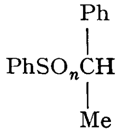
Diastereomeric Differentiation of Sulphone Oxygens by ^{17}O N.M.R. Spectroscopy

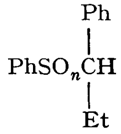
By KEIJI KOBAYASHI*
(*Department of Chemistry, College of General Education, University of Tokyo, Komaba, Meguro, Tokyo* 153, *Japan*)
and TADASHI SUGAWARA and HIIZU IWAMURA*
(*Division of Applied Molecular Science, Institute for Molecular Science, Myodaiji, Okazaki* 444, *Japan*)

Summary Magnetic non-equivalence of diastereotopic oxygens in phenyl 1-phenylethyl and phenyl 1-phenylpropyl sulphones has been observed in their ^{17}O n.m.r. spectra and a configurational assignment has been made by stereospecific labelling with ^{17}O.

THE magnetic non-equivalence of geminal groups close to a centre of molecular asymmetry has been observed in ^{1}H, ^{13}C, and ^{19}F n.m.r. spectra and widely recognized as a useful probe in stereochemical problems.[1] Because of the tetrahedral geometry of the sulphur atom, the two oxygen atoms of a sulphone should also be in a diastereotopic relationship in chiral molecules. Thus it was of interest to see if there is magnetic non-equivalence observable in ^{17}O n.m.r. spectra. We report here for the first time the differentiation and assignment of diastereotopic sulphone oxygens.

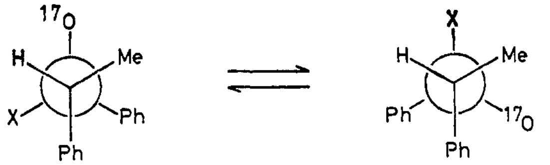

$\mathrm{PhSO}_n\overset{\mathrm{Ph}}{\underset{\mathrm{Me}}{\mathrm{CH}}}$

(1) $n = 1$
(2) $n = 2$


$\mathrm{PhSO}_n\overset{\mathrm{Ph}}{\underset{\mathrm{Et}}{\mathrm{CH}}}$

(3) $n = 1$
(4) $n = 2$

Since a preliminary study of unlabelled sulphones showed only a broad or flat-head singlet for their ^{17}O n.m.r. spectra at 10·782 MHz,[2,3] we employed a diastereomeric pair of sulphones in which one of the oxygens was enriched stereospecifically with the ^{17}O-isotope. Oxidation of phenyl 1-phenylethyl sulphide with iodobenzene dichloride and $H_2[^{17}O]$ (10 atom %, Prochem) in pyridine,[4] followed by separation using column chromatography on silica gel, gave the diastereomeric phenyl 1-phenylethyl [^{17}O]sulphoxides, (*RR*/*SS*)-(**1**) and (*RS*/*SR*)-(**1**) of known configuration.[5] Further oxidation of these sulphoxides with *m*-chloroperoxybenzoic acid gave the corresponding



(RR/SS)-(**1**) X = lone pair
(RR/SS)-(**2**) X = O

(RS/SR)-(**1**) X = lone pair
(RS/SR)-(**2**) X = O

[^{16}O, ^{17}O]sulphones (RR/SS)-(**2**) and (RS/SR)-(**2**). Phenyl 1-phenylpropyl sulphoxides, (**3a**), m.p. 142—143 °C and (**3b**), m.p. 90—93 °C, were similarly prepared and converted into the corresponding sulphones, (**4a**) and (**4b**).[6]

We find distinct chemical shift non-equivalence for the diastereotopic oxygens of these sulphones (Table). The magnitude of the difference in the p.p.m. scale is larger than those found in ^{1}H, ^{13}C, and ^{19}F n.m.r.,[1,7] indicating that the ^{17}O-shielding is more sensitive to the magnetic environment than other nuclei.

TABLE. ^{17}O N.m.r. chemical shifts[a] and chemical shift non-equivalence (Δ) for diastereomeric phenyl 1-phenylethyl and 1-phenylpropyl sulphones and the corresponding sulphoxides.

Solvent	(RR/SS)-(**1**)	(RS/SR)-(**1**)	Δ	(RR/SS)-(**2**)	(RS/SR)-(**2**)	Δ	(**3a**)	(**3b**)	Δ	(**4a**)	(**4b**)	Δ
$CDCl_3$	3[b]	7[b]	4				3[c]	19[d]	16			
C_6H_6				137	141	4				136	142	6
$CHCl_3$				134	139	5				134	140	6
MeOH				132	137	5				132	139	7
CF_3CO_2H[e]				127	133	6				124	134	10

[a] The exact Larmor frequency for water relative to which all chemical shifts are expressed in p.p.m. was 10·783170 MHz with the D lock frequency (external D_2O) at 12·210 MHz. Chemical shifts are accurate to ± 1 p.p.m. unless otherwise stated. The line width was in the range 150—200 Hz at ambient temperatures. [b] At 60 °C. [c] At 142—143 °C. [d] At 90—93 °C. [e] Accurate to ±4 p.p.m. owing to phase distortion by the strong nearby signal of the carboxylic oxygen of the solvent.

The higher shielding of the oxygen in (RR/SS)-(**1**) as compared with (RS/SR)-(**1**) can be rationalized in terms of the γ-effect induced by the methyl group. It has been suggested that the sulphoxides are present predominantly in the conformation which causes the two phenyl groups to be oriented in the *gauche* rather than the *trans* disposition.[8] For (RR/SS)-(**1**), therefore, the sulphoxide oxygen is *gauche* to the methyl group in both of the preferred conformations, whereas only one of the two predominant conformers is subject to the *gauche* γ-effect in (RS/SR)-(**1**). Thus a more pronounced γ-effect is expected for (RR/SS)-(**1**) as a result of a weighted average of the conformers. The interpretation of the chemical shifts based on the γ-effect is supported by ^{13}C n.m.r. spectroscopy as well. The methyl ^{13}C resonance of (RR/SS)-(**1**) appears at δ 12·18, whereas that of (RS/SR)-(**1**) shows the downfield shift to δ 14·09.

We also note that the chemical shift difference of the diastereomeric sulphoxides remains practically unchanged in the diastereomeric sulphones labelled with ^{17}O (Table). The observation seems to indicate that the conformer population around the C–SO_2 bond should not be significantly altered on changing from the sulphoxide to the sulphone. Our attempt to evaluate the intrinsic diastereomerism from the measurement of the ^{17}O chemical shift difference at lower temperatures[9] was unsuccessful because of serious line-broadening due to efficient quadrupolar relaxation before reaching the conformational freezing.

Appreciable upfield shifts of the ^{17}O resonances of the sulphones are observed in protic solvents (Table). As the magnitude of the non-equivalence is almost constant, the conformer population of the sulphones is considered to be independent of the solvent. The upfield shift is in accord with the trend induced by hydrogen bonding or some weak interaction with the time-averaged solvent cluster.

We believe the diastereotopic differentiation of the oxygens will be useful in stereochemical studies of sulphones, *e.g.*, molecular dynamics and stereochemistry of α-sulphonyl carbanions.

(*Received*, 10*th February* 1981; *Com.* 159.)

---

[1] For a review, see W. B. Jennings, *Chem. Rev.*, 1975, **75**, 307.

[2] Measured on a Varian FT-80A spectrometer. For details of spectral measurements, see T. Sugawara, Y. Kawada, M. Katoh, and H. Iwamura, *Bull. Chem. Soc. Jpn.*, 1979, **52**, 3391.

[3] The sulphone oxygens in conformationally rigid thietan dioxides were recently reported to give discrete resonances with a chemical shift difference of up to 33 p.p.m. (E. Block, A. A. Bazzi, J. B. Lambert, S. M. Wharry, K. K. Andersen, D. C. Dittmer, B. H. Patwardhan, and D. J. H. Smith, *J. Org. Chem.*, 1980, **45**, 4810).

[4] G. B. M. Cinquini, S. Colonna, and F. Montanari, *J. Chem. Soc. C*, 1968, 659.

[5] G. Modena, U. Quintily, and G. Scorrano, *J. Am. Chem. Soc.*, 1972, **94**, 202, and references therein.

[6] K. Kobayashi, to be published elsewhere. From the similar ^{17}O n.m.r. chemical shift pattern of the 1-phenylethyl and 1-phenylpropyl derivatives, we make the stereochemical assignment that (**3a**) and the corresponding sulphone (**4a**) should have the (RR/SS) configuration.

[7] For a recent report on ^{13}C n.m.r. spectroscopy, see H. Gunther, W. Herring, H. Steel, and S. Tobias, *J. Org. Chem.*, 1980, **45**, 4329.

[8] Y. Kodama, S. Zushi, K. Nishihata, and M. Nishio, *J. Chem. Soc., Perkin Trans.* 2, 1980, 1306; M. Nishio and K. Nishihata, *J. Chem. Soc., Chem. Commun.*, 1970, 1485.

[9] M. Raban, *Tetrahedron Lett.*, 1966, 3105.