

Supporting Information

Synthesis of Pyrazoles from Sulfonyl hydrazone and benzyl acrylate under transition-metal-free conditions

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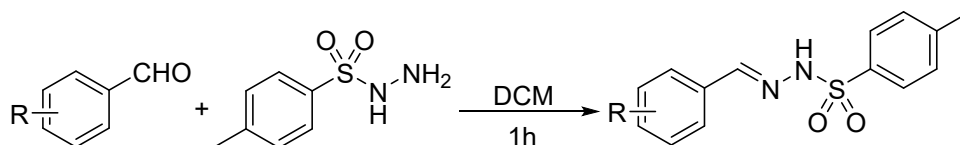
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1. General Experiment Information

All reagents were obtained from commercial sources and used as received without further purification unless otherwise stated. NMR spectra were recorded on a BrukerAvanceII 400 spectrometer and BrukerAvanceII 600 spectrometer in CDCl₃ with tetramethylsilane (TMS) as an internal standard; chemical shifts δ were given in ppm and coupling constants J in Hz. HRMS were measured on a QSTAR Pulsar I LC/TOF MS mass spectrometer.

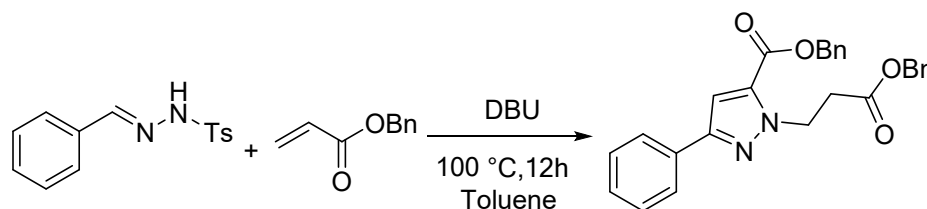
2. General Procedures

2.1 General procedure for Synthesis of various sulfonylhydrazone.



A mixture of hydrazine (6.0 mmol), aldehyde (5.0 mmol) and anhydrous MgSO₄ (1.25 g) in CH₂Cl₂ (25 mL) was stirred 1h at room temperature. After filtration of MgSO₄, CH₂Cl₂ was removed under reduced pressure. The hydrazone, which was usually obtained in nearly quantitative yield, was used directly for the next step without further purification.

2.2 General procedure for Synthesis of pyrazole derivatives



A mixture of substrates *p*-Toluenesulfonyl Hydrazone **1a** (0.2 mmol), Benzyl acrylate **2a** (0.44 mmol), DBU (2.0 equiv) in Toluene (2 mL) was charged in a round-bottom flask and stirred at 100 °C (oil bath) for 12 h. Upon completion of the reaction, water (20 mL) and DCM (10 mL) were added to the mixture, then the aqueous layer was extracted with DCM (100 mL \times 3). The combined organic layer was dried over anhydrous Na₂SO₄. Finally, the solution was concentrated in vacuo to provide a crude product, which was further purified via a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 20:1 to 15:1) to supply the desired products **3a** as a yellow oil.

2.3 Single crystal structure of **2b**

Empiric

al

formula

Formul

a

weight

Temperature

Wavelength

Crystal system

Space group

Unit cell dimensions

Volume

Z

Density (calculated)

Absorption coefficient

F(000)

Crystal size

Theta range for data collection

Index ranges

Reflections collected

Independent reflections

Completeness to theta = 67.679°

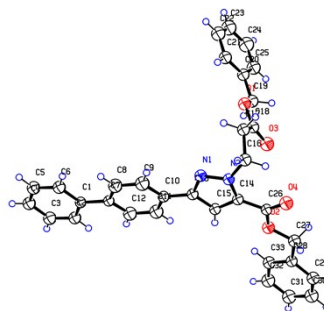
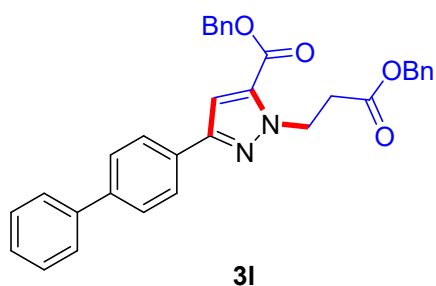
Refinement method

Data / restraints / parameters

Goodness-of-fit on F²

Final R indices [I > 2σ(I)]

R indices (all data)



X-ray Single crystal structure of **31**
516.57

200(2) K

1.54178 Å

Monoclinic

P2₁/n

a = 20.6627(8) Å

α = 90°.

b = 5.9304(2) Å

β = 114.2360(10)°.

c = 23.2569(9) Å

γ = 90°.

2598.68(17) Å³

4

1.320 Mg/m³

0.700 mm⁻¹

1088

0.15 x 0.09 x 0.01 mm³

2.414 to 68.275°.

-24 ≤ h ≤ 24, -7 ≤ k ≤ 5, -28 ≤ l ≤ 27

30322

4701 [R(int) = 0.0508]

99.2 %

Full-matrix least-squares on F²

4701 / 216 / 396

1.098

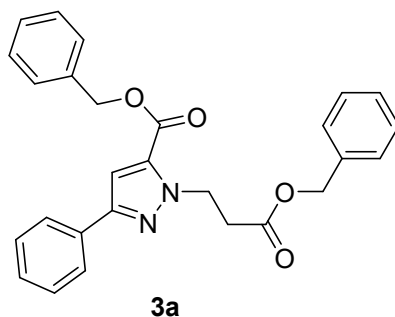
R1 = 0.0370, wR2 = 0.0944

R1 = 0.0463, wR2 = 0.0968

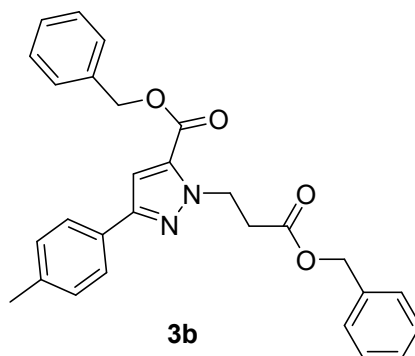
Extinction coefficient 0.0220(6)

Largest diff. peak and hole 0.180 and -0.174 e.Å⁻³

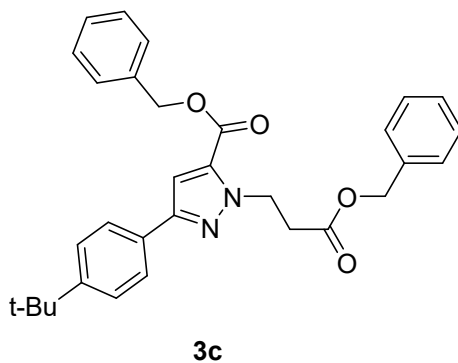
3. Characterization of Materials



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (3a): Compound **3a** was isolated as a yellow oil (66.1mg, 75%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.81 (d, *J* = 7.3 Hz, 2H), 7.51 – 7.43 (m, 4H), 7.42 (d, *J* = 7.6 Hz, 3H), 7.40 – 7.31 (m, 6H), 7.18 (s, 1H), 5.38 (s, 2H), 5.17 (s, 2H), 4.97 (t, *J* = 7.1 Hz, 2H), 3.06 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.81, 159.59, 150.35, 135.80, 135.49, 133.32, 132.51, 128.85, 128.80, 128.67, 128.48, 128.36, 128.22, 125.68, 108.52, 66.95, 66.69, 47.42, 34.93. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₄N₂O₄: 440.1736. Found: 440.1739.

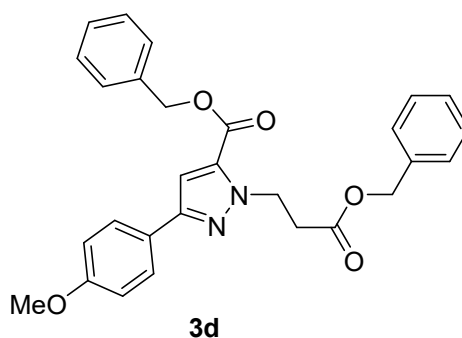


Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(*p*-tolyl)-1H-pyrazole-5-carboxylate (3b): Compound **3b** was isolated as a yellow oil (66.4mg, 73%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.58 (d, *J* = 8.1 Hz, 2H), 7.39 – 7.27 (m, 5H), 7.26 – 7.21 (m, 5H), 7.11 (d, *J* = 7.9 Hz, 2H), 7.03 (s, 1H), 5.25 (s, 2H), 5.04 (s, 2H), 4.85 (t, *J* = 7.2 Hz, 2H), 2.94 (t, *J* = 7.2 Hz, 2H), 2.29 (s, 3H). ¹³C NMR (150 MHz, CDCl₃) δ 170.83, 159.62, 150.44, 138.06, 135.82, 135.51, 133.21, 129.71, 129.50, 128.84, 128.66, 128.48, 128.37, 125.59, 108.30, 66.92, 66.68, 47.37, 34.97, 21.41. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₆N₂O₄: 454.1893. Found: 454.1896.



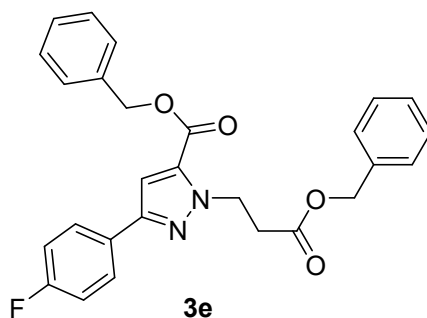
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-(tert-butyl)phenyl)-1H-pyrazole-5-carboxylate (3c):

Compound **3c** was isolated as a white solid (67.5mg, 68%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 93.5–94.2 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.74 (d, *J* = 8.4 Hz, 2H), 7.49 (d, *J* = 7.4 Hz, 2H), 7.47 – 7.40 (m, 5H), 7.39 – 7.32 (m, 5H), 7.17 (s, 1H), 5.38 (s, 2H), 5.17 (s, 2H), 4.97 (t, *J* = 7.2 Hz, 2H), 3.06 (t, *J* = 7.2 Hz, 2H), 1.39 (s, 9H). ¹³C NMR (150 MHz, CDCl₃) δ 170.83, 159.63, 151.28, 150.36, 135.82, 135.51, 133.19, 129.72, 128.83, 128.65, 128.47, 128.36, 128.33, 125.70, 125.42, 108.33, 66.90, 66.65, 47.36, 34.94, 34.75, 31.42. HRMS (EI): *m/z* [M]⁺ calcd. for C₃₁H₃₂N₂O₄: 496.2362. Found: 496.2363.



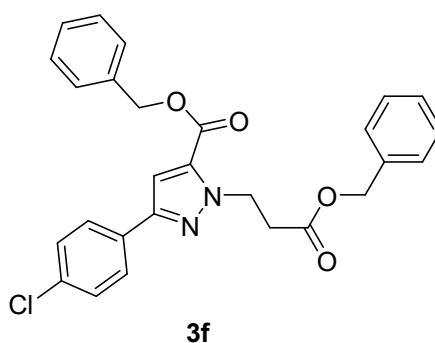
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-methoxyphenyl)-1H-pyrazole-5-carboxylate (3d):

Compound **3d** was isolated as a yellow oil (62.1mg, 66%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.77 – 7.60 (m, 2H), 7.46 – 7.33 (m, 5H), 7.34 – 7.27 (m, 5H), 7.06 (s, 1H), 7.00 – 6.86 (m, 2H), 5.33 (s, 2H), 5.12 (s, 2H), 4.91 (t, *J* = 7.2 Hz, 2H), 3.83 (s, 3H), 3.00 (t, *J* = 7.2 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.85, 159.75, 159.64, 150.23, 135.83, 135.53, 133.21, 128.84, 128.67, 128.47, 128.37, 126.97, 125.34, 114.20, 107.97, 66.91, 66.67, 55.45, 47.32, 34.98. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₆N₂O₅: 470.1842. Found: 470.1840.



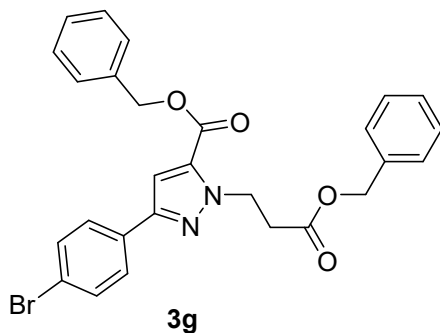
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-fluorophenyl)-1H-pyrazole-5-carboxylate (3e):

Compound **3e** was isolated as a yellow oil (58.7mg, 64%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.72 (dd, *J* = 8.7, 5.4 Hz, 2H), 7.41 (dt, *J* = 15.9, 8.0 Hz, 5H), 7.36 – 7.27 (m, 5H), 7.11 – 7.03 (m, 3H), 5.33 (s, 2H), 5.12 (s, 2H), 4.92 (t, *J* = 7.1 Hz, 2H), 3.01 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.81, 163.67 (d, *J* = 224.5 Hz), 162.04 (d, *J* = 224.5 Hz), 159.52, 149.45, 135.76, 135.42 (d, *J* = 51 Hz), 133.43 (d, *J* = 51 Hz), 128.85, 128.71, 128.67, 128.49, 128.40, 128.36, 127.41 (d, *J* = 9 Hz), 127.35 (d, *J* = 9 Hz), 115.81 (d, *J* = 22.5 Hz), 115.66 (d, *J* = 22.5 Hz), 108.27, 67.00, 66.70, 47.40, 34.89. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₃FN₂O₄: 458.1642. Found: 458.1645.



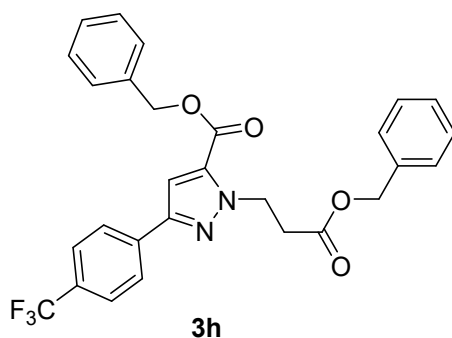
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-chlorophenyl)-1H-pyrazole-5-carboxylate (3f):

Compound **3f** was isolated as a yellow oil (61.7mg, 65%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1), m.p. 63.0–63.6 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.74 (d, *J* = 8.5 Hz, 2H), 7.52 – 7.40 (m, 6H), 7.40 – 7.33 (m, 6H), 7.16 (s, 1H), 5.39 (s, 2H), 5.17 (s, 2H), 4.98 (t, *J* = 7.1 Hz, 2H), 3.07 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.71, 159.39, 149.14, 135.71, 135.35, 133.91, 133.44, 130.98, 128.92, 128.81, 128.67, 128.62, 128.46, 128.35, 128.30, 126.86, 108.39, 66.98, 66.65, 47.41, 34.79. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₃ClN₂O₄: 474.1346. Found: 474.1347.



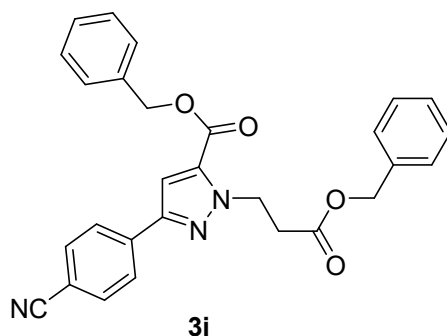
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-bromophenyl)-1H-pyrazole-5-carboxylate (3g):

Compound **3g** was isolated as a white solid (72.7mg, 70%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1), m.p. 73.0–73.5 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.62 (d, *J* = 8.5 Hz, 2H), 7.49 (d, *J* = 8.5 Hz, 2H), 7.46 – 7.34 (m, 5H), 7.35 – 7.27 (m, 5H), 7.10 (s, 1H), 5.33 (s, 2H), 5.11 (s, 2H), 4.91 (t, *J* = 7.1 Hz, 2H), 3.00 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.78, 159.47, 149.25, 135.75, 135.39, 133.53, 131.94, 131.49, 128.87, 128.74, 128.68, 128.53, 128.43, 128.38, 127.22, 122.18, 108.46, 67.06, 66.73, 47.49, 34.87. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₃BrN₂O₄: 518.0841. Found: 518.0843.



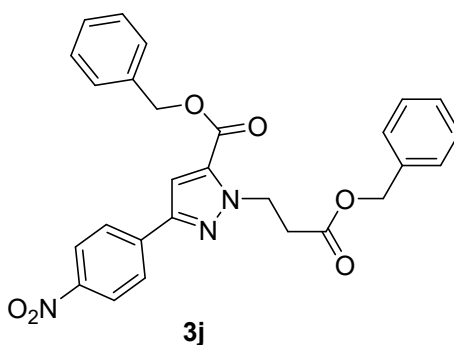
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-(trifluoromethyl)phenyl)-1H-pyrazole-5-carboxylate (3h):

Compound **3h** was isolated as a white solid (71.2mg, 70%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1), m.p. 80.9–81.4 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.95 (d, *J* = 8.0 Hz, 2H), 7.71 (d, *J* = 8.1 Hz, 2H), 7.57 – 7.43 (m, 5H), 7.43–7.35 (m, 5H), 7.27 (s, 1H), 5.44 (s, 2H), 5.21 (s, 2H), 5.03 (t, *J* = 7.0 Hz, 2H), 3.12 (t, *J* = 7.0 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.72, 159.39, 148.83, 135.90, 135.74, 135.35, 133.71, 130.33 (q, *J* = 33 Hz), 130.11 (q, *J* = 33 Hz), 129.90 (q, *J* = 33 Hz), 129.68 (q, *J* = 33 Hz), 128.88, 128.77, 128.67, 128.56, 128.42, 128.38, 127.01 (q, *J* = 270 Hz), 125.79, 125.21 (q, *J* = 270 Hz), 123.41 (q, *J* = 270 Hz), 121.61 (q, *J* = 270 Hz), 108.91, 67.13, 66.73, 47.59, 34.81. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₃F₃N₂O₄: 508.1610. Found: 508.1614.



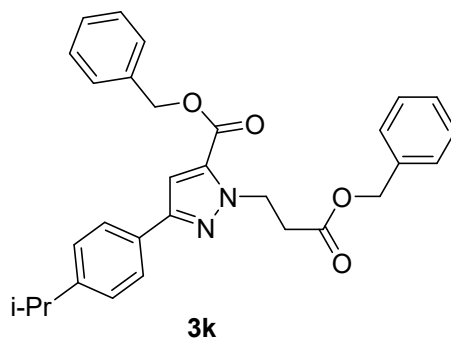
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-cyanophenyl)-1H-pyrazole-5-carboxylate (3i):

Compound **3i** was isolated as a white solid (37.2mg, 40%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 112.5–113.2 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.89 (d, *J* = 8.2 Hz, 2H), 7.70 (d, *J* = 8.2 Hz, 2H), 7.53 – 7.38 (m, 5H), 7.40 – 7.31 (m, 5H), 7.23 (s, 1H), 5.39 (s, 2H), 5.16 (s, 2H), 4.98 (t, *J* = 7.0 Hz, 2H), 3.07 (t, *J* = 7.0 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.67, 159.28, 148.29, 136.82, 135.71, 135.26, 133.93, 132.68, 128.89, 128.81, 128.68, 128.57, 128.45, 128.36, 126.03, 111.49, 109.13, 67.21, 66.76, 47.68, 34.73. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₃N₃O₄: 465.1689. Found: 465.1686.



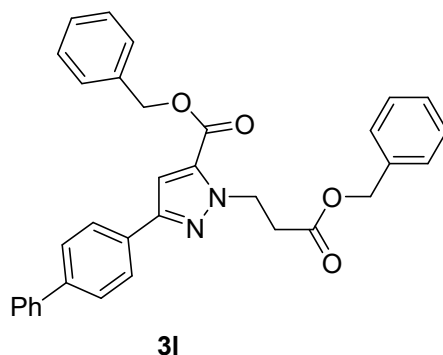
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-nitrophenyl)-1H-pyrazole-5-carboxylate (3j):

Compound **3j** was isolated as a yellow solid (58.3mg, 60%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 143.1–143.5 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.27 (d, *J* = 8.8 Hz, 2H), 7.94 (d, *J* = 8.8 Hz, 2H), 7.53 – 7.39 (m, 5H), 7.39 – 7.32 (m, 5H), 7.27 (s, 1H), 5.40 (s, 2H), 5.17 (s, 2H), 5.00 (t, *J* = 7.0 Hz, 2H), 3.08 (t, *J* = 7.0 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.61, 159.19, 147.87, 147.39, 138.64, 135.67, 135.21, 134.01, 128.86, 128.79, 128.65, 128.55, 128.42, 128.34, 126.05, 124.20, 109.38, 67.21, 66.72, 47.70, 34.66. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₃N₃O₆: 485.1587. Found: 485.1591.



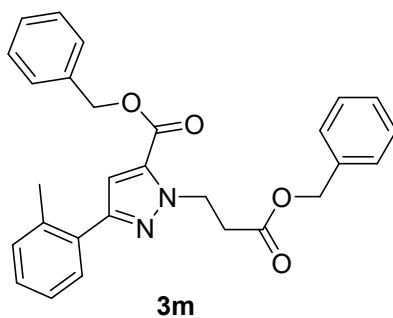
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-isopropylphenyl)-1H-pyrazole-5-carboxylate (3k):

Compound **3k** was isolated as a yellow oil (66.6mg, 69%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.73 (d, *J* = 8.1 Hz, 2H), 7.52 – 7.38 (m, 5H), 7.39 – 7.32 (m, 5H), 7.29 (d, *J* = 7.3 Hz, 2H), 7.15 (s, 1H), 5.38 (s, 2H), 5.16 (s, 2H), 4.97 (t, *J* = 7.2 Hz, 2H), 3.05 (t, *J* = 7.2 Hz, 2H), 2.97 (dt, *J* = 13.8, 6.9 Hz, 1H), 1.31 (d, *J* = 6.9 Hz, 6H). ¹³C NMR (150 MHz, CDCl₃) δ 170.84, 159.64, 150.46, 149.06, 135.81, 135.52, 133.19, 130.11, 128.84, 128.65, 128.48, 128.36, 126.86, 125.69, 108.32, 66.91, 66.67, 47.36, 34.96, 34.05, 24.06. HRMS (EI): *m/z* [M]⁺ calcd. for C₃₀H₃₀N₂O₄: 482.2206. Found: 482.2205.

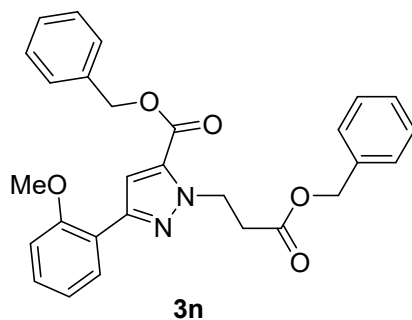


Benzyl 3-([1,1'-biphenyl]-4-yl)-1-(3-(benzyloxy)-3-oxopropyl)-1H-pyrazole-5-carboxylate (3l):

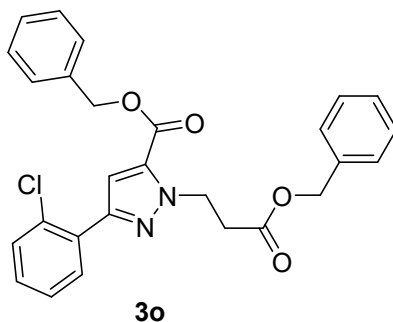
Compound **3l** was isolated as a white solid (62.0mg, 60%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 129.9–130.5 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.90 (d, *J* = 8.3 Hz, 2H), 7.69 (d, *J* = 8.0 Hz, 4H), 7.54 – 7.45 (m, 6H), 7.43 (dd, *J* = 11.2, 4.8 Hz, 2H), 7.40 – 7.33 (m, 5H), 7.24 (s, 1H), 5.41 (s, 2H), 5.19 (s, 2H), 5.01 (t, *J* = 7.1 Hz, 2H), 3.10 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.79, 159.55, 149.97, 140.92, 140.77, 135.78, 135.46, 133.35, 131.47, 128.91, 128.83, 128.66, 128.65, 128.48, 128.35, 127.47, 127.09, 126.05, 108.53, 66.95, 66.67, 47.43, 34.91. HRMS (EI): *m/z* [M]⁺ calcd. for C₃₃H₂₈N₂O₄: 516.2049. Found: 516.2053.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(*o*-tolyl)-1*H*-pyrazole-5-carboxylate (3m): Compound **3m** was isolated as a yellow oil (38.2mg, 42%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.53 (d, *J* = 6.6 Hz, 1H), 7.43 (ddd, *J* = 16.4, 10.0, 6.9 Hz, 5H), 7.33 (d, *J* = 12.1 Hz, 5H), 7.25 (dt, *J* = 8.9, 4.0 Hz, 3H), 7.04 (s, 1H), 5.37 (s, 2H), 5.15 (s, 2H), 4.97 (t, *J* = 7.1 Hz, 2H), 3.05 (t, *J* = 7.1 Hz, 2H), 2.48 (s, 3H). ¹³C NMR (150 MHz, CDCl₃) δ 170.83, 159.72, 150.79, 136.19, 135.80, 135.54, 132.54, 132.19, 131.03, 129.25, 128.84, 128.66, 128.47, 128.37, 128.16, 126.00, 111.52, 66.90, 66.69, 47.29, 34.88, 21.35. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₆N₂O₄: 454.1893. Found: 454.1896.

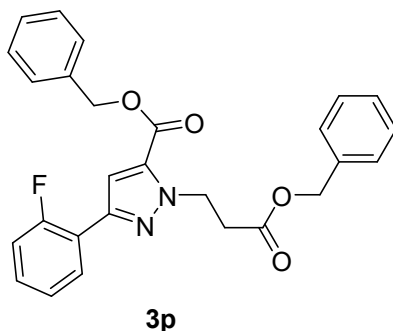


Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(2-methoxyphenyl)-1*H*-pyrazole-5-carboxylate (3n): Compound **3n** was isolated as a yellow oil (35.8mg, 38%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.96 (d, *J* = 7.6 Hz, 1H), 7.48 (d, *J* = 7.3 Hz, 2H), 7.46 – 7.38 (m, 4H), 7.38 – 7.31 (m, 6H), 7.02 (dd, *J* = 15.4, 7.9 Hz, 2H), 5.39 (s, 2H), 5.16 (s, 2H), 4.98 (t, *J* = 7.2 Hz, 2H), 3.94 (s, 3H), 3.05 (t, *J* = 7.2 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.85, 159.86, 156.87, 147.18, 135.84, 135.69, 129.39, 128.80, 128.70, 128.67, 128.57, 128.44, 128.37, 121.26, 120.96, 112.75, 111.34, 66.80, 66.67, 55.64, 47.41, 35.01. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₆N₂O₅: 470.1842. Found: 470.1844.



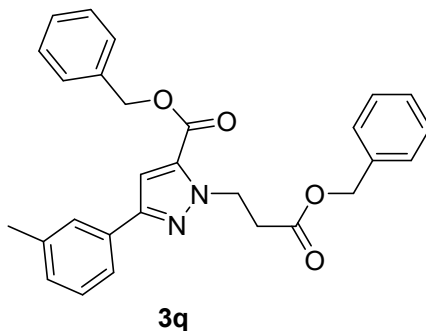
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(2-chlorophenyl)-1H-pyrazole-5-carboxylate (3o):

Compound **3o** was isolated as a yellow oil (47.5mg, 50%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.96 – 7.69 (m, 1H), 7.46 (dd, *J* = 9.7, 4.7 Hz, 3H), 7.44 – 7.37 (m, 4H), 7.37-7.32 (m, 5H), 7.31 (dd, *J* = 7.1, 3.1 Hz, 2H), 5.38 (s, 2H), 5.16 (s, 2H), 4.99 (t, *J* = 7.2 Hz, 2H), 3.06 (t, *J* = 7.2 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.76, 159.63, 147.89, 135.78, 135.50, 132.64, 132.30, 131.39, 130.56, 130.46, 129.29, 128.83, 128.67, 128.65, 128.47, 128.39, 128.37, 127.03, 112.57, 66.96, 66.71, 47.47, 34.90. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₃ClN₂O₄: 474.1346. Found: 474.1342.

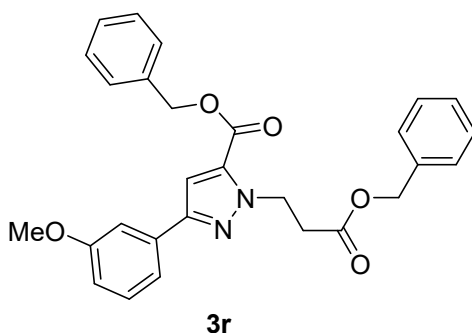


Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(2-fluorophenyl)-1H-pyrazole-5-carboxylate (3p):

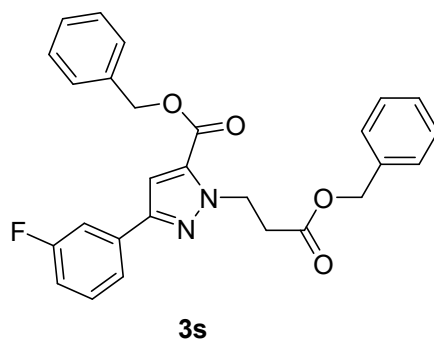
Compound **3p** was isolated as a yellow solid (53.2mg, 58%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 61.8–62.3 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.02 (td, *J* = 7.7, 1.2 Hz, 1H), 7.53 – 7.38 (m, 5H), 7.39 – 7.29 (m, 7H), 7.18 (dt, *J* = 10.9, 8.0 Hz, 2H), 5.39 (s, 2H), 5.18 (s, 2H), 5.00 (t, *J* = 7.1 Hz, 2H), 3.07 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.77, 160.98 (d, *J* = 249 Hz), 159.62, 159.32 (d, *J* = 249 Hz), 144.89, 135.77, 135.48, 133.11, 129.59 (d, *J* = 7.5 Hz), 129.54 (d, *J* = 7.5 Hz), 128.82, 128.65, 128.45, 128.35, 124.43 (d, *J* = 3 Hz), 124.41 (d, *J* = 3 Hz), 120.42 (d, *J* = 12 Hz), 120.34 (d, *J* = 12 Hz), 116.25 (d, *J* = 22.5 Hz), 116.10 (d, *J* = 22.5 Hz), 112.06 (d, *J* = 9 Hz), 112.00 (d, *J* = 9 Hz), 66.93, 66.70, 47.49, 34.88. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₃FN₂O₄: 458.1642. Found: 458.1647.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(*m*-tolyl)-1*H*-pyrazole-5-carboxylate (3q): Compound **3q** was isolated as a white solid (61.8mg, 68%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 67.2–68.1 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.66 (s, 1H), 7.60 (d, *J* = 7.6 Hz, 1H), 7.53 – 7.39 (m, 5H), 7.35 (d, *J* = 8.0 Hz, 5H), 7.31 (d, *J* = 8.8 Hz, 1H), 7.16 (d, *J* = 15.4 Hz, 2H), 5.38 (s, 2H), 5.17 (s, 2H), 4.98 (t, *J* = 7.0 Hz, 2H), 3.07 (t, *J* = 7.0 Hz, 2H), 2.43 (s, 3H). ¹³C NMR (150 MHz, CDCl₃) δ 170.79, 159.59, 150.49, 138.42, 135.78, 135.48, 133.23, 132.37, 129.00, 128.82, 128.70, 128.65, 128.47, 128.34, 126.31, 122.84, 108.55, 66.92, 66.66, 47.39, 34.96, 21.56. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₆N₂O₄: 454.1893. Found: 454.1896.

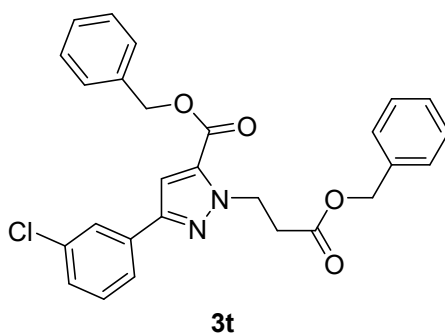


Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-methoxyphenyl)-1*H*-pyrazole-5-carboxylate (3r): Compound **3r** was isolated as a yellow oil (61.2mg, 65%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.45 (dt, *J* = 9.7, 4.8 Hz, 4H), 7.41 – 7.31 (m, 8H), 7.30 (s, 1H), 7.17 (s, 1H), 6.96 – 6.83 (m, 1H), 5.38 (s, 2H), 5.16 (s, 2H), 4.97 (t, *J* = 7.2 Hz, 2H), 3.88 (s, 3H), 3.06 (t, *J* = 7.2 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.79, 160.09, 159.54, 150.19, 135.79, 135.45, 133.72, 133.39, 129.87, 128.86, 128.71, 128.68, 128.51, 128.39, 128.37, 118.27, 114.36, 110.84, 108.68, 67.01, 66.72, 55.48, 47.43, 34.97. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₆N₂O₅: 470.1842. Found: 470.1845.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-fluorophenyl)-1H-pyrazole-5-carboxylate (3s):

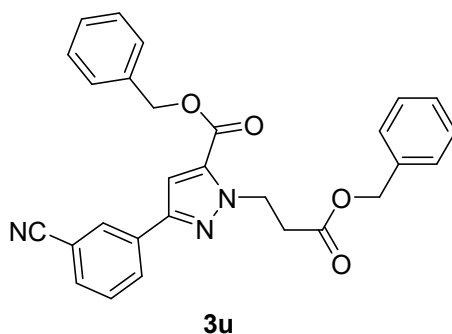
Compound **3s** was isolated as a white solid (59.6mg, 65%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 88.4–89.1 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.57 (d, *J* = 7.8 Hz, 1H), 7.53 (dd, *J* = 9.8, 1.9 Hz, 1H), 7.51 – 7.37 (m, 6H), 7.38 – 7.33 (m, 5H), 7.17 (s, 1H), 7.05 (td, *J* = 8.4, 2.1 Hz, 1H), 5.39 (s, 2H), 5.18 (s, 2H), 4.98 (t, *J* = 7.1 Hz, 2H), 3.07 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.73, 164.07 (d, *J* = 243 Hz), 162.45 (d, *J* = 243 Hz), 159.42, 149.14, 135.73, 135.38, 134.74 (d, *J* = 9 Hz), 134.68 (d, *J* = 9 Hz), 133.50, 130.34 (d, *J* = 9 Hz), 130.28 (d, *J* = 9 Hz), 128.84, 128.70, 128.64, 128.48, 128.37, 128.35, 121.27 (d, *J* = 1.5 Hz), 121.26 (d, *J* = 1.5 Hz), 115.04 (d, *J* = 21 Hz), 114.90 (d, *J* = 21 Hz), 112.61 (d, *J* = 22.5 Hz), 112.46 (d, *J* = 22.5 Hz), 108.65, 67.01, 66.70, 47.47, 34.80. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₃FN₂O₄: 458.1642. Found: 458.1644.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-chlorophenyl)-1H-pyrazole-5-carboxylate (3t):

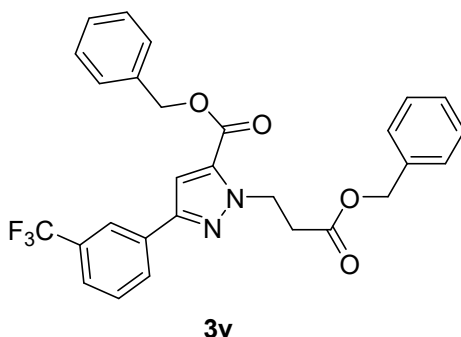
Compound **3t** was isolated as a yellow oil (59.8mg, 63%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.76 (s, 1H), 7.62 (dd, *J* = 8.2, 6.4 Hz, 1H), 7.49 – 7.35 (m, 5H), 7.36 – 7.22 (m, 7H), 7.12 (s, 1H), 5.33 (s, 2H), 5.12 (s, 2H), 4.92 (t, *J* = 7.1 Hz, 2H), 3.01 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.76, 159.43, 148.97, 135.73, 135.37, 134.82, 134.29, 133.54, 130.08, 128.87, 128.73, 128.68, 128.52, 128.41, 128.38, 128.18, 125.75, 123.74, 108.66, 67.06, 66.75, 47.50, 34.84. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₇H₂₃ClN₂O₄:

474.1346. Found: 474.1342.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-cyanophenyl)-1H-pyrazole-5-carboxylate (3u):

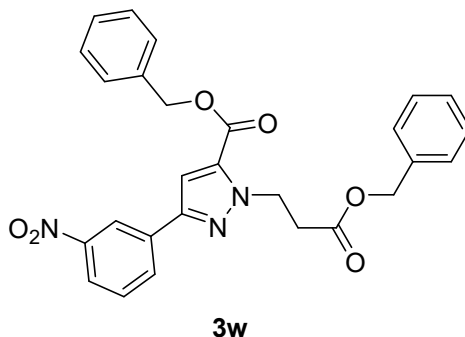
Compound **3u** was isolated as a white solid (49.3mg, 53%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 123.5–124.2 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.08 (s, 1H), 8.01 (d, *J* = 7.8 Hz, 1H), 7.62 (d, *J* = 7.6 Hz, 1H), 7.56 – 7.38 (m, 6H), 7.33 (d, *J* = 17.6 Hz, 5H), 7.20 (s, 1H), 5.39 (s, 2H), 5.17 (s, 2H), 4.98 (t, *J* = 6.9 Hz, 2H), 3.07 (t, *J* = 6.9 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.63, 159.26, 148.02, 135.68, 135.26, 133.80, 131.43, 129.70, 129.61, 129.10, 128.86, 128.77, 128.65, 128.53, 128.41, 128.35, 118.76, 113.02, 108.61, 67.15, 66.73, 47.58, 34.73. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₈H₂₃N₃O₄: 465.1689. Found: 465.1692.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-(trifluoromethyl)phenyl)-1H-pyrazole-5-carboxylate (3v):

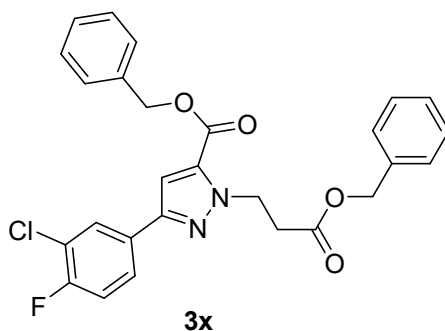
Compound **3v** was isolated as a white solid (66.1mg, 65%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 76.9–77.5 °C. ¹H NMR (400 MHz, CDCl₃) δ 8.08 (s, 1H), 7.99 (d, *J* = 7.7 Hz, 1H), 7.62 (d, *J* = 7.8 Hz, 1H), 7.55 (d, *J* = 7.7 Hz, 1H), 7.53 – 7.41 (m, 5H), 7.39 – 7.33 (m, 5H), 7.23 (s, 1H), 5.40 (s, 2H), 5.18 (s, 2H), 5.00 (t, *J* = 7.1 Hz, 2H), 3.09 (t, *J* = 7.1 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 170.71, 159.39, 148.86, 135.72, 135.34, 133.68, 133.33, 131.53 (q, *J* = 33 Hz), 131.32 (q, *J* = 33 Hz), 131.10 (q, *J* = 33 Hz), 130.89 (q, *J* = 33 Hz), 129.27, 128.86, 128.78, 128.74, 128.64, 128.54, 128.39, 128.35, 126.93 (q, *J* = 270 Hz), 125.12 (q, *J* = 270 Hz), 124.76 (q, *J* = 4.5 Hz), 124.74 (q, *J* = 4.5 Hz), 124.71 (q, *J* = 4.5 Hz), 124.68 (q, *J* = 4.5 Hz), 123.32 (q, *J* = 270

(Hz), 122.44 (q, $J = 3$ Hz), 122.42 (q, $J = 3$ Hz), 122.40 (q, $J = 3$ Hz), 122.37 (q, $J = 3$ Hz), 121.51 (q, $J = 270$ Hz), 108.62, 67.09, 66.72, 47.52, 34.83; HRMS (EI): m/z $[M]^+$ calcd. for $C_{28}H_{23}F_3N_2O_4$: 508.1610. Found: 508.1607.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-nitrophenyl)-1H-pyrazole-5-carboxylate (3w):

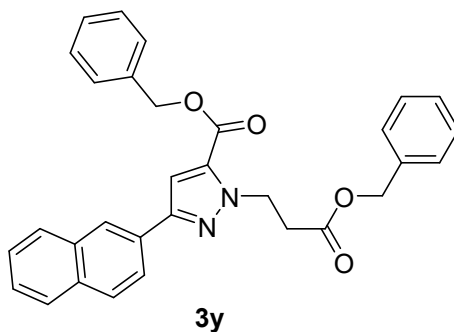
Compound **3w** was isolated as a yellow solid (61.2mg, 63%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1), m.p. 100.1–100.6 °C. 1H NMR (400 MHz, $CDCl_3$) δ 8.63 (s, 1H), 8.19 (dd, $J = 8.2, 1.3$ Hz, 1H), 8.12 (d, $J = 7.8$ Hz, 1H), 7.58 (t, $J = 8.0$ Hz, 1H), 7.52 – 7.38 (m, 5H), 7.39 – 7.31 (m, 5H), 7.25 (s, 1H), 5.39 (s, 2H), 5.17 (s, 2H), 4.99 (t, $J = 7.0$ Hz, 2H), 3.08 (t, $J = 7.0$ Hz, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 170.68, 159.28, 148.78, 147.93, 135.71, 135.26, 134.30, 133.94, 131.32, 129.77, 128.89, 128.79, 128.66, 128.56, 128.41, 128.38, 122.74, 120.46, 108.79, 67.19, 66.76, 47.61, 34.75. HRMS (EI): m/z $[M]^+$ calcd. for $C_{27}H_{23}N_3O_6$: 485.1587. Found: 485.1581.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-chloro-3-fluorophenyl)-1H-pyrazole-5-carboxylate (3x):

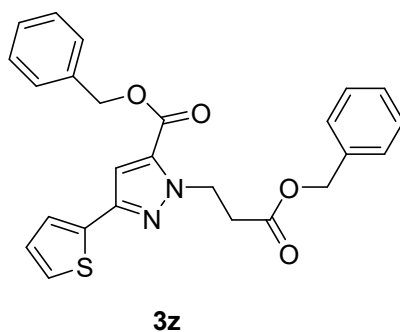
Compound **3x** was isolated as a white solid (67.0mg, 68%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1), m.p. 45.6–46.2 °C. 1H NMR (400 MHz, $CDCl_3$) δ 7.85 (dd, $J = 7.0, 1.8$ Hz, 1H), 7.64 (ddd, $J = 8.4, 4.4, 1.9$ Hz, 1H), 7.52 – 7.39 (m, 5H), 7.39 – 7.30 (m, 5H), 7.18 (t, $J = 8.7$ Hz, 1H), 7.12 (s, 1H), 5.38 (s, 2H), 5.17 (s, 2H), 4.96 (t, $J = 7.1$ Hz, 2H), 3.05 (t, $J = 7.1$ Hz, 2H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.71, 159.36, 158.84 (d, $J = 247.5$ Hz), 157.19 (d, $J = 247.5$ Hz), 148.22, 135.72 (d, $J = 58.5$ Hz), 135.33 (d, $J = 58.5$ Hz), 133.65, 129.88 (d, $J = 4.5$ Hz),

129.85 (d, $J = 4.5$ Hz), 128.86, 128.75, 128.66, 128.53, 128.41, 128.36, 127.83, 125.37 (d, $J = 6$ Hz), 125.33 (d, $J = 6$ Hz), 121.55 (d, $J = 18$ Hz), 121.43 (d, $J = 18$ Hz), 116.98 (d, $J = 22.5$ Hz), 116.83 (d, $J = 22.5$ Hz), 108.37, 67.08, 66.73, 47.48, 34.81. HRMS (EI): m/z $[M]^+$ calcd. for $C_{27}H_{22}ClFN_2O_4$: 492.1252. Found: 492.1249.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(naphthalen-2-yl)-1H-pyrazole-5-carboxylate (3y):

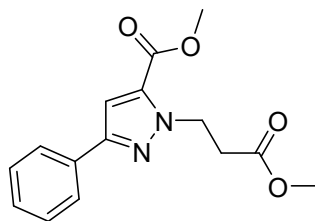
Compound **3y** was isolated as a yellow oil (54.0mg, 55%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). 1H NMR (400 MHz, $CDCl_3$) δ 8.48 (dd, $J = 6.1, 3.4$ Hz, 1H), 7.93 (dd, $J = 11.1, 5.6$ Hz, 2H), 7.68 (d, $J = 7.1$ Hz, 1H), 7.60 – 7.52 (m, 3H), 7.50 (d, $J = 6.9$ Hz, 2H), 7.48 – 7.39 (m, 3H), 7.39 – 7.31 (m, 5H), 7.22 (s, 1H), 5.42 (s, 2H), 5.18 (s, 2H), 5.08 (t, $J = 7.1$ Hz, 2H), 3.13 (t, $J = 7.1$ Hz, 2H). ^{13}C NMR (150 MHz, $CDCl_3$) δ 170.80, 159.67, 150.34, 135.76, 135.48, 134.05, 132.81, 131.27, 130.41, 128.88, 128.84, 128.67, 128.65, 128.48, 128.38, 128.36, 127.31, 126.64, 126.01, 125.40, 112.33, 66.99, 66.72, 47.45, 35.02. HRMS (EI): m/z $[M]^+$ calcd. for $C_{31}H_{26}N_2O_4$: 490.1893. Found: 490.1895.



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(thiophen-2-yl)-1H-pyrazole-5-carboxylate (3z):

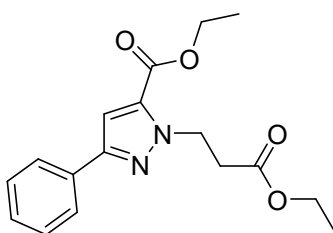
Compound **3z** was isolated as a yellow solid (52.7mg, 59%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1), m.p. 87.6–88.2 °C. 1H NMR (400 MHz, $CDCl_3$) δ 7.45 (dt, $J = 16.2, 8.2$ Hz, 5H), 7.38 (d, $J = 9.8$ Hz, 5H), 7.35 – 7.33 (m, 1H), 7.29 (d, $J = 4.3$ Hz, 1H), 7.08 (dd, $J = 6.1, 4.9$ Hz, 2H), 5.37 (s, 2H), 5.17 (s, 2H), 4.95 (t, $J = 7.2$ Hz, 2H), 3.04 (t, $J = 7.2$ Hz, 2H). ^{13}C

NMR (150 MHz, CDCl₃) δ 170.69, 159.38, 145.80, 135.77, 135.58, 135.37, 133.28, 128.84, 128.69, 128.65, 128.48, 128.38, 128.36, 127.62, 125.10, 124.23, 108.30, 67.01, 66.70, 47.31, 34.92. HRMS (EI): m/z [M]⁺ calcd. for C₂₅H₂₂N₂O₄S: 446.1300. Found: 446.1304.



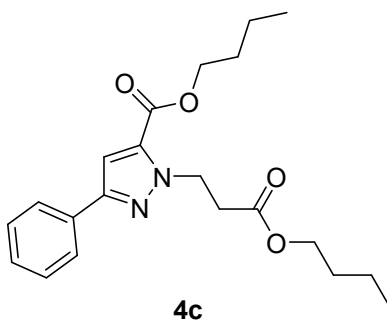
4a

Methyl 1-(3-methoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4a): Compound **4a** was isolated as a yellow oil (44.4mg, 77%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.78 (d, J = 7.4 Hz, 2H), 7.40 (t, J = 7.5 Hz, 2H), 7.32 (t, J = 7.3 Hz, 1H), 7.12 (s, 1H), 4.90 (t, J = 7.3 Hz, 2H), 3.91 (s, 3H), 3.69 (s, 3H), 2.96 (t, J = 7.3 Hz, 2H). ¹³C NMR (150 MHz, CDCl₃) δ 171.37, 160.22, 150.32, 133.29, 132.52, 128.80, 128.21, 125.63, 108.28, 52.17, 51.96, 47.37, 34.77. HRMS (EI): m/z [M]⁺ calcd. for C₂₅H₁₆N₂O₄: 288.1110. Found: 288.1107.

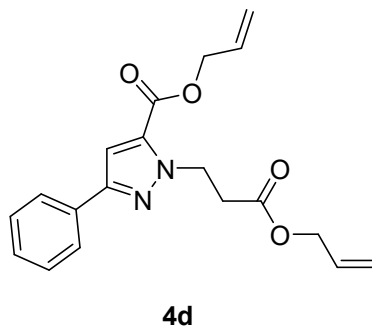


4b

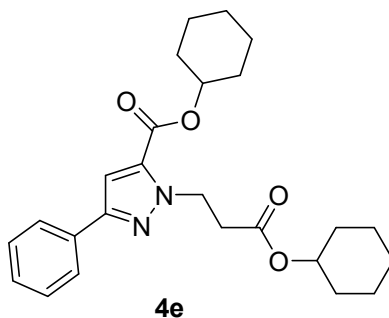
Ethyl 1-(3-ethoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4b): Compound **4b** was isolated as a yellow oil (44.3mg, 70%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.79 (d, J = 7.3 Hz, 2H), 7.40 (t, J = 7.5 Hz, 2H), 7.31 (t, J = 7.3 Hz, 1H), 7.13 (s, 1H), 4.90 (t, J = 7.3 Hz, 2H), 4.38 (q, J = 7.1 Hz, 2H), 4.15 (q, J = 7.1 Hz, 2H), 2.95 (t, J = 7.3 Hz, 2H), 1.41 (t, J = 7.1 Hz, 3H), 1.24 (t, J = 7.2 Hz, 3H). ¹³C NMR (150 MHz, CDCl₃) δ 170.96, 159.79, 150.22, 133.65, 132.59, 128.79, 128.17, 125.64, 108.23, 61.30, 60.84, 47.46, 35.06, 14.36. HRMS (EI): m/z [M]⁺ calcd. for C₁₇H₂₀N₂O₄: 316.1423. Found: 316.1425.



Butyl 1-(3-butoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4c): Compound **4c** was isolated as a yellow oil (54.4mg, 73%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.79 (d, *J* = 7.6 Hz, 2H), 7.39 (t, *J* = 7.6 Hz, 2H), 7.31 (t, *J* = 7.3 Hz, 1H), 7.11 (s, 1H), 4.90 (t, *J* = 7.3 Hz, 2H), 4.32 (t, *J* = 6.6 Hz, 2H), 4.09 (t, *J* = 6.7 Hz, 2H), 2.96 (t, *J* = 7.3 Hz, 2H), 1.80 – 1.71 (m, 2H), 1.63 – 1.54 (m, 2H), 1.53 – 1.43 (m, 2H), 1.39 – 1.28 (m, 2H), 0.99 (t, *J* = 7.4 Hz, 3H), 0.90 (t, *J* = 7.4 Hz, 3H). ¹³C NMR (150 MHz, CDCl₃) δ 171.03, 159.87, 150.23, 133.63, 132.61, 128.77, 128.15, 125.65, 108.19, 65.14, 64.75, 47.48, 35.03, 30.76, 19.19, 13.83. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₁H₂₈N₂O₄: 372.2049. Found: 372.2046.

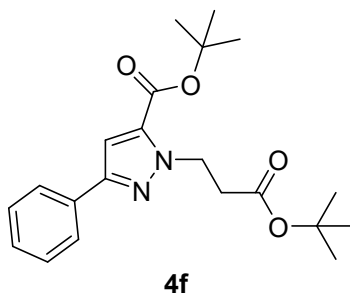


Allyl 1-(3-(allyloxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4d): Compound **4d** was isolated as a yellow oil (34.0mg, 50%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 7.79 (d, *J* = 7.2 Hz, 2H), 7.40 (t, *J* = 7.4 Hz, 2H), 7.32 (t, *J* = 7.3 Hz, 1H), 7.15 (s, 1H), 6.09 – 5.98 (m, 1H), 5.95 – 5.84 (m, 1H), 5.43 (d, *J* = 17.2 Hz, 1H), 5.31 (t, *J* = 13.5 Hz, 2H), 5.21 (d, *J* = 10.4 Hz, 1H), 4.92 (t, *J* = 7.2 Hz, 2H), 4.82 (d, *J* = 5.7 Hz, 2H), 4.60 (d, *J* = 5.8 Hz, 2H), 3.00 (t, *J* = 7.2 Hz, 2H). ¹³C NMR (150 MHz, DMSO) δ 170.22, 158.69, 149.12, 133.19, 132.46, 132.14, 131.98, 128.73, 128.10, 125.21, 118.39, 117.78, 108.05, 65.26, 64.64, 46.94, 34.04. HRMS (EI): *m/z* [M]⁺ calcd. for C₁₉H₂₀N₂O₄: 340.1423. Found: 340.1425.

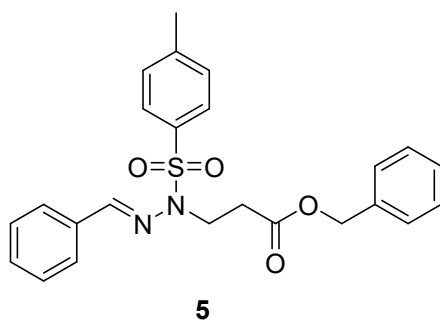


Cyclohexyl 1-(3-(cyclohexyloxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4e):

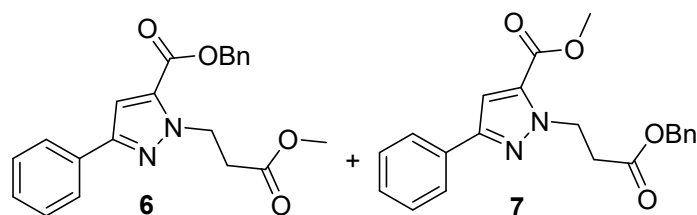
Compound **4e** was isolated as a white solid (58.6mg, 69%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1), m.p. 65.9–66.4 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.79 (d, *J* = 7.2 Hz, 2H), 7.39 (t, *J* = 7.5 Hz, 2H), 7.31 (t, *J* = 7.3 Hz, 1H), 7.12 (s, 1H), 5.06 – 4.97 (m, 1H), 4.89 (t, *J* = 7.3 Hz, 2H), 4.83 – 4.73 (m, 1H), 2.94 (t, *J* = 7.3 Hz, 2H), 2.00 – 1.28 (m, 20H). ¹³C NMR (150 MHz, CDCl₃) δ 170.39, 159.24, 150.15, 134.09, 132.67, 128.76, 128.12, 125.68, 108.24, 73.87, 73.14, 47.65, 35.44, 31.66, 25.47, 23.80. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₅H₃₂N₂O₄: 424.2362. Found: 424.2365.



Tert-butyl 1-(3-(tert-butoxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4f): Compound **4f** was isolated as a white solid (55.9mg, 75%) by a column chromatography on silica gel (eluent: petroleum ether/ethyl acetate = 15:1), m.p. 57.6–58.2 °C. ¹H NMR (400 MHz, CDCl₃) δ 7.79 (d, *J* = 7.2 Hz, 2H), 7.39 (t, *J* = 7.5 Hz, 2H), 7.30 (t, *J* = 7.3 Hz, 1H), 7.04 (s, 1H), 4.82 (t, *J* = 7.4 Hz, 2H), 2.87 (t, *J* = 7.4 Hz, 2H), 1.61 (s, 9H), 1.43 (s, 9H). ¹³C NMR (150 MHz, CDCl₃) δ 170.21, 158.99, 149.87, 134.96, 132.79, 128.75, 128.04, 125.66, 108.19, 82.53, 81.00, 47.73, 36.27, 28.36. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₁H₂₈N₂O₄: 372.2049. Found: 372.2047.



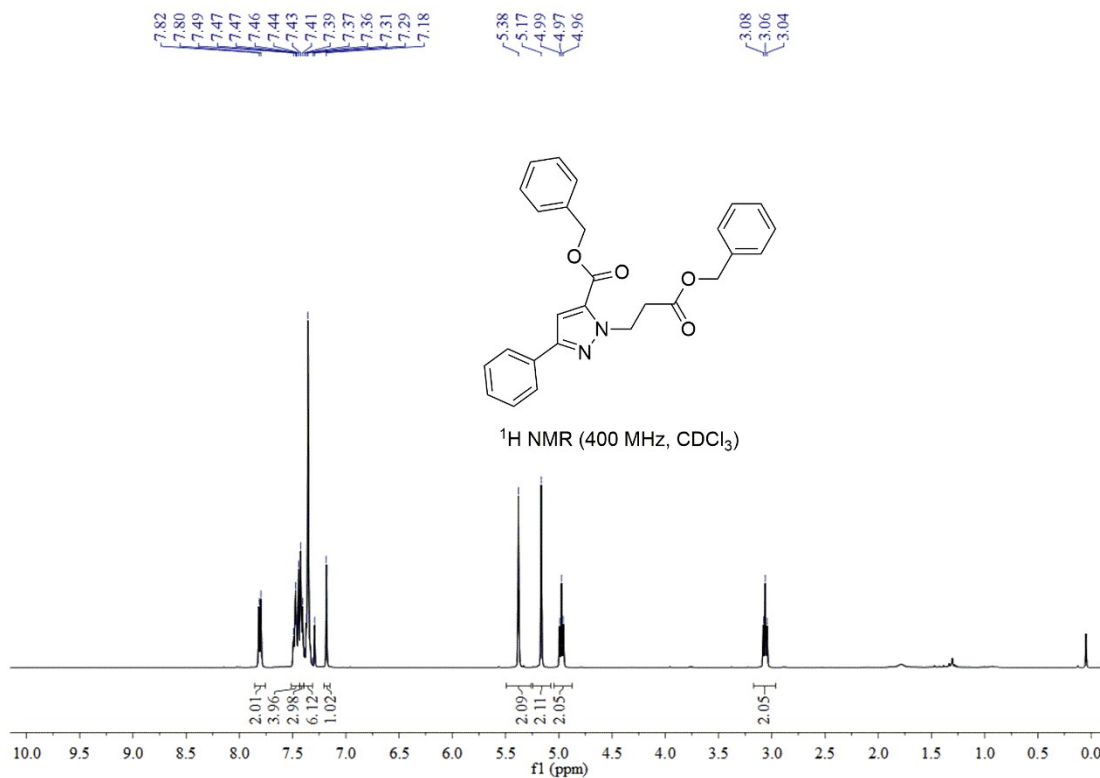
Benzyl (*E*)-3-(2-benzylidene-1-tosylhydrazinyl)propanoate (5): Compound **5** was isolated as a yellow oil (52.4 mg, 60%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 15:1). ¹H NMR (400 MHz, CDCl₃) δ 8.19 (s, 1H), 7.74 (d, *J* = 7.9 Hz, 2H), 7.65 (d, *J* = 6.8 Hz, 2H), 7.45 – 7.29 (m, 10H), 5.12 (s, 2H), 3.85 (t, *J* = 7.2 Hz, 2H), 2.67 (t, *J* = 7.2 Hz, 2H), 2.42 (s, 3H). ¹³C NMR (150 MHz, CDCl₃) δ 170.95, 155.15, 144.38, 135.62, 133.71, 133.63, 131.08, 129.69, 128.84, 128.68, 128.48, 128.46, 128.44, 128.11, 66.77, 45.46, 33.19, 21.69. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₄H₂₄N₂O₄S: 436.1457. Found: 436.1460.



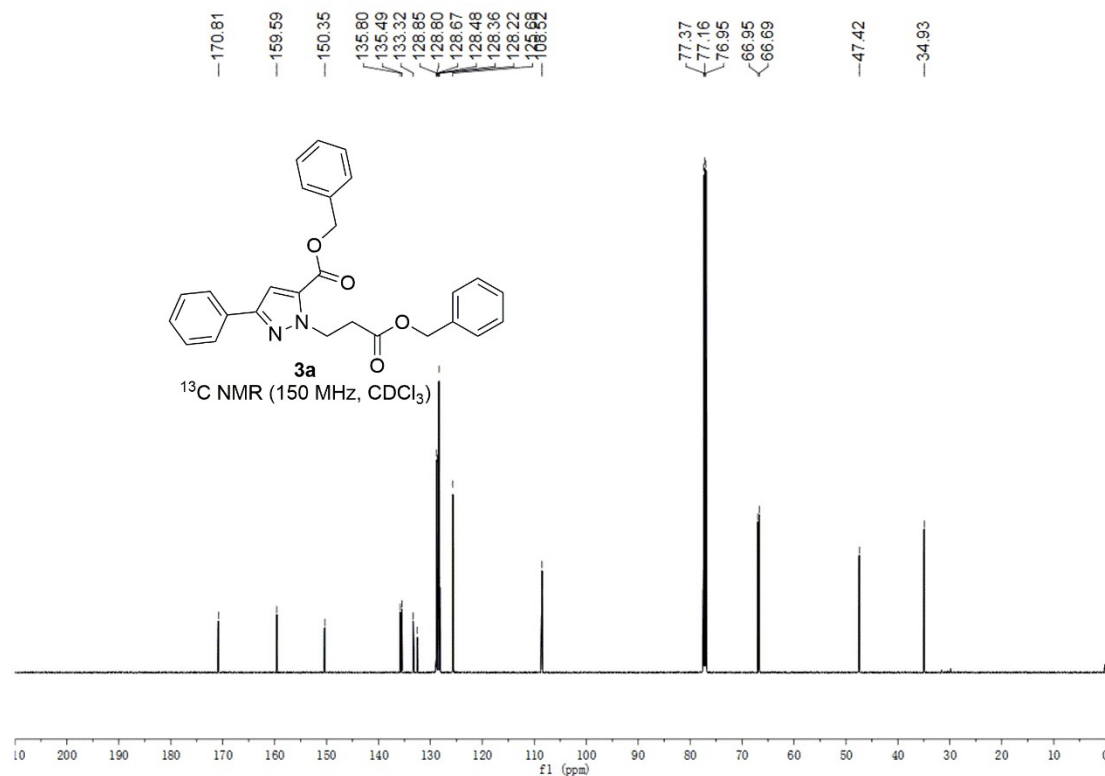
The mixture of compound 6 and 7: Compound **6** and **7** was isolated as a white solid (32.8mg, 45%) by a column chromatography on silica gel (eluents: petroleum ether/ethyl acetate = 13:1). ¹H NMR (400 MHz, CDCl₃) δ 7.81 (d, *J* = 7.4 Hz, 3H), 7.48 (d, *J* = 7.3 Hz, 1H), 7.43 (t, *J* = 7.2 Hz, 4H), 7.39–7.31 (m, 6.55H), 7.19 (s, 0.43H), 7.15 (s, 1H), 5.39 (s, 0.89H), 5.17 (s, 2H), 4.95 (q, *J* = 7.3 Hz, 3H), 3.93 (s, 3H), 3.72 (s, 1.38H), 3.06 (t, *J* = 7.1 Hz, 2H), 2.99 (t, *J* = 7.2 Hz, 1H). ¹³C NMR (151 MHz, CDCl₃) δ 171.28, 170.74, 160.13, 159.49, 150.27, 150.23, 135.68, 135.37, 133.22, 133.20, 132.44, 132.40, 128.74, 128.72, 128.58, 128.55, 128.39, 128.26, 128.12, 125.56, 108.40, 108.23, 66.86, 66.60, 52.07, 51.87, 47.33, 47.26, 34.83, 34.69. HRMS (EI): *m/z* [M]⁺ calcd. for C₂₁H₂₀N₂O₄: 364.1423. Found: 364.1426.

4. Copies of NMR Spectra

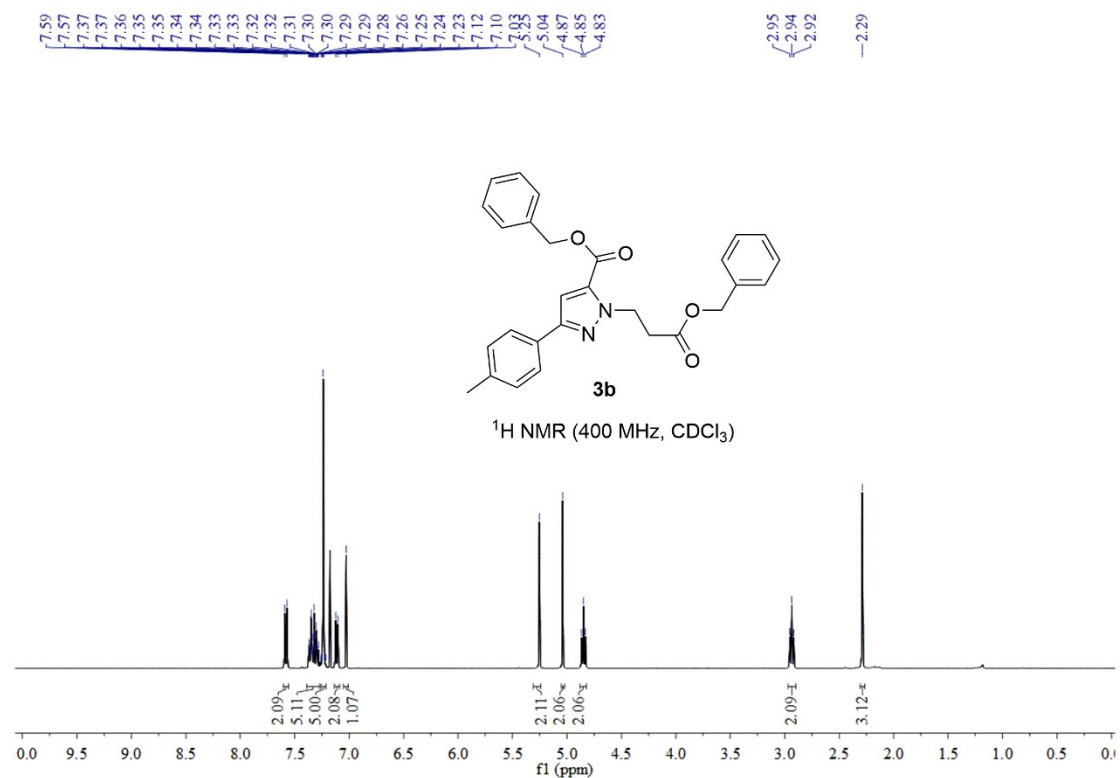
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-phenyl-1*H*-pyrazole-5-carboxylate (3a): ¹H NMR



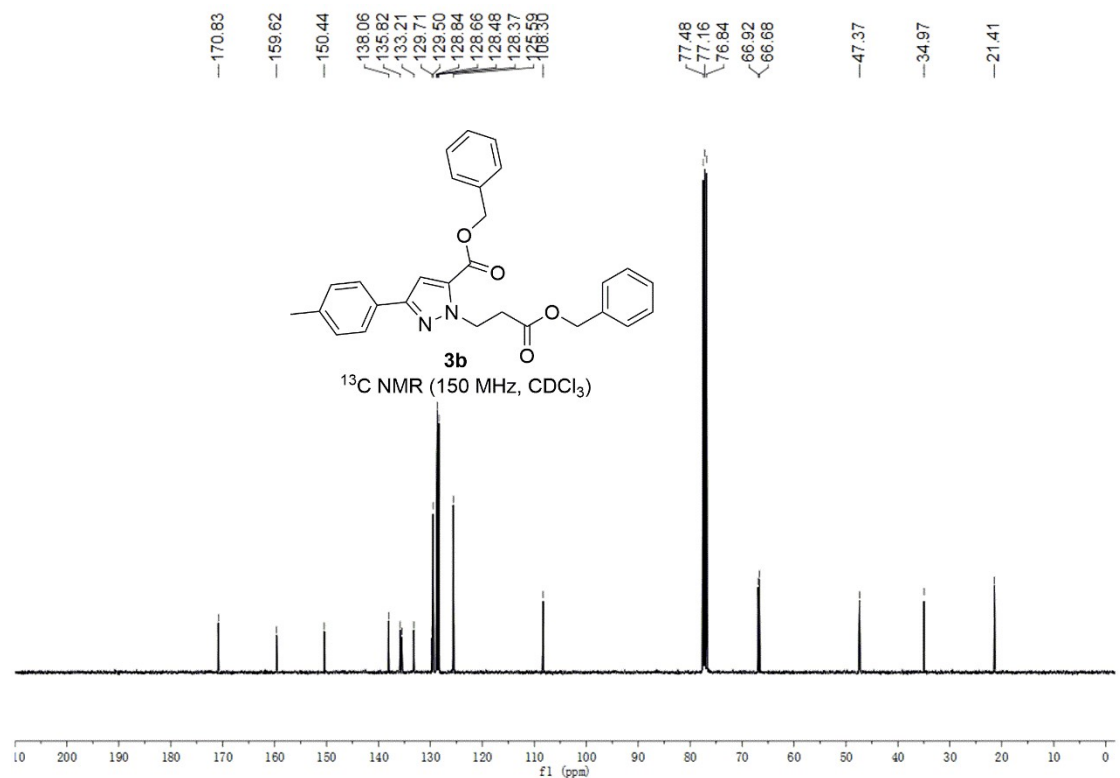
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-phenyl-1*H*-pyrazole-5-carboxylate (3a): ¹³C NMR



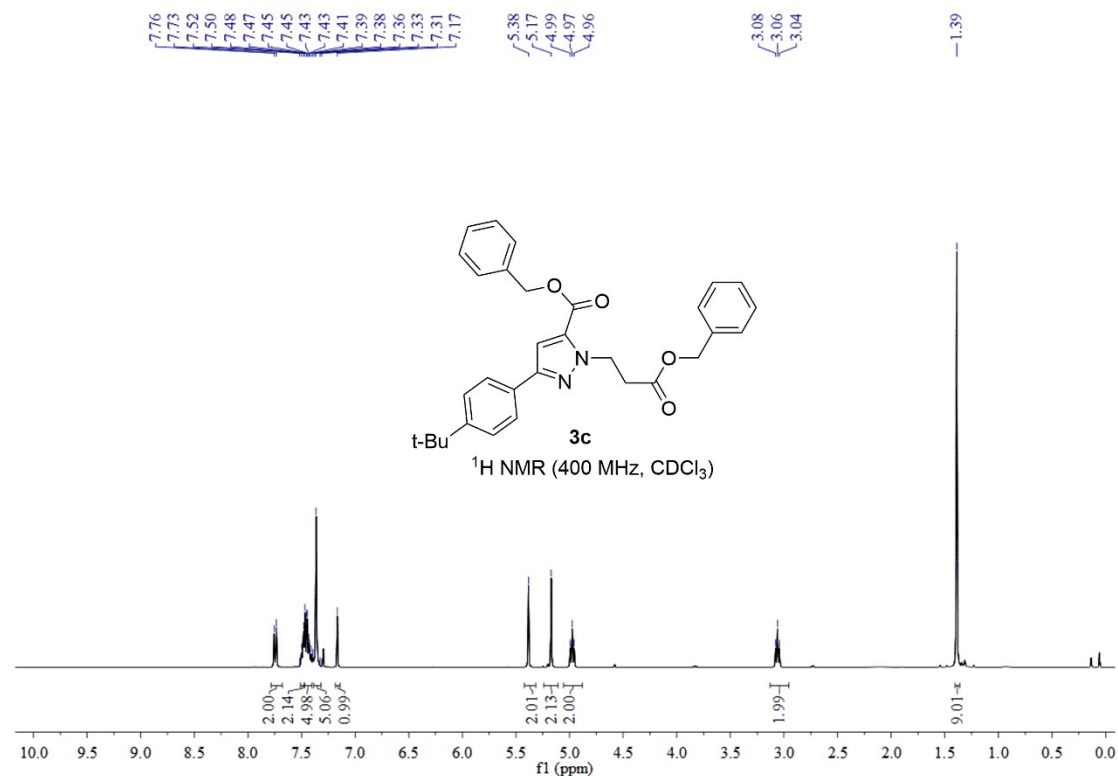
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(p-tolyl)-1H-pyrazole-5-carboxylate (3b): ¹H NMR



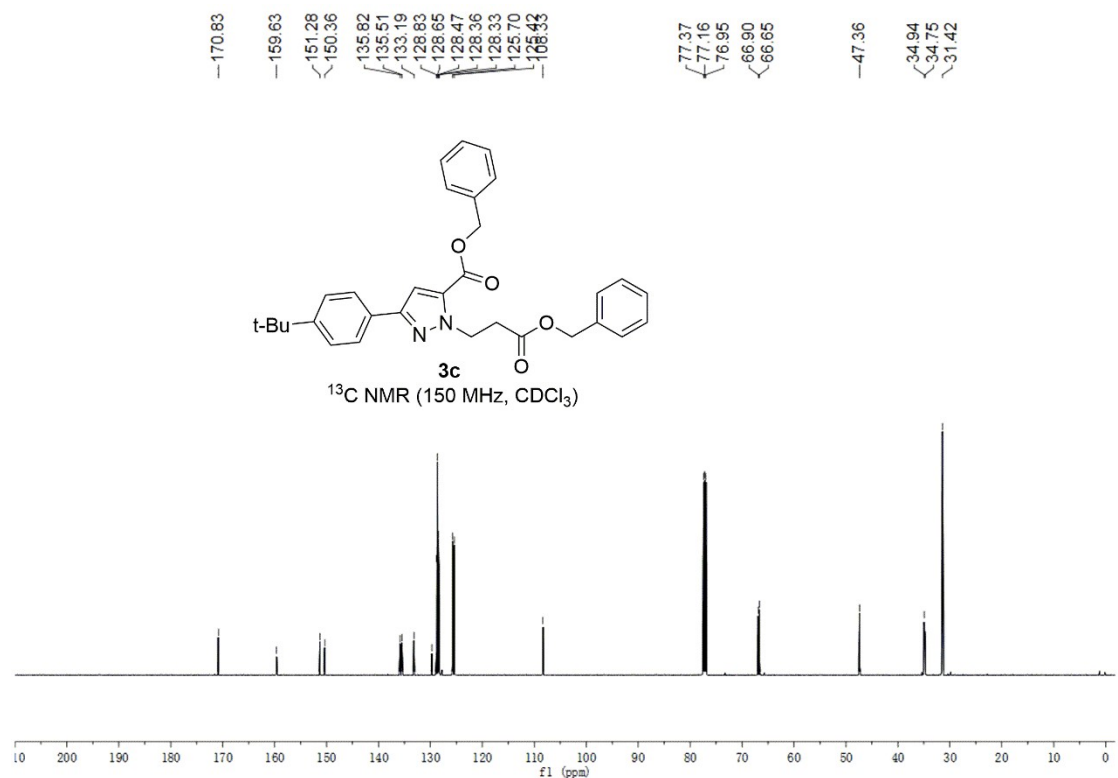
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(p-tolyl)-1H-pyrazole-5-carboxylate (3b): ¹³C NMR



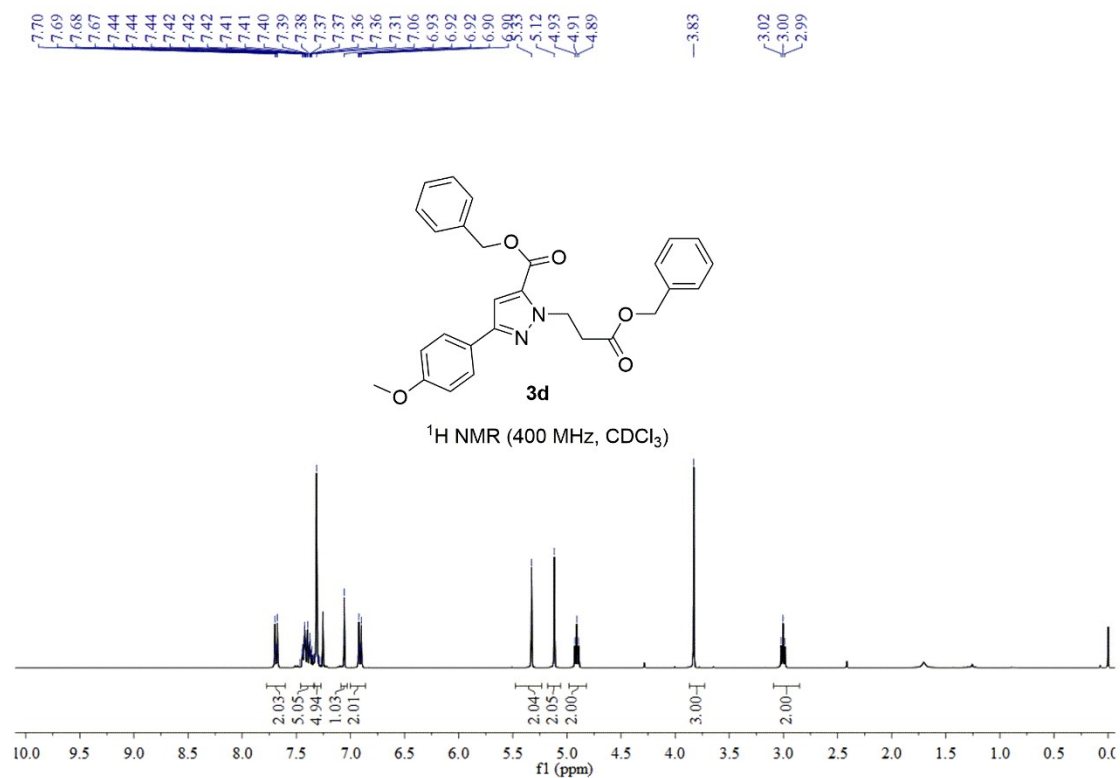
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-(tert-butyl)phenyl)-1H-pyrazole-5-carboxylate (3c): ¹H NMR



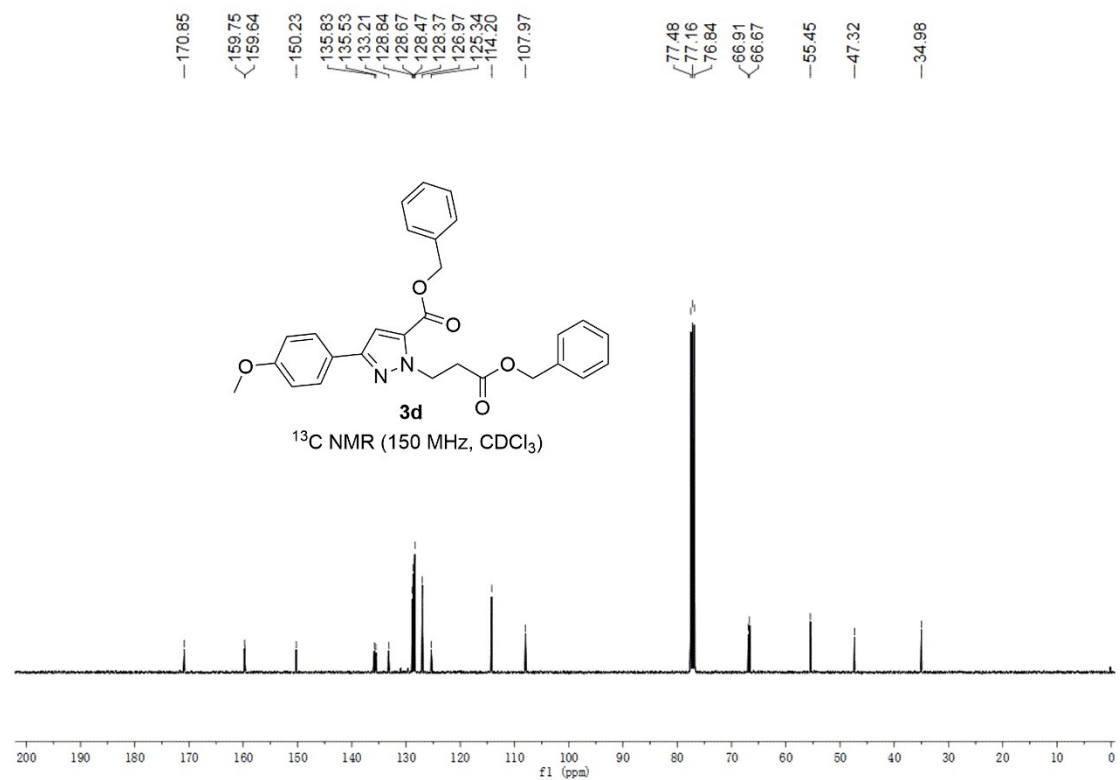
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-(tert-butyl)phenyl)-1H-pyrazole-5-carboxylate (3c): ¹³C NMR



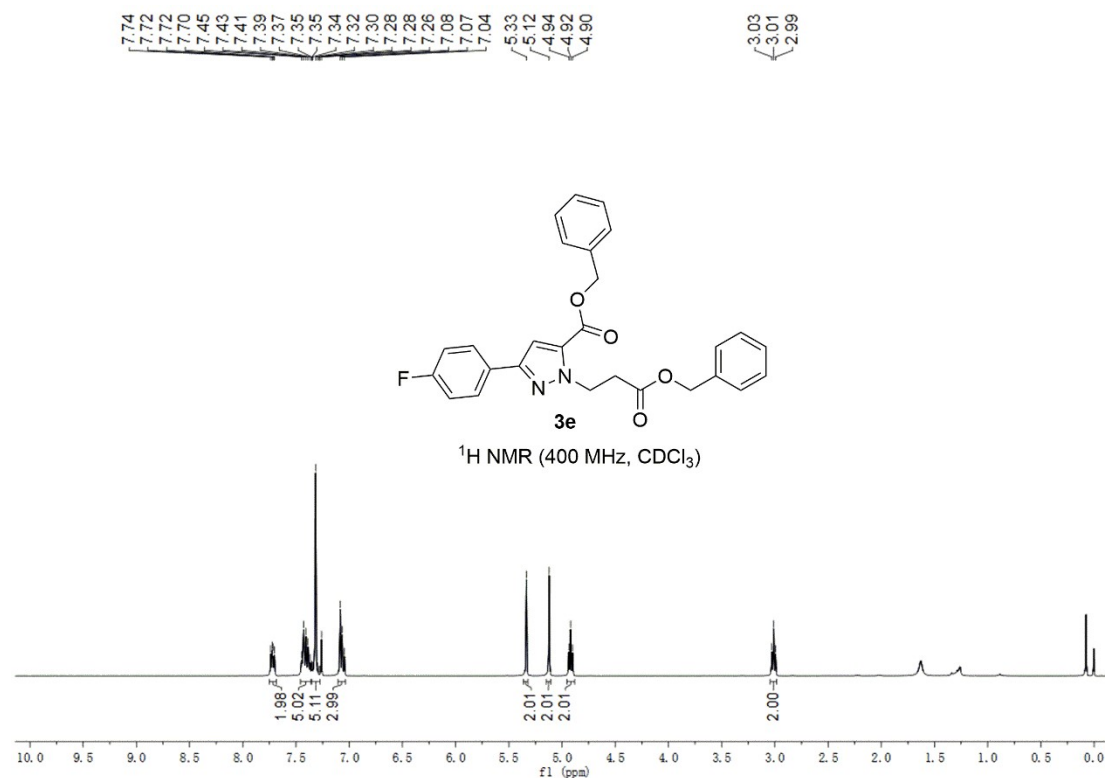
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-methoxyphenyl)-1H-pyrazole-5-carboxylate (3d): ¹H NMR



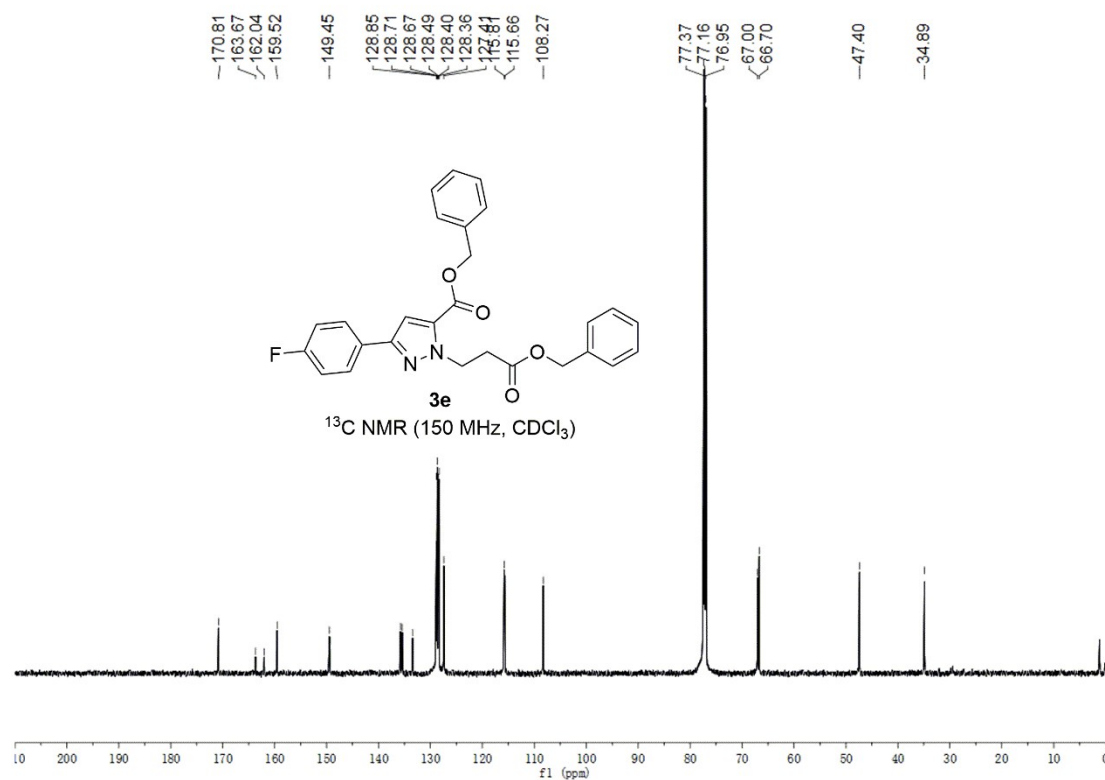
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-methoxyphenyl)-1H-pyrazole-5-carboxylate (3d): ¹³C NMR



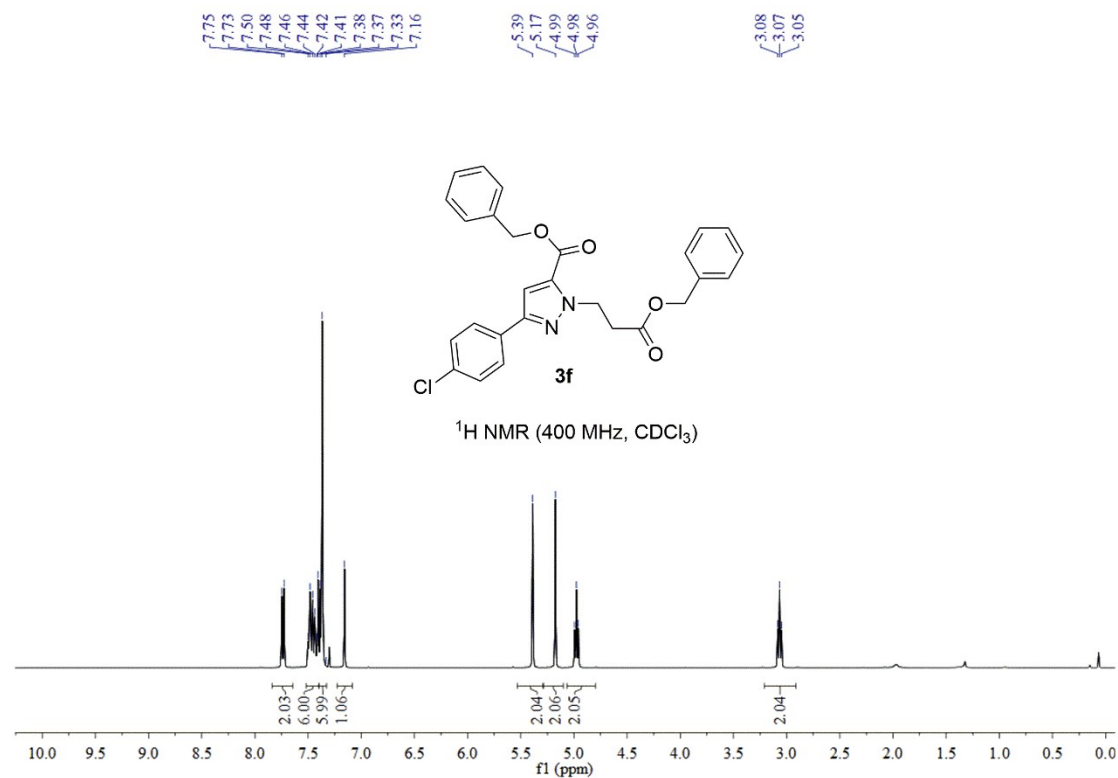
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-fluorophenyl)-1H-pyrazole-5-carboxylate (3e): ¹H NMR



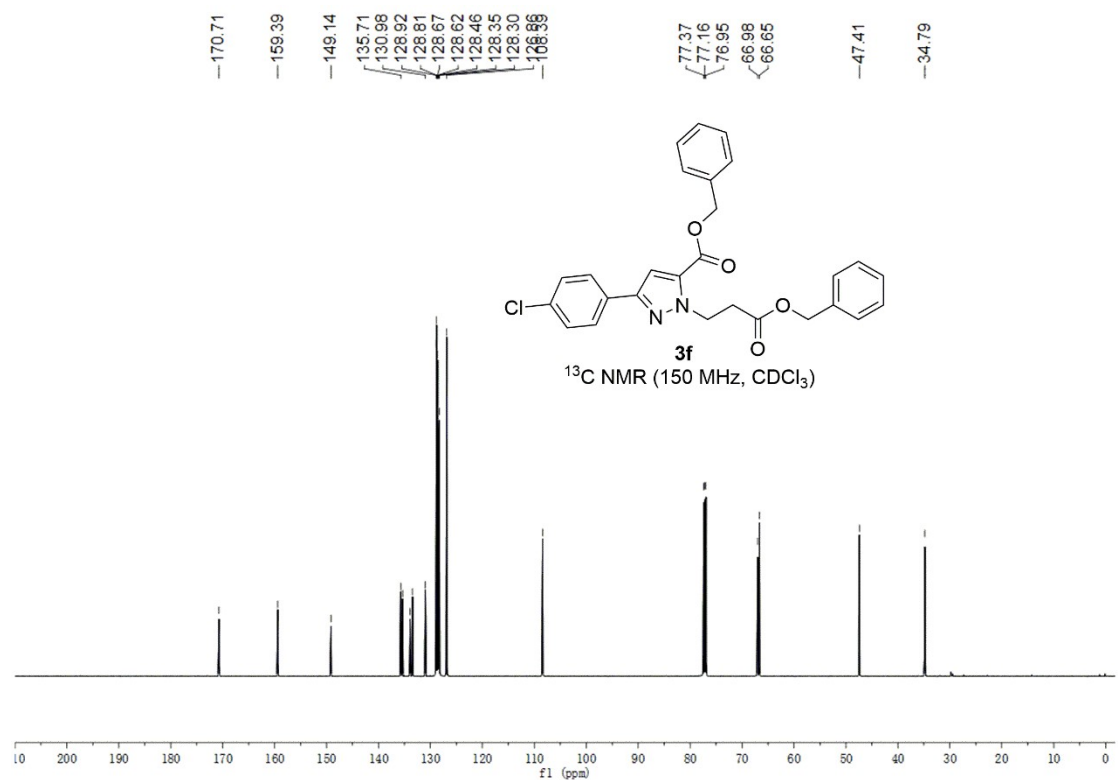
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-fluorophenyl)-1H-pyrazole-5-carboxylate (3e): ¹³C NMR



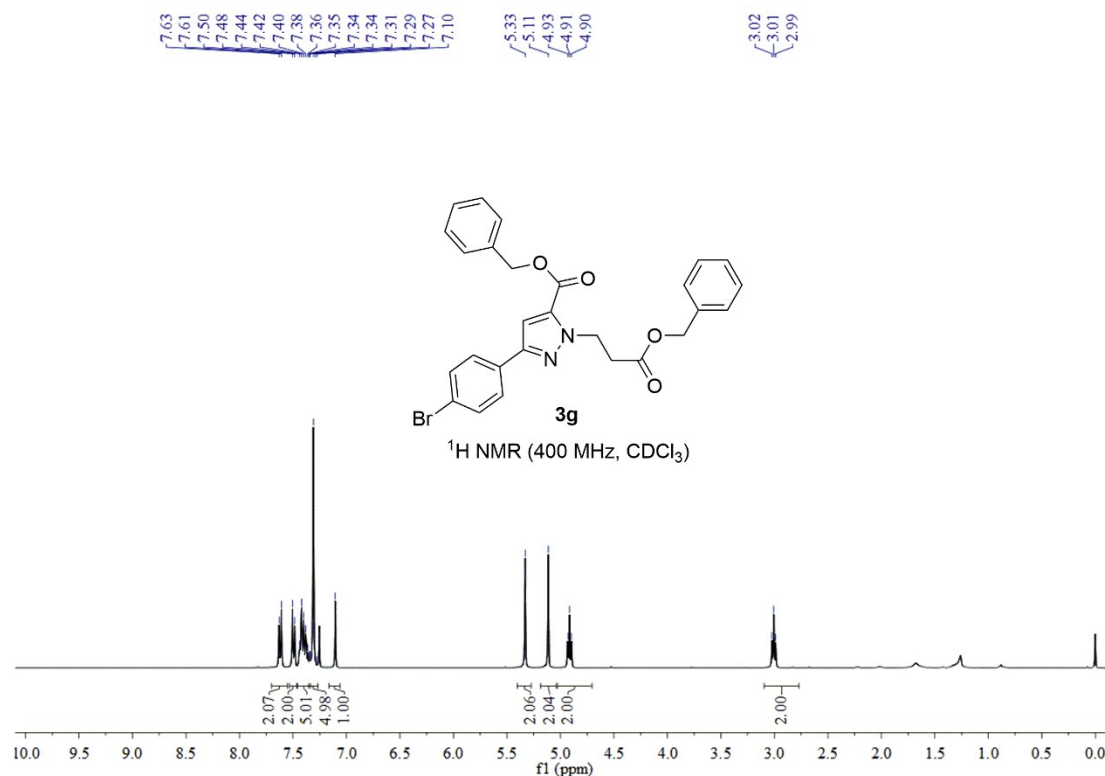
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-chlorophenyl)-1H-pyrazole-5-carboxylate (3f): ¹H NMR



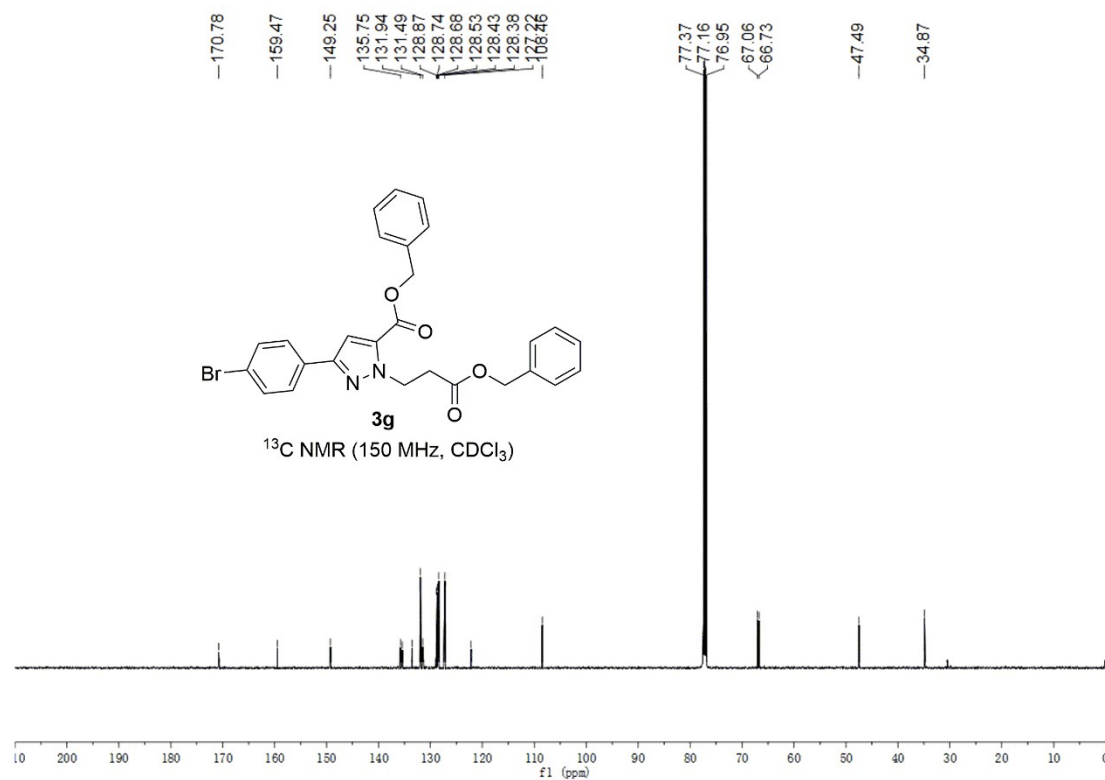
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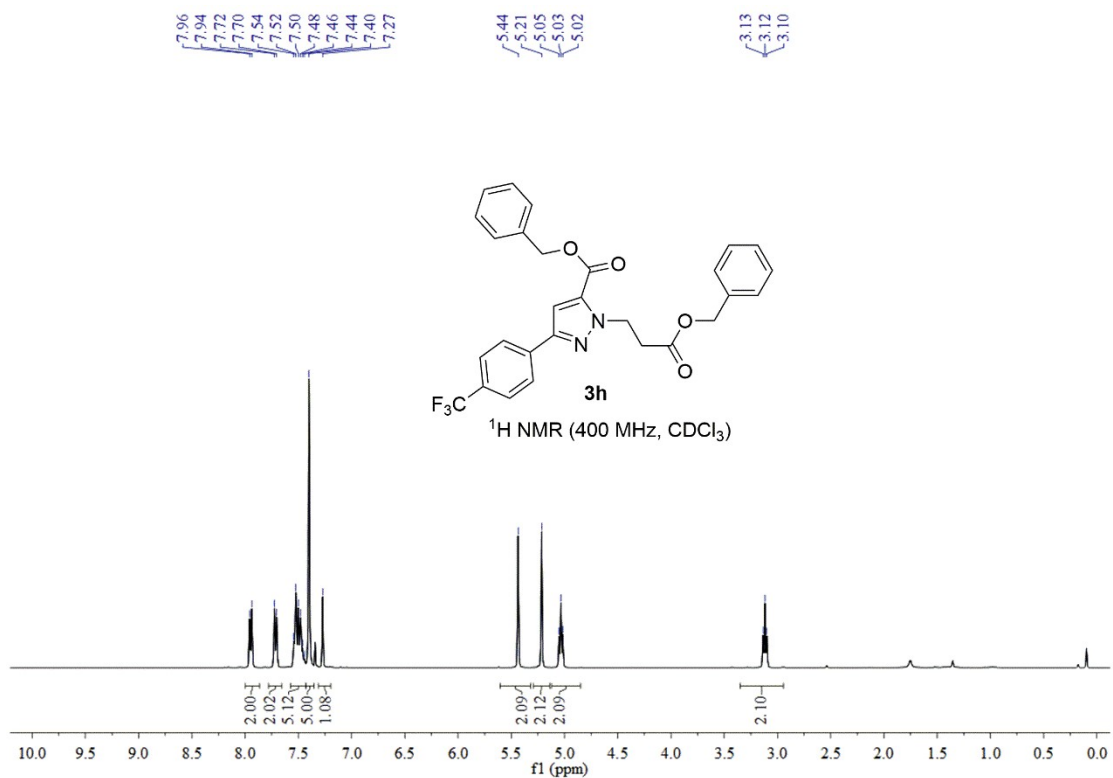
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-bromophenyl)-1H-pyrazole-5-carboxylate (3g): ¹H NMR



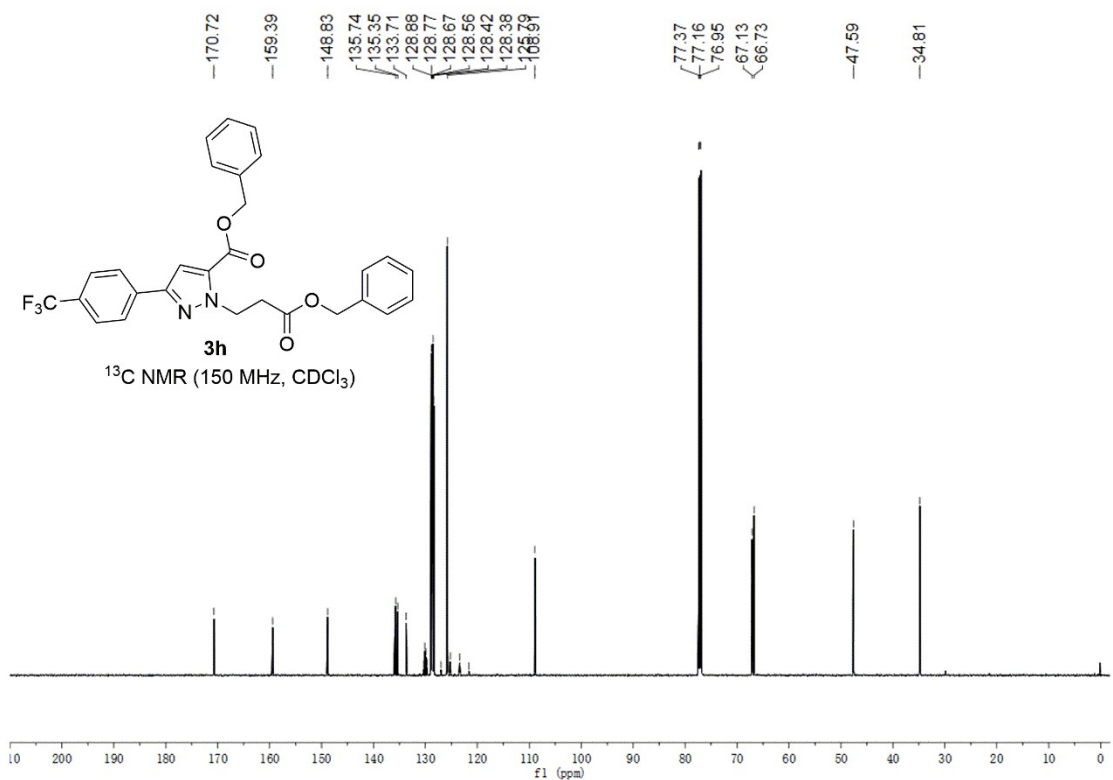
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-bromophenyl)-1H-pyrazole-5-carboxylate (3g): ¹³C NMR



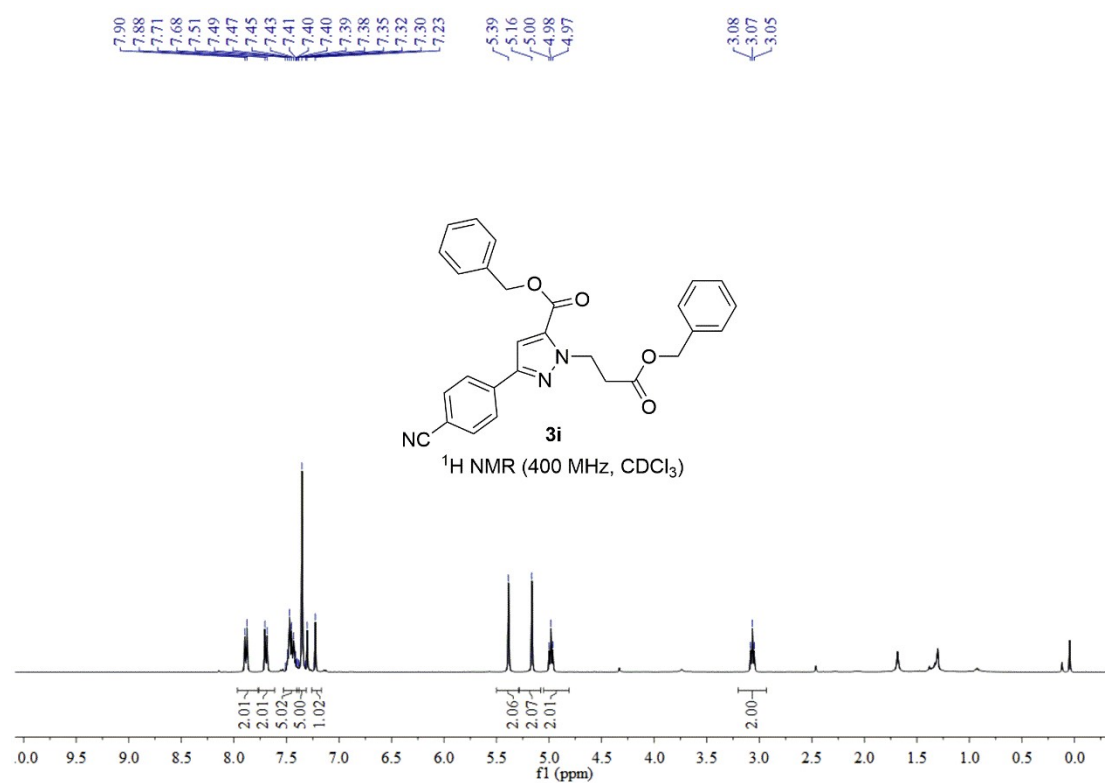
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-(trifluoromethyl)phenyl)-1H-pyrazole-5-carboxylate (3h): ¹H NMR



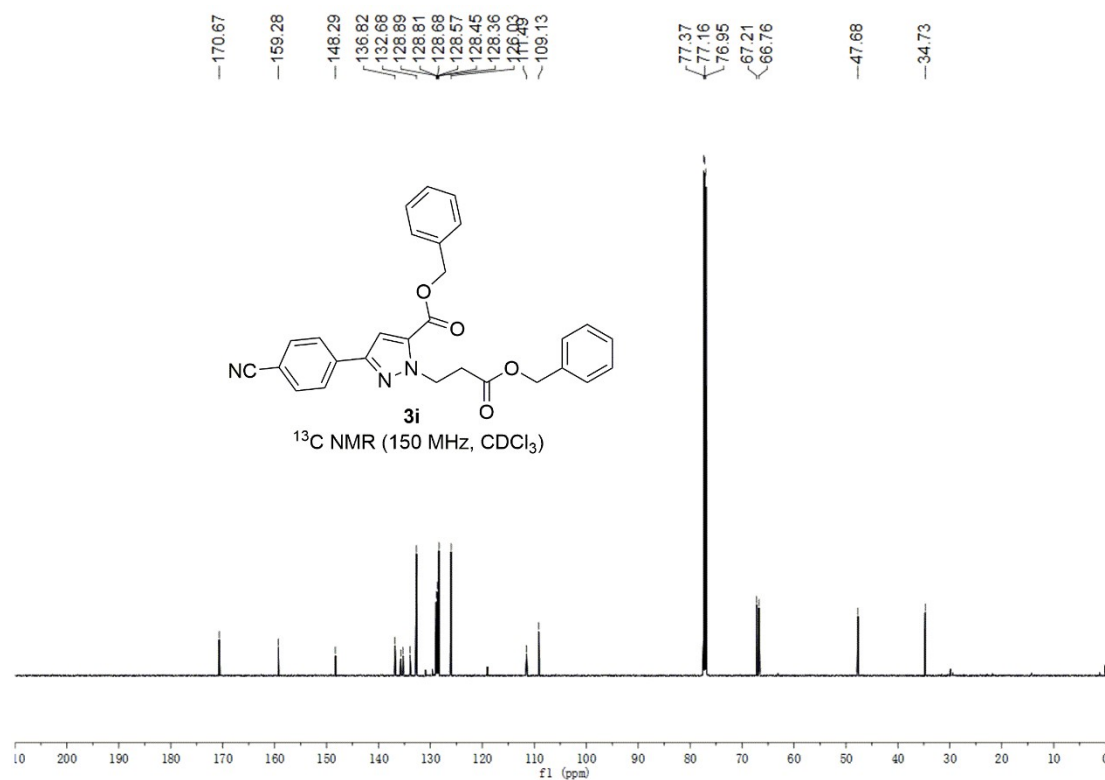
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-(trifluoromethyl)phenyl)-1H-pyrazole-5-carboxylate (3h): ¹³C NMR



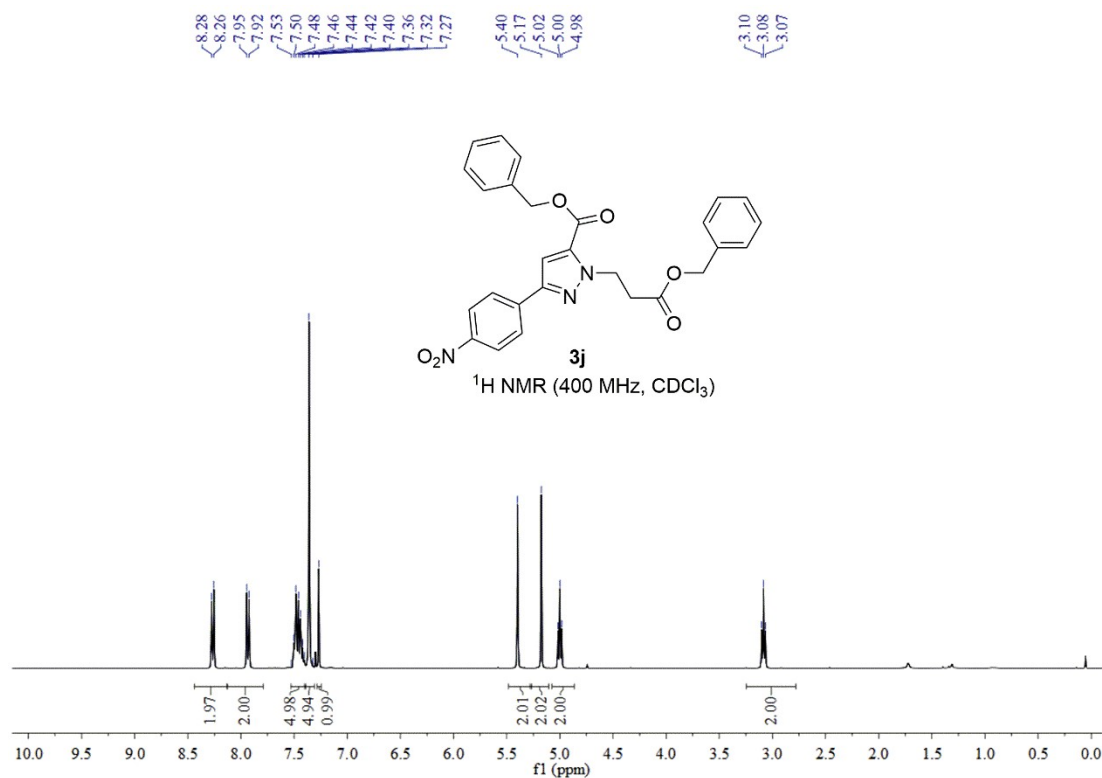
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-cyanophenyl)-1H-pyrazole-5-carboxylate (3i): ¹H NMR



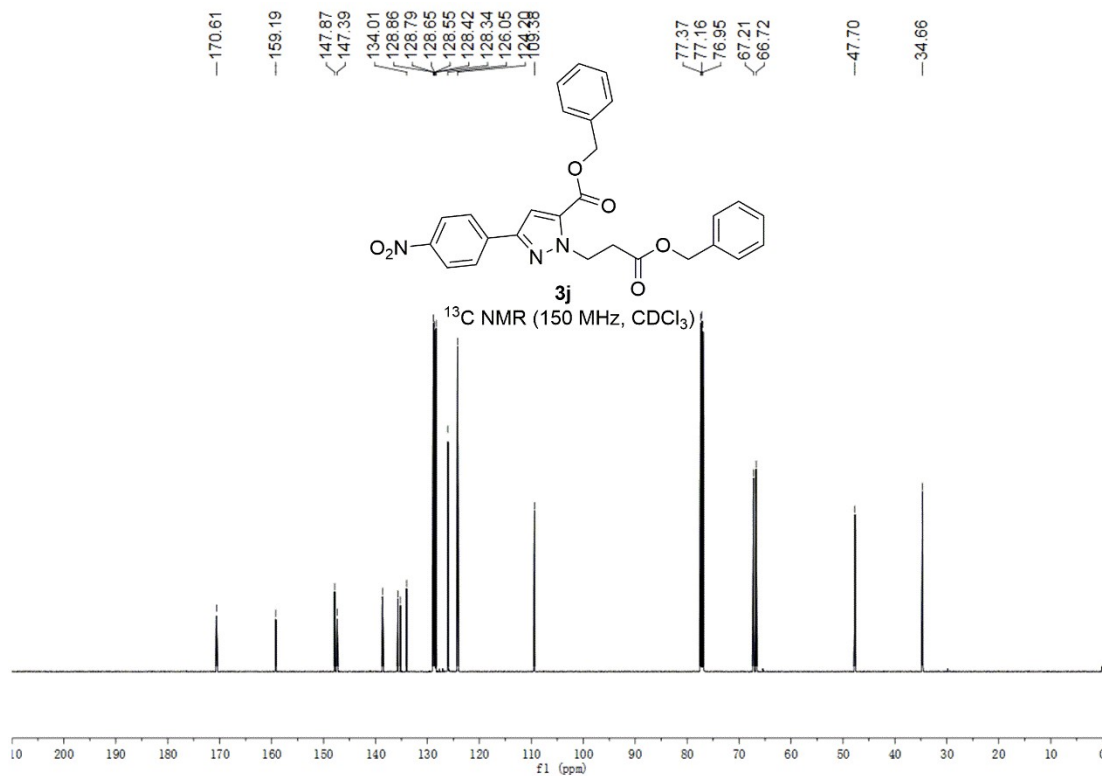
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-cyanophenyl)-1H-pyrazole-5-carboxylate (3i): ¹³C NMR



Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-nitrophenyl)-1H-pyrazole-5-carboxylate (3j): ¹H NMR

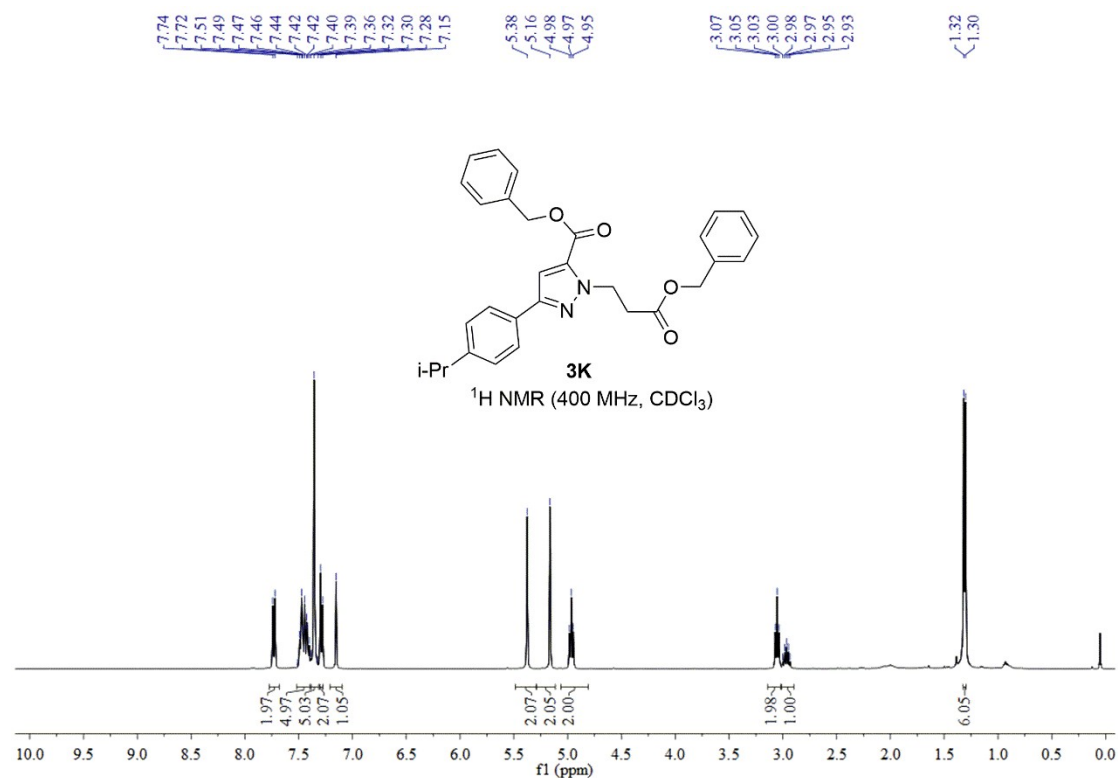


Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-nitrophenyl)-1H-pyrazole-5-carboxylate (3j): ¹³C NMR



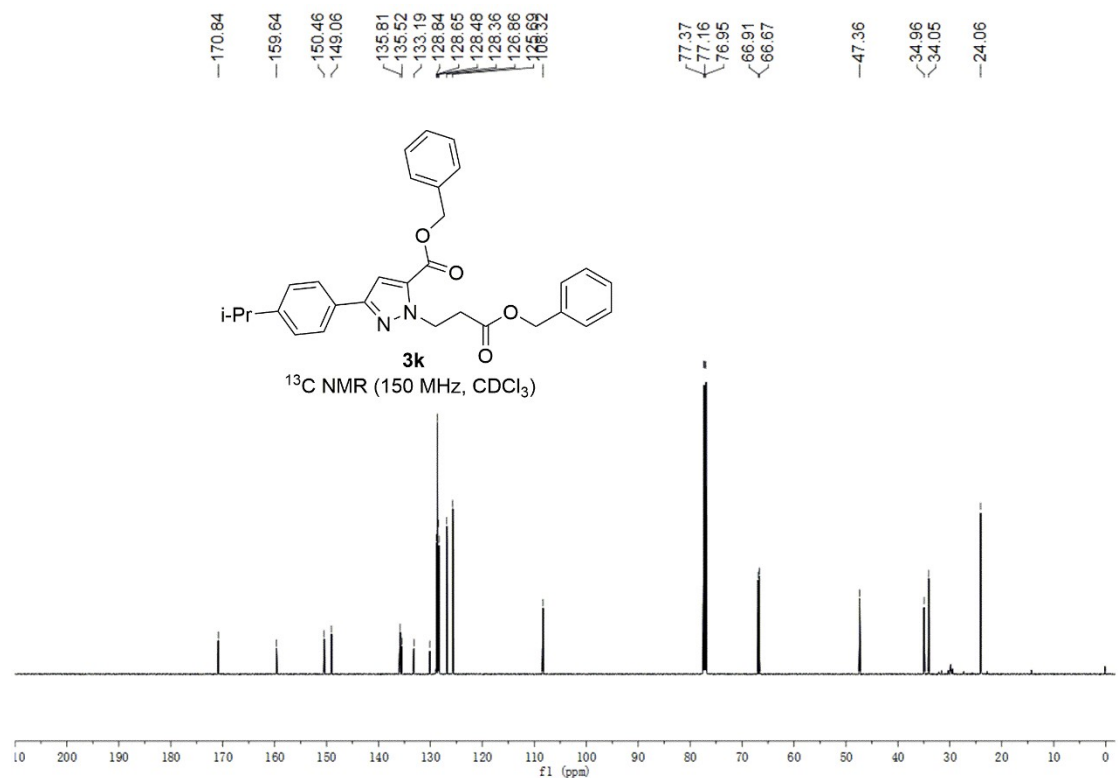
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-isopropylphenyl)-1H-pyrazole-5-carboxylate (3k): ¹H

NMR

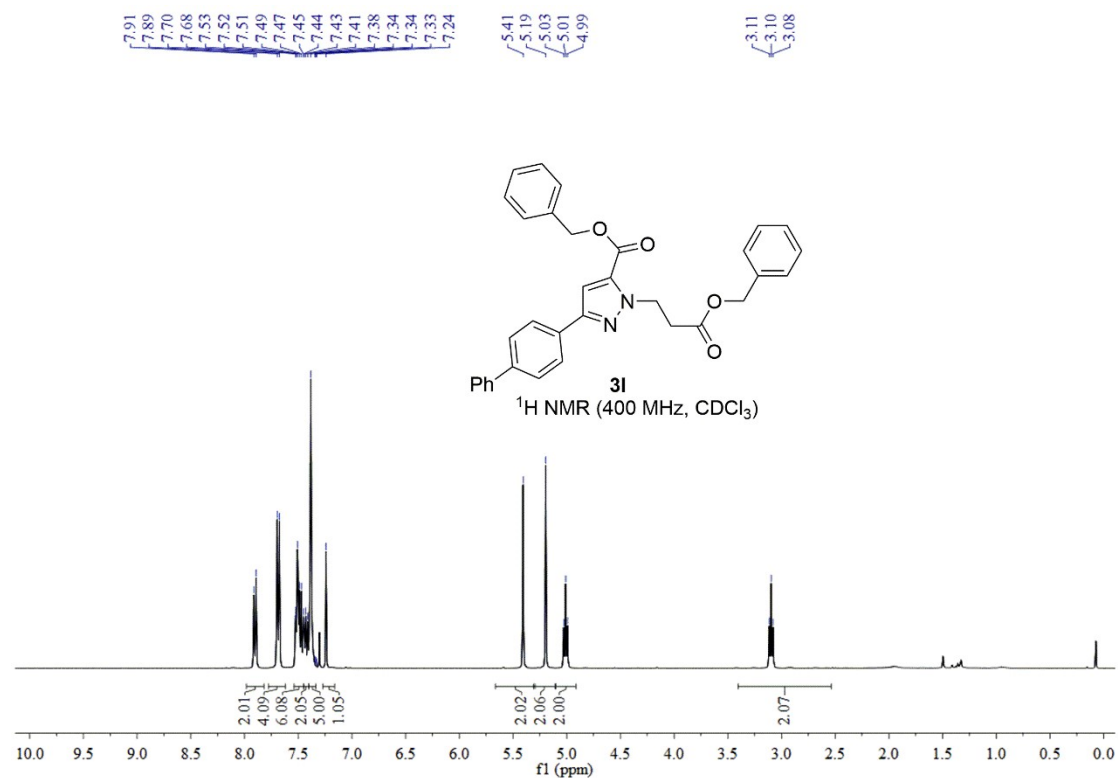


Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-isopropylphenyl)-1H-pyrazole-5-carboxylate (3k): ¹³C

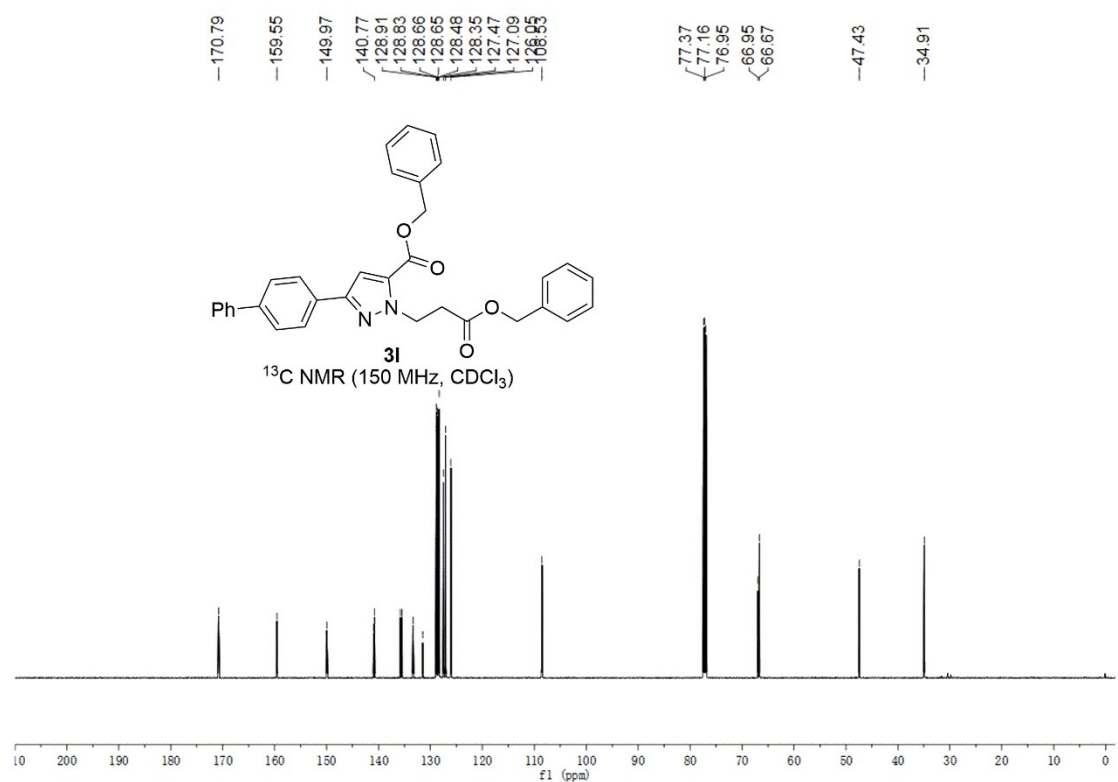
NMR



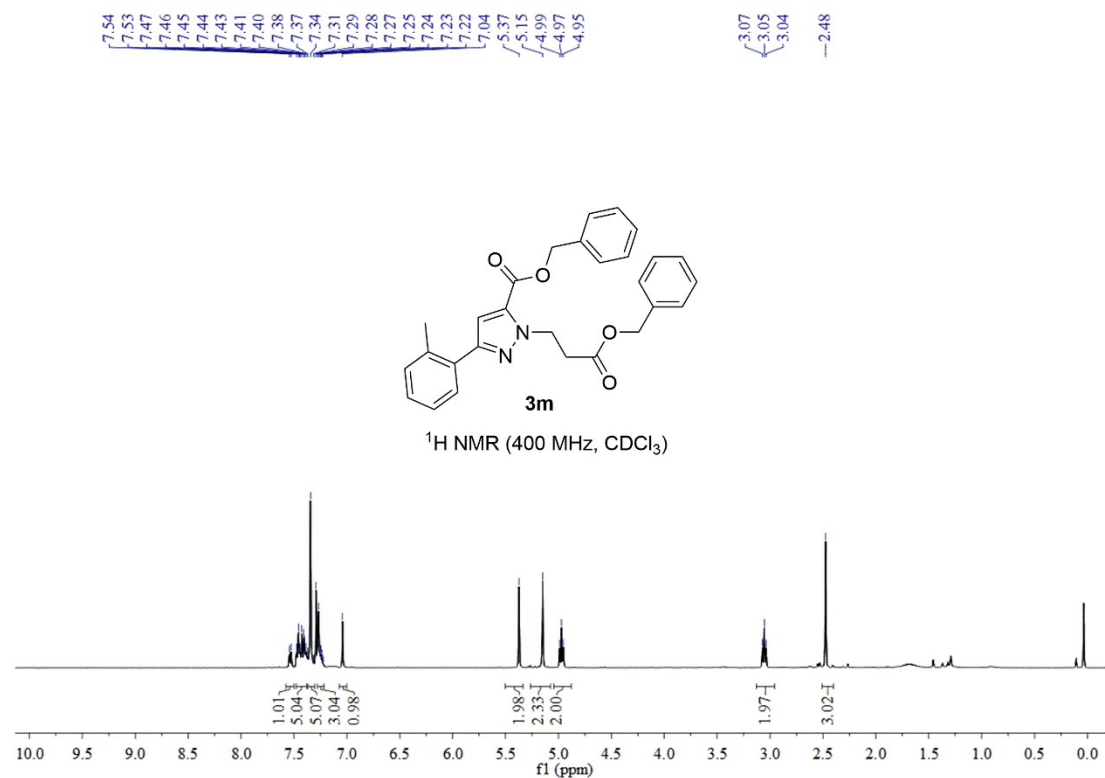
Benzyl 3-([1,1'-biphenyl]-4-yl)-1-(3-(benzyloxy)-3-oxopropyl)-1H-pyrazole-5-carboxylate (3I): ¹H NMR



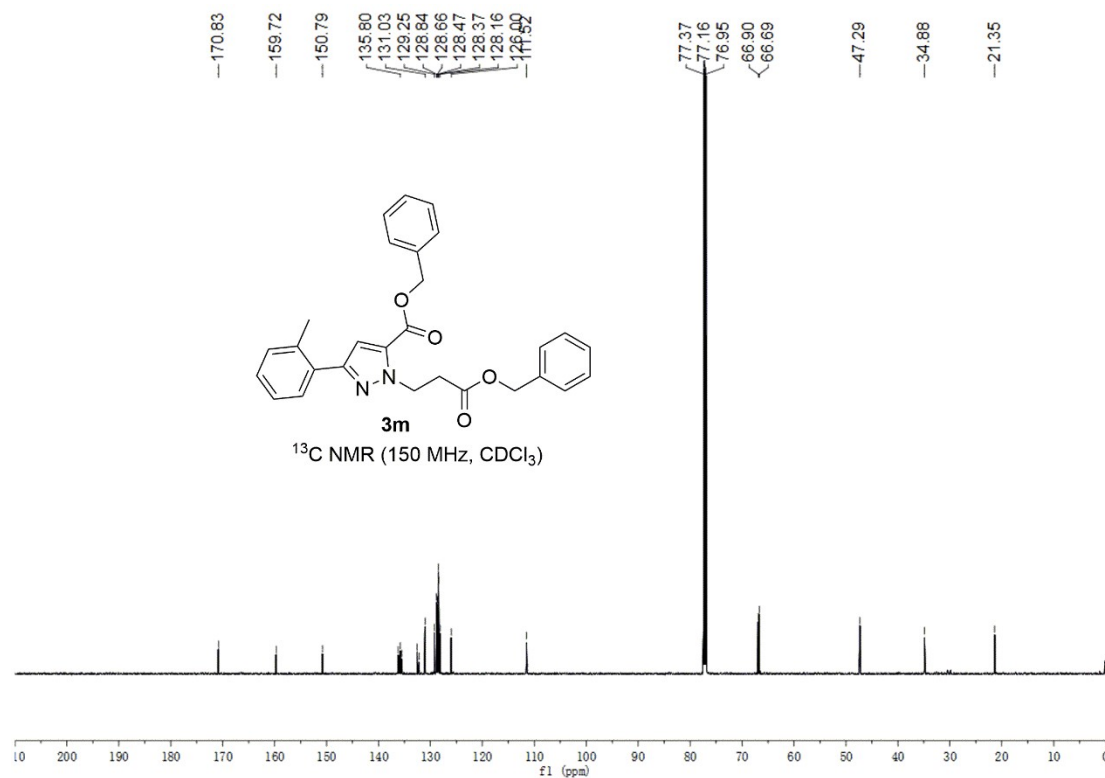
Benzyl 3-([1,1'-biphenyl]-4-yl)-1-(3-(benzyloxy)-3-oxopropyl)-1H-pyrazole-5-carboxylate (3I): ¹³C NMR



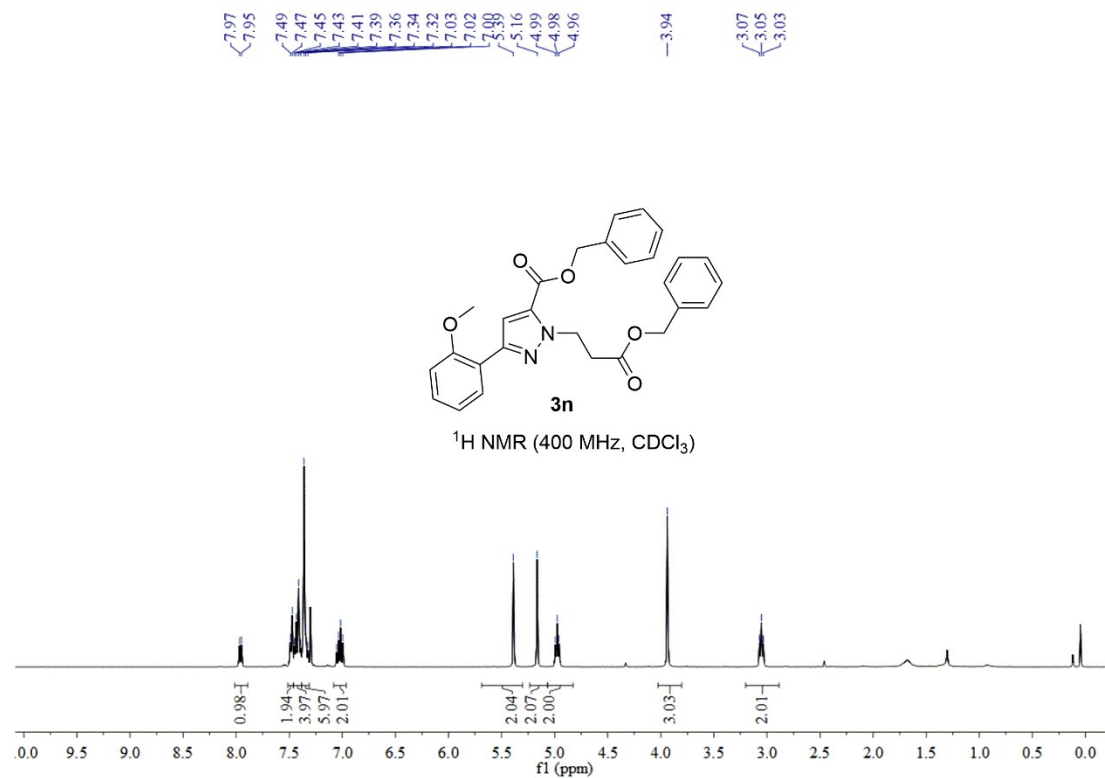
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(*o*-tolyl)-1*H*-pyrazole-5-carboxylate (3m): ¹H NMR



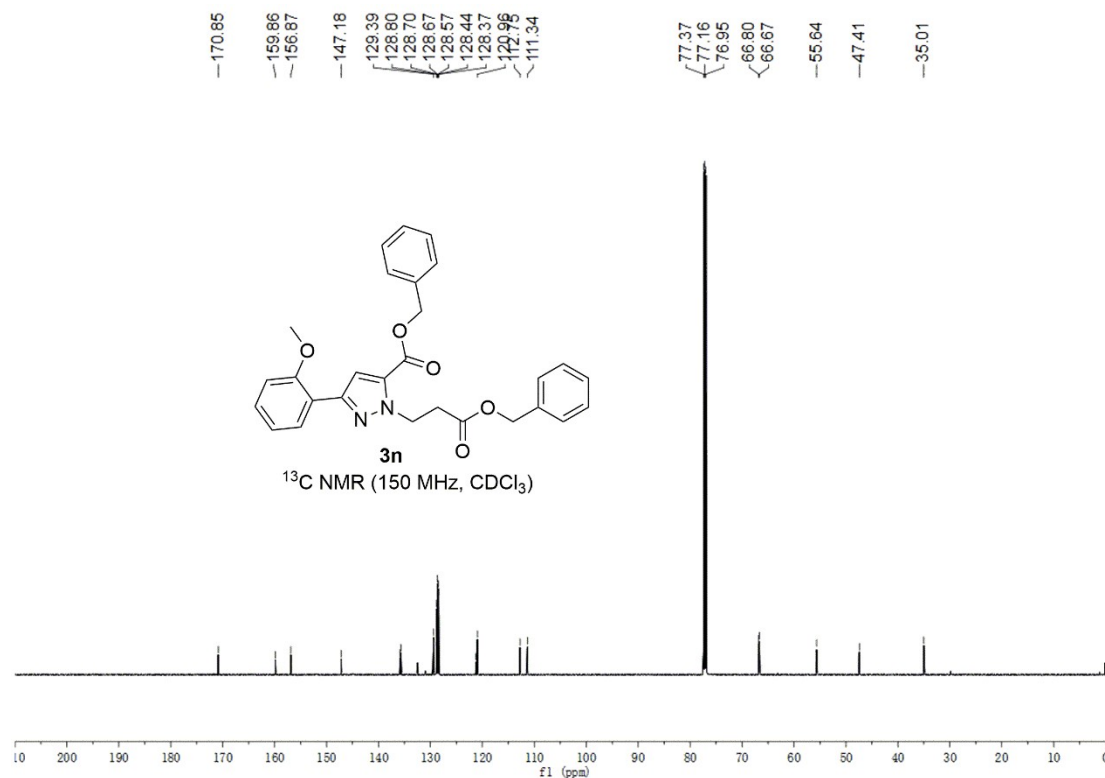
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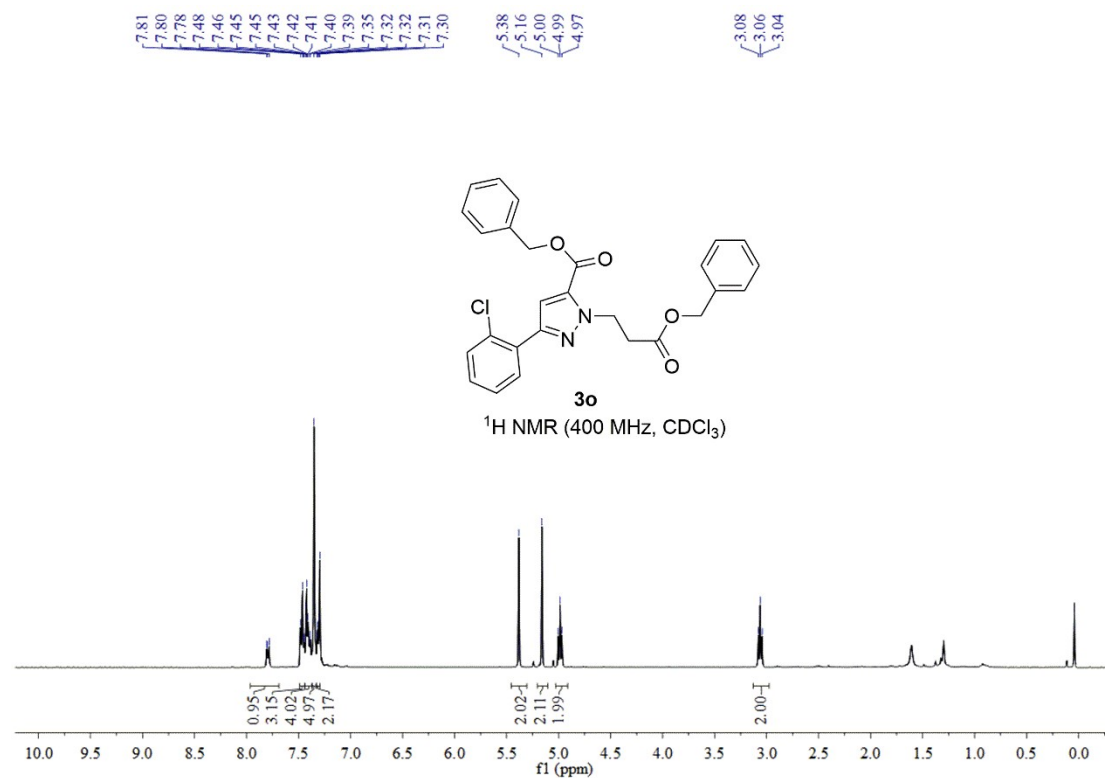
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(2-methoxyphenyl)-1H-pyrazole-5-carboxylate (3n): ¹H NMR



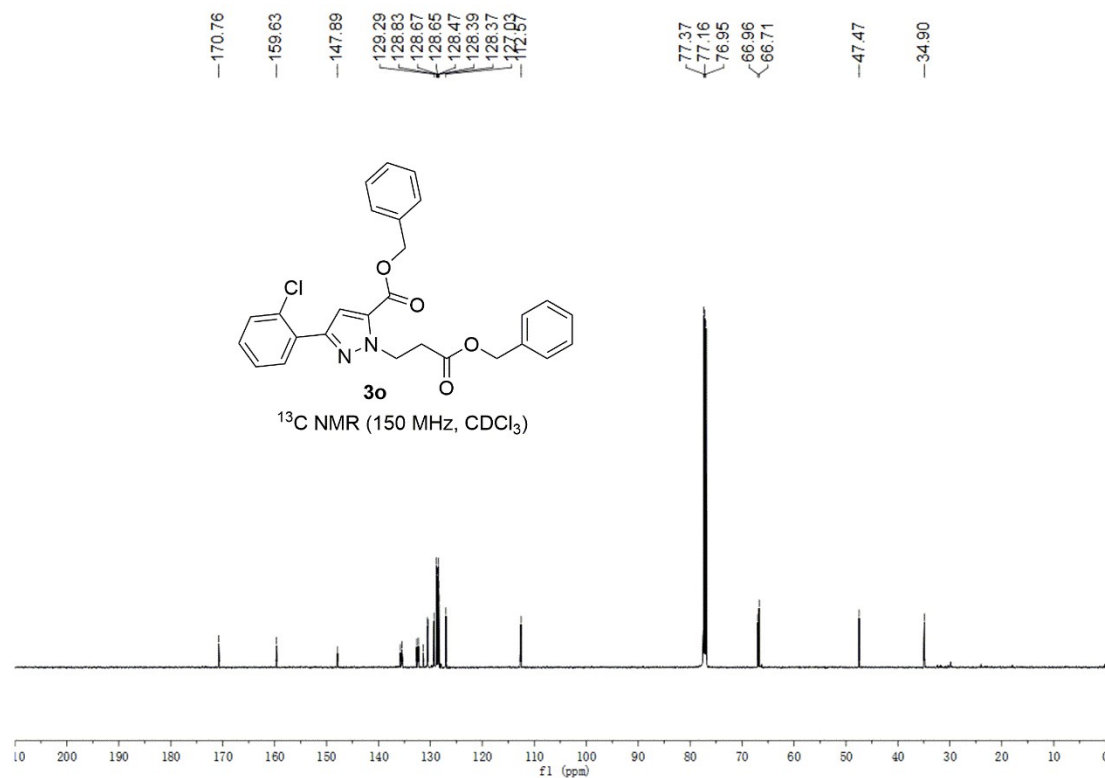
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(2-methoxyphenyl)-1H-pyrazole-5-carboxylate (3n): ¹³C NMR



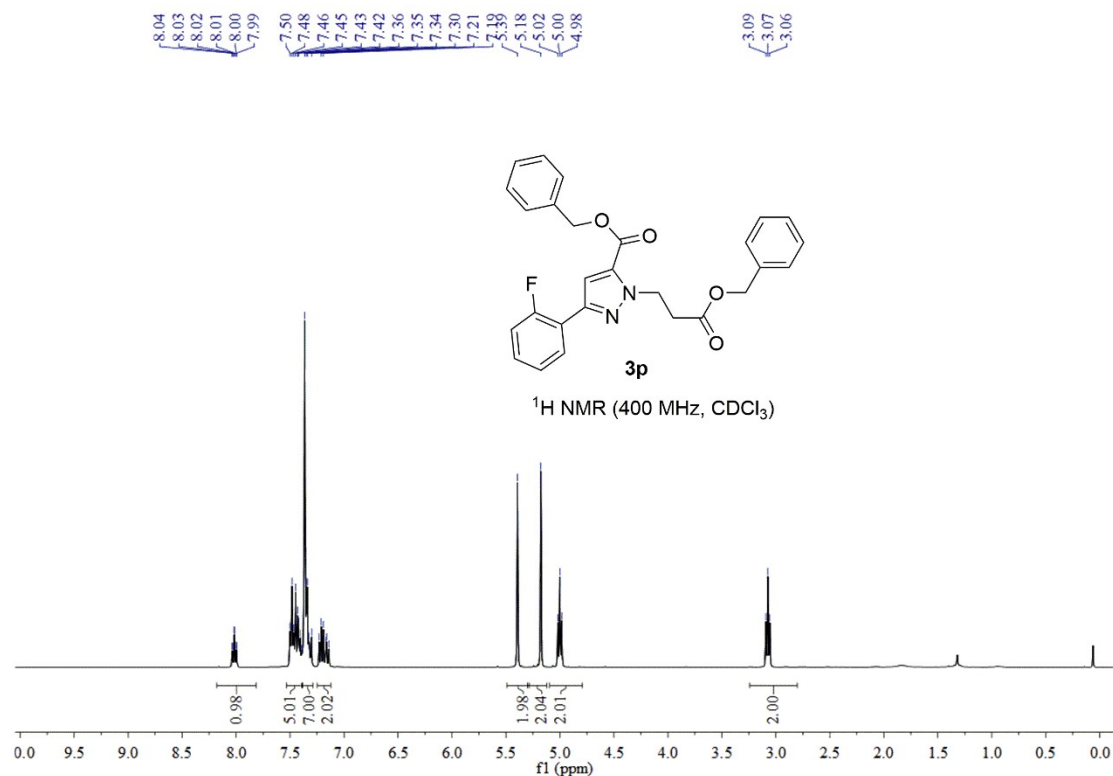
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(2-chlorophenyl)-1H-pyrazole-5-carboxylate (3o): ¹H NMR



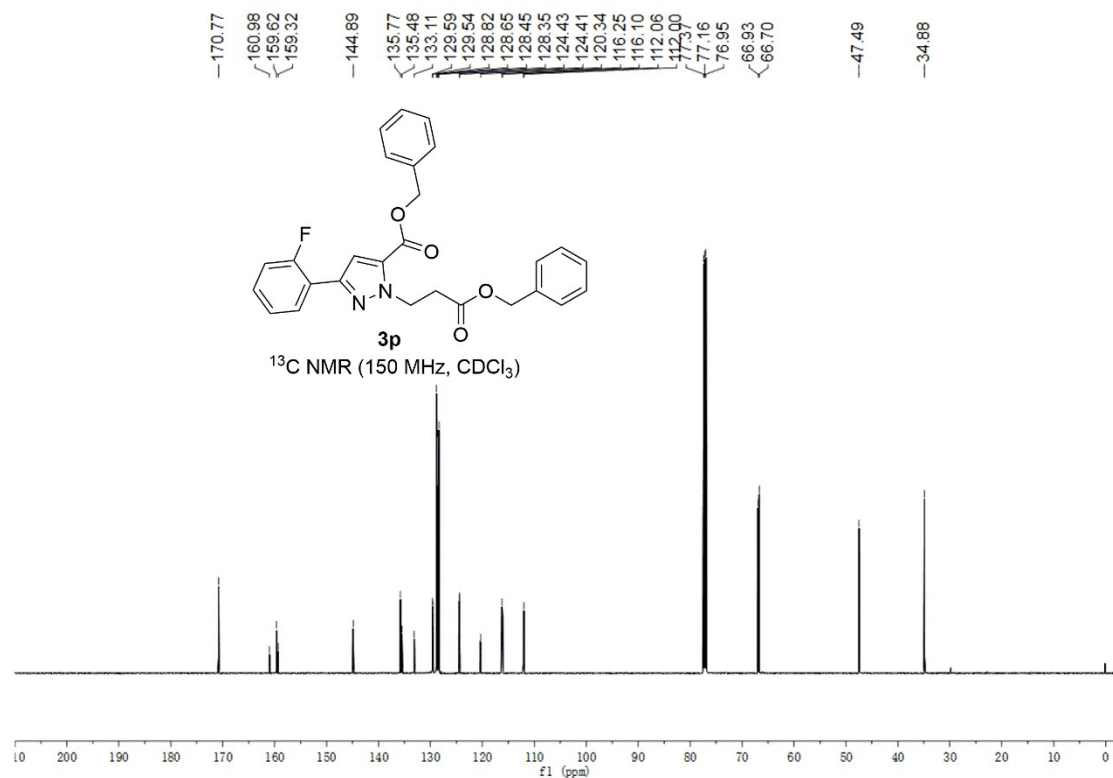
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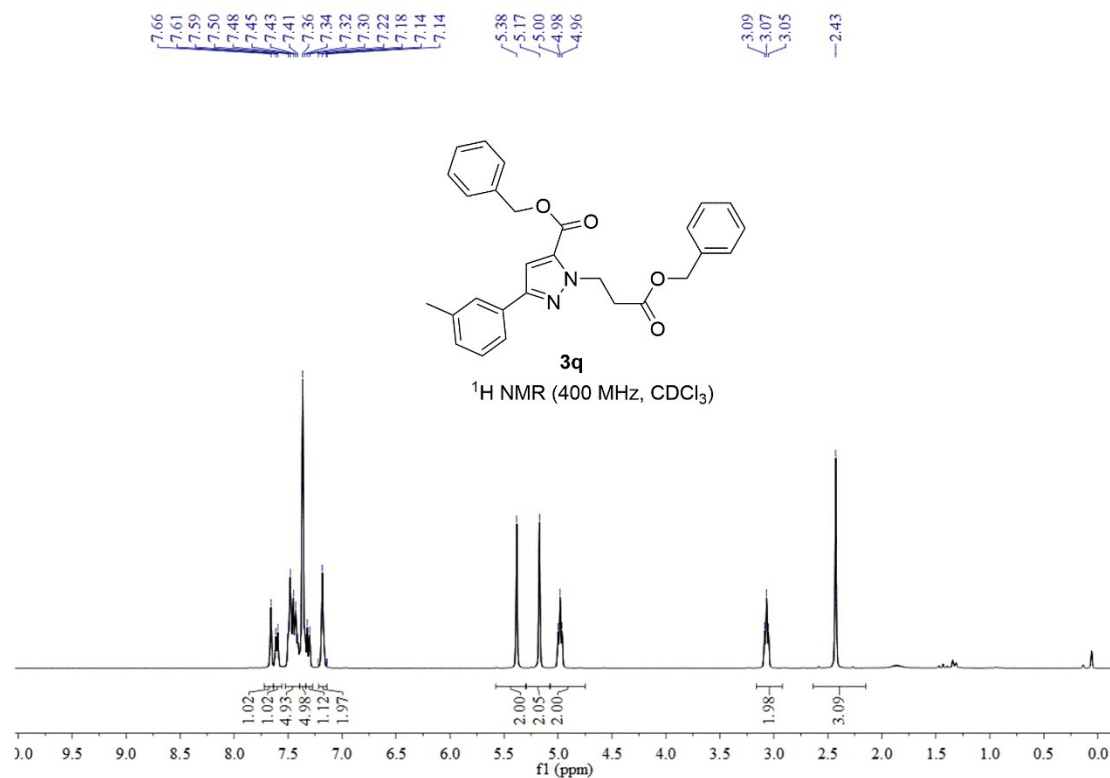
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(2-fluorophenyl)-1H-pyrazole-5-carboxylate (3p): ¹H NMR



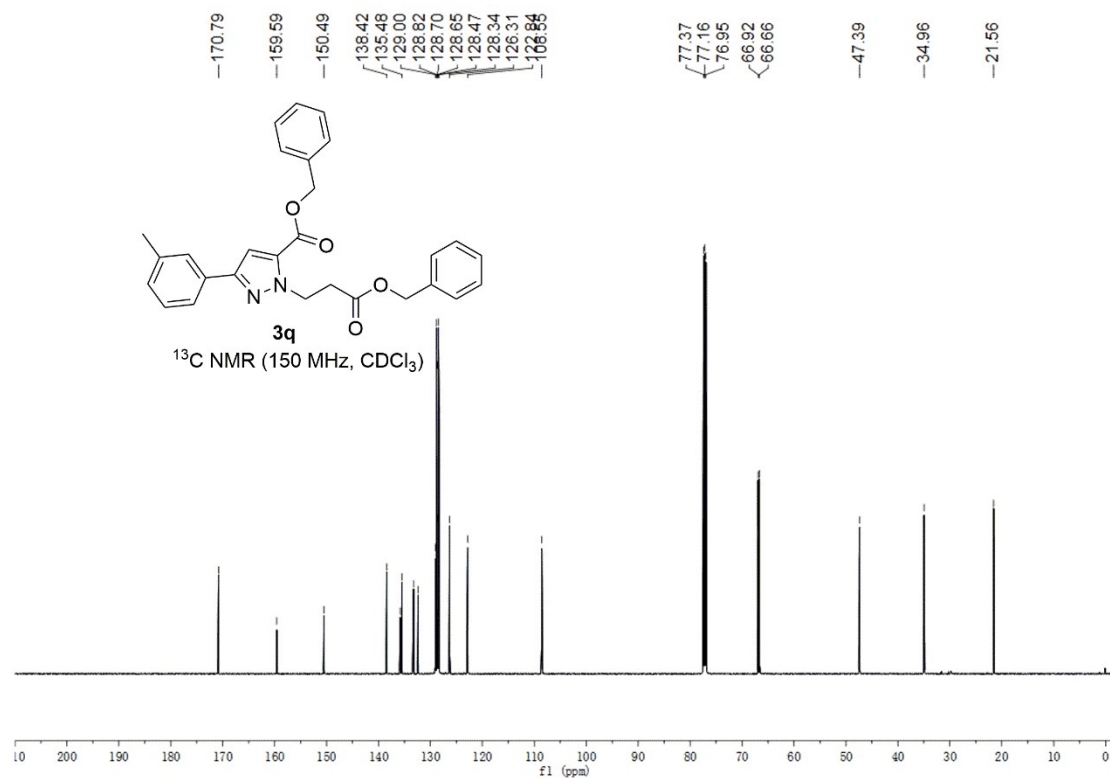
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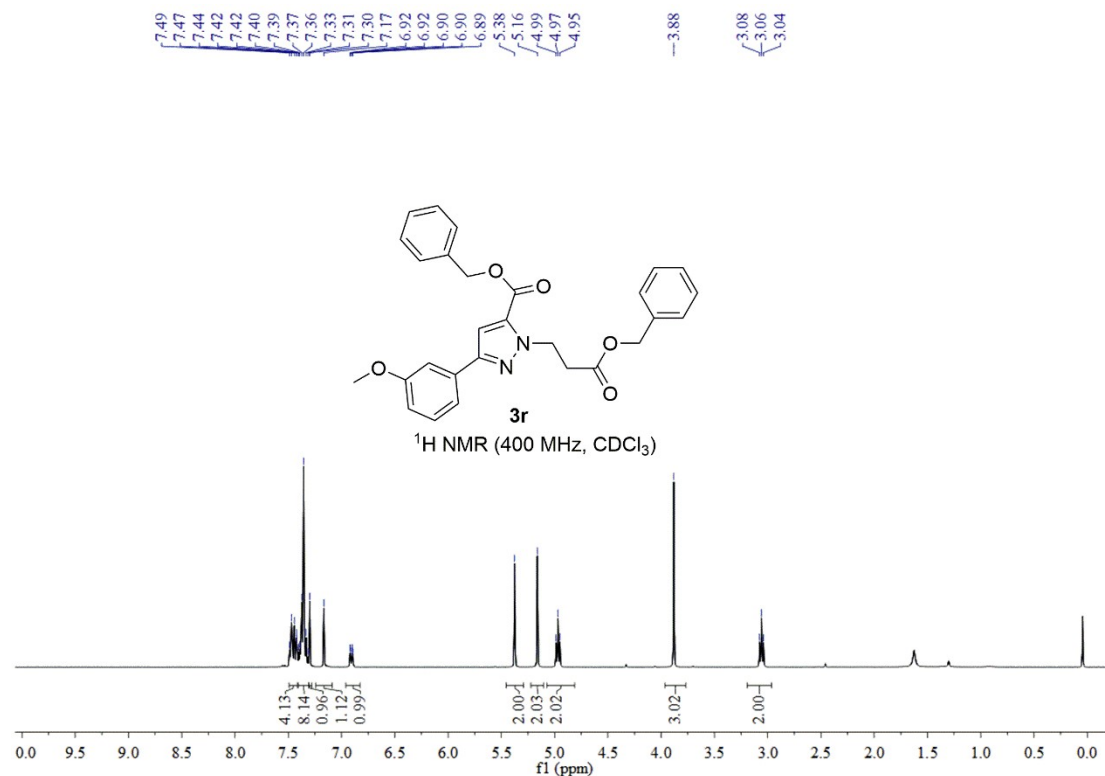
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(*m*-tolyl)-1*H*-pyrazole-5-carboxylate (3q): ¹H NMR



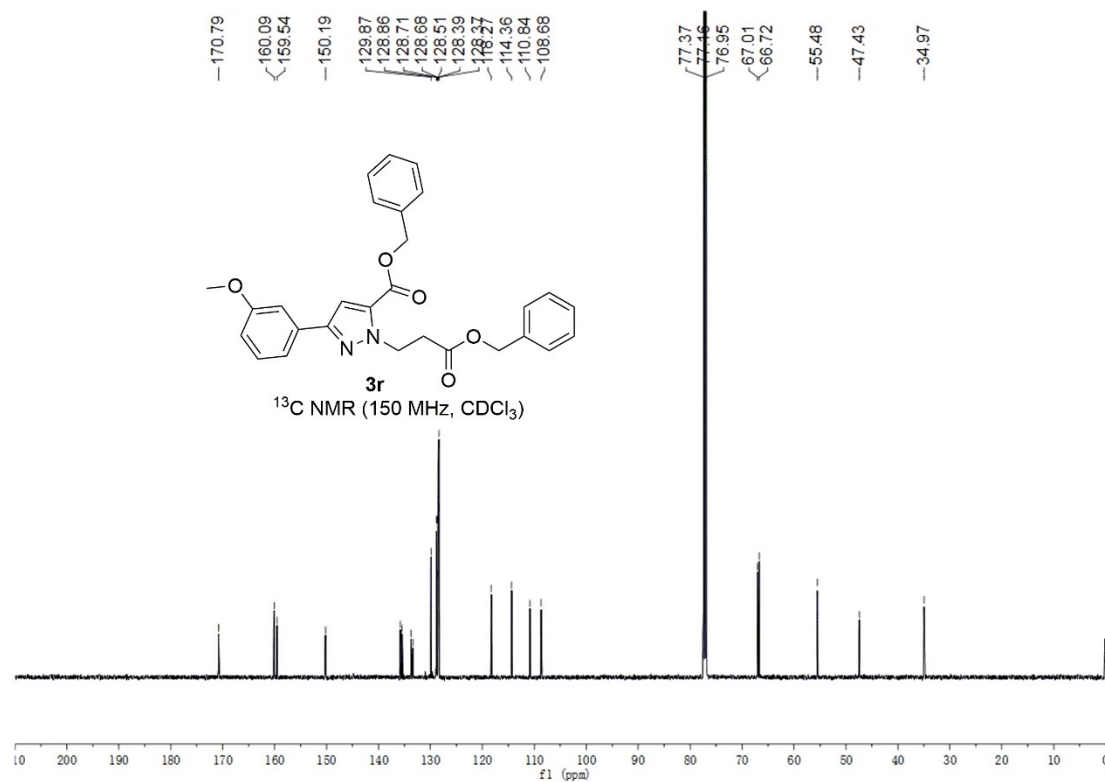
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(*m*-tolyl)-1*H*-pyrazole-5-carboxylate (3q): ¹³C NMR



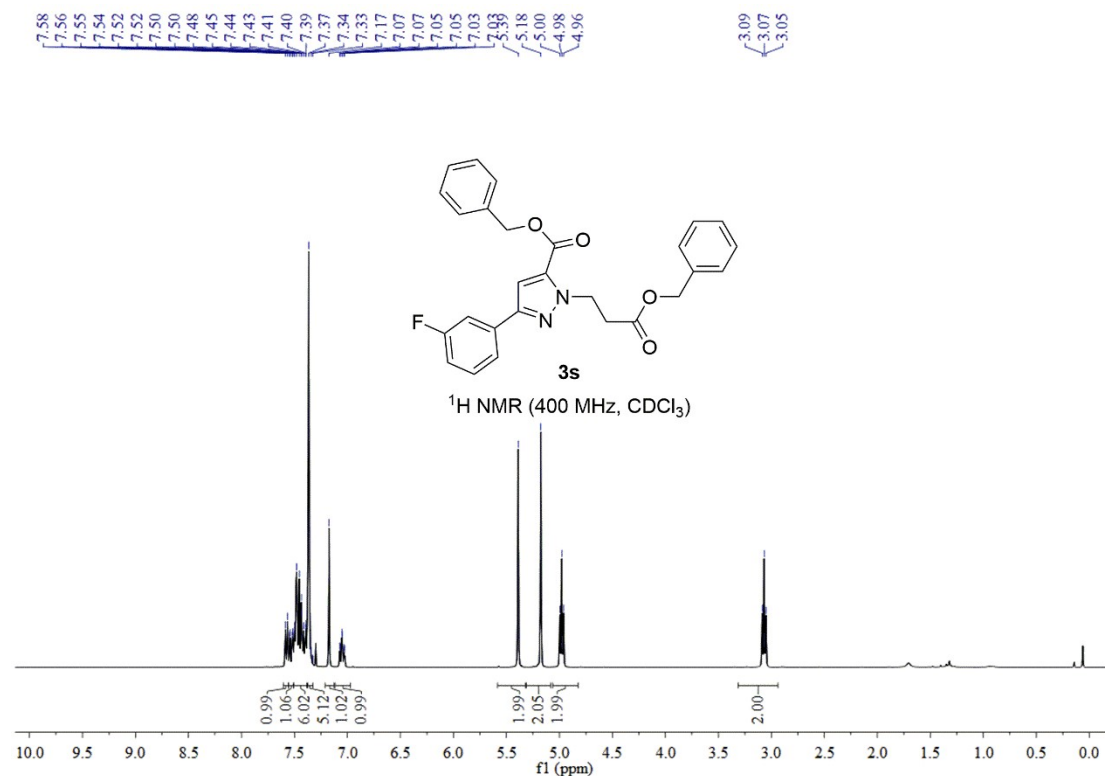
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-methoxyphenyl)-1H-pyrazole-5-carboxylate (3r): ¹H NMR



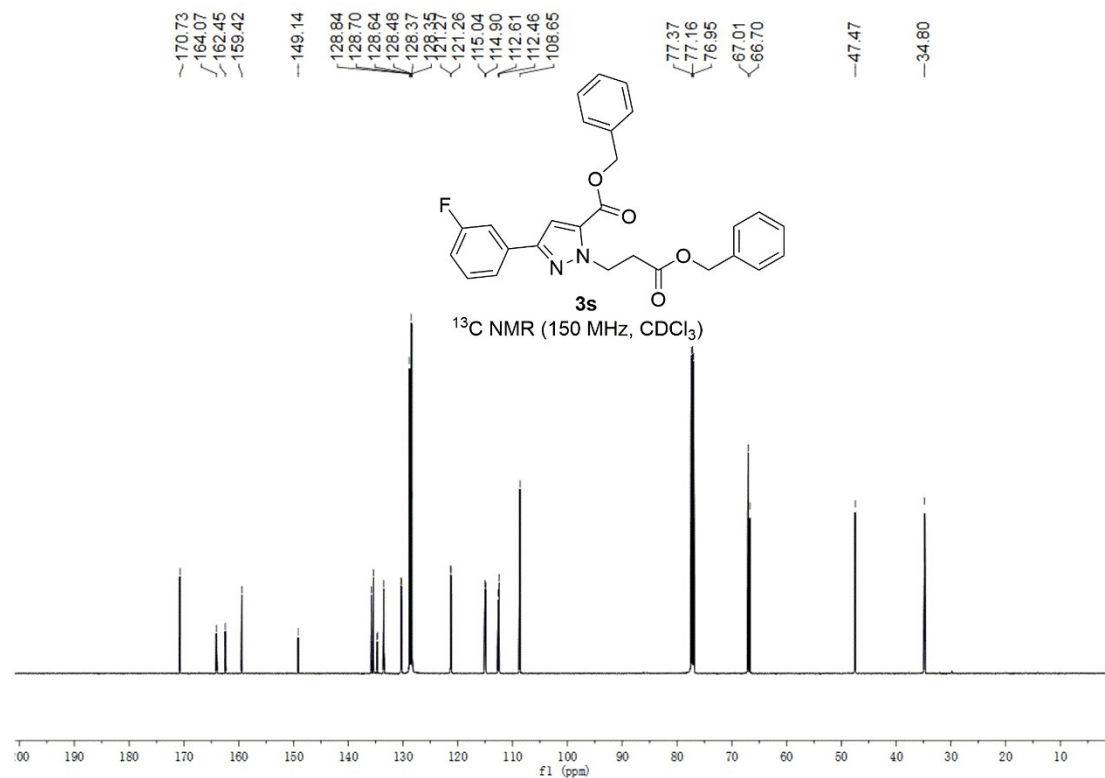
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-methoxyphenyl)-1H-pyrazole-5-carboxylate (3r): ¹³C NMR



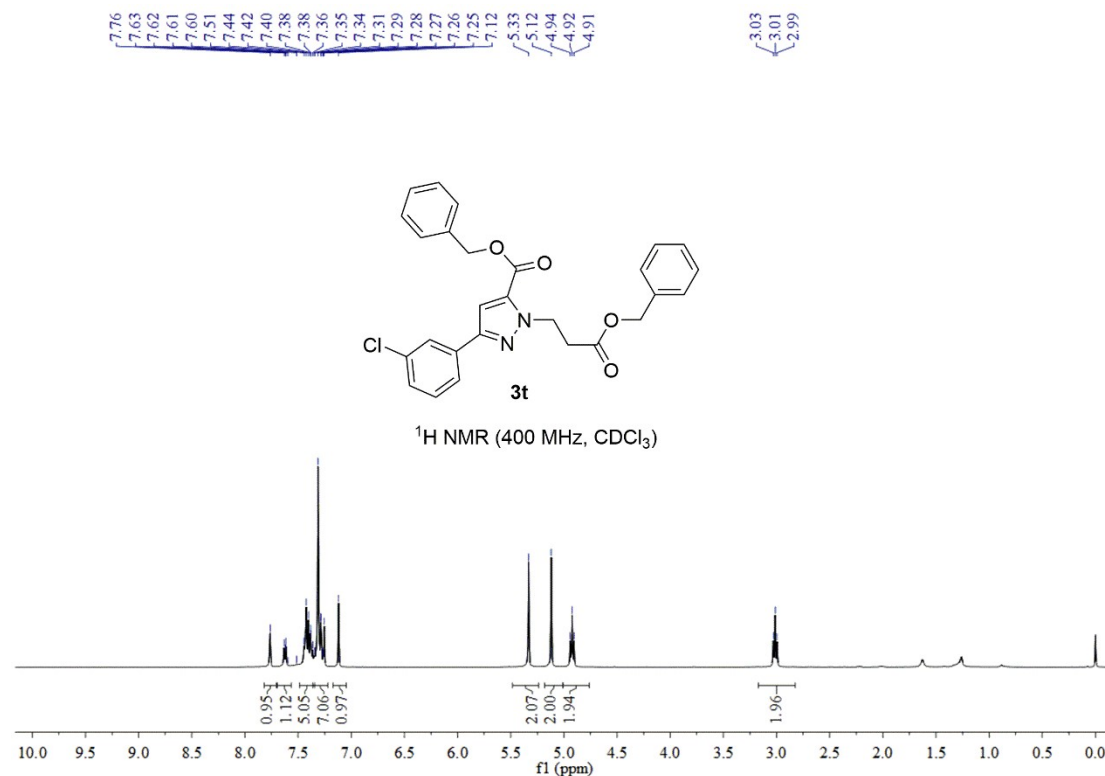
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-fluorophenyl)-1H-pyrazole-5-carboxylate (3s): ¹H NMR



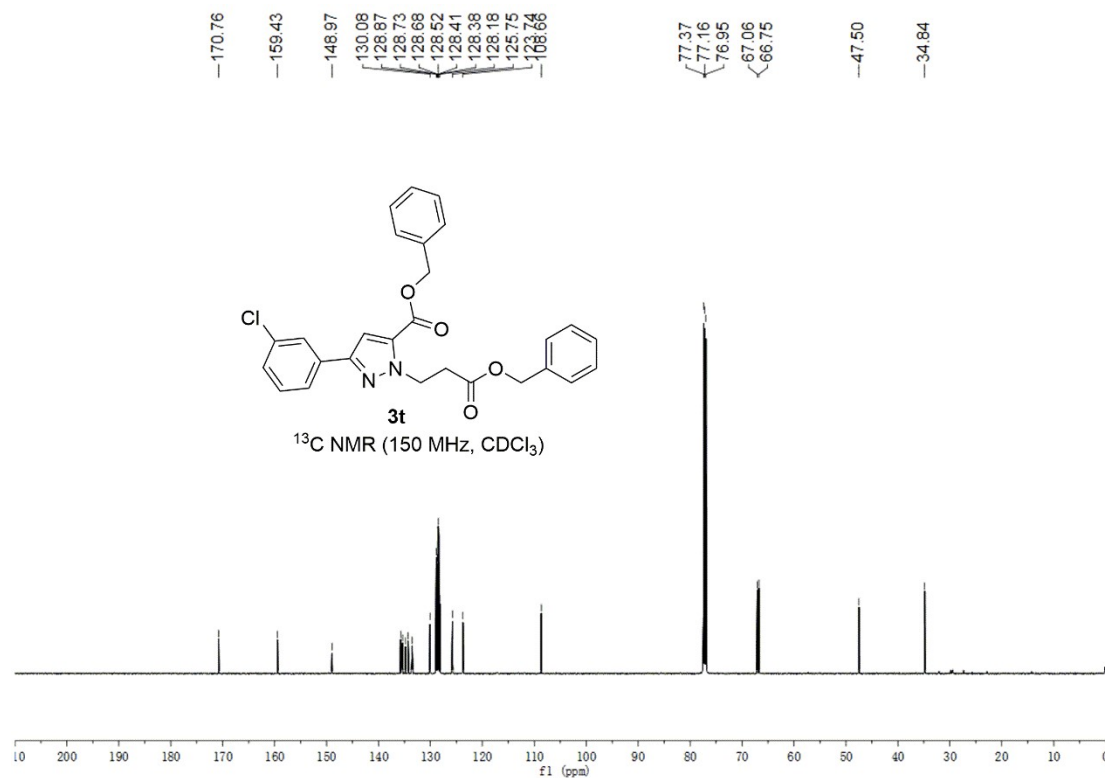
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-fluorophenyl)-1H-pyrazole-5-carboxylate (3s): ¹³C NMR



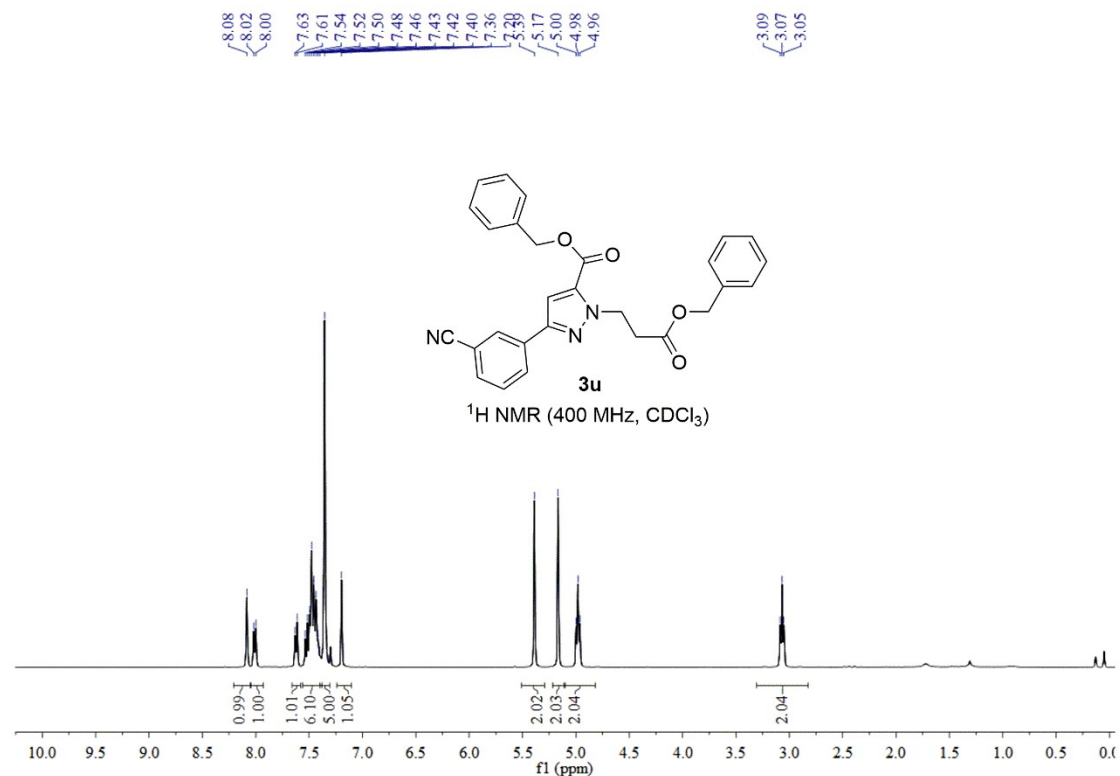
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-chlorophenyl)-1H-pyrazole-5-carboxylate (3t): ¹H NMR



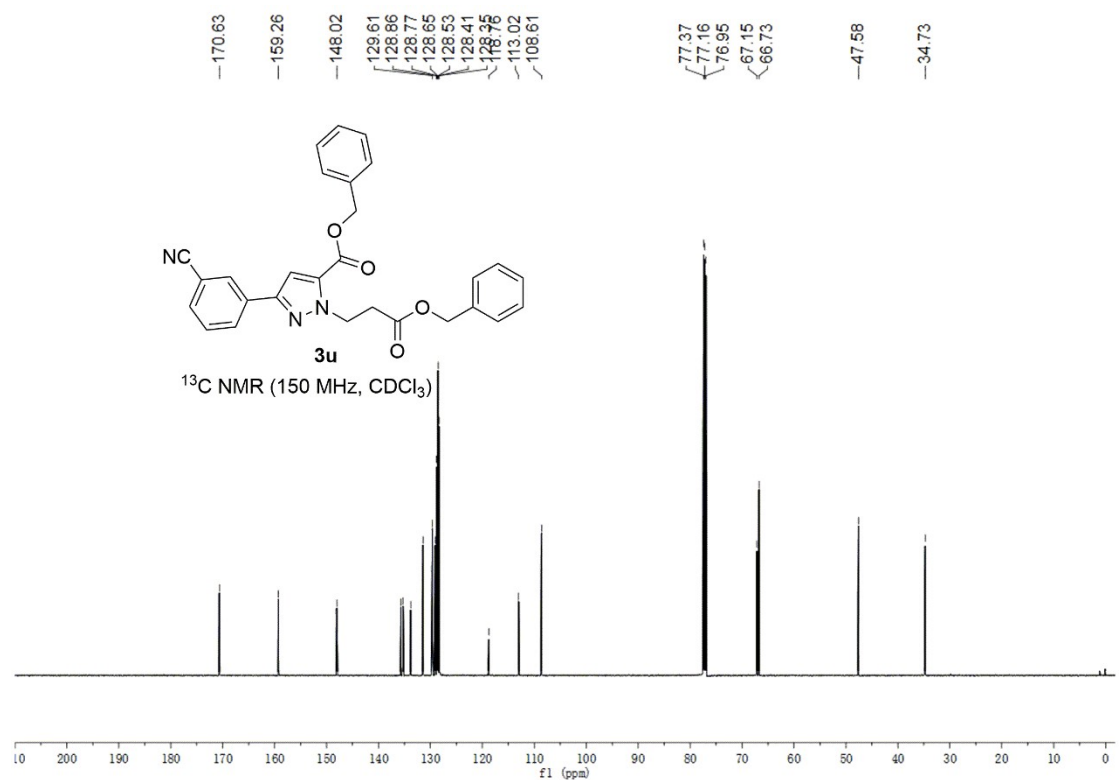
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-chlorophenyl)-1H-pyrazole-5-carboxylate (3t): ¹³C NMR



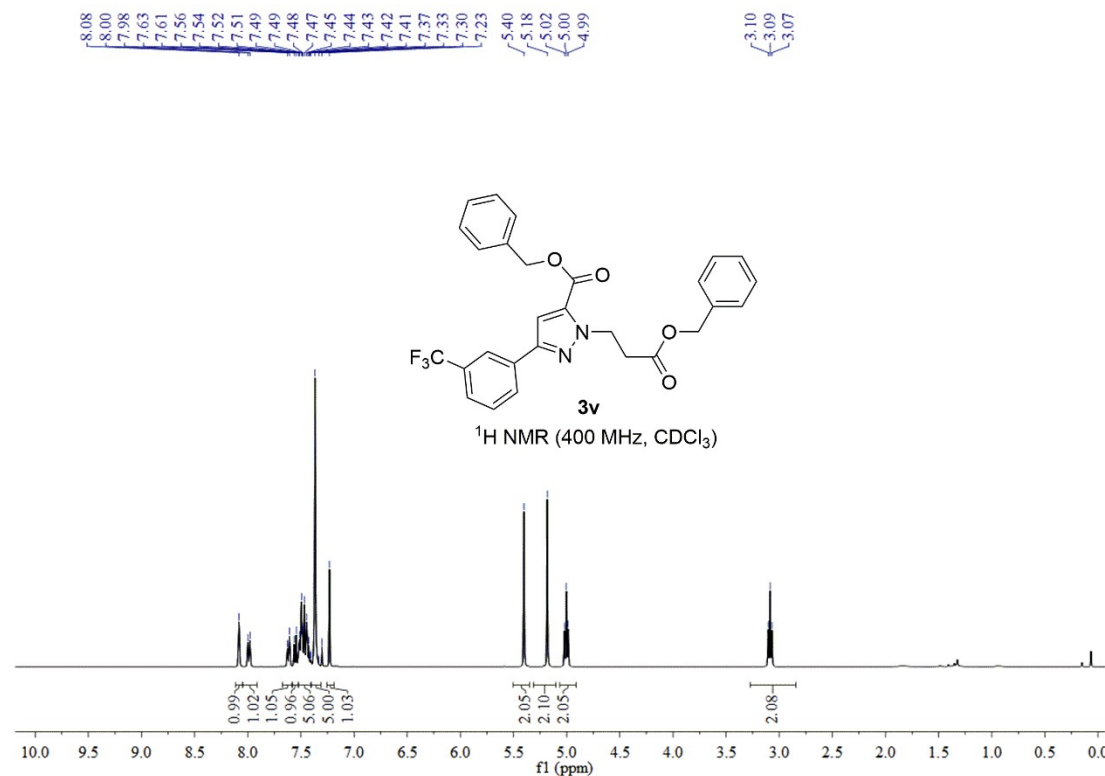
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-cyanophenyl)-1H-pyrazole-5-carboxylate (3u): ¹H NMR



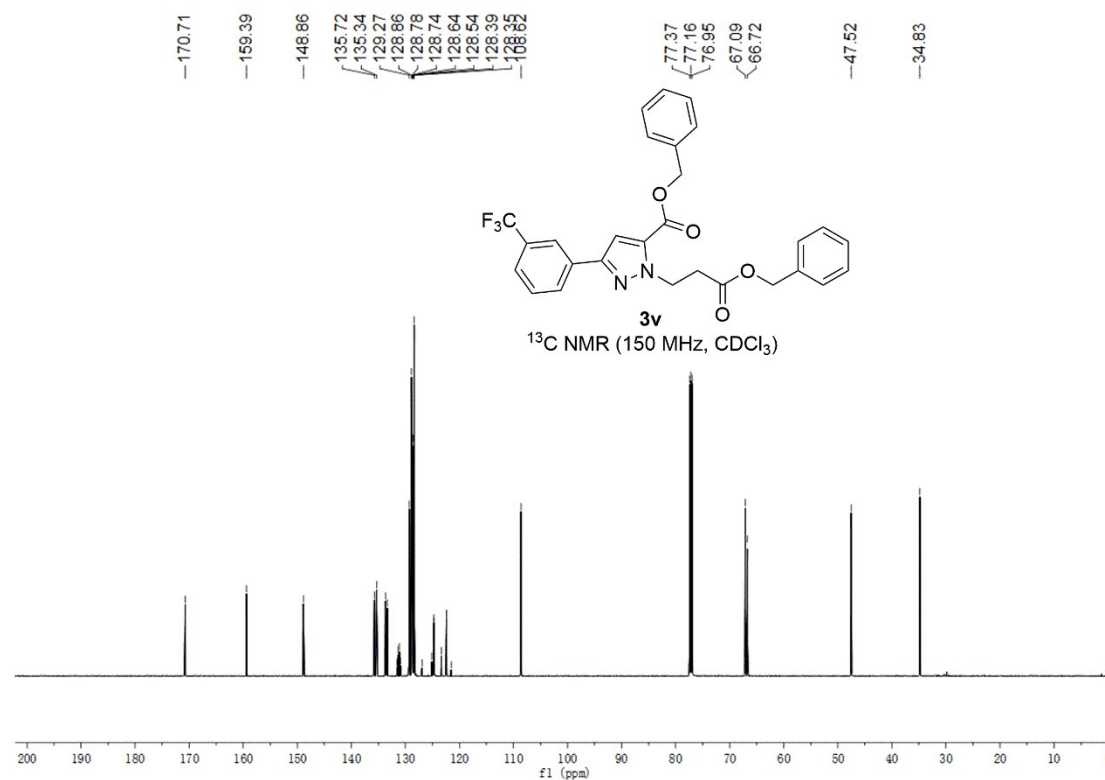
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-cyanophenyl)-1H-pyrazole-5-carboxylate (3u): ¹³C NMR



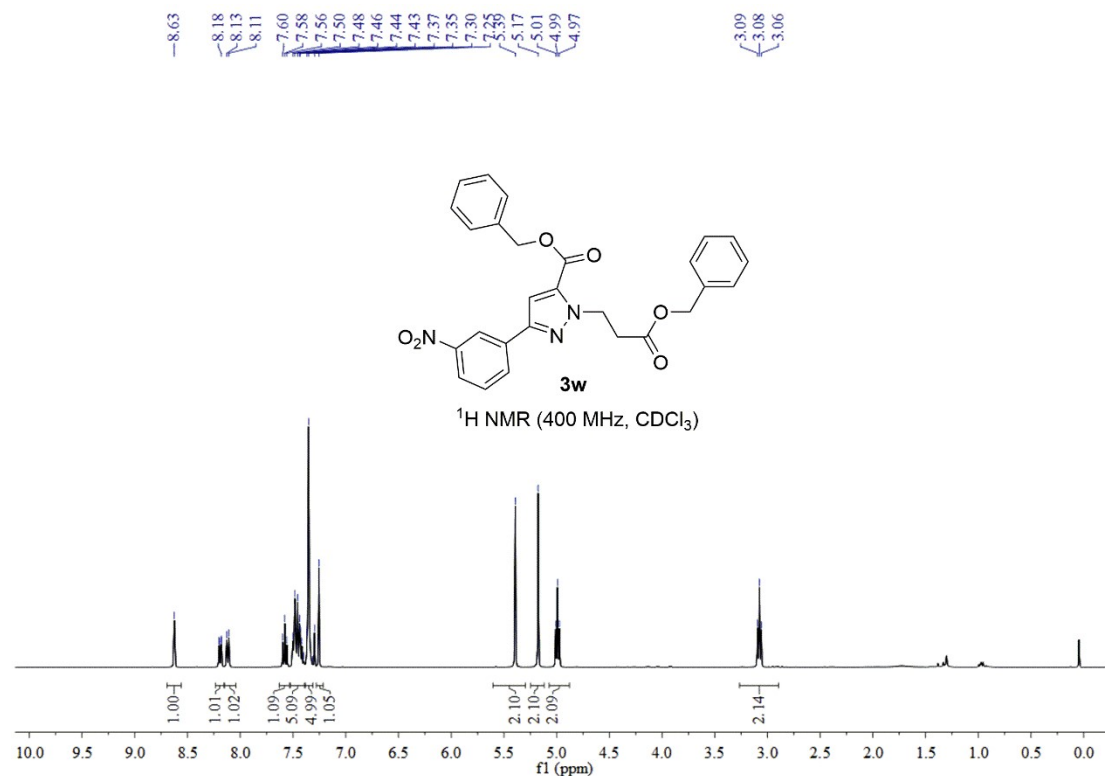
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-(trifluoromethyl)phenyl)-1H-pyrazole-5-carboxylate (3v): ¹H NMR



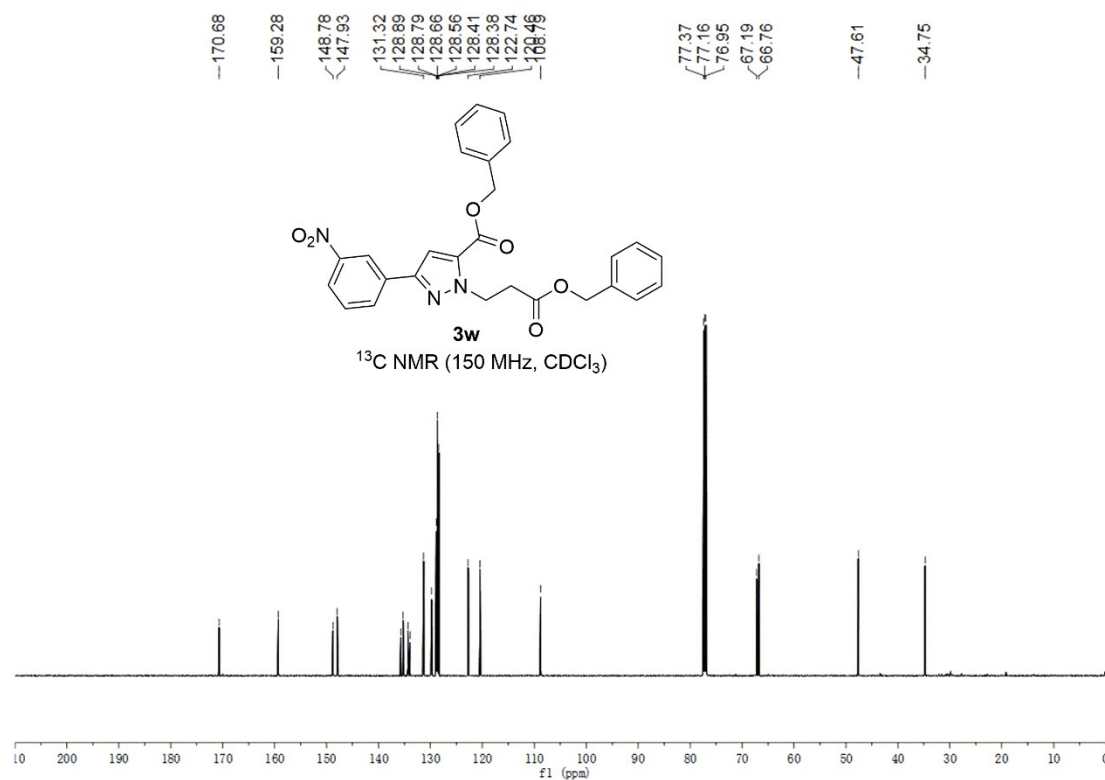
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(3-(trifluoromethyl)phenyl)-1H-pyrazole-5-carboxylate (3v): ¹³C NMR



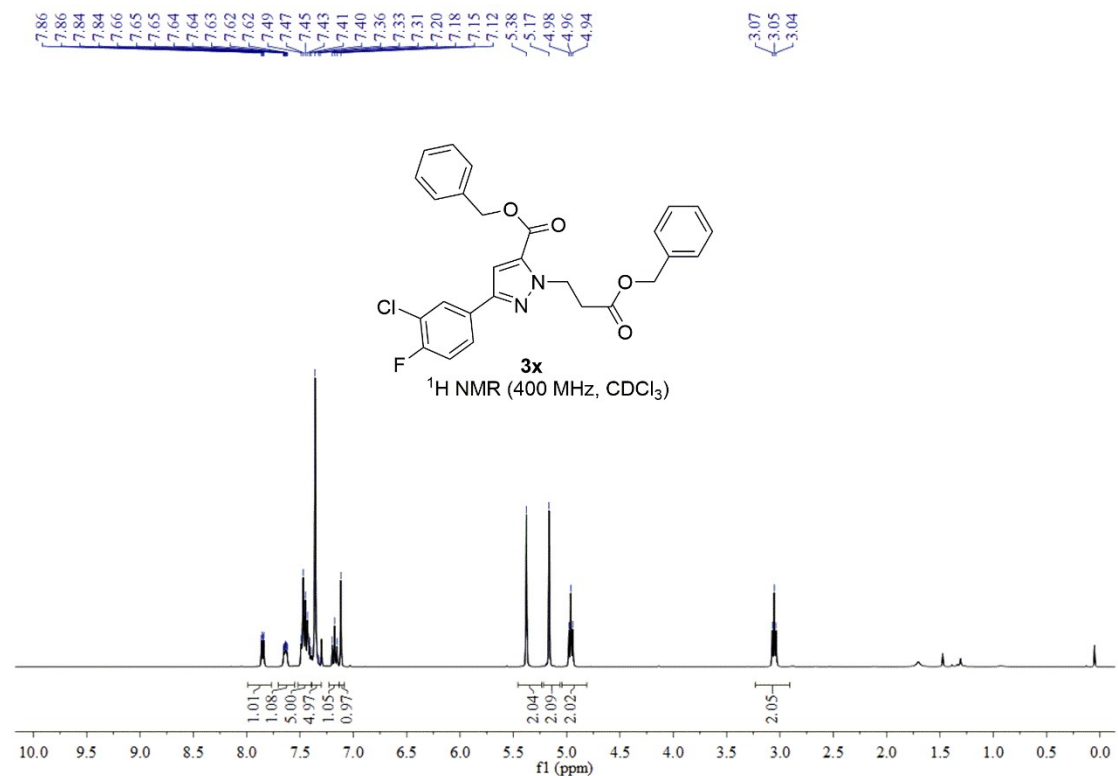
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-nitrophenyl)-1H-pyrazole-5-carboxylate (3w): ¹H NMR



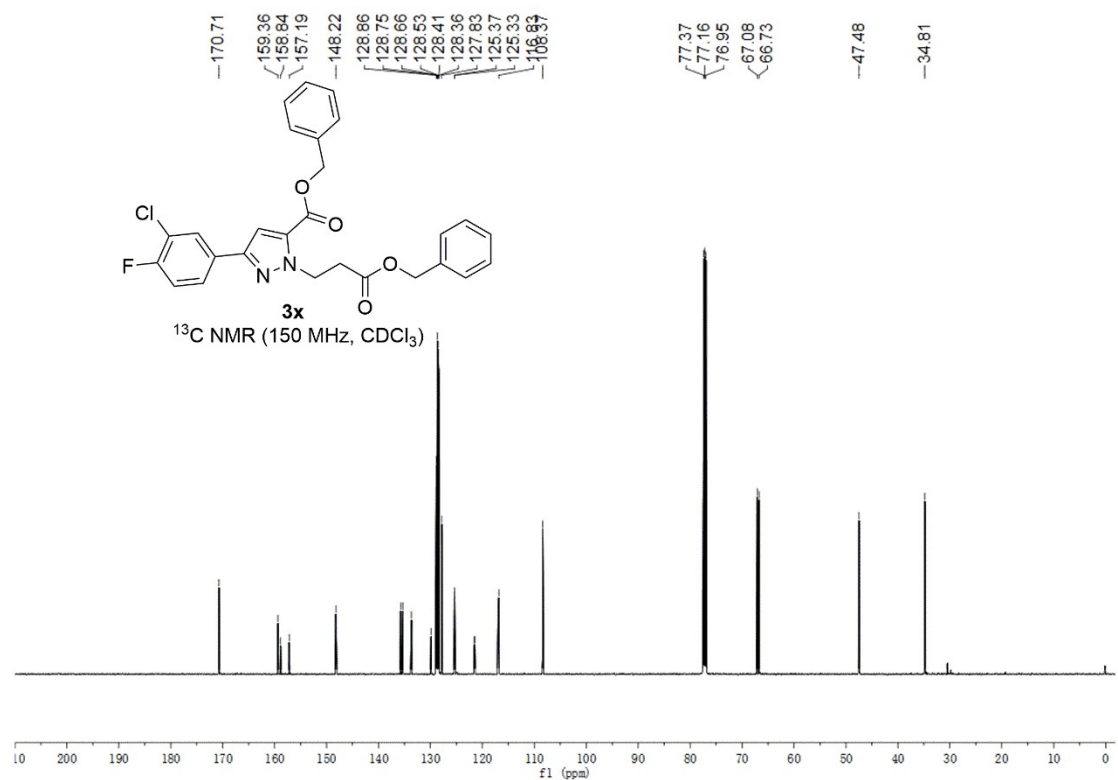
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-nitrophenyl)-1H-pyrazole-5-carboxylate (3w): ¹³C NMR



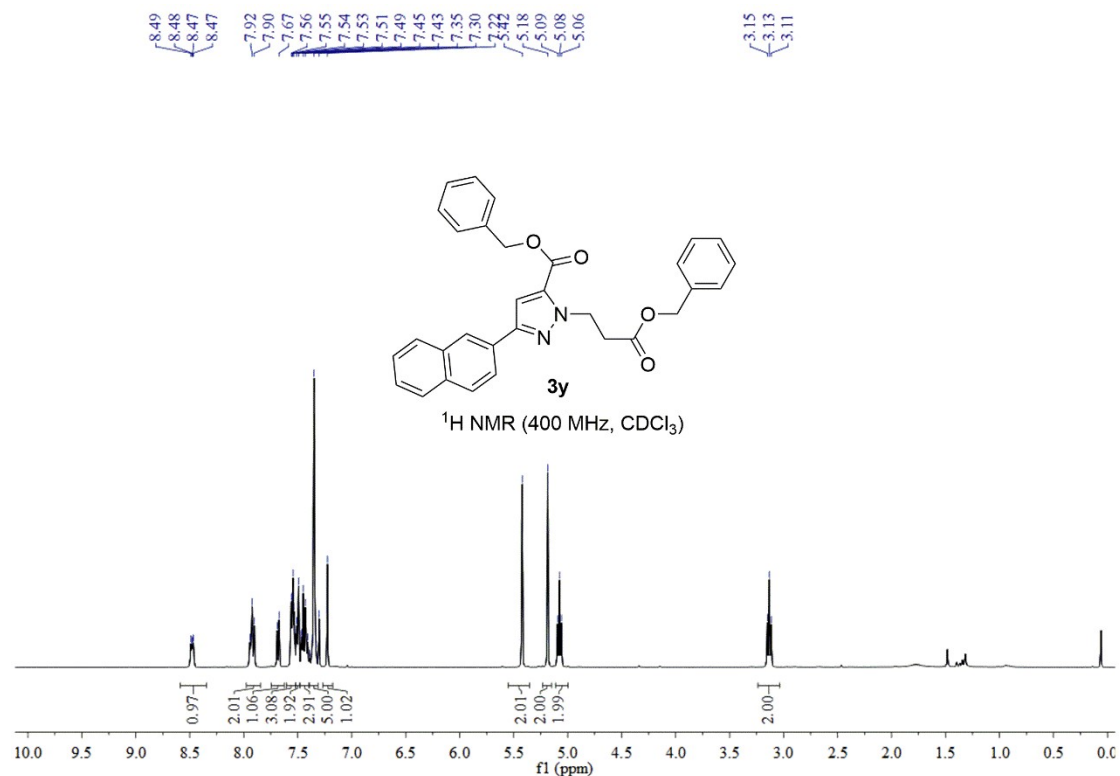
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-chloro-3-fluorophenyl)-1H-pyrazole-5-carboxylate (3x): ¹H NMR



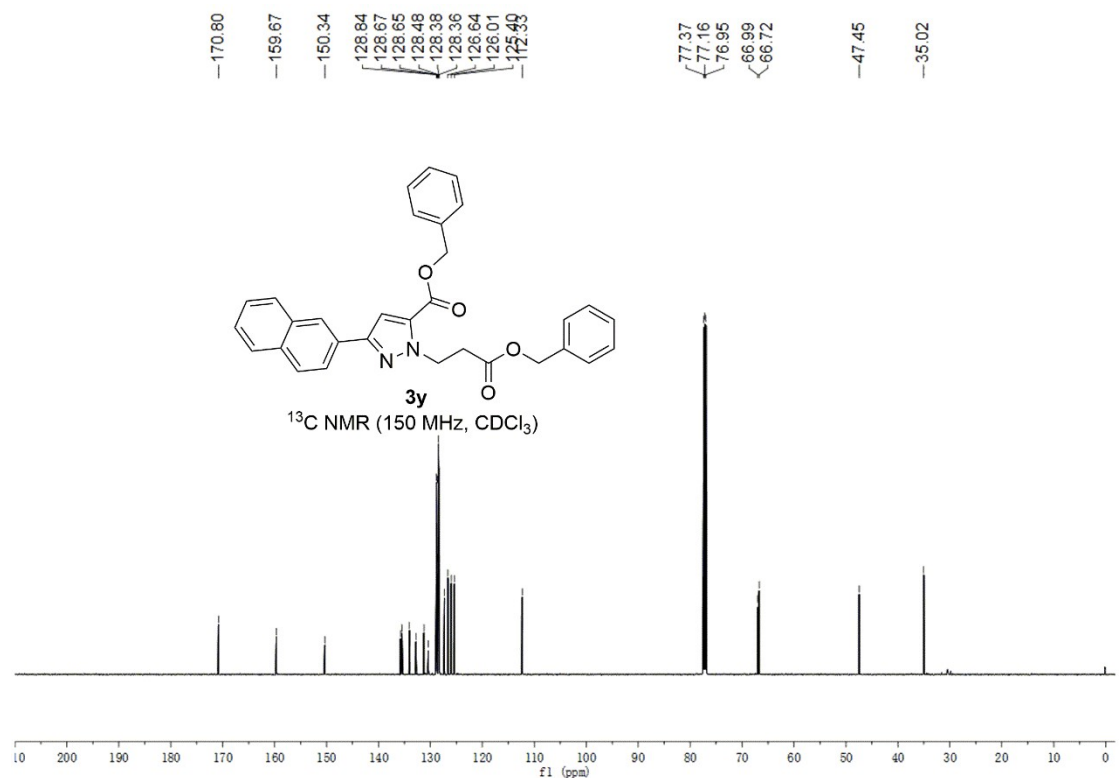
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(4-chloro-3-fluorophenyl)-1H-pyrazole-5-carboxylate (3x): ¹³C NMR



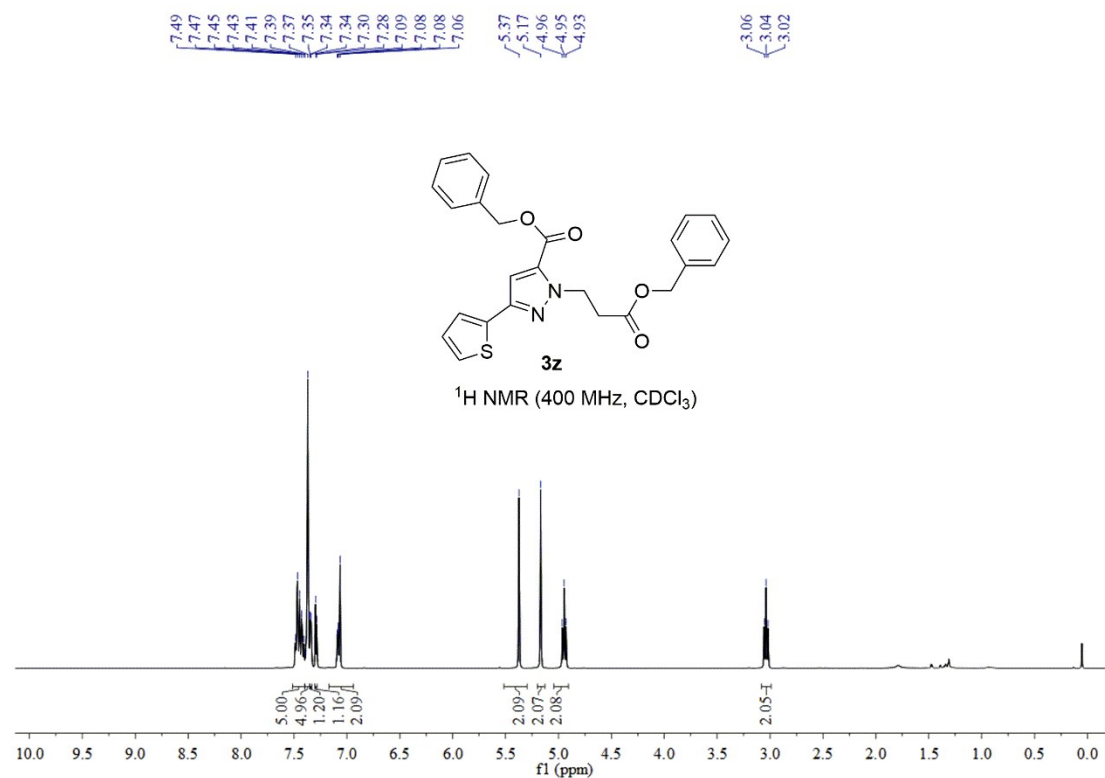
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(naphthalen-2-yl)-1H-pyrazole-5-carboxylate (3y): ¹H NMR



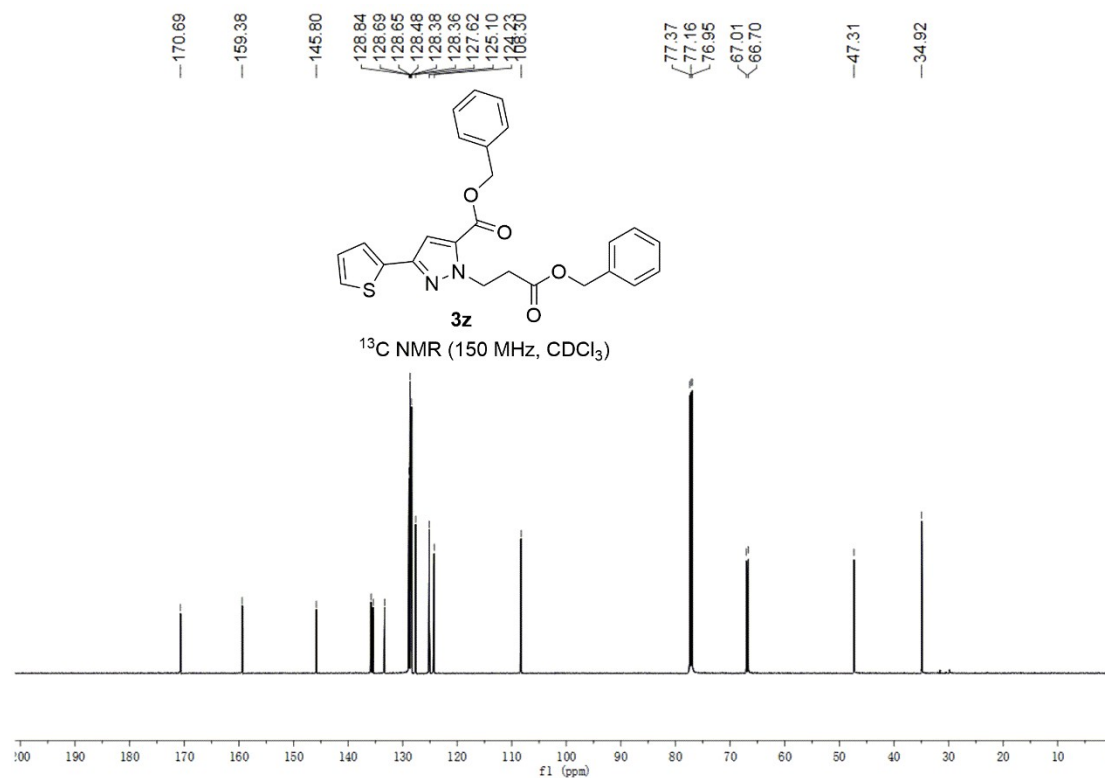
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(naphthalen-2-yl)-1H-pyrazole-5-carboxylate (3y): ¹³C NMR



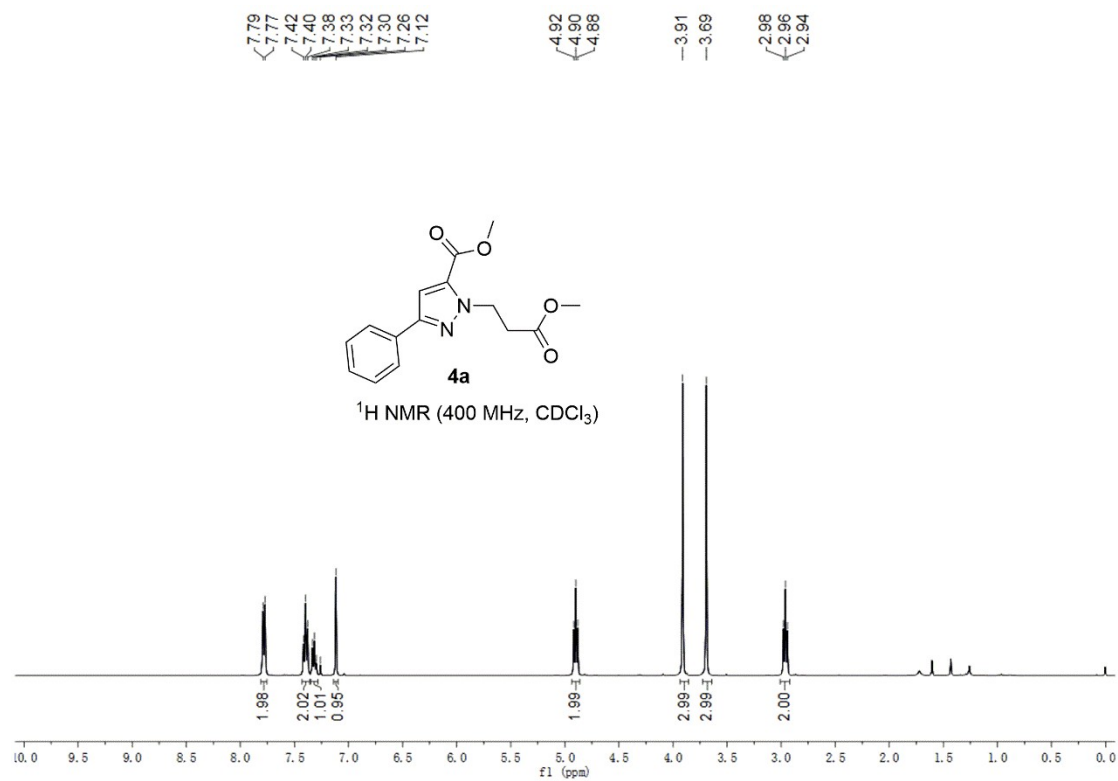
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(thiophen-2-yl)-1H-pyrazole-5-carboxylate (3z): ¹H NMR



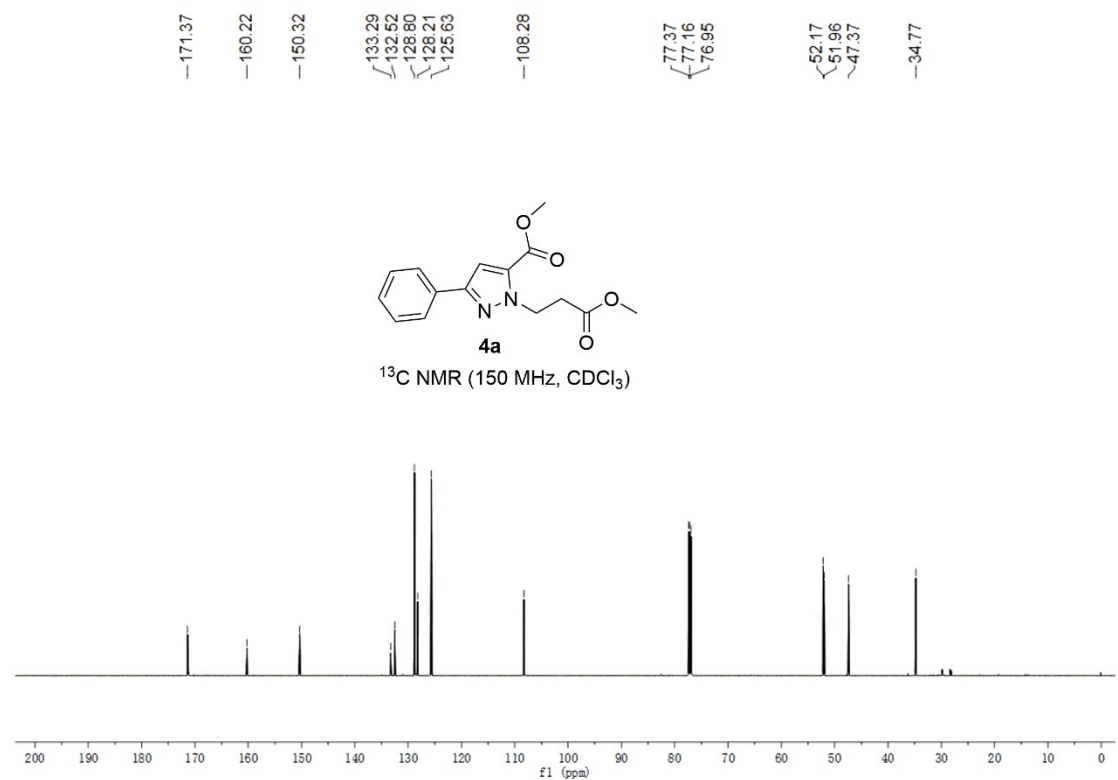
Benzyl 1-(3-(benzyloxy)-3-oxopropyl)-3-(thiophen-2-yl)-1H-pyrazole-5-carboxylate (3z): ¹³C NMR



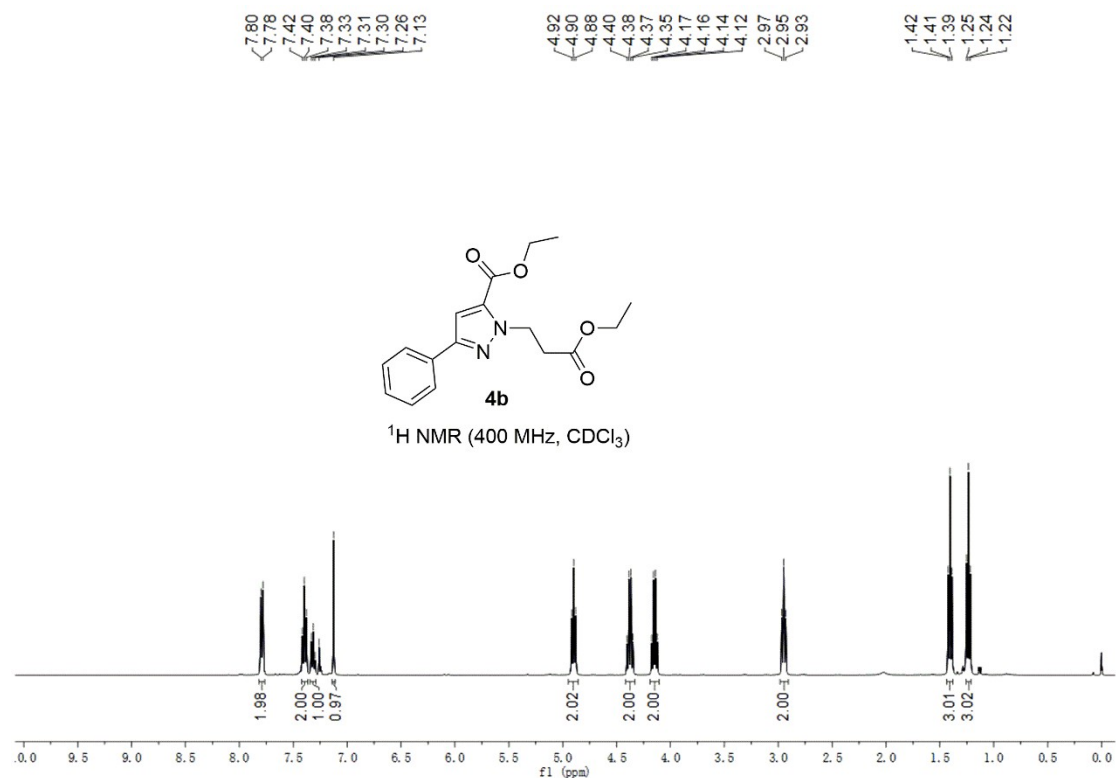
Methyl 1-(3-methoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4a): ¹H NMR



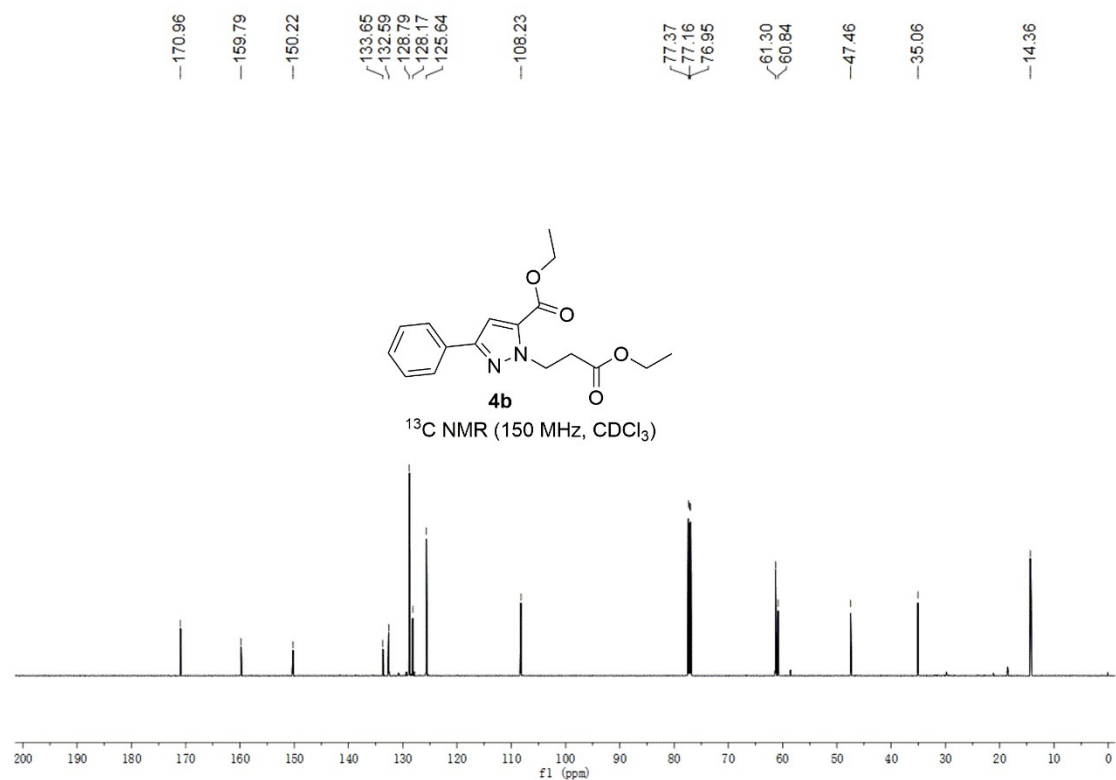
Methyl 1-(3-methoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4a): ¹³C NMR



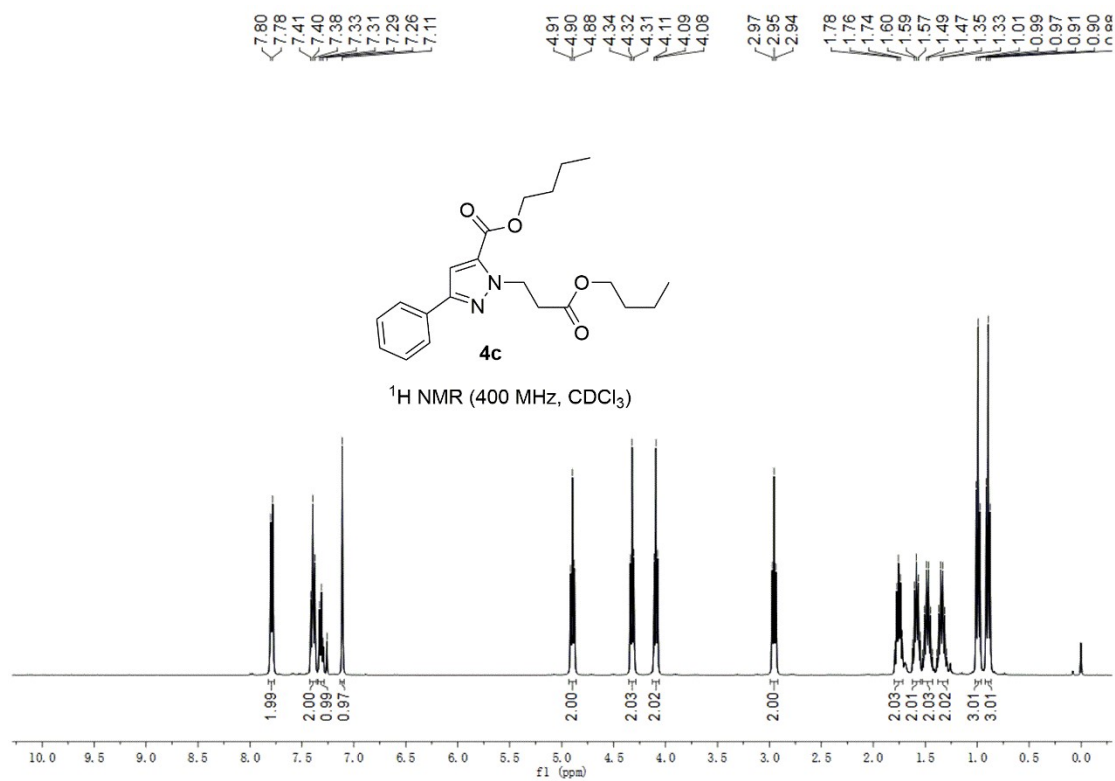
Ethyl 1-(3-ethoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4b): ¹H NMR



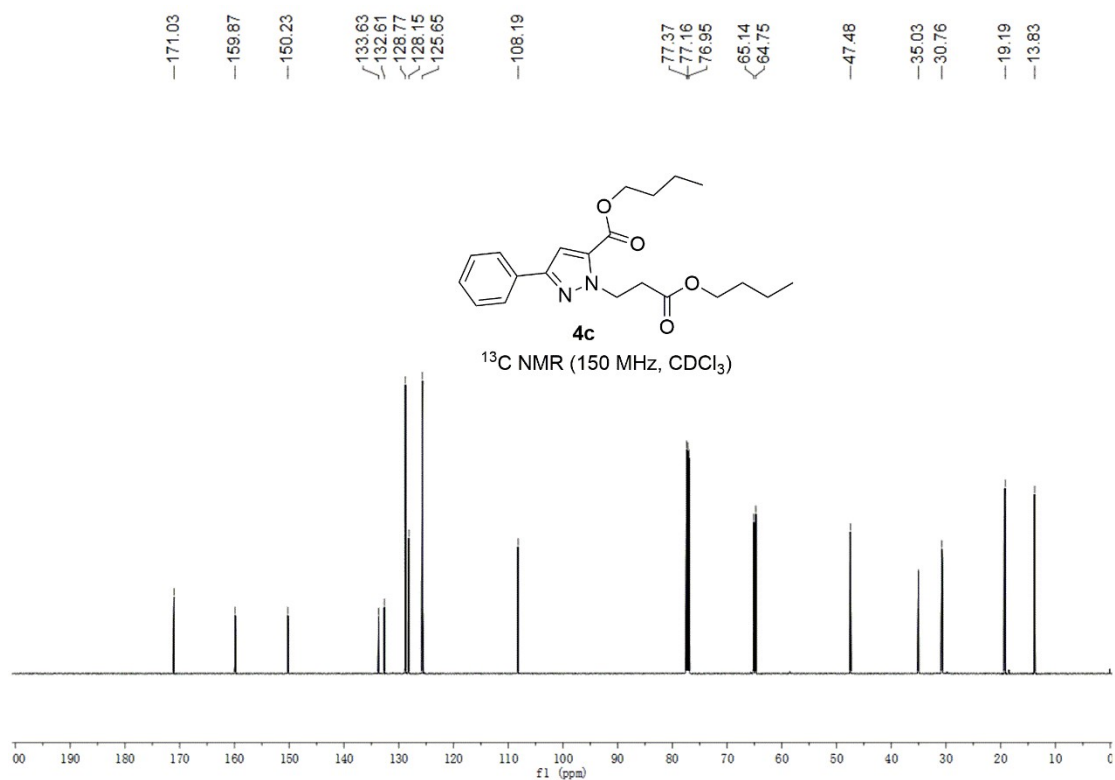
Ethyl 1-(3-ethoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4b): ¹³C NMR



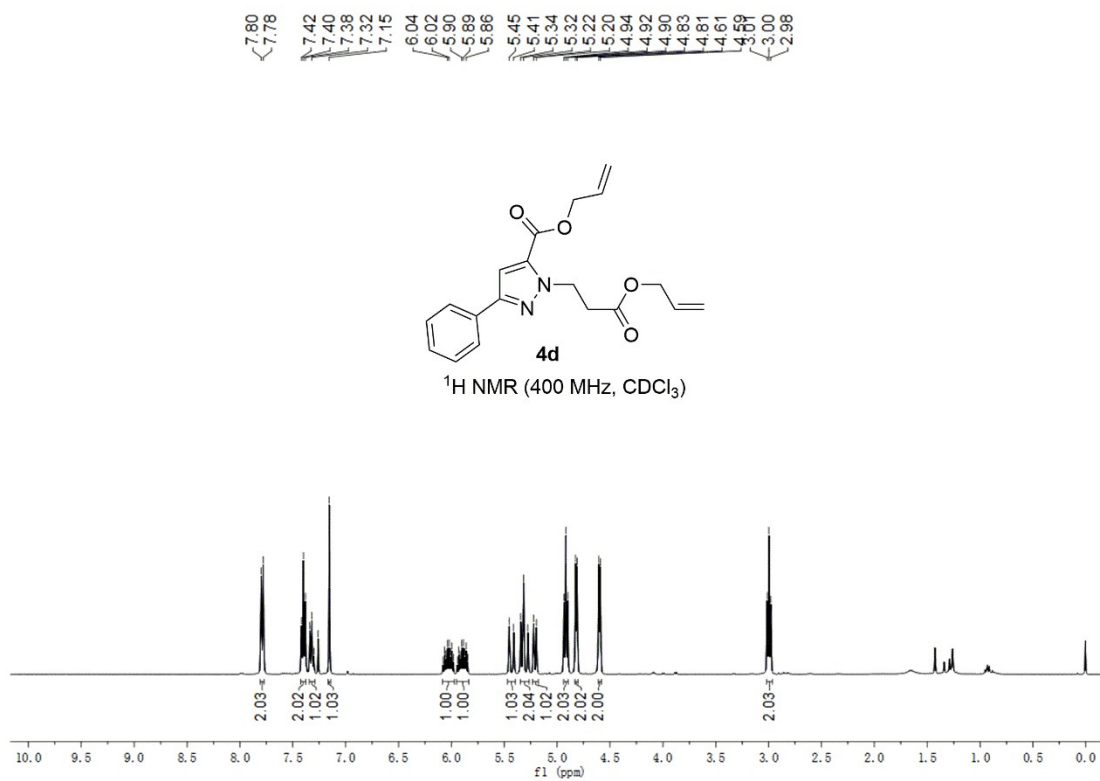
Butyl 1-(3-butoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4c): ¹H NMR



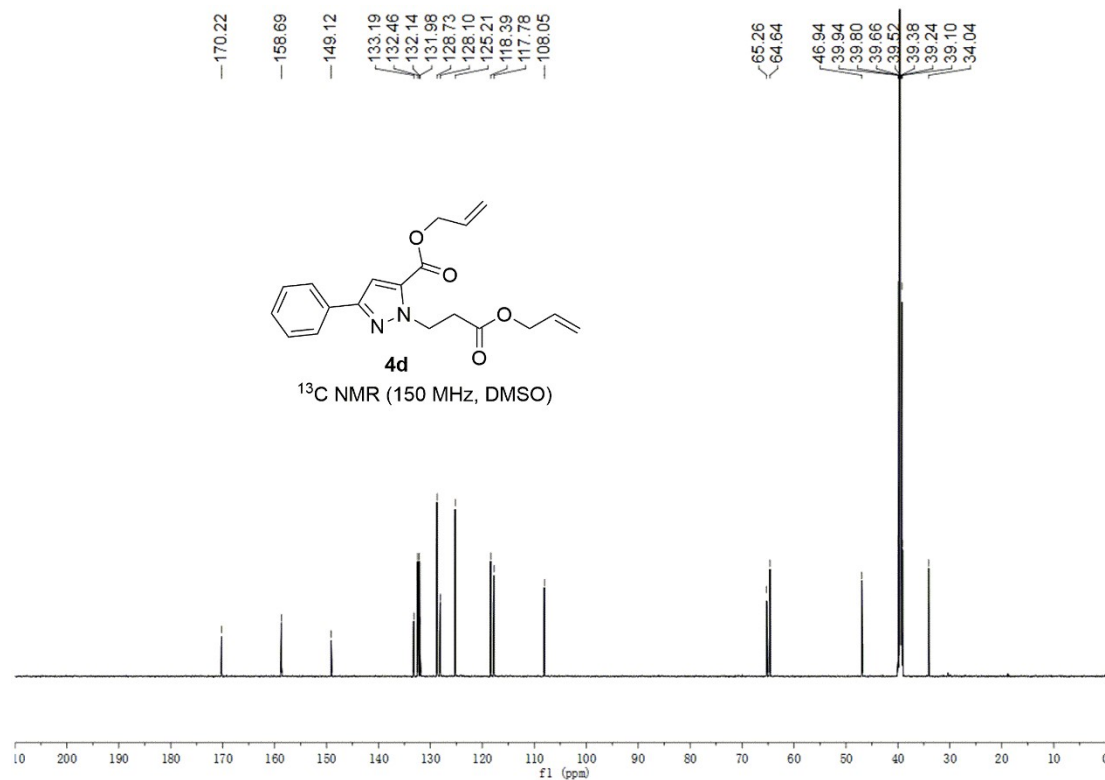
Butyl 1-(3-butoxy-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4c): ¹³C NMR



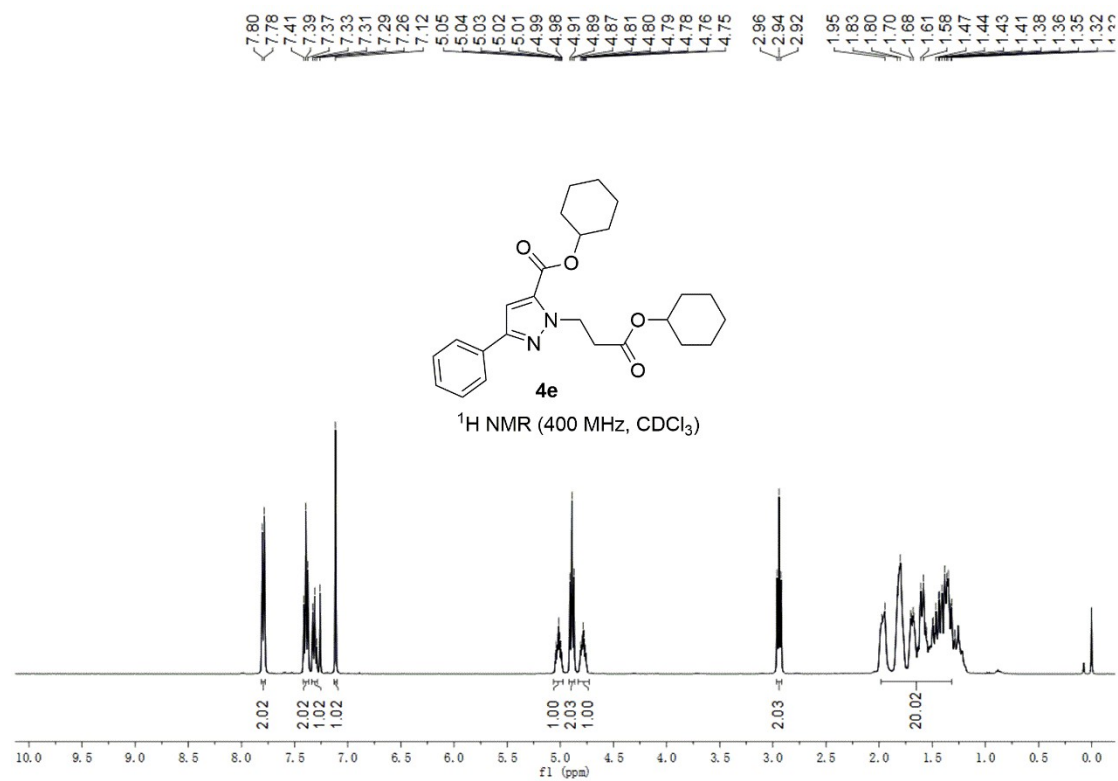
Allyl 1-(3-(allyloxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4d): ¹H NMR



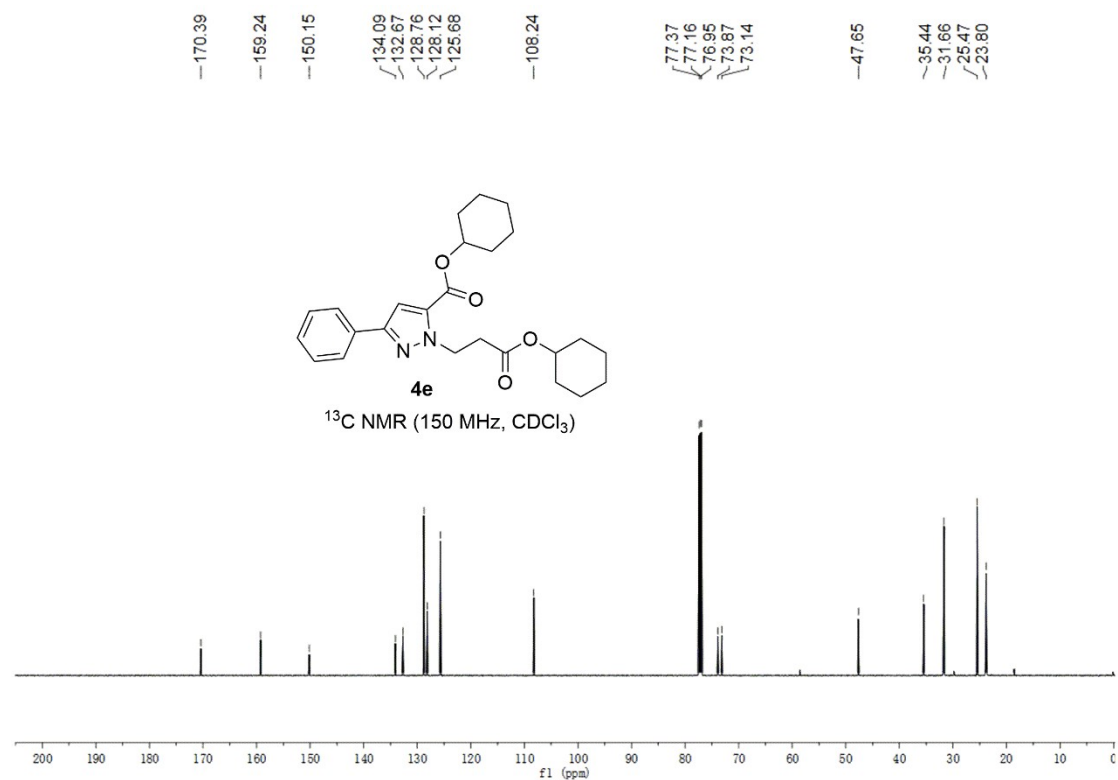
Allyl 1-(3-(allyloxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4d): ¹³C NMR



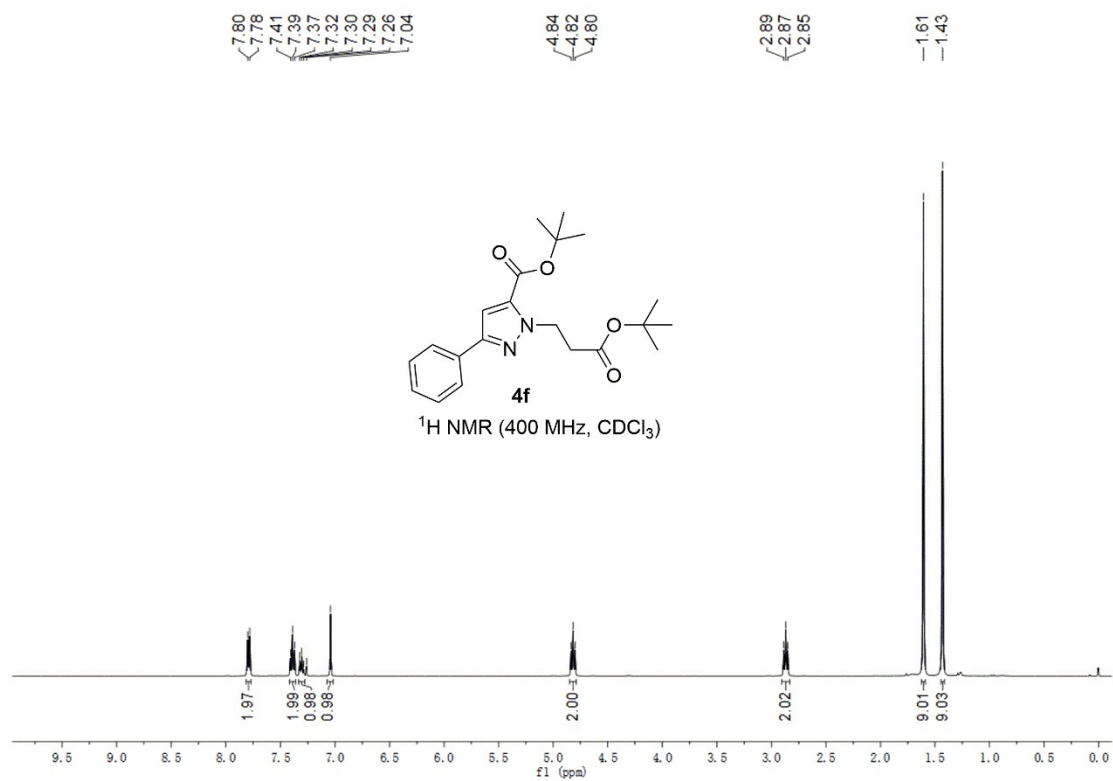
Cyclohexyl 1-(3-(cyclohexyloxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4e): ¹H NMR



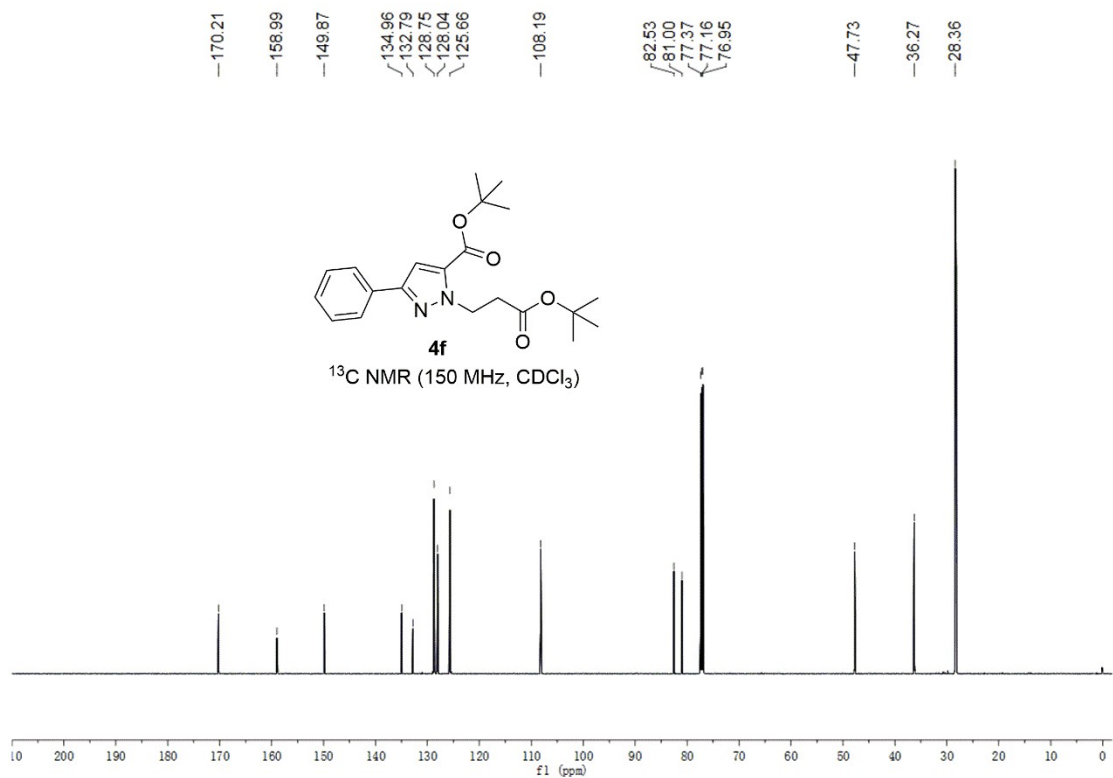
Cyclohexyl 1-(3-(cyclohexyloxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4e): ¹³C NMR



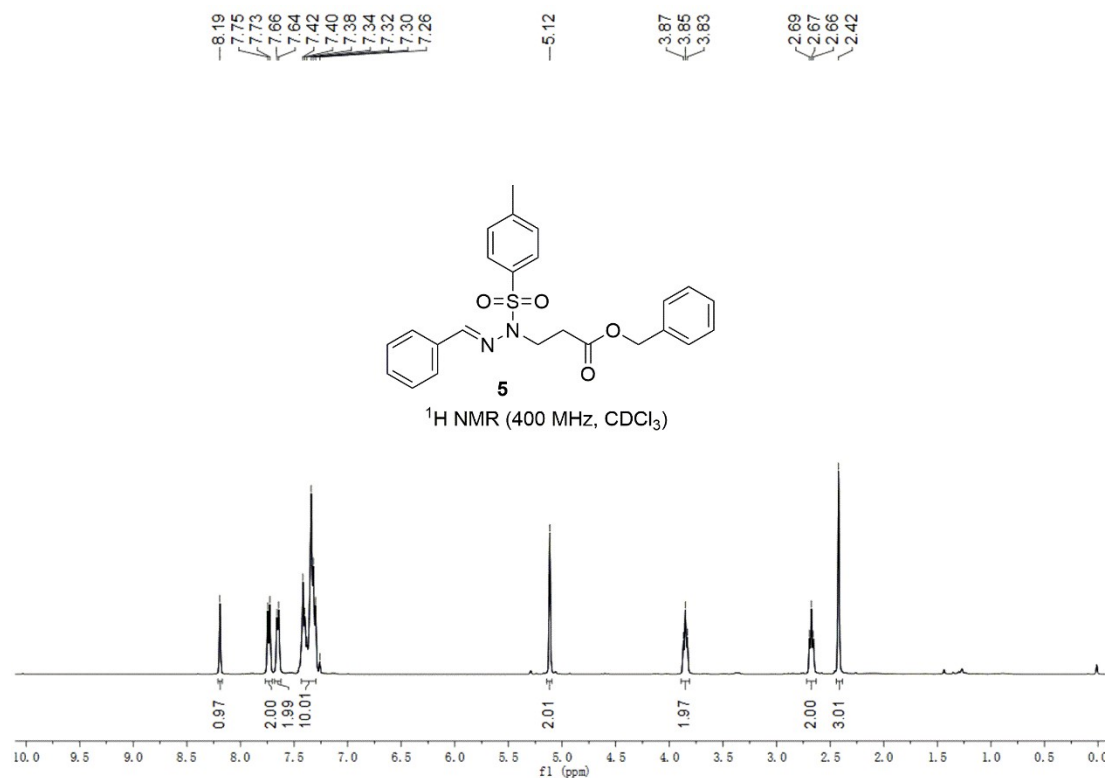
Tert-butyl 1-(3-(tert-butoxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4f): ¹H NMR



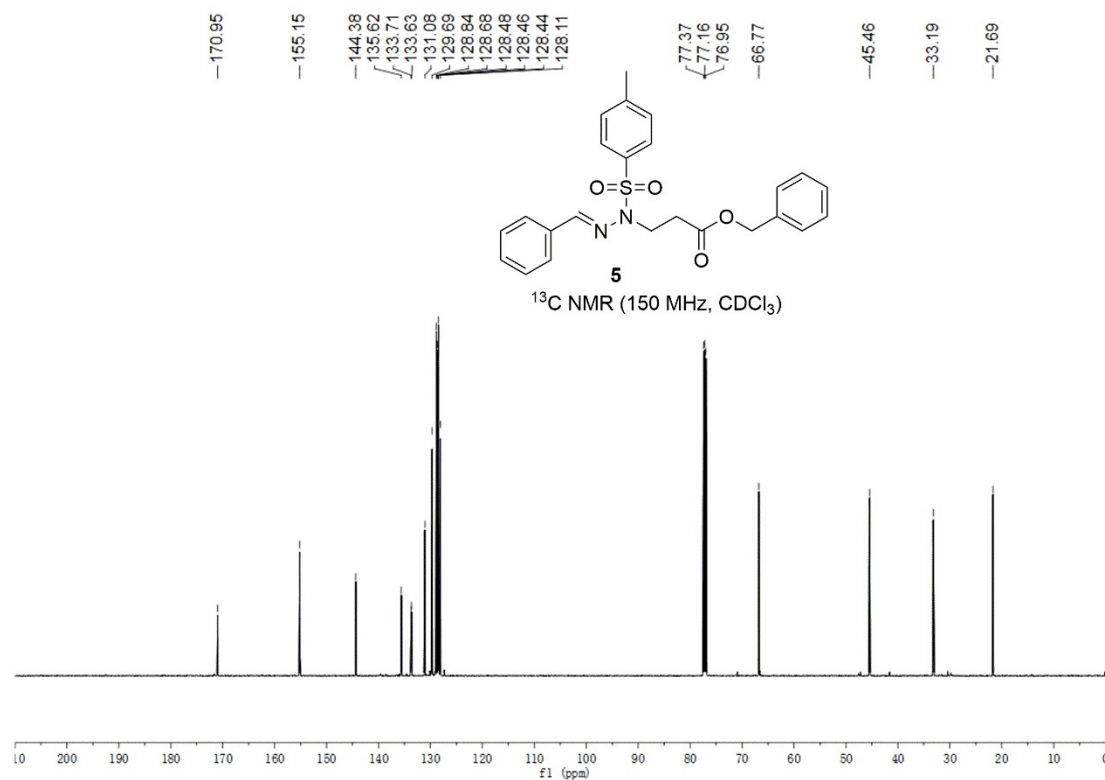
Tert-butyl 1-(3-(tert-butoxy)-3-oxopropyl)-3-phenyl-1H-pyrazole-5-carboxylate (4f): ¹³C NMR



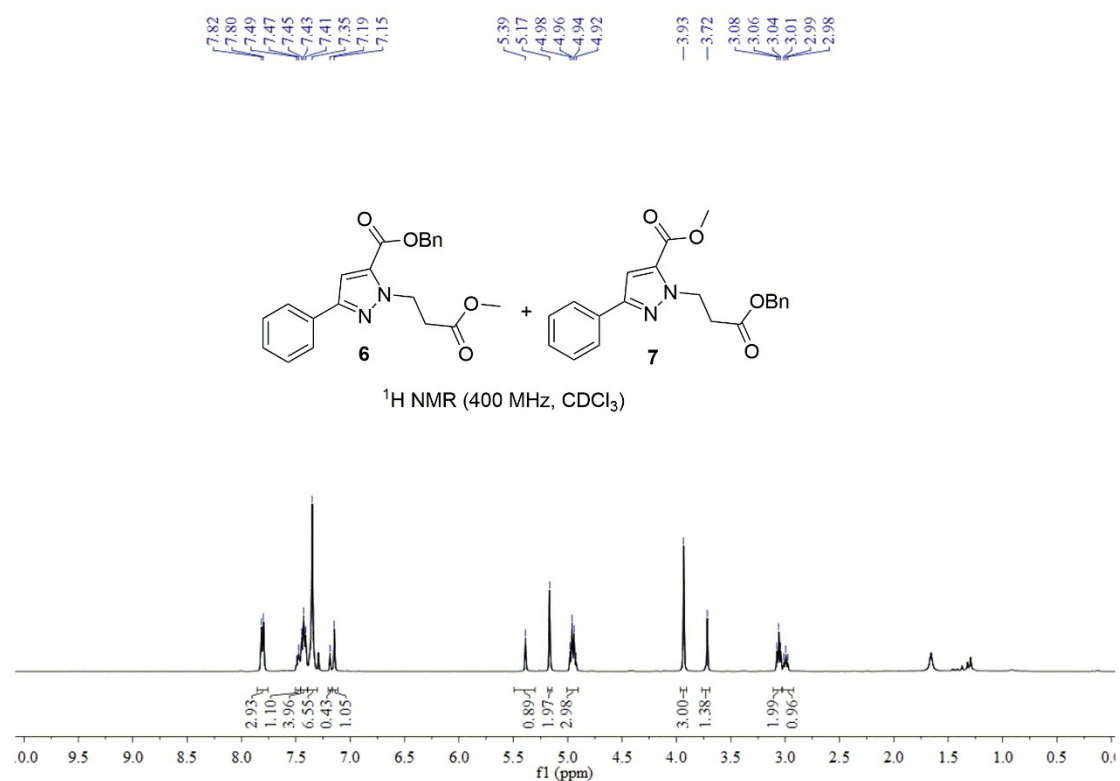
Benzyl (E)-3-(2-benzylidene-1-tosylhydrazinyl)propanoate (5): ¹H NMR



Benzyl (E)-3-(2-benzylidene-1-tosylhydrazinyl)propanoate (5): ¹³C NMR



The mixture of compound 6 and 7: ¹H NMR



The mixture of compound 6 and 7: ¹³C NMR

