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It was established by means of PMR spectroscopy that, depending on the method of preparation, 2-imino-5-arylidene-4-thiazolidones exist in the form of various geometrical isomers relative to the exocyclic C = N bond. The Eisomers are obtained as a result of condensation of 2-imino-4-thiazolidone with the corresponding benz-aldehydes, whereas the Z isomers are formed in the solvolysis of hydroxymethyl and piperidinomethyl derivatives. The geometrical isomers retain their individuality in solutions in d_6 -DMSO and in ethanol. Upon dissolving in alkali with subsequent neutralization the E isomer of 2-imino-5-benzylidene-4-thiazolidinone is converted to the Z isomer. Reverse conversion of the Z isomer to the E isomer occurs when a solid sample is heated to $180^{\circ}C$.

In [1] it was shown that hydroxymethyl and piperidinomethyl derivatives of 2-imino-5arylidene-4-thiazolidinones (I-III) undergo solvolysis to the starting compounds when attempts are made to recrystallize them. We have observed that the iminothiazolidinones Ib-IIIb obtained by this method are identical to Ia-IIIa obtained by the method in [2] by condensation of 2-imino-4-thiazolidinone with the corresponding benzaldehydes with respect to such characteristics as elementary compositions, melting points, and IR and UV spectra but differ with respect to the position and form of the signals of the NH protons in the PMR spectra in d₆-DMSO. In the PMR spectra of thoroughly dried samples of Ia-IIIa recrystallized from acetic acid or ethanol the resonance of the NH protons is doubled (9.16 and 9.52 ppm for Ia) with a signal-intensity ratio of 1:1 and an overall intensity of the doublet of 1.7-1.9H (Fig. 1 and Table 1).

The observed doubled resonances are not related to the signals of two different forms of I-III (for example, the monomer and dimer and the amino and imino tautomers), since that coincidence that the equilibrium constant would ensure the indicated ratio of the intensities of the signals of the NH protons and would not depend on the substituent in the 5-arylidene grouping is unlikely. In addition, prototropic tautomeric equilibrium cannot always be detected from the signals of the NH protons of the separate forms [3]. The stereoisomers, relative to the $C_5=C$ bond, should differ with respect to the position of the signals of the olefinic and aromatic protons [4]; however, the corresponding resonances in the PMR spectrum of Ia are not split and coincide in frequencies with those in the PMR spectrum of Ib.

Moreover, E, Z isomerism relative to the $C_2 = N_2'$ bond or retarded rotation about the $C_2 = N_2'$ partially double bond in the amino form also cannot be the reason for splitting of the resonance of the NH protons for the following considerations. A long (!) signal of NH protons with an intensity of $\sim 1.8-1.9$ H (9.30 ppm for Ib) is observed in the PMR spectra of Ib-IIIb (Fig. 2 and Table 1). If one assumes that the signals of the doublet in the PMR spectra of Ia-IIIa belong to the NH protons of the E and Z isomers of the imino form or to the NH₂ protons of the amino form, one must still assume that Ia-IIIa and Ib-IIIb are different stereo-

Com- pound	R	UV spectrum, λ_{\max} , nm (log ε)	IR spectrum $C=0+C=N$	PMR spectrum, NH ppm	
			cm ⁻¹	Ia-IIIa	Ib-III _b

 $\begin{array}{c} 238 \ (4,00), \ 288 \ (4,12), \ 330 \ (4,34) \\ 246 \ (4,09), \ 296 \ (3,93), \ 350 \ (4,39) \end{array}$

224 (4,05), 293 (4,12), 354 (4,29)

H

H

III

p-OCH₃

p-NO₂

TABLE 1. Spectral Characteristics of 2-Imino-5-arylidene-4-thiazolidinones I-III

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9,16; 9,52

9,15; 9,40

9,30

9,20

9,43

1665

1680

1650, 1670 9,28; 9,67



Fig. 1. PMR spectra of Ia in d_6 -DMSO at 60 MHz: a) overall form; b) temperature dependence of the signals of the NH protons: 1) 20°C; 2) 29°C; 3) 38°C; 4) 47°C; 5) 56°C; 6) 65°C; 7) 73°C; c) form of the signal of the NH protons after the addition of CH₃COOH.

Fig. 2. PMR spectra of Ib in d_6 -DMSO at 60MHz: a) general form; b) temperature dependence of the signals of the NH protons: 1) 20°C; 2) 29°C; 3) 38°C: 4) 47°C; 5) 56°C; c) form of the signal of the NH protons after the addition of CH₃COOH.

isomers relative to the $C_5=C$ bond of one of the possible tautomers or are individual (desmotropic) tautomeric forms. The coincidence of the signals of the olefinic and aromatic protons in the PMR spectra of Ia-IIIa and Ia-IIIa and Ib-IIIb and of the signals in their UV (in ethanol) and IR (in the solid state) spectra refutes both assumptions.

The only reasonable assumption that can be advanced is that Ia-IIIa and Ib-IIIb are E and Z isomers of the imino form. This is evidently the first instance of the isolation of individual E and Z isomers for ketimines [5]. The difference in the PMR spectra of the E and Z isomers is explained by the different rates of exchange of the NH protons. It is logical to assume that the hydroxymethyl and piperidinomethyl derivatives exist primarily in the sterically more favorable E form. As a result of solvolysis, Z isomers Ib-IIIb should then be formed.

Compound Ib is light-cream or pink in color, whereas Ia is yellow. We were unable to detect reproducible differences in the region of low-intensity long-wave absorption (λ 390-600 nm, $\varepsilon \sim 1600-500$) between solutions of the two samples. Compounds IIa, IIIa, and IIb and IIIb have the same color.



I a, b R=H; II a, b R=p-OCH₃; III a, b R=p-NO₂; R'=OH, piperidyl

If E isomer Ia is dissolved in 10% alkali, and the solution is then neutralized with hydrochloric acid, Z isomer Ib is obtained. This transformation is in agreement with coordination of the Na⁺ cation with the "harder" N₂', atom of the anion, via which the reactions with "hard" electrophiles, formaldehyde, and the carbonium-immonium ion are directed [1].

When several drops of acetic acid are added to ampuls containing Ia and Ib in d₆-DMSO, the PMR spectra of both samples take on the same form: One signal at 9.16 ppm with an intensity of 1H remains in the region of absorption of the NH protons. The observed spectral pattern is explained by rapid exchange of the N₂'-H imino proton with the carboxy proton of the acid, as a result of which one observes the appearance of an averaged signal in the form of a broad line at 11.17-11.53 ppm, the position of which depends on the acid concentration. Protonation does not occur under these conditions, for the position of the signal of the amido proton (9.16 ppm) does not change. The conversion of Z isomer Ib to E isomer Ia is excluded, since specially designed experiments showed that upon dissolving both the Z and E isomers in concentrated sulfuric acid with subsequent neutralization of the resulting solution with aqueous alkali both samples retain their individuality, which is characterizable by the difference in the PMR spectra. Thus protonation at the exocyclic N₂' atom does not occur in concentrated sulfuric acid.

The signals at 9.16 and 9.52 ppm for Ia and at 9.30 ppm for Ib pertain to the signals of the monomeric forms of these compounds. When the concentration is varied over the range 5-20 mg/ml (the lower and upper limits are restricted by the sensitivity of the spectrometer and the solubilities in d_6 -DMSO), the position, form, and intensity of the signals of the NH protons do not change. The changes in the form and position of the signals of the NH protons in the PMR spectra of Ia and Ib as the temperature is raised are explained by the increase in the rate of the exchange processes and by weakening of the degree of intermolecular interaction with the solvent (Figs, 1 and 2). The signals of the NH protons in the PMR spectrum of E isomer Ia coalesce at $\sim 50^{\circ}$ C (Fig. 1). Both the individual signals of the doublet prior to their merging and the averaged signal are shifted to the strong-field side as the temperature is raised. When the temperature is lowered to room temperature, the signal of the NH proton takes on its original form. The activation parameters were not determined in view of the impossibility of an accurate analysis of the form of the lines because of the low intensities of the signals and their considerable broadening. When the temperature is raised, the signal of the NH protons of Z isomer Ib at 9.30 ppm also undergoes a diamagnetic shift, thereby taking on its original form upon cooling to room temperature (Fig. 2). In the case of both isomers an increase in the temperature does not change the integral intensity of the signals of the NH protons (\vee 2H).

The PMR spectra of both the E and Z isomers contain a very weak broad signal at 8.0 ppm. It was impossible to study its concentration temperature dependence because of the low intensities. We assume that this is the resonance of the NH protons of the dimeric associate.

According to the results of derivatography, heat absorption without a change in mass occurs when a solid sample of Z isomer Ib is heated at 30 to 180°C, and the color of the sample changes from light-cream or pink to yellow. The IR and UV spectra of the sample coincide before and after derivatography, but in the PMR spectrum the signal of the NH protons shows up in the form of a doublet; this confirms an endothermic conversion to E isomer Ia.

The E and Z isomers are also individual in ethanol, as in the crystalline state, and the individual isomeric forms could not be isolated either by crystallization from this solvent.

Similar peculiarities in the PMR spectra are also characteristic for thiazolidinones II and III (Table 1). In the case of IIIa the temperature of coalescence of the signals of the NH protons lies at ~ 54 °C. The same changes in the PMR spectra that are observed for I are also observed when several drops of acetic acid are added to ampuls containing solutions of both isomers of II in d_s-DMSO. In the case of III the signals of the NH protons in the PMR spectra of the E and Z isomers vanish completely after the addition of acetic acid. The participation of the amino proton of III in exchange with the carboxy protons of acetic acid is evidently due to the acidifying effect of the substituent in the benzene ring.

According to the results of derivatography and PMR spectroscopy, IIa and IIIa form monosolvates with acetic acid that undergo decomposition at \sim 120 and 90°C, respectively. Only a strong-field component of a doublet of NH protons at 9.15 with an intensity of \sim 1H is observed in the PMR spectrum.

The resonance of the protons of the methoxy group in the PMR spectrum of II is doubled, and the ratio of the intensities of the signals at 3.68 and 3.77 ppm is $\1:20$. The splitting of this resonance is possibly associated with the existence of stereoisomers relative to the $C_5=C$ double bond.

Proceeding from the analogies in the PMR spectra of I-III, it may be concluded that II and III, just like I, exist in the imino form both in the crystalline state and in solutions

in d_6 -DMSO and ethanol. It was also concluded [6] that I-III exist in the imino form in a crystalline state. The low values of the C=O frequencies (Table 1) are explained, in our opinion, by the formation of dimeric associates with the participation of the carbonyl group.

EXPERIMENTAL

The PMR spectra of solutions of the compounds in d_6 -DMSO were recorded with Tesla BS-467 (60 MHz) and Tesla BS-487C (80 MHz) spectrometers with hexamethyldisiloxane as the internal standard. The IR spectra were recorded with an IKS-29 spectrophotometer. The UV spectra of solutions of the compounds in ethanol were recorded with an SF-16 spectrophotometer. The derivatograms were recorded with a Paulik-Paulik-Erdey derivatograph (Hungary).

2-Imino-5-arylidene-4-thiazolidinones Ia-IIIa were obtained by the method in [2] and were crystallized from acetic acid or ethanol; the physical data were presented in [1], while the spectral characteristics are given in Table 1.

<u>2-Imino-5-benzylidene-4-thiazolidinone (Ib).</u> A) A 3.0-g (0.01 mole) sample of 2-piperidinomethylamino-5-benzylidene-4-thiazolinone in 100 ml of ethanol was refluxed for 15 min, after which the mixture was cooled, and the precipitated Ib was removed by filtration and crystallized from ethanol to give 0.35 g (17%) of a product with mp 284-286°C (284°C [6]) and mp 289-290°C after derivatography. Found: N 13.6; S 15.6%. $C_{10}H_{9}N_{2}OS$. Calculated: N 13.7; S 15.7%.

B) A 2.3-g (0.01 mole) sample of 2-hydroxymethylamino-5-benzylidene-4-thiazolinone was heated rapidly to the boiling point in 200 ml of pure-grade dioxane. Complete dissolving of the starting compound was observed at the instant boiling commenced, after which Ib began to precipitate from the boiling dioxane in a few seconds. The reaction mixture was cooled, and the precipitate was removed by filtration and crystallized from ethanol to give 0.53 g (26%) of a product with mp 285-286°C. Found: N 13.4; S 15.3%. $C_{10}H_8N_2OS$. Calculated: N 13.7; S 15.7%. Compounds IIb and IIIb were similarly obtained. The melting points and results of elementary analysis were the same as for IIa and IIIa [1]. The IR and UV spectra of Ib-IIIb were identical to those for Ia-IIIa; the characteristics of the PMR spectra are presented in Table 1.

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