assume restricted rotation of the benzene rings, of the methoxyl groups, or of both. We are studying this question in greater detail.

Experimental Part[5]

Preparation of the β,β,β-Trichloro-α,α-bis-(halogenotolyl)-ethanes.[6]—To a mixture of 2.2 parts of monohalogenotoluene and 1 part of chloral 98.5% sulfuric acid was added with strong stirring during a period of 30 minutes; quantities of 0.03–0.05 mole of chloral were used, and 6 g. of sulfuric acid was employed for 1 g. of chloral. Ordinarily the reaction temperature was 10°, but in the case of the iodotoluenes it was 1–2°. A reaction period of 2 hours is sufficient for the quantities given.

After completion of the reaction the mixture was poured on ice, the organic layer washed with water, and unchanged starting materials were steam distilled. The products were purified by recrystallization (Table I), preceded by vacuum distillation in the case of *o*-halogenotoluene derivatives (Table I[e,i,l,f]).

Preparation of β,β,β-Trichloro-α,α-bis-(2-methoxy-3,5-dichlorophenyl)-ethane (I). (a) **Isomer M.p. 154°.**—To a well-stirred mixture of 5 g. (0.03 mole) of chloral hydrate and 80 g. of 96% sulfuric acid was added at 10° 10 g. (0.06 mole) of molten 2,4-dichlorophenol. Two hours later the mixture was poured on ice, washed with water and with pentane and recrystallized from ethanol. One gram of the ethane so obtained was dissolved in a little ether and treated for 2 days at 0° with 100 cc. of a 4% diazomethane solution. The recovered material was recrystallized from ethanol and melted at 154° (see Table I).

(b) **Isomer M.p. 160°.**—To a stirred mixture of 3.3 g. (0.02 mole) of chloral hydrate and 50 g. of 96% sulfuric acid 7 g. (0.04 mole) of 2,4-dichloroanisole was gradually added at room temperature. After 4 hours the mixture was decomposed as above, washed with water and pentane, and recrystallized from alcohol, yielding the product m.p. 160° (*cf.* Table I). A mixture of the stereoisomeric I melts at ~135°.

The β,β-Dichloro-α,α-bis-(X-phenyl)-ethylenes.—The ethanes were boiled, in 1-g. portions, in methanol with 50–100 cc. of 0.5 *N* methanolic potassium hydroxide for 2–3 hours. The cooled mixtures were diluted, extracted with ether if required, and the products were recrystallized from ethanol (see Table II).

Quantitative Dehydrohalogenation of β,β,β-trichloro-α,α-bis-(X-phenyl)-ethanes.—Samples of from 75–200 mg. (±0.1 mg.) of this substance were treated at 15–18° with 25 ml. of 1 *N* methanolic potassium hydroxide. After intervals of 0.1, 5, 20 and 72 hours the samples were diluted with 25 ml. of water and the residual alkali was titrated with 0.25 *N* hydrochloric acid against phenolphthalein. The results are listed in the last column of Table I.

It was observed that the low-melting isomer of structure I is more stable toward alkali than the high-melting one; *cf.* Table I, footnotes *t*, *u*.

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(5) All melting points are uncorrected.

(6) *Cf.* R. Riemschneider, 9th supplement to the 1st supplementary volume of *Pharmazie*, 673 (1949). There references to the earlier literature are given.

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Reaction between Glycine and the Hexose Phosphates

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Some of the browning which occurs in foodstuffs during concentration, or dehydration, or during the storage of concentrated or dehydrated products, can be attributed to reactions between reducing sugars and amino compounds (the Maillard reaction).[1] Enders[2] showed that monoses became brown in the presence of glycine at different rates, with xylose the most rapid, followed by arabinose, mannose, galactose, fructose and glucose. He also found that glucose browned about 4 to 6 times as fast as "hexose diphosphate." Neuberg and Kobel[3] studied the reaction of hexose phosphates with glycine polarimetrically. However, no information has been recorded on the relative rates of browning of the now well-characterized hexose phosphates of the glycolytic cycle. Inasmuch as these may account for a considerable proportion of the reducing sugars in certain vegetables,[4] it was pertinent to determine what role they may play in "browning."

The potassium salts of the hexose phosphates in aqueous solution (0.33 *M*) (see Table I) were allowed to react with 0.33 *M* glycine at 70° for 18 hours. The free sugars were allowed to react under the same conditions in the presence and absence of 0.33 *M* phosphate buffer *p*H 6.5. After diluting the reaction mixture 133-fold, *p*H and color were measured. The intensity of the color was determined in an Evelyn colorimeter at 420 mμ. In Table I, degree of browning is expressed in terms of percentage of the increase in the optical density (0.296) of the diluted reaction mixture of glucose, glycine and phosphate buffer. The data show that esterification of the aldehyde group of the glucose resulted in complete inhibition of browning. On the other hand, the presence of a phosphate ester at the primary alcohol group of both glucose and fructose increases the rate of browning. The extent of browning of these phosphate esters was roughly in proportion to their reducing action toward some of the common sugar reagents.[5,6] In the absence of phosphate buffer, the extent of browning of fructose and glucose was

TABLE I

REACTION OF THE HEXOSE PHOSPHATES WITH GLYCINE[a]

Substance	*p*H Initial	*p*H Final	Brown color	Relative reducing values[b] A	B	C
Glucose, phosphate	6.5	6.1	100	100	100	100
Fructose, phosphate	6.5	6.3	28	...	...	...
Glucose-1-phosphate	7.7	7.7	0	0	0	0
Glucose-6-phosphate	6.6	5.9	146	19	80	100
Fructose-6-phosphate	6.6	6.6	82	46	80	4
Fructose-1,6-diphosphate	6.5	6.5	21	18	40	2
Glucose[c]	5.4	5.1	8	...	...	...
Fructose[c]	5.4	4.8	16	...	...	...

[a] Concentration of reactants and buffer, 0.33 *M*, 70°, 18 hours. [b] On a molar basis: Reagent A, Folin–Malmrose[5]; B, Hagedorn–Jensen[6]; C, Hypoiodite.[6] [c] No buffer present.

(1) J. P. Danehy and W. W. Pigman, *Advances in Food Research*, **3**, 241 (1951).

(2) C. Enders, *Biochem. Z.*, **312**, 339 (1942).

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(4) B. Arreguin-Lozano and J. Bonner, *Plant Physiol.*, **24**, 720 (1949).

(5) W. W. Umbreit, R. H. Burris and J. F. Stauffer, "Manometric Techniques and Tissue Metabolism," Burgess Publishing Co., Minneapolis, Minn., 1949, p. 188.

(6) R. Robinson and M. G. Macfarlane, *Methoden der Fermentforschung*, **1**, 312 (1940).

much less than in its presence. However, the values obtained without buffer are not comparable to those with buffer, since the final levels of *p*H were much lower in the absence of phosphate buffer. Although some previous work[7-9] suggested that phosphate accelerated the browning reaction, no significant differences in the rate of browning of a bovine serum albumin–glucose system were noted by Mohammad, *et al.*,[10] in the presence of phosphate, barbiturate or carbonate buffers.

When the soluble barium salt (instead of the potassium salt) of glucose-6-phosphate reacted with glycine, an insoluble brown precipitate was formed.

The fate of the phosphate groups during the browning reaction was determined by measuring the release of inorganic orthophosphate and the susceptibility of the remaining esterified phosphate to alkaline phosphatase.

One ml. of the diluted reaction mixture was incubated for 40 hours with 17 micrograms of a commercial preparation of phosphatase prepared according to Schmidt and Tannhauser[11] in a total of 1.1 ml. of 0.1 *M* NH_4Cl–NH_3 buffer *p*H 8.9. The inorganic phosphate content of the glucose–glycine–phosphate mixture was also determined before and after the browning reaction.[12] The results of these measurements are shown in Table II. The data indicate that the reaction of the hexose derivatives caused liberation of inorganic phosphate, the extent of liberation being in proportion to the intensity of the browning reaction. Furthermore, the remaining esterified phosphate could be split off by alkaline phosphatase, the total phosphate split off being about the same as that split off from the original hexose derivatives. No net esterification of orthophosphate occurred in the glucose–glycine–phosphate mixture. These results are in accord with the hypothesis that oxidation may occur during some stage of the browning reaction at what was originally the 6-carbon position of the sugar, resulting in the formation of an acyl phosphate. Alternatively, dehydration of the sugar derivatives (known to occur in browning reactions) by removal of a hydrogen atom from the 6-carbon and a hydroxyl group from the 5-carbon would result in the formation of the phosphate ester of an enolic hydroxyl on the 6-carbon. Both of these unstable esters would then be easily hydrolyzable.

TABLE II

LIBERATION OF PHOSPHATE[a]

Phosphate liberated due to	Glucose-6-phosphate	Fructose-6-phosphate	Fructose-1,6-diphosphate
A. Reaction with glycine	25	14	7
B. Phosphatase action on reacted ester–glycine mixture	48	38	72
C. Total phosphate liberated (A + B)	73	52	79
D. Phosphatase action on unreacted phosphate ester	77	59	82

[a] Per cent. liberation of total esterified phosphate originally present.

During the course of this study it was observed that the browning reaction can be detected readily on filter paper containing spots of the sugars and their phosphates. This could be accomplished by spraying the chromatogram with a solution of 1 *M* glycine in 0.1 *M* phosphate buffer *p*H 6.5, and incubating at 70° in a moisture-saturated atmosphere. The development of intense fluorescence of the spot, greater than the feeble background fluorescence due to the interaction of glycine with cellulose of the filter paper,[13] could be detected with as little as 2 micrograms of sugar at comparatively early stages of the reaction.

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The Propargylic Rearrangement.[1] V. 1-Bromoheneicosyne-2 and its Reaction with Lithium Aluminum Hydride

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In a study of the dehalogenation of propargylic bromides it was reported[3] that such halides react with lithium aluminum hydride and yield a mixture of acetylenic and allenic hydrocarbons. Thus, 1-bromoheptyne-2, C_4H_9—C≡C—CH_2Br (I), formed a mixture of heptyne-2 and heptadiene-1,2.

The bromide I was prepared[4] from the corresponding alcohol using phosphorus tribromide in the presence of a catalytic amount of pyridine. It was purified by distillation and was a liquid at room temperature.

In this paper we are reporting the preparation of a solid primary propargylic bromide, 1-bromoheneicosyne-2, *n*-$C_{18}H_{37}$—C≡C—CH_2Br (II) and its reaction with lithium aluminum hydride to yield only the acetylenic hydrocarbon, heneicosyne-2. These observations cast some doubt on the homogeneity of the bromide I. Such doubt has also arisen from the study of the infrared spectra of these bromides. The infrared spectrum[5] of I showed the presence of an unexplained strong band at 1720 cm.$^{-1}$ (5.8 μ). Since the band could have originated from an impurity containing a carbonyl group, several lines of evidence were presented to rule out this possibility.[5,6] The possibility that this band is due to an isomeric allenic impurity was raised.[6] It is interesting to note that a sample of 3-

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(2) The authors wish to express their gratitude to the Research Corporation for their generous financial support.
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