# Supporting Information

# Palladium-Catalyzed Defluorinative Coupling of Indoles with α,α-Difluoro-β,γ-Unsaturated Ketones: Direct Access to Functionalized α-Fluoroenones

Chunming Chen, [a#] Huixuan Zhu, [a#] Zhenli Luo, Jinhui Hu, Zhuang Xiong, [a*] Fucheng Zhou, [b*] and Jia-Qiang Wu [a*]

[a] School of Pharmacy and Food Engineering, Wuyi University, *J*iangmen, 529090, P. R. China

[b] Cyber Security Detachment, Zhuhai Public Security Bureau, Doumen Brigade, 519100, China.

# Table of Contents

# 1 General information

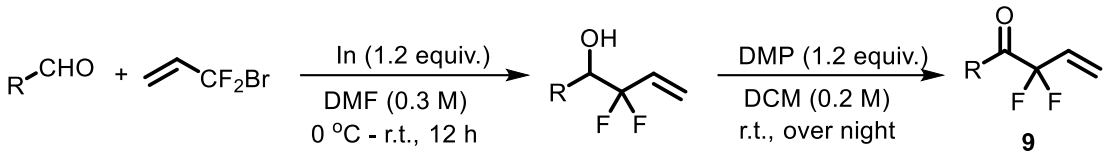
Unless otherwise noted, commercial reagents were purchased from Adamas, Aladdin, Alfa, Bide, TCI and used without further purification. All reaction were carried out using oven-dried glassware and proceeded without special care. Thin layer chromatography (TLC) was carried out using precoated silica gel plates (0.25 mm, GF254) and visualization was accomplished under UV light (254 nm). Column chromatography was performed on 200-300 mesh silica gel and neutral alumina.

$^{1}H$, $^{19}F$ and $^{13}C$ NMR was recorded on a Bruker AV 400 MHz、500 MHz and 600 MHz in solvents as indicated. Chemical shifts (δ) are given in ppm relative to TMS. The residual solvent signals were used as references and the chemical shifts converted to the TMS scale ($CDCl_3$: $\delta_H$ = 7.26 ppm, $\delta_C$ = 77.16 ppm; $d_6$-DMSO: $\delta_H$ = 2.50 ppm, $\delta_C$ = 39.52 ppm). The following abbreviations were used to describe peak splitting patterns when appropriate: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of the doublet. Coupling constants, *J*, were reported in the hertz unit (Hz). High-resolution mass spectra (HRMS) were recorded on a Thermo Scientific Q Exactive UHMR ((Ultra-High Mass Range) Hybrid Quadrupole Orbitrap™ mass spectrometer.

No attempts were made to optimize yields for substrate synthesis.

## 2. Experimental procedure and data

### 2.1 General procedure for the synthetic of coupling reagents 9

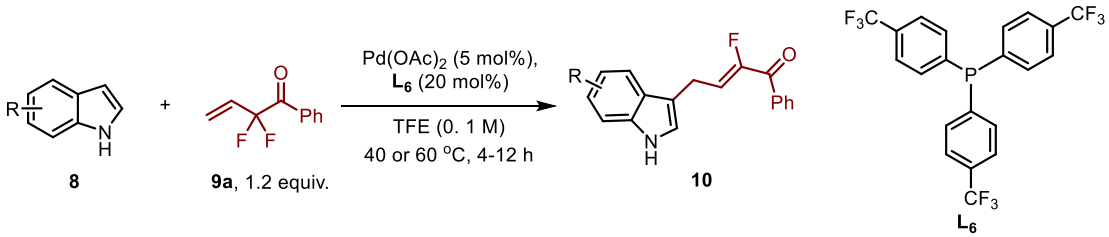



The synthesis of coupling reagent **9** was carried out following a known synthetic procedure [1]:

A suspension consisting of an aldehyde (5 mmol), 3-bromo-3,3-difluoropropene (6 mmol), powdered indium (10 mmol) and DMF (15 ml) was stirred for 12 h at room temperature. The reaction mixture was then quenched with 10% HCl and extracted with EA. The combined organic extract was dried over anhydrous sodium sulfate, filtered, and the solvent was removed in vacuo.

The mixture obtained above, DMP (6 mmol) was dissolved in DCM and stirred at room temperature overnight. The reaction mixture was quenched with $NaHCO_3$ and extracted with DCM. The combined organic extract was dried over anhydrous sodium sulfate, filtered, and the solvent was removed in vacuo. The crude product was purified by column chromatography on silica gel (petroleum ether / ethyl acetate) to afford the corresponding product **9**.

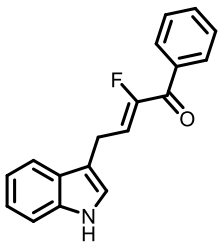
### 2.2 General Procedure for the synthesis of products




To a 15 mL-thick-walled reaction tube charged with a stirring bar was added corresponding indole (0.2 mmol), 2,2-difluoro-1-phenylbut-3-en-1-one (0.24 mmol), $Pd(OAc)_2$ (5 mol%), **L6** (20 mol%), and 2 mL of TFE (0.1 M). The reaction mixture was continuously stirred at 40 °C (unless otherwise stated) via metal block heating for 4 h. After the reaction completed, the product was concentrated under vacuum and purified by a 200-mesh silica gel column.

## 2.3 Characterization data for the products

### (*Z*)-2-fluoro-4-(1H-indol-3-yl)-1-phenylbut-2-en-1-one (10aa)



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10aa** was successfully isolated. as a yellow oil (50.3 mg, 0.18 mmol, 90% yield; $R_f$ = 0.45 in PE/EA = 8:1).

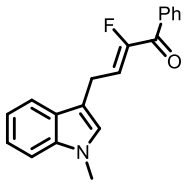
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.80 (dt, *J* = 8.3, 1.2 Hz, 2H), 7.61 (dd, *J* = 8.1, 1.2 Hz, 1H), 7.58 – 7.53 (m, 1H), 7.44 (t, *J* = 8.3 Hz, 2H), 7.38 (d, *J* = 8.1 Hz, 1H), 7.25 – 7.20 (m, 1H), 7.17 – 7.12 (m, 1H), 7.06 (d, *J* = 2.4 Hz, 1H), 6.27 (dt, *J* = 33.4, 7.8 Hz, 1H), 3.83 (dd, *J* = 7.8, 1.5 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.8 (d, $^2J_{C\text{-}F}$ = 27.7 Hz), 154.9 (d, $^1J_{C\text{-}F}$ = 260.8 Hz), 136.44, 136.34, 133.0, 129.4 (d, $^4J_{C\text{-}F}$ = 3.4 Hz), 128.6, 127.1, 123.2 (d, $^2J_{C\text{-}F}$ = 12.5 Hz), 122.5, 122.1, 119.8, 118.7, 112.2 (d, $^4J_{C\text{-}F}$ = 2.1 Hz), 111.4, 20.9 (d, $^3J_{C\text{-}F}$ = 5.2 Hz). 13C NMR (101 MHz, CDCl3) δ 129.42.

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.90.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{15}FNO$ 280.1132; Found: 280.1132.

### (*Z*)-2-fluoro-4-(1-methyl-1H-indol-3-yl)-1-phenylbut-2-en-1-one (10ba)



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10ba** was successfully isolated. as a yellow oil (29.9 mg, 0.102 mmol, 51% yield; $R_f$ = 0.45 in PE/EA = 8:1).

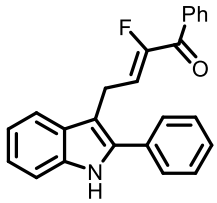
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 7.9 Hz, 2H), 7.62 (d, *J* = 7.9 Hz, 1H), 7.56 (t, *J* = 7.5 Hz, 1H), 7.45 (t, *J* = 7.7 Hz, 2H), 7.33 (d, *J* = 8.3 Hz, 1H), 7.28 (t, *J* = 7.7 Hz, 1H), 7.16 (t, *J* = 7.4 Hz, 1H), 6.93 (s, 1H), 6.28 (dt, *J* = 33.5, 7.8 Hz, 1H), 3.83 (dd, *J* = 7.8, 2.2 Hz, 2H), 3.76 (s, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 188.1 (d, $^2J_{C\text{-}F}$ = 27.6 Hz), 155.1 (d, $^1J_{C\text{-}F}$ = 260.8 Hz), 137.5, 136.7, 133.2, 129.7 (d, $^4J_{C\text{-}F}$ = 3.3 Hz), 128.8, 127.8, 127.2, 123.7 (d, $^2J_{C\text{-}F}$ = 12.6 Hz), 122.3, 119.6, 119.1, 110.8 (d, $^4J_{C\text{-}F}$ = 2.1 Hz), 109.8, 33.1, 21.1 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.23.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{17}FNO$ 294.1288; Found: 294.1285.

**(*Z*)-2-fluoro-1-phenyl-4-(2-phenyl-1H-indol-3-yl)but-2-en-1-one (10ca)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10ca** was successfully isolated. as a yellow oil (46.2 mg, 0.130 mmol, 65% yield; $R_f$ = 0.5 in PE/EA = 8:1).

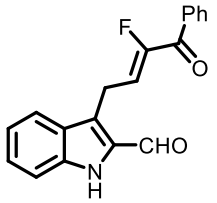
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.22 (s, 1H), 7.69 (d, *J* = 8.3 Hz, 2H), 7.64 (d, *J* = 8.0 Hz, 1H), 7.58 – 7.47 (m, 5H), 7.44 – 7.37 (m, 4H), 7.27 – 7.22 (m, 1H), 7.21 – 7.16 (m, 1H), 6.19 (dt, *J* = 33.6, 7.5 Hz, 1H), 3.97 (dd, *J* = 7.5, 2.3 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 188.1 (d, $^2J_{C\text{-}F}$ = 27.4 Hz), 154.9 (d, $^1J_{C\text{-}F}$ = 260.6 Hz), 136.6, 136.2, 135.7, 133.2, 132.9, 129.7 (d, $^4J_{C\text{-}F}$ = 3.2 Hz), 129.4, 129.2, 128.8, 128.6, 128.5, 124.0 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 123.1, 120.5, 119.2, 111.4, 109.0 (d, $^4J_{C\text{-}F}$ = 2.0 Hz), 20.8 (d, $^3J_{C\text{-}F}$ = 4.9 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.18.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{24}H_{19}FNO$ 456.1445; Found: 456.1445.

**(Z)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-2-carbaldehyde (10da)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 16:1), **10da** was successfully isolated. as a yellow oil (21.5 mg, 0.07 mmol, 35% yield; $R_f$ = 0.4 in PE/EA = 4:1).

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 10.12 (s, 1H), 9.04 (s, 1H), 7.81 (d, *J* = 8.4 Hz, 2H), 7.77 (d, *J* = 8.4 Hz, 1H), 7.59 (t, *J* = 7.4 Hz, 1H), 7.49 – 7.42 (m, 4H), 7.25 – 7.19 (m, 1H), 6.26 (dt, *J* = 32.6, 7.8 Hz, 1H), 4.17 (dd, *J* = 7.8, 2.2 Hz, 2H).

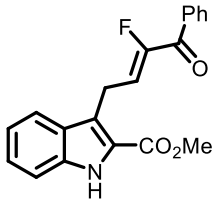
**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.2 (d, $^2J_{C\text{-}F}$ = 28.2 Hz), 180.3, 155.1 (d, $^1J_{C\text{-}F}$ = 264.5 Hz), 137.5, 135.9, 133.3, 132.1, 129.4 (d, $^4J_{C\text{-}F}$ = 3.9 Hz), 128.7, 128.0, 127.3, 123.7 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 121.4, 121.3, 120.7 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 112.7, 19.3 (d, $^3J_{C\text{-}F}$ = 5.4 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -122.83.

**HRMS (ESI) m/z:** $[M-H]^-$ Calcd for $C_{19}H_{13}FNO_2$ 306.0935; Found: 306.0933.

**methyl (*Z*)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-2-carboxylate (10ea)**

The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 16:1), **10ea** was successfully isolated. as a yellow oil (45.8 mg, 0.136 mmol, 68% yield; $R_f$ = 0.3 in PE/EA = 8:1).



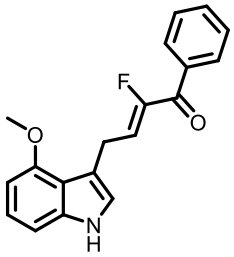

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.93 (s, 1H), 7.79 (d, *J* = 7.6 Hz, 2H), 7.75 (d, *J* = 8.2 Hz, 1H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 3H), 7.40 – 7.34 (m, 1H), 7.24 – 7.17 (m, 1H), 6.22 (dt, J = 33.4, 7.7 Hz, 1H), 4.21 (d, *J* = 7.7 Hz, 2H), 3.99 (s, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.7 (d, $^2J_{C\text{-}F}$ = 27.8 Hz), 162.5, 154.7 (d, $^1J_{C\text{-}F}$ = 261.4 Hz), 136.3, 136.0, 133.0, 129.4 (d, $^4J_{C\text{-}F}$ = 3.5 Hz), 128.5, 127.6, 126.2, 123.5, 122.4 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 120.9, 120.7, 119.6 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 112.1, 52.1, 20.46 (d, $^3J_{C\text{-}F}$ = 5.3 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.38

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{20}H_{17}FNO_3$ 338.1186; Found: 338.1185.

**(*Z*)-2-fluoro-4-(4-methoxy-1H-indol-3-yl)-1-phenylbut-2-en-1-one (10fa)**




The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10fa** was successfully isolated as a yellow oil (44.5 mg, 0.14 mmol, 72% yield; $R_f$ = 0.5 in PE/EA = 4:1).

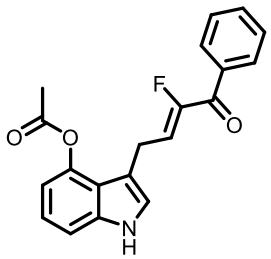
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.24 (s, 1H), 7.79 (d, *J* = 8.4 Hz, 2H), 7.58 – 7.52 (m, 1H), 7.43 (t, *J* = 7.7 Hz, 2H), 7.21 (d, *J* = 7.9 Hz, 1H), 7.06 (t, *J* = 7.9 Hz, 1H), 7.03 (d, *J* = 2.4 Hz, 1H), 6.67 (d, *J* = 7.8 Hz, 1H), 6.26 (dt, *J* = 33.4, 7.8 Hz, 1H), 3.96 (s, 3H), 3.81 (dd, *J* = 7.7, 2.3 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.8 (d, $^2J_{C\text{-}F}$ = 27.6 Hz), 154.8 (d, $^1J_{C\text{-}F}$ = 261.0 Hz), 146.4, 136.4, 132.9, 129.4 (d, $^4J_{C\text{-}F}$ = 3.3 Hz), 128.5, 128.4, 127.0, 123.3 (d, $^2J_{C\text{-}F}$ = 12.6 Hz), 121.6, 120.3, 112.6 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 111.4, 102.3, 55.5, 21.1 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.0.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{17}FNO_2$ 310.1237; Found: 310.1236.

**(*Z*)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indol-4-yl acetate (10ga)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 8:1), **10ga** was successfully isolated as a yellow oil (55.3 mg, 0.16 mmol, 82% yield; $R_f$ = 0.35 in PE/EA = 4:1).

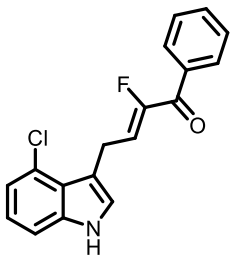
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.31 (s, 1H), 7.80 (d, *J* = 8.4 Hz, 1H), 7.55 (t, *J* = 7.5 Hz, 1H), 7.43 (t, *J* = 7.8 Hz, 2H), 7.19 (dd, *J* = 8.4, 1.0 Hz, 1H), 7.13 (t, *J* = 7.8 Hz, 1H), 6.89 (d, *J* = 2.4 Hz, 1H), 6.83 (dd, *J* = 7.5, 1.0 Hz, 1H), 6.26 (dt, *J* = 33.9, 7.3 Hz, 1H), 3.81 (dd, *J* = 7.3, 2.4 Hz, 1H), 2.37 (s, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.8 (d, $^2J_{C\text{-}F}$ = 27.4 Hz), 170.2, 154.4 (d, $^1J_{C\text{-}F}$ = 260.8 Hz), 144.0, 138.7, 136.2, 133.0, 129.4 (d, $^4J_{C\text{-}F}$ = 3.1 Hz), 128.6, 124.0 (d, $^2J_{C\text{-}F}$ = 12.3 Hz), 123.0, 122.6, 119.5, 112.7, 110.7 (d, $^4J_{C\text{-}F}$ = 1.6 Hz), 109.6, 21.9 (d, $^3J_{C\text{-}F}$ = 5.0 Hz), 21.3.

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -123.9.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{20}H_{17}FNO_3$ 338.1186; Found: 338.1189.

**(Z)-4-(4-chloro-1H-indol-3-yl)-2-fluoro-1-phenylbut-2-en-1-one (10ha)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 20:1), **10ha** was successfully isolated as a yellow oil (37.7 mg, 0.12 mmol, 60% yield; $R_f$ = 0.45 in PE/EA = 8:1).

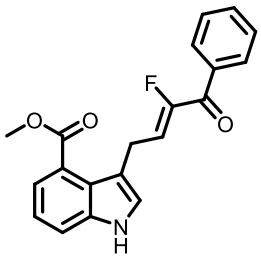
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.23 (s, 1H), 7.81 (d, *J* = 8.3 Hz, 2H), 7.59 – 7.53 (m, 1H), 7.44 (t, *J* = 7.7 Hz, 2H), 7.28 – 7.23 (m, 1H), 7.08 (d, *J* = 4.1 Hz, 2H), 7.06 (d, *J* = 2.4 Hz, 1H), 6.39 (dt, *J* = 33.9, 7.5 Hz, 1H), 4.07 (dd, *J* = 7.5, 1.4 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 188.0 (d, $^2J_{C\text{-}F}$ = 27.3 Hz), 154.4 (d, $^1J_{C\text{-}F}$ = 260.6 Hz), 137.9, 136.4, 133.0, 129.5 (d, $^4J_{C\text{-}F}$ = 3.2 Hz), 128.5, 126.3, 124.5 (d, $^2J_{C\text{-}F}$ = 12.2 Hz), 124.0, 123.8, 123.0, 120.8, 112.8 (d, $^4J_{C\text{-}F}$ = 1.8 Hz), 110.3, 22.2 (d, $^3J_{C\text{-}F}$ = 4.7 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -123.2 – -126.5.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{14}FNO$ 314.0742; Found: 314.0742.

**methyl (*Z*)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-4-carboxylate (10ia)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 10:1), **10ia** was successfully isolated as a yellow oil (48.6 mg, 0.14 mmol, 72% yield; $R_f$ = 0.45 in PE/EA = 4:1).

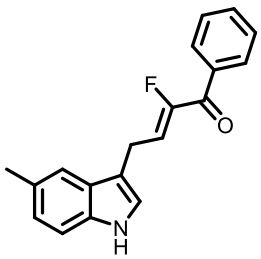
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.53 (s, 1H), 7.78 (d, *J* = 7.7 Hz, 2H), 7.72 (d, *J* = 7.9 Hz, 1H), 7.56-7.52 (m, 2H), 7.42 (t, *J* = 7.8 Hz, 2H), 7.20 (t, *J* = 7.8 Hz, 1H), 7.15 (s, 1H), 6.33 (dt, *J* = 34.5, 7.5 Hz, 1H), 4.01 (d, *J* = 7.5 Hz, 2H), 3.93 (s, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 188.1 (d, $^2J_{C\text{-}F}$ = 27.2 Hz), 168.6, 154.4 (d, $^1J_{C\text{-}F}$ = 259.6 Hz), 137.8, 136.3, 132.8, 129.3 (d, $^4J_{C\text{-}F}$ = 3.1 Hz), 128.4, 125.7, 125.3 (d, $^2J_{C\text{-}F}$ = 11.9 Hz), 124.2, 123.5, 123.4, 121.2, 115.9, 113.0 (d, $^4J_{C\text{-}F}$ = 1.8 Hz), 52.1, 23.4 (d, $^3J_{C\text{-}F}$ = 4.6 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.4.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{20}H_{17}FNO_3$ 338.1186; Found: 338.1185.

**(Z)-2-fluoro-4-(5-methyl-1H-indol-3-yl)-1-phenylbut-2-en-1-one (10ja)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 25:1), **10ja** was successfully isolated as a yellow oil (44.6 mg, 0.15 mmol, 76% yield; Rf = 0.6 in PE/EA = 8:1).

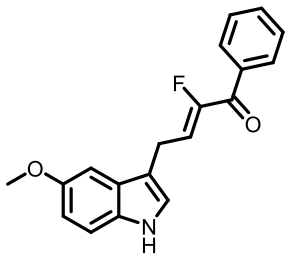
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.98 (s, 1H), 7.80 (d, *J* = 8.4 Hz, 2H), 7.58 – 7.53 (m, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.39 (s, 1H), 7.27 (d, *J* = 8.4 Hz, 1H), 7.05 (dd, *J* = 8.4, 1.3 Hz, 1H), 7.02 (d, *J* = 2.4 Hz, 1H), 6.27 (dt, *J* = 33.5, 7.7 Hz, 1H), 3.80 (dd, *J* = 7.7, 1.3 Hz, 2H), 2.47 (s, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 188.2 (d, $^2J_{C\text{-}F}$ = 27.7 Hz), 155.1 (d, $^1J_{C\text{-}F}$ = 260.7 Hz), 136.7, 135.1, 133.3, 129.7 (d, $^4J_{C\text{-}F}$ = 3.3 Hz), 129.4, 128.9, 127.7, 124.4, 123.8 (d, $^2J_{C\text{-}F}$ = 12.6 Hz), 122.5, 118.6, 112.0 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 111.4, 22.0, 21.2 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.95.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{17}FNO$ 294.1288; Found: 294.1288.

**(Z)-2-fluoro-4-(5-methoxy-1H-indol-3-yl)-1-phenylbut-2-en-1-one (10ka)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10ka** was successfully isolated as a yellow oil (30.9 mg, 0.10 mmol, 50% yield; $R_f$ = 0.25 in PE/EA = 8:1).

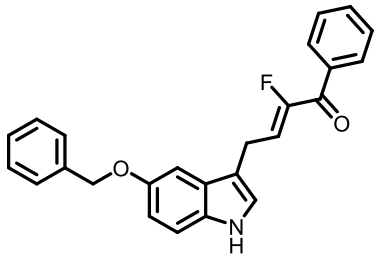
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.93 (s, 1H), 7.80 (d, *J* = 8.4 Hz, 2H), 7.58 – 7.52 (m, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.27 (d, *J* = 7.6 Hz, 1H), 7.03 (t, *J* = 2.4 Hz, 2H), 6.88 (dd, *J* = 8.8, 2.4 Hz, 1H), 6.26 (dt, *J* = 33.5, 7.8 Hz, 1H), 3.86 (s, 3H), 3.79 (dd, *J* = 7.7, 2.4 Hz, 2H).

**$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 187.8 (d, $^2J_{C\text{-}F}$ = 27.8 Hz), 154.9 (d, $^1J_{C\text{-}F}$ = 261.0 Hz), 154.3, 136.4, 133.0, 131.5, 129.4 (d, $^4J_{C\text{-}F}$ = 3.2 Hz), 128.6, 127.5, 123.1 (d, $^2J_{C\text{-}F}$ = 12.7 Hz), 122.8, 112.8, 112.2, 112.0 (d, $^4J_{C\text{-}F}$ = 2.3 Hz), 100.4, 56.0, 20.9 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.9.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{17}FNO_2$ 310.1237; Found: 310.1235.

**(Z)-4-(5-(benzyloxy)-1H-indol-3-yl)-2-fluoro-1-phenylbut-2-en-1-one (10la)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 10:1), **10la** was successfully isolated as a yellow oil (42.4 mg, 0.11 mmol, 55% yield; $R_f$ = 0.4 in PE/EA = 4:1).

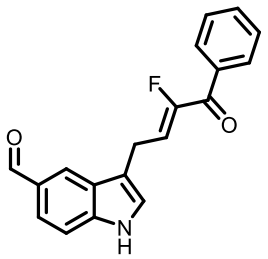
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.97 (s, 1H), 7.78 (d, *J* = 8.4 Hz, 2H), 7.58 – 7.52 (m, 1H), 7.48 (d, *J* = 7.3 Hz, 2H), 7.43 (t, *J* = 7.8 Hz, 2H), 7.37 (t, *J* = 7.3 Hz, 2H), 7.32 – 7.27 (m, 2H), 7.12 (d, *J* = 2.4 Hz, 1H), 7.03 (d, *J* = 2.4 Hz, 1H), 6.96 (dd, *J* = 8.8, 2.4 Hz, 1H), 6.24 (dt, *J* = 33.5, 7.8 Hz, 1H), 5.1 (s, 2H), 3.77 (dd, *J* = 7.8, 2.2 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.8 (d, $^2J_{C\text{-}F}$ = 27.4 Hz), 154.9 (d, $^1J_{C\text{-}F}$ = 260.9 Hz), 153.5, 137.7, 136.3, 133.0, 131.7, 129.4 (d, $^4J_{C\text{-}F}$ = 3.3 Hz), 128.7, 128.5, 128.0, 127.7, 127.5, 123.1 (d, $^2J_{C\text{-}F}$ = 12.7 Hz), 122.9, 113.4, 112.2, 111.9 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 102.1, 71.0, 20.9 (d, $^3J_{C\text{-}F}$ = 5.3 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.9.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{25}H_{20}FNO_2$ 386.1550; Found: 386.1552.

**(Z)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-5-carbaldehyde (10ma)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 5:1), **10ma** was successfully isolated as a yellow oil (44.9 mg, 0.15 mmol, 73% yield; $R_f$ = 0.35 in PE/EA = 2:1).

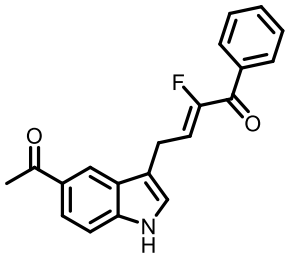
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 10.05 (s, 1H), 8.43 (s, 1H), 8.16 (s, 1H), 7.85 – 7.77 (m, 3H), 7.60 – 7.54 (m, 1H), 7.50 – 7.41 (m, 3H), 7.17 (d, *J* = 2.5, 1H), 6.29 (dt, *J* = 33.2, 7.8 Hz, 1H), 3.9 (dd, *J* = 7.8, 1.3 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 192.5, 187.6 (d, $^2J_{C\text{-}F}$ = 28.6 Hz), 155.3 (d, $^1J_{C\text{-}F}$ = 263.2 Hz), 139.9, 136.1, 133.2, 129.7, 129.5 (d, $^4J_{C\text{-}F}$ = 3.8 Hz), 128.6, 127.1, 123.83, 123.81, 123.1, 121.6 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 114.4 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 112.0, 20.6 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -118.7.

**HRMS (ESI) m/z:** $[M\text{-}H]^-$ Calcd for $C_{19}H_{13}FNO_2$ 306.0935; Found: 306.0934.

**(*Z*)-4-(5-acetyl-1H-indol-3-yl)-2-fluoro-1-phenylbut-2-en-1-one (10na)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 16:1), **10na** was successfully isolated as a yellow oil (32.1 mg, 0.10 mmol, 50% yield; $R_f$ = 0.25 in PE/EA = 4:1).

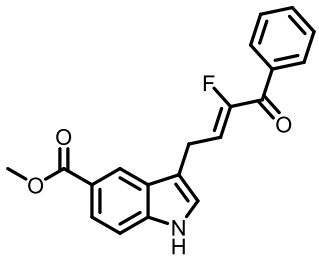
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.42 (s, 1H), 8.29 (s, 1H), 7.89 (dd, *J* = 8.4, 1.7 Hz, 1H), 7.82 (d, *J* = 8.4 Hz, 2H), 7.80 – 7.77 (m, 1H), 7.58 – 7.55 (m, 1H), 7.47 – 7.42 (m, 2H), 7.40 (d, *J* = 8.4 Hz, 1H), 7.13 (s, 1H), 6.29 (dt, *J* = 33.3, 7.8 Hz, 1H), 3.85 (dd, *J* = 7.8, 1.2 Hz, 2H), 2.68 (s, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 198.4, 187.6 (d, $^2J_{C\text{-}F}$ = 28.3 Hz), 155.3 (d, $^1J_{C\text{-}F}$ = 262.6 Hz), 139.1, 136.2, 133.2, 130.0, 129.5 (d, $^4J_{C\text{-}F}$ = 3.7 Hz), 128.6, 126.8, 123.6, 123.0, 121.9 (d, $^2J_{C\text{-}F}$ = 12.5 Hz), 120.8, 114.2 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 111.3, 26.8, 20.6 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -123.9.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{20}H_{17}FNO_2$ 322.1237; Found: 322.1239.

**methyl (Z)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-5-carboxylate (10oa)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 8:1), **10oa** was successfully isolated as a yellow oil (57.3 mg, 0.17 mmol, 85% yield; $R_f$ = 0.35 in PE/EA = 4:1).

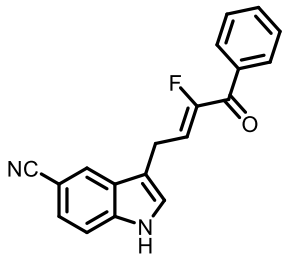
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.39 (s, 2H), 7.93 (d, *J* = 8.4 Hz, 1H), 7.82 (d, *J* = 8.4 Hz, 2H), 7.56 (t, *J* = 7.5 Hz, 1H), 7.44 (t, *J* = 7.5 Hz, 2H), 7.38 (d, *J* = 8.6 Hz, 1H), 7.12 (s, 1H), 6.29 (dt, *J* = 33.3, 7.8 Hz, 1H), 3.94 (s, 3H), 3.84 (d, *J* = 7.8 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.6 (d, $^2J_{C\text{-}F}$ = 28.3 Hz), 168.2, 155.1 (d, $^1J_{C\text{-}F}$ = 262.6 Hz), 139.0, 136.2, 133.1, 129.49, 129.45, 128.5, 126.8, 123.9, 123.4, 122.2(d, $^2J_{C\text{-}F}$ = 12.6 Hz), 122.0, 121.7, 113.7 (d, $^3J_{C\text{-}F}$ = 2.2 Hz), 111.1, 52.1, 20.5 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -123.8.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{20}H_{17}FNO_3$ 338.1186; Found: 338.1189.

**(Z)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-5-carbonitrile (10pa)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 6:1), **10pa** was successfully isolated as a yellow oil (21.3 mg, 0.07 mmol, 35% yield; $R_f$ = 0.45 in PE/EA = 2:1).

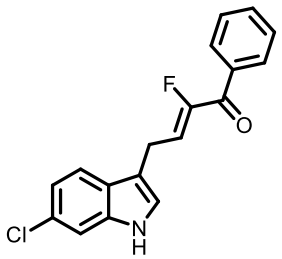
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.53 (s, 1H), 7.95 (s, 1H), 7.9 – 7.8 (m, 2H), 7.61 – 7.55 (m, 1H), 7.51 – 7.41 (m, 4H), 7.19 (d, *J* = 2.5 Hz, 1H), 6.24 (dt, *J* = 33.0, 7.8 Hz, 1H), 3.8 (dd, *J* = 7.8, 2.2 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.5 (d, $^2J_{C\text{-}F}$ = 28.4 Hz), 155.4 (d, $^1J_{C\text{-}F}$ = 263.4 Hz), 138.1, 136.0, 133.3, 129.5, 129.4, 128.7, 127.0, 125.5, 124.4, 124.3, 121.2 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 120.7, 113.4 (d, $^3J_{C\text{-}F}$ = 2.2 Hz), 112.4, 103.0, 20.5 (d, $^3J_{C\text{-}F}$ = 5.2 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.9.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{14}FN_2O$ 305.1084; Found: 305.1088.

**(*Z*)-4-(6-chloro-1H-indol-3-yl)-2-fluoro-1-phenylbut-2-en-1-one (10qa)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 18:1), **10qa** was successfully isolated as a yellow oil (47.1 mg, 0.15 mmol, 75% yield; $R_f$ = 0.4 in PE/EA = 8:1).

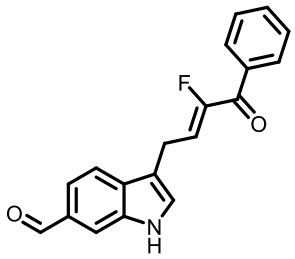
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.09 (s, 1H), 7.79 (d, *J* = 8.4 Hz, 2H), 7.59 – 7.54 (m, 1H), 7.50 (d, *J* = 8.4 Hz, 1H), 7.44 (t, *J* = 7.7 Hz, 2H), 7.36 (d, *J* = 1.8 Hz, 1H), 7.11 (dd, *J* = 8.5, 1.8 Hz, 1H), 7.05 (d, *J* = 2.4 Hz, 1H), 6.23 (dt, *J* = 33.3, 7.8 Hz, 1H), 3.79 (dd, *J* = 7.8, 1.3 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.7 (d, $^2J_{C\text{-}F}$ = 28.0 Hz), 155.0 (d, $^1J_{C\text{-}F}$ = 261.7 Hz), 136.8, 136.2, 133.1, 129.44, 129.41, 128.6, 128.5, 125.8, 122.7, 122.5 (d, $^2J_{C\text{-}F}$ = 12.6 Hz), 120.6, 119.6, 112.5 (d, $^3J_{C\text{-}F}$ = 2.2 Hz), 111.4, 20.8 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.4.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{14}FClNO$ 314.0742; Found: 314.0744.

**(Z)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-6-carbaldehyde (10ra)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 6:1), **10ra** was successfully isolated as a yellow oil (47.9 mg, 0.16 mmol, 78% yield; $R_f$ = 0.4 in PE/EA = 2:1).

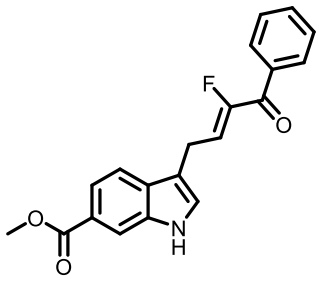
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 10.05 (s, 1H), 8.62 (s, 1H), 7.94 (s, 1H), 7.81 (d, *J* = 8.4 Hz, 2H), 7.71 (d, *J* = 8.4 Hz, 1H), 7.68 (dd, *J* = 8.2, 1.3 Hz, 1H), 7.61 – 7.52 (m, 1H), 7.47 – 7.41 (m, 2H), 7.31 (d, *J* = 2.3 Hz, 1H), 6.26 (dt, *J* = 33.1, 7.8 Hz, 1H), 3.84 (dd, *J* = 7.8, 1.3 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 192.7, 187.6 (d, $^2J_{C\text{-}F}$ = 27.9 Hz), 155.2 (d, $^1J_{C\text{-}F}$ = 262.6 Hz), 136.1, 136.0, 133.2, 132.0, 131.5, 129.5, 129.4, 128.6, 126.8, 122.0 (d, $^2J_{C\text{-}F}$ = 12.5 Hz), 121.2, 119.1, 114.3, 113.1 (d, $^3J_{C\text{-}F}$ = 2.2 Hz), 20.7 (d, $^3J_{C\text{-}F}$ = 5.2 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -123.9.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{13}FNO_2$ 306.0935; Found: 306.0937.

**methyl (Z)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-6-carboxylate (10sa)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 16:1), **10sa** was successfully isolated as a yellow oil (53.3 mg, 0.16 mmol, 79% yield; $R_f$ = 0.40 in PE/EA = 4:1).

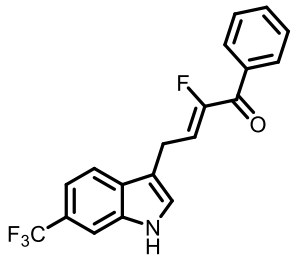
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.43 (s, 1H), 8.14 (s, 1H), 7.83 (dd, *J* = 8.4, 1.5 Hz, 1H), 7.80 (d, *J* = 8.4 Hz, 2H), 7.62 (d, *J* = 8.4 Hz, 1H), 7.58 – 7.53 (m, 1H), 7.46 – 7.40 (m, 2H), 7.23 (d, *J* = 2.4 Hz, 1H), 6.25 (dt, *J* = 33.2, 7.8 Hz, 1H), 3.94 (s, 3H), 3.82 (dd, *J* = 7.8, 1.3 Hz, 2H).

**$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 187.7 (d, $^2J_{C\text{-}F}$ = 27.8 Hz), 168.2, 155.1 (d, $^1J_{C\text{-}F}$ = 262.2 Hz), 136.2, 135.8, 133.1, 130.6, 129.4 (d, $^4J_{C\text{-}F}$ = 3.4 Hz), 128.6, 125.5, 124.3, 122.3 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 120.9, 118.3, 113.8, 112.7 (d, $^4J_{C\text{-}F}$ = 2.3 Hz), 52.2, 20.8 (d, $^3J_{C\text{-}F}$ = 5.2 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.1.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{20}H_{17}FNO_3$ 338.1186; Found: 338.1187.

**(Z)-2-fluoro-1-phenyl-4-(6-(trifluoromethyl)-1H-indol-3-yl)but-2-en-1-one (10ta)**



The title compound was prepared via the general procedure at 60 °C for 12 h, after purification by silica gel column (PE/EA = 16:1), **10ta** was successfully isolated as a yellow oil (55.6 mg, 0.16 mmol, 80% yield; $R_f$ = 0.5 in PE/EA = 4:1).

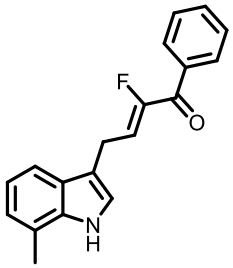
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.37 (s, 1H), 7.80 (d, *J* = 8.4 Hz, 2H), 7.68 (d, *J* = 8.4 Hz, 1H), 7.66 (s, 1H), 7.62 – 7.52 (m, 1H), 7.47 – 7.41 (m, 2H), 7.38 (d, *J* = 8.4 Hz, 1H), 7.21 (d, *J* = 2.4 Hz, 1H), 6.2 (dt, *J* = 33.2, 7.8 Hz, 1H), 3.83 (dd, *J* = 7.8, 1.3 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.7 (d, $^2J_{C\text{-}F}$ = 27.9 Hz), 155.1 (d, $^1J_{C\text{-}F}$ = 262.0 Hz), 136.2, 135.3, 133.1, 129.4(d, $^3J_{C\text{-}F}$ = 3.5 Hz), 128.6, 125.2 (q, $^1J_{C\text{-}F}$ = 271.6 Hz), 124.8, 124.7 (q, $^2J_{C\text{-}F}$ = 31.6 Hz), 122.2 (d, $^2J_{C\text{-}F}$ = 12.6 Hz), 119.2, 116.6 (q, $^3J_{C\text{-}F}$ = 3.2 Hz), 112.7(d, $^4J_{C\text{-}F}$ = 2.1 Hz), 109.0 (q, $^3J_{C\text{-}F}$ = 4.4 Hz), 20.7 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -60.6, -124.1.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{14}F_4NO$ 348.1006; Found: 348.1007.

**(Z)-2-fluoro-4-(7-methyl-1H-indol-3-yl)-1-phenylbut-2-en-1-one (10ua)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 8:1), **10ua** was successfully isolated as a yellow oil (44.0 mg, 0.15 mmol, 75% yield; $R_f$ = 0.35 in PE/EA = 4:1).

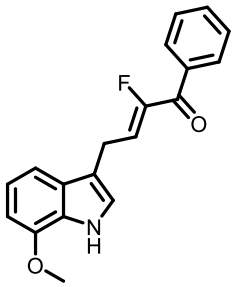
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.02 (s, 1H), 7.79 (d, *J* = 8.3 Hz, 2H), 7.59 – 7.51 (m, 1H), 7.47 (d, *J* = 7.8 Hz, 1H), 7.45 – 7.40 (m, 2H), 7.09 (t, *J* = 7.3 Hz, 2H), 7.04 (t, *J* = 7.3 Hz, 1H), 6.27 (dt, *J* = 33.5, 7.8 Hz, 1H), 3.83 (dd, *J* = 7.8, 1.3 Hz, 2H), 2.49 (s, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.9 (d, $^2J_{C\text{-}F}$ = 27.7 Hz), 154.8 (d, $^1J_{C\text{-}F}$ = 260.7 Hz), 136.4, 136.0, 132.9, 129.4 (d, $^4J_{C\text{-}F}$ = 3.2 Hz), 128.5, 126.7, 123.4 (d, $^2J_{C\text{-}F}$ = 12.7 Hz), 123.0, 121.8, 120.6, 120.1, 116.4, 112.7 (d, $^4J_{C\text{-}F}$ = 2.0 Hz), 21.1 (d, $^3J_{C\text{-}F}$ = 5.1 Hz), 16.7.

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.0.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{17}FNO$ 294.1288; Found: 294.1288.

**(Z)-2-fluoro-4-(7-methoxy-1H-indol-3-yl)-1-phenylbut-2-en-1-one (10va)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10va** was successfully isolated as a yellow oil (47.6 mg, 0.15 mmol, 77% yield; $R_f$ = 0.55 in PE/EA = 4:1).

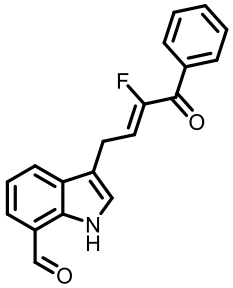
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.25 (s, 1H), 7.79 (d, *J* = 8.4 Hz, 2H), 7.59 – 7.51 (m, 1H), 7.43 (t, *J* = 7.7 Hz, 2H), 7.21 (d, *J* = 8.0 Hz, 1H), 7.06 (t, *J* = 8.0 Hz, 1H), 7.03 (d, *J* = 2.4 Hz, 1H), 6.67 (d, *J* = 7.7 Hz, 1H), 6.26 (dt, *J* = 33.4, 7.8 Hz, 1H), 3.96 (s, 3H), 3.81 (dd, *J* = 7.8, 2.2 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.8 (d, $^2J_{C\text{-}F}$ = 27.7 Hz), 154.8 (d, $^1J_{C\text{-}F}$ = 260.8 Hz), 146.3, 136.4, 132.9, 129.4 (d, $^4J_{C\text{-}F}$ = 3.2 Hz), 128.5, 128.4, 127.0, 123.4 (d, $^2J_{C\text{-}F}$ = 12.6 Hz), 121.6, 120.3, 112.6 (d, $^4J_{C\text{-}F}$ = 1.8 Hz), 111.4, 102.3, 55.5, 21.1 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.0.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{17}FNO_2$ 310.1237; Found: 310.1238.

**(Z)-3-(3-fluoro-4-oxo-4-phenylbut-2-en-1-yl)-1H-indole-7-carbaldehyde (10wa)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10wa** was successfully isolated as a yellow oil (47.3 mg, 0.15 mmol, 77% yield; $R_f$ = 0.6 in PE/EA = 4:1).

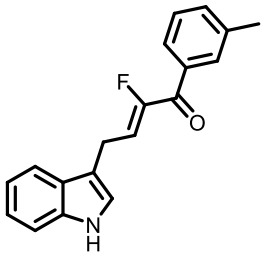
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 10.12 (s, 1H), 10.00 (s, 1H), 7.92 (d, *J* = 7.8 Hz, 1H), 7.80 (d, *J* = 7.8 Hz, 2H), 7.68 (d, *J* = 7.4 Hz, 1H), 7.56 (t, *J* = 7.4 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.29 (t, *J* = 7.6 Hz, 1H), 7.20 (s, 1H), 6.25 (dt, *J* = 33.2, 7.8 Hz, 1H), 3.85 (dd, *J* = 7.8, 1.9 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 193.5, 187.5 (d, $^2J_{C\text{-}F}$ = 27.9 Hz), 154.9 (d, $^1J_{C\text{-}F}$ = 262.2 Hz), 136.1, 134.1, 130.2, 129.3 (d, $^4J_{C\text{-}F}$ = 3.4 Hz), 129.2, 128.5, 128.3, 126.0, 123.7, 122.2 (d, $^2J_{C\text{-}F}$ = 12.7 Hz), 120.5, 119.4, 112.4 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 20.5 (d, $^3J_{C\text{-}F}$ = 5.3 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.2.

**HRMS (ESI) m/z:** $[M\text{-}H]^-$ Calcd for $C_{19}H_{13}FNO_2$ 306.0935; Found: 306.0937.

**(Z)-2-fluoro-4-(1H-indol-3-yl)-1-(m-tolyl)but-2-en-1-one (10ab)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 12:1), **10ab** was successfully isolated as a yellow oil (48.7 mg, 0.17 mmol, 83% yield; $R_f$ = 0.35·in PE/EA= 8:1).

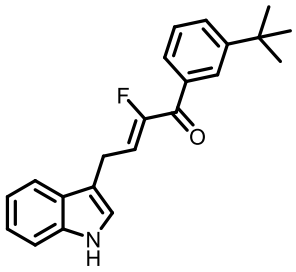
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.05 (s, 1H), 7.68 – 7.55 (m, 3H), 7.37 (t, *J* = 8.1 Hz, 2H), 7.31 (t, *J* = 7.5 Hz, 1H), 7.24 – 7.18 (m, 1H), 7.17 – 7.13 (m, 1H), 7.06 (dd, *J* = 2.3 Hz, 1H), 6.26 (dt, *J* = 33.5, 7.8 Hz, 1H), 3.8 (ddd, *J* = 7.8, 2.2, 0.9 Hz, 2H), 2.4 (s, 3H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 188.1 (d, $^2J_{C\text{-}F}$ = 27.6 Hz), 155.0 (d, $^1J_{C\text{-}F}$ = 261.2 Hz), 138.5, 136.4 (d, $^3J_{C\text{-}F}$ = 5.5 Hz), 133.7, 129.9 (d, $^4J_{C\text{-}F}$ = 3.0 Hz), 128.3, 127.1, 126.6 (d, $^4J_{C\text{-}F}$ = 3.5 Hz), 123.1 (d, $^2J_{C\text{-}F}$ = 12.6 Hz), 122.5, 122.0, 119.8, 118.7, 112.3, 111.4, 21.4, 20.9 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.8.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{17}FNO$ 294.1288; Found: 294.1291.

**(Z)-1-(3-(tert-butyl)phenyl)-2-fluoro-4-(1H-indol-3-yl)but-2-en-1-one (10ac)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10ac** was successfully isolated as a.yellow oil (53.7 mg, 0.16 mmol, 80% yield; $R_f$ = 0.4·in PE/EA= 8:1).

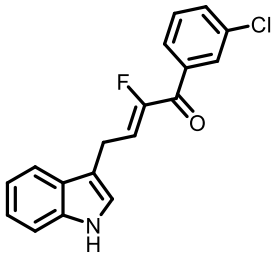
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.78 (s, 1H), 7.65 – 7.54 (m, 3H), 7.39 – 7.33 (m, 2H), 7.22 (t, *J* = 8.2 Hz, 1H), 7.14 (t, *J* = 8.2 Hz, 1H), 7.06 (d, *J* = 2.3 Hz, 1H), 6.24 (dt, *J* = 33.5, 7.7 Hz, 1H), 3.83 (dd, *J* = 7.7, 1.3 Hz, 2H), 1.29 (s, 9H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 188.4 (d, $^2J_{C\text{-}F}$ = 27.1 Hz), 154.9 (d, $^1J_{C\text{-}F}$ = 261.1 Hz), 151.7, 136.5, 136.2, 130.1, 128.2, 127.1, 126.7 (d, $^4J_{C\text{-}F}$ = 3.4 Hz), 126.4 (d, $^4J_{C\text{-}F}$ = 2.9 Hz), 123.2 (d, $^2J_{C\text{-}F}$ = 12.7 Hz), 122.5, 122.0, 119.9, 118.7, 112.3 (d, $^3J_{C\text{-}F}$ = 1.8 Hz), 111.4, 34.9, 31.3, 21.0 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.9.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{22}H_{23}FNO$ 336.1758; Found: 336.1760.

**(*Z*)-1-(3-chlorophenyl)-2-fluoro-4-(1H-indol-3-yl)but-2-en-1-one (10ad)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 12:1), **10ad** was successfully isolated as a yellow oil (47.1 mg, 0.15 mmol, 75% yield; $R_f$ = 0.35·in PE/EA= 8:1).

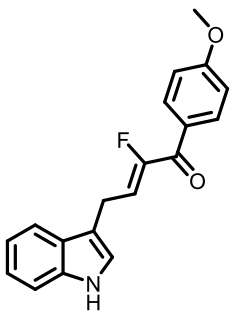
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.79 (s, 1H), 7.68 (dd, *J* = 7.7, 1.4 Hz, 1H), 7.61 (d, *J* = 7.8 Hz, 1H), 7.54 – 7.51 (m, 1H), 7.38 (t, *J* = 7.8 Hz, 2H), 7.23 (t, *J* = 7.6 Hz, 1H), 7.16 (t, *J* = 7.5 Hz, 1H), 7.07 (d, *J* = 2.4 Hz, 1H), 6.30 (dt, *J* = 33.3, 7.8 Hz, 1H), 3.8 (dd, *J* = 7.8, 1.4 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 186.3 (d, $^2J_{C\text{-}F}$ = 28.6 Hz), 154.6 (d, $^1J_{C\text{-}F}$ = 261.5 Hz), 137.8, 136.4, 134.8, 133.0, 129.9, 129.4 (d, $^4J_{C\text{-}F}$ = 3.9 Hz), 127.5 (d, $^4J_{C\text{-}F}$ = 4.0 Hz), 127.1, 123.5 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 122.6, 122.1, 119.9, 118.7, 112.0 (d, $^3J_{C\text{-}F}$ = 2.2 Hz), 111.4, 21.0 (d, $^3J_{C\text{-}F}$ = 5.0 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.1.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{14}ClFNO$ 314.0742; Found: 314.0740.

**(*Z*)-2-fluoro-4-(1H-indol-3-yl)-1-(4-methoxyphenyl)but-2-en-1-one (10ae)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 20:1), **10ae** was successfully isolated as a.yellow oil (52.6 mg, 0.17 mmol, 85% yield; $R_f$ = 0.5·in PE/EA= 8:1).

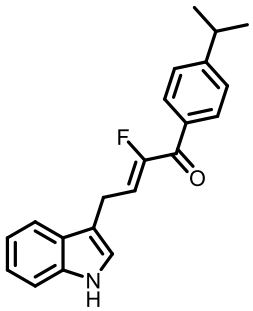
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.14 (s, 1H), 7.87 (d, J = 7.8 Hz, 2H), 7.63 (d, *J* = 7.8 Hz, 1H), 7.38 (d, *J* = 8.1 Hz, 1H), 7.19 – 7.24 (m, 1H), 7.16 (t, *J* = 7.8 Hz, 1H), 7.05 (d, *J* = 2.2 Hz, 1H), 6.92 (d, *J* = 8.9 Hz, 2H), 6.26 (dt, *J* = 33.8, 7.8 Hz, 1H), 3.86 (s, 3H), 3.82 (dd, *J* = 7.8, 1.3 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 186.1 (d, $^2J_{C\text{-}F}$ = 28.2 Hz), 163.7, 155.2 (d, $^1J_{C\text{-}F}$ = 262.2 Hz), 136.4, 132.0 (d, $^4J_{C\text{-}F}$ = 4.4 Hz), 128.8, 127.1, 122.4, 122.0, 121.5 (d, $^2J_{C\text{-}F}$ = 12.7 Hz), 119.7, 118.7, 113.8, 112.4 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 111.4, 55.6, 20.8 (d, $^3J_{C\text{-}F}$ = 5.2 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -123.6.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{16}FNO_2$ 310.1237; Found: 310.1238.

**(*Z*)-2-fluoro-4-(1H-indol-3-yl)-1-(4-isopropylphenyl)but-2-en-1-one (10af)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10af** was successfully isolated as a.yellow oil (51.4 mg, 0.16 mmol, 80% yield; $R_f$ = 0.4·in PE/EA= 8:1).

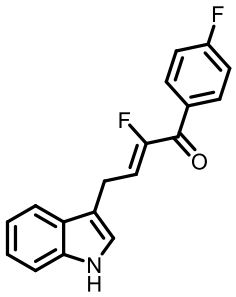
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.76 (d, *J* = 7.8 Hz, 2H), 7.62 (d, *J* = 7.8 Hz, 1H), 7.38 (d, *J* = 8.0 Hz, 1H), 7.28 (d, *J* = 8.0 Hz, 2H), 7.24 – 7.19 (m, 1H), 7.17 – 7.12 (m, 1H), 7.06 (d, *J* = 2.3 Hz, 1H), 6.26 (dt, *J* = 33.5, 7.8 Hz, 1H), 3.82 (dd, *J* = 7.8, 1.3 Hz, 2H), 2.95 (m, 1H), 1.26 (d, *J* = 6.9 Hz, 6H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 187.4 (d, $^2J_{C\text{-}F}$ = 27.4 Hz), 155.0 (d, $^1J_{C\text{-}F}$ = 261.2 Hz), 154.6, 136.4, 134.0, 129.8 (d, $^4J_{C\text{-}F}$ = 3.5 Hz), 127.2, 126.7, 122.6 (d, $^2J_{C\text{-}F}$ = 12.2 Hz), 122.5, 122.1, 119.8, 118.8, 112.4 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 111.4, 34.4, 23.8, 20.9 (d, $^3J_{C\text{-}F}$ = 5.2 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.5.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{21}H_{21}FNO$ 322.1601; Found: 322.1602.

**(*Z*)-2-fluoro-1-(4-fluorophenyl)-4-(1H-indol-3-yl)but-2-en-1-one (10ag)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 15:1), **10ag** was successfully isolated as a yellow oil (38.5 mg, 0.14 mmol, 69% yield; $R_f$ = 0.35·in PE/EA= 8:1).

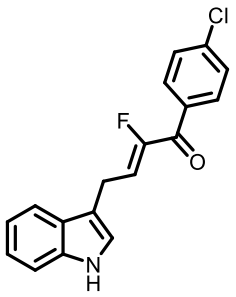
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.89 – 7.82 (m, 2H), 7.61 (d, *J* = 8.0 Hz, 1H), 7.38 (d, *J* = 8. 0 Hz, 1H), 7.25 – 7.21 (m, 1H), 7.17 – 7.14 (m, 1H), 7.13 – 7.09 (m, 2H), 7.06 (d, *J* = 2.4 Hz, 1H), 6.29 (dt, *J* = 33.5, 7.8 Hz, 1H), 3.8 (ddd, *J* = 7.8, 2.3, 0.9 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 186.0 (d, $^2J_{C\text{-}F}$ = 28.7 Hz), 165.7 (d, $^1J_{C\text{-}F}$ = 255.0 Hz), 154.9 (d, $^1J_{C\text{-}F}$ = 261.7 Hz), 136.5, 132.4 (d, $^3J_{C\text{-}F}$ = 3.1 Hz), 132.2 (dd, $^3J_{C\text{-}F}$ = 9.2 Hz, $^4J_{C\text{-}F}$ = 4.3 Hz), 127.1, 122.6 (d, $^2J_{C\text{-}F}$ = 12.7 Hz), 122.5, 122.1, 119.9, 118.7, 115.8 (d, $^2J_{C\text{-}F}$ = 21.9 Hz), 112.2 (d, $^4J_{C\text{-}F}$ = 2.0 Hz), 111.4, 20.9 (d, $^3J_{C\text{-}F}$ = 5.2 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -104.8, -124.4.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{14}F_2NO$ 298.1037; Found: 298.1040.

**(*Z*)-1-(4-chlorophenyl)-2-fluoro-4-(1H-indol-3-yl)but-2-en-1-one (10ah)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 13:1), **10ah** was successfully isolated as a yellow oil (46.4 mg, 0.15 mmol, 74% yield; $R_f$ = 0.35·in PE/EA= 8:1).

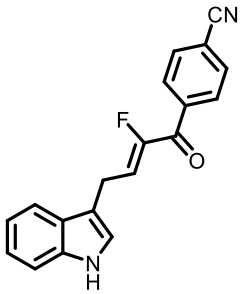
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.09 (s, 1H), 7.77 (d, *J* = 7.6 Hz, 2H), 7.61 (d, *J* = 7.6 Hz, 1H), 7.41 (d, *J* = 8.4 Hz, 2H), 7.38 (d, *J* = 8.4 Hz, 1H), 7.25 – 7.20 (m, 1H), 7.18 – 7.13 (m, 1H), 7.06 (d, *J* = 2.4 Hz, 1H), 6.29 (dt, *J* = 33.5, 7.8 Hz, 1H), 3.82 (dd, *J* = 7.8, 1.4 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 186.4 (d, $^2J_{C\text{-}F}$ = 28.6 Hz), 154.8 (d, $^2J_{C\text{-}F}$ = 261.5 Hz), 139.5, 136.4, 134.5, 130.9 (d, $^4J_{C\text{-}F}$ = 4.1 Hz), 128.9, 127.1, 123.1 (d, $^2J_{C\text{-}F}$ = 12.6 Hz), 122.5, 122.1, 119.9, 118.6, 112.1 (d, $^4J_{C\text{-}F}$ = 2.1 Hz), 111.5, 20.9 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -124.8.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{14}ClFNO$ 314.0742; Found: 314.0741.

**(*Z*)-4-(2-fluoro-4-(1H-indol-3-yl)but-2-enoyl)benzonitrile (10ai)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 16:1), **10ai** was successfully isolated as a yellow oil (32.3 mg, 0.11 mmol, 53% yield; $R_f$ = 0.35·in PE/EA= 8:1).

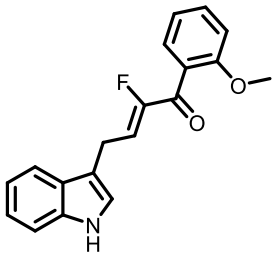
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.10 (s, 1H), 7.87 (d, *J* = 7.5 Hz, 2H), 7.73 (d, *J* = 8.4 Hz, 2H), 7.59 (d, *J* = 8.1 Hz, 1H), 7.39 (d, *J* = 8.1 Hz, 1H), 7.25 – 7.20 (m, 1H), 7.16 (t, *J* = 7.5 Hz, 1H), 7.07 (d, *J* = 2.4 Hz, 1H), 6.31 (dt, *J* = 33.2, 7.8 Hz, 1H), 3.83 (dd, *J* = 7.8, 1.4 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 186.4 (d, $^2J_{C\text{-}F}$ = 29.5 Hz), 154.7 (d, $^1J_{C\text{-}F}$ = 261.1 Hz), 140.0, 136.8, 132.7, 130.1 (d, $^4J_{C\text{-}F}$ = 4.0 Hz), 127.3, 124.6 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 122.9, 122.5, 120.3, 118.9, 118.3, 116.6, 112.0 (d, $^4J_{C\text{-}F}$ = 2.1 Hz), 111.8, 21.3 (d, $^3J_{C\text{-}F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.6.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{14}FN_2O$ 305.1084; Found: 305.1085.

**(*Z*)-2-fluoro-4-(1H-indol-3-yl)-1-(2-methoxyphenyl)but-2-en-1-one (10aj)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 10:1), **10aj** was successfully isolated as a yellow oil (48.3 mg, 0.16 mmol, 78% yield; $R_f$ = 0.4·in PE/EA= 4:1).

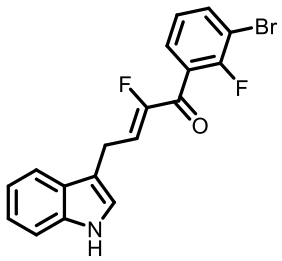
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.03 (s, 1H), 7.59 (d, *J* = 7.9 Hz, 1H), 7.41 (td, *J* = 7.9, 1.8 Hz, 1H), 7.37 (d, *J* = 8.1 Hz, 1H), 7.31 (dd, *J* = 7.6, 1.8 Hz, 1H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.13 (t, *J* = 7.5 Hz, 1H), 7.02 (d, *J* = 2.3 Hz, 1H), 6.96 (t, *J* = 7.5 Hz, 1H), 6.90 (d, *J* = 8.1 Hz, 1H), 6.09 (dt, *J* = 32.5, 7.8 Hz, 1H), 3.77 (dd, *J* = 7.8, 2.1 Hz, 2H), 3.7 (s, 3H).

**$^{13}$C NMR** (151 MHz, $CDCl_3$) δ 188.7 (d, $^2J_{C\text{-}F}$ = 29.1 Hz), 157.6, 155.5 (d, $^1J_{C\text{-}F}$ = 259.8 Hz), 136.4, 132.6, 129.6, 127.2, 127.1, 123.0 (d, $^2J_{C\text{-}}$ = 13.1 Hz), 122.5, 122.0, 120.6, 119.8, 118.9, 112.3, 111.5, 111.3, 55.7, 21.0 (d, $^3J_{C\text{-}F}$ = 4.6 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -128.6.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{17}FNO_2$ 310.1237; Found: 310.1240.

**(*Z*)-1-(3-bromo-2-fluorophenyl)-2-fluoro-4-(1H-indol-3-yl)but-2-en-1-one (10ak)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 20:1), **10ak** was successfully isolated as a yellow oil (57.9 mg, 0.15 mmol, 77% yield; $R_f$ = 0.5·in PE/EA= 8:1).

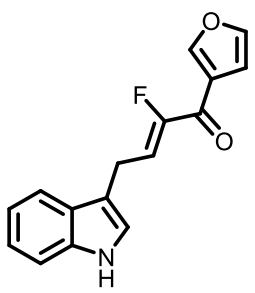
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.69 (dd, *J* = 8.0, 1.7 Hz, 1H), 7.59 (d, *J* = 8.0 Hz, 1H), 7.44 – 7.34 (m, 2H), 7.25 – 7.20 (m, 1H), 7.16 (td, *J* = 7.8, 0.9 Hz, 1H), 7.05 (d, *J* = 2.4 Hz, 1H), 6.23 (dd, *J* = 32.3, 7.8 Hz, 1H), 3.8 (ddd, *J* = 7.8, 2.3, 0.9 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 184.3 (d, $^2J_{C\text{-}F}$ = 31.1 Hz), 156.3 (d, $^1J_{C\text{-}F}$ = 253.6 Hz), 154.5 (d, $^1J_{C\text{-}F}$ = 259.4 Hz), 137.0, 136.4, 129.3, 127.0, 126.7 (d, $^2J_{C\text{-}F}$ = 16.2 Hz), 125.4 (d, $^3J_{C\text{-}F}$ = 4.5 Hz), 124.4 (d, $^2J_{C\text{-}F}$ = 12.4 Hz), 122.6, 122.2, 119.9, 118.6, 111.7 (d, $^4J_{C\text{-}F}$ = 2.1 Hz), 111.4, 110.2 (d, $^2J_{C\text{-}F}$ = 21.5 Hz), 21.0 (d, $^3J_{C\text{-}F}$ = 4.4 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -106.3, -128.2.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{13}BrF_2NO$ 376.0143; Found: 376.0141.

**(*Z*)-2-fluoro-1-(furan-3-yl)-4-(1H-indol-3-yl)but-2-en-1-one (10al)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 18:1), **10al** was successfully isolated as a.yellow oil (45.8 mg, 0.17 mmol, 85% yield; $R_f$ = 0.4·in PE/EA= 8:1).

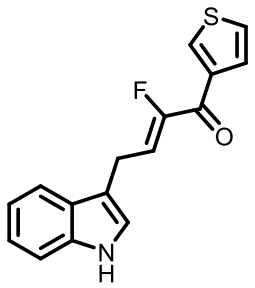
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.25 –8.24 (m, 1H), 8.10 (s, 1H), 7.64 (s, 1H), 7.62 (d, *J* = 2.9 Hz, 1H), 7.38 (d, *J* = 8.1, 1H), 7.32 (dd, *J* = 5.1, 2.9 Hz, 1H), 7.25 – 7.20 (m, 1H), 7.17 – 7.13 (m, 1H), 7.05 (d, *J* = 2.2 Hz, 1H), 6.45 (dt, *J* = 34.1, 7.8 Hz, 1H), 3.80 (dd, *J* = 7.9, 2.4 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 179.8 (d, $^2J_{C\text{-}F}$ = 31.0 Hz), 155.6 (d, $^1J_{C\text{-}F}$ = 263.4 Hz), 139.1 (d, $^5J_{C\text{-}F}$ = 2.8 Hz), 136.4, 134.4 (d, $^4J_{C\text{-}F}$ = 12.2 Hz), 128.5 (d, $^4J_{C\text{-}F}$ = 3.0 Hz), 127.1, 126.0, 122.5, 122.0, 120.4 (d, $^2J_{C\text{-}F}$ = 12.3 Hz), 119.8, 118.7, 112.3 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 111.4, 20.7 (d, $^3J_{C\text{-}F}$ = 5.4 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.95.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{16}H_{13}FNO_2$ 270.0924; Found: 270.0927.

**(Z)-2-fluoro-4-(1H-indol-3-yl)-1-(thiophen-3-yl)but-2-en-1-one (10am)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 20:1), **10am** was successfully isolated as a yellow oil (47.9 mg, 0.17 mmol, 84% yield; $R_f$ = 0.5·in PE/EA= 8:1).

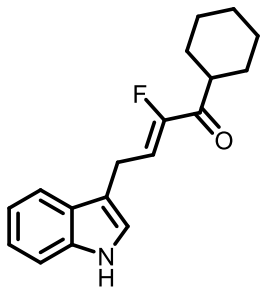
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.26 – 8.24 (m, 1H), 8.16 (s, 1H), 7.64 (d, *J* = 6.1 Hz, 2H), 7.38 (d, *J* = 8.0 Hz, 1H), 7.32 (dd, *J* = 5.1, 2.9 Hz, 1H), 7.24 (t, *J* = 8.0 Hz, 1H), 7.17 (t, *J* = 7.0 Hz, 1H), 7.04 (d, *J* = 2.4 Hz, 1H), 6.46 (dt, *J* = 34.1, 7.8 Hz, 1H), 3.8 (dd, *J* = 7.8, 2.4 Hz, 2H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 179.8 (d, $^2J_{C\text{-}F}$ = 30.9 Hz), 155.5 (d, $^2J_{C\text{-}F}$ = 263.1 Hz), 139.1 (d, $^5J_{C\text{-}F}$ = 2.8 Hz), 136.4, 134.4 (d, $^4J_{C\text{-}F}$ = 12.2 Hz), 128.5 (d, $^4J_{C\text{-}F}$ = 2.9 Hz), 127.1, 126.0, 122.4, 122.0, 120.6 (d, $^2J_{C\text{-}F}$ = 12.2 Hz), 119.7, 118.7, 112.2 (d, $^4J_{C\text{-}F}$ = 2.2 Hz), 111.4, 20.7 (d, $^3J_{C\text{-}F}$ = 5.4 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -125.9.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{16}H_{13}FNOS$ 286.0696; Found: 286.0699.

**(Z)-1-cyclohexyl-2-fluoro-4-(1H-indol-3-yl)but-2-en-1-one (10an)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 18:1), **10an** was successfully isolated as a yellow oil (38.8 mg, 0.14 mmol, 68% yield; $R_f$ = 0.3·in PE/EA= 16:1).

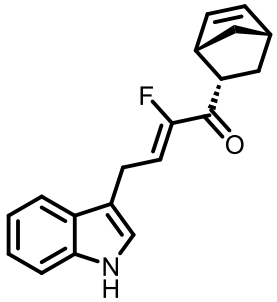
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.25 (s, 1H), 7.62 (d, *J* = 8.0 Hz, 1H), 7.39 (d, *J* = 8.0 Hz, 1H), 7.27 – 7.22 (m, 1H), 7.20 – 7.14 (m, 1H), 7.03 (d, *J* = 2.4 Hz, 1H), 6.32 (dt, *J* = 34.0, 7.8 Hz, 1H), 3.75 (dd, *J* = 7.8, 2.4 Hz, 2H), 2.86 (m, 1H), 1.88 – 1.81 (m, 4H), 1.77 – 1.68 (m, 1H), 1.51 – 1.18 (m, 5H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 197.6 (d, $^2J_{C\text{-}F}$ = 28.5 Hz), 154.4 (d, $^1J_{C\text{-}F}$ = 262.3 Hz), 136.4, 127.1, 122.3, 122.1, 119.6, 118.6, 118.5 (d, $^2J_{C\text{-}F}$ = 12.7 Hz), 112.1 (d, $^4J_{C\text{-}F}$ = 2.1 Hz), 111.4, 45.3, 28.6, 25.8, 25.7, 20.5 (d, $^3J_{C\text{-}F}$ = 5.3 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -130.4.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{21}FNO$ 286.1601; Found: 286.1601.

**(Z)-1-((1S,2S,4S)-bicyclo[2.2.1]hept-5-en-2-yl)-2-fluoro-4-(1H-indol-3-yl)but-2-en-1-one (10ao)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 18:1), **10ao** was successfully isolated as a yellow oil (35.4 mg, 0.12 mmol, 60% yield; $R_f$ = 0.25·in PE/EA= 16:1).

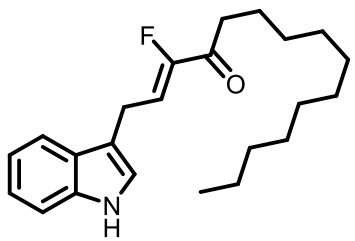
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.60 (d, *J* = 8.0 Hz, 1H), 7.38 (d, *J* = 8.0 Hz, 1H), 7.25 – 7.19 (m, 1H), 7.18 – 7.11 (m, 1H), 7.03 (d, *J* = 2.4 Hz, 1H), 6.26 (dt, *J* = 34.1, 7.8 Hz, 1H), 6.17 (dd, *J* = 5.7, 3.1 Hz, 1H), 5.84 (dd, *J* = 5.7, 2.9 Hz, 1H), 3.73 (ddd, *J* = 7.8, 2.2, 0.9 Hz, 2H), 3.45 – 3.40 (m, 1H), 3.29 (s, 1H), 2.93 (s, 1H), 1.86 – 1.80 (m, 1H), 1.5 (m, 1H), 1.5 (m, 1H), 1.37 (d, *J* = 8.2 Hz, 1H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 194.7 (d, $^2J_{C-F}$ = 30.2 Hz), 155.2 (d, $^1J_{C-F}$ = 262.7 Hz), 137.8, 136.4, 131.6, 127.1, 122.4, 121.9, 119.7, 118.7, 117.5 (d, $^2J_{C-F}$ = 12.5 Hz), 112.4 (d, $^4J_{C-F}$ = 2.1 Hz), 111.4, 50.1, 47.2 (d, $^4J_{C-F}$ = 1.7 Hz), 46.6 (d, $^3J_{C-F}$ = 2.2 Hz), 42.9, 28.2, 20.5 (d, $^3J_{C-F}$ = 5.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -129.4.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{19}H_{18}FNO$ 296.1445; Found: 296.1447.

**(Z)-3-fluoro-1-(1H-indol-3-yl)pentadec-2-en-4-one (10ap)**



The title compound was prepared via the general procedure, after purification by silica gel column (PE/EA = 125:1), **10ap** was successfully isolated as a white solid (46.5 mg, 0.13 mmol, 65% yield; $R_f$ = 0.4·in PE/EA= 16:1).

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.59 (d, *J* = 8.0 Hz, 1H), 7.38 (d, *J* = 8.0 Hz, 1H), 7.25 – 7.19 (*m*, 1H), 7.17 – 7.12 (*m*, 1H), 7.04 (d, *J* = 2.3 Hz, 1H), 6.27 (dt, *J* = 33.8, 7.8 Hz, 1H), 3.73 (dd, *J* = 7.8, 2.2 Hz, 2H), 2.62 (td, *J* = 7.4, 1.6 Hz, 2H), 1.67 – 1.57 (m, 2H), 1.34 – 1.26 (m, 16H), 0.9 (t, *J* = 6.8 Hz, 3H).

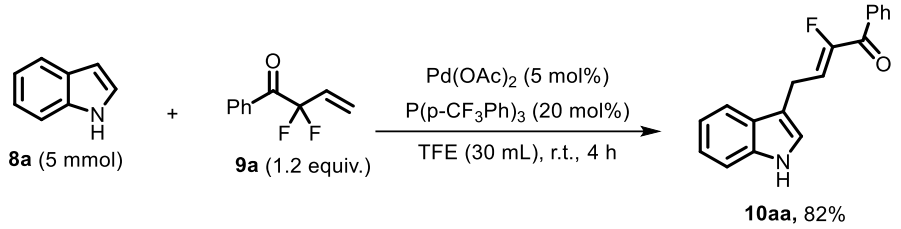
**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 194.5 (d, $^2J_{C-F}$ = 29.8 Hz), 154.9 (d, $^1J_{C-F}$ = 261.5 Hz), 136.4, 127.1, 122.5, 122.0, 119.8, 118.7, 118.1 (d, $^2J_{C-F}$ = 12.5 Hz), 112.3 (d, $^4J_{C-F}$ = 2.1

Hz), 111.4, 38.0, 32.0, 29.7, 29.6, 29.51, 29.47, 29.3, 23.8, 22.8, 20.5 (d, $^{3}J_{C\text{-}F}$ = 5.1 Hz), 14.3.

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -129.7.

**HRMS (ESI) m/z:** $[M\text{-}H]^-$ Calcd for $C_{23}H_{31}FNO$ 356.2395; Found: 356.2393.

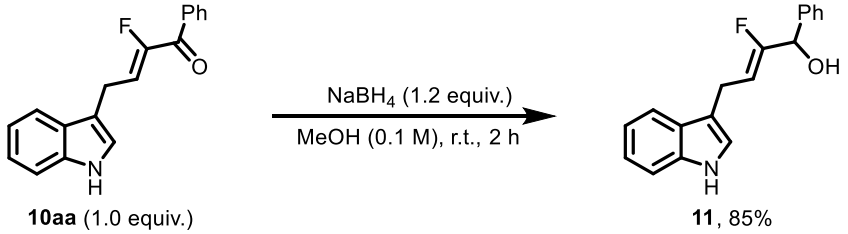
2.4 Gram scale synthesis




A dry 100 mL round-bottom flask was charged with compound **8aa** (885.75 mg, 5 mmol, 1 equiv.), **9aa** (1093.02 mg, 6 mmol, 1.2 equiv.), catalyst $Pd(OAc)_2$ (56.13 mg, 5 mol%), and ligand P($p$-$CF_3C_6H_4$)$_3$ (466.28 mg, 20 mol%) in TFE (30 mL). The reaction mixture was stirred at room temperature for 4 h, and monitored by TLC until complete consumption of **8aa** was observed. The mixture was then concentrated under reduced pressure and purified by silica gel column chromatography (PE/EA = 16:1 - 10:1) to afford product **10aa** (4.1 mmol, 1145.2 mg, 82%).

2.5 The synthetic applications of **10aa**

Synthetic Transformation of **10aa** to **11**




A dry 10 mL round-bottom flask was charged with compound **10aa** (0.2 mmol, 55.9 mg, 1 equiv.) and $NaBH_4$ (0.24 mmol, 9.1 mg, 1.2 equiv.) in MeOH (2 mL). The reaction mixture was stirred at room temperature for 2 h and monitored by TLC until complete consumption of **10aa** was observed. The reaction was quenched by adding water (2 mL), and the mixture was extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous $Na_2SO_4$, concentrated under reduced pressure, and purified by silica gel column chromatography (PE/EA = 8:1 -

4:1). Coupound **11** was successfully isolated as a colorless oil (0.17 mmol, 47.8 mg, 85% yield, $R_f$ = 0.3·in PE/EA= 4:1).

**(*Z*)-2-fluoro-4-(1H-indol-3-yl)-1-phenylbut-2-en-1-ol (11)**

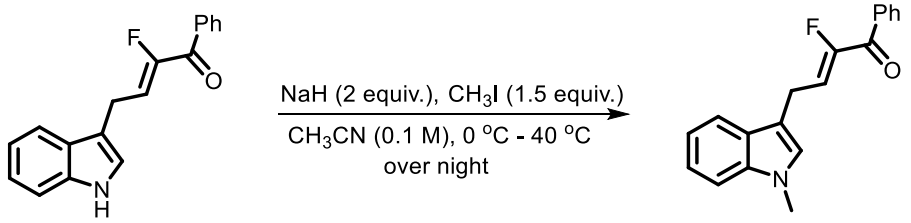
**$^1$H NMR** (400 MHz, $CDCl_3$) δ 7.92 (s, 1H), 7.61 (d, *J* = 7.9 Hz, 1H), 7.46 – 7.42 (m, 2H), 7.44 – 7.31 (m, 5H), 7.23 (t, *J* = 6.9 Hz, 1H), 7.14 (t, *J* = 7.5 Hz, 1H), 6.95 (d, *J* = 2.3 Hz, 1H), 5.30 – 5.14 (m, 2H), 3.61 (d, *J* = 7.5 Hz, 2H), 2.45 (s, 1H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 158.6 (d, $^1J_{C-F}$ = 256.6 Hz), 139.6, 136.5, 128.7, 128.4, 127.3, 126.8, 122.2, 121.6, 119.4, 119.0, 114.3 (d, $^4J_{C-F}$ = 1.8 Hz), 111.3, 106.8 (d, $^2J_{C-F}$ = 13.0 Hz), 72.9 (d, $^2J_{C-F}$ = 31.8 Hz), 19.7 (d, $^3J_{C-F}$ = 6.1 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -123.2.

**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{17}FNO$ 282.1288; Found: 282.1286.

Synthetic Transformation of **10aa** to **12** (Notice: Compound**12** is structurally identical to compound **3ba** shown in Scheme 2).



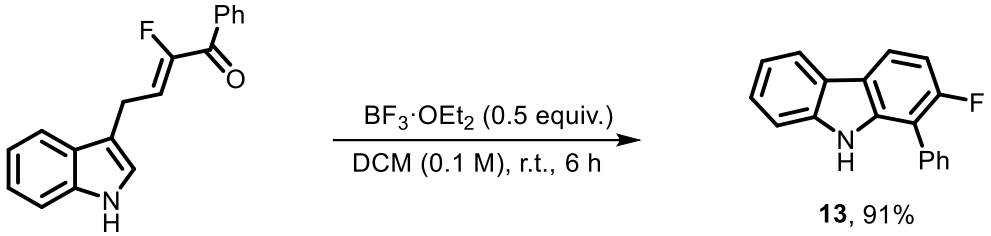

**10aa** (1.0 equiv)

**12**, 93%

A dry 10 mL round-bottom flask was charged with compound **10aa** (0.2 mmol, 55.9 mg, 1 equiv.) and NaH (0.4 mmol, 9.6 mg, 2 equiv.) in $CH_3CN$ (2 mL). The reaction mixture was stirred at 0 °C for 30 min, followed by dropwise addition of $CH_3I$ (0.3 mmol, 1.5 equiv.). The mixture was then gradually warmed to 40 °C and stirred overnight. The reaction was monitored by TLC, which indicated complete consumption of **10aa**. It was quenched by adding water (2 mL) and extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over anhydrous $Na_2SO_4$, concentrated under reduced pressure, and purified by silica gel column chromatography (PE/EA = 6:1 - 4:1) to afford compound **12.** Compound **12** was successfully isolated as a.yellow oil (0.19 mmol, 54.6 mg, 93% yield, $R_f$ = 0.45·in PE/EA= 8:1)).

$^1$H, $^{13}$C, and $^{19}$F NMR spectroscopic data of compound **12** are consistent with those of compound **3ba**.

Synthetic Transformation of **10aa** to **13**




**10aa** (1.0 equiv.)

**13**, 91%

A dry 10 mL round-bottom flask was charged with compound **10aa** (0.2 mmol, 55.9 mg, 1 equiv.) and $BF_3 \cdot OEt_2$ (3.4 M in THF, 0.1 mmol, 0.5 equiv.) in DCM (2 mL). The reaction mixture was stirred at room temperature for 6 h and monitored by TLC until complete consumption of **10aa** was observed. The reaction was quenched by adding water (2 mL) and extracted with DCM (3 × 10 mL). The combined organic layers were dried over anhydrous $Na_2SO_4$, concentrated under reduced pressure, and purified by silica gel column chromatography (PE/EA = 60:1 - 32:1) to afford **13**. Compound **13** was obtained as a white solid (0.18 mmol, 47.6 mg, 91% yield, $R_f$ = 0.52 (PE/EA = 32/1).

**2-fluoro-1-phenyl-9H-carbazole (13)**

**$^1$H NMR** (400 MHz, $CDCl_3$) δ 8.15 (s, 1H), 8.05 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.98 (dd, *J* = 8.5, 4.9 Hz, 1H), 7.65 (dt, *J* = 8.2, 1.2 Hz, 2H), 7.61 – 7.55 (m, 2H), 7.52 – 7.43 (m, 1H), 7.42 – 7.36 (m, 2H), 7.30 – 7.21 (m, 1H), 7.09 (dd, *J* = 10.4, 8.5 Hz, 1H).

**$^{13}$C NMR** (101 MHz, $CDCl_3$) δ 158.2 (d, $^1J_{C\text{-}F}$ = 242.3 Hz), 139.9 (d, $^4J_{C\text{-}F}$ = 2.1 Hz), 138.8 (d, $^3J_{C\text{-}F}$ = 8.0 Hz), 132.6, 129.8 (d, $^4J_{C\text{-}F}$ = 1.5 Hz), 129.3, 128.3, 125.6, 123.4, 120.3 (d, $^3J_{C\text{-}F}$ = 10.7 Hz), 120.2, 120.1, 119.9, 112.3 (d, $^2J_{C\text{-}F}$ = 20.3 Hz), 110.8, 108.3 (d, $^2J_{C\text{-}F}$ = 25.7 Hz).

**$^{19}$F NMR** (377 MHz, $CDCl_3$) δ -122.09.

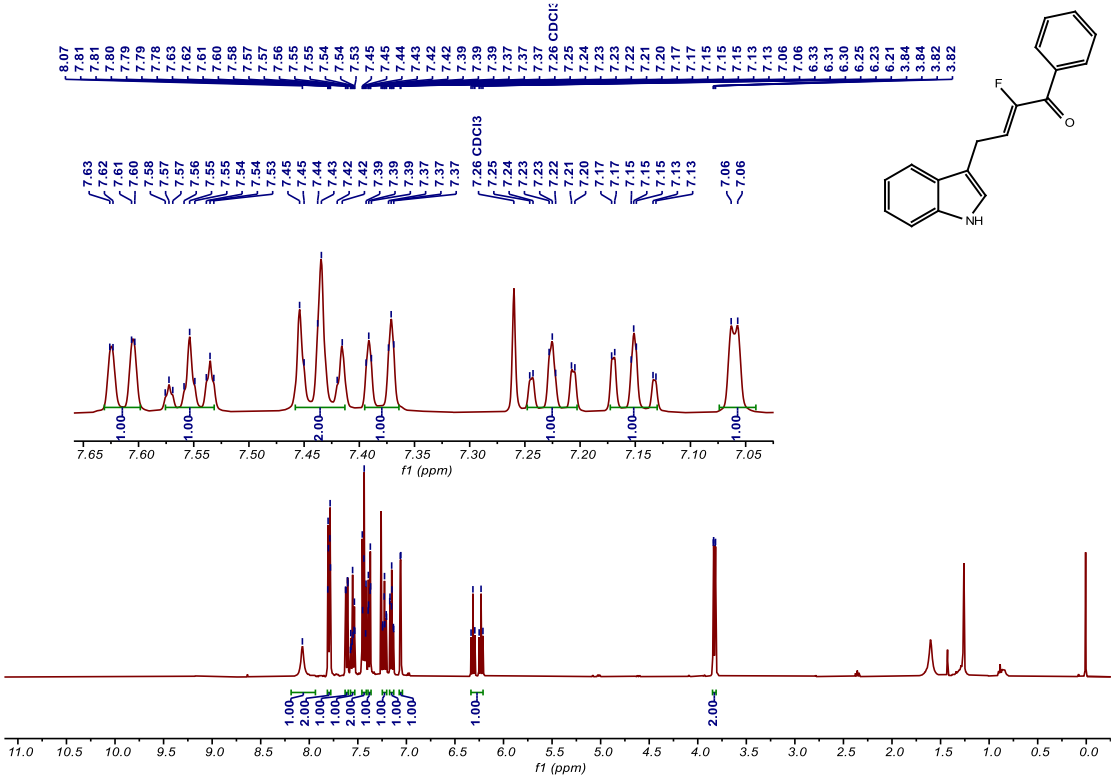
**HRMS (ESI) m/z:** $[M+H]^+$ Calcd for $C_{18}H_{13}FN$ 262.1026; Found 262.1026.

# 3. References

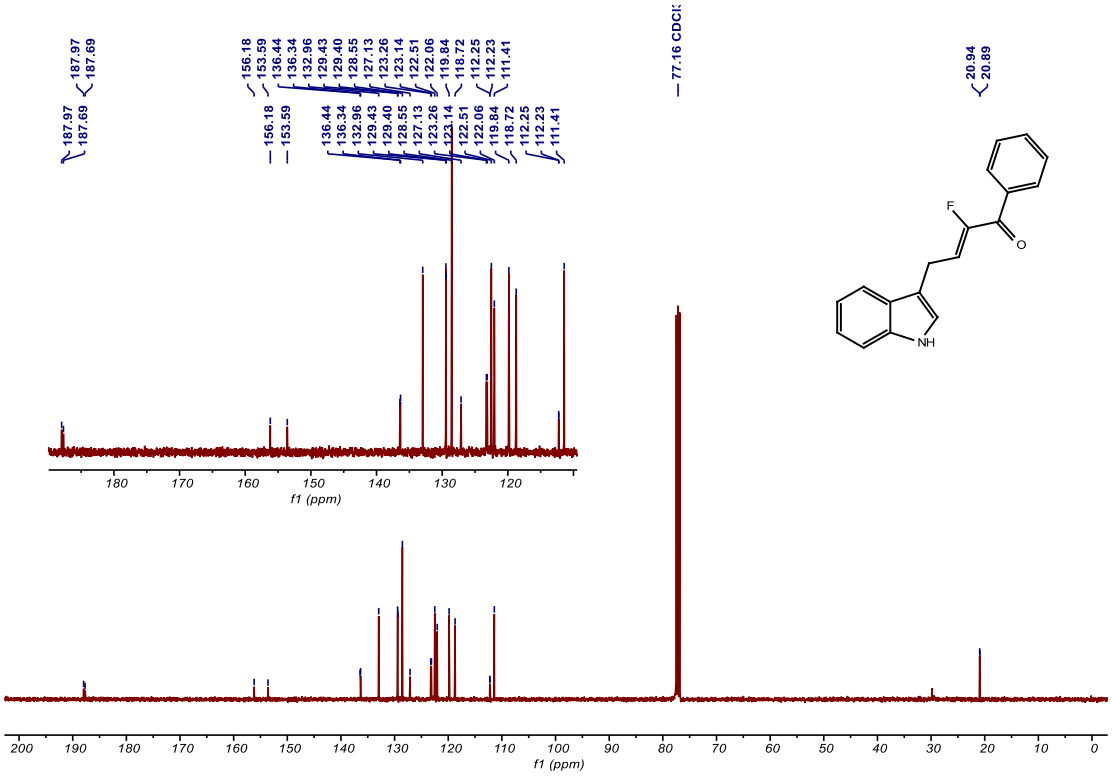

1. Lin, W.; Luo, Z.; Zhu, H.; Hu, J.; Xiong, Z.; Wu, J.-Q. *Chem. Commun.*, **2025**, *61*, 18709-18712.
2. Xie. M.; Luo, Z.; Chen, C.; Xiong, Z.; Hu, J.; Wu, J.-Q. *Org. Lett.* **2025**, *27*, 9920–9926

# 4. Copies of NMR Spectra for Compound

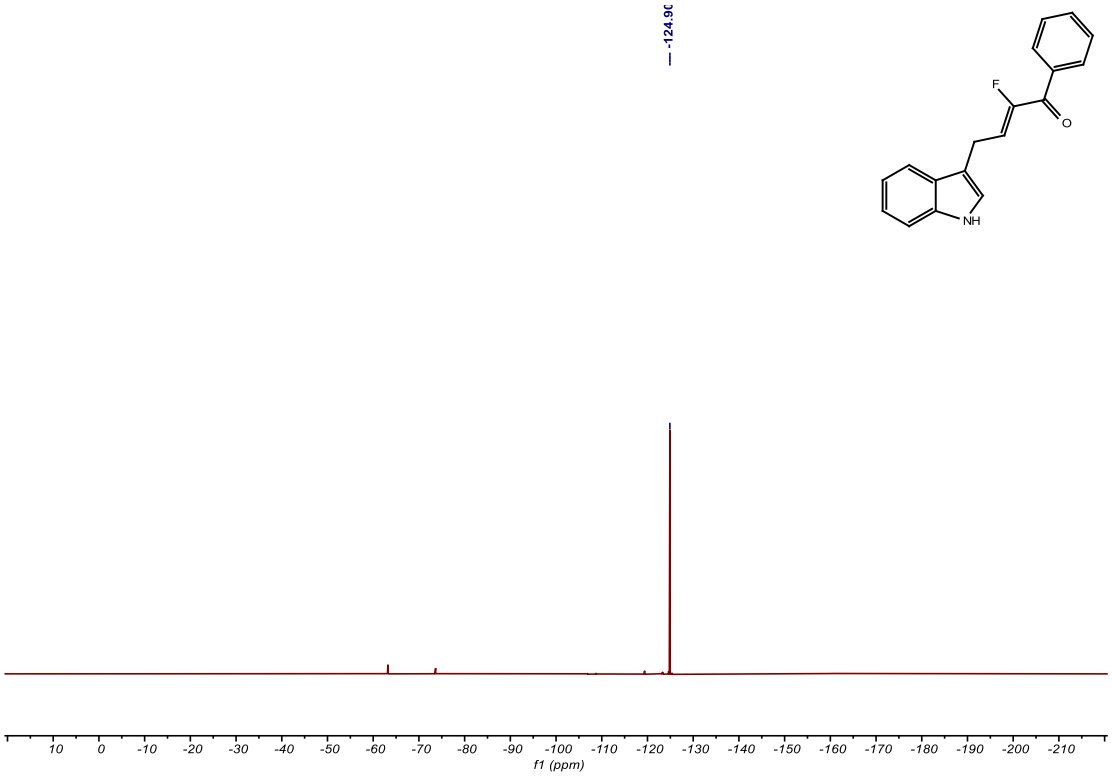
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10aa**



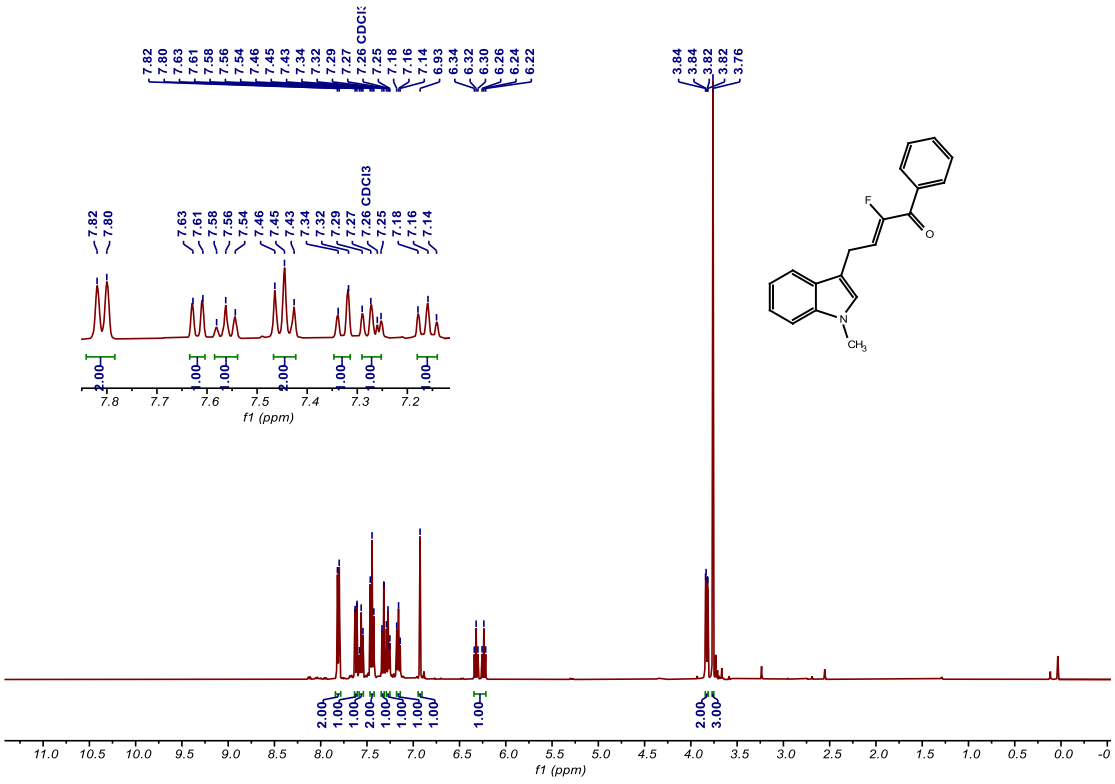

**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10aa**



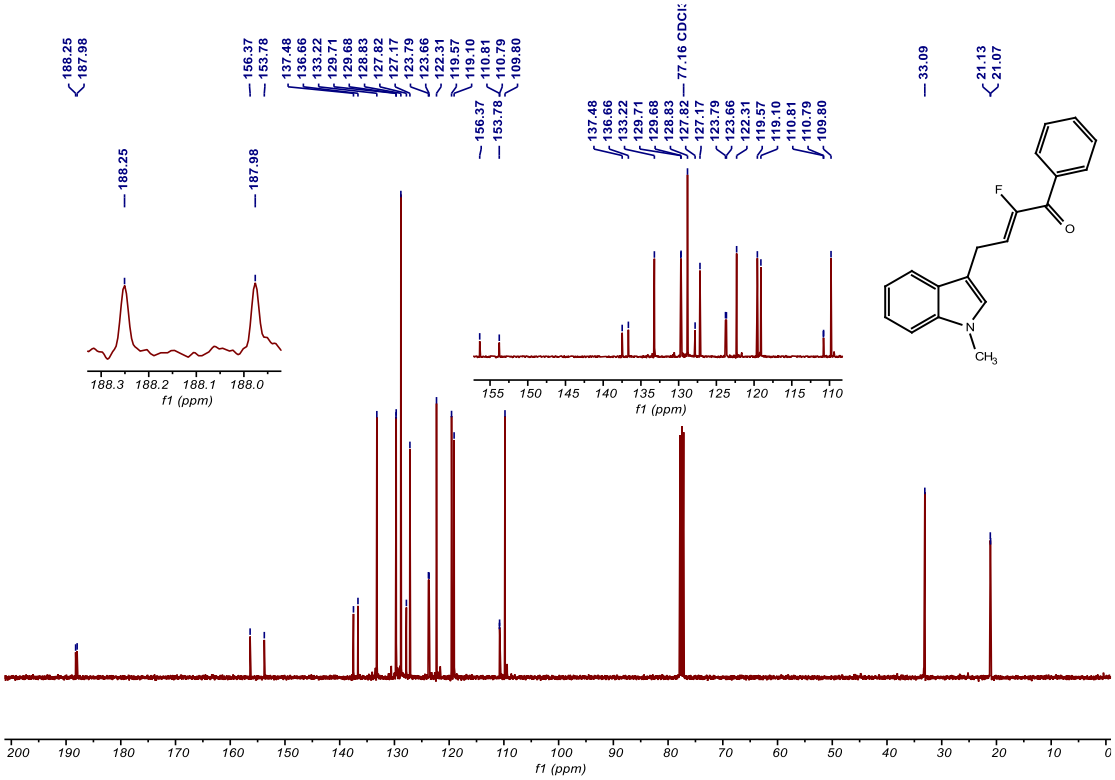
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10aa**



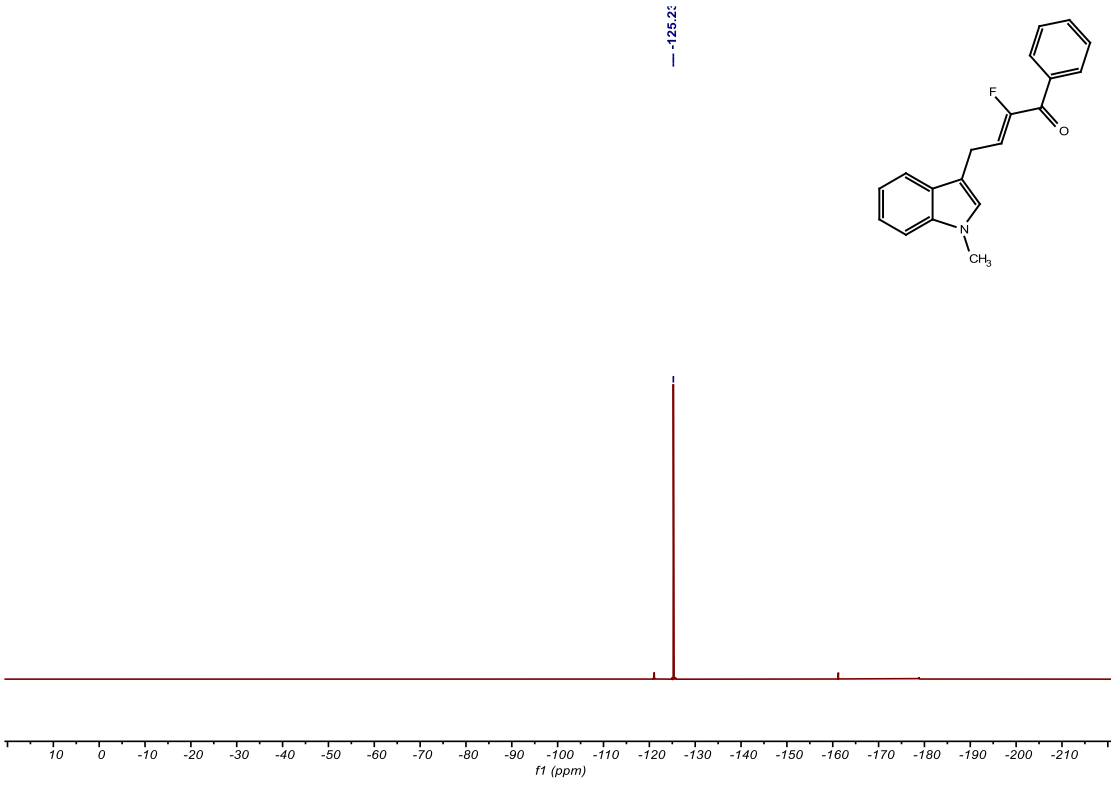

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ba**



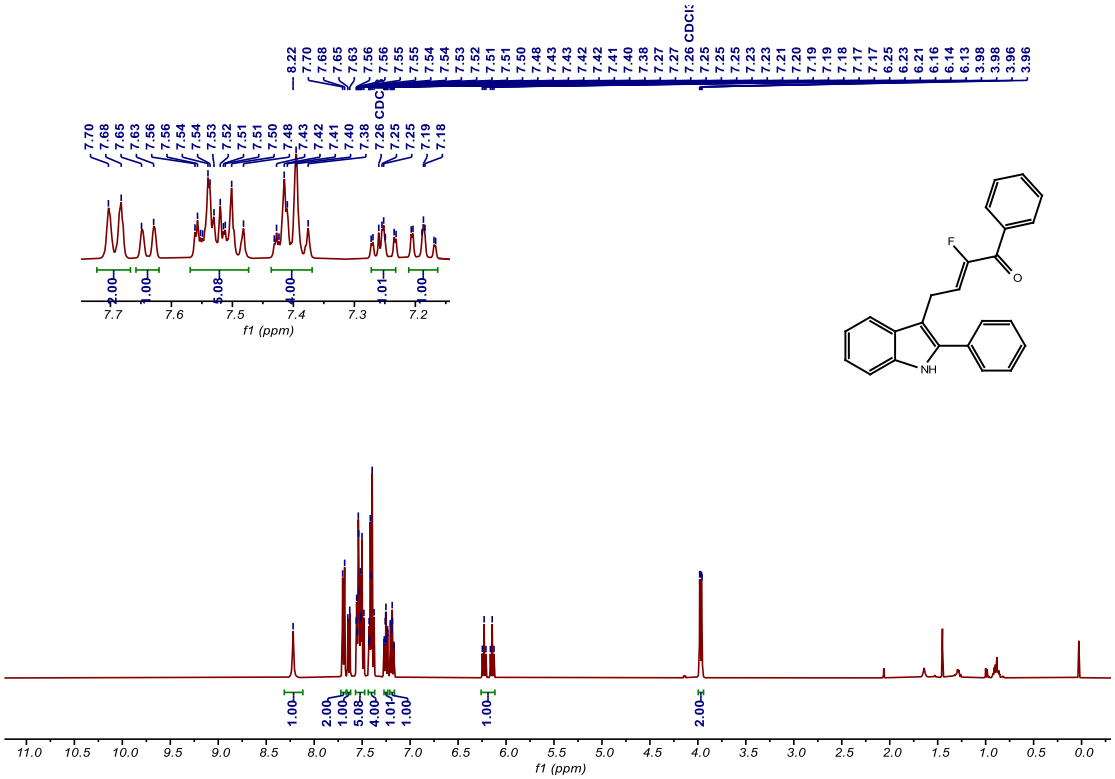
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ba**



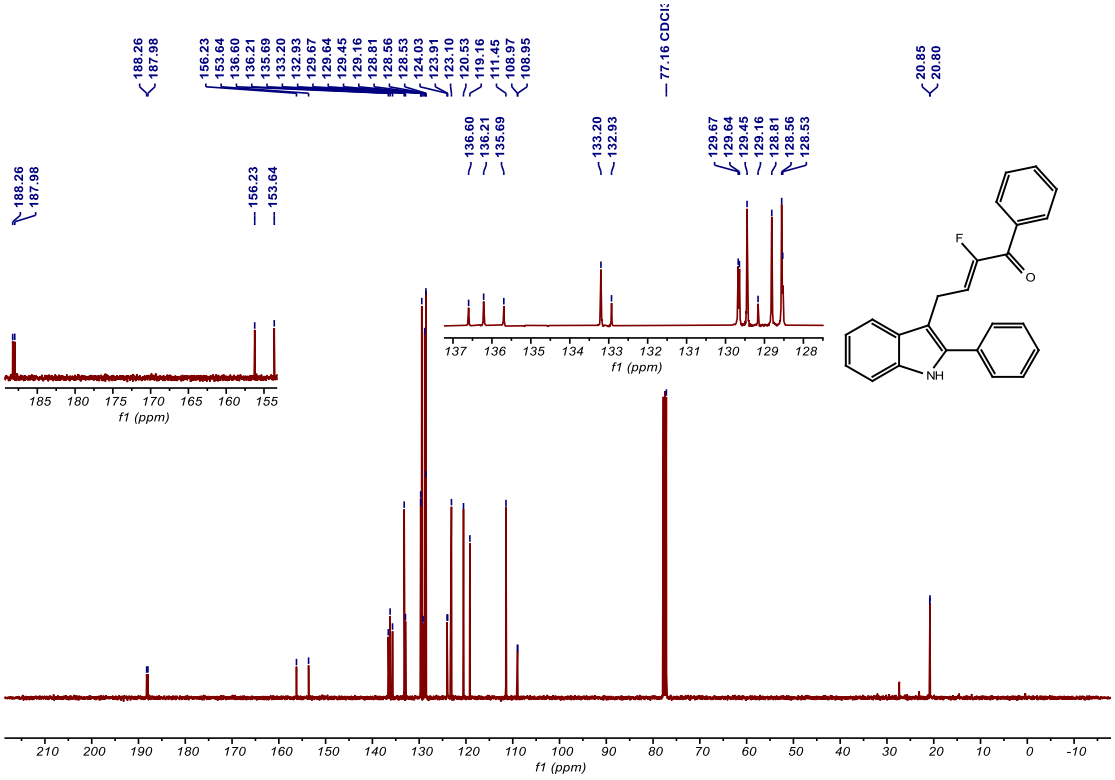

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ba**



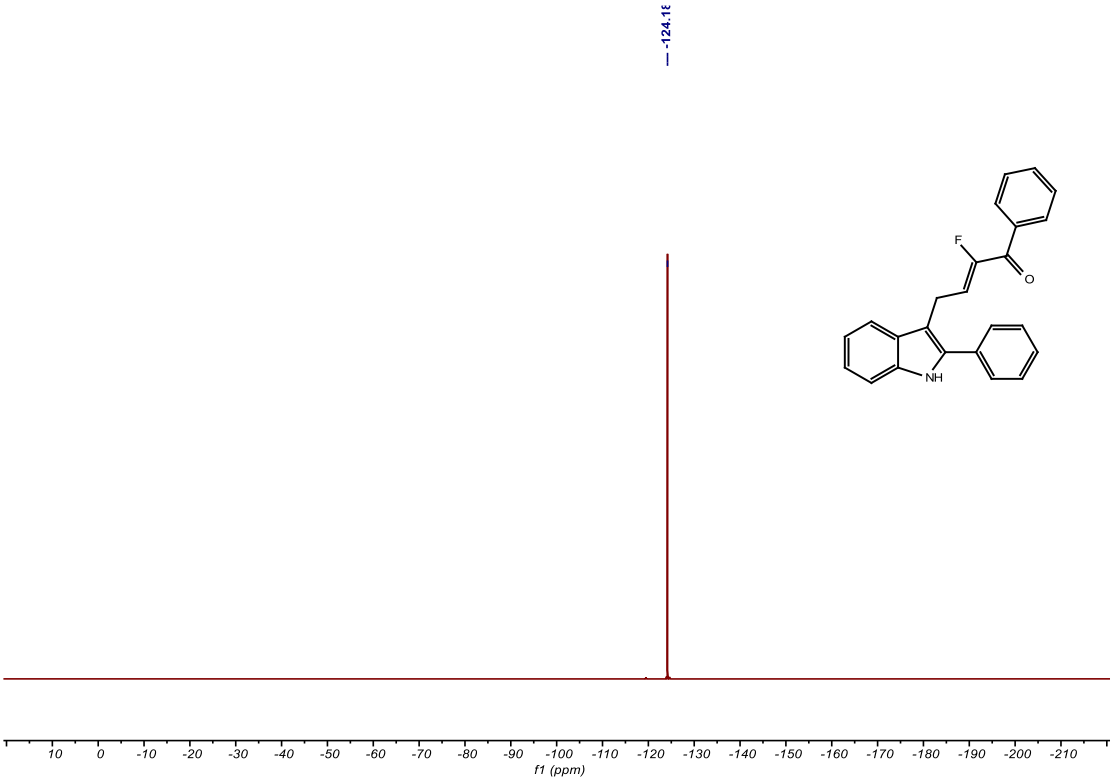
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ca**



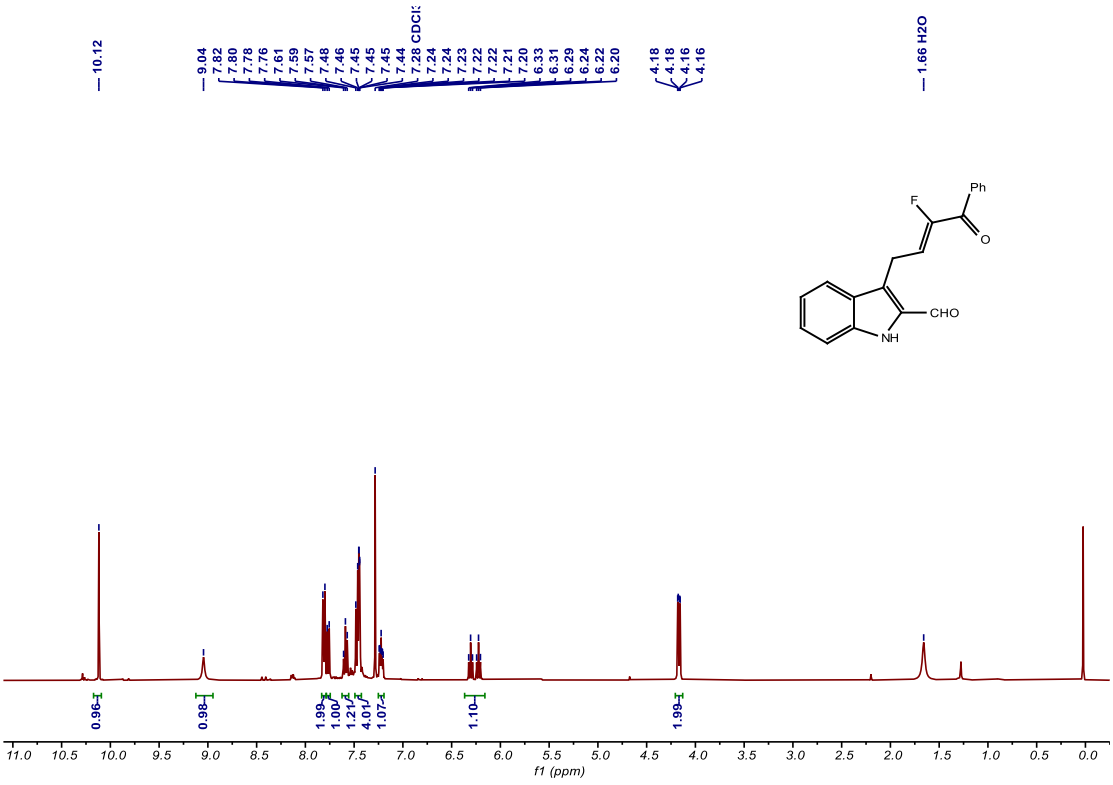

**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ca**



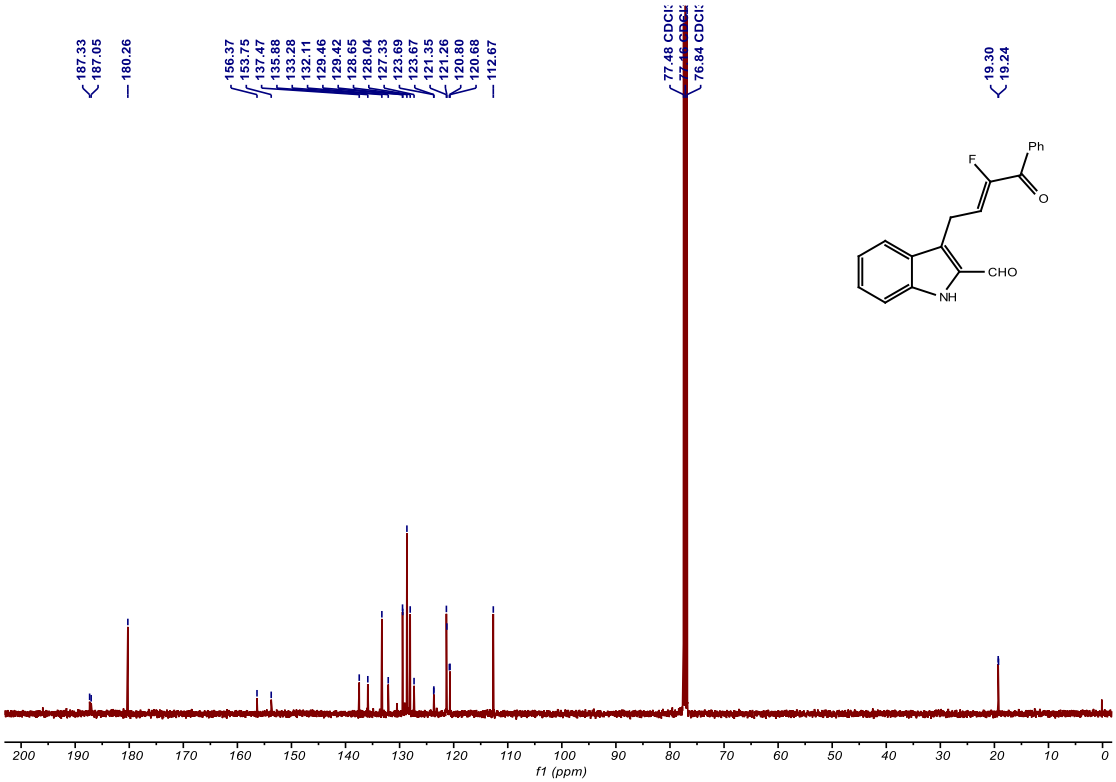
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ca**



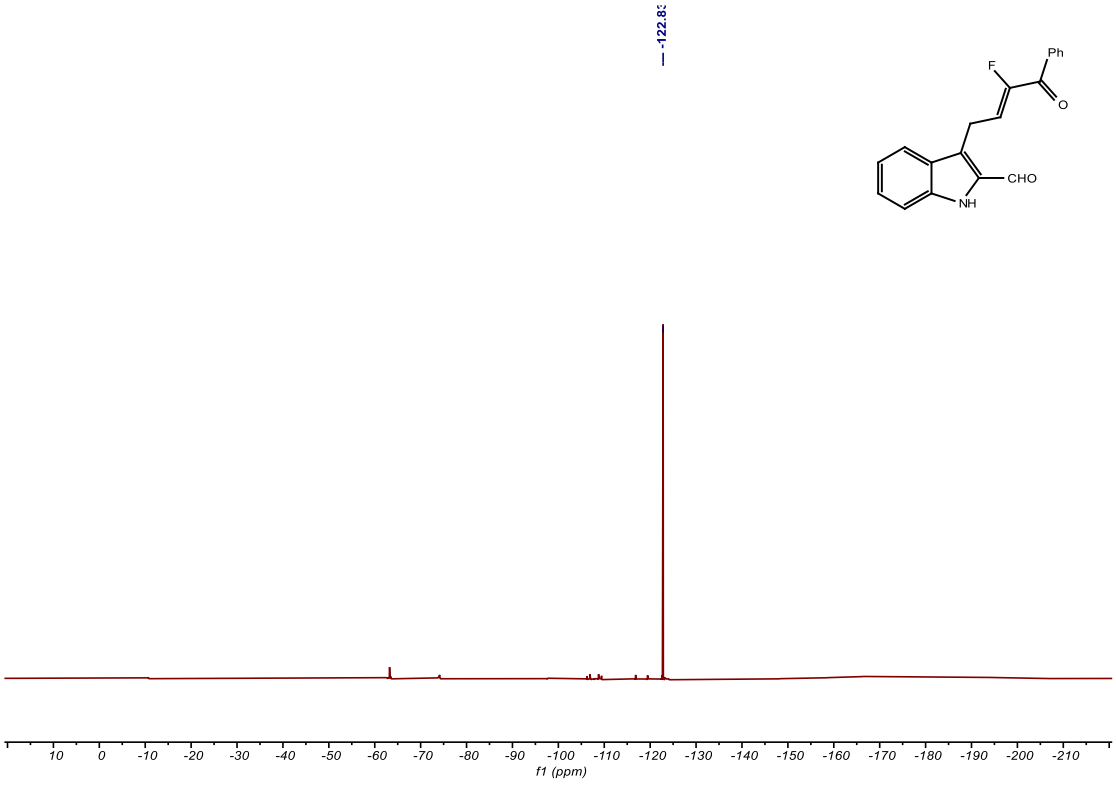

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10da**



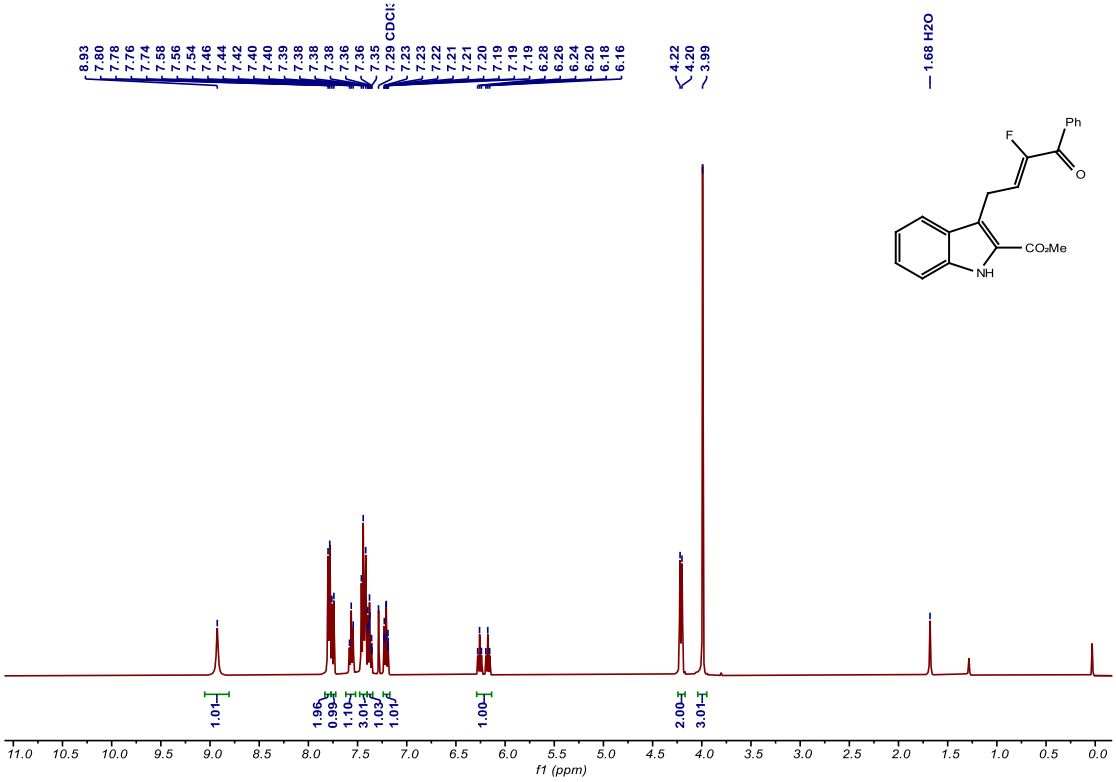
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10da**



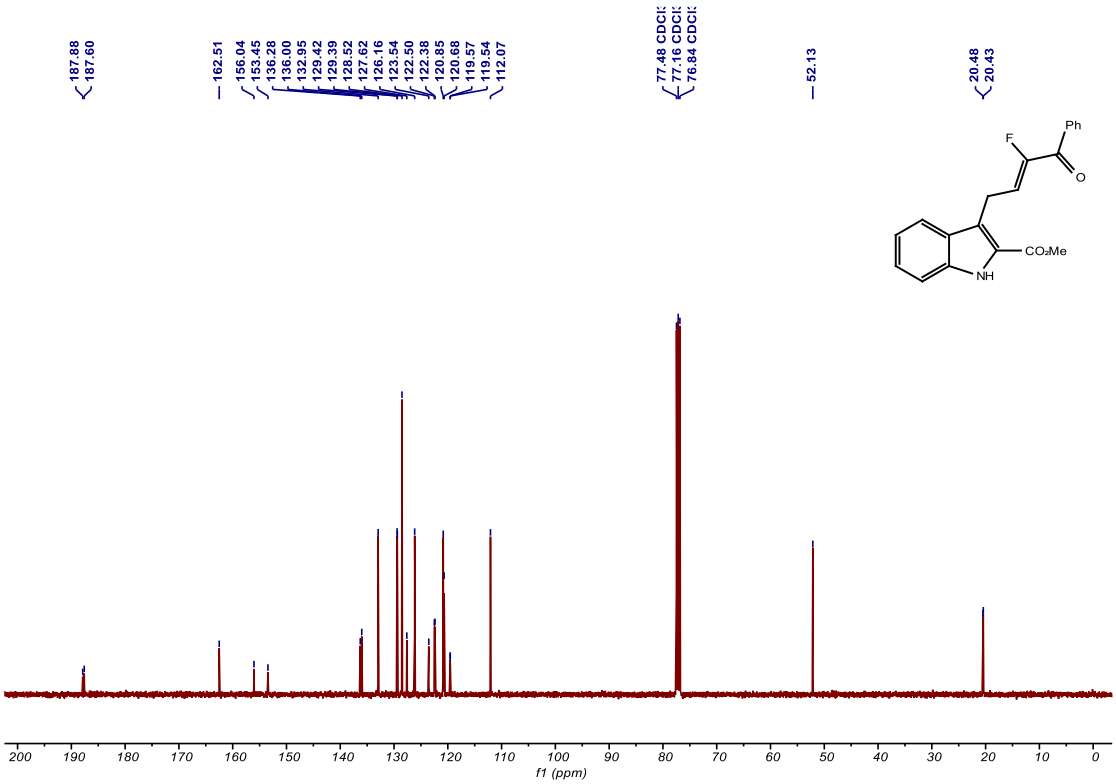

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10da**



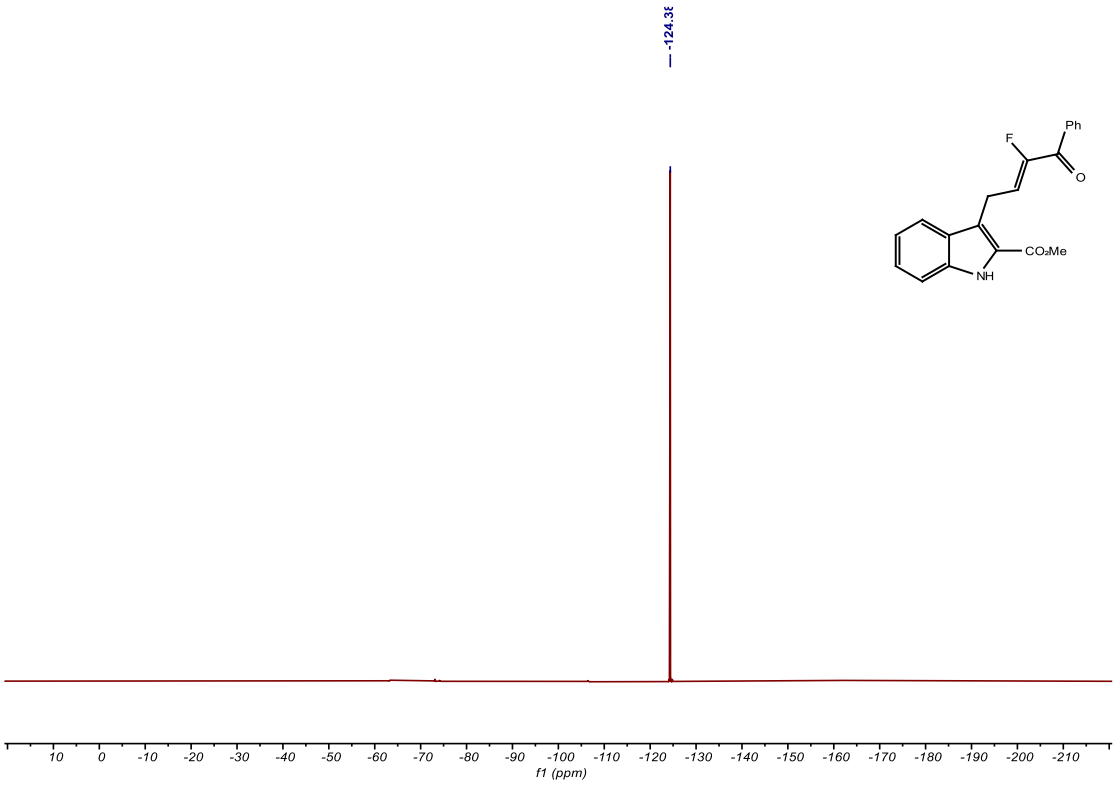
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ea**



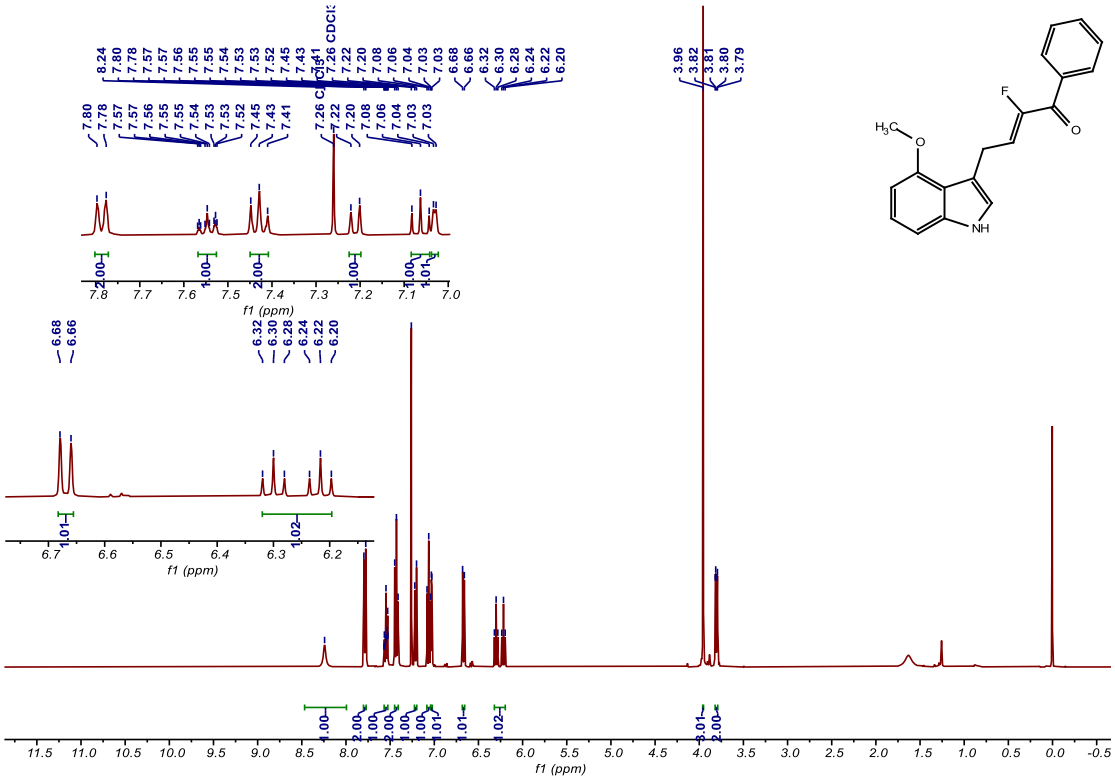

**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ea**



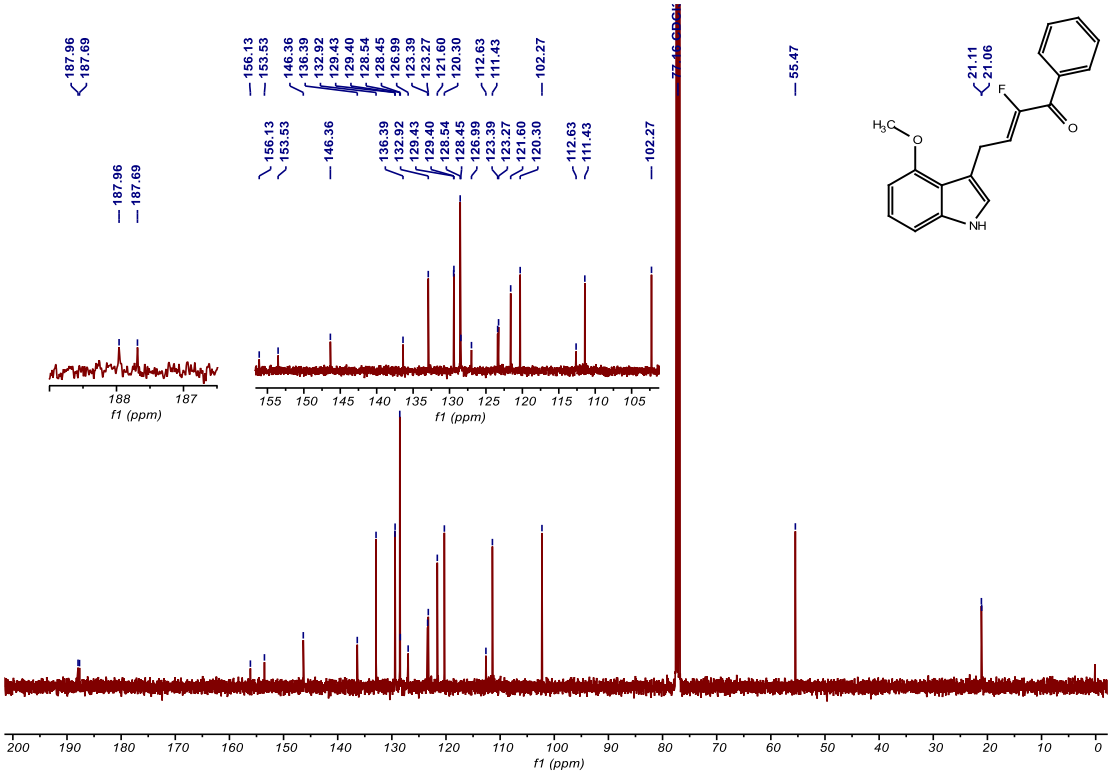
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ea**



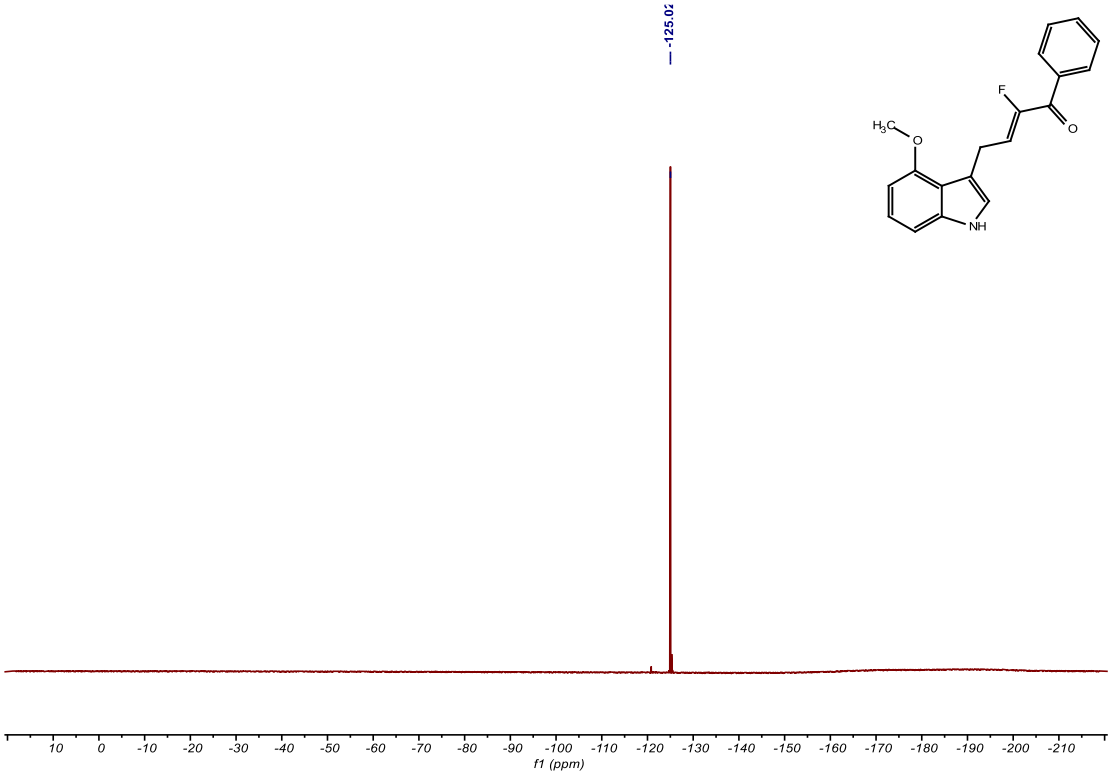

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10fa**



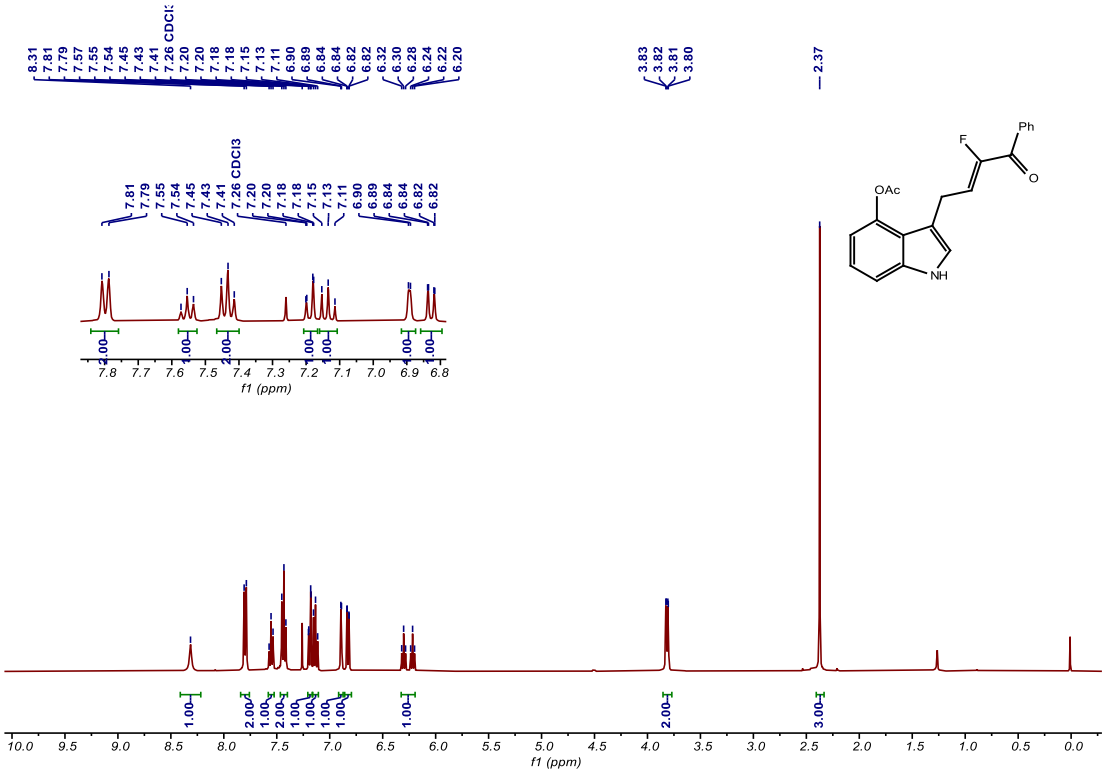
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10fa**



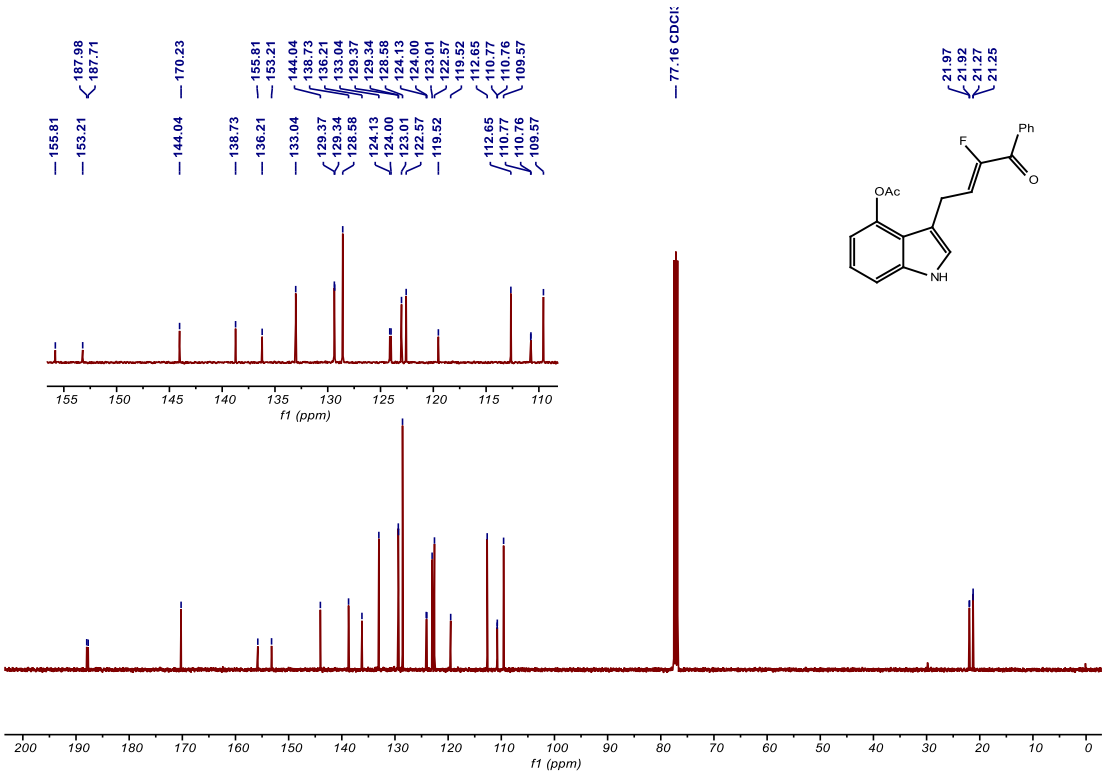

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10fa**



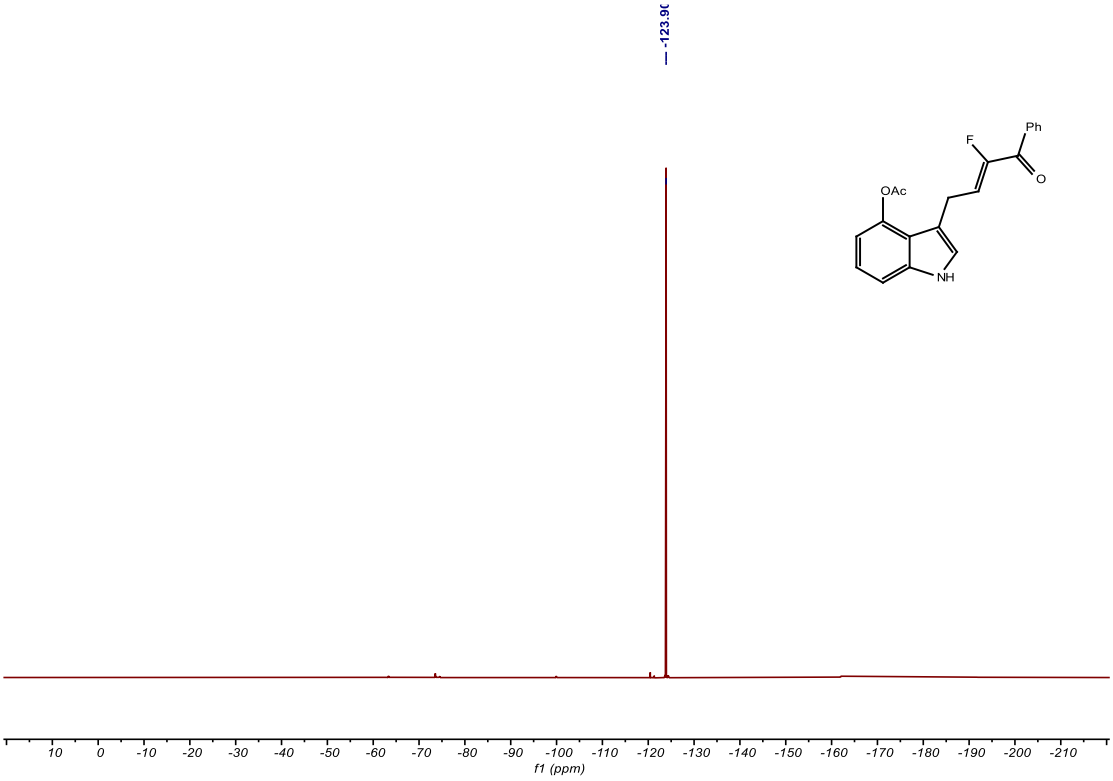
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ga**



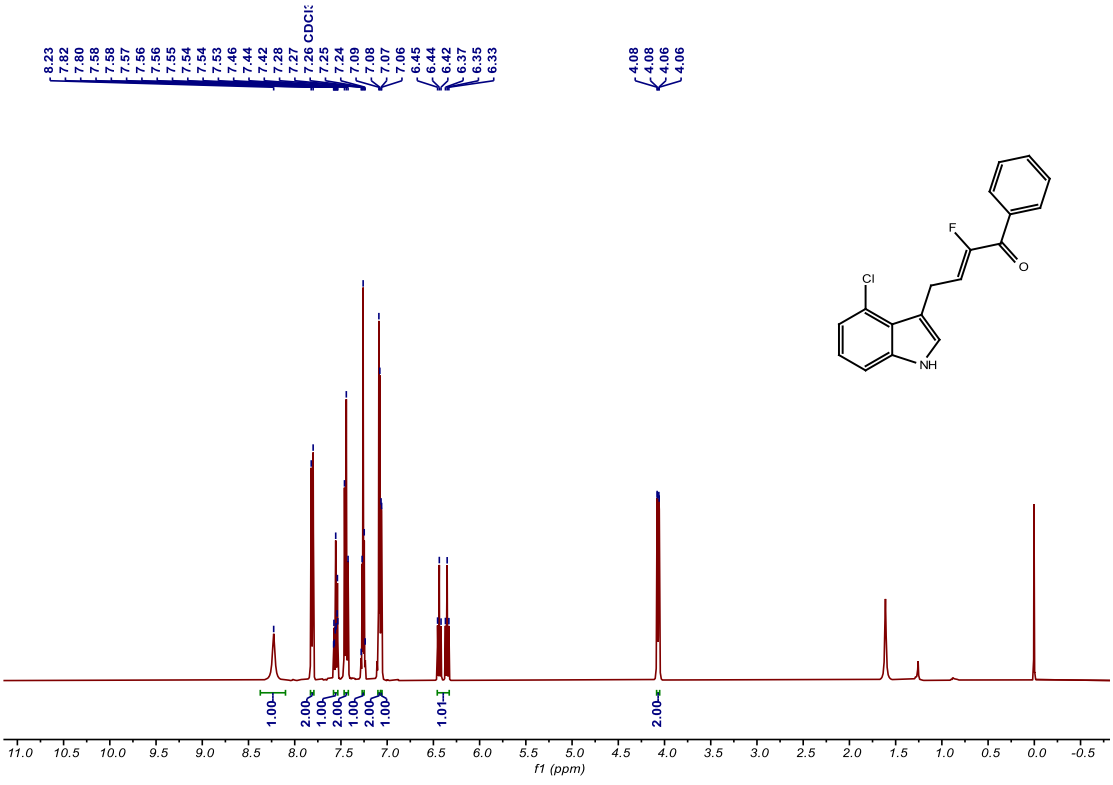

**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ga**



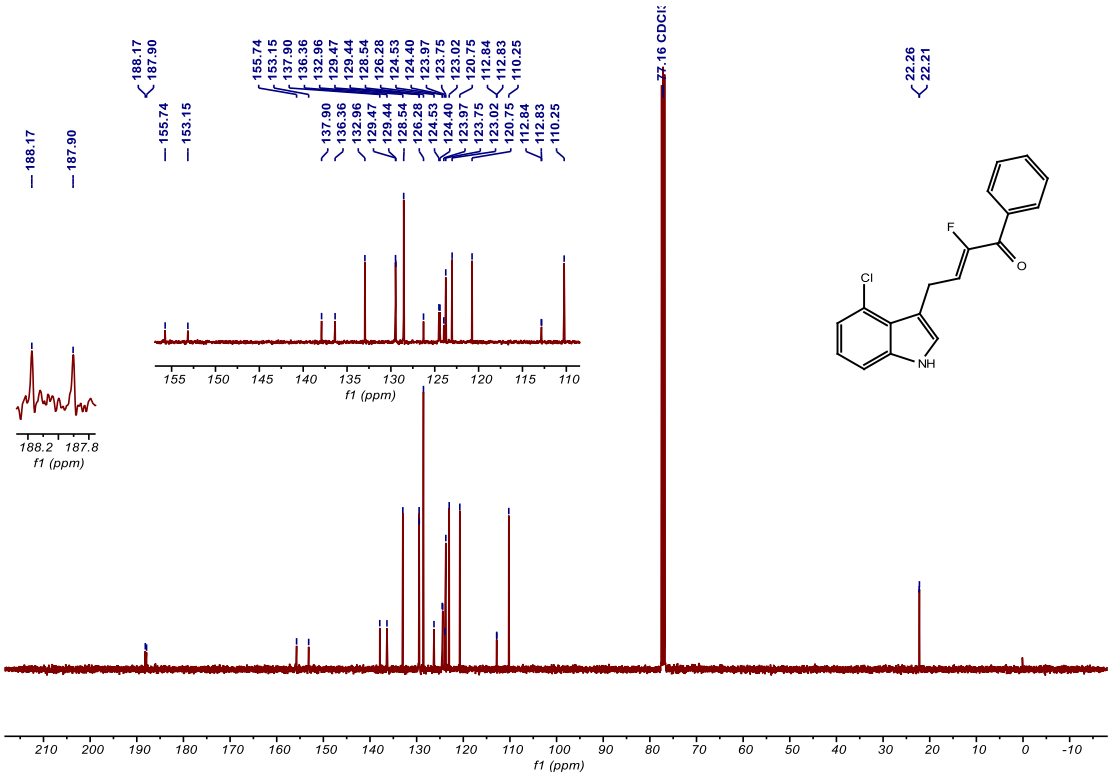
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ga**



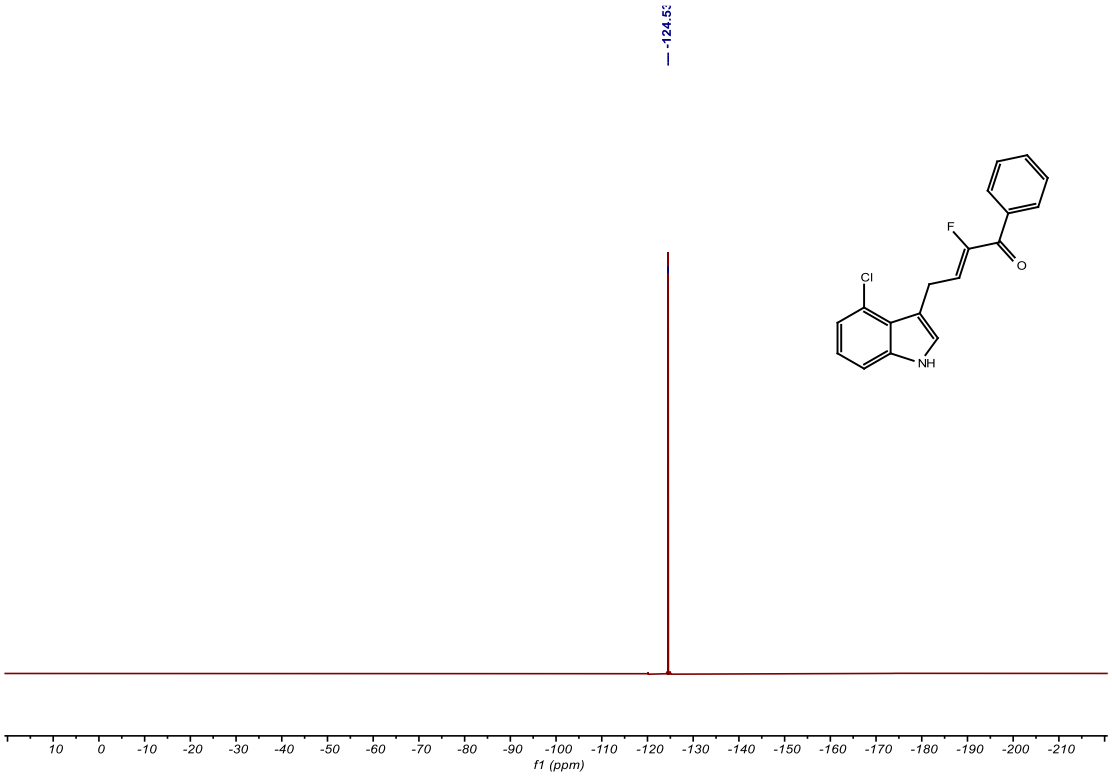

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ha**



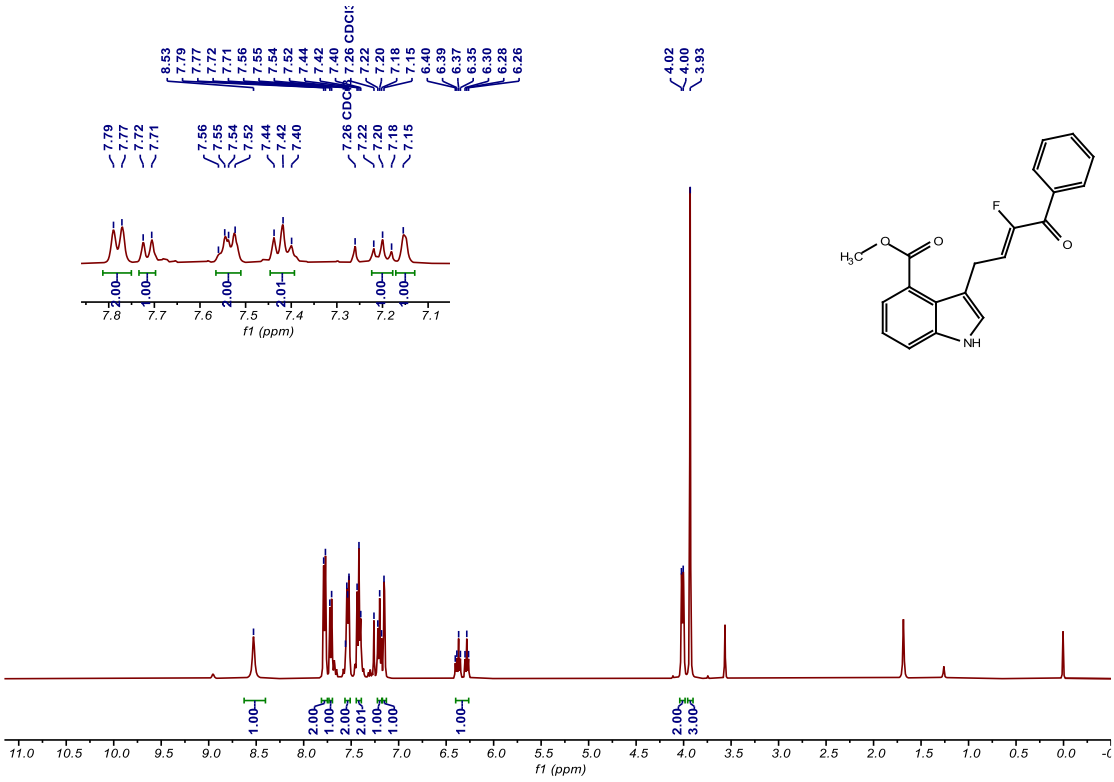
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ha**



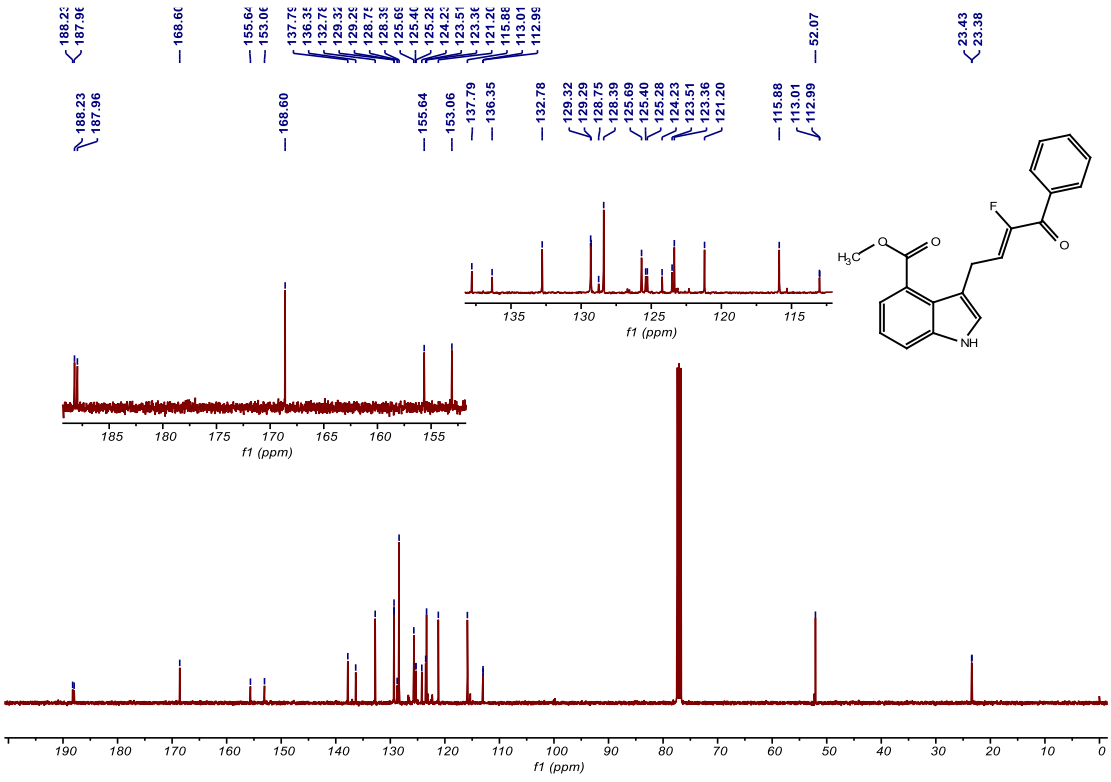

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ha**



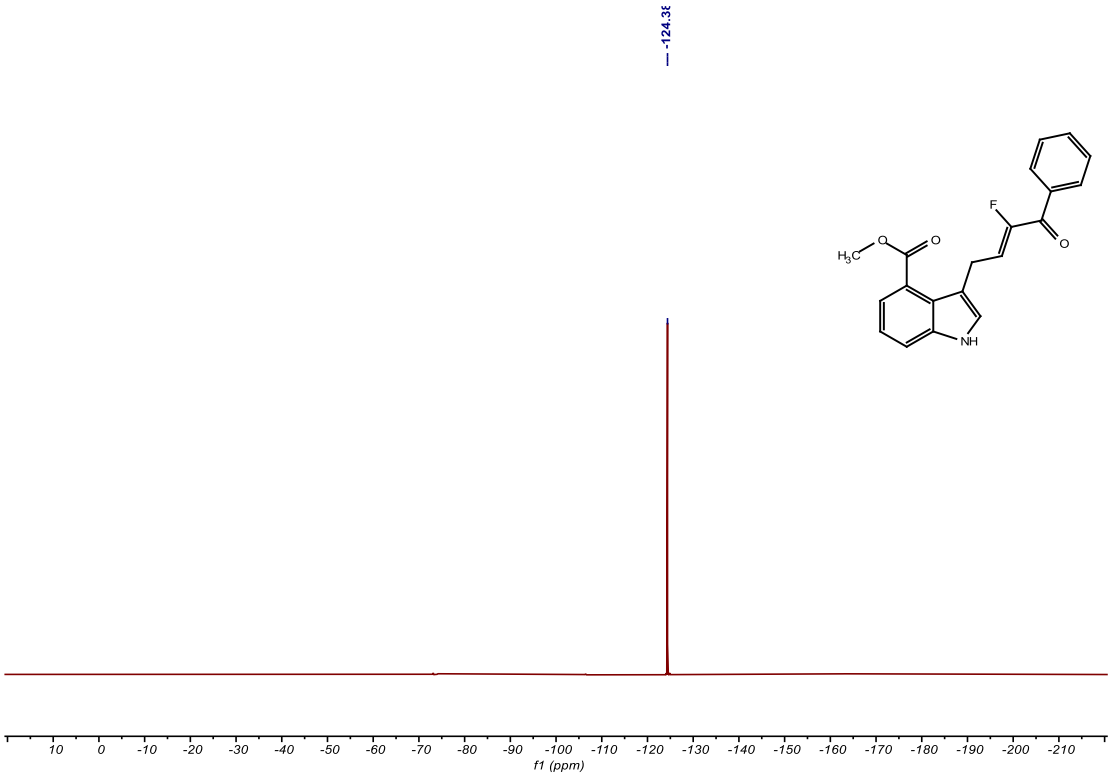
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ia**



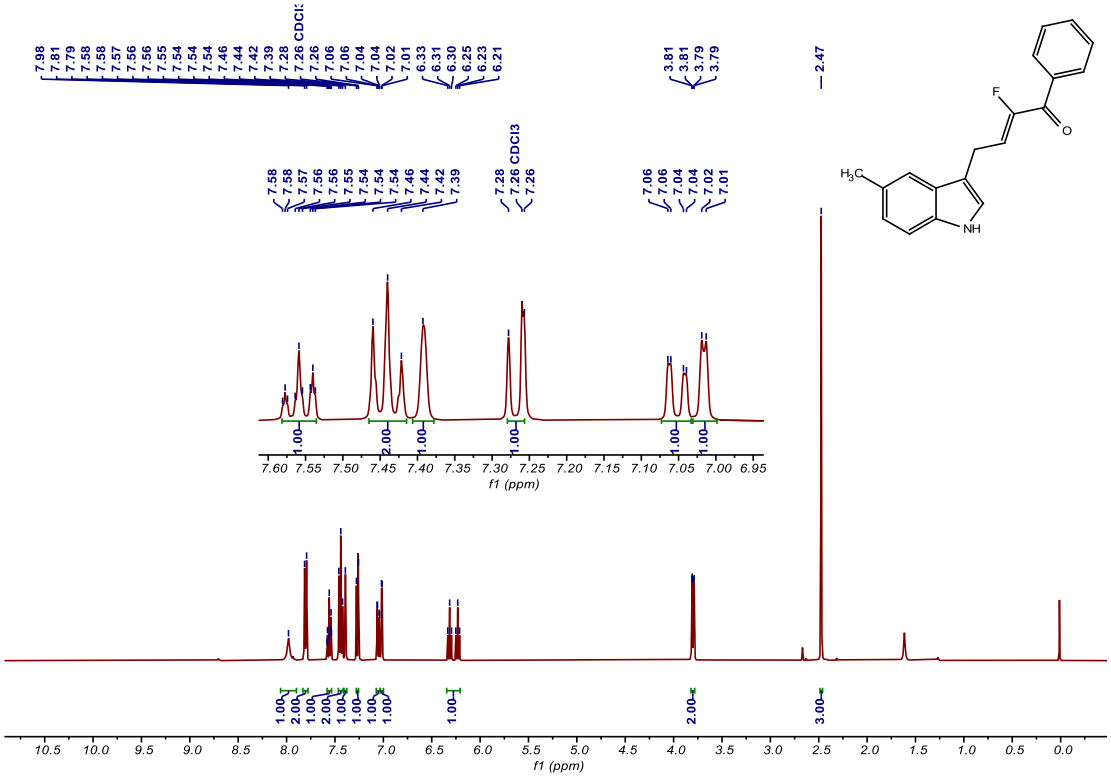
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ia**



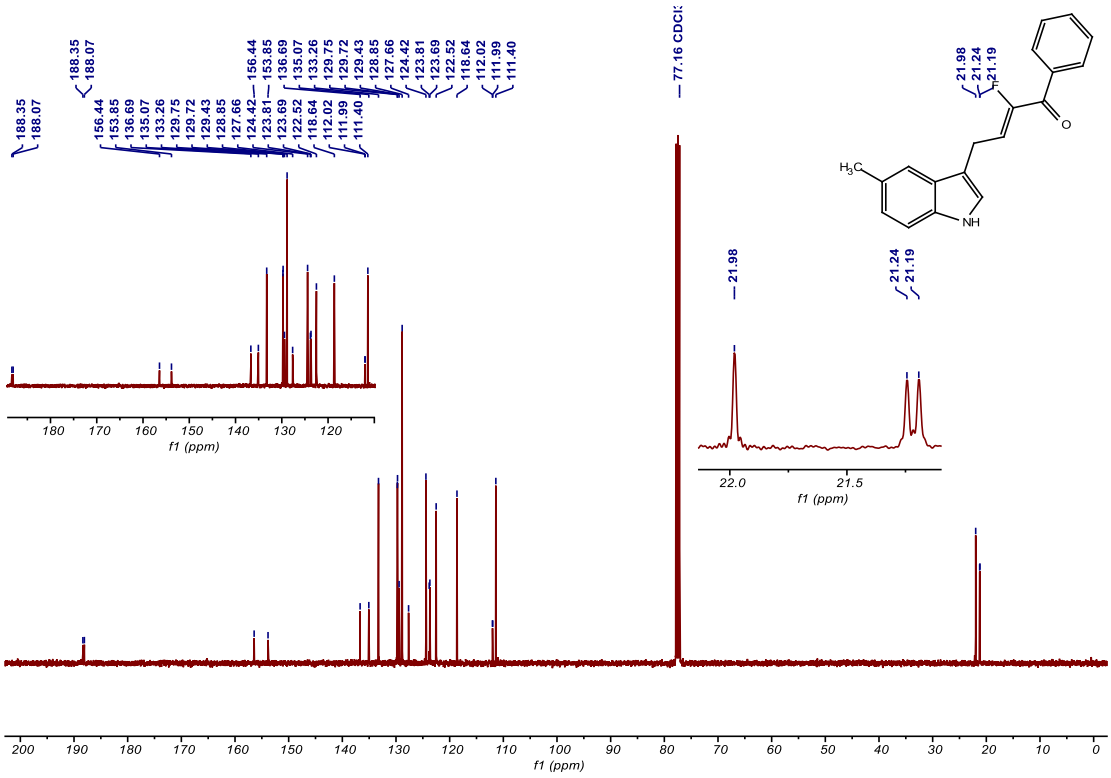
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ia**



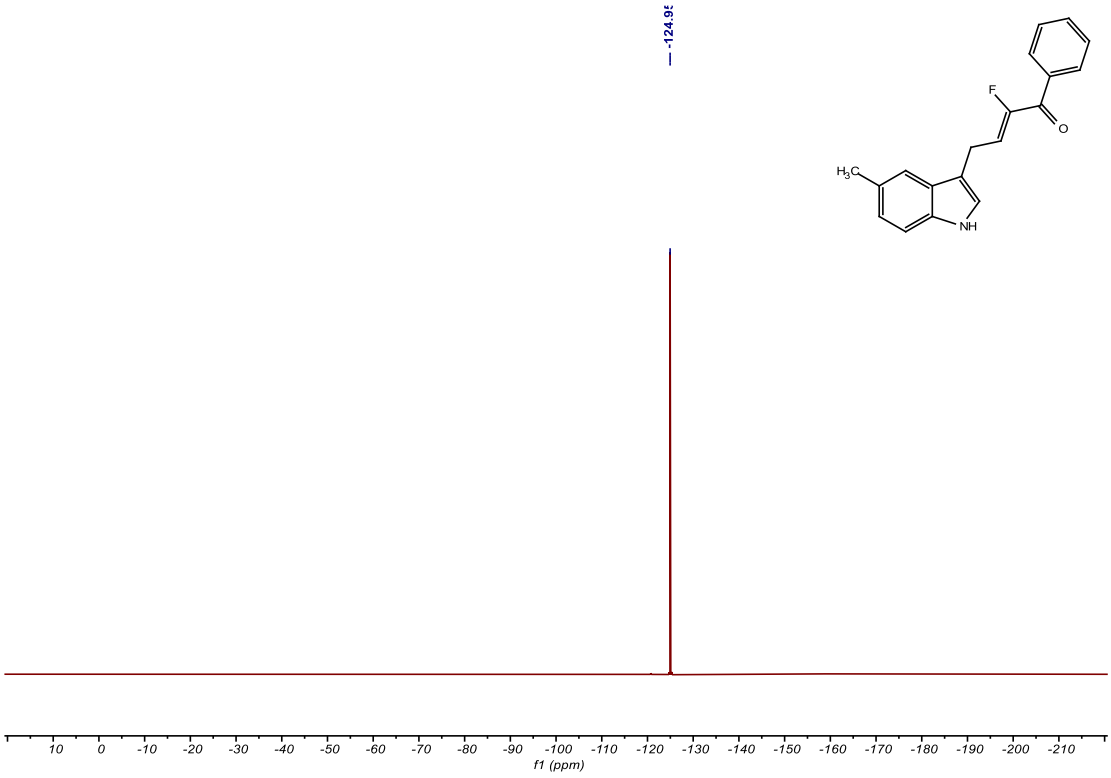

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ja**



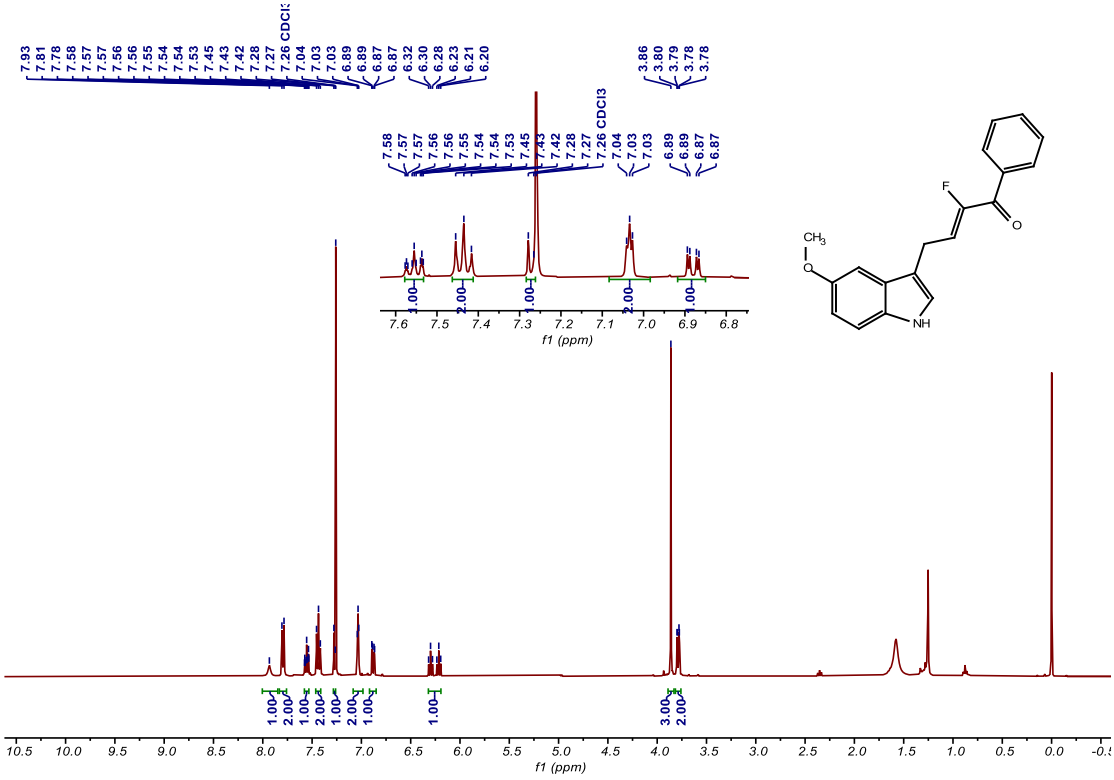
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ja**



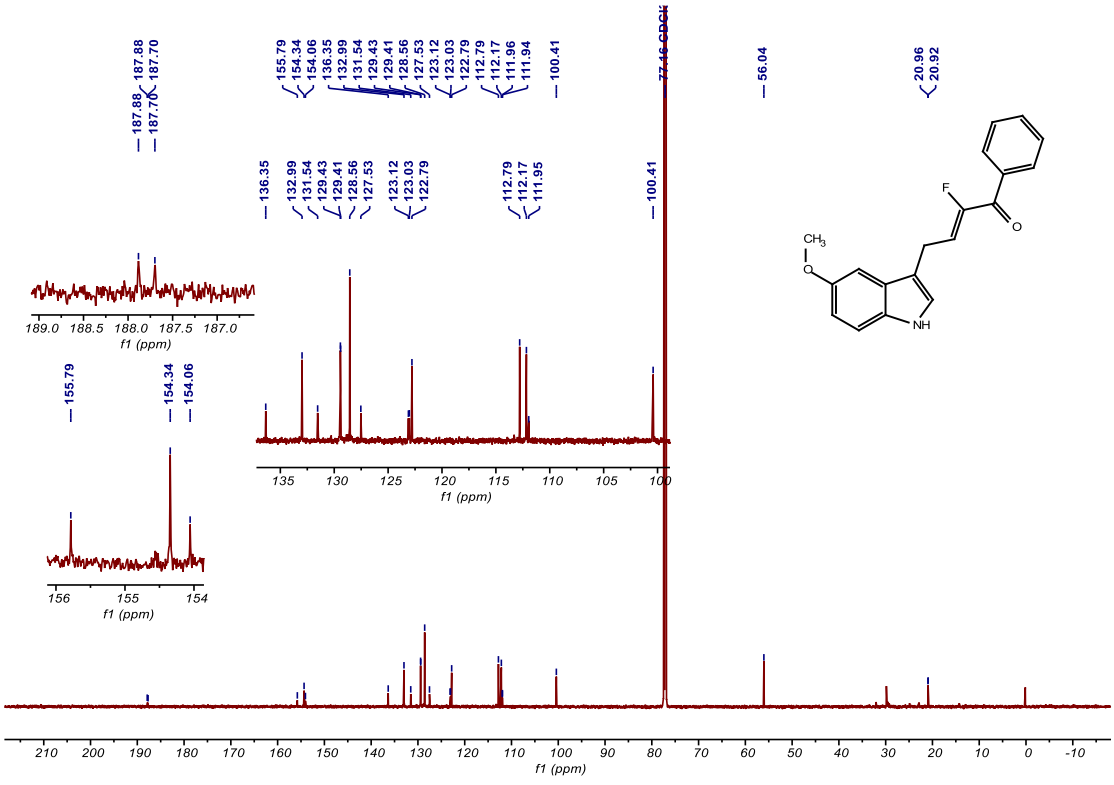

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ja**



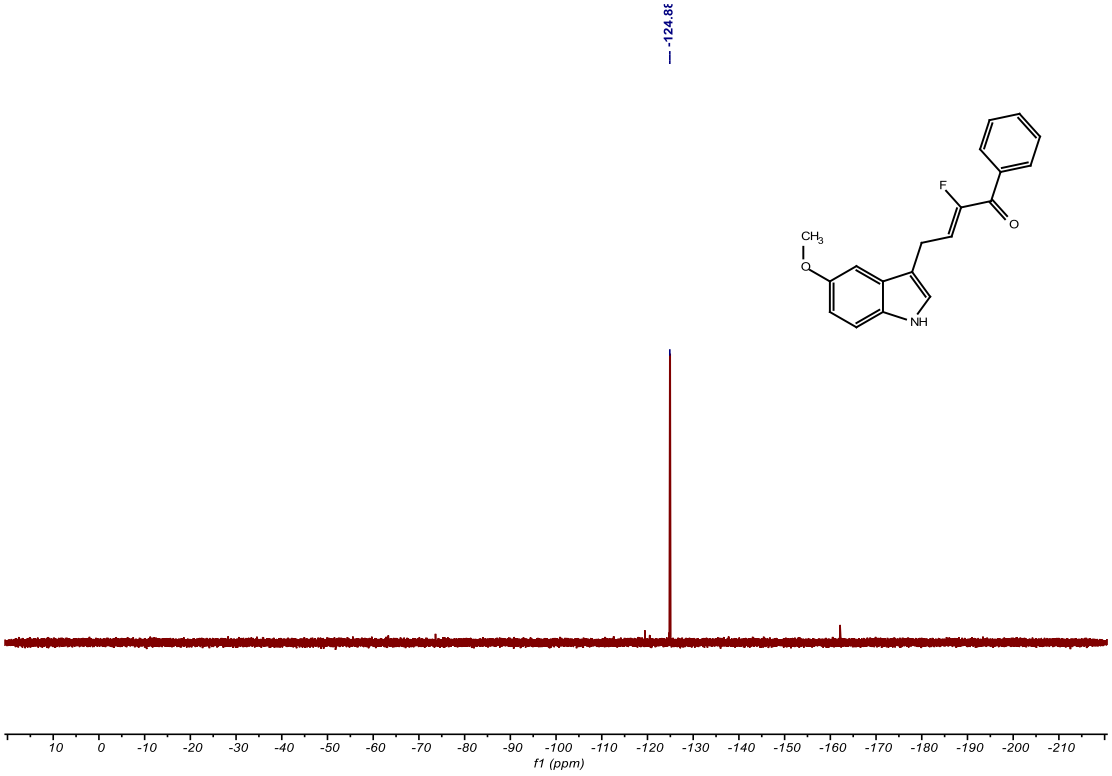
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ka**



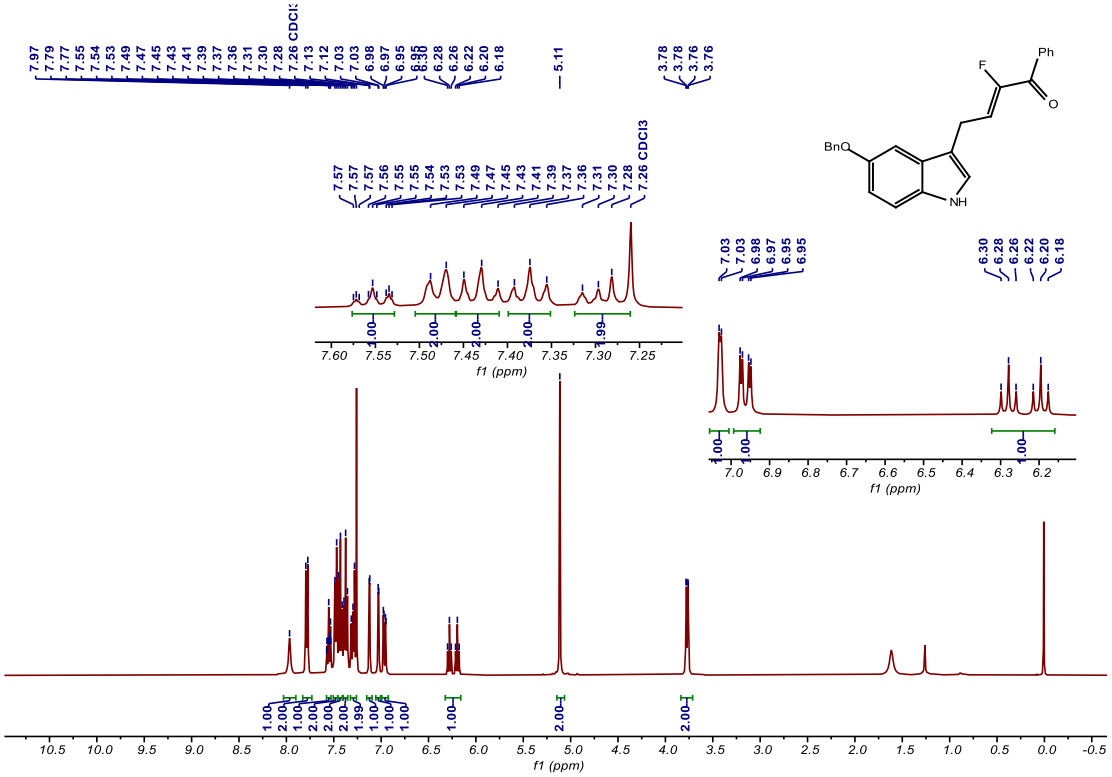
**$^{13}$C NMR** (151 MHz, $CDCl_3$) of **10ka**



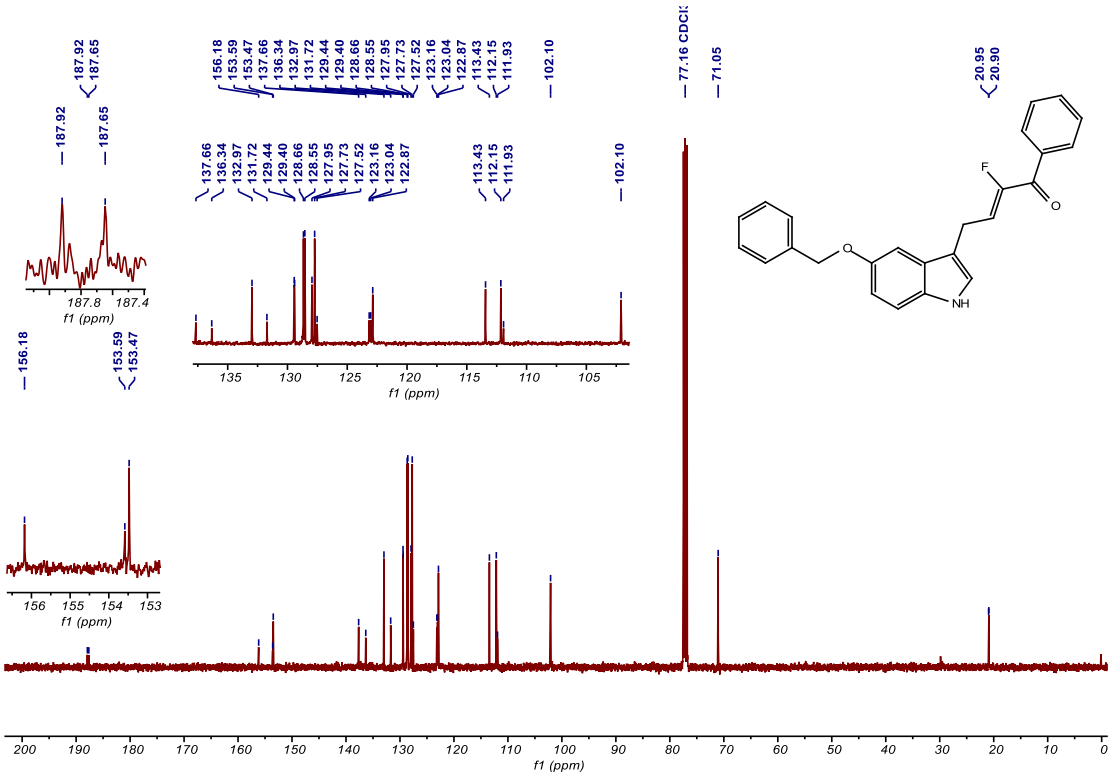
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ka**



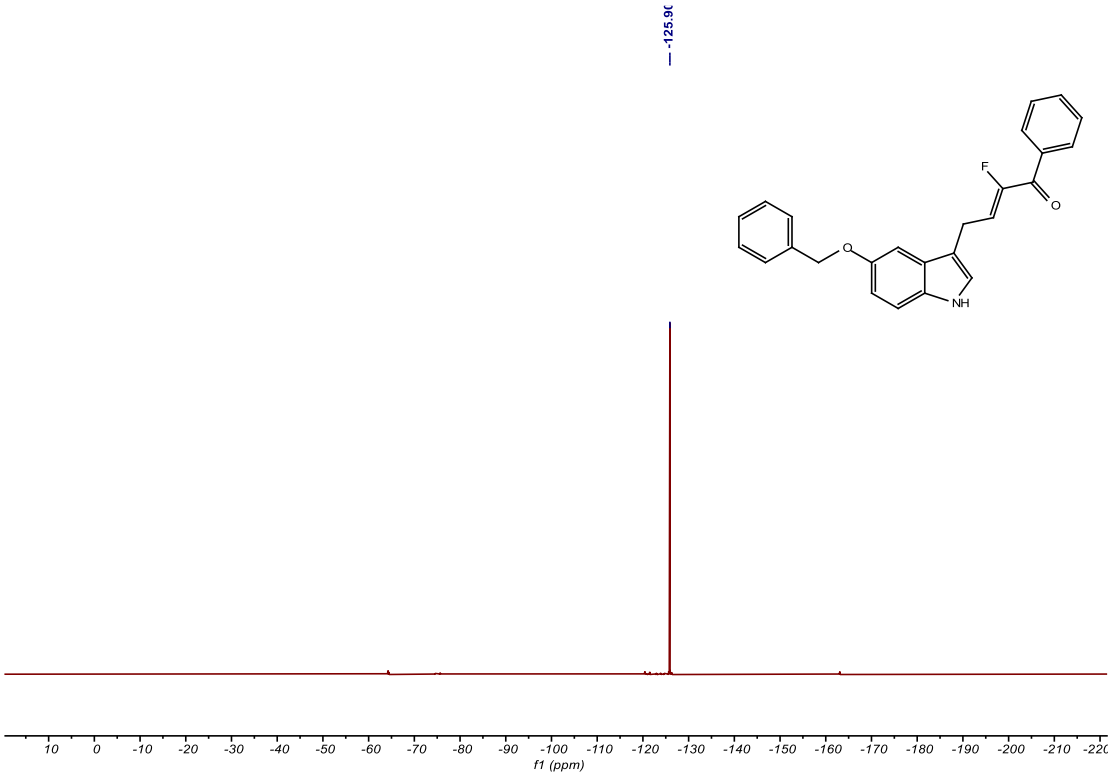

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10la**



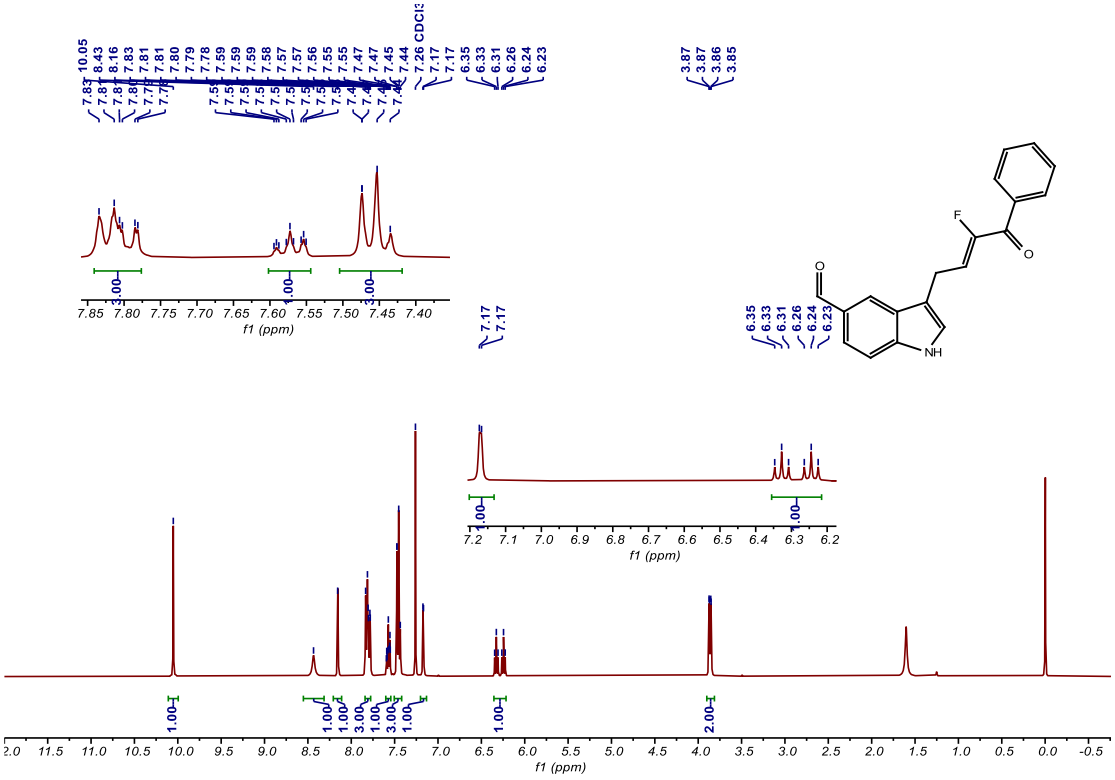
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10la**



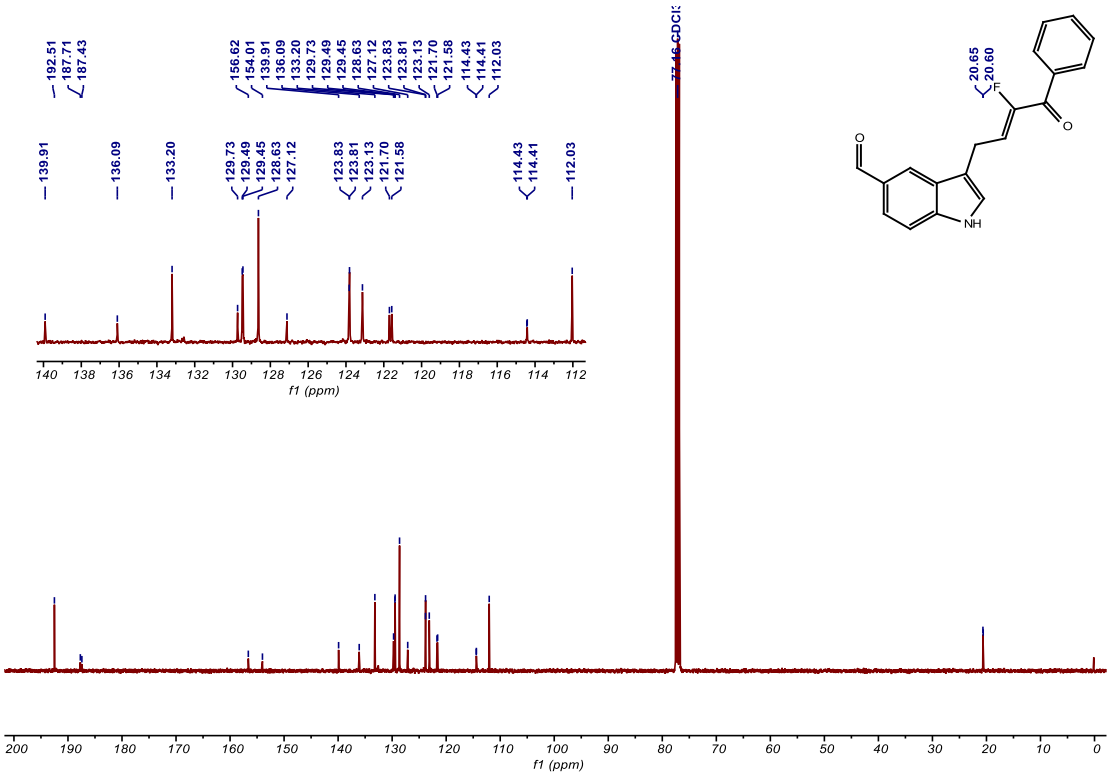

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10la**



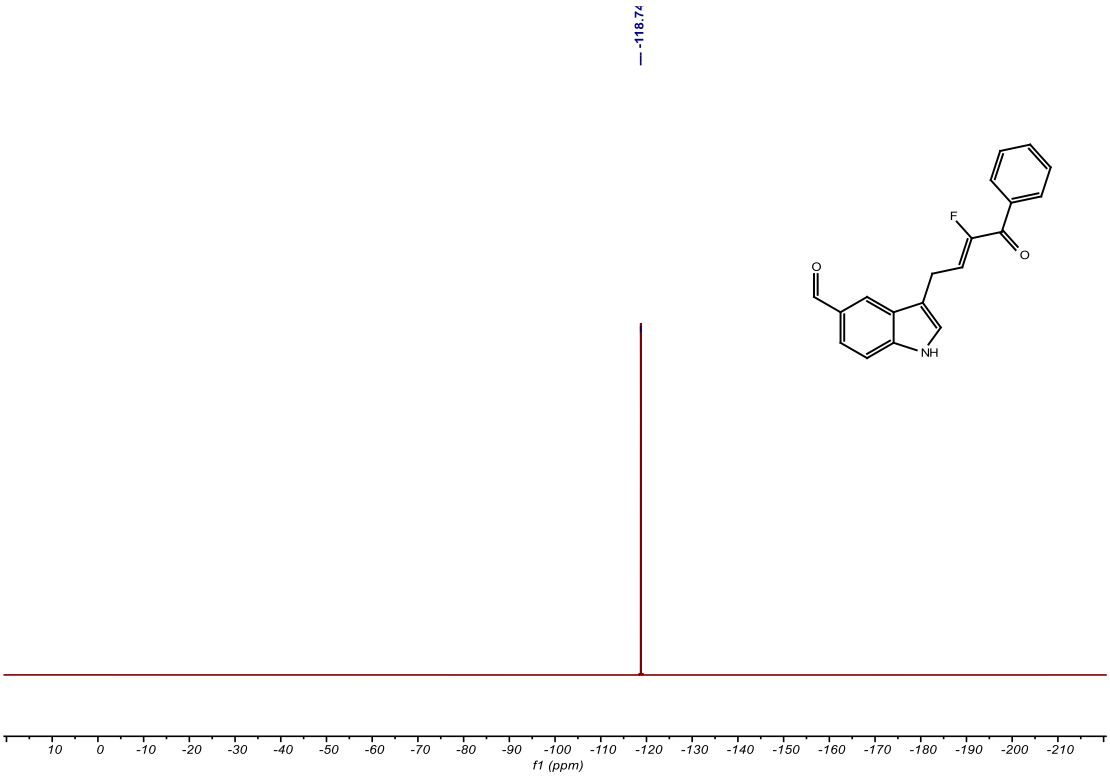
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ma**



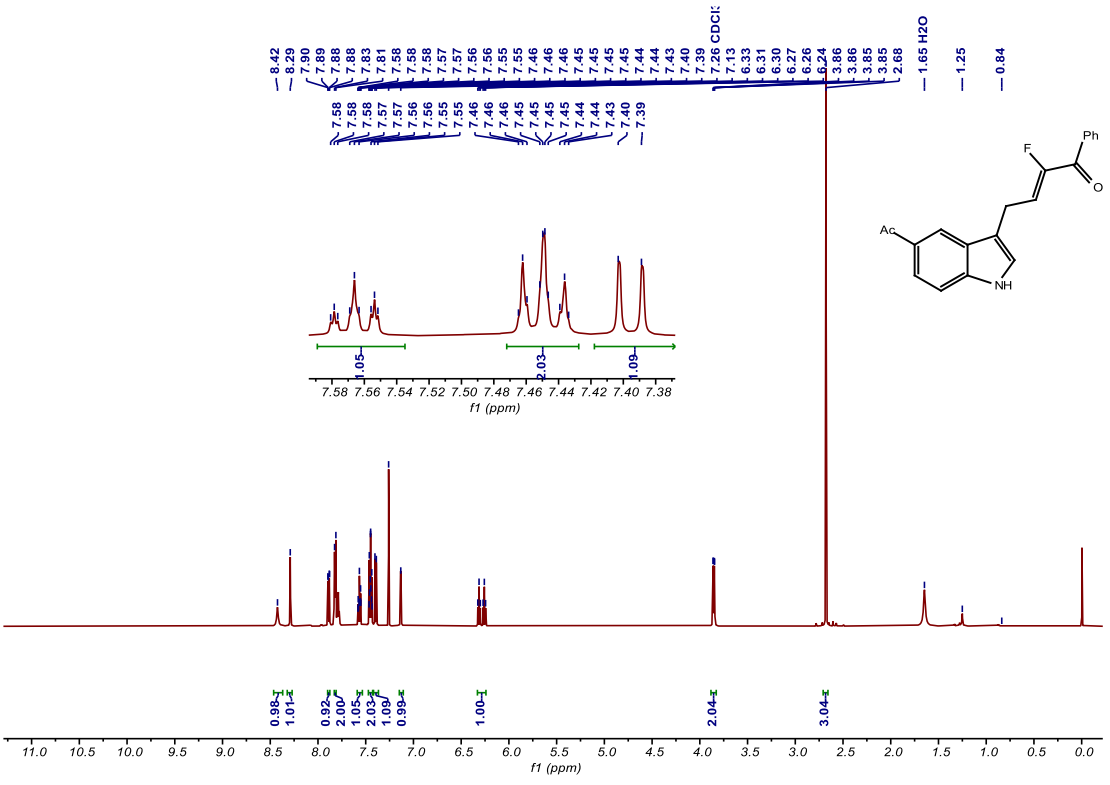
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ma**



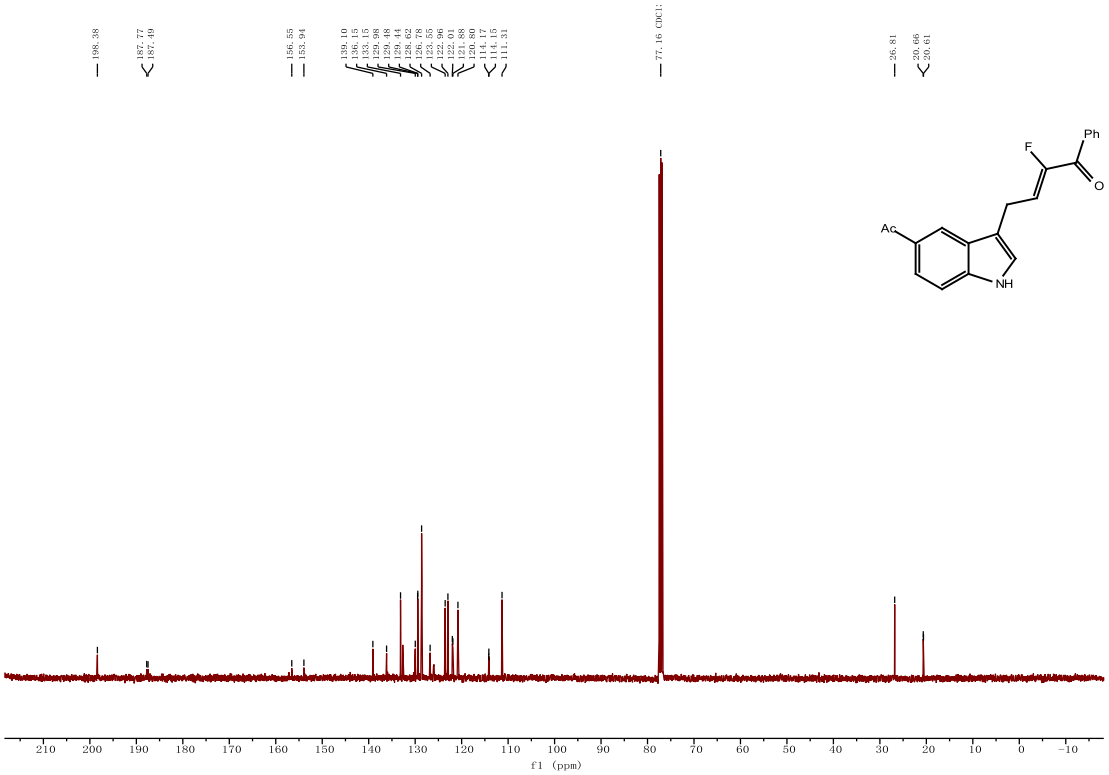
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ma**



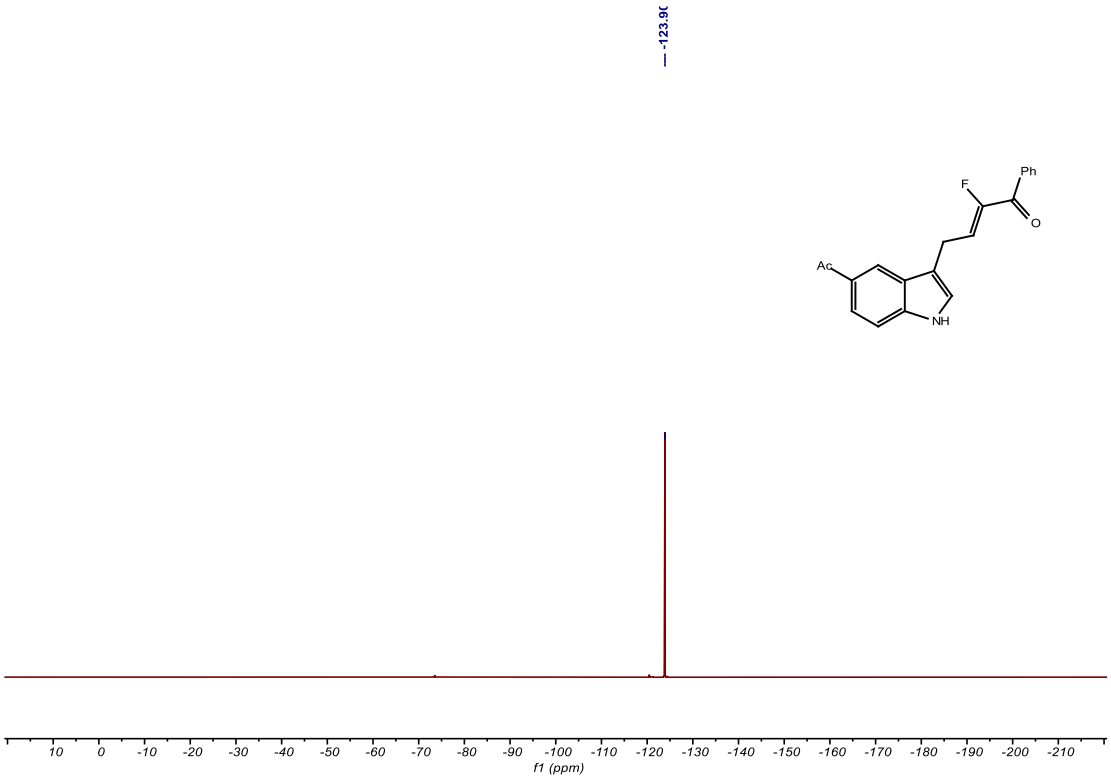

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10na**



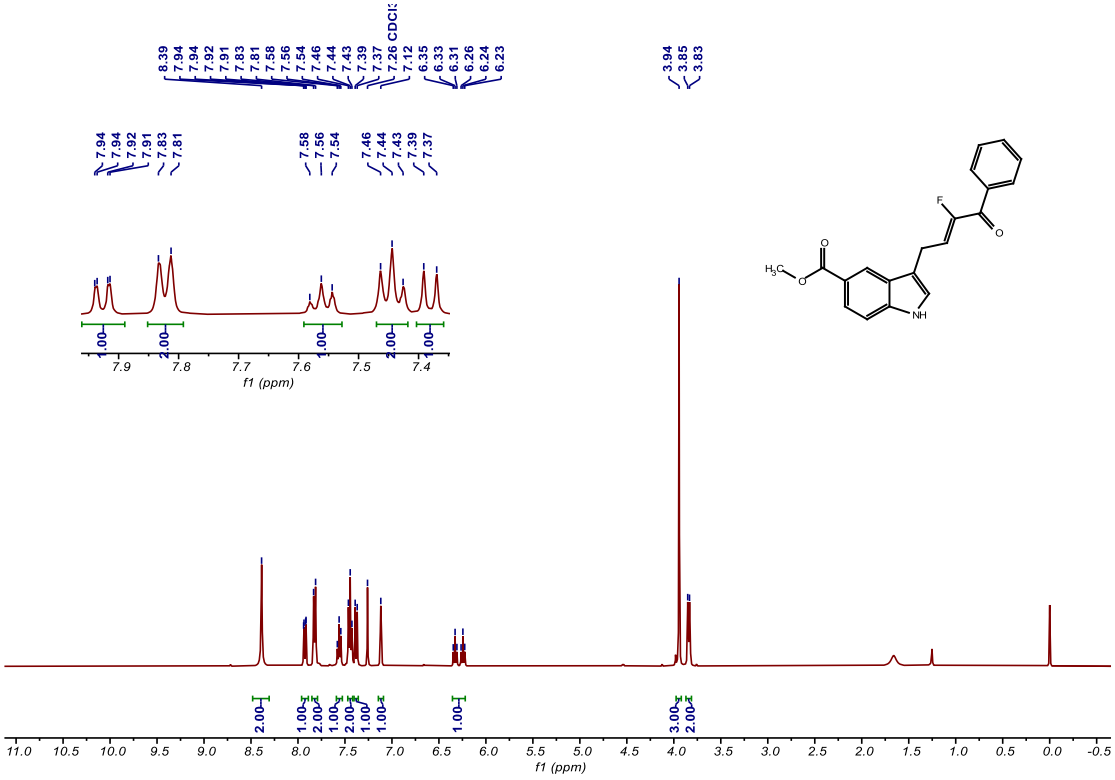
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10na**



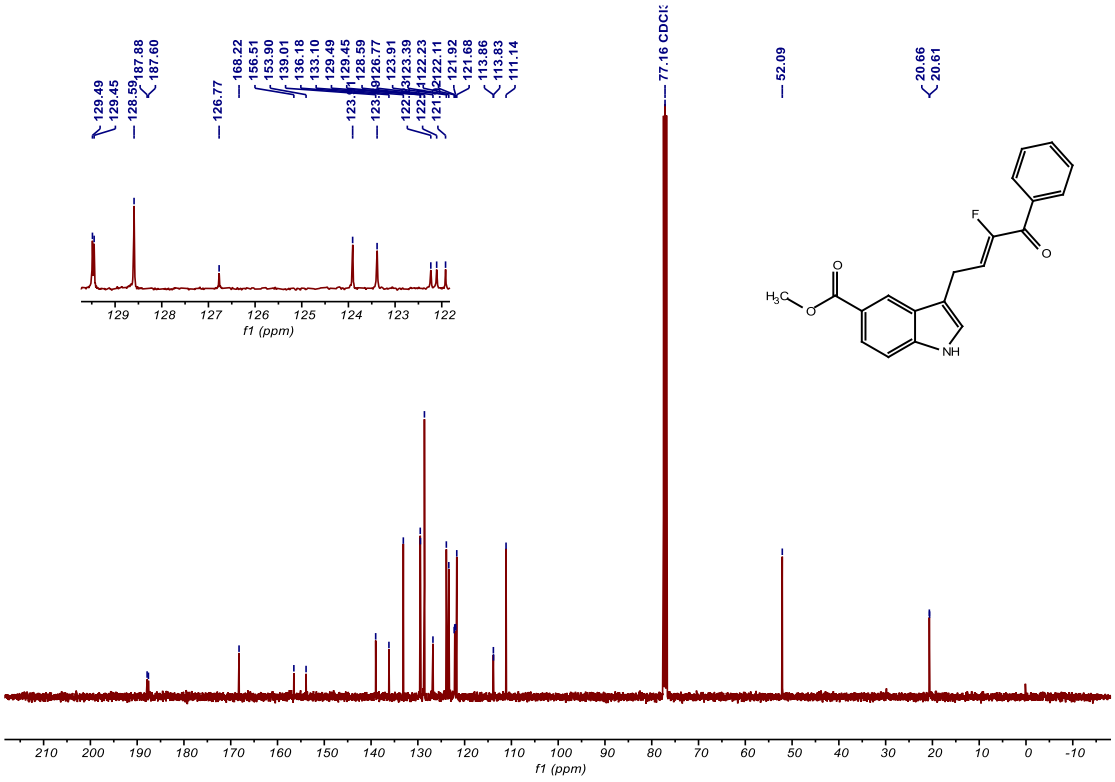

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10na**



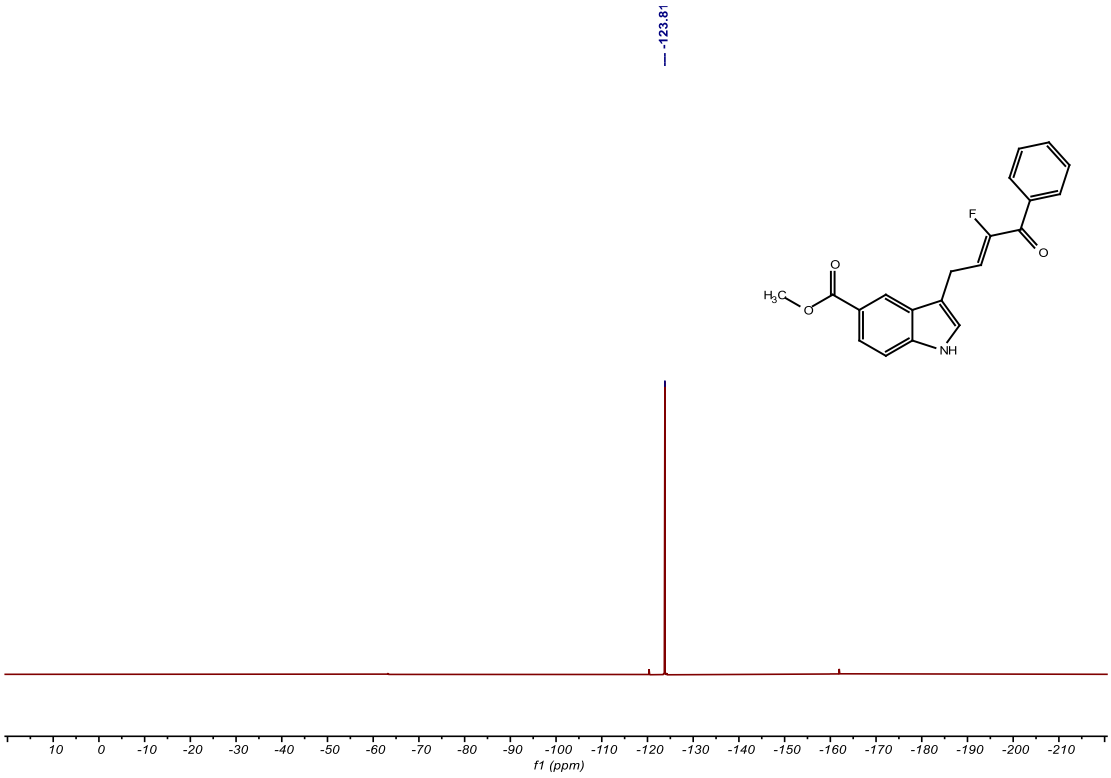
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10oa**



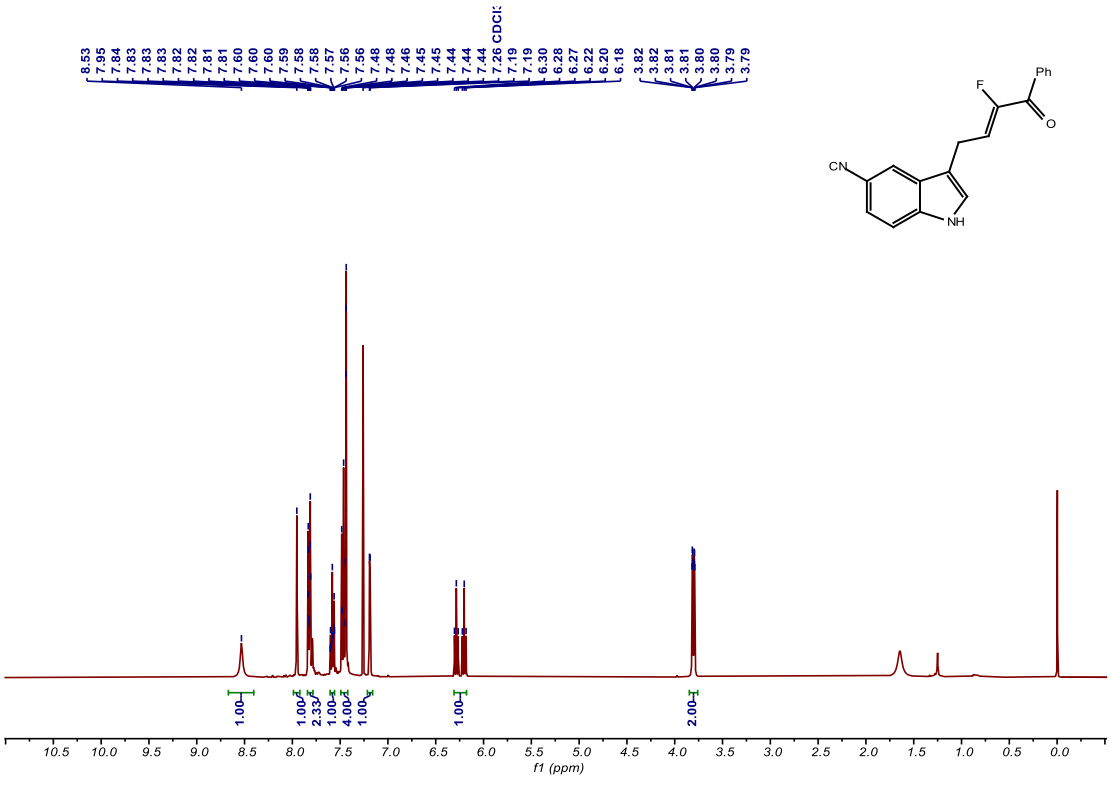

**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10oa**



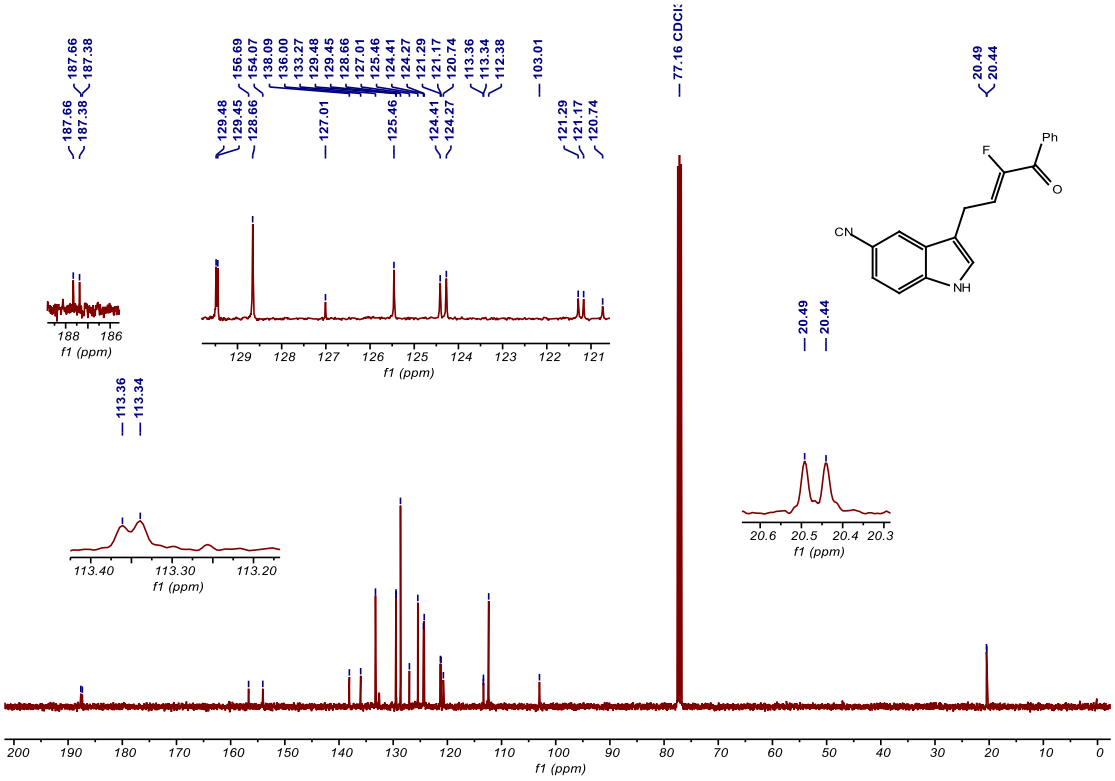
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10oa**



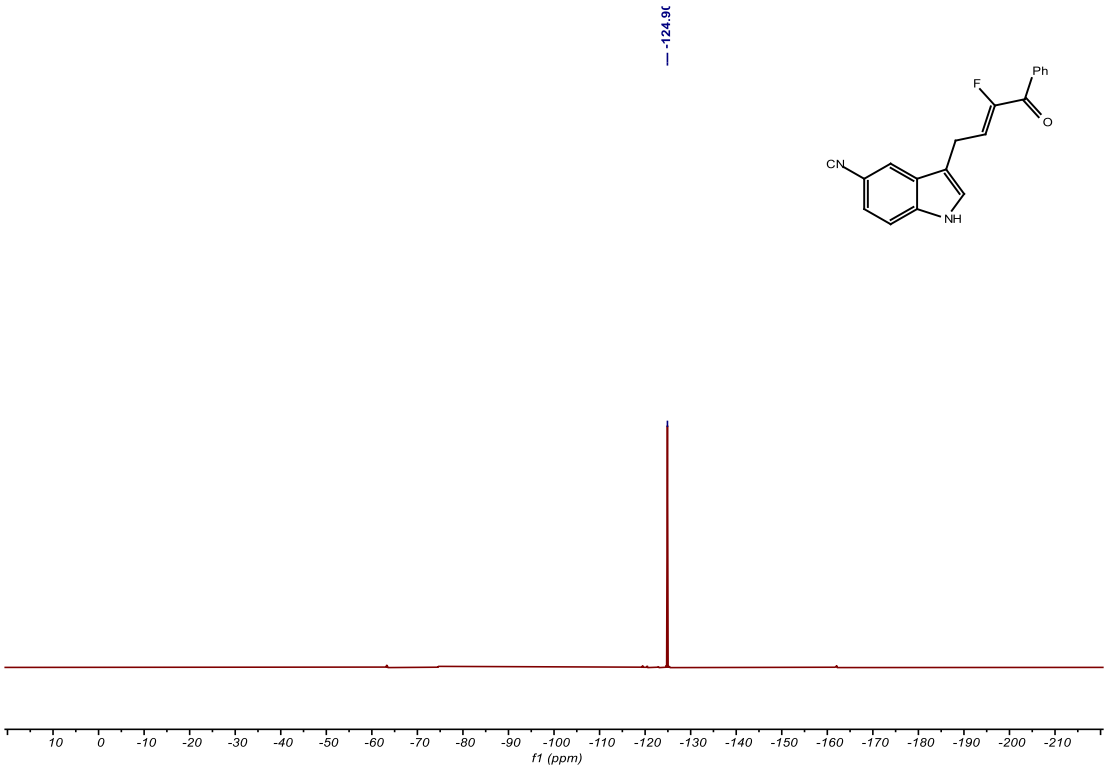

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10pa**



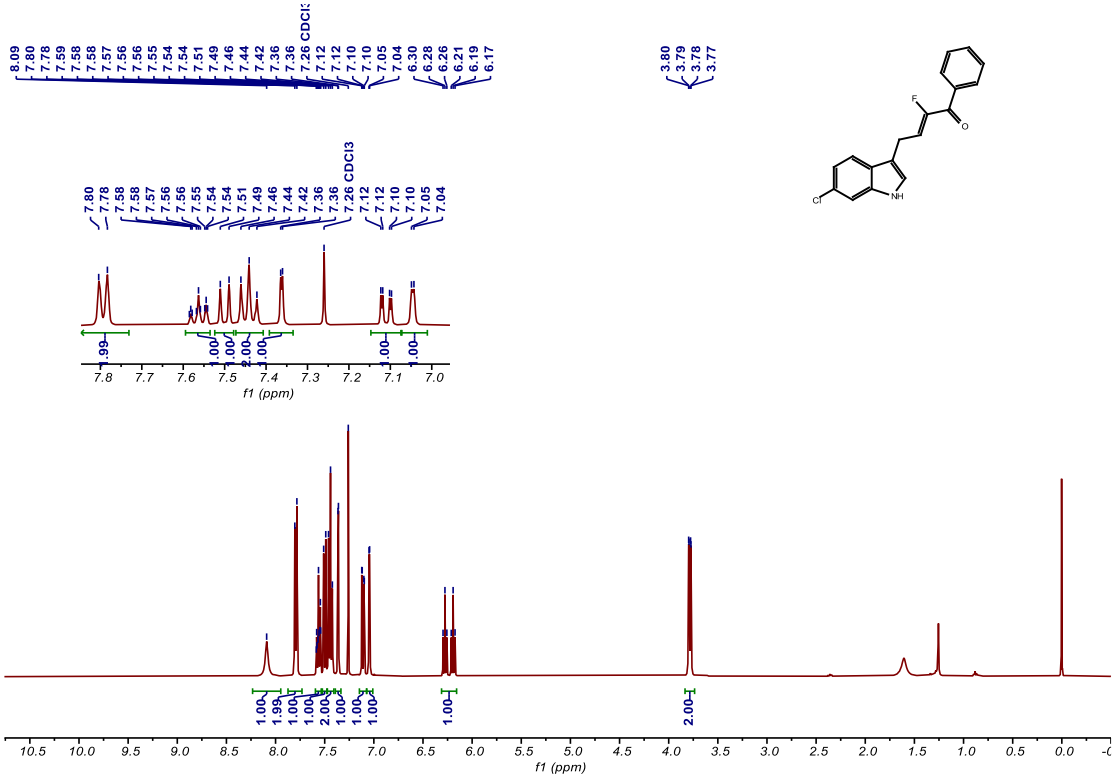
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10pa**



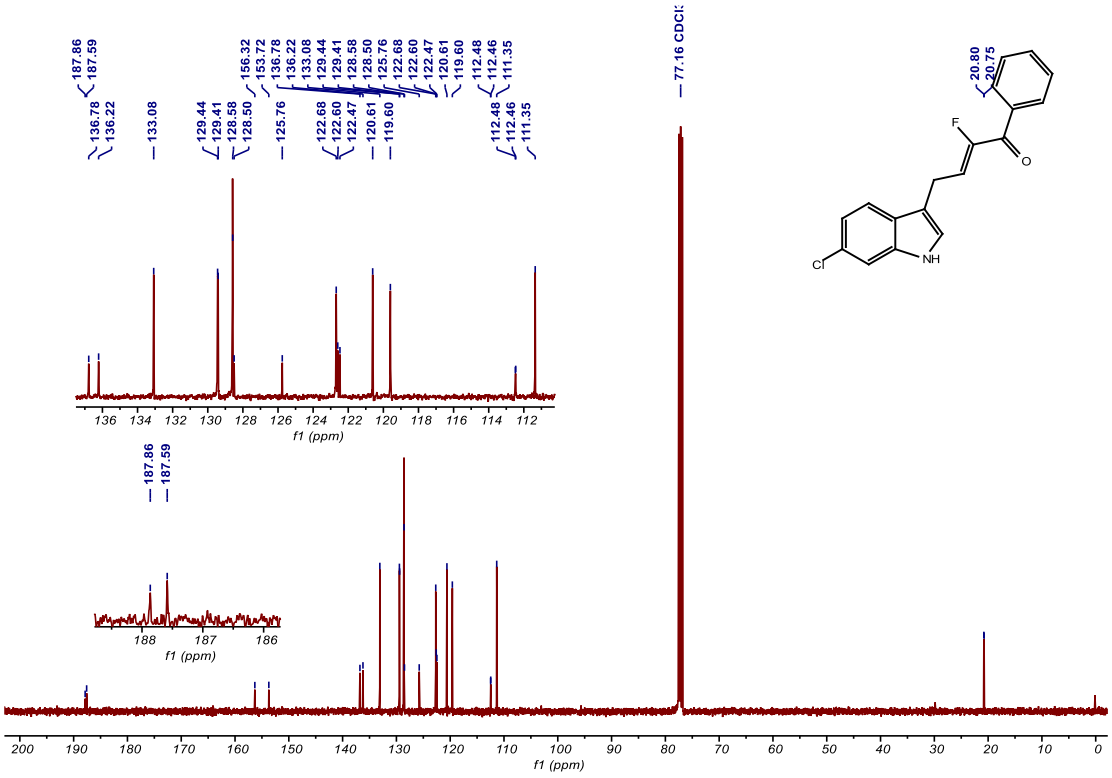

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10pa**



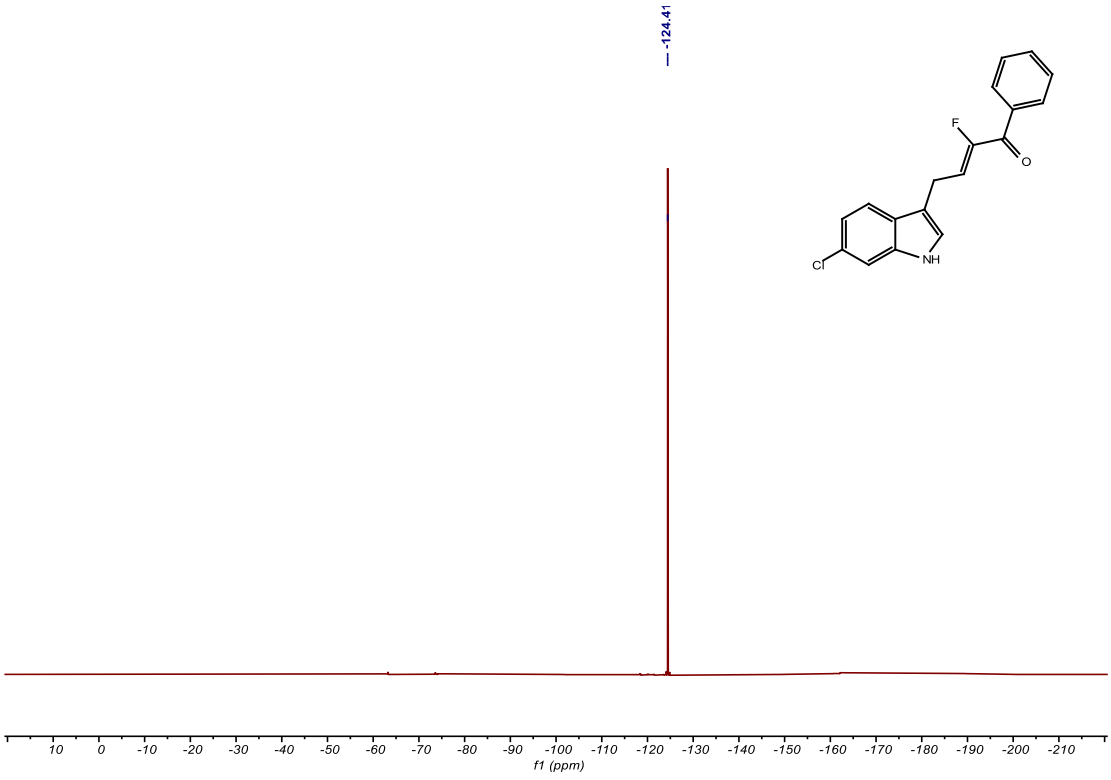
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10qa**



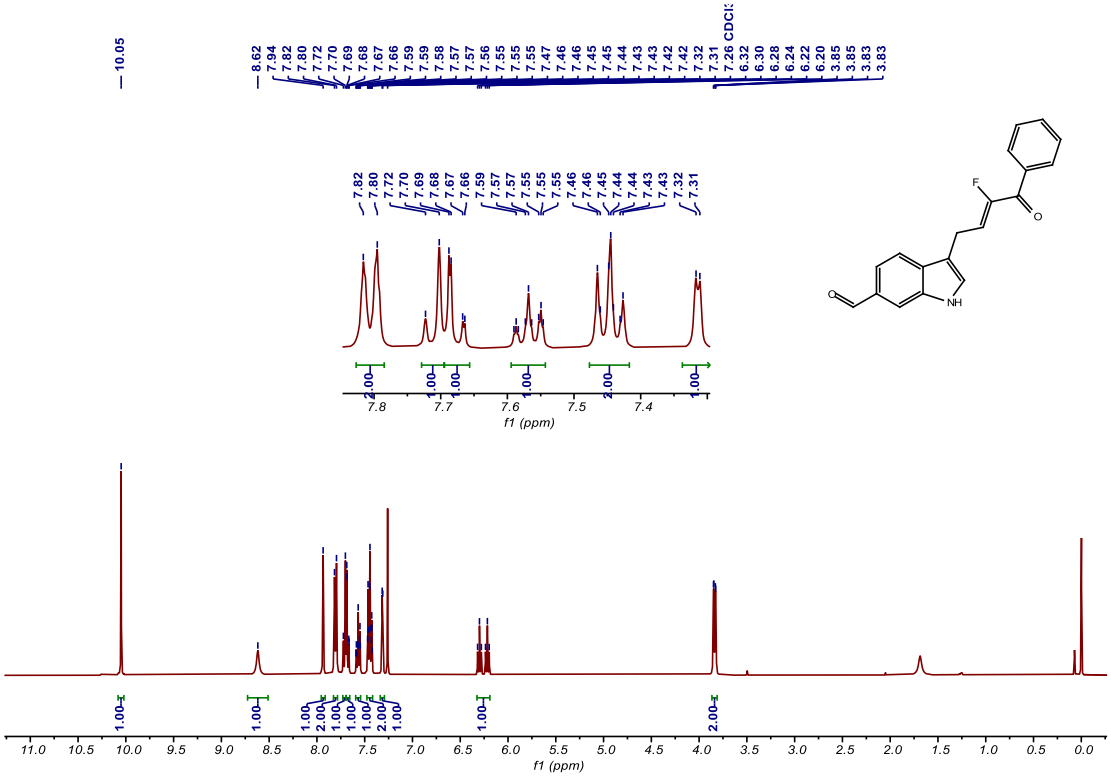
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10qa**



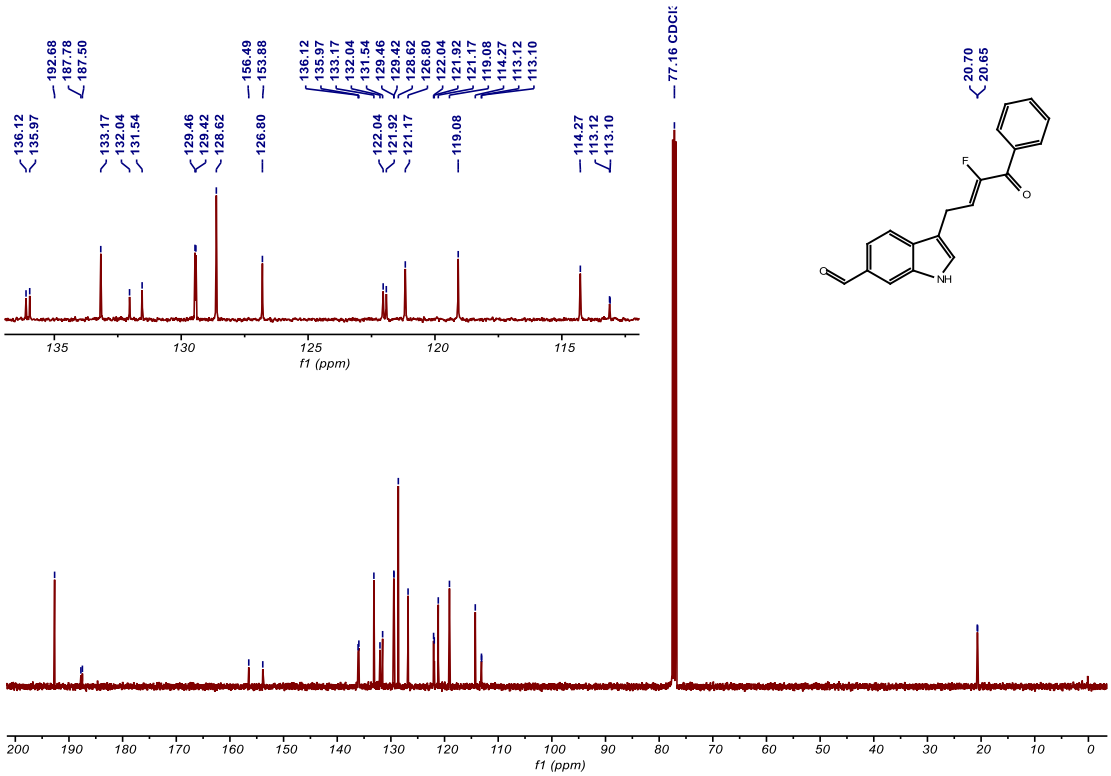
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10qa**



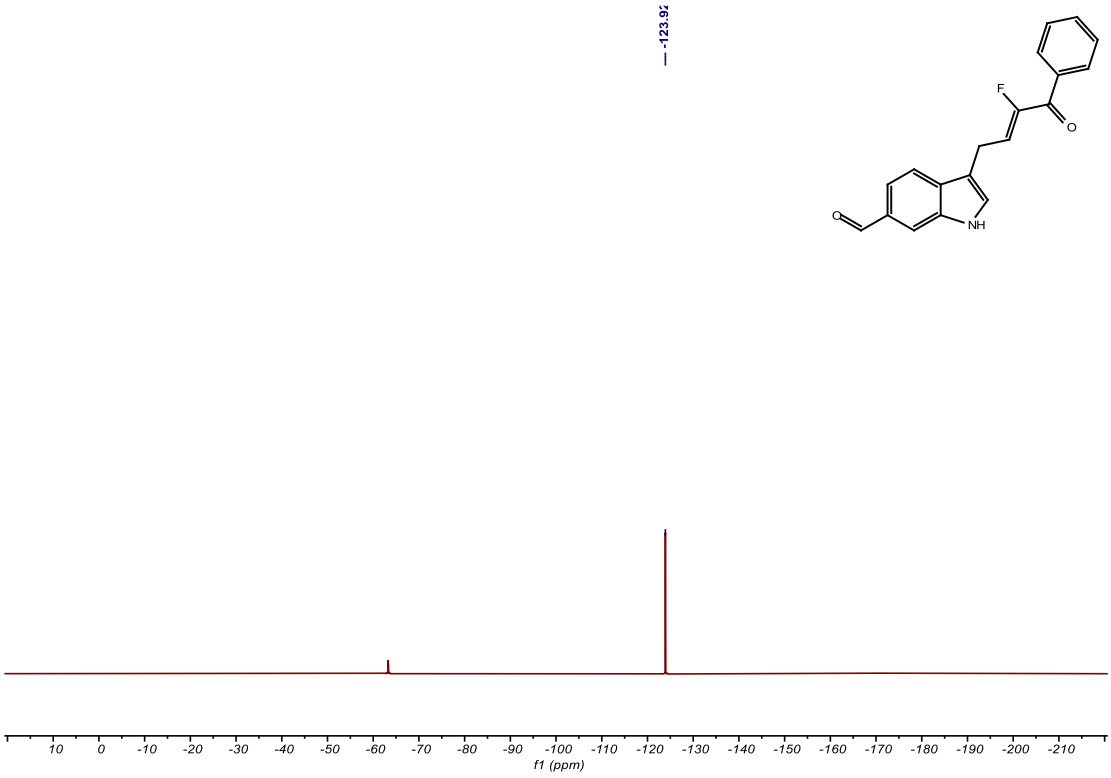

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ra**



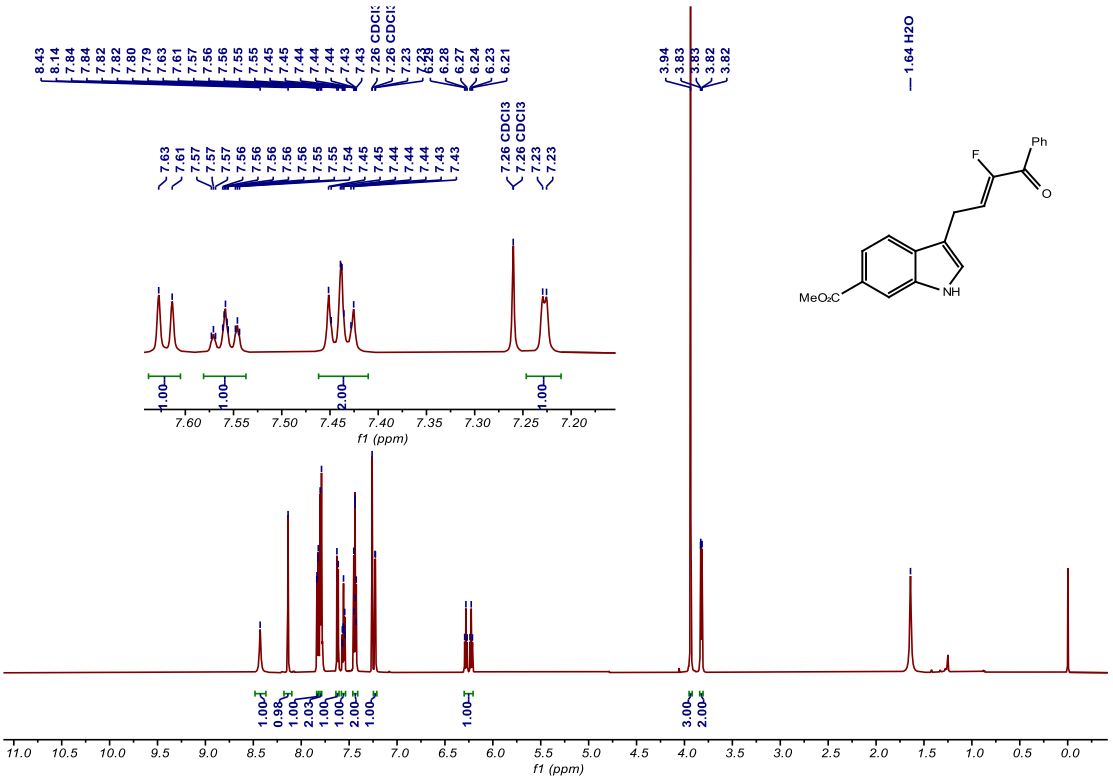
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ra**



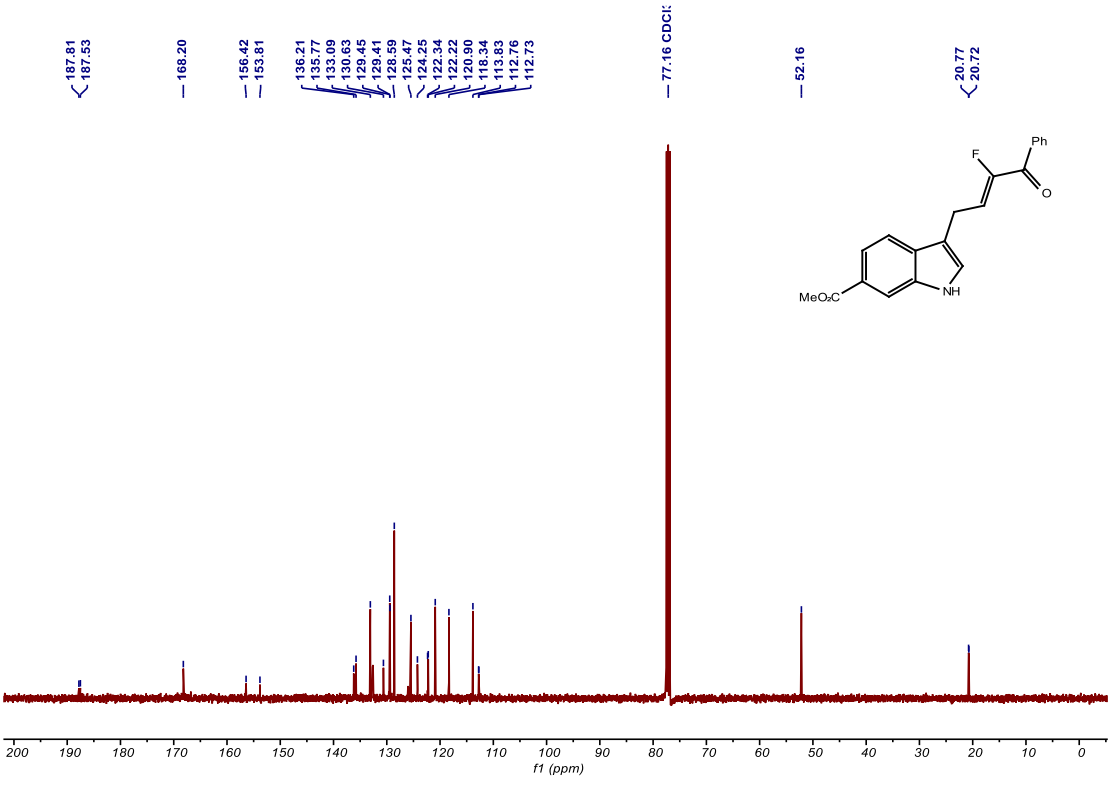

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ra**



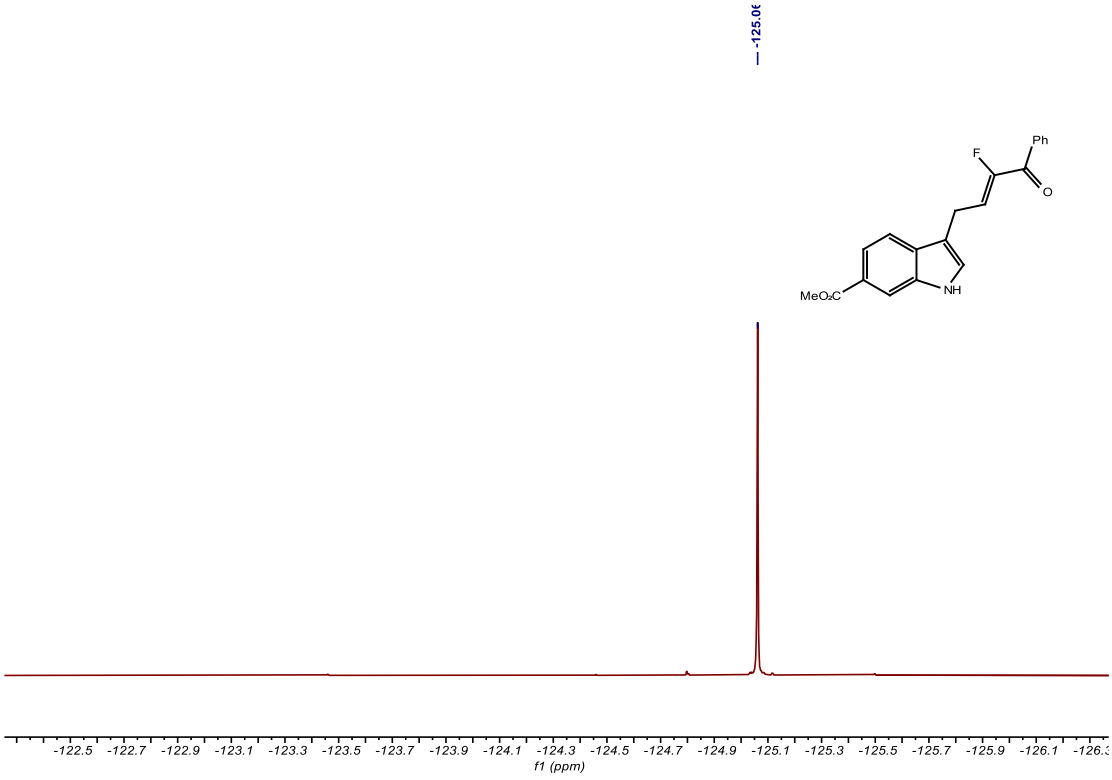
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10sa**



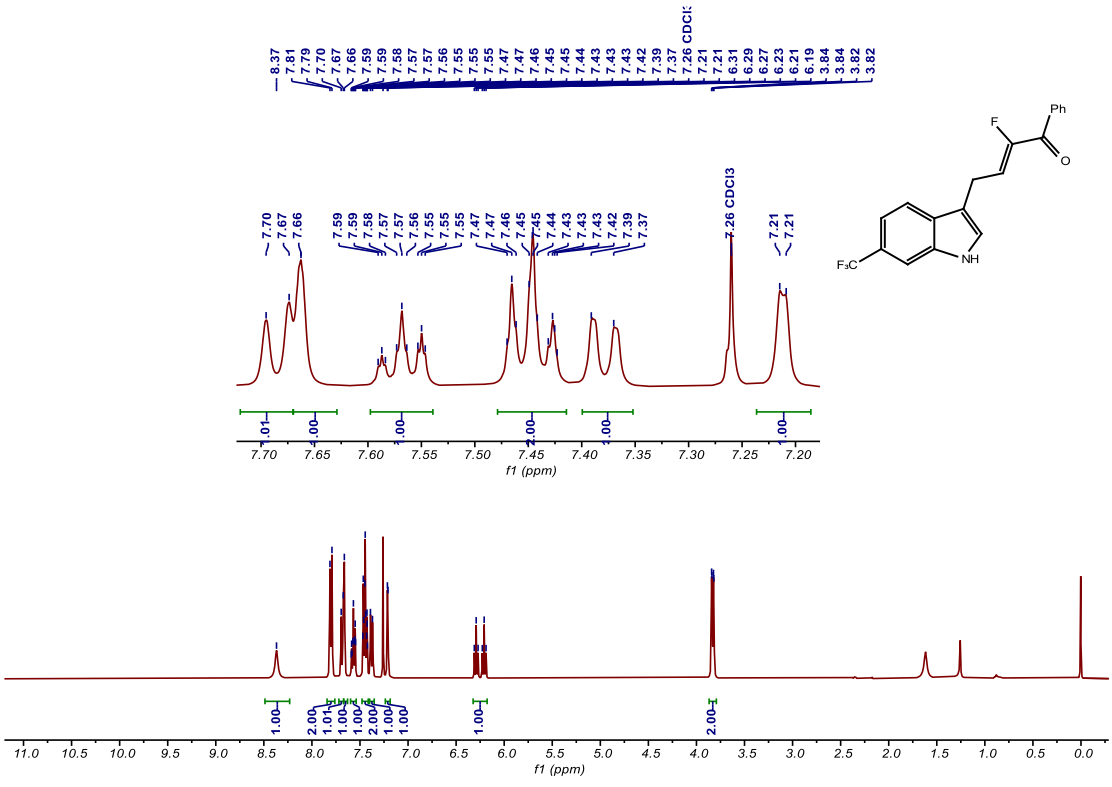

**$^{13}$C NMR** (151 MHz, $CDCl_3$) of **10sa**



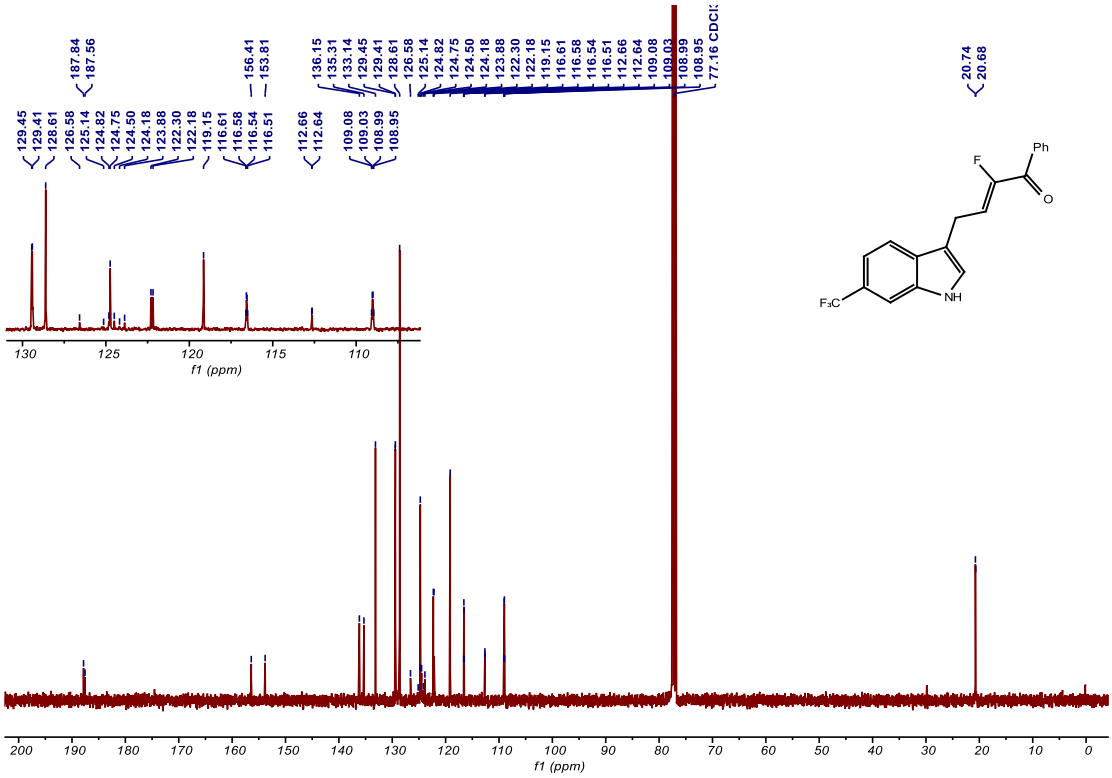
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10sa**



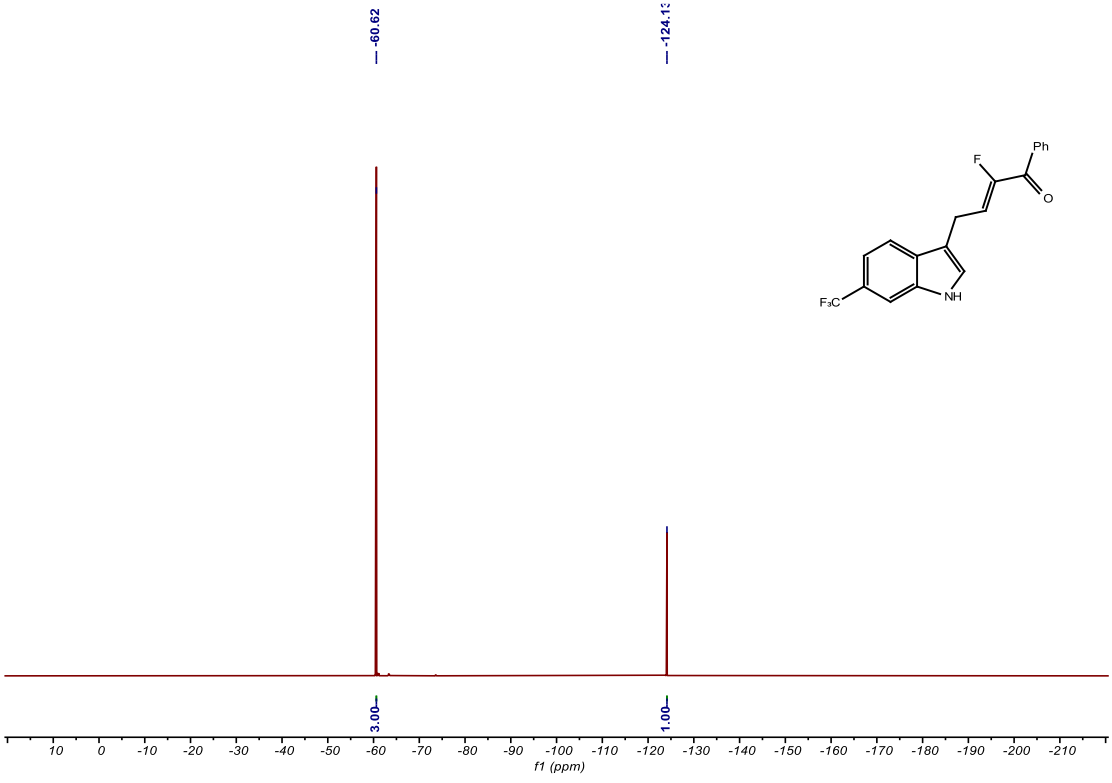

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ta**



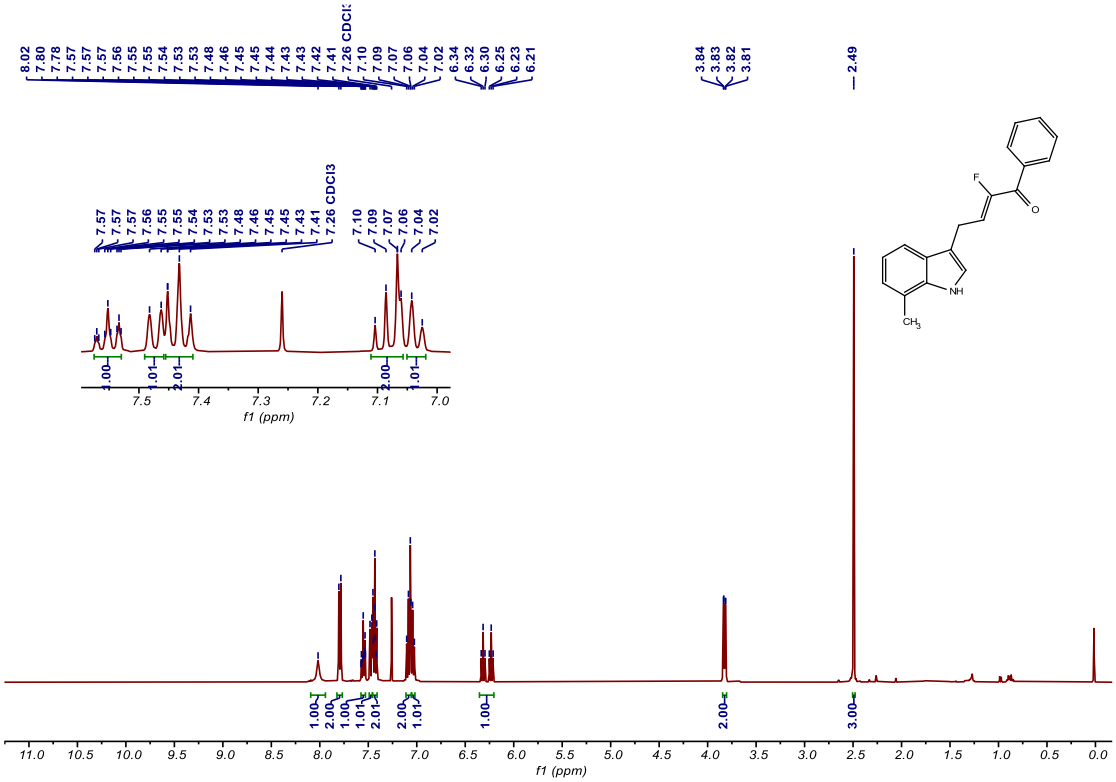
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ta**



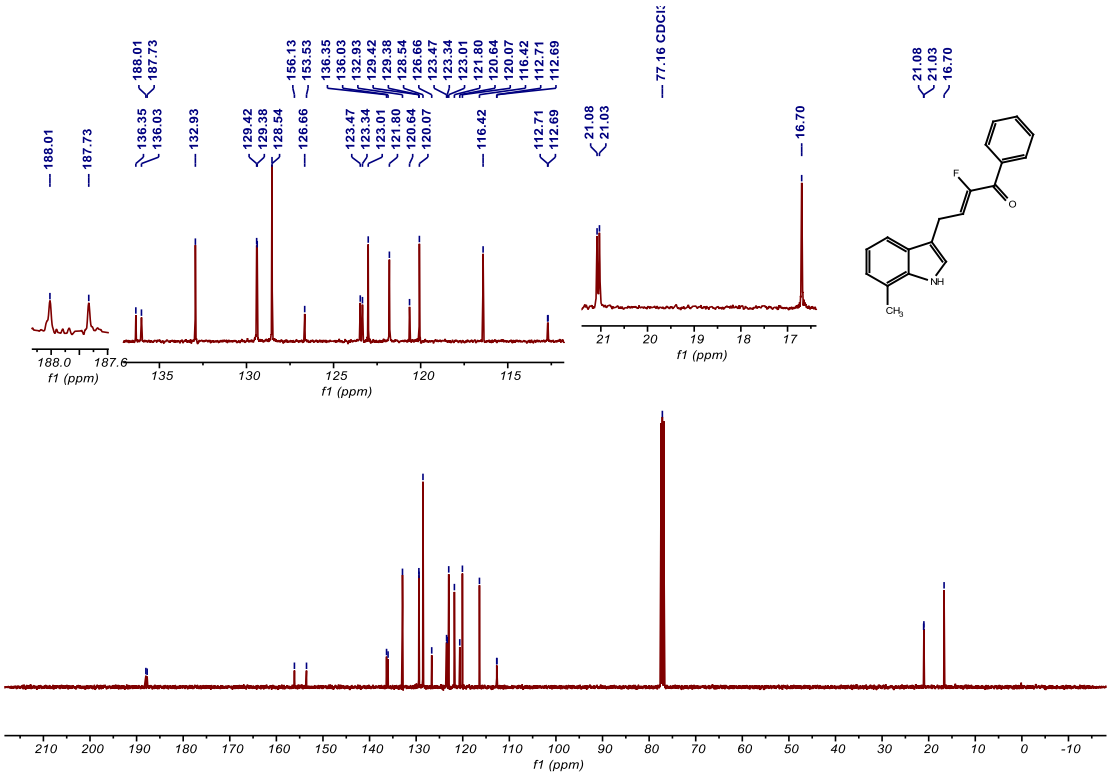

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ta**



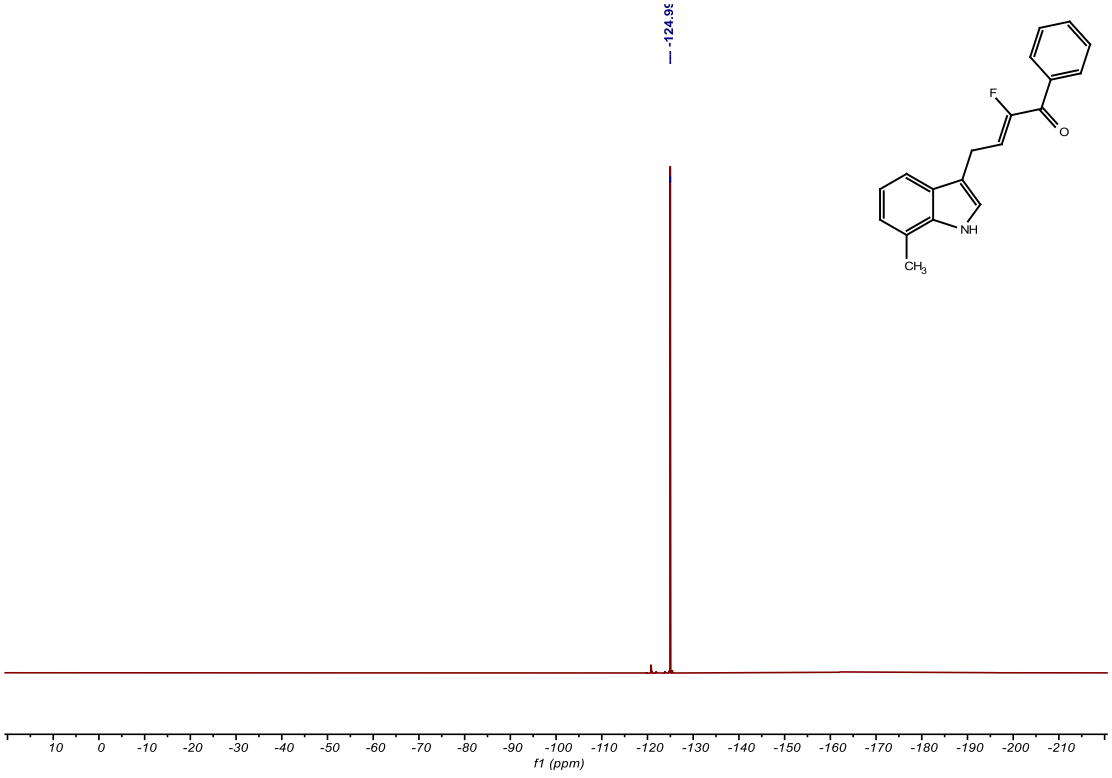
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ua**



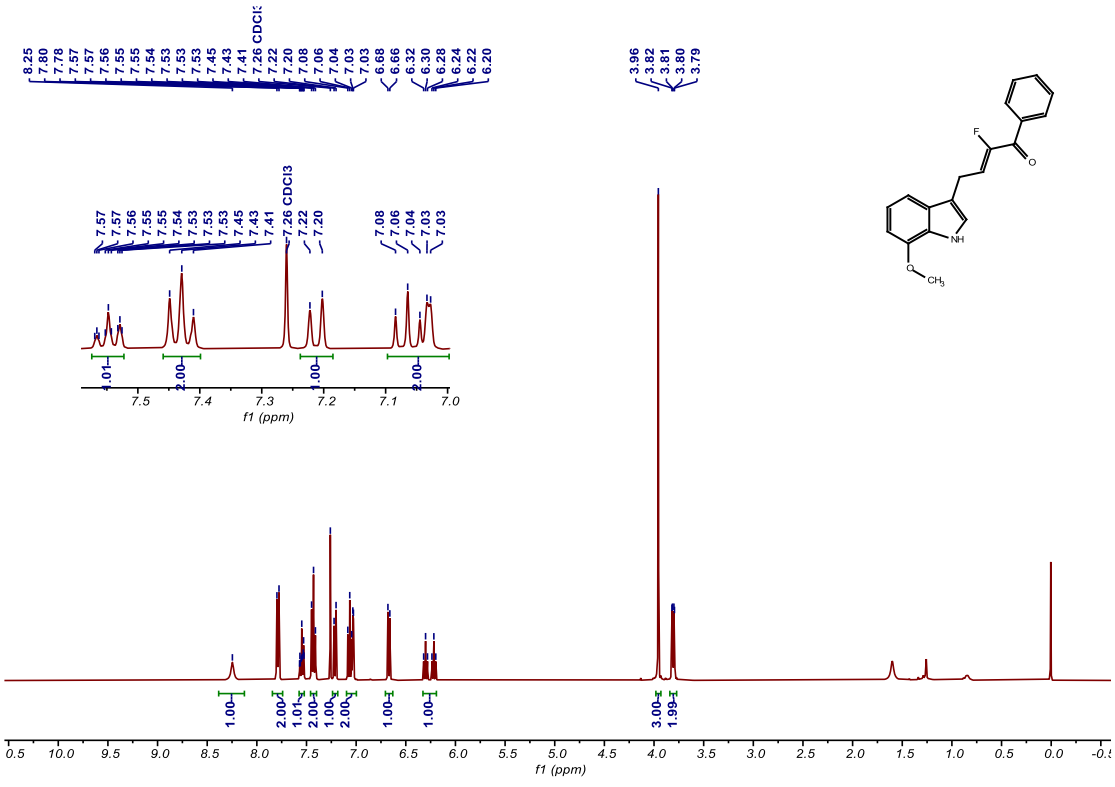
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ua**



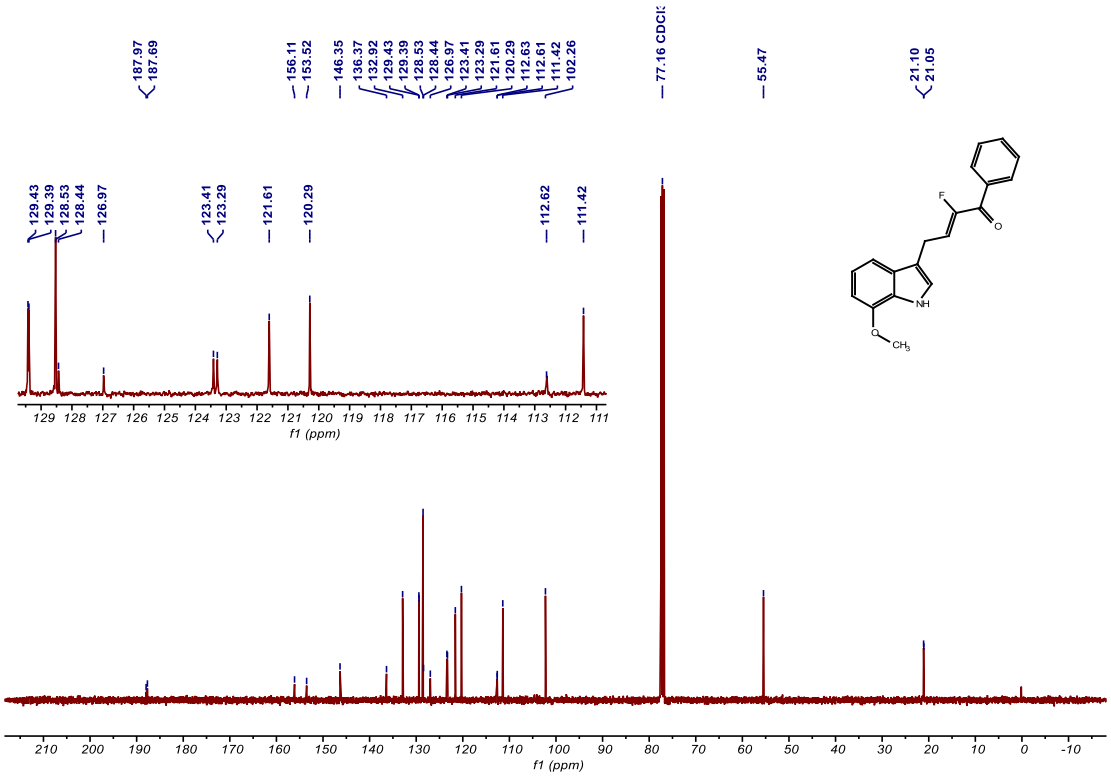
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ua**



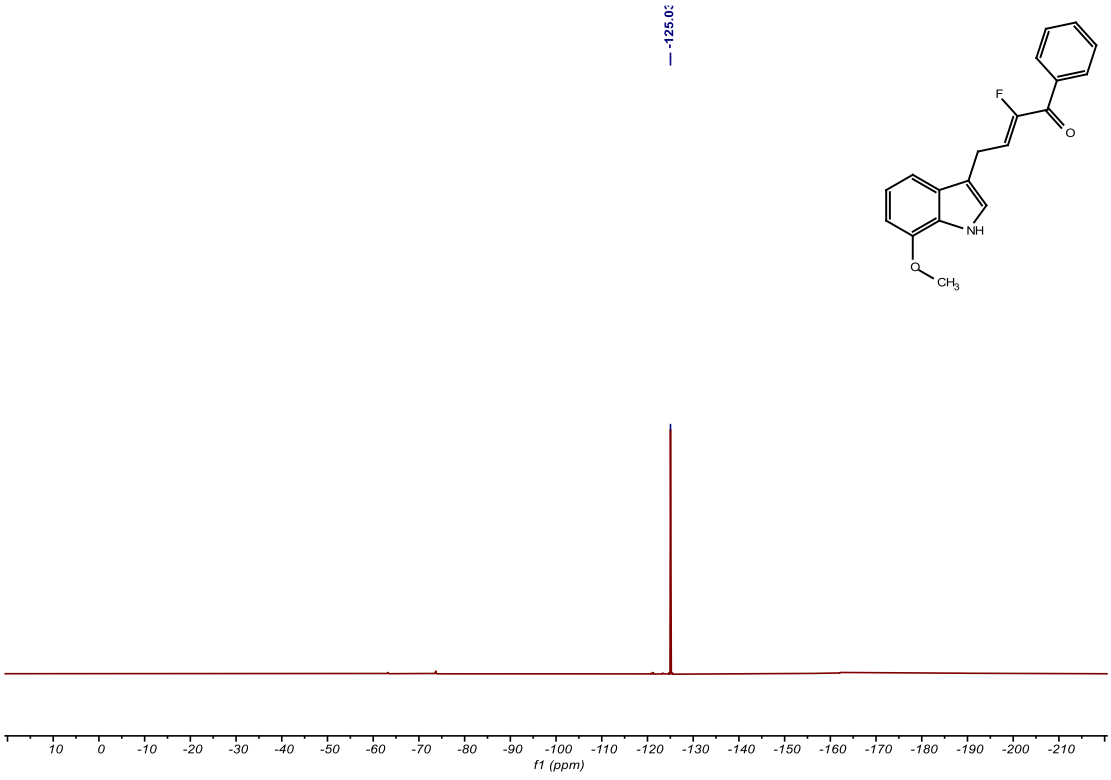

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10va**



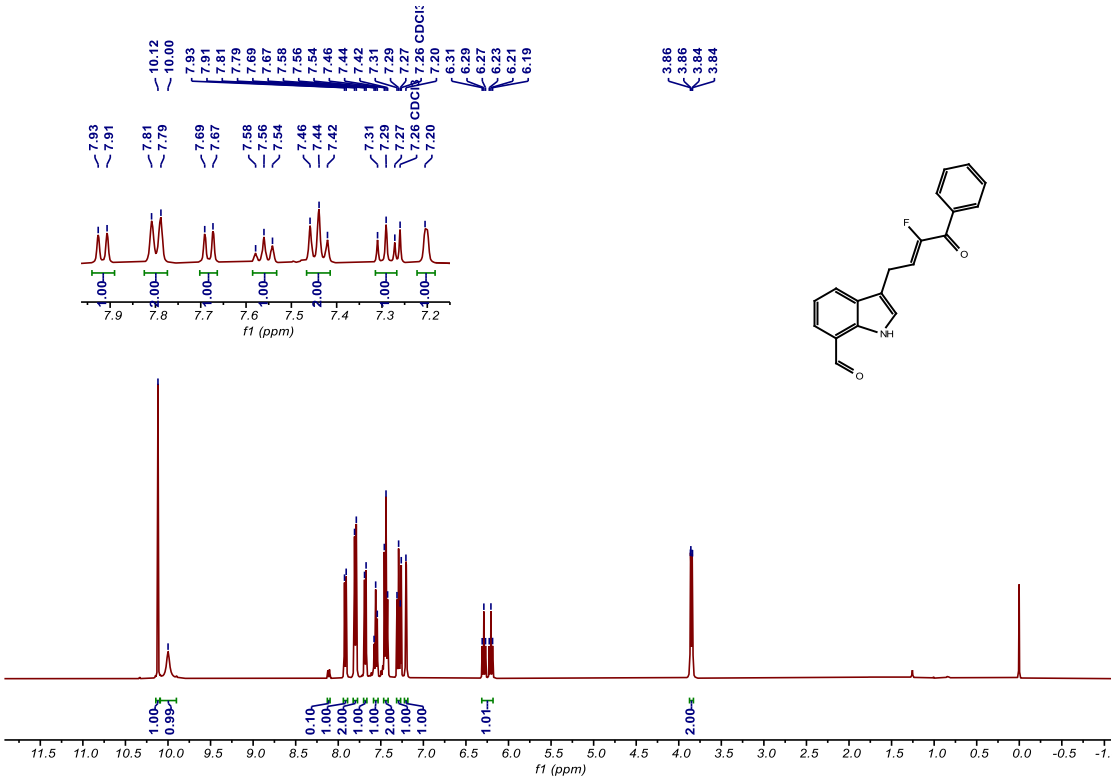
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10va**



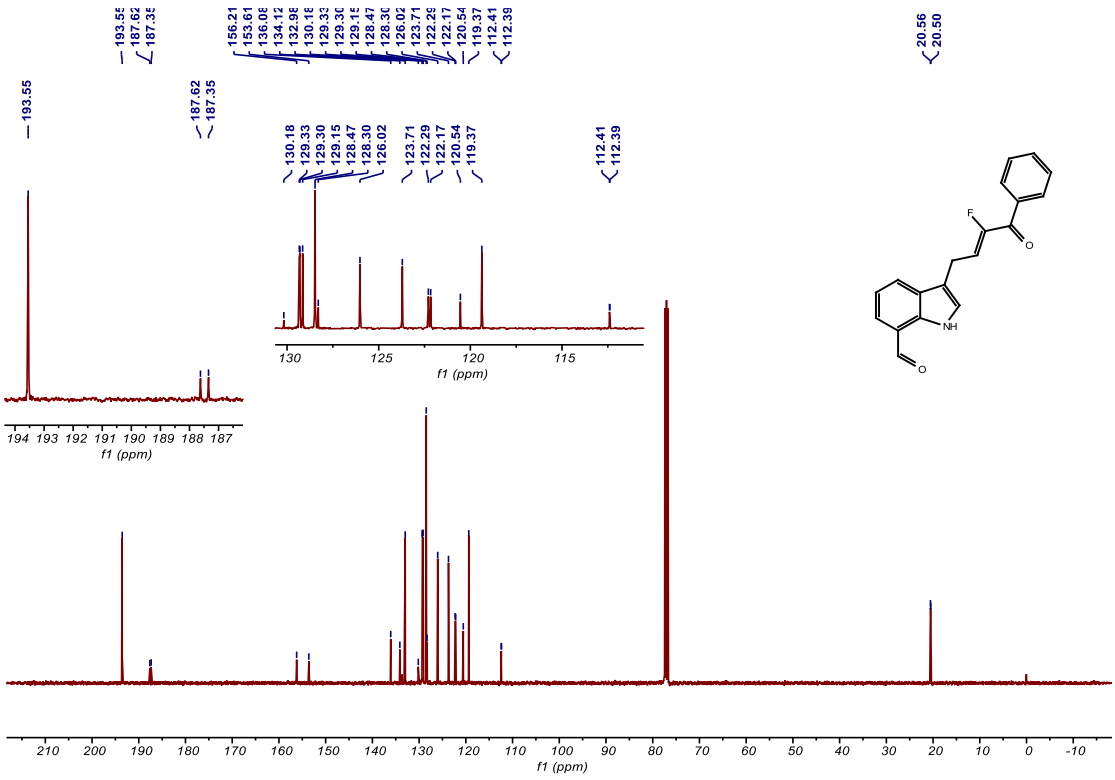

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10va**



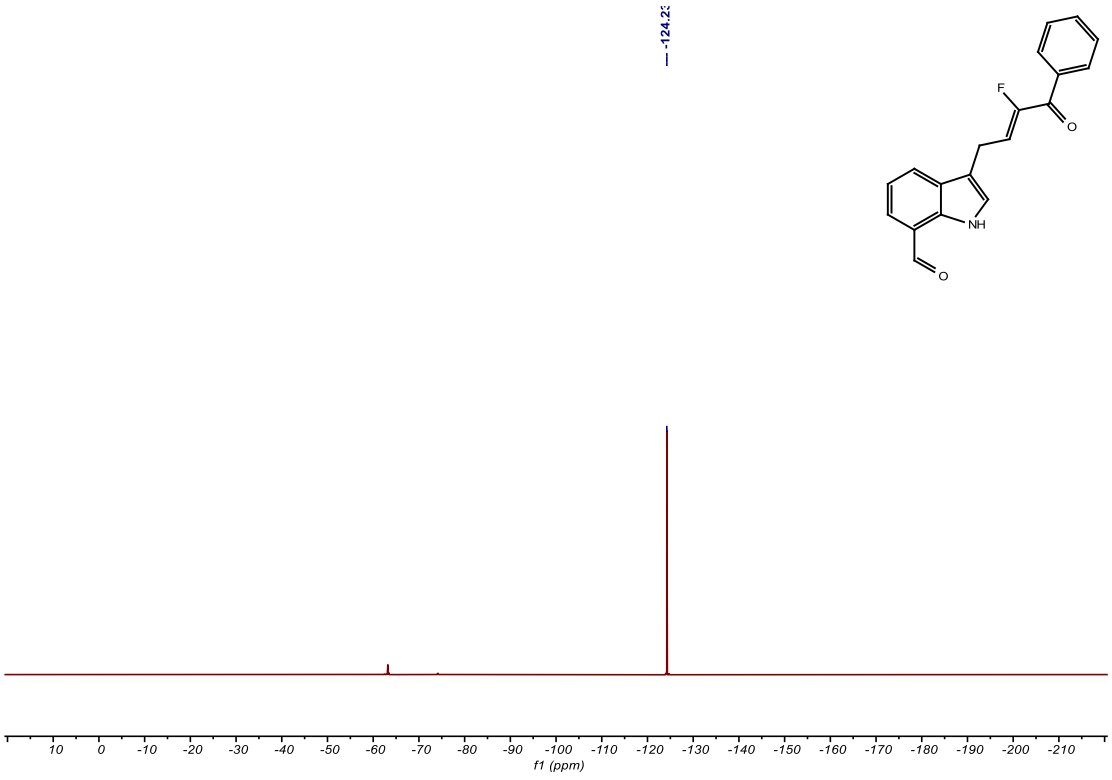
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10wa**



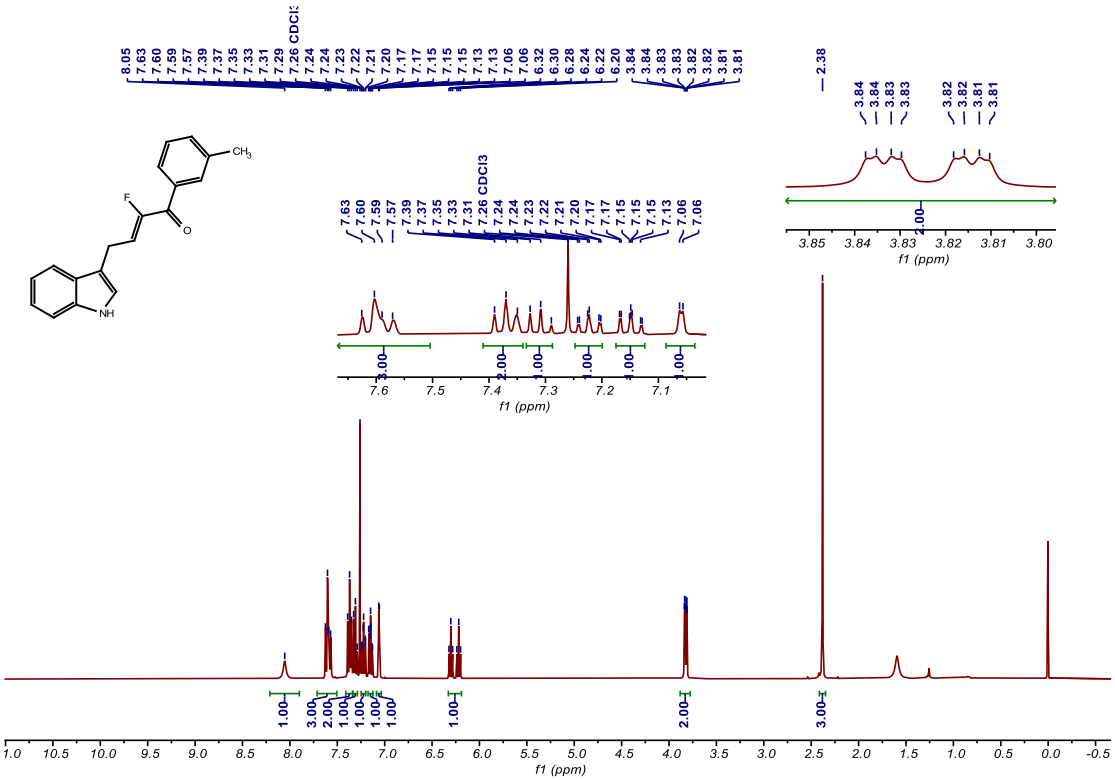
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10wa**



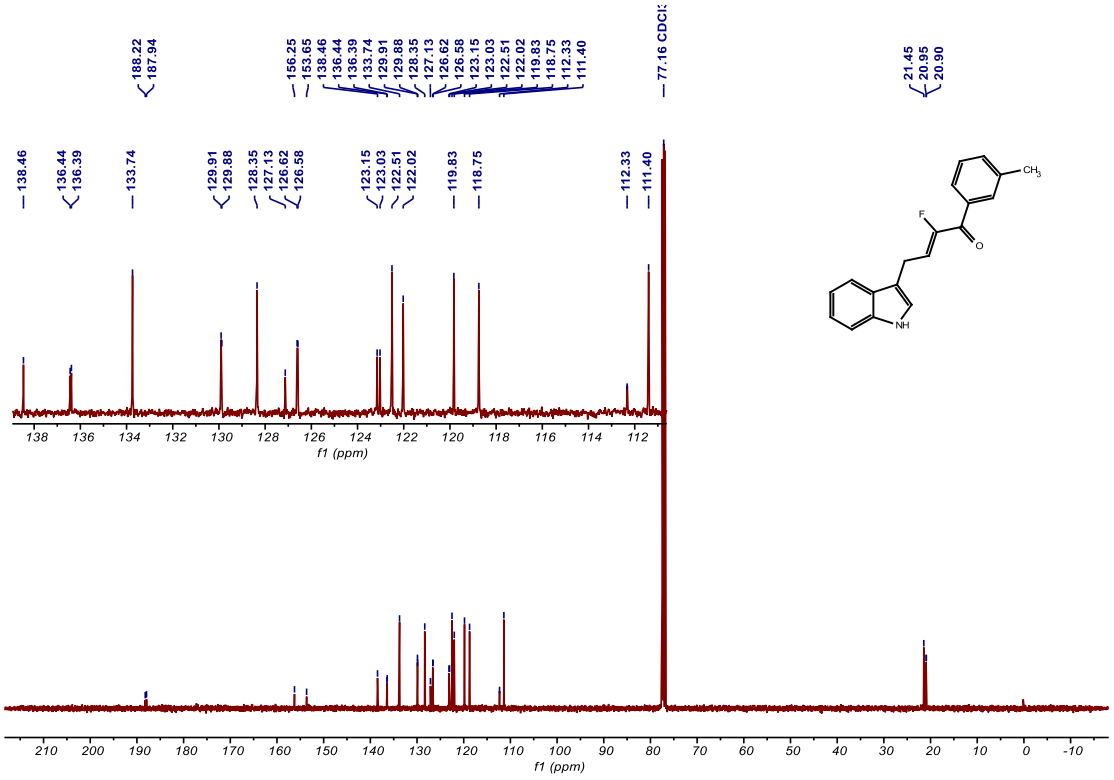
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10wa**



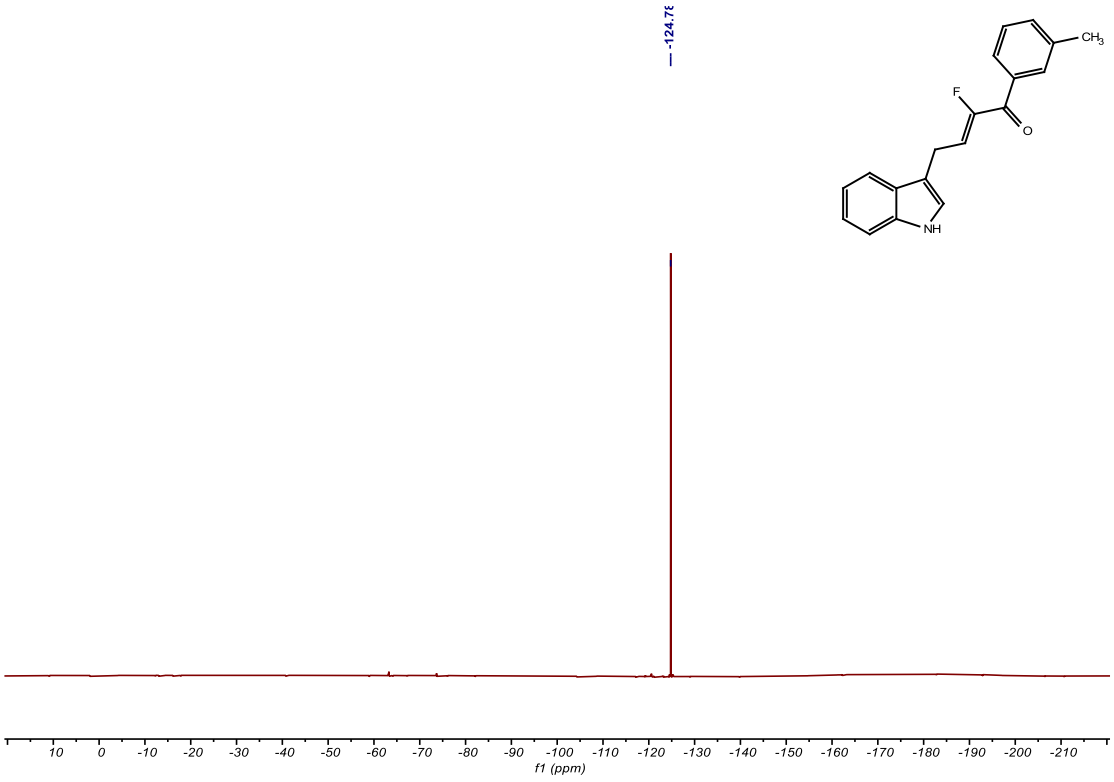

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ab**



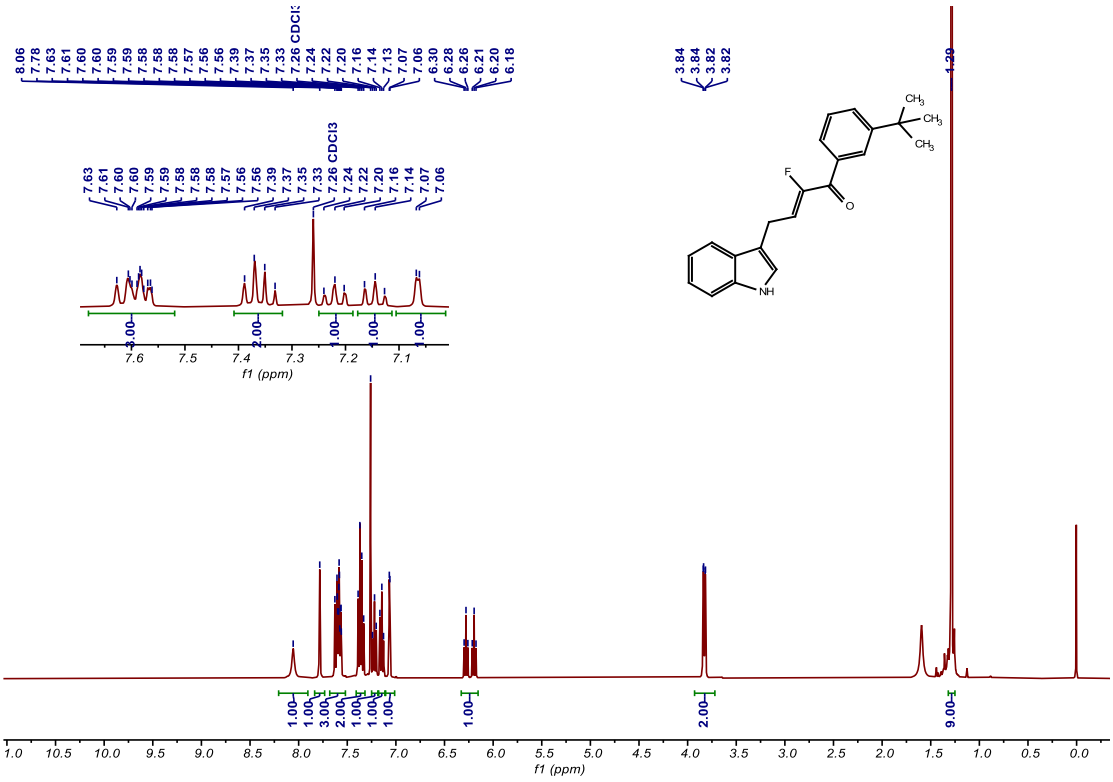
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ab**



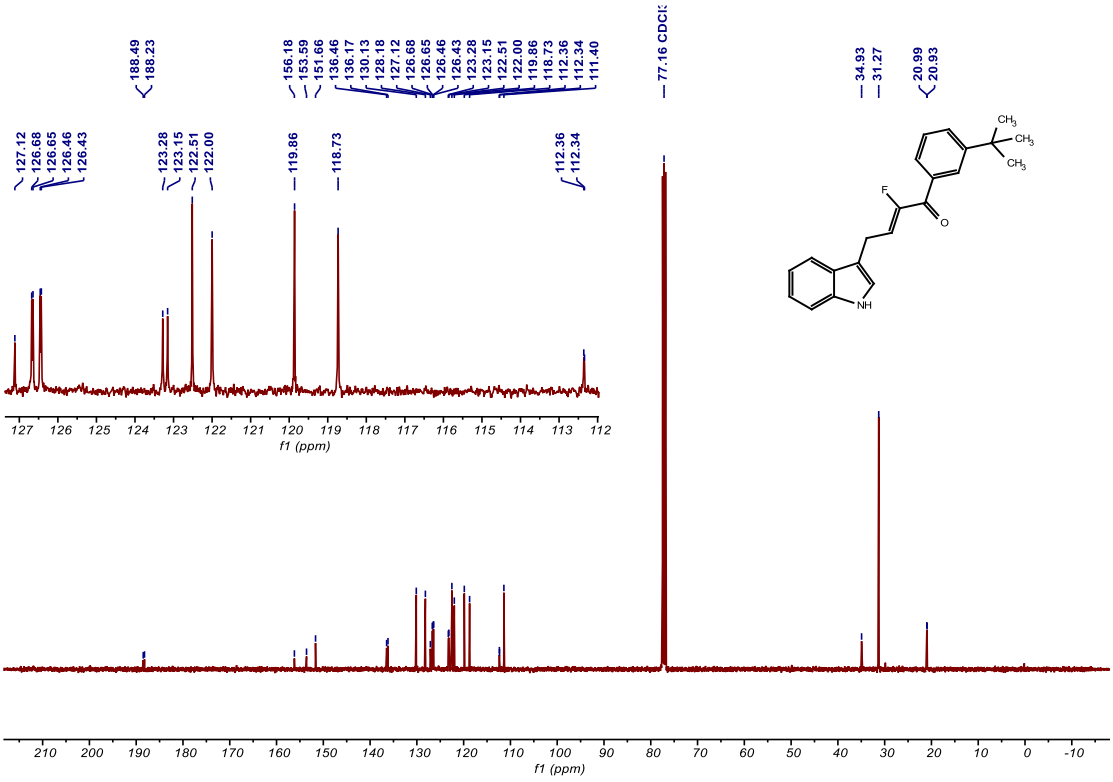

**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10ab**



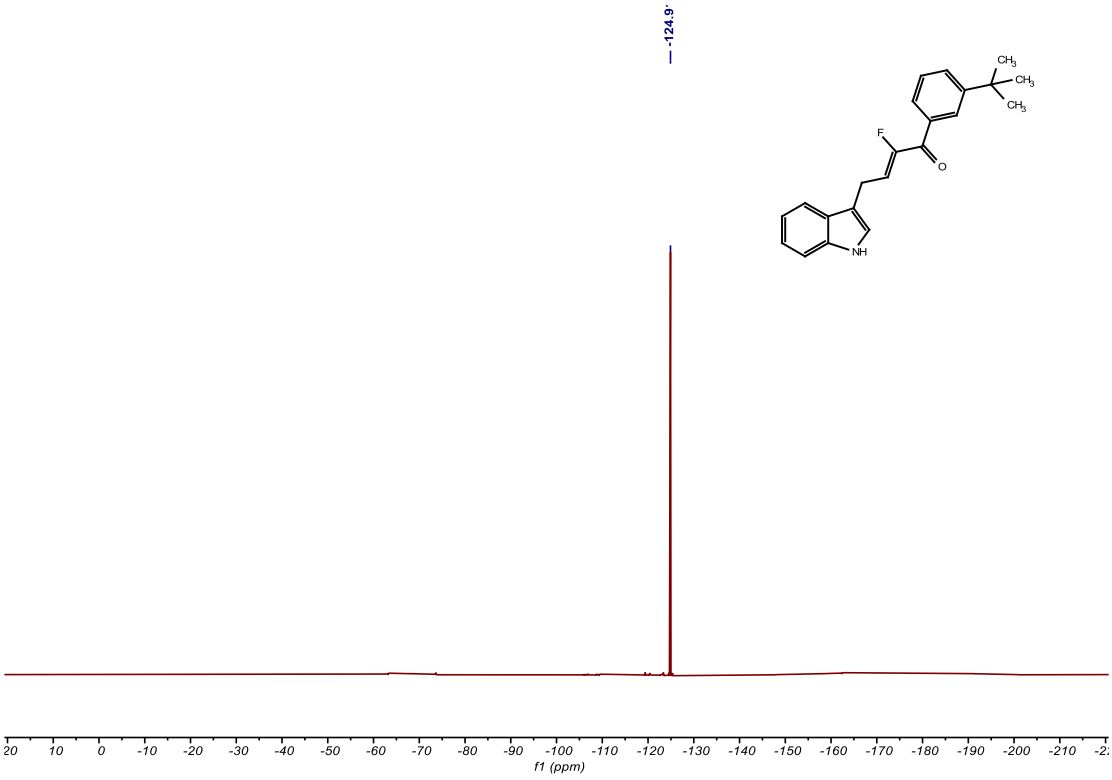
**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10ac**



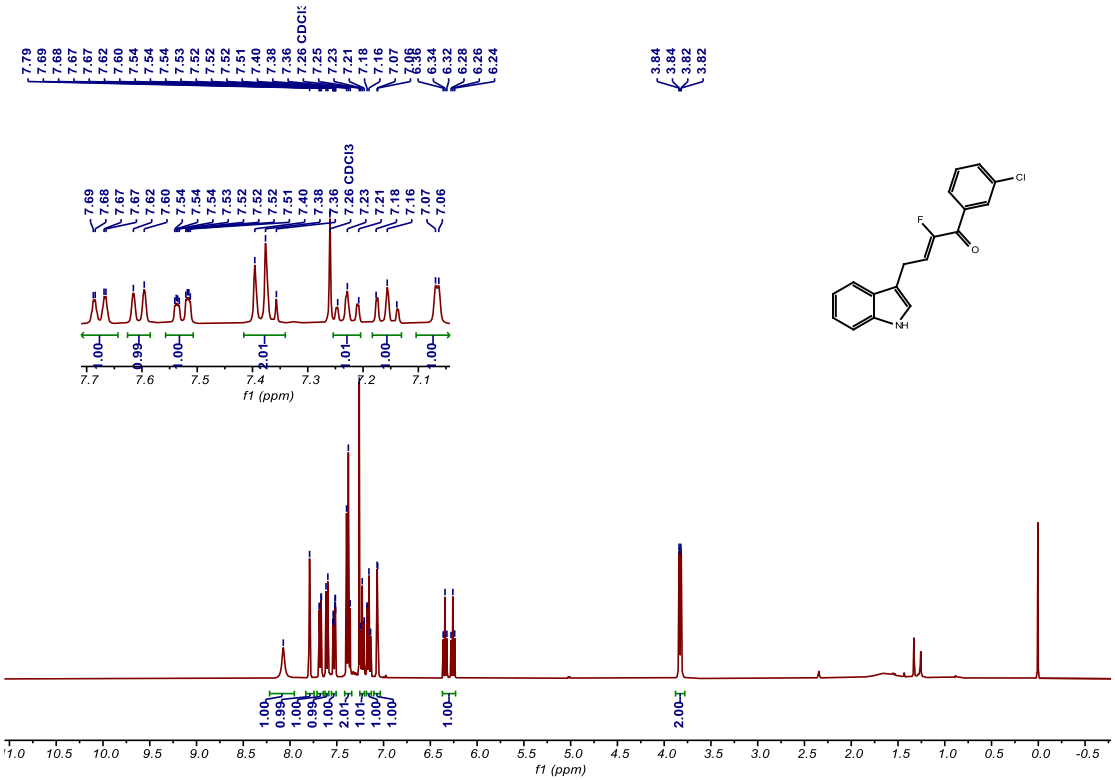
**$^{13}$C NMR** (101 MHz, $CDCl_3$) **of 10ac**



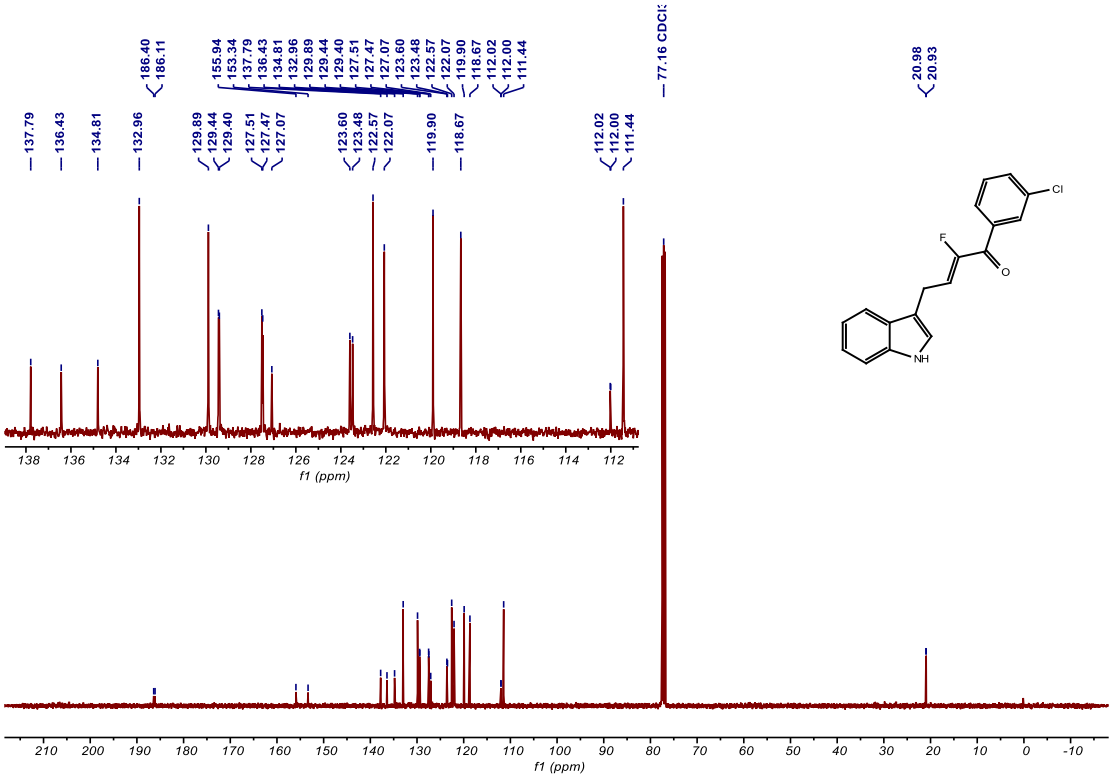
**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10ac**



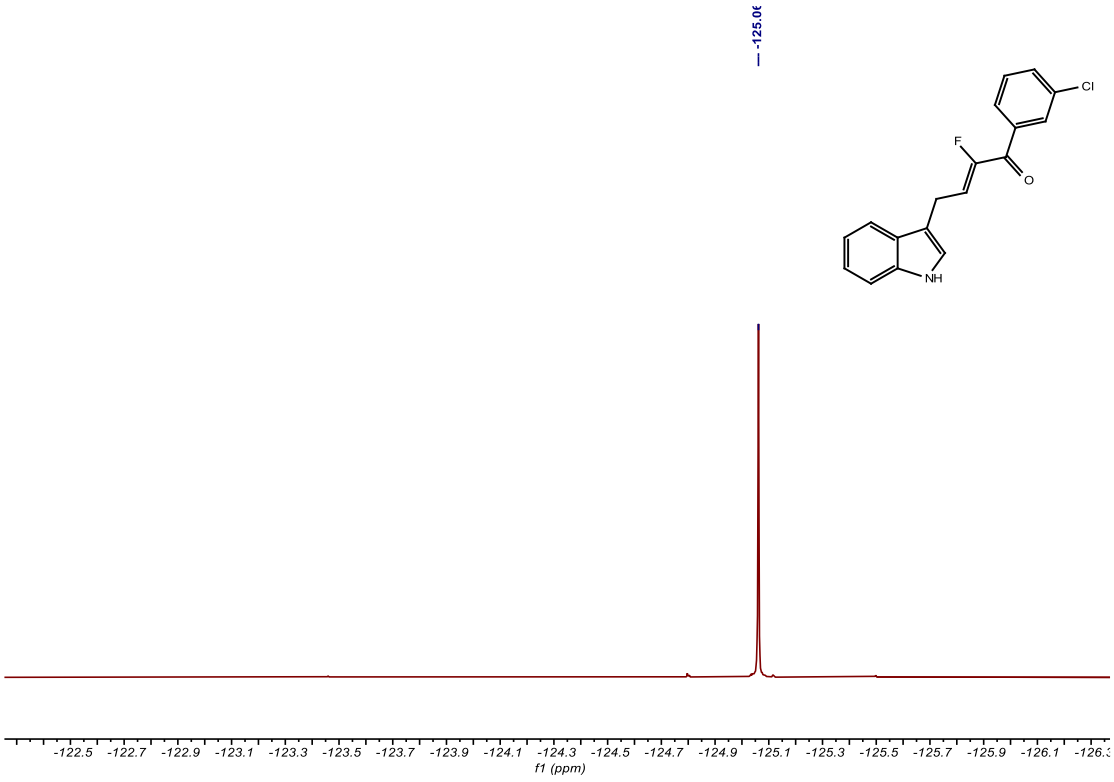

**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10ad**



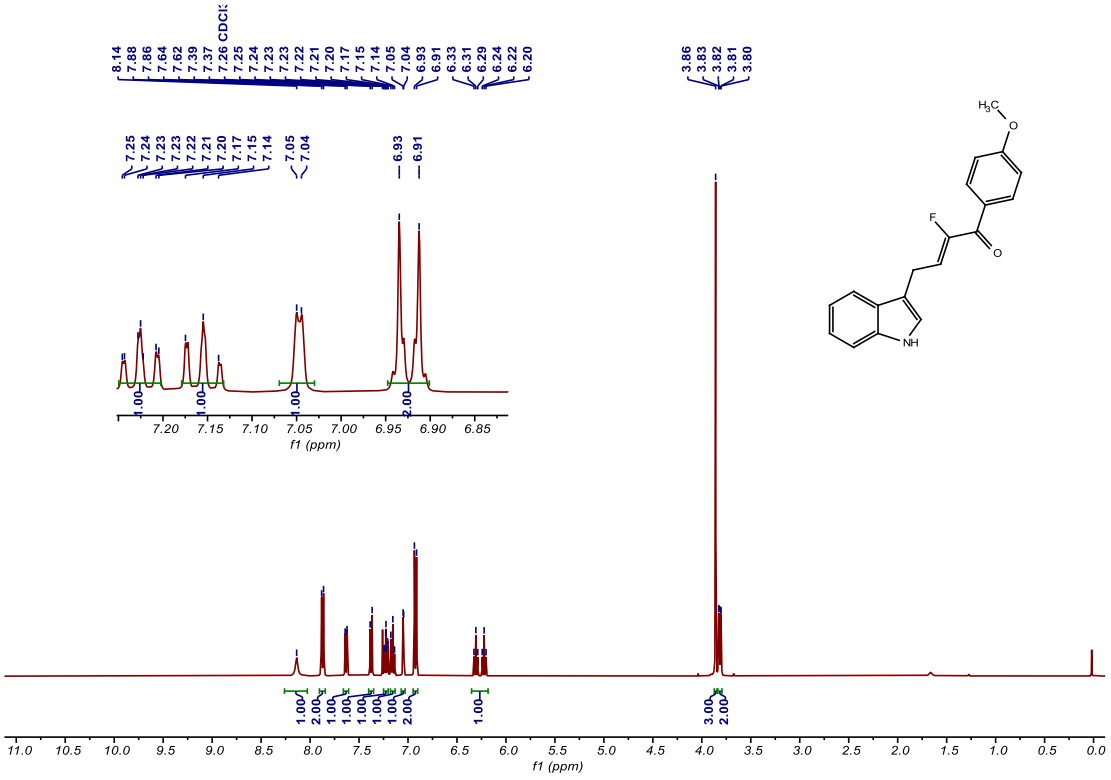
**$^{13}$C NMR** (101 MHz, $CDCl_3$) **of 10ad**



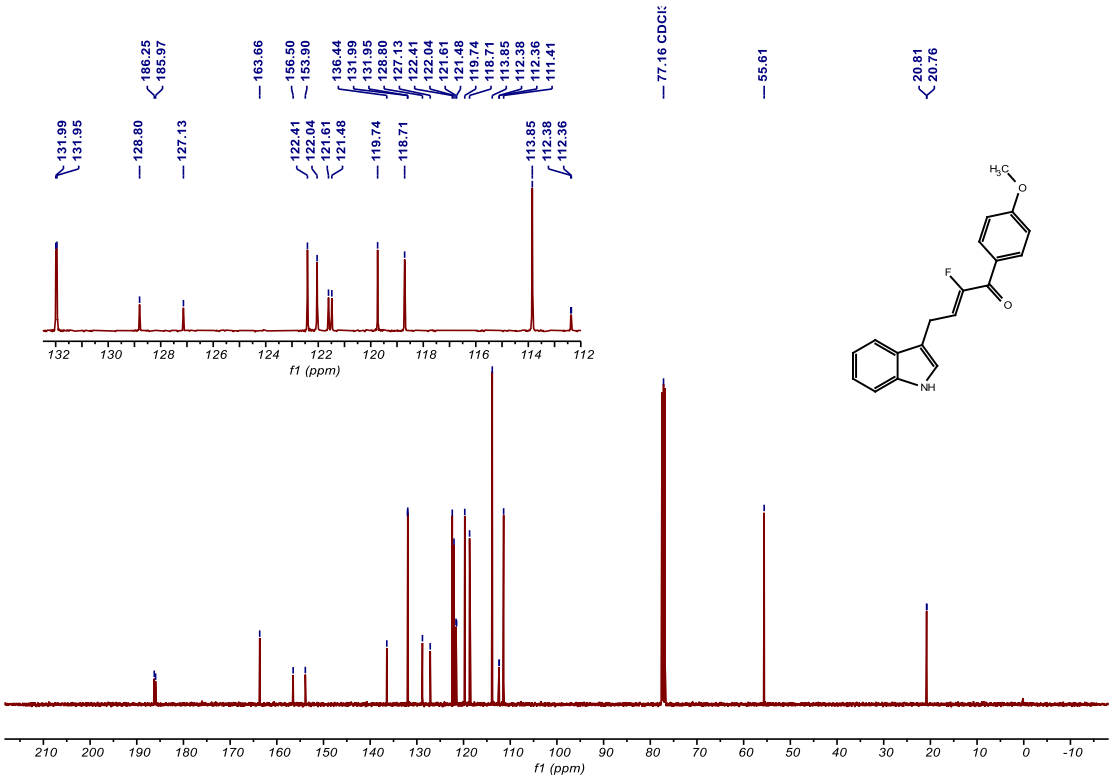

**$^{19}$F NMR** (377 MHz, $CDCl_3$ ) **of 10ad**



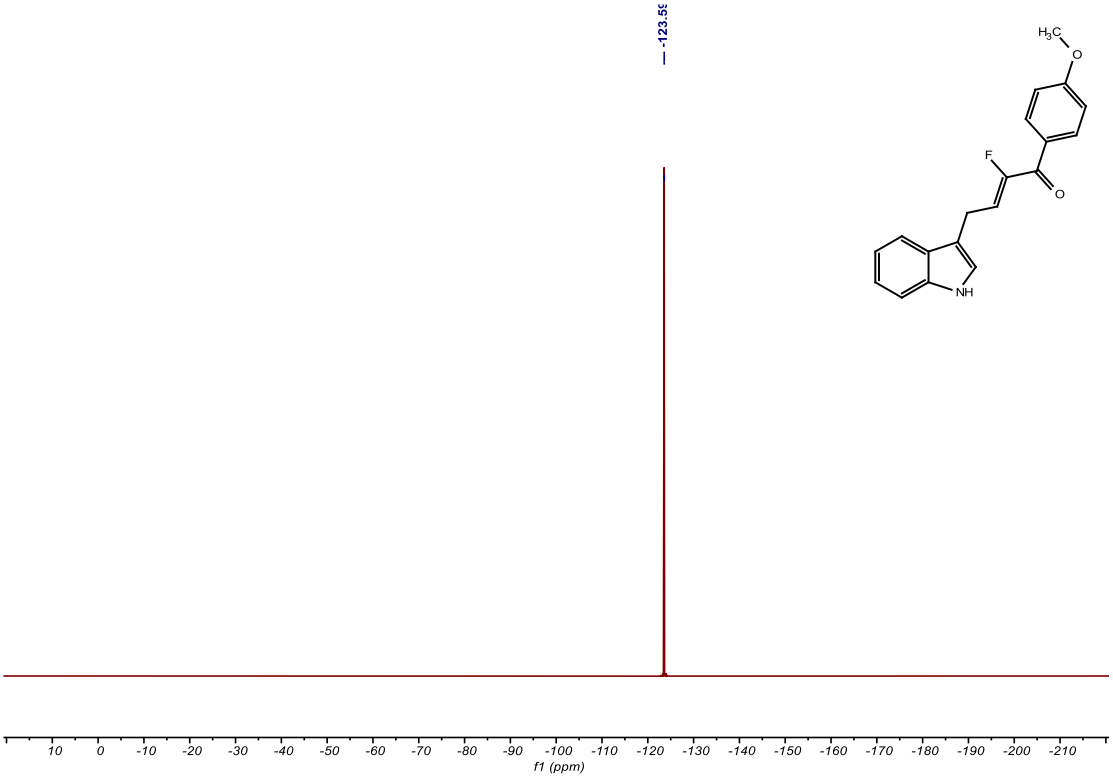
**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10ae**



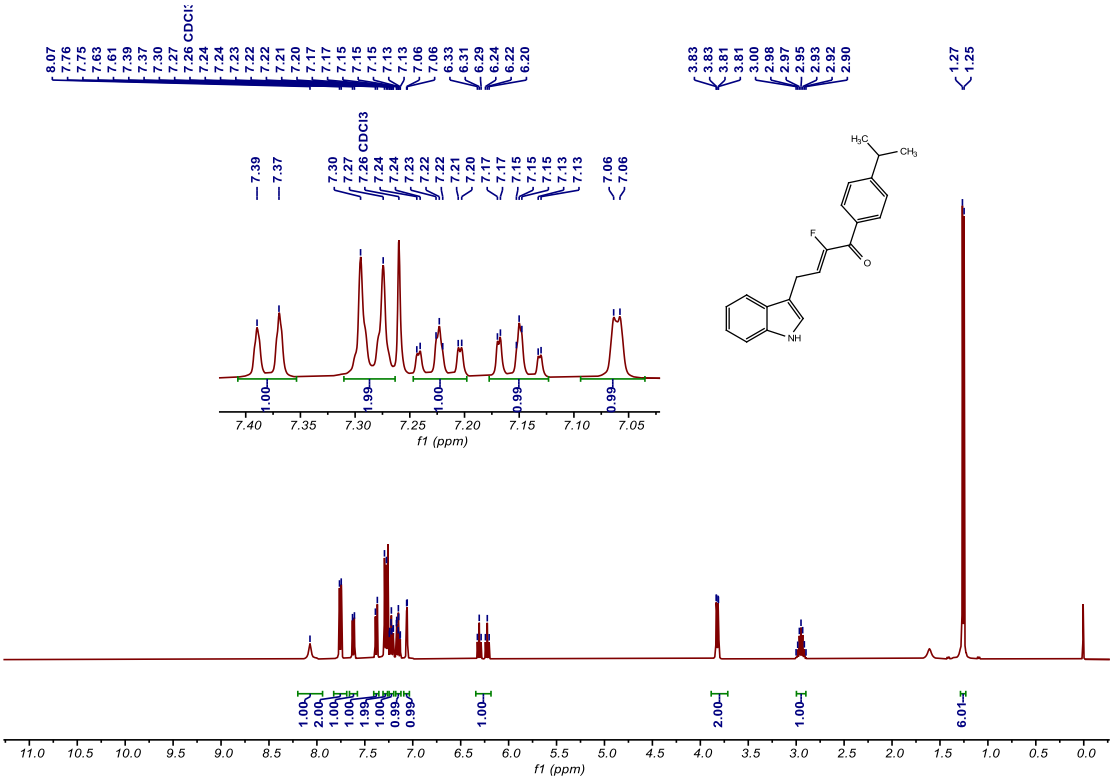

**$^{13}$C NMR** (101 MHz, $CDCl_3$) **of 10ae**



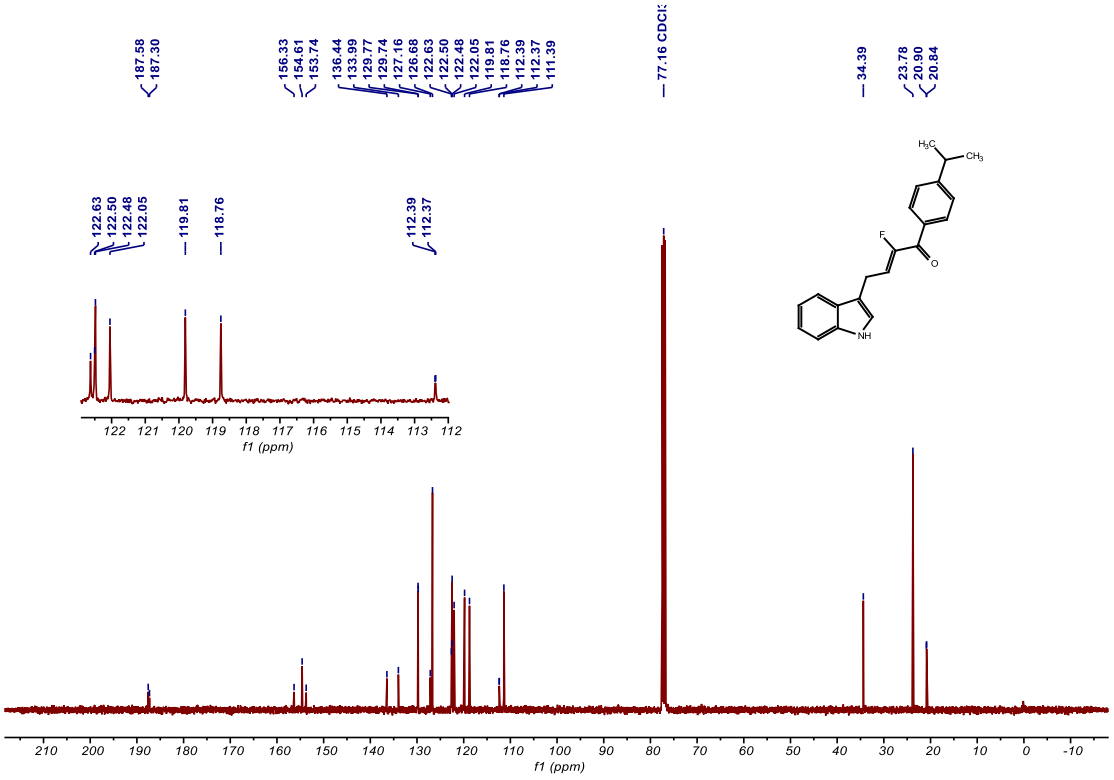
**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10ae**



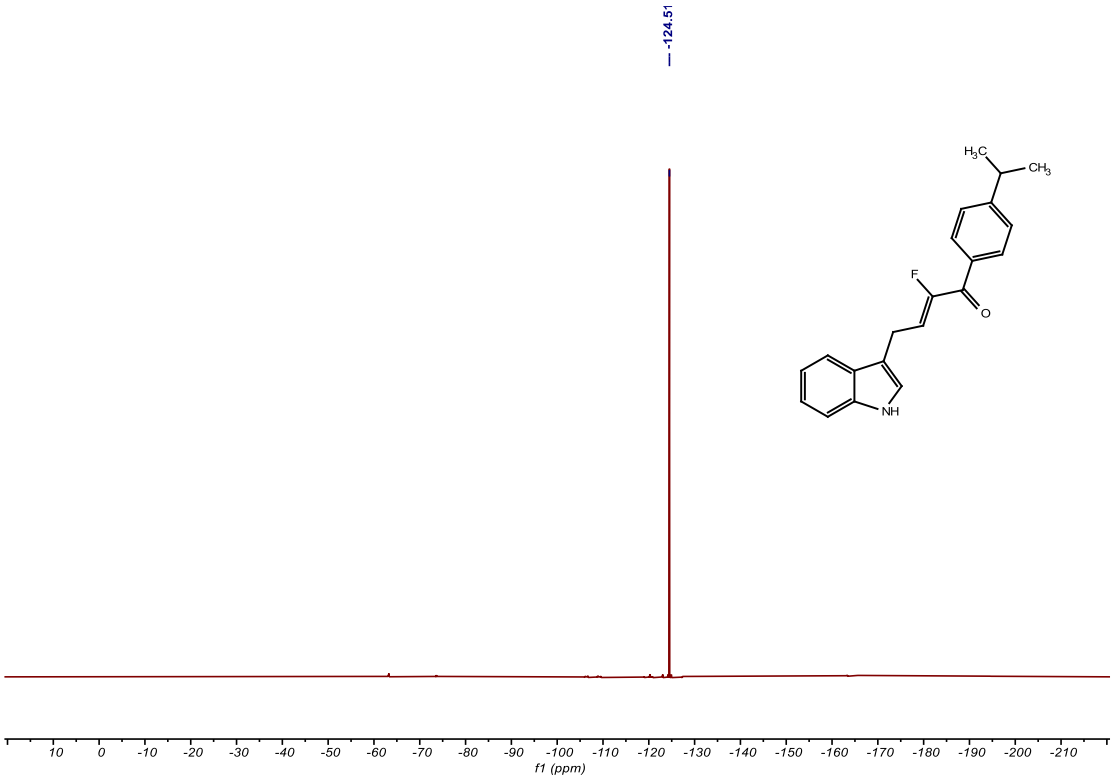

**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10af**



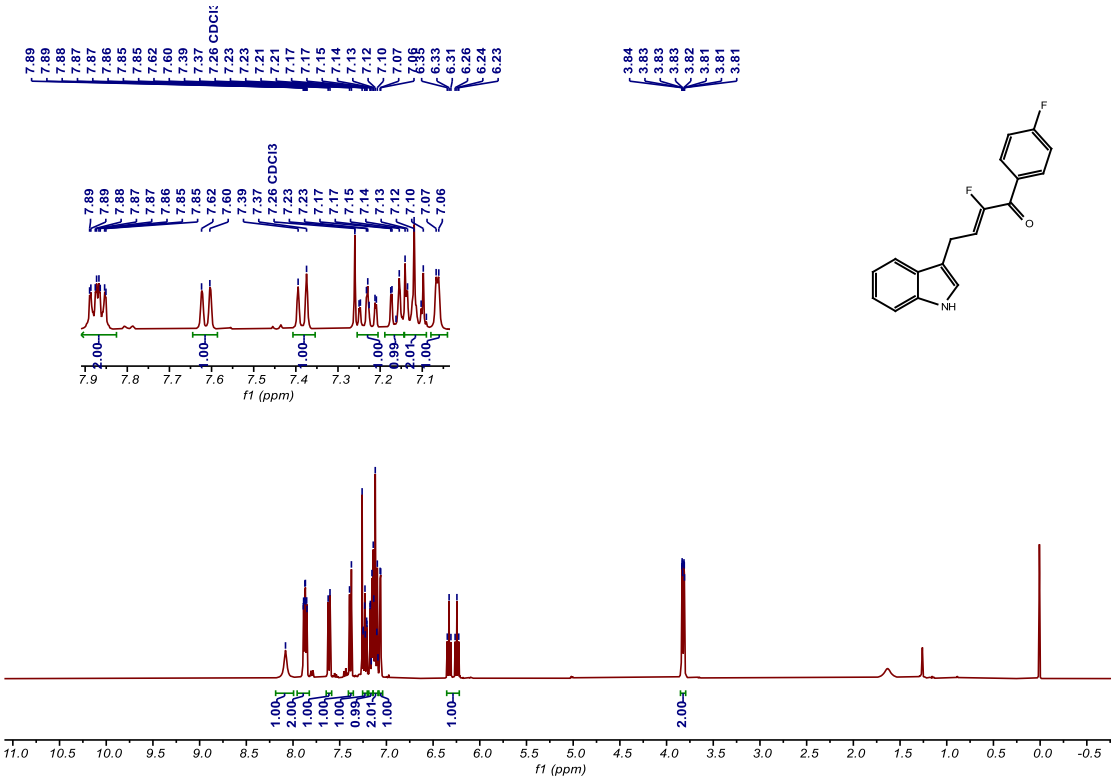
**$^{13}$C NMR** (101 MHz, $CDCl_3$) **of 10af**



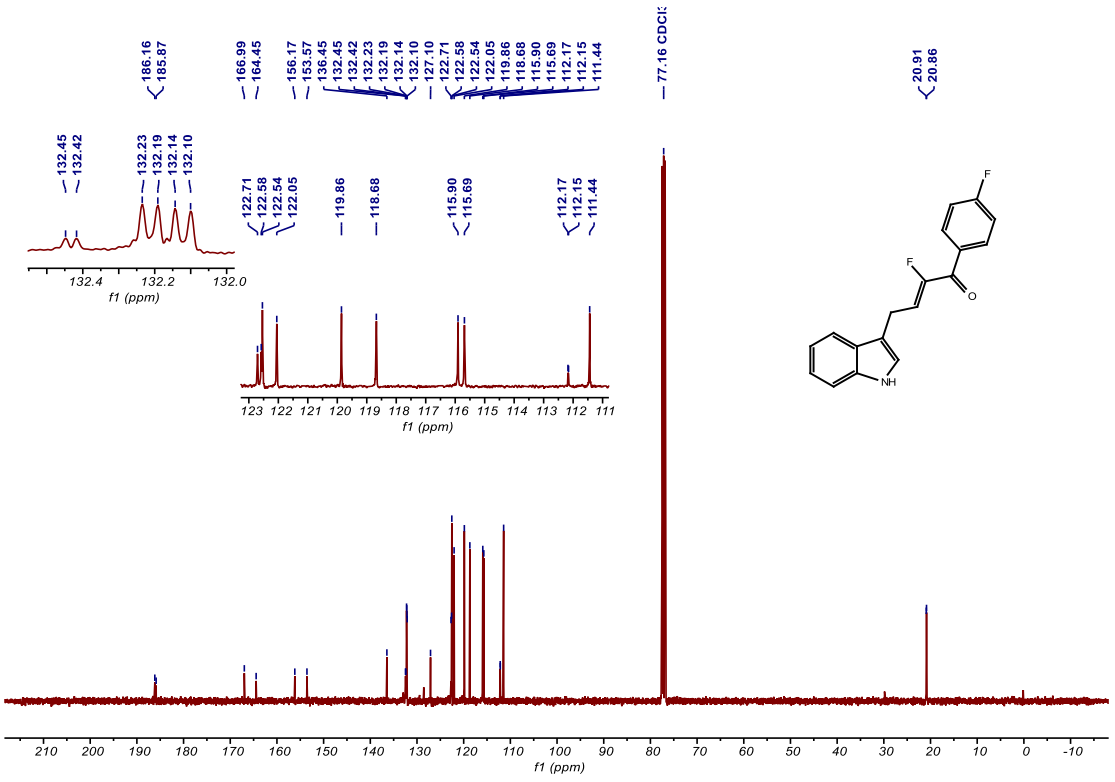

**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10af**



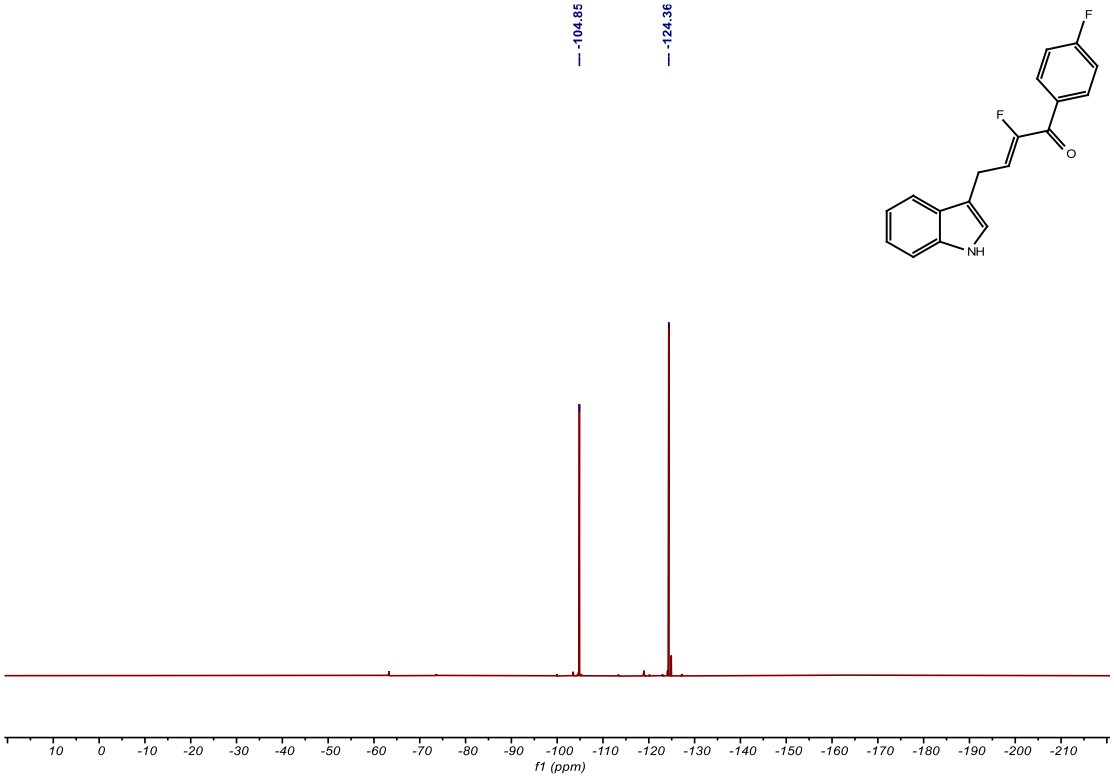
## $^{1}$H NMR (400 MHz, $CDCl_3$) of 10ag



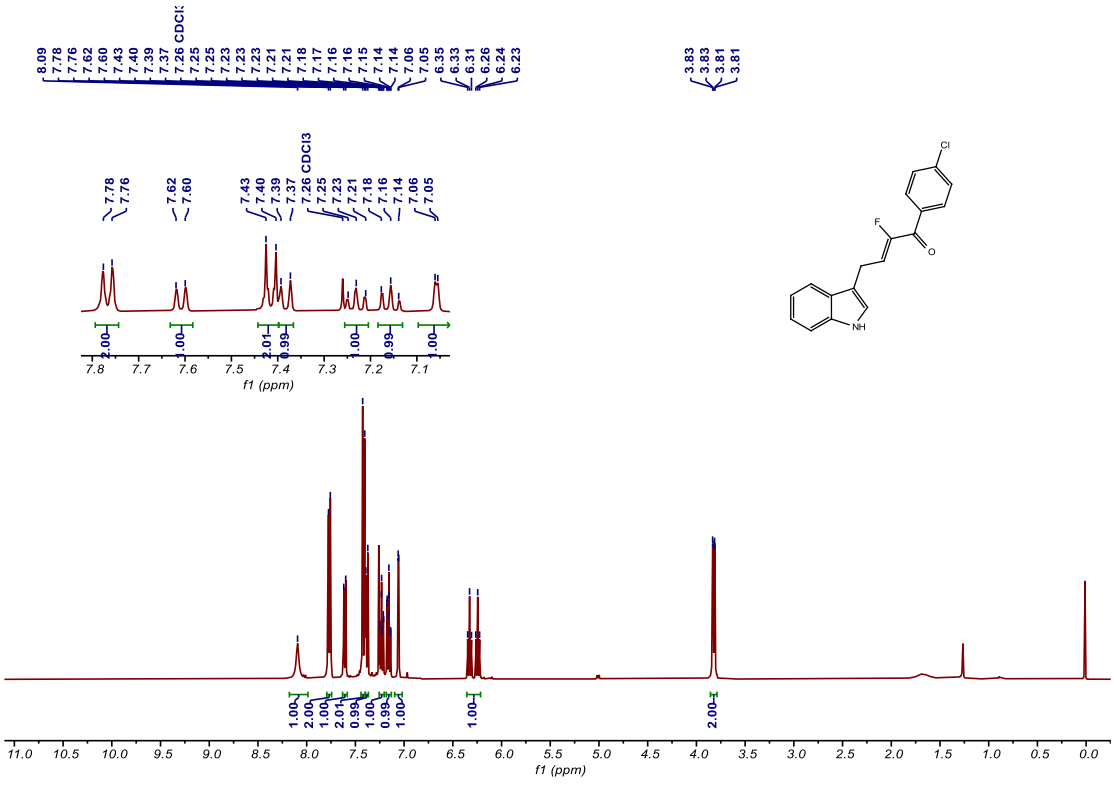

## $^{13}$C NMR (101 MHz, $CDCl_3$) of 10ag



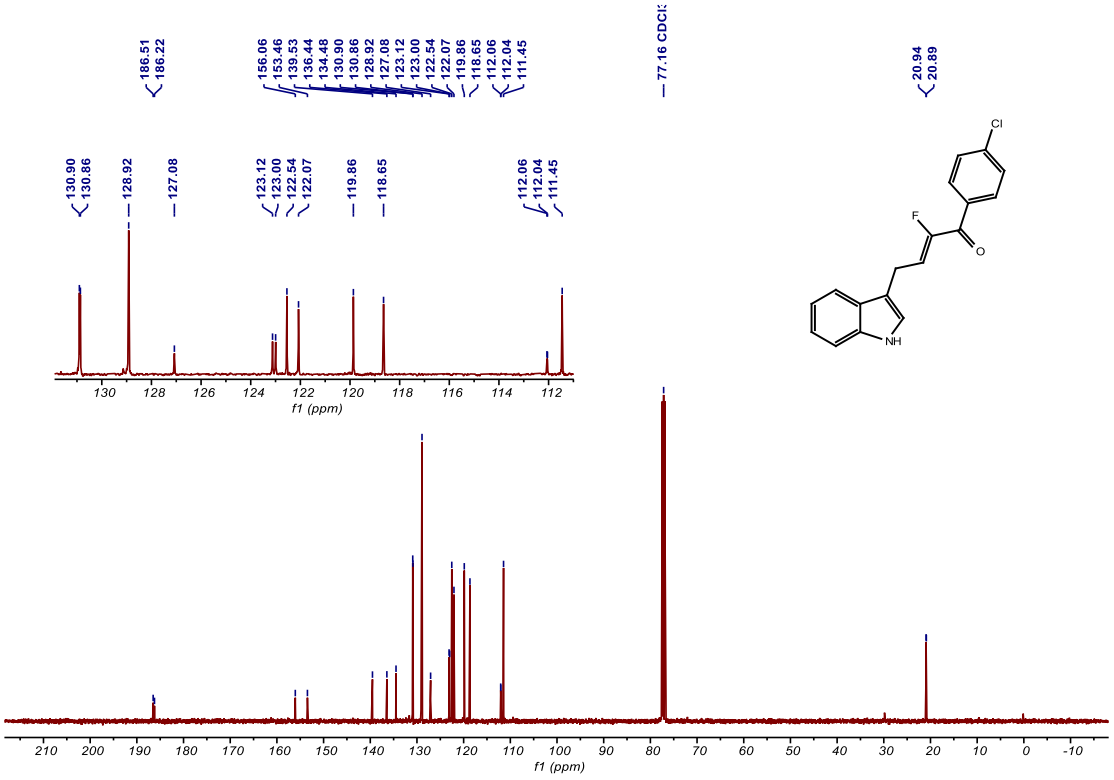
**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10ag**



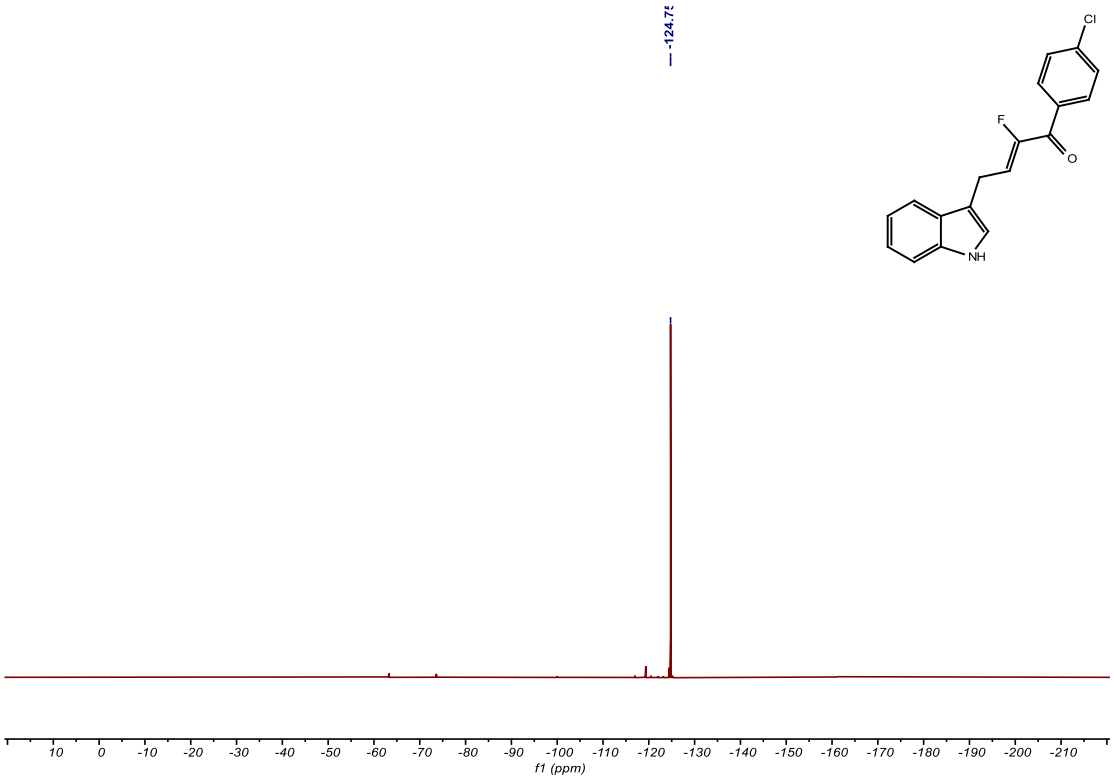

**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10ah**



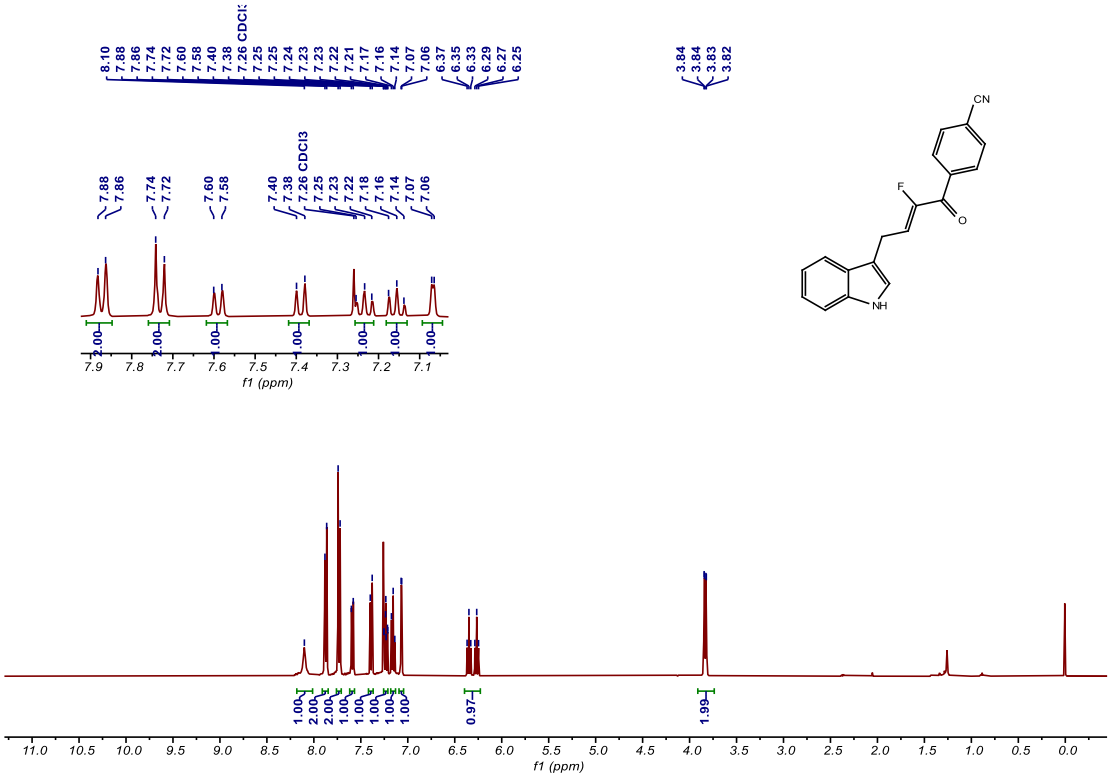
**$^{13}$C NMR** (101 MHz, $CDCl_3$) **of 10ah**



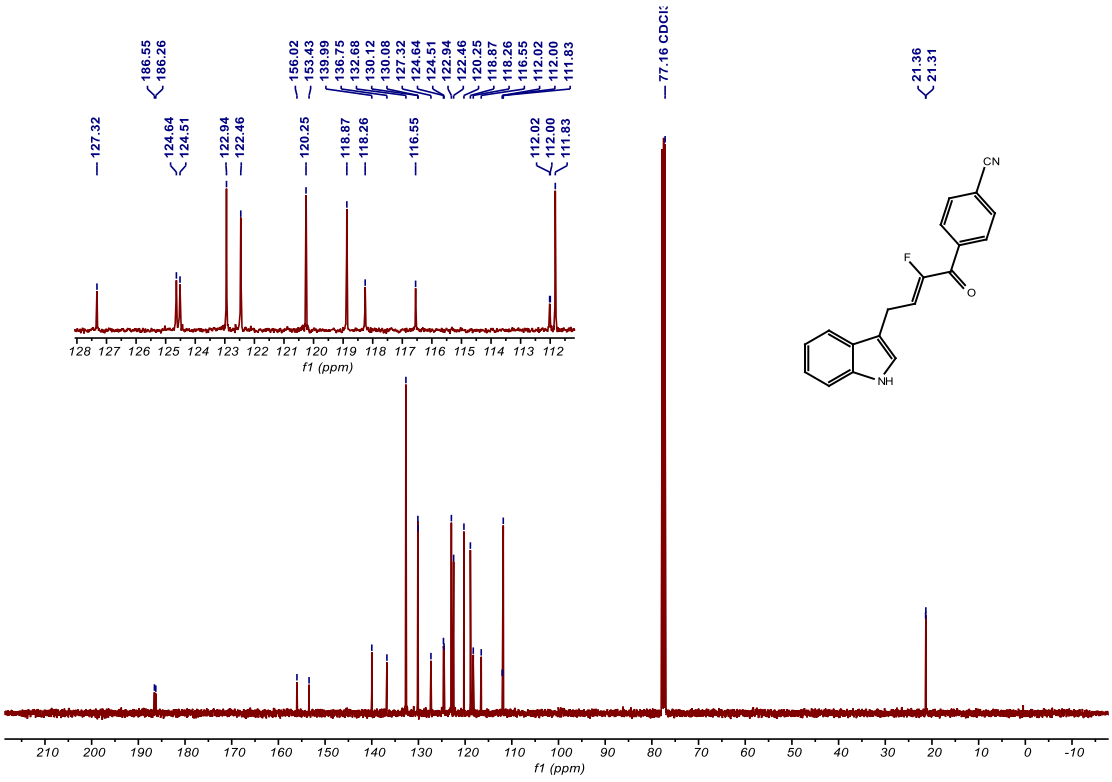

**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10ah**



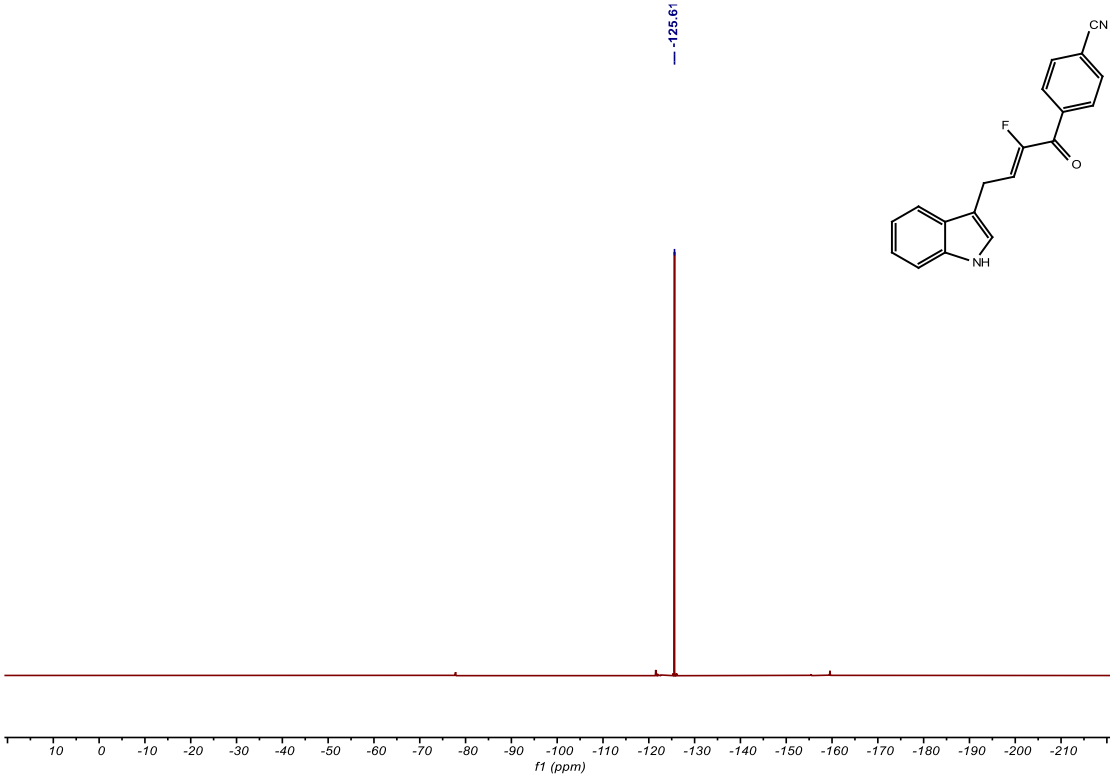
**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10ai**



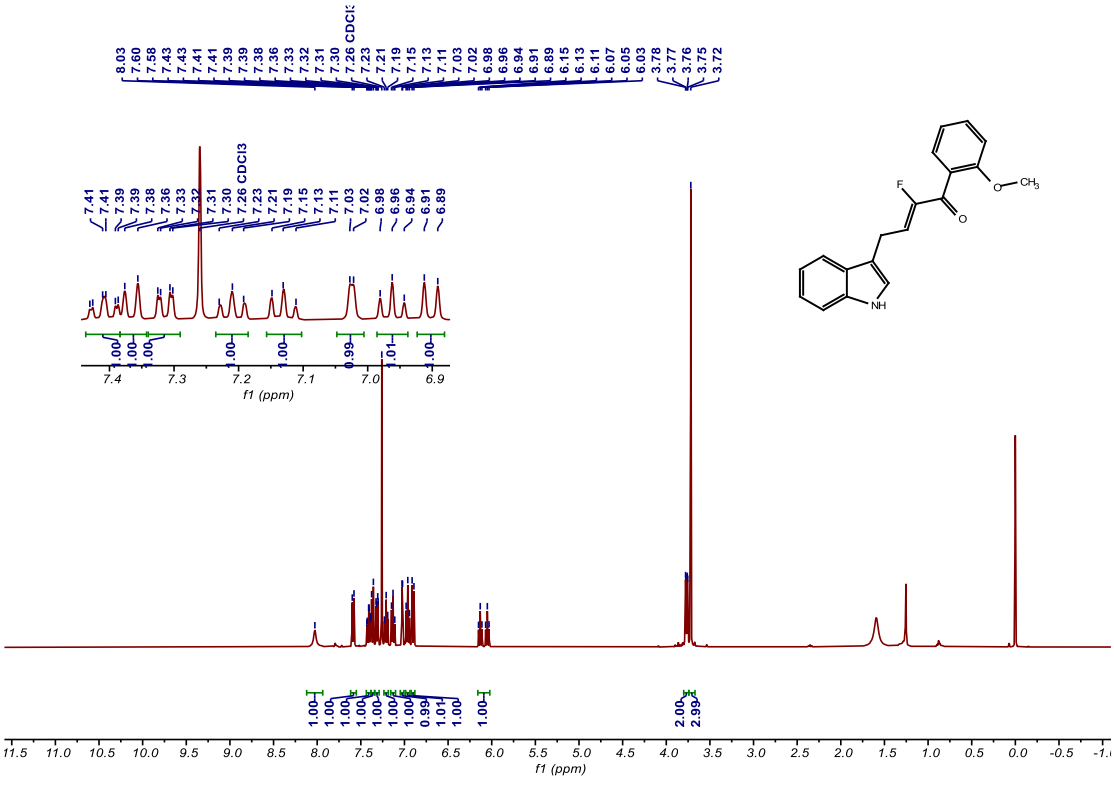

**$^{13}$C NMR** (101 MHz, $CDCl_3$) **of 10ai**



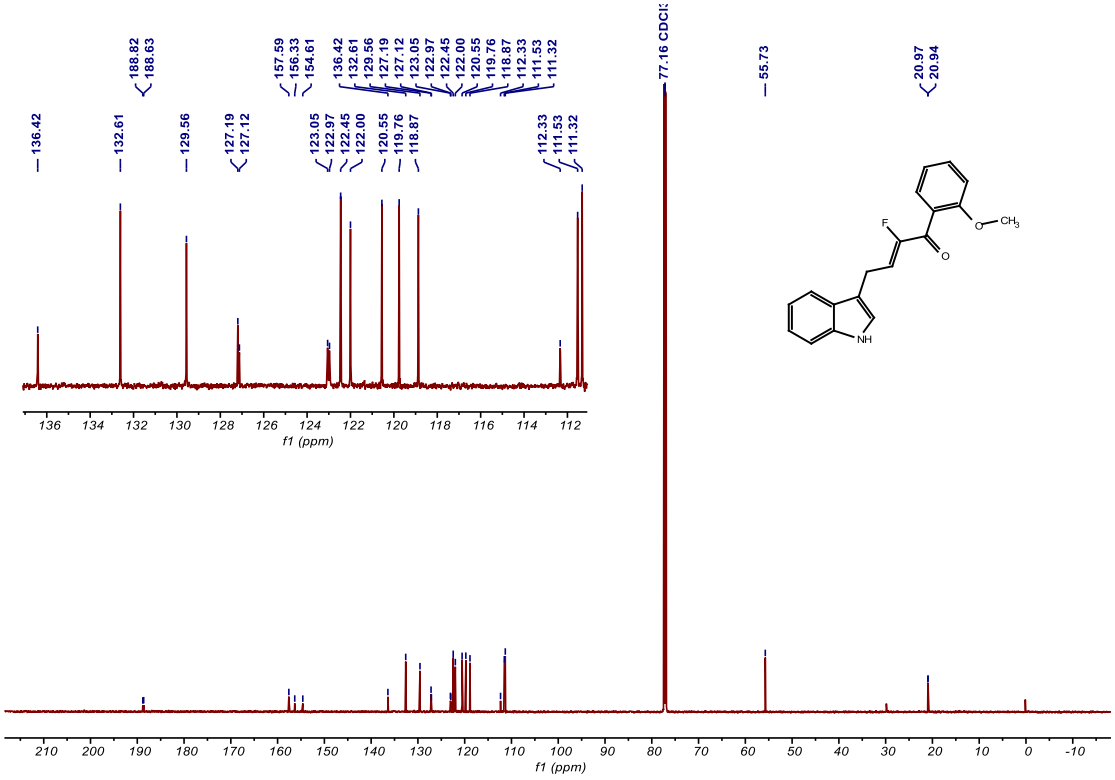
**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10ai**



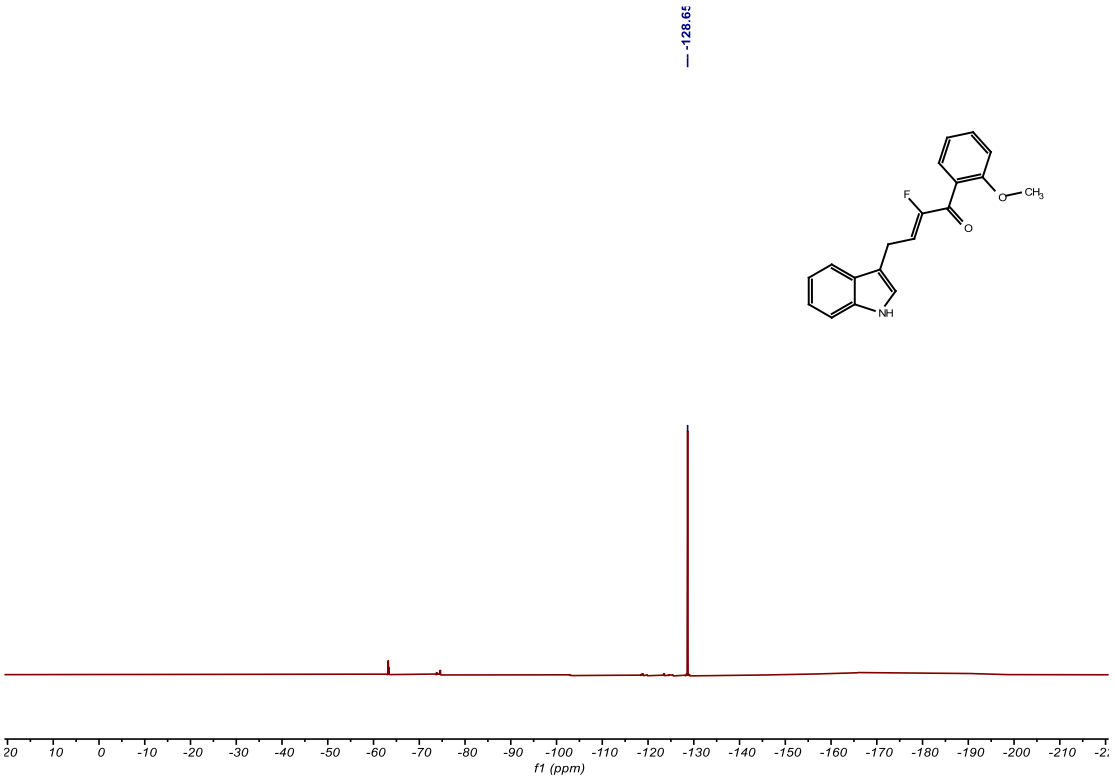

**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10aj**



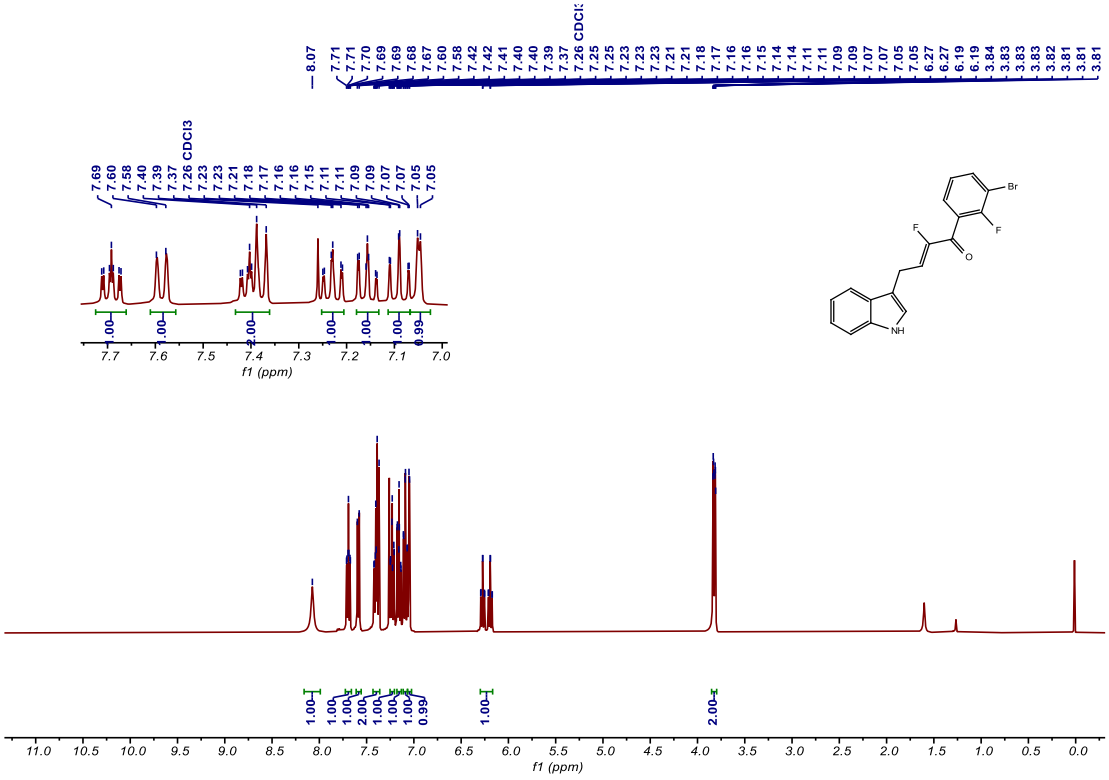
**$^{13}$C NMR** (151 MHz, $CDCl_3$) **of 10aj**



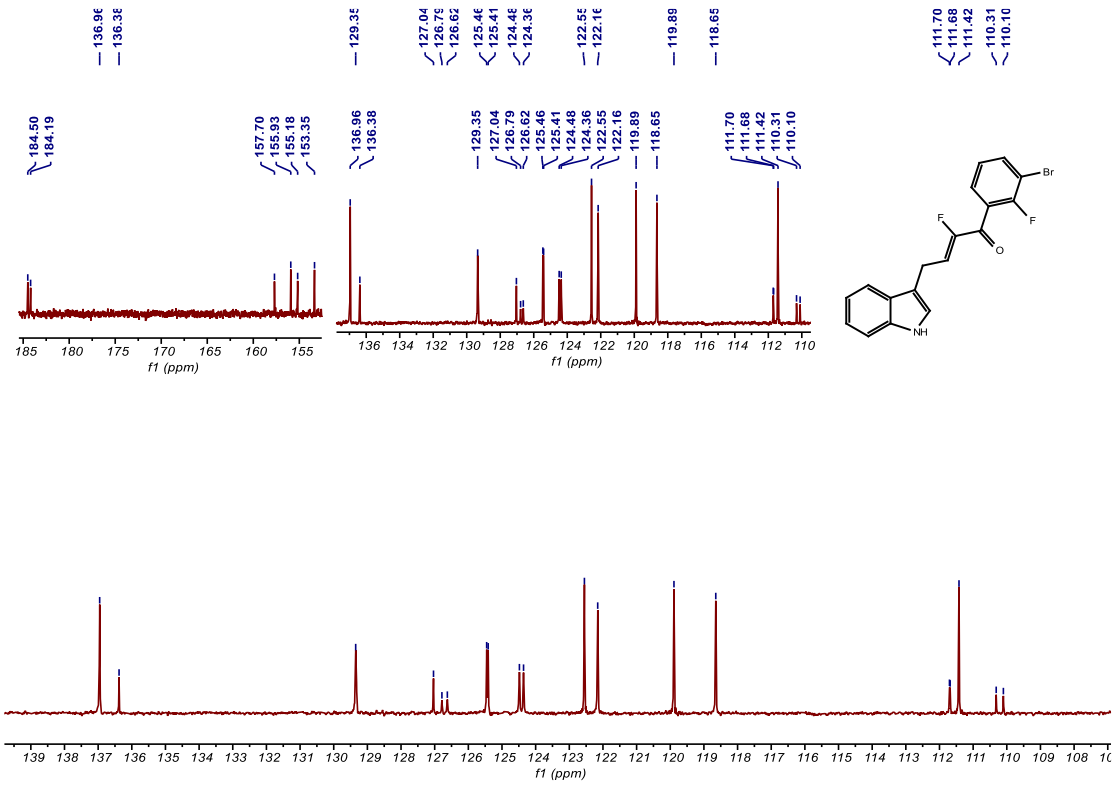

**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10aj**



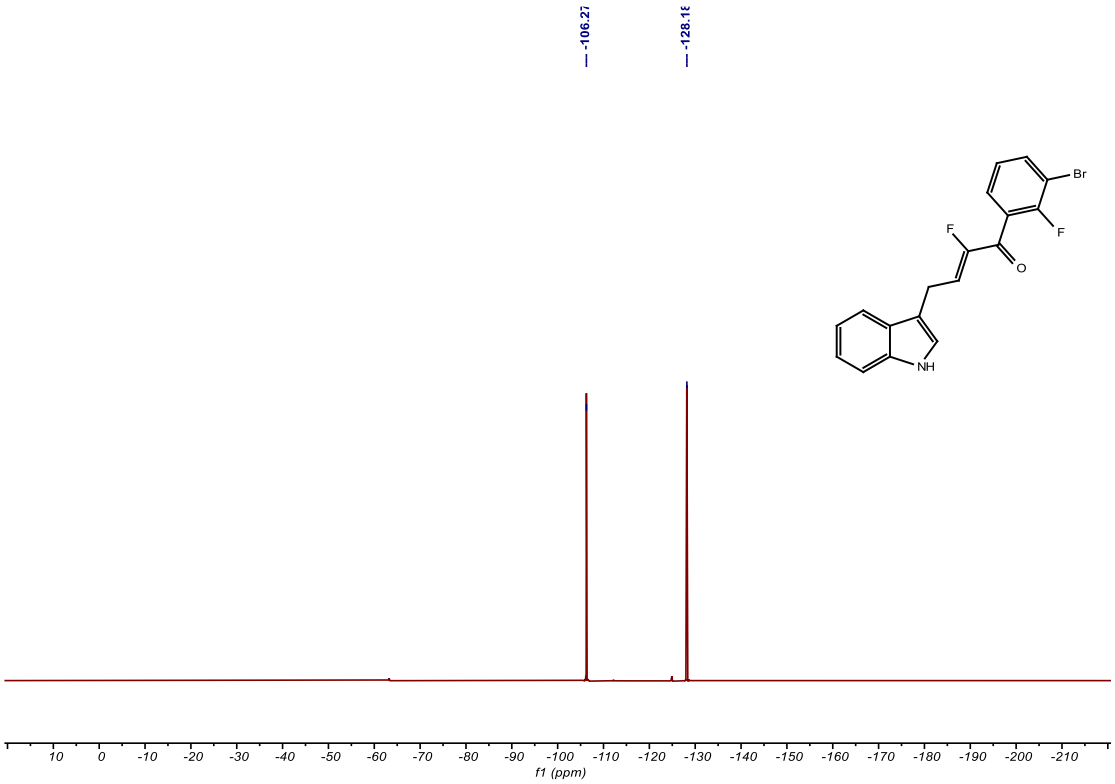
## $^{1}$H NMR (400 MHz, $CDCl_3$) of 10ak



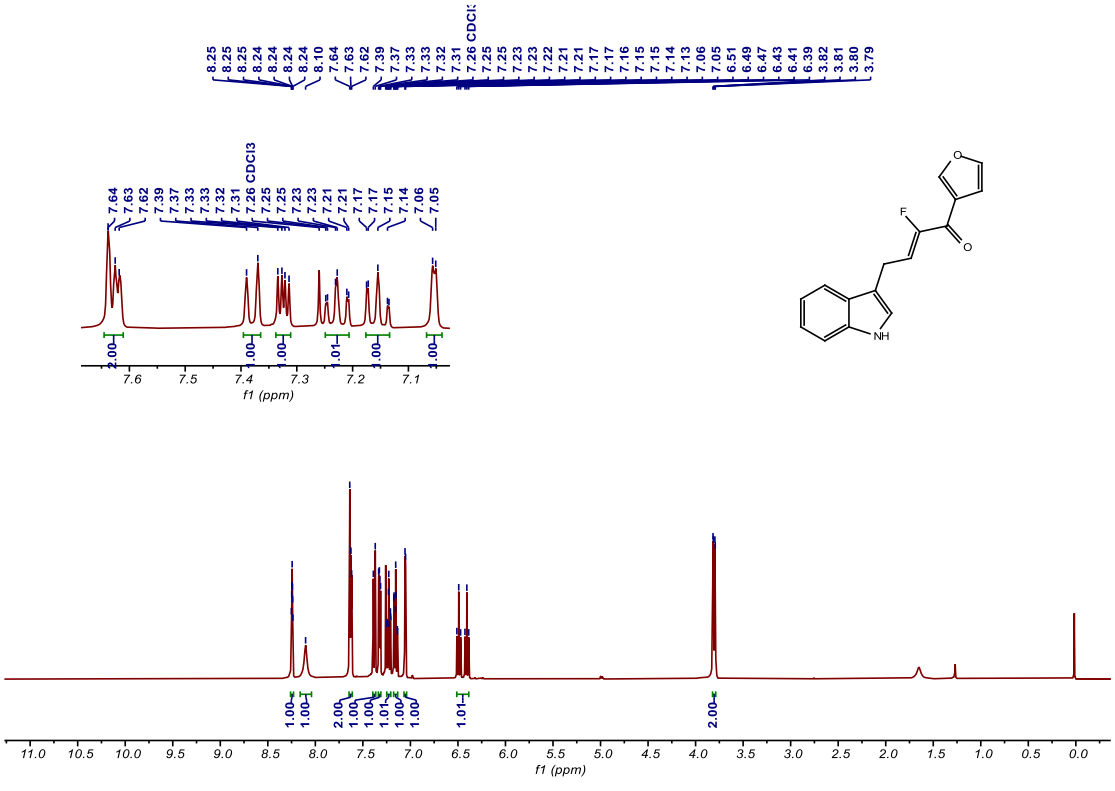

## $^{13}$C NMR (101 MHz, $CDCl_3$) of 10ak



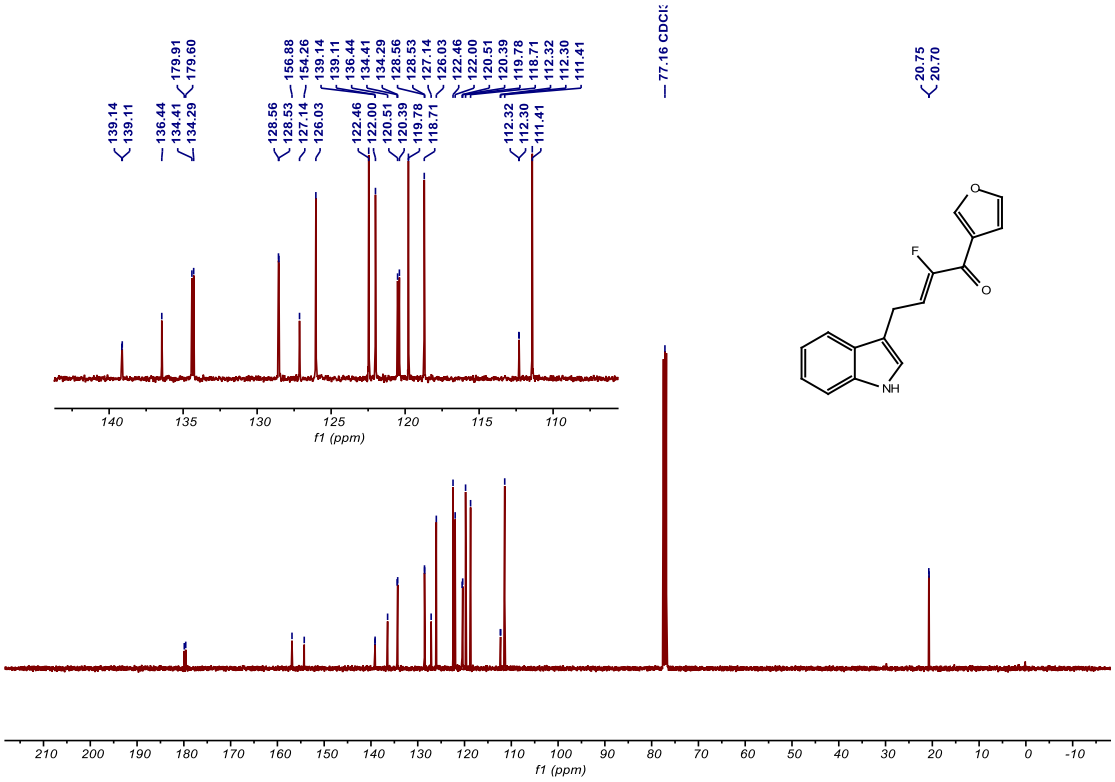
**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10ak**



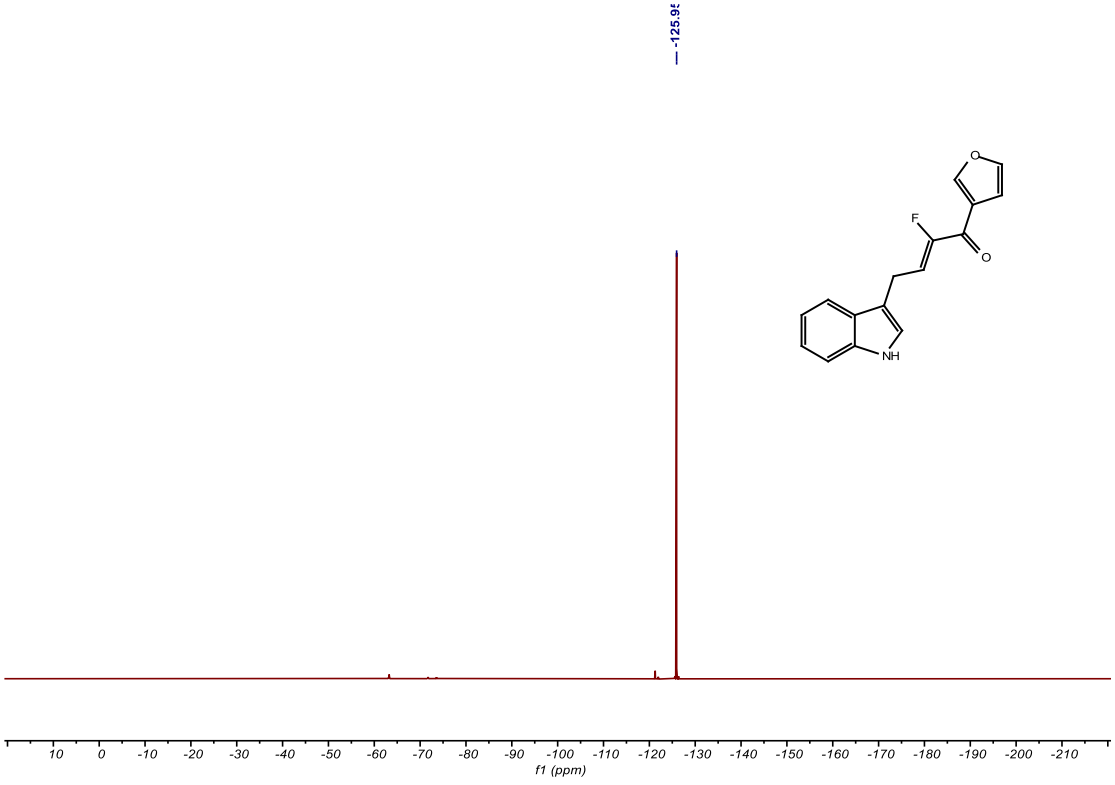

**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10al**



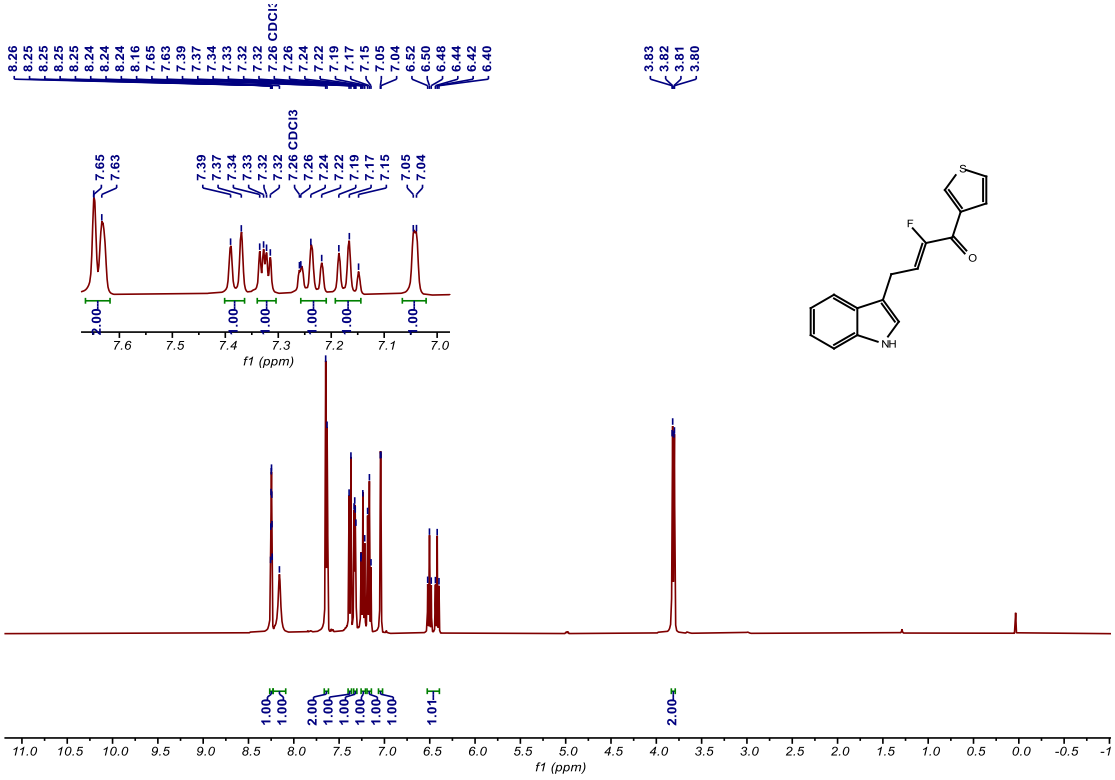
**$^{13}$C NMR** (101 MHz, $CDCl_3$) **of 10al**



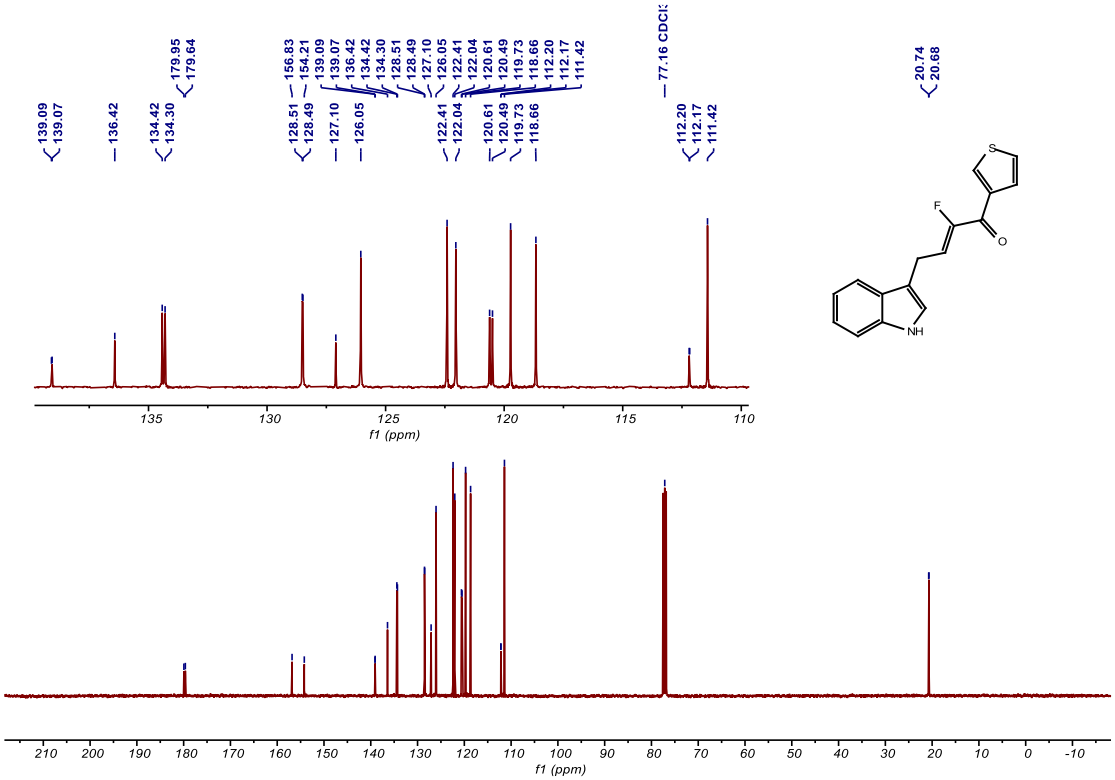

**$^{19}$F NMR** (377 MHz, $CDCl_3$) **of 10al**



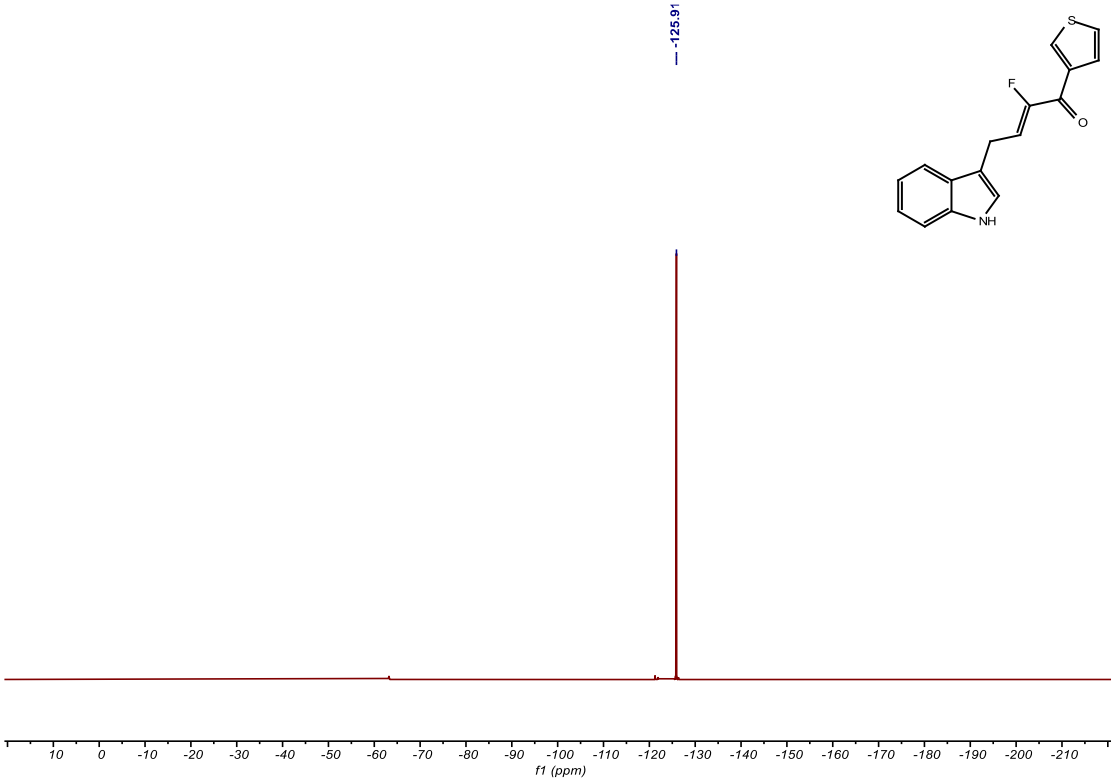
**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10am**



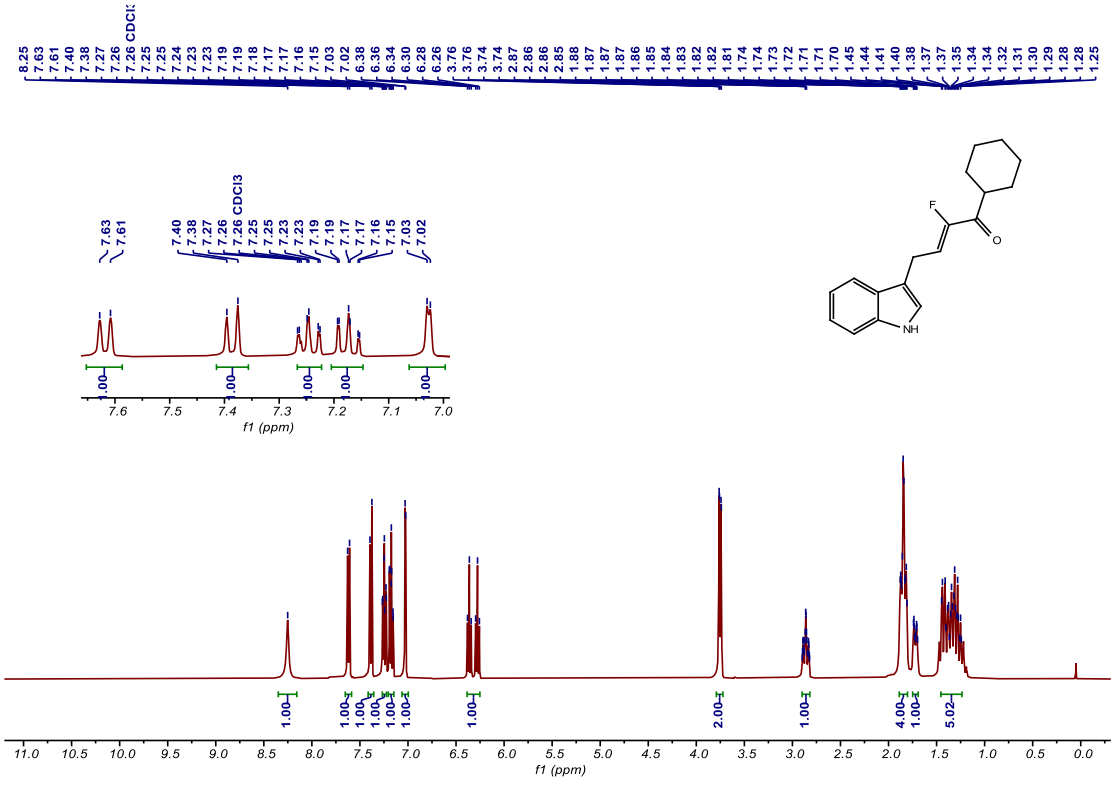
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10am**



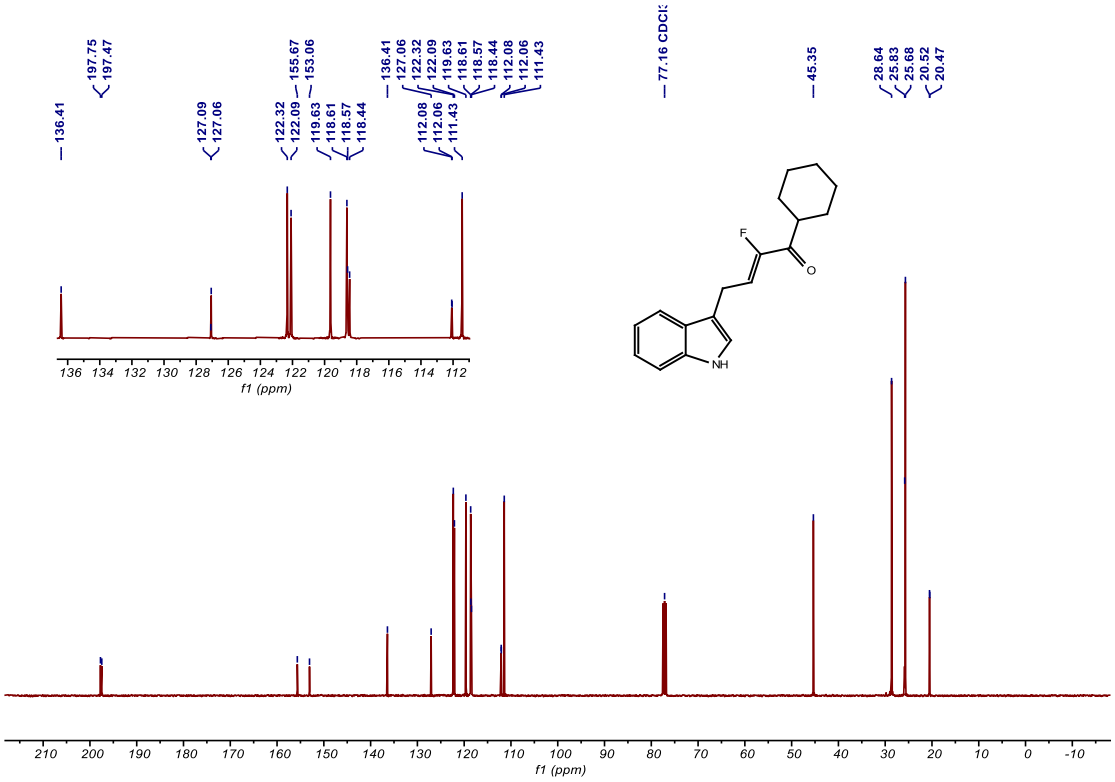
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10am**



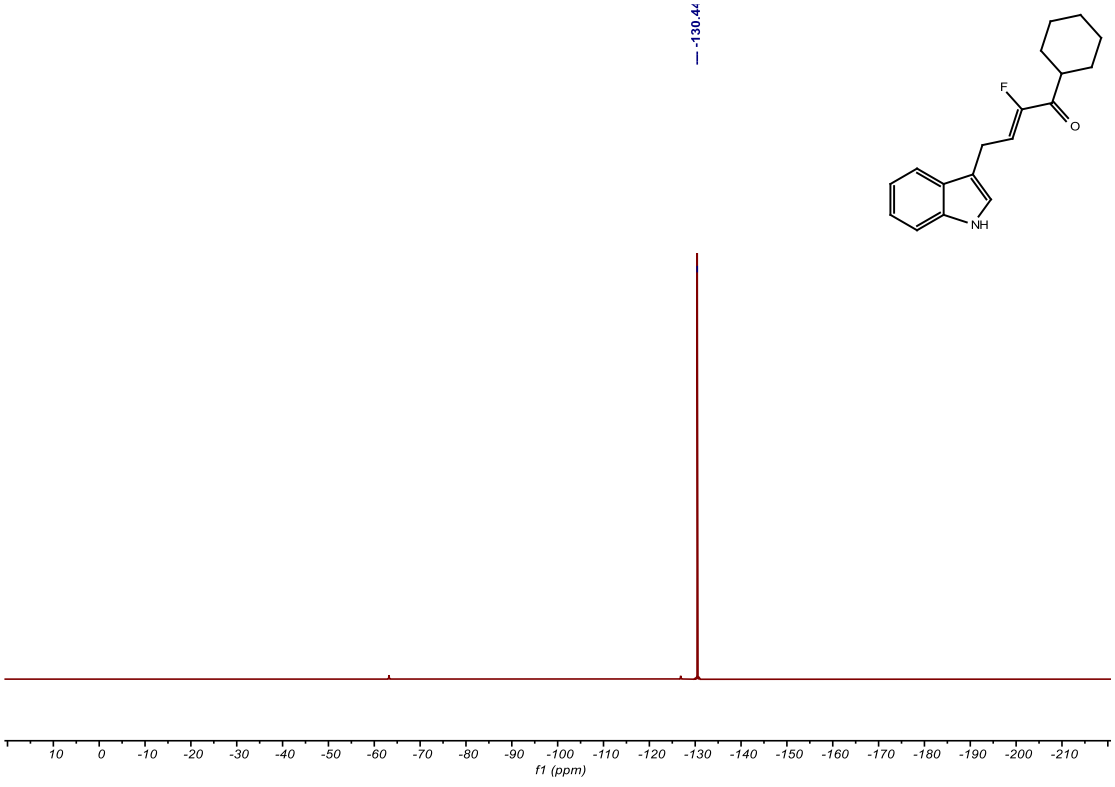

**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10an**



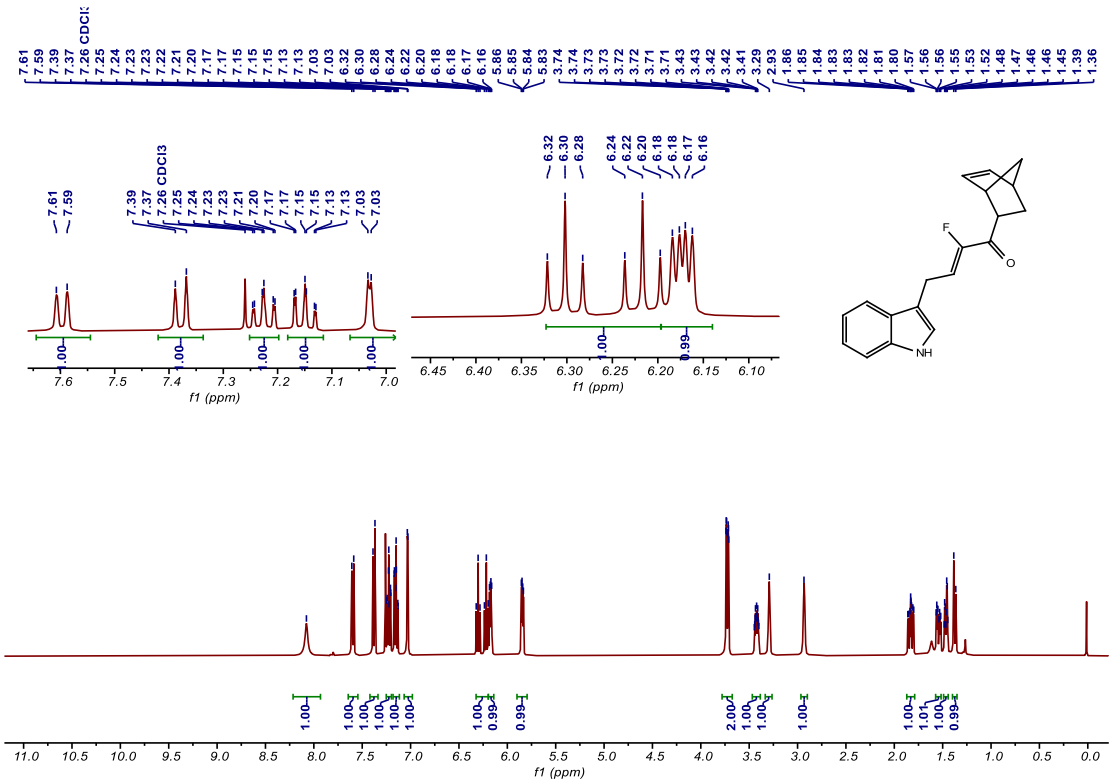
**$^{13}$C NMR** (101 MHz, $CDCl_3$) **of 10an**



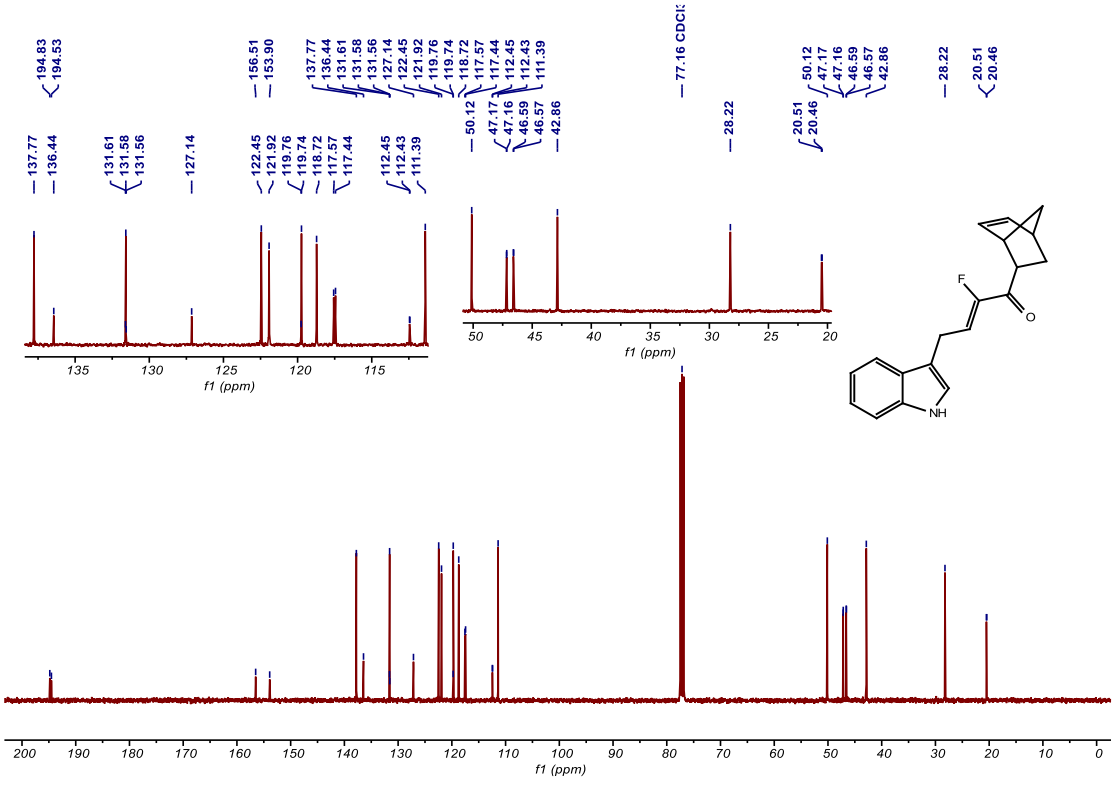

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10an**



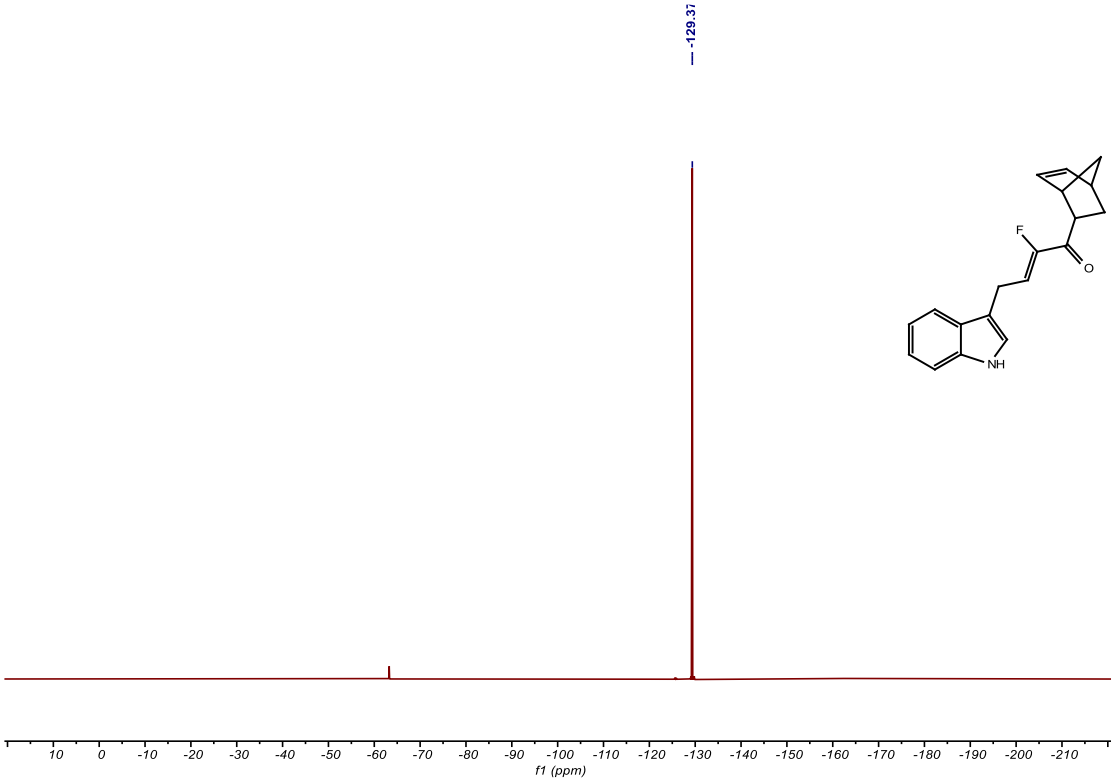
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **10ao**



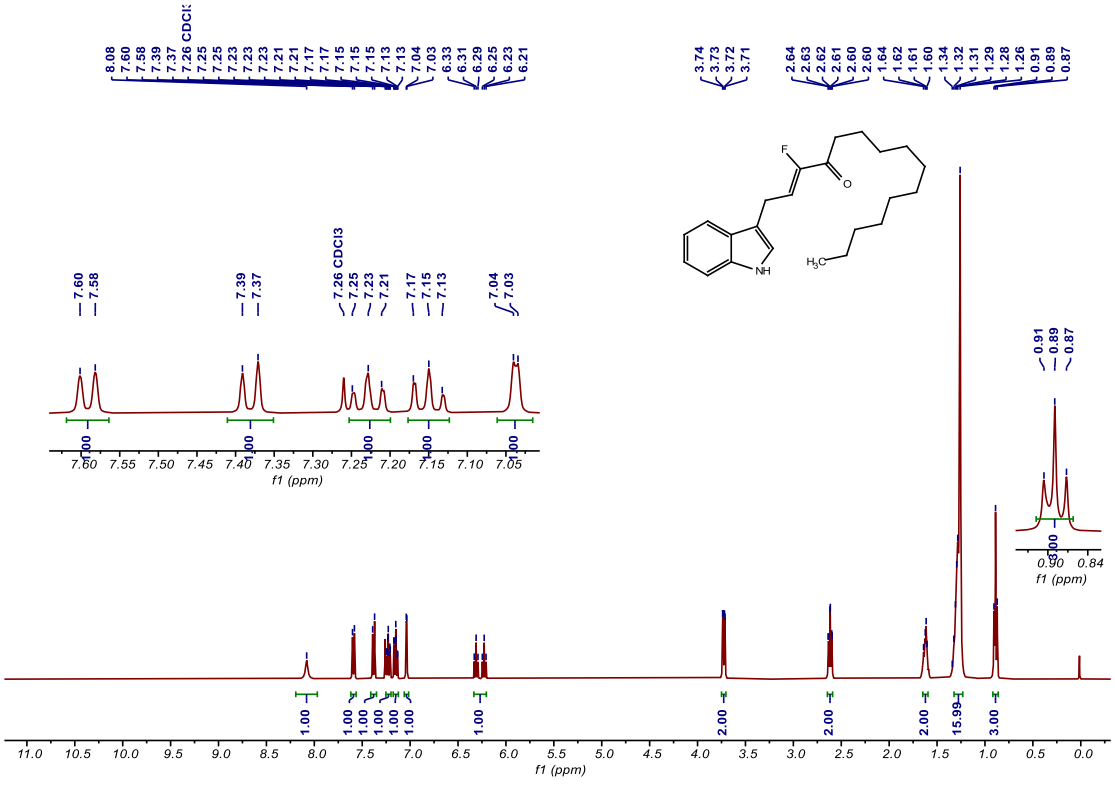
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ao**



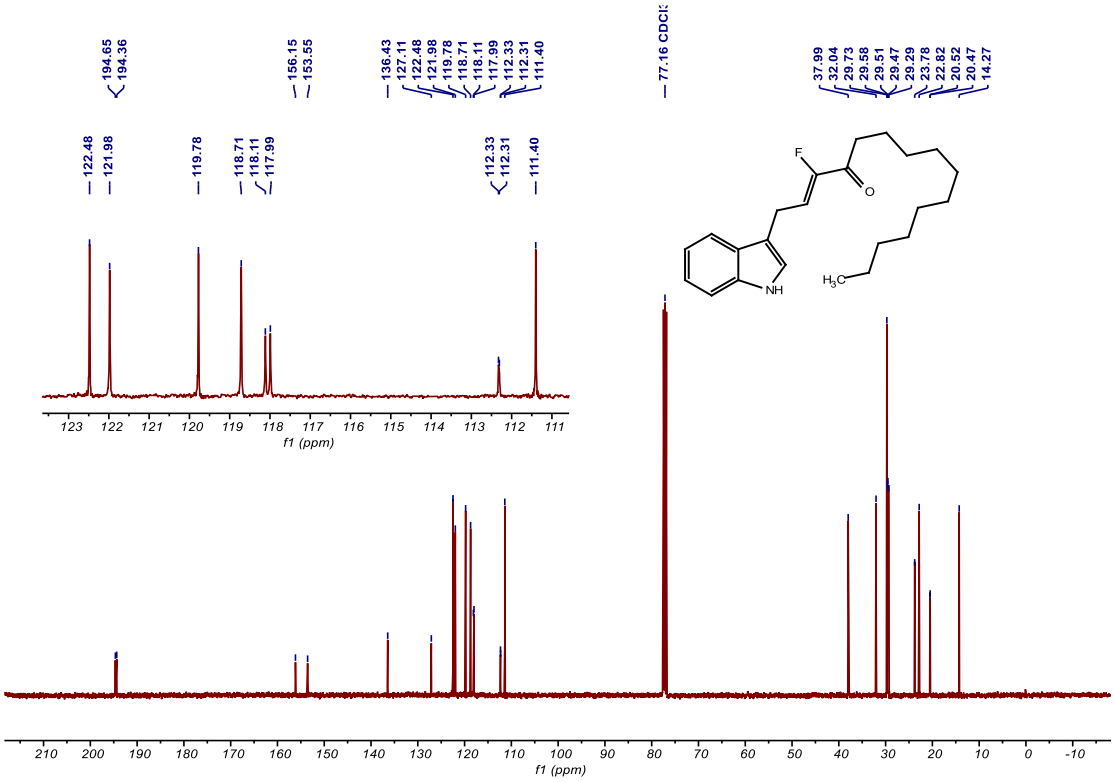
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ao**



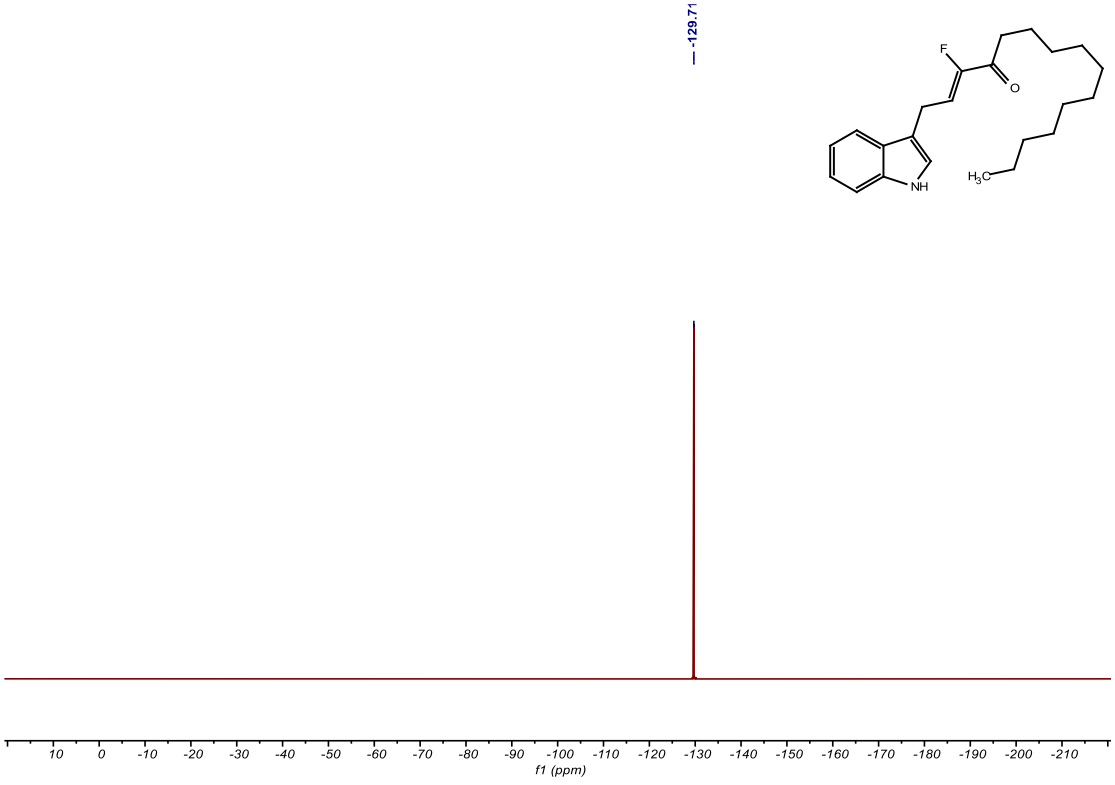

**$^{1}$H NMR** (400 MHz, $CDCl_3$) **of 10ap**



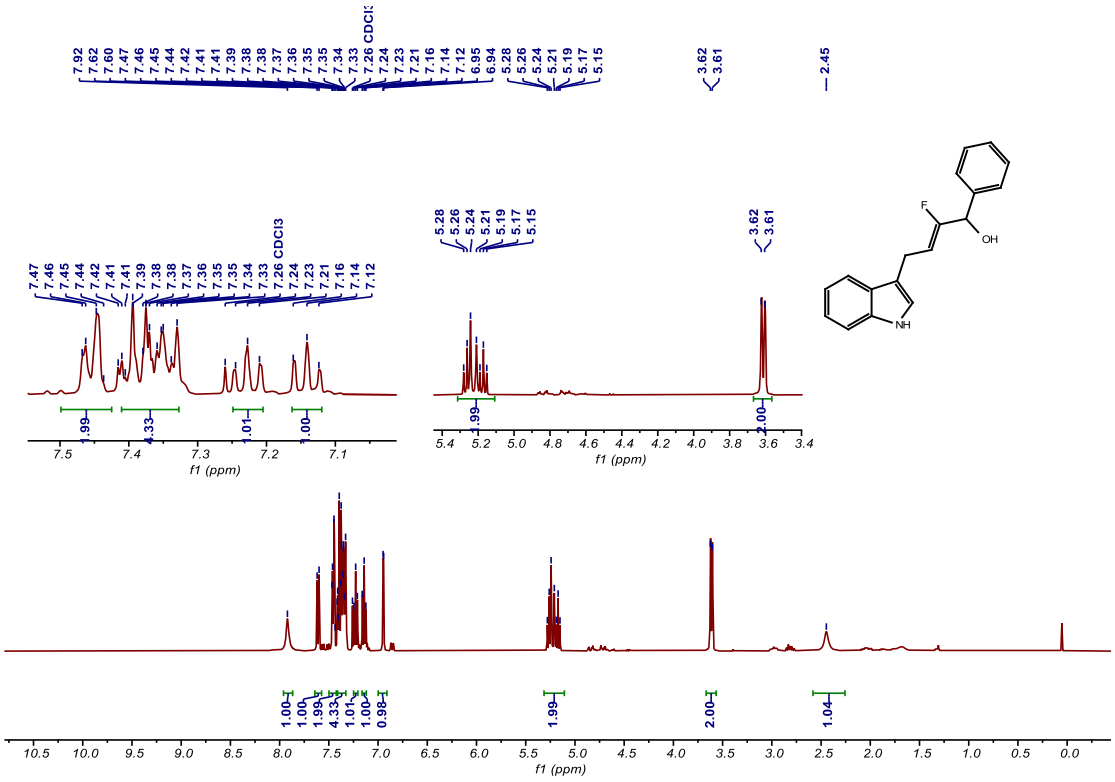
**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **10ap**



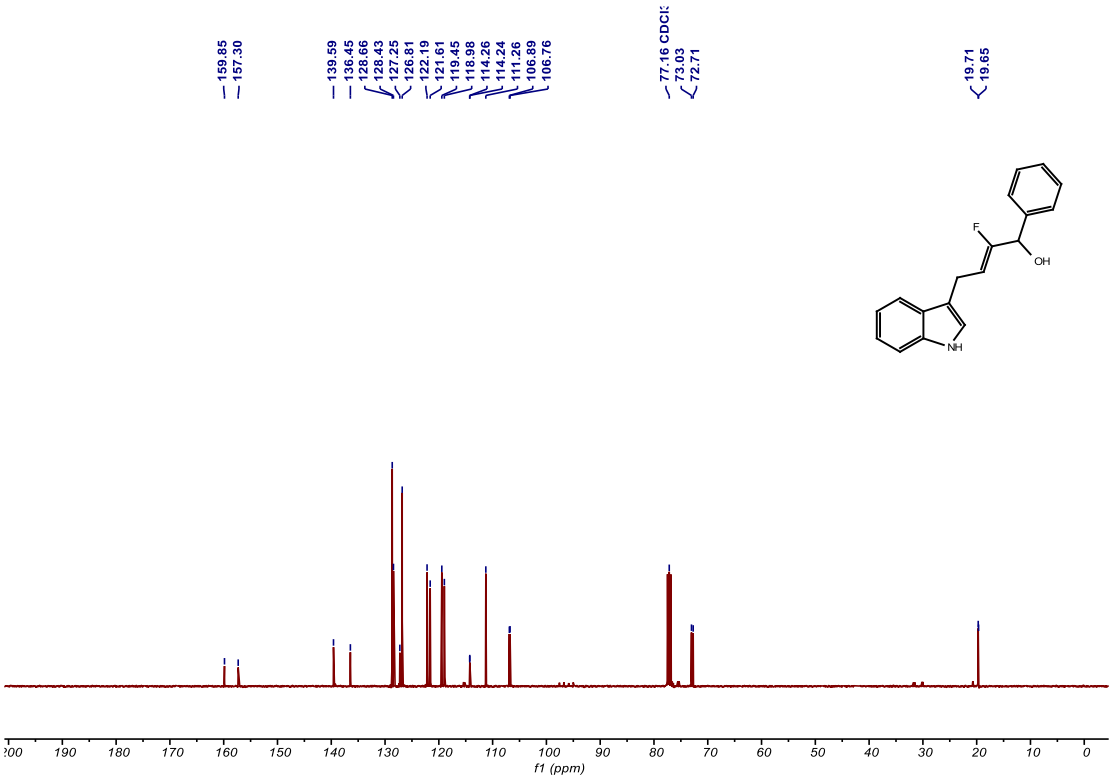

**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **10ap**



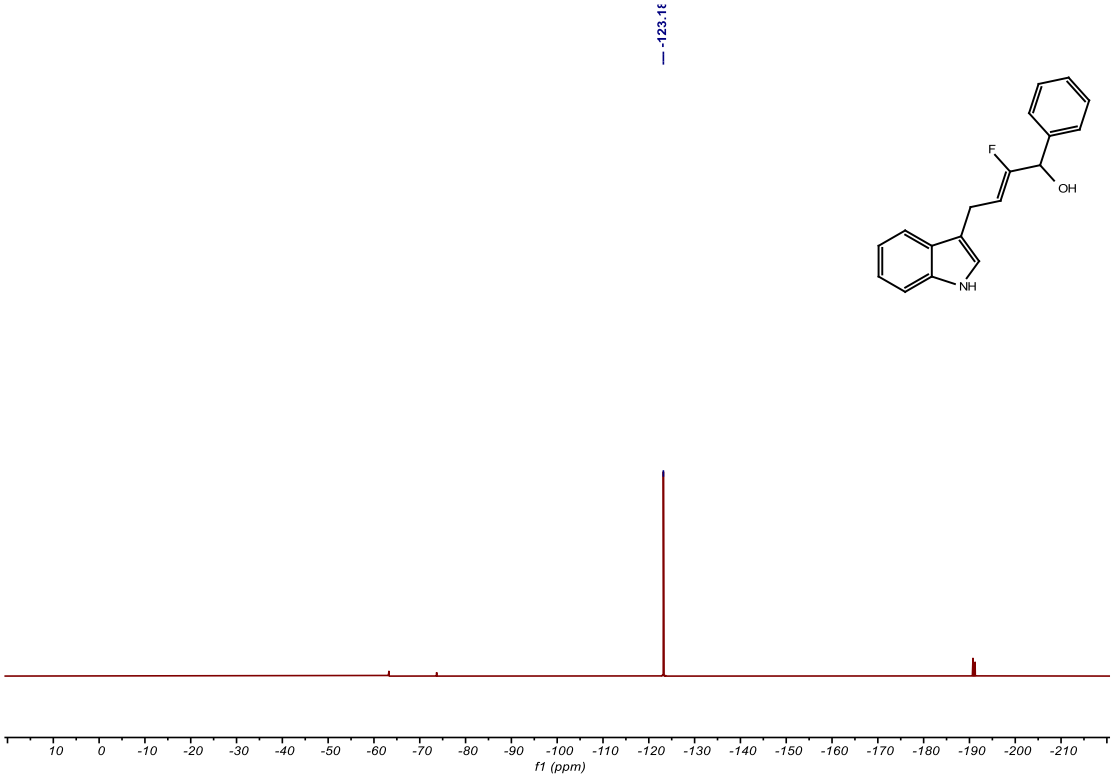
**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **11**



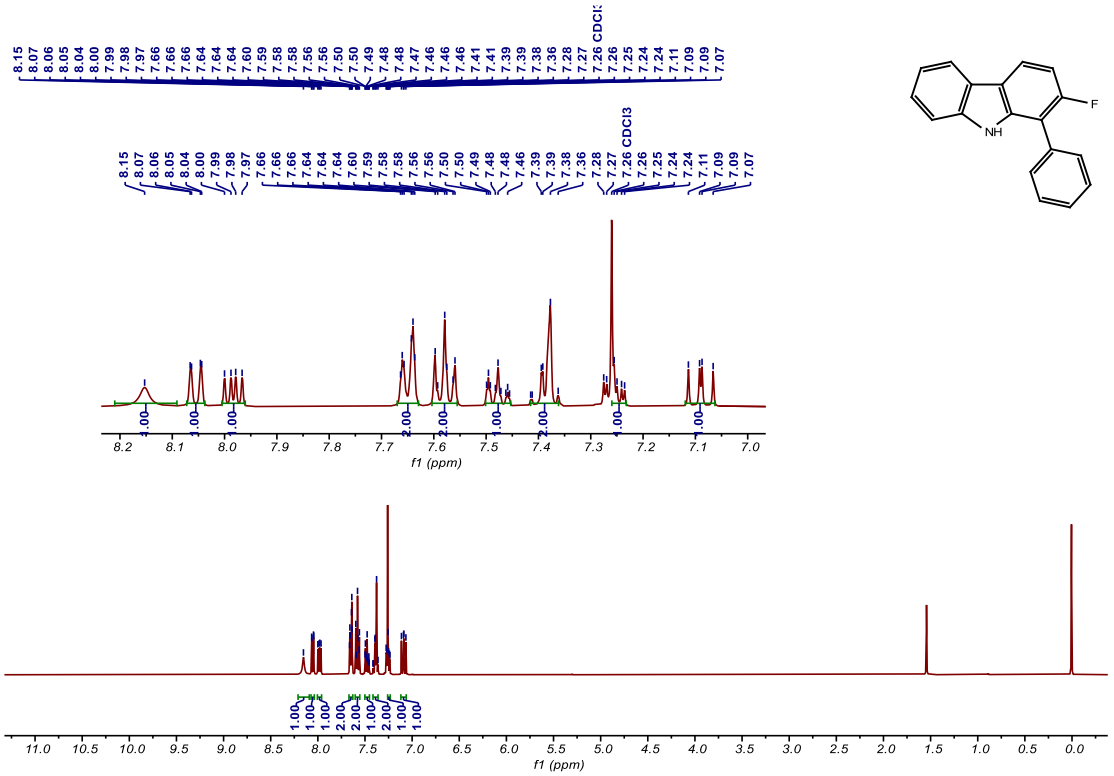

**$^{13}$C NMR** (101 MHz, $CDCl_3$) of **11**



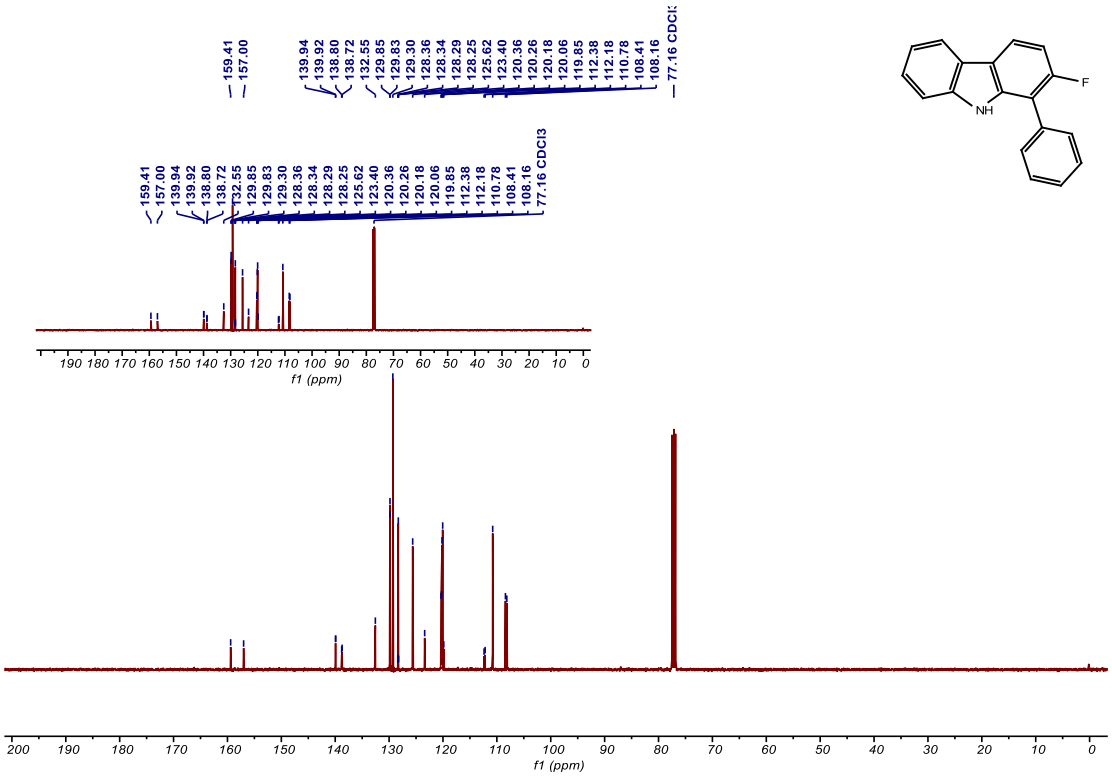
**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **11**




**$^{1}$H NMR** (400 MHz, $CDCl_3$) of **13**



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




**$^{19}$F NMR** (377 MHz, $CDCl_3$) of **13**