High stereoselectivity synthesis of *Z*-3-methyleneisoindolin-1-ones on Cu/ETS-10 catalyst via domino coupling-cyclization without the use of protective groups and ligands

Huiling Hu, Changjun Liu,* Chaojie Zhu, Chenghong Liu and Tiandi Tang*

School of Petrochemical Engineering, Changzhou University, Changzhou, Jiangsu 213164, P. R. China.

*Corresponding author.

***E-mail address*:** 20070303032@smail.cczu.edu.cn (C. Liu)

tangtiandi@cczu.edu.cn (T. Tang)

Table of Contents

1. General remarks

Reagents and solvents: Unless otherwise noted, the chemicals were commercially available and were used without further purification.

Purification: The products were isolated from the reaction mixture by column chromatography on silica gel, 100-300 mesh. Gradient flash chromatography was conducted eluting with PE/EA, PE refers to the mixture of pentane and hexane, and EA refers to ethyl acetate.

Data collection: The yields of production were calculated by gas chromatography (GC). GC analysis was performed on an Agilent 7890B instrument with FID detector and HP-5 capillary column (polydimethylsiloxane with 5% phenyl groups, 30 m, 0.32 mm i.d., 0.25 μm film thickness) using argon as carrier gas. Infrared spectra were recorded on a Bruker TENSOR 27 FT-IR spectrometer. NMR spectra were recorded on Bruker AVANCE III 300 MHz and Bruker AVANCE III 400 MHz spectrometers. Chemical shifts (ppm) were given relative to tetramethylsilane (TMS). Electron impact (EI) mass spectra were recorded on Agilent 5977B mass spectrometer (70 eV). The data were given as mass units per charge (m/z). High resolution mass spectra (HRMS) were obtained on Thermo Fisher Exactive spectrometer with an ESI source. All measurements were carried out at room temperature unless otherwise stated. Where given, systematic compound names were those generated by ChemDraw 19.0. The spectra data were consistent with previously reported compound structures.

2. The textural parameters of the samples

Table S1 Textural parameters of the samples.

Sample	S_{BET}(m^2/g)[a]	S_{EXT}(m^2/g)[b]	$V_{micro.}$(cm^3/g)[c]	$V_{meso.}$(cm^3/g)[d]
ETS-10	375	104	0.11	0.03
Cu/ETS-10	367	98	0.11	0.03
Cu/Beta	536	124	0.19	0.05
Cu/ZSM-5	349	58	0.12	0.05
Cu/Silicata-1	417	231	0.10	0.17

[a]BET specific surface area. [b]External surface area, obtained from t-plot method. [c]Microporous poor volume.

[d]Mesoporous pore volume.

3. Experiment

3.1 General procedure of the domino coupling-cyclization reaction

A typical procedure for the domino coupling-cyclization reaction of 2-halogenated benzamide with terminal alkynes was as follows: A mixture of 2-iodobenzamide (**1a**, 0.7 mmol), phenylacetylene (**2a**, 0.5 mmol), 1,3,5-trimethylbenzene (as internal standard, 0.5 mmol), Cu/ETS-10 (30 mg), Cs_2CO_3 (0.1 mmol) and DMSO (1.5 mL) was added in a 10 mL reaction tube. The reaction mixture was heated at 100 °C for 6 h under vigorous stirring (500 rpm). After reaction, the catalyst was removed by filtration. The liquid product was collected and analyzed by GC.

3.2 The experiment of competitive reaction

In the fume hood, a reaction tube (10 mL) containing a stirring magneton was charged with Cu/ETS-10 (30 mg), Cs_2CO_3 (0.1 mmol), 2-iodobenzamide (**1a**, 0.70 mmol), 4-trifluoromethyl phenylacetylene (**2n**, 0.25 mmol), 4-methoxy phenylacetylene (**2e**, 0.25 mmol), 1,3,5-trimethylbenzene (0.25 mmol) and DMSO (1.5 mL). Then, the mixture was stirred at 100 °C for 2 h. After the reaction was complete, the reaction tube cooled down to room temperature, and the catalyst was removed by filtration. A proper amount of solution was taken for GC analysis.

In the fume hood, a reaction tube (10 mL) containing a stirring magneton was charged with Cu/ETS-10 (30 mg), Cs_2CO_3 (0.1 mmol), 2-iodobenzamide (**1a**, 0.70 mmol), 4-methoxy phenylacetylene (**2e**, 0.25 mmol), 4-methyl phenylacetylene (**2b**, 0.25 mmol), 1,3,5-trimethylbenzene (0.25 mmol) and DMSO (1.5 mL). Then, the mixture was stirred at 100 °C for 2 h. After the reaction was completed, the reaction tube cooled down to room temperature, and the catalyst was removed by filtration. A proper amount of solution was taken for GC analysis.

3.3 The effect of catalysts on configuration selectivity

In the fume hood, a reaction tube (10 mL) containing a stirring magneton was

charged with Cu/ETS-10 (30 mg), Cs_2CO_3 (0.1 mmol), 2-iodobenzamide (**1a**, 0.7 mmol), phenylacetylene (**2a**, 0.5 mmol), 1,3,5-trimethylbenzene (0.5 mmol) and DMSO (1.5 mL). The mixture was stirred at 60 °C for 6 h. After reaction, the catalyst was removed by filtration. The liquid product was collected and analyzed by GC. The ratio of *Z*- and *E*-isomers was determined by ^{1}H NMR analysis of the product **3a** mixture. In addition, four reaction experiments were prepared and the reaction temperatures were changed to 70 °C, 80 °C, 90 °C, and 100 °C, respectively. Repeating the experiments according to the same experimental procedure above.

As comparative experiment, the Cu/ETS-10 catalyst in the reaction system was replaced with CuO (1.2 mg), and repeating the experiments according to the same experimental procedure above.

3.4 The exploring of initial activation step

In the fume hood, a reaction tube (10 mL) containing a stirring magneton was charged with Cu/ETS-10 (30 mg), Cs_2CO_3 (0.1 mmol), 2-iodobenzamide (**1a**, 0.7 mmol), 1,3,5-trimethylbenzene (0.5 mmol) and DMSO (1.5 mL). The mixture was stirred at 100 °C for 1 h. The reaction tube was cooled down to room temperature and phenylacetylene (**2a**, 0.5 mmol) was added to the reaction tube. The reaction tube was stirred at 100 °C for 1 hour again. After the reaction was completed, the catalyst was removed by filtration. A proper amount of solution was taken for GC analysis.

In the fume hood, a reaction tube (10 mL) containing a stirring magneton was charged with Cu/ETS-10 (30 mg), Cs_2CO_3 (0.1 mmol), phenylacetylene (**2a**, 0.5 mmol), 1,3,5-trimethylbenzene (0.5 mmol) and DMSO (1.5 mL). The mixture was stirred at 100 °C for 1 h. The reaction tube was cooled down to room temperature and 2-iodobenzamide (**1a**, 0.8 mmol) was added to the reaction tube. The reaction tube was stirred at 100 °C for 1 hour again. After the reaction was completed, the catalyst was removed by filtration. A proper amount of solution was taken for GC analysis.

3.5 IR experiment

Infrared (IR) spectra of the phenylacetylene (**2a**) chemisorbed Cu/ETS-10 sample were obtained on a Bruker TENSOR 27 infrared spectroscope equipped with

an *in suit* reactor cell. Before measurement, the Cu/ETS-10 sample was firstly evacuated to 10^{-2} Pa at 350 ºC for 3 h, and then the temperature was cooled to room temperature. Subsequently, the background spectrum for the Cu/ETS-10 sample was measured. Then, the phenylacetylene was introduced into the reactor cell by He flows (20 mL/min) for 5 min and then the sample was degassed to 10^{-2} Pa for 30 min. Immediately, the spectrum was obtained in the absorbance mode and was shown after subtraction of a background spectrum for the Cu/ETS-10 sample. Then, the sample was heated to 100 °C at a rate of 10 °C/min and kept at 100 °C, the IR spectra were also collected at intervals of 2 min.

3.6 Catalyst reusability

After the reaction was completed, the Cu/ETS-10 catalyst was filtered and separated, then subsequently washed with ethyl acetate. The obtained Cu/ETS-10 catalyst was dried at 120 °C for 12 h before the next recycle. The Cu/ETS-10 catalyst has good repeatability and activity in the preparation of *Z*-3-methyleneisoindolin-1-one system by the domino coupling-cyclization of 2-iodobenzamide with phenylacetylene. After five cycles, the catalytic activity had barely decreased.

4. The XRD patterns of the samples

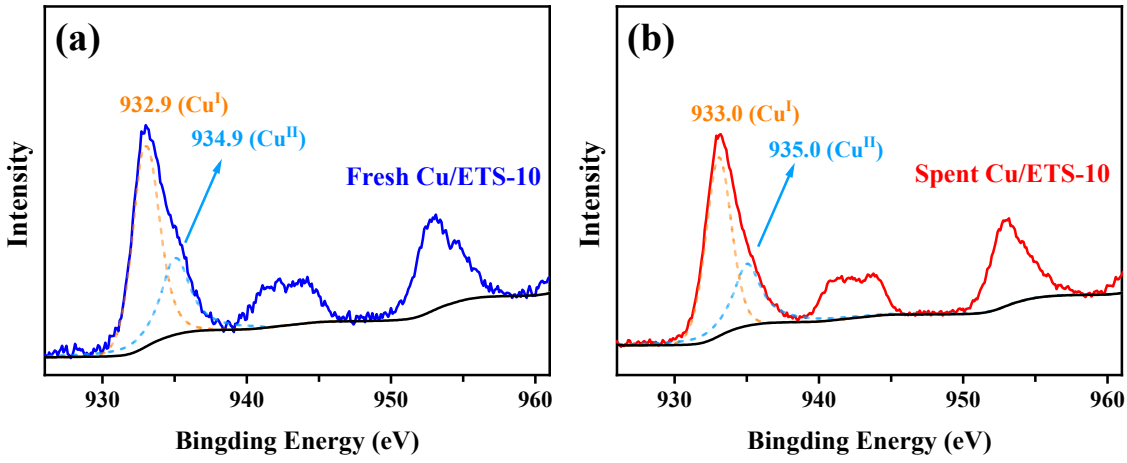
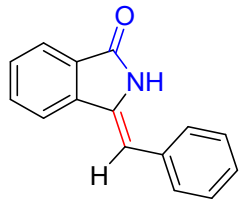


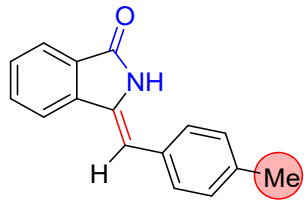
Fig. S1 XRD patterns of the (a) fresh Cu/ETS-10 and (a) spent Cu/ETS-10 samples.

5. Characterization of the products



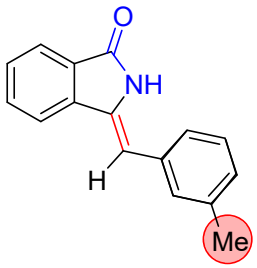
***Z*-3-benzylideneisoindol-1-one (3a)**[1]

white solid, 97% yield; IR (KBr, cm^{-1}): 3449, 3251, 2920, 1700, 1637; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.76 (s, 1H), 8.07 (d, J = 7.6 Hz, 1H), 7.77 (d, J = 7.6 Hz, 1H), 7.72 (t, J = 7.6 Hz, 1H), 7.65 (d, J = 7.6 Hz, 2H), 7.57 (t, J = 7.6 Hz, 1H), 7.42 (t, J = 7.6 Hz, 2H), 7.33 – 7.27 (m, 1H), 6.78 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d6) δ 169.14, 138.86, 134.70, 132.42 (d, J = 14.9 Hz), 129.18, 128.82, 128.32, 127.30, 122.78, 120.46, 105.96; **GCMS** (70 eV) m/z %: 221 (M^+, 100), 193 (31), 165 (32); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{15}H_{12}NO^+$ 222.0919, found 222.0904.



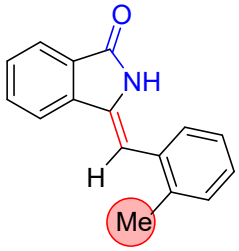
***Z*-3-(4-methylbenzylidene)isoindolin-1-one (3b)**

yellow solid, 97% yield; IR (KBr, cm^{-1}): 3174, 1682, 1650, 1311; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.68 (s, 1H), 8.04 (d, J = 8.0 Hz, 1H), 7.76 (d, J = 7.6 Hz, 1H), 7.70 (td, J = 7.6, 1.2 Hz, 1H), 7.56 (d, J = 7.6 Hz, 3H), 7.23 (d, J = 8.0 Hz, 2H), 6.73 (s, 1H), 2.33 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.05, 138.94, 136.82, 132.25, 131.86, 131.72, 129.44, 129.14, 128.97, 128.23, 122.74, 120.32, 106.10; **GCMS** (70 eV) m/z %: 235 (M^+, 100), 206 (30), 165 (28); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{16}H_{14}NO^+$ 236.1075, found 236.1067.



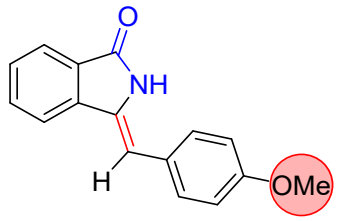
***Z*-3-(3-methylbenzylidene)isoindolin-1-one (3c)**

white solid, 95% yield; IR (KBr, cm^{-1}): 3184, 1680, 1667, 1314; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.76 (s, 1H), 8.06 (dt, J = 7.6, 0.8 Hz, 1H), 7.76 (dt, J = 7.6, 0.8 Hz, 1H), 7.70 (td, J = 7.6, 0.8 Hz, 1H), 7.56 (td, J = 7.6, 0.8 Hz, 1H), 7.51 (q, J = 1.4 Hz, 1H), 7.41 – 7.38 (m, 1H), 7.29 (t, J = 7.6 Hz, 1H), 7.10 (ddt, J = 7.6, 1.8, 0.8 Hz, 1H), 6.73 (s, 1H), 2.36 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.13, 138.88, 138.05, 134.55, 132.31, 132.28, 129.45, 129.12, 128.66, 128.28, 128.08, 126.57, 122.76, 120.41, 106.09, 21.02; **GCMS** (70 eV) m/z %: 235 (M^+, 100), 220 (28), 206 (40). HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{16}H_{14}NO^+$ 236.1075, found 236.1059.



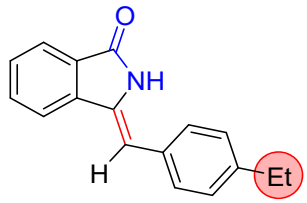
***Z*-3-(2-methylbenzylidene)isoindolin-1-one (3d)**

yellow solid, 92% yield; IR (KBr, cm^{-1}): 3184, 1687, 1652, 1307; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.57 (s, 1H), 8.13 (dt, J = 8.0, 0.8 Hz, 1H), 7.77 – 7.69 (m, 2H), 7.59 – 7.51 (m, 2H), 7.27 – 7.19 (m, 3H), 6.78 (s, 1H), 2.38 (s, 3H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 168.87, 138.40, 136.54, 133.56, 133.38, 132.23, 130.08, 129.46, 129.24, 128.77, 127.41, 126.29, 122.68, 120.66, 104.10, 19.92; **GCMS** (70 eV) m/z %: 235 (M^+, 100), 220 (30), 206 (32); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{16}H_{14}NO^+$ 236.1075, found 236.1064.



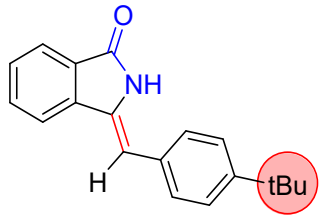
***Z*-3-(4-methoxybenzylidene)isoindolin-1-one (3e)**[1a]

light yellow solid, 98% yield; **^{1}H NMR** (300 MHz, DMSO-d_6) δ 10.66 (s, 1H), 8.03 (d, J = 7.6 Hz, 1H), 7.72 (dd, J = 7.6, 0.8 Hz, 2H), 7.61 (d, J = 8.4 Hz, 2H), 7.52 (d, J = 7.6 Hz, 1H), 6.98 (d, J = 7.6 Hz, 2H), 6.72 (s, 1H), 3.80 (s, 3H); **^{13}C NMR** (75 MHz, DMSO-d_6) δ 169.40, 159.04, 139.41, 132.56, 131.06, 129.12, 128.48, 127.61, 123.10, 120.57, 114.73, 114.57, 106.44, 55.67; **GCMS** (70 eV) m/z %: 251 (M^+, 100), 236 (44), 208 (32).



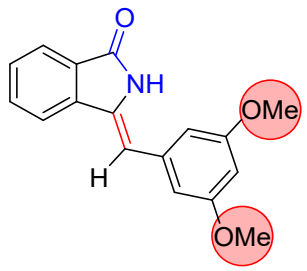
***Z*-3-(4-ethylbenzylidene)isoindolin-1-one (3f)**

yellow solid, 94% yield; IR (KBr, cm^{-1}): 3057, 1590, 1510, 1296; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.68 (s, 1H), 8.05 (dt, J = 8.0, 0.8 Hz, 1H), 7.76 (dt, J = 8.0, 0.8 Hz, 1H), 7.70 (td, J = 8.0, 1.0 Hz, 1H), 7.59 – 7.53 (m, 3H), 7.25 (d, J = 8.0 Hz, 2H), 6.74 (s, 1H), 2.63 (q, J = 7.6 Hz, 2H), 1.20 (t, J = 7.6 Hz, 3H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.06, 143.13, 138.94, 132.28, 132.15, 131.77, 129.23, 129.00, 128.26, 128.24, 122.75, 120.35, 106.10, 28.05, 15.57; **GCMS** (70 eV) m/z %: 249 (M^+, 100), 234 (94), 130 (21); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{17}H_{16}NO^+$ 250.1232, found 250.1237.



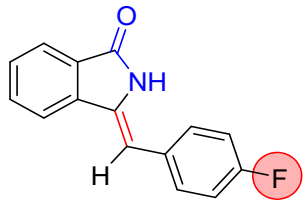
***Z*-3-(4-(tert-butyl)benzylidene)isoindolin-1-one (3g)**

white solid, 95% yield; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.69 (s, 1H), 8.06 (dt, J = 8.0, 0.8 Hz, 1H), 7.77 (dt, J = 8.0, 0.8 Hz, 1H), 7.70 (td, J = 7.6, 0.8 Hz, 1H), 7.62 – 7.58 (m, 2H), 7.55 (td, J = 7.6, 0.8 Hz, 1H), 7.44 – 7.41 (m, 2H), 6.74 (s, 1H), 1.30 (s, 9H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.06, 149.90, 138.93, 132.28, 131.94, 129.08, 129.02, 129.01, 128.29, 125.60, 122.77, 120.37, 105.94, 34.46, 31.12; **GCMS** (70 eV) m/z %: 277 (M^+, 49), 262 (100),117 (10).



***Z*-3-(3,5-dimethoxybenzylidene)isoindolin-1-one (3h)**

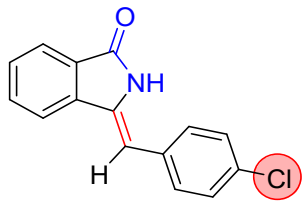
yellow solid, 93% yield; IR (KBr, cm^{-1}): 3674, 3427, 3200, 2924, 1769, 627; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.78 (s, 1H), 8.04 (dt, J = 8.0, 0.8 Hz, 1H), 7.77 (dt, J = 8.0, 1.2 Hz, 1H), 7.71 (td, J = 8.0, 1.2 Hz, 1H), 7.56 (td, J = 8.0, 0.8 Hz, 1H), 6.75 (d, J = 2.2 Hz, 2H), 6.72 (s, 1H), 6.43 (t, J = 2.2 Hz, 1H), 3.82 (s, 6H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.17, 160.63, 138.80, 136.55, 132.85, 132.36, 129.26, 128.45, 122.79, 120.44, 106.98, 106.16, 100.17, 55.33; **GCMS** (70 eV) m/z %: 281 (M^+, 100), 266 (12), 250 (18); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{17}H_{16}NO_3^+$ 282.1130, found 282.1107.



***Z*-3-(4-fluorobenzylidene)isoindolin-1-one (3i)**

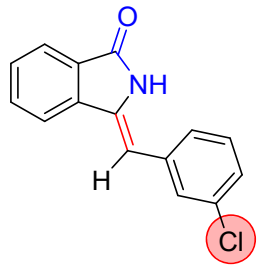
yellow solid, 93% yield; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.75 (s, 1H), 8.05 (dt, J = 7.8, 0.8 Hz, 1H), 7.76 (dt, J = 7.4, 0.8 Hz, 1H), 7.71 – 7.66 (m, 3H), 7.56 (td, J = 7.4, 0.8 Hz, 1H), 7.24 (t, J = 8.8 Hz, 2H), 6.77 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-

d_6) δ 169.16, 138.81, 132.35, 132.32, 131.23, 131.15, 129.20, 128.32, 122.78, 120.41, 115.81, 115.59, 104.82; **GCMS** (70 eV) m/z %: 239 (M^+, 100), 211 (25), 183 (33).



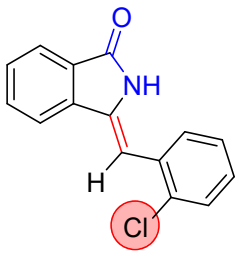
***Z*-3-(4-chlorobenzylidene)isoindolin-1-one (3j)**[1a]

white solid, 98% yield; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.79 (s, 1H), 8.06 (dt, J = 7.8, 0.8 Hz, 1H), 7.77 (dt, J = 7.8, 0.8 Hz, 1H), 7.72 (td, J = 7.4, 0.8 Hz, 1H), 7.68 – 7.62 (m, 2H), 7.58 (td, J = 7.4, 0.8 Hz, 1H), 7.49 – 7.42 (m, 2H), 6.77 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.18, 138.73, 133.65, 133.12, 132.44, 131.68, 130.83, 129.39, 128.76, 128.34, 122.84, 120.54, 104.58; **GCMS** (70 eV) m/z %: 256 (M^+, 100), 220 (28), 165 (24).



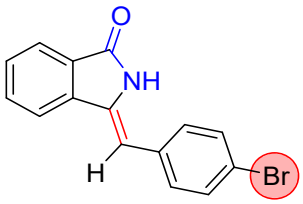
***Z*-3-(3-chlorobenzylidene)isoindolin-1-one (3k)**

yellow solid, 97% yield, Z/E = 100: 11; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.91 (s, 1H), 8.05 (dt, J = 7.8, 0.8 Hz, 1H), 7.77 – 7.69 (m, 3H), 7.60 – 7.56 (m, 2H), 7.43 (t, J = 7.8 Hz, 1H), 7.35 – 7.32 (m, 1H), 6.76 (s, 1H); **^{13}C NMR** (75 MHz, Chloroform-d) δ 169.03, 138.05, 134.97, 132.75, 132.70, 132.59, 131.29, 129.82, 129.49, 129.01, 128.84, 127.67, 122.87, 120.77, 101.53; **GCMS** (70 eV) m/z %: 255 (M^+, 100), 227 (25), 165 (29).



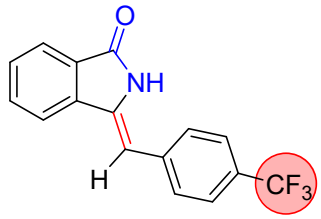
***Z*-3-(2-chlorobenzylidene)isoindolin-1-one (3l)**

white solid, 93% yield; IR (KBr, cm^{-1}): 3240, 1675, 1660, 1294, 674; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.78 (s, 1H), 8.11 (dd, J = 7.8, 0.8 Hz, 1H), 7.78 (dt, J = 7.8, 0.8 Hz, 1H), 7.76 – 7.67 (m, 2H), 7.61 (td, J = 7.8, 0.8 Hz, 1H), 7.54 (dd, J = 7.6, 1.2 Hz, 1H), 7.40 (td, J = 7.6, 1.2 Hz, 1H), 7.33 (td, J = 7.6, 1.2 Hz, 1H), 6.77 (s, 1H); **^{13}C NMR** (75 MHz, DMSO-d_6) δ 169.02, 138.04, 134.97, 132.75, 132.69, 132.57, 131.30, 129.81, 129.48, 128.99, 128.84, 127.66, 122.87, 120.77, 101.52; **GCMS** (70 eV) m/z %: 255 (M^+, 94), 220 (100), 165 (46); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{15}H_{11}ClNO^+$ 256.0529, found 256.0547.



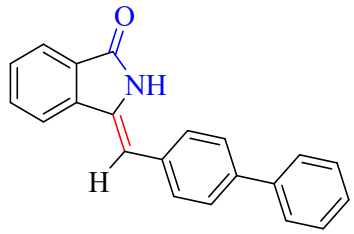
***Z*-3-(4-bromobenzylidene)isoindolin-1-one (3m)**

white solid, 92% yield; IR (KBr, cm^{-1}): 3230, 2949, 1708, 1569, 1482, 1149, 780, 685; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.78 (s, 1H), 8.05 (dt, J = 7.8, 0.8 Hz, 1H), 7.76 (dt, J = 7.8, 0.8 Hz, 1H), 7.71 (td, J = 7.8, 1.2 Hz, 1H), 7.60 – 7.54 (m, 5H), 6.74 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.19, 138.73, 134.00, 133.20, 132.46, 131.67, 131.12, 129.42, 128.34, 122.85, 120.57, 120.32, 104.64; **GCMS** (70 eV) m/z %: 299 (M^+, 100), 219 (37), 165 (50); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{15}H_{11}BrNO^+$ 300.0024, found 300.0036.



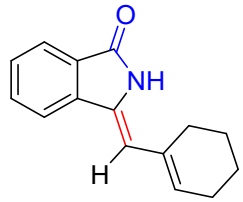
***Z*-3-(4-(trifluoromethyl)benzylidene)isoindolin-1-one (3n)**[1a]

white solid, 91% yield; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.88 (s, 1H), 8.09 (dt, J = 7.6, 0.8 Hz, 1H), 7.84 – 7.81 (m, 2H), 7.78 (dt, J = 7.6, 0.8 Hz, 1H), 7.73 (ddd, J = 7.6, 2.0, 0.8 Hz, 3H), 7.62 – 7.58 (m, 1H), 6.85 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 168.75, 138.49, 137.77, 132.42, 131.06, 129.05, 128.84, 128.29, 127.34, 126.75, 122.94, 120.47, 99.11; **GCMS** (70 eV) m/z %: 289 (M^+, 100), 261 (28), 220 (18).



***Z*-3-(4-(trifluoromethyl)benzylidene)isoindolin-1-one (3o)**

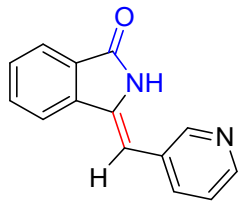
white solid, 88% yield; IR (KBr, cm^{-1}): 3251, 3207, 1668, 1297; **^{1}H NMR** (300 MHz, DMSO-d_6) δ 10.81 (s, 1H), 8.09 (d, J = 7.8 Hz, 1H), 7.74 (d, J = 2.4 Hz, 5H), 7.48 (tt, J = 32.0, 7.2 Hz, 7H), 6.82 (s, 1H); **^{13}C NMR** (75 MHz, DMSO-d_6) δ 169.17, 139.59, 138.89, 138.75, 134.45, 133.95, 132.63, 132.40, 129.81, 129.14, 128.28, 127.71, 126.96, 126.61, 122.84, 120.52, 105.59; **GCMS** (70 eV) m/z %: 297 (M^+, 100), 165 (22), 269.11 (12); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{21}H_{16}NO^+$ 298.1232, found 298.1261.



***Z*-3-(cyclohex-1-en-1-ylmethylene)isoindolin-1-one (3p)**

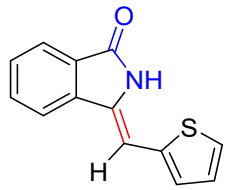
yellow solid, 71% yield; IR (KBr, cm^{-1}): 3251, 3207, 1767, 1660, 1284; **^{1}H NMR**

(300 MHz, DMSO-d_6) δ 10.09 (s, 1H), 7.92 (d, J = 7.6 Hz, 1H), 7.71 (d, J = 7.4 Hz, 1H), 7.64 (t, J = 7.4 Hz, 1H), 7.50 (t, J = 7.4 Hz, 1H), 6.24 (s, 1H), 6.05 (d, J = 7.2 Hz, 1H), 2.37 (d, J = 7.2 Hz, 2H), 2.18 (s, 2H), 1.67 – 1.55 (m, 4H); **^{13}C NMR** (75 MHz, DMSO-d_6) δ 168.41, 138.85, 133.39, 132.01, 131.49, 129.77, 128.57, 123.05, 122.64, 120.08, 109.95, 27.50, 25.77, 22.32, 21.57; **GCMS** (70 eV) m/z %: 225 (M^+, 84), 196 (71), 169(100); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{15}H_{16}NO^+$ 226.1232, found 226.1219.



***Z*-3-(pyridin-3-ylmethylene)isoindolin-1-one (3q)**

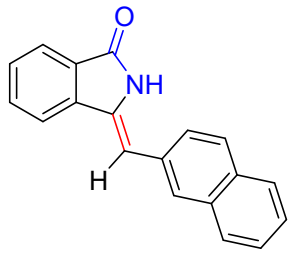
white solid, 87% yield, *Z*/*E* = 100: 9; IR (KBr, cm^{-1}): 3427, 2917, 2439, 1751, 1637, 1284;**^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.90 (s, 1H), 8.79 (d, J = 2.4 Hz, 1H), 8.47 (dd, J = 4.8, 1.6 Hz, 1H), 8.09 (dt, J = 7.6, 0.8 Hz, 2H), 7.79 (dd, J = 7.6, 0.8 Hz, 1H), 7.76 – 7.72 (m, 1H), 7.61 (dd, J = 7.6, 0.8 Hz, 1H), 7.46 – 7.43 (m, 1H), 6.79 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 169.21, 150.08, 147.73, 138.53, 135.59, 134.30, 132.51, 129.58, 128.28, 123.76, 122.85, 120.63, 106.91, 102.15; **GCMS** (70 eV) m/z %: 222 (M^+, 100), 194 (44), 120 (20); HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{14}H_{11}N_2O^+$ 223.0871, found 223.0849.



***Z*-3-(thiophen-2-ylmethylene)isoindolin-1-one (3r)**

white solid, 94% yield; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.50 (s, 1H), 8.06 (dt, J = 7.6, 0.8 Hz, 1H), 7.76 (dt, J = 7.6, 0.8 Hz, 1H), 7.69 (td, J = 7.6, 0.8 Hz, 1H), 7.62 – 7.60 (m, 2H), 7.54 (td, J = 7.6, 0.8 Hz, 1H), 7.17 (dd, J = 5.2, 3.4 Hz, 1H), 6.96 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 168.65, 138.39, 137.66, 132.31, 130.96,

128.94, 128.74, 128.18, 127.23, 126.64, 122.83, 120.36, 99.00; **GCMS** (70 eV) m/z %: 227 (M^+, 100), 130 (28), 120 (13).

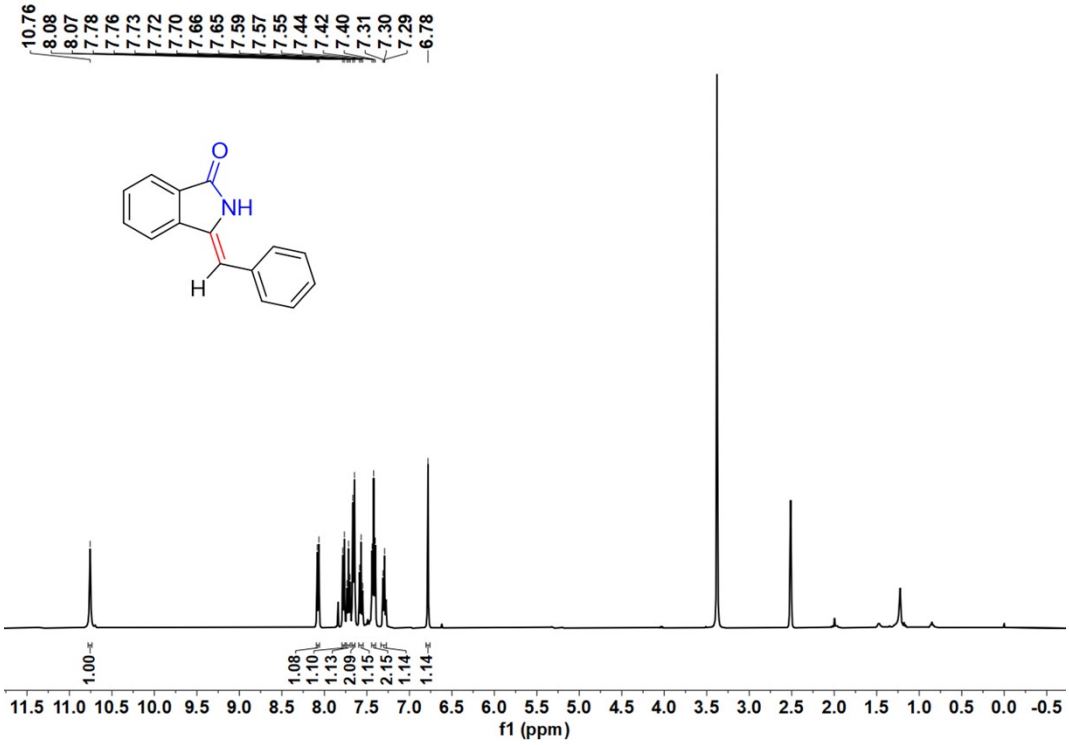


***Z*-3-(naphthalen-2-ylmethylene)isoindolin-1-one (3s)**[1a]

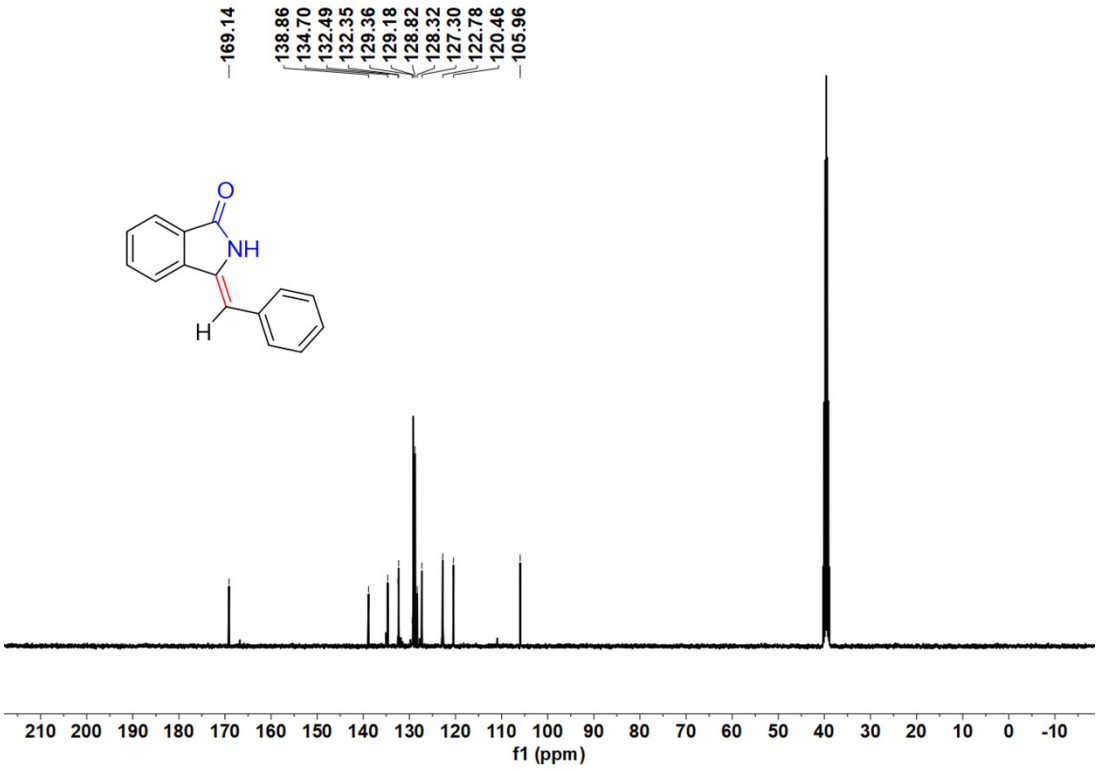
white solid, 90% yield, *Z*/*E* = 100: 4; **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.71 (s, 1H), 8.35 – 8.25 (m, 2H), 7.98 (dd, *J* = 6.4, 2.4 Hz, 1H), 7.90 (d, *J* = 8.2 Hz, 1H), 7.80 – 7.73 (m, 3H), 7.62 – 7.57 (m, 4H), 7.37 (s, 1H); **^{13}C NMR** (101 MHz, DMSO-d_6) δ 168.88, 138.27, 134.76, 133.37, 132.26, 131.42, 131.32, 129.38, 128.98, 128.56, 127.93, 127.70, 126.39, 126.15, 126.09, 124.58, 122.67, 121.06, 102.96; **GCMS** (70 eV) m/z %: 271 (M^+, 100), 243 (36), 121(33).

6. The NMR spectrum

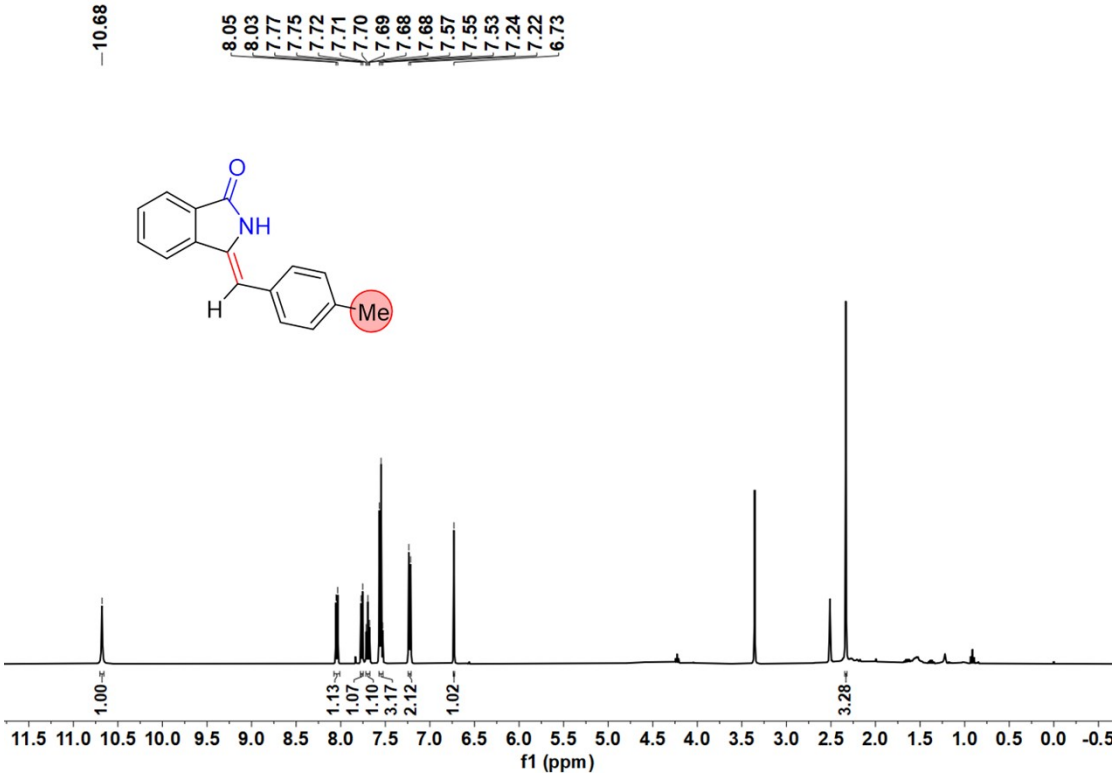
^{1}H NMR spectrum of compound 3a (400 MHz, DMSO-d_6)



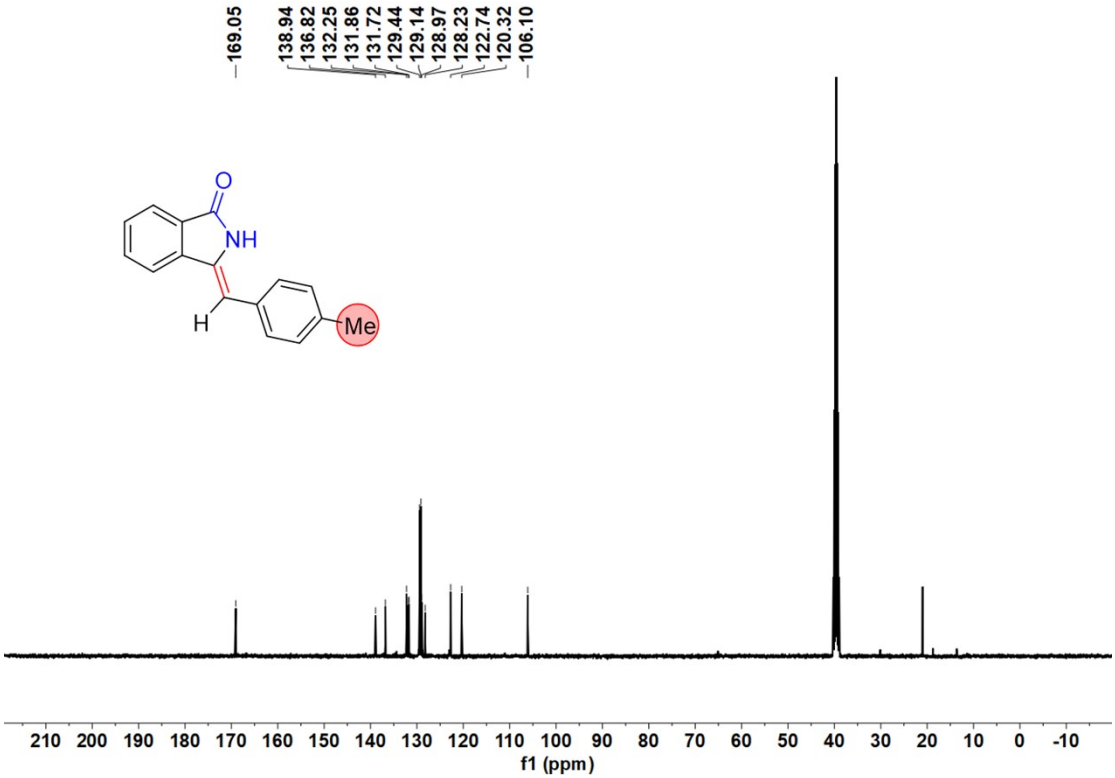
^{13}C NMR spectrum of compound 3a (101 MHz, DMSO-d_6)



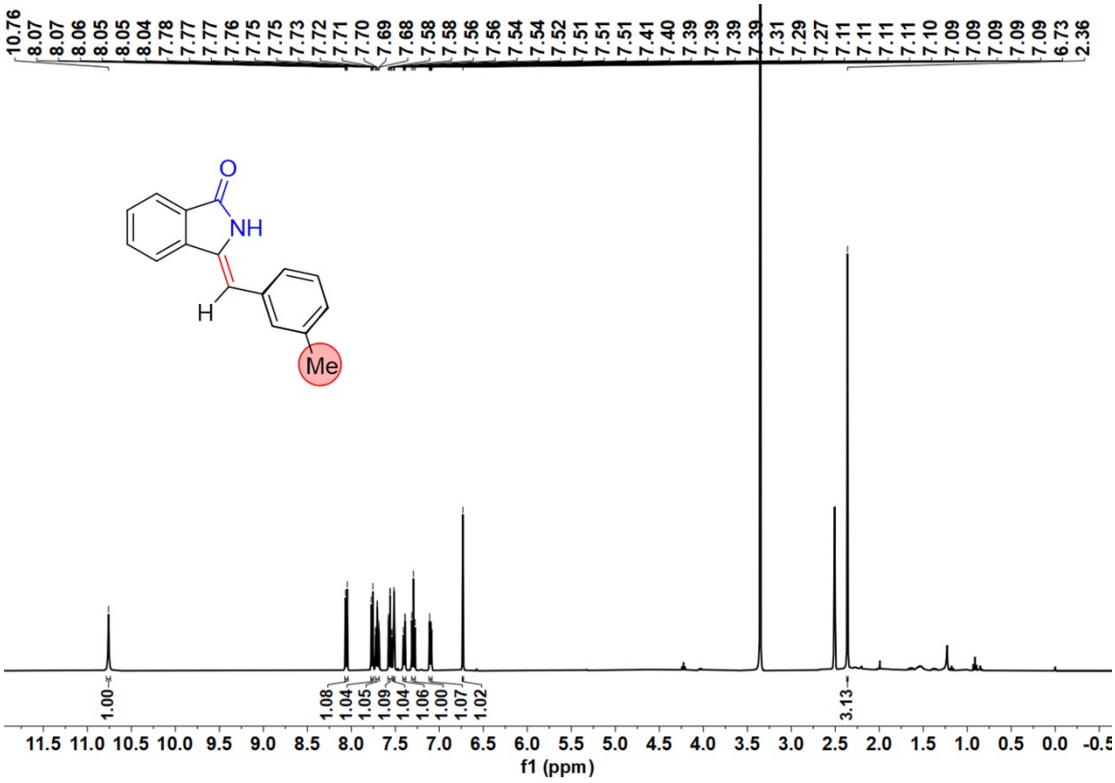
^{1}H NMR spectrum of compound 3b (400 MHz, DMSO-d_6)



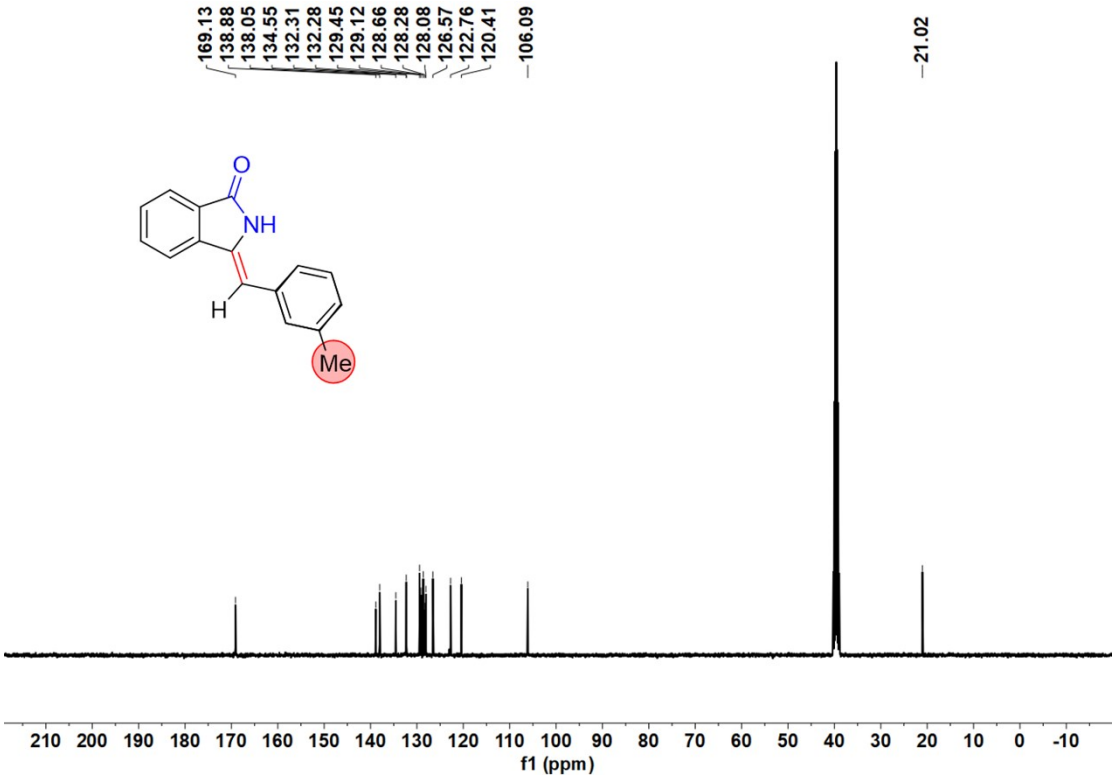
^{13}C NMR spectrum of compound 3b (101 MHz, DMSO-d_6)



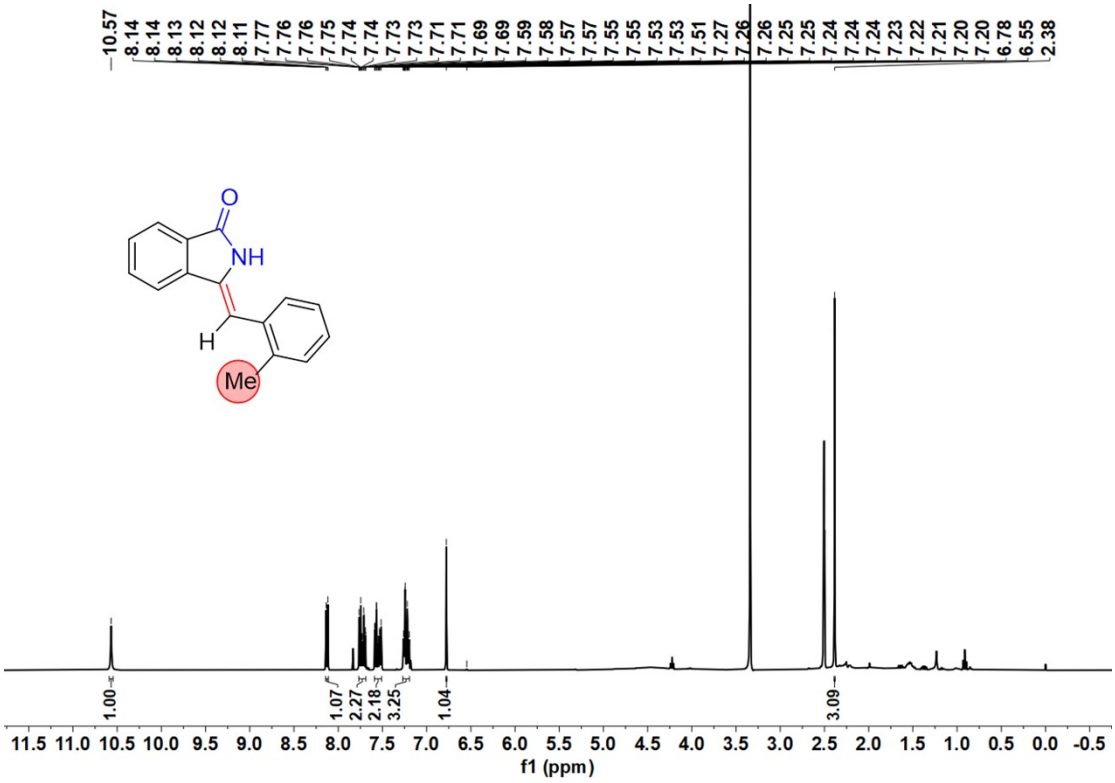
^{1}H NMR spectrum of compound 3c (400 MHz, DMSO-d_6)



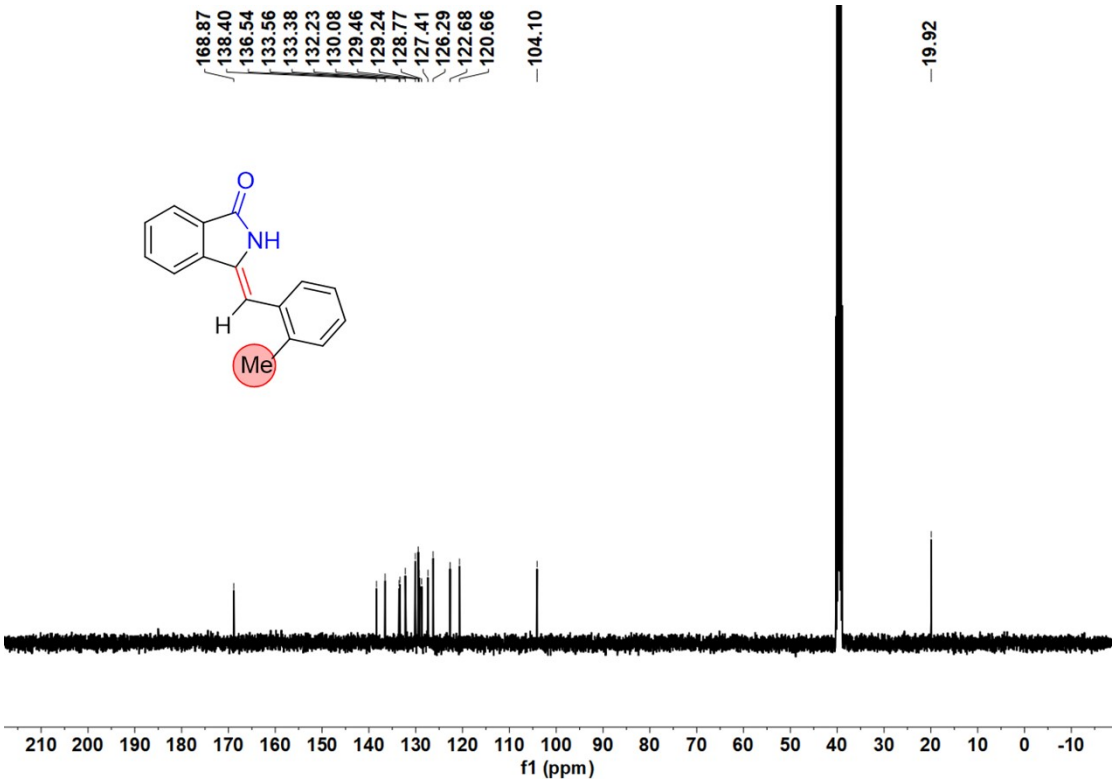
^{13}C NMR spectrum of compound 3c (101 MHz, DMSO-d_6)



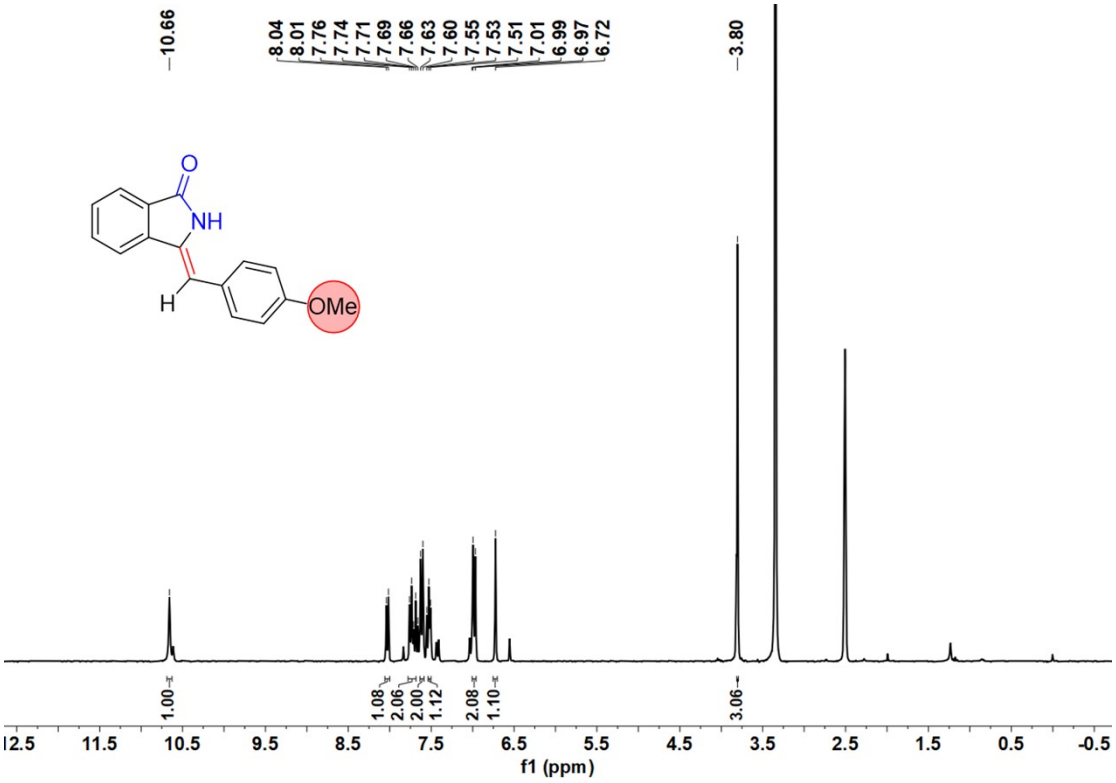
^{1}H NMR spectrum of compound 3d (400 MHz, DMSO-d_6)



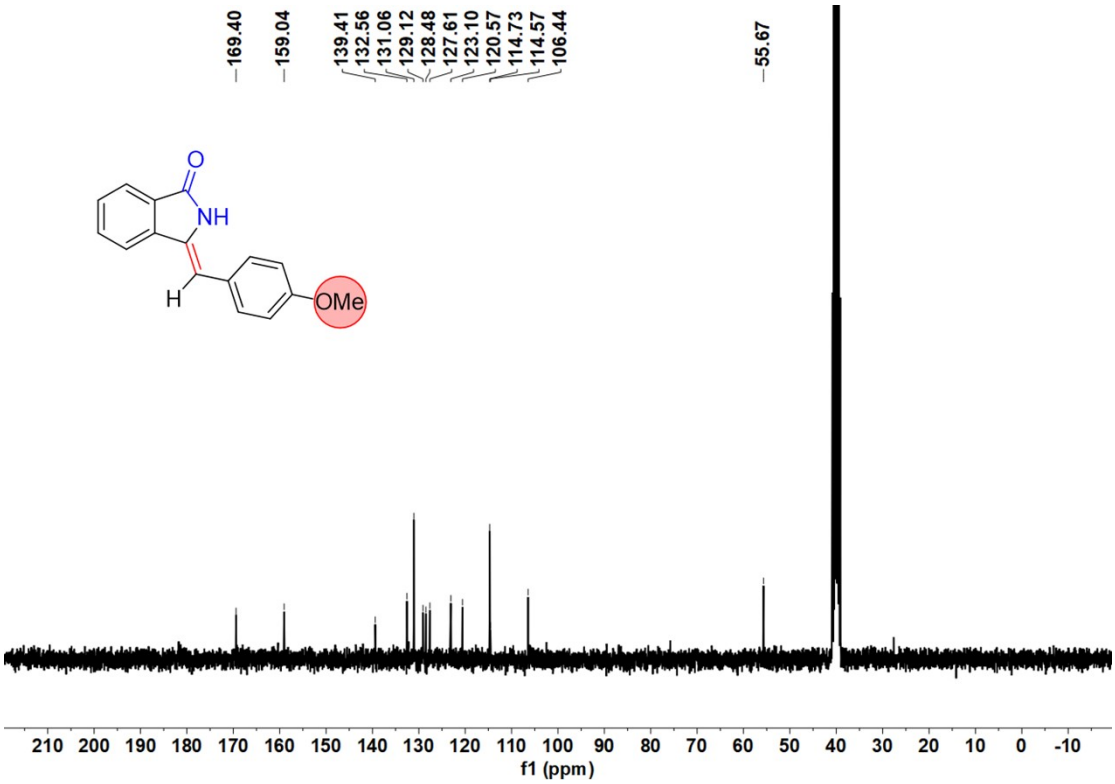
^{13}C NMR spectrum of compound 3d (101 MHz, DMSO-d_6)



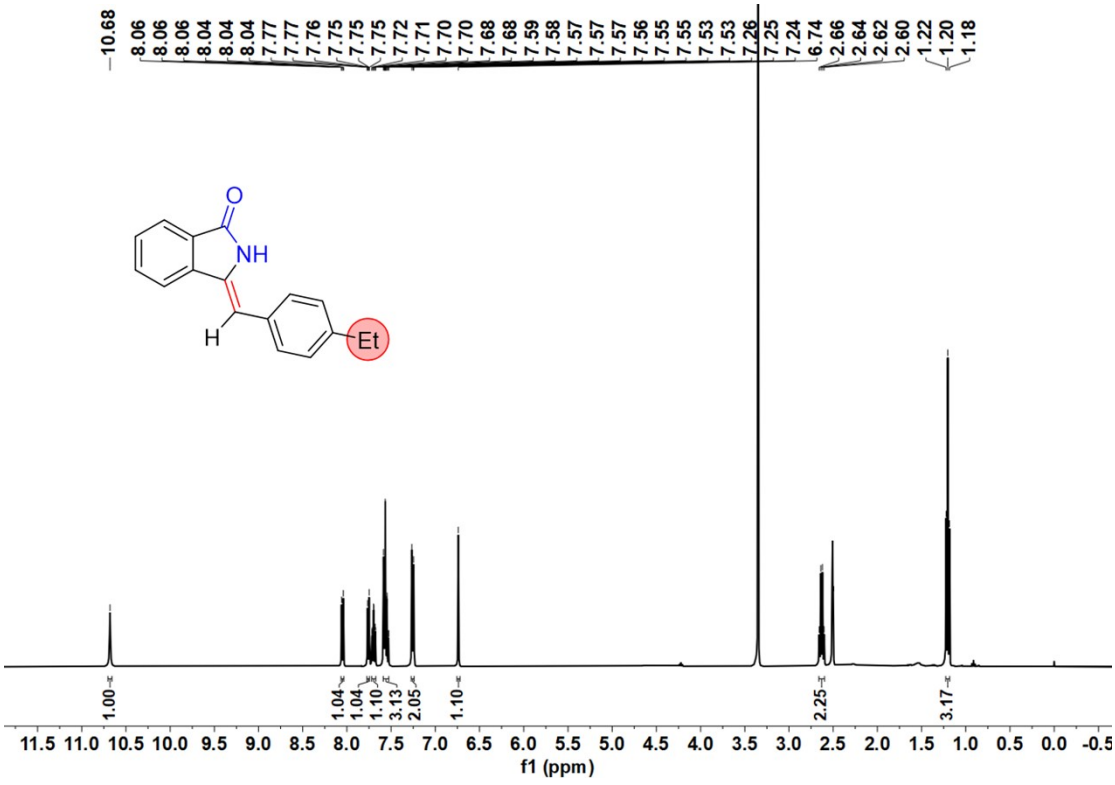
^{1}H NMR spectrum of compound 3e (300 MHz, DMSO-d_6)



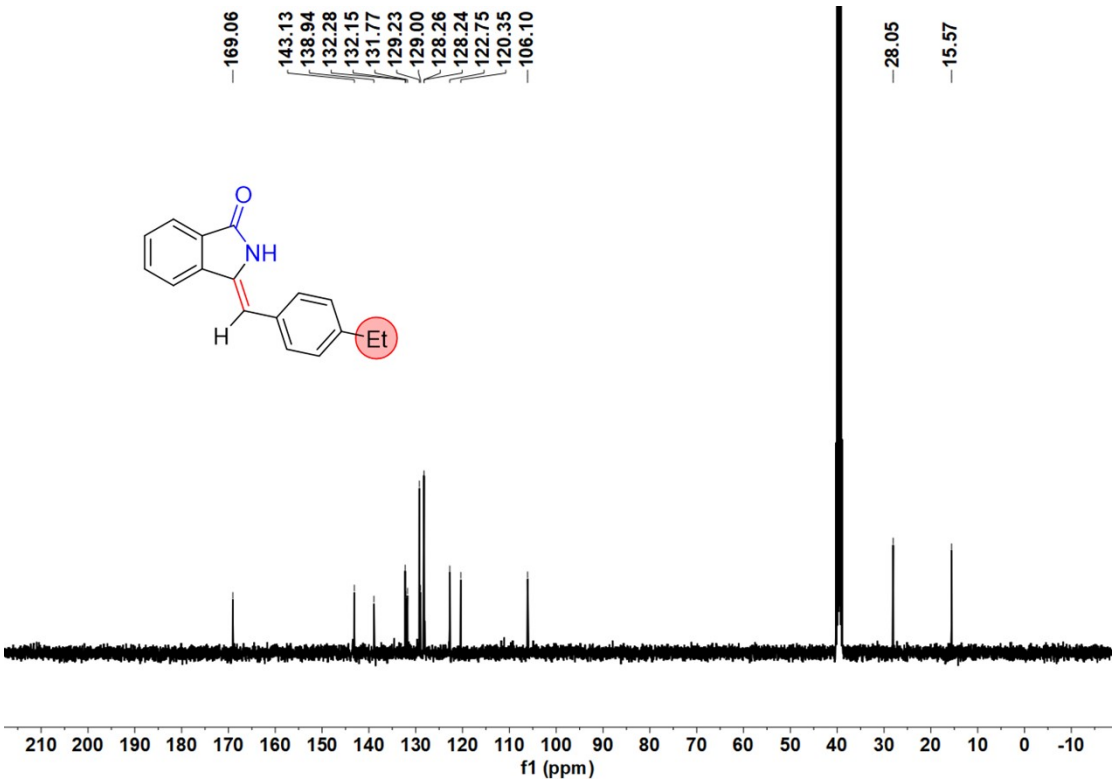
^{13}C NMR spectrum of compound 3e (75 MHz, DMSO-d_6)



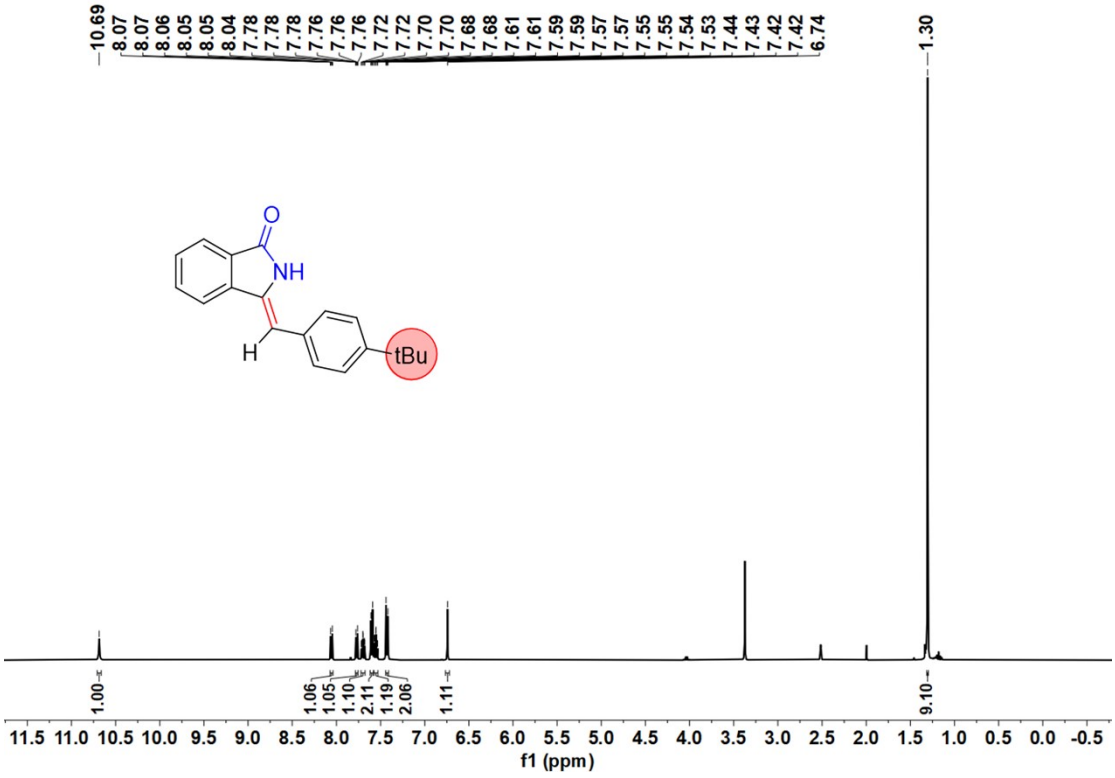
^{1}H NMR spectrum of compound 3f (400 MHz, DMSO-d_6)



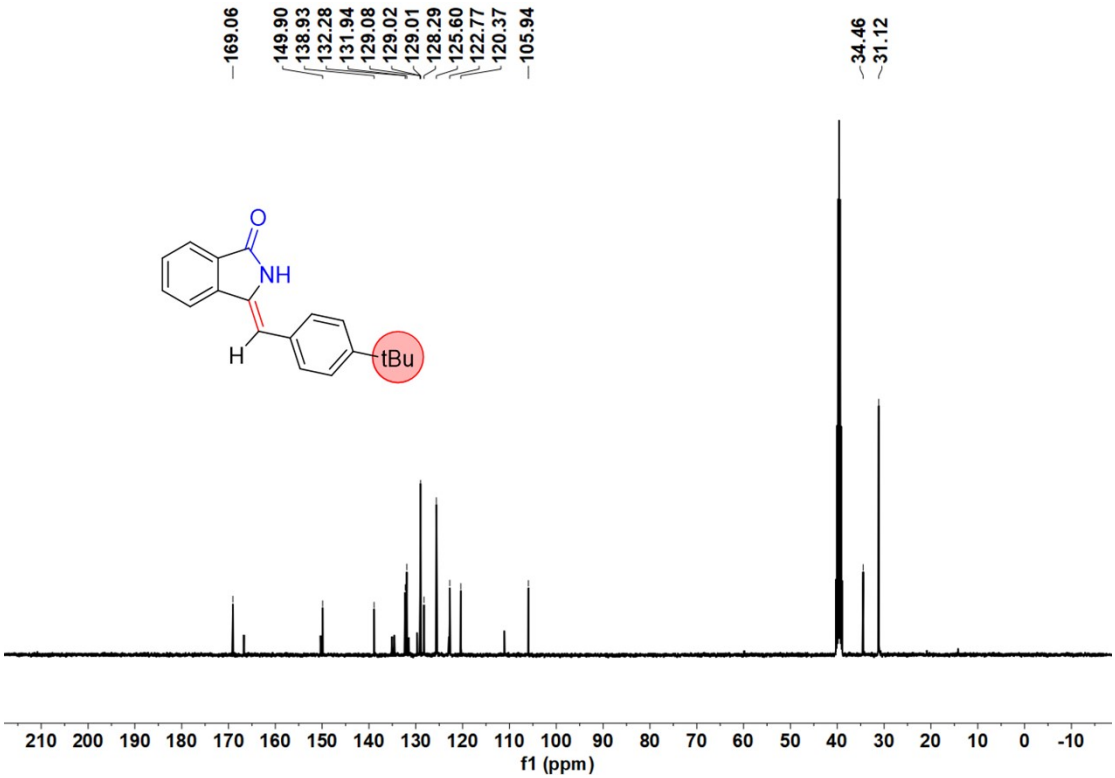
^{13}C NMR spectrum of compound 3d (101 MHz, DMSO-d_6)



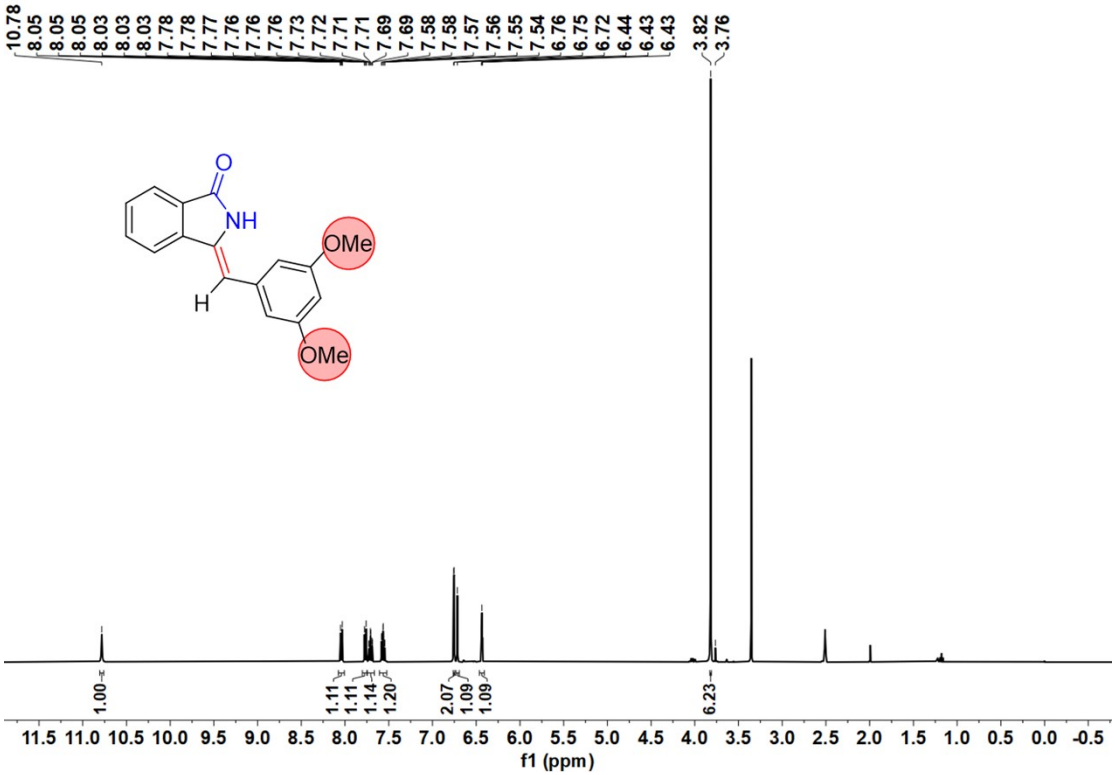
^{1}H NMR spectrum of compound 3g (400 MHz, DMSO-d_6)



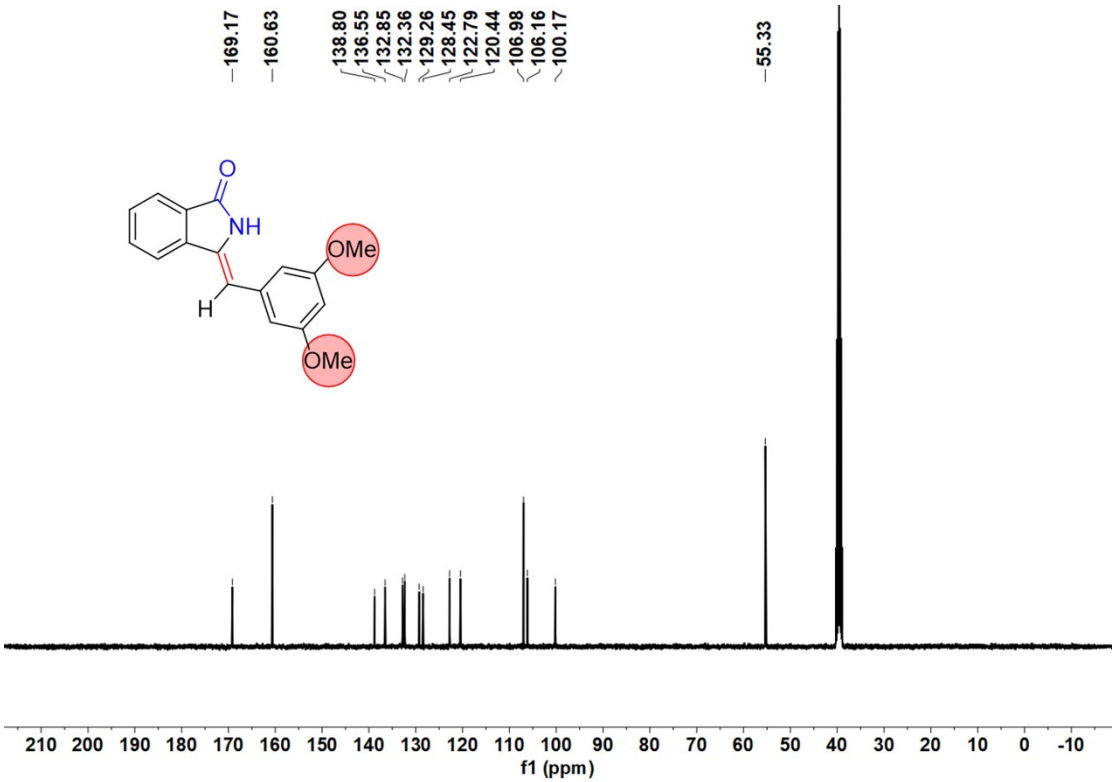
^{13}C NMR spectrum of compound 3g (101 MHz, DMSO-d_6)



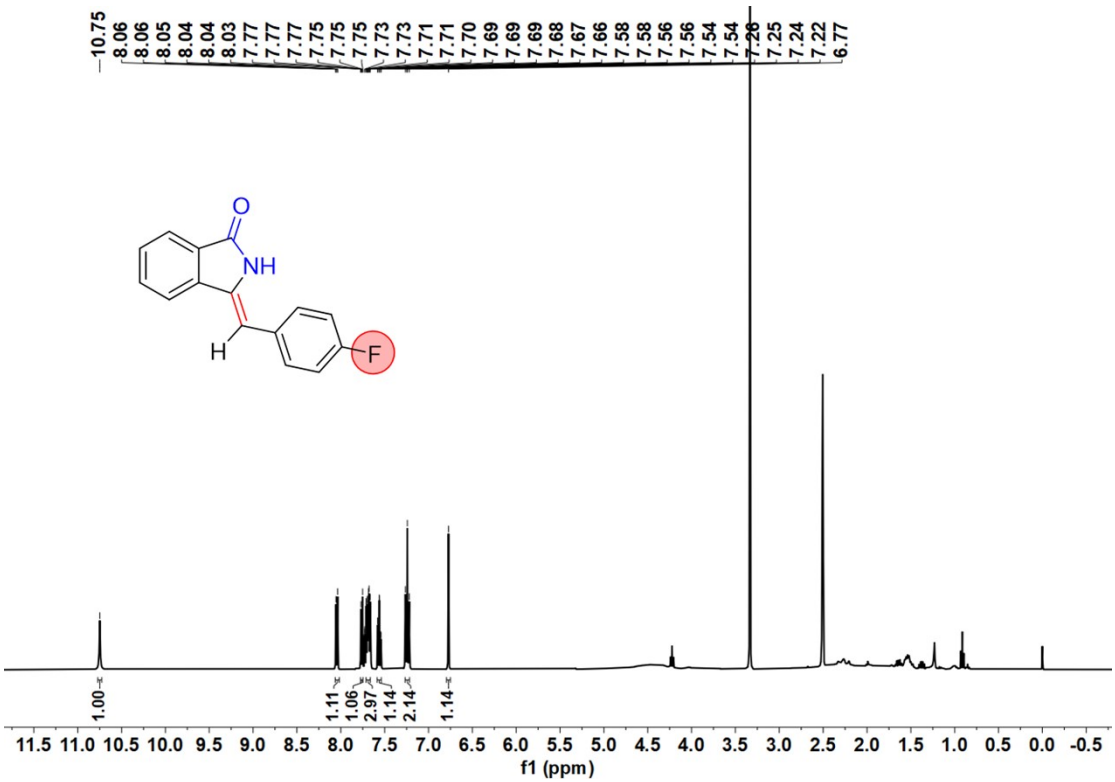
[1]H NMR spectrum of compound 3h (400 MHz, DMSO-d_6)



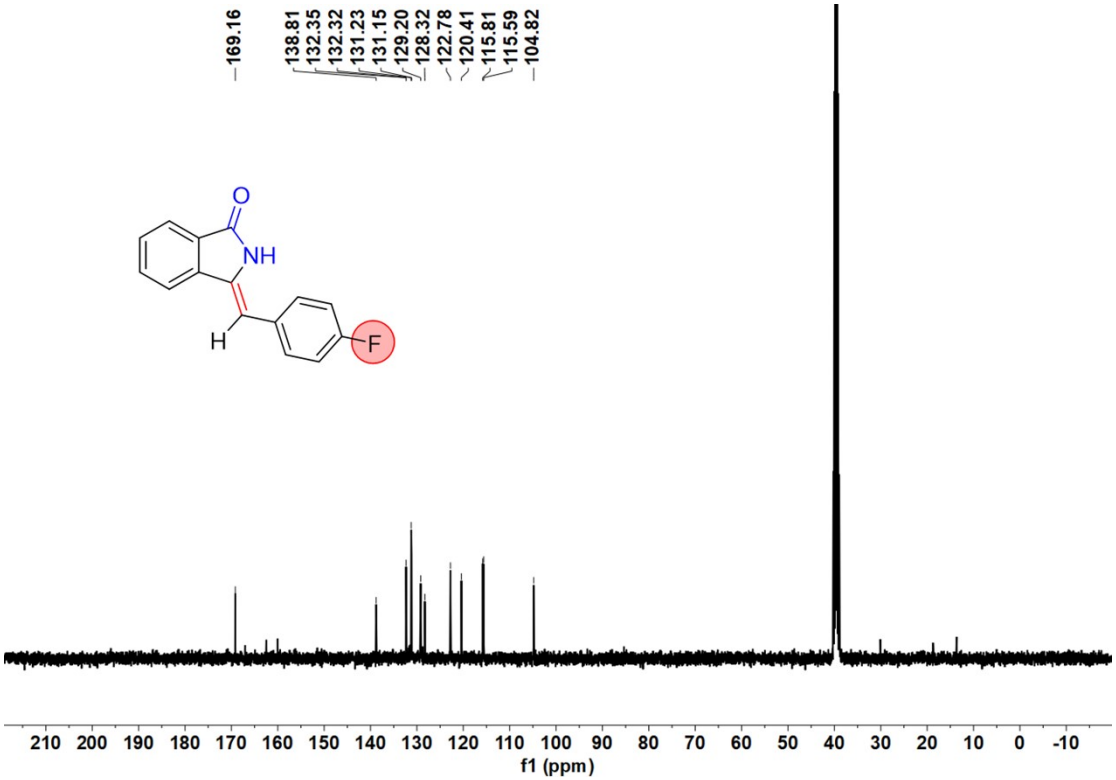
[13]C NMR spectrum of compound 3h (101 MHz, DMSO-d_6)



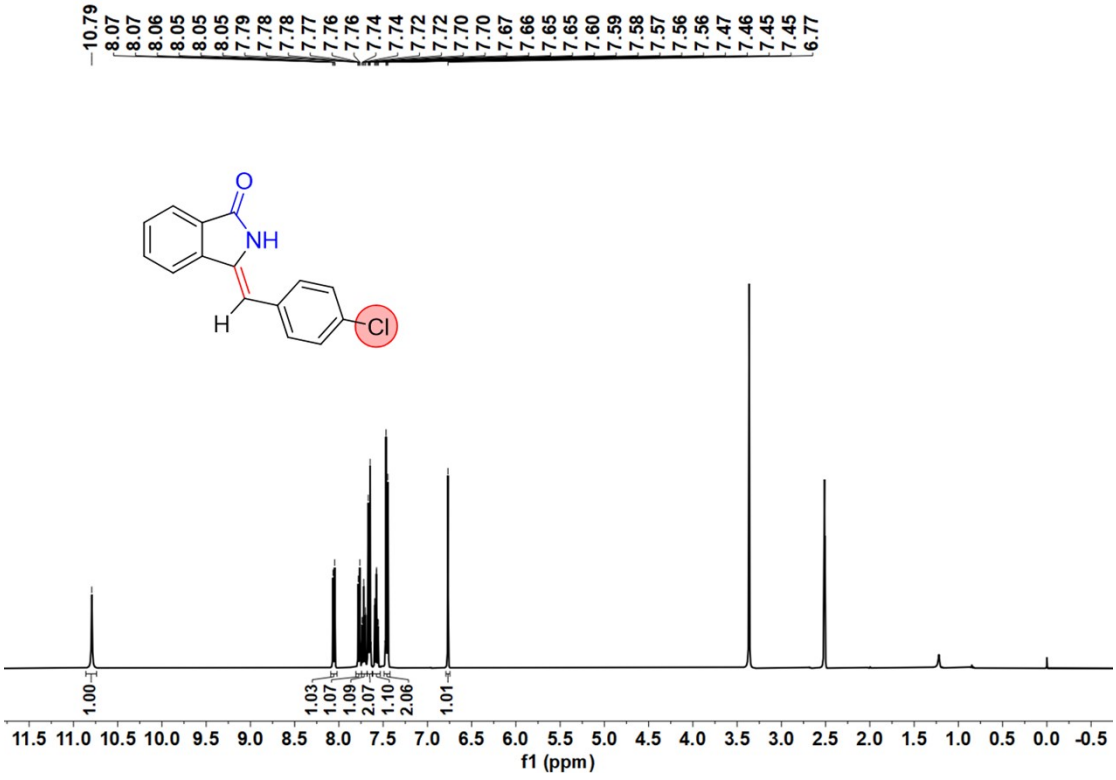
^{1}H NMR spectrum of compound 3i (400 MHz, DMSO-d_6)



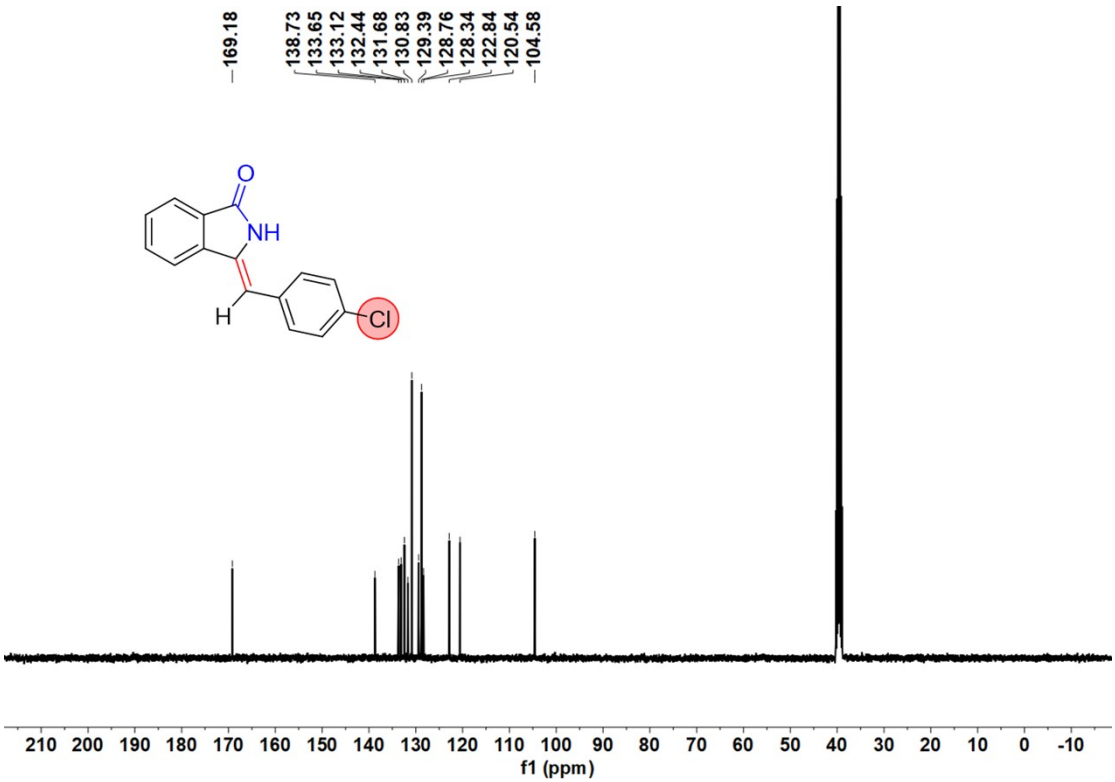
^{13}C NMR spectrum of compound 3i (101 MHz, DMSO-d_6)



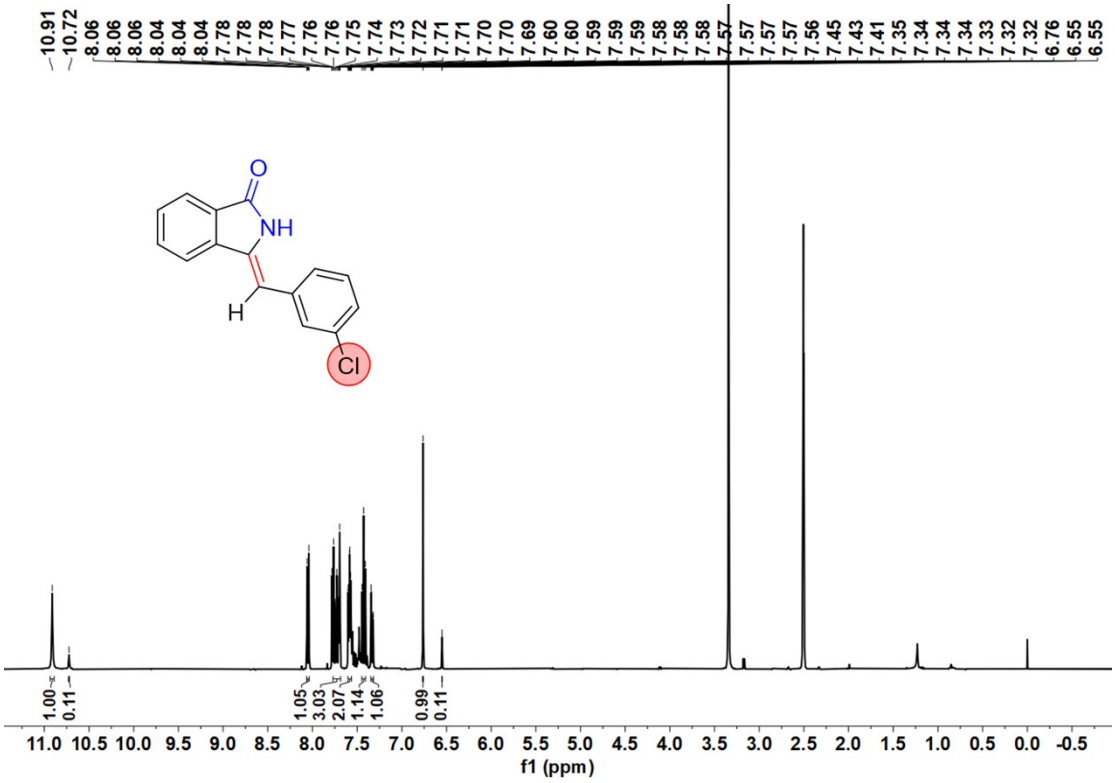
^{1}H NMR spectrum of compound 3j (400 MHz, DMSO-d_6)



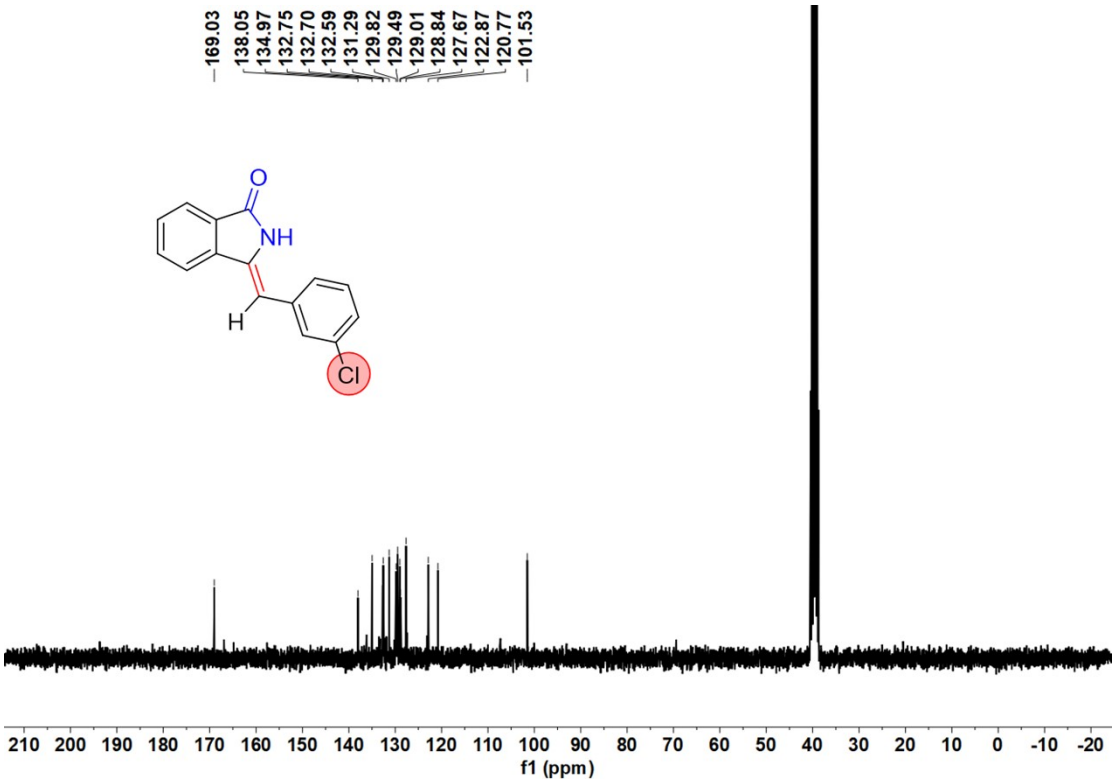
^{13}C NMR spectrum of compound 3j (101 MHz, DMSO-d_6)



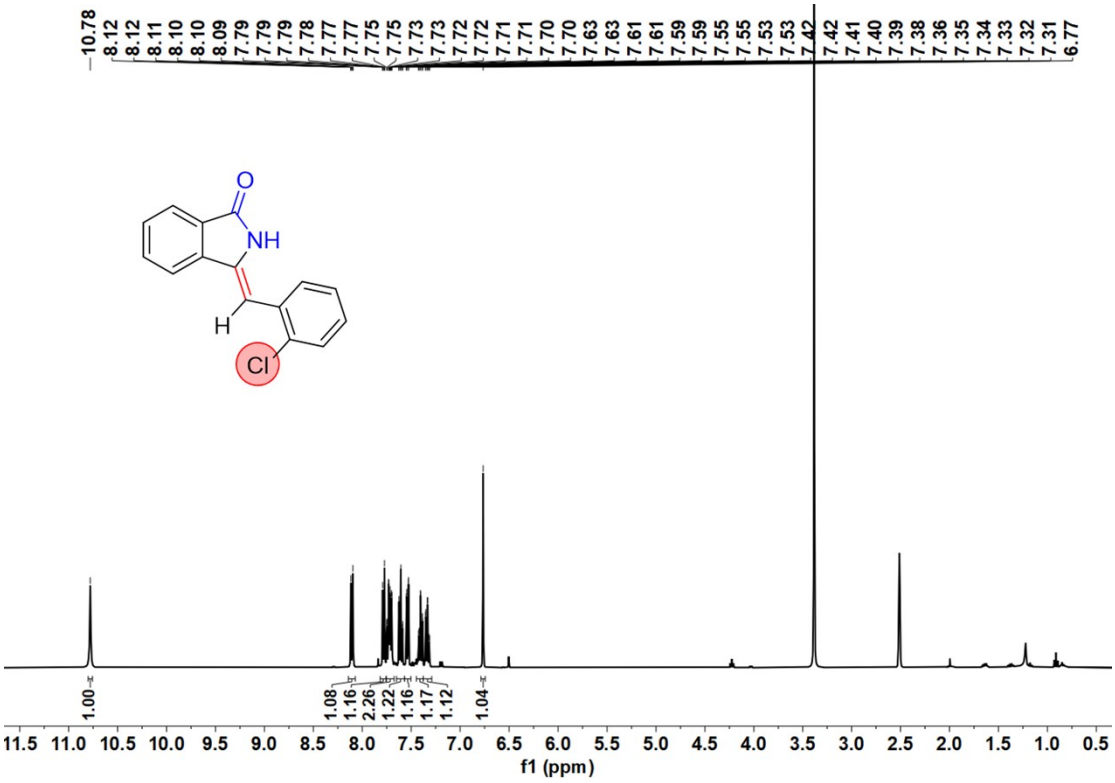
^{1}H NMR spectrum of compound 3k (*Z*/*E*=100:11) (400 MHz, DMSO-d_6)



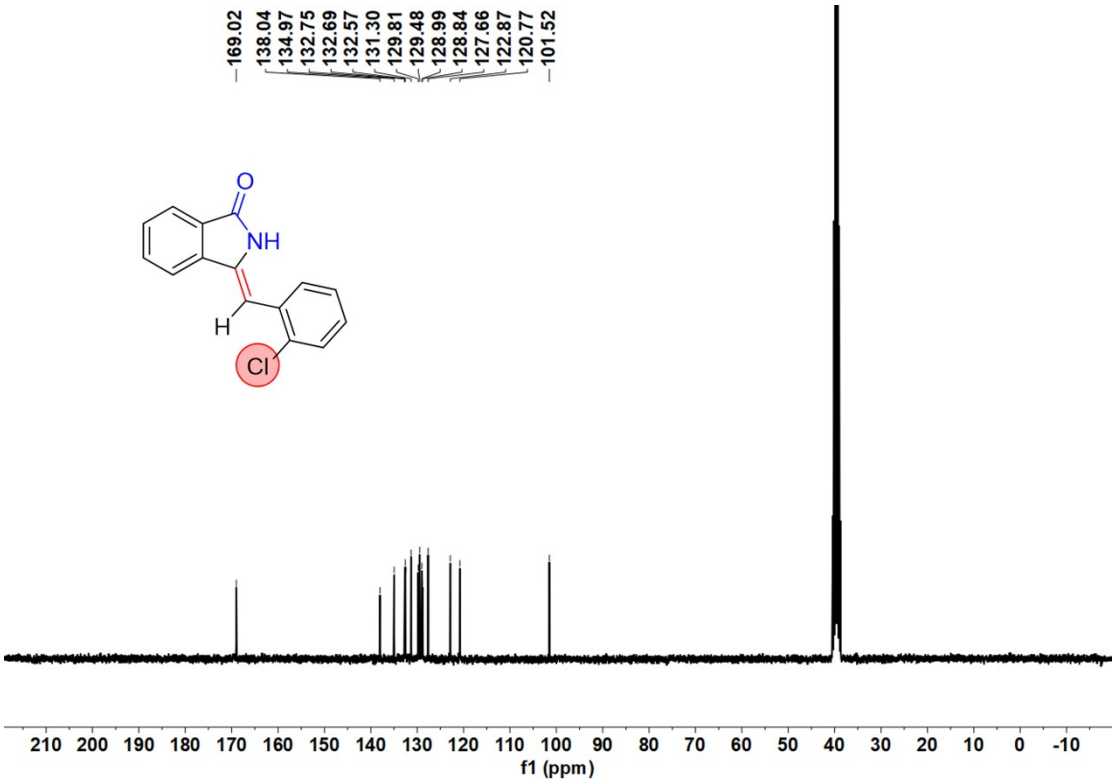
^{13}C NMR spectrum of compound 3k (*Z*/*E*=100:11) (101 MHz, DMSO-d_6)



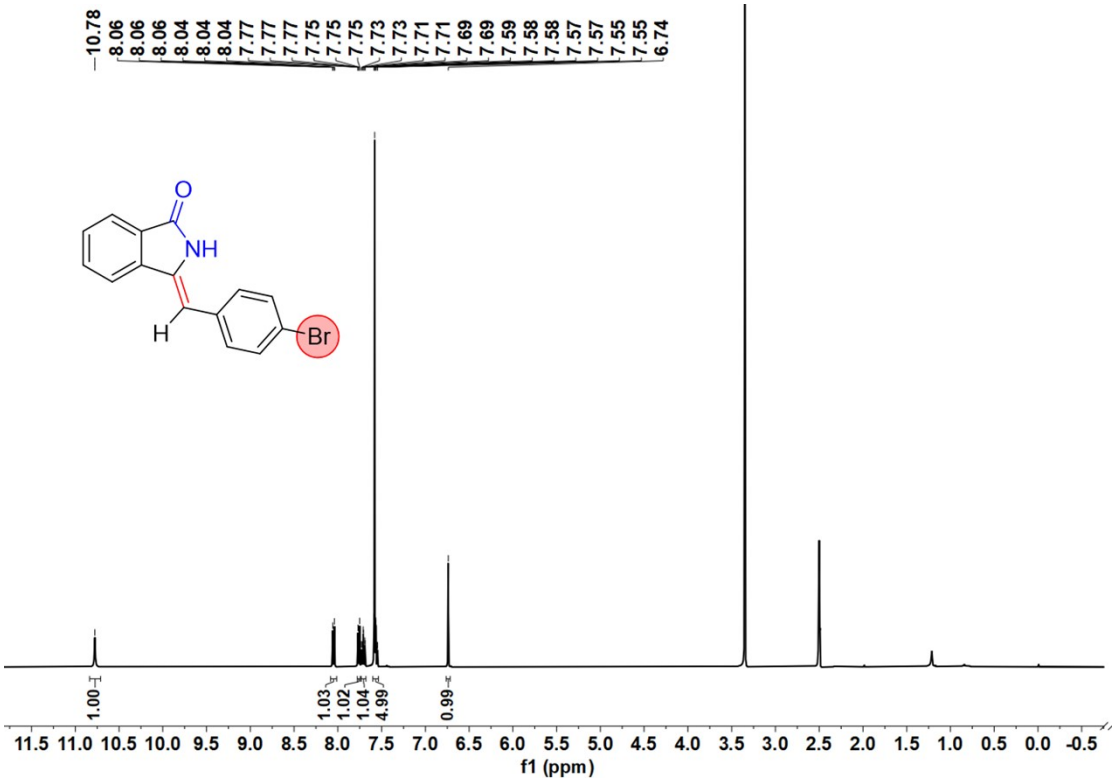
^{1}H NMR spectrum of compound 3l (400 MHz, DMSO-d_6)



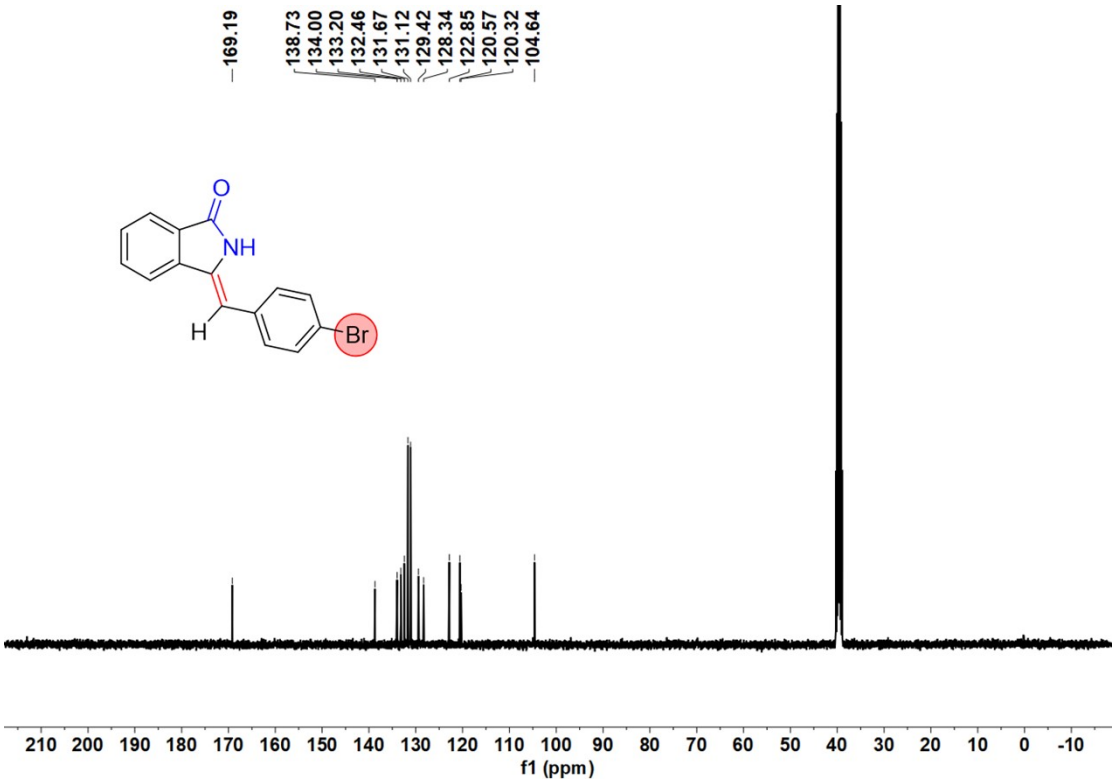
^{13}C NMR spectrum of compound 3l (101 MHz, DMSO-d_6)



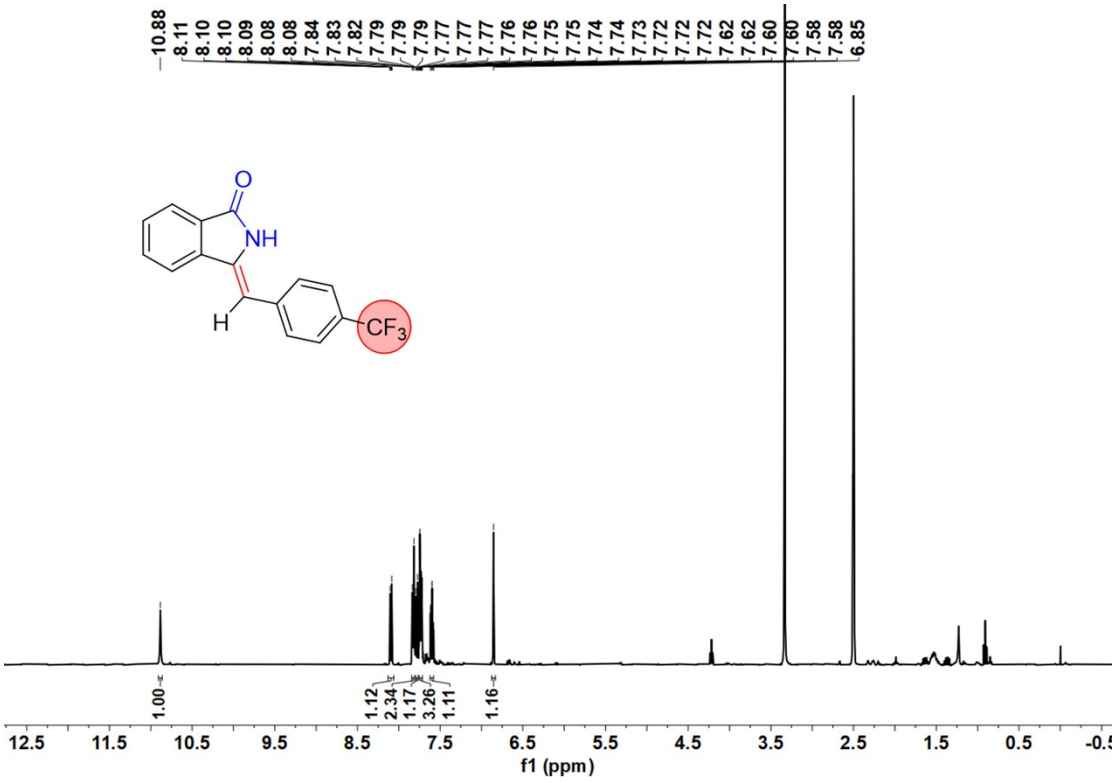
^{1}H NMR spectrum of compound 3m (400 MHz, DMSO-d_6)



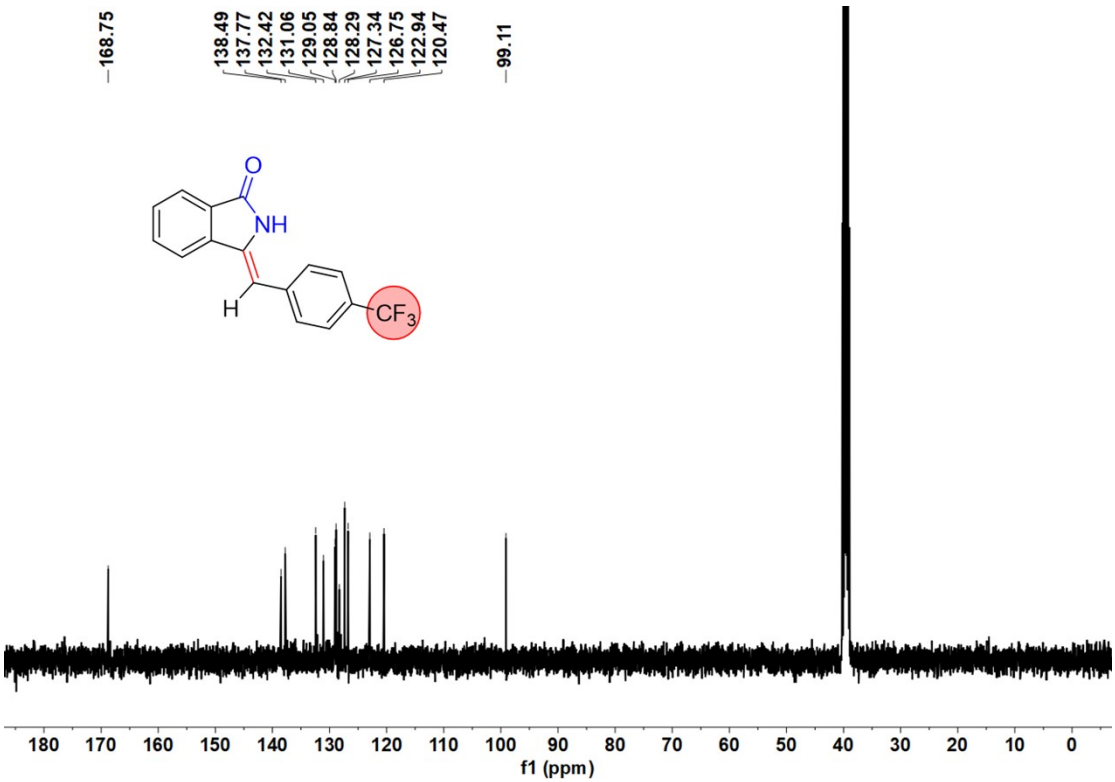
^{13}C NMR spectrum of compound 3m (101 MHz, DMSO-d_6)



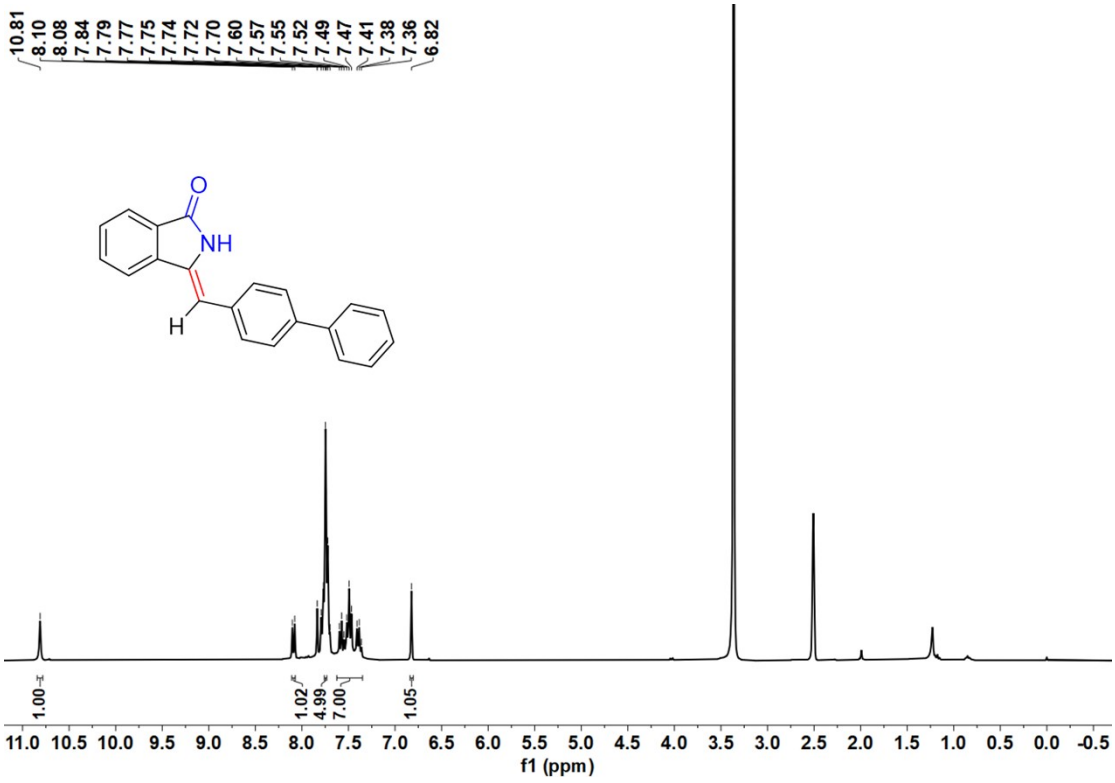
^{1}H NMR spectrum of compound 3n (400 MHz, DMSO-d_6)



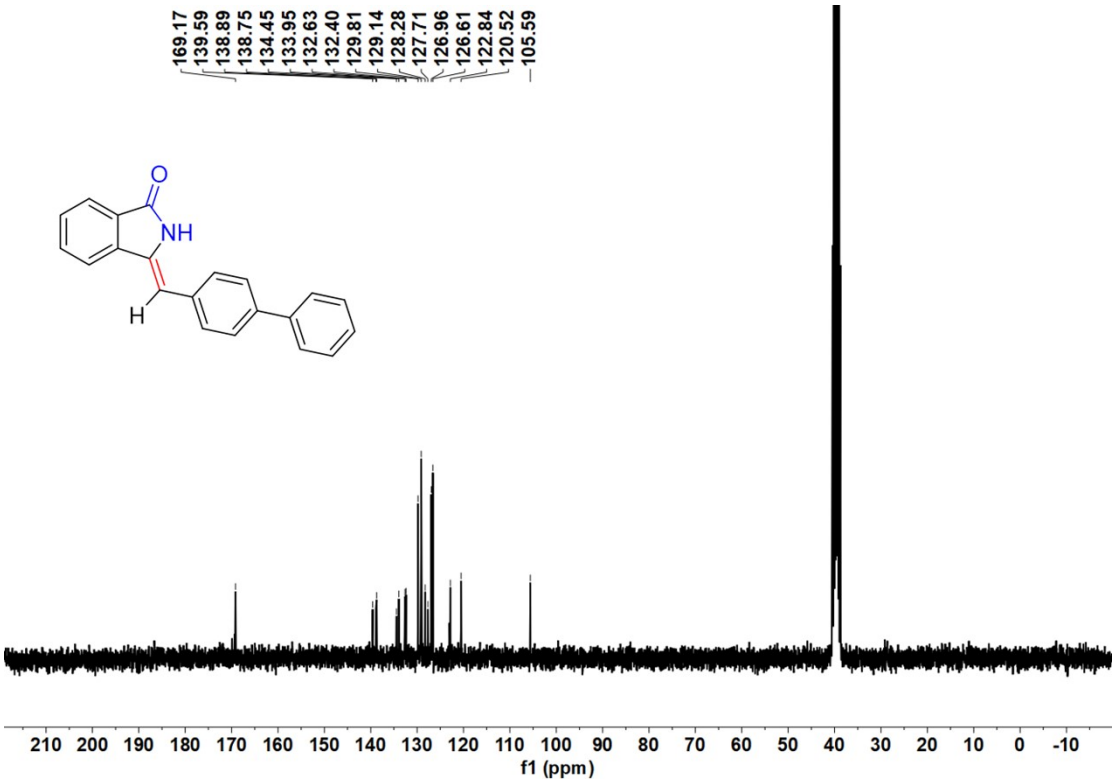
^{13}C NMR spectrum of compound 3n (101 MHz, DMSO-d_6)



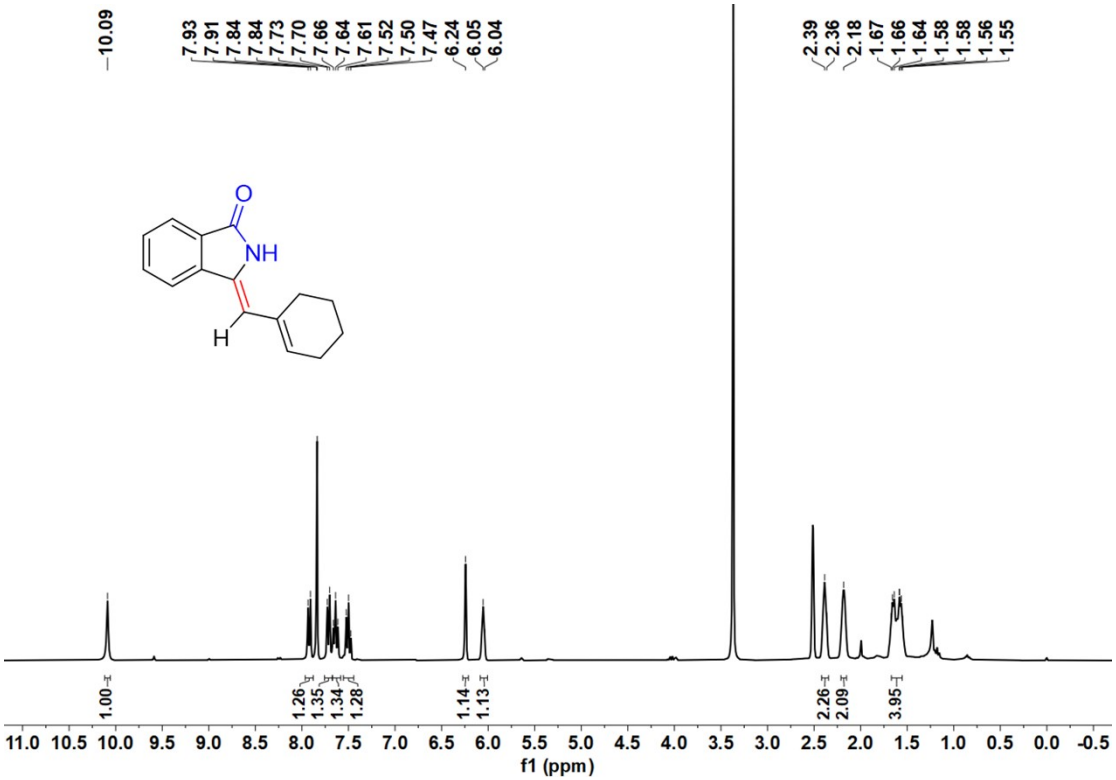
^{1}H NMR spectrum of compound 3o (400 MHz, DMSO-d_6)



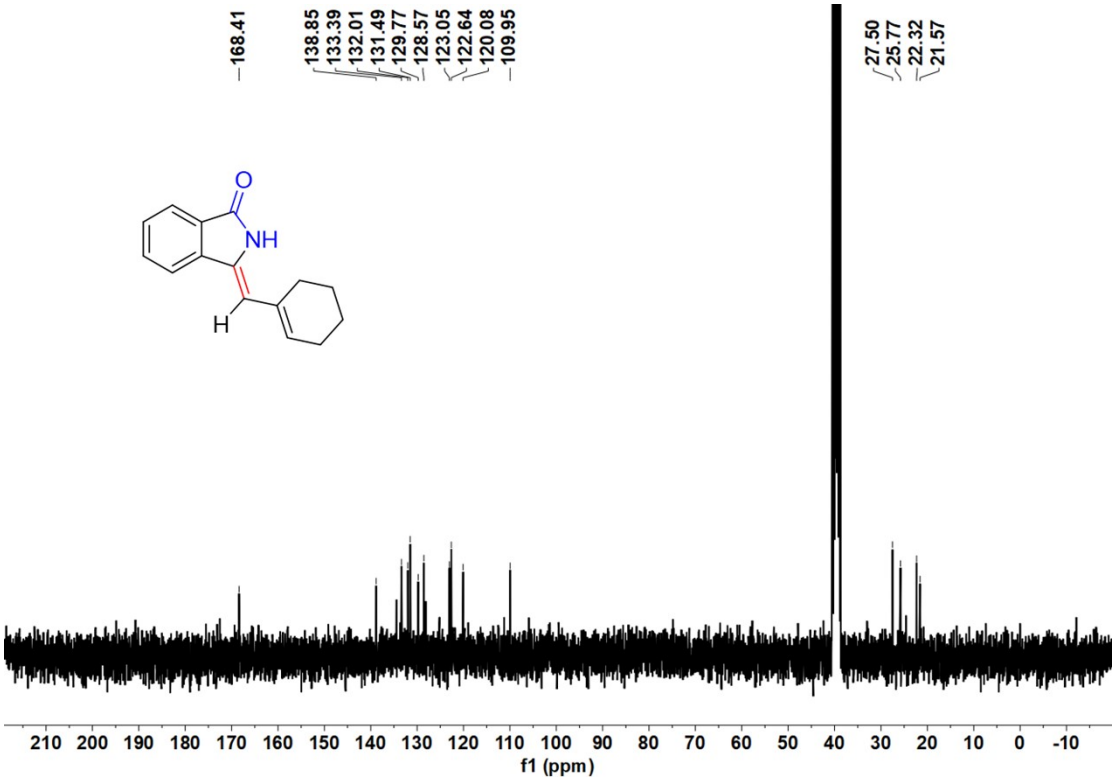
^{13}C NMR spectrum of compound 3o (101 MHz, DMSO-d_6)



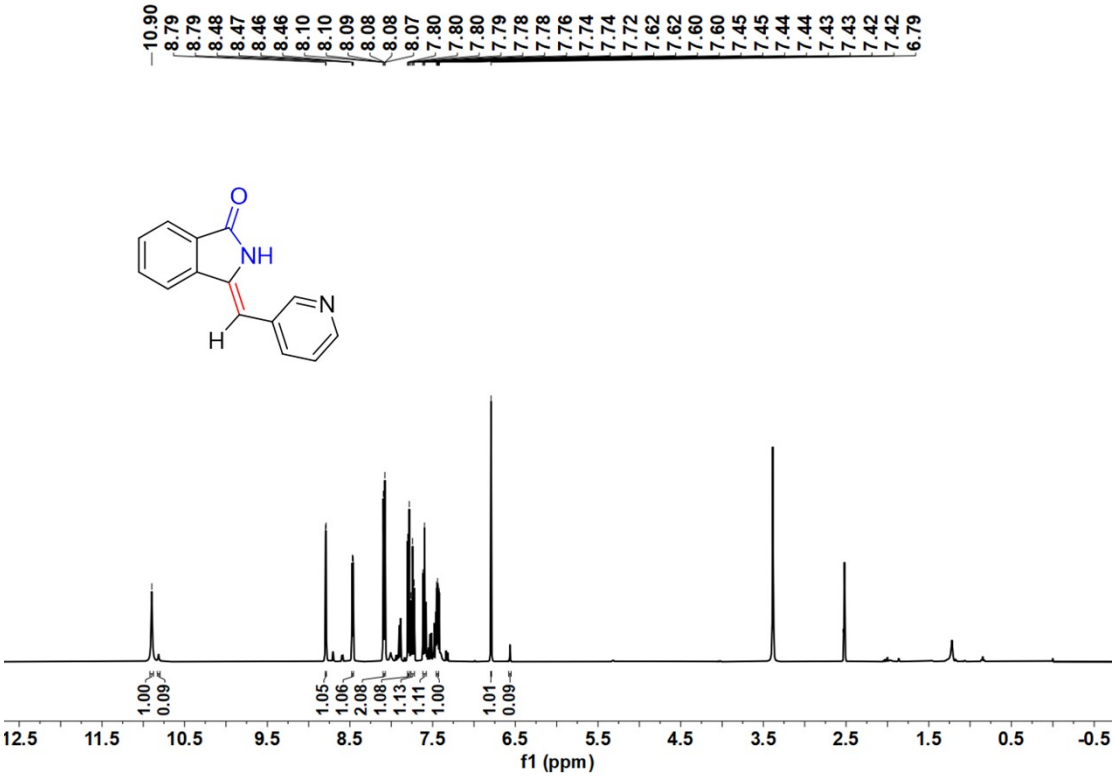
^{1}H NMR spectrum of compound 3p (400 MHz, DMSO-d_6)



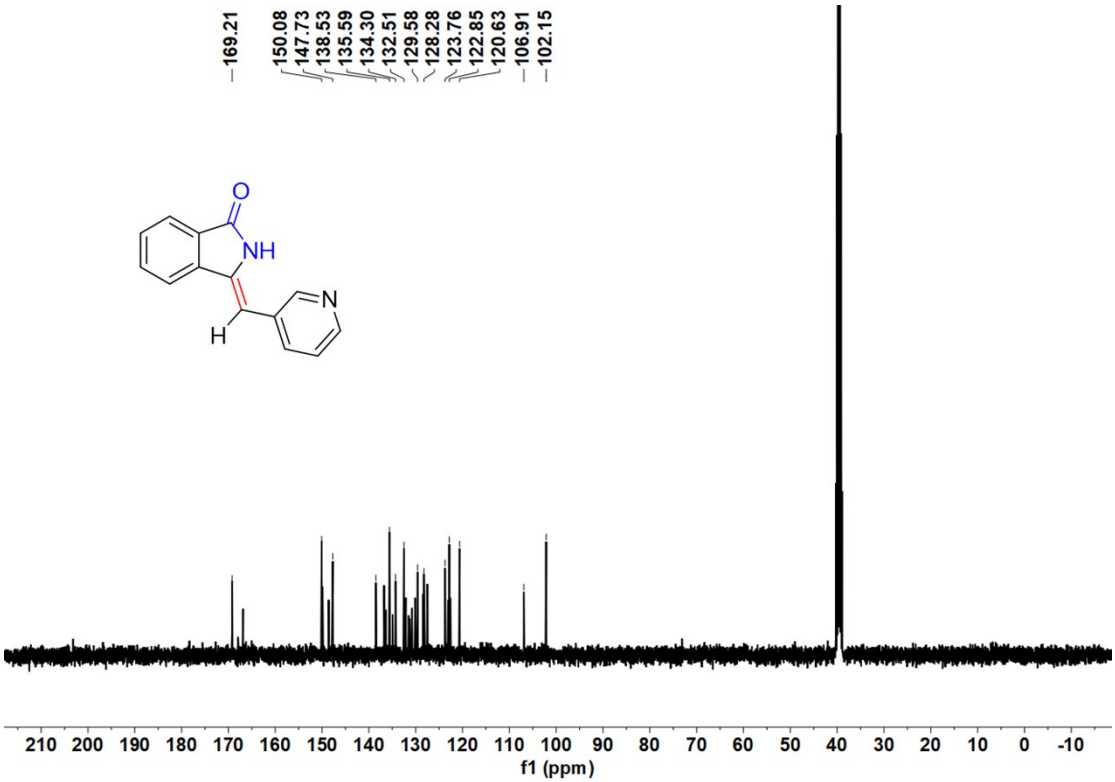
^{13}C NMR spectrum of compound 3p (101 MHz, DMSO-d_6)



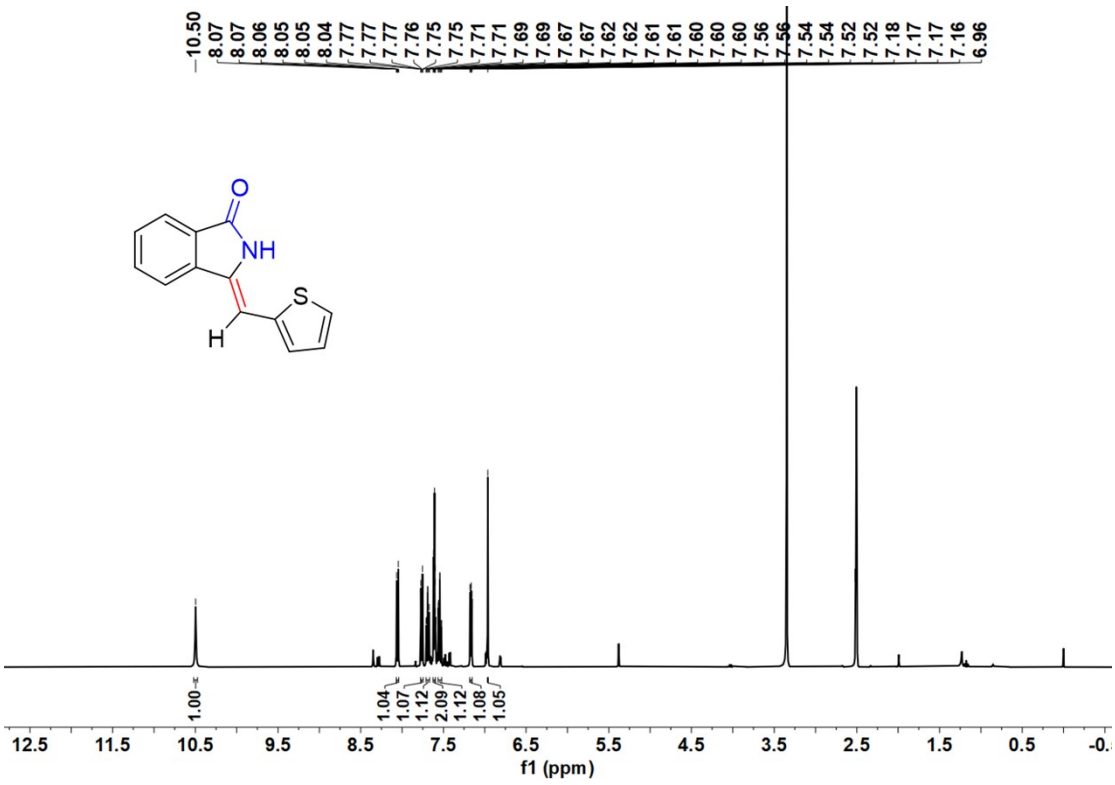
^{1}H NMR spectrum of compound 3q (*Z*/*E*=100:9) (400 MHz, DMSO-d_6)



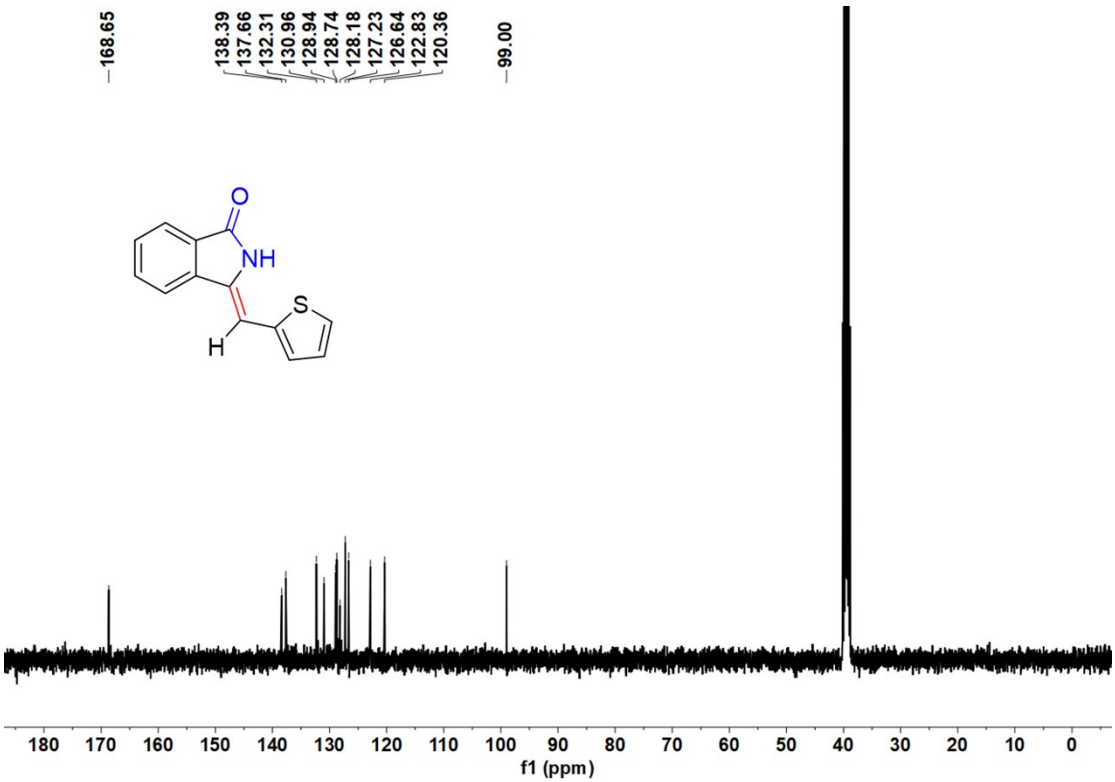
^{13}C NMR spectrum of compound 3q (*Z*/*E*=100:9) (101 MHz, DMSO-d_6)



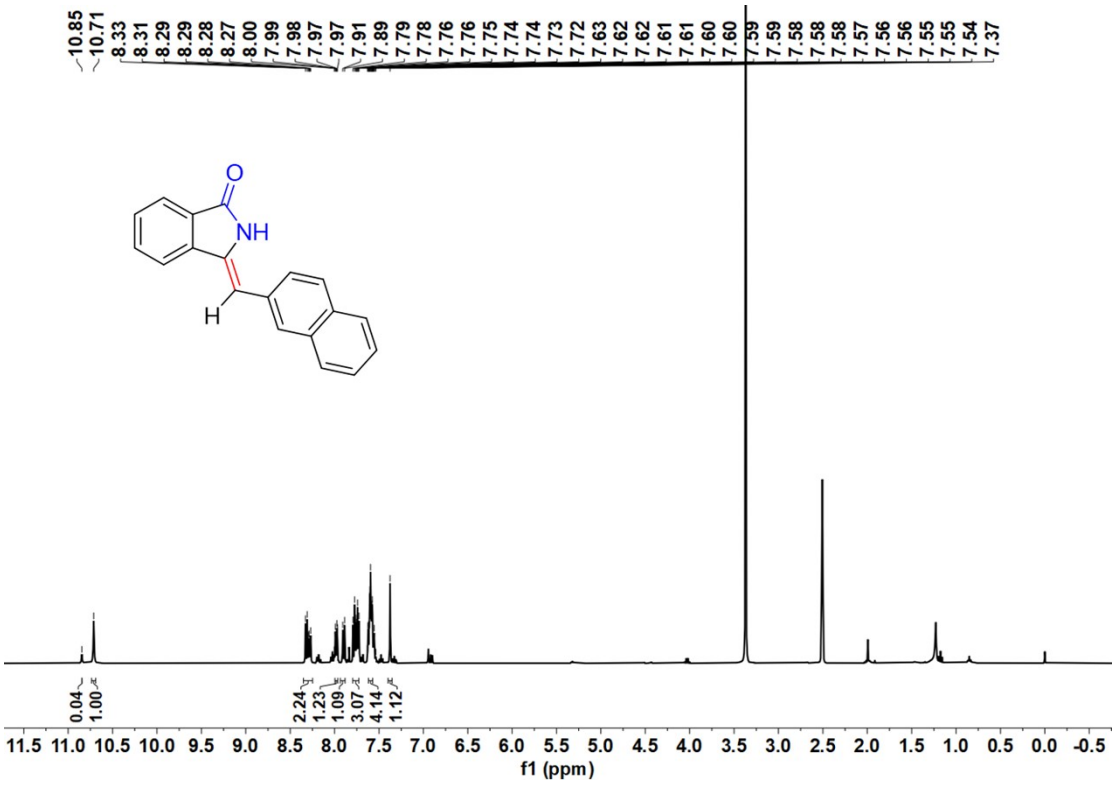
^{1}H NMR spectrum of compound 3r (400 MHz, DMSO-d_6)



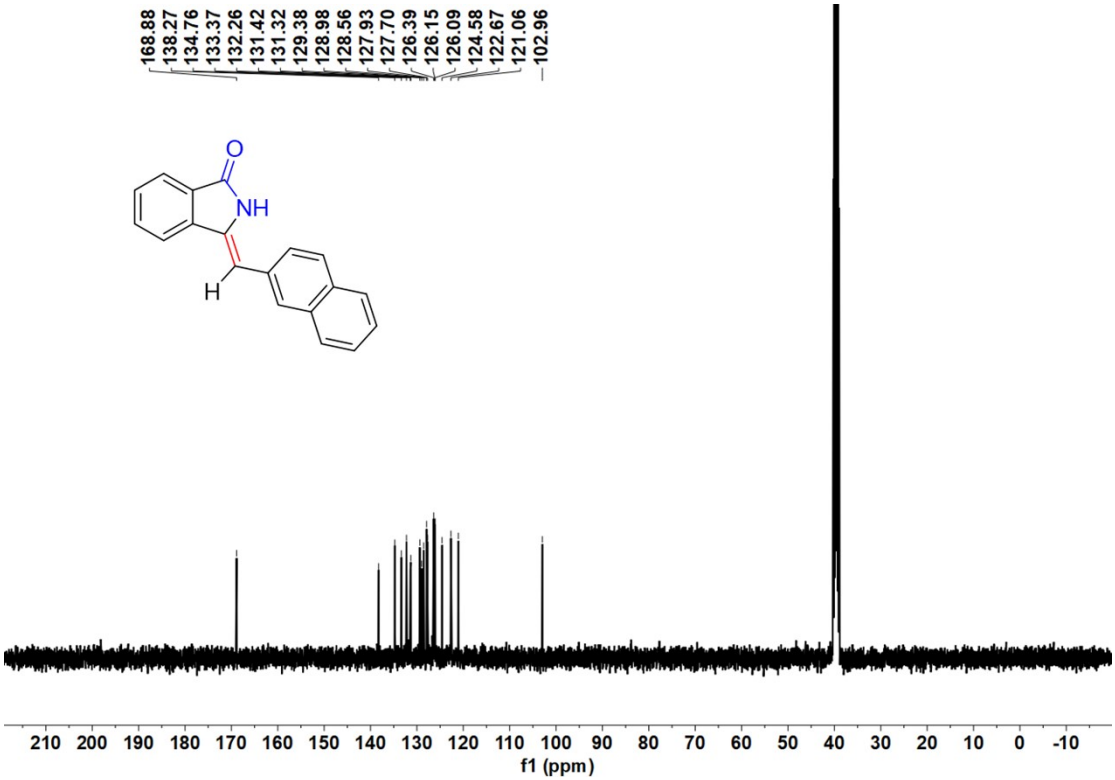
^{13}C NMR spectrum of compound 3r (101 MHz, DMSO-d_6)



^{1}H NMR spectrum of compound 3s (*Z*/*E*=100:4) (400 MHz, DMSO-d_6)



^{13}C NMR spectrum of compound 3s (*Z*/*E*=100:4) (101 MHz, DMSO-d_6)



7. References

1 (*a*) C. Sun and B. Xu. *J. Org. Chem.*, 2008, **73**, 7361-7364; (*b*) N. Topolovčan, F. Duplić and M. Gredičak. *Eur. J. Org. Chem.*, 2021, **2021**, 3920-3924.