931; molecular weight (by melting point method) ranges from 473 to 526, mean 493; analysis (mean of three): C, 73.5%; H, 5.2%; N, 13.5%; S absent; proposed empirical formula $C_{30}H_{25}N_5O_2$ (mol. wt. 487.54).

Antibacterial Action (These studies were carried out by Miss Alice McDonald and Miss Marjorie Jewell in the laboratories of the Evans Memorial).—Bactericidal or bacteriostatic effects were determined by adding the compound (dissolved in physiological salt solution) to cultures of several organisms in veal infusion broth, with or without horse serum. Plate counts were made at intervals of eight, twenty-four and forty-eight hours.

The results are shown in tabular form. The effect is characterized as bactericidal if no organisms survive after eight hours, as bacteriostatic if no significant increase in the number of organisms occurs for forty-eight hours. Control tubes were carried through all experiments.

Discussion

The results of the antibacterial tests show no consistent relationship between bacteriostatic concentration and the size of the inoculum. Two conclusions are apparent: (1) The reduced form has approximately equal activity with the oxidized form, and (2) the activity is diminished in the presence of serum.

Attention should be called to the remarkable antibacterial potency of the compound. Comparable results with the sulfonamides would require concentrations higher by a factor of about 25 (against streptococci in the presence of serum). The action of gramicidin is more comparable; gramicidin is bactericidal against pneumococci in concentrations of 1 microgram per ml., and against streptococci in concentrations of 5 micrograms per ml., under approximately similar conditions.[10]

It should also be emphasized that Dr. Barkan left no significant data in regard to the toxicity of the product. A few preliminary tests with mice indicated that it is not prohibitively toxic.

There are no data in regard to antibacterial action *in vivo*.

Summary

A water-soluble oxidation product of sulfanilamide is blue in its oxidized form and colorless when reduced. The oxidation and reduction are reversible. In both forms, the compound is bacteriostatic against streptococci, staphylococci, and pneumococci.

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[10] D. H. Heilman and W. E. Herrell, *Proc. Staff Meetings Mayo Clinic*, **17**, 321 (1942).

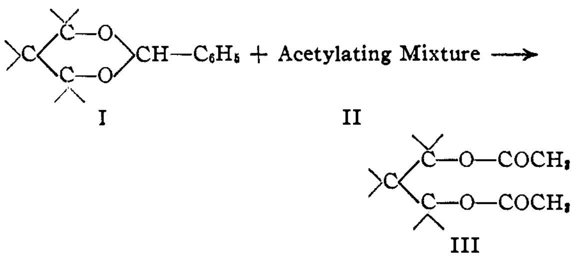
BOSTON, MASS. RECEIVED JANUARY 25, 1946

[CONTRIBUTION FROM RESEARCH AND DEVELOPMENT DEPARTMENT, COMMERCIAL SOLVENTS CORPORATION]

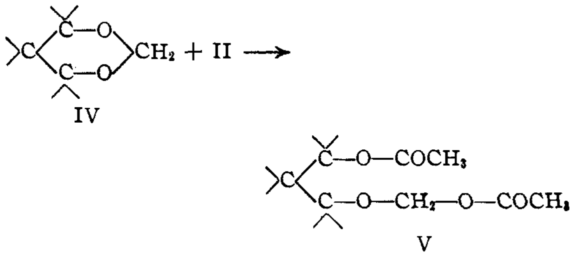
Reaction of Some Cyclic Acetals with Acid Anhydrides[1]

BY MURRAY SENKUS

Haskins, Hann and Hudson[2] observed that when an acetylating mixture (II) composed of 35 volumes of acetic anhydride, 15 volumes of acetic acid and 1 volume of sulfuric acid is allowed to react at 20–25° with some cyclic benzaldehyde acetals (I) of polyhydric alcohols, the benzylidene radical is eliminated from the substituted 2-phenyl-1,3-dioxanes (I) and substituted diacetates (III) are formed



Ness, Hann and Hudson[3] extended this reaction to some cyclic formals prepared from polyhydric alcohols and found that the methylene radical is not eliminated from each of the substituted cyclic formals (IV) during the acetolysis but leads to the formation of an acetoxymethoxy group



They were also able to show that in each of the products from the cyclic formals which contain a primary carbon atom, the acetoxy group is attached to this atom and the acetoxymethoxy group is attached to the secondary carbon atom.

We now wish to report the acetolysis of some cyclic acetals derived from dihydric alcohols. Each of the formals that was investigated gave as a main product a compound similar in structure to the compounds prepared by Hudson, *et al.* 1,3-Dioxolane and 1,3-dioxane gave small amounts of other products whose structures are discussed herein. The direct conversion of 4,5-dimethyl-1,3-dioxolane to formaldehyde and 2,3-butanediol diacetate was also studied with some success and is reported.

The cyclic acetals other than formals failed to react with 1% sulfuric acid acetic anhydride at 100° in two hours. Reactions did take place on

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[1] Prepared for the 1945 Meeting-in-Print of the Division of Organic Chemistry, A. C. S.

[2] Haskins, Hann and Hudson, THIS JOURNAL, **64**, 134 (1942).

[3] Ness, Hann and Hudson, *ibid.*, **65**, 2215 (1943).

TABLE I

REACTION OF SOME CYCLIC ACETALS WITH ACID ANHYDRIDES

Acetic anhydride and reactant	Products, diacetates	Conversion, %	B. p. °C.	B. p. Mm.	d^{20}_{20}	n^{20}_D	Molecular refraction Calcd.	Molecular refraction Found	Saponification equivalent[d] Calcd.	Saponification equivalent[d] Found	Analyses, % Carbon Calcd.	Analyses, % Carbon Found	Analyses, % Hydrogen Calcd.	Analyses, % Hydrogen Found
1,3-Dioxolane[5]	1,2-Ethanediol	9	78–80	10					73.02	74.00				
	2-Oxa-1,4-butanediol	75	114–116	10	1.1382	1.4223	39.48	39.33	88.03	86.99	47.72	47.58	6.87	6.59
	2,5-Dioxa-1,6-pentanediol	6	134–137	10	1.1533	1.4253	45.74	45.74	103.09	100.73	46.60	47.02	6.84	6.70
1,3-Dioxane[5]	1,3-Propanediol	8	91–92	10					80.03	80.00				
	2-Oxa-1,5-pentanediol	78	121–122	10	1.1032	1.4237	44.09	43.95	95.09	94.90	50.52	50.82	7.42	7.34
	2,6-Dioxa-1,7- heptanediol	6	145–147	10	1.1267	1.4275	50.35	50.24	110.11	110.49	49.08	49.22	7.32	7.23
4-Chloromethyl-1,3-dioxolane[6]	3-Chloromethyl-2-oxa-1,4-butanediol	77	125–126	3	1.2265	1.4440	48.96	48.65			15.78[b]	15.79[b]		
5-Nitro-5-ethyl-1,3-dioxane[7]	4-Nitro-4-ethyl-2-oxa-1,5-pentanediol	79	133	1	1.1949	1.4440					5.32[c]	5.47[c]		
4,5-Dimethyl-1,3-dioxolane[8]	3-Methyl-2-oxa-1,4-butanediol	96	228–232	750	1.0676	1.4212	48.71	48.53	102.11	104.30	52.93	53.01	7.90	7.98
4,5-Dimethyl-1,3-dioxolane[8] and butyric anhydride	3-Methyl-2-oxa-1,4-butanediol dibutyrate	74	197	10	1.0012	1.4280	67.18	66.90	130.16	130.85	59.97	59.38	9.29	8.79
4,5-Dimethyl-2-propyl-1,3-dioxolane[a]	2,3-Butanediol acetic acid	78	82	10					87.10	87.05				
2,2,4,5-Tetramethyl-1,3-dioxolane[8]	2,3-Butanediol acetic acid	65	82	10					87.10	87.15				
2-Chloromethyl-2-methyl-1,3-dioxolane[9]	1,2-Ethanediol acetic acid	60	78–80	10					73.02	74.10				

[a] This acetal is new, b. p. 152° at 750 mm. *Anal.* Calcd. for $C_8H_{16}O_2$: C, 66.62; H, 11.18. Found: C, 66.42; H, 10.85; n^{20}_D 1.4178; d^{20}_{20} 0.9377. [b] Chlorine content. [c] Nitrogen content. [d] According to the method of Kunz, THIS JOURNAL, **48**, 1982 (1926).

continued refluxing of these mixtures. This work is also described.

Experimental

Reaction of Cyclic Formals with Acid Anhydride.—The reactions of cyclic formals with acid anhydrides were all similar. To one mole of formal were added one mole of acid anhydride and 0.5–1.0 g. of sulfuric acid. The temperature of the mixture rose to about 100° in several minutes. The mixture was heated on the steam-bath for several hours and then allowed to stand in the room overnight. Sodium acetate was then added to the mixture and after agitation several minutes the mixture was filtered and the filtrate was rectified through a 3-foot laboratory column. The products which were isolated from these experiments are set forth in Table I.

Some work was done on the conversion of 4,5-dimethyl-1,3-dioxolane to formaldehyde and 2,3-butanediol diacetate. The procedure which gave the best results at the time the problem was discontinued was as follows. A mixture which consisted of 204 g. (2 moles) of 4,5-dimethyl-1,3-dioxolane, 240 g. (2.2 moles) of 95% acetic anhydride, 200 g. of acetic acid and 10 g. of sulfuric acid was refluxed in a 2-liter round-bottom flask which was connected to a water-jacketed Dean and Stark moisture trap[4] which was connected to a condenser. The slurry of trioxymethylene, acetic acid and anhydride which separated in the trap was withdrawn at intervals and filtered. The solid was saved and the filtrate was returned to the reaction vessel. Refluxing was continued for four hours. Altogether, 31 g. of trioxymethylene was isolated from the trap and the condenser. To the reaction vessel was added 20 g. of sodium acetate and the mixture was heated to 120°, cooled to room temperature and filtered. The filtrate was rectified through a 3-foot laboratory column at atmospheric pressure. This rectification gave 185 g. of 2,3-butanediol diacetate, boiling range 189–192°, conversion 53%. The distillation also yielded 100 g. of 3-methyl-2-oxa-1,4-butanediol diacetate.

Reaction of Cyclic Acetals other than Formals with Acetic Anhydride.—2,2,4,5-Tetramethyl-1,3-dioxolane, 2-chloromethyl-2-methyl-1,3-dioxolane and 2,2,4,5-tetramethyl-1,3-dioxolane failed to react with 1% sulfuric acid acetic anhydride at 100° in two hours. Prolonged refluxing of each of the above mixtures gave the diacetate of the glycol from which the acetal was prepared, acetic acid and tar. The following experiment is representative of this series. A mixture of 130 g. (1 mole) of 2,2,4,5-tetramethyl-1,3-dioxolane, 230 g. (2.2 moles) of 95% acetic anhydride and 2 g. of sulfuric acid was refluxed for sixteen hours. The mixture was rectified through a 3-foot laboratory column. This distillation gave 85 g. of acetic acid, 35 g. of unreacted acetal and 113 g. of 2,3-butanediol diacetate, b. p. 80–82° at 10 mm.

Discussion

The structures which were assigned to the main products from the cyclic formals and acid anhydrides are supported by their elementary analyses, saponification equivalents and molecular refractions and also by the observation that one mole of 4,5-dimethyl-1,3-dioxolane reacted with one mole of acetic anhydride to give almost the calculated amount of the expected product. Further confirmation of these structures is provided by the examination of the boiling points of these compounds. For example the boiling point of 3-methyl-2-oxa-1,4-butanediol diacetate is about

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(4) Dean and Stark, *Ind. Eng. Chem.*, **12**, 486 (1920).

(5) Clarke, *J. Chem. Soc.*, **101**, 1788 (1912).

(6) Verley, *Bull. soc. chim.*, [3] **21**, 275 (1899).

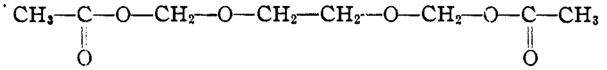
(7) Senkus, THIS JOURNAL, **63**, 2635 (1941).

(8) Backer, *Rec. trav. chim.*, **55**, 1036 (1936).

(9) Morey, U. S. Patent 2,260,265.

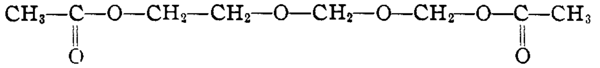
40° higher than the boiling point of 2,3-butanediol diacetate. This difference is in range that would be predicted for the —O—CH_2— grouping. Finally the work of Hudson and co-workers provides additional confirmation of these structures.

Attention is called to the fact that some of the above reactions of formals with acid anhydrides were accompanied by side reactions. This is evident from the examination of the yields of the expected products. Painstaking rectification of the by-products from the 1,3-dioxolane-acetic anhydride reaction led to the isolation of 1,2-ethanediol diacetate and a compound which is believed to be 2,5-dioxa-1,5-hexanediol diacetate



$$CH_3-\underset{\displaystyle O}{\underset{\|}{C}}-O-CH_2-O-CH_2-CH_2-O-CH_2-O-\underset{\displaystyle O}{\underset{\|}{C}}-CH_3$$

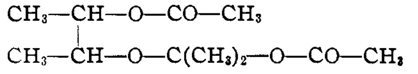
This structure is supported by elementary analysis, saponification equivalent and molecular refraction, although these same data would not exclude 2,4-dioxa-1,6-hexanediol diacetate



$$CH_3-\underset{\displaystyle O}{\underset{\|}{C}}-O-CH_2-CH_2-O-CH_2-O-CH_2-O-\underset{\displaystyle O}{\underset{\|}{C}}-CH_3$$

which could form under the conditions of the experiment. The product at hand may also be a mixture of these two compounds, the former probably being predominant in the mixture.

Each of the reactions of cyclic acetals other than formals with acetic anhydride gave acetic acid, the diacetate of the glycol for which the acetal was derived and a tar. These products may result from the decomposition of intermediates similar in structure to the compounds derived from the cyclic formals. For example 2,2,4,5-tetramethyl-1,3-dioxolane may first react with acetic anhydride to give 2,4-dimethyl-3-oxa-1,5-hexanediol diacetate



$$\begin{array}{l} CH_3-CH-O-CO-CH_3 \\ \qquad\;\, | \\ CH_3-CH-O-C(CH_3)_2-O-CO-CH_3 \end{array}$$

which reacts further with acetic anhydride to give 2,3-butanediol diacetate and isopropylidene diacetate. The latter decomposes to acetic acid and 1-propene-2-ol acetate which polymerizes to a tar in the presence of sulfuric acid at the elevated temperature of the experiment.

Acknowledgment.—The author is indebted to Professor C. D. Hurd for naming the new compounds which are described in this paper.

Summary

The reactions of acid anhydrides with some cyclic acetals derived from dihydric alcohols have been investigated.

4,5-Dimethyl-1,3-dioxolane (2,3-butanediol formal) reacted almost quantitatively with sulfuric acid acetic anhydride to give 3-methyl-2-oxa-1,4-butanediol diacetate

CH_3—CO—O—CH_2—O—CH(CH_3)—CH(CH_3)—O—CO—CH_3

and with sulfuric acid butyric anhydride to give the corresponding dibutyrate.

Each of the other cyclic formals that was studied reacted with sulfuric acid acetic anhydride to give as a main product a similar diacetate. 1,3-Dioxolane gave in addition in small yields 1,2-ethanediol diacetate and a compound which is likely 2,5-dioxa-1,6-hexanediol diacetate and 1,3-dioxane gave in addition in small yields 1,3-propanediol diacetate and a compound which is believed to be 2,6-dioxa-1,7-heptanediol diacetate.

4,5-Dimethyl-1,3-dioxolane has been converted to 2,3-butanediol diacetate and formaldehyde.

The cyclic acetals other than formals failed to react with 1% sulfuric acid acetic anhydride at 100° in two hours. Prolonged refluxing of each of these mixtures yielded acetic acid, the diacetate of the glycol from which the acetal was derived and a tar.

TERRE HAUTE, INDIANA RECEIVED AUGUST 22, 1945

[CONTRIBUTION FROM THE NOYES CHEMICAL LABORATORY, UNIVERSITY OF ILLINOIS]

The Preparation and Polymerization of Some Substituted Styrenes[1,2]

BY C. S. MARVEL, C. G. OVERBERGER, R. E. ALLEN AND J. H. SAUNDERS

In order to investigate the effects of different groups on the polymerization and copolymerization of styrene derivatives, a study of a wide variety of styrenes has been in progress in this Laboratory. This paper reports a method of synthesis for the new *m*-trifluoromethylstyrene and gives some details on new procedures for the preparation of *m*-methylstyrene[3] and *m*-nitrostyrene[4] and abnormalities of *p*-N,N-dimethylaminostyrene.[5] In addition a brief summary of the properties of the polymers of these styrenes is given. The copolymerization studies will be reported later. It should be noted that *m*-nitrostyrene does not polymerize or copolymerize under

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[1] This investigation was carried out under the sponsorship of the Office of Rubber Reserve, Reconstruction Finance Corporation, in connection with the Government Synthetic Rubber Program.

[2] This is the twentieth communication on vinyl polymers. For the nineteenth, see THIS JOURNAL, **67**, 2250 (1945).

[3] (a) Müller, *Ber.*, **20**, 1215 (1887); (b) Titley, *J. Chem. Soc.*, 517 (1926); (c) Shorygin and Shorygina, *J. Gen. Chem.*, *U. S. S. R.*, **5**, 555 (1935).

[4] Prausnitz, *Ber.*, **17**, 596 (1884).

[5] v. Braun and Blessing, *ibid.*, **56**, 2154, 2161 (1923).