Supporting Information

A new method for C(sp^2)-H sulfonylmethylation with glyoxylic acid and sodium sulfinates

Jiewen Chen, Jinhong Tian, Kangmei Wen, Qiwen Gao, Jie Shi, Xingang Yao, Ting Wu* and Xiaodong Tang*

Guangdong Provincial Key Laboratory of New Drug Screening, School of Pharmaceutical Sciences, Southern Medical University, 1023 South Shatai Road, Baiyun District, 510515, China;
E-mail: tangxdong@smu.edu.cn

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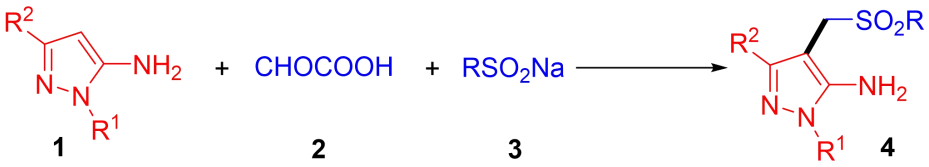
General Information

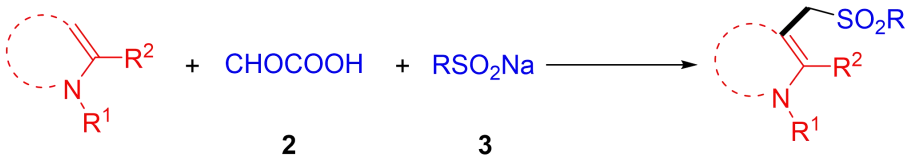
^{1}H and ^{13}C NMR spectra were recorded on BRUKER DRX-400 spectrometer with $CDCl_3$ as the solvent. ^{1}H shifts were referenced to $CDCl_3$ at 7.26 ppm. ^{13}C shifts were referenced to $CDCl_3$ at 77 ppm. IR spectra were obtained with an infrared spectrometer on either potassium bromide pellets or liquid films between two potassium bromide pellets. HRMS was carried out on a high-resolution mass spectrometer (LCMS-IT-TOF). TLC was performed using commercially available 100−400 mesh silica gel plates (GF_{254}). Unless otherwise noted, all of the commercial reagents were used without further purification.

The General Procedure A for Products 4



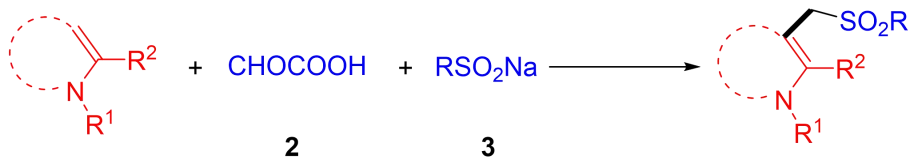
General procedure for products **4**: pyrazol-5-amines **1** (0.3 mmol), glyoxylic acid **2** (0.45 mmol, 1.5 equiv.), sodium sulfinates **3** (0.45 mmol, 1.5 equiv.), H_2O (1.5 mL), were added to a 25 mL tube with magnetic stirrer bar. The reaction mixture was stirred at 90°C (oil bath temperature) for 24 h. After the reaction was finished, the mixture was cooled to room temperature, quenched with aqueous solution of $NaHCO_3$ (10 mL) and extracted with EtOAc (3 × 10 mL). The combined organic layers were dried over anhydrous $MgSO_4$ and the solvent was removed under vacuum. The crude product was purified by column chromatography (petroleum ether /EtOAc) on silica gel.

The General Procedure B for Products 5, 6, 8, 10



General procedure for products **5, 6, 8, 10**: C(sp^2)-H substrates (0.3 mmol), glyoxylic acid **2** (0.45 mmol, 1.5 equiv.), sodium sulfinates **3** (0.45 mmol, 1.5 equiv.), H_2O (1.5 mL), were added to a 25 mL tube with magnetic stirrer bar. The reaction mixture was stirred at 90°C (oil bath temperature) for 24 h. After the reaction was finished, the mixture was cooled to room temperature, quenched with aqueous solution of $NaHCO_3$ (10 mL) and extracted with EtOAc (3 × 10 mL). The combined organic layers were dried over anhydrous $MgSO_4$ and the solvent was removed under vacuum. The crude product was purified by column chromatography (petroleum ether /EtOAc) on silica gel.

The General Procedure C for Products 7, 9



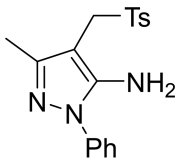
2 **3**

General procedure for products **7, 9**: C(sp^2)-H substrates (0.3 mmol), glyoxylic acid **2** (0.45 mmol, 1.5 equiv.), sodium sulfinates **3** (0.45 mmol, 1.5 equiv.), $Sc(OTf)_3$ (10 mol%), CH_3CN (1.5 mL), were added to a 25 mL tube with magnetic stirrer bar. The reaction mixture was stirred at 90°C (oil bath temperature) for 24 h. After the reaction was finished, the mixture was cooled to room temperature, quenched with aqueous solution of $NaHCO_3$ (10 mL) and extracted with EtOAc (3 × 10 mL). The combined organic layers were dried over anhydrous $MgSO_4$ and the solvent was removed under vacuum. The crude product was purified by column chromatography (petroleum ether /EtOAc) on silica gel.

Cell Culture and Evaluation of the Antiproliferative Activity

The compounds were evaluated for their in vitro cytotoxicity against the cancer cell lines Hela, HepG2 and B16-F10 by 3-(4,5-dimethylthiazol-2-yl)-2,5 -diphenyltetrazolium Bromide (MTT) assay. The cancer cell lines were purchased from American Type Culture Collection (ATCC). Hela cells, HepG2 cells and B16-F10 cells were grown in DMEM medium. The medium for all cell lines were supplemented with 10% fetal bovine serum (FBS, Invitrogen, Carlsbad, CA) and 1% penicillin-streptomycin (Life Technologies, USA) and maintained in a humidified incubator at 37 °C adjusted to 5% CO_2. Cells were seeded into 96-well plates at a density of 5000 cells/well. On the next day, medium containing the new compounds at different concentrations was added into per well for at least three cell doublings and incubated at 37°C for another 48 h, with 5-Fluorouracil (FU) as the positive control. At the indicated time, the culture medium was replaced with 100 μL medium containing 10% MTT solution (5 mg/mL in PBS) and further incubated for 4 h. The absorbance was detected with a microplate reader at a wavelength of 570 nm. The IC_{50} values were calculated by nonlinear regression analysis using GraphPad Prism 8.0.

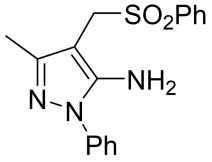
Characterization Data for All Products



3-Methyl-1-phenyl-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4a)

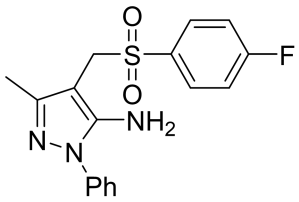
The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a yellow solid (95.3 mg, 93%), m.p. = 107-108 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, J = 8.0 Hz, 2H), 7.49 – 7.48 (m, 4H), 7.39 – 7.34 (m, 1H), 7.32 (d, J = 7.9 Hz, 2H), 4.38 (br, 2H), 4.11 (s, 2H), 2.44 (s, 3H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.7, 145.5, 144.9, 138.0, 134.6, 129.7, 129.5, 128.5, 127.6, 124.0,

90.1, 53.1, 21.6, 11.2. IR (KBr): 2086, 1596, 1519, 1499, 1305, 1137, 1084, 552 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{18}H_{20}N_3O_2S$ 342.1271; Found 342.1269.



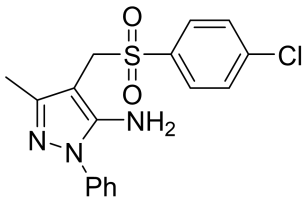
3-Methyl-1-phenyl-4-((phenylsulfonyl)methyl)-1*H*-pyrazol-5-amine (4b)

The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium benzenesulfinate (0.45 mmol, 73.9 mg) as a yellow solid (86.4 mg, 88%), m.p. = 147-148 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J* = 8.1 Hz, 2H), 7.67 (t, *J* = 7.2 Hz, 1H), 7.54 (t, *J* = 7.7 Hz, 2H), 7.49 – 7.48(m, 4H), 7.40 – 7.35 (m, 1H), 4.37 (br, 2H), 4.14 (s, 2H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.7, 145.5, 138.0, 137.6, 133.9, 129.6, 129.1, 128.5, 127.7, 124.0, 90.0, 53.1, 11.1. IR (KBr): 2085, 1451, 1301, 1137, 1081, 758, 692, 551 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{17}H_{18}N_3O_2S$ 328.1114; Found 328.1110.



4-(((4-Fluorophenyl)sulfonyl)methyl)-3-methyl-1-phenyl-1*H*-pyrazol-5-amine (4c)

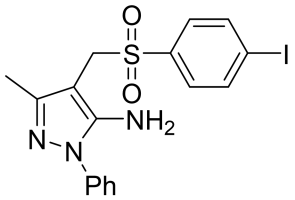
The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-fluorobenzenesulfinate (0.45 mmol, 82.0 mg) as a yellow solid (82.9 mg, 80%), m.p. = 130-131 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 – 7.75 (m, 2H), 7.49 – 7.48 (m, 4H), 7.38 (s, 1H), 7.21 (t, *J* = 8.2 Hz, 2H), 4.38 (br, 2H), 4.14 (s, 2H), 1.65 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0 (*J* = 256 Hz), 148.5, 145.5, 138.0, 133.6 (*J* = 3 Hz), 131.4 (*J* = 10 Hz), 129.6, 127.7, 124.0, 116.5 (*J* = 22 Hz), 89.8, 53.2, 11.2. IR (KBr): 2085, 1591, 1521, 1490, 1289, 1137, 1084, 553 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{17}H_{17}N_3O_2SF$ 346.1020; Found 346.1015.



4-(((4-Chlorophenyl)sulfonyl)methyl)-3-methyl-1-phenyl-1*H*-pyrazol-5-amine (4d)

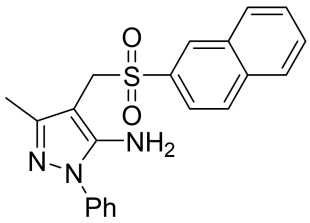
The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-chlorobenzenesulfinate (0.45 mmol, 89.4 mg) as a yellow solid (83.6 mg, 77%), m.p. = 125-126 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.1 Hz, 2H), 7.53 – 7.47 (m, 6H), 7.39 – 7.38 (d, *J* = 6.0 Hz, 1H), 4.38 (br, 2H), 4.14 (s, 2H), 1.66 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.5, 145.5, 140.8, 137.9, 136.1, 130.0, 129.6, 129.4, 127.7, 124.0, 89.6, 53.2, 11.3. IR (KBr):

2086, 1397, 1311, 1140, 1086, 759, 551 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{17}H_{17}N_3O_2SCl$ 362.0725; Found 362.0722.



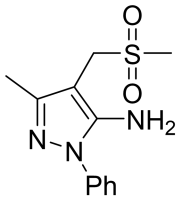
4-(((4-Iodophenyl)sulfonyl)methyl)-3-methyl-1-phenyl-1*H*-pyrazol-5-amine (4e)

The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-iodobenzenesulfinate (0.45 mmol, 130.5 mg) as a brown solid (114.2 mg, 84%), m.p. = 161-162 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, *J* = 8.5 Hz, 2H), 7.48 – 7.47 (m, 6H), 7.40 – 7.36 (m, 1H), 4.37 (br, 2H), 4.13 (s, 2H), 1.66 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.6, 145.5, 138.4, 138.0, 137.3, 129.8, 129.6, 127.7, 124.0, 102.0, 89.6, 53.1, 11.3. IR (KBr): 1731, 1569, 1310, 1138, 1082, 1004, 698, 548 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{17}H_{17}N_3O_2SI$ 454.0081; Found 454.0076.



3-Methyl-4-((naphthalen-2-ylsulfonyl)methyl)-1-phenyl-1*H*-pyrazol-5-amine (4f)

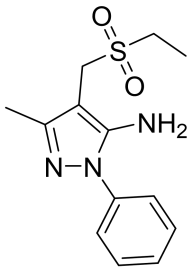
The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium naphthalene-2-sulfinate (0.45 mmol, 96.4 mg) as a yellow solid (89.5 mg, 79%), m.p. = 113-114 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.38 (s, 1H), 8.02 – 7.90 (m, 3H), 7.75 (d, *J* = 8.5 Hz, 1H), 7.69 (t, *J* = 7.5 Hz, 1H), 7.64 (t, *J* = 7.2 Hz, 1H), 7.50 – 7.48 (m, 4H), 7.41 – 7.34 (m, 1H), 4.41 (br, 2H), 4.22 (s, 2H), 1.59 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.7, 145.5, 138.0, 135.3, 134.7, 132.0, 130.4, 129.5, 129.4, 129.3, 129.3, 127.9, 127.7, 127.6, 124.0, 123.0, 90.0, 53.2, 11.3. IR (KBr): 1303, 1143, 1121, 1071, 757, 698, 548 cm^{-1}. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{21}H_{19}N_3O_2SNa$ 400.1090; Found 400.1087.



3-Methyl-4-((methylsulfonyl)methyl)-1-phenyl-1*H*-pyrazol-5-amine (4g)

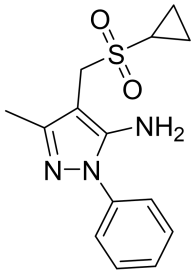
The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium methanesulfinate (0.45 mmol, 45.9 mg) as a yellow solid (65.3 mg, 82%), m.p. = 159-160

°C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.49 (m, 4H), 7.40 – 7.35 (m, 1H), 4.41 (br, 2H), 4.08 (s, 2H), 2.87 (s, 3H), 2.25 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.0, 145.6, 137.9, 129.6, 127.7, 124.0, 89.5, 51.3, 38.3, 12.1. IR (KBr): 1597, 1521, 1498, 1455, 1297, 1124, 697, 513 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{12}H_{16}N_3O_2S$ 266.0958; Found 266.0954.



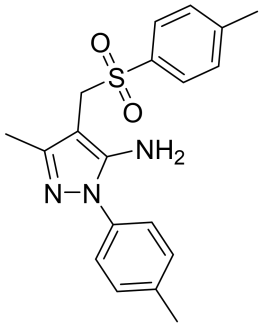
4-((Ethylsulfonyl)methyl)-3-methyl-1-phenyl-1*H*-pyrazol-5-amine (4h)

The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium ethanesulfinate (0.45 mmol, 52.2 mg) as a yellow gum (62.9 mg, 75%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.48 (m, 4H), 7.39 – 7.36 (m, 1H), 4.45 (br, 2H), 4.06 (s, 2H), 3.00 (q, *J* = 7.5 Hz, 2H), 2.24 (s, 3H), 1.42 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.1, 145.6, 137.9, 129.6, 127.7, 124.0, 89.2, 49.1, 44.7, 12.1, 6.2. IR (KBr): 3350, 2922, 1733, 1521, 1499, 1302, 1122, 698 cm^{-1}. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{13}H_{18}N_3O_2S$ 302.0934; Found 302.0931.



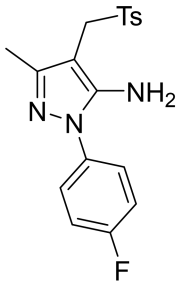
4-((Cyclopropylsulfonyl)methyl)-3-methyl-1-phenyl-1*H*-pyrazol-5-amine (4i)

The compound was obtained from the general prodecure A of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium cyclopropanesulfinate (0.45 mmol, 57.7 mg) as a yellow solid (73.4 mg, 84%), m.p. = 151-152 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.48 (m, 4H), 7.39 – 7.34 (m, 1H), 4.40 (br, 2H), 4.10 (s, 2H), 2.47 – 2.40 (m, 1H), 2.26 (s, 3H), 1.28 – 1.23 (m, 2H), 1.05 (d, *J* = 6.4 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.4, 145.5, 138.0, 129.6, 127.6, 124.0, 89.5, 50.2, 27.5, 12.1, 4.7. IR (KBr): 1520, 1498, 1315, 1287, 1121, 887, 698 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{14}H_{18}N_3O_2S$ 292.1114; Found 292.1110.



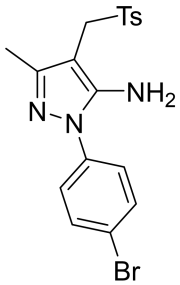
3-Methyl-1-(*p*-tolyl)-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4j)

The compound was obtained from the general prodecure A of 3-methyl-1-(*p*-tolyl)-1*H*-pyrazol-5-amine (0.3 mmol, 56.2 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a brown solid (98.1 mg, 92%), m.p. = 96-97 °C.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (s, 2H), 7.35 – 7.29 (m, 6H), 4.36 (br, 2H), 4.12 (s, 2H), 2.44 (d, *J* = 15.5 Hz, 6H), 1.63 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.4, 145.5, 144.9, 137.7, 135.4, 134.6, 130.1, 129.7, 128.5, 124.0, 89.9, 53.1, 21.6, 21.0, 11.1. IR (KBr): 1521, 1311, 1300, 1136, 1084, 821, 551 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{19}H_{22}N_3O_2S$ 356.1427; Found 356.1426.



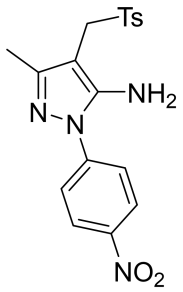
1-(4-Fluorophenyl)-3-methyl-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4k)

The compound was obtained from the general prodecure A of 1-(4-fluorophenyl)-3-methyl-1*H*-pyrazol-5-amine (0.3 mmol, 57.4 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a yellow solid (81.9 mg, 76%), m.p. = 174-175 °C.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.0 Hz, 2H), 7.49 – 7.46 (m, 2H), 7.33 (d, *J* = 7.9 Hz, 2H), 7.19 (t, *J* = 8.5 Hz, 2H), 4.36 (br, 2H), 4.11 (s, 2H), 2.45 (s, 3H), 1.64 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.8, 145.6, 145.1, 134.7, 129.8, 128.5, 126.2 (*J* = 9 Hz), 116.5 (*J* = 23 Hz), 90.3, 53.1, 21.6, 11.2. IR (KBr): 2085, 1508, 1300, 1224, 1135, 1084, 551, 510 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{18}H_{19}N_3O_2SF$ 360.1177; Found 360.1176.



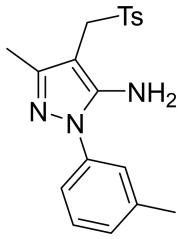
1-(4-Bromophenyl)-3-methyl-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4l)

The compound was obtained from the general prodecure A of 1-(4-bromophenyl)-3-methyl-1*H*-pyrazol-5-amine (0.3 mmol, 75.6 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a brown solid (89.5 mg, 71%), m.p. = 175-176 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.0 Hz, 2H), 7.61 (d, *J* = 8.3 Hz, 2H), 7.40 (d, *J* = 8.3 Hz, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 4.37 (br, 2H), 4.10 (s, 2H), 2.45 (s, 3H), 1.63 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.2, 145.5, 145.1, 137.2, 134.7, 132.7, 129.8, 128.5, 125.4, 121.1, 90.7, 53.0, 21.6, 11.2. IR (KBr): 1520, 1498, 1300, 1135, 1084, 831, 552 cm^{-1}. HRMS (ESI) m/z: $[M+K]^+$ Calcd for $C_{18}H_{18}BrN_3O_2SK$ 457.9935; Found 457.9937.



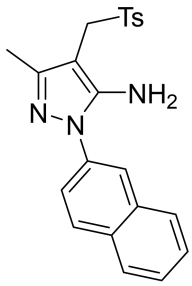
3-Methyl-1-(4-nitrophenyl)-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4m)

The compound was obtained from the general prodecure A of 3-methyl-1-(4-nitrophenyl)-1*H*-pyrazol-5-amine (0.3 mmol, 65.5 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a yellow solid (107.8 mg, 93%), m.p. = 197-198 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35 (d, *J* = 8.9 Hz, 2H), 7.80 (d, *J* = 8.9 Hz, 2H), 7.68 (d, *J* = 7.9 Hz, 2H), 7.34 (d, *J* = 7.9 Hz, 2H), 4.49 (br, 2H), 4.11 (s, 2H), 2.46 (s, 3H), 1.67 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 150.6, 145.9, 145.6, 145.3, 143.7, 134.6, 129.9, 128.5, 125.2, 122.8, 92.3, 52.9, 21.7, 11.3. IR (KBr): 2087, 1594, 1507, 1337, 1136, 853, 554 cm^{-1}. HRMS (ESI) m/z: $[M+K]^+$ Calcd for $C_{18}H_{18}N_4O_4SK$ 425.0680; Found 425.0676.



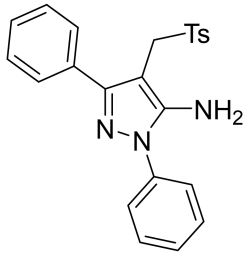
3-Methyl-1-(*m*-tolyl)-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4n)

The compound was obtained from the general prodecure A of 3-methyl-1-(*m*-tolyl)-1*H*-pyrazol-5-amine (0.3 mmol, 56.2 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a brown gum (82.1 mg, 77%). ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 8.1 Hz, 2H), 7.37 (d, *J* = 7.7 Hz, 1H), 7.32 (d, *J* = 8.1 Hz, 3H), 7.26 (s, 1H), 7.18 (d, *J* = 7.5 Hz, 1H), 4.39 (br, 2H), 4.11 (s, 2H), 2.44 (s, 3H), 2.41 (s, 3H), 1.62 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.5, 145.4, 144.9, 139.8, 137.9, 134.6, 129.7, 129.2, 128.5, 128.4, 124.8, 120.8, 90.0, 53.1, 21.6, 21.3, 11.1. IR (KBr): 1611, 1594, 1311, 1300, 1136, 1085, 553 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{19}H_{22}N_3O_2S$ 356.1427; Found 356.1426.



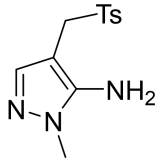
3-Methyl-1-(naphthalen-2-yl)-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4o)

The compound was obtained from the general prodecure A of 3-methyl-1-(naphthalen-2-yl)-1*H*-pyrazol-5-amine (0.3 mmol, 67.0 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a brown solid (91.6 mg, 78%), m.p. = 61-63 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (d, *J* = 8.7 Hz, 1H), 7.94 – 7.86 (m, 3H), 7.73 – 7.62 (m, 3H), 7.57 – 7.51 (m, 2H), 7.34 (d, *J* = 7.8 Hz, 2H), 4.47 (br, 2H), 4.14 (s, 2H), 2.45 (s, 3H), 1.66 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.9, 145.7, 144.9, 135.4, 134.6, 133.3, 132.1, 129.7, 129.7, 128.5, 127.9, 127.8, 126.9, 126.5, 122.4, 121.6, 90.2, 53.0, 21.6, 11.2. IR (KBr): 2089, 1531, 1294, 1136, 1084, 817, 551 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{23}H_{22}N_3O_2S$ 392.1427; Found 392.1426.



1, 3-Diphenyl-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4p)

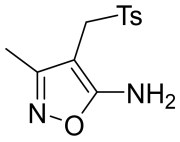
The compound was obtained from the general prodecure A of 1,3-diphenyl-1*H*-pyrazol-5-amine (0.3 mmol, 70.6 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a brown solid (118.6 mg, 98%), m.p. = 64-65 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.57 (m, 4H), 7.55 – 7.50 (m, 2H), 7.40 (d, *J* = 7.0 Hz, 1H), 7.28 – 7.24 (m, 4H), 7.22 (s, 3H), 4.68 (br, 2H), 4.29 (s, 2H), 2.42 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 152.2, 146.2, 144.9, 138.0, 134.8, 132.3, 129.7, 129.6, 128.2, 128.2, 128.0, 127.9, 124.4, 123.9, 89.1, 53.3, 21.6. IR (KBr): 1594, 1508, 1490, 1455, 1300, 1141, 559 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{22}H_{22}N_3O_2S$ 404.1427; Found 404.1424.



1-Methyl-4-(tosylmethyl)-1*H*-pyrazol-5-amine (4q)

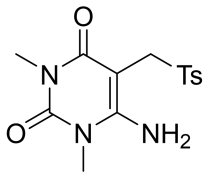
The compound was obtained from the general prodecure A of 1-methyl-1*H*-pyrazol-5-amine (0.3 mmol, 29.1 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a yellow solid (58.9 mg, 74%), m.p. = 164-165 °C. ^{1}H NMR (400 MHz, $CDCl_3$)

δ 7.60 (d, *J* = 8.0 Hz, 2H), 7.28 (d, *J* = 8.0 Hz, 2H), 6.76 (s, 1H), 4.09 (s, 2H), 3.65 (s, 3H), 2.41 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.8, 139.0, 134.5, 129.7, 128.4, 91.7, 53.4, 34.6, 21.6. IR (KBr): 2089, 1652, 1541, 1507, 1287, 1145, 1084, 551 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{12}H_{16}N_3O_2S$ 266.0958; Found 266.0953.



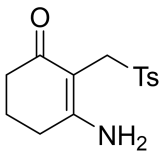
3-Methyl-4-(tosylmethyl)isoxazol-5-amine (5)

The compound was obtained from the general prodecure B of 3-methylisoxazol-5-amine (0.3 mmol, 29.4 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a white solid (76.7 mg, 96%), m.p. = 191-192 ºC.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, *J* = 8.0 Hz, 2H), 7.33 (d, *J* = 8.0 Hz, 2H), 3.94 (s, 2H), 2.44 (s, 3H), 1.56 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.2, 160.5, 145.4, 134.2 , 130.0, 128.5, 81.3, 51.6, 21.7, 9.4. IR (KBr): 2086, 1649, 1512, 1471, 1277, 1135, 551 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{12}H_{15}N_2O_3S$ 267.0798; Found 267.0795.



6-Amino-1,3-dimethyl-5-(tosylmethyl)pyrimidine-2,4(1*H*,3*H*)-dione (6)

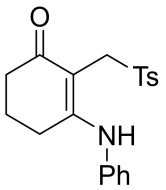
The compound was obtained from the general prodecure B of 6-amino-1,3-dimethylpyrimidine-2,4(1*H*,3*H*)-dione (0.3 mmol, 46.5 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a white solid (80.5 mg, 83%), m.p. = 224-225 ºC.^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.1 Hz, 2H), 5.66 (br, 2H), 4.35 (s, 2H), 3.48 (s, 3H), 3.17 (s, 3H), 2.43 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.6, 153.7, 150.9, 145.1, 134.8, 129.7, 128.3, 100.0, 53.6, 29.4, 28.4, 21.9. IR (KBr): 2086, 1696, 1610, 1503, 1278, 551, 515 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{14}H_{18}N_3O_4S$ 324.1013; Found 324.1008.



3-Amino-2-(tosylmethyl)cyclohex-2-en-1-one (7a)

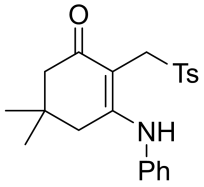
The compound was obtained from the general prodecure C of 3-aminocyclohex-2-en-1-one (0.3 mmol, 33.3 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a yellow solid (73.4 mg, 88%), m.p. = 230-231 ºC. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J* = 8.1 Hz, 2H), 7.28 (d, *J* = 8.0 Hz, 2H), 4.29 (s, 2H), 2.47 (t, *J* = 6.0 Hz, 2H), 2.41 (s, 3H), 2.11 (t, *J* = 6.0 Hz, 2H), 1.88 – 1.82 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.4, 164.6, 144.6, 135.0, 129.3, 128.4, 98.5, 52.0, 35.6, 30.5, 21.7, 20.8. IR (KBr): 1558, 1541, 1507, 1436,

1283, 1147, 1118, 750 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{14}H_{18}NO_3S$ 280.1002; Found 280.0999.



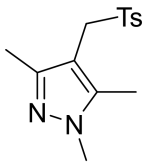
3-(Phenylamino)-2-(tosylmethyl)cyclohex-2-en-1-one (7b)

The compound was obtained from the general prodecure C of 3-(phenylamino)cyclohex-2-en-1-one (0.3 mmol, 56.2 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a yellow solid (104.5 mg, 98%), m.p. = 172-173 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.72 (br, 1H), 7.79 (d, *J* = 8.1 Hz, 2H), 7.39 (t, *J* = 7.7 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 7.4 Hz, 1H), 7.15 (d, *J* = 7.7 Hz, 2H), 4.44 (s, 2H), 2.57 (t, *J* = 6.0 Hz, 2H), 2.42 (s, 3H), 2.20 (t, *J* = 6.0 Hz, 2H), 1.83 – 1.79 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.3, 163.7, 144.7, 138.2, 134.7, 129.3, 128.4, 125.7, 124.3, 100.7, 52.4, 35.9, 27.6, 21.6, 21.6. IR (KBr): 1578, 1507, 1495, 1404, 1385, 1132, 1083, 701 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{20}H_{22}NO_3S$ 356.1315; Found 356.1311.



5,5-Dimethyl-3-(phenylamino)-2-(tosylmethyl)cyclohex-2-en-1-one (7c)

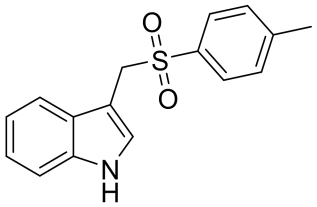
The compound was obtained from the general prodecure C of 5,5-dimethyl-3-(phenylamino)cyclohex-2-en-1-one (0.3 mmol, 64.6 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a yellow solid (100.1 mg, 87%), m.p. = 144-145 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.80 (br, 1H), 7.81 (d, *J* = 8.2 Hz, 2H), 7.39 (t, *J* = 7.8 Hz, 2H), 7.30 (d, *J* = 8.1 Hz, 2H), 7.23 (t, *J* = 7.4 Hz, 1H), 7.12 (d, *J* = 7.6 Hz, 2H), 4.46 (s, 2H), 2.41 (s, 5H), 2.07 (s, 2H), 0.90 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 193.0, 162.0, 144.7, 138.2, 135.1, 129.4, 129.3, 128.3, 125.6, 124.3, 99.6, 52.4, 49.5, 40.8, 32.2, 28.0, 21.6. IR (KBr): 2957, 1594, 1577, 1495, 1404, 1386, 1132, 701 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{22}H_{26}NO_3S$ 384.1628; Found 384.1624.



1,3,5-Trimethyl-4-(tosylmethyl)-1*H*-pyrazole (8)

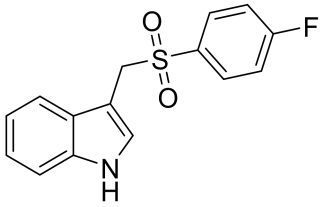
The compound was obtained from the general prodecure B of 1,3,5-trimethyl-1*H*-pyrazole (0.3 mmol, 33.0 mg), glyoxylic acid(0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a white solid (67.6 mg, 81%), m.p. = 127-128 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.0 Hz, 2H), 7.28 (d, *J* = 7.9 Hz, 2H), 4.07 (s, 2H), 3.69 (s, 3H), 2.43 (s, 3H), 2.05 (s, 3H), 1.72 (s,

3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.3, 144.7, 139.6, 135.1, 129.6, 128.6, 103.9, 52.9, 36.0, 21.5, 11.0, 9.6. IR (KBr): 1313, 1302, 1146, 1086, 823, 683, 550 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{14}H_{19}N_2O_2S$ 279.1162; Found 279.1160.



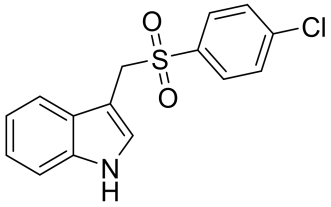
3-(Tosylmethyl)-1*H*-indole (9a)[1]

The compound was obtained from the general prodecure C of 1*H*-indole (0.3 mmol, 35.1 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a red solid (71.9 mg, 84%), m.p. = 173-174 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.34 (br, 1H), 7.56 (d, *J* = 7.5 Hz, 2H), 7.33 (d, *J* = 8.2 Hz, 1H), 7.29 (d, *J* = 8.0 Hz, 1H), 7.20 – 7.13 (m, 3H), 7.06 (s, 1H), 7.02 (t, *J* = 7.5 Hz, 1H), 4.52 (s, 2H), 2.37 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 135.7, 135.3, 129.5, 128.5, 126.9, 125.9, 122.4, 120.1, 118.5, 111.3, 102.7, 54.5, 21.5. IR (KBr): 3366, 1294, 1144, 1084, 815, 742, 542 cm^{-1}.



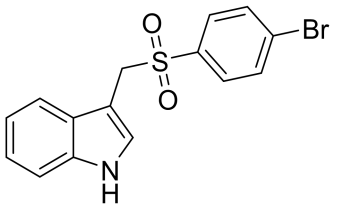
3-(((4-Fluorophenyl)sulfonyl)methyl)-1*H*-indole (9b)[1]

The compound was obtained from the general prodecure C of 1*H*-indole (0.3 mmol, 35.1 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-fluorobenzenesulfinate (0.45 mmol, 82.0 mg) as a red solid (60.8 mg, 70%), m.p. = 144-145 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.30 (br, 1H), 7.64 (dd, *J* = 8.7, 5.1 Hz, 2H), 7.34 (d, *J* = 8.2 Hz, 1H), 7.24 (d, *J* = 8.0 Hz, 1H), 7.17 (t, *J* = 7.6 Hz, 1H), 7.09 –7.08 (m, 1H), 7.06 – 7.00 (m, 3H), 4.54 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7 (*J* = 255 Hz), 135.7, 134.1 (*J* = 3 Hz), 131.4 (*J* = 10 Hz), 126.7, 126.0, 122.5, 120.3, 118.3, 116.1 (*J* = 23 Hz), 111.4, 102.4, 54.6. IR (KBr): 3367, 1307, 1144, 1086, 853, 763, 552 cm^{-1}.



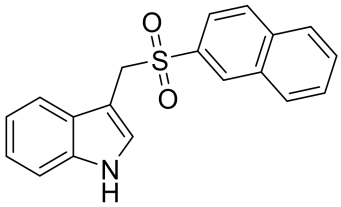
3-(((4-Chlorophenyl)sulfonyl)methyl)-1*H*-indole (9c)[1]

The compound was obtained from the general prodecure C of 1*H*-indole (0.3 mmol, 35.1 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-chlorobenzenesulfinate (0.45 mmol, 89.4 mg) as a yellow solid (48.6 mg, 53%), m.p. = 135-136 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.31 (br, 1H), 7.57 (d, *J* = 8.5 Hz, 2H), 7.35 – 7.32 (m, 3H), 7.28 (s, 1H), 7.18 (t, *J* = 7.5 Hz, 1H), 7.09 – 7.01 (m, 2H), 4.54 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 140.3, 136.6, 135.7, 130.1, 129.1, 126.7, 125.9, 122.6, 120.4, 118.4, 111.4, 102.5, 54.5. IR (KBr): 3370, 1300, 1124, 1084, 1003, 742, 550 cm^{-1}.



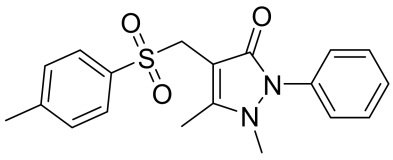
3-(((4-Bromophenyl)sulfonyl)methyl)-1*H*-indole (9d)

The compound was obtained from the general prodecure C of 1*H*-indole (0.3 mmol, 35.1 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-bromobenzenesulfinate (0.45 mmol, 109.4 mg) as a red solid (64.1 mg, 61%), m.p. = 175-176 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.27 (br, 1H), 7.49 (s, 4H), 7.34 (d, *J* = 8.2 Hz, 1H), 7.28 (d, *J* = 8.5 Hz, 1H), 7.19 (t, *J* = 7.6 Hz, 1H), 7.09 – 7.02 (m, 2H), 4.53 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 137.2, 135.7, 132.1, 130.1, 128.9, 126.7, 125.9, 122.7, 120.5, 118.4, 111.3, 102.6, 54.5. IR (KBr): 3365, 1308, 1163, 1145, 1084, 823, 542 cm^{-1}. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{15}H_{12}BrNO_2SNa$ 371.9664; Found 371.9662.



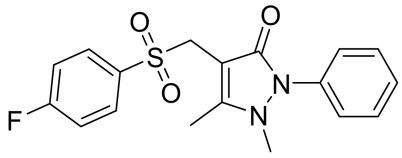
3-((Naphthalen-2-ylsulfonyl)methyl)-1*H*-indole (9e)

The compound was obtained from the general prodecure C of 1*H*-indole (0.3 mmol, 35.1 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium naphthalene-2-sulfinate (0.45 mmol, 96.4 mg) as a yellow solid (50.1 mg, 52%), m.p. = 181-182 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.26 (s, 1H), 8.19 (s, 1H), 7.90 – 7.81 (m, 3H), 7.67 – 7.61 (m, 2H), 7.56 (t, *J* = 7.5 Hz, 1H), 7.35 – 7.29 (m, 2H), 7.12 (t, *J* = 7.7 Hz, 1H), 7.02 (d, *J* = 2.1 Hz, 1H), 6.94 (t, *J* = 7.8 Hz, 1H), 4.62 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 135.7, 135.2, 135.2, 132.0, 130.4, 129.3, 129.1, 129.0, 127.8, 127.4, 126.9, 125.8, 123.2, 122.5, 120.3, 118.7, 111.2, 54.5. IR (KBr): 3365, 1304, 1144, 1084, 832, 712, 553 cm^{-1}. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{19}H_{15}NO_2SNa$ 344.0716; Found 344.0715.



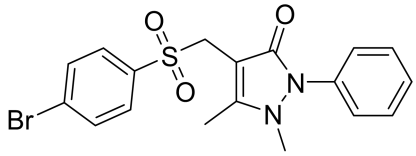
1,5-Dimethyl-2-phenyl-4-(tosylmethyl)-1,2-dihydro-3*H*-pyrazol-3-one (10a)

The compound was obtained from the general prodecure B of 1,5-dimethyl-2-phenyl-1,2-dihydro-3*H*-pyrazol-3-one(0.3 mmol, 56.5 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-methylbenzenesulfinate (0.45 mmol, 80.2 mg) as a white solid (104.8 mg, 98%), m.p. = 125-126 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 8.2 Hz, 2H), 7.38 (t, *J* = 7.8 Hz, 2H), 7.28 – 7.16 (m, 5H), 4.11 (s, 2H), 3.07 (s, 3H), 2.31 (d, *J* = 6.3 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.5, 155.6, 144.5, 135.4, 134.7, 129.4, 129.0, 128.4, 126.8, 124.2, 97.2, 50.9, 35.3, 21.5, 11.8. IR (KBr): 2089, 1652, 1540, 1491, 1455, 1309, 1142, 550 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{19}H_{21}N_2O_3S$ 357.1267; Found 357.1264.



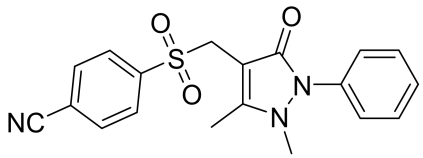
4-(((4-Fluorophenyl)sulfonyl)methyl)-1,5-dimethyl-2-phenyl-1,2-dihydro-3*H*-pyrazol-3-one(10b)

The compound was obtained from the general prodecure B of 1,5-dimethyl-2-phenyl-1,2-dihydro-3*H*-pyrazol-3-one(0.3 mmol, 56.5 mg), glyoxylic acid(0.45 mmol, 50 uL), sodium 4-fluorobenzenesulfinate (0.45 mmol, 82.0 mg) as a white solid (98.4 mg, 91%), m.p. = 167-168 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 – 7.76 (m, 2H), 7.38 (t, *J* = 7.7 Hz, 2H), 7.24 (t, *J* = 7.4 Hz, 1H), 7.16 (d, *J* = 7.5 Hz, 2H), 7.08 (t, *J* = 8.5 Hz, 2H), 4.12 (s, 2H), 3.08 (s, 3H), 2.33 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7 (*J* = 255 Hz), 164.2, 155.6, 134.5, 134.3 (*J* = 4 Hz), 131.2 (*J* = 9 Hz), 129.1, 127.0, 124.1, 116.1 (*J* = 22 Hz), 96.8, 51.0, 35.2, 11.8. IR (KBr): 1655, 1591, 1491, 1310, 1291, 1145, 553 cm^{-1}. HRMS (ESI) m/z: $[M+K]^+$ Calcd for $C_{18}H_{17}FN_2O_3SK$ 399.0575; Found 399.0574.



4-(((4-Bromophenyl)sulfonyl)methyl)-1,5-dimethyl-2-phenyl-1,2-dihydro-3*H*-pyrazol-3-one (10c)

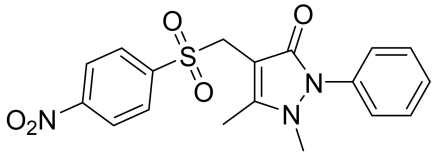
The compound was obtained from the general prodecure B of 1,5-dimethyl-2-phenyl-1,2-dihydro-3*H*-pyrazol-3-one (0.3 mmol, 56.5 mg), glyoxylic acid(0.45 mmol, 50 uL), sodium 4-bromobenzenesulfinate (0.45 mmol, 109.4 mg) as a white solid (108.7 mg, 86%), m.p. = 225-226 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (d, *J* = 8.4 Hz, 2H), 7.56 (d, *J* = 8.4 Hz, 2H), 7.40 (t, *J* = 7.7 Hz, 2H), 7.26 (t, *J* = 7.4 Hz, 1H), 7.16 (d, *J* = 7.7 Hz, 2H), 4.14 (s, 2H), 3.09 (s, 3H), 2.34 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.3, 155.5, 137.4, 134.6, 132.1, 130.0, 129.2, 129.0, 127.0, 124.2, 96.7, 51.0, 35.2, 11.9. IR (KBr): 1652, 1574, 1492, 1314, 1291, 1143, 749, 545 cm^{-1}. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{18}H_{17}N_2O_3SBrNa$ 443.0035; Found 443.0032.



4-(((1,5-Dimethyl-3-oxo-2-phenyl-2,3-dihydro-1*H*-pyrazol-4-yl)methyl)sulfonyl)benzonitrile (10d)

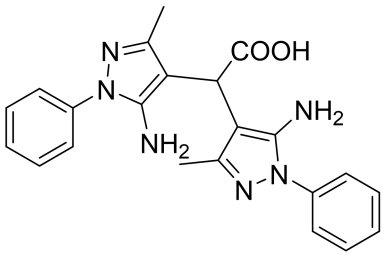
The compound was obtained from the general prodecure B of 1,5-dimethyl-2-phenyl-1,2-dihydro-3*H*-pyrazol-3-one (0.3 mmol, 56.5 mg), glyoxylic acid(0.45 mmol, 50 uL), sodium 4-cyanobenzenesulfinate (0.45 mmol, 85.1 mg) as a white solid (83.8 mg, 76%), m.p. = 220-221 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (d, *J* = 8.2 Hz, 2H), 7.70 (d, *J* = 8.2 Hz, 2H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.29 (t, *J* = 7.4 Hz, 1H), 7.14 (d, *J* = 7.8 Hz, 2H), 4.20 (s, 2H), 3.13 (s, 3H), 2.39 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.2, 155.5, 142.5, 134.4, 132.4, 129.3,

127.3, 124.2, 117.3, 117.2, 95.9, 50.9, 35.2, 11.9. IR (KBr): 1654, 1507, 1496, 1489, 1457, 1317, 1140 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{19}H_{18}N_3O_3S$ 368.1063; Found 368.1062.



1,5-Dimethyl-4-(((4-nitrophenyl)sulfonyl)methyl)-2-phenyl-1,2-dihydro-3*H*-pyrazol-3-one (10e)

The compound was obtained from the general prodecure B of 1,5-dimethyl-2-phenyl-1,2-dihydro-3*H*-pyrazol-3-one (0.3 mmol, 56.5 mg), glyoxylic acid (0.45 mmol, 50 uL), sodium 4-nitrobenzenesulfinate (0.45 mmol, 94.1 mg) as a yellow solid (95.3 mg, 82%), m.p. = 226-227 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (d, *J* = 8.7 Hz, 2H), 8.02 (d, *J* = 8.7 Hz, 2H), 7.41 (t, *J* = 7.7 Hz, 2H), 7.32 – 7.26 (m, 1H), 7.14 (d, *J* = 7.7 Hz, 2H), 4.24 (s, 2H), 3.16 (s, 3H), 2.43 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.2, 155.5, 150.7, 144.1, 134.4, 130.0, 129.3, 127.4, 124.3, 123.8, 95.9, 51.1, 35.2, 11.9. IR (KBr): 1654, 1532, 1496, 1457, 1349, 1307, 1145, 737 cm^{-1}. HRMS (ESI) m/z: $[M+Na]^+$ Calcd for $C_{18}H_{17}N_3O_5SNa$ 410.0781; Found 410.0780.



2, 2-Bis(5-amino-3-methyl-1-phenyl-1*H*-pyrazol-4-yl)acetic acid (11)

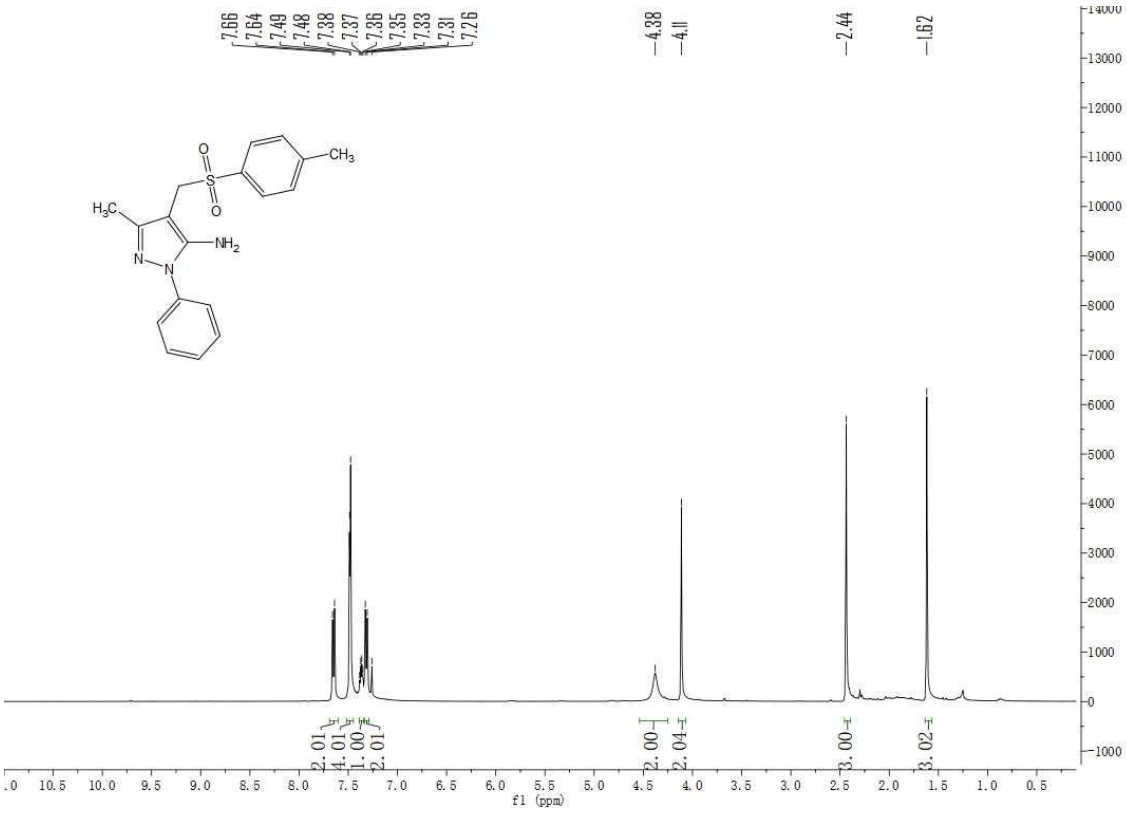
The compound was obtained from the reaction of 3-methyl-1-phenyl-1*H*-pyrazol-5-amine (0.3 mmol, 52.0 mg), glyoxylic acid (0.45 mmol, 50 uL) as a yellow solid (72.7 mg, 98%), m.p. = 212-213 °C. ^{1}H NMR (400 MHz, Methanol-d_4) δ 7.53 – 7.49 (m, 7H), 7.42 – 7.36 (m, 3H), 5.88 (s, 1H), 2.31 (s, 6H). ^{13}C NMR (100 MHz, Methanol-d_4) δ 177.3, 149.3, 145.9, 139.3, 130.3, 128.8, 126.0, 101.3, 67.4, 12.0. IR (KBr): 2364, 2087, 1615, 1503, 1465, 1307, 1141, 551 cm^{-1}. HRMS (ESI) m/z: $[M+H]^+$ Calcd for $C_{22}H_{23}N_6O_2$ 403.1877; Found 403.1874.

References

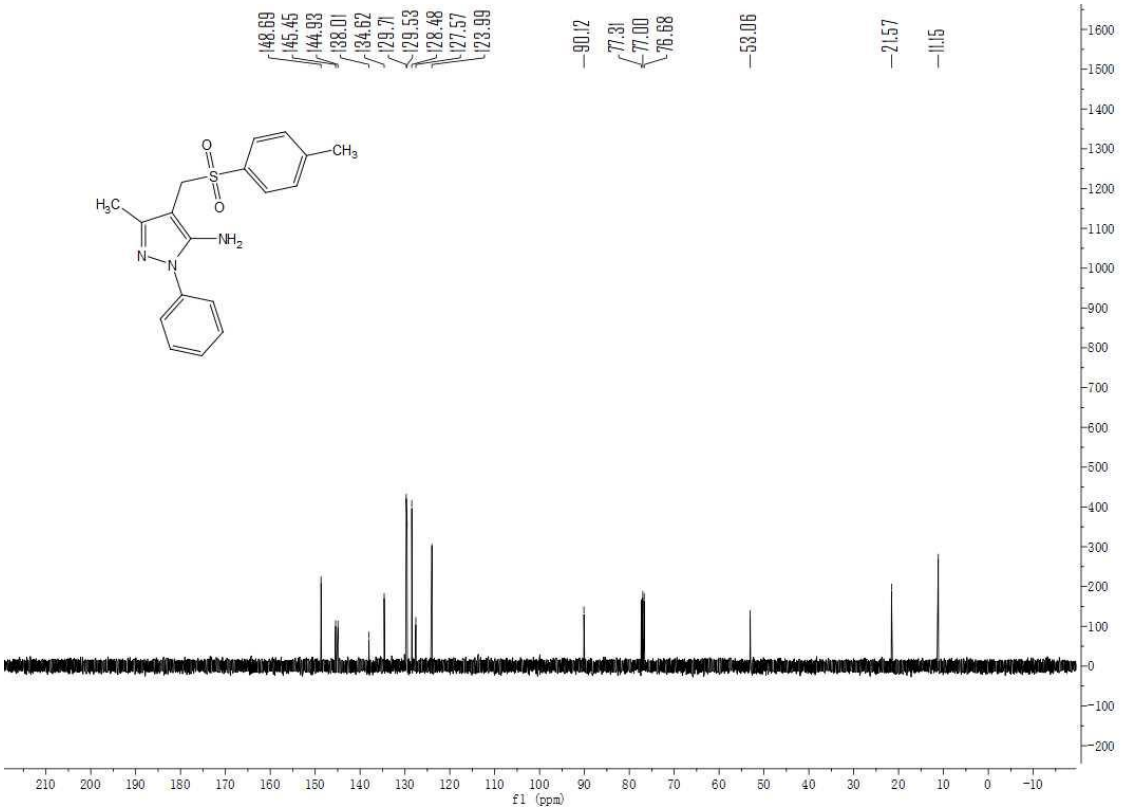
1. S. Lu, Y.-S. Zhu, K.-X. Yan, T.-W. Cui, X. Zhu, X.-Q. Hao and M.-P. Song, *Synlett*, 2019, **30**, 1924.

NMR Spectra for All Compounds

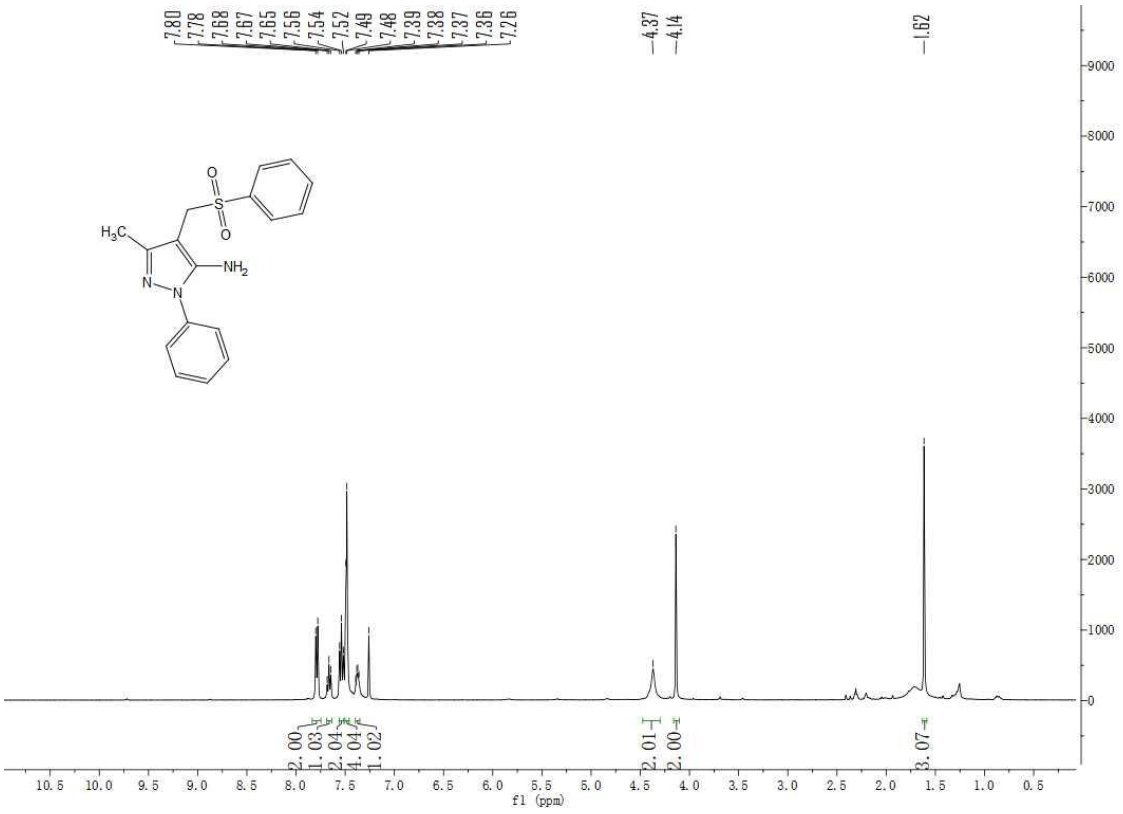
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4a



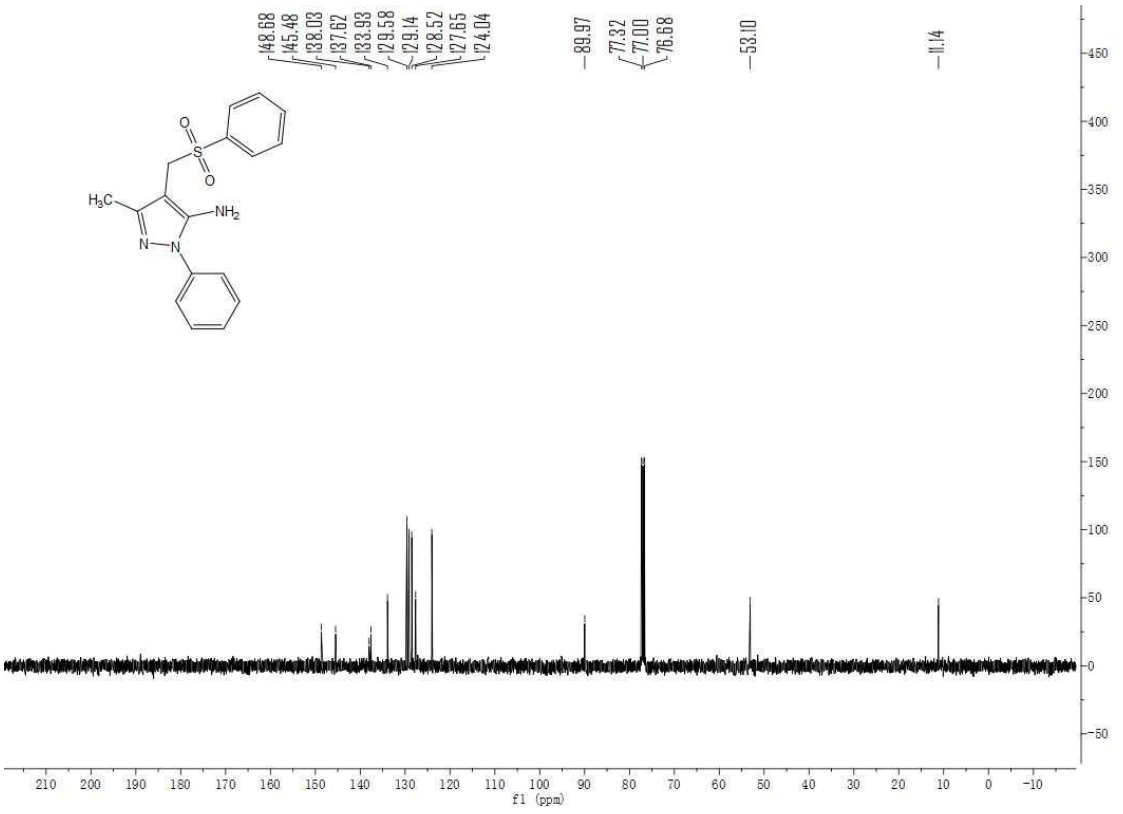
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4a



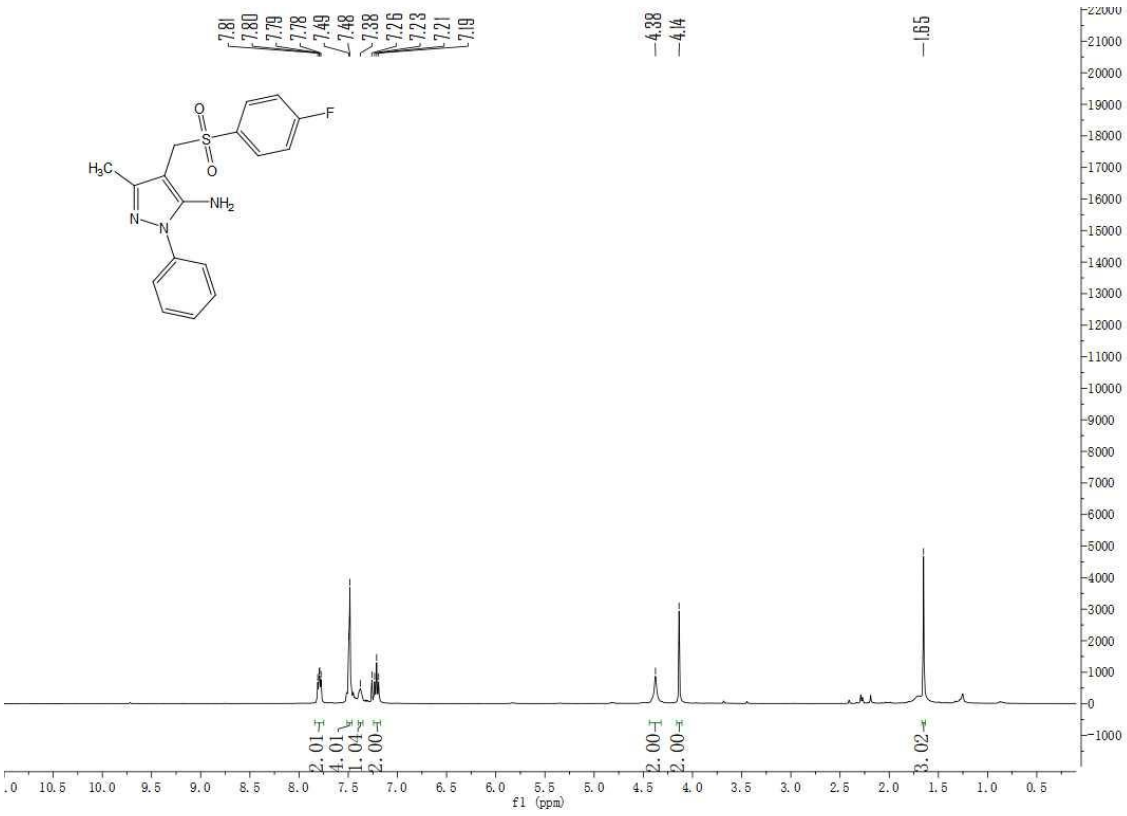
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4b



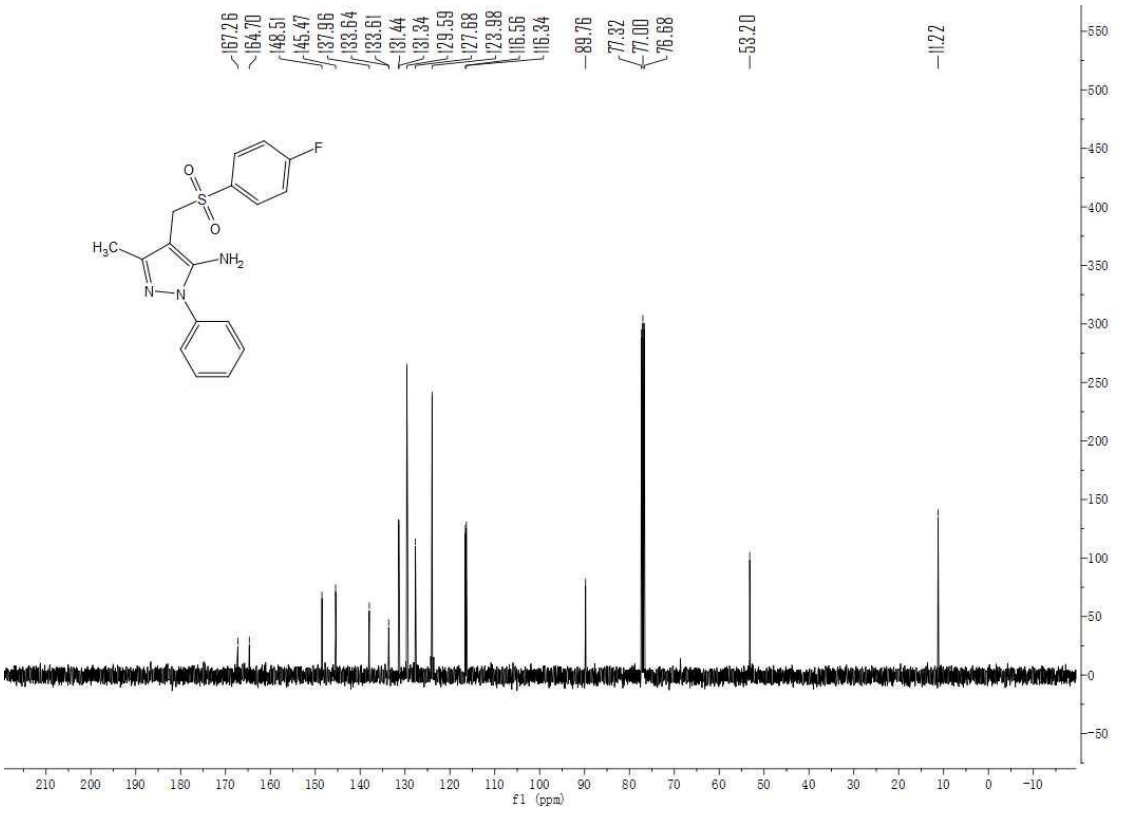
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4b



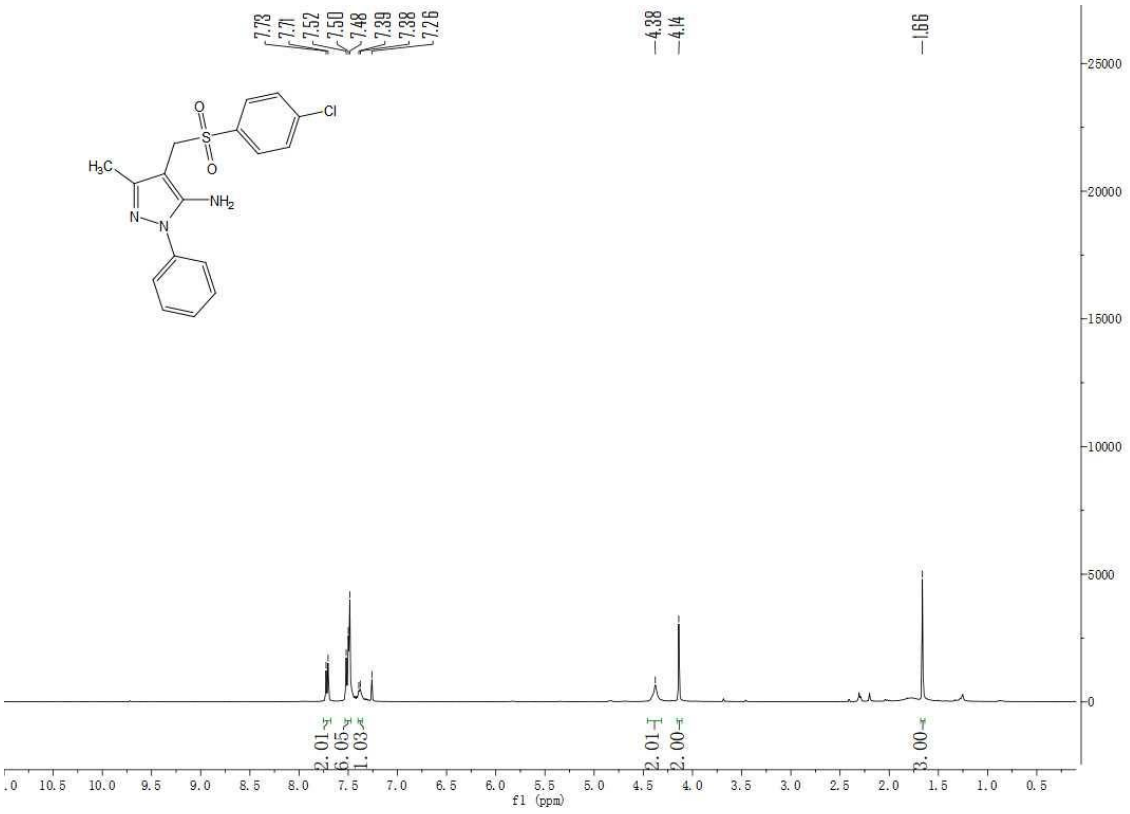
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4c



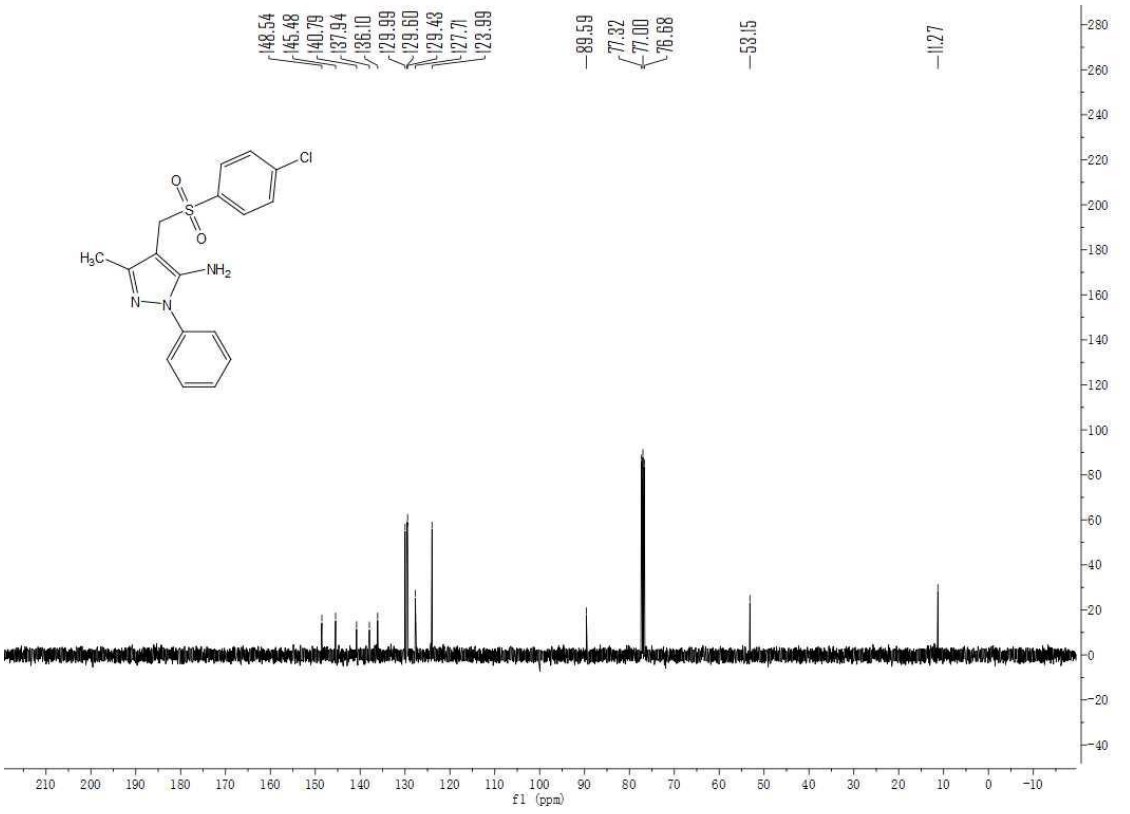
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4c



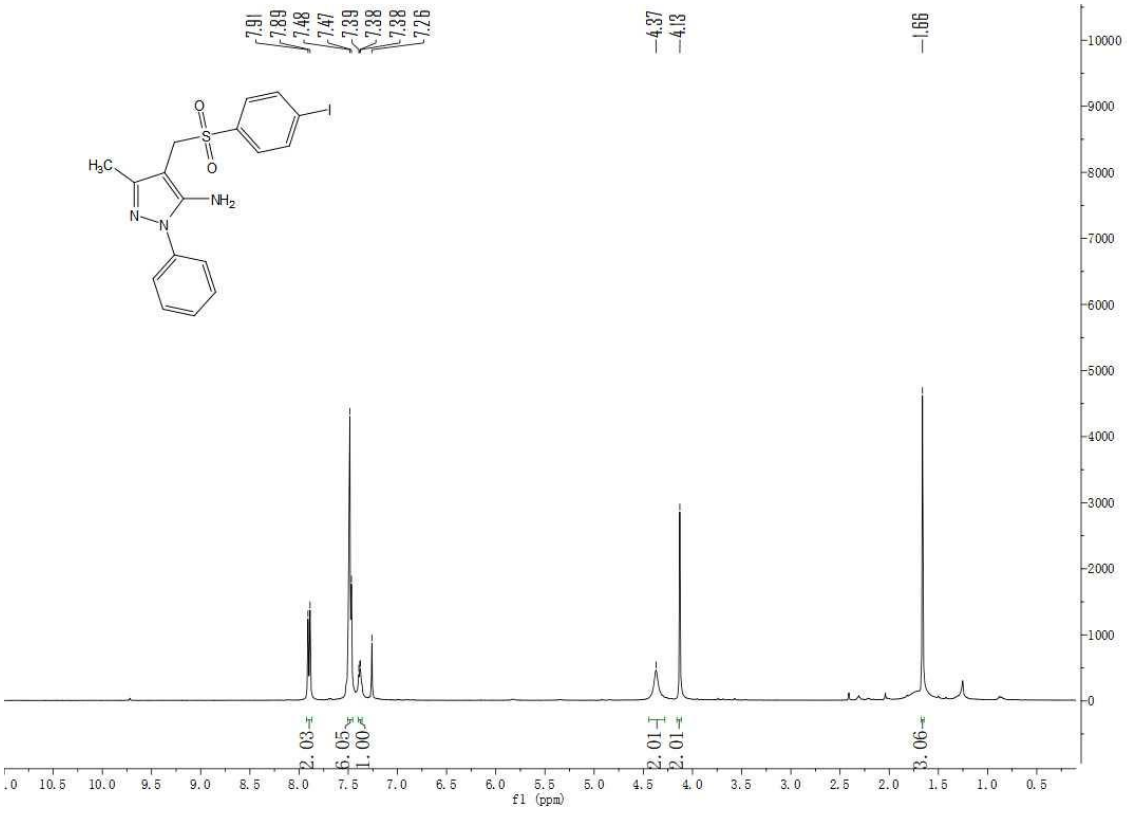
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4d



^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4d



^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4e



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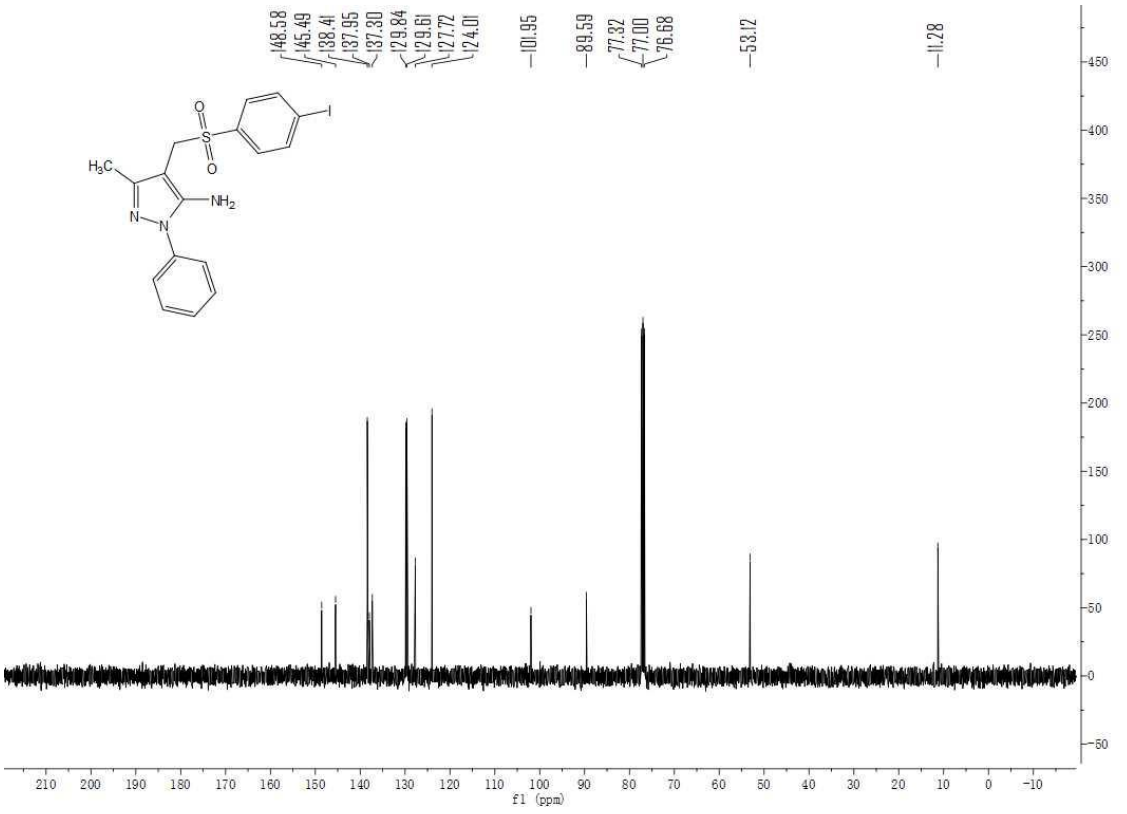
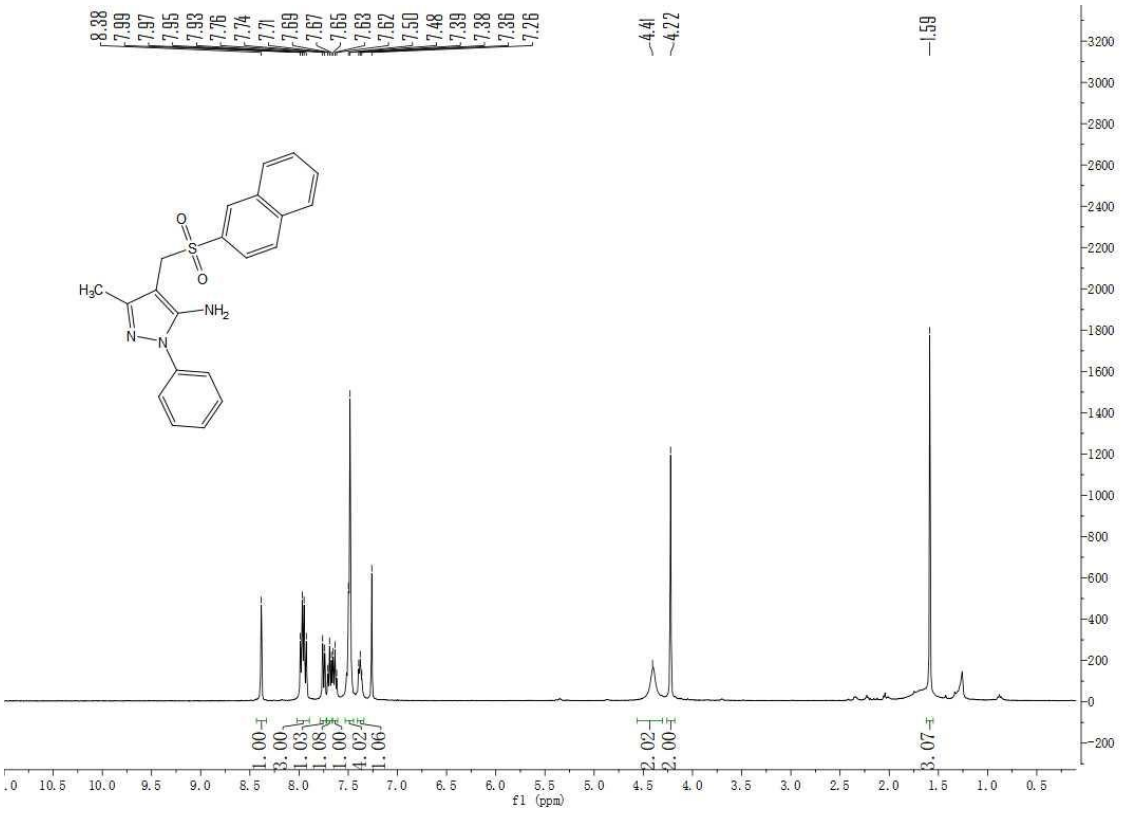
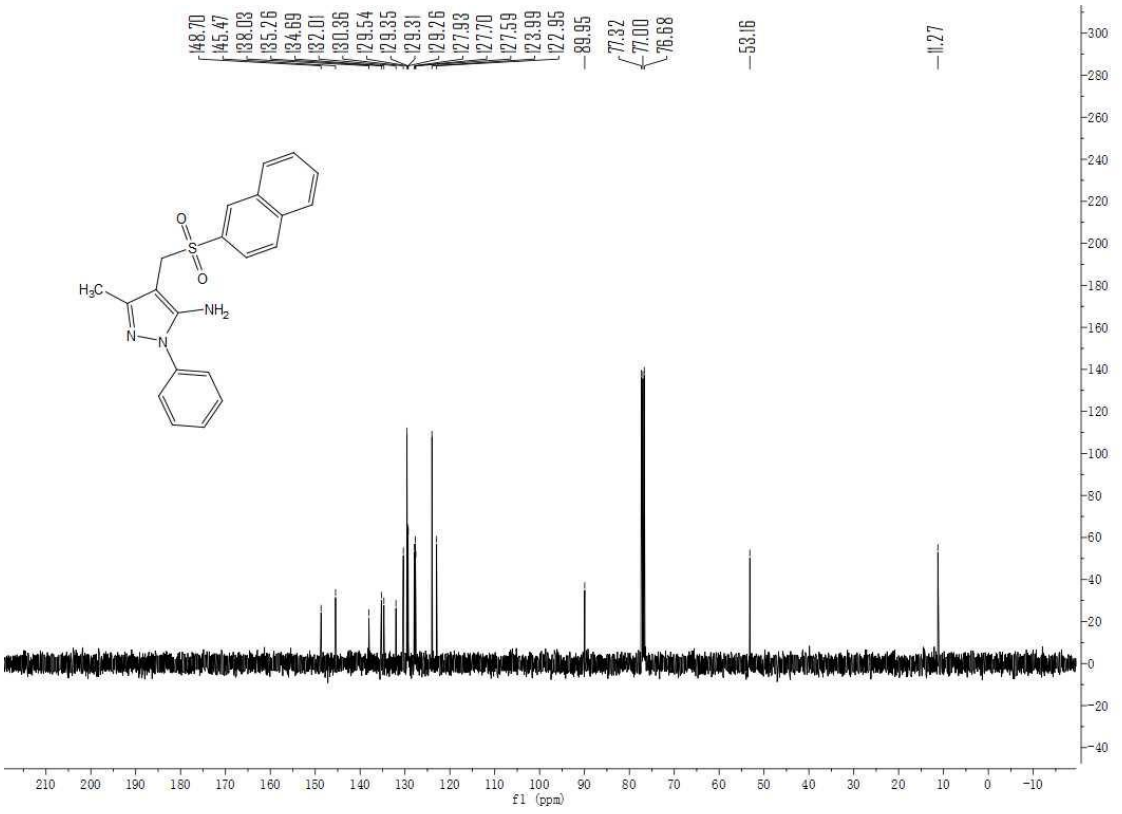


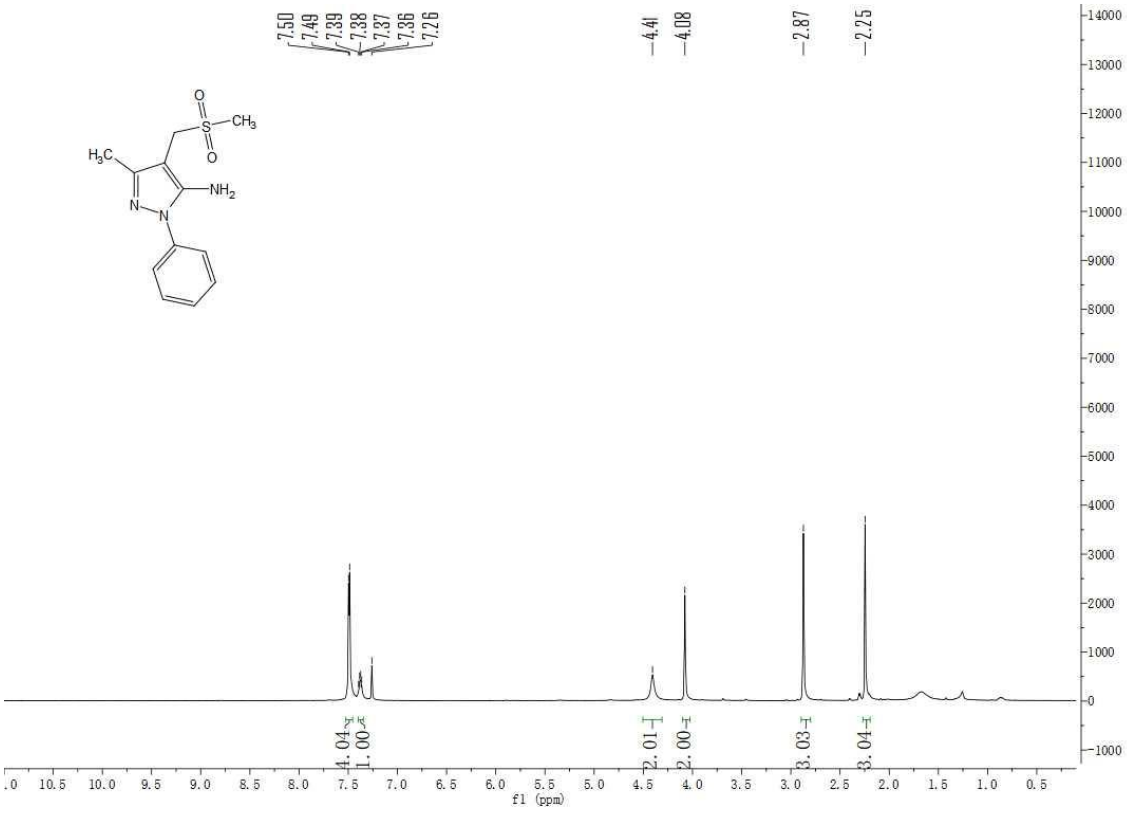
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4f



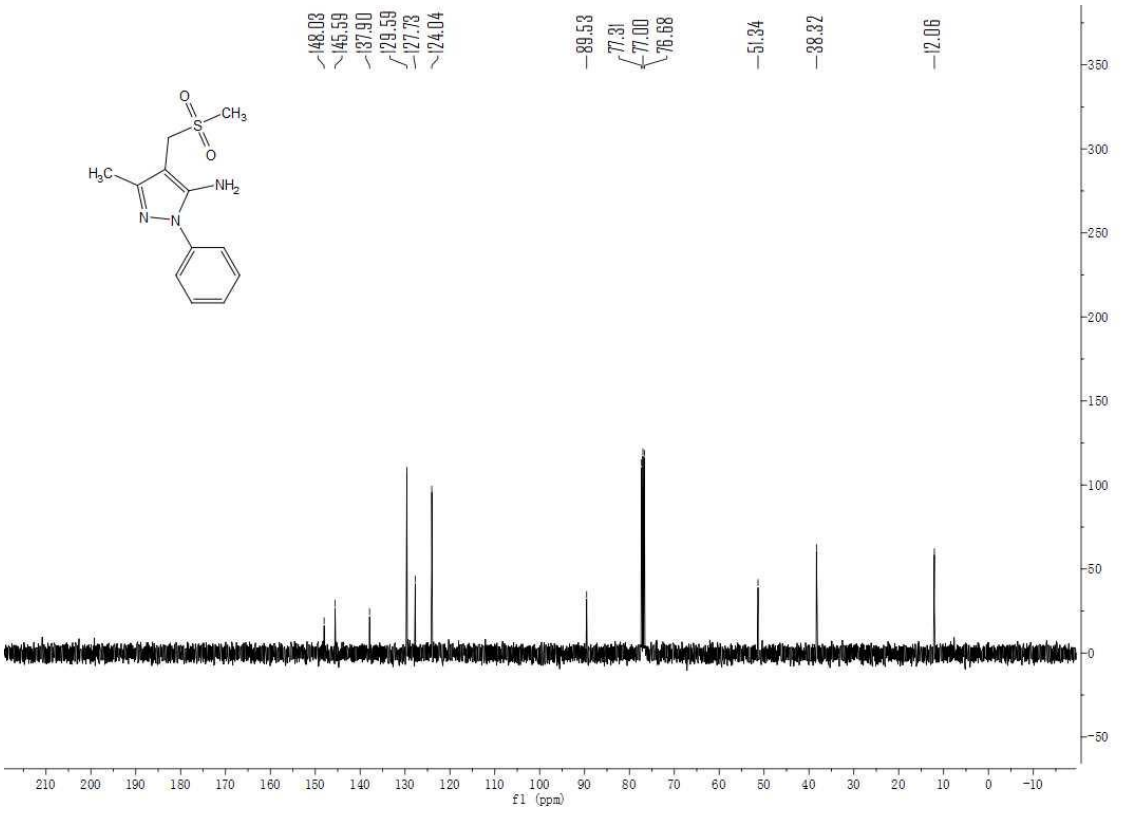
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4f



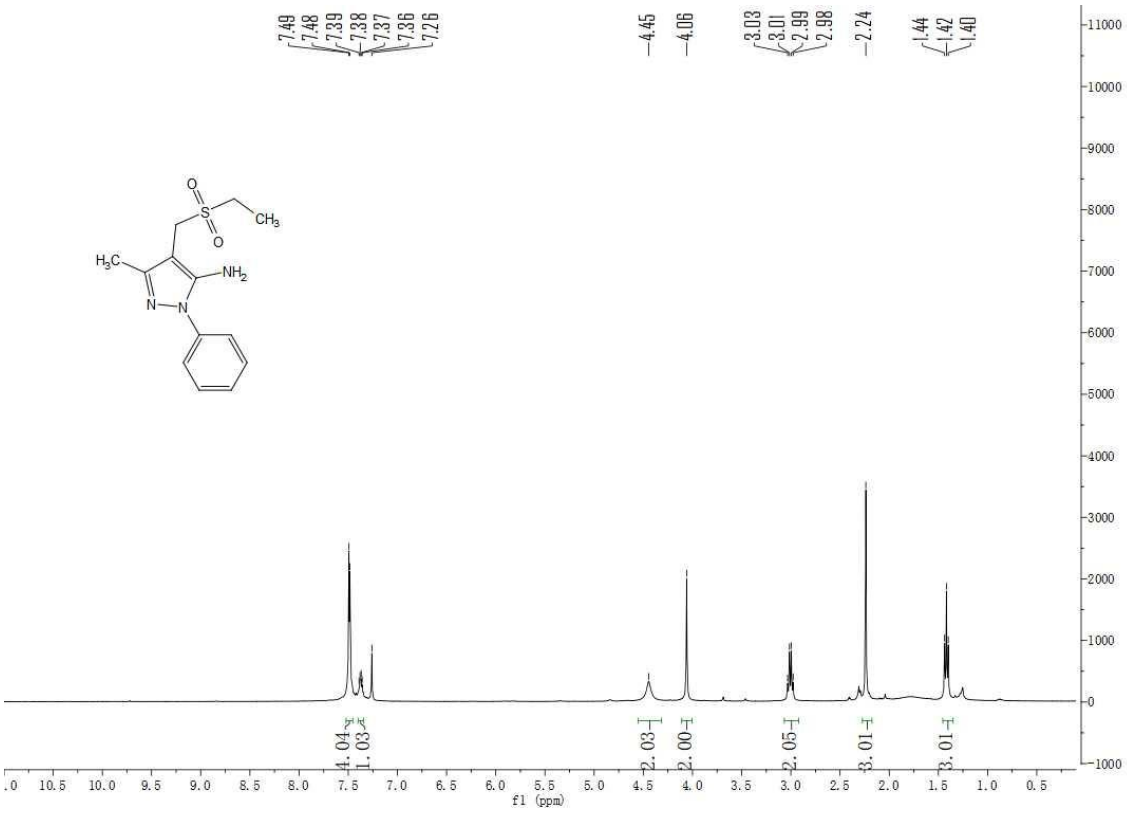
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4g



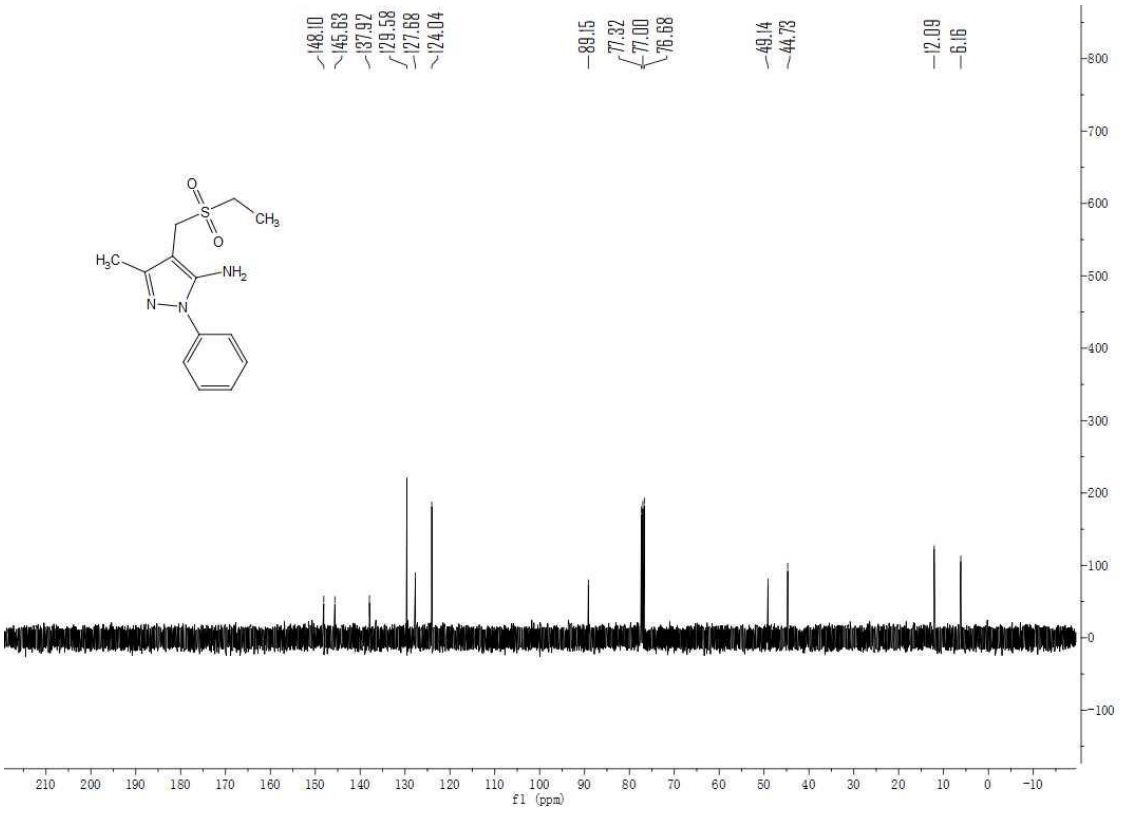
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4g



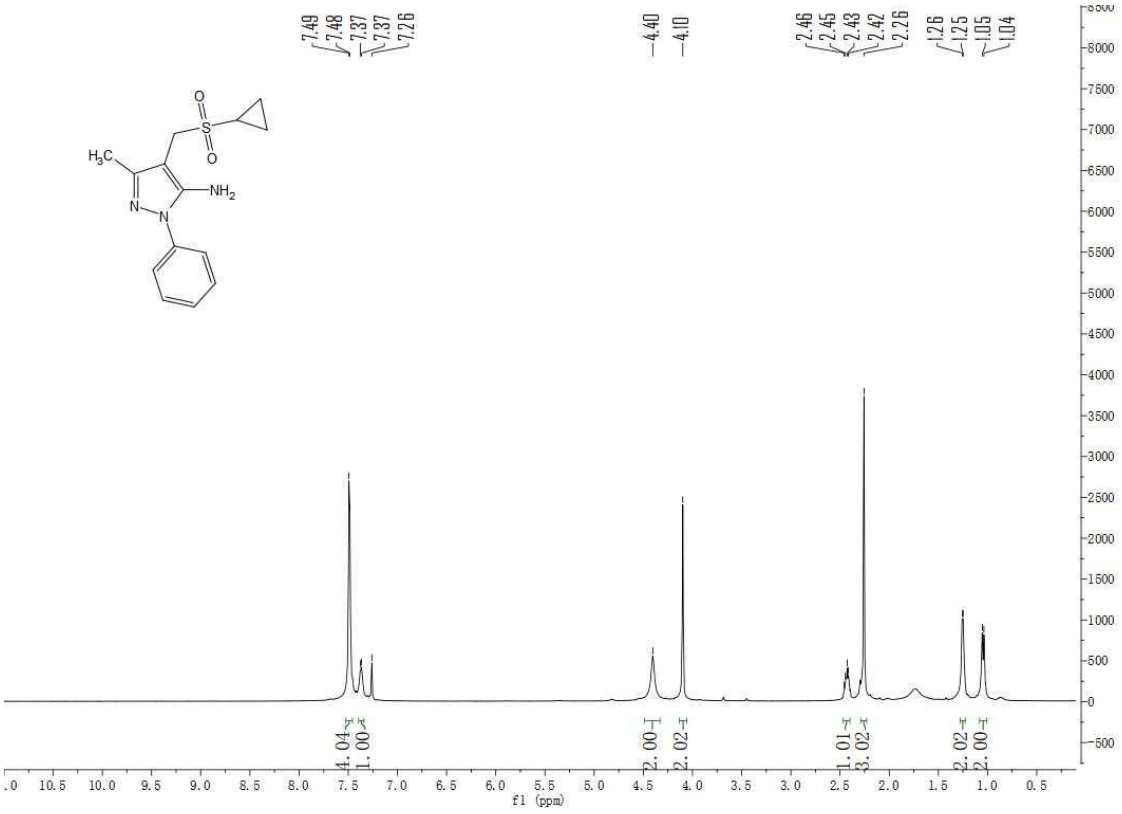
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4h



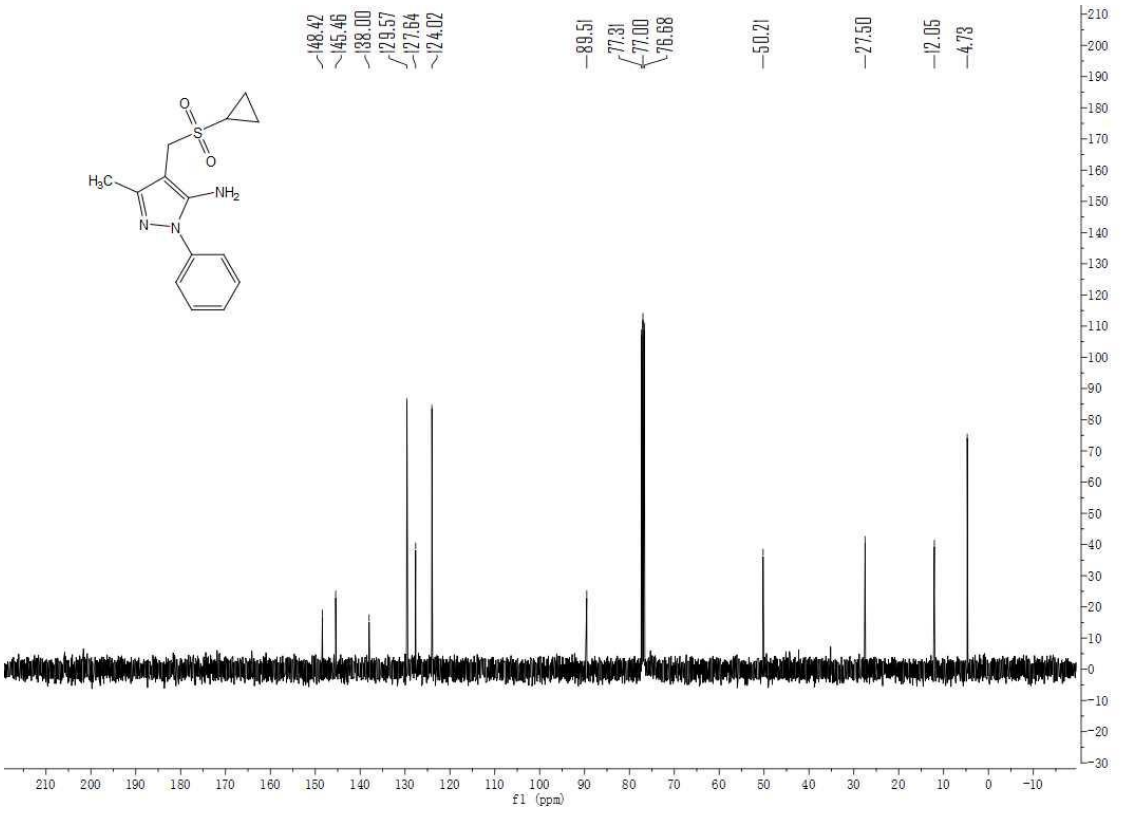
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4h



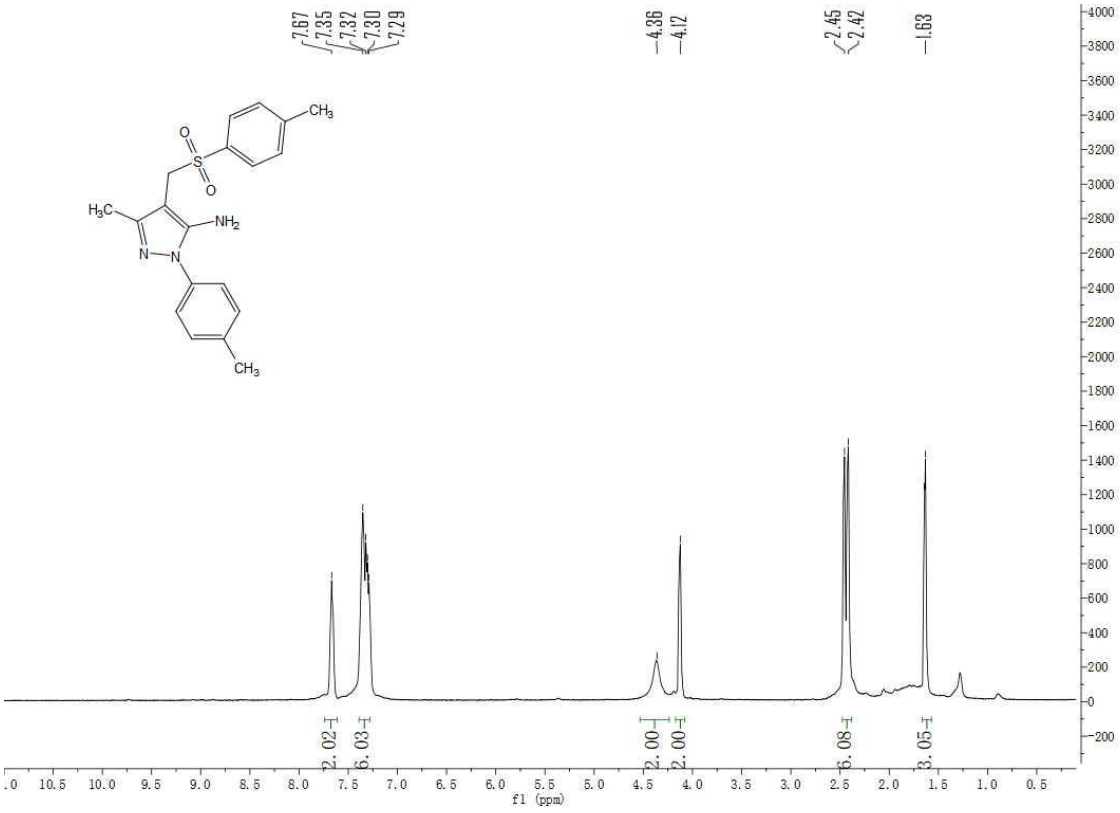
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4i



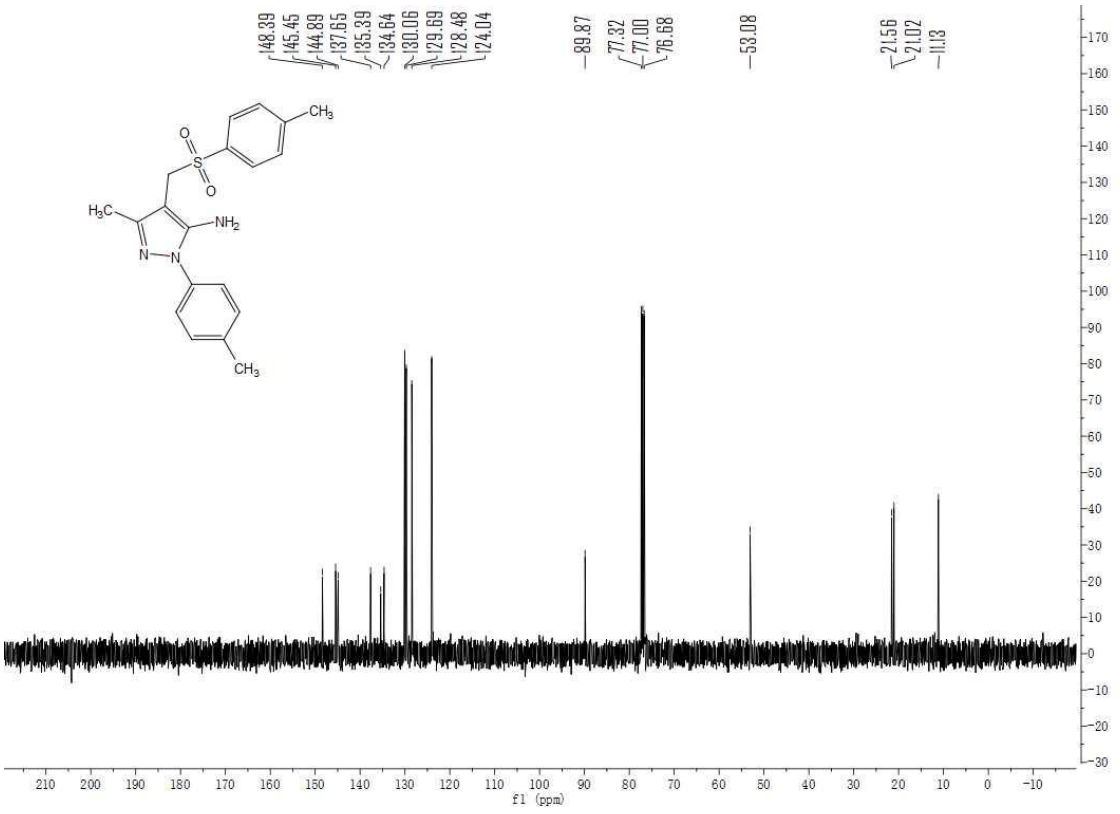
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4i



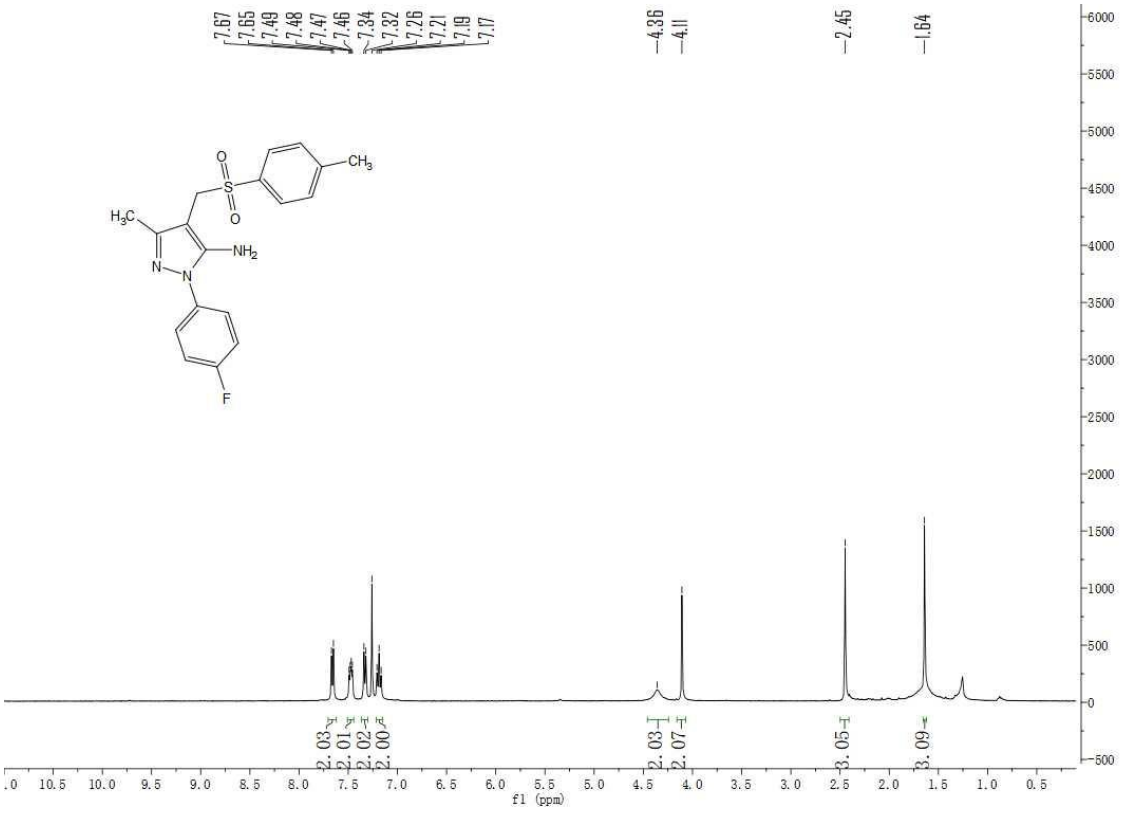
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4j



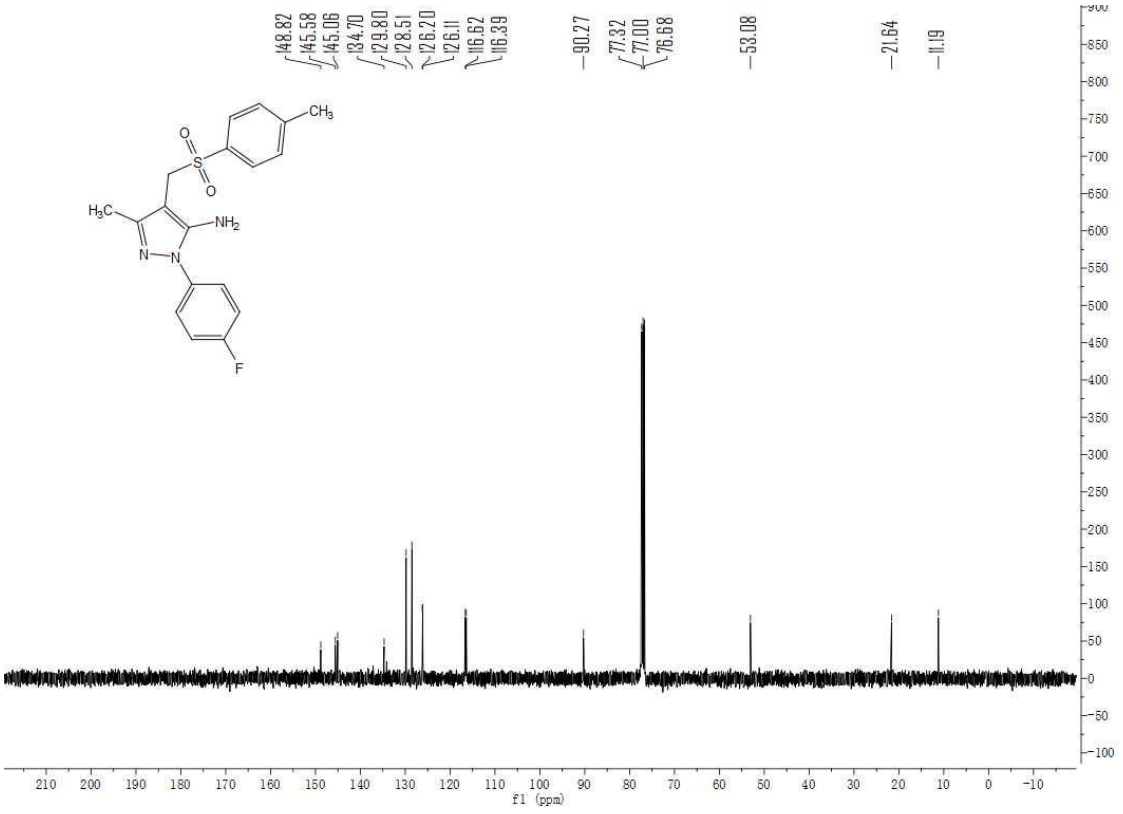
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4j



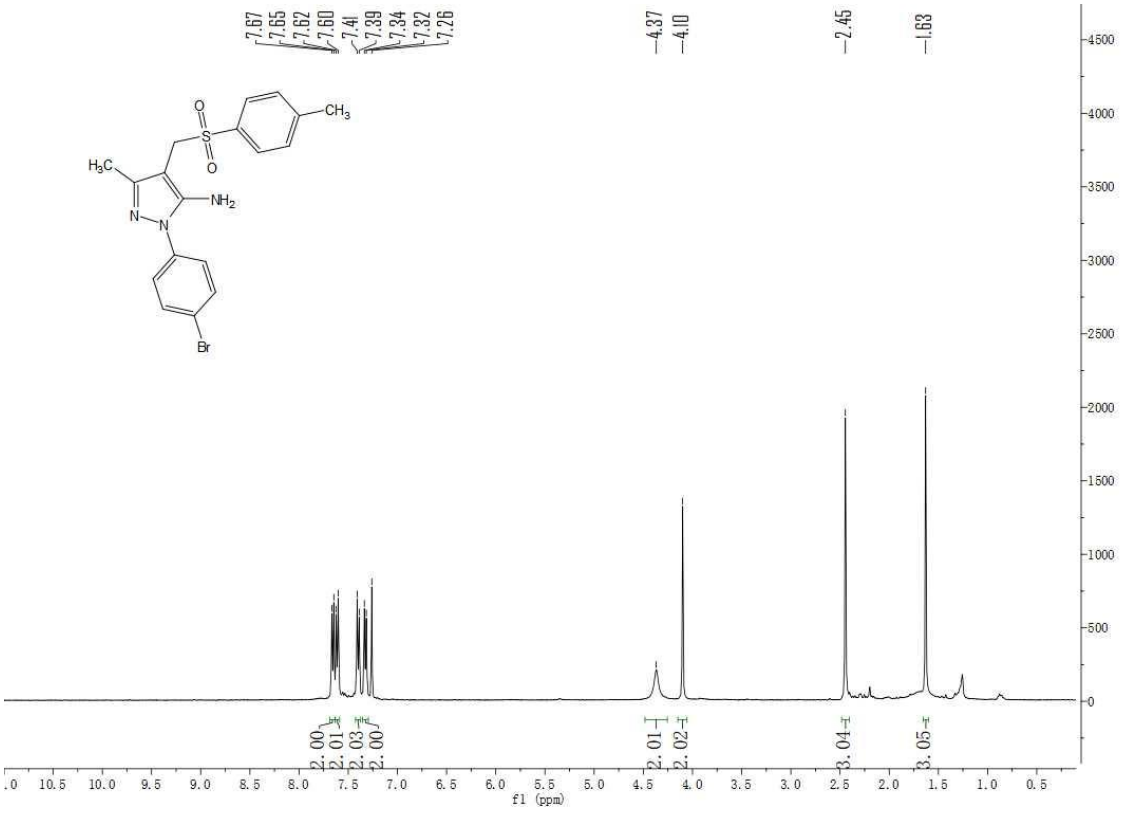
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4k



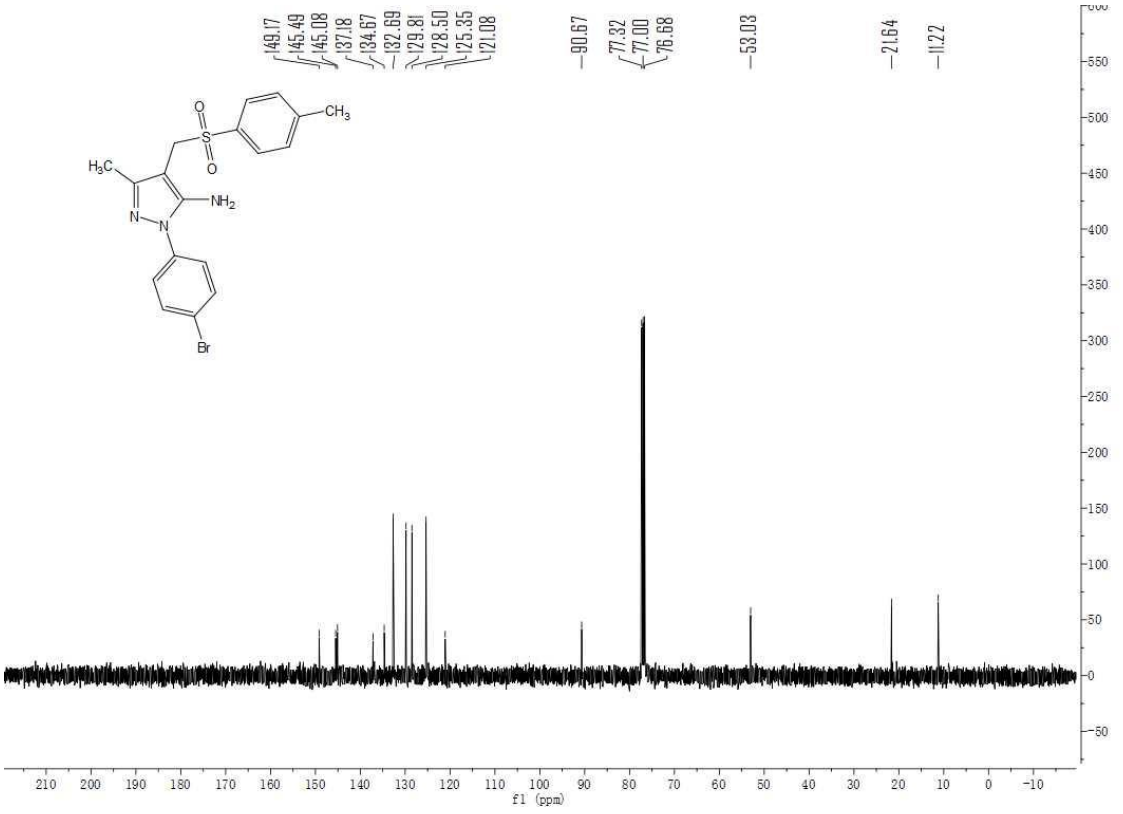
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4k



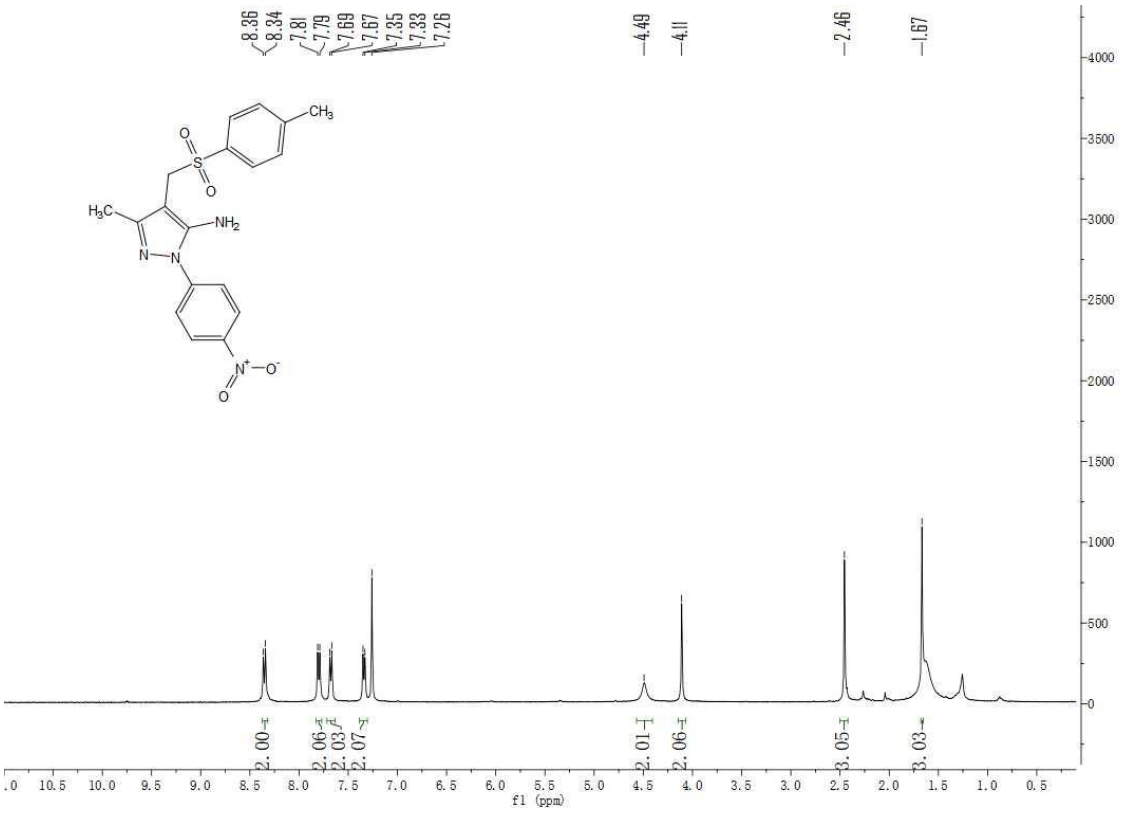
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4l



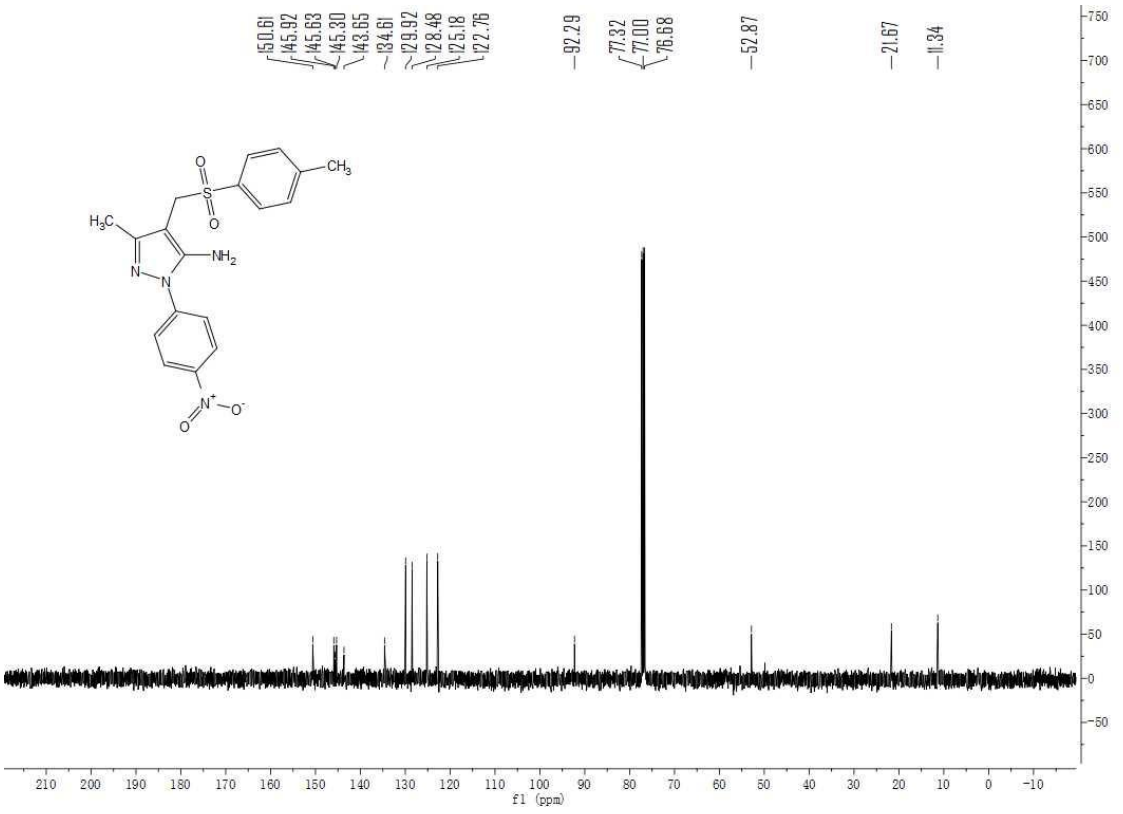
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4l



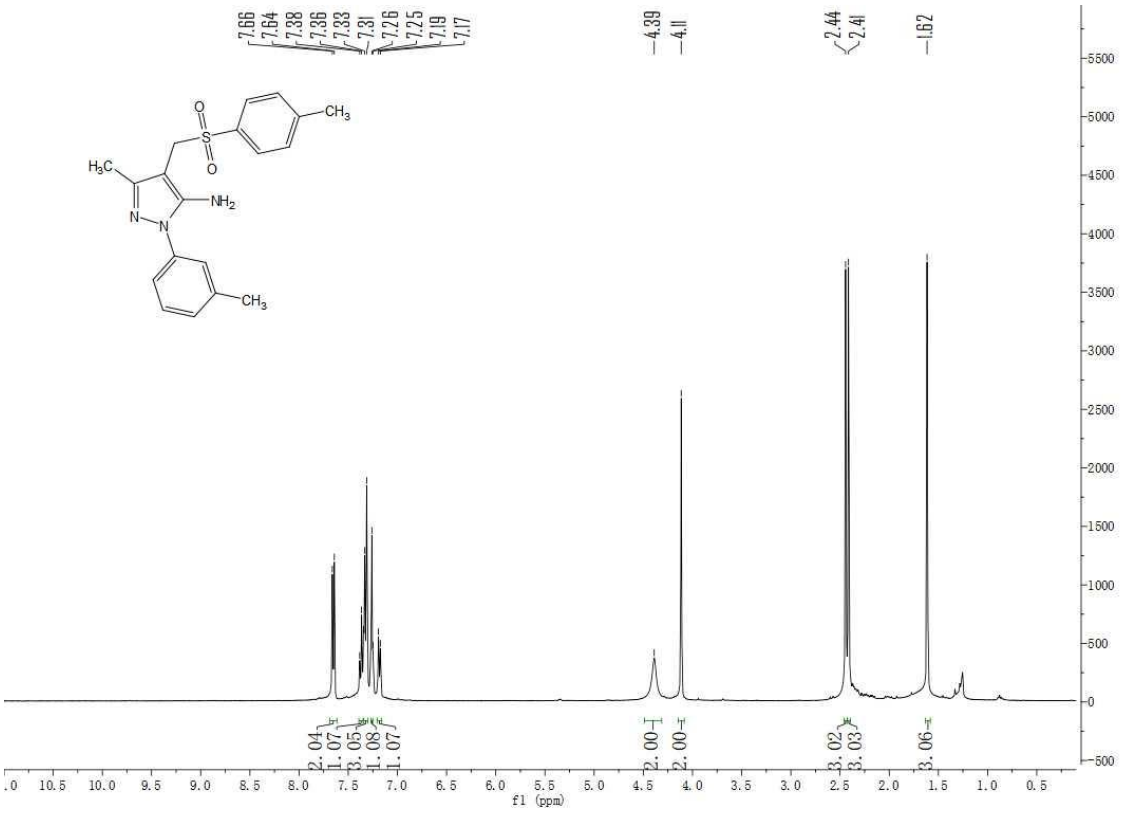
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4m



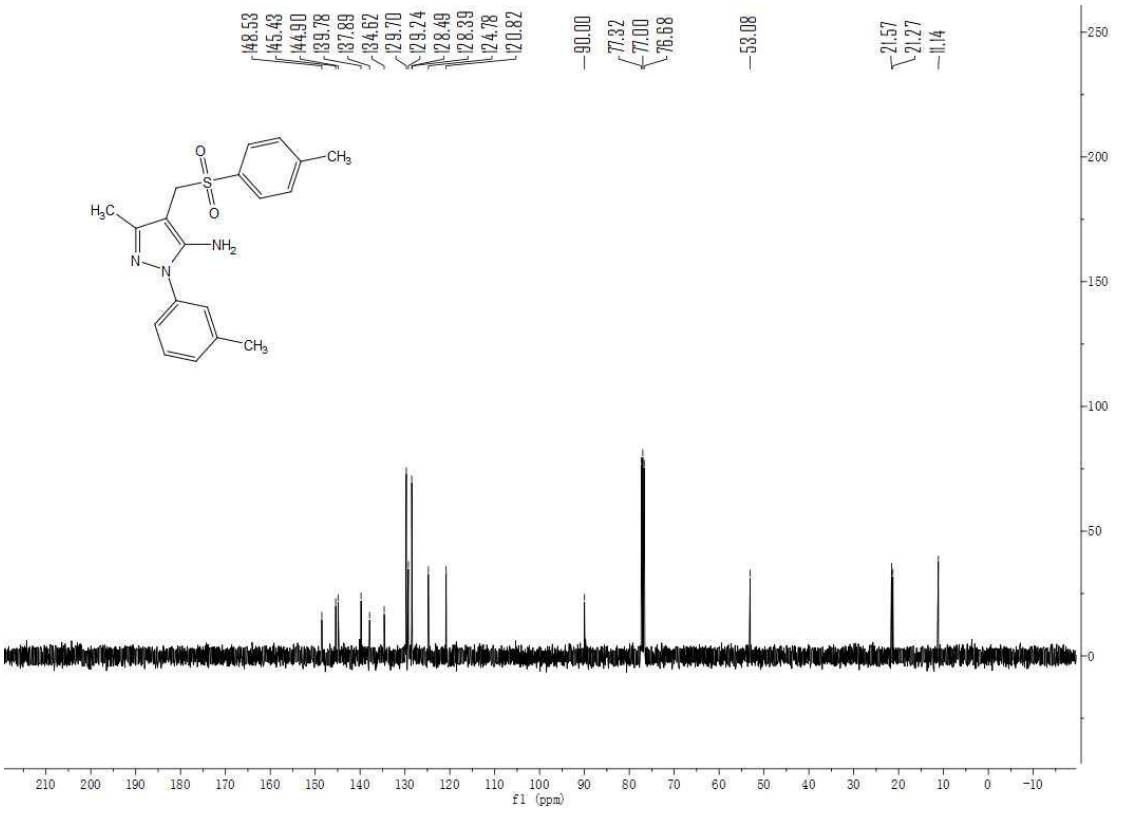
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4m



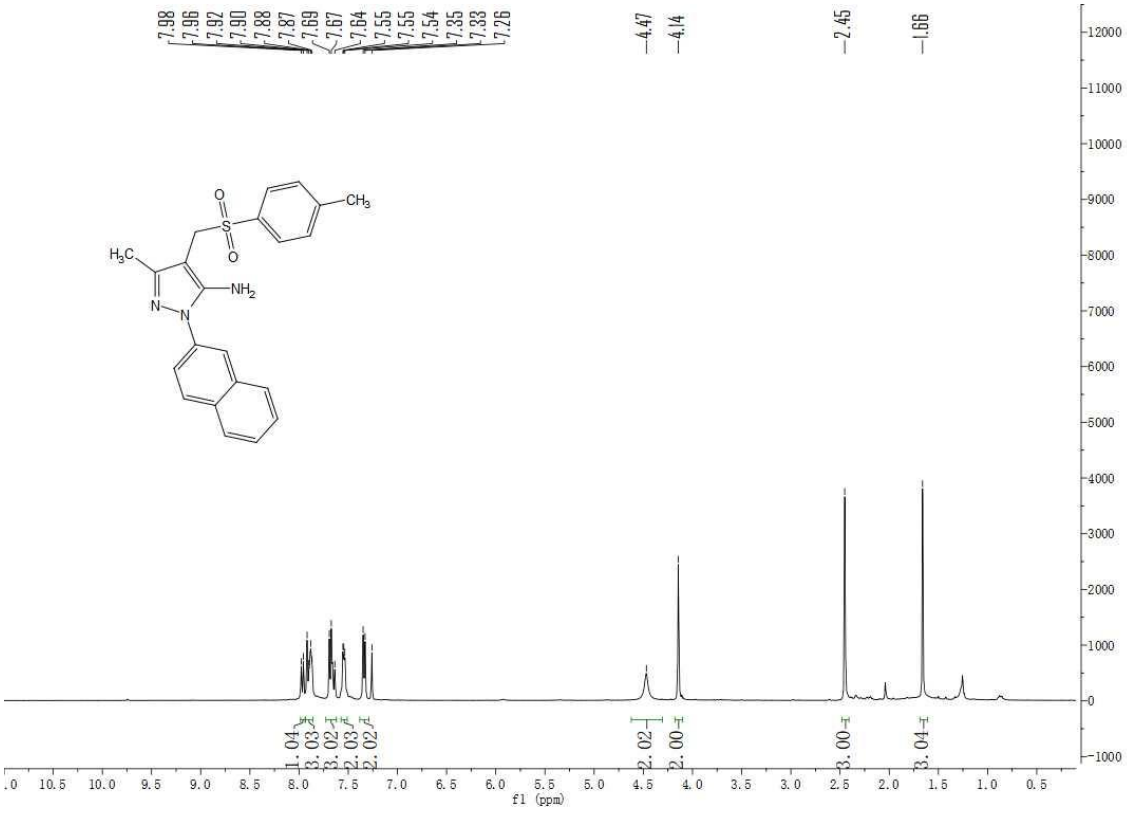
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4n



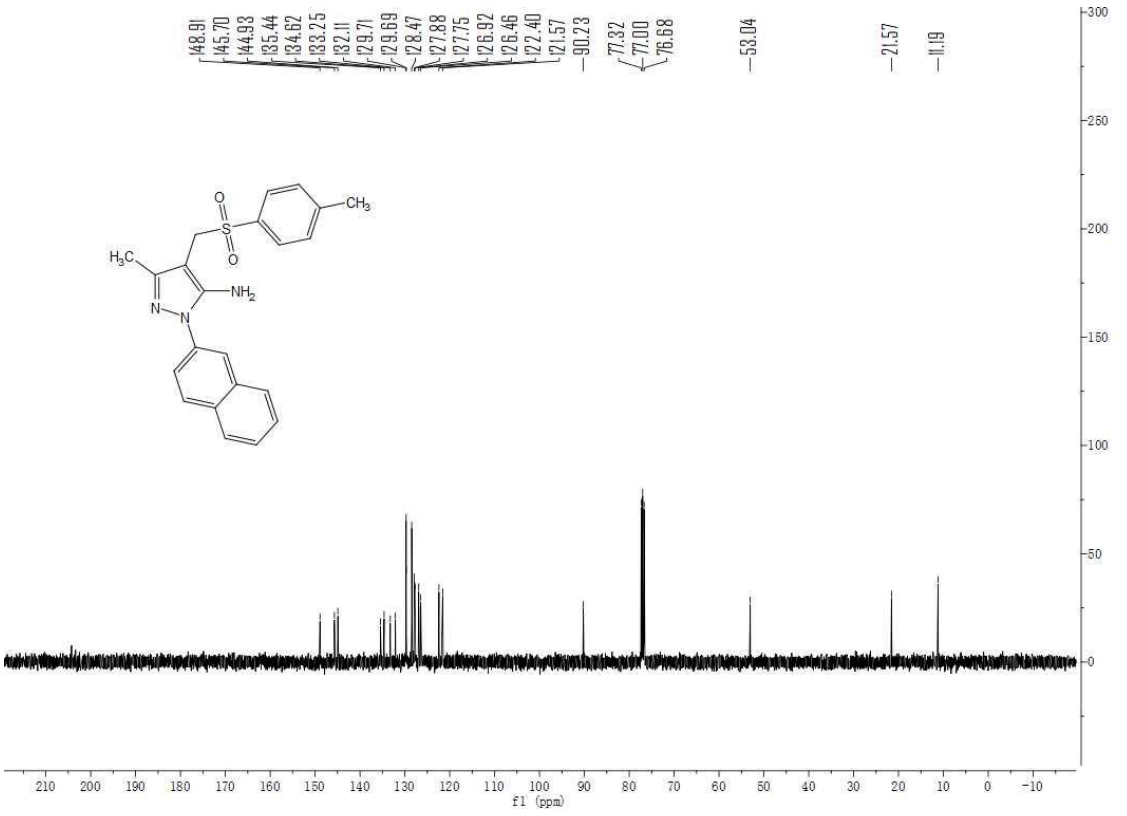
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4n



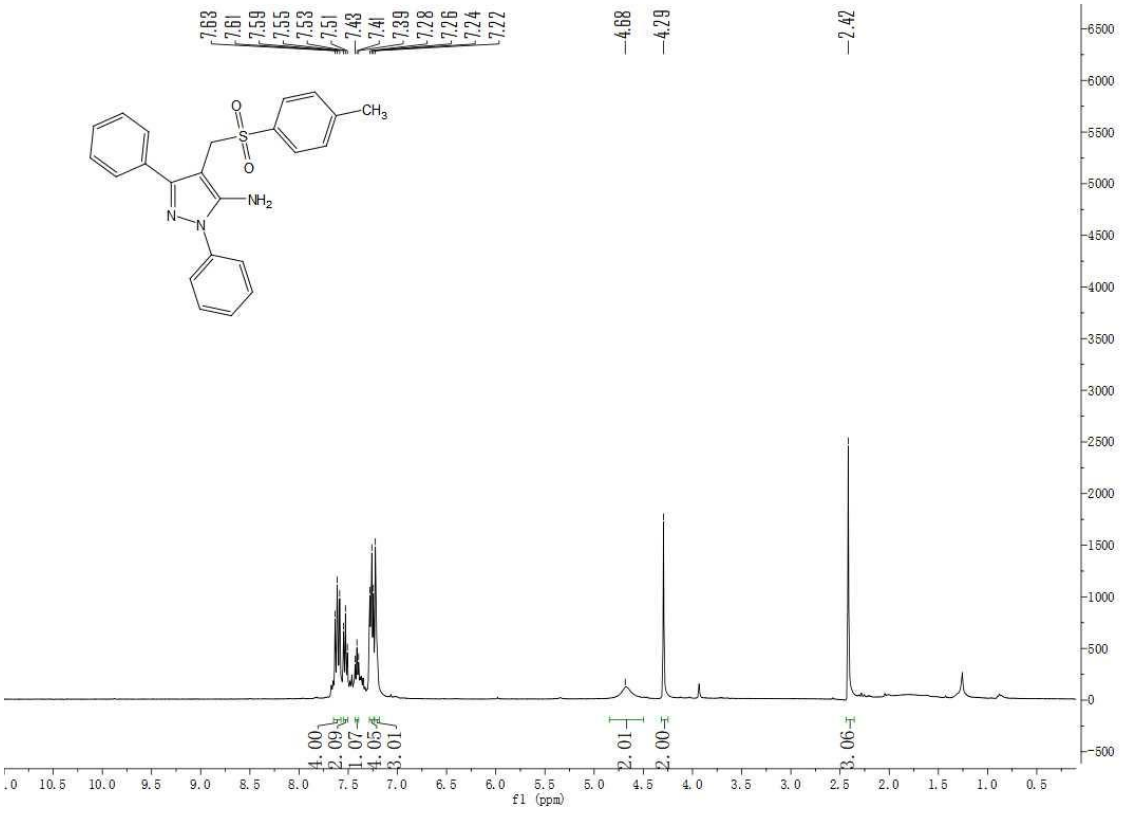
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4o



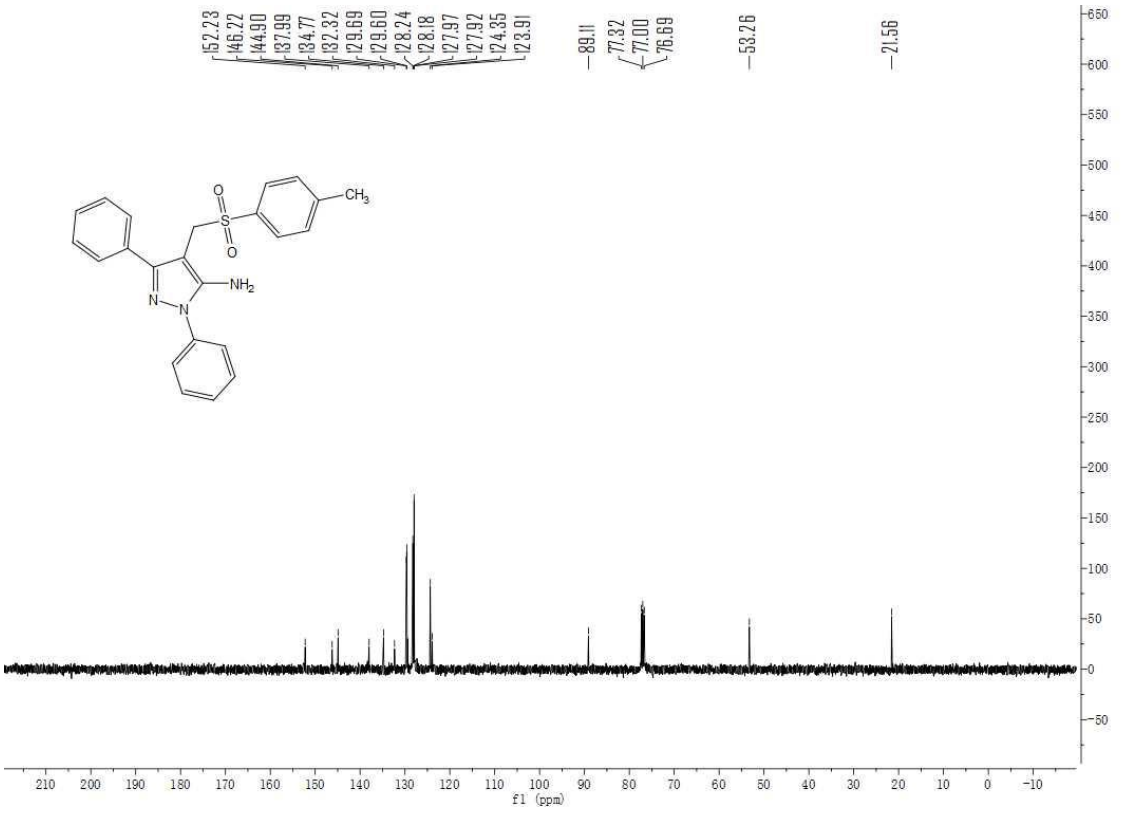
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4o



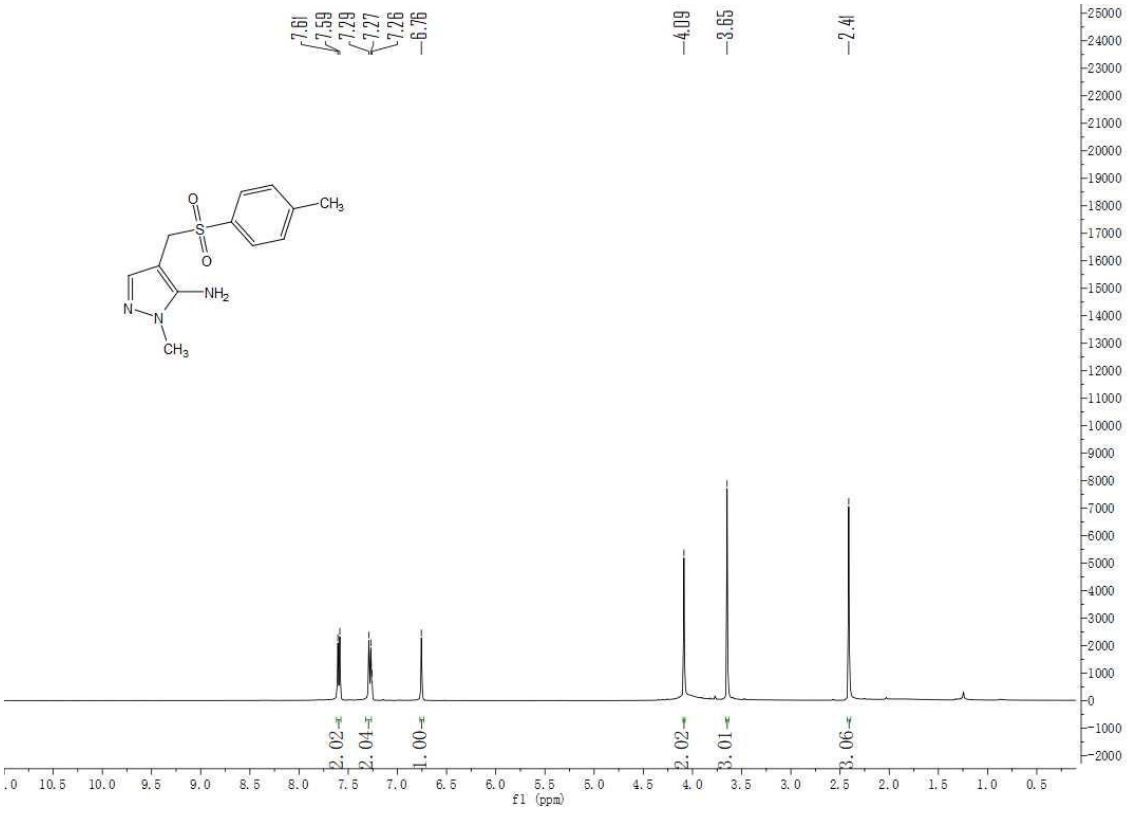
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4p



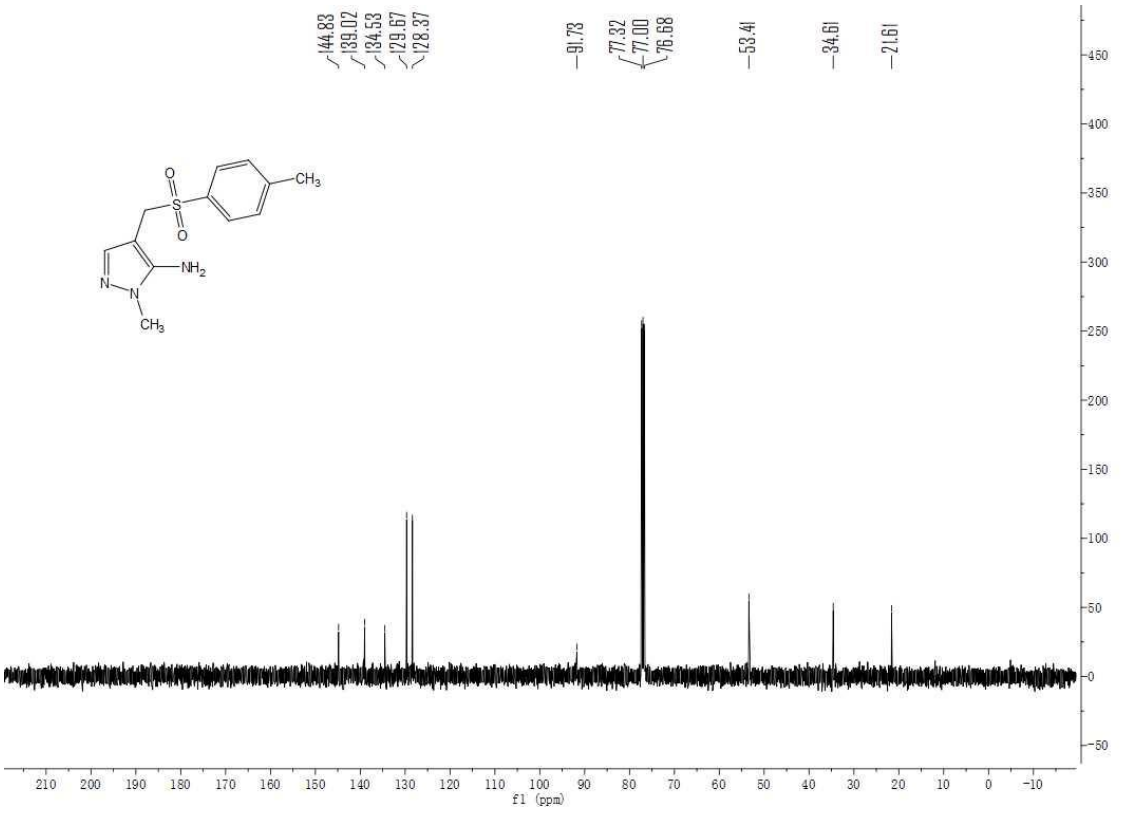
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4p



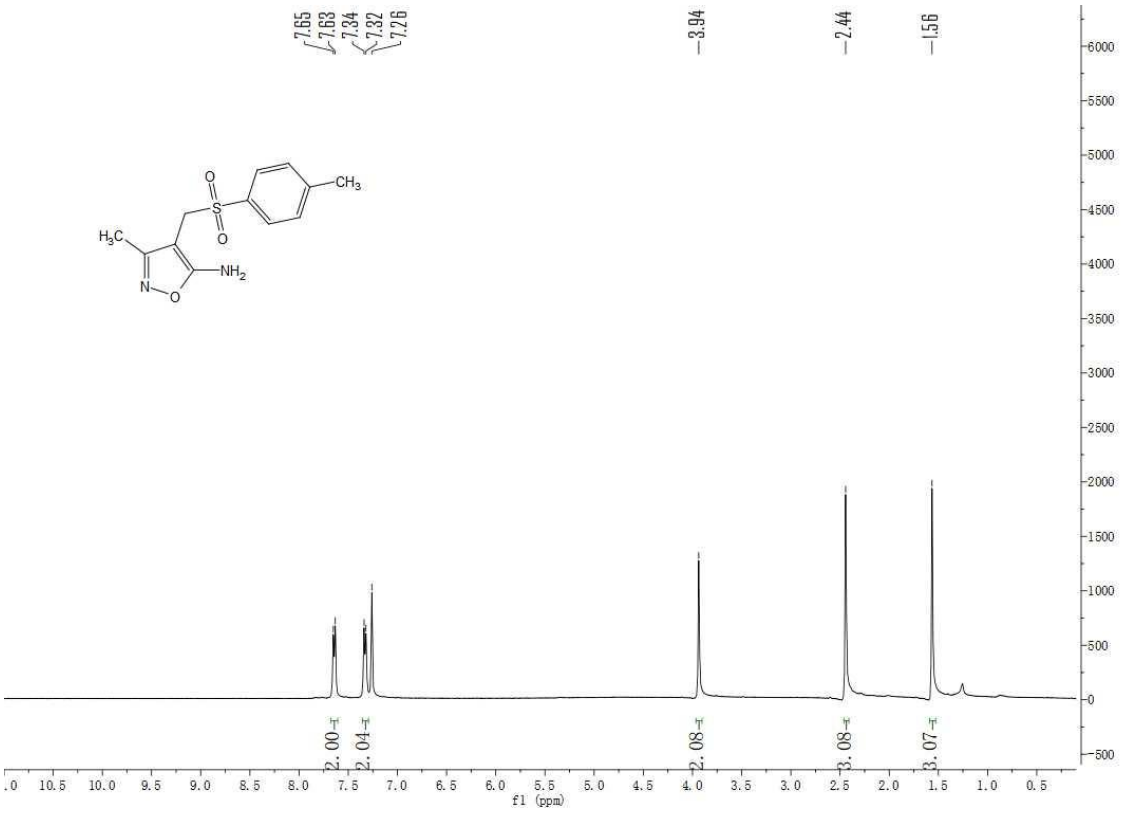
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 4q



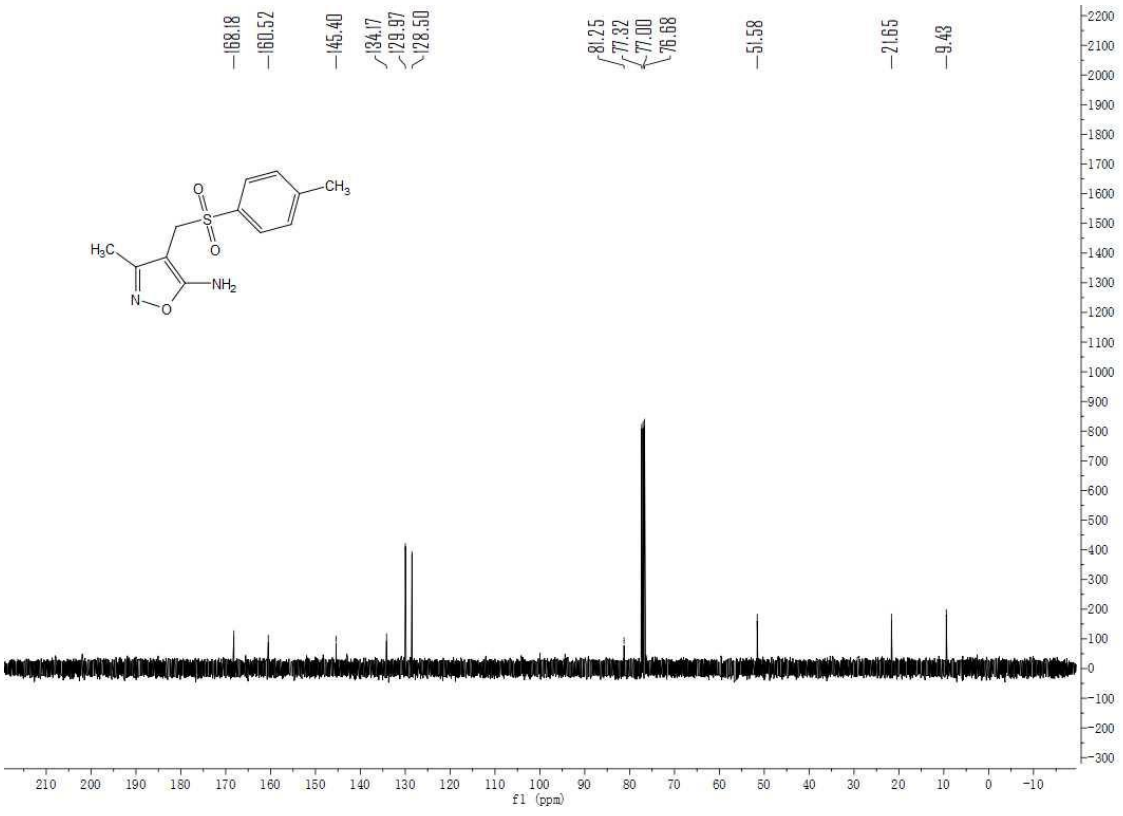
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 4q



^{1}H NMR spectra (400 MHz, $CDCl_3$) of 5



^{13}C NMR spectra (100 MHz, $CDCl_3$) of 5



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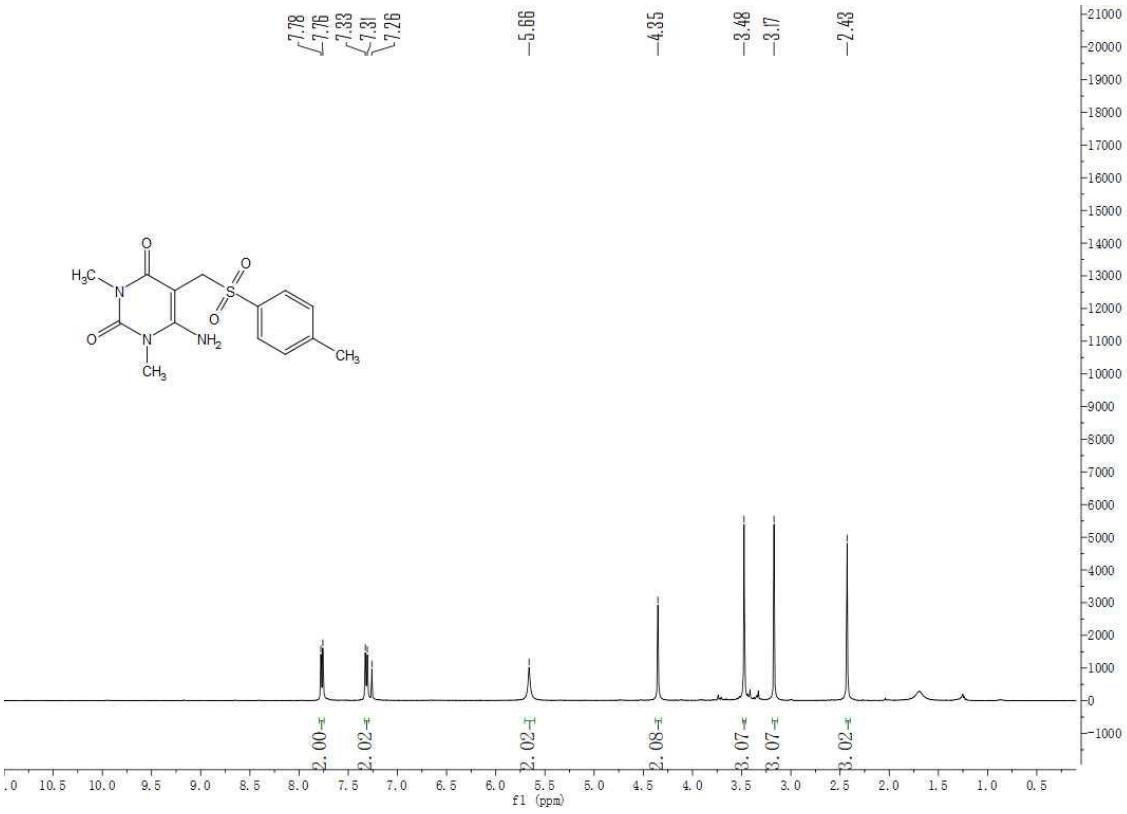
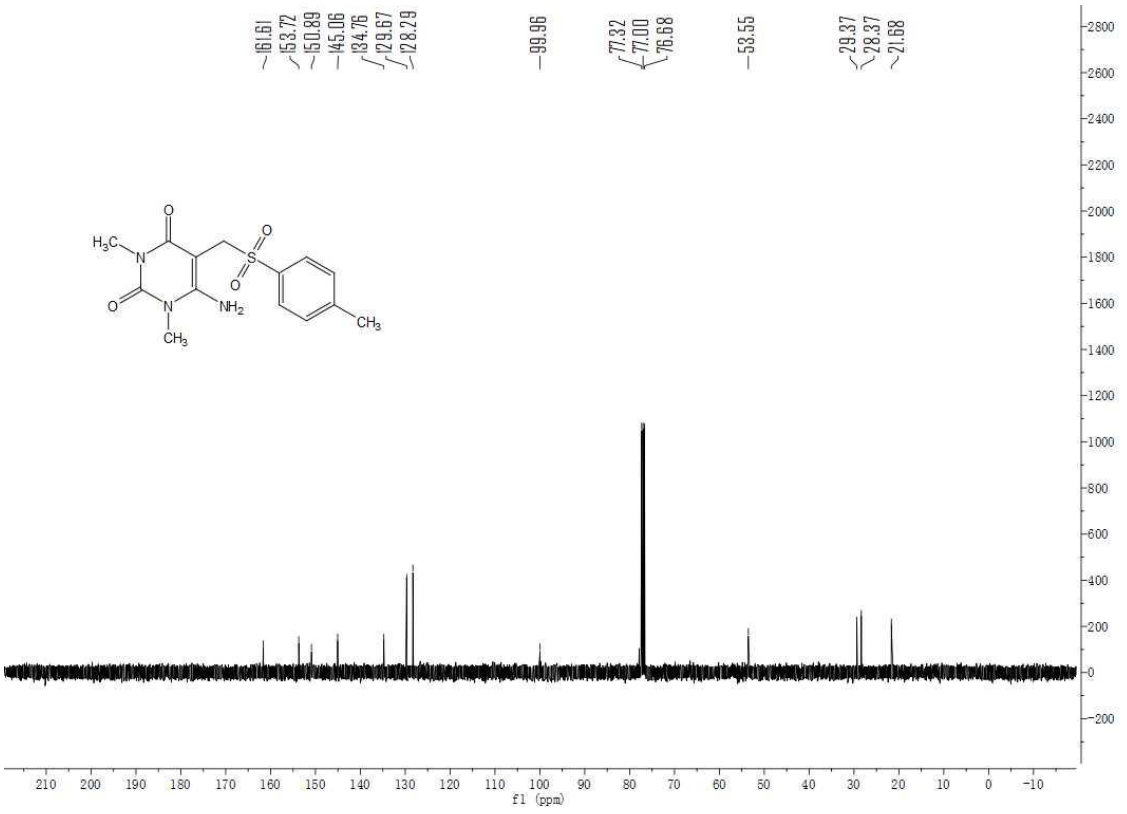
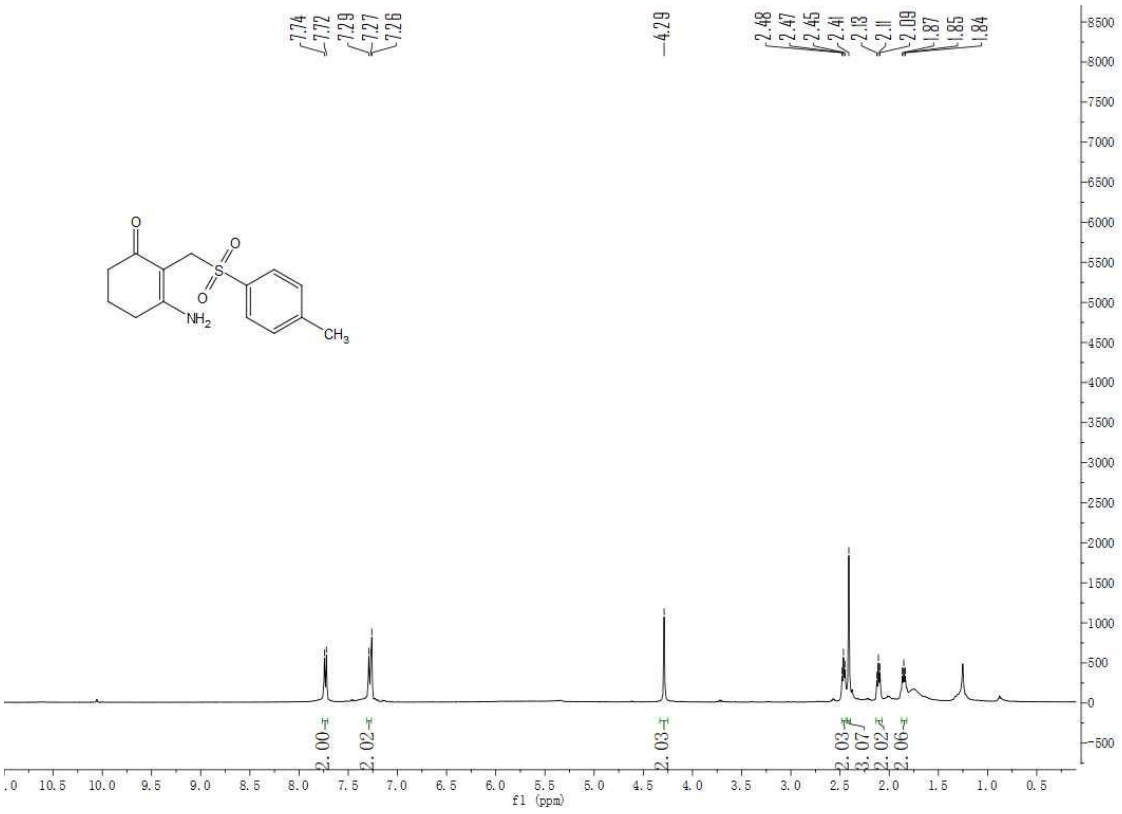


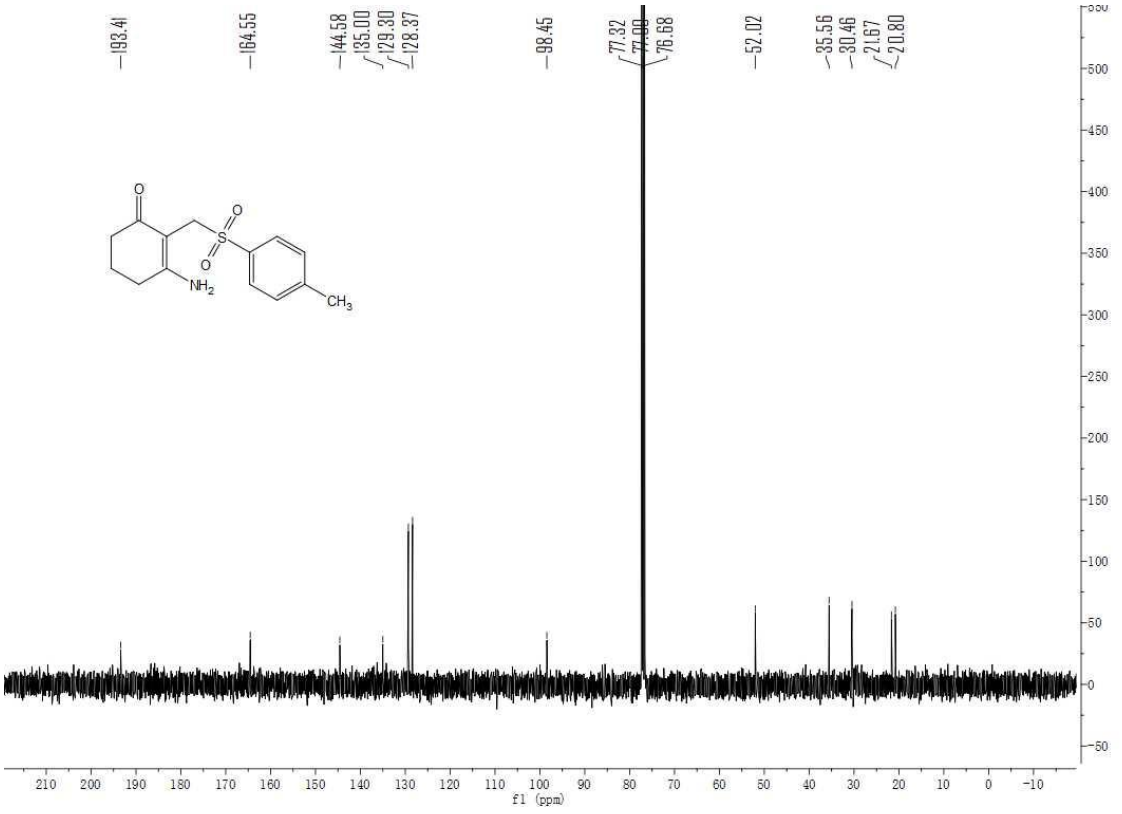
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 6



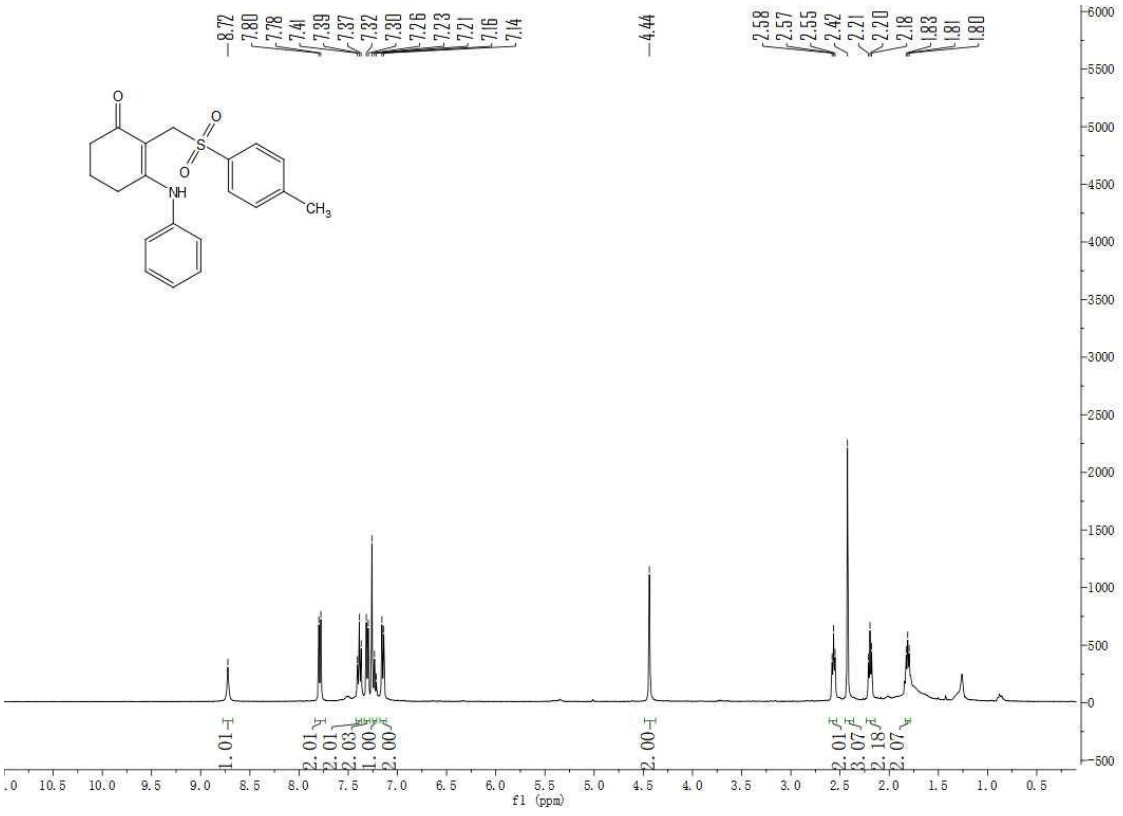
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 7a



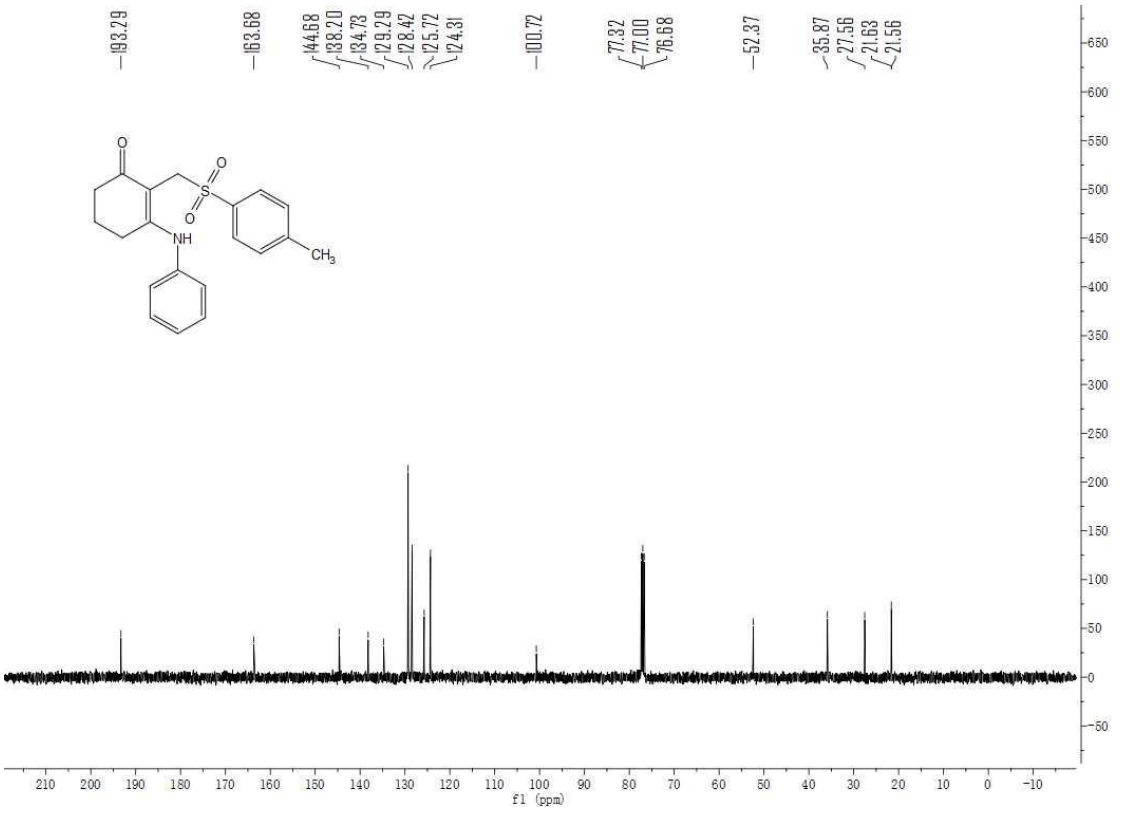
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 7a



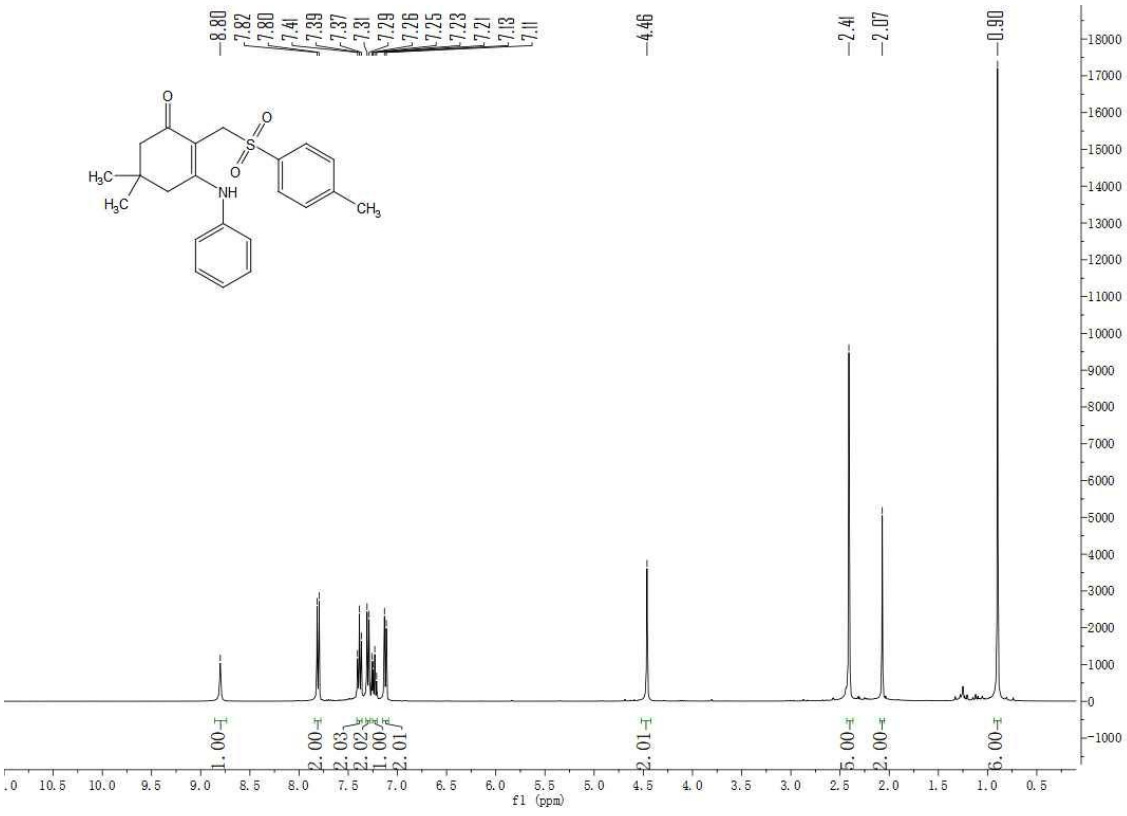
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 7b



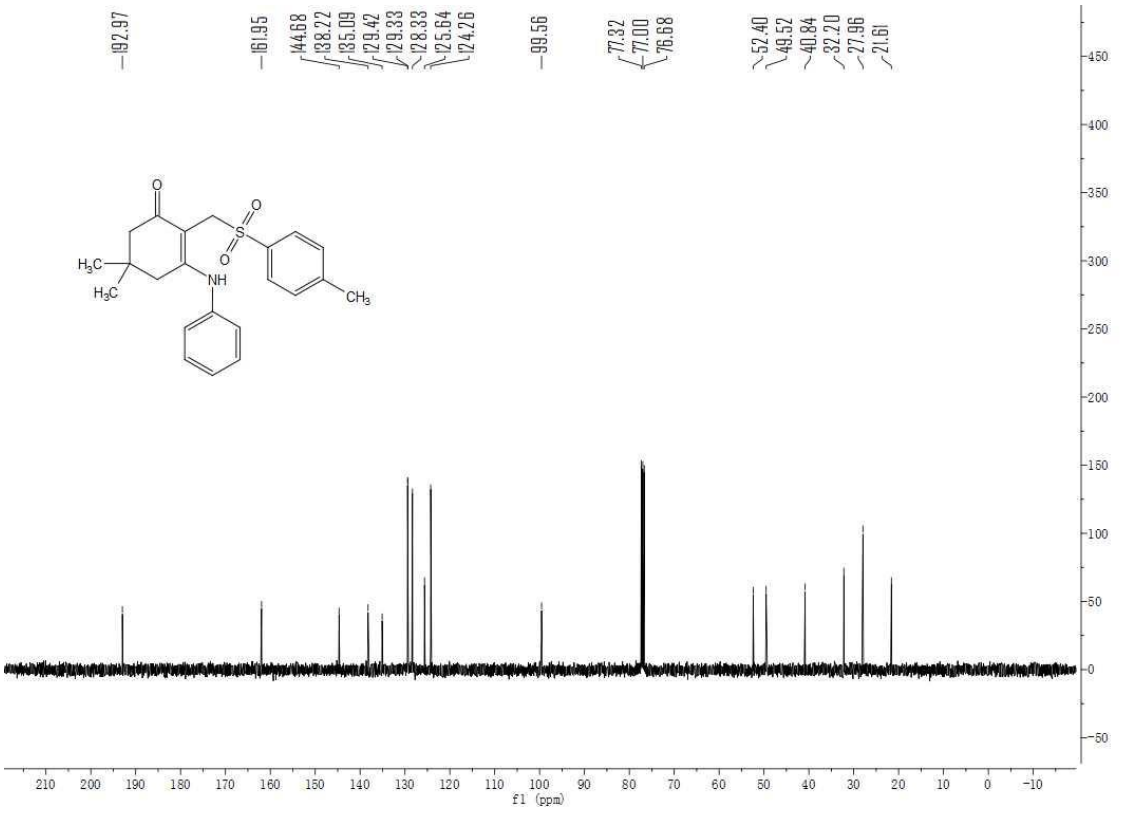
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 7b



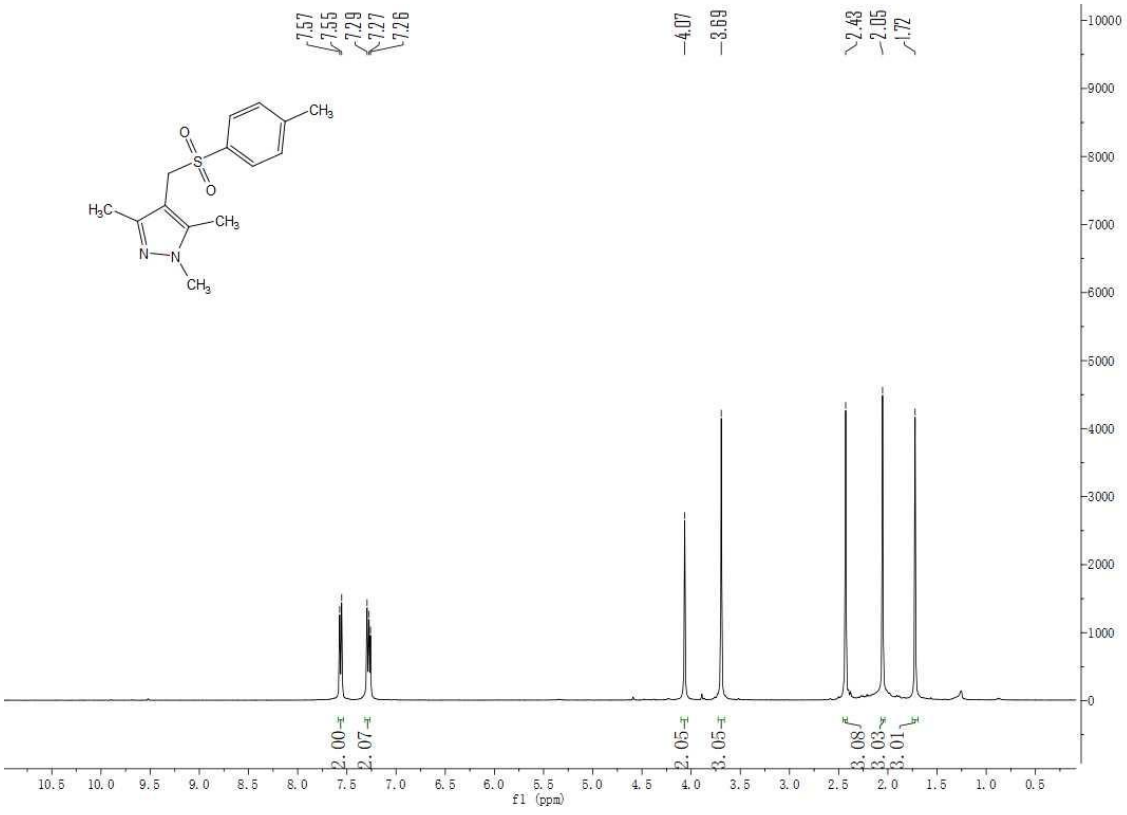
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 7c



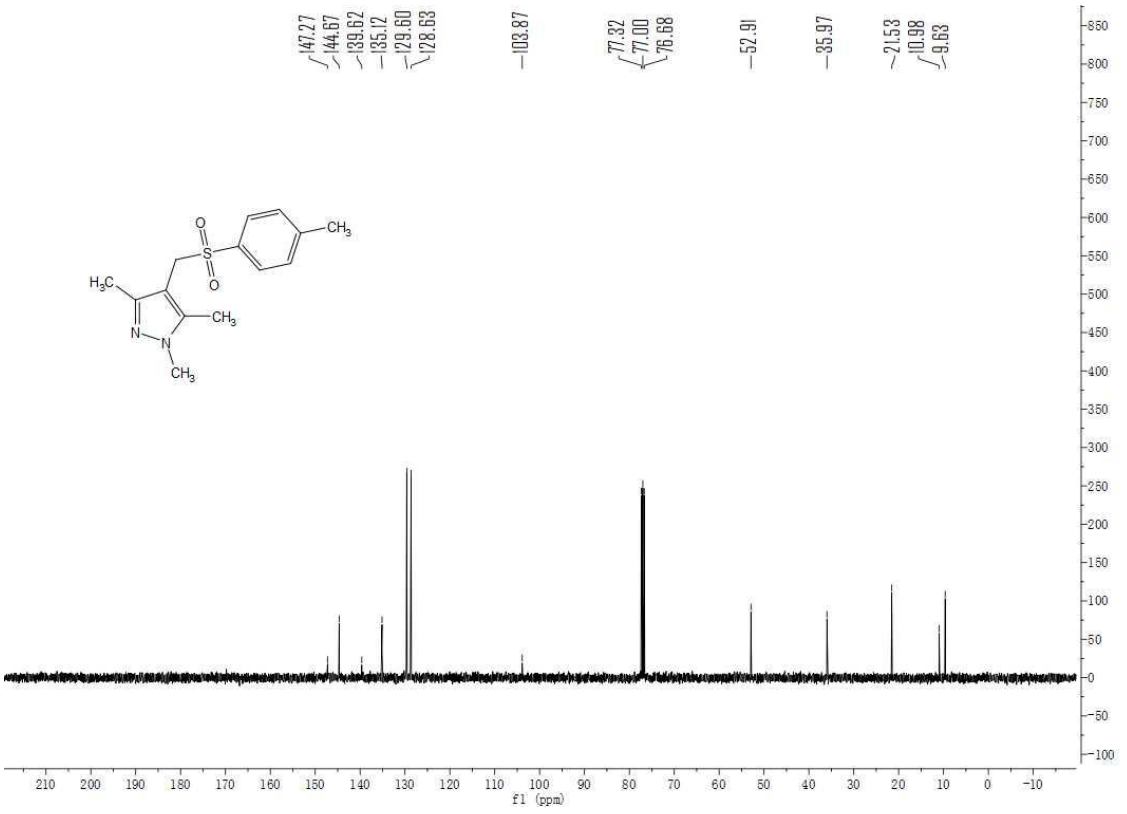
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 7c



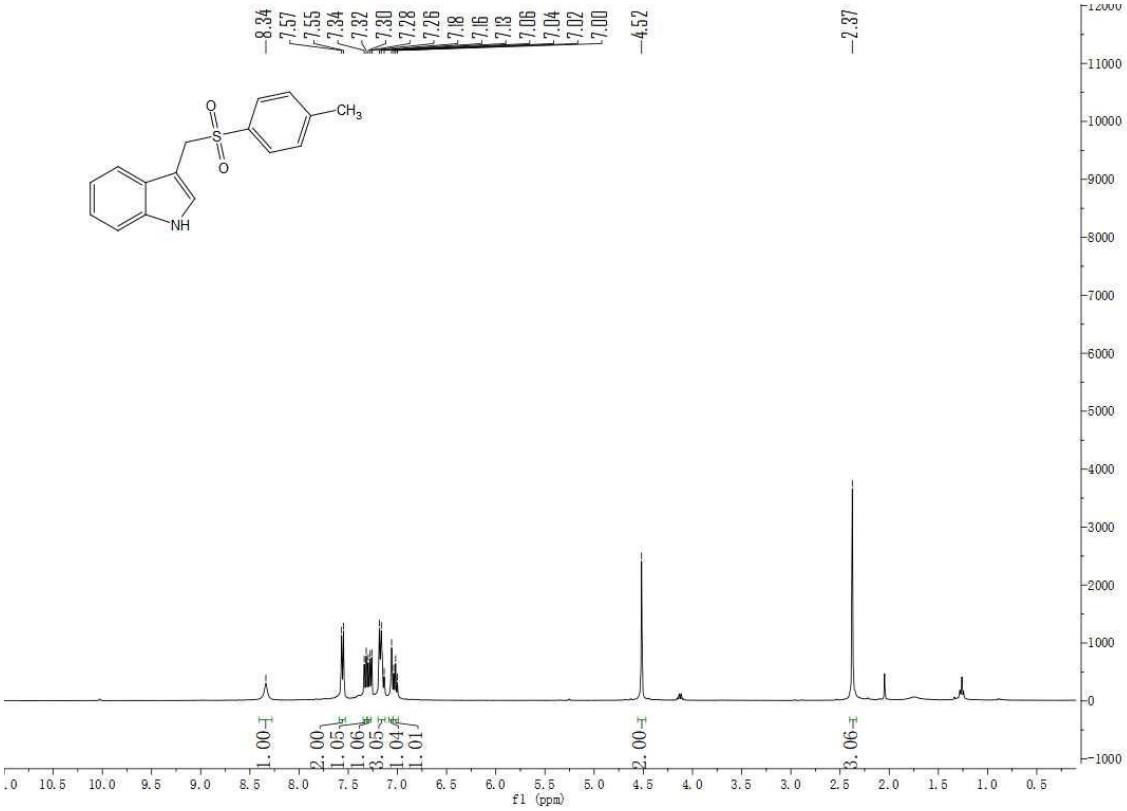
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 8



^{13}C NMR spectra (100 MHz, $CDCl_3$) of 8



^{1}H NMR spectra (400 MHz, $CDCl_3$) of 9a



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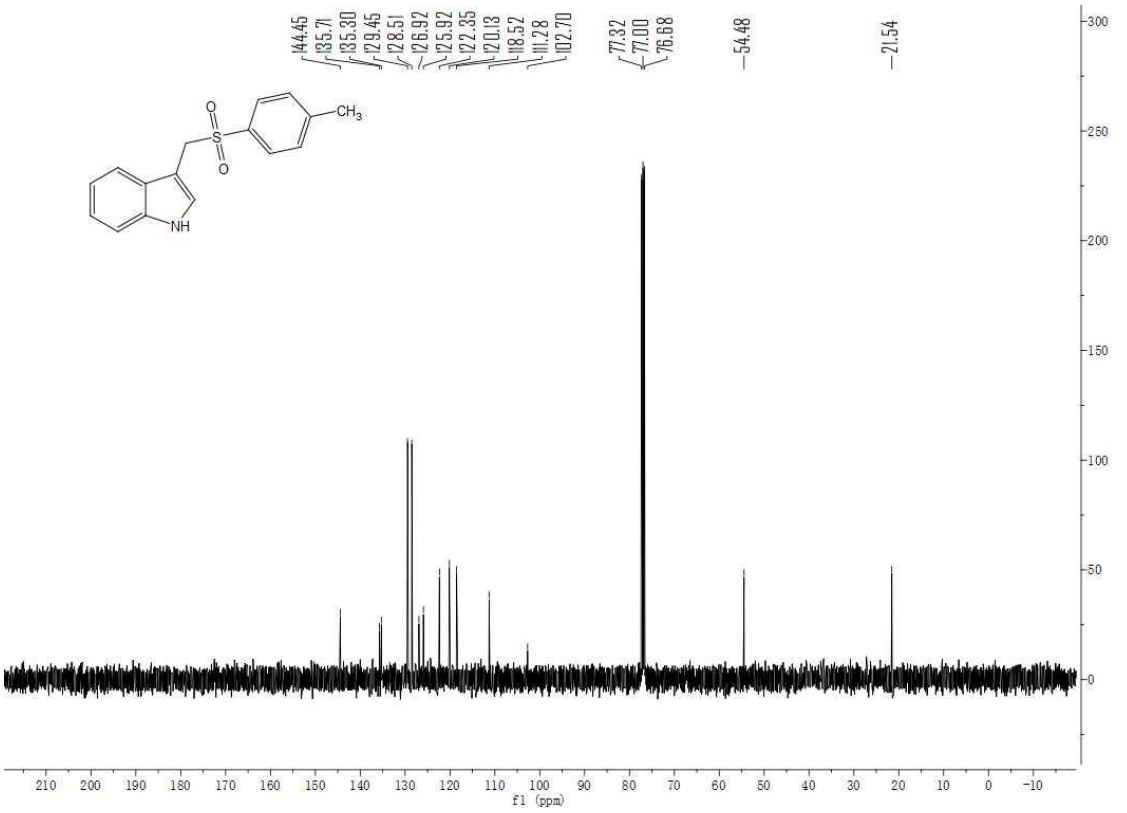

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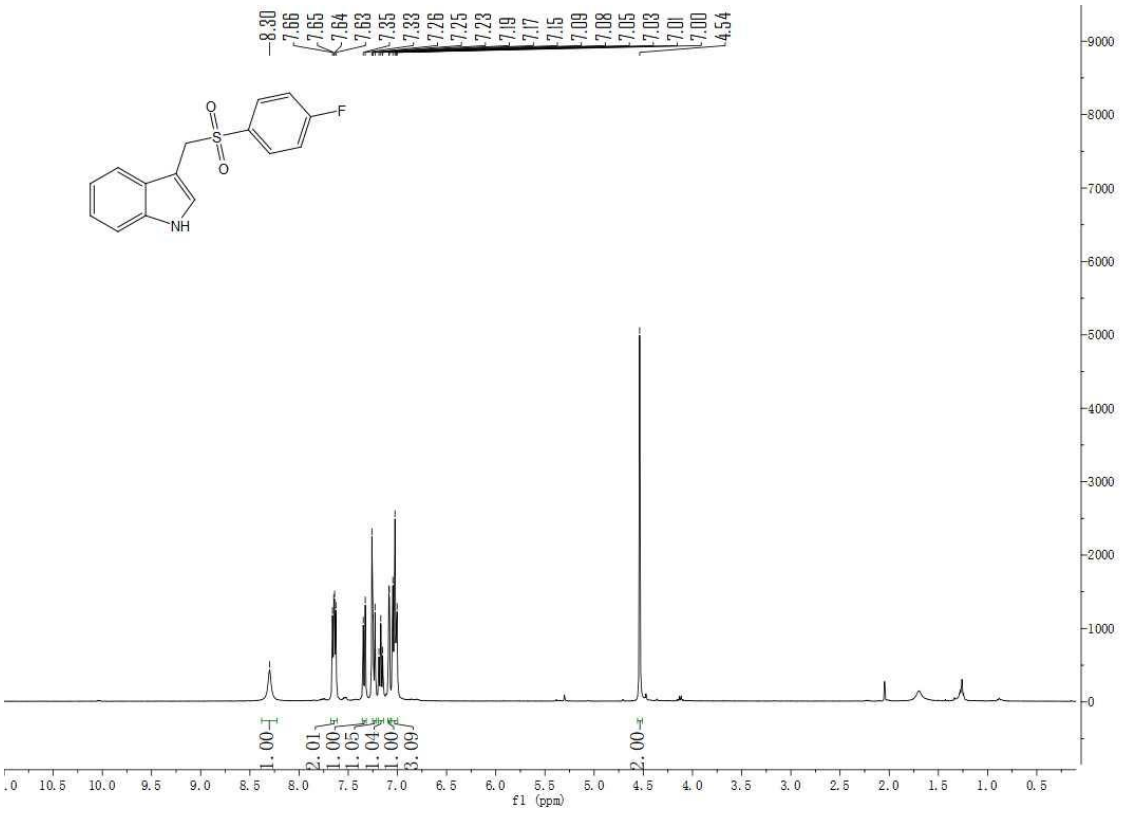
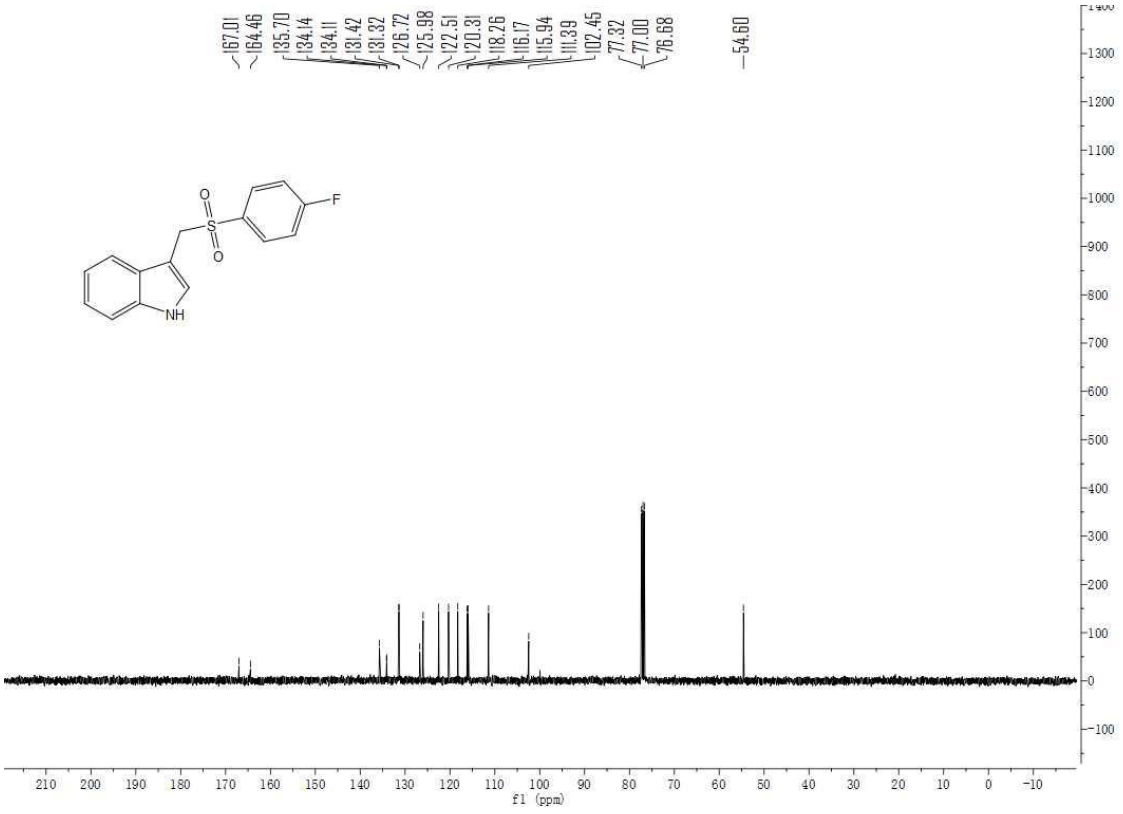
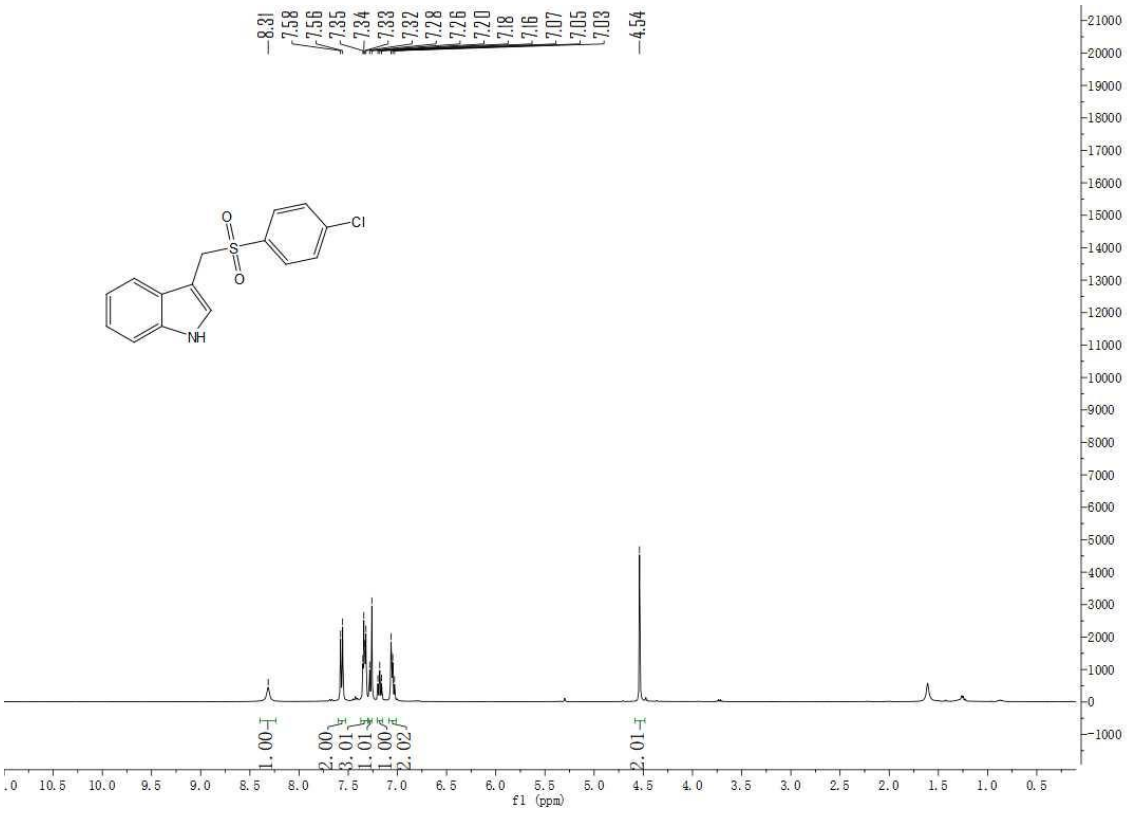


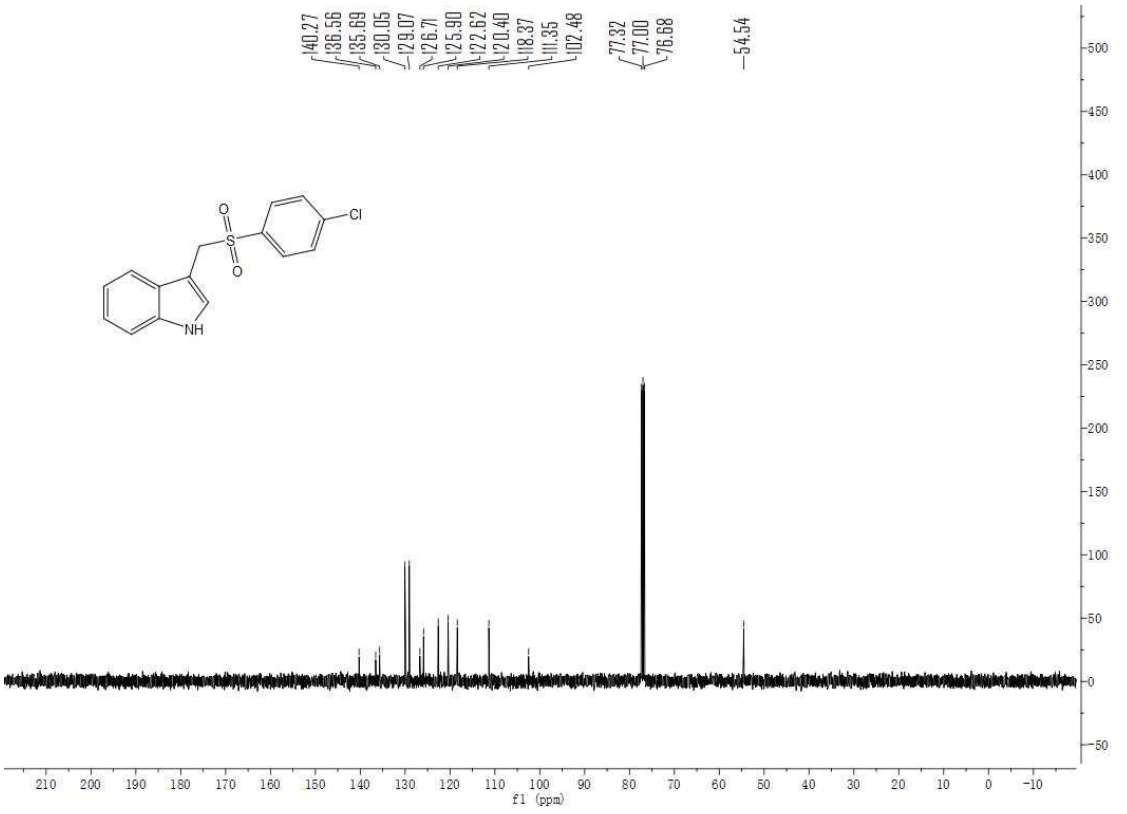
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 9b



^{1}H NMR spectra (400 MHz, $CDCl_3$) of 9c



^{13}C NMR spectra (100 MHz, $CDCl_3$) of 9c



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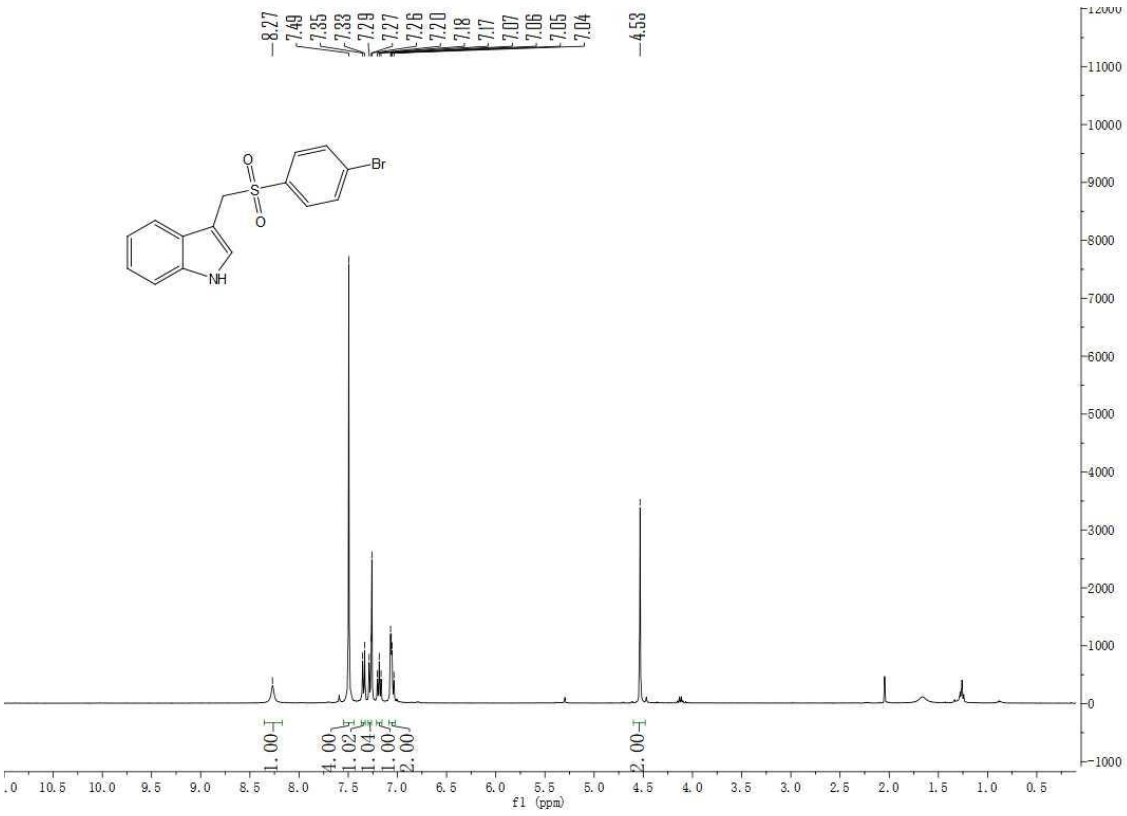

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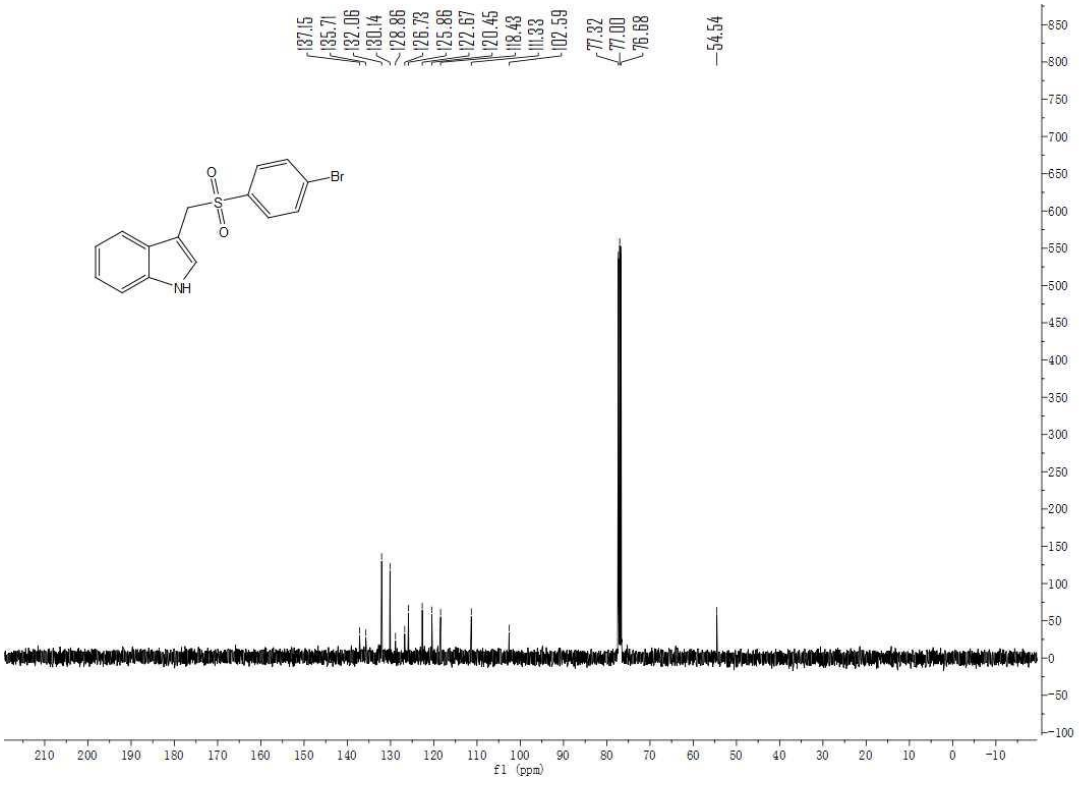

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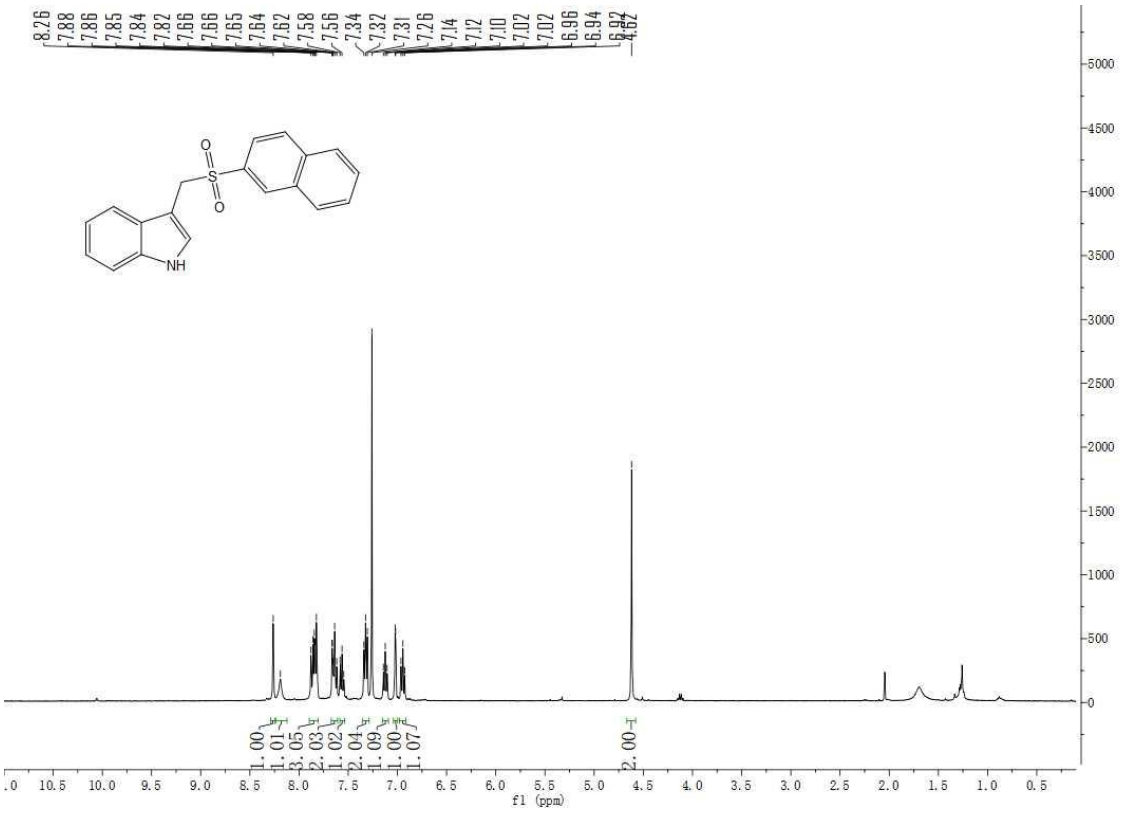

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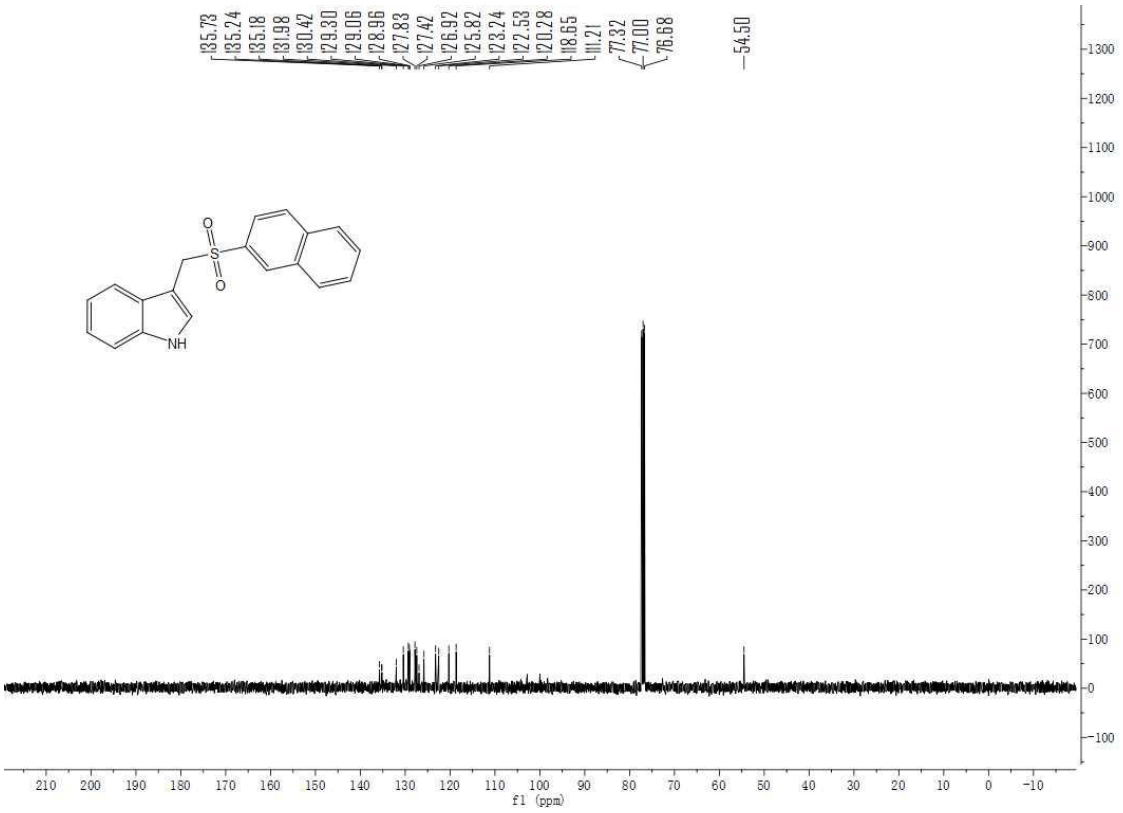
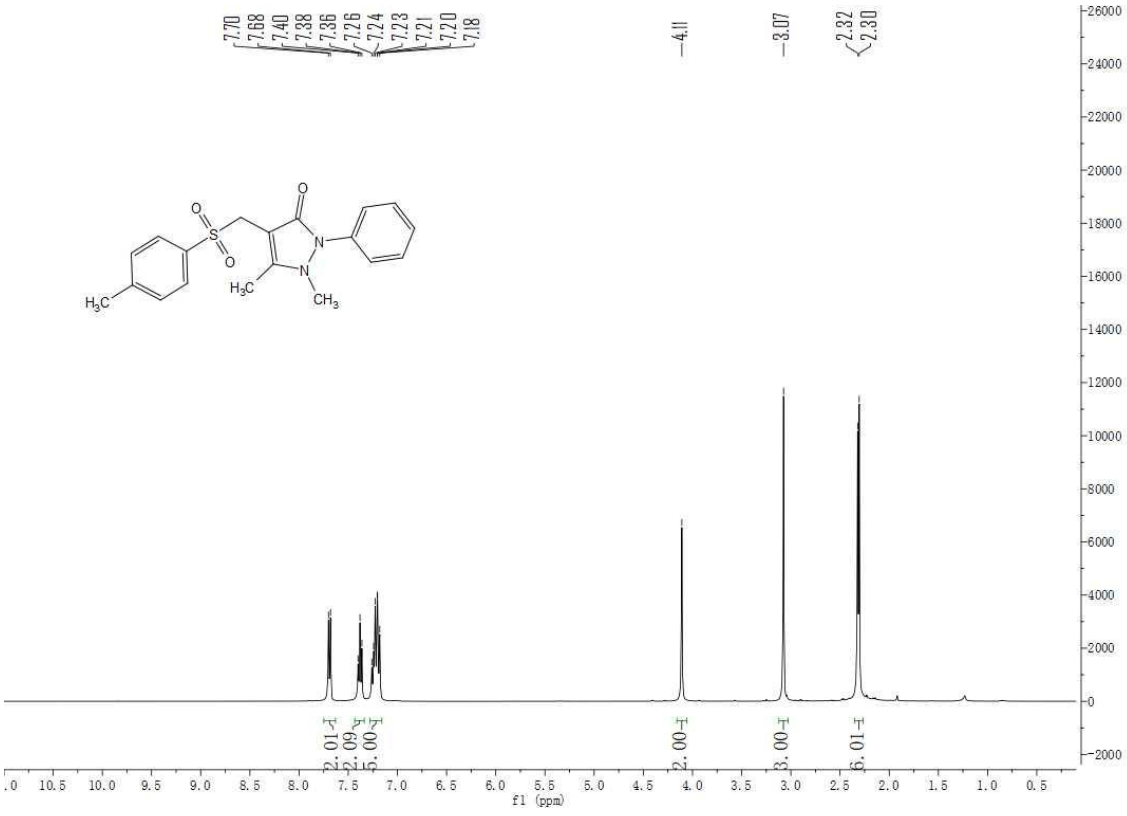
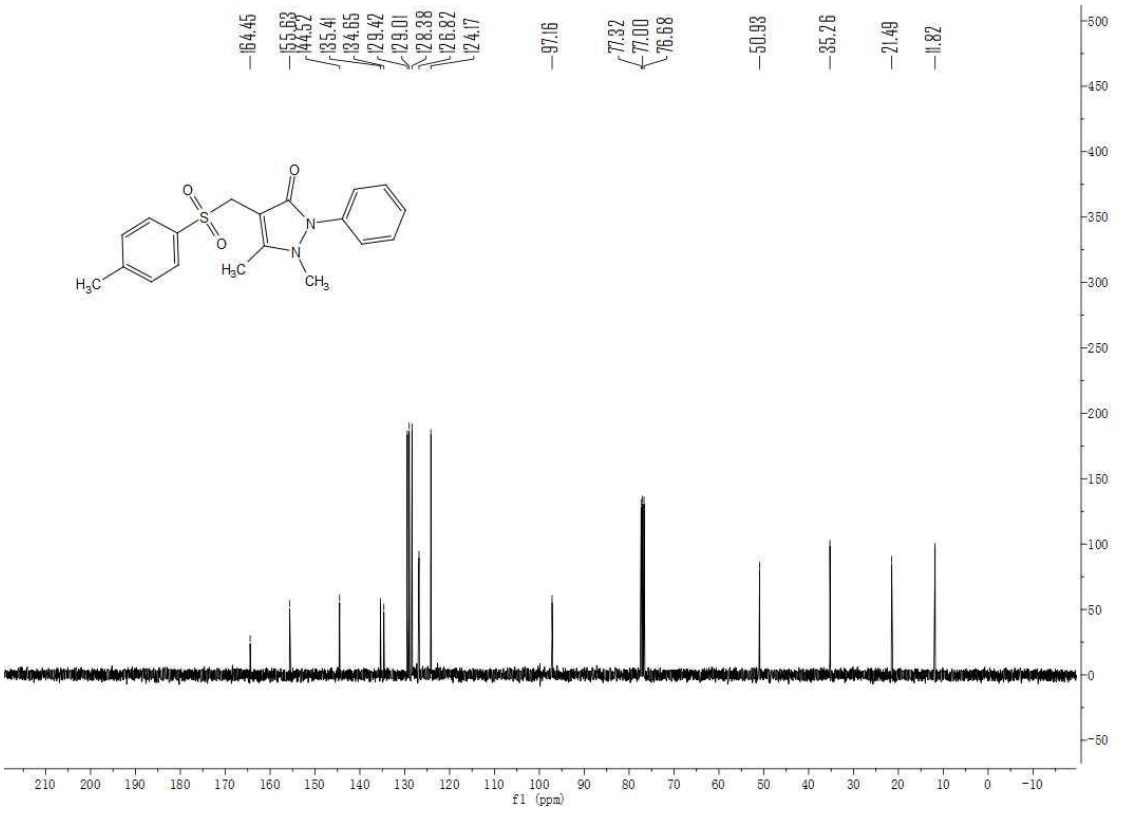


^{1}H NMR spectra (400 MHz, $CDCl_3$) of 10a



^{13}C NMR spectra (100 MHz, $CDCl_3$) of 10a



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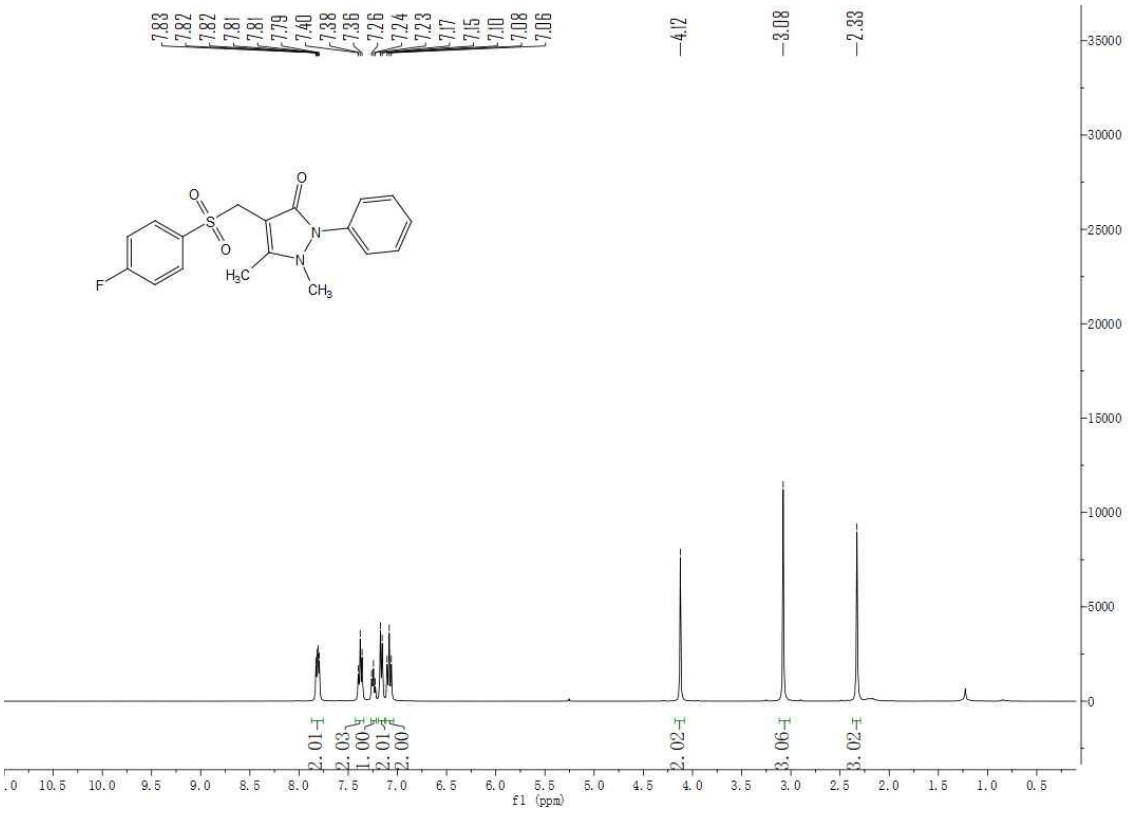
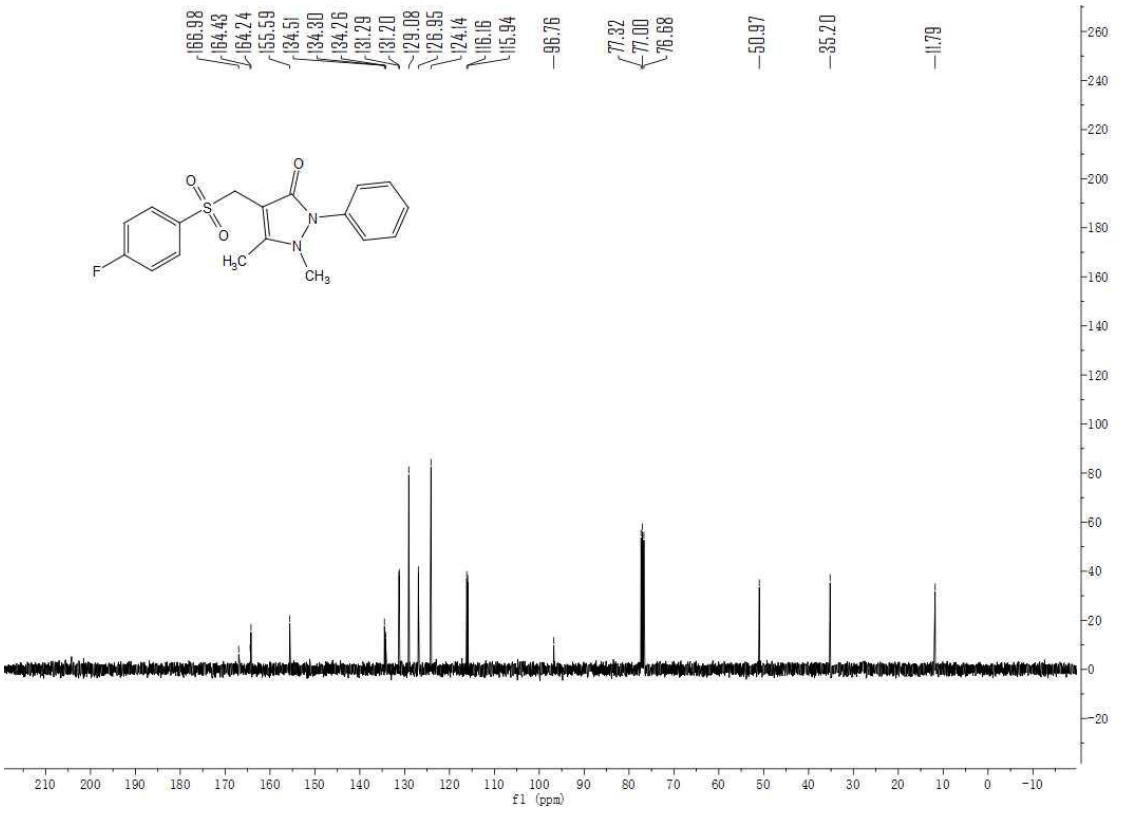


^{13}C NMR spectra (100 MHz, $CDCl_3$) of 10b



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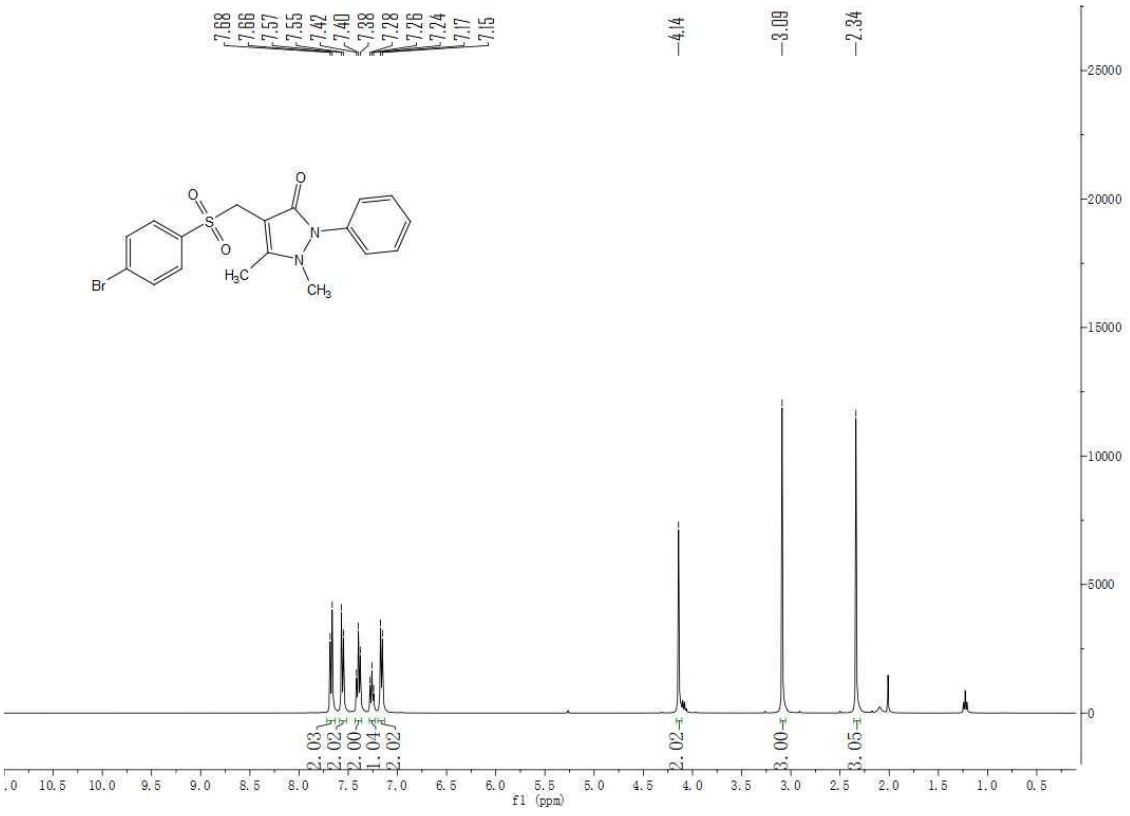
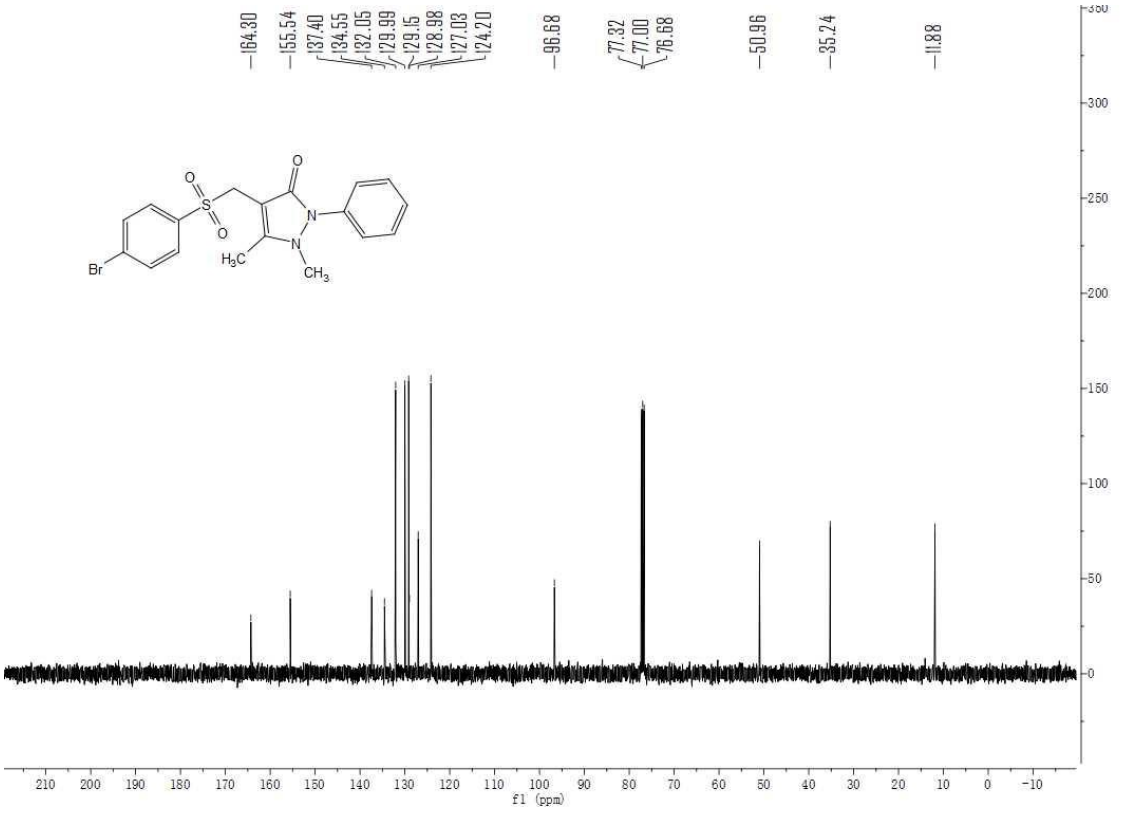
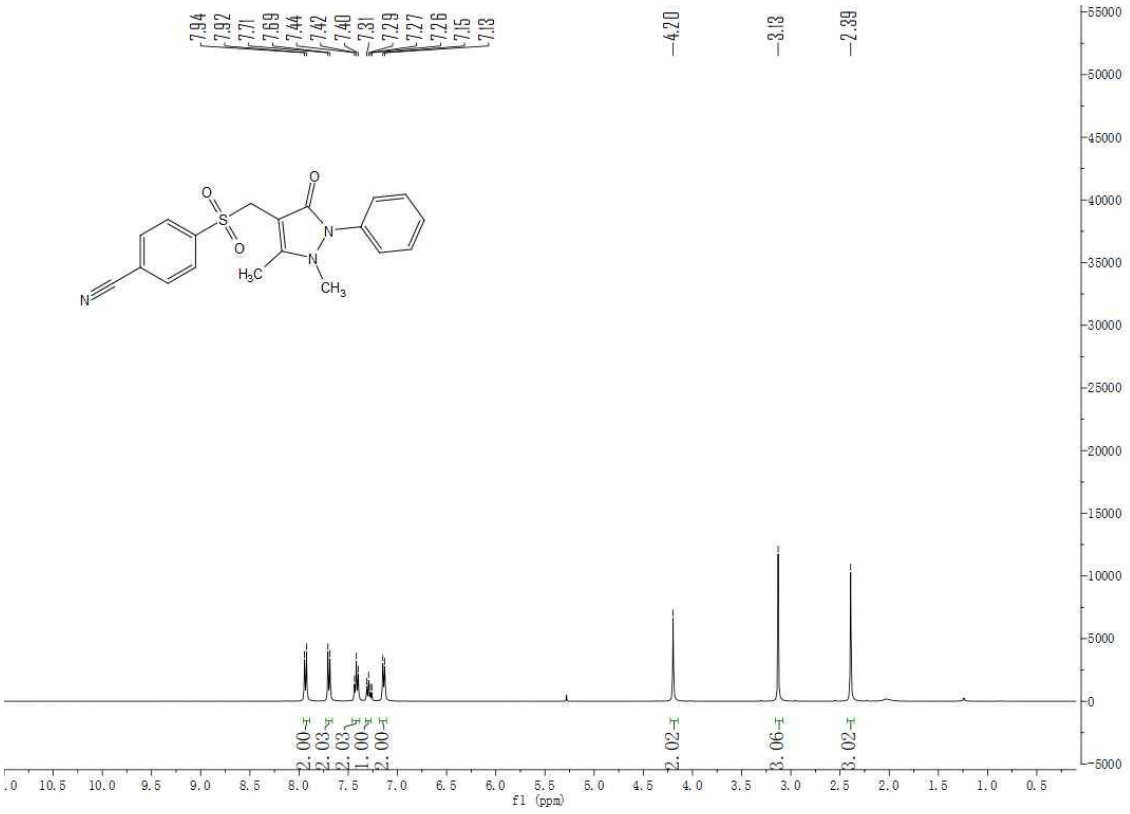


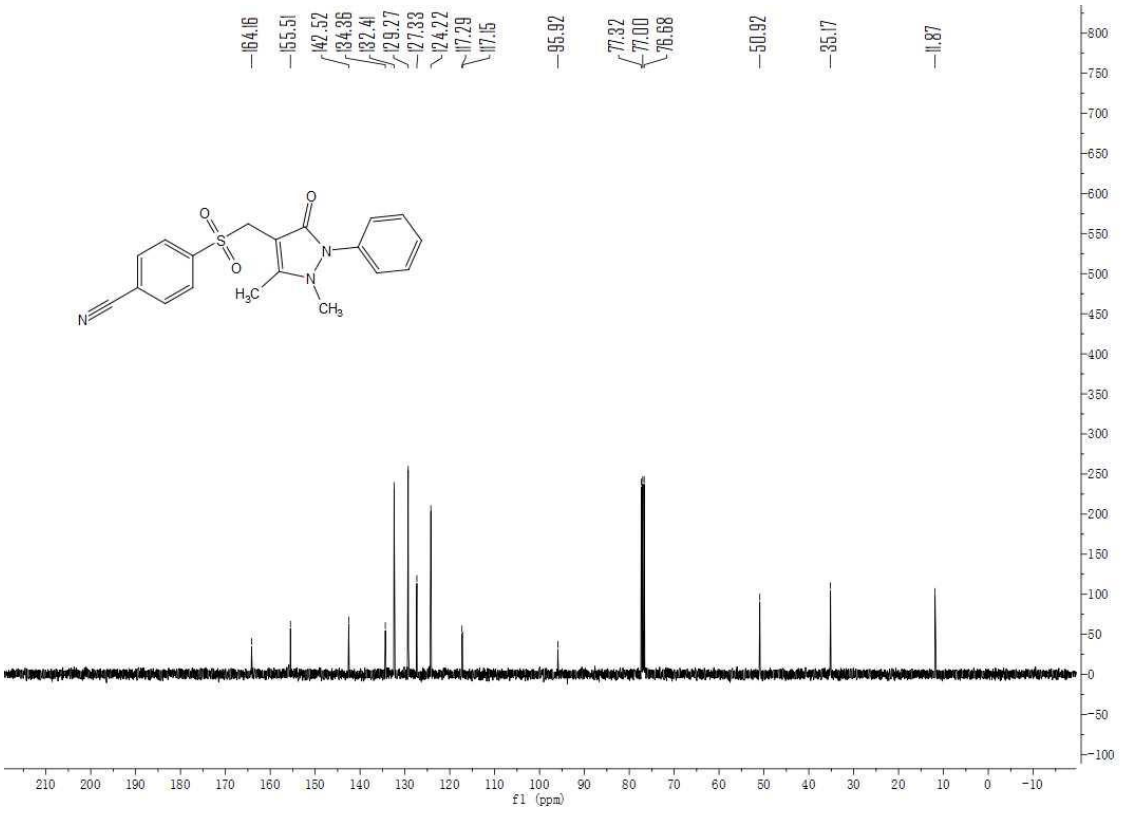
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 10c



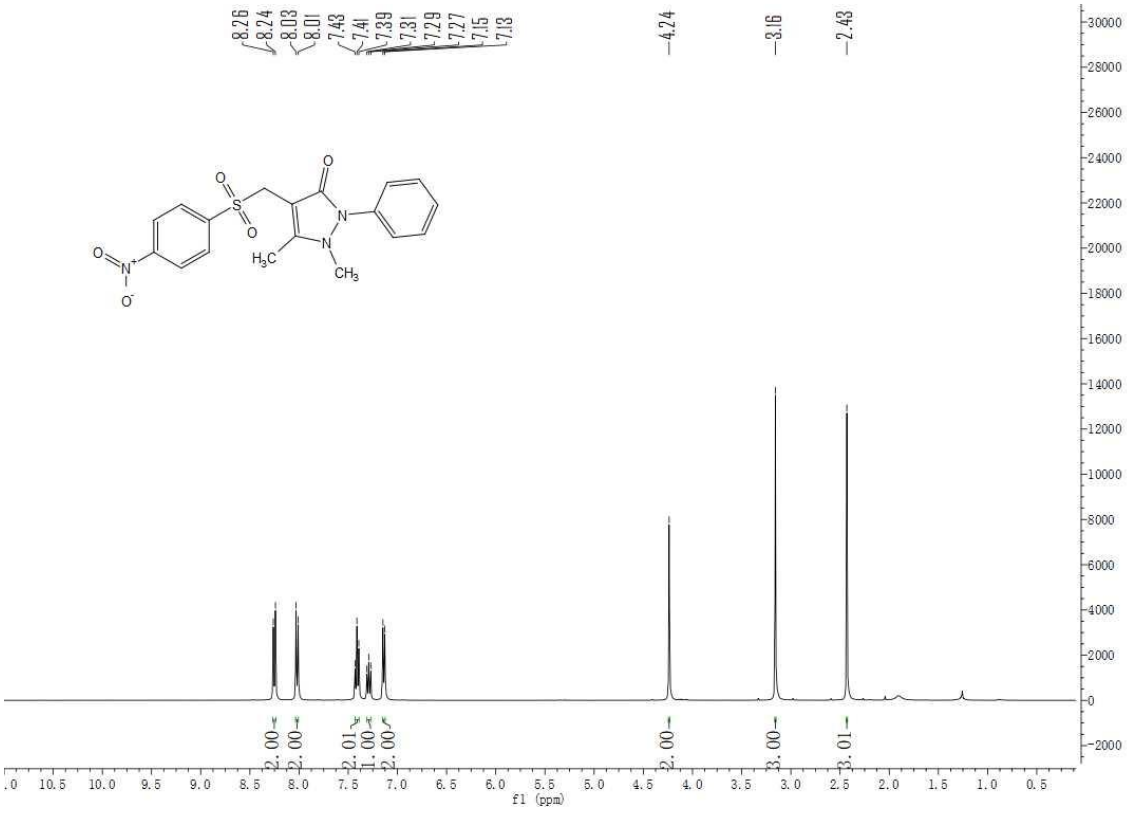
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 10d



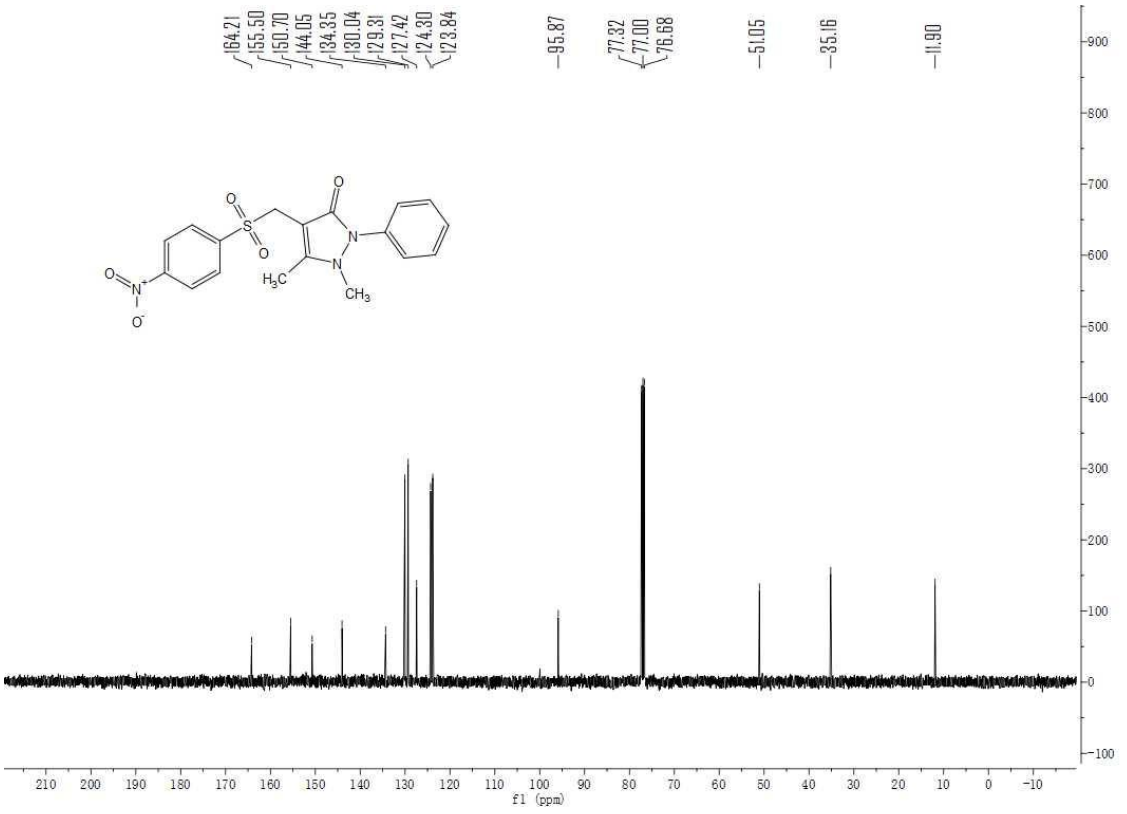
^{13}C NMR spectra (100 MHz, $CDCl_3$) of 10d



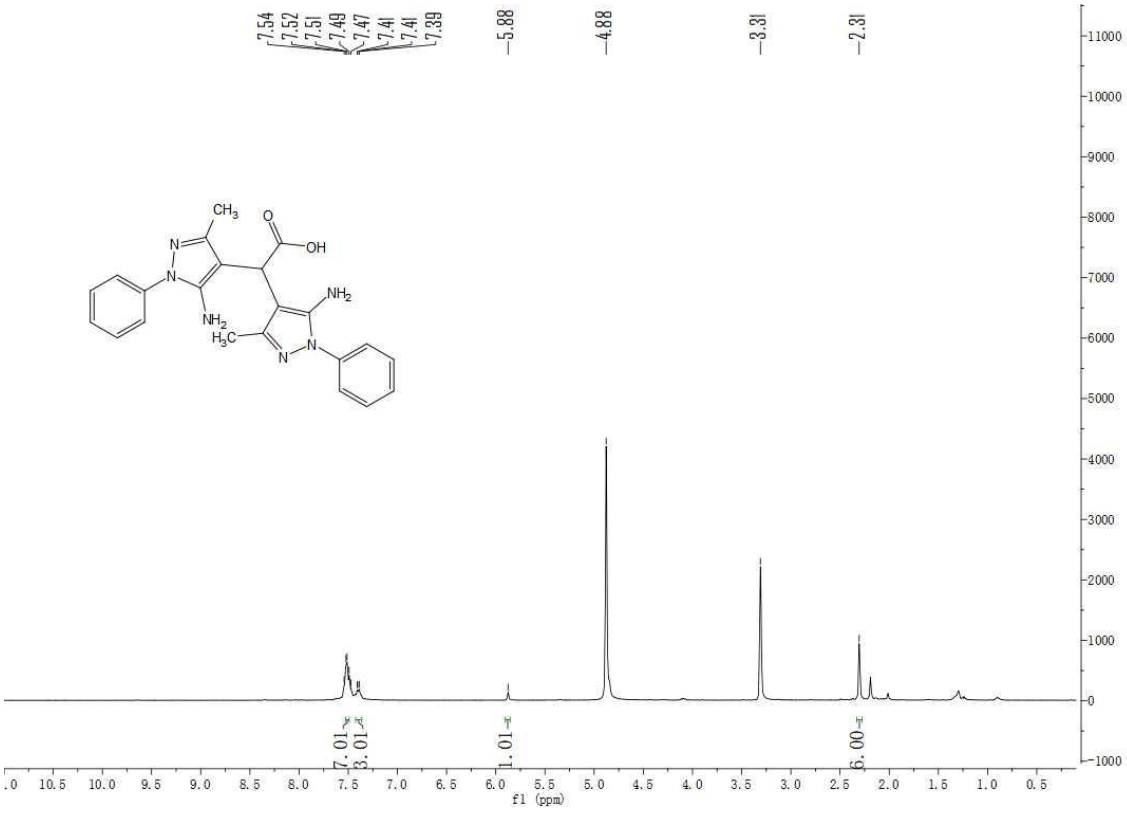
^{1}H NMR spectra (400 MHz, $CDCl_3$) of 10e



^{13}C NMR spectra (100 MHz, $CDCl_3$) of 10e



^{1}H NMR spectra (400 MHz, Methanol-d_4) of 11



^{13}C NMR spectra (100 MHz, Methanol-d_4) of 11