HYDROACRIDINES AND RELATED COMPOUNDS.

23.* CAPROLACTAM DERIVATIVES AND HYDROCOUMARINS FROM 4a,10a-EPIDIOXYPERHYDROACRIDINES

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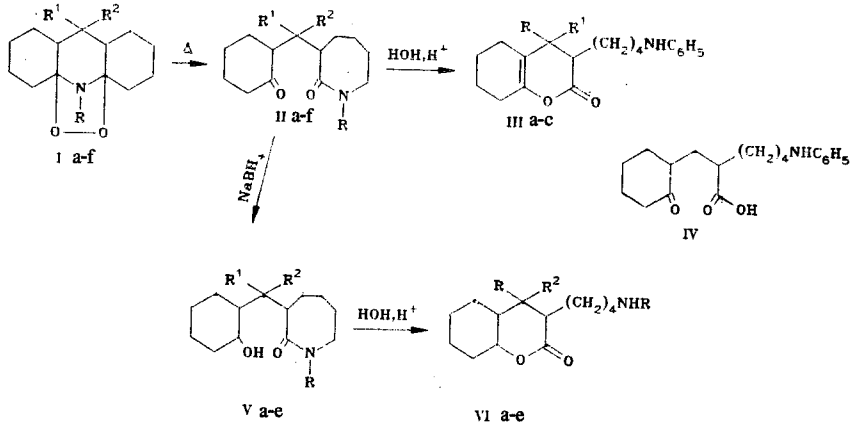
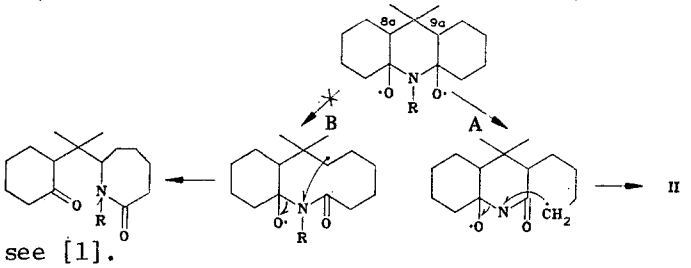
The thermolysis of 10-R,9-R^1,9-R^2-4a,10a-epidioxyperhydroacridines has given 1-R-3-[α-(2'-oxocyclohexyl)alkyl]hexahydroazepin-2-ones which have been reduced to the corresponding 2'-hydroxycyclohexyl derivatives. Hydrolysis of the compounds obtained led to 3-[δ-(R-amino)butyl]hydrocoumarins.

4a,10a-Epidioxyperhydroacridines (I) are obtained by the addition of hydrogen peroxide to the readily accessible decahydroacridines [1]. The thermolysis of 1,1'-peroxydicyclohexylamine gives caprolactam and cyclohexanone [2], and the thermolysis of the amino peroxides (I) should by an analogous mechanism lead to products combining caprolactam and cyclohexanone fragments, which presents preparative interest.



I, II, V, VI a $R=R^1=C_6H_5$, $R^2=H$; b $R=C_6H_5$, $R^1=R^2=H$; c $R=CH_2C_6H_5$, $R^1=C_6H_5$, $R^2=H$; d $R=C_6H_5$, $R^1=CH_2C_6H_5$, $R^2=H$; e $R=C_6H_5$, $R^1+R^2=(CH_2)_5$; f $R=C_6H_4OH$-*o*, $R^1+R^2=(CH_2)_5$; III a $R=C_6H_5$, $R^1=H$; b $R=CH_2C_6H_5$, $R^1=H$; c $R+R^1=(CH_2)_5$

The thermolysis of compounds (Ia-e) took place readily at 140-145°C (boiling in xylene), while on boiling in toluene the process was considerably slower. The main products of thermolysis were the keto lactams (IIa-f), in the majority of cases with preparative yield. The formation of the keto lactams took place regiospecifically. On the basis of an analogy with the thermolysis of 1,1'-peroxydicyclohexylamine [2], it may be assumed that the fragmentation of the biradical initially formed took place only by route A.



*For communication 22, see [1].

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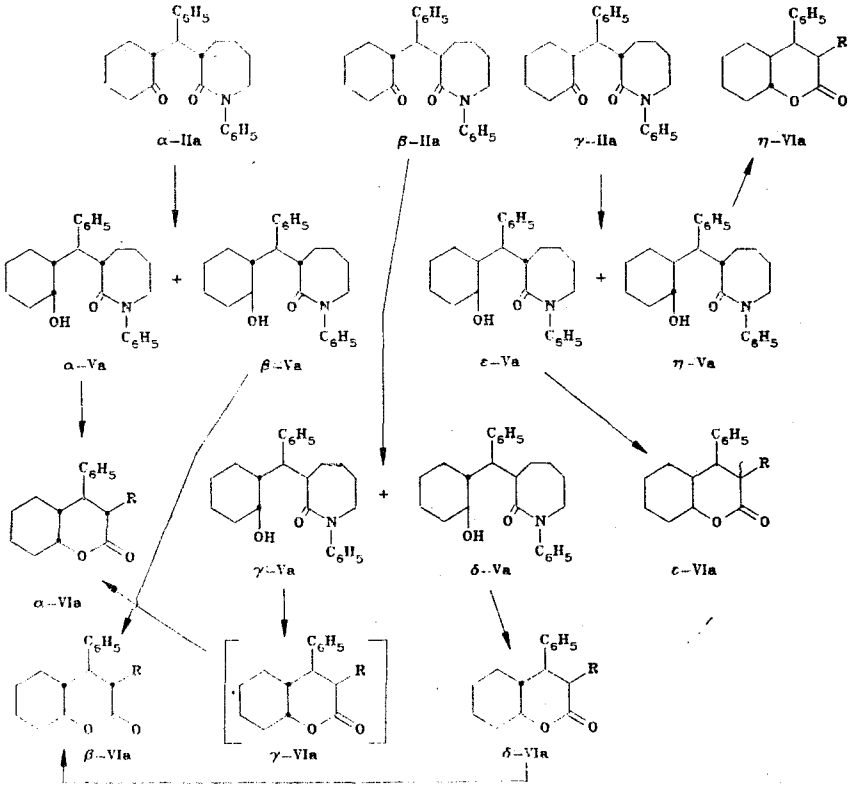
This was confirmed by the fact that thermolysis proceeded without affecting the (C_{8a}) and (C_{9a}) centers of the hydroacridine system of the peroxides [1]: their stereoisomeric peroxides [1] formed different stereoisomers of the keto lactams (II). Trans-syn-trans-(Ia) formed the keto lactam α-(IIa); while trans-anti-cis-(Ia) formed a mixture of two other stereoisomers — β-(IIa) and γ-(IIa); trans-syn-trans-(Ib) gave the keto lactam α-(IIb), and trans-anti-cis-(Ib) the stereoisomeric keto lactam β-(IIb); peroxide (Ic), having the trans-syn-trans configuration and the peroxides (Ie) and (If) symmetrically substituted in position 9 and having the trans-anti-cis configuration each formed a single keto lactam — (IIc), (IIe), and (IIf), respectively; from peroxide (Id), possessing the trans-anti-cis configuration, a mixture of the stereoisomeric keto lactams α-(IId) and β-(IId) was obtained.



$R = (CH_2)_4NHC_6H_5$

The IR spectra of compounds (II) (Table 1) contained two strong absorption bands of C=O groups: amide in the 1630-1655 and ketone in the 1700-1705 cm^{-1} regions. Absorption in the region above 3100 cm^{-1} was observed only in the spectrum of the lactam (IIf).

The mass spectra of the keto lactams (II) contained, in addition to the peaks of the molecular ions corresponding to the calculated molecular weights, relatively weak peaks with m/z M − 28 (ejection of CO), fairly strong peaks with m/z M − 97 (detachment of a cyclohexanone fragment from the molecular ion), and peaks with the maximum intensity corresponding to the masses of the corresponding N-R-caprolactams (m/z 189 for (IIa, b, d, e), 203 for (IIc) and 205 for (IIf)); the latter shows an intense fragmentation of the molecular ion by a retro-Michael scheme, which is characteristic for the mass spectra of 1,5-dicarbonyl compounds [3].

When the keto lactams (IIa, b, d, e) were boiled with solutions of acids, the lactam rings opened and, in cases (IIa, d, e), derivatives of 3,4,5,6,7,8-hexahydrochromen-2-one (hexahydrocoumarin) (IIIa-c) were formed, while (IIb) gave the amino keto acid (IV). The process was accompanied by an interconversion of the stereoisomeric keto lactams (II). The occurrence of the process by a mechanism of intramolecular alcoholysis of the lactam ring after the enolization of the cyclohexanone fragment is not excluded, since the (II)→(III) transformation also proceeded in an anhydrous medium in the presence of a catalytic amount of p-toluenesulfonic acid (shown for the case of α-(IIa) as example). The opening of the lactam ring took place fairly slowly (apart from the case of (IIe)), and in the case of (IIc) it could not be performed.

TABLE 1. IR Spectra of Compounds (II-VI)

Compound	IR spectrum, cm^{-1}	Compound	IR spectrum, cm^{-1}	Compound	IR spectrum, cm^{-1}
α-IIa	1651, 1704	IV	1710, 3440	α-VIa	1730, 3420
β-IIa	1645, 1702	α-Va	1643, 3460 (s), 3600 (vw)	β-VIa	1719, 3410
γ-IIa	1640, 1699			δ-VIa	1734, 3415
α-IIb	1644, 1705	β-Va	1640, 3435 (s), 3618 (w)	ε-VIa	1712, 3410
β-IIb	1635, 1700	γ-Va	1641, 3440 (s), 3624 (w)	η-VIa	1727, 3410
IIc	1638, 1703	δ-Va	1636, 3430 (s), 3626 (w)	VIb	1718, 3426
α-IId	1644, 1701	ε-Va	1640, 3445 (s), 3615 (w)	α-VIc	1730, 3400
β-IId	1640, 1700	η-Va	1640, 3435 (s), 3618 (w)	β-VIc	1710, 3450
IIe	1654, 1701	α-Vb	1645, 3465 (s), 3625 (vw)	α-VId[a]	1705
IIf	1630, 1701, 3600			β-VId	1709, 3408
IIIa	1746, 1700, 3400	β-Vb	1634, 3450 (s), 3615 (vw)	γ-VId	1734, 3410
IIIb	1753, 1710, 3420			VIe	1714, 3426
IIIc	1746, 1700, 3430	α-Vc	1620, 3440		
		β-Vc	1630, 3440		
		α-Vd	1643, 3453, 3620 (w)		
		β-Vd	1635, 3445 (s), 3615 (w)		
		γ-Vd	1629, 3435 (s), 3610 (vw)		

[a] α-(VId) — hydrochloride.

In the IR spectra of the hexahydrocoumarins (III) there was strong absorption of the lactone carbonyl at about 1750 cm^{-1} and a band of lower intensity at about 1700 cm^{-1} (C=C), which corresponds to known features of similar hexahydrocoumarins [4], and there was also a band at about 3400 cm^{-1} (NH). In the spectrum of compound (IV) a strong band of carbonyl absorption was located at 1700 cm^{-1} and there was the absorption of a bound OH group in the form of a broad band in the 2600-3200 cm^{-1} region which was absent from the spectra of compounds (III). Compounds (IV), unlike compounds (III), readily dissolved in solutions of alkali in the cold.

The transition to hydroxycoumarins took place considerably more readily if the keto groups of the keto lactams (II) were first reduced to hydroxy groups. In all the cases that we investigated, the reduction of one of the keto lactams (II) led to a mixture of two stereoisomeric hydroxy lactams (V), one of which had the cis and the other the trans configuration with respect to the cyclohexane fragment (determined from the nature of the linkage of the rings in the perhydrocoumarins (VI) obtained from the hydroxy lactams (V)). This permits the assumption that in the course of the reduction the asymmetric centers of the keto lactams (II) were not affected. All six stereoisomeric hydroxy lactams (Va) (α-Va–η-Va) formed from the three stereoisomeric keto lactams (IIa) were isolated. When the keto lactams α-(IIb), (IIc) and α-(IId) were reduced, the corresponding cis (α-(Vb), α-(Vc), and α-(Vd)) and trans (β-(Vb), β-(Vc), and β-(Vd)) hydroxy lactams were isolated, while the reduction of the keto lactam β-(IId) gave only the trans hydroxy lactam γ-(Vd).

In the IR spectra of the hydroxy lactams (V) the absorption band of the ketone carbonyl had disappeared while the band of the amide carbonyl was retained, and strong absorption of an OH group appeared in the 3435-3465 cm^{-1} region. The position of the latter did not change on dilution, which shows the existence of a strong intramolecular hydrogen bond, while the bands of an unbound OH group had a low or insignificant intensity even at maximum dilution. The mass spectra of the hydroxy lactams(V) contained, in addition to the peaks of the molecular ions corresponding to the calculated molecular weights, strong peaks with m/z M − 18 and m/z M − 99 (ejection of a hydroxycyclohexyl fragment), and also peaks corresponding to the masses of the corresponding N-R caprolactams, the intensities of which were considerably lower than for the keto lactams (II).

When they were heated with solutions of acids, the hydroxy lactams (V) passed readily and quantitatively into perhydrocoumarin derivatives (VI). There was no need for acid catalysis to obtain the coumarin (VIe); it was formed directly in the course of the reduction of the keto lactam (IIe) with $NaBH_4$, and the intermediate hydroxy lactam (Ve) could not be detected. The ease of conversion is obviously explained by the fact that in compounds (V) the intramolecular alcoholysis of the amide bond of the lactam ring is substantially facilitated in comparison with the keto lactams (II).

For each pair of hydroxy lactams (V) obtained from a single keto lactam (II) two different hydrocoumarins (VI) were formed, one of which, according to PMR spectra, had the cis and the

TABLE 2. PMR Spectra of the Perhydrocoumarin Derivative (VI)

Compound	Chemical shifts, ppm (SSCC, Hz)						
	3-H (1H)	4-H (1H)	8a-H (1H)	CH_2NR (2H)	NH (1H)	Ar—H[a] (1H)	Ar—H[b] (1H)
α-VIa	2,72 m	2,40 q (12; 4,5)	4,77 m (9)[c]	3,00 t (7)	3,63 nr. s	6,55 d (8)	6,68 t (8)
β-VIa	2,78 m	2,57 t (10,8)	4,03 t.d (11; 4,5)	3,04 t (6,5)	3,58 nr.s.	6,56 d (8)	6,68 t (7)
δ-VIa	2,85 m	2,80 q[d]	4,12 t.d (10; 4,5)	2,98 t (6,5)	3,63 br.s.	6,53 d (8)	6,68 t (7)
ε-VIa	3,10 m	3,20 q (12,5; 4)	4,65 m (7)[c]	3,03 t (6,5)	3,53 br.s.	6,56 d (8)	6,67 t (8)
η-VIa[e]	2,78 m	2,93 t (6)	4,15 t.d (11; 4,5)	3,13 t (8)	—	—	—
VIb	2,56 m	—	3,85 t.d (10,5; 4)	3,14 t (6,5)	3,62 s	6,62 d (8)	6,69 t (7)
α-VIc	2,74 m	2,38 q (12; 4,5)	4,77 br.s (9)[c]	2,53 t (7)	2,50[d]	—	—
β-VIc	2,80 m	2,50[d]	4,03 t.d (11; 4,5)	2,56t (7)	2,75[d]	—	—
α-VId[e]	2,30 m	—	4,35 m (8)[c]	3,23 t (7)	—	—	—
β-VId	2,20 m	—	4,20 t.d (10,5; 4,5)	2,90 t (7)	—	6,53 d (8)	6,60 t (7)
γ-VId	—	—	3,94 t.d (11; 4,5)	3,17 t (6,5)	3,69 nr.s	6,63 d (8)	6,70 t (7)
VIe	2,90 m	—	4,03 t.d (11; 4)	3,14t (6,5)	3,70 nr.s.	6,62 d(8)	6,70 t (7)

[a]Protons in the ortho position to the NH group. [b]Protons in the para position to the NH group. [c]Width of the signal, Hz. [d]Signal partially masked by neighboring signals. [e]Hydrochloride.

other trans linkage of the rings. This permits the conclusion that in the course of hydrolysis the configuration of the cyclohexane fragment of the hydroxy lactam (V) did not change and, consequently, this fragment of the corresponding hydroxy lactam (V) had the cis or the trans configuration. At the same time, in individual cases the configuration in the α position to the carbonyl of the lactam ring of the hydroxy lactam (V) (in position 3 of the corresponding hydrocoumarin (VI)) did change. The hydroxy lactams α-(Va) and β-(Va) formed the cis-linked coumarin α-(VIa) and the trans-linked coumarin β-(VIa), respectively. Mild hydrolysis of the hydroxy lactam δ-(Va) gave the trans-linked coumarin δ-(VIa), which, under more severe conditions using acids or alkalis, isomerized to the coumarin β-(VIa) as the result of inversion of the configuration at $C_{(3)}$. In the case of the hydroxy lactam γ-(Va), such isomerization was observed even under mild conditions: as the product of its hydrolysis it was possible to isolate only the coumarin α-(VIa). On the basis of the PMR spectrum, for isomer β-(VIa) it was possible to assume the trans-trans-trans configuration, i.e., it retained the configuration of the asymmetric centers of the initial keto lactam α-(IIa). The isomer δ-(VIa), which, in this case, should have the cis-trans-trans configuration (here and below, reckoning from $C_{(3)}$) was less stable than β-(VIa) (since it contained the group R in the axial position), which explains the isomerization of δ-(VIa) into β-(VIa). The isomer α-(VIa) most probably had the trans-trans-cis configuration (i.e., it likewise retained the configuration of the keto lactam α-(IIa)), while an isomer that we did not obtain, γ-(VIa), has the cis-trans-cis configuration, since the latter is less stable (either phenyl or R in the axial position), which explains the formation of the isomer α-(VIa) in the hydrolysis of the hydroxy lactam γ-(Va). The cis-linked coumarin ε-(VIa) was synthesized from the hydroxy lactam ε-(Va), and the trans-linked coumarin η-(VIa) from the hydroxy lactam η-(Va). It does not appear possible to judge the complete spatial configuration of the isomer ε-(VIa) from the PMR spectrum, but of its two possible configurations, trans-cis-cis (hydrolysis of ε-(Va) without inversion at $C_{(3)}$) is more stable than cis-cis-cis (hydrolysis with inversion). For the coumarin η-(VIa) the cis-cis-trans configuration is proposed on the basis of the PMR spectrum, i.e., the hydrolysis of the hydroxy lactam η-(Va) took place with the inversion of the configuration at $C_{(3)}$. In actual fact, the alternative trans-cis-trans configuration (hydrolysis without inversion) should possess the lowest stability (both phenyl and R axial).

The hydrolysis of the hydroxy lactam β-(Vb) gave the trans-linked coumarin (VIb); the hydroxy lactam α-(Vc) and β-(Vc) gave the cis-coumarin α-(VIc) and the trans-coumarin β-(VIc),

TABLE 3. Characteristics of the Compounds Synthesized

Compound	mp,[a] °C	Found, %			Empirical formula	Calculated, %			Yield, %
		C	H	N		C	H	N	
α-IIa	169—170	79,8	7,5	3,9	$C_{25}H_{29}NO_2$	80,0	7,8	3,7	83
β-IIa	131—132	80,0	7,5	3,6	$C_{25}H_{29}NO_2$	80,0	7,8	3,7	35
γ-IIa	147—148	80,1	7,5	4,0	$C_{25}H_{29}NO_2$	80,0	7,8	3,7	26
α-IIb	104—105	76,5	8,4	4,4	$C_{19}H_{25}NO_2$	76,2	8,4	4,7	69
β-IIb	79—80	76,4	8,8	4,9	$C_{19}H_{25}NO_2$	76,2	8,4	4,7	42
IIc	187—188	80,1	8,0	3,5	$C_{26}H_{31}NO_2$	80,2	8,0	3,6	45
α-IId	155—156	80,5	8,0	3,7	$C_{26}H_{31}NO_2$	80,2	8,0	3,6	29
β-IId	152—153	80,0	7,8	3,6	$C_{26}H_{31}NO_2$	80,2	7,8	3,6	42
IIe	152—152	78,4	8,2	4,0	$C_{24}H_{33}NO_2$	78,4	9,1	3,8	55
IIf[b]	178—179	75,4	8,4	3,8	$C_{24}H_{33}NO_3$	75,2	8,7	3,7	40
IIIa	151—155	73,4	7,7	3,0	$C_{25}H_{30}ClNO_2$	72,9	7,3	3,4	30
IIIb	133—134	80,6	8,3	3,8	$C_{26}H_{31}NO_2$	80,2	8,0	3,6	35
IIIc	Oil	77,8	9,1	4,1	$C_{24}H_{33}NO_2$	78,4	9,1	3,8	94
IV[c]	167—168	60,6	6,4	14,1	$C_{25}H_{31}N_5O_6$	60,4	6,3	14,1	90
α-Va	203—204	79,6	8,4	3,9	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	66
β-Va	178—180	79,5	8,2	4,1	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	15
γ-Va	199—201	79,5	8,0	3,5	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	44
δ-Va	197—198	79,9	8,7	3,7	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	45
ε-Va	191—192	79,6	8,7	3,6	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	43
η-Va	204—205	79,9	8,6	3,9	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	30
α-Vb	110—111	75,5	9,3	4,6	$C_{19}H_{27}NO_2$	75,7	9,0	4,7	36
β-Vb	113—114	75,4	9,3	4,4	$C_{19}H_{27}NO_2$	75,7	9,0	4,7	49
α-Vc	182—183	80,7	8,6	3,4	$C_{26}H_{33}NO_2$	79,8	8,5	3,6	45
β-Vc	162—163	80,3	8,8	3,4	$C_{26}H_{33}NO_2$	79,8	8,5	3,6	41
α-Vd	167—169	80,1	8,7	3,8	$C_{26}H_{33}NO_2$	79,8	8,5	3,6	21
β-Vd	125—127	79,9	8,8	3,9	$C_{26}H_{33}NO_2$	79,8	8,5	3,6	60
γ-Vd	158—160	79,6	8,2	3,6	$C_{26}H_{33}NO_2$	79,8	8,5	3,6	55
α-VIa[b]	98—99	79,4	8,3	3,8	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	91
β-VIa[b]	174—176	72,3	8,0	3,0	$C_{25}H_{32}ClNO_2$	72,5	7,8	3,4	88
δ-VIa	123—124	79,1	8,2	3,9	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	71
ε-VIa	111—112	80,0	8,8	3,6	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	80
η-VIa	94—95	79,8	8,5	3,5	$C_{25}H_{31}NO_2$	79,5	8,3	3,7	85
VIb[b]	82—83	75,9	9,2	4,7	$C_{19}H_{27}NO_2$	75,7	9,0	4,7	92
α-VIc[b]	174—176	73,1	7,7	3,1	$C_{26}H_{34}ClNO_2$	73,0	8,0	3,3	90
β-VIc[b]	151—154	73,5	8,5	3,4	$C_{26}H_{34}ClNO_2$	73,0	8,0	3,3	86
α-VId[b]	160—161	72,5	7,8	3,1	$C_{26}H_{34}ClNO_2$	73,0	8,0	3,3	88
β-VId	98—100	80,2	8,6	3,3	$C_{26}H_{33}NO_2$	79,8	8,5	3,6	95
γ-VId	115—116	79,5	8,6	3,8	$C_{26}H_{33}NO_2$	79,8	8,5	3,6	90
VIe	113—114	78,1	9,6	3,8	$C_{24}H_{35}NO_2$	78,0	9,6	3,8	58

[a]Compounds α-(IIa), (IIc, e, f), α-, β-, γ-, and δ-(Va), and α- and β-(Vc) were crystallized from ethyl acetate; α-(IIb) from 70% ethanol; ε- and η-(Va), α, and β-(Vb), α-, β-, and γ-(Vd), β- and γ-(VId), and (VIe) from acetone—hexane (1:2); β-(VIa), α-(VIIc), and α-(VID) from ethanol—ether (1:2). The other compounds were crystallized from ethanol. [b]Hydrochloride. [c]2,4-DNPH.

respectively; and the hydroxy lactams α-(Vd), β-(Vd), and γ-(Vd) gave, respectively, the cis-coumarin α-(VId), the trans-coumarin β-(VId), and the trans-coumarin γ-(VId). The coumarin (VIe) had the trans linkage.

In the IR spectra of compounds (VI), the absorption of an OH group had disappeared, and weak absorption had appeared in the 3400 cm^{-1} region (NH). The C=O group gave a strong band in the 1705-1735 cm^{-1} region.

In the PMR spectra (Table 2) of all the trans-linked perhydrocoumarins (VI), the signal of the 8a-H proton appeared in the form of a sharp triplet of doublets (J_1 = 10-11 Hz, J_2 = 4-5 Hz) in the 3.9-4.1 ppm region; in the spectra of all the cis-linked coumarins (VI), the signal of this proton was a narrow (width of the signal 8-9 Hz) almost unresolved multiplet in the 4.4-4.8 ppm region. This agrees well with literature information for cis- and trans-linked perhydrocoumarins [5, 6]. The signal of the 4-H proton in the spectrum of the coumarin β-(VIa) appeared in the form of a triplet with an SSCC of about 11 Hz, which shows the trans-axial arrangement of the interacting 3-H, 4-H, and 4a-H protons, i.e., the trans-trans-trans configuration of this compound. In the spectrum of the hydrochloride of the coumarin η-(VIa), the signal of the 4-H proton gave a triplet with a smaller SSCC (6 Hz), which probably shows the cis arrangement of the above-mentioned protons, i.e., the cis-cis-

trans configuration of this isomer. For the remaining isomers of (VIa), the signal of the 4-H proton was a quartet. In the spectra of the majority of the hydrocoumarins (VI) signals were observed of the NH group, triplets (2 H) relating to the protons of the methylene group of the side chain adjacent to the nitrogen atom, and multiplet signals of the 3-H proton, and in the spectra of the N-phenyl derivatives there were the signals of the protons of a benzene nucleus present in the ortho and para positions relative to the amino group.

EXPERIMENTAL

IR spectra were taken on a Specord IR-75 instrument (in chloroform), PMR spectra on a Bruker WP-250 (250 MHz) instrument (with TMS as internal standard), and mass spectra on a LKB-9000 instrument at an ionization energy of 70 eV. The course of the reactions and the purity of the products obtained were checked by TLC on Silufol plates.

The characteristics of the compounds synthesized are given in Table 3.

Thermolysis of the 4a,10a-Epidioxyperhydroacridines. A solution of 10 g of one of the amino peroxides (I) in 150-200 ml of xylene was boiled until the spot of the initial compound on TLC had disappeared (revealed by a solution of NaI in dilute CH_3COOH) (1-3 h). To isolate the keto lactams α-(IIa), α-(IIb), (IIc), β-(IId), and (IIe), the residue after the evaporation of the xylene (in vacuum) was treated with ether, and after 1-2 h the corresponding keto lactam was filtered off; the other compounds (II) were isolated by chromatographing the residue after the evaporation of the xylene on silica gel [with, as eluent, mixtures of hexane and ethyl acetate from (5:1) to (2:1)].

Hydrolysis of the Keto Lactams (II). A. A mixture of 1 g of a keto lactam in 5 ml of CH_3COOH and 5 ml of concentrated HCl was boiled; the hydrolysis of the lactam (IIe) was complete in a few minutes, while in the case of α-(IIb) and α-(IId) it required 2-3 h. The mixture was neutralized with ammonia solution (in the case of the hydrolysis of (IIb), strictly to pH 7), and extracted with ether, the extract was washed with water and dried, and the ether was distilled off. In the case of the hydrolysis of α-(IId), the residue was treated with ethanol and the coumarin (IIIb) was filtered off; in the case of the hydrolysis of (IIe) the residue consisted of the practically pure coumarin (IIIc); in the case of the hydrolysis of α-(IIb) compound (IV) was obtained in the residue, and for purification it was dissolved in ethanol and the 2,4-DNPH was obtained.

B. A solution of 1 g of the keto lactam α-(IIa) in 20 ml of xylene was treated with 20 mg of p-toluenesulfonic acid and the mixture was boiled for 20 h after which the xylene was evaporated off in vacuum and the residue was chromatographed on silica gel, the compound (IIIa) being eluted with hexane–ethyl acetate (4:1). In addition to the compound (IIIa), 0.2 g of the keto lactam γ-(IIa) was isolated. To purify the coumarin (IIIa) it was converted into the hydrochloride by the passage of HCl through an ethereal solution.

Reduction of the Keto Lactams (II). A solution of 3 g of one of the keto lactams (IIa-e) in 15-20 ml of ethanol was treated with 0.3-0.4 g of $NaBH_4$, and the mixture was boiled for a few minutes and cooled. In the case of the reduction of the keto lactam β-(IIa), the hydroxy lactam γ-(Va) deposited and was filtered off. The mixture was diluted with water four-fold and extracted with ether, and the solvent was evaporated off from the extract. In the case of the reduction of the keto lactam β-(IId), the hydroxy lactam γ-(Vd) was isolated from the residue by crystallization from acetone–hexane (1:2). After a similar treatment of the residue in the case of the keto lactam (Ve), the hydrocoumarin (VIe) was isolated. All the other compounds (V) were isolated by chromatographing the residue on Al_2O_3 of activity grade II with elution by mixtures of hexane and ether from (4:1) to (2:1).

Hydrolysis of the Hydroxy Lactams (V). The hydrolysis of the hydroxy lactams (Va-d) was carried out in a similar manner to the hydrolysis of the keto lactams (II) by method A. The reaction was complete in 2-5 min. To purify the hydrocoumarins β-(VIa), α-(VIc), β-(VIc), and α-(VId), they were converted into the hydrochlorides by the passage of HCl through their ethereal solutions. The other compounds (VI) were purified by recrystallization.

LITERATURE CITED

1. S. A. Shumakov, V. A. Kaminskii, and M. N. Tilichenko, Khim. Geterotsikl. Soedin., No. 1, 89 (1985).
2. E. G. E. Hawkins, J. Chem. Soc., No. 10, 2663 (1969).
3. G. Ferard, R. Ropert, M. Keravec, and P. F. C. Casals, C. R. Acad. Sci., Paris, Serie C, 279, 957 (1974).

4. E. A. Luk'yanets, N. P. Shusherina, E. G. Treshchova, L. A. Kazitsina, and R. Ya. Levina, Zh. Org. Khim., 1, 1194 (1965).
5. P. Dufey, J. C. Duplan, and J. Delman, Bull. Chim. Fr., No. 12, 5030 (1968).
6. M. F. Semmelhack and S. J. Brickner, J. Org. Chem., 46, 1723 (1981).

SPECTRAL AND ELECTROCHEMICAL PROPERTIES OF ortho-AMINO-1-METHYLNITROPYRAZOLES

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The influence of the electron density distribution in the pyrazole ring and the efficacy of the action of amino and nitro groups in the ortho position of amino-1-methylnitropyrazoles on their electrochemical characteristics and IR and electron absorption spectra has been studied.

The influence of features of the electron density distribution in the pyrazole ring on the physicochemical properties of 3- and 4-substituted 1-R-pyrazoles has been the subject of a considerable amount of attention in the literature [1]. At the same time, disubstituted 1-R-pyrazoles have scarcely been studied at all from these points of view and there are no experimental results permitting an estimate of the efficacy of the transfer of electron interactions between substituents along the $C_{(3)}$—$C_{(4)}$ and $C_{(4)}$—$C_{(5)}$ bonds, which have different π-orders in the pyrazole ring [2].

We have previously synthesized amino-1-methylnitropyrazoles [3, 4] containing amino and nitro groups in neighboring positions of the heterocycle and forming the pyrazole analogs of o-nitroaniline, characteristic features of which have been studied by various spectral methods.

In the electronic absorption spectrum of o-nitroaniline (I) (Table 1), the long-wave band is caused by an electronic transition having a contribution of the transfer of charge from the electron donor to the electron-acceptor ($CT^{NO_2}_{NH_2}$ band) [5], and the band in the 280 nm region has a contribution of the transfer of charge from the π-system to the nitro group ($CT^{NO_2}_{\pi}$ band). The electronic spectrum of 4-amino-1-methyl-5-nitropyrazole (II) is very close to the spectrum of o-nitroaniline, which permits an analogous refinement of the absorption bands. In the spectra of 4-amino-1-methyl-3-nitropyrazole (III), 3-amino-1-methyl-4-nitropyrazole (IV), and 5-amino-1-methyl-4-nitropyrazole (V), the number of bands is the same as in the spectra of compounds (I) and (II) but the position and intensity of the long-wave band depend greatly on the mutual positions of the amino and nitro groups in the pyrazole ring.

A feature of the $CT^{NO_2}_{NH_2}$ band is the large value of the bathochromic shift with a change from a nonpolar solvent to a polar solvent, but the presence of an intramolecular hydrogen bond in the o-nitroaniline molecule leads to a decrease in this magnitude as compared, for example, with the spectra of p-nitroaniline. The strength of the intramolecular hydrogen bond is characterized by the increase in the distance between the $\nu_s NH$ and $\nu_{as} NH$ bands in the IR spectra [6], and for o-nitroaniline in chloroform $\Delta\nu$ is 118 cm^{-1} (Table 1), which considerably exceeds $\Delta\nu$ for m-nitroaniline (91 cm^{-1}) [7]. We have obtained the IR spectra of compounds (I-IV) in chloroform (the isomer (V) is practically insoluble in chloroform) which

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