

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

THE CLEAVAGE OF PHENACYLPYRIDINIUM HALIDES BY ALKALI

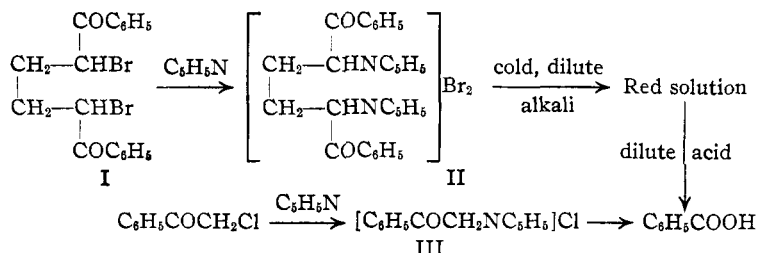
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An attempt to eliminate hydrogen bromide from 1,4-dibromo-1,4-dibenzoylbutane (I) by treatment with pyridine and then with dilute aqueous alkali resulted in a cleavage of the carbon chain and the production of benzoic acid. An investigation of this apparently novel reaction has shown it to be applicable to a number of phenacyl halides. This article is a preliminary report of these studies.

The first step in the reaction has been found to be the formation of the pyridinium halide. When 1,4-dibromo-1,4-dibenzoylbutane was heated with pyridine the dipyridinium bromide (II) was formed. The salt was



difficult to study because of its hygroscopicity but when allowed to stand in the air or when recrystallized from 95% alcohol, it took up two molecules of water and gave a dihydrate which was stable. This hydrated salt dissolved in cold 10% aqueous sodium hydroxide solution, giving a red-colored solution. The solution immediately deposited benzoic acid when acidified with hydrochloric acid.

In order to see if this type of cleavage was general for phenacyl halides, phenacyl chloride was treated with pyridine and alkali in the manner just described. In this case the pyridinium salt (III) formed a monohydrate. Decomposition gave benzoic acid in good yield. It should be mentioned at this point that a similar observation was recorded by Bamberger in 1887.¹ He found that phenacylpyridinium bromide when treated with concentrated aqueous alkali gave benzoic acid and ascribed the result to the action of alkali on phenacyl bromide reformed by dissociation of the salt into its original components. It is apparent that the results described in the present paper cannot be explained in this way. Neither phenacyl bromide nor its hydrolysis product, benzoylcarbinol, gives benzoic acid when treated with dilute aqueous alkali.²

¹ Bamberger, *Ber.*, 20, 3344 (1887).² Zincke, *Ann.*, 216, 311 (1882).

The solubility of benzoic acid in water made it somewhat difficult to determine the yield accurately. Since *p*-bromobenzoic acid is only slightly soluble in water, it was thought that the cleavage of *p*-bromophenacyl bromide would be easier to study. *p*-Bromophenacylpyridinium bromide likewise formed a monohydrate which was found to undergo the cleavage and gave *p*-bromobenzoic acid in a yield of 89% of the theoretical.

The effect of steric hindrance on the cleavage has also been studied. ω -Chloroacetomesitylene has been found to react very slowly with pyridine to give 2,4,6-trimethylphenacylpyridinium chloride. This salt, however, does not form a hydrate and does not undergo cleavage when treated with cold alkali. From this it would appear that the hydration is necessary to the cleavage.

Sufficient data are available to indicate that phenacylpyridinium halides are in general cleaved by alkali to give the salts of the corresponding aromatic acids. The fate of the rest of the molecule is being investigated. The reaction is also being applied to a variety of similarly constituted compounds. It seems best to leave the question of mechanism entirely open until these studies shall have furnished more information as to the products of the reaction as well as to its limitations.

Experimental

1,4-Dibenzoyltetramethylenedipyridinium Bromide.—To 4.5 g. of 1,4-dibromo-1,4-dibenzoylbutane dissolved in 25 cc. of ethyl benzoate at 120° was added 10 g. of pyridine. The solution became turbid and 1,4-dibenzoyltetramethylenedipyridinium bromide immediately began to separate in the form of crystals. At the end of four or five minutes the solution became clear and the reaction was complete. The product when filtered had a variable melting point and rapidly absorbed moisture from the air to become a pasty mass which hardened within an hour to a friable solid. This when crystallized from 95% ethyl alcohol separated as a colorless crystalline powder melting at 212.5° (corr.). The yield was 4.5 g. or 74% of the theoretical.

Anal. Calcd. for $C_{28}H_{28}N_4O_2Br_2 \cdot 2H_2O$: Br, 25.9. Found: Br, 26.1, 25.7.

The Cleavage of 1,4-Dibenzoyltetramethylenedipyridinium Bromide.—To a solution of 2.5 g. of the salt dissolved in 10 cc. of cold water was added 15–20 cc. of a 5% sodium hydroxide solution. A brick-red color immediately developed. The addition of dilute hydrochloric acid to the red solution discharged the color and immediately caused the separation of a crystalline compound which melted at 121° and was proved by the method of mixed melting points to be benzoic acid.

Phenacylpyridinium Chloride.—To a solution of 13.2 g. of phenacyl chloride in 50 cc. of benzene 8 g. of pyridine was added. The reaction mixture was warmed and crystals separated. In this way 5 g. of phenacylpyridinium chloride melting at 109–110° was obtained.

The same quantities of phenacylchloride and pyridine were mixed without a solvent. Considerable decomposition occurred and the mixture became a solid black mass. This was combined with the mother liquor from the first run, the solvent was evaporated and the residue was recrystallized twice from 95% ethyl alcohol. In this manner an additional 12 g. of phenacylpyridinium chloride was obtained as a yellowish powder. Concentration of the mother liquors gave oils which were discarded.

Anal. Calcd. for $C_{13}H_{12}ONCl \cdot H_2O$: Cl, 14.1. Found: Cl, 14.0, 14.1.

Cleavage of Phenacylpyridinium Chloride.—A small amount of the salt was dissolved in water and treated with a dilute solution of sodium hydroxide. A deep red color immediately developed. Acidification of the mixture with dilute sulfuric acid discharged the color and caused the separation of crystals which were identified as benzoic acid.

***p*-Bromophenacylpyridinium Bromide.**—To a solution of 27.8 g. of *p*-bromophenacyl bromide in ether was added 10 g. of pyridine. The mixture was heated for an hour under reflux and the solid *p*-bromophenacylpyridinium bromide was removed by filtration. The salt separated from alcohol in long, colorless crystals melting at 225–230°. It was sparingly soluble in cold water and in alcohol.

Anal. Calcd. for $C_{13}H_{11}ONBr_2 \cdot H_2O$: Br, 21.3. Found: Br, 21.5, 21.7.

Cleavage of *p*-Bromophenacylpyridinium Bromide.—To 3.75 g. of the salt dissolved in 15 cc. of hot water was added 10 cc. of a 10% solution of sodium hydroxide. A dark red oil separated at once but redissolved after a few minutes. The solution upon acidification with dilute sulfuric acid deposited crystals which proved to be *p*-bromobenzoic acid.

The mother liquor was again made alkaline with sodium hydroxide and was warmed for half an hour. By acidification an additional crop of *p*-bromobenzoic acid was obtained. The whole process was repeated and a third crop of crystals was obtained. The total yield of *p*-bromobenzoic acid was 1.79 g. or 89% of the theoretical.

2,4,6-Trimethylphenacylpyridinium Chloride.—Twenty grams of ω -chloroacetomesitylene and 10 g. of pyridine were dissolved in 100 cc. of ether and the solution was heated under reflux. No reaction took place. The ether was evaporated and replaced by ethyl acetate. After this solution had been boiled for ten minutes it was cooled and 4.5 g. of unchanged ω -chloroacetomesitylene separated and was filtered.

The filtrate which now contained an excess of pyridine was heated under reflux on a steam cone for three and one-half hours, at the end of which time there was a small amount of a colorless crystalline product. When filtered and dried it weighed 0.5 g. and melted at 245–246°. It was extremely soluble in water.

The 4.5 g. of unchanged ω -chloroacetomesitylene was returned to the pyridine-ethyl acetate solution. Twenty-five cc. of pyridine was added and the mixture was heated under reflux for sixteen hours. In this way was obtained 7.5 g. of 2,4,6-trimethylphenacylpyridinium chloride melting at 245–246°.

Anal. Calcd. for $C_{16}H_{15}ONCl$: Cl, 12.9. Found: Cl, 12.9, 12.8.

Action of Alkali on 2,4,6-Trimethylphenacylpyridinium Chloride.—A small quantity of the salt was dissolved in cold water and a dilute (10%) sodium hydroxide solution was added. After the solution was allowed to remain alkaline for five minutes it was acidified with dilute sulfuric acid. There resulted a precipitate of a salt-like character having no definite melting point. There was no evidence of the formation of any isodurylic acid.

Summary

It has been shown that certain phenacylpyridinium halides are cleaved by alkali to give the corresponding aromatic acids. The evidence indicates that the cleavage is rapid and nearly quantitative and that it is greatly retarded by steric hindrance.

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