205. *Preparation of 3-Substituted Oxazolid-2,4-diones by Cyclisation of N-Substituted N-Chloroacylcarbamates.**

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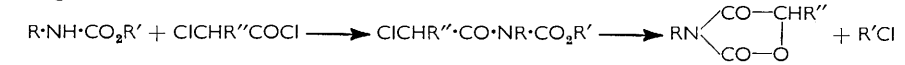
3-Substituted oxazolid-2,4-diones have been prepared from *N*-substituted carbamates and α-chloroacyl chlorides. The intermediate *N*-substituted chloroacylcarbamates cyclise at higher temperatures to the diones. The plots of the cyclisation rates of ethyl *N*-alkyl-*N*-chloroacetylcarbamates were straight, and steric effects influenced the cyclisation. Infrared spectra of the *N*-substituted chloroacylcarbamates and of 3-substituted oxazolid-2,4-diones are discussed.

3-Substituted oxazolid-2,4-diones (III) are an important class, as several members possess analgesic [1] and anti-epileptic [2] properties. 3-Alkyl derivatives have been prepared by alkylation of oxazolid-2,4-dione [1,3-5] or by treatment of α-hydroxy-esters with alkyl isocyanates and cyclisation of the resulting urethanes, by which method also the 3-aryl derivatives have been synthesised.[6]

We found that a convenient preparation of 3-alkyl- and 3-aryl-oxazolid-2,4-diones was to heat at ≥180° lower alkyl alkyl- or aryl-carbamates (I) with an α-chloroacyl chloride, according to the scheme shown.



(I) (II) (III)

N-α-*Chloroacylcarbamates.*—No difficulties were experienced in preparing *N*-chloroacetyl- and *N*-chloroacetyl-alkylcarbamates, though the yields of the desired products decreased when the size of the alkyl group R or R′ increased (Table 4), because of increased steric hindrance. However, neither ethyl isopropylcarbamate nor ethyl arylcarbamates yielded pure *N*-chloroacetyl derivatives; a large proportion of unchanged

Table 1. *Infrared spectra of bromoform solutions of carbamic esters.*

Carbamate	NH or NH_2	Ester CO	Amide CO	Second amide band
Ethyl	3520, & 3380	1728	1580	
Ethyl *N*-acetyl-	3380	1754	1704	1488
Methyl *N*-chloroacetyl-	3400	1792, 1760	1725, 1710	1485
Ethyl *N*-chloroacetyl-	3380	1788, 1755	1724, 1705	1486
Propyl *N*-chloroacetyl-	3350	1790, 1755	1725, 1708	1490
Butyl *N*-chloroacetyl-	3350	1790, 1758	1726, 1704	1490
Hexyl *N*-chloroacetyl-	3350	1790, 1756	1725, 1705	1486
Dodecyl *N*-chloroacetyl-	3400	1792, 1758	1725, 1708	1486
Allyl *N*-chloroacetyl-	3400	1790, 1755	1720, 1706	1482
2-Fluoroethyl *N*-chloroacetyl-	3350	1796, 1762	1730, 1700	1490
p-Nitrobenzyl *N*-chloroacetyl-	3400	1795, 1762	1730, 1704	1488
Ethyl *N*-α-chloropropionyl-	3400	1786, 1758	1720, 1710	1485

carbamate was always recovered. This may have been due to considerable steric inhibition with the *N*-branched alkylcarbamate and with the arylcarbamates, owing to the lower availability of the lone electron pair on the nitrogen atom through their participation in the resonance of the aromatic nucleus. The yields of 3-aryloxazolid-2,4-diones (Table 6) follow, in general, the degree of basicity of the arylcarbamates.

* B.P. Appn. 38,502/58.

[1] Spielman, *J. Amer. Chem. Soc.*, 1944, **66**, 1244.
[2] Clark-Lewis, *Chem. Rev.*, 1958, **58**, 63.
[3] Davies and Hook, B.P. 632,423.
[4] Davies, Fitzgerald, and Hook, *J.*, 1950, 34.
[5] Iwaya, Mitsuhashi, Yoshida, and Kijima, *J. Pharm. Soc. Japan*, 1948, **68**, 245.
[6] Rekker, Faber, Tom, Verleur, and Nauta, *Rec. Trav. chim.*, 1951, **70**, 113.

The Infrared Absorption of Acetylcarbamic Ester and of N-α-*chloroacylcarbamic Esters.*—The infrared spectra we recorded of urethane and acetylurethane (Table 1) differ considerably from those reported by Randall *et al.*,[7] but our spectrum of urethane agrees with that described by Pinchas and Ben-Ishai.[8] Our measurements show that *N*-acetylurethane in bromoform solution is in the keto-form.

The spectra of the chloroacetylcarbamates in bromoform showed the expected nitrogen–hydrogen stretching band at about 3500 cm.$^{-1}$, but four instead of the two expected carbonyl bands (Table 1). The 1710—1700 cm.$^{-1}$ band usually appeared as a relatively weak shoulder on the strong 1730—1720 cm.$^{-1}$ band. The ratio of the intensities of the 1796—1786 cm.$^{-1}$ and the 1762—1755 cm.$^{-1}$ bands was of the same order as that of the 1710—1700 cm.$^{-1}$ shoulder and the 1730—1720 cm.$^{-1}$ peak. In carbon disulphide, the frequencies of the four carbonyl bands are about 10 cm.$^{-1}$ higher, but their relative intensities are about the same as in bromoform solution. In spectra of Nujol mulls, the carbonyl bands tend to coalesce to one strong band at 1770—1756 cm.$^{-1}$.

The 1796—1786 and 1762—1755 cm.$^{-1}$ bands are probably associated with the ester, and the 1730—1720 and 1710—1700 cm.$^{-1}$ doublet with the amide group.

TABLE 2. *Infrared spectra of bromoform solutions of* N-*alkyl*-N-*chloroacetylcarbamic esters.*

Carbamate	Ester CO	Amide CO	Carbamate	Ester CO	Amide CO
Methyl *N*-chloroacetyl-*N*-methyl-	1732	1712	Ethyl *N*-butyl-*N*-chloroacetyl- ...	1725	1712
Ethyl *N*-chloroacetyl-*N*-methyl-...	1730	1712	Ethyl *N*-chloroacetyl-*N*-nonyl- ...	1726	1710
n-Butyl *N*-chloroacetyl-*N*-methyl-	1730	1710	Ethyl *N*-allyl-*N*-chloroacetyl- ...	1730	1715
Ethyl *N*-chloroacetyl-*N*-ethyl- ...	1725	1710	Ethyl *N*-benzyl-*N*-chloroacetyl-...	1726	1710

TABLE 3. *Infrared spectra of bromoform solutions of oxazolid-2,4-diones.*

Oxazolid-2,4-diones	2-CO	4-CO	Oxazolid-2,4-diones	2-CO	4-CO
3-Methyl-	1826	1748 & 1732	3-Phenyl-	1860 & 1825	1750
3-Ethyl-	1815	1730	3-*p*-Tolyl-	1842 & 1817	1745
3-Butyl-	1814	1736	3-*p*-Chlorophenyl-	1836 & 1812	1748
3-Nonyl	1814	1738	3-*p*-Nitrophenyl-	1844	1752
3-Allyl-	1814	1740	3-1′-Naphthyl-	1845 & 1820	1750
3-Benzyl-	1815	1750	3-2′-Naphthyl-	1840 & 1818	1745
			3,5-Dimethyl-	1812	1730

The frequency of the amide carbonyl should, however, depend on its steric relation to the adjacent chlorine atom,[9] and we can assign the 1710—1700 cm.$^{-1}$ shoulder and the strong 1730—1720 cm.$^{-1}$ band to the *gauche* and the *cis*-form, respectively. We had some difficulty in explaining the unusually high ester band at 1796—1786 cm.$^{-1}$, until Dr. L. J. Bellamy (personal communication) suggested that *N*-chloroacetylurethane could make a fairly compact structure in which a *gauche* chloroacetyl group brings its chlorine atom close to the oxygen of the ester carbonyl. This effect would push the ester carbonyl frequency up to about 1790 cm.$^{-1}$. A *cis*-chloroacetyl group would not affect the ester carbonyl frequency. It thus appears that the 1796—1786 cm.$^{-1}$ band and the 1710—1700 cm.$^{-1}$ shoulder are associated with the *gauche* form and the 1762—1755 and 1730—1720 cm.$^{-1}$ bands with the *cis*-form of the molecule. In the Nujol spectrum, the splitting of the NH band into a doublet at about 3250 and 3180 suggests enolisation. The strong carbonyl band at 1770—1756 cm.$^{-1}$ is presumably an ester band.

The ethyl *N*-alkyl-*N*-chloroacetylcarbamates in bromoform (Table 2) showed two strong carbonyl bands; their frequencies were unchanged in Nujol mull, but were about 10 cm.$^{-1}$ higher in spectra of carbon disulphide solutions. As in the spectrum of *N*-acetylurethane, the 1732—1725 and 1715—1710 cm.$^{-1}$ bands are probably associated with the

[7] Randall, Fowler, Fuson, and Dangl, "Infrared Determination of Organic Structures," Van Nostrand, New York, 1949.
[8] Pinchas and Ben-Ishai, *J. Amer. Chem. Soc.*, 1957, **79**, 4099.
[9] Bellamy and Williams, *J.*, 1957, 4294.

TABLE 4. *Chloroacetyl carbamates* $Cl{\cdot}CH_2{\cdot}CO{\cdot}NR{\cdot}CO_2R'$.*

R	R′	Temp. of oil-bath	Period of heating	M. p. or b. p./mm.	Yield (%)	Appearance †	Formula	Found: Cl (%)	Req.: Cl (%)
H	Me [a]	130—140°	1 hr.	143—145°	55	Needles	—[g]	—	—
H	Et [b]	100	1 hr.	129	95		—[h]	—	—
H	Pr^n [c]	100	1 hr.	110—112	76	Plates	$C_6H_{10}O_3NCl$	19·8	19·8
H	Bu^n [b]	100	1 hr.	96·5	74	Prisms	$C_7H_{12}O_3NCl$	18·5	18·3
H	Hexyl [d, e]	130—140	24 hr.	90—92	54	Platelets	$C_9H_{16}O_3NCl$	16·1	16·0
H	Dodecyl [e]	130—140	3·5 hr.	85—87	57	Microcrystals	$C_{15}H_{28}O_3NCl$	11·6	11·6
H	2-Fluoroethyl [e]	100	2 hr.	126—127	82	Plates	$C_5H_7O_3NClF$	18·9	19·3
Me	Et [f]	125—130	3 hr.	36—37	90	Prismatic needles	$C_6H_{10}O_3NCl$	19·8	19·8
Et	Et	130	3 hr.	95—96/3	77	n_D^{20} 1·4613	$C_7H_{12}O_3NCl$	18·3	18·3
Bu^n	Et	130	40 min.	98—103/1·1—1·6	49·6	n_D^{25} 1·4573	$C_9H_{16}O_3NCl$	15·7	16·0
Nonyl	Et	140	1·5 hr.	132—134·5/0·8	49·4	n_D^{20} 1·4593	$C_{14}H_{26}O_3NCl$	12·2	12·15
Allyl	Et	100—120	3 hr.	127—128/13	39·1	n_D^{25} 1·4712	$C_8H_{12}O_3NCl$	17·4	17·3
Me	Me	100	2 hr.	110—113·5/14	65·9	n_D^{20} 1·4703	$C_5H_8O_3NCl$	21·9	21·45
Me	Bu^n	130	3 hr.	140—142/15	32·8	n_D^{20} 1·4632	$C_8H_{14}O_3NCl$	17·7	17·1

* Compounds analysed are new. † n is given for liquids.

Solvents for crystallisation: [a] water; [b] benzene; [c] alcohol; [d] benzene–light petroleum; [e] aqueous alcohol; [f] light petroleum. [g] Voswinkel, G.P. 266,121/1913. [h] Frerichs, *Arch. Pharm.*, 1899, **237**, 288.

TABLE 5. 3-*Alkyloxazolid-2,4-diones prepared by heating ethyl* N-*alkyl*-N-*chloroacylcarbamates at* 180° (*method* I).

3-Alkyl group	Weight of carbamate (g.)	Period of heating	M. p. or b. p./mm.	Unchanged chloro-compound	Appearance	Formula	Found (%)	Reqd. (%)	Ref.
Me	3·21	110 min.	133—134°	Nil	White rhomboidal crystals	$C_4H_5O_3N$	N, 12·3	N, 12·2	*a*
Et	3·47	160 min.	116—117/12	Trace	n_D^{20} 1·4611	—	—	—	*b*
Allyl	2·61	4·5 hr.	132—133/12	Trace	n_D^{20} 1·4804	—	—	—	*c*
Bu^n	3·54	4·5 hr.	137—139/16	Trace	n_D^{20} 1·4602	—	—	—	*d*
Nonyl	3·47	13 hr.	115—117/0·4	Nil	n_D^{20} 1·4620	$C_{12}H_{21}O_3N$	C, 63·25; H, 9·15	C, 63·45; H, 9·25	
3,5-Dimethyl	2·24	6·5 hr.	118—119/20	Nil	n_D^{20} 1·4569	$C_5H_7O_3N$	N, 10·6	N, 10·8	*e*

[a] Iwaya *et al.* (ref. 5) record m. p. 134°; Spielman (ref. 1) gives m. p. 128°. [b] Spielman and Everett (*J. Amer. Chem. Soc.*, 1948, **70**, 1021) record b. p. 133—136°/32 mm., n_D^{25} 1·4619; Rekker *et al.* (ref. 6) report b. p. 119—121°/17 mm. [c] Davies, Fitzgerald, and Hook (ref. 4) record b. p. 72°/5 mm., n_D^{20} 1·4815. [d] Davies, Fitzgerald, and Hook (ref. 4) record b. p. 137—139°/16 mm., n_D^{20} 1·4614. [e] Spielman (ref. 1) reported b. p. 140—144°/50 mm., n_D^{25} 1·4574. Our specimen was prepared from ethyl *N*-α-chloropropionyl-*N*-methylcarbamate.

TABLE 6. 3-*Aryl(or -aralkyl)oxazolid-2,4-diones prepared by heating ethyl* N-*aryl(or -aralkyl)carbamates and chloroacetyl chloride* (*method* II).

3-Aryl group	Weight of carbamate (g.)	Weight of chloride (g.)	Yield of dione (%)	M. p.	Appearance	Formula	Found (%) C	Found (%) H	Found (%) N	Required (%) C	Required (%) H	Required (%) N
Ph [a]	3·68	2·65	64·7	122°	Felted needles	$C_9H_7O_3N$			7·6			7·9
p-*Tolyl*	3·58	2·42	51·8	146—147	Needles	$C_{10}H_9O_3N$	63·8	5·15	6·9	62·8	4·7	7·3
p-*Chlorophenyl*	3·99	2·5	59·8	134—135	Needles	$C_9H_6O_3NCl$	51·5	3·2	6·3	51·3	2·85	6·65
p-*Nitrophenyl*	1·74	1·09	29·9 *	204	Yellow needles	$C_9H_6O_5N_2$	48·7	2·6	12·5	48·6	2·7	12·6
1-*Naphthyl*	3·15	1·67	47·7	141—142	Buff prisms	$C_{13}H_9O_3N$	68·7	3·95	6·4	68·7	3·95	6·2
2-*Naphthyl*	3·13	1·76	43	160—161	Needles	$C_{13}H_9O_3N$	68·0	3·9	5·9	68·7	3·95	6·2
Benzyl [b]	3·58	2·45	62·8	53·5—54·5	Rhomboids	$C_{10}H_9O_3N$	62·55	4·5	7·2	62·8	4·7	7·3

Crystallisation: With the exception of the benzyl compound these diones were crystallised from methanol (charcoal). For the benzyl compound this solvent was followed by light petroleum.

* The residue was unchanged carbamate (ex benzene).

[a] Rekker *et al.* (ref. 6) give m. p. 121—122°. [b] Davies *et al.* (ref. 4) give m. p. 44—45°.

ester and amide carbonyl groups, respectively. The *N*-alkyl group sterically hinders rotation, so that the chlorine atom is unable to rotate to the *gauche* form and interact with the ester carbonyl group.

The Cyclisation of N-α-*Chloroacylcarbamates.*—The *N*-alkyl-*N*-α-chloroacylcarbamates lost ethyl chloride at ⩾180° to form the corresponding diones (Table 5). Intractable mixtures were obtained from ethyl *N*-chloroacetyl- and *N*-α-chloropropionyl-carbamates, from which diones could not be isolated. However, oxazolid-2,5-diones were prepared in good yields by heating *N*-methoxycarbonylglycyl chlorides.[10] This may be due to the higher reactivity of the chlorine in acyl chlorides than in the chloroalkyl compounds.

McKay and Braun [11] examined the cyclisation of 2-chloroethylcarbamates, *N*-2-chloroethylureas, and *N*-2-chloroethyl-*N'*-nitroguanidine, and suggested the participation of carbonium-ion intermediates. They argued that the greater the possibilities for resonance the easier the formation of carbonium ion and the readier the cyclisation. We believe that a similar mechanism can operate in the cyclisation of *N*-chloroacylcarbamates which can exhibit a number of resonance forms.

FIG. 1. FIG. 2.

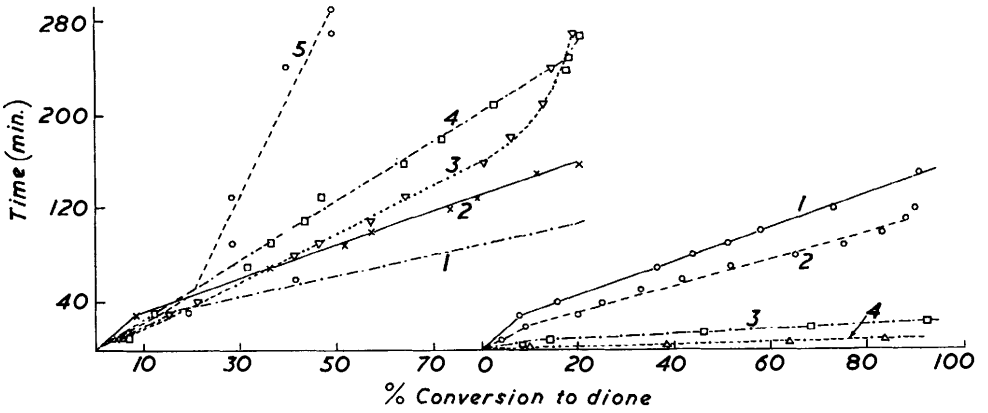


FIG. 1. *Rates of cyclisation of* $ClCH_2{\cdot}CO{\cdot}NR{\cdot}CO_2Et$ *at* 180°.
1, R = *methyl*; 2, R = *ethyl*; 3, R = *allyl*; 4, R = *n-butyl*; 5, R = *n-nonyl*.

FIG. 2. *Rates of cyclisation of* $ClCH_2{\cdot}CO{\cdot}NEt{\cdot}CO_2Et$.
1, *at* 180°; 2, *at* 180° *in presence of glass-wool*; 3, *at* 210°; 4, *at* 240°.

The inductive effect of the *N*-alkyl group would render the chlorine atom more negative and increase the attraction between the chlorine and the ethoxyl group.
Rearrangement to the carbonium ion (IV)

$$\text{(IV)}\quad [^{+}CH_2{\cdot}C(O){\cdot}NR{\cdot}CO^{-}{:}O{\cdot}EtCl] \longrightarrow \text{(III; R'' = H)} + EtCl$$

and cyclisation with elimination of ethyl chloride would follow.

In ethyl *N*-aryl-*N*-chloroacetylcarbamates the aryl substituent would have the effect of increasing the number of resonance structures. This would stabilise the electronic structure of the carbamate, thus facilitating the formation of the intermediate carbonium ion (IV; R = aryl) and its cyclisation to the dione (III; R = aryl, R'' = H). If more extensive resonance assists carbonium-ion formation, the yield of *N*-aryl-diones should increase. Since this is not the case (Table 6), we assume that the governing step is the chloroacetylation, which is affected by the decreasing basicity of the aromatic carbamates.

[10] Leuchs, *Ber.*, 1906, **39**, 857.
[11] McKay and Braun, *J. Org. Chem.*, 1951, **16**, 1829.

Steric Effects on Cyclisation.—Leuchs *et al.*[12] obtained a lower yield (50%) of 4-phenyloxazolid-2,5-dione from *N*-methoxycarbonyl-α-phenylglycyl chloride than of the 3-phenyl isomer (80%) from *N*-ethoxycarbonyl-*N*-phenylglycyl chloride. Similarly we find that ethyl *N*-α-chloropropionyl-*N*-methylcarbamate cyclises less readily than ethyl *N*-chloroacetyl-*N*-methylcarbamate (Table 5). This steric inhibition became evident also when the substituents were in a different position. Thus, increase in the bulk of the ester group affected the ease of cyclisation.

The rate of cyclisation (Fig. 1) depended on the number of carbon atoms in the *N*-alkyl chain (II; R = alkyl, R′ = Et, R″ = H). Increase in the length of that group would increase steric inhibition of the resonance state, which would lead to greater difficulty in the formation of the carbonium ion (IV) and in cyclisation.

Rates of Cyclisation of Ethyl N-*Alkyl*-N-*chloroacetylcarbamates.*—Plots of the cyclisation rates of ethyl *N*-alkyl-*N*-chloroacetylcarbamates alone (Fig. 1) and of ethyl *N*-chloroacetyl-*N*-ethylcarbamate in the presence of glass-wool (Fig. 2) are linear (after the initial lag period) up to about 80% conversion.

The non-dependence of the rate of cyclisation on concentration of reactants suggests reaction of zero order: as long as there is the carbonium substrate from which ethyl chloride can detach itself, the rate of loss of ethyl chloride would be independent of the concentration of substrate. The more effective the substrate, as in the presence of glass-wool, the faster appeared to be the formation of the carbonium ion and the detachment of the ethyl chloride (Fig. 2). An alternative explanation is that of a self-catalysed reaction in which the product catalyses the cyclisation. The alkyl halide eliminated during the reaction exerts no effect on the rate of cyclisation. Though n-butyl chloride was retained during the heating of n-butyl *N*-chloroacetyl-*N*-methylcarbamate, an excellent yield of dione (III; R = Me, R″ = H) resulted, the butyl chloride only acting as solvent for the dione. Nor was there any interaction between this dione and butyl chloride in a sealed tube, so that the reaction is irreversible.

The Infrared Absorption of Oxazolid-2,4-diones.—Our oxazolid-2,4-diones in bromoform solution (Table 3) showed two carbonyl bands, *i.e.* at 1828—1812 and 1754—1730 cm.$^{-1}$, probably associated with the 2- and the 4-oxo-group (*i.e.* the ester and amide carbonyl), respectively. In bromoform or carbon disulphide the intensity of the 1828—1812 cm.$^{-1}$ band is 10—25% of that of the 1754—1730 cm.$^{-1}$ band. The 1820 cm.$^{-1}$ band of the spectra of 3-phenyloxazolid-2,4-diones has two components, at about 1844 and 1820 cm.$^{-1}$. The intensity of the former increases and that of the latter decreases with increase in polarity of the *N*-substituent. In the spectrum of the *p*-nitrophenyl compound, the 1844 cm.$^{-1}$ is considerably stronger than the 1820 cm.$^{-1}$ band.

The carbonyl frequencies for 5-(2,4-dimethoxyphenyl)-3-methyloxazolid-2,4-dione reported by Clark-Lewis,[2] *i.e.* 1835 and 1745 cm.$^{-1}$, are close to our values.

Experimental

Preparation of Chloroformates.—To an ice-cooled solution of carbonyl chloride in benzene were added below 20° the alcohol and then dimethylaniline in equimolar proportions.[13] Stirring was continued until separation of dimethylanilinium chloride was complete. The solution of the chloroformate was then separated by filtration or decantation, and the benzene solution used for the preparation of the carbamate.

Preparation of Carbamates.—The solution of the chloroformate was treated below 50° with ammonia for the preparation of unsubstituted carbamic esters [14] or with two equivalents of the appropriate amine in benzene for the preparation of the *N*-substituted compound.[15] The amine hydrochloride was filtered off, the solvent distilled, and the carbamate distilled or crystallised from a suitable solvent.

[12] Leuchs and Manasse, *Ber.*, 1907, **40**, 3243; Leuchs and Geiger, *ibid.*, 1908, **41**, 1721.
[13] Oesper, Broker, and Cook, *J. Amer. Chem. Soc.*, 1925, **47**, 2609; Raiford and Inman, *ibid.*, 1934, **56**, 1586.
[14] Cf. Thiele and Dent, *Annalen*, 1898, **302**, 258.
[15] Cf. Hofmann, *Ber.*, 1870, **3**, 656.

The following new carbamates were thus prepared: ***n-Butyl methylcarbamate***, b. p. 95°/16 mm., n_D^{20} 1·4288 (Found: N, 10·9. $C_6H_{13}O_2N$ requires N, 10·7%). *Ethyl nonylcarbamate*, b. p. 104—106°/1·4 mm., n_D^{20} 1·4429 (Found: N, 6·8. $C_{12}H_{25}O_2N$ requires N, 6·5%).

Preparation of Chloroacylcarbamates.—The carbamate (0·1 mole) and the chloroacyl chloride (0·1 mole) were heated (reflux) until evolution of hydrogen chloride almost ceased. The product was distilled and/or crystallised from suitable solvents. Table 4 summarises the preparation and physical properties of chloroacetylcarbamates.

N-*Chloroacetylurethane* (No. 2). Crystallised first from an aqueous solution of potassium carbonate and then from benzene, this formed short needles (Found: Cl, 21·1. Calc. for $C_5H_8O_3NCl$: Cl, 21·45%).

Ethyl N-α-*chloropropionylcarbamate*. Ethyl carbamate (15·6 g.) and α-chloropropionyl chloride (22·2 g.) were heated at 120° for 3 hr. The *compound* crystallised from ligroin in short white needles, m. p. 83—84° (14 g.; 44·5%) (Found: Cl, 19·5. $C_6H_{10}O_3NCl$ requires Cl, 19·8%).

Ethyl N-α-*chloropropionyl*-N-*methylcarbamate*. Ethyl methylcarbamate (10·3 g.) and α-chloropropionyl chloride (12·7 g.) were heated at 130—150° (oil-bath) for 30 min. Distillation gave the *carbamate*, b. p. 116—118°/19—20 mm., n_D^{20} 1·4571 (12·05 g.; 62·5%) (Found: Cl, 18·5. $C_7H_{12}O_3NCl$ requires Cl, 18·3%).

N-*Acetylurethane*. Prepared as described by Atkinson and Polya,[16] this ester had m. p. 78° (from benzene–light petroleum).

Oxazolid-2,4-diones.—The 3-substituted oxazolid-2,4-diones (Tables 5 and 6) were prepared by either method I [heating the ethyl *N*-alkyl-*N*-chloroacetylcarbamate and ethyl *N*-α-chloropropionyl-*N*-methylcarbamate at 180° (oil bath) (Table 5)] or by method II [heating equivalent proportions of *N*-alkyl- or *N*-aryl-carbamate and chloroacetyl chloride first at 100° until evolution of hydrogen chloride nearly ceased, then at 180° for 4 hr. (Table 6)]. The products were then crystallised from a convenient solvent or distilled.

The liquid 3-ethyl-, 3-allyl-, and 3-butyl-oxazolid-2,4-diones could not be separated from the ethyl *N*-alkyl-*N*-chloroacetylcarbamates used; infrared spectra confirmed the presence of the latter contaminants.

The tubes containing the 3-phenyl-, 3-*p*-nitrophenyl-, 3-1′-naphthyl-, and 3-2′-naphthyl-oxazolid-2,4-diones were weighed hourly; the proportional losses due to the evolution of hydrogen chloride and of ethyl chloride during the same time were not significantly different.

Reactions of N-*Methylcarbamic Esters with Chloroacetyl Chloride.—Effect of the ester group.* Mixtures of (*a*) methyl *N*-methylcarbamate (3·02 g.) and chloroacetyl chloride (3·91 g.), (*b*) ethyl *N*-methylcarbamate (3·40 g.) and chloroacetyl chloride (3·81 g.), and (*c*) butyl *N*-methylcarbamate (2·92 g.) and chloroacetyl chloride (2·56 g.) were heated for 1 hr. at 180° (oil-bath). Mixtures (*a*) and (*b*) gave 60 and 68% yields, respectively, of 3-methyloxazolid-2,4-dione, mixture (*c*) yielded largely butyl *N*-chloroacetyl-*N*-methylcarbamate, b. p. 145—150°/18 mm.

Effect of excess of chloroacetyl chloride at 140°. Ethyl *N*-methylcarbamate was heated with chloroacetyl chloride (1·0; 1·1; 1·5; 2·0 mol.) for 3 hr. at 140°. The excess of chloroacetyl chloride was removed at 20 mm., and 3-methyloxazolid-2,4-dione filtered off at 40°. The dione was 8—8·5% of the derived ethyl *N*-chloroacetyl-*N*-methylcarbamate.

Rates of Cyclisation of Ethyl N-*Alkyl*-N-*chloroacetylcarbamates at* 180°.—The following ethyl *N*-chloroacetylcarbamates were heated (the ethyl chloride being allowed to escape) at 180° (oil-bath): *N*-methyl- (3·67 g.), *N*-ethyl- (3·47 g.), *N*-allyl- (2·61 g.), *N*-butyl- (3·54 g.), and *N*-nonyl- (3·47 g.). Samples were analysed for chlorine at intervals, and the % conversion into 3-alkyloxazolid-2,4-dione calculated on the basis of simple % proportion and plotted against time (Fig. 1).

Rates of Cyclisation of Ethyl N-*Chloroacetyl*-N-*ethylcarbamate to* 3-*Ethyloxazolid*-2,4-*dione at* 210° *and* 240°.—Ethyl *N*-chloroacetyl-*N*-ethylcarbamate (4 g. and 3 g.) was heated at 210° and 240° (oil-bath) and samples were analysed for chlorine after 5 and 2·5 min., respectively. The % conversions into the dione were plotted against time (Fig. 2).

Irreversibility of the Reaction.—(a) *Cyclisation of butyl* N-*chloroacetyl*-N-*methylcarbamate*. Butyl *N*-chloroacetyl-*N*-methylcarbamate (2·94 g.) was heated at 180° (oil-bath) for 2 hr. After distillation of butyl chloride (b. p. 77°), 3-methyloxazolid-2,4-dione (1·03 g.; 81·6%) was obtained.

(b) 3-*Methyloxazolid*-2,4-*dione and butyl chloride*. The dione (2·3 g.; 0·02 mole) and butyl

[16] Atkinson and Polya, *J.*, 1954, 3319.

chloride (1·8 g.; 0·02 mole) were heated in a sealed tube at 180° (oil-bath) for 2 hr. Butyl chloride (1·8 g.) was recovered by distillation. The residue was unchanged dione (2·3 g.), m. p. 133—134° (not depressed by the original sample).

Infrared Determinations.—All the compounds were examined as 1·0% bromoform solutions in 0·8-mm. cells in the spectral range 4000—650 cm.$^{-1}$ by using a Perkin-Elmer model 21 double-beam infrared spectrophotometer fitted with sodium chloride optics. Compounds that were sufficiently soluble were also studied as 1·0% solutions in carbon disulphide; the less-soluble compounds were re-examined as either Nujol mulls or thin films.

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