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## Preparation and Properties of 2, 3, 4, 6-Tetramethoxybenzotropylium Perchlorate Salts

Robert E. Suder

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PREPARATION AND PROPERTIES  
OF 2,3,4,6-TETRAMETHOXY-  
BENZOTROPYLIUM PERCHLORATE  
SALTS

by

Robert E. Suder

A thesis submitted to the  
Faculty of the School of Graduate  
Studies in partial fulfillment  
of the  
Degree of Master of Arts

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Kalamazoo, Michigan  
April 1968

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Robert E. Suder

MASTER'S THESIS

M-1511

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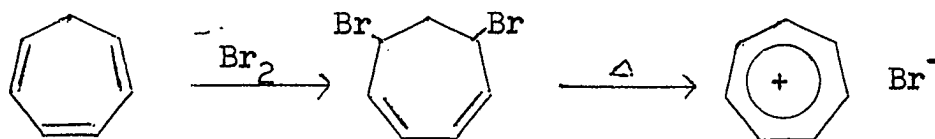
## INTRODUCTION

The purpose of this work is to investigate the preparation and properties of 2,3,4,6-tetramethoxy-5H-benzocyclohepten-5-one and its derivatives. The formation of the perchlorate salt was attempted by a direct reaction of the starting material with acid, and also by treating the corresponding alcohol with acid.

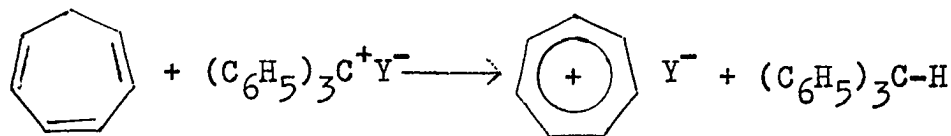
The possibility of the addition of Grignard reagents and amines to the benzotropolone system was also investigated.

## HISTORICAL

In 1931 Hückel proposed that the  $C_7H_7^+$  ion should have aromatic character<sup>1</sup>. In fact, tropylium bromide had been prepared in 1891 by Merlin<sup>2</sup>, but it was not identified. In 1954 the work was repeated and the yellow solid that was isolated was proven to be tropylium bromide<sup>3</sup>. Mild pyrolysis of the dibromo addition product affords the salt.

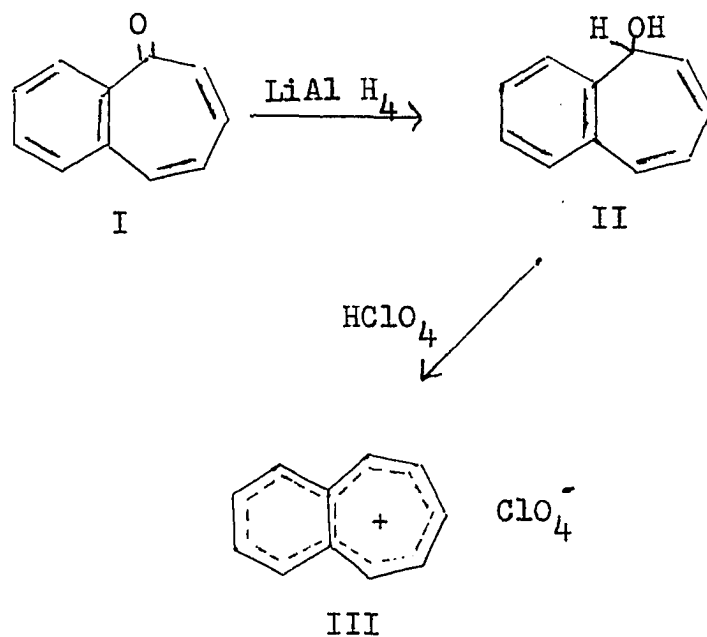


The perchlorate, iodide, tetrafluoroborate<sup>4</sup>, and the tetrabromoborate<sup>5</sup> salts have also been prepared. Recently, Dauben has been able to prepare various types of tropylium salts by hydride exchange between cycloheptatrienes and triphenylcarbonium ions in acetonitrile<sup>6</sup>.

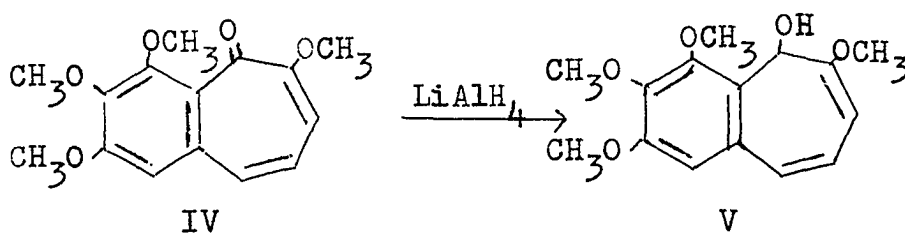


A number of benzotropylium salts have also been prepared. They are usually obtained by treating the corresponding alcohols with acid. The first isolation of benzotropylium perchlorate was achieved by Rennhard

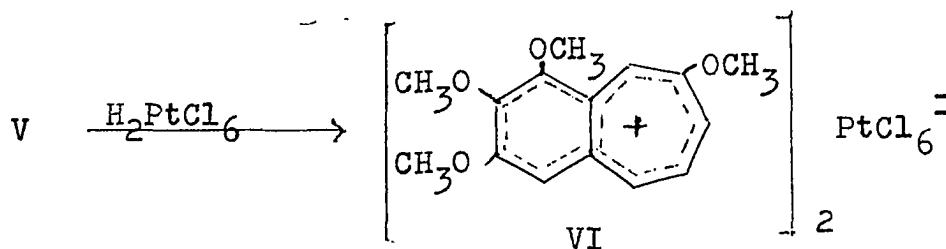
in 1955<sup>7</sup>. He treated II with 70% perchloric acid to obtain a yellow salt, III.



One of the more extensively studied benzotropolones is the one obtained from the methylation of the natural product purpurogallin (2,3,4,6-tetrahydroxy-5H-benzocyclohepten-5-one). Eschenmoser and coworkers were able to isolate the 2,3,4,6-tetramethoxybenzotropylium chloroplatinate salt, VI<sup>8</sup>.

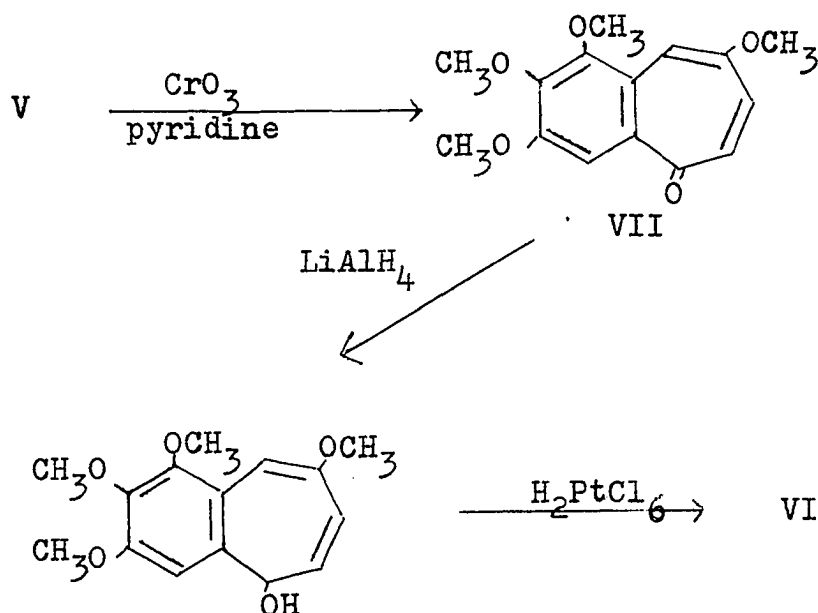






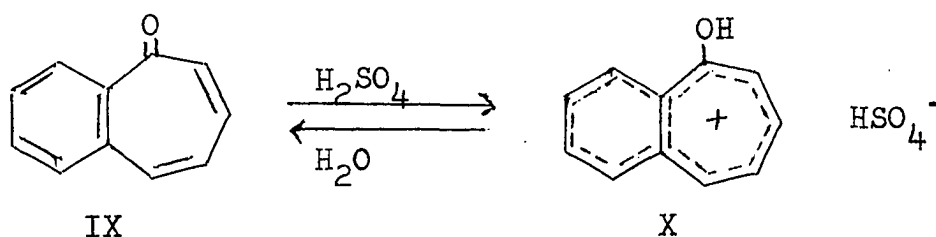
They first reduced the carbonyl group on IV with lithium aluminum hydride to form the alcohol V, and treatment of this with chloroplatinic acid afforded the salt, VI. However, they were unable to isolate the perchlorate salt.

If V is oxidized with chromium trioxide one obtains the rearranged compound, 2,3,4,6-tetramethoxy-9H-benzocyclohepten-9-one (VII). This was reduced with lithium aluminum hydride to the alcohol and reacted with chloroplatinic acid.



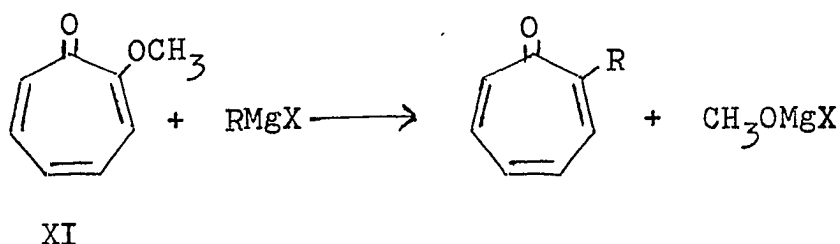
The compound prepared was identical with VI, demonstrating that for the benzotropylium chloroplatinate salt, the positive charge is delocalized over the seven-membered ring, and probably over the six-membered ring.

Buchanan found that with benzocyclohepten-5-one (IX) it was possible to prepare the 5-hydroxybenzotropylium bisulfate salt,  $X^9$ .

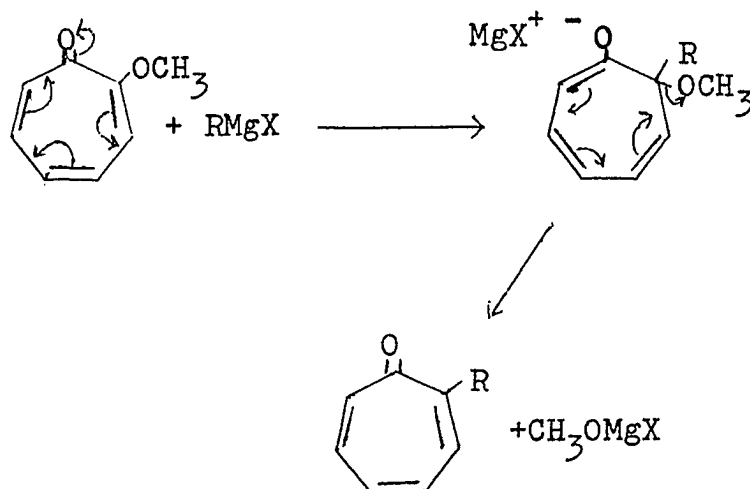


However, he was unable to prove the structure because of the inability to isolate the product. He did find that the addition of water will reverse the reaction.

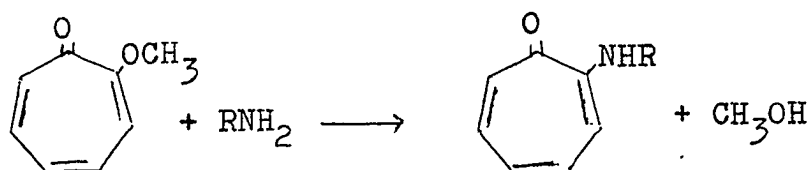
The reaction of Grignard reagents with tropolones has been studied because of the interesting products that result. For example, the addition of a Grignard reagent to 1-methoxytropolone (XI) causes the methoxyl group to be displaced<sup>10</sup>.



The following mechanism is believed to occur;



Amines can also be added to 1-methoxytropolone to give a displacement product.<sup>10,11</sup>



It is interesting to note that when the carbonyl group of a benzotropolone is reduced with lithium aluminum hydride an alcohol is formed. However, the lithium aluminum hydride reduction of 1-methoxytropolone results in the formation of benzaldehyde<sup>12</sup>.



## EXPERIMENTAL

All melting points reported are corrected and expressed in degrees centigrade.

The infrared spectra were measured with a Beckman IR-8 instrument. The ultraviolet spectra were obtained with a Cary Model 14 spectrophotometer. Elemental analyses were performed by Galbraith Microanalytical Laboratories, Knoxville, Tennessee. The nuclear magnetic resonance spectra were obtained with a Varian A-60 instrument; resonances were measured in cycles per second downfield from a tetramethylsilane internal standard. Thin-layer chromatography was performed on silica gel-G (Darmstadt) using chloroform as a solvent. The spots were developed by iodine vapor.

The 2,3,4,6-tetrahydroxy-5H-benzocyclohepten-5-one was obtained from Aldrich Chemical Company, Inc., and used as received.

## Preparation of benzotropylium salts

Preparation of 2,3,6-trimethoxy-4-hydroxy-5H-benzocyclohepten-5-one XIII

A solution containing 14 g. of sodium hydroxide dissolved in 100 ml. of water was added to 22 g. (0.1 mole) of 2,3,4,6-tetrahydroxy-5H-benzocyclohepten-5-one, 28 g. (0.039mole) of dimethyl sulfate, and 50 g. of ice. This mixture was stirred for eight hours. By this time a heavy precipitate formed and was collected by

vacuum filtration, washed with water, recrystallized from methanol, and air dried to give 14 g. (53.5%) of orange plates, m.p. 173- 175(lit.<sup>13</sup>m.p. 176);  $\nu$  max (nujol) 1730, 1648, 1250, and 1091  $\text{cm}^{-1}$ . The nmr spectra in a chloroform solution showed a resonance at  $\delta=15$  (1H), a series of multiplets between  $\delta=7.2$  and  $\delta=6.6$  (4H), and three singlets between  $\delta=4.0$  and  $\delta=3.8$  (9H).

Preparation of 2,3,4,6-tetramethoxy-5H-benzocyclohepten-5-one (XIV)

A solution of 150 ml. of 65% aqueous potassium hydroxide was added to 10 g. (0.04 mole) of XIII and 23 g. (0.32 mole) of dimethyl sulfate. The mixture was heated and stirred, causing a vigorous reaction which continued without further heating. After several hours the solid which formed was collected by vacuum filtration, washed with water, recrystallized from cyclohexane, and air dried to give 6 g. (57%) of pale green plates, m.p. 88-90°(lit.<sup>14</sup>m.p.94);  $\nu$  max (nujol) 1730, 1648, and 1090  $\text{cm}^{-1}$ . The nmr spectrum in perdeuterated acetonitrile exhibits a series of resonances between  $\delta=7.0$  and  $\delta=6.0$  (4H), and three singlets between  $\delta=4.0$  and  $\delta=4.3$  (12H) which are attributed to the methoxyl protons.

Preparation of 2,3,4,6-tetramethoxy-5H-benzocyclohepten-5-ol (XV)

A suspension of 0.32 g. (0.0084 mole) of lithium aluminum hydride in 25 ml. of anhydrous ether was added

to 2.0 g. (0.0072 mole) of XIV in 25 ml. of anhydrous ether. The mixture was stirred for three hours at  $0^{\circ}$ , and for one hour at room temperature. The excess lithium aluminum hydride was decomposed by adding water until the evolution of hydrogen ceased. The solution was filtered and the ether removed by evaporation under reduced pressure. The residual oil, presumed to be XV, did not crystallize. The infrared spectrum showed the absence of a carbonyl group, and the presence of a hydroxyl group at  $3500\text{ cm}^{-1}$ .

Preparation of 2,3,4,6-tetramethoxybenzotropylium perchlorate (XVI)

To 2.0 g. (0.0072 mole) of XV dissolved in 25 ml. of ether was added 4 g. (0.03 mole) of 70% perchloric acid. After a few minutes, crystallization of the bright red perchlorate salt began. The solution was cooled to insure complete precipitation. The crystals were collected by vacuum filtration, washed with ethyl acetate, and air dried to yield 1.5 g. of product, m.p. 130-133 (dec.);  $\lambda_{\text{max}}^{98\% \text{ H}_2\text{SO}_4}$  327 m $\mu$  ( $\epsilon$  max 50,000), 373 m $\mu$  ( $\epsilon$  max 5600), and 475 m $\mu$  ( $\epsilon$  max 2500), and  $\nu$  max (nujol) 1585, 1480, and  $1081\text{ cm}^{-1}$ . The nmr spectrum in perdeuterated acetonitrile has a series of resonances between  $\delta=9.2$  and  $\delta=5.6$  (5H), and two singlets at  $\delta=4.2$  (12H).

Anal. Calcd for  $C_{15}H_{17}ClO_8$ : C, 50.0; H, 4.40; Cl, 10.1.  
 Found: C, 50.24; H, 4.61; Cl, 9.90.

Preparation of 2,3,4,6-tetramethoxy-5-hydroxybenzo-  
tropylium perchlorate (XVII)

To a suspension of 0.5 g. (0.002 mole) of XIV in 25 ml. of ether was added 5 g. (.04 mole) of 70% perchloric acid. A yellow-orange precipitate appeared at once.

This was collected by vacuum filtration, recrystallized from glacial acetic acid, washed with ethyl acetate, and air dried to yield 0.45 g. (68%) m.p. 140-142 (dec.);  
 $\lambda_{\max}^{98\% H_2SO_4}$  317 mu ( $\epsilon$  max 21,300), 363 mu ( $\epsilon$  max 2180), and 435 mu ( $\epsilon$  max 1630), and  $\nu$  max (nujol) 1600, 1570, and  $1080\text{ cm}^{-1}$ . The nmr spectrum in perdeuterated acetonitrile showed a single resonance at  $\delta=12.9$ , which is assigned to the hydroxyl proton, a series of multiplets between  $\delta=7.4$  and  $\delta=9.4$  (4H), and three singlets between  $\delta=4.1$  and  $\delta=4.2$  (12H).

Anal. Calcd for  $C_{15}H_{17}ClO_9$ : C, 47.8; H, 4.53; Cl, 9.32.  
 Found: C, 47.61; H, 4.58; Cl, 9.32.

Preparation of 2,3,4,6-tetramethoxy-9H-benzocyclo-  
hepten-9-one (XVIII)

A suspension of 2.0 g. of chromium trioxide in 20 ml. of pyridine was added to 2.0 g. (0.0082 mole) of XV at  $5^\circ$ . The mixture was stirred for twelve hours. At the end of this time 20 ml. of water was added, and the reaction mixture extracted with ether. The ether

solution was then washed with 500 ml. of dilute hydrochloric acid, and dried over anhydrous magnesium sulfate. The ether was removed by evaporation under reduced pressure to yield 1.0 g. (50%) of product, m.p. 100-105 (lit.<sup>8</sup> m.p. 106). This was used without further purification for the next preparation.

Preparation of 2,3,4,6-tetramethoxy-9-acetobenzotropylium perchlorate (XIX)

To 1.0 g. (0.004 mole) of XVIII in 20 ml. of ether was added 5 g. (0.04 mole) of 70% perchloric acid. The yellow precipitate that formed was collected by vacuum filtration, washed with ether, and air dried to give 0.4 g. (62%) of yellow crystals, m.p. 164-166 (dec.);  $\lambda_{\max}^{98\% \text{ H}_2\text{SO}_4}$  323 mu ( $\epsilon$  max 27,200), 365 mu ( $\epsilon$  max 4380), and 465 mu ( $\epsilon$  max 3440) and  $\nu$  max (nujol) 1610, 1495, 1220, and 1096  $\text{cm}^{-1}$ . The nmr spectrum in a solution of perdeuterated dimethyl sulfoxide exhibits a resonance at  $\delta=5.6$  which is due to the hydroxyl proton, a series of resonances between  $\delta=7.0$  and  $\delta=9.0$  (4H), for the ring hydrogen atoms, and a broad singlet at  $\delta=4.0$  (12H). When XIX was recrystallized from acetic acid, the acetate, XX, formed, m.p. 184-187 (dec.);  $\nu$  max (nujol) 1790, 1600, and 1090  $\text{cm}^{-1}$ . The nmr spectrum in perdeuterated acetonitrile exhibits a series of multiplets between  $\delta=8.0$  and  $\delta=7.2$  for the ring hydrogen atoms (4H), four singlets between  $\delta=4.1$  and  $\delta=4.0$  (12H), and a singlet at  $\delta=3.6$  attributed to



the acetate protons.

Anal. Calcd for  $C_{17}H_{19}ClO_{10}$ : C, 48.8; H, 4.54; Cl, 8.57.  
Found: C, 48.54; H, 4.67; Cl, 8.62.

#### Reduction of XVII with lithium aluminum hydride

A suspension of 0.2 g. (0.053 mole) of lithium aluminum hydride in 20 ml. of anhydrous ether was added to 0.5 g. (0.002 mole) of XVIII in 20 ml. of anhydrous ether. The mixture was stirred for three hours at  $0^{\circ}$ , and for one hour at room temperature. The mixture was filtered and 5g. (.18 mole) of 70% perchloric acid added. After a few minutes the crystals formed. The crystals were collected by vacuum filtration and washed with ether. Thin-layer chromatography indicated that this compound was identical with XVI. In addition, a mixture of this compound and XVI gave no melting point depression.

#### Attempted reaction of XIV with Grignard reagents

An attempt was made to react XIV with a series of Grignard reagents. The Grignard reagents used were *p*-chlorophenyl magnesium bromide, benzyl magnesium chloride, and phenyl magnesium bromide. In each case, 0.5 g. (0.002 mole) of XIV was dissolved in 25 ml. of ether and 0.002 mole of the Grignard reagent added. A precipitate formed immediately and 50 ml. of water was added. The resulting mixture was extracted with ether. The ether was removed by evaporation under

reduced pressure to give 0.5 g. of a solid residue, m.p. 88-90°. A mixture of this and XIV gave no melting point depression. Thin-layer chromatography also indicated that no reaction had occurred.

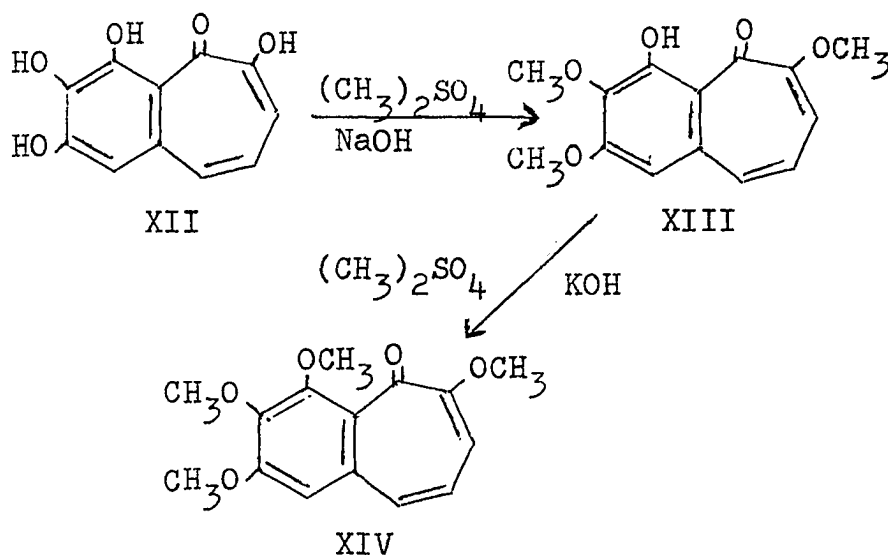
Attempted reaction of N,N-dimethylethylenediamine with XIV

A solution of 0.15 g. (0.002 mole) of N,N-dimethylethylenediamine in 10 ml. of benzene was added to 0.5 g. (0.002 mole) of XIV in 20 ml. of benzene. The solution was heated at reflux for eight hours. At the end of this time the benzene was removed by evaporation under reduced pressure to give 0.5 g. of a solid residue, m.p. 88-90°. This was confirmed to be starting material by the melting point of a mixture of this and XIV, and also by thin-layer chromatography.

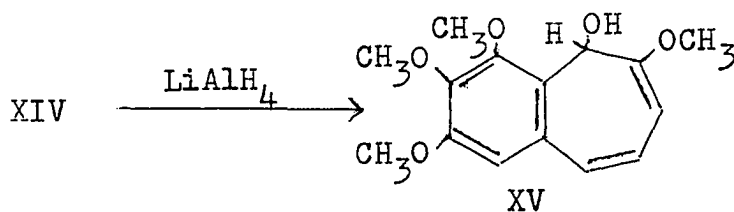
The reaction was repeated using o-xylene as a solvent. Again, only starting material was recovered.

## DISCUSSION

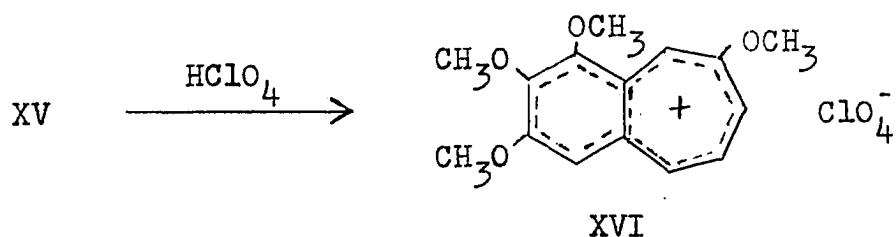
Compound XV can be prepared by methylating XII with dimethyl sulfate in a 10% aqueous sodium hydroxide solution, and then with dimethyl sulfate in a 65% potassium hydroxide solution.



Lithium aluminum hydride reduction of XIV gives the corresponding alcohol, XV.

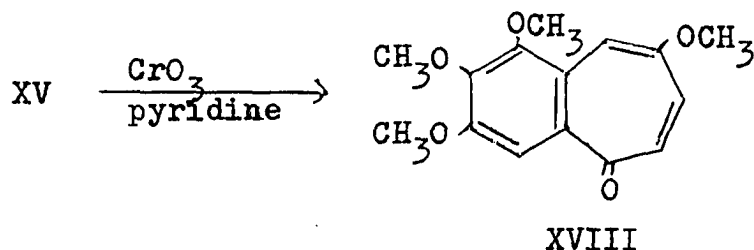


When this is reacted with 70% perchloric acid the 2,3,4,6-tetramethoxybenzotropylium perchlorate salt (XVI) forms, which can be isolated.

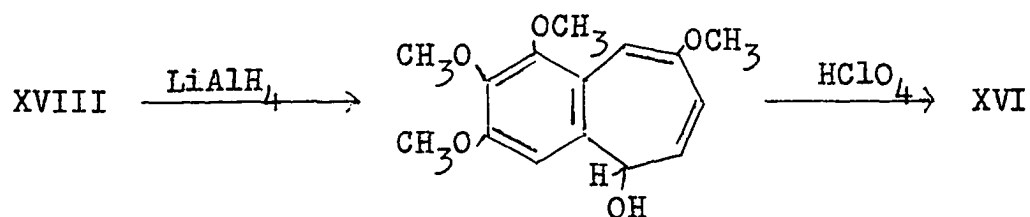


When the benzotropylium salts were prepared by the earlier workers<sup>5,9</sup>, they had no direct evidence that the positive charge was delocalized over both rings, or just over the seven-membered ring. However, the nmr spectral data now seems to indicate that the positive charge is delocalized over both rings because of the downfield chemical shift of the substituents on the rings. This downfield shift is attributed to the delocalized positive charge, which decreases the electron density and increases deshielding. The resonances due to the methoxyl protons are shifted about 24 cps further downfield in the salt, as compared to XIV. In addition, the resonances caused by the ring hydrogen atoms are shifted about 90 cps further downfield in XVI. The ultraviolet spectra is consistent with other benzotropylium ions. For example, benzotropylium perchlorate has a  $\lambda_{\text{max}}$  at 282, 338, and 426 m $\mu$ . The absorption at 282 corresponds to the K band, which is a  $\pi \rightarrow \pi^*$  transition. This absorption is shifted to a longer wavelength by substitution on the ring<sup>15</sup>. Thus, it is at 327 in XVI.

Compound XV, when reacted with chromium trioxide in pyridine, gives the rearranged compound, XVIII.

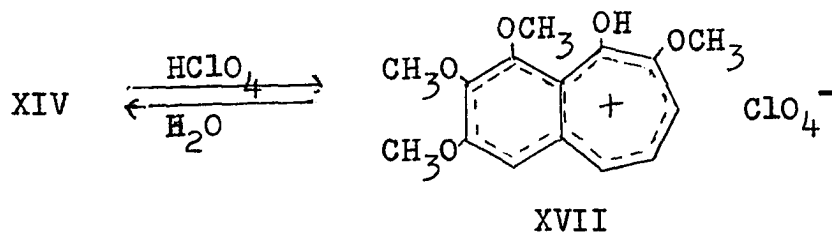


After being reduced with lithium aluminum hydride, compound XVIII can be reacted with perchloric acid to form a compound identical with XVI.



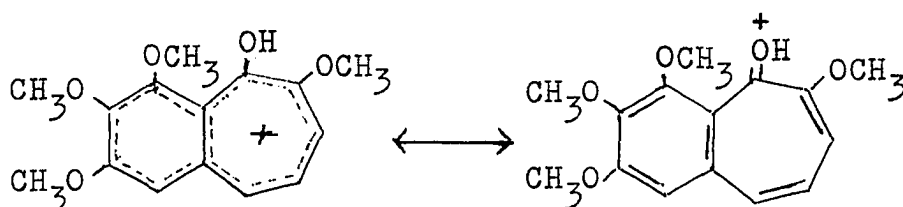
This is consistent with the fact that the positive charge is delocalized over the seven-membered ring.

It was found that XIV can be reacted directly with perchloric acid to prepare a hydroxybenzotropylium perchlorate salt, XVII.



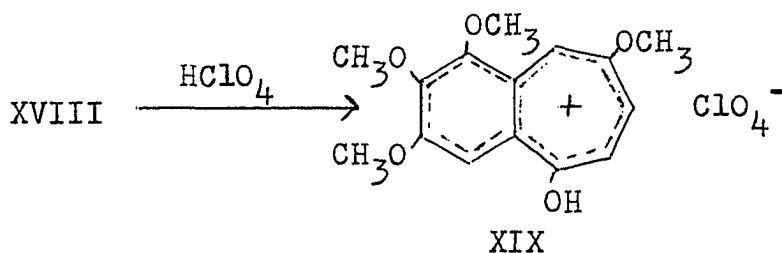
The nmr spectra of XVII shows a resonance at  $\delta=12.9$ . This large chemical shift is attributed to both the positive charge and to the strong intramolecular hydrogen

bonding. As with XVI, the positive charge seems to be delocalized over both rings. The resonances of the methoxyl protons are about 15 cps, and the ring hydrogen atoms are about 60 cps further downfield than in XIV. The shifts in resonance signals are not as large in XVII as they are for XVI, possibly because of the resonance effect of the hydroxyl group.



The ultraviolet spectrum of XVII is similar to XVI, except that the absorptions are not as intense.

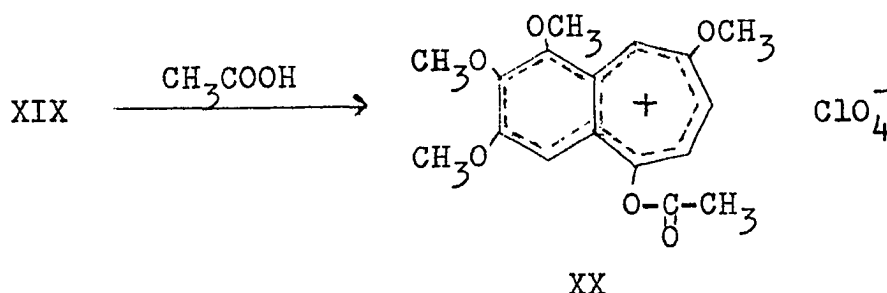
Compound XVIII can also be treated with perchloric acid to form the rearranged hydroxybenzotropylium perchlorate salt, XIX.



The nmr spectrum of XIX is more difficult to interpret because a satisfactory spectrum could not be obtained in acetonitrile. When dimethyl sulfoxide was used as a solvent, the nmr spectrum was only slightly better. Even so, the downfield shifts of the methoxyl protons

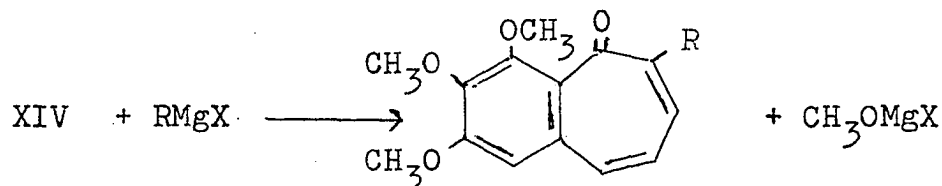
and ring hydrogen atoms are apparent. The hydroxyl proton on XIX, which is not hydrogen bonded as in XVII, resonates at  $\delta=5.6$ . The ultraviolet spectrum is similar to XVII.

Compound XIX, when crystallized from glacial acetic acid, forms the acetate, XX.



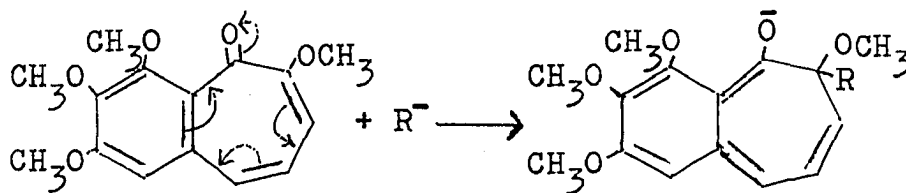
The nmr spectrum shows a resonance at  $\delta=3.3$  from the acetate protons, instead of a hydroxyl proton as in XIX. The failure of XVII to also form the acetate is probably a consequence of the steric interaction of the neighboring methoxyl groups.

An attempt was made to react XIV with several Grignard reagents in order to synthesize a variety of substitution products.



However, in each case, only starting material was recovered. It is assumed that the formation of the substitution product is unlikely because it involves the loss of

aromaticity of the six-membered ring during the course of the reaction.



Polarographic data<sup>16</sup> indicate that this intermediate is likely, although it has not been proven conclusively.

The failure of the amines to add to XIV is probably due to the same cause.



## SUMMARY

It was found that it was possible to prepare and isolate the perchlorate salts of 2,3,4,6-tetramethoxy-5H-benzocyclohepten-5-one and its derivatives. The perchlorate salts could be formed by treating the corresponding alcohol with perchloric acid. In addition, a perchlorate salt could be prepared by a direct reaction of the starting material with acid. The perchlorate salts of the rearranged compound, 2,3,4,6-tetramethoxy-9H-benzocyclohepten-9-one, were also prepared. For all the benzotropolone salts prepared, the nmr spectral data seems to indicate that the positive charge is delocalized over both rings.

It was learned that it was not possible to add Grignard reagents or amines to the benzotropolone system. This could possibly be attributed to the loss of aromaticity of the six-membered ring during the course of the reaction. However, this was not proven conclusively.

## BIBLIOGRAPHY

1. Huckel, E., Z. Physik, 70, 204 (1931).
2. Merling, G., Ber., 24, 3108 (1891).
3. Doering, E. and Knox, L., J. Am. Chem. Soc., 76, 3203 (1954).
4. Dauben, H. and Gadecki, F., J. Am. Chem. Soc., 79, 4557 (1959).
5. Harmon, K., J. Am. Chem. Soc., 83, 865 (1961).
6. Dauben, H., J. Am. Chem. Soc., 77, 4557 (1957).
7. Rennhard, H., Chem. and Ind., 415 (1955).
8. Eschenmoser, A., and Schaeppi, W., Helv. Chim. Acta, 38, 1874 (1955).
9. Buchanan, L. and Lockhart, D., J. Chem. Soc., 1959, 3586.
10. Doering, W. and Hiskey, F., J. Am. Chem. Soc., 74, 5688 (1952).
11. Nozoe, T. and Seto, S., Proc. Japan Acad., 27, 224 (1951).
12. Cook, J. and Raphael, R., J. Chem. Soc., 1952, 4416.
13. Barltrop, J. and Nicholson, J., J. Chem. Soc., 1948, 116.
14. Haworth, R. and More, J., J. Chem. Soc., 1948, 1409.
15. Gillam, A., "An Introduction to Electronic Absorption Spectra in Organic Chemistry," Arnold, London,

1954.

16. Neish, W. and Muller, O., Rec. trav. chim., 72,  
301 (1953).

## VITA

The author was born on December 4, 1942 in Detroit, Michigan. In 1961 he graduated from Cooley High School in Detroit. In 1966 he was graduated from Wayne State University with a degree of Bachelor of Science. The following September he began his graduate studies at Western Michigan University. For his first year, he was awarded a Research Fellowship. During his second year, he was granted a teaching assistantship. He is a member of the American Chemical Society.