Electronic Supplementary Information (ESI) for:

A Cooperative Water Effect in Proazaphosphatrane-Catalysed Heterocycle Synthesis

Mark A. Honey, Yosuhiro Yamashita and Shu Kobayashi*

Table of Contents

*Department of Chemistry, School of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan. E-mail: shu_kobayashi@chem.s.u-tokyo.ac.jp

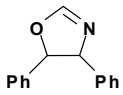
General Experimental

Commercially available reagents were used throughout without purification unless otherwise stated. Tetrahydrofuran was distilled from sodium benzophenone ketyl under a nitrogen atmosphere. Commercially available dry DMF was stored over MS 4A. *i*Bu-PAP and imines were either used as purchased or prepared following normal literature procedures. Reactions were routinely set up in a glove box under an atmosphere of argon. Reactions were monitored with analytical thin-layer chromatography (TLC) on silica gel 60 F254 plates and/or Chromatorex TLC (NH) plates and visualised under UV (254 nm). Hydrophobic PTFE membrane filters refer to Puradisc™ 25TF 0.45 μm filters. NMR spectra were recorded with JEOL JMNLA 400, 500 or 600 spectrometers. Chemical shifts are given in parts per million, referenced to the solvent peak of $CDCl_3$, defined at 77.0 ppm (^{13}C NMR) and 7.27 ppm (^{1}H NMR). Infrared spectra were recorded on an FT-IR spectrometer in the range 4000−600 cm^{-1}. High resolution mass spectra were recorded on a JEOLJMS-T100TD (DART®) spectrometer. The structures of the known compounds were confirmed by comparison with commercially available compounds or data shown in literature. Oxazolines were purified by kugelrohr distillation, and imidazolines by flash column chromatography over silica gel (NH).

General procedure for the synthesis of Oxazolines

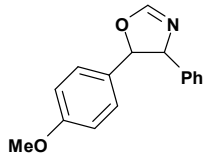
Under an atmosphere of argon, *i*Bu-PAP (5 mol%), dry DMF (0.6 mL) and a stirrer bar were added to a biotage microwave vial (5 mL) and sealed. To the solution of *i*Bu-PAP was added the isocyanide (0.33 mmol) by microsyringe, followed by water (10 mol%). The vial was placed in an oil bath and heated to 100 ^{o}C and stirred for 5 min. To the reaction mixture the aldehyde (0.30 mmol) was added and stirred at 100 ^{o}C for 20 h. After the completion of the reaction, the vial was removed from the heat source and water (2 mL) was added. The suspension was decanted into a separating funnel and diluted with water (10 mL).The organic material was extracted with ether (3 x 5 mL) and the organic layers combined and dried over Na_2SO_4. The suspension was filtered and the solvent removed under reduced pressure. The crude mixture was purified by distillation under reduced pressure to give the desired oxazoline.

Preparation of 4,5-diphenyl-4,5-dihydrooxazole[1]



Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.44-7.23 (11 H, m, ArH, OCHN), 5.22 (1 H, d, *J* 8.0 Hz, PhCH), 5.07 (1 H, dd, *J* 7.9, 2.0 Hz, PhCH); δ_C (150 MHz; $CDCl_3$) 154.9 (CH), 141.3 (C), 139.9 (C), 128.9 (CH), 128.8 (CH), 128.6 (CH), 127.8 (CH), 126.5 (CH), 125.7 (CH), 87.8 (CH), 77.5 (CH); υ_{max}/CM^{-1} 3246, 3061, 3030, 2925, 1686, 1630, 1603, 1586, 1496, 1451, 1308, 1230, 1095; HRMS (DART) Calcd. for $C_{15}H_{14}NO$: 224.1075 ([M + H]+), Found: 224.1086 ([M + H]+).

Preparation of 5-(4-methoxyphenyl)-4-phenyl-4,5-dihydrooxazole[2]

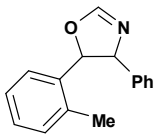


Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.39-7.36 (2 H, m, ArH), 7.33-7.30 (1 H, m, CH), 7.26-7.23 (4 H, m, ArH), 7.20-7.19 (1 H, m, ArH), 6.95-6.93 (2 H, m, ArH), 5.16-5.14 (1 H, m, CH), 5.07-5.05 (1 H, m, CH), 3.84-3.83 (3 H, m, OMe); δ_C (150 MHz; $CDCl_3$) 159.9 (CH), 157.9 (C), 141.5 (C), 131.8 (C), 128.8 (CH), 127.7 (CH), 127.4 (CH), 126.5 (CH), 114.4 (CH), 87.8 (CH), 77.2 (CH), 55.3 (Me); υ_{max}/CM^{-1} 3276, 3064, 3027, 3006, 2959, 2937, 2906, 2834, 1684, 1629, 1584, 1512, 1455, 1383, 1303, 1249, 1178, 1096, 1033; HRMS (DART) Calcd. for $C_{16}H_{16}NO_2$: 254.1181 ([M + H]+), Found: 254.1187 ([M + H]+).

[1]J. Peng, M. E. Barr, D. A. Ashburn, J. D. Odom, R. B. Dunlap and L. A. Silks III, *J. Org. Chem*, 1994, **59**, 4977

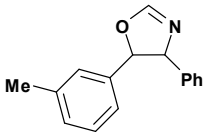
[2] U. Schoellkopf, F. Gerhart, I. Hoppe, R. Harms, K. Hantke, K. D. Scheunemann, E. Eilers and E. Blume, *Justus Liebigs Annalen der Chemie*, 1976, **1**, 183

Preparation of 4-phenyl-5-*o*-tolyl-4,5-dihydrooxazole



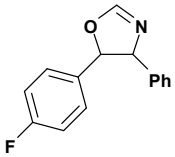
Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.37-7.16 (10 H, ArH, OCHN), 5.48 (1H, d, *J* 7.9 Hz PhCH), 4.99 (1H, d, *J* 7.9 Hz, PhCH), 2.12 (3 H, s, Me); δ_C (150 MHz; $CDCl_3$) 154.9 (CH), 141.4 (C), 137.74(C), 135.1 (C), 130.8 (CH), 128.8 (CH), 128.3 (CH), 127.9 (CH), 126.7 (CH), 126.6 (CH), 125.5 (CH), 85.2 (CH), 77.1 (CH), 19.4 (Me); υ_{max}/CM^{-1} 3282, 3064, 3029, 2956, 2930, 1687, 1628, 1493, 1456, 1384, 1096; HRMS (DART) Calcd. for $C_{16}H_{16}NO$: 238.1232 ([M + H]+), Found: 238.1229 ([M + H]+).

Preparation of 4-phenyl-5-*m*-tolyl-4,5-dihydrooxazole



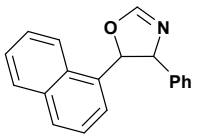
Colourless oil; δ_H (500 MHz; $CDCl_3$) 7.40-7.09 (10 H, m, ArH), 5.17 (1 H, d, *J* 7.9 Hz, CH), 5.05 (1 H, d, *J* 7.9 Hz, CH), 2.39 (3 H, s, Me); δ_C (125 MHz; $CDCl_3$) 154.9 (CH), 141.4 (C), 139.8 (C), 138.8 (C), 129.4 (CH), 128.8 (CH), 127.8 (CH), 126.8 (CH), 126.5 (CH). 126.3 (CH), 122.9 (CH), 87.9 (CH), 77.4 (CH), 21.4 (Me); υ_{max}/CM^{-1} 3315, 1686, 1626, 1491, 1455, 1384, 1093; HRMS (DART) Calcd. for $C_{16}H_{16}NO$: 238.1232 ([M + H]+), Found: 238.1234 ([M + H]+).

Preparation of 5-(4-fluorophenyl)-4-phenyl-4,5-dihydrooxazole



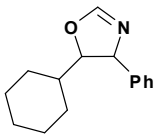
Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.40-7.38 (2 H, m, ArH), 7.35-7.32 (1 H, m, ArH), 7.30-7.28 (2 H, m, ArH), 7.24-7.22 (3 H, m, ArH), 7.12-7.09 (2 H, m, ArH), 5.19 (1 H, d, *J* 8.0 Hz, CH), 5.02 (1 H, dd, *J* 8.0, 2.0 Hz, CH); δ_C (150 MHz; $CDCl_3$) 162.8 (*d*, *J* 246.8 Hz, CF), 154.8 (CH), 141.1 (C), 135.6 (C), 128.9 (CH), 127.9 (CH), 127.1 (*d*, *J* 8.3 Hz, CH), 127.5 (CH), 115.9 (*d*, *J* 21.6 Hz, CH), 87.2 (CH), 77.6 (CH); δ_F (565 MHz, $CDCl_3$) -113.00 (s, CF); υ_{max}/CM^{-1} 1631, 1512, 1228, 1092

Preparation of 5-(naphthalen-1-yl)-4-phenyl-4,5-dihydrooxazole



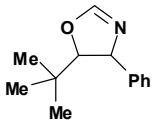
Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.93-7.87 (2 H, m, ArH), 7.60 (1H, d, *J* 9.6 Hz, CH), 7.54-7.50 (3 H, m, ArH), 7.43-7.34 (5 H, m, ArH + CH), 7.29 (2 H, d, *J* 7.0 Hz, ArH), 5.89 (1 H, d, *J* 7.3 Hz, CH), 5.13 (1 H, d, *J* 7.3 Hz, CH); δ_C (150 MHz; $CDCl_3$) 154.8 (CH), 141.3 (C), 135.2 (C), 134.0 (C), 130.0 (C), 129.0 (CH), 129.0 (CH), 128.9 (CH), 128.0 (CH), 127.1 (CH), 126.4 (CH), 125.9 (CH), 125.4 (CH), 123.3 (CH), 123.0 (CH), 85.7 (CH), 76.9 (CH); υ_{max}/CM^{-1} 3253, 3067, 2935, 1697, 1634, 1601, 1515, 1493, 1454, 1394, 1266, 1094; HRMS (DART) Calcd. for $C_{19}H_{16}NO$: 274.1232 ([M + H]+), Found: 274.1237 ([M + H]+).

Preparation of 5-cyclohexyl-4-phenyl-4,5-dihydrooxazole



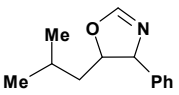
Colourless oil: δ_H (600 MHz; $CDCl_3$) 7.36-7.34 (2 H, m, ArH), 7.29-7.27 (1 H, m, ArH), 7.22 (2 H, d, *J* 8.0 Hz, ArH), 7.02 (1 H, s, OCHN), 4.83 (1 H, d, *J* 6.9 Hz, PhCH), 4.12 (1 H, t, *J* 6.6 Hz, CH_2CHCH), 1.87-1.70 (5 H, m, 2.5xCH_2), 1.62-1.57 (1 H, m, $CHCH_2$), 1.31-1.04 (5 H, m, 2.5xCH_2); δ_C (150 MHz; $CDCl_3$) 154.9 (CH), 142.4 (C), 128.7 (CH), 127.5 (CH), 126.7 (CH), 90.6 (CH), 71.5 (CH), 42.2 (CH), 28.2 (CH_2), 27.8 (CH_2), 26.3 (CH_2), 25.8 (CH_2), 25.6 (CH_2); υ_{max}/CM^{-1} 3272, 2923, 2857, 1652, 1525, 1453, 1387, 1224, 1085, 1068; HRMS (DART) Calcd. for $C_{15}H_{22}NO_2$: 248.1651 ([M + H_3O]+), Found: 248.1650248.1651 ([M + H_3O]+).

Preparation of 5-*tert*-butyl-4-phenyl-4,5-dihydrooxazole



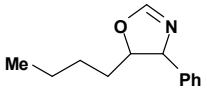
The crude mixture was extracted as per the general method and was analysed without further purification. Colourless solid; δ_H (600 MHz; $CDCl_3$) 7.37-7.34 (2 H, m, ArH), 7.30-7.28 (1 H, m, ArH), 7.23-7.22 (2 H, m, ArH), 7.05 (1 H, d, *J* 1.9 Hz, OCHN), 4.84 (1 H, dd, *J* 6.7, 1.9 Hz, CCH), 4.08 (1 H, d, *J* 6.7 Hz, PhCH), 0.97 (9 H, s, Me_3C); δ_C (150 MHz; $CDCl_3$) 155.0 (CH), 142.8 (C), 128.7 (CH), 127.5 (CH), 126.9 (CH), 94.2 (CH), 69.8 (CH), 34.2 (C), 24.7 (Me); υ_{max}/CM^{-1} 3247, 3066, 3030, 2961, 2871, 1686, 1633, 1493, 1479, 1455, 1397, 1368, 1104; HRMS (DART) Calcd. for $C_{13}H_{18}NO$: 204.1388 ([M + H]+), Found: 204.1380 ([M + H]+).

Preparation of 5-isobutyl-4-phenyl-4,5-dihydrooxazole



Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.31-7.23 (5 H, m, ArH), 7.01 (1 H, s, OCHN), 4.68 (1 H, d, *J* 7.9 Hz, PhCH), 4.37-4.33 (1 H, m, CH_2CHCH), 1.89-1.83 (1 H, m, $CHMe_2$), 1.76-1.71 (1 H, m, CH_2), 1.57-1.52 (1 H, m, CH_2), 0.94 (6 H, dd, *J* 6.6, 2.9 Hz, Me_2CH); δ_C (150 MHz; $CDCl_3$) 155.0 (CH), 141.7 (C), 128.7 (CH), 127.6 (CH), 126.5 (CH), 85.2 (CH), 74.8 (CH), 44.7 (CH_2), 25.1 (CH), 22.3 (Me), 22.1 (Me); HRMS (DART) Calcd. for $C_{13}H_{20}NO_2$: 222.1494 ([M + H_3O]+), Found: 222.1496 ([M + H_3O]+).

Preparation of 5-butyl-4-phenyl-4,5-dihydrooxazole



Colourless oil (53 mg, 67%); δ_H (600 MHz; $CDCl_3$) 7.38-7.22 (5 H, m, ArH), 7.02 (1 H, s, OCHN), 4.71 (1 H, dd, *J* 7.2, 1.5 Hz, PhCH), 4.31-4.26 (1 H, m, CH_2CH), 1.79-1.72 (2 H, m, CH_2), 1.49-1.35 (4 H, m, CH_2CH_2), 0.95-0.91 (3 H, m, CH_2Me); δ_C (150 MHz; $CDCl_3$) 155.0 (CH), 141.9 (C), 128.7 (CH), 127.6 (CH), 126.5 (CH), 86.7 (CH), 74.2(CH), 35.0 (CH_2), 27.3 (CH_2), 22.4 (CH_2), 13.9 (Me); υ_{max}/CM^{-1} 3292, 3065, 3029, 2958, 2931, 2869, 1685, 1628, 1495, 1466, 1454, 1381, 1101; HRMS (DART) Calcd. for $C_{13}H_{18}NO$: 201.1388 ([M + H]+), Found: 204.1383 ([M + H]+).

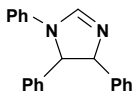
General procedure for the synthesis of imidazolines A

Under an atmosphere of argon, *i*Bu-PAP (5 mol%), dry THF (0.3 mL) and a stirrer bar were added to a microwave vial (5 mL) and sealed. To the solution of *i*Bu-PAP was added benzyl isocyanide (0.33 mmol) by microsyringe, followed by water (100 mol%). The vial was placed in an oil bath and heated to 40 ^{o}C. To the reaction mixture a solution of imine (0.30 mmol) in THF (0.3 mL) was added and stirred at 40 ^{o}C for 24 h. After the completion of the reaction, the vial was removed from the heat source and water (2 mL) was added. The suspension was decanted into a separating funnel and diluted with water (5 mL).The organic material was extracted with ethyl acetate (3 x 5 mL) and the organic layers combined and dried over Na_2SO_4. The suspension was filtered and the solvent removed under reduced pressure. The crude mixture was purified by flash column chromatography over silica gel (NH).

General procedure for the synthesis of imidazolines B

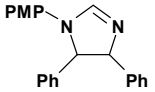
Under an atmosphere of argon, *i*Bu-PAP (5 mol%), dry DMF (0.3 mL) and a stirrer bar were added to a microwave vial (5 mL) and sealed. To the solution of *i*Bu-PAP was added benzyl isocyanide (0.33 mmol) by microsyringe, followed by water (100 mol%). The vial was placed in an oil bath and heated to 40 ^{o}C. To a separate reaction mixture, the aldehyde (0.30 mmol) and 4-methoxyaniline (0.30 mmol) were dissolved in DMF (0.6 mL) and $MgSO_4$ (~60 mg) was added and the suspension was stirred at room temperature for 1 h. The crude imine was extracted by syringe and filtered through a hydrophobic PTFE membrane filter, and added to the pre-formed *i*Bu-PAP/benzyl isocyanide solution. The reaction mixture was stirred at 100 ^{o}C for 24 or 65 h. After the completion of the reaction, the vial was removed from the heat source and water (2 mL) was added. The suspension was decanted into a separating funnel and diluted with water (5 mL).The organic material was extracted with diethyl ether (3 x 5 mL) and the organic layers combined and dried over Na_2SO_4. The suspension was filtered and the solvent removed under reduced pressure. The crude mixture was purified by flash column chromatography over silica gel (NH).

Preparation of 1,4,5-triphenyl-4,5-dihydro-1*H*-imidazole



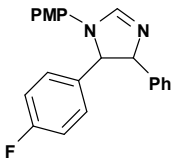
Following general method A. Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.98 (1 H, s, CH), 7.40-7.36 (4 H, m, ArH), 7.34-7.26 (6 H, m, ArH), 7.23-7.20 (2 H, m, ArH), 6.95-6.91 (3 H, m, ArH), 5.08 (1 H, d, *J* 7.4 Hz, CH), 4.92 (1 H, d, *J* 7.4 Hz, CH); δ_C (150 MHz; $CDCl_3$) 150.5 (CH), 142.6 (C), 141.1 (C), 139.5 (C), 129.5 (CH), 129.2 (CH), 128.7 (CH), 127.8 (CH), 127.6 (CH), 126.6 (CH), 126.0 (CH), 122.0 (CH), 115.7 (CH), 80.6 (CH), 70.9 (CH); υ_{max}/CM^{-1} 3062, 3031, 1595, 1581, 1503, 1454, 1374, 1345, 1299, 1176; HRMS (DART) Calcd. for $C_{21}H_{19}N_2$: 299.1548 ([M + H]+), Found: 299.1546 ([M + H]+).

Preparation of 1-(4-methoxyphenyl)-4,5-diphenyl-4,5-dihydro-1*H*-imidazole



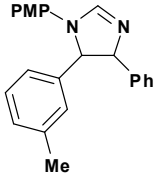
Following general method A. Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.81 (1 H, s, CH), 7.39-7.26 (10 H, m, ArH), 6.86-6.84 (2 H, m, ArH), 6.77-6.75 (2 H, m, ArH), 5.07 (1 H, dd, *J* 7.9, 1.6 Hz, CH), 4.85 (1 H, d, *J* 7.9 Hz, CH), 3.71 (3 H, s, OMe); δ_C (150 MHz; $CDCl_3$) 155.6 (CH), 151.4 (C), 142.8 (C), 141.2 (C), 133.2 (C), 129.1 (CH), 128.7 (CH), 127.8 (CH), 127.5 (CH), 126.6 (CH), 126.2 (CH), 117.7 (CH), 114.7 (CH), 80.6 (CH), 71.8 (CH), 55.4 (Me); υ_{max}/CM^{-1} 3061, 3031, 3003, 2954, 2932, 2906, 2834, 1602, 1582, 1513, 1456, 1378, 1293, 1246, 1177; HRMS (DART) Calcd. for $C_{22}H_{21}N_2O$: 329.1654 ([M + H]+), Found: 329.1660 ([M + H]+).

Preparation of 5-(4-fluorophenyl)-1-(4-methoxyphenyl)-4-phenyl-4,5-dihydro-1*H*-imidazole



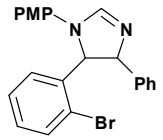
Following general method A. Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.78 (1H, d, *J* 1.8 Hz, CH), 7.39-7.36 (2 H, m, ArH), 7.33-7.30 (1 H, m, ArH), 7.26-7.23 (4 H, m, ArH), 7.06-7.03 (2 H, m, ArH), 6.84-6.82 (2 H, m, ArH), 6.78-6.76 (2 H, m, ArH), 5.03 (1 H, dd, *J* 8.1, 1.5 Hz, CH), 4.83 (1 H, d, *J* 8.1 Hz, CH), 3.73 (3 H, s OMe); δ_C (150 MHz; $CDCl_3$) 162.3 (*d*, *J* 250.0 Hz, CF), 155.4 (CH), 151.6 (C), 142.6 (C), 136.9 (C), 133.0 (C), 128.7 (CH), 127.9 (*d*, *J* 7.9 Hz, CH), 127.6 (CH), 126.6 (CH), 117.9 (CH), 116.1 (*d*, *J* 21.8 Hz, CH), 114.8 (CH), 80.6 (CH), 71.3 (CH), 55.5 (Me); δ_F (466 MHz, $CDCl_3$) -114.12 (s, CF); υ_{max}/CM^{-1} 3062, 3029, 3003, 2950, 2933, 2907, 2834, 1604, 1579, 1512, 1453, 1375, 1292, 1250, 1176; HRMS (DART) Calcd. for $C_{22}H_{20}FN_2O$: 347.1560 ([M + H]+), Found: 347.1556 ([M + H]+).

Preparation of 1-(4-methoxyphenyl)-4-phenyl-5-*m*-tolyl-4,5-dihydro-1*H*-imidazole



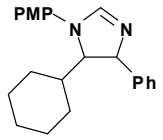
Following general method A. Colourless oil; δ_H (400 MHz; $CDCl_3$) 7.83 (1 H, s, CH), 7.40-7.23 (6 H, m, ArH), 7.12-7.06 (3 H, m, ArH), 6.86 (2 H, d, *J* 8.7 Hz, ArH), 6.77 (2 H, *J* 8.7 Hz, ArH), 5.06 (1 H, d, *J* 7.6 Hz, CH), 4.80 (1 H, d, *J* 7.6 Hz, CH), 3.73 (3 H, s, Me), 2.35 (3 H, s, Me); δ_C (150 MHz; $CDCl_3$) 155.1 (CH), 151.3 (C), 143.0 (C), 141.3 (C), 138.8 (C), 133.3 (C), 128.9 (CH), 128.6 (CH), 128.6 (CH), 127.4 (CH), 126.7 (CH), 126.6 (CH), 123.3 (CH), 117.6 (CH), 114.7 (CH), 80.6 (CH), 71.7 (CH), 55.4 (Me), 21.5 (Me); υ_{max}/CM^{-1} 3027, 3003, 2952, 2933, 2909, 2833, 1604, 1582, 1513, 1491, 1454, 1377, 1292, 1247, 1179, 1042; HRMS (DART) Calcd. for $C_{23}H_{23}N_2O$: 343.1810 ([M + H]+), Found: 343.1818 ([M + H]+).

Preparation of 5-(2-bromophenyl)-1-(4-methoxyphenyl)-4-phenyl-4,5-dihydro-1*H*-imidazole



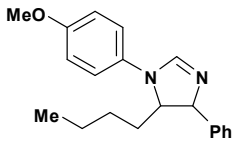
Following general method A. Colourless solid; δ_H (500 MHz; $CDCl_3$) 7.88 (1 H, s, CH), 7.59 (1 H, d, *J* 7.6 Hz, ArH), 7.38-7.29 (7 H, m, ArH), 7.17-7.14 (1 H, m, ArH), 6.84-6.78 (4 H, m, ArH), 5.47 (1 H, s, CH), 5.03 (1 H, s, CH), 3.73 (3 H, s, OMe); δ_C (150 MHz; $CDCl_3$); 155.2 (CH), 150.6 (C), 142.2 (C), 133.3 (C), 132.7 (C), 129.3 (CH), 128.6 (CH), 128.3 (CH), 127.6 (CH), 127.5 (CH), 127.4 (CH), 126.9 (CH), 122.5 (C), 117.1 (CH), 115.0 (CH), 80.3 (CH), 69.1 (CH), 55.5 (Me); υ_{max}/CM^{-1} 3060, 3031, 3002, 2954, 2935, 2907, 2833, 1602, 1582, 1514, 1466, 1455, 1440, 1378, 1292, 1248, 1178, 1043; HRMS (DART) Calcd. for $C_{22}H_{20}{}^{79}B\ rN_2O$: 407.0759 ([M + H]+), Found: 407.0773 ([M + H]+).

Preparation of 5-cyclohexyl-1-(4-methoxyphenyl)-4-phenyl-4,5-dihydro-1*H*-imidazole



Following general method B. Colourless oil; δ_H (400 MHz; $CDCl_3$) 7.50 (1 H, s, CH), 7.35-7.25 (5 H, m, ArH), 6.96 (2 H, d, *J* 8.9 Hz, ArH), 6.87 (2 H, d, *J* 8.9 Hz, ArH), 5.01 (1 H, d, *J* 5.1 Hz, CH), 4.00-3.98 (1 H, m, CH), 3.79 (3 H, s, OMe), 1.84-1.49 (6 H, m, Cy), 1.25-1.06 (5 H, m, Cy); δ_C (100 MHz; $CDCl_3$) 155.4 (CH), 151.2 (C), 144.6 (C), 133.0 (C), 128.6 (CH), 127.1 (CH), 126.1 (CH), 119.2 (CH), 114.9 (CH), 71.3 (CH), 70.6 (CH), 55.5 (Me), 39.1 (CH), 28.3 (CH_2), 26.5 (CH_2), 26.2 (CH_2), 25.8 (2 X CH_2); υ_{max}/CM^{-1} 3030, 3003, 2925, 2852, 1604, 1582, 1513, 1464, 1451, 1384, 1288, 1245, 1208, 1177, 1111, 1039; HRMS (DART) Calcd. for $C_{22}H_{27}N_2O$: 335.2123 ([M + H]+), Found: 335.2130 ([M + H]+).

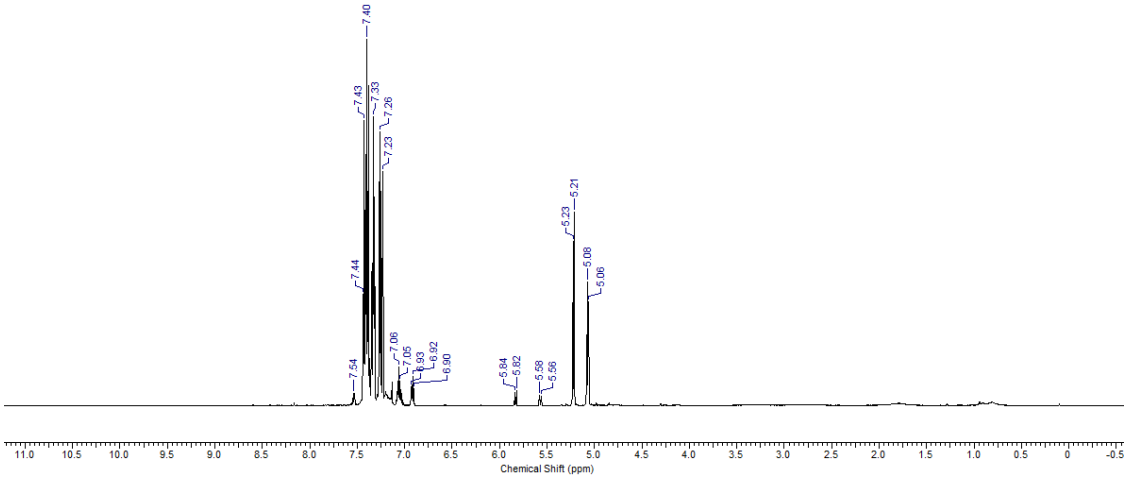
Preparation of 5-butyl-1-(4-methoxyphenyl)-4-phenyl-4,5-dihydro-1*H*-imidazole

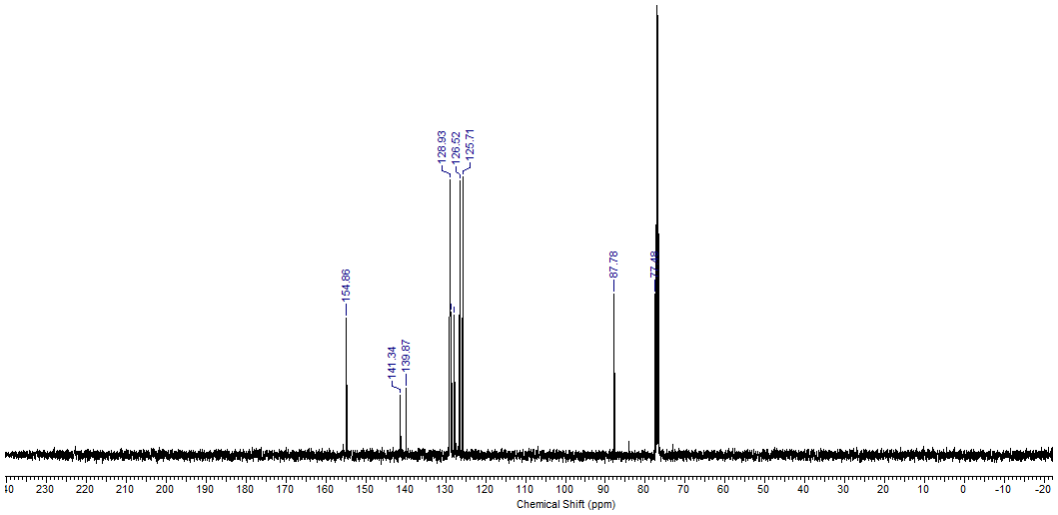


Following general method B. Colourless oil; δ_H (600 MHz; $CDCl_3$) 7.52 (1 H, s, CH), 7.37-7.34 (2 H, m, ArH), 7.30-7.28 (3 H, m, ArH), 6.97-6.94 (2 H, m, ArH), 6.90-6.87 (2 H, m, ArH), 4.94 (1 H, dd, *J* 5.9, 1.1 Hz, CH), 4.02 (1 H, ddd, *J* 8.3, 5.9, 3.0 Hz, CH), 3.80 (3 H, s, OMe), 1.78-1.66 (2 H, m, CH_2), 1.40-1.26 (4 H, m, 2xCH_2), 0.88 (3 H, t, *J* 7.1 Hz, Me); δ_C (151 MHz; $CDCl_3$); 155.4 (CH), 151.1 (C), 144.0 (C), 132.9 (C), 128.7 (CH), 127.3 (CH), 126.6 (CH), 118.6 (CH), 115.0 (CH), 75.3 (CH), 66.4 (CH), 55.6 (Me), 32.1 (CH_2), 26.1 (CH_2), 22.6 (CH_2), 14.0 (Me); υ_{max}/CM^{-1} 3031, 2957, 2931, 2861, 1677, 1600, 1581, 1513, 1465, 1454, 1383, 1290, 1247, 1177, 1042; HRMS (DART) Calcd. for $C_{20}H_{25}N_2O$: 309.1952 ([M + H]+), Found: 309.1927 ([M + H]+).

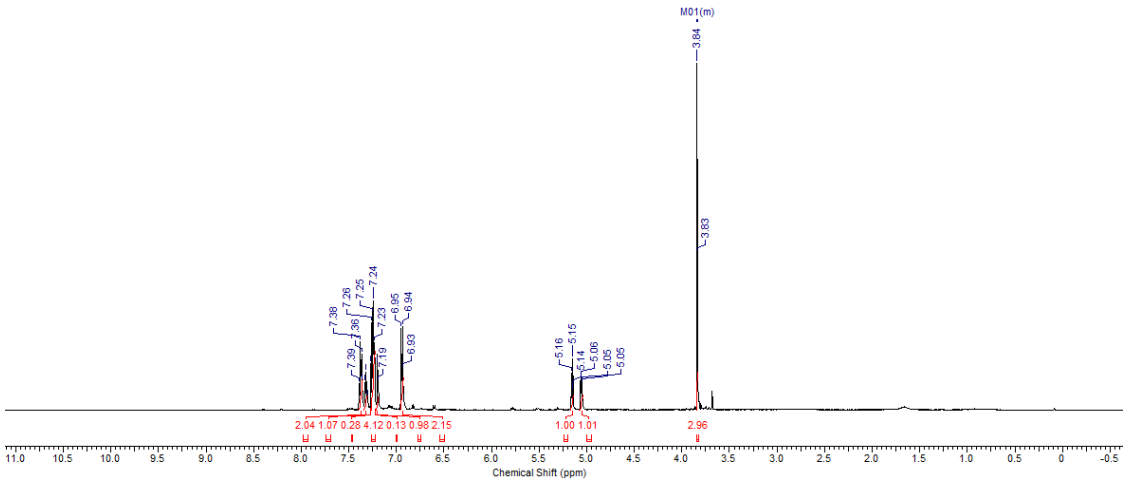
Supporting NMR Spectra

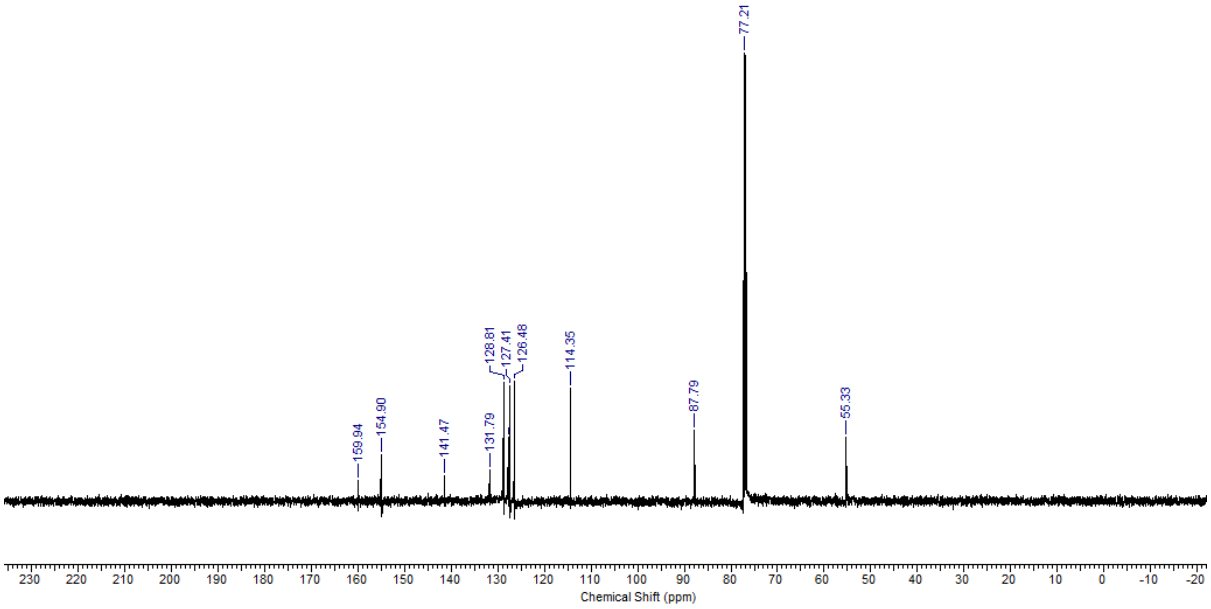
4,5-Diphenyl-4,5-dihydrooxazole



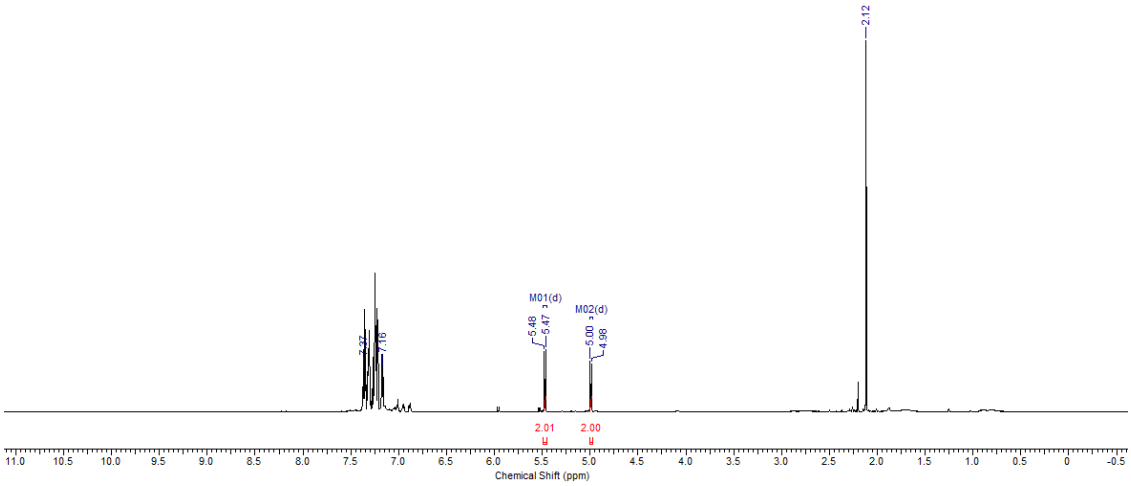


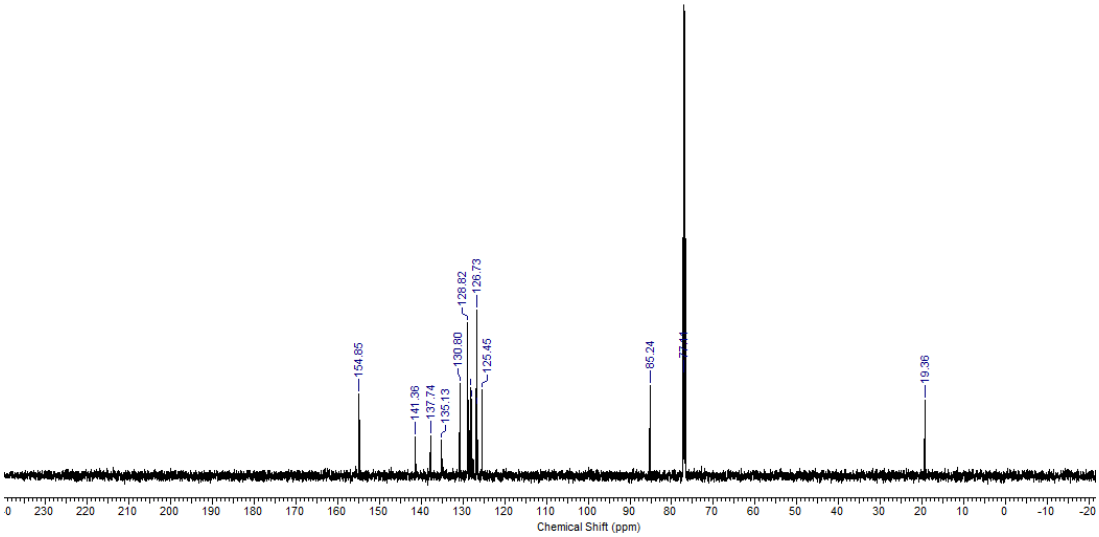
5-(4-methoxyphenyl)-4-phenyl-4,5-dihydrooxazole



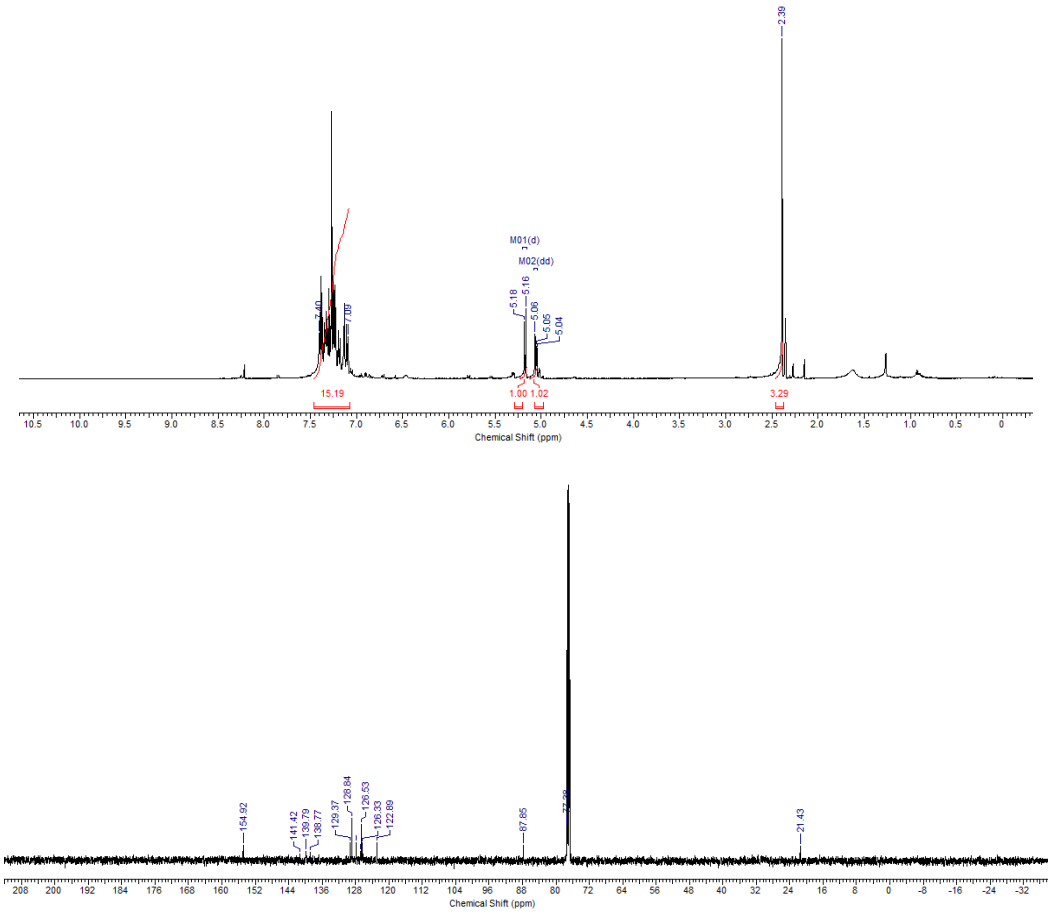


4-Phenyl-5-*o*-tolyl-4,5-dihydrooxazole

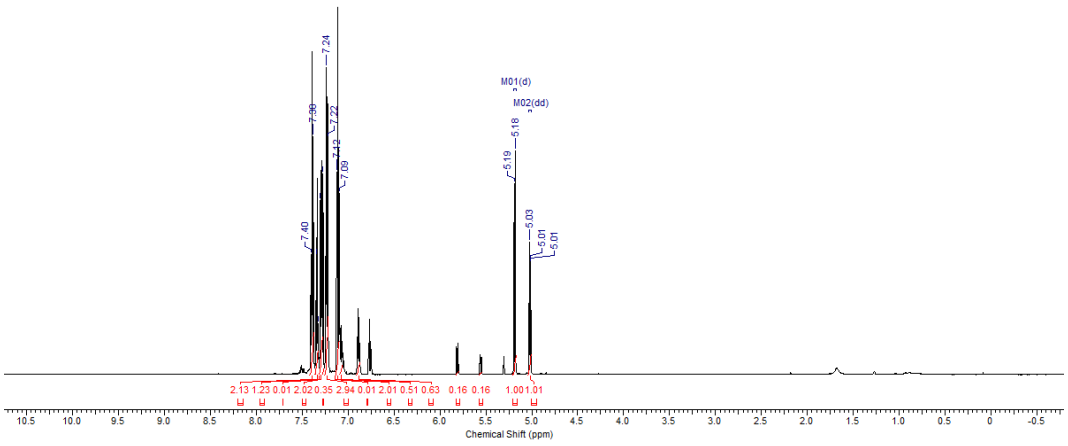


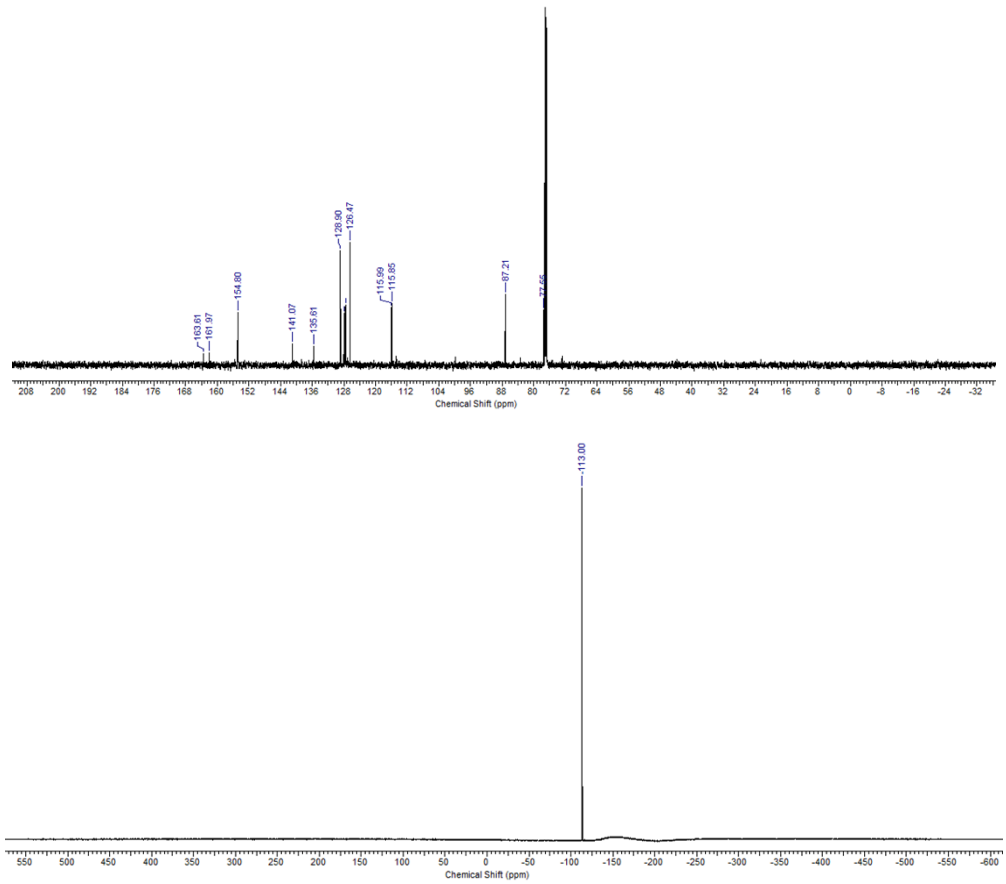


4-Phenyl-5-m-tolyl-4,5-dihydrooxazole

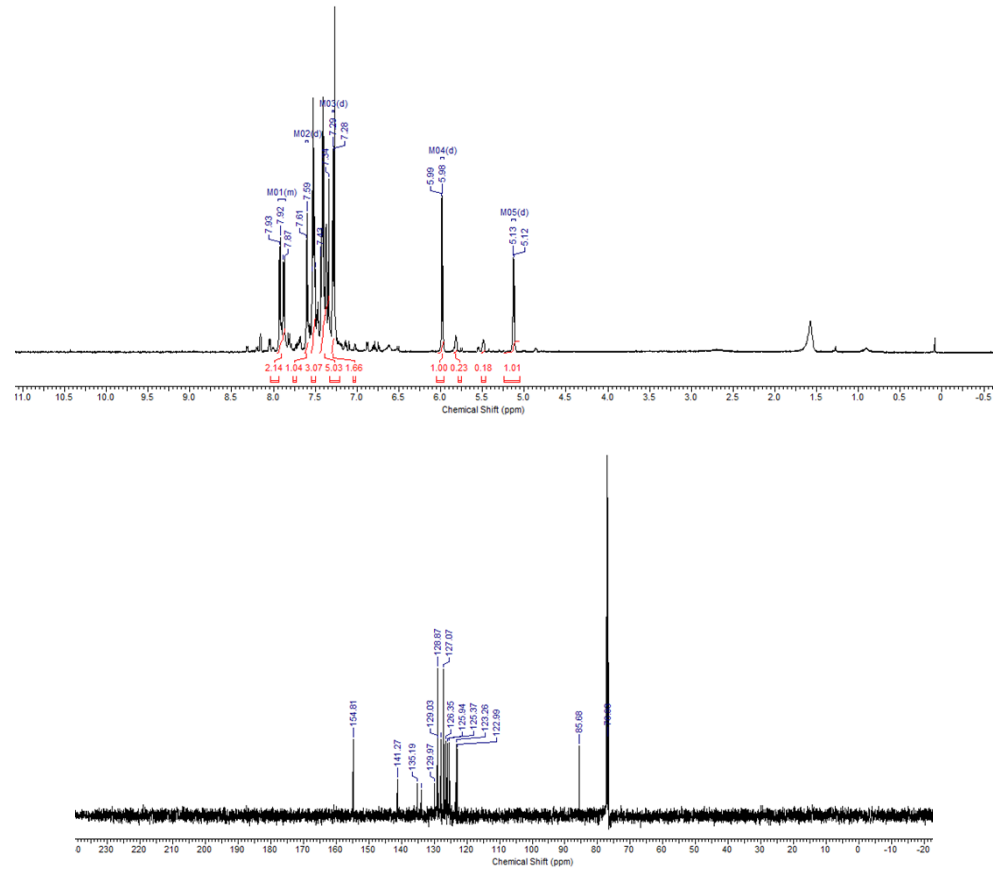


5-(4-Fluorophenyl)-4-phenyl-4,5-dihydrooxazole

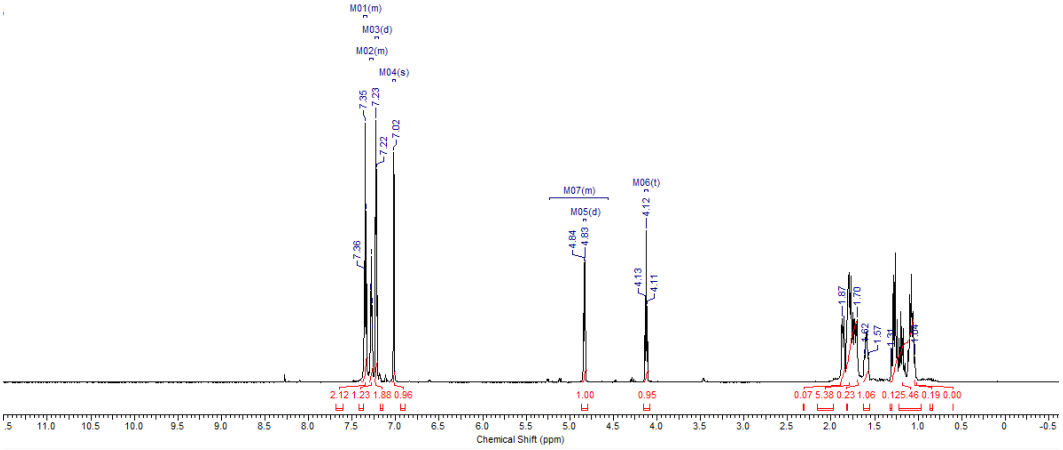


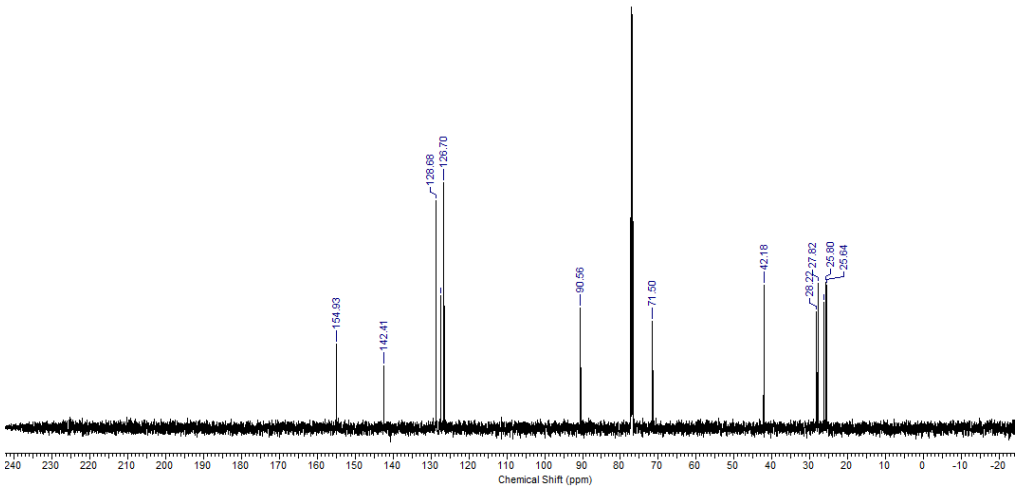


5-(Naphthalen-1-yl)-4-phenyl-4,5-dihydrooxazole

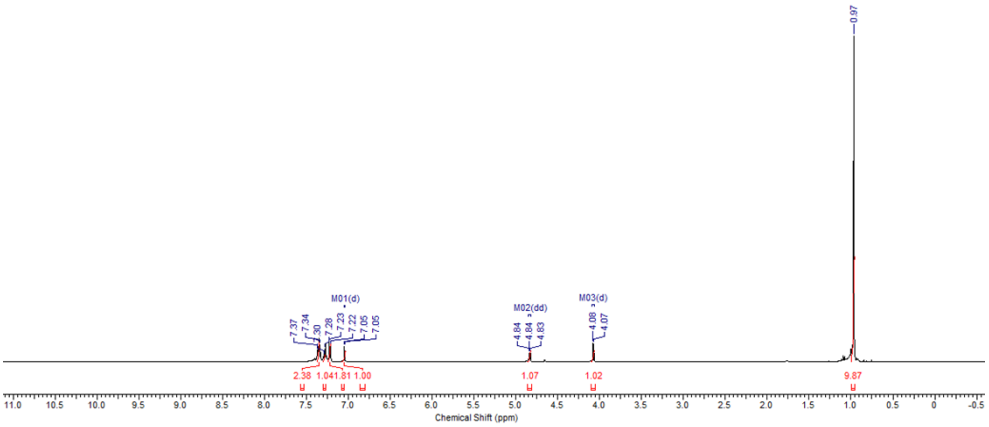


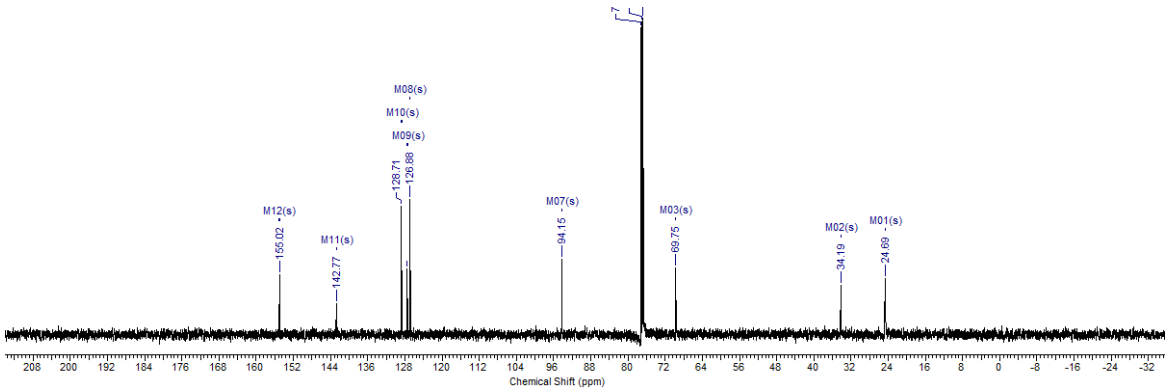
5-Cyclohexyl-4-phenyl-4,5-dihydrooxazole



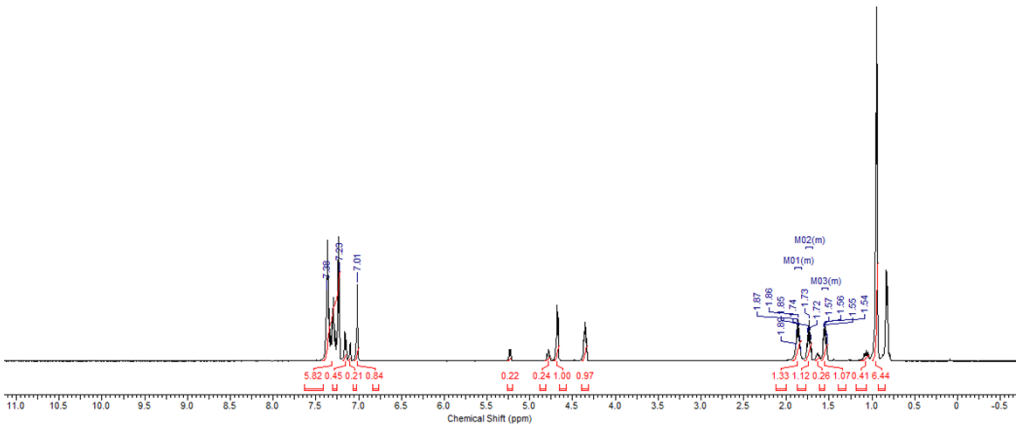


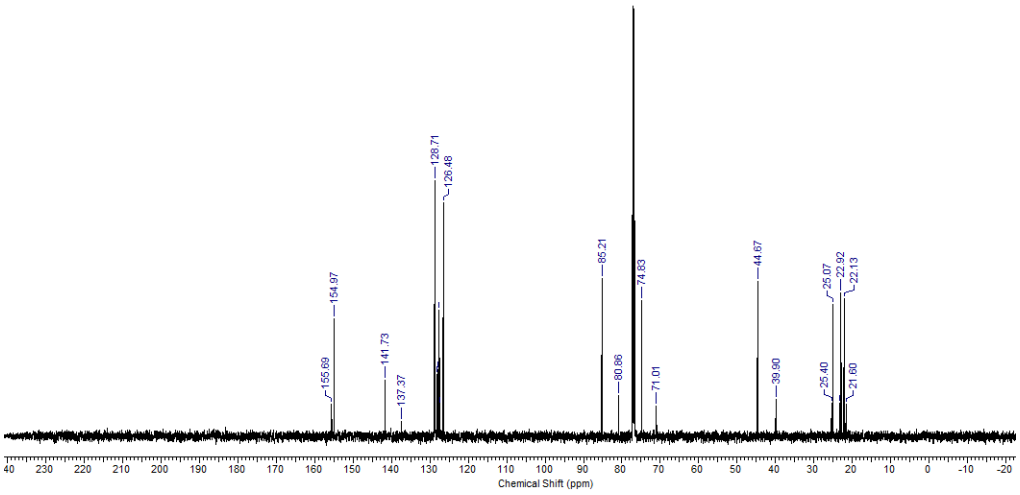
5-*tert*-Butyl-4-phenyl-4,5-dihydrooxazole



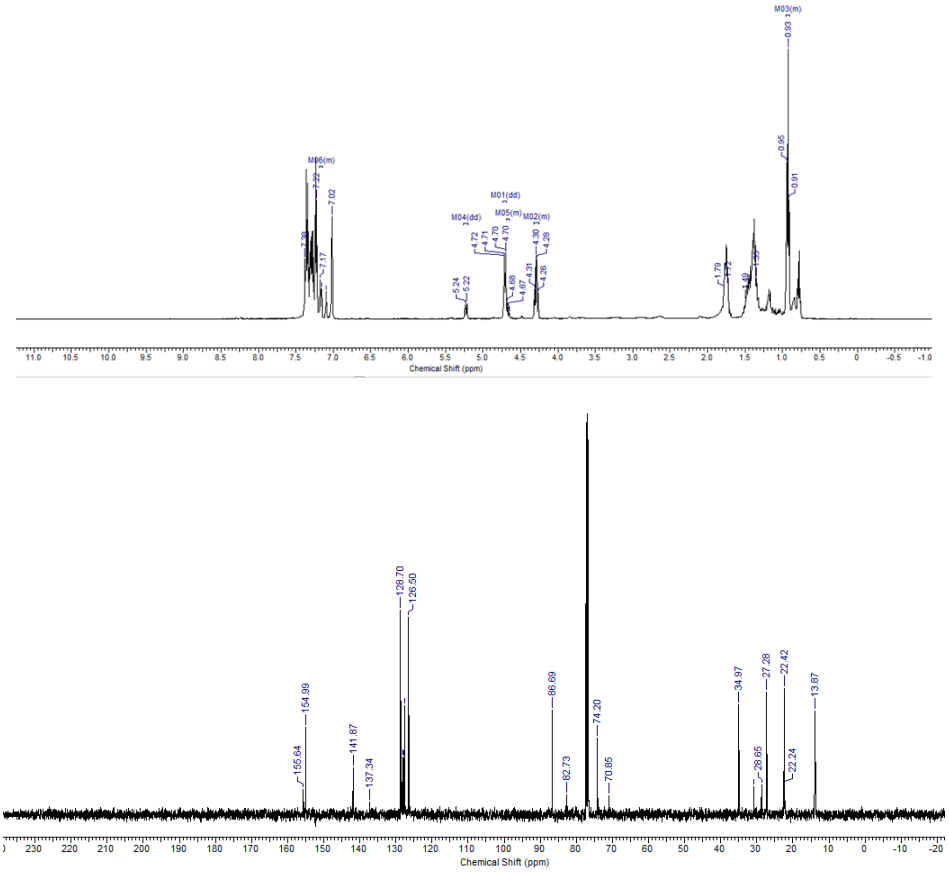


5-*iso*Butyl-4-phenyl-4,5-dihydrooxazole

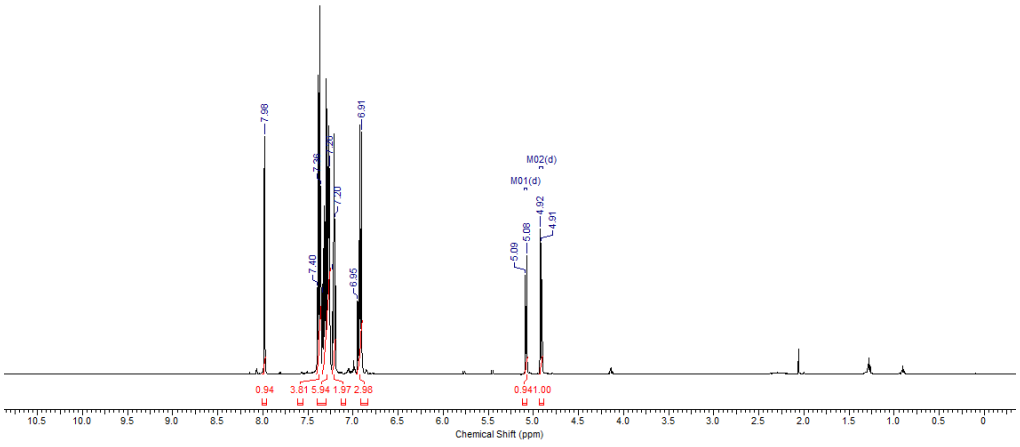


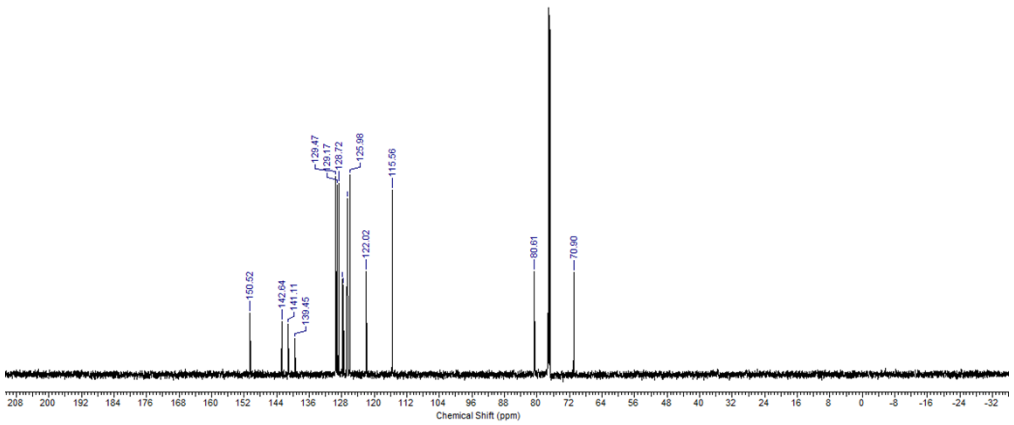


5-Butyl-4-phenyl-4,5-dihydrooxazole

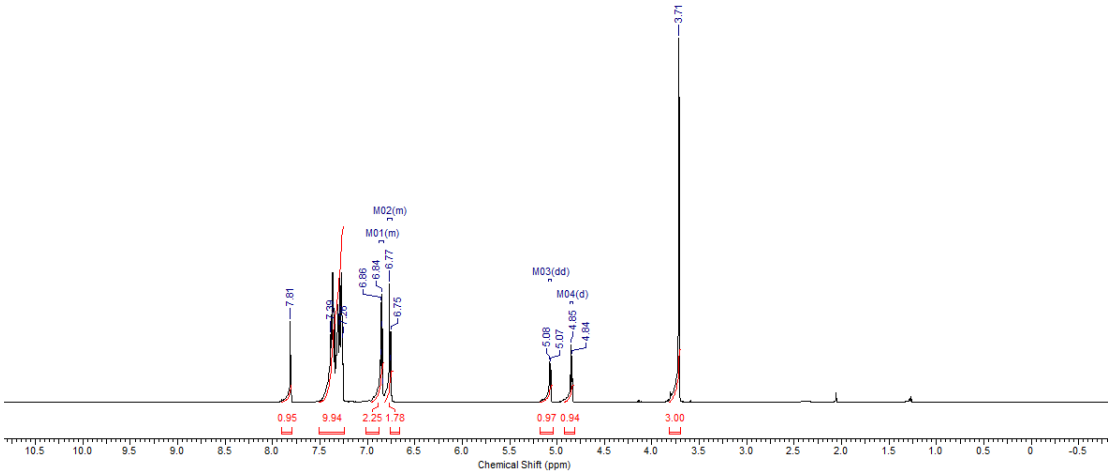


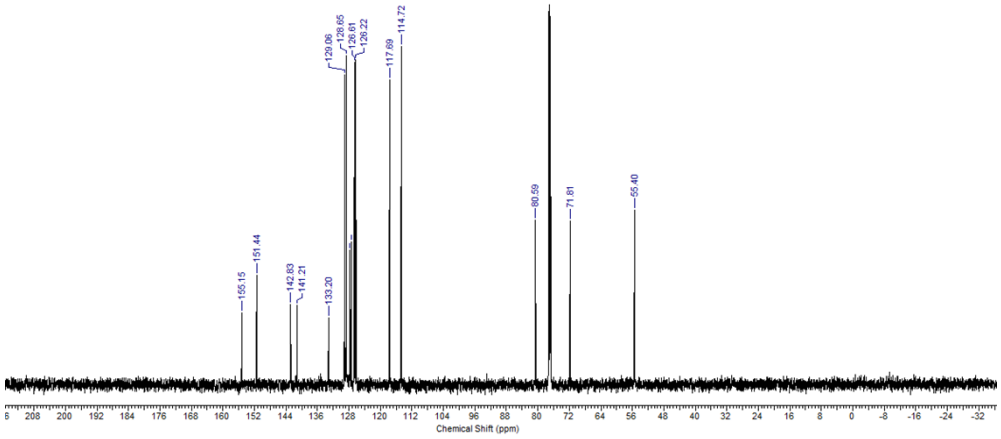
1,4,5-Triphenyl-4,5-dihydro-1*H*-imidazole



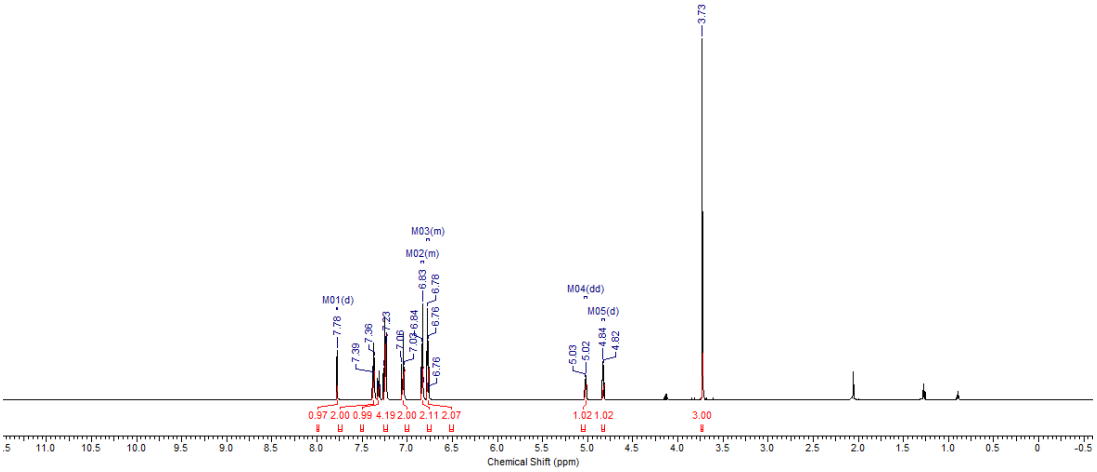


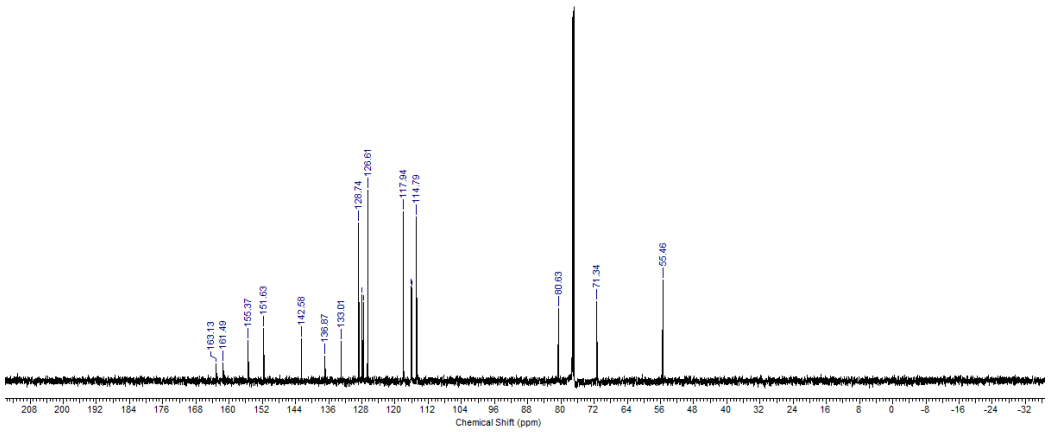
1-(4-Methoxyphenyl)-4,5-diphenyl-4,5-dihydro-1*H*-imidazole

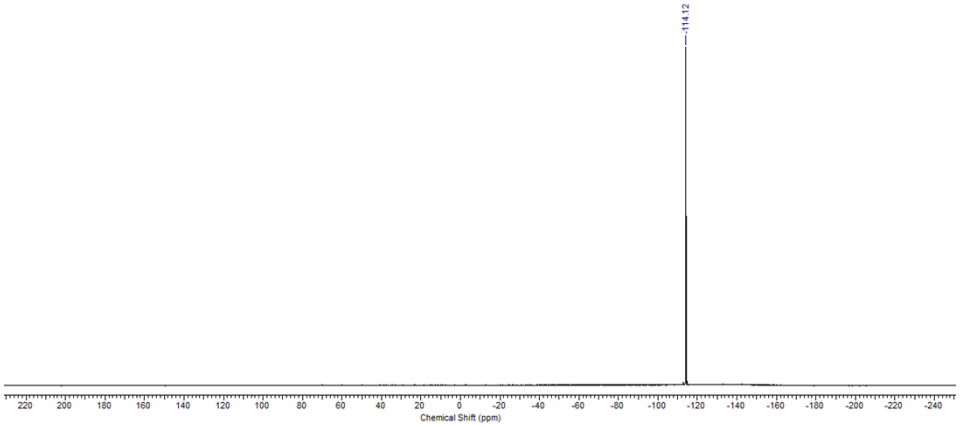




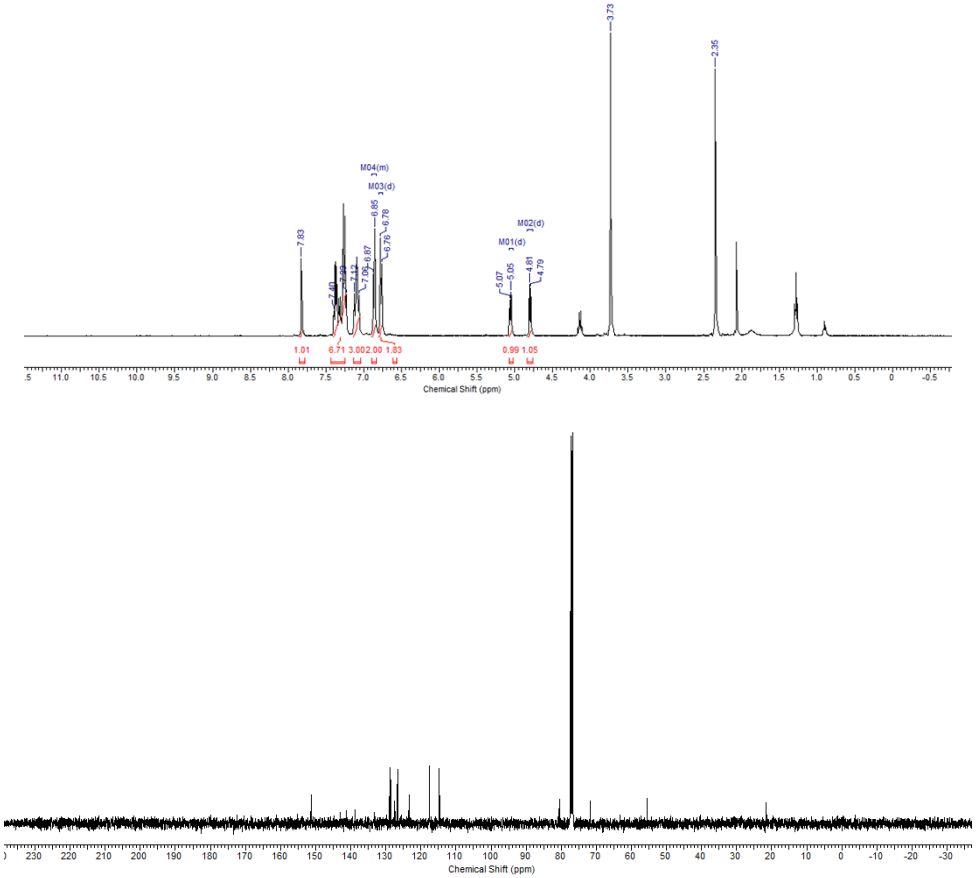
5-(4-Fluorophenyl)-1-(4-methoxyphenyl)-4-phenyl-4,5-dihydro-1*H*-imidazole



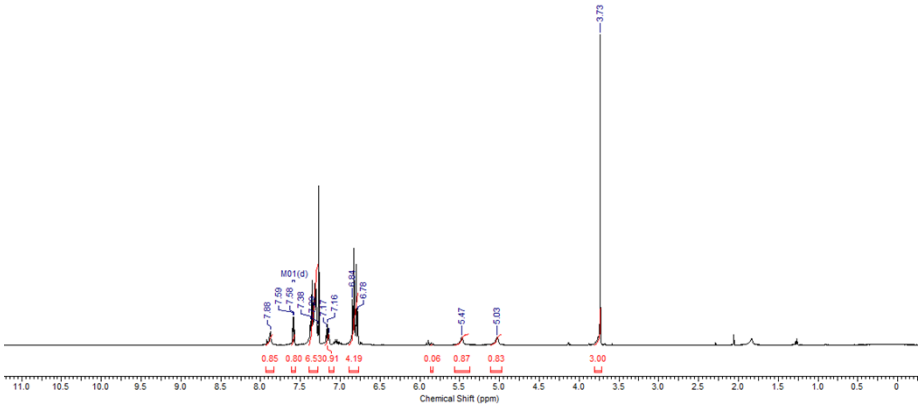


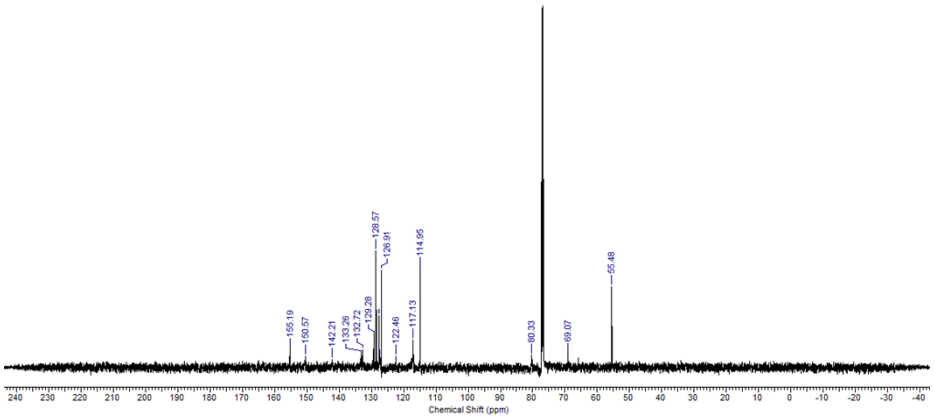


1-(4-Methoxyphenyl)-4-phenyl-5-*m*-tolyl-4,5-dihydro-1*H*-imidazole

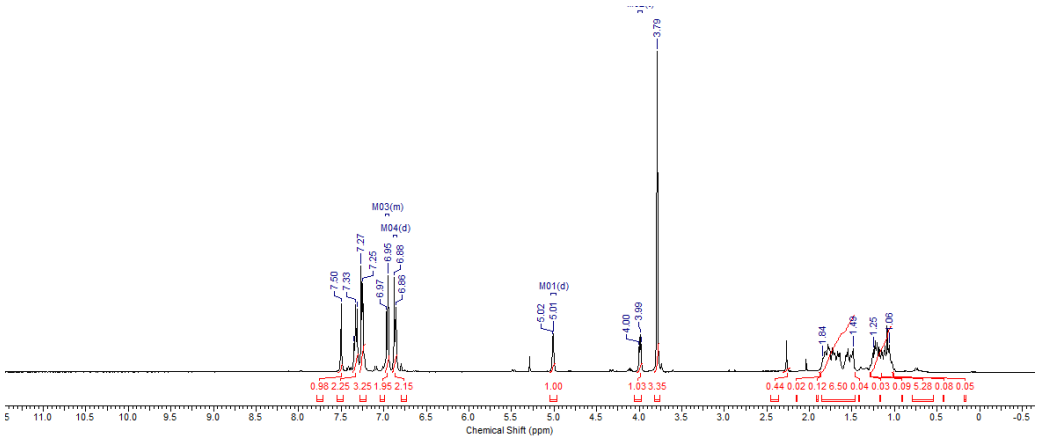


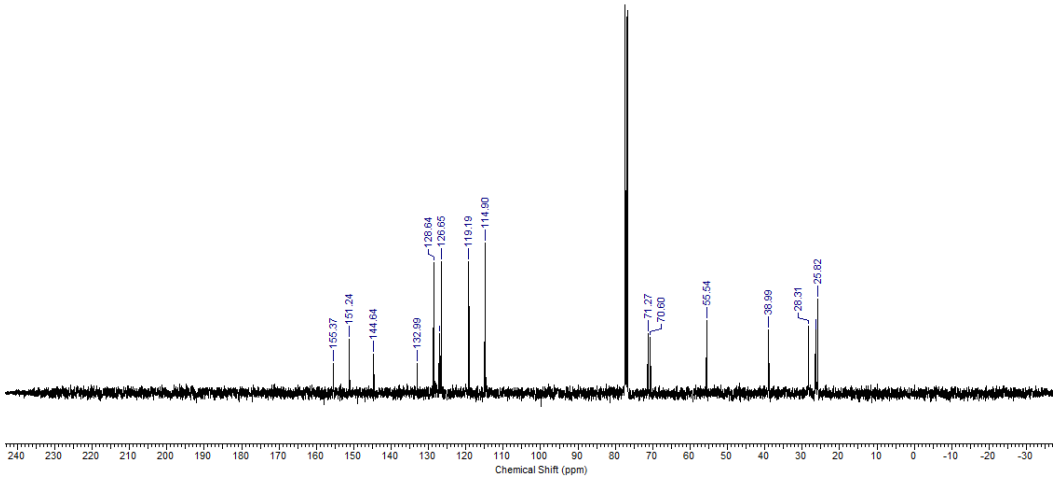
5-(2-Bromophenyl)-1-(4-methoxyphenyl)-4-phenyl-4,5-dihydro-1*H*-imidazole



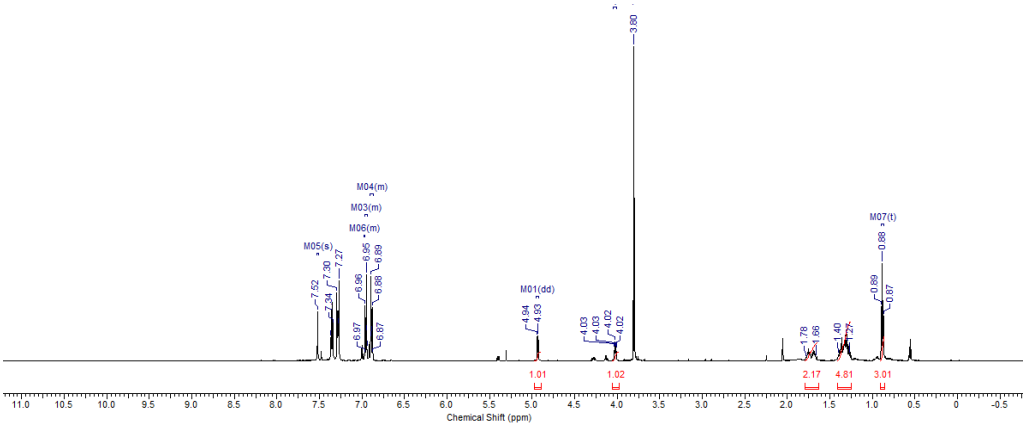


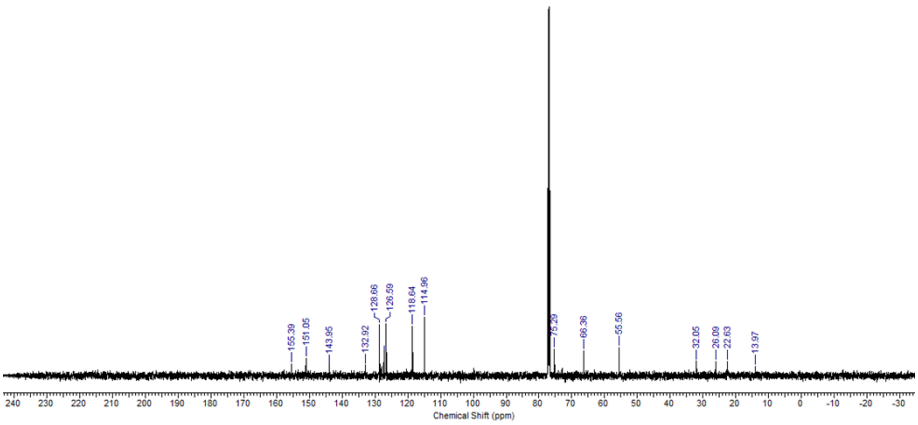
5-Cyclohexyl-1-(4-methoxyphenyl)-4-phenyl-4,5-dihydro-1*H*-imidazole





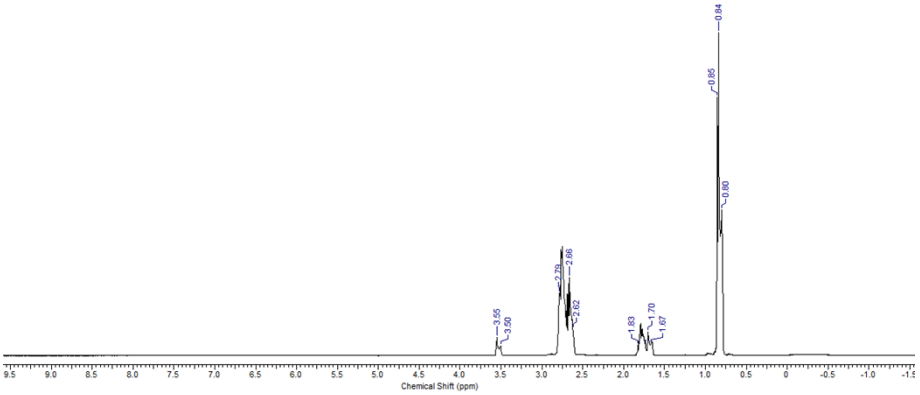
5-Butyl-1-(4-methoxyphenyl)-4-phenyl-4,5-dihydro-1*H*-imidazole



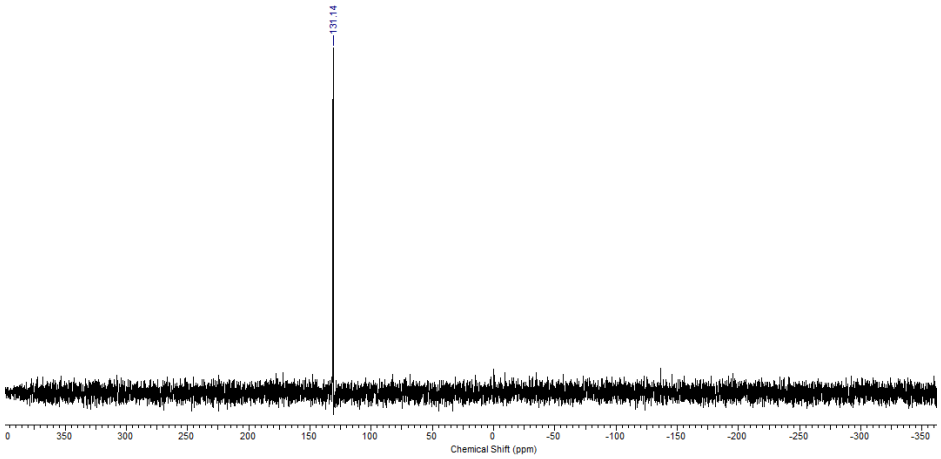


Mechanistic Study NMR Spectra

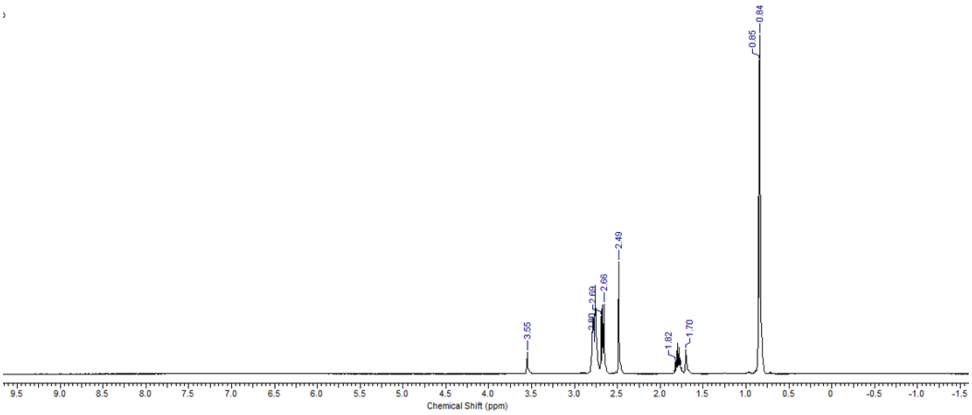
*i*Bu-PAP in THF-d_8: ^{1}H NMR Spectrum



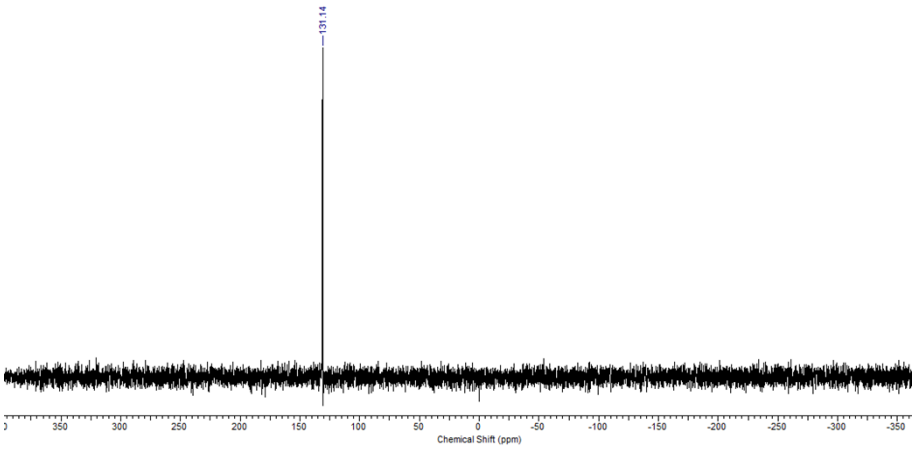
*i*Bu-PAP in THF-d_8: ^{31}P NMR Spectrum



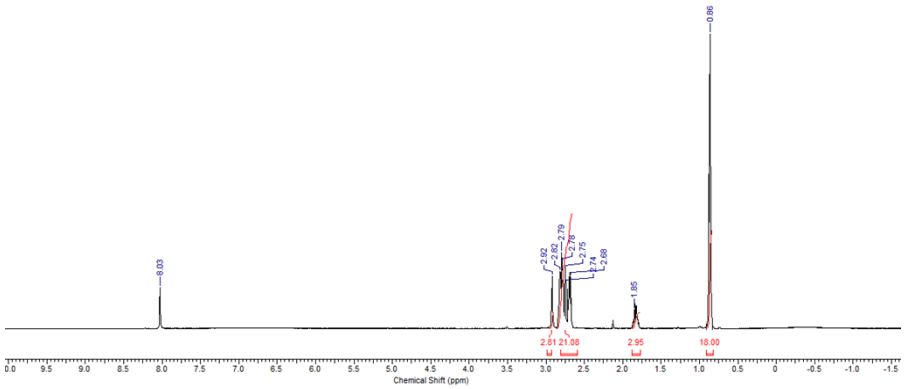
*i*Bu-PAP in THF-d_8 + 2 eq H_2O (2 h): ^{1}H NMR Spectrum



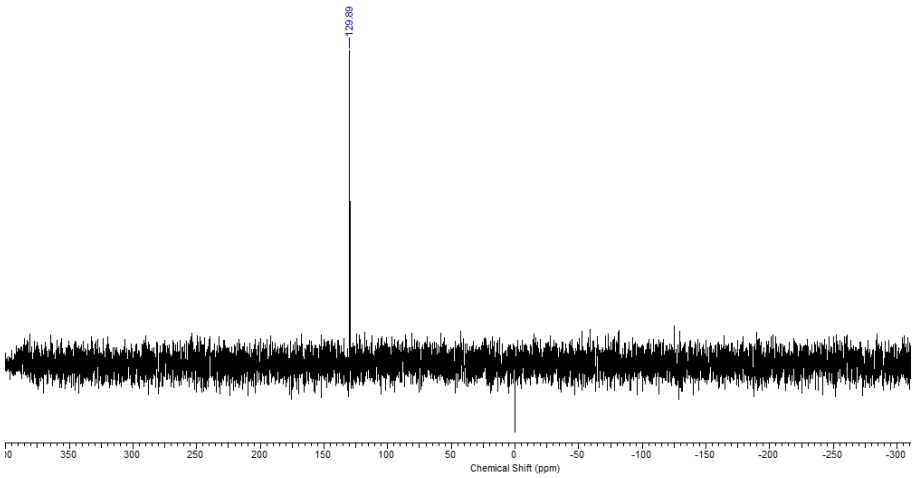
*i*Bu-PAP in THF-d_8 + 2 eq H_2O (2 h): ^{31}P NMR Spectrum



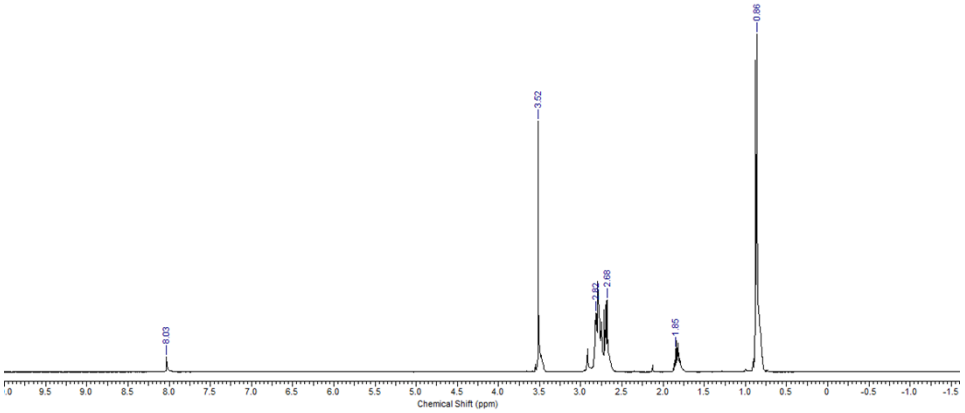
*i*Bu-PAP in DMF-d_7: ^{1}H NMR Spectrum



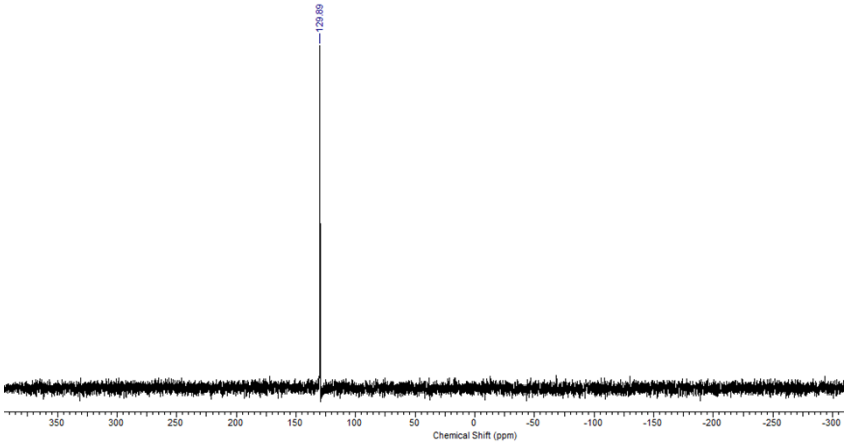
*i*Bu-PAP in DMF-d_7: ^{31}P NMR Spectrum



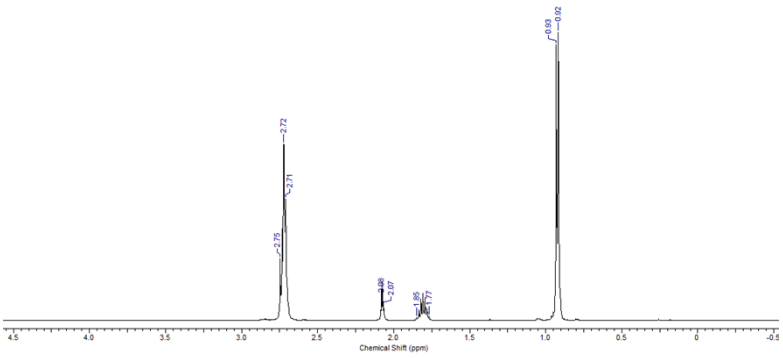
*i*Bu-PAP + H_2O (3 eq) (18 h) in DMF-d_7: ^{1}H NMR Spectrum



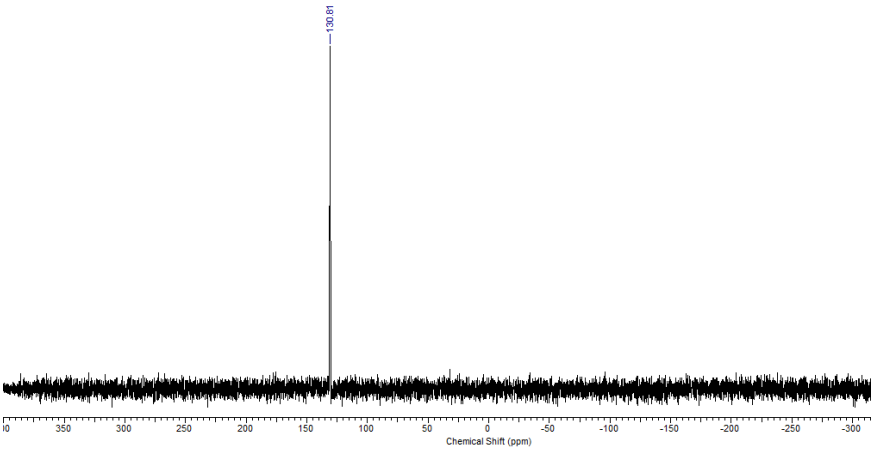
*i*Bu-PAP + H_2O (3 eq) (18 h) in DMF-d_7: ^{31}P NMR Spectrum



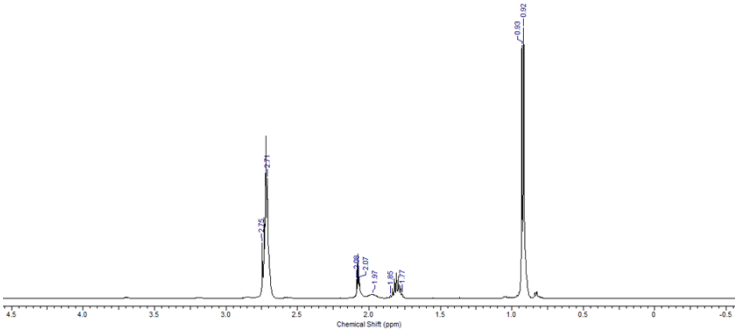
*i*Bu-PAP in toluene-d_8: ^{1}H NMR Spectrum



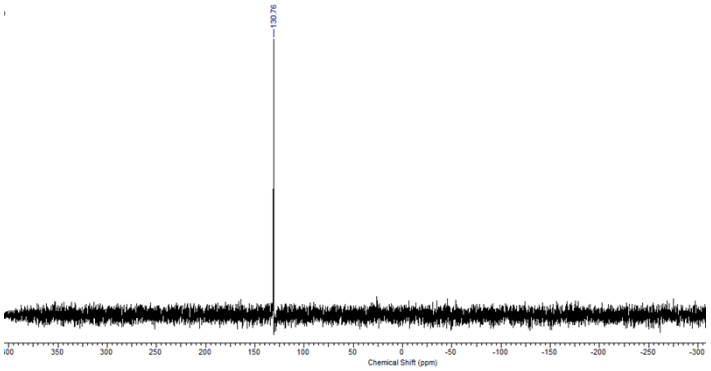
*i*Bu-PAP in toluene-d_8: ^{31}P NMR Spectrum



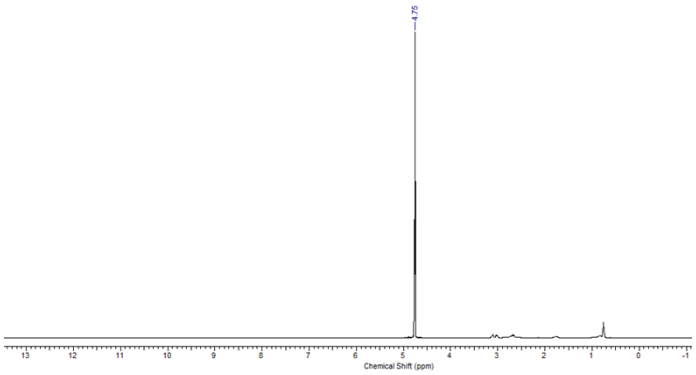
*i*Bu-PAP + H_2O (2 eq) in toluene-d_8 (2 h): ^{1}H NMR Spectrum



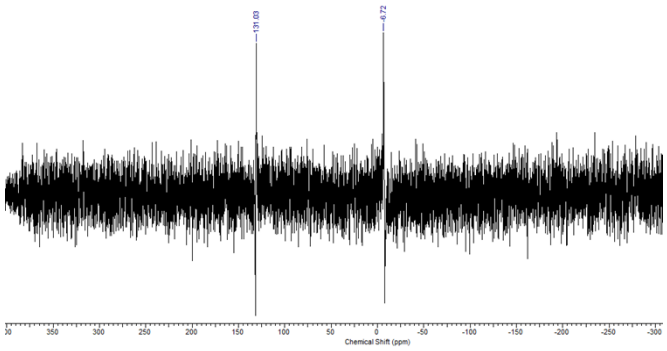
*i*Bu-PAP + H_2O (2 eq) in toluene-d_8 (2 h): ^{31}P NMR Spectrum



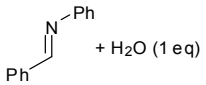
*i*Bu-PAP in D_2O: ^1H NMR Spectrum

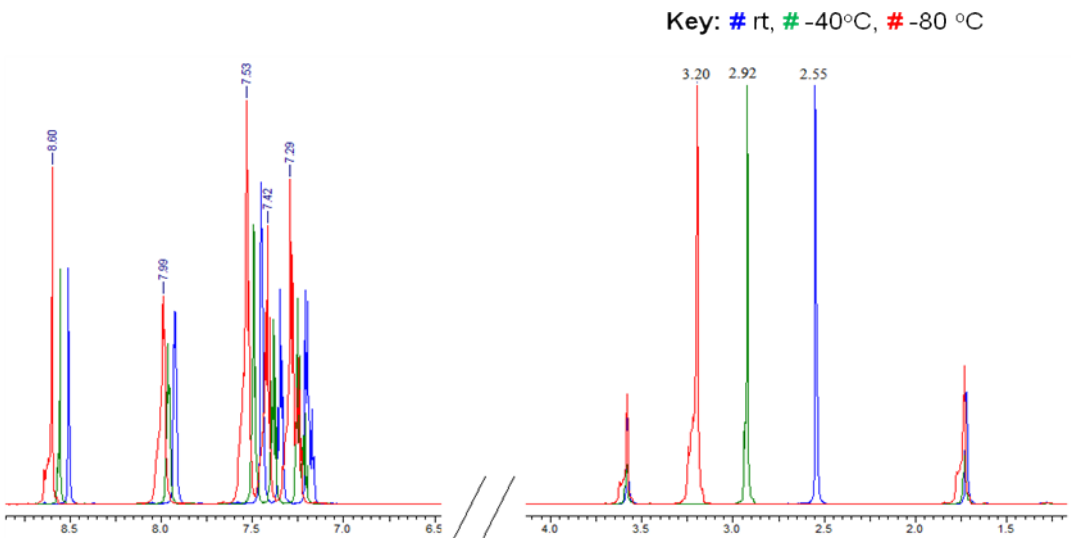


*i*Bu-PAP in D_2O: ^{31}P NMR Spectrum



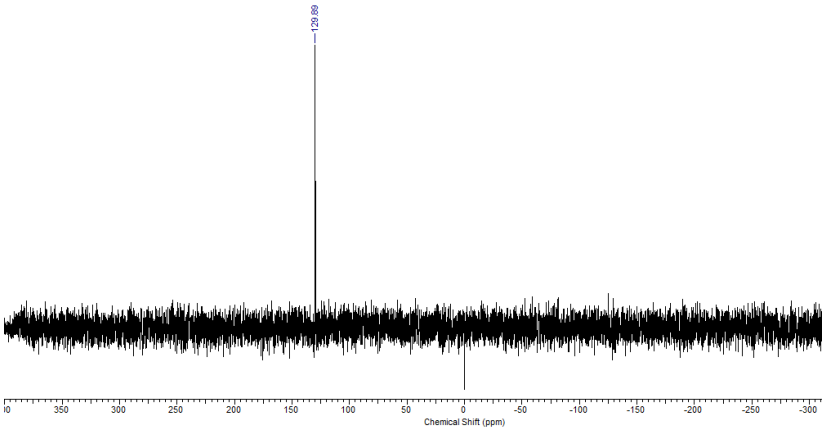
Water (1 eq) in THF-d_8 + imine



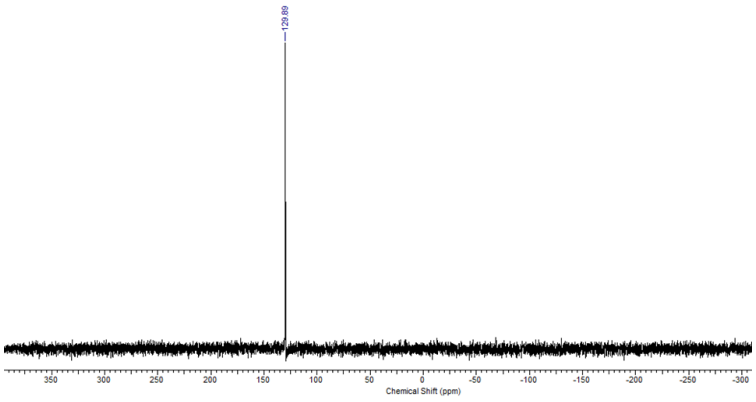


The above figure shows the ^{1}H NMR spectra of water and imine in THF-d_8 at room temperature at varying temperatures. It can be seen that at lower temperatures the chemical shift for water dramatically changes, possibly due to increased hydrogen bonding interaction. However, an almost identical trend in chemical shift in the absence of the imine, and so could be due to increased complexation of water by THF-d_8.

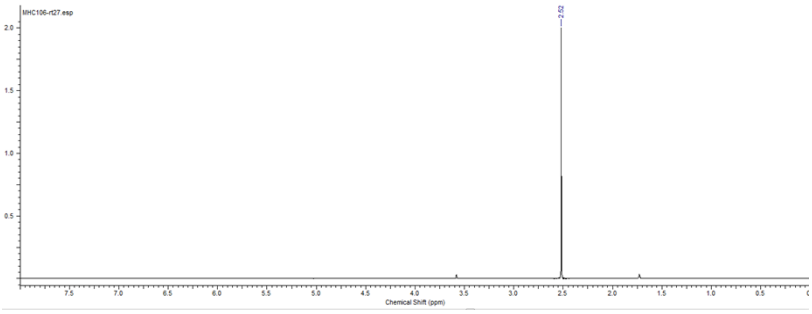
*i*Bu-PAP in DMF-d_7: ^{31}P NMR Spectrum



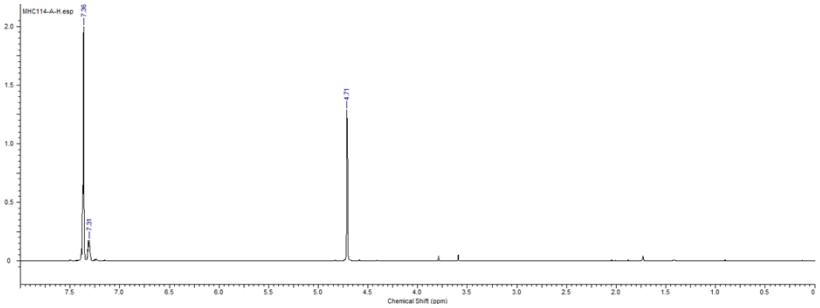
*i*Bu-PAP + H_2O (3 eq) (18 h) in DMF-d_7: ^{31}P NMR Spectrum

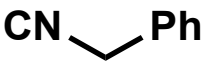


Interactions of benzyl isocyanide and water in THF-d_8

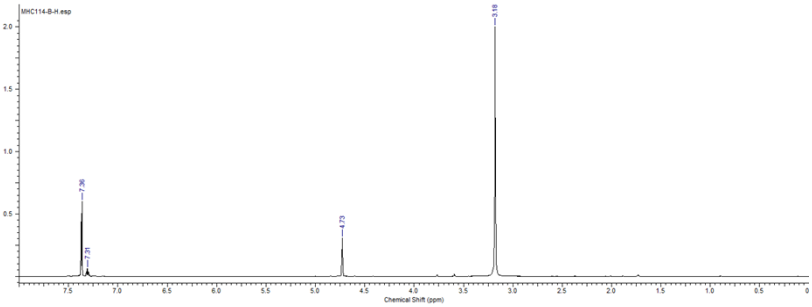


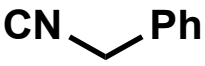
H_2O (2.52 ppm)





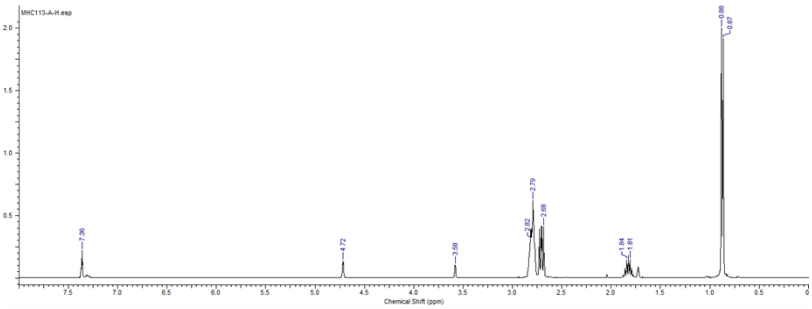
CH_2 (4.71 ppm)

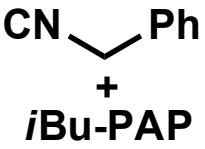




CH_2 (4.73 ppm)

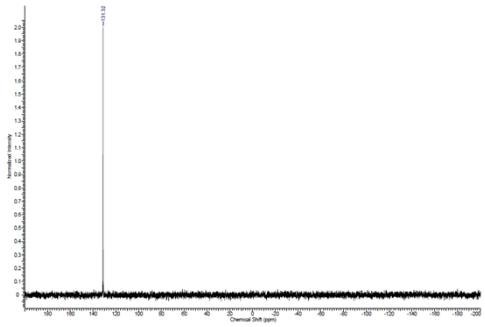
+ H_2O (3.18 ppm)



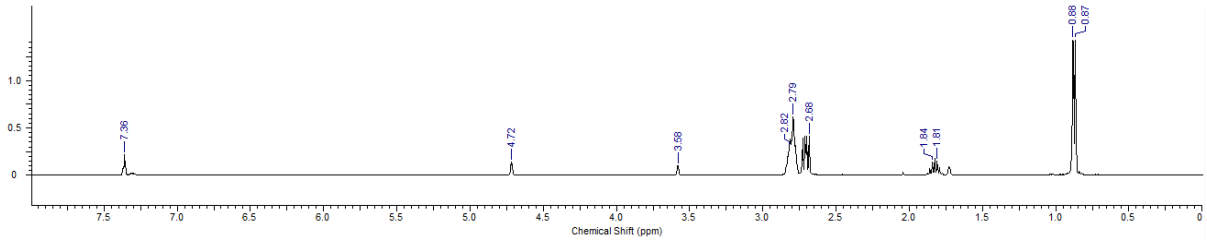


CH_2 (4.72 ppm)

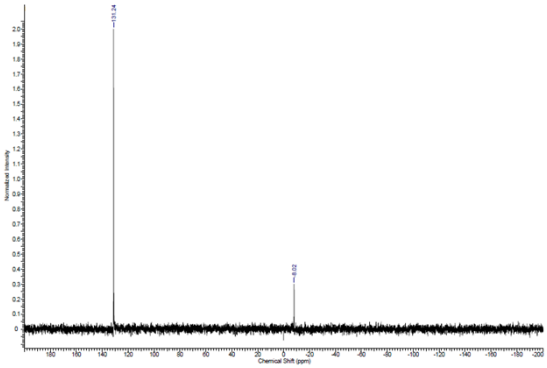
*i*Bu-PAP + benzyl isocyanide (^{31}P NMR)



*i*Bu-PAP + benzyl isocyanide (^{1}H NMR)



*i*Bu-PAP + benzyl isocyanide + H_2O (6 eq) (^{31}P NMR)



*i*Bu-PAP + benzyl isocyanide + H_2O (6 eq) (^{1}H NMR)