# Facile Scalable Reduction of *N*-Acylated Dihydropyrazoles

Michael D. Curtis*, Nancy C. Hayes, and Patricia A. Matson

*Chemical Development, Procter & Gamble Pharmaceuticals, Norwich, NY 13815*

## SUPPORTING INFORMATION

### General Experimental

All reactions were carried out using commercial grade raw materials which were used as is without further purification. The dihydropyrazole used for the preparation of the *N*-acylated reduction substrates **13-26** was purchased from TCI chemicals while all other materials were obtained from Aldrich.

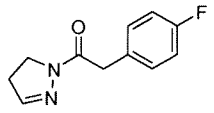
Flash column chromatography was performed using 230-400 mesh silica gel while analytical TLC was carried out on Merck silica gel plates with QF-254 indicator with visualization by UV or $KMnO_4$ staining solution.

$^1H$ and $^{13}C$ NMR spectra were recorded on a Varian 300 (300 MHz $^1H$, 75 MHz $^{13}C$) spectrometer. Chemical shifts are reported in ppm relative to residual chloroform ($\delta$ 7.26 ppm $^1H$, $\delta$ 77.23 ppm $^{13}C$) or DMSO ($\delta$ 2.54 ppm $^1H$, $\delta$ 39.7 ppm $^{13}C$). Chemical shifts are reported in ppm and the multiplicities are indicated by *s* (singelts), d (doublet), t (triplet), q (quartet), m (multiplet), or b (broad). Coupling constants (*J*) are reported in Hertz.

The purity of compounds reported herein is established by CHN combustion analysis carried out by *PharmAssist*, New Berlin, NY. In instances where microanalytical data was not available, the purity of compounds is estimated to be greater than 95% based on $^1H$ and $^{13}C$ spectral data included herein.

Enantiomeric purity of **39** and **40** was established by comparison to the corresponding racemates using Chiral Stationary Phase HPLC on a Chiral Pak AD chial Column (Chiral Technologies INC. Exton, PA 19241).

**Preparation of *N*-Acylated dihydropyrazoles**



9

**Kilo-scale preparation of 1-(4,5-Dihydropyrazol-1-yl)-2-(4-fluorophenyl)ethanone (9):** A 50L reactor was charged with toluene (18 liters), p-toluenesulfonic acid monohydrate (345 g, 1.81M) followed by hydrazine hydrate (1.715 kg, 34.25M). The addition port was closed and the reactor purged with $N_2$. The addition vessel was charged with acrolein (2.158 kg, 38.5M) followed by a line wash with toluene (1 liter). The reactor jacket temperature was set at 20°C and the acrolein was added over 20 minutes as the reaction temperature rose to 52°C. Following complete addition of acrolein the reaction temperature was raised to 115°C. Azeotropic distillation initiated at a reaction temperature of 87°C. After approximately 1 hour the distillation was complete and the reaction was cooled to ambient temperature. When the reaction temperature reached ~30°C the agitation was stopped and the reaction mixture left to settle. Approximately 600 ml of oil was removed from the bottom and the agitation was restarted. The addition vessel was charged with 4-fluorophenylacetyl chloride (2.657 kg, 15.4M). The reaction was cooled to –1.5 °C, the 4-fluorophenyl acetyl chloride was added over 40 minutes maintaining the internal reaction temperature < 10 °C. The reaction was then slowly warmed to 18°C at which time a saturated $NaHCO_3$ solution (20 liters) was slowly added to control potential foaming. Agitation was stopped and the layers were separated returning the aqueous layer to the reactor which was further extracted with ethyl acetate (2 x 8 liters). The organic portions (ethyl acetate and toluene) were combined in the reactor and washed with saturated $NaHCO_3$ solution (20 liters) followed by a water (20 liters) and a brine wash (20 liters). The organic layer was dried over magnesium sulfate (1.1 kg). The slurry was filtered through a Nutsche filter over a celite bed. The cake was washed with ethyl acetate (6 liters). The filtrate was concentrated under reduced pressure to a waxy solid which was dried in a vacuum oven at 40°C to give the desired product **9** (3.2 kg, 101% crude yield, 90% corrected yield when mass assayed by HPLC relative to a product standard). $^1H$ NMR ($CDCl_3$, 300MHz): δ 2.95 (dt, 2H, *J*= 10.0 and 1.6, $C\underline{H}_2$-CH=N); 4.05 (t, 2H, *J*= 10.0, $CH_2$-N-

CO); 7.00 (t, 1H, *J*= 1.4, CH=N); 7.39-7.46 (m, 3H, Ph); 7.80-7.83 (m, 2H, Ph). $^{13}C$ NMR ($CDCl_3$, 75 MHz): δ 28.19, 38.48, 123.23, 124.84, 126.30, 129.93, 144.18, 162.92.

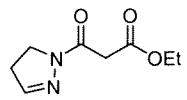
The remaining dihydropyrazoles **13-26** prepared for the development of this reduction methodology were prepared by direct acylation of dihydropyrazole (**11**) with either the corresponding acid chloride or carboxylic acid in the presence of EDAC as a coupling promoter. A general experimental protocol for each follows:

**METHOD A: *N*-Acylation of dihydropyrazole (11) with an Acid Chloride. Preparation of 13, 14, 16, 18 19, 20, 21, & 22**

To a round bottom flask, purged with nitrogen, was combined **11**, dichloromethane solvent (15 ml/g), and triethylamine (1.2 eq.). This mixture was cooled to 0 °C and the desired acid chloride (1.05 eq) was added to this reaction mixture dropwise (or in portions if a solid). Upon complete addition of the acid chloride, the reaction was stirred for 1 hour while warming to ambient temperature. The product was isolated by extracting 3 times with $Na_2CO_3$ and $CH_2Cl_2$. The combined organic portions were washed with brine, dried over $MgSO_4$ and concentrated under reduced pressure. The product was then purified by either silica gel chromatography, trituration, or recrystallization.

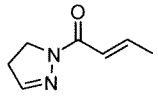
**METHOD B: *N*-Acylation of dihydropyrazole (11) with a Carboxylic Acid in the presence of EDAC. Preparation of 15, 17, 23, 24, 25, & 26**

To a round bottom flask was added **11**, DMF (10 ml/g), EDAC (1.1 equiv.), the corresponding carboxylic acid (1.05 equiv), HOBt•$H_2O$ (1.1 euiv), and triethylamine (1.1 equiv). The mixture was stirred at ambient temperature for 1 hour. The resulting reaction mixture was then treated with saturated $NaHCO_3$. The resulting aqueous portion was extracted with ethyl acetate (2 X 10 ml/g). All the organic portions are then combined washed with water (1 X 10 ml), brine (1 X 10 ml), dried over $MgSO_4$, and concentrated under reduced pressure. The product was then purified by either silica gel chromatography, trituration, or recrystallization.



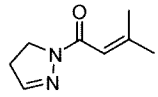
13

**3-(4,5-Dihydropyrazol-1-yl)-3-oxo-propionic acid ethyl ester (13):** The dihydropyrazole **13** was prepared according to Method A. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3, 1:1, 3:1) to provide **13** as a yellow oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 1.25 (t, 3H, *J*= 7.1, $CH_3$); 2.92 (dt, 2H, *J*= 10.3 and 1.5, C<u>H</u>$_2$-CH=N); 3.69 (s, 2H, C<u>H</u>$_2$-$CO_2Et$); 3.85 (t, 2H, *J*= 10.1, $CH_2$-N-CO); 4.17 (q, 2H, *J*= 7.1, C<u>H</u>$_2$-$CH_3$); 6.94 (t, 3H, *J*= 1.6, CH=N). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 9.51, 28.98, 37.01, 37.21, 56.59, 144.02, 159.77, 163.18. Anal. Calcd for $C_8H_{12}N_2O_3$: C, 52.17; H, 6.57; N, 15.21; found: C, 51.97; H, 6.51; N, 14.97.



14

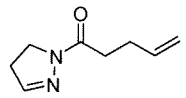
**1-(4,5-Dihydropyrazol-1-yl)-but-2-en-1-one (14):** The dihydropyrazole **14** was prepared according to both Methods A and B. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3 to 1:1 to 3:1) to provide **14** as a colorless oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 1.90 (dd, 3H, $CH_3$); 2.89 (m, 2H, C<u>H</u>$_2$-CH=N); 3.88 (t, 2H, $CH_2$-N-CO); 6.76 (dd, 1H, C<u>H</u>=CH-$CH_3$); 6.92 (t, 1H, CH=N); 6.92-7.02 (m, 2H, CH=C<u>H</u>-$CH_3$). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 13.52, 28.37, 37.27, 117.68, 136.80, 142.98, 159.58. The unstable nature of the reaction product precluded definitive CHN analysis.



15

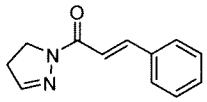
**1-(4,5-Dihydropyrazol-1-yl)-3-methyl-but-2-en-1-one (15):** The dihydropyrazole **15** was prepared according to Method B. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 to 3:1) to provide **15** as a white solid. m.p. 56 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 1.90 (d, 3H, *J*= 1.2, $CH_3$); 2.17 (d, 3H, *J*= 1.2, $CH_3$); 2.86 (dt, 2H, *J*= 10.3 and 1.6, C<u>H</u>$_2$-CH=N); 3.86 (t, 2H, *J*=

10.2, $CH_2$-N-CO); 6.46 (d, 1H, *J*= 1.2, CH-CO); 6.89 (d, 1H, *J*= 1.5, CH=N). $^{13}C$ NMR ($CDCl_3$, 75MHz): δ 20.40, 27.75, 32.98, 41.88, 116.10, 146.93, 152.72, 165.19. Anal. Calcd for $C_8H_{12}N_2O$: C, 63.13; H, 7.95; N, 18.41; found: C, 63.22; H, 7.88; N, 18.16.



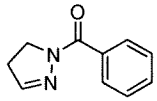
16

**1-(4,5-Dihydropyrazol-1-yl)-pent-4-en-1-one (16):** The dihydropyrazole **16** was prepared according to Method A. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3 to 1:1 to 3:1) to provide **16** as a pale yellow oil. $^1H$ NMR ($CDCl_3$, 300MHz): δ 2.44 (m, 2H, C<u>H</u>$_2$-CH=$CH_2$); 2.76 (t, 2H, *J*= 7.7, $CH_2$-CO); 2.88 (dt, 2H, *J*= 10.1 and 1.5, C<u>H</u>$_2$-CH=N); 3.82 (t, 2H, *J*= 10.2, $CH_2$-N-CO); 4.98 (d, 1H, *J*= 10.2, C<u>H</u>$_2$b=CH); 5.07 (dd, 1H, *J*= 17.2 and 1.5, C<u>H</u>$_2$a=CH); 5.87 (m, 1H, C<u>H</u>=$CH_2$); 6.92 (s, 1H, CH=N). $^{13}C$ NMR ($CDCl_3$, 75MHz): δ 24.35, 28.51, 28.55, 37.19, 110.41, 132.86, 142.96, 166.54. Anal. Calcd for $C_8H_{12}N_2O$: C, 63.13; H, 7.95; N, 18.41; found: C, 63.21; H, 8.00; N, 18.07.



17

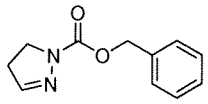
**1-(4,5-Dihydropyrazol-1-yl)-3-phenyl-propenone (17):** The dihydropyrazole **17** was prepared according to Method B. The product was purified by trituration in refluxing ethyl acetate to provide **17** as an off white solid. m.p. 147 °C. $^1H$ NMR ($CDCl_3$, 300MHz): δ 2.94 (dt, 2H, *J*= 10.0 and 1.5, C<u>H</u>$_2$-CH=N); 3.97 (t, 2H, *J*= 10.0, $CH_2$-N-CO); 6.99 (s, 1H, CH=N); 7.34-7.45 (m, 4H, Ph and CH=C<u>H</u>-Ph); 7.58-7.61 (m, 2H, Ph); 7.75 (d, 1H, *J*= 15.9, C<u>H</u>=CH-Ph). $^{13}C$ NMR ($CDCl_3$, 75MHz): δ 28.54, 37.59, 113.54, 123.57, 124.21, 125.15, 130.76, 137.34, 143.14, 159.64. Anal. Calcd for $C_{12}H_{12}N_2O$: C, 71.98; H, 6.04; N, 13.99; found: C, 72.11; H, 6.17; N, 13.96.



18

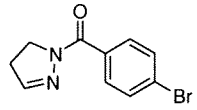
**(4,5-Dihydropyrazol-1-yl)-phenyl-methanone (18):** The dihydropyrazole **18** was prepared according to both Methods A & B. The product was purified by silica gel

chromatography employing a gradient of ethyl acetate/hexanes (1:3 to 1:1 to 3:1) to provide **18** as a colorless oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.95 (dt, 2H, *J*= 10.0 and 1.6, C<u>H</u>$_2$-CH=N); 4.05 (t, 2H, *J*= 10.0, $CH_2$-N-CO); 7.00 (t, 1H, *J*= 1.4, CH=N); 7.39-7.46 (m, 3H, Ph); 7.80-7.83 (m, 2H, Ph). $^{13}$C NMR ($CDCl_3$, 75 MHz): δ 28.19, 38.48, 123.23, 124.84, 126.30, 129.93, 144.18, 162.92. MS ($M^+$ 175).



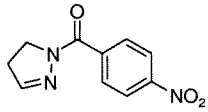
**19**

**4,5-Dihydropyrazole-1-carboxylic acid benzyl ester (19):** The dihydropyrazole **19** was prepared according to Method A. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3 to 1:1 to 3:1) to provide **19** as a colorless oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.89 (dt, 2H, *J*= 9.5 and 1.5, C<u>H</u>$_2$-CH=N); 3.81 (t, 2H, *J*= 10.3, $CH_2$-N-CO); 5.27 (s, 2H, $CH_2$-Ph); 6.91 (s, 1H, CH=N); 7.33-7.43 (m, 5H, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 28.95, 38.79, 62.99, 123.66, 123.76, 123.97, 131.71, 142.67, 148.46. Anal. Calcd for $C_{11}H_{12}N_2O_2$: C, 64.69; H, 5.92; N, 13.72; found: C, 64.58; H, 6.06; N, 13.67.[16]



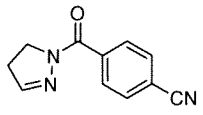
**20**

**(4-Bromo-phenyl)-(4,5-dihydropyrazol-1-yl)-methanone (20):** The dihydropyrazole **20** was prepared according to Method A. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3 to 1:1 to 3:1) to provide **20** as a pale yellow solid. m.p. 74 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.94 (dt, 2H, *J*= 10.2 and 1.5, C<u>H</u>$_2$-CH=N); 4.03 (t, 2H, *J*= 10.1, $CH_2$-N-CO); 7.00 (s, 1H, CH=N); 7.54 (d, 2H, *J*= 8.8, Ph); 7.73 (d, 2H, *J*= 8.8, Ph).$^{13}$C NMR ($CDCl_3$, 75MHz): δ 28.21, 38.53, 120.91, 126.42, 126.70, 128.64, 144.44, 161.64. Anal. Calcd for $C_{10}H_9BrN_2O$: C, 47.46; H, 3.58; N, 11.07; found: C, 47.61; H, 3.67; N, 11.00.



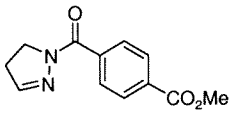
**21**

**(4,5-Dihydropyrazol-1-yl)-(4-nitro-phenyl)-methanone (21):** The dihydropyrazole **21** was prepared according to Method A. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3 to 1:1 to 3:1) to provide **21** as a yellow solid. m.p. 114 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 3.00 (dt, 2H, *J*= 9.9 and 1.4, C<u>H</u>$_2$-CH=N); 4.06 (t, 2H, *J*= 9.9, $CH_2$-N-CO); 7.05 (s, 1H, CH=N); 7.98 (d, 2H, *J*= 8.5, Ph); 8.25 (d, 2H, *J*= 8.2, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 28.43, 38.45, 118.36, 125.99, 135.75, 144.27, 145.31, 160.52. Anal. Calcd for $C_{10}H_9N_3O_3$: C, 54.79; H, 4.14; N, 19.17; found: C, 54.74; H, 4.22; N, 19.10.



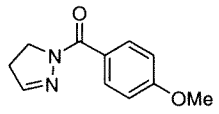

22

**4-(4,5-Dihydropyrazole-1-carbonyl)-benzonitrile (22):** The dihydropyrazole **22** was prepared according to Method A. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3 to 1:1 to 3:1) to provide **22** as a pale yellow solid. m.p. 109 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.97 (dt, 2H, *J*= 9.9 and 1.6, C<u>H</u>$_2$-CH=N); 4.03 (t, 2H, *J*= 9.9, $CH_2$-N-CO); 7.03 (t, 1H, *J*= 1.6, CH=N); 7.69 (dd, 2H, *J*=6.7, 2.0, Ph); 7.90 (d, 2H, *J*= 6.7, 2.0, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 28.38, 38.45, 109.50, 113.79, 125.54, 127.01, 134.02, 145.23, 160.73. Anal. Calcd for $C_{11}H_9N_3O$: C, 66.32; H, 4.55; N, 21.09; found: C, 66.43; H, 4.62; N, 21.20.



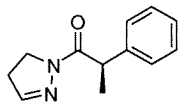

23

**(4,5-Dihydropyrazole-1-carbonyl)-benzoic acid methyl ester (23):** The dihydropyrazole **23** was prepared according to Method B. The product was purified by a recrystallization in ethyl acetate to provide **23** as an off white solid. m.p. 118 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.96 (dt, 2H, *J*= 10.2, 1.7, C<u>H</u>$_2$-CH=N); 3.92 (s, 3H, $CH_3$); 4.05 (t, 2H, *J*= 10.0, $CH_2$-N-CO); 7.01 (t, 1H, *J*= 1.7, CH=N); 7.56 (dd, 2H, *J*= 6.8, 1.8, Ph); 8.07 (dd, 2H, *J*= 6.8, 1.8, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 28.27, 38.40, 47.73, 124.41, 124.80, 127.28, 134.05, 144.62, 161.88. Anal. Calcd for $C_{12}H_{12}N_2O_3$: C, 62.06; H, 5.21; N, 12.06; found: C, 62.20; H, 5.32; N, 12.02.



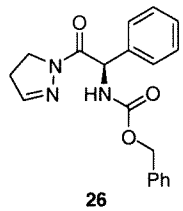

**24**

**(4,5-Dihydropyrazol-1-yl)-(4-methoxy-phenyl)-methanone (24):** The dihydropyrazole **24** was prepared according to Method B. The product was purified by silica gel chromatography employing ethyl acetate/hexanes (1:1) to provide **24** as a white solid. m.p. 104 °C. $^{1}$H NMR ($CDCl_3$, 300MHz): δ 2.92 (dt, 2H, *J*= 10.2 and 1.6, C<u>H</u>$_2$-CH=N); 3.84 (s, 3H, $CH_3$-O); 4.03 (t, 2H, *J*= 10.3, $CH_2$-N-CO); 6.91 (d, 2H, *J*= 9.1, Ph); 6.99 (t, 1H, *J*= 1.7, CH=N); 7.88 (d, 2H, *J*= 8.8, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 32.78, 43.39, 55.55, 113.24, 126.74, 131.85, 148.36, 161.88, 167.09. Anal. Calcd for $C_{11}H_{12}N_2O_2$: C, 64.69; H, 5.92; N, 13.72; found: C, 64.81; H, 6.00; N, 13.51.




**25**

**(*R*)-1-(4,5-Dihydropyrazol-1-yl)-2-phenyl-propan-1-one (25):** The dihydropyrazole **25** was prepared according to Method B. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3 to 1:1 to 3:1) to provide **25** as a white solid. m.p. 56 °C. $^{1}$H NMR ($CDCl_3$, 300MHz): δ 1.50 (d, 3H, *J*= 7.0, $CH_3$); 2.82 (m, 2H, C<u>H</u>$_2$-CH=N); 3.80 (m, 2H, $CH_2$-N-CO); 4.58 (q, 1H, *J*= 7.1, C<u>H</u>-$CH_3$); 6.88 (s, 1H, CH=N); 7.21-7.31 (m, 3H, Ph); 7.39 (d, 2H, *J*= 7.3, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 19.01, 33.21, 42.22, 43.01, 126.89, 128.10, 128.63, 142.03, 147.78, 172.66. Anal. Calcd for $C_{12}H_{14}N_2O$: C, 71.26; H, 6.98; N, 13.85; found: C, 71.41; H, 7.09; N, 13.72.

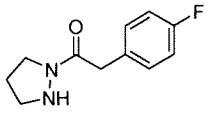



**26**

**(*R*)-[2-(4,5-Dihydropyrazol-1-yl)-2-oxo-1-phenyl-ethyl]-carbamic acid benzyl ester (26):** The dihydropyrazole **26** was prepared according to Method B. The product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:3

to 1:1 to 3:1) to provide **26** as a white solid. m.p. 101 °C. $^1$H NMR (DMSO-$d_6$, 300MHz): δ 2.83 (m, 2H, C<u>H</u>$_2$-CH=N); 3.65 (m, 2H, CH$_2$-N-CO); 5.02 (s, 2H, C<u>H</u>$_2$-Ph); 6.01 (d, 1H, *J*= 8.8, C<u>H</u>-NH); 7.19 (s, 1H, CH=N); 7.25-7.38 (m, 10H, Ph); 8.00 (d, 1H, *J*= 8.8, NH-Cbz).$^{13}$C NMR ($CDCl_3$, 75MHz): δ 33.32, 42.25, 56.52, 67.05, 127.98, 128.31, 128.72, 128.86, 136.70, 138.25, 149.13, 155.67, 168.27. Anal. Calcd for $C_{19}H_{19}N_3O_3$: C, 67.64; H, 5.68; N, 12.46; found: C, 67.52; H, 5.76; N, 12.46.

**Reduction of *N*-Acylated dihydropyrazoles with $BH_3$•pyridine**

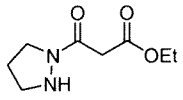



**12**

**General representative reduction procedure: 2-(4-Fluorophenyl)-1-pyrazolidin-1-yl-ethanone (12):**

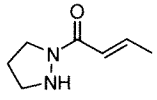
At room temperature, the reactor was charged with **9** (1.9 kg, 9.21M) followed by absolute ethanol (11 liters). The addition port was closed and the reactor purged with $N_2$. The addition vessel was charged with the borane pyridine complex (2.3 liters, 18.5M, 2 equiv) by vacuum. The borane pyridine complex was added to the reaction mixture rinsing the addition vessel with ethanol (~1 liter). The reaction was cooled to 0°C (total concentration 10 ml/g). A solution consisting of ethanol (3 liters) and 6N HCl (3.1 liters, 4 equiv) was added to the reaction over 40 minutes maintaining the internal reaction temperature < 15°C. The reaction was gradually warmed to 20°C over 30 minutes. The reaction was noted complete by TLC and the reaction was subsequently cooled to 10°C. The reaction was quenched by additional 6N HCl (2.5 liters) over 10 minutes followed by water (4 liters) over ~15 minutes. Additional water (4 liters) was added followed by 6N NaOH (~6.5 liters) to bring the pH from 0.84 to 8.7 over ~40 minutes. The reaction was extracted with ethyl acetate (2x10 liters). The combined organics portions were then washed with water (20 liters) and sat NaCl solution (19 liters). The organic layer was then dried over $MgSO_4$ and filtered through a Nutsche filter over a celite bed. The reactor and filter were washed with ethyl acetate (3 liters) and concentrated under reduced pressure. The filtrate was reduced to ~8 liters and heptane (3 liters) was added and to azeotrope off any remaining pyridine. The residue was dried with a stream of

nitrogen to give the desired product **12** as a waxy solid, (2.0 kg, wt assay 74.1%, corrected product yield 77%). $^1$H NMR ($CDCl_3$, 300MHz): δ 2.10 (m, 2H, C<u>H</u>$_2$-$CH_2$-N); 3.02 (bs, 2H, $CH_2$-NH); 3.71 (bs, 2H, $CH_2$-N-CO); 7.34-7.41 (m, 3H, Ph); 7.65 (bs, 2H, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.09, 45.06, 48055, 127.73, 128.72, 130.23, 135.93, 169.37.



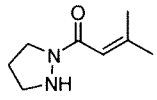

**27**

**3-Oxo-3-pyrazolidin-1-yl-propionic acid ethyl ester (27):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **27**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 up to 3:1) to provide **27** as a colorless oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 1.26 (t, 3H, *J*= 7.1, $CH_3$); 2.08 (m, 2H, C<u>H</u>$_2$-$CH_2$-N); 2.97 (m, 2H, $CH_2$-NH); 3.53 (t, 2H, *J*= 7.7, $CH_2$-N-CO); 3.57 (s, 2H, CO-$CH_2$-CO); 4.05 (t, 1H, NH); 4.17 (q, 2H, *J*= 7.1, C<u>H</u>$_2$-$CH_3$). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 9.53, 22.99, 37.57, 39.52, 43.15, 56.43, 161.92, 163.72. Anal. Calcd for $C_8H_{14}N_2O_3$: C, 51.60; H, 7.58; N, 15.04; found: C, 51.45; H, 7.49; N, 14.70.



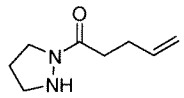

**28**

**1-Pyrazolidin-1-yl-but-2-en-1-one (28):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **28**. The isolated product was purified by silica gel chromatography using dichloromethane/acetone (3:1) to provide **28** as a yellow oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 1.85 (dd, 3H, *J*= 6.0 and 1.5, $CH_3$); 2.03 (m, 2H, C<u>H</u>$_2$-$CH_2$-N); 2.97 (bs, 2H, $CH_2$-NH); 3.56 (t, 2H, *J*= 7.6, $CH_2$-N-CO); 6.69 (d, 1H, *J*= 15.6, C<u>H</u>=CH-$CH_3$); 6.87 (m, 1H, CH=C<u>H</u>-$CH_3$). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 18.15, 27.36, 44.15, 48.25, 123.05, 140.31, 166.18. The unstable nature of the reaction product prevented accurate CHN analysis.



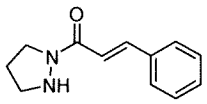

**29**

**3-Methyl-1-pyrazolidin-1-yl-but-2-en-1-one:** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **29**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (3:2 up to 4:1) to provide **29** as a colorless oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 1.87 (s, 3H, $CH_3$); 2.06 (m, 2H, $C\underline{H}_2$-$CH_2$-N); 2.14 (s, 3H, $CH_3$); 3.00 (m, 2H, $CH_2$-NH); 3.57 (t, 2H, *J*= 7.5, $CH_2$-N-CO); 6.38 (s, 1H, CH). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 20.19, 27.61, 27.67, 44.00, 48.48, 116.94, 151.07, 167.43.



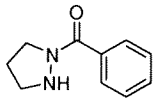
**30**

**1-Pyrazolidin-1-yl-pent-4-en-1-one (30):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **30**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 up to 3:1) to provide **30** as a colorless oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.05 (m, 2H, $C\underline{H}_2$-$CH_2$-N); 2.37 (m, 2H, $C\underline{H}_2$-CH=$CH_2$); 2.64 (t, 2H, *J*= 7.6, $CH_2$-CO); 2.98 (m, 2H, $CH_2$-NH); 3.53 (t, 2H, *J*=7.6, $CH_2$-N-CO); 3.83 (t, 1H, *J*= 8.7, NH); 4.97 (d, 1H, *J*= 10.3, $C\underline{H}_2$b=CH); 5.06 (dd, 1H, *J*= 16.4 and 1.7, $C\underline{H}_2$a=CH); 5.87 (m, 1H, $C\underline{H}$=$CH_2$). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.67, 29.44, 33.42, 44.15, 48.36, 115.00, 138.01, 173.41.



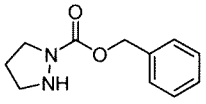
**31**

**3-Phenyl-1-pyrazolidin-1-yl-propenone (31):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **31**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 up to 3:1 to 100% ethyl acetate) to provide **31** as a pale yellow solid. m.p. 141 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.10 (m, 2H, $C\underline{H}_2$-$CH_2$-N); 3.05 (m, 2H, $CH_2$-NH); 3.66 (t, 2H, *J*= 7.5, $CH_2$-N-CO); 3.96 (t, 1H, *J*= 8.8, NH); 7.32-7.42 (m, 4H, 3Ph and CH=C$\underline{H}$-Ph); 7.57 (d, 2H, *J*= 7.6, Ph); 7.66 (d, 1H, *J*= 16.1, C$\underline{H}$=CH-Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.55, 44.55, 48.46, 119.07, 128.17, 128.92, 129.61, 135.80, 141.40, 166.39. Anal. Calcd for $C_{12}H_{14}N_2O$: C, 71.26; H, 6.98; N, 13.85; found: C, 71.10; H, 7.01; N, 13.69.



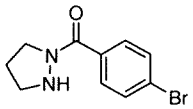
32

**Phenyl-pyrazolidin-1-yl-methanone (32):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **32**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 up to 3:1) to provide **32** as a white solid. m.p. 64 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.10 (m, 2H, $C\underline{H}_2$-$CH_2$-N); 3.02 (bs, 2H, $CH_2$-NH); 3.71 (bs, 2H, $CH_2$-N-CO); 7.34-7.41 (m, 3H, Ph); 7.65 (bs, 2H, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.09, 45.06, 48055, 127.73, 128.72, 130.23, 135.93, 169.37. Anal. Calcd for $C_{10}H_{12}N_2O$: C, 68.16; H, 6.86; N, 15.90; found: C, 67.80; H, 6.81; N, 15.68.



33

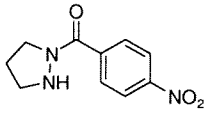
**Pyrazolidine-1-carboxylic acid benzyl ester (33)** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **33**. The product **33** was isolated in pure form from the reaction mixture as a colorless oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.05 (m, 2H, $C\underline{H}_2$-$CH_2$-N); 3.04 (t, 2H, $J$= 6.6, $CH_2$-NH); 3.52 (m, 2H, $CH_2$-N-CO); 3.82 (bs, 1H, NH); 5.19 (s, 3H, $C\underline{H}_2$-Ph); 7.29-7.42 (m, 5H, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 23.49, 41.26, 43.36, 62.59, 123.46, 123.57, 123.90, 132.19, 151.20. Anal. Calcd for $C_{11}H_{14}N_2O_2$: C, 64.06; H, 6.84; N, 13.58; found: C, 63.77; H, 6.96; N, 13.58.



34

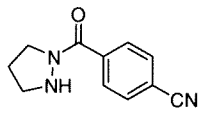
**(4-Bromo-phenyl)-pyrazolidin-1-yl-methanone (34):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **34**. The isolated product **34** was purified by triturating in hot dichloromethane to provide **34** as a white solid. m.p. 149 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.12 (m, 2H, $C\underline{H}_2$-$CH_2$-N); 3.04 (bs, 2H, $CH_2$-NH); 3.72 (bs, 2H, $CH_2$-N-CO); 4.02 (bs, 1H, NH); 7.50-7.58 (m, 4H, Ph). $^{13}$C

NMR ($CDCl_3$, 75MHz): δ 27.38, 45.34, 48.89, 124.90, 130.63, 131.10, 134.60, 168.73. Anal. Calcd for $C_{10}H_{11}BrN_2O$: C, 47.08; H, 4.35; N, 10.98; found: C, 47.31; H, 4.38; N, 10.82.



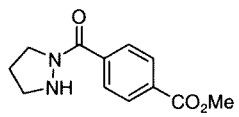
**35**

**(4-Nitro-phenyl)-pyrazolidin-1-yl-methanone (35):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **35**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 to 3:1 to 100% ethyl acetate) to provide **35** as a yellow solid. m.p. 106 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.16 (m, 2H, C<u>H</u>$_2$-$CH_2$-N); 3.03 (m, 2H, $CH_2$-NH); 3.75 (m, 2H, $CH_2$-N-CO); 4.06 (bs, 1H, NH); 7.84 (d, 2H, *J*= 8.2, Ph); 8.22 (d, 2H, *J*= 8.8, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.30, 45.31, 48.83, 123.08, 129.86, 142.04, 148.62, 167.68. Anal. Calcd for $C_{10}H_{11}N_3O_3$: C, 54.29; H, 5.01; N, 19.00; found: C, 54.38; H, 5.07; N, 18.87.



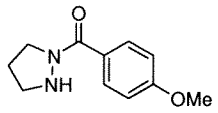
**36**

**4-(Pyrazolidine-1-carbonyl)-benzonitrile (36):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **36**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 to 3:1 to 100% ethyl acetate) to provide **36** as a white solid. m.p. 133 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.15 (m, 2H, C<u>H</u>$_2$-$CH_2$-N); 3.04 (m, 2H, $CH_2$-NH); 3.75 (bs, 2H, $CH_2$-N-CO); 4.01 (bs, 1H, NH); 7.67 (d, 2H, *J*= 8.2, Ph); 7.79 (d, 2H, *J*= 7.6, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.33, 45.31, 48.86, 113.75, 118.65, 129.49, 131.74, 140.18, 167.97. Anal. Calcd for $C_{11}H_{11}N_3O$: C, 65.66; H, 5.51; N, 20.88; found: C, 65.64; H, 5.62; N, 20.64.



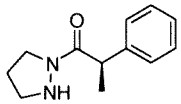
**37**

**4-(Pyrazolidine-1-carbonyl)-benzoic acid methyl ester (37):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **37**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 to 3:1) to provide **37** as a white solid. m.p. 105 °C. $^1$H NMR ($CDCl_3$, 300MHz): δ 2.13 (m, 2H, C<u>H</u>$_2$-CH$_2$-N); 3.02 (bs, 2H, CH$_2$-NH); 3.74 (bs, 2H, CH$_2$-N-CO); 3.92 (s, 3H, CH$_3$); 4.05 (bs, 1H, NH); 7.72 (d, 2H, *J*= 7.3, Ph); 8.03 (d, 2H, *J*= 8.5, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.35, 45.20, 48.80, 52.46, 128.67, 129.13, 131.48, 140.24, 166.70, 168.97. Anal. Calcd for $C_{12}H_{14}N_2O_3$: C, 61.53; H, 6.02; N, 11.96; found: C, 61.66; H, 6.01; N, 11.84.




**38**

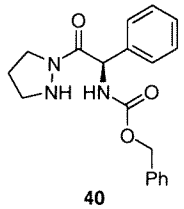
**(4-Methoxy-phenyl)-pyrazolidin-1-yl-methanone (38):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **38**. The crude isolated product was purified by recrystallization from ethyl acetate to provide **38** as a white solid. m.p. 94 °C.$^1$H NMR ($CDCl_3$, 300MHz): δ 2.10 (m, 2H, C<u>H</u>$_2$-CH$_2$-N); 3.04 (m, 2H, CH$_2$-NH); 3.73 (t, 2H, *J*= 7.5, CH$_2$-N-CO); 3.83 (s, 3H, CH$_3$); 4.15 (bs, 1H, NH); 6.89 (d, 2H, *J*= 8.8, Ph); 7.72 (d, 2H, *J*= 8.2, Ph). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.41, 55.52, 113.18, 127.88, 130.88, 161.36.




**39**

**2-Phenyl-1-pyrazolidin-1-yl-propan-1-one (39):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **39**. The isolated product was purified by silica gel chromatography employing a gradient of ethyl acetate/hexanes (1:1 to 3:1) to provide **39** as a colorless oil. $^1$H NMR ($CDCl_3$, 300MHz): δ 1.39 (d, 3H, *J*= 7.0, CH$_3$); 1.85 (m, 1H, C<u>H</u>$_2$a-CH2-NH); 2.01 (m, 1H, C<u>H</u>$_2$b-CH2-NH); 2.85 (m, 2H, CH$_2$-NH); 3.38 (m, 1H, CH$_2$a-N-CO); 3.52 (m, 1H, CH$_2$b-N-CO); 3.64 (t, 1H, NH); 4.39 (q, 1H, *J*= 7.0, C<u>H</u>-CH$_3$); 7.18 (m, 1H, Ph); 7.23-7.33 (m, 4H, Ph). $^{13}$C

NMR ($CDCl_3$, 75MHz): δ 19.21, 27.48, 43.38, 44.46, 48.20, 126.62, 127.96, 128.71, 142.90, 174.35.




**40**

**(2-Oxo-1-phenyl-2-pyrazolidin-1-yl-ethyl)-carbamic acid benzyl ester (40):** The general reduction protocol described above was utilized for the preparation of the pyrazolidine **40**. The isolated product was purified by silica gel chromatography employing a gradient of dichloromethane/acetone (100% to 95:5) to provide **40** as a colorless oil. $^1$H NMR (DMSO-$d_6$, 300MHz): δ 1.86 (m, 2H, C$\underline{H}_2$-$CH_2$-N); 2.84 (m, 2H, $CH_2$-NH); 3.21 (m, 1H, $CH_2$a-N-CO); 3.37 (m, 2H, $CH_2$b-N-CO and NH-N); 5.00 (s, 2H, C$\underline{H}_2$-Ph); 5.00-5.07, (t, 1H, *J*= 8.2, NH); 5.96 (d, 1H, *J*= 8.8, C$\underline{H}$-CN); 7.19-7.38 (m, 10H, Ph); 7.71 (d, 1H, *J*= 8.8, NH-Cbz). $^{13}$C NMR ($CDCl_3$, 75MHz): δ 27.10, 44.71, 47.95, 56.54, 66.83, 128.05, 128.23, 128.68, 128.88, 136.80, 139.05, 155.68, 170.18.

| INDEX | FREQUENCY | PPM | HEIGHT |
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| 5 | 2050.465 | 6.834 | 41.0 |
| 6 | 2015.822 | 6.718 | 34.0 |
| 7 | 2000.263 | 6.666 | 19.5 |
| 8 | 1075.194 | 3.583 | 42.1 |
| 9 | 1067.561 | 3.558 | 65.8 |
| 10 | 1059.928 | 3.532 | 47.9 |
| 11 | 1049.946 | ~~3.499~~ | ~~20.7~~ |
| 12 | 892.294 | 2.974 | 52.2 |
| 13 | 623.963 | 2.079 | 18.8 |
| 14 | 617.210 | 2.057 | 47.6 |
| 15 | 609.871 | 2.033 | 62.5 |
| 16 | 602.531 | 2.008 | 46.3 |
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| 18 | 556.733 | 1.855 | 179.4 |
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| 21 | 277.245 | ~~0.924~~ | 31.1 |

m, ave = 6.87

d, ave = 6.69

t

bs

m

dd, ave = 1.85

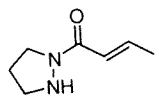
15.6

7.6

7.6

6.0 ~~6.0~~ >15

6.0 >15



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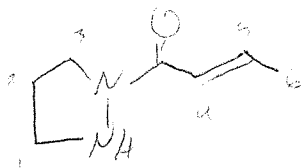
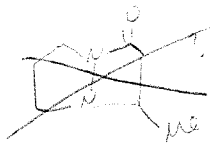




NRS2814-058B
CDCl3
6-18-04

Archive directory: /export/home
Sample directory:
File: PROTON

Pulse Sequence: s2pul

#1 #2 #3 #4 #5 NH NH2

1+2+3

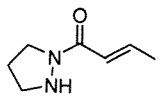
4+5

6

8 7 6 5 4 3 2 1 ppm

5.65 5.21 1.15 1.56 6.93 16.10 1.86 16.83 1.59 18.31 19.91 2.17 2.73

| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 12537.881 | 166.177 | 52.9 |
| 2 | 10586.483 | 140.313 | 150.6 |
| 3 | 9283.728 | 123.046 | 129.9 |
| 4 | 5878.715 | 77.916 | 108.5 |
| 5 | 5846.470 | 77.489 | 112.9 |
| 6 | 5814.513 | 77.065 | 110.7 |
| 7 | 3640.567 | 48.252 | 182.0 |
| 8 | 3331.361 | 44.154 | 165.6 |
| 9 | 2080.140 | 27.570 | 53.8 |
| 10 | 2064.018 | 27.356 | 176.8 |
| 11 | 1369.311 | 18.149 | 177.1 |

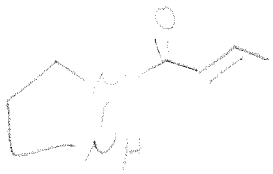


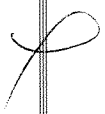
**28**

NRS2814-058B
CDCl3
6-22-04

Archive directory: /export/home
Sample directory:
File: CARBON

Pulse Sequence: s2pul





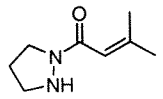
| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 2178.759 | ~~7.261~~ | 28.5 |
| 2 | 1913.950 | 6.379 | 29.6 |
| 3 | 1078.423 | 3.594 | 34.9 |
| 4 | 1071.084 | 3.570 | 53.2 |
| 5 | 1063.451 | 3.544 | 37.4 |
| 6 | 899.927 | 2.999 | 37.5 |
| 7 | 640.697 | 2.135 | 129.7 |
| 8 | 620.146 | 2.067 | 28.4 |
| 9 | 612.807 | 2.042 | 33.1 |
| 10 | 561.137 | 1.870 | 162.6 |

7.3
7.6

NRS2968-005B
CDCl3
7-27-04

Archive directory: /export/home
Sample directory:
File: PROTON

Pulse Sequence: s2pul



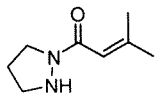
**29**

| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 12632.025 | 167.425 | 33.7 |
| 2 | 11398.078 | 151.070 | 45.4 |
| 3 | 8822.797 | 116.937 | 132.1 |
| 4 | 5864.032 | 77.722 | 273.3 |
| 5 | 5832.075 | 77.298 | 283.8 |
| 6 | 5800.118 | 76.875 | 276.4 |
| 7 | 3657.553 | 48.477 | 109.1 |
| 8 | 3319.845 | 44.001 | 104.0 |
| 9 | 2087.626 | 27.669 | 133.5 |
| 10 | 2083.019 | 27.608 | 175.8 |
| 11 | 1523.338 | 20.190 | 97.4 |

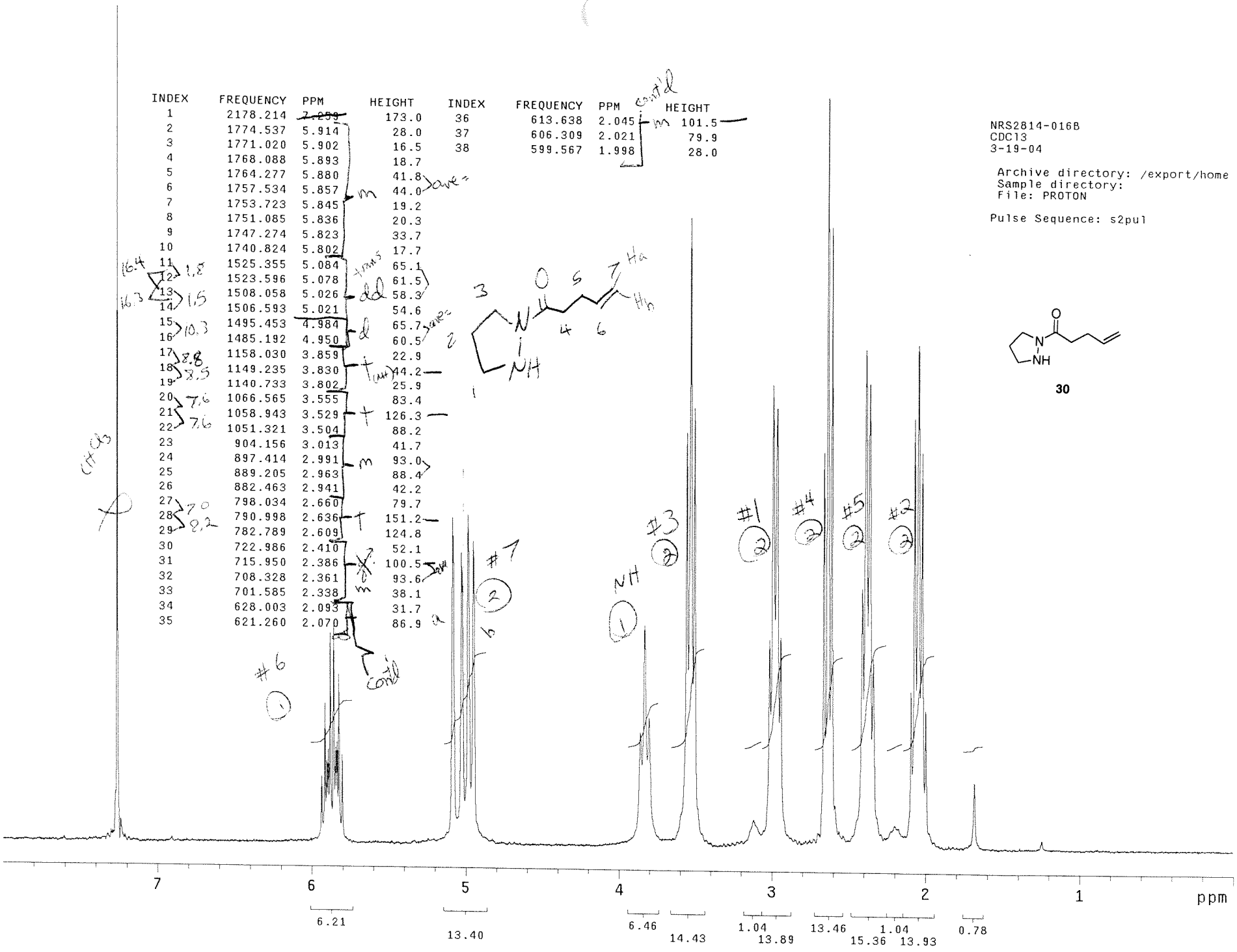
NRS2968-005B
CDCl3
7-27-04

Archive directory: /export/home
Sample directory:
File: CARBON

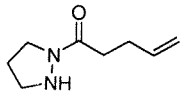
Pulse Sequence: s2pul




**29**


NRS2814-016B
CDCl3
3-19-04
Archive directory: /export/home
Sample directory:
File: PROTON
Pulse Sequence: s2pul
30
INDEX FREQUENCY PPM HEIGHT
1 2178.214 2.259 173.0
2 1774.537 5.914 28.0
3 1771.020 5.902 16.5
4 1768.088 5.893 18.7
5 1764.277 5.880 41.8
6 1757.534 5.857 44.0
7 1753.723 5.845 19.2
8 1751.085 5.836 20.3
9 1747.274 5.823 33.7
10 1740.824 5.802 17.7
11 1525.355 5.084 65.1
12 1523.596 5.078 61.5
13 1508.058 5.026 58.3
14 1506.593 5.021 54.6
15 1495.453 4.984 65.7
16 1485.192 4.950 60.5
17 1158.030 3.859 22.9
18 1149.235 3.830 44.2
19 1140.733 3.802 25.9
20 1066.565 3.555 83.4
21 1058.943 3.529 126.3
22 1051.321 3.504 88.2
23 904.156 3.013 41.7
24 897.414 2.991 93.0
25 889.205 2.963 88.4
26 882.463 2.941 42.2
27 798.034 2.660 79.7
28 790.998 2.636 151.2
29 782.789 2.609 124.8
30 722.986 2.410 52.1
31 715.950 2.386 100.5
32 708.328 2.361 93.6
33 701.585 2.338 38.1
34 628.003 2.093 31.7
35 621.260 2.070 86.9
INDEX FREQUENCY PPM HEIGHT
36 613.638 2.045 101.5
37 606.309 2.021 79.9
38 599.567 1.998 28.0
ppm
7
6
5
4
3
2
1
6.21
13.40
6.46
14.43
1.04
13.89
13.46
1.04
15.36
13.93
0.78

| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 13083.742 | 173.412 | 49.4 |
| 2 | 10412.591 | 138.008 | 124.8 |
| 3 | 8676.831 | 115.003 | 153.6 |
| 4 | 5869.790 | 77.788 | 98.8 |
| 5 | 5837.545 | 77.371 | 101.1 |
| 6 | 5805.588 | 76.947 | 101.4 |
| 7 | 3648.916 | 48.363 | 180.3 |
| 8 | 3330.785 | 44.146 | 171.8 |
| 9 | 2521.205 | 33.416 | 180.6 |
| 10 | 2221.212 | 29.440 | 177.5 |
| 11 | 2087.913 | 27.673 | 176.8 |

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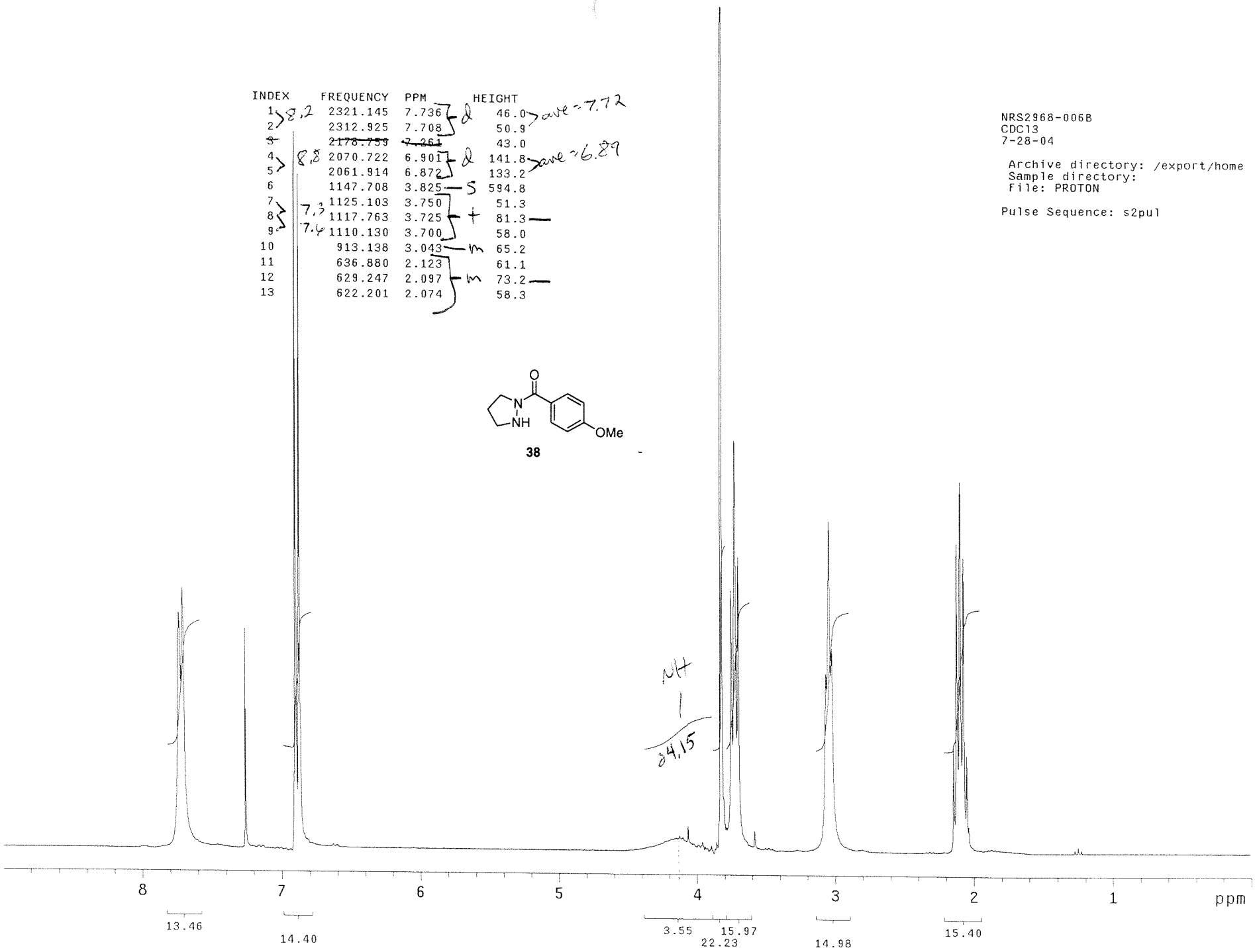
NRS2814-016B
CDCl3
3-22-04

Archive directory: /export/home
Sample directory:
File: CARBON

Pulse Sequence: s2pul

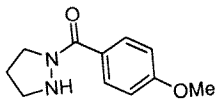

INDEX FREQUENCY PPM HEIGHT
1 2321.145 7.736 d 46.0
2 2312.925 7.708 50.9
3 2178.759 7.261 43.0
4 2070.722 6.901 d 141.8
5 2061.914 6.872 133.2
6 1147.708 3.825 s 594.8
7 1125.103 3.750 51.3
8 1117.763 3.725 t 81.3
9 1110.130 3.700 58.0
10 913.138 3.043 m 65.2
11 636.880 2.123 61.1
12 629.247 2.097 m 73.2
13 622.201 2.074 58.3
8.2
8.8
7.3
7.6
ave = 7.72
ave = 6.89
NRS2968-006B
CDCl3
7-28-04
Archive directory: /export/home
Sample directory:
File: PROTON
Pulse Sequence: s2pul
O
N
NH
OMe
38
NH
1
4.15
8
7
6
5
4
3
2
1
ppm
13.46
14.40
3.55
15.97
22.23
14.98
15.40

| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 12174.549 | 161.361 | 68.7 |
| 2 | 9874.502 | 130.876 | 94.5 |
| 3 | 9648.212 | 127.877 | 47.6 |
| 4 | 8538.926 | 113.175 | 178.7 |
| 5 | 5874.972 | ~~77.867~~ | 95.8 |
| 6 | 5843.015 | ~~77.443~~ | 96.8 |
| 7 | 5810.770 | ~~77.016~~ | 93.7 |
| 8 | 4188.732 | 55.517 | 145.5 |
| 9 | 2068.048 | 27.410 | 85.8 |

NRS2968-006B
CDCl3
7-28-04

Archive directory: /export/home
Sample directory:
File: CARBON

Pulse Sequence: s2pul

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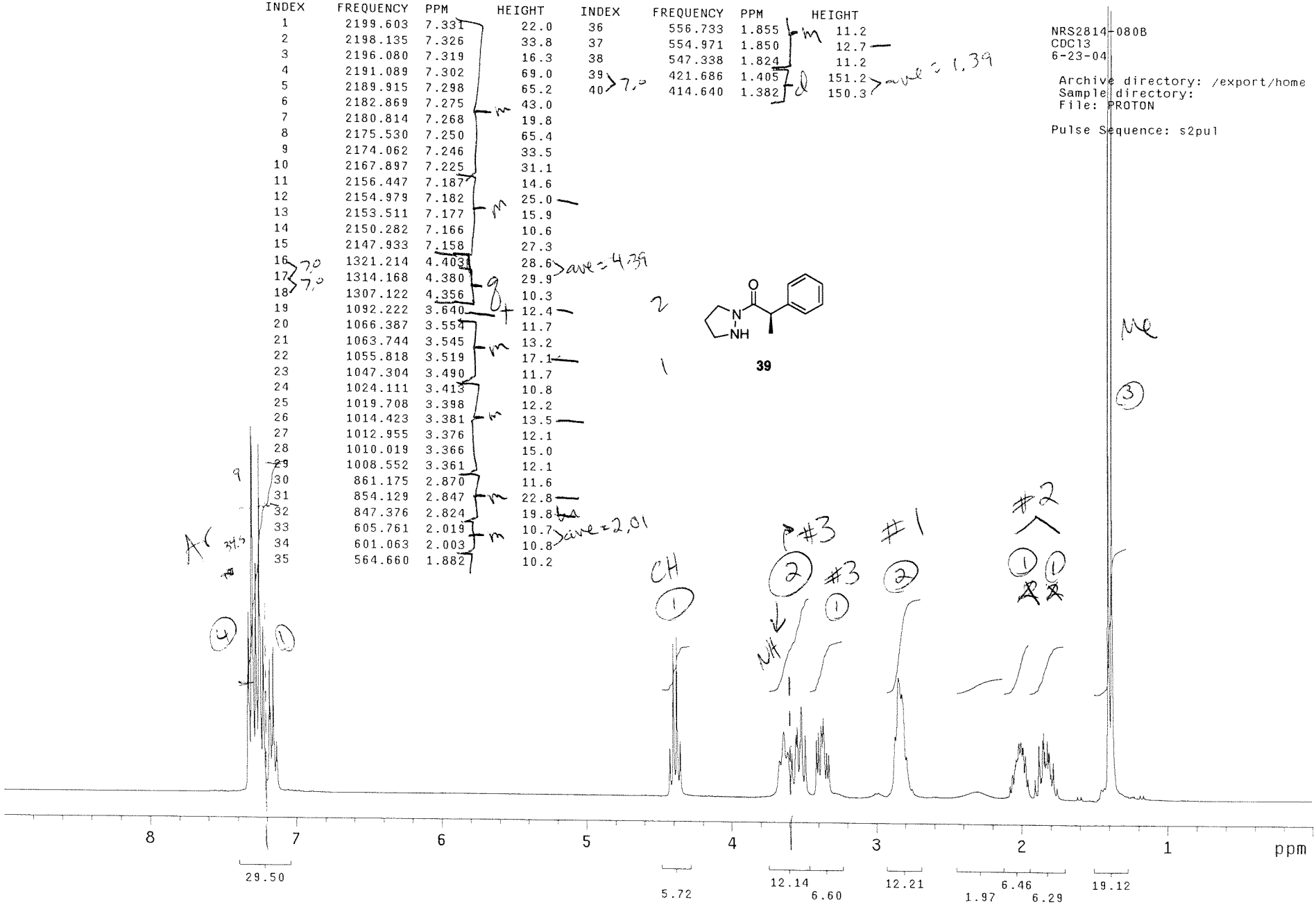
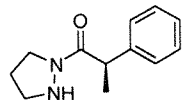

INDEX FREQUENCY PPM HEIGHT
1 2199.603 7.331 22.0
2 2198.135 7.326 33.8
3 2196.080 7.319 16.3
4 2191.089 7.302 69.0
5 2189.915 7.298 65.2
6 2182.869 7.275 43.0
7 2180.814 7.268 19.8
8 2175.530 7.250 65.4
9 2174.062 7.246 33.5
10 2167.897 7.225 31.1
11 2156.447 7.187 14.6
12 2154.979 7.182 25.0
13 2153.511 7.177 15.9
14 2150.282 7.166 10.6
15 2147.933 7.158 27.3
16 1321.214 4.403 28.6
17 1314.168 4.380 29.9
18 1307.122 4.356 10.3
19 1092.222 3.640 12.4
20 1066.387 3.554 11.7
21 1063.744 3.545 13.2
22 1055.818 3.519 17.1
23 1047.304 3.490 11.7
24 1024.111 3.413 10.8
25 1019.708 3.398 12.2
26 1014.423 3.381 13.5
27 1012.955 3.376 12.1
28 1010.019 3.366 15.0
29 1008.552 3.361 12.1
30 861.175 2.870 11.6
31 854.129 2.847 22.8
32 847.376 2.824 19.8
33 605.761 2.019 10.7
34 601.063 2.003 10.8
35 564.660 1.882 10.2
INDEX FREQUENCY PPM HEIGHT
36 556.733 1.855 11.2
37 554.971 1.850 12.7
38 547.338 1.824 11.2
39 421.686 1.405 151.2
40 414.640 1.382 150.3
NRS2814-080B
CDCl3
6-23-04
Archive directory: /export/home
Sample directory:
File: PROTON
Pulse Sequence: s2pul
39
8
7
6
5
4
3
2
1
ppm
29.50
5.72
12.14
6.60
12.21
6.46
1.97
6.29
19.12

| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 13154.278 | 174.347 | 38.4 |
| 2 | 10781.680 | 142.900 | 45.6 |
| 3 | 9710.686 | 128.705 | 180.3 |
| 4 | 9654.258 | 127.957 | 178.6 |
| 5 | 9553.492 | 126.622 | 94.1 |
| 6 | 5871.229 | 77.817 | 86.2 |
| 7 | 5838.984 | 77.380 | 87.3 |
| 8 | 5807.027 | 76.956 | 84.2 |
| 9 | 3636.249 | 48.195 | 98.7 |
| 10 | 3354.105 | 44.455 | 93.4 |
| 11 | 3272.629 | 43.375 | 88.7 |
| 12 | 2073.518 | 27.482 | 101.1 |
| 13 | 1449.348 | 19.210 | 88.8 |

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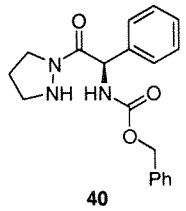
NRS2814-080B
CDCl3
6-23-04

Archive directory: /export/home
Sample directory:
File: CARBON

Pulse Sequence: s2pul



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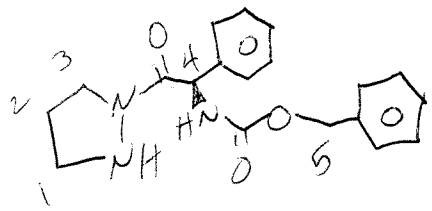
| INDEX | FREQUENCY | PPM | | HEIGHT |
|---|---|---|---|---|
| 1 | 2239.483 | 7.464 | d | 57.2 |
| 2 | 2232.448 | 7.440 | | 83.8 |
| 3 | 2197.562 | 7.324 | m | 331.6 |
| 4 | 2190.526 | 7.300 | | 123.8 |
| 5 | 2179.386 | 7.265 | | 151.2 |
| 6 | 1886.816 | 6.288 | d | 23.2 |
| 7 | 1879.487 | 6.264 | | 26.9 |
| 8 | 1796.817 | 5.988 | d | 45.3 |
| 9 | 1788.902 | 5.962 | | 39.1 |
| 10 | 1539.719 | 5.131 | dd? | 32.0 |
| 11 | 1527.407 | 5.090 | | 70.2 |
| 12 | 1508.058 | 5.026 | | 72.6 |
| 13 | 1495.746 | 4.985 | | 30.8 |
| 14 | 1077.118 | 3.590 | | 44.4 |
| 15 | 1071.548 | 3.571 | m | 27.3 |
| 16 | 1068.031 | 3.559 | | 25.8 |
| 17 | 1022.005 | 3.406 | m | 23.2 |
| 18 | 1018.194 | 3.393 | | 24.3 |
| 19 | 860.476 | 2.868 | | 38.8 |
| 20 | 853.733 | 2.845 | m | 45.0 |
| 21 | 846.111 | 2.820 | | 26.2 |
| 22 | 623.019 | 2.076 | | 19.9 |
| 23 | 619.501 | 2.065 | m | 20.0 |
| 24 | 615.397 | 2.051 | | 18.6 |
| 25 | 569.372 | 1.898 | | 19.6 |
| 26 | 561.163 | 1.870 | m | 17.8 |
| 27 | 495.789 | ~~1.652~~ | | 36.1 |

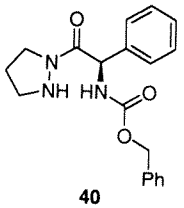
NRS2814-024C
CDCl3
4-12-04

Archive directory: /export/home
Sample directory:
File: PROTON

Pulse Sequence: s2pul



| INDEX | FREQUENCY | PPM | HEIGHT |
|---|---|---|---|
| 1 | 12839.890 | 170.180 | 34.9 |
| 2 | 11745.575 | 155.676 | 33.8 |
| 3 | 10490.900 | 139.046 | 35.5 |
| 4 | 10321.326 | 136.799 | 32.3 |
| 5 | 9723.642 | 128.877 | 119.4 |
| 6 | 9708.959 | 128.682 | 122.4 |
| 7 | 9674.699 | 128.228 | 165.4 |
| 8 | 9661.167 | 128.049 | 203.8 |
| 9 | 5042.360 | 66.831 | 52.1 |
| 10 | 4265.602 | 56.536 | 48.6 |
| 11 | 3617.823 | 47.951 | 63.4 |
| 12 | 3373.107 | 44.707 | 57.2 |
| 13 | 2044.728 | 27.101 | 51.3 |




**40**

NRS2814-024C
CDCl3
4-12-04

Archive directory: /export/home
Sample directory:
File: CARBON

Pulse Sequence: s2pul