Supplementary Information (SI) for Green Chemistry.

Electrochemical dehydrogenative annulation for the synthesis of 4-oxo-oxazolines

Yong Yuan,* Xincong Liu, Feng Zhang, Chunyan Bai, Yuyan Tao, Xiazhen Bao, Dongsheng Ji, and Congde Huo

College of Chemistry and Chemical Engineering, Northwest Normal University, Lanzhou, Gansu 730070, China

*Email: yuanyong@nwnu.edu.cn

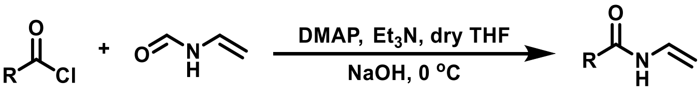
Table of Contents

1. General Information

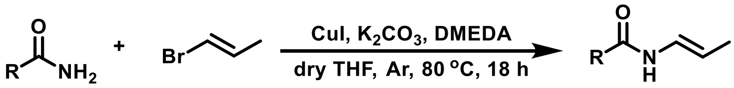
All glassware was oven dried at 110 ºC for hours and cooled down under vacuum. Unless otherwise noted, materials were obtained from commercial suppliers and used without further purification. Flash column chromatography was performed with silica gel (200 - 300 mesh). Cyclic voltammograms were recorded on a CHI 660E potentiostat. ^{1}H NMR, ^{13}C NMR, and ^{19}F NMR experiments were carried out using Vnmr Mercury plus 400 MHz or Agilent DD2-600 MHz spectrometers. All chemical shifts (δ) are reported in ppm relative to internal tetramethyl silane (TMS, 0 ppm) for ^{1}H, $CDCl_3$ (77.16 ppm) or DMSO-d_6 (39.52 ppm) for ^{13}C. The abbreviations used for explaining the multiplicities were as follows: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad. Coupling constants (*J*) are reported in Hz. High-resolution mass spectra (HRMS) spectra were obtained from the Thermo Fisher Q-Exactive mass spectrometer in electrospray ionization (ESI$^+$) mode. X-ray crystallographic analyses were performed on a Rigaku XtaL AB Synergy-DW diffractometer.

2. Experimental Details

2.1 General procedure for the synthesis of enamides[1]

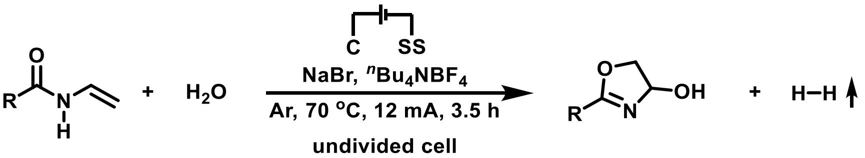


An oven-dried 100 mL two-neck glass tube was equipped with a stir bar was charged with freshly distilled *N*-vinylformamide (10 mmol) and dry THF (40 mL) under an argon atmosphere. Triethylamine (1.4 equiv., 1.9 mL) was added via syringe and the reaction mixture was then cooled to 0 °C. The corresponding acyl chloride (1.2 equiv.) was added dropwise via syringe followed by the slow addition of 4-dimethylamino pyridine (10 mol%, 0.12 g). The reaction was warmed to room temperature and let stir until the reaction was completed by TLC monitoring. After the reaction was cooled to 0 °C, 5 N NaOH was added. The reaction mixture was next stirred vigorously at room temperature until complete consumption of the imide (TLC). The reaction mixture was diluted with water (30 mL) and extracted with EtOAc (30 mL × 3). The combined organic layers were dried (Na_2SO_4), filtered, and concentrated. Target product was finally purified by flash column chromatography on silica gel (petroleum ether : ethyl acetate = 15:1 to 10:1).



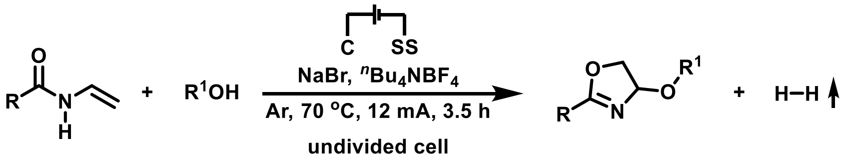
An oven-dried 100 mL two-neck glass tube was equipped with a stir bar was charged with freshly distilled (E)-1-bromoprop-1-ene (10 mmol, 1.2 g) and dry THF (40 mL) under an argon atmosphere. CuI (10% mol, 0.2 g), DMEDA (40 mol%, 0.35 g) and K_2CO_3 (2 equiv., 2.76 g) were added via syringe and the reaction mixture was then heat up to 80 °C. The corresponding amide (1.2 equiv.) was added dropwise via syringe. The reaction was warmed 18 h and let stir until the reaction was completed by TLC monitoring. The reaction mixture was diluted with water (30 mL) and extracted with EtOAc (30 mL × 3). The combined organic layers were dried (Na_2SO_4), filtered, and concentrated. Target product was finally purified by flash column chromatography on silica gel (petroleum ether : ethyl acetate = 15:1 to 10:1).

2.2 General procedure for the electrochemical dehydrogenative annulation for the synthesis of 4-hydroxy substituted oxazolines



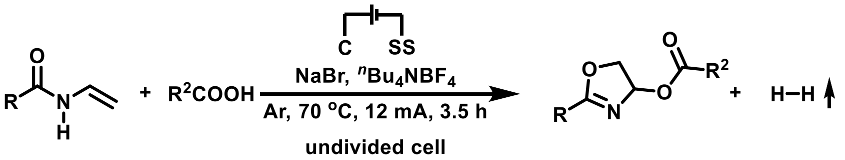
In an oven-dried undivided three-necked bottle (25 mL) equipped with a stir bar, enamides (0.5 mmol), water (1.5 mL), NaBr (1.0 mmol, 2.0 equiv., 102 mg) and ${}^{n}Bu_4NBF_4$ (0.5 mmol, 1.0 equiv., 165 mg) were combined and added. The bottle was equipped with a carbon cloth (15 mm × 15 mm × 0.33 mm) anode and a stainless steel plate (15 mm × 15 mm × 1 mm) cathode and was then charged with argon. Under the protection of argon, MeCN (10.5 mL) was injected into the tubes via syringes. The reaction mixture was stirred and electrolyzed at a constant current of 12 mA at 70 °C for 3.5 h. After the reaction was completed, the reaction mixture was concentrated under reduced pressure. The pure product was obtained by flash column chromatography on silica gel (petroleum ether : ethyl acetate = 2:1 to 1:1).

2.3 General procedure for the electrochemical dehydrogenative annulation for the synthesis of 4-alkoxy substituted oxazolines



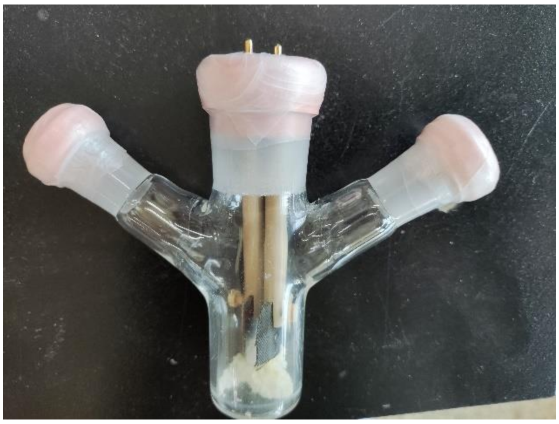
In an oven-dried undivided three-necked bottle (25 mL) equipped with a stir bar, enamides (0.5 mmol), alcohols (0.5 mL), NaBr (1.0 mmol, 2.0 equiv., 102 mg) and ${}^{n}Bu_4NBF_4$ (0.5 mmol, 1.0 equiv., 165 mg) were combined and added. The bottle was equipped with a carbon cloth (15 mm × 15 mm × 0.33 mm) anode and a stainless steel plate (15 mm × 15 mm × 1 mm) cathode and was then charged with argon. Under the protection of argon, MeCN (10.5 mL) was injected into the tubes via syringes. The reaction mixture was stirred and electrolyzed at a constant current of 12 mA at 70 ºC for 3.5 h. After the reaction was completed, the reaction mixture was concentrated under reduced pressure. The pure product was obtained by flash column chromatography on silica gel (petroleum ether : ethyl acetate = 10:1 to 4:1).

2.4 General procedure for the electrochemical dehydrogenative annulation for the synthesis of 4- acyloxy substituted oxazolines

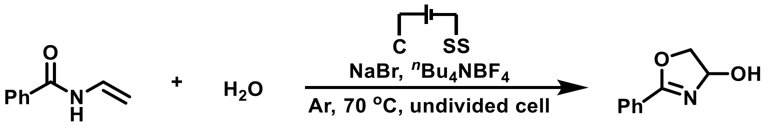


In an oven-dried undivided three-necked bottle (25 mL) equipped with a stir bar, enamides (0.5 mmol), acids (2 equiv.), NaBr (1.0 mmol, 2.0 equiv., 102 mg) and ^{n}Bu$_4$NBF$_4$ (0.5 mmol, 1.0 equiv., 165 mg) were combined and added. The bottle was equipped with a carbon cloth (15 mm × 15 mm × 0.33 mm) anode and a stainless steel plate (15 mm × 15 mm × 1 mm) cathode and was then charged with argon. Under the protection of argon, MeCN (10.5 mL) was injected into the tubes via syringes. The reaction mixture was stirred and electrolyzed at a constant current of 12 mA at 70 ºC for 3.5 h. After the reaction was completed, the reaction mixture was concentrated under reduced pressure. The pure product was obtained by flash column chromatography on silica gel (petroleum ether : ethyl acetate = 10:1 to 4:1).

2.5 The experimental setup for electrolysis



2.6 Procedure for the gram scale synthesis of 2a



10 mmol 30 mL **2a,** 72% (1.17 g)

In an oven-dried undivided three-necked bottle equipped with a stir bar, N-vinylbenzamide (10.0 mmol, 1.5 g), water (30 mL), NaBr (10.0 mmol, 1.0 equiv., 2.1 g) and ^{n}Bu$_4$NBF$_4$ (1.0 mmol, 0.1 equiv., 0.33 g) were combined and added. The bottle was equipped with two carbon cloths (15 mm × 30 mm × 0.33 mm) as the anodes and two stainless steel plates (15 mm × 30 mm × 1 mm) as the cathodes and was then charged with argon. Under the protection of argon, MeCN (80 mL) was injected into the tubes via syringes. The reaction mixture was stirred and electrolyzed at a constant current of 48 mA at 70 ºC for 8.75 h. After the reaction was completed, the reaction mixture was concentrated under reduced pressure. The pure product was obtained by flash column chromatography on silica gel (petroleum ether : ethyl acetate = 1:1) with 72% as a white solid.

3. Mechanistic Investigations

3.1 Cyclic voltammetry study

Cyclic voltammetry (CV) experiments were conducted in an electrolyte of $^{n}Bu_4NPF_6$ (0.01 M) in MeCN and H_2O using a glassy carbon disk working electrode (diameter, 1 mm), a Pt wire auxiliary electrode and a Ag/AgCl reference electrode. The scan rate is 100 mV/s.

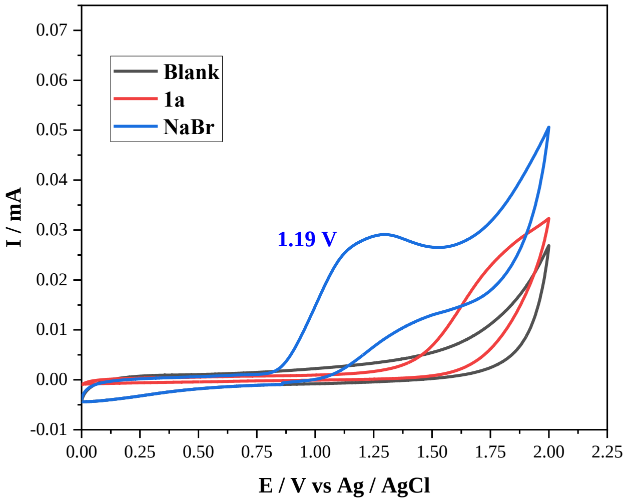
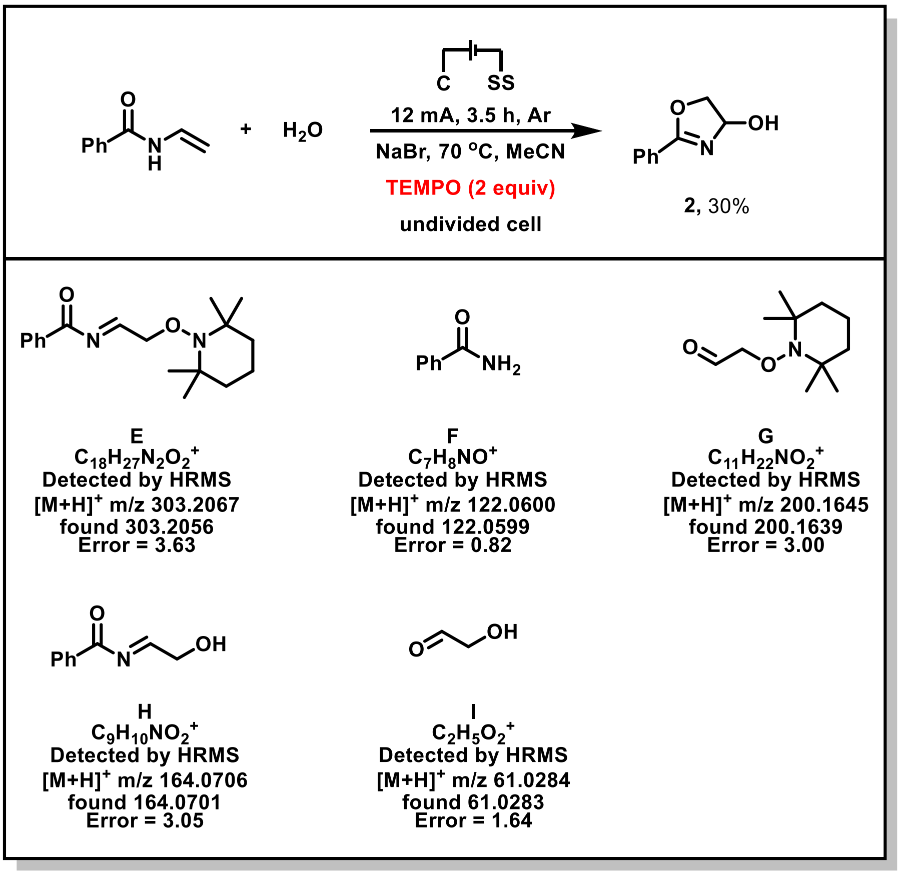
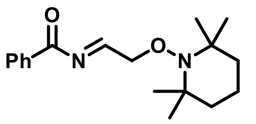


Fig. S1. Cyclic voltammogram of **1a**, **NaBr**, and their mixture in MeCN and H_2O. Conditions: $^{n}Bu_4NPF_6$ (0.1 M in MeCN), and with (a) **1a** (2.0 mM), (b) **NaBr** (2.0 mM), or. Scan rate: 100 mV/s.

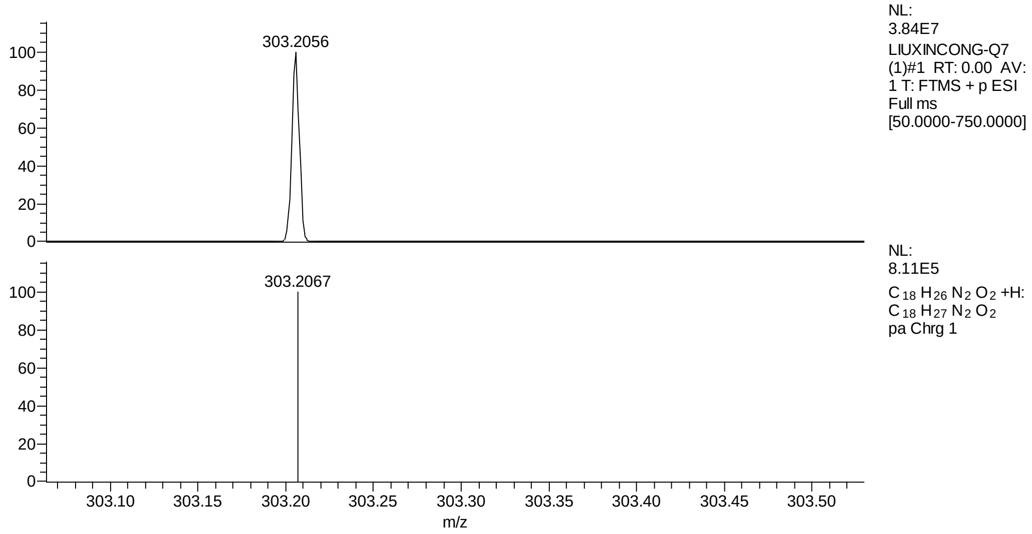
3.2 Radical trapping by TEMPO

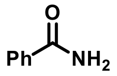
In an oven-dried undivided three-necked bottle (25 mL) equipped with a stir bar, N-vinylbenzamide (0.5 mmol, 1.0 equiv., 73 mg), water (1.5 mL), NaBr (1.0 mmol, 2.0 equiv., 102 mg) and 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO) (1.0 mmol, 2.0 equiv., 156 mg) were combined and added. The bottle was equipped with a carbon cloth (15 mm × 15 mm × 0.33 mm) anode and a stainless steel plate (15 mm × 15 mm × 1 mm) cathode and was then charged with argon. Under the protection of argon, MeCN (11.5 mL) was injected into the tubes via syringes. The reaction mixture was stirred and electrolyzed at a constant current of 12 mA at 70 °C for 3.5 h. After the reaction was completed, the reaction mixture was concentrated under reduced pressure. Pure product obtained by silica gel rapid column chromatography with a yield of 30%. Other intermediate products were detected by HRMS analysis of the reaction mixture.



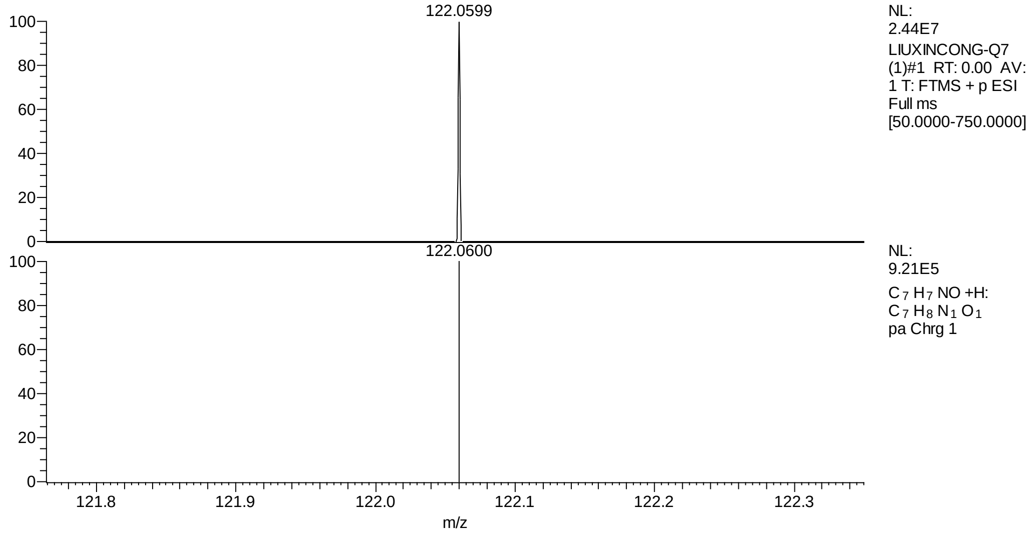


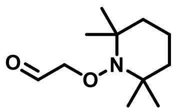
E
$C_{18}H_{27}N_2O_2^+$
Detected by HRMS
$[M+H]^+$ m/z 303.2067
found 303.2056
Error = 3.63



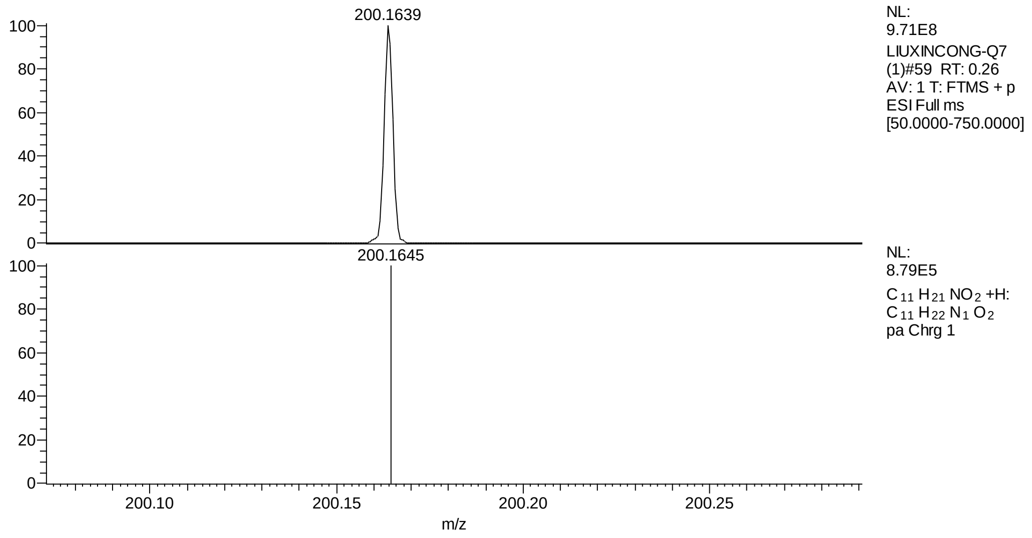


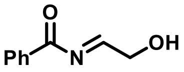
F
$C_7H_8NO^+$
Detected by HRMS
$[M+H]^+$ m/z 122.0600
found 122.0599
Error = 0.82



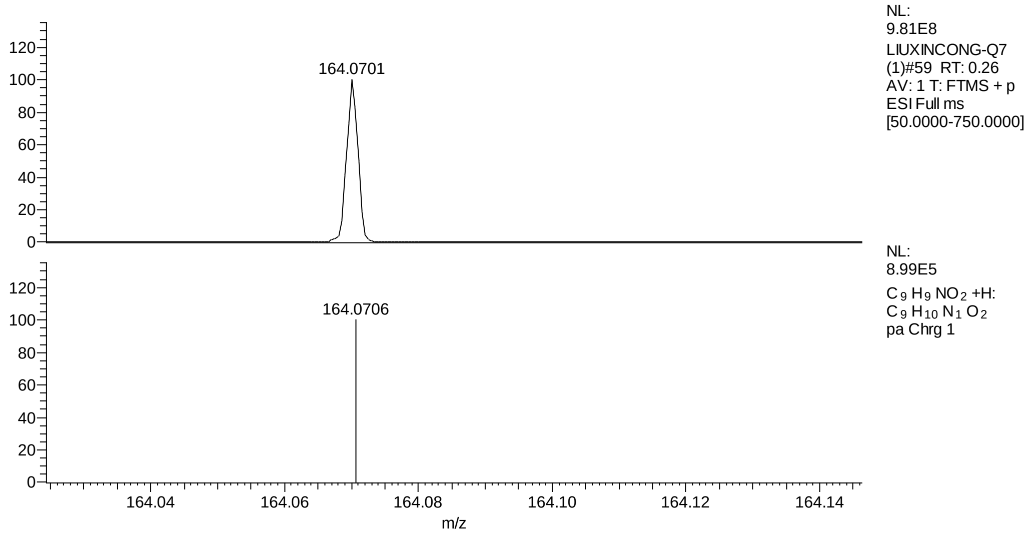


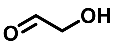
G
$C_{11}H_{22}NO_2^+$
Detected by HRMS
$[M+H]^+$ m/z 200.1645
found 200.1639
Error = 3.00





H
$C_9H_{10}NO_2^+$
Detected by HRMS
$[M+H]^+$ m/z 164.0706
found 164.0701
Error = 3.05





I

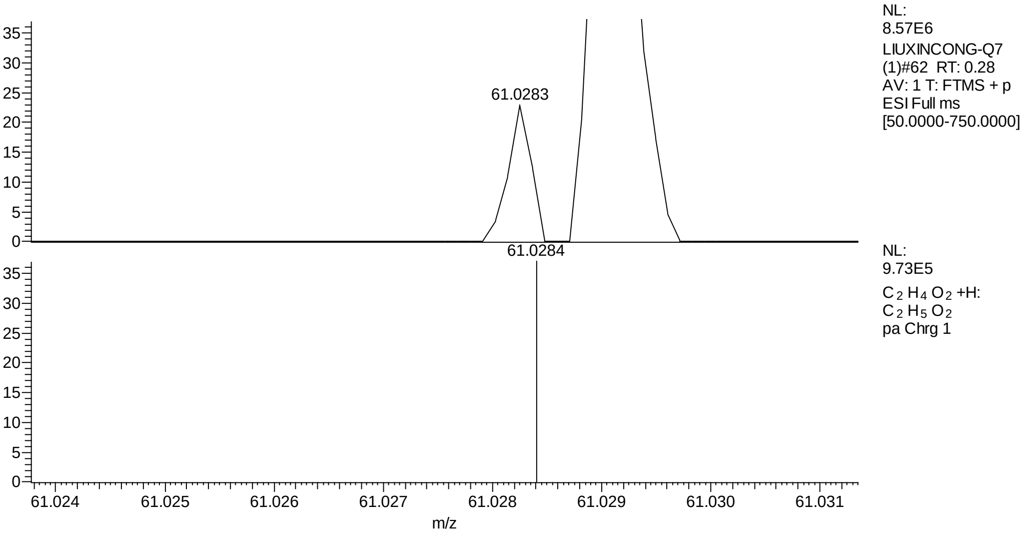
$C_2H_5O_2^+$

Detected by HRMS

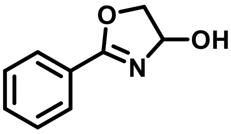
$[M+H]^+$ m/z 61.0284

found 61.0283

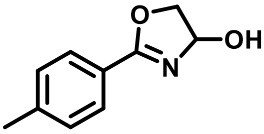
Error = 1.64



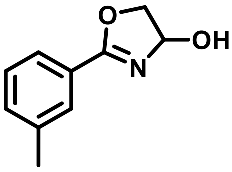
4. Characterization of the products



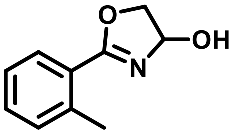
2-Phenyl-4,5-dihydrooxazol-4-ol (2a). The desired pure product was obtained in 89% yield (73 mg) as a white solid. M.P. = 88 ºC - 90 ºC. ^{1}H NMR (400 MHz, DMSO-*d6*) δ 7.90 (d, *J* = 6.4 Hz, 2H), 7.55 - 7.53 (m, 1H), 7.48 - 7.45 (m, 2H), 6.18 (s, 1H), 5.74 - 5.73 (m, 1H), 4.40 - 4.04 (m, 2H). ^{13}C NMR (151 MHz, DMSO-*d6*) δ 164.3, 132.2, 129.1, 128.5, 127.8, 90.0, 74.4. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_9H_{10}NO_2$ 164.0706; found 164.0706.



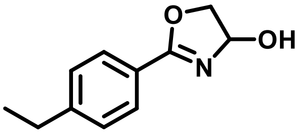
2-(*p*-Tolyl)-4,5-dihydrooxazol-4-ol (2b). The desired pure product was obtained in 78% yield (69 mg) as a white solid. M.P. = 103 ºC - 105 ºC. ^{1}H NMR (400 MHz, CDCl$_3$) δ 7.84 (d, *J* = 8.2 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 6.01 (dd, *J* = 7.0, 4.4 Hz, 1H), 4.47 - 4.33 (m, 2H), 2.38 (s, 3H). ^{13}C NMR (151 MHz, CDCl$_3$) δ 166.8, 142.7, 129.2, 128.6, 124.0, 89.2, 74.2, 21.6. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_{10}H_{12}NO_2$ 178.0863; found 178.0862.



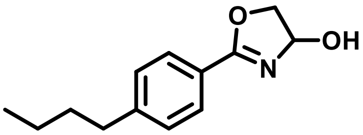
2-(*m*-Tolyl)-4,5-dihydrooxazol-4-ol (2c). The desired pure product was obtained in 71% yield (63 mg) as a white solid. M.P. = 107 ºC - 109 ºC. ^{1}H NMR (600 MHz, CDCl$_3$) δ 7.77 (s, 2H), 7.32 - 7.30 (m, 2H), 6.02 (dd, *J* = 7.0, 4.4 Hz, 1H), 4.47 - 4.34 (m, 2H), 2.39 (s, 3H). ^{13}C NMR (151 MHz, CDCl$_3$) δ 166.9, 138.2, 132.9, 129.2, 128.4, 126.8, 125.8, 89.3, 74.2, 21.3. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{10}H_{12}NO_2$ 178.0863; found 178.0862.



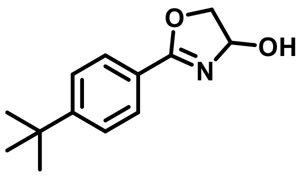
2-(*o*-Tolyl)-4,5-dihydrooxazol-4-ol (2d). The desired pure product was obtained in 74% yield (66 mg) as a white solid. M.P. = 117 °C - 119 °C. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.80 (d, *J* = 7.4 Hz, 1H), 7.36 (t, *J* = 7.5 Hz, 1H), 7.24 (d, *J* = 7.4 Hz, 2H), 5.99 (dd, *J* = 7.1, 4.5 Hz, 1H), 4.42 - 4.27 (m, 2H), 2.57 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 167.7, 138.8, 131.3, 131.2, 130.1, 126.5, 125.7, 89.5, 73.6, 21.5. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{10}H_{12}NO_2$ 178.0863; found 178.0860.



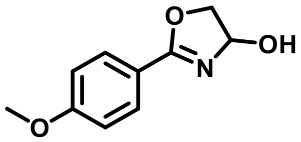
2-(4-Ethylphenyl)-4,5-dihydrooxazol-4-ol (2e). The desired pure product was obtained in 85% yield (82 mg) as a white solid. M.P. = 93 °C - 95 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.0 Hz, 2H), 7.25 (d, *J* = 7.7 Hz, 2H), 6.03 - 6.00 (m, 1H), 4.48 - 4.34 (m, 2H), 2.68 (dd, *J* = 15.1, 7.6 Hz, 2H), 1.23 (t, *J* = 7.6 Hz, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.9, 148.9, 128.7, 128.0, 124.2, 89.3, 74.2, 28.9, 15.2. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{11}H_{14}NO_2$ 192.1019; found 192.1019.



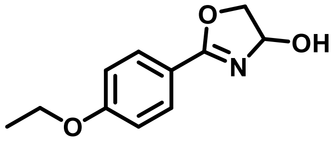
2-(4-Butylphenyl)-4,5-dihydrooxazol-4-ol (2f). The desired pure product was obtained in 96% yield (112 mg) as a white solid. M.P. = 115 °C - 117 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.3 Hz, 2H), 7.23 (d, *J* = 7.9 Hz, 2H), 6.01 (dd, *J* = 7.0, 4.3 Hz, 1H), 4.48 - 4.33 (m, 2H), 2.65 (t, *J* = 7.7 Hz, 2H), 1.64 - 1.56 (m, 2H), 1.40 - 1.30 (m, 2H), 0.92 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.9, 147.6, 128.6, 128.6, 124.2, 89.2, 74.2, 35.6, 33.2, 22.3, 13.9. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{13}H_{18}NO_2$ 220.1332; found 220.1333.



2-(4-(*tert*-Butyl) phenyl)-4,5-dihydrooxazol-4-ol (2g). The desired pure product was obtained in 84% yield (92 mg) as a white solid. M.P. = 110 °C - 112 °C. ^1H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, J = 8.4 Hz, 2H), 7.45 (d, J = 8.3 Hz, 2H), 6.02 (dd, J = 7.1, 4.4 Hz, 1H), 4.48 - 4.34 (m, 2H), 1.32 (s, 9H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.8, 155.7, 128.5, 125.5, 124.0, 89.2, 74.2, 35.0, 31.1. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{13}H_{18}NO_2$ 220.1332; found 220.1331.

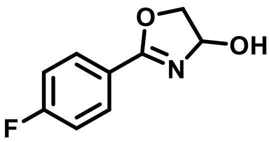


2-(4-Methoxyphenyl)-4,5-dihydrooxazol-4-ol (2h). The desired pure product was obtained in 66% yield (63 mg) as a white solid. M.P. = 128 °C - 130 °C. ^1H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, J = 8.8 Hz, 2H), 6.91 (d, J = 8.8 Hz, 2H), 5.99 (dd, J = 7.0, 4.3 Hz, 1H), 4.46 - 4.31 (m, 2H), 3.82 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.5, 162.7, 130.5, 119.2, 113.9, 89.2, 74.2, 55.3. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{10}H_{12}NO_3$ 194.0812; found 194.0813.

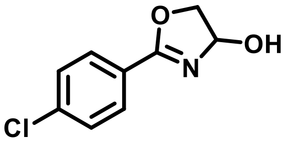


2-(4-Ethoxyphenyl)-4,5-dihydrooxazol-4-ol (2i). The desired pure product was obtained in 87% yield (90 mg) as a white solid. M.P. = 143 °C - 145 °C. ^1H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, J = 8.8 Hz, 2H), 6.91 (d, J = 8.8 Hz, 2H), 6.01 (dd, J = 6.9, 4.3 Hz, 1H), 4.48 - 4.33 (m, 2H), 4.06 (q, J = 7.0 Hz, 2H), 1.42 (t, J = 7.0 Hz, 3H). ^{13}C

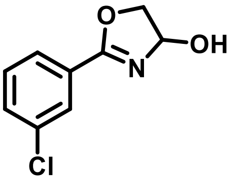
NMR (151 MHz, $CDCl_3$) δ 166.6, 162.1, 130.5, 119.0, 114.3, 89.3, 74.2, 63.6, 14.7. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{11}H_{14}NO_3$ 208.0968; found 208.0968.



2-(4-Fluorophenyl)-4,5-dihydrooxazol-4-ol (2j). The desired pure product was obtained in 80% yield (73 mg) as a white solid. M.P. = 127 °C - 129 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 - 7.96 (m, 2H), 7.14 - 7.09 (m, 2H), 6.01 (dd, *J* = 7.0, 4.3 Hz, 1H), 4.51 - 4.34 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.9, 131.1 (d, *J* = 15.1 Hz), 115.8 (d, *J* = 15.1 Hz), 89.4, 74.4. ^{19}F NMR (376 MHz, $CDCl_3$) δ -106.47. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_9H_9FNO_2$ 182.0612; found 182.0611.

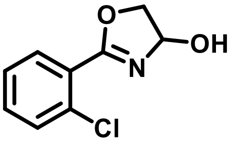


2-(4-Chlorophenyl)-4,5-dihydrooxazol-4-ol (2k). The desired pure product was obtained in 78% yield (77 mg) as a white solid. M.P. = 112 °C - 114 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 8.5 Hz, 2H), 7.42 (d, *J* = 8.5 Hz, 2H), 6.00 (dd, *J* = 6.9, 4.4 Hz, 1H), 4.51 - 4.34 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.0, 138.5, 130.0, 128.8, 125.4, 89.7, 74.4. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_9H_9ClNO_2$ 198.0316; found 198.0317.

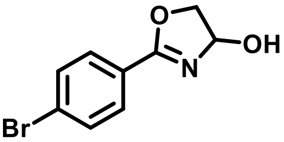


2-(3-Chlorophenyl)-4,5-dihydrooxazol-4-ol (2l). The desired pure product was obtained in 68% yield (67 mg) as a white solid. M.P. = 114 °C - 116 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (s, 1H), 7.86 (d, *J* = 7.8 Hz, 1H), 7.51 - 7.48 (m, 1H), 7.40 - 7.36 (m, 1H), 6.01 (dd, *J* = 7.0, 4.4 Hz, 1H), 4.52 - 4.35 (m, 2H). ^{13}C NMR (151 MHz,

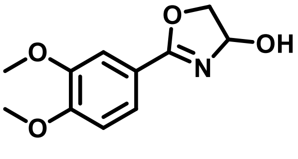
$CDCl_3$) δ 165.7, 132.2, 129.8, 128.7, 127.7, 126.8, 125.4, 89.5, 74.4. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_9H_{10}ClNO_2$ 198.0316; found 198.0314.



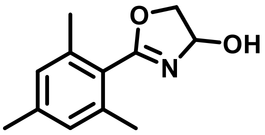
2-(2-Chlorophenyl)-4,5-dihydrooxazol-4-ol (2m). The desired pure product was obtained in 72% yield (71 mg) as a white solid. M.P. = 105 °C - 106 °C. ^1H NMR (400 MHz, $CDCl_3$) δ 7.82 - 7.79 (m, 1H), 7.48 - 7.39 (m, 2H), 7.35 - 7.31 (m, 1H), 6.05 (dd, J = 7.2, 4.5 Hz, 1H), 4.49 - 4.31 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.3, 133.6, 132.2, 131.4, 130.9, 126.7, 126.6, 89.7, 73.9. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_9H_{10}ClNO_2$ 198.0316; found 198.0316.



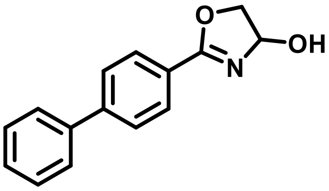
2-(4-Bromophenyl)-4,5-dihydrooxazol-4-ol (2n). The desired pure product was obtained in 82% yield (99 mg) as a white solid. M.P. = 152 °C - 154 °C. ^1H NMR (400 MHz, DMSO-d_6) δ 7.81 (d, J = 8.6 Hz, 2H), 7.69 (d, J = 8.6 Hz, 2H), 6.20 - 6.19 (m, 1H), 5.75 - 5.70 (m, 1H), 4.42 - 4.02 (m, 2H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 163.6, 132.3, 130.5, 127.0, 126.0, 90.0, 74.6. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_9H_9BrNO_2$ 241.9811; found 241.9812.



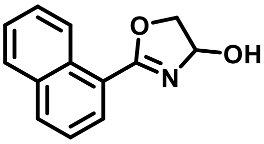
2-(3,4-Dimethoxyphenyl)-4,5-dihydrooxazol-4-ol (2o). The desired pure product was obtained in 86% yield (117 mg) as a white solid. M.P. = 138 °C - 140 °C. ^1H NMR (400 MHz, $CHCl_3$) δ 7.59 (d, J = 8.5 Hz, 1H), 7.51 (s, 1H), 6.89 (d, J = 8.3 Hz, 1H), 5.98 (s, 1H), 4.46 - 4.32 (m, 2H), 3.93 (s, 6H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.8, 152.3, 148.7, 122.4, 119.3, 111.2, 110.5, 89.5, 74.4, 56.0, 55.9. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{11}H_{14}NO_4$ 224.0917; found 224.0917.



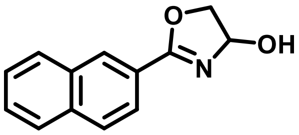
2,4,6-Trimethyl-4,5-dihydroxazol-4-ol (2p). The desired pure product was obtained in 68% yield (70 mg) as a white solid. M.P. = 135 °C - 137 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.86 (s, 2H), 5.92 (dd, *J* = 7.0, 4.2 Hz, 1H), 4.37 - 4.21 (m, 2H), 2.30 (s, 6H), 2.28 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 167.7, 139.6, 136.7, 128.3, 125.1, 89.3, 73.7, 21.1, 19.5. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{12}H_{16}NO_2$ 206.1176; found 206.1176.



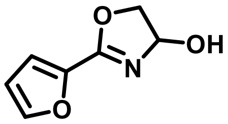
2-([1,1'-Biphenyl]-4-yl)-4,5-dihydrooxazol-4-ol (2q). The desired pure product was obtained in 70% yield (84 mg) as a white solid. M.P. = 175 °C - 177 °C. ^{1}H NMR (600 MHz, DMSO-*d*$_6$) δ 7.97 - 7.95 (m, 2H), 7.78 (d, *J* = 2.0 Hz, 2H), 7.72 - 7.69 (m, 3H), 7.48 - 7.44 (m, 2H), 6.19 (d, *J* = 6.0 Hz, 1H), 5.77 - 5.74 (m, 1H), 4.42 - 4.39 (m, 2H). ^{13}C NMR (151 MHz, DMSO-*d*$_6$) δ 164.1, 143.7, 139.4, 129.5, 128.6, 127.3, 127.2, 126.9, 126.8, 90.0, 74.4. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{15}H_{14}NO_2$ 240.1019; found 240.1023.



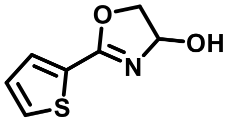
2-(Naphthalen-1-yl)-4,5-dihydrooxazol-4-ol (2r). The desired pure product was obtained in 78% yield (85 mg) as a white solid. M.P. = 120 °C - 122 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.87 (d, *J* = 8.5 Hz, 1H), 8.08 (d, *J* = 7.3 Hz, 1H), 7.98 (d, *J* = 8.2 Hz, 1H), 7.88 (d, *J* = 8.0 Hz, 1H), 7.63 - 7.47 (m, 3H), 6.08 (dd, *J* = 7.1, 4.4 Hz, 1H), 5.93 (s, 1H), 4.48 - 4.32 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 167.3, 133.7, 132.5, 130.9, 129.4, 128.5, 127.4, 126.3, 125.9, 124.7, 124.2, 90.0, 73.7. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{13}H_{12}NO_2$ 214.0863; found 214.0861.



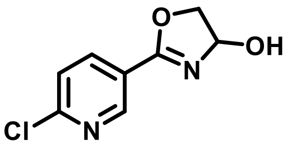
2-(Naphthalen-2-yl)-4,5-dihydrooxazol-4-ol (2s). The desired pure product was obtained in 86% yield (92 mg) as a white solid. M.P. = 143 °C - 145 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49 (s, 1H), 8.04 (d, *J* = 8.6 Hz, 1H), 7.94 - 7.85 (m, 3H), 7.60 - 7.51 (m, 2H), 6.13 - 6.10 (m, 1H), 4.58 - 4.43 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.9, 135.1, 132.6, 129.7, 129.1, 128.4, 128.0, 127.8, 126.7, 124.7, 124.2, 89.6, 74.4. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{13}H_{12}NO_2$ 214.0863; found 214.0862.



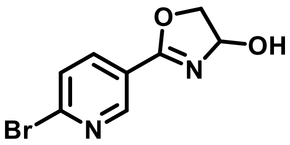
2-(Furan-2-yl)-4,5-dihydrooxazol-4-ol (2t). The desired pure product was obtained in 57% yield (44 mg) as a white solid. M.P. = 100 °C - 102 °C. ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.59 - 7.58 (m, 1H), 7.06 (d, *J* = 3.5 Hz, 1H), 6.50 - 6.49 (m, 1H), 6.01 (dd, *J* = 6.8, 4.2 Hz, 1H), 4.44 - 4.32 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 158.7, 146.1, 142.2, 116.2, 111.7, 89.3, 74.4. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_7H_8NO_3$ 154.0499; found 154.0501.



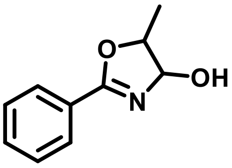
2-(Thiophen-2-yl)-4,5-dihydrooxazol-4-ol (2u). The desired pure product was obtained in 87% yield (74 mg) as a white solid. M.P. = 88 °C - 90 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 (d, *J* = 3.7 Hz, 1H), 7.52 (d, *J* = 4.7 Hz, 1H), 7.11 - 7.09 (m, 1H), 6.00 (dd, *J* = 6.9, 4.2 Hz, 1H), 4.49 - 4.35 (m, 2H). ^{13}C NMR (151 MHz, CDCl$_3$) δ 162.4, 131.8, 131.1, 129.3, 127.9, 89.4, 74.7. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_7H_8NO_2S$ 170.0270; found 170.0271.



2-(6-Chloropyridin-3-yl)-4,5-dihydrooxazol-4-ol (2v). The desired pure product was obtained in 74% yield (73 mg) as a white solid. M.P. = 135 ºC - 137 ºC. ^{1}H NMR (600 MHz, CDCl$_3$) δ 8.96 (d, *J* = 1.8 Hz, 1H), 8.19 (dd, *J* = 8.3, 2.4 Hz, 1H), 7.42 (d, *J* = 8.3 Hz, 1H), 6.01 (dd, *J* = 7.0, 4.4 Hz, 1H), 4.53 - 4.37 (m, 2H). ^{13}C NMR (151 MHz, CDCl$_3$) δ 164.2, 155.0, 150.0, 138.5, 124.3, 122.1, 89.4, 74.6. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_8H_8ClN_2O_2$ 199.0269; found 199.0269.

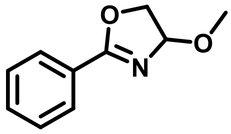


2-(6-Bromopyridin-3-yl)-4,5-dihydrooxazol-4-ol (2w). The desired pure product was obtained in 64% yield (68 mg) as a white solid. M.P. = 140 ºC - 142 ºC. ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.96 (d, *J* = 1.6 Hz, 1H), 8.19 (dd, *J* = 8.3, 2.4 Hz, 1H), 7.42 (d, *J* = 8.4 Hz, 1H), 6.01 (dd, *J* = 7.0, 4.4 Hz, 1H), 5.75 (s, 1H), 4.54 - 4.36 (m, 2H). ^{13}C NMR (151 MHz, CDCl$_3$) δ 164.2, 155.0, 150.0, 138.5, 124.3, 122.1, 89.5, 74.6. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_8H_8BrN_2O_2$ 242.9764; found 242.9764.

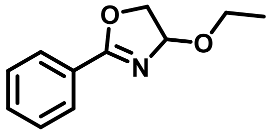


5-Methyl-2-phenyl-4,5-dihydrooxazol-4-ol (2x). The desired pure product was obtained in 57% yield (51 mg) as a colorless oil. ^{1}H NMR (400 MHz, CDCl$_3$) δ 7.96 (d, *J* = 7.3 Hz, 2H), 7.54 - 7.42 (m, 3H), 5.84 - 5.53 (m, 1H), 4.77 - 4.65 (m, 1H), 1.56 -

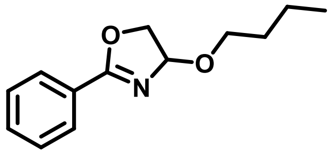
1.43 (m, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 161.3, 127.3, 127.2, 123.9, 123.8, 123.7, 123.7, 122.5, 122.4, 90.5, 84.1, 78.2, 75.3, 14.0, 13.9. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_{10}H_{12}NO_2$ 178.0863; found 178.0863.



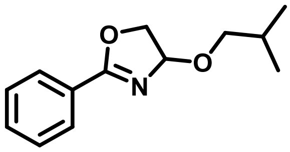
4-Methoxy-2-phenyl-4,5-dihydrooxazole (4a). The desired pure product was obtained in 90% yield (80 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 7.4 Hz, 2H), 7.50 (t, *J* = 7.4 Hz, 1H), 7.41 (t, *J* = 7.5 Hz, 2H), 5.53 (dd, *J* = 7.2, 4.4 Hz, 1H), 4.42 - 4.22 (m, 2H), 3.53 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 167.0, 131.9, 128.7, 128.3, 127.4, 97.9, 72.4, 55.4. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_{10}H_{12}NO_2$ 178.0863; found 178.0862.



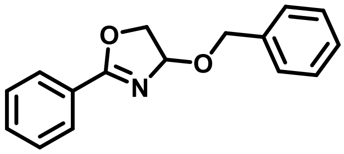
4-Ethoxy-2-phenyl-4,5-dihydrooxazole (4b). The desired pure product was obtained in 92% yield (88 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.6 Hz, 2H), 7.49 (t, *J* = 7.6 Hz, 1H), 7.41 (t, *J* = 7.5 Hz, 2H), 5.63 - 5.60 (m, 1H), 4.44 - 4.25 (m, 2H), 4.00 - 3.61 (m, 2H), 1.25 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.8, 131.8, 128.7, 128.3, 127.5, 96.7, 72.6, 63.6, 15.3. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_{11}H_{14}NO_2$ 192.1019; found 192.1019.



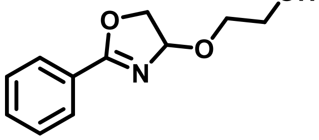
4-Butoxy-2-phenyl-4,5-dihydrooxazole (4c). The desired pure product was obtained in 82% yield (90 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.0 Hz, 2H), 7.50 - 7.47 (m, 1H), 7.42 - 7.39 (m, 2H), 5.61 - 5.58 (m, 1H), 4.42 - 4.23 (m, 2H), 3.92 - 3.53 (m, 2H), 1.61 - 1.56 (m, 2H), 1.41 - 1.35 (m, 2H), 0.92 (t, *J* = 6.7 Hz, 3H). ^{13}C NMR (151 MHz, CDCl$_3$) δ 166.7, 131.8, 128.7, 128.3, 127.5, 96.8, 72.6, 68.0, 31.9, 19.3, 13.9. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_{13}H_{18}NO_2$ 220.1332; found 220.1331.



4-Isobutoxy-2-phenyl-4,5-dihydrooxazole (4d). The desired pure product was obtained in 80% yield (88 mg) as a colorless oil. ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.00 (d, *J* = 7.3 Hz, 2H), 7.52 - 7.47 (m, 1H), 7.41 (t, *J* = 7.6 Hz, 2H), 5.60 (dd, *J* = 7.2, 4.5 Hz, 1H), 4.43 - 4.25 (m, 2H), 3.70 - 3.29 (m, 2H), 1. 92 - 1.86 (m, 1H), 0.93 - 0.91 (m, 6H). ^{13}C NMR (151 MHz, CDCl$_3$) δ 166.6, 131.8, 128.7, 128.3, 127.5, 97.0, 74.9, 72.6, 28.6, 19.4, 19.3. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_{13}H_{18}NO_2$ 220.1332; found 220.1332.

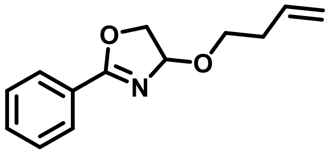


4-(Benzyloxy)-2-phenyl-4,5-dihydrooxazole (4e). The desired pure product was obtained in 79% yield (100 mg) as a colorless oil. ^{1}H NMR (400 MHz, CDCl$_3$) δ 8.04 (d, *J* = 7.2 Hz 2H), 7.55 - 7.23 (m, 8H), 5.74 (dd, *J* = 7.2, 4.5 Hz, 1H), 4.86 (dd, *J* = 104.9, 11.7 Hz, 2H), 4.45 - 4.33 (m, 2H). ^{13}C NMR (151 MHz, CDCl$_3$) δ 167.1, 138.0, 131.9, 128.8, 128.4, 128.3, 128.0, 127.7, 127.5, 96.2, 72.7, 69.9. HRMS (ESI) m/z: [M + H]$^+$ calcd for $C_{16}H_{16}NO_2$ 254.1176; found 254.1176.

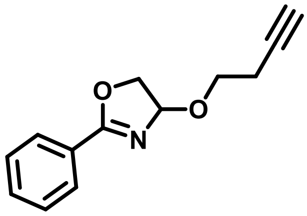


2-((2-Phenyl-4,5-dihydrooxazol-4-yl)oxy)ethan-1-ol (4f). The desired pure product was obtained in 90% yield (94 mg) as a colorless oil. ^{1}H NMR (400 MHz, CDCl$_3$) δ

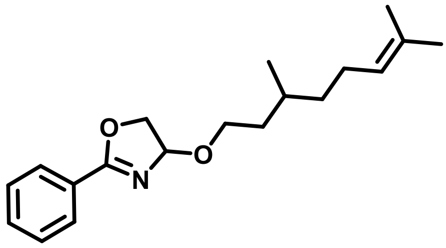
7.97 (d, *J* = 7.8 Hz, 2H), 7.53 (t, *J* = 7.1 Hz, 1H), 7.43 (t, *J* = 7.6 Hz, 2H), 5.60 (dd, *J* = 7.4, 4.7 Hz, 1H), 4.54 - 4.30 (m, 2H), 4.00 - 3.84 (m, 2H), 3.80 - 3.67 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 167.1, 132.3, 128.8, 128.5, 126.7, 97.7, 73.1, 73.0, 62.9. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{11}H_{14}NO_3$ 208.0968; found 208.0969.



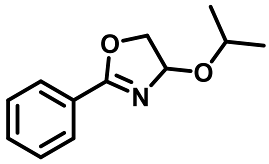
4-(But-3-en-1-yloxy)-2-phenyl-4,5-dihydrooxazole (4g). The desired pure product was obtained in 60% yield (65 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 - 7.98 (m, 2H), 7.52 - 7.48 (m, 1H), 7.44 - 7.39 (m, 2H), 5.89 - 5.79 (m, 1H), 5.62 (dd, *J* = 7.2, 4.5 Hz, 1H), 5.14 - 5.02 (m, 2H), 4.43 - 4.26 (m, 2H), 3.99 - 3.61 (m, 2H), 2.42 - 2.36 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.8, 135.1, 131.9, 128.7, 128.3, 127.4, 116.4, 96.9, 72.6, 67.4, 34.3. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{13}H_{16}NO_2$ 218.1176; found 218.1176.



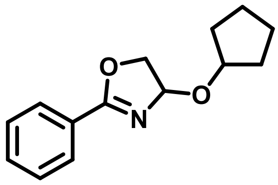
4-(But-3-yn-1-yloxy)-2-phenyl-4,5-dihydrooxazole (4h). The desired pure product was obtained in 63% yield (67 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.4 Hz, 2H), 7.50 (t, *J* = 7.3 Hz, 1H), 7.41 (t, *J* = 7.6 Hz, 2H), 5.66 (dd, *J* = 7.2, 4.3 Hz, 1H), 4.44 - 4.29 (m, 2H), 4.03 - 3.71 (m, 2H), 2.55 - 2.48 (m, 2H), 1.99 (t, *J* = 2.6 Hz, 1H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 167.0, 131.9, 128.7, 128.4, 127.3, 97.0, 81.3, 72.6, 69.3, 66.1, 20.1. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{13}H_{14}NO_2$ 216.1019; found 216.1019.



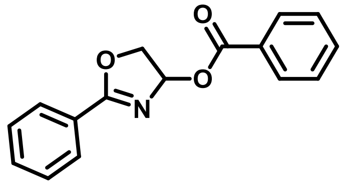
4-((3,7-Dimethyloct-6-en-1-yl) oxy)-2-phenyl-4,5-dihydrooxazole (4i). The desired pure product was obtained in 81% yield (122 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, *J* = 7.3 Hz, 2H), 7.50 (t, *J* = 7.4 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 5.60 (dd, *J* = 7.2, 4.5 Hz, 1H), 5.12 - 5.06 (m, 1H), 4.43 - 4.25 (m, 2H), 3.98 - 3.58 (m, 2H), 2.02 - 1.95 (m, 2H), 1.67 (s, 4H), 1.59 (s, 3H), 1.46 - 1.18 (m, 4H), 0.91 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.7, 131.8, 128.7, 128.3, 124.8, 96.9, 72.6, 66.6, 66.5, 37.2, 36.8, 36.7, 29.5, 25.7, 25.4, 19.5, 17.6. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{19}H_{28}NO_2$ 302.2115; found 302.2113.



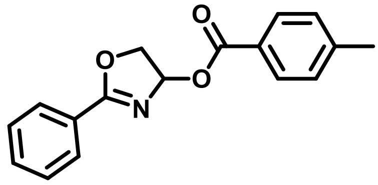
4-Isopropoxy-2-phenyl-4,5-dihydrooxazole (4j). The desired pure product was obtained in 83% yield (84 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 - 7.98 (m, 2H), 7.51 - 7.47 (m, 1H), 7.43 - 7.38 (m, 2H), 5.69 (dd, *J* = 7.3, 4.4 Hz, 1H), 4.44 - 4.20 (m, 2H), 4.16 - 4.08 (m, 1H), 1.28 - 1.22 (m, 6H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.4, 131.7, 128.7, 128.3, 127.6, 94.9, 73.1, 70.0, 23.5, 22.0. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{12}H_{16}NO_2$ 206.1176; found 206.1167.



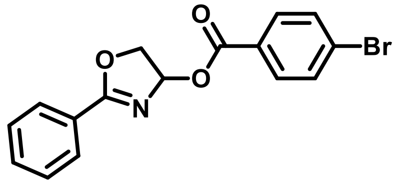
4-(Cyclopentyloxy)-2-phenyl-4,5-dihydrooxazole (4k). The desired pure product was obtained in 86% yield (100 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 - 7.96 (m, 2H), 7.54 - 7.46 (m, 1H), 7.45 - 7.37 (m, 2H), 5.66 (dd, *J* = 7.3, 4.6 Hz, 1H), 4.50 - 4.35 (m, 2H), 4.22 (dd, *J* = 9.8, 4.6 Hz, 1H), 1.93 - 1.78 (m, 2H), 1.76 - 1.65 (m, 4H), 1.60 - 1.49 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 166.4, 131.7, 128.7, 128.3, 127.6, 95.5, 79.6, 73.0, 33.4, 32.3, 23.42, 23.39. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{14}H_{18}NO_2$ 232.1332; found 232.1332.



2-Phenyl-4,5-dihydrooxazol-4-yl benzoate (4l). The desired pure product was obtained in 75% yield (100 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 – 8.03 (m, 4H), 7.61 – 7.51 (m, 2H), 7.49 – 7.40 (m, 4H), 6.92 (dd, *J* = 7.1, 4.2 Hz, 1H), 4.75 – 4.46 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 169.3, 165.9, 133.4, 132.5, 129.9, 129.5, 129.0, 128.5, 128.4, 126.7, 92.5, 73.2. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{16}H_{14}NO_3$ 268.0968; found 268.0966.

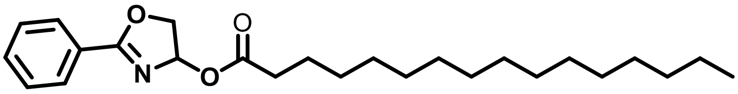


2-Phenyl-4,5-dihydrooxazol-4-yl 4-methylbenzoate (4m). The desired pure product was obtained in 70% yield (99 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 - 7.96 (m, 4H), 7.57 - 7.43 (m, 3H), 7.22 (d, *J* = 1.8 Hz, 2H), 6.90 (dd, *J* = 7.1, 4.1 Hz, 1H), 4.72 - 4.46 (m, 2H), 2.40 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 169.2, 165.9, 144.1, 132.4, 129.9, 129.1, 128.9, 128.4, 126.7, 126.6, 92.4, 73.2, 21.7. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{17}H_{16}NO_3$ 282.1125; found 282.1126.

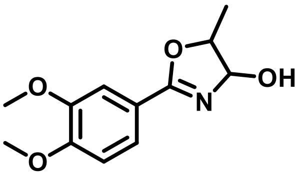


2-Phenyl-4,5-dihydrooxazol-4-yl 4-bromobenzoate (4n). The desired pure product was obtained in 55% yield (95 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ

8.03 (d, *J* = 7.7 Hz, 2H), 7.60 - 7.39 (m, 6H), 6.53 (dd, *J* = 8.6, 5.5 Hz, 1H), 6.29 - 6.28 (m, 1H), 4.79 - 4.70 (m, 2H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 169.3, 165.9, 133.4, 132.5, 129.9, 129.5, 129.0, 128.5, 128.4, 126.6, 92.5, 73.1. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{16}H_{13}BrNO_3$ 346.0073; found 346.0071.



2-Phenyl-4,5-dihydrooxazol-4-yl palmitate (4o). The desired pure product was obtained in 60% yield (120 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (d, *J* = 7.2 Hz, 2H), 7.54 - 7.42 (m, 3H), 6.66 (dd, *J* = 7.1, 4.2 Hz, 1H), 4.63 - 4.31 (m, 2H), 2.35 (dd, *J* = 7.6, 2.7 Hz, 2H), 1.66 - 1.62 (m, 2H), 1.24 (s, 24H), 0.87 (t, *J* = 6.7 Hz, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 173.2, 169.1, 132.4, 128.9, 128.4, 126.6, 91.8, 73.2, 34.2, 31.9, 29.7, 29.7, 29.6, 29.6, 29.6, 29.6, 29.4, 29.3, 29.2, 29.1, 24.7, 22.7, 14.1. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{25}H_{40}NO_3$ 402.3003; found 402.3003.



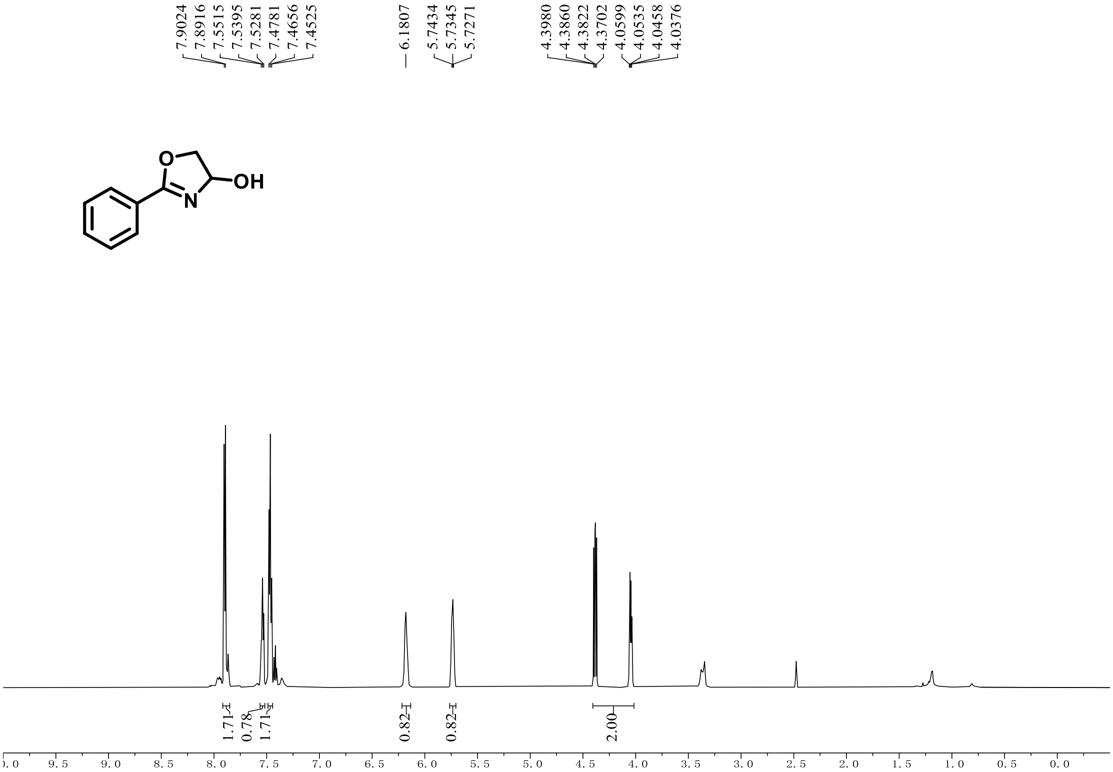
2-(3,4-Dimethoxyphenyl)-5-methyl-4,5-dihydrooxazol-4-ol (2y). The desired pure product was obtained in 81% yield (96 mg) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57- 7.26 (m, 2H), 6.86 (dd, *J* = 9.5, 8.4 Hz, 1H), 5.77- 5.46 (m, 1H), 4.72- 4.56 (m, 1H), 3.91 (s, 6H), 1.52- 1.24 (m, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 169.1, 166.0, 152.2, 152.2, 148.9, 148.7, 125.9, 122.3, 120.1, 119.7, 111.1, 110.8, 110.5, 110.2, 95.5, 88.9, 83.1, 80.2, 56.0, 55.9, 55.9, 55.9, 18.7, 13.1. HRMS (ESI) m/z: $[M + H]^+$ calcd for $C_{12}H_{16}NO_4$ 238.1074; found 238.1074.

5. References

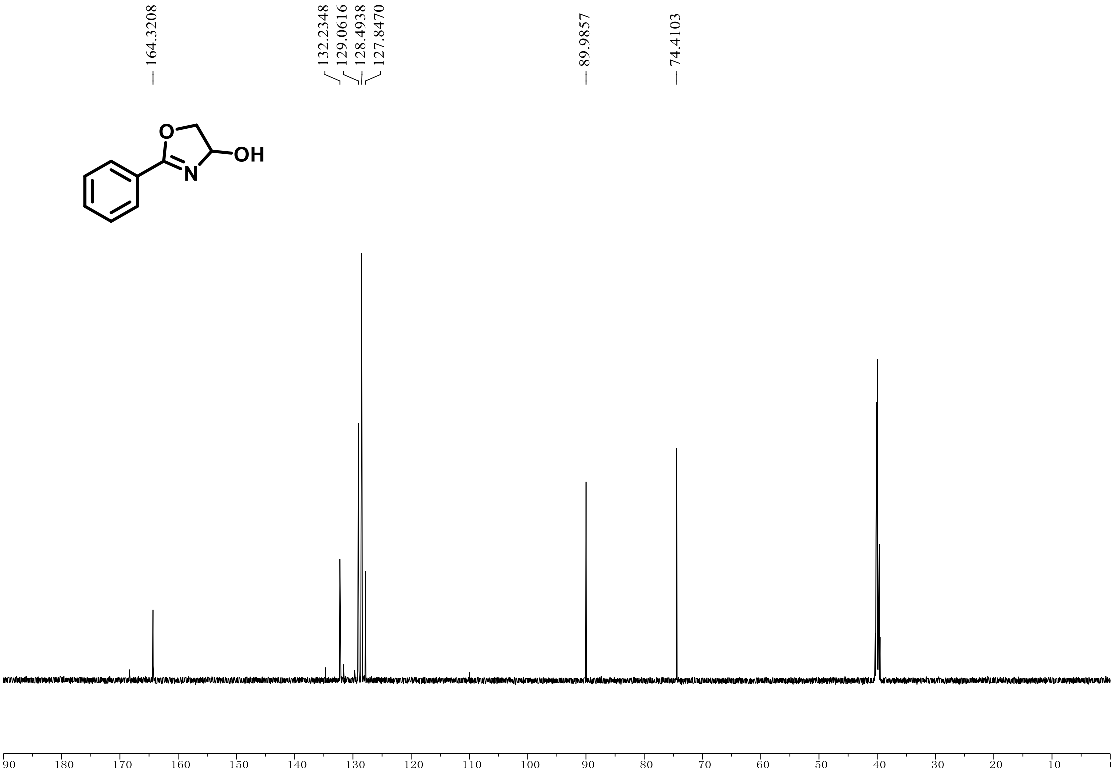
1. Boyington, A. J.; Seath, C. P.; Zearfoss, A. M.; Xu, Z.; Jui, N. T. Catalytic Strategy for Regioselective Arylethylamine Synthesis. *J. Am. Chem. Soc.* **2019**, *141*, 4147-4153.

6. NMR Spectra of Products

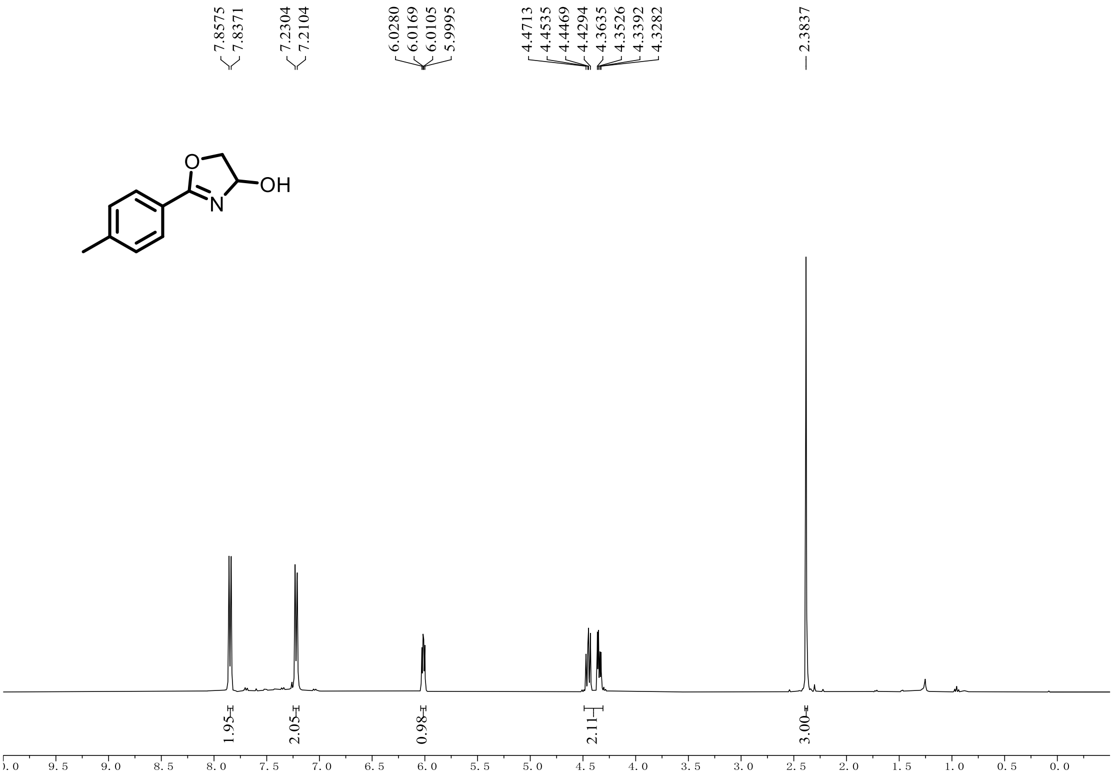
^{1}H NMR (400 MHz, DMSO-d_6) of compound **2a**



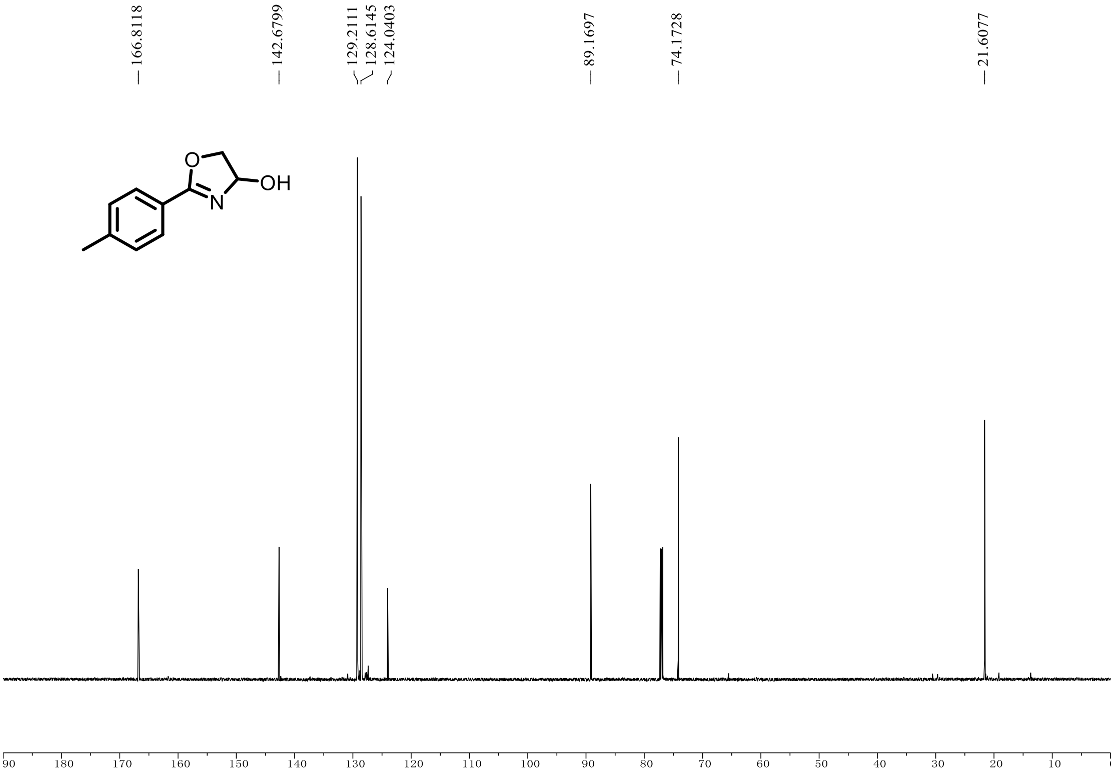
^{13}C NMR (151 MHz, DMSO-d_6) of compound **2a**



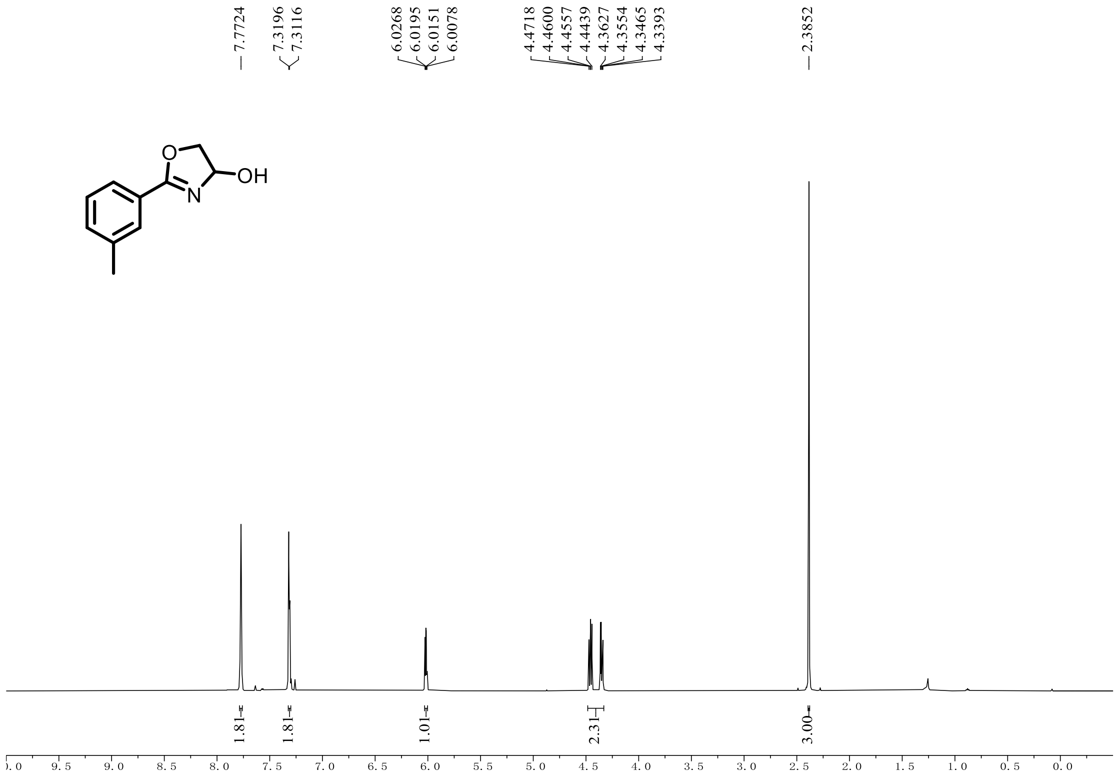
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2b**



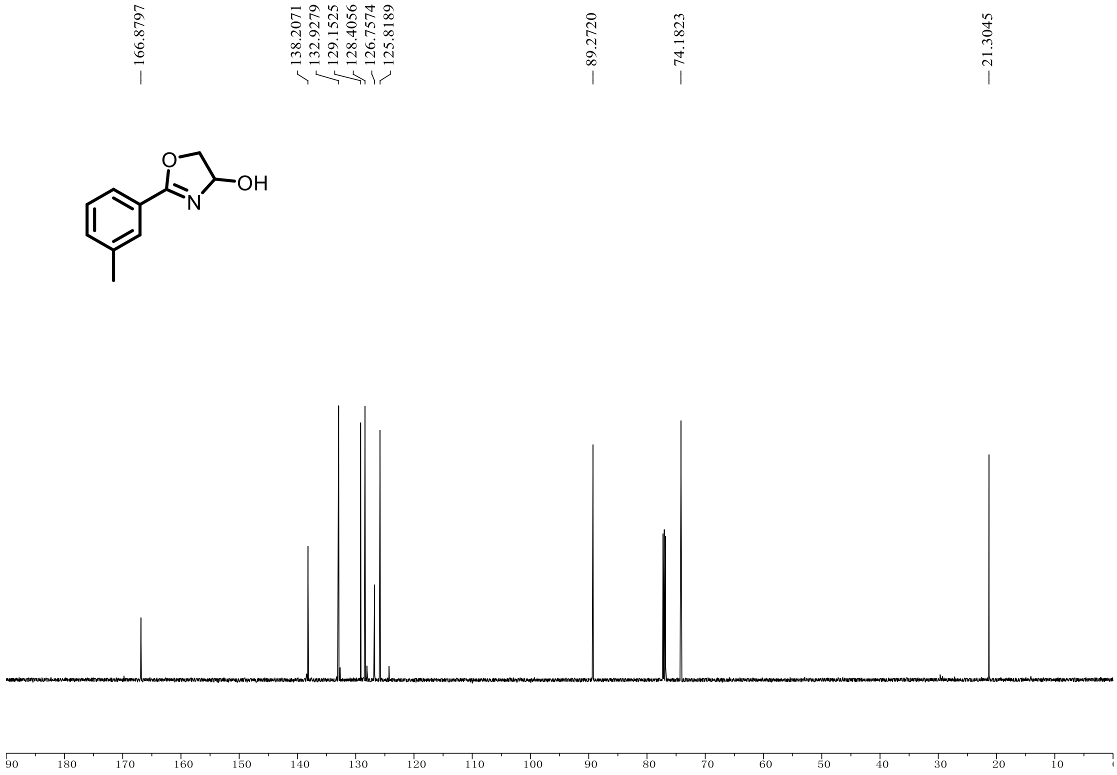
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2b**



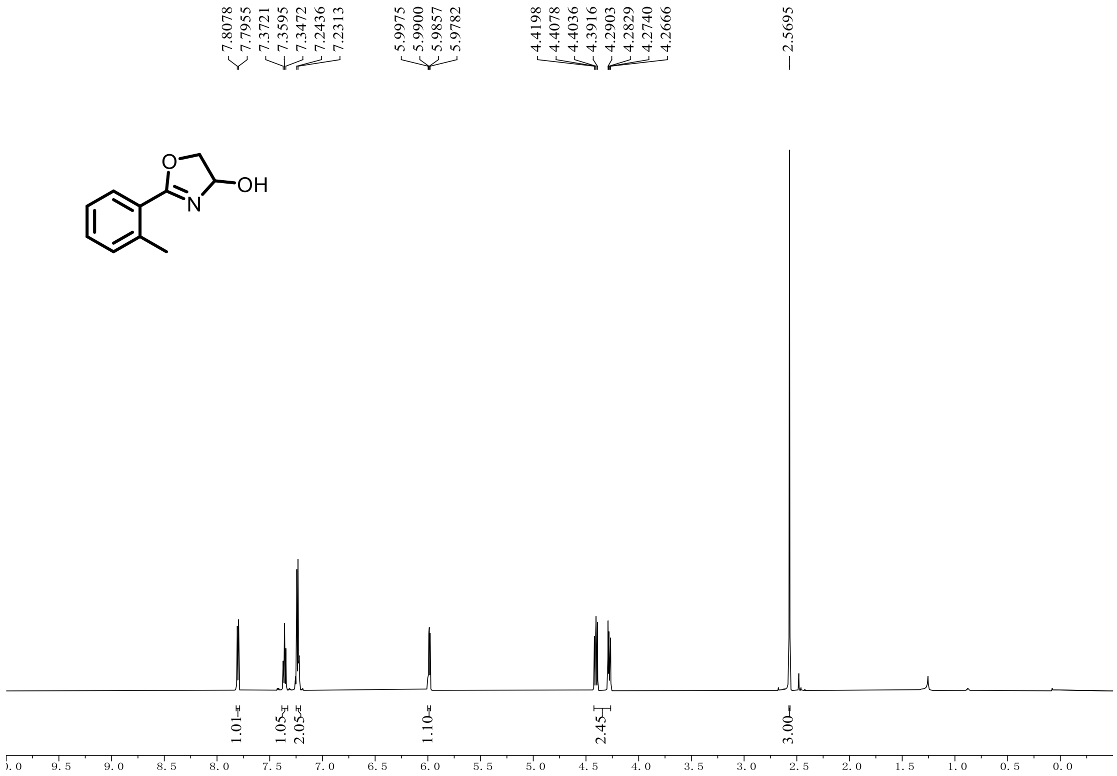
^{1}H NMR (600 MHz, CDCl$_3$) of compound **2c**



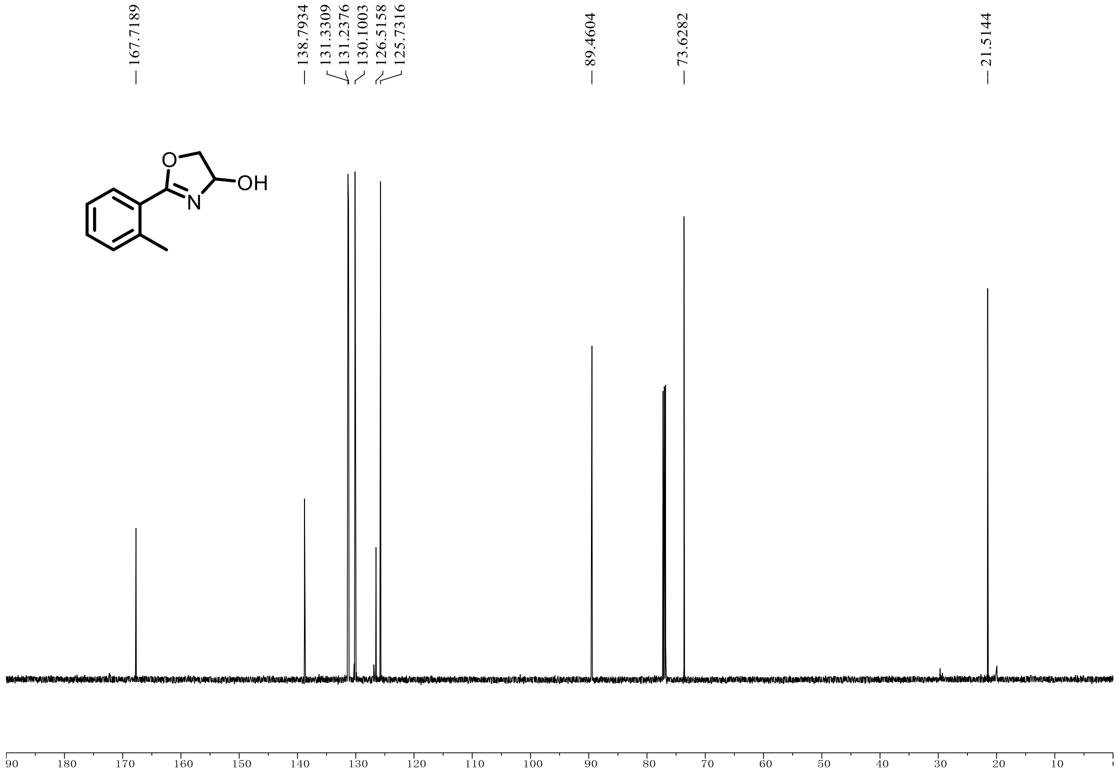
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2c**



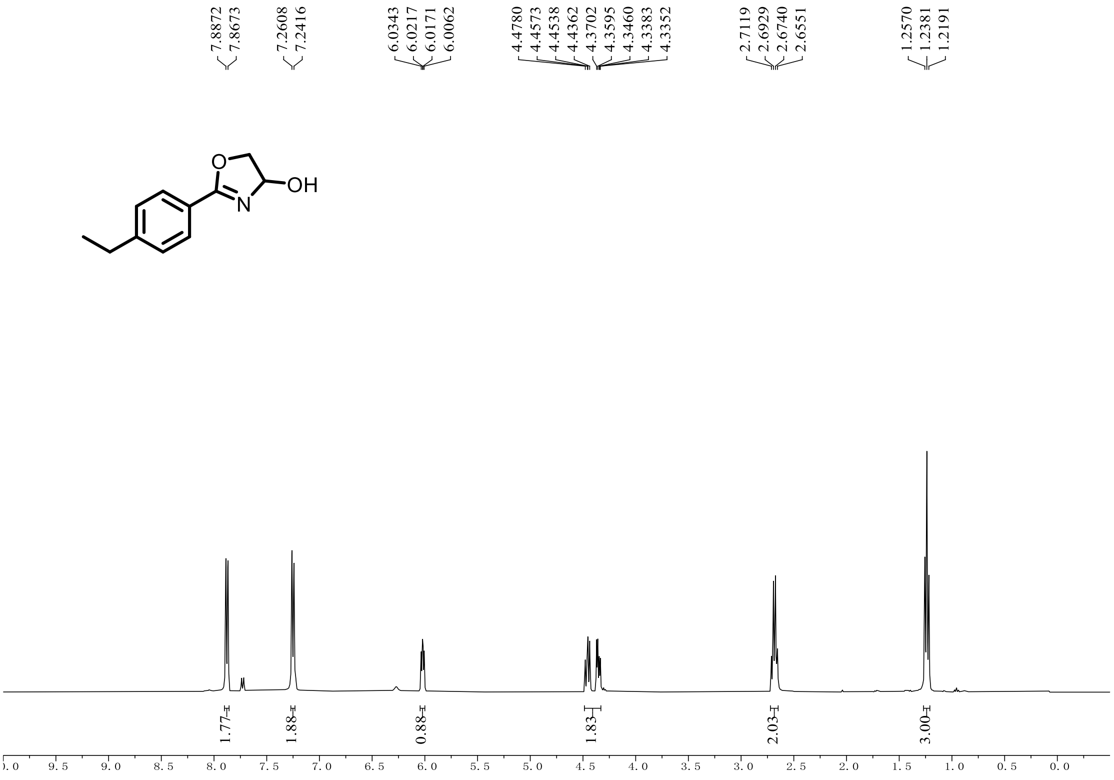
^{1}H NMR (600 MHz, $CDCl_3$) of compound **2d**



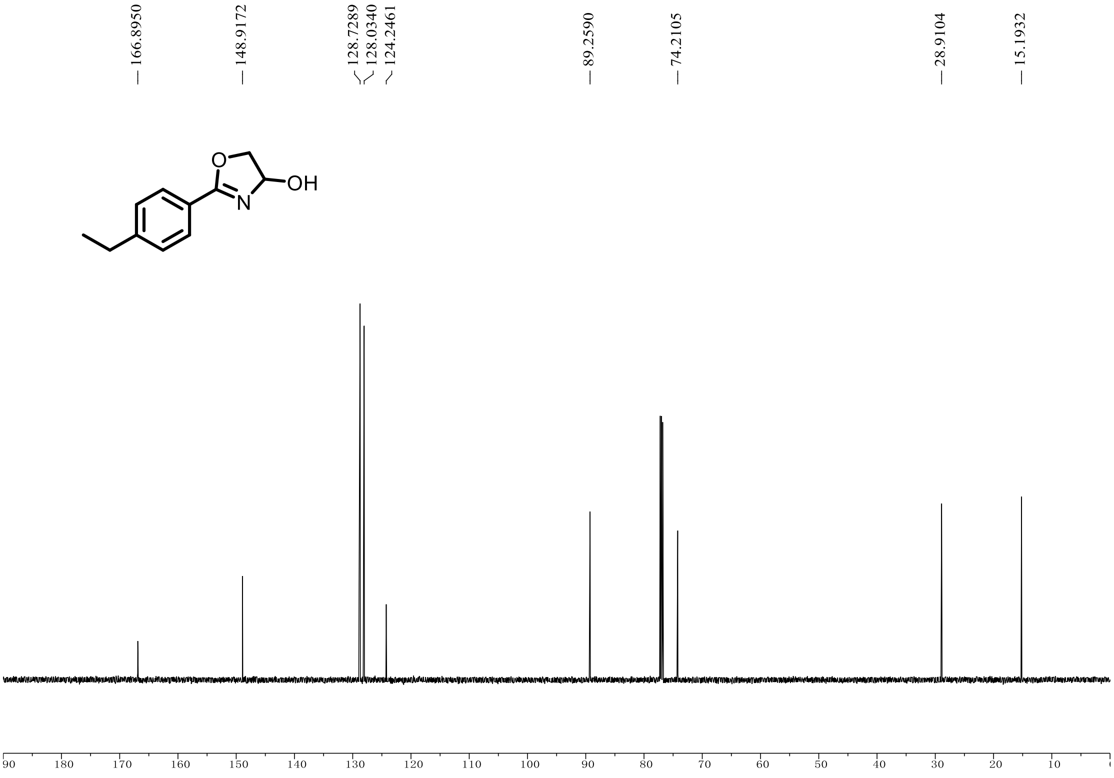
^{13}C NMR (151 MHz, $CDCl_3$) of compound **2d**



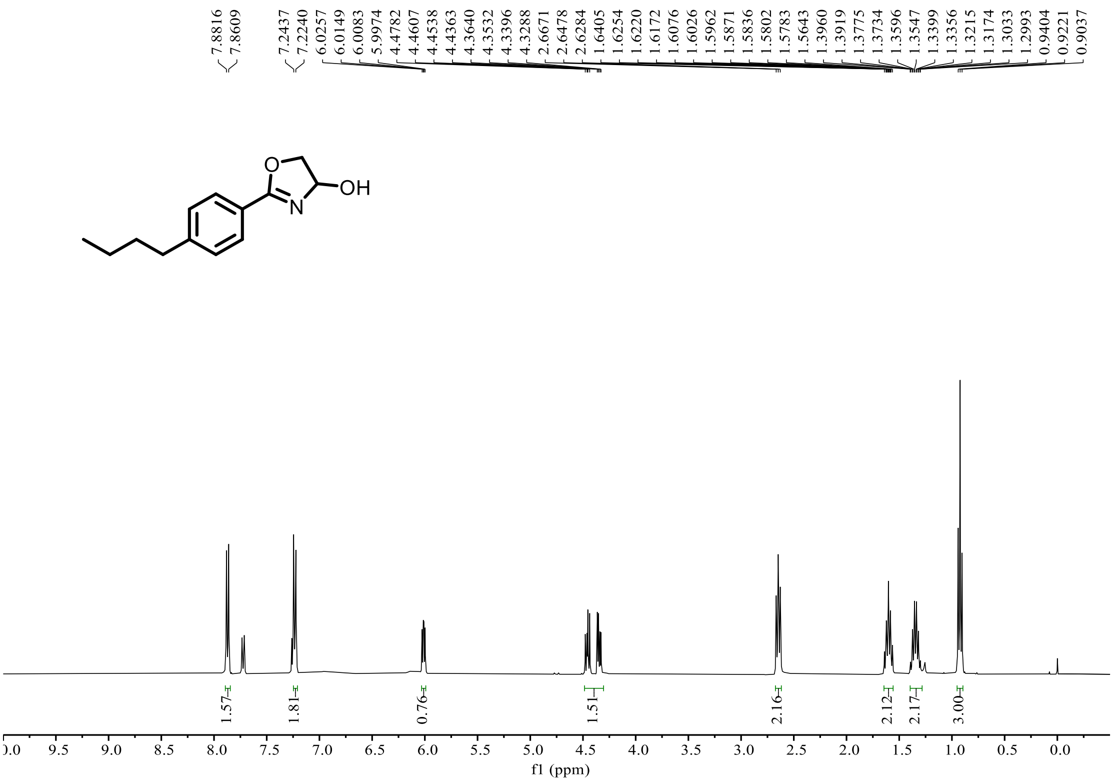
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2e**



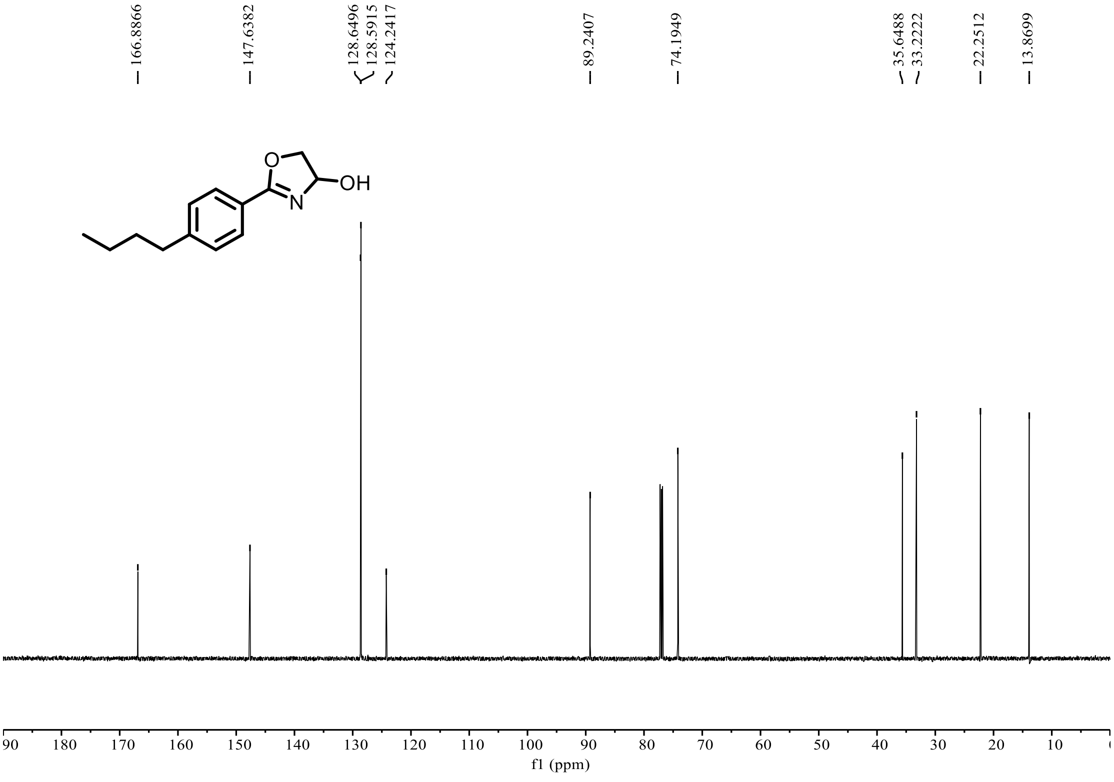
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2e**



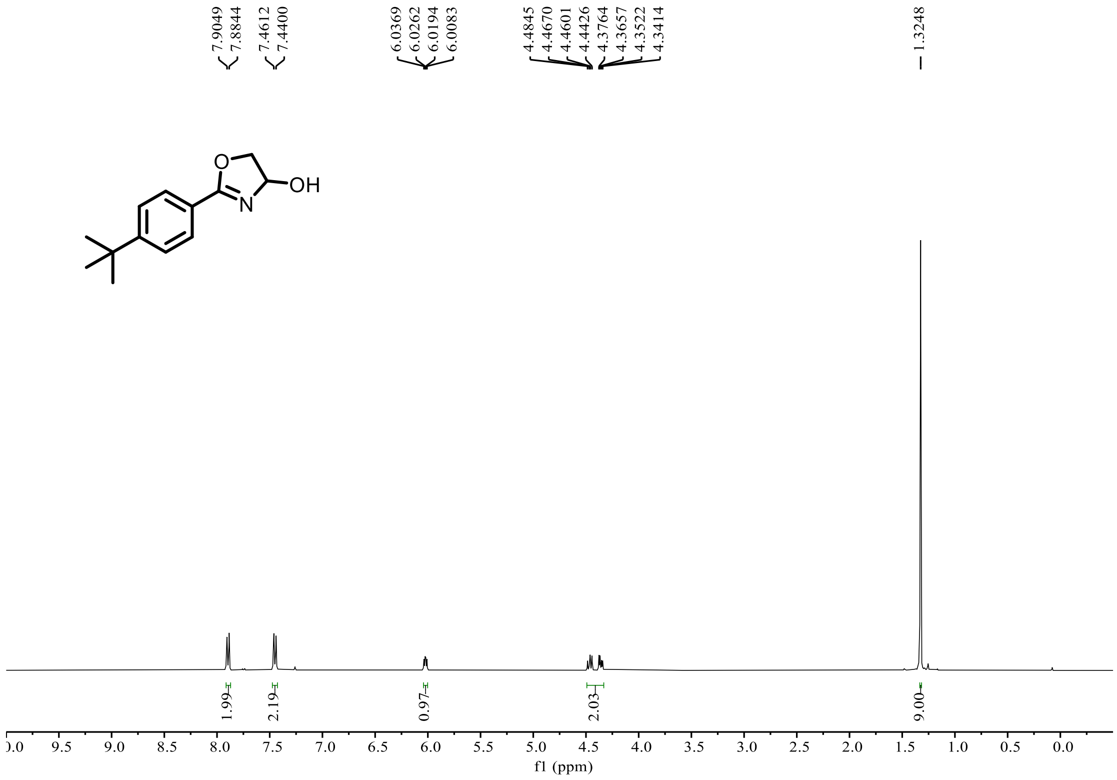
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2f**



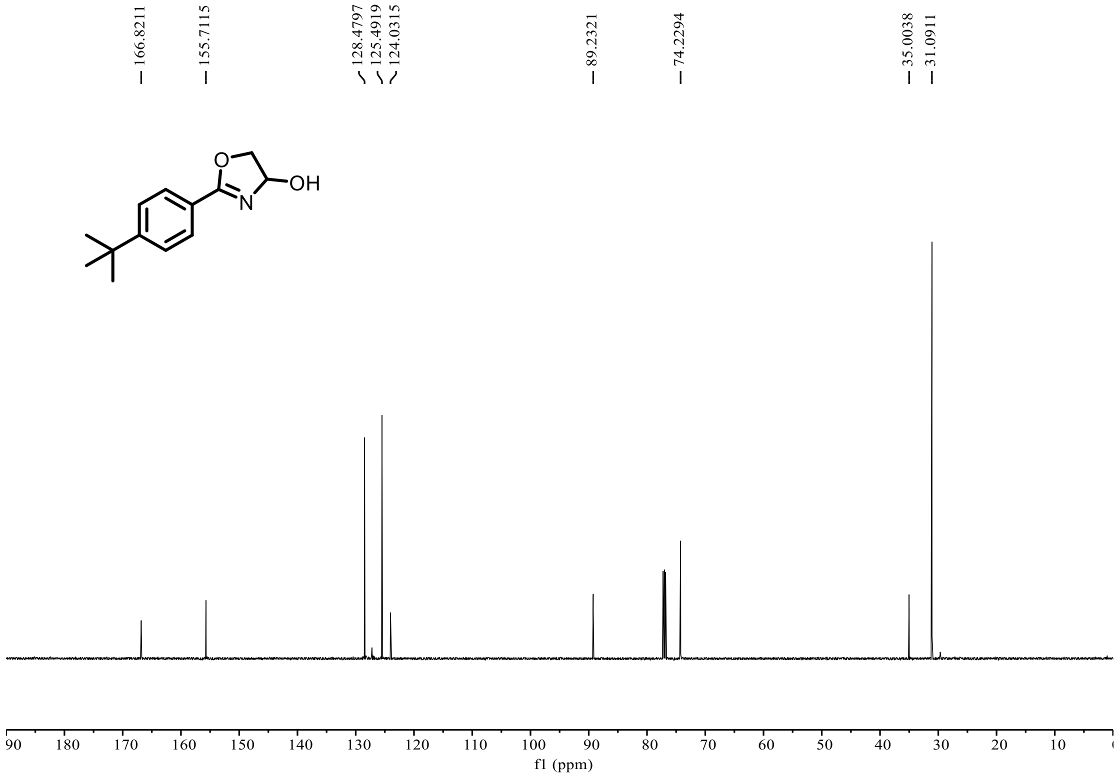
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2f**



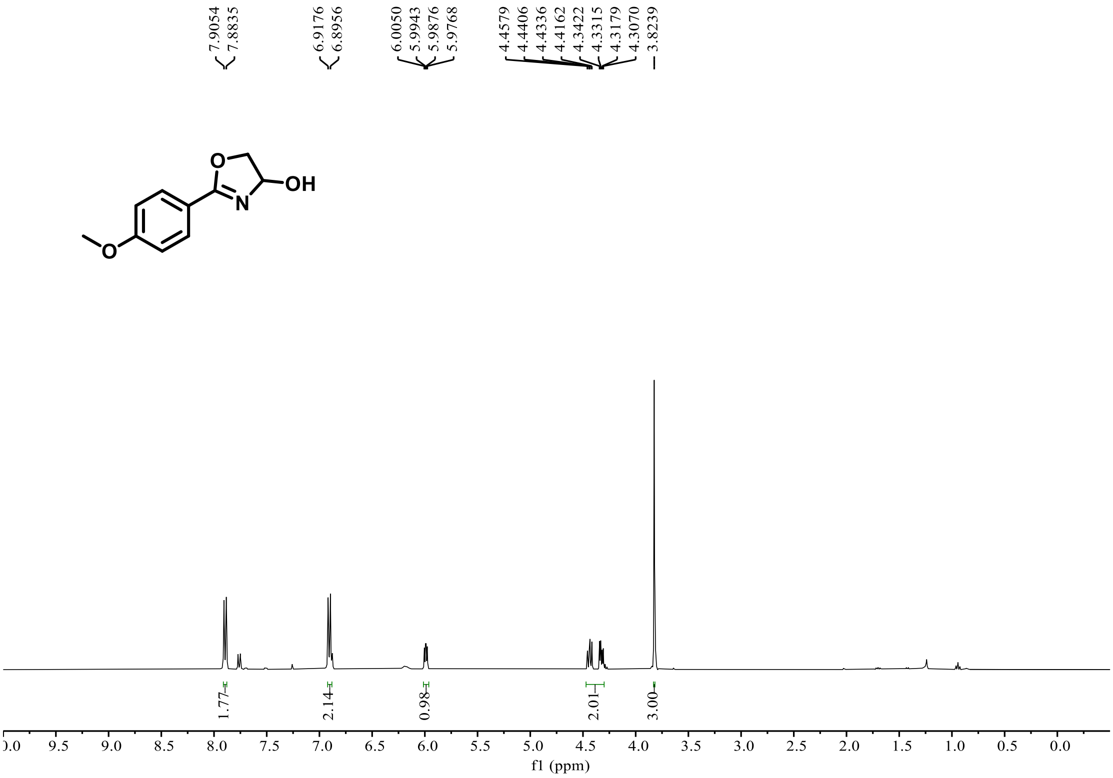
^1H NMR (400 MHz, $CDCl_3$) of compound **2g**



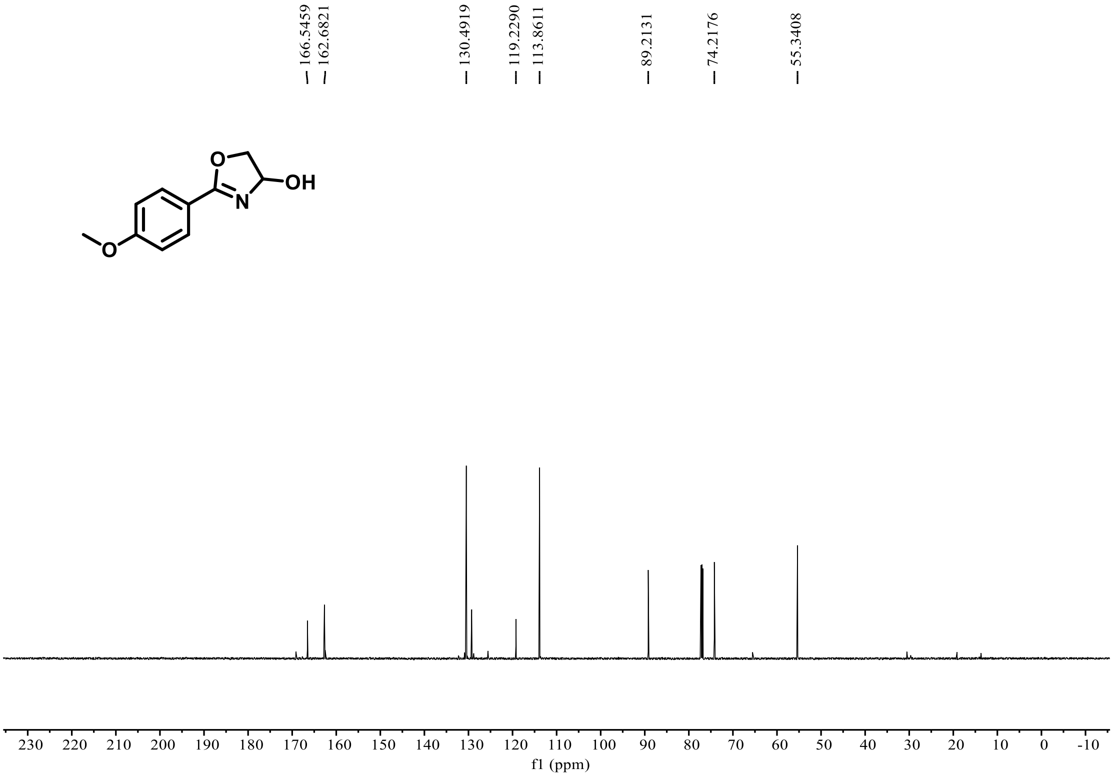
^{13}C NMR (151 MHz, $CDCl_3$) of compound **2g**



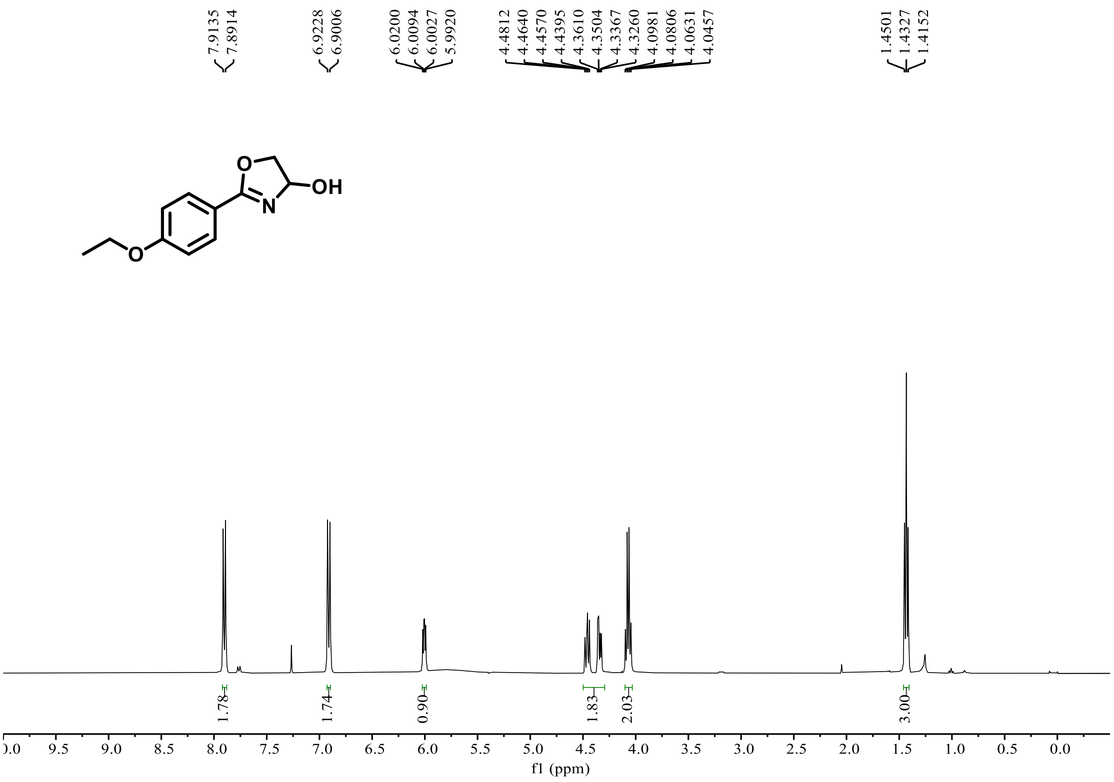
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2h**



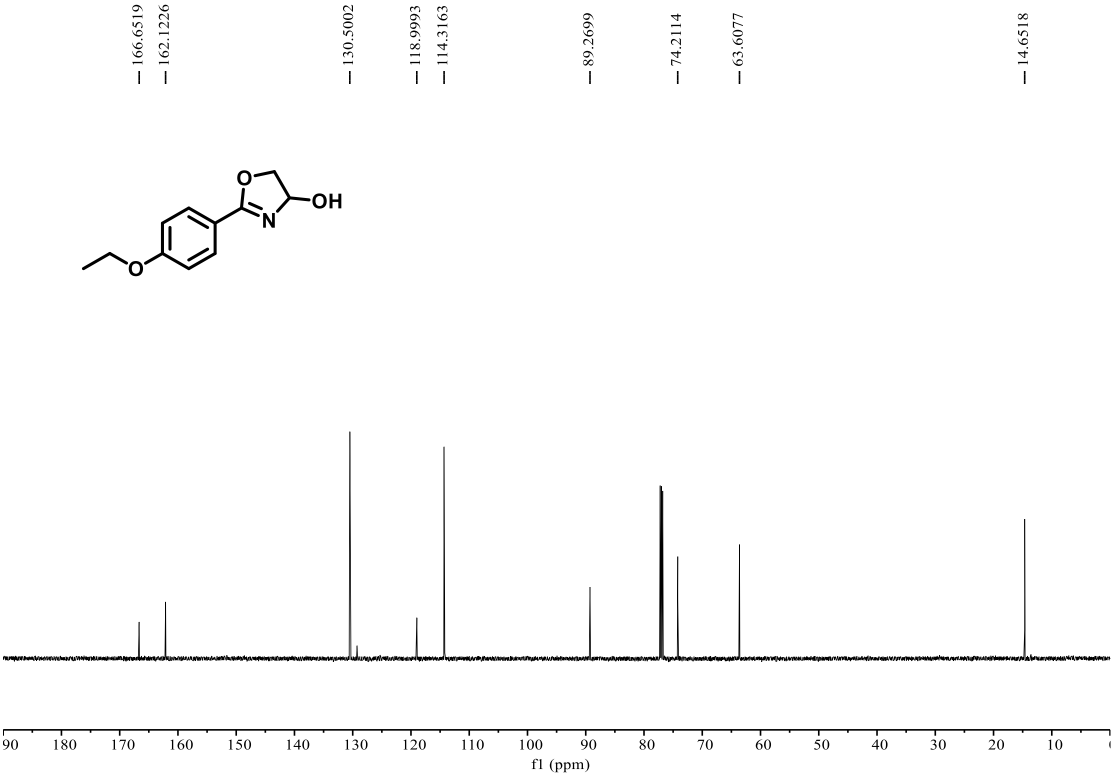
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2h**



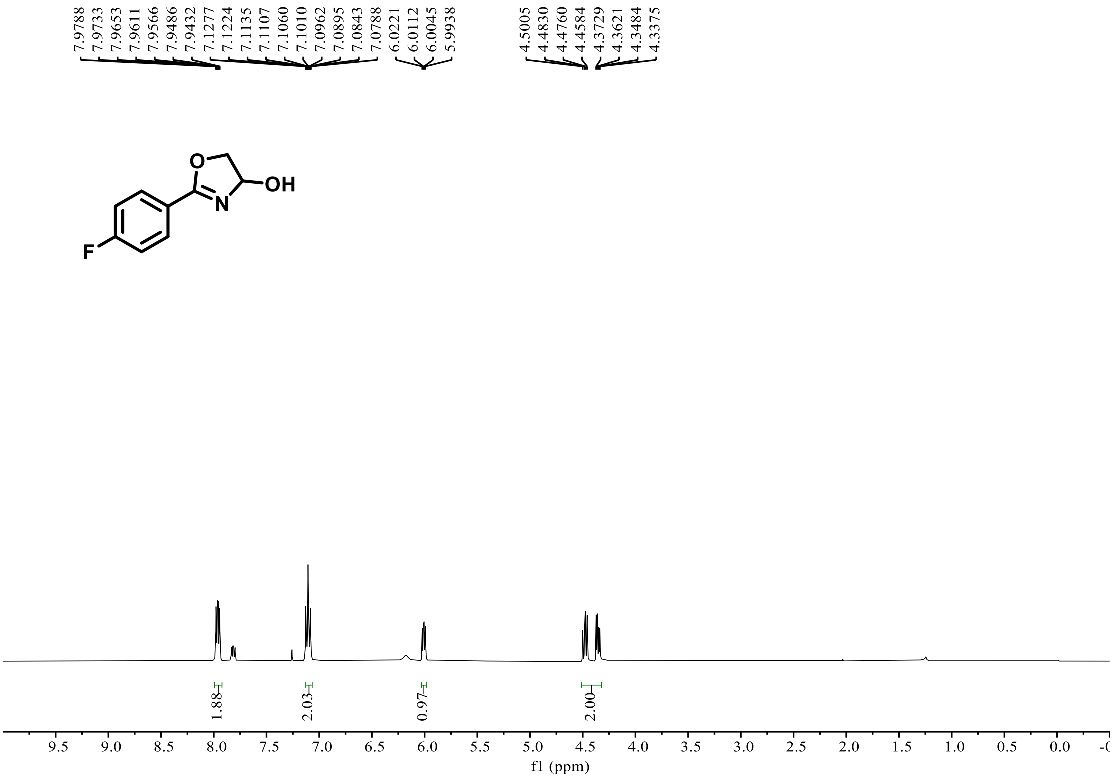
^{1}H NMR (400 MHz, $CDCl_3$) of compound **2i**



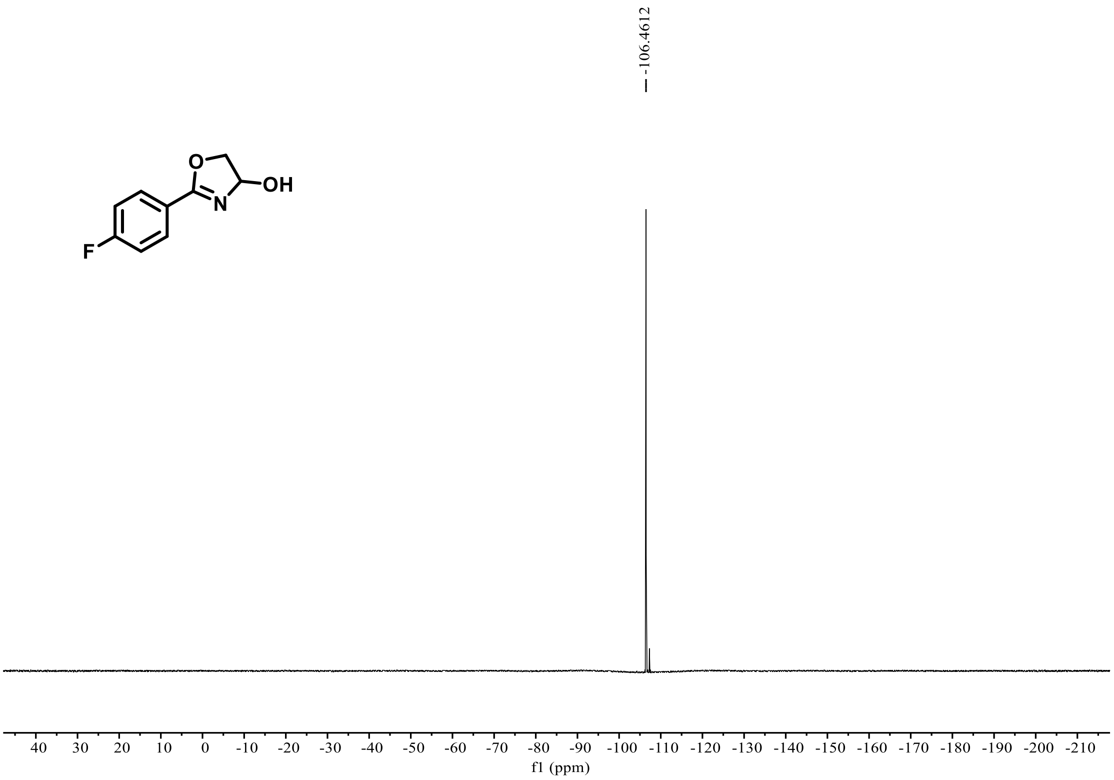
^{13}C NMR (151 MHz, $CDCl_3$) of compound **2i**



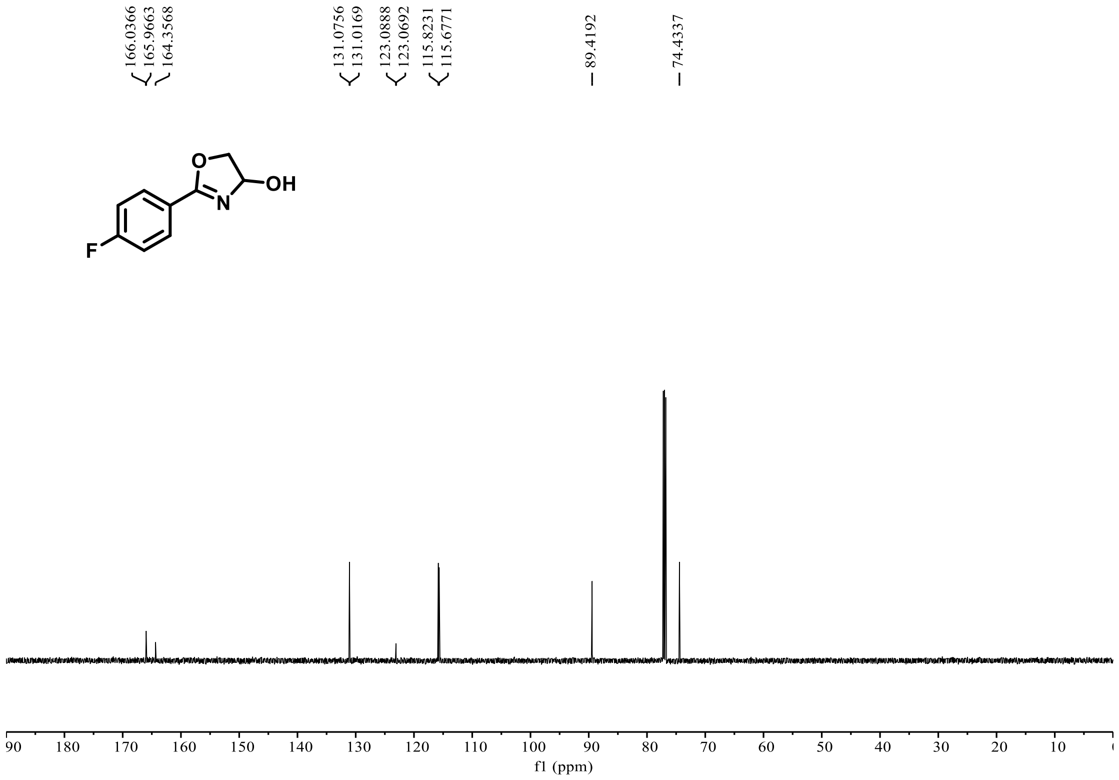
^1H NMR (400 MHz, $CDCl_3$) of compound **2j**



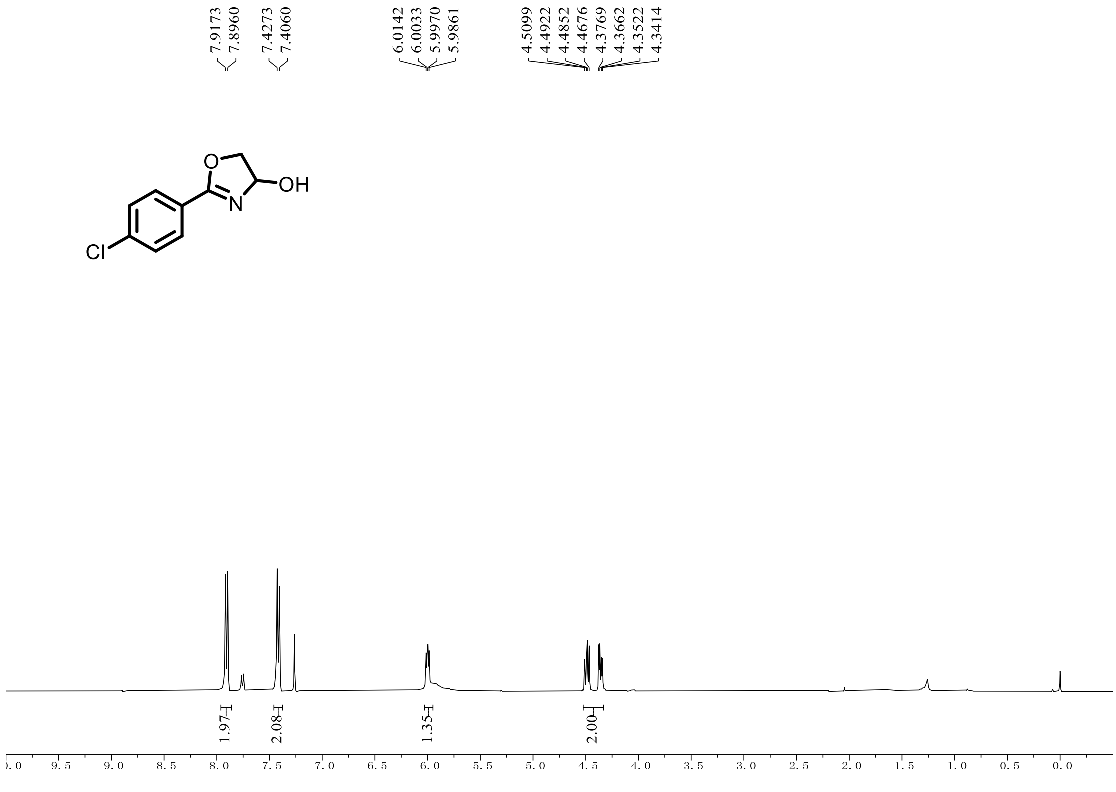
^{19}F NMR (376 MHz, $CDCl_3$) of compound **2j**



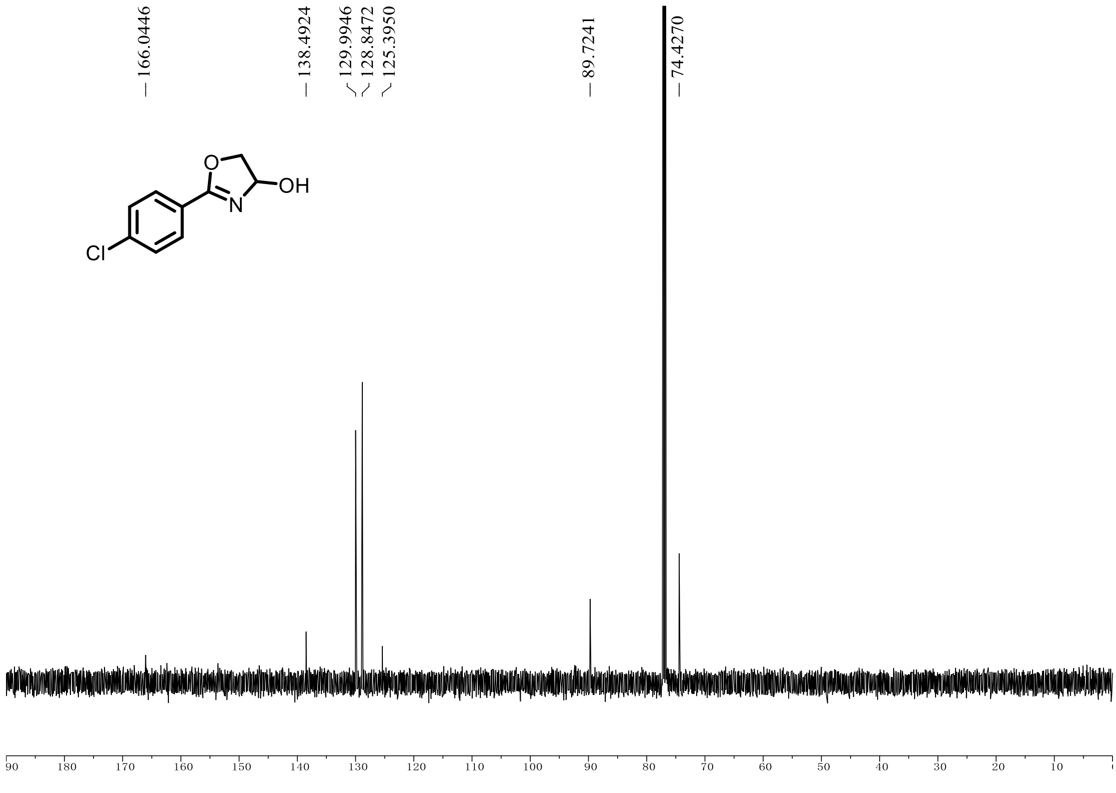
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2j**



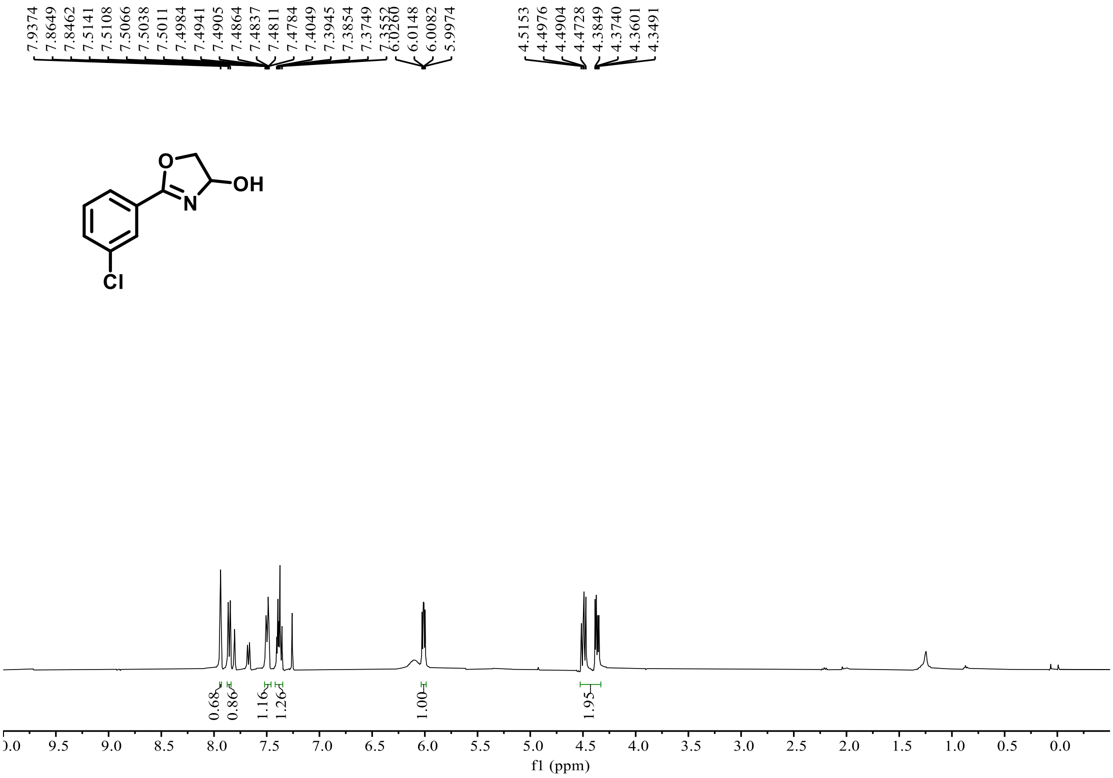
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2k**



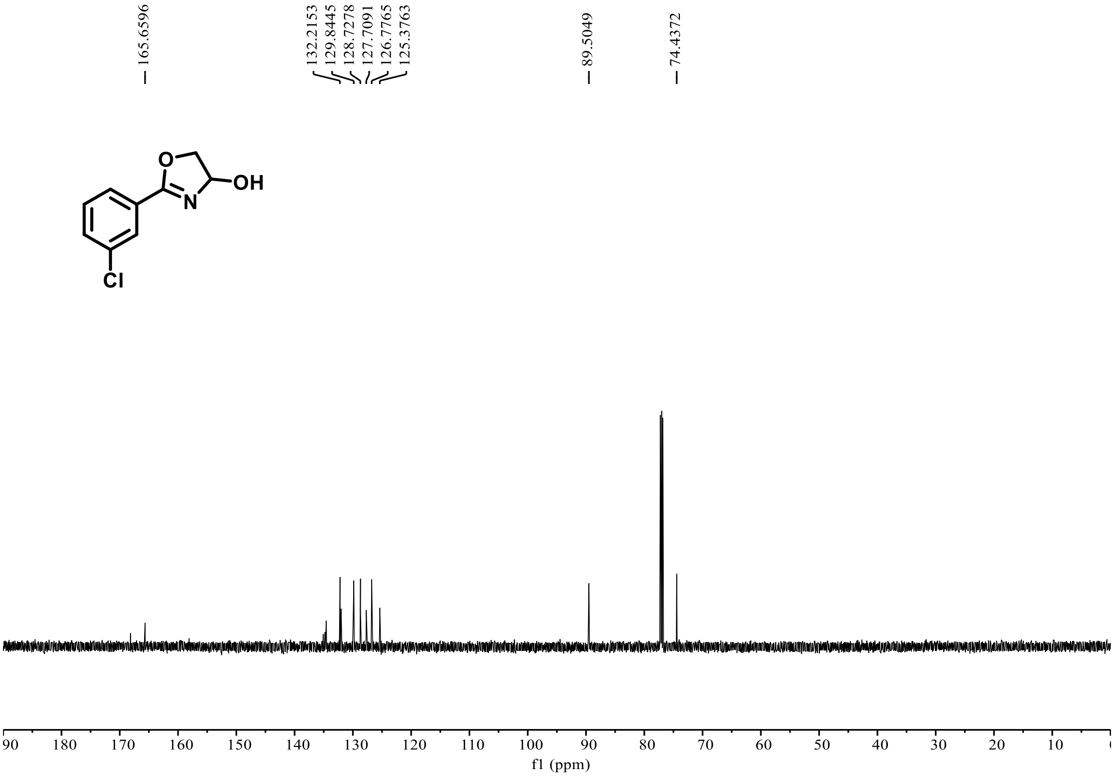
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2k**



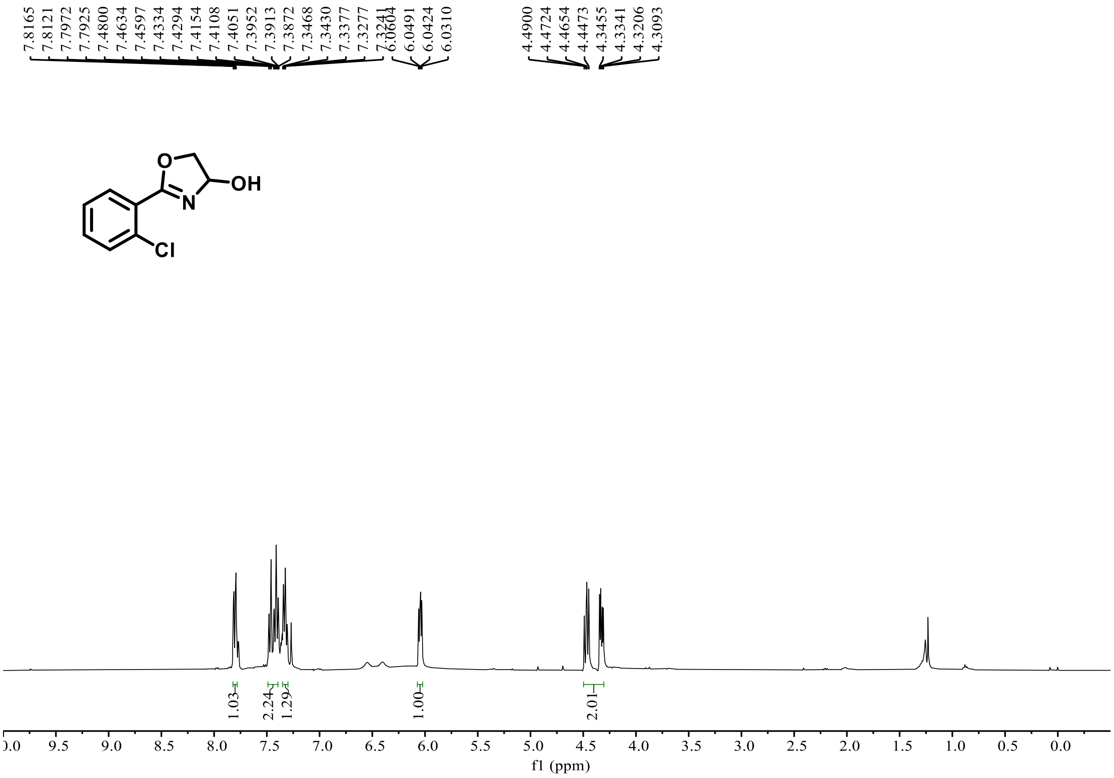
^{1}H NMR (400 MHz, $CDCl_3$) of compound **2l**



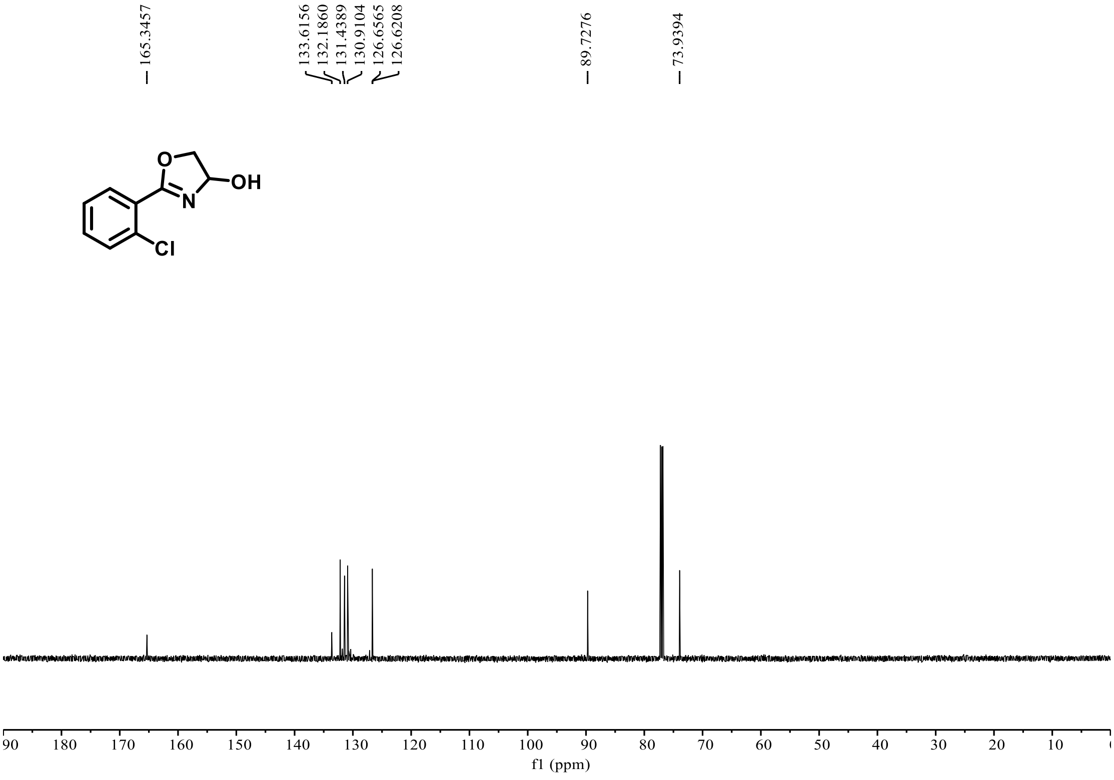
^{13}C NMR (151 MHz, $CDCl_3$) of compound **2l**



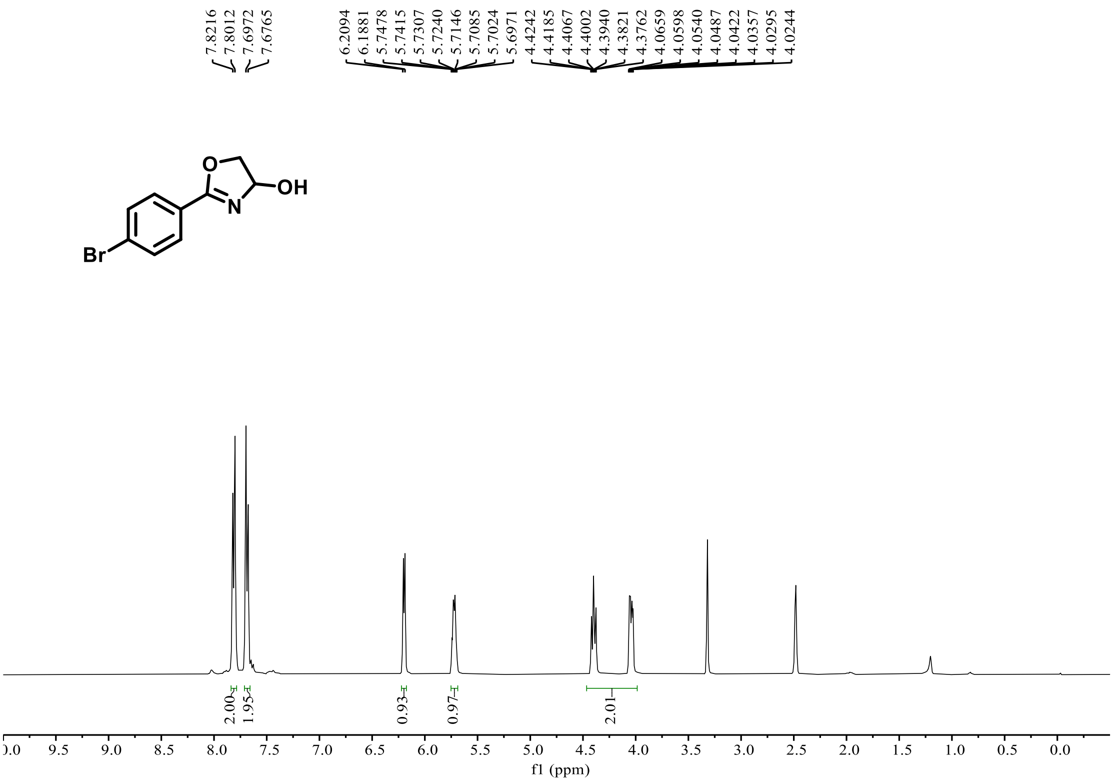
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2m**



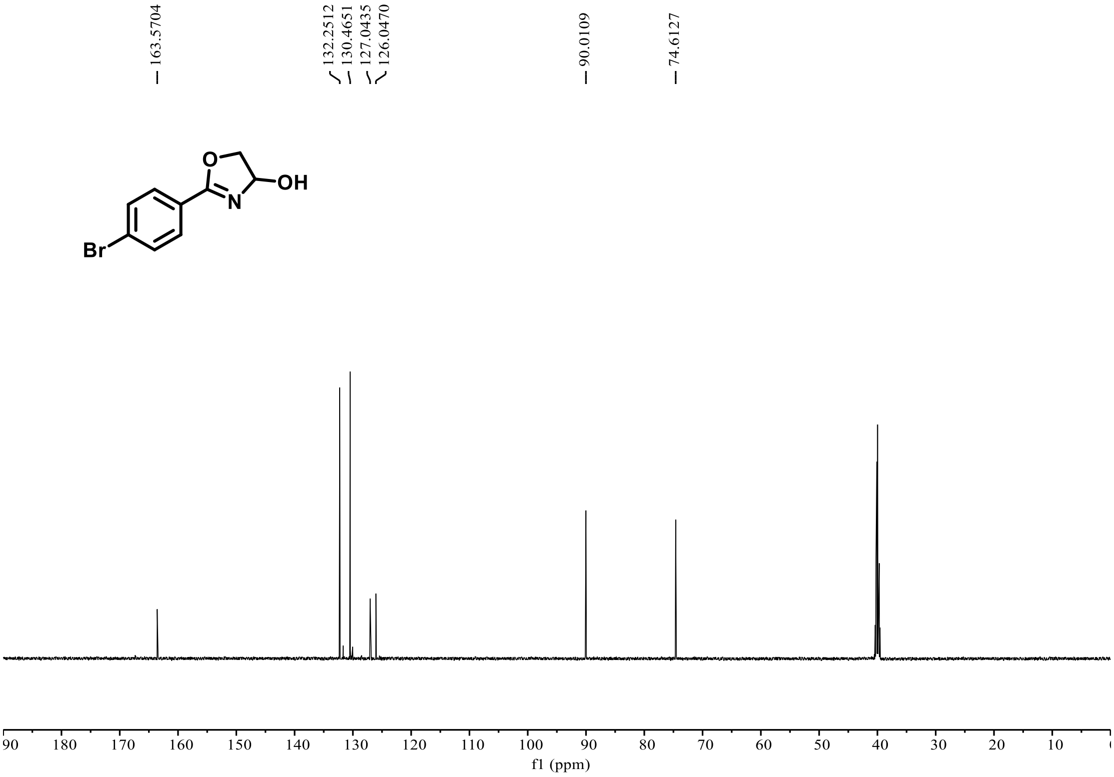
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2m**



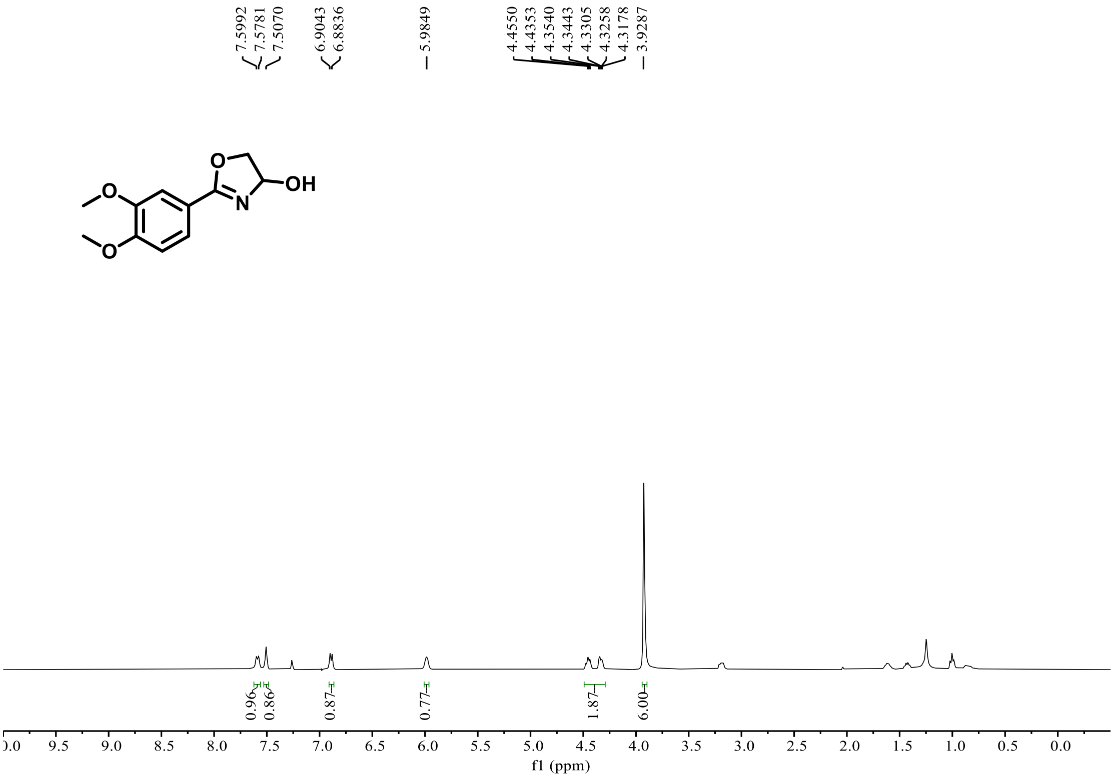
^{1}H NMR (400 MHz, DMSO-d_6) of compound **2n**



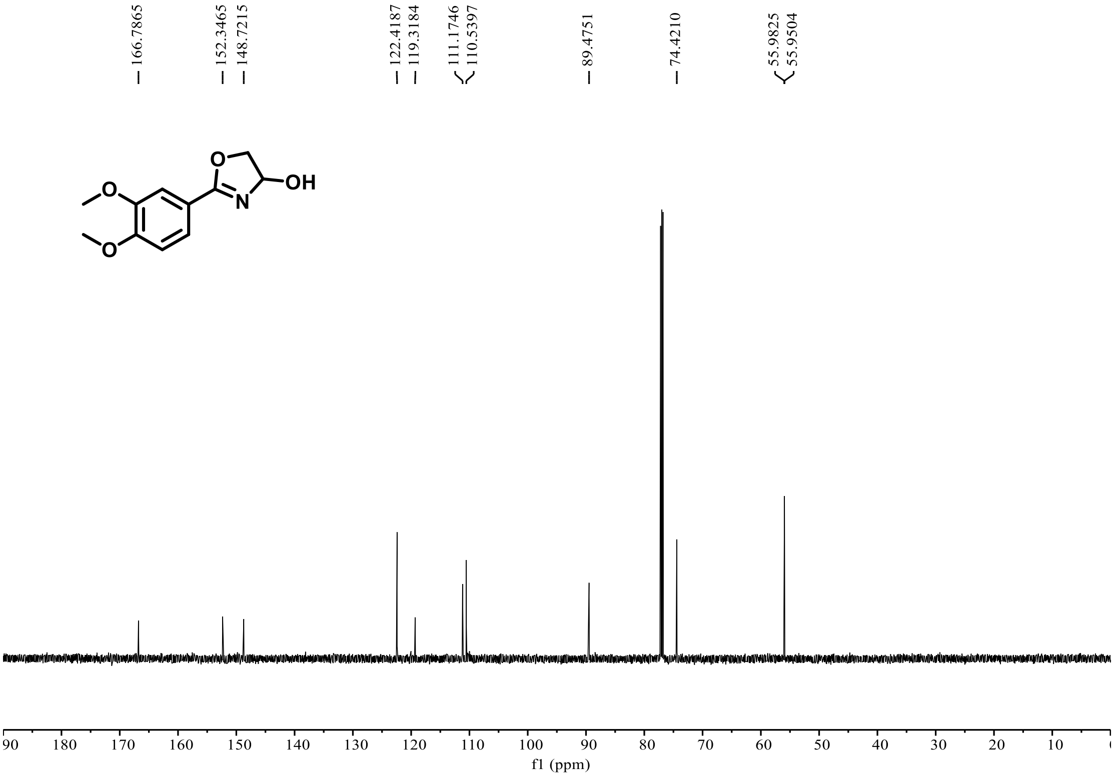
^{13}C NMR (151 MHz, DMSO-d_6) of compound **2n**



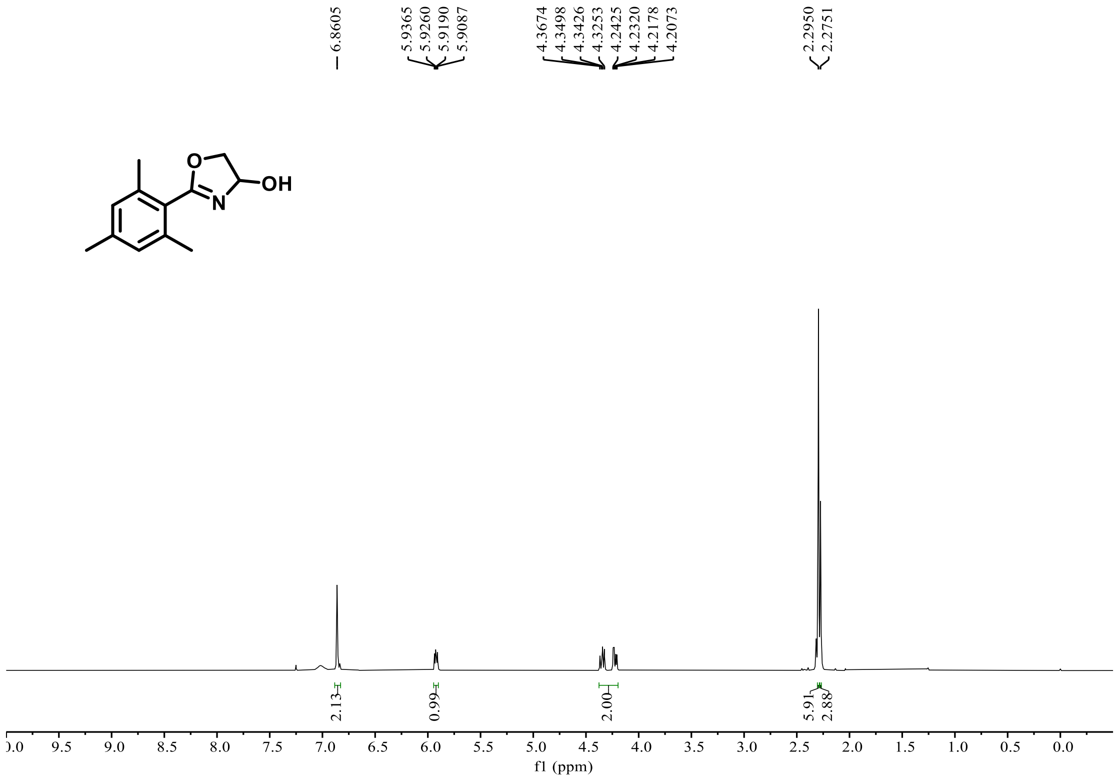
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2o**



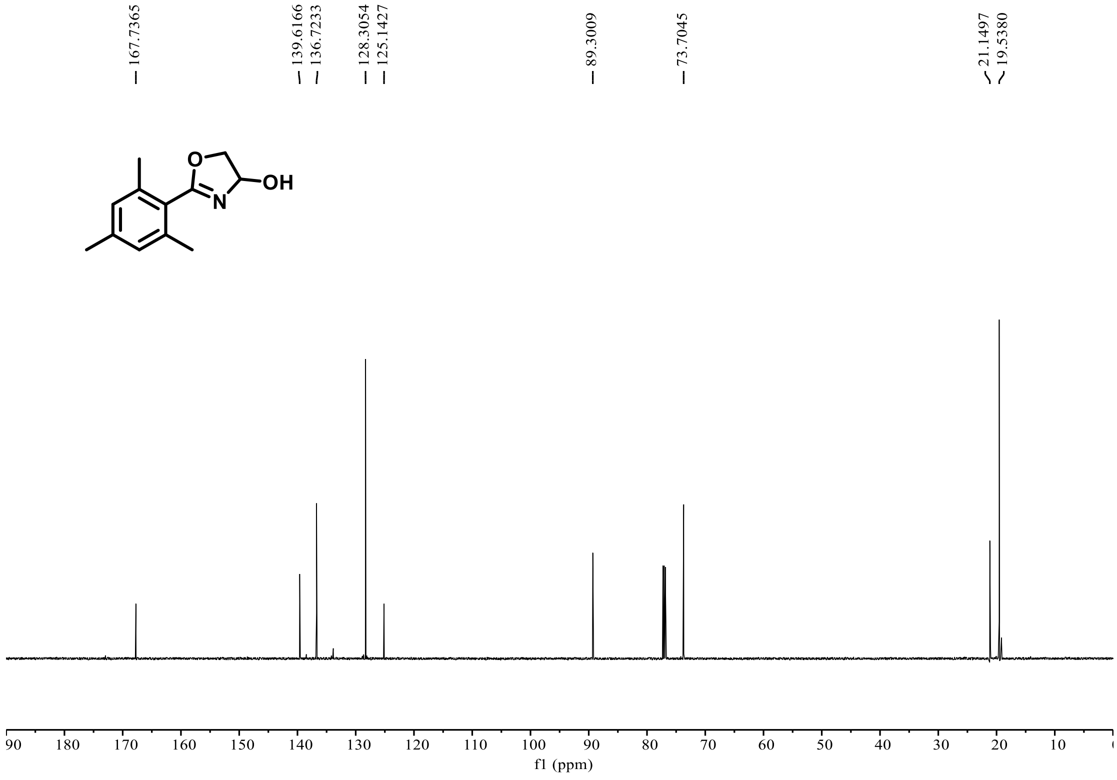
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2o**



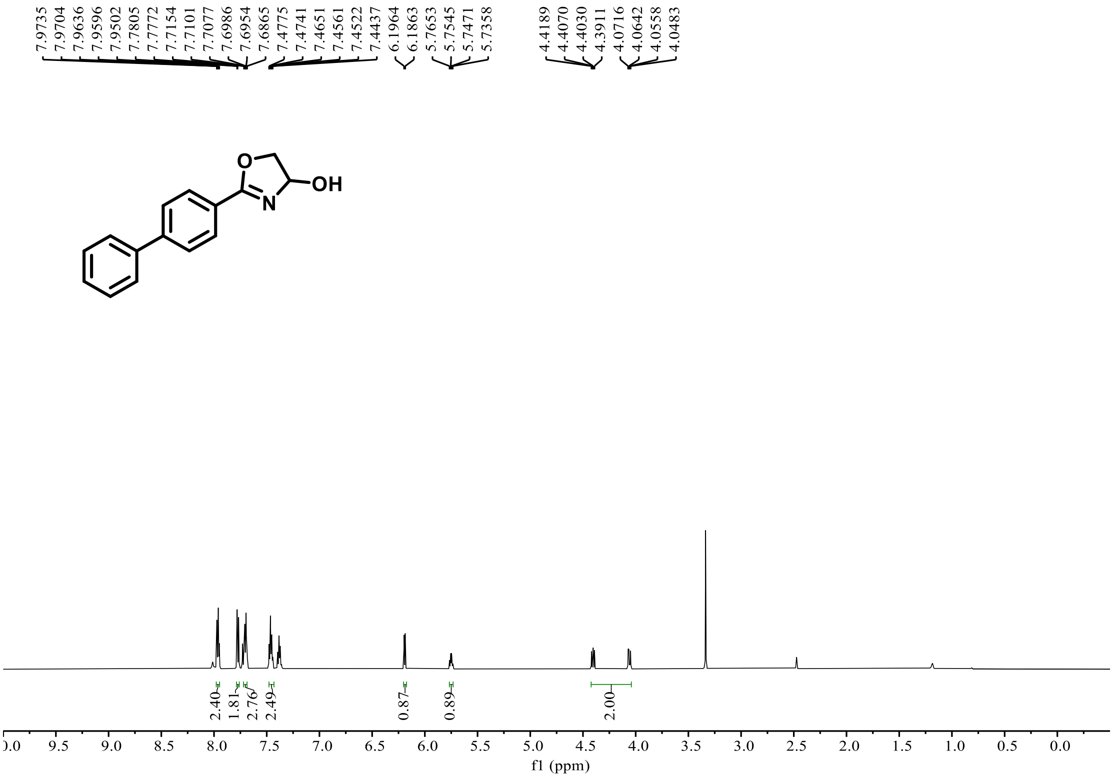
^{1}H NMR (400 MHz, $CDCl_3$) of compound **2p**



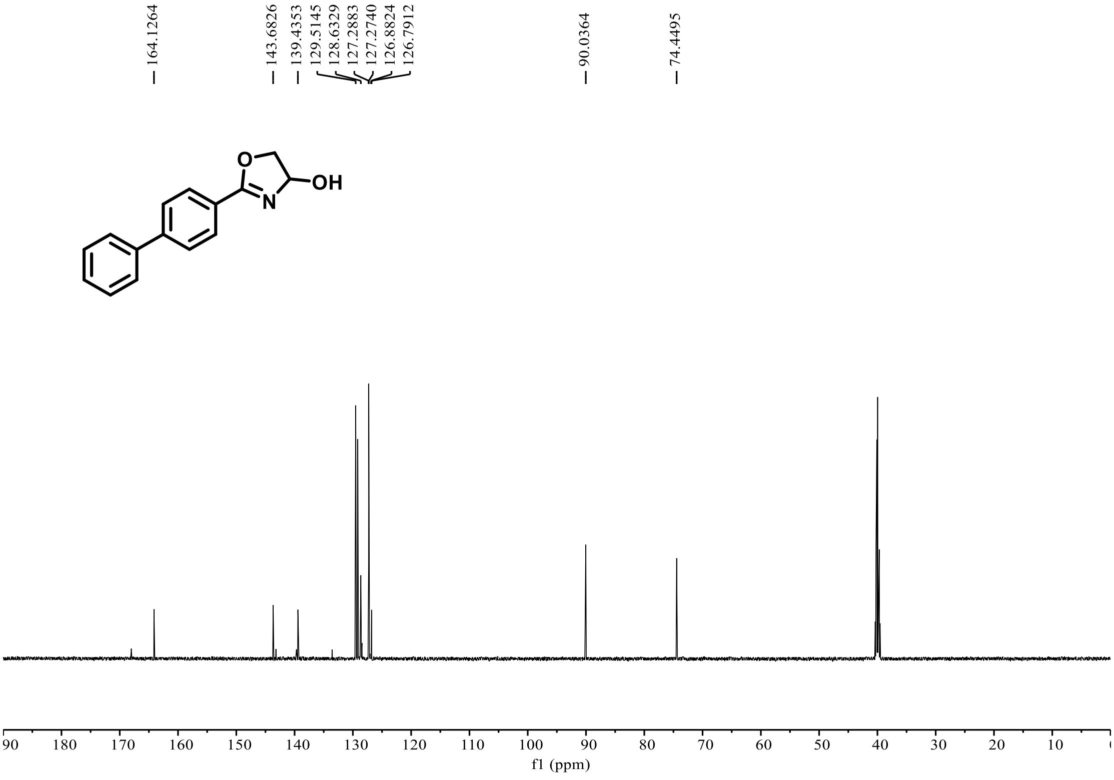
^{13}C NMR (151 MHz, $CDCl_3$) of compound **2p**



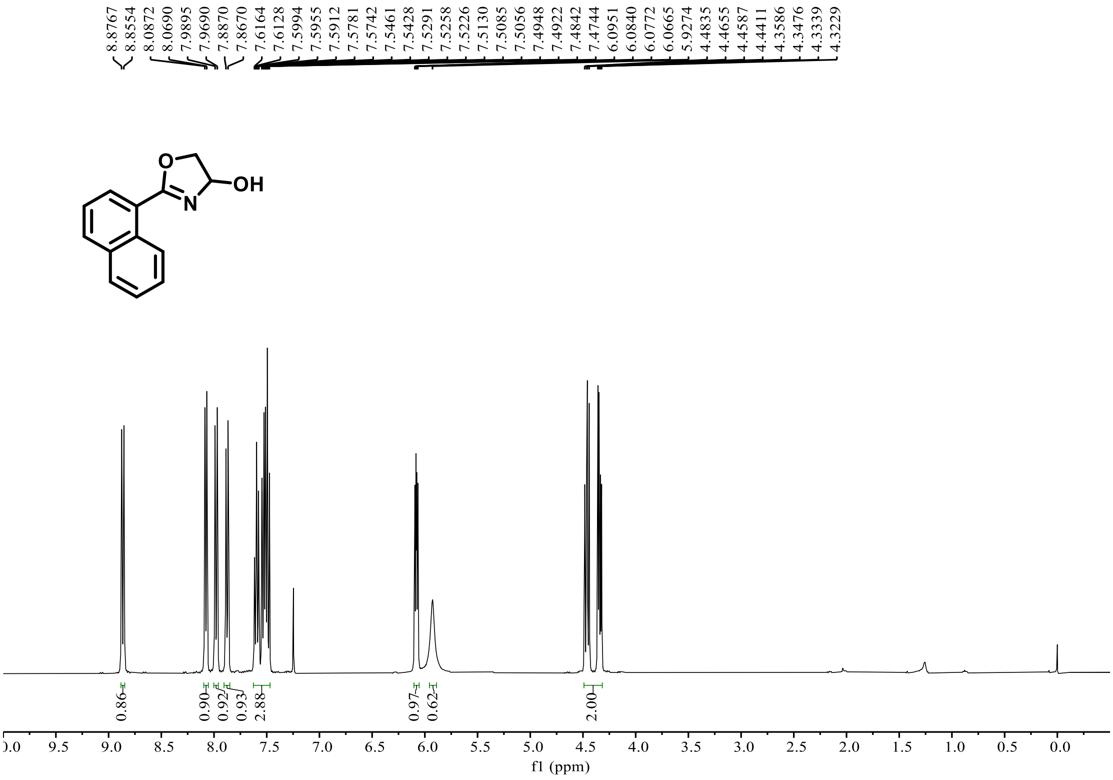
^{1}H NMR (400 MHz, DMSO-d_6) of compound **2q**



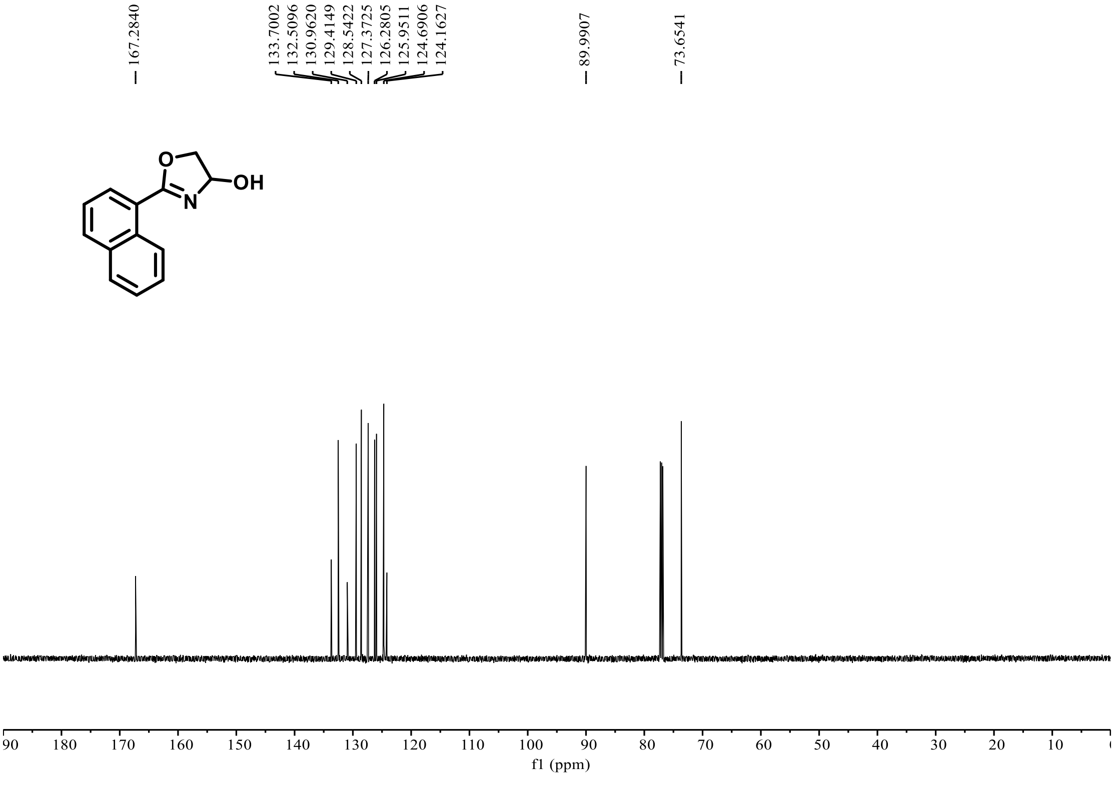
^{13}C NMR (151 MHz, DMSO-d_6) of compound **2q**



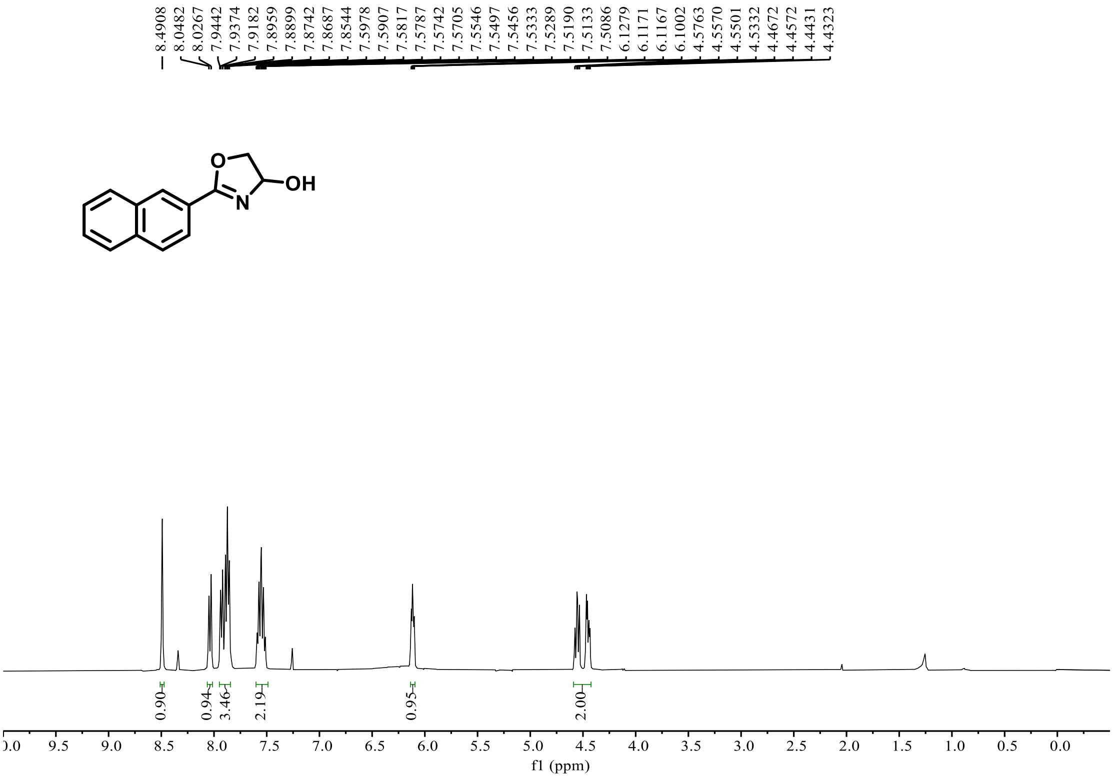
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2r**



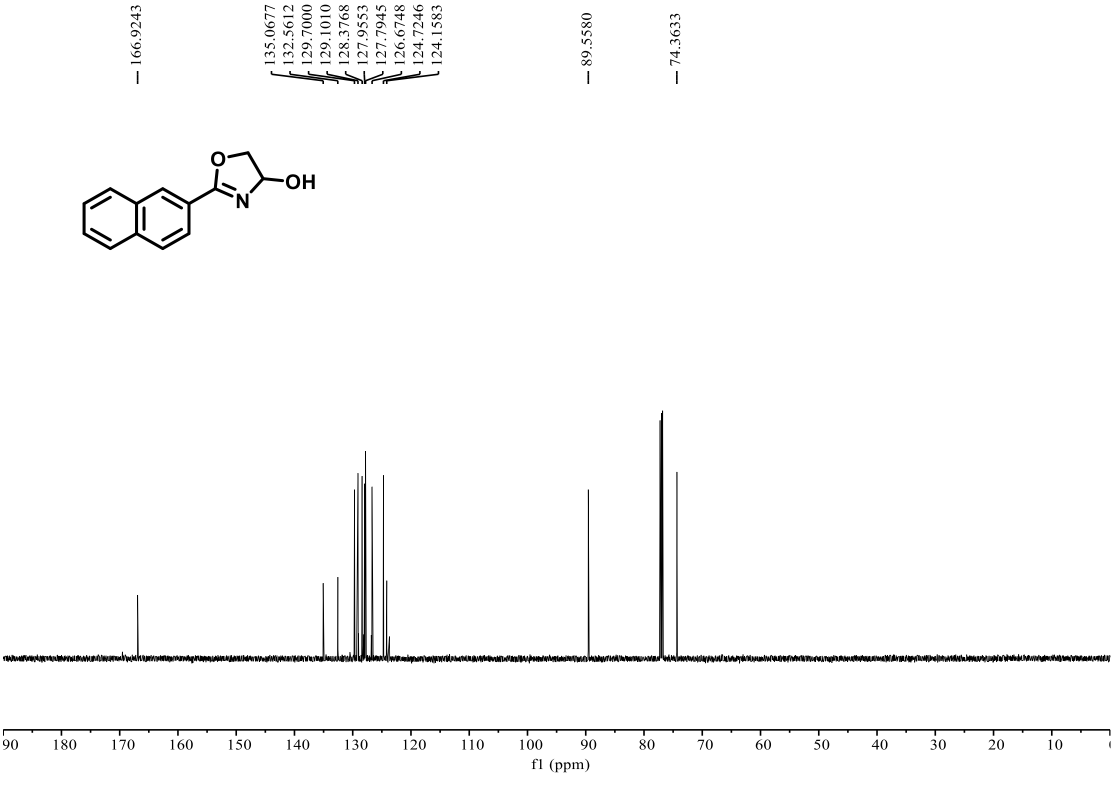
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2r**



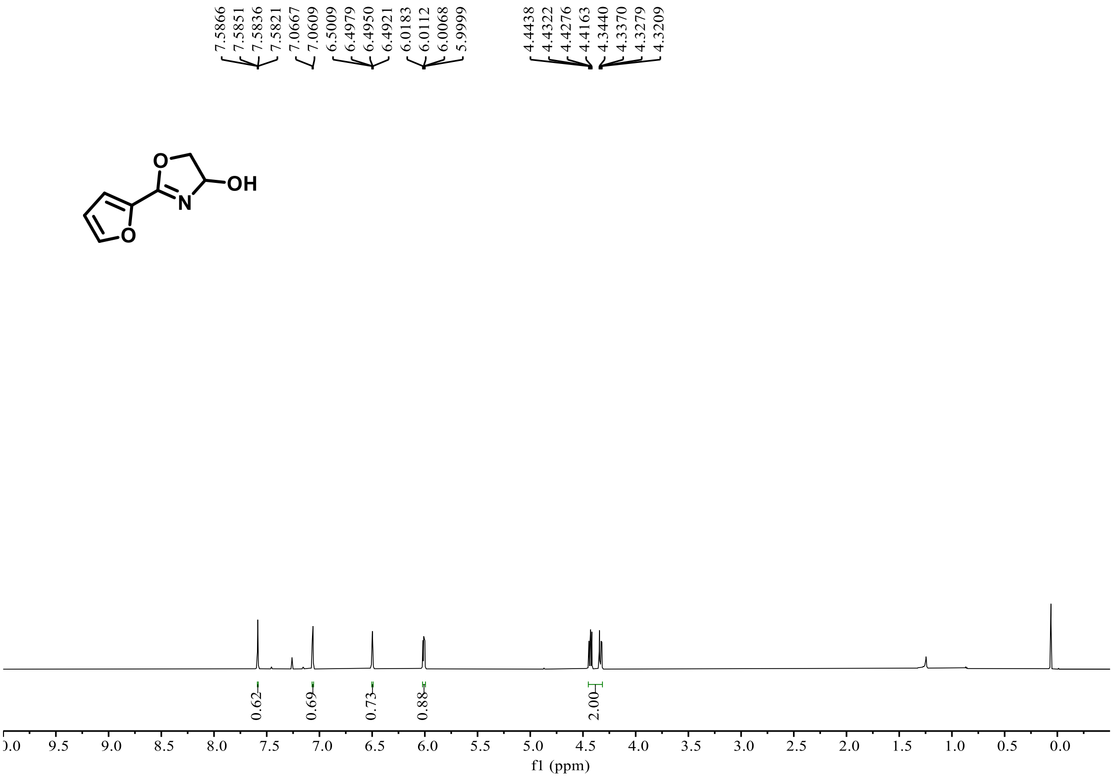
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2s**



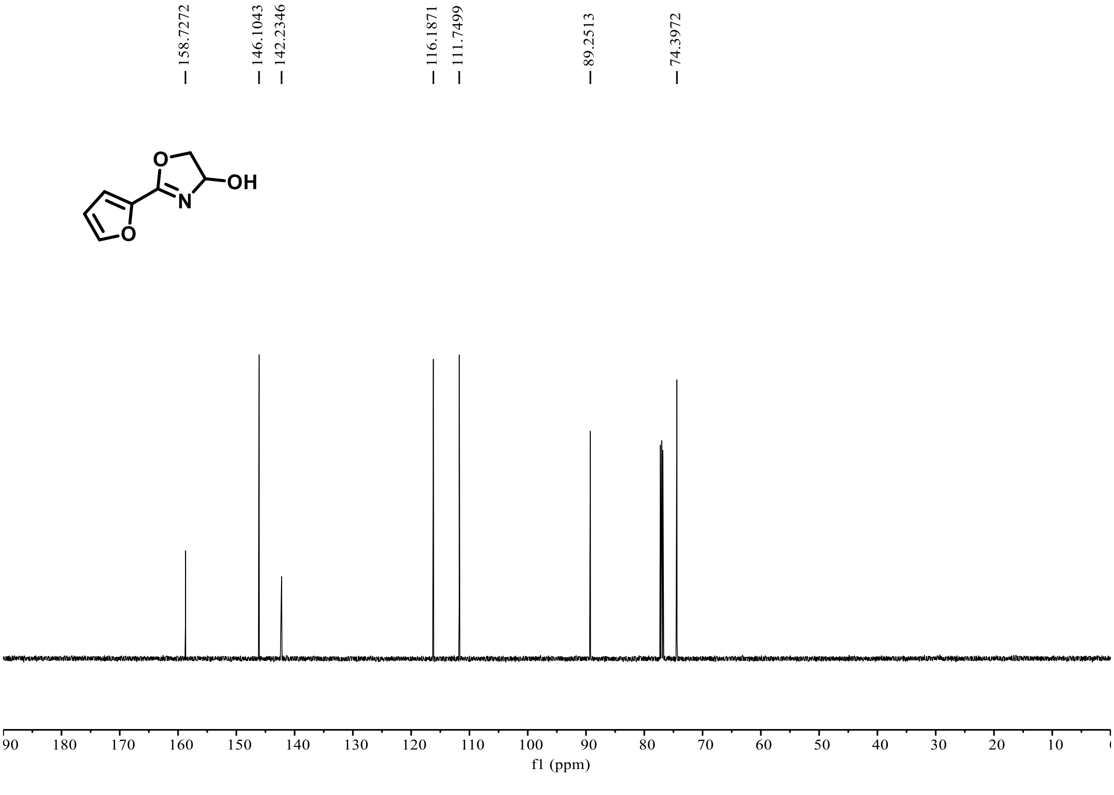
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2s**



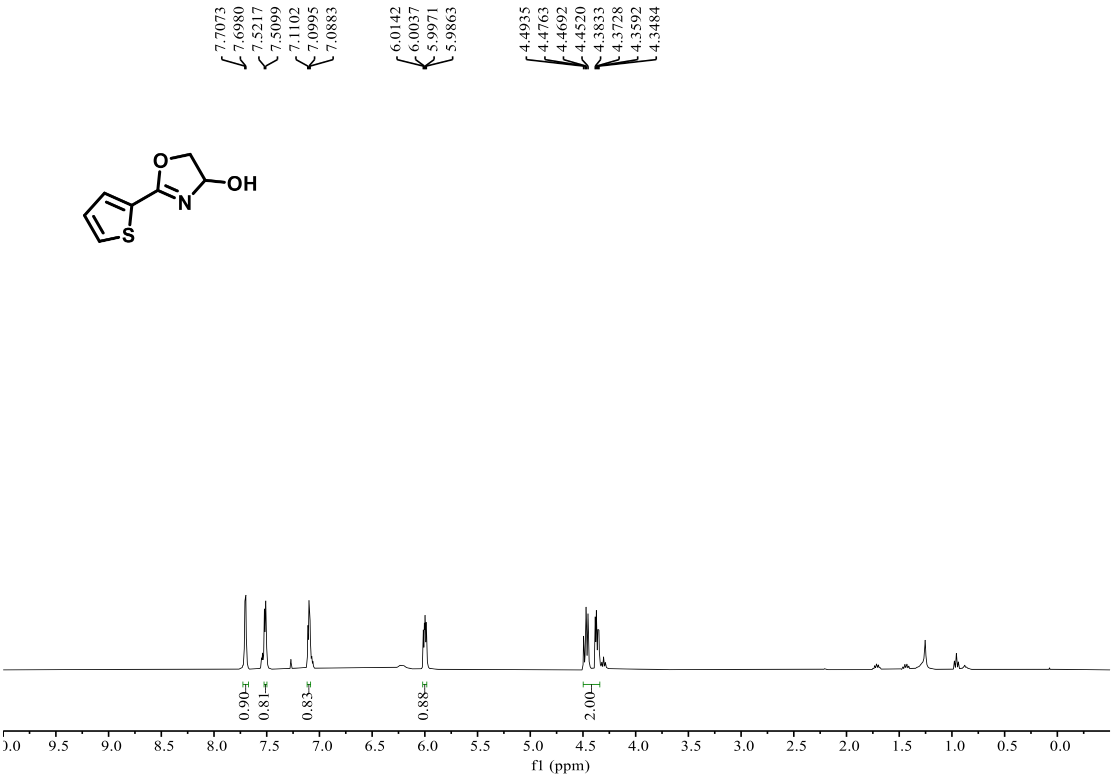
^{1}H NMR (600 MHz, CDCl$_3$) of compound **2t**



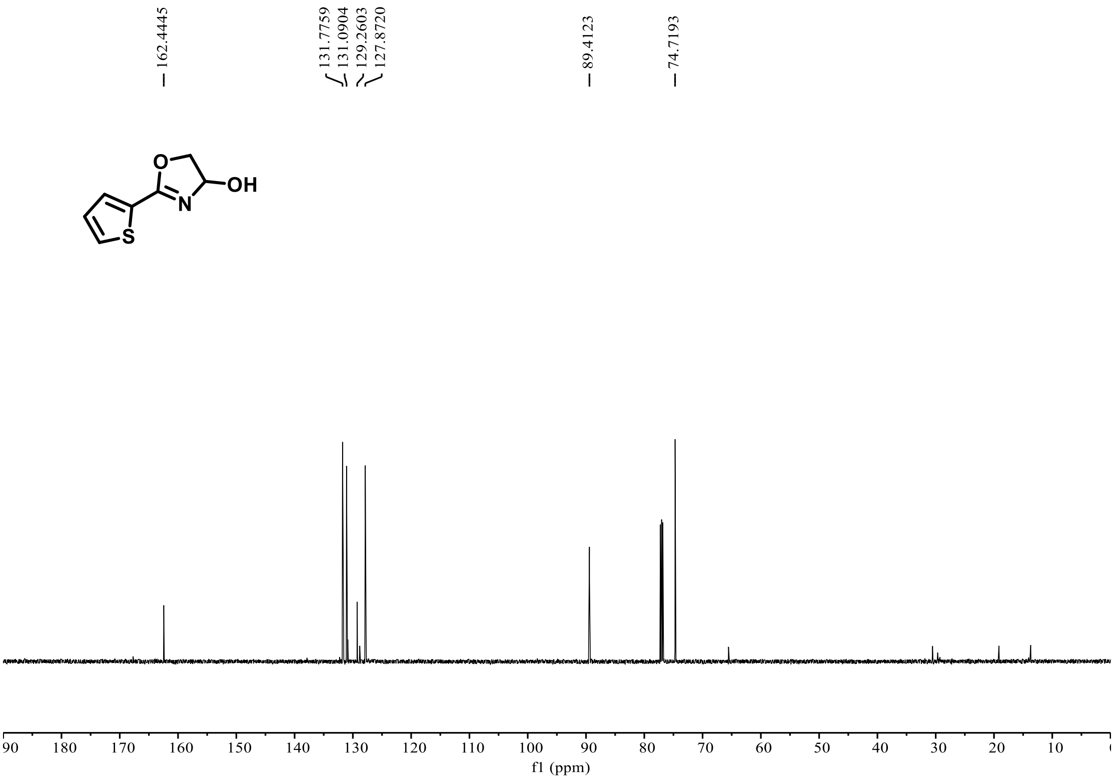
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2t**



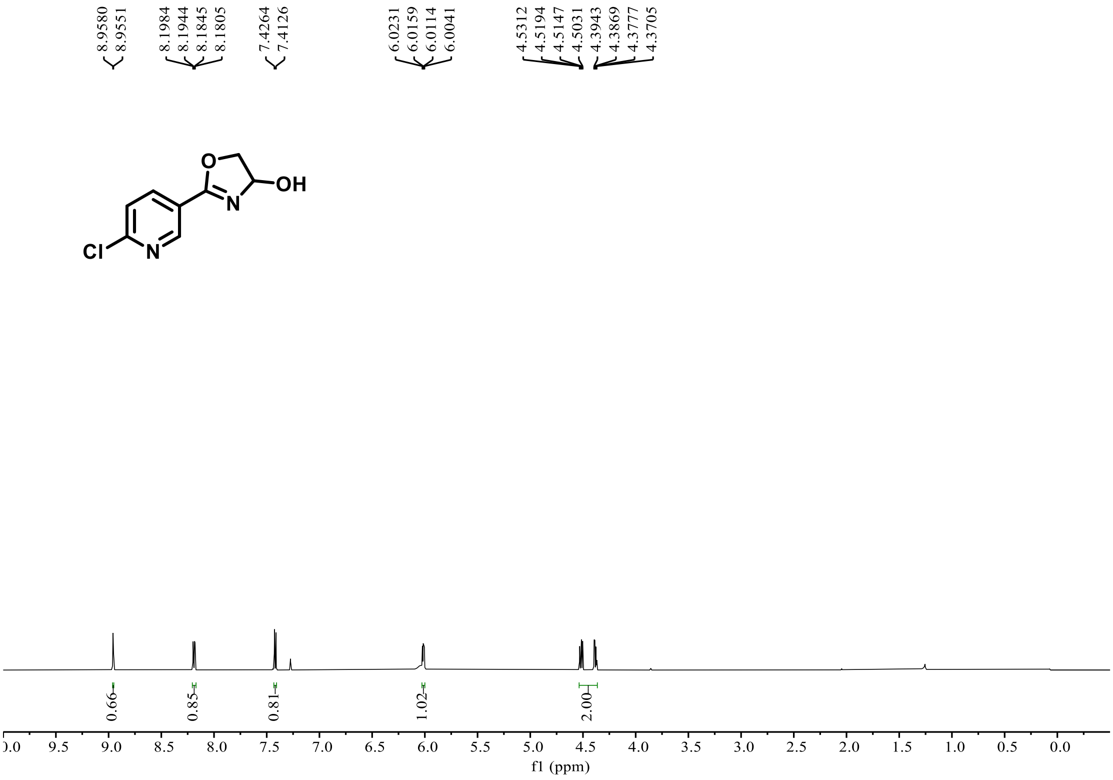
^1H NMR (400 MHz, $CDCl_3$) of compound **2u**



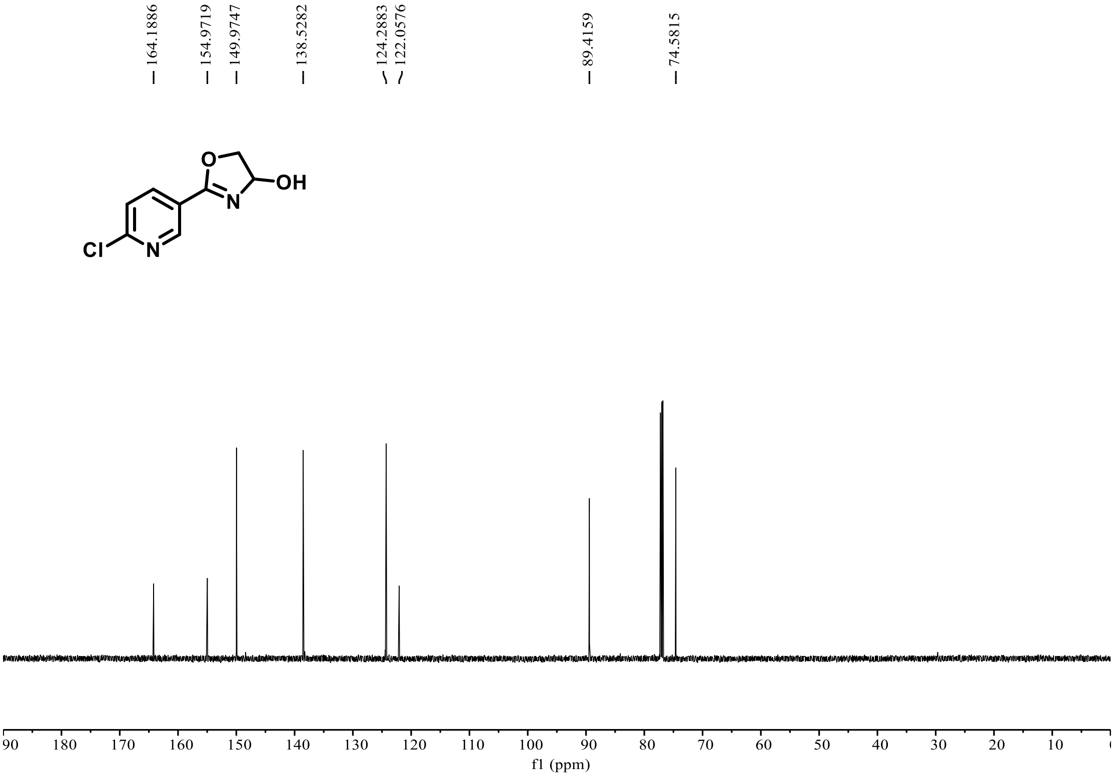
^{13}C NMR (151 MHz, $CDCl_3$) of compound **2u**



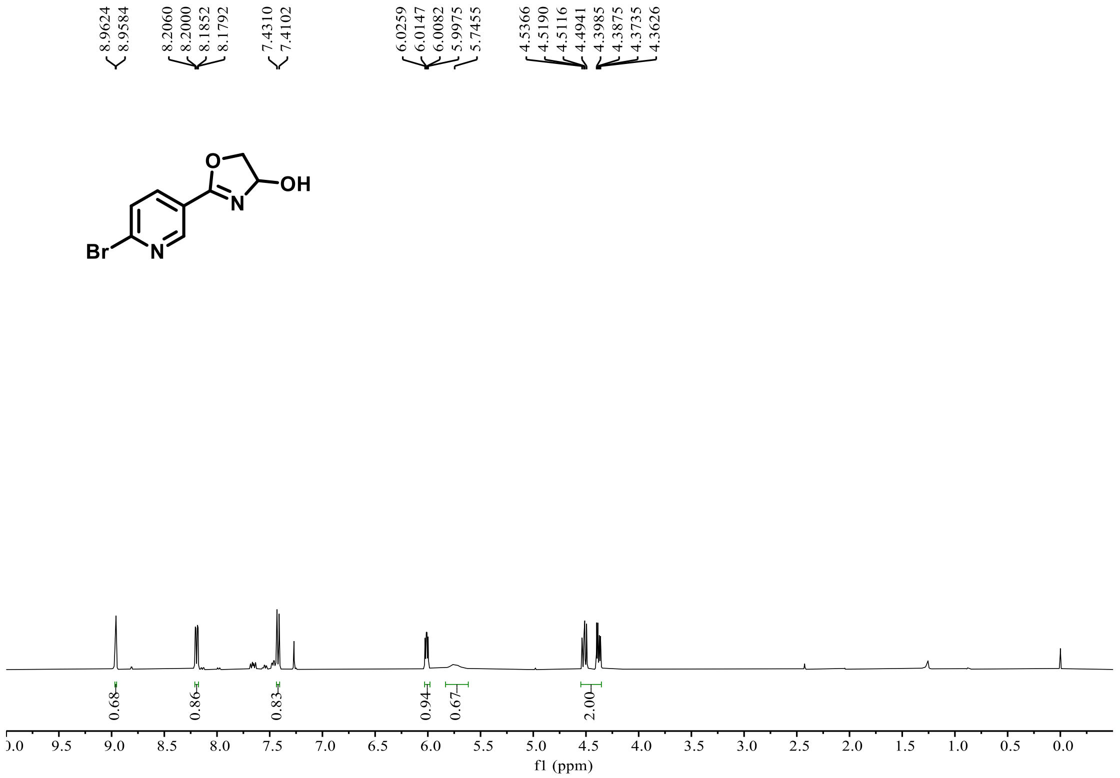
^{1}H NMR (600 MHz, CDCl$_3$) of compound **2v**



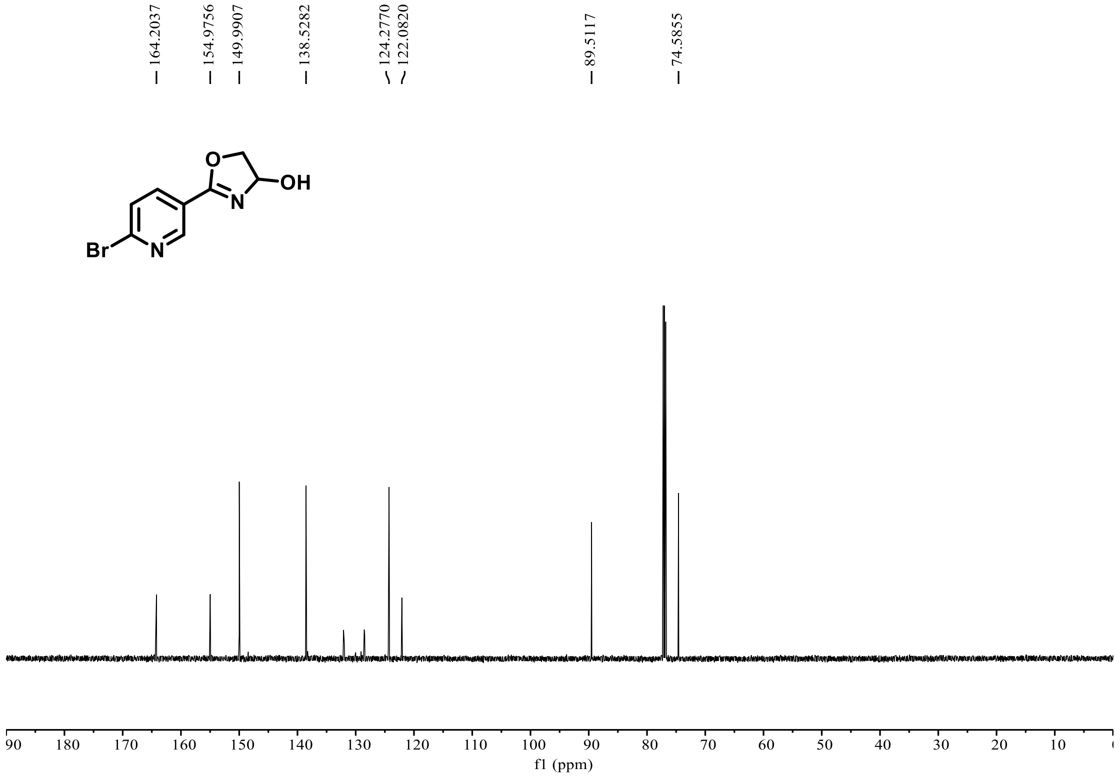
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2v**



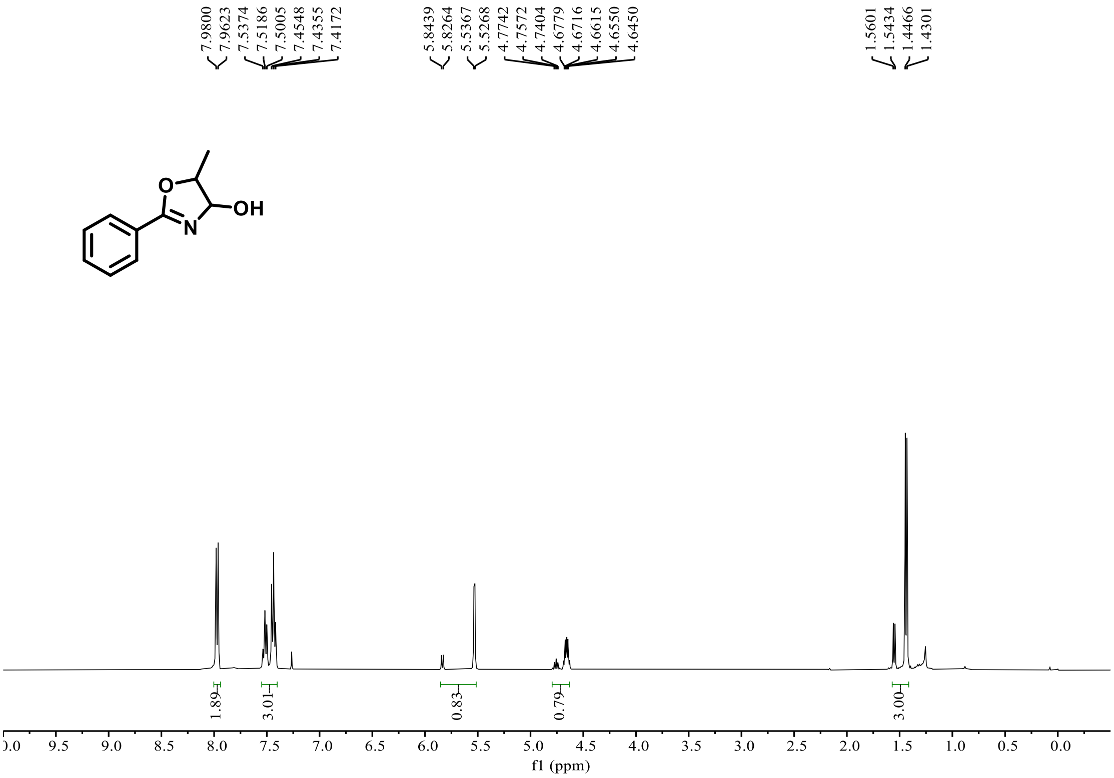
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2w**



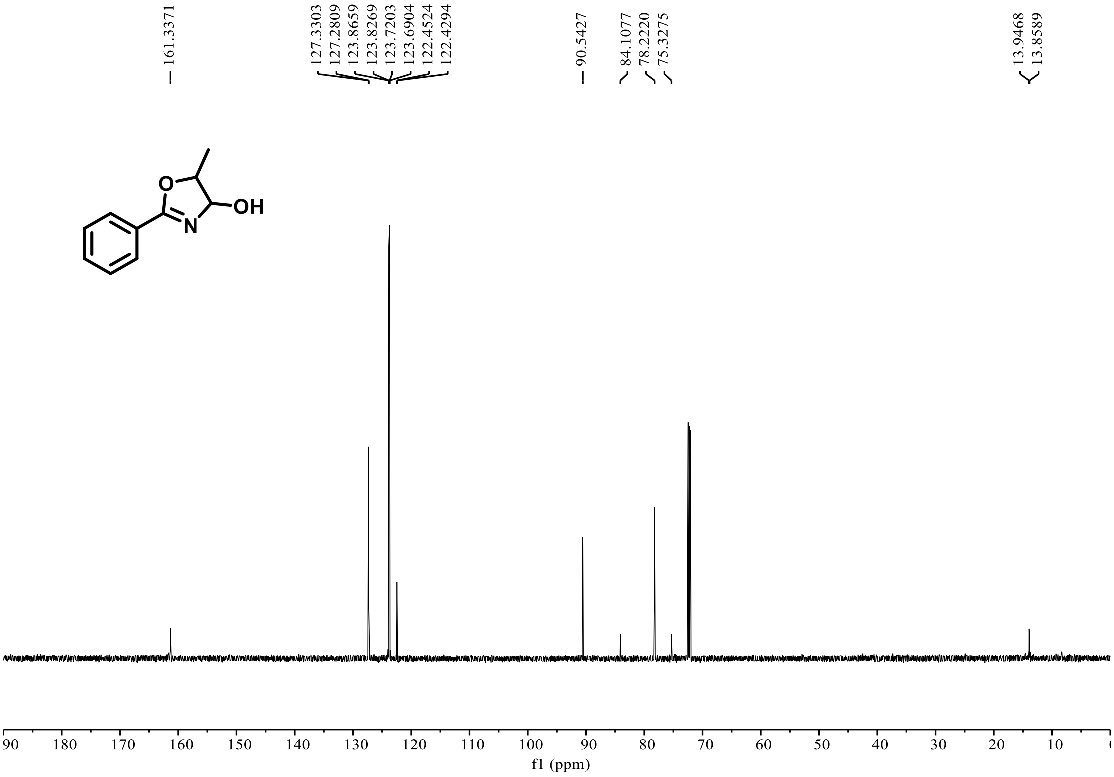
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2w**



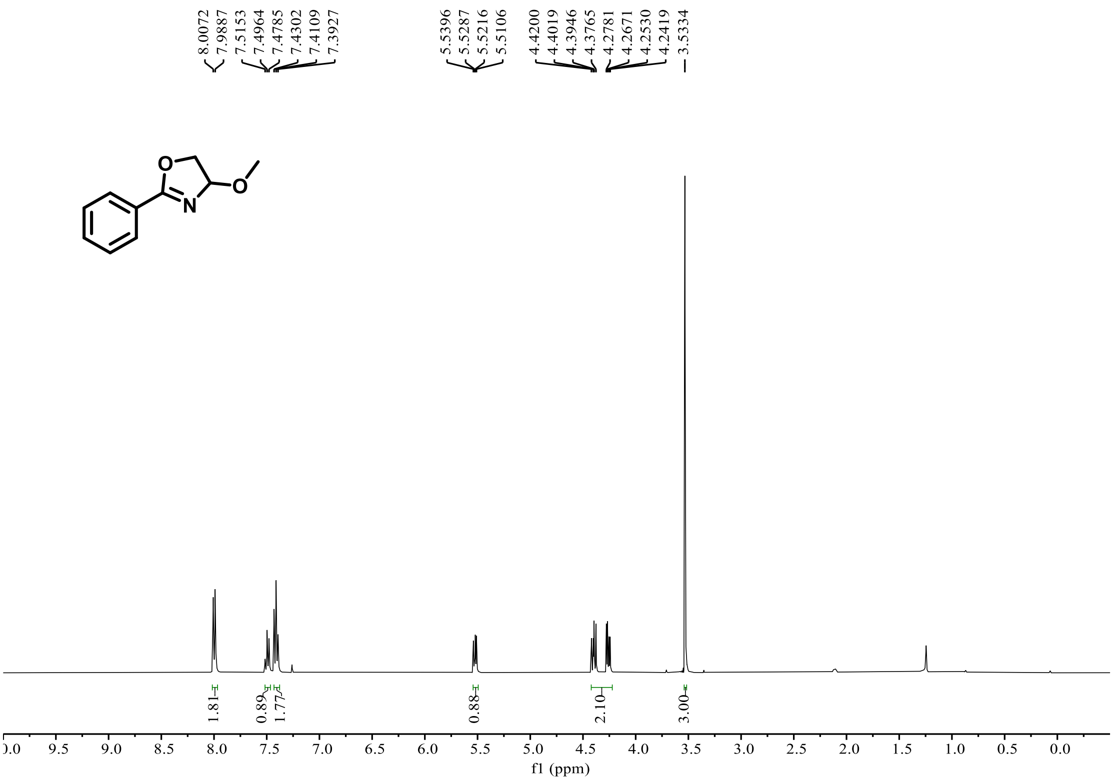
^{1}H NMR (400 MHz, CDCl$_3$) of compound **2x**



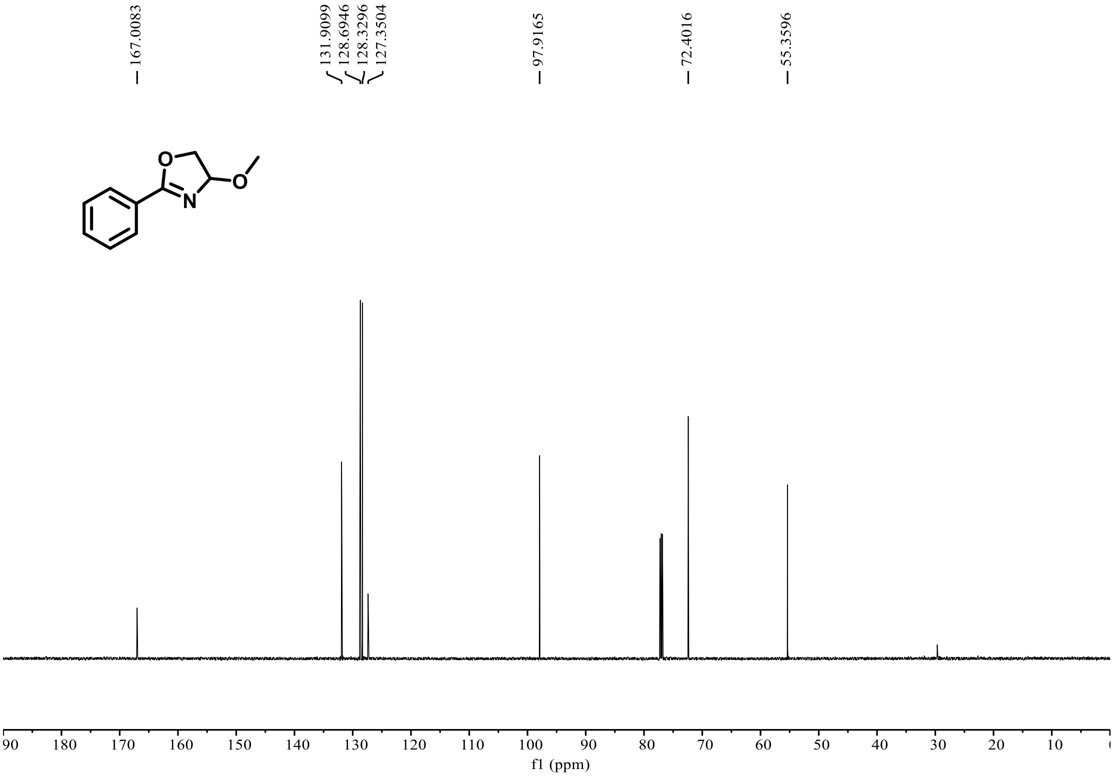
^{13}C NMR (151 MHz, CDCl$_3$) of compound **2x**



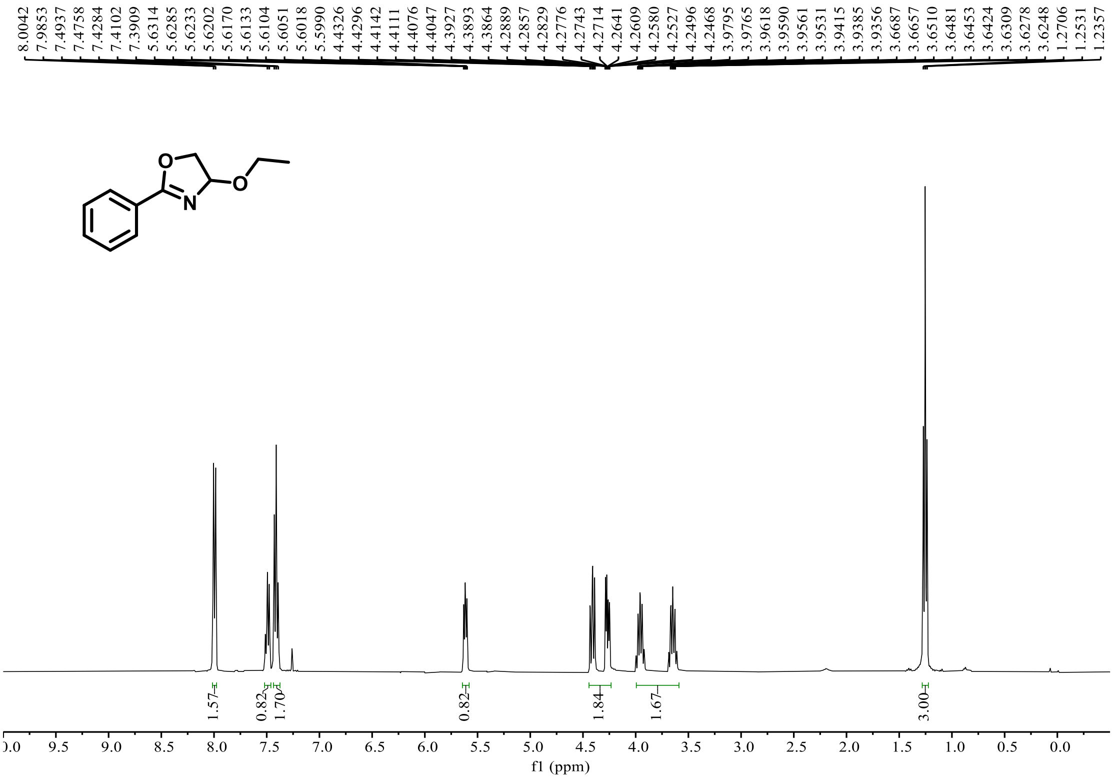
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4a**



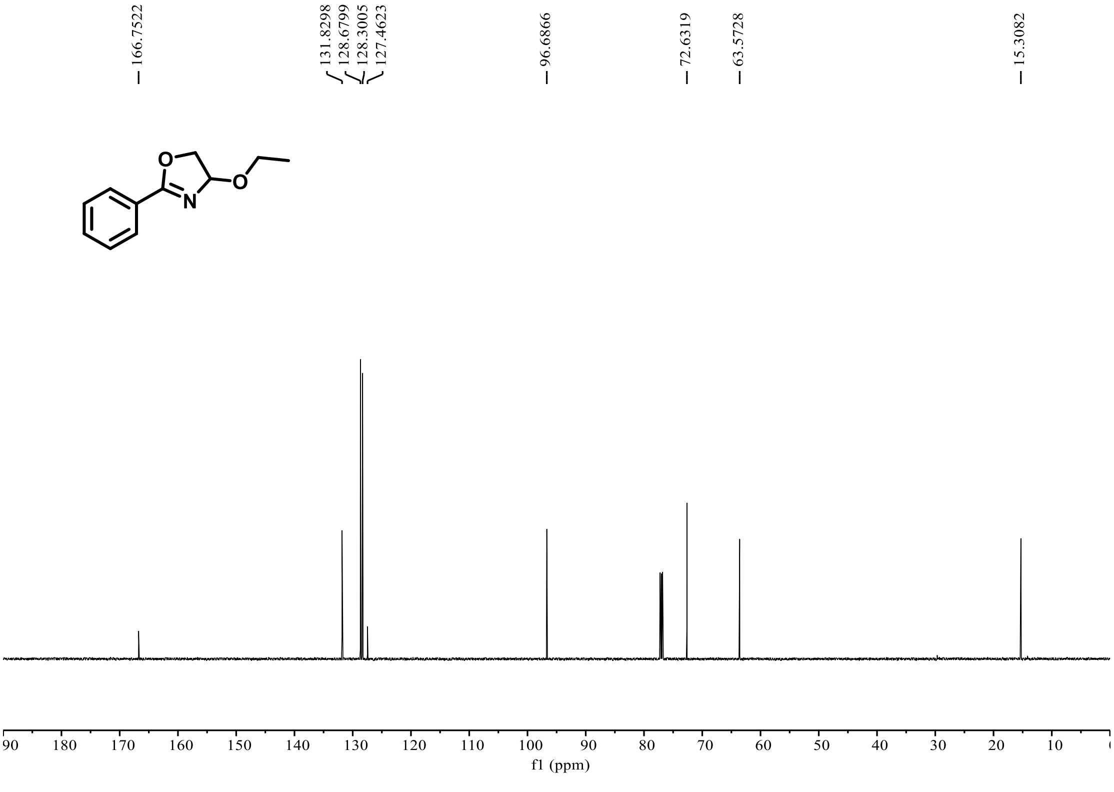
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4a**



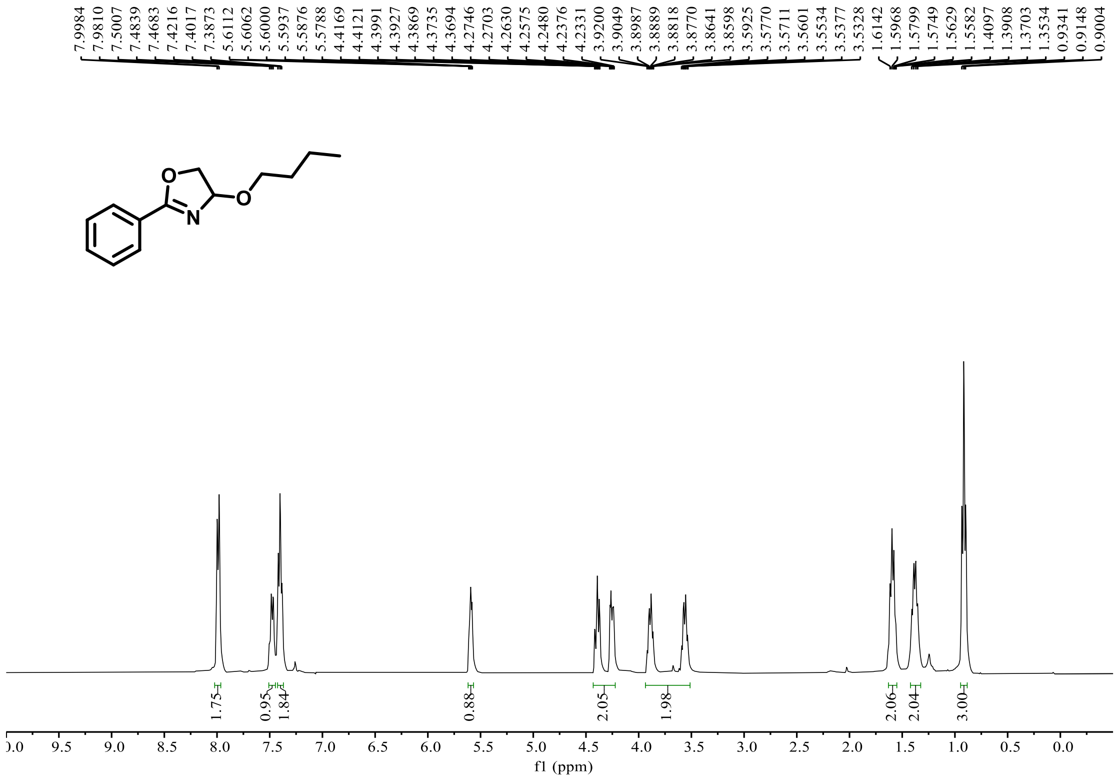
^{1}H NMR (400 MHz, $CDCl_3$) of compound **4b**



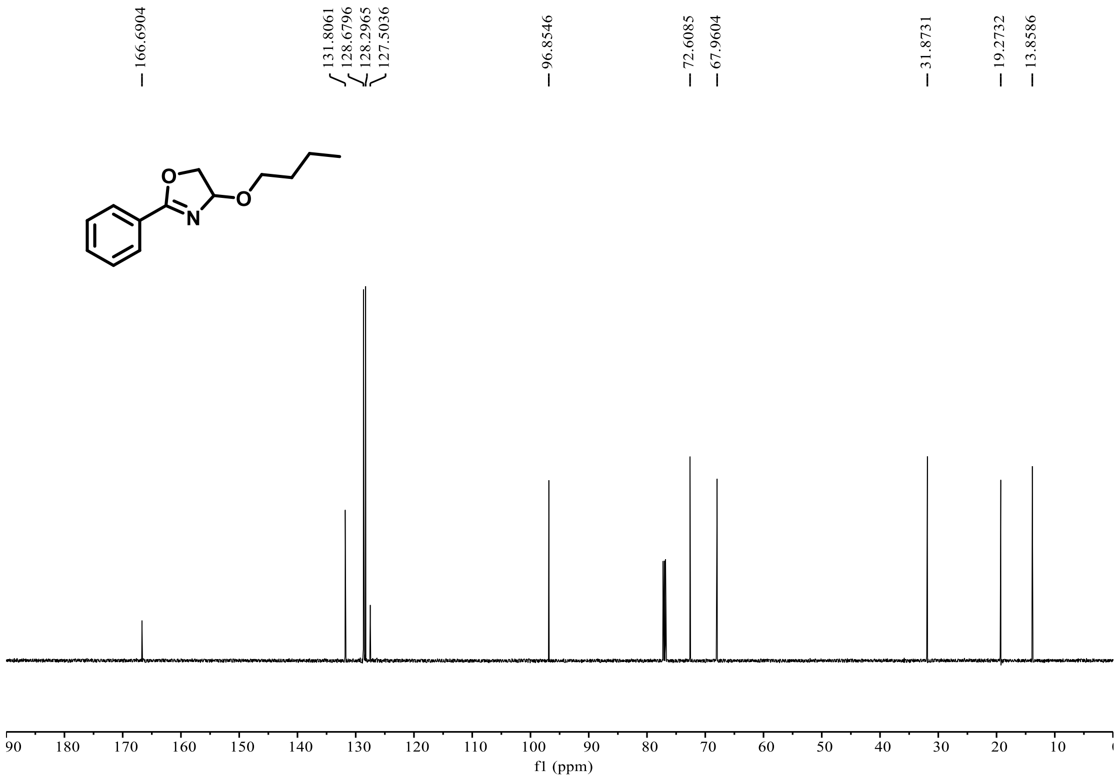
^{13}C NMR (151 MHz, $CDCl_3$) of compound **4b**



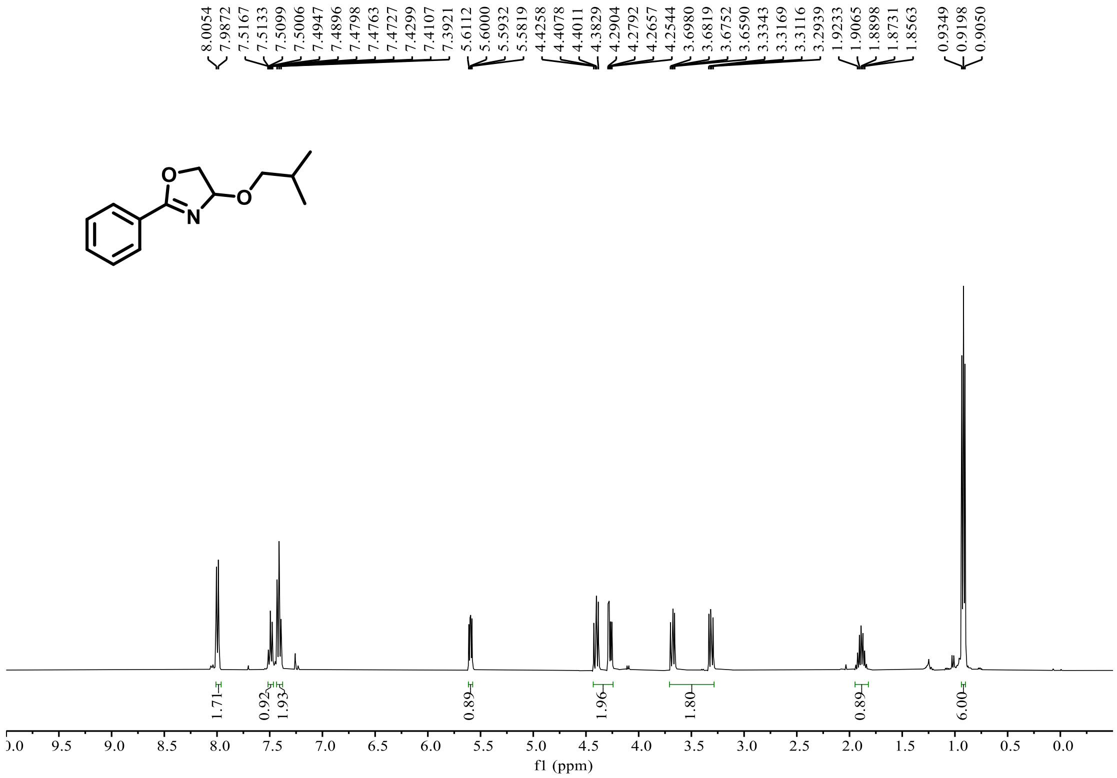
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4c**



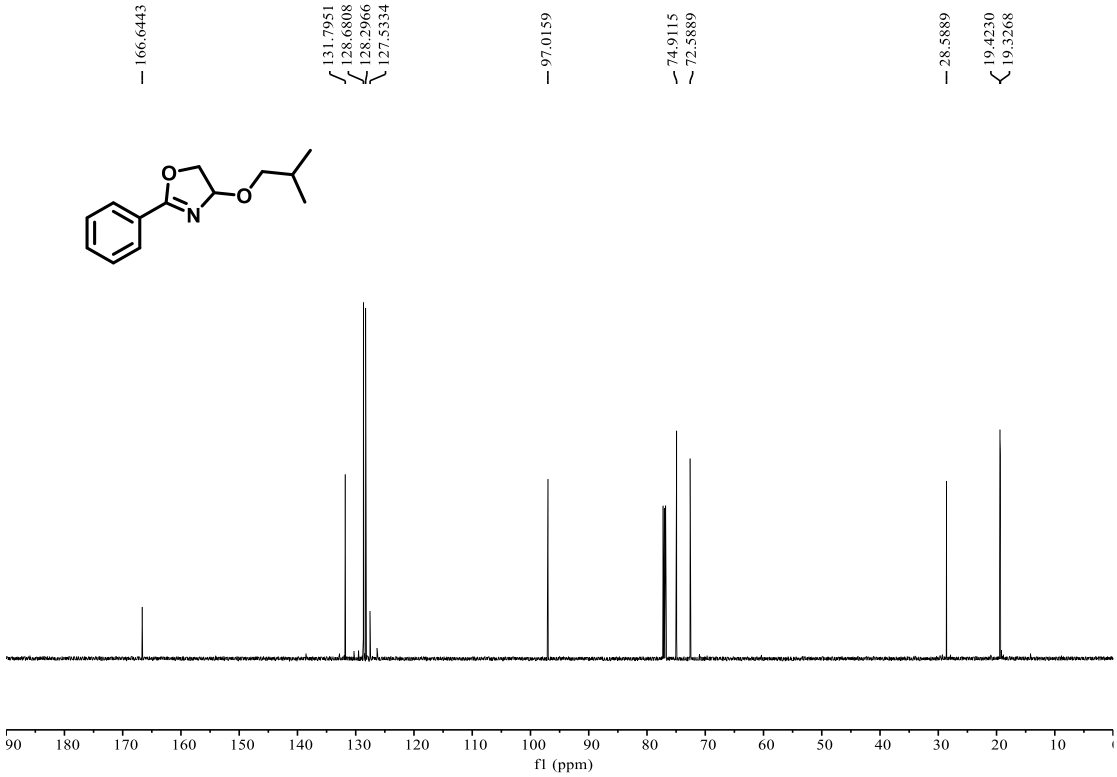
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4c**



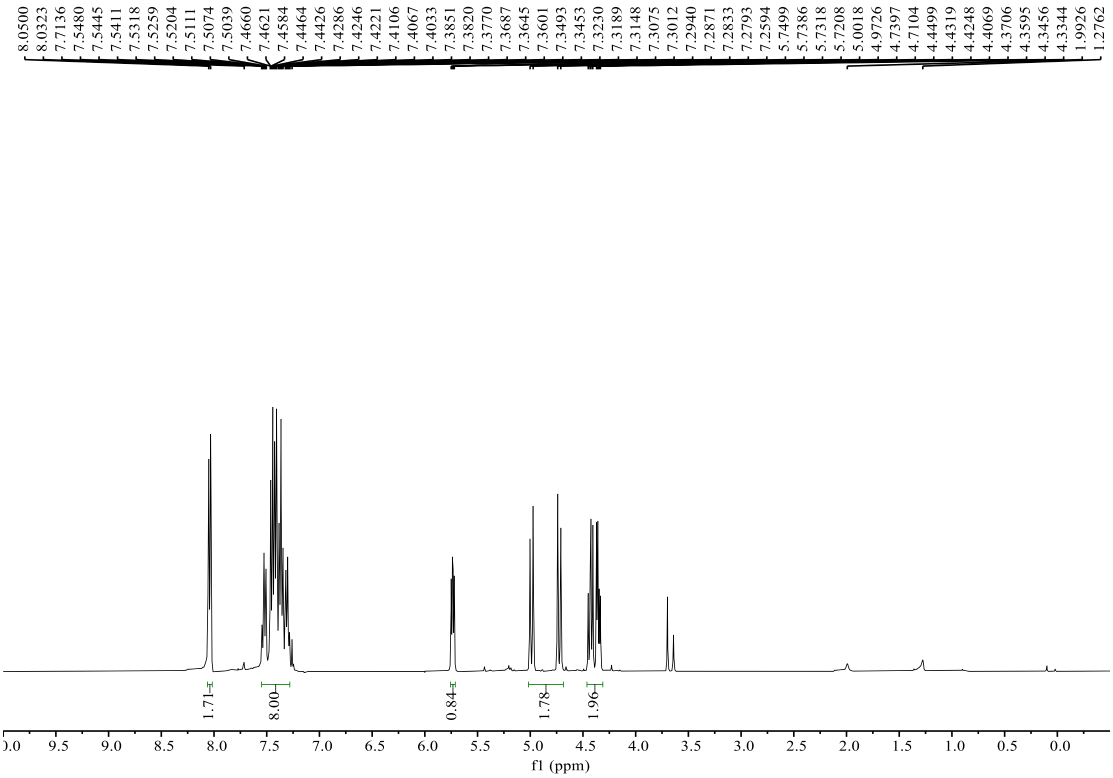
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4d**



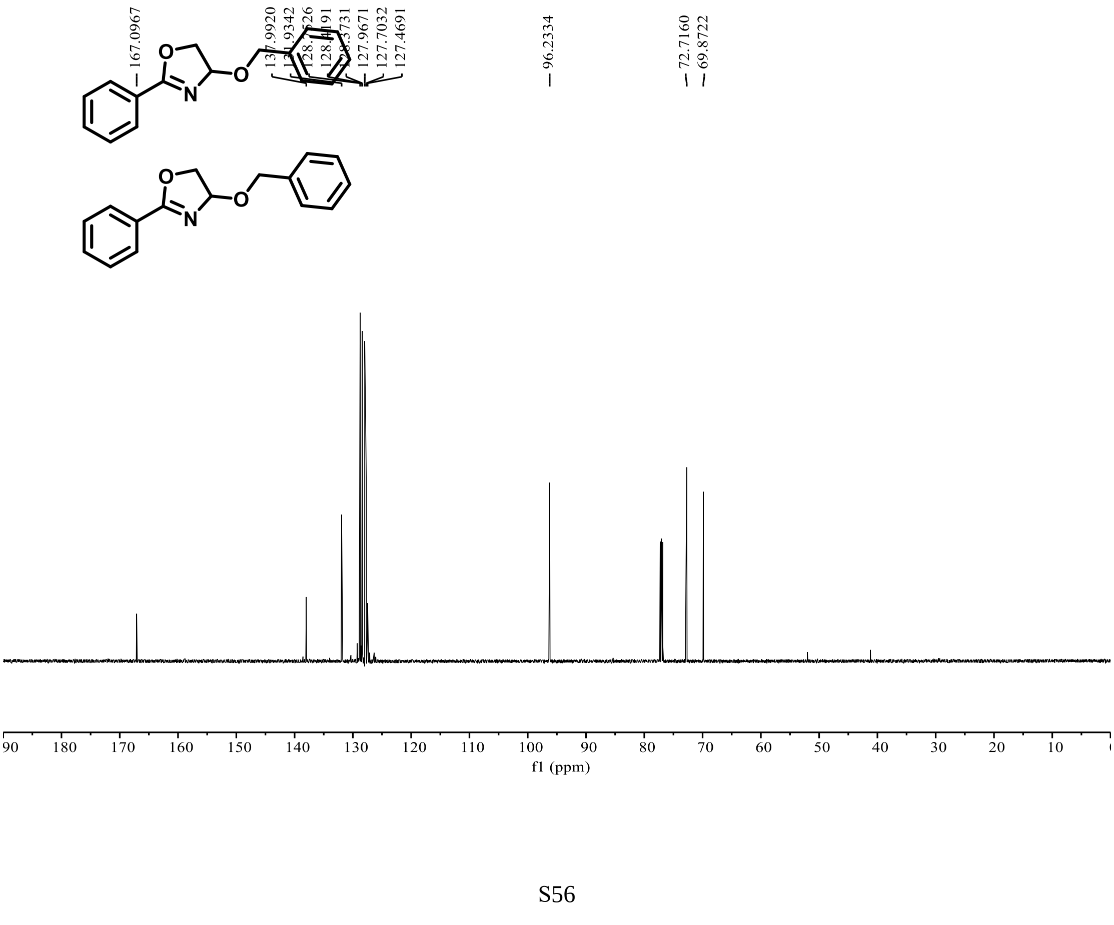
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4d**



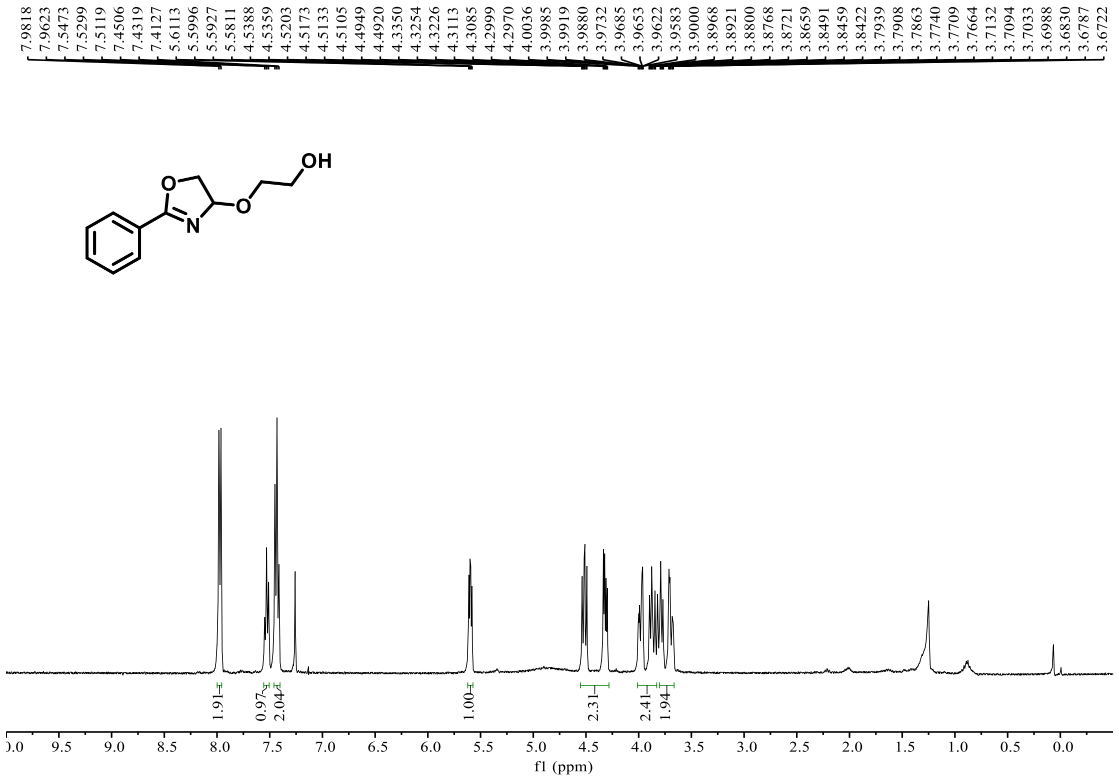
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4e**



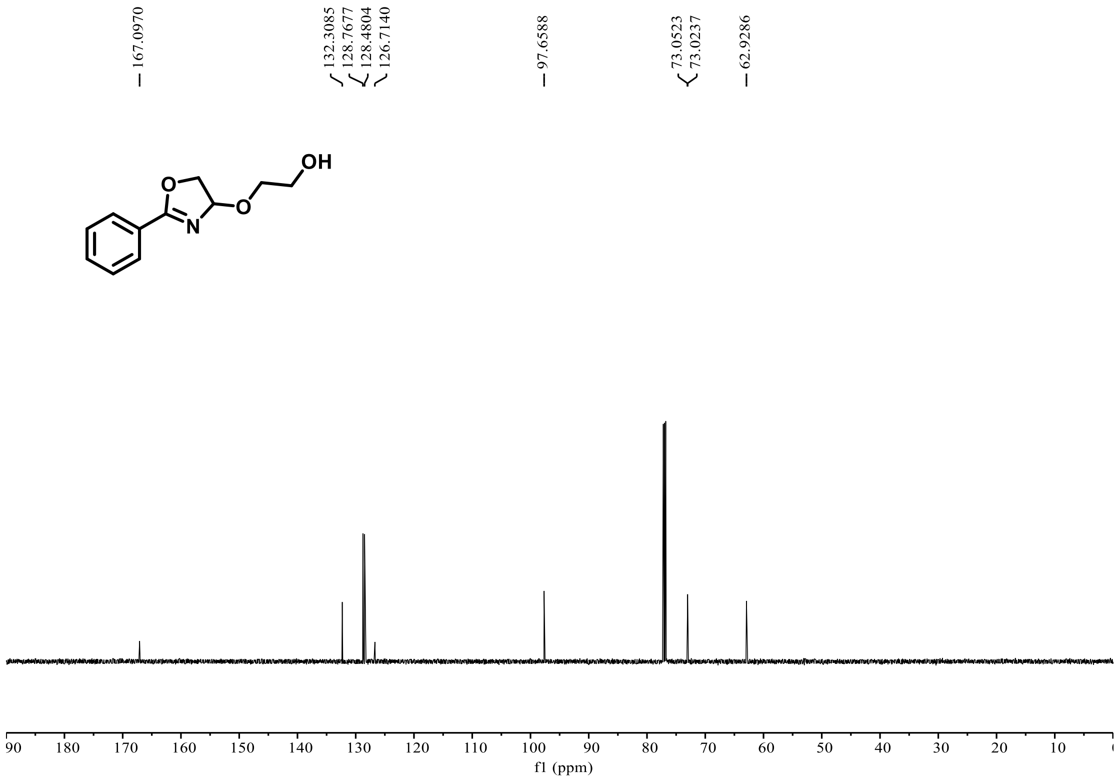
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4e**



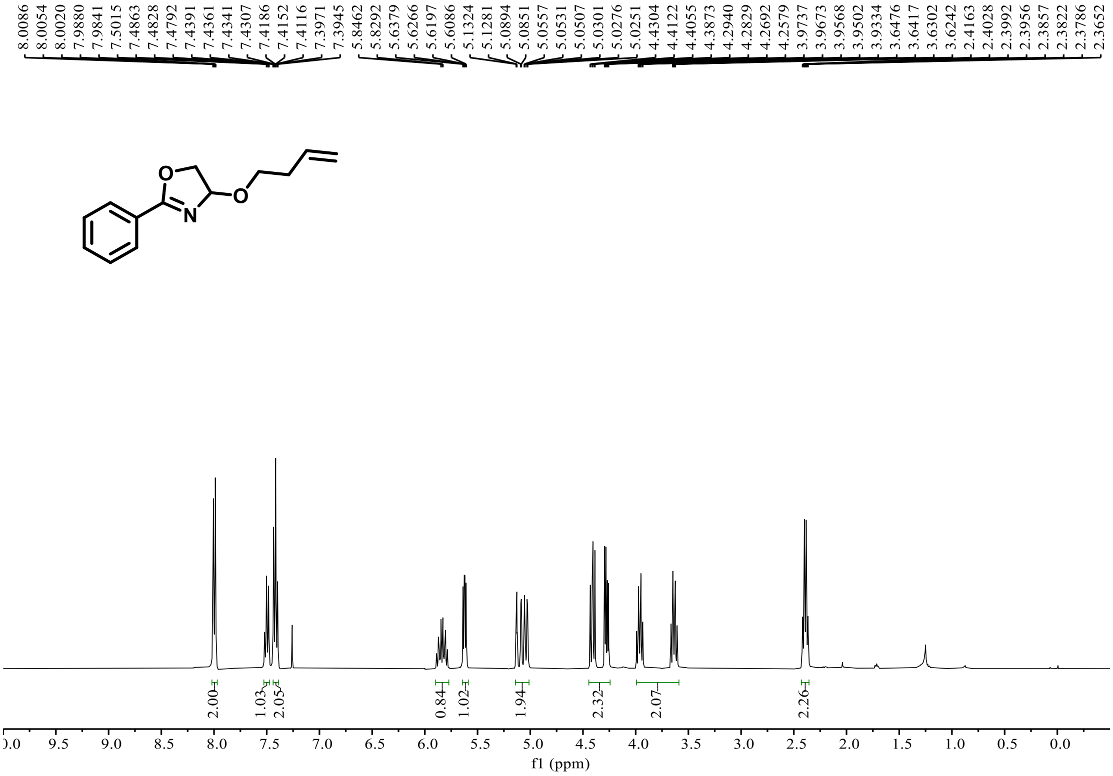
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4f**



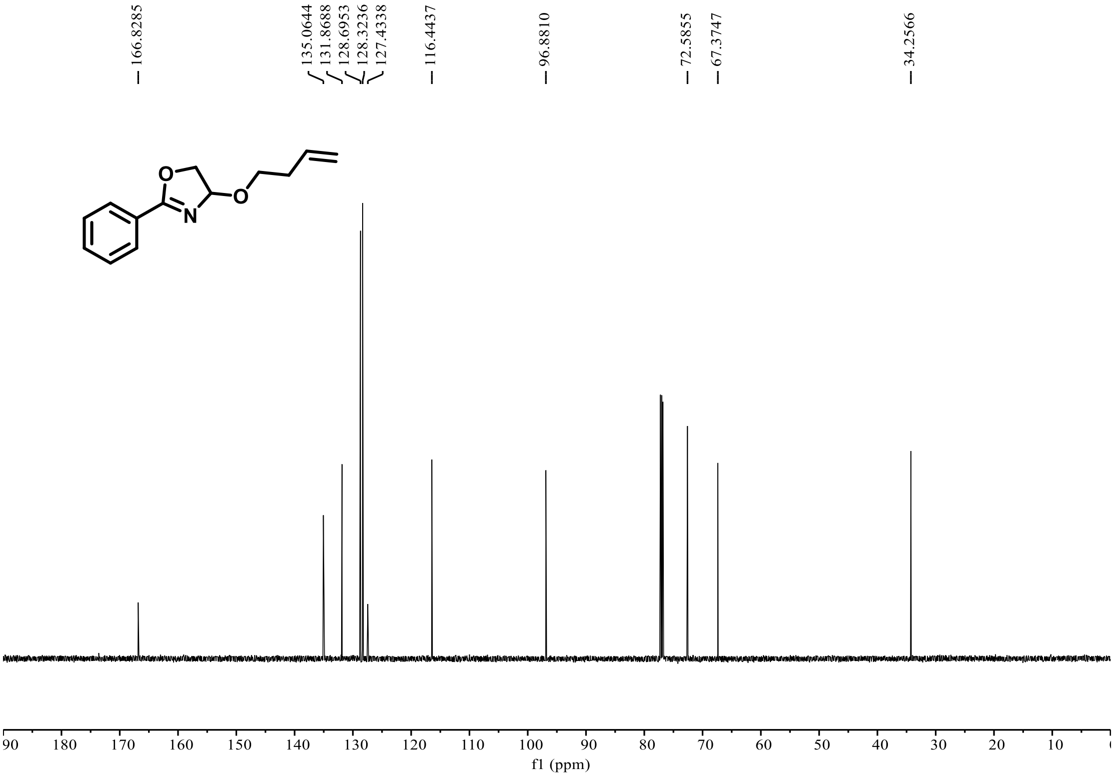
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4f**



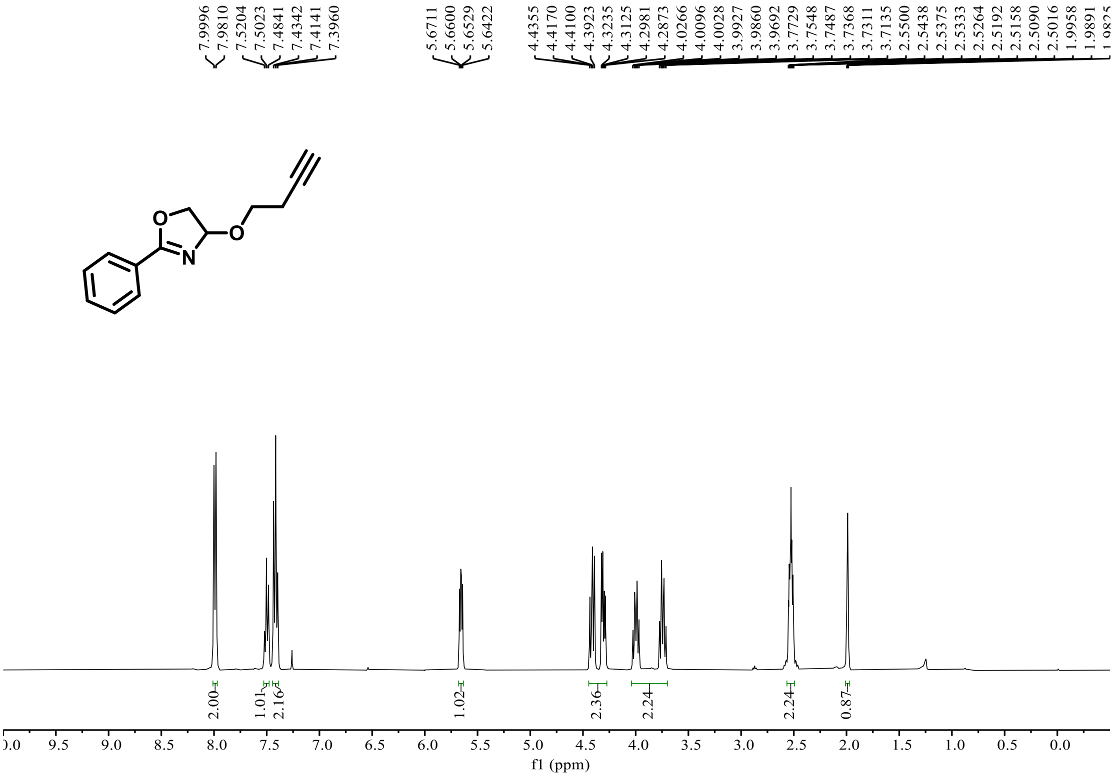
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4g**



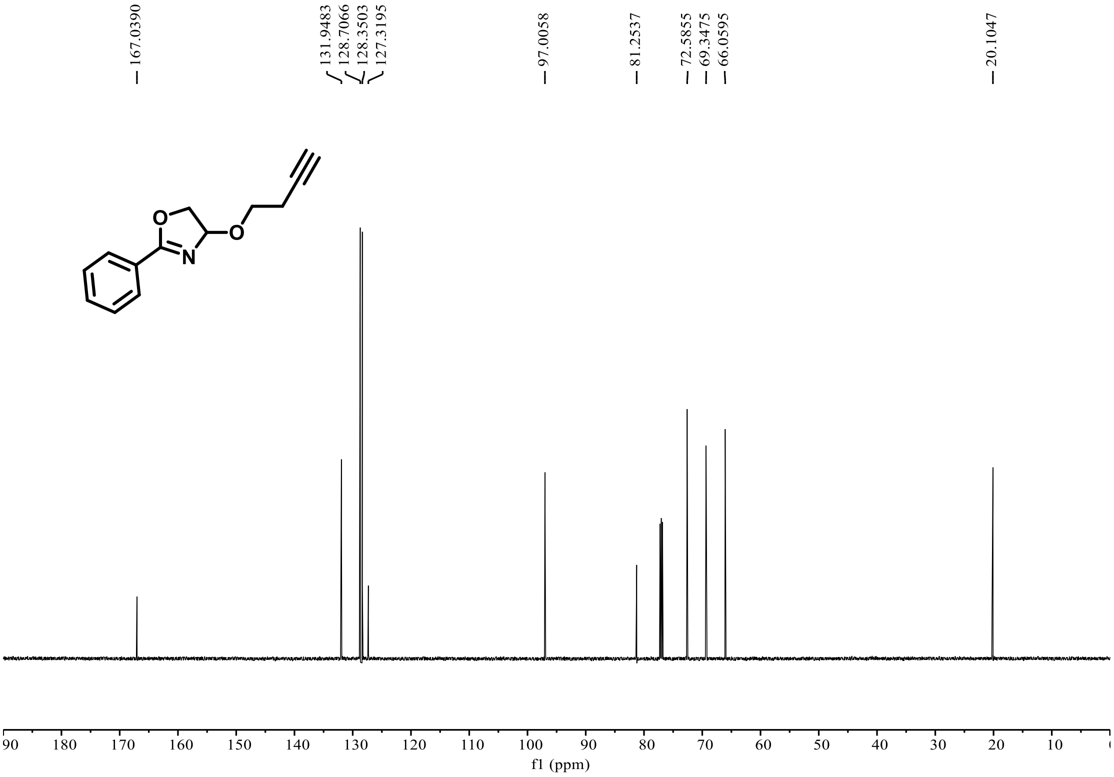
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4g**



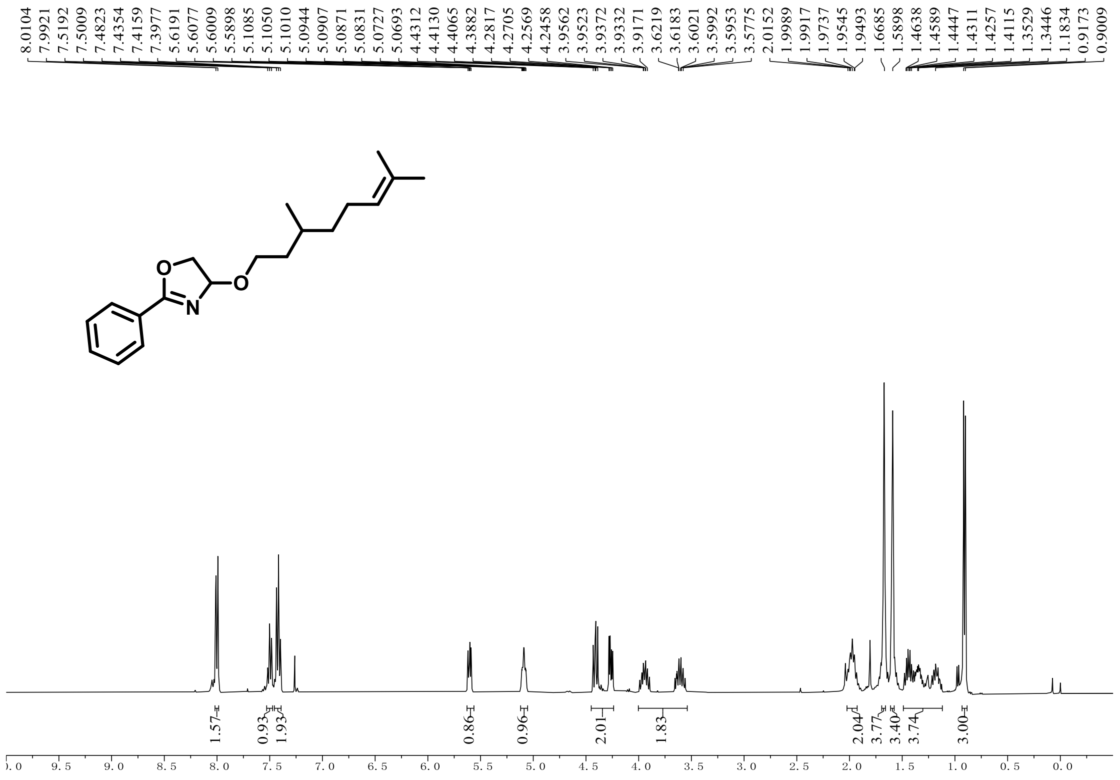
^{1}H NMR (400 MHz, $CDCl_3$) of compound **4h**



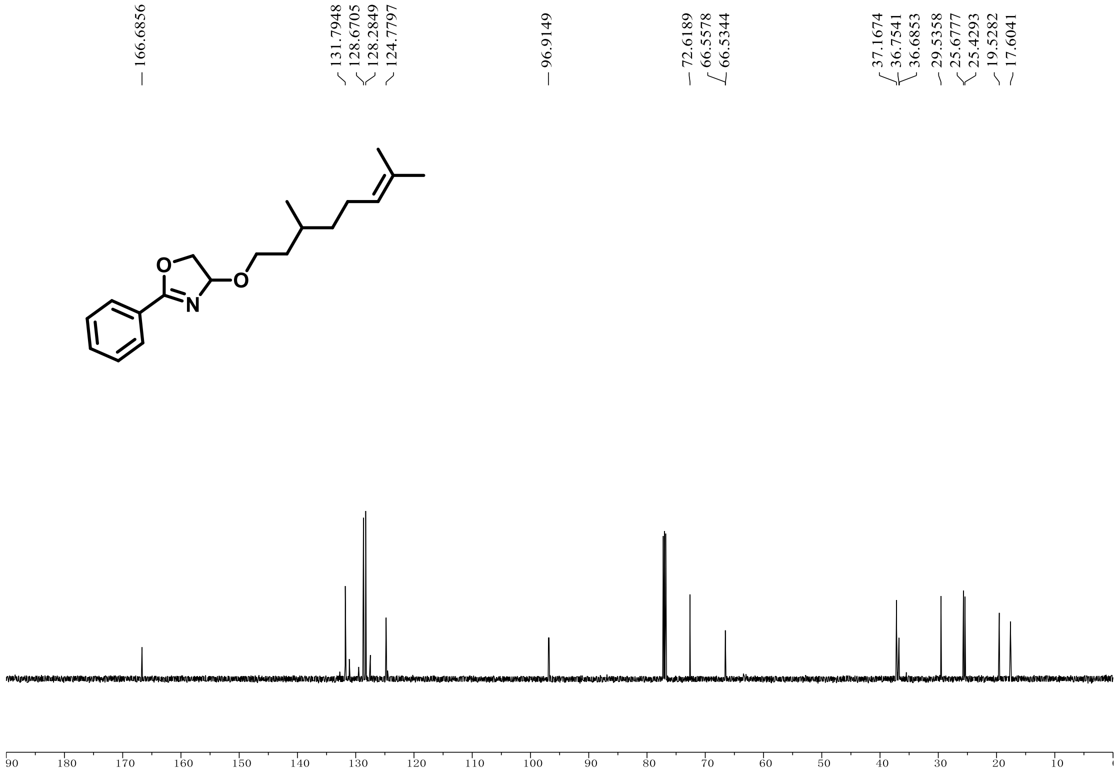
^{13}C NMR (151 MHz, $CDCl_3$) of compound **4h**



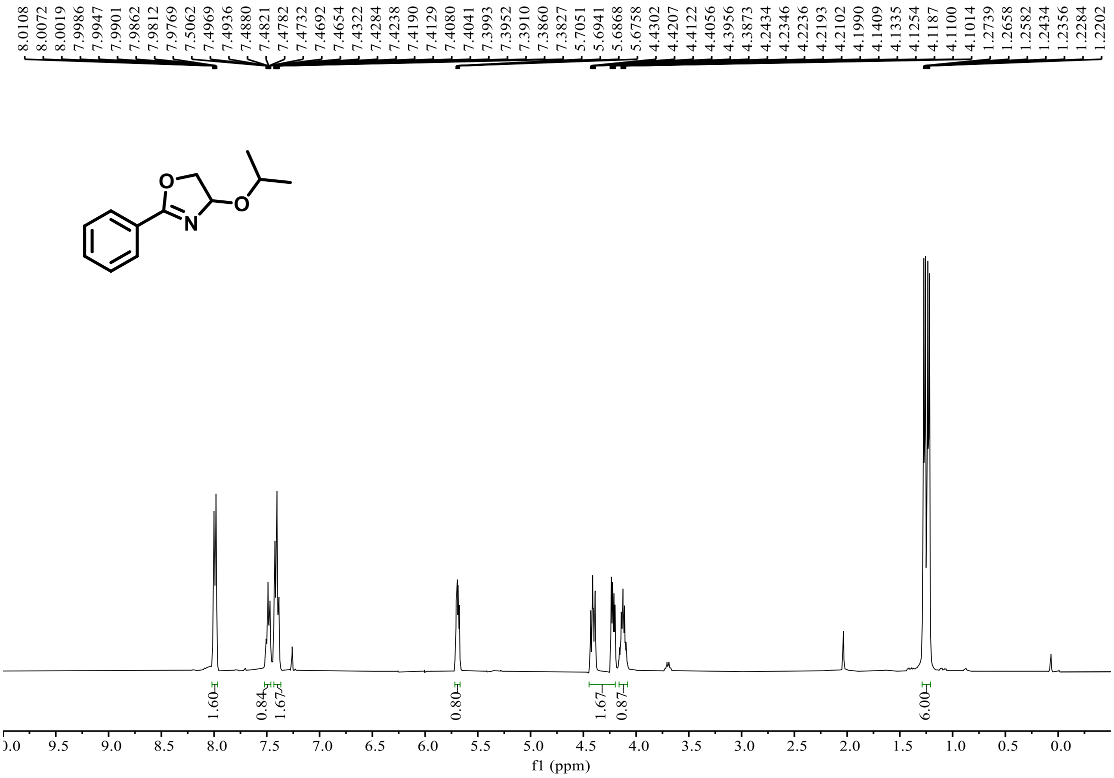
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4i**



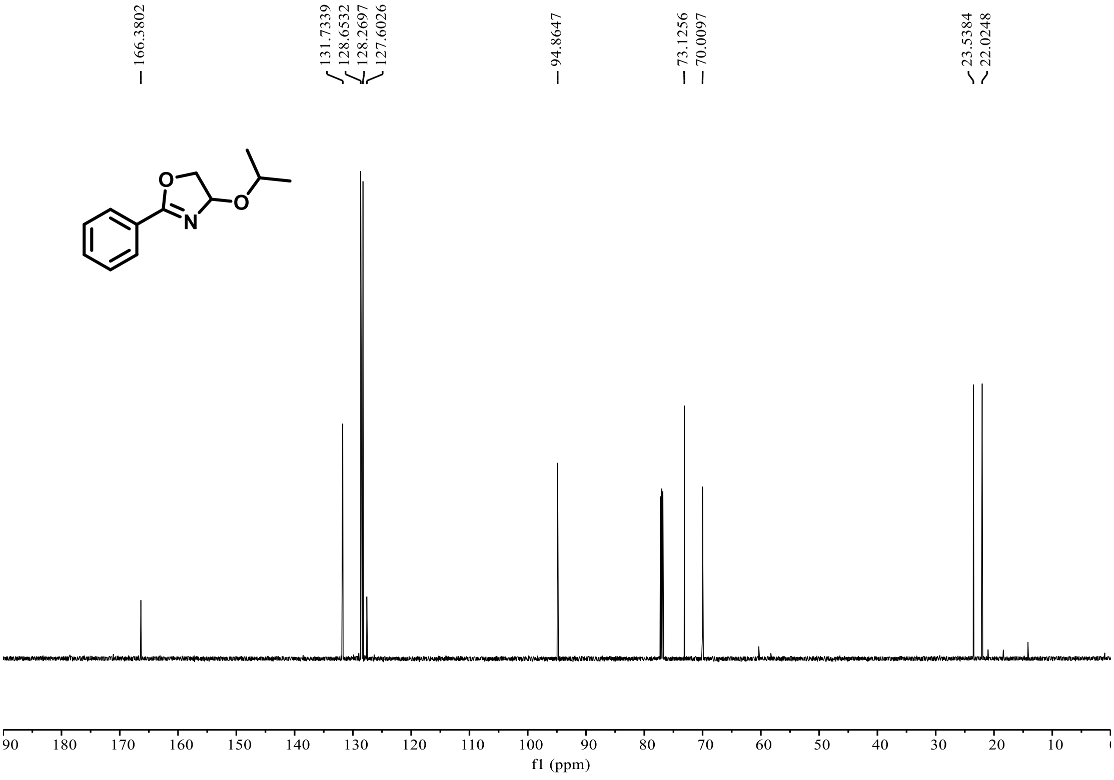
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4i**



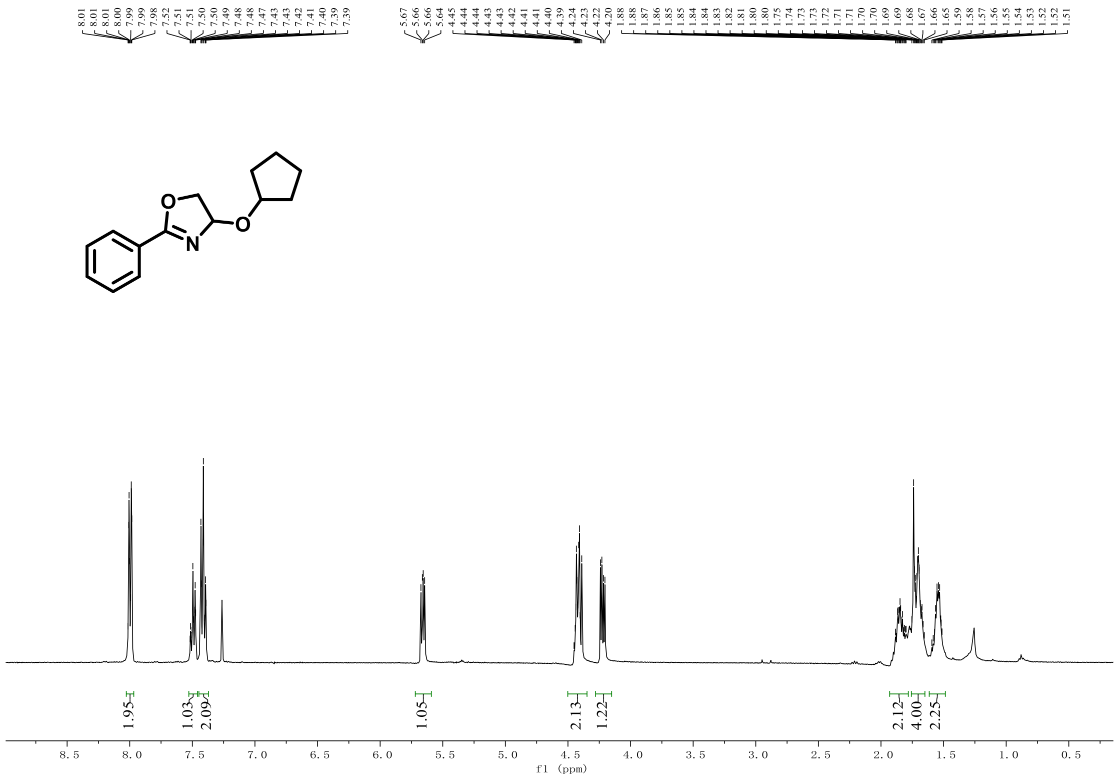
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4j**



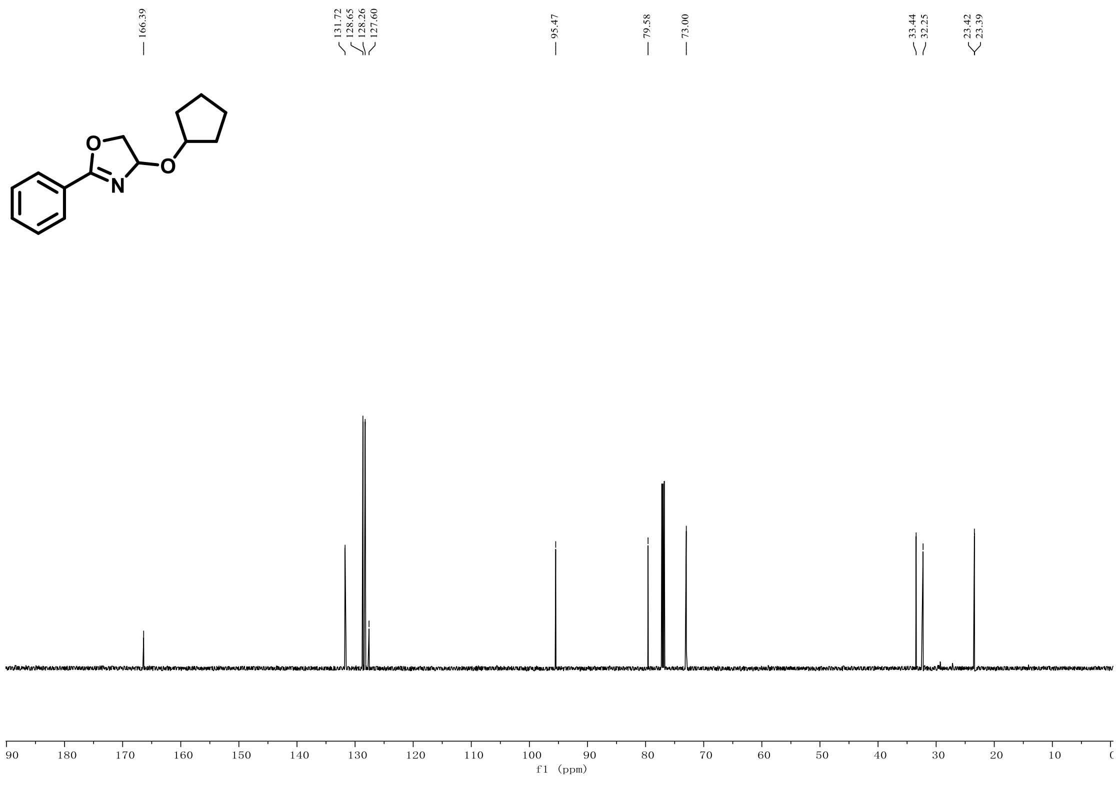
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4j**



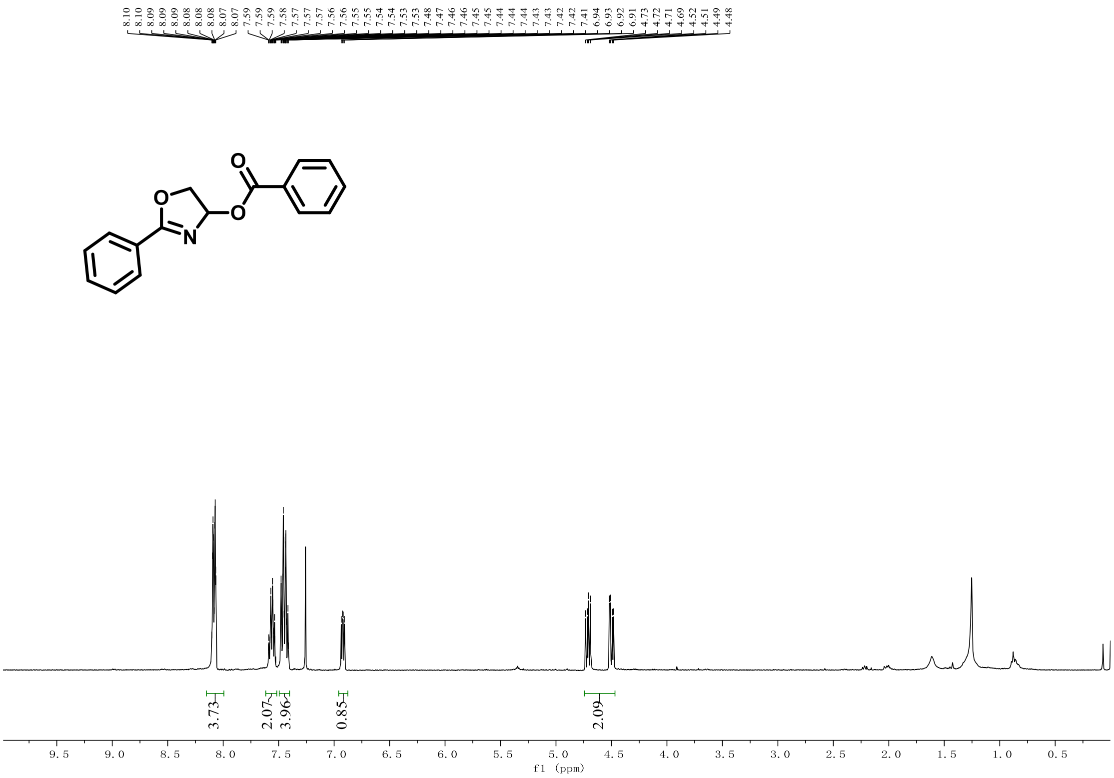
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4k**



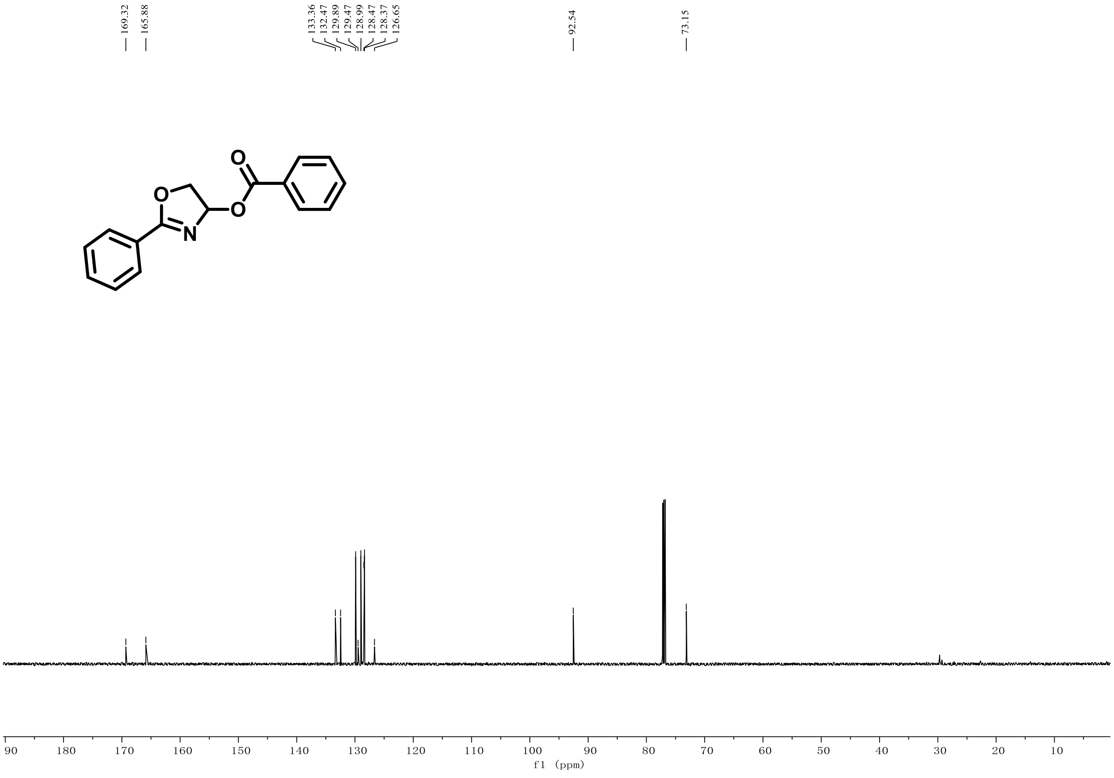
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4k**



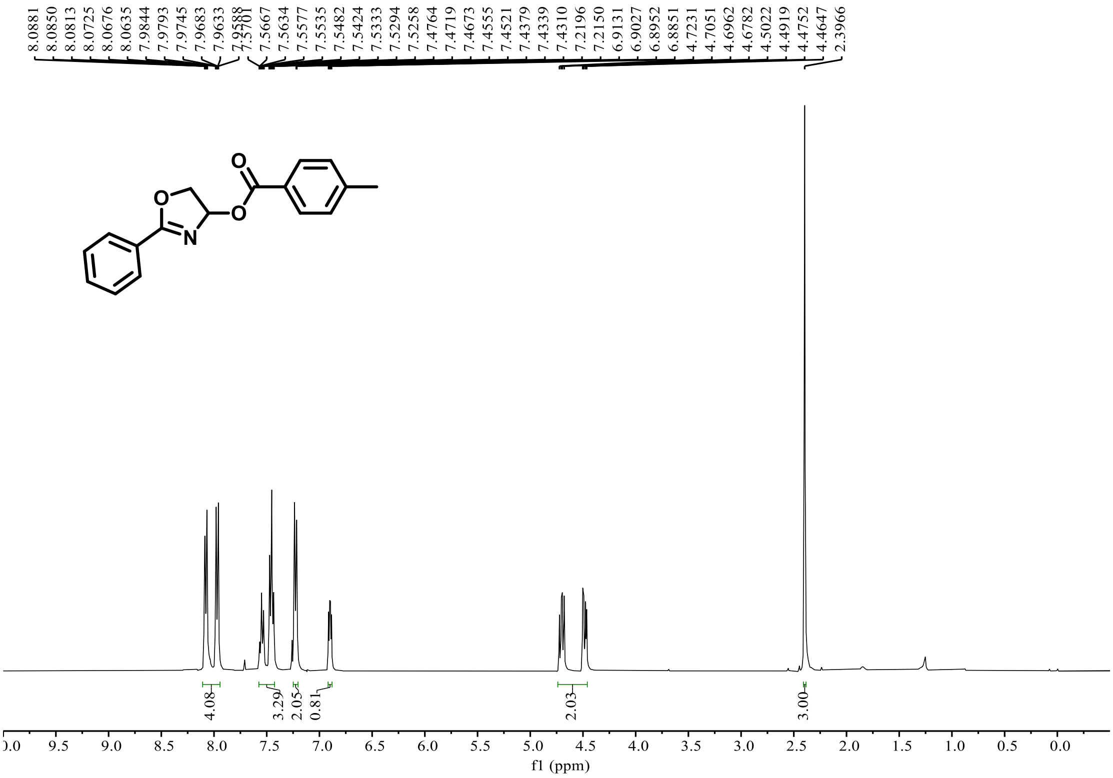
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4l**



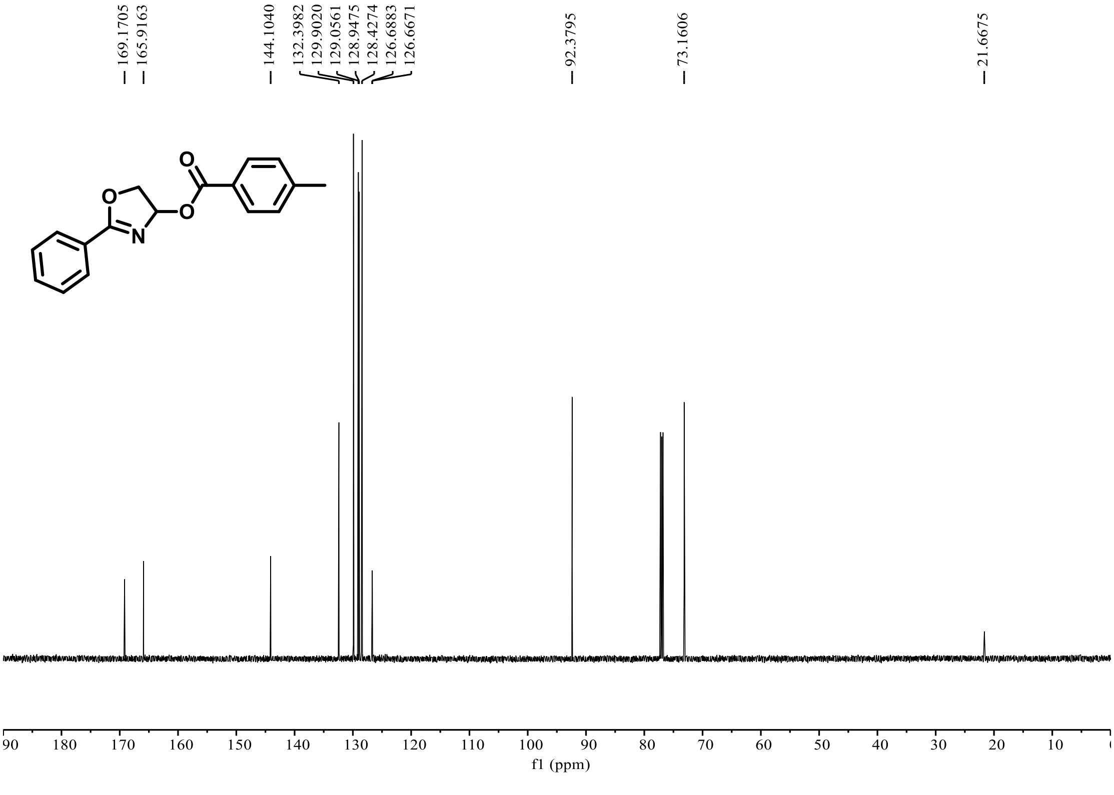
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4l**



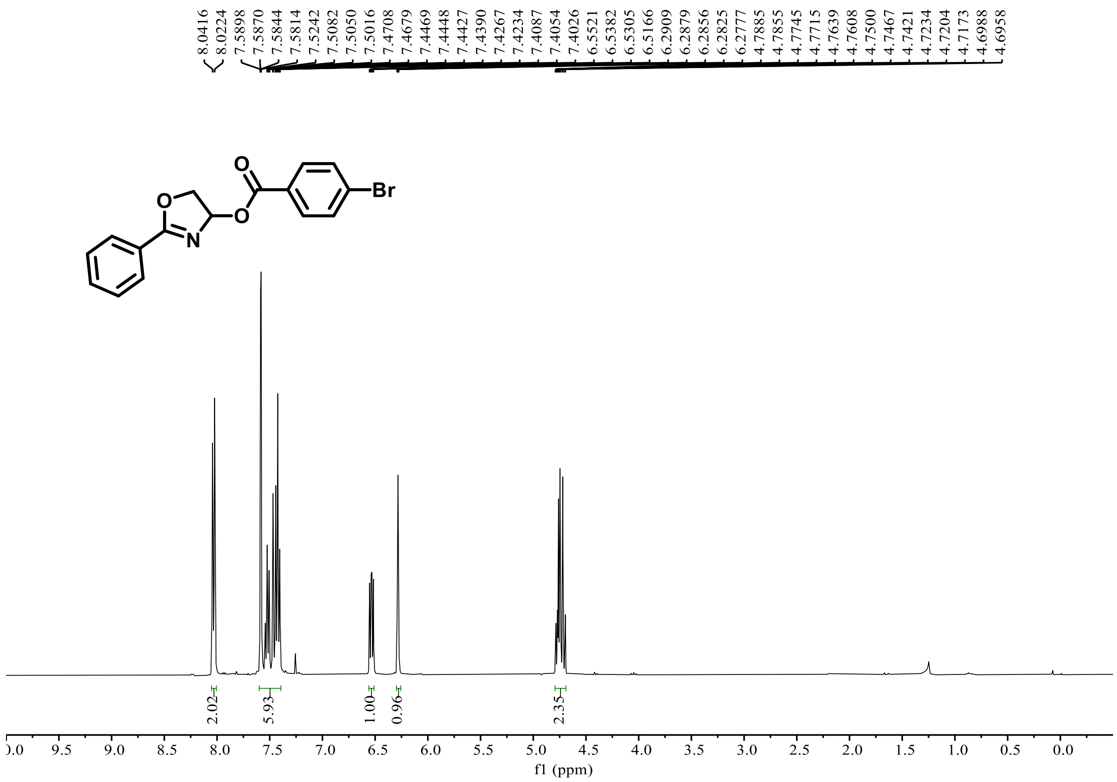
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4m**



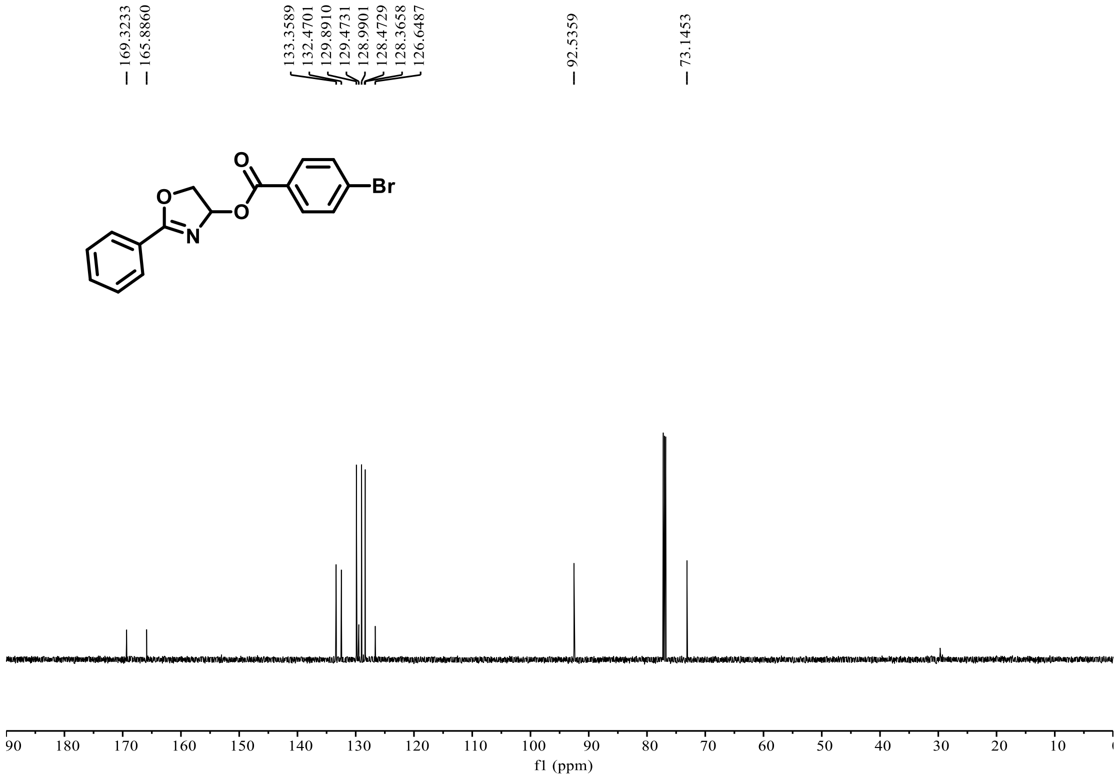
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4m**



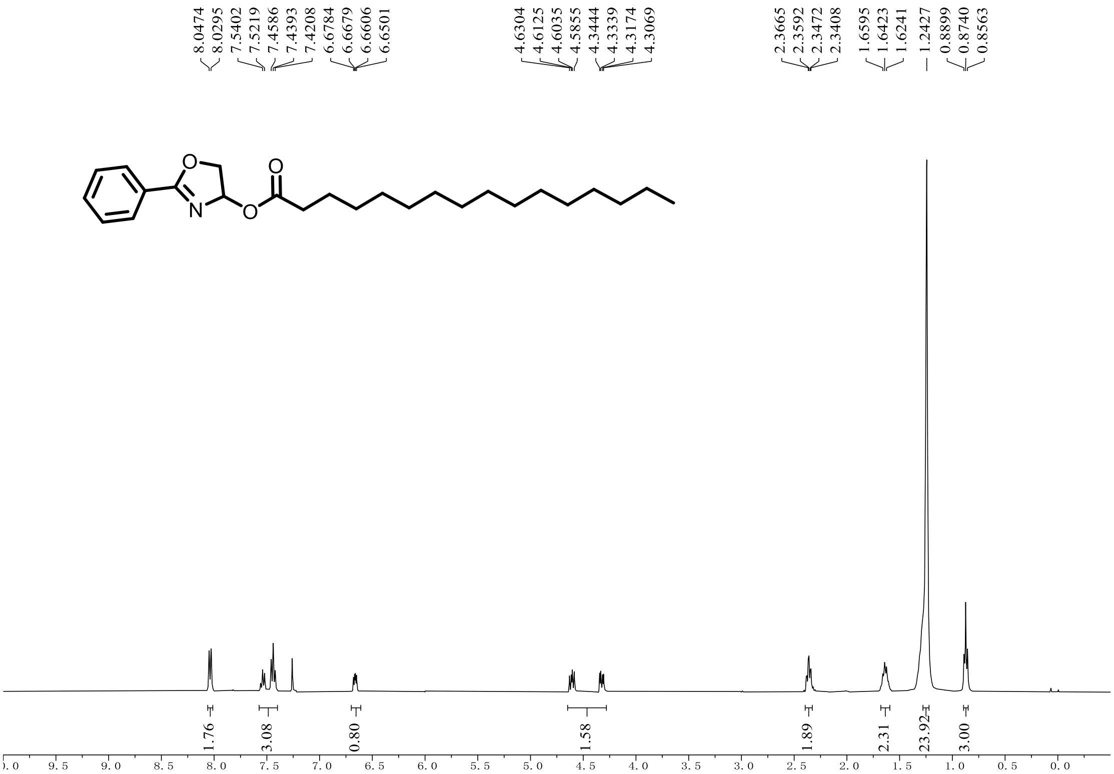
^{1}H NMR (400 MHz, CDCl$_3$) of compound **4n**



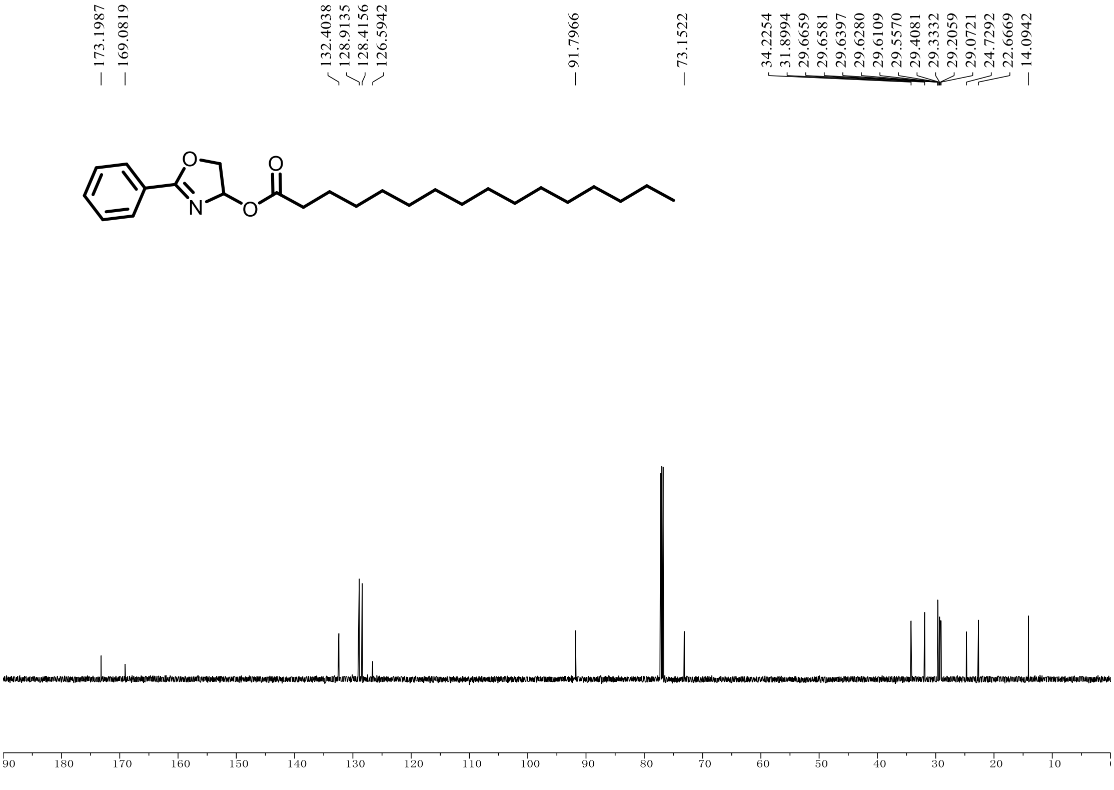
^{13}C NMR (151 MHz, CDCl$_3$) of compound **4n**



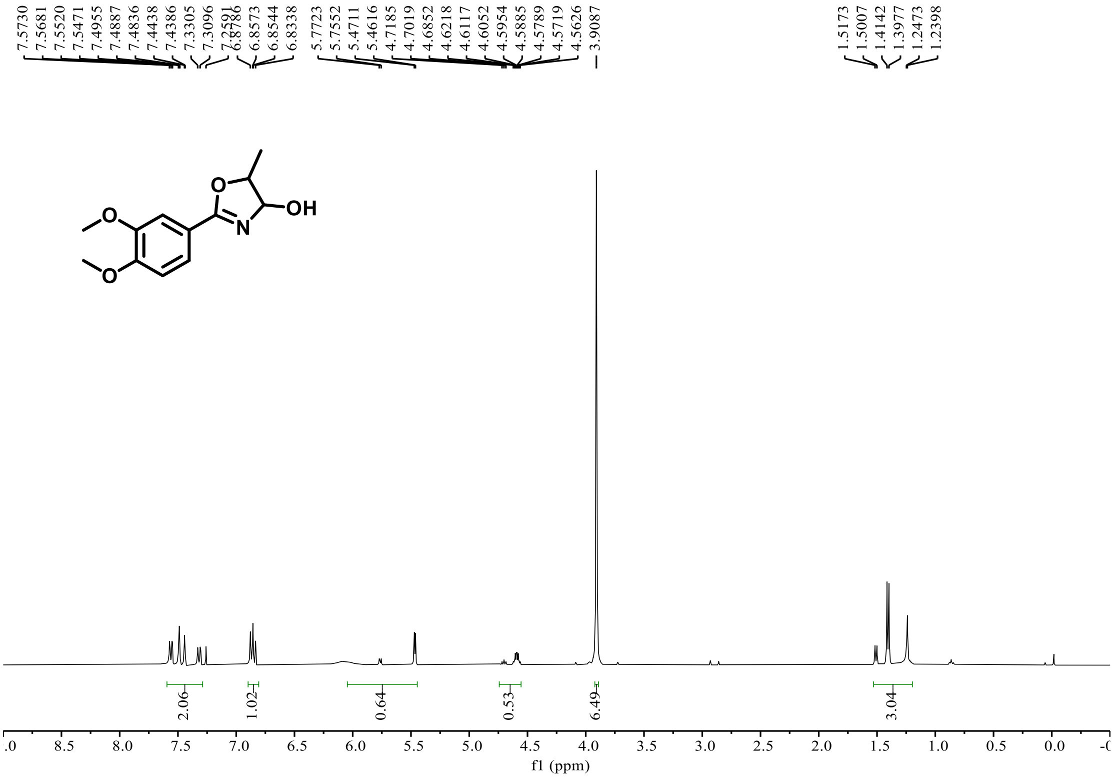
^{1}H NMR (400 MHz, $CDCl_3$) of compound **4o**



^{13}C NMR (151 MHz, $CDCl_3$) of compound **4o**



^{1}H NMR (400 MHz, CDCl$_3$) of compound **2y**



^{13}C NMR (151 MHz, CDCl$_3$) of compound **2y**