

First Direct Osmium-Catalysed Ketamination of Alkenes

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Supporting Information

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1 General Procedures

General procedure A for ketamination of olefins:

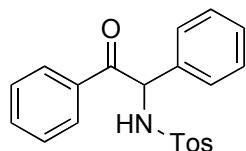
A portion of potassium osmate $K_2[OsO_2(OH)_4]$ (0.02 mmol) is added to 20 mL of a mixture of distilled water and *tert*-butanol (1/1, v/v) and stirring is applied until complete dissolution of the solid. The respective chloramine sodium salt (3.0 mmol) is added in one portion and the resulting solution is warmed to 30°C to 35°C with stirring. The respective olefin (1.0 mmol) is added to the reaction mixture and stirring is continued for 2d. The reaction mixture is cooled to room temperature, treated with an aqueous solution of sodium bisulfite and extracted three times with ethyl acetate. Drying of the organic phases over $MgSO_4$ and removal of the solvents under reduced pressure leaves an oily to solid residue which is analysed by nmr. Purification by column chromatography (silica gel, hexanes/ethyl acetate, 4/1, v/v) gave the 2-amino ketones in analytically pure form.

General procedure B for osmium-catalysed oxidation of amino alcohols to amino ketones:

A portion of potassium osmate $K_2[OsO_2(OH)_4]$ (0.02 mmol) is added to 10 mL of a mixture of distilled water and *tert*-butanol (1/1, v/v) and stirring is applied until complete dissolution of the solid. Chloramine-T or NMO (2.2 mmol) is added in one portion and the resulting solution is kept stirring at room temperature. The respective amino alcohol (1.0 mmol) is added to the reaction mixture and stirring is continued for a period between 8 to 48h with tlc control. The reaction mixture is treated with an aqueous solution of sodium bisulfite and extracted three times with ethyl acetate. Drying of the organic phases over $MgSO_4$ and removal of the solvents under reduced pressure leaves an oily to solid residue which is analysed by nmr. Purification by column chromatography (silica gel, hexanes/ethyl acetate, 4/1, v/v) gave the 2-amino ketones in analytically pure form.

2 Product Characterisation

2-(*N*-Tosylamino)-1,2-diphenylethanone^[1]



Synthesised from (*E*)-stilbene and chloramine-T according to the general procedure A.

Synthesised in enantiomerically pure form from (1*S*,2*S*)-1,2-diphenyl-2-tosylamino-ethanol and NMO according to the general procedure B.

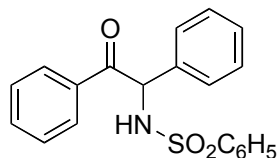
¹H nmr (CDCl₃, 400 MHz): δ = 2.30 (s, 3H), 5.99 (d, *J* = 7.3 Hz, 1H), 6.22 (d, *J* = 7.3 Hz, 1H), 7.06 (d, *J* = 8.6 Hz, 1H), 7.06 (d, *J* = 8.5 Hz, 1H), 7.14-7.19 (m, 5H), 7.30-7.39 (m, 2H), 7.47-7.55 (m, 3H), 7.79 (d, *J* = 8.6 Hz, 1H), 7.80 (d, *J* = 8.5 Hz, 1H).

¹³C nmr (CDCl₃, 100 MHz): δ = 21.35, 61.70, 126.95, 128.12, 128.44, 128.66, 128.92, 129.06, 129.32, 133.86, 133.90, 135.71, 137.46, 143.09, 194.59.

HRMS calcd for C₂₁H₁₉NO₃S: 365.1086. Found: 365.1088.

HPLC: Chiralcel-OD, n-hexane/2-propanol, 95/5, 0.5 mL/min, retention times 49 and 64 min.

2-(*N*-Phenylsulfonylamino)-1,2-diphenylethanone^[2]



Synthesised from (*E*)-stilbene and chloramine-B according to the general procedure A.

Synthesised in enantiomerically pure form from (1*S*,2*S*)-1,2-diphenyl-2-(phenylsulfonylamino)-ethanol and NMO according to the general procedure B.

^1H nmr (CDCl_3 , 300 MHz): δ = 5.95 (d, J = 7.3 Hz, 1H), 6.19 (d, J = 7.3 Hz, 1H), 7.07-7.09 (m, 5H), 7.15-7.22 (m, 2H), 7.24-7.32 (m, 3H), 7.38-7.45 (m, 1H), 7.54-7.58 (m, 2H), 7.71-7.75 (m, 2H).

^1H nmr (DMSO-d_6 , 300 MHz): δ = 4.44 (d, J = 5.5 Hz, 1H), 4.65 (d, J = 5.5 Hz, 1H), 6.99-7.14 (m, 10H), 7.21-7.36 (m, 2H), 7.42 (d, J = 7.2 Hz, 2H), 8.02 (d, J = 8.7 Hz, 1H).

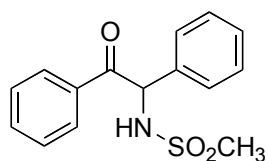
^{13}C nmr (CDCl_3 , 75 MHz): δ = 61.79, 126.85, 128.13, 128.70, 128.94, 129.08, 132.27, 133.95, 135.49, 140.51, 162.33, 194.38.

^{13}C nmr (CD_3OD , 75 MHz): δ = 65.98, 78.11, 127.89, 128.00, 128.10, 128.48, 128.78, 128.87, 128.95, 129.58, 132.97, 139.99, 142.45, 142.58, 203.77.

HRMS calcd for $\text{C}_{20}\text{H}_{17}\text{NO}_3\text{S}$: 351.0929. Found: 351.0940.

HPLC: Chiralcel-OD, n-hexane/2-propanol, 95/5, 0.5 mL/min, retention times 56.3 and 72.7 min.

2-(*N*-Mesylamino)-1,2-diphenylethanone



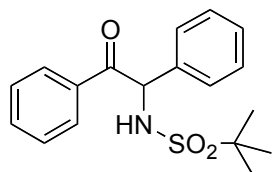
Synthesised from (*E*)-stilbene and chloramine-M according to the general procedure A.

^1H nmr (CDCl_3 , 400 MHz): δ = 2.51 (s, 3H), 5.93 (br d, J = 6.1 Hz, 1H), 6.05 (d, J = 6.1 Hz, 1H), 7.23-7.35 (m, 7H), 7.44-7.48 (m, 1H), 7.85-7.87 (m, 2H).

^{13}C nmr (CDCl_3 , 75 MHz): δ = 42.29, 62.14, 128.28, 128.82, 129.05, 129.16, 129.59, 133.68, 134.09, 136.23, 194.22.

HRMS calcd for $\text{C}_{15}\text{H}_{15}\text{NO}_3\text{S}$: 289.0773. Found: 289.0778.

2-(*N*-*tert*-Butylsulfonylamino)-1,2-diphenylethanone^[3]



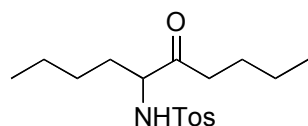
Synthesised from (*E*)-stilbene and *N*-chloro *tert*-butylsulfonamide sodium salt^[4] according to the general procedure A.

¹H nmr (CDCl₃, 400 MHz): δ = 1.24 (s, 9H), 5.76 (br d, J = 7.3 Hz, 1H), 6.14 (d, J = 7.3 Hz, 1H), 7.28-7.37 (m, 8H), 7.90-7.93 (m, 2H).

¹³C nmr (CDCl₃, 100 MHz): δ = 23.89, 59.83, 62.22, 127.60, 128.01, 128.53, 128.74, 128.97, 129.21, 133.85, 137.34, 195.64.

HRMS calcd for C₁₈H₂₁NO₃S: 331.1242. Found: 331.1241.

6-(*N*-Tosylamino)-decan-5-one^[5]



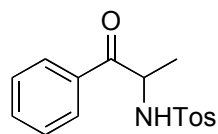
Synthesised from (*E*)-5-pentene and chloramine-T according to the general procedure A at 40°C.

¹H nmr (CDCl₃, 400 MHz): δ = 0.79 (t, J = 7.1 Hz, 3H), 0.83 (t, J = 6.8 Hz, 3H), 1.05-1.11 (m, 1H), 1.18-1.33 (m, 8H), 1.70-1.73 (m, 1H), 2.14-2.19 (m, 1H), 2.28-2.30 (m, 1H), 2.40 (m, 3H), 3.82 (dd, J = 7.3, 4.3 Hz, 1H), 5.50 (d, J = 7.6 Hz, 1H), 2.27 (d, J = 8.2 Hz, 2H), 7.69 (d, J = 8.2 Hz, 1H).

¹³C nmr (CDCl₃, 100 MHz): δ = 13.55, 13.68, 21.39, 21.94, 22.24, 25.37, 26.61, 32.03, 39.11, 61.25, 127.24, 129.57, 136.78, 143.46, 207.97.

HRMS calcd for C₁₇H₂₇NO₃S: 325.1712. Found: 325.1724.

1-Phenyl-2-(*N*-tosylamino)-propanone^[6]



Synthesised from (*E*)- β -methyl styrene and chloramine-T according to the general procedure A.

Synthesised in enantiomerically pure form from (1*S*,2*S*)-1-phenyl-2-tosylamino-propanol and NMO according to the general procedure B.

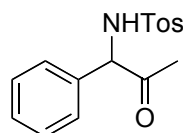
¹H nmr (CDCl₃, 400 MHz): δ = 1.32 (d, *J* = 7.2 Hz, 3H), 2.24 (s, 3H), 4.86 (dq, *J* = 7.2, 7.5 Hz, 1H), 5.73 (d, *y* = 7.5 Hz, 1H), 7.09 (d, *y* = 8.2 Hz, 2H), 7.32-7.39 (m, 2H), 7.48-7.53 (m, 1H), 7.62 (d, *y* = 8.2 Hz, 2H), 7.66-7.71 (m, 2H).

¹³C nmr (CDCl₃, 100 MHz): δ = 21.02, 21.36, 53.30, 127.02, 128.44, 128.80, 129.61, 133.41, 134.02, 137.12, 143.45, 198.07.

HRMS calcd for C₁₆H₁₇NO₃S: 303.0929. Found: 303.0925.

HPLC: Chiralcel-OD, n-hexane/2-propanol, 97/3, 0.5 mL/min, retention times 72 and 76.9 min.

1-Phenyl-1-(tosylamino)-propan-2-one^[6]



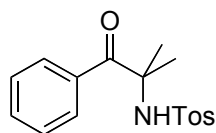
Synthesised in enantiomerically enriched form from (1*S*,2*S*)-1-phenyl-1-tosylamino-propan-2-ol and NMO according to the general procedure B. Purification of this compound was carried out by column chromatography on neutral alox under argon employing n-hexane/ethyl acetate (1/1, v/v) as eluent.

^1H nmr (CDCl_3 , 400 MHz): δ = 1.91 (s, 3H), 2.27 (s, 3H), 4.97 (br s, 1H), 5.99 (d, J = 5.4 Hz, 1H), 6.97-7.02 (m, 3H), 7.04-7.06 (m, 2H), 7.21 (d, J = 8.2 Hz, 2H), 7.74 (d, J = 8.2 Hz).

^{13}C nmr (CDCl_3 , 100 MHz): δ = 21.08, 26.26, 66.34, 127.08, 128.36, 128.95, 135.37, 137.66, 143.57, 202.60.

HPLC: Chiralcel-OD, n-hexane/2-propanol, 95/5, 0.5 mL/min, retention times 41.2 and 47.6 min.

2-Methyl-1-phenyl-2-tosylamino-propanone



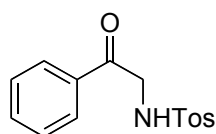
Synthesised from 2-methyl-1-phenyl-2-tosylamino-propanol and chloramine-T according to the general procedure B.

^1H nmr (CDCl_3 , 300 MHz): δ = 1.54 (s, 6H), 2.33 (s, 3H), 5.60 (s, 1H), 7.17 (d, J = 8.4 Hz, 2H), 7.18-7.35 (m, 2H), 7.40-7.46 (m, 1H), 7.62 (d, J = 8.4 Hz, 2H), 7.74-7.77 (m, 2H).

^{13}C nmr (CDCl_3 , 75 MHz): δ = 21.46, 26.67, 63.99, 126.95, 128.28, 128.95, 129.53, 132.09, 135.33, 139.81, 143.21, 201.60.

HRMS calcd for $\text{C}_{17}\text{H}_{19}\text{NO}_3\text{S}$: 317.1086. Found: 317.1092.

2-Tosylamino-acetophenone^[7]



Synthesised from styrene and chloramine-T according to the general procedure A.

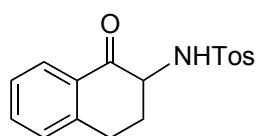
Synthesised from 1-phenyl-2-tosylamino-ethanol and chloramine-T according to the general procedure B.

^1H nmr (CDCl_3 , 400 MHz): δ = 2.38 (s, 3H), 4.46 (d, J = 4.5 Hz, 2H), 5.63 (br s, 1H), 7.27 (d, J = 8.1 Hz, 2H), 7.43-7.49 (m, 2H), 7.60-7.81 (m, 3H), 7.79 (d, J = 8.1 Hz, 2H).

^{13}C nmr (CDCl_3 , 100 MHz): δ = 21.50, 48.64, 127.22, 128.89, 129.91, 133.76, 124.35, 136.24, 143.66, 192.48.

HRMS calcd for $\text{C}_{15}\text{H}_{15}\text{NO}_3\text{S}$: 289.0773. Found: 289.0780.

2-Tosylamino- α -tetralone^[8]



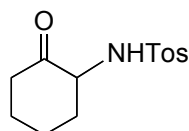
Synthesised from *trans*-2-tosylamino-1,2,3,4-tetrahydronaphthol and chloramine-T according to the general procedure B.

^1H nmr (CDCl_3 , 300 MHz): δ = 1.92-2.08 (m, 1H), 2.32 (s, 3H), 2.66 (dddd, J = 2.5, 5.7, 8.3, 13.2 Hz, 1H), 2.86-3.02 (m, 2H), 3.78 (ddd, J = 2.6, 4.9, 13.8 Hz, 1H), 5.97 (d, J = 2.6 Hz, 1H), 7.12-7.24 (m, 2H), 7.28 (d, J = 8.3 Hz, 2H), 7.42 (dt, 1.5, 7.5 Hz, 1H), 7.72 (d, J = 8.3 Hz, 2H), 7.86 (dd, J = 1.1, 7.9 Hz, 1H).

^{13}C nmr (CDCl_3 , 75 MHz): δ = 21.46, 28.09, 31.84, 59.09, 126.87, 127.17, 127.83, 128.91, 129.79, 130.61, 134.40, 136.28, 143.66, 143.81, 193.78.

HRMS calcd for $\text{C}_{17}\text{H}_{17}\text{NO}_3\text{S}$: 315.0929. Found: 315.0930.

2-Tosylamino-cyclohexanone^[9]



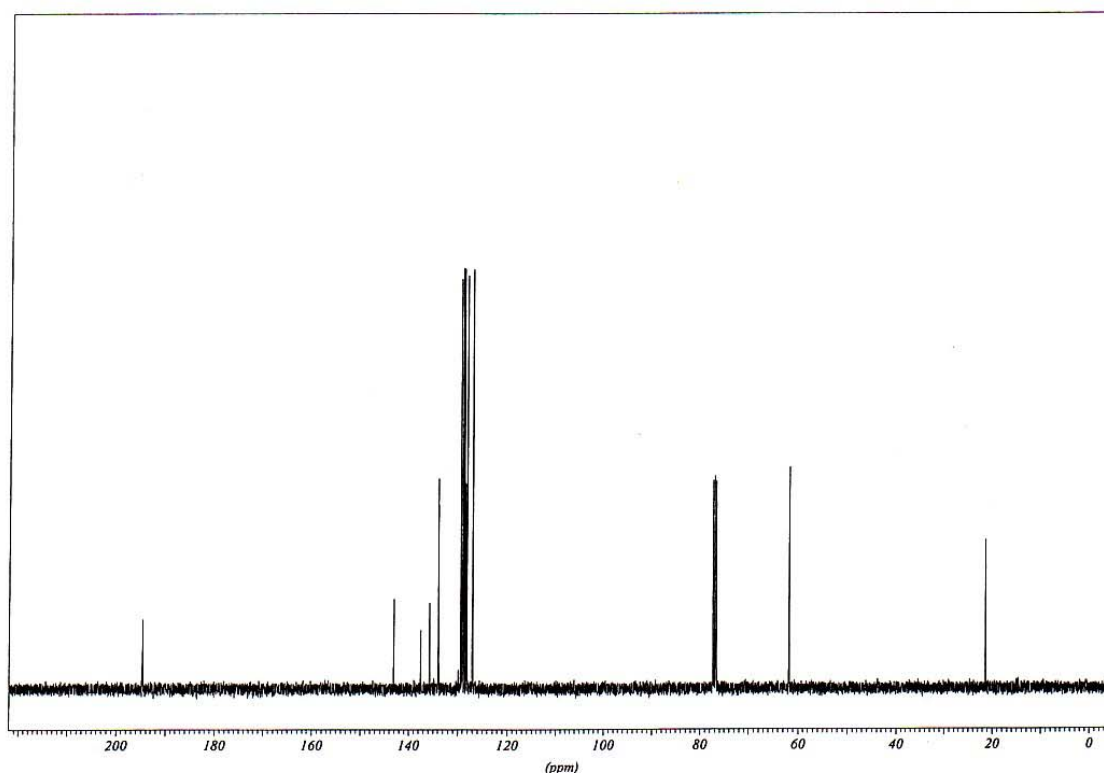
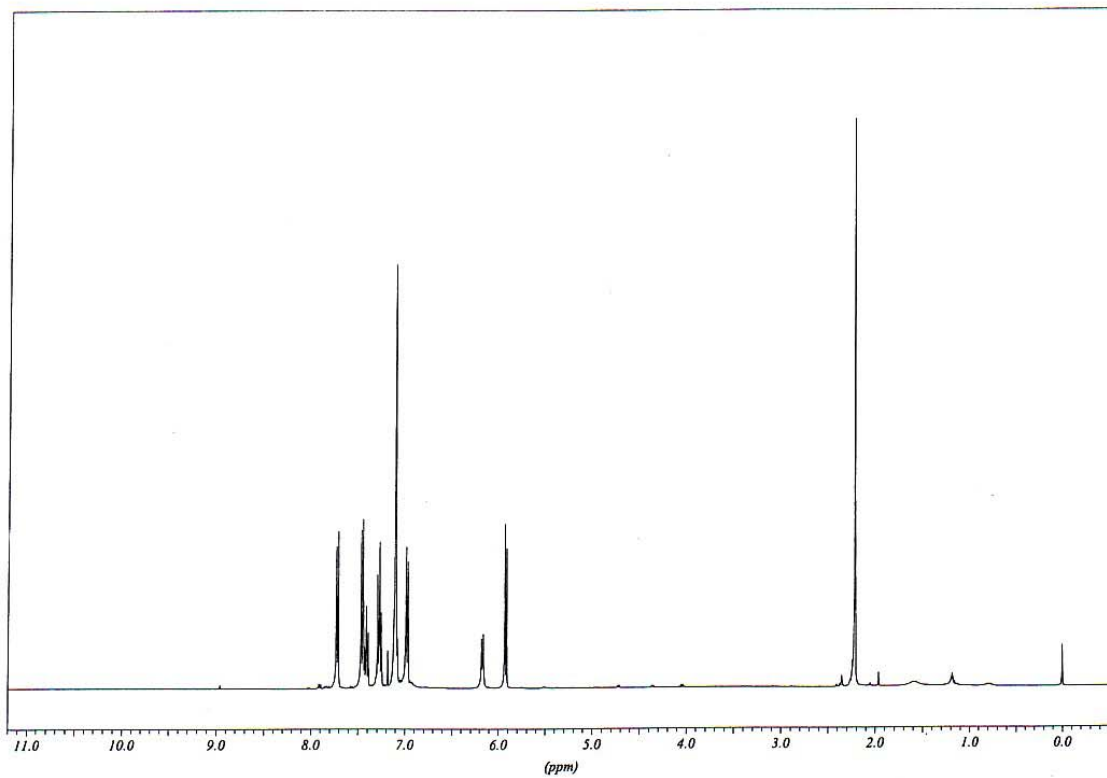
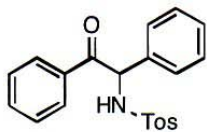
Synthesised from 2-tosylamino-cyclohexanol and chloramine-T according to the general procedure B.

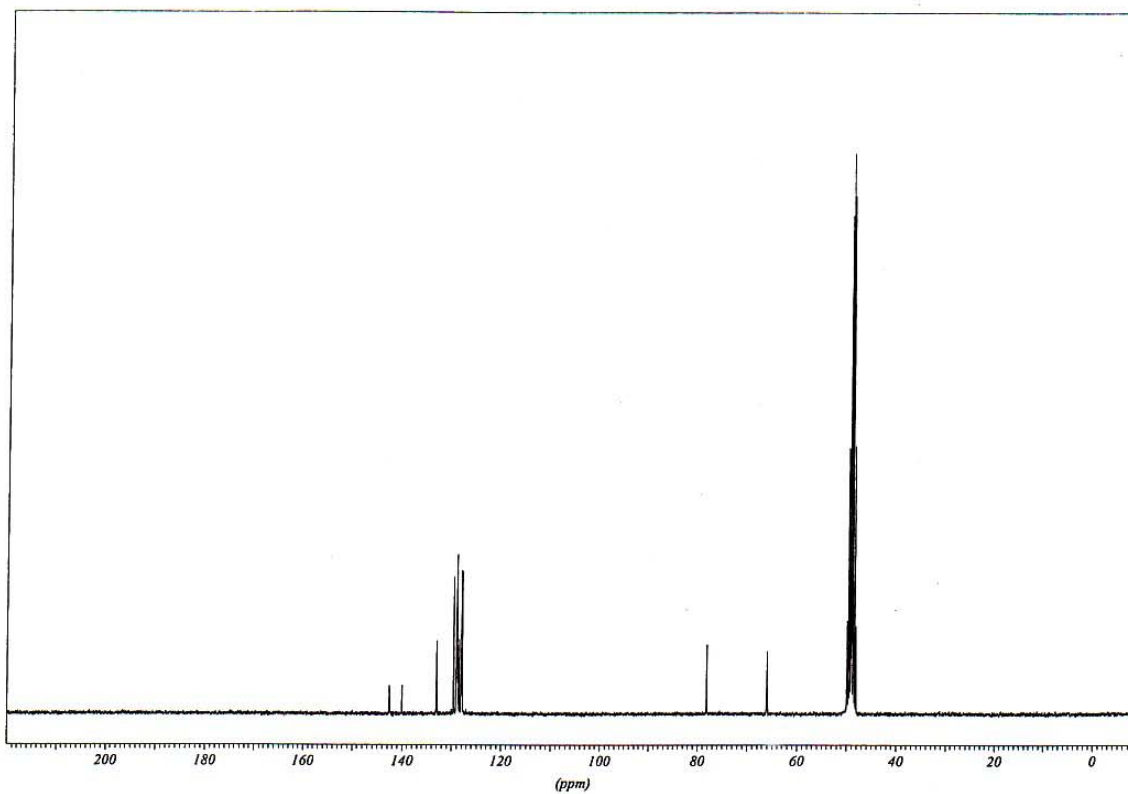
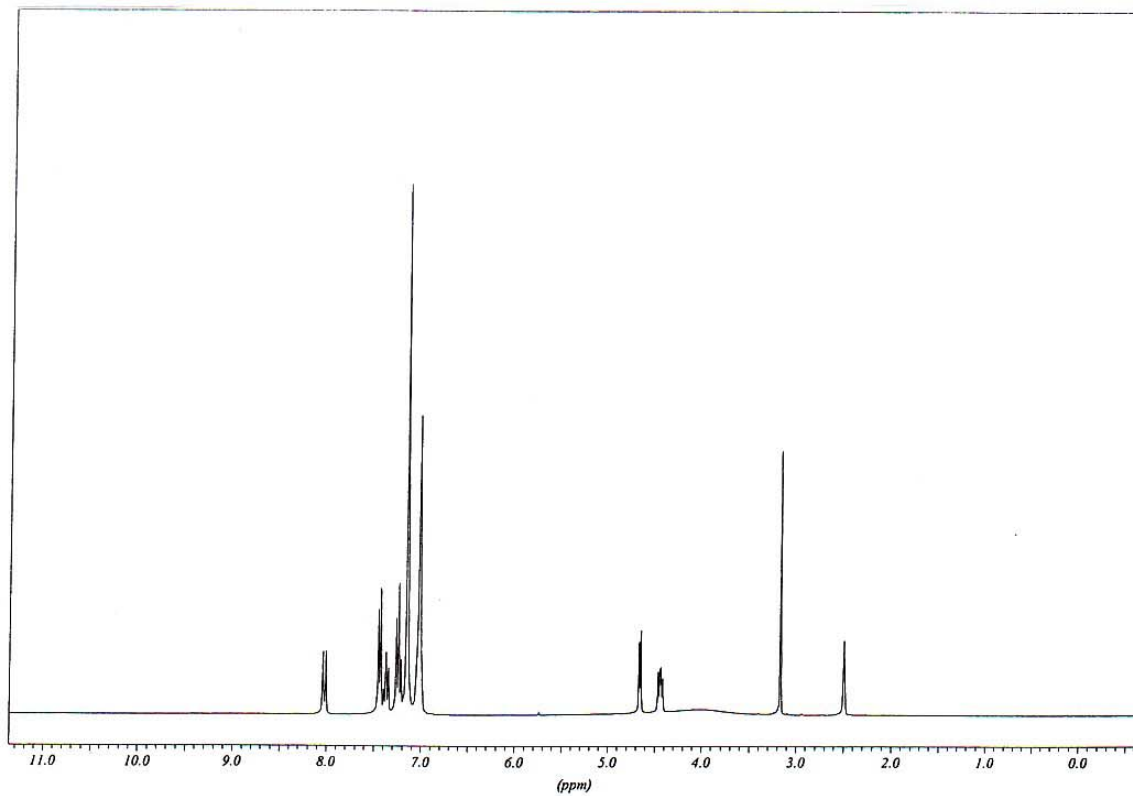
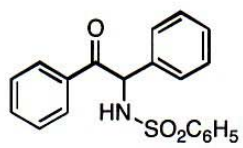
^1H nmr (CDCl_3 , 300 MHz): δ = 1.44-1.73 (m, 3H), 1.83-1.88 (m, 1H), 2.05-2.09 (m, 1H), 2.21 (dt, J = 1.1, 10.4 Hz, 1H), 2.40 (s, 3H), 2.42-2.53 (m, 2H), 3.77 (m, 1H), 5.76 (br d, J = 4.6 Hz, 1H), 7.28 (d, J = 8.3 Hz, 2H), 7.70 (d, J = 8.3 Hz, 2H).

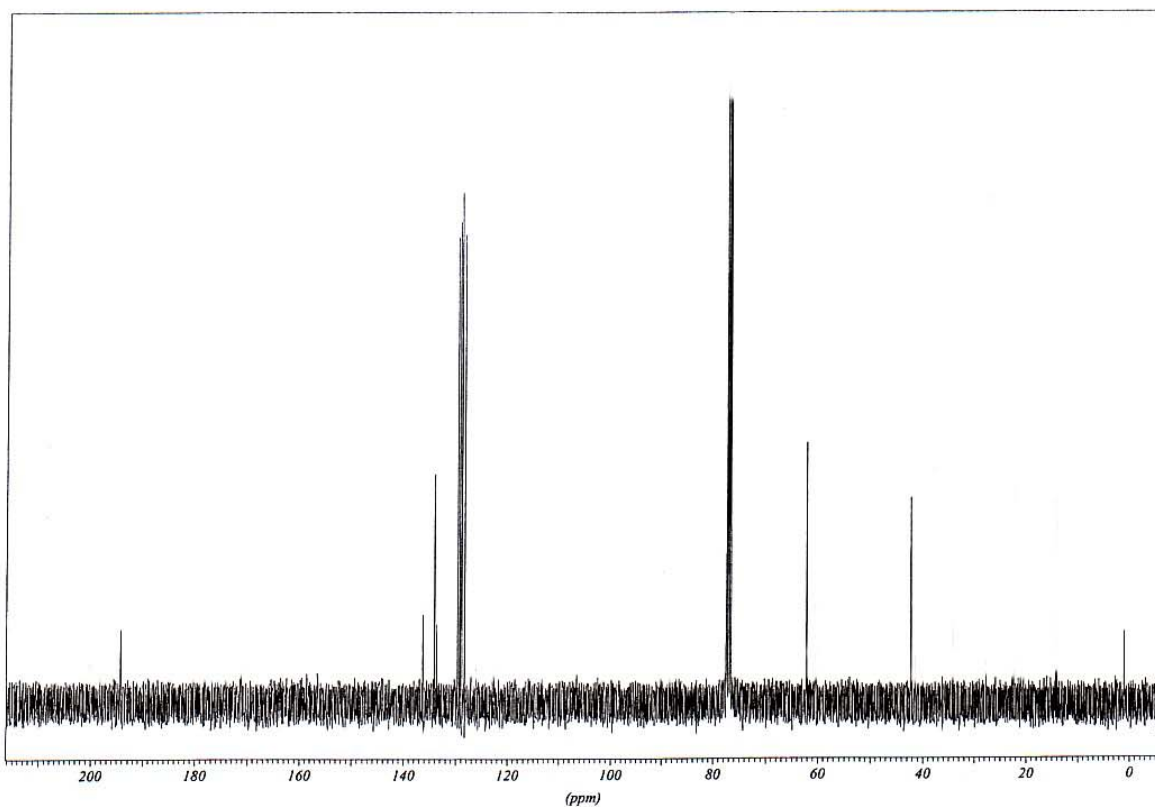
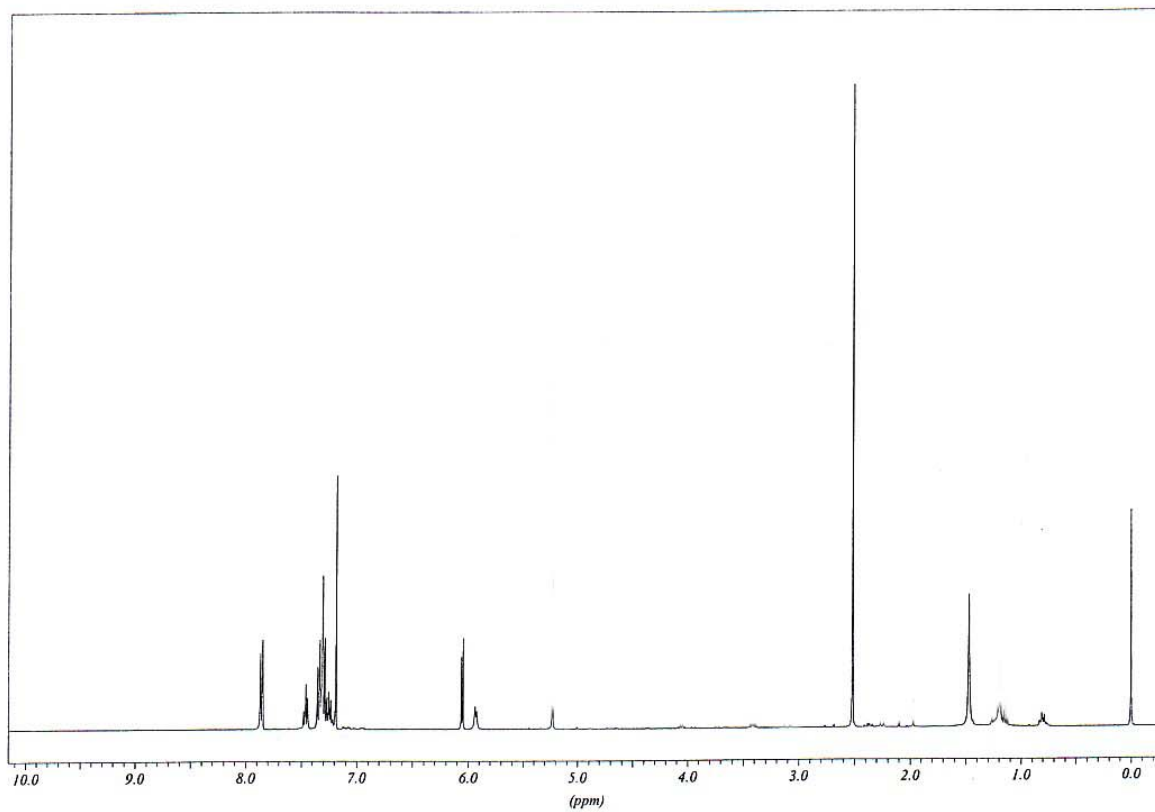
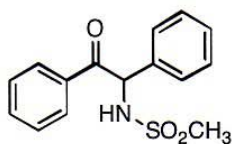
^{13}C nmr (CDCl_3 , 75 MHz): δ = 21.38, 23.89, 27.44, 36.92, 40.55, 60.63, 127.1, 129.69, 137.04, 143.47, 205.58.

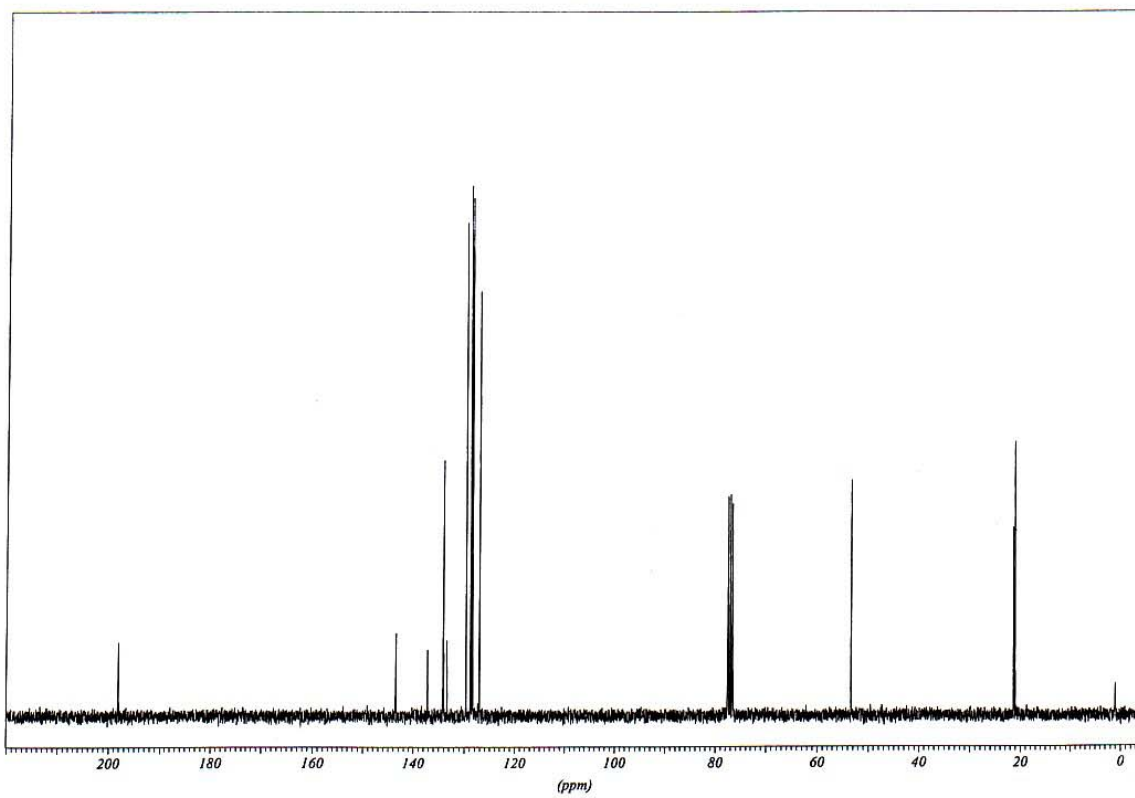
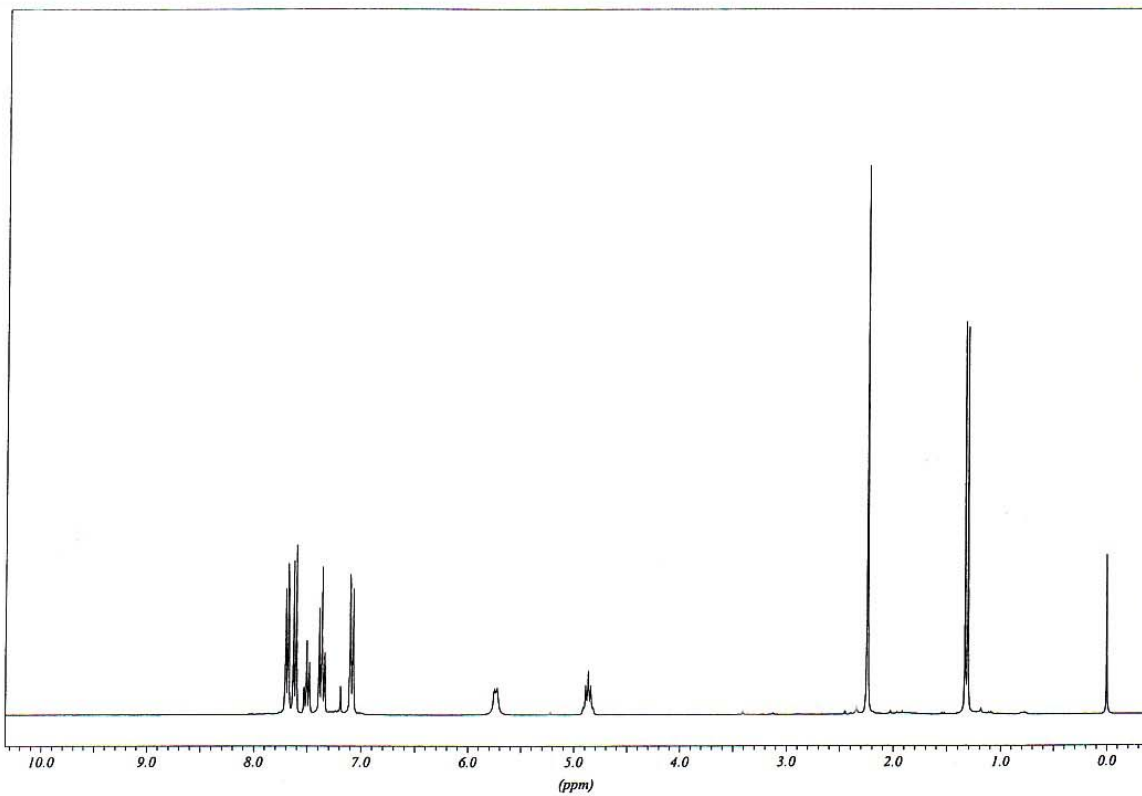
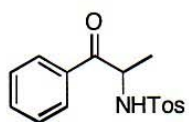
HRMS calcd for $\text{C}_{13}\text{H}_{17}\text{NO}_3\text{S}$: 267.0929. Found: 267.0938.

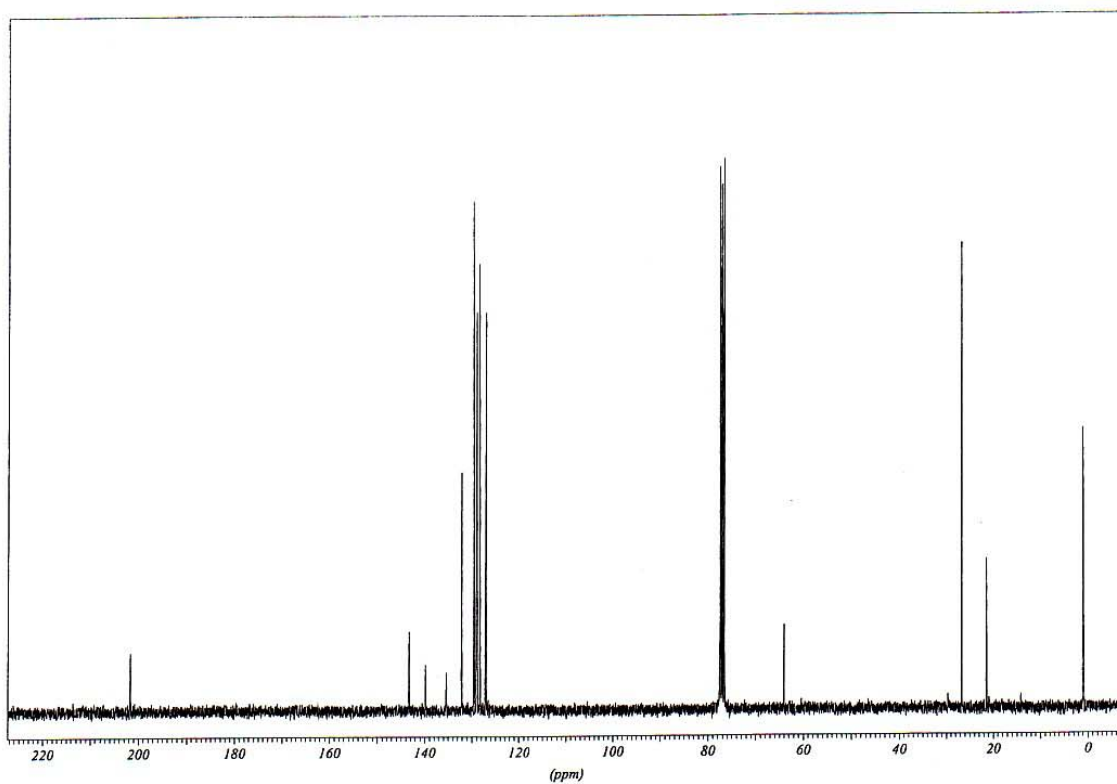
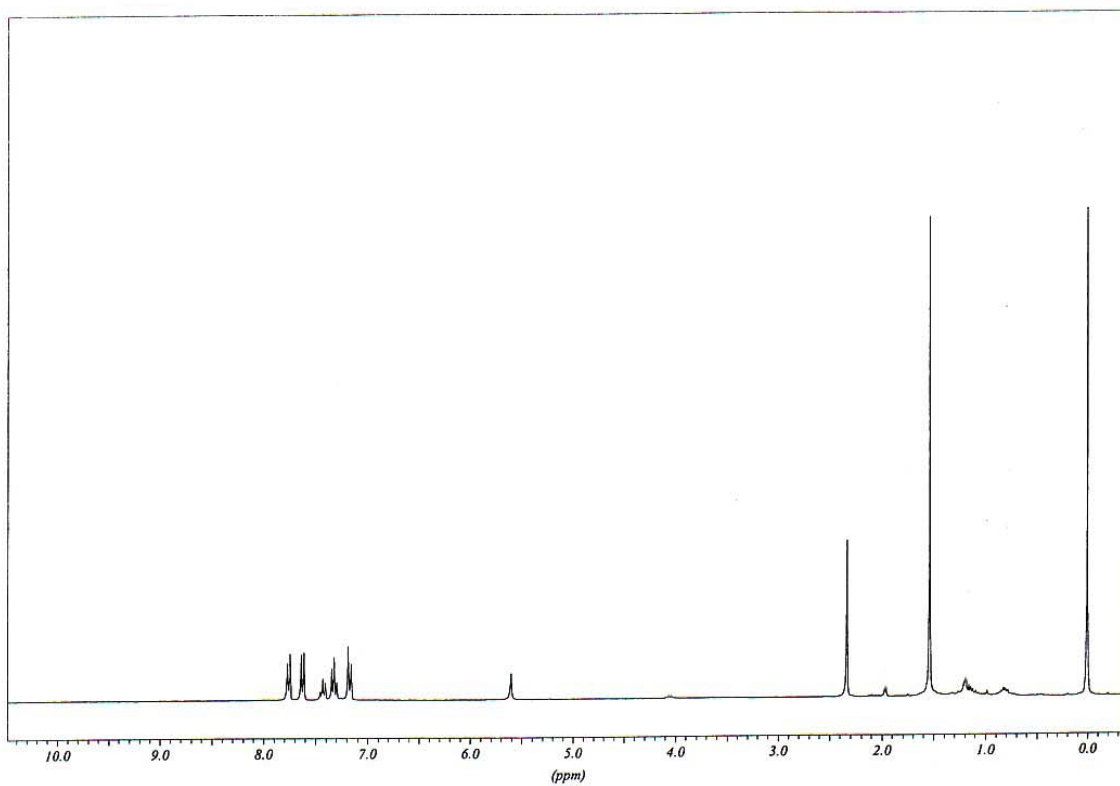
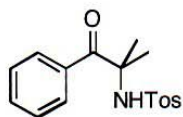
3 Spectral Characterisation

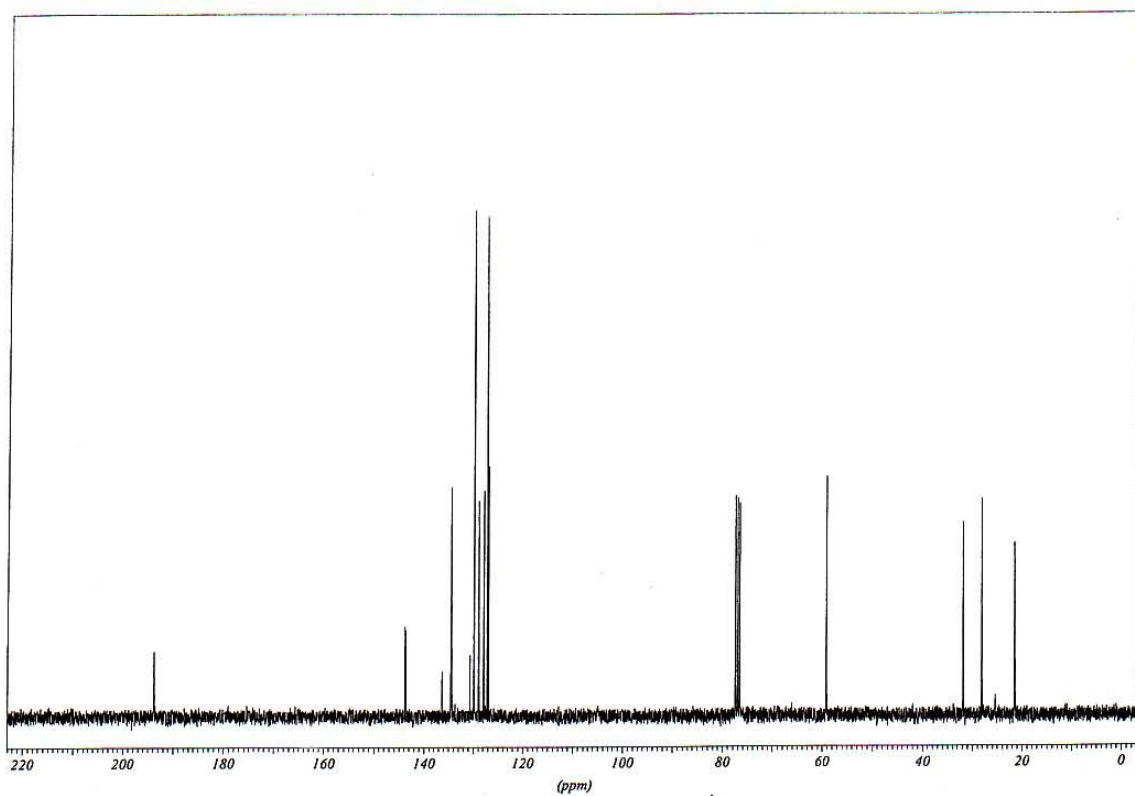
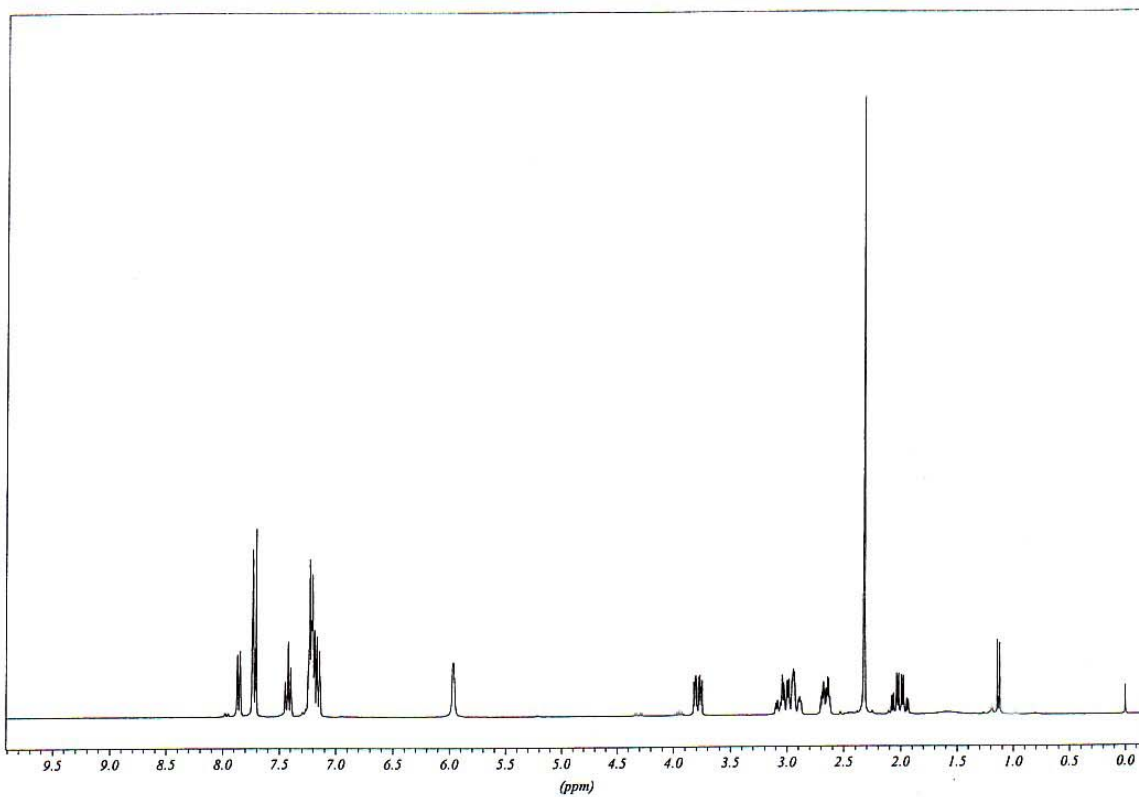
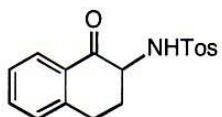












4 References

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