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STEREODIRECTED CATALYTIC SYNTHESIS OF PERHYDROACRIDINES AND THEIR ISOLOGS FROM DECAHYDROACRIDINE-1,8-DIONES

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The catalytic reduction of decahydroacridine-1,8-diones has been studied under hydrogen pressure in the presence of Raney nickel and with nascent hydrogen from alkaline treatment of nickel–aluminum alloy. Conditions have been developed for the stereodirected synthesis of 8-hydroxy-cis-dodecahydroacridin-1-ones and perhydroacridines of the cis-syn-cis and cis-anti-cis configurations. The structure of the hydroacridines was established by ^{1}H NMR spectroscopy, ^{13}C, and IR spectra, and chromato-mass spectrometry.

Keywords: 8-hydroxydodecahydroacridin-1-ones, decahydroacridine-1,8-diones, perhydroacridines, catalytic hydrogenation, stereochemistry.

The presence of several reaction centers in decahydroacridine-1,8-diones opens broad synthetic possibilities. Previously we investigated the chemical conversions of decahydroacridine-1,8-diones in phenylhydrazination and oximation reactions, and showed that, depending on the structure of the substrate and the conditions, these processes may occur either selectively at the carbonyl group or with the participation of the latter and other reaction centers [1,2].

The present communication is devoted to a study of the chemical behavior of 1,8-dioxodecahydroacridines in catalytic hydrogenation reactions. It is known that decahydroacridine-1,8-diones are stable to the action of complex metal hydrides [3], and in the presence of sodium thioglycolate only reduction of the keto groups to hydroxyl occurs [4]. Decahydroacridine-1,8-diones have not previously been subjected to hydrogenation under conditions of heterogeneous catalysis.

Catalytic hydrogenation of decahydroacridine-1,8-diones was effected under various conditions, under hydrogen pressure in the presence of Raney nickel, and with nascent hydrogen formed on alkaline treatment of nickel–aluminum alloy. The latter method was previously used successfully for the reduction of pyridines, quinolines, and other related compounds [5,6].

The substrates selected were 1,8-dioxodecahydroacridines differing in the degree of substitution and the nature of the substituent at positions 3, 6, 9, and 10, which enables the influence of the structure of the initial compounds on the direction of the studied processes to be followed.

Reduction of acridines **1** with hydrogen *in situ* (addition of nickel–aluminum alloy to an alkaline aqueous methanolic solution) occurs at 60°C for 10-12 h. Under these conditions the direction of the conversion is determined by the structure of the substrate.

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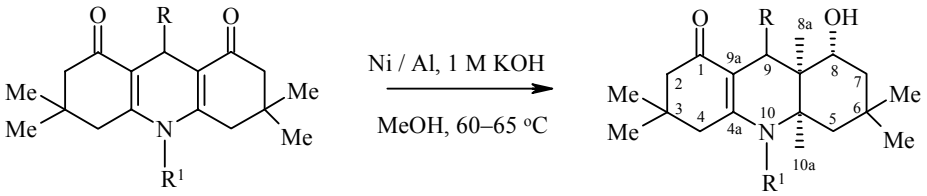


1a–k **2a–d**

1a–e R = H, **a** R^1 = H, **b** R^1 = Me, **c** R^1 = Ph, **d** R^1 = $PhCH_2$, **e** R^1 = PhNH, **f** R = 2-C_4H_3O (2-furyl), R^1 = Me, **g** R = R^1 = Me, **h** R = Ph, R^1 = H, **i** R = Ph, R^1 = $PhCH_2$, **j** R = 4-$MeOC_6H_4$, R^1 = Ph, **k** R = 4-$MeOC_6H_4$, R^1 = H; **2a–c** R = H, **a** R^1 = H, **b** R^1 = Me, **c** R^1 = Ph, **d** R = 2-C_4H_3O (2-furyl), R^1 = Me

The decahydroacridinediones **1a-e** unsubstituted at position 9 undergo selective reduction of one of the oxovinyl fragments, being converted into 8-hydroxy-*cis*-dodecahydroacridin-1-ones **2a-c** in 74-89% yield, while hydrogenation of N-benzyl- and N-phenylaminodecahydroacridinediones **1d,e** is accompanied by hydrogenolysis of the N–CH_2 and N–NH bonds and leads to the formation of compound **2a** (72-79% yield).

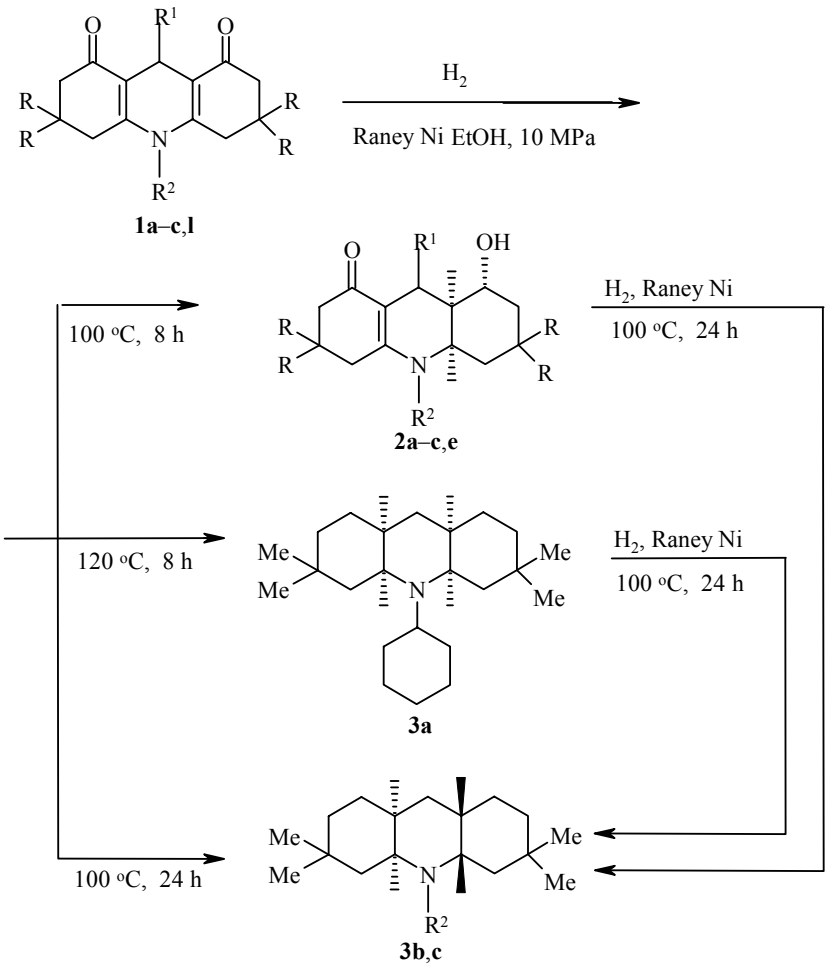
Reduction *in situ* of 9- and 9,10-substituted decahydroacridine-1,8-diones **1f-j** proceeds ambiguously and depends on the structure of the substituting group. Thus 9-(2-furyl)-10-methyldecahydroacridine-1,8-dione (**1f**), like compounds **1a-c,** is converted into the corresponding *cis*-dodecahydroacridinone **2d** in 78% yield. On reacting 9-aryl- or 9-alkyl-1,8-dioxoacridines **1g-j** neither the heterocycle nor the oxo group is reduced even at significantly increased reaction times (24-30 h). In the case of 9-aryl-10-benzyldecahydroacridine-1,8-diones **1i,j** only hydrogenolysis of the N–CH_2 bond was observed and 9-aryl-10H-1,8-dioxodecahydroacridines **1h,k** were formed. The marked stability of 9-aryl- and 9-alkyldecahydroacridinones **1g-j**, unlike the 9-furyl-substituted compound, towards catalytic hydrogenation is evidently caused by the steric disposition of the aryl or alkyl substituents at position 9 relative to the 1,4-dihydropyridine ring, as a result of which either adsorption of the substrate onto the surface of the catalyst is hindered or steric hindrance is built up against the approach of the reducing agent.

The 1,8-dioxodecahydroacridines were subject to more profound catalytic conversion on carrying out the hydrogenation on Raney Ni under forcing conditions, at a hydrogen pressure of 10 MPa and a temperature of 100-120°C (the reaction was carried out in batch autoclaves in alcoholic solution). Depending on the duration of contact and the process temperature a directed conversion was successfully effected both to *cis*-dodecahydroacridine and also to a substituted perhydroacridine with a *cis-cis* structure.

If the hydrogenation of 1,8-dioxodecahydroacridines **1a-c,l** is carried out at 100°C (at lower temperatures no reaction occurs) for 8 h then 9-R^1-10-R^2-8-hydroxy-*cis*-dodecahydroacridinones **2a-c,e** are formed (57-72% yield) irrespective of the structure of the substrate. On raising the temperature to 120°C or increasing the time of contact with the catalyst to 24 h at 100°C, in addition to hydrogenation of the heterocycle, reduction of the carbonyl groups to methylene occurs, and in the case of compound **1a** of a phenyl substituent to cyclohexyl. The resulting reaction products are perhydroacridines of the *cis-cis* type **3a-c**. The *cis-syn-cis* isomer **3a** was isolated on hydrogenation on Raney Ni at 120°C for 8 h, and the *cis-anti-cis* isomers **3b,c** at 100°C for 24 h. Special experiments on the isomerization of compound **3a** into isomer **3b** showed that perhydroacridines of the *cis-syn-cis* configuration arise initially, which are converted subsequently into the thermodynamically more stable *cis-anti-cis* forms (Scheme 1).

By varying the catalytic hydrogenation conditions for 1,8-dioxodecahydroacridines it is therefore possible to effect a stereodirected synthesis of perhydroacridines of a given structure, for the *cis-anti-cis* isomer Raney Ni at 100°C, 24 h and for the *cis-syn-cis* isomer Raney Ni at 120°C, 8 h. It was established that in all cases the intermediate compounds were *cis*-dodecahydroacridines. On hydrogenation of compounds **2b,c** on Raney Ni at 100°C for 24 h *cis-anti-cis*-perhydroacridines **3b,c** were isolated in 74-78% yield.

Scheme 1



1, **2 a–c** R = Me, R^1 = H, **a** R^2 = H, **b** R^2 = Me, **c** R^2 = Ph; **1l**, **2e** R = R^2 = H, R^1 = Ph;
3b R^2 = C_6H_{11} (cyclohexyl), **c** R^2 = Me

It may be concluded on the basis of the data obtained that the reduction of 1,8-dioxodecahydroacridines in the presence of nickel catalysts proceeds in a stereodirected manner with *cis* addition of hydrogen characteristic of catalytic processes, while more forcing conditions of hydrogenation aid the exhaustive saturation of multiple bonds (Table 1).

The structure of compounds **2a-e** and **3a-e** was established by data of ^{1}H and ^{13}C NMR spectroscopy, IR spectra and chromato-mass spectrometry. Characteristic of the IR spectra of the dodecahydroacridines were the presence of intense absorption bands at 3300-3500 cm^{-1}, confirming the presence of hydroxyl groups, and two absorption bands at 1600 and 1640 cm^{-1} corresponding to the stretching vibrations of the C=C–C=O conjugated bond system. In the spectra of compounds **3a-c** there was no absorption in these regions. The enamine NH group in the spectra of compounds **2a,e** is characterized by absorption at 3250-3300 cm^{-1}, and the phenyl substituents (compounds **2c,e**) by absorption at 3080-3100 cm^{-1}.

The chromato-mass spectra of hydroacridines **2a-e** and **3a-c** indicate their homogeneity and consequently their existence as one of the possible isomers. This is indicated by the presence of a single peak on the chromatogram, and the retention times of compounds **2a-c** obtained by various routes coincided (for **2a** 25.79 min, for **2b** 27.51 min, and for **2c** 28.99 min). The molecular ion peaks for compounds **2a-e** and **3a-c** correspond to their molecular masses (Table 2).

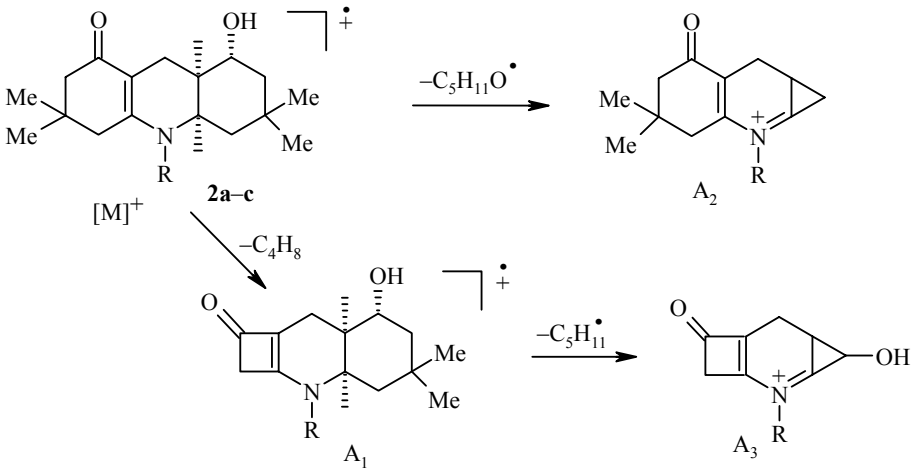
TABLE 1. Catalytic Hydrogenation of Compounds **1a-f,l, 2b,c** on Nickel Catalysts

Initial compound	Catalyst	Medium	Temperature, °C	Pressure, MPa	Reaction time, h	Reaction product	Yield, %
1a	Ni–Al	1 M KOH + MeOH	60	Atmospheric	10-12	**2a**	89
	Raney Ni	EtOH	100	10	8	**2a**	70
1b	Ni–Al	1 M KOH + MeOH	60	Atmospheric	10-12	**2b**	74
	Raney Ni	EtOH	100	10	8	**2b**	67
	Raney Ni	EtOH	100	10	24	**3c**	67
1c	Ni–Al	1 M KOH + MeOH	60	Atmospheric	10-12	**2c**	75
	Raney Ni	EtOH	100	10	8	**2c**	57
	Raney Ni	EtOH	120	10	8	**3a**	56
	Raney Ni	EtOH	100	10	24	**3b**	63
1d	Ni–Al	1 M KOH + MeOH	60	Atmospheric	10-12	**2a**	72
1e	Ni–Al	1 M KOH + MeOH	60	Atmospheric	10-12	**2a**	79
1f	Ni–Al	1 M KOH + MeOH	60	Atmospheric	10-12	**2d**	78
1l	Raney Ni	EtOH	100	10	8	**2e**	72
2b	Raney Ni	EtOH	100	10	24	**3c**	74
2c	Raney Ni	EtOH	100	10	24	**3b**	78

TABLE 2. Mass Spectra of Compounds **2a-e** and **3a-c**

Compound	*m/z* (I_{rel}, %)
2a	277 $[M]^+$ (15), 262 (9), 221 (23), 190 (100), 150 (11.5), 87 (38)
2b	291 $[M]^+$ (21), 276 (8.5), 235 (29), 204 (100), 164 (14), 87 (34)
2c	353 $[M]^+$ (16.5), 338 (7.5), 297 (34), 266 (100), 226 (9), 87 (31)
2d	357 $[M]^+$ (9), 329 (13), 301 (39), 270 (100), 230 (19), 87 (35)
2e	297 $[M]^+$ (12.5), 295 (5.5), 238 (100), 217 (62), 77 (21)
3a	332 (7), 331 $[M]^+$ (28), 260 (100), 71 (25)
3b	332 (5), 331 $[M]^+$ (19), 260 (100), 71 (28)
3c	264 (7), 263 $[M]^+$ (34), 192 (100), 71 (19)

In the mass spectra of compounds **2a-c**, which contain no substituent at position 9, an intense peak was present for ion A_1, arising by loss of a C_4H_8 molecule by a retro-Diels–Alder reaction characteristic of derivatives of 5,5-dimethylcyclohex-2-enone [7-9]. The formation of cations A_2 and A_3 is the result of fission of $C_5H_{11}^{\cdot}$ and $C_5H_{11}^{\cdot}$ from the M^+ and A_1 ions (Table 2).



The presence of intense peaks A_3 with *m/z* 238 and A_4 *m/z* 217 was characteristic of the spectrum of 8-hydroxy-9-phenyldodecahydroacridinone (**2e**). Ion A_4 arises by fission of a phenyl group from the $[M]^+$ ion. The absence of geminal methyl substituents in the alicycle of compound **2e** probably excludes breakdown by a retro-Diels–Alder reaction.

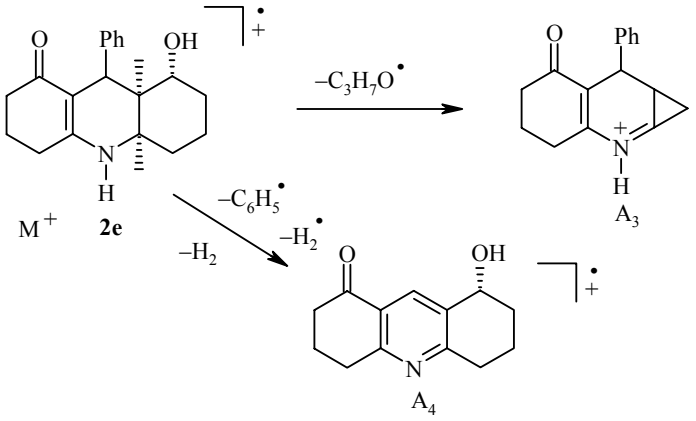


TABLE 3. ^{1}H NMR Spectra of 8-Hydroxydodecahydroacridin-1-ones **2a-e**

Com-pound	Chemical shifts, δ, ppm (coupling constants, *J*, Hz)								
	$C_{(2)}H$, 2H	$C_{(4)}H$, 2H	$C_{(5)}H$, 2H	$C_{(7)}H$, 2H	$C_{(8)}H$, 1H, m	$C_{(8a)}H$, 1H, m	$C_{(9)}H$, m	$C_{(10a)}H$, 1H, m	Other signals
2a	2.3 (s)	2.1 (s)	1.3 (dd, J_1 = 5.0, J_2 = 12.0, H_a); 1.7 (dd, J_1 = 5.0, J_2 = 12.0, H_e)	1.8 (dd, J_1 = 5.0, J_2 = 12.0, H_a); 2.2 (dd, J_1 =5.0, J_2 = 12.0, H_e)	4.0	1.9	2.0 (2H)	3.4	0.8-1.0 (12H, s, 4CH_3); 4.5 (1H, br. s, OH); 6.7 (1H, s, NH)
2b	2.3 (s)	2.1 (s)	1.3 (dd, J_1 = 5.5, J_2 = 11.5, H_a); 1.7 (dd, J_1 = 5.5, J_2 = 11.5, H_e)	1.8 (dd, J_1 = 5.0, J_2 = 12.0, H_a); 2.4 (dd, J_1 = 5.0, J_2 = 12.0, H_e)	4.0	1.9	2.0 (2H)	3.4	0.8-1.0 (12H, s, 4 CH_3); 4.6 (1H, br. s, OH); 3.0 (3H, s, NCH_3)
2c	2.4 (s)	2.1 (s)	1.3 (dd, J_1 = 5.0, J_2 = 11.0, H_a); 1.7 (dd, J_1 =5.0, J_2 = 11.0, H_e)	1.8 (dd, J_1= 5.0, J_2 = 12.0, H_a); 2.3 (dd, J_1 = 5.0, J_2 = 12.0, H_e)	4.2	1.9	2.0 (2H)	3.6	0.7-0.9 (12H, s, 4 CH_3); 4.8 (1H, s, OH); 7.1 (3H, m, C_6H_5); 7.3 (2H, m, C_6H_5)
2d	2.4 (s)	2.2 (s)	1.3 (dd, J_1 = 6.0, J_2 = 11.5, H_a); 1.7 (dd, J_1 = 6.0, J_2 = 11.5, H_e)	1.8 (dd, J_1 = 5.5, J_2 = 12.0, H_a); 2.3 (dd, J_1 = 5.5, J_2 = 12.0, H_e)	4.3	1.9	3.0 (1H)	3.5	0.9-1.0 (12H, s, 4 CH_3); 3.1 (3H, s, NCH_3); 4.7 (1H, br. s, OH); 6.1 (1H, d, *J* = 3.6, Fur); 6.3 (1H, t, Fur); 7.2 (1H, d, *J* = 3.6, Fur)
2e	2.3 (m)	2.0 (m)	1.1 (m)	1.3 (m)	4.4	1.9	2.9 (1H)	3.5	7.3 (1H, s, NH); 7.2 (5H, m, C_6H_5); 4.9 (1H, s, OH); 0.9-1.4 (4H, s, $C_{(3)}H$ and $C_{(6)}H$)

TABLE 4. ^{13}C NMR Spectra of 8-Hydroxy-*cis*-dodecahydroacridin-1-ones **2a-e**

Compound	Chemical shifts, δ, ppm																
	$C_{(1)}$	$C_{(2)}$	$C_{(3)}$	$C_{(4)}$	$C_{(4a)}$	$C_{(5)}$	$C_{(6)}$	$C_{(7)}$	$C_{(8)}$	$C_{(8a)}$	$C_{(9)}$	$C_{(9a)}$	$C_{(10a)}$	R		R^1	R^2
														Me (at $C_{(3)}$)	Me (at $C_{(6)}$)		
2a	190.79	50.05	32.29	45.75	159.92	41.82	31.17	45.75	68.11	41.33	21.89	102.17	47.16	28.92_e; 28.21_a	34.40_e; 28.30_a	—	—
2b	191.40	49.21	31.49	40.89	156.84	36.49	30.33	39.57	66.31	37.31	14.01	101.69	57.79	29.17_e; 25.76_a	32.97_e; 27.77_a	—	37.10
2c	192.88	49.57	32.04	45.31	156.59	42.12	31.08	44.78	68.46	41.25	21.92	105.41	54.50	28.53_e; 7.75_a	34.19_e; 27.91_a	—	142.18; 129.74*; 129.39*; 127.78
2d	191.91	49.48	31.70	41.63	157.02	36.55	29.84	41.05	68.66	40.67	25.51	103.38	58.82	29.62_e; 27.61_a	32.60_e; 28.11_a	158.01; 139.15; 111.11; 107.38	37.90
2e	190.41	36.67	21.48	28.51	159.30	29.17	20.49	29.17	69.95	42.58	34.37	106.56	51.95	—	—	145.48*; 126.72*; 125.20*	—

* Signal corresponds to two carbon atoms.

The mass spectra of perhydroacridines **3a-c** were generally poorly informative and contain, besides the $[M]^+$ peak, an intense $[M-C_5H_{11}]^+$ peak with *m/z* 260 (for compounds **3a,b**) and 192 (for compound **3c**).

The ^{1}H NMR spectra of dodecahydroacridines **2a-e** (Table 3) and perhydroacridines **3a-c** corresponded completely with their structures. The most characteristic for compounds **2a-e** were the signals of the hydroxyl group protons, which are displayed as a broadened singlet at 4.5-4.9 ppm, and the chemical shift of the hydrogen atom at position 8 at 4.0-4.4 ppm, which indicates the equatorial disposition of the hydroxyl functions [10]. The presence of the phenyl substituents in compounds **2c,e** is confirmed by the presence of multiplets at 7.1-7.3 ppm, and the chemical shift of the N–Me group protons in compounds **2b,d** were at 3.0-3.1 ppm. The signals of the angular protons at $C_{(8a)}$ and $C_{(10a)}$ (multiplets) are at 1.8-1.9 and 3.4-3.6 ppm respectively, which permits the conclusion that one type of steric structure exists for dodecahydroacridines **2a-e** irrespective of the degree and character of substitution. The disposition of the proton signal for the $C_{(10a)}$ atom at 3.4-3.6 ppm in compounds **2a-e** corresponds, according to the data of [11], to a *cis* linkage of the carbo- and heterocycles, but in the case of the N-phenyl-substituted compound **2c** this leads to splitting of the signal of the protons of the phenyl substituent at the nitrogen atom.

The ^{1}H NMR spectra of perhydroacridines **3a-c** indicate the absence from the structure of these compounds of aromatic substituents or hydroxyl functions. They contain signals for methyl and methylene groups and for methine protons at 0.9-3.7 ppm of which the most characteristic are the chemical shifts of the geminal methyl substituents (0.9-1.1 ppm) and the N–Me group in compound **3c** (2.2 ppm).

In the analysis of the ^{13}C NMR spectra of dodecahydroacridinones **2a-e** and perhydroacridines **3a-c** off-resonance decoupling spectra and the literature data of ^{13}C NMR spectra of the isomeric perhydroacridines [12-14] and 3,3-dimethylhydroxanthenes [15] were used for the assignment of signals.

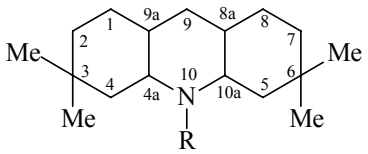
The use of off-resonance spectra for compounds **2a-e** enabled the tertiary atoms $C_{(8)}$, $C_{(8a)}$, and $C_{(10a)}$ to be distinguished. At lowest field were the signals for the $C_{(8)}$ atom located at 66.31-69.95 ppm (Table 4). The resonance signals for the junction atoms $C_{(8a)}$ and $C_{(10a)}$, the position of which depends directly on the character of the linkage of the rings, were displayed at 37.31-42.58 and 47.16-58.82 ppm respectively. The chemical shifts of the $C_{(8a)}$ and $C_{(10a)}$ signals in compounds **2b-e** correlate well with the data for the corresponding *cis* type 10- and 9,10-substituted perhydroacridines [12,13]. Displacement of the $C_{(10a)}$ atom signal in compound **2a** towards high field (47.16 ppm) may probably be explained by the reduction of the deshielding effect of the nitrogen atom due to the absence of electron-donating substituents on it. The presence in the spectra of compounds **2a-e** of a high field signal at 14.01-21.92 ppm indicates that the dodecahydroacridinones mentioned are *cis* isomers [12-15]. The appearance of this signal is explained by the *gauche* interaction of the heteroatom with the carbon atom found in the χ-position. In 3,3,6,6-tetramethyl-8-hydroxydodecahydroacridin-1-ones this effect is only possible with the participation of the $C_{(9)}$ atom. The signals at 14.01-21.29 ppm were therefore assigned to the indicated atom (Table 4). The greatest high field displacement was sustained by the $C_{(9)}$ atom in dodecahydroacridine **2b** which is linked with the strengthening of the shielding influence of the heteroatom due to the introduction of a methyl group onto it. An analogous effect may already have been observed in the example of piperidine and methylpiperidine [16].

In the case of dodecahydroacridinone **2e**, containing no substituent in position 3 and no *gem*-dimethyl substituents in position 6, the greatest χ-*gauche* effect was sustained by atoms $C_{(3)}$ and $C_{(6)}$, the resonance signals of which are displayed at 21.48 and 20.49 ppm respectively, but the chemical shift of the $C_{(9)}$ atom carrying a phenyl residue was at 34.37 ppm in this case.

In the spectra of compounds **2a-e** (Table 4) the signals of $C_{(1)}$–$C_{(4)}$, $C_{(4a)}$, $C_{(6)}$, and $C_{(9a)}$ and of the geminal methyl groups correlate well with the spectra of the corresponding *cis*-dodecahydroxanthenones. Assignment of the other resonance signals was made more precise by comparison with the spectra of 3,3-dimethylperhydroxanthenes and the isomeric perhydroacridines.

Dodecahydroacridin-1-ones **2a-e** are therefore obtained in the form of *cis* isomers under conditions of catalytic synthesis. The criterion for the *cis* junction of the cyclohexane and hydropyridine rings, as in the case

TABLE 5. ^{13}C NMR Spectra of Perhydroacridines **3a-c**



Compound	Chemical shifts, δ, ppm									
	$C_{(1)}$, $C_{(8)}$	$C_{(2)}$, $C_{(7)}$	$C_{(3)}$, $C_{(6)}$	$C_{(4)}$, $C_{(5)}$	$C_{(4a)}$, $C_{(10a)}$	$C_{(8a)}$, $C_{(9a)}$	$C_{(9)}$	Me_a	Me_e	R
3a	39.45	31.37	31.94	34.33	56.89	37.67	23.22	25.36	33.79	50.67 ($C_{(\alpha)}$); 28.23 ($C_{(\beta)}$ and $C_{(\beta')}$); 26.10 ($C_{(\delta)}$); 25.73 ($C_{(\chi)}$ and $C_{(\chi')}$)
3b	33.80	31.06	31.36	32.64	58.62	37.62	25.34	30.85	31.46	56.89 ($C_{(\alpha)}$); 27.13 ($C_{(\beta)}$ and $C_{(\beta')}$); 26.83 ($C_{(\delta)}$); 26.42 ($C_{(\chi)}$ and $C_{(\chi')}$)
3c	34.29	30.67	31.69	33.30	57.07	37.53	25.87	29.82	32.51	40.44

of perhydroacridines [12-14] and hydroxanthenes [15], is the presence of a high field signal, which depending on the presence or absence of substituent groups in positions 3 and 6, may belong either to the $C_{(9)}$ atom (compounds **2a-d**) or to the $C_{(3)}$ and $C_{(6)}$ atoms (compound **2e**).

In the spectra of isomers **3a-c** (Table 5) seven resonance signals belong to the perhydroacridine skeleton, one of which is at high field and is located at 25.34-25.87 ppm, which, as already mentioned above, is the criterion for the *cis* linkage of the hetero- and carbocycles, *cis-syn-cis* or *cis-anti-cis* [12-14]. In the first case the reduction in the number of signals is linked with the symmetricality of the structure of the molecule, and in the second with the readiness of inversion of the possible conformers, readily changing from one to another even at room temperature. This leads to a reduction in the number of signals in the ^{13}C NMR spectra and their width, apart from the signals of the $C_{(9)}$ atoms and the carbon atoms of the substituents [14]. A similar picture is observed in the spectra of compounds **3b,c**, unlike the spectrum of isomer **3a**, where the resonance signals of the carbon atoms were not broadened. The varied character of the spectra of perhydroacridines **3a-c** serves as a basis for assigning compound **3a** to an isomer with a *cis-syn-cis* configuration, and compounds **3b,c** to an isomer with a *cis-anti-cis* structure.

A special feature of the *cis-syn-cis*-perhydroacridine is the possibility of existing as two conformers differing in energy *A* (axial C–C bonds are in the position β to the heteroatom) and *B* (axial C–C bonds are in the position α to the nitrogen atom). As is known [12-14] the position and intensity of the $C_{(9)}$ atom serves as a conformational label in this case For conformer *A* this signal is displayed at lower field (~35 ppm and more), while for conformer *B* a displacement of the chemical shift of the $C_{(9)}$ atom of ~11 ppm towards high field is observed. In the spectrum of compound **3a** the resonance signal of the $C_{(9)}$ atom is displayed at 23.22 ppm, which points in favor of conformation B of *cis-syn-cis*-perhydroacridine for **3a**. The good correlation between the resonance signals of the angular atoms $C_{(4a)}$–$C_{(10a)}$, $C_{(8a)}$–$C_{(9a)}$ in compounds **3a-c** and the corresponding N-R-perhydroacridines [14] is an additional argument in favor of the conclusions on the spatial structure of isomers **3a-c**.

The assignment of the other carbon atoms (Table 5) was made more precise on comparison with the spectra of the isomeric perhydroacridines and perhydroxanthenes [12-15]. The introduction of two methyl groups into positions $C_{(3)}$ and $C_{(6)}$ is satisfactorily described by the α-, β-, and χ-increments for dimethyl-substituted cyclohexanes [17] and 3,3-dimethylperhydroxanthenes [15].

TABLE 6. Characteristics of the Compounds Synthesized

Compound	Empirical formula	Found, % / Calculated, %			mp, °C
		C	H	N	
2a	$C_{17}H_{27}NO_2$	73.33 / 73.65	9.97 / 9.75	5.17 / 5.05	220-222
2b	$C_{18}H_{29}NO_2$	74.57 / 74.23	10.00 / 9.97	5.00 / 4.81	229-231
2c	$C_{23}H_{31}NO_2$	77.83 / 78.19	9.02 / 8.78	4.11 / 3.97	237-238
2d	$C_{22}H_{31}NO_3$	74.17 / 73.95	8.89 / 8.68	3.92 / 3.92	230-232
2e	$C_{19}H_{23}NO_2$	77.00 / 76.77	8.13 / 7.74	4.83 / 4.71	281-283
3a	$C_{23}H_{41}N$	83.86 / 83.38	12.30 / 12.39	4.81 / 4.23	86-87
3b	$C_{23}H_{41}N$	83.54 / 83.38	12.55 / 12.39	4.29 / 4.23	71-73
3c	$C_{18}H_{33}N$	82.07 / 82.13	12.68 / 12.55	5.49 / 5.32	64-65

We have therefore studied for the first time the catalytic hydrogenation of decahydroacridine-1,8-diones under various conditions and have found conditions for reducing them to *cis*-dodecahydroacridin-1-ones and perhydroacridines of the *cis-syn-cis* and *cis-anti-cis* types.

EXPERIMENTAL

The IR spectra were recorded on a Specord M 80 instrument (suspensions in nujol and in hexachlorobutadiene), and the ^{1}H and ^{13}C NMR spectra on a Bruker AC 300 (300 and 75 MHz respectively) spectrometer in $CDCl_3$ and CD_3OD, the internal standard was TMS. The chromato-mass spectra were obtained on a Hewlett-Packard HP 5972A gas chromatograph with a HP 5890 mass-selective detector on a capillary column (30 m × 0.25 mm) with 5% methylphenylsilicone, carrier gas was nitrogen, energy of ionising electrons was 70 eV. A check on the course of reactions and the homogeneity of the compounds isolated was effected by TLC on Silufol UV 254 plates, eluent was hexane–acetone–chloroform, 3:1:1, visualizing with iodine vapor.

The decahydroacridine-1,8-diones **1a-l** were synthesized by the known procedure of [1,2].

9-(2-Furyl)-8-hydroxy-3,3,6,6,10-pentamethyl-1,2,3,4,5,6,7,8,8a,9,10,10a-*cis*-dodecahydroacridin-1-one (2d). Acridinedione **1f** (5.295 g, 15 mmol), methanol (100 ml), and 1 M KOH solution (100 ml) were placed in a three-necked flask of capacity 0.5 liter fitted with a mechanical stirrer, a reflux condenser, and a thermometer. The mixture was brought to boiling (60°C) with stirring, and each 20-30 min finely powdered Ni–Al alloy (40% Ni) was carefully added in portions of about 0.5 g. At the end of the reaction (10-12 h) the hot reaction mixture was filtered, and the solid $Al(OH)_3$ + Ni was washed with hot methanol (4 × 20 ml). The filtrate was evaporated, the residue was refluxed in acetone (50 ml) for 20 min, then without cooling an additional portion of $Al(OH)_3$ was filtered off. The filtrate was evaporated to half volume, cooled, and crystalline solid compound **2d** was precipitated. This was separated and recrystallized from methanol.

Compounds **2a-c** were obtained analogously from acridinediones **1a-e** (see Tables 1 and 6.

The reduction of acridinediones **1i,j** was accompanied by the formation of NH-decahydroacridinediones **1h,l**. Compound **1g** was not reduced under the conditions indicated.

8-Hydroxy-9-phenyl-1,2,3,4,5,6,7,8,8a,9,10,10a-*cis*-dodecahydroacridin-1-one (2e). Acridinedione **1l** (2.97 g, 10 mmol), ethanol (50 ml), and Raney Ni (~0.5 g) were placed in a steel rotating autoclave of capacity 150 ml. Initial hydrogen pressure was 10 MPa and temperature 100°C. The reaction was completed after 8 h after absorption of the calculated amount of hydrogen (20 mmol). After removing the catalyst and solvent, compound **2e** was crystallized.

Compounds **2a-c** were synthesized in the same way from acridinediones **1a-c**.

Perhydroacridines 3a-c (Tables 1, 6) were obtained by the hydrogenation of decahydroacridines **1b,c** and *cis*-dodecahydroacridinones **2b,c** by the procedure described above.

3,3,6,6-Tetramethyl-10-cyclohexyl-*cis-anti-cis*-perhydroacridine (3b). Isomerization of 3,3,6,6-tetramethyl-10-cyclohexyl-*cis-syn-cis*-perhydroacridine **3a**. Compound **3a** (3.31 g, 10 mmol), ethanol (50 ml), and Raney Ni (~0.5 g) were placed in a steel rotating autoclave of capacity 150 ml. The initial hydrogen pressure was 10 MPa, and temperature 100°C. After 24 h compound **3a** was completely isomerised into **3b** (check by TLC). The catalyst was filtered off, and compound **3b** was crystallized after removing the solvent.

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