AZOLES AND AZINES.

## 65.* DIPOLE MOMENTS AND CONFORMATION OF SOME 2-ARYL-4-CHLORO-5-FORMYL-6-OXO-1,3-THIAZINES

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The dipole moments of 2-aryl-4-chloro-6-oxo-1,3-thiazines and 2-aryl-4-chloro-5-formyl-6-oxo-1,3-thiazines (Ar = C_6H_5, C_6H_5Cl-p, $C_6H_5CH_3$-p) were determined experimentally in benzene and calculated by the additive scheme with the vector method, as well as by the PPDP/2 method. Comparison of the data obtained with the calculated data showed that the formyl group is taken out of the plane of the thiazine ring.

We previously showed [2] that the 2-aryl-4-chloro-6-oxo-1,3-thiazines (II) and their 5-formyl derivatives (III) can be obtained by the reaction of 2-aryl-4-hydroxy-6-oxo-1,3-thiazines (I) with the Vilsmeier reagents. The compounds (III) react readily with nucleophiles forming the products of the addition to the carbon atom of the formyl group (V) and/or the products of the substitution of the halogen at $C_{(4)}$ (IV). Bifunctional nucleophiles (phenylhydrazine, hydroxylamine) attack the formyl carbonyl at first with the formation of the compounds (V); the intramolecular cyclization only then proceeds under more drastic conditions as a result of the nucleophilic substitution of the halogen at $C_{(4)}$.

I—V a Ar=C_6H_5, b Ar=4-ClC_6H_4, c Ar=$CH_3C_6H_4$
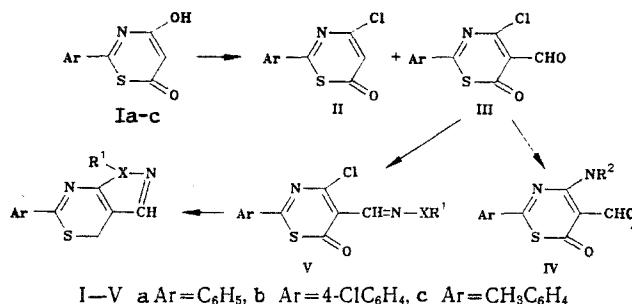
Electron-acceptor substituents at the position 4 of the benzene ring increase the availability of the halogen at $C_{(4)}$ of the heterocyclic fragment; electron-donor substituents decrease it. It was also to be expected that the introduction of the formyl group at $C_{(5)}$ of the thiazine ring will lead to an increase in the reactivity of the 4-chlorothiazin-6-ones in nucleophilic substitution reactions. In fact, 4-chloro-2-phenyl-1,3-thiazin-6-one and its formyl derivative react with diisobutylamine forming the corresponding 4-diisobutyl-aminothiazinones in 70% yield by heating in dioxane for 7 and 1 h respectively. Such an influence will evidently be maximal with the maximal conjugation of the thiazine ring and the formyl group. The steric disposition of the formyl group in the compounds (IIIa-c), on which the effectiveness of the conjugation depends, should be determined by the competitive influence of two factors. The first of them is associated with the electrostatic repulsion of the oxygen of the formyl group from the chlorine and oxygen atoms at $C_{(4)}$ and $C_{(6)}$ of the thiazine ring. The structure with the formyl carbonyl group taken out of the plane of the heterocycle should thereby correspond with the minimum of the Coulomb interaction. The second factor is determined by the tendency toward the most energetically favorable conformations with the flat s-trans- or s-cis disposition of the endo- and exocyclic double bonds.

*For Communication 64, see [1].

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Compound	R	α	γ	μ_{exp}, D (φ_0*)	μ_v, D (φ_0*)	μ_p, D ($\theta = 0°$)†	Charge on $C_{(4)}$
IIa	H	17,58	1,15	3,44 (±18)	3,32 (±17)	3,55	0,230
IIb	Cl	6,77	1,32	1,98 (±32)	1,85 (±31)	1,37	0,291
IIc	CH₃	23,21	1,16	3,99 (±15)	3,87 (±14)	3,97	0,290
IIIa	H	41,90	1,31	5,40	6,35; 5,15 †	6,57; 5,53 ‡	0,308; 0,311‡
IIIb	Cl	22,35	1,65	3,86	4,93; 3,59	4,32; 3,22	0,310; 0,312
IIIc	CH₃	49,90	1,54	5,90	6,87; 5,73	6,88; 5,90	0,308; 0,310

*The angle between the direction of the dipole moment and the Ar–$C_{(2)}$ bond.
†The values of μ_p for the compounds (IIIa-c) at $\theta = 30°$ equal 6.38, 4.13, and 6.76 D. The corresponding values at $\theta = 60°$ are 5.96, 3.76, and 6.30 D; the corresponding respective values at $\theta = 90°$ are 5.61, 3.41, and 5.95 D.
‡The first number pertains to the plane s-trans-isomer ($\theta = 0°$); the second number pertains to the plane s-cis-isomer ($\theta = 180°$).

s=trans ($\theta=0°$)   s=cis ($\theta=180°$)
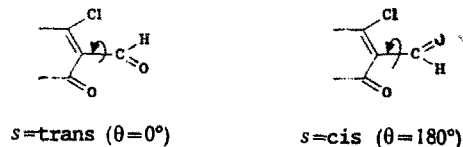
The comparison of the energy parameters of the rotational isomers can give information on the structure of the compounds (IIIa-c). In connection with this, we carried out a quantum-chemical calculation of the total energies of five conformers of each of the compounds (IIIa-c) by the semiempirical SSP MO LCAO method with the PPDP/2 approximation. The difference in the energies of the plane and restrained conformations with the 30, 60, and 90° rotation angles ( ) of the formyl group is small and does not exceed 2-4 kJ/mole. Such differences in the energy of the conformers indicate the relative ease of the free rotation about the single $C_{(5)}$–CHO bond and the low probability of the appreciable predominance of one of the conformers. In order to solve the problem of the structure of the compounds (IIIa-c), the values of their dipole moments were determined experimentally in benzene; they were compared with the values calculated by the vector scheme, and obtained from quantum-chemical calculations (Table 1).

The main geometrical dimensions of the investigated compounds were taken from the work [3]. The direction of the dipole moment of the unsubstituted 2-phenyl-4-chloro-6-oxo-1,3-thiazine was found by the solution of the system of equations relative to μ_{exp} of the compounds (IIa, b) utilizing $\mu(C_6H_5Cl) = 1.6$ D [4]. The selection between the roots of the equations determining the orientation of the vector μ_{exp} to the side of the chlorine atom or the oxygen atom was made using the vector analysis of the dipole moments of these compounds according to the additive scheme.
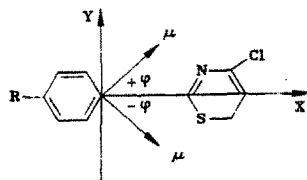
The calculation of the μ_v was carried out by the summation of the dipole moments of cyclohexanone 3.06 [4], the azomethine group 1.80 D, and the Ar-C 0.50 D and C_{sp_2}–N_{sp_2} 0.40 D [5] bonds, as well as the C_{sp_2}-S-C_{sp_2} group found from the dipole moment of divinyl sulfide 1.20 D [4]; the $\mu(Cl)$ in the 1,3-thiazine ring was taken as 1.60 D since it follows from the difference between the dipole moments of trans-1-chloropropene (1.97 D) and propene (0.36 D) [4]. The presence of the vinylcarbonyl grouping in the molecule requires the calculation of the moment of interaction μ_{int} at the C=C–C=O bonds. However, the literature data on the evaluation is very contradictory. According to the empirical scheme [6], μ_{int} is directed along

the C=C (0.20 D) and C—C (0.10 D) bonds, whereas μ_{int} equals 0.80 D in the direction (taken a priori) from the $C_{(3)}$ atom to the oxygen atom according to the calculations of [7].

We calculated the value of μ_{int} relying on the data of the microwave spectra and the Stark effect for the s-trans-conformer of acrolein (μ_0 = 3.11 D, φ = 14 ± 2°) [8] and acetaldehyde (μ_0 = 2.69 D, φ = 14° from the C=O bond) [9]. The moment of interaction due to the substitution of the methyl group by the vinyl comprises 0.40 D in the direction of the double bonds, and 0.12 D in the direction of the C—C bond. The same result (0.40 and 0.10 D) is obtained by the comparison of the dipole moments of these compounds in benzene (2.90 and 2.49 D) [4], if it is assumed that the directions of μ_{exp} are unchanged in comparison with those found in the gas phase. The result of the vector evaluation of the dipole moments of (IIa, b) showed that μ_{exp} is directed to the side of the oxygen atom (see Table 1). The values of μ_V are somewhat lower than μ_{exp}. The variation of the parameters of the calculation $\mu(Cl)$ = 1.44 D is as in vinyl chloride; the $\mu(CSC)$ = 1.25 D on the basis of the difference of 1.71 D of thiacyclohexane [4] and the μ_{int} = 0.40 D along the $S-C_{sp_2}$ bond [10] changes the μ_V in the limits of 0.10 1kD and the angle φ in the limits of ±2°.

A special position is held by the 4-tolylthiazine (IIc), for which the μ_{exp} exceeds the sum of the μ_{exp} of the unsubstituted 2-phenylthiazine (IIa) and the $\mu(CH_3C_6H_5)$ = 0.37 D. The contribution, calculated from experimental data, of $\mu(CH_3)$ = 0.57 D, is practically the same as that in the vinyl ketones: $\mu(CH_3)$ = 0.50–0.60 D [6].

The vector analysis of the dipole moments of the 5-formyl derivatives of the 1,3-thiazines (III) is possible by three approximations: 1) the heterocycle is the donor of electrons in relation to the CHO group, and $\mu(CHO)$ is close to $\mu(C_6H_5CHO)$ = 2.96 D, φ = 146° [11], 2) the donor capacity of the $C_{(5)}$ atom is suppressed as the result of its interaction with the carbonyl group $C_{(4)}$ = 0 of the ring, and $\mu(CHO)$ is close to $\mu(CH_3CHO)$ = 2.49 D, φ = 138° [11], and 3) the interaction of the formyl group is limited by the vinylaldehyde fragment, i.e., $\mu(CHO)$ = $\mu(CH_3CHO)$ + μ_{int}(C=C—C=O). The question on the choice of one of these approximations can be solved if it is assumed that the compounds (IIIa) and (IIIb) are isoconformational. In this case, the difference in the values of μ_{exp} for the compounds (IIIa) and (IIIb) is only determined by the value of the projection of μ_{exp} on the Ar-$C_{(2)}$ axis, the value of which does not depend on the angle of rotation of the CHO group. The comparison of the calculated value m_x = 2.04 D with the projections of $\mu(CHO)$ in the approximations indicated above, taking into account the fact that the $C_{(4)}$—CO bond is directed at less than the angle of 12° to the Ph–$C_{(2)}$ axis [3], are as follows: 1) 2.45 D, 2) 1.85 D, and 3) 2.15–2.17 D. This showed that the degree of the conjugation of the formyl group to the heterocycle is close to that in the vinylcarbonyl compounds.

The calculation of the dipole moments of the rotational isomers of the compounds (IIIa-c) in this approximation on the basis of the direction of μ_{exp} in the compounds (IIa-c) showed that the CHO group in the compounds (IIIa,b) is rotated to the side of the chlorine atom, and is taken out of the plane of the heterocycle by the angle θ 130°. In the case of the para-methyl derivative (IIIc), the angle θ comprises 136°.

Therefore, the results of the investigations performed on the steric disposition of the formyl group in 2-aryl-4-chloro-5-formyl-6-oxo-1,3-thiazines provide the basis to indicate that it is not situated in the plane of the heterocyclic fragment; the higher availability of the chlorine at $C_{(4)}$ in these compounds by comparison with 2-aryl-4-chloro-6-oxo-1,3-thiazines in regard to nucleophilic agents is probably the result of the I-effect of the formyl group. The insignificant increase of the positive charge on $C_{(4)}$ of the heterocycle in the 5-formyl analogs (IIIa-c) of the 4-chlorothiazines (IIa-c), shown by the analysis of the results of quantum-chemical calculations (Table 1), also serves as additional confirmation of this proposition.

EXPERIMENTAL

The dielectric constants of the solutions of (II) and (III) in benzene were measured at concentrations of $(1-6)\cdot10^{-3}$ M using a Tangent dielectric meter. The refractive indexes of the solutions were measured at the concentrations of $(1-5)\cdot10^{-2}$ M using and IRF-23 refractometer. The calculation of the dipole moments was performed by the formula of Guggenheim-Smit [11].

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NITROGEN—TELLURIUM HETEROCYCLES.

1. PREPARATION OF BENZOTELLURAZOLES AND THEIR DERIVATIVES

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Cyclization of previously isolated and purified N-acyl derivatives of o-methyltelluroaniline under the influence of POCl$_3$ leads to 2-R-benzotellurazoles in yields of 35-65%. 1,1-Dichloro-2-R-benzotellurazoles are intermediates in this reaction.

In recent years there has been marked progress in the study of methods of preparation, structure, and reactivity of five-membered tellurium containing heterocycles [1]. However, in contrast to benzoxazole [2] and its sulfur [3] and selenium [4] analogs, benzotellurazole (I) has been little studied. In an isolated communication [5], devoted to these compounds, a three-stage synthesis of benzotellurazole and its 2-substituted derivatives was described: reaction of o-nitrophenyl diazonium fluoroborate with diethylditelluride in the presence of 18-crown-6 with the formation of o-ethyltelluronitrobenzene [6], reduction of the latter to o-ethyltelluroaniline, acylation of the aniline with an acyl chloride and cyclization (without previous isolation and purification) of the N-acyl derivative by boiling in POCl$_3$. The yield of compound I by this method amounted to 2-15% overall, calculated on o-ethyltelluronitrobenzene.

As starting materials for the preparation of benzotellurazoles we have used N-acylated derivatives of o-methyltelluroaniline (II), and POCl$_3$ as cyclizing agent as in [5]. Preparation of compound II was carried out in four stages. Reaction of azobenzene with tellurium tetrachloride by the method of [7] yielded o-trichlorotelluroazobenzene. Reduction of this by sodium borohydride in ethanol led to di(o-aminophenyl)ditelluride (III). Acylation of compound III with acyl chloride in the presence of triethylamine gave di(o-acylaminophenyl)ditelluride (IV) reduction of which with sodium borohydride in methanol with subsequent treatment of the telluropheolate with dimethyl sulfate led to compound II. Although the method which we used has four steps whereas the method of [5] has but three, our method