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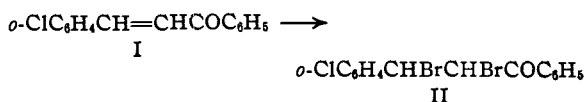
The Preparation and Alkaline Cleavage of *o*-Chlorodibenzoylmethane

BY CHARLES L. BICKEL

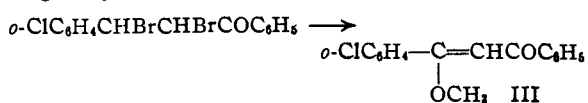
A recent paper from this Laboratory described the alkaline cleavage of some unsymmetrical diaryl beta diketones and their monomethyl derivatives.¹ The results indicated that the cleavage is concerned with the ketonic rather than the enolic forms of the diketones. Bradley and Robinson² concluded that the direction of cleavage is determined by the strength of the two possible aryl acids, the stronger acid being formed in the larger proportion.

This paper is concerned with the above conclusion of Bradley and Robinson. *o*-Chlorodibenzoylmethane was chosen for this study because (1) the result of the cleavage of *p*-chlorodibenzoylmethane is available for comparison¹ and (2) *o*-chlorobenzoic acid is a much stronger acid than *p*-chlorobenzoic acid.

o-Chlorodibenzoylmethane was prepared in the usual way. However, an unexpected and stable intermediate compound was isolated and merits attention. The bromination of *o*-chlorobenzalacetophenone I gave the expected dibromide II.

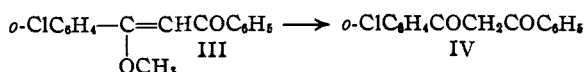


The dibromide was then boiled with methyl alcoholic potassium hydroxide and the resulting hot solution was acidified with hydrochloric acid. The expected diketone was not obtained; instead, the precursor of the diketone was isolated in good yield.



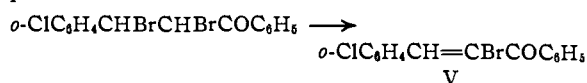
Kohler and Addinall summarized the action of bases on α,β -dibromo ketones³; compounds like III have been prepared but in no case is the conversion to this type of substance predominant. Moreover, the stability of III in the presence of acids is unusual, most of these substances being converted to the diketone by standing in the air of the laboratory.

β -Methoxy-*o*-chlorobenzalacetophenone III was converted to the diketone IV by heating it on the steam-bath with concentrated hydrochloric acid.

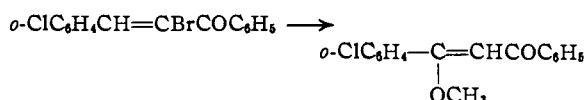


The methoxyl compound III was also prepared by the following method. The dibromide II

was converted to the monobromide V by alcoholic potassium acetate.



The monobromide V gave the methoxyl compound III when treated with alcoholic potassium hydroxide



When either the dibromide II or the monobromide V is treated with alcoholic potassium hydroxide at room temperature, the methoxyl compound III is obtained in less than 50% yield. The residues of these reactions have so far yielded no solid products. A more complete study of these reactions and a study of the stereoisomer of the dibromide II are in progress, to be reported later.

o-Chlorodibenzoylmethane IV, like the para-isomer, is quantitatively cleaved by aqueous sodium hydroxide. The results of cleavage of these diketones, as well as *p*-methoxydibenzoylmethane, are shown in tabular form.

TABLE I

Diketone	X-C ₆ H ₄ CO ₂ H ^a moles/100 moles diketone	Ionization constant of X-C ₆ H ₄ CO ₂ H at 25° ^b
<i>o</i> -Chloro	44	132 × 10 ⁻⁵
<i>p</i> -Chloro	60 ^c	9.3 × 10 ⁻⁵
<i>p</i> -Methoxy	42 ^c	3.2 × 10 ⁻⁵

^a The substituent is represented by X. ^b Scudder, "Ionization Constants of Organic Compounds." ^c Ref. 1.

The results indicate that there is no apparent relationship between the strength of the acids and the direction of cleavage, at least in these cases. *o*-Chlorobenzoic acid is stronger than benzoic acid (ionization constant at 25° = 6.6 × 10⁻⁵) but is formed in a lesser amount; *o*-chlorobenzoic acid is stronger than *p*-chlorobenzoic acid but is formed in a lesser amount. This does not mean, however, that the *weaker* acid is formed in the larger amount: Anisic acid is weaker than *o*-chlorobenzoic acid but when these are compared by means of the common denominator, benzoic acid, there is no significant difference between them.

Experimental

o-Chlorobenzalacetophenone, I.—The preparation of this substance has been reported⁴ but the method herein described is much simpler, employing sodium hydroxide instead of sodium methylate.

(4) Kohler and Bickel, *ibid.*, 57, 1100 (1935).

(1) Bickel, *THIS JOURNAL*, 67, 2204 (1945).

(2) Bradley and Robinson, *J. Chem. Soc.*, 129, 2380 (1926).

(3) Kohler and Addinall, *THIS JOURNAL*, 52, 3728 (1930).

A solution of 14 g. of sodium hydroxide in 100 cc. of methyl alcohol was added to a stirred solution of 75 g. of *o*-chlorobenzaldehyde and 63 g. of acetophenone in 200 cc. of methyl alcohol. The mixture was stirred in an ice bath until thoroughly chilled and then gave a tan solid when inoculated with *o*-chlorobenzalacetophenone. Stirring was continued for forty-five minutes, 300 cc. of cold water was added with stirring to the chilled solution over a period of forty-five minutes, the mixture was then stirred for thirty minutes in the ice-bath, and was finally placed in the refrigerator overnight. The solid product was filtered, washed with 200 cc. of cold 50% methyl alcohol and then with cold water until free of alkali. The dry product melted at 50–52° and weighed 124 g., a yield of 97% based on the acetophenone used.

o-Chlorobenzalacetophenone Dibromide, II.—A solution of 81.5 g. of bromine in 25 cc. of chloroform was added with stirring to a solution of 123 g. of *o*-chlorobenzalacetophenone in 100 cc. of chloroform. The addition was complete in fifteen minutes and the mixture was then allowed to stand for forty-five minutes. No solid separated so the solvent was removed completely by a current of dry air, the mixture being warmed during the evaporation to prevent caking of the resulting solid. About 200 cc. of ether was added to the solid residue, the solid was broken up and filtered. The filtrate gave two more crops of solid. The total weight of dibromide was 152 g., a yield of 75%. The residual material has not as yet crystallized.

o-Chlorobenzalacetophenone dibromide is quite soluble in chloroform, soluble in ether, sparingly soluble in cold methyl alcohol and insoluble in petroleum ether. It crystallizes from ether as clusters of colorless stout needles and melts at 123.5–124.5°.

Anal. Calcd. for $C_{12}H_{11}OCl_2Br_2$: C, 44.7; H, 2.76. Found: C, 44.8; H, 2.85.

α -Bromo-*o*-chlorobenzalacetophenone, V.—A suspension of 30 g. of *o*-chlorobenzalacetophenone dibromide was refluxed for three hours with a solution of 8 g. of fused potassium acetate in 100 cc. of methyl alcohol. The dibromide dissolved and a fine suspension of potassium bromide appeared. Addition of 150 cc. of water precipitated an oil which gradually solidified in the refrigerator. The pasty solid was filtered, washed thoroughly with water and allowed to dry. Recrystallization of the dry solid from ether and petroleum ether gave 21.5 g. of sharp-melting crystals, a yield of 90%.

α -Bromo-*o*-chlorobenzalacetophenone is extremely soluble in ether and sparingly soluble in petroleum ether. It crystallizes as very pale yellow octahedra, sulfur yellow in bulk, melting at 59°.

Anal. Calcd. for $C_{12}H_{10}OClBr$: C, 55.9; H, 3.14. Found: C, 55.8; H, 3.27.

β -Methoxy-*o*-chlorobenzalacetophenone, III

A. From *o*-Chlorobenzalacetophenone Dibromide.—A solution of 22 g. of potassium hydroxide in 100 cc. of methyl alcohol was added over a period of fifteen minutes to a suspension of 70 g. of *o*-chlorobenzalacetophenone dibromide in 100 cc. of methyl alcohol and the mixture was refluxed for one hour. Addition of 200 cc. of water to the cooled solution produced a granular precipitate. After standing in the refrigerator overnight, the solid was filtered, washed with water until free of alkali and then allowed to dry. Recrystallization from acetone gave 44 g. of pure product, a yield of 93%.

B. From α -Bromo-*o*-chlorobenzalacetophenone.—A solution of one gram of potassium hydroxide in 10 cc. of methyl alcohol was added to a solution of 5 g. of α -bromo-*o*-chlorobenzalacetophenone in 20 cc. of methyl alcohol. A precipitate of potassium bromide appeared immediately. After standing for thirty minutes, the solution was diluted with 100 cc. of water and extracted with ether. The ether solution gave 1.9 g. of β -methoxy-*o*-chlorobenzalacetophenone, a yield of 45%.

β -Methoxy-*o*-chlorobenzalacetophenone is quite soluble in hot acetone, sparingly soluble in ether and very slightly soluble in petroleum ether. It melts at 114° and crystal-

lizes as colorless octahedra which may grow to unusual size.

Anal. Calcd. for $C_{12}H_{13}O_2Cl$: C, 70.5; H, 4.81. Found: C, 70.6; H, 4.98.

o-Chlorodibenzoylmethane, IV.—A mixture of 25 g. of β -methoxy-*o*-chlorobenzalacetophenone and 50 cc. of concentrated hydrochloric acid was heated for fifteen minutes on the steam-bath, five minutes after the solid had changed to an oil. The mixture was extracted with ether after the addition of iced water. The washed ether solution gave 26.5 g. of the copper salt of the diketone when shaken with saturated cupric acetate solution, a quantitative yield.

The copper salt is practically insoluble in the common solvents, melts at 255° *au bloc*, and separates as tiny clusters of shiny dark green nodules.

Anal. Calcd. for $C_{20}H_{20}O_2Cl_2Cu$: C, 62.2; H, 3.5; Cu, 11.0. Found: C, 62.3; H, 3.6; Cu, 10.9.

The copper salt gave the diketone when shaken with dilute hydrochloric acid and ether. The diketone is quite soluble in all the common solvents with the exception of petroleum ether and water, melts at 58°, and crystallizes as very pale yellow needles. It gives an intense color with ferric chloride and is completely enolic by Kurt Meyer titration.

Anal. Calcd. for $C_{12}H_{11}O_2Cl$: C, 69.7; H, 4.28. Found: C, 69.7; H, 4.38.

The Alkaline Cleavage of *o*-Chlorodibenzoylmethane.—The diketone, 14.9 g., was refluxed for nine and one-half hours with 135 cc. of 2% sodium hydroxide solution. The cooled solution was twice extracted with ether, the ether extracts giving no test for unchanged diketone. The ether extracted aqueous solution was acidified with hydrochloric acid and extracted twice with ether. The ether solution of the acids was dried over anhydrous sodium sulfate, filtered and concentrated to constant weight. The weight of mixed acids was 7.92 g.

Analysis of the Acid Mixture.—In 1912, Bornwater and Hollemann published the phase diagram for mixtures of benzoic acid and *o*-chlorobenzoic acid, thus providing a thermal method of analysis.⁵ Since their directions did not indicate clearly whether fusion or solidification temperatures were determined and since preliminary experiments by the present author indicated small but significant deviations from the results previously reported, this method of analysis was reinvestigated.

Benzoic acid and *o*-chlorobenzoic acid were purified by repeated crystallization until there was no change in the freezing points. The samples for analysis are shown below in tabular form, each sample weighing 7–8 g.

TABLE II

Mole fraction benzoic acid	Initial halt in cooling curve, °C.	Mole fraction benzoic acid	Initial halt in cooling curve, °C.
1.0	122.4	0.6	92.3
0.9	113.7	.5	103.3
.8	103.3	.4	112.4
.75	97.0	.3	120.7
.7	91.7	.2	128.4
.675	89.7	.1	134.7
.65	89.6	.0 ^a	140.2

^a Pure *o*-chlorobenzoic acid.

The cooling curve for each sample was obtained as outlined in reference 6 and the initial halts in the cooling

(5) Bornwater and Hollemann, *Rec. trav. chim.*, **31**, 242–245 (1912).

(6) Each sample, contained in a 17 × 145-mm. Pyrex test-tube, was melted and the thermometer bulb centered in the liquid. The temperature of the melt was then raised to about 160° and a 32 × 200-mm. test-tube clamped in place around the Pyrex tube, providing a "dead air" jacket. About forty temperature readings, taken at thirty second intervals, were recorded for each sample. In each case the solid was remelted and a second set of readings taken. A calibrated 0.1° thermometer was used and immersion corrections were applied to all readings.

curves were plotted against composition to give the phase diagram.

Since the weight of acids obtained by the cleavage of *o*-chlorodibenzoylmethane indicated a mixture falling near the eutectic point and since these mixtures are not suited to thermal analysis, the cleavage mixture was first diluted by the addition of five grams of pure *o*-chlorobenzoic acid. The cooling curve for the diluted mixture showed an initial halt at 115.8°, representing a mixture containing 0.640 mole fraction of *o*-chlorobenzoic acid. The original mixture of acids therefore contained 0.442 mole fraction of *o*-chlorobenzoic acid.

The following calculation indicates that a quantitative conversion of the diketone into the two acids had taken place. Cleavage in one direction only would have produced 7.04 g. of benzoic acid while cleavage in the other direction would have produced 9.02 g. of *o*-chlorobenzoic acid.

Calcd. wt. of benzoic acid = $0.558 \times 7.04 \text{ g.} = 3.93 \text{ g.}$

Calcd. wt of *o*-chlorobenzoic

acid = $0.442 \times 9.02 \text{ g.} = 3.99$

Total 7.92

Summary

The preparation and alkaline cleavage of *o*-chlorodibenzoylmethane are reported.

β -Methoxy-*o*-chlorobenzalacetophenone, the precursor of the diketone, was easily isolated and proved to be much more stable than closely related compounds.

The evidence of cleavage does not support the conclusion of Bradley and Robinson that the direction of cleavage is determined by the strength of the two possible aryl acids, the stronger acid being formed in the larger proportion. In fact, no relationship between the strength of the acids and the direction of the cleavage can be established in the cases studied.

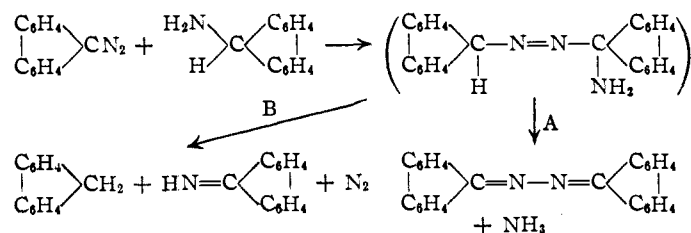
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Reaction of Diazofluorene with 9-Substituted Fluorene Derivatives

BY LOUIS A. PINCK AND GUIDO E. HILBERT¹

A reaction of diazofluorene with 9-aminofluorene in an alkaline medium, such as liquid ammonia, was obtained, yielding fluorenone ketazine in an amount corresponding to 65% of the theoretical, and small amounts of fluorylidene-imine and fluorene. The formation of these products may be interpreted by the formation of an unstable intermediate product involving a 1,3-addition. In liquid ammonia at room temperature, approximately two-thirds of the azo intermediate undergoes transformation by reaction A and the rest by reaction B. These transformations may be modified by altering the substituents of the addendum in the 9 position. Thus in the



reaction of diazofluorene with 9-anilino fluorene, A is augmented to a yield of 76% with a corresponding decrease in the yield of products resulting from B. By a proper choice of a suitable 9-substituted fluorene derivative in place of 9-aminofluorene, A or B can be eliminated. When diazofluorene reacts with 9-chlorofluorene the reaction is principally in the direction of A, and when 9-fluorenyl is

used A is entirely eliminated, the products formed are fluorene and fluorenone in accord with B. These reactions can also be obtained in an alcoholic solution of sodium ethylate.

With the possible exception of the ethylene formation by the pyrolysis of diazofluorene, the chemical properties of this compound are in general similar to those of other aliphatic diazo compounds and it is therefore postulated that other substituted diazomethane derivatives will undergo a 1,3-addition with 9-substituted fluorenes (substituents being amino, anilino, halogeno or hydroxy groups) to form either a mixed ketazine and/or other derivatives corresponding to B.

Experimental

Reaction of Diazofluorene with 9-Aminofluorene.—When 0.500 g. of diazofluorene and 0.564 g. of 9-aminofluorene hydrochloride were treated with 10–15 cc. of liquid ammonia in a sealed tube at room temperature, a rapid deposition of a brick-red, amorphous precipitate was observed. After completion of the reaction, the contents of the tube were cooled to liquid ammonia temperature, transferred into a Dewar tube, and the ammonia was evaporated spontaneously through a tube containing calcium chloride to prevent the absorption of moisture. The dry residue was triturated with anhydrous ether. The ether-insoluble fraction was crystallized from xylene yielding 0.605 g. of fluorenone ketazine, melting and mixed m. p. 269° (65.3% of the theoretical).

Anal. Calcd. for $\text{C}_{22}\text{H}_{16}\text{N}_2$: C, 87.60; H, 4.53; N, 7.87. Found: C, 87.26; H, 4.75; N, 8.07.

On treatment of the ether filtrate with dry hydrogen chloride a mixture of white and orange colored hydrochlorides (0.15 g.) precipitated simultaneously. The orange color is one of the characteristic properties of fluorylidene-imine hydrochloride. The formation of fluo-

(1) Present address: Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, Peoria, Illinois. Article not copyrighted.