

## REACTIONS OF 2,3,4,4,5,5,6,6-OCTACHLOROCYCLOHEXEN-2-ONE-1 WITH SODIUM HYDROXIDE AND SODIUM ACETATE

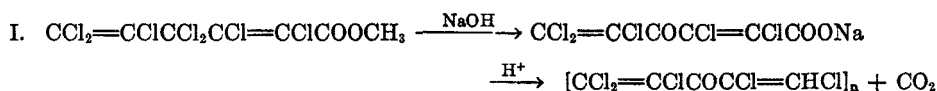
CHARLES J. PENNINO

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The cleavage of certain chlorine-substituted alicyclic ketones with sodium hydroxide to give chlorine-substituted aliphatic acids has been described by Zincke and his co-workers. Thus 2,2,4,4,5,5-hexachlorocyclopentadione-1,3 (I) on treatment with 10% aqueous sodium hydroxide formed trichloroacrylic acid (III) and dichloroacetic acid (1): the latter compound was not isolated. Under the same conditions, 2,3,4,4,5,5-hexachlorocyclopenten-2-one-1 (IV) was cleaved (1) and the product was isolated and identified as 2,3,4,5,5-pentachloropentadien-2,4-oic acid (V). In addition the cleavage product of 2,2,3,4,5,5-hexachlorocyclopenten-3-one-1 (VI) was suggested to be 2,2,3,5,5-pentachloropentadien-3,4-oic acid (VII). Zincke further reported that the chlorinated cyclic ketone 2,3,4,4,5,5,6,6-octachlorocyclohexen-2-one-1 (VIII), m.p. 103°, obtained by the chlorination of pentachlorophenol in acetic acid, was not affected by potassium hydroxide in the cold and decomposed in the presence of alkali at higher temperatures (2).

The present investigation, to the contrary, revealed that the chlorinated cyclohexenone behaves similarly to the chlorinated cyclopentenone (IV). At room temperatures (20–30°) in the presence of 2 *N* sodium hydroxide a practically quantitative cleavage of 2,3,4,4,5,5,6,6-octachlorocyclohexen-2-one-1 (VIII), m.p. 103–104°, occurred with the formation of sodium 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate (IX). The acid, liberated on acidification of the cold salt, was a white crystalline solid, m.p. 136–137° when crystallized from benzene.

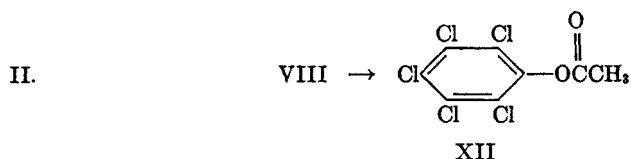
The cleavage of VIII has also been accomplished with sodium formate, sodium acetate, and sodium propionate under a unique set of conditions. In a solvent mixture of methanol and dioxane, VIII reacted with sodium formate, sodium acetate, and sodium propionate respectively to form methyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate (XI) in good yields at room temperature or at reflux. The ethyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate has been prepared by the replacement of methanol with ethanol under the same conditions. The reactions with sodium acetate were practically quantitative. The ester XI was hydrolyzed at room temperature, and the acid released by acidification of the cold alkaline reaction mixture was identical to the acid obtained by the interaction of VIII and 2 *N* sodium hydroxide. The hydrolysis of the ester (XI) with 2 *N* sodium hydroxide at 60°, equation I, displaced two chlorine atoms yielding an acid which decarboxylated readily on acidification with the liberation of CO<sub>2</sub>, precipitated as barium carbonate, equation I. A polymeric solid was obtained on attempting to distill the decarboxylation product. The infrared absorption spectrum of the polymeric product showed the characteristic absorption for the carbonyl group at 5.6  $\mu$ .



The acid (IX) has been converted to the methyl ester through the acid chloride, equation iv C. The allyl and phenyl esters of IX have also been prepared through the acid chloride.

The infrared spectra of the acid IX and the methyl ester XI compare favorably: the two spectra are similar in many respects with absorption peaks at 5.65  $\mu$ , 6.17–6.18  $\mu$  and 6.39–6.4  $\mu$  for the carbonyl groups and a pair of double bonds. The peaks at 12.12 and 12.20  $\mu$  indicate the presence of the =CCl<sub>2</sub> which has been found at 12.35  $\mu$  for 1,1-dichloropropene-1, Figure 1.

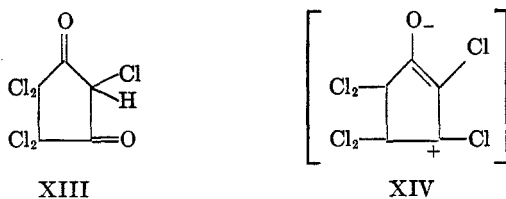
Attempts to cleave VIII with sodium acetate (2 N aqueous solution) failed at room temperature and at reflux. No appreciable reaction was observed between VIII and sodium acetate in glacial acetic acid at reflux. In acetic anhydride, at reflux, sodium acetate dechlorinated VIII with aromatization of the ring forming pentachlorophenyl acetate (XII), equation II.



The cleavage of the chlorinated cyclopentenones and cyclohexenone may be elucidated and explained by the mechanisms proposed and presented in the reaction scheme. The reaction of I with aqueous sodium hydroxide involves a nucleophilic attack on the carbonyl group followed by ring cleavage and most likely, a simultaneous elimination of a chloride ion, equation i. The resulting  $\beta$ -ketone II is subsequently hydrolyzed in the presence of the excess OH ion to trichloroacrylic acid and dichloroacetic acid.

The isomers IV and VI react with the OH ion by the same mechanism to form respectively 2,3,4,5,5-pentachloropentadien-3,4-oic acid and the proposed 2,2,3,5,5-pentachloropentadien-3,4-oic acid, equations ii and iii.

It should be noted that the products reported by Zincke, *et al.*, for the reaction of IV with the hydroxyl ion do not indicate a 1,4 addition to the conjugated system which would, under the given conditions lead to the formation of the diketone (XIII). The cleavage products of XIII would be trichloroacrylic acid and monochloroacetic acid rather than V. The 1,4 addition could be anticipated from the resonant structure XIV.



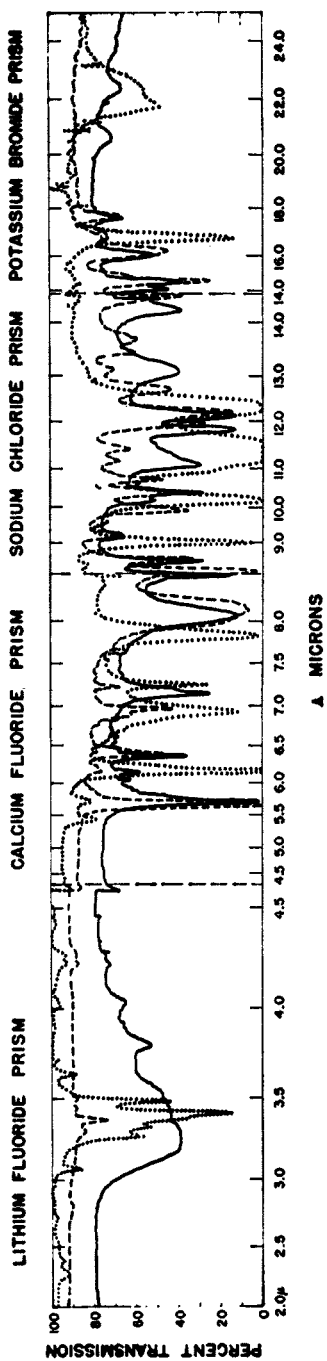
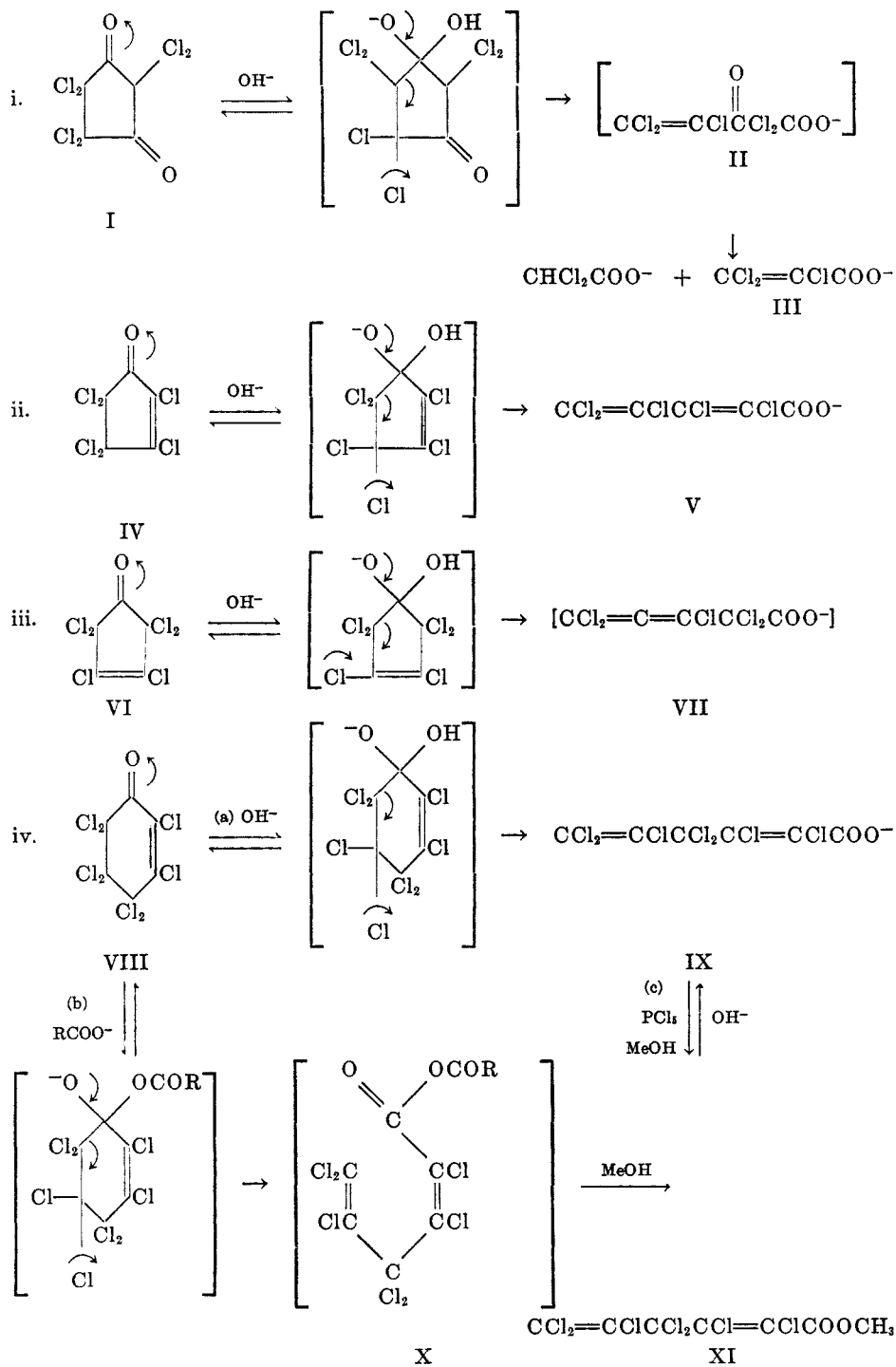


Figure 1. INFRARED SPECTRA of 2, 3, 4, 5, 6 - HEPTACHLOROHXADIEN-2, 5-DIC ACID (—), its METHYLESTER (---), FUSED CAP, and, 1, 1-DICHLOROPROPENE-(---)X.0001\*



R = H, CH<sub>3</sub> or C<sub>2</sub>H<sub>5</sub>

In the reaction of VIII, the octachlorocyclohexenone, with sodium hydroxide, the mechanism proposed is the same as that described for I, IV, and VI, equation iv a. The mechanism applies similarly to the respective reactions of sodium formate, sodium acetate, and sodium propionate with VIII and occurs in two steps; (a) the formation of an anhydride intermediate (X) by the addition of the appropriate ion to the carbonyl group followed by ring cleavage and the simultaneous elimination of a chloride ion, (b) esterification by the interaction of the anhydride and methanol as described in equation iv b.

#### EXPERIMENTAL

*2,3,4,4,5,6,6-Heptachlorocyclohexadien-2,5-oic acid (IX)*. This acid was prepared by stirring a mixture of 25 g. of 2,3,4,4,5,5,6,6-octachlorocyclohexen-2-one-1 (VIII), m.p. 103–104°, and 100 cc. of 2 *N* NaOH at 20–30° for 7 days. The reaction mixture was cooled in an ice-bath and filtered through a cold Buchner funnel. The white crystalline plates were washed with ice-water and the dry weight was 21.8 g., 86.5% yield. Acidification of the sodium salt at 10° gave 21.0 g. of the acid, m.p. 134–136°, crystallized from benzene m.p. 135–137°. The acidified filtrate yielded an additional 2 g. of acid, m.p. 130–132°. The total crude yield of acid was 96.3%. The neutralization equivalent, m.p. 134–136°, was 350, 352: theory, 353.5;  $pK \approx 3$ ; the % chlorine removed by treatment with 2 *N* sodium hydroxide at reflux; 1.5 hrs., 19.72; 4 hrs., 19.81; theory 20.07. CO<sub>2</sub> liberated on acidification of the hydrolyzed acid and precipitated as barium carbonate, 79% of theory.

*Anal.* Calc'd for C<sub>6</sub>HCl<sub>7</sub>O<sub>2</sub>: C, 20.36; H, 0.28; Cl, 70.29.

Found: C, 20.50; H, 0.53; Cl, 70.51.

*Methyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate (XI)*. A solution of 25 g. of 2,3,4,4,5,5,6,6-octachlorocyclohexen-2-one-1 (VIII) and 44 g. of sodium acetate in 75 cc. dioxane and 150 cc. of methanol was refluxed for 4½ hours. The cooled reaction mixture was poured into ice-water; the precipitated oil crystallized slowly on standing. The solid was removed, washed thoroughly with water, and dried, weight 22.9 g., 95% yield, m.p. 42–44°, (water-bath). The m.p. of a sample crystallized from methyl alcohol was 44–45°.

This reaction was repeated at room temperature with stirring for 24 hours. The ratio of the reagents was in the same proportion. The yield of ester was 95% m.p. 43–45°.

The same product was obtained by the replacement of sodium acetate with sodium formate and sodium propionate respectively. A mixture of 6 g. of the sodium formate, acetate, and propionate products in equal parts was crystallized from methanol in 85% yield: respectively m.p.'s, 41–43°, 43–45°, and 42–44°; mixture m.p. 43–45°.

*Anal.* Calc'd for C<sub>7</sub>H<sub>3</sub>Cl<sub>7</sub>O<sub>2</sub>: C, 22.82; H, 0.81; Cl, 67.61.

Found: C, 22.85; H, 1.04; Cl, 66.9.

*Ethyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate from VIII*. A mixture of 10 g. of 2,3,4,4,5,5,6,6-octachlorocyclohexen-2-one (VIII), 25 g. of sodium acetate, 30 cc. of dioxane, and 50 cc. of ethanol was refluxed for 5 hours. On pouring the cooled reaction mixture into cold water, an oil appeared which weighed 8.3 g. on isolation with the aid of diethyl ether. The oil was distilled at 125–128°/0.5 mm., weighed 6.3 g.

*Anal.* Calc'd for C<sub>8</sub>H<sub>5</sub>Cl<sub>7</sub>O<sub>2</sub>: C, 25.11; H, 1.31.

Found: C, 25.27; H, 1.46.

*Methyl ester (XI) from the acid chloride of IX*. A weight of 2 g. of the acid chloride, prepared by the interaction of 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oic acid and phosphorus pentachloride, was reacted with 5 cc. of methanol. The crystalline product, 1.8 g., melted 42–44°, mixture m.p. with XI, 43–44°.

*Allyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate from the acid chloride of IX*. A weight of 2 g. of the acid chloride was added to 10 cc. of allyl alcohol containing 1 drop of pyridine. The excess allyl alcohol was removed under a vacuum and the residue was washed with water, dried, and distilled, b.p. 135–140°/0.3 mm, wt. 1.6 g.

*Anal.* Calc'd for C<sub>9</sub>H<sub>5</sub>Cl<sub>7</sub>O<sub>2</sub>: C, 27.44; H, 1.27.

Found: C, 27.43; H, 1.17.

*Phenyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate from the acid chloride of IX.* A weight of 7.4 g. of the acid chloride was added to 3 g. of phenol containing 1 ml. of pyridine and warmed to 60°. The product was dissolved in benzene and washed thoroughly with water. The residue from the dried benzene solution was distilled, b.p. 175–180°/0.5 mm., weight 6.4 g. The distillate solidified, m.p. 57–62°, and 2 g. were crystallized from hexane and then methanol, weight, 1.7 g., m.p. 63–65°.

*Anal.* Calc'd for  $C_{12}H_5Cl_7O_2$ : C, 33.52; H, 1.16.

Found: C, 33.43; H, 1.38.

*Hydrolysis of the methyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate (XI) with 2 N sodium hydroxide at room temperature.* A mixture of 3.3 g. of XI and 50 cc. 2 N NaOH was stirred for 7 days. The reaction mixture was filtered, cooled, acidified, and re-filtered. The crystalline solid was washed with water, dried, and weighed; 1.1 g., m.p. 135–137°, mixture m.p. with IX from the cyclic ketone, 135–136°.

*Hydrolysis of the methyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate (XI) with 2 N sodium hydroxide at 80–90°.* A weight of 15 g. of the ester was heated in 100 cc. of 2 N sodium hydroxide for 7 hours. On acidification, carbon dioxide [trapped as barium carbonate] was liberated. The precipitated oil was picked up in ether and washed with dilute sodium hydroxide. Attempts to distill the washed and dried oil led to a polymeric solid.

*Anal. of Oil.* Calc'd for  $C_6HCl_6O$ : C, 23.55; H, 0.39; Cl, 69.7.

Found: C, 22.68; H, 0.80; Cl, 69.5.

*Pentachlorophenyl acetate (XIII).* A mixture of 18.6 g. of 2,3,4,4,5,6,6-octachlorocyclohexen-2-one (VIII), m.p. 104–106°, 24.6 g. of sodium acetate, and 75 cc. of acetic anhydride was refluxed for 1 hour. The mixture was cooled, poured into water, and the precipitated solid was filtered off, weight 13 g. (theory 15.4 g.), m.p. 147–150°. On recrystallization from ethanol the solid melted at 150–151°, mixture m.p. with pentachlorophenyl acetate 150–152°.

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#### SUMMARY

1. 2,3,4,4,5,6,6-Heptachlorohexadien-2,5-oic acid has been prepared from 2,3,4,4,5,6,6-octachlorocyclohexenone by cleavage with dilute sodium hydroxide. The methyl ester of 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oic acid has been obtained by cleavage of the chlorinated cyclic ketone with sodium formate, sodium acetate, or sodium propionate in the presence of methanol; the ethyl ester has also been prepared by the same method.

2. The hydrolysis of methyl 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oate with dilute sodium hydroxide in the cold gave 2,3,4,4,5,6,6-heptachlorohexadien-2,5-oic acid which, in turn, could be converted to the identical ester by the interaction of the corresponding acid chloride and methanol. The allyl and phenyl esters have also been prepared through the acid chloride.

3. A mechanism is proposed for the cleavage of certain chlorine-substituted 5- and 6-membered cyclic ketones with bases.

BRECKSVILLE, OHIO

#### REFERENCES

- (1) ZINCKE AND KUSTER, *Ber.*, **21**, 2728 (1888).
- (2) ZINCKE, *Ber.*, **27**, 551 (1894).