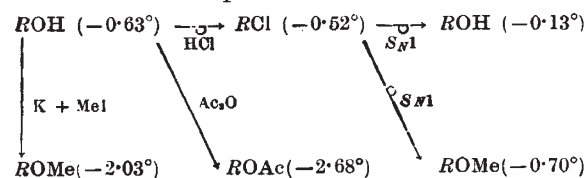


which have been shown to produce inversion of configuration. It could not be established for any preparation of the chloride that no optical purity was lost; an attempt by our usual method of back-conversion in kinetically controlled bimolecular conditions ( $S_N2$ ) was frustrated by a large incursion of olefin formation ( $E2$ ). The (-)alcohol was converted, through its potassium salt and methyl iodide, into the (-)methyl ether, and, with the aid of acetic anhydride, into the (-)acetate, reactions which leave untouched the asymmetric centre. It follows that the (-)alcohol, the (+)chloride, the (-)methyl ether, and the (-)acetate have corresponding configurations.

The hydrolysis of the chloride in 80 vol. per cent aqueous acetone was followed kinetically ( $k_1$  at  $60^\circ$ ,  $1.58 \times 10^{-4}$  sec. $^{-1}$ ), and shown to be unimolecular; it could not be appreciably accelerated by added alkali. Under mildly alkaline conditions, the (-)chloride gave a (-)alcohol with 21 per cent of the optical activity of the original alcohol, and therefore at least 21 per cent of the activity which would have resulted from a completely non-racemizing hydrolysis. The alcohol was shown to be optically stable under the conditions of its production.

The alcoholysis of the chloride in anhydrous methyl alcohol was shown to be unimolecular ( $k_1$  at  $60^\circ$ ,  $2.74 \times 10^{-4}$  sec. $^{-1}$ ), added sodium methoxide producing only a slight acceleration. Under mildly alkaline conditions, the (-)chloride gave a (-)ether with 34 per cent of the activity of ether prepared by methylation of the original alcohol, and therefore at least 34 per cent of the activity which would have resulted from a non-racemizing alcoholysis. The ether was optically stable in the conditions of its production, though it was rapidly racemized in acidic methyl alcohol.

The rotations indicated below ( $\alpha_D^{17}$ ,  $l = 10$ ) were measured in the experiments mentioned:



The symbol  $\text{---}\ominus\text{---}$  indicates predominating inversion of configuration. It is satisfactory that excess of inversion is now realized in demonstrably pure  $S_N1$  reactions.

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<sup>1</sup> *J. Chem. Soc.*, 1196 *et seq.* (1937) (six papers).

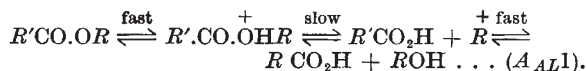
<sup>2</sup> *ibid.*, 157 *et seq.* (1946) (seven papers).

<sup>3</sup> Stevens and McNiven. *J. Amer. Chem. Soc.*, **61**, 1295 (1939).

### Walden Inversion in the Acid Hydrolysis of Carboxylic Esters by Unimolecular Alkyl Fission

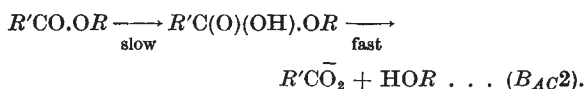
ONE of the less thoroughly investigated of the seven mechanisms of carboxylic ester hydrolysis, which Day and Ingold listed and associated with

observed or predicted structural, kinetic and stereochemical characteristics<sup>1</sup>, is the acid-catalysed, unimolecular reaction involving alkyl-oxygen fission,  $-A^1$  as they labelled it, or  $A_{AL1}$  as we now prefer to write:



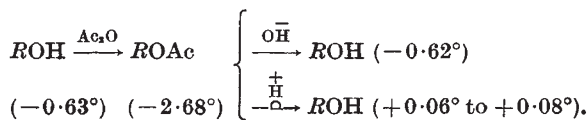
This mechanism was expected to be easily realizable when  $R$  was a tertiary alkyl group. Having an optically active tertiary alkyl acetate in our hands (see preceding note), it was an obvious task to set up the conditions for  $A_{AL1}$  hydrolysis, and to verify the stereochemical course of the process.

The base-catalysed hydrolysis of methylethylisohexylcarbinyl acetate was first examined. The reaction with 0.02–0.04  $N$  sodium hydroxide in 64 vol. per cent aqueous dioxan had the kinetic form: rate =  $k_2$  [ester]  $[\text{OH}^-]$  (with  $k_2 = 2.82 \times 10^{-3}$  sec. $^{-1}$  gm.-mol. $^{-1}$  l. at  $90^\circ$ ). The alcohol produced had a retained configuration and 99 per cent of its original optical activity. Obviously this is the usual base-catalysed, bimolecular reaction with acyl-oxygen fission,  $B_{AC2}$ :



The acid hydrolysis with 0.01–0.06  $N$  hydrogen chloride in 70 vol. per cent aqueous acetone had the kinetic form: rate =  $k_2$  [ester]  $[\text{H}^+]$  (with  $k_2 = 10.4 \times 10^{-3}$  sec. $^{-1}$  gm.-mol. $^{-1}$  l. at  $76.1^\circ$ ). Samples of alcohol recovered from hydrolyses with 0.02  $N$  hydrogen chloride had predominantly inverted configurations, and 9–12 per cent of the maximal optical activity. It has to be taken into account that the alcohol itself undergoes racemization in these acid solutions. The rate of this process having been determined, it was computed that the alcohol, as freshly produced by hydrolysis, had about 19 per cent of its maximal activity.

The following rotations ( $\alpha_D^{17}$ ,  $l = 10$ ) were measured in these experiments:



Evidently the acid reaction is producing racemization with some excess of inversion, as would be expected from the presumed mechanism and the general rules governing the stereochemistry of substitution. The smallness of the resulting activities shows that acid-catalysed bimolecular alkyl-fission (mechanism  $A_{AL2}$ ) is either absent, or present to only a small extent.

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<sup>1</sup> *Trans. Farad. Soc.*, **37**, 686 (1941).