cipitate of merocyanine IIIg was separated and washed with alcohol. Workup gave 0.20 g of spirochroman Vg and 0.11 g of merocyanine IIIg. IR spectrum of the merocyanine: 1520 and 1340 cm^{-1} (NO_2). Found and calculated: M 426 (for ^{79}Br).

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CRYSTAL AND MOLECULAR STRUCTURE OF 2-CHLORO-1-METHYL-4-PHENYL-α-CARBOLINE HYDROCHLORIDE

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A compound with the composition $C_{18}H_{16}Cl_2ON_2$ was subjected to an x-ray diffraction study. All of the rings in the molecule are planar. Both of the six-membered rings of the carboline system are inclined slightly and identically with respect to the central pyrrole ring, forming angles of 3° with it and 6° with one another. The phenyl ring is turned at an angle of 52.7° relative to the average plane of the carboline system.

2-Chloro-α-carbolines have cytotoxic properties [1, 2]. Their biological activity depends only slightly on the size and position of the alkyl substituents in the pyridine ring and parameters such as the coefficient of distribution and the basicity constant. However, 1- and 4-aryl derivatives do not display cytotoxic properties.

α-Carbolines form complexes with DNA [3], and this may be the reason for their biological activity. It might be assumed that intercalation of the planar heterocyclic chromophore into the space between parallel layers of the bases in the DNA double helix occurs in these complexes [4]. The biological inertness of aryl derivatives may be a consequence of the nonplanarity of their molecules: Rotation of the benzene ring relative to the plane of the heteroring may create hindrance to intercalation. In order to evaluate the degree of deviation from planarity we subjected crystals of 2-chloro-1-methyl-4-phenyl-α-carboline hydrochloride (I) [5] grown from solution in isopropyl alcohol to x-ray diffraction analysis (see following page).

The molecule as a whole is nonplanar. Its noncoplanarity is determined primarily by the phenyl substituent, which forms an angle of 51° with the pyridine ring and an angle of 52.7° with the average plane of the carboline system. The latter is approximately planar.

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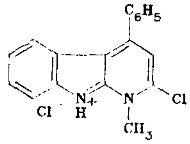

I

Both of its six-membered rings are inclined slightly and identically with respect to the central pyrrole ring, forming angles of 3° with it and 6° with one another.

All of the rings in the molecule are planar. The maximum deviations of the atoms of which they are composed from the mean-square planes determined by them do not exceed 0.04 Å and are comparable in magnitude to the accuracy in the determination of the coordinates of the atoms. The chlorine atom and the methyl carbon atom are situated close to the plane of the pyridine ring, deviating 0.05 and 0.01 Å from it, respectively.

A similar conformation for a related molecule has been observed in a structure [6] in which, however, the phenyl substituent deviates more markedly from the plane of the molecule, forming an angle of 70.4° with it. Steric factors — the distance between the C_5 and C_6 atoms is 3.18 Å — hinder further drawing together of the planes of the carboline system and the phenyl substituent in the structure under investigation.

The bond distances and angles in the molecule are presented in Fig. 1. The standard deviations in the distances between the nonhydrogen atoms and in the bond angles range from 0.01 to 0.02 Å and 0.7 to 1.1°, respectively.

Judging from the interatomic distances, delocalization of the double bond between the C_{9a} atom and the two nitrogen atoms (pyrrole and pyridine) occurs in the molecule; of these two bonds, the $N_{(1)}-C_{(9a)}$ bond in the pyridine ring proves to be the shorter (but only slightly shorter considering the standard deviations). It takes on a value that is intermediate between a sesqui and double C–N bond. The $N_{(1)}-C_{(2)}$ interatomic distance of 1.37 Å, which only slightly exceeds the length of the sesqui bond between atoms of this sort, is shortened as compared with the length of the N–C single bond. The $C_{(2)}-C_{(3)}$ distance, which is 1.35 Å in the given structure, virtually coincides with the length of the C=C bond. The $N_{(9)}-C_{(8a)}$ and $C_{(4a)}-C_{(4b)}$ interatomic distances are somewhat shorter than the lengths of the single bonds between corresponding atoms in the sp^2-hybridization state, and the $C_{(4a)}-C_{(9a)}$ bond is shortened quite insignificantly. The $C_{(3)}-C_{(4)}$ and $C_{(4)}-C_{(4a)}$ interatomic distances are equalized and coincide with the length of the sesqui bond. The distances in the phenyl ring take on the standard values. The distance between the $N_{(1)}$ atom and the methyl carbon atom is lengthened somewhat, whereas $C_{(2)}-Cl_{(1)}$ coincides with the length of the corresponding single bond. The magnitude of the distance between $C_{(4)}$ and $C_{(1')}$ (1.49 Å) and the angle between the plane of the pyridine ring and the phenyl substituent (51°) constitute evidence for the absence of appreciable π interaction between them.

The projection of the structure is presented in Fig. 2. Hydrogen bonds formed between the $Cl_{(2)}$ atom and the pyrrole nitrogen atom are observed in the structure. The $Cl_{(2)}\ldots N_{(9)}$ distance is 3.11 Å. In addition, the same chlorine atom is also bonded to two molecules of water: $Cl^*_{(2)}\ldots O$ = 3.262 Å and $Cl^*_{(\ )}\ldots O^*$ = 3.212 Å. The atoms obtained from those presented in Table 1 by reflection in the *a* plane are designated by asterisks. Each molecule of water is bonded to two $Cl_{(2)}$ atoms in this case.

The experimental accuracy did not make it possible to localize the hydrogen atoms on either $Cl_{(2)}$ or $N_{(9)}$, so that it is impossible to state the form (neutral or ionic) in which the molecules in the given structure exist from the x-ray diffraction data. In addition to the hydrogen bonds noted above, the other intermolecular distances exceed the sum of the van der Waals radii of the corresponding atoms.

Thus the benzene ring of the substituent in the 4 position in the investigated crystal is turned at a large angle relative to the plane of the chromophore, and steric factors do not permit the molecule to assume a planar conformation even in solution. Intercalation in DNA should therefore be strongly hindered.

EXPERIMENTAL

The crystals with the composition $C_{18}H_{16}Cl_2ON_2$ have a prismatic habitus, rhombic syngony, a = 8.872(4), b = 15.315(9), c = 12.323(8) Å, V = 1674(1) Å^3, space group $Pna2_1$, d_{calc} =

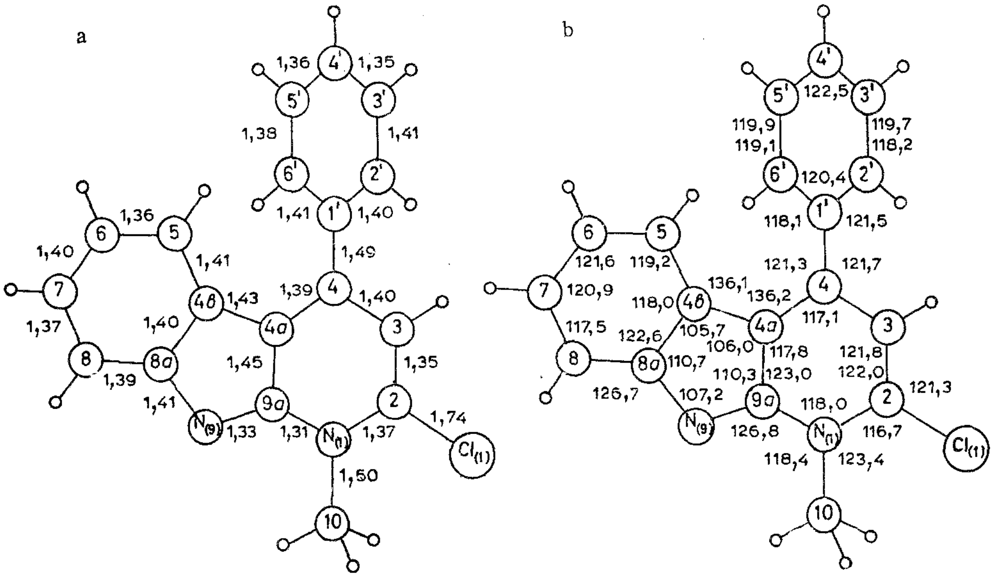

Fig. 1. Bond distances in angstroms (a) and bond angles in degrees (b) in the molecule.

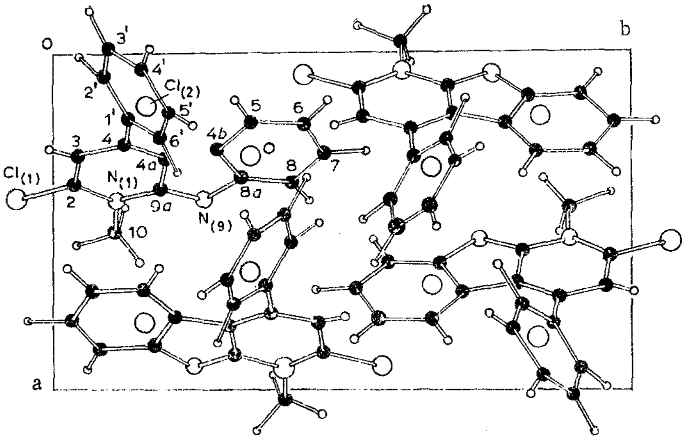

Fig. 2. Projection of the structure on the (001) plane.

$1.38\ g\cdot cm^{-3}$, $Z = 4$, and $\mu(Cu\ K_\alpha) = 32.8\ cm^{-1}$. The experimental data were obtained from a 0.25 by 0.28 by 1.1 mm sample with a DAR-UMB diffractometer with equally sloped geometry (Cu K_α emission, graphite monochromator). A total of 1040 independent reflections with $I > 3\sigma$ were used in the calculations. No correction for absorption was introduced into the intensity.

Attempts to solve the structure by means of the Patterson function and direct methods were unsuccessful. The structure was solved by the combined use of differences in the D(u) interatomic function and the usual Patterson function. Resolution of the peaks in D(u) on the Harker line corresponding to the sliding reflection plane *a* made it possible to limit the possible regions for localization of the chlorine atoms, which are the heaviest atoms in the structure. Evaluation of the heights of the maxima on the absolute scale of the usual Patterson function made it possible to exclude some of the peaks from consideration as not corresponding to the Cl—Cl interatomic vectors, since their heights were lower by a factor of more than two than the theoretical heights of the peaks for such pairs of atoms. The peaks corresponding to them in the Harker sections of the differential function were rejected. The remaining peaks made it possible to determine the possible positions of both of the independent chlorine atoms relative to the symmetry elements. Examination of the D(u) peaks in general positions made it possible to fix the mutual orientation of these atoms. The assignment of the two chlorine atoms made it possible to localize in the electron density syn-

TABLE 1. Coordinates of the Basis Atoms ($\cdot 10^4$)

Atom	*x*	*y*	*z*
Cl (1)	4374 (3)	−641 (2)	3759 (4)
Cl (2)	1522 (3)	1642 (2)	1900
O	3095 (10)	3446 (6)	1064 (8)
N (1)	4424 (8)	1091 (4)	3762 (8)
C (2)	3898 (10)	370 (6)	4300 (9)
C (3)	3080 (12)	435 (6)	5221 (9)
C (4)	2710 (10)	1246 (6)	5674 (8)
C (4a)	3124 (10)	1984 (6)	5095 (8)
C (4b)	2909 (10)	2905 (5)	5201 (8)
C (5)	2070 (11)	3463 (6)	5888 (8)
C (6)	2083 (12)	4339 (6)	5699 (10)
C (7)	2945 (13)	4704 (6)	4861 (9)
C (8)	3787 (12)	4183 (7)	4184 (9)
C (8a)	3707 (10)	3283 (6)	4341 (8)
N (9)	4427 (8)	2635 (5)	3715 (7)
C (10)	5330 (12)	1043 (7)	2740 (8)
C (1′)	1925 (10)	1316 (6)	6737 (8)
C (2′)	583 (12)	869 (7)	6940 (10)
C (3′)	−172 (14)	1031 (8)	7928 (11)
C (4′)	436 (15)	1587 (10)	8660 (10)
C (5′)	1785 (13)	1988 (9)	8497 (9)
C (6′)	2537 (11)	1880 (7)	7525 (9)

thesis all of the nonhydrogen atoms of the structure except O, $C_{(6)}$, and $C_{(7)}$, which were localized in the subsequent electron density synthesis.

Refinement of the structure by the method of least squares by means of the UANKh program (Institute of Heteroorganic Compounds of the Academy of Sciences of the USSR) with allowance for the hydrogen atoms and the anisotropy of the thermal vibrations of the nonhydrogen atoms led to R = 0.062. An experimental weighting scheme was used in the method of least squares. We were unable to localize the hydrogen atoms in the HCl and H_2O molecules. The hydrogen atom attached to the pyrrole $N_{(9)}$ atom also was not detected. The methyl group was refined as a rigid fragment with fixed C—H distances (1.08 Å) and H—C—H angles (109.5°). The remaining hydrogen atoms were fixed during the application of the method of least squares at distances of 1.08 Å from the carbon atoms on the bisectrices of the external angles with the apexes in the carbon atoms. Isotropic temperature parameters V = 0.06 $Å^2$ were assigned to all of the fixed hydrogen atoms.

The coordinates of the basis nonhydrogen atoms with the standard deviations are presented in Table 1.

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