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^{31}P-NMR NONEQUIVALENCE OF DIASTEREOMERIC (-)α-PHENYLETHYLAMINE SALTS OF O-ALKYL ALKYLPHOSPHONOTHIOIC ACIDS

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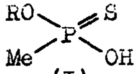
In our previous communication[1] we reported that the diastereomeric (-)α-phenylethylamine salts of chiral phosphorus thioacids have different proton nmr spectra in nonpolar solvents. The observed chemical shift differences and the integrated intensities constitute useful parameters for direct determination of optical purity of chiral phosphorus thioacids, whereas the so-called sense of the Magnetic nonequivalence can be utilised for the determination of their relative or absolute configurations. Thus, it has been found that the (-)α-phenylethylamine salts of (-)O-alkyl methylphosphonothioic acids(I) having the same configuration at the phosphorus atom[2,3] show their P-methyl resonances at lower field than do their diastereomers.



(I)

R = Me(Ia); Et(Ib); Pr^n(Ic); Pr^i(Id); Bu^n(Ie)

We have also shown[4] that such factors as temperature, concentration and optical purity of the components of the salts do not change the sense of the magnetic nonequivalence[5], but only change its magnitude.

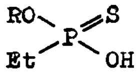
Now we would like to report that it is also possible to differentiate between diastereomeric (-)α-phenylethylamine salts of chiral phosphorus thioacids by means of ^{31}P-nmr spectroscopy. The spectra of O-isopropyl methylphosphonothioic acid(Id) and those of its salts (see fig. 1) are the best illustration of this first example of the magnetic nonequivalence of diastereomeric dynamic systems in ^{31}P-nmr spectra[7].

The ^{31}P-nmr spectrum of the free acid at - 84.2 ppm is a typical A_3MX system (a double quartet with splittings of 15 and 11.4 Hz). The salt of the (±)acid(Id) with (±)α-phenylethylamine has a similar spectrum, which indicates that the investigated system is dynamic and that its life time on the nmr scale is short. On the other hand, as could be expected, the ^{31}P-nmr spectrum of the salt of the racemic acid(Id) with (-)α-phenylethylamine consists of 16 clearly separated resonance lines corresponding to two diastereomeric salts (two A_3MX systems). In this case the magnitude of nonequivalence, $\Delta\delta$, is 6.4 Hz. In order to determine the sense of the magnetic nonequivalence we have obtained the spectrum of the salt of (-)α-phenylethylamine with (+)acid(Id) having the optical purity about 70%, and we have found that the signal of the predominant diastereomer was in the higher field.

Similar results to those outlined above have been obtained for the other O-alkyl methylphosphonothioic acid(I) and are summarized in Table 1.

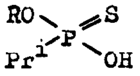
In our studies the ^{1}H-heteronuclear decoupling experiments were found to be particularly useful, since they made it possible to simplify all the complex spectra of the diastereomeric salts and to reduce them to two signals corresponding to the diastereomers (see fig. 1).

By means of this method we were also able to determine the magnitude and sense of the magnetic nonequivalence of (-)α-phenylethylamine salts of O-alkyl ethylphosphonothioic acids(II) and O-alkyl isopropylphosphonothioic acids(II). The results are shown in Table 1.



(II)

R = Me(IIa); Et(IIb)



(III)

R = Me(IIIa); Et(IIIb)

In conclusion we should emphasize the most significant fact that the salts of all the levorotatory thioacids (I),(II) and (III) having the same configuration at the phosphorus atom[2,3] exhibit the same sense of the magnetic nonequivalence in the ^{31}P-nmr spectra. As a result of the studies outlined in the present communication the range of application of magnetic nonequivalence to the determination of optical purity and of absolute configuration has been extended.

Table 1

^{31}P-nmr data[†] for O-alkyl alkylphosphonothioic acids and their salts with (–)α-phenylethylamine

Thioacids			Salts with (–)α-PhEA[‡]			Nonequivalence sense of (–)[I,II,III]· ·(–)α-PhEA
Formula	δ ppm[*] (H_3PO_4)	Spectrum system (lines)	δ ppm[*] (H_3PO_4)	Spectrum system (lines)	Δδ (Hz)[§]	
(±)Ia	-89.6	AM_3X_3 (16)	-75.0	$2xAM_3X_3$ (32)	2.0	low
(±)Ib	-87.5	AM_3X_2 (12)	-73.1	$2xAM_3X_2$ (24)	2.1	low
(±)Ic	-90.5	AM_3X_2 (12)	-73.1	$2xAM_3X_2$ (24)	3.9	low
(±)Id	-84.2	AM_3X (8)	-71.5	$2xAM_3X$ (16)	6.4	low
(±)Ie	-88.1	AM_3X_2 (12)	-73.2	$2xAM_3X_2$ (24)	3.5	low
(±)IIa	-95.9	-	-81.5	-	2.1	low
(±)IIb	-95.3	-	-81.6	-	2.1	low
(±)IIIa	-98.3	-	-83.7	-	1.2	low
(±)IIIb	-	-	-83.5	-	1.1	low

[†] The spectra were recorded with a Jeol spectrometer INM-C-60HL in benzene solution. [‡] PhEA means phenylethylamine; [*] Centre of multiplet; [§] from decoupled spectra.

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[3] M.Mikołajczyk, M.Para, J.Omelańczuk, M.Kajtar and G.Snatzke, paper sent to Tetrahedron.

[4] M.Mikołajczyk, A.Ejchart and J.Jurczak, Bull.Acad.Polon.Sci., 19, 721 (1971).

[5] It was suggested by Pirkle[6] that these factors may change the sense of the magnetic nonequivalence of the diastereomeric salts.

[6] W.H.Pirkle, Chem.Comm., 1970, 1525.

[7] Apart from ^{1}H-nmr spectroscopy the differences between the chemical shifts of diastereomeric solvates have been observed in ^{19}F-nmr spectra[8].

[8] W.H.Pirkle, J.Am.Chem.Soc., 88, 1837 (1966); W.H.Pirkle and T.G.Burlingame, Tetrahedron Letters, 1967, 4039.