THE CHROMOUS CHLORIDE PROMPTED ADDITION OF N-CHLOROCARBAMATES TO OLEFINS THE SYNTHESIS OF 6-CHLOROCARBAMATES

J. Lessard¹ and J.M. Paton²

Biochemistry Laboratory, National Research Council, Ottawa, Canada.

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 β -chlorocarbamates have previously been prepared from olefins by thermal addition of N,Ndichlorourethane (1,2,3) and by photochemical addition of N-chlorourethane (NCU) (3 a-c, 4). We discovered a convenient way of adding various N-chlorocarbamates to olefins in very good yields using chromous chloride as the promoting agent. This new reaction constitutes a novel use for the chromous ion and appears to be of theoretical and synthetic importance.

The reaction with cyclohexene is illustrated in Scheme I. The general procedure is as



follows. To a stirred solution of N-chlorocarbamate and olefin in absolute methanol or in a 1:5 mixture of this solvent and chloroform at -40° or -78° C and under an atmosphere of carbon dioxide, was added dropwise a 1M methanolic chromous chloride solution. The addition was stopped when all the N-chlorocarbamate was consumed (starch-iodide paper test). The reaction mixture was allowed to warm up to 0° C and the chromic ion was precipitated as chromic hydroxide by adding sodium bicarbonate. The products were then extracted with methylene chloride and separated by column or preparative layer chromatography on silica gel. The results for the reaction with cyclohexene are

 ¹ Present address: Département de chimie, Université de Sherbrooke, Sherbrooke, Québec, Canada.
 ² NRCC Postdoctorate Fellow, 1968-1970.

presented in table I. A fast rate of addition of chromous chloride resulted in a decrease in the yields of the addition products 3a (3a) and 4a (2, 3a)¹. The use of chloroform as cosolvent was necessary at -78° C to maintain an homogeneous solution. In the presence of this solvent a higher proportion of the CiS isomer 3a was observed. In the absence of olefin, NCU (1a) was reduced quantitatively into urethane (7a). Allthe NCU (1a) which has not added to cyclohexene was recovered as urethane (7a). As indicated, the reaction is without complication of products derived from reaction with chlorine atoms and is very clean. It is possible to obtain very high yields of 3a and 4a by using an excess of NCU (1a). Other N-chlorocarbamates such as the N-chloro-2-chloroethyl-carbamate (1b) (1), the N-chloro-2,2,2-trichloroethylcarbamate (1c), m.p. 63-63.5°C, and the N-chlorocarbamates: 3b (m.p. 80-80.5°C) and 4b (m.p. 93.5-94°C); 3c (m.p. 78.5-79.5°C) and 4c (m.p. 113.5-114°C); 3d (m.p. 64-65°C) and 4d (m.p. 103-104°C) respectively. The ratio of cis and trans isomers is close to that obtained with NCU (1a).

	R	2/1 ^b) solvent	т(^о с)	CrCl ₂ /l ^{b)}	React. Time min	3+4(3/4)	5	6	7
1	CH2CH3	2	снс13-сн3он	-78 ⁰	0.9	70	87% (6.7)	6%	< 1%	6.5%
2	сн ₂ сн ₃	2	снс1 ₃ -сн ₃ он	-78 ⁰	1.0	5	63% (6.0)	7%	2.5%	33%
3	сн ₂ сн ₃	2	снсі _з -сн _з он	-40 [°]	1.0	10	55% (4.9)	5%	4%	41%
4	сн ₂ сн ₃	2	сн _з он	-40 ⁰	1.0	10	50% (1.9)	5%	4%	45%
5	сн ₂ сн ₃	0.5	сн _з он	-40 ⁰	1.5	15	99% (1.9)	<1%	<1%	
6	сн ₂ сн ₃	0	сн _з он	-40 ⁰	2.0	15			q	uant.
7	сн ₂ сн ₂ с1	2	снс1 ₃ -сн ₃ он	-78 ⁰	0.8	475	80% (6.5)			
8	сн ₂ сс13	2	снс1 ₃ -сн ₃ он	-78 ⁰	0.8	150	80% (4.7)			
9	^{СН} 2 ^С 6 ^Н 5	2	снс1 ₃ -сн ₃ он	-78 ⁰	1.0	10	65% (5.0)			

Table I: Addition of ROCONHCl to Cyclohexene: Reaction Conditions and Yields of Products^{a)}

a) The yields are based on the starting N-chlorocarbamates except in entry 5 where they refer to cyclohexene. For compounds 3 and 4, they represent yields of isolated pure products. The yields of 5a⁽⁵⁾, 6 and 7a have been measured by VPC (0S-138 on chromosorb W).

b) Mole ratio

¹ All compounds had I.R. and N.M.R. (CCl₄ or CDCl₃-TMS) spectra consistent with their structure. All new compounds gave satisfactory analytical data.

	σ	U1	4	ω	2	1	
	Benzy l	Ethy 1	Ethy 1	Ethyl	Ethy1	E thy 1	R
	=	Pregnenolone acetate	Tretramethyl- ethylene	n-Octene	Norbornene	1-Methy1-1- cyclohexene	Olefin
	B 3 hr	B 3 hr	A 2 hr	A 5 hr	A 2 hr	A 1.25 hr	Reaction Conditions ^{a)}
	-	Ac0	(сн ₃)2 <mark>с-с</mark> (сн ₃)2 с1 инсооет	C6 ^H 13CH-CH2 C1 NHCOOEt	NHCOOEt C1	C1 NHCOOEt	
	617	, 70%	712	857 ^{d)}	cis 35% ^{d)} trans 6% ^{d)}	cis 77% trans 3%	Yield ^{b)} (1
1	198–199 ⁰ ([a] _D ^{20°} –20 [°])	198–200 ⁰ c ([م] 2 ⁰⁰ –20 ⁰)		(4)	(3Ъ) 50–52 ^о с (3Ъ) 88–90 ^о с	81-82 ⁰ C 98-99.5 ⁰ C	Ref) m.p. ^{c) P} rod
	=	Act C1 NHCOOR	сн ₂ =с-с(сн ₃) ₂ NHCOOEt		(exo)	C1 cis	lucts of addition
	13%	187	7%		54% ^{d)}	5.42 ^d e) 1.62 ^d	(ield ^{b)}
	amorphous ([a] _D ^{20°} + 30°)	116-117°c ([a] 20°+ 35°			48–49 ⁰ с		m.p.c)

Table II: Addition of ROCONHC1 to various Olefins

- Chloroform-methanol, -78°C; A: mole ratio of olefin to N-chlorocarbamate of 2; B: mole ratio of 0.5.
- The yields are based on the starting N-chlorocarbamates in entries 1 to 4; they are based on the olefin entries 5 and 6.
- a) Chloroform-methanol, -78°C; A: mole ratio
 b) The yields are based on the starting N-chlc
 c) Liquids were purified by microdistillation.
- d) Yields were estimated by VPC (OS-138 or SE-30 on Chromosorb W).
- e The trans isomer was not isolated as such. The mixture of the cis and trans isomers was treated with alcoholic potassium hydroxide at 100° C for 30 min to convert the trans isomer to the aziridine 9 which was identified by VPC (05-138 and SE-30 on Chromosorb W) with an authentic sample. On silica gel, the aziridine 9 was converted to the trans β -hydroxyethyl-carbamate 10 (m.p. 110-111°C) which could be easily separated from the corresponding cis β -chlorocarbamate.

cis-2-chloro-cyclohexylamine (8)(6) characterized as its N-acetyl derivative 8a (m.p. 97-97.5°C) was easily obtainable from the adducts 3b, 3c and 3d. Removal of the chloroethoxycarbonyl and trichloroethoxycarbonyl (7,8) groups was achieved by cleavage with zinc dust. In the former case, excess potassium iodide was added and the reaction was carried out at 80° C. The benzyloxycarbonyl group was removed by hydrogenolysis. Thus the use of N-chlorocarbamates lb, lc and ld show the potential of this method for the synthesis of primary β -chloroamines.

The reaction has been extended to include a great variety of olefins with satisfactory results (Table II). Further studies on the mechanism and with other N-halocarbamates are in progress. Preliminary experiments have shown that N-chloroamides can also undergo analogous additions albeit in lower yields and that vanadous chloride is much less efficient in promoting the addition of N-chlorocarbamates to olefins.



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