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BULLETIN OF THE CHEMICAL SOCIETY OF JAPAN VOL. 42 2885-2894 (1969)

Configuration and Conformation of So-called Bis(alkylidenearylamines)

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(Received November 27, 1968)

The proposed structures of the dimeric products obtained from aliphatic aldehydes and arylamines were reexamined by IR and NMR spectra. The 1,2,3,4-tetrahydroquinoline structure was ascertained in the case of acetaldehyde or propionaldehyde, and aldolic structure was confirmed in the case of *n*-butyraldehyde. It was observed that the latter readily isomerizes to the former type in the presence of acetic acid. Conformational analysis of a racemic pair of the former (IIIa—c: 2,4-disubstituted, IIId-2,3,4-trisubstituted) indicated that two isomers of IIIa—c (one has 2-equatorial, 4-quasi-equatorial and the other 2-equatorial, 4-quasi-axial substituents) have a flattened half-chair conformation and two isomers of IIId (one has 2,3-diequatorial, 4-quasi-equatorial, 3-axial, 4-quasi-axial substituents) have a more remarkably flattened half-chair, *i. e.* a nearly plane structure. The acylation of ring nitrogen enhanced this tendency, and one of the 1-acetyl derivatives of III was deduced to have a twist half-boat conformation.

On the structure of so-called bis(alkylidenearylamincs) which have been regarded as one of the key-intermediates¹⁾ in the Doebner-von Miller synthesis of quinolines from arylamines and aliphatic aldehydes, the following three formulas have been proposed; the acyclic structure of the aldol type (I), the enamine structure due to the isomerization of I (II) and the cyclic structure having 1,2,3,4-tetrahydroquinoline skelton (III).

1) N. Campbell, R. E. Fairbairn, E. Hoggarth, J. D. Loudon and T. S. Stevens, "Chemistry of Carbon Compounds," Vol. IV, ed. by E. H. Rodd and S. Coffey, Elsevier Publishing Company, Amsterdam, London, New York (1957), p. 588.



For a long time, structure I has been accepted without any definite evidences.²⁾ However, Minkin and Tumakoba³⁾ have recently proposed that, on the basis of IR and UV spectral investigation, both bis(ethylideneaniline) and bis(propylideneaniline) are of structure III, and bis(butylideneaniline), to which Kharasch *et al.*,⁴⁾ had given structure I, is of structure II.

In a previous paper,⁵⁾ the authors have reported the easy dimerization of N-phenyl-acetone-Dglyceraldimine to 4-anilino-1,2,3,4-tetrahydroquinoline derivatives in the presence of catalytic amount of acetic acid, and the determination of their partial absolute configuration by chemical degradation and spectral measurements.

These results stimulated us to determine the configuration and conformation of general bis-(alkylidenearylamines) and their isomers by IR and NMR spectral studies, in connection with the mechanism of Doebner-von Miller reaction. The results obtained are discussed in this paper.

Results and Discussion

Configuration of Bis(alkylidenearylamines). The structures I, II, and III would be easily distinguished by the presence or absence of a characteristic absorption of C=C and C=N bonds in IR spectra, and azomethine and olefinic proton signals in NMR spectra. The results obtained indicated that bis(ethylideneaniline)²) (IIIa), bis-(ethylidene p-toluidine)⁶) (IIIb), bis(ethylidene m-xylidine)⁷) (IIIc) and bis(propylideneaniline)²) (IIId) have structure III, because they showed the absence of C=C and C=N absorption band in IR spectra and the absence of azomethine and olefinic proton signals in NMR spectra, and furthermore, their monoacyl derivatives still showed the presence of NH absorption band at *ca.* 3300 cm⁻¹. The NMR spectra of these compounds will be shown and discussed in the next paragraph.

Contrary to Minkin's findings, NMR spectrum of bis(butylideneaniline) (I) shown in Fig. 1 indicated that it has aldol type structure. Irradiation of Ha caused Hc to collapse to a quartet, and reversal irradiation of Hc caused Ha to collapse to a seemingly narrow triplet with a long range coupling. Therefore, the quintet at τ 7.43, the quartet at τ 6.3 and the doublet at τ 2.2 (J=6.25) can be assigned to Hc, Hb and Ha, respectively.

The chemical shift of Ha is too low for that of olefinic proton and moreover, the coupling constants, which remained unchanged by addition of deuterium oxide, are too large to expect a long range coupling of the olefinic proton in structure II. The following examples of the chemical shifts of azomethine protons may also support the above conclusion; τ 1.65 in benzylideneaniline,⁸⁾ τ 2.37 in ethylidenepropylamine,⁸⁾ τ 2.56—3.16 in aceto-aldoxime.⁹⁾ On the other hand, 2-ethylhexylidene-aniline (IV), which is partially analogous to I and obtained from aniline and 2-ethylhexaldehyde, showed the presence of azomethine proton signal at τ 2.4 (J=6.5).

It has thus become clear that acetaldehyde or propionaldehyde give type III in the condensation with arylamines even in the absence of an acid catalyst, and a higher aldehyde such as *n*-butyraldehyde gives acyclic type I. In order to clarify such an effect of acid catalyst as was observed in a previous study⁵ and the relationship between I and III, a catalytic amount of acetic acid was added to a solution of I in CDCl₃ (Fig. 2). The azomethine proton signal (Ha) disappeared promptly and a ring proton signal of 1,2,3,4-tetrahydroquinoline appeared at τ 5.62. This fact suggests the conversion of I to III, whose structure was also ascertained by UV (λ_{max} 251, 302 mµ) and IR (the disappearence of the absorption

W. v. Miller, J. Plöchl and F. Eckstein, Ber., 25, 1241, 2020 (1892); W. v. Miller and J. Plöchl, *ibid.*, 27, 1299 (1894).

³⁾ V. I. Minkin and Z. A. Tumakoba, Zh. Obschch. Khim., 33, 642 (1963); ibid., 34, 357 (1964).

⁴⁾ M. S. Kharasch, J. Richlin and F. R. Mayo, J. Am. Chem. Soc., 62, 494 (1940).

⁵⁾ M. Funabashi and J. Yoshimura, This Bulletin, 41, 2735 (1968).

⁶⁾ M. G. Edward, R. E. Garrod and H. O. Jones, J. Chem. Soc., 1912, 1383.

⁷⁾ H. O. Jones and E. J. White, *ibid.*, **1910**, 632.
8) J. F. King and T. Durst, *Can. J. Chem.*, **40**, 882 (1962).

⁹⁾ Varian's "NMR Spectra Catalog," Vol. 2.



Fig. 1. NMR spectra of bis(butylideneaniline) (1) (100 Mc, CDC₃l).



Fig. 2. NMR spectra of the isomerised compound (IIIe) of I in the presence of acetic acid (100 Mc, CDCl₃).

band of C=N and the increase of the intensity of the absorption band of NH), and moreover, by the fact that 1-tosyl derivative of IIIe still showed NH absorption band at 3300 cm⁻¹. Besides, distillation of I caused the β -elimination of aniline to give 2-ethyl-2-hexenylideneaniline (V). Such a phenomenon is characteristic for structure I, but not for III.

The Doebner-von Miller synthesis of quinolines from arylamines and lower aliphatic aldehydes has been done in a strongly acidic condition at a high temperature, and two reaction mechanisms¹) have been postulated for it; one includes the formation of α,β -unsaturated aldehydes due to the aldol condensation, the β -addition of arylamines and cyclization similar to that of the Skraup synthesis, and the other the intermediate such as I formed by the aldolic addition of alkylidenearylamines. The results described above seem to be closely related to the latter mechanism, and more detailed work is being undertaken.

Conformation of Bis(ethylidenearylamines) and **Bis(propylidenearylamines)**. It is known that there are usually two isomers in bis-(ethylideneaniline). Some workers¹⁰⁾ considered them to be a pair of geometric isomers of structure II. However, it is now obvious that they should be the diastereomer of substituted 1,2,3,4-tetrahydroquinolines. Minkin and Gorelob¹¹⁾ distinguished them from

10) A. Eibner, Ann., 318, 58 (1901).

11) V. I. Minkin and M. I. Gorelob, Zh. Obschch. Khim., 33, 647 (1963); Chem. Abstr., 59, 2624f (1963). their dipole moment, but the results are doubtful becasse of fundamental misunderstanding of stereochemistry. Therefore, the authors attempted to analyse the conformation of known and some new tetrahydroquinolines with NMR technique.

It has been concluded by X-ray analysis¹²) that the cyclohexene molecule preferentially exists as a half-chair conformation, and the result has been applied to the conformational analysis of 1,2,3,4tetrahydroquinolines,¹³) glucal triacetate,¹⁴) shikimic acid¹⁵) and 1,2,3,4-tetrahydroisoquinolines.¹⁸)

a) Conformation of Bis(ethylidenearylamines). Theoretically, there are two cis and two trans racemic stereoisomers, respectively in bis(ethylidenearylamines), *i.e.*, 1,2,3,4-tetrahydro-2,4-disubstitutedquinolines. Two substituents at C_2 and C_4 are equatorial and quasi-equatorial, or axial and quasiaxial in the case of cis-1 and cis-2, and equatorial and quasi-axial, or axial and quasiequatorial*¹ in the case of trans-1 and trans-2, respectively.



The order of the stability of four conformation will be empirically given as follows; *cis*-1, *trans*-1, *trans*-2 and *cis*-2. As has been pointed out by Booth¹³) that the methyl group of 1,2,3,4-tetrahydro-2-methylquinoline prefers an equatorial orientation, it is probable that the favoured conformations of two known isomers of bis(ethylideneaniline) should be *cis*-1 and *trans*-1. The coupling constants of each ring protons, which can be calculated from the angle parameters of cyclohexene¹⁷) and are listed in Table 1, make it possible to distinguish them. The order of the chemical shifts (τ) of ring protons will be given; H₃ (a), H₃' (e), H₂ and

13) H. Booth, J. Chem. Soc., 1964, 1841.

Table 1. The expected dihedral angles^(a) for 2,4-disubstituted 1,2,3,4-tetrahydroquinolines and the corresponding coupling constants^(b)

	(H ₂ , H ₃)	(H ₂ , H _{3'})	(H _{3'} , H ₄)	(H ₃ , H ₄)
cis-1	178°	62°	45°	165°
J	14.2	2.7	6.2	13.4
	(11.0)	(3.0)	(7.1)	(10.0)
trans-1	178°	62°	75°	45°
J	14.2	2.7	0.83	6.2
	(11.0)	(3.0)	(0.77)	(7.1)
cis-2	62°	58°	75°	45°
J	2.7	2.8	0.83	6.2
	(3.0)	(3.0)	(0.77)	(7.1)
trans-2	62°	58°	45°	165°
J	2.7	2.8	6.2	13.4
	(3.0)	(3.2)	(7.1)	(10.3)

a) obtained from Bucourt's parameters

b) calculated from Abraham's equation¹⁸)

(Lemieux's equation¹⁹)

H₄ from higher to lower field.

The NMR spectrum of the one isomer of 1,2,3,4tetrahydro-4-anilino-2-methylquinoline (IIIa, mp 126°C) is shown in Fig. 3. Inspection of this chart indicates that the $\delta v/J$ is sufficiently large to allow a first-order analysis. The quartet at τ 8.50, which is partly superimposed on the methyl proton signal, the octet at τ 7.67, the multiplet at τ 6.4, and the quartet at τ 5.2 are easily assigned to H_3 ($J_{3,3'}=J_{3,2}=J_{3,4}=11.5$ Hz), $H_{3'}(J_{3',4}=11.5$ Hz), $H_{3'}(J_{3',4}=11.5)$ 5.0, $J_{3',2}=2.5$ Hz), H₂ and H₄ respectively. Comparison of the above data with that of Table 1 clearly demonstrated that IIIa, belongs to cis-1 conformation. The dihedral angles of IIIa, are estimated from the equation of Abraham¹⁸⁾ as follows; $(H_2, H_3) = (H_3, H_4) = 155^\circ$, $(H_2, H_{3'}) = 63^\circ$ and $(H_{3'}, H_4) = 51^{\circ}$.

The NMR spectrum of another isomer (IIIa₂, mp 86°C) is shown in Fig. 4. In this case, the sextet at τ 8.57 and τ 7.93, the multiplet at τ 6.63 and the quartet at τ 5.58 are assigned to H₃ ($J_{3,3'}=$ $J_{2,3}=11.3$, $J_{3,4}=3.75$ Hz), H_{3'} ($J_{2,3'}=J_{2',4}=2.5$ Hz), H₂ ($J_{2,CH_3}=6.5$ Hz) and H₄, respectively. The results indicate that IIIa₂ belongs to *trans*-1 conformation, and the dihedral angles are estimated in the similar manner: (H₂, H₃)=152°, (H₂, H_{3'})= (H_{3'}, H₄)=63° and (H₃, H₄)=58°.

The analytic data of IIIa, IIIb, IIIc and their 1-acyl derivatives, and 1,2,3,4-tetrahydro-2,6-dimethyl-4-hydroxyquinoline²) (III'a; *trans*), 1,2,3,4tetrahydro-1-acetyl-4-acetoxy-2,6-dimethylquinoline²) (III'b; *cis*) and 1,2,3,4-tetrahydro-1-acetyl-4ethoxy-2-phenylquinoline (III'c; *cis*) are summarized in Table 2. The ratio of the formation

^{*1} Axial, equatorial, quasi-axial and quasi-equatorial are abbreviated to a, e, qa and qe, respectively.

¹²⁾ J. M. Lindsay and W. H. Barnes, Acta Cryst., 8, 227 (1955).

¹⁴⁾ L. D. Hall and L. F. Johnson, Tetrahedron, 20, 883 (1968).

¹⁵⁾ R. McCrindle, K. H. Overton and R. A. Baphael, Tetrahedron Letters, **1968**, 1847.

¹⁶⁾ G. Grethe, M. Uskovic, T. Williams and A. Brossi, *Helv. Chim. Acta*, **50**, 2397 (1967).

¹⁷⁾ R. Bucourt, Bull. Soc. Chim. France, 1964, 2080;

R. Bucourt and D. Hainaut, ibid., 1965, 1366.

¹⁸⁾ R. J. Abraham, Mol. Phys., 5, 513 (1962).

¹⁹⁾ R. U. Lemieux and W. J. Lown, Can. J. Chem., 42, 893 (1964).



Fig. 3. NMR spectrum of 1,2,3,4-tetrahydro-4-anilino-2-methylquinoline (IIIa₁) [bis(ethylideneaniline):*cis*] (100 Mc, CDCl₉).



Fig. 4. NMR spectrum of 1,2,3,4-tetrahydro-4-anilino-2-methylquinoline (IIIa₂) [bis(ethylideneaniline):trans] (100 Mc, CDCl₃).

of IIIa₁ and IIIa₂ in the crude product was estimated from the intensity of each H₄ proton signal, to be 1:1, whereas, in the case of IIIc, *trans*-1 type was preferentially formed. The latter case will be probably due to the allylic strain²⁰) between the carbon atom at C₅ and *m*-xylidine residue at C₄ bulkier than phenyl.

The phenomenon that the spiltting number of the methylene proton in 4-ethoxy group of III'c is not a quartet, but a double quartet, suggests the presence of such a hindrance.

The fact that the dihedral angles (H_2, H_3) and (H_3, H_4) are less than that of cyclohexene indicates a considerable flattening of the typical half-chair

conformation. A more remarkable tendency to flatten the conformation has been observed in the case of 1-acyl derivatives of IIIa, IIIb and IIIc, in which the coupling constants between H₂ and H₃ are generally smaller than those of the parent compounds. For example the coupling constant: $J_{2,3}$ (7.5 Hz) of 1-acetyl derivative of IIIc indicates the decrease of the angle from 156° to 136°. This change will be attribuable to the 1,2-skew interaction of acetyl group at C₁ and methyl group at C₂, and also to the allylic strain between acetyl group and methyl group at C₈.

As a general tendency of the NMR data (see Table 2), H_4 proton (qa) of 1-acyl derivatives of *cis*-1 type shifts to a higher magnetic field than H_4 proton of the parent compounds free of acyl group.

²⁰⁾ F. Johnson, Chem. Revs., 68, 378 (1968).

However, it is scarcely changed in the case of *trans*-1 type. H_3 proton also indicates a similar tendency. The former case is consistent with the report of Lambert²¹) *et al.*, in which they indicated that the anticoplanarity between H_7 proton and axial lone pair electron of nitrogen atom in the *N*-substituted piperidine ring causes the chemical shift of H_7 (τ) to a higher magnetic field.

b) Conformation of Bis(propylidenearylamines). In the case of bis(propylidenearylamines), *i. e.*, 1,2,3,4-tetrahydro-4-anilino-2-ethyl-3-methylquinoline, eight half-chair conformations of racemic diastereoisomers are theoretically possible, and among them, the most favored ones will be the two having C_2 -e, C_3 -e, C_4 -qe or C_2 -e, C_3 -e, C_4 -qa substituents. Miller *et al.*²⁾ have found only one isomer (IIId₁; mp 103°C). However, another one should exist as in the case of bis(ethylideneaniline), and in fact, we have succeeded in isolating one (IIId₂) as a syrup from the mother liquor of IIId₁. The IR spectrum of IIId₂, which is very similar to that of IIId₁, showed absence of C=C or C=N absorption band, and that of 1-acyl derivative of IIId₂ still showed NH absorption band at 3320 cm⁻¹.

In the NMR spectrum of IIId₁ shown in Fig. 5,



Fig. 5. NMR spectrum of 1,2,3,4-tetrahydro-4-anilino-2-ethyl-3-methylquinoline (IIId₁) [bis(propylideneaniline): 2,4-cis] (100 Mc, CDCl₃).



Fig. 6. NMR spectrum of 1,2,3,4-tetrahydro-4-anilino-2-ethyl-3-methylquinoline (IIId₂) [bis(propylideneaniline): 2,4-trans] (100 Mc, CDCl₃).

²¹⁾ J. B. Lambert, R. G. Keste, R. E. Carhart and A. P. Javanovich, J. Am. Chem. Soc., 89, 3761 (1967).

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the multiplet at ca. τ 8.2, which is partly superimposed on C₃ methyl proton signal, the octet at τ 6.90 and the doublet at τ 5.72 are assigned to H₃ $(J_{2,3}=4.5 \text{ Hz})$, H₂ $(J_{2,CH_2}=7.0, 7.5 \text{ Hz})$ and H₄ $(J_{3,4}=8.75)$, respectively. The irradiation of H₃ caused H₄ proton signal to collapse to a singlet. The coupling constants mentioned above roughly support the fact that the substituents of IIId₁ at C₂, C₃ and C₄ are e, e and qe. The dihedral angles of ring protons; (H₂, H₃)=124° and (H₃, H₄) =141° indicate a more remarkably flattened half-chair (rather plane) conformation than that of IIIa.

In the NMR spectrum of the other isomer $(IIId_2)$ shown in Fig. 6, a multiplet centered at τ 7.97, a triplet doublet at τ 6.80 and a narrow doublet at au 5.95 are assigned to H₃, (J_{2,3}=2.5 Hz), H₂ (J_{2,CH_2} =6.5 Hz) and H₄ ($J_{3,4}$ =ca. 1 Hz), respectively. The dihedral angles are similarly estimated to be $(H_2, H_3) = 114^\circ$ or 64° and $(H_3, H_4) = 105^\circ$ or 74°. The most profitable conformation to be justified by these angles is a flattened half-chair having C2-e, C3-a and C4-qa substituents or a rather contracted half-boat conformation having C_2 -e, C_3 -e and C_4 -qa substituents, but not a halfchair having C2-e, C3-e and C4-qa which was mentioned above as a stable one. Among the two probable conformations, however, the latter is not adoptable because of the instability factor due to the constraction strain. Therefore, the former is preferable to $IIId_2$.

This conclusion will be supported by the following considerations. If IIId₁ and IIId₂ can be formed through the structure of type I, as in the case in which I cyclizes to IIIe, racemic three and erythro isomers of type I should exist in the intermediate step. The threo isomer will preferentially cyclize to the conformation having C_2 -e and Ca-e substituents. However, the erythro isomer should give a half-chair conformation having C_2 -a or C_3 -a substituent. Though C_4 configuration can not be estimated unless the transition state of such a cyclization is clarified, we can understand that IIId₁ is preferentially formed, so far as stability is concerned. However, in the case of erythro, two stable conformations are equally possible from the standpoint of the nonbonded interaction. The following consideration may be allowed: there are four possible conformations to be formed by the cyclization of the erythro intermediate;

A) C_2 -a, C_3 -e and C_4 -qe, B) C_2 -a, C_3 -e and C_4 -qa, C) C_2 -e, C_3 -a and C_4 -qe, D) C_2 -e, C_3 -a and C_4 -qa. The instability factor of the substituents can be roughly estimated as follows: A; 3 skews (C_2 -a and C_3 -e, C_2 -a and C_3 - C_4 bond, C_3 -e and C_4 -e), B; 4 skews (C_2 -a and C_3 - C_4 bond, C_4 -a and C_3 -e, C_4 -a and C_2 - C_3 -a and C_3 - C_4 bond, C_4 -a and C_3 -e, C_4 -a and C_2 - C_3 -bond) and 1,3-diaxial interaction (C_2 -a and C_4 -a), C_3 + a kews (C_3 -a and C_2 -e, C_3 -a and C_2 -N bond, C_3 -a and C_4 -c, C_3 -a and C_4 -C_{benzene}), and D; 4 skews (C_3 -a and C_2 -e, C_3 -a and C_4 - $C_{benzene}$, C_3 -a and C2-N bond, C4-a and C2-C3 bond), respectively. Among these skew interactions, C2-a and C3-C4 bond, C3-e and C4-e, C3-a and C2-N bond, C3-a and C₄-C_{benzene}, C₄-a and C₂-C₃ bond interactions will be weakened by flattening of half-chair conformation (enlargement of the dihedral angles), and others will be enhanced because of the eclipse effect of the substituents. Therefore, both A and D conformations are almost equivalent with respect to the instability factor. The A conformation, however, is rejected so far as NMR is concerned, because the coupling constant $(J_{3,4})$ of IIId₂ is too small (ca. 1 Hz) for that of A conformation (H₃ and H₄; trans-diaxial). Accordingly, D conformation is preferable to IIId₂.

The formation ratio of $IIId_1$ (threo) and $IIId_2$. (erythro) was measured from the intensity of each H_4 protons in the crude mixture to be 55:45. The coupling constants of ring protons of acetyl derivatives of $IIId_1$ and $IIId_2$ shown in Table 3 indicate that the conformation of $IIId_1$ remained almost unchanged. However, $J_{3,4}$ value of $IIId_2$ changed remarkably from *ca.* 1 to 11.3. This change may be explained by the conversion of the conformation from half-chair to a twisted half-boat or by the conversion to A conformation, in order to avoid 1,2-interaction between acetyl and ethyl group.



Scheme 3

On the other hand, the NMR data in Table 3 indicate that H_4 proton of 1-acetyl derivative of $IIId_1$ (2,4-*cis*) shifts to a higher magnetic field than that of IIId₁ as in the case of IIIa or IIIb. This phenomenon may be of use for the conformational analysis of 4-, or 2,4- or 2,3,4-substituted 1,2,3,4-tetrahydroquinolines and others.

A general conclusion may be given for the conformation of the substituted 1,2,3,4-tetrahydroquinolines that; 1) 2,4-disubstituted 1,2,3,4tetrahydroquinolines have a flattened half-chair conformation (C_2 -e, C_4 -qe or C_2 -e, C_4 -qa). 2) 2,3,4-Trisubstituted 1,2,3,4-tetrahydroquinolines have a remarkably flattened half-chair or twisted half-boat conformation (C_2 -e, C_3 -e and C_4 -qe or C_2 -e, C_3 -a and C_4 -qa). 3) 1-Acyl derivatives of the substituted 1,2,3,4-tetrahydroquinolines have a more flattened half-chair than the acyl free derivatives.

Experimental

All the aliphatic aldehydes and arylamines were purified before use by distillation of the commercial products. The melting points were uncorrected. The measurements of NMR spectra were effected with JEOL JNM-4H-100 in deuteriochloroform by using TMS as an internal reference. IR spectra were measured with Hitachi EPI-G2. UV spectra were measured with Hitachi EPS-3T in methanol solution. TLC was carried out on layers of silica gel (WAKO-GEL B-Q) on glass plates, using benzene (system A) or benzene-ligroin (3:1, system B) as developers and 2% aqueous potassium permanganate-sodium carbonate or chromic-sulfuric acid (5%-K₂Cr₂O₇ in 40% H₂SO₄) as spray reagents. R_a value is the rate of movement of the 1,2,3,4-tetrahydroquinolines relative to aniline.

Bis(butylideneaniline) (I : 3-anilino - 2 - ethylhexylideneaniline). Equimolar amount of freshly distilled aniline and *n*-butyraldehyde was mixed and allowed to stand at room temperature for 24 hr according to the method of Kharasch *et al.*⁴⁾ White crystals were obtained in a yield of 55%. Mp 92°C (lit, 92.5°C). I in an alcoholic solution gradually isomerized to 1,2,3,4tetrahydro-4-aniline-3-ethyl-2-propylquinoline (IIIe) and the yield decreased.

1,2,3,4-Tetrahydro-4-anilino-3-ethyl -2-propylquinoline (IIIe). To a solution of bis(butylideneaniline) (I: 2.94 g, 10 mmol) dissolved in chloroform (10 ml) was added two drops of acetic acid and the solution was allowed to stand at room temperature overnight, neutralized with an aqueous sodium hydrogene carbonate, washed with water and dried over Na₂SO₄. Evaporation of chloroform gave a pale yellow syrup (2.9 g), which shows no absorption band of imine at *ca*. 1650 cm⁻¹. UV: λ_{max}^{Meon} 251 m μ (log ε =4.43), 302 m μ (log ε =3.87).

1-Tosyl Derivative of IIIe. IIIe was tosylated with *p*-toluenesulfonyl chloride (1.2 times mole of IIIe) in pyridine in an usual manner to give 1,2,3,4-tetrahydro-4-anilino-3-ethyl-2-propyl-1-tosylquinoline in a yield of 22% (crystals). Mp 210-211°C (recrystallized from acetone). IR; 3400 cm⁻¹ (NH), 1340, 1162cm⁻¹ (*N*-tosyl).

Found: C, 72.04; H, 7.33; N, 6.50; S, 7.42%. Calcd for $C_{27}H_{32}O_2N_2S$ (448): C, 72.29; H, 7.19; N, 6.29; S, 7.15%.

2-Ethyl-1-hexylideneaniline (IV). 2-Ethylhexaldehyde (12.8 g, 0.1 mol) was added to aniline (9.3 g, 0.1 mol) with cooling in an ice-water and the mixture was allowed to stand at room temperature overnight. After drying over Na_2SO_4 , distillation of the reaction product was effected under 1 mmHg to give a pale yellow oil (15.8 g, 77.6%). Bp 92—95°C/1 mmHg.

Found: C, 82.75; H, 10.19; N, 6.76%. Calcd for C₁₄H₂₁N: C, 82.70; H, 10.41; N, 6.89%.

Pyrolysis of Bis(butylideneaniline)(I) to 2-Ethyl-2-hexenylideneaniline (V). I (3 g, 10.2 mmol) was filled in a sealed tube and heated in an oil bath at 120—140°C for 12 hr. Distillation of the reaction product *in vacuo* gave an oil (V) (1.5 g, 74%) having bp 142—147°C/11 mmHg (lit,⁴) 146—148°C/15 mmHg). Refluxing of the acidic ethanol solution of V with 2,4-dinitrophenylhydrazine for 2 hr gave 2,4-dinitrophenylhydrazone (red crystals). Mp 118°C (lit,⁴) 119—120°C).

Bis(ethylideneaniline) (1,2,3,4 - Tetrahydro - 4 - anilino-2-methylquinoline: IIIa₁ and IIIa₂). IIIa₁ (*cis*) and IIIa₂ (*trans*) were prepared from aniline (0.1 mol) and acetaldehyde (0.1 mol) in a mixture of ethanol

(150 ml) and water (100 ml) in a yield of 20% (IIIa₁) and 22% (IIIa₂), respectively, by the Method of Minikin and Tumakoba.

IIIa₁: mp 121—124°C (lit,²⁾ 126°), R_a 1.64 (system A).

IIIa₂: syrup (lit,²⁾ 85.5°), R_a 2.07 (system A).

(Found of IIIa₂: C, 80.45: H, 7.92; N, 11.40%. Calcd for $C_{16}H_{18}N_2$: C, 80.63; H, 7.61; N, 11.78%).

1-Acetyl derivative of IIIa₁. To a solution of IIIa₁ (0.3 g, 1.26 mmol) in pyridine (2 ml), acetic anhydride (1 g, 10 mmol) was added and the mixture was allowed to stand at room temperature for 2 days, and then poured into ice-water. The precipitated crystalline products were filtered, washed with water, dried and recrystallized from ethanol. Yield, 0.3 g (84.6%). Mp 110.5—111°C.

Found: C, 77.40; H, 6.92; N, 9.52%. Calcd for C₁₈H₂₀N₂O: C, 77.11; H, 7.19; N, 9.99%.

1-Benzoyl derivative of IIIa₁: mp 216-217°C (lit,²⁾ 218°C).

1-Benzoyl derivative of IIIa₂: mp 156—157°C (lit,²⁾ 186°C).

Bis(ethylidene *p*-toluidine) [1,2,3,4-Tetrahydro-2,6-dimethyl-4-(*p*-toluidino)quinoline: IIIb]. IIIb (*cis*) was prepared by the method of Jones *et al.*⁶) in a yield of 43%. Mp 113—114°C (lit, 114—116°C).

1-Acetyl derivative of IIIb; mp 141-143°C, yield 57.5%.

Found: C, 77.38; H, 7.65; N, 8.74%. Calcd for C₂₀H₂₄N₂O: C, 77.88; H, 7.85; N, 9.08%.

Bis(ethylidene *m*-xylidine) [1,2,3,4-Tetrahydro-2,6,8 - trimethyl - 4 - (*m*-xylidino)quinoline: IIIc]. IIIc was prepared by the method of white *et al.*⁸⁾ in a yield of 97%. Mp 141–143°C (lit, 145°C). 1acetylation was difficult probably because of the steric hindrance due to the 8-methyl group. Yield, 15%. Mp 142–143°C (lit, 145°C).

1,2,3,4-Tetrahydro-4-hydroxy-2,6-dimethylquinoline (III'a : trans): mp 107.5—110°C (lit,*) 108— 110°C).

1,2,3,4-Tetrahydro-4-acetoxy -1- acetyl-2,6 - dimethylquinoline (III'b : *cis***):** mp 119—119.5°C (lit,²⁾ 117 —119°C).

1,2,3,4-Tetrahydro -1- acetyl -4- ethoxy -2- phenylquinoline (III'c: cis). A mixture of 1,2,3-4-tetrahydro-4-ethoxy-2-phenylquinoline²²) (1 g, 3.93 mmol), acetic anhydride (10 ml) and pyridine (1 ml) was refluxed for 15 min, allowed to stand at room temperature for 2 hr and then poured into ice-water. Precipitated oil was extracted with chloroform, and organic layer was neutralized with aqueous NaHCO₃, washed with water and dried over Na₂SO₄. Evaporation of chloroform gave a syrup, which was purified with a silica gel column (WAKO-GEL Q-50). From the fraction of benzene and benzene-acetone (10:1), crystalline product was obtained in a yield of 53%. Mp 120-121°C.

Found: C, 76.89; H, 6.83; N, 4.57%. Calcd for C₁₉H₂₁NO₂: C, 77.26; H, 7.17; N, 4.74%.

Bis(propylideneaniline) (1,2,3,4 - Tetrahydro -4anilino-2-ethyl-3-methylquinoline: IIId₁ and IIId₂). To a cold solution of aniline (9.3 g, 0.1 mol) in ethanol (25 ml), propionaldehyde (5.8 g, 0.1 mol) was added and

²²⁾ V. I. Grigos, L. S. Povarov and B. M. Mikhailov, Izv. Akad. Nauk. SSSR, Ser. Khim., 1965, 2163; Chem. Abstr., 64, 9680c (1966).

the reaction solution was allowed to stand in a refrigerator for 2 days. The white crystalline mass was filtered and the crude product (IIId₁, 4.8 g) was recrystallized from ethanol. Mp 104–105°C (lit,²⁾ 103°C), R_a 2.46 (system B). The mother liquor, scarcely containing any IIId₁, was evaporated *in vacuo* to a syrup (IIId₂, 5.2 g) and the small amount of remaining aniline was distilled off. R_a 2.88 (system B).

Found: C, 80.99; H, 8.31; N, 11.42%. Calcd for $C_{18}H_{22}N_2$: C, 81.16; H, 8.33; N, 10.52%.

Acetylation of $IIId_1$ and $IIId_2$ with acetic anhydride and pyridine gave 1-acetyl derivatives respectively in good yields.

1-Acetyl derivative of IIId₁: mp 135-136°C.

Found: C, 78.09; H, 7.86; N, 8.73%. Calcd for C₂₀H₂₄N₂O: C, 77.88; H, 7.84; N, 9.08%.

1-Acetyl derivative of IIId₂: mp 175-175.5°C. Found: C, 78.12; H, 8.10; N, 9.27%. Calcd for C₂₀H₂₄N₂O: C, 77.88; H, 7.84; N, 9.08%.