

DISPLACEMENT OF CHLORINE FROM 2-CHLORO-2-OXO-1,3,2-DIOXAPHOSPHORINANE
WITH RETENTION OF CONFIGURATION

T.D. Inch and G.J. Lewis

Chemical Defence Establishment, Porton Down, Salisbury, Wiltshire

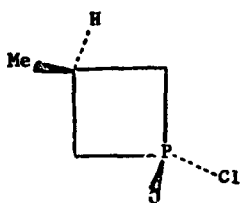
(Received in UK 26 April 1973; received in UK for publication 3 May 1973)

In a variety of phosphorus halides it has been shown that nucleophilic displacement of halide by alcohols^{1,2}, amines¹, and Grignard reagents³ occurs with preponderant inversion of configuration at phosphorus. Thus in terms of current concepts of the stereochemistry of reactions at phosphorus, the substitutions can be considered to take place via a trigonal bipyramid intermediate in which both entering and leaving groups occupy apical positions⁴. In the cyclic phosphinylchloride (λ), however a geometrical arrangement in which the incoming nucleophile and the leaving group both initially occupy apical positions is not possible and displacement of chlorine from λ with retention of configuration has been observed⁵. In this paper further demonstration of the complexity of nucleophilic displacement reactions at phosphorus is provided by results which appear to indicate that the stereochemical course of such displacements in 2-chloro-2-oxo-1,3,2-dioxaphosphorinanes is dependent on the conformation of the 1,3,2-dioxaphosphorinane ring.

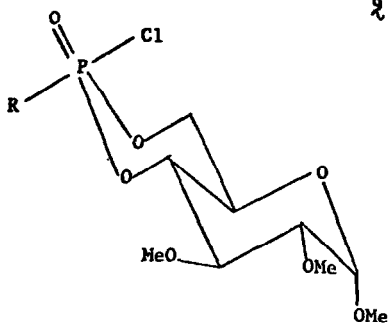
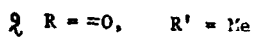
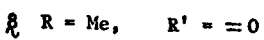
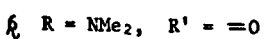
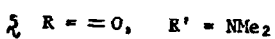
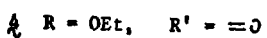
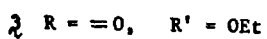
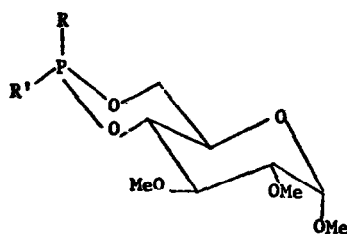
By analogy with other 2-halogeno-2-oxo-1,3,2-dioxaphosphorinanes in which axial preference for electronegative 2-substituents has been demonstrated⁶, the crystalline phosphorochloridate λ [m.p. 127 - 129° (from diisopropylether), $[\alpha]_D + 114^\circ$ (CHCl₃), which was prepared as the only product by treatment of methyl 2,3-di-O-methyl- α -D-glucopyranoside with POCl₃ and triethylamine in ether] may be assigned a chair conformation in which the chlorine atom is orientated axially. Supporting evidence for this structure was provided when λ , on treatment with ethanol or ethanol/triethylamine, was found to afford as the preponderant

product compound λ in which the P - OEt group is orientated equatorially⁷, (a ratio for $\lambda:\mu$ of > 9 was found). Further, on treatment with dimethylamine λ was converted into a mixture of ξ and η in the ratio 10:1. Compounds ξ Δ m.p. 145 - 147° (from diisopropylether); $\Delta\alpha\Delta_D + 105^\circ$ (CHCl₃); $\nu_{\max(P=O)}$, 1250 (KBr) 1240 (CDCl₃) cm⁻¹; δ , N-Me₂, 2.76 ($J_{P-N-CH_3} = 10$ Hz), OMe, 3.49, 3.57 and 3.62 p.p.m. Δ and η Δ m.p. 105 - 110° (from diisopropylether); $\Delta\alpha\Delta_D + 83^\circ$ (CH₂Cl₂); $\nu_{\max(P=O)}$, 1263 (KBr), 1252 (CDCl₃) cm⁻¹; δ , N-Me₂, 2.75 ($J_{P-N-CH_3} = 11.3$ Hz), OMe, 3.46, 3.57 and 3.66 p.p.m. Δ were separated chromatographically over silica in benzene - ethanol (9:1) ΔR_f values 0.16 and 0.13 respectively Δ . The P - NMe₂ groups in ξ and η were assigned equatorial and axial orientations respectively since it has been established that P = O i.r. stretching bands in 1,3,2-dioxaphosphorinanes are at higher frequency when the P = O group is equatorial than when it is axial^{7,8}. The above results are consistent with a situation in which the preponderant reaction (viz. direct displacement of chlorine from λ with inversion of configuration) has occurred probably via the transition intermediate λ in which both entering and departing groups occupy apical positions. Whether the minor isomers μ and η are formed following initial exchange of λ with Cl⁻ or by some other mechanism is open to question. In related compounds, results which are far from unequivocal, have been interpreted as favouring a SN1 mechanism⁹.

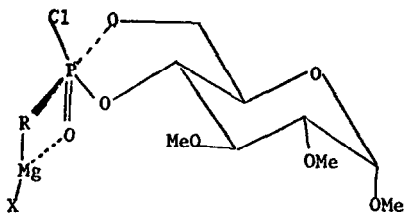
In contrast with Grignard reagent - acyclic phosphorohalide reactions which take place with inversion of configuration³, compound λ on treatment with methylmagnesium iodide (1.3 equivalents) in benzene - ether underwent displacement of chlorine with preponderantly retention of configuration to afford five times more β than α ⁷. A possible explanation of this result is that the initial formation of a complex¹⁰ between methylmagnesium iodide and λ causes a conformational change which places the chlorine atom in a pseudo-equatorial orientation, e.g. λ . The consequence is that the incoming methyl group and the departing chlorine atom cannot both occupy apical positions in



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9 R = OEt or NMe₂



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the initial transition intermediate and thus displacement of chlorine will take place either directly from a basal position in the trigonal bipyramid or from an apical position after pseudorotation¹¹. The observed retention of configuration is consistent with either mechanism.

REFERENCES

1. J. Michalski and M. Mikolajczyk, Chem.Ind., 1964, 661; M. Mikolajczyk, J. Omelanczuk and M. Para, Tetrahedron, 1972, 28, 3855.
2. H.L. Boter, A.J. Ooms, G.R. van den Berg and C. van Dijk, Rec.Trav.Chim., 1966, 85, 147.
3. G.R. van den Berg, D.H.J.M. Platenburg and H.P. Benschop, Rec.Trav.Chim., 1972, 91, 929.
4. M.J. Gallagher and I.D. Jenkins, Topics in Stereochemistry, 1968, 3, 1.
5. J.R. Corfield, N.J. De'ath and S. Trippett, Chem.Comm., 1970, 1502.
6. T.A. Beinke, Acta Cryst., 1969, B25, 413; L. Silver and R. Rudman, Acta Cryst., 1972, B28, 574; W.G. Bentrude and J.H. Hargis, Chem.Comm., 1969, 1113; R.S. Edmundson, J.C.S. Perkin I, 1972, 1660.
7. T.D. Inch and G.J. Lewis, Chem.Comm., in press.
8. J.P. Majoral and J. Navech, Bull.Soc.Chim. France, 1971, 95, 1331, 2609.
9. W.S. Wadsworth and H.L. Horton, J.Amer.Chem.Soc., 1970, 92, 3785; W.S. Wadsworth, J.C.S. Perkin II, 1972, 1686.
0. H.R. Hays, J.Org.Chem., 1971, 36, 98.
1. I. Ugi and F. Ramirez, Chem. in Britain, 1972, 198.