

GLYOXAL ACETALS
AND
RELATED COMPOUNDS

By

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TABLE OF CONTENTS

	Page
Historical	1
Experimental	7
Preparation of Acetals	7
Preparation of Alpha-Chloro Ethers	14
Prins Reaction with Allyl Bromide	16
Reaction with Hydrogen Chloride	17
Discussion	18
Summary	24
Bibliography	25
Biography	27

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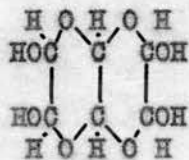
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HISTORICAL

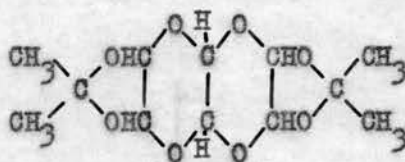
Glyoxal was first isolated in the polymeric state by Debus (6) in 1856 as a colorless, amorphous, and somewhat brittle mass. The unimolecular form of glyoxal can be prepared from the Debus product, which is a mixture of polymers of glyoxal, by distillation with phosphorus pentoxide (14). A green gas is obtained which can be condensed to yellow crystals, m.p. 15° ; the green liquid form boils at 50° . Hess and Ubrig (16) obtained the monomer by heating the polyglyoxal with anethole, phenetole, safrole, methyl nonyl ketone, or benzaldehyde, and Walker (36) by distillation of the polyglyoxal at 150 mm. at 75° to 90° . The monomer is stable for only a few hours, readily undergoing polymerization to an insoluble modification, called paraglyoxal, even when placed in a freezing mixture. This change occurs immediately in the presence of a small amount of water; if, however, monomeric glyoxal is poured into a large quantity of water, it dissolves completely, hydrating extensively and remaining at least temporarily in the unimolecular form. Trimolecular glyoxal (14) can be prepared by subjecting cinnamaldehyde, dissolved in chloroform, to the action of ozone and then warm water. It resembles polyglyoxal in general properties, but differs from the latter and the hydrated unimolecular form in that it reduces Fehling solution. It seems most remarkable that Fehling solution cannot oxidize the unimolecular form of glyoxal, but no reference has been found to contradict this statement.

The structure of the trimolecular form was first supposed to result from an aldol condensation, and to be $\text{CHO}\cdot\text{CH}(\text{OH})\text{COCH}(\text{OH})\text{CO}\cdot\text{CHO}$ (14).

However, the recent work of Raudnitz (33) led to the conclusion that trimeric glyoxal is 2,3,6,7-tetrahydroxy-p-dioxano-[b]-p-dioxane

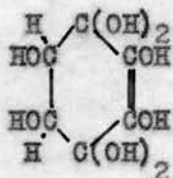


When the trimer is treated with acetone containing sulfuric acid as condensing agent, a well-crystallized substance is formed.



This was first prepared by H. O. L. Fischer and Taube in 1926 (10).

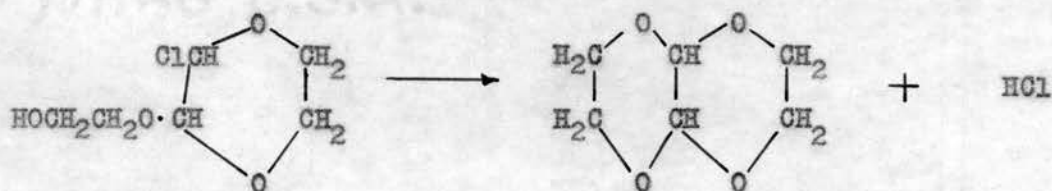
Dyson (8) objected to the dioxane structure for the trimer because of its non-convertibility into that of tetrahydroxy-p-benzoquinone by oxidation in the presence of sodium carbonate. He proposed the following alternate structure:



However, Raudnitz has confirmed the earlier statement (14) that the trimer shows neither carbonyl properties nor unsaturation, and suggested that the quinone ring arises by depolymerization and recombination into a homocyclic pattern before oxidation. He thus appears to have the better of the argument.

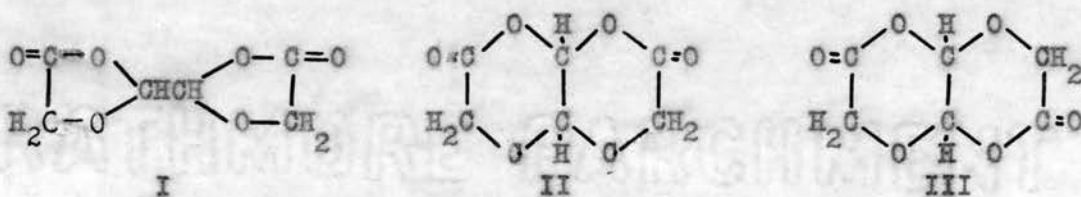
The tetraacetals of glyoxal are, in general, water-clear liquids with relatively high boiling points and mild fragrant odors, and have

been derived by several different processes. From glyoxal sulfate and the desired alcohol H. O. L. Fischer and Taube (10) prepared the tetramethyl and tetraethyl acetals, and Baker and Field (3) the tetraethyl and cyclic diethylene acetal. Recently, Purves (32) prepared the tetra-isopropyl and tetraamyl acetals in the same manner, but in the presence of calcium chloride or a similar salt to form an insoluble sulfate from the sulfuric acid formed. The glyoxal sulfate is obtained from the reaction of fuming sulfuric acid upon a tetrahaloethane (27, 28, 38). Pinner (30) long ago showed that by heating sodium ethoxide with dichloroacetaldehyde the impure tetraethyl acetal is obtained. Harris and Temme (14) prepared the same compound by mixing the trimeric glyoxal with absolute ethyl alcohol and hydrochloric acid, the reaction being performed at ordinary temperature, but they failed to obtain the tetramethyl acetal pure. MacDowell and McNamee (22) derived tetraacetals from methanol, ethanol, 2-propanol, 1-butanol, 1-hexanol, 2-ethylbutanol, 2-ethylhexanol, 2-chloroethanol, 2-methoxyethanol, and 2-butoxyethanol, the water and alcohol being distilled over as a constant boiling mixture, except with methanol, which was distilled without fractionation. The sulfuric acid catalyst was neutralized with sodium acetate. Donciu (7) formed *p*-dioxano- $[\eta]$ -*p*-dioxane, the cyclic acetal of ethylene glycol, with ethylene glycol, glyoxal and hydrochloric acid as catalyst. He also



obtained the compound as a product from the chlorination of ethylene glycol and isolated an intermediate product. The cyclic acetal can also be prepared from 2,3-dichlorodioxane (made by chlorination of dioxane) and ethylene glycol (4). The semiacetal, $\text{OCH}=\text{CH}(\text{OC}_2\text{H}_5)_2$, was obtained by ozonization of acrolein acetal, $\text{CH}_2=\text{CH}(\text{OC}_2\text{H}_5)_2$ (12), and by degradation of glyceraldehyde diethyl acetal with lead tetraacetate (9).

The tetraacylals, $(\text{RCOO})_2\text{CHCH}(\text{OCOR})_2$, are prepared from glyoxal or its derivatives and the anhydride of the acid. sym-Tetraacetoxyethane has been made from glyoxal sulfate and acetic anhydride (10) and from polyglyoxal and acetic anhydride (16). The tetraacylals of α -methylene monocarboxylic acids (19), such as acrylic, α -methylacrylic, and α -phenylacrylic, were obtained from glyoxal sulfate or polymers of glyoxal when treated with the corresponding anhydride in the presence of polymerization inhibitors. A compound halfway between these compounds and the acetals was derived by the condensation of glyoxal sulfate and glycolic acid (10).



The five-membered ring (structure I) was proposed by the authors; however, it is possible to have two other isomers. The six-membered rings seem more probable since the acetal of ethylene glycol forms a six-membered ring instead of the five-membered one (7).

Few reactions of acetals and acylals have been found in the literature. The obvious acid-catalyzed hydrolysis of the tetraethyl acetal to

to glyoxal and ethanol was described by Harries and Temme (14). Hydrogenolysis of glyoxal tetrakis(methoxyethyl)acetal under pressure yielded the dimethyl ether of triethylene glycol (24). The toxicity of glyoxal tetrabutyl acetal was reported as 8.9 LD₅₀ for rats in grams per kilogram (35). The tetraethyl acetal does not equal paraldehyde as a hypnotic (20). Kinetic studies were made on the decomposition of gaseous sym-tetraacetoxyethane to acetic anhydride and glyoxal (2), the reaction having been suggested by the work of Hess and Ubrig (16). The hydrolysis of the tetraacetoxy compound to recover glyoxal has been patented (21).

The formation of α -chloro ethers from glyoxal by Henry's method (17) has not been reported in the literature, although this is a well-known procedure for monoaldehydes, as illustrated with propionaldehyde and methanol (18).



The chief interest in such chloro-ethers lies in the ease with which the halogen can be replaced by other atoms.

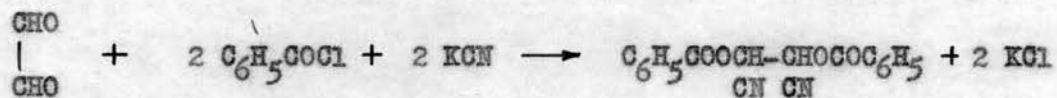
Wohl and Mylo (37) performed the following reaction:



The method was similar to Henry's, in which dried hydrogen chloride gas was passed into the solution. They, however, used the sodium bisulfite addition product of glyoxal suspended in acetic anhydride. Prudhomme (3) prepared the same compound from acetyl hypochlorite and acetylene, the hypochlorite being derived from hypochlorous acid and acetic anhydride.



The benzoylated dicyanohydrin of glyoxal was prepared by gradually adding benzoyl chloride to an aqueous solution of glyoxal and potassium cyanide (1).



The addition of hydrogen sulfide to glyoxal has not been reported in the literature. However, the literature research did reveal a reaction between glyoxal and mercapto compounds giving unstable, readily dissociated products (34).

EXPERIMENTAL

All glyoxal used in this work was the commercial 30% solution manufactured by the controlled vapor-phase oxidation of ethylene glycol (23). Assay of our samples for carbonyl content by the hydroxylamine hydrochloride method showed 36% present, calculated as glyoxal. Precipitation of the bisulfite addition compound from a saturated solution of sodium bisulfite gave yields indicated 34% glyoxal present; this is satisfactory agreement since the bisulfite method is not regarded as quantitative. Attempts to determine glyoxal volumetrically by the sodium sulfite method used for formaldehyde failed entirely, discoloration and unreasonable titers of alkali resulting. The precipitation of the osazone with 2,4-dinitrophenylhydrazine (25, 26) gave 42% apparent glyoxal. In this method, the reagent was prepared by dissolving 1 mole of 2,4-dinitrophenylhydrazine in 60 moles of 2 N hydrochloric acid and 1/100 volume of ethanol. The mixture containing the sample was slowly refluxed on a water bath for 12 to 24 hours and the osazone filtered from the warm (55°) liquid, washed with cold dilute hydrochloric acid, then with water, and dried in a vacuum desiccator.

Other reagents used were storeroom materials of ordinary grade.

Preparation of Acetals

Glyoxal tetrabutyl acetal was prepared according to the method of



MacDowell and McNamee (22). The reaction was carried out in the following manner: 200 ml. of commercial glyoxal solution and 1.0 ml. of con-

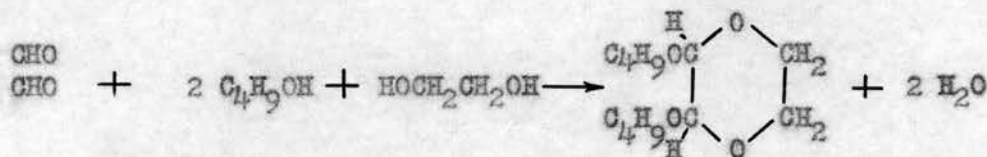
centrated sulfuric acid catalyst in a 500-ml. distillation flask were treated with an excess of *n*-butyl alcohol, which was maintained throughout the reaction. Water and butyl alcohol were distilled continuously as an azeotrope until only butyl alcohol came over. At first the water-alcohol distillation was performed in vacuo at approximately 35°, but several runs with no apparent yield showed that it was necessary to increase the temperature to complete the reaction. Without the increase a large amount of charring occurred during subsequent distillation of products, indicating incomplete breakup of glyoxal polymers. The later runs were conducted at atmospheric pressure with some darkening before the last trace of water had been removed. When no more water could be distilled the acid was neutralized by adding anhydrous sodium acetate, and the acetic acid formed was distilled over with more butyl alcohol. The reaction mixture was cooled and washed with water to extract sodium sulfate. The mixture was returned to the distillation flask and the product dried by azeotropically distilling over the water with the excess butyl alcohol, the acetal being stable in basic solution. Further rapid distillation gave a rough cut at 100 to 220° (25 mm.), the liquid having a yellowish color presumably due to unimolecular glyoxal.

The crude derivatives of glyoxal collected from the quick vacuum distillation were fractionated through a 30-plate Oldershaw column at 65 mm., yielding one short plateau at 134° and one long one at 177°. It was impossible to continue efficient fractional distillation of the higher products under the same conditions, since equilibrium could not be attained in the column. The stillpot was therefore attached to the Todd semimicro column, where fractionation was continued with no diffi-

culties and a third plateau obtained at 187-8° (5 mm.). All three fractions had a slightly yellow color but after subsequent refractionation in the Todd column the products were water-clear.

With the isolation and purification of the three cuts accomplished, the structure identification of the First and Third Cuts was undertaken. The Second Cut was assumed to be the tetrabutyl acetal of glyoxal. However, the literature values (22) for the boiling point and the density are 162° at 10 mm. and 0.890 at 20° respectively; these are not in good agreement with our values of 177° at 65 mm. and 0.969 at 29°, since the boiling point should be about 195° at 65 mm. (calculated by means of the Hass-Newton equation). The observed molar refraction, 85.1, is in fair agreement with the theoretical value, 87.1. The molecular weight of 308 for the acetal was determined from its depression of the freezing point of benzene, while the theoretical value is 318. The results of the determination of glyoxal as the 2,4-dinitrophenylosazone were consistently high: found, 23.85, 23.82, 24.00%; calculated 18.2%.

All the evidence found supports the structure for the First Cut as 2,3-dibutoxy-1,4-dioxane, shown as product of the following equation:



The formation of the First Cut, which is a mixed acetal of butyl alcohol and ethylene glycol, depends upon the presence of the latter in a commercial solution of glyoxal. Guest and McNamee (1) found that a 30% solution of glyoxal contained 10% ethylene glycol. Therefore increasing the amount of glycol should increase the yield of the First Cut. This was found to be the case; in a new run in which 25 ml. of

ethylene glycol was added to 150 ml. of glyoxal solution before treatment with butyl alcohol, 4.2 g. of the acetal was obtained before interruption of electrical service prevented further operation of the fractionating column. The fractionation was not continued afterward since an increase of yield was already apparent, the regular run having given only 3.3 g. of First Cut from 200 ml. of glyoxal. The physical constants are tabulated below in order to show the conformity of the observed values with the theoretical ones.

Table 1
Properties of First Cut

	Experimental	Theoretical for $C_{12}H_{24}O_4$
Carbon content, per cent	61.42, 61.82	62.07
Hydrogen content, per cent	10.25, 10.60	10.34
Glyoxal, per cent*	24.58, 24.50	25.00
Molecular weight**	226, 228	232
Molar refraction	61.2	60.0
Boiling point at 65 mm.	140°	
Refractive index, n_D^{29}	1.4324	
Density at 29.8°, g./ml.	0.984	

* By 2,4-dinitrophenylhydrazine method.

** By depression of the freezing point of benzene.

The structure, 2,3,5,6-tetrautoxy-1,4-dioxane, postulated for the Third Cut is in excellent agreement with the physical data obtained.

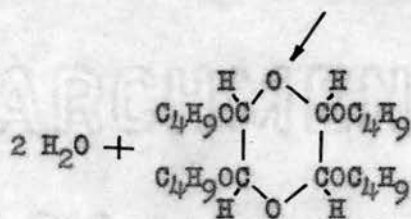
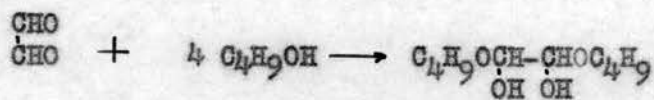


Table II

Properties of Third Cut

	Experimental	Theoretical for $\text{C}_{20}\text{H}_{40}\text{O}_6$
Carbon content, per cent	64.60, 64.04	63.80
Hydrogen content, per cent	10.92, 11.22	10.70
Molecular weight*	350, 359	376
Molar refraction	102.2	101.9
Boiling point at 10 mm.	198°	
Refractive index, $n_D^{29^\circ}$	1.4315	
Density at 29°, g./ml.	0.957	

* By depression of the freezing point of benzene.

The 2,3,5,6-tetrautoxy-1,4-dioxane gave little or no osazone and an oil layer, presumably the original sample, remained. The concentration of the acid was increased to 6 N but with no better results.

Table III

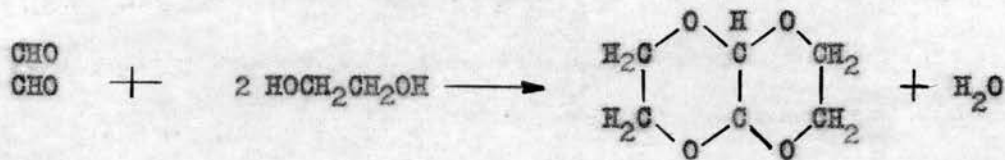
Yields of Butylated Products from 35% Glyoxal Solution
(200 ml. = 246 g.)

	Weight, g.	Yield, %
Forerun	38.0	
2,3-Dibutoxy-1,4-dioxane	3.3	1.1
Intermediate	10.9	
Glyoxal tetrabutyl acetal	95.5	20.3
Intermediate	28.7	
2,3,5,6-Tetrabutoxy-1,4-dioxane	40.0	14.3
Residue (both distillations)	60 (approx.)	

An attempt was made to duplicate the preparation of glyoxal tetramethyl acetal claimed by MacDowell and McNamee (22). Commercial glyoxal solution (100 ml.) was evaporated to near dryness in a 500-ml. beaker and dissolved in methanol, 0.3 ml. of concentrated sulfuric acid catalyst was added, and a total of 2 liters of methyl alcohol was added in portions. Methanol and water were distilled over without fractionation at the rate of 600 ml. per hour. At the end of this time the distillate still gave a positive test for water, so that the yield of the acetal was not expected to be great. The sulfuric acid was neutralized with solid sodium carbonate, and the mixture was distilled under vacuum. The amount of higher fractions was negligible and no further attempt was made to isolate the products. This result was expected, since methanol forms no azeotrope with water and consequently dehydration by distilla-

tion fails; the patent is believed impractical in this case.

In first attempts to prepare the cyclic acetal of glyoxal with ethylene glycol (p-dioxane-[b]p-dioxane), 100 ml. of commercial glyoxal,

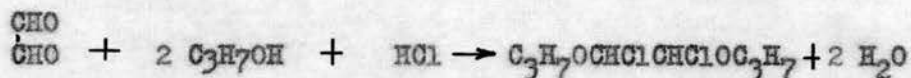


100 ml. of ethylene glycol, 0.5 ml. of concentrated sulfuric acid, and a third component to remove the water azeotropically were mixed and distilled. Benzene, toluene, and xylene were added in successive trials, but only xylene removed appreciable amounts of water. The inability of these components to accomplish dehydration must be due to the capacity of the glycol to bond with water and lower its partial pressure.

In the next run the water was removed with butyl alcohol before the addition of ethylene glycol. In a distillation flask 100 ml. of commercial glyoxal, 0.5 ml. of concentrated sulfuric acid and excess of butyl alcohol was distilled as described in the preparation of the tetrabutyl acetal. After the water had been removed 100 ml. of ethylene glycol was added and the remaining butyl alcohol distilled over. The sulfuric acid was then neutralized with sodium acetate and the mixture distilled at 25 mm. to remove the acetic acid and excess ethylene glycol. The flask was then cooled, whereupon the cyclic acetal crystallized out and was filtered off. The crystals were distilled, giving a white solid. Upon one recrystallization from benzene they melted at 133-134°; literature value, 137° (3).

Preparation of Alpha-Chloro Ethers

The 1,2-dichloro-1,2-dipropoxyethane was prepared according to the method of Henry (17) by saturating a mixture of the aldehyde and alcohol



with dry hydrogen chloride. The commercial solution of glyoxal (150 ml.) was evaporated to approximately 75 ml. of a viscous liquid. This viscous liquid and 250 ml. of propyl alcohol were placed in a three-necked flask fitted with a mechanical stirrer and a gas diffuser. While the mixture was held at 0-10° in a ice bath, dry hydrogen chloride gas was slowly introduced. About four hours were required to saturate the mixture with the gas and as the reaction progressed, the mixture darkened a little. After stirring for half an hour longer at 0-10°, the reaction products were poured into a water-ice mixture. The lower layer comprised about 200 g. of crude product. The aqueous layer was saturated with calcium chloride in an attempt to increase this yield, but the additional amount of insoluble material separated was insignificant. The crude product was treated with anhydrous calcium chloride, placed under vacuum for thirty minutes to remove the dissolved hydrogen chloride, and stored in the refrigerator overnight with no change in the appearance or odor of the liquid. However, one batch similarly treated but allowed to stand at room temperature for twelve hours became dark brown and developed a strong odor of hydrogen chloride. Thus it is apparent that this compound is unstable like other α -chloro ethers.

The chloro ether was fractionated in the Todd semimicro column, and a plateau was observed at 106-107° (15 mm.).

Table IV
Properties of
1,2-dichloro-1,2-dipropoxyethane

	Experimental	Theoretical for $C_6H_{16}O_2Cl_2$
Molecular weight	199, 202	215
Chlorine content, per cent	31.02, 30.81	32.61
Molar Refraction	52.6	52.1
Boiling point at 15 mm.	106-7	
Refractive index, $n_D^{29^\circ}$	1.4420	
Density at 29° , g./ml.	1.083	

Since the chlorine values were over one per cent low, it was suspected that an impure sample had been obtained. The chloro ether fraction was again placed in the Todd fractionating column and redistilled at 60 mm., the higher pressure being used in the hope of getting better separation. A plateau was obtained at 145° , but the chlorine analysis of the material showed 26.53 and 26.57%. The material remaining was not sufficient to refractionate so a new run was made starting with 150 ml. of glyoxal. The same procedure was used throughout. Upon fractionation at 60 mm. a plateau appeared at 140° , presumably the chloro ether. However the index of refraction of this cut was 1.4350, whereas the expected value was 1.4420 at 29° . Chlorine values of 22.86 and 23.32% were obtained. Thus it seems evident that the chloro ether cannot be distilled at this pressure without decomposition.

The chlorine content of 1,2-dichloro-1,2-dipropoxyethane was determined by boiling with sodium hydroxide, which splits out hydrogen chloride,

chloride, cooling the sample, and acidifying with nitric acid. The chloride was precipitated as silver chloride by addition of excess silver nitrate solution. The precipitate was filtered, washed with very dilute nitric acid, dried at 100° and finally weighed as silver chloride.

An attempt was made to prepare 1,2-dichloro-1,2-dimethoxyethane in the same manner as the propyl derivative. Dry hydrogen chloride gas was added to a solution of concentrated glyoxal (150 ml. of 30% solution evaporated to a viscous liquid) and methyl alcohol (250 ml.). After the solution became saturated with hydrogen chloride the products were poured into an ice-water mixture, but there was no separation of a chloro-ether layer. Even with a large excess of water it was still impossible to form two immiscible layers. The solution was saturated with calcium chloride but with no better results. Ether extraction of the mixture was attempted but owing to the large amount of hydrogen chloride present even the ether was soluble.

Prins Reaction with Allyl Bromide

The reaction of glyoxal tetrabutyl acetal with allyl bromide was attempted to find if glyoxal could be added into the double bond of allyl bromide. The reaction was carried out in the following manner: to 0.08 moles (25 g.) of the acetal, which had been cooled in an ice bath, 5 g. of boron trifluoride catalyst was slowly added, changing the color to a dark brown. The addition of 0.41 moles (50 g.) of redistilled allyl bromide caused no apparent reaction. After 24 hours the mixture was poured into excess sodium hydroxide solution to neutralize the acid catalyst. A sample was removed and steam distillation attempted but no product was obtained. The remaining portion was extracted three times

with ether and the combined extracts were dried over solid potassium carbonate. The solution was first distilled at about 40 mm. without regard for fractions to remove tarry products. Upon fractional distillation at 3/4 mm. in the Todd semimicro column the tetraacetal was recovered as the main product and decomposition was apparent at higher temperatures.

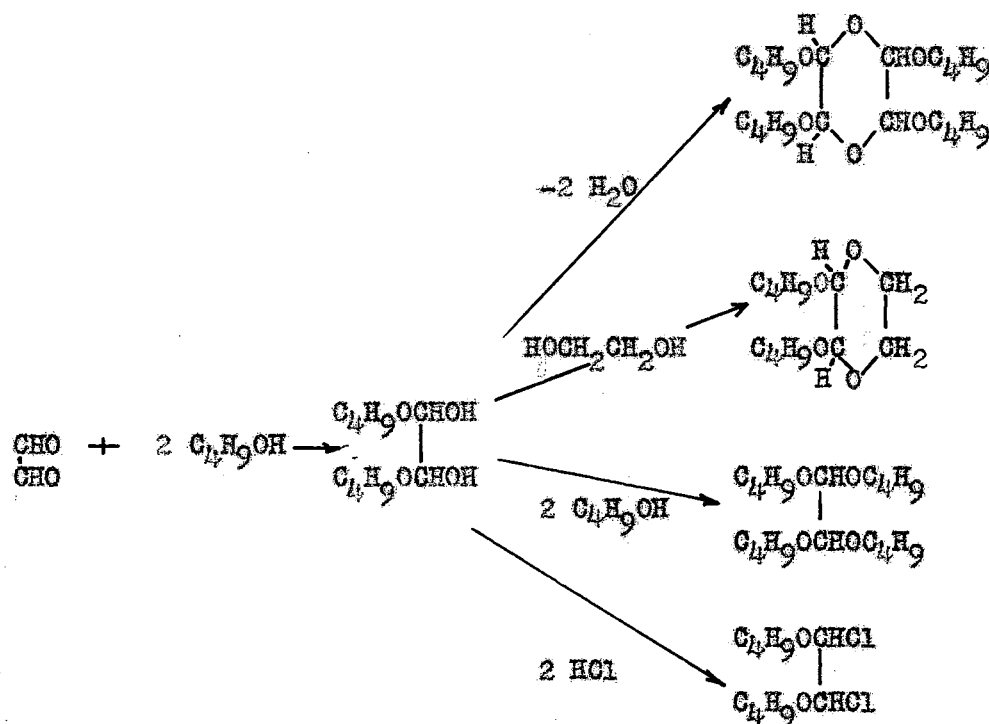
Reaction with Hydrogen Sulfide

Ten ml. of 30% solution of glyoxal, 20 ml. of water and 25 ml. of concentrated sulfuric acid was added to a 125 ml. Erlenmeyer flask. The mixture was cooled with running water to room temperature, and hydrogen sulfide was added slowly by means of a gas diffuser over a period of three hours. At the end of this time a yellowish-brown precipitate had formed. This was filtered off and washed several times with water. It was insoluble in water, ether, ethanol, benzene, glacial acetic acid, and carbon disulfide, each both hot and cold. The practically odorless, amorphous material melted with decomposition below 90° and, if allowed to remain in contact with the air, turns dark in appearance. Since no single means of purifying it was found, it was not further studied.

DISCUSSION

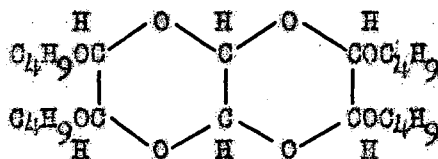
This research in the preparation of the acetals of glyoxal was initiated to find a starting material suitable for non-aqueous reactions of glyoxal, especially the Prins-type reaction. The tetrabutyl acetal was chosen because butyl alcohol forms a water-rich azeotrope, and the alcohol phase could be returned to the mixture.

In all the reactions involving alcohols a hemi-acetal of glyoxal can be postulated as the intermediate product.



The first two products were definitely identified, but the third, glyoxal tetrabutyl acetal, is somewhat in doubt. It was regarded as the acetal since it was the largest fraction, even though the boiling point did not agree well with the literature value. Later as additional data were obtained the purity of the sample became doubtful. Thus it seems that additional work should be done to verify the structure.

The residue from the distillation probably contains such other condensation products of the hemi-acetal as the following, derived from one mole of glyoxal and two moles of the hemi-acetal.



This product would be analogous to that of condensing acetone and trimeric glyoxal (10, 33).

The 2,3-dibutoxy-1,4-dioxane has not been reported in the literature, but the diethoxy homolog has been obtained from the reaction of 2,3-dichloro-1,4-dioxane and either absolute ethanol (5) or sodium ethoxide (4). 2,3,5,6-tetrabutoxy-1,4-dioxane and its homologs could probably be prepared from 2,3,5,6-tetrachloro-1,4-dioxane (5) through the Williamson synthesis.

The total yield of butylated acetals was only about 35% of the theoretical amount based on glyoxal (Table III) whereas MacDowell and McNamee (22) obtained a yield of 85.8% of the tetrabutyl acetal. Several factors may explain so low a yield of products.

1. The yields were based upon a 35% content of glyoxal in the commercial solution, as given by our assay. Since Guest and McNamee (11) use the figure 28.8%, and our methods unquestionably included other carbonyl compounds, the 35% is doubtless too high by at least 5%.

2. No attempt was made to obtain maximum yields of the acetals by perfecting technique through repetition.

3. The high value for the glyoxal content in the tetrabutyl acetal, signifying the presence of some unidentified glyoxal-rich compound, accounts for some of the glyoxal.

4. The azeotropic distillate contains an indeterminate amount of glyoxal.

The chief interest in chloro ethers lies in the ease with which the halogen linked into the α positions can be replaced by other atoms or groups, leading particularly to the formation of cyano ethers, ether amides, ether thioamides, alkoxy acids and esters, branched-chain aldehydes, alkoxy tertiary alcohols, and keto ethers. The last mentioned are capable of conversion into heterocyclic compounds of varying degrees of physiological activity.

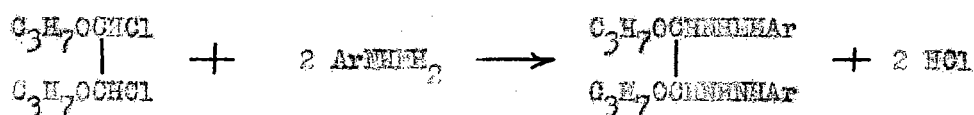
The final analytical data for the 1,2-dichloro-1,2-dipropoxyethane were not fully satisfactory owing to the instability of the compound. However, it is believed that the chloro ether can be obtained pure if fractionated at lower pressures. While the pressure remained at 15 mm. the chlorine content was fairly close to the theoretical amount, but when it was increased the chlorine content dropped, presumably owing to loss of hydrogen chloride. Even if it is impossible to isolate a perfectly pure sample of the 1,2-dichloro-1,2-dipropoxyethane, stable derivatives could surely be prepared.

The preparation of the 1,2-dichloro-1,2-dimethoxyethane might have been successful if the solution had been saturated with calcium chloride while the mixture remained below 10° , and then extracted with benzene or petroleum ether. When a mixture of water and the propyl derivative was allowed to remain at room temperature for a few hours the chloro

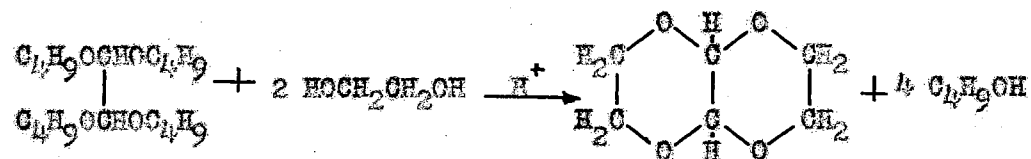
ether layer disappeared.

The known compound 2,3-dichloro-1,4-dioxane is a chloro ether of ethylene glycol, and it would be interesting to see if it could be prepared by the chloro ether procedure.

Attempts to apply 2,4-dinitrophenylhydrazine to the determination of glyoxal and its hydrolyzable derivatives have led to indecisive results, although the literature has several references to the determination of free glyoxal as the osazone, *p*-nitrophenylosazone, and 2,4-dinitrophenylosazone. When the method was applied to commercial glyoxal solutions it gave results conspicuously higher than obtained via hydroxylamine hydrochloride or sodium bisulfite; this may be attributed to glycolaldehyde in the commercial solution, which would be monofunctional toward hydroxylamine and sodium bisulfite but bind two dinitrophenylhydrazine radicals when converted to the osazone. In addition, the 2,4-dinitroaniline produced in the process, being very feebly basic, may have remained in the precipitate. The First Cut, 2,3-dibutoxy-1,4-dioxane, gave essentially theoretical results for glyoxal content. The Second Cut gave values far too high, as already noted. The Third Cut practically failed to react with 2,4-dinitrophenylhydrazine; this stability is at present unaccountable. The 1,2-dipropoxy-1,2-dichloroethane, on the other hand, in one unduplicated and therefore untrustworthy run, gave equally unaccountable results that were too high, even for coupling of the active chlorine atoms with the hydrazine instead of osazone formation:



The preparation of γ-dioxano-[b]-γ-dioxane by the alcoholysis of some other glyoxal acetal has not been reported in the literature.



It is a new and simple method for the preparation of certain acetals unobtainable from commercial glyoxal by azeotropic dehydration methods. This process might be adaptable to the preparation of tetraacetoxyethane from glyoxal and acetic acid instead of acetic anhydride as starting materials.

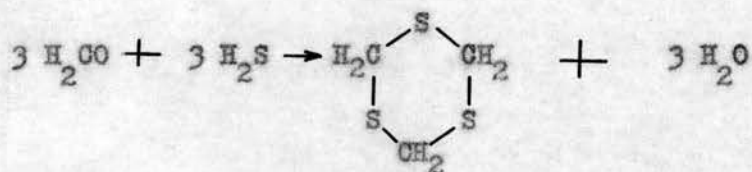
The Prins-type reaction was attempted upon the tetrabutyl acetal and allyl bromide. At least three reasons can be suggested for failure of the reaction.

1. The activity of the bromine in allyl bromide might make this compound difficult to use since more-complex products would then be expected in the reaction. Better results might have been obtained with styrene.

2. From the work of Hawkins (15) it is known that methylal may add into double bonds to form several compounds. However, no acetals of higher molecular weight have ever been investigated. Greater success might have been obtained if glyoxal tetramethyl acetal could have been used as the starting material instead of the tetrabutyl.

3. Acetals of glyoxal may be inherently less reactive than simple acetals. This is suggested by the recovery of considerable tetrabutyl acetal in the run tried.

Since formaldehyde and hydrogen sulfide are well known to yield the



easily purified 1,3,5-trithiane in strongly acid solutions, the reaction of glyoxal and hydrogen sulfide was tried under the same conditions.

However, only an ill-defined product, probably polymeric, resulted.

Since it was readily oxidized, a structure containing thiol groups seems probable .

SUMMARY

In the preparation of the tetra-n-butyl acetal of glyoxal two new compounds have been isolated and their structures have been established. The acetal of ethylene glycol has been prepared by a new method. The acetal of methanol could not be obtained from glyoxal and methanol.

Henry's method for the preparation of α -chloro ethers was applied to glyoxal with the isolation and identification of a new compound, 1,2-dichloro-1,2-dipropoxyethane. Preparation of the methoxy derivative was attempted without success.

A solid material was obtained from the reaction of hydrogen sulfide and glyoxal but attempts to purify it failed.

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BIOGRAPHY

James P. Yuk was born at Grand Haven, Michigan, September 16, 1924. After completing his grade school and high school education in Grand Haven he enrolled in Hope College, Holland, Michigan. In June 1948 he received the degree of Bachelor of Arts from the institution.

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