Difficulty was experienced in obtaining pure aminostearic and aminohendecanoic acids from the corresponding sulfates, although yields of crude amino acids were high. The reasons for this are not known. Possible explanations are the difficulty in finding the point of exact neutralization and the mixture of isomers may be more complex than that obtained when acetonitrile,[2] rather than hydrogen cyanide, is added to the double bond. Acetic acid is not as satisfactory as hydrochloric acid for neutralization of the solution of the amino acid sulfates in aqueous alkali since ash-free products could not be obtained. Solution of aminostearic acid sulfates in an excess of ammonia followed by boiling off of the ammonia did not give the amino acids alone but yielded mixtures of the free amino acid and its sulfates.

Reaction of hydrogen cyanide with linoleic acid resulted in some addition, but no identifiable products could be isolated. The high viscosity of the reaction product suggested that polymerization, caused by sulfuric acid, predominated.

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[CONTRIBUTION FROM THE DEPARTMENT OF ENTOMOLOGY, UNIVERSITY OF CALIFORNIA, CITRUS EXPERIMENT STATION]

Insecticidal Action of Esters and Ethers of 2,2,2-Trichloro-1-(*p*-chlorophenyl)-ethanol[1]

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The acaricidal activity of 2,2,2-trichloro-1-(*p*-chlorophenol)-ethanol gave an opportunity to study the effect of the hydroxyl group in the toxic action of this compound. Fifteen ester and ether derivatives, nine of them new, of this compound were synthesized and bioassayed against four species of insects and one species of mite. In this manner the effects of the reduction of polarity of the hydroxyl group upon penetration and transport and the possible hydrolysis of the esters could be studied. No marked differences in toxicity were noted in the experiments with the mite and with the three species of insects, but a specificity of certain compounds was observed for the confused flour beetle.

In order to be effective, a contact insecticide must be able to penetrate insect cuticle and subsequently reach the site of action where the penetrated molecule then exerts its biochemical effect with both primary and secondary actions.[2] In a previous paper,[3] the role of the ring in Ring-CH$_2$OH·CCl$_3$ compounds in insecticidal action was briefly discussed; against mosquito larvae, *Culex quinquefasciatus* Say, and greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), such rings appeared to function primarily[2] as spacers with polarizable characteristics.

As discussed previously,[3] compounds of the 2,2,2-trichloro-1-arylethanol type are synthetic precursors of the DDT-type molecule, yet they have demonstrable insecticidal and acaricidal activity.[4,5] Of a series of compounds containing a single *p*-chlorophenyl group, 2,2,2-trichloro-1-*p*-chlorophenylethanol was found to be the most effective.

Since esters are in general lipoid soluble, some aliphatic esters of this compound, varying in chain length and isomerism, were prepared to attempt enhancement of penetration and transport by alteration of the polar hydroxyl group. During the course of this investigation the *n*-butyrate was found to be the most effective of the *n*-esters against the confused flour beetle, *Tribolium confusum* Duv.; therefore, its isomer and isomers of higher esters were also included. To determine whether hydrolysis of the esters during transport or at the site of action occurred, some homologous ethers of this same ethanol were prepared.

Several investigators have prepared other miscellaneous esters and ethers of this alcohol for insecticidal evaluation.[6] Neither their compounds nor the parent alcohol were found to be as effective as DDT and certain of its analogs against several insects. Our compounds synthesized by standard methods are shown in Table I along with pertinent physical and analytical data.

These ester and ether derivatives were bioassayed against four species of insects and one species of mite. The insect and mite assays, except for that of the confused flour beetle, were made by standard methods as previously reported.[7]

Bioassays with the latter species were made by confining adult beetles in whole-wheat flour adulterated with the test compounds. Percentage-by-weight mixtures (5% for this test) were prepared by careful and thorough blending with mortar and pestle, and five grams of each mixture was placed in each of four one-ounce seamless salve tins. Twenty adult beetles selected at random from a mass culture of the confused flour beetle were placed in each container, and mortality determinations were made at the end of 24-, 72-, 168- and 360-hour exposures.

Discussion

The toxicity data for mosquito larvae exhibited an LD_{50} concentration, which ranged from 1×10^{-2} M to 2×10^{-3} M, and demonstrated an approximately equal toxicity for all the compounds. The

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(1) Paper No. 862, University of California Citrus Experiment Station, Riverside, California.

(2) F. A. Gunther, R. C. Blinn, G. E. Carman and R. L. Metcalf, *Arch. Biochem. Biophys.*, **50**, 504 (1954).

(3) R. C. Blinn, F. A. Gunther and R. L. Metcalf, THIS JOURNAL, **76**, 37 (1954).

(4) R. L. Metcalf, *J. Econ. Entomol.*, **41**, 875 (1948).

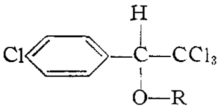
(5) T. C. Chen and W. T. Summerford, THIS JOURNAL, **72**, 5124 (1950).

(6) (a) J. W. Howard, *ibid.*, **57**, 2317 (1935); (b) G. T. Barry and R. Boyer, *Can. J. Research*, **26B**, 511 (1948); (c) A. W. A. Brown, D. B. W. Robinson, H. Hurtig and B. J. Wenner, *ibid.*, **26D**, 177 (1948); (d) H. C. Browning, F. C. Fraser, S. K. Shapiro, I. Glickman and M. Dubride, *ibid.*, **26D**, 282 (1948).

(7) R. L. Metcalf, *J. Econ. Entomol.*, **41**, 875 (1948).

TABLE I

PHYSICAL PROPERTIES OF ESTERS AND ETHERS OF



R	M.p., °C.	Yield, %	Mol. wt.		Analyses, % Carbon		Hydrogen	
			Calcd.	Found[a]	Calcd.	Found	Calcd.	Found
CH_3CO[b]	123–124.5	72	....	..	...	...	..	..
C_2H_5CO[b]	77.5–78.5	58	316.02	322	41.80	41.74	3.19	3.22
n-C_3H_7CO[b]	20[c]	58	330.5	333	43.67	43.87	3.67	3.67
i-C_3H_7CO	66.5–68	68	330.05	330	43.67	43.84	3.67	3.91
n-C_4H_9CO	47.5–48.5	90	344.07	342	45.38	45.09	4.16	4.16
i-C_4H_9CO	41.5–42.5	50	344.07	347	45.38	45.72	4.16	4.40
t-C_4H_9CO	92.5–93.5	52	344.07	345	45.38	45.47	4.16	4.46
n-$C_5H_{11}CO$	36–37	27	358.10	359	46.95	47.20	4.50	4.65
Cyclo-$C_6H_{11}CO$	60–61	47	370.11	367	48.67	49.17	4.56	4.59
n-$C_7H_{15}CO$	43–44	45	386.15	391	49.76	50.00	5.22	5.03
n-$C_{11}H_{23}CO$	40–41	57	442.25	458	54.31	54.58	6.38	6.67
n-$C_{15}H_{31}CO$	53–53.5	76	498.38	493	57.83	58.02	7.28	7.47
CH_3[d]	B.p. 115–120 (2 mm.)	85	....	..	...	...	..	..
n-C_4H_9[e]	B.p. 135–138 (2.5 mm.)	23	316.06	322	45.60	45.82	4.46	4.37
n-C_8H_{17}[f]	B.p 161–163 (10.6 mm.)	19	372.17	370	51.63	52.01	5.96	6.07

[a] Rast method with "Exaltone." [b] See J. W. Howard, THIS JOURNAL, **57**, 2317 (1935), for previous preparations. [c] B.p. 148° (2 mm.), $n^{20}D$ 1.5319. Calcd. Cl, 42.86; found 42.81. This compound has been reported previously as an oil; see footnote *b* above. [d] See G. T. Barry and R. Boyer, *Can. J. Research*, **26B**, 511 (1948), for previous preparation. [e] Calcd. Cl, 44.88; found Cl, 44.65; $n^{20}D$ 1.5342. [f] $n^{20}D$ 1.5118.

toxicity data for greenhouse thrips with an LD_{50} concentration which ranged from 1.4 to 0.6 *M*, and for the citrus red mite, *Metatetranychus citri* (McGregor), with an LD_{50} concentration, which ranged from 1.3 to 0.7 *M* do not demonstrate wide differences among the toxicities of any of the compounds.

Significant differences were apparent in the relative toxicities to the confused flour beetle. With all the compounds (Table I) the mortality at 24 and 72 hours was very low. In regard to the ethers (Table I), the methyl, *n*-butyl and *n*-octyl showed, respectively, percentage mortalities of 100, 12.5 and 7.0 at 168 hours, and of 100, 26.2 and 9.3 at 360 hours. In regard to the esters (Table I), only the *n*-butyrate and *n*-caprate exhibited significant toxic properties, the percentage mortalities being, respectively, 39.6 and 27.5 at 168 hours and 100 and 43.0 at 360 hours.

From these results it may be inferred that melting point or molecular weight had little correlation with toxicity, and hydrolysis *in situ* is not indicated since closely related esters should exhibit essentially equivalent toxicities after 360 hours. In addition, if the free carbinol were the toxic agent, the ethers would not be toxic. Apparently the entire molecule is involved in the toxic action, affording another instance of specificity of toxicants to certain insects.

Experimental

General Preparation of the Esters.—The esters listed in Table I were prepared by the Schotten–Baumann reaction between 2,2,2-trichloro-1-(*p*-chlorophenyl)-ethanol[6a,6b,8] and the acid chloride, and they were purified by repeated washing of an ether solution of the reaction mixture with cold 5% sodium bicarbonate solution, drying over anhydrous sodium sulfate, then evaporating the ether. All the esters crystallized well from methyl alcohol solutions which generally became supersaturated on cooling; seeding was usually necessary.

Preparation of 2,2,2-Trichloro-1-(*p*-chlorophenyl)-ethyl *n*-Butyrate.—*n*-Butyryl chloride (10.3 g., 0.096 mole) and 2,2,2-trichloro-1-(*p*-chlorophenyl)-ethanol (10.4 g., 0.04 mole) were heated on the steam-bath until the initial vigorous reaction subsided. House vacuum was then applied to the system until evolution of hydrogen chloride ceased. The residue was dissolved in ether, washed with cold 5% sodium bicarbonate solution until gas evolution ceased, then dried over anhydrous sodium sulfate, concentrated on the steam-bath, and distilled. The fraction boiling at 148° (2 mm.) crystallized after several weeks to afford 4 g. (30% yield) of colorless crystals from methyl alcohol, m.p. 20°. When a seed crystal is available, the vacuum distillation is not necessary and the yield is doubled.

Preparation of Ethers.[6b]—The ethers listed in Table I were prepared by mixing 2 moles of alkyl iodide for one mole of 2,2,2-trichloro-1-(*p*-chlorophenyl)-ethanol followed by the addition of a mole of freshly prepared silver oxide in small portions. The reaction was started by heating and controlled by cooling. When the reaction with one portion of silver oxide had subsided, another portion (*ca.* 1 g.) was added. The final mixture was then refluxed for 8 hours, cooled and extracted with four 50-ml. portions of ether. The combined extracts were filtered, dried over anhydrous sodium sulfate, evaporated, and the residue was distilled. Homologs above octyl could not be prepared by this method.

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