

broadening disappeared after treatment with methanol.⁶ Qualitative oxidation experiments confirm these conclusions; thus three phosphates were obtained by cumene hydroperoxide oxidation of the mixture. These three phosphates were also obtained by oxidation of a mixture of IVa and V with mercuric oxide.

The results of these experiments are most readily explained by assuming that Ia,b, IIIa,b, and IVa,b represent pairs of geometric isomers.⁷ Preparation of these materials by transesterification apparently yields the thermodynamic equilibrium mixture of each pair. This is not unreasonable; however, it is very interesting that in the pairs IIIa,b and IVa,b there is such a strong preference for one isomer. This is further evidenced by the rapid conversion of IIIb and IVb into IIIa and IVa on treatment with methanol.

The preparation of IIIb and IVb *via* the cyclic phosphorochloridites most probably involves an inversion about the phosphorus atom during the displacement by methoxide ion. Apparently the phosphorochloridites are formed in the main in one preferred configuration and this corresponds to that of the most stable phosphites. The fact that pure or nearly pure IIIb and IVb have not been obtained as yet is probably due to their isomerization under the reaction conditions.

It is clear that these geometric isomers will be of considerable value in studying the stereochemistry and mechanisms of phosphite reactions. Furthermore, it has already been observed that IIIb and IVb are considerably more reactive in the oxidation reactions than their counterparts and thus some interesting structure-reactivity effects may be in the offing.

(6) Analysis of all of these cyclic phosphites by glpc is quite difficult. Conventional instruments are totally inadequate and success when obtained has been with an instrument with glass injection ports and very low column temperatures. Even with these precautions resolution often varies from day to day in a nonpredictable manner.

(7) It could be argued that these are pairs of noninterconverting conformers. At the moment there seems to be no reason for adopting this extreme view. There are some very interesting conformational problems in this series and these will be considered when more information becomes available.

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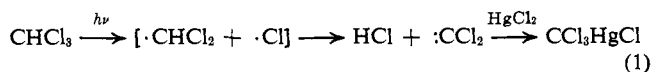
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The Insertion of Halocarbenes into the Mercury-Halogen Bond

Sir:

In 1960 Reutov and Lovtsova¹ reported a useful synthesis of trihalomethyl derivatives of mercury by the reaction of an organomercuric halide with haloform and potassium *t*-butoxide. A mechanism involving dihalocarbene insertion into the Hg-X linkage was suggested for this reaction by these authors. Our subsequent work provided strong evidence that this reaction did not occur by a dihalocarbene insertion mechanism, but rather that the trihalomethylmercury products were formed by nucleophilic attack of initially generated CX₃⁻ at mercury.² Similarly, the preparation of trichloromethylmercury compounds by the decarboxylation of sodium trichloroacetate in the presence of mercuric

chloride or arylmercuric chlorides does not proceed *via* dichlorocarbene insertion into the Hg-Cl linkage.³ Razuvaev and Vasileiskaya⁴ recently have reported the formation of CCl₃HgCl by photolysis of chloroform in the presence of mercuric chloride and pyridine. A mechanism in which dichlorocarbene inserted into the Hg-Cl bond was claimed by these workers (eq 1). Con-



vincing experimental verification of this postulated mechanism was, however, lacking, and alternative polar or radical mechanisms could well be operative in this case.

Our previous studies have shown that phenyl(bromodichloromethyl)mercury reacts rapidly with olefins at 80° in benzene solution to produce phenylmercuric bromide and *gem*-dichlorocyclopropanes in high yield.⁵ Evidence which strongly suggests that this CCl₂ transfer reaction involves the intermediacy of dichlorocarbene—either free or complexed with phenylmercuric bromide—has been obtained.⁵⁻⁷ Consideration of preliminary kinetic data^{7,8} suggested to us that the extrusion of CCl₂ from C₆H₅HgCCl₂Br might be a reversible process, *i.e.*, that dichlorocarbene might insert into the Hg-X bond under *neutral* conditions. This has been found to be the case.

A mixture of 10 mmoles each of phenylmercuric chloride and phenyl(bromodichloromethyl)mercury in 25 ml of benzene was heated at reflux for 2 hr. Filtration produced a flaky, white solid which was identified by thin layer chromatography and melting behavior as phenylmercuric bromide with admixed smaller amounts of phenylmercuric chloride. The filtrate was distilled under vacuum; glpc showed the distillate to contain tetrachloroethylene (4% yield, based on C₆H₅HgCCl₂Br). The solid distillation residue, mp 105–109°, was recrystallized from hexane-chloroform to give 2.46 g (62%) of phenyl(trichloromethyl)mercury, mp 115.5–116.5°, whose identity was confirmed by its mixture melting point and infrared spectrum. Thus the reaction shown in eq 2 had occurred. In an identical reac-

tion the crude, benzene-soluble solid was treated with bromine in carbon tetrachloride. Glpc analysis of the volatile cleavage products showed the presence of bromotrichloromethane (70%), dibromodichloromethane (3%), and bromobenzene (72%). Such bromine cleavage has been shown to serve well in the analysis of phenyl(trihalomethyl)mercurials.²

In a similar experiment, *p*-tolylmercuric chloride was converted to *p*-tolyl(trichloromethyl)mercury, mp 120–122°, in 57% yield. Reaction of 10 mmoles of mercuric chloride with 25 mmoles of phenyl(bromodichloromethyl)mercury in benzene at 80° gave a mixture of bis-(trichloromethyl)mercury, mp 141–143°, *lit.*³ mp 140–

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(4) G. A. Razuvaev and N. S. Vasileiskaya, *Izv. Akad. Nauk SSSR, Ser. Khim.*, 1285 (1965).

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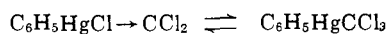
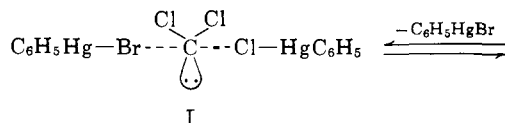
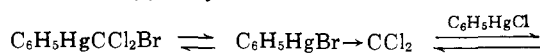
(1) O. A. Reutov and A. N. Lovtsova, *Izv. Akad. Nauk SSSR, Otd. Khim. Nauk*, 1716 (1960); *Dokl. Akad. Nauk SSSR*, **139**, 622 (1961).

(2) D. Seyferth and J. M. Burlitch, *J. Am. Chem. Soc.*, **84**, 1757 (1962); *J. Organometal. Chem.*, **4**, 127 (1965).

142° (47%), and trichloromethylmercuric chloride (20% yield). The latter could not be separated from the phenylmercuric halides, and the yield is based on the bromotrichloromethane formed in the bromine cleavage of the RHgX mixture.

Such transfer reactions are not confined to phenyl-(bromodichloromethyl)mercury + mercury chloride systems. We found a similar reaction to occur when phenylmercuric chloride and phenyl(bromochloromethyl)mercury⁹ were heated in chlorobenzene at reflux for 34 hr. At the end of this time a mixture of $\text{C}_6\text{H}_5\text{-HgCHCl}_2$ and $\text{C}_6\text{H}_5\text{-HgCHClBr}$ was present (qualitative identification by infrared and nmr: cf. ref 9). Bromination of this mixture showed that the former had been formed in 76% yield.

These reactions appear to occur rapidly only at temperatures at which rapid CX_2 transfer from $\text{C}_6\text{H}_5\text{-HgCX}_2\text{-Br}$ to olefins occurs, and thus it is most likely that we are dealing here with bona fide CCl_2 transfer from $\text{C}_6\text{H}_5\text{-HgCCl}_2\text{Br}$ to ArHgCl and HgCl_2 . This reaction very likely involves transfer of free or complexed CCl_2 to substrate. If the latter is the case, a three-center transition state (I) may be considered. However, a direct,



bimolecular transfer mechanism, which we consider less likely, cannot be ruled out at this time.

It is the greater thermal stability of trichloromethylmercury compounds as compared with bromodichloromethylmercury compounds⁵ which makes the observation of these reactions possible. One would have to use isotopic labeling in order to see an analogous reaction between $\text{C}_6\text{H}_5\text{-HgCCl}_2\text{Br}$ and $\text{C}_6\text{H}_5\text{-HgBr}$. However, one would expect that added phenylmercuric bromide should decrease the rate of olefin consumption in the olefin + $\text{C}_6\text{H}_5\text{-HgCCl}_2\text{Br}$ reaction. Experiments have shown this to be the case.⁸

The finding that under proper conditions CX_2 insertion into the mercury-halogen bond does indeed occur would lead one to expect that similar insertion should be possible into other metal-halogen linkages. We are exploring this possibility, especially with heavy metal (Sn, Pb, Sb) halides and organometallic halides, and have thus far been able to prepare R_3SnCX_3 compounds by this procedure.¹⁰

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(11) Alfred P. Sloan Foundation Fellow, 1962-1966.

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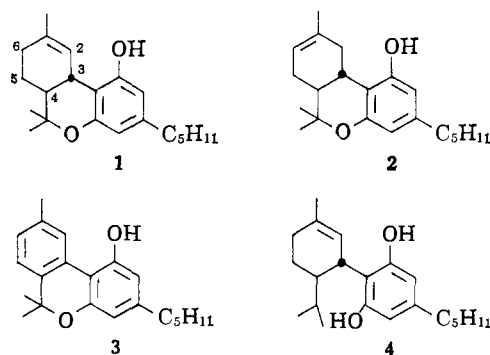
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Isolation of *trans*- Δ^6 -Tetrahydrocannabinol from Marijuana

Sir:

The structure¹ and the total synthesis² of the *dl* modification of a psychotomimetically active constituent, *trans*- Δ^1 -tetrahydrocannabinol (1), present in hashish, have recently been reported.

We wish to report the isolation of a second psychotomimetically active constituent,³ *trans*- Δ^6 -tetrahydrocannabinol (2), from marijuana. Chromatography of a petroleum ether (bp 30-60°) extract of the flowering tops and leaves of a fresh sample of marijuana⁴ grown in Maryland on silicic acid yielded on elution with benzene a phenolic fraction. This fraction was shown to contain the *trans*- Δ^1 - and - Δ^6 -tetrahydrocannabinols, cannabinol (3), and cannabidiol (4) by thin layer chromatography on silica gel-silver nitrate (5:1). The phenolic fraction was separated into its various com-



ponents by chromatography on silicic acid-silver nitrate (5:1), using benzene as the eluting solvent. Cannabinol was eluted first followed by the *trans*- Δ^1 -tetrahydrocannabinol and then the *trans*- Δ^6 -tetrahydrocannabinol. The cannabidiol was eluted from the column with ether. The *trans*- Δ^6 -tetrahydrocannabinol (2) was also obtained from the phenolic fraction present in a fresh sample of marijuana of Mexican origin. In this case the phenolic fraction was separated into its constituents by partition chromatography.⁵ *N,N*-Dimethylformamide on Celite was used as the stationary phase and cyclohexane saturated with *N,N*-dimethylformamide as the mobile phase. The *trans*- Δ^1 -tetrahydrocannabinol accounted for 90% and the *trans*- Δ^6 -tetrahydrocannabinol 10% of the total tetrahydrocannabinol content of the above two samples of marijuana.

It was demonstrated that 2 was not an artifact formed during the workup of the marijuana extract by two different experiments. Chromatography of a pure sample of 1 by either of the two methods described did not result in the formation of any of 2. The tetrahydrocannabinol (2) was not formed during the extraction of the marijuana with petroleum ether, since the petroleum ether extracts of a 2-year-old sample of marijuana of

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(4) We wish to thank Dr. M. Lerner of the U. S. Customs Laboratories, Baltimore, Md., for supplying the marijuana used in this investigation.

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