

SYNTHESIS OF PYRYLIUM SALTS AND PYRIDINE BASES BY THE BISACYLATION OF CYCLIC TERTIARY ALCOHOLS

G. N. Dorofeenko, Yu. A. Zhdanov, and L. N. Étmetchenko

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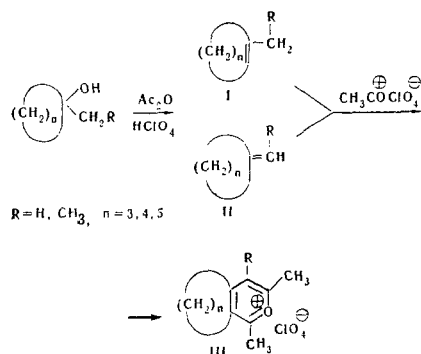
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The catalytic acylation of 1-methyl- and 1-ethylcyclopentan-1-ols, 1-methyl- and 1-ethylcyclohexan-1-ols, 1-methylcycloheptan-1-ol, and 1-methyl- and 1-ethyl-1-tetralols with carboxylic acid anhydrides in the presence of 70% HClO_4 has been studied. A method for the synthesis of substituted 3,4-cycloalkeno-3',4'-dihydro(3,4:2',1')naphthopyrylium salts and the corresponding pyridine bases has been developed.

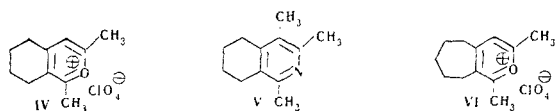
The bisacylation of olefins, discovered in 1959 [1,2], has acquired importance for the synthesis of pyrylium salts of various structures [3,4]. As the starting materials for the preparation of pyrylium compounds, aliphatic [5-8] and aliphatic-aromatic [9,10] tertiary and even secondary alcohols [11] have previously been used with success, in addition to olefins.

Recently, we discovered that extremely readily-accessible cyclic alcohols can take part in the bisacylation reaction with the formation of pyrylium salts [12]. The object of the present work is a further investigation of the method of synthesizing pyrylium salts and pyridine bases using the catalytic acylation of cyclic tertiary alcohols with acid anhydrides in the presence of 70% perchloric acid.

We have shown that under the conditions of the reaction tertiary alicyclic alcohols first undergo dehydration with the formation of a mixture of unsaturated compounds with endocyclic (I) and exocyclic (II) double bonds. The olefins I and II then undergo the bisacylation reaction, forming pyrylium salts of the general formula III by the mechanism reported previously [3,4,7]:



In this way, the bisacylation of 1-methylcyclohexan-1-ol gave a 60% yield of 1,3-dimethyl-5,6,7,8-tetrahydro-2-benzopyrylium perchlorate (IV), which proved to be identical with a sample synthesized previously [7,13].

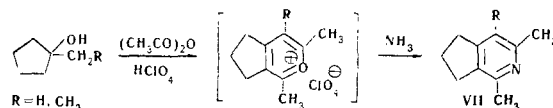


The reaction takes place under mild conditions when the mixture of components (in a ratio of tertiary alcohol to anhydride to 70% HClO_4 of 1 : 6 : 1) is allowed to stand at room temperature for a short time (20-30 min).

In the acetylation of 1-ethylcyclohexan-1-ol it was impossible to isolate a pyrylium salt in the crystalline state, but when the mixture was treated with aqueous ammonia a 64% yield of 1,3,4-trimethyl-5,6,7,8-tetrahydroquinoline (V) was obtained.

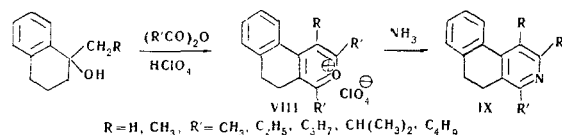
1-Methylcycloheptan-1-ol is readily acetylated by acetyl perchlorate, forming in good yield (47%) the previously unknown 2,6-dimethyl-3,4-cycloheptenopyrylium perchlorate (VI).

Pyrylium salts condensed with a cyclopentene ring are of considerable interest, since these compounds and the quaternary pyridinium salts easily obtained from them are convenient starting materials for the synthesis of pseudoazulenes. We have shown that when 1-methyl- and 1-ethylcyclopentan-1-ols are bisacylated under these conditions, after the treatment of the reaction mixture with ammonia 1,3-dimethyl- and 1,3,4-trimethyl-6,7-dihydro-5H-cyclopenta[c]-pyridines (VII) are obtained with a yield of 45-48%.



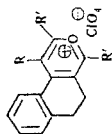
The first of these bases was obtained previously with a yield of 18% by the bisacetylation of methylenecyclopentane [14].

The tertiary alcohols obtained by the reaction of 1-tetralone with organomagnesium compounds [15] (1-methyl- and 1-ethyl-1-tetralols) are also readily bisacylated with acid anhydrides (acetic, propionic, butyric, isobutyric, and valeric) in the presence of 70% HClO_4 with the formation of alkyl-substituted dihydronaphthopyrylium salts (VIII):



The dihydronaphthopyrylium salts of type VIII (see table) were practically unknown previously, with the exception of one representative synthesized recently by a more complicated route [16]. When the pyrylium salts V are treated with an excess of aqueous ammonia

Characteristics of the Dihydronaphthopyrylium Salts



| R | R' | Mp*, °C | Principal strong bands in the IR spectrum, cm ⁻¹ | Empirical formula | Found, % | | | Calculated, % | | | Yield, % |
|-----------------|---|-------------|---|--|----------|------|-------|---------------|------|-------|-------------|
| | | | | | C | H | Cl | C | H | Cl | |
| H | CH ₃ | 189—190 | 1632, 1596, 1570, 1523, 1492, 1096 | C ₁₃ H ₁₃ ClO ₅ | 58.24 | 5.07 | 11.05 | 57.97 | 4.84 | 11.43 | 45 |
| H | C ₂ H ₅ | 159—160 | 1617, 1605, 1560, 1528, 1496, 1094 | C ₁₇ H ₁₉ ClO ₅ | 60.21 | 5.68 | 10.40 | 60.26 | 5.51 | 10.49 | 24 |
| H | C ₃ H ₇ | 156—157 | 1626, 1603, 1580, 1527, 1496, 1102 | C ₁₉ H ₂₃ ClO ₅ | 62.17 | 6.35 | 9.54 | 62.21 | 6.27 | 9.68 | 13 |
| H | CH(CH ₃) ₂ | 121—122 | 1624, 1602, 1564, 1524, 1494, 1100 | C ₁₉ H ₂₃ ClO ₅ | 62.35 | 6.40 | 9.86 | 62.21 | 6.27 | 9.68 | 10 |
| H | <i>n</i> -C ₄ H ₉ | 118—119 | 1623, 1602, 1580, 1524, 1494, 1089 | C ₂₁ H ₂₇ ClO ₅ | 64.05 | 6.90 | 8.93 | 63.87 | 6.84 | 8.99 | 28 |
| CH ₃ | CH ₃ | 177—178 | 1597, 1564, 1478, 1096 | C ₁₆ H ₁₇ ClO ₅ | 59.43 | 5.55 | 10.55 | 59.17 | 5.24 | 10.94 | 30 |
| CH ₃ | C ₂ H ₅ | 124.5—125.5 | 1650, 1602, 1576, 1565, 1516, 1098 | C ₁₈ H ₂₁ ClO ₅ | 61.30 | 6.03 | 9.67 | 61.28 | 5.95 | 10.07 | 11 |

*All the products, isolated in the form of yellow or yellow-green crystals, were purified by crystallization from glacial acetic acid.

solution, they are converted in high yield (70–75%) into dihydroazaphenanthrene compounds (IX).

All the pyrylium salts and pyridine bases that we obtained were individual substances, as was shown by the chromatography of samples of the materials in a thin layer of gypsum [solvent: benzene–chloroform (7 : 8); revealing agent: iodine [17]].

The IR spectra of the salts and pyridine obtained were recorded on an IKS-14 spectrophotometer (NaCl prism) in the form of mulls in paraffin oil. The IR spectra of all the pyrylium compounds obtained exhibited extremely strong absorption bands in the 1650–1617 cm^{-1} (8a), 1560–1520 cm^{-1} (8b), and 1496–1492 cm^{-1} (19a) regions, which are characteristic for the stretching vibrations widely used for the identification of the pyrylium cation [18,19]. A very strong and broad band in the 1100–1090 cm^{-1} region is due to the stretching vibrations of the ClO_4^- anion.

EXPERIMENTAL

The tertiary alcohols were synthesized from methyl- and ethylmagnesium iodides and the corresponding cyclic ketones [15,20].

1,3-Dimethyl-5,6,7,8-tetrahydro-2-benzopyrylium perchlorate. In drops, 0.4 ml of 70% HClO_4 was added to a mixture of 0.5 g of 1-methylcyclohexan-1-ol and 3 ml of acetic anhydride. The reaction mixture became very hot and turned red-brown; it was left for 20–30 min and diluted with a tenfold volume of ether, after which the oily product was separated off and was reprecipitated from propanol. This gave 0.7 g (60%) of colorless crystals with mp 80.5°C. According to the literature [7,13], mp 79–80.5°C. The product gave no depression of the melting point in a mixture with an authentic sample, and their IR spectra—1630, 1528, 1446, and 1088 cm^{-1} —coincided. Found, %: C 50.56; H 5.80; Cl 12.94. Calculated for $\text{C}_{11}\text{H}_{15}\text{ClO}_5$, %: C 50.28; H 5.71; Cl 13.52.

1,3,4-Trimethyl-5,6,7,8-tetrahydroisoquinoline. With ice cooling, 2.4 ml of 70% HClO_4 was added to a solution of 4.1 ml of 1-ethylcyclohexan-1-ol in 18.4 ml of acetic anhydride, and the mixture was left at room temperature for 20–30 min. Then it was poured into a three-fold excess of water and an excess of 22% ammonia solution was added. After 2–3 hr, the organic layer was extracted with ether and re-extracted with 10% HCl. The hydrochloric acid solution was separated off, boiled with activated carbon, and made alkaline. The product was extracted with ether, the solvent was driven off and the residue was distilled in vacuum at 118°C (4–5 mm), giving 0.47 g (64%) of a substance in the form of a colorless liquid (d_{20}^{20} 1.010; n_D^{20} 1.5464) which on standing gradually formed colorless crystals with mp 40–41°C (from petroleum ether). IR spectrum, cm^{-1} : 1678, 1671, 1566, 1480, 1438. Found, %: N 8.30. Calculated for $\text{C}_{12}\text{H}_{17}\text{N}$, %: N 8.00. R_f 0.85 [solvent: benzene–chloroform (2 : 3); revealing agent: iodine]. **Picrate:** mp 135–136°C (from ethanol). Found, %: C 53.37; H 4.97; N 13.67. Calculated for $\text{C}_{12}\text{H}_{17}\text{N} \cdot \text{C}_6\text{H}_3(\text{NO}_2)_3\text{OH}$, %: C 53.46; H 4.95; N 14.86.

1,3-Dimethyl-6,7-dihydro-5H-cyclopenta[c]pyridine was obtained by the method described above from 10 ml of 1-methylcyclopentan-1-ol, 61 ml of acetic anhydride, and 4.2 ml of 70% HClO_4 . Yield 7.14 g (45%) of a dark yellow oil which distilled with decomposition at 15 mm. The pyridine was identified in the form of the picrate with mp 121–122°C. According to the literature [14], mp 121–122°C. Found, %: N 14.60. Calculated for $\text{C}_{10}\text{H}_{13}\text{N} \cdot \text{C}_6\text{H}_3(\text{NO}_2)_3\text{OH}$, %: N 14.89.

1,3,4-Trimethyl-6,7-dihydro-5H-cyclopenta[c]pyridine. 1-Ethylcyclopentan-1-ol was dissolved in 24 ml of acetic anhydride and to this solution 3.2 ml of 70% HClO_4 was added dropwise with ice cooling. By the method described above, the product was obtained in the form of a colorless liquid with bp 103–104°C (8 mm); d_{20}^{20} 0.910; n_D^{25} 1.5360. R_f 0.58 (benzene; revealing agent iodine). Found, %: N 8.65, M_{rD} 69.93. Calculated for $\text{C}_{11}\text{H}_{15}\text{N}$, %: N 8.69, M_{rD} 71.5. IR spectrum, cm^{-1} : 1672, 1656, 1584, 1412–1430.

Picrate, mp 146–147°C (from ethanol). Found, %: C 52.37; H 4.70; N 14.20. Calculated for $\text{C}_{11}\text{H}_{15}\text{N} \cdot \text{C}_6\text{H}_3(\text{NO}_2)_3\text{OH}$, %: C 52.30; H 4.61; N 14.36.

2,6-Dimethyl-3,4-cycloheptenopyrylium perchlorate. A mixture of 1.28 g of 1-methylcycloheptan-1-ol and 10 ml of acetic anhydride was treated in drops with 1 ml of 70% HClO_4 . After the mixture had stood for 20 min at room temperature it was heated in the boiling water bath for 1–2 hr and was then cooled and diluted with 40 ml of ether. The precipitate was filtered off and washed with small portions of tert-butanol and then with ether. This gave 1.3 g (47%) of the pyrylium salt in the form of colorless crystals with mp 111°C (from ethanol). IR spectrum, cm^{-1} : 1634, 1534, 1492, 1092. Found, %: C 52.07; H 6.10; Cl 12.8. Calculated for $\text{C}_{12}\text{H}_{17}\text{ClO}_5$, %: C 52.00; H 6.19; Cl 12.84.

2,6-Dimethyl-3',4'-dihydronaphtho[2',1':3,4]pyrylium perchlorate. A mixture of 0.8 g of 1-methyl-1-tetralol and 3 ml of acetic anhydride was treated with 0.3 ml of 70% HClO_4 , and after 5–10 min it was diluted with a large volume of ether. The crystalline product that had separated out was filtered off, washed with ether, and dried in the air. Yield 0.7 g (45%), mp 189–190°C (from acetic acid).

The other dihydronaphthopyrylium salts information on the yields and properties of which is given in the table were obtained similarly.

1,3-Dimethyl-9,10-dihydro-2-azaphenanthrene. One gram of 2,6-dimethyl-3',4'-dihydronaphtho[2',1':3,4]pyrylium perchlorate was treated with 5–10 ml of 22% ammonia solution and left for 1 hr. The product was extracted with ether and re-extracted with 10% HCl solution. The hydrochloric acid solution was decolorized with carbon and made alkaline and the product was extracted with ether. After the solvent had been distilled off, 0.5 g (75%) of a crystalline product with mp 110–111°C (from petroleum ether) was obtained. R_f 0.72 [solvent: benzene–chloroform (2 : 3); revealing agent: iodine]. IR spectrum, cm^{-1} : 1645, 1593, 1542, 1520, 1508, 1463. Found, %: C 86.18; H 7.20; N 6.45. Calculated for $\text{C}_{15}\text{H}_{15}\text{N}$, %: C 86.12; H 7.17; N 6.69.

1,3,4-Trimethyl-9,10-dihydro-2-azaphenanthrene was obtained by treating 2,5,6-trimethyl-3',4'-dihydronaphtho[2',1':3,4]pyrylium perchlorate with ammonia. Yield 70%, colorless crystals with mp 124–125°C (from petroleum ether). R_f 0.75 [solvent: benzene–chloroform (2 : 3); revealing agent: iodine]. IR spectrum, cm^{-1} : 1562, 1542, 1515, 1462. Found, %: C 86.16; H 7.86; N 6.16. Calculated for $\text{C}_{16}\text{H}_{17}\text{N}$, %: C 86.09; H 7.62; N 6.27.

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Rostov-on-Don State University