

Table II. Origin of Deuterium in m/e 165 and m/e 149 from **2a-d**

m/e		Per cent ^a			
		α	β	γ	δ
165	d_1^b	16.1	25.8	27.7	27.4
	d_2	1.0	3.7	2.7	3.3
149	d_1	10.2	17.2	19.1	17.2
	Calcd ^c	9.1	16.6	16.6	17.0

^a Corrected for presence of protium resulting from incomplete labeling. ^b Maximum possible total for all positions is 200%, or 100% per deuterium atom. ^c Calculated for m/e 149 and equal to one-half the deuterium content of m/e 165: $\% d_2 + 0.5\% d_1$.

were systematically labeled¹³ on the first four carbons from both ends ($\alpha, \alpha-d_4$, **2a**; $\beta, \beta-d_4$, **2b**; $\gamma, \gamma-d_4$, **2c**; $\delta, \delta-d_4$, **2d**). The results, shown in Table II, reveal that approximately 59% of the hydrogen involved in the formation of m/e 165 originates from the first four positions. This double hydrogen transfer is not site specific, but shows great preference for those positions which are sterically accessible to oxygen atoms in the cyclic M — CH₃ precursor. The absence of site specificity is also reflected in m/e 149 which, as shown by comparison of the last two lines of Table II, retains statistically half of the label regardless of its positional origin.¹⁵

At progressively shorter chain lengths, the cyclic M — CH₃ complex can be expected to become conformationally less flexible. As a consequence, interactions between ether oxygens and the first several methylene groups become more restricted, ultimately resulting in the decreased abundance of m/e 165 and 149 which is observed at short chain lengths.¹² For very large values of n , the reaction occurring between the termini of a long chain bears a distinct similarity to an ion-molecule reaction,¹⁶ as recently demonstrated in a study of the chemical ionization mass spectra of α, ω -diols.¹⁷ In fact, the ring-closure reaction of M — CH₃ ion in the present case has analogy in the intermolecular formation of adducts between various siliconium ions and heteroatom-containing molecules, reported by Harvey and his collaborators.¹⁸ Clearly, the occurrence of major fragments from reactions between the termini of very long chains represents further strong evidence for the ability of these molecules to extensively wind and coil in the vapor phase, doubtless due to such factors as dipole interactions and internal solvation.³ Equally important, recognition of such processes is crucial in the application of mass spectrometry for the determination of molecular structure.

(13) $\alpha, \alpha-d_4-1,22$ -Docosanediol was prepared by LiAlD₄ reduction of the corresponding diacid. The remaining d_4 -diols were synthesized by chain elongation (reduction to the diol and conversion to the corresponding bromide, then nitrile, and followed by hydrolysis) of the appropriate $\alpha, \alpha-d_4$ -dicarboxylic acids, which were derived¹⁴ by heating the acid (370 mg) with basic D₂O (2 ml, 50 mg of Na) in a stainless steel bomb for 2 weeks at 200°. After trimethylsilylation,⁵ mass spectra of **2a-d** were acquired completely free of contamination by minor glc peaks, and showed deuterium incorporation levels of 95–97.5%.

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(15) These data do not mean that the two hydrogens in m/e 165 are equivalent with regard to loss of methane. Likewise, the methyl groups in m/e 165 cannot be distinguished, and m/e 149 can also have the structure Me₃SiO⁺SiMeOH.

(16) We thank Dr. F. H. Field for first bringing this similarity to our attention.

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Phoshepanium Salts. Nucleophilic Substitution at Heterocyclic Phosphorus with Complete Inversion of Configuration

Sir:

Recent work has shown that the stereochemistry of nucleophilic substitution at phosphorus contained in saturated heterocyclic phosphonium salts varies with ring size, although complete inversion of configuration has never before been observed. Thus a comparison of such systems, where benzyl is the leaving group and hydroxide ion the nucleophile, can be summarized as follows: (a) *cis* and *trans* isomers of phosphetanium salts **1** and **2** decompose to give *identical mixtures* of the *cis* and *trans* isomers of **3** and **4**, respectively;¹ (b) pure *cis* and *trans* isomers of the phospholanium salts **5**² and **6**³ undergo alkali cleavage with *complete retention* of configuration at phosphorus to yield the respective oxides **7** and **8**; and (c) each of the pure *cis*- and *trans*-phosphorinanium salts of structure **9** leads to *mixtures* of stereoisomeric oxides (**10**) of *different composition*⁴ indicating the absence of a common intermediate between the isomeric salts and the oxides formed.

We now wish to report that a still different stereochemical result is realized upon hydroxide cleavage of the *cis*- and *trans*-1-benzyl-4-methyl-1-phenylphoshepanium bromide salts (**11**).⁵ Within limits of experimental error it has been determined that substitution occurs with *complete inversion* of configuration at phosphorus to yield **12**. Apparently, the greater flexibility of the seven-membered ring, as compared to the smaller rings previously studied, permits accommodation of C-P ring bonds in comparatively unstrained equatorial positions in the phosphorane intermediate **14**. The significance of this work lies in the fact that the seven-membered ring represents the smallest ring system in this series which allows complete inversion of configuration at phosphorus. Therefore, there is in evidence a return to the "McEwen mechanism," first observed for the base-induced conversion of the acyclic, optically pure methylethylphenylbenzylphosphonium iodide to optically pure methylethylphenylphosphine oxide of opposite configuration *via* the unstrained intermediate **15**.⁶ Also, the results obtained for the cleavage of the di-

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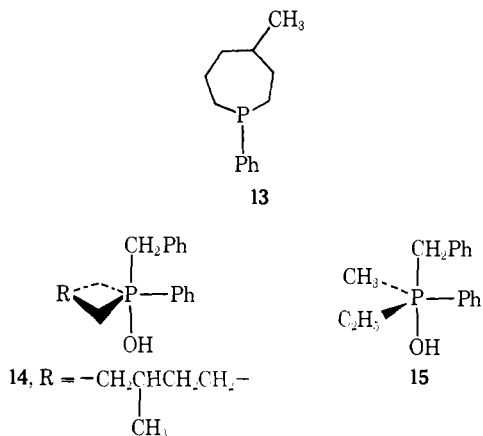
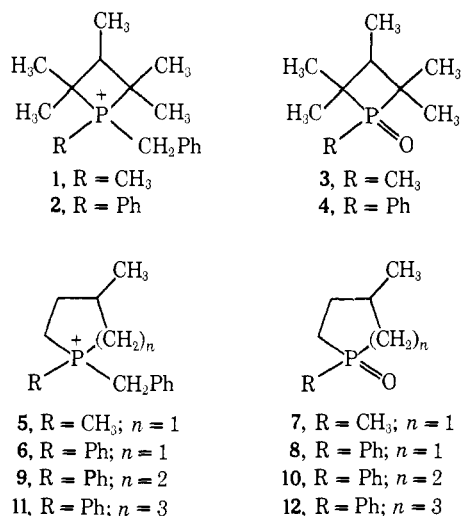
(2) K. L. Marsi, *ibid.*, 846 (1968); *J. Amer. Chem. Soc.*, **91**, 4724 (1969).

(3) W. Egan, G. Chauviere, K. Mislow, R. T. Clark, and K. L. Marsi, *Chem. Commun.*, 733 (1970).

(4) K. L. Marsi and R. T. Clark, *J. Amer. Chem. Soc.*, **92**, 3791 (1970).

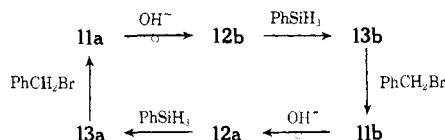
(5) These compounds were prepared by an adaptation of the Märkl cyclization procedure [G. Märkl, *Angew. Chem., Int. Ed. Engl.*, **2**, 620 (1963)]. Further details of the synthesis will be published elsewhere. Stereochemical assignments of the isomers of **11**, **12**, and **13** have not yet been made but are not essential to the discussion of the stereochemistry of the reactions reported herein.

astereomers of the six-membered ring analog **9**⁴ can now best be explained in terms of the operation of two simultaneous mechanisms, the "McEwen mechanism" leading to inverted product, and a mechanism of the type observed for the base decomposition of the diastereomers of **5** and **6** yielding the oxide of retained configuration.



The stereochemical cycle shown in Scheme I was followed beginning with **11a**, estimated to be 92 ± 5%

Scheme I



isomerically pure. Phenylsilane has previously been shown to reduce phosphine oxides with complete retention of configuration,^{2,3} and quaternization of phosphines is also known to be accompanied by retention of configuration at phosphorus.^{7,8} Both are high-yield reactions as shown in Table I.

The properties of **11a**, obtained after the six consecutive reactions shown, were found to be essentially identical with those of the starting **11a**. The compounds designated **a** belong to the same diastereomeric family and are converted to the **b** family by inversion of configuration at phosphorus by base cleavage of **11a**. Treat-

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(7) L. D. Quin and T. P. Barket, *ibid.*, **92**, 4303 (1970).

(8) W. E. McEwen, *Top. Phosphorus Chem.*, **2**, 23 (1965).

Table I. Characteristics of Phosphepanes and Their Derivatives

Compd	Mp (bp), °C	Yield, ^a %	δ ³¹ P nmr ^b	Purity, ^c %
11a	187.5–189		+110.13	92
11a ^{d,e}	182.5–183.5	97	+110.15	94
12b	80–82	98	+98.85	92
13b	115 (0.05 mm)	91		
11b ^e	161.5–163	100	+109.96	92
12a ^f	80.5–81.5	88	+99.18	89
13a	97 (0.03 mm)	97		

^a From the preceding step in the cycle (Scheme I). ^b Determined on a 220-MHz Varian spectrometer at a resonance frequency of 89 MHz and expressed as parts per million from trimethyl phosphite, used as an external standard. The chemical shift of trimethyl phosphite relative to 85% phosphoric acid is reported as -139.6 ppm [J. G. Verkade, R. W. King, and C. W. Heitsch, *Inorg. Chem.*, **3**, 884 (1964)]. ^c Expressed as the principal isomer and determined by integration of proton-decoupled ³¹P nmr signals; estimated to be accurate within ± 5%. ^d Crude salt obtained by quaternization of **13a** from the fifth step of the cycle (Scheme I). ^e Unrecrystallized. ^f Although **12a** and **12b** have very similar melting points and δ values, mixtures of the two provide a proton-decoupled ³¹P nmr spectrum consisting of two separated signals of δ values reported in Table I.

ment of **11a** with phenyllithium and benzaldehyde (Wittig reaction) gave an oxide identical with **12a** as expected.⁹ The diastereomer **11b** was prepared separately from the cycle shown in Scheme I and was found to be identical with **11b** prepared in the cycle. Elemental analyses on all compounds were satisfactory, and ¹H nmr spectra were consistent with assigned structures. A summary of characteristics of phosphepanes and derivatives employed in this study are given in Table I.

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Concerning the Stereochemistry of Deoxygenation of Ribonucleotides. The Specifically 2'-Monodeuterated 2'-Deoxycytidines

Sir:

In the biosynthesis of deoxyribonucleic acids (DNA), the reduction of ribonucleotides to deoxyribonucleotides constitutes a critical step which might be susceptible to regulation.¹ In view of this possibility, the mechanism of the reduction has received well-warranted attention,¹⁻⁸ and several features of the process have

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