Tetrahedron Letters No.1, pp. 71-76, 1968. Pergamon Press Ltd. Printed in Great Britain.

THE PREPARATION AND REACTIONS OF A MIXED HALOGEN YLID

Donald J. Burton and Henry C. Krutzsch
Department of Chemistry, University of Iowa
Iowa City, Iowa 52240

(Received in USA 14 August 1967)

Various dihalomethylene ylids have been synthesized either by the reaction of a carbon tetrahalide with a trialkyl or triaryl phosphine (1,2) or by the addition of a dihalocarbene moiety to a trialkyl or triaryl phosphine (3). Subsequent reaction of the ylid with either an aldehyde or a ketone leads to the β,β-dihaloolefin. Employing the carbon tetrahalide method, Ramirez (1) has prepared dibromolefins, and Rabinowitz (2) has reported the preparation of dichloroolefins. The generation of a dihalo carbene and trapping of the carbene by a phosphine to form an ylid has been investigated extensively by Speziale and Ratts (3) as a route to dichloro and dibromo olefins. More recently, the formation of the difluoromethylene ylid (4), generated by decarboxylating sodium chlorodifluoroacetate in the presence of a trialkyl or triaryl phosphine, has also been investigated as a convenient route to terminal 1,1-difluoroolefins.

The difluoromethylene ylid differed in two major respects from the analogous dichloro- and dibromo ylids. Whereas the dichloro- and dibromo-ylids exhibited considerable stability in solution, as evidenced by the fact that subsequent addition of the carbonyl moiety still gave the dihalo olefin in good yield, similar stability was not demonstrated by the difluoromethylene ylid (5). Subsequent addition of an aldehyde or ketone to a solution in which the difluoromethylene ylid had been generated, gave no 1,1-difluoroolefin. Also, the dichloro- and dibromo ylids exhibited enhanced reactivity with carbonyl moieties as compared to the difluoro analog. The dichloromethylene- and dibromomethylenetriphenylphosphorane ylids gave good yields of olefins with both aldehydes and ketones, whereas the difluoromethylenetriphenylphosphorane reacted easily only with aldehydes and with ketones containing an α-perfluoroalkyl group. Typical ketones, such as acetophenone and benzophenone, which reacted easily with dichloro- and dibromo ylids, gave no 1,1-difluoroolefins or only low yields under forcing conditions.

The only simple mixed halogen ylid reported in the literature has been the chlorofluoro methylene ylid (3), $(C_6H_5)_3P{=}CFCl$, generated by the carbene method. Speziale reported a 40% yield of the corresponding olefin from benzophenone with this ylid. In our hands, this reaction could not be repeated, and we are at a loss to explain this earlier report.

This simple mixed ylid, however, is of considerable interest for the following reasons: (a) it will allow a comparison of the dichloro- and difluoromethylene ylids and show the effect of chlorine on the stability and reactivity of a dihalomethylene ylid; (b) in contrast to the other simple halogen ylids it will allow a study of the stereochemistry of these dihalo ylids when reacted with carbonyl compounds; and (c) particularly with ketones containing a perfluoroalkyl group, it will allow the preparation of model geometrical isomers for nucleophilic displacement reactions.

For these reasons we have investigated the preparation and some reactions of this ylid and this report outlines the results to the questions raised above.

Two methods of generation were employed for the chlorofluoromethylene ylid, namely, the decarboxylation of sodium dichlorofluoroacetate and the dehydrohalogenation of dichlorofluoromethane as outlined below:

$$(C_6H_5)_3P + CFCl_2CO_2Na + >C{=}O \xrightarrow[\text{triglyme}]{85^\circ} >C{=}CFCl + (C_6H_5)_3PO + NaCl$$

$$(C_6H_5)_3P + CFCl_2H + KO\overset{t}{B}u \xrightarrow[\text{heptane}]{0^\circ C} (C_6H_5)_3P{=}CFCl \xrightarrow{>C=O} >C{=}CFCl + (C_6H_5)_3PO$$

By comparing the cis/trans ratio of olefins obtained by both methods, it was possible to check if the mode of generation or the reaction conditions had any effect on the isomer ratio. Also, since no direct comparison of yields had been made by these different methods in any of the previously reported work, it was of synthetic interest to make this relationship here. Some representative cases are summarized in Table I. This data demonstrates that the decarboxylation method with aldehydes or reactive ketones generally gives somewhat higher yields of olefin. With unreactive ketones, such as cyclopentanone, the reactivity and stability of the intermediate ylid become more important. At the higher reaction temperature of the decarboxylation mode of generation, more of the ylid decomposes before undergoing reactions with the unreactive carbonyl species. At the lower temperature of the haloform method of generation, the ylid is more stable and, hence reaction even with an unreactive carbonyl compound

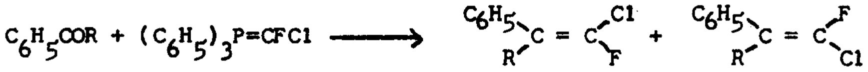
TABLE I

Carbonyl Compound	% Olefin	Method of Generation
C_6H_5CHO	49	decarboxylation
C_6H_5CHO	39	haloform
$C_6H_5COCF_3$	56	decarboxylation
$C_6H_5COCF_3$	31	haloform
$(C_6H_5)_2CO$	0	decarboxylation
$(C_6H_5)_2CO$	0	haloform
	9	decarboxylation
	27	haloform

gives a higher yield. Some substatiation for this hypothesis was found when tri-n-butylphosphine was substituted for triphenylphosphine in this reaction with cyclopentanone. In this case the ylid, $Bu_3P=CFCl$, which was generated was less stable, but more reactive, than the $(C_6H_5)_3P=CFCl$ ylid. Consequently, a 25% yield of olefin was obtained with cyclopentanone by using Bu_3P as the phosphine in the decarboxylation method of ylid generation.

Some representative examples of the stereochemical nature of the reaction are summarized in Table II. Elemental anaylsis, I.R. and U.V. data were consistent with the postulated structures. Isomer assignments were made on the basis of ${}^{J}HF$ and ${}^{J}F$, CF_3 in the N.M.R. spectrum of these compounds. The ratio of *cis-trans* isomers was determined by G.L.C. (no thermal isomerization occured on the column under these conditions). The preceding data indicates that the method of generation of this ylid has practically no effect on the isomer ratio obtained in the final product. As expected, the isomer ratio of trans/cis increases with increasing

TABLE II



A trans B cis

Carbonyl	Method of Generation	% Yield	Ratio A/B
C_6H_5CHO	decarboxylation	49	1.34
C_6H_5CHO	haloform	39	1.26
$C_6H_5COCF_3$	decarboxylation	56	1.12
$C_6H_5COCF_3$	haloform	31	1.05
$C_6H_5COCF_2CF_3$	decarboxylation	42	1.45
$C_6H_5COCF_2CF_2CF_3$	decarboxylation	41	1.52

size of the perfluoroalkyl group with the bulky chlorine and alkyl group being trans. In the case of benzaldehyde, the trans-isomer (cis phenyl and chlorine) might be expected to be the less favored isomer; apparently, however hydrogen-bonding between the hydrogen and fluorine controls the final ratio in this case.

Hine (6) has previously illustrated the carbene nature of the intermediate generated in haloform reactions of this kind. To determine the type of intermediate formed in the decarboxylation method of ylid preparation, the decarboxylation of sodium dichlorofluoroacetate was carried out in the presence of tetramethylethylene. A 37% yield of the corresponding cyclopropane adduct was obtained. When a similar decarboxylation was carried out in the presence of equivalent amounts of tetramethylethylene and triphenylphosphine, no cyclopropane formation occurred. Either triphenylphosphine is a better trapping agent for the :CFCl carbene or the salt reacts faster with $(C_6H_5)_3P$ to form a phosphobetaine salt such as: $(C_6H_5)_3\overset{\oplus}{P}\text{-CFClCO}_2^{\ominus}$ before decarboxylation. To evaluate this former possibility, the $(C_6H_5)_3P\text{=CFCl}$ ylid was generated *via* $CHFCl_2$ and KO$\overset{t}{\text{B}}$u in the presence of equivalent amounts of tetramethylethylene and triphenylphosphine. Subsequently, $C_6H_5COCF_3$ was added to this reaction mixture. After workup, 14% of the cyclopropane adduct and 19% of $C_6H_5C(CF_3)\text{=CFCl}$ were determined by GLPC. These results indicate that triphenylphosphine and tetramethylethylene are of comparable ability as trapping agents for the :CFCl carbene. Consequently, the absence of cyclopropane adduct in the decarboxylation experiment containing tetramethylethylene lends additional support to the phosphobetaine salt as the precursor to the ylid in the decarboxylation generation method.

Acknowledgement: This work was supported in part by the Public Health Service (GM 11809).

References

1. F. Ramirez, H. B. Desai, and N. McKelvie, *J. Am. Chem. Soc.*, **84**, 1745 (1962).
2. R. Rabinowitz and R. Marcus, *J. Am. Chem. Soc.*, **84**, 1312 (1962).
3. A. J. Speziale and K. W. Ratts, *J. Am. Chem. Soc.*, **84**, 854 (1962).
4. S. A. Fuqua, G. W. Duncan, and R. M. Silverstein, *Tetrahedron Letters*, 1461 (1964).
5. F. E. Herkes and D. J. Burton, *J. Org. Chem.*, **32**, 1311 (1967).
6. J. Hine and D. C. Duffy, *J. Am. Chem. Soc.*, **81**, 1131 (1959).