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REACTIONS OF CHLORAL WITH OPTICALLY ACTIVE PHENYLMETHYLPROPYLPHOSPHINE[1]

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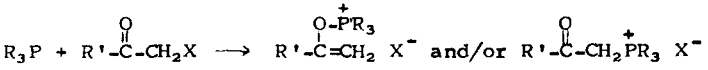
Various α-haloketones, aldehydes and esters react with trisubstituted phosphines to give enol-phosphonium salts (I) and/or quaternary phosphonium salts (II).[2] The structural features which govern the relative rates of formation of these



$$R_3P + R'\text{-}\overset{O}{\overset{\|}{C}}\text{-}CH_2X \longrightarrow R'\text{-}\overset{\overset{+}{O\text{-}PR_3}}{\overset{|}{C}}{=}CH_2\ X^- \text{ and/or } R'\text{-}\overset{O}{\overset{\|}{C}}\text{-}CH_2\overset{+}{P}R_3\ X^-$$

I II

two products are not well established. Tripett[3] and Hoffman and Diehr[4] have shown that triphenylphosphine reacts with chloral in aprotic media to give an enolphosphonium salt, $(C_6H_5)_3\overset{+}{P}\text{-}OCH{=}CCl_2\ Cl^-$. This substance is very unstable towards moisture and is hydrolyzed rapidly to triphenylphosphine oxide.

It has now been found that optically active phenylmethylpropylphosphine (III) reacts with chloral in anhydrous ether to give a precipitate which is readily hydrolyzed to give phenylmethylpropylphosphine oxide (IV). The oxide is at least 95% racemized, see Table I. When the same experiment was conducted in tetrahydrofuran-water, the oxide was also found to be essentially racemic. When chloral and optically active III were allowed to react in methylene chloride, the optical rotation of the reaction mixture was found to be virtually zero.

TABLE I

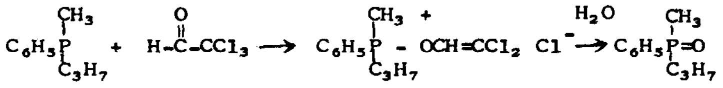
Reactions of Optically Active Phenylmethylpropylphosphine

Reactant	Phosphine Oxide $[\alpha]_D^{22^\circ}$	Conditions
$(CH_3)_3COOH$[a]	-19.0°	Pentane, 0°
CCl_3CHO	-0.84	Ether, 0°
CCl_3CHO	+0.97	Tetrahydrofuran-Water, 0°
CCl_3CHO	-0.74[b]	Methylene Chloride, 0°

[a] This reaction was used to establish the optical purity of the phosphine, see D. B. Denney and J. W. Hanifin, Jr. Tetrahedron Letters, 30, 2177 (1963).

[b] Calculated assuming all the material was converted to V. The observed rotations in this experiment were subject to a somewhat greater error than in the others.

It is believed that III reacts with chloral to form the enol-phosphonium salt (V). This belief is predicated on the ready hydrolysis of the material obtained in ether

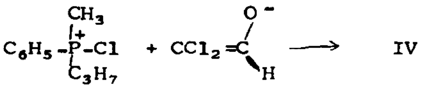


$$C_6H_5\overset{CH_3}{\underset{C_3H_7}{P}} + H-\overset{O}{\overset{\|}{C}}-CCl_3 \longrightarrow C_6H_5\overset{CH_3\ +}{\underset{C_3H_7}{P}} - OCH=CCl_2\ Cl^- \xrightarrow{H_2O} C_6H_5\overset{CH_3}{\underset{C_3H_7}{P}}=O$$

III V IV

to IV and by analogy to the triphenylphosphine reaction. Other substantiating evidence is provided by the reaction of phenyldipropylphosphine in ether with chloral. A solid was obtained whose infrared spectrum showed no carbonyl absorption. The n.m.r. spectrum showed no aldehydic proton. An absorption for the olefinic proton was not found. It probably occurs in the aromatic region.

The stereochemical results have an important bearing on the mechanism of enol-phosphonium salt formation. Two routes have been proposed. The first suggests direct attack on oxygen to give IV. The other envisions attack on halogen to give the ion pair (VI) which collapses to IV. Although



$$C_6H_5-\overset{CH_3}{\underset{C_3H_7}{\overset{+}{P}}}-Cl + CCl_2=C\begin{matrix}O^-\\ H\end{matrix} \longrightarrow IV$$

VI

the general stereochemistry of reactions at phosphorus is not as well understood as it might be, it is possible to make predictions as to the outcome of the processes outlined above.[5,6,7] Direct attack on oxygen by the phosphine should lead to an enol-phosphonium salt with retention of configuration, subsequent hydrolysis would be expected to lead to inversion. Attack on halogen should proceed with retention, recombination by inversion and hydrolysis with inversion. In the presence of water, hydrolysis of the chlorophosphonium salt should proceed with inversion. Clearly these mechanisms predict that the phosphine oxide will be formed with a high degree of conservation of optical activity, which is not the case.

The reaction in methylene chloride in which there was essentially no observation of optical activity suggests that the salt, V, is racemic as formed,[8] and racemization is not just an outcome of the hydrolysis of IV. The results of these experiments are most easily accommodated by a mechanism in which chloral and the phosphine react to give a pentacovalent compound which is racemic or undergoes rapid racemization before ionization and hydrolysis. Several transition states can be suggested, however a transition state in which both chlorine and oxygen are being bonded to phosphorus is inviting. It is important to note that these stereochemical results can only be applied to this particular reaction. Indeed, work in progress indicates that displacement reactions in related systems by phosphines need not always lead to racemization.

These results further illustrate that attempts to generalize mechanisms in organophosphorus chemistry is a perilous task and leads to much confusion.

References

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6. R. F. Hudson and M. Green, *Angew. Chem. Internat. Edit.* *2* 11 (1963)
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8. This experiment is significant but since the specific rotation of the salt, V, is unknown one cannot be absolutely confident that it was not optically active. A survey of known salts, oxides, etc. indicates that they have substantial rotation; in this series ca 20°. In this particular experiment, V with such a specific rotation would have led to an observed rotation of around 3°.