

New Addition Reactions VI.

The Addition of Epoxides to Isocyanide Dichlorides

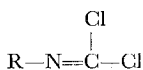
Ryohei ODA, Tetsuo HAMADA, Yoshihiko ITO
and Masaya OKANO*

(Oda Laboratory)

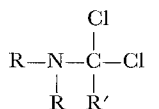
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The formation of 3-aryl-2-oxazolidinones from aryl isocyanide dichlorides and aliphatic epoxides, in the presence of a Lewis acid catalyst (*e.g.*, zinc chloride or stannic chloride), has been described.

The structural resemblance between isocyanide dichlorides (I) and N,N-dialkylamide dichlorides (II) seems to be reflected in their behavior toward certain nucleophiles. For example, the fact that various active hydrogen compounds such as alcohols and amines easily react with both dichlorides to give the corresponding condensation products has been known.¹⁾ On the other hand, our recent results have shown that the electrophilic additions of II to the C=C bond of enamines and the N=C bonds of Schiff bases and isocyanates readily take place to afford the 1:1 adducts in good yields, while similar attempts for I are entirely unsuccessful.²⁾ Perhaps such difference in reactivity would arise from their relative ease of ionization to the corresponding carbonium cations.



I



II

If we pay an attention to the N=C bond of I, its interaction with appropriate unsaturated components having an electrophilic character would be expected, because various cycloadditions of Schiff bases or isocyanates to such electrophilic unsaturated components as epoxides, ketenes and isocyanates have already been known³⁾. However, so far as we know, no examples of cycloaddition in which I participates have been found. The present paper deals with the formation of 2-oxazolidinones from I and epoxides.

Generally, in the presence of a Lewis acid catalyst such as zinc chloride or stannic chloride, a mixed solution of an arylisocyanide dichloride and an aliphatic epoxide in chloroform was stirred at 60°C for 24 hrs., if necessary in a sealed tube, and the product was isolated after treatment with water. Some results are shown in Table I. The yields were generally low, and this may be due to the lowered electron-density on the nitrogen atom of I which is affected by the electron-attracting chlorine atoms. In this reaction, some formation of a high boiling fraction assumed to be a mixture

* 小田良平, 浜田哲夫, 伊藤嘉彦, 岡野正弥

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Table 1. The Formation of 2-Oxazolidinones from Epoxides and Isocyanide Dichlorides.

Isocyanide Dichloride (mole)	Epoxide (mole)	Catalyst (mole)	Substituted 2-Oxazolidinone Yield, M.p. (°C)
$p\text{-ClC}_6\text{H}_4\text{N}=\text{CCl}_2$ (1.0)	$\text{CH}_2\text{---CH}_2$ $\diagup$ $\diagdown$ O (3.0)	none	unreacted
$p\text{-ClC}_6\text{H}_4\text{N}=\text{CCl}_2$ (1.0)	$\text{CH}_2\text{---CH}_2$ $\diagup$ $\diagdown$ O (3.0)	ZnCl_2 (0.5)	3- <i>p</i> -Chlorophenyl- 23%, 115–117 ^(a)
$\text{C}_6\text{H}_5\text{N}=\text{CCl}_2$ (0.9)	$\text{CH}_2\text{---CH}_2$ $\diagup$ $\diagdown$ O (1.5)	ZnCl_2 (0.5)	3-Phenyl- 13%, 114–115 ^(b)
$p\text{-NO}_2\text{C}_6\text{H}_4\text{N}=\text{CCl}_2$ (1.0)	$\text{CH}_2\text{---CH}_2$ $\diagup$ $\diagdown$ O (3.0)	ZnCl_2 (0.5)	3- <i>p</i> -Nitrophenyl- 16%, 152–154 ^(c)
$p\text{-ClC}_6\text{H}_4\text{N}=\text{CCl}_2$ (1.0)	$\text{CH}_3\text{---CH---CH}_2$ $\diagup$ $\diagdown$ O (1.5)	ZnCl_2 (0.1)	3- <i>p</i> -Chlorophenyl-5-methyl- 5%, 104–106 ^(d)
$p\text{-ClC}_6\text{H}_4\text{N}=\text{CCl}_2$ (1.0)	$\text{C}_6\text{H}_5\text{OCH}_2\text{---CH---CH}_2$ $\diagup$ $\diagdown$ O (1.0)	ZnCl_2 (0.2)	3- <i>p</i> -Chlorophenyl- 5-phenoxyethyl- 13%, 154 ^(e)
$p\text{-ClC}_6\text{H}_4\text{N}=\text{CCl}_2$ (1.0)	$\text{C}_6\text{H}_5\text{OCH}_2\text{---CH---CH}_2$ $\diagup$ $\diagdown$ O (1.0)	SnCl_4 (0.1)	3- <i>p</i> -Chlorophenyl- 5-phenoxyethyl- 17%, 154 ^(e)

(a) Reported. m.p. 117–117°C [R. Tsuzuki *et al.*, J. Org. Chem., **25**, 1009 (1960)].

(b) Reported. m.p. 118°C [R. Oda *et al.*, Bull. Chem. Soc. Japan, **35**, 1309 (1962)].

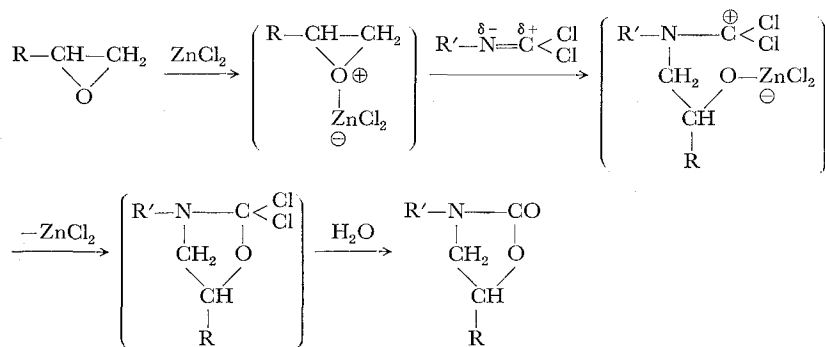
(c) Reported. m.p. 154.5°C [Idem.].

(d) Reported. m.p. 114°C [J.I. Jones, J. Chem. Soc., 2735 (1957)].

(e) Reported m.p. 158–160°C [Y. Iwakura *et al.*, J. Org. Chem., **29**, 379 (1964)].

of urethane derivatives (based on its IR spectrum) accompanied, but further characterization was not undertaken since its amount was not sufficient for complete fractionation. When the reaction was carried out without the catalyst, no product was isolated and most of isocyanide dichloride was recovered.

A possible reaction scheme may be represented as follows. It involves an nucleophilic attack of isocyanide dichloride on the oxonium salt derived from epoxide, like the mechanism of the zinc chloride-catalyzed reaction between epoxide and Schiff base.⁴⁾ This Sn 2-like mechanism can also explain the observed orientation in the ring-opening of substituted epoxides.⁵⁾



As regards to the notable catalytic action of organotin compounds in urethane formation from isocyanate and alcohol, an interesting suggestion that the active attacking species would be the carbonium cation which is formed by the coordination of the nitrogen of isocyanate with the tin of the catalyst⁶⁾ has been made. If a similar interpretation can be applicable to our reaction, a certain organotin catalyst would also be effective. However, no appreciable catalytic action was observed when dibutyltin dilaurate was added which had been known as the most effective catalyst in urethane formation. Therefore, the possibility of an electrophilic attack by isocyanide dichloride on epoxide may be excluded.

EXPERIMENTAL

Materials.—Three aromatic isocyanide dichlorides were prepared by the reaction of the corresponding formanilides with thionyl chloride and sulfur chloride according to Kühle's procedure.¹⁾ Phenyl isocyanide dichloride b.p. 115–117°C (28 mm Hg); the *p*-chloro compound, b.p. 78–80°C (3.5 mm Hg); the *p*-nitro compound, m.p. 78–80°C. The epoxides used were of the best grade.

Reaction of isocyanide dichloride with epoxide.—Typical examples are given below.

(a) 3-*p*-Chlorophenyl-2-oxazolidinone.—A mixed solution of 8.34 g (0.04 mole) of *p*-chlorophenyl isocyanide dichloride, 5.30 g (0.12 mole) of ethylene oxide, and 2.72 g. (0.020 mole) of zinc chloride in 40 ml. of chloroform was heated in a sealed tube for 24 hrs. at 60°C, with stirring by a magnetic stirrer. Then 30 ml. of water was added to this reaction mixture, and stirring was continued for 0.5 hr. at 20°C. The chloroform layer that separated was washed with water to remove some acidic impurities, dried, and evaporated. Distillation in vacuo gave 1.8 g (23%) of the oxazolidinone, b.p. 155–157°C (1 mm Hg), which solidified on cooling. The pure compound after recrystallization from benzene melted at 115–117°C. A mixed melting point with an authentic material prepared by condensation between *p*-chlorophenyl isocyanate and ethylene carbonate^{5a)} showed no depression.

(b) 3-*p*-Chlorophenyl-5-phenoxyethyl-2-oxazolidinone.—To a mixture of 8.34 g. (0.04 mole) of *p*-chlorophenyl isocyanide dichloride and 6.0 g. (0.04 mole) of phenyl glycidyl ether in 40 ml. of chloroform, 1.0 g. (0.004 mole) of stannic chloride was gradually added, and the mixed solution was heated for 24 hrs. at 60°C with stirring. After hydrolysis with water had been finished, evaporation of the solvent from the chloroform layer afforded 2.0 g. (17%) of the crude product as a solid. Recrystallization from benzene gave the pure product, m.p. 154°C. A mixed melting point with an authentic material prepared by addition of *p*-chlorophenyl isocyanate to phenyl glycidyl ether^{5b)} showed no depression.

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- (5) In the base-catalyzed cyclization of epoxides and isocyanates, a similar orientation has been observed. Cf. (a), K. Gulbins et al., *Chem. Ber.*, **93**, 1975 (1960); (b), M.L. Weiner, *J. Org. Chem.*, **26**, 951 (1961).
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