Chiral *N,N′*-Dioxide/$Mg(OTf)_2$ Complex-Catalyzed Asymmetric [2,3]-Rearrangement of *in situ* Generated Ammonium Salts

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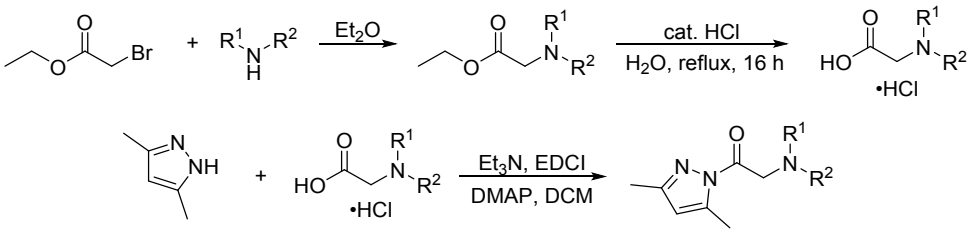
(A) General Information

CH_2Cl_2, EtOAc, MeCN were freshly distilled from CaH_2 prior to use, THF, toluene, $C_2H_5OC_2H_5$ were freshly distilled from sodium metal prior to use, MeOH was freshly distilled from magnesium metal/I_2 prior to use. ^1H NMR spectra were recorded at 400 M Hz. The chemical shifts were recorded in ppm relative to tetramethylsilane and with the solvent resonance as the internal standard. Data were reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, m = multiplet, q = quartet), coupling constants (Hz), integration. $^{13}C\{^1H\}$ NMR data were collected at 100 MHz with complete proton decoupling. $^{19}F\{^1H\}$ NMR was measured at 376 M Hz. Metal salts obtained from commercial sources were used without further purification. Enantiomeric excesses were determined by chiral HPLC analysis on Daicel Chiralcel IA/IE/IF/IG/IH/OJH/Lux 5u Cellulose-2 in comparison with the authentic racemates. Optical rotations were reported as follows: $[\alpha]^T_D$ = (*c* = g/100 mL, in solvent, unless otherwise noted, λ = 589 nm). HRMS was recorded on a commercial apparatus (FTMS+c ESI/APCI). The chiral *N,N'*-dioxide ligands were synthesized by the same procedure in the literature.[1]

(B) Experimental Procedures

1 General procedure for the synthesis of amino amide according to the literature procedure.[2]



1.1 Synthesis of amino esters from ethyl bromoacetates:

Ethyl bromoacetate (1.0 equiv) was dissolved in dry Et_2O (0.5 M), the corresponding amine (2.5 equiv) was added and the reaction mixture was stirred at rt for 30 min. The insoluble precipitate was removed by filtration and the filtrate was concentrated in vacuo. If no precipitate was observed, the reaction was quenched with aq. NaOH (1 M, equal volume). The phases were separated and the aqueous phase was extracted with Et_2O (2×equal volume). The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$, filtered and concentrated in vacuo. The crude residue was used in next step without further purification or purified by flash column chromatography over silica gel or distillation as indicated.

1.2 Hydrolysis of amino esters:

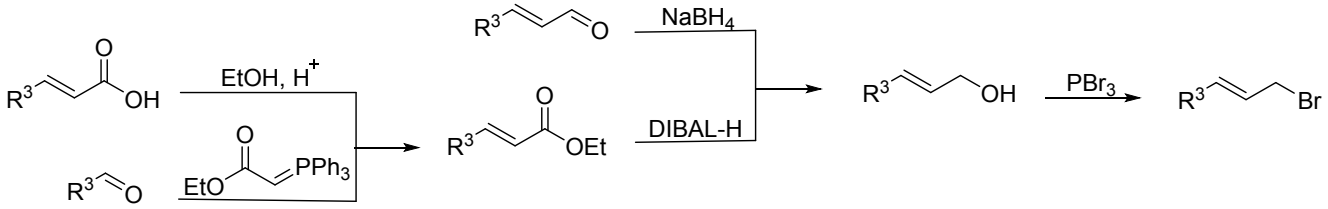
A solution of amino ester (1.0 equiv) in water (10 mL/g amino ester) was treated with conc. aq. HCl (ca. 1 mL/g amino ester) and the reaction mixture was heated to reflux for 16 h. The solution was cooled to rt, washed with Et_2O (3×equal volume) and concentrated in vacuo to afford pure amino acid which was used in next step without further purification.

Note: residual water was removed by forming azeotrope with toluene.

1.3 Synthesis of amino amides from amino acids:

A solution of amino acid or the corresponding hydrochloride (1.1 equiv) in anhydrous CH_2Cl_2 (0.5 M) was cooled to 0 °C. Et_3N (1.1 equiv) was added and the resulting solution was stirred for 10 min at 0 °C. The 3,5-dimethyl-1*H*-pyrazole (1.0 equiv), EDCI (1.1 equiv) and a small amount of DMAP were successively added, the reaction mixture was warmed to rt and stirred for 24 h. To the mixture was added brine (equal volume) and the aqueous layer was separated and extracted with CH_2Cl_2 (3×equal volume). The combined organic extracts were dried over anhydrous Na_2SO_4, filtered and concentrated. The residue was subjected to column chromatography (silica gel impregnated in the PET of 3‰ Et_3N) to give the product. The residue eluted with PET/EtOAc (v/v, 4:1) (exception, **1a**: PET/Ace, v/v, 10:1; **1c**: EtOAc).

2 General procedure for the synthesis of allylic bromides according to the literature procedure.[3]



2.1 Synthesis of α,β-unsaturated esters from aldehydes:

To a stirred solution of the aldehyde (1.0 equiv) in CH_2Cl_2 (10 mL/g aldehyde) was added ethyl (triphenylphosphoranylidene) acetate (1.05 equiv). The reaction was stirred overnight at rt. The solvent was removed in vacuo and the crude residue purified by flash chromatography on silica gel to give the pure α,β-unsaturated esters.

2.2 Synthesis of α,β-unsaturated esters from acids:

To a stirred solution of the α,β-unsaturated acid (1.0 equiv) in ethanol (10 mL/g acid) was added conc. H_2SO_4 (0.1 mL/g acid). The reaction was heated to reflux for 3 h, allowed to cool, and concentrated in vacuo. The residue was neutralised with sat aq. $NaHCO_3$, extracted with EtOAc (3×equal volume) and the combined organics were washed with brine (equal volume). The organic layer was dried over anhydrous Na_2SO_4, filtered, and concentrated in vacuo to give the pure α,β-unsaturated esters.

2.3 Synthesis of allylic alcohols from α,β-unsaturated esters:

To a stirred solution of the α,β-unsaturated ester (1.0 equiv) in anhydrous CH_2Cl_2 (0.2 M) at −78 °C under N_2 was added DIBAL-H (1.0–1.5 M in toluene or hexane, 2.2 equiv) dropwise. The reaction was stirred for 1.5 h at −78 °C, and quenched with 10% aq. NaOH (equal volume). The resultant mixture was allowed to warm to rt and stirred for 1 h. The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (2×equal volume). The combined organics were washed with brine (equal volume), dried over anhydrous Na_2SO_4, filtered, and concentrated in vacuo. The crude product was purified by column chromatography (PET/EtOAc = 4:1) to give the product.

2.4 Synthesis of allylic alcohols from aryl cinnamaldehydes:

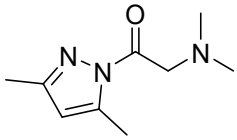
A solution of aryl cinnamaldehyde (1.0 equiv) in methanol (0.5 M) was cooled to 0 °C. $NaBH_4$ (1.1 eq) was added and the reaction mixture was allowed to warm to rt and stirred for 1 h. The reaction was quenched by sat aq. NH_4Cl, extracted with EtOAc (3×equal volume) and the combined organics were washed with brine (equal volume). The organic layer was dried over anhydrous Na_2SO_4, filtered and concentrated. The crude product was purified by column chromatography (PET/EtOAc = 4:1) to give the product.

2.5 Synthesis of allylic bromides from allylic alcohols:

To a stirred solution of allylic alcohol (1.0 equiv) in diethylether (0.5 M) at 0 °C was added phosphorus tribromide (1.0 equiv). The reaction mixture was warmed to room temperature and stirred for 24 h. After a saturated solution of ammoniumchloride had been added, the organic layer was separated and the aqueous layer was extraced with diethylether (3×equal volume). The combined organics were successively washed with sat aq. $Na_2S_2O_3$ (equal volume) and brine (equal volume). The combined organic layers were dried with anhydrous Na_2SO_4, filtered and concentrated in vacuo to afford pure amino acid that was used without further purification.

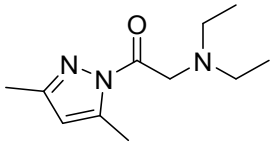
(C) Characterization of Typical Substrates

1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)ethan-1-one (1a)



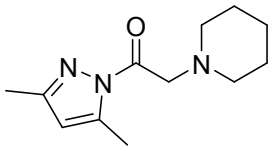
Colorless liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 5.96 (s, 1H), 3.97 (s, 2H), 2.56 (s, 3H), 2.45 (s, 6H), 2.23 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.4, 152.1, 144.2, 110.8, 61.1, 45.6, 14.3, 13.7 ppm. **IR** (neat): ν (cm^{-1}) 2931, 2772, 1737, 1583, 1445, 1385, 1321, 1248, 1174, 1043, 958, 862, 802, 748. **HRMS** (ESI-FT) calcd for $C_8H_{16}N_3O^+$ ([M]+H$^+$) = 182.1288, found 182.1288.

2-(Diethylamino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1b)



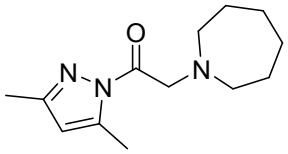
Colorless liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 5.95 (s, 1H), 4.11 (s, 2H), 2.79 – 2.71 (m, 4H), 2.55 (d, *J* = 0.8 Hz, 3H), 2.23 (s, 3H), 1.10 (t, *J* = 3.2 Hz, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.5, 152.0, 144.2, 110.7, 55.1, 47.8, 14.4, 13.8, 12.3 ppm. **IR** (neat): ν (cm^{-1}) 2969, 2931, 2361, 1734, 1582, 1452, 1381, 1316, 1246, 1169, 954, 801, 742. **HRMS** (ESI-FT) calcd for $C_{11}H_{20}N_3O^+$ ([M]+H$^+$) = 210.1601, found 210.1598.

1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(piperidin-1-yl)ethan-1-one (1c)



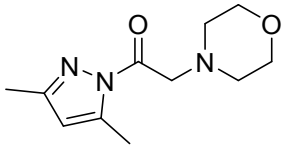
White solid. **MP**: 63 – 66 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 5.95 (s, 1H), 3.97 (s, 2H), 2.60 (t, *J* = 1.6 Hz, 4H), 2.55 (d, *J* = 0.8 Hz, 3H), 2.23 (s, 3H), 1.71 – 1.63 (m, 4H), 1.51 – 1.42 (m, 2H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.5, 152.1, 144.4, 110.8, 60.9, 54.9, 25.9, 24.1, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2930, 2852, 1736, 1582, 1445, 1403, 1319, 1242, 1171, 1114, 1037, 954, 862, 802, 744, 592, 548, 459. **HRMS** (ESI-FT) calcd for $C_{12}H_{20}N_3O^+$ ([M]+H$^+$) = 222.1601, found 222.1600.

2-(Azepan-1-yl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1d)



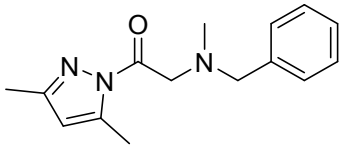
Colorless liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 5.94 (s, 1H), 4.19 (s, 2H), 2.86 (t, *J* = 6.0 Hz, 4H), 2.55 (d, *J* = 0.8 Hz, 3H), 2.22 (s, 3H), 1.71 – 1.56 (m, 8H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.5, 152.1, 144.4, 110.8, 60.9, 54.9, 25.9, 24.1, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2924, 2852, 2362, 1734, 1582, 1448, 1407, 1143, 957, 801, 748. **HRMS** (ESI-FT) calcd for $C_{12}H_{20}N_3O^+$ ([M]+H$^+$) = 236.1757, found 236.1763.

1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-morpholinoethan-1-one (1e)



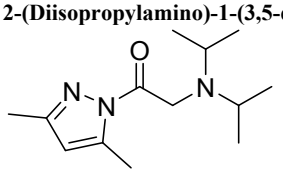
White solid. **MP**: 50 – 53 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 5.97 (s, 1H), 4.01 (s, 2H), 3.79 (t, *J* = 4.8 Hz, 4H), 2.67 (t, *J* = 4.8 Hz, 4H), 2.55 (d, *J* = 0.8 Hz, 3H), 2.23 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 169.7, 152.2, 144.2, 110.9, 66.7, 60.3, 53.7, 14.2, 13.6 ppm. **IR** (neat): ν (cm^{-1}) 2853, 1735, 1582, 1450, 1407, 1318, 1244, 1170, 1115, 1070, 1035, 957, 917, 864, 805, 745, 552, 466. **HRMS** (ESI-FT) calcd for $C_{11}H_{18}N_3O_2^+$ ([M]+H$^+$) = 224.1394, found 224.1388.

2-(Benzyl(methyl)amino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1f)



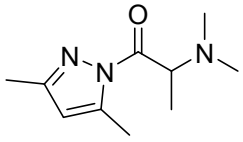
Colorless liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.42 – 7.37 (m, 2H), 7.34 – 7.28 (m, 2H), 7.28 – 7.20 (m, 1H), 5.93 (s, 1H), 4.09 (s, 2H), 3.76 (s, 2H), 2.55 (d, *J* = 0.8 Hz, 3H), 2.46 (s, 3H), 2.20 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.9, 152.1, 144.2, 138.8, 129.1, 128.3, 127.1, 110.9, 61.4, 58.7, 42.5, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2925, 1734, 1582, 1450, 1382, 1318, 1245, 1177, 1139, 1054, 955, 871, 803, 741, 698, 461. **HRMS** (ESI-FT) calcd for $C_{15}H_{20}N_3O^+$ ([M]+H$^+$) = 258.1061, found 258.1062.

2-(Diisopropylamino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1g)



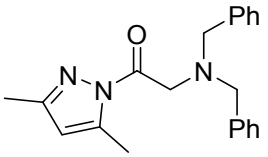
Pale yellow liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 5.95 (s, 1H), 4.06 (s, 2H), 3.19 – 3.11 (m, 2H), 2.54 (s, 3H), 2.25 (s, 3H), 1.06 (d, *J* = 6.8 Hz, 12H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 173.8, 151.7, 144.3, 110.6, 110.6, 49.88, 48.8, 20.8, 14.5, 14.4, 13.8, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2965, 1741, 1581, 1460, 1376, 1315, 1243, 1176, 1034, 957, 802, 578. **HRMS** (ESI-FT) calcd for $C_{13}H_{24}N_3O^+$ ([M]+H$^+$) = 238.1914, found 238.1904.

1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)propan-1-one (1h)



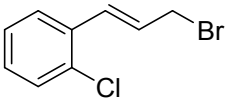
Colorless liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 5.94 (s, 1H), 4.75 – 4.67 (m, 1H), 2.54 – 2.50 (m, 3H), 2.43 – 2.37 (m, 6H), 2.30 – 2.19 (m, 3H), 1.37 – 1.31 (m, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 174.1, 151.9, 144.2, 111.4, 59.6, 41.6, 41.6, 14.6, 14.6, 14.3, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2977, 1647, 1458, 1375, 1270, 1218, 1145, 1093, 1065, 990, 792, 632. **HRMS** (ESI-FT) calcd for $C_{10}H_{18}N_3O^+$ ([M]+H$^+$) = 196.1444, found 196.1436.

2-(Dibenzylamino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1i)



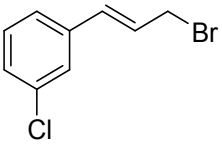
White solid. **MP**: 51 – 54 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.46 – 7.40 (m, 4H), 7.32 – 7.25 (m, 4H), 7.23 – 7.17 (m, 2H), 5.87 (s, 1H), 4.14 (s, 2H), 3.90 (s, 4H), 2.54 (d, J = 0.4 Hz, 3H), 2.13 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.5, 152.0, 144.1, 139.5, 128.8, 128.4, 127.1, 110.9, 110.8, 57.8, 54.9, 14.5, 14.5, 13.8, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2925, 1729, 1582, 1449, 1379, 1316, 1244, 1140, 1074, 1028, 952, 805, 739, 697, 477. **HRMS** (ESI-FT) calcd for $C_{21}H_{24}N_3O^+$ ([M]+H$^+$) = 334.1914, found 334.1912.

(*E*)-1-(3-Bromoprop-1-en-1-yl)-2-chlorobenzene (2b)



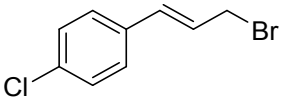
Pale yellow liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.56 – 7.50 (m, 1H), 7.38 – 7.33 (m, 1H), 7.26 – 7.16 (m, 2H), 7.04 (d, J = 15.6 Hz, 1H), 6.43 – 6.33 (m, 1H), 4.20 – 4.15 (m, 2H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 133.9, 133.4, 130.4, 129.8, 129.3, 127.9, 127.1, 127.0, 32.9 ppm. **IR** (neat): ν (cm^{-1}) 3048, 1469, 1434, 1272, 1201, 1123, 1038, 961, 749, 696, 522, 580, 517, 451. **HRMS** (APCI-FT) calcd for $C_9H_8{}^{34.9659}Cl^+$ ([M]-Br$^-$) = 151.0309, found 151.0309, $C_9H_8{}^{36.9659}Cl^+$ ([M]-Br$^-$) = 153.0280, found 153.0279.

(*E*)-1-(3-Bromoprop-1-en-1-yl)-3-chlorobenzene (2c)



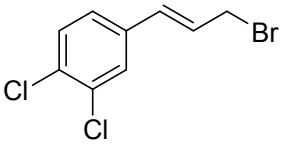
Pale yellow liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.38 – 7.34 (m, 1H), 7.27 – 7.20 (m, 3H), 6.56 (d, J = 15.6 Hz, 1H), 6.44 – 6.34 (m, 1H), 4.15 – 4.10 (m, 2H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 137.7, 134.6, 133.1, 129.9, 128.3, 126.7, 126.7, 125.0, 32.8 ppm. **IR** (neat): ν (cm^{-1}) 2924, 1592, 1556, 1474, 1421, 1201, 1137, 1083, 960, 917, 882, 856, 776, 685, 627, 587, 533, 440. **HRMS** (APCI-FT) calcd for $C_9H_8{}^{34.9659}Cl^+$ ([M]-Br$^-$) = 151.0309, found 151.0313, $C_9H_8{}^{36.9659}Cl^+$ ([M]-Br$^-$) = 153.0280, found 153.0283.

(*E*)-1-(3-Bromoprop-1-en-1-yl)-4-chlorobenzene (2d)



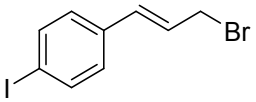
White solid. **MP**: 61 – 64 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.34 – 7.28 (m, 4H), 6.69 (d, J = 15.6 Hz, 1H), 6.42 – 6.32 (m, 1H), 4.17 – 4.12 (m, 2H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 134.3, 134.1, 133.3, 128.9, 128.0, 125.9, 33.1 ppm. **IR** (neat): ν (cm^{-1}) 3038, 2361, 1644, 1590, 1488, 1434, 1403, 1300, 1265, 1205, 1140, 1093, 1058, 1010, 971, 817, 739, 684, 579, 513, 484. **HRMS** (APCI-FT) calcd for $C_9H_8{}^{34.9659}Cl^+$ ([M]-Br$^-$) = 151.0309, found 151.0313, $C_9H_8{}^{36.9659}Cl^+$ ([M]-Br$^-$) = 153.0280, found 153.0283.

(*E*)-4-(3-Bromoprop-1-en-1-yl)-1,2-dichlorobenzene (2e)



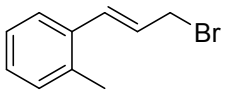
Colorless liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.80 (d, J = 2.0 Hz, 1H), 7.33 (d, J = 8.0 Hz, 1H), 7.15 – 7.10 (m, 1H), 6.47 (d, J = 15.6 Hz, 1H), 6.38 – 6.28 (m, 1H), 4.12 – 4.07 (m, 2H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 135.9, 132.8, 132.0, 132.0, 130.6, 128.4, 127.2, 125.9, 32.6 ppm. **IR** (neat): ν (cm^{-1}) 3049, 1551, 1469, 1389, 1303, 1262, 1201, 1132, 1062, 1028, 959, 923, 884, 804, 702, 671, 600, 557, 438. **HRMS** (APCI-FT) calcd for $C_9H_7{}^{34.9659}Cl_2^+$ ([M]-Br$^-$) = 184.9919, found 184.9927, $C_9H_7{}^{34.9659}Cl^{36.9659}Cl^+$ ([M]-Br$^-$) = 186.9890, found 186.9898, $C_9H_7{}^{36.9659}Cl_2^+$ ([M]-Br$^-$) = 188.9860, found 188.9871.

(*E*)-1-(3-Bromoprop-1-en-1-yl)-4-iodobenzene (2h)



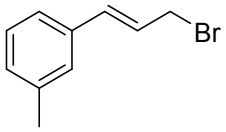
White solid. **MP**: 100 – 103 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.68 – 7.62 (m, 2H), 7.14 – 7.08 (m, 2H), 6.56 (d, J = 15.6 Hz, 1H), 6.45 –6.34 (m, 1H), 4.16 – 4.10 (m, 2H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 137.8, 135.3, 133.4, 128.5, 126.1, 93.9, 33.0 ppm. **IR** (neat): ν (cm^{-1}) 2362, 1643, 1579, 1482, 1433, 1396, 1259, 1203, 1057, 1004, 972, 811, 754, 650, 573, 497. **HRMS** (APCI-FT) calcd for $C_9H_8I^+$ ([M]-Br$^-$) = 242.9665, found 242.9668.

(*E*)-1-(3-Bromoprop-1-en-1-yl)-2-methylbenzene (2j)



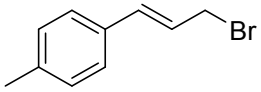
Colorless liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.46 – 7.40 (m, 1H), 7.19 – 7.11 (m, 3H), 6.85 (d, *J* = 15.6 Hz, 1H), 6.33 – 6.22 (m, 1H), 4.19 – 4.14 (m, 2H), 2.34 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 135.8, 134.9, 132.3, 130.5, 128.3, 126.5, 126.2, 125.9, 33.7, 19.8 ppm. **IR** (neat): ν (cm^{-1}) 2952, 1484, 1200, 1139, 962, 748, 582, 510, 447. **HRMS** (ESI-FT) calcd for $C_{10}H_{12}{}^{78.9183}Br^+$ ([M]+H$^+$) = 211.0117, found 211.0118, $C_{10}H_{12}{}^{80.9163}Br^+$ ([M]+H$^+$) = 213.0096, found 213.0098.

(*E*)-1-(3-Bromoprop-1-en-1-yl)-3-methylbenzene (2k)



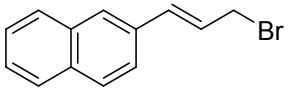
Colorless liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.23 – 7.13 (m, 3H), 7.09 – 7.03 (m, 1H), 6.57 (d, *J* = 15.6 Hz, 1H), 6.40 – 6.30 (m, 1H), 4.15 – 4.09 (m, 2H), 2.32 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 138.3, 135.8, 134.7, 129.2, 128.6, 127.5, 125.1, 124.0, 33.7, 21.5 ppm. **IR** (neat): ν (cm^{-1}) 3030, 1644, 1603, 1485, 1433, 1200, 1136, 962, 776, 692, 631, 584, 527, 440. **HRMS** (ESI-FT) calcd for $C_{10}H_{12}{}^{78.9183}Br^+$ ([M]+H$^+$) = 211.0117, found 211.0123, $C_{10}H_{12}{}^{80.9163}Br^+$ ([M]+H$^+$) = 213.0096, found 213.0101.

(*E*)-1-(3-Bromoprop-1-en-1-yl)-4-methylbenzene (2l)



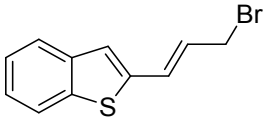
Pale yellow solid. **MP**: 60 – 62 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.27 (d, *J* = 7.6 Hz, 2H), 7.12 (d, *J* = 8.0 Hz, 2H), 6.60 (d, *J* = 15.6 Hz, 1H), 6.39 – 6.28 (m, 1H), 4.15 (d, *J* = 8.0 Hz, 2H), 2.34 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 138.4, 1346, 133.1, 129.4, 126.7, 124.2, 33.9, 21.3 ppm. **IR** (neat): ν (cm^{-1}) 2912, 2361, 1642, 1608, 1510, 1429, 1199, 1142, 1062, 971, 803, 749, 582, 497. **HRMS** (ESI-FT) calcd for $C_{10}H_{12}{}^{78.9183}Br^+$ ([M]+H$^+$) = 211.0117, found 211.0113, $C_{10}H_{12}{}^{80.9163}Br^+$ ([M]+H$^+$) = 213.0096, found 213.0096.

(*E*)-2-(3-Bromoprop-1-en-1-yl)naphthalene (2m)



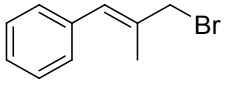
White solid. **MP**: 103 – 108 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.81 – 7.72 (m, 3H), 7.69 (s, 1H), 7.57 – 7.51 (m, 1H), 7.48 – 7.40 (m, 2H), 6.74 (d, *J* = 15.6 Hz, 1H), 6.63 – 6.42 (m, 1H), 4.20 – 4.15 (m, 2H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 134.7, 133.5, 133.4, 133.3, 128.4, 128.2, 127.8, 127.2, 126.5, 126.4, 125.6, 123.5, 33.7 ppm. **IR** (neat): ν (cm^{-1}) 3052, 2362, 1637, 1507, 1435, 1363, 1204, 969, 902, 861, 818, 743, 583, 513, 479. **HRMS** (ESI-FT) calcd for $C_{13}H_{12}{}^{78.9183}Br^+$ ([M]+H$^+$) = 247.0117, found 247.0119, $C_{13}H_{12}{}^{80.9163}Br^+$ ([M]+H$^+$) = 249.0096, found 249.0098.

(*E*)-2-(3-Bromoprop-1-en-1-yl)benzo[*b*]thiophene (2n)



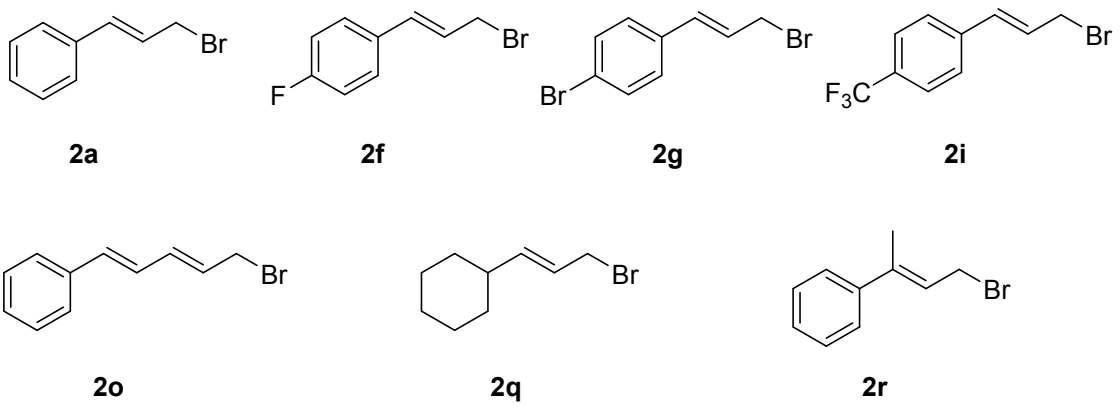
Pale yellow solid. **MP**: 93 – 99 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.79 – 7.64 (m, 2H), 7.34 – 7.26 (m, 2H), 7.17 (s, 1H), 6.88 – 6.81 (m, 1H), 6.33 – 6.23 (m, 1H), 4.16 – 4.11 (m, 2H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 140.8, 139.8, 139.3, 128.3, 127.2, 125.2, 124.6, 124.3, 123.8, 122.3, 32.7 ppm. **IR** (neat): ν (cm^{-1}) 3054, 2361, 1632, 1432, 1309, 1274, 1199, 1130, 1067, 951, 864, 839, 811, 745, 677, 590, 554, 505, 441. **HRMS** (ESI-FT) calcd for $C_{11}H_{10}{}^{78.9183}BrS^+$ ([M]+H$^+$) = 252.9681, found 252.9688, $C_{11}H_{10}{}^{80.9163}BrS^+$ ([M]+H$^+$) = 254.9661, found 254.9657.

(*E*)-(3-Bromo-2-methylprop-1-en-1-yl)benzene (2p)



Pale yellow liquid. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.36 – 7.29 (m, 2H), 7.29 – 7.19 (m, 3H), 6.62 (s, 1H), 6.11 (d, *J* = 0.8 Hz, 2H), 2.00 (d, *J* = 1.2 Hz, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 136.9, 134.5, 130.2, 129.0, 128.3, 127.2, 42.3, 16.6 ppm. **IR** (neat): ν (cm^{-1}) 2953, 1597, 1490, 1439, 1387, 1205, 1074, 1009, 920, 849, 744, 695, 606, 513, 476. **HRMS** (ESI-FT) calcd for $C_{10}H_{12}{}^{78.9183}Br^+$ ([M]+H$^+$) = 211.0117, found 211.0117, $C_{10}H_{12}{}^{80.9163}Br^+$ ([M]+H$^+$) = 213.0096, found 213.0088.

Substrates that have been reported[3]

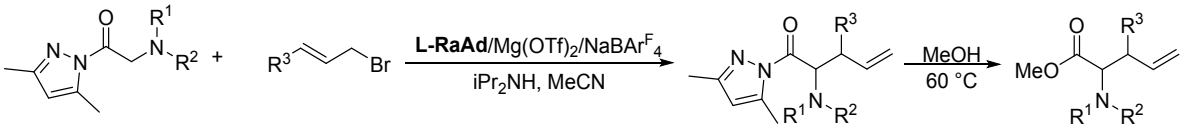


2a **2f** **2g** **2i**

2o **2q** **2r**

(D) Typical Experimental Procedure for Asymmetric [2,3]-Rearrangement of Allylic Ammonium Ylides

1 Typical procedure for the asymmetric [2,3]-rearrangement.

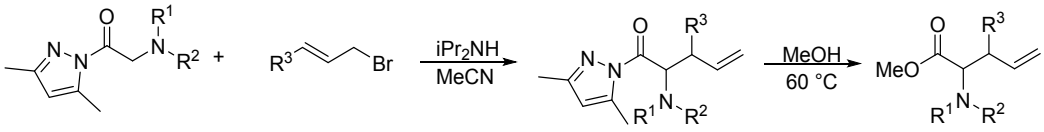


1 **2** **3** **4**

Procedure A: The reaction was conducted with $Mg(OTf)_2$ (0.02 mmol), **L-RaAd** (0.02 mmol) and $NaBAr^F{}_4$(0.04 mmol) in 0.8 mL of EtOAc. The mixture was stirred at 35 °C for 50 min under a N_2 atmosphere, and then concentrated in vacuo. The mixture was dissolved in 2.0 mL of MeCN. Allylic bromides **2** (0.20 mmol), amino amides **1** (0.20 mmol) and diisopropylamine (0.30 mmol) were added at −20 °C under a N_2 atmosphere, the resulting mixture was stirred at −20 °C. The reaction mixture was subjected to column chromatography on silica gel to afford the corresponding product **3**.

Procedure B: The reaction was conducted with $Mg(OTf)_2$ (0.02 mmol), **L-RaAd** (0.02 mmol) and $NaBAr^F{}_4$(0.04 mmol) in 0.8 mL of EtOAc. The mixture was stirred at 35 °C for 50 min under a N_2 atmosphere, and then concentrated in vacuo. The mixture was dissolved in 2.0 mL of MeCN. Allylic bromides **2** (0.20 mmol), amino amides **1** (0.20 mmol) and diisopropylamine (0.30 mmol) were added at −20 °C under an N_2 atmosphere, the resulting mixture was stirred at −20 °C. The reaction mixture was subjected to column chromatography on silica gel to afford the corresponding product **3**. The product **3** was dissolved in 1.0 mL of methanol. The reaction was stirred at 60 °C overnight. The reaction mixture was subjected to column chromatography on silica gel to afford the corresponding product **4**.

2 General procedure for the preparation of the racemic products.



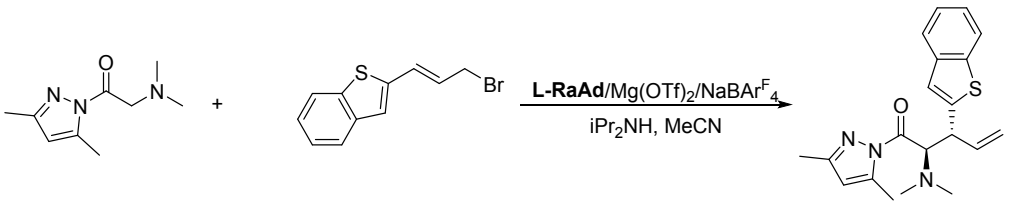
1 **2** **3** **4**

Procedure A: The reaction was conducted with amino amides **1** (0.10 mmol), allylic bromides **2** (0.10 mmol) and diisopropylamine (0.15 mmol) in 1.0 mL of MeCN. The mixture was stirred at 35 °C overnight. The reaction mixture was subjected to column chromatography on silica gel to afford the corresponding product **3**.

Procedure B: The reaction was conducted with amino amides **1** (0.10 mmol), allylic bromides **2** (0.10 mmol) and diisopropylamine (0.15 mmol) in 1.0 mL of MeCN. The mixture was stirred at 35 °C overnight. The reaction mixture was subjected to column chromatography on silica gel to afford the corresponding product **3**. The product **3** was dissolved in 1.0 mL of methanol. The reaction was stirred at 60 °C overnight. The reaction mixture was subjected to column chromatography on silica gel to afford the corresponding product **4**.

The racemic products **3a**, **3b** and **3p** were prepared with ***race*-L-PiPr$_2$**/$Mg(OTf)_2$ complex as catalyst. The purification processes were the same as those for the chiral products.

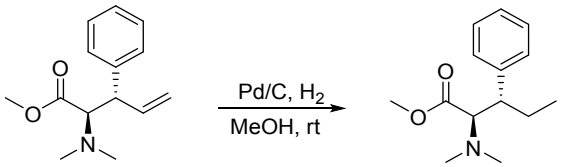
3 Procedure for the gram-scale of asymmetric [2,3]-rearrangement.



1a **2n** **3r**

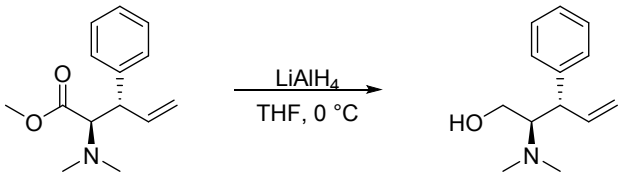
A 100 mL of dry round-bottom flask was charged with **L-RaAd** (10 mol%), $Mg(OTf)_2$ (10 mol%) and $NaBAr^F_4$ (20 mol%) under an N_2 atmosphere. Then EtOAc (12 mL) was added and the mixture was stirred at 35 °C for 5 h. The mixture was then concentrated in vacuo. The mixture was dissolved in 30 mL of MeCN. Allylic bromide **2n** (3.0 mmol), amino amide **1a** (3.0 mmol) and diisopropylamine (0.3 mmol) were added at –20 °C under a N_2 atmosphere, the resulting mixture was stirred at –20 °C for 3 days. The reaction mixture was subjected to column chromatography on silica gel to afford the corresponding major diastereomer **3r** (PET/EtOAc = 50/1 to PET/EtOAc = 30/1 as eluent) as pale yellow solid (0.9429 g, 89% yield, >19:1 *anti:syn*, 98:2 er). The *anti:syn* ratio was as determined by ^{1}H NMR analysis and the er value was determined by high-performance liquid chromatography (HPLC) with chiralcel Lux 5u Cellulose-2 column.

4 Experimental procedures for further transformations of product 4.



4a: >19:1 *anti:syn*, 97:3 er **5a**: 88% yield, >19:1 *anti:syn*, 96.5:3.5 er

A dry tube was charged with 10% Pd/C (9.0 mg), **4a** (0.17 mmol, 40.2 mg), then, MeOH (1.0 mL) was added. The mixture was stirred at room temperature for 48 h under an H_2 atmosphere. The reaction mixture was filtered with a pad of celite and the filtrate was concentrated in vacuo to afford the product (35.2 mg, 88% yield, >19:1 *anti:syn*, 96.5:3.5 er).

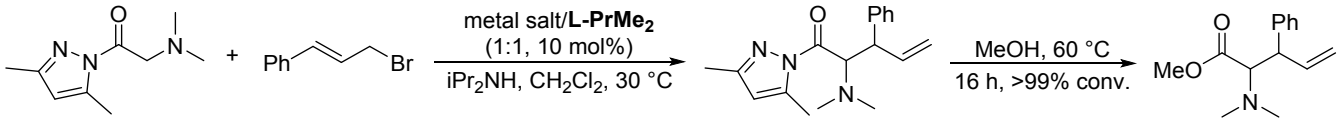


4a: >19:1 *anti:syn*, 97:3 er **6a**: 71% yield, >19:1 *anti:syn*, 97.5:2.5 er

To a solution of **4a** (29.3 mg, 0.13 mmol) in THF (1.0 mL) was added $LiAlH_4$ (14.3 mg, 0.39 mmol, 3.0 equiv.) at 0 ºC. After stirring for 60 minutes at 0 ºC, the reaction mixture was allowed to warm to room temperature for an additional 12 h. Then, the reaction mixture was diluted with Et_2O and cooled to 0 ºC. H_2O (15 µL), 15% NaOH (aq. 15 µL) and H_2O (45 µL) were added, the reaction mixture was allowed to warm to room temperature to stir for 15 minutes. The mixture was dried over Mg_2SO_4, filtered and evaporated in vacuo, and was subjected to column chromatography on silica gel (eluted with ethyl acetate) to give the product (18.3 mg, 71% yield, >19:1 *anti:syn*, 97.5:2.5 er).

(E) Optimization of Conditions

Table S1. Screening of metal salts



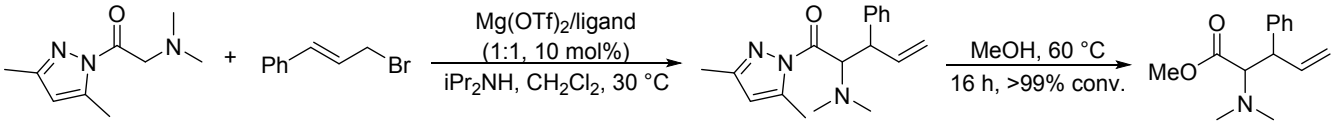
1a **2a** **3a** **4a**

entry[a]	metal salt	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	$Sc(OTf)_3$	77	47:53	50:50/50:50
2	$Ni(OTf)_2$	90	53:47	54:46/57.5:42.5
3	$Zn(OTf)_2$	57	47:53	50:50/50:50
4	$Fe(OTf)_2$	64	47:53	50:50/50:50
5	$Y(OTf)_3$	74	50:50	50:50/50:50
6	$Yb(OTf)_3$	70	48:52	50:50/50:50

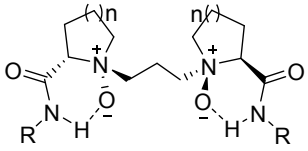
7	$Mg(OTf)_2$	91	65:35	67.5:32.5/67.5:32.5
8	$Mg(NTf)_2$	93	62:38	65.5:34.5/64.5:35.5
9	$Mg(ClO_4)_2$	83	54:46	57.5:42.5/54.5:45.5
10	$MgBr_2$	83	54:46	57:43:54:46
11[d]	--	91	50:50	50:50/50:50

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), iPr_2NH (0.15 mmol) and metal salt/**L-PrMe$_2$** (1:1, 10 mol%) in CH_2Cl_2 (1.0 mL) at 30 °C for 14 h. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase. [d] Without metal salt/**L-PrMe$_2$**.

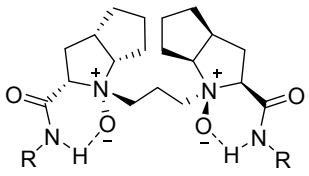
Table S2. Screening of chiral *N,N'*-dioxide ligands



1a **2a** **3a** **4a**



L-PrMe$_2$: R = 2,6-$Me_2C_6H_3$, n = 1
L-PrEt$_2$: R = 2,6-$Et_2C_6H_3$, n = 1
L-Pr*t*Bu: R = *tert*-butyl, n = 1
L-PrAd: R = 1-adamantyl, n = 1
L-PiAd: R = 1-adamantyl, n = 2

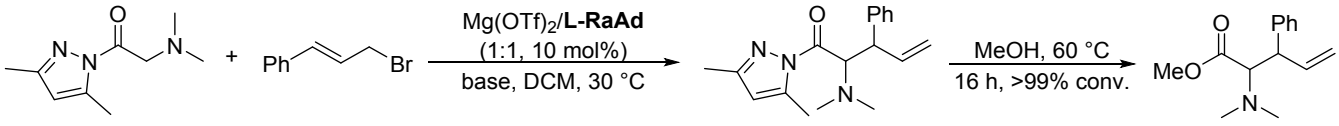


L-RaAd: R = 1-adamantyl
L-RaCHPh$_2$: R = Ph_2CH
L-RaBn: R = $CH_2C_6H_5$
L-RaCy: R = C_6H_{11}
L-RaAd^2: R = 2-adamantyl
L-RaMe$_2$: R = 2,6-$Me_2C_6H_3$
L-RaEt$_2$: R = 2,6-$Et_2C_6H_3$

entry[a]	ligand	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	**L-PrMe$_2$**	91	65:35	67.5:32.5/67.5:32.5
2	**L-PrEt$_2$**	99	74:26	61:39/80:20
3	**L-Pr*t*Bu**	90	67:33	56.5:43.5/52.5:47.5
4	**L-PrAd**	98	84:16	75.5:24.5/57:43
5	**L-PiAd**	94	70:30	52.5:47.5/50:50
6	**L-RaAd**	91	74:26	81:19/54.5:45.5
7	**L-RaCHPh$_2$**	84	74:26	45:55/56:44
8	**L-RaBn**	83	54:46	50:50/52:48
9	**L-RaCy**	83	58:42	47.5:52.5/56:44
10	**L-RaAd^2**	86	61:39	54.5:45.5/55.5:44.5
11	**L-RaMe$_2$**	88	50:50	56.5:43.5/51:49
12	**L-RaEt$_2$**	65	57:43	61:39/61.5:38.5

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), iPr_2NH (0.15 mmol) and $Mg(OTf)_2$/ligand (1:1, 10 mol%) in CH_2Cl_2 (1.0 mL) at 30 °C for 14 h. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase.

Table S3. Screening of bases

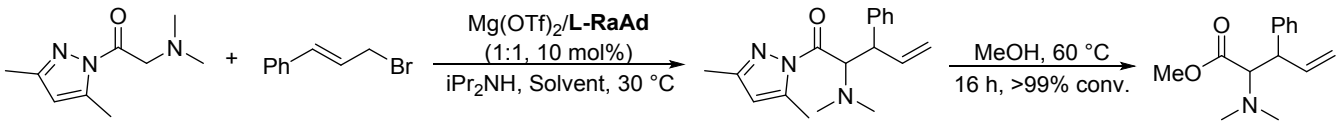


1a **2a** **3a** **4a**

entry[a]	base	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	Na_2CO_3	62	70:30	77:23/52:48
2	K_2CO_3	42	82:18	86.5:13.5/57:13
3	$NaHCO_3$	trace	--	--
4	K_2HPO_4	6	92:8	92:8/74.5:25.5
5	K_3PO_4	34	83:17	86.5:13.5/55.5:44.5
6	DMAP	37	53:47	60:40/51.5:48.5
7	DABCO	31	83:17	86.5:13.5/57.5:42.5
8	DBU	60	52:48	56:44/50:50
9	Et_3N	47	72:28	79.5:20.5/52.5:47.5
10	iPr_2NH	91	74:26	81:19/54.5:45.5

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), base (0.15 mmol) and $Mg(OTf)_2$/**L-RaAd** (1:1, 10 mol%) in CH_2Cl_2 (1.0 mL) at 30 °C for 14 h. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase.

Table S4. Screening of solvents

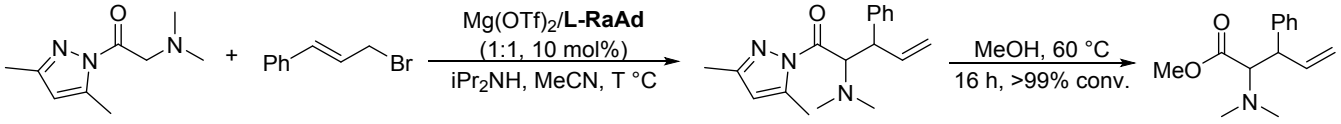


1a **2a** **3a** **4a**

entry[a]	solvent	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	CH_2Cl_2	91	74:26	81:19/54.5:45.5
2	toluene	43	61:39	66:34/52:48
3	EtOAc	99	79:21	84:16/57:43
4	THF	94	67:33	71:29/51.5:48.5
5	MeOH	N.R.	--	--
6	$C_2H_5OC_2H_5$	71	60:40	63.5:36.5/52:48
7	MeCN	99	93:7	93.5:6.5

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), iPr_2NH (0.15 mmol) and $Mg(OTf)_2$/**L-RaAd** (1:1, 10 mol%) in solvent (1.0 mL) at 30 °C for 14 h. $Mg(OTf)_2$/**L-RaAd** was pretreated by CH_2Cl_2. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase. N.R.: no reaction.

Table S5. Screening of temperature

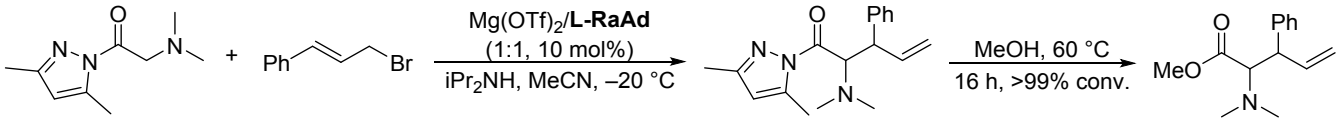


1a **2a** **3a** **4a**

entry[a]	T °C	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	40	88	93:7	93:7
2	30	99	93:7	93.5:6.5
3[d]	20	90	92:8	93:7
4[d]	0	91	93:7	94.5:5.5
5[d]	–10	87	89:11	95:5
6[d]	–20	82	92:8	95.5:4.5

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), iPr_2NH (0.15 mmol) and $Mg(OTf)_2$/**L-RaAd** (1:1, 10 mol%) in MeCN (1.0 mL) at T °C for 14 h. $Mg(OTf)_2$/**L-RaAd** was pretreated by CH_2Cl_2. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase. [d] stirred for 24 h.

Table S6. Screening of concentration of 1a

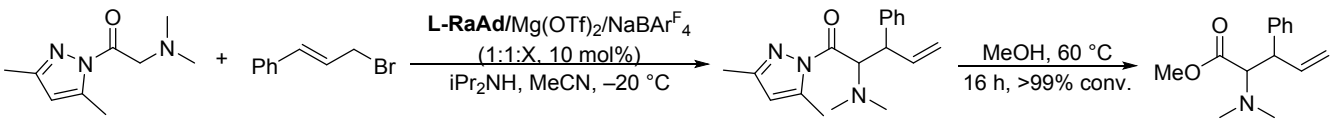


1a **2a** **3a** **4a**

entry[a]	concentration	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	2.0 M	62	70:30	83.5:16.5/52.5:47.5
2	1.0 M	82	92:8	95.5:4.5
3	0.7 M	70	92.8	95:5
4[d]	1.0 M	40	60:40	50:50/50:50

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), iPr_2NH (0.15 mmol) and $Mg(OTf)_2$/**L-RaAd** (1:1, 10 mol%) in MeCN at –20 °C for 24 h. $Mg(OTf)_2$/**L-RaAd** was pretreated by CH_2Cl_2. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase. [d] Without $Mg(OTf)_2$/**L-RaAd**.

Table S7. Screening of the amount of $NaBAr^F_4$



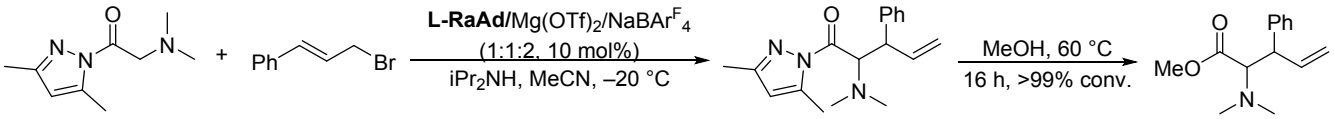
1a **2a** **3a** **4a**

entry[a]	X	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	0	91	94:6	96.5:3.5

2	1	85	93:7	95.5:4.5
3	2	85	95:5	96.5:3.5

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), iPr_2NH (0.15 mmol) and **L-RaAd**/$Mg(OTf)_2$/$NaBAr^F_4$ (1:1:X, 10 mol%) in MeCN at –20 °C for 24 h. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase.
Note: Because of the low solubility of $NaBAr^F_4$ in CH_2Cl_2, **L-RaAd**/$Mg(OTf)_2$/$NaBAr^F_4$ was pretreated by THF.

Table S8. Screening of the solvent to pretreat L-RaAd/$Mg(OTf)_2$/$NaBAr^F_4$

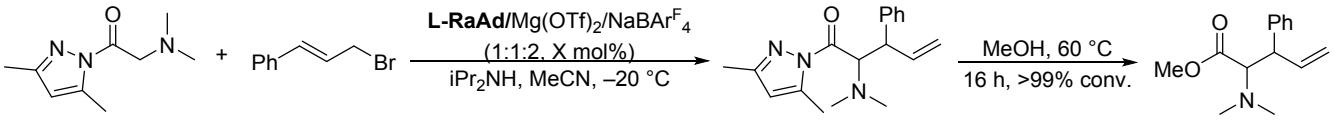


1a **2a** **3a** **4a**

entry[a]	solvent	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	THF	85	95:5	96.5:3.5
2	DCM	64	88:12	93.5:6.5
3	EtOAc	94	95:5	97:3
4	MeCN	99	94:6	96.5:3.5

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), iPr_2NH (0.15 mmol) and **L-RaAd**/$Mg(OTf)_2$/$NaBAr^F_4$ (1:1:2, 10 mol%) in MeCN at –20 °C for 24 h. **L-RaAd**/$Mg(OTf)_2$/$NaBAr^F_4$ was pretreated by solvent. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase.

Table S9. Screening of the the amount of the L-RaAd/$Mg(OTf)_2$/$NaBAr^F_4$ complex

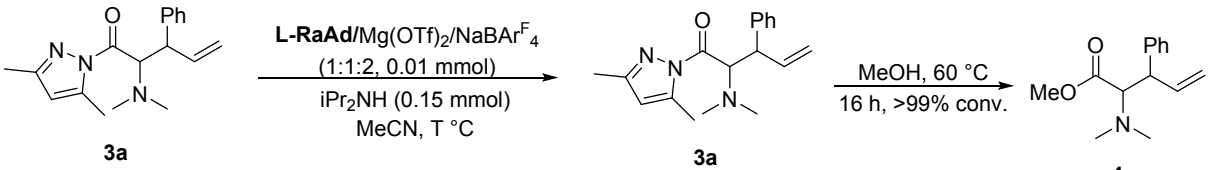


1a **2a** **3a** **4a**

entry[a]	X	yield of **3a** (%)[b]	*anti:syn* of **4a**[c]	er of **4a**[c]
1	10	94	95:5	97:3
2	5	44	82:18	90.5:9.5/56.5:43.5

[a] Unless otherwise noted, all reactions were carried out with **1a** (0.10 mmol), **2a** (0.10 mmol), iPr_2NH (0.15 mmol) and $Mg(OTf)_2$/**L-RaAd** (1:1, X mol%) in MeCN at –20 °C for 24 h. **L-RaAd**/$Mg(OTf)_2$/$NaBAr^F_4$ was pretreated by EtOAc. [b] Isolated yield of **3a**. [c] Determined by HPLC on a chiral stationary phase.

Table S10. Control experiment



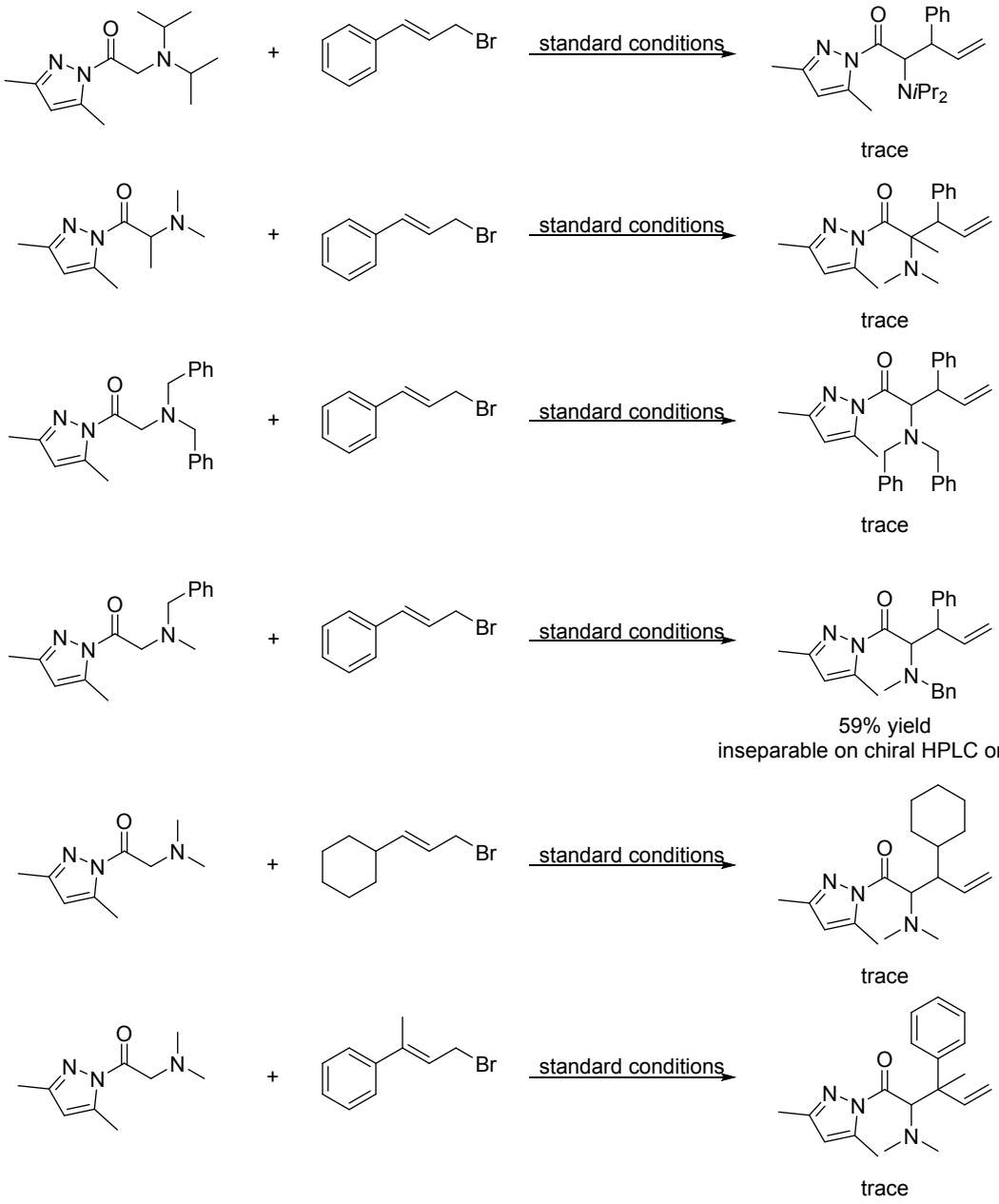
3a **3a** **4a**

67:33 *anti:syn*, 80.5:19.5/52.5:47.5 er

entry[a]	T °C	*anti:syn* of **4a**[b]	er of **4a**[b]
1[c]	30	68:32	81:19/52.5:47.5
2	0	67:33	80.5:19.5/52.5:47.5
3	–20	67:33	80.5:19.5/52.5:47.5
4[d]	–20	67:33	81:19/52:48

[a] Unless otherwise noted, all reactions were carried out with **3a** (20 mg), iPr_2NH (0.15 mmol) and **L-RaAd**/$Mg(OTf)_2$/$NaBAr^F_4$ (1:1:2, 0.01 mmol) in MeCN (1.0 mL) at T °C for 24 h. **L-RaAd**/$Mg(OTf)_2$/$NaBAr^F_4$ was pretreated by EtOAc. [b] Determined by HPLC on a chiral stationary phase. [c] Without $NaBAr^F_4$. [d] Without **L-RaAd**/$Mg(OTf)_2$/$NaBAr^F_4$.

(F) Scope Limitation



(G) X-ray Crystal Structure of Product 4u

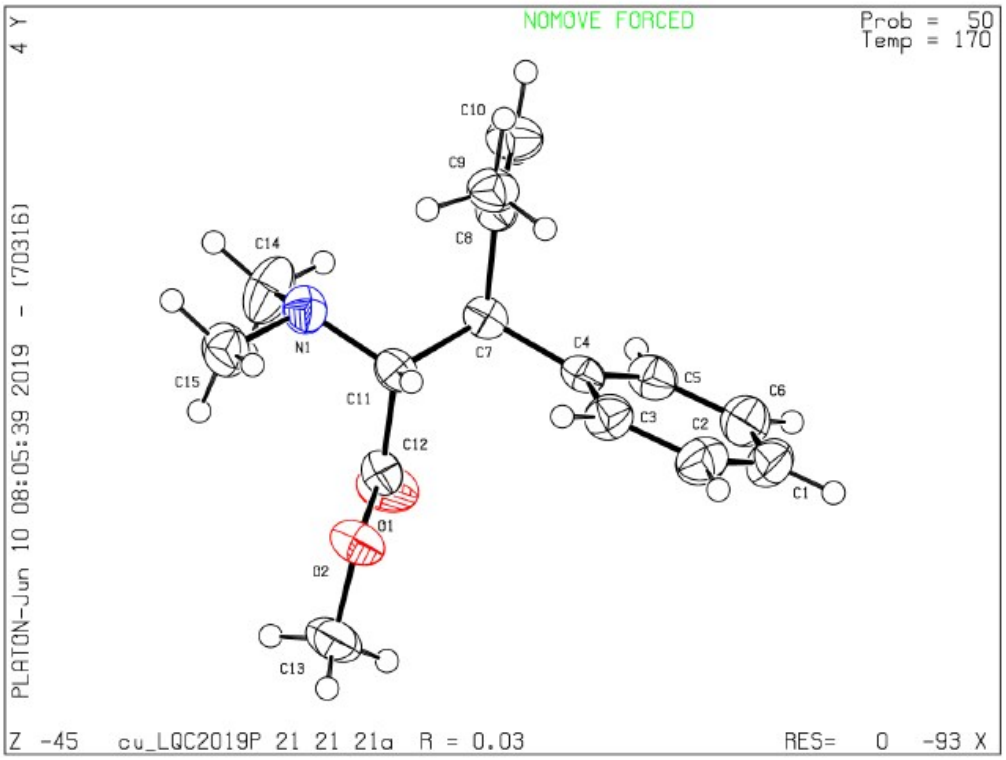
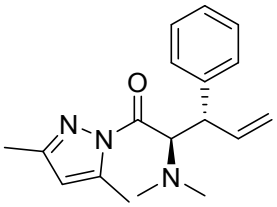


Figure S1. X-ray Crystal Structure of **4u**, CCDC 1960932.

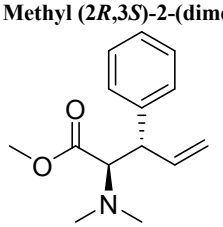
(H) Characterization of Typical [2,3]-Rearrangement Products

(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-phenylpent-4-en-1-one (3a)

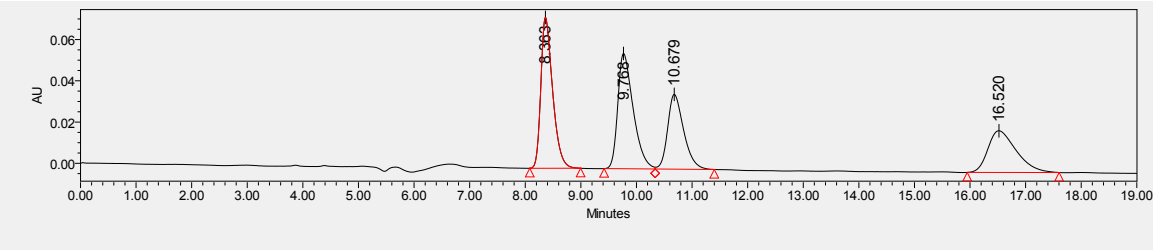


55.9 mg, 94% yield; colorless liquid; R_f = 0.7 (petroleum ether/ethyl acetate = 10/1). $[\alpha]^{24}_D$ = +82.0 (*c* = 1.02, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.26 – 7.20 (m, 2H), 7.18 – 7.11 (m, 2H), 7.09 – 7.03 (m 1H), 6.26 – 6.14 (m, 1H), 5.76 (d, *J* = 0.4 Hz, 1H), 5.36 (d, *J* = 11.6 Hz, 1H), 5.16 – 5.08 (m, 2H), 3.95 – 3.87 (m, 1H), 2.44 (s, 6H), 2.30 (d, *J* = 0.8 Hz, 3H), 2.16 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.0, 151.3, 143.3, 140.4, 139.7, 128.5, 128.2, 126.6, 115.9, 111.1, 66.4, 49.9, 41.3, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2933, 2788, 1713, 1583, 1451, 1410, 1378, 1350, 1302, 1222, 1175, 1031, 959, 914, 876, 815, 758, 700, 515. **HRMS** (ESI-FT) calcd for $C_{18}H_{24}N_3O^+$ ([M]+H^+) = 298.1914, found 298.1917.

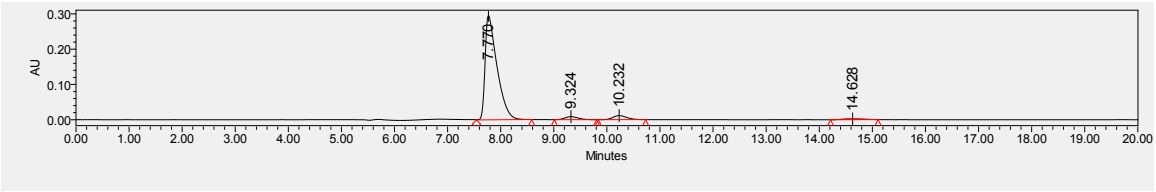
Methyl (2*R*,3*S*)-2-(dimethylamino)-3-phenylpent-4-enoate (4a)



41.2 mg, 94% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **OJH**, hexane/iPrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm) major isomer: t_r (major) = 17.770 min, t_r (minor) = 9.324 min, ee = 94%; minor isomer: t_r(major) = 10.232 min, t_r (minor) = 14.628 min, ee = 57%. *anti:syn* = 95:5. $[\alpha]^{23}_D$ = +95.4 (*c* = 0.55, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.30 – 7.24 (m, 2H), 7.23 – 7.15 (m, 3H), 6.18 – 6.06 (m, 1H), 5.16 – 5.06 (m, 2H), 3.79 – 3.71 (m, 1H), 3.58 (d, *J* = 12.0 Hz, 1H), 3.41 (s, 3H), 2.39 (s, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.2, 140.8, 138.9, 128.6, 128.2, 126.9, 116.08, 71.7, 50.6, 49.8, 41.3 ppm. **IR** (neat): ν (cm^{-1}) 2943, 2788, 1729, 1452, 1342, 1158, 1036, 981, 914, 870, 760, 700, 515. **HRMS** (ESI-FT) calcd for $C_{14}H_{20}NO_2^+$ ([M]+H^+) = 234.1489, found 234.1486.

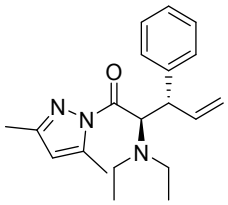


	Retention Time	Area	% Area
1	8.363	1073057	29.87
2	9.768	1074818	29.92
3	10.679	728342	20.28
4	16.520	715951	19.93



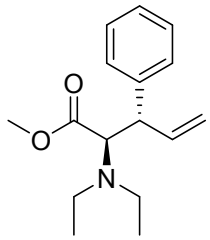
	Retention Time	Area	% Area
1	7.770	4587849	91.69
2	9.324	147946	2.96
3	10.232	210501	4.21
4	14.628	57420	1.15

(2*R*,3*S*)-2-(Diethylamino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-3-phenylpent-4-en-1-one (3b)

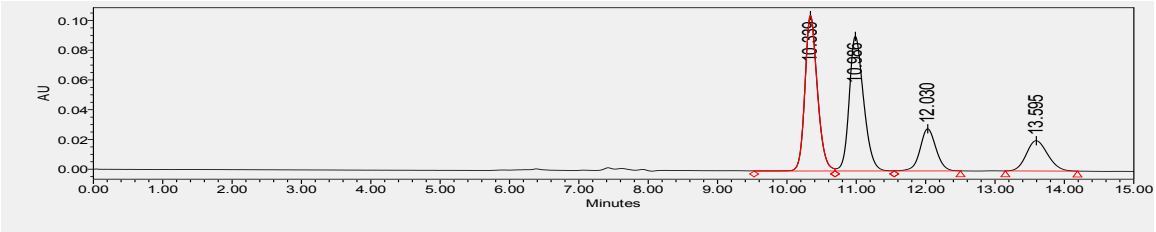


41.7 mg, 64% yield; colorless liquid; R_f = 0.7 (petroleum ether/ethyl acetate = 10/1). $[\alpha]^{26}_D$ = +116.0 (*c* = 0.75, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.25 – 7.20 (m, 2H), 7.18 – 7.12 (m, 2H), 7.10 – 7.04 (m 1H), 6.29 – 6.18 (m, 1H), 5.77 (d, *J* = 0.4 Hz, 1H), 5.38 (d, *J* = 11.6 Hz, 1H), 5.11 – 5.05 (m, 1H), 5.00 – 4.92 (m, 1H), 3.96 – 3.88 (m, 1H), 2.99 – 2.87 (m, 2H), 2.52 – 2.42 (m, 2H), 2.29 (d, *J* = 0.8 Hz, 3H), 2.17 (s, 3H), 1.08 (t, *J* = 6.4 Hz, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 172.7, 151.0, 143.4, 140.8, 140.5, 128.7, 128.1, 126.4, 115.5, 110.9, 63.2, 49.8, 43.8, 14.2, 14.1, 13.7. ppm. **IR** (neat): ν (cm^{-1}) 2970, 2928, 1715, 1583, 1452, 1377, 1346, 1300, 1216, 1170, 1067, 959, 913, 802, 757, 697, 631, 591, 515. **HRMS** (ESI-FT) calcd for $C_{20}H_{28}N_3O^+$ ([M]+H$^+$) = 326.2227, found 326.2225.

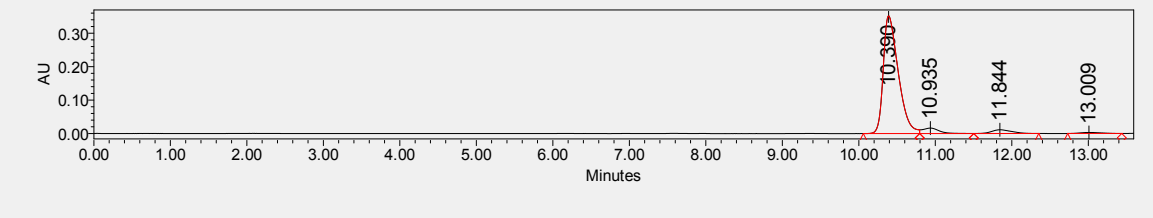
Methyl (2*R*,3*S*)-2-(diethylamino)-3-phenylpent-4-enoate (4b)



29.2 mg, 87% yield; colorless liquid; R_f = 0.60 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IG**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 10.390 min, t_r (minor) = 10.935 min, ee = 90%; minor isomer: t_r(major) = 11.844 min, t_r (minor) = 13.009 min, ee = 54%. *anti:syn* = 95:5. $[\alpha]^{26}_D$ = +141.3 (*c* = 0.41, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.30 – 7.24 (m, 2H), 7.22 – 7.15 (m, 3H), 6.21 – 6.10 (m, 1H), 5.10 – 5.04 (m, 1H), 5.00 – 4.93 (m, 1H), 3.84 – 3.76 (m, 1H), 3.70 (d, *J* = 11.2 Hz, 1H), 3.40 (s, 3H), 2.95 – 2.82 (m, 2H), 2.45 – 2.33 (m, 2H), 1.07 (t, *J* = 7.2 Hz, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.5, 141.3, 139.6, 128.5, 128.4, 126.7, 115.7, 67.4, 50.6, 49.6, 44.1, 13.8. ppm. **IR** (neat): ν (cm^{-1}) 2972, 1732, 1453, 1381, 1251, 1198, 1159, 1070, 984, 914, 760, 700. **HRMS** (ESI-FT) calcd for $C_{16}H_{24}NO_2^+$ ([M]+H$^+$) = 262.1802, found 262.1803.

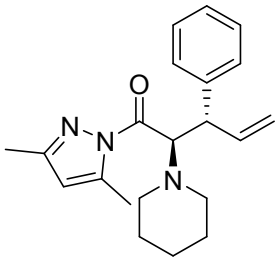


	Retention Time	Area	% Area
1	10.339	1306745	37.32
2	10.986	1305693	37.29
3	12.030	450689	12.87
4	13.595	438490	12.52



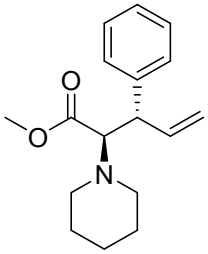
	Retention Time	Area	% Area
1	10.390	4765938	90.40
2	10.935	245837	4.66
3	11.844	200217	3.80
4	13.009	60306	1.14

(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-3-phenyl-2-(piperidin-1-yl)pent-4-en-1-one (3c)

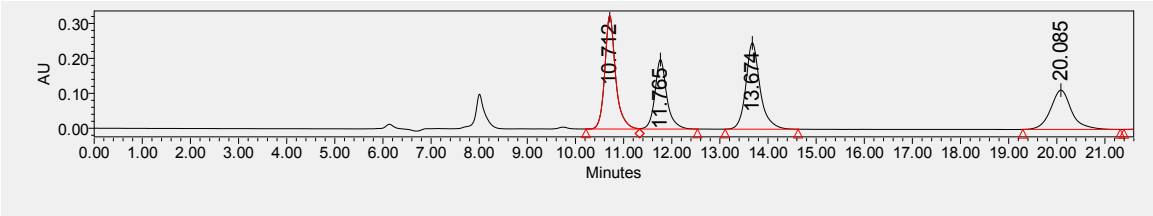


48.1 mg, 71% yield; pale yellow solid; R_f = 0.7 (petroleum ether/ethyl acetate = 10/1). $[\alpha]^{26}_D$ = +63.1 (*c* = 0.87, in CH_2Cl_2). **MP**: 55 – 60 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.25 – 7.20 (m, 2H), 7.18 – 7.12 (m, 2H), 7.10 – 7.04 (m 1H), 6.31 – 6.20 (m, 1H), 5.78 (d, *J* = 0.4 Hz, 1H), 5.29 (d, *J* = 11.6 Hz, 1H), 5.12 – 5.07 (m, 1H), 5.02 – 4.94 (m, 1H), 3.99 – 3.91 (m, 1H), 2.70 – 2.58 (m, 4H), 2.33 (d, *J* = 0.8 Hz, 3H), 2.16 (s, 3H), 1.64 – 1.35 (m, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.1, 151.0, 143.2, 140.6, 140.0, 128.7, 128.2, 126.5, 115.4, 111.0, 67.4, 50.6, 48.8, 26.8, 24.8, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2929, 2805, 1713, 1583, 1448, 1409, 1377, 1352, 1303, 1223, 1162, 1101, 1032, 959, 910, 867, 798, 758, 698, 580, 514, 453. **HRMS** (ESI-FT) calcd for $C_{21}H_{28}N_3O^+$ ([M]+H$^+$) = 338.2227, found 338.2231.

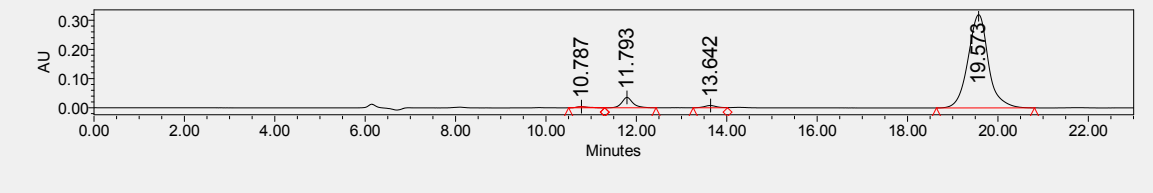
Methyl (2*R*,3*S*)-3-phenyl-2-(piperidin-1-yl)pent-4-enoate (4c)



32.4 mg, 83% yield; pale yellow solid; R_f = 0.60 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IA**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 210 nm) major isomer: t_r (major) = 19.573 min, t_r (minor) = 11.793 min, ee = 89%; minor isomer: t_r(major) = 13.642 min, t_r (minor) = 10.787 min, ee = 35%. *anti:syn* = 98:2. $[\alpha]^{22}_D$ = +95.8 (*c* = 0.62, in CH_2Cl_2). **MP**: 75 – 77 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.30 – 7.23 (m, 2H), 7.21 – 7.14 (m, 3H), 6.23 – 6.12 (m, 1H), 5.11 – 5.05 (m, 1H), 5.01 – 4.93 (m, 1H), 3.85 – 3.78 (m, 1H), 3.51 (d, *J* = 11.6 Hz, 1H), 3.41 (s, 3H), 2.73 – 2.64 (m, 2H), 2.49 – 2.41 (m, 2H), 1.66 – 1.38 (s, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.5, 141.0, 139.2, 128.5, 128.5, 126.7, 115.6, 72.6, 50.7, 50.5, 48.7, 26.5, 24.7 ppm. **IR** (neat): ν (cm^{-1}) 2932, 2808, 1730, 1449, 1342, 1198, 1158, 1120, 982, 912, 862, 762, 700, 513. **HRMS** (ESI-FT) calcd for $C_{17}H_{24}NO_2^+$ ([M]+H$^+$) = 274.1802, found 274.1802.

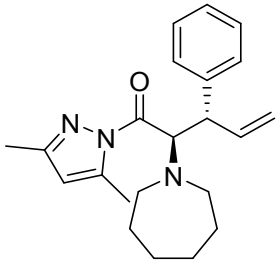


	Retention Time	Area	% Area
1	10.712	5074269	29.96
2	11.765	3405465	20.11
3	13.674	5062506	29.89
4	20.085	3393297	20.04



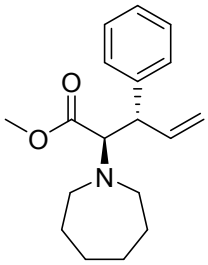
	Retention Time	Area	% Area
1	10.787	69433	0.64
2	11.793	606168	5.62
3	13.642	143210	1.33
4	19.573	9957891	92.40

(2*R*,3*S*)-2-(Azepan-1-yl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-3-phenylpent-4-en-1-one (3d)

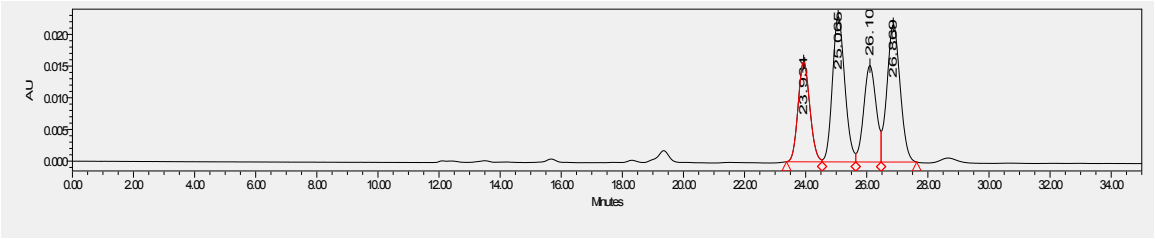


45.4 mg, 65% yield; colorless liquid; R_f = 0.8 (petroleum ether/ethyl acetate = 10/1). $[\alpha]^{23}_D$ = +81.1 (*c* = 0.79, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.26 – 7.21 (m, 2H), 7.19 – 7.13 (m, 2H), 7.10 – 7.04 (m 1H), 6.32 – 6.20 (m, 1H), 5.79 (s, 1H), 5.30 (d, *J* = 11.6 Hz, 1H), 5.13 – 5.08 (m, 1H), 5.04 – 4.96 (m, 1H), 3.99 – 3.91 (m, 1H), 2.99 – 2.84 (m, 4H), 2.31 (d, *J* = 0.8 Hz, 3H), 2.18 (s, 3H), 1.62 – 1.47 (m, 8H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.9, 150.9, 143.5, 140.8, 140.4, 128.7, 128.2, 126.4, 115.7, 110.9, 67.8, 51.3, 49.6, 29.9, 27.2, 14.3, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 1714, 1582, 1450, 1408, 1377, 1351, 1303, 1221, 1132, 1081, 960, 912, 870, 805, 757, 699, 591, 513. **HRMS** (ESI-FT) calcd for $C_{22}H_{30}N_3O^+$ ([M]+H$^+$) = 352.2383, found 352.2383.

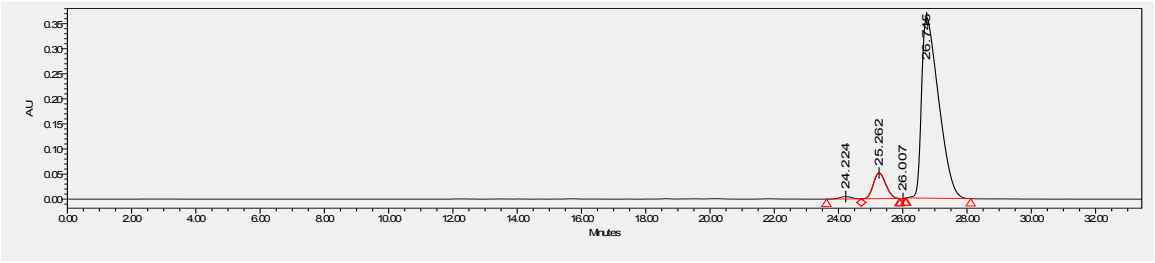
Methyl (2*R*,3*S*)-2-(azepan-1-yl)-3-phenylpent-4-enoate (4d)



37.4 mg, 99% yield; pale yellow liquid; R_f = 0.7 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IF**, hexane/iPrOH = 99.8/0.2, flow rate 0.3 mL/min, λ = 254 nm) major isomer: t_r (major) = 26.745 min, t_r (minor) = 25.262 min, ee = 81%; minor isomer: t_r(major) = 24.224 min, t_r (minor) = 26.007 min, ee = 97%. *anti:syn* = 99:1. $[\alpha]^{24}_D$ = +81.1 (*c* = 0.61, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.29 – 7.23 (m, 2H), 7.21 – 7.15 (m, 3H), 6.25 – 6.14 (m, 1H), 5.11 – 5.06 (m, 1H), 5.00 – 4.94 (m, 1H), 3.80 – 3.72 (m, 1H), 3.58 (d, *J* = 11.6, 1H), 3.404 (s, 3H), 2.96 – 2.86 (m, 2H), 2.70 – 2.61 (m, 2H), 1.66 – 1.53 (m, 8H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.6, 141.2, 139.7, 128.5, 128.4, 126.7, 115.8, 72.7, 51.8, 50.6, 49.7, 29.48, 27.1 ppm. IR (neat): ν (cm^{-1}) 2924, 2851, 1731, 1452, 1343, 1243, 1154, 987, 913, 758, 700. **HRMS** (ESI-FT) calcd for $C_{18}H_{26}NO_2^+$ ([M]+H$^+$) = 288.1958, found 288.1957.

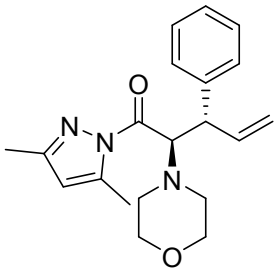


	Retention Time	Area	% Area
1	23.934	422675	19.65
2	25.065	646858	30.07
3	26.103	430796	20.03
4	26.869	650545	30.25

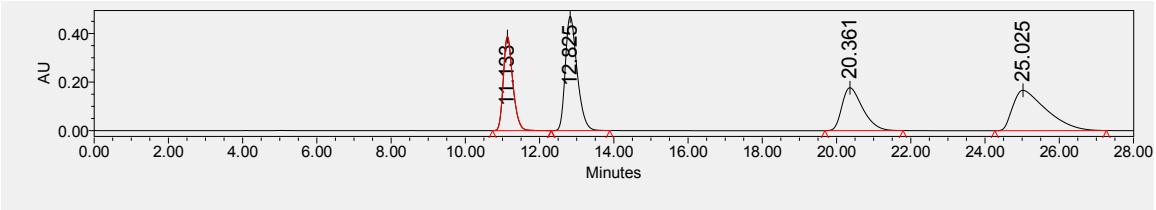


	Retention Time	Area	% Area
1	24.224	119500	0.81
2	25.262	1385197	9.33
3	26.007	1849	0.01
4	26.745	13335528	89.85

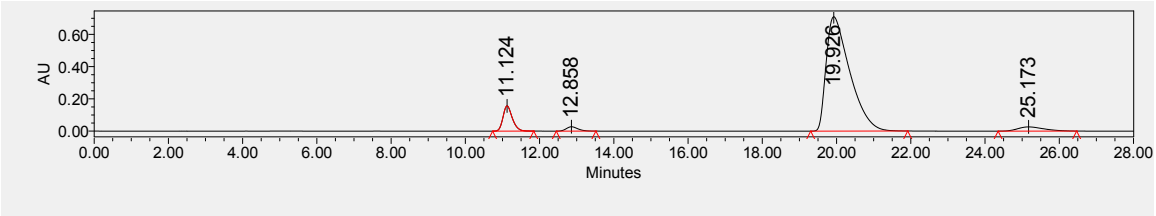
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-morpholino-3-phenylpent-4-en-1-one (3e)



18.0 mg, 27% yield; white solid; R_f = 0.3 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **Lux 5u Cellulose-2**, hexane/iPrOH = 99.8/0.2, flow rate 0.3 mL/min, λ = 254 nm) major isomer: t_r (major) = 19.926 min, t_r (minor) = 11.124 min, ee = 84%; minor isomer: t_r(major) = 25.173 min, t_r (minor) = 12.858 min, ee = 54%. *anti:syn* = 95:5. $[\alpha]^{26}_D$ = +74.1 (*c* = 0.22, in CH_2Cl_2). **MP**: 80–87 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.24 – 7.19 (m, 2H), 7.19 – 7.13 (m, 2H), 7.12 – 7.05 (m 1H), 6.30 – 6.18 (m, 1H), 5.78 (d, *J* = 0.8 Hz, 1H), 5.33 (d, *J* = 12.0 Hz, 1H), 5.13 – 5.08 (m, 1H), 5.04 – 4.97 (m, 1H), 3.97 – 3.90 (m, 1H), 3.76 – 3.68 (m, 2H), 3.66 – 3.58 (m, 2H), 2.77 – 2.65 (m, 4H), 2.32 (d, *J* = 0.8 Hz, 3H), 2.16 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.5, 151.5, 143.5, 140.2, 139.6, 128.6, 128.3, 126.7, 115.7, 111.3, 67.7, 66.8, 49.8, 48.6, 14.3, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2959, 2852, 1714, 1585, 1450, 1410, 1379, 1355, 1301, 1250, 1219, 1116, 960, 916, 865, 829, 761, 701, 516. **HRMS** (ESI-FT) calcd for $C_{20}H_{26}N_3O_2^+$ ([M]+H^+) = 340.2020, found 340.2021.

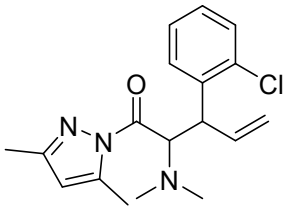


	Retention Time	Area	% Area
1	11.133	6870596	19.91
2	12.825	10407307	30.16
3	20.361	6841135	19.82
4	25.025	10391822	30.11



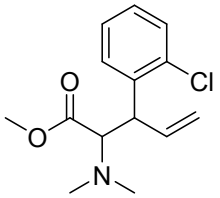
	Retention Time	Area	% Area
1	11.124	2729994	7.61
2	12.858	587683	1.64
3	19.926	31293083	87.19
4	25.173	1281359	3.57

3-(2-Chlorophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3f)

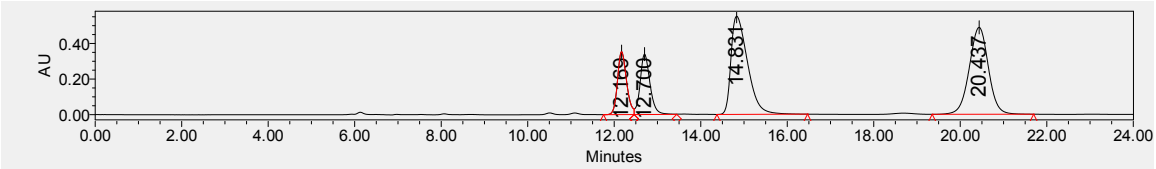


39.5 mg, 60% yield; white solid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). **MP**: 83 – 92 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.48 – 7.02 (m, 4H), 6.17 – 6.05 (m 1H), 5.81 (s, 1H), 5.45 (d, *J* = 11.6 Hz, 1H), 5.17 – 4.89 (m, 2H), 4.62 – 4.51 (m 1H), 2.46 (s, 6H), 2.32 (d, *J* = 0.8 Hz, 3H), 2.20 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.4, 170.3, 151.6, 151.4, 143.7, 143.4, 138.3, 137.8, 137.0, 134.3, 134.2, 129.8, 129.2, 129.0, 127.6, 127.5, 126.9, 126.6, 117.4, 116.5, 111.6, 111.2, 65.8, 65.1, 45.8, 44.6, 41.4, 14.7, 14.3, 13.9, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2934, 2789, 1714, 1583, 1447, 1410, 1379, 1353, 1325, 1223, 1178, 1135, 1033, 961, 805, 757, 685, 658. **HRMS** (ESI-FT) calcd for $C_{18}H_{23}{}^{34.9659}ClN_3O^+$ ([M]+H$^+$) = 332.1524, found 332.1529, $C_{18}H_{23}{}^{36.9659}ClN_3O^+$ ([M]+H$^+$) = 334.1495, found 334.1495.

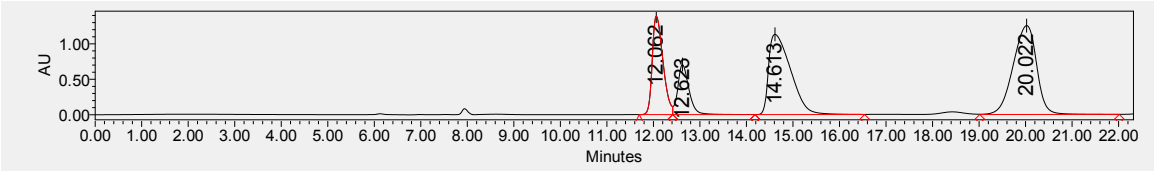
Methyl 3-(2-chlorophenyl)-2-(dimethylamino)pent-4-enoate (4f)



24.3 mg (from 31.6 mg **3f**), 95% yield; colorless liquid; R_f = 0.5 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IG**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 210 nm) major isomer: t_r (major) = 20.022 min, t_r (minor) = 14.613 min, ee = 9%; minor isomer: t_r(major) = 12.062 min, t_r (minor) = 12.613 min, ee = 31%. *anti:syn* = 29:71. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.38 – 7.10 (m, 4H), 6.11 – 6.00 (m, 1H), 5.15 – 5.02 (m, 2H), 4.45 – 4.33 (m, 1H), 3.74 – 3.65 (m, 1H), 3.45 (s, 3H), 2.43 (s, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.9, 169.8, 138.1, 137.9, 137.7, 136.8, 134.2, 134.1, 130.1, 129.9, 128.8, 127.9, 127.6, 127.0, 126.9, 117.6, 116.6, 70.7, 70.2, 50.8, 50.7, 45.9, 41.5 ppm. **IR** (neat): ν (cm^{-1}) 2945, 2788, 1729, 1637, 1437, 1350, 1159, 1033, 982, 920, 753, 558, 456. **HRMS** (ESI-FT) calcd for $C_{14}H_{19}{}^{34.9659}ClNO_2^+$ ([M]+H$^+$) = 268.1099, found 268.1100, $C_{14}H_{19}{}^{36.9659}ClNO_2^+$ ([M]+H$^+$) = 270.1069, found 270.1068.



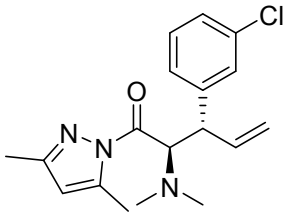
	Retention Time	Area	% Area
1	12.169	5130730	12.78
2	12.700	5379906	13.40
3	14.831	14646827	36.49
4	20.437	14984691	37.33



	Retention Time	Area	% Area
1	12.062	22155652	19.24

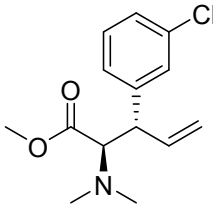
2	12.623	11768852	10.22
3	14.613	37143447	32.25
4	20.022	44099217	38.29

(2*R*,3*S*)-3-(3-Chlorophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3g)

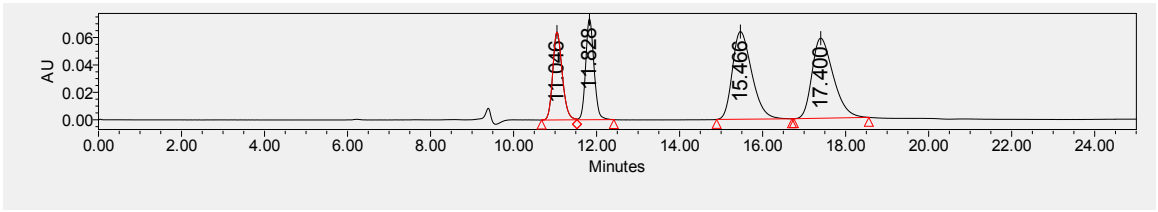


58.1 mg, 88% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). $[\alpha]^{25}_D$ = +76.7 (*c* = 1.08, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.29 – 7.24 (m, 1H), 7.13 – 7.00 (m, 3H), 6.22 – 6.10 (m 1H), 5.79 (s, 1H), 5.30 (d, *J* = 11.6 Hz, 1H), 5.19 – 5.08 (m, 2H), 3.92 – 3.83 (m 1H), 2.44 (s, 6H), 2.33 (s 3H), 2.18 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.0, 151.6, 143.3, 142.3, 138.9, 134.0, 129.4, 128.8, 126.8, 126.7, 116.5, 111.3, 66.2, 49.6, 41.2, 14.3, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2933, 2788, 1711, 1581, 1409, 1378, 1349, 1301, 1222, 1174, 1134, 957, 916, 815, 785, 759, 694, 663, 509. **HRMS** (ESI-FT) calcd for $C_{18}H_{23}{}^{34.9659}ClN_3O^+$ ([M]+H$^+$) = 332.1524, found 332.1520, $C_{18}H_{23}{}^{36.9659}ClN_3O^+$ ([M]+H$^+$) = 334.1495, found 334.1495.

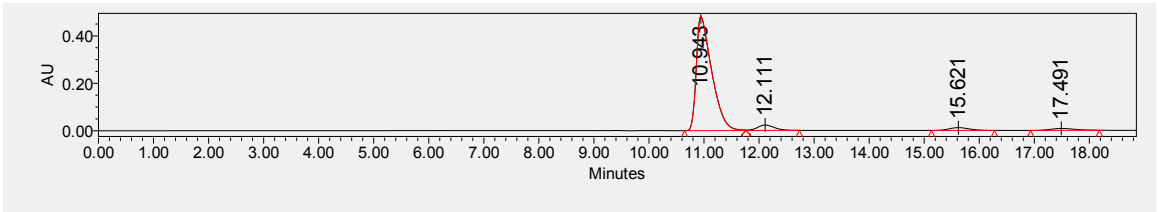
Methyl (2*R*,3*S*)-3-(3-chlorophenyl)-2-(dimethylamino)pent-4-enoate (4g)



44.7 mg, 95% yield; colorless liquid; R_f = 0.5 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **OJH**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 10.943 min, t_r (minor) = 12.111 min, ee = 90%; minor isomer: t_r(major) = 15.621 min, t_r (minor) = 17.491 min, ee = 12%. *anti:syn* = 95:5. $[\alpha]^{25}_D$ = +87.5 (*c* = 0.74, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.23 – 7.14 (m, 3H), 7.10 – 7.04 (m, 1H), 6.13 – 6.02 (m, 1H), 5.17 – 5.12 (m, 1H), 5.12 – 5.05 (m, 1H), 3.76 – 3.69 (m, 1H), 3.52 (d, *J* = 11.6 Hz, 1H), 3.46 (s, 3H), 2.37 (s, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 169.9, 142.9, 138.2, 134.3, 129.8, 128.4, 127.1, 126.5, 116.7, 71.5, 50.7, 49.3, 41.3 ppm. **IR** (neat): ν (cm^{-1}) 2944, 2788, 1728, 1572, 1432, 1340, 1160, 1081, 1038, 981, 916, 783, 694, 445. **HRMS** (ESI-FT) calcd for $C_{14}H_{19}{}^{34.9659}ClNO_2^+$ ([M]+H$^+$) = 268.1099, found 268.1100, $C_{14}H_{19}{}^{36.9659}ClNO_2^+$ ([M]+H$^+$) = 270.1069, found 270.1077.

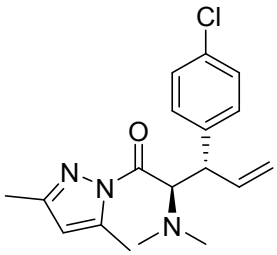


	Retention Time	Area	% Area
1	11.046	1017390	16.42
2	11.828	1021661	16.49
3	15.466	2076441	33.51
4	17.400	2081163	33.59

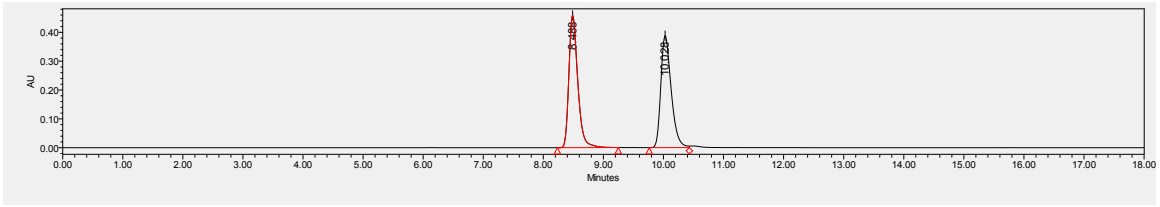


	Retention Time	Area	% Area
1	10.943	9312745	89.96
2	12.111	491920	4.75
3	15.621	302257	2.92
4	17.491	244747	2.36

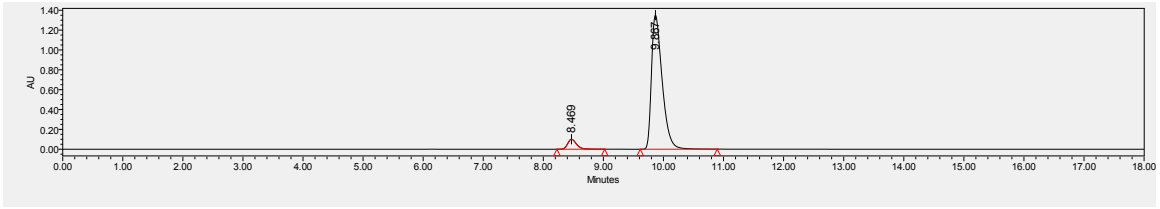
(2*R*,3*S*)-3-(4-Chlorophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3h)



41.6 mg, 63% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IA**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 9.722 min, t_r (minor) = 8.209 min, ee = 88%. *anti:syn* = 6:1. $[\alpha]^{24}_D$ = +106.1 (*c* = 0.74, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.20 – 7.15 (m, 2H), 7.15 – 7.10 (m, 2H), 6.22 – 6.10 (m 1H), 5.81 (s, 1H), 5.31 (d, *J* = 11.6 Hz, 1H), 5.16 – 5.12 (m, 1H), 5.12 – 5.04 (m, 1H), 3.93 – 3.85 (m 1H), 2.42 (s, 6H), 2.34 (s, 3H), 2.17 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.6, 151.5, 143.4, 139.2, 139.0, 132.3, 129.9, 128.4, 116.2, 111.4, 66.3, 49.0, 41.3, 41.3, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2934, 2789, 1712, 1585, 1489, 1453, 1409, 1379, 1350, 1302, 1222, 1175, 1092, 1019, 959, 916, 876, 817, 761, 720, 622, 559, 521. **HRMS** (ESI-FT) calcd for $C_{18}H_{23}{}^{34.9659}ClN_3O^+$ ([M]+H$^+$) = 332.1524, found 332.1526, $C_{18}H_{23}{}^{36.9659}ClN_3O^+$ ([M]+H$^+$) = 334.1495, found 334.1495.

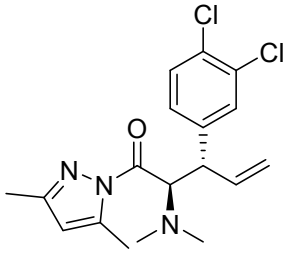


	Retention Time	Area	% Area
1	8.488	4708275	50.32
2	10.028	4647906	49.68

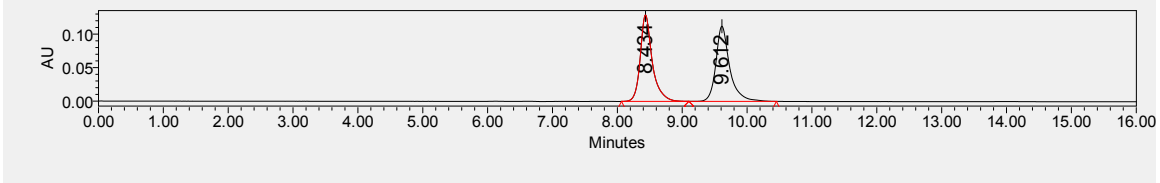


	Retention Time	Area	% Area
1	8.469	1031820	5.83
2	9.867	16654839	94.17

(2*R*,3*S*)-3-(3,4-Dichlorophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3i)

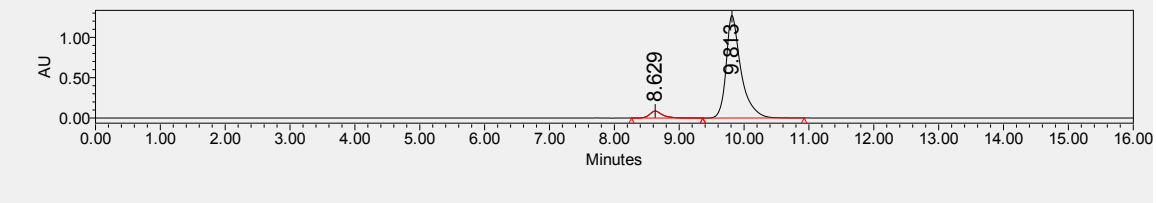


54.4 mg, 75% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IA**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 9.813 min, t_r (minor) = 8.629 min, ee = 89%. *anti:syn* = 7:1. $[\alpha]^{24}_D$ = +93.2 (*c* = 1.14, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.38 (d, *J* = 2.4 Hz, 1H), 7.21 (d, *J* = 8.4 Hz, 1H), 7.09 – 7.04 (m, 1H), 6.19 – 6.07 (m 1H), 5.83 (s, 1H), 5.30 (d, *J* = 12.0 Hz, 1H), 5.19 – 5.14 (m, 1H), 5.14 – 5.06 (m, 1H), 3.90 – 3.81 (m 1H), 2.42 (s, 6H), 2.36 (d, *J* = 0.8 Hz, 3H), 2.18 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.6, 151.8, 143.4, 140.7, 138.6, 132.2, 130.6, 130.5, 130.1, 128.0, 116.7, 111.5, 66.1, 48.9, 41.2, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2934, 2788, 1710, 1585, 1469, 1378, 1349, 1302, 1222, 1176, 1134, 1030, 957, 917, 817, 759, 707, 628, 446. **HRMS** (ESI-FT) calcd for $C_{18}H_{22}{}^{34.9659}Cl_2N_3O^+$ ([M]+H$^+$) = 366.1134, found 366.1134, $C_{18}H_{22}{}^{34.9659}Cl^{36.9659}ClN_3O^+$ ([M]+H$^+$) = 368.1105, found 368.1104, $C_{18}H_{22}{}^{36.9659}Cl_2N_3O^+$ ([M]+H$^+$) = 370.1075, found 370.1069.



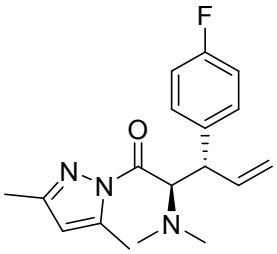
	Retention Time	Area	% Area
1	8.434	1664125	50.00

2	9.612	1663950	50.00

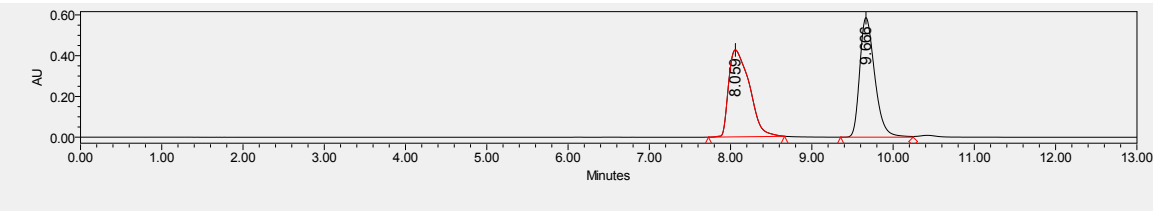


	Retention Time	Area	% Area
1	8.629	1192303	5.59
2	9.813	20148106	94.41

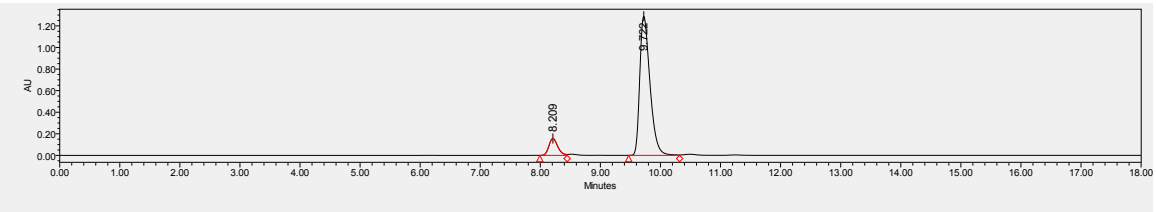
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(4-fluorophenyl)pent-4-en-1-one (3j)



35.9 mg, 57% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IA**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 9.722 min, t_r (minor) = 8.209 min, ee = 81%. *anti:syn* = 8:1. $[\alpha]^{23}_D$ = +64.0 (*c* = 0.51, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.23 – 7.16 (m, 2H), 6.88 – 6.80 (m, 2H), 6.23 – 6.12 (m 1H), 5.80 (s, 1H), 5.31 (d, *J* = 11.6 Hz, 1H), 5.17 – 5.12 (m, 1H), 5.12 – 5.05 (m, 1H), 3.93 – 3.85 (m 1H), 2.43 (s, 6H), 2.33 (s, 3H), 2.17 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.9, 161.5 (d, J_{CF} = 243.1 Hz), 151.4, 143.3, 139.5, 136.1, 130.01 (d, J_{CF} = 79.0 Hz), 116.0, 115.0 (d, J_{CF} = 21.1 Hz), 111.28, 66.46, 48.93, 41.26, 14.37, 13.78 ppm. **^{19}F{^{1}H} NMR** (376 MHz, Chloroform-*d*) δ = –116.38 ppm. **IR** (neat): ν (cm^{-1}) 2935, 2789, 1713, 1584, 1509, 1453, 1410, 1379, 1350, 1302, 1224, 1163, 1035, 960, 917, 878, 825, 761, 716, 652, 589, 534. **HRMS** (ESI-FT) calcd for $C_{18}H_{23}FN_3O^+$ ([M]+H$^+$) = 316.1820, found 316.1820.

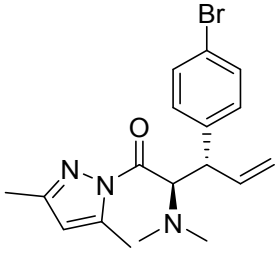


	Retention Time	Area	% Area
1	8.059	7555817	50.11
2	9.666	7522549	49.89



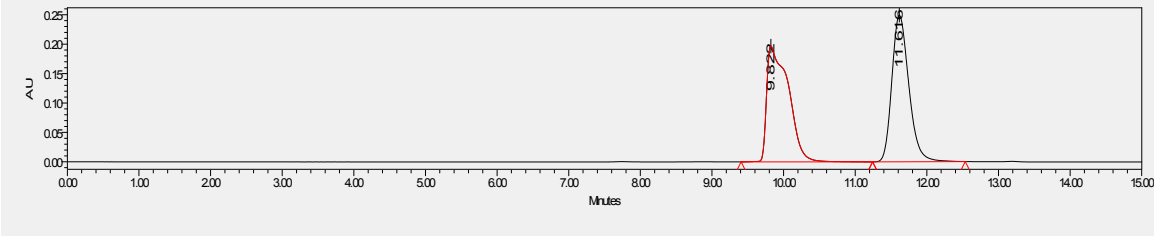
	Retention Time	Area	% Area
1	8.209	1607827	9.57
2	9.722	15201171	90.43

(2*R*,3*S*)-3-(4-Bromophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3k)

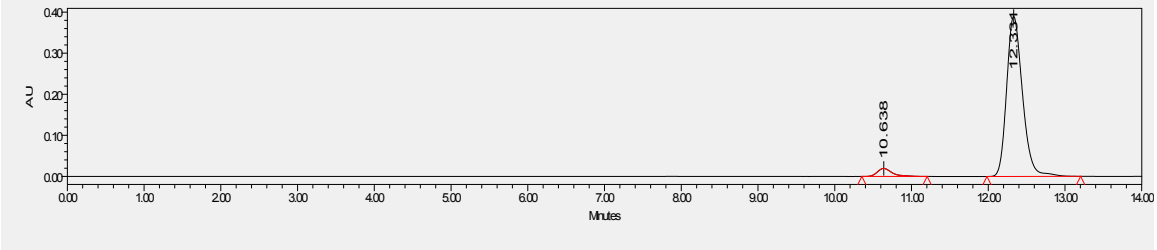


46.4 mg, 62% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IA**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 12.311 min, t_r (minor) = 10.638 min, ee = 91%. *anti:syn* =

5:1. $[\alpha]^{23}_D$ = +110.1 (*c* = 0.91, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.31 – 7.25 (m, 2H), 7.14 – 7.09 (m, 2H), 6.21 – 6.09 (m 1H), 5.82 (s, 1H), 5.31 (d, *J* = 11.6 Hz, 1H), 5.16 – 5.11 (m, 1H), 5.11 – 5.05 (m, 1H), 3.92 – 3.84 (m 1H), 2.41 (s, 6H), 2.34 (d, *J* = 0.8 Hz, 3H), 2.17 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.5, 151.5, 143.4, 139.6, 139.2, 131.4, 130.3, 120.5, 116.3, 111.40, 66.2, 49.0, 41.2, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2934, 2789, 1713, 1585, 1486, 1453, 1408, 1379, 1351, 1303, 1222, 1175, 1072, 1010, 960, 917, 876, 816, 761, 716, 518. **HRMS** (ESI-FT) calcd for $C_{18}H_{23}{}^{78.9183}BrN_3O^+$ ([M]+H$^+$) = 376.1019, found 376.1014, $C_{18}H_{23}{}^{80.9163}ClN_3O^+$ ([M]+H$^+$) = 378.0999, found 378.0992.

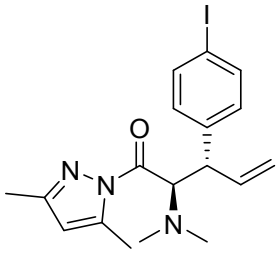


	Retention Time	Area	% Area
1	9.822	4131873	50.16
2	11.616	4105994	49.84

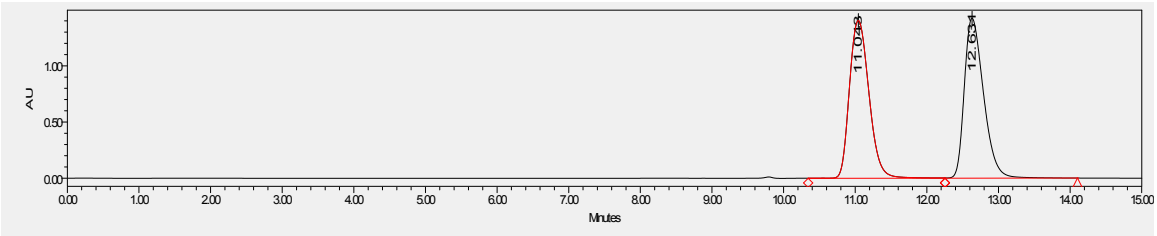


	Retention Time	Area	% Area
1	10.638	263288	4.50
2	12.331	5582456	95.50

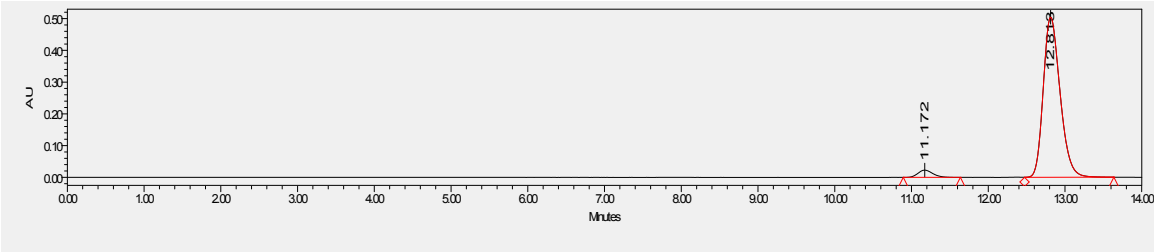
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(4-iodophenyl)pent-4-en-1-one (3l)



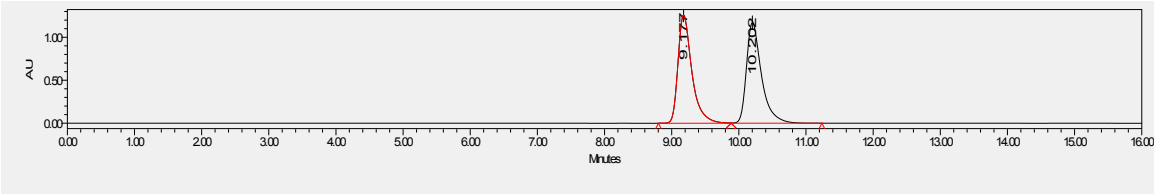
59.2 mg, 70% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IA**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 12.813 min, t_r (minor) = 11.172 min, ee = 92%; minor isomer: t_r(major) = 11.246 min, t_r (minor) = 9.893 min, ee = 28%. *anti:syn* = 4:1. $[\alpha]^{24}_D$ = +119.5 (*c* = 1.16, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.51 – 7.44 (m, 2H), 7.02 – 6.97 (m, 2H), 6.20 – 6.08 (m 1H), 5.82 (s, 1H), 5.30 (d, *J* = 12.0 Hz, 1H), 5.15 – 5.11 (m, 1H), 5.11 – 5.04 (m, 1H), 3.90 – 3.82 (m 1H), 2.41 (s, 6H), 2.34 (d, *J* = 0.8 Hz, 3H), 2.17 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.5, 151.5, 143.4, 140.3, 139.2, 137.3, 130.5, 116.3, 111.4, 92.1, 66.1, 49.1, 41.3, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2932, 2786, 1711, 1583, 1481, 1452, 1407, 1377, 1349, 1301, 1221, 1174, 1032, 1004, 958, 916, 875, 807, 760, 714, 607, 547, 516. **HRMS** (ESI-FT) calcd for $C_{18}H_{23}IN_3O^+$ ([M]+H$^+$) = 424.0880, found 424.0880.



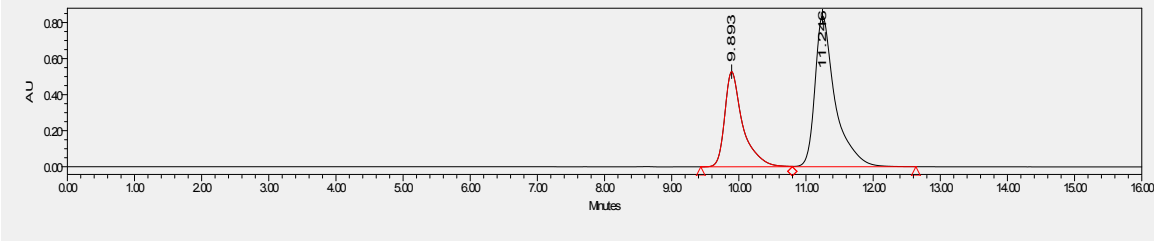
	Retention Time	Area	% Area
1	11.043	26572010	50.06
2	12.631	26507981	49.94



	Retention Time	Area	% Area
1	11.172	308182	3.87
2	12.813	7655850	96.13

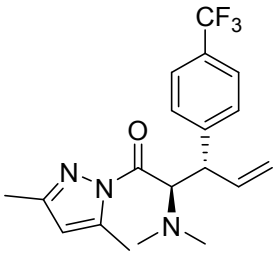


	Retention Time	Area	% Area
1	9.177	18072657	49.88
2	10.202	18161938	50.12

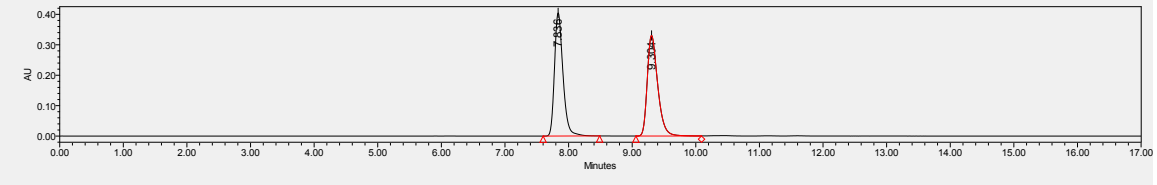


	Retention Time	Area	% Area
1	9.893	9834542	36.04
2	11.246	17456802	63.96

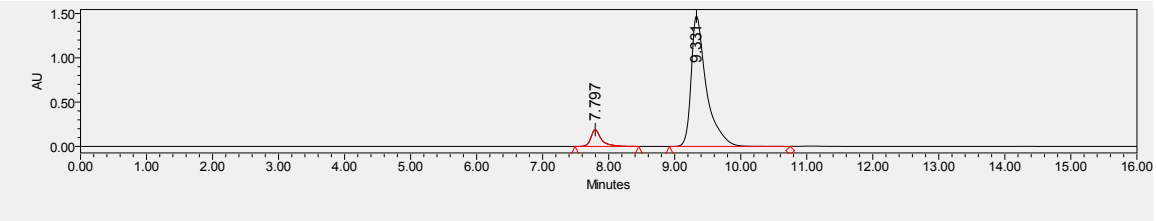
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(4-(trifluoromethyl)phenyl)pent-4-en-1-one (3m)



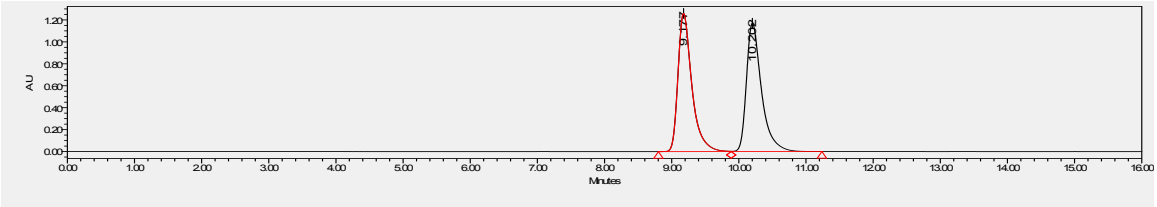
41.8 mg, 57% yield; white solid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IA**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 9.331 min, t_r (minor) = 7.797 min, ee = 84%; minor isomer: t_r(major) = 10.131 min, t_r (minor) = 8.821 min, ee = 22%. *anti:syn* = 4:1. $[\alpha]^{21}_D$ = +85.6 (*c* = 0.72, in CH_2Cl_2). **MP**: 36 – 39 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.45 – 7.39 (m, 2H), 7.38 – 7.33 (m, 2H), 6.24 – 6.13 (m 1H), 5.81 (s, 1H), 5.36 (d, *J* = 11.6 Hz, 1H), 5.19 – 5.14 (m 1H), 5.14 – 5.07 (m 1H), 4.02 – 3.94 (m 1H), 2.43 (s, 6H), 2.33 (s, 3H), 2.17 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.5, 151.6, 144.6, 143.4, 138.8, 128.8, 125.5, 125.2 (q, J_{CF} = 4.0 Hz, J_{CF} = 8.0 Hz), 122.8, 116.6, 111.4, 66.2, 49.5, 41.3, 14.3, 13.8 ppm. **^{19}F{^{1}H} NMR** (376 MHz, Chloroform-*d*) δ = –62.53 ppm. **IR** (neat): ν (cm^{-1}) 2936, 1714, 1380, 1327, 1166, 1126, 1068, 959, 824, 710. **HRMS** (ESI-FT) calcd for $C_{19}H_{23}F_3N_3O^+$ ([M]+H^+) = 366.1788, found 366.1788.



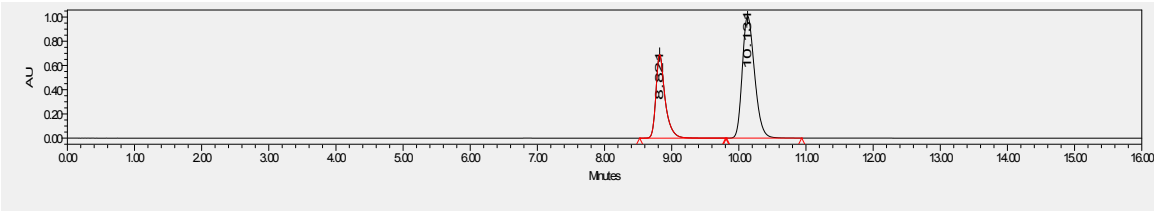
	Retention Time	Area	% Area
1	7.836	3748673	49.93
2	9.304	3758589	50.07



	Retention Time	Area	% Area
1	7.797	2085249	8.12
2	9.331	23610504	91.88

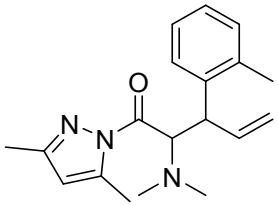


	Retention Time	Area	% Area
1	9.177	18072657	49.88
2	10.202	18161938	50.12



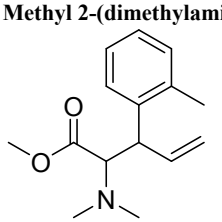
	Retention Time	Area	% Area
1	8.821	6550336	33.85
2	10.131	12800855	66.15

1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(o-tolyl)pent-4-en-1-one (3n)

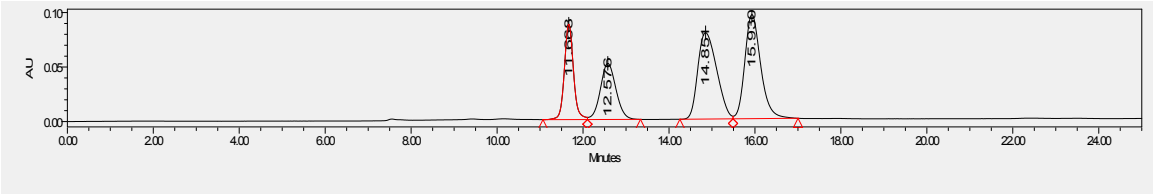


33.5 mg, 54% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.42 – 6.94 (m 4H), 5.97 (s, 1H), 5.73 – 5.62 (m 1H), 5.54 (d, *J* = 11.6 Hz, 1H), 5.12 – 4.82 (m, 2H), 4.25 – 4.13 (m 1H), 2.57 (d, *J* = 0.8 Hz, 3H), 2.40 (s, 3H), 2.26 (s, 9H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 172.1, 170.8, 151.5, 151.3, 143.6, 143.2, 139.5, 138.6, 138.4, 138.12, 136.4, 136.1, 130.6, 130.4, 127.4, 127.4, 126.3, 126.2, 126.1, 125.8, 116.4, 115.6, 111.6, 111.1, 66.2, 65.0, 45.6, 44.2, 41.4, 41.3, 19.9, 19.6, 14.7, 14.3, 13.9, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2933, 2786, 1713, 1583, 1454, 1409, 1378, 1352, 1324, 1173, 1030, 960, 918, 813, 755, 664, 627, 507, 454, 421. **HRMS** (ESI-FT) calcd for $C_{19}H_{26}N_3O^+$ ([M]+H$^+$) = 312.2070, found 312.2073.

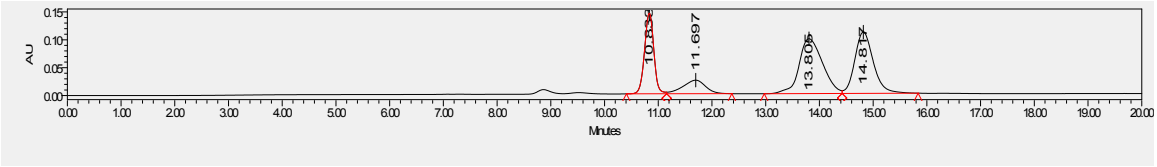
Methyl 2-(dimethylamino)-3-(o-tolyl)pent-4-enoate (4n)



24.4 mg, 91% yield; colorless liquid; R_f = 0.5 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **OJH**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 13.805 min, t_r (minor) = 14.817 min, ee = 6%; minor isomer: t_r(major) = 10.833 min, t_r (minor) = 11.697 min, ee = 42%. *anti:syn* = 30:70. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.23 – 7.05 (m, 4H), 6.10 – 5.66 (m, 1H), 5,10 – 4.96 (m, 2H), 4.11 – 3.96 (m, 1H), 3.73 – 3.67 (m, 1H), 3.71 (s, 3H), 2.37 (s, 3H), 2.23 (s, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.4, 170.1, 139.0, 138.6, 138.1, 138.0, 136.4, 136.1, 130.7, 130.6, 126.9, 126.8, 126.5, 126.3, 126.1, 116.6, 115.6, 71.3, 70.1, 50.7, 50.5, 45.5, 44.1, 41.5, 41.4, 19.8, 19.5 ppm. **IR** (neat): ν (cm^{-1}) 2946, 2787, 1730, 1456, 1160, 1036, 983, 918, 756, 667, 453. **HRMS** (ESI-FT) calcd for $C_{15}H_{22}NO_2^+$ ([M]+H$^+$) = 248.1645, found 248.1644.

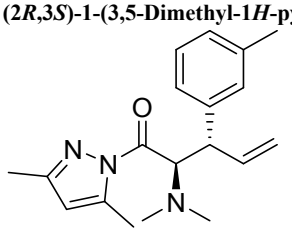


	Retention Time	Area	% Area
1	11.668	1284528	17.25
2	12.576	1294352	17.38
3	14.851	2412728	32.40
4	15.930	2454417	32.96



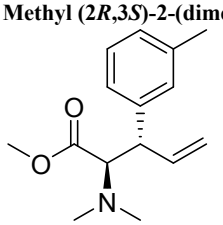
	Retention Time	Area	% Area
1	10.833	1736651	21.51
2	11.697	713154	8.83
3	13.805	2989874	37.04
4	14.817	2633118	32.62

(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(*m*-tolyl)pent-4-en-1-one (3o)

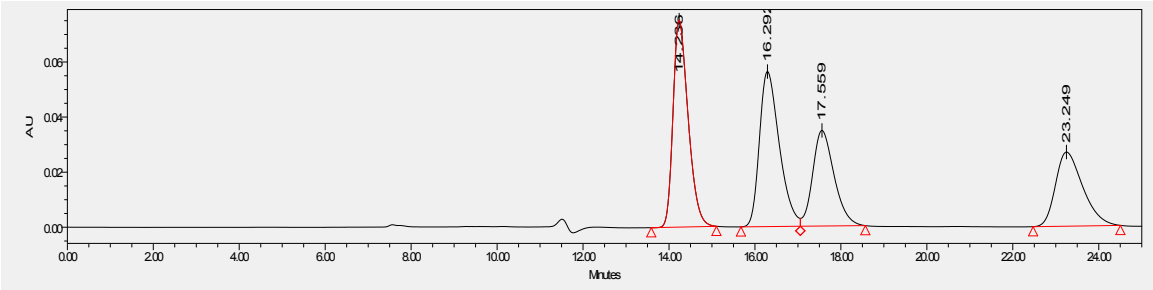


52.0 mg, 83% yield; colorless liquid; R_f = 0.7 (petroleum ether/ethyl acetate = 10/1). $[\alpha]^{25}_D$ = +88.5 (*c* = 1.07, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.10 – 6.99 (m, 3H), 6.91 – 6.83 (m, 1H), 6.25 – 6.12 (m 1H), 5.77(s, 1H), 5.36 (d, *J* = 11.6 Hz, 1H), 5.18 – 5.09 (m, 2H), 3.91 – 3.82 (m 1H), 2.46 (s, 6H), 2.30 (s, 3H), 2.21 (s, 3H), 2.18 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.2, 151.2, 143.3, 140.1, 139.8, 137.7, 129.2, 128.1, 127.3, 125.5, 115.7, 111.1, 66.3, 50.1, 41.3, 21.3, 14.3, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2931, 2787, 1714, 1584, 1452, 1410, 1378, 1349, 1302, 1221, 1174, 1034, 959, 913, 818, 763, 704, 674. **HRMS** (ESI-FT) calcd for $C_{19}H_{26}N_3O^+$ ([M]+H^+) = 312.2070, found 312.2073

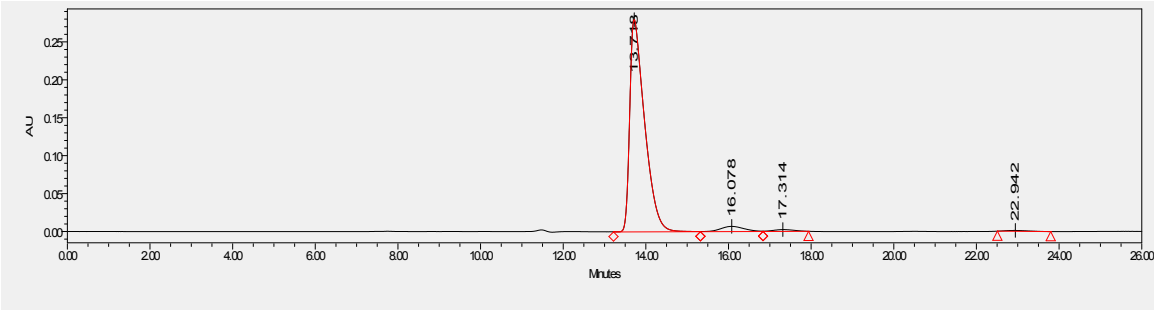
Methyl (2*R*,3*S*)-2-(dimethylamino)-3-(*m*-tolyl)pent-4-enoate (4o)



40.5 mg, 98% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **OJH**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 13.718 min, t_r (minor) = 16.078 min, ee = 92%; minor isomer: t_r(major) = 17.314 min, t_r (minor) = 22.942 min, ee = 31%. *anti:syn* = 98:2. $[\alpha]^{24}_D$ = +91.3 (*c* = 0.62, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.08 – 7.13 (m, 1H), 7.02 – 6.96 (m, 3H), 6.16 – 6.05 (m, 1H), 5.14 – 5.07 (m, 2H), 3.75 – 3.68 (m, 1H), 3.57 (d, *J* = 11.6 Hz, 1H), 3.43 (s, 3H), 2.39 (s, 6H), 2.31 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.2, 140.7, 139.0, 138.2, 128.9, 128.4, 127.6, 125.1, 115.9, 71.7, 50.5, 49.7, 41.3, 21.5 ppm. **IR** (neat): ν (cm^{-1}) 2943, 2788, 1731, 1607, 1454, 1342, 1159, 1039, 983, 914, 776, 705. **HRMS** (ESI-FT) calcd for $C_{15}H_{22}NO_2^+$ ([M]+H^+) = 248.1645, found 248.1647.

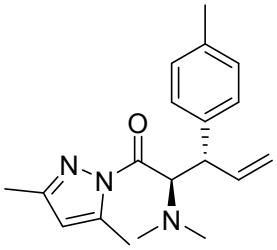


	Retention Time	Area	% Area
1	14.236	1836143	30.40
2	16.292	1811517	29.99
3	17.559	1206933	19.98
4	23.249	1185349	19.63



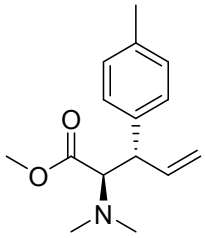
	Retention Time	Area	% Area
1	13.718	7005094	94.61
2	16.078	270594	3.65
3	17.314	84334	1.14
4	22.942	44362	0.60

(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(*p*-tolyl)pent-4-en-1-one (3p)

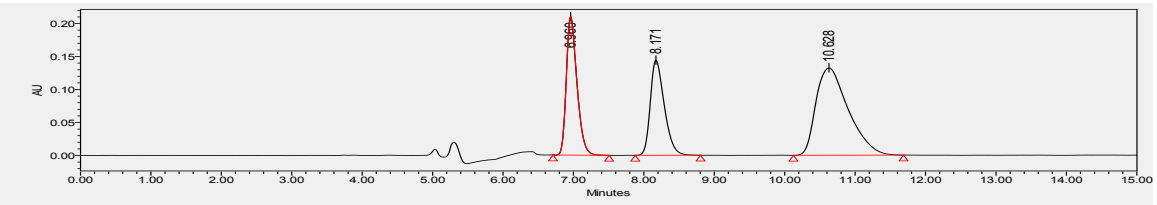


53.4 mg, 86% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). $[\alpha]^{26}_D$ = +107.4 (*c* = 0.86, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.13 (d, *J* = 8.0 Hz, 2H), 6.96 (d, *J* = 8.0 Hz, 2H), 6.23 – 6.12 (m 1H), 5.79(s, 1H), 5.35 (d, *J* = 11.6 Hz, 1H), 5.14 – 5.08 (m, 2H), 3.93 – 3.85 (m 1H), 2.43 (s, 6H), 2.33 (d, *J* = 0.4 Hz, 3H), 2.21 (s, 3H), 2.18 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.8, 151.2, 143.3, 140.0, 137.4, 136.0, 129.0, 128.3, 115.5, 111.1, 66.3, 49.4, 41.3, 21.0, 14.4, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2930, 2787, 1713, 1583, 1513, 1451, 1409, 1377, 1349, 1302, 1221, 1174, 1135, 1030, 959, 913, 877, 813, 759, 715, 654, 590, 526. **HRMS** (ESI-FT) calcd for $C_{19}H_{26}N_3O^+$ ([M]+H^+) = 312.2070, found 312.2071.

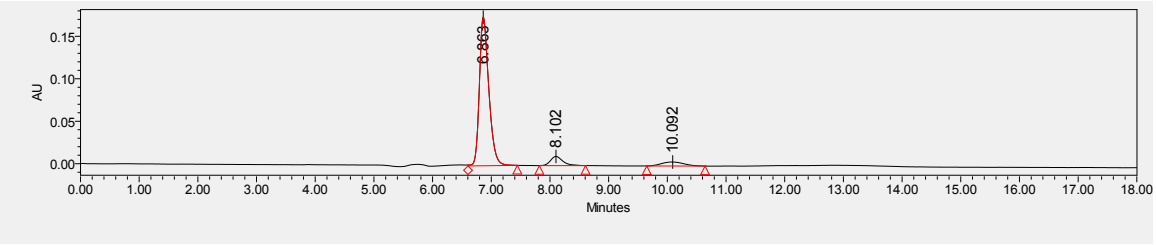
Methyl (2*R*,3*S*)-2-(dimethylamino)-3-(*p*-tolyl)pent-4-enoate (4p)



32.0 mg (from 42.7 mg **3p**), 94% yield; colorless liquid; R_f = 0.5 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **OJH**, hexane/iPrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm) major isomer: t_r (major) = 6.863 min, t_r (minor) = 10.092 min, ee = 85%. *anti:syn* = 93:7. $[\alpha]^{24}_D$ = +89.2 (*c* = 0.38, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.08 (s, 4H), 6.16 – 6.04 (m 1H), 5.14 – 5.05 (m, 2H), 3.76 – 3.67 (m 1H), 3.56 (d, *J* = 11.6 Hz, 1H), 3.44 (s, 3H), 2.39 (s, 6H), 2.29 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.2, 139.1, 137.7, 136.4, 129.3, 128.0, 115.8, 71.8, 50.6, 49.3, 41.3, 21.1 ppm. **IR** (neat): ν (cm^{-1}) 2946, 2787, 1730, 1456, 1160, 1036, 983, 918, 756, 667, 454. **HRMS** (ESI-FT) calcd for $C_{15}H_{22}NO_2^+$ ([M]+H^+) = 248.1645, found 248.1646.

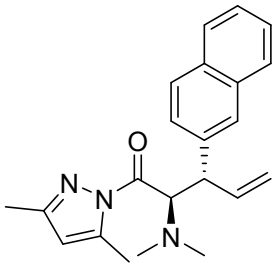


	Retention Time	Area	% Area
1	6.960	2203794	26.22
2	8.171	1985607	23.63
3	10.628	4214185	50.15

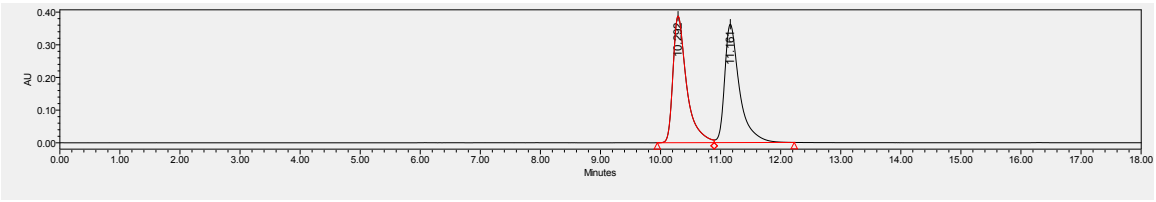


	Retention Time	Area	% Area
1	6.863	1949129	87.38
2	8.102	157460	7.06
3	10.092	123995	5.56

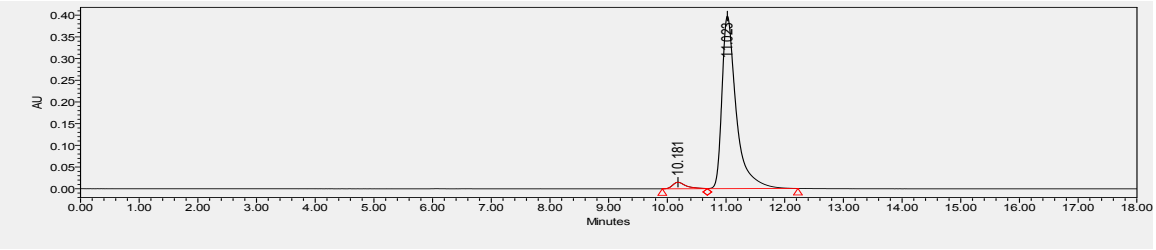
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(naphthalen-2-yl)pent-4-en-1-one (3q)



59.2 mg, 85% yield; white solid; R_f = 0.7 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IA**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 11.023 min, t_r (minor) = 10.181 min, ee = 93%. *anti:syn* > 19:1. $[\alpha]^{24}_D$ = +98.0 (*c* = 1.20, in CH_2Cl_2). **MP**: 83 – 87 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.76 – 7.64 (m, 4H), 7.43 – 7,34 (m, 3H), 6.35 – 6.24 (m 1H), 5.70 (s, 1H), 5.53 (d, *J* = 11.6 Hz, 1H), 5.19 (s, 1H), 5.18 – 5.13 (m, 1H), 4.15 – 4.07 (m 1H), 2.50 (s, 6H), 2.26 (s, 3H), 2.17 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.8, 151.3, 143.3, 139.6, 138.0, 133.5, 132.4, 127.9, 127.8, 127.5, 127.1, 127.0, 125.7, 125.4, 116.1, 111.2, 66.2, 49.8, 41.4, 14.3, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 2933, 2787, 1712, 1635, 1584, 1451, 1409, 1376, 1348, 1303, 1221, 1176, 1032, 958, 914, 855, 817, 750, 663, 621, 585, 478. **HRMS** (ESI-FT) calcd for $C_{22}H_{26}N_3O^+$ ([M]+H$^+$) = 348.2070, found 348.2068.

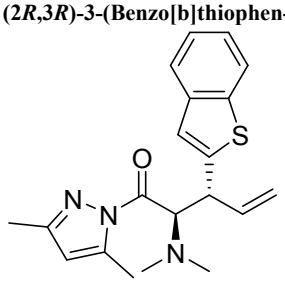


	Retention Time	Area	% Area
1	10.292	6108009	49.61
2	11.161	6204862	50.39

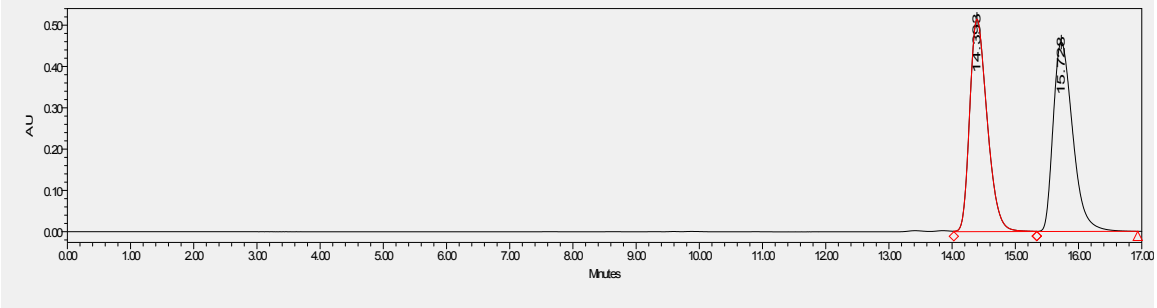


	Retention Time	Area	% Area
1	10.181	240346	3.45
2	11.023	6735453	96.55

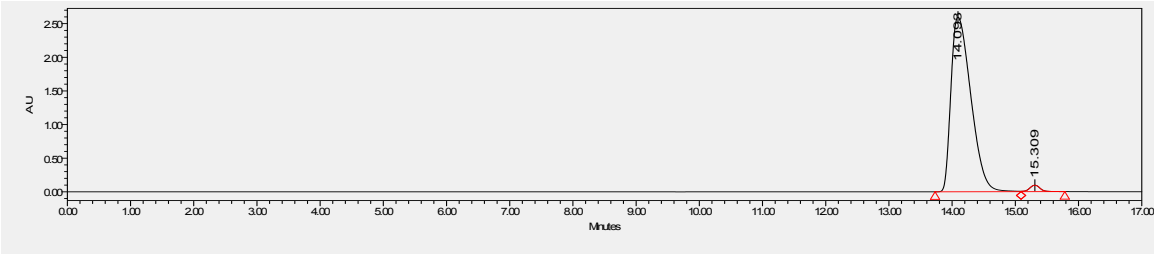
(2*R*,3*R*)-3-(Benzo[b]thiophen-2-yl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3r)



64.5 mg, 91% yield; pale yellow solid; R_f = 0.7 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **Lux 5u Cellulose-2**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 14.093 min, t_r (minor) = 15.309 min, ee = 93%. *anti:syn* > 19:1. $[\alpha]^{24}_D$ = +208.5 (*c* = 1.01, in CH_2Cl_2). **MP**: 87 – 92 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.69 (d, *J* = 12.0 Hz, 1H), 7.60 – 7,54 (m, 1H), 7.27 – 7.16 (m, 2H), 7.12 (s, 1H), 6.24 – 6.12 (m, 1H), 5.82 (s, 1H), 5.39 (d, *J* = 11.6 Hz, 1H), 5.27 – 5.18 (m, 2H), 4.35 – 4.27 (m 1H), 2.43 – 2.38 (m, 9H), 2.20 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 169.8, 151.7, 145.0, 143.6, 139.9, 139.5, 138.6, 123.9, 123.6, 123.2, 122.1, 121.3, 116.7, 111.5, 66.7, 45.0, 41.3, 14.5, 13.9 ppm. **IR** (neat): ν (cm^{-1}) 2945, 2786, 1704, 1588, 1434, 1410, 1377, 1352, 1299, 1218, 1029, 963, 861, 825, 753, 621. **HRMS** (ESI-FT) calcd for $C_{20}H_{24}N_3OS^+$ ([M]+H^+) = 354.1635, found 354.1632.

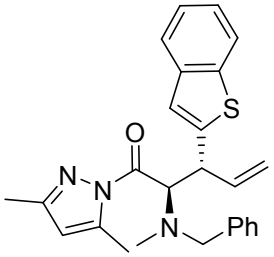


	Retention Time	Area	% Area
1	14.393	9873589	50.07
2	15.728	9846799	49.93

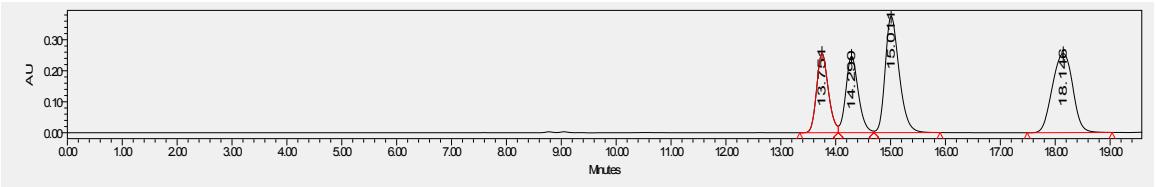


	Retention Time	Area	% Area
1	14.093	56835128	98.09
2	15.309	1109409	1.91

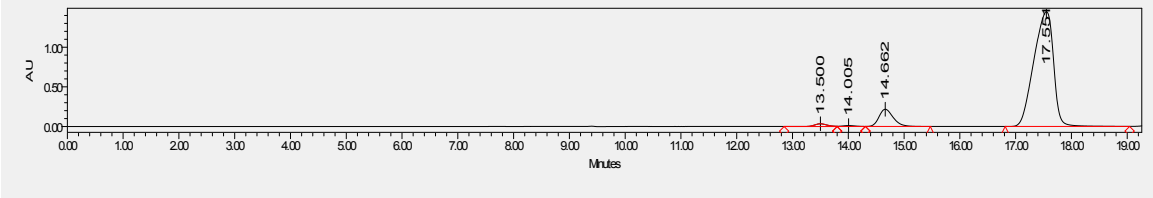
(2*R*,3*R*)-3-(Benzo[b]thiophen-2-yl)-2-(benzyl(methyl)amino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)pent-4-en-1-one (3s)



52.0 mg, 60% yield; white solid; R_f = 0.8 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IF**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 17.551 min, t_r (minor) = 14.662 min, ee = 80%; minor isomer: t_r(major) = 13.500 min, t_r (minor) = 14.005 min, ee = 49%. *anti:syn* = 98:2. $[\alpha]^{25}_D$ = +123.6 (*c* = 0.45, in CH_2Cl_2). **MP**: 73 – 76 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.72 – 7.68 (m, 1H), 7.60 – 7.56 (m, 1H), 7.34 – 7.17 (m, 7H), 7.12 (s, 1H), 6.33 – 6.22 (m 1H), 5.86 (s, 1H), 5.52 (d, *J* = 11.6 Hz, 1H), 5.26 (s, 1H), 5.24 – 5.20 (m, 1H), 4.46 – 4.39 (m 1H), 3.77 (d, *J* = 2.8 Hz, 2H), 2.44 (d, *J* = 0.4 Hz, 3H), 2.28 (s, 3H) , 2.20 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.2, 151.7, 145.0, 143.8, 139.9, 139.8, 139.5, 138.8, 128.6, 128.1, 126.9, 123.9, 123.6, 123.2, 122.1, 121.4, 116.8, 111.5, 66.9, 58.4, 45.1, 37.2, 14.5, 13.8 ppm. **IR** (neat): ν (cm^{-1}) 1710, 1584, 1452, 1377, 1352, 1300, 1216, 1133, 1025, 960, 917, 825, 740, 700, 624, 472, 431. **HRMS** (ESI-FT) calcd for $C_{26}H_{28}N_3OS^+$ ([M]+H^+) = 430.1948, found 430.1949.

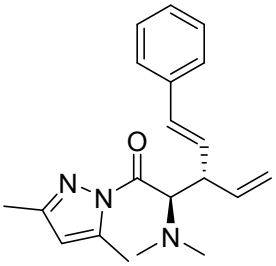


	Retention Time	Area	% Area
1	13.751	3811840	18.19
2	14.290	3909445	18.66
3	15.011	6631763	31.65
4	18.146	6599897	31.50

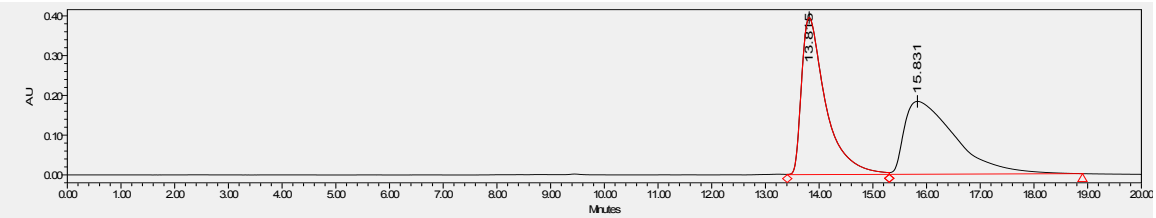


	Retention Time	Area	% Area
1	13.500	546694	1.37
2	14.005	186833	0.47
3	14.662	3851022	9.63
4	17.551	35424681	88.54

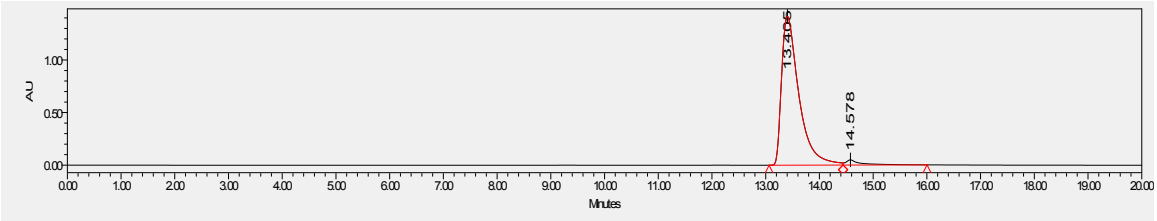
(2*R*,3*S*,*E*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-5-phenyl-3-vinylpent-4-en-1-one (3t)



53.0 mg, 82% yield; pale yellow liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IE**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 13.405 min, t_r (minor) = 14.578 min, ee = 94%. *anti:syn* > 19:1. $[\alpha]^{24}_D$ = +33.6 (*c* = 0.79, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.25 – 7.13 (m, 5H), 6.42 (d, *J* = 15.6 Hz, 1H), 6.10 – 5.99 (m, 2H), 5.88 (d, *J* = 0.8 Hz, 1H), 5.26 – 5.17 (m, 2H), 5.06 (d, *J* = 11.2 Hz, 1H), 3.60 – 3.50 (m 1H), 2.47 (d, *J* = 0.8 Hz, 3H), 2.43 (s, 6H), 2.23 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 171.7, 151.6, 143.6, 138.1, 137.3, 131.8, 128.5, 128.3, 127.2, 126.2, 116.2, 111.5, 66.0, 47.6, 41.3, 14.6, 13.9 ppm. **IR** (neat): ν (cm^{-1}) 2933, 2788, 1715, 1584, 1451, 1410, 1379, 1348, 1303, 1220, 1175, 1033, 961, 915, 811, 754, 694. **HRMS** (ESI-FT) calcd for $C_{20}H_{26}N_3O^+$ ([M]+H$^+$) = 324.2070, found 324.2069.

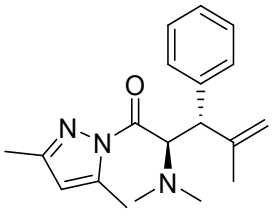


	Retention Time	Area	% Area
1	13.815	12308584	50.47
2	15.831	12080095	49.53



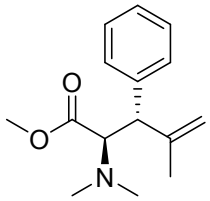
	Retention Time	Area	% Area
1	13.405	31652467	96.95
2	14.578	997354	3.05

(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-4-methyl-3-phenylpent-4-en-1-one (3u)

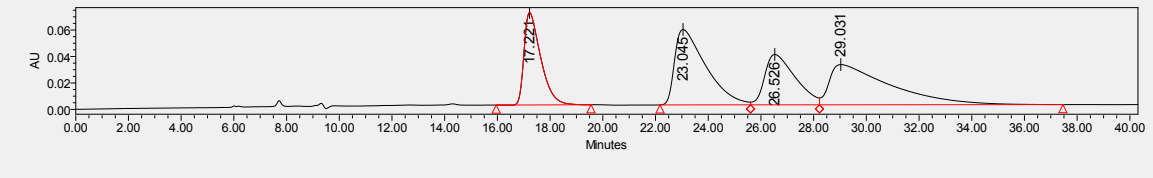


59.1 mg, 95% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). $[\alpha]^{25}_D$ = +145.6 (*c* = 1.16, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.33 – 7.28 (m, 2H), 7.18 – 7.06 (m, 2H), 7.10 – 7.04 (m 1H), 5.84 (s, 1H), 5.62 (d, *J* = 12.4 Hz, 1H), 5.13 (s, 1H), 4.88 (t, *J* = 1.6 Hz,, 1H), 4.05 (d, *J* = 12.4 Hz, 1H), 2.42 (s, 6H), 2.32 (d, *J* = 0.8 Hz, 3H), 2.26 (s, 3H), 1.75 (s, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.5, 151.4, 146.0, 143.4, 139.9, 128.3, 128.1, 126.5, 112.5, 111.2, 63.1, 52.8, 41.4, 18.8, 14.4, 13.9 ppm. **IR** (neat): ν (cm^{-1}) 2933, 2786, 1714, 1644, 1583, 1450, 1410, 1377, 1352, 1218, 1175, 1030, 958, 888, 802, 755, 700, 624, 593, 535. **HRMS** (ESI-FT) calcd for $C_{19}H_{26}N_3O^+$ ([M]+H^+) = 312.2070, found 312.2069.

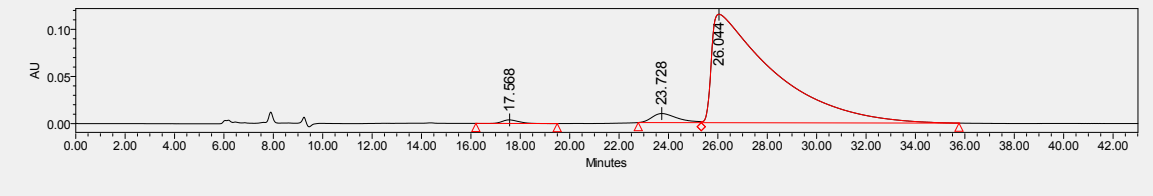
Methyl (2*R*,3*S*)-2-(dimethylamino)-4-methyl-3-phenylpent-4-enoate (4u)



19.8 mg (from 27.1 mg **3u**), 92% yield; colorless solid; R_f = 0.5 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **OJH**, hexane/iPrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 26.044 min, t_r (minor) = 17.568 min, ee = 98%. *anti:syn* = 97:3. $[\alpha]^{23}_D$ = +120.0 (*c* = 0.10, in CH_2Cl_2). **MP**: 79 – 84 °C. **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.29 – 7.22 (m, 4H), 7.22 – 7.15 (m, 1H), 5.05 (d, *J* = 0.4 Hz, 1H), 4.87 (t, *J* = 1.6 Hz, 1H), 3.85 (s, 2H), 3.45 (s, 3H), 2.39 (s, 6H), 1.66 (d, *J* = 0.4 Hz, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.1, 145.2, 139.9, 128.3, 128.0, 126.8, 112.5, 68.1, 52.6, 50.6, 41.5, 19.0 ppm. **IR** (neat): ν (cm^{-1}) 2948, 2785, 1713, 1641, 1494, 1451, 1364, 1250, 1160, 1030, 983, 885, 761, 706, 622, 539. **HRMS** (ESI-FT) calcd for $C_{15}H_{22}NO_2^+$ ([M]+H^+) = 248.1645, found 248.1647.

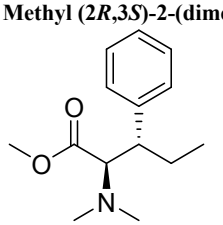


	Retention Time	Area	% Area
1	17.221	3056366	19.51
2	23.045	4679408	29.87
3	26.526	3062710	19.55
4	29.031	4867796	31.07

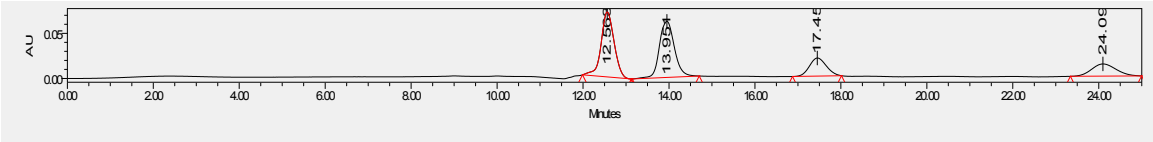


	Retention Time	Area	% Area
1	17.568	178331	0.86
2	23.728	684091	3.29
3	26.044	19949849	95.86

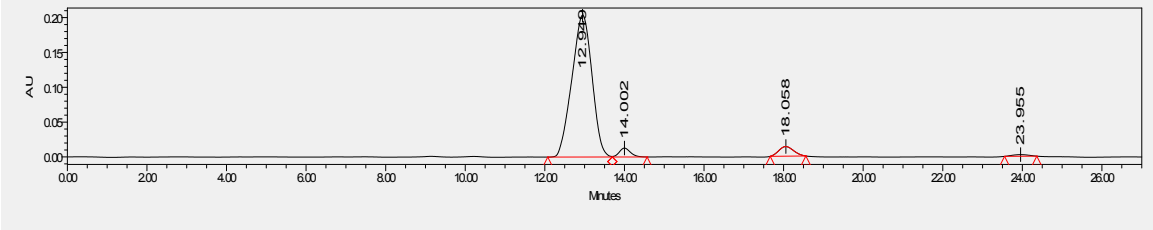
Methyl (2*R*,3*S*)-2-(dimethylamino)-3-phenylpentanoate (5a)



35.2 mg, 88% yield; colorless liquid; R_f = 0.6 (petroleum ether/ethyl acetate = 10/1). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **OJH**, hexane/iPrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm) major isomer: t_r (major) = 12.949 min, t_r (minor) = 14.002 min, ee = 93%; minor isomer: t_r(major) = 18.058 min, t_r (minor) = 23.955 min, ee = 69%. *anti:syn* = 95:5. $[\alpha]^{25}_D$ = +21.6 (*c* = 0.54, in CH_2Cl_2, λ = 436 nm). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.29 – 7.23 (m, 2H), 7.21 – 7.13 (m, 3H), 7.38 (d, *J* = 7.2 Hz, 1H), 3.34 (s, 3H), 2.92 – 2.83 (m, 1H), 2.37 (s, 6H), 2,15 – 2.03 (m, 1H), 1.56 – 1.43 (m, 1H), 0.72 (t, *J* = 12.0 Hz, 3H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 170.8, 141.3, 128.6, 128.2, 126.6, 72.5, 50.3, 46.9, 41.3, 24.8, 11.5 ppm. **IR** (neat): ν (cm^{-1}) 2936, 2788, 1730, 1453, 1328, 1156, 1100, 1040, 972, 893, 757, 699, 612, 557, 525. **HRMS** (ESI-FT) calcd for $C_{14}H_{22}NO_2^+$ ([M]+H^+) = 236.1645, found 236.1649.

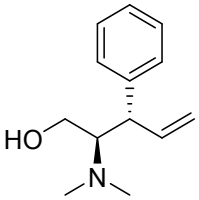


	Retention Time	Area	% Area
1	12.563	1508574	36.82
2	13.951	1507490	36.79
3	17.451	546159	13.33
4	24.098	535188	13.06

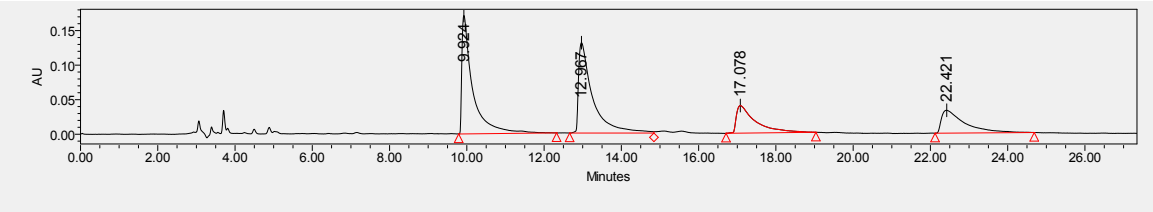


	Retention Time	Area	% Area
1	12.949	7172153	91.42
2	14.002	249183	3.18
3	18.058	357307	4.55
4	23.955	66571	0.85

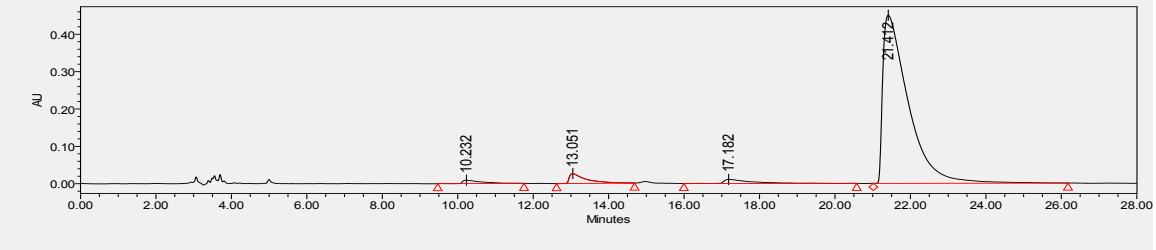
(2*R*,3*S*)-2-(Dimethylamino)-3-phenylpent-4-en-1-ol (6a)



18.3 mg, 71% yield; colorless liquid; R_f = 0.2 (ethyl acetate). Dissolved in hexane for HPLC; **HPLC** (Chiralcel **IH**, hexane/iPrOH = 96/4, flow rate 1 mL/min, λ = 210 nm) major isomer: t_r (major) = 21.412 min, t_r (minor) = 17.182 min, ee = 95%; minor isomer: t_r(major) = 13.051 min, t_r (minor) = 10.232 min, ee = 45%. *anti:syn* = 95:5. $[\alpha]^{20}_D$ = +105.3 (*c* = 0.28, in CH_2Cl_2). **^{1}H NMR** (400 MHz, Chloroform-*d*) δ = 7.32 – 7.25 (m, 2H), 7.22 – 7.17 (m, 1H), 7.16 – 7.11 (m, 2H), 6.23 – 6.11 (m, 1H), 5.15 – 5.08 (m, 1H), 5.07 – 5.02 (m, 1H), 3.52 – 3.43 (m, 1H), 3.12 – 2.96 (m, 3H), 2.55 (s, 6H) ppm. **^{13}C{^{1}H} NMR** (100 MHz, Chloroform-*d*) δ = 141.6, 141.2, 128.9, 127.5, 126.7, 115.6, 68.0, 59.7, 51.5, 40.6 ppm. **IR** (neat): ν (cm^{-1}) 3393, 2927, 1636, 1453, 1411, 1279, 1178, 1026, 913, 848, 751, 701, 525. HRMS (ESI-FT) calcd for $C_{13}H_{20}NO^+$ ([M]+H$^+$) = 206.1539, found 206.1542.

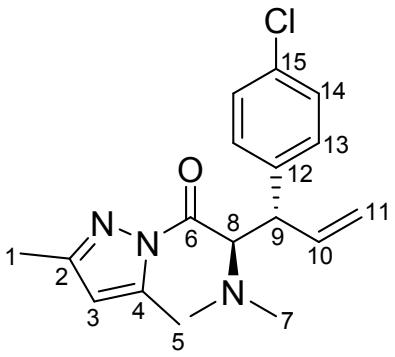


	Retention Time	Area	% Area
1	9.924	3340501	35.46
2	12.967	3318066	35.22
3	17.078	1375223	14.60
4	22.421	1387380	14.73



	Retention Time	Area	% Area
1	10.232	310040	1.36
2	13.051	819346	3.60
3	17.182	538259	2.37
4	21.412	21085999	92.67

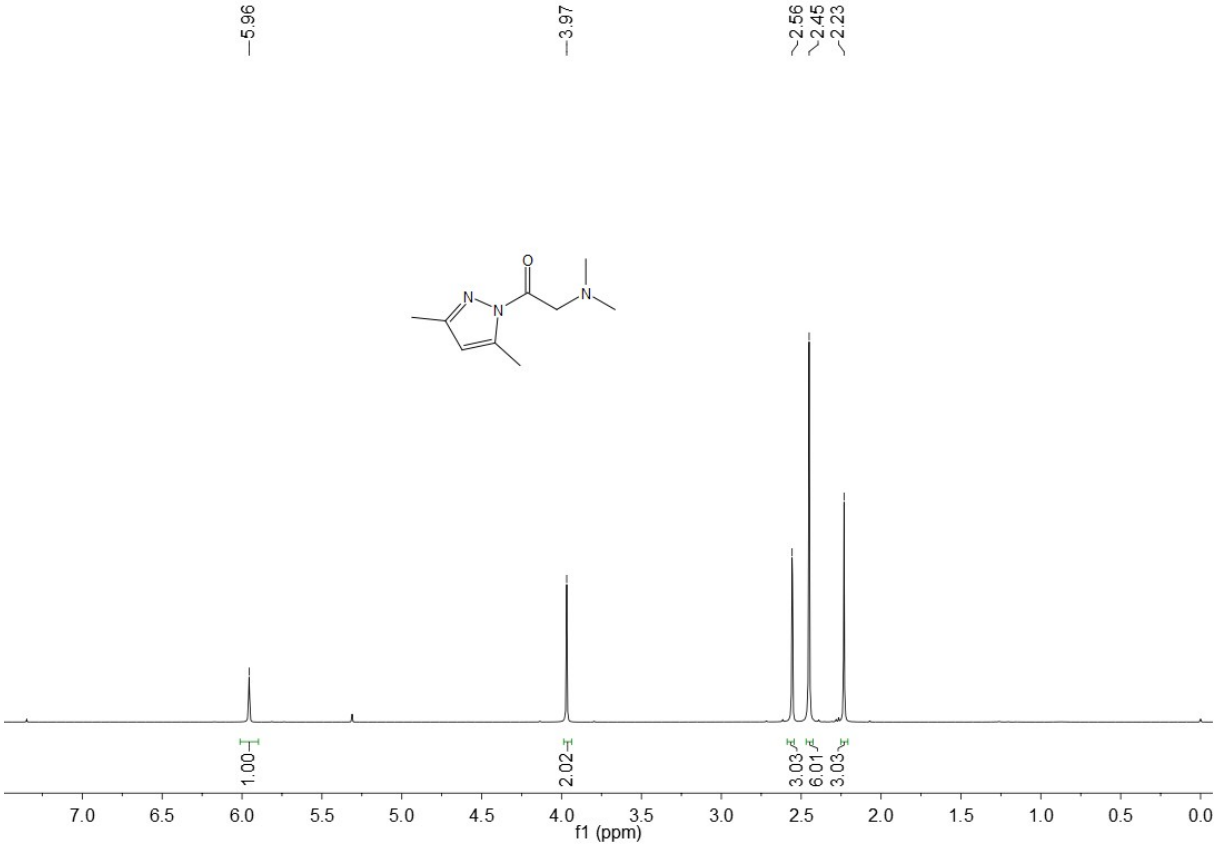
Analysis results of 2D NMR spectra of typical compounds (3h)

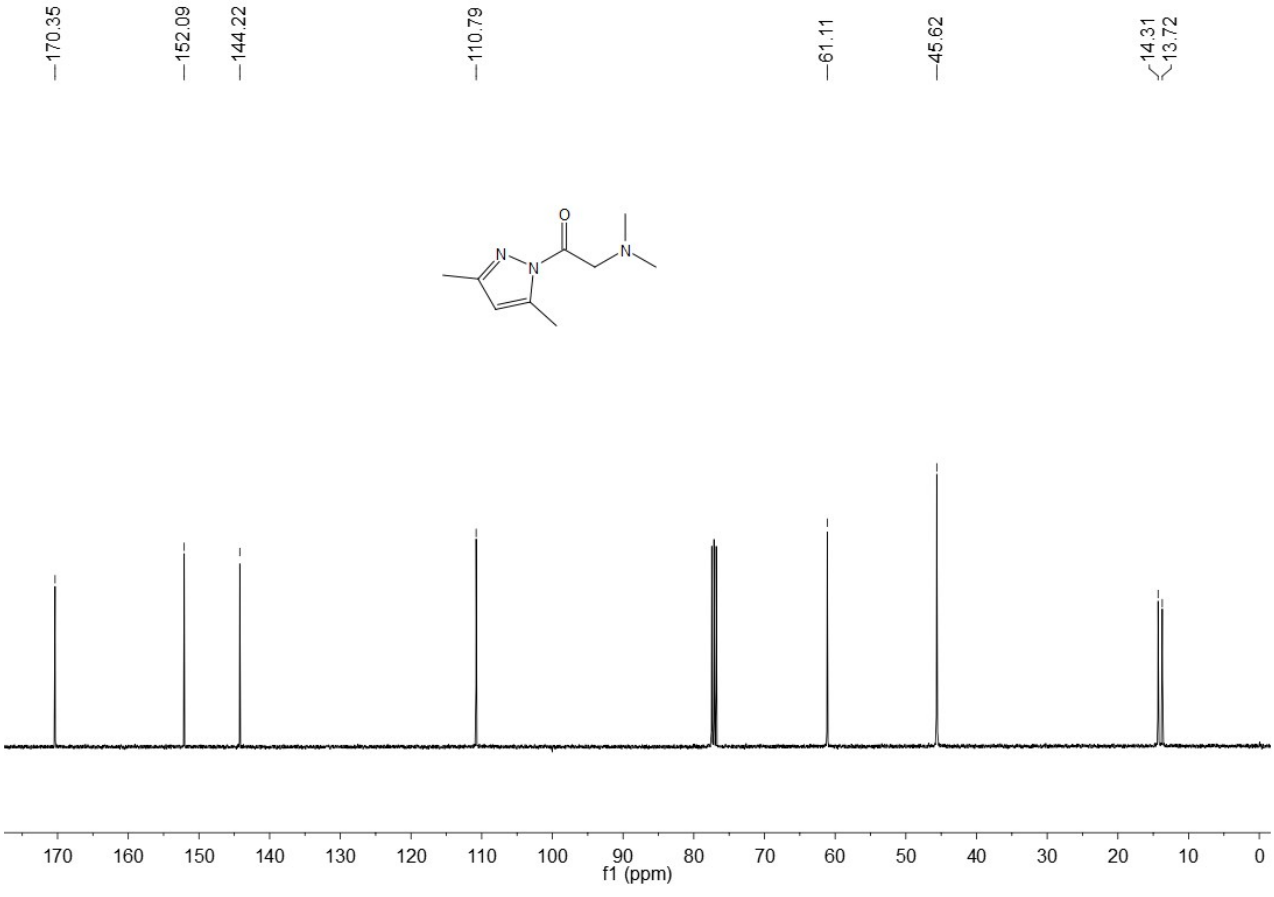


Number of Atom	C	H	Number of Atom	C	H
1	13.8	2.17	9	49.0	3.93 – 3.85
2	151.5		10	139.2	6.22 – 6.10
3	111.4	5.81	11	116.2	5.16 – 5.04
4	143.4		12	139.0	
5	14.4	2.34	13	129.9	7.20 – 7.15
6	170.6		14	128.4	7.15 – 7.10
7	41.3	2.42	15	132.3	
8	66.3	5.31			

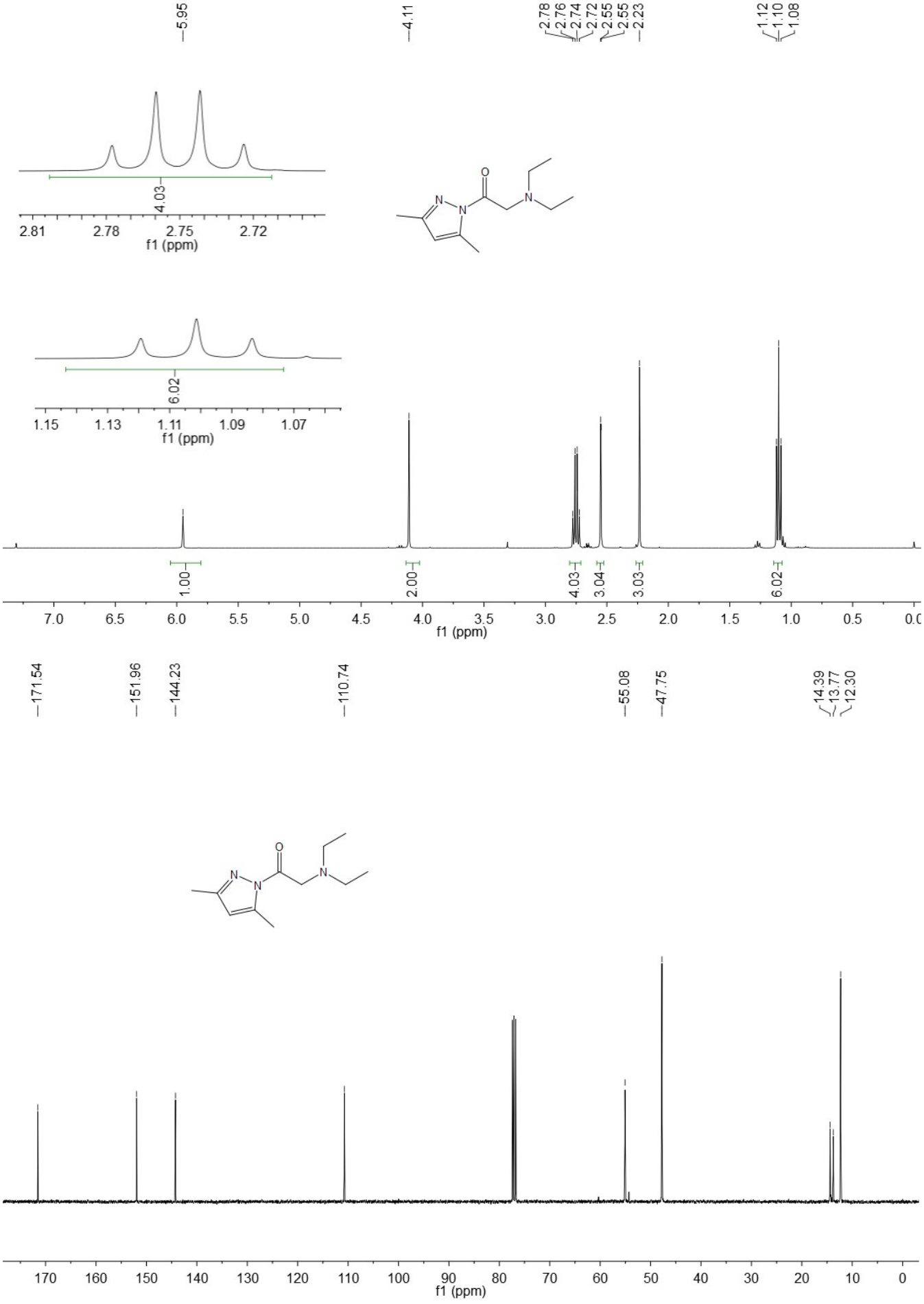
(I) Copies of NMR Spectra for Substrates and Products

1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)ethan-1-one (1a)

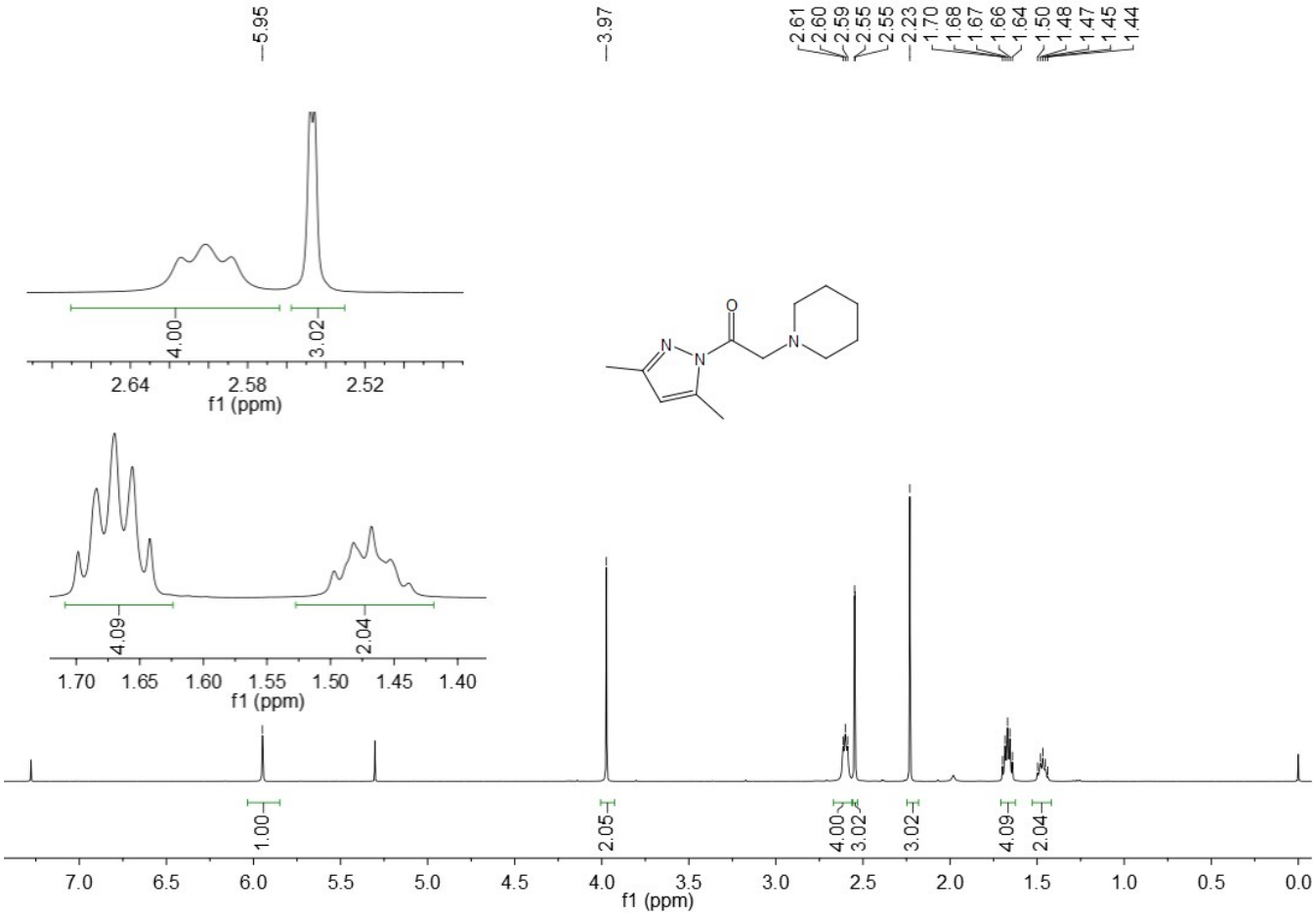


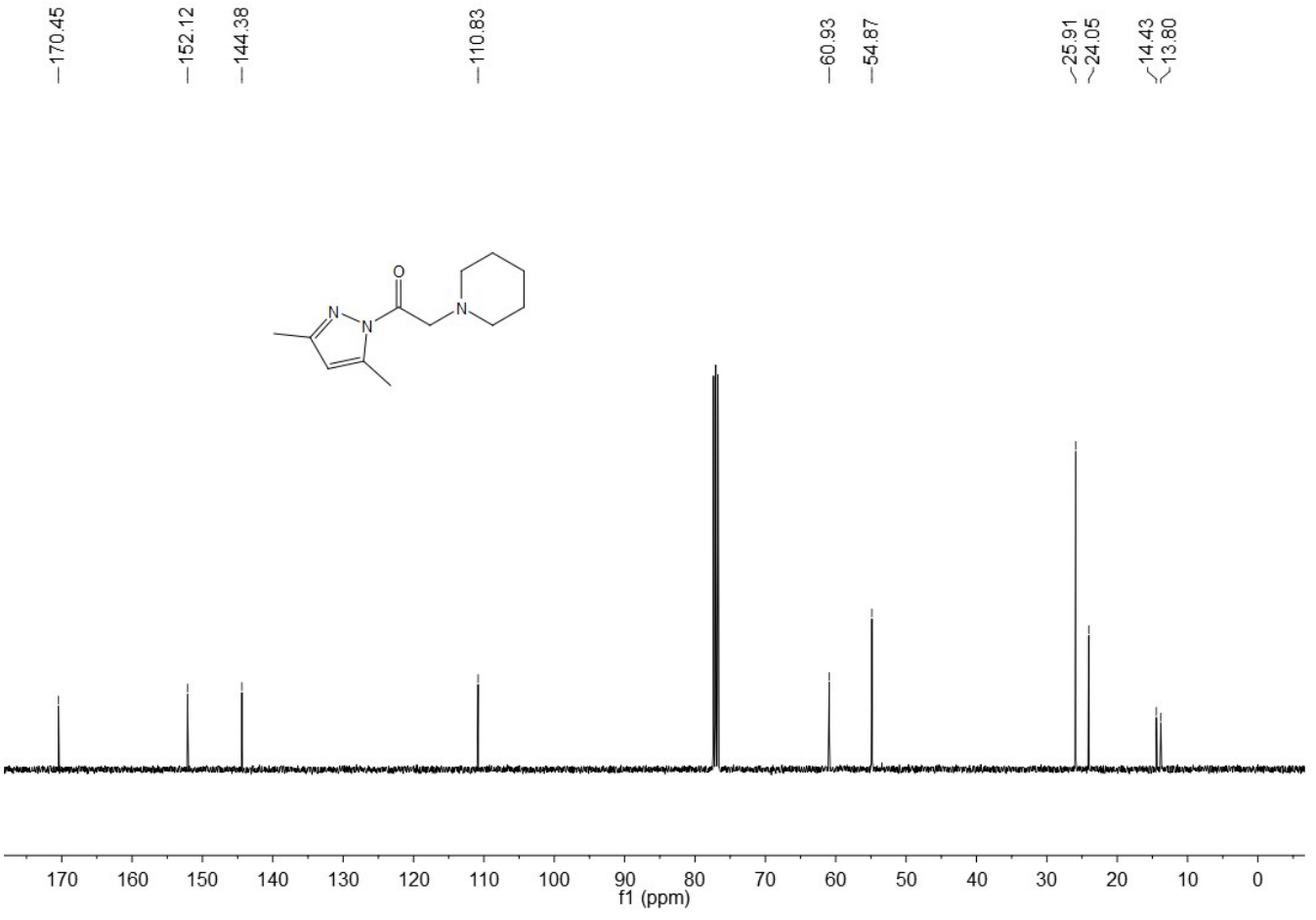


2-(Diethylamino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1b)

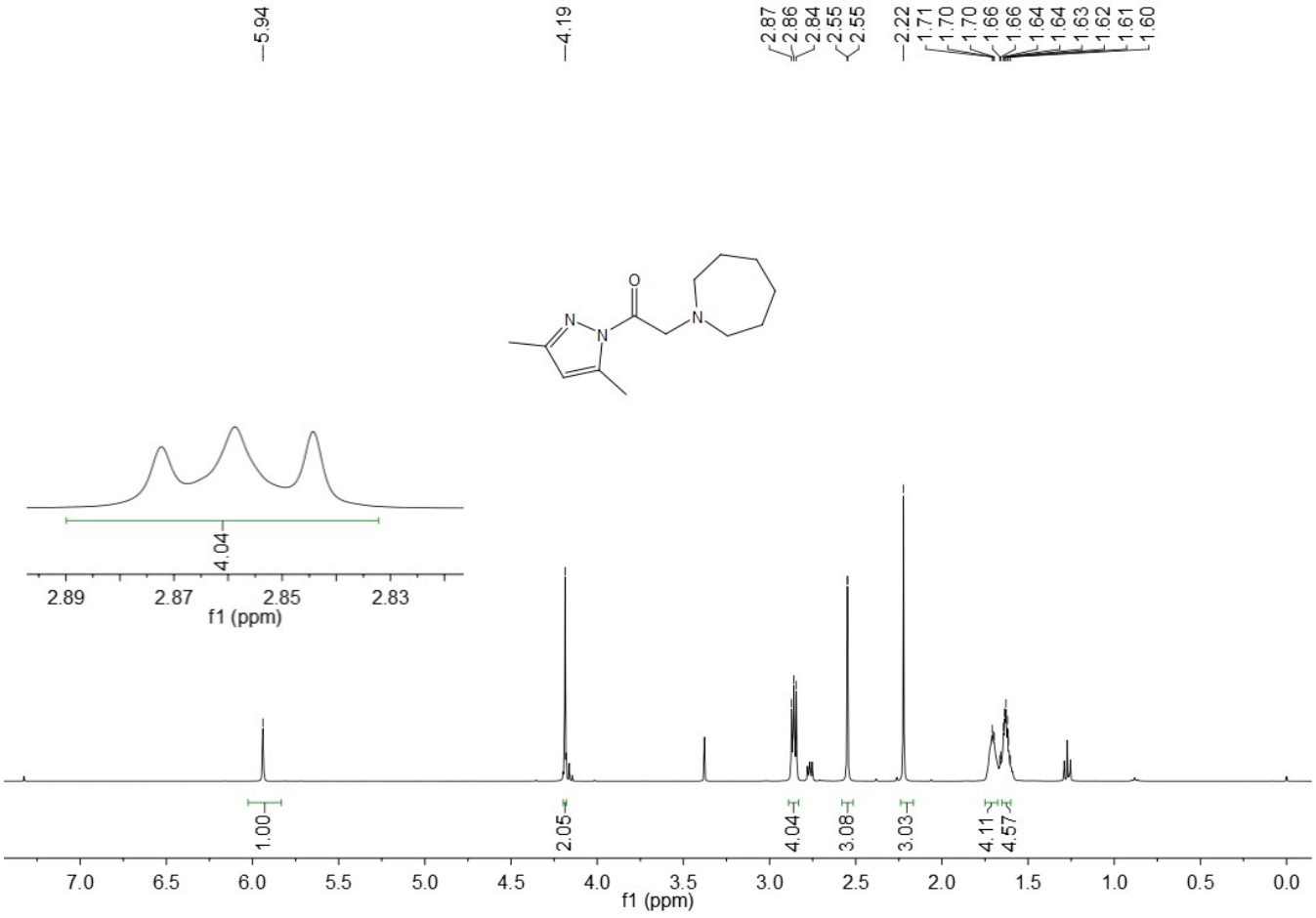


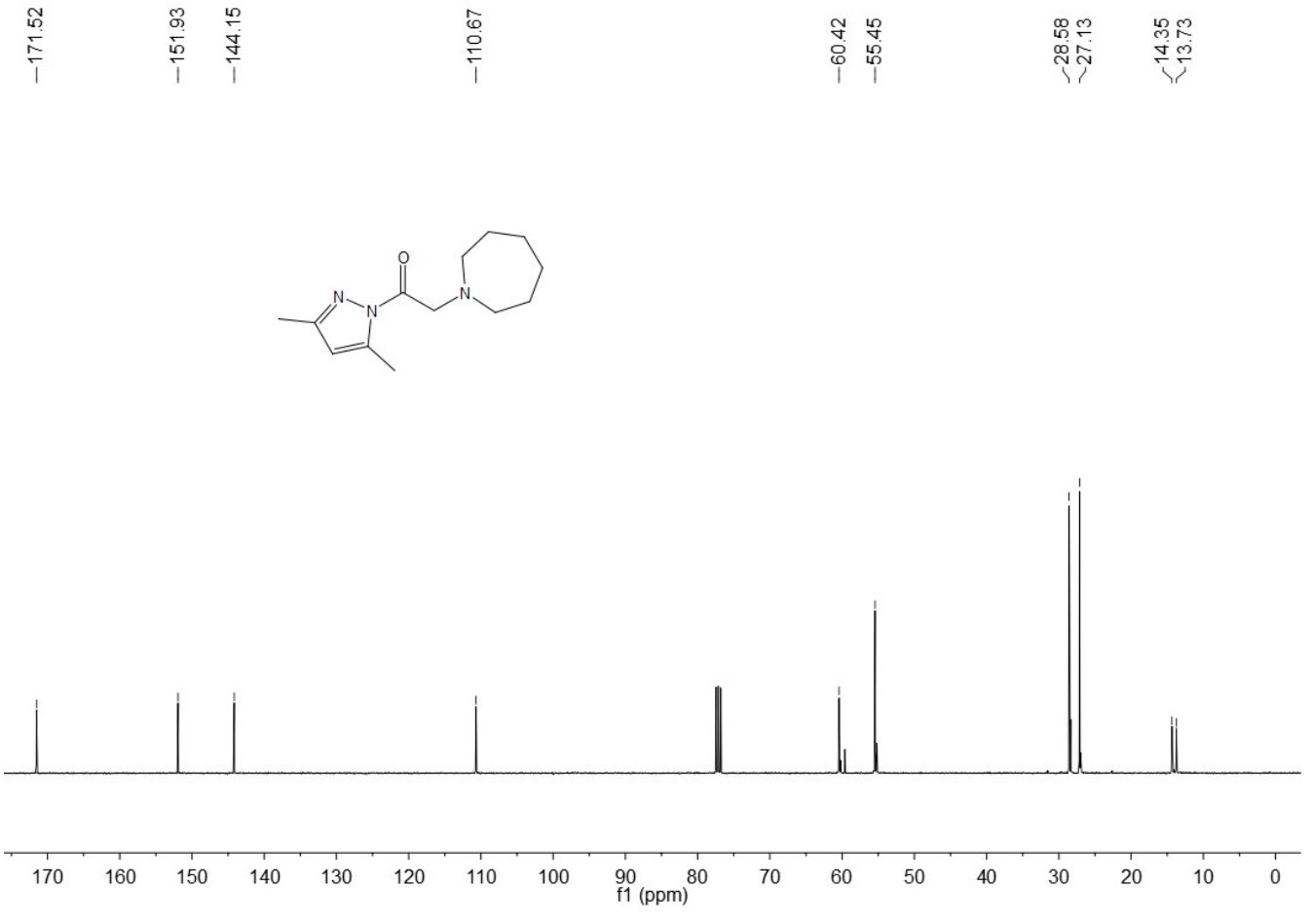
1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(piperidin-1-yl)ethan-1-one (1c)



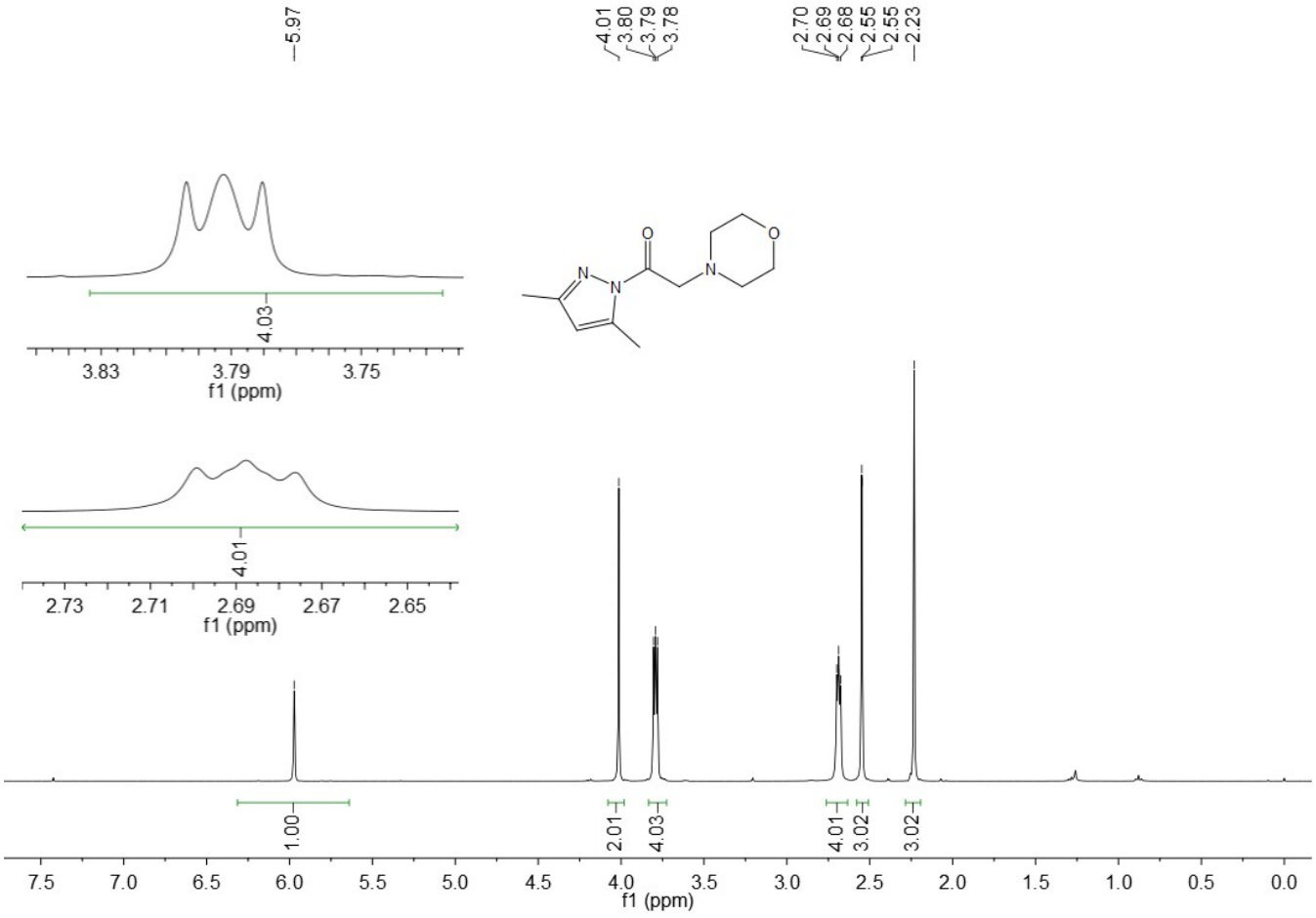


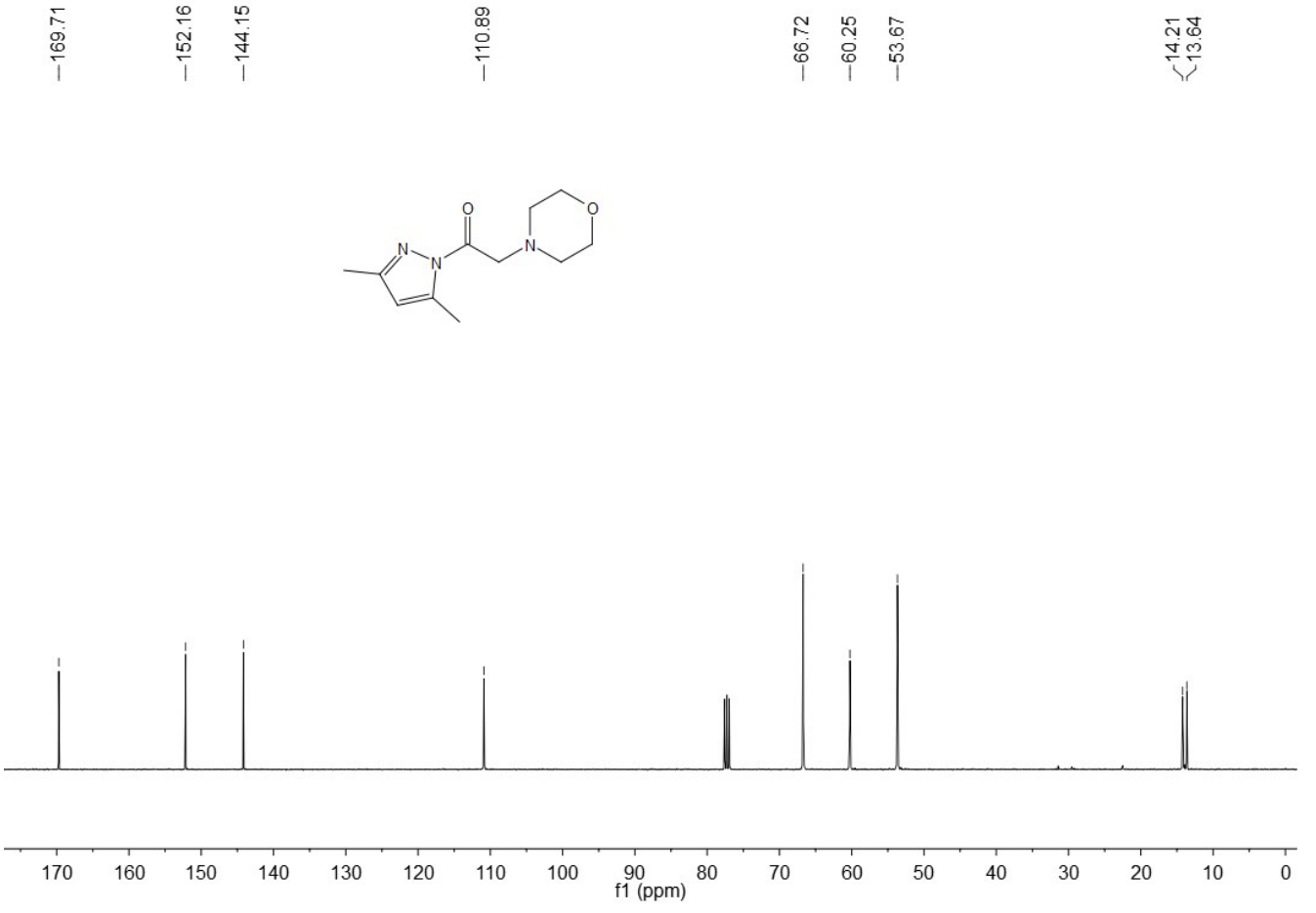
2-(Azepan-1-yl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1d)



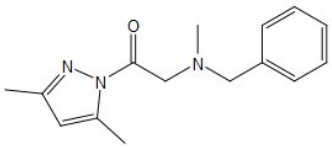


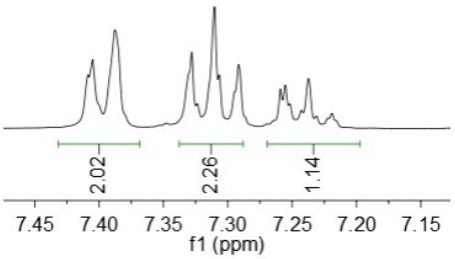
1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-morpholinoethan-1-one (1e)

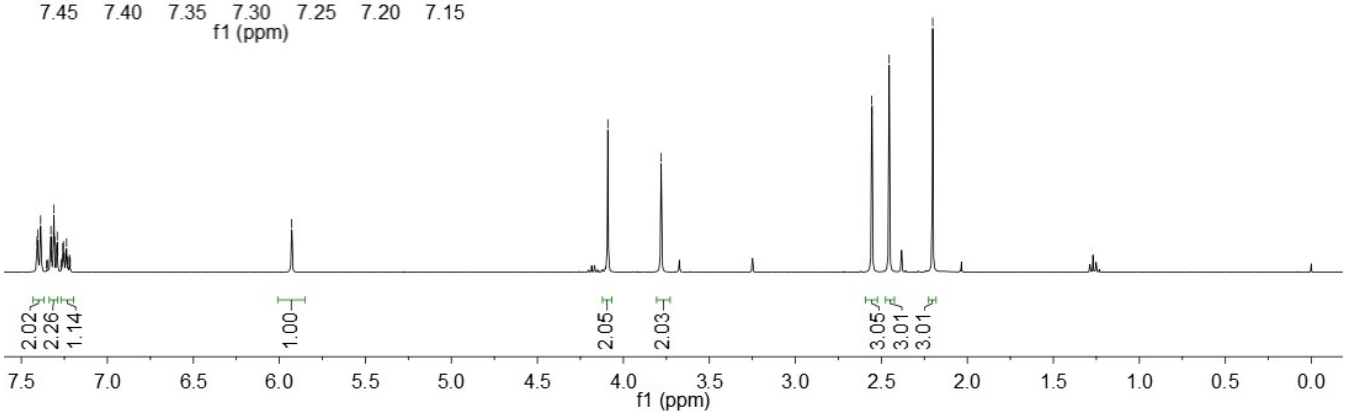


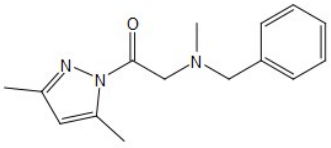


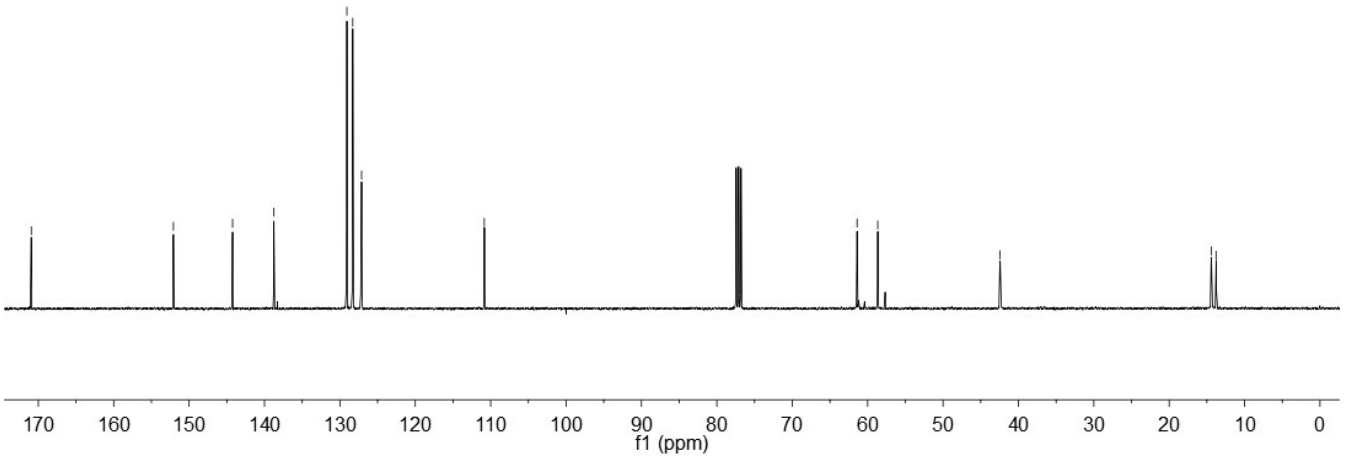
2-(Benzyl(methyl)amino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1f)



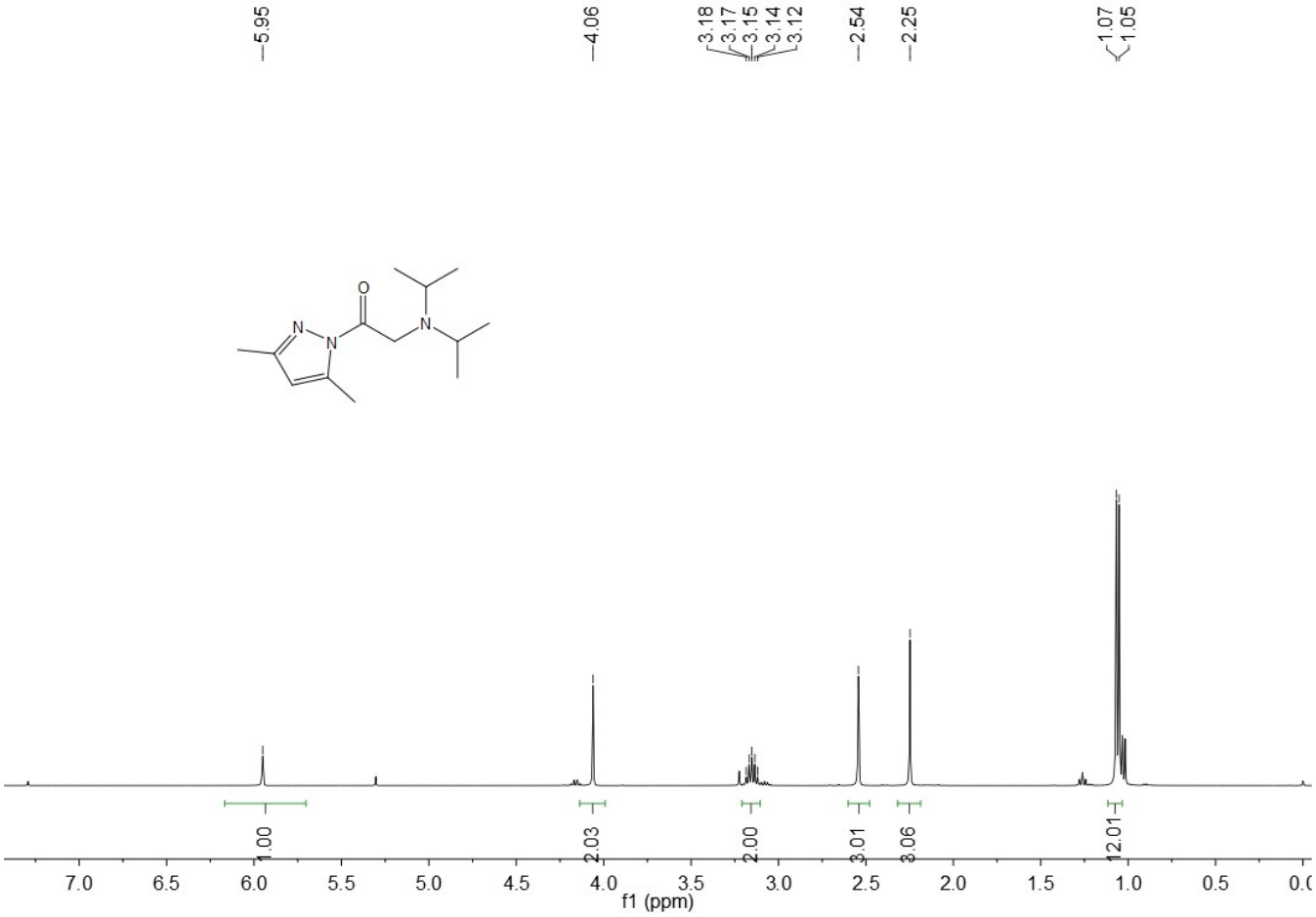


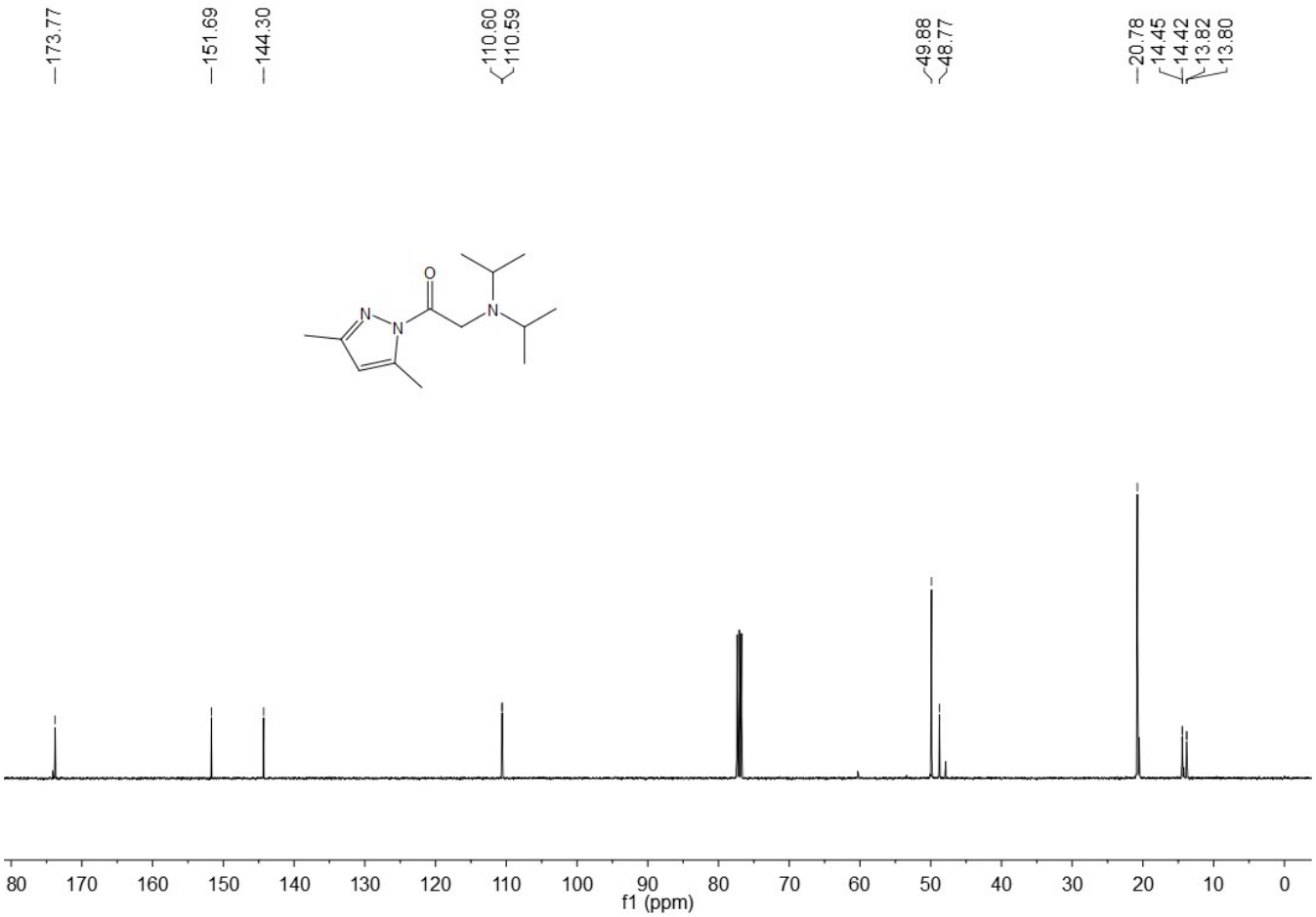




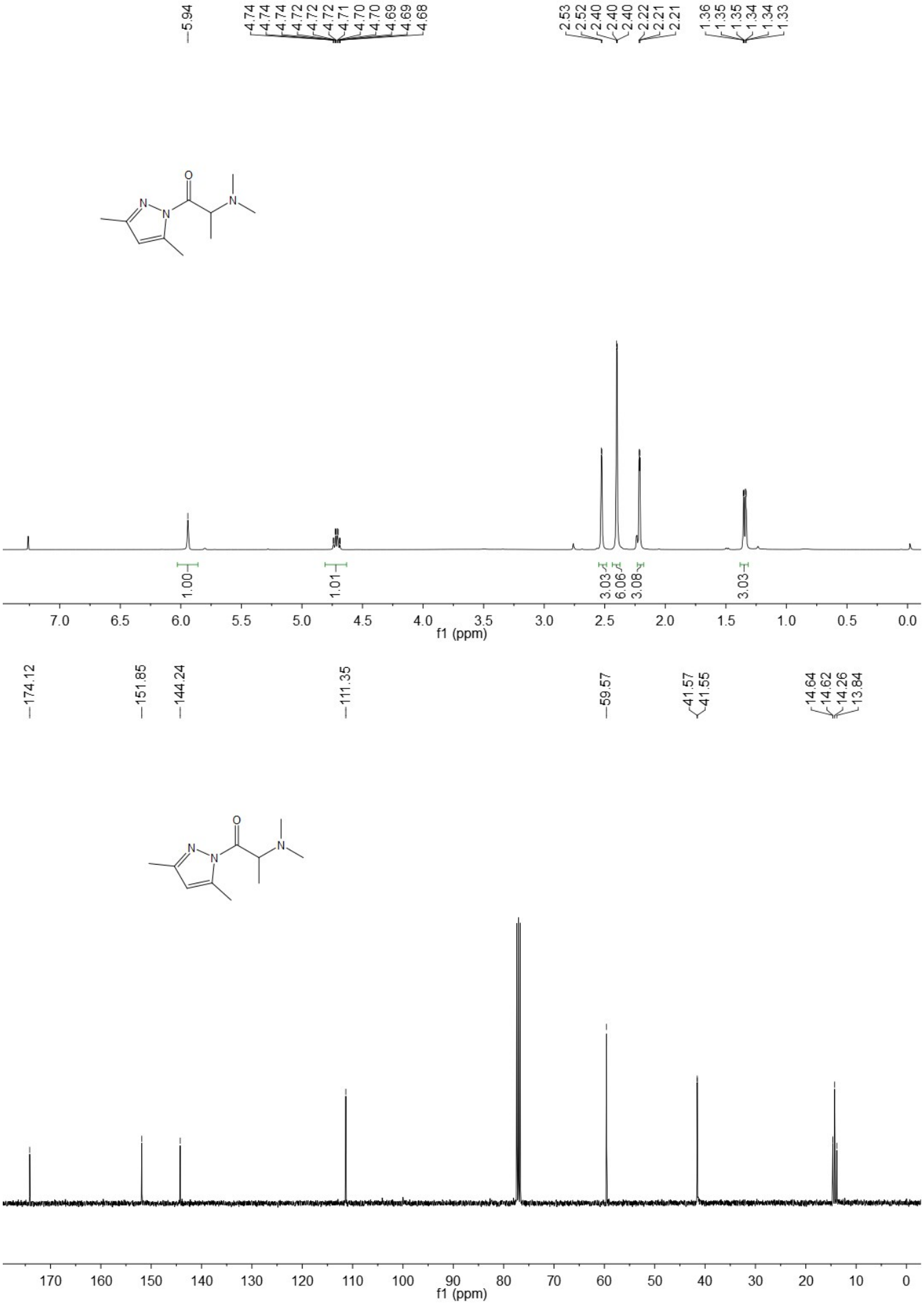


2-(Diisopropylamino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1g)

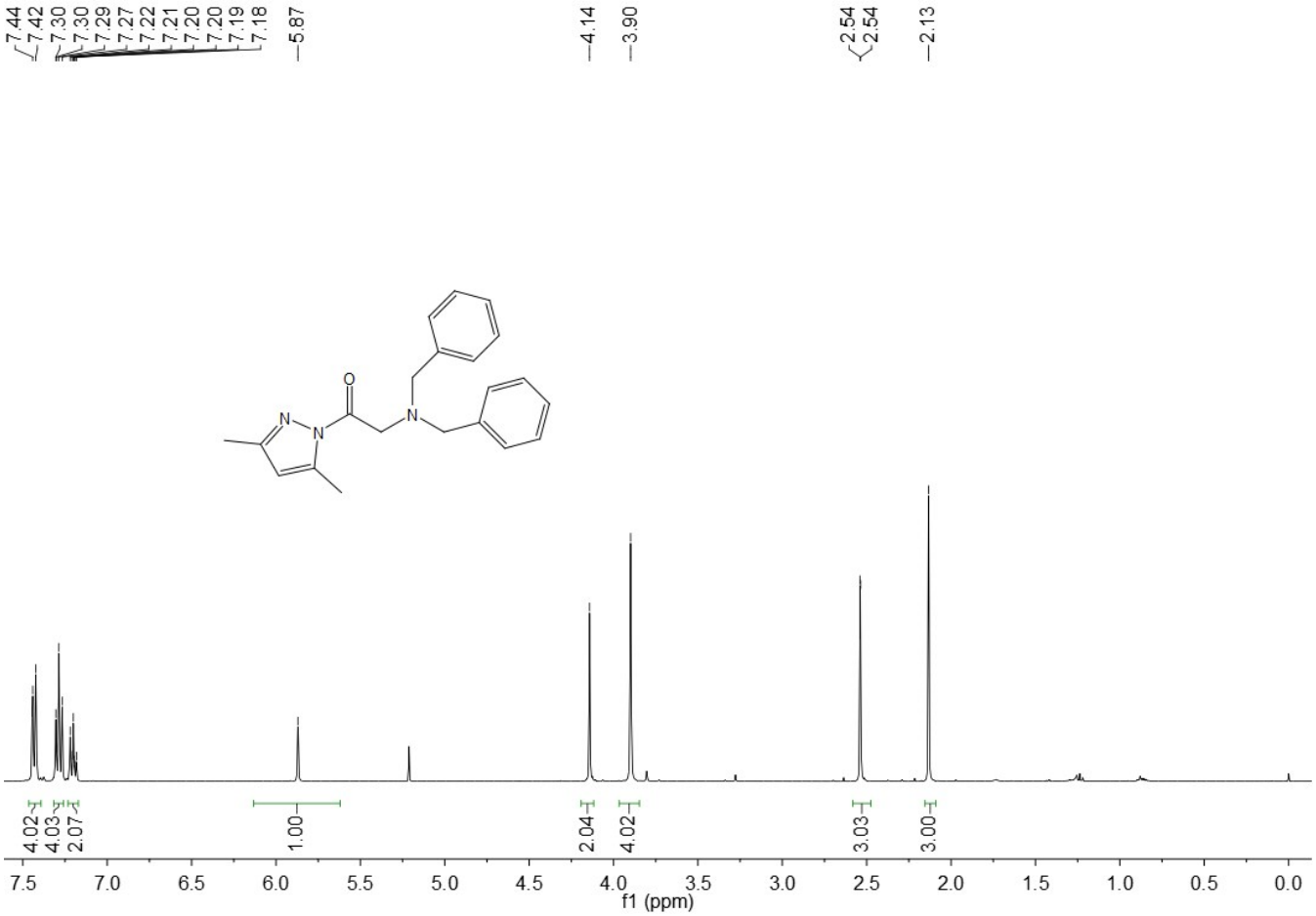


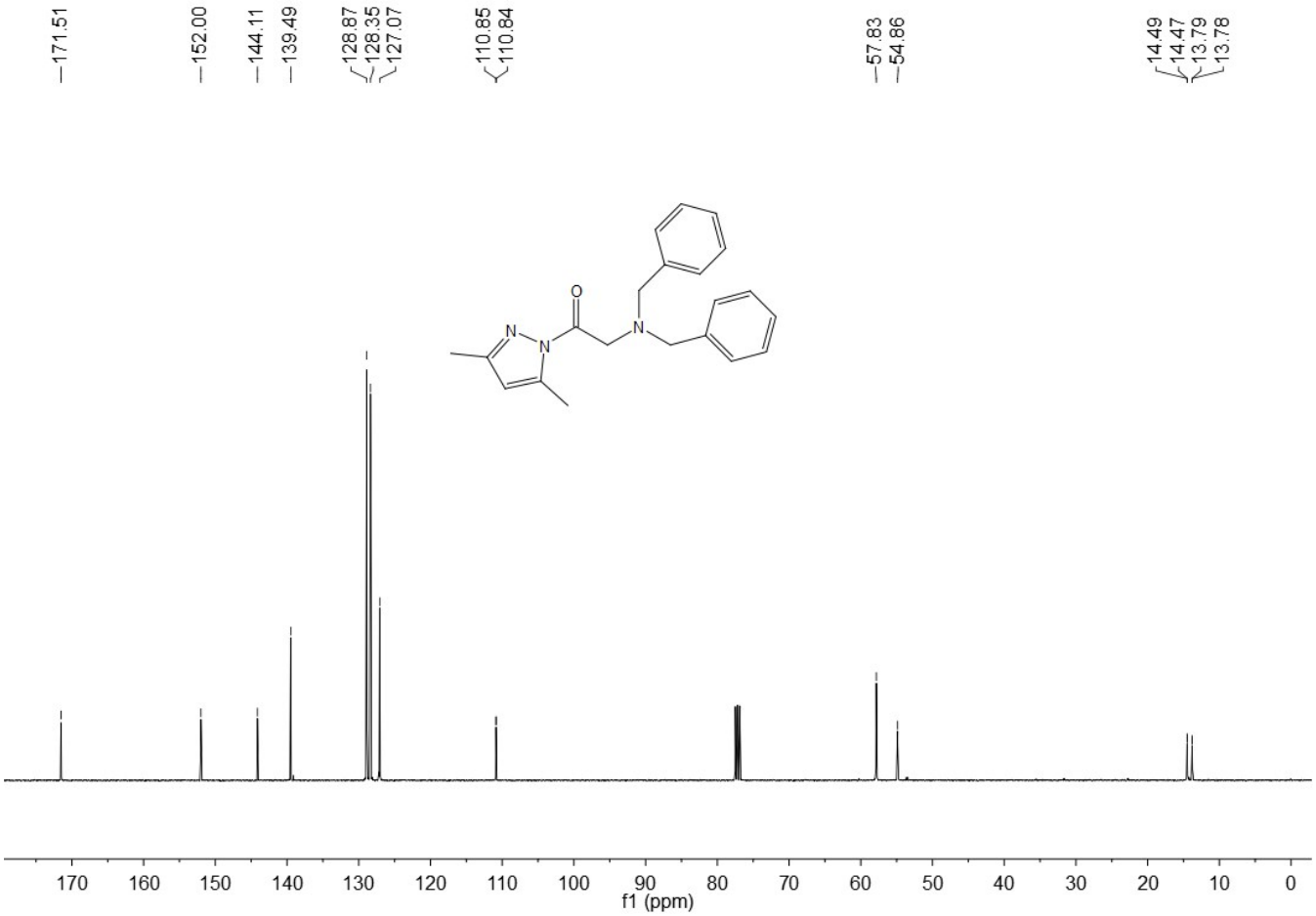


1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)propan-1-one (1h)

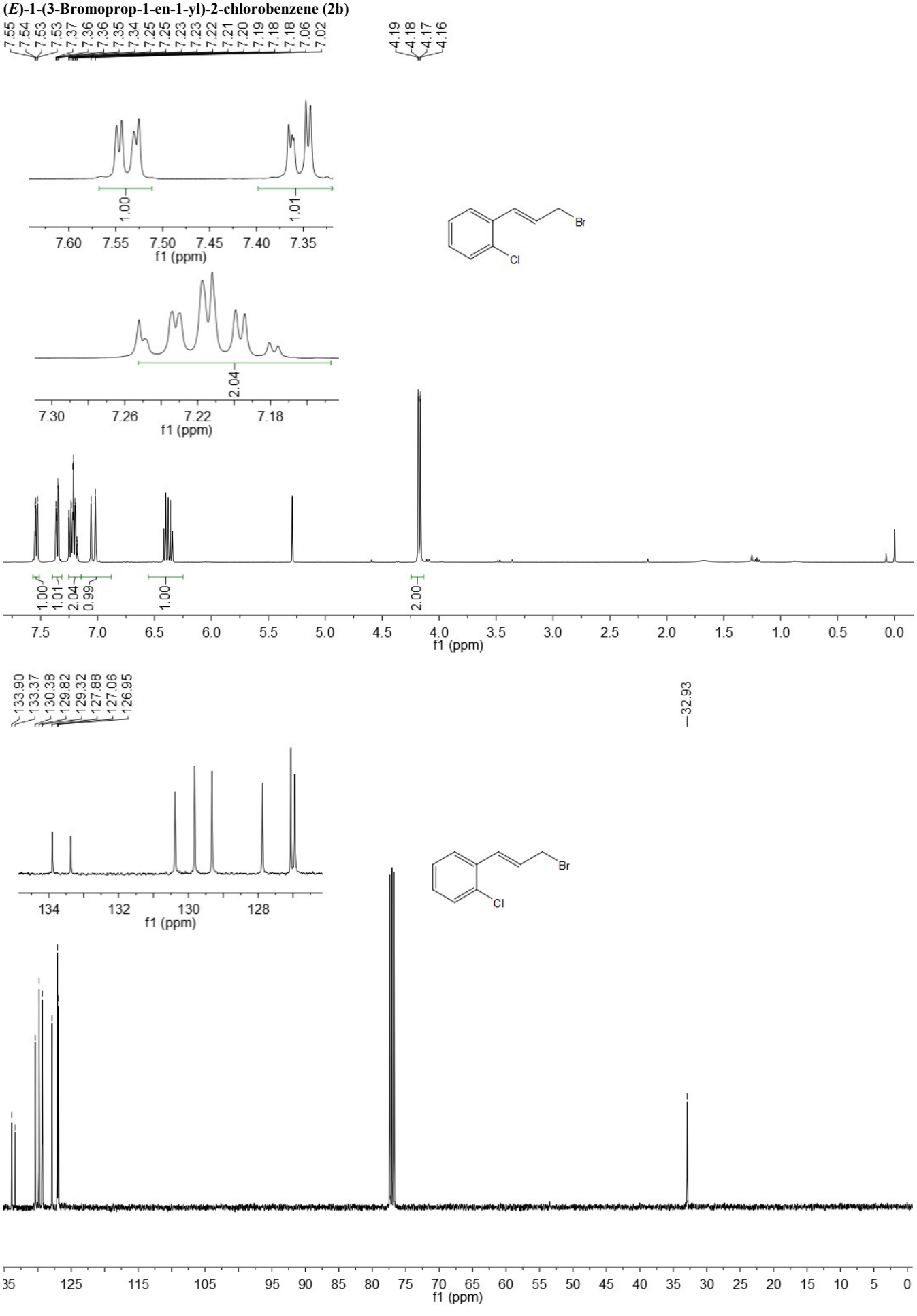


2-(Dibenzylamino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)ethan-1-one (1i)

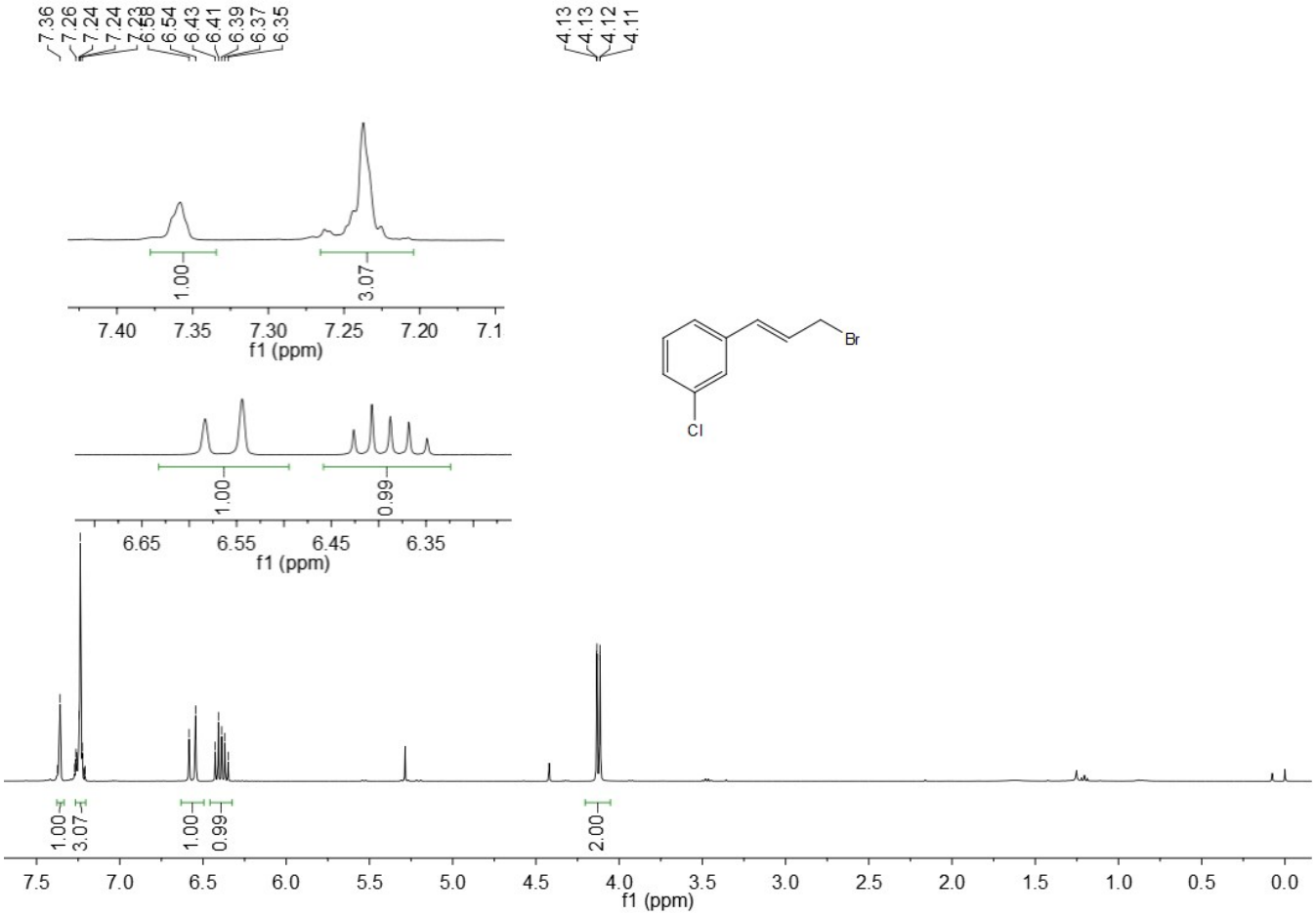


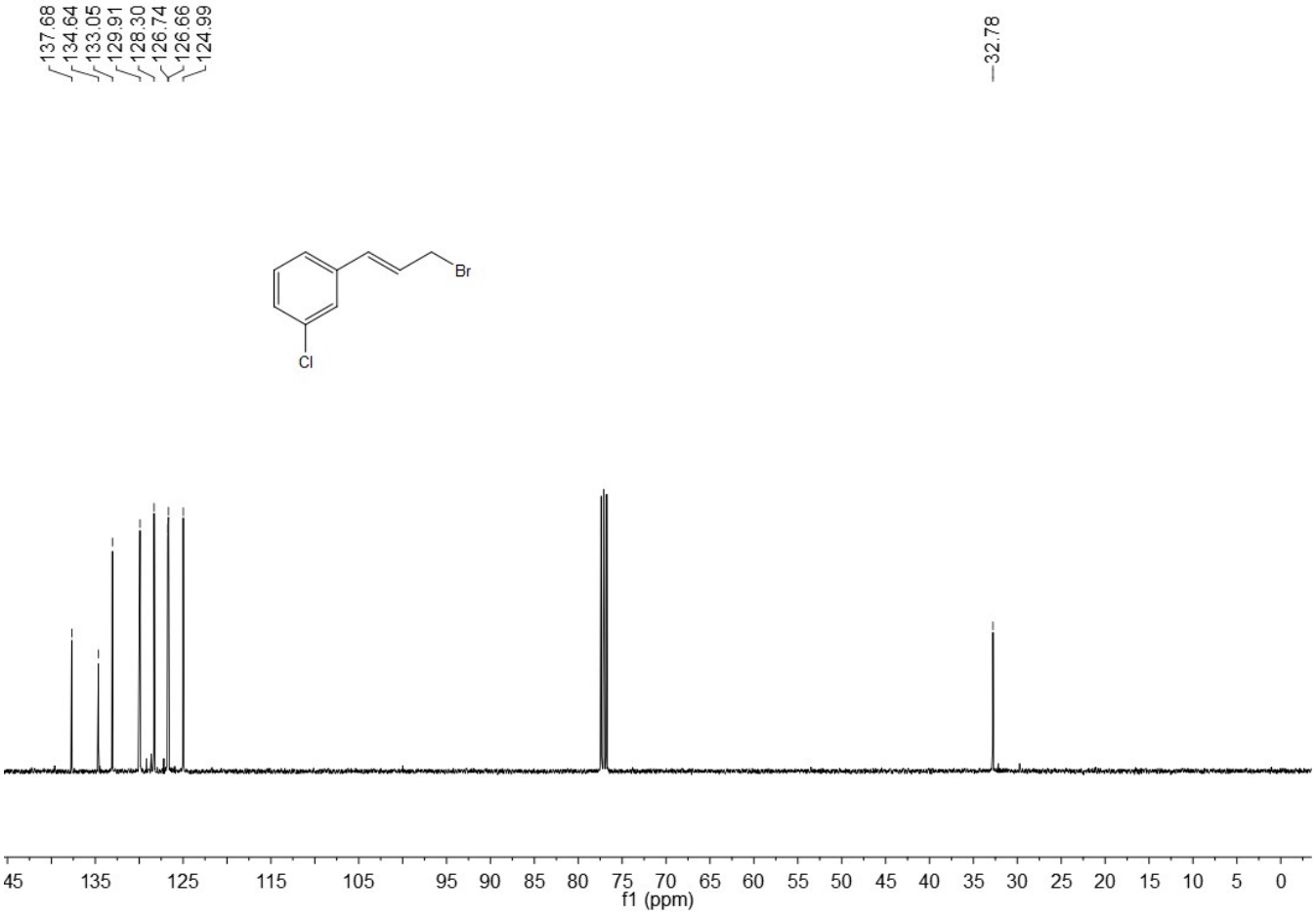


(*E*)-1-(3-Bromoprop-1-en-1-yl)-2-chlorobenzene (2b)

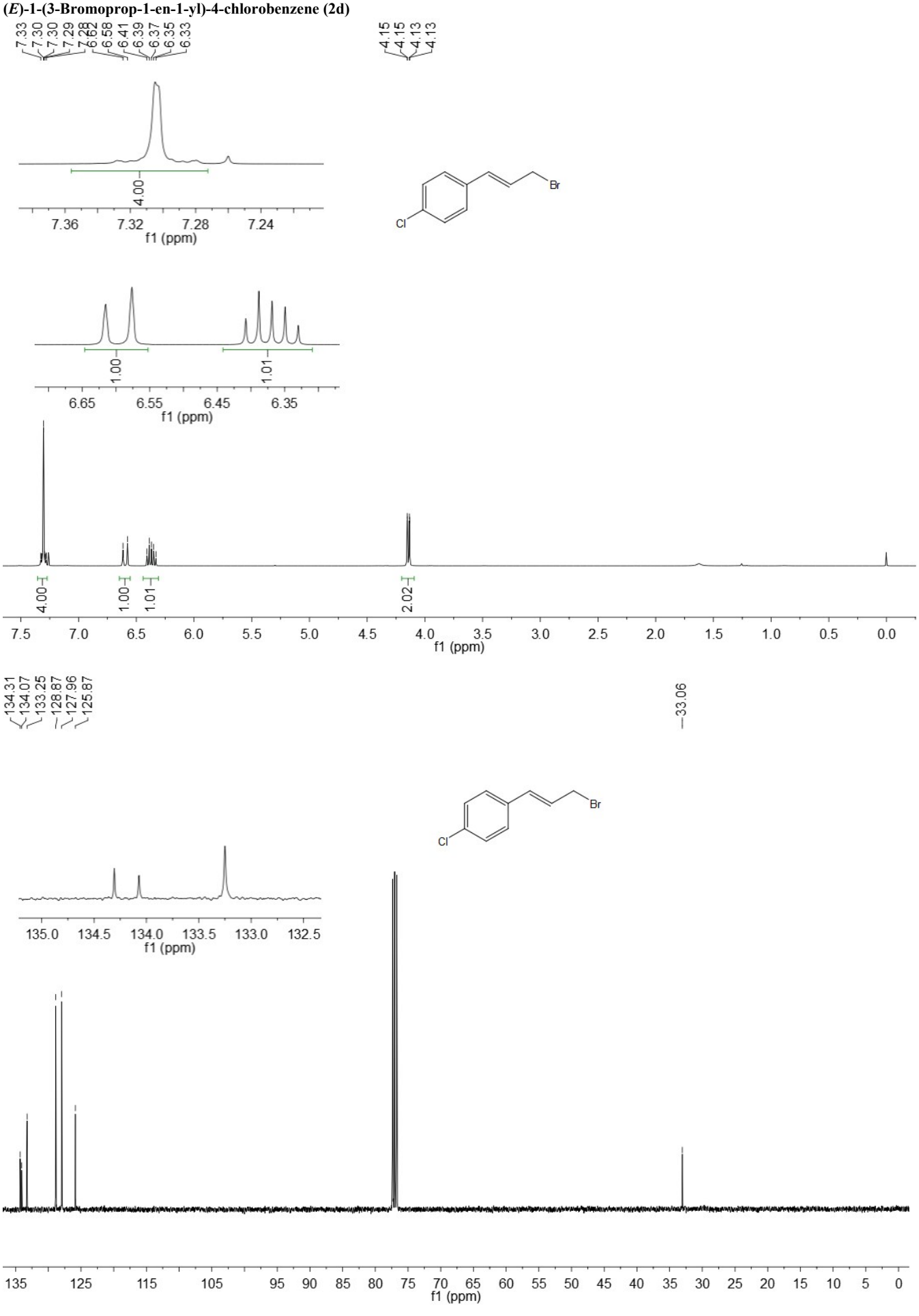


(*E*)-1-(3-Bromoprop-1-en-1-yl)-3-chlorobenzene (2c)

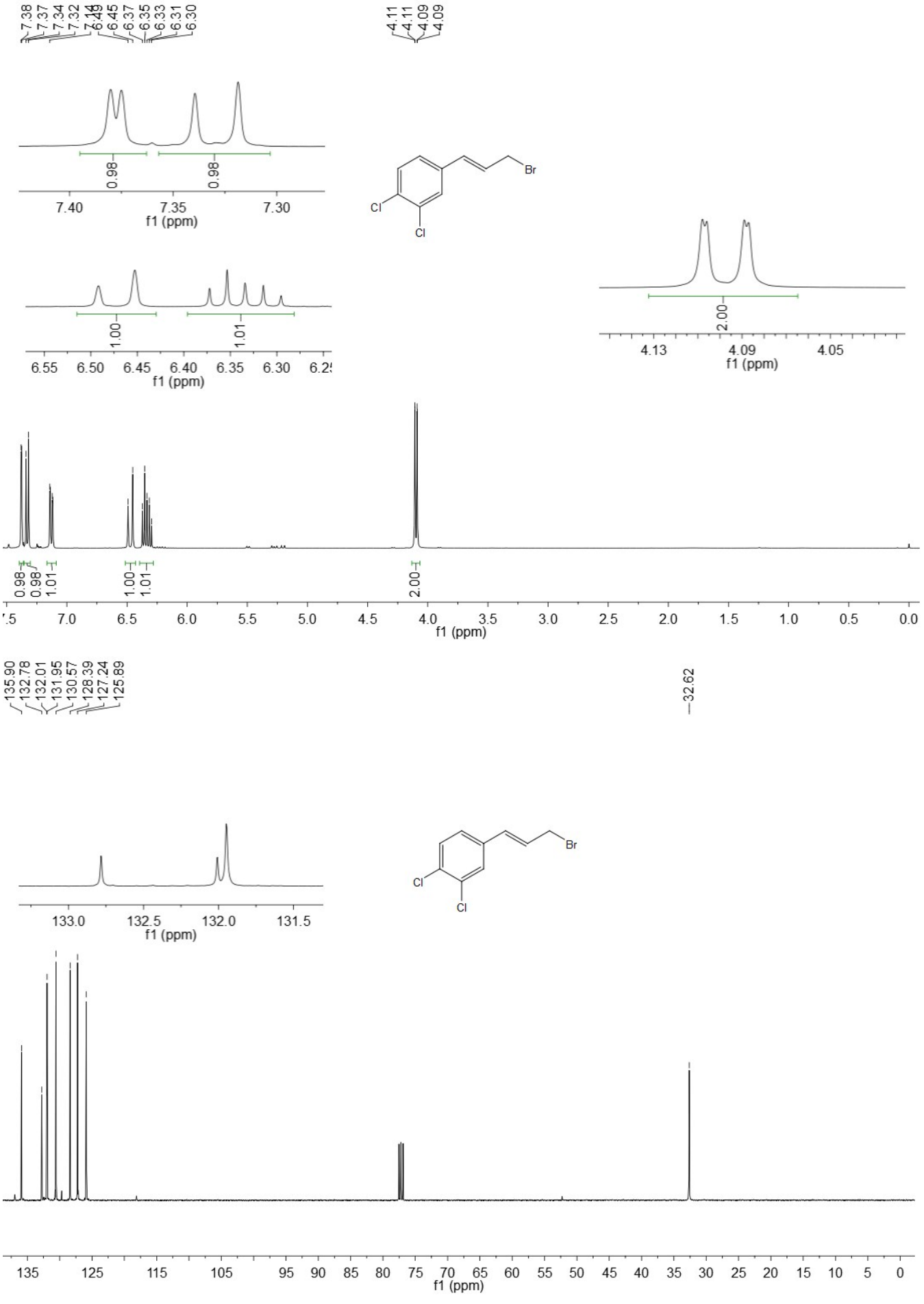




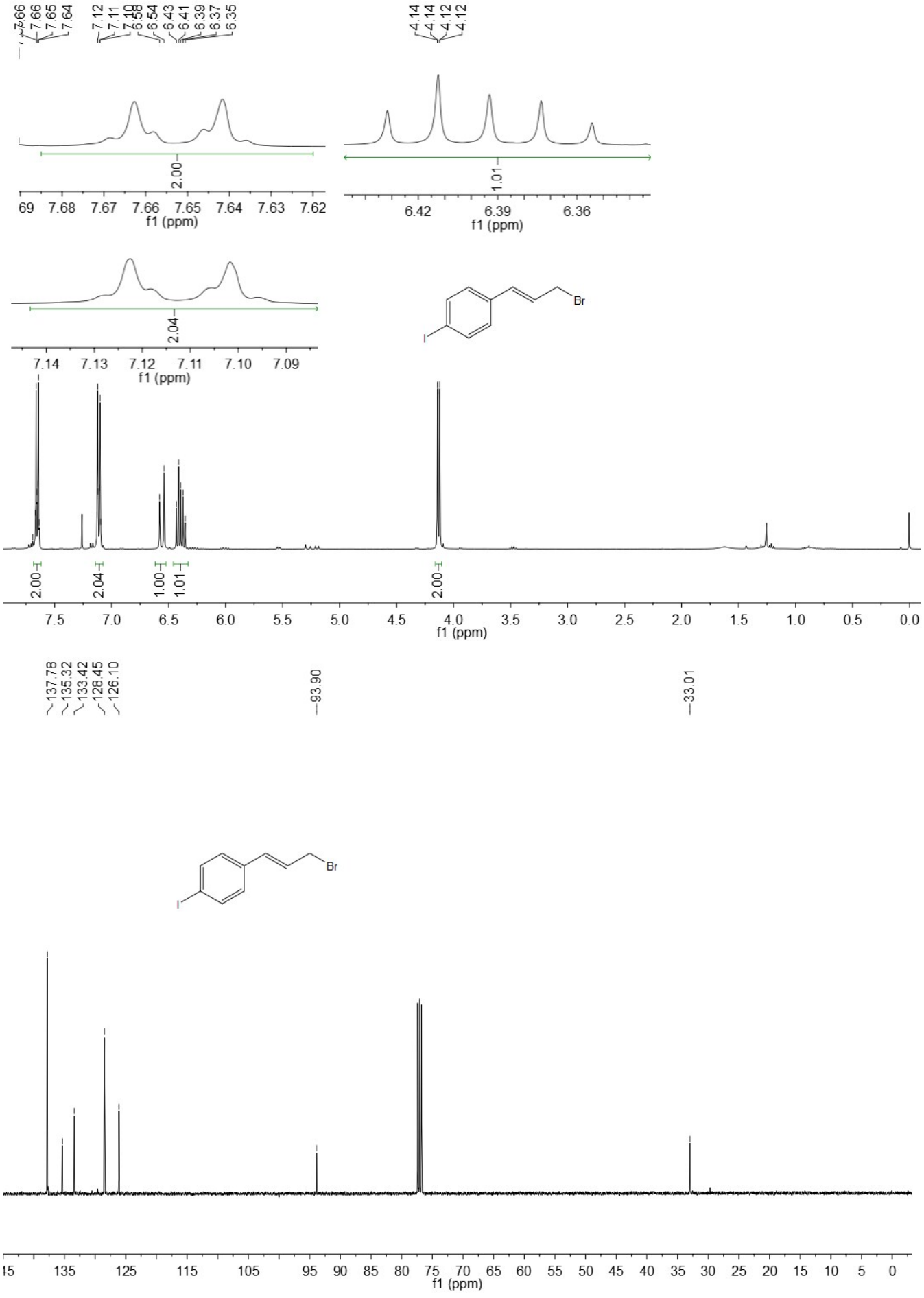
(*E*)-1-(3-Bromoprop-1-en-1-yl)-4-chlorobenzene (2d)



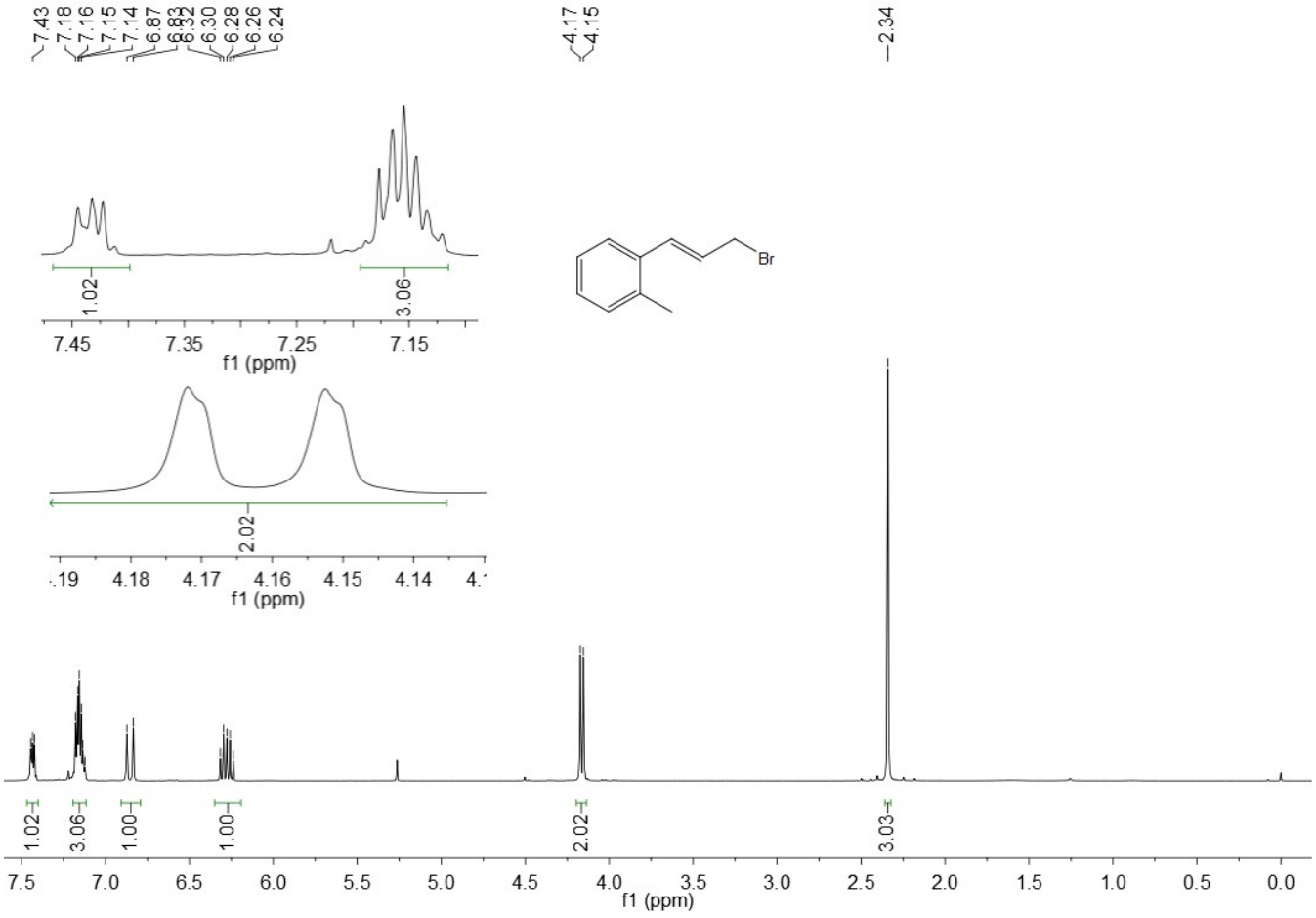
(*E*)-4-(3-Bromoprop-1-en-1-yl)-1,2-dichlorobenzene (2e)

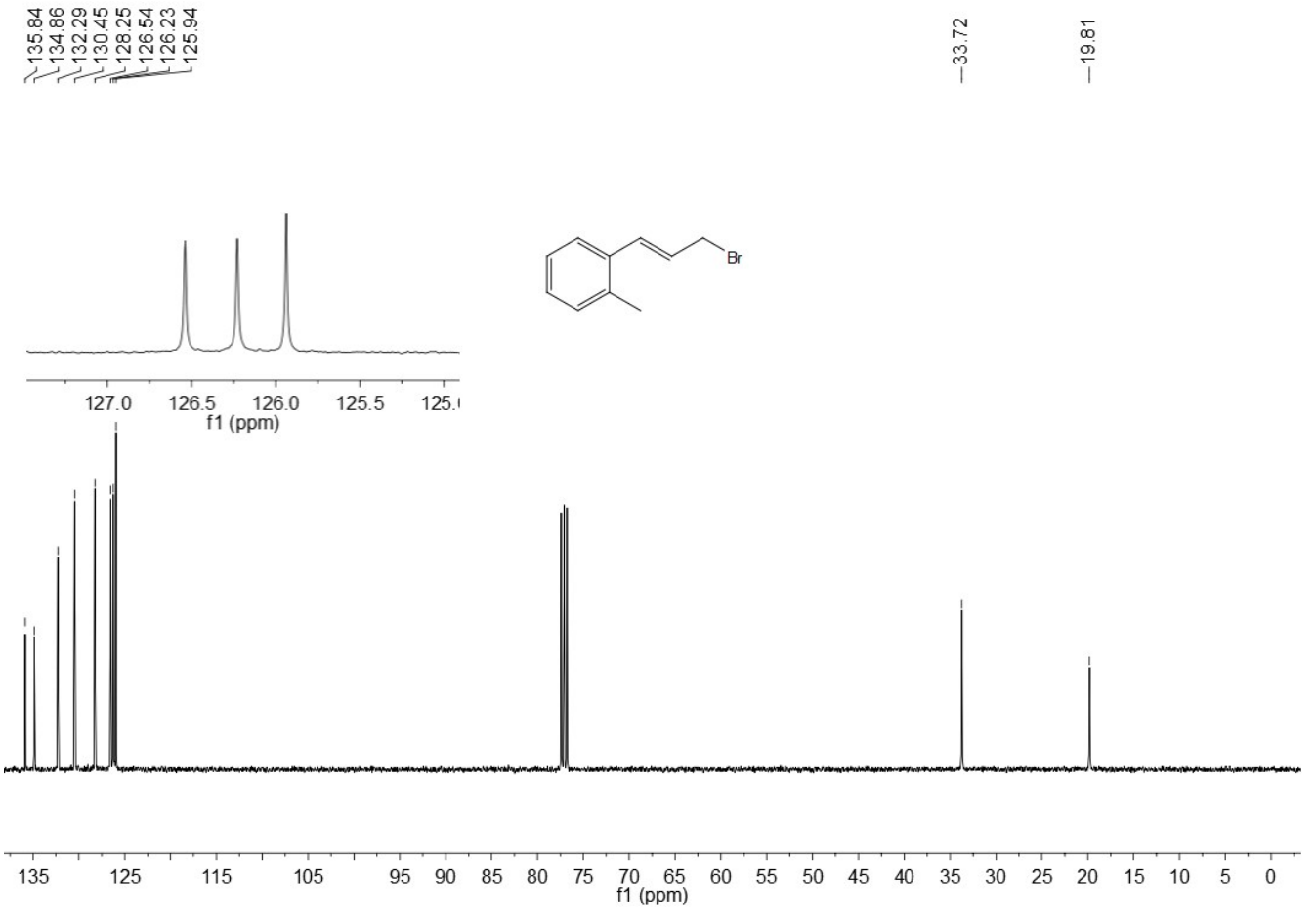


(*E*)-1-(3-Bromoprop-1-en-1-yl)-4-iodobenzene (2h)

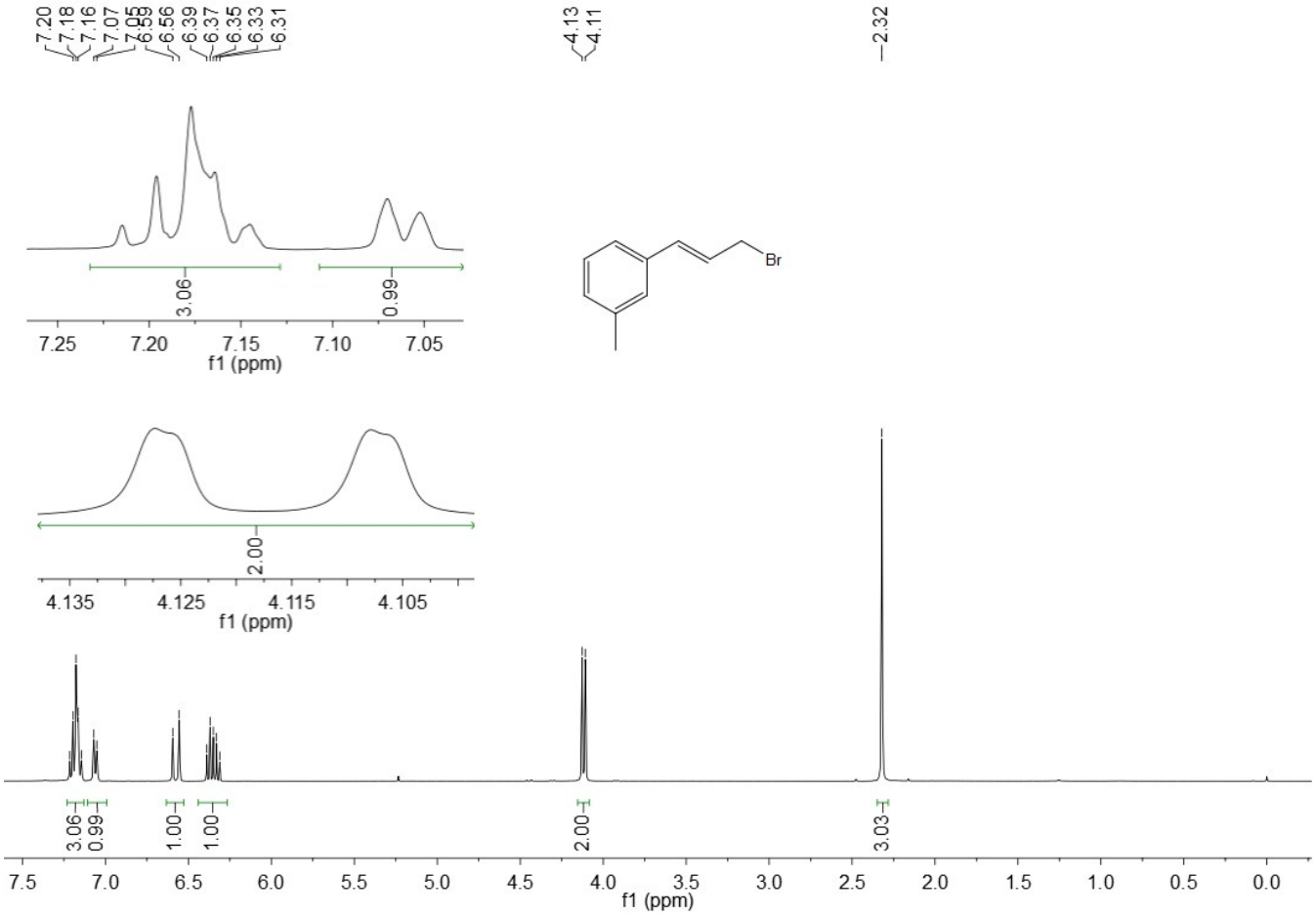


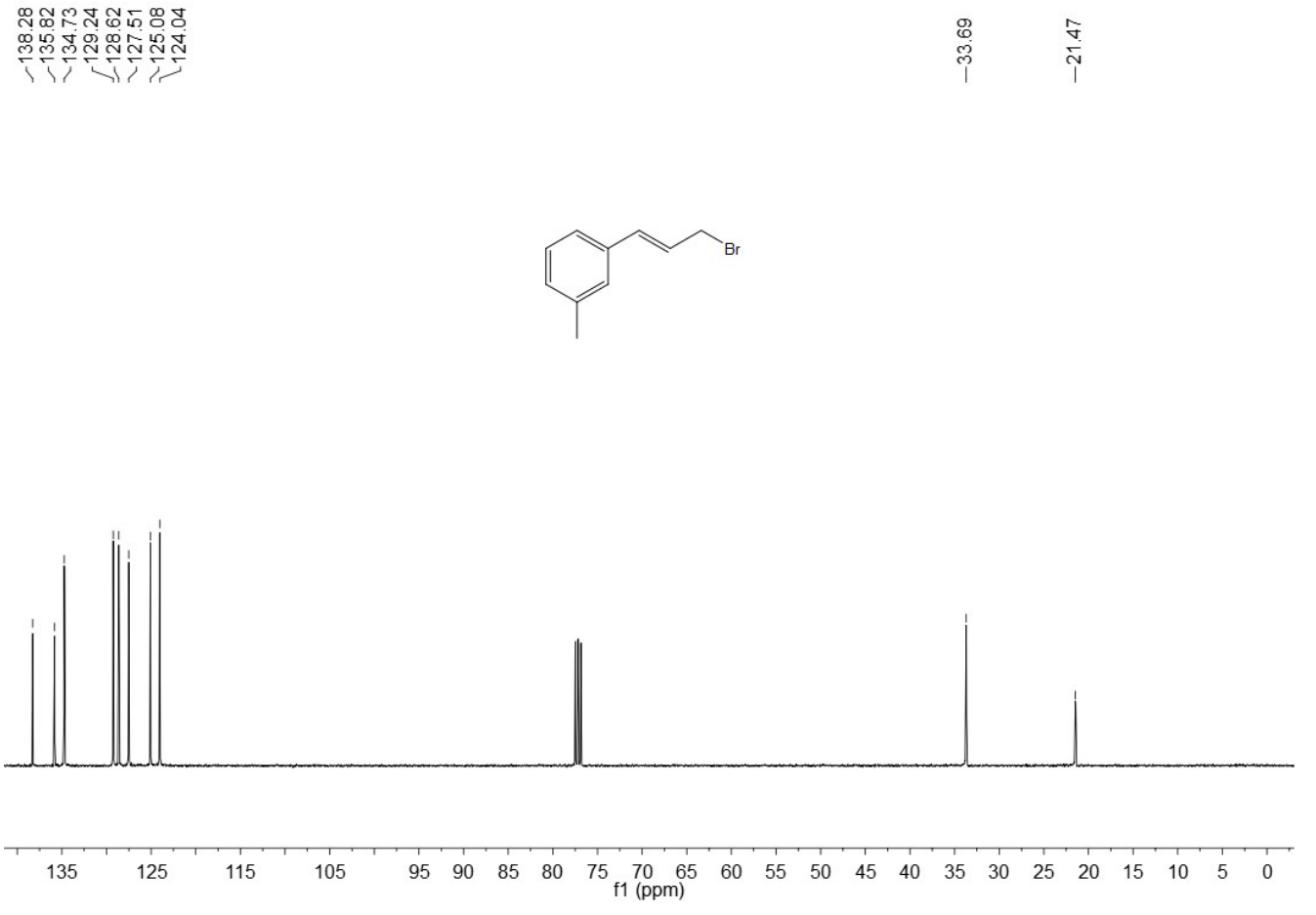
(*E*)-1-(3-Bromoprop-1-en-1-yl)-2-methylbenzene (2j)



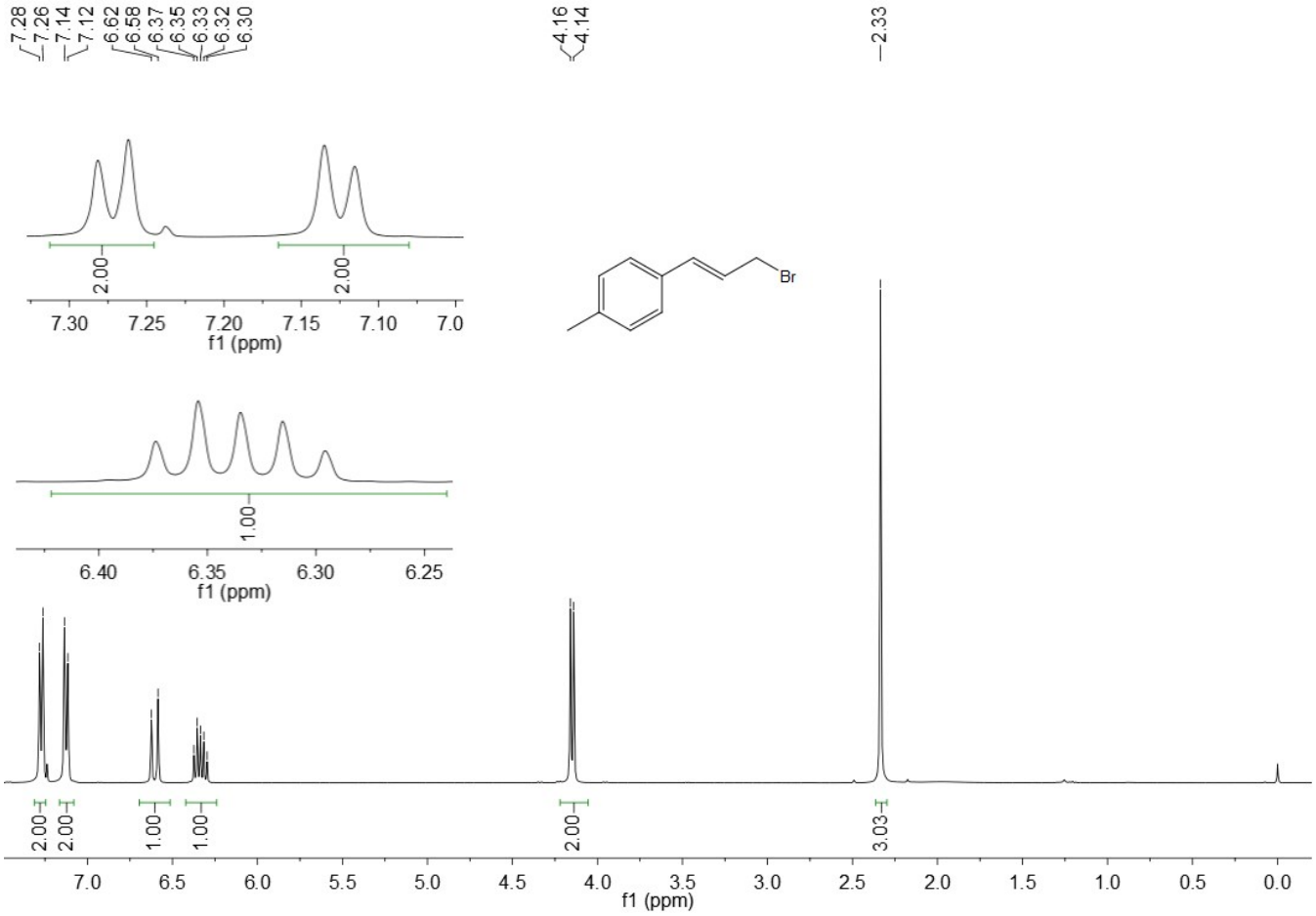


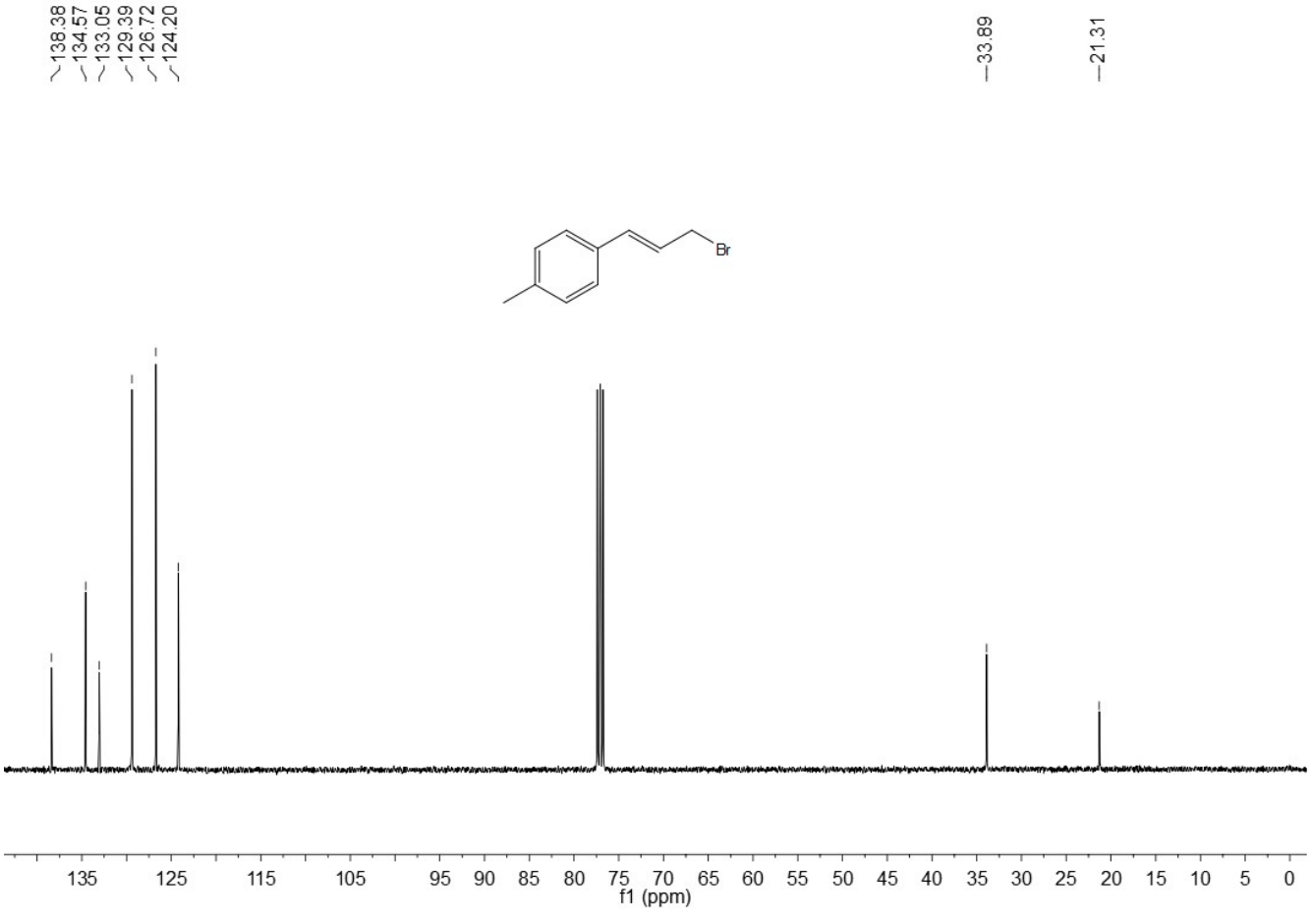
(*E*)-1-(3-Bromoprop-1-en-1-yl)-3-methylbenzene (3k)



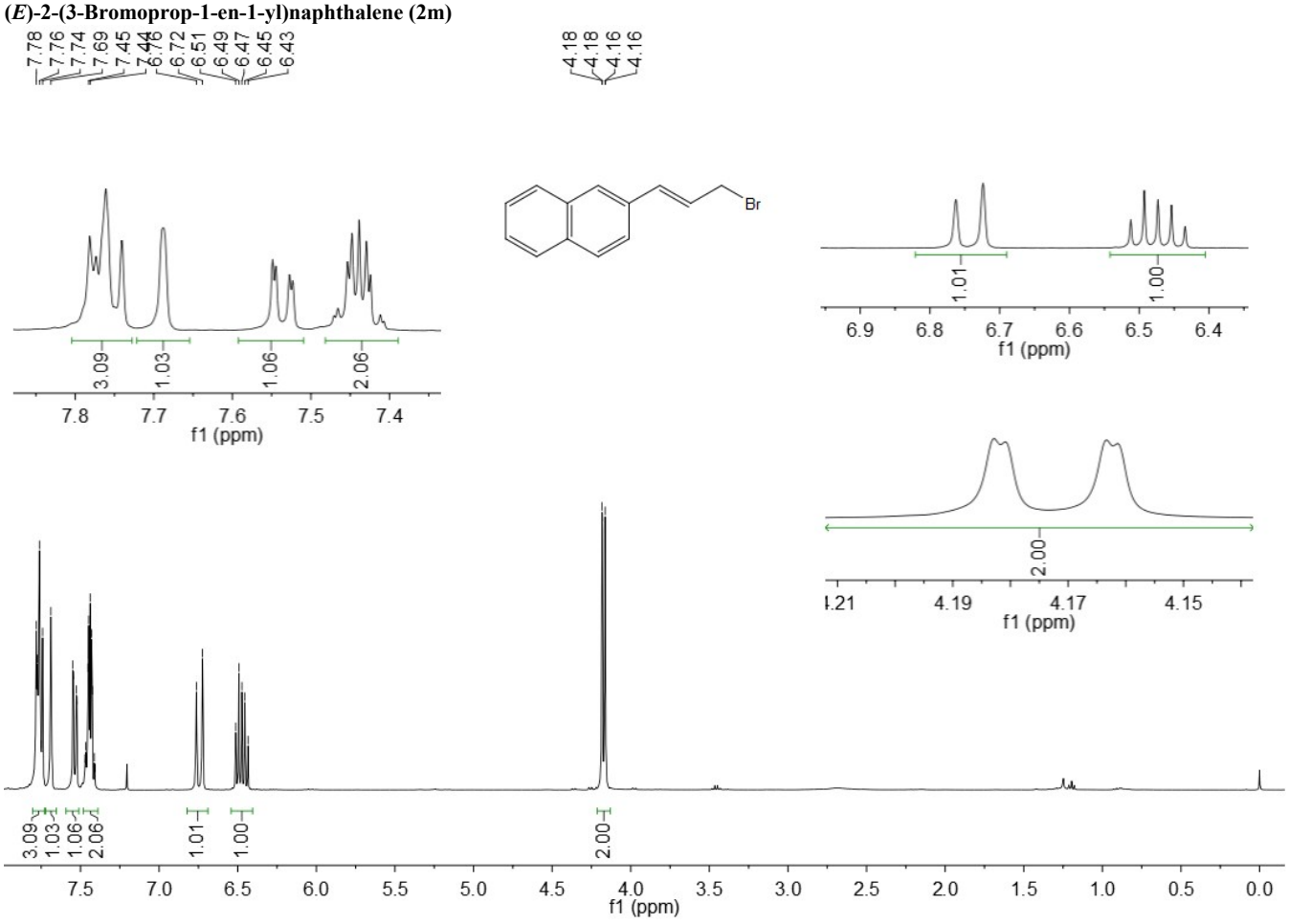


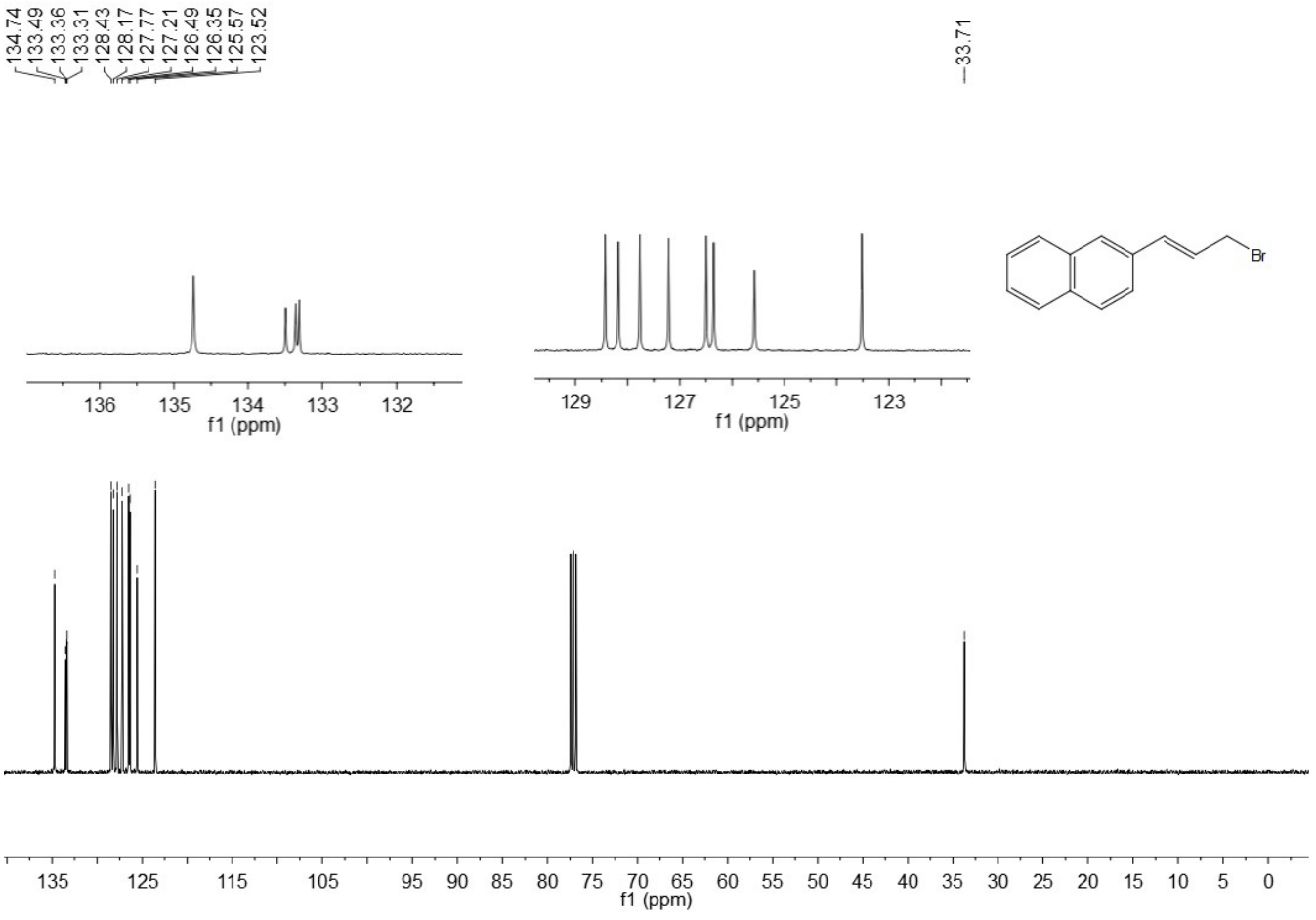
(*E*)-1-(3-Bromoprop-1-en-1-yl)-4-methylbenzene (2l)



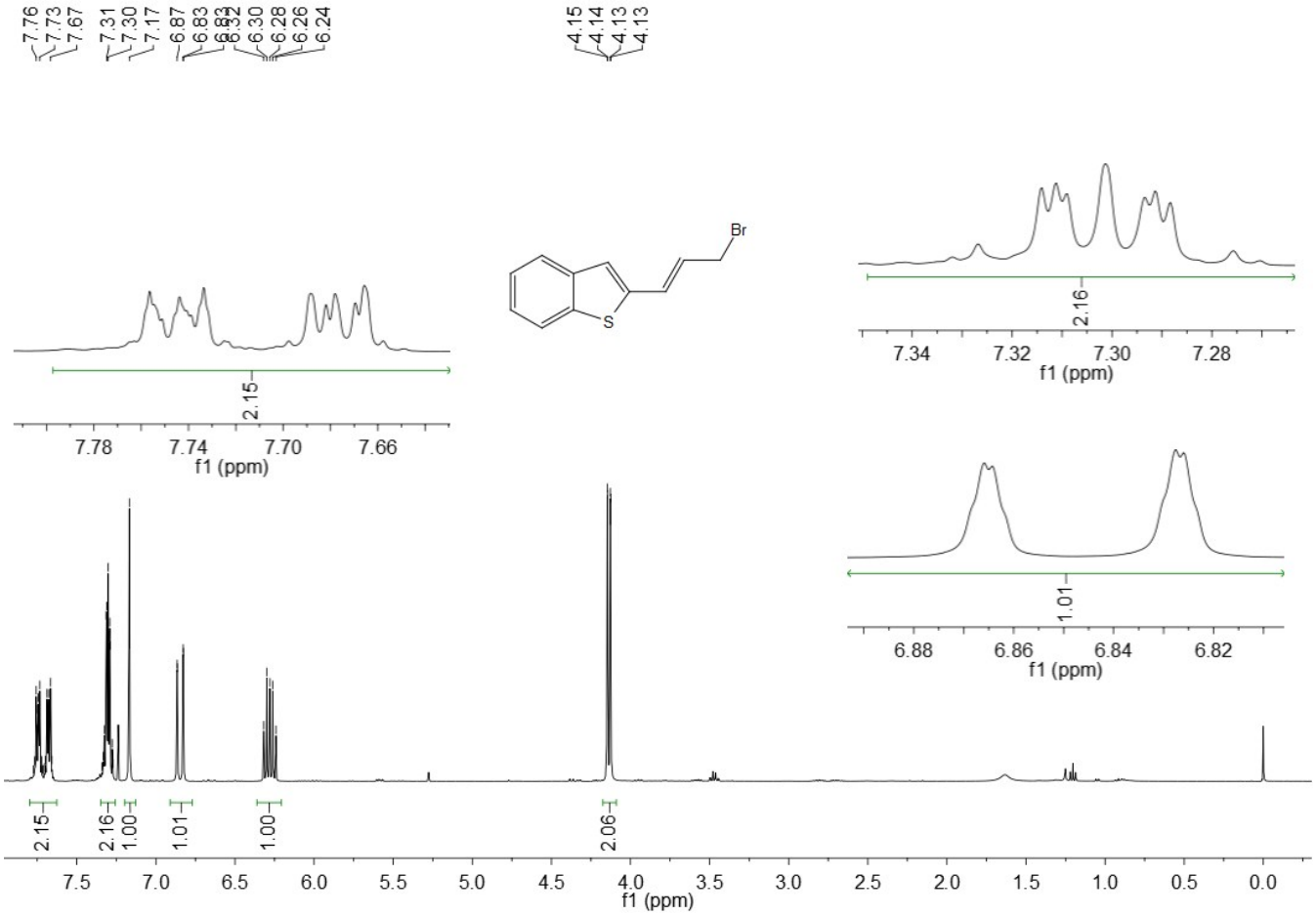


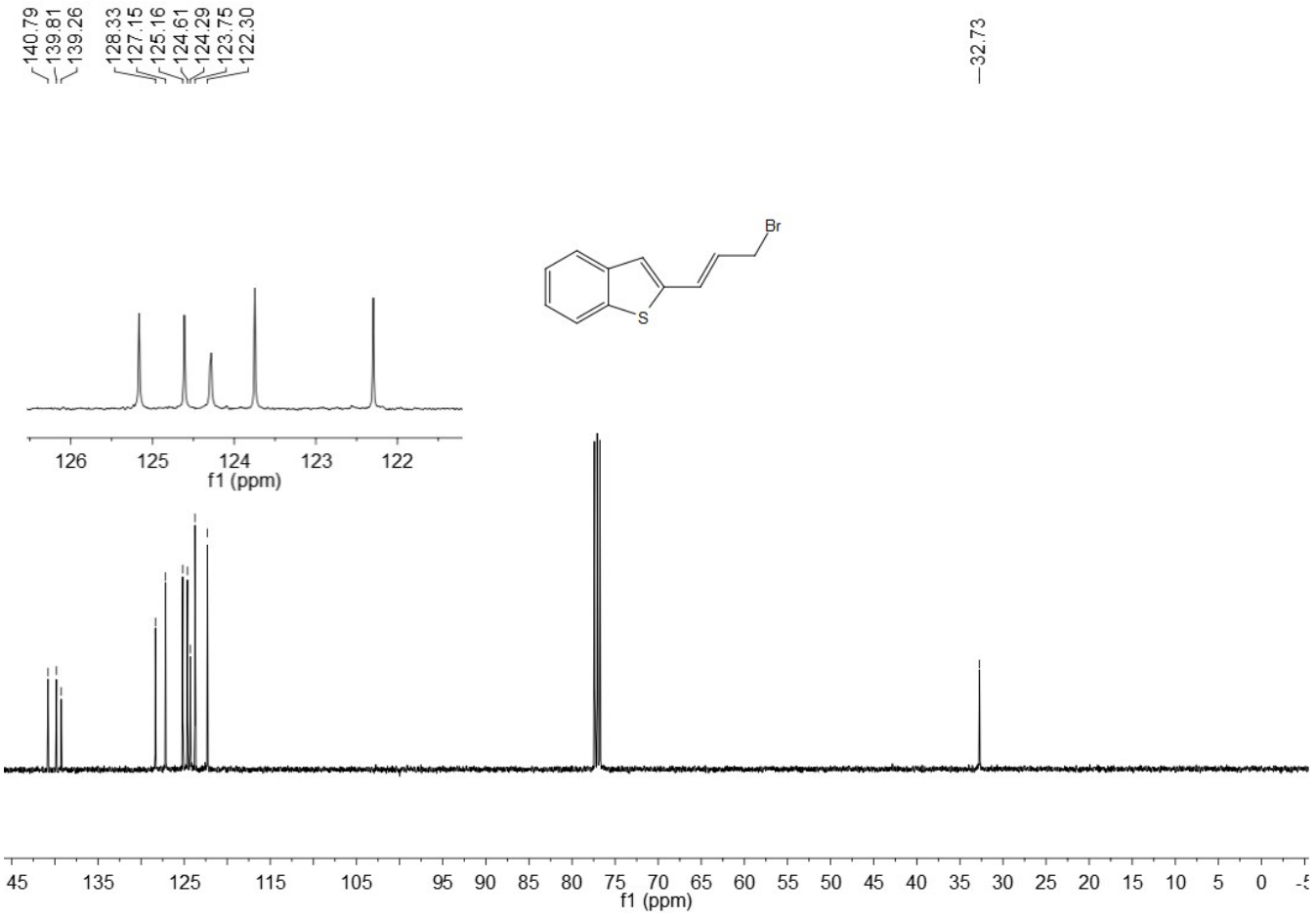
(*E*)-2-(3-Bromoprop-1-en-1-yl)naphthalene (2m)



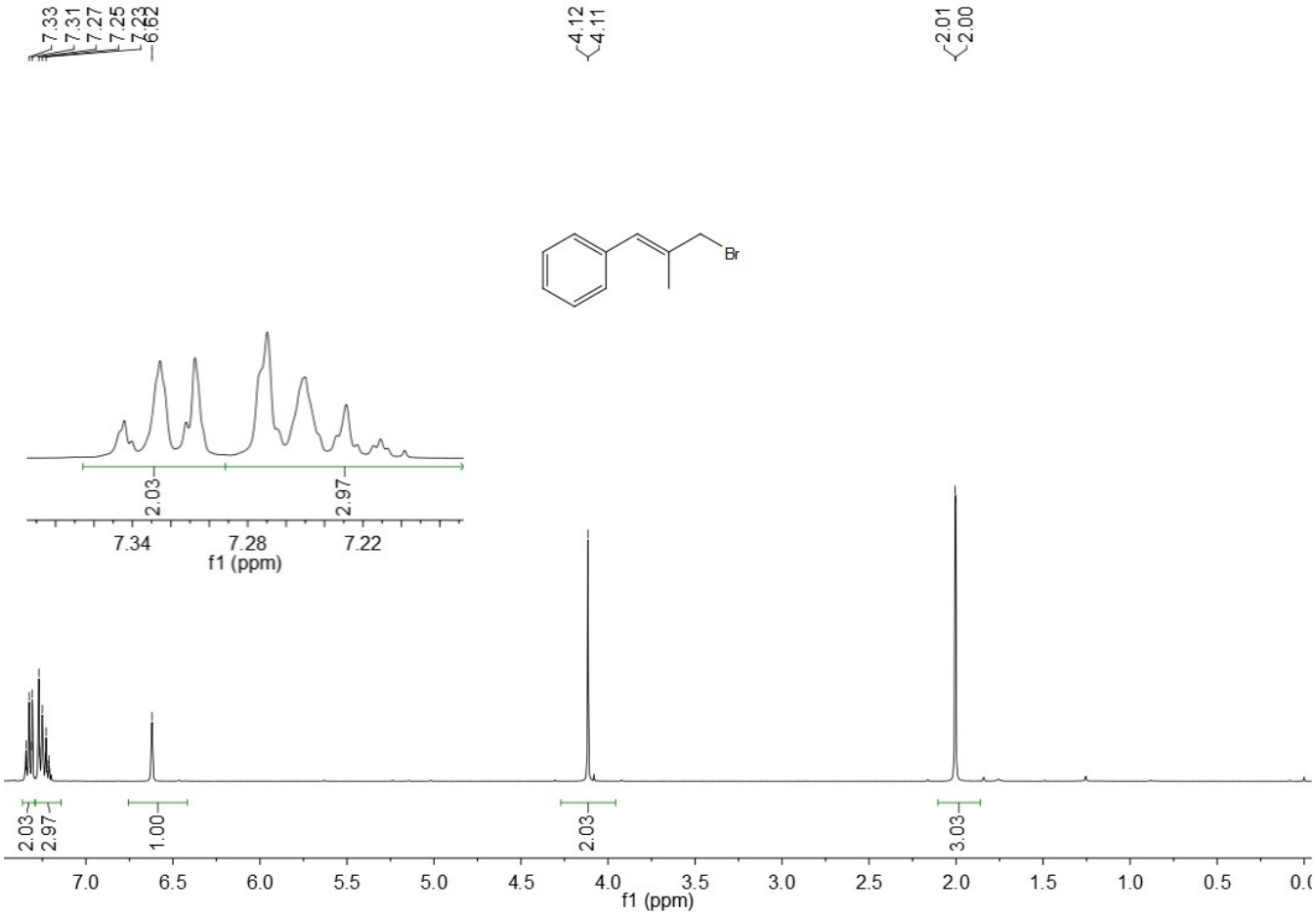


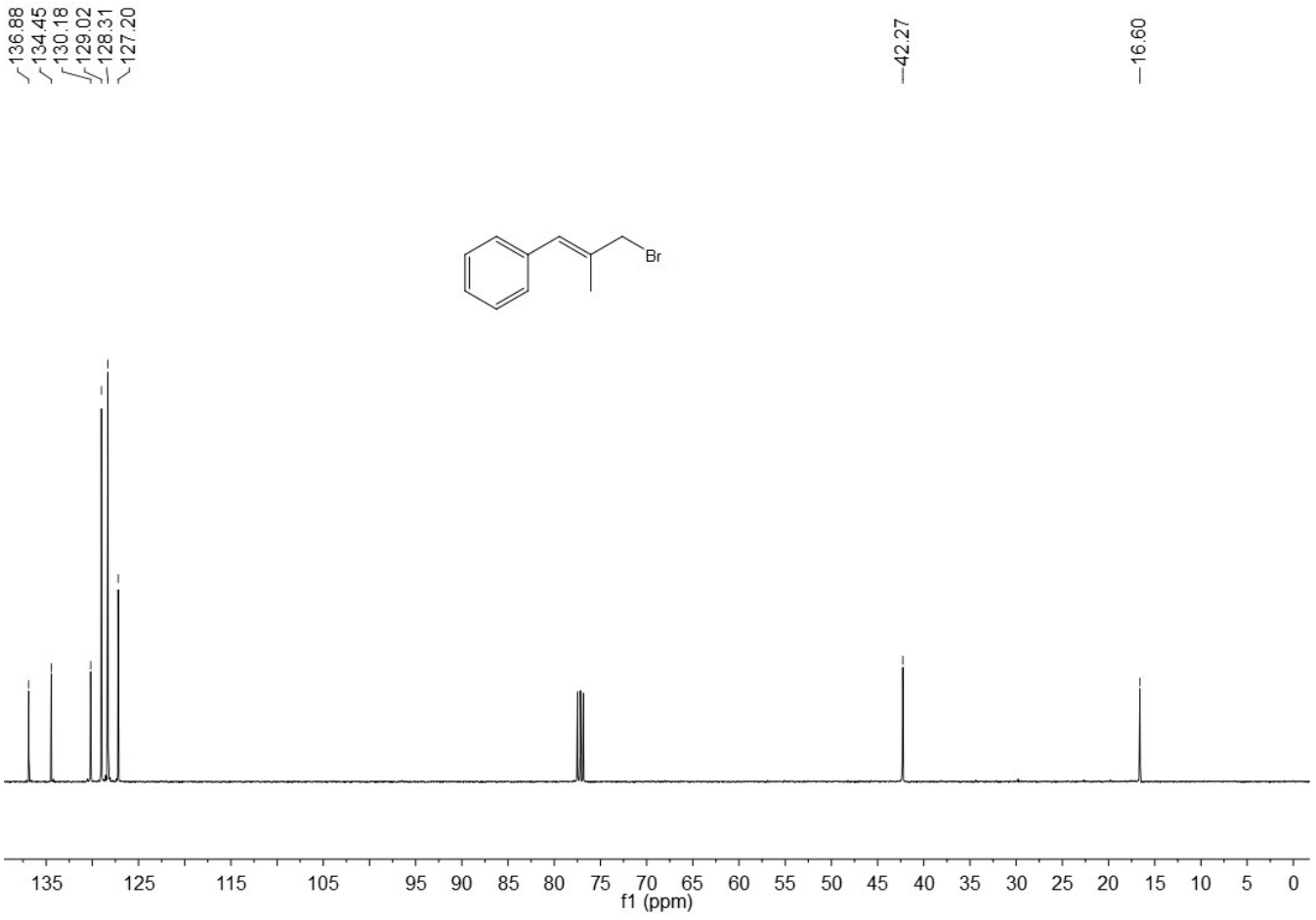
(*E*)-2-(3-Bromoprop-1-en-1-yl)benzo[*b*]thiophene (2n)



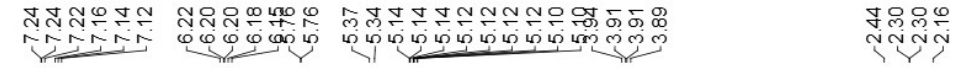


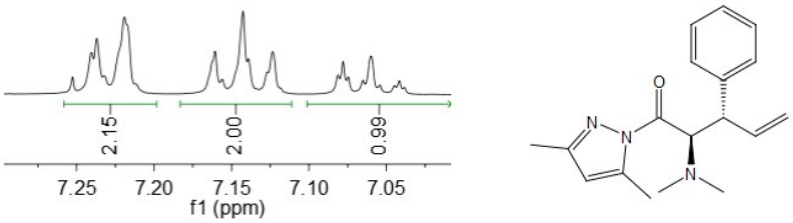
(*E*)-(3-Bromo-2-methylprop-1-en-1-yl)benzene (2p)

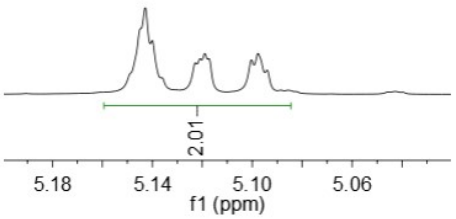


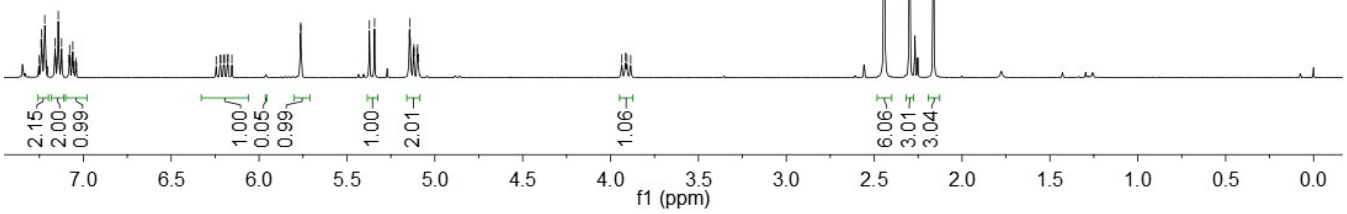


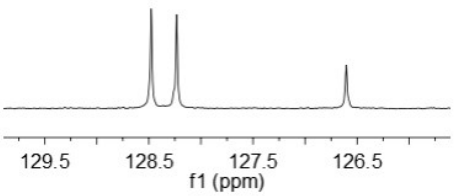
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-phenylpent-4-en-1-one (3a)

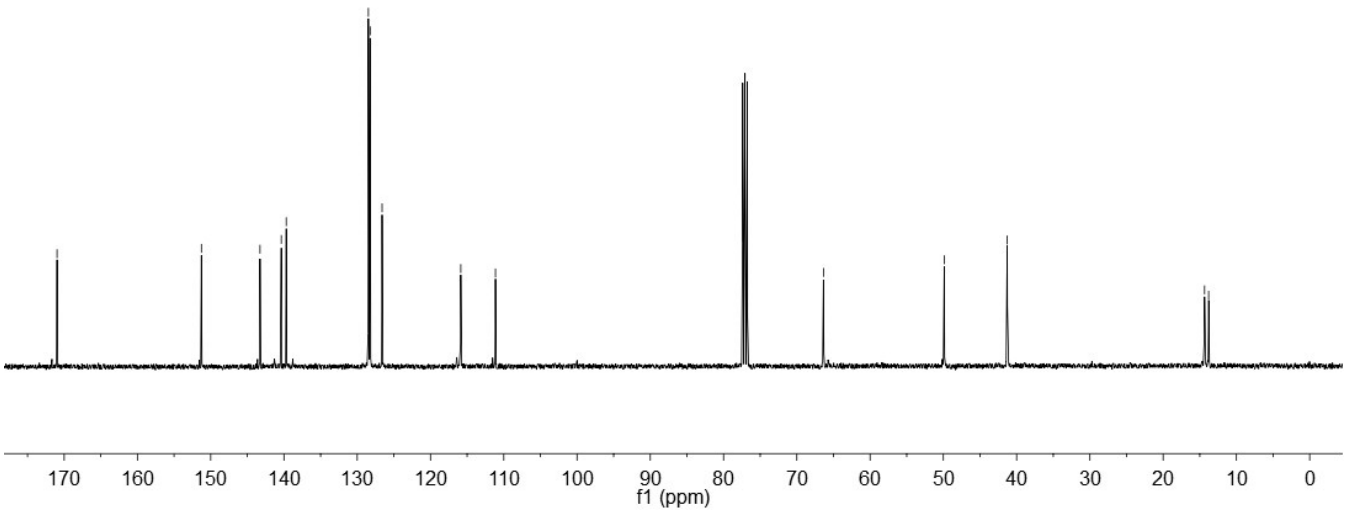




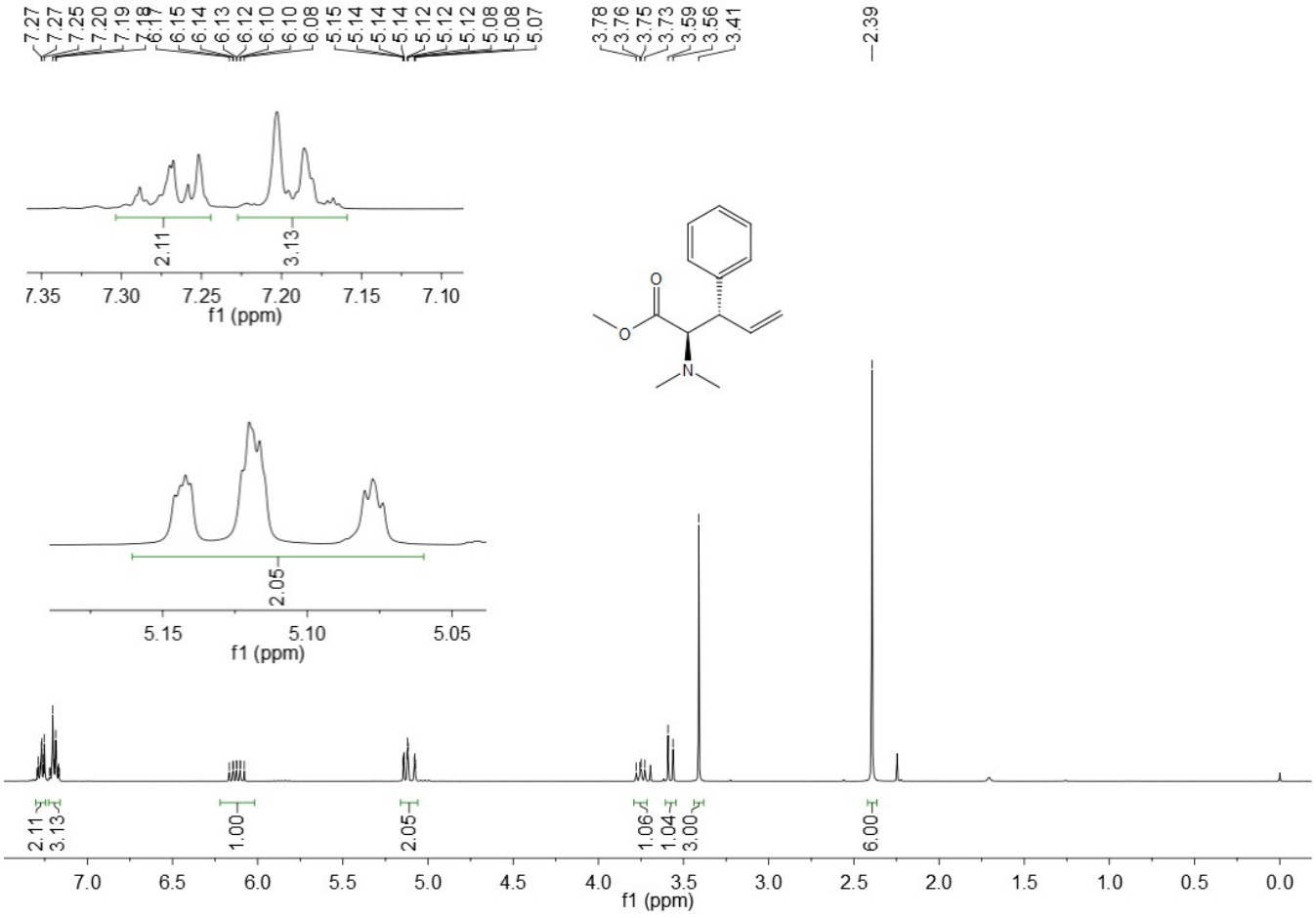


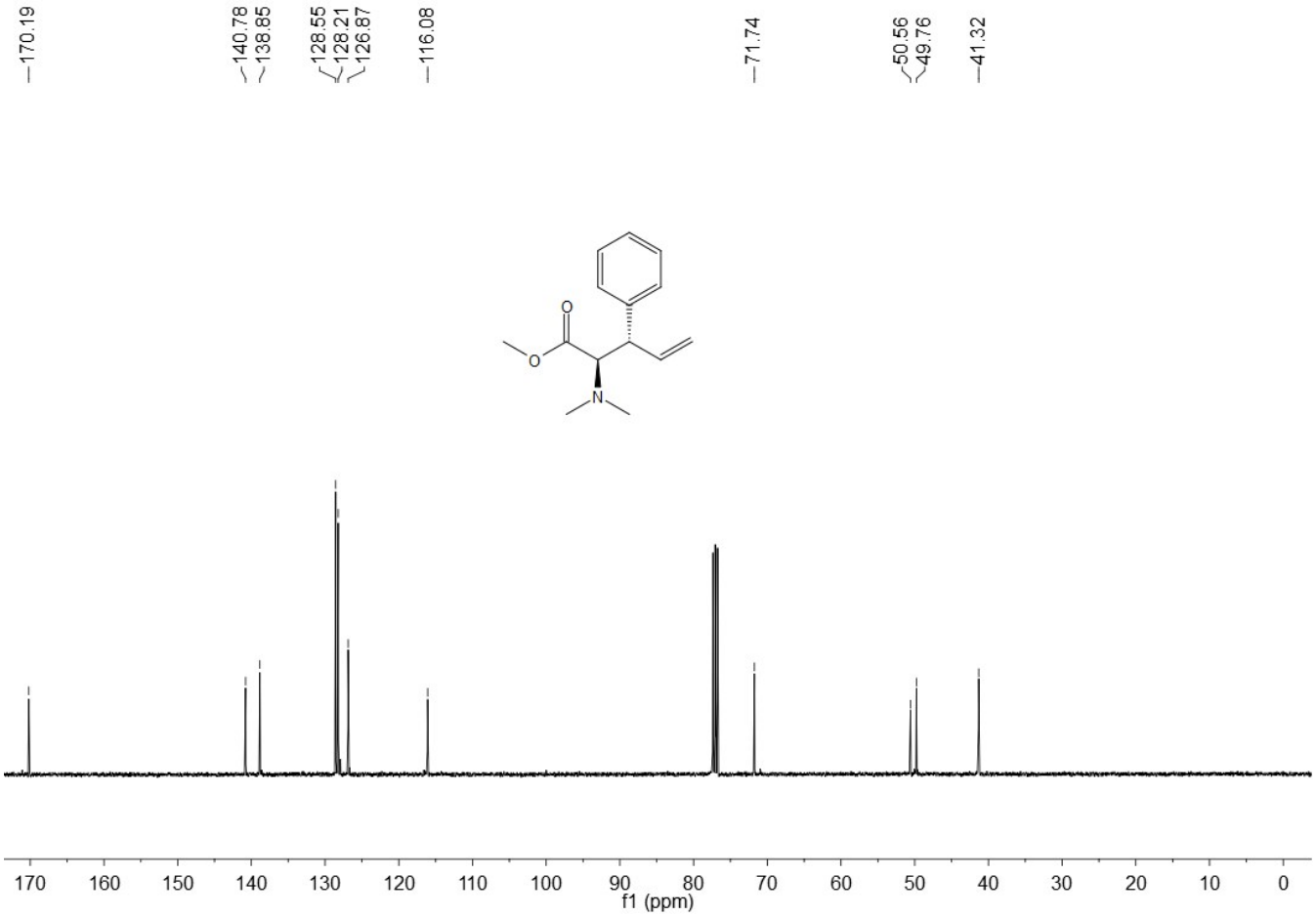




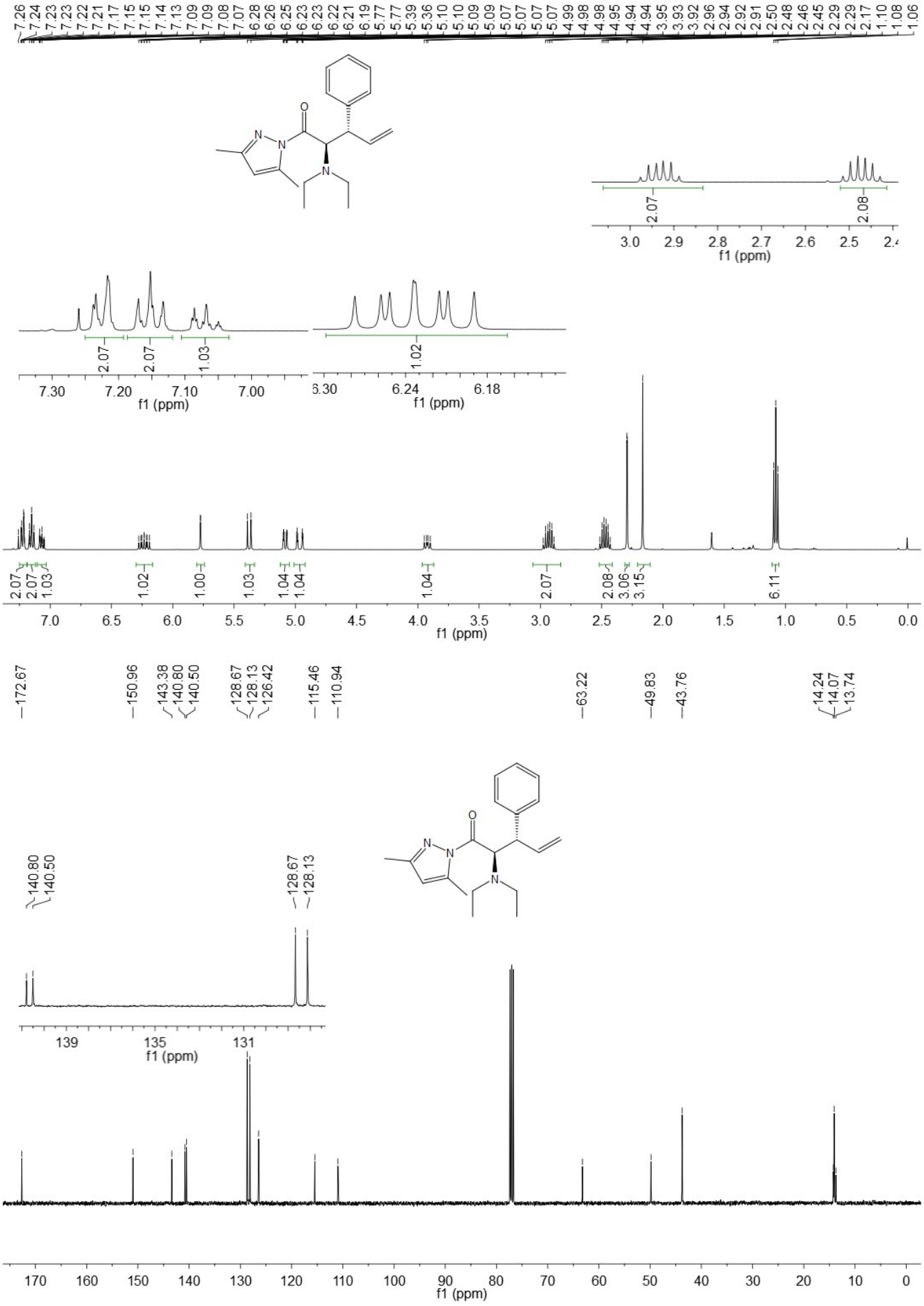


Methyl (2*R*,3*S*)-2-(dimethylamino)-3-phenylpent-4-enoate (4a)

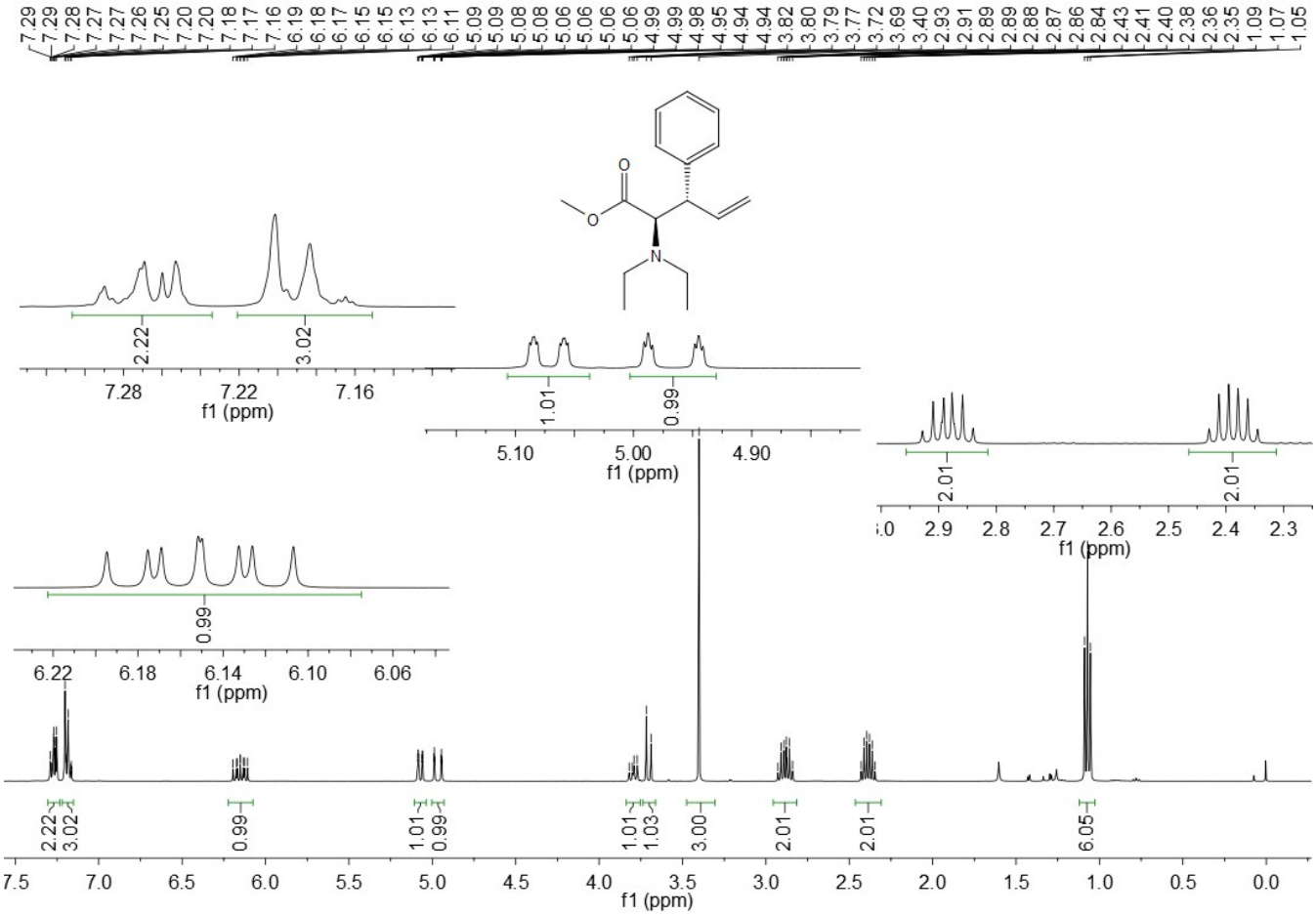


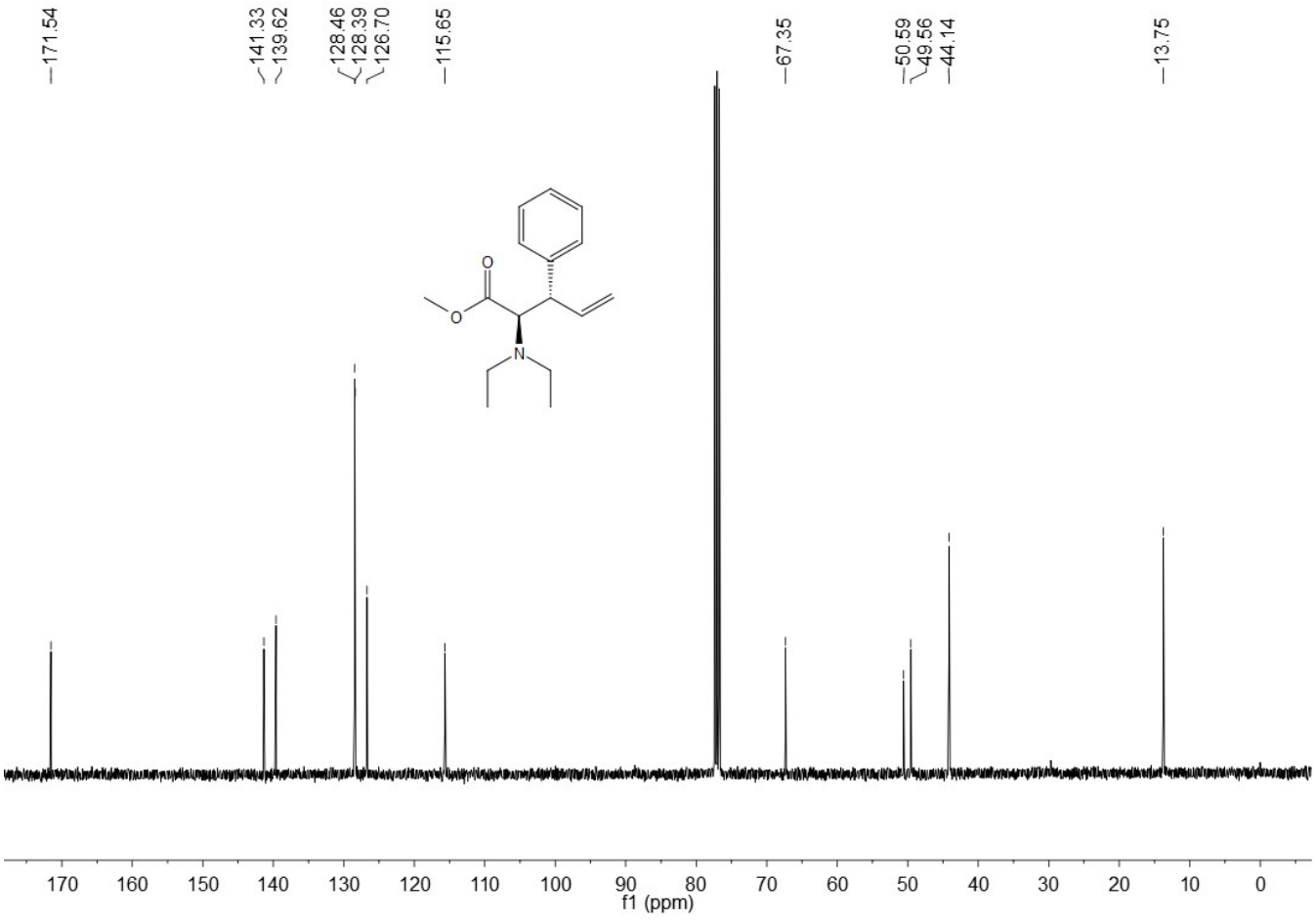


(2*R*,3*S*)-2-(Diethylamino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-3-phenylpent-4-en-1-one (3b)

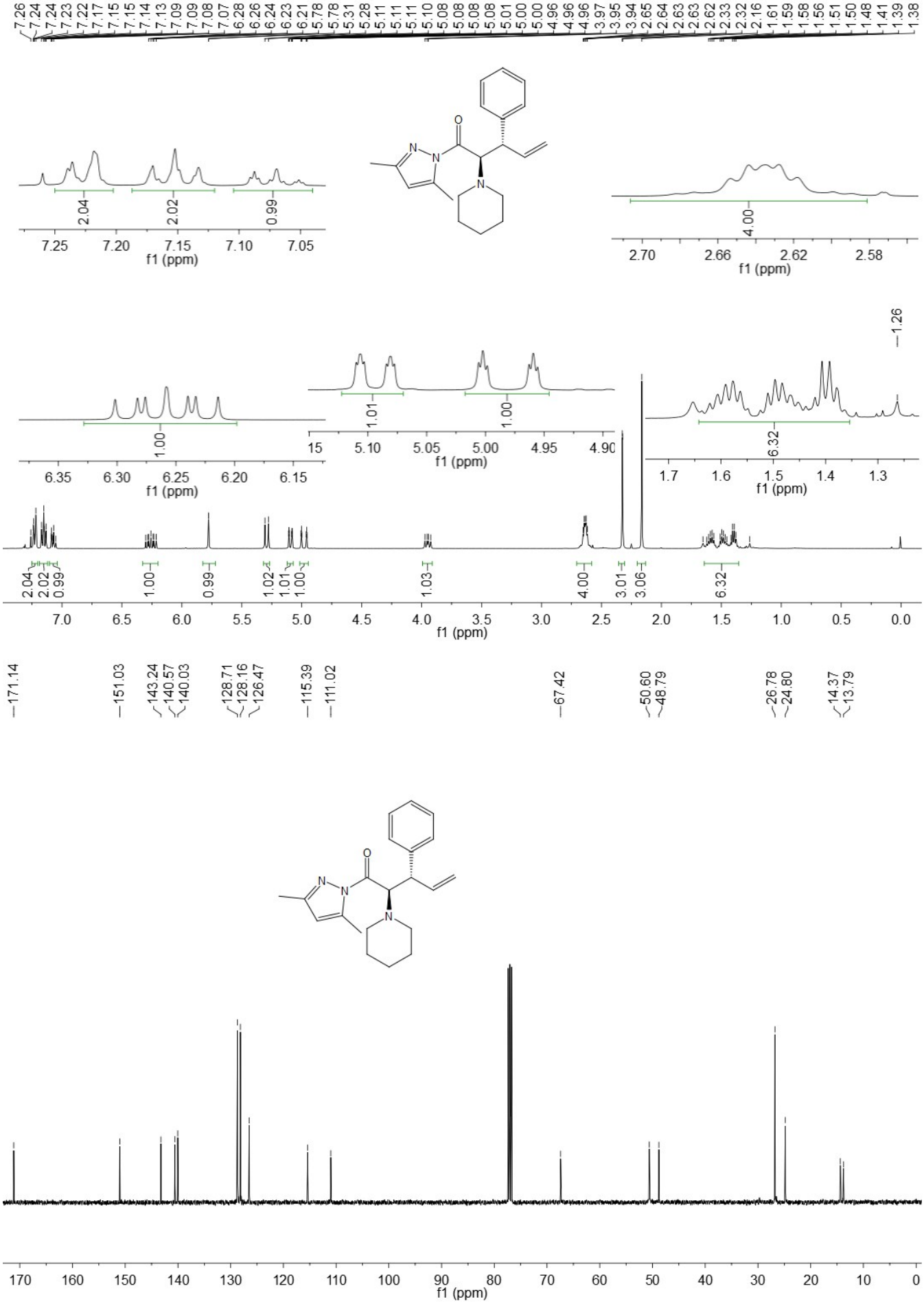


Methyl (2*R*,3*S*)-2-(diethylamino)-3-phenylpent-4-enoate (4b)

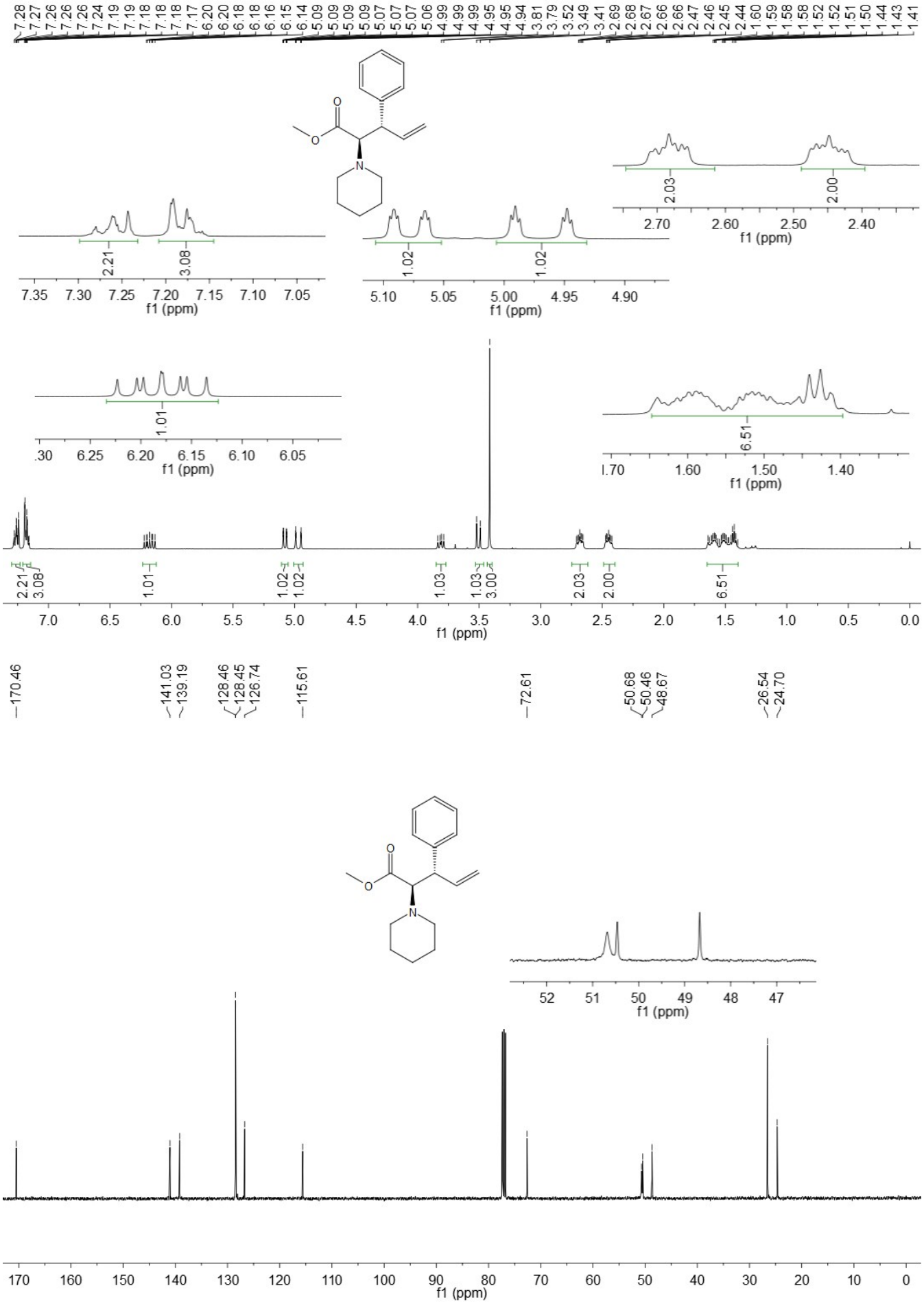




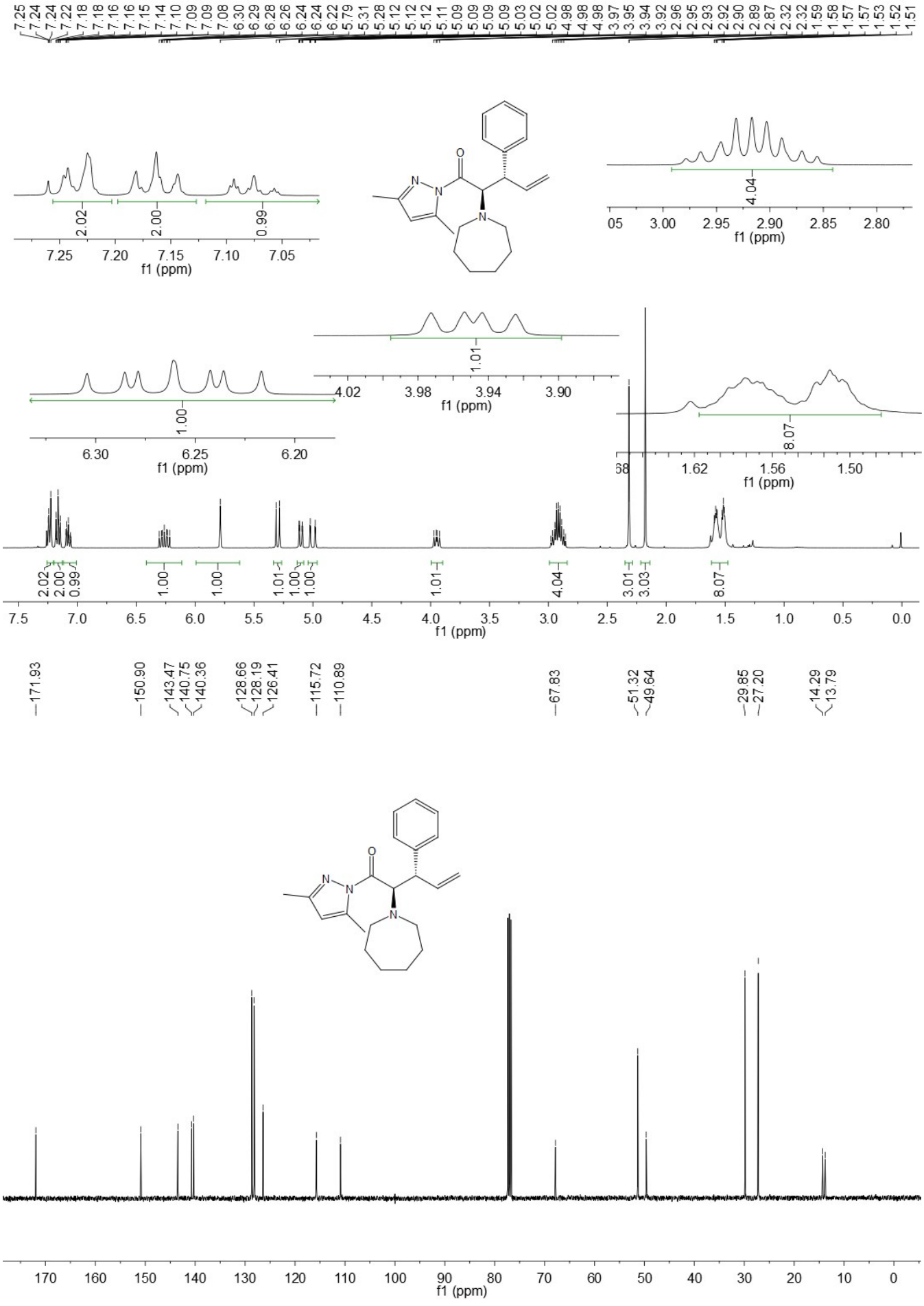
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-3-phenyl-2-(piperidin-1-yl)pent-4-en-1-one (3c)



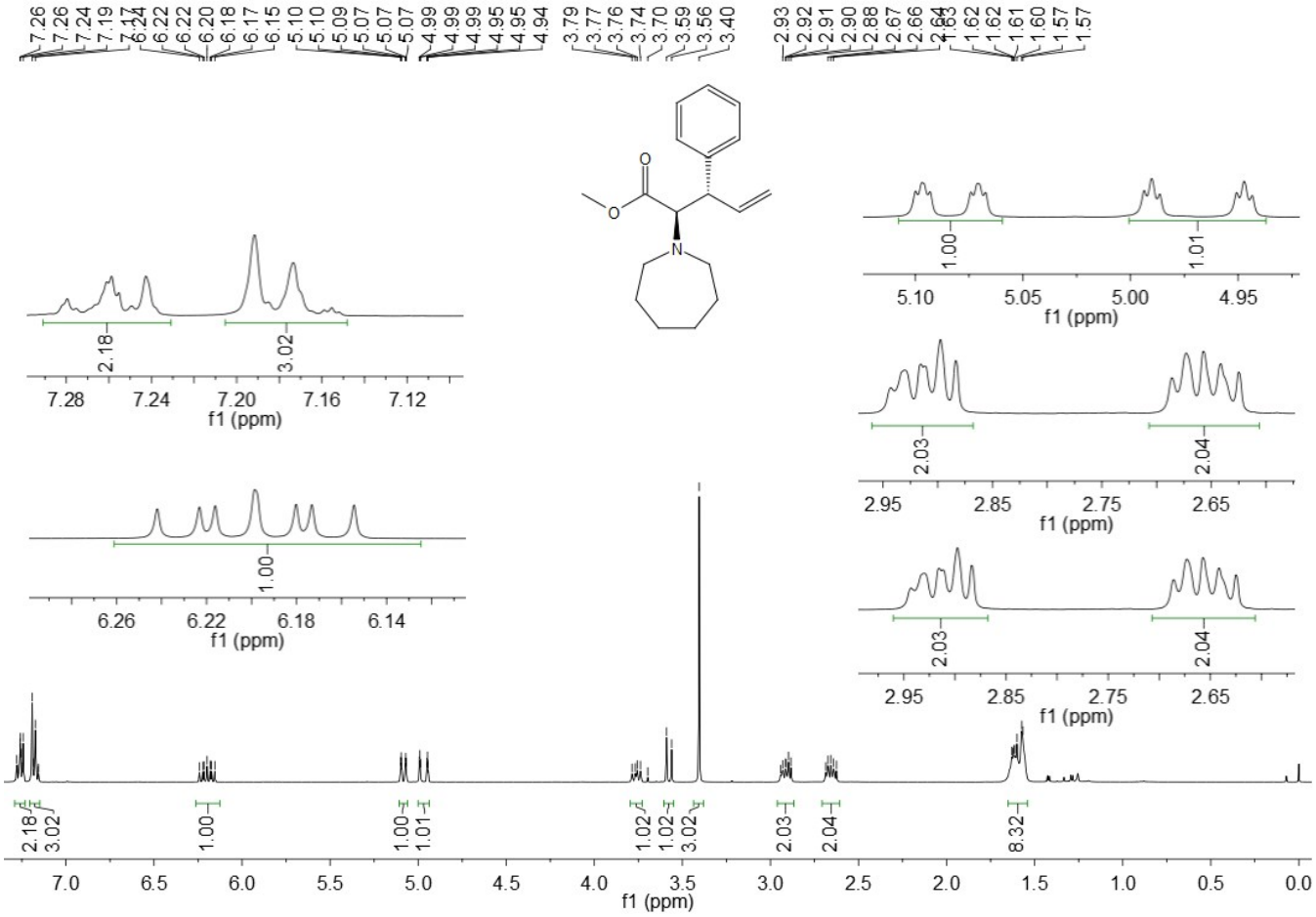
Methyl (2*R*,3*S*)-3-phenyl-2-(piperidin-1-yl)pent-4-enoate (4c)

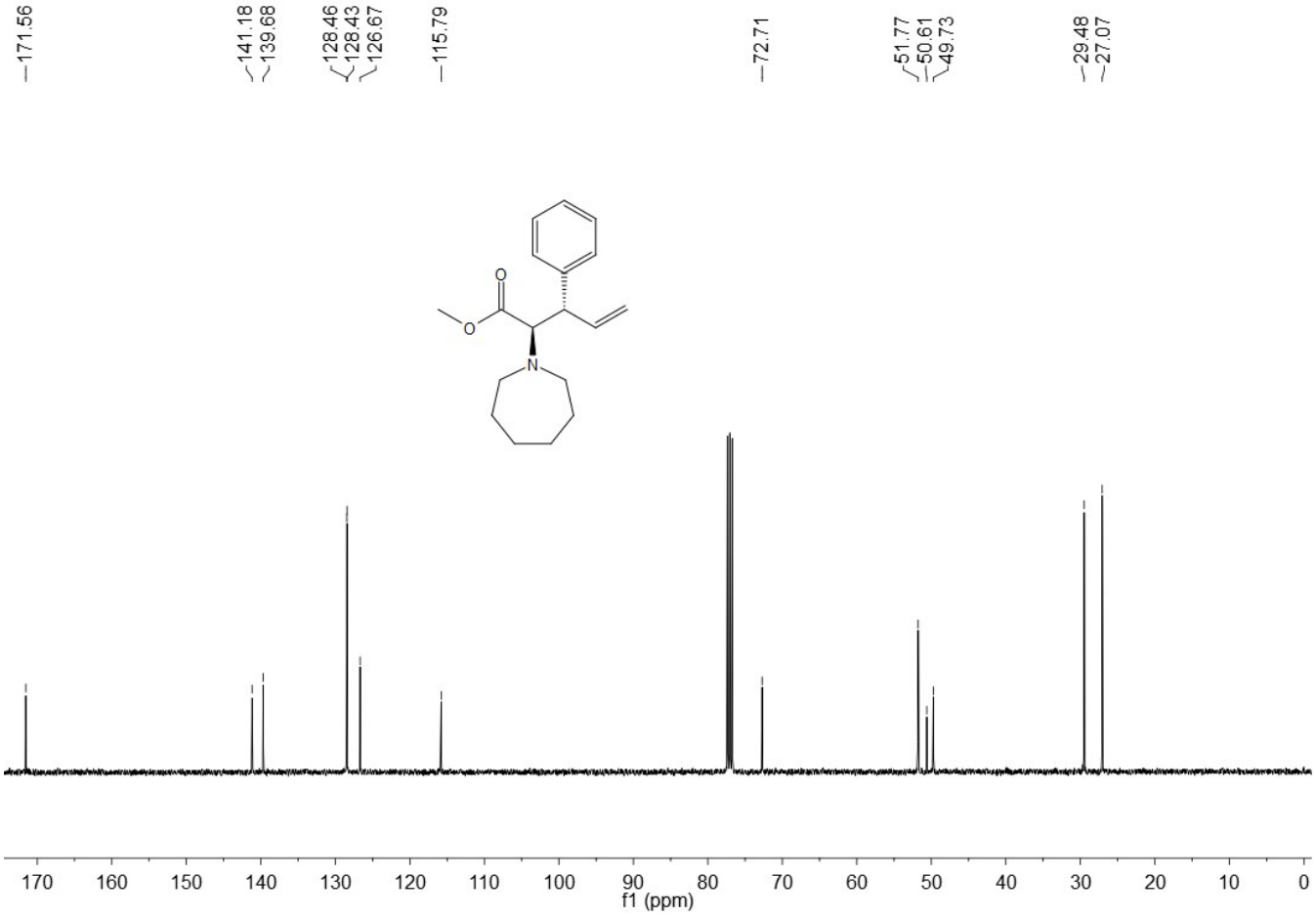


(2*R*,3*S*)-2-(Azepan-1-yl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-3-phenylpent-4-en-1-one (3d)

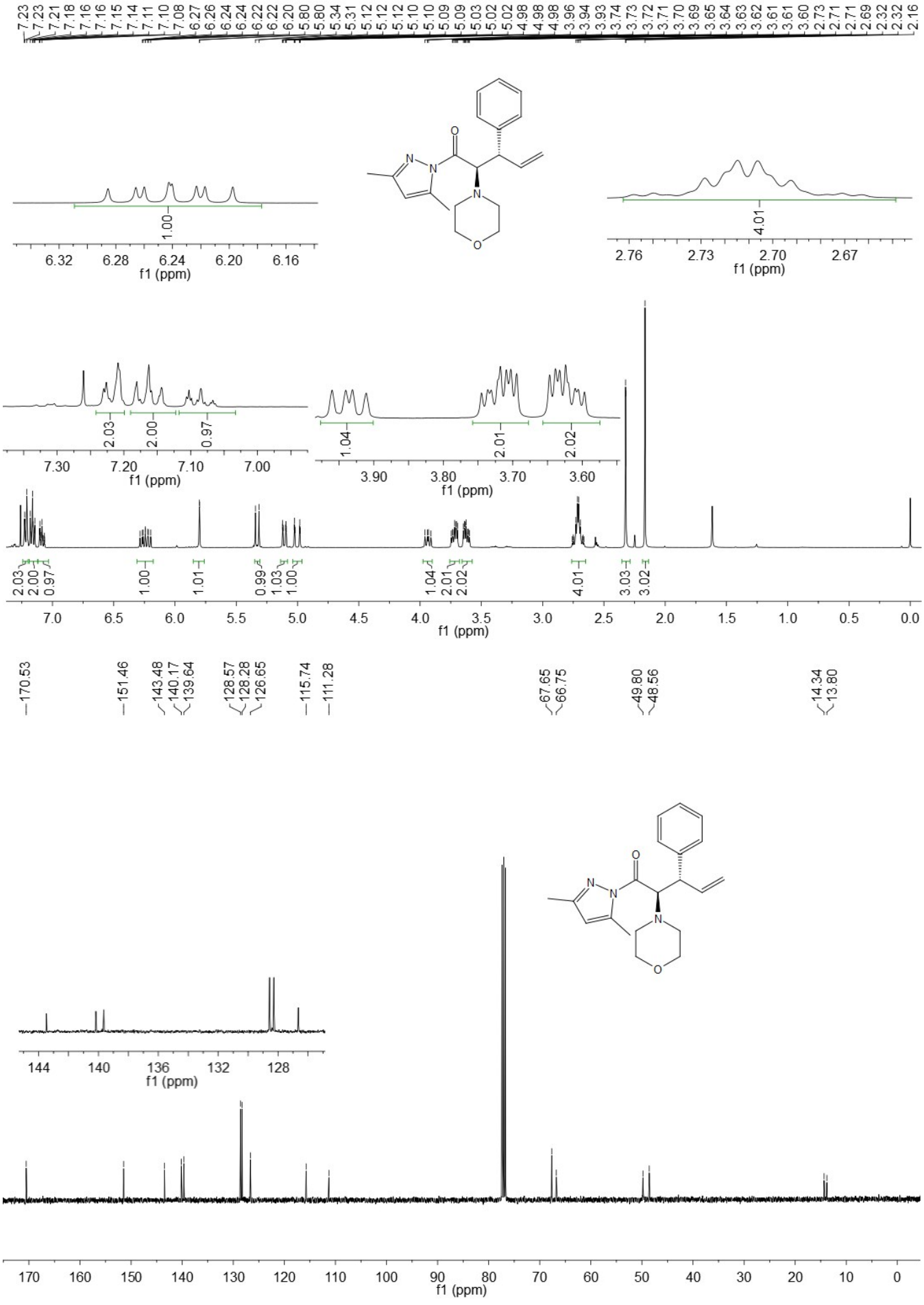


Methyl (2*R*,3*S*)-2-(azepan-1-yl)-3-phenylpent-4-enoate (4d)

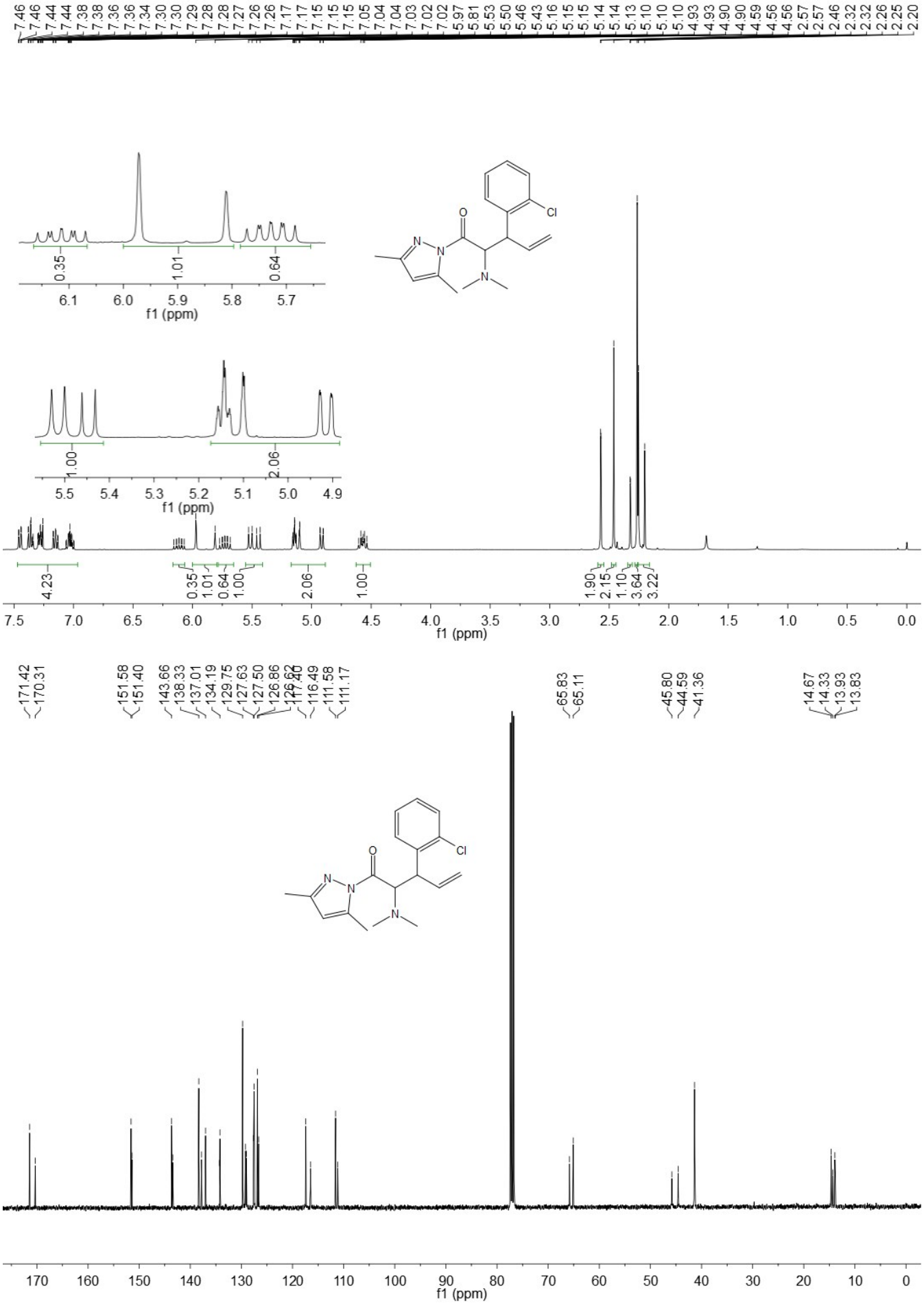




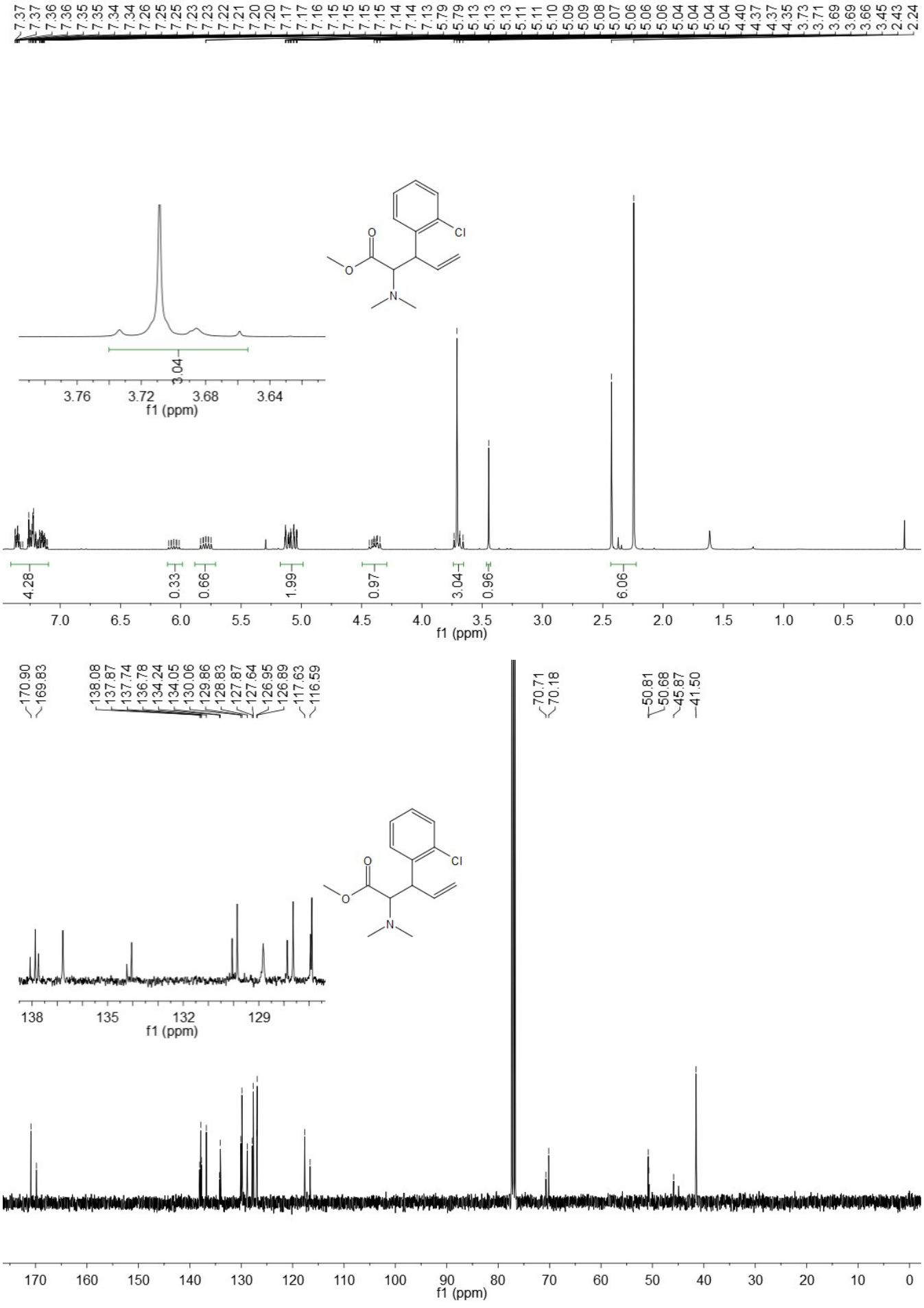
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-morpholino-3-phenylpent-4-en-1-one (3e)



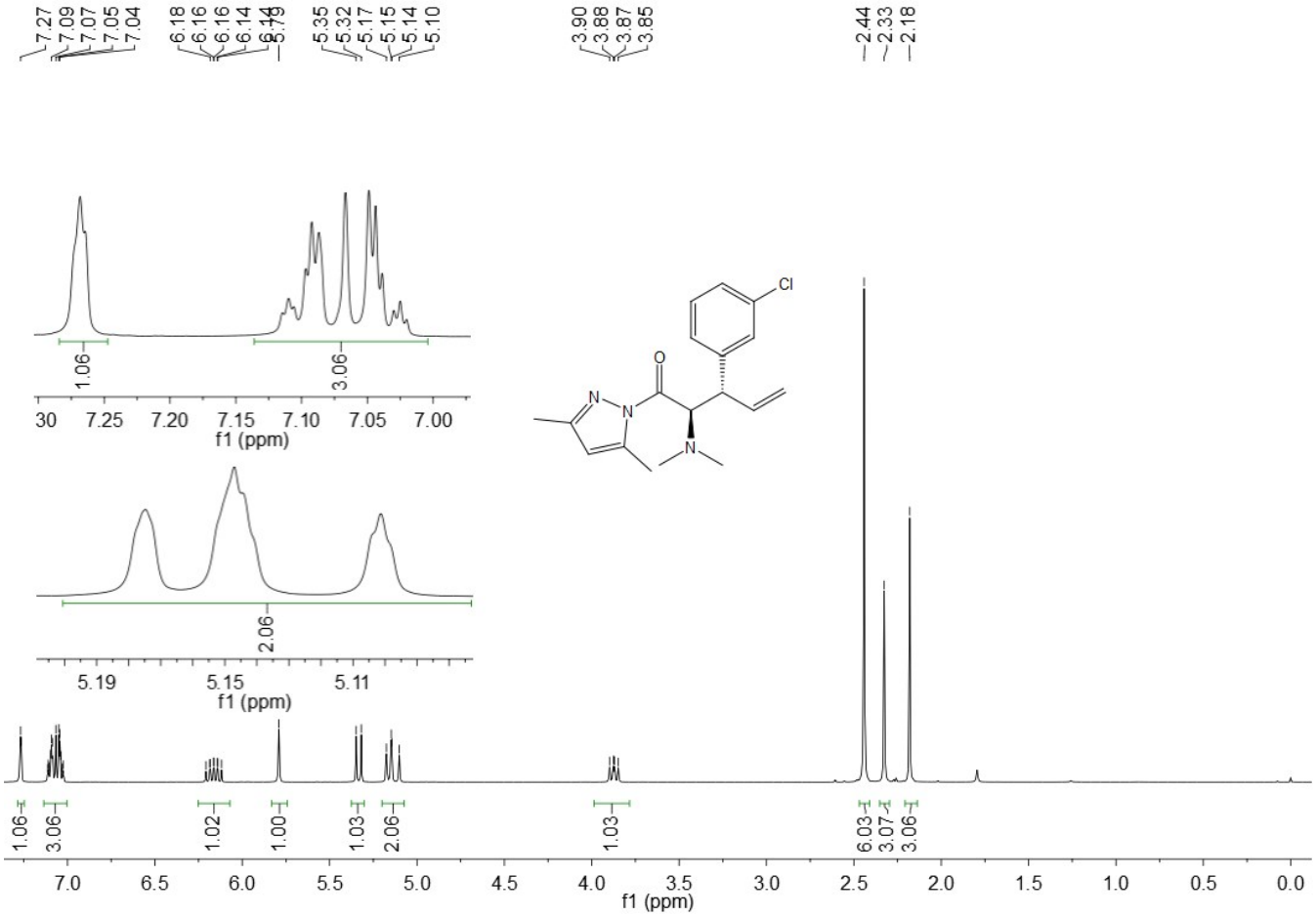
3-(2-Chlorophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3f)

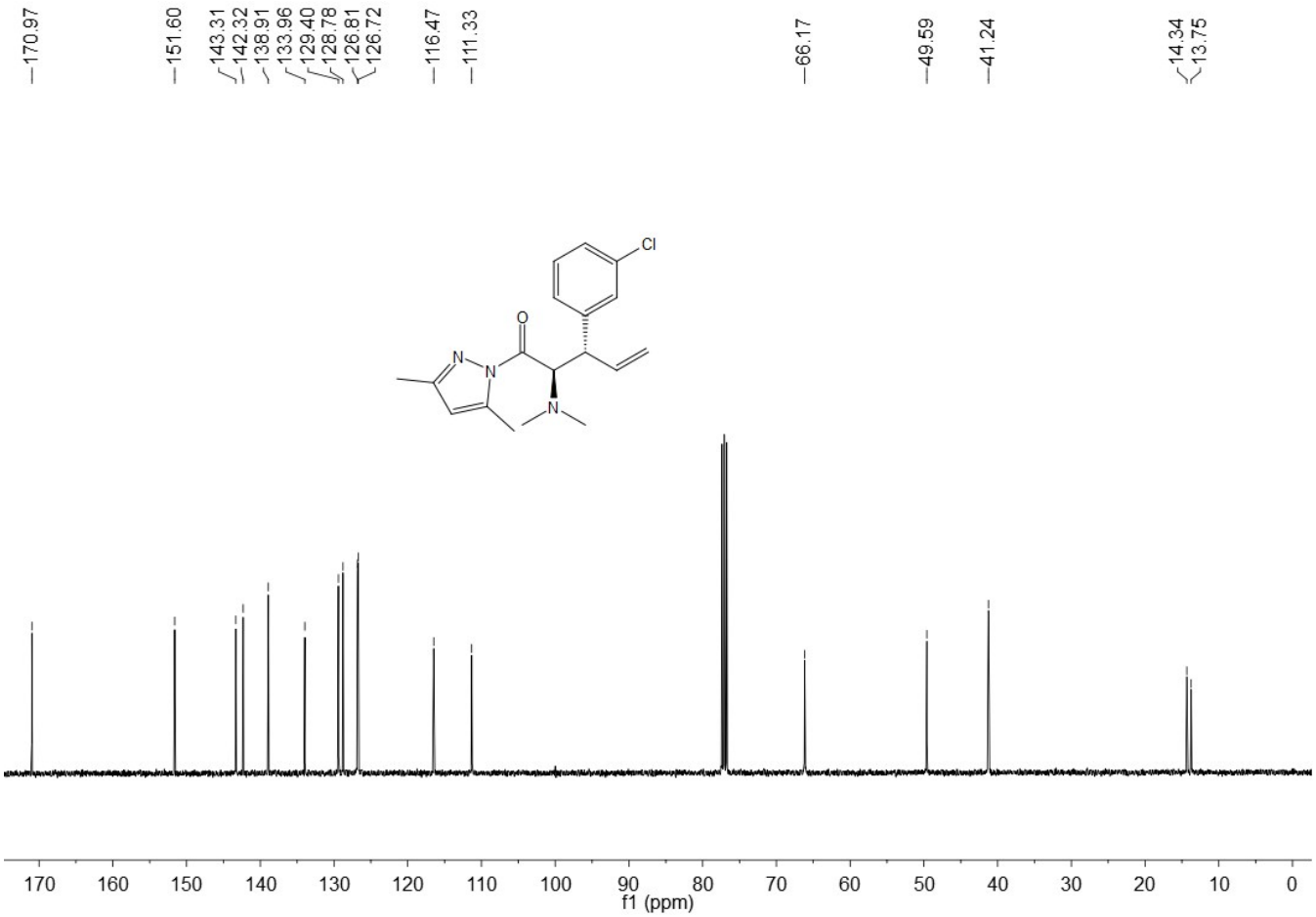


Methyl 3-(2-chlorophenyl)-2-(dimethylamino)pent-4-enoate (4f)

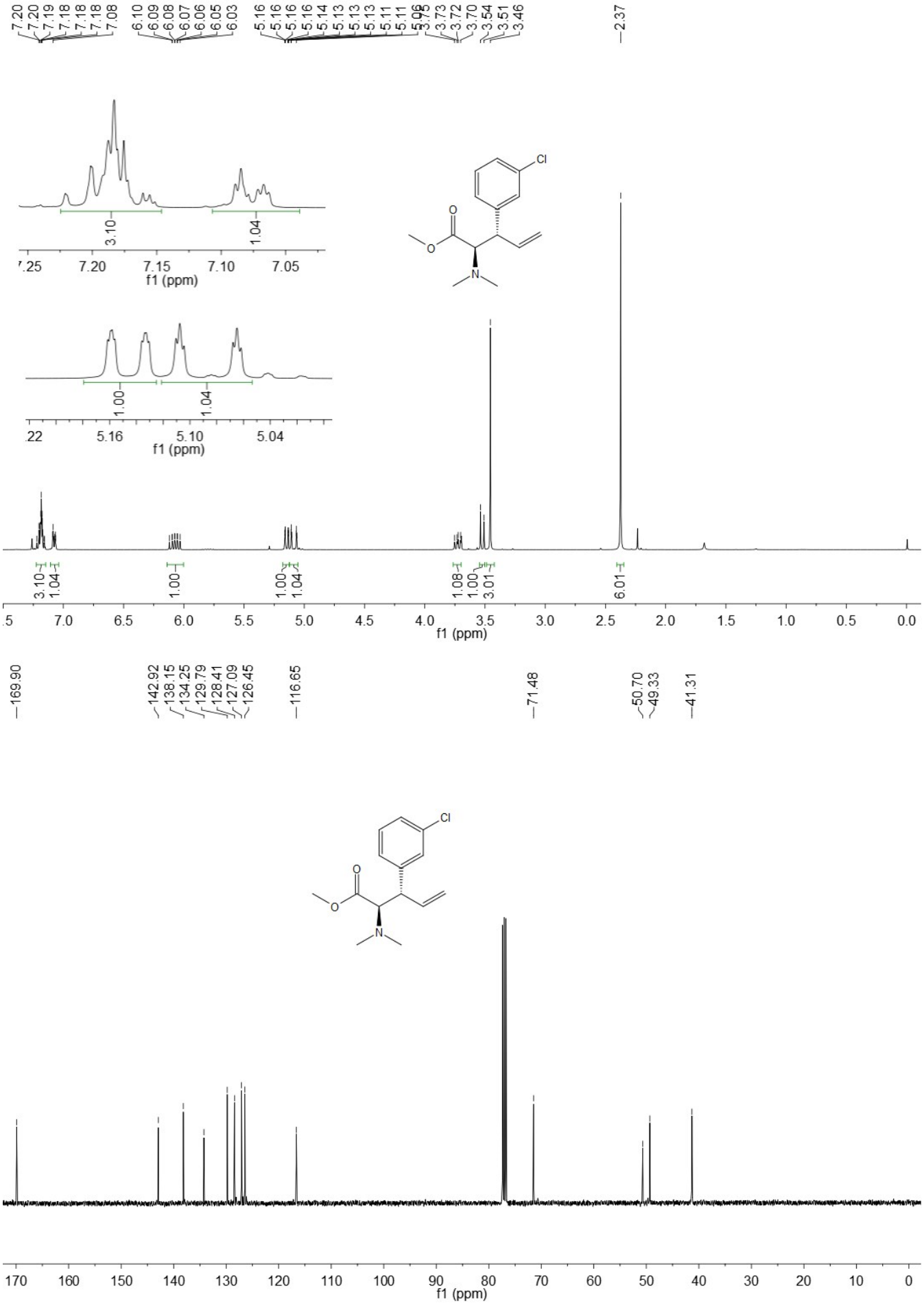


(2*R*,3*S*)-3-(3-Chlorophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3g)

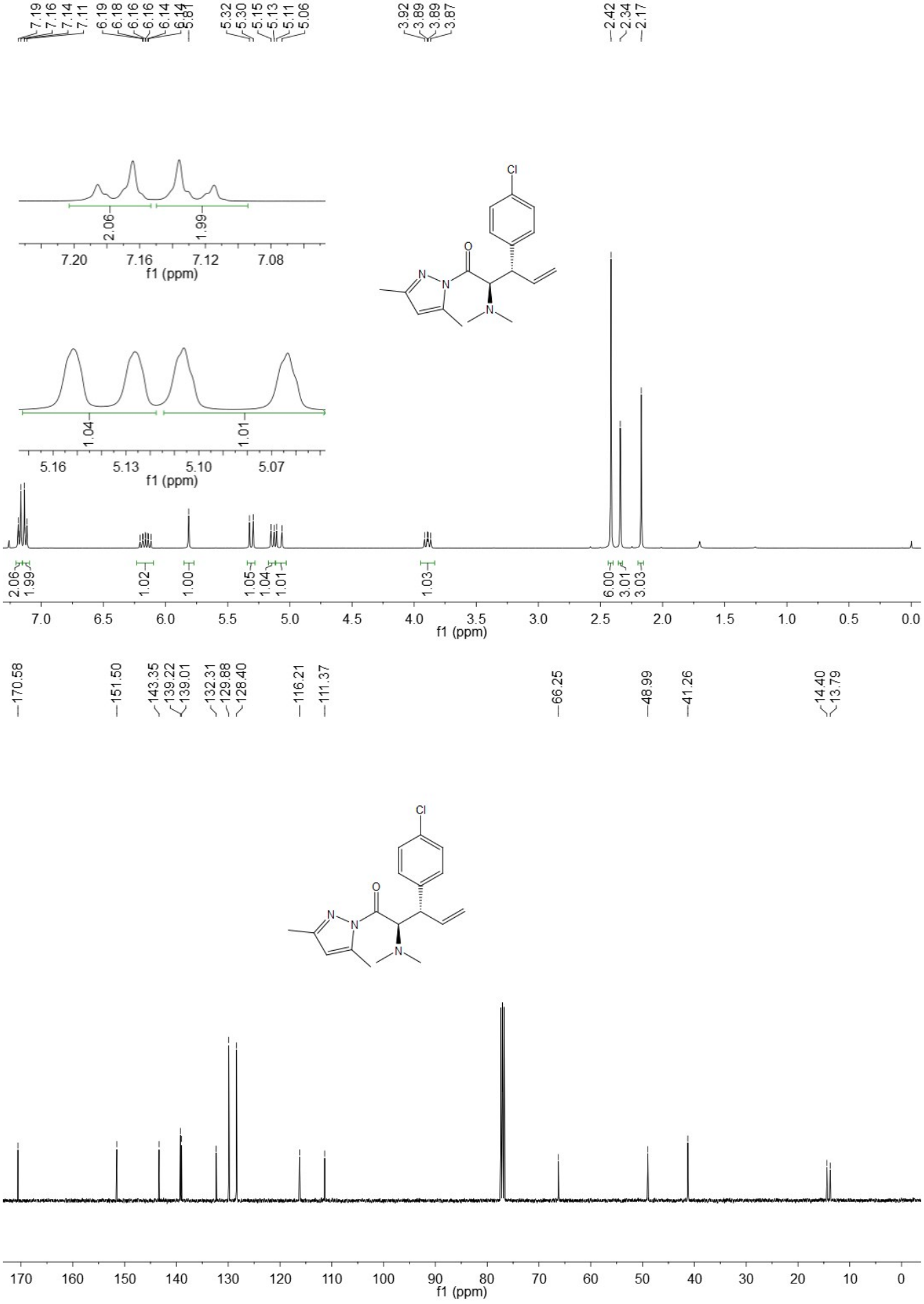




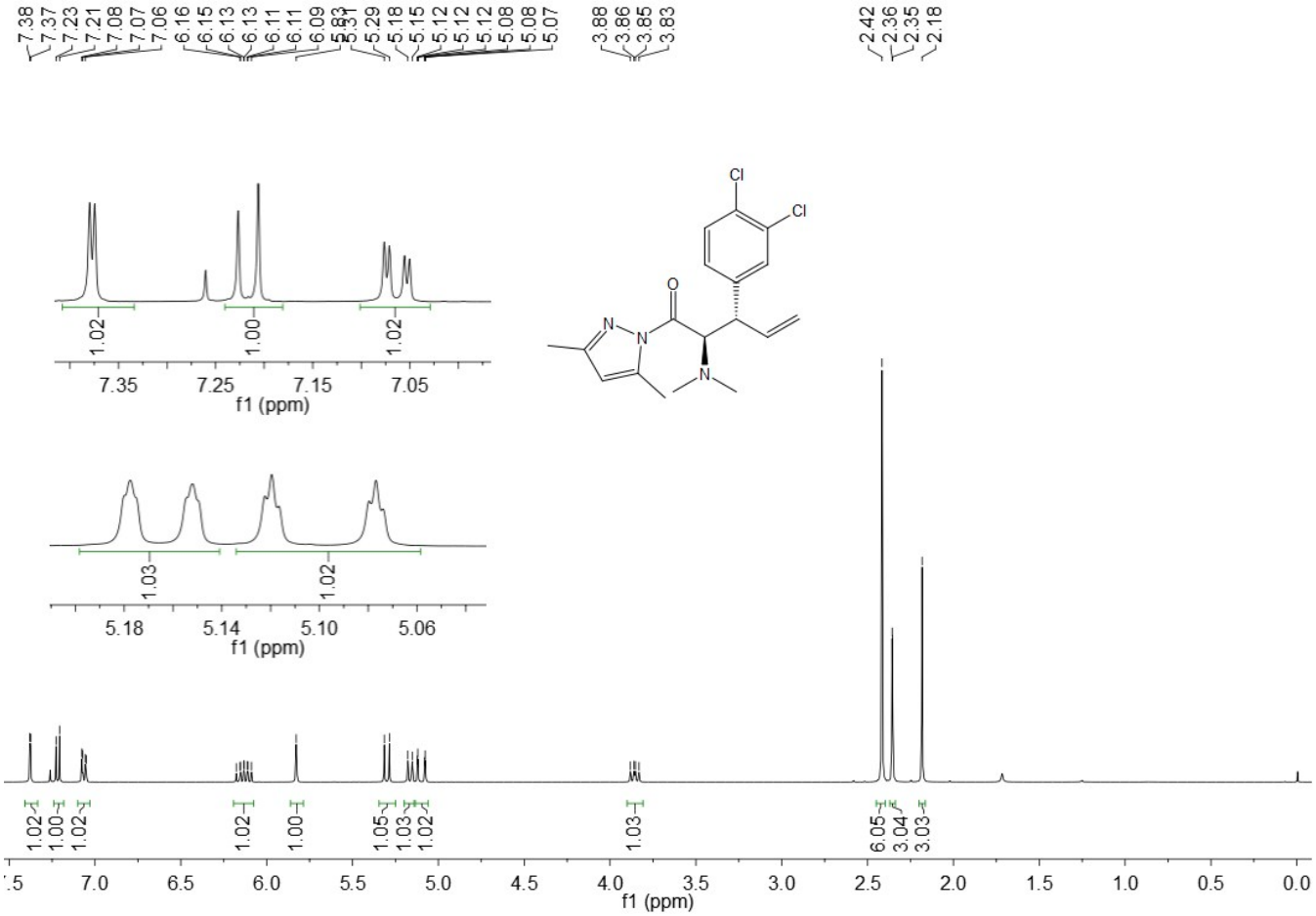
Methyl (2*R*,3*S*)-3-(3-chlorophenyl)-2-(dimethylamino)pent-4-enoate (4g)

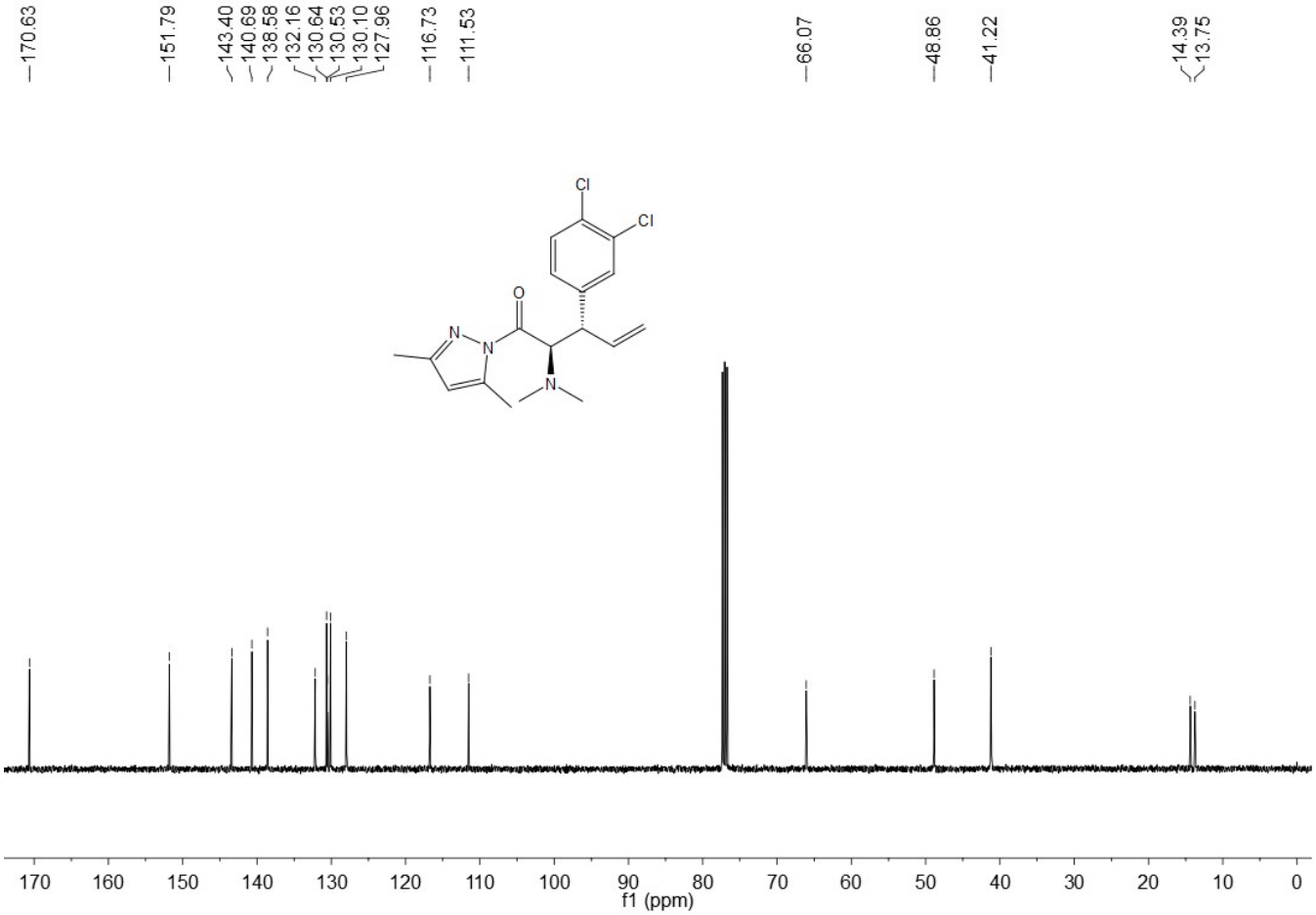


(2*R*,3*S*)-3-(4-Chlorophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3h)

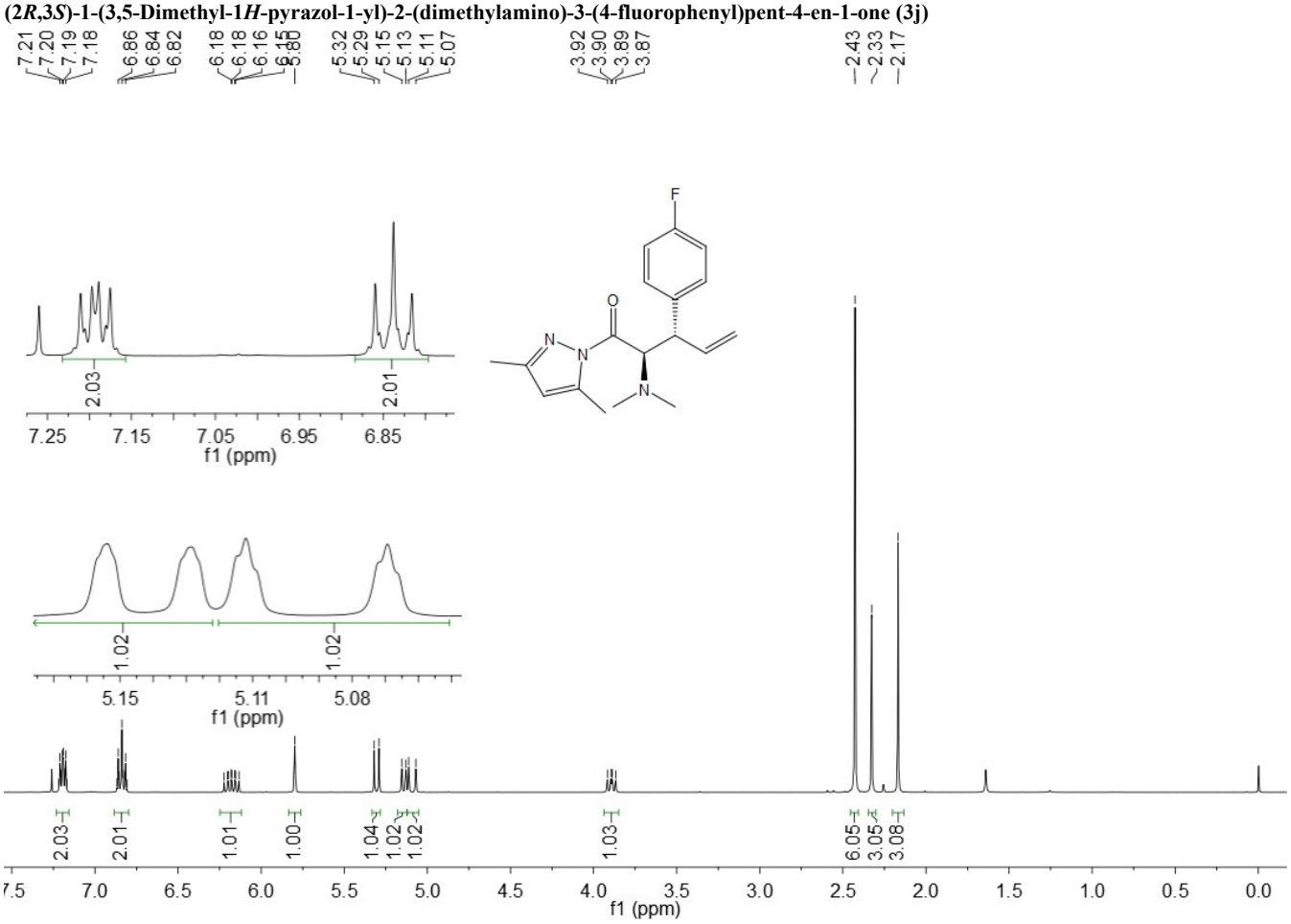


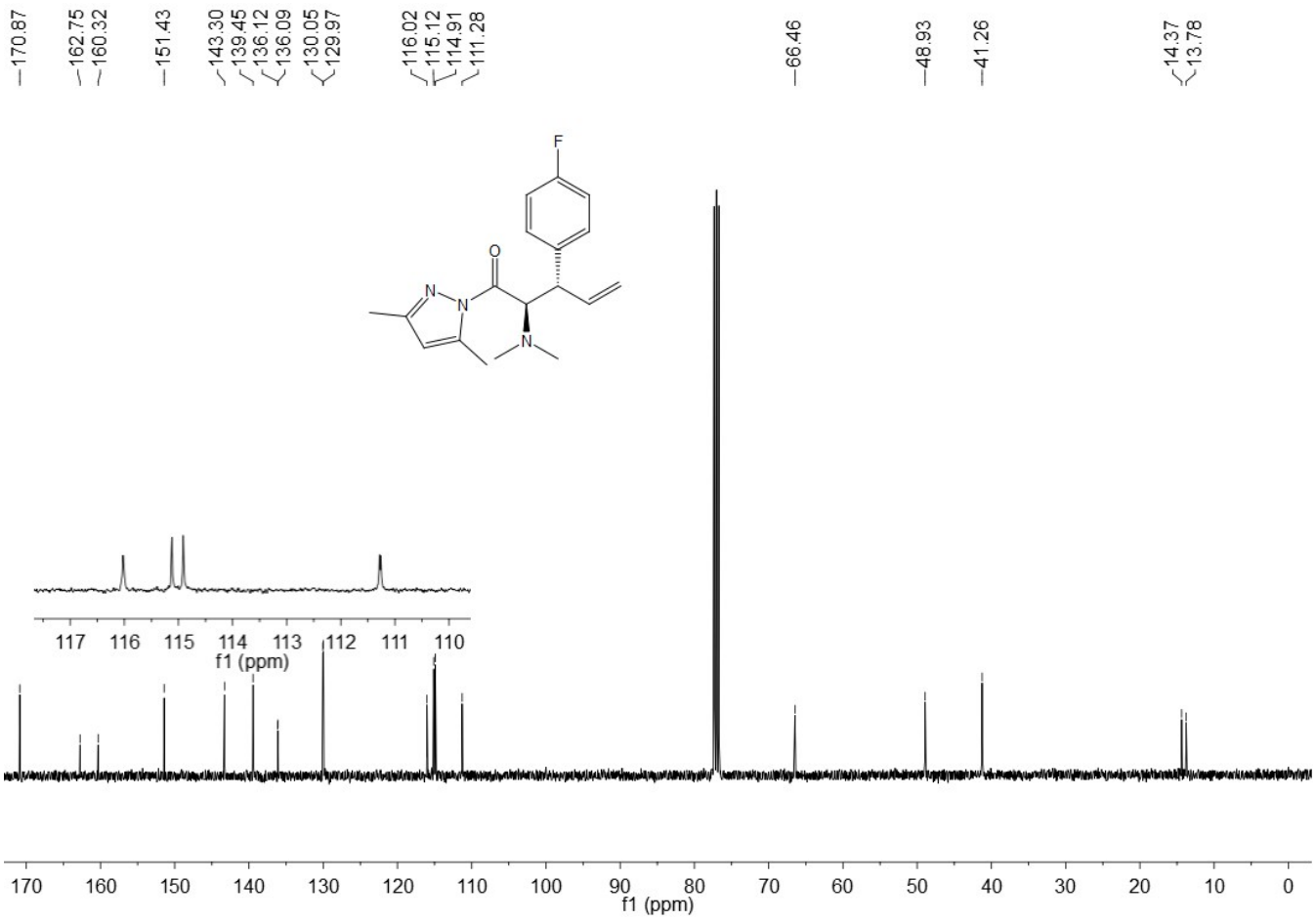
(2*R*,3*S*)-3-(3,4-Dichlorophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3i)

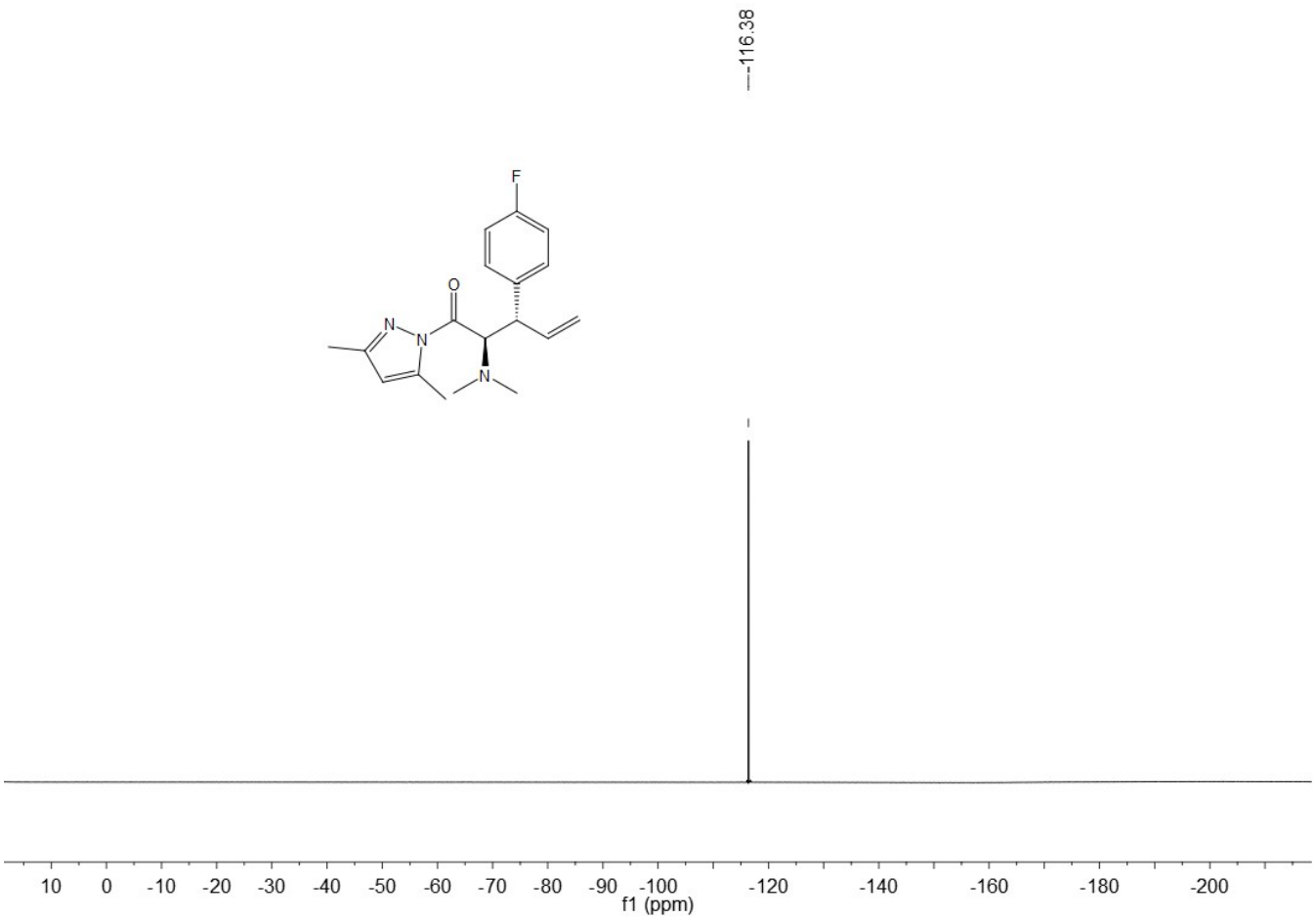




(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(4-fluorophenyl)pent-4-en-1-one (3j)






-116.38
F
O
N
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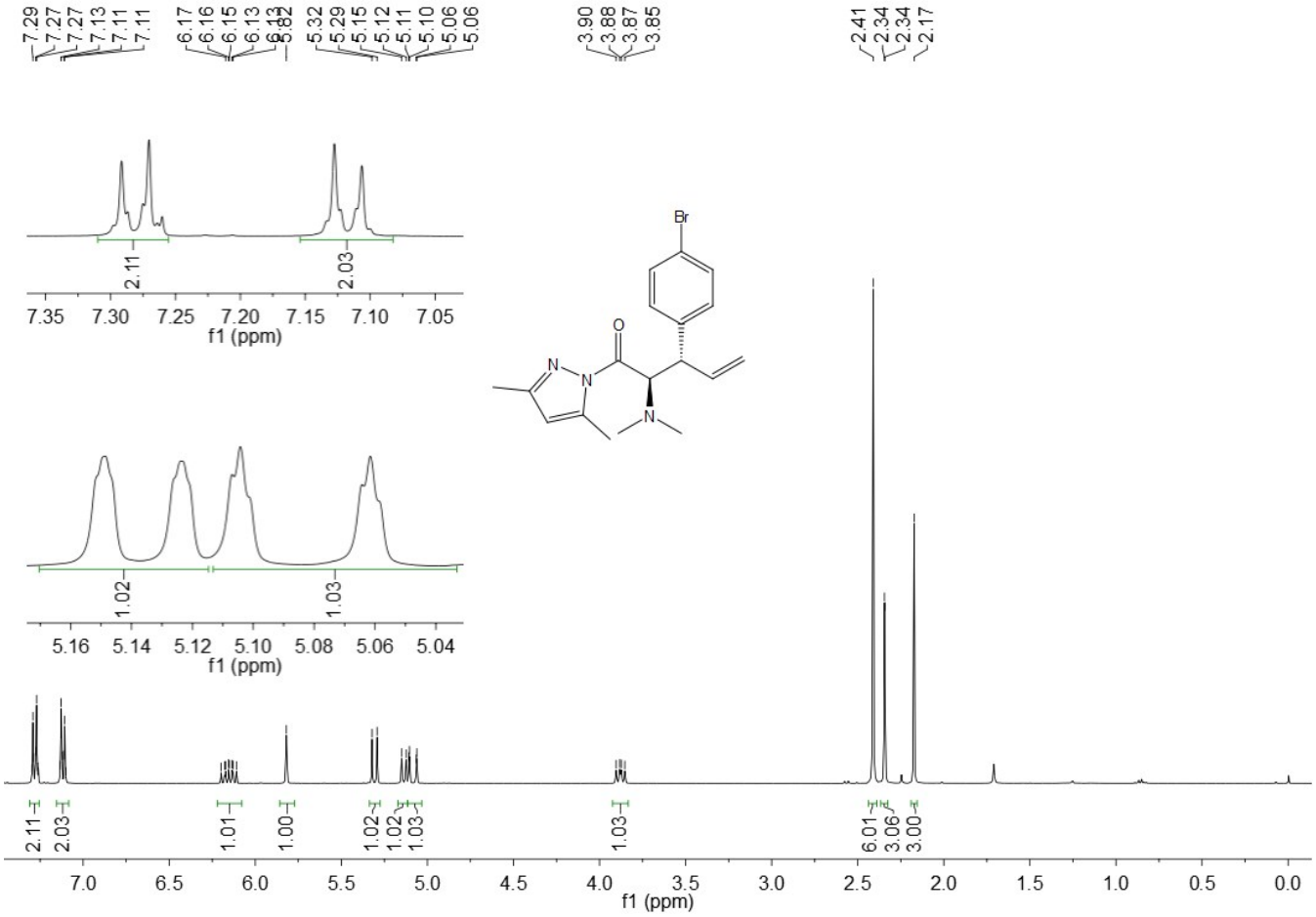
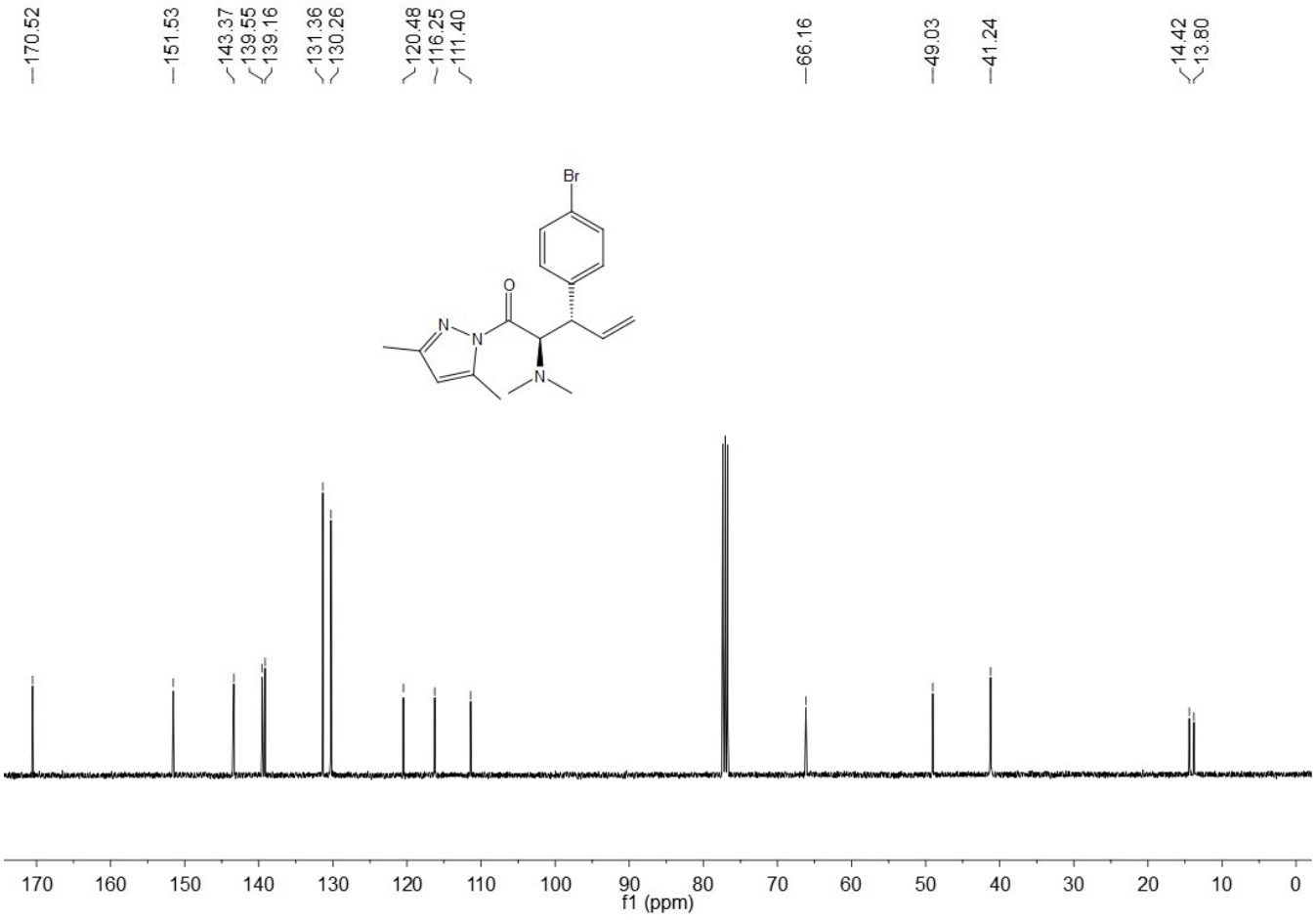
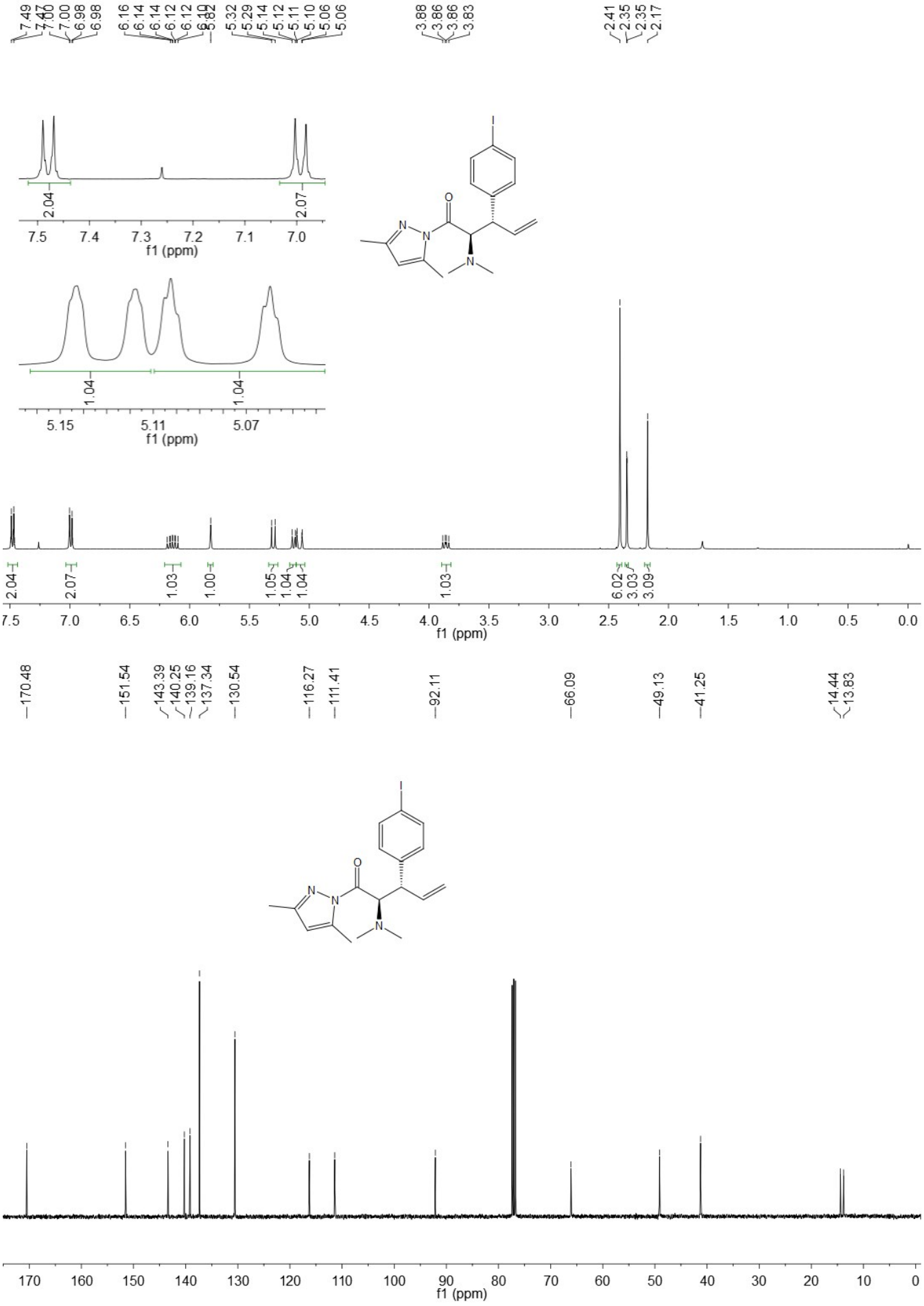
N
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-120
-140
-160
-180
-200
f1 (ppm)

(2*R*,3*S*)-3-(4-Bromophenyl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3k)

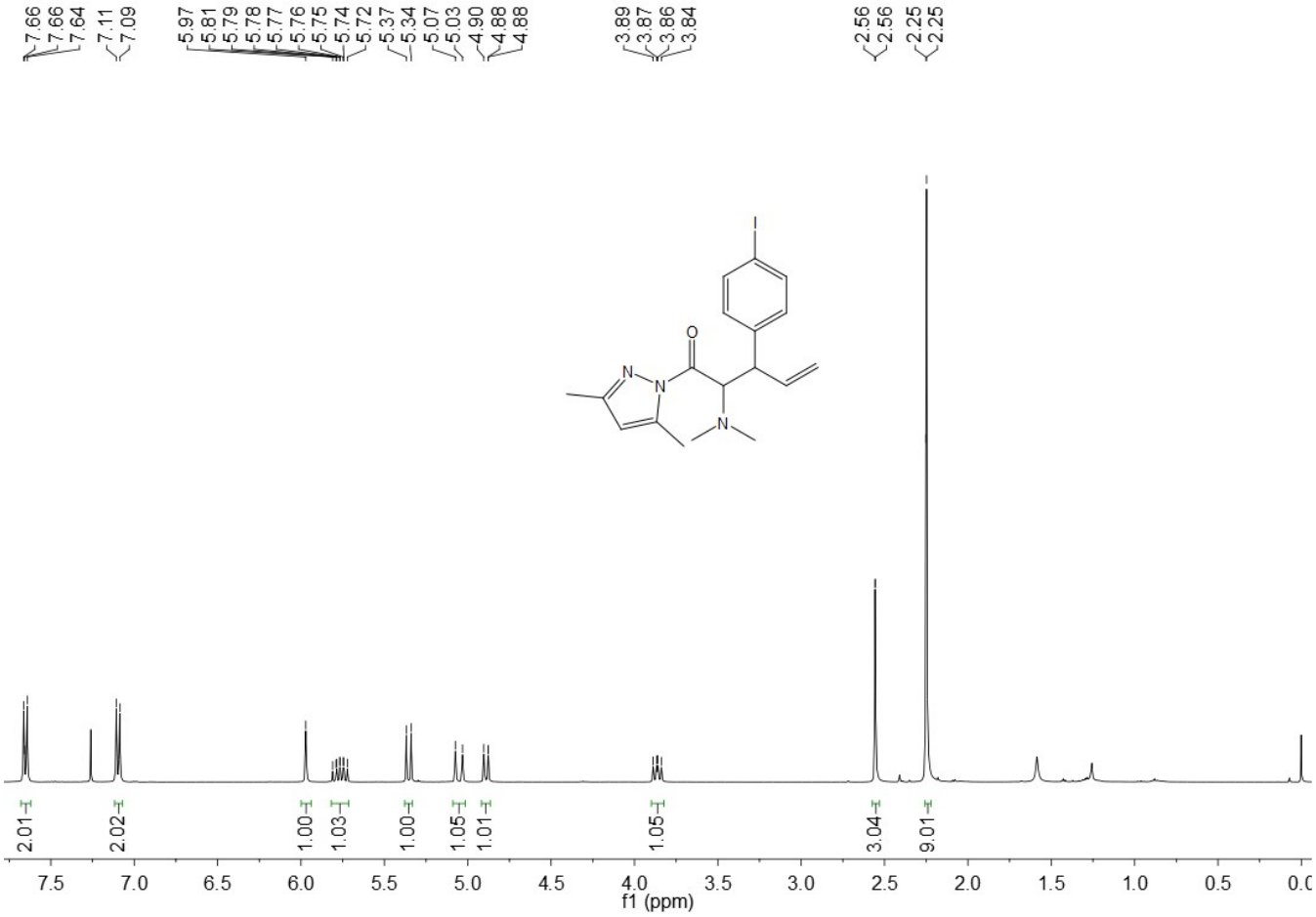


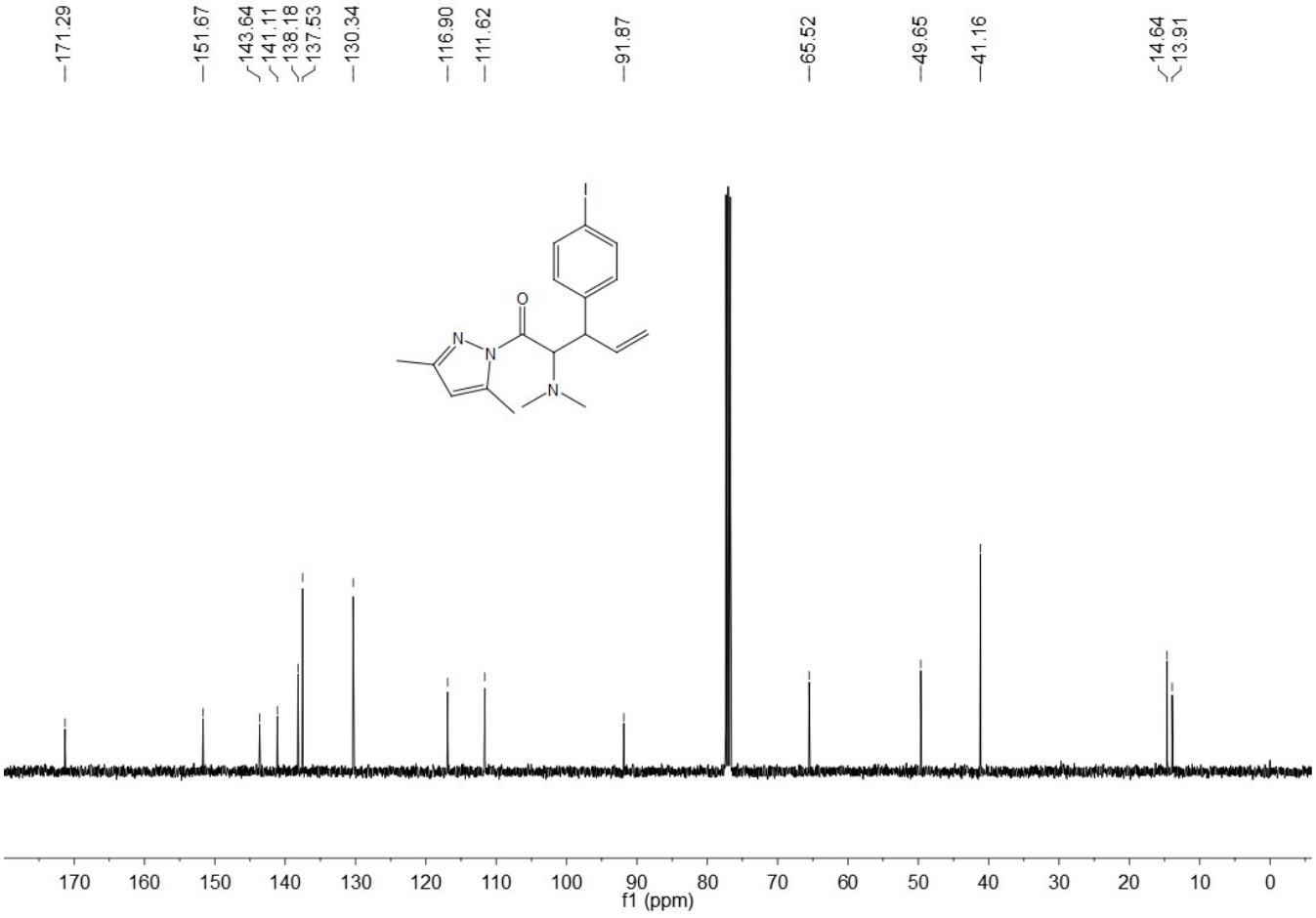


(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(4-iodophenyl)pent-4-en-1-one (3l)

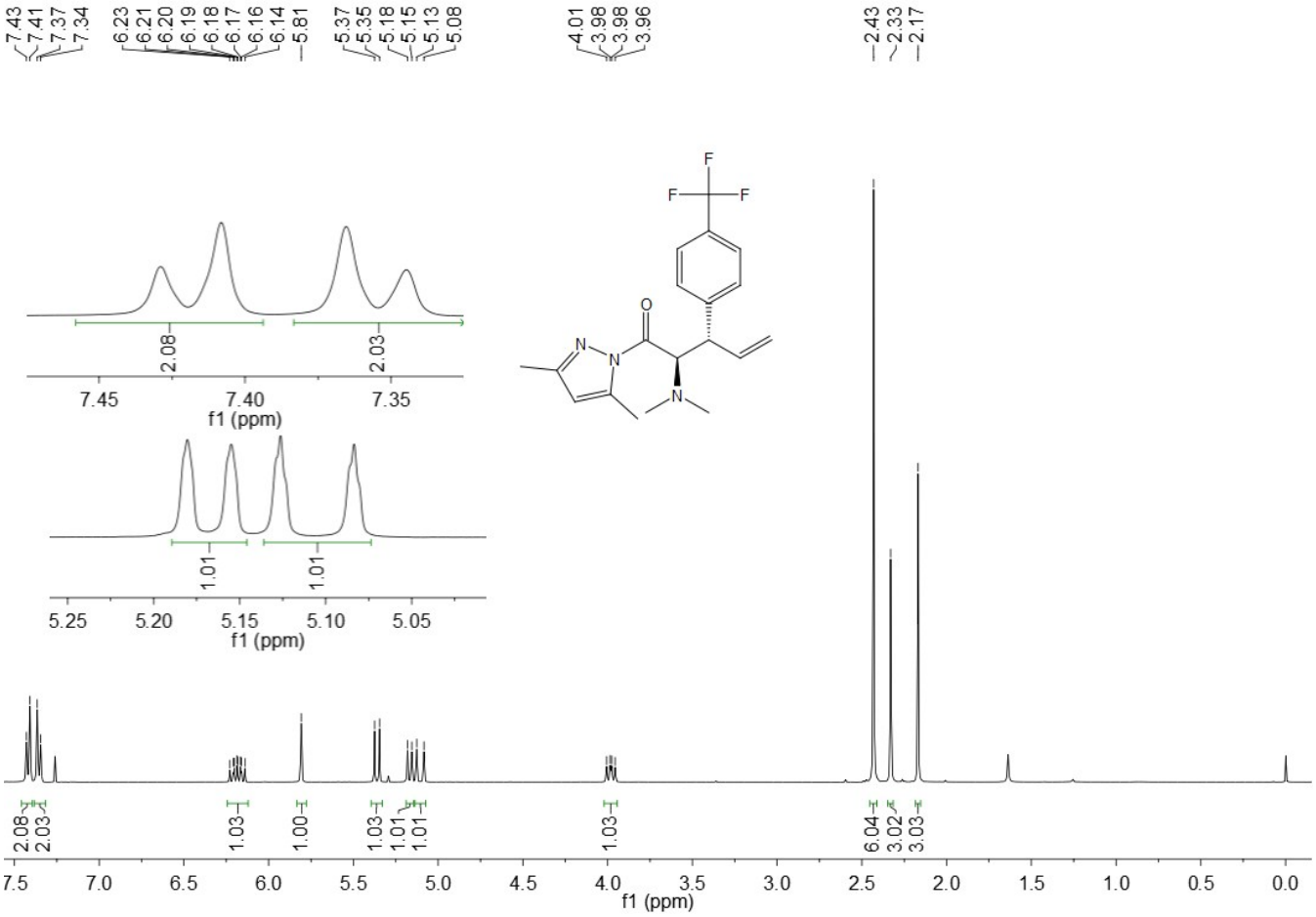


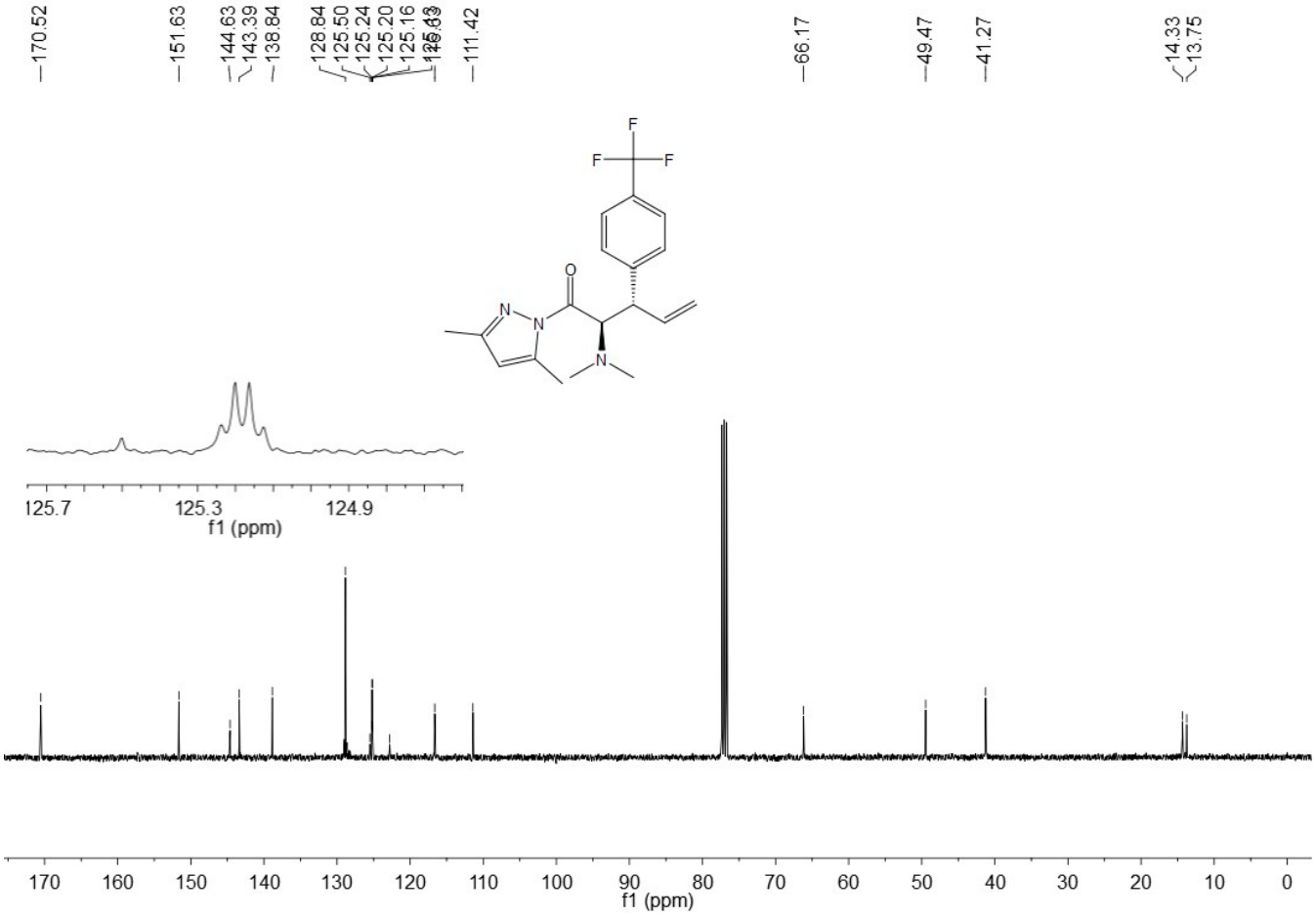
3l-minor product

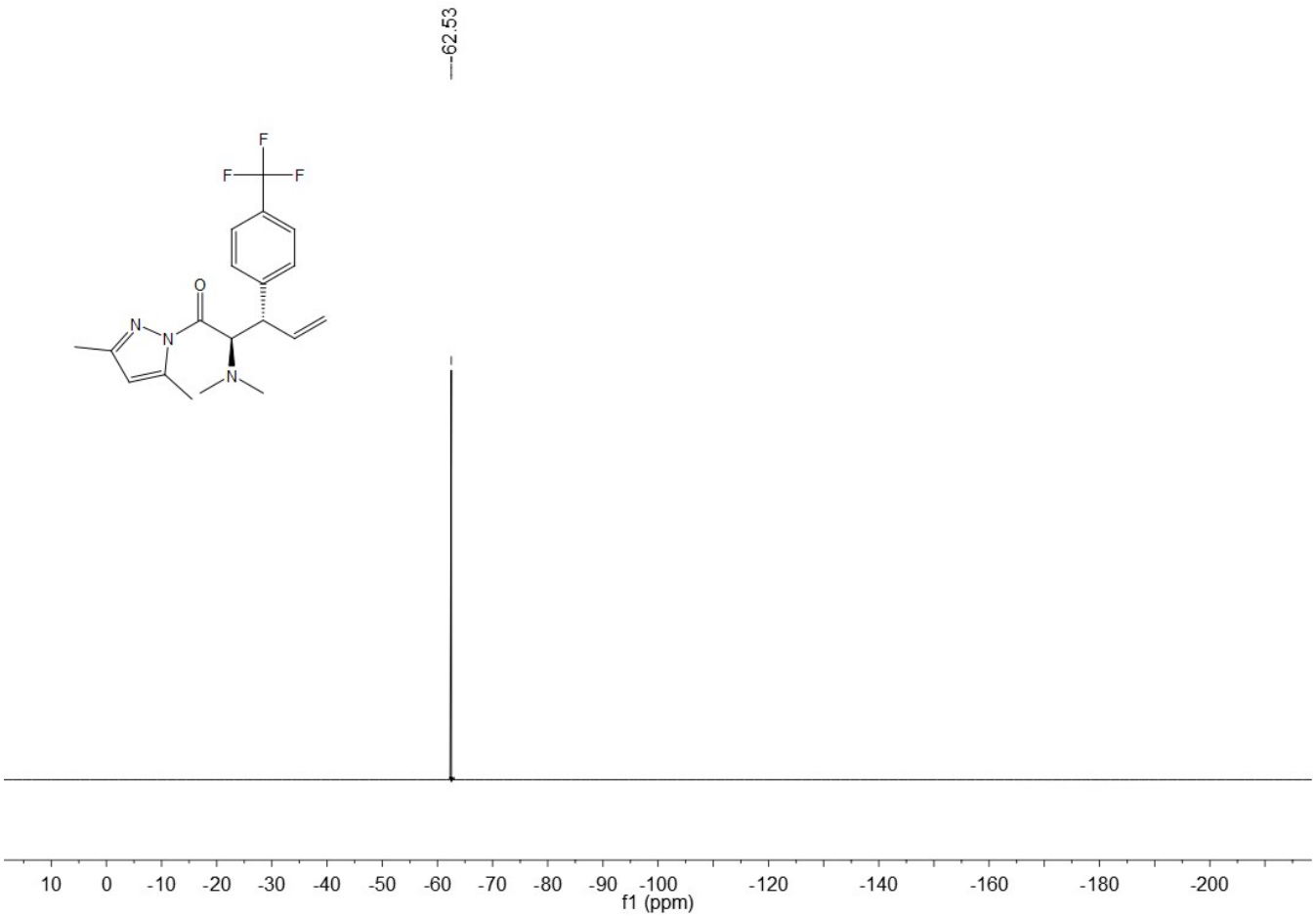




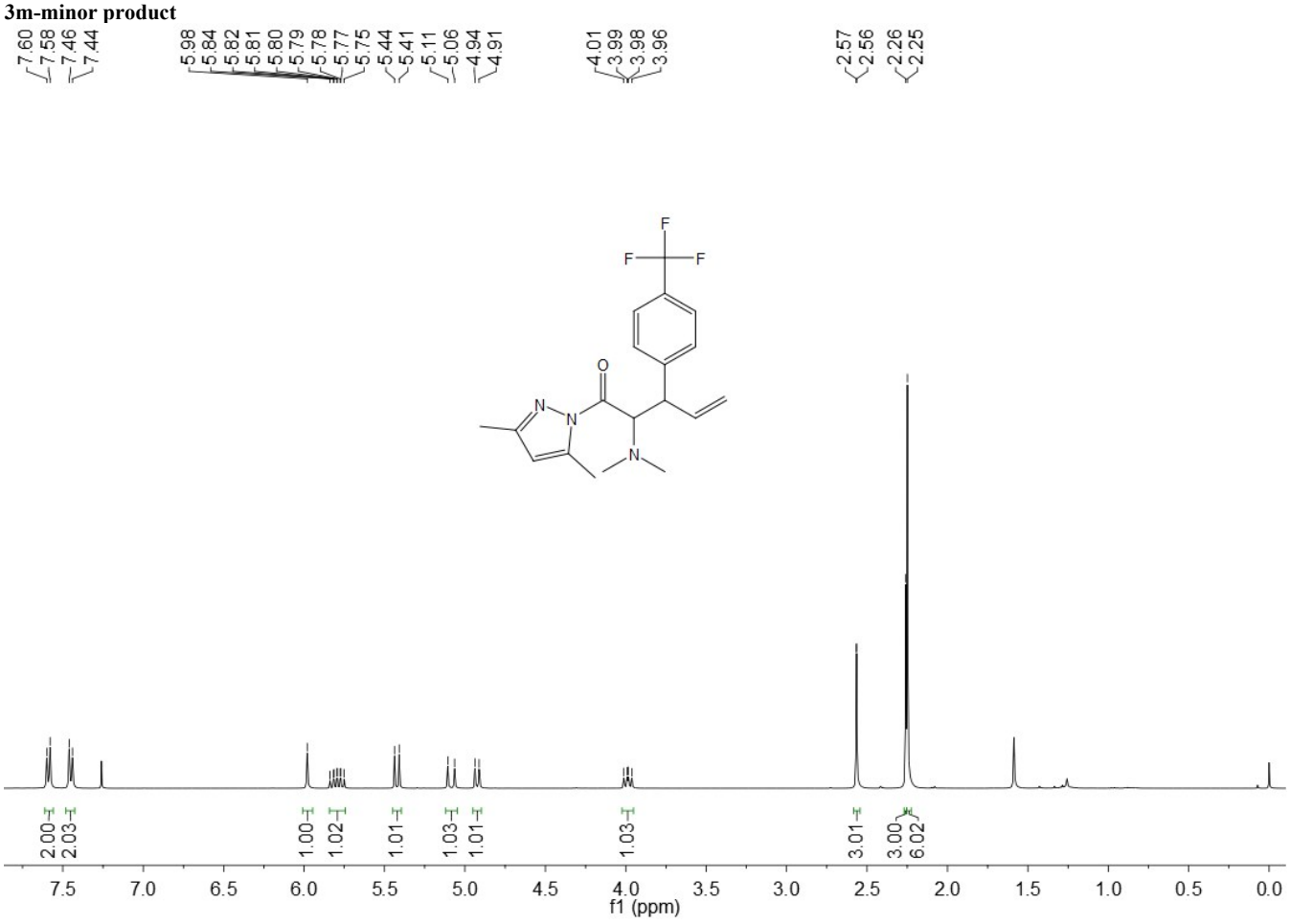
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(4-(trifluoromethyl)phenyl)pent-4-en-1-one (3m)

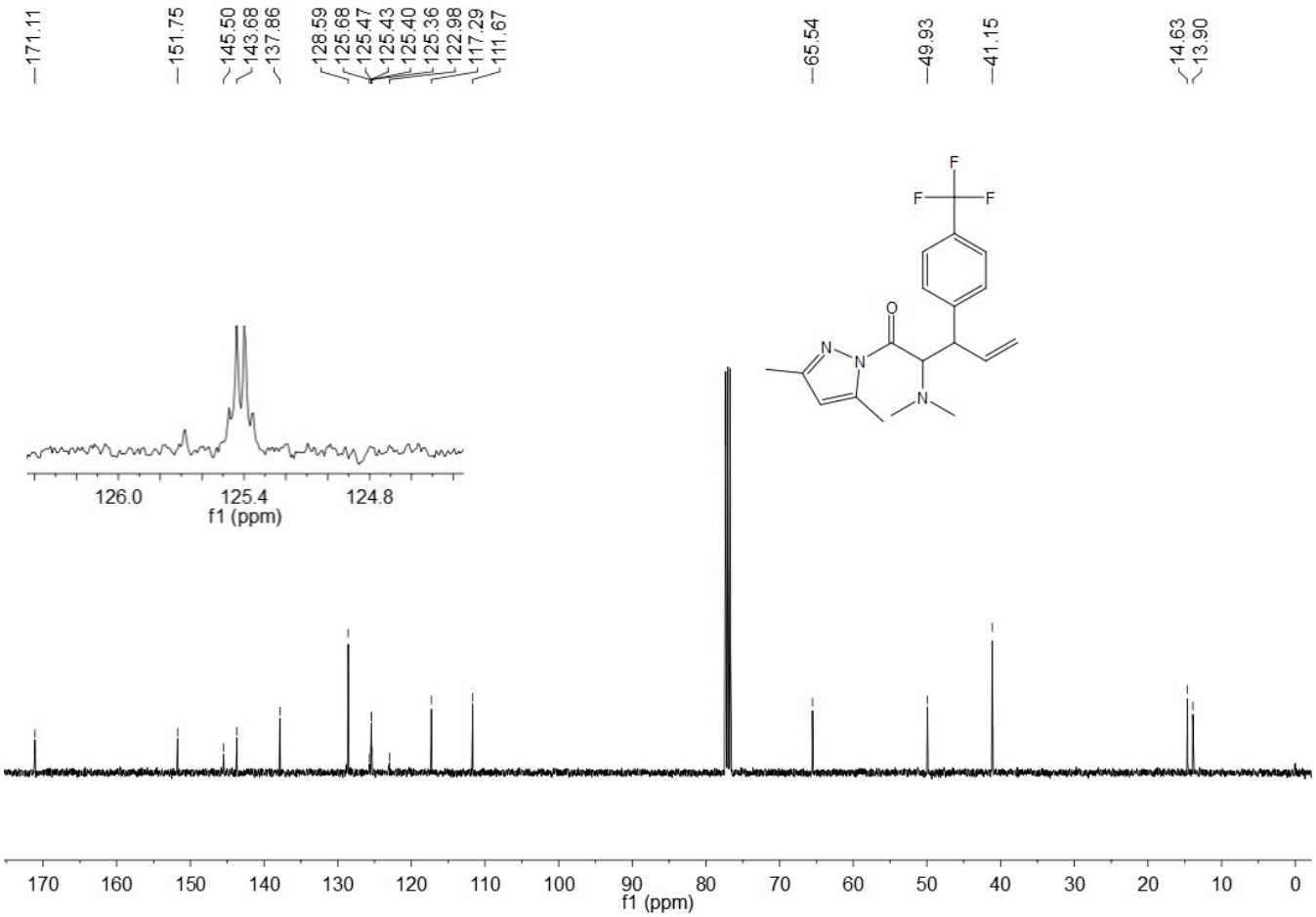


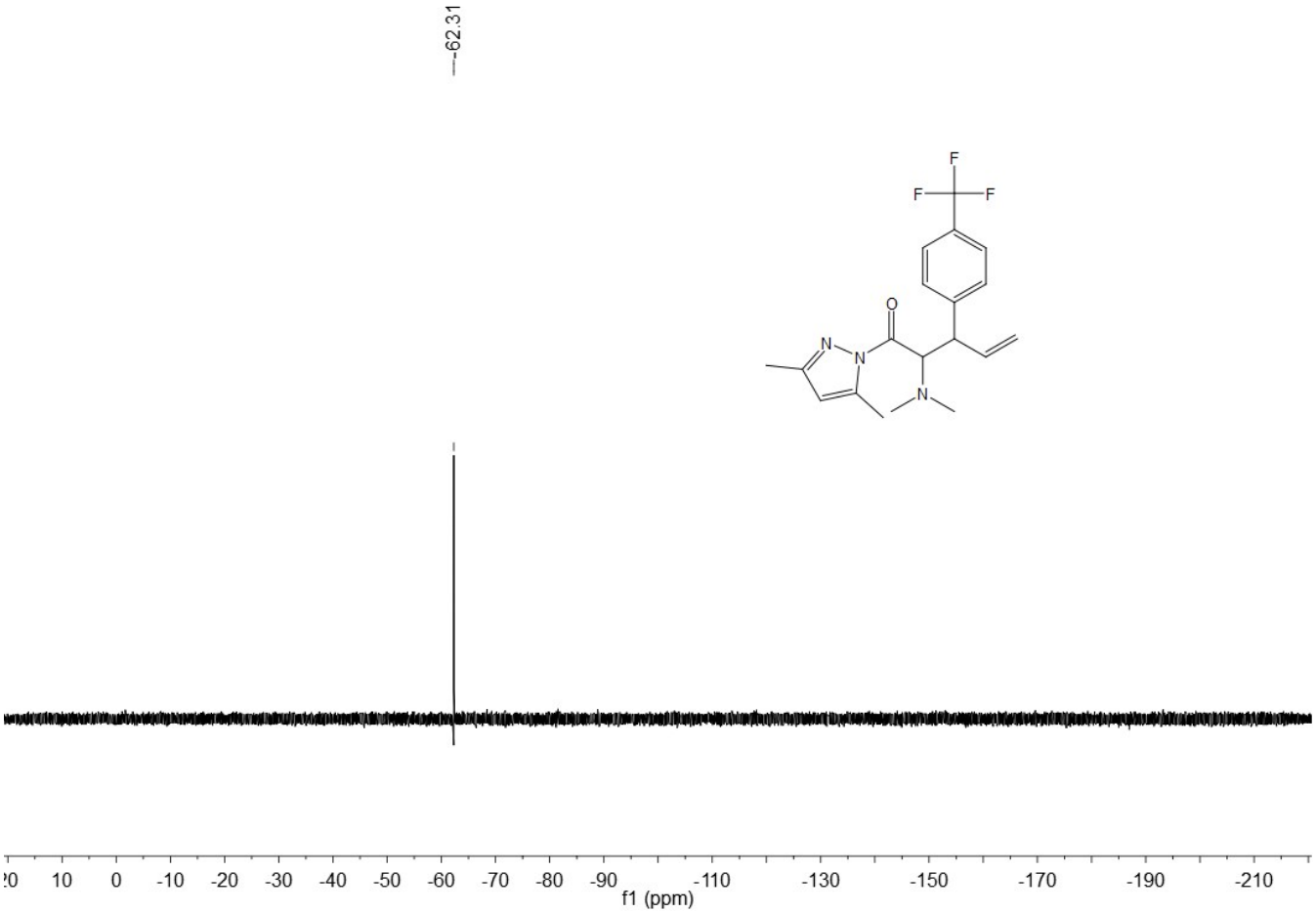




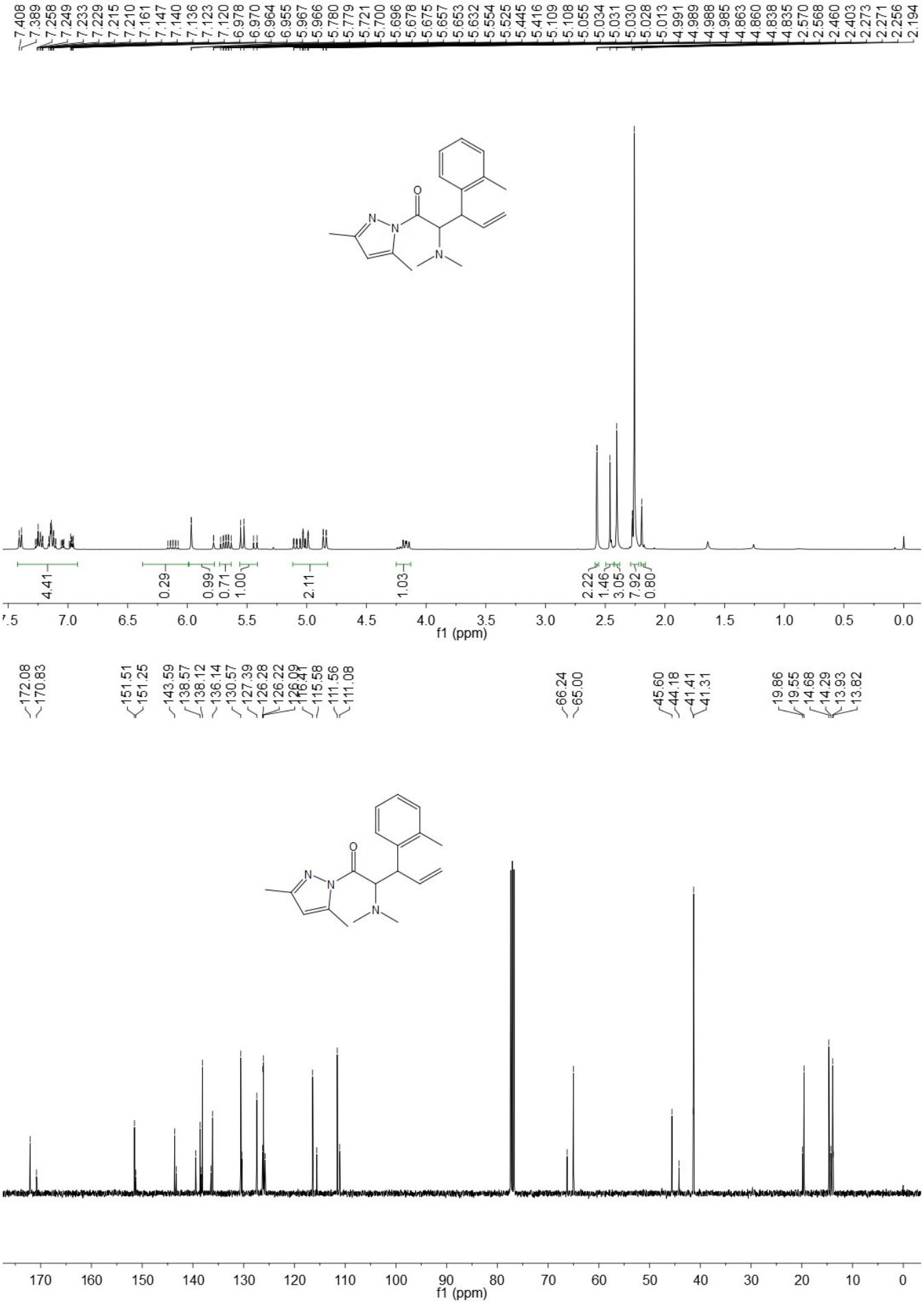
3m-minor product



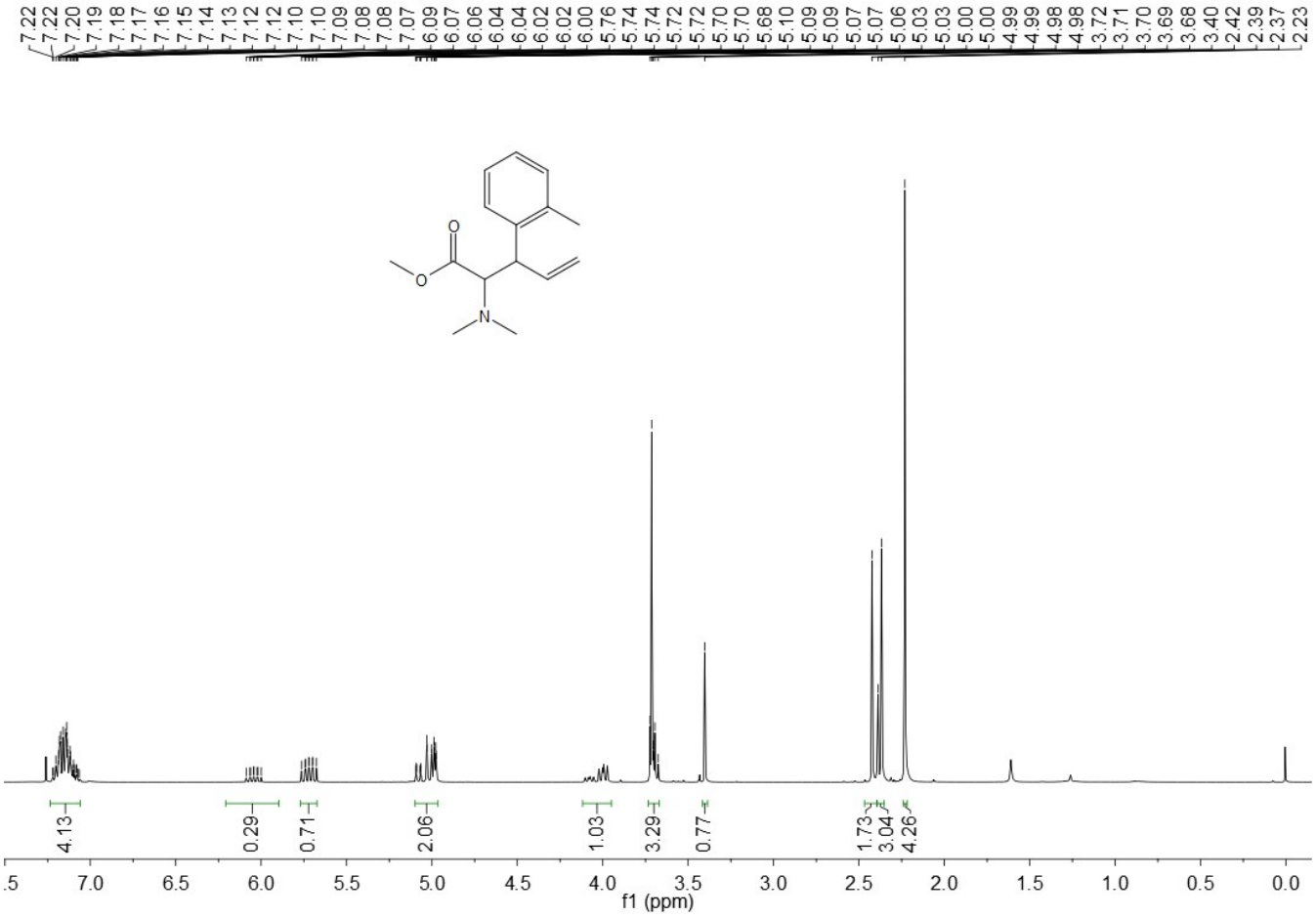

171.11
151.75
145.50
143.68
137.86
128.59
125.68
125.47
125.43
125.40
125.36
122.98
117.29
111.67
65.54
49.93
41.15
14.63
13.90
F
F
F
O
N
N
N
126.0
125.4
124.8
f1 (ppm)
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

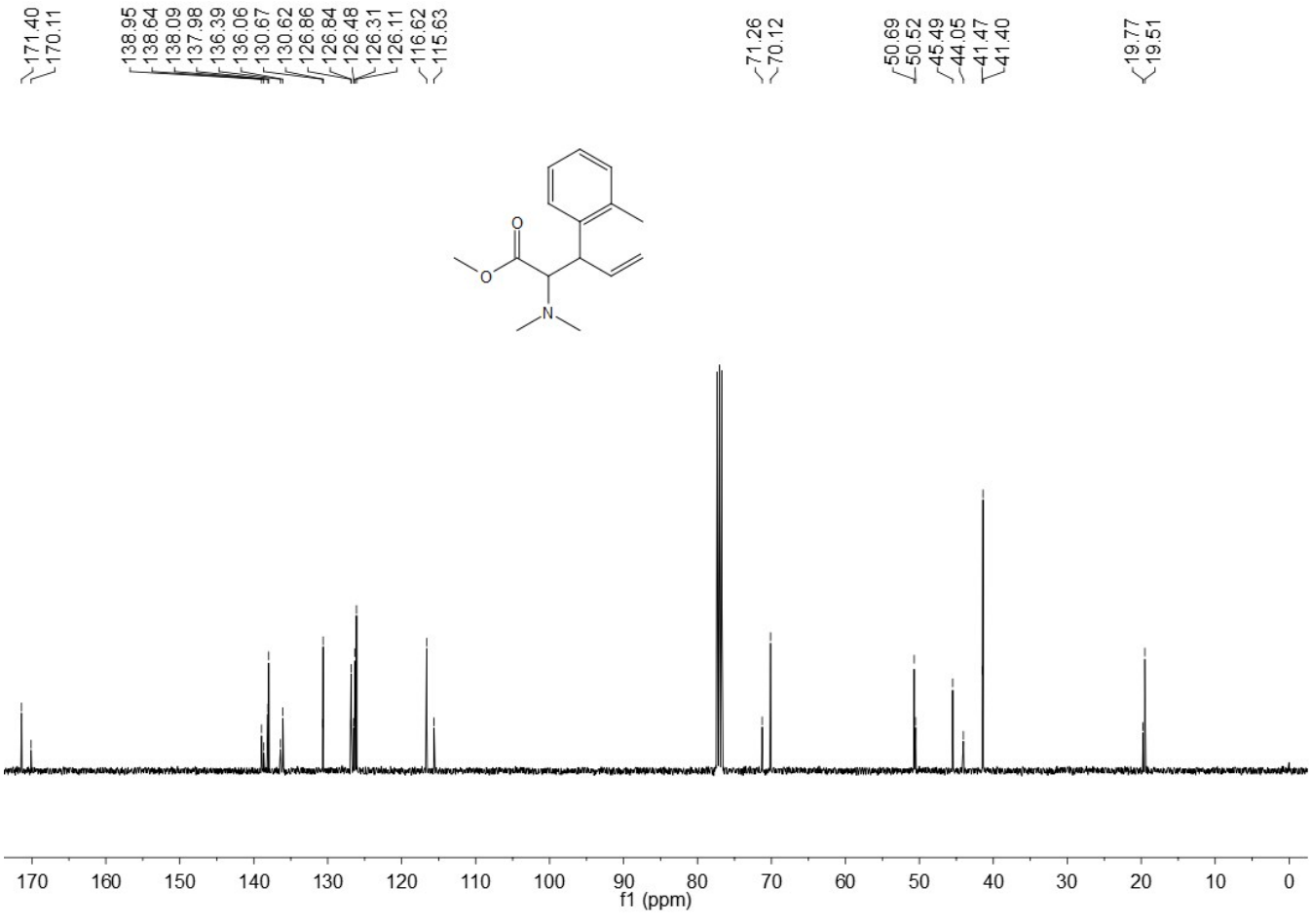

62.31
F
F
F
O
N
N
N
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -110 -130 -150 -170 -190 -210
f1 (ppm)

1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(o-tolyl)pent-4-en-1-one (3n)

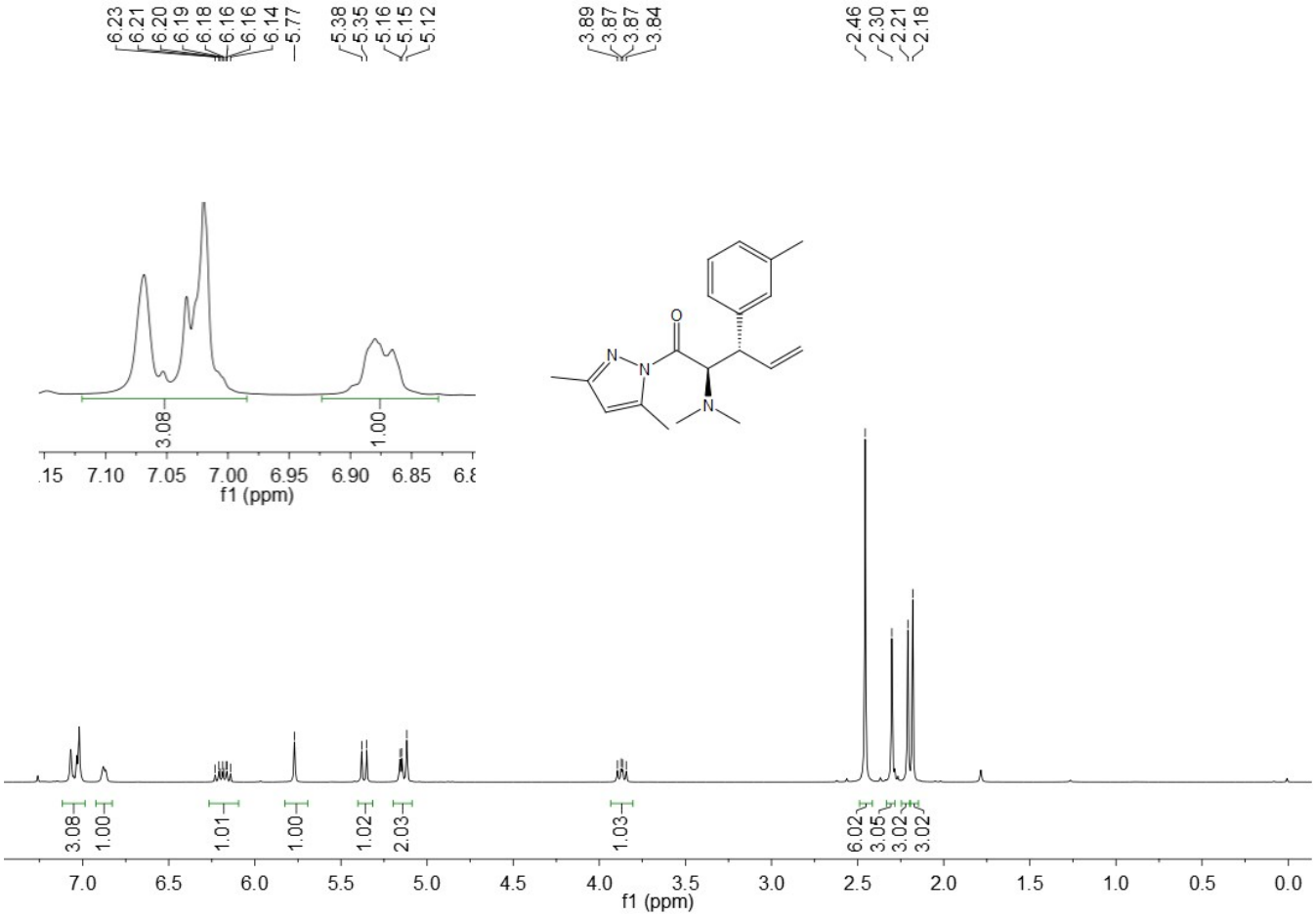


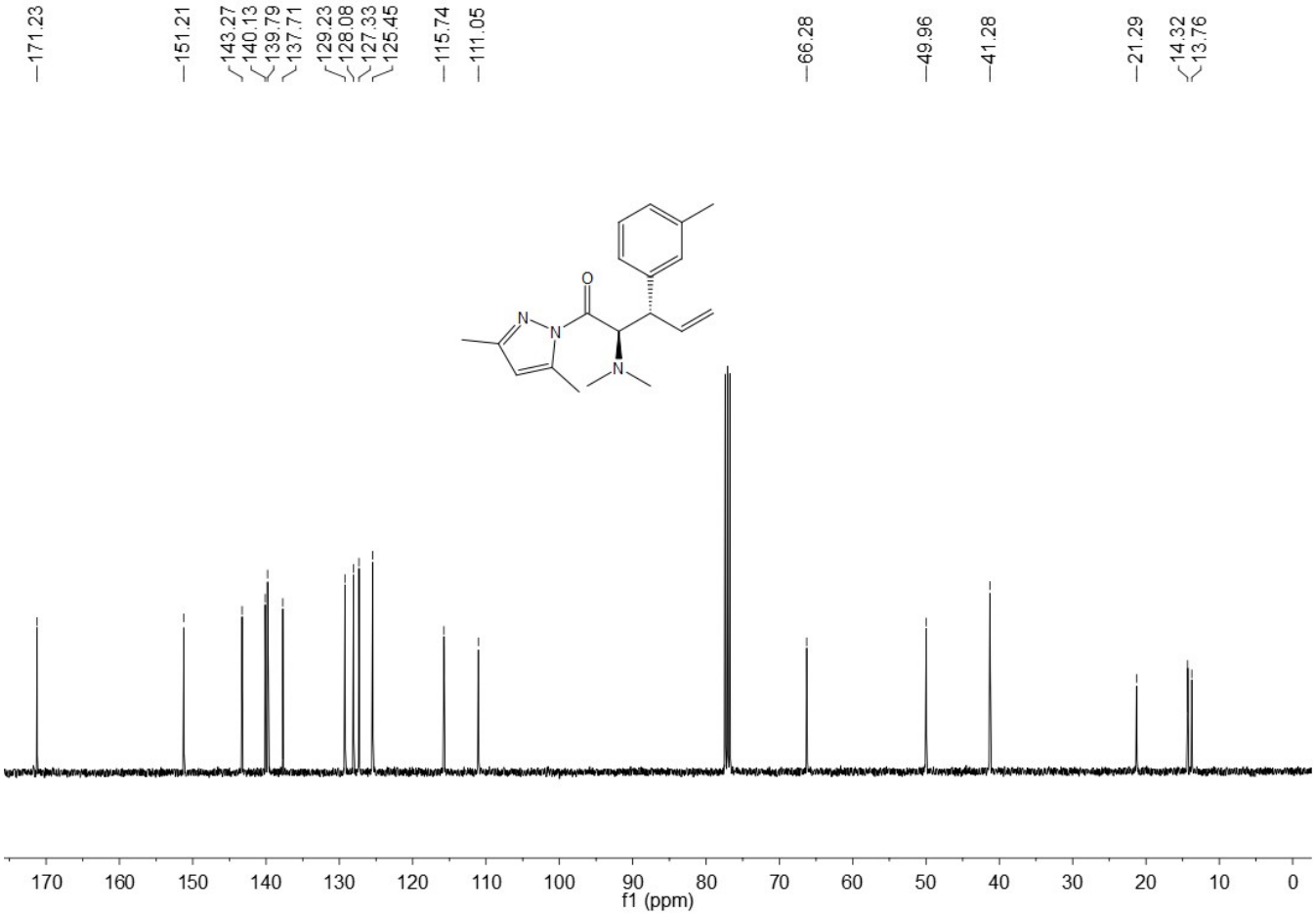
Methyl 2-(dimethylamino)-3-(o-tolyl)pent-4-enoate (4n)



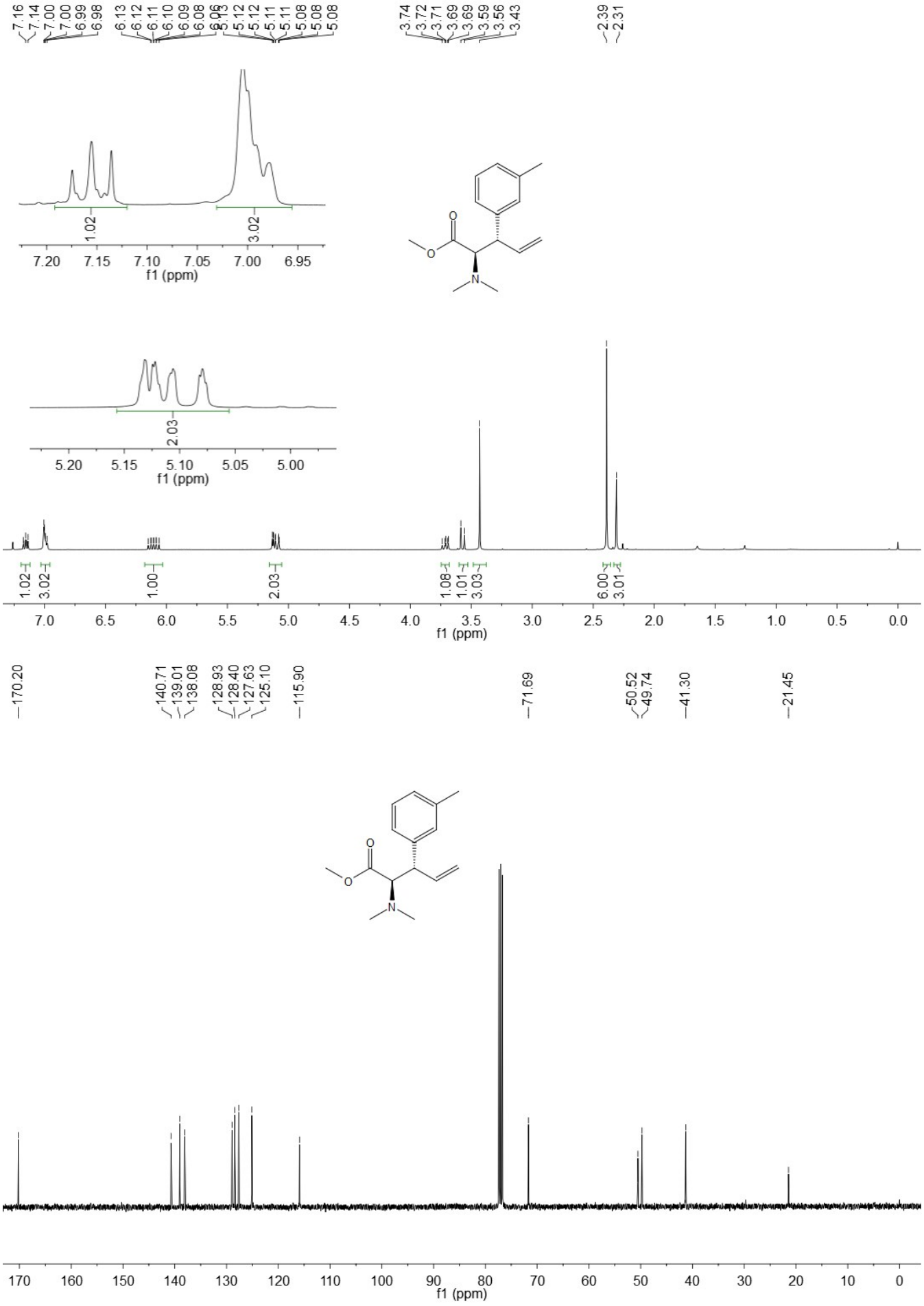


(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(*m*-tolyl)pent-4-en-1-one (3o)

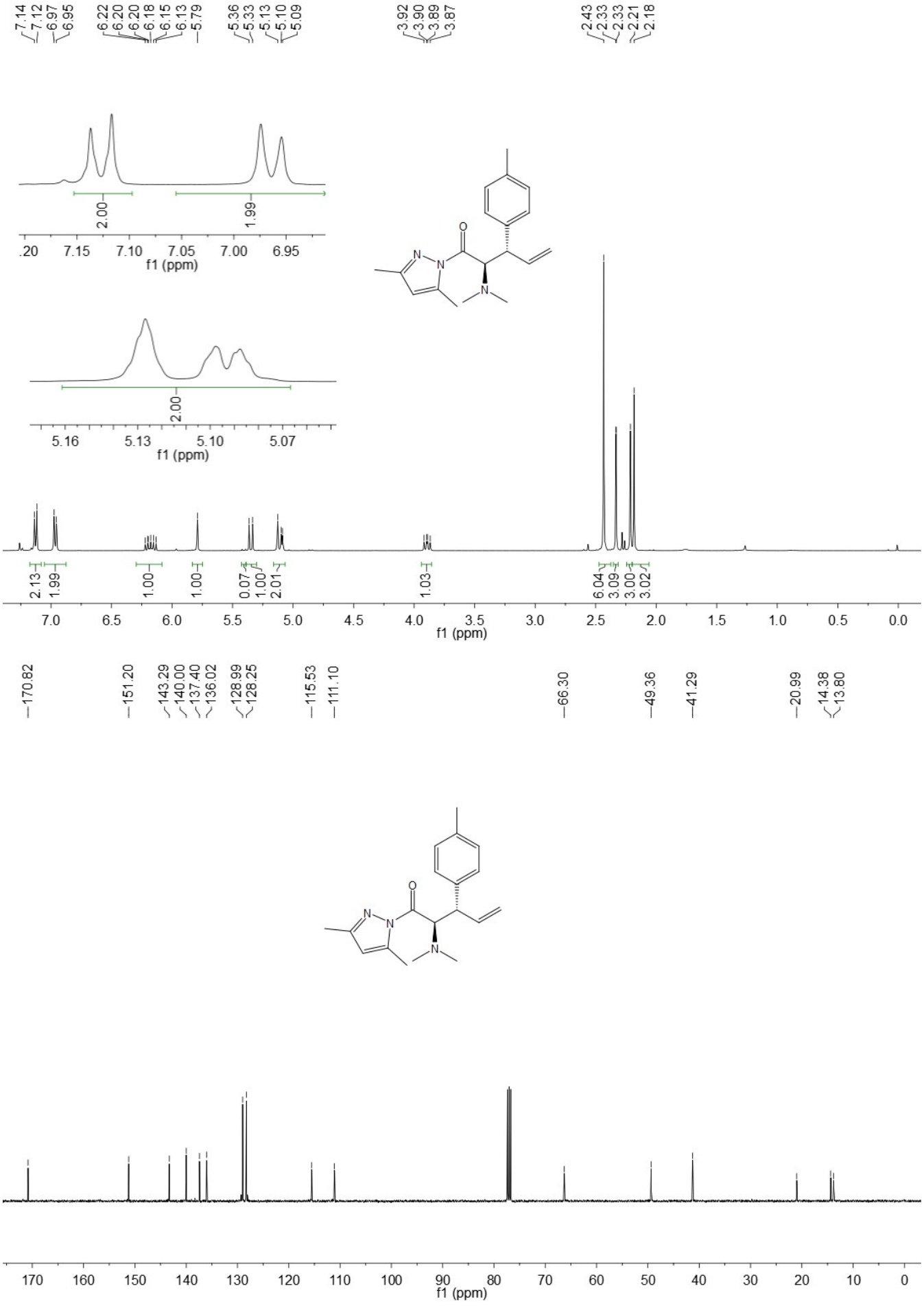




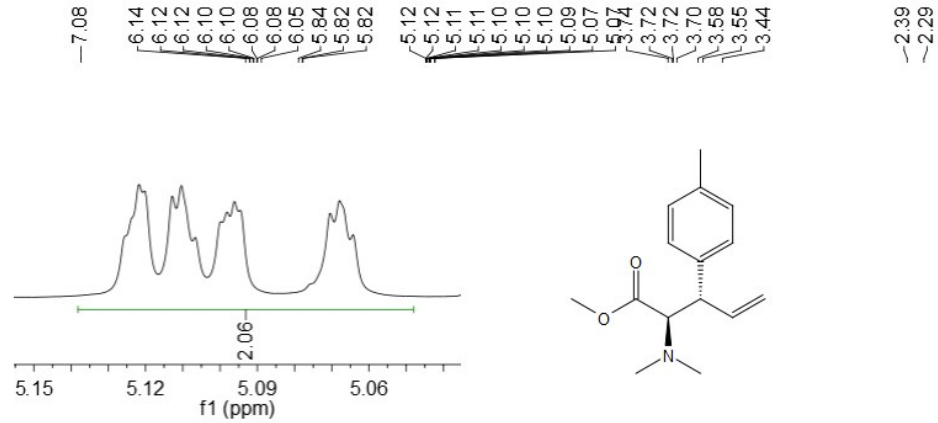
Methyl (2*R*,3*S*)-2-(dimethylamino)-3-(*m*-tolyl)pent-4-enoate (4o)

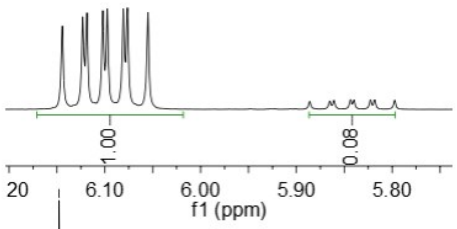


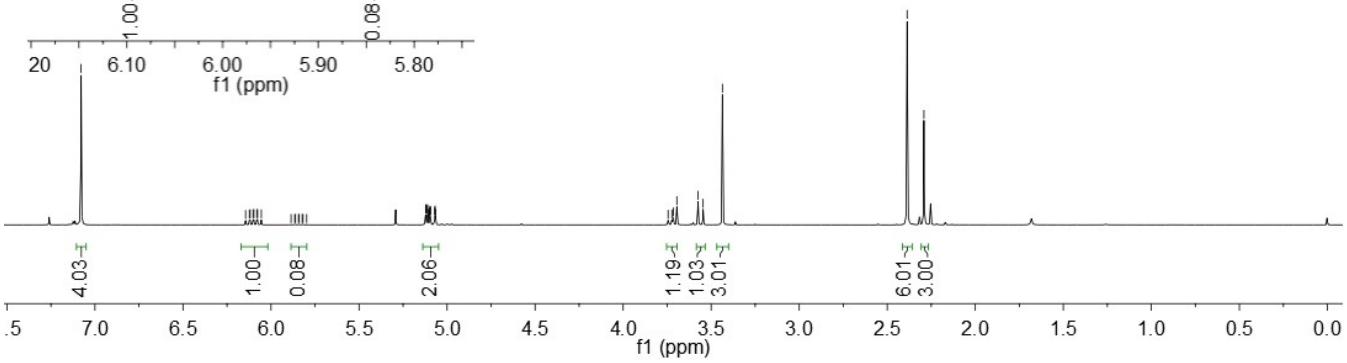
(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(*p*-tolyl)pent-4-en-1-one (3p)

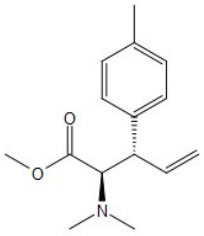


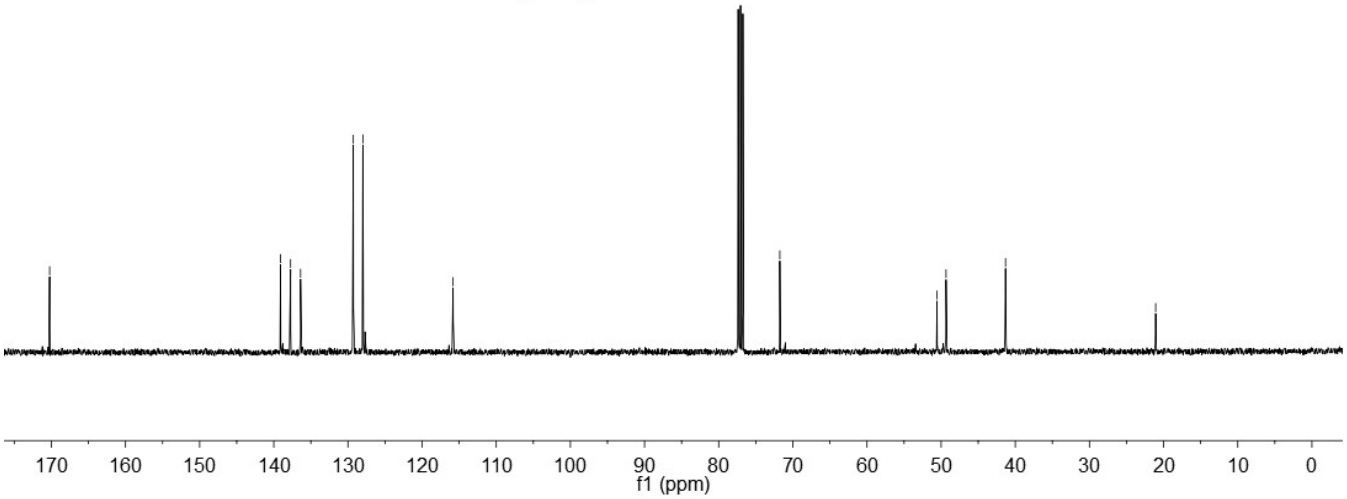
Methyl (2*R*,3*S*)-2-(dimethylamino)-3-(*p*-tolyl)pent-4-enoate (4p)



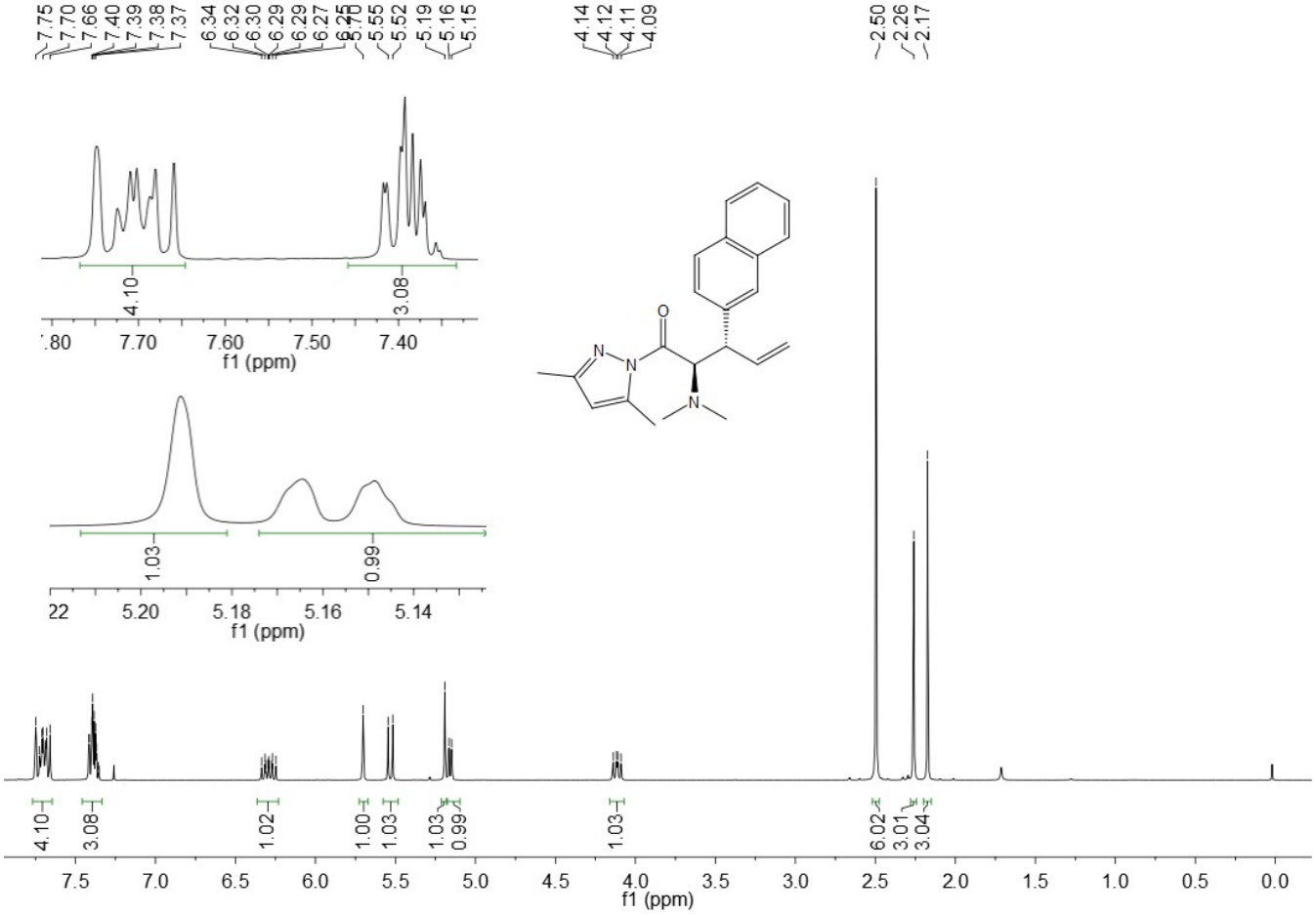


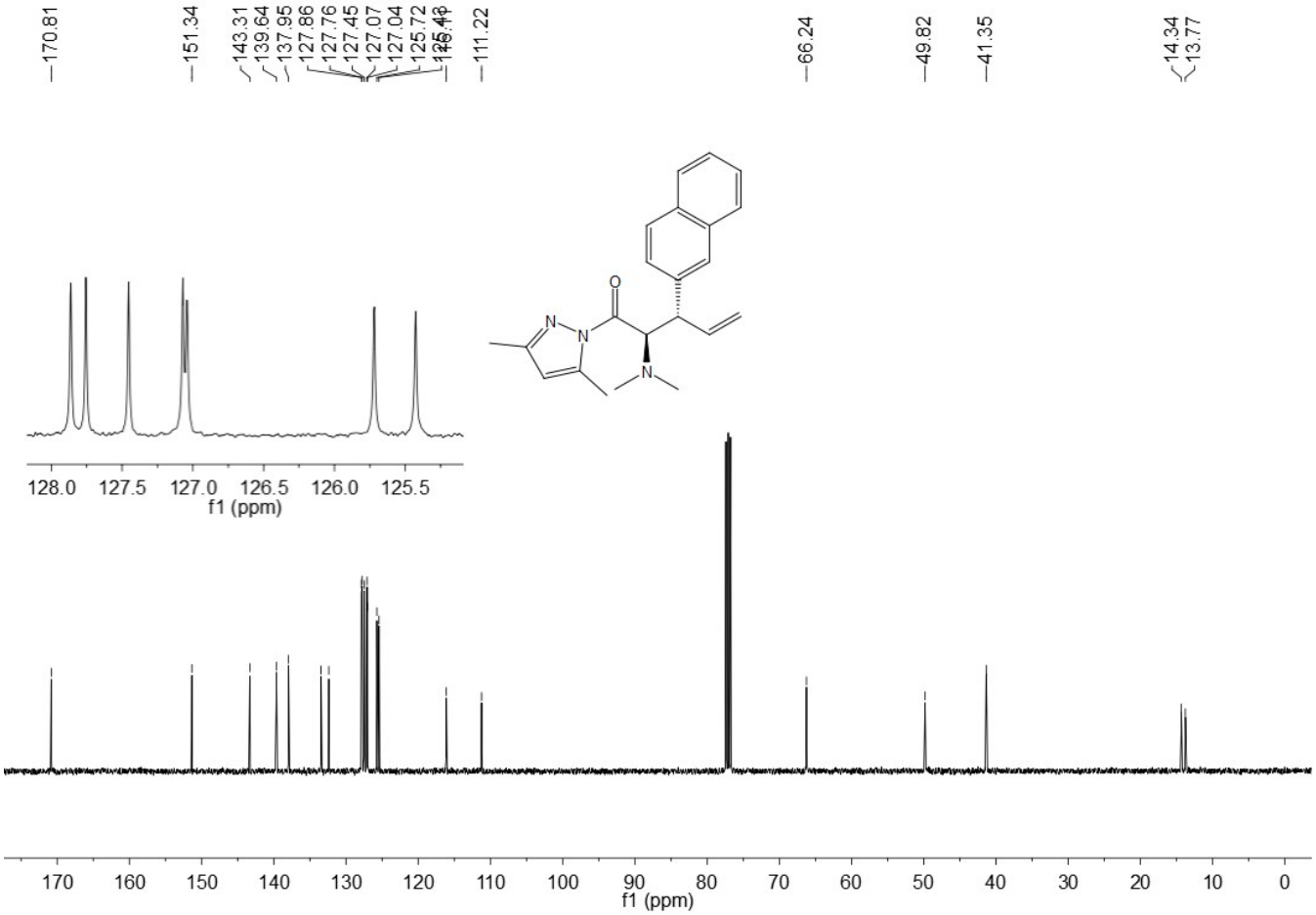




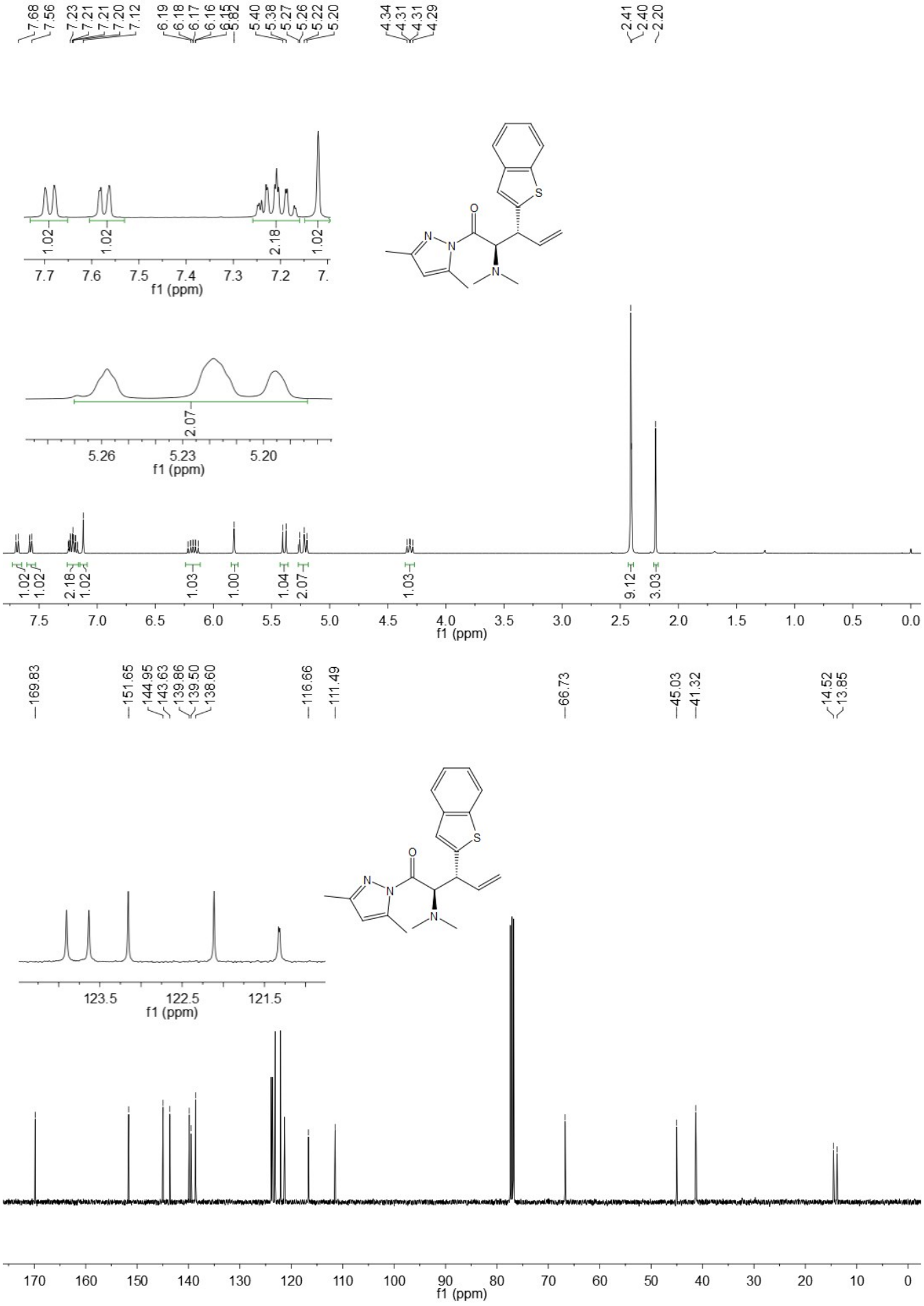


(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-3-(naphthalen-2-yl)pent-4-en-1-one (3q)

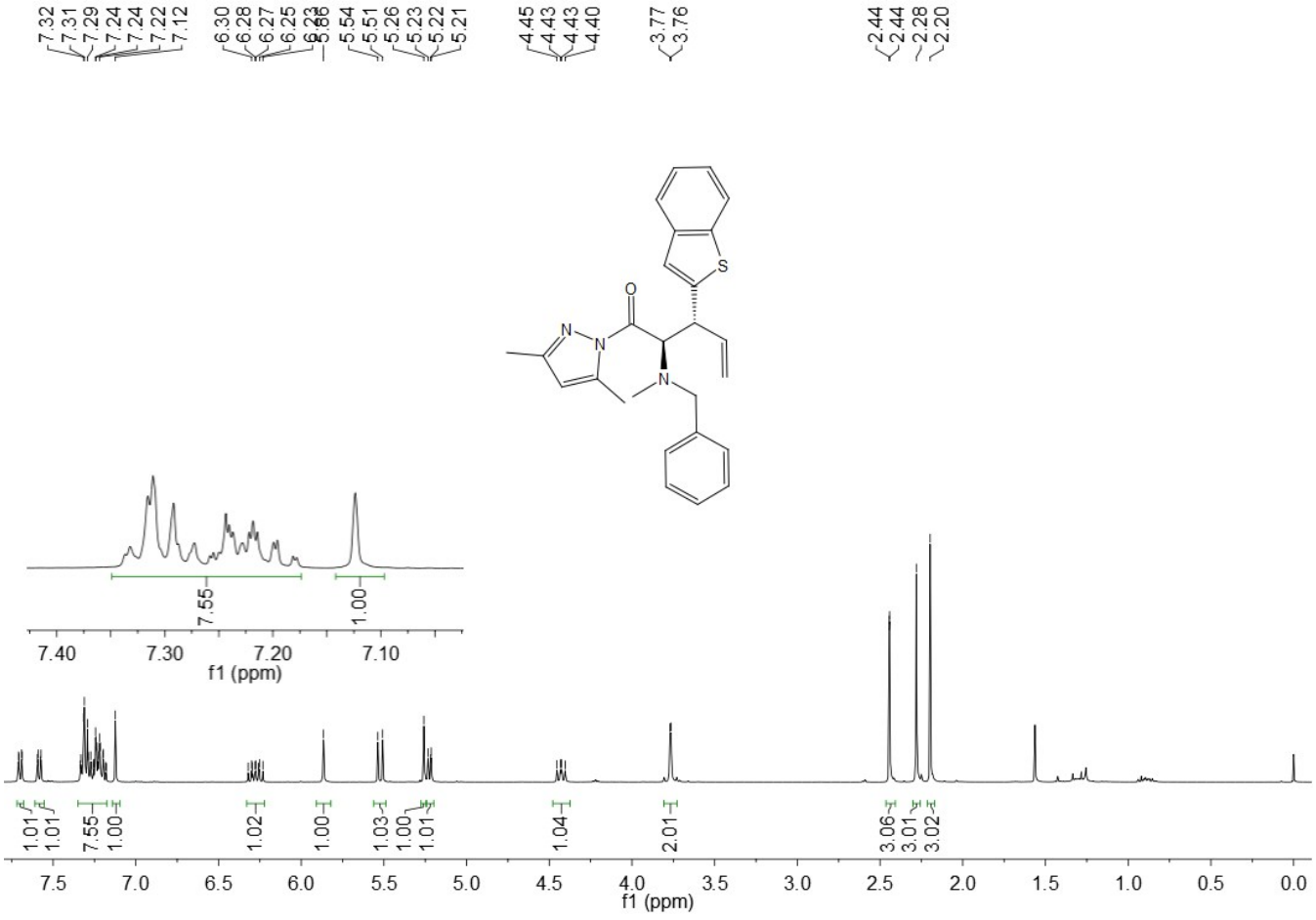


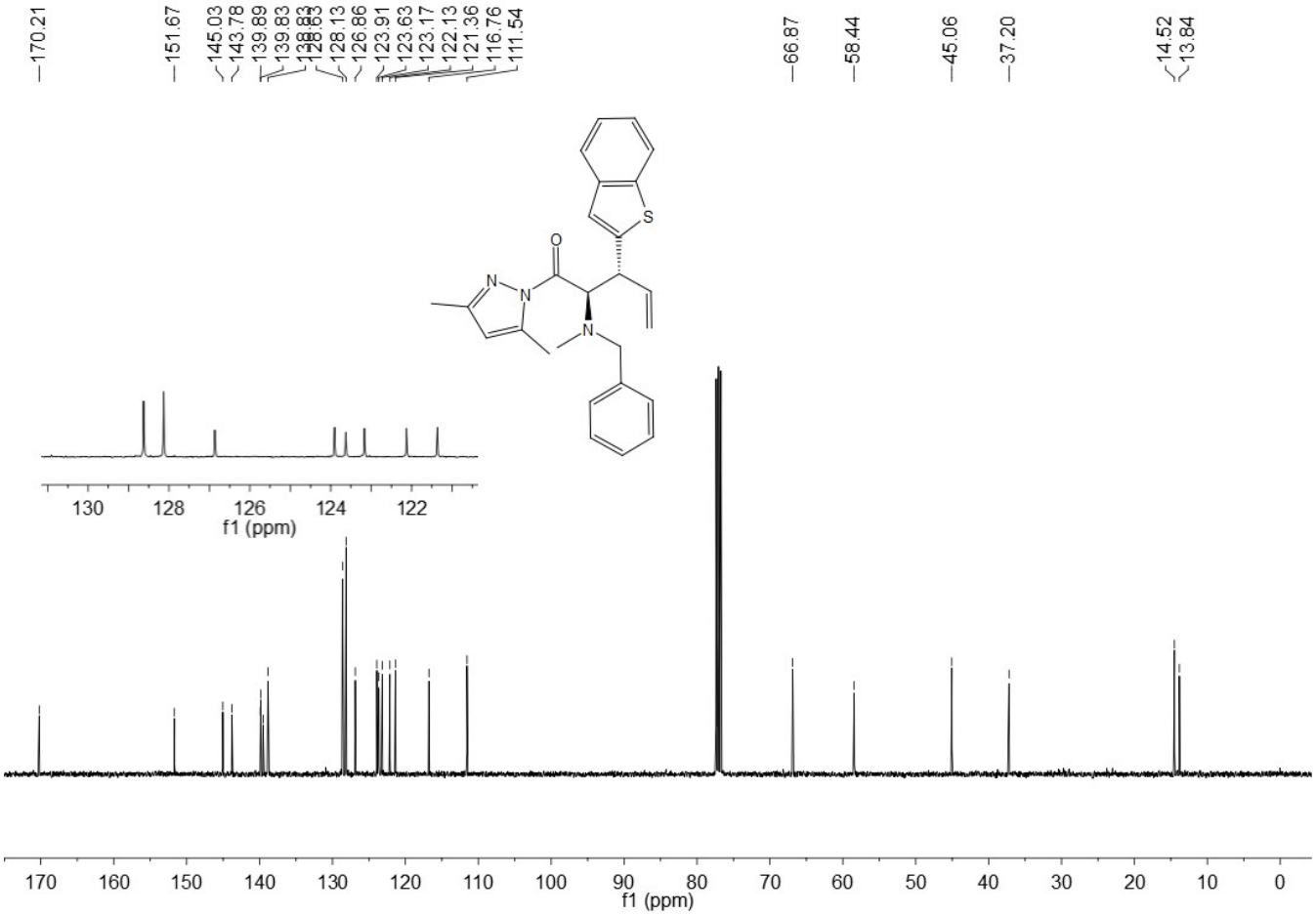


(2*R*,3*R*)-3-(Benzo[b]thiophen-2-yl)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)pent-4-en-1-one (3r)

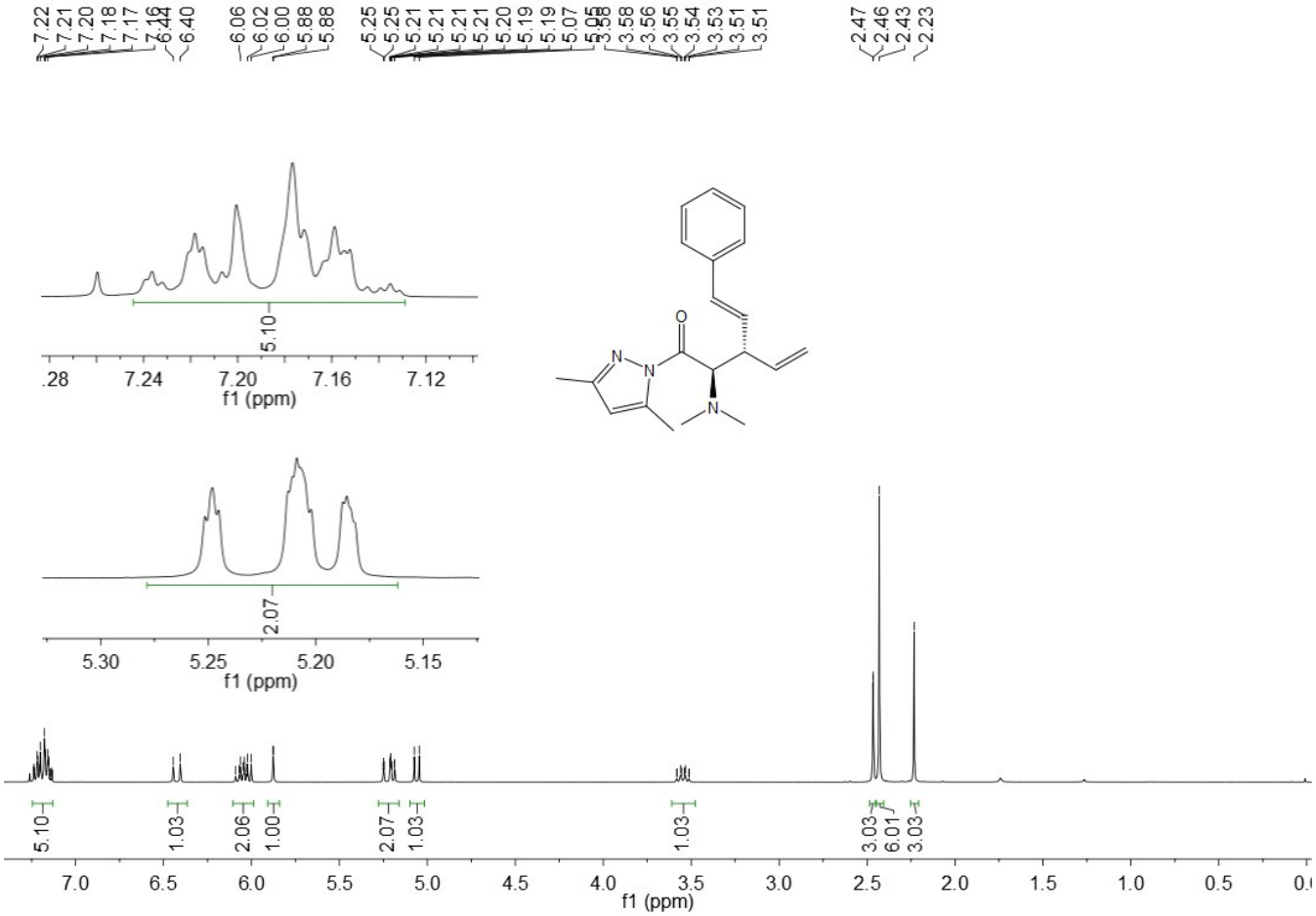


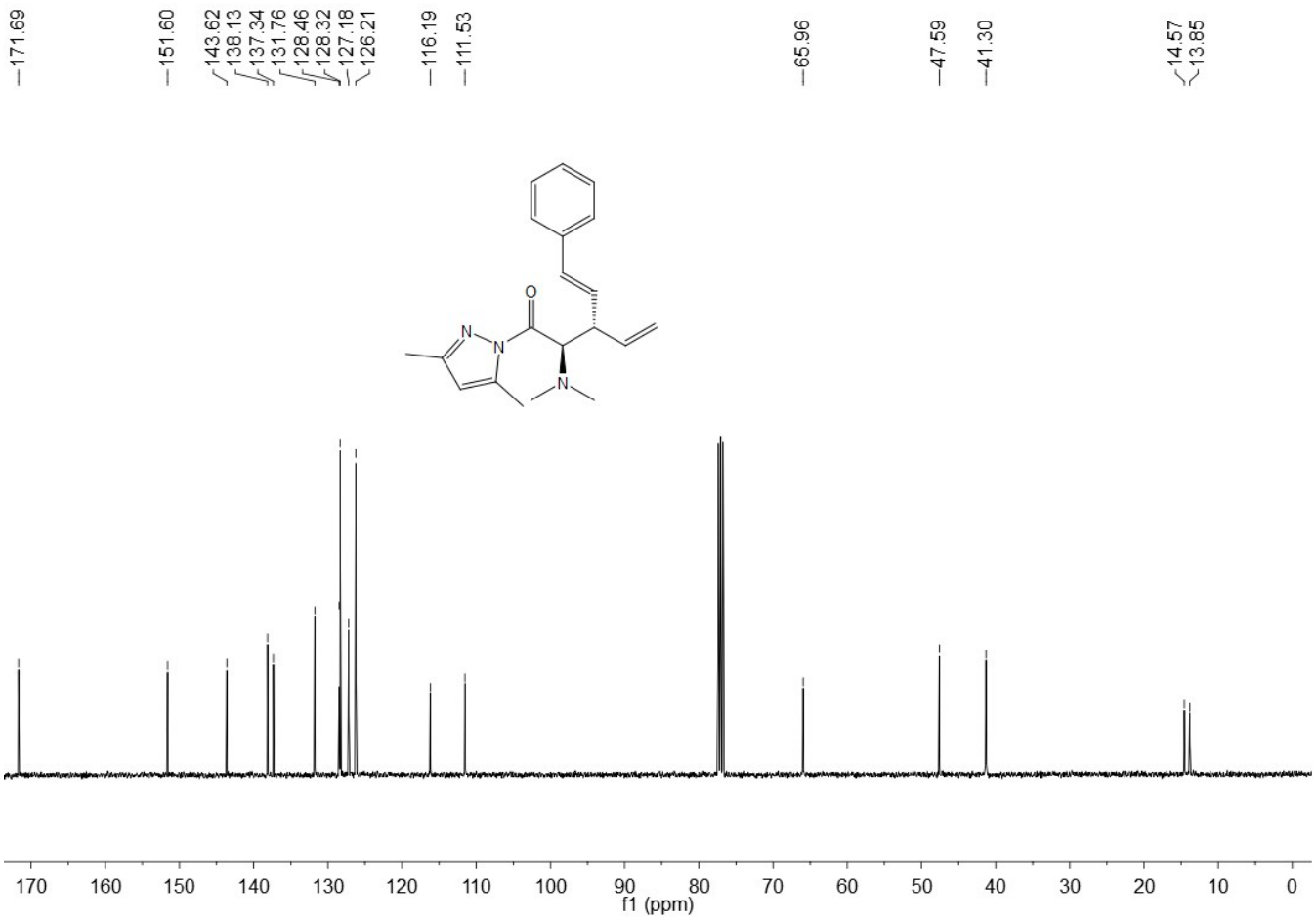
(2*R*,3*R*)-3-(Benzo[b]thiophen-2-yl)-2-(benzyl(methyl)amino)-1-(3,5-dimethyl-1*H*-pyrazol-1-yl)pent-4-en-1-one (3s)



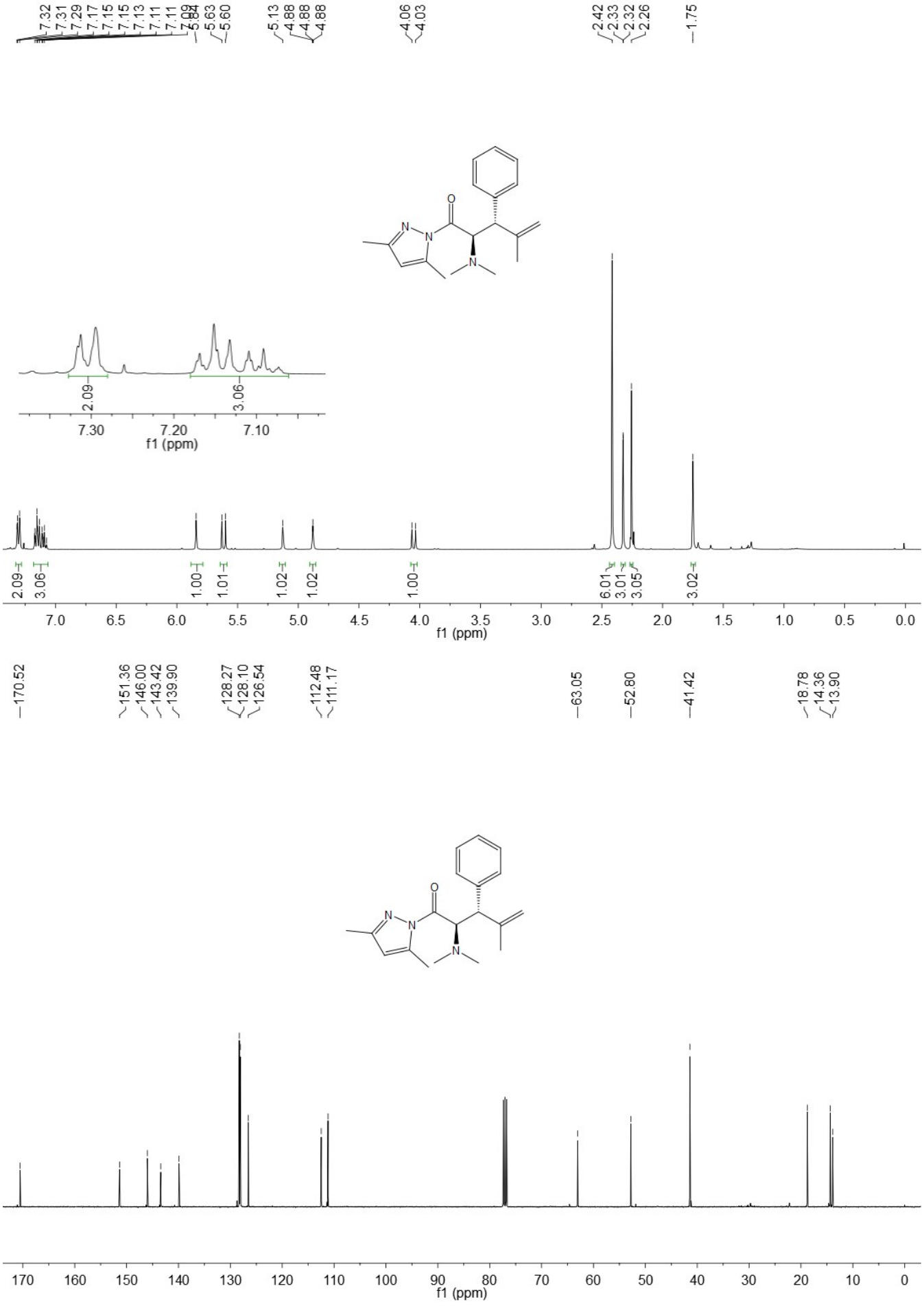


(2*R*,3*S*,*E*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-5-phenyl-3-vinylpent-4-en-1-one (3t)

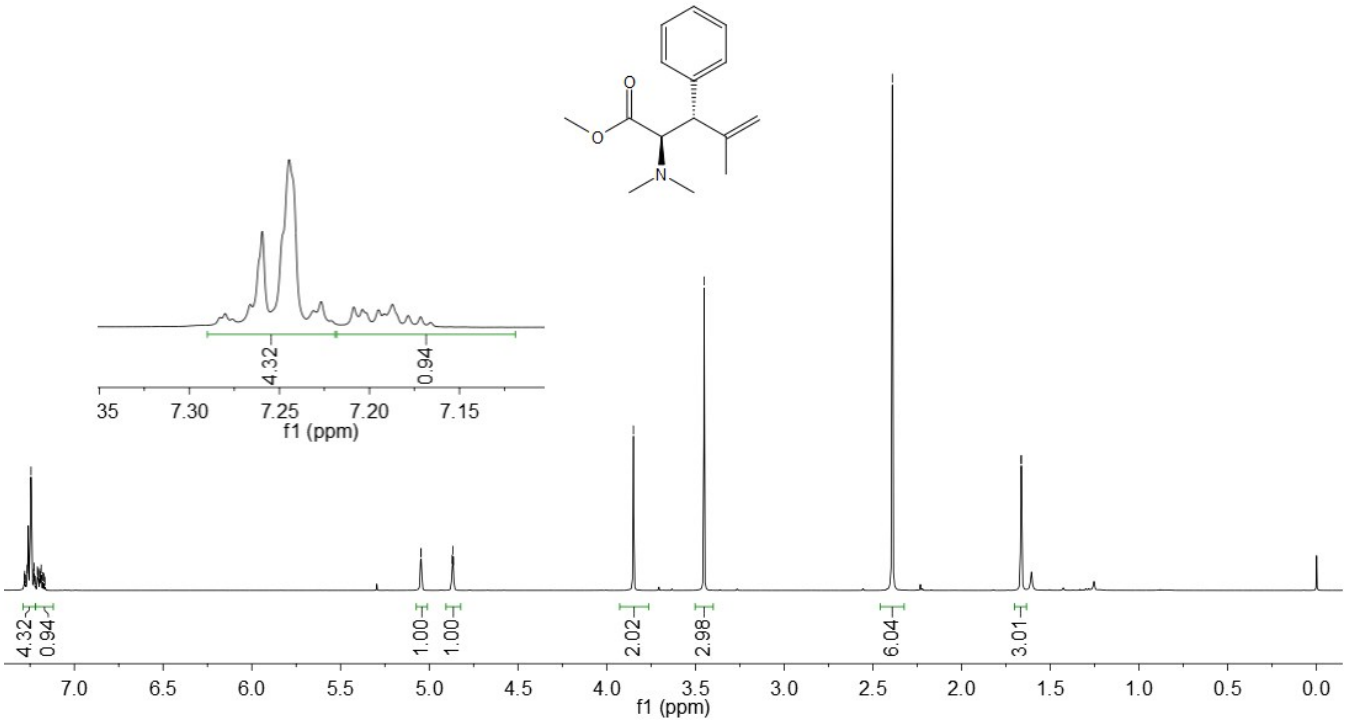


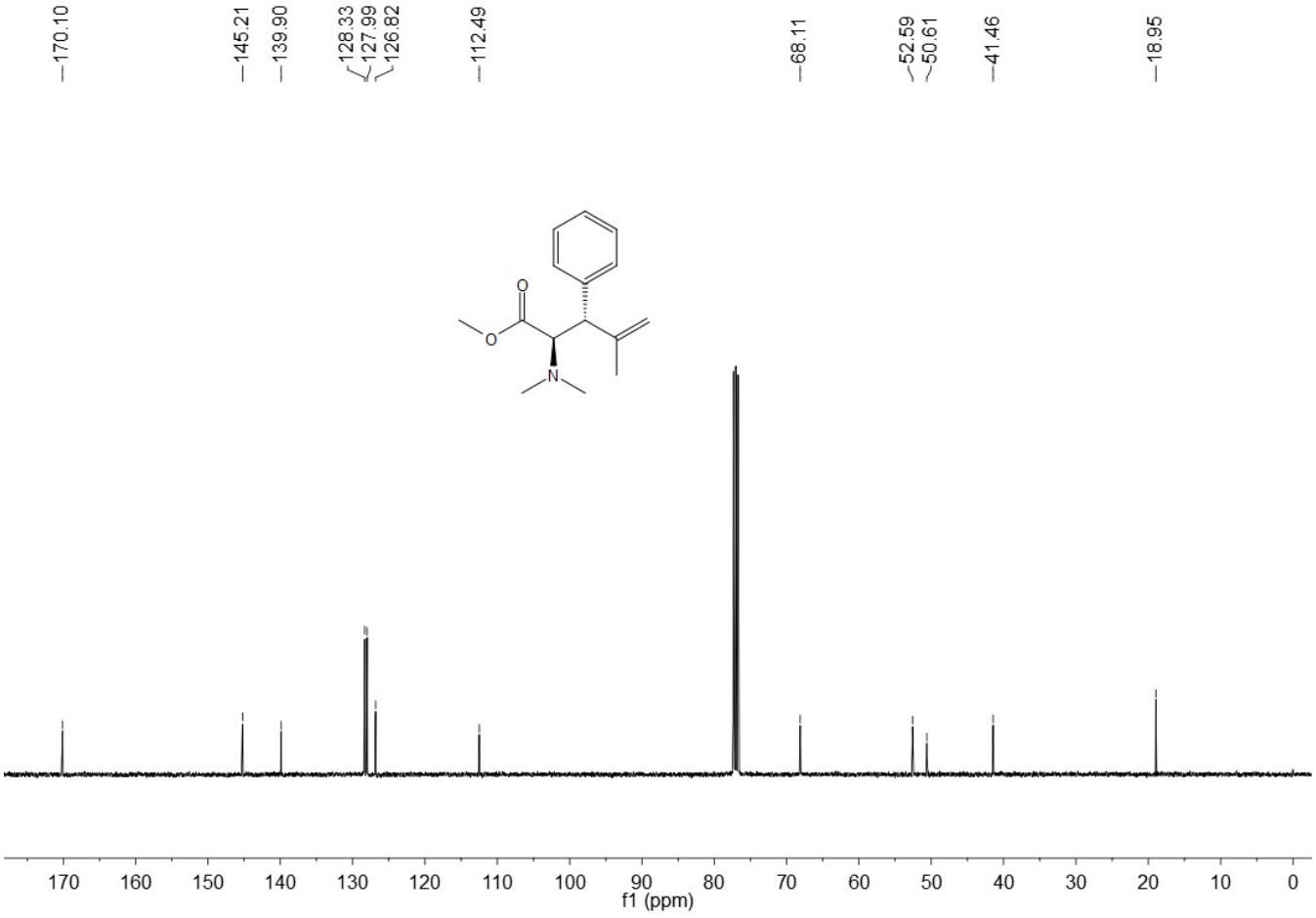


(2*R*,3*S*)-1-(3,5-Dimethyl-1*H*-pyrazol-1-yl)-2-(dimethylamino)-4-methyl-3-phenylpent-4-en-1-one (3u)

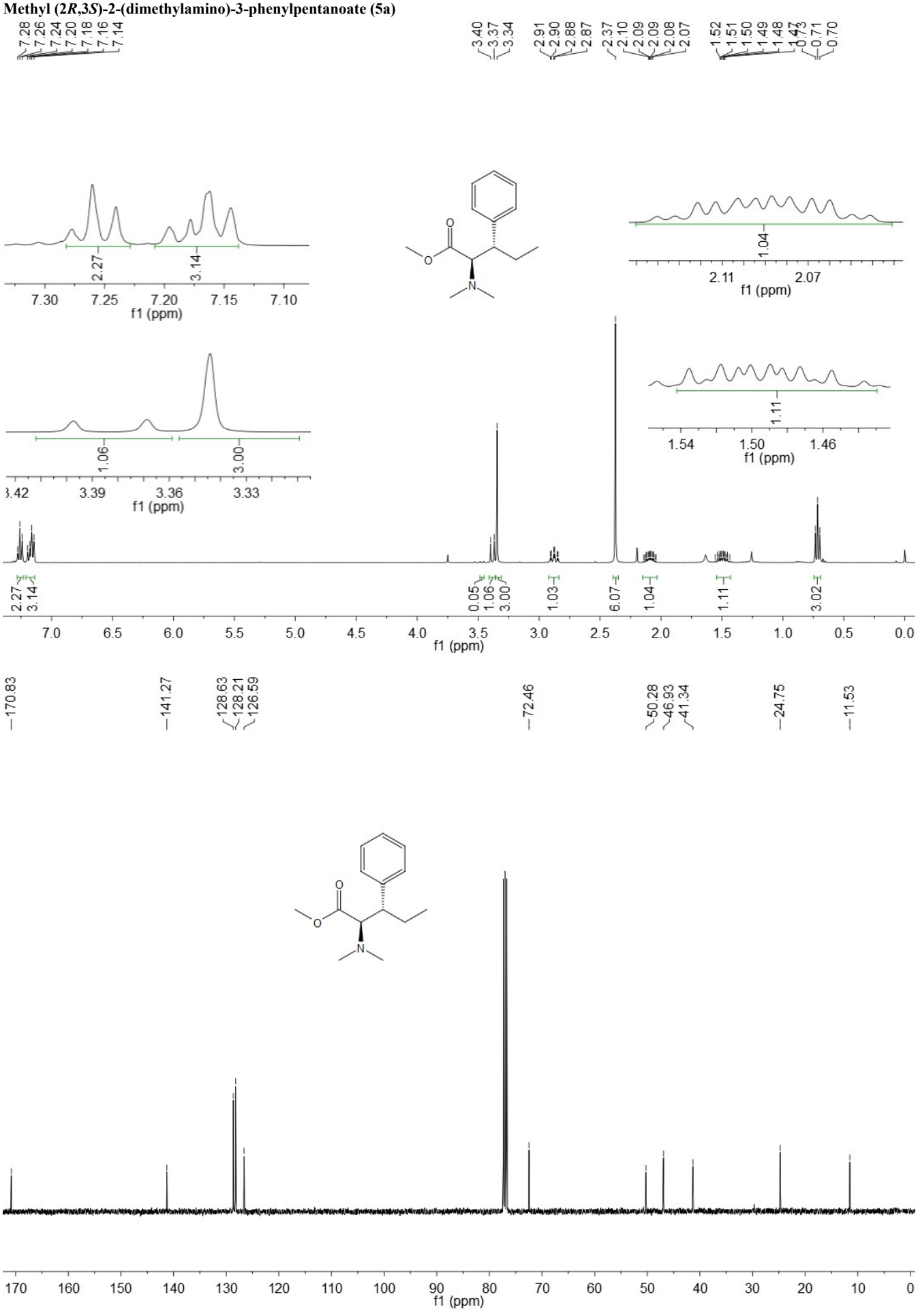


Methyl (2*R*,3*S*)-2-(dimethylamino)-4-methyl-3-phenylpent-4-enoate (4u)

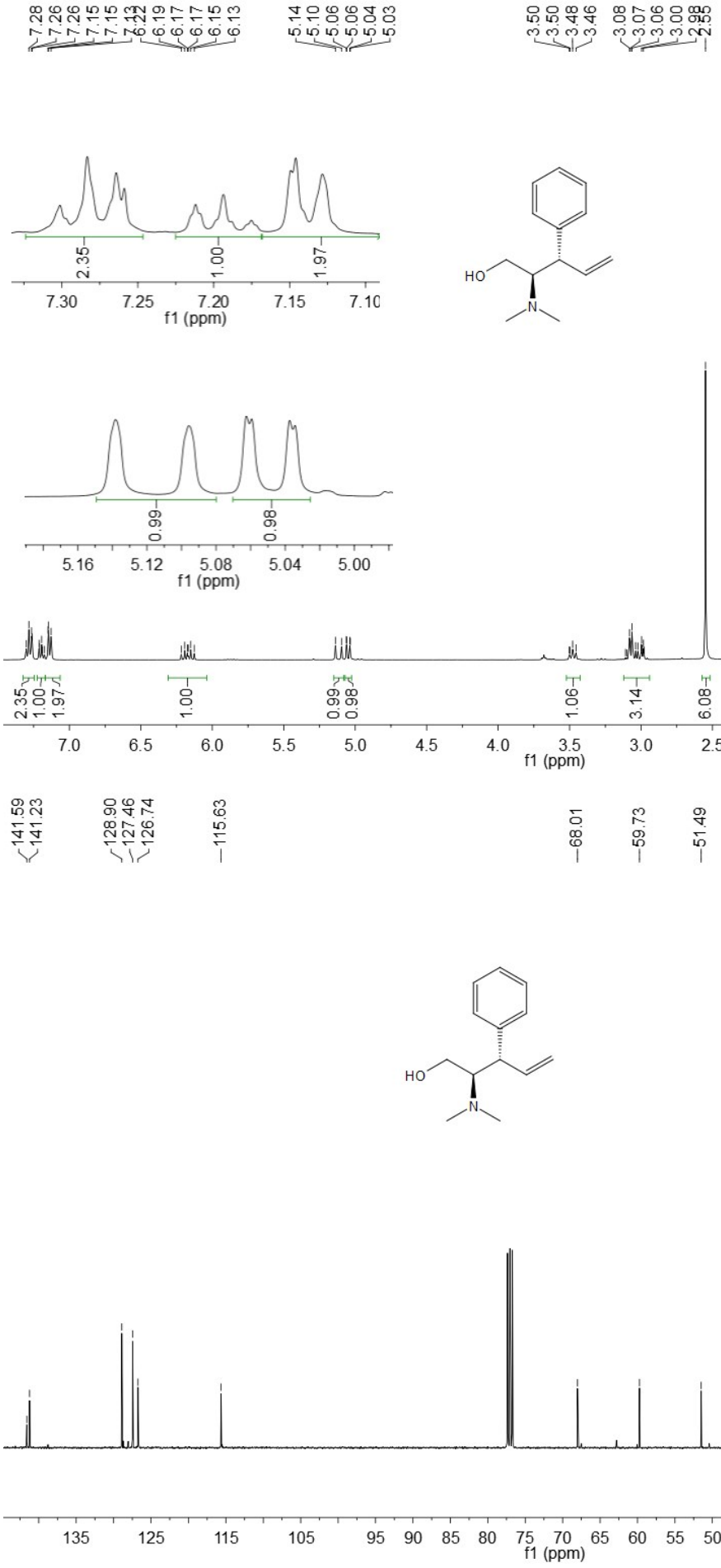




Methyl (2*R*,3*S*)-2-(dimethylamino)-3-phenylpentanoate (5a)

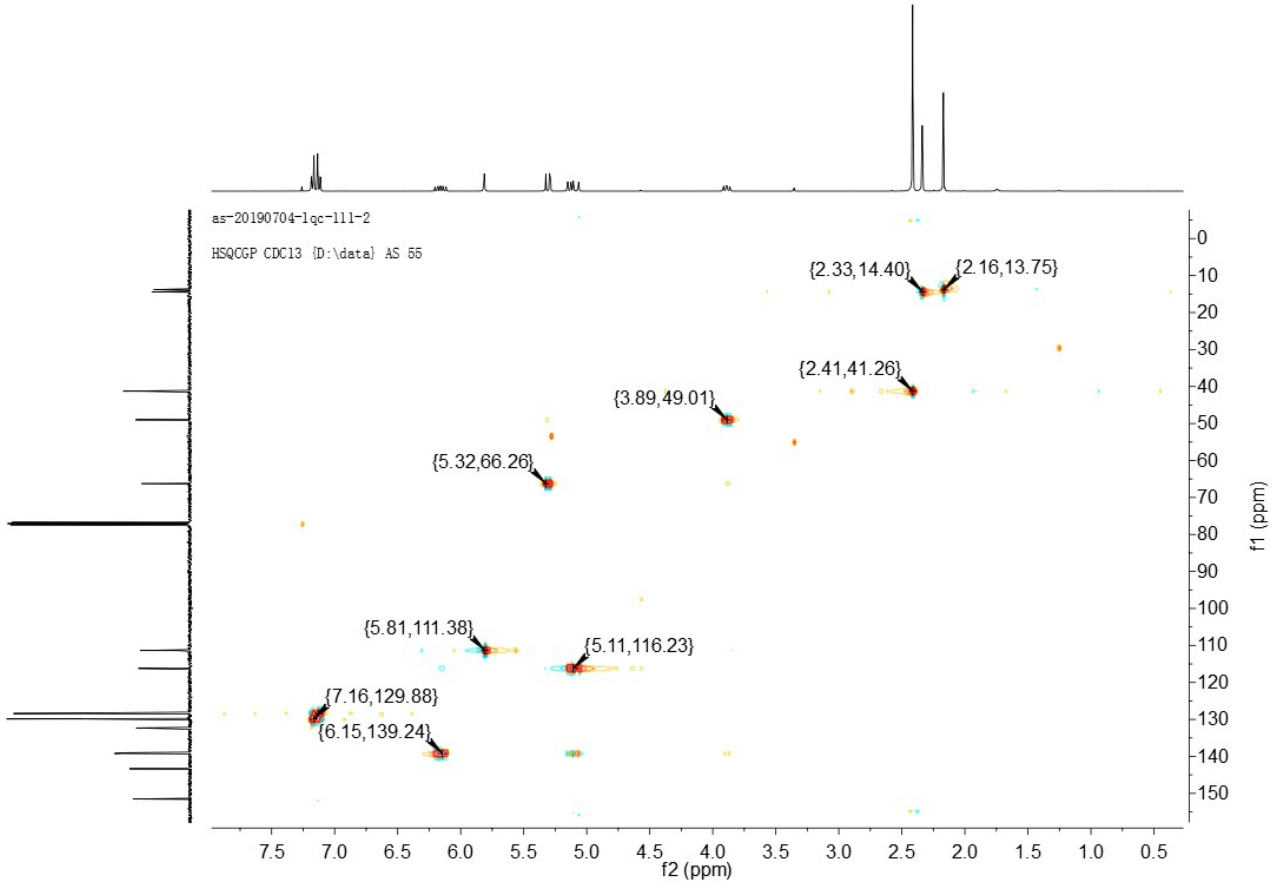


(2*R*,3*S*)-2-(Dimethylamino)-3-phenylpent-4-en-1-ol (6a)

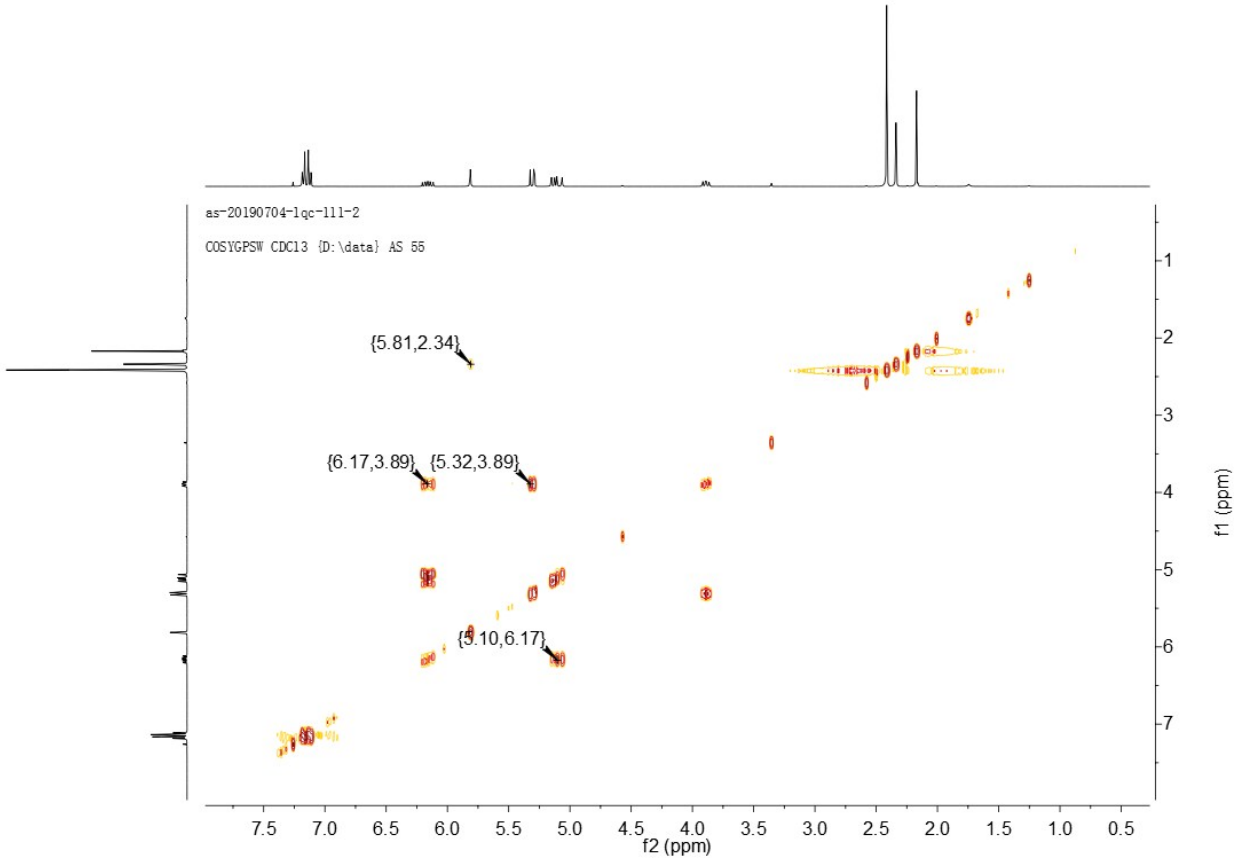


(J) Copies of 2D NMR Spectra (2D NMR Spectra of 3h)

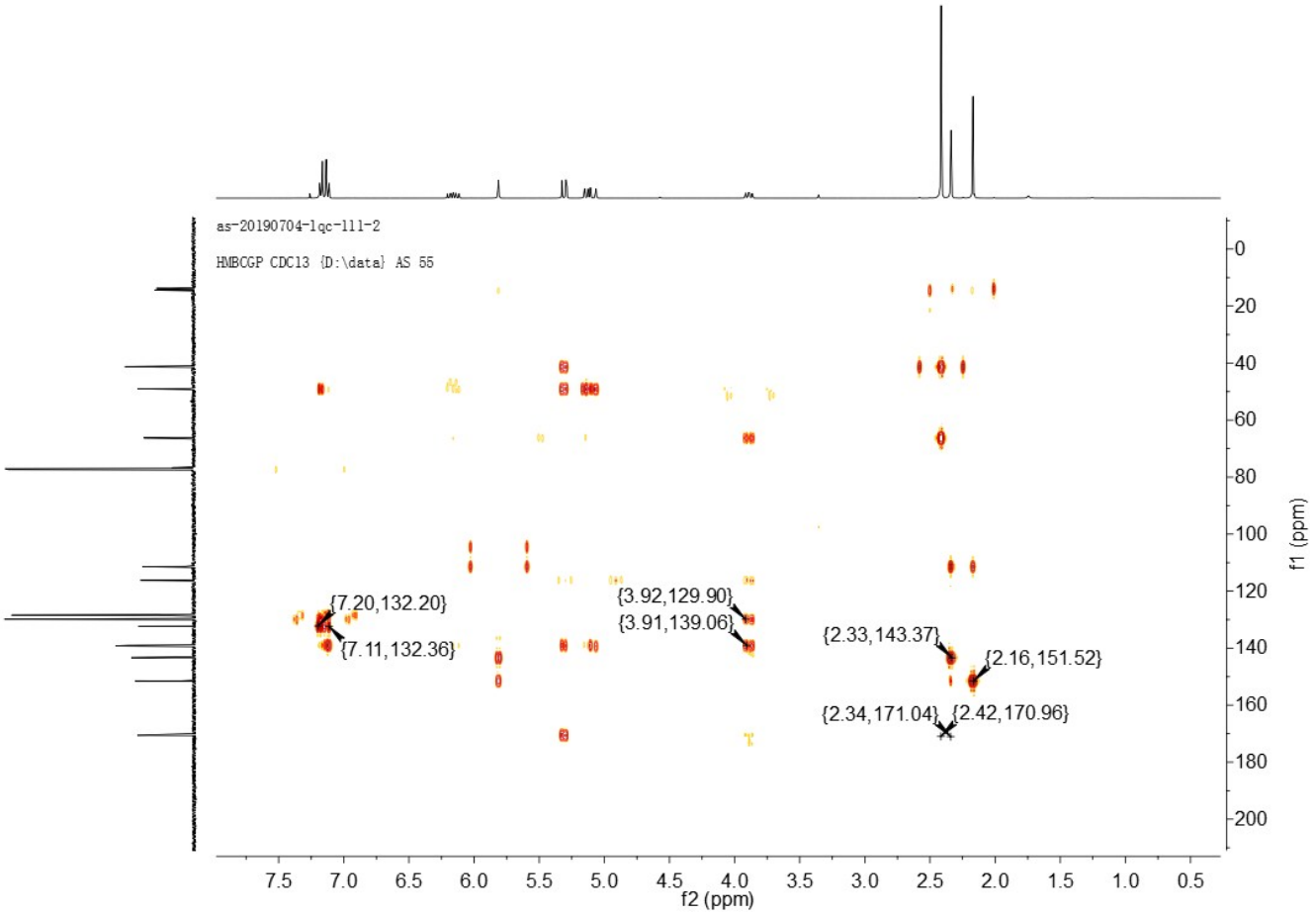
HSQC spectra of 3h



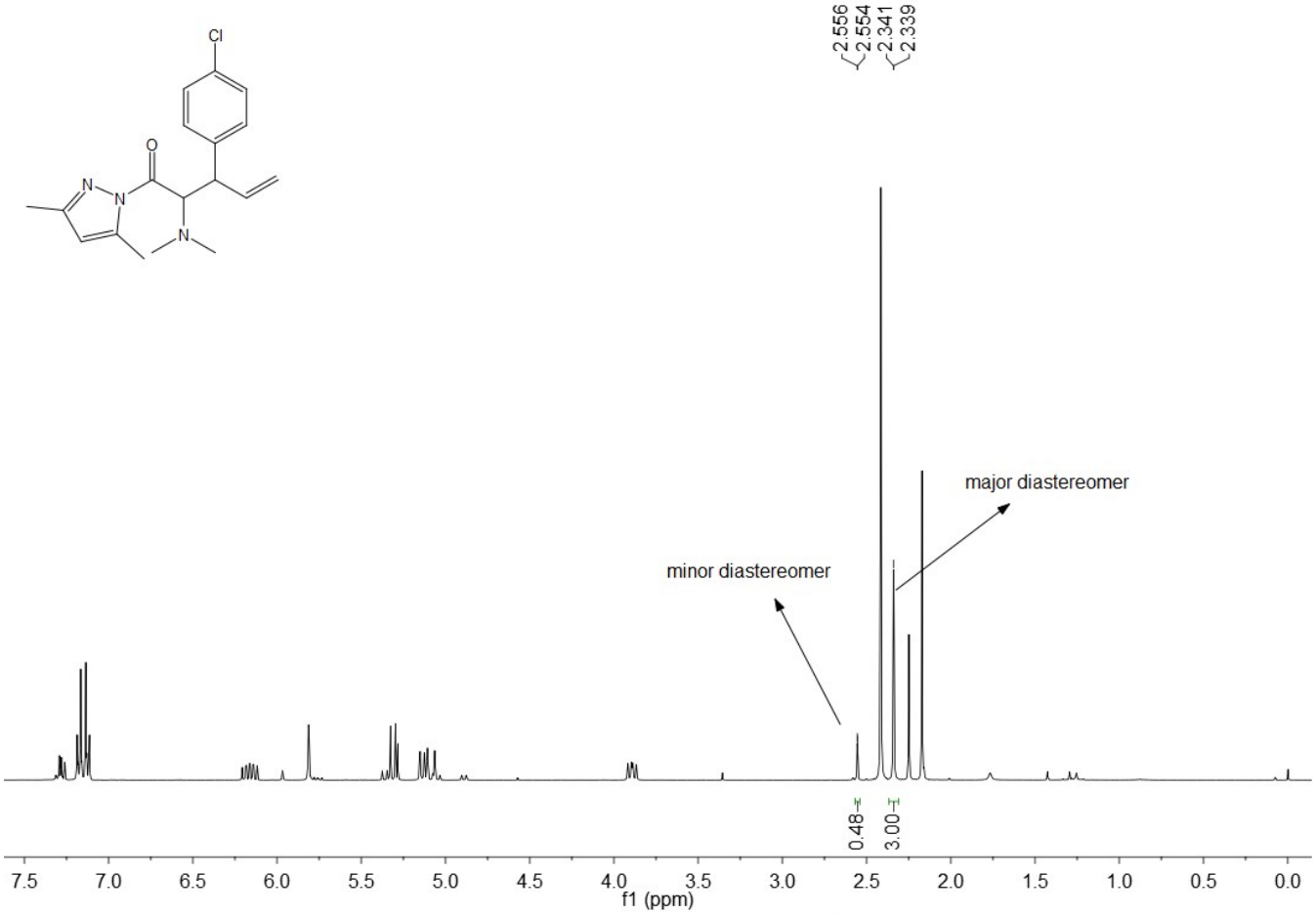
COSY spectra of 3h

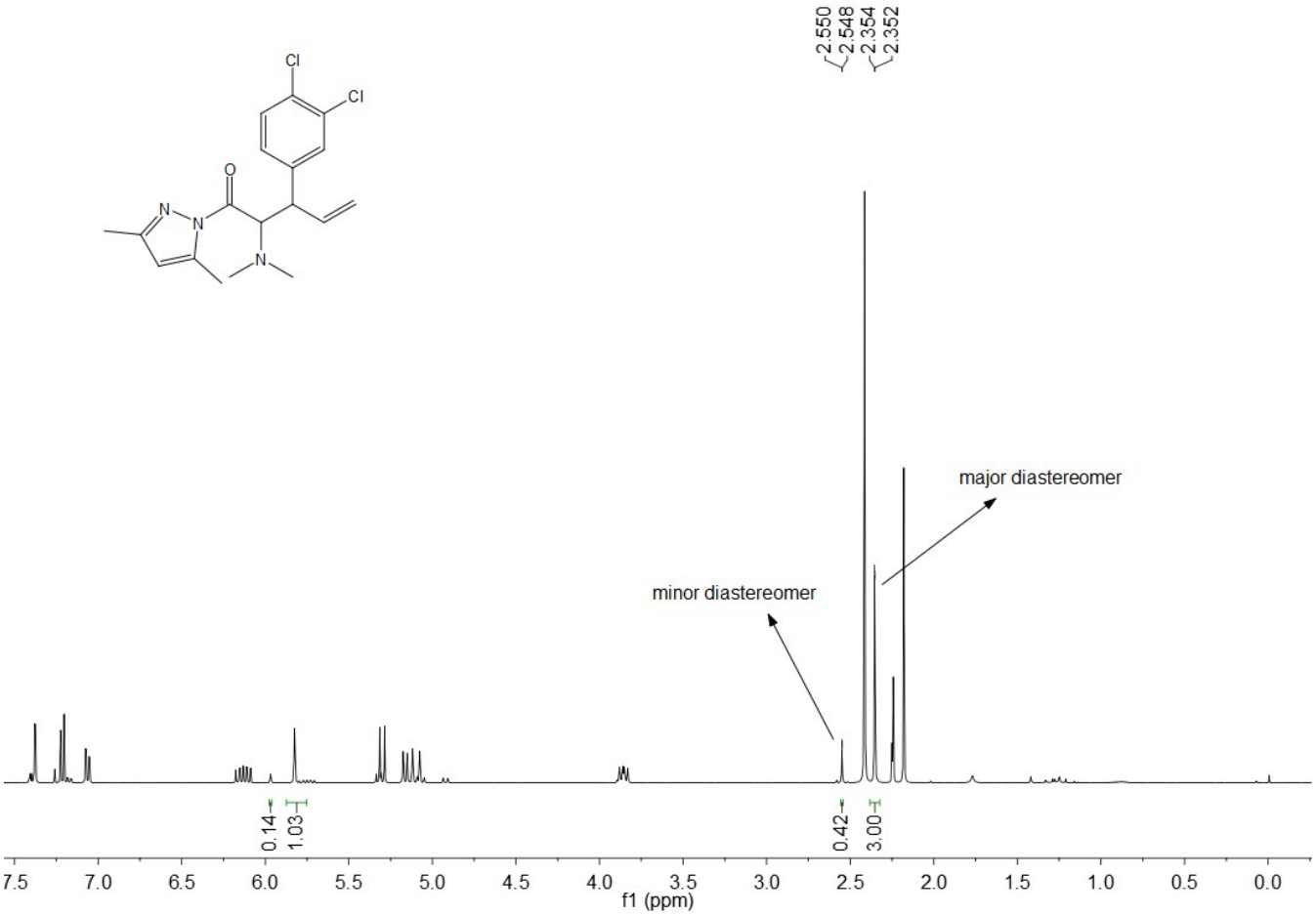


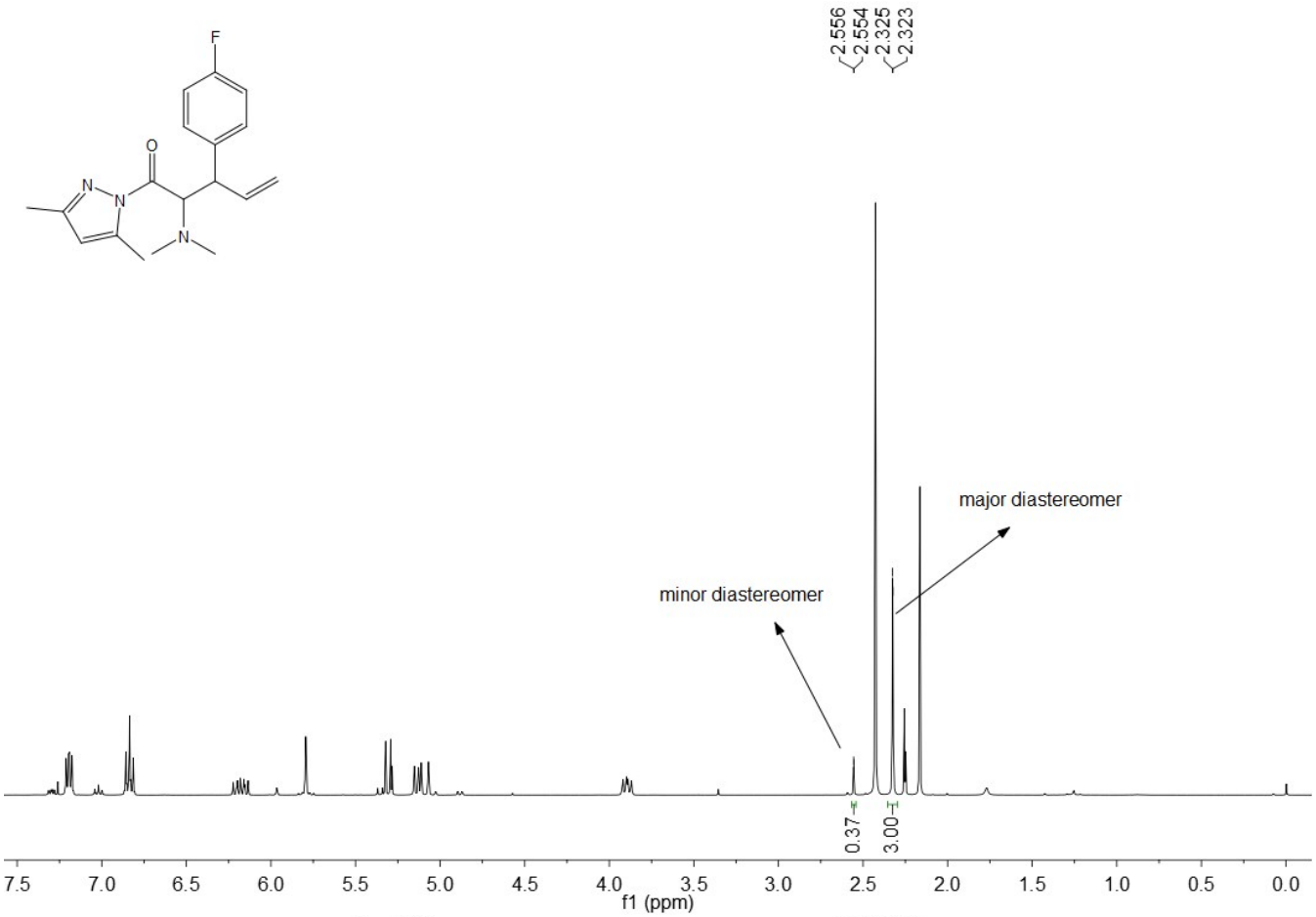
HMBC spectra of 3h

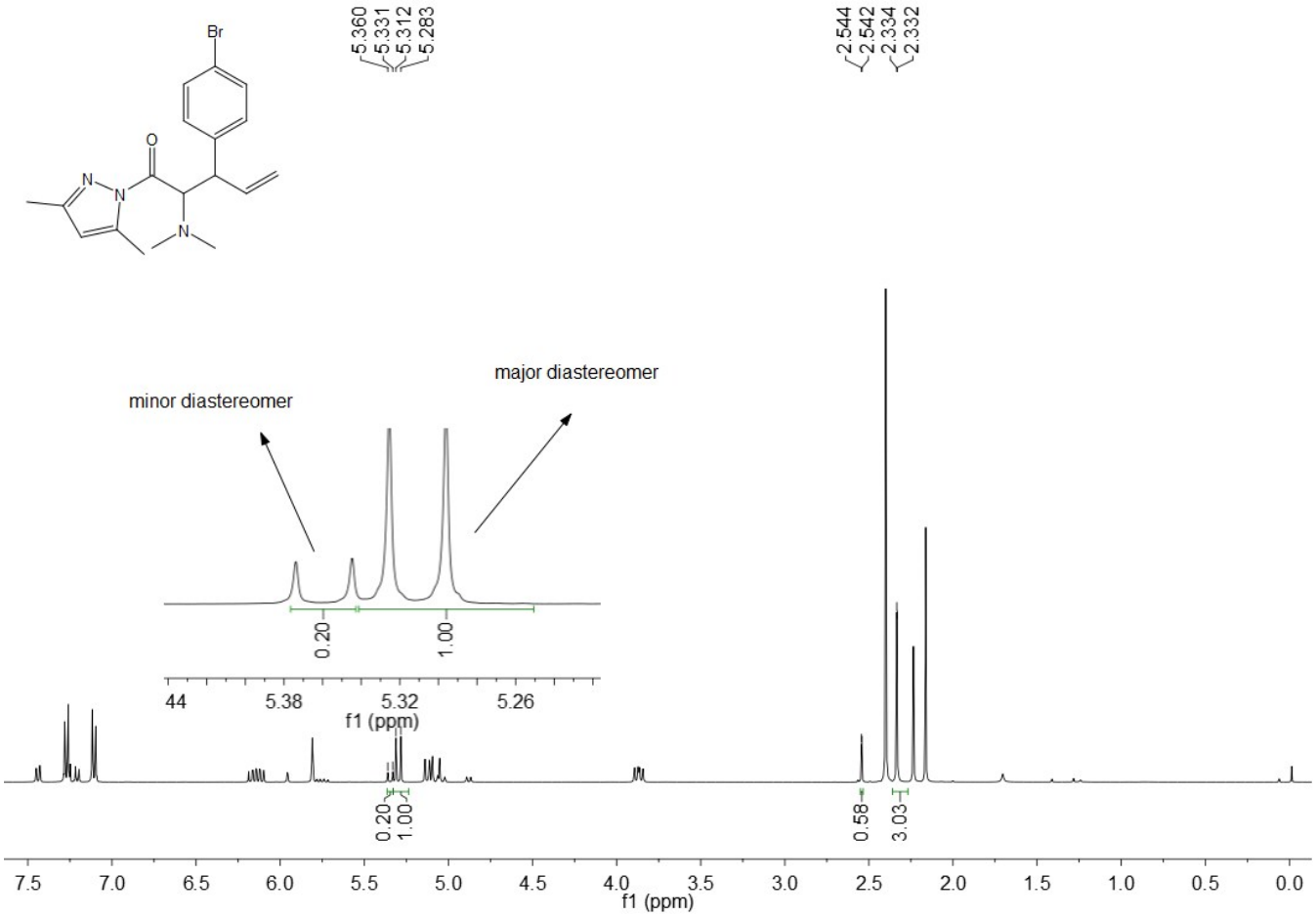


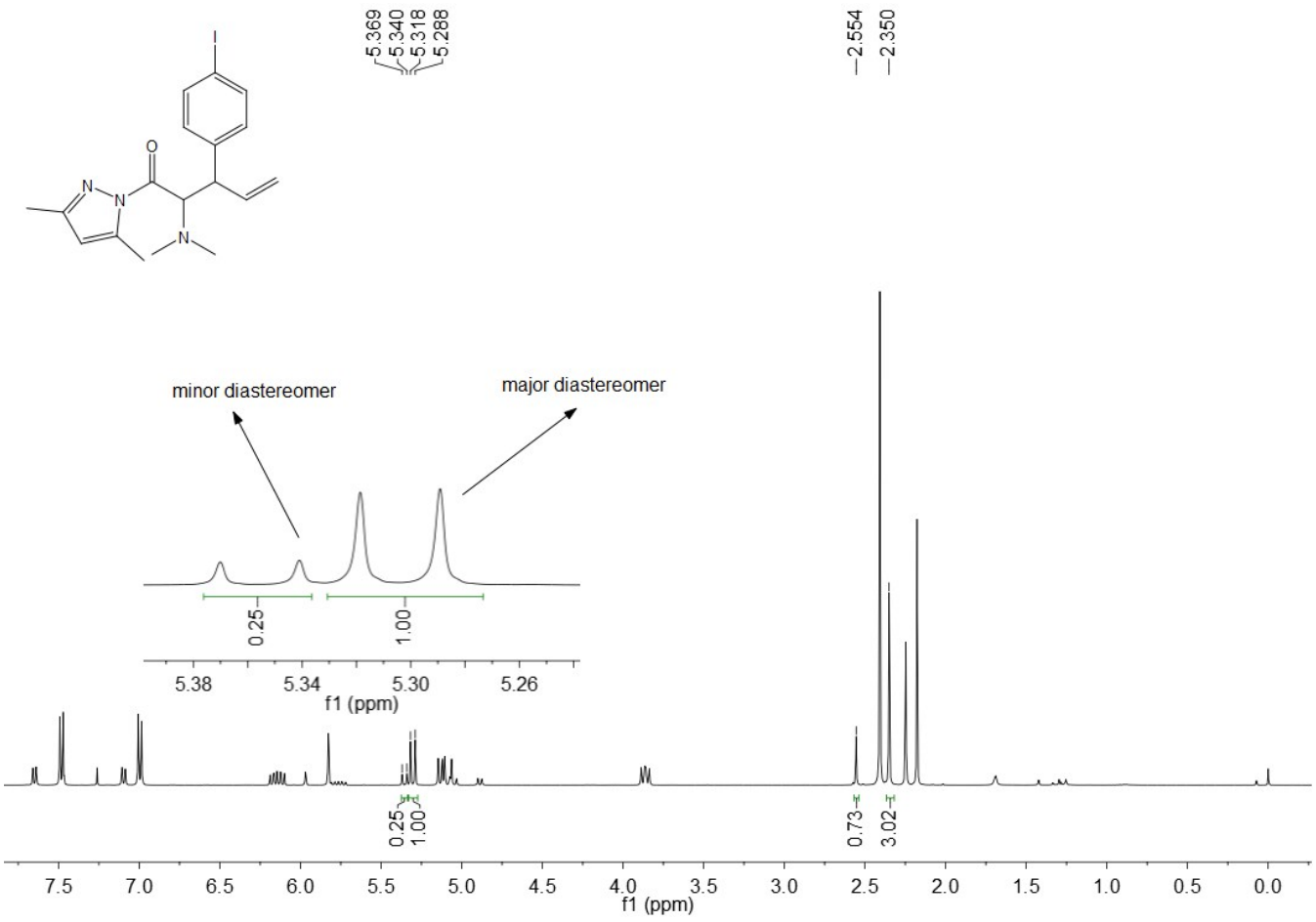
(K) Copies of ^{1}H NMR Spectra for the Determination of *anti:syn* ratio

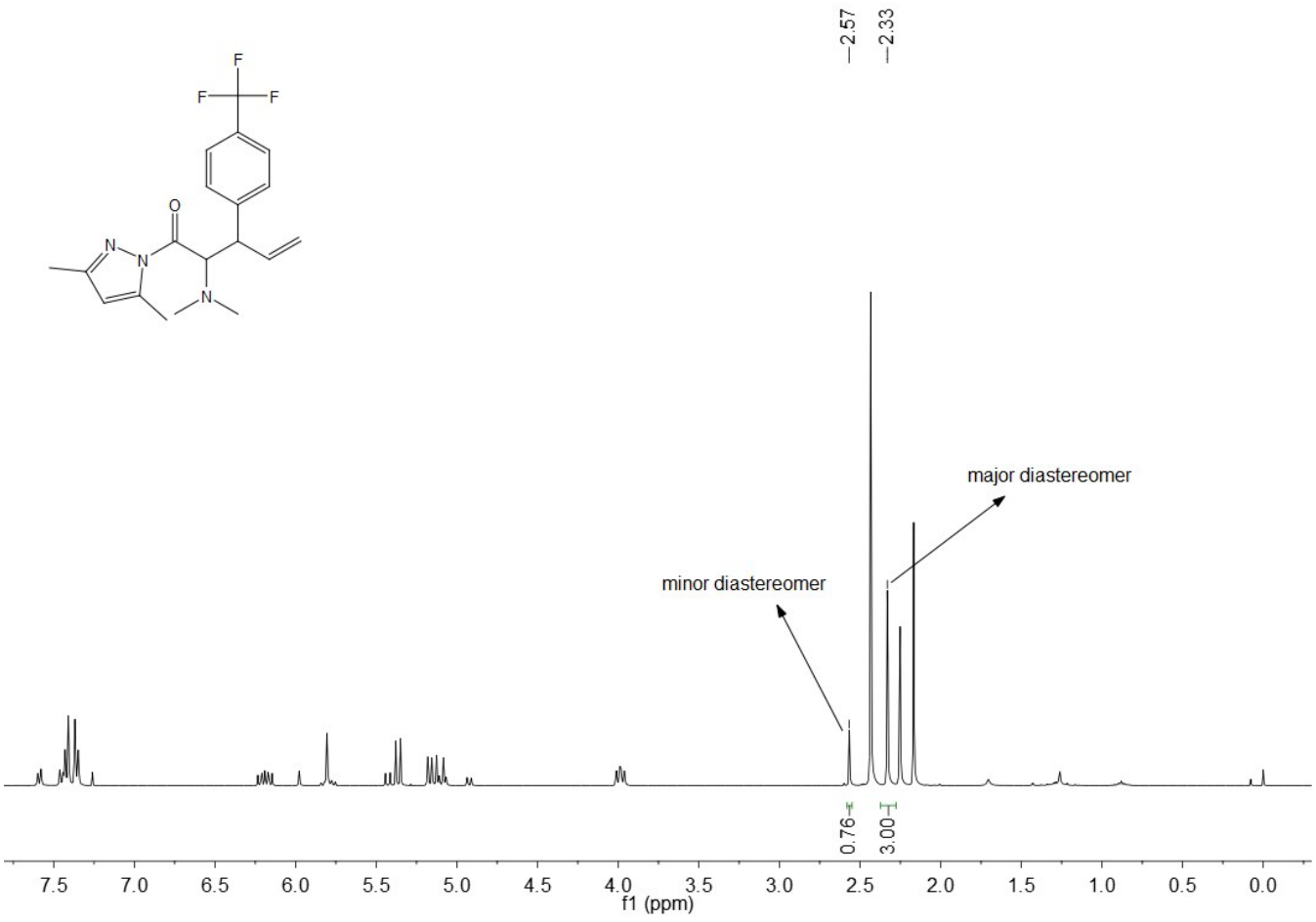


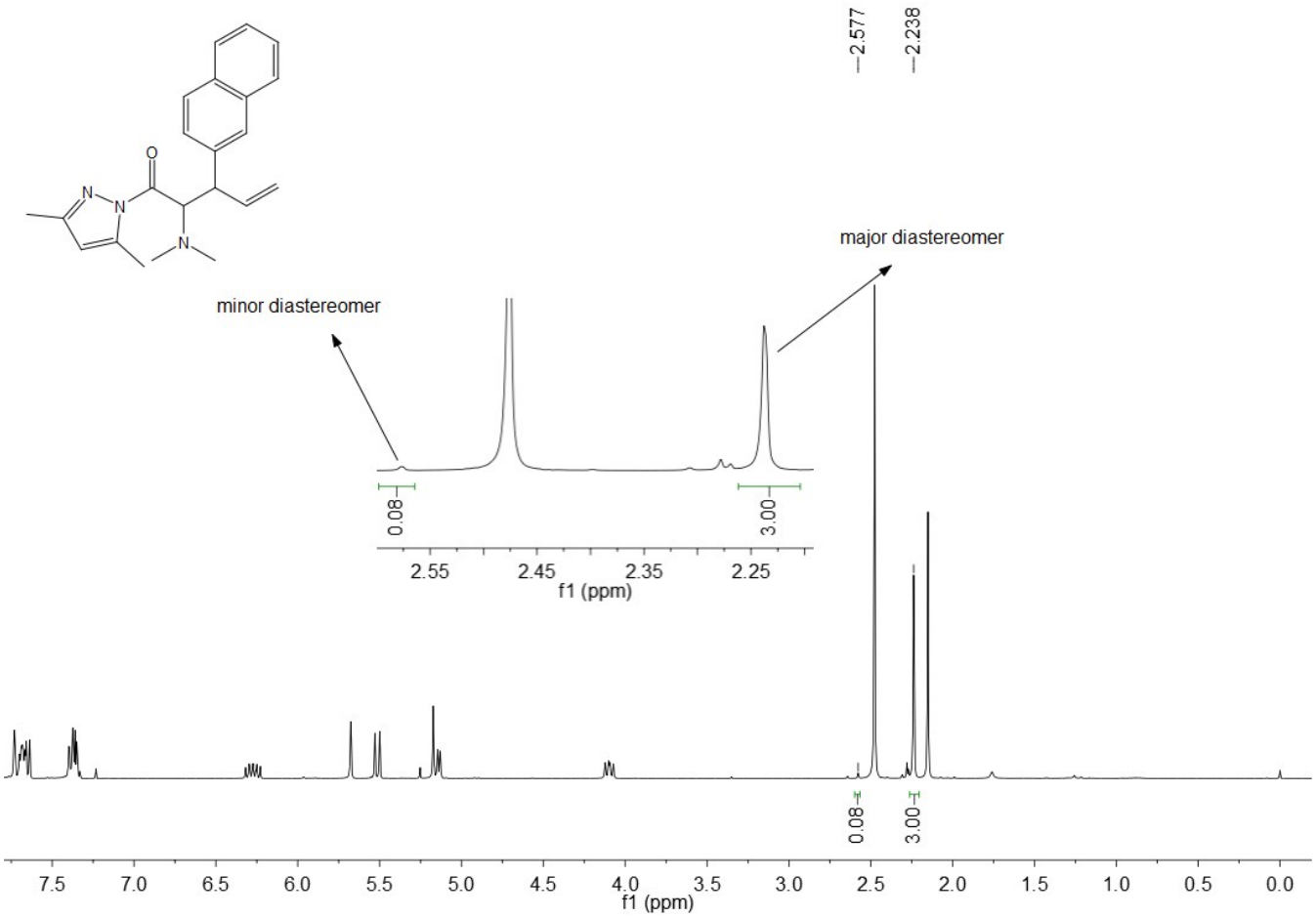


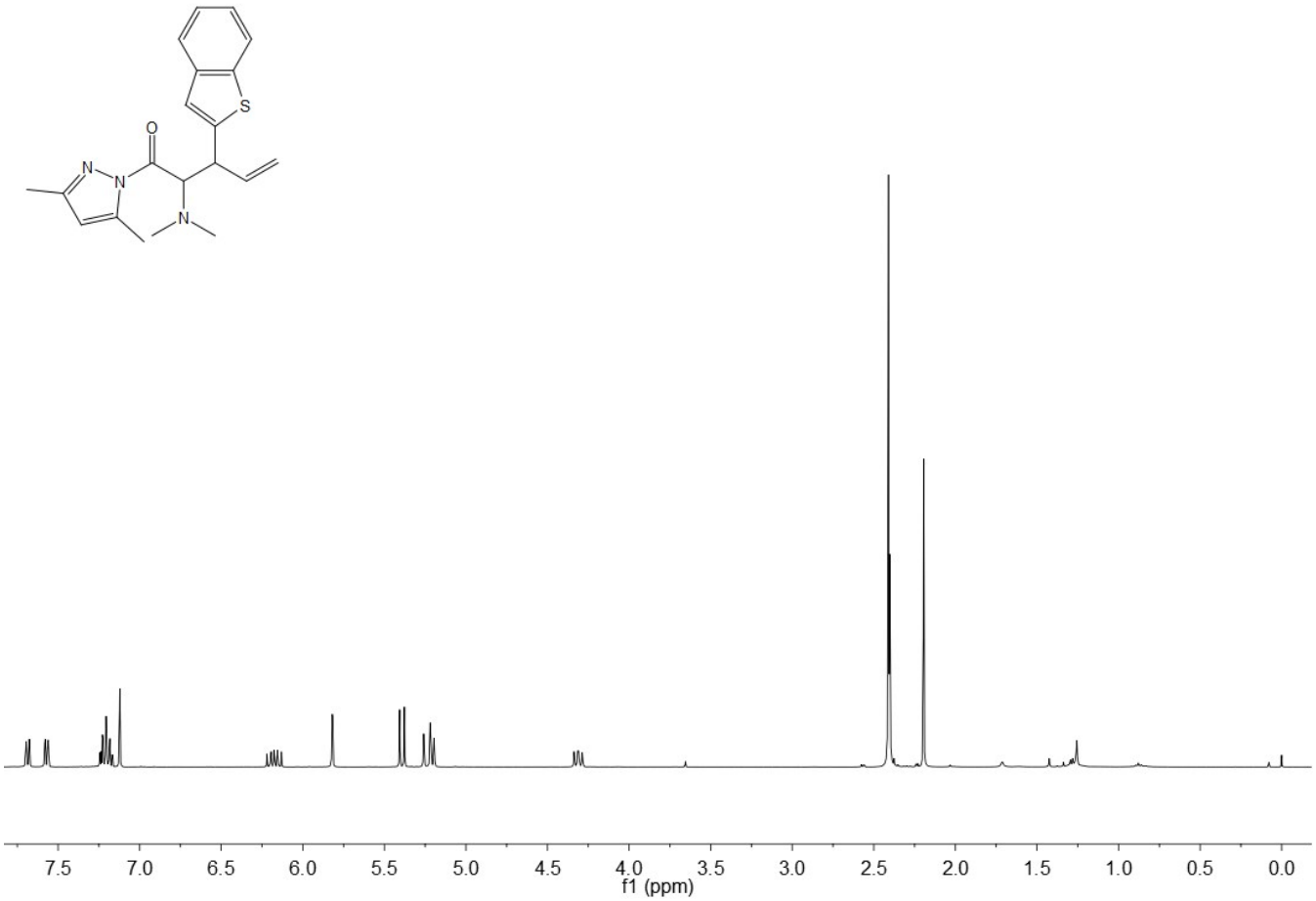

F
O
N
N
N
2.556
2.554
2.325
2.323
major diastereomer
minor diastereomer
0.37
3.00
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

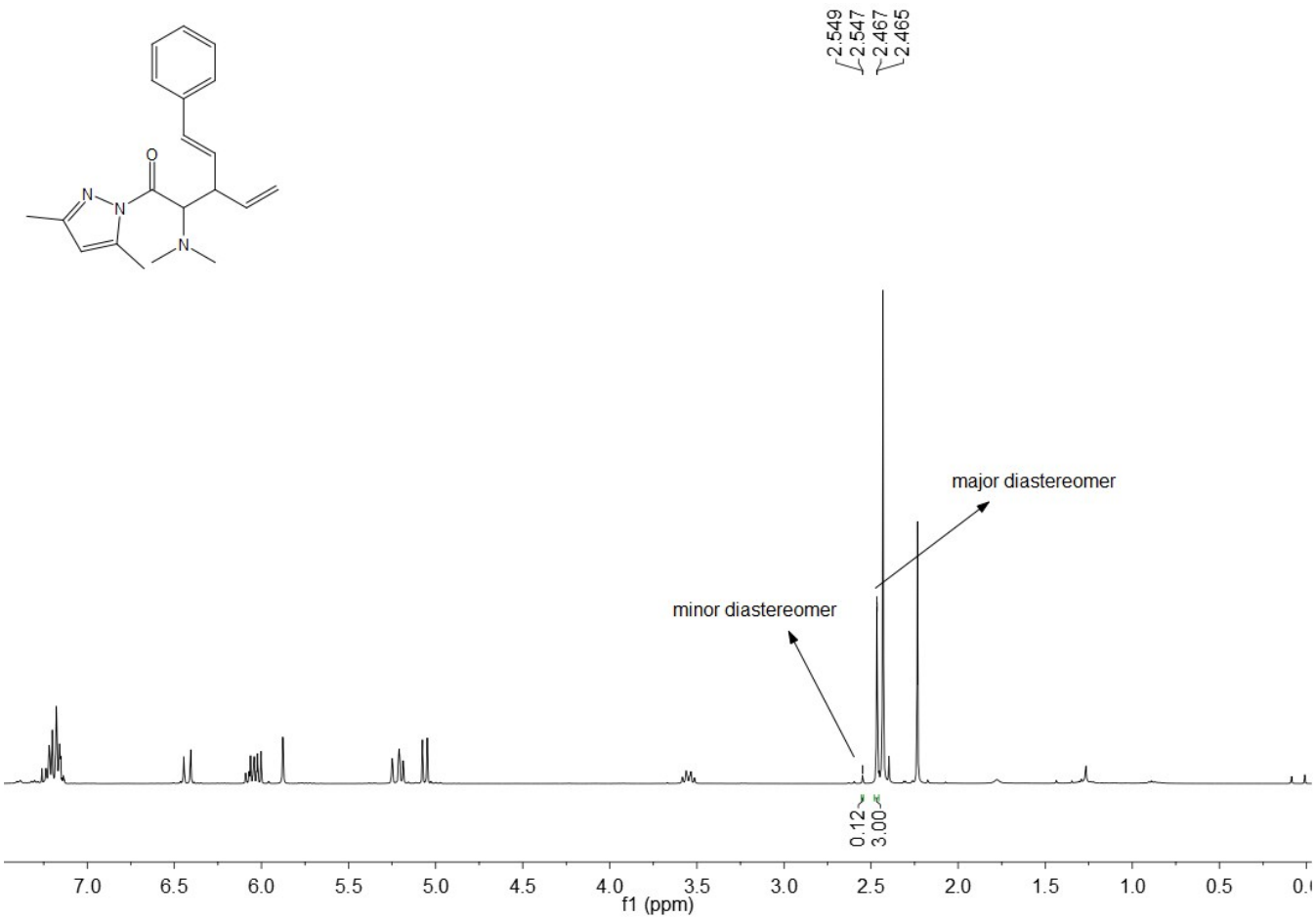

Br
O
N
N
N
5.360
5.331
5.312
5.283
2.544
2.542
2.334
2.332
minor diastereomer
major diastereomer
0.20
1.00
44 5.38 5.32 5.26
f1 (ppm)
0.20
1.00
0.58
3.03
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


5.369
5.340
5.318
5.288
2.554
2.350
minor diastereomer
major diastereomer
0.25
1.00
5.38
5.34
5.30
5.26
f1 (ppm)
0.25
1.00
0.73
3.02
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

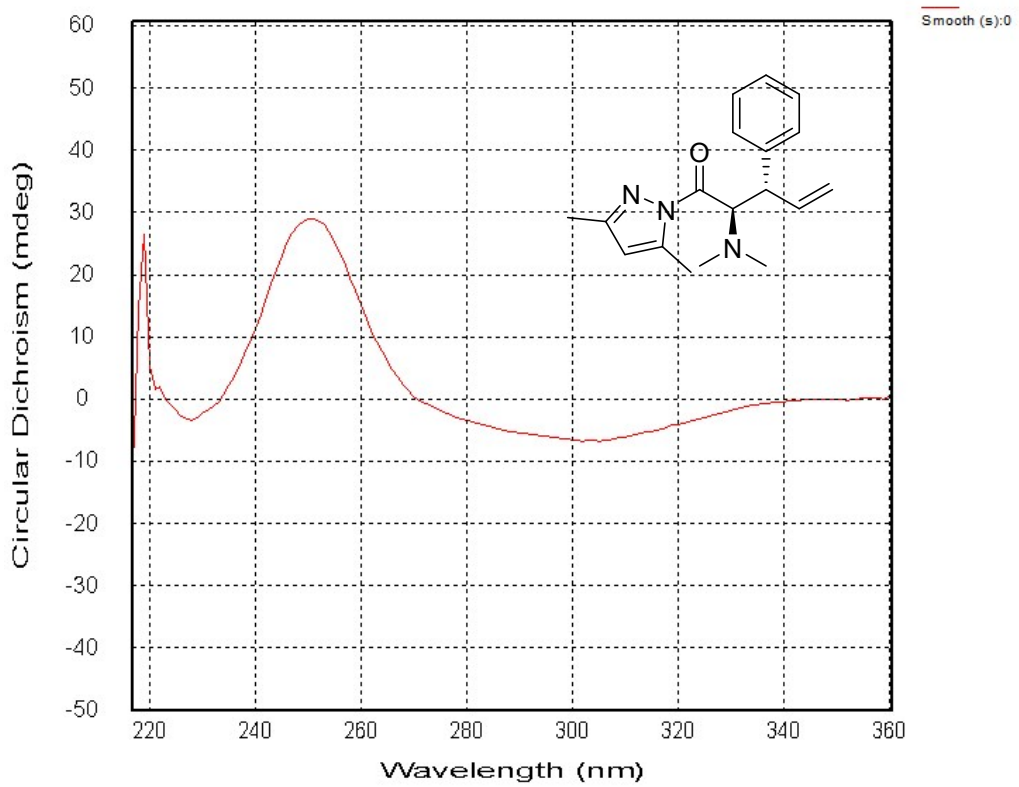

2.57
2.33
major diastereomer
minor diastereomer
0.76
3.00
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

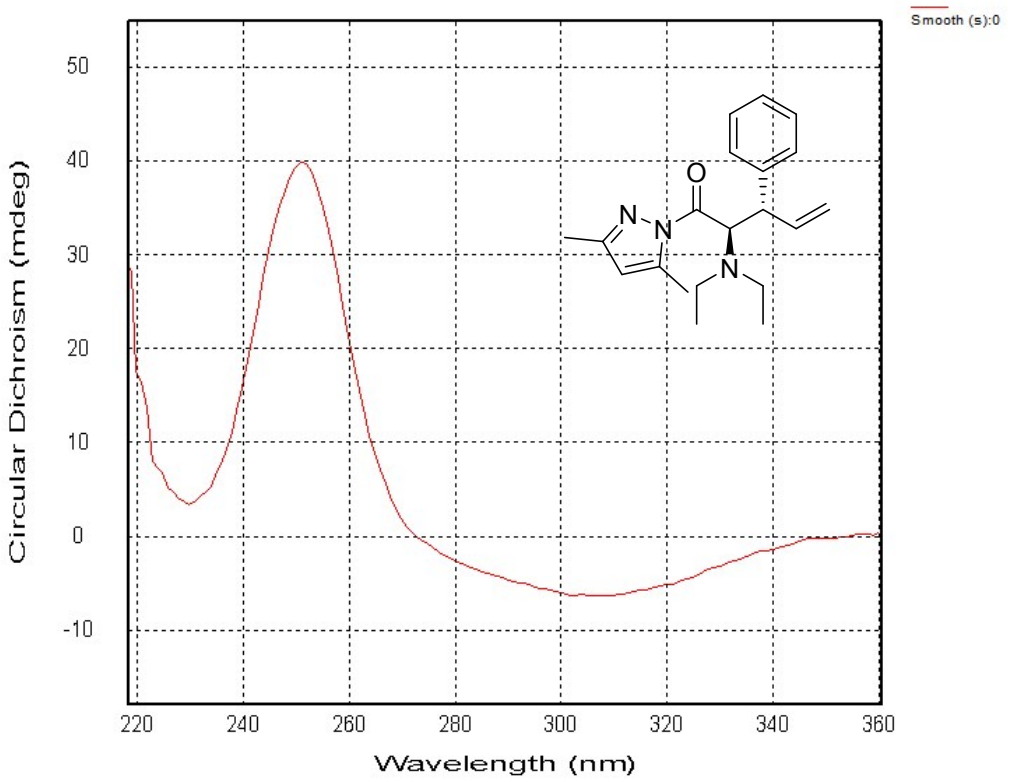

2.577
2.238
major diastereomer
minor diastereomer
0.08
3.00
2.55
2.45
2.35
2.25
f1 (ppm)
0.08
3.00
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

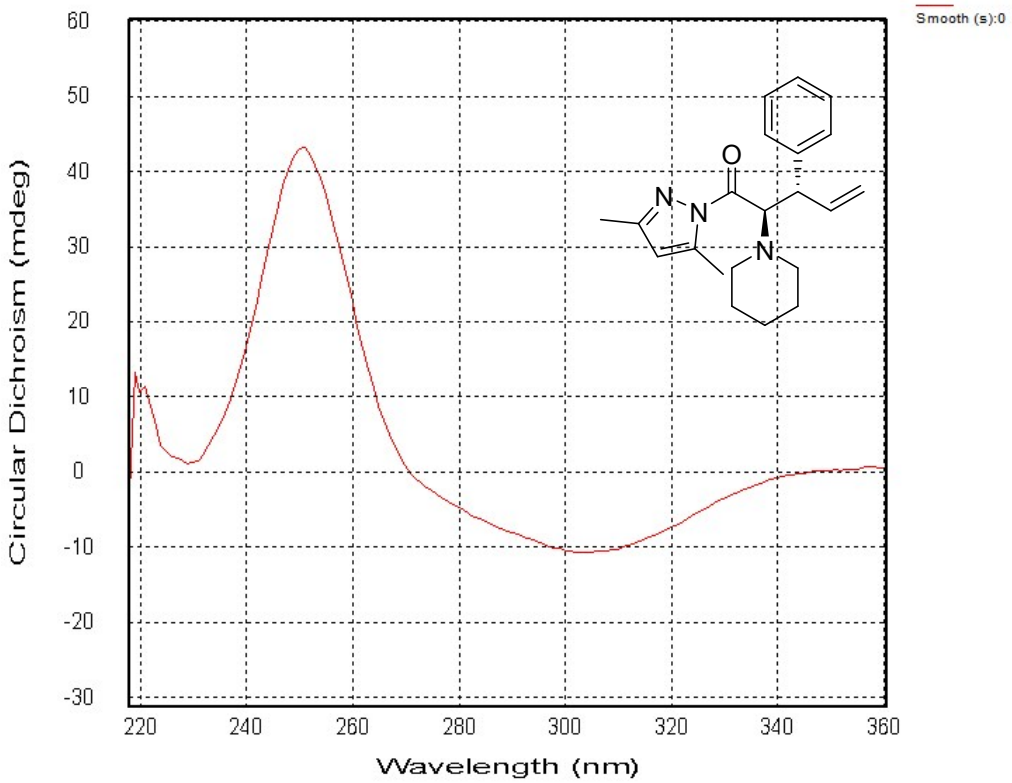

7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)



(L) Copies of CD Spectra in CH_2Cl_2




Smooth (s):0
Circular Dichroism (mdeg)
50
40
30
20
10
0
-10
220
240
260
280
300
320
340
360
Wavelength (nm)
O
N
N
N


Smooth (s):0
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50
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30
20
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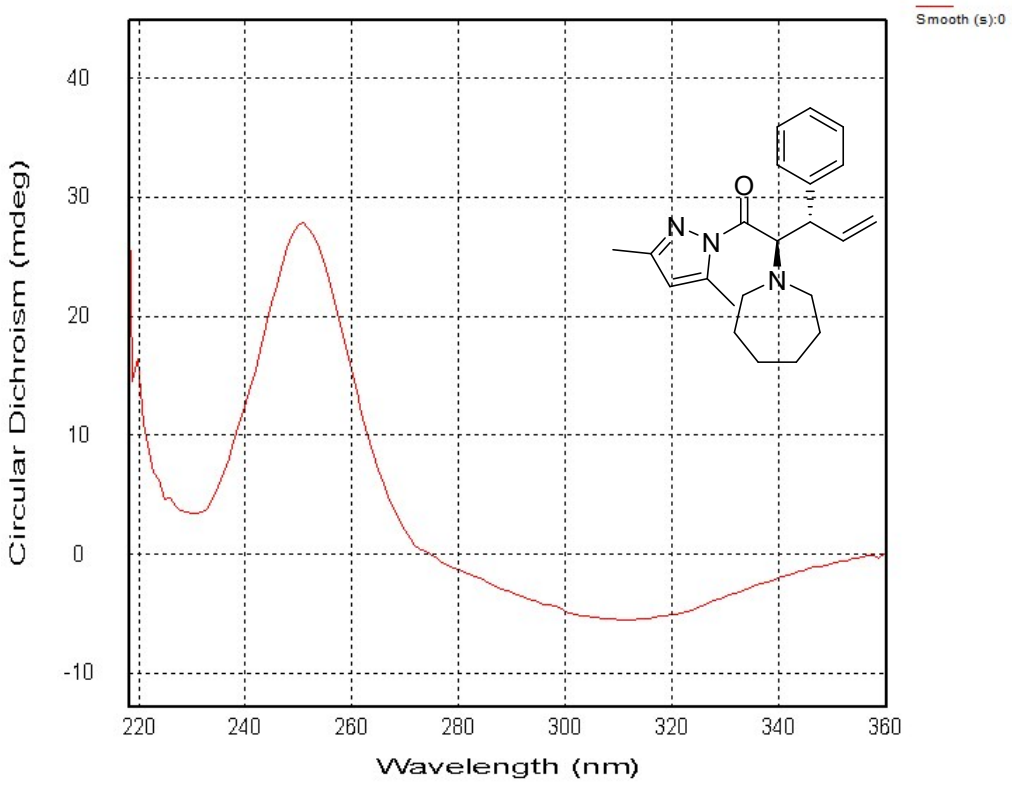
260
280
300
320
340
360
Wavelength (nm)
O
N
N
N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-10
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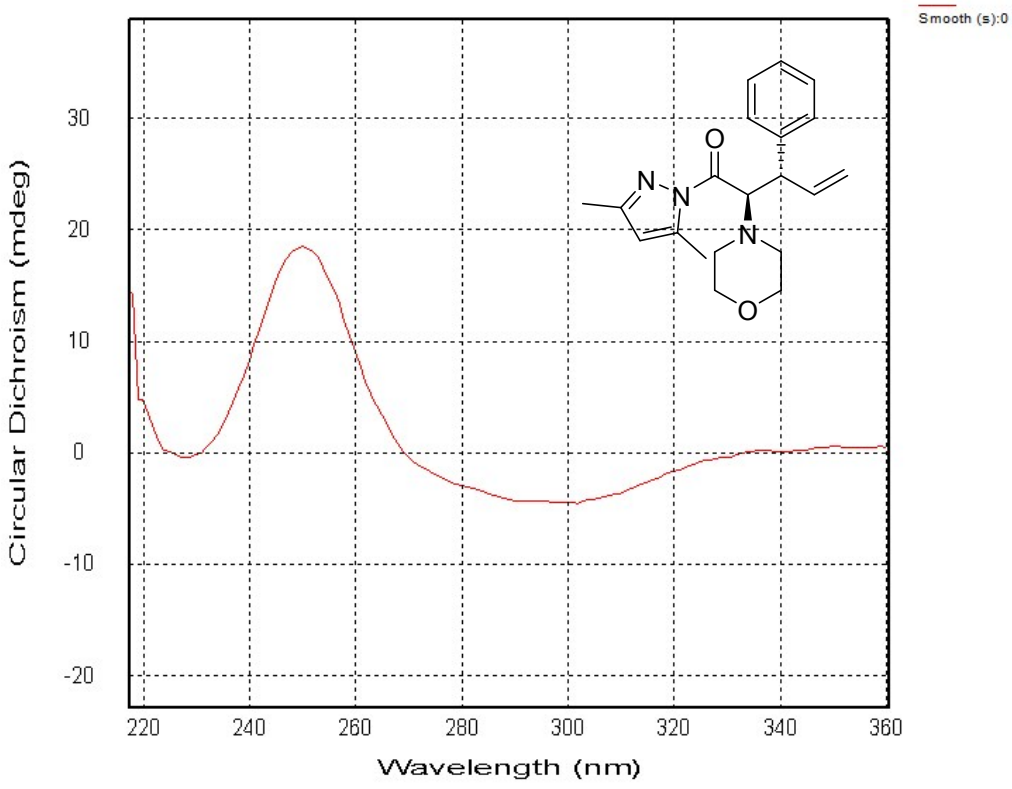
260
280
300
320
340
360
Wavelength (nm)
O
N
N
N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0
-10
-20
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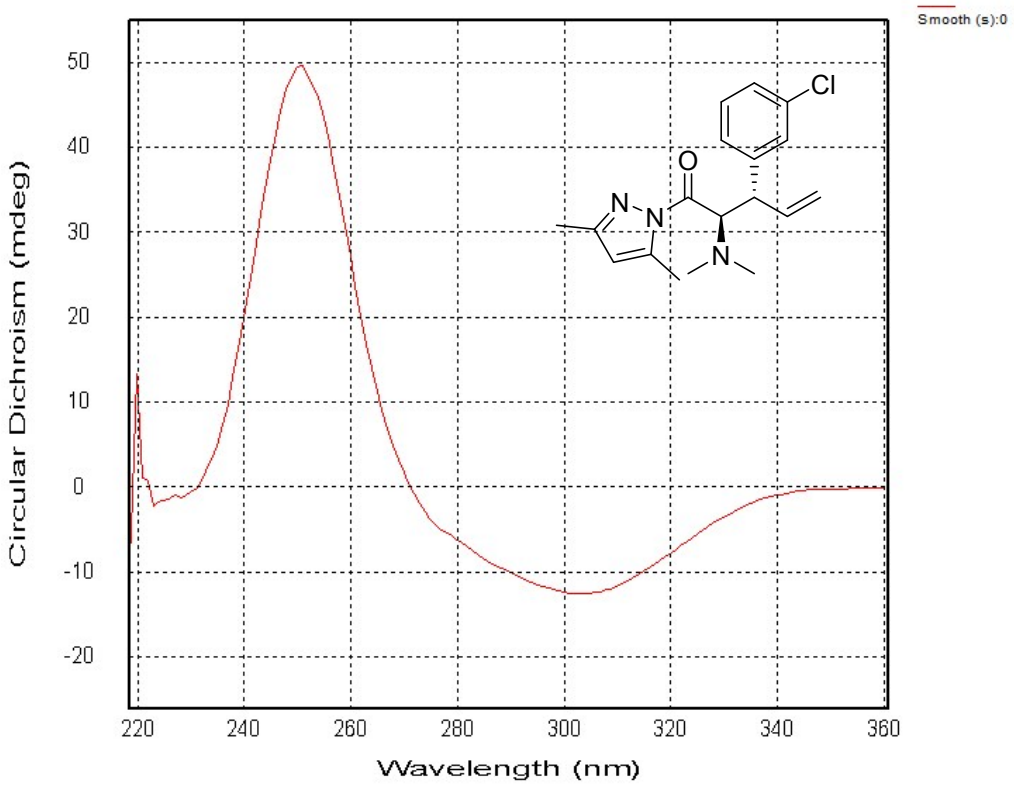
240
260
280
300
320
340
360
Wavelength (nm)
O
N
N
N
O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30
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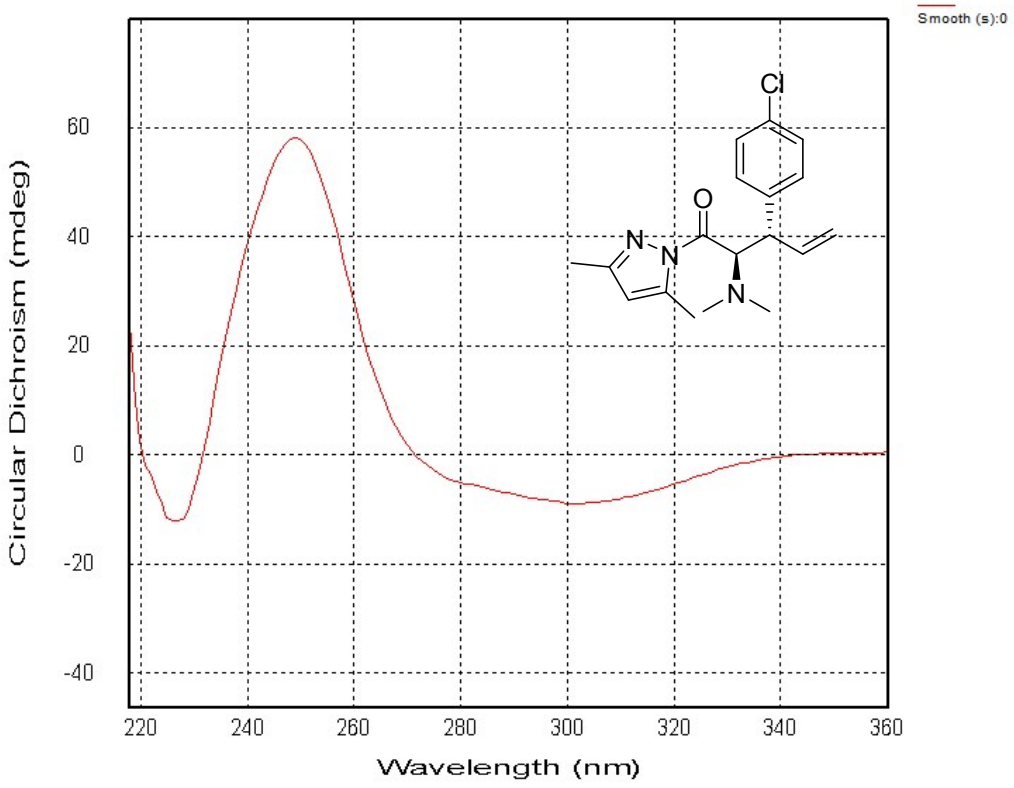
260
280
300
320
340
360
Wavelength (nm)
Cl
O
N
N
N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320
340
360
Wavelength (nm)
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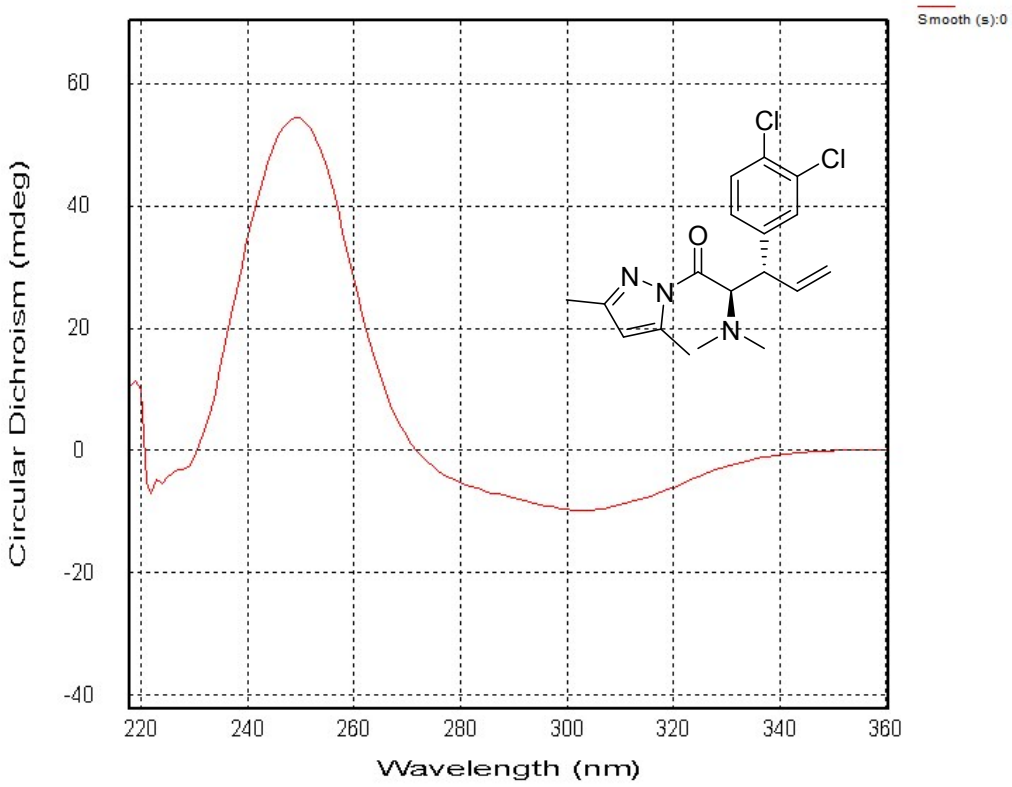
O
N
N
N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-20
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260
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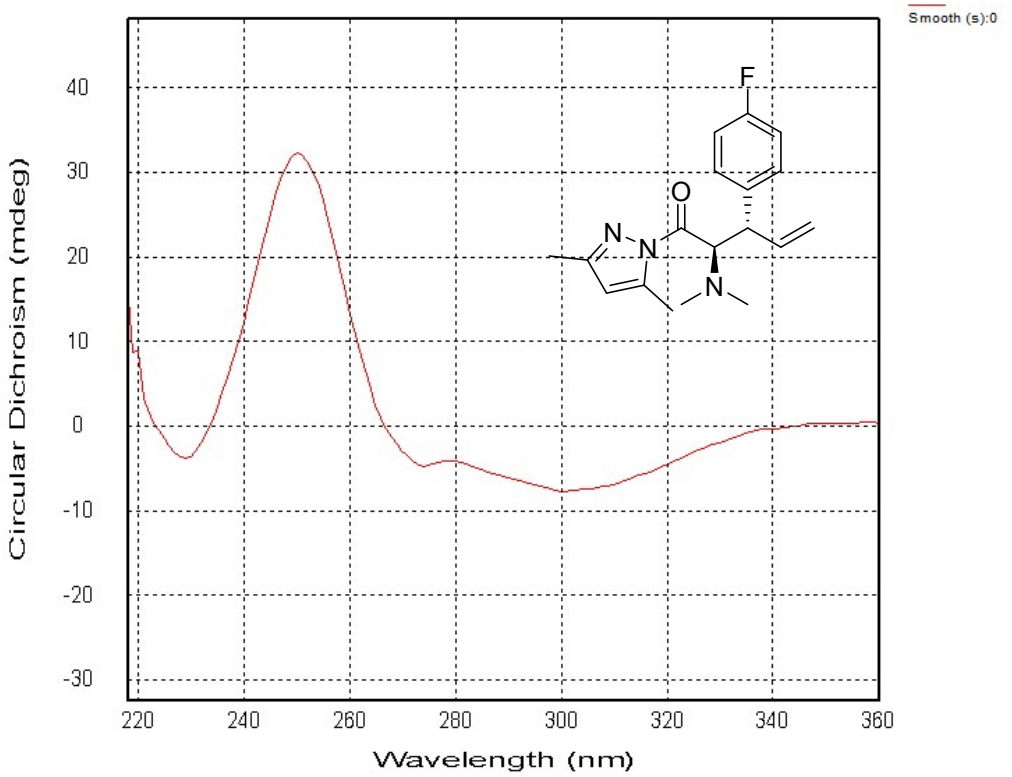
300
320
340
360
Wavelength (nm)
Cl
Cl
O
N
N
N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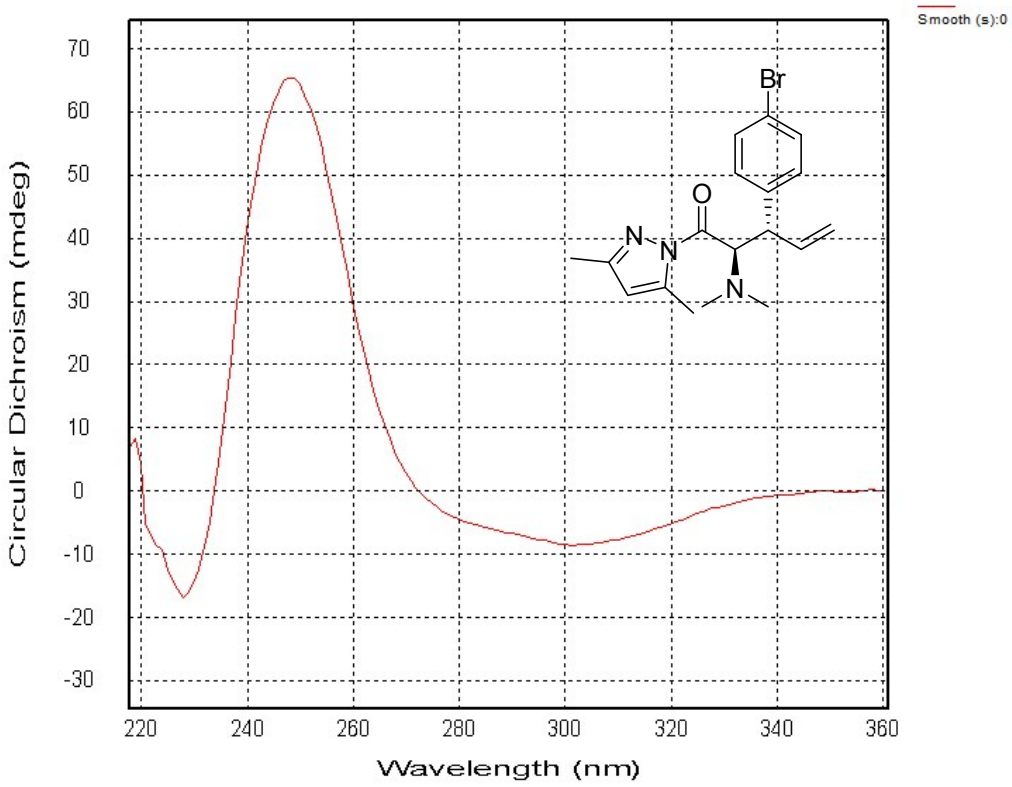
320
340
360
Wavelength (nm)
F
O
N
N
N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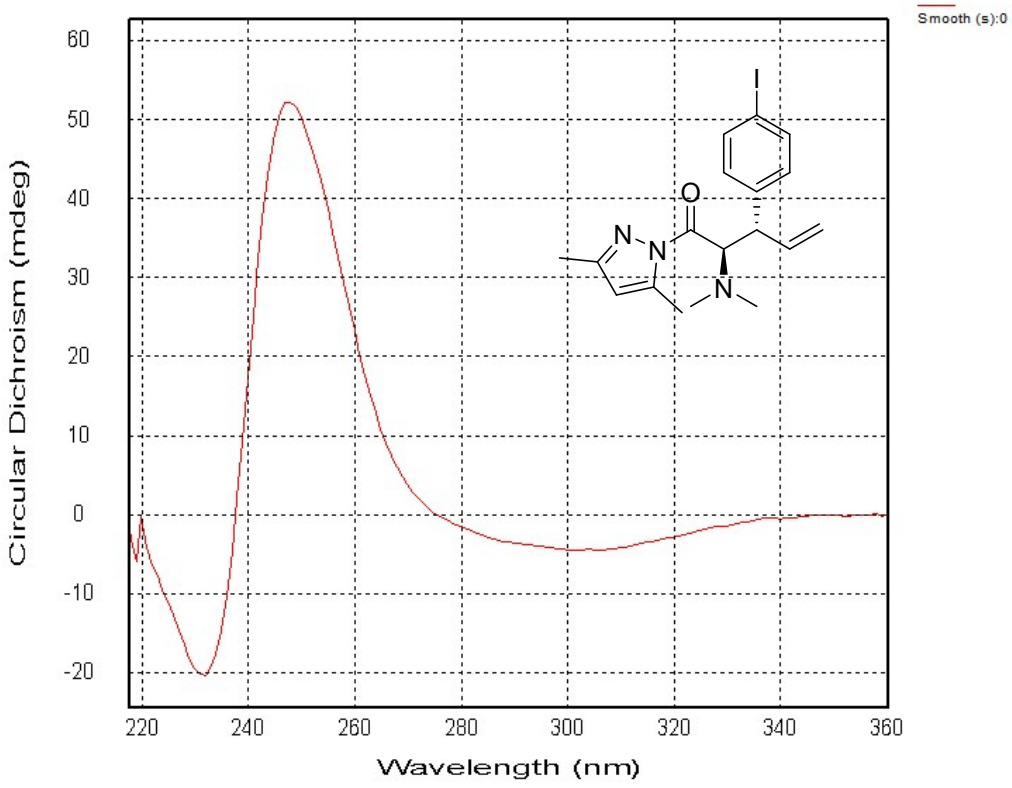
300
320
340
360
Wavelength (nm)
Br
O
N
N
N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Circular Dichroism (mdeg)
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30
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0
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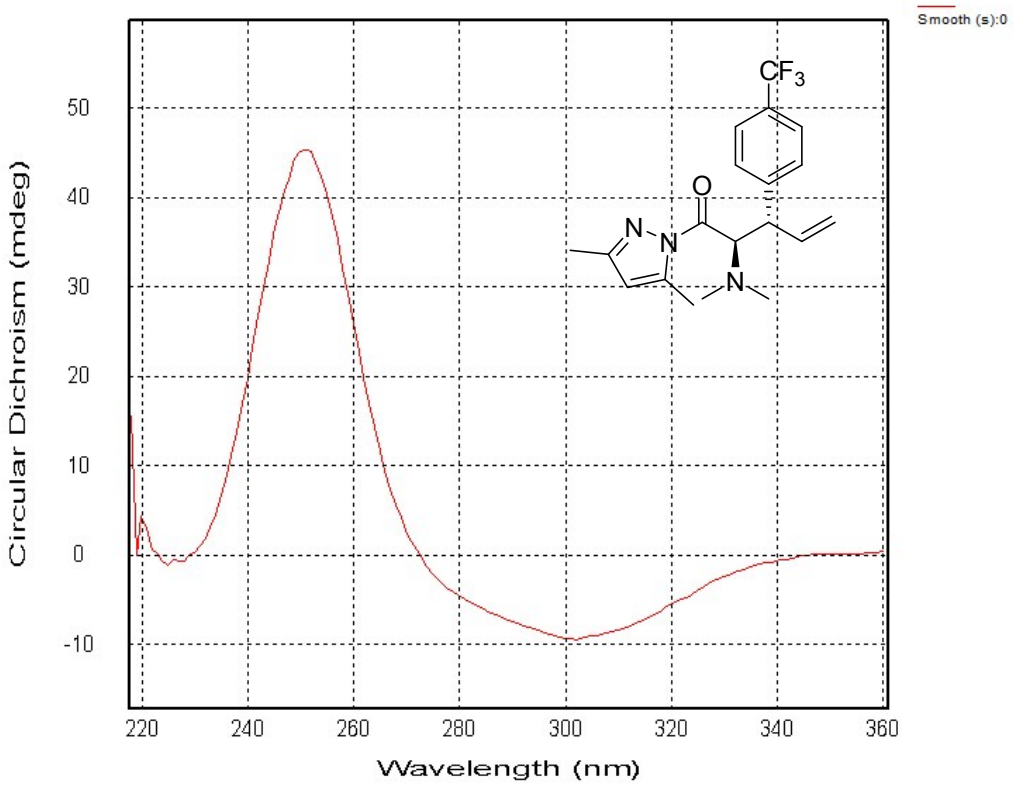
280
300
320
340
360
Wavelength (nm)
I
O
N
N
N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260
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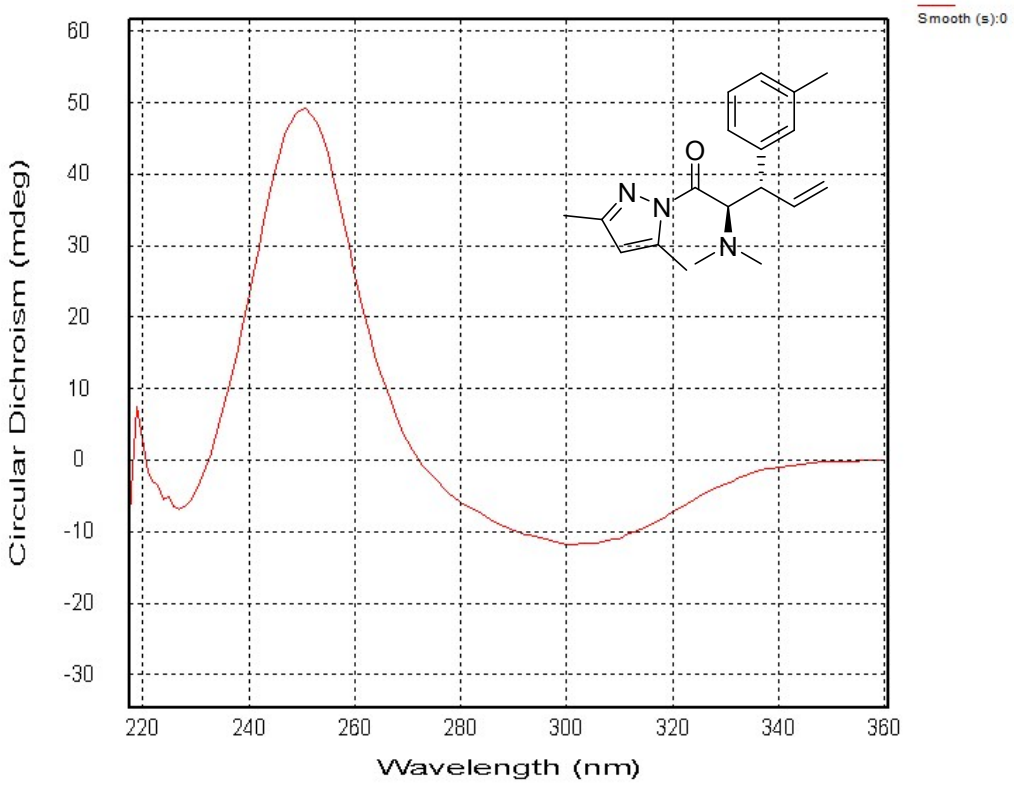
300
320
340
360
Wavelength (nm)
CF3
O
N
N
N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300
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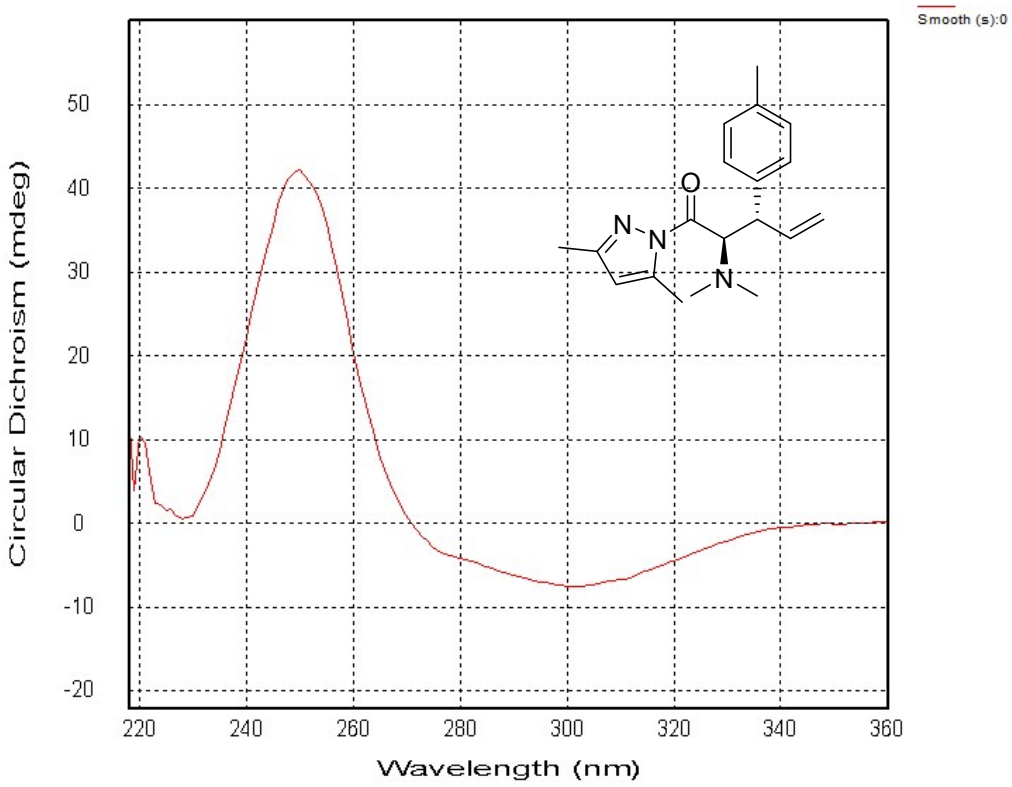
340
360
Wavelength (nm)
O
N
N
N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Circular Dichroism (mdeg)
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10
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-10
-20
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260
280
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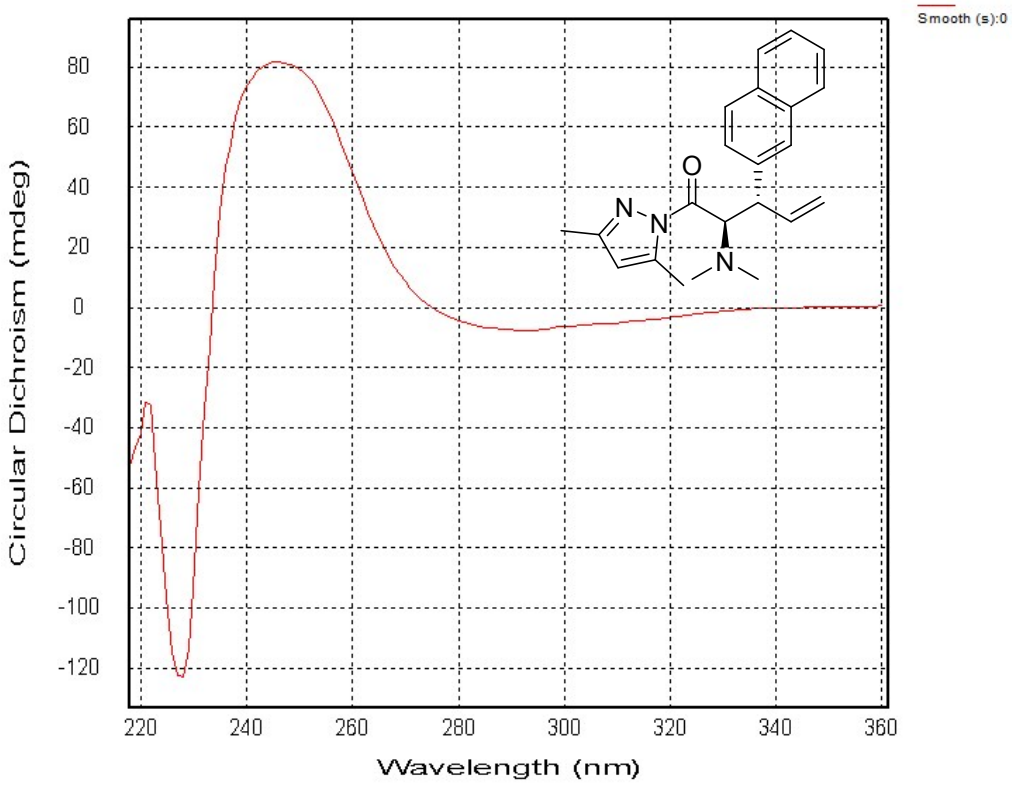
320
340
360
Wavelength (nm)
O
N
N
N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Circular Dichroism (mdeg)
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40
20
0
-20
-40
-60
-80
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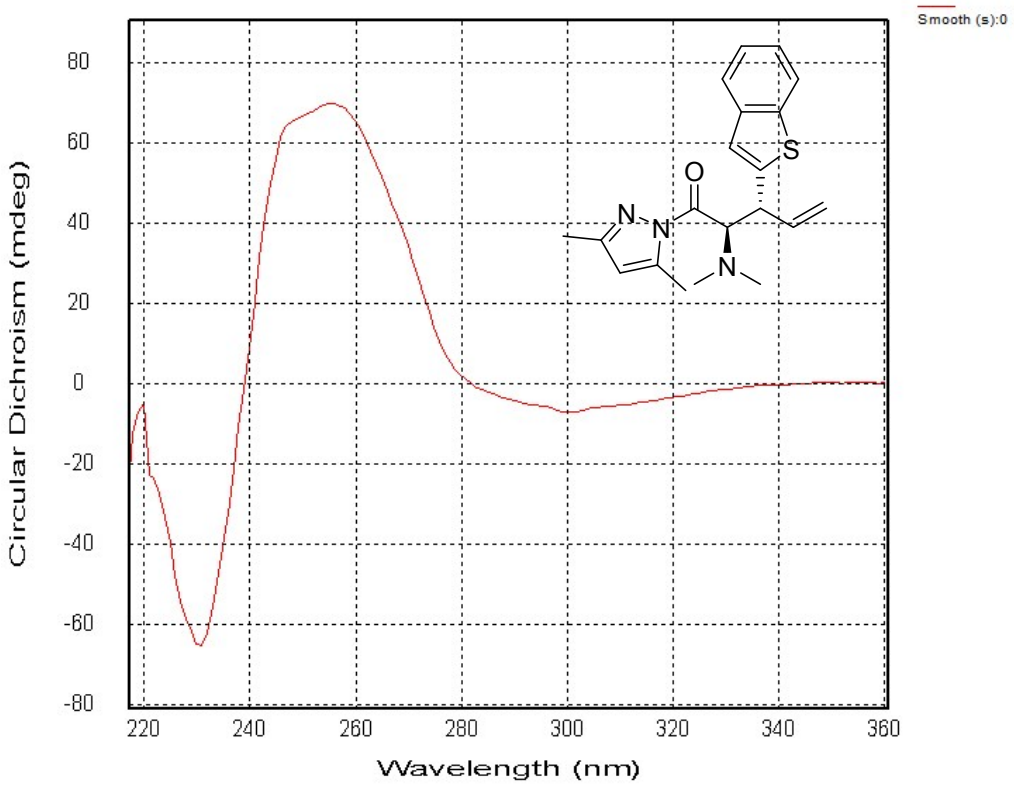
-120
220
240
260
280
300
320
340
360
Wavelength (nm)
O
N
N
N


Smooth (s):0
Circular Dichroism (mdeg)
80
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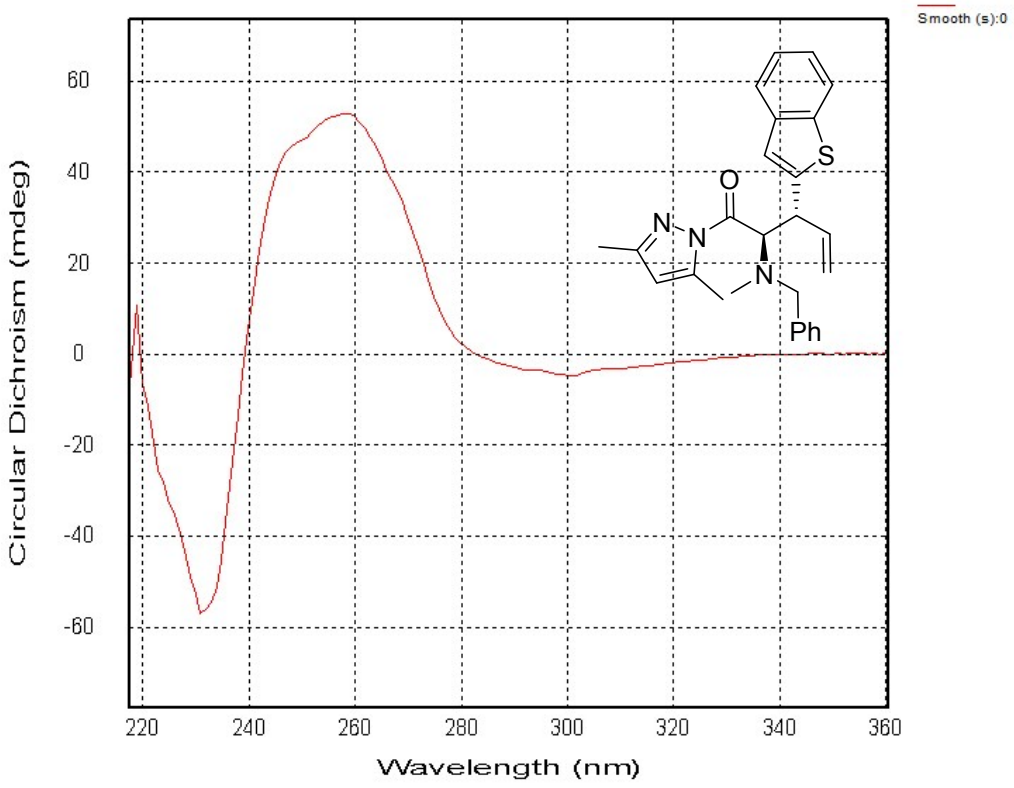
40
20
0
-20
-40
-60
-80
220
240
260
280
300
320
340
360
Wavelength (nm)
S
O
N
N
N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240
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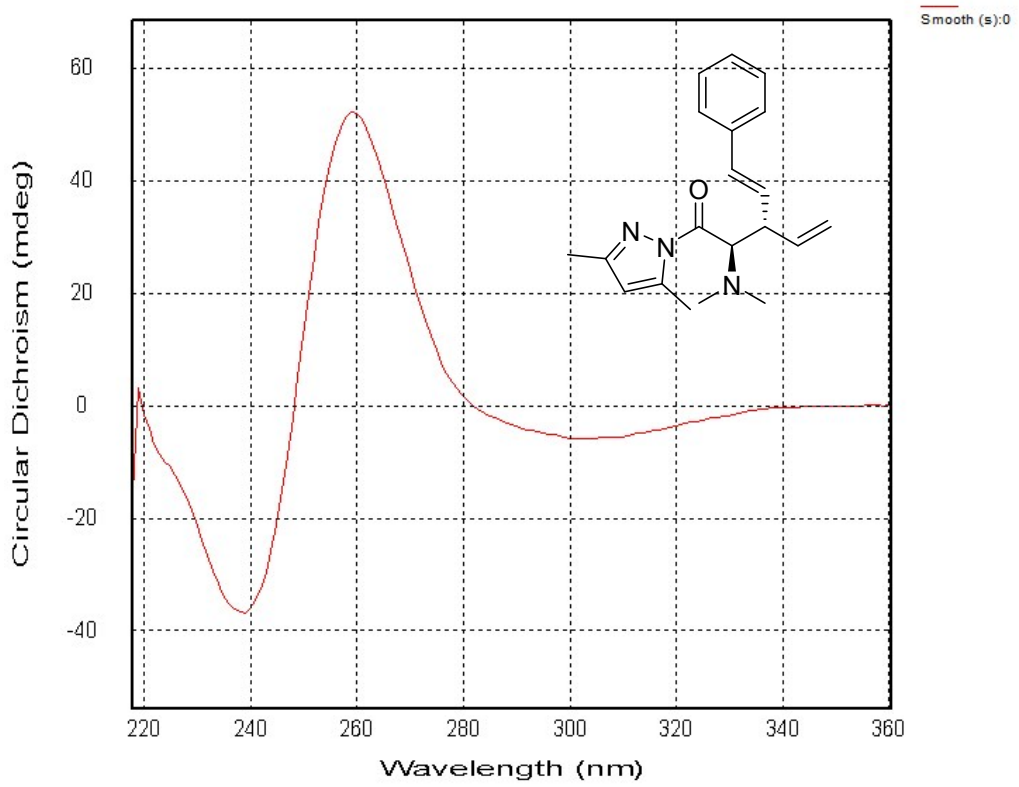
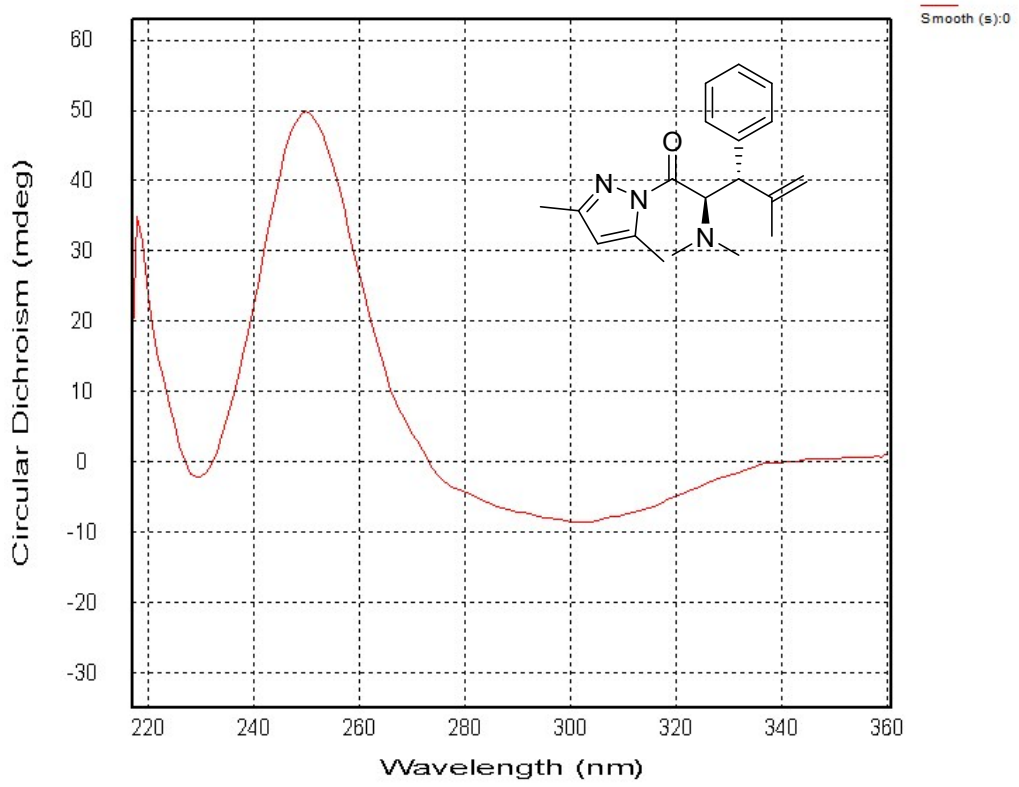
280
300
320
340
360
Wavelength (nm)
S
O
N
N
N
Ph





(M)References

(1) Y. H. Wen, X. Huang, J. L. Huang, Y. Xiong, B. Qin and X. M. Feng, *Synlett,* 2005, **2005**, 2445.

(2) S. S. M. Spoehrle, T. H. West, J. E. Taylor, A. M. Z. Slawin and A. D. Smith, *J. Am. Chem. Soc*., 2017, **139**, 11895.

(3) (a) T. H. West, D. S. B. Daniels, A. M. Z. Slawin and A. D. Smith, *J. Am. Chem. Soc.,* 2014, **136**, 4476; (b) U. Kroesen, L. Knauer and C. Strohmann, *Angew. Chem., Int. Ed*., 2017, **56**, 6232; (c) G. A. Pinna, G. Cignarella, G. Loriga, G. Murineddu, J.-M. Mussinu, S. Ruiu, P. Fadda and W. Fratta, *Bioorg. Med. Chem*., 2002, **10**, 1929; (d) H. X. Wang, J. C. Yang and S. L. Buchwald, *J. Am. Chem. Soc*., 2017, **139**, 8428.