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RACEMIZATION OF SULPHOXIDES IN ACETIC ANHYDRIDE CATALYZED BY LEWIS ACIDS

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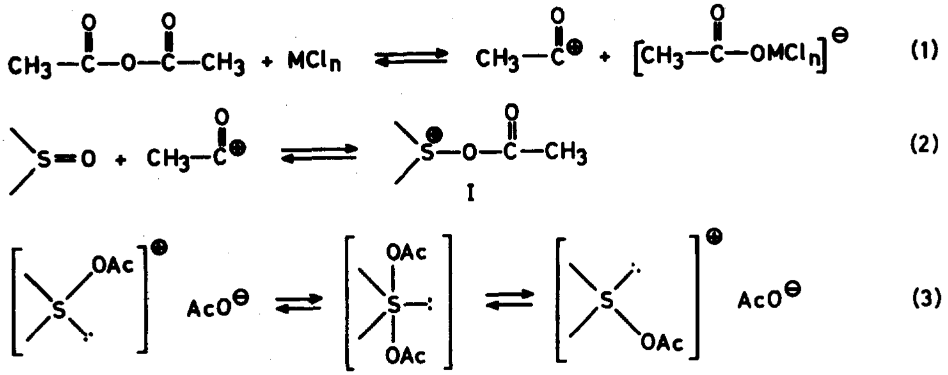
Many reactions with dimethyl sulphoxide in acidic medium or acetic anhydride proceed by way of an acyloxy- or alkoxysulphonium ion. Examples are Kornblum oxidation of halogenides, tosylates and alcohols (1), Pummerer rearrangements (2) and thiomethoxymethylation of phenols (3).

A related reaction has been described in a paper now in press (4) where equilibration and racemization of sulphoxides were shown to take place in trifluoroacetic acid. The rearrangement was catalyzed by strong mineral acids. A mechanism was proposed involving the formation of an acyloxysulphonium ion. In acetic anhydride a slow racemization also took place. This reaction has now been found to be catalyzed by Lewis acids like $FeCl_3$, $ZnCl_2$, $MgCl_2$, $HgCl_2$, $AgClO_4$ and by acetyl chloride.

In the Friedel-Crafts acetylation reactions these Lewis acids give with acetic anhydride complexes which are assumed to ionize with the formation of reactive acetylium ions (5). In the racemization reaction of sulphoxides the acetylium ion formed reacts with the sulphoxide giving an acetoxysulphonium ion. The racemization is then brought about by exchange of acetate groups through a symmetrical transition state as proposed earlier (4). The mechanism of the reaction is illustrated in Fig. 1.

Recently Oae and Kise (6) reported racemization and oxygen exchange of sulphoxides in acetic anhydride and they proposed a similar mechanism. They studied the reaction at 120° but by using Lewis acids as catalysts it was possible in this work to follow the racemization at 25°. With a mole ratio

FIG.1



of 5:1 of methyl p-tolyl sulphoxide-acetyl chloride the half-life ($t_{\frac{1}{2}}^{25}$) is less than 10 sec. The rate constants of the uncatalyzed and the acetyl chloride catalyzed racemization differ by a factor of 2.2 x 10^5.

From the kinetic data given in TABLE 1 it follows that the effect of the metal halides as catalysts follows the same order as in the Friedel-Crafts reactions.

The rapid racemization caused by acetyl chloride must be due to the rapid acetylation of the sulphoxide group giving an acetoxysulphonium ion. In the quantitative determination of sulphoxides, by Allenmark's method (7), the acetylation in the presence of iodide was also found to be fast.

When silver perchlorate was used as catalyst in the racemization reaction a very rapid racemization took place and the reaction was complete within a few minutes. No rate constants could be obtained because when the silver perchlorate in acetic anhydride was added to methyl p-tolyl sulphoxide, a precipitate of a silver perchlorate-sulphoxide complex was slowly formed. Dimethyl sulphoxide was also found to give a solid silver perchlorate adduct from acetic anhydride. These adducts have not been isolated earlier but they are probable intermediates in the preparation of alkoxysulphonium salts (8). The adducts explode on heating.

An interesting deviation from the first-order kinetics was found with the

TABLE 1

Pseudo First-order Rate Constants of Racemization of Methyl p-tolyl sulphoxide at 25.0°. 5.0 ml of Acetic Anhydride Containing 0.2 mmole of Catalyst were added to 1 mmole of Sulphoxide.

Catalyst	$k_{obs} \times 10^4$ min^{-1}
------ a)	0.2
$HgCl_2$	12
$ZnCl_2$	68
$FeCl_3$	1.4×10^3
CH_3COCl	4.4×10^4

a) 20 % racemization

weak catalyst mercuric chloride. When the catalyst was dissolved in acetic anhydride just before starting a kinetic run, an induction period was obtained, but when the catalyst was allowed to stand for a day in acetic anhydride, no induction period was obtained. This indicates that the ionization equilibrium 1 is slow with this weak acid. Evans et al. (9) have found evidence that the self-ionization of acetic anhydride is slow.

A weak catalytic effect was obtained with sodium perchlorate as also reported by Oae and Kise (6) but the kinetics was found to be very complicated at 25°.

The rate of racemization, just like the Friedel-Crafts reaction, is very sensitive to impurities which act as cocatalysts. In this work pro analysi chemicals have been used throughout without further purification, but, when using methyl p-tolyl sulphoxide prepared in the usual manner, (10, 4) i.e. by adding Grignard reagent to (-)-menthyl p-toluenesulphinate, impurities, probably magnesium chloride, where found to catalyze the racemization. By dissolving the sulphoxide once more in water and extracting with chloroform, these impurities could be removed.

With the method described, optically active m-carboxyphenyl ethyl sulphoxide has been racemized, and cis and trans dihydrothianaphthene-3-carboxylic acid 1-oxides have been equilibrated showing the generality of the reaction. The method is simple, rapid and free from side reactions.

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