Oxidation of IIa-c with Chloranil. A solution of 0.01 mole of II and 0.01 mole of chloranil in 30 ml of absolute toluene was refluxed for 1 h, after which the solvent was removed by distillation, and the residue was dissolved by heating in 40-50 ml of 15% hydrochloric acid. The acid solution was boiled with charcoal twice and filtered. The filtrate was cooled and filtered to remove the unchanged chloranil. The filtrate was neutralized with ammonia, and the reaction product was extracted with chloroform. The extract was washed with water and dried, and the solvent was removed by distillation to give chromatographically pure crystals of 2-substituted perimidine.

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HETEROCYCLIC ANALOGS OF PLEIADIENE

XX.* ACYLATION OF PERIMIDONES, THIOPERIMIDONES, AND 2,3-DIHYDROPERIMIDINES

I. V. Borovlev and A. F. Pozharskii

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Perimidones, thioperimidones, and 2,3-dihydroperimidines are acylated by carboxylic acids in polyphosphoric acid somewhat more readily than perimidines and give 6-acetyl derivatives when there are substituents attached to the nitrogen atom or a mixture of 4- and 6-acetyl derivatives with predominance of the latter in the case of N-unsubstituted compounds.

In our previous paper [2] we showed that perimidines (I), like π-donor aromatic systems (for example, phenols and their alkyl ethers [3]), are readily acylated by carboxylic acids in polyphosphoric acid (PPA) to give 6(7)-acylperimidines at 70-80°C and 4(9)-acylperimidines at 120-150°. Inasmuch as this is hardly the first case of Friedel-Crafts acylation in heterocycles containing a pyridine nitrogen atom, it was important to ascertain whether it is the result of the specific π-donor character of the perimidine system as a whole [4] or is a phenomenon peculiar to the π-donor 1,8-naphthalenediamine fragment. In the latter case, one might have expected that compounds such as 2,3-dihydroperimidines (II), perimidones (III), and thioperimidones (IV) would also underto acylation by carboxylic acids in PPA. The present research was devoted to verification of this possibility. [See structure on top of next page.]

We have found that 1,3-dimethyl-2,3-dihydroperimidine (II) is acetylated by the CH_3COOH–PPA system at 45-50° to give V in 55% yield. The structure of acylation product V and of 6(7)-acylperimidines [2] are readily proved by PMR spectroscopy owing to deshielding of the aromatic peri proton of the unshared pair of electrons of the oxygen atom of the CH_3CO group.

The acylation of perimidones has already been reported. It has been shown [5] that perimidone is acylated by benzoyl chloride in the presence of $AlCl_3$ to give a monobenzoylperimidone of unestablished structure.

*See [1] for communication XIX.

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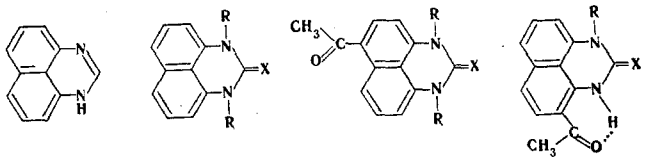

I II-IV V-IX X-XII

II X=H_2, R=CH_3, III X=O; a R=H; b R=CH_3; IV X=S; a R=H; b R=CH_3; V X=H_2; R=CH_3; VI X=O, R=H; VII X=O, R=CH_3; VIII X=S, R=H; IX X=S, R=CH_3; X X=O, R=H; XI X=O, R=CH_3; XII X=S, R=H

Christmann [6] later found that perimidone is acylated by aroyl chlorides at high temperatures without a catalyst to give 4-aroylperimidones. However, he was unable to acylate 1,3-dimethylperimidone (IIIb) under these conditions [6].

Despite Christmann's findings, we have found that IIIb is acylated extremely readily in PPA: 6-Acetyl derivative VII is formed in 60% yield at 50-55°. However, in addition to VII, we also isolated another compound in 30% yield to which we assigned the 1,3,8-trimethyl-2,3-dihydro-6H-benzo[g,h]perimidine-2,6-dione structure (Fig. 1) on the basis of the results of elementary analysis and the IR and PMR spectra. The formation of such peri-cyclic compounds – phenalenones – is known in the chemistry of α-acylnaphthalenes [7]. Unsubstituted perimidone (IIIa) is acetylated by the CH_3COOH–PPA system to give 4- and 6-acetylperimidones (X and VI) in low yields at 50-55°. The amount of side products and the amount of resinification products increased sharply when the temperature is raised to 75-80°. It is difficult to separate isomeric X and VI because of their low solubilities in many solvents. To prove their structures we subjected them to exhaustive methylation with excess methyl iodide in alkaline media and obtained 6-acetyl-1,3-dimethylperimidone (VII), which we have already described, from VI and 1-methyl-4-acetylperimidone (XI) from X. The IR spectrum of XI contains a broad ν_{NH} band at 3230 cm^{-1}, which constitutes evidence for the presence of a strong intramolecular hydrogen bond that is not cleaved in alkaline media. Aceperimidone, in which the 6 and 7 positions, are blocked forms only a 4-acetyl derivative on acylation.

Acetylation of 1,3-dimethylthioperimidone (IVb) at 50-55° in PPA gives 6-acetyl derivative IX, the structure of which was proved by alternative synthesis by thiolation of V with elementary sulfur. Thioperimidone IVa, like perimidone, is acetylated under the same conditions to give two isomeric acetylthioperimidones (VIII and XII), which we also obtained by thiolation of, respectively, 6(7)- and 4(9)-acetylperimidines. Although the thiolation of the latter, in contrast to the thiolation of V, proceeds with extremely pronounced resinification, it makes it possible to confirm the structures of thiones VIII and XII.

Our study showed that electrophilic C-acylation with carboxylic acids in PPA is characteristic not only for perimidines but also for 2,3-dihydroperimidines, perimidones, and thioperimidones. This confirms an earlier conclusion regarding the isolated character of the 1,8-naphthalenediamine π-electron fragment in the I molecule, which is also responsible for the π-donor character of perimidines. The more difficult acylation of I can be explained by the fact that perimidine undergoes reaction in the cationic form, whereas the considerably less basic II-IV are acylated in the base form.

EXPERIMENTAL

The PMR spectra of 0.4 M solutions of the compounds in $CDCl_3$ were recorded with a Tesla spectrometer (80 MHz) with hexamethyldisiloxane as the internal standard. The IR spectra were recorded with a UR-20 spectrometer. The identical character of the substances obtained by alternative syntheses was determined from the absence of melting-point depressions and from the IR spectra.

Acetylation of 1,3-Dimethyl-2,3-dihydroperimidine. A mixture of 1 g (5 mmole) of II, 0.33 ml (5.5 mmole) of acetic acid, and 10 g of PPA was stirred at 45-50° for 5 h, after which it was poured into 100 ml of water, and the aqueous mixture was made alkaline to pH 8 with ammonia. The resulting precipitate was removed by filtration, washed with water, and chromatographed with a column filled with Al_2O_3 with elution of the first fraction by chloroform to give 0.66 g (55%) of light-green crystals of V with mp 143-144° (from alcohol). PMR spectrum,* δ, ppm: 2.56 (CH_3CO, s); 2.82 and 2.91 (N–CH_3 groups, two s); 4.05 ($\rangle CH_2$, s); 6.26 (aromatic H_4, d, J_{4-5} = 8 Hz); 6.48 (H_9, d, J_{8-9} = 7.8 Hz); 7.38 (H_8, m); 7.87 (H_5, d, J_{5-4} = 8 Hz); 8.58 (H_7, d, J_{7-8} = 9 Hz). Found %: C 74.8; H 7.0; N 11.8. $C_{15}H_{16}N_2O$. Calculated %: C 75.0; H 6.7; N 11.7.

*Here and subsequently, s is singlet, d is doublet, and m is multiplet.

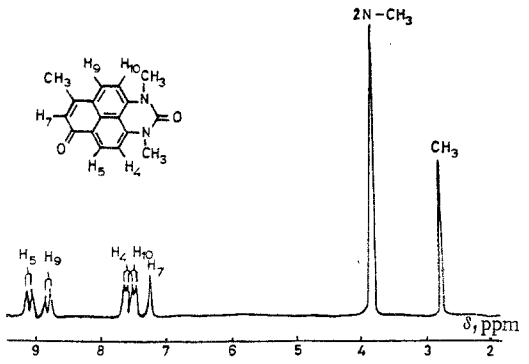

Fig. 1. PMR spectrum of the side product in the acetylation of 1,3-dimethylperimidone (in CF_3COOH).

Acetylation of 1,3-Dimethylperimidone. A mixture of 1.05 g (5 mmole) of IIIb, 0.36 ml (6 mmole) of acetic acid, and 10 g of PPA was stirred at 50-55° for 3.5 h, after which it was poured into 100 ml of water, and the aqueous mixture was made alkaline to pH 8 with ammonia. The resulting precipitate was removed by filtration, washed with water, dried, and chromatographed with a column filled with ~200 g of Al_2O_3 with elution of the first and second zones with chloroform. The first fraction yielded 0.7 g (60%) of pale-yellow crystals of 6-acetyl-1,3-dimethylperimidone with mp 210-211° (from alcohol). PMR spectrum, δ, ppm: 2.58 (CH_3CO, s), 3.32 (two N–CH_3 groups, s), 6.34 (aromatic H_4, d, $J_{4-5} = 8.4$ Hz); 6.54 (H_9, d, $J_{8-9} = 8.2$ Hz); 7.4 (H_8, m); 7.85 (H_5, d, $J_{5-4} = 8.4$ Hz); 8.9 (H_7, d, $J_{7-8} = 8.9$ Hz). Found %: C 70.4; H 5.4; N 10.9. $C_{15}H_{14}N_2O_2$. Calculated %: C 70.8; H 5.6; N 11.0. The second fraction yielded 0.4 g (30%) of orange crystals of 1,3,8-trimethyl-2,3-dihydro-6H-benzo[g,h]perimidine-2,6-dione with mp 314-315° (dec., from xylene). Found %: C 73.1; H 5.3; N 10.1. $C_{17}H_{14}N_2O_2$. Calculated %: C 73.4; H 5.1; N 10.0.

Acetylation of 1,3-Dimethylthioperimidone. A mixture of 1.15 g (5 mmole) of IVb, 0.45 ml (7.5 mmole) of acetic acid, and 10 g of PPA was stirred at 50-55° for 7 h, after which it was poured into 100 ml of water, and the aqueous mixture was made alkaline. The resulting yellow precipitate was removed by filtration, washed with water, dried, and dissolved in the minimum amount of chloroform. The chloroform solution was transferred to a chromatographic column, and the first and second zones were eluted with benzene.* The first fraction yielded 0.54 g (47%) of starting IVb, and the second fraction yielded 0.65 g (48%) of 6-acetyl-1,3-dimethylthioperimidone (IX), which was obtained as light-brown crystals with mp 240-241° (from benzene). Found %: N 10.2. $C_{15}H_{14}N_2OS$. Calculated %: N 10.4.

Acetylation of Perimidone. A mixture of 0.9 g (5 mmole) of IIIa, 0.45 ml (7.5 mmole) of acetic acid, and 10 g of PPA was stirred at 50-55° for 3 h, after which it was poured into 100 ml of water, and the aqueous mixture was made alkaline with ammonia. The resulting precipitate was removed by filtration, washed with water, dried, pulverized, and treated twice with a hot chloroform–alcohol mixture (20:1) (40 × 30 ml [sic]). The extracts were combined and transferred to a chromatographic column filled with ~350 g of Al_2O_3; the first zone was eluted with the same solvent mixture (it is convenient to follow the movement of the zones in UV light). The second zone was separated by extrusion of the Al_2O_3 from the column and elution with alcohol. The first fraction yielded 0.11 g (10%) of 4-acetylperimidone (X) as light-green crystals with mp 279-281° (dec., from nitrobenzene). Found %: C 68.6; H 4.4; N 12.6. $C_{13}H_{10}N_2O_2$. Calculated %: C 69.0; H 4.5; N 12.4. The second zone yielded 0.22 g (20%) of 6-acetylperimidone (VI) as yellow crystals with mp 313-315° (dec., from aqueous acetic acid). Found %: C 69.4; H 4.8; N 12.8. $C_{13}H_{10}N_2O_2$. Calculated %: C 69.0; H 4.5; N 12.4.

Acetylation of Aceperimidone. The acetylation was carried out under the conditions used for the acetylation of perimidone (for 3.5 h). The reaction product was purified by refluxing a solution of it in acetic acid with charcoal; dilution of the solution with water precipitated 4-acetylaceperimidone. A 1.05-g sample of aceperimidone yielded 0.6 g (48%) of yellow-green crystals of 4-acetylaceperimidone with mp 340-341° (dec., from glacial acetic acid). Found %: C 70.9; H 5.1; N 10.8. $C_{15}H_{12}N_2O_2$. Calculated %: C 71.4; H 4.8; N 11.1.

Acetylation of Thioperimidone. The acetylation was carried out under the conditions used to acetylate perimidone (for 3.5 h). The reaction product was pulverized, heated with 20 ml of chloroform, and the solution, together with the solid, was transferred to a chromatographic column filled with Al_2O_3 (~200 g); the contents were eluted successively with chloroform (first fraction) and chloroform–alcohol (10:1) (second fraction). The first fraction yielded 0.09 g (7%) of XII, and the second fraction yielded 0.5 g (41%) of VIII. 4-Acetylthioperimidone (XII) was obtained as yellow-green crystals with mp 286-288° (dec., from xylene). Found %: N 11.7. $C_{13}H_{10}N_2OS$. Calculated %: N 11.6. 6-Acetylthioperimidone (VIII) was obtained as yellow-green crystals with mp 300-302° (dec., from aqueous alcohol). Found %: N 11.7. $C_{13}H_{10}N_2OS$. Calculated %: N 11.6.

Methylation of 4- and 6-Acetylperimidones. A 0.68-g (3 mmole) sample of VI or X and 1.1 ml (18 mmole) of CH_3I were added to a solution of 1.2 g (18 mmole) of KOH in 30 ml of alcohol, after which the mixture was

*After evaporation of the solvent, 0.1 g of brown crystals was obtained by extrusion of the Al_2O_3 from the column and elution of the substance from the third zone, adjoining the start; however, we were unable to isolate an individual compound from the crystals.

refluxed for 3 h. The alcohol was then removed by distillation, and the residue was treated with 10 ml of chloroform and chromatographed with a column filled with Al_2O_3 (~150 g); the first fraction was eluted with chloroform. This procedure gave 0.21 g (28%) of VII, with mp 209-210°, (from alcohol), from VI. It also gave 0.21 g (30%) of yellow-green crystals of 1-methyl-4-acetylperimidone, with mp 163-164° (from aqueous alcohol), from X. Found %: C 70.4; H 5.0; N 12.0. $C_{14}H_{12}N_2O_2$. Calculated %: C 70.0; H 5.0; N 11.7.

Thiolation of 6-Acetyl-1,3-dimethyl-2,3-dihydroperimidine. A thoroughly ground mixture of 0.72 g (3 mmole) of V and 0.3 g (9 mmole) of sulfur was heated on an oil bath to 145° and held at this temperature for 1 h, after which it was cooled, and the solid was dissolved in chloroform and chromatographed with a column filled with Al_2O_3. The first fraction was eluted with chloroform. The yield of thione IX was 0.8 g (close to quantitative).

Thiolation of 4(9)- and 6(7)-Acetylperimidines. A thoroughly ground mixture of 0.63 g (3 mmole) of 4(9)- or 6(7)-acetylperimidine and 0.3 g (9 mmole) of sulfur was heated on a silicone bath to 205-215° and held at this temperature for 30 min. The product was purified by chromatography. The yield of XII was 0.1 g (14%) (elution with chloroform). The yield of VIII was 0.07 g (10%) [elution with chloroform–ethanol (10:1)].

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HETEROCYCLIC ANALOGS OF PLEIADIENE

XXI.* ELECTROPHILIC ACYLATION AND NITRATION OF THE PERIMIDINIUM CATION

I. V. Borovlev, A. F. Pozharskii, and V. N. Koroleva

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The 6 position of the 1,3-dimethylperimidinium cation is readily acylated by acetic acid in polyphosphoric acid and nitrated by nitric acid in acetic acid. 6-Acetyl- and 6-nitro-1,3-dimethylperimidinium salts are converted to a mixture of 6-acetyl and 6-nitro derivatives of 1,3-dimethylperimidone and 1,3-dimethyl-2,3-dihydroperimidine on treatment with aqueous alkali.

It is known that aza aromatic compounds such as azines and azoles usually are not acylated by the Friedel–Crafts reaction and also undergo other electrophilic substitution reactions (for example, nitration) with difficulty. This is explained by the formation in acidic media of cations of the corresponding heterocycles, which are distinguished by their low reactivities with respect to electrophiles. However, even in extremely acidic media electrophilic substitution reactions may, theoretically, proceed with the participation of small equilibrium amounts of the unprotonated form of the heterocycle [2]. In connection with the exceptionally high reactivities of perimidines (which we observed in [3]), which are acylated [3] and nitrated [4] in acidic media

*See [1] for communication XX.

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