Cobalt-catalyzed reductive Mannich reactions of 4-acryloylmorpholine with *N*-tosyl aldimines

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Supplementary Information

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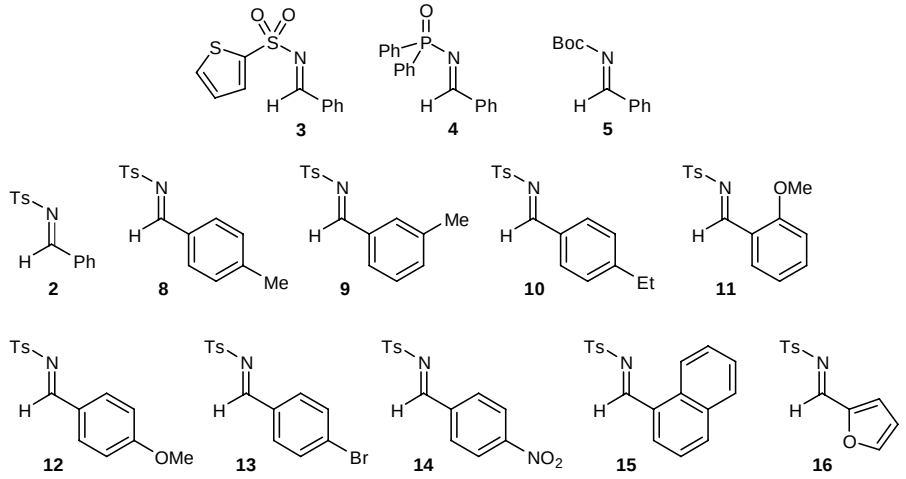
General Information

All reactions were carried out under a nitrogen atmosphere in oven-dried apparatus. CH_2Cl_2 and THF were dried and purified by passage through activated alumina columns using a solvent purification system from www.glasscontour.com 'Petrol' refers to that fraction of light petroleum ether boiling in the range 40-60 °C. All other commercially available reagents were used as received. Thin layer chromatography (TLC) was performed on Merck DF-Alufoilien $60F_{254}$ 0.2 mm precoated plates. Product spots were visualized by UV light at 254 nm, and subsequently developed using potassium permanganate or ceric ammonium molybdate solution as appropriate. Flash column chromatography was carried out using silica gel (Fisher Scientific 60Å particle size 35-70 micron) employing the method of Still and co-workers.[1] Melting points were recorded on a Gallenkamp melting point apparatus and are uncorrected. Infra-red spectra were recorded on a Jasco FT/IR-460 Plus instrument as a thin film on sodium chloride plates or as a dilute solution in $CHCl_3$. ^{1}H NMR spectra were recorded on a Bruker DPX360 (360 MHz) spectrometer or a Bruker ARX250 (250 MHz) spectrometer. Chemical shifts (δ) are quoted in parts per million (ppm) downfield of tetramethylsilane, using residual

1. Still, W. C.; Kahn, M.; Mitra, A. *J. Org. Chem.* **1978**, *43*, 2923–2925.

protonated solvent as internal standard ($CDCl_3$ at 7.27 ppm). Abbreviations used in the description of resonances are: s (singlet), d (doublet), t (triplet), q, (quartet), app (apparent), br (broad). Coupling constants (*J*) are quoted to the nearest 0.1 Hz. Proton-decoupled ^{13}C NMR spectra were recorded on a Bruker DPX360 (90.6 MHz) spectrometer or a Bruker ARX250 (62.9 MHz) spectrometer. Chemical shifts (δ) are quoted in parts per million (ppm) downfield of tetramethylsilane, using deuterated solvent as internal standard ($CDCl_3$ at 77.0 ppm). Assignments were made using the DEPT sequence with secondary pulses at 90° and 135°. High resolution mass spectra were recorded on a Finnigan MAT 900 XLT spectrometer using the electrospray (ES) positive ion mode at the EPSRC National Mass Spectrometry Service Centre, University of Wales Swansea, or on a Kratos MS50TC spectrometer using the fast atom bombardment (FAB) technique in the mass spectrometry laboratory at the School of Chemistry, University of Edinburgh. Stated calculated mass values refer to that of the *ion* (i.e. the actual species being detected), *not* that of the neutral parent compound.

Preparation of Imines



The known thienylsulfonyl imine **3**,[2] diphenylphosphinoyl imine **4**,[3] and *tert*-butoxycarbonylimine **5**[4] were prepared according to literature procedures.[2–4] The known *N*-tosylimines **2**,[5] **8**,[5] **9**,[5] **10**,[6] **11**,[7] **12**,[7] **13**,[8] **14**,[9] **15**[7] and **16**[7] were prepared according to literature procedures.[9]

2. González, A. S.; Arrayás, R. G.; Carretero, J. C. *Org. Lett.* **2006**, *8*, 2977–2980.
3. Boyd, D. R.; Malone, J. F.; McGuckin, M. R.; Jennings, W. B.; Rutherford, M.; Saket, B. M. *J. Chem. Soc., Perkin Trans. 2* **1998**, 1145–1150.
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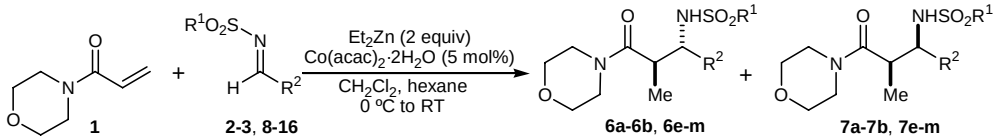
5. Nishimura, T.; Yasuhara, Y.; Hayashi, T. *Org. Lett.* **2006**, *8*, 979–981.
6. Xu, Y.-M.; Shi, M. *J. Org. Chem.* **2004**, *69*, 417–425.
7. Tokunaga, N.; Otomaru, Y.; Okamoto, K.; Ueyama, K.; Shintani, R.; Hayashi, T. *J. Am. Chem. Soc.* **2004**, *126*, 13584–13585.
8. Buskens, P.; Klankermayer, J.; Leitner, W. *J. Am. Chem. Soc.* **2005**, *127*, 16762–16763.
9. Sivakumar, A. V.; Babu, G. S.; Bhat, S. V. *Tetrahedron: Asymmetry* **2001**, *12*, 1095–1099.

Cobalt-Catalyzed Reductive Mannich Reactions: General Procedure



A solution of 4-acryloylmorpholine (**1**) (140 μL, 1.10 mmol), the appropriate imine (1.00 mmol) and $Co(acac)_2{\cdot}2H_2O$ (12.9 mg, 0.05 mmol) in CH_2Cl_2 (20 mL) was stirred at room temperature for 10 min. The mixture was cooled to 0 °C and Et_2Zn (1 M solution in hexane, 2.00 mL, 2.00 mmol) was then added dropwise over 1 min. The reaction was stirred at 0 °C for 15 min and then at room temperature for 5 h. The reaction was quenched carefully with saturated aqueous NH_4Cl solution (30 mL) and the mixture was then extracted with CH_2Cl_2 (3 x 30 mL). The combined organic layers were dried ($MgSO_4$) and concentrated *in vacuo*. Purification of the residue by column chromatography afforded the Mannich product.

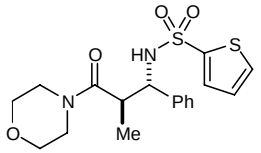
(±)-*N*-[(1*S*,2*R*)-2-Methyl-3-morpholin-4-yl-3-oxo-1-phenylpropyl]-4-methylbenzenesulfonamide (6a) and (±)-*N*-[(1*R*,2*R*)-2-methyl-3-morpholin-4-yl-3-oxo-1-phenylpropyl]-4-methylbenzenesulfonamide (7a)

The General Procedure was followed using imine **2** (259 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (20% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6a** (290 mg, 72%) as a white solid followed by *syn-Mannich product* **7a** (44 mg, 11%) as a white solid.

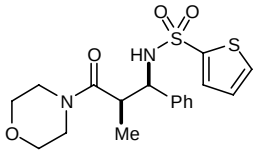
Data for **6a**: m.p. 134-136 °C; IR ($CHCl_3$) 3153 (NH), 2922, 2359, 2341, 1615 (C=O), 1456, 1159, 668 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.53 (2H, d, *J* = 8.3 Hz, Ar**H**), 7.15-7.14 (3H, m, Ar**H** and N**H**), 7.10-7.04 (5H, m, Ar**H**), 4.59 (1H, dd, *J* = 8.3, 3.8 Hz, C**H**NH), 3.64-3.49 (2H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N) 3.35-3.23 (3H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 3.13-3.01 (2H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 2.85-2.79 (1H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 2.68-2.62 (1H, m, CH_3C**H**), 2.32 (3H, s, ArC$\mathbf{H}_3$), 1.23 (3H, d, *J* = 6.9 Hz, C$\mathbf{H}_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.9 (C), 142.5 (C), 140.1 (C), 138.4 (C), 129.0 (2 x CH), 128.3 (2 x CH), 127.3 (CH), 126.7 (2 x CH), 126.2 (2 x CH), 66.4 (CH_2), 66.0 (CH_2), 60.3 (CH), 46.1 (CH_2), 41.8 (CH_2), 39.8 (CH), 21.3 (CH_3), 16.4 (CH_3); HRMS (ES) Exact mass calcd for $C_{21}H_{27}N_2O_4S$ $[M+H]^+$: 403.1687, found: 403.1680.

Data for **7a**: m.p. 118-120 °C; IR ($CHCl_3$) 3209 (NH), 2920, 2360, 1616, (C=O), 1457, 1159, 1024 cm^{-1}; ^1H NMR (360 MHz, $CDCl_3$) δ 7.55 (2H, d, *J* = 8.4 Hz, Ar**H**), 7.18-7.11 (5H, m, Ar**H**), 7.07-7.04 (2H, m, Ar**H**), 5.54 (1H, d, *J* = 7.0 Hz, N**H**), 4.40 (1H, app t, *J* = 7.4 Hz, C**H**NH), 3.55-3.39 (3H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 3.34-3.13 (4H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 3.10-3.03 (1H, m, CH_3C**H**), 3.01-2.95 (1H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 2.36 (3H, s, ArC$\mathbf{H}_3$)**,** 1.19 (3H, d, *J* = 6.8 Hz, C$\mathbf{H}_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.1 (C), 143.1 (C), 139.4 (C), 136.9 (C), 129.2 (2 x CH), 128.2 (2 x CH), 127.5 (CH), 127.3 (2 x CH), 127.0 (2 x CH), 66.5 (CH_2), 66.3 (CH_2), 60.4 (CH), 46.0 (CH_2), 41.9 (CH_2), 41.5 (CH), 21.4 (CH_3), 14.6 (CH_3); HRMS (FAB) Exact mass calcd for $C_{21}H_{27}N_2O_4S$ $[M+H]^+$: 403.1687, found: 403.1677.

(±)-*N*-[(1*S*,2*R*)-2-Methyl-3-morpholin-4-yl-3-oxo-1-phenylpropyl]-2-thienylsulfonamide (6b) and (±)-*N*-[(1*R*,2*R*)-2-methyl-3-morpholin-4-yl-3-oxo-1-phenylpropyl]-2-thienylsulfonamide (7b)



6b



7b

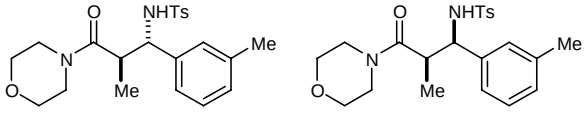
The General Procedure was followed using imine **3** (251 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (80% EtOAc/Hexane) to give *anti-Mannich product* **6b** (204 mg, 52% yield) as a white solid, followed by *syn-Mannich product* **7b** (39 mg, 10%) as a white solid.

Data for **6b**: m.p. 121-123 °C; IR ($CHCl_3$) 3276 (NH), 2968, 2923, 2857, 1618 (C=O), 1453, 1404, 1157, 729 cm^{-1}; ^1H NMR (360 MHz, $CDCl_3$) δ 7.37-7.34 (2H, m, Ar**H**), 7.31-7.30 (1H, m, Ar**H**), 7.22-7.16 (3H, m, Ar**H**), 7.12-7.09 (2H, m, Ar**H**), 6.83 (1H, dd, *J* = 5.0, 3.8 Hz, N**H**), 4.64 (1H, dd, *J* = 8.3, 3.8 Hz, C**H**NH), 3.68-3.49 (2H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 3.36-3.23 (3H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 3.15-3.07 (2H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 2.86-2.80 (1H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 2.68-2.62 (1H, m, CH_3C**H**), 1.26 (3H, d, *J* = 6.9 Hz, C$\mathbf{H}_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.9 (C), 142.4 (C), 139.8 (C), 131.5 (CH), 131.0 (CH), 128.4 (2 x CH), 127.5 (CH), 126.8 (CH), 126.0 (2 x CH), 66.4 (CH_2), 65.9 (CH_2), 60.5 (CH), 46.1 (CH_2), 41.9 (CH_2), 39.7 (CH), 16.2 (CH_3); HRMS (FAB) Exact mass calcd for $C_{18}H_{23}N_2O_4S_2$ $[M+H]^+$: 395.1094, found: 395.1102.

Data for **7b**: m.p. 132-134 °C; IR ($CHCl_3$) 3276 (NH), 2968, 2919, 2857, 1618 (C=O), 1453, 1331, 1157, 729 cm^{-1}; ^1H NMR (360 MHz, $CDCl_3$) δ 7.44 (1H, dd, *J* = 5.0, 1.4 Hz, Ar**H**), 7.38 (1H, dd, *J* = 3.8, 1.4 Hz, Ar**H**), 7.21-7.17 (3H, m, Ar**H**), 7.13-7.10 (2H, m, Ar**H**), 6.90 (1H, dd, *J* = 5.0, 3.8 Hz, Ar**H**), 5.85 (1H, d, *J* = 7.6 Hz, N**H**), 4.54 (1H, t, *J* = 8.0 Hz, C**H**NH), 3.55-3.43 (3H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 3.35-3.14 (4H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N), 3.09-3.01 (2H, m, OC$\mathbf{H}_2$C$\mathbf{H}_2$N and CH_3C**H**), 1.24 (3H, d, *J* = 6.8 Hz,

C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.0 (C), 140.9 (C), 139.1 (C), 132.6 (CH), 131.9 (CH), 128.3 (2 x CH), 127 .7 (CH), 127.1 (CH), 126.9 (2 x CH), 66.6 (CH_2), 66.3 (CH_2), 60.7 (CH), 46.1 (CH_2), 42.0 (CH_2), 41.5 (CH), 14.6 (CH_3); HRMS (FAB) Exact mass calcd for $C_{18}H_{23}N_2O_4S_2$ $[M+H]^+$: 395.1094, found: 395.1104.

(±)-*N*-[(1*S*,2*R*)-2-Methyl-1-(3-methylphenyl)-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (6e) and (±)-*N*-[(1*R*,2*R*)-2-methyl-1-(3-methylphenyl)-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (7e)



6e **7e**

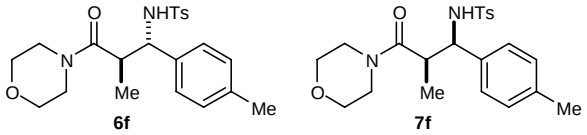
The General Procedure was followed using imine **8** (273 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (20% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6e** (270 mg, 65% yield) as a pale yellow solid followed by the *syn-Mannich product* **7e** (39 mg, 9%) as a white solid.

Data for **6e**: m.p. 75-77 °C; IR ($CHCl_3$) 3275 (NH), 2966, 2922, 2858, 1618 (C=O), 1334, 1158, 914 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.51 (2H, dm, *J* = 8.3 Hz, Ar**H**), 7.07-7.01 (4H, m, Ar**H** and N**H**), 6.93 (1H, app d, *J* = 7.5 Hz, Ar**H),** 6.85 (1H, app d, *J* = 7.6 Hz, Ar**H**), 6.74 (1H, br s, Ar**H**), 4.55 (1H, dd, *J* = 8.3, 3.9 Hz, C**H**NH), 3.67-3.49 (2H, m, OC**H**$_2$C**H**$_2$N), 3.34-3.29 (1H, m, OC**H**$_2$C**H**$_2$N), 3.27-3.19 (2H, m, OC**H**$_2$C**H**$_2$N), 3.12-3.06 (2H, m, OC**H**$_2$C**H**$_2$N), 2.86-2.80 (1H, m, OC**H**$_2$C**H**$_2$N), 2.63-2.57 (1H, m, CH_3C**H**), 2.32 (3H, s, ArC**H**$_3$), 2.15 (3H, ArC**H**$_3$), 1.22 (3H, d, *J* = 6.9 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 173.0 (C), 142.4 (C), 139.8 (C), 138.5 (C), 137.8 (C), 128.9 (2 x CH), 128.2 (CH), 128.0 (CH), 126.8 (3 x CH), 123.4 (CH), 66.5 (CH_2), 66.0 (CH_2), 60.4 (CH), 46.2 (CH_2), 41.9 (CH_2), 39.7 (CH), 21.3 (CH_3), 21.2 (CH_3), 16.4 (CH_3); HRMS (FAB) Exact mass calcd for $C_{22}H_{29}N_2O_4S$ $[M+H]^+$: 417.1843, found: 417.1851.

Data for **7e**: m.p. 124-126 °C; IR ($CHCl_3$) 3206 (NH), 2965, 2921, 2857, 1616 (C=O), 1436, 1159, 1025 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.54 (2H, dm, *J* = 8.3 Hz, Ar**H**), 7.11-7.09 (2H, m, Ar**H**), 7.05-7.01 (1H, m, Ar**H**), 6.93 (1H, app d, *J* = 7.5 Hz, Ar**H**), 6.86 (1H, app d, *J* = 7.6 Hz, Ar**H**), 6.73 (1H, br s, Ar**H**), 5.76 (1H, d, *J* = 7.8 Hz, N**H**), 4.37 (1H, t, *J* = 8.1 Hz, C**H**NH), 3.69-3.64 (1H, m, OC**H**$_2$C**H**$_2$N), 3.54-3.43 (3H, m, OC**H**$_2$C**H**$_2$N), 3.30-3.12 (3H, m, OC**H**$_2$C**H**$_2$N) 3.06-2.93 (2H, m, OC**H**$_2$C**H**$_2$N and CH_3C**H**), 2.35 (3H, s, ArC**H**$_3$), 2.16 (3H, s, ArC**H**$_3$), 1.21 (3H, d, *J* = 6.7 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.1 (C), 143.0 (C), 139.2 (C), 137.7 (C), 137.0 (C), 129.1

(2 x CH), 128.2 (2 x CH), 127.8 (CH), 127.3 (2 x CH), 123.8 (CH), 66.6 (CH_2), 66.3 (CH_2), 60.4 (CH), 46.1 (CH_2), 41.9 (CH_2), 41.3 (CH), 21.4 (CH_3), 21.2 (CH_3), 14.7 (CH_3); HRMS (ES) Exact mass calcd. for $C_{22}H_{29}N_2O_4S$ $[M+H]^+$: 417.1843, found: 453.1843.

(±)-*N*-[(1*S*,2*R*)-2-Methyl-1-(4-methylphenyl)-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (6f) and (±)-*N*-[(1*R*,2*R*)-2-methyl-1-(4-methylphenyl)-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (7f)

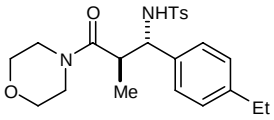


The General Procedure was followed using imine **9** (273 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (20% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6f** (279 mg, 67%) as a white solid followed by *syn-Mannich product* **7f** (46 mg, 11%) as a white solid.

Data for **6f**: m.p. 114-116 °C; IR ($CHCl_3$) 3212 (NH), 2966, 2922, 2858, 1617 (C=O), 1437, 1325, 1159, 811 cm^{-1}; ^1H NMR (360 MHz, $CDCl_3$) δ 7.52 (2H, d, *J* = 8.2 Hz, Ar**H**), 7.06 (2H, d, *J* = 8.2 Hz, Ar**H**), 7.01 (1H, d, *J* = 8.3 Hz, N**H**), 6.93 (4H, s, Ar**H**), 4.52 (1H, dd, *J* = 8.3, 4.0 Hz, C**H**NH), 3.59-3.48 (2H, m, OC**H**$_2$C**H**$_2$N), 3.36-3.26 (3H, m, OC**H**$_2$C**H**$_2$N), 3.14-3.04 (2H, m, OC**H**$_2$C**H**$_2$N), 2.87-2.81 (1H, m, OC**H**$_2$C**H**$_2$N), 2.76-2.70 (1H, m CH_3C**H**), 2.32 (3H, s, ArC**H**$_3$), 2.25 (3H, s, ArC**H**$_3$), 1.19 (3H, d, *J* = 6.9 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 173.0 (C), 142.4 (C), 138.4 (C), 137.1 (C), 137.0 (C), 129.0 (2 x CH), 128.9 (2 x CH), 126.8 (2 x CH), 126.1 (2 x CH), 66.4 (CH_2), 66.0 (CH_2), 60.2 (CH), 46.1 (CH_2), 41.8 (CH_2), 39.8 (CH), 21.3 (CH_3), 20.9 (CH_3), 16.3 (CH_3); HRMS (FAB) Exact mass calcd for $C_{22}H_{29}N_2O_4S$ $[M+H]^+$: 417.1843, found: 417.1844.

Data for **7f**: m.p. 183-185 °C; IR ($CHCl_3$) 3212 (NH), 2967, 2922, 2858, 1616 (C=O), 1437, 1325, 1159, 1024 cm^{-1}; ^1H NMR (360 MHz, $CDCl_3$) δ 7.55 (2H, d, *J* = 8.1 Hz, Ar**H**), 7.12 (2H, d, *J* = 8.1 Hz, Ar**H**), 6.94 (4H, s, Ar**H**), 5.73 (1H, d, *J* = 7.3 Hz, N**H**), 4.36 (1H, t, *J* = 7.8 Hz, C**H**NH), 3.54-3.38 (3H, m, OC**H**$_2$C**H**$_2$N), 3.34-3.20 (3H, m, OC**H**$_2$C**H**$_2$N), 3.17-3.11 (1H, m, OC**H**$_2$C**H**$_2$N), 3.09-2.95 (2H, m, OC**H**$_2$C**H**$_2$N and CH_3C**H**), 2.36 (3H, s, ArC**H**$_3$), 2.26 (3H, s, ArC**H**$_3$), 1.19 (3H, d, *J* = 6.8 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.2 (C), 143.0 (C), 137.2 (C), 136.9 (C), 136.4 (C), 129.2 (2 x CH), 128.8 (2 x CH), 127.3 (2 x CH), 126.9 (2 x CH), 66.6 (CH_2), 66.3 (CH_2), 60.1 (CH), 46.0 (CH_2), 41.9 (CH_2), 41.4 (CH), 21.4 (CH_3), 21.0 (CH_3) 14.5 (CH_3); HRMS (FAB) Exact mass calcd for $C_{22}H_{29}N_2O_4S$ $[M+H]^+$: 417.1843, found: 417.1836.

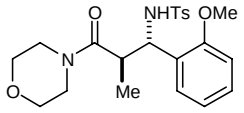
(±)-*N*-[(1*S*,2*R*)-1-(4-Ethylphenyl)-2-methyl-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (6g)



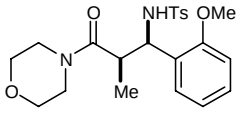
The General Procedure was followed using imine **10** (287 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (20% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6g** (334 mg, 78%) as a white solid. The *syn-Mannich product* could not be isolated in pure form.

m.p. 88-90 ºC; IR ($CHCl_3$) 3276 (NH), 2965, 2929, 2859, 1618 (C=O), 1446, 1159 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.51 (2H, d, *J* = 8.2 Hz, Ar**H**), 7.05 (2H, d, *J* = 8.2 Hz, Ar**H**), 7.02 (1H, d, *J* = 8.5 Hz, N**H**), 6.94 (4H, s, Ar**H**), 4.55 (1H, dd, *J* = 8.3, 4.0 Hz, C**H**NH), 3.67-3.60 (1H, m, OC**H**$_2$C**H**$_2$N), 3.56-3.49 (1H, m, OC**H**$_2$C**H**$_2$N), 3.34-3.20 (3H, m, OC**H**$_2$C**H**$_2$N), 3.12-3.04 (2H, m, OC**H**$_2$C**H**$_2$N), 2.87-2.81 (1H, m, OC**H**$_2$C**H**$_2$N), 2.66-2.60 (1H, m, CH_3C**H**), 2.54 (2H, q, *J* = 7.6 Hz, C**H**$_2$$CH_3$), 2.31 (3H, s, ArC**H**$_3$), 1.21 (3H, d, *J* = 6.9 Hz, C**H**$_3$CH), 1.15 (3H, t, *J* = 7.6 Hz, CH_2C**H**$_3$); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 173.0 (C), 143.5 (C), 142.3 (C), 138.4 (C), 137.2 (C), 129.0 (2 x CH), 127.7 (2 x CH), 126.8 (2 x CH), 126.2 (2 x CH), 66.4 (CH_2), 66.0 (CH_2), 60.2 (CH), 46.2 (CH_2), 41.9 (CH_2), 39.8 (CH), 28.4 (CH_2), 21.3 (CH_3), 16.3 (CH_3), 15.9 (CH_3); HRMS (FAB) Exact mass calcd for $C_{23}H_{31}N_2O_4S$ $[M+H]^+$: 431.2000, found: 431.1985.

(±)-*N*-[(1*S*,2*R*)-1-(2-Methoxyphenyl)-2-methyl-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (6h) and (±)-*N*-[(1*R*,2*R*)-1-(2-methoxyphenyl)-2-methyl-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (7h)



6h



7h

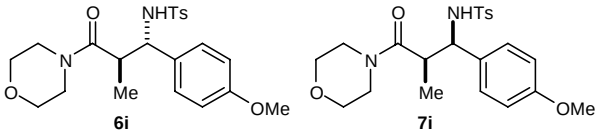
The General Procedure was followed using imine **11** (289 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (20% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6h** (213 mg, 49%) as a white solid followed by *syn-Mannich product* **7h** (30 mg, 7%) as a white solid.

Data for **6h**: m.p. 166-168 °C; IR ($CHCl_3$) 3287 (NH), 2965, 2924, 2857, 1618 (C=O), 1491, 1464, 1159, 668 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.57 (2H, dm, *J* = 8.3 Hz, Ar**H**), 7.15-7.10 (1H, m, Ar**H**), 7.10-7.08 (2H, m, Ar**H**), 7.01-6.99 (1H, m, Ar**H**), 6.82 (1H, d, *J* = 8.7 Hz, N**H**), 6.77-6.69 (2H, m, Ar**H**), 4.87 (1H, dd, *J* = 8.7, 4.5 Hz, C**H**NH), 3.82 (3H, s, OC**H**$_3$) 3.66-3.48 (2H, m, OC**H**$_2$C**H**$_2$N), 3.37-3.09 (5H, m, OC**H**$_2$C**H**$_2$N), 2.92-2.86 (1H, m, OC**H**$_2$C**H**$_2$N), 2.68-2.62 (1H, m, CH_3C**H**), 2.32

(3H, s, ArC**H**$_3$)**,** 1.10 (3H, d, *J* = 6.9 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 173.3 (C), 155.5 (C), 142.5 (C), 138.3 (C), 129.0 (2 x CH), 128.4 (CH), 127.8 (C and CH), 126.8 (2 x CH), 120.5 (CH), 110.0 (CH), 66.5 (CH_2), 66.1 (CH_2), 55.5 (CH_3), 55.3 (CH), 46.1 (CH_2), 41.9 (CH_2), 36.4 (CH), 21.3 (CH_3), 16.0 (CH_3); HRMS (ES) Exact mass calcd. for $C_{22}H_{29}N_2O_5S$ $[M+H]^+$: 433.1792, found: 433.1792.

Data for **7h**: m.p. 125-126 °C; IR ($CHCl_3$) 3286 (NH), 2966, 2857, 1618 (C=O), 1464, 1240, 1159 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.49 (2H, d, *J* = 8.1 Hz, Ar**H**), 7.13-7.08 (1H, m, Ar**H**), 7.03 (2H, d, *J* = 8.1 Hz, Ar**H**), 6.91-6.86 (1H, m, Ar**H**), 6.71-6.67 (2H, m, Ar**H**), 5.76 (1H, d, *J* = 9.2 Hz, N**H**), 4.42 (1H, app t, *J* = 9.0 Hz, C**H**NH), 3.79 (3H, s, OC**H**$_3$), 3.52-3.42 (3H, m, OC**H**$_2$C**H**$_2$N), 3.33-3.24 (2H, m, OC**H**$_2$C**H**$_2$N), 3.19-3.12 (2H, m, OC**H**$_2$C**H**$_2$N), 3.05-2.98 (1H, m, OC**H**$_2$C**H**$_2$N), 2.85-2.79 (1H, m, CH$_3$C**H**), 2.30 (3H, s, ArC**H**$_3$)**,** 1.23 (3H, d, *J* = 6.7 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.4 (C), 155.8 (C), 142.8 (C), 137.1 (C), 130.9 (C), 129.0 (2 x CH), 128.7 (CH), 127.0 (2 x CH), 126.1 (CH), 120.7 (CH), 110.2 (CH), 66.6 (CH_2), 66.4 (CH_2), 55.2 (CH and CH_3), 45.9 (CH_2), 41.9 (CH_2), 38.7 (CH), 21.4 (CH_3), 14.7 (CH_3); HRMS (FAB) Exact mass calcd for $C_{22}H_{29}N_2O_5S$ $[M+H]^+$: 433.1792, found: 433.1787.

(±)-*N*-[(1*S*,2*R*)-1-(4-Methoxyphenyl)-2-methyl-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (6i) and (±)-*N*-[(1*R*,2*R*)-1-(4-methoxyphenyl)-2-methyl-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (7i)



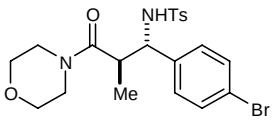
The General Procedure was followed using imine **12** (289 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (20% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6i** (233 mg, 54%) as a white solid followed by *syn-Mannich product* **7i** (34 mg, 8%) as a white solid.

Data for **6i**: m.p. 106-108 °C; IR ($CHCl_3$) 3273 (NH), 2923, 2359, 1614 (C=O), 1513, 1159, 1030 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.51 (2H, d, *J* = 8.2 Hz, Ar**H**), 7.07 (2H, d, *J* = 8.2 Hz, Ar**H**), 7.01 (1H, d, *J* = 8.3 Hz, N**H**), 6.95 (2H, dm, *J* = 8.7 Hz, Ar**H**), 6.65 (2H, dm, *J* = 8.7 Hz, Ar**H**), 4.52 (1H, dd, *J* = 8.2, 4.1 Hz, C**H**NH), 3.73 (3H, s, OC**H**$_3$) 3.59-3.49 (2H, m, OC**H**$_2$C**H**$_2$N), 3.39-3.30 (3H, m, OC**H**$_2$C**H**$_2$N), 3.17-3.02 (2H, m, OC**H**$_2$C**H**$_2$N), 2.91-2.80 (2H, m, OC**H**$_2$C**H**$_2$N and CH$_3$C**H**), 2.32 (3H, s, ArC**H**$_3$)**,** 1.20 (3H, d, *J* = 6.9 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 173.1 (C), 158.8 (C), 142.4 (C), 138.4 (C), 132.2 (C), 129.0 (2 x CH), 127.4 (2 x CH), 126.8 (2 x CH), 113.6 (2 x CH), 66.5

(CH_2), 66.1 (CH_2), 59.9 (CH), 55.2 (CH_3), 46.1 (CH_2), 41.8 (CH_2), 40.0 (CH), 21.3 (CH_3), 16.3 (CH_3); HRMS (ES) Exact mass calcd for $C_{22}H_{29}N_2O_5S$ $[M+H]^+$: 433.1792, found: 433.1792.

Data for **7i**: m.p. 97-98 °C; IR ($CHCl_3$) 3284 (NH), 2964, 2855, 1614 (C=O), 1456, 1464, 1158, 1025 cm^{-1}; ^1H NMR (360 MHz, $CDCl_3$) δ 7.56-7.54 (2H, m, Ar**H**), 7.14 (2H, d, *J* = 7.9 Hz, Ar**H**), 6.99-6.95 (2H, m, Ar**H**), 6.70-6.65 (2H, m, Ar**H**), 5.55 (1H, d, *J* = 7.0 Hz, N**H**), 4.35 (1H, app t, *J* = 7.5 Hz, C**H**NH), 3.75 (3H, s, OC**H**$_3$) 3.56-3.47 (2H, m, OC**H**$_2$C**H**$_2$N), 3.40-3.35 (2H, m, OC**H**$_2$C**H**$_2$N), 3.33-3.26 (2H, m, OC**H**$_2$C**H**$_2$N), 3.22-3.13 (2H, m, OC**H**$_2$C**H**$_2$N), 2.98 (1H, qd, *J* = 13.9, 6.9 Hz, CH_3C**H**), 2.37 (3H, s, ArC**H**$_3$)**,** 1.17 (3H, d, *J* = 6.9 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.2 (C), 158.8 (C), 143.0 (C), 137.0 (C), 131.5 (C), 129.2 (2 x CH), 128.1 (2 x CH), 127.3 (2 x CH), 113.5 (2 x CH), 66.6 (CH_2), 66.4 (CH_2), 59.9 (CH), 55.2 (CH_3), 46.0 (CH_2), 41.9 (CH_2), 41.5 (CH), 21.4 (CH_3), 14.7 (CH_3); HRMS (FAB) Exact mass calcd for $C_{22}H_{29}N_2O_5S$ $[M+H]^+$: 433.1792, found: 433.1792.

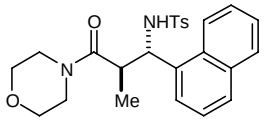
(±)-*N*-[(1*S*,2*R*)-1-(4-Bromophenyl)-2-methyl-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (6j)



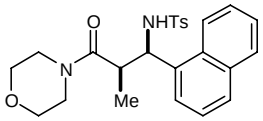
The General Procedure was followed using imine **13** (338 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (20% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6j** (210 mg, 44%) as a white solid. The *syn-Mannich product* could not be isolated in pure form.

m.p. 128-130 °C; IR ($CHCl_3$) 3144 (NH), 2983, 2898, 2858, 1615 (C=O), 1469, 1159, 910 cm^{-1}; ^1H NMR (360 MHz, $CDCl_3$) δ 7.49 (2H, dm, *J* = 8.2 Hz, Ar**H**), 7.23 (2H, dm, *J* = 8.5 Hz, Ar**H**), 7.12 (1H, d, *J* = 8.4 Hz, N**H**), 7.08 (2H, d, *J* = 8.2 Hz, Ar**H**), 6.92 (2H, dm, *J* = 8.5 Hz, Ar**H**), 4.51 (1H, dd, *J* = 8.4, 4.0 Hz, C**H**NH), 3.57-3.46 (2H, m, OC**H**$_2$C**H**$_2$N), 3.42-3.31 (3H, m, OC**H**$_2$C**H**$_2$N), 3.19-3.12 (1H, m, OC**H**$_2$C**H**$_2$N), 3.04 (1H, dq, *J* = 6.9, 4.2 Hz, CH_3C**H**), 2.95-2.89 (2H, m, OC**H**$_2$C**H**$_2$N), 2.34 (3H, s, ArC**H**$_3$), 1.19 (3H, d, *J* = 6.9 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.7 (C), 142.8 (C), 139.0 (C), 138.1 (C), 131.2 (2 x CH), 129.1 (2 x CH), 128.2 (2 x CH), 126.7 (2 x CH), 121.1 (C), 66.5 (CH_2), 66.1 (CH_2), 59.9 (CH), 46.1 (CH_2), 41.8 (CH_2), 39.8 (CH), 21.3 (CH_3), 16.3 (CH_3); HRMS (FAB) Exact mass calcd for $C_{21}H_{26}{}^{79}BrN_2O_4S$ $[M+H]^+$: 481.0792, found: 481.0792.

(±)-*N*-[(1*S*,2*R*)-2-Methyl-3-morpholin-4-yl-1-naphthalen-1-yl-3-oxopropyl]-4-methylbenzenesulfonamide (6l) and (±)-*N*-[(1*R*,2*R*)-2-methyl-3-morpholin-4-yl-1-naphthalen-1-yl-3-oxopropyl]-4-methylbenzenesulfonamide (7l)



6l



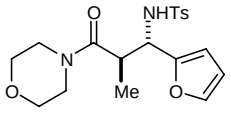
7l

The General Procedure was followed using imine **15** (309 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (20% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6l** (221 mg, 49%) as a white solid followed by *syn-Mannich product* **7l** (50 mg, 11%) as a white solid.

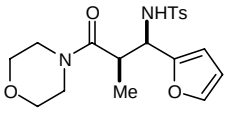
Data for **6l**: m.p. 102-104 °C; IR ($CHCl_3$) 3284 (NH), 2966, 2922, 2587, 1618 (C=O), 1444, 1333, 913 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.91 (1H, d, *J* = 8.4 Hz, Ar**H**), 7.86-7.83 (1H, m, Ar**H**), 7.68 (1H, d, *J* = 7.9 Hz, Ar**H**), 7.58-7.47 (4H, m, Ar**H**), 7.28-7.19 (3H, m, Ar**H** and N**H**), 7.02 (2H, d, *J* = 8.0 Hz, Ar**H**), 5.43 (1H, dd, *J* = 7.9, 3.7 Hz, C**H**NH), 3.62-3.57 (1H, m, OC**H**$_2$C**H**$_2$N), 3.47-3.38 (2H, m, OC**H**$_2$C**H**$_2$N), 3.13-3.02 (2H, m, OC**H**$_2$C**H**$_2$N), 2.94-2.89 (1H, m, OC**H**$_2$C**H**$_2$N), 2.77-2.70 (1H, m, OC**H**$_2$C**H**$_2$N), 2.29 (3H, s, ArC**H**$_3$), 2.27-2.22 (1H, m, OC**H**$_2$C**H**$_2$N), 1.98-1.92 (1H, m, CH_3C**H**), 1.33 (3H, d, *J* = 6.8 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.9 (C), 142.6 (C), 138.4 (C), 135.0 (C), 133.6 (C), 129.7 (C), 129.3 (CH), 129.1 (2 x CH), 128.0 (CH), 126.7 (3 x CH), 125.6 (CH), 125.2 (CH), 124.3 (CH), 121.3 (CH), 66.4 (CH_2), 65.5 (CH_2), 56.4 (CH), 46.0 (CH_2), 41.8 (CH_2), 37.4 (CH), 21.3 (CH_3), 16.3 (CH_3); HRMS (ES) Exact mass calcd. for $C_{25}H_{29}N_2O_4S$ $[M+H]^+$: 453.1843, found: 453.1841.

Data for **7l**: m.p. 94-96 °C; IR ($CHCl_3$) 3218 (NH), 2923, 2857, 2359, 1616 (C=O), 1435, 1158, 914 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.90-7.87 (1H, m, Ar**H**), 7.76-7.72 (1H, m, Ar**H**), 7.65 (1H, d, *J* = 8.3 Hz, Ar**H**), 7.45-7.40 (3H, m, Ar**H**), 7.38-7.35 (2H, m, Ar**H**), 7.31-7.24 (1H, m, Ar**H**), 6.84 (2H, d, *J* = 7.9 Hz, Ar**H**), 6.10 (1H, br s, N**H**), 5.21 (1H, br s, C**H**NH), 3.70-2.75 (9H, br m, 2 x OC**H**$_2$C**H**$_2$N and CH_3C**H**), 2.21 (3H, s, ArC**H**$_3$), 1.31 (3H, d, *J* = 6.6 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 172.2 (C), 142.8 (C), 136.3 (C), 133.6 (C), 130.4 (C), 128.8 (C and 2 x CH), 128.2 (CH), 127.1 (2 x CH), 126.2 (CH), 125.5 (CH), 124.9 (CH), 122.6 (CH), 66.4 (CH_2), 66.1 (CH_2), 46.1 (CH_2), 41.9 (CH_2), 40.2 (CH), 21.3 (CH_3), 15.0 (CH_3); HRMS (ES) Exact mass calcd. for $C_{25}H_{29}N_2O_4S$ $[M+H]^+$: 453.1843, found: 453.1845.

(±)-*N*-[(1*S*,2*R*)-1-Furan-2-yl-2-methyl-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (6m) and (±)-*N*-[(1*R*,2*R*)-1-furan-2-yl-2-methyl-3-morpholin-4-yl-3-oxopropyl]-4-methylbenzenesulfonamide (7m)



6m



7m

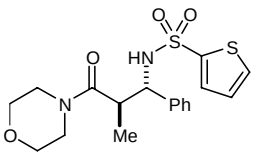
The General Procedure was followed using imine **16** (249 mg, 1.00 mmol) and the reaction mixture was purified by column chromatography (50% EtOAc/CH_2Cl_2) to give *anti-Mannich product* **6m** (141 mg, 36%) as a pale yellow solid followed by *syn-Mannich product* **7m** (67 mg, 17%) as a pale yellow solid.

Data for **6m**: m.p. 144-146 °C; IR ($CHCl_3$) 3153 (NH), 2922, 2359, 2341, 1615 (C=O), 1456, 1159, 668 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.64 (2H, dm, *J* = 8.3 Hz, Ar**H**), 7.20-7.16 (3H, m, Ar**H** and C**H**), 6.82 (1H, d, *J* = 8.6 Hz, N**H**), 6.15 (1H, dd, *J* = 3.3, 1.8 Hz, C**H**), 5.94-5.93 (1H, m, C**H**), 4.61 (1H, dd, *J* = 8.6, 4.4 Hz, C**H**NH), 3.63-3.27 (9H, m, 2 x OC**H**$_2$C**H**$_2$N and CH_3C**H**), 2.37 (3H, s, ArC**H**$_3$), 1.15 (3H, d, *J* = 7.1 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 173.1 (C), 153.2 (C), 142.7 (C), 141.5 (CH), 138.3 (C), 129.2 (2 x CH), 126.8 (2 x CH), 110.5 (CH), 107.2 (CH), 66.7 (CH_2), 66.4 (CH_2), 54.7 (CH), 46.2 (CH_2), 42.0 (CH_2), 37.4 (CH), 21.4 (CH_3), 15.4 (CH_3); HRMS (FAB) Exact mass calcd. for $C_{19}H_{25}N_2O_5S$ $[M+H]^+$: 393.1479, found: 393.1482.

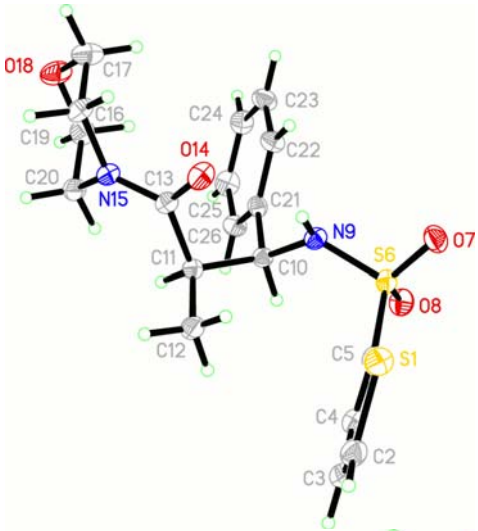
Data for **7m**: m.p. 133-135 °C; IR ($CHCl_3$) 3262 (NH), 2857, 2858, 1620 (C=O), 1444, 1332, 1159 cm^{-1}; ^{1}H NMR (360 MHz, $CDCl_3$) δ 7.58 (2H, dm, *J* = 8.3 Hz, Ar**H**), 7.17-7.14 (2H, m, Ar**H**), 7.10 (1H, dd, *J* = 1.8, 0.8 Hz, C**H**), 6.07 (1H, dd, *J* = 3.2, 1.8 Hz, C**H**), 5.82 (1H, d, *J* = 3.2 Hz, C**H**), 5.58 (1H, d, *J* = 9.1 Hz, N**H**), 4.56 (1H, app t, *J* = 9.1 Hz, C**H**NH), 3.67-3.26 (8H, m, OC**H**$_2$C**H**$_2$N), 3.18 (1H, qd, *J* = 9.1, 6.8 Hz, C**H**$_3$CH), 2.36 (3H, s, ArC**H**$_3$)**,** 1.23 (3H, d, *J* = 6.8 Hz, C**H**$_3$CH); ^{13}C NMR (62.9 MHz, $CDCl_3$) δ 171.9 (C), 151.5 (C), 143.0 (C), 141.4 (CH), 137.1 (C), 129.2 (2 x CH), 127.0 (2 x CH), 110.3 (CH), 107.9 (CH), 66.7 (CH_2), 66.5 (CH_2), 54.1 (CH), 46.0 (CH_2), 42.0 (CH_2), 39.6 (CH), 21.4 (CH_3), 14.8 (CH_3); HRMS (FAB) Exact mass calcd. for $C_{19}H_{25}N_2O_5S$ $[M+H]^+$: 393.1479, found: 393.1486.

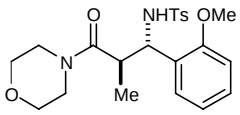
Stereochemical Determinations

- The relative stereochemistries of **6b**, **6h** and **6i** were determined by X-ray crystallography.

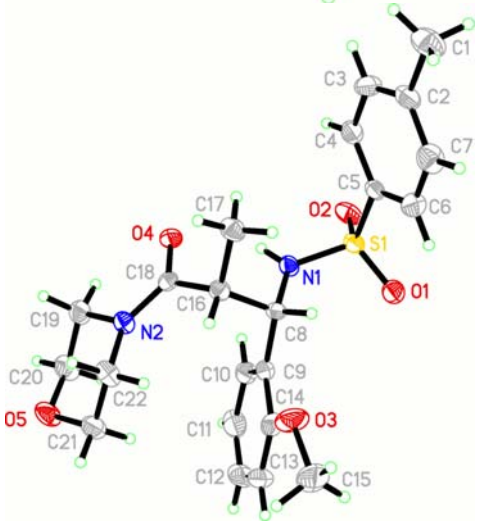


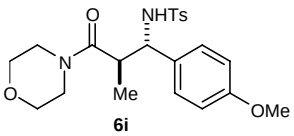
6b



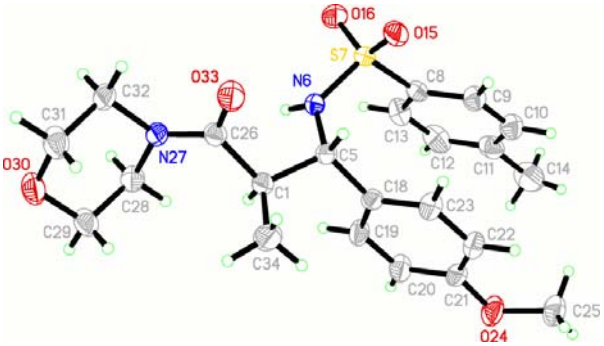


6h



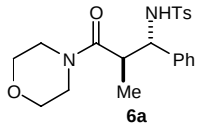


6i

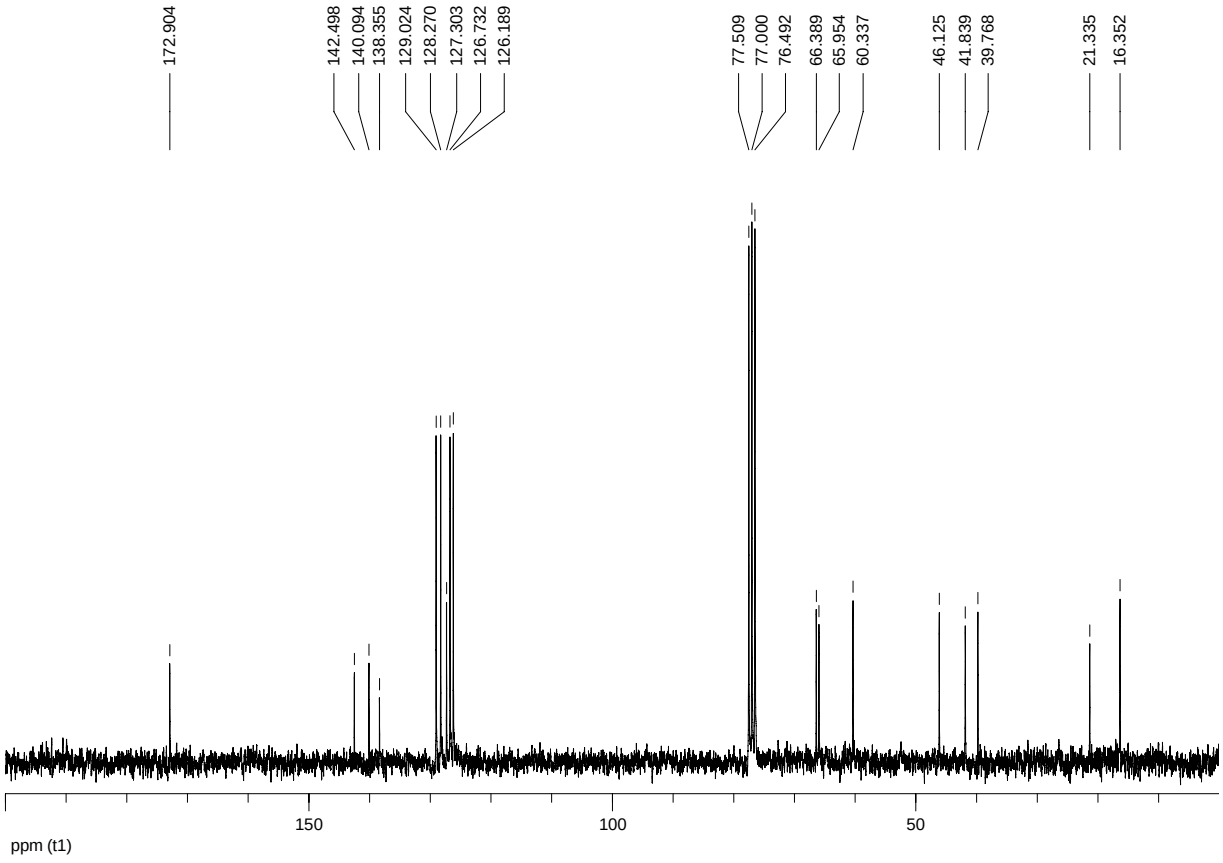


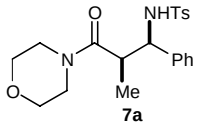
- The relative stereochemistries of the remaining products were assigned by analogy.

NMR Spectra of New Compounds

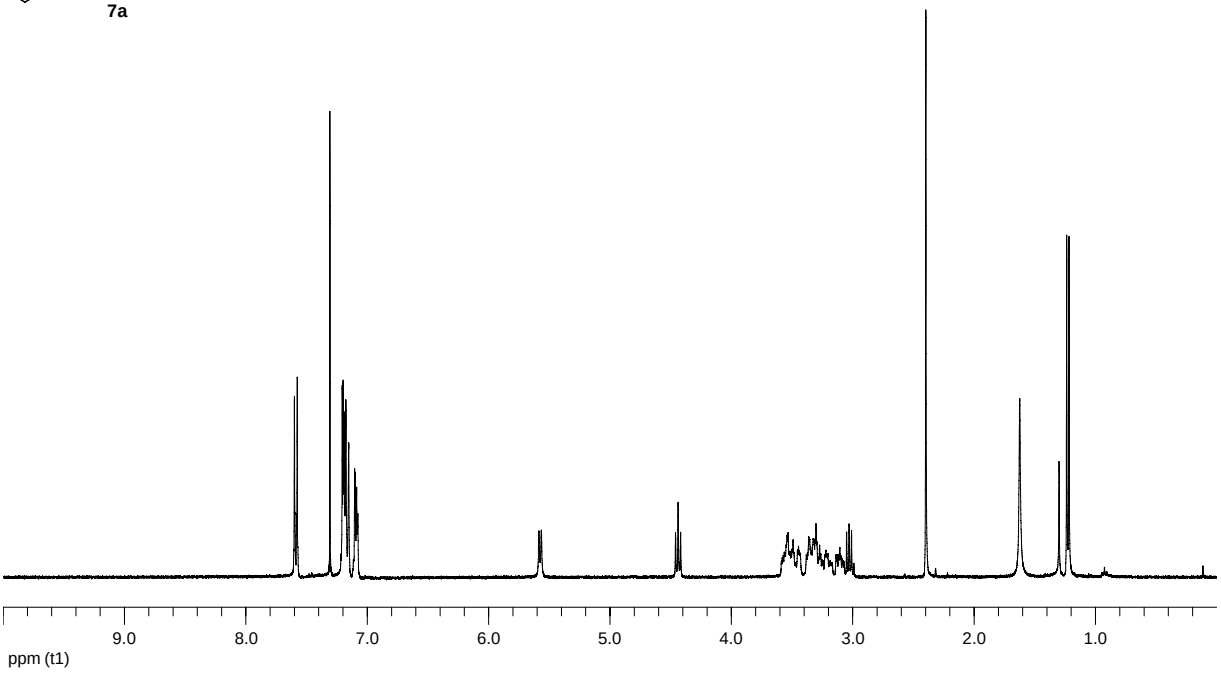


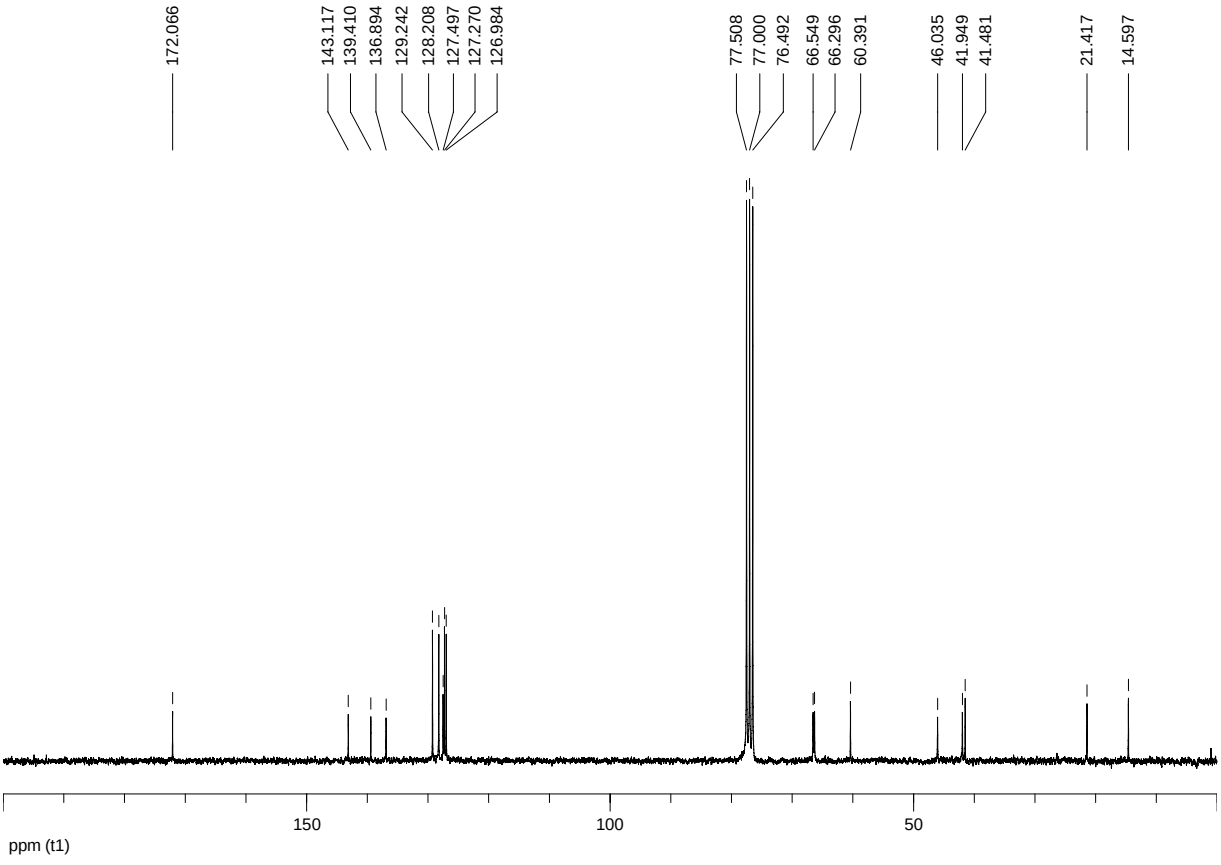
6a

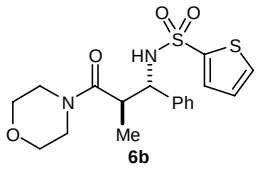



O
NHTs
N
Ph
O
Me

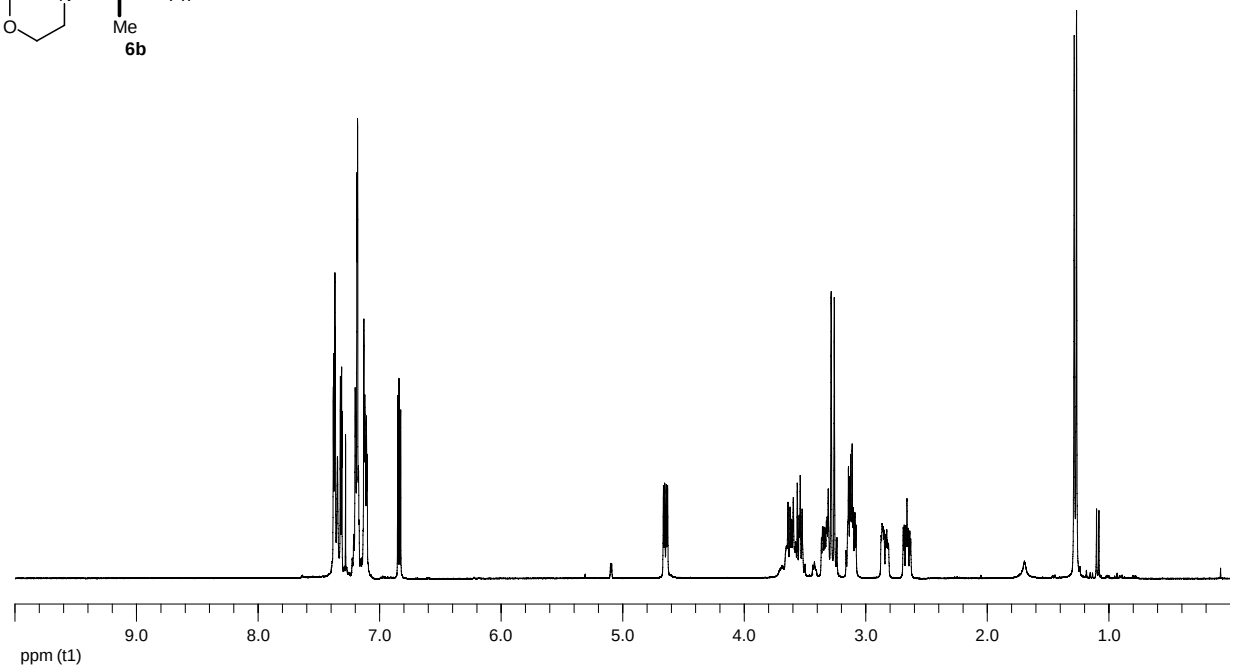
7a

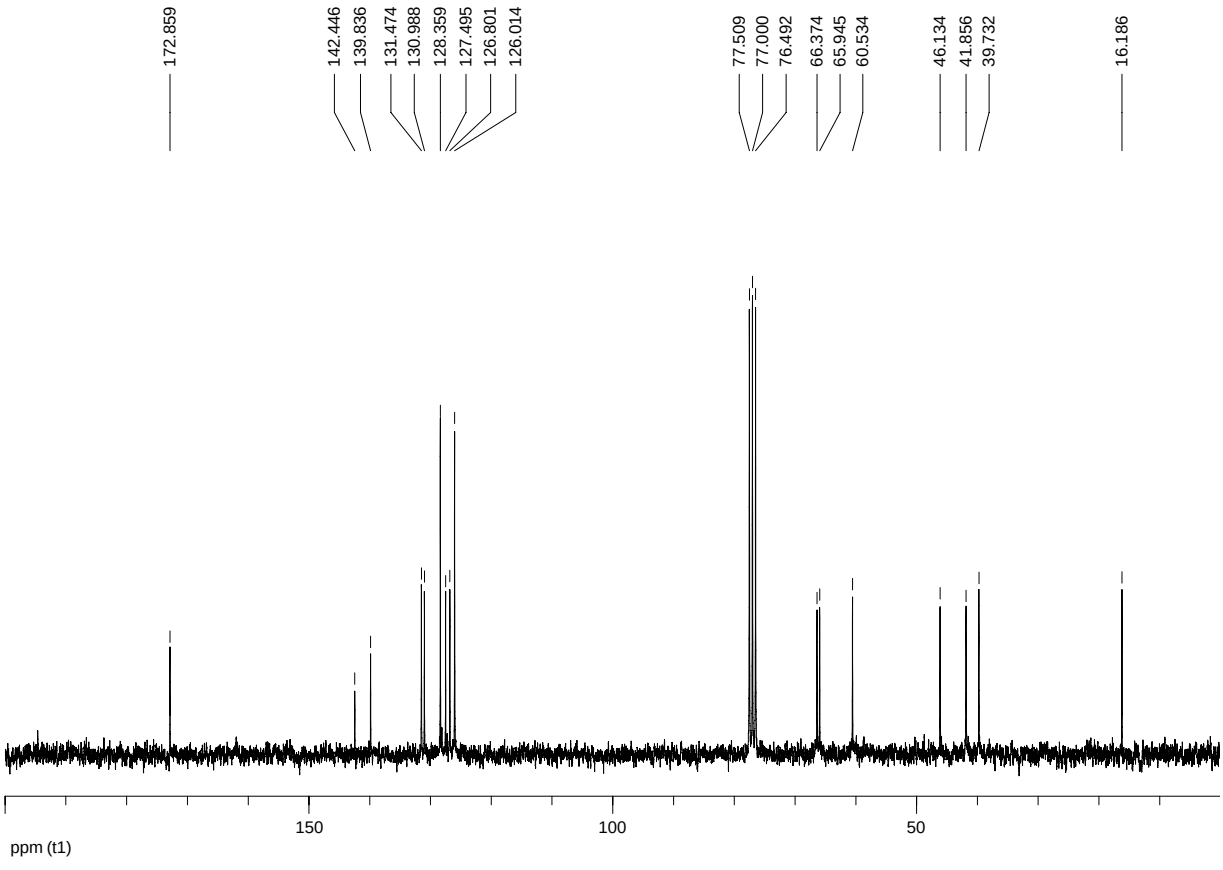

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

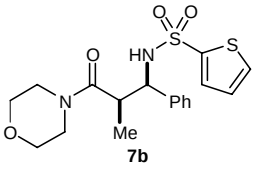

172.066
143.117
139.410
136.894
129.242
128.208
127.497
127.270
126.984
77.508
77.000
76.492
66.549
66.296
60.391
46.035
41.949
41.481
21.417
14.597
150
100
50
ppm (t1)


O
O
S
HN
S
O
N
Ph
Me
O

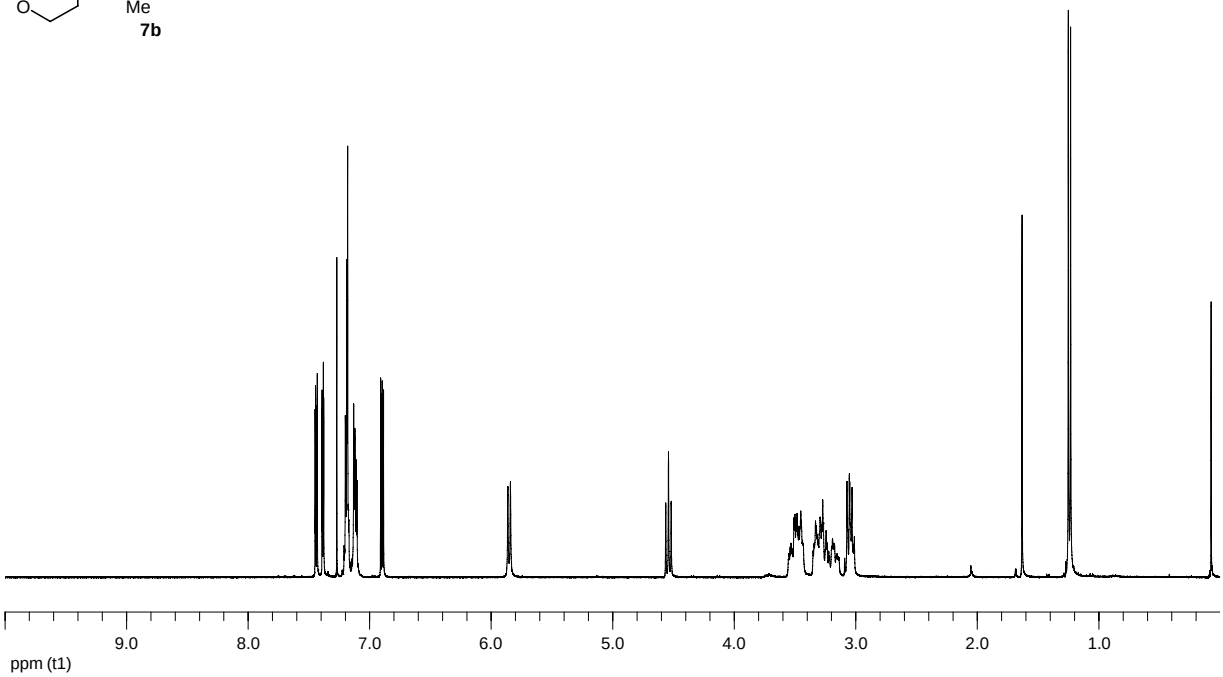
6b

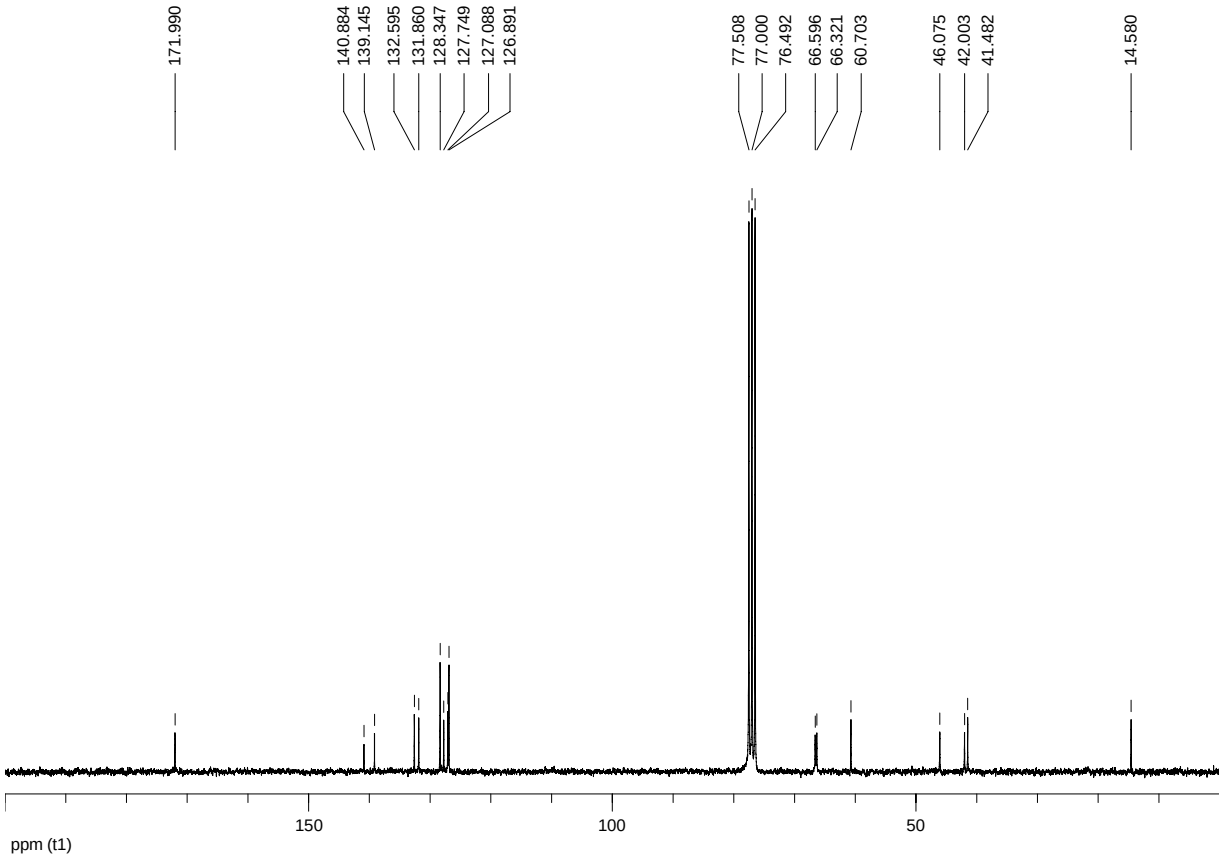

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

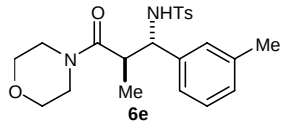

172.859
142.446
139.836
131.474
130.988
128.359
127.495
126.801
126.014
77.509
77.000
76.492
66.374
65.945
60.534
46.134
41.856
39.732
16.186
150
100
50
ppm (t1)


O
O
S
HN
S
O
N
Ph
Me
O

7b

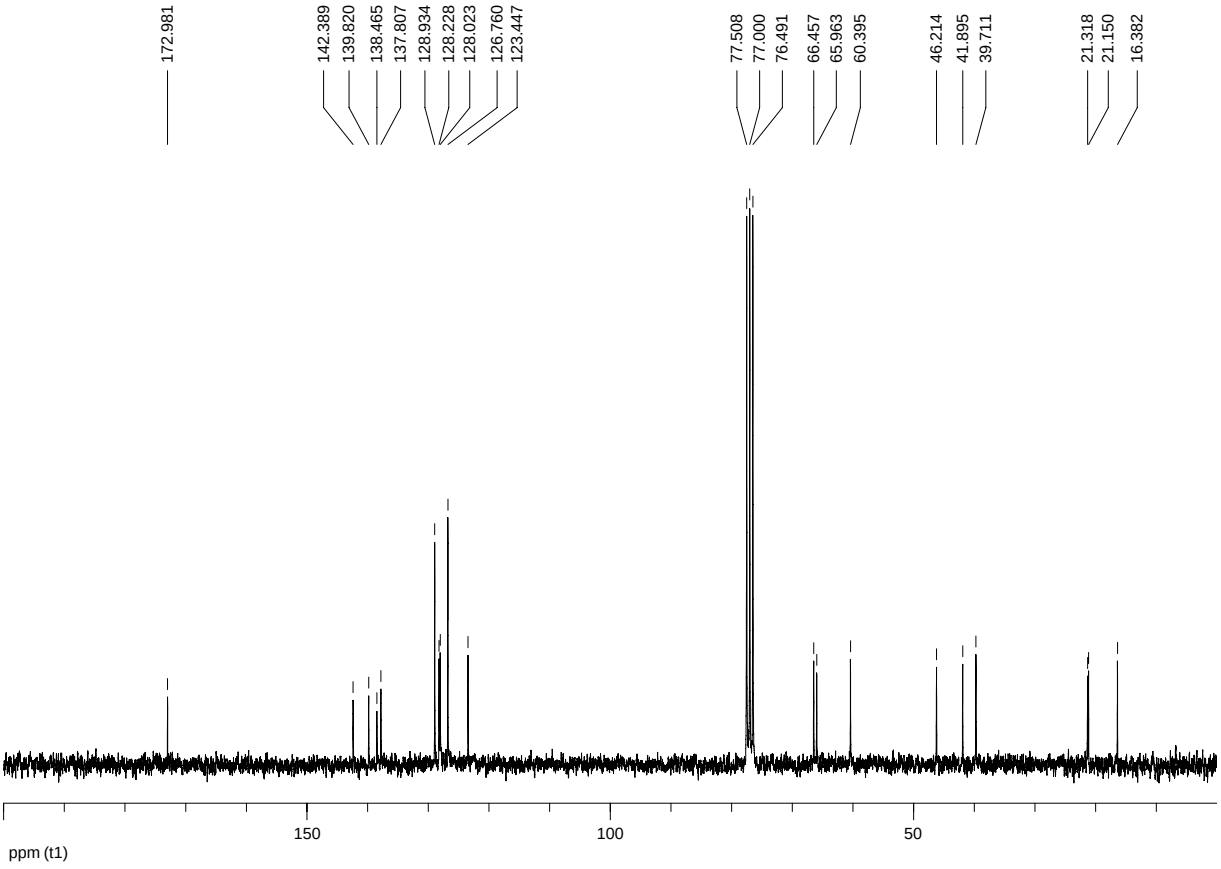

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

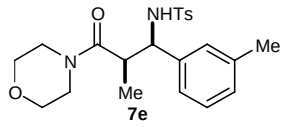

171.990
140.884
139.145
132.595
131.860
128.347
127.749
127.088
126.891
77.508
77.000
76.492
66.596
66.321
60.703
46.075
42.003
41.482
14.580
150
100
50
ppm (t1)


O
NHTs
N
Me
O
Me

6e

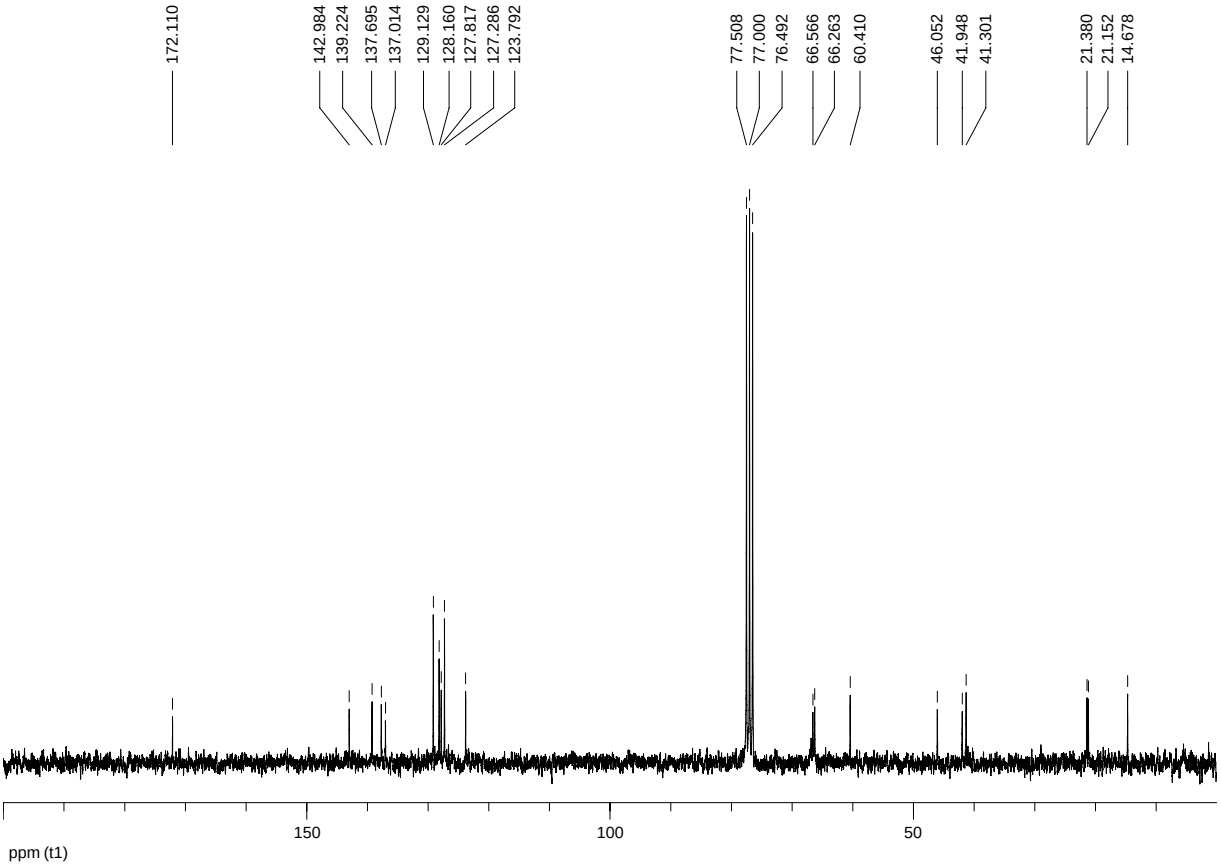
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

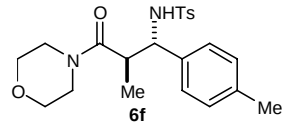

172.981
142.389
139.820
138.465
137.807
128.934
128.228
128.023
126.760
123.447
77.508
77.000
76.491
66.457
65.963
60.395
46.214
41.895
39.711
21.318
21.150
16.382
150
100
50
ppm (t1)


O
NHTs
N
Me
O
Me

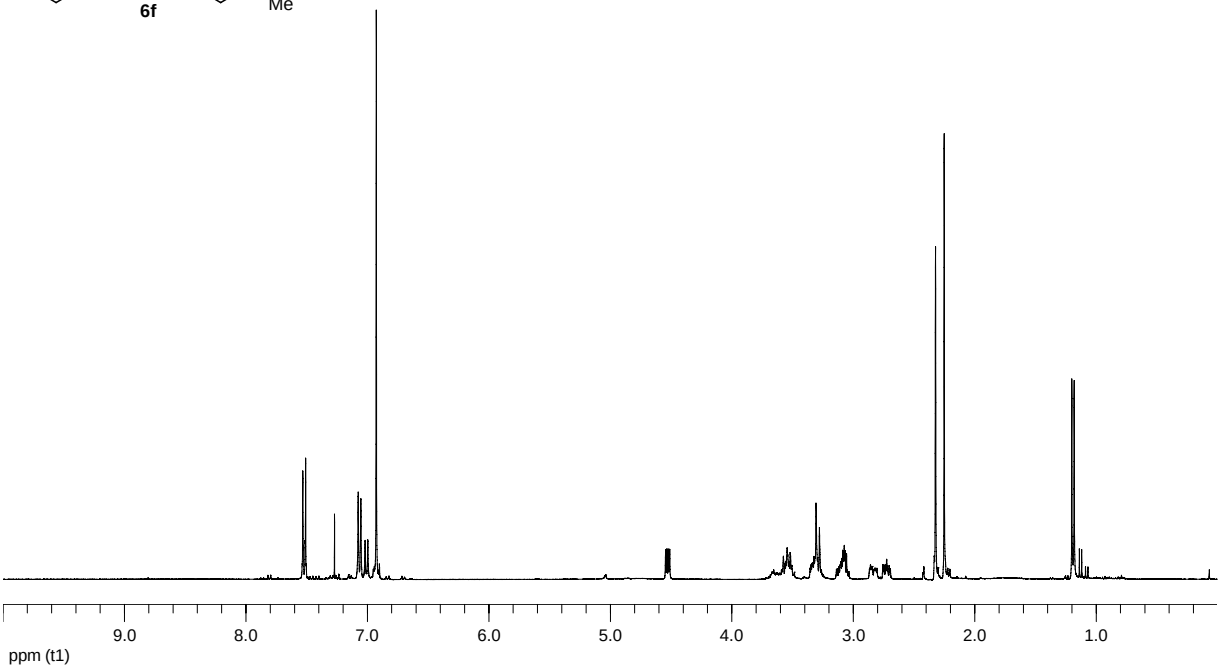
7e

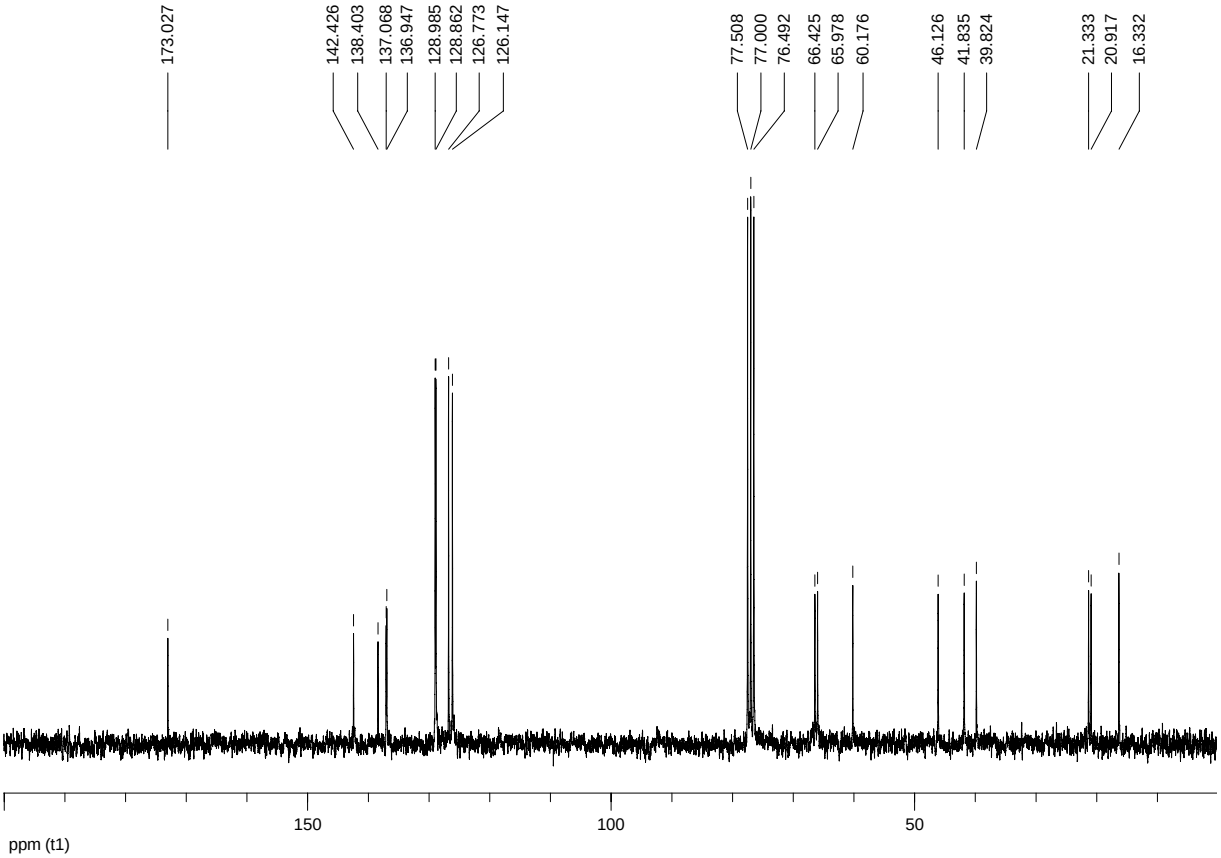
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

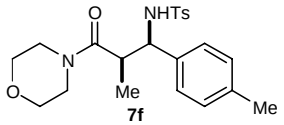

172.110
142.984
139.224
137.695
137.014
129.129
128.160
127.817
127.286
123.792
77.508
77.000
76.492
66.566
66.263
60.410
46.052
41.948
41.301
21.380
21.152
14.678
150
100
50
ppm (t1)


O
NHTs
N
O
Me
Me

6f

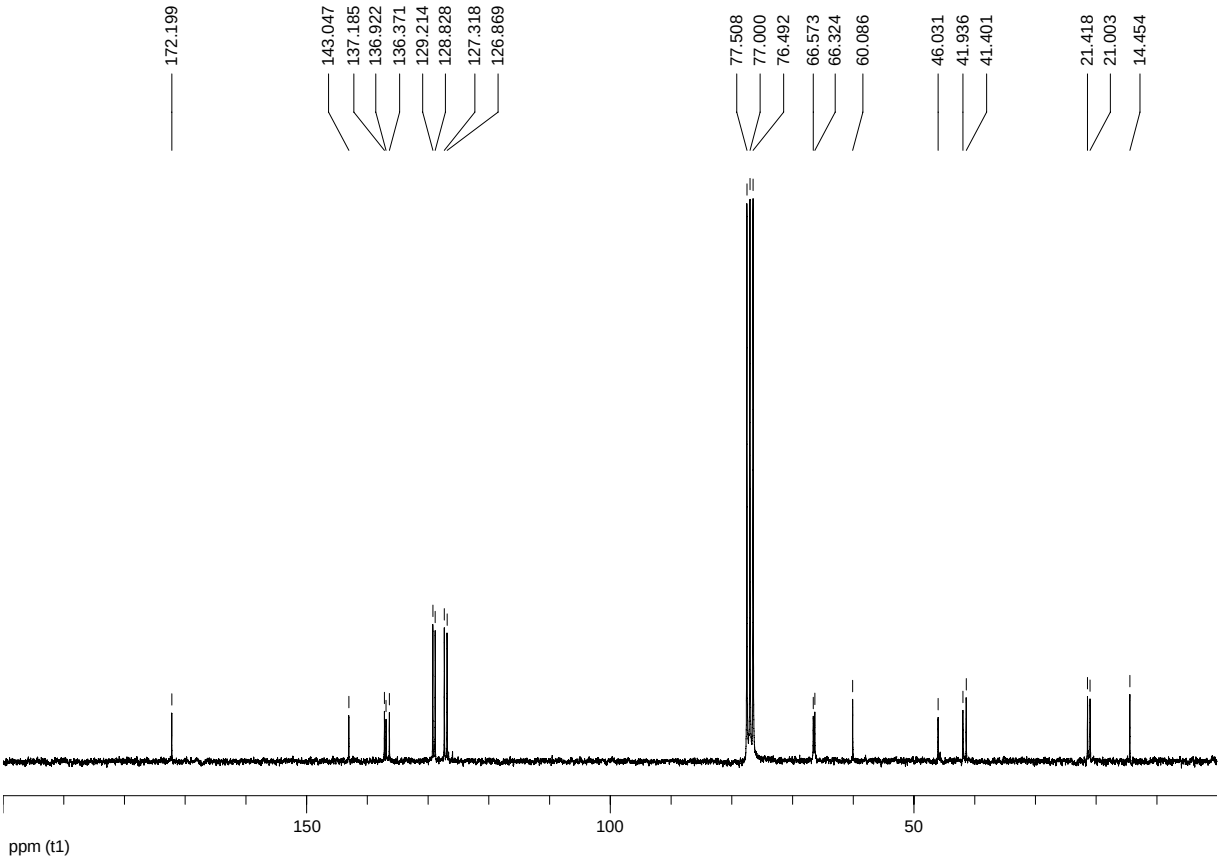

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

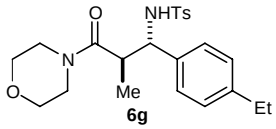

173.027
142.426
138.403
137.068
136.947
128.985
128.862
126.773
126.147
77.508
77.000
76.492
66.425
65.978
60.176
46.126
41.835
39.824
21.333
20.917
16.332
150
100
50
ppm (t1)


O
NHTs
N
O
Me
Me

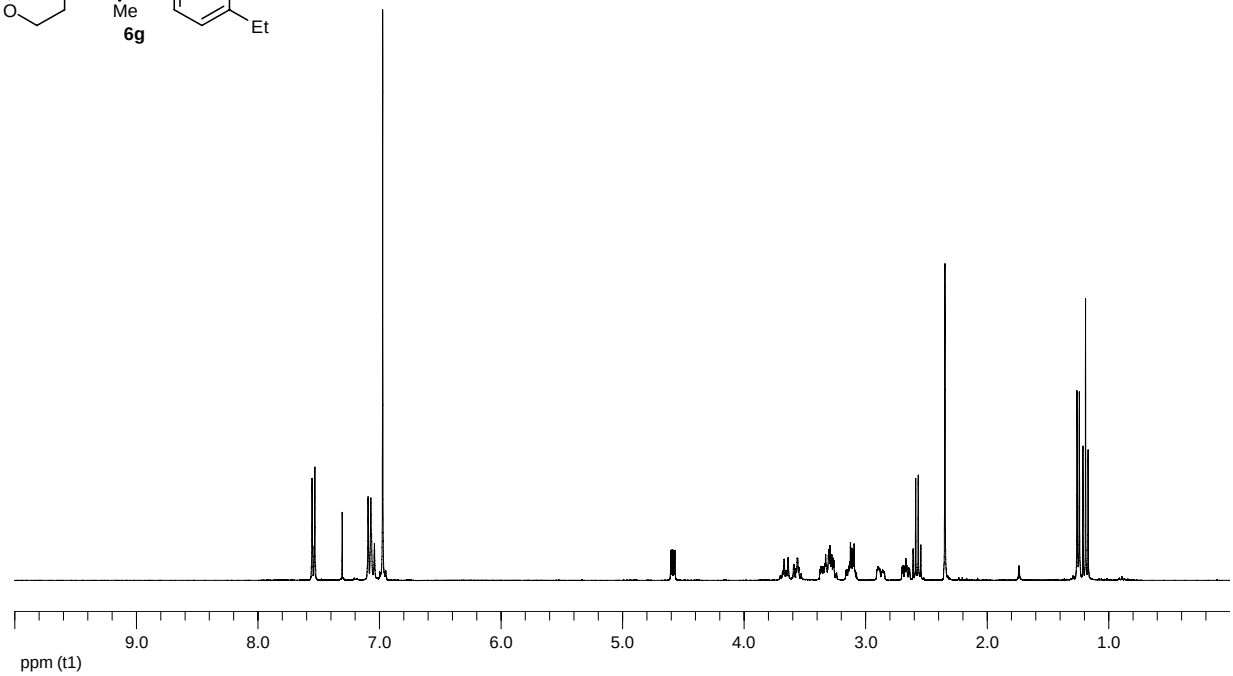
7f

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)


172.199
143.047
137.185
136.922
136.371
129.214
128.828
127.318
126.869
77.508
77.000
76.492
66.573
66.324
60.086
46.031
41.936
41.401
21.418
21.003
14.454
150
100
50
ppm (t1)


O
NHTs
N
O
Me
Et

6g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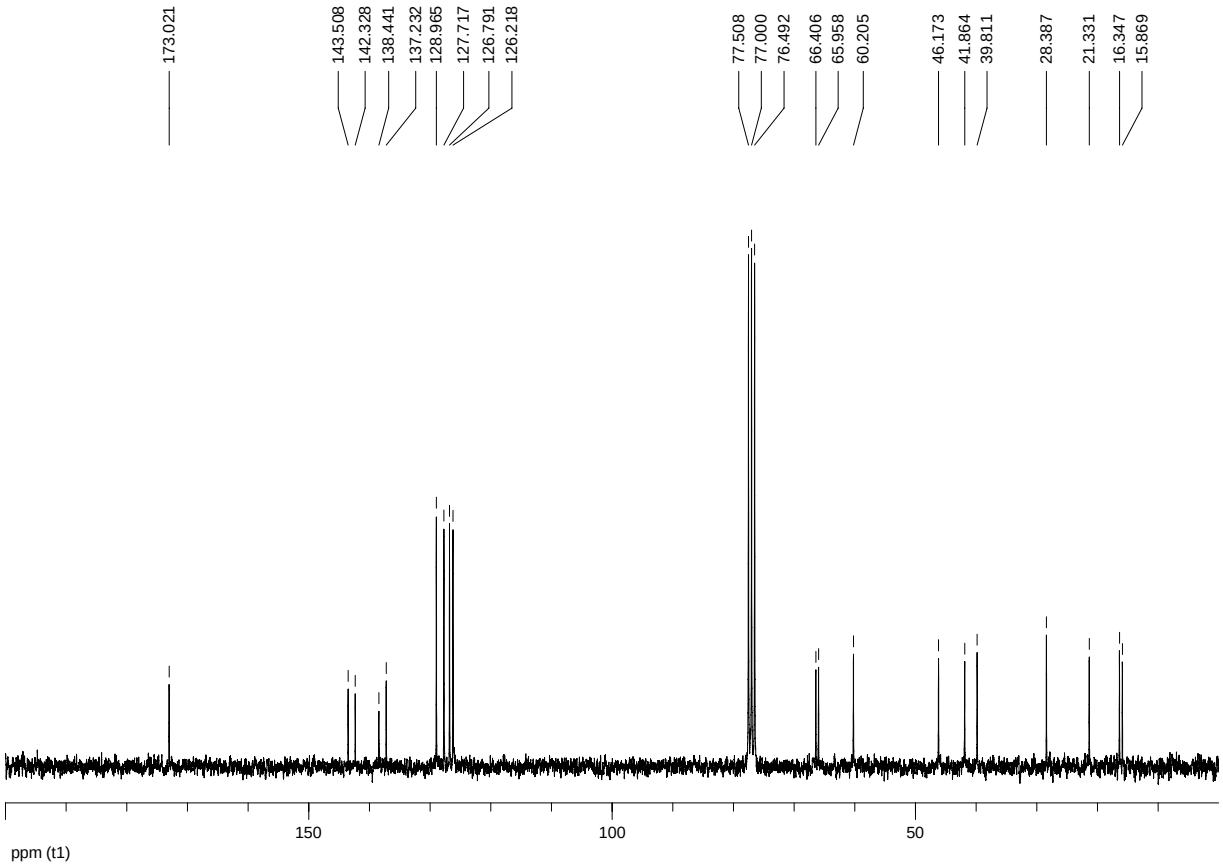
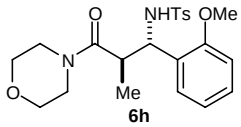
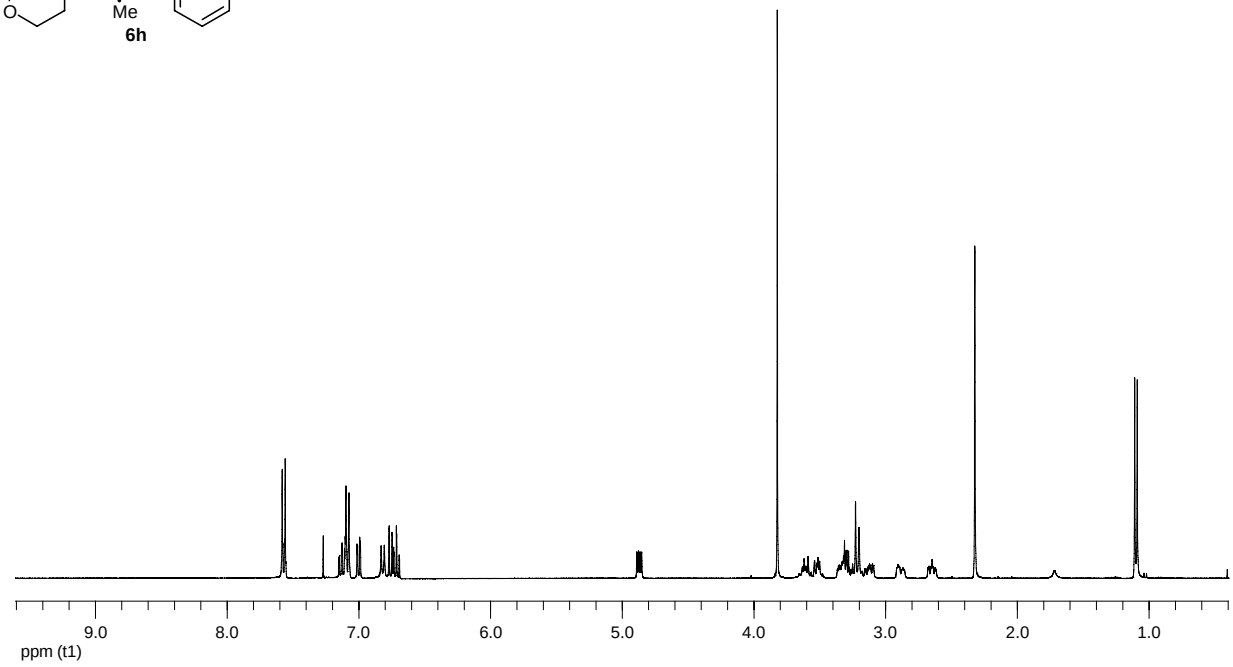
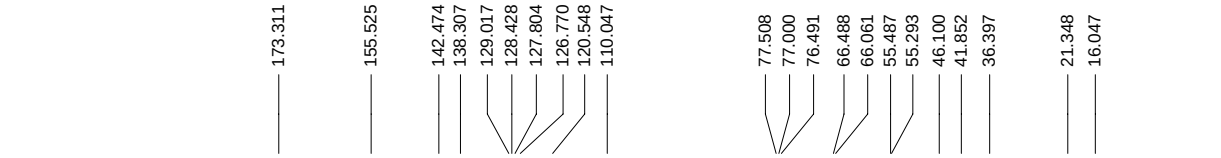
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

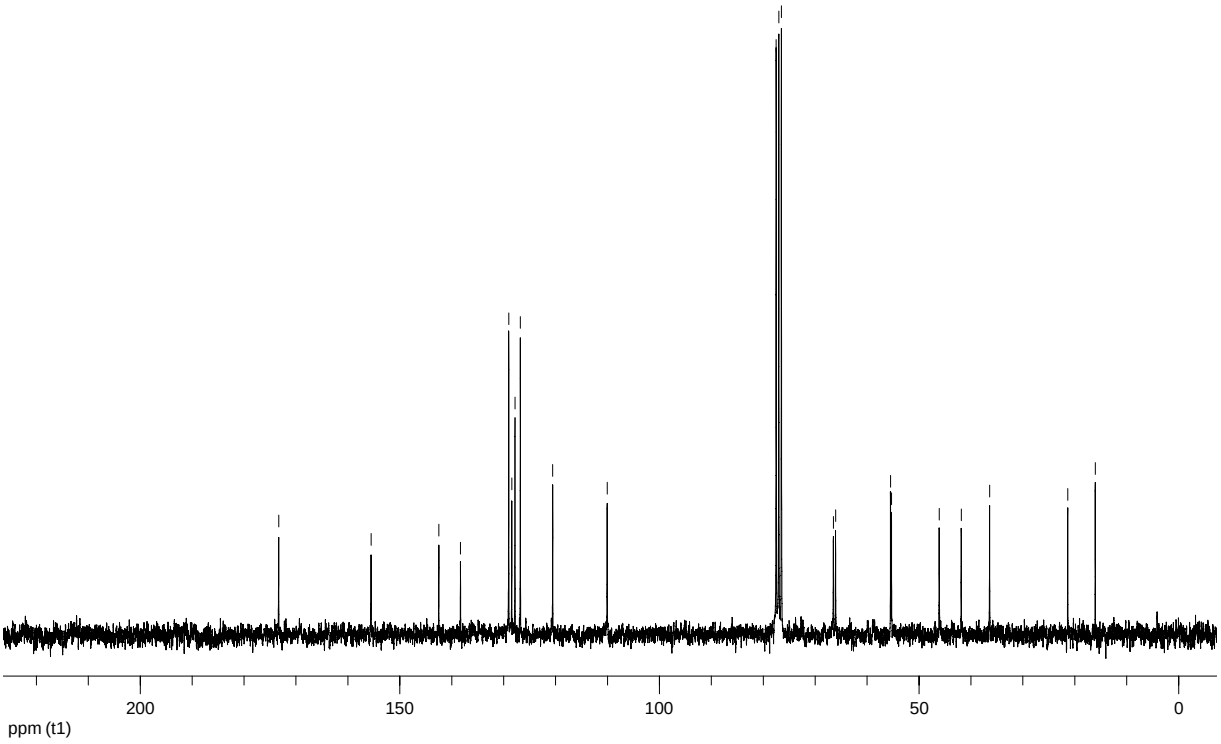

173.021
143.508
142.328
138.441
137.232
128.965
127.717
126.791
126.218
77.508
77.000
76.492
66.406
65.958
60.205
46.173
41.864
39.811
28.387
21.331
16.347
15.869
150
100
50
ppm (t1)

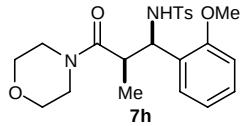

O
NHTs
OMe
N
O
Me

6h


9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

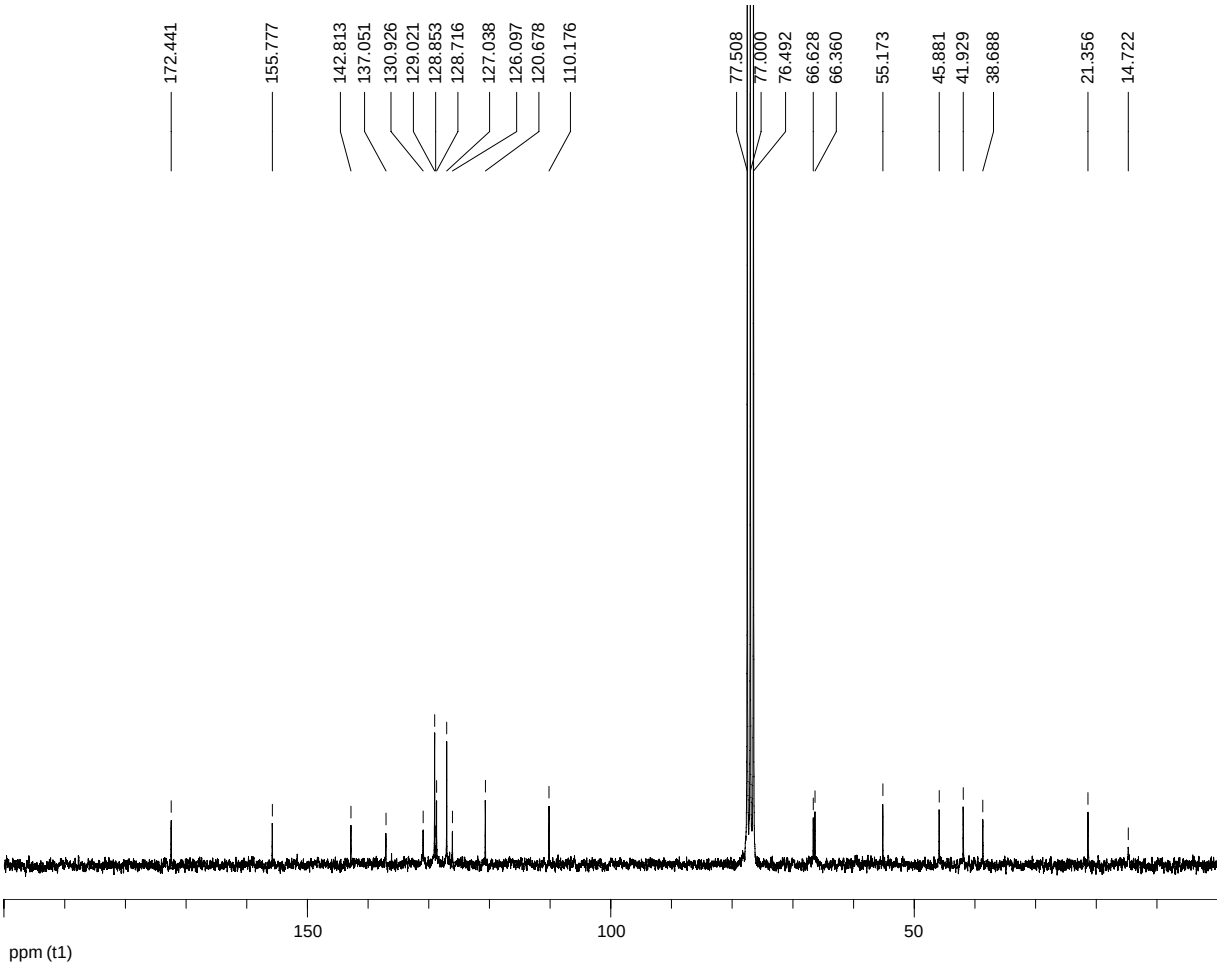

173.311
155.525
142.474
138.307
129.017
128.428
127.804
126.770
120.548
110.047
77.508
77.000
76.491
66.488
66.061
55.487
55.293
46.100
41.852
36.397
21.348
16.047


200
150
100
50
0
ppm (t1)


O
NHTs
OMe
N
O
Me

7h

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)


172.441
155.777
142.813
137.051
130.926
129.021
128.853
128.716
127.038
126.097
120.678
110.176
77.508
77.000
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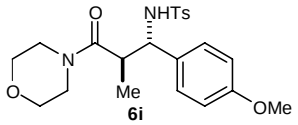
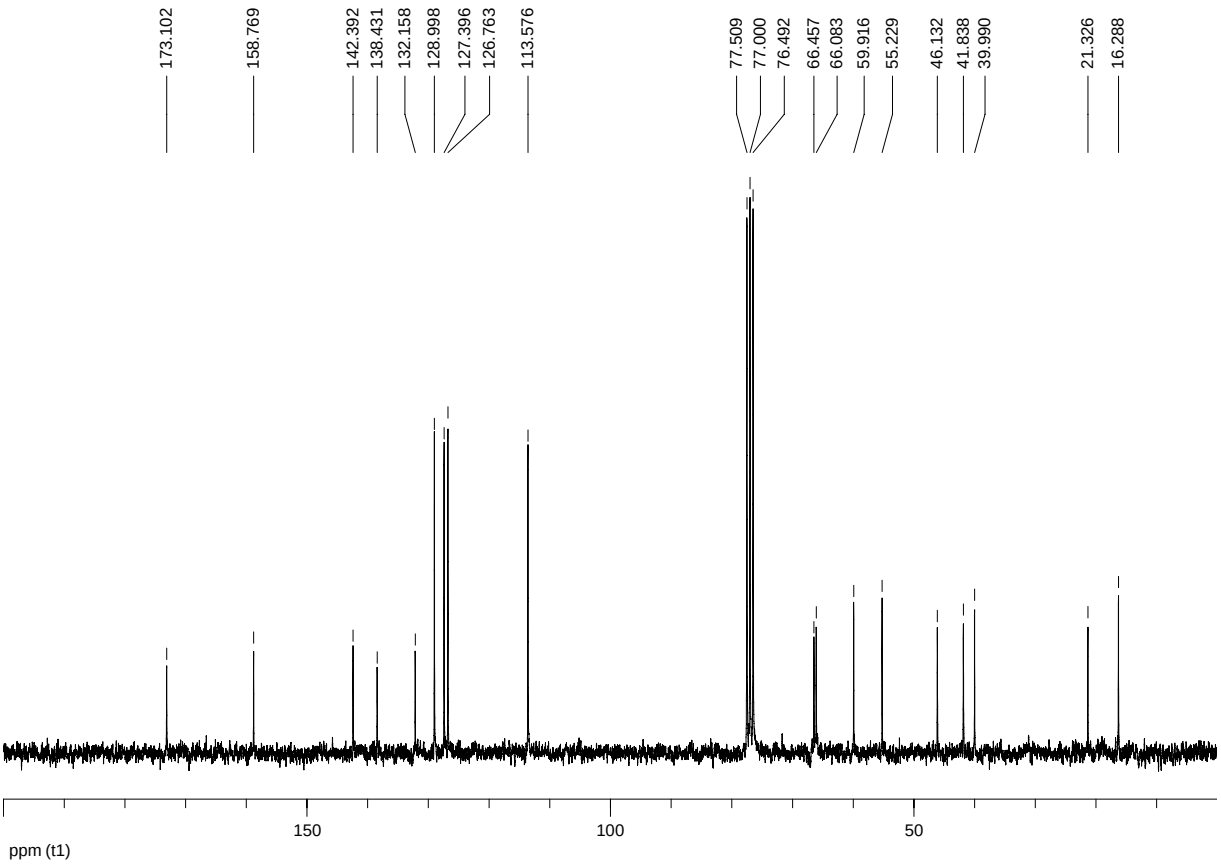
21.356
14.722
150
100
50
ppm (t1)


O
NHTs
N
O
Me
OMe

6i

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)


173.102
158.769
142.392
138.431
132.158
128.998
127.396
126.763
113.576
77.509
77.000
76.492
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55.229
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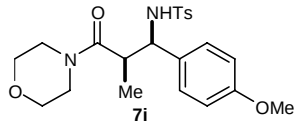
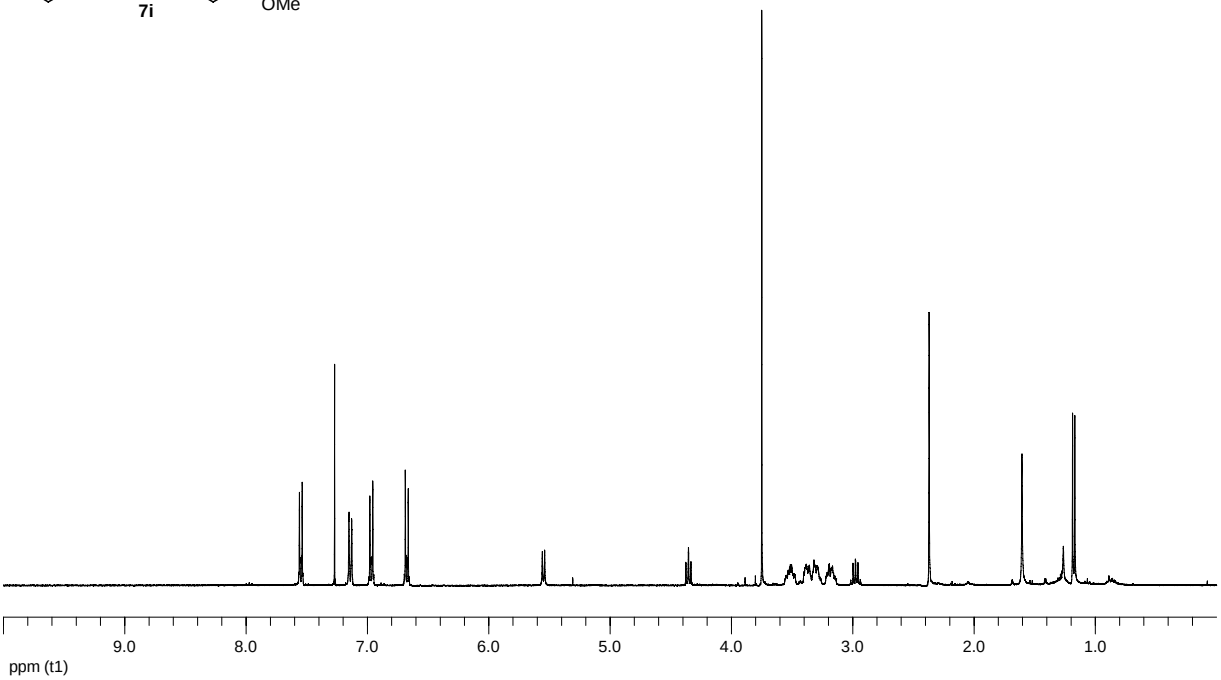
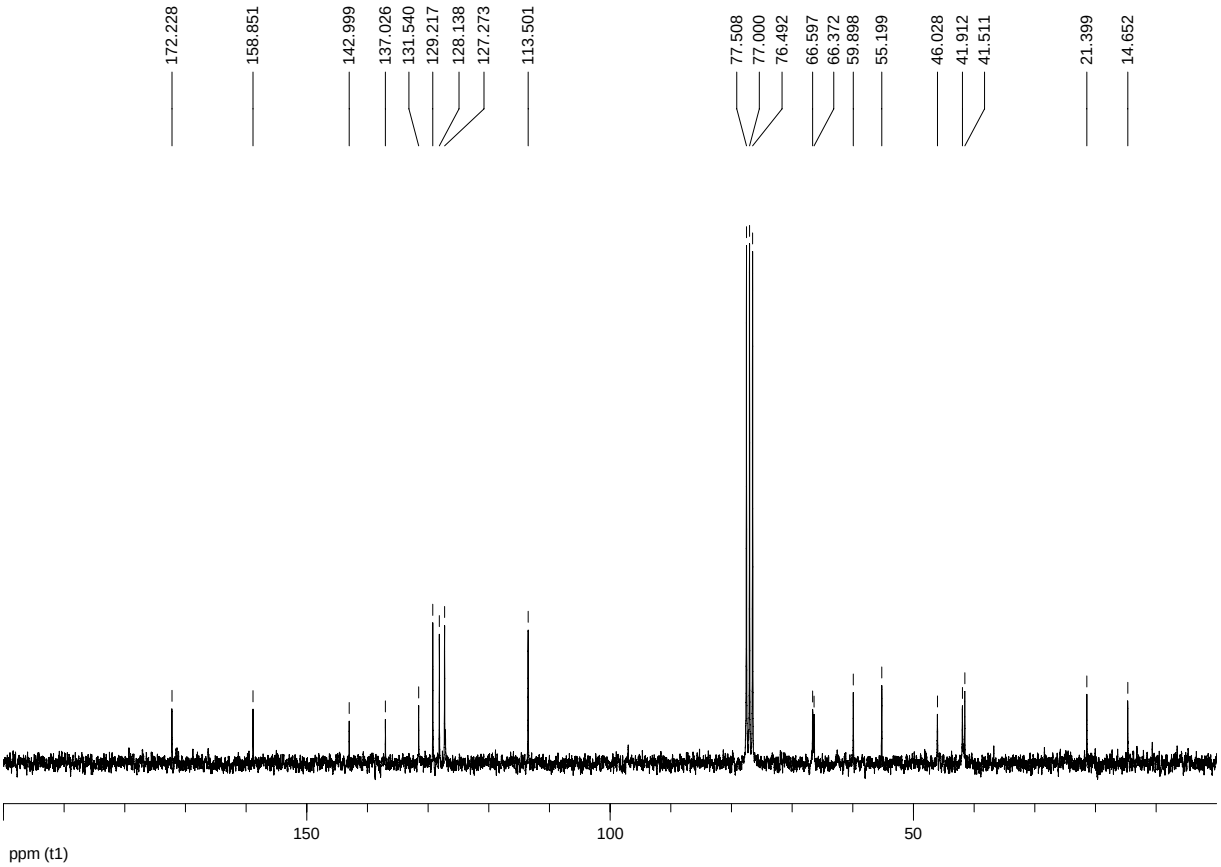
21.326
16.288
150
100
50
ppm (t1)


O
NHTs
N
O
Me
OMe

7i


9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)


172.228
158.851
142.999
137.026
131.540
129.217
128.138
127.273
113.501
77.508
77.000
76.492
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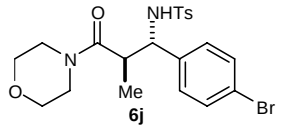
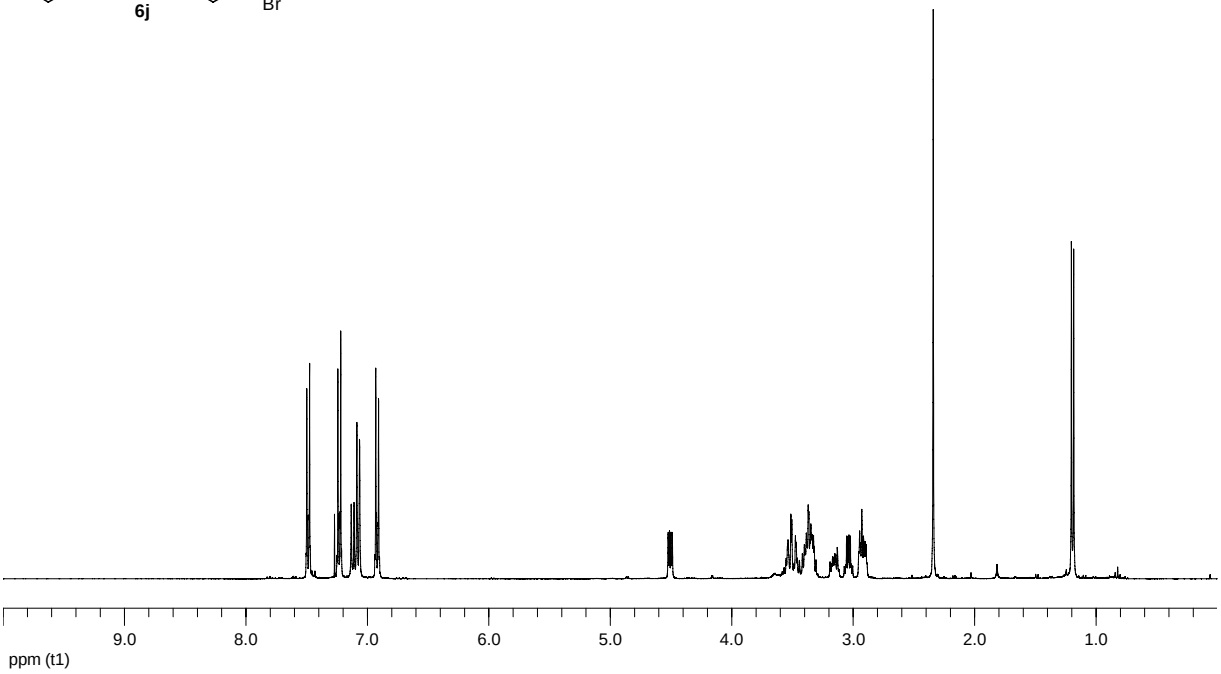
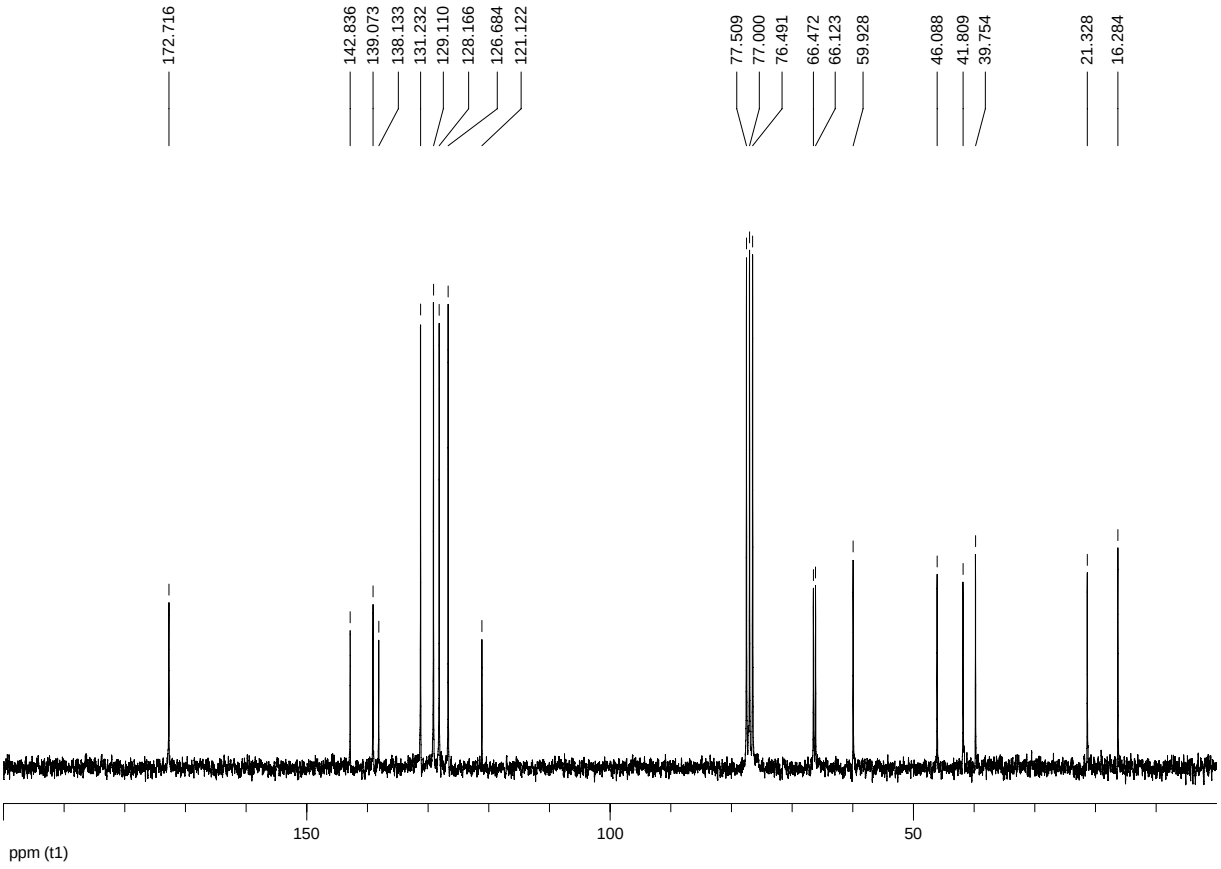
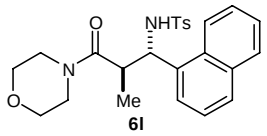
21.399
14.652
150
100
50
ppm (t1)


O
NHTs
N
O
Me
Br

6j

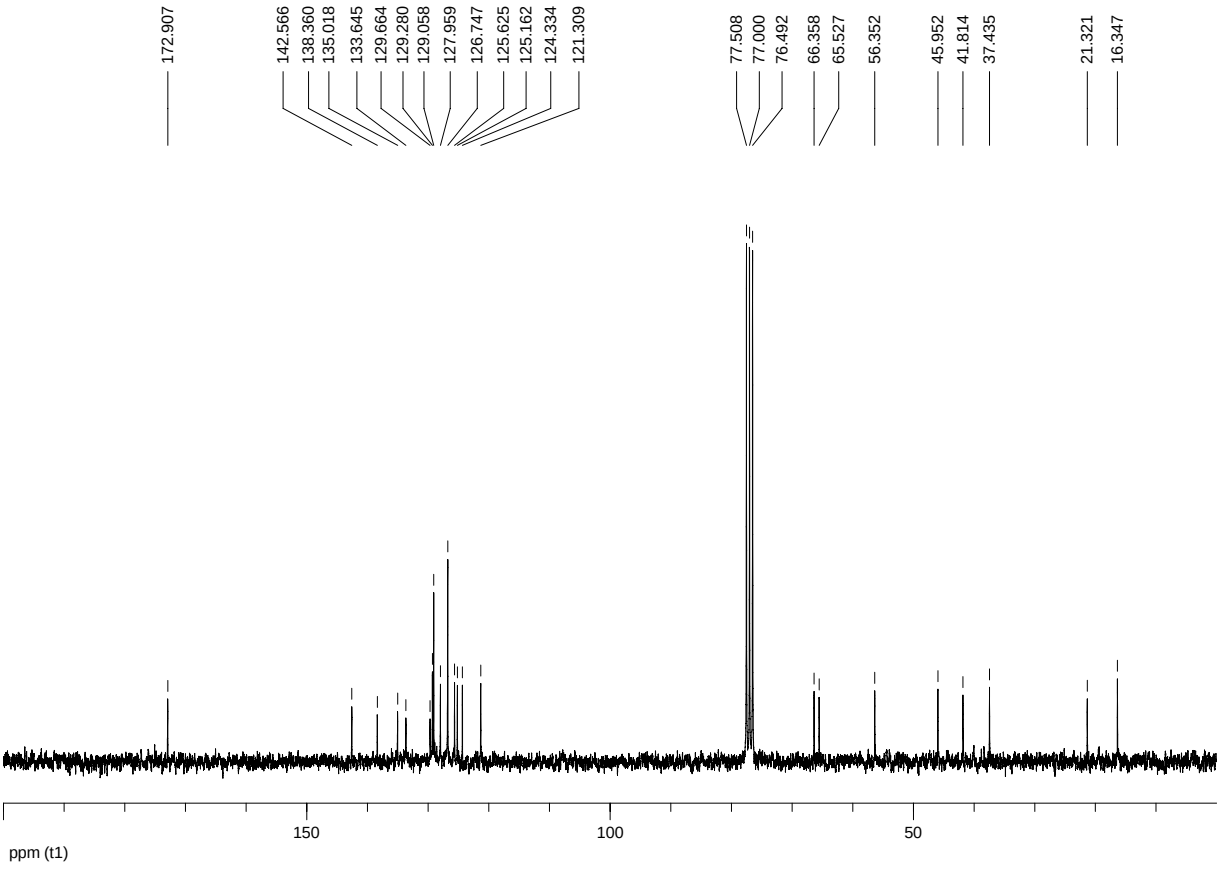

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

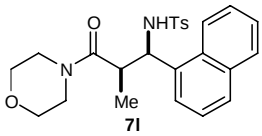

172.716
142.836
139.073
138.133
131.232
129.110
128.166
126.684
121.122
77.509
77.000
76.491
66.472
66.123
59.928
46.088
41.809
39.754
21.328
16.284
150
100
50
ppm (t1)


O
NHTs
N
O
Me

6l

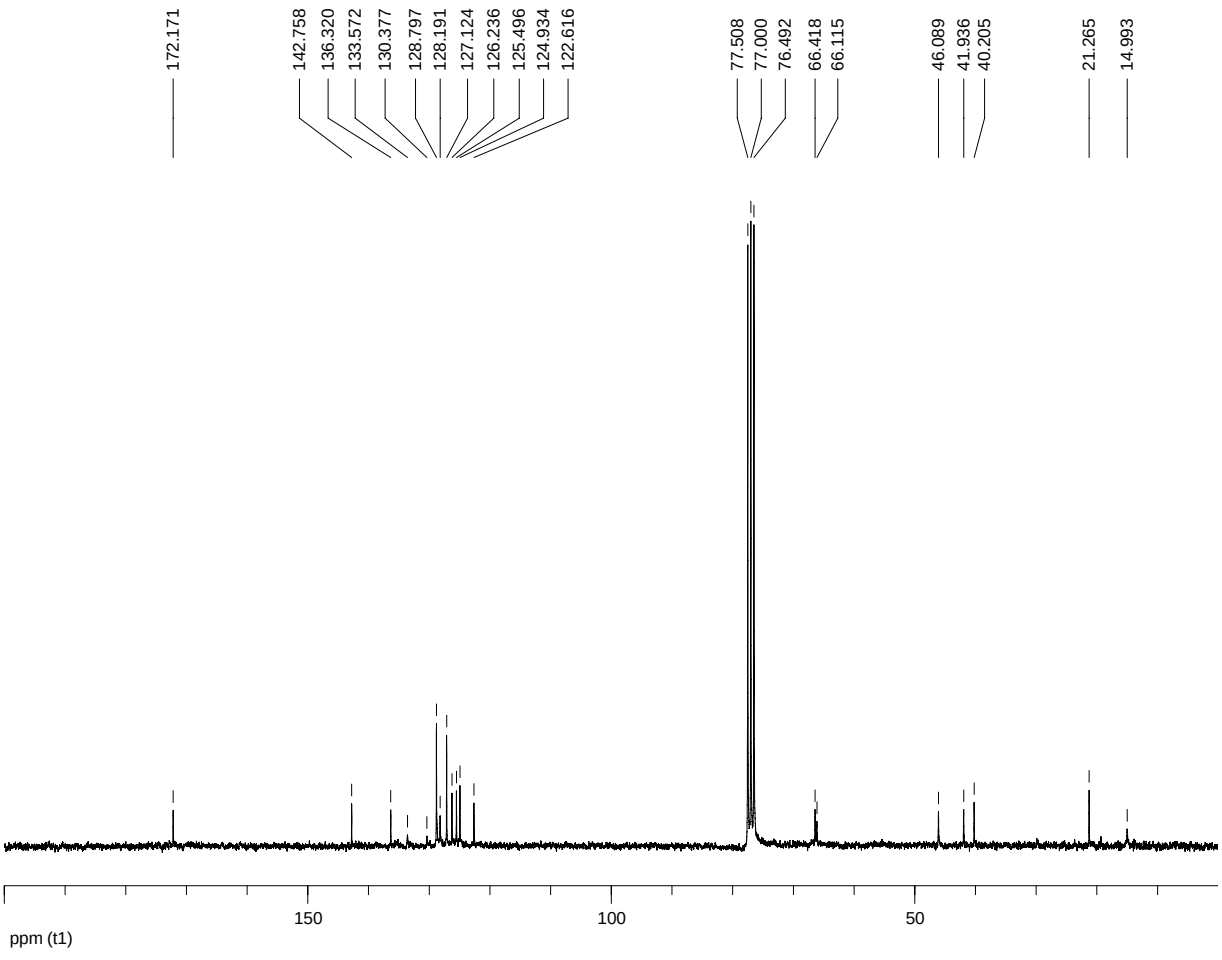
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

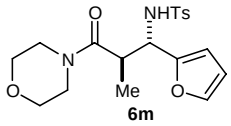

172.907
142.566
138.360
135.018
133.645
129.664
129.280
129.058
127.959
126.747
125.625
125.162
124.334
121.309
77.508
77.000
76.492
66.358
65.527
56.352
45.952
41.814
37.435
21.321
16.347
150
100
50
ppm (t1)


O
NHTs
N
O
Me

7l

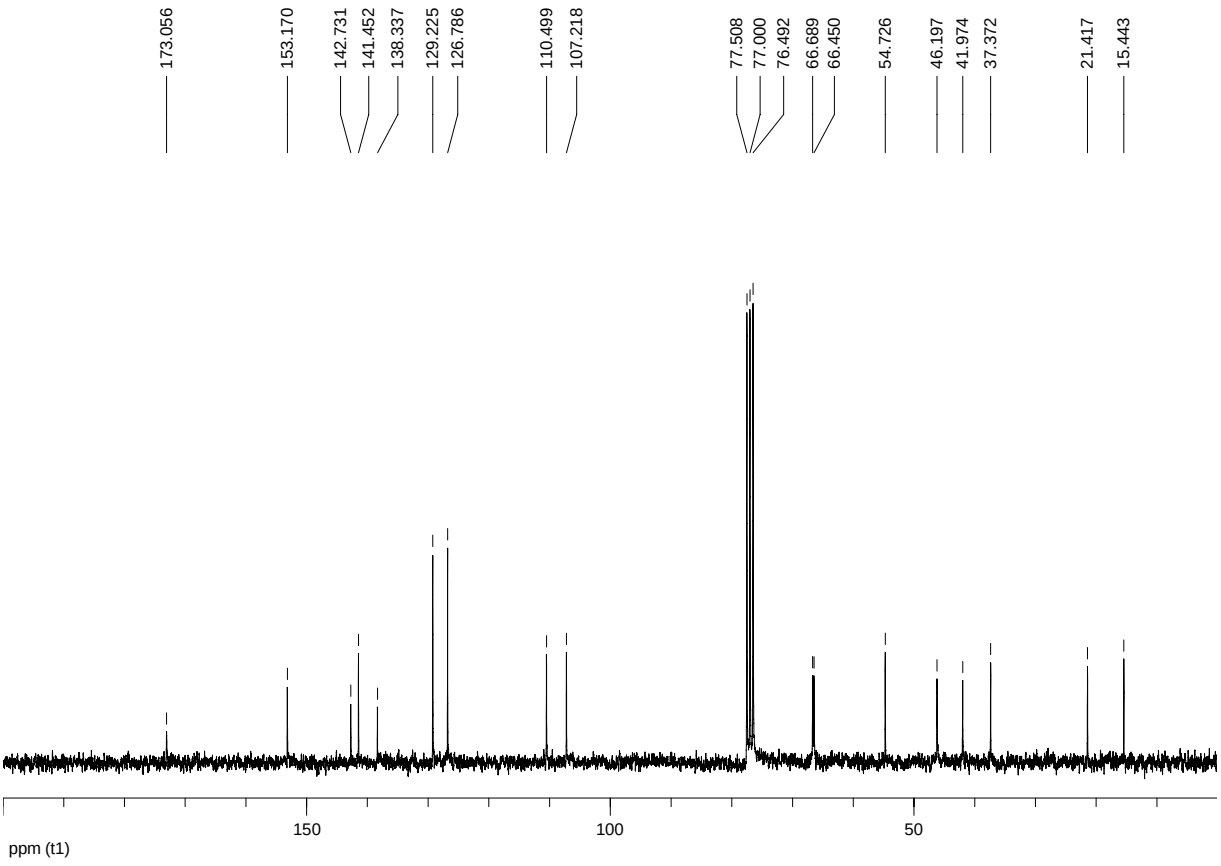
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

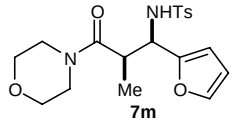

172.171
142.758
136.320
133.572
130.377
128.797
128.191
127.124
126.236
125.496
124.934
122.616
77.508
77.000
76.492
66.418
66.115
46.089
41.936
40.205
21.265
14.993
150
100
50
ppm (t1)


O
NHTs
N
Me
O
O

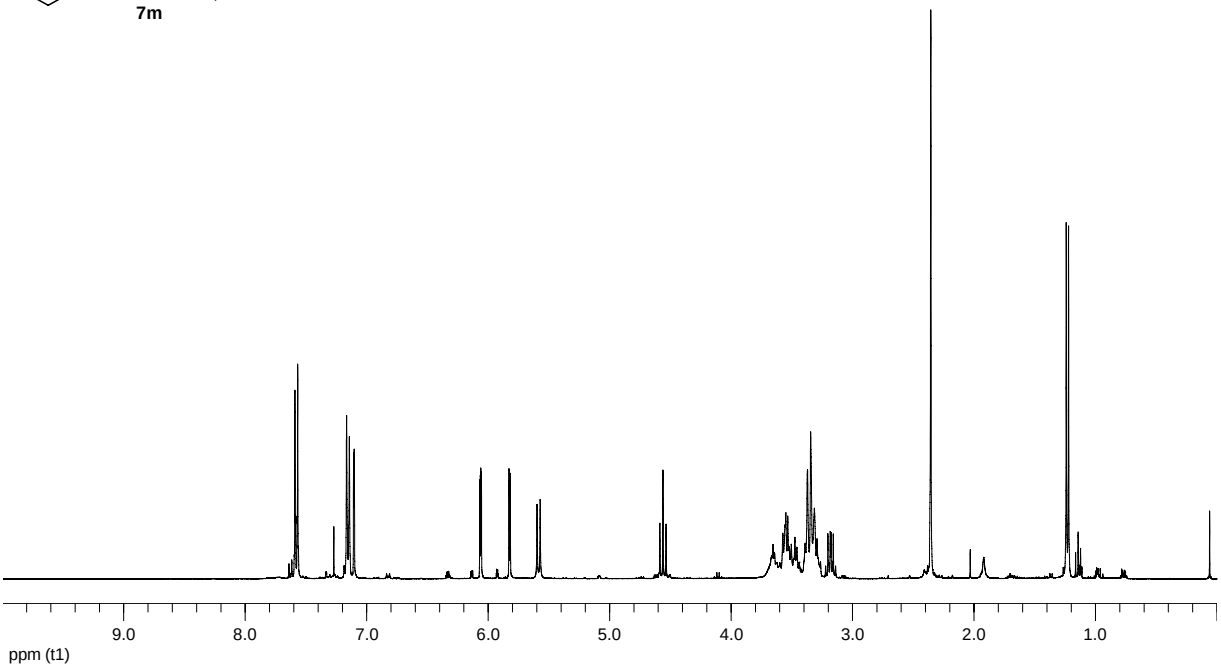
6m

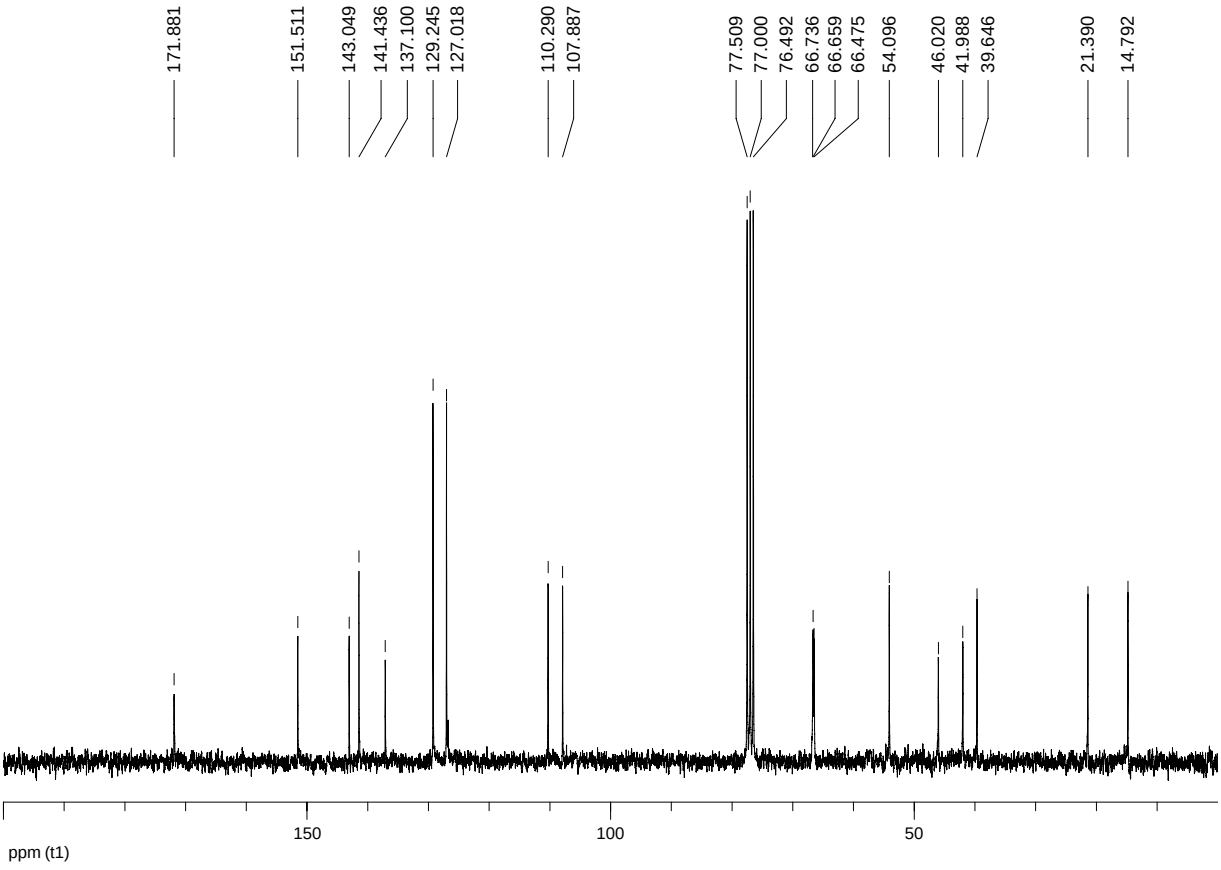
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)


173.056
153.170
142.731
141.452
138.337
129.225
126.786
110.499
107.218
77.508
77.000
76.492
66.689
66.450
54.726
46.197
41.974
37.372
21.417
15.443
150
100
50
ppm (t1)


O
NHTs
N
Me
O
O

7m


9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)


171.881
151.511
143.049
141.436
137.100
129.245
127.018
110.290
107.887
77.509
77.000
76.492
66.736
66.659
66.475
54.096
46.020
41.988
39.646
21.390
14.792
150
100
50
ppm (t1)