seconds. The mixture was then allowed to warm to 15° for four minutes and as no further evolution of gas was noticed the solvent was evaporated under reduced pressure. Dry air was then admitted and three 1.5-ml. portions of benzene were added and evaporated, keeping the temperature below 15° at all times. Finally the acid chloride was dissolved in 5 ml. of benzene, filtered through a dry, sintered glass funnel into a cooled receiver and diluted with an equal volume of ether. The acid chloride was added slowly to a cold (−15°) ethereal solution of diazomethane (prepared from 6 g. of nitrosomethylurea[12]), maintained at −15° for one-half hour and at 0° for one-half hour, then the solvent was evaporated under reduced pressure. Trituration of the residual oil with acetone gave a total of 439 mg. (81%) of the light yellow diazoketone which decomposed at 177–178° (reported,[2] 182–184°).

Desoxycorticosterone Acetate (IVa).—To 10 ml. of boiling, purified[13] acetic acid was slowly added 163 mg. of 21-diazoprogesterone; there was immediate evolution of nitrogen and a light yellow solution resulted. After refluxing for three minutes the acetic acid was evaporated under reduced pressure and the residual oil dissolved in acetone. On cooling long needles were obtained which changed to 109 mg. of a powder upon drying at room temperature, m. p. 155–157°. A second crop of 14 mg., m. p. 153–155°, and an additional 8 mg., m. p. 146–154°, after molecular distillation of the filtrate at 160° (0.001 mm.) brought the total yield of desoxycorticosterone acetate to 73%. Recrystallization of a sample from acetone raised the m. p. to 158–159° (reported,[2] 158–159°).

Hydrolysis of the acetate by the method of Reichstein and von Euw[14] gave desoxycorticosterone; after molecular distillation at 150° (0.001 mm.) and two recrystallizations from acetone–ether, this melted at 140–142° and showed no depression when mixed with an authentic sample.

Summary

A procedure has been developed for preparing acid chlorides from α,β-unsaturated keto acids using the sodium salt and oxalyl chloride in the cold. By means of this reaction it has been possible to convert 3-keto-Δ^4-etiocholenic acid to 21-diazoprogesterone and desoxycorticosterone acetate in good yields.

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[12] The diazomethane solution was distilled, dried for two hours over potassium hydroxide pellets, and then for one hour over sodium wire before use; see Fieser and Turner, This Journal, **69**, 2341 (1947).

[13] The acetic acid was refluxed for six hours with 5% by weight of potassium permanganate, distilled and the distillate fractionated, collecting the last fraction, b.p. 117°.

[14] Reichstein and v. Euw, *Helv. Chim. Acta*, **21**, 1181 (1938).

MADISON 6, WISCONSIN RECEIVED MARCH 19, 1948

[CONTRIBUTION FROM THE RESEARCH LABORATORY OF EVANS RESEARCH AND DEVELOPMENT CORPORATION]

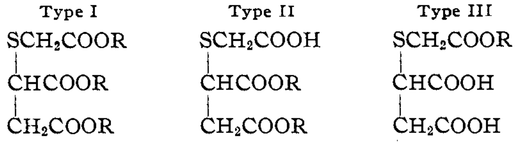
Esters of (Carboxymethylmercapto)-succinic Acid

BY JOHN F. MULVANEY,[1a] JAMES G. MURPHY AND RALPH L. EVANS

(Carboxymethylmercapto)-succinic acid has been prepared by Fitger,[1] by Morgan and Friedmann[2] and by Larsson.[3] Larsson gives a procedure for the preparation of the *dl*-acid in excellent yield by the interaction of maleic acid and thioglycolic acid at water-bath temperature.

During an investigation of derivatives of thioglycolic acid, we prepared esters of (carboxymethylmercapto)-succinic acid of the three types indicated in Fig. 1. No attempt was made during this work to isolate any optically active forms of these esters.

Fig. 1



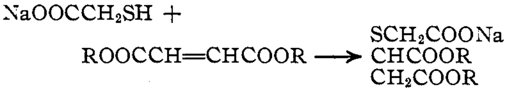
$$\begin{array}{lll} \text{SCH}_2\text{COOR} & \text{SCH}_2\text{COOH} & \text{SCH}_2\text{COOR} \\ | & | & | \\ \text{CHCOOR} & \text{CHCOOR} & \text{CHCOOH} \\ | & | & | \\ \text{CH}_2\text{COOR} & \text{CH}_2\text{COOR} & \text{CH}_2\text{COOH} \end{array}$$

Esters of Type I.—These were prepared in the usual manner with an acid catalyst and with toluene or benzene as water-entraining agents.

The esters were purified by fractional distillation. The octadecyl ester was crystallized from toluene, alcohol and acetone.

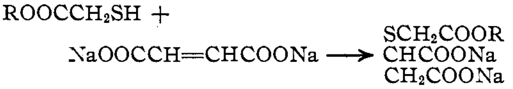
The properties of the esters of Type I are listed in Table I. The *n*-propyl (b. p. 125–131° at 0.1 mm.) and isopropyl (b. p. 124–129° at 0.4 mm.) esters were prepared but were not purified for analysis.

Esters of Types II and III.—Preliminary attempts to prepare esters of Type II by the addition of thioglycolic acid to alkyl maleates gave only slow and partial reaction. The isolation of fumaric acid from the reaction mixture indicated hydrolysis and isomerization. When sodium thioglycolate was used, the reaction proceeded almost to completion at room temperatures.



$$\text{NaOOCCH}_2\text{SH} + \text{ROOCCH=CHCOOR} \longrightarrow \begin{array}{l} \text{SCH}_2\text{COONa} \\ \text{CHCOOR} \\ \text{CH}_2\text{COOR} \end{array} \qquad (1)$$

Similarly, it was found that thioglycolic acid esters reacted more completely with sodium maleate than with maleic acid to give esters of Type III.



$$\text{ROOCCH}_2\text{SH} + \text{NaOOCCH=CHCOONa} \longrightarrow \begin{array}{l} \text{SCH}_2\text{COOR} \\ \text{CHCOONa} \\ \text{CH}_2\text{COONa} \end{array} \qquad (2)$$

Experimental

In general, 0.25 mole of the acid was neutralized with 15% sodium hydroxide and an alcoholic solution of the ester (0.25 mole) was added. The mixture was allowed to stand at room temperature until titration with iodine showed that the addition was almost complete.

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[1] Fitger, Diss. Lund, 1924.

[1a] Present address: General Aniline Works, General Aniline and Film Corporation, Grasselli, N. J.

[2] E. J. Morgan and E. Friedmann, *Biochem. J.*, **32**, 733 (1938).

[3] E. Larsson, *Trans. Chalmers Univ. Technol.*, **47**, 3–7 (1945).

TABLE I

ESTERS OF TYPE I

R	B. p. °C.	B. p. Mm.	$n^{25}D$	d^{25}_{25}	MD Calcd.	MD Obs.	Sulfur, % Calcd.	Sulfur, % Found
Ethyl	140–145	0.8	1.4646	1.1498	70.5	70.4	10.96	10.82
n-Butyl	161–163	0.2	1.4606	1.0517	98.2	98.6	8.54	8.92
Octadecyl	50 (melting point, uncor.)						3.43	3.43

TABLE II

Compound	Formula	M. p., °C.	Analyses, % Calculated S	Calculated Na	Found S	Found Na
(Carboxymethylmercapto)-butyl-succinate[a]	$C_{14}H_{23}O_6SNa$	148	9.37	6.72	9.51	6.49
(Carboxymethylmercapto)-benzyl-succinate[a]	$C_{20}H_{19}O_6SNa$	156–157	7.81	...	8.10	...
(Carbobutoxymethylmercapto)-succinate[b,d]	$C_{10}H_{14}O_6SNa_2$	.....	10.39	...	9.98	...
(Carboctoxymethylmercapto)-succinate[b,d]	$C_{14}H_{22}O_6SNa_2$	.....	8.80	12.62	9.01	12.50
(Carbododecoxymethylmercapto)-succinate[c,d]	$C_{18}H_{30}O_6SNa_2$	.....	7.62	...	7.32	...

[a] Purified by dissolving in methanol and precipitating with ether. [b] Purified by dissolving in methanol–water (1:1) and precipitating with acetone. [c] Purified by dissolving in water and precipitating with acetone. [d] White, waxy solids. The octyl and dodecyl compounds have surface-active properties.

The compounds prepared, all as their sodium salts, are listed in Table II.

The (carboctoxymethylmercapto) disodium succinate was converted to the free acid by acidifying an aqueous solution with hydrochloric acid. The oil that separated was dissolved in ether and washed with water. The ether then was evaporated and the oil dried in vacuum. Alkali titration gave an equivalent weight of 165 (theory 160.3) $n^{25}D$ 1.4840, d^{25}_{25} 1.146.

Acknowledgment.—The authors wish to express their appreciation to Miss Lillian Weiss and Mr. J. W. Veale for assistance in the experimental work.

Summary

1. Three tri-esters, two di-esters and three mono-esters of (carboxymethylmercapto)-succinic acid (the latter two types as sodium salts) have been prepared and some of their physical constants determined.

2. An indirect method for the preparation of certain of the mono-esters and di-esters of (carboxymethylmercapto)-succinic acid is reported.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF NORTHWESTERN UNIVERSITY]

Mechanism for the Reaction of Dioxane Sulfotrioxide with Olefins. II. Sulfonation of Styrene

BY F. G. BORDWELL AND CHRISTIAN S. RONDESTVEDT, JR.[1]

In a continuation of the attempt to elucidate the mechanism[2] of the reaction of dioxane sulfotrioxide with olefins,[3] the sulfonation of styrene has been investigated. Styrene was chosen because of its ready availability in a pure state and because preliminary studies[4] indicated that a variety of products are formed in its sulfonation.

To ensure uniformity in the sulfonating agent and a fixed ratio of dioxane to sulfur trioxide the dioxane sulfotrioxide was prepared by adding an equimolar quantity of dioxane to a solution of sulfur trioxide in ethylene dichloride. In this way a fine suspension of dioxane sulfotrioxide was obtained.

In most of the experiments of the present investigation the sulfonation mixture, prepared at −5 to 0° by dropwise addition of a solution of styrene in ethylene dichloride to the sulfonating agent, was hydrolyzed without allowing the temperature to rise above 5°. When the aqueous layer was neutralized with sodium hydroxide, the water-soluble products were sodium 2-phenylethene-1-sulfonate[4] (I), sodium 2-phenyl-2-hydroxy-1-ethanesulfonate (II) and sodium sulfate. The identity of II was established by separation from I and sodium sulfate by fractional crystallization using alcohol–water mixtures,[5] and comparison of the S-*p*-chlorobenzylthiouronium salt[6] with an authentic sample.[7] From the ethylene dichloride layer 2,4-diphenyl-1,4-butanesultone (III) was obtained.[4,8] At higher reaction temperatures the amount of I increased at the expense of II.

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(1) National Research Council Predoctoral Fellow, 1946–1947. Present address: University of Michigan, Ann Arbor, Michigan. This material was abstracted from the Ph.D. Dissertation of Christian S. Rondestvedt, Jr., October, 1947.

(2) Bordwell, Suter and Webber, THIS JOURNAL, **67**, 827 (1945).

(3) Suter and co-workers, *ibid.*, **60**, 538 (1938); **63**, 978, 1594 (1941); **65**, 507 (1943); **66**, 1105 (1944).

(4) Bordwell, Suter, Holbert and Rondestvedt, *ibid.*, **68**, 139 (1946).

(5) Kharasch, Schenk and Mayo, *ibid.*, **61**, 3092 (1939).

(6) Suter and Milne, *ibid.*, **65**, 582 (1943).

(7) We wish to thank Frank Colton for carrying out this experiment.

(8) This structure is assigned on the basis of unpublished results.