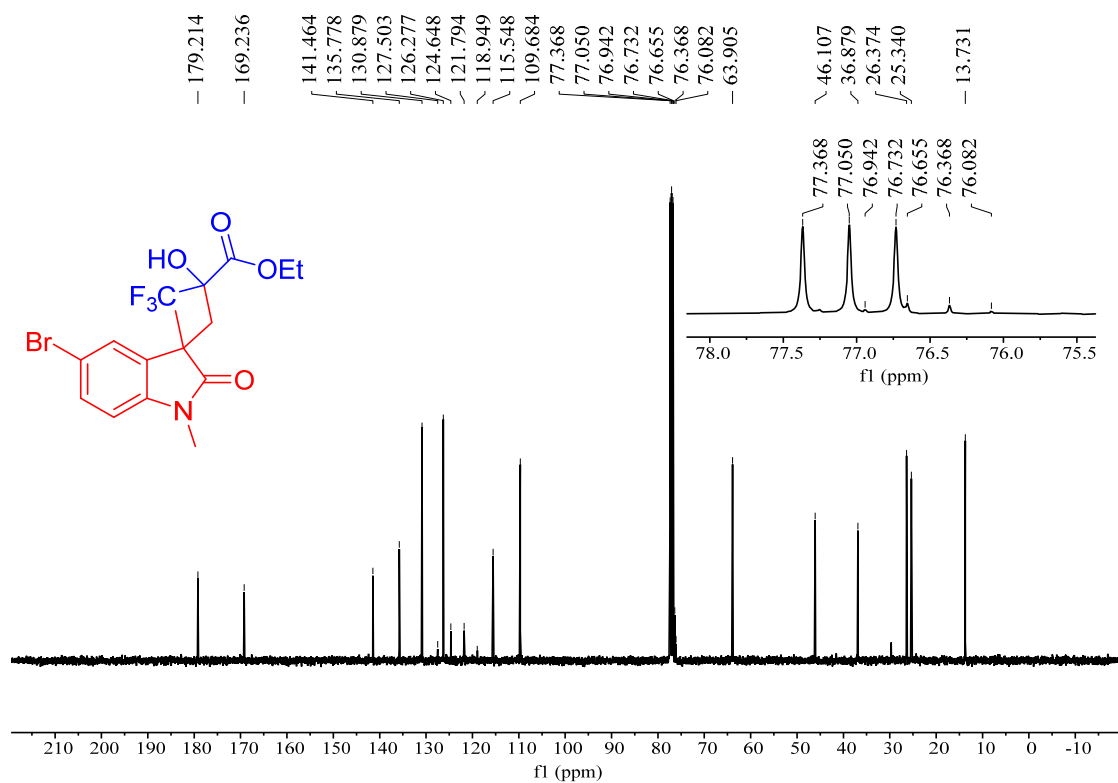
¹⁹F NMR of **10** (anti isomer) (376 MHz, CDCl₃)



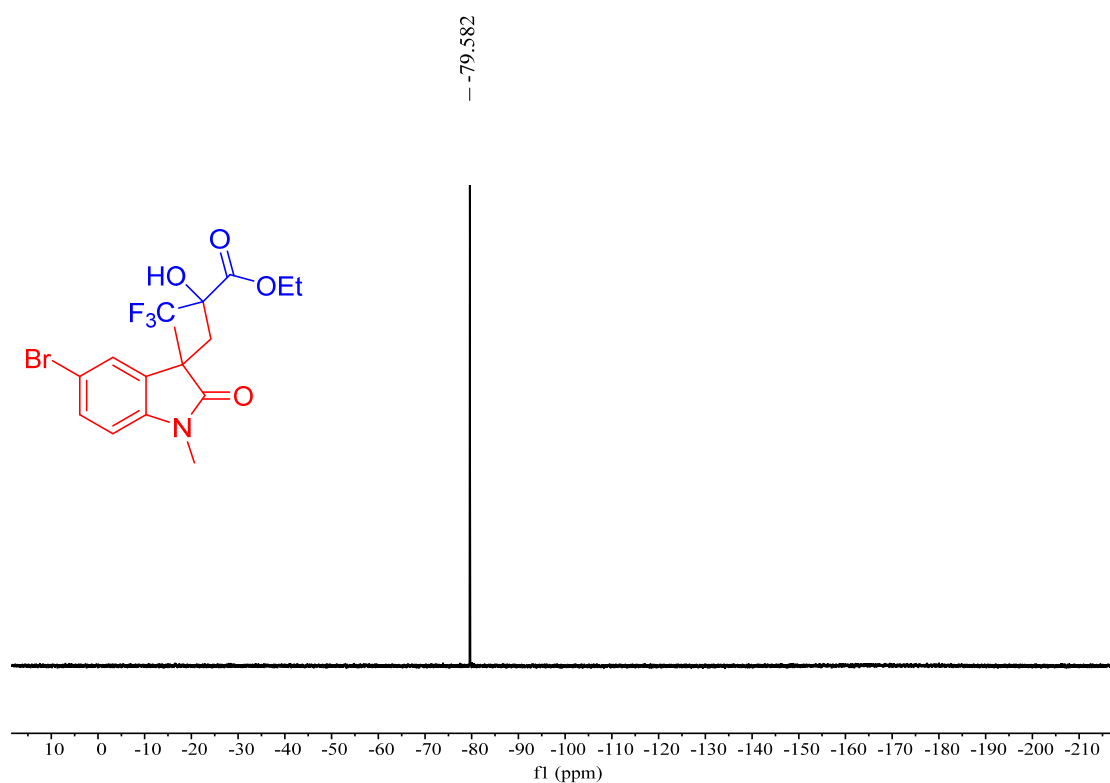
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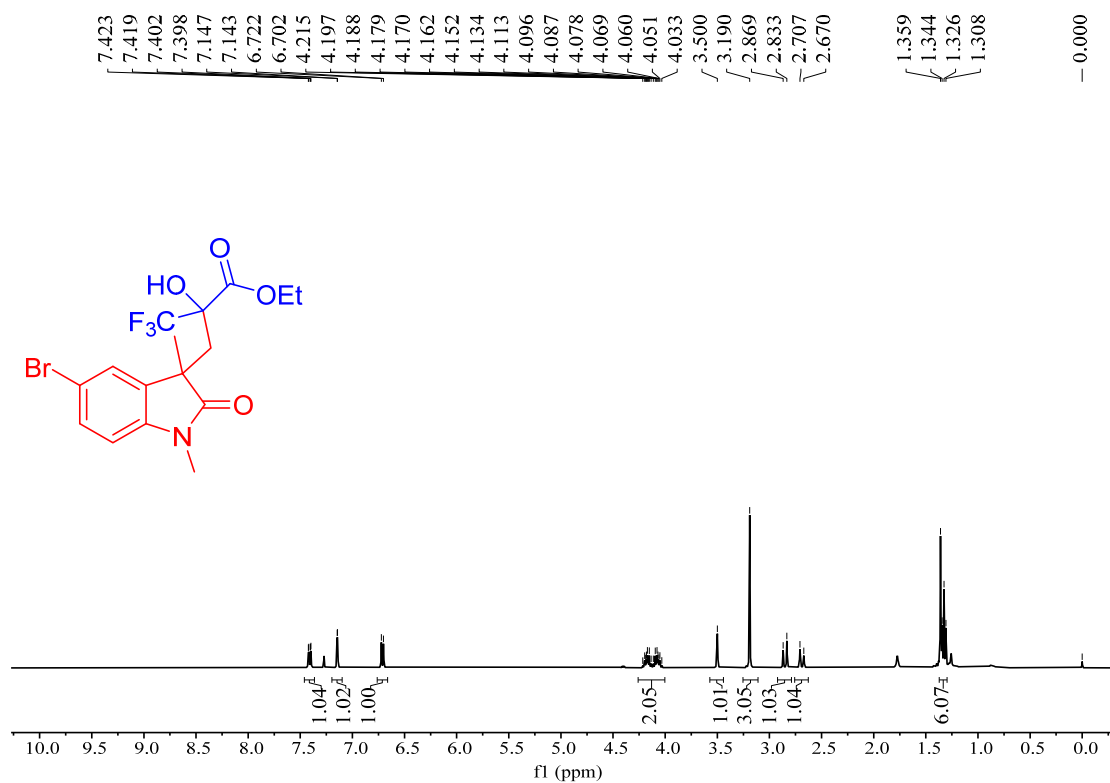
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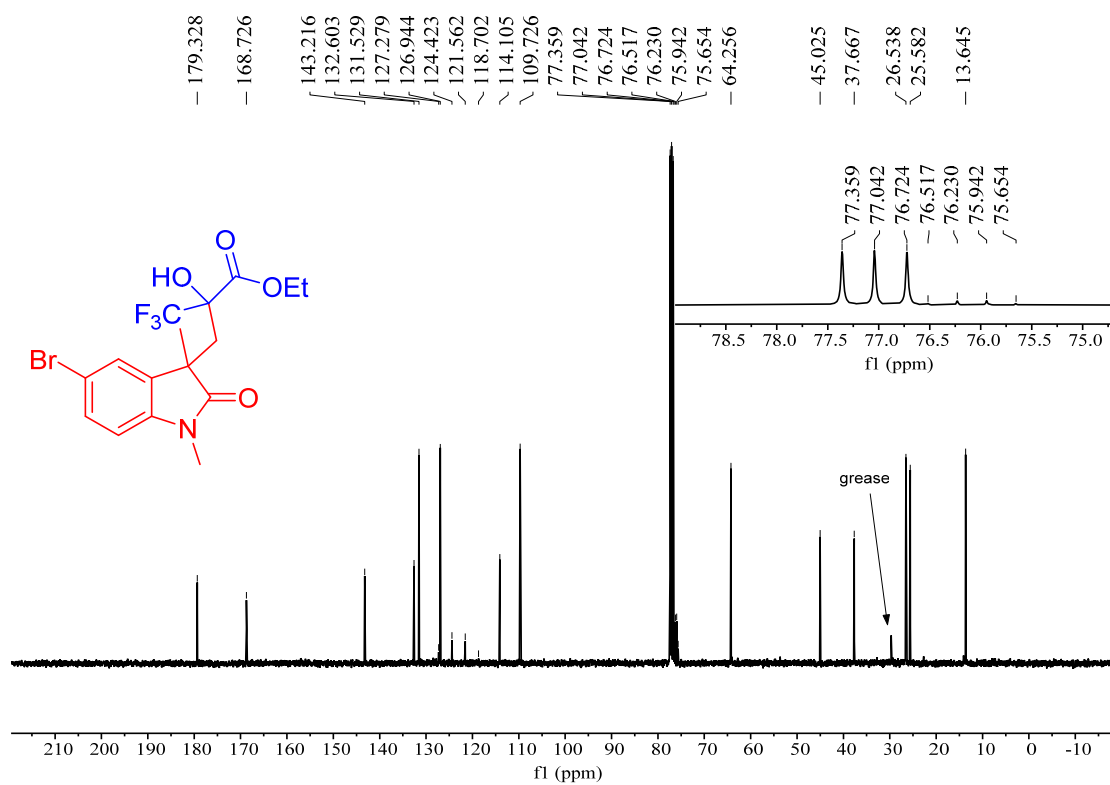
^{19}F NMR of **11** (syn isomer) (376 MHz, CDCl_3)



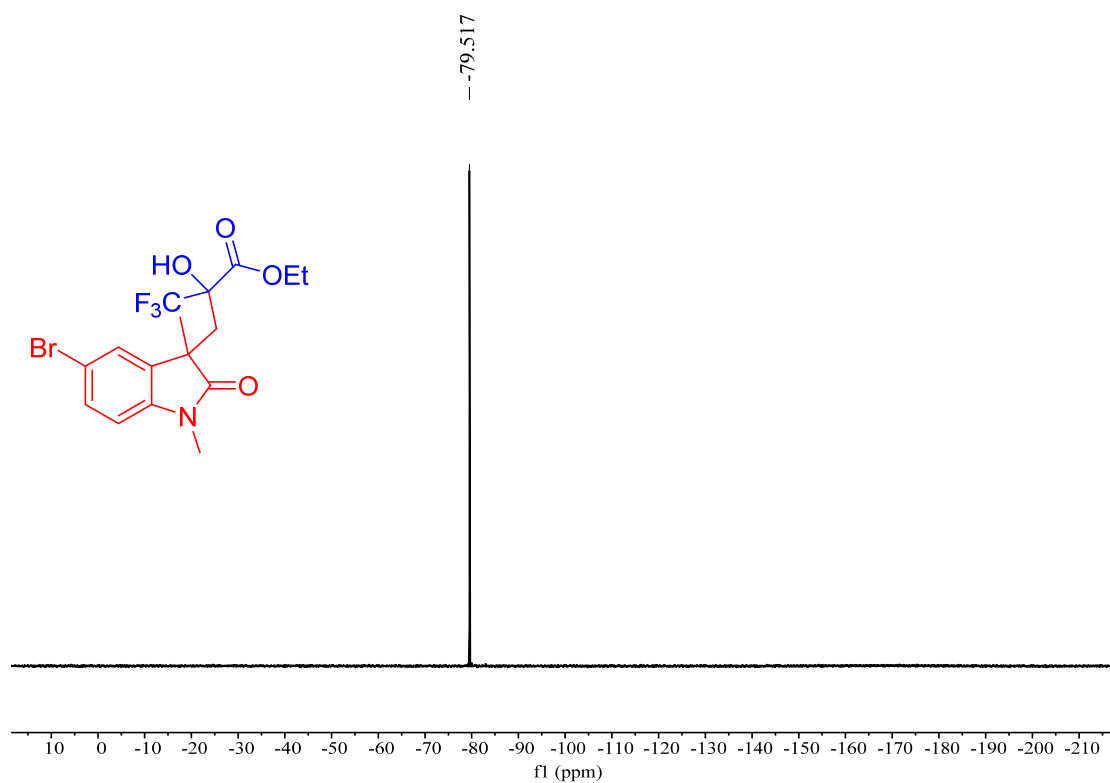
^1H NMR of **11** (anti isomer) (400 MHz, CDCl_3)



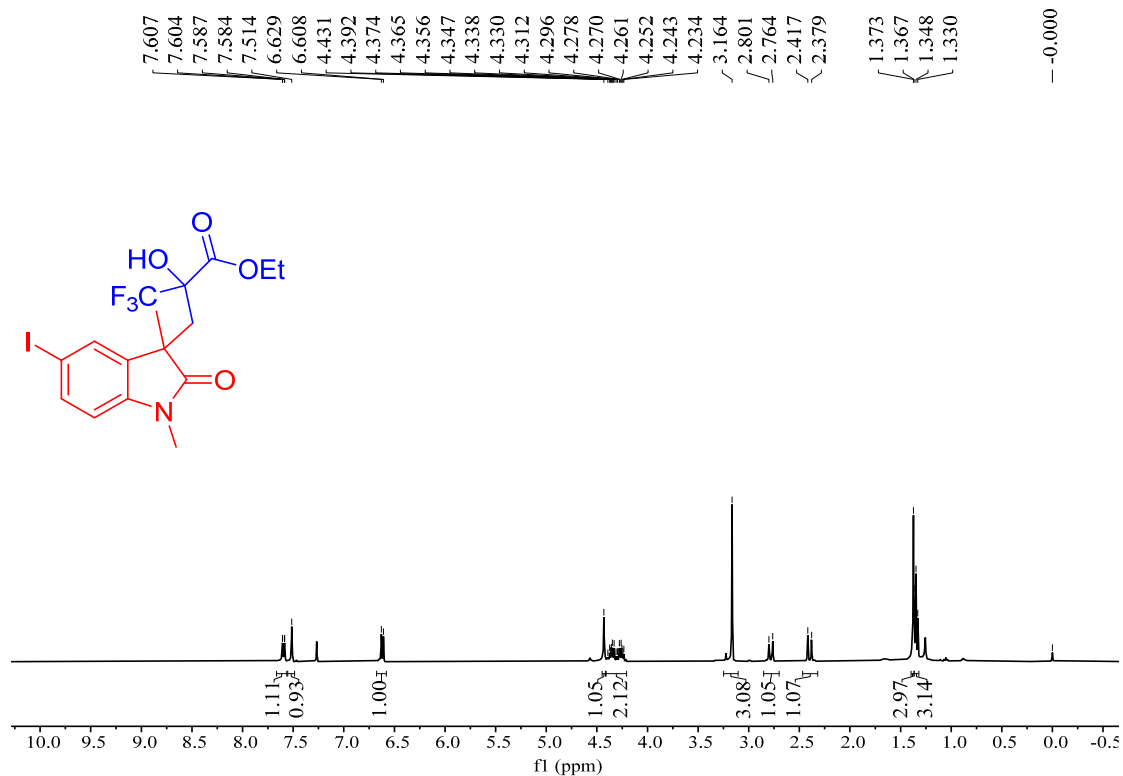
¹³C NMR of **11** (anti isomer) (101 MHz, CDCl₃)



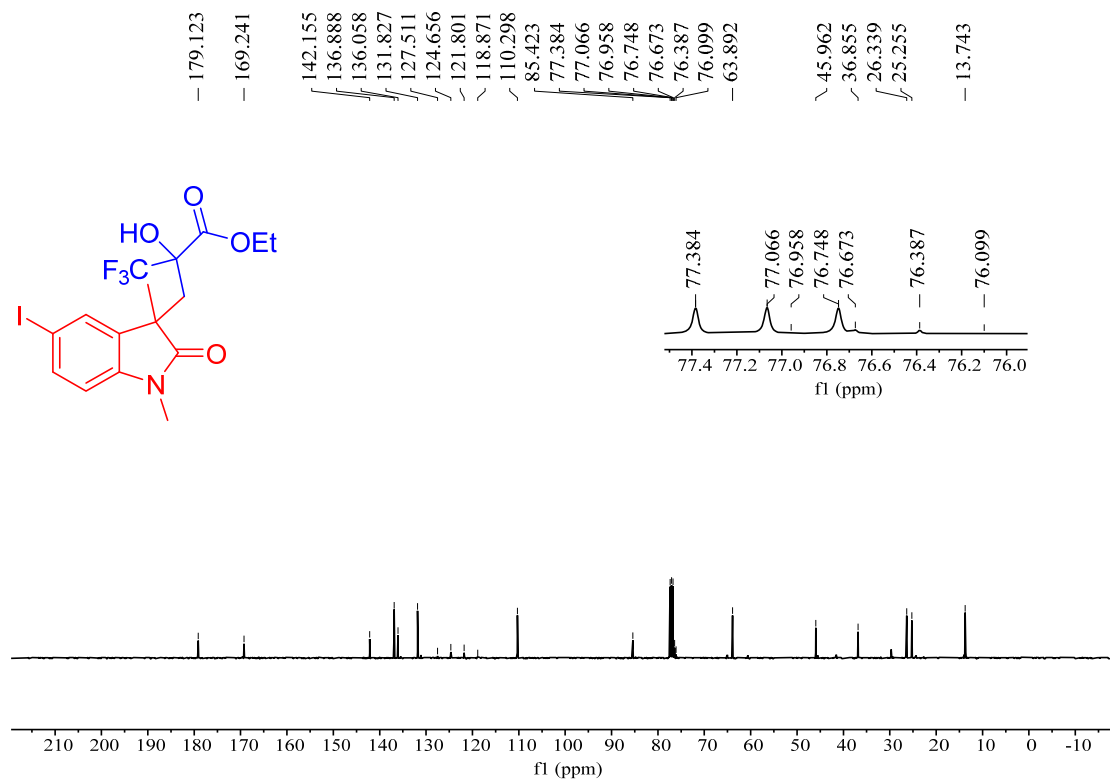
¹⁹F NMR of **11** (anti isomer) (376 MHz, CDCl₃)



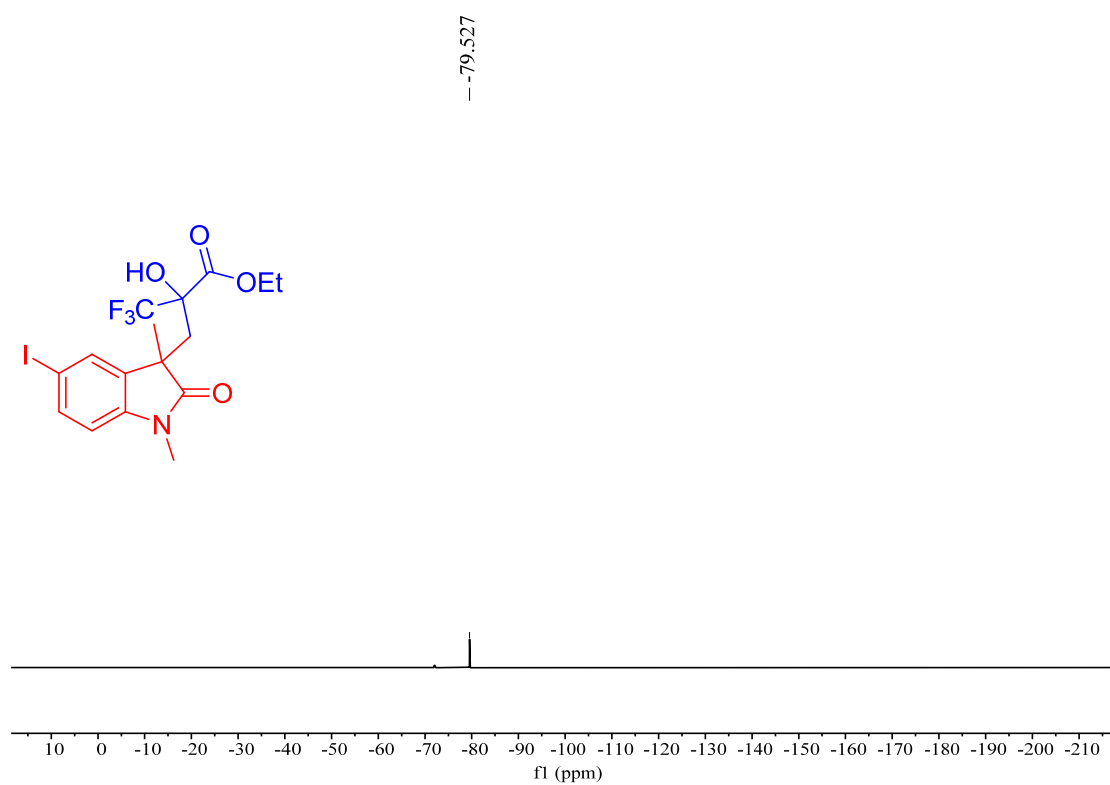
¹H NMR of **12** (syn isomer) (400 MHz, CDCl₃)



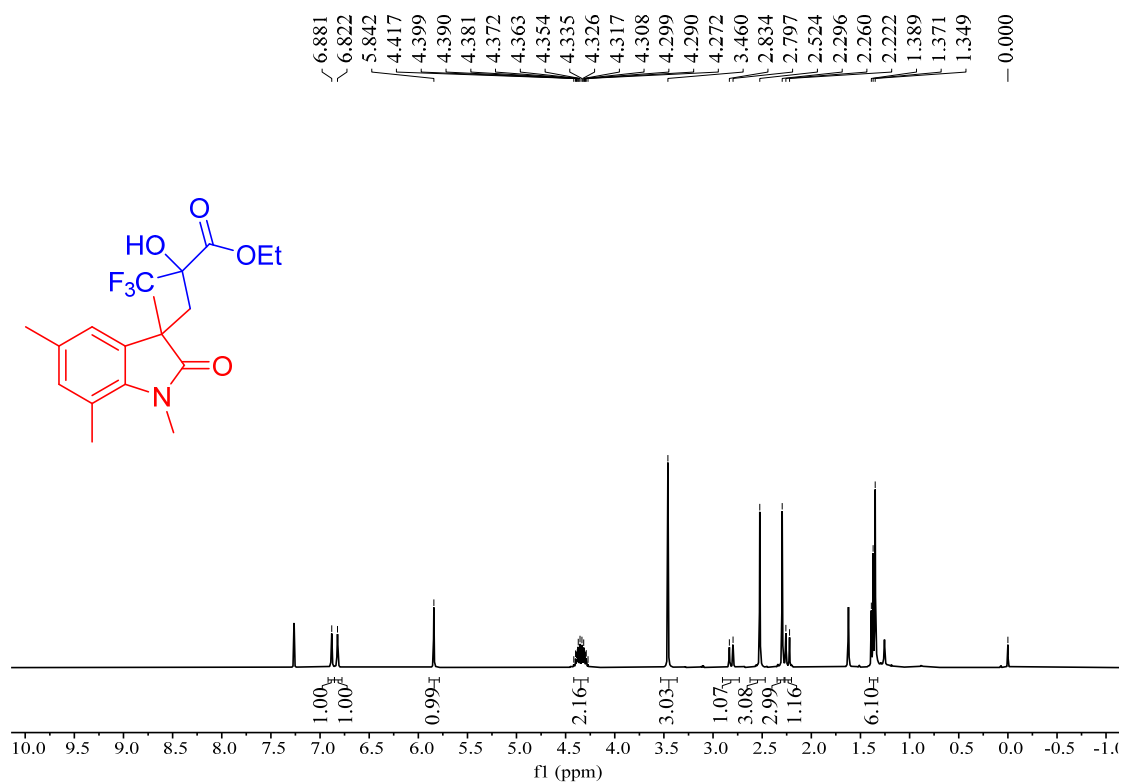
¹³C NMR of **12** (syn isomer) (101 MHz, CDCl₃)



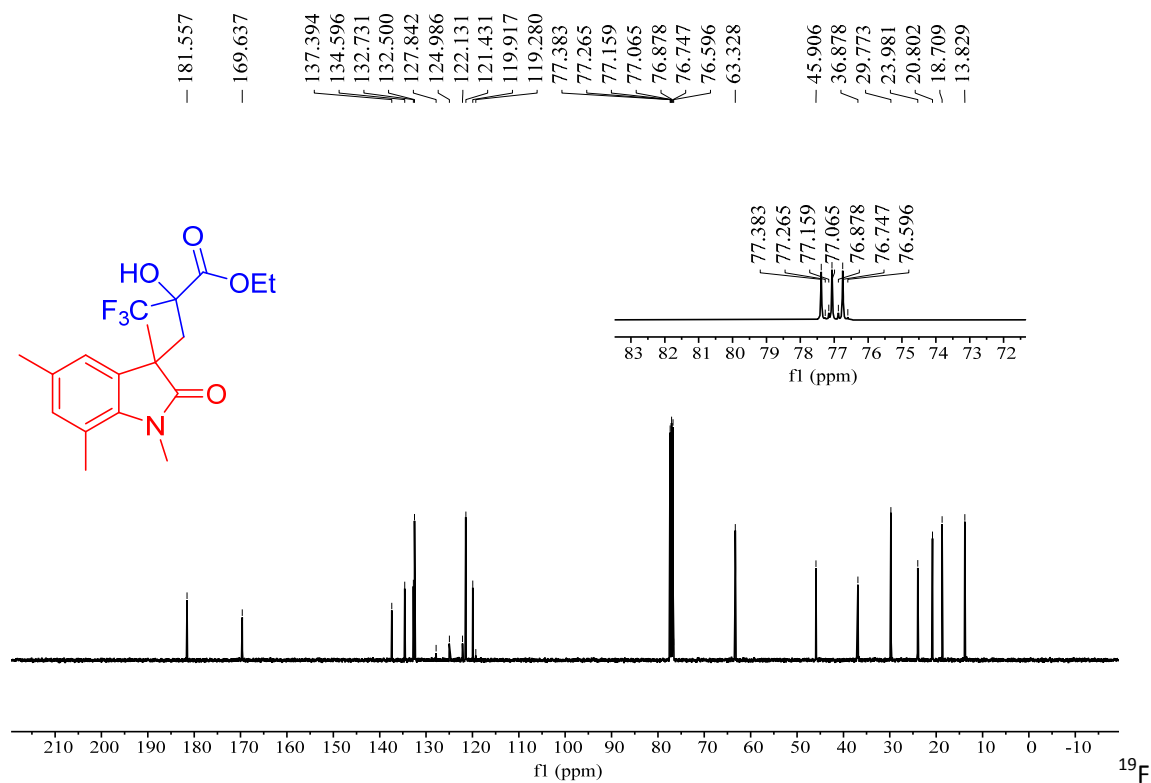
^{19}F NMR of **12** (syn isomer) (376 MHz, CDCl_3)



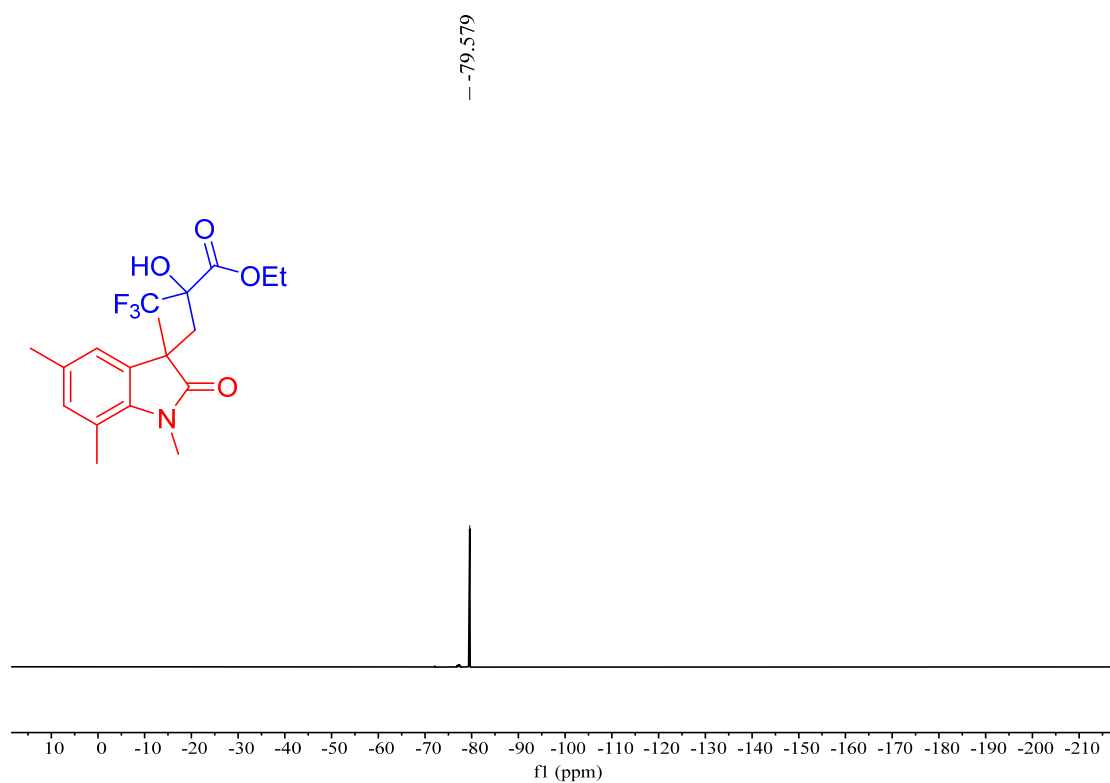
^1H NMR of **13** (syn isomer) (400 MHz, CDCl_3)



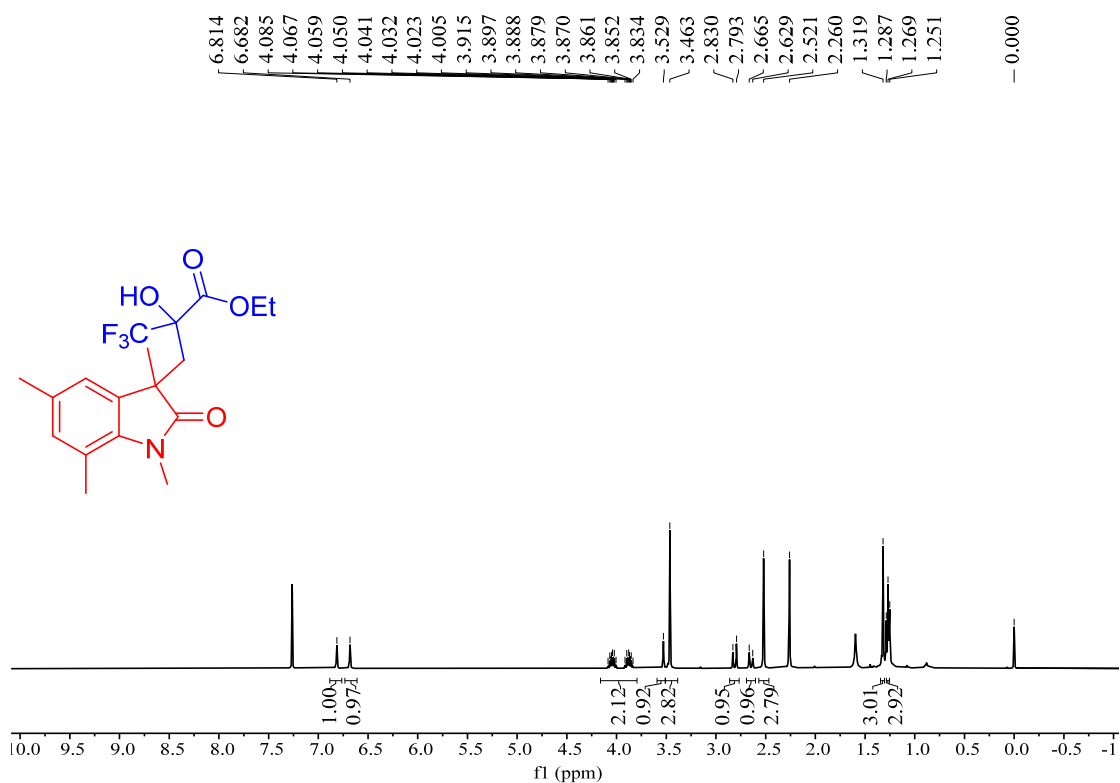
¹³C NMR of **13** (syn isomer) (101 MHz, CDCl₃)



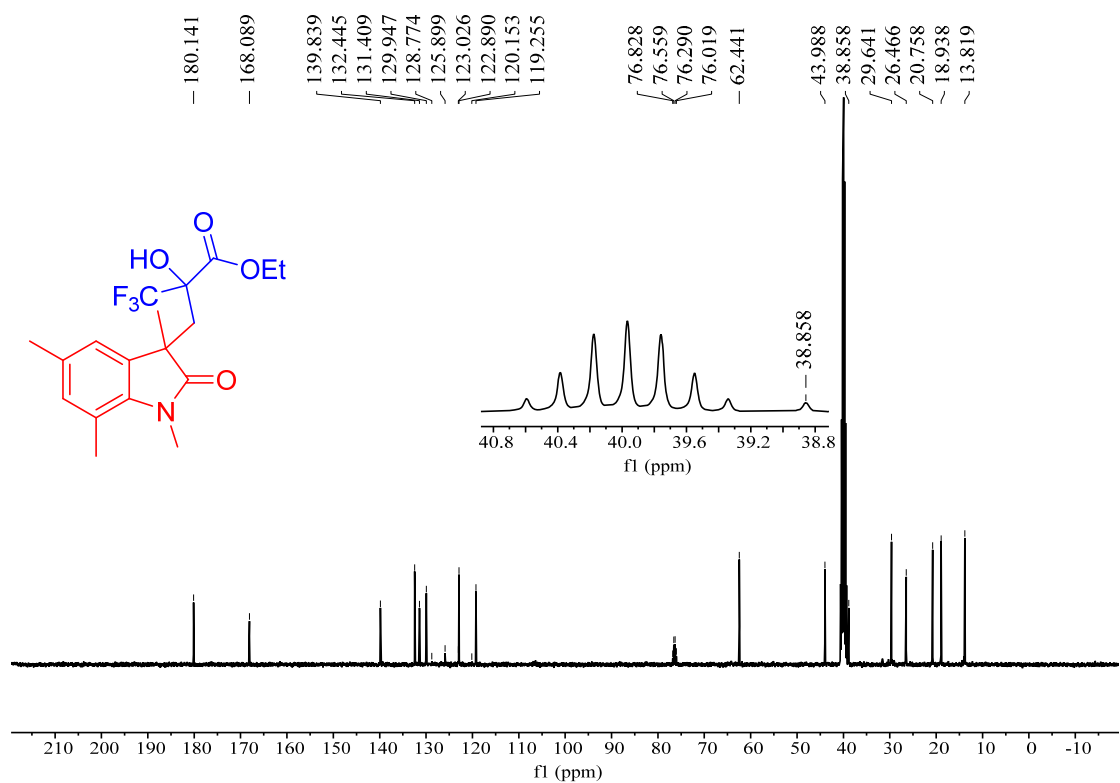
NMR of **13** (syn isomer) (376 MHz, CDCl₃)



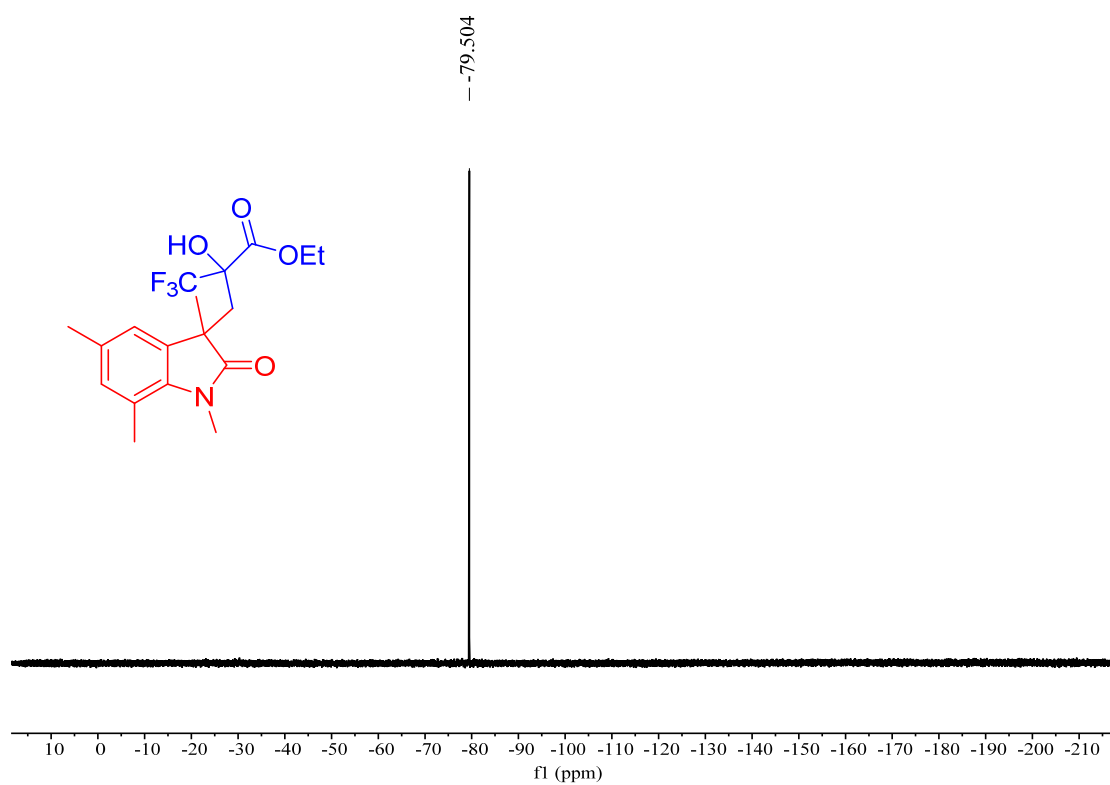
¹H NMR of **13** (anti isomer) (400 MHz, CDCl₃)



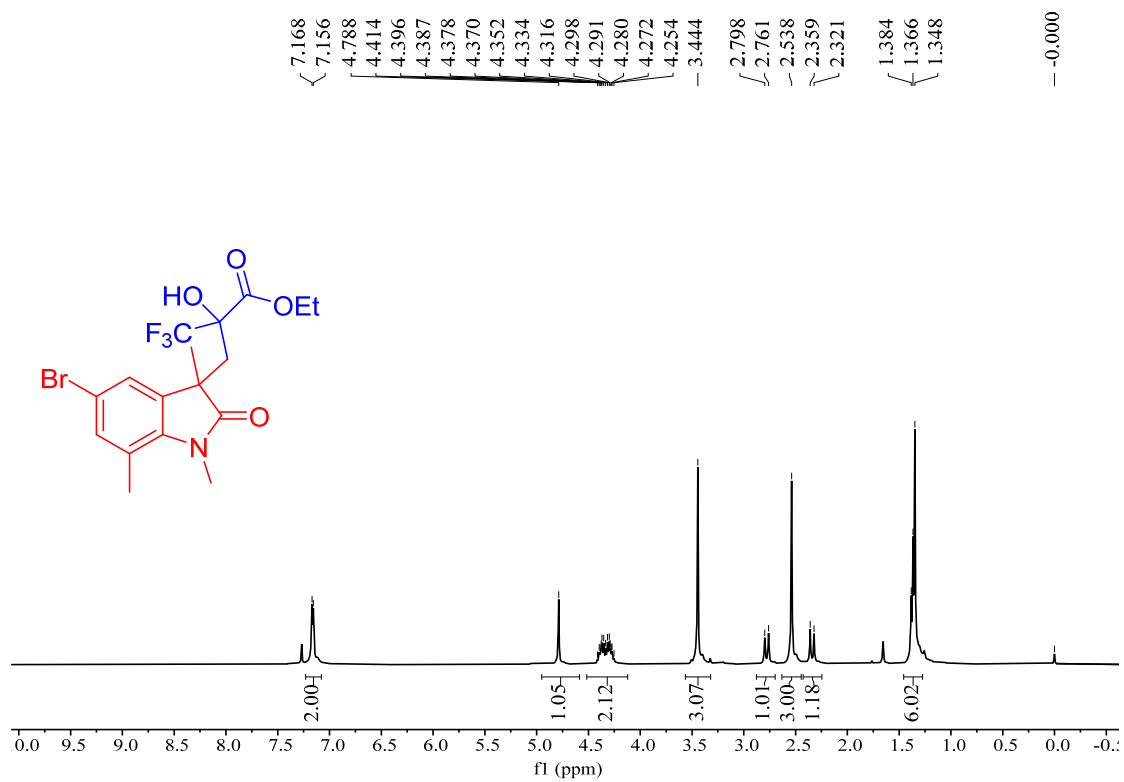
¹³C NMR of **13** (anti isomer) (101 MHz, CDCl₃)



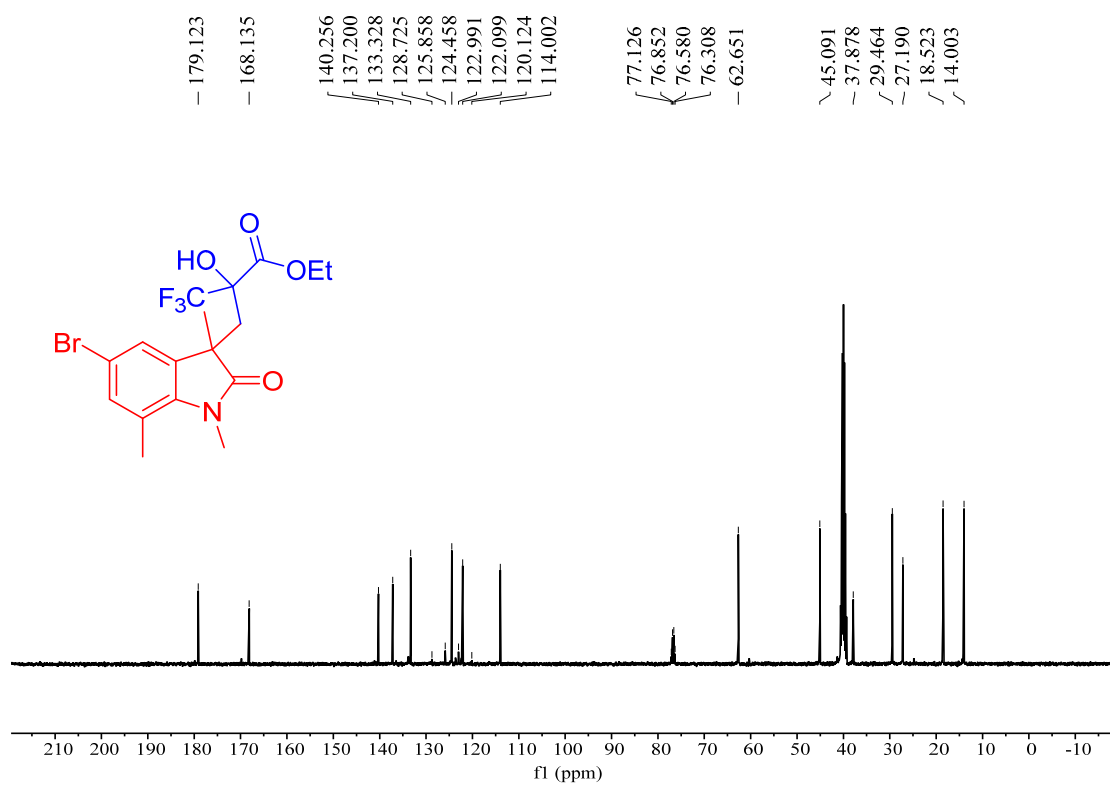
¹⁹F NMR of **13** (anti isomer) (376 MHz, CDCl₃)



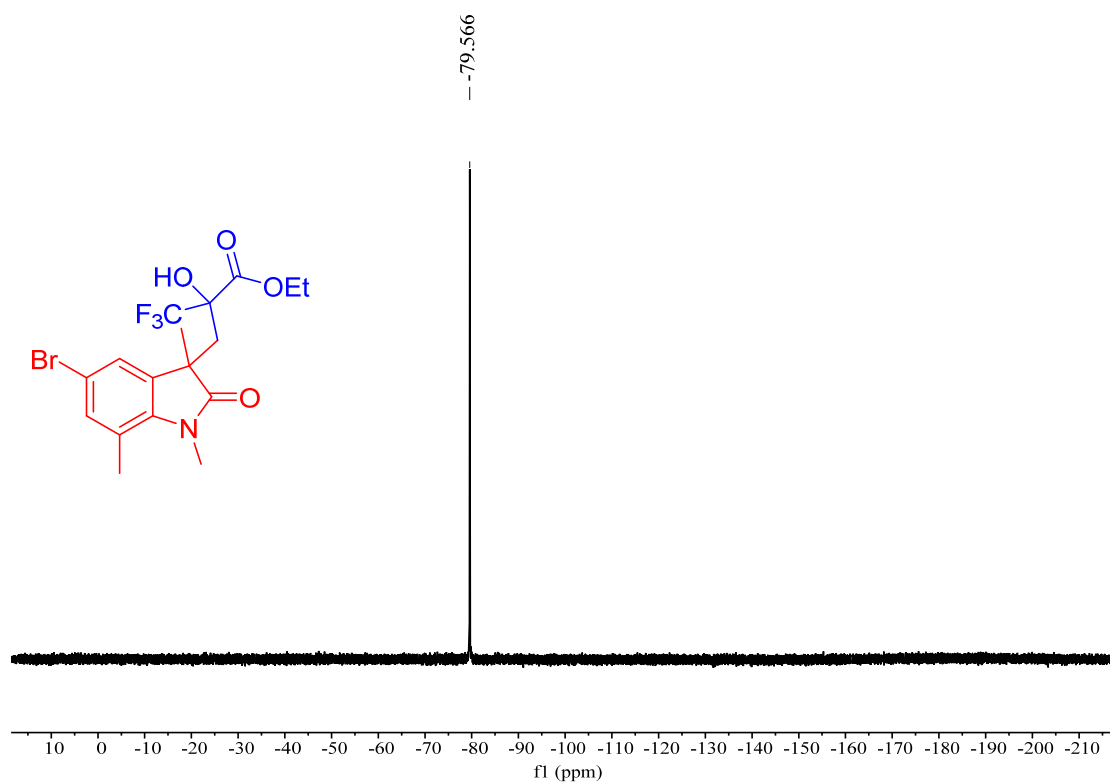
¹H NMR of **14** (syn isomer) (400 MHz, CDCl₃)



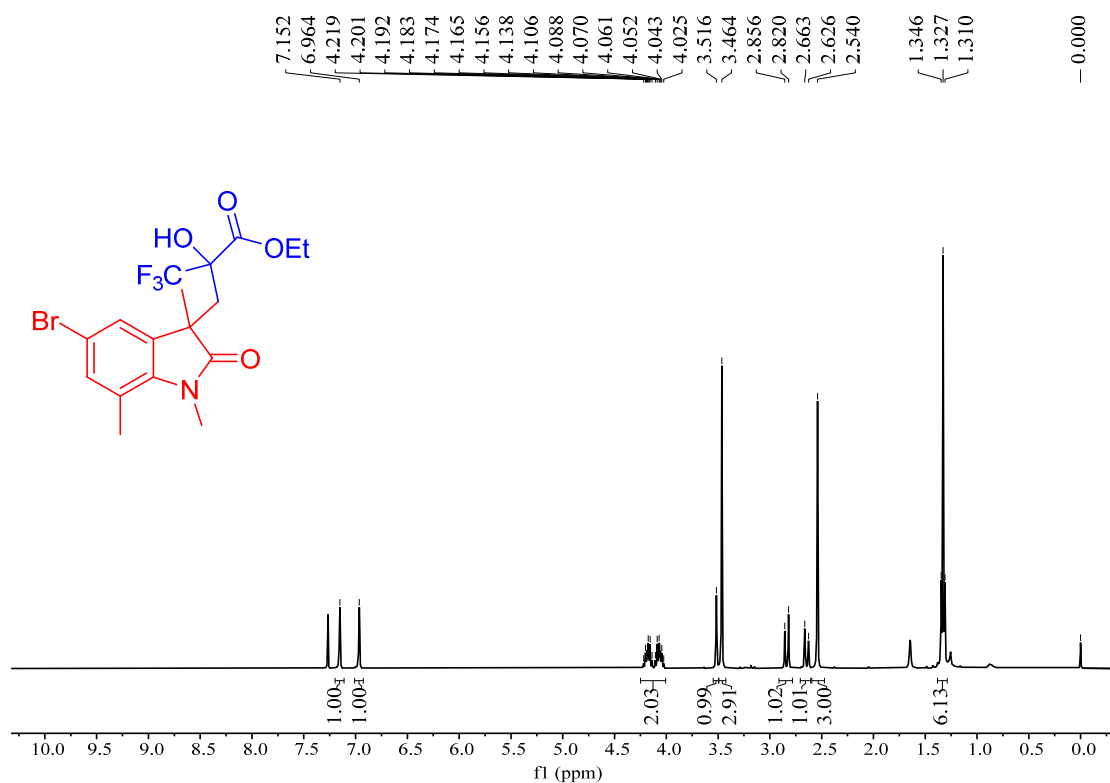
¹³C NMR of **14** (syn isomer) (101 MHz, DMSO-*d*₆)



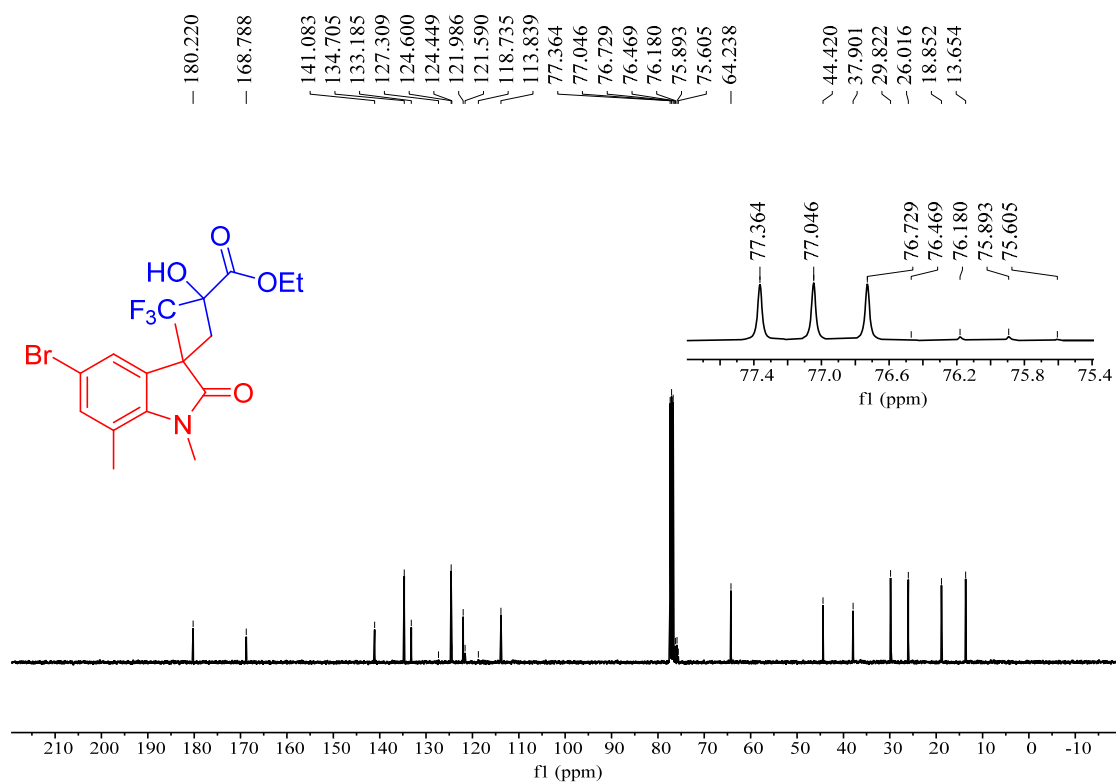
¹⁹F NMR of **14** (syn isomer) (376 MHz, CDCl₃)



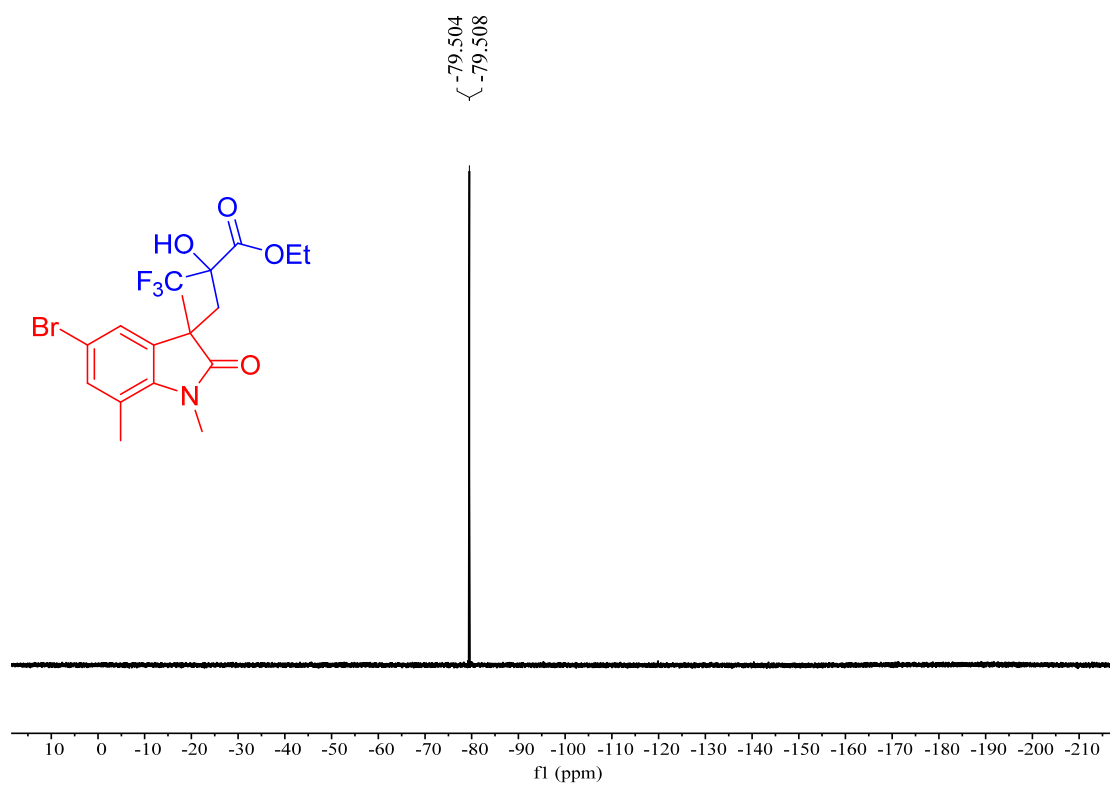
¹H NMR of **14** (anti isomer) (400 MHz, CDCl₃)



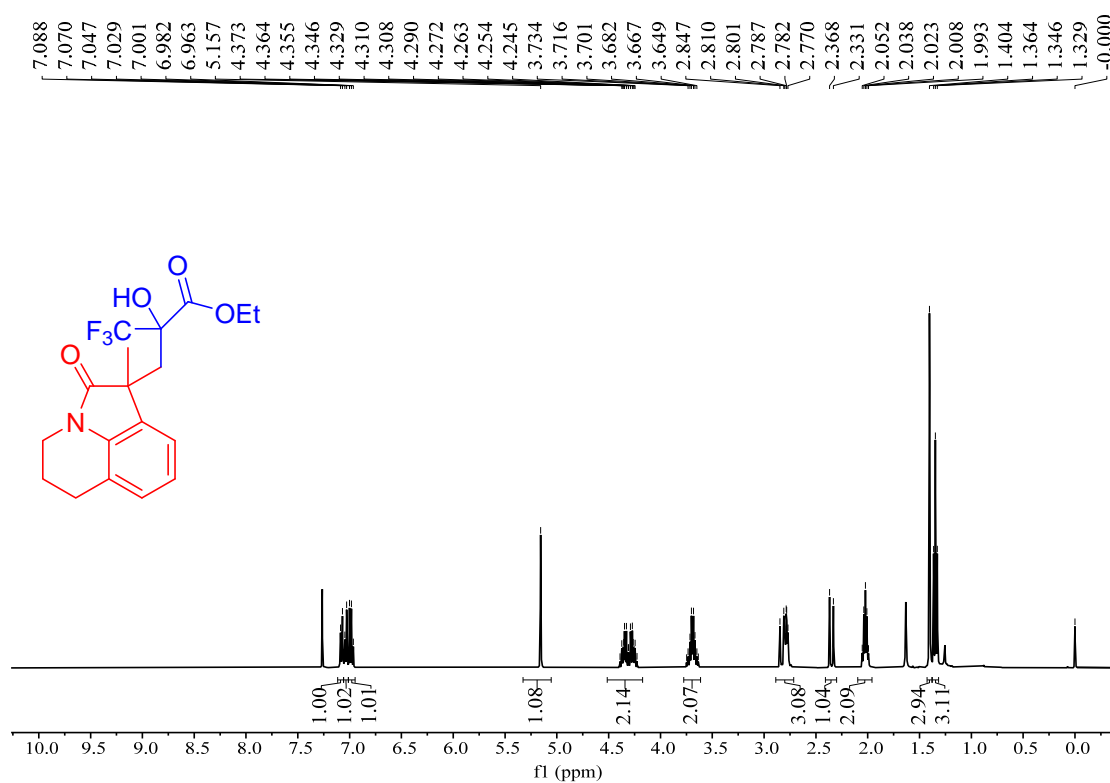
¹³C NMR of **14** (anti isomer) (101 MHz, CDCl₃)



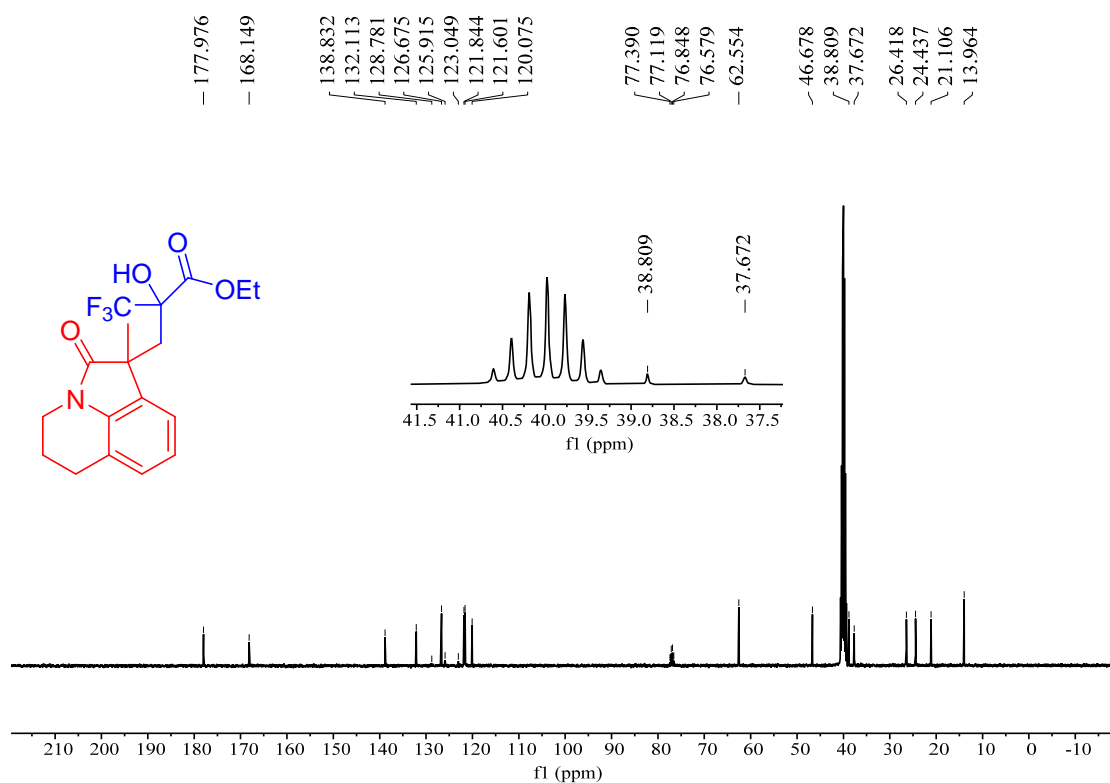
¹⁹F NMR of **14** (anti isomer) (376 MHz, CDCl₃)



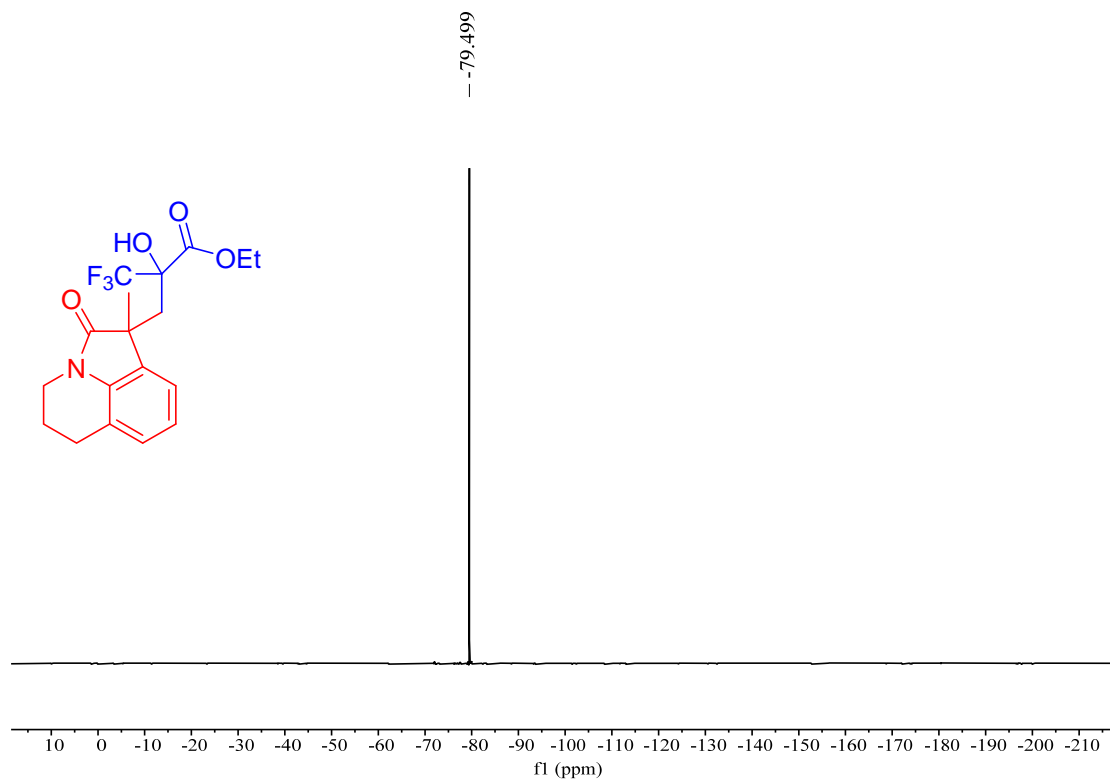
¹H NMR of **15** (syn isomer) (400 MHz, CDCl₃)



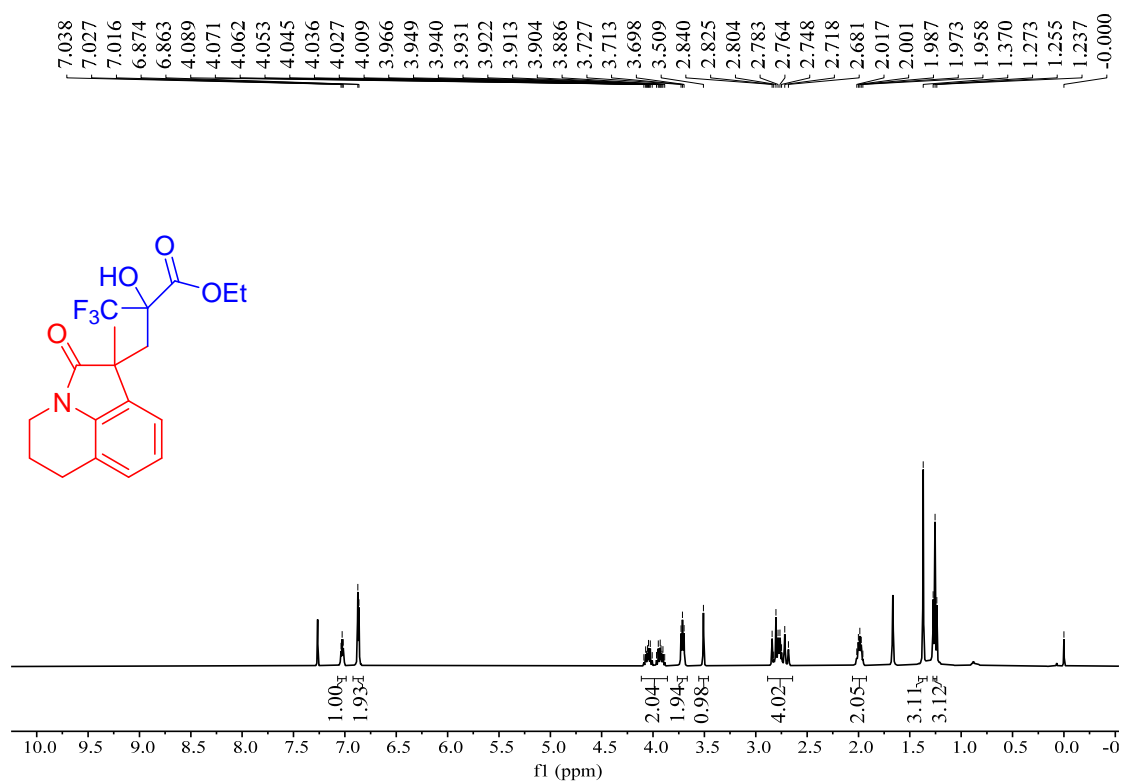
¹³C NMR of **15** (syn isomer) (101 MHz, CDCl₃)



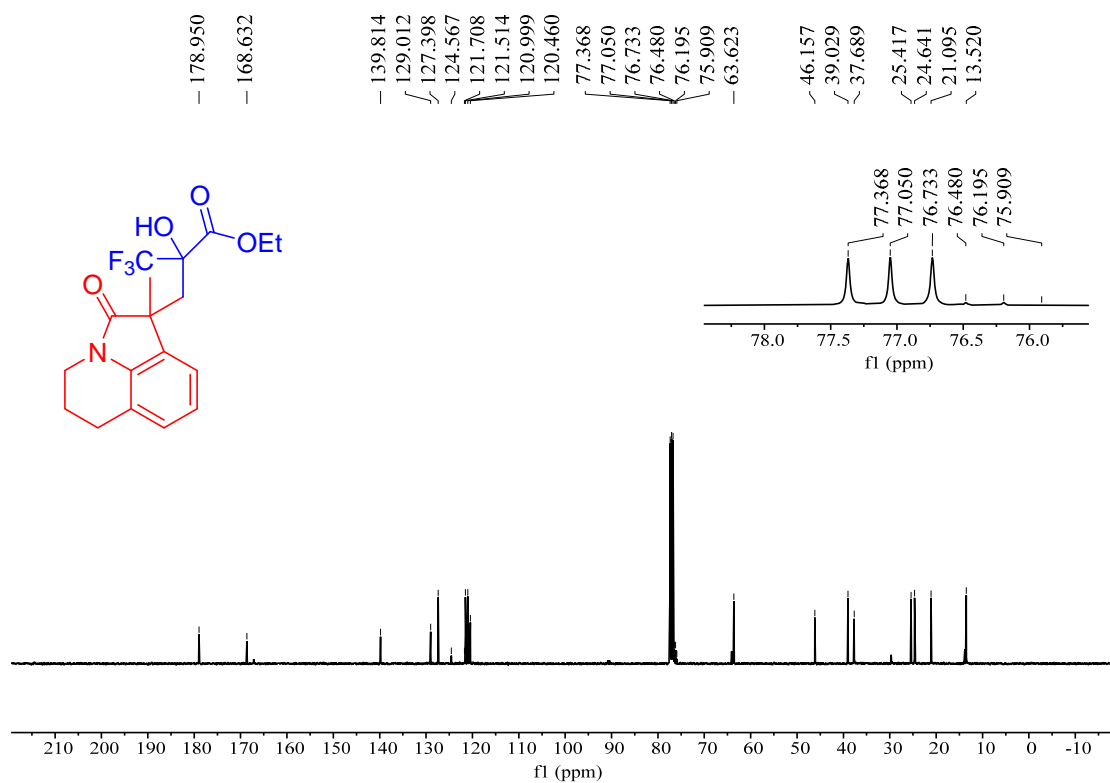
¹⁹F NMR of **15** (syn isomer) (376 MHz, CDCl₃)



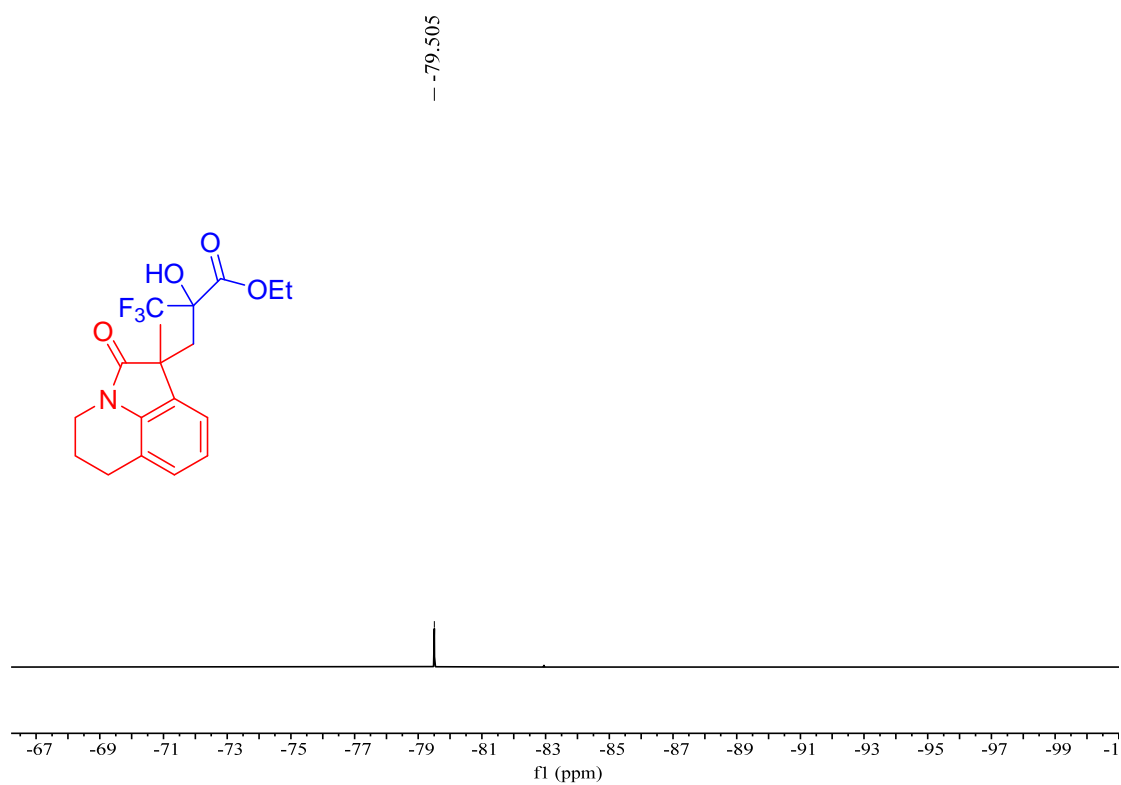
¹H NMR of **15** (anti isomer) (400 MHz, CDCl₃)



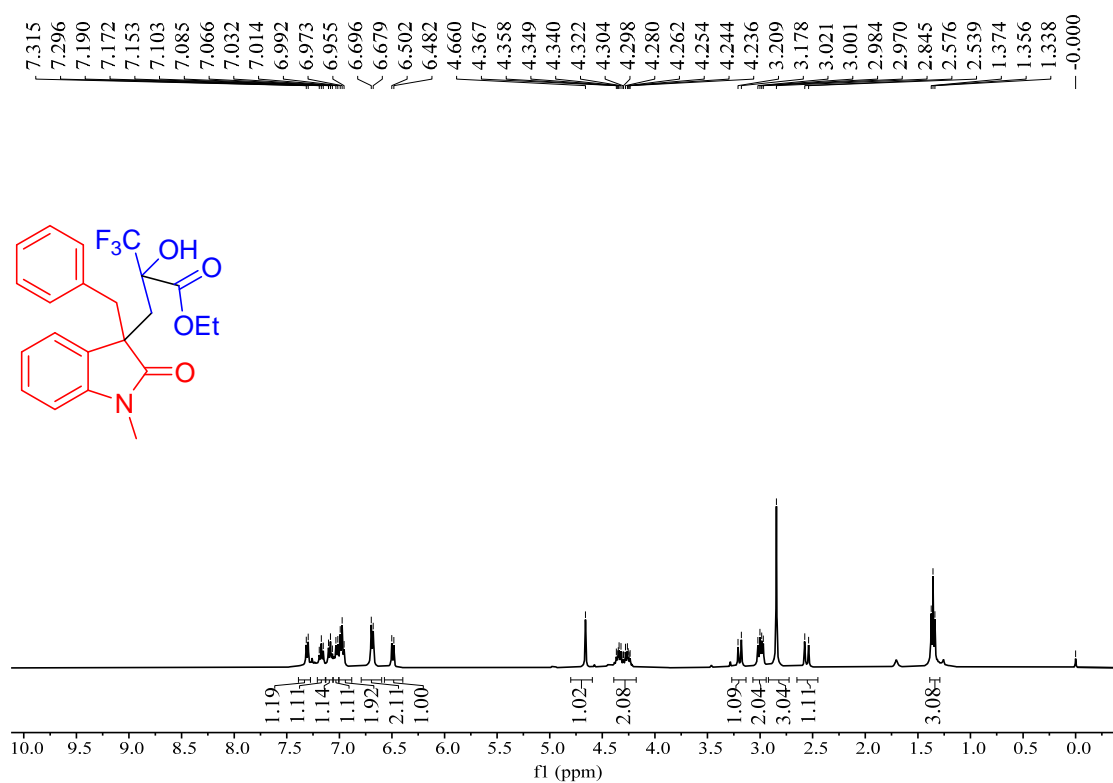
¹³C NMR of **15** (anti isomer) (101 MHz, CDCl₃)



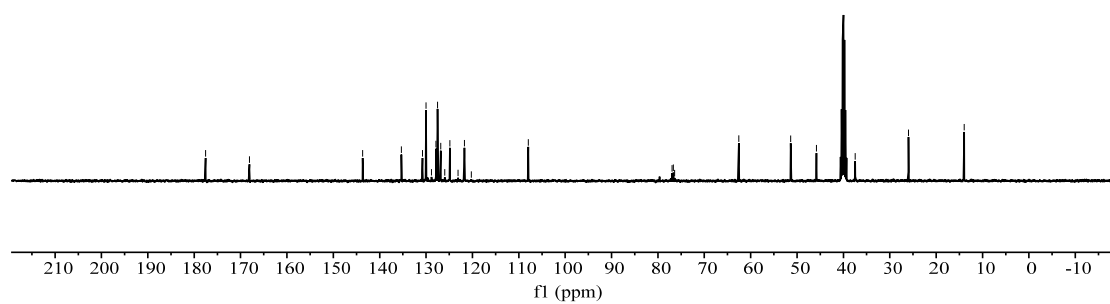
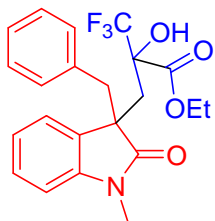
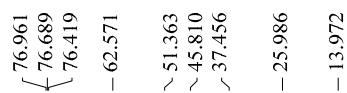
^{19}F NMR of **15** (anti isomer) (376 MHz, CDCl_3)



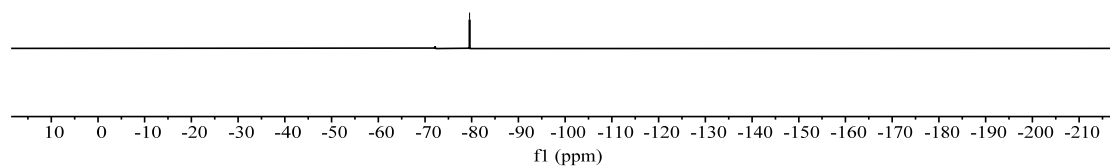
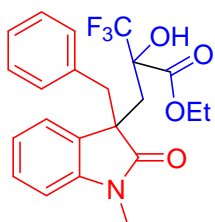
^1H NMR of **16** (syn isomer) (400 MHz, CDCl_3)



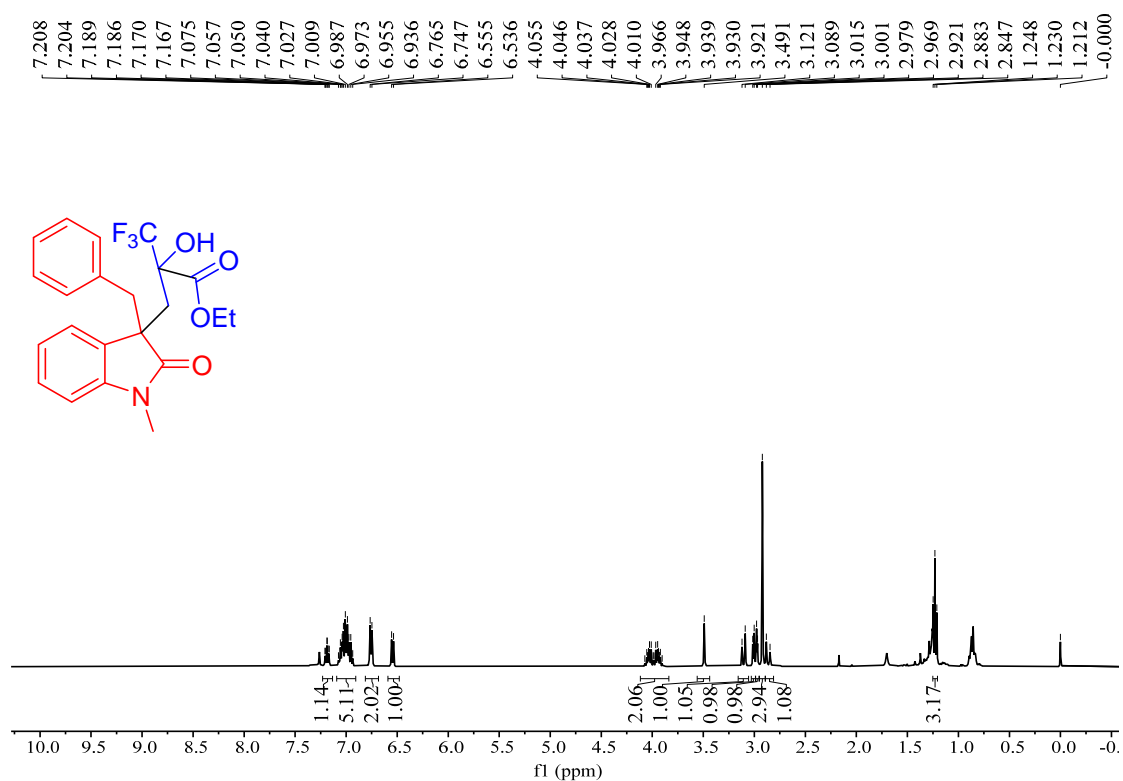
¹³C NMR of **16** (syn isomer) (101 MHz, DMSO-*d*₆)



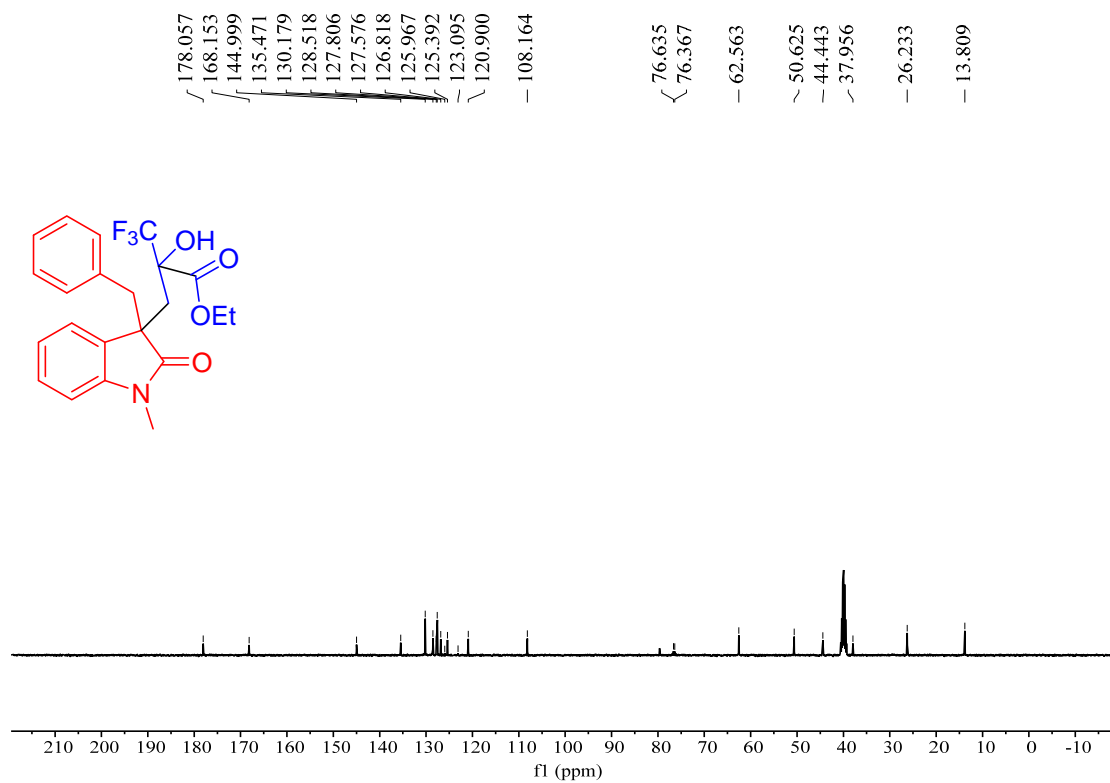
¹⁹F NMR of **16** (syn isomer) (376 MHz, CDCl₃)



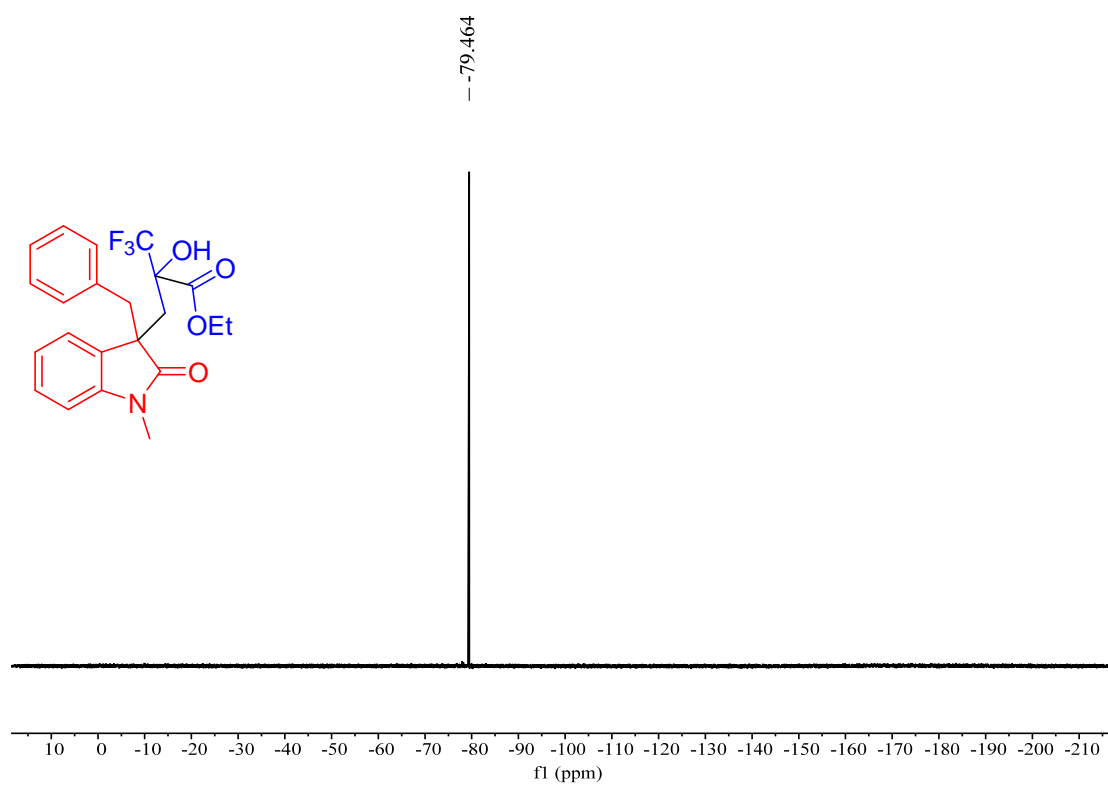
¹H NMR of **16** (anti isomer) (400 MHz, CDCl₃)



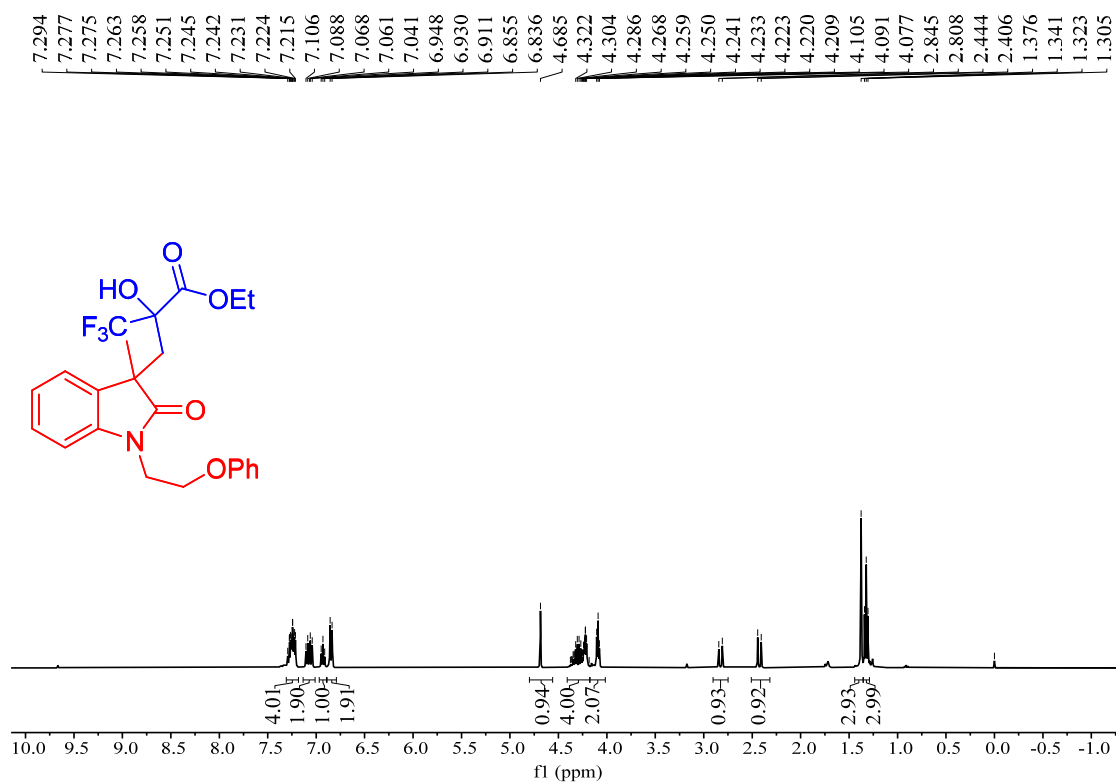
¹³C NMR of **16** (anti isomer) (101 MHz, DMSO-*d*₆)



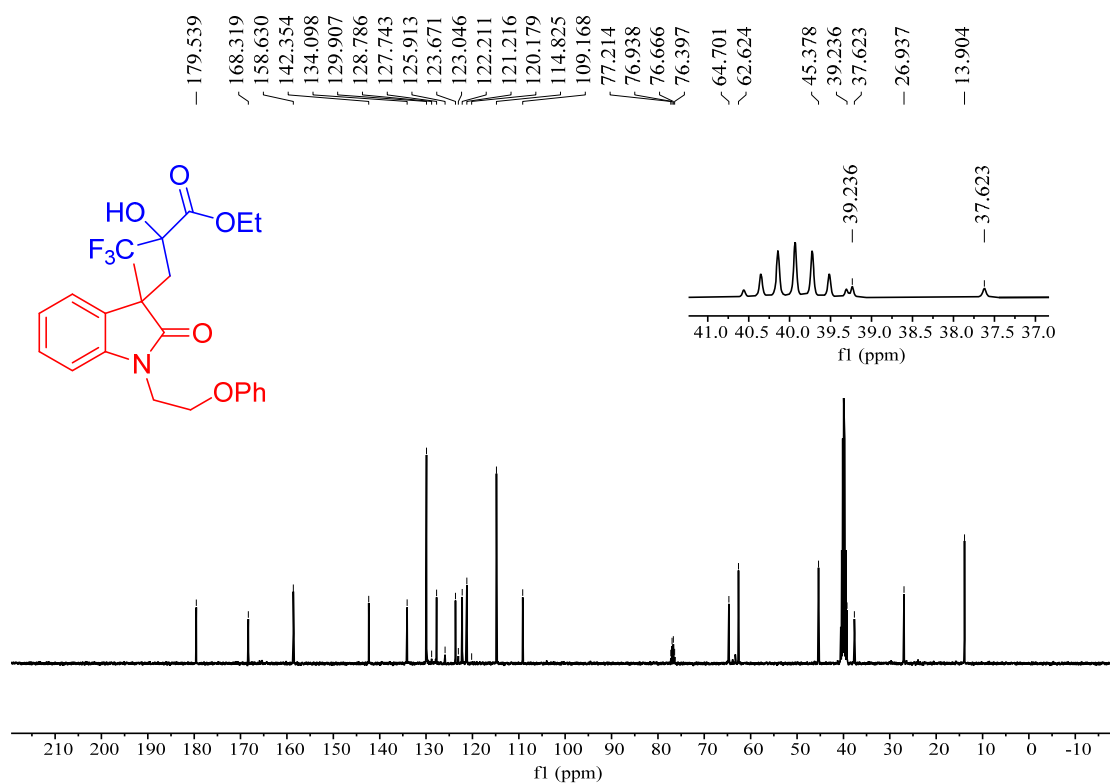
^{19}F NMR of **16** (anti isomer) (376 MHz, CDCl_3)



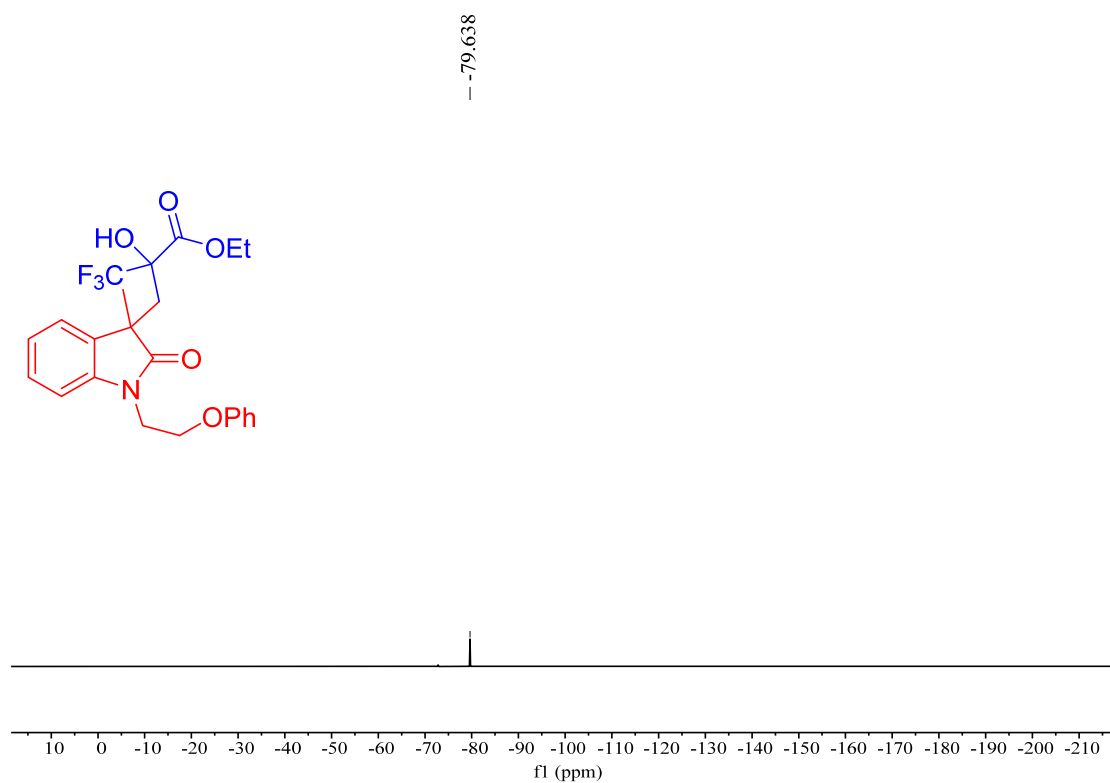
^1H NMR of **17** (syn isomer) (400 MHz, CDCl_3)



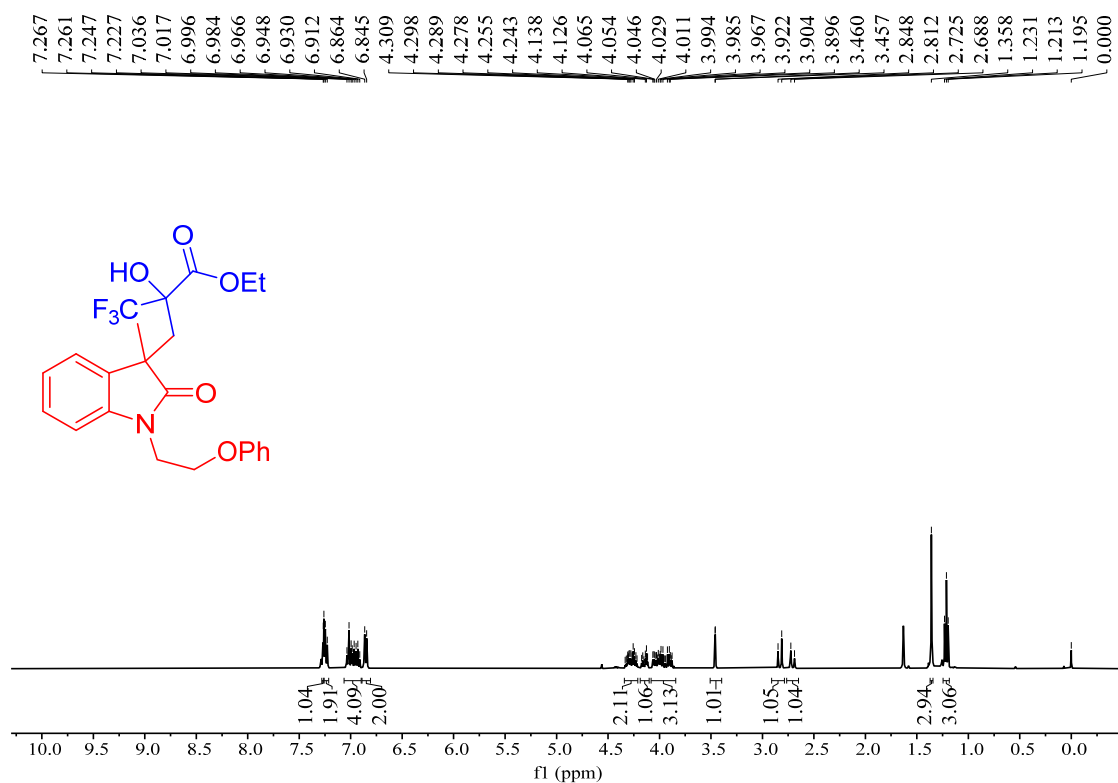
¹³C NMR of **17** (syn isomer) (101 MHz, CDCl₃)



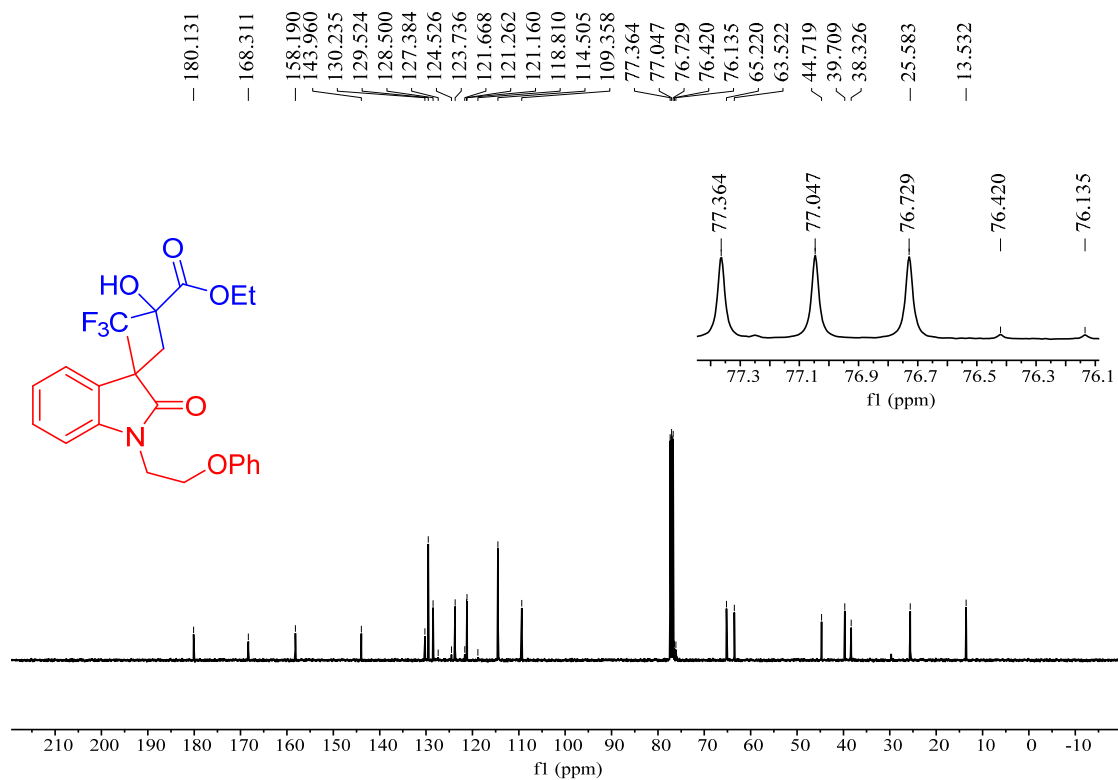
¹⁹F NMR of **17** (syn isomer) (376 MHz, CDCl₃)



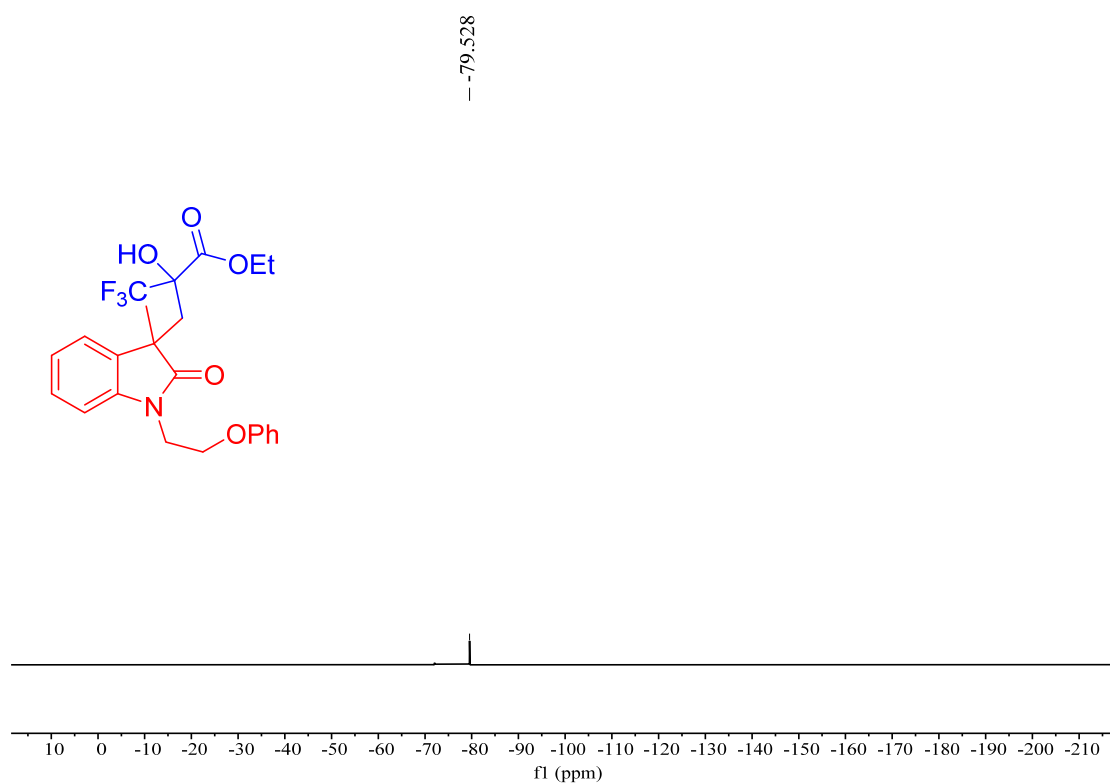
¹H NMR of **17** (anti isomer) (400 MHz, CDCl₃)



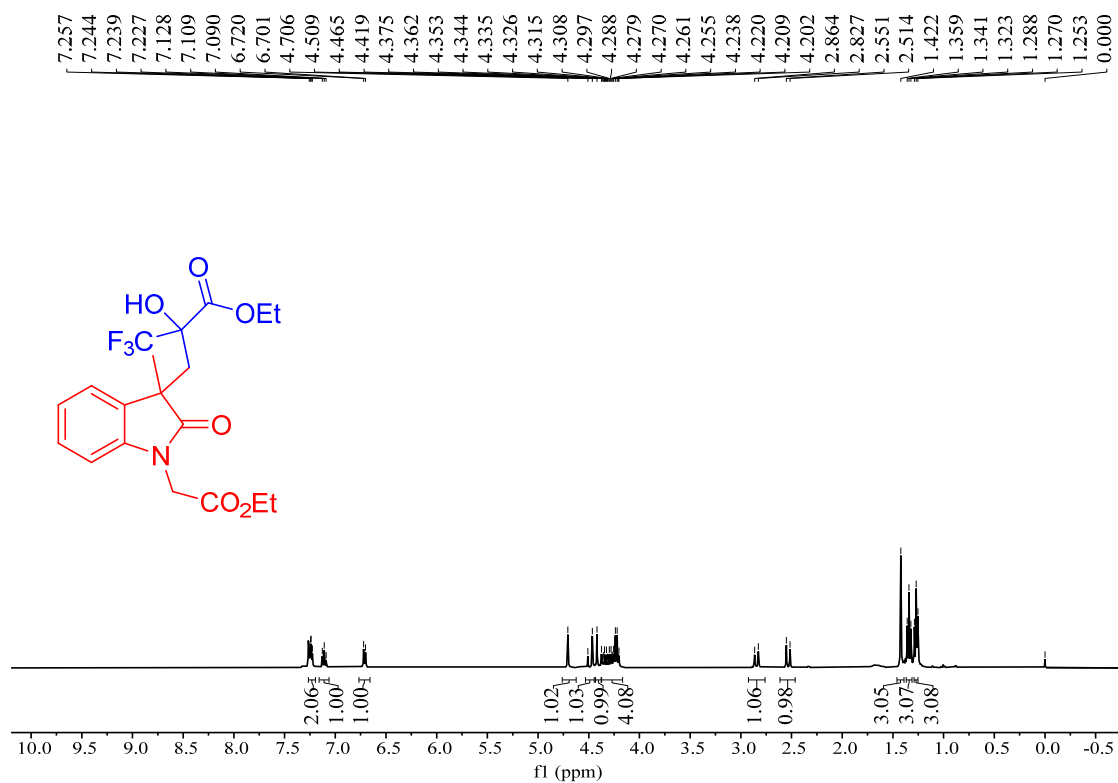
¹³C NMR of **17** (anti isomer) (101 MHz, CDCl₃)



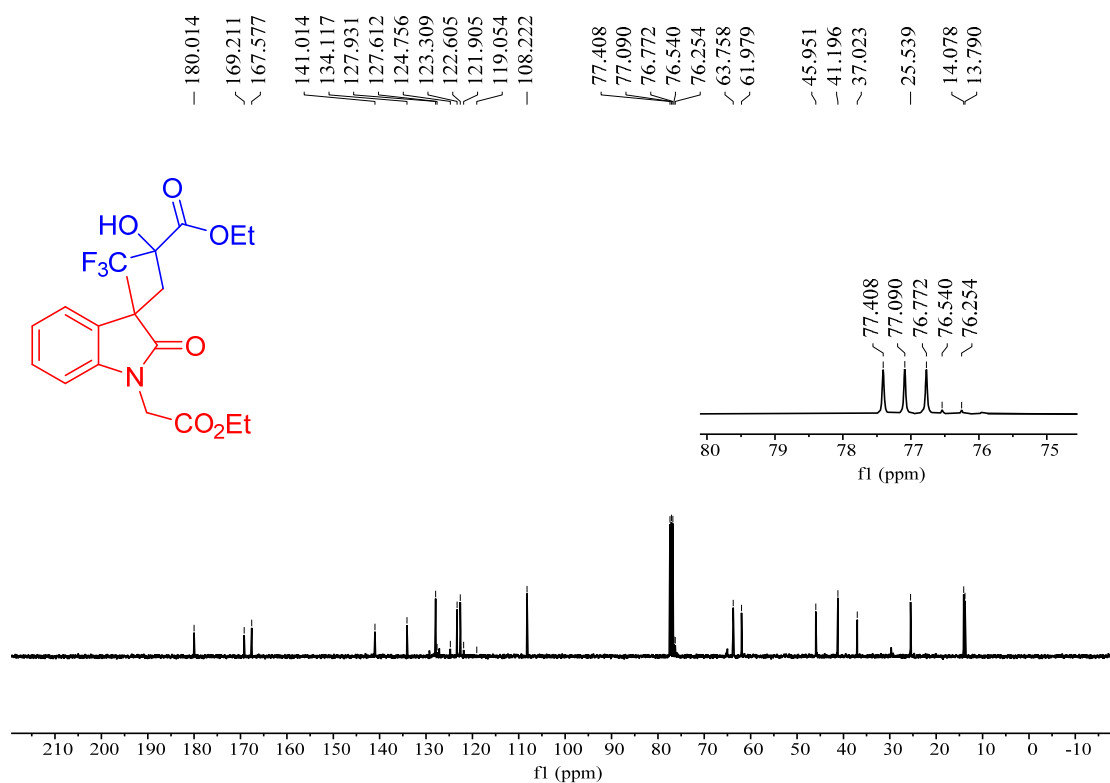
¹⁹F NMR of **17** (anti isomer) (376 MHz, CDCl₃)



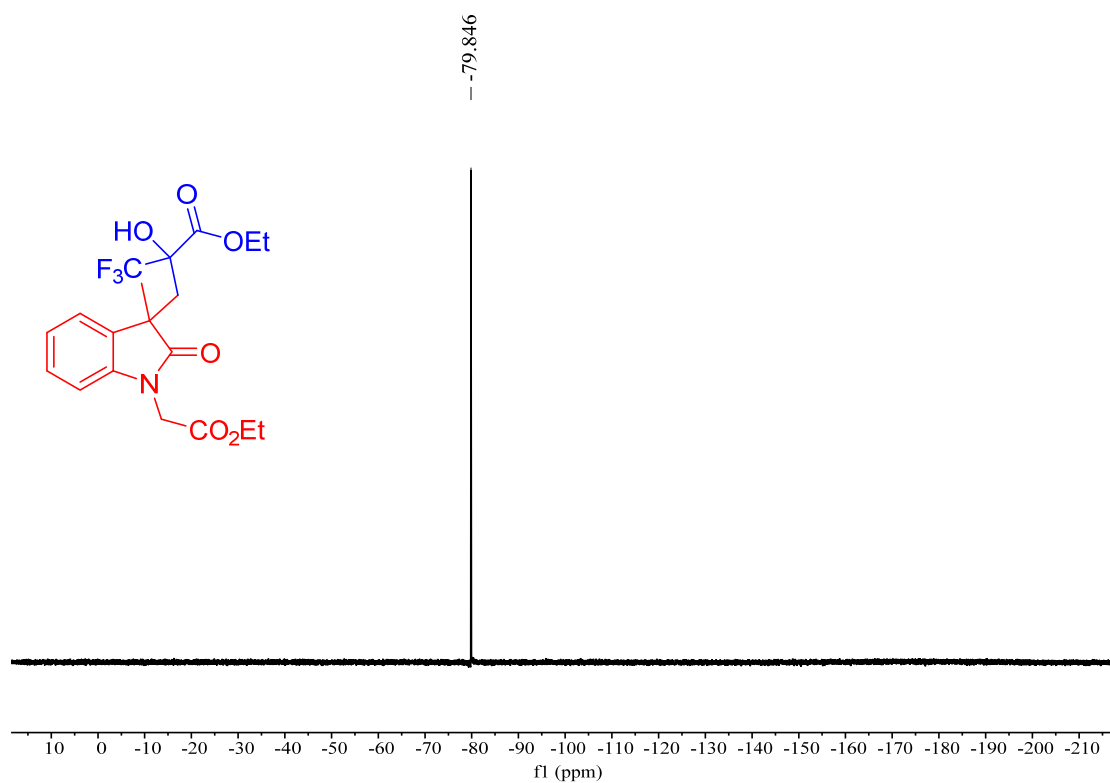
¹H NMR of **18** (syn isomer) (400 MHz, CDCl₃)



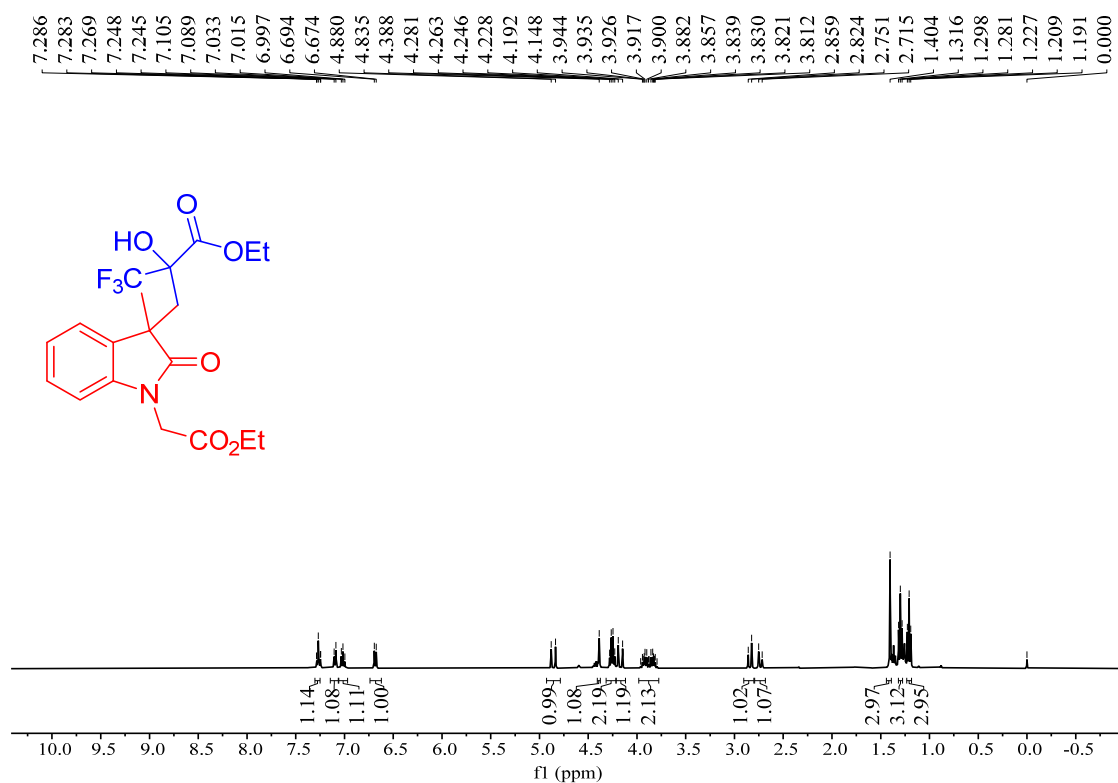
¹³C NMR of **18** (syn isomer) (101 MHz, CDCl₃)



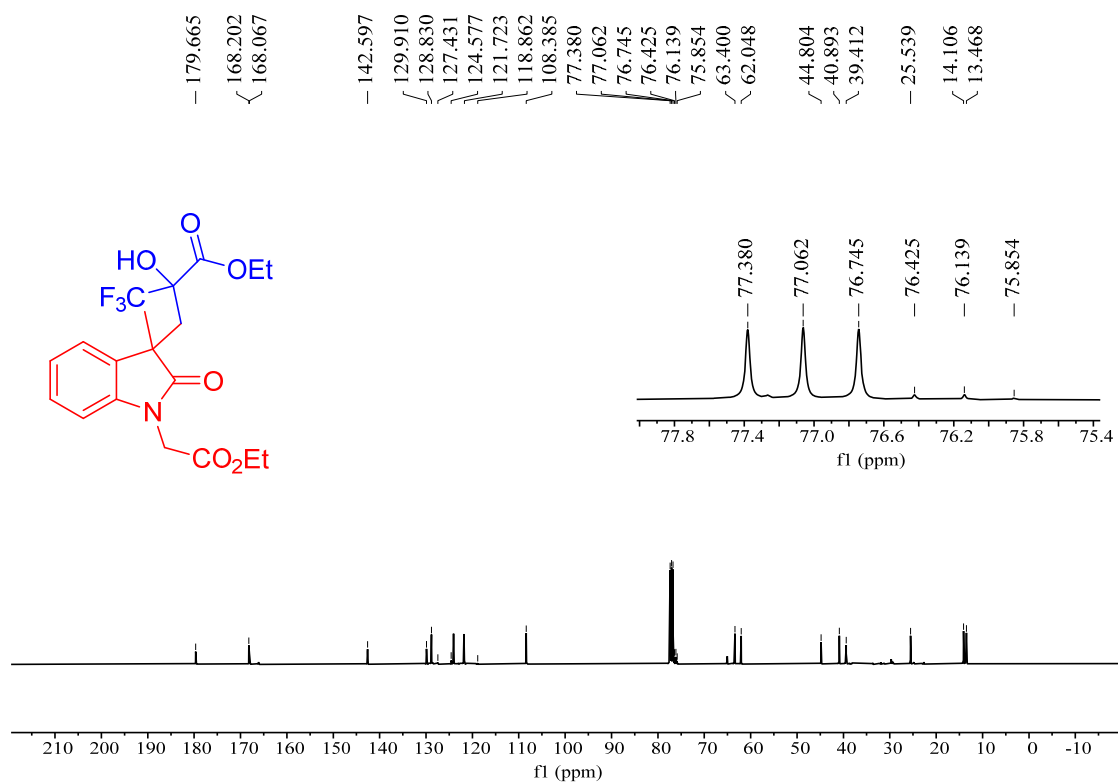
¹⁹F NMR of **18** (syn isomer) (376 MHz, CDCl₃)



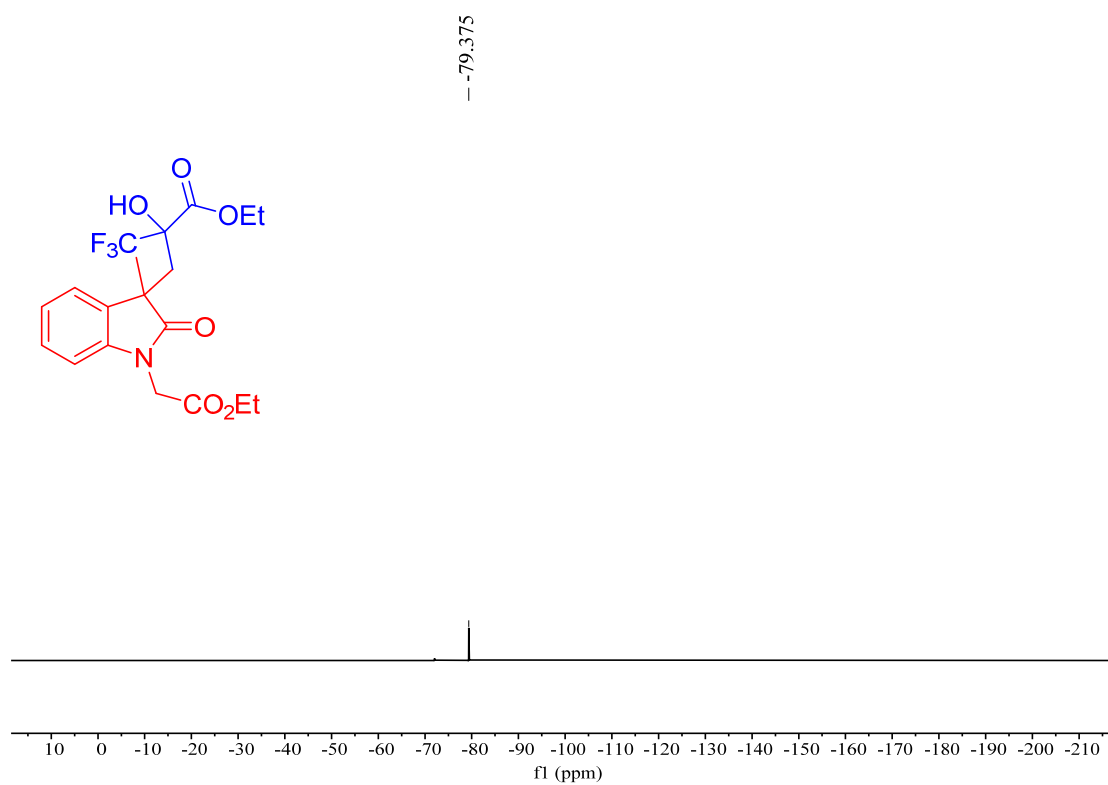
¹H NMR of **18** (anti isomer) (400 MHz, CDCl₃)



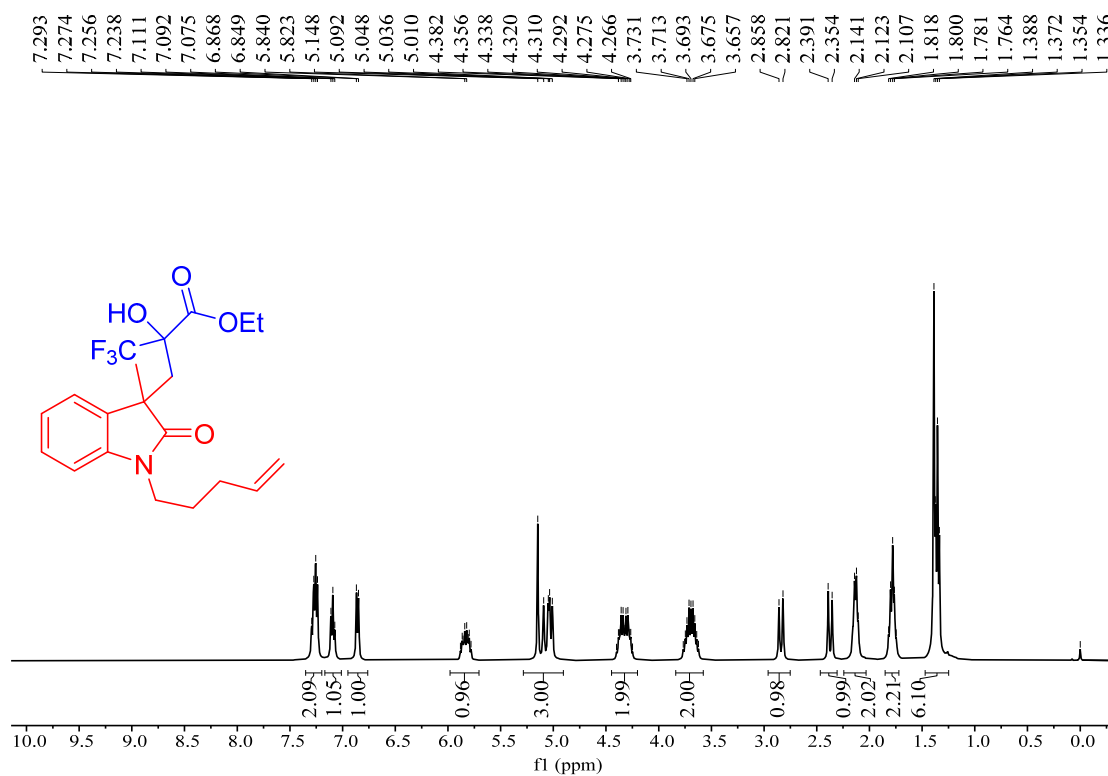
¹³C NMR of **18** (anti isomer) (101 MHz, CDCl₃)



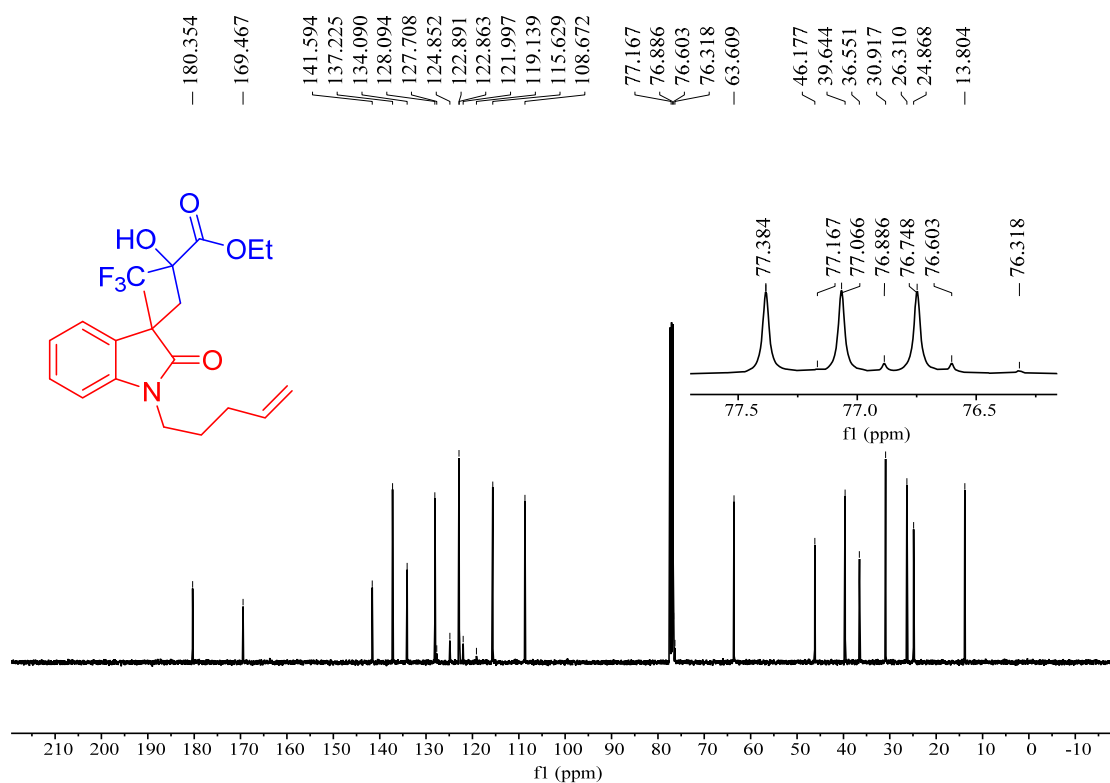
^{19}F NMR of **18** (anti isomer) (376 MHz, CDCl_3)



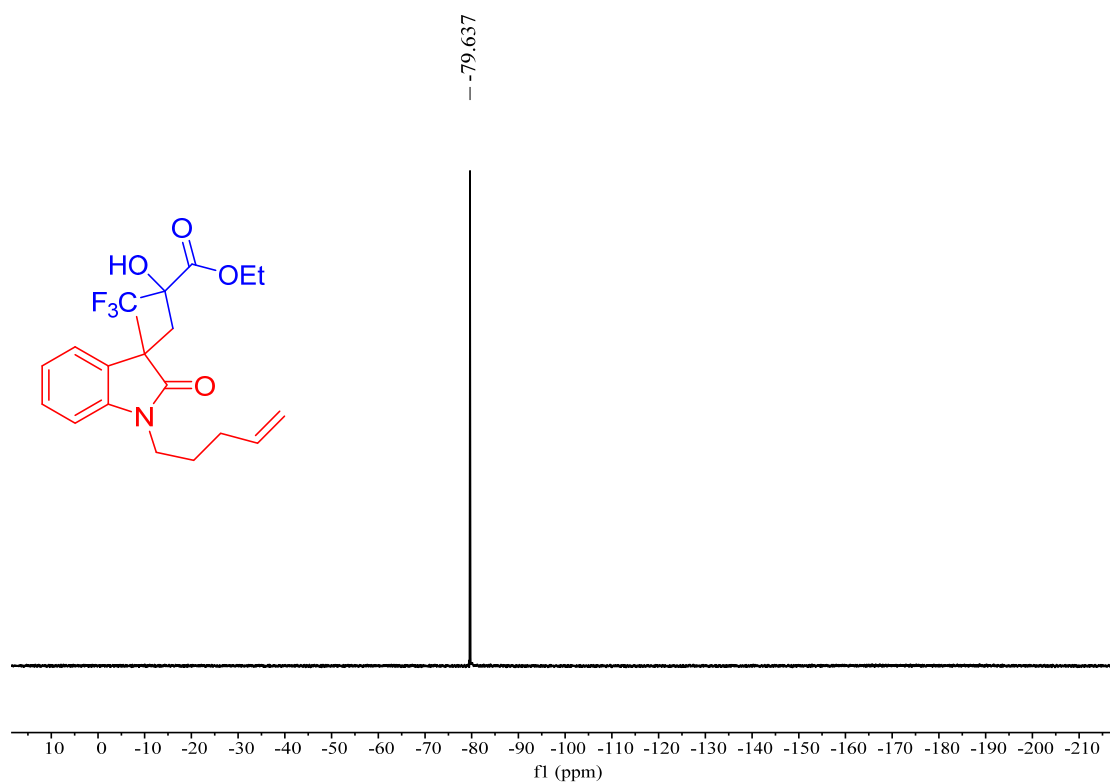
^1H NMR of **19** (syn isomer) (400 MHz, CDCl_3)



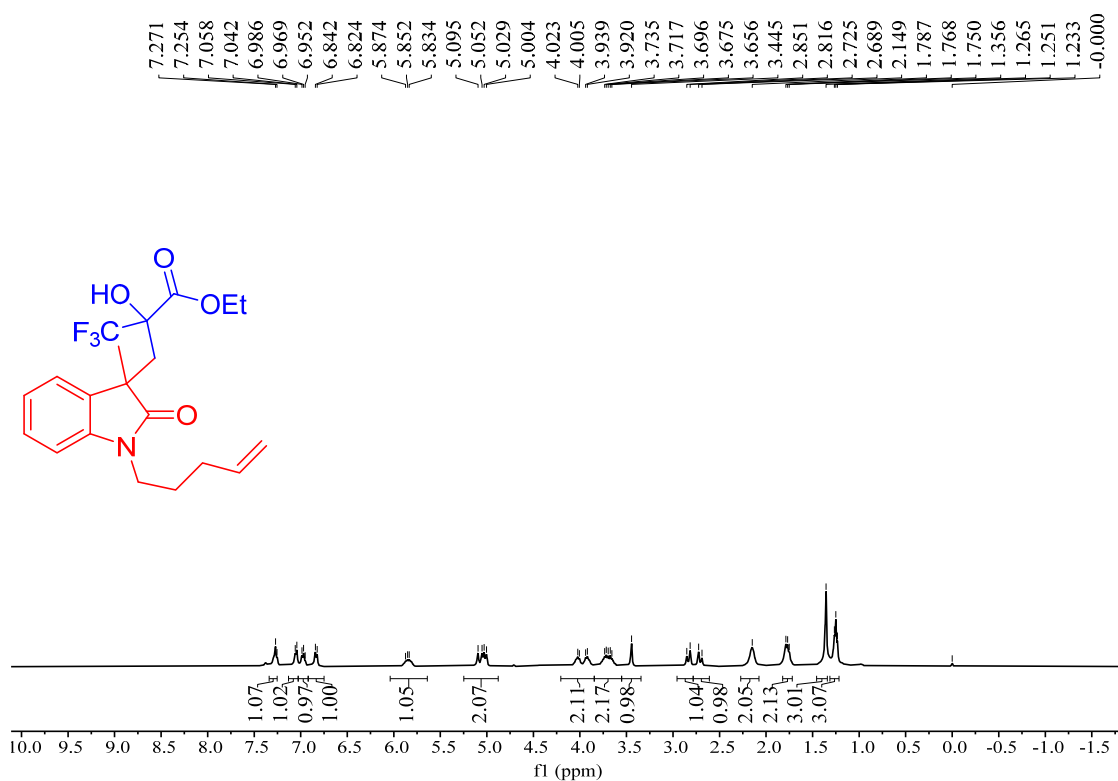
¹³C NMR of **19** (syn isomer) (101 MHz, CDCl₃)



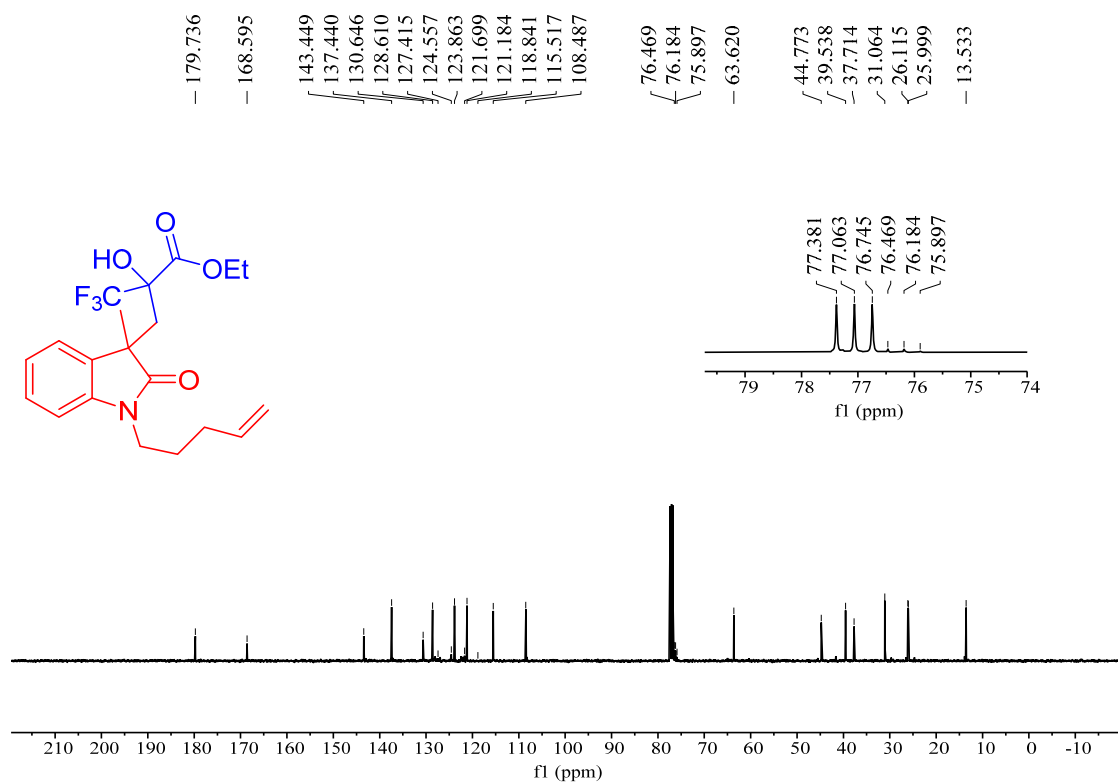
¹⁹F NMR of **19** (syn isomer) (376 MHz, CDCl₃)



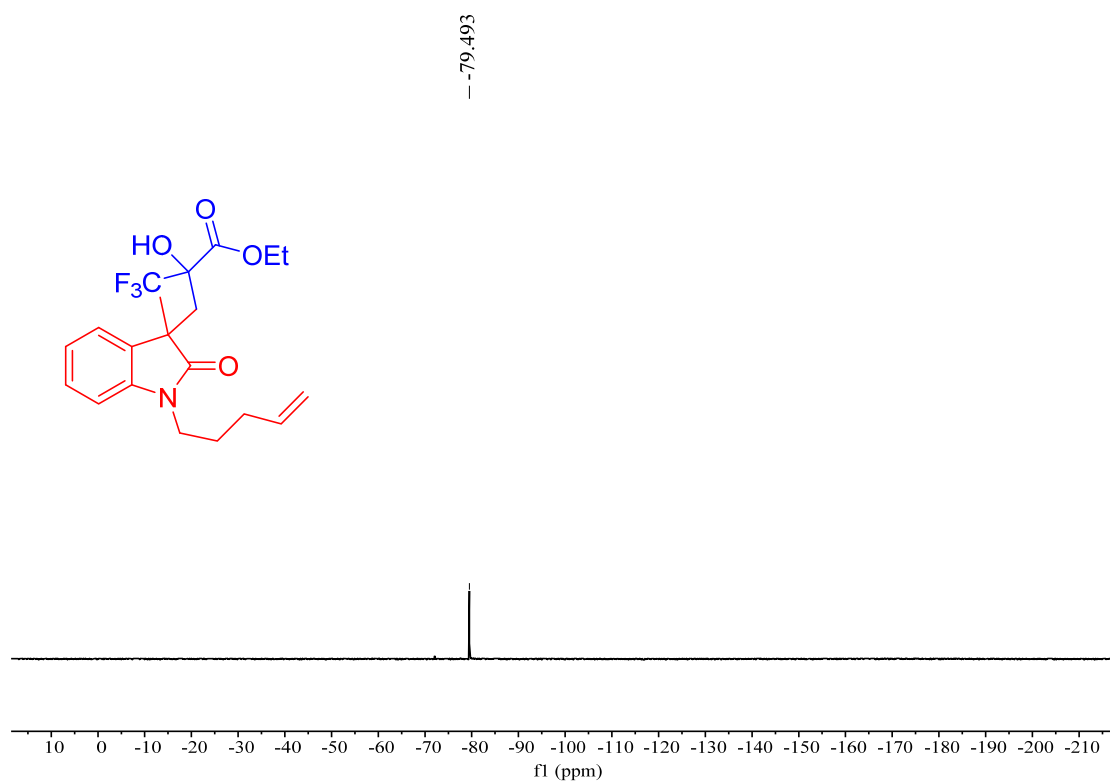
¹H NMR of **19** (anti isomer) (400 MHz, CDCl₃)



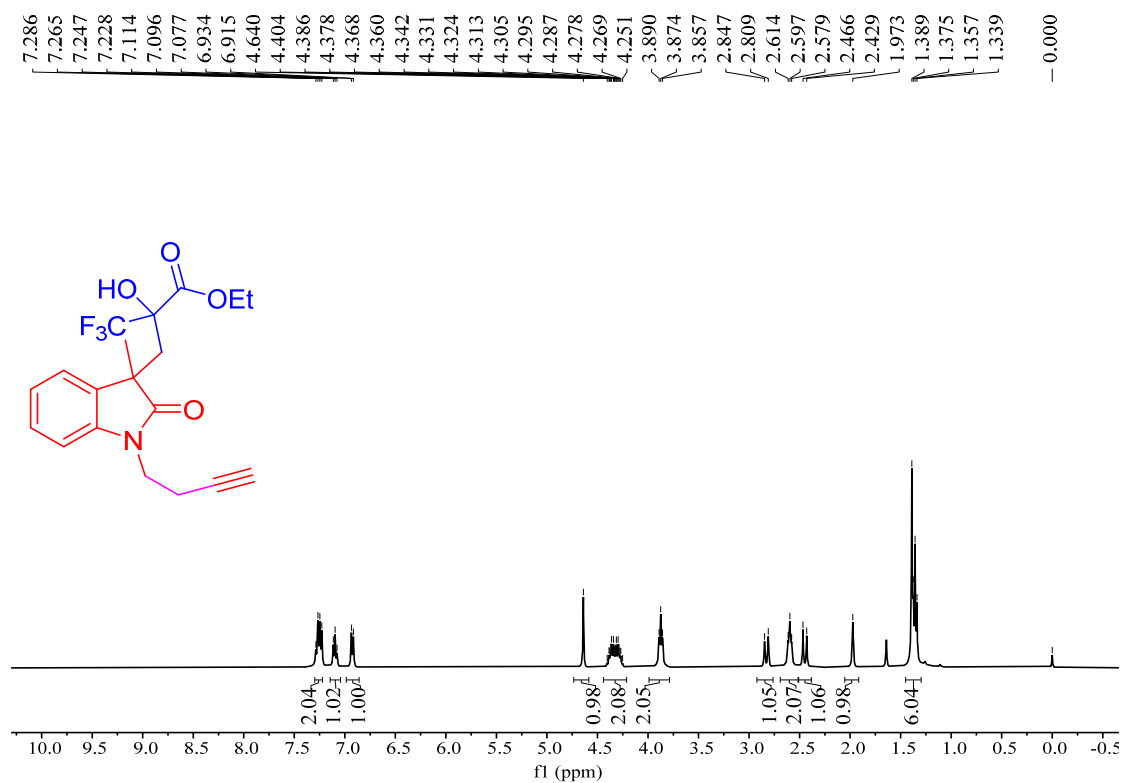
¹³C NMR of **19** (anti isomer) (101 MHz, CDCl₃)



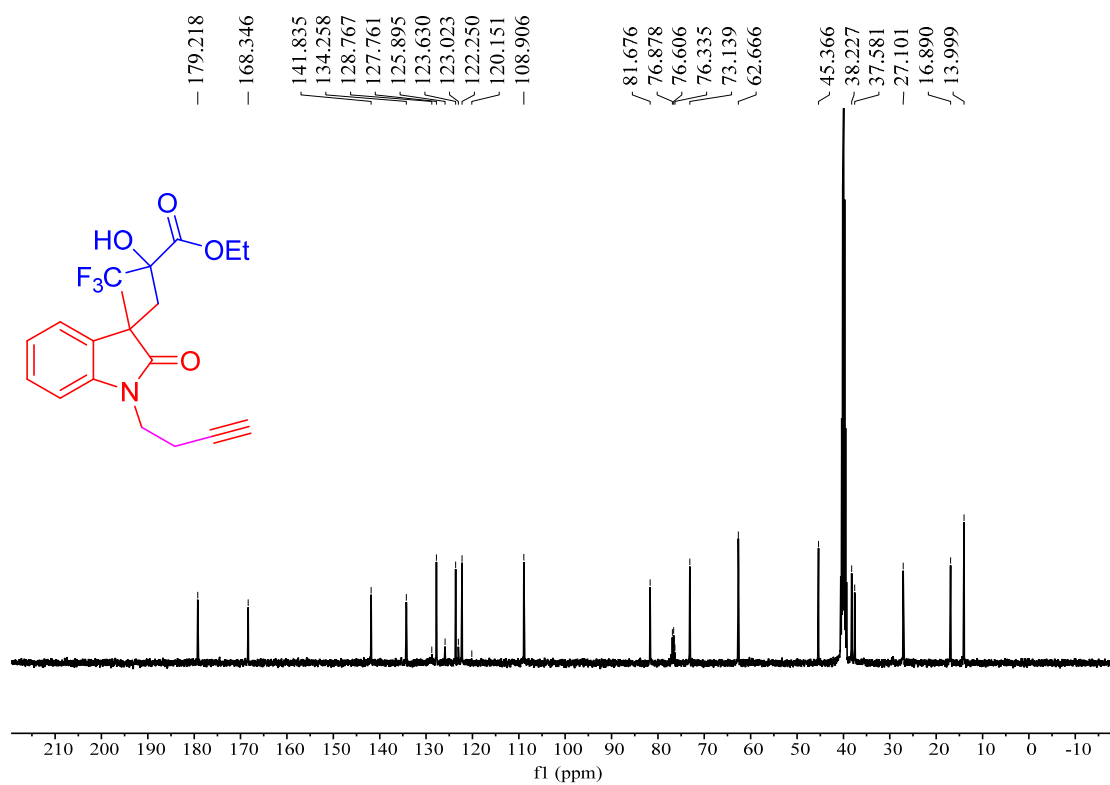
^{19}F NMR of **19** (anti isomer) (376 MHz, CDCl_3)



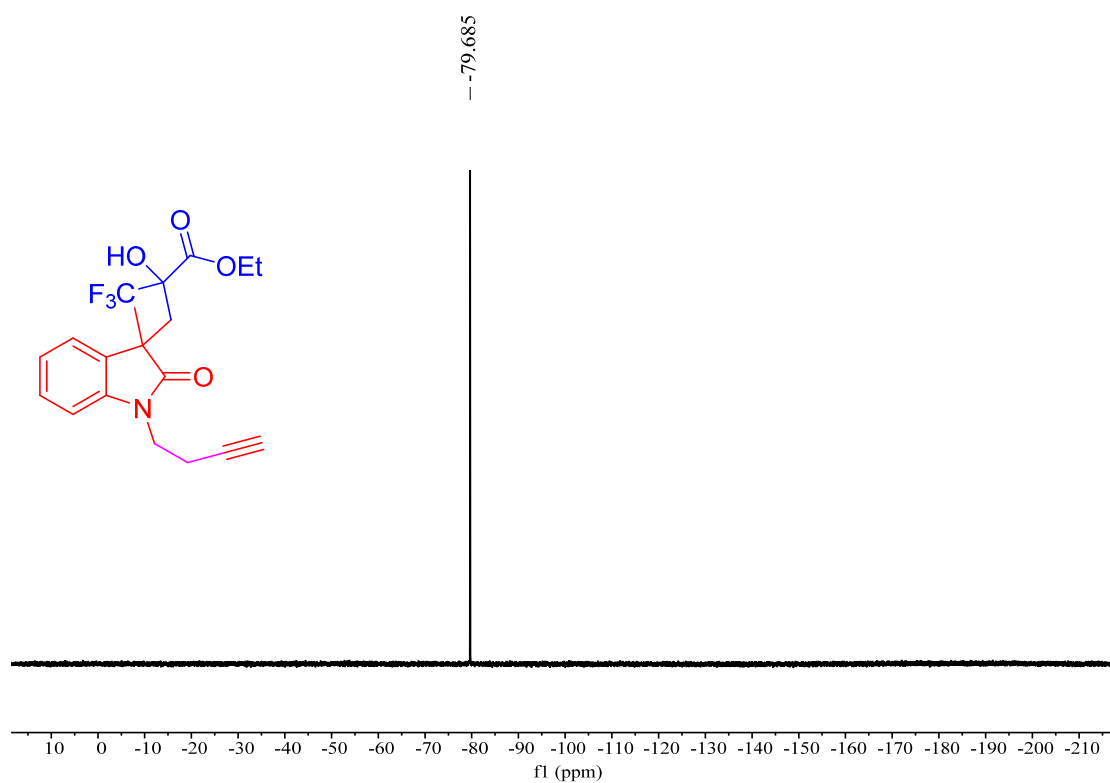
^1H NMR of **20** (syn isomer) (400 MHz, CDCl_3)



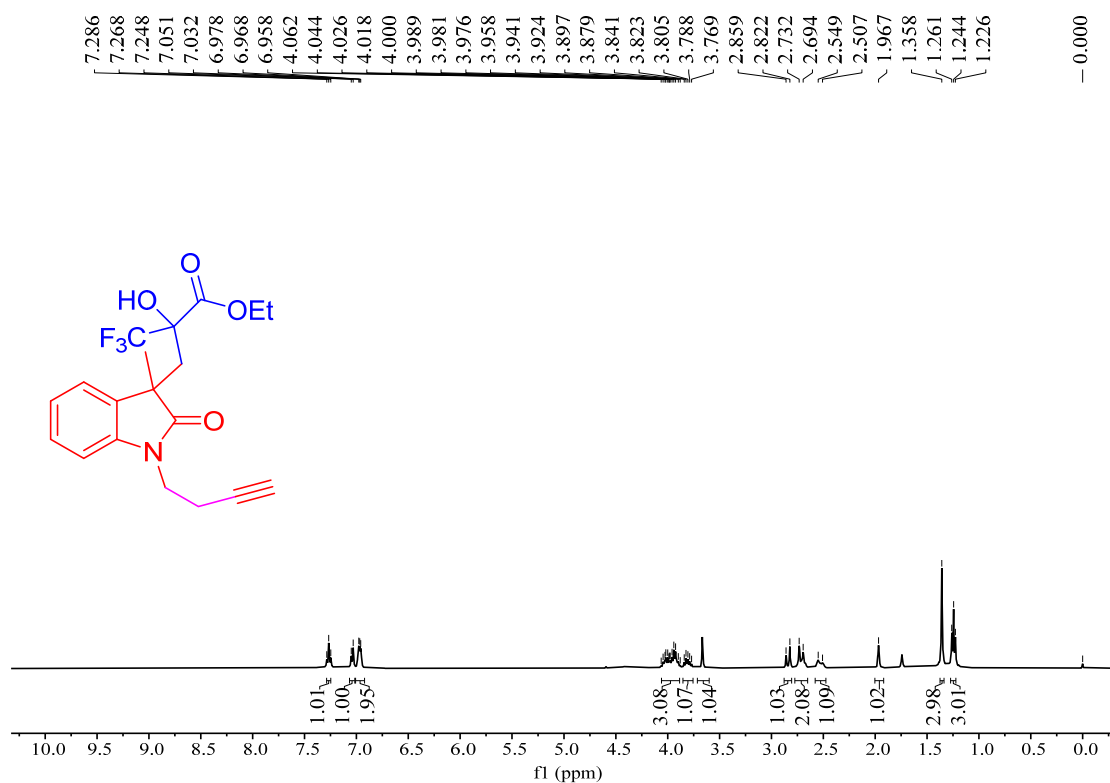
¹³C NMR of **20** (syn isomer) (101 MHz, DMSO-*d*₆)



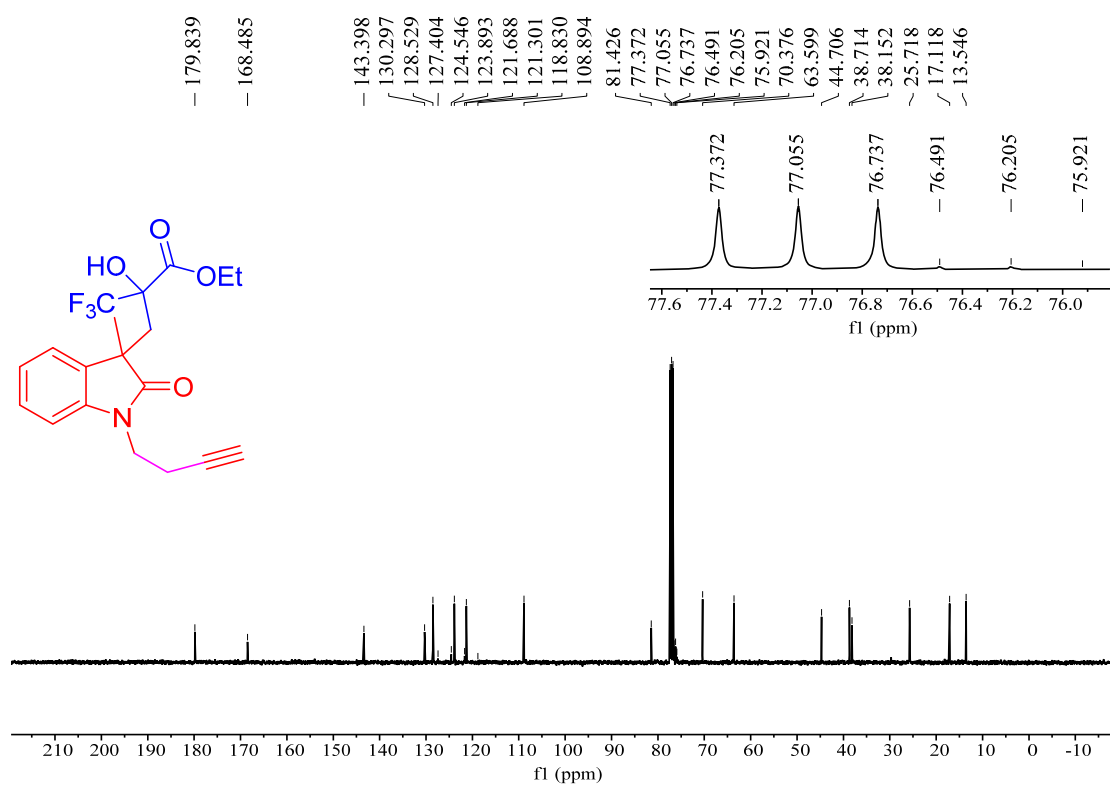
¹⁹F NMR of **20** (syn isomer) (376 MHz, CDCl₃)



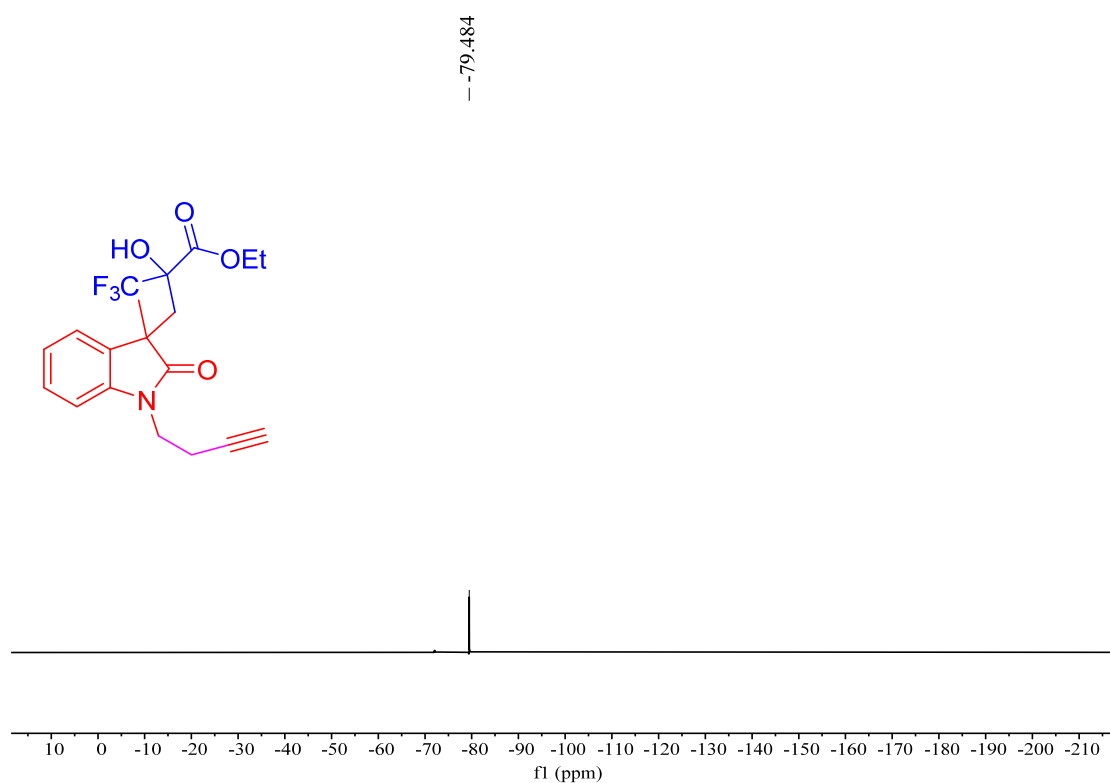
¹H NMR of **20** (anti isomer) (400 MHz, CDCl₃)



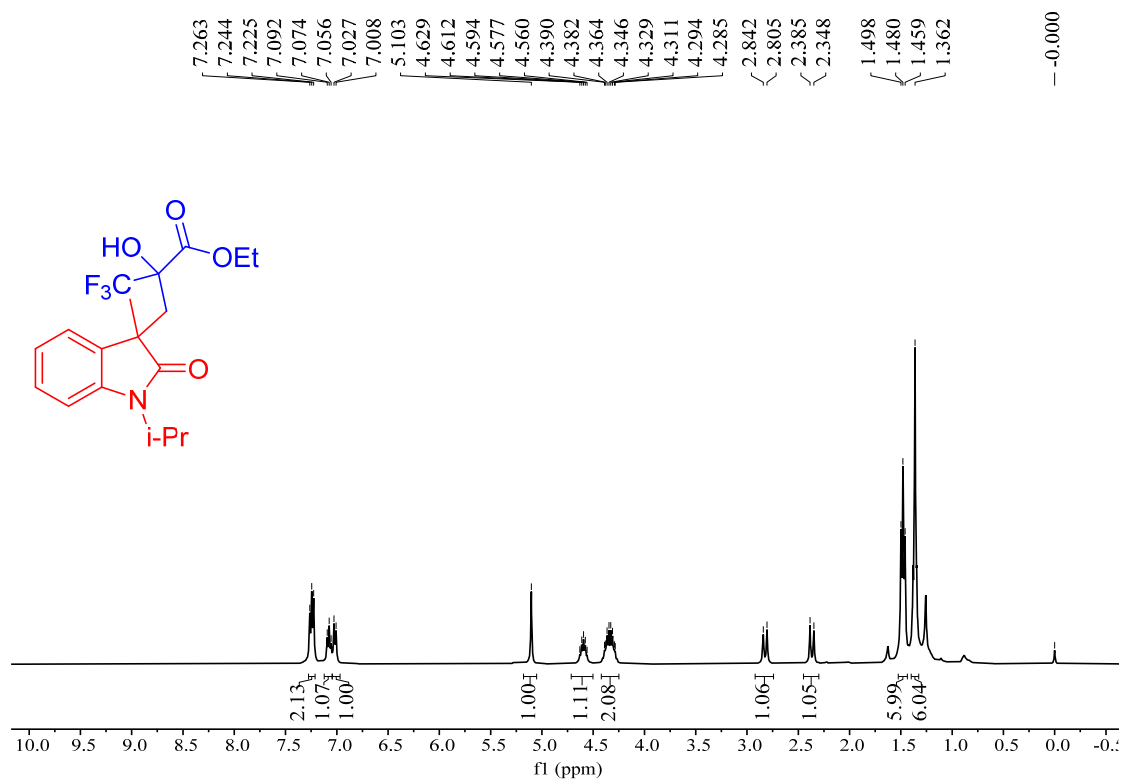
¹³C NMR of **20** (anti isomer) (101 MHz, CDCl₃)



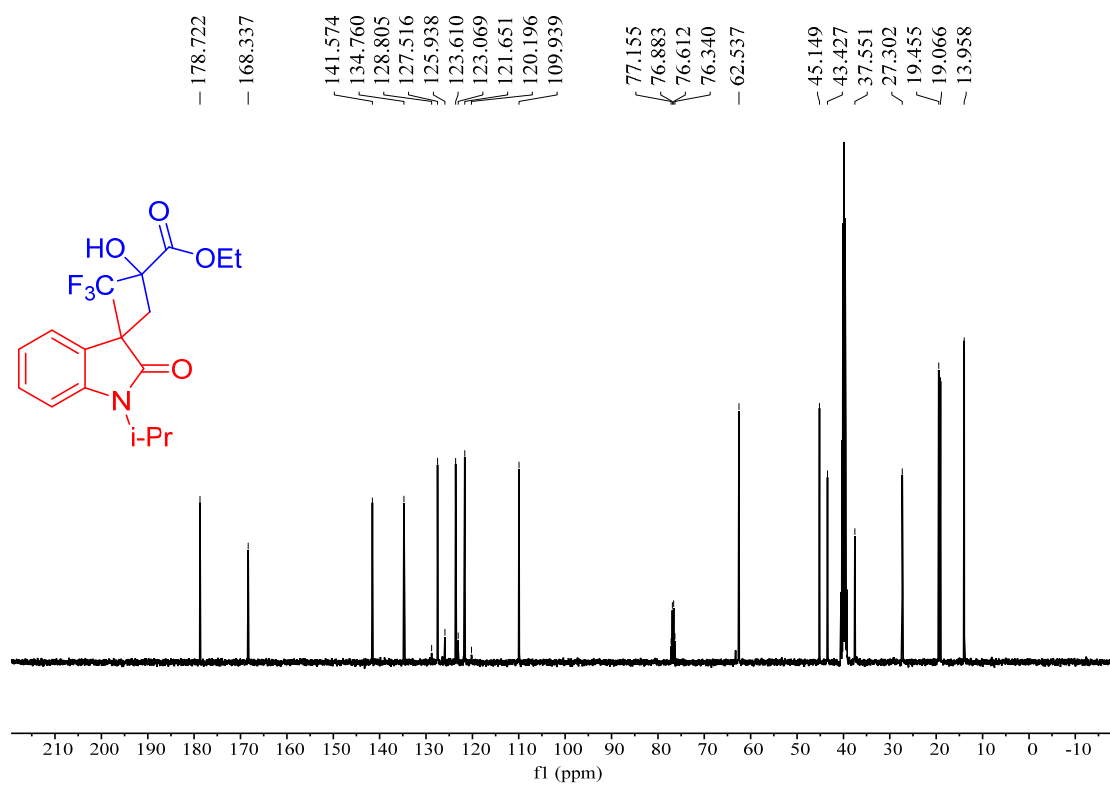
^{19}F NMR of **20** (anti isomer) (376 MHz, CDCl_3)



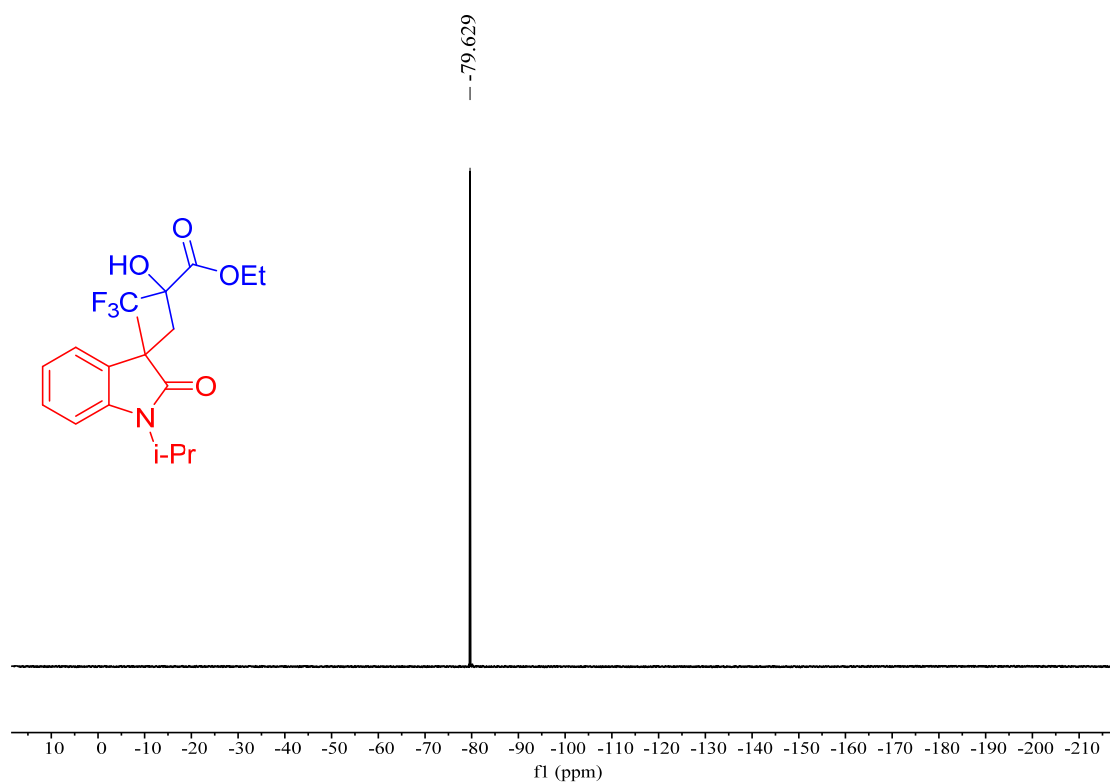
^1H NMR of **21** (syn isomer) (400 MHz, CDCl_3)



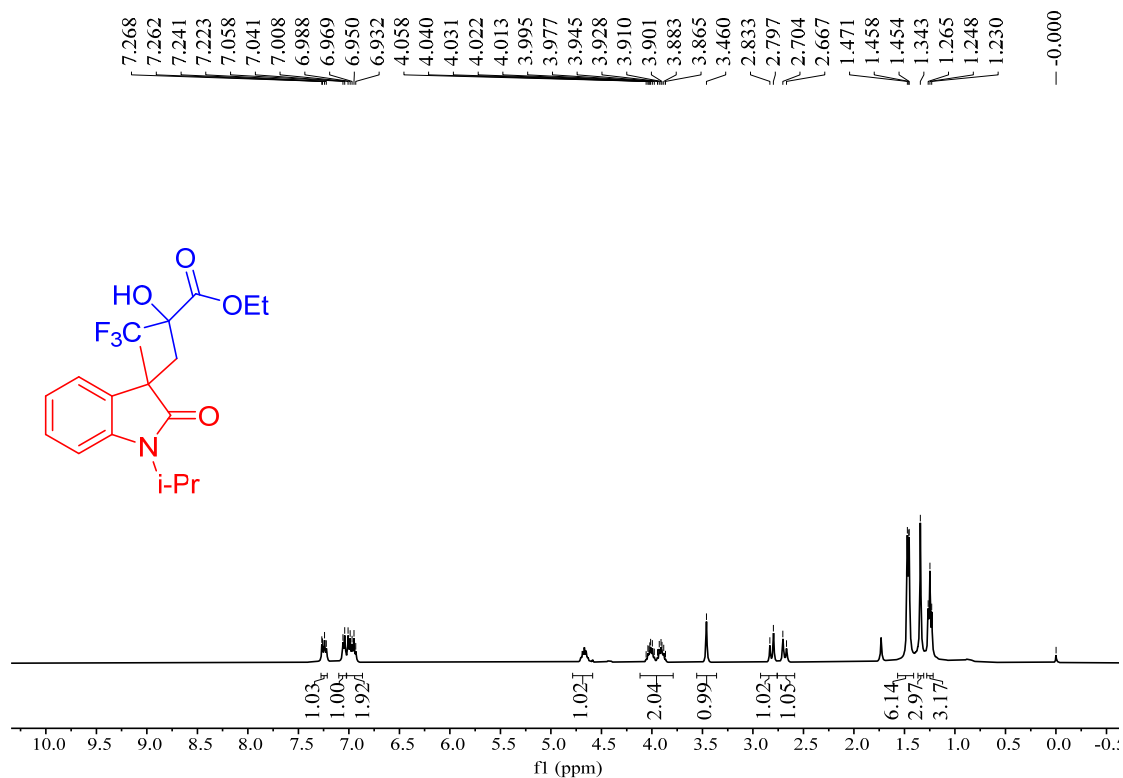
¹³C NMR of **21** (syn isomer) (101 MHz, DMSO-*d*₆)



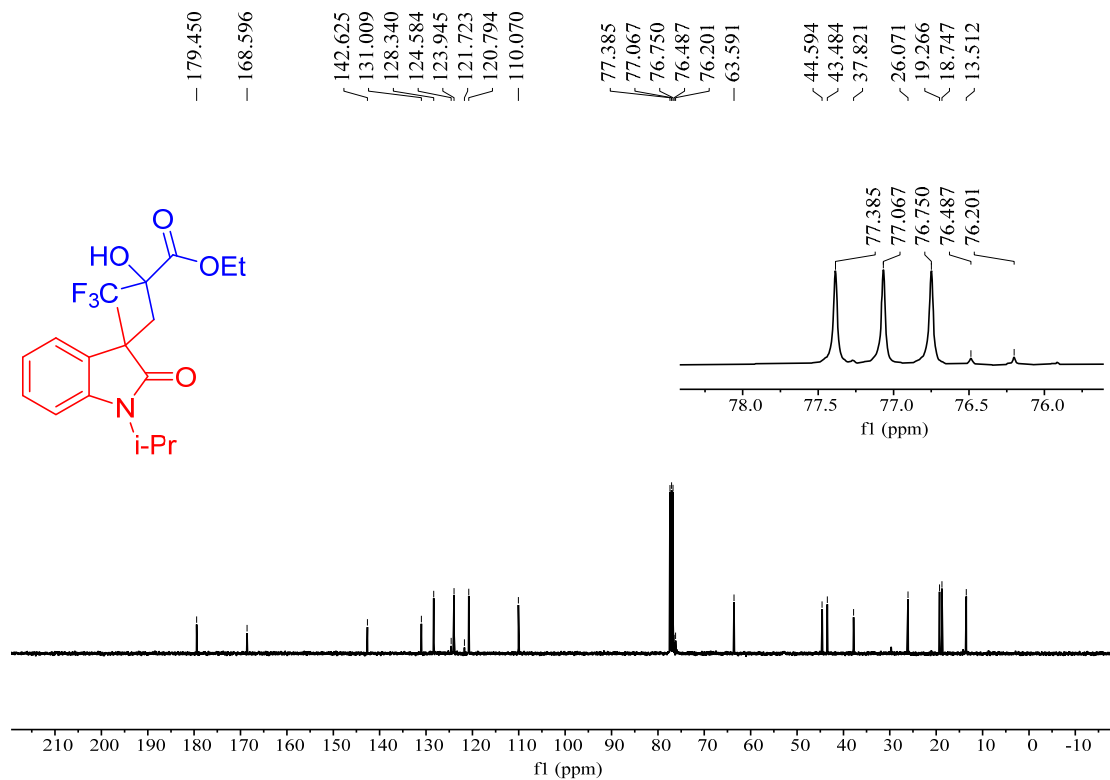
¹⁹F NMR of **21** (syn isomer) (376 MHz, CDCl₃)



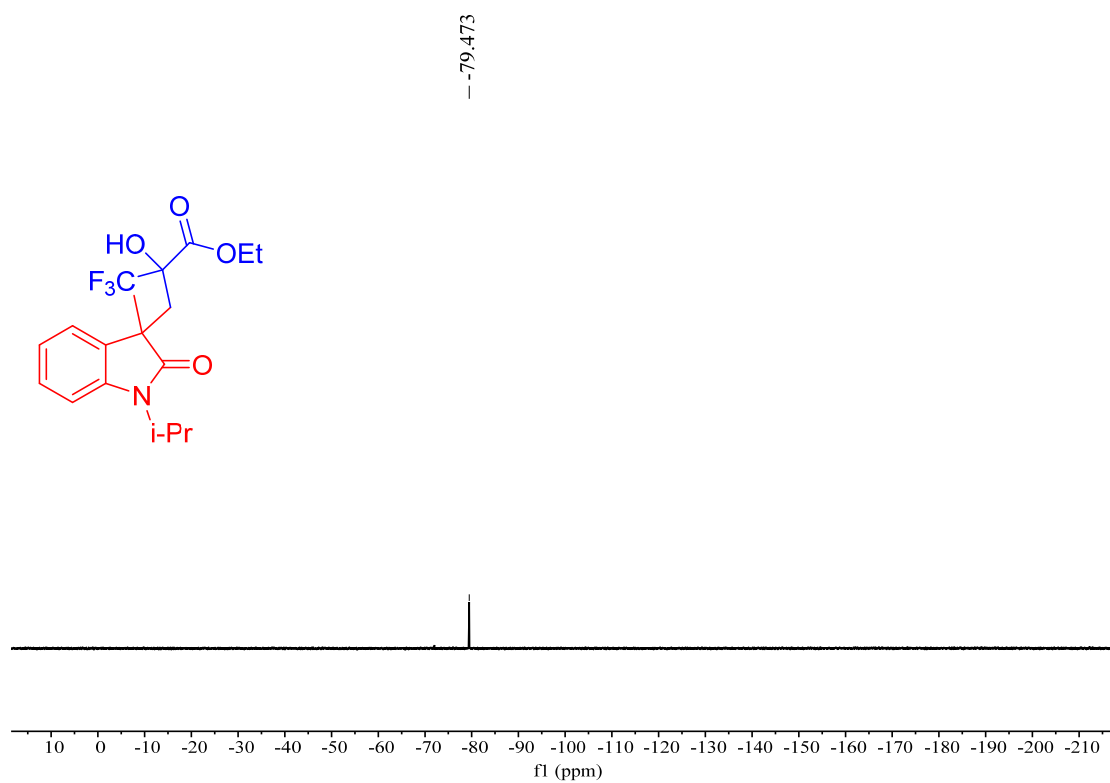
¹H NMR of **21** (anti isomer) (400 MHz, CDCl₃)



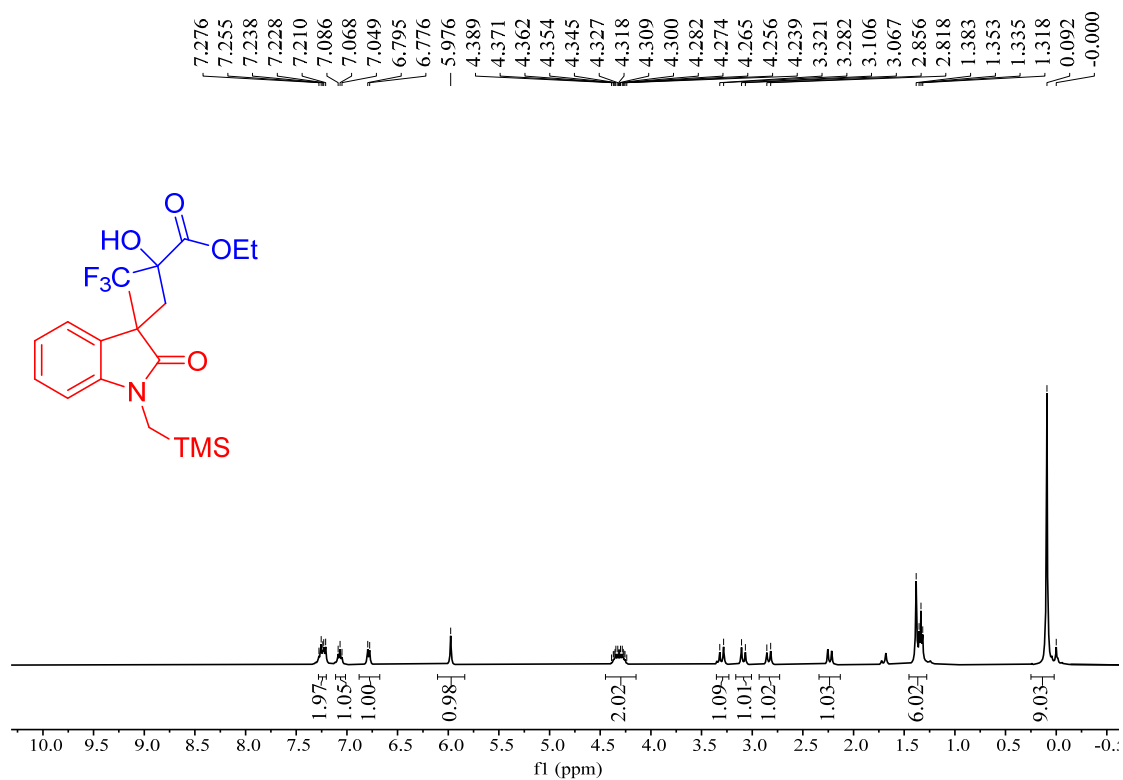
¹³C NMR of **21** (anti isomer) (101 MHz, CDCl₃)



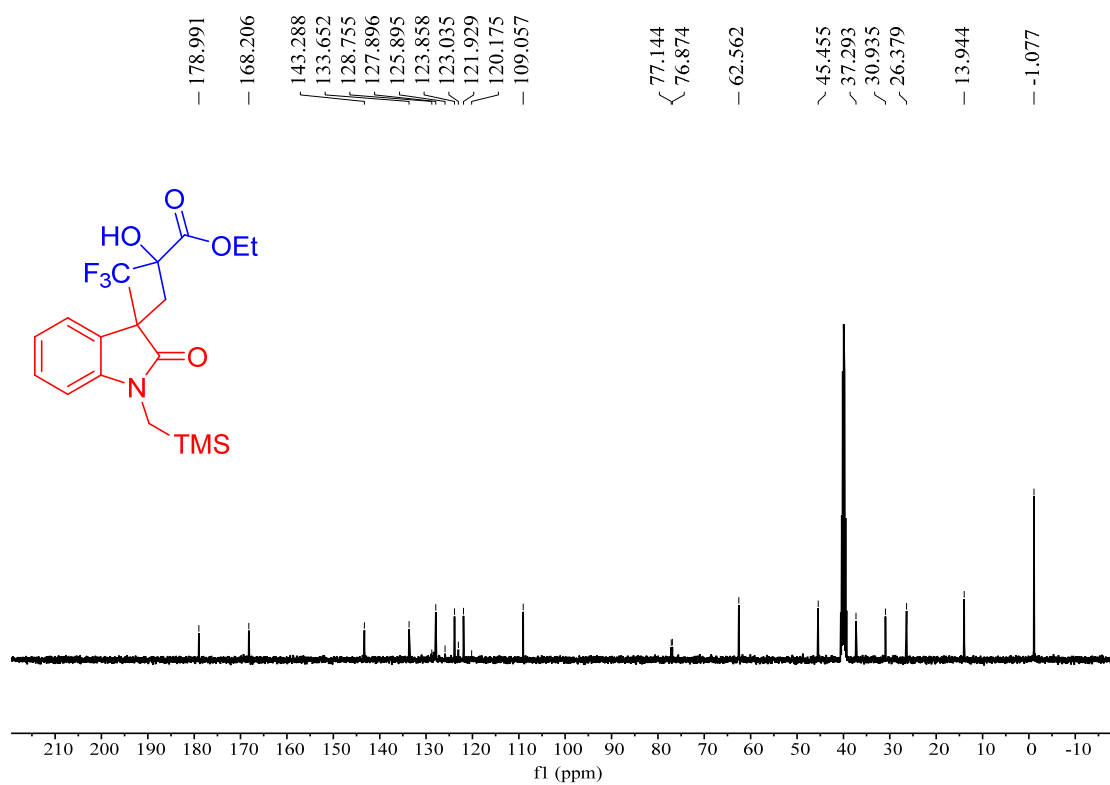
¹⁹F NMR of **21** (anti isomer) (376 MHz, CDCl₃)



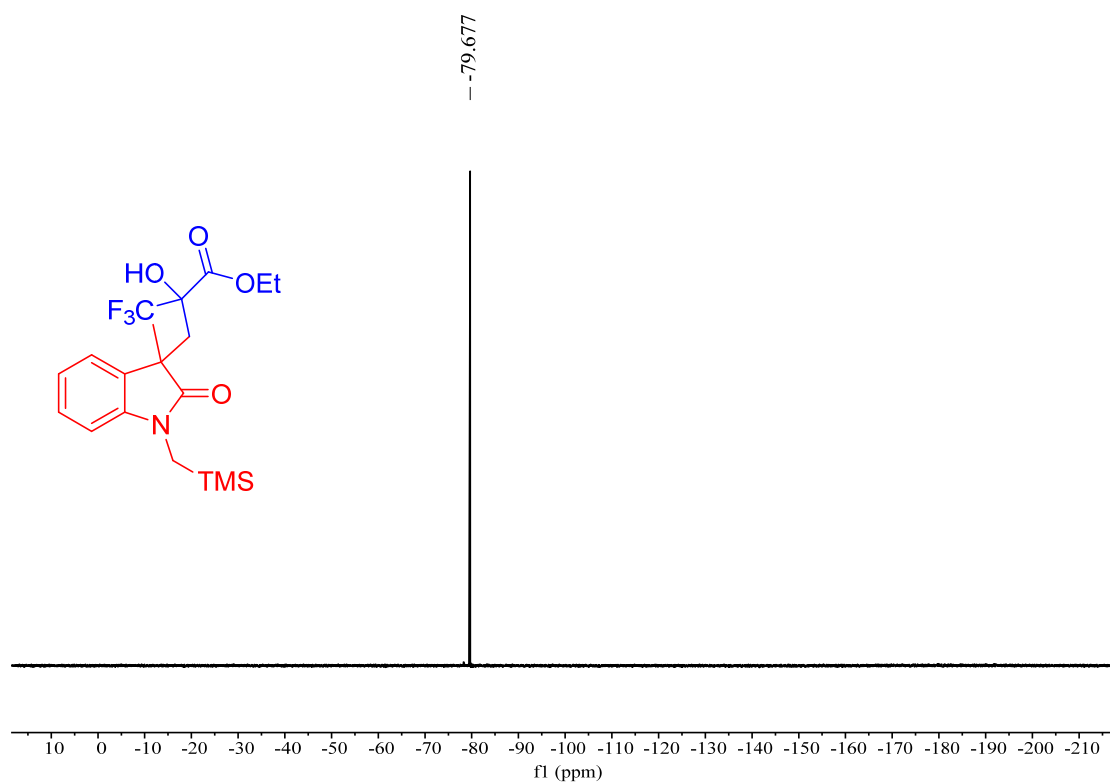
¹H NMR of **22** (syn isomer) (400 MHz, CDCl₃)



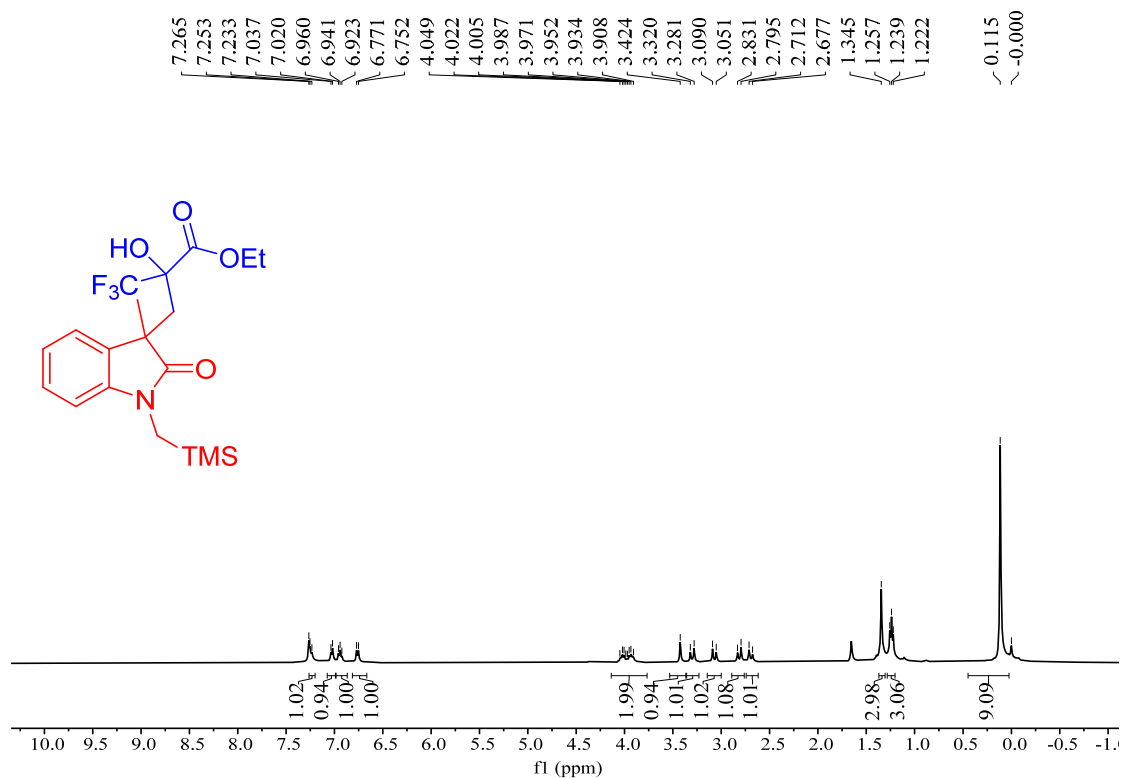
¹³C NMR of **22** (syn isomer) (101 MHz, DMSO-*d*₆)



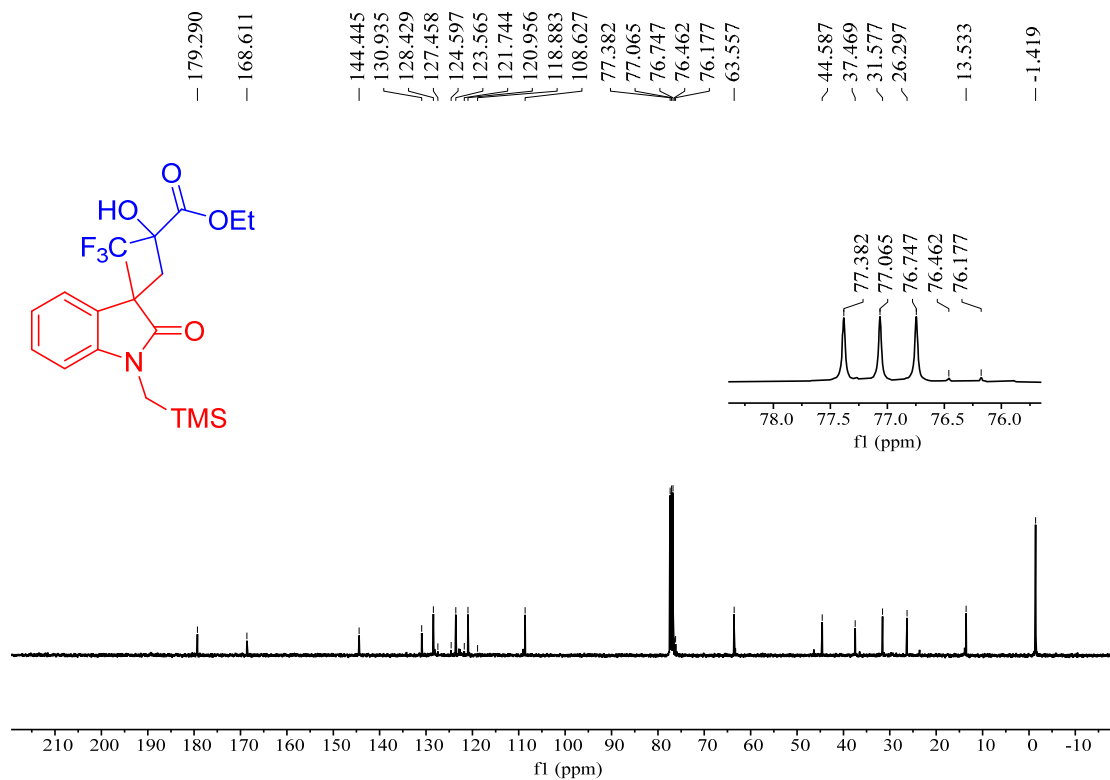
¹⁹F NMR of **22** (syn isomer) (376 MHz, CDCl₃)



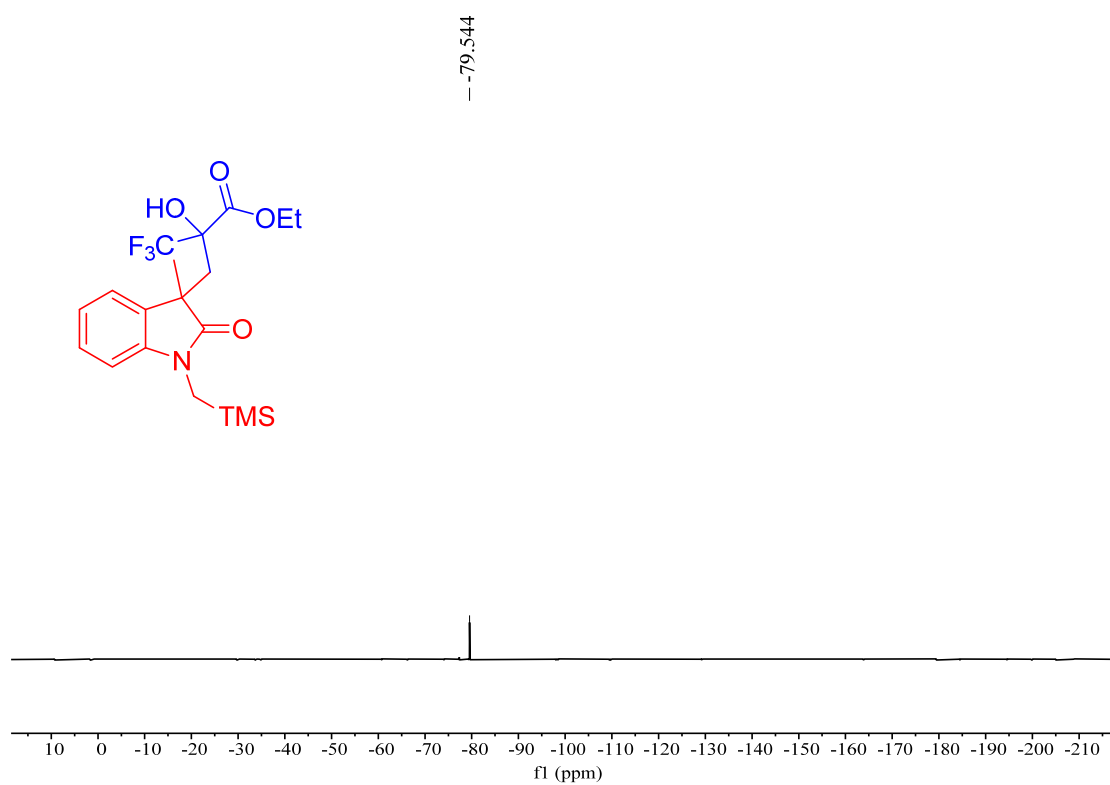
¹H NMR of **22** (anti isomer) (400 MHz, CDCl₃)



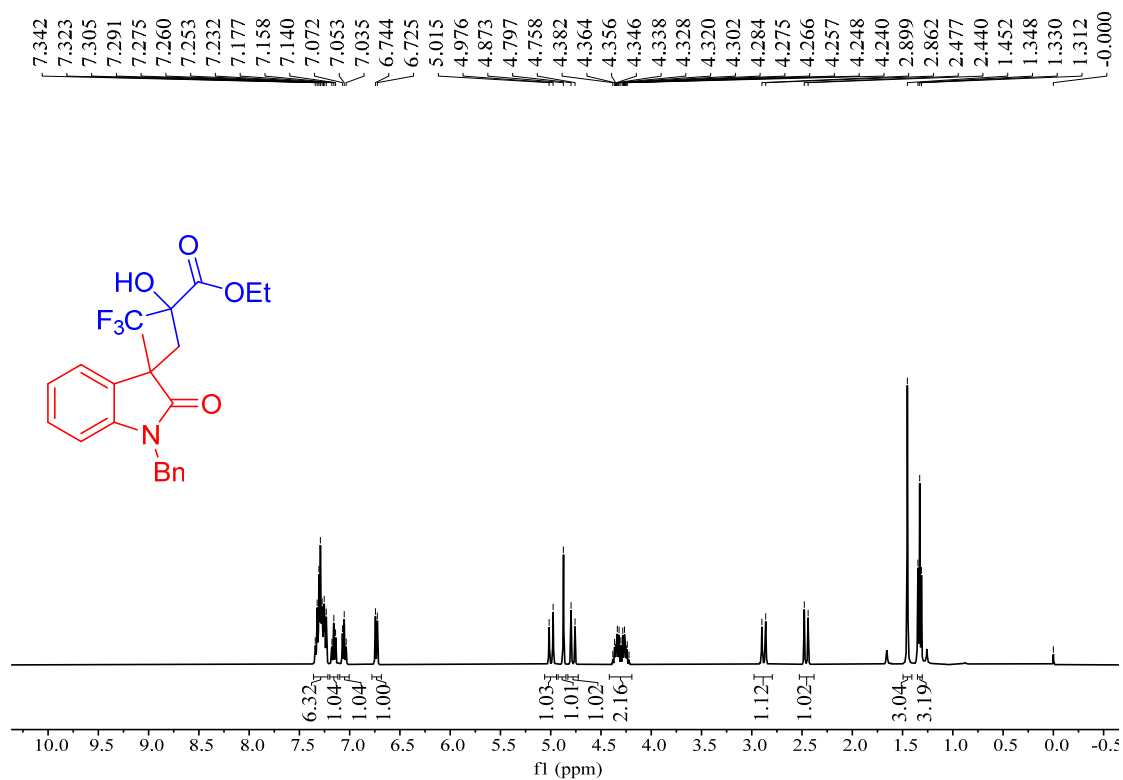
¹³C NMR of **22** (anti isomer) (101 MHz, CDCl₃)



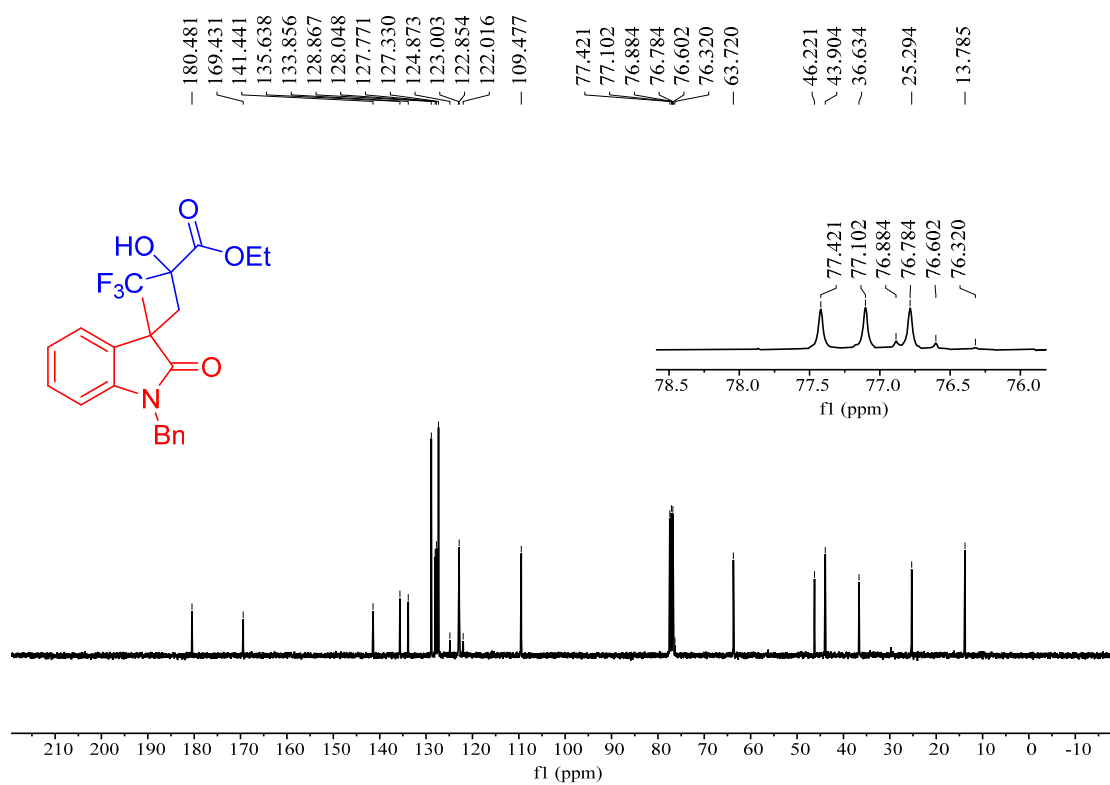
¹⁹F NMR of **22** (anti isomer) (376 MHz, CDCl₃)



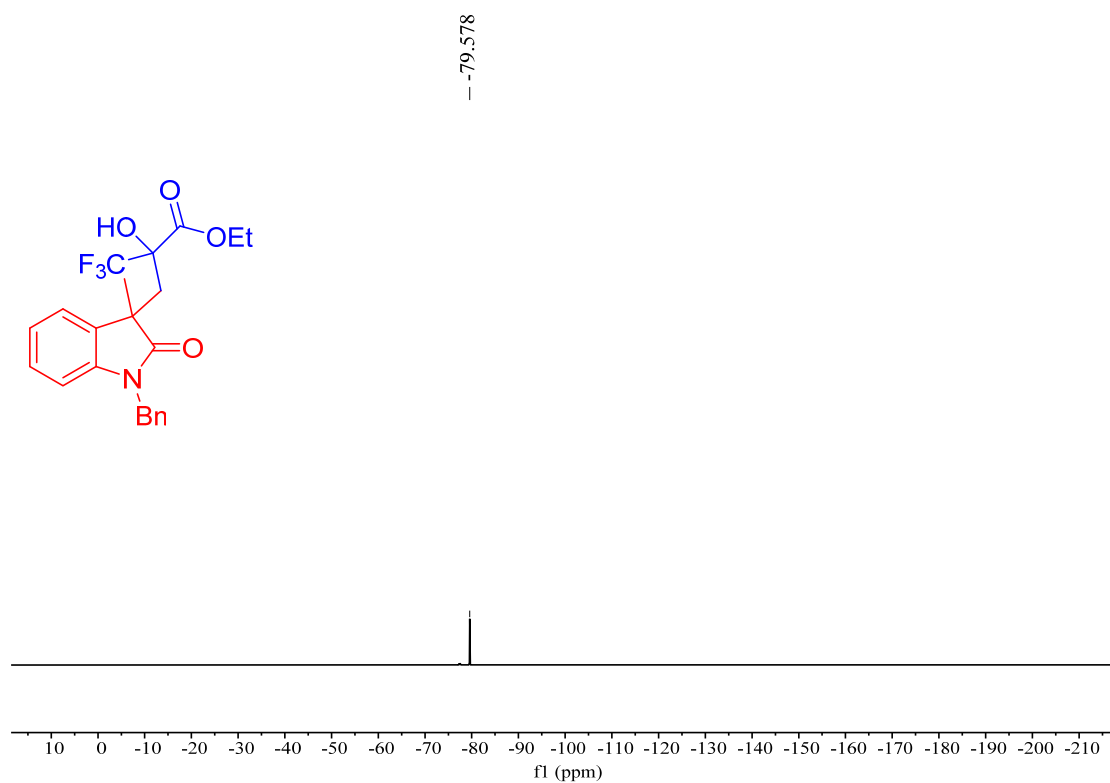
¹H NMR of **23** (syn isomer) (400 MHz, CDCl₃)



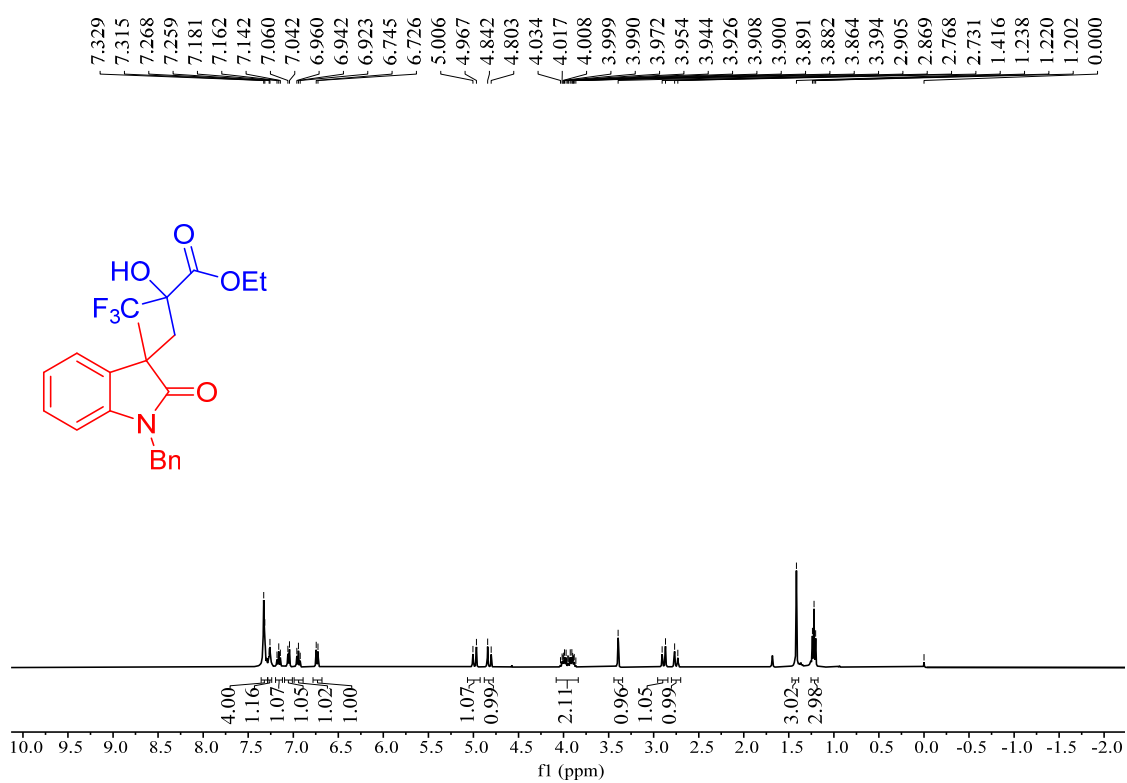
¹³C NMR of **23** (syn isomer) (101 MHz, CDCl₃)



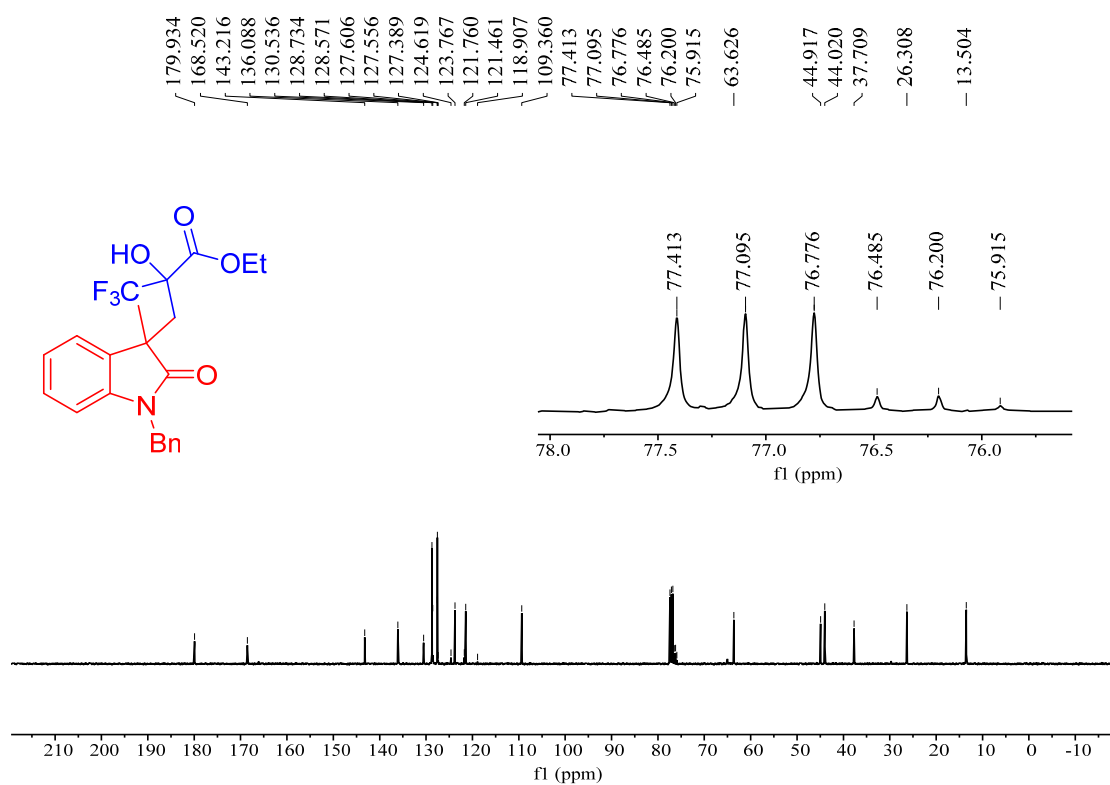
¹⁹F NMR of **23** (syn isomer) (376 MHz, CDCl₃)



¹H NMR of **23** (anti isomer) (400 MHz, CDCl₃)

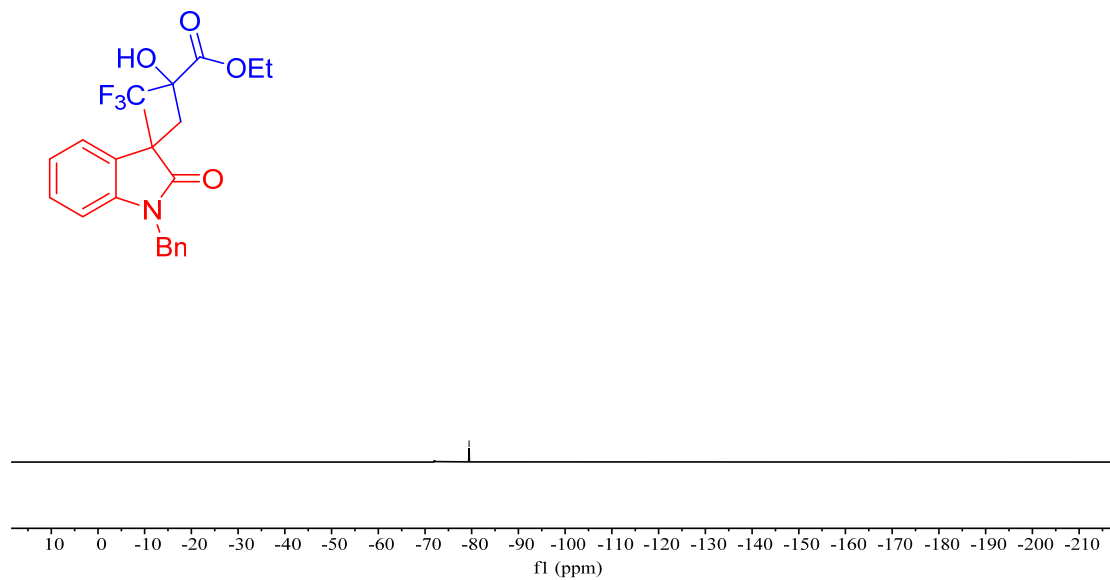


¹³C NMR of **23** (anti isomer) (101 MHz, CDCl₃)

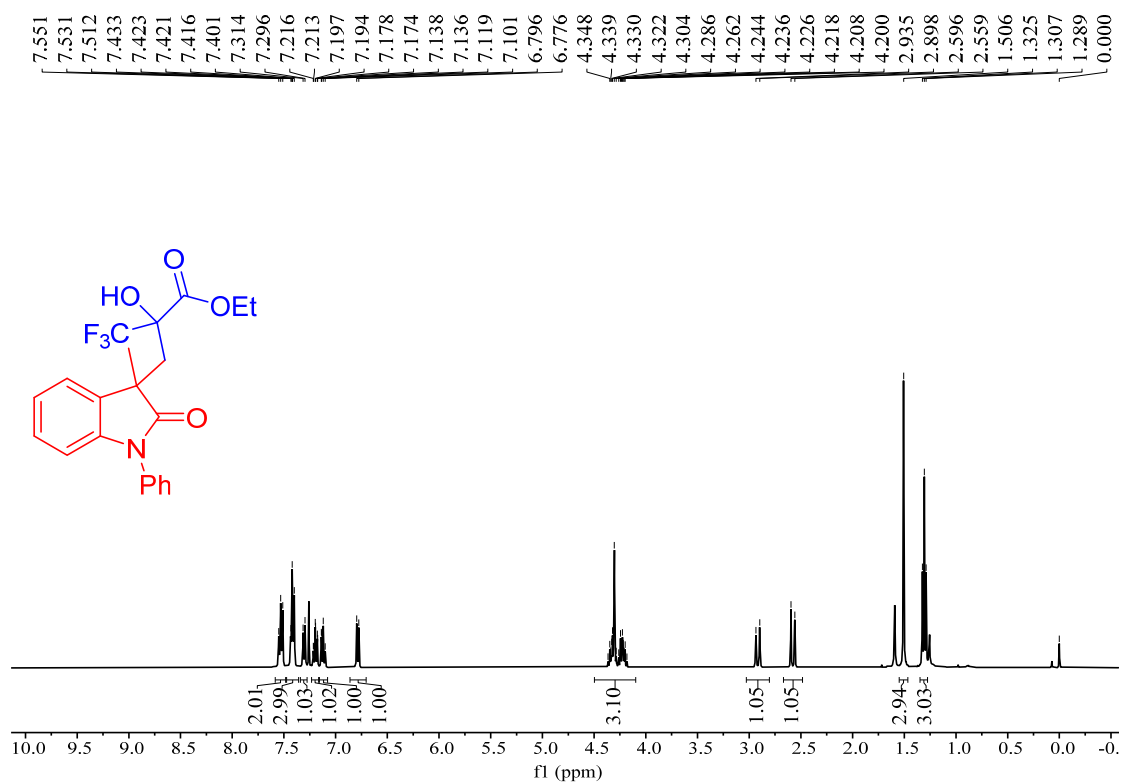


¹⁹F NMR of **23** (anti isomer) (376 MHz, CDCl₃)

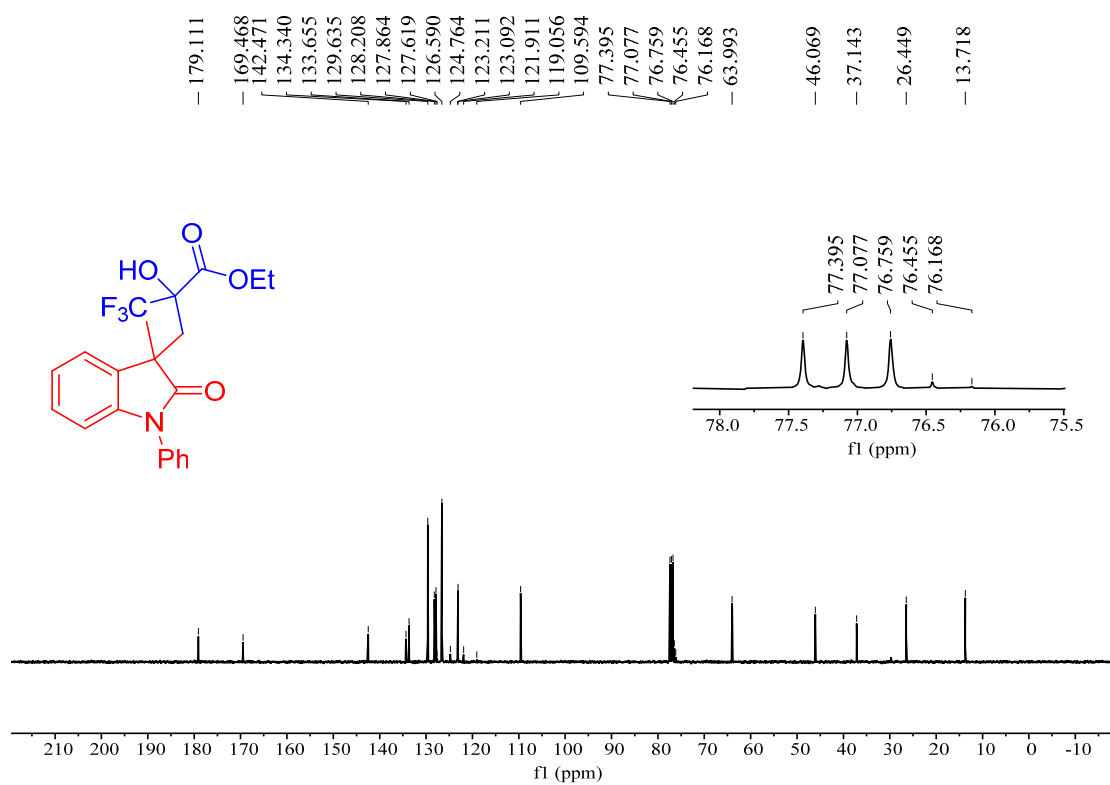
-79.434



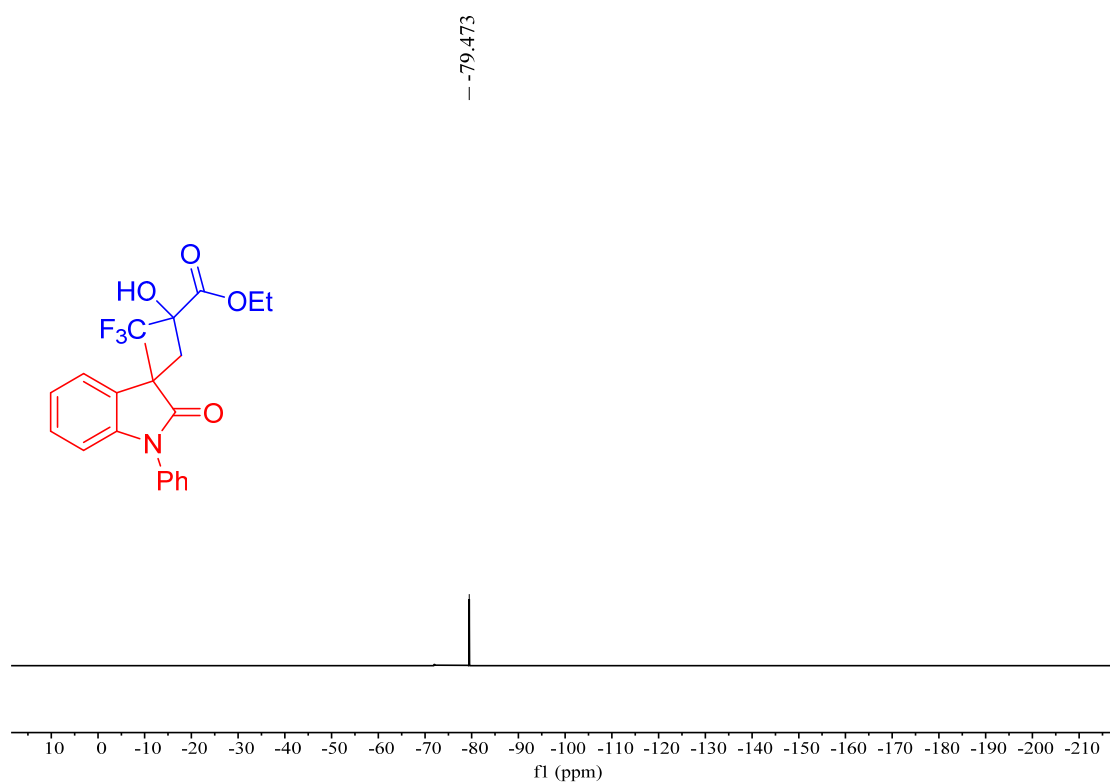
¹H NMR of **24** (syn isomer) (400 MHz, CDCl₃)



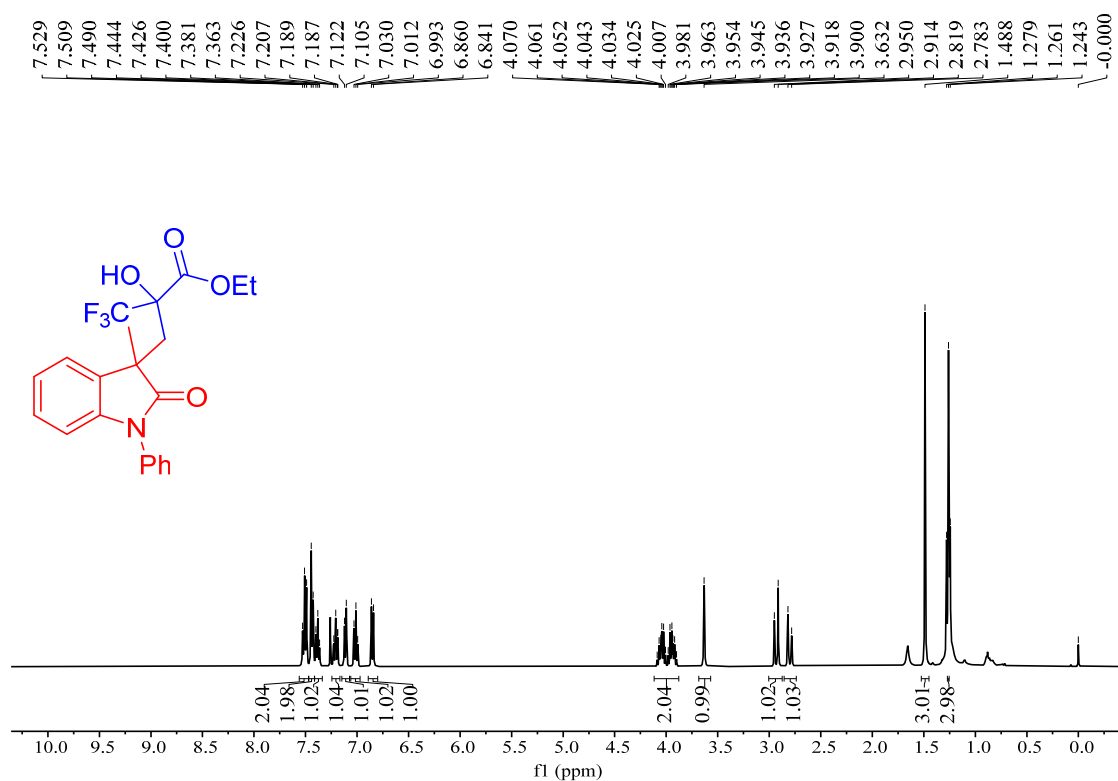
¹³C NMR of **24** (syn isomer) (101 MHz, CDCl₃)



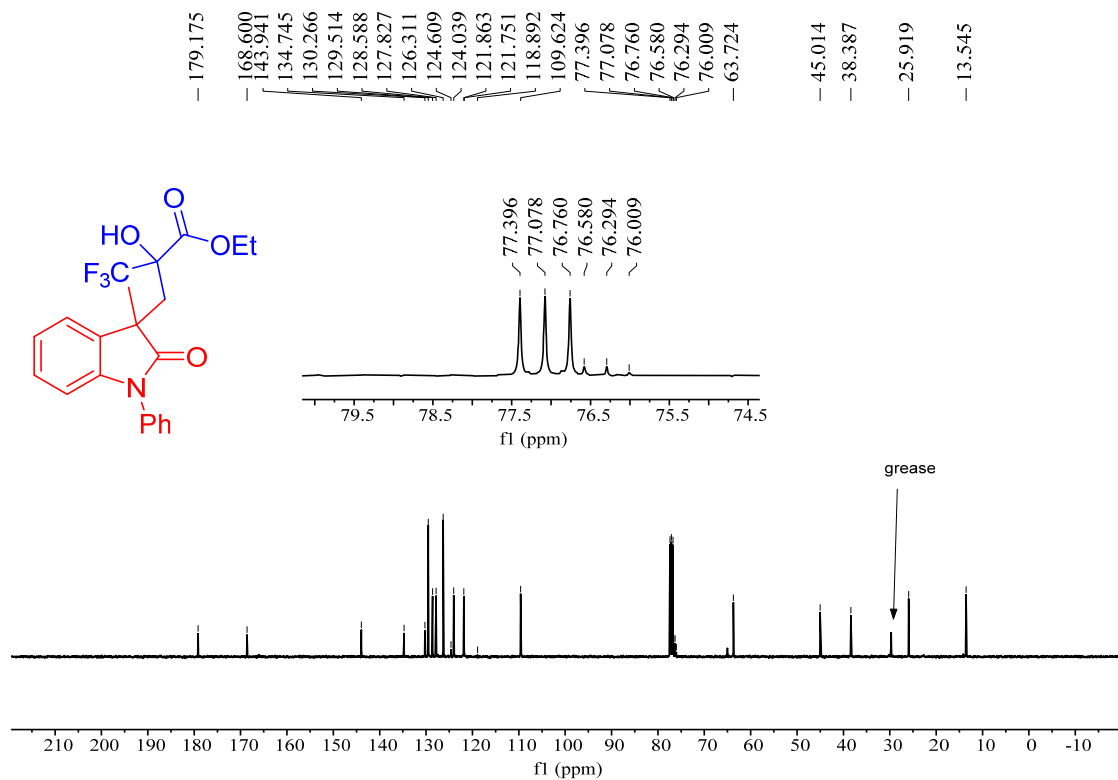
¹⁹F NMR of **24** (syn isomer) (376 MHz, CDCl₃)



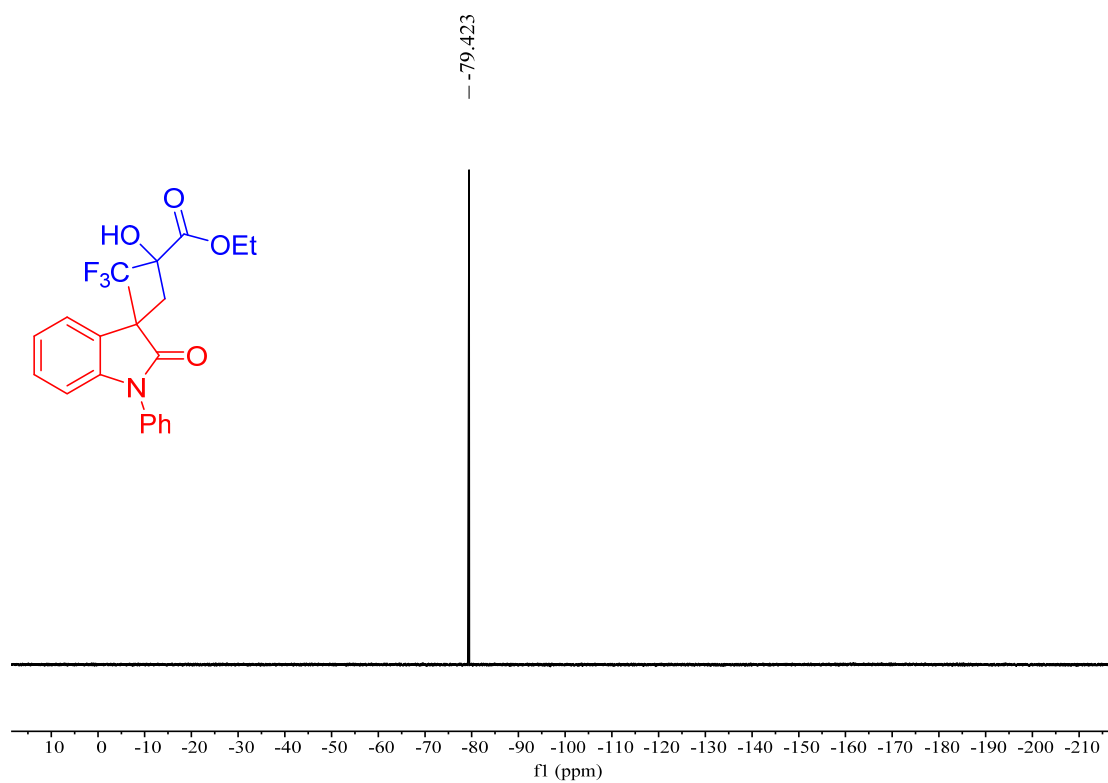
¹H NMR of **24** (anti isomer) (400 MHz, CDCl₃)



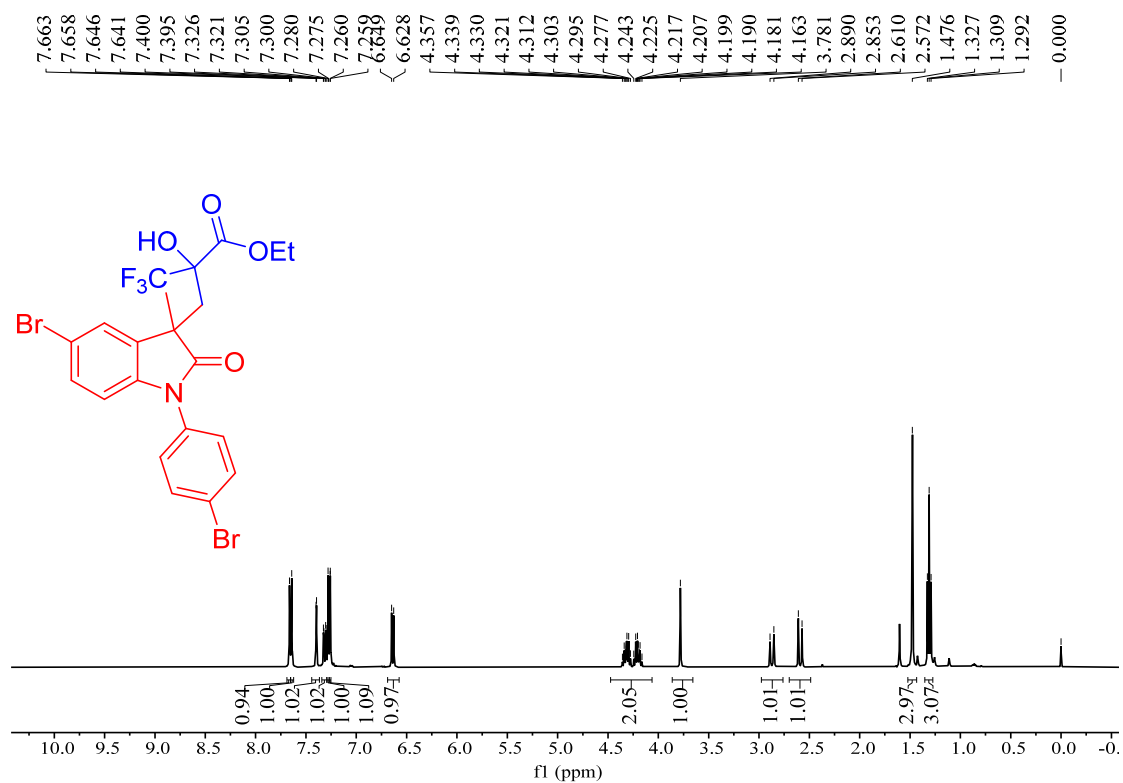
¹³C NMR of **24** (anti isomer) (101 MHz, CDCl₃)



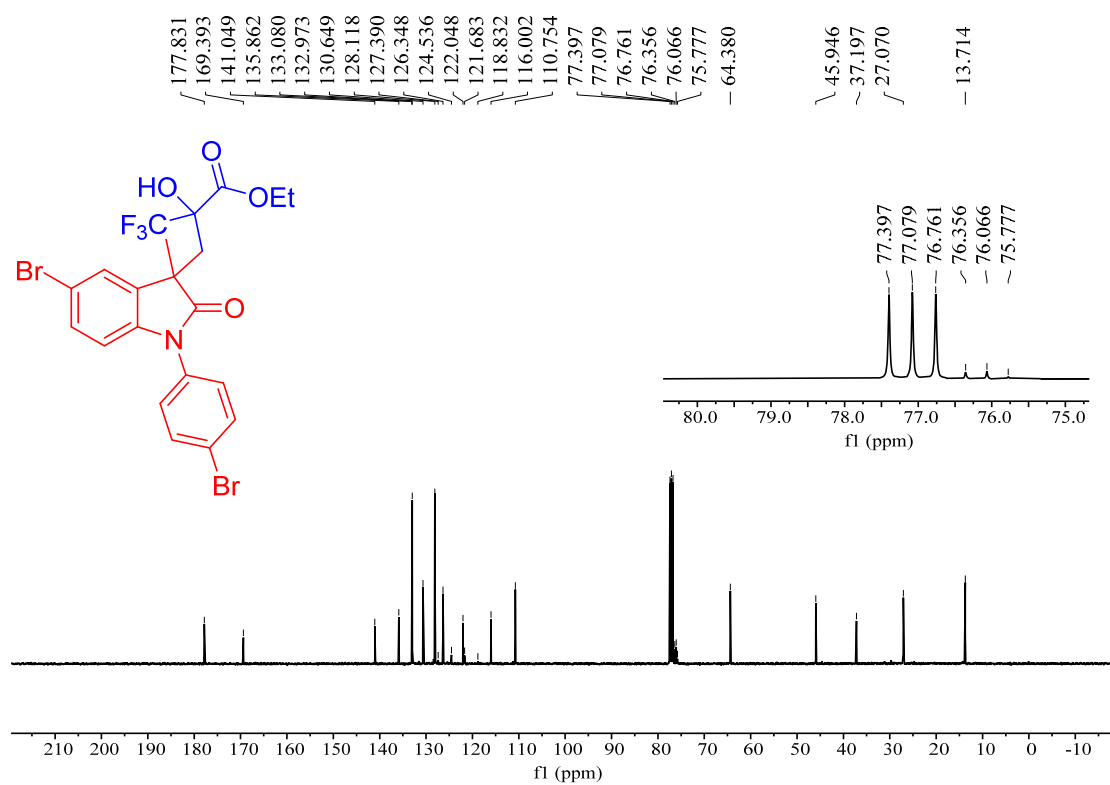
¹⁹F NMR of **24** (anti isomer) (376 MHz, CDCl₃)



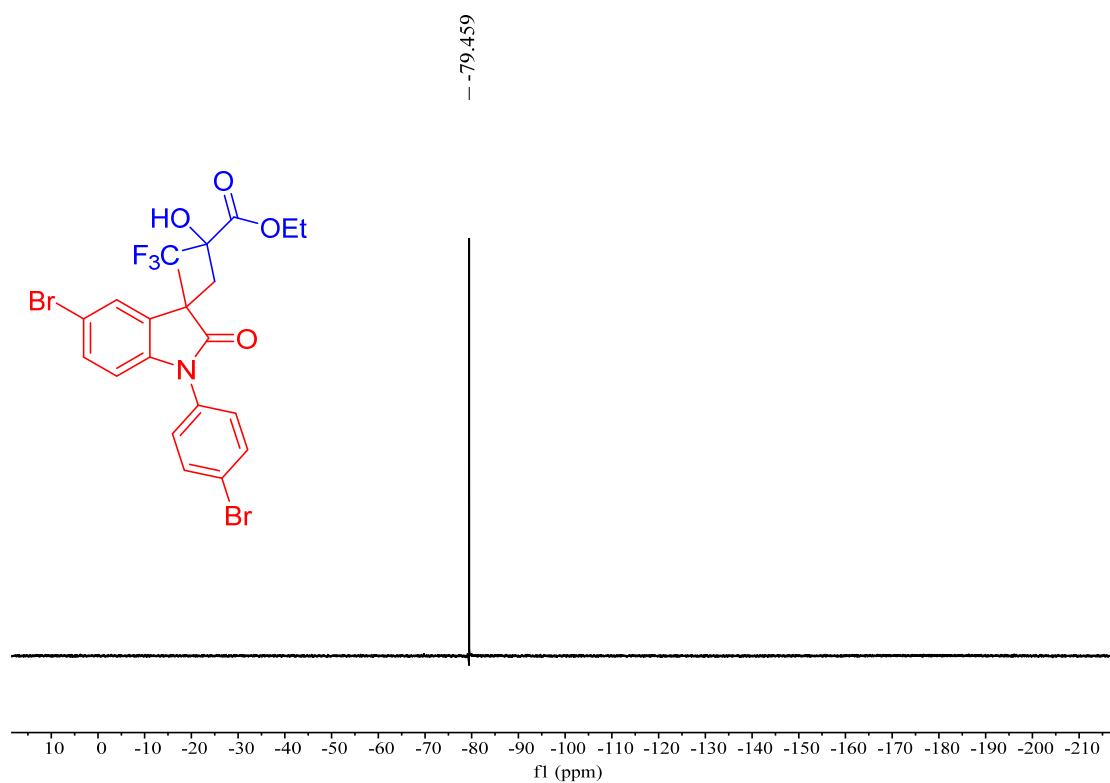
¹H NMR of **25** (syn isomer) (400 MHz, CDCl₃)



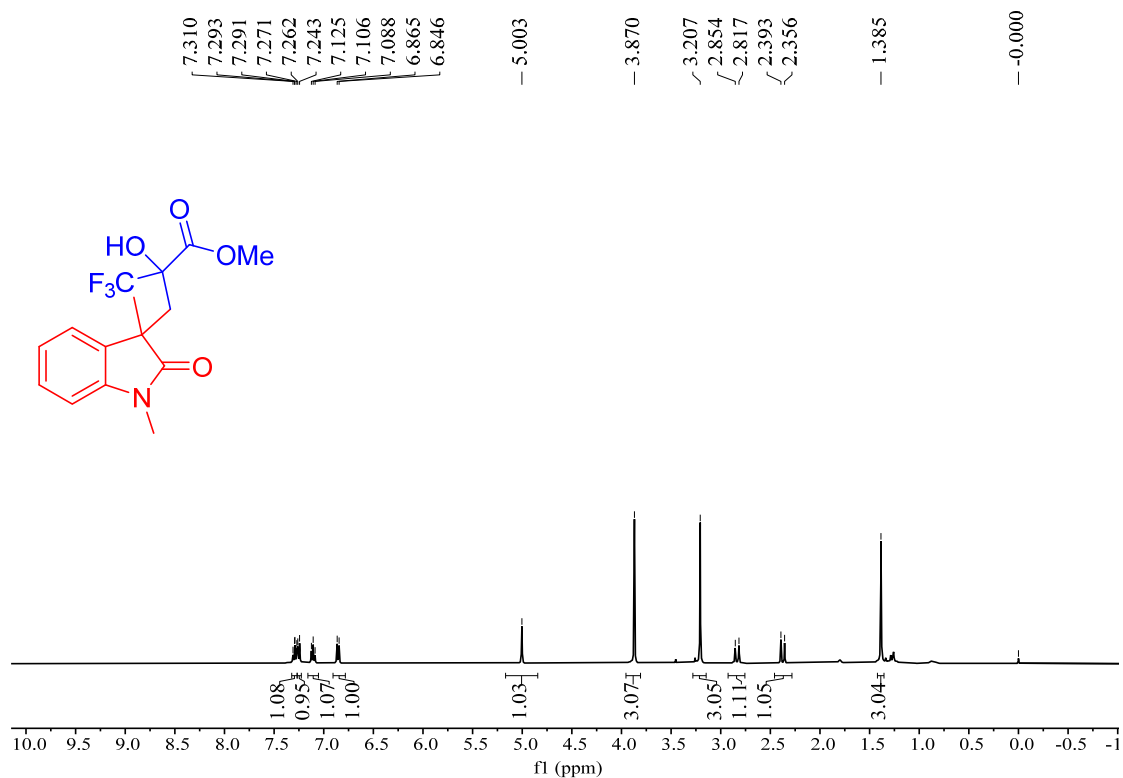
¹³C NMR of **25** (syn isomer) (101 MHz, CDCl₃)



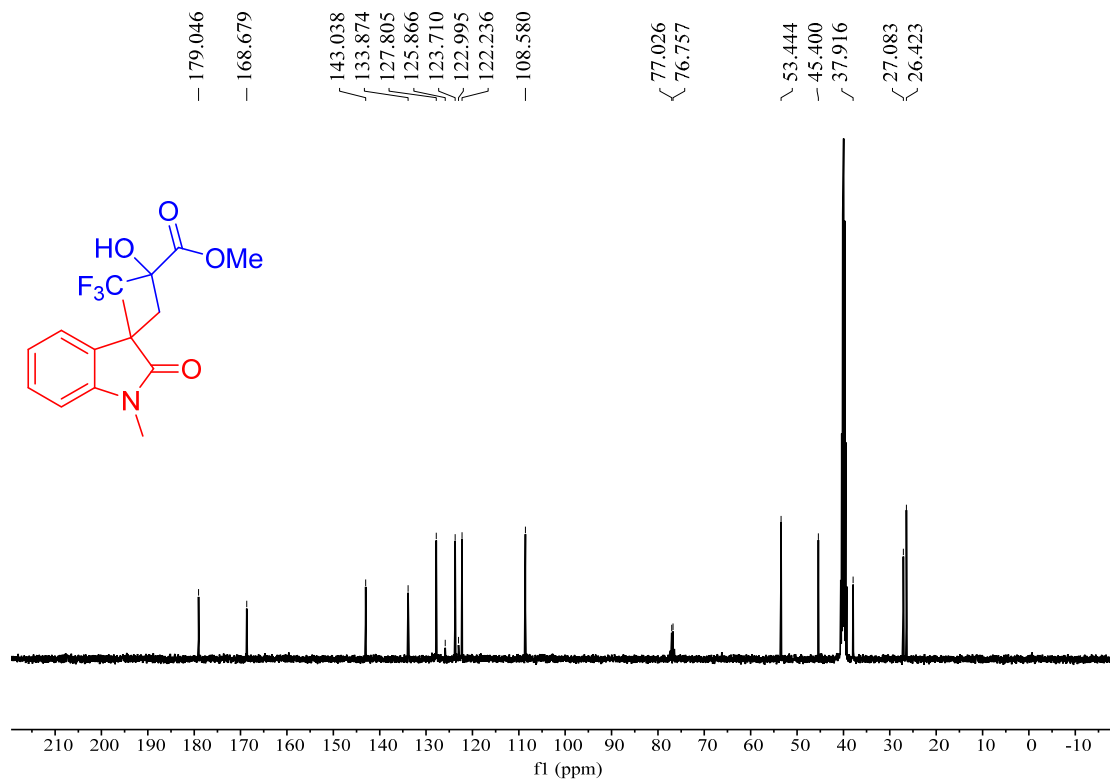
¹⁹F NMR of **25** (syn isomer) (376 MHz, CDCl₃)



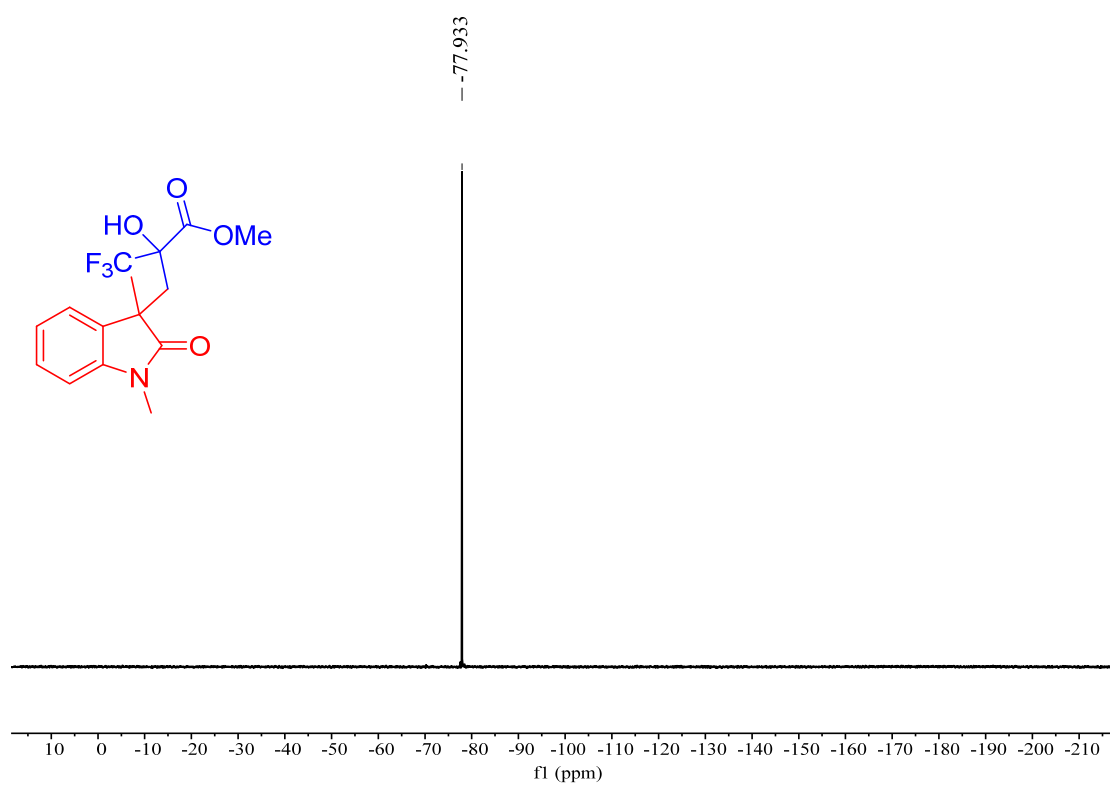
¹H NMR of **26** (syn isomer) (400 MHz, CDCl₃)



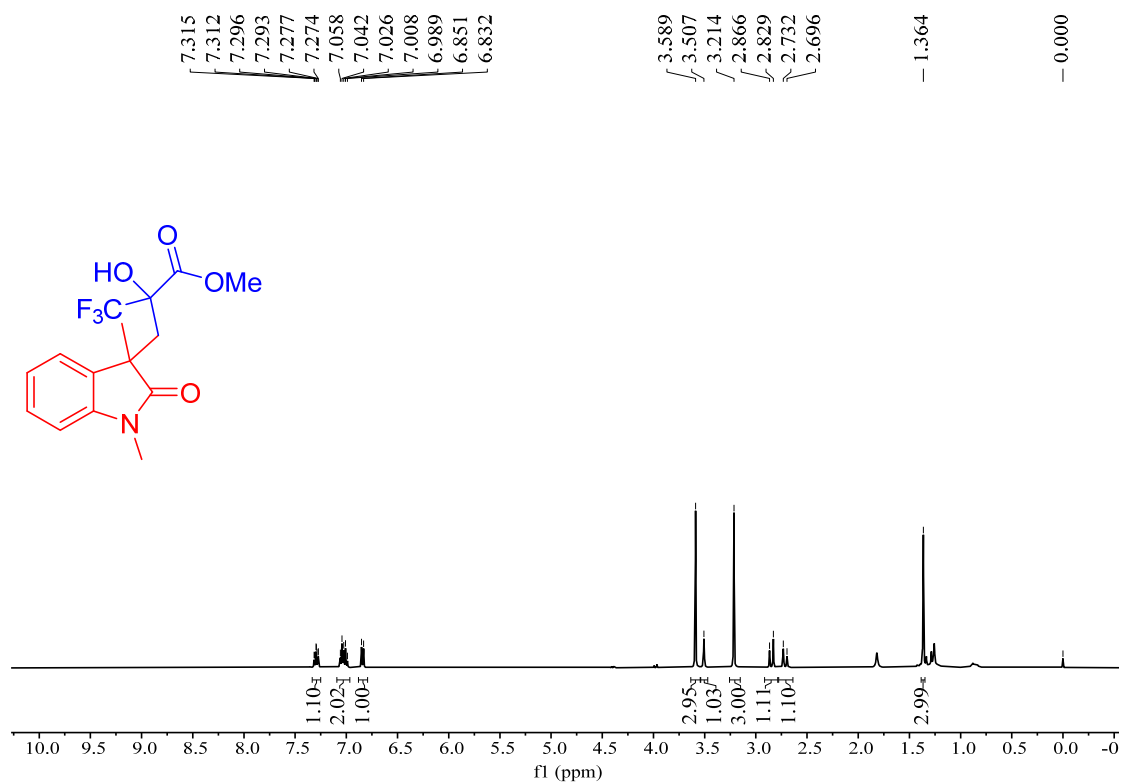
¹³C NMR of **26** (syn isomer) (101 MHz, DMSO-*d*₆)



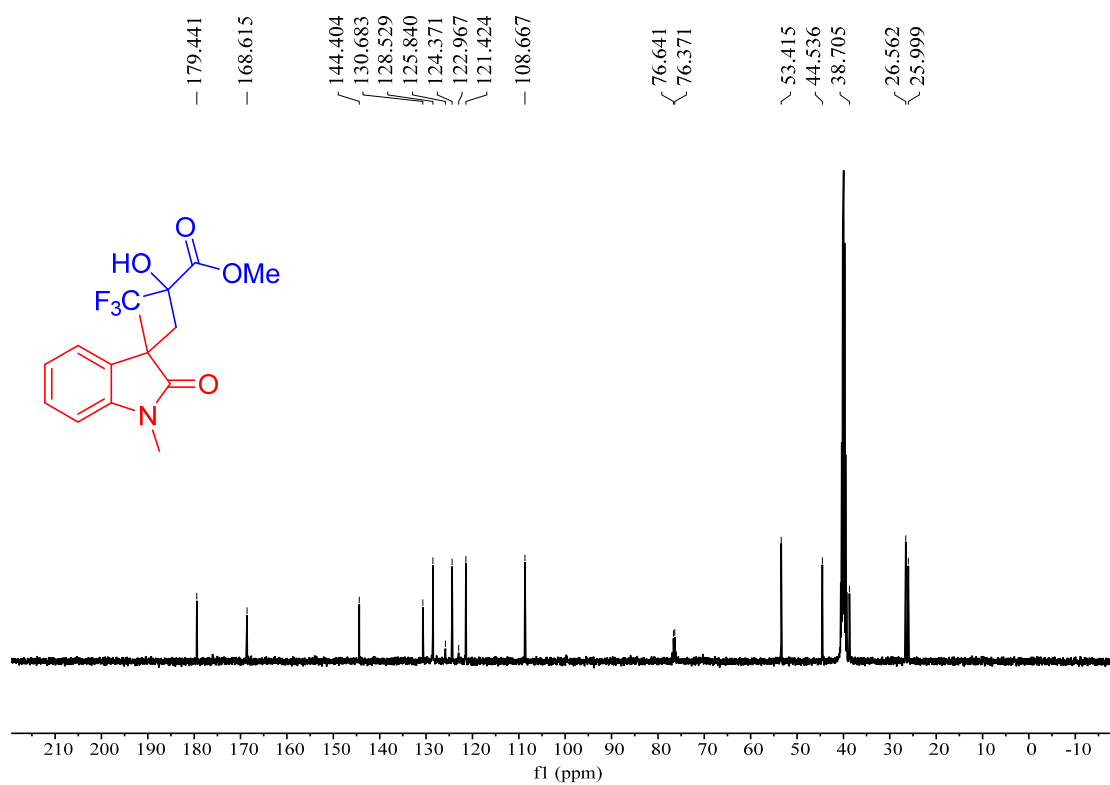
^{19}F NMR of **26** (syn isomer) (376 MHz, CDCl_3)



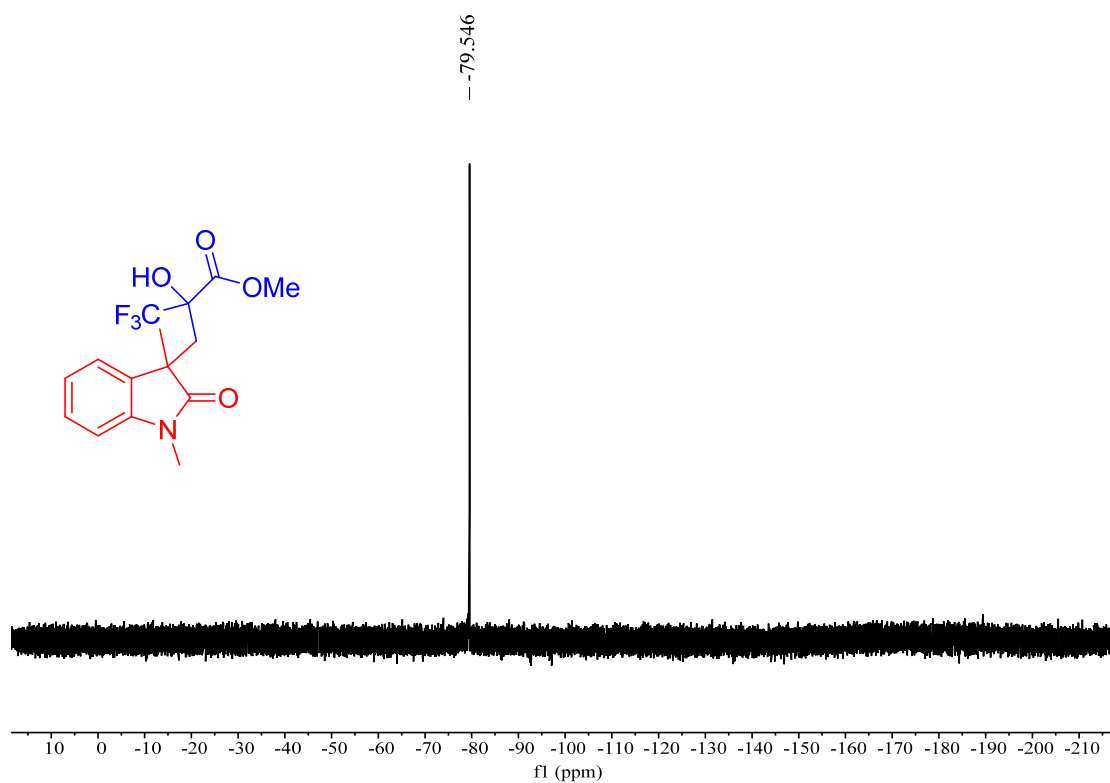
^1H NMR of **26** (anti isomer) (400 MHz, CDCl_3)



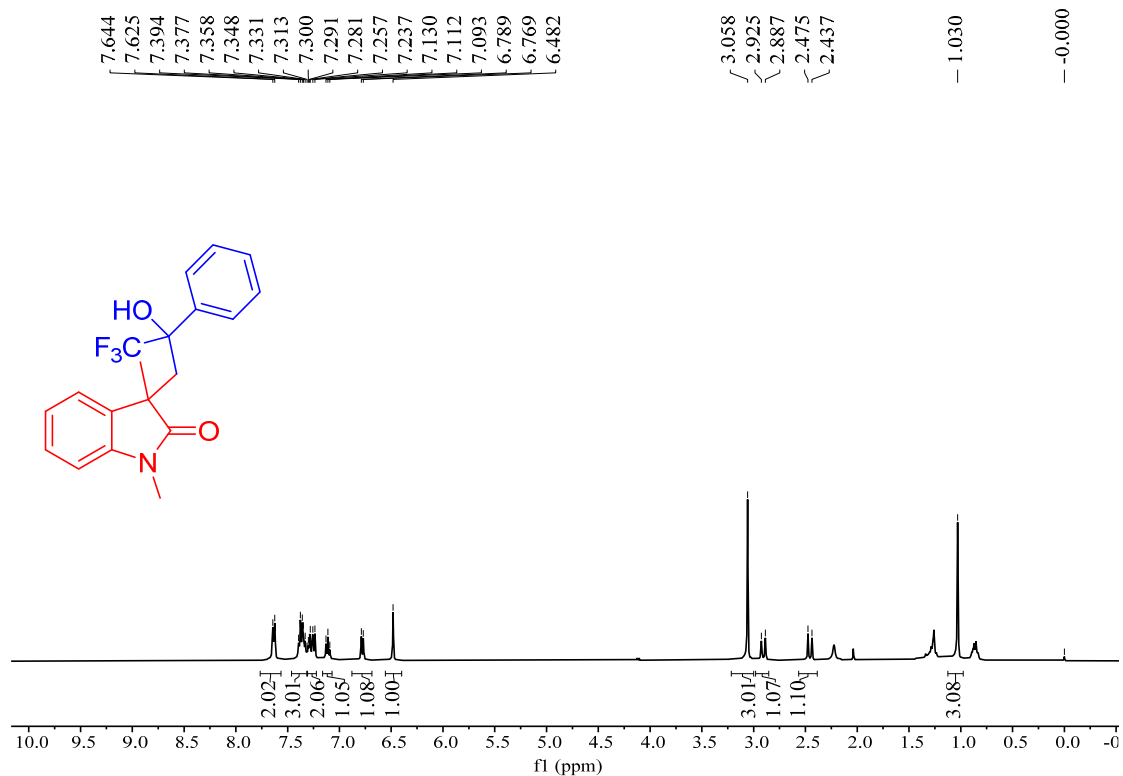
¹³C NMR of **26** (anti isomer) (101 MHz, DMSO-*d*₆)



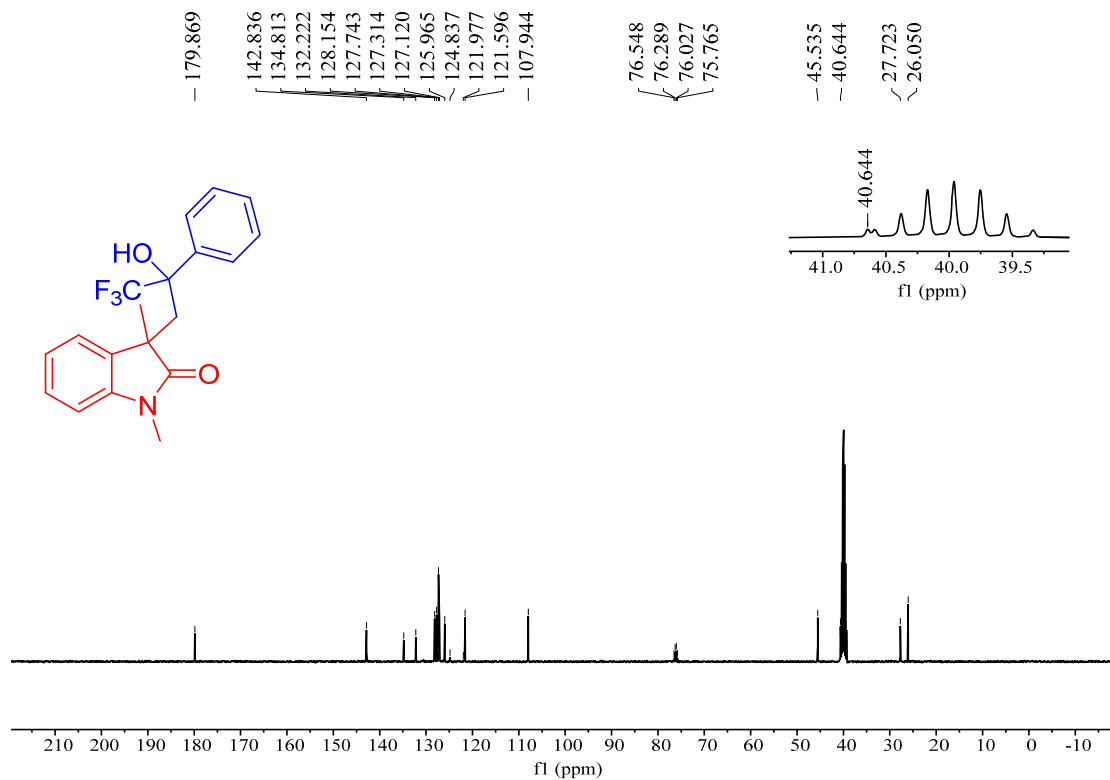
¹⁹F NMR of **26** (anti isomer) (376 MHz, CDCl₃)



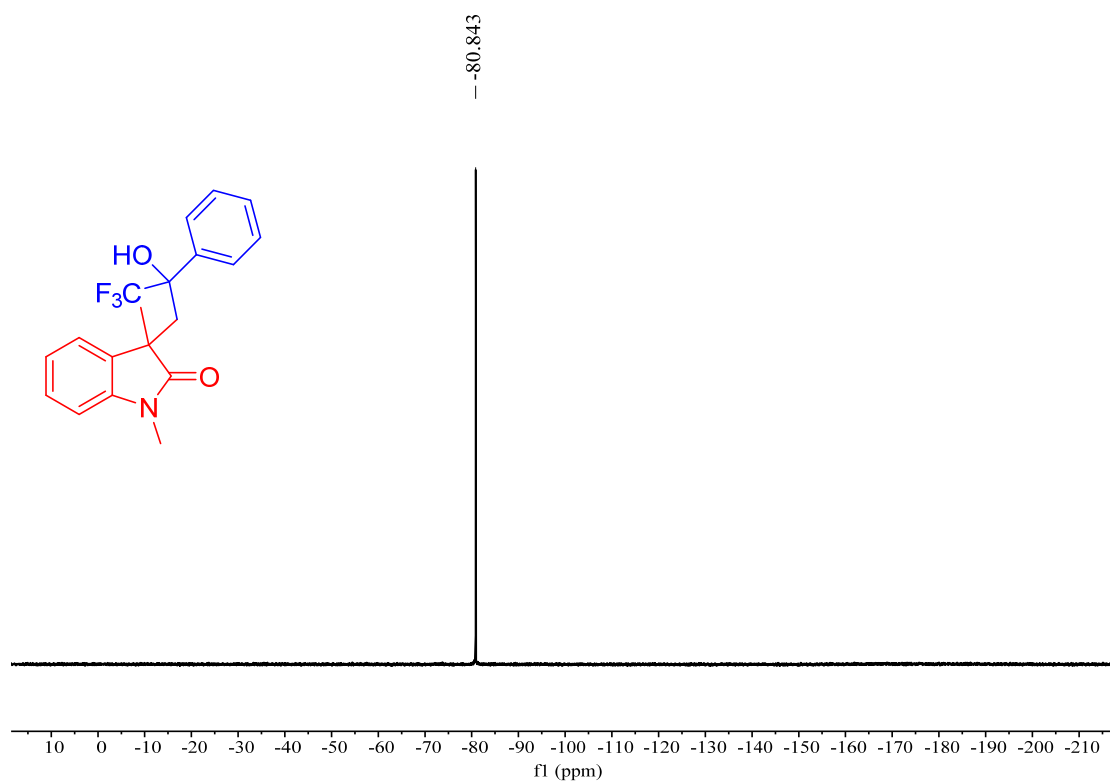
¹H NMR of **27** (400 MHz, CDCl₃)



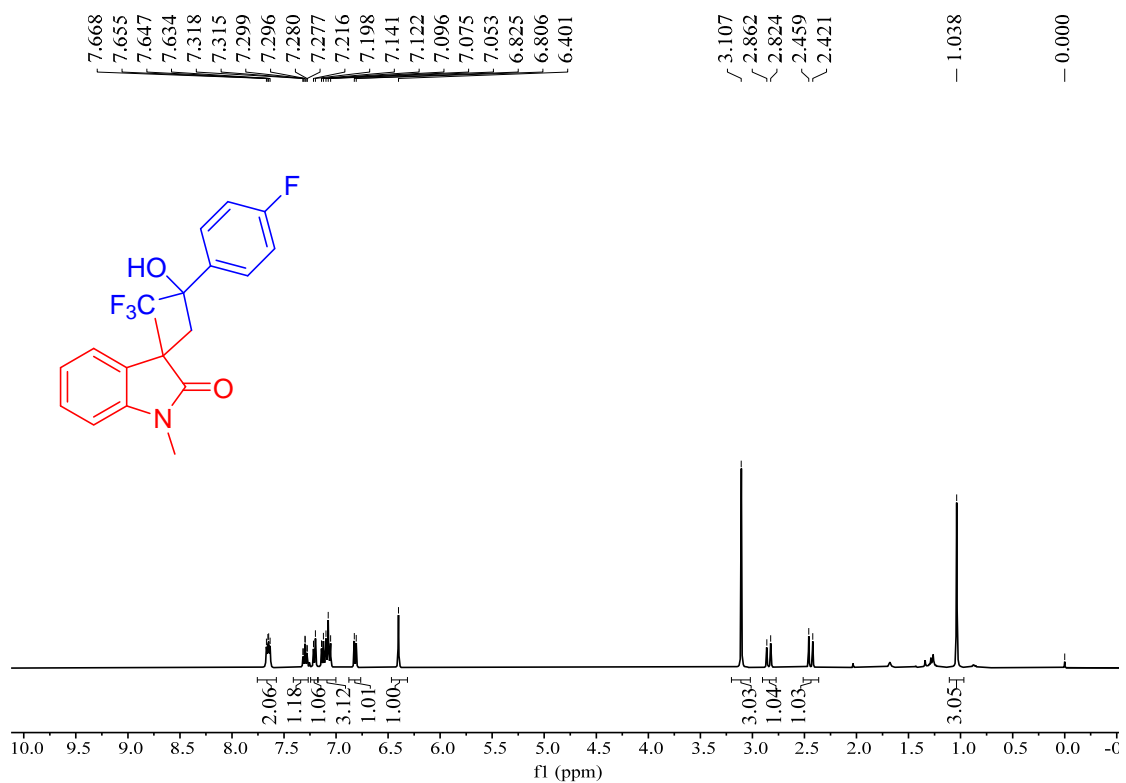
¹³C NMR of **27** (101 MHz, DMSO-*d*₆)



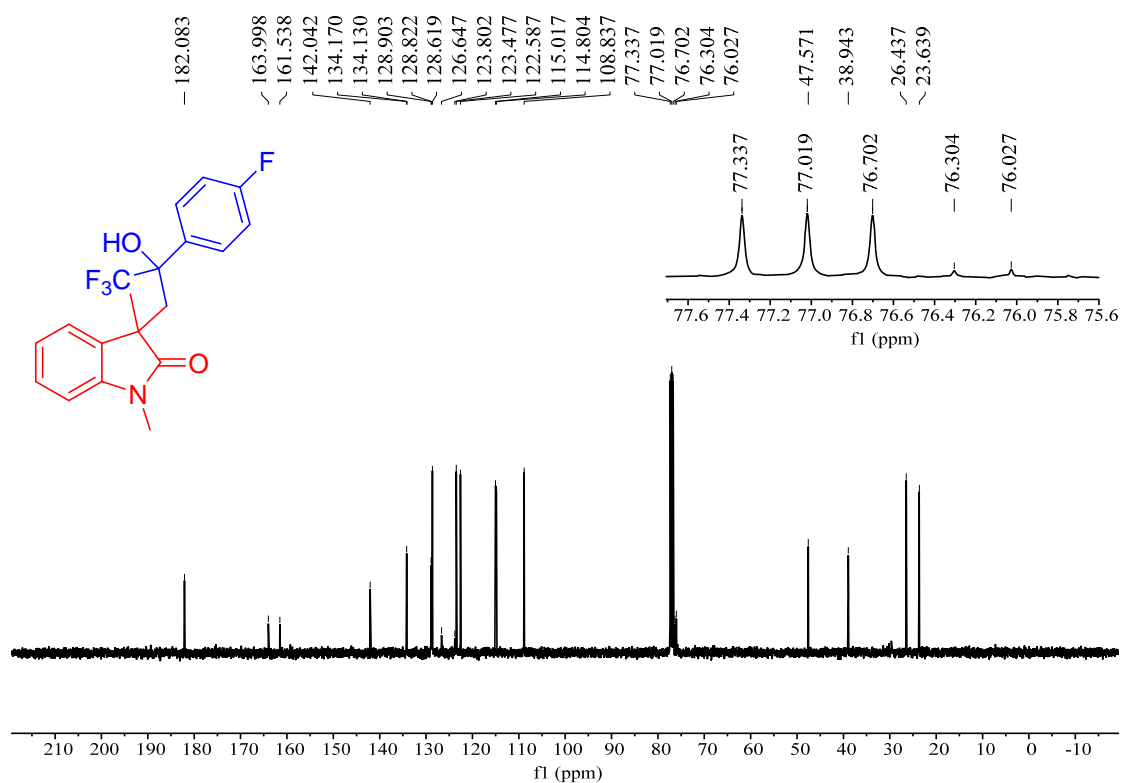
¹⁹F NMR of **27** (376 MHz, CDCl₃)



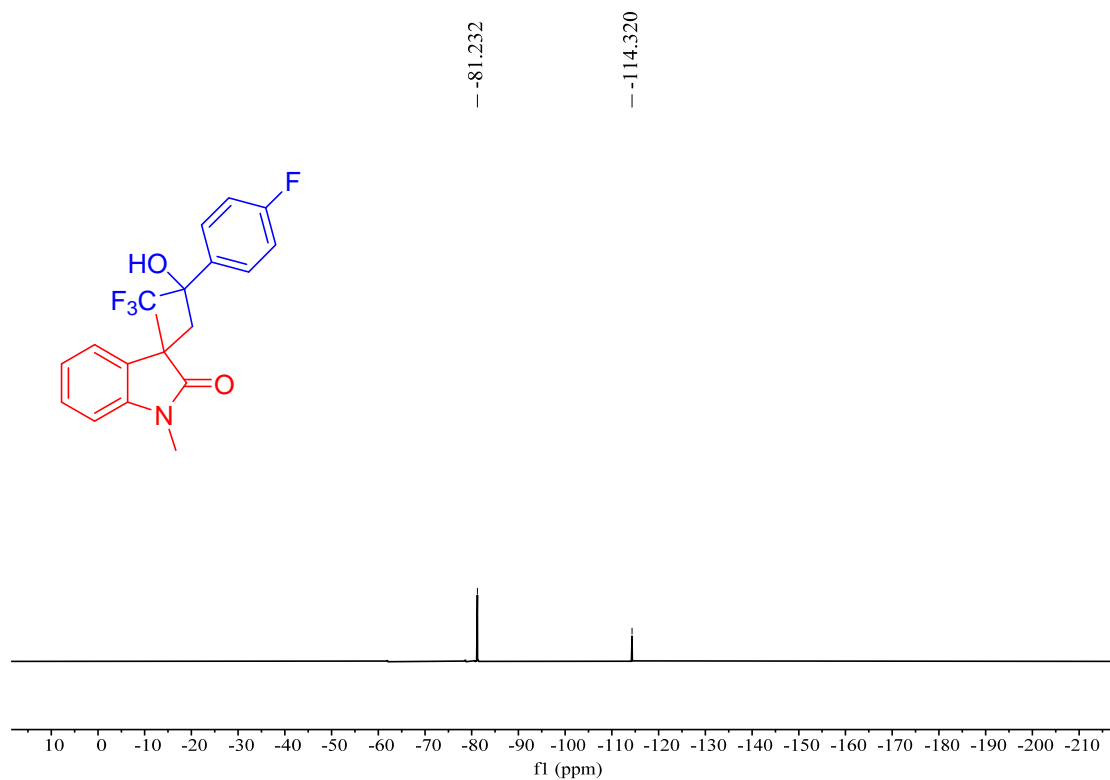
¹H NMR of **28** (400 MHz, CDCl₃)



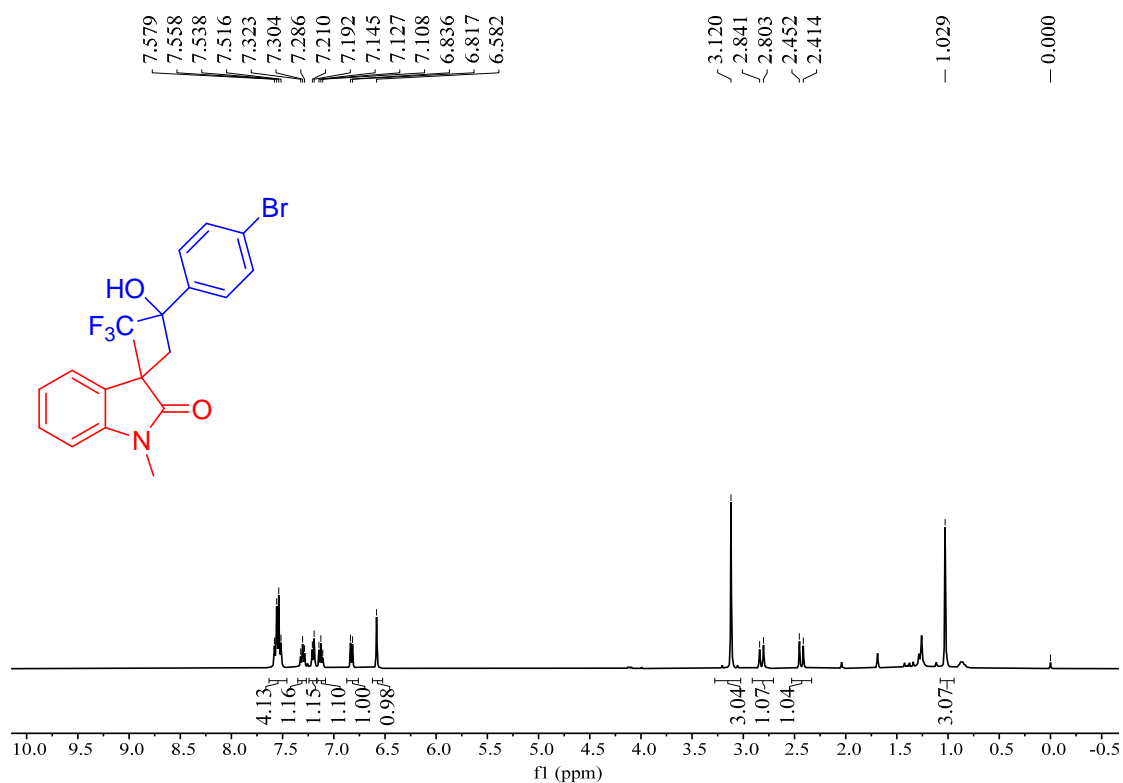
¹³C NMR of **28** (101 MHz, CDCl₃)



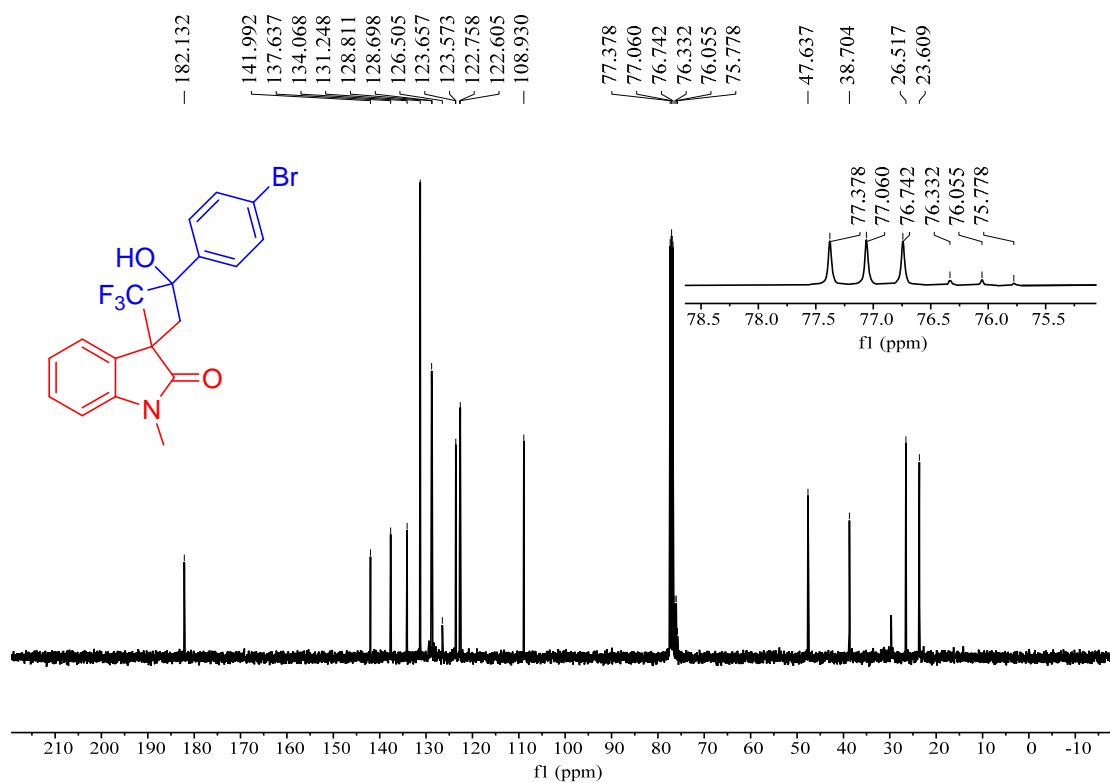
¹⁹F NMR of **28** (376 MHz, CDCl₃)



¹H NMR of **29** (400 MHz, CDCl₃)



¹³C NMR of **29** (101 MHz, CDCl₃)



¹⁹F NMR of **29** (376 MHz, CDCl₃)

