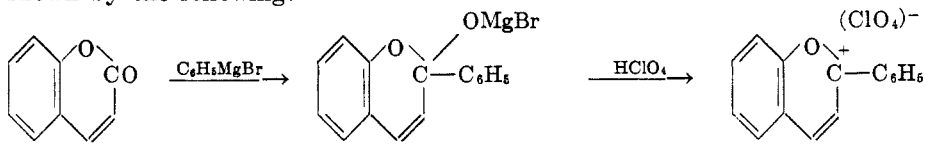
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF INDIANA UNIVERSITY]

ISOBENZOPYRYLIUM SALTS. I. PREPARATION AND REACTIONS OF 1-PHENYL-2-BENZOPYRYLIUM SALTS[1]

R. L. SHRINER,[2] H. W. JOHNSTON,[3] AND C. E. KASLOW

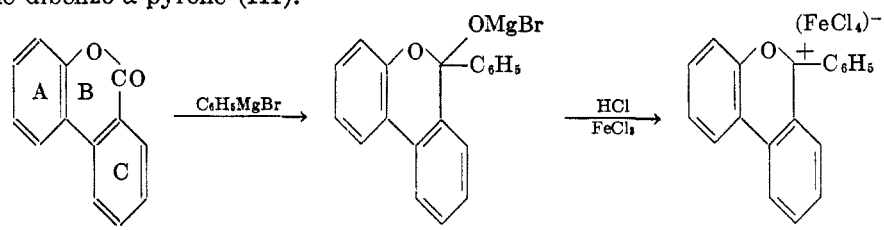
Received June 17, 1948

One of the general methods for preparing 1-benzopyrylium salts (II) consists in treating coumarin (I) (or substituted coumarins) with one mole of the Grignard reagent under conditions such that 1,2 addition to the carbonyl group occurs and then reaction of the adduct or the pyranol with a strong acid (1) as shown by the following:



I II

In 1908 Decker and Felser (2) prepared the dibenzopyrylium salt (IV) from the dibenzo-α-pyrone (III).



III IV

Now the lactone (III) may be regarded as a coumarin (Rings A + B) or as an isocoumarin (Rings C + B). Hence, the question arises whether isocoumarin itself (V) would undergo similar reactions and lead to isobenzopyrylium salts (VII).

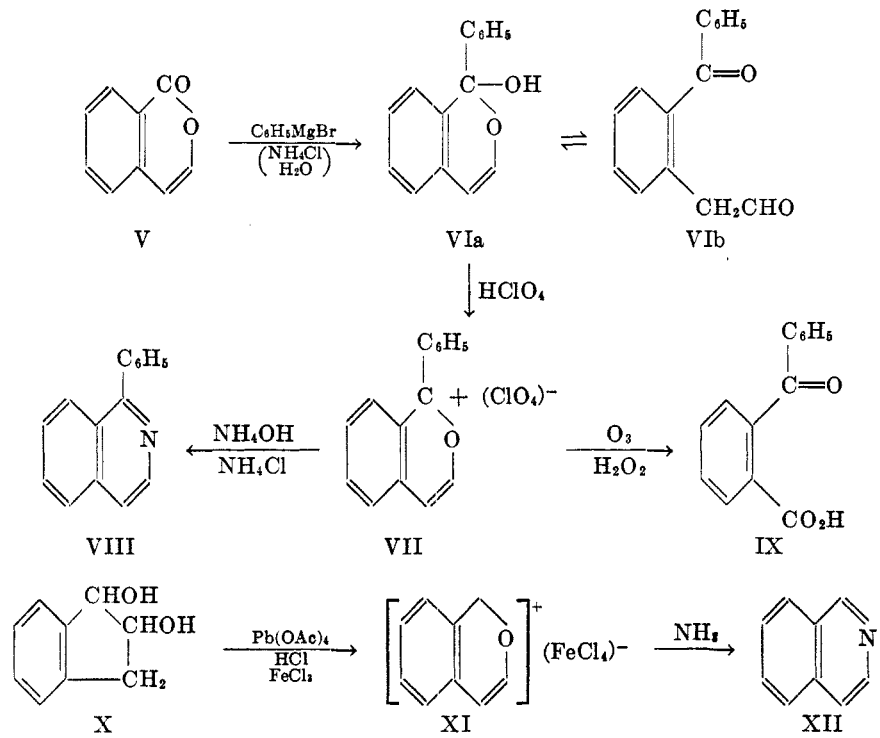
A study of this possibility has shown that the above reactions do occur and that the isobenzopyrylium perchlorate (VII) can be isolated as golden-orange crystals. To establish the structure of this salt it was subjected to ozonolysis and *o*-benzoylbenzoic acid (IX) isolated. When VII was heated with ammonium hydroxide and ammonium chloride in a sealed tube at 160°, 1-phenylisoquinoli n (VIII) was formed.

This last reaction parallels the behavior of unsubstituted 2-benzopyrylium ferrichloride (XI) which is the only other example of an isobenzopyrylium salt which could be found in the literature. Blount and Robinson (3) oxidized *trans*-1,2-hydrindanediol (X) with lead tetraacetate and treated the product with ferric chloride and hydrogen chloride to produce a compound assigned the structure XI, since ammonia converted it to isoquinoline (XII).

[1] From a thesis submitted by H. W. Johnston to the Graduate School of Indiana University in partial fulfilment of the requirements for the Ph.D. in chemistry.

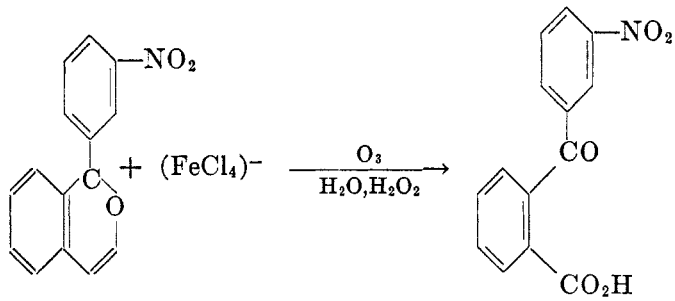
[2] Present address, State University of Iowa, Iowa City, Iowa.

[3] Present address, The Bakelite Corporation, Bloomfield, N. J.



In the present work, the intermediate carbinol VIa could not be isolated in the pure state. It is a hemiketal and is probably in equilibrium with the structure VIb which was indicated by the fact that treatment of this intermediate product with phenylhydrazine gave a compound whose analysis indicated it was the *bis*-phenylhydrazone of VIb.

Additional evidence for the carbonium structure shown by formula VII was obtained by nitration with nitric and sulfuric acids at 45°. A mononitro derivative was obtained both as the perchlorate and as the ferrichloride. The structure of the latter was established as 1-(3-nitrophenyl)-2-benzopyrylium ferrichloride (XIII) since ozonolysis and mild oxidation produced



o-(3-nitrobenzoyl)benzoic acid (XIV). The latter was characterized by comparison with a known sample prepared by nitration of *o*-benzoylbenzoic acid

according to the procedures of Lang (4) and Ranier (5). No nitration products could be found in which a nitro group had entered the benzo nucleus. Nitration experiments at higher temperatures and longer times led to complete decomposition and no di- or tri-nitro derivatives could be obtained.

These nitration results parallel the results obtained by LeFevre (6) in nitration of 2-phenyl-1-benzopyrylium perchlorate and by Shriner and Moffett (7) in nitration of 1,2-diphenyl-1-benzopyrylium perchlorate.

The results indicate that the 1-carbon atom in the salt (VII) carried a positive charge since the nitro group entered the position *meta* to it. The ozonolysis experiments indicate that the heterocyclic ring is retained in both VII and XIII since opening of this ring followed by mild oxidation with hydrogen peroxide would have given substituted phenylacetic acids.

It is evident that a considerable number of theoretically possible resonance structures could be written for these isobenzopyrylium salts. The structure shown by VII represents only one of the possibilities. It has been selected as a useful working carbonium ion structure compatible with: (a) its formation from the intermediate carbinol (VIa) by a double decomposition reaction with perchloric acid, (b) entrance of the nitro group in the 3-position of the 1-phenyl group and (c) the selective ozonolysis to give *o*-benzoylbenzoic acid which indicates the double bond in the heterocyclic ring is in the 3,4-position. This does not mean that it is the only structure but that it is the one involved in these particular chemical properties. Undoubtedly one of the reasons why these salts can be isolated and are so stable is due to resonance with all the other possibilities.

EXPERIMENTAL PART

1-Phenyl-2-benzopyrylium perchlorate (VII). To a solution of 21 g. (0.14 mole) of isocoumarin (8) in 100 ml. of absolute ether cooled to 0° was added 0.13 mole of phenylmagnesium bromide in 100 ml. of absolute ether. After stirring for 5 hours the yellow complex was decomposed by addition of 300 ml. of 20% ammonium chloride solution. The ether layer containing the carbinol (VIa) was separated, washed with water, and dried with magnesium sulfate. It was cooled to 0° and a solution of 15.0 g. of 70% perchloric acid in 30 ml. of acetic anhydride and 150 ml. of absolute ether added dropwise with vigorous stirring. The yellow perchlorate was removed by filtration, washed with dry ether and recrystallized three times from anhydrous ethylene chloride. The golden-orange crystals then melted constantly at 210–211° (with decomposition) and amounted to 9 g. (21%).

Anal. Calc'd for $C_{15}H_{11}ClO_5$: ClO_4, 32.43. Found: ClO_4, 32.58.

Ozonolysis of 1-phenyl-2-benzopyrylium perchlorate. A solution of 0.8 g. of the above salt in 50 ml. of ethylene chloride was treated with 3% ozone for 2 hours. After removal of the solvent under reduced pressure, the ozonide was decomposed with 10 ml. of water and 1 ml. 30% hydrogen peroxide. This mixture was extracted with ether and the ether solution extracted with 10% sodium carbonate solution. Acidification of the latter gave a red gum which was removed by filtration and the filtrate was chilled in an ice-box. The solid precipitate, after recrystallization from water-methanol mixture (3:1) gave white crystals of the hydrate of *o*-benzoylbenzoic acid; m.p. 92–93°. Recrystallization from benzene gave the anhydrous acid; m.p. 125–126°. When mixed with a known sample no depression of the melting point occurred. Kunckell and Knigge (9) report 93–94° for the hydrate and 127° for the anhydrous acid.

Bis-phenylhydrazone of o-benzoylphenylacetaldehyde (VIb). Evaporation of the ether from a solution of the carbinol (VIa) obtained as described above, gave an oil which could

not be crystallized or purified by distillation. However, the oil was dissolved in dioxane and refluxed with a solution of 2.9 g. of phenylhydrazine hydrochloride and 5.5 g. of sodium acetate in 100 ml. of water for one hour. After cooling and standing for some time, yellow crystals separated. After three recrystallizations from 95% ethanol there was obtained 0.3 g. of pale yellow needles melting constantly at 197–199°.

Anal. Calc'd for $C_{27}H_{24}N_4$: N, 13.86. Found: N, 14.15; 13.98.

1-Phenylisoquinoline. A mixture of 0.2 g. of 1-phenyl-2-benzopyrylium perchlorate, 5 ml. of concentrated ammonium hydroxide, and 0.1 g. of ammonium chloride was heated in a sealed tube at 160° for one hour. After cooling and opening the tube, the contents were boiled to drive off the excess ammonia and then clarified by adding a few ml. of ethanol. Upon cooling the solution, a tan powder of m.p. 90–95° was obtained. It was dissolved in 10 ml. of hot alcohol, decolorized with Norit, and the filtrate diluted with water until turbid and then cooled in an ice-bath. The product was again recrystallized from 50% ethanol and was obtained as white needles melting at 93–94°.

Rosenmund, Nothnagel, and Riesenfeld (10) reported the melting point 94° for 1-phenylisoquinoline; Späth, Berger, and Kuntara (11) reported 95–96° from petroleum ether; Ziegler and Zieser (12) reported 97° from toluene-petroleum ether; and Rodionov and Yavorskaya (13) recorded 94–95° from alcohol.

1-(3-Nitrophenyl)-2-benzopyrylium perchlorate. One gram of 1-phenyl-2-benzopyrylium perchlorate was dissolved in a mixture of 5 ml. of concentrated nitric acid and 5 ml. of concentrated sulfuric acid at 45°. The reaction mixture was held at this temperture for five minutes and then poured onto 25 g. of cracked ice. The yellow mixture was extracted twice with 25 ml. of ether. The ether solution was washed three times with small portions of cold water and dried over magnesium sulfate.

The magnesium sulfate was removed by filtration and washed twice with small portions of dry ether which were added to the filtrate. The ether mixture was chilled in an ice-salt bath and 0.28 ml. (0.47 g., 0.00326 mole) of 70% perchloric acid in 5 ml. of acetic anhydride and 25 ml. of dry ether was added. A yellow powder was obtained which decomposed at 200°. The product was dissolved in about 15 ml. of warm pure nitromethane. Dry ether was added dropwise until fine orange needles of 1-(3-nitrophenyl)-2-benzopyrylium perchlorate precipitated. The purification procedure was repeated three times until the product melted constantly at 240.5° with decomposition. The yield was 0.5 g. (43%).

Anal. Calc'd for $C_{15}H_{10}ClNO_7$: ClO_4, 28.38. Found: ClO_4, 28.17.

1-(3-Nitrophenyl)-2-benzopyrylium ferrichloride (XIII). Two grams (0.0065 mole) of 1-phenyl-2-benzopyrylium perchlorate was dissolved in a mixture of 10 ml. of concentrated nitric acid and 10 ml. of concentrated sulfuric acid at 45°. The reaction mixture was held at this temperature for five minutes and then poured onto 25 g. of cracked ice. The yellow powder was collected on a filter, washed with distilled water, and dissolved in 70 ml. of warm concentrated hydrochloric acid. An excess of ferric chloride (also dissolved in concentrated hydrochloric acid) was added. The solid yellow product was collected on a filter and recrystallized twice from glacial acetic acid. Bright yellow needles, m.p. 138° (decomp.) were obtained; yield 1 g. (34%).

Anal. Calc'd for $C_{15}H_{10}Cl_4FeNO_3$: N, 3.11; Fe, 12.42.
Found: N, 3.00; Fe, 12.34.

Ozonolysis of 1-(3-nitrophenyl)-2-benzopyrylium ferrichloride. One gram of 1-(3-nitrophenyl)-2-benzopyrylium ferrichloride was dissolved in 500 ml. of glacial acetic acid and subjected to a stream of 3% ozone for 3 hours. The solvent was removed on the water-bath under reduced pressure and about 50 ml. of distilled water and 1 ml. of 30% hydrogen peroxide were added. The mixture was heated to boiling, cooled, and acidified with hydrochloric acid. The solution was extracted with three 50-ml. portions of ether. The ether solution was extracted with two 25-ml. portions of 10% sodium carbonate and the aqueous portion was then removed and acidified with hydrochloric acid. A milky oil appeared which solidified upon chilling in the ice-box overnight. A pale yellow powder was obtained which was recrystallized several times from dilute acetic acid. Pale yellow needles, m.p. 181.5–

183.5° were obtained. This compound was identified as 2-(3-nitrobenzoyl)benzoic acid since it did not depress the melting point of an authentic sample prepared by the nitration of *o*-benzoylbenzoic acid following the procedure described by Lang (4) and Ranier (5). The melting point of 2-(3-nitrobenzoyl)benzoic acid is quite different from the other known isomeric nitrobenzoylbenzoic acids described by Ranier (14) and by Lawrence (15).

Properties and analysis of organic perchlorates. Since perchloric acid may react violently with certain organic compounds, the preparation and recrystallization of the benzopyrylium and isobenzopyrylium perchlorates should always be carried out behind laminated safety glass shields. It will be noted that the yields of some of the perchlorates are rather low. Undoubtedly more of the compounds are present in the filtrates but the concentration of these is rather hazardous and is not recommended. The various carbonium perchlorates are crystalline, non-hydroscopic solids which are stable under ordinary conditions. They possess characteristic and reproducible melting points with more or less decomposition depending on the particular compound. When heated above their melting points the organic perchlorates decompose vigorously—sometimes explosively. For this reason, it is usually impossible to obtain good analyses for carbon, hydrogen, or nitrogen since the combustion cannot be easily controlled.

The analysis of the organic perchlorates may be accomplished by treatment of an alcoholic solution of the sample with a solution of potassium acetate. The potassium perchlorate is collected on a filter, dried, and weighed. However, the appreciable solubility of potassium perchlorate in the aqueous alcohol medium, makes it necessary to determine and apply a correction. The best method for the analysis of organic perchlorates utilizes precipitation of the perchlorate anion by tetraphenylarsonium chloride (16) from a methanolic solution of the sample. The tetraphenylarsonium perchlorate is quite insoluble and is collected on a sintered glass filter, dried at 105° and weighed. This reagent is more accurate since the quaternary perchlorate is quite insoluble in methanol and the factor $ClO_4/(C_6H_5)_4AsClO_4 (= 0.2060)$ is very favorable. This method is an application of the procedure of Willard and Smith (17) for the analysis of inorganic perchlorates. The isobenzopyrylium perchlorates described in this paper were analyzed by this method.

SUMMARY

1-Phenyl-2-benzopyrylium perchlorate was produced by the action of phenylmagnesium bromide on isocoumarin followed by treatment with perchloric acid. Nitration of this salt formed 1-(3-nitrophenyl)-2-benzopyrylium perchlorate as shown by conversion to *o*-(3-nitrobenzoyl)benzoic acid.

BLOOMINGTON, IND.

REFERENCES

(1) DECKER AND FELLENBERG, *Ber.*, **40**, 3815 (1907); *Ann.*, **356**, 281 (1907); WILLSTÄTTER AND SCHMIDT, *Ber.*, **57**, 1945 (1924); WILLSTÄTTER, ZECHMEISTER, AND KINDLER, *Ber.*, **57**, 1938 (1924); SHRINER AND MOFFETT, *J. Am. Chem. Soc.*, **63**, 1694 (1941).

(2) DECKER AND FELSER, *Ber.*, **41**, 3755 (1908).

(3) BLOUNT AND ROBINSON, *J. Chem. Soc.*, 555 (1933).

(4) LANG, *Monatsh.*, **26**, 972 (1905).

(5) RANIER, *Monatsh.*, **29**, 180 (1908).

(6) LEFEVRE, *J. Chem. Soc.*, 2771 (1929); LEFEVRE AND LEFEVRE, *J. Chem. Soc.*, 1988 (1932); LEFEVRE, LEFEVRE AND PEARSON, *J. Chem. Soc.*, 37 (1934).

(7) SHRINER AND MOFFETT, *J. Am. Chem. Soc.*, **66**, 301 (1944).

(8) JOHNSTON, KASLOW, LANGSJOEN, AND SHRINER, *J. Org. Chem.*, **13**, 477 (1948).

(9) KUNCKELL AND KNIGGE, *Ber.*, **39,** 194 (1906).
(10) ROSENMUND, NOTHNAGEL, AMD RISENFELD, *Ber.*, **60,** 392 (1927).
(11) SPÄTH, BERGER, AND KUNTARA, *Ber.*, **63,** 135 (1930).
(12) ZIEGLER AND ZEISER, *Ann.*, **485,** 174 (1931).
(13) RODINOV AND YAVORSKAYA, *J. Gen. Chem.* (*U.S.S.R.*), **11,** 446 (1941) *Chem. Abstr.*, **35,** 6592 (1941).
(14) RANIER, *Monatsh.*, **29,** 431 (1908).
(15) LAWRENCE, *J. Am. Chem. Soc.*, **42,** 1876 (1920).
(16) BLICKE AND MONROE, *J. Am. Chem. Soc.*, **57,** 720 (1935).
(17) WILLARD AND SMITH, *Anal. Chem.*, **11,** 186 (1939).