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THE STEREOCHEMISTRY OF SOME OXIDATIONS OF PHENYLMETHYLPROPYLPHOSPHINE

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The recent preparation of optically active phosphines[1,2] has provided the means for studying the stereochemistry of their reactions. Several oxidation reactions of phosphines, which have been investigated by other techniques in this laboratory[3,4,5], have now been studied using optically active phenylpropylmethylphosphine(I). The stereochemical results are collected in the Table.

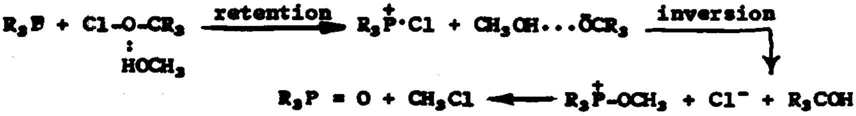
TABLE

Series*	Reactant	Oxide $[\alpha]^{26}_{D}$ MeOH+	Conditions
A	$(CH_3)_3COOH$	+19.6°	Pentane, 0°
A	$(CH_3)_3COCl$	+ 0.1°	Pentane, -78°
B	$(CH_3)_3COOH$	+18.5°	Methylene Chloride, 0°
B	$(CH_3)_3COCl$	-13.3°	Methylene Chloride - Methanol, -78°
B	$CH_3CO_3C(CH_3)_3$	+17.4°	Benzene, 80°

*Two separate samples of phosphine were used. +Purification of the phosphine oxide was accomplished by molecular distillation and identification was conducted by infrared and n.m.r. spectroscopy.

Previously it was proposed that trisubstituted phosphines and phosphites react with t-alkyl hydroperoxides by nucleophilic displacement on the hydroxyl oxygen. The stereochemical results obtained in this study are in agreement with this view. It does not seem reasonable that inversion occurs in this process, although it should be noted that absolute proof is not available.

The phosphine-hydroperoxide reaction has been taken as a standard in interpreting the results obtained with the other oxidizing agents. With this proviso it is possible to conclude that the reaction of I with t-butyl hypochlorite in the presence of methanol has proceeded with a large measure (72%) of inversion. Overall inversion is in accord with the mechanism originally suggested[4] and which is outlined below. Initial displacement by phosphine with retention of configuration gives a chlorophosphonium ion and a solvated alkoxide ion. Rapid proton transfer yields a methoxide ion which attacks the chlorophosphonium ion by an inversion reaction to give an alkoxy phosphonium ion which decomposes by a typical S_N2 reaction to phosphine oxide and alkyl halide. This scheme accounts for the majority of product, however, it is clear that some racemization has occurred. No evidence is available on how this racemization takes place.

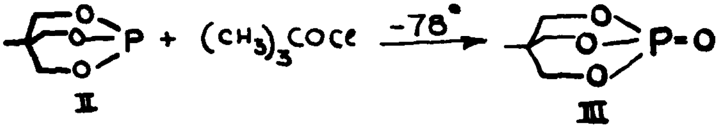


$$R_3P + \underset{\underset{HOCH_3}{\vdots}}{Cl-O-CR_3} \xrightarrow{\text{retention}} R_3\overset{+}{P}\cdot Cl + CH_3OH\cdots\bar{O}CR_3 \xrightarrow{\text{inversion}}$$

$$R_3P = O + CH_3Cl \longleftarrow R_3\overset{+}{P}-OCH_3 + Cl^- + R_3COH$$

Reaction of I with t-butyl hypochlorite in the absence of alcohol yields racemic phosphine oxide. This result indicates a substantially different course for the reaction than was found with methanol present. Originally it was suggested that the reaction in the absence of alcohol gave a pentacovalent phosphorus compound as an intermediate[4]. Racemization could arise by (a) direct formation of a racemic pentacovalent intermediate, (b) intramolecular racemization of an initially optically active pentacovalent intermediate[6] or (c) intermolecular racemization by a dissociation recombination process. At the moment it is not possible to distinguish between these possibilities.

In this connection it has been found that the bicyclic phosphite (II) is smoothly oxidized to the phosphate (III).



Clearly this reaction has proceeded with retention of configuration and it illustrates that several reaction paths are available for the oxidation.

Earlier work had suggested that the reaction of t-butyl peresters with trisubstituted phosphines involves a pentacovalent intermediate. The fact that the reaction occurs with essentially complete retention of configuration is not in disagreement with this idea. Several pentacovalent intermediates can be written which accommodate the stereochemical results and of course, many are eliminated. The difference in the stereochemistry of this reaction and that of the hypochlorite reaction is particularly interesting and points once again to the complexeties to be found with reactions of organosilicon[7] and phosphorus compounds.[8]

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