The Intermolecular Transfer of Trimethylsilyl Groups Induced by Electron Impact

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Summary The mass spectra of the trimethylsilyl derivatives of various biologically-active compounds provide evidence to substantiate the intermolecular transfer of trimethylsilyl groups upon electron impact.

THE migratory properties of trimethylsilyl groups in mass spectrometric fragmentations have been well established.[1] In this respect trimethylsilyl groups have been shown to resemble hydrogen atoms, which have long been known to undergo various rearrangements and migrations upon electron impact. Till now, only intramolecular migrations have been reported for trimethylsilyl groups. This is unlike the intermolecular hydrogen transfers which, *via* an ion molecule collision, result in the production of $M+1$ peaks in the mass spectra of a large number of compounds.[2] Similar intermolecular transfers have been observed[3] for groups such as acetyl and acetonitrile resulting in peaks 43 and 41 a.m.u. higher than the respective molecular ions. During recent m.s. studies of trimethylsilyl derivatives of biologically-active compounds, we observed several examples of compounds which exhibited a peak 73 a.m.u. higher than the peak due to the molecular ion. We now report the preliminary results of experiments which establish that the $M+73$ peaks arise from the intermolecular transfer of a trimethylsilyl group *via* an ion molecule reaction.

So far, we have been able to observe $M+73$ ions in

per-trimethylsilylated derivatives of four different classes of compounds: glycerophosphates, *N*-acetylamino-sugars, aminoalkylphosphonates, and 1,3-dimethyl-5-(3-hydroxyalkyl)barbituric acid derivatives. To confirm that the $M+73$ peak was due to an ion molecule reaction, it was necessary to study the variation in the relative abundance of the $M+73$ ion as a function of sample pressure in the ion source. Increased pressure should enhance the number of effective collisions and, consequently, an increase in the relative intensity of the $M+73$ peak should be observed.

Experiments were conducted with representative compounds from each class; (I), the tetratrimethylsilyl derivative of L-α-glycerophosphate; (II), the tetratrimethylsilyl derivative of *N*-acetylglucosamine; (III), the tetratrimethylsilyl derivative of 3-aminopropylphosphonic acid, and (IV), the monotrimethylsilyl derivative of 5-ethyl-5-(3-hydroxy-1-methylbutyl)-1,3-dimethylbarbituric acid.

Varying amounts of sample were introduced through the gas chromatographic inlet of an LKB 9000 mass spectrometer. The mass spectra were recorded (source temperature 250°, electron energy 70 ev, accelerating voltage 3·5 kv) at the maximum of the gas chromatographic elution peak to avoid a biased spectrum.[4] Although sample pressure in the source will increase with the quantity of sample introduced into the gas chromatograph, it does not necessarily follow a linear relationship. The data summarized in the Table, however, show a definite dependence on the relative abundance of the $M+73$ ion on sample pressure.

Relative intensities of M+73 *peaks as a function of quantity of sample introduced*[a]

Volume of solution introduced (μl)[b]	(I) $M+1$	(I) $M+73$	(II) $M+73$	(III) $M+73$	(IV) $M+73$
0·1	0·0	0·0	0·0		
0·2	0·0	0·0	0·02		
0·3	0·15	0·12	0·06		
0·4	0·19	0·19	0·09		
0·5	0·27	0·23	0·11	0·04	0·0
1·0	0·35	0·35	0·11	0·22	0·14
1·5	0·57	0·65			
2·0	0·85	1·00		0·28	0·98
3·0	2·12	2·50			1·43
4·0	5·78	7·31		0·40	

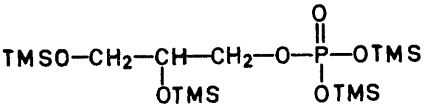
[a] Intensities are expressed as percentage of the base peak. [Base peak for compound (I) *m/e* 299; (II) *m/e* 173; (III) *m/e* 412; (IV) *m/e* 117.]

[b] Samples were prepared by heating 1 mg of each compound with bistrimethylsilyltrifluoroacetamide (0·1 ml) and trimethylchlorosilane (0·05 ml) in acetonitrile (0·1 ml) for 30 min at 85°.

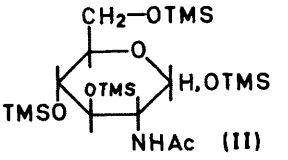
The mass spectrum of the glycerophosphate derivative (I) does not exhibit a molecular ion, but instead shows a peak at $M+1$ whose increase in relative intensity with sample pressure closely parallels that of the $M+73$ peak. When [$^2H_{18}$]bistrimethylsilylacetamide was substituted for bistrimethylsilyltrifluoroacetamide, the $M+$trimethylsilyl peak in the perdeuteriotrimethylsilyl derivatives of the above compounds showed the expected shift of nine a.m.u. ($M+82$), further confirming the intermolecular transfer of a trimethylsilyl group.

In the case of (II) and (III) there is a possibility of enolization and the observed peak at $M+73$ could be due to an $M+1$ ion of the enolized trimethylsilyl derivative. This is very unlikely, however, as the observed gas chromatographic properties and stability of these derivatives are not those to be expected from trimethylsilyl-enols of this type.[5] No possibility of enolization exists for (I) and (IV).

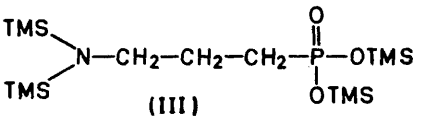
The presently available data do not provide concrete information regarding the site of attachment of the additional trimethylsilyl group. It is possible that in L-α-glycerophosphate the most likely site is the unsilylated oxygen of the phosphate group resulting in ion (V). This does not exclude the possibility that in compounds (II), (III), and (IV) the transferred trimethylsilyl group may be bonded to the nitrogen.



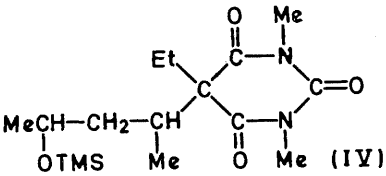
(I)



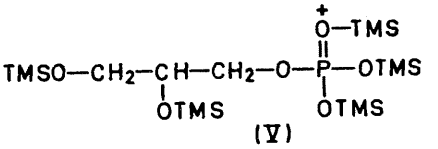
(II)



(III)



(IV)



(V)

TMS = Trimethylsilyl

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[1] J. A. McCloskey, R. N. Stillwell, and A. M. Lawson, *Analyt. Chem.*, 1968, **40**, 233; J. Å. Gustafsson, R. Ryhage, J. Sjövall, and R. M. Moriarty, *J. Amer. Chem. Soc.*, 1969, **91**, 1234; G. H. Draffan, R. N. Stillwell, and J. A. McCloskey, *Org. Mass Spectrometry*, 1968, **1**, 669.

[2] For examples of compounds containing $M+1$ peaks, see: K. Biemann, "Mass Spectrometry," McGraw-Hill, New York, 1962, pp. 269, 287.

[3] J. H. Beynon, "Mass Spectrometry and Its Application to Organic Chemistry," Elsevier, Amsterdam, 1960, pp. 276, 405.

[4] F. A. J. M. Leemans and J. A. McCloskey, *J. Amer. Oil Chemists' Soc.*, 1967, **44**, 11.

[5] E. C. Horning and M. G. Horning, unpublished results.