Electronic Supplementary Material (ESI) for RSC Advances.

Supplementary Information

Readily switchable one-pot 5-exo-dig cyclization using palladium catalyst

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Contents

1. General information

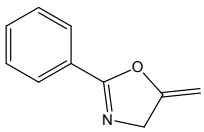
All chemicals were purchased from Sigma Aldrich, S. D. Fine Chemicals, Lancaster (Alfa-Aesar) and commercial suppliers. Commercially available reagents were used without further purification. All reaction mixtures were stirred magnetically and were monitored by thin-layer chromatography using Merck silica gel 60 F-254 aluminum sheets, visualized with UV light and then developed using iodine. Dry solvents were used for reaction wherever mentioned. Products were purified by column chromatography on a silica gel (100–200) mesh with distilled solvents. Melting points are uncorrected. ^{1}H NMR (400 MHz) and ^{13}C NMR (125 MHz) spectra were recorded on Agilent Technology MR400 spectrometer. Deuterated chloroform was used as the solvent and chemical shifts are reported in parts per million (δ) relative to tetramethylsilane as an internal standard. Mass spectra were recorded by Shimadzu instrument in Electro Spray Ionization (ESI) mode.

2. General procedures and analytical data

General procedure for the synthesis of dihydrooxazoles 3

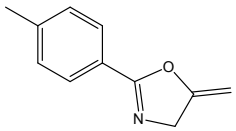
A sealable reaction tube was charged with propargylamine (**2a**, 1.81 mmol), dry toluene (2mL), triethylamine (2.17 mmol), benzoyl chloride (**1a**, 1.82 mmol) and $Pd(OAc)_2$ (5 mol %) sequentially. The tube was sealed immediately and contents in the tube were stirred at 100 ^{o}C for 5 h. The reaction mixture was then concentrated under reduced pressure and the residue was purified by silica gel column chromatography (Eluent: Hexane/ethyl acetate) to obtain the desired oxazoline derivatives in 45 to 92 % yields.

2-phenyl-5-methylene-4, 5-dihydrooxazole (3a) [1, 2]



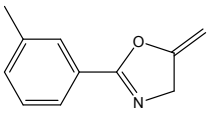
Yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (m, 2H), 7.45 (m, 3H), 4.79 (q, *J* = 3.0 Hz, 1H), 4.63 (t, *J* = 3.0 Hz, 2H), 4.34 (q, 3.0 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.69, 158.76, 131.75, 128.64, 128.43, 127.95, 126.70, 83.71, 57.67.

5-methylene-2-(p-tolyl)-4, 5-dihydrooxazole (3b) [3]



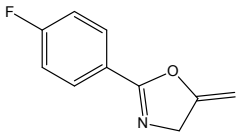
Colorless liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 4.77 (q, *J* = 5.0 Hz, 1H), 4.61 (t, *J* = 2.0 Hz, 2H), 4.32 (q, *J* = 3.0 Hz, 1H), 2.38 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.75, 158.86, 142.23, 129.36, 129.17, 127.91, 127.75, 125.85, 125.08, 123.96, 123.92, 83.51, 57.64, 21.56.

5-methylene-2-(m-tolyl)-4, 5-dihydrooxazole (3c) [1]



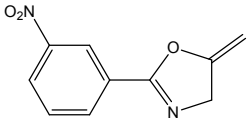
Pale yellow viscous oil; ^{1} H NMR (400 MHz, CDCl3): δ = 7.81 (s, 1H), 7.77 (t, J = 4.0Hz, 1H),7.30 (dd, J = 4.0Hz,1Hz, 2H), 4.80 (q, J = 3Hz, 1H), 4.63 (t, J = 3 Hz, 2H), 4.35 (q, J = 3Hz, 1H), 2.39 (s, 3H); ^{13}C NMR (101 MHz, CDCl3) δ = 163.75, 158.80 , 138.4 , 132.7 , 128.6 , 128.5 , 126.7 , 125.2 , 83.8 , 57.7 , 21.4.

2-(4-fluorophenyl)-5-methylene-4, 5-dihydrooxazole (3d) [3, 4]



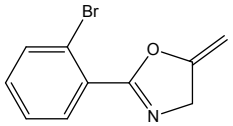
White solid, M.P 57 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 – 7.94 (m, 2H), 7.12-7.08 (m, 2H), 4.79 (q, *J* = 3.0 Hz, 1H), 4.62 (t, *J* = 3.0 Hz, 2H), 4.35 (q, *J* = 3.0 Hz 1H) ; ^{13}C NMR (101 MHz, $CDCl_3$) δ 166.14, 163.69, 161.83, 158.65, 130.30, 130.21, 115.79, 115.57, 83.92, 57.73.

2-(3-nitrophenyl)-5-methylene-4, 5-dihydrooxazole (3e) [1]



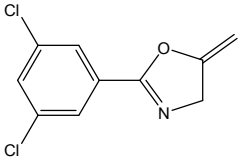
Yellow solid; M.P 123-124^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.80 (dd, J=1Hz, 1H), 8.36-8.34 (m, 2H), 7.65 (t, J=8.0Hz, 1H), 4.89 (q, *J* = 3 Hz, 1H), 4.65 (t, *J* = 3 Hz, 2H), 4.44 (q, *J* = 3Hz 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.75, 158.3, 149.1, 132.6, 129.7, 128.6, 126.3, 123.0, 84.9, 57.9.

2-(2-bromophenyl)-5-methylene-4, 5-dihydrooxazole (3f) [2]



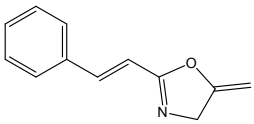
Pale yellow liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78 (dd, *J* = 8.0 Hz, 2.0 Hz, 1H), 7.69 (dd, *J* = 8.0 Hz, 1Hz, 1H), 7.36 (m, 2H), 4.86-4.74 (m, 1H), 4.72 (t, *J* = 3 Hz, 2H), 4.39 (q, *J* = 3Hz 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 162.6, 158.4, 134.3, 132.1, 131.5, 128.4, 127.2, 121.9, 84.1, 58.2.

2-(3, 5-dichlorophenyl)-5-methylene-4,5-dihydrooxazole (3g)[1]



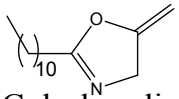
White solid; M.P 73-74^{o}C, ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (d, *J* = 2 Hz, 2H), 7.50 (t, *J* = 2 Hz, 1H), 4.84 (q, *J* = 3.0 Hz, 1H), 4.65 (t, *J* = 3.0 Hz, 2H), 4.40 (q, *J* = 3.0 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.6, 158.3, 135.4, 131.7, 129.5, 126.4, 84.7, 57.71.

5-methylene-2-styryl-4, 5-dihydrooxazole (3h) [4, 5]



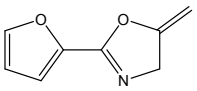
White solid, M.P. 90-91^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50-7.32 (m, 6H), 6.61 (d, *J* = 17 Hz, 1H), 4.74 (dd, *J* = 5.0 Hz,3.0Hz, 1H), 4.56 (s, 2H), 4.30 (d, 9.0 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.48, 158.47, 140.78, 134.87, 129.74, 128.86, 127.55, 114.09, 83.32, 57.71.

5-methylene-2-undecyl-4, 5-dihydrooxazole (3i)



Colorless liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.59 (d, *J* = 2.0 Hz, 1H), 4.35 (s, 2H), 4.19 (s, 1H), 1.66 – 1.56 (m, 2H), 1.21 (s, 18H), 0.83 (t, *J* = 6.0 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ ^{13}C NMR (101 MHz,$CDCl_3$) δ 167.68, 159.01, 82.82, 57.08, 31.85, 29.55, 29.39, 29.28, 29.17, 29.08, 28.05, 25.42, 22.63, 21.38, 14.05; GC-MS (EI, 70eV): m/z 237 (6%, M+), 208 (4%), 194 (12%), 166 (8%), 139(30%), 124(7%), 110(59%), 97(100%), 67(5%), 41(17%). Calculated for $C_{15}H_{27}NO$: C, 75.90; H, 11.46; N, 5.90; found C, 75.83; H, 11.38; N, 5.81

2-(2-furyl)-5-methylene-4,5-dihydrooxazole (3j)[4]

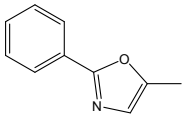


Colourless liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 (d, *J* = 1.0 Hz, 1H), 6.96 (d, *J* = 3 Hz, 1H), 6.45 (dd, *J* = 3 Hz, *J* = 2 Hz, 1H), 4.74 (q, *J* = 3.0 Hz, 1H), 4.56 (t, *J* = 3.0 Hz, 2H)), 4.31 (q, *J* = 3.0 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 158.04, 155.80, 145.57, 141.86, 114.86, 111.50, 84.09, 57.30.

General procedure for the synthesis of oxazoles 4

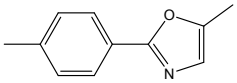
A sealable reaction tube was charged with propargylamine (**2a**, 1.81mmol), dry toluene (2mL), benzoyl chloride (**1a**, 1.82 mmol), $Pd(OAc)_2$ (5 mol %) and acetic acid (1.81 mmol) sequentially. The tube was sealed immediately and contents in the tube were stirred at 100^{o}C for 24 h. The reaction mixture was then concentrated under reduced pressure and the residue was purified by silica gel column chromatography (Eluent: Hexane/ethyl acetate) to obtain the desired oxazole derivatives in 42 to 90% yields.

2-phenyl-5-methyl-1, 3-oxazole (4a) [3]



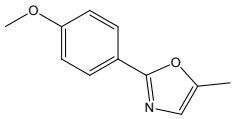
Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 – 7.97 (m, 2H), 7.44-7.37 (m, 3H), 6.81 (s, 1H), 2.37 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.70, 148.83, 129.79, 128.66, 127.74, 125.89, 124.13, 10.92.

5-methyl-2-(p-tolyl)-1, 3-oxazole (4b) [7]



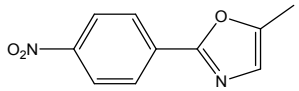
Colorless liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ7.89 (d, *J* = 8.0 Hz, 2H), 7.24 (d, *J* = 8.0 Hz, 2H), 6.81 (s, 1H), 2.39 (s, 3H), 2.38 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.70, 148.83, 139.9, 129.2, 125.7, 124.9, 123.8, 21.3, 10.92.

5-methyl-2-(4-methoxyphenyl)-1, 3-oxazole (4c) [6]



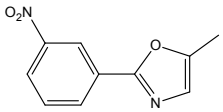
White Solid, M.P. 62-63 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93-7.90 (d, *J* = 9.0 Hz, 2H), 6.95-6.94 (d, *J* = 9.0 Hz, 2H), 6.77 (s, 1H), 3.84 (s, 3H), 2.36 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.92, 160.73, 148.19, 127.52, 123.81, 120.64, 114.07, 55.31, 10.98.

5-methyl-2-(4- nitrophenyl)-1, 3-oxazole (4d) [3]



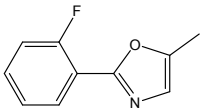
Yellow solid; M.P 116-117^{o}C, ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.30 (d, *J* = 9.0 Hz, 2H), 8.15 (d, *J* = 9.0 Hz, 2H), 6.94 (s, 1H), 2.44 (s, *3*H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 158.5, 150.7, 148.83, 133.1, 126.7, 125.4, 124.3, 29.7, 11.0.

5-methyl-2-(3-nitrophenyl)-1, 3-oxazole (4e) [3]



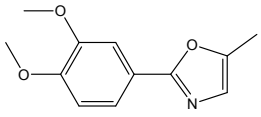
Yellow solid, M.P.134-136^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.81 (s, 1H), 8.31-8.23 (m, 2H), 7.63-7.59 (t, *J* = 8.0 Hz, 1H), 6.89 (s, 1H), 2.41 (s, 3H); ^{13}C NMR (101 MHz $CDCl_3$) δ 158.91, 150.15, 148.88, 131.42, 129.85, 129.29, 124.81, 124.21, 120.80, 10.96.

2-(2-fluorophenyl)-5-methylene-1, 3-oxazole (4f)



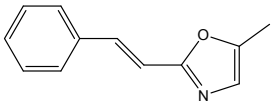
Colorless liquid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (t, *J* = 7.0 Hz, 1H), 7.38 (dd, *J* = 13.0, 7.0 Hz, 1H), 7.25 – 7.17 (m, 2H), 6.90 (s, 1H), 2.40 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.04, 158.49,149.19, 131.34, 129.12, 124.35, 124.25, 124.21, 116.87, 116.66, 11.04; GC-MS (EI, 70eV): m/z 177.10 (36%, M^{+}), 148.09 (12%), 134.07 (100%), 107.08 (63%), 75.08 (28%), 43.08 (34%). Calculated for $C_{10}H_8FNO$: C, 67.79; H, 4.55; N, 7.91; found C, 67.84; H, 4.58; N, 7.82

5-methyl-2-(3,4-dimethoxyphenyl)-1, 3-oxazole (4g)



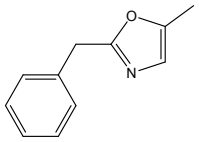
Pale yellow solid, 74-76 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.51 (m, 2H), 6.91 (d, *J* = 8.0 Hz, 1H), 6.78 (s, 1H), 3.95 (s, 3H), 3.92 (s, 3H) 2.37 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.73, 150.51, 149.02, 148.39, 123.86, 120.74, 118.98, 110.91, 108.70, 55.79, 11.12; GC-MS (EI, 70eV): m/z 219.13 (57%, M+), 204.11 (20%), 176.11 (44%), 149.11 (30%), 133.10 (37%), 121.08 (46%), 91.10 (18%), 77.10 (31%), 63.08 (68%), 43.08 (100%). Calculated for $C_{12}H_{13}NO_3$: C, 65.74; H, 5.98; N, 6.39; found C, 65.78; H, 5.89; N, 6.31

5-methyl-2-styryl-1, 3-oxazole (4h) [8]



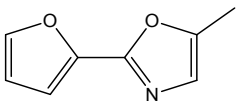
Yellow solid; M.P 53-54 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49-7.53 (m, 2H), 7.42 (d, *J* = 16 Hz, 1H), 7.33-7.39 (m, 2H), 7.30-7.32 (m, 1H) 6.90 (d, *J* = 16 Hz, 1H), 6.79 (s, 1H), 2.37 (s, 3H); ^{13}C NMR (101 MHz, CDCl3) δ 160.70, 148.65, 135.7,134.9,128.9, 128.83, 127.0, 124.2, 114.03, 11.03.

2-benzyl-5-methyl-1,3-oxazole (4i)[4]



Colourless oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.11 (m, 5H), 6.42 (s, 1H), 3.87(s, 2H), 2.07 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 161.70, 149.8, 137.0, 129.6, 129.3, 127.6, 123.5, 35.4, 11.40.

2-(furan-2-yl)-5-methyl-1, 3-oxazole (4j) [3]



Yellow solid; M.P 37-38^{o}C, ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53-7.52 (m, 1H), 6.95 (d, *J* = 3.0 Hz, 1H), 6.82 (s, 1H), 6.52-6.50 (m, 1H), 2.37 (d, *J* = 1Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.6, 148.4, 143.8, 143.1, 123.8, 111.6, 110.03, 10.80.

3. References

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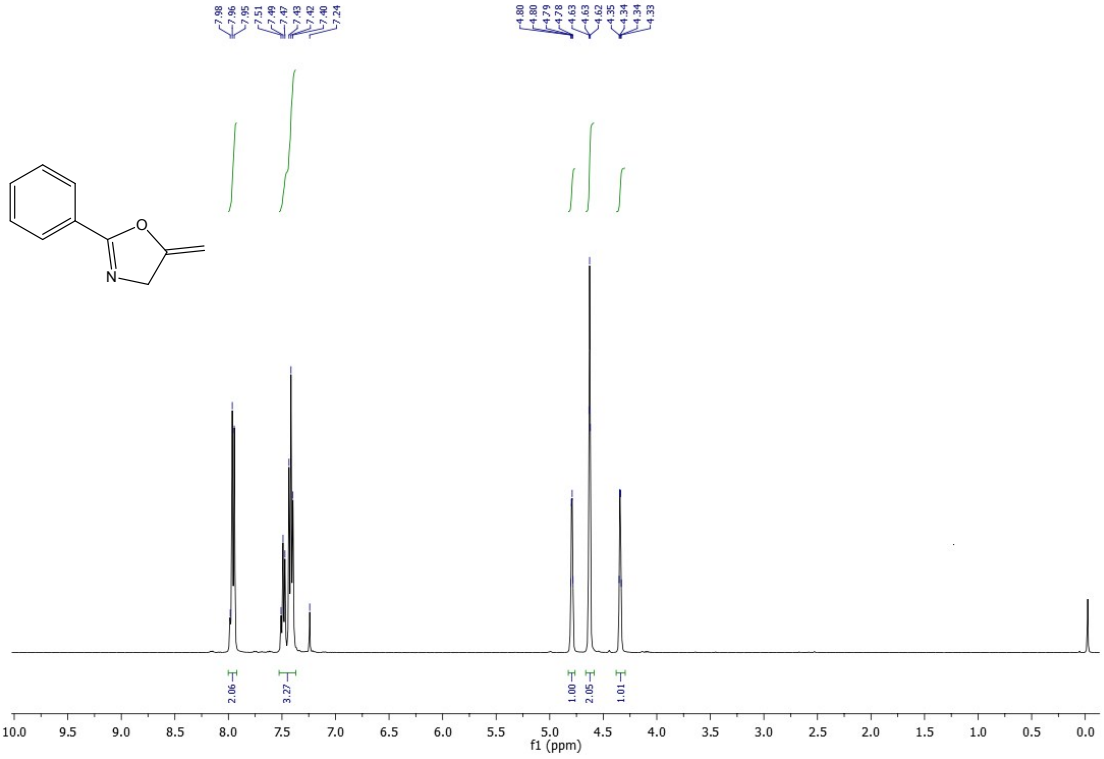
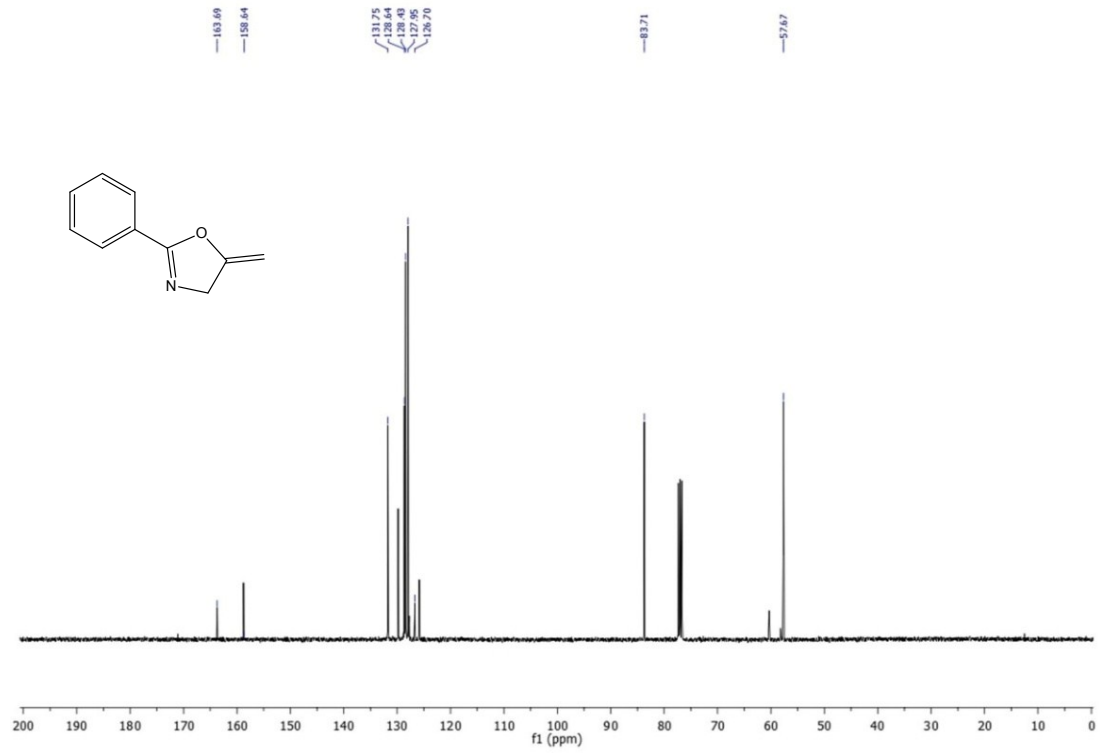
4. ^{1}H, ^{13}C NMR spectra and mass spectra

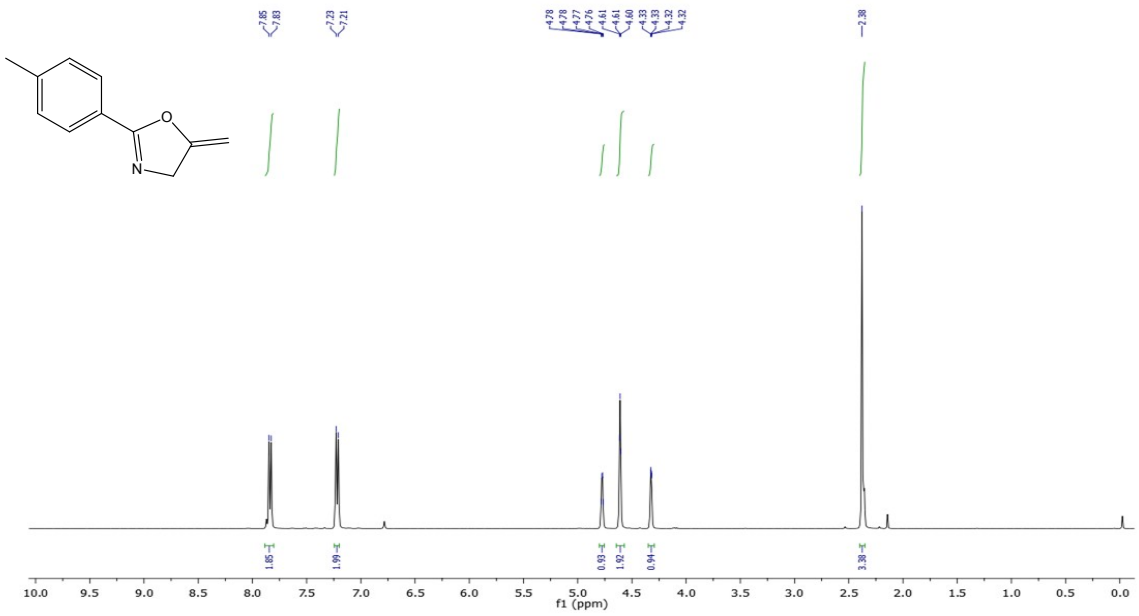
^{1}H NMR spectrum of 2-phenyl-5-methylene-4, 5-dihydrooxazole **(3a)**



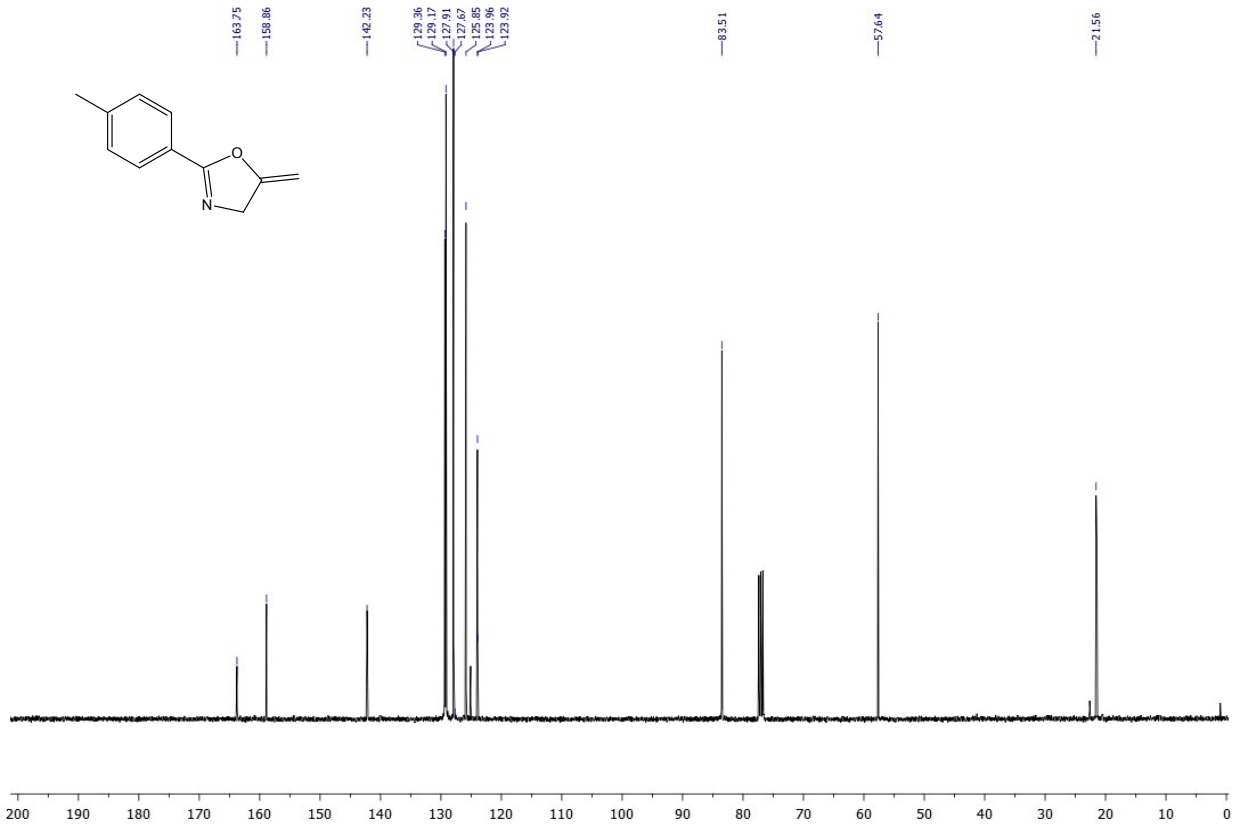
^{13}C NMR spectrum of 2-phenyl-5-methylene-4, 5-dihydrooxazole **(3a)**



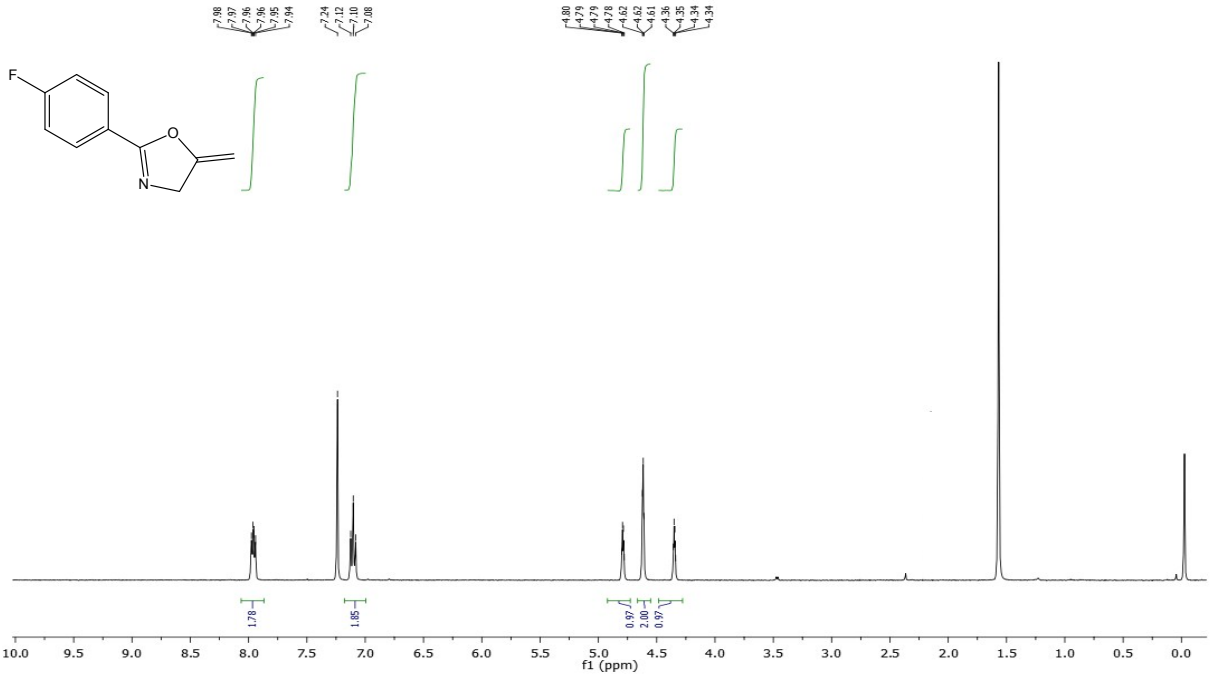
^{1}H NMR spectrum of 5-methylene-2-(p-tolyl)-4, 5-dihydrooxazole **(3b)**



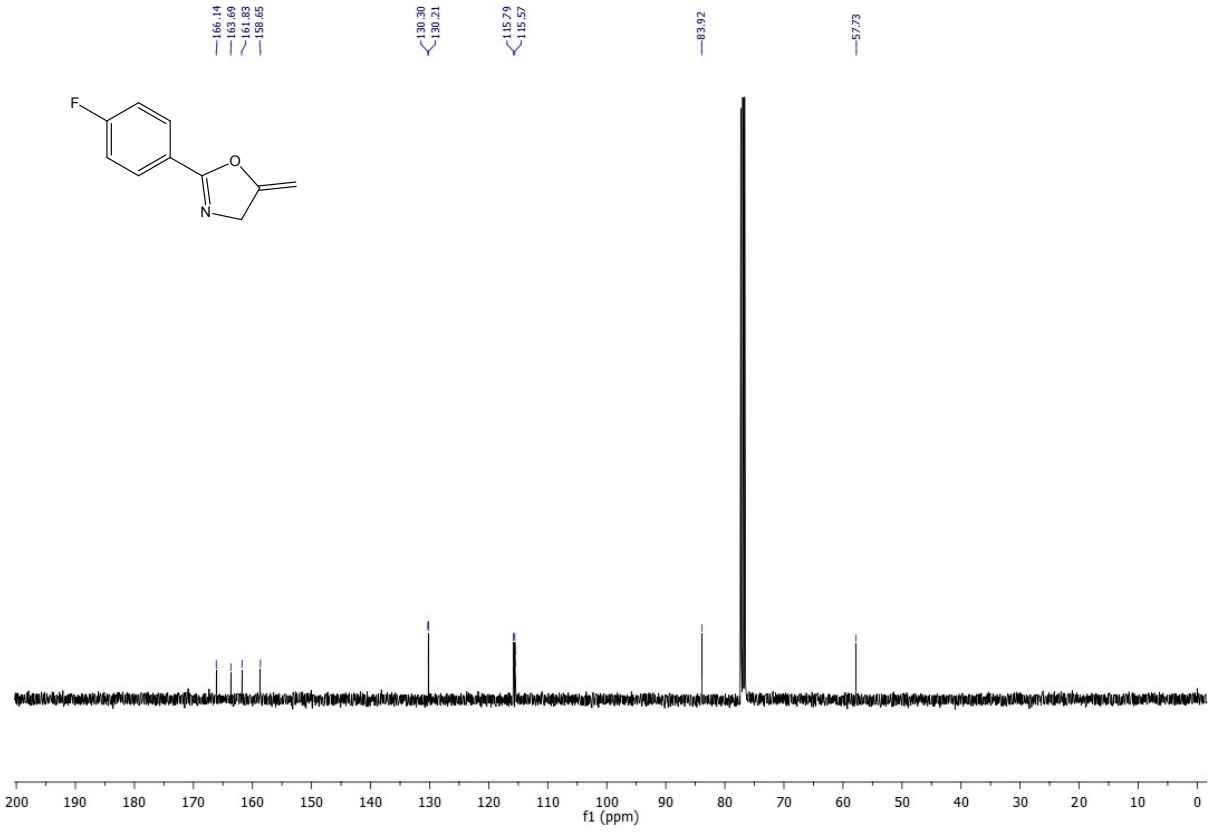
^{13}C NMR spectrum of 5-methylene-2-(p-tolyl)-4, 5-dihydrooxazole **(3b)**



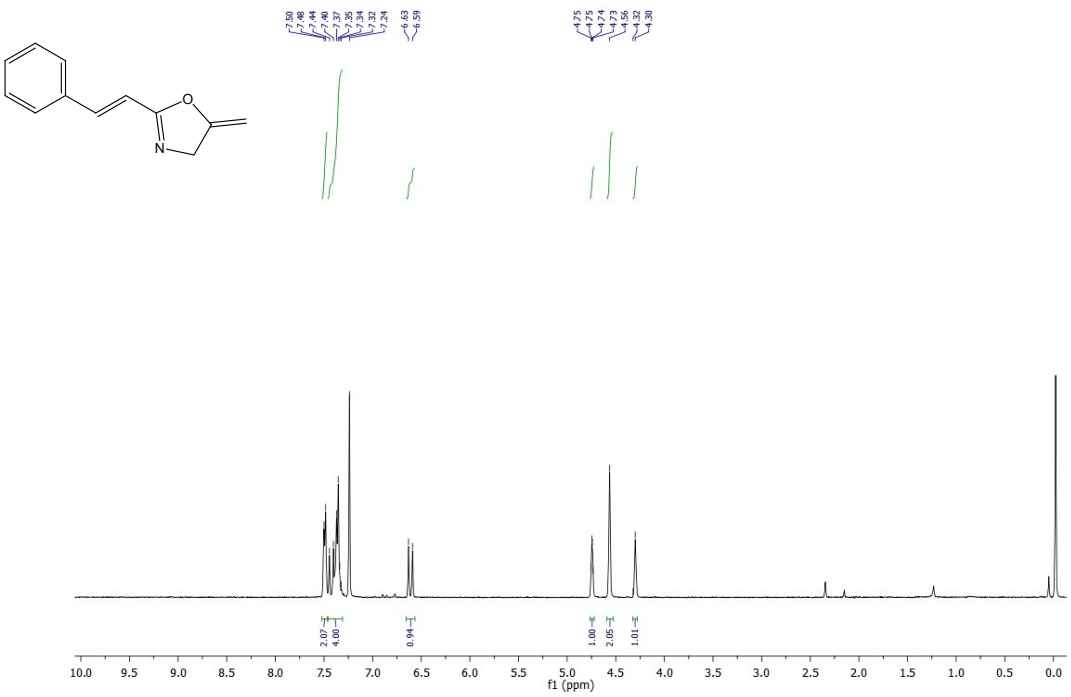
^{1}H NMR spectrum of 2-(4-fluorophenyl)-5-methylene-4, 5-dihydrooxazole **(3d)**



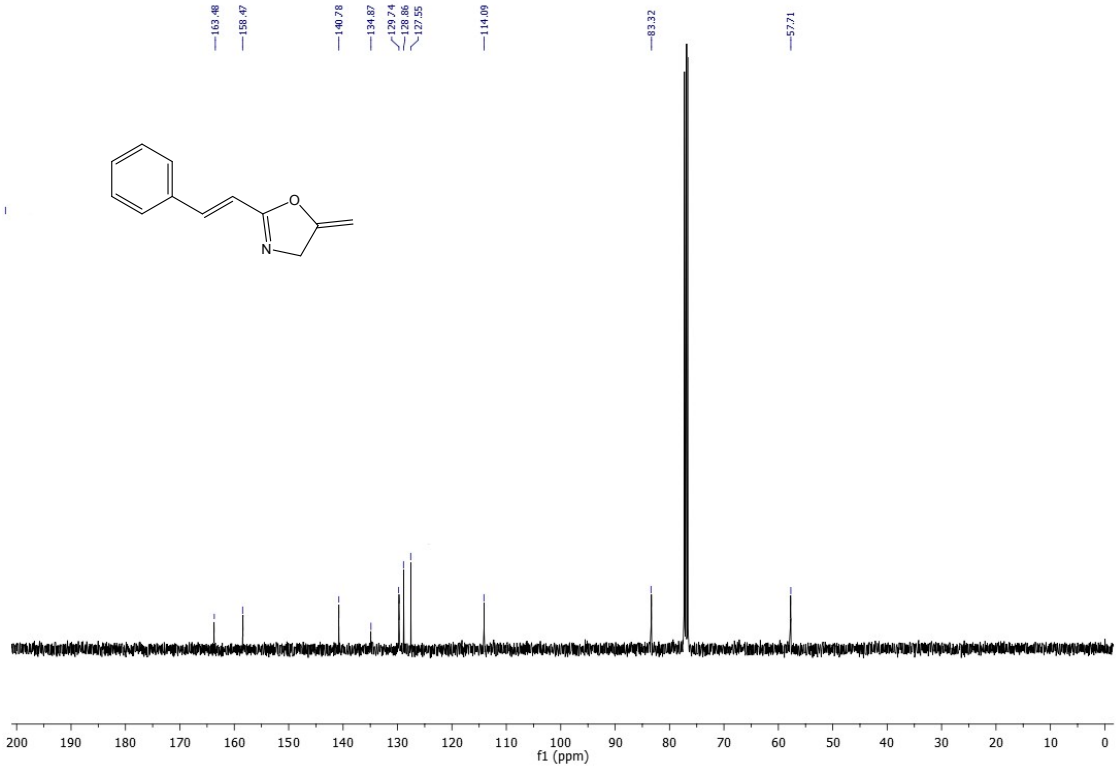
^{13}C NMR spectrum of 2-(4-fluorophenyl)-5-methylene-4, 5-dihydrooxazole **(3d)**



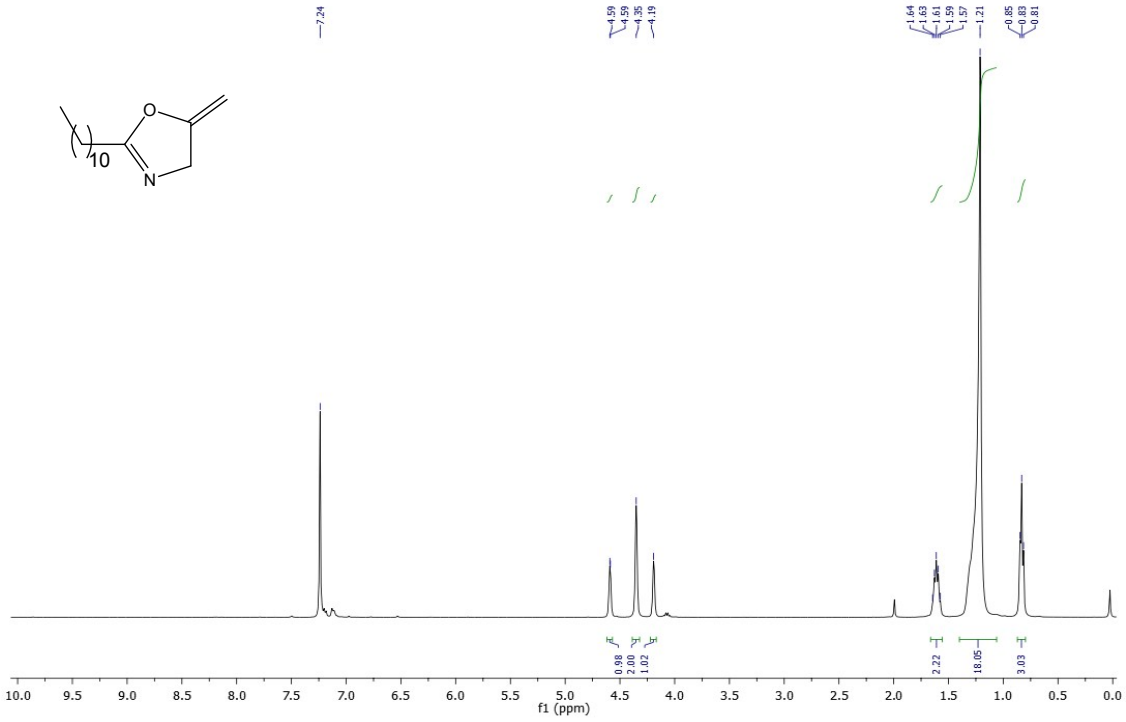
^{1}H NMR spectrum of 5-methylene-2-styryl-4,5-dihydrooxazole **(3h)**



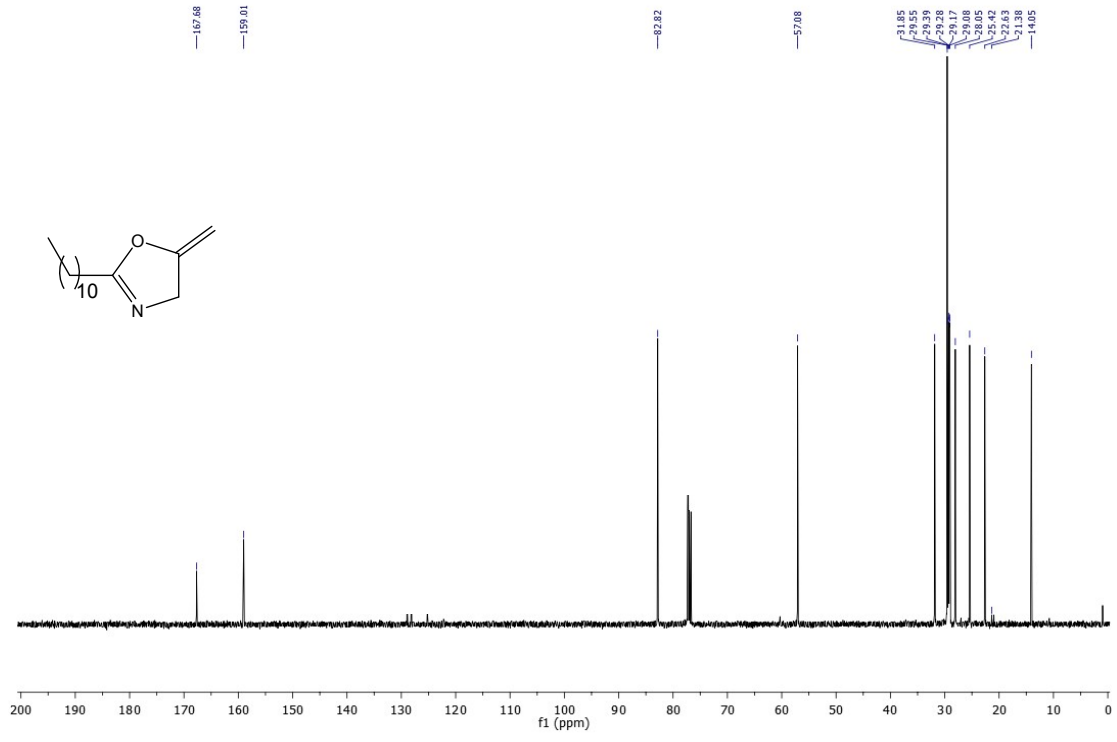
^{13}C NMR spectrum of 5-methylene-2-styryl-4,5-dihydrooxazole **(3h)**



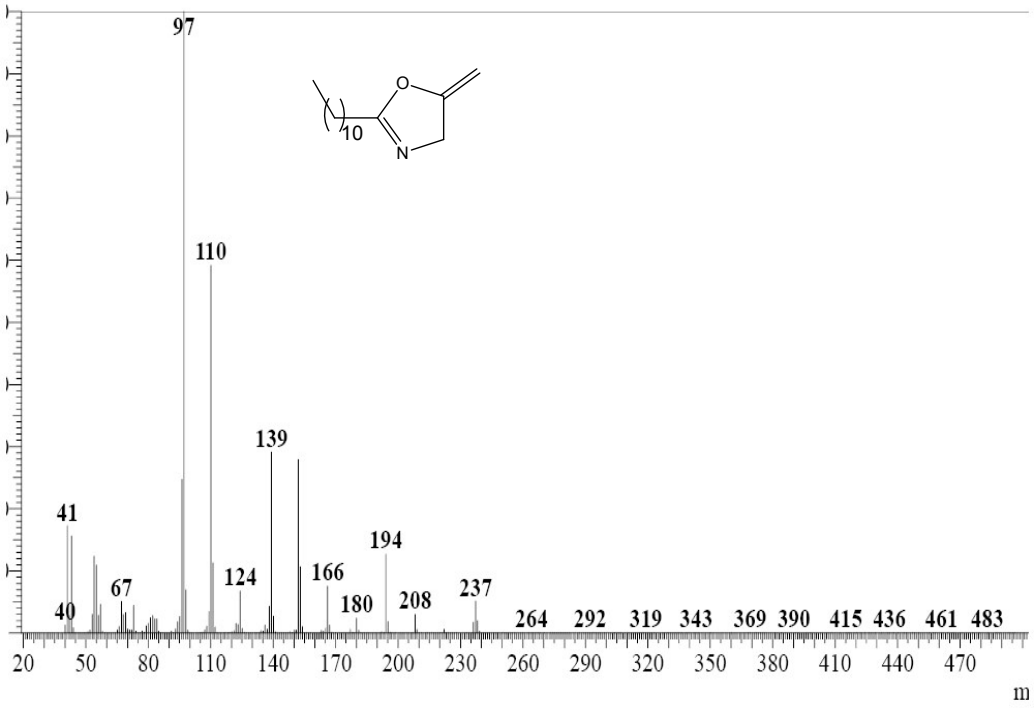
^{1}H NMR spectrum of 5-methylene-2-undecyl-4, 5-dihydrooxazole **(3i)**



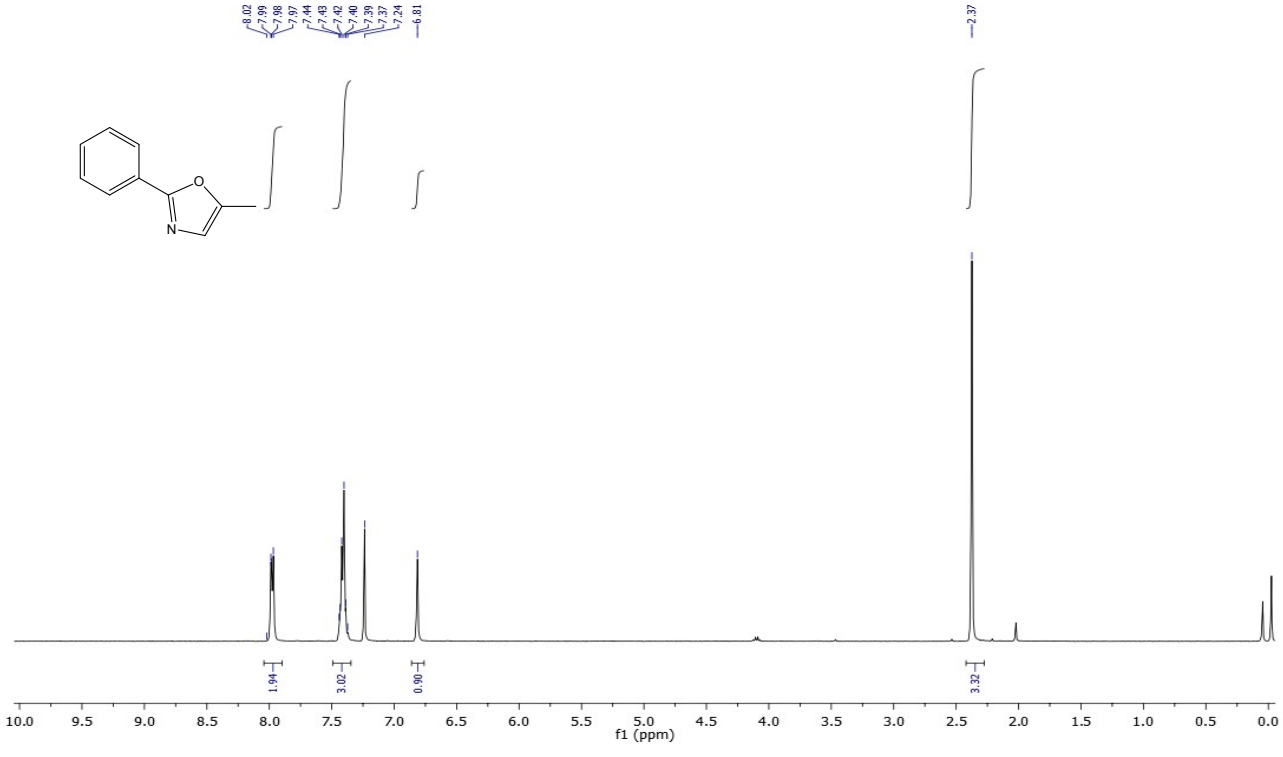
^{13}C NMR spectrum of 5-methylene-2-undecyl-4, 5-dihydrooxazole **(3i)**



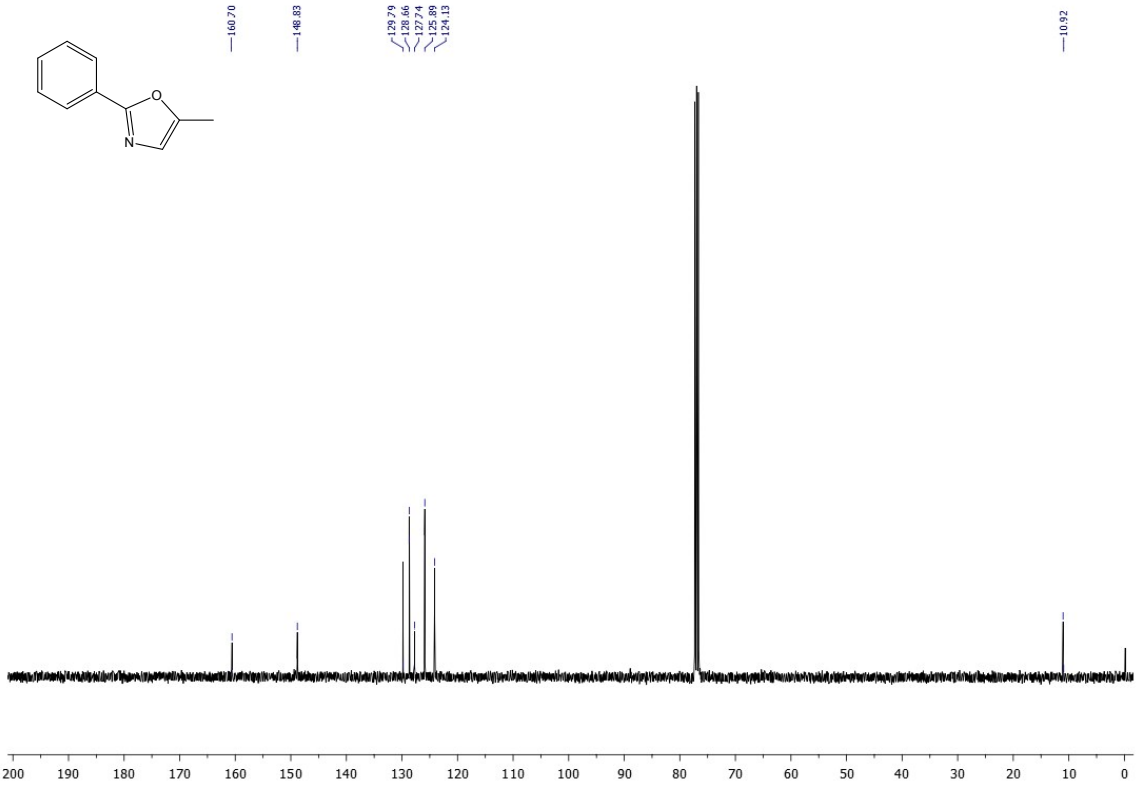
GC-MS Spectrum of 5-methylene-2-undecyl-4, 5-dihydrooxazole **(3i)**



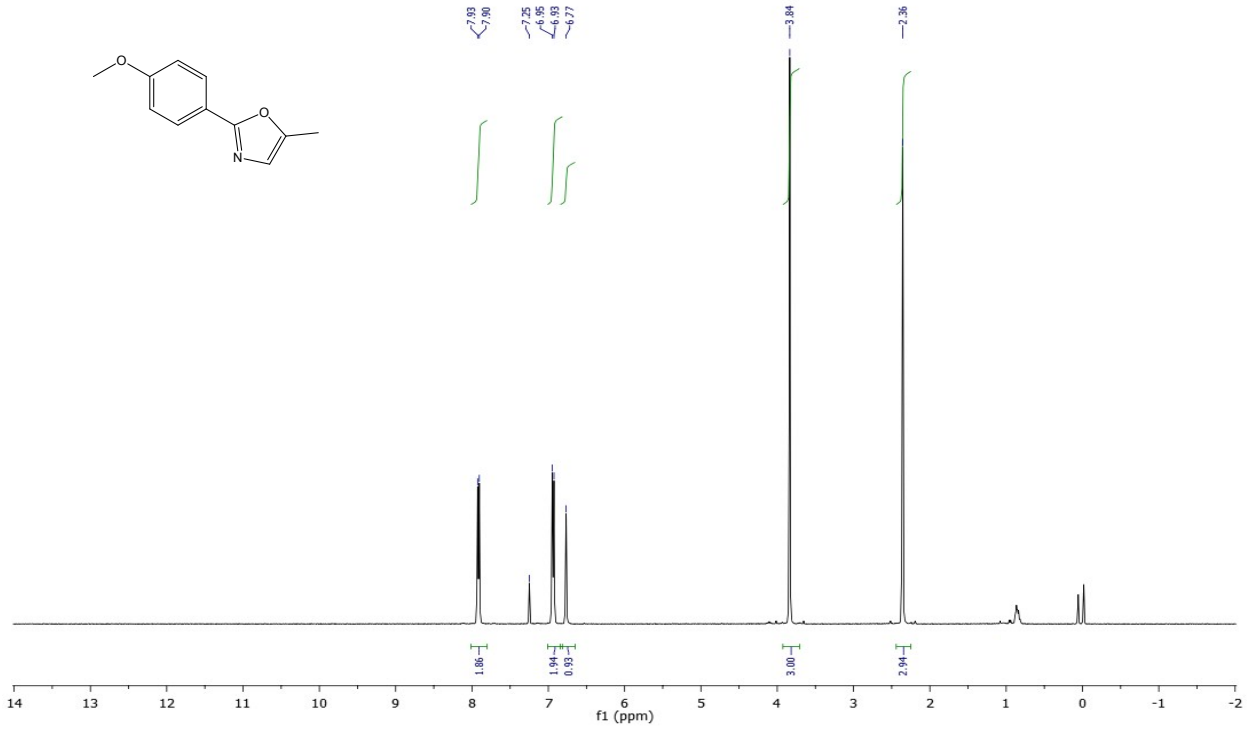
^{1}H NMR spectrum of 2-phenyl-5-methyl-1,3-oxazole **(4a)**



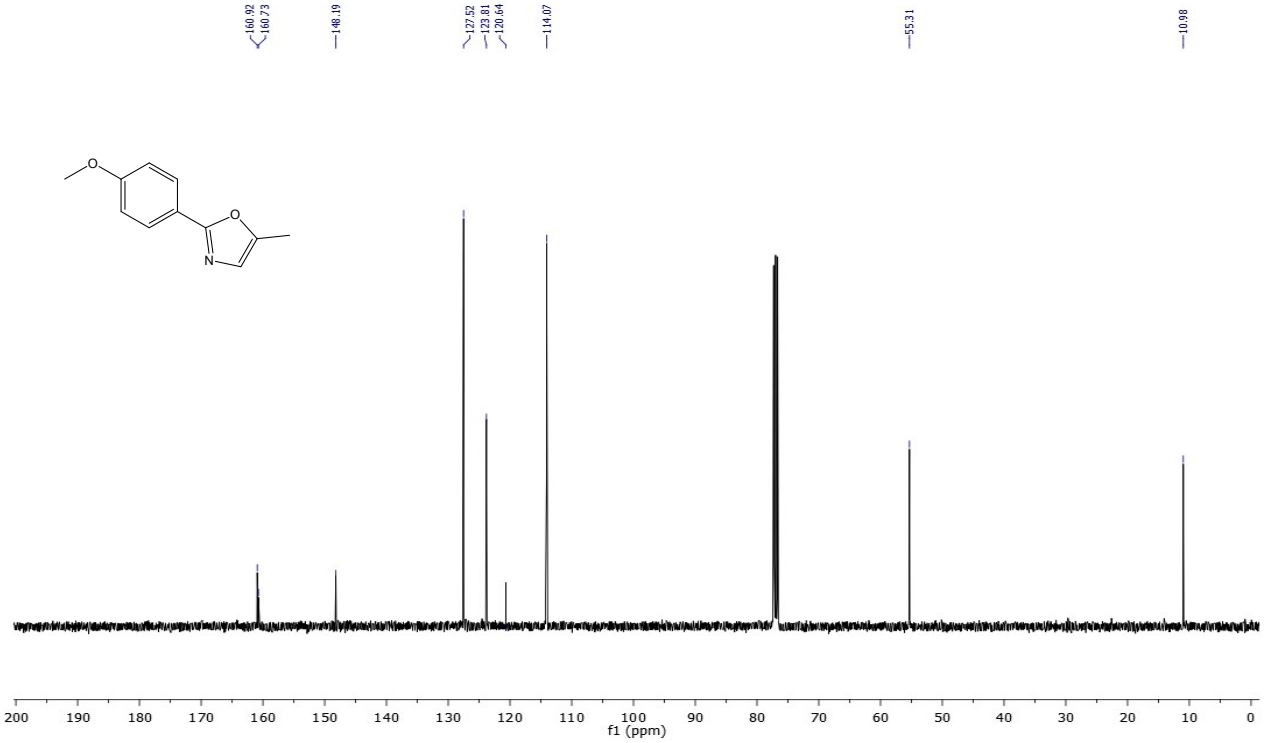
^{13}C NMR spectrum of 2-phenyl-5-methyl-1,3-oxazole **(4a)**



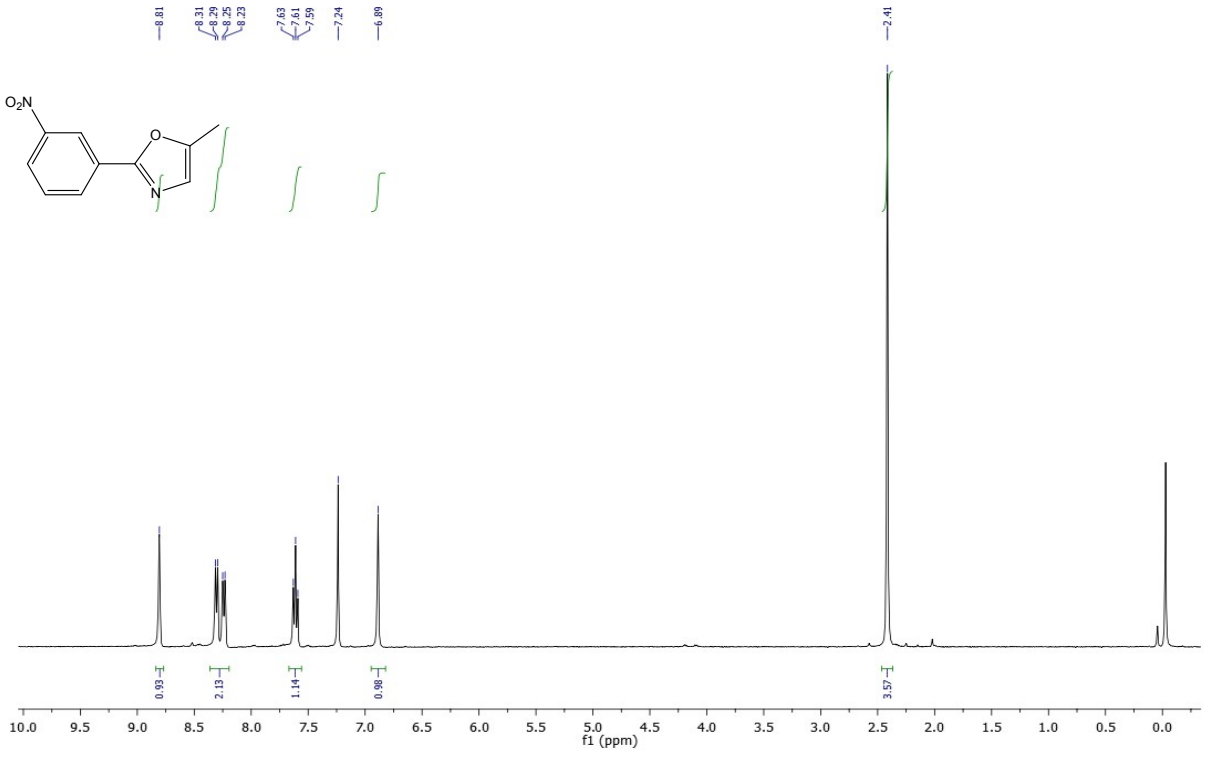
^{1}H NMR spectrum of 5-methyl-2-(4-methoxyphenyl)-1, 3-oxazole **(4c)**



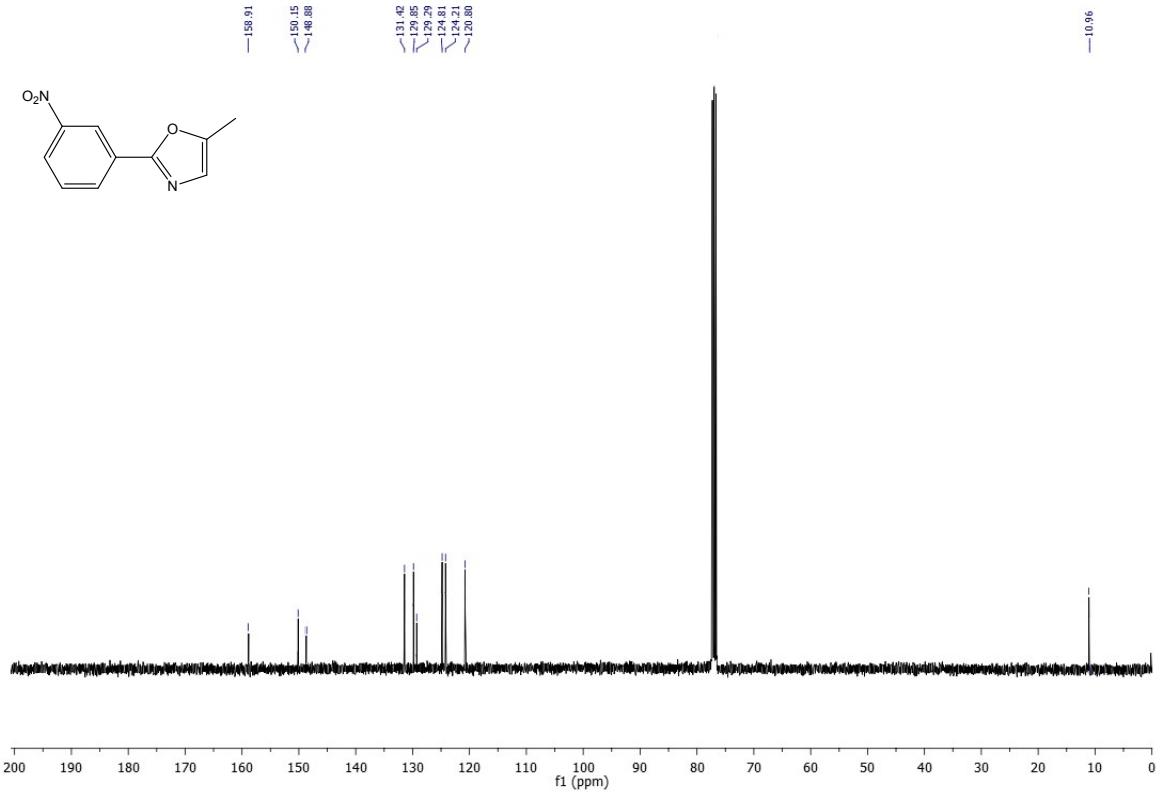
^{13}C NMR spectrum of 5-methyl-2-(4-methoxyphenyl)-1, 3-oxazole **(4c)**



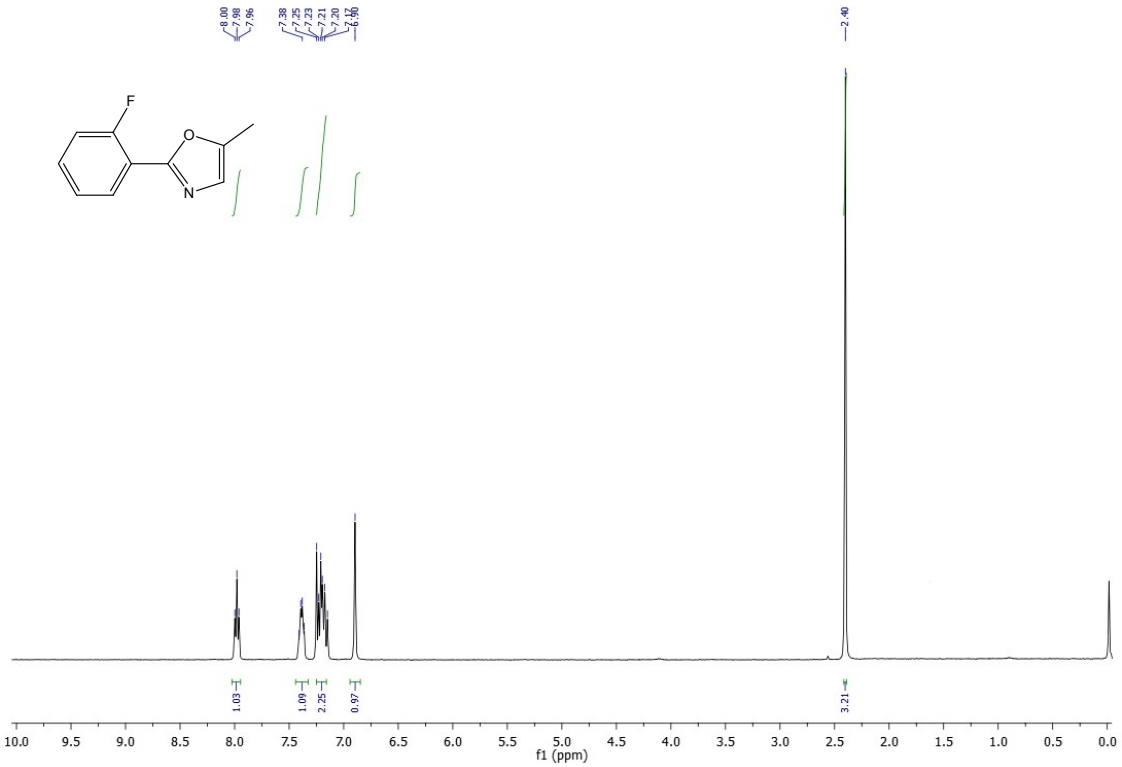
^{1}H NMR spectrum of 5-methyl-2-(3-nitrophenyl)-1, 3-oxazole **(4e)**



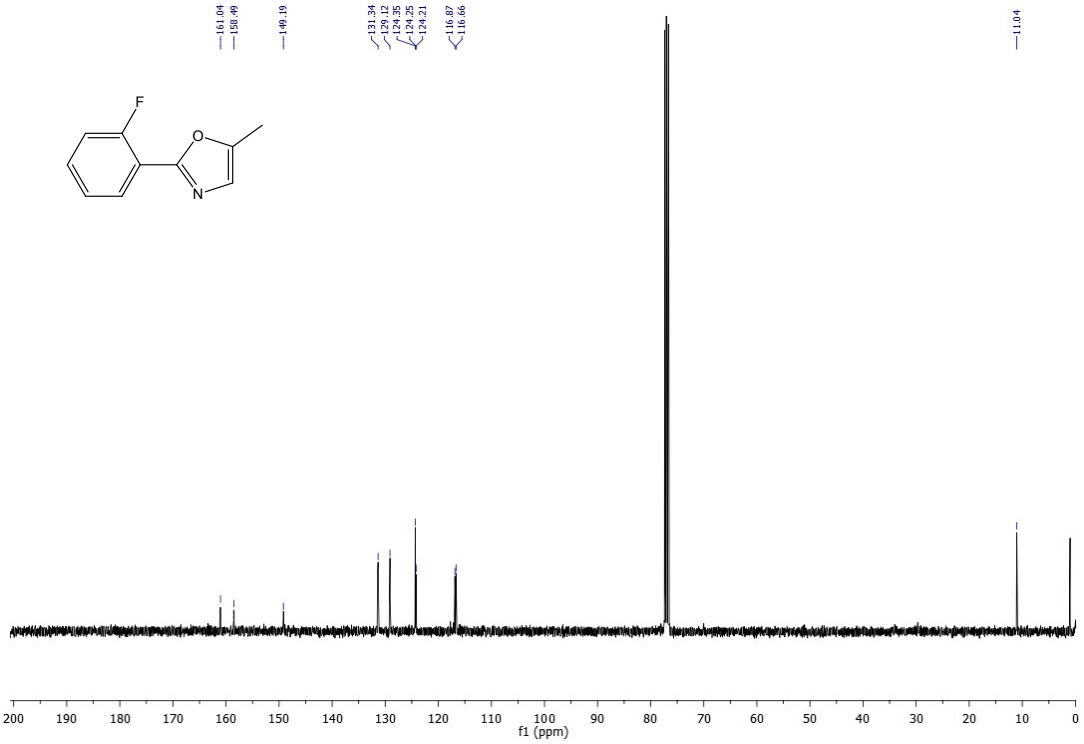
^{13}C NMR spectrum of 5-methyl-2-(3-nitrophenyl)-1, 3-oxazole **(4e)**



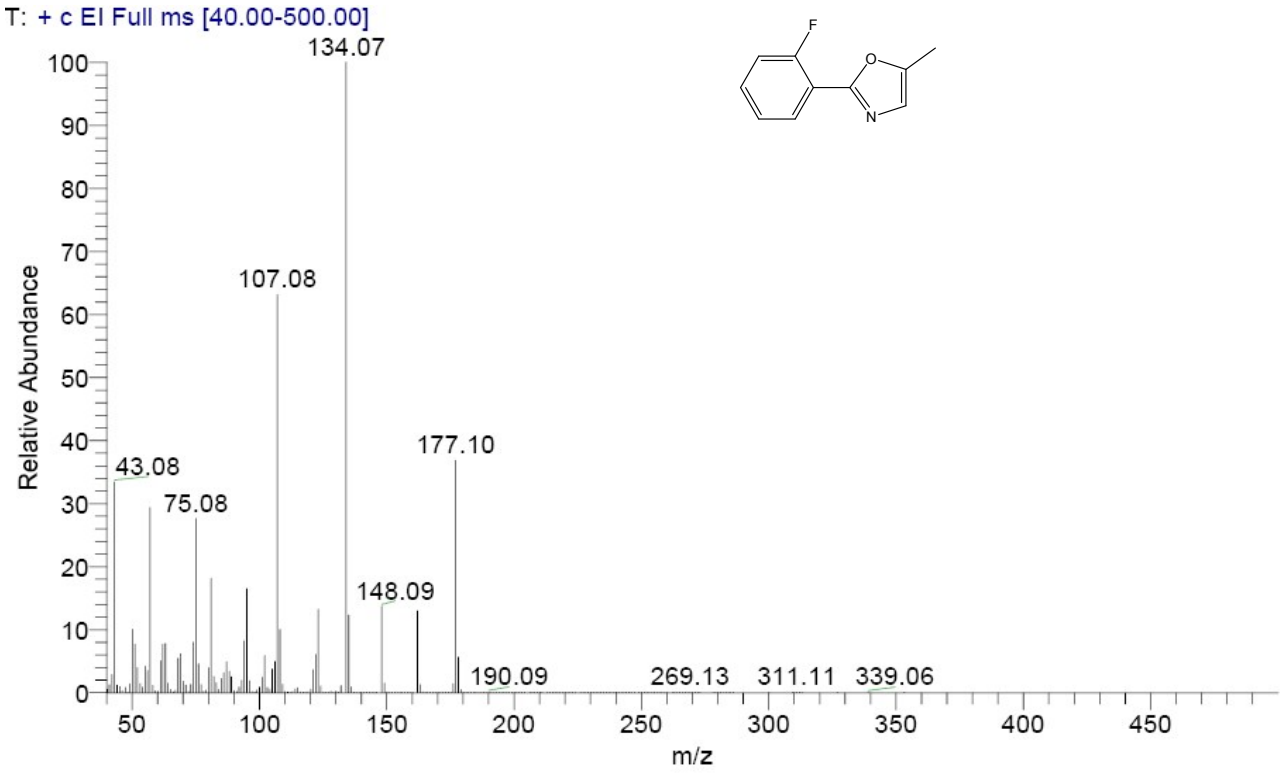
^{1}H NMR spectrum of 2-(2-fluorophenyl)-5-methylene-1, 3-oxazole **(4f)**



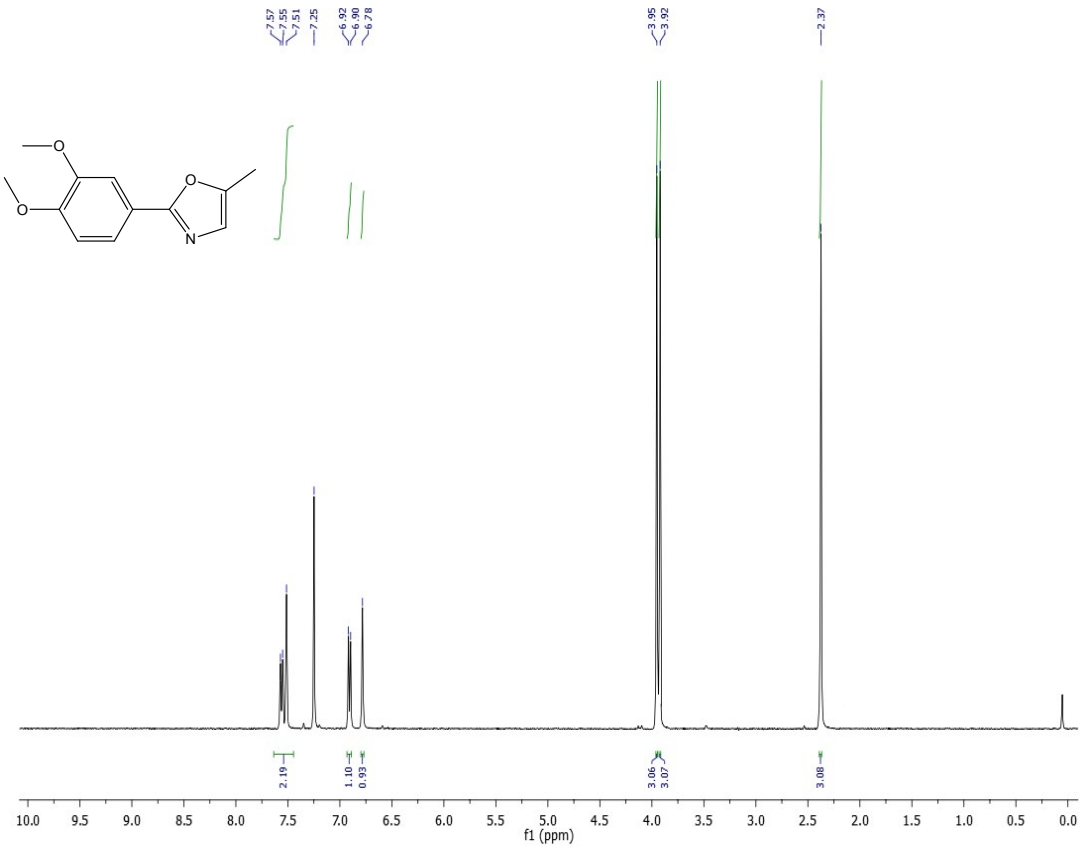
^{13}C NMR spectrum of 2-(2-fluorophenyl)-5-methylene-1, 3-oxazole **(4f)**



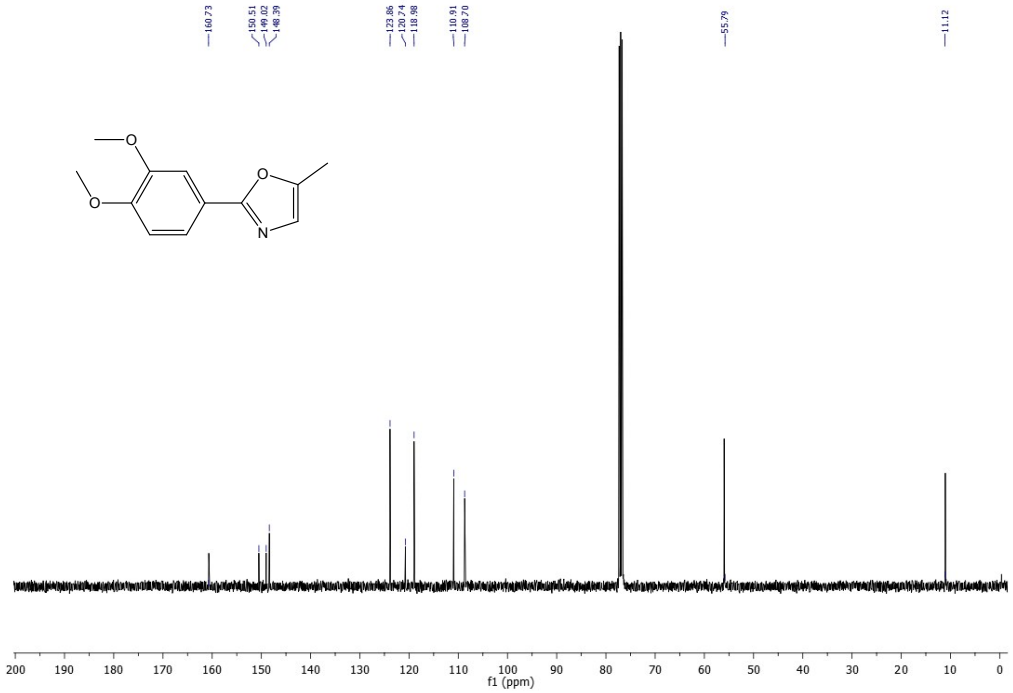
GC-MS Spectrum of 2-(2-fluorophenyl)-5-methylene-1, 3-oxazole **(4f)**



^{1}H NMR spectrum of 5-methyl-2-(3,4-dimethoxyphenyl)-1, 3-oxazole **(4g)**



^{13}C NMR spectrum of 5-methyl-2-(3, 4-dimethoxyphenyl)-1, 3-oxazole **(4g)**



GC-MS Spectrum of 5-methyl-2-(3,4-dimethoxyphenyl)-1, 3-oxazole **(4g)**