

## The Preparation and the Kinetics of Solvolysis of Some Derivatives of $\beta,\beta,\beta$ -Trichloroethanol

PENTTI SALOMAA and RAILI LINNANTIE

*Department of Chemistry, University of Turku, Turku, Finland*

In continuation of earlier investigations on the kinetics of alkoxy-substituted compounds<sup>1-4</sup>, a number of compounds of the type  $XCH_2OCH_2CCl_3$ , where X is a chlorine atom, an alkoxyl group or an acyloxy group, were prepared from  $\beta,\beta,\beta$ -trichloroethanol. These compounds were of interest from the kinetic standpoint because they contain three electron-attracting chlorine atoms bound to one carbon atom, which combination was expected to lower greatly the rates of solvolysis (*cf.* Ref.<sup>4</sup>).

*Experimental.*  $\beta,\beta,\beta$ -Trichloroethanol (I) was prepared by reducing chloral according to the directions of Chalmers<sup>5</sup>. Derivatives of this alcohol, which have not been described previously, were synthesized by methods described below. The yields of the pure compounds varied from 30 to 70%. The compounds and their physical constants are shown in Table 1. The values of the molecular refractivity in the last column were calculated using values of the group refractivities reported by Vogel<sup>6</sup> and the refractivity value 18.078 for three chlorine atoms attached to the same carbon atom. The purities of most of the compounds were also checked by volumetric analysis of formaldehyde liberated on their hydrolysis in 80% sulphuric acid or, in the case of  $\alpha$ -chloromethyl  $\beta,\beta,\beta$ -trichloroethyl ether, the formaldehyde and hydrogen chloride formed on hydrolysis of

the compound by water, and by determining the molecular weights by cryoscopy in benzene solution. The results of the analyses were in satisfactory agreement with the theoretical values. Thus, for example, the molecular weight determinations of (III) gave the mean value  $316 \pm 8$ , whereas the true molecular weight is 311.

$\alpha$ -Chloromethyl  $\beta,\beta,\beta$ -trichloroethyl ether (II) was prepared from the trichloroethanol, paraformaldehyde and hydrogen chloride. Although the method of preparation was similar in principle to that employed when preparing other  $\alpha$ -chloroethers (for references, see Ref.<sup>1</sup>), poor yields were obtained when the cooled mixture of alcohol and formaldehyde was saturated with hydrogen chloride. The reason for this was that the formal that is produced in a concurrent or intermediate reaction reacts very slowly with hydrogen chloride to form the  $\alpha$ -chloroether. In addition, the stream of hydrogen chloride removes from the reaction mixture appreciable amounts of formaldehyde derived from paraformaldehyde evidently owing to the lower solubility of formaldehyde in trichloroethanol than in unsubstituted aliphatic alcohols. The influence of these factors was avoided by saturating the reaction mixture with hydrogen chloride and allowing it to stand about one week at  $-2^\circ\text{C}$  with intermittent shaking and then resaturating it with hydrogen chloride. The volatilization of formaldehyde was prevented by covering the reaction mixture with concentrated hydrochloric acid before passing hydrogen chloride into the mixture.

Details of a typical synthesis are presented in the following. About 20 ml of concentrated hydrochloric acid was added to form a layer over a mixture of 47 g (0.31 mole) of trichloroethanol and 13 g (0.43 mole) of paraformaldehyde and the whole was cooled in an ice-water mixture and then saturated with hydrogen chloride gas over a period of 5 h. The reaction

Table 1. Boiling points, densities and refractive indexes of the compounds  $XCH_2OCH_2CCl_3$ .

X	B.p. $^\circ\text{C}/\text{mm Hg}$	$d_4^{20}$	$n_D^{20}$	$R_D$	
				obs.	calc.
(II) Cl	80—84/24	1.5113	1.4833	37.41	37.57
(III) $CCl_3CH_2O$	125—128/ 7	1.5482	1.4942	58.47	58.49
(IV) $n-C_3H_7O$	76— 78/ 6	1.2379	1.4510	48.19	48.14
(V) <i>sec.</i> - $C_3H_7O$	69— 70/ 7	1.2349	1.4486	48.08	48.15
(VI) HCOO	90— 92/ 7	1.4722	1.4670	38.10	38.96
(VII) $C_3HCOO$	104—106/ 7	1.3784	1.4568	43.74	43.58

mixture was stored eight days at  $-2^{\circ}\text{C}$ , during which the phases were mixed from time to time by shaking the flask. After the mixture had again been saturated with hydrogen chloride, the upper layer was removed and the lower layer containing the chloroether dried with anhydrous calcium chloride; the hydrogen chloride was removed with a current of carbon dioxide. The layer was then fractionally distilled under reduced pressure. After about 10 % of the distillate had passed over, the main fraction (about 60 %) distilled at  $80-84^{\circ}\text{C}$  and 24 mm Hg; then the temperature rose abruptly owing to the distillation of formal (III) formed as a side product.

Di-( $\beta,\beta,\beta$ -trichloroethoxy)methane (III) was prepared by two different methods. In the first method, an equimolar mixture of (I) and (II) was kept at a temperature of  $50^{\circ}\text{C}$  for 10 h, during which carbon dioxide was passed through the mixture to expel the hydrogen chloride formed. The crude product was washed with sodium bicarbonate solution and water, dried with anhydrous sodium sulphate, and purified by fractional distillation under reduced pressure. In the second method, (I), formaldehyde (added as paraformaldehyde) and anhydrous zinc chloride in the molar ratio of 2:1:0.1 were allowed to react 24 h at  $50-60^{\circ}\text{C}$ . The formal (III) formed in the reaction was isolated by shaking the reaction product with a mixture containing one volume of water and 5 volumes of petroleum ether. The petroleum ether layer containing the formal was dried with sodium sulphate and distilled under reduced pressure. The former method gave the higher yield (about 60 % of theory) of pure product. An attempt was also made to synthesize the formal (III) by distilling a mixture of di-*sec*-propyl formal and trichloroethanol acidified with *p*-toluenesulphonic acid to remove the *sec*-propanol formed in the reaction, but it was found that the replacement of the second alkyl group of di-*sec*-propyl formal (the same was the case with di-*n*-

Normal and secondary propyl- $\beta,\beta,\beta$ -trichloroethyl formals, (IV) and (V), were prepared from the respective dipropyl formals and trichloroethanol. Equimolar amounts of the reactants were heated together in the presence of *p*-toluenesulphonic acid and the mixture was subjected to fractional distillation to remove the most volatile component, the propanol. Nearly quantitative yields of (IV) and (V) were obtained. When twice the amount of trichloroethanol relative to the dialkyl formal was employed in the first reaction (to prepare IV), only the asymmetric formal was produced. When an equimolar amount of trichloroethanol was added to (IV) or (V), no reaction was observed to take place when the mixture was heated, although the catalyst concentration was greatly increased, as no propanol distilled over during a period of several hours.

The  $\beta,\beta,\beta$ -trichloroethoxymethyl esters of formic and acetic acids, (VI) and (VII), were prepared from the chloroether (II) and anhydrous potassium formate or potassium acetate by a procedure similar to that previously employed to prepare alkoxymethyl esters<sup>2-4</sup>.

The method of performing the kinetic measurements was the same as described previously<sup>1</sup>.

The intention was to obtain kinetic data for a direct comparison with previously reported data on the solvolysis of alkoxy-methyl compounds<sup>4</sup>. It was, however, possible to study only the ethanolsis of chloromethyl  $\beta,\beta,\beta$ -trichloroethyl ether (II) in ethanol and a 53.3 wt. % ethanol-dioxan mixture. All the compounds prepared in this work were so sparingly soluble in water that their hydrolysis reactions in this solvent could not be studied by customary methods.

The first-order rate coefficients measured for the ethanolsis of the chloroether (II) and the respective parameters of the Arrhenius equation are the following:

		15°	25°	35°	<i>E</i> (kcal/mole)	log <i>A</i>
Ethanol	10 <sup>5</sup> <i>k</i> (s <sup>-1</sup> )	6.19	17.6	47.7	18.44	9.77
53.3 wt. %	"	1.56	3.95	9.62	16.43	7.64
ethanol-dioxan						

propyl formal) by a  $\beta,\beta,\beta$ -trichloroethyl group took place so slowly that the method can be employed only to prepare asymmetric formals (see below).

A comparison of the values with previous data for  $\alpha$ -chloroethers<sup>4</sup>,  $\text{ROCH}_2\text{Cl}$ , reveals that the rate of ethanolsis diminishes rapidly (by a factor of 12-14 for each

chlorine substitution) in the sequence  $R = CH_2CH_2-$ ,  $CH_2ClCH_2-$ ,  $CCl_2CH_2-$  owing to a large increase in the activation energy. The activation energies in the ethanolsis of the first two compounds in 53.3 wt. % ethanol-dioxan are, respectively, 11.13 and 13.55 kcal per mole<sup>1,4</sup>. The logarithms of the frequency factor for the three compounds have values varying from 7.04 to 7.66 and hence the entropies of activation differ only insignificantly. The structural effects are thus consistent with the unimolecular carbonium ion mechanism of ethanolsis.

On the basis of the data presented it is possible to estimate the effect of the  $\beta,\beta,\beta$ -trichloroethyl group on the hydrolysis mechanism of the corresponding alkoxy-methyl esters in dilute acid solutions. The polar substituent constant  $\bar{\sigma}^*$ , as defined in Ref.<sup>4</sup>, for this group is +2.87. From this value it can be estimated that the rate coefficient for the hydrolysis of  $\beta,\beta,\beta$ -trichloroethoxymethyl acetate (VII) by the unimolecular  $A_{AL}1$  mechanism in dilute aqueous acid at 25°C should be about  $7 \times 10^{-7}$  l mole<sup>-1</sup>s<sup>-1</sup>. As this latter value is of a much lower order of magnitude than the rate coefficients relating to the normal type of acid-catalysed hydrolysis reactions of alkyl acetates (about  $10^{-4}$  l mole<sup>-1</sup>s<sup>-1</sup>), *i.e.* reactions taking place by the bimolecular  $A_{AC}2$  mechanism, it can be assumed that also the ester (VII) hydrolyses almost exclusively by the latter mechanism. In the case of the corresponding formate, (VI), the conditions for the unimolecular hydrolysis mechanism are even less favourable.

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## The Effect of Acetone Treatment on Vitamin A<sub>1</sub>-Aldehyde Extracts from Herring Roe

OLAF R. BRÆKKAN, HAKON MYKLESTAD  
and LEIF REIN NJAA

*Governmental Vitamin Laboratory,  
Norwegian Fisheries Research Institute,  
Bergen, Norway*

Plack *et al.*<sup>1</sup> have demonstrated the presence of vitamin A<sub>1</sub> aldehyde in herring ova (*Clupea harengus*) and some other marine teleosts. They investigated several extraction methods, but found that extraction of the eggs with light petroleum followed by addition of ethanol to the blended mixture gave the best results. Pollard and Bieri<sup>2</sup> confirmed some of these findings, but reported that all their samples of herring roe contained only vitamin A<sub>2</sub> aldehyde. They extracted the ova several times with ethanol and isolated the vitamins by hexane extraction of the alcohol extracts.

During studies of the occurrence of vitamin A aldehydes in fish in our laboratory, we applied both the proposed extraction methods on the herring roe (*Clupea harengus*), and found only vitamin A<sub>1</sub> aldehyde to be present. We were further only able to demonstrate the presence of vitamin A alcohol in these extracts but not the ester. Plack *et al.*<sup>1</sup> estimated the vitamin concentrations by the Carr-Price test, and reported for herring ova 2.4–5.7  $\mu$ g vitamin A<sub>1</sub> aldehyde per g and 0.3–0.9  $\mu$ g vitamin A<sub>1</sub> ester and alcohol per g. We have carried out the estimations by spectrophotometric measurements in the ultraviolet and found only 1  $\mu$ g vitamin A<sub>1</sub> aldehyde and 0.3  $\mu$ g vitamin A<sub>1</sub> alcohol per g herring roe. The absorption curves of the fractions were plotted, thus establishing the identity of the compounds.

Plack *et al.*<sup>1</sup> studied the effect of acetone treatment of the light-petroleum extracts. They found in liver storage tests in rats that only the acetone-soluble fraction contained biological activity, while the acetone-insoluble fraction showed no activity. In repeated experiments they could only recover about 40 % of the activity originally present in the extracts. This suggested a further investigation of the soluble portion, and the present communication reports some of the findings.