at 137–140° when recrystallized from a butanone–ether mixture.

Summary

A series of twenty-two new aminoesters of 1-substituted cycloalkanecarboxylic acids has been prepared, and their spasmolytic activity reported. The substituents were 2-thienyl, β-cyclohexylethyl, cyclohexyl, *n*-octyl, *n*-heptyl, *n*-hexyl, 2-methylpentyl, 2-ethylbutyl, *n*-amyl, *i*-amyl, 2-methylbutyl, 1-ethylpropyl, 1-methylbutyl, *n*-butyl, *i*-butyl, *n*-propyl, β-diethylaminoethyl and β-diethylaminoethoxy.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF BUFFALO]

The Preparation and Properties of Esters Related Structurally to Certain Insecticides

BY HENRY M. WOODBURN AND CYRUS E. SROOG[1]

The commercial introduction of four chlorobenzoic acids, following close on the outstanding success of D.D.T. as an insecticide, suggested the possibility that the chloroethanol esters of these acids might possess useful toxic properties. Trichloroethyl *p*-chlorobenzoate, $ClC_6H_4CO_2CH_2CCl_3$, for example, contains two of the structural units of D. D. T. The presence of the ester link might also be helpful, since Läuger,[2,3] from a study of natural substances and certain related compounds, concluded that the grouping  $=\overset{|}{C}-\overset{|}{C}=\overset{|}{C}-\underset{\overset{\|}{O}}{C}-O-$ was very important in conferring toxic properties on such compounds.

Twelve esters were prepared without difficulty by the interaction of 2-chloro-, 2,2-dichloro- and 2,2,2-trichloroethanol with the acid chlorides of *p*-chloro-, *o*-chloro-, 2,4-dichloro- and 3,4-dichlorobenzoic acids. They were either white crystalline solids melting between 30 and 65°, or high boiling colorless liquids. The solids were soluble in acetone and benzene and easily recrystallized from hot 95% ethanol. Liquids were miscible with acetone and benzene, partially miscible with 95% ethanol.

In toxicity tests compounds 1, 2, 3, 9, 10 and 12 (Table I) formulated as 5% dusts proved to be inactive in a simple walk-around test against the confused flour beetle (*Tribolium confusum*), the German cockroach, and the large milkweed bug. Compounds 4, 5, 6, 7, 8 and 11, also as 5% dusts, were inactive against the Mexican bean beetle on potted bean plants and against greenhouse spider. The toxicity tests were admittedly limited and on a specific type of formulation. Insecticidal activity against other types of insects might develop on further examination.

TABLE I

ESTERS OF CHLOROBENZOIC ACIDS

	Yield, %	M. p., °C., uncor.	B. p.			Chlorine, %		
			°C.	Mm.	$n^{25}D$	Calcd.	Found[a]	
2,2,2-Trichloroethyl *p*-chlorobenzoate	84	49–49.5				49.3	49.2	49.4
2,2,2-Trichloroethyl *o*-chlorobenzoate	84	39–40.5				49.3	49.4	49.8
2,2,2-Trichloroethyl 2,4-dichlorobenzoate	75	33–34				55.0	54.9	55.1
2,2,2-Trichloroethyl 3,4-dichlorobenzoate	65		208–209	38	1.564	55.0	55.2	55.3
2,2-Dichloroethyl *p*-chlorobenzoate	78	60–62				42.0	41.6	41.8
2,2-Dichloroethyl *o*-chlorobenzoate	86		150–154	8–9	1.549	42.0	42.1	41.8
2,2-Dichloroethyl 2,4-dichlorobenzoate	85		180–182	10		49.3	49.3	49.1
2,2-Dichloroethyl 3,4-dichlorobenzoate	89	64–65				49.3	49.1	49.1
2-Chloroethyl *p*-chlorobenzoate	79	38–38.5				32.4	32.2	32.2
2-Chloroethyl *o*-chlorobenzoate	74	30–31				32.4	32.3	32.7
2-Chloroethyl 2,4-dichlorobenzoate	80		198–199	35	1.561	42.0	41.6	41.6
2-Chloroethyl 3,4-dichlorobenzoate	89	47–48.5				42.0	42.3	42.1

[a] Rauscher, *Ind. Eng. Chem., Anal. Ed.*, 9, 296 (1937).

Experimental

Acids.—The following acids were furnished by the Heyden Chemical Co., to whom grateful acknowledgment is made: *p*-chlorobenzoic, *o*-chlorobenzoic, 3,4-dichlorobenzoic, and 2,4-dichlorobenzoic.

Acid Chlorides.—Acid chlorides were prepared by the reaction at elevated temperatures (100–135°) of a 100% excess of thionyl chloride on the appropriate acid. The products were recovered and purified by vacuum distillation; yields 72–90%; *p*-chlorobenzoyl chloride b. p. 127–129° (32 mm.); *o*-chlorobenzoyl chloride b. p. 133–137° 45 mm.); 3,4-dichlorobenzoyl chloride b. p. 153–155° (42 mm.) low melting solid; 2,4-dichlorobenzoyl chloride b. p. 146–149° (28 mm.).

Chloroalcohols. **2-Chloroethanol.**—C. P. ethylene chlorohydrin obtained from the Eastman Kodak Co. was redistilled before use.

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[1] From the thesis submitted by C. E. Sroog in partial fulfillment of the requirements for the M.A. degree, June, 1948.

[2] Läuger, *Helv. Chim. Acta*, **27**, 71 (1944).

[3] Läuger, Martin and Muller, *Helv. Chim. Acta*, **27**, 892 (1944).

2,2-Dichloroethanol.—This compound was prepared by the reduction of dichloroacetyl chloride by lithium aluminum hydride in absolute ether. Details are given in the accompanying paper.[4]

2,2,2-Trichloroethanol.—The method of Chalmers[5] given in "Organic Syntheses" was followed.

Esters.—The procedure for the synthesis of all twelve esters reported in this paper was essentially as follows.

2,2,2-Trichloroethyl *p*-Chlorobenzoate.—In a 200-ml. round-bottom flask, fitted with a reflux condenser and dropping funnel, was placed 18.5 g. (0.12 mole) of 2,2,2-trichloroethanol. All openings were protected by calcium chloride tubes and the flask was heated in an oil-bath maintained at 110–115°. *p*-Chlorobenzoyl chloride (21.7 g., 0.12 mole) was added slowly over a period of twenty minutes. Hydrogen chloride was evolved vigorously and heating was continued for seventy-five minutes after which no further evolution could be noted.

On cooling in the oil-bath the reaction mixture became solid. It was recrystallized several times from 95% alcohol giving 30 g., 84% yield, of white crystals melting at 49–49.5°; very soluble in benzene, acetone and hot 95% ethanol.

Anal. Calcd. for $C_9H_6Cl_4O_2$: Cl, 49.3. Found: Cl, 49.2, 49.4.

Acknowledgment.—Toxicity tests were carried out in the laboratories of the Niagara Chemical Division, Food Machinery Corporation, Middleport, New York.

Summary

The mono-, di- and trichloroethanol esters of *p*-chloro-, *o*-chloro-, 2,4-dichloro- and 3,4-dichlorobenzoic acids have been synthesized.

Preliminary toxicity tests gave no indication of insecticidal activity.

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(4) Sroog, Chih, Short and Woodburn, THIS JOURNAL, **71**, 1710 (1949).

(5) Chalmers, "Organic Syntheses," Coll. Vol. II, p. 598 (1943).

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF BUFFALO]

Reduction of Chloro-acid Derivatives by Lithium Aluminum Hydride: Synthesis of Dichloroethanol

BY CYRUS E. SROOG, CHEN MING CHIH, FRANKLIN A. SHORT AND HENRY M. WOODBURN

Nystrom and Brown[1] have reported the reduction of ketones, aldehydes, acid chlorides, esters, anhydrides, simple acids and certain types of substituted acids to form alcohols in yields exceeding 80%. Successful results with substances possessing aromatically bound halogen were reported but no reductions of those containing aliphatically bound halogen. Our need for relatively large amounts of 2,2-dichloroethanol led us to investigate this method of converting dichloroacetic acid derivatives to the alcohol and ultimately resulted in a method for the synthesis of the desired compound in 65% yield.

The conventional method for making 2,2-dichloroethanol requires the production of dichloroacetal, hydrolysis of this substance to dichloroacetaldehyde and reduction of the latter to the desired alcohol. In our hands the process gave disappointing results, in addition to requiring many hours of time. Except for the final drying and distillation, the synthesis described below can be completed in about four hours.

The reduction was accomplished by the slow addition of the halogen compound to an ether suspension of lithium aluminum hydride and was equally successful with the free acid, the ethyl ester and the acid chloride. The fact that the chloroalcohol formed the major part of the product, indicated that the principle reaction occurred at the carboxyl end of the molecule.

The study was then extended to the free acid, the ethyl ester and the acid chloride of monochloroacetic acid and trichloroacetic acid. Results were similar to those obtained before, although considerably poorer yields of alcohol resulted from the free acids.

A summary of results is given in Table I.

TABLE I

PRODUCTION OF ALCOHOLS FROM CHLOROACID DERIVATIVES

Reactant	Alcohol produced	Yield, %
$CHCl_2CO_2H$	$CHCl_2CH_2OH$	65
$CHCl_2CO_2Et$	$CHCl_2CH_2OH$	65
$CHCl_2COCl$	$CHCl_2CH_2OH$	63
CH_2ClCO_2H	CH_2ClCH_2OH	13
CH_2ClCO_2Et	CH_2ClCH_2OH	37
$CH_2ClCOCl$	CH_2ClCH_2OH	62
CCl_3CO_2H	CCl_3CH_2OH	31
CCl_3CO_2Et	CCl_3CH_2OH	65
CCl_3COCl	CCl_3CH_2OH	64

After this work had been completed, Henne, Alm and Smook[2] published a description of the lithium aluminum hydride reduction of trifluoroacetyl chloride. Like the reactions above, this offers an attractive method for the preparation of the haloalcohol.

Experimental

The chloroalcohols prepared in this work were made by completely analogous reactions whether the free acid, the ester or the acid chloride was the source material. The stoichiometric relationships given by Nystrom and Brown[1] were used. Details of only one specific case are given below.

The lithium aluminum hydride was purchased from Metal Hydrides Incorporated. Organic reagents were C. P. Eastman Kodak Co. products.

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(1) Nystrom and Brown, THIS JOURNAL, **69**, 1197, 2548 (1947).

(2) Henne, Alm and Smook, *ibid.*, **70**, 1968 (1948).