REACTION OF 2,2'-METHYLENEDICYCLOHEXANONE WITH PRIMARY AROMATIC DIAMINES*

A. N. Saverchenko, V. A. Kaminskii,
and M. N. Tilichenko

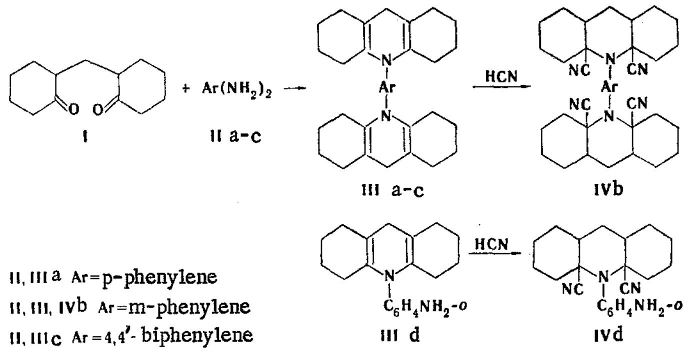
UDC 547.835.2:543.422.4

The reaction of 2,2'-methylenedicyclohexanone with o-, m-, and p-phenylenediamines and benzidine under various conditions was investigated. N,N'-Arylenedi(decahydroacridines) and N-(o-aminophenyl)decahydroacridine were obtained, and their disproportionation was studied.

We have previously reported the reaction of 2,2'-methylenedicyclohexanone (I) with primary monoamines in the presence of CCl_4 [1] and in acetic acid [2]. In the first case, the intermediately formed N-R-decahydroacridines are oxidized to N-R-octahydroacridinium salts, while in the second case, the same decahydroacridines are disproportionated to N-R-dodecahydroacridines and N-R-octahydroacridinium salts.

We have made a further study of the reaction of diketone I with primary aromatic diamines – p-, m-, and o-phenylenediamines (IIIa,b,d) and benzidine (IIc) – under various conditions: in an inert solvent, in CH_3COOH, in the presence of CCl_4, and in the presence of $HClO_4$. We have obtained products of the reaction of I with both one and two NH_2 groups of the diamines except for o-phenylenediamine, where only one NH_2 group reacts in all cases (steric factor).

When the reaction is carried out in an inert solvent (m-xylene), in the case of diamines IIa-c we were able to isolate N,N'-arylenedi(decahydroacridines) (IIIa-c), which proved to be quite stable, in contrast to N-phenyldecahydroacridine [3]. In the case of diamine IId, we isolated N-(o-aminophenyl)decahydroacridine (IIId), which is also relatively stable.

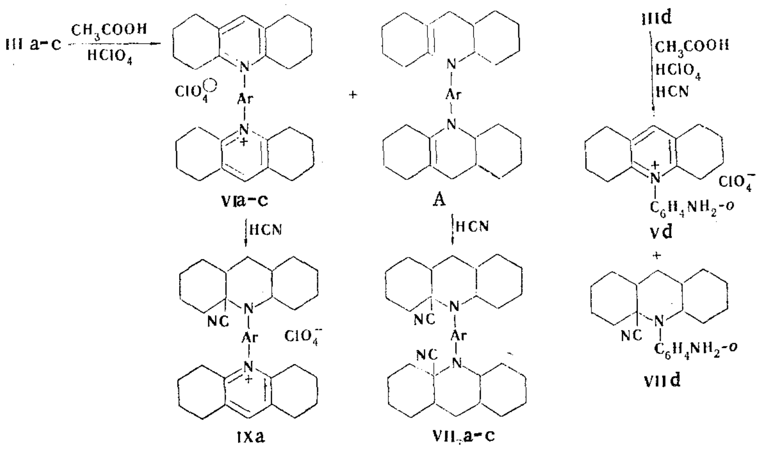


Two characteristic bands at 1670 and 1700 cm^{-1} were observed in the IR spectra of IIIa-d. A similar doublet is observed in the spectra of 1,4-dihydropyridine [4] and decahydroxanthene [5] derivatives. N,N'-Arylenedi(decahydroacridines) add four HCN molecules (in the case of IIIb), while IIId adds two HCN molecules, and the products are IVb and IVd, respectively.

---

*Communication VI from the series "Reactions of 1,5-Diketones." See [7] for communication V.

Far-Eastern State University, Vladivostok. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 9, pp. 1232-1236, September, 1972. Original article submitted June 8, 1971.



III, VI, VII, IXa Ar=p-phenylene III, VI, VIIb Ar=m-phenylene III, VI, VIIc Ar=4,4'-biphenylene

Bisdihydropyridine compounds IIIa-c disproportionate in acetic acid solution to give three types of reaction products: two symmetrical compounds – N,N'-arylenedi(octahydroacridinium)salts (Va-c) and arylene-N,N'-arylenedi($\Delta^{11(12)}$-dodecahydroacridines) (A) – and one unsymmetrical compound – N-(N'-$\Delta^{11(12)}$-dodecahydroacridyl)aryloctahydroacridinium salts (VIa-c). Compounds A were isolated as products of the addition to them of two HCN molecules – N,N'-arylenedi(11-cyanoperhydroacridines) (VIIa-c). Instead of salt VIa, the product of the addition of one HCN molecule (IXa) was also isolated.

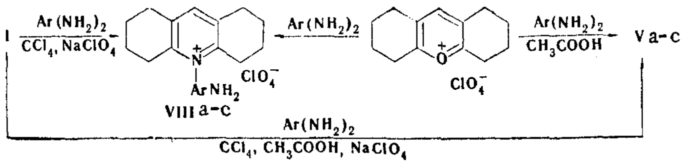
Compound IIId disproportionates as in the previously described cases [2] to give Vd and VIId (in the presence of HCN).

When the reaction of diketone I with each of diamines IIa-d is carried out in acetic acid, the same products that are obtained in the disproportionation of the corresponding decahydroacridines (IIIa-d) are formed. The yields of the disproportionation products are usually better; this variant is therefore a convenient method for the preparation of compounds of the VI and VII types.

The structures of the disproportionation products were confirmed by the IR spectra; there is one absorption band at 1670-1700 cm^{-1} (C=C) in the spectra of VI, while this band is absent in the spectra of VII and IXa, but the absorption band of the CN group appears at 2240 cm^{-1}. There is intense absorption at 1100 cm^{-1} (ClO_4^-) in the spectra of perchlorates V and VI. Two bands at 3380 and 3500 cm^{-1} (NH_2) appear in the spectra of Vd and VIId. The position of the cyano groups in the nitriles that we obtained was confirmed by the PMR spectra of nitrile IVb and of N-phenyl-11,14-dicyanoperhydroacridine, which we previously obtained [3]. All of the nonaromatic protons of these compounds give signals at δ 1.3-1.8, i.e., there are no protons in the α position relative to the nitrogen atom. For comparison, it may be pointed out that the protons in the 11 and 14 positions of N-phenylperhydroacridine give signals at 3.42 ppm [6]. Consequently, under the hydrocyanation conditions that we used (in CH_3COOH), the CN groups occupy the 11 and 14 positions.

Octahydroacridinium salts are formed when the reaction of diketone I with diamines IIa-d is carried out in the presence of CCl_4, and in neutral solvents (alcohol and benzene) one observes a tendency for all the diamines to form reaction products involving only one NH_2 group of the diamine – N-(aminoaryl)octahydroacridinium salts (VIIIa-c, Vd). A certain amount of bis product Vc is formed only in the case of benzidine. The structures of VIIIa-c were confirmed by the IR spectra, in which there is absorption at 3380 and 3500 cm^{-1} (NH_2). The indicated result of the reaction is apparently explained by the fact that the dihydropyridine ring in the intermediately formed N-(aminoaryl)decahydroacridines is oxidized before the NH_2 group has time to react with a second molecule of diketone; the basicity of the NH_2 group in the resulting salts (VIIIa-c) is reduced, and it does not react with the diketone. If, however, CH_3COOH is added after carrying out the reaction, the reaction recommences, and bis products Va-c (acid catalysis) are formed. The results that we obtained with respect to the reaction of diamines IIa-c with octahydroxanthylium perchlorates are in agreement with the data presented. Primarily N-(aminoaryl)octahydroacridinium salts are formed in alcohol, while N,N'-arylenedi(octahydroacridinium) salts (for example IIa,c) are formed in the presence of CH_3COOH. (See scheme on following page.)

When the reaction of I with diamines is carried out in benzene in the presence of $HClO_4$, octahydroacridinium salts are obtained. In this case, Va-c are the preferred products for diamines IIa-c, although the formation of a certain amount of VIIIa-c is also observed. The reaction also proceeds well with



V, VIII a Ar = p-phenylene b Ar = m-phenylene c Ar = 4,4'-biphenylene

aromatic monoamines – aniline, α- and β-naphthylamines, p-anisidine, and p-nitroaniline. The reaction apparently proceeds through the oxidation of the intermediately formed decahydroacridines rather than through the intermediate formation of octahydroxanthylium perchlorate and subsequent reaction of it with the amines; no octahydroxanthylium salt was detected on treatment of diketone I with $HClO_4$ in benzene.

EXPERIMENTAL

N,N'-Arylenedi(decahydroacridines) (IIIa-c) and N-(o-Aminophenyl)decahydroacridine (IIId). A solution of 0.02 mole of diamine in 20 ml of m-xylene was added to a solution of 8.3 g (0.04 mole) of I in 20 ml of m-xylene, and the mixture was refluxed under argon with a Dean–Stark trap until the liberation of water was complete. The solvent was then removed by vacuum distillation in a stream of argon. In the preparation of IIIa-c, the residue was treated with alcohol. The crystalline material was separated, washed with alcohol, and dried; in the case of IIId, the residue was dissolved in acetone, and the solution was cooled to −50°. The precipitated IIId was separated, washed with cold acetone, and dried. The compounds obtained (see Table 1) were purified by recrystallization from ethanol (IIIa,d) or from ethanol–benzene (1 : 2) (IIIb,c). Compounds IIIa-c were slightly yellowish crystalline substances, while IIId was obtained as colorless crystals.

Reaction of IIIb,d with HCN. A 1-g sample of IIIb or IIId was added slowly with stirring to a solution of 1 g of KCN in 20 ml of CH_3COOH, and the mixture was allowed to stand overnight. Compounds IVb,d were separated, washed with water, dried, and recrystallized from alcohol (see Table 1).

Disproportionation of N,N'-Arylenedi(decahydroacridines) (IIIa-c). A solution of 0.01 mole of IIIa-c in 20 ml of 98% CH_3COOH was held at room temperature under argon for 2 h. The mixture was then cooled, and a solution of 1 g of NaCN in 5 ml of water was added. The mixture was stirred for 2 h, and the precipitated VIIa-c were separated. The filtrate was made alkaline to pH 9 with sodium carbonate solution and extracted with ether. A solution of NH_4ClO_4 was added to the aqueous layer, during which a mixture of perchlorates precipitated. The mixture of IXa and Va was separated by refluxing with alcohol,

TABLE 1. Hydroacridine Derivatives

Comp.	mp, °C	Empirical formula	Found, %			Calc., %			Yield, %*
			C	H	N	C	H	N	
III a	303 (dec.)	$C_{32}H_{40}N_2$	84,9	8,9	6,4	84,9	8,8	6,2	35
III b	141	$C_{32}H_{40}N_2$	84,9	9,2	6,4	84,9	8,8	6,2	40
III c	248–250	$C_{38}H_{44}N_2$	86,2	8,4	5,6	86,3	8,3	5,3	32
III d	126–127	$C_{19}H_{24}N_2$	81,4	8,7	9,3	81,4	8,6	10,0	30
IV b	272	$C_{36}H_{44}N_6$	—	—	15,0	—	—	15,0	65
IV d	210	$C_{21}H_{26}N_4$	—	—	16,6	—	—	16,8	60
V a	314	$C_{32}H_{38}Cl_2N_2O_8$	60,8	5,7	4,3	59,3	5,9	4,3	21
V b	281	$C_{32}H_{38}Cl_2N_2O_8$	59,2	6,1	4,3	59,3	5,9	4,3	16
V c	310	$C_{38}H_{42}Cl_2N_2O_8$	62,8	6.0	3,8	62,7	5,8	3,9	21
V d	188–190	$C_{19}H_{23}ClN_2O_4$	60,6	6,2	7,7	60,2	6,1	7,4	43
VI b	136	$C_{32}H_{41}ClN_2O_4$	69,2	6,9	5,1	69,4	7,4	5,1	26
VI c	200 (dec.)	$C_{38}H_{45}ClN_2O_4$	71,4	7,5	4,5	72,6	7,2	4,5	46
VII a	206	$C_{34}H_{46}N_4$	—	—	11,3	—	—	11,0	20
VII b	228–229	$C_{34}H_{46}N_4$	—	—	10,9	—	—	11,0	21
VII c	202 (dec.)	$C_{40}H_{50}N_4$	—	—	9,1	—	—	9,5	17
VII d	171–172	$C_{20}H_{27}N_3$	—	—	13,8	—	—	13,6	33
VIII a	240 (dec.)	$C_{19}H_{23}ClN_2O_4$	59,4	6,4	7,2	60,2	6,1	7,4	53
VIII b	160 (dec.)	$C_{19}H_{23}ClN_2O_4$	59,7	6,4	7,6	60,2	6,1	7,4	53
VIII c	210	$C_{25}H_{27}ClN_2O_4$	65,7	6,4	6,1	66,1	5,9	6,2	50
IX a	300 (dec.)	$C_{33}H_{42}ClN_3O_4$	—	—	6,9	—	—	7,3	35

---

*The yields of disproportionation products V, VII, and IX are presented for the reaction of IIIa-d in CH_3COOH. They were calculated as the ratio of the number of moles of disproportionation product to the number of moles taken for the reaction of III.

in which Va is insoluble. In the remaining cases, the perchlorates could not be separated. The reaction for IIIb,c was therefore repeated according to the method indicated above but without the addition of NaCN. This procedure gave a mixture of perchlorates Vb,c and VIb,c, which were separated by column chromatography on Al_2O_3. Compounds VIb,c were eluted with acetone–ethyl acetate (2 : 1), while Vb,c were eluted with acetone. The disproportionation products were purified by recrystallization from ethanol (VIIa–c, IXa, and VIb,c) or from water (Va–c). Nitriles VIIa–c, IXa, and perchlorates Va–c were colorless crystalline powders, while perchlorates VIb,c were pale yellow crystals.

Disproportionation of IIId. This was carried out by the same method with the addition of NaCN. The reaction products (Vd and VIId), which were purified by recrystallization from alcohol, were colorless crystalline powders.

Reaction of Diketone I with Diamines in CH_3COOH. A mixture of 0.03 mole of I and 0.015 mole of diamine in 35 ml of CH_3COOH was held at room temperature under argon for 2 h. The reaction products were isolated as indicated above. All of the compounds obtained were identified with the products of the disproportionation of the corresponding decahydroacridines by thin-layer chromatography and from the IR spectra. The percent yields of the products were: Va 24, IXa 35, VIIa 11, Vb 16, VIb 26, VIIb 23, Vc 24, VIc 42, VIIc 17, Vd 46, and VIId 33.

Reaction of I with Aromatic Diamines in the Presence of CCl_4. A. Solutions of 0.03 mole of I in 20 ml of alcohol or benzene and of 0.01 mole of diamines IIa–c in 15 ml of the same solvent were mixed, 0.05 mole of CCl_4 was added, and the mixture was refluxed under argon for 2 h. Water (100 ml) was added, the mixture was extracted with ether, and saturated NH_4ClO_4 solution was added to the aqueous layer until the precipitation of the perchlorates was complete. The perchlorates were separated, washed with water, and dried. Compounds VIIIa–c were obtained as yellowish crystalline substances. In the case of IIc, Vc was also obtained and was separated from VIIIc by chromatography with a column filled with Al_2O_3 by gradient elution (acetone–ethyl acetate). The yield of Vc was 30%.

B. At first, the method described above was repeated, but 0.05 mole of CH_3COOH was added after refluxing for 2 h, upon which the mixture effervesced violently. It was refluxed for another hour and was then treated as in variant A. The products were identified with authentic samples of Va–c by thin-layer chromatography and from the IR spectra.

Reaction of Octahydroxanthylium Perchlorate with Diamines. A. A 0.001-mole sample of diamine IIIa–c was added to 0.003 mole of octahydroxanthylium salt in 10 ml of ethanol, and the mixture was refluxed for 2 h. It was then cooled, and the precipitated perchlorates were separated. In the case of IIa, only VIIIa was obtained. Mixtures of VIIIb,c and Vb,c were obtained in the case of IIb,c. Identification with genuine samples was carried out by thin-layer chromatography and, in the case of VIIIa, also from the IR spectra.

B. The mixture obtained after refluxing in experiment A was treated with 0.003 mole of CH_3COOH, refluxed for 1 h, and cooled to give Va–c, which were identified with known samples.

Reaction of Diketone I with Diamines and Monoamines in the Presence of $HClO_4$. A total of 0.03 mole of 70% $HClO_4$ was added with stirring to a solution of 0.03 mole of I and 0.01 mole of diamine IIa–c in 35 ml of benzene, the mixture was stirred at room temperature for 2 h, and the perchlorates were separated. In the case of diamine IIa, only Va was formed, while VIIb,c were also present in the case of IIb,c. N-Aryloctahydroacridinium perchlorates were obtained in the reaction with monoamines. The yields of perchlorates with the monoamines were 90% with aniline, 90% with α-naphthylamine, 72% with β-naphthylamine, 84% with p-anisidine, and 65% with p-nitroaniline. The yields with the diamines were 98% with Va, 50% with Vb, and 80% with Vc.

LITERATURE CITED

1. V. A. Kaminskii, A. N. Saverchenko, and M. N. Tilichenko, Zh. Organ. Khim., 6, 404 (1970).
2. V. A. Kaminskii, A. N. Saverchenko, and M. N. Tilichenko, Khim. Geterotsikl. Soedin., 1538 (1970).
3. V. A. Kaminskii, L. N. Donchak, and M. N. Tilichenko, Khim. Geterotsikl. Soedin., 1134 (1969).
4. E. M. Kosower and T. S. Sorensen, J. Org. Chem., 27, 3764 (1962).
5. V. I. Vysotskii and M. N. Tilichenko, Khim. Geterotsikl. Soedin., 299 (1971).
6. N. Bărbulescu and F. Potmischil, Rev. Roum. Chim., 15, 1601 (1970).
7. M. N. Tilichenko, G. V. Pavel', and A. D. Chumak, Zh. Organ. Khim., 7, 704 (1971).