Supporting Information

Asymmetric Copper-Catalysed C-H Insertion Reactions of α-Diazo-β-keto Sulfones.

Catherine N. Slattery and Anita R. Maguire*

Department of Chemistry, School of Pharmacy and Analytical and Biological Chemistry Research Facility, University College Cork, Ireland

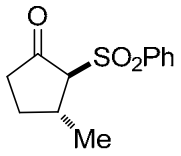
Table of Contents

General: DCM was distilled from phosphorous pentoxide and was further distilled from calcium hydride. All C-H insertion reactions were performed in oven-dried or flame-dried glassware under an atmosphere of dry N_2. Thin layer chromatography (TLC) was carried out on precoated silica gel plates. Visualisation was achieved by UV light detection (254 nm) and vanillin staining. Infra red spectra were recorded as thin films on sodium chloride plates for oils or as potassium bromide (KBr) discs for solids on a 1000 FT-IR spectrometer. ^{1}H (300/400 MHz), ^{13}C (75.5 MHz) and ^{1}H COSY NMR spectra were recorded on a 300/400 NMR spectrometer. All spectra were recorded at 20 °C in deuterated chloroform ($CDCl_3$) using tetramethylsilane (TMS) as an internal standard unless otherwise stated. Chemical shifts (δ_H and δ_C) are reported in parts per million (ppm) relative to TMS and coupling constants are expressed in Hertz (Hz). Splitting patterns in ^{1}H spectra are designated as s (singlet), d (doublet), t (triplet), q (quartet), dd (doublet of doublets), m (multiplet) and sym m (symmetrical multiplet). ^{13}C NMR spectra were calibrated using the solvent signals, *i.e.* $CDCl_3$: δ_C 77.0 ppm. Low resolution mass spectra were recorded in electrospray ionization (ESI) mode using 50% acetonitrile-water containing 0.1% formic acid as eluent; samples were made up in acetonitrile. High resolution precise mass spectra (HRMS) were recorded in electrospray ionization (ESI) mode using 50% acetonitrile-water containing 0.1% formic acid as eluent; samples were made up in acetonitrile. Melting points were measured on a capillary melting point apparatus. Enantiopurity of the chiral compounds were determined by chiral HPLC performed on a Chiralpak AS-H, Chiralpak OJ-H or Chiralcel OD-H column. Optical rotations were measured on a polarimeter at 589 nm in a 10 cm cell; concentrations (*c*) are expressed in g/100 mL. $[\alpha]_D^T$ is the specific rotation of a compound and is expressed in units of 10^{-1} deg cm^2 g^{-1}.

Representative Procedure of the C-H Insertion Reaction. The CuCl-L-(NaBARF) catalyst was generated *in situ* from a mixture of CuCl (5 mol%) and bis(oxazoline) ligand **1-4** (6 mol%) in CH_2Cl_2 (20 mL), with or without NaBARF (6 mol%). This catalytic mixture was stirred under nitrogen at 40 °C for 1.5 h. α-Diazo-β-keto sulfone **5-9** (150mg, 1 equiv) was then added dropwise in CH_2Cl_2 (10 mL) over 0.5 h to the refluxing solution. The progress of the reaction was monitored by TLC and IR spectroscopy, where reaction completion was indicated by the disappearance of the characteristic diazo peak at 2110-2126 cm^{-1}. Upon reaction completion, evaporation of the reaction solvent at reduced pressure gave the crude product as a coloured oil. Purification by flash chromatography on silica gel, employing EtOAc-hexane as eluent, gave cyclopentanones **10-14** as white solids.

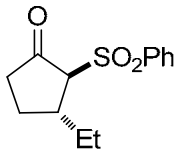
Compound Characterisation:

trans-2-*Phenylsulfonyl*-3-*methylcyclopentanone* **10**



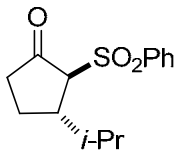
White solid, mp 123-125 °C (lit.[1,2] 124-126 °C); ν_{max}(KBr)/cm^{-1} 1744 (C=O), 1305, 1141 (SO_2), δ_H(400MHz, $CDCl_3$) 1.29 (3H, d, *J* 6.8, C*H*$_3$), 1.45-1.53 [1H, m, one of C(4)*H*$_2$], 2.25-2.40 [3H, m, C(5)*H*$_2$, one of C(4)*H*$_2$], 2.95-3.04 [1H, m, C(3)*H*CH_3] 3.34 [1H, d, *J* 8.0, C(2)*H*SO_2], 7.55-7.90 (5H, m, aromatic H). Spectral characteristics were consistent with previously reported data.[2]

trans-2-*Phenylsulfonyl*-3-*ethylcyclopentanone* **11**



White solid, (Found C, 62.12; H, 6.48. $C_{13}H_{16}O_3S$ requires C, 61.88; H, 6.39); mp 78-80 °C (lit.[2] 79-81 °C); ν_{max}(KBr)/cm^{-1} 1743 (C=O), 1308, 1147 (SO_2), δ_H(300MHz, $CDCl_3$) 0.98 (3H, t, *J* 7.2, C*H*$_3$), 1.39-1.57 (2H, m, one of C*H*$_2$CH$_3$ and one of C(4)*H*$_2$), 1.74-1.87 [1H, m, one of C*H*$_2$CH$_3$], 2.28-2.46 [3H, m, C(5)*H*$_2$, one of C(4)*H*$_2$], 2.82-2.94 [1H, m, C(3)*H*CH_2CH_3], 3.39 [1H, d, *J* 6.9, C(2)*H*SO_2], 7.55-7.89 (5H, m, aromatic H). Spectral characteristics were consistent with previously reported data.[2]

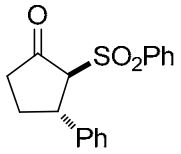
trans-2-*Phenylsulfonyl*-3-i-*propylcyclopentanone* **12**



White solid, (Found C, 63.06; H, 6.79. $C_{14}H_{18}O_3S$ requires C, 63.13; H, 6.81); mp 96-98 °C; ν_{max}(KBr)/cm^{-1} 1746 (C=O), 1302, 1140 (SO_2), δ_H(400MHz, $CDCl_3$) 0.91 [3H, d, *J* 6.8, one of CH(C*H*$_3$)$_2$], 0.97 [3H, d, *J* 6.8, one of CH(C*H*$_3$)$_2$], 1.65-1.74 [1H, m, one of C(4)*H*$_2$], 1.85-1.96 [1H, sym m, C*H*(CH$_3$)$_2$], 2.19-2.35 [2H, m, one of C(4)*H*$_2$ and one of C(5)*H*$_2$], 2.44-2.54 [1H, m, one of C(5)*H*$_2$], 2.86-2.94 [1H, sym m, C(3)*Hi*-Pr], 3.51 [1H, d, *J* 5.2, C(2)*H*SO_2],

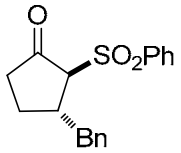
7.57-7.87 (5H, m, aromatic H); δ_C(75.5MHz, $CDCl_3$) 18.1 [one of $CH(CH_3)_2$], 20.5 [one of $CH(CH_3)_2$], 22.1 [$C(4)H_2$], 31.0 [$CH(CH_3)_2$], 38.4 [$C(5)H_2$], 43.2 (*C*H*i*-Pr), 73.0 ($CHSO_2Ph$), 129.1 (CH, s, 4 × *C*H aromatic), 134.1 (*C*H aromatic), 134.0 (*C* aromatic), 207.6 (*C*O); m/z (ES+) 267.0 [$(M+H)^+$, 100%], 284.1 [$(M+H_2O)^+$, 72%], 552.4 (89%).

trans-2-*Phenylsulfonyl*-3-*phenylcyclopentanone* **13**



White solid, (Found C, 67.59; H, 5.43. $C_{17}H_{16}O_3S$ requires C, 67.98; H, 5.37); mp 96-99 °C (lit.[2] 96-98 °C); ν_{max}(KBr)/cm^{-1} 1743 (C=O), 1306, 1150 (SO_2), δ_H(400MHz, $CDCl_3$) 1.94-2.05 [1H, m, one of C(4)H_2], 2.52-2.68 [3H, m, C(5)H_2, one of C(4)H_2], 3.91 [1H, d, *J* 7.6, C(2)HSO_2], 4.07-4.17 [1H, sym m, *J* 7.6, C(3)*H*Ph], 7.19-7.31 (5H, m, aromatic H of phenyl group), 7.48-7.81 (5H, m, aromatic H of phenylsulfonyl group). Spectral characteristics were consistent with previously reported data.[2]

trans-2-*Phenylsulfonyl*-3-*benzylcyclopentanone* **14**

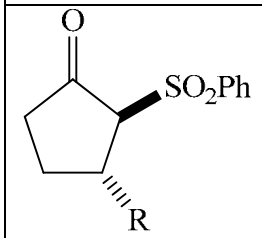


White solid, (Found C, 68.54; H, 5.69. $C_{18}H_{18}O_3S$ requires C, 68.76; H, 5.77); mp 83-85 °C (lit.[2] 85-86 °C); ν_{max}(KBr)/cm^{-1} 1750 (C=O), 1307, 1142 (SO_2), δ_H(400MHz, $CDCl_3$) 1.57-1.66 [1H, m, one of C(4)H_2], 2.16-2.41 [3H, m, C(5)H_2, one of C(4)H_2], 2.74-2.80 [1H, dd, H_A of ABC, *J* 13.6, 8.8 one of CH_2Ph], 3.04-3.08 [1H, dd, H_B of ABC, *J* 13.2, 5.2, one of CH_2Ph], 3.14-3.24 [1H, m, H_C of ABC, C(3)*H*Bn], 3.49 [1H, d, *J* 7.2, C(1)HSO_2], 7.16-7.32 (5H, m, aromatic H of phenyl group), 7.55-7.86 (5H, m, aromatic H of phenylsulfonyl group). Spectral characteristics were consistent with previously reported data.[2]

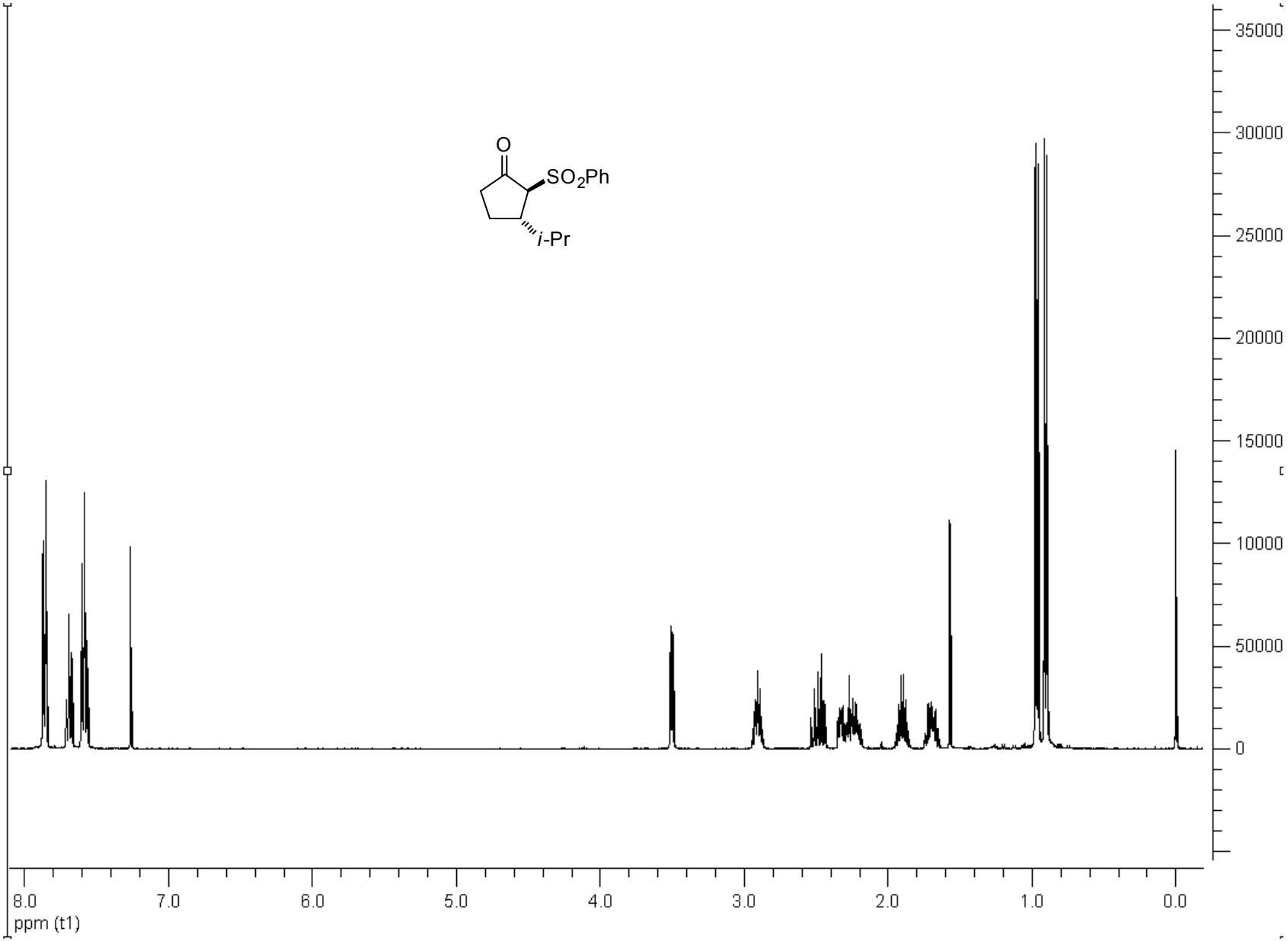
References:

(1) Monteiro, H. J. *Tetrahedron Lett.* **1987**, *28*, 3459.
(2) Maguire, A. R.; Kelleher, L. L.; Ferguson, G. *Journal of Molecular Catalysis B: Enzymatic* **1996**, *1*, 115.

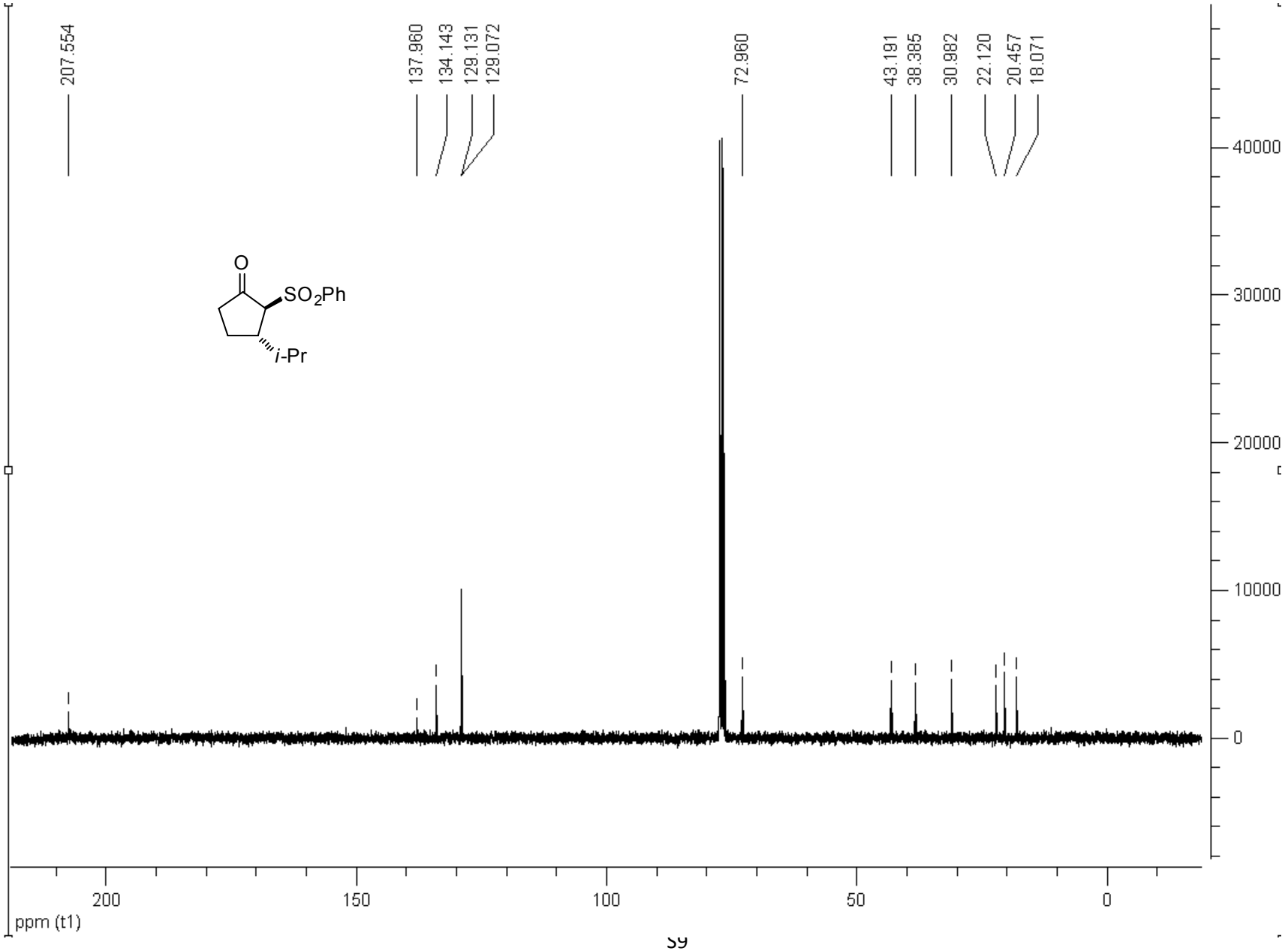
HPLC conditions for the resolution of cyclopentanones **10-14**

Figure	R	Compound	Column	UV (nm)	Eluent	Flow (ml/min)	Temp.	Retention Time	
								Enantiomer	(min)
	Me	**10**	Chiralcel OD-H	210	Hexane : IPA 90 : 10	1.0	rt	(2*R*, 3*S*)	40
								(2*S*, 3*R*)	50
	Et	**11**	Chiralcel OD-H	210	Hexane : IPA 90 : 10	1.0	rt	(2*R*, 3*S*)	22
								(2*S*, 3*R*)	27
	i-Pr	**12**	Chiralpak OJ-H	218	Hexane : IPA 70 : 30	1.0	rt	(2*R*, 3*R*)	16
								(2*S*, 3*S*)	20
	Ph	**13**	Chiralpak OJ-H	217	Hexane : IPA 60 : 40	1.0	rt	(2*R*, 3*R*)	84
								(2*S*, 3*S*)	139
	Bn	**14**	Chiralpak AS-H	210	Hexane : IPA 90 : 10	1.0	rt	(2*R*, 3*R*)	71
								(2*S*, 3*S*)	202

^{1}H NMR of **12**


O
SO2Ph
i-Pr
35000
30000
25000
20000
15000
10000
50000
0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

^{13}C NMR of **12**


207.554
137.960
134.143
129.131
129.072
72.960
43.191
38.385
30.982
22.120
20.457
18.071
O
SO2Ph
i-Pr
40000
30000
20000
10000
0
200
150
100
50
0
ppm (t1)