

THE PROBLEM OF THE TAUTOMERISM OF 2-IMINOTHIAZOLIDIN-4-ONE AND SOME OF ITS DERIVATIVES

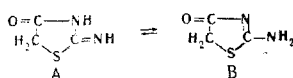
N. N. Khovratovich and I. I. Chizhevskaya

Khimiya Geterotsiklicheskih Soedinenii, Vol. 3, No. 4, pp. 637-641, 1967

UDC 547.789.1.3:543.422.4

IR spectroscopy is used to investigate imino-amine tautomerism of 2-iminothiazolidin-4-one and 2-phenyl (p-tolyl, benzyl)-imino derivatives of thiazolidin-4-one. It is shown that in the crystalline state 2-iminothiazolidin-4-one exists in the 2-imino form, while in solution (chloroform) it exists in the amino form. 2-Phenyl- and 2-p-tolylimino derivatives of thiazolidin-4-one exist in the imino form, while 2-benzyl-iminothiazolidin-4-one exist in the amino form.

In a series of papers [1, 2] UV spectroscopy, and in part IR spectroscopy, have been used to investigate possible tautomeric forms of 2-iminooxadiazolidin-4-one and its selenium analog. It was shown that in methanol the former has mainly the tautomeric amino structure, and the latter in aqueous solution the imino one [3].



With regard to the structures of 2-iminothiazolidin-4-one (I), potentially capable of exhibiting imino-amine tautomerism, opinions are rather contradictory. Some authors [4, 5] are inclined to regard it as having the imino structure, others [6, 7] the amino one. The two maxima (220 and 250 nm) in the UV spectra of aqueous solutions of 2-iminothiazolidin-4-one and its hydrochloride are taken to indicate the presence of two tautomeric forms with the imino form distinctly preponderating [4].

In the present paper IR spectroscopy has been used to settle the problems of the tautomerism of 2-iminothiazolidin-4-one and its 2-phenyl-(p-tolyl, benzyl) imino derivatives. To facilitate interpretation of IR spectra of 2-iminothiazolidin-4-one the ability of the hydrogen atoms at its exo- and endocyclic nitrogen atoms to undergo replacement by silver to give silver derivatives was utilized.

Figure 1 shows IR absorption spectra of 2-iminothiazolidin-4-one (I), thiazolidin-2, 4-dione (II), 3-phenylthiazolidin-2, 4-dione (III), the di-silver derivatives of 2-iminothiazolidin-4-one (IV), 2-acetaminothiazolin-4-one (V), the 2-Ag derivative of 2-N-acetaminothiazolin-4-one (VI) and 2-aminothiazolin-4-one hydrochloride (VII). The spectra were registered on a UR-10 IR spectrometer, using prisms of LiF, NaCl, and KBr. The specimens were investigated tabletted with KBr, or in vaseline mulls (identical spectra were obtained)*. Figure 2 gives the IR spectra of 2-phenyliminothiazolidin-4-one (VIII), 2-p-tolyliminothiazolidin-4-one (IX); and 2-benzylaminothiazolidin-4-one

(X). In the case of I the broken line gives the spectrum of a dilute CHCl_3 solution.

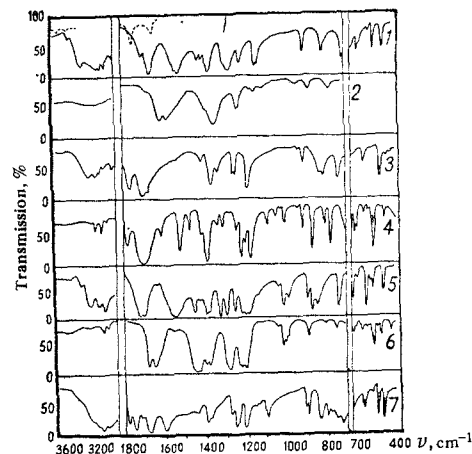


Fig. 1. IR spectra: 1) 2-iminothiazolidin-4-one; 2) thiazolidin-2, 4-dione; 3) 3-phenyl-thiazolidin-2, 4-dione; 4) di-silver derivative of 2-iminothiazolidin-4-one; 5) 2-acetaminothiazolin-4-one; 6) 2-Ag derivative of 2-N-acetaminothiazolin-4-one; 7) 2-aminothiazolin-4-one hydrochloride.

Starting from the assumption that 2-iminothiazolidin-4-one exists in two tautomeric forms A and B, the IR spectrum of form A would be expected to exhibit bands characteristic of the ring element $\text{CO}-\text{NH}$, and the bands of the imino group $=\text{NH}$, while the spectrum of form B would be expected to show bands corresponding to the amino group NH_2 , which are rather intense for primary amines [8, 9].

To interpret the IR spectrum of I, the spectra of compounds II and III were first studied. The element $\text{CO}-\text{NH}-\text{CO}$ in II gives rise, in the region of the valence vibration of NH groups, to bands of frequencies 3136 and 3048 cm^{-1} . These bands are absent from the spectrum of III, where the hydrogen at the endocyclic nitrogen atom is replaced by a phenyl group. But the spectrum of a dilute CCl_4 solution of II has only one narrow band, frequency 3410 cm^{-1} , due to free vibrations of the NH group. This makes it possible to unambiguously assign the above-mentioned bands to vibrations of the bond group NH. The spectrum of I shows an analogous picture of bands of frequencies 3230 and 3013 cm^{-1} , so that it can be inferred that structure I contains the element $\text{CO}-\text{NH}$, inherent in the imino

*Fig. 1 and 2 give spectra for materials tabletted with KBr.

form A (similar bands were found by one of the present authors in the spectra of a series of ring structures, containing elements of the type CO—NH—CO [8]). Then the band of frequency 3380 cm^{-1} characterizes the

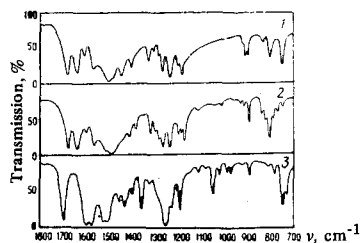


Fig. 2. IR spectra: 1) 2-phenyliminothiazolidin-4-one; 2) 2-p-tolyliminothiazolidin-4-one; 3) 2-benzyliminothiazolidin-4-one.

vibration of a NH bond of an imino group. An intense band frequency 1656 cm^{-1} is assigned by us to vibration of the C=N double bond [10, 11]. That band is present in the spectra of 3-phenyl (p-tolyl, benzyl)-2-phenyl (p-tolyl, benzyl) imino derivatives of thiazolidin-4-one, where both hydrogen atoms at the endo- and exocyclic nitrogen atoms are replaced by phenyl, p-tolyl, and benzyl radicals, and which exist in the imino form. A double band in the 1520 cm^{-1} region in the spectrum of I can be assigned to deformation vibration of the imino group NH, and possibly to vibration of the ring NH group. Then the remaining unextended band frequency 1690 cm^{-1} characterizes vibration of the C=O group of the thiazolidene ring of I. Actually the spectrum of the di-silver derivative of 2-iminothiazolidine-4-one (IV) has, in the region of valence vibrations of double bonds, two bands (1606 and 1575 cm^{-1}), probably characteristic of vibrations of C=O and C=N. In the same spectrum there is complete disappearance of bands in the region of NH group valence vibrations and in the region 1520 cm^{-1} , which we ascribe to deformation vibrations of the NH group.

From all that is stated above, it can be concluded that compound I in the solid state exists in the imino form A. Spectrum I, taken at liquid nitrogen temperature (-196°), has not undergone appreciable changes compared with the spectrum taken at room temperature. Dilution of a CHCl_3 solution of I clearly gives the spectrum of the amino form B, as shown by the appearance of two bands (3512 and 3400 cm^{-1}), ν_{asym} and ν_{sym} of vibrations of the amino group NH_2 , as well as deformation vibration bands of the NH_2 group of frequency 1632 cm^{-1} (were this the C=N bond vibration band, it would not be lowered so much on passing from the solid phase to dilute solution). In the region of vibration of double bonds there is only one band of the C=O group, with frequency 1735 cm^{-1} , considerably shifted in the high frequency direction as compared with its value in the solid phase spectrum because of breaking of the intermolecular hydrogen bond C=O...NH.

The spectra of V-VI differ considerably from the spectra of I. The spectrum of V has very intense absorption bands due to the C=O group in the ring, the C=O group of the acetyl group (1712 and 1700 cm^{-1}), and also a strong amide band (1545 cm^{-1}). Instead of a very intense vibration band of the C=N bond, present in the spectrum of imino formula structures, there appeared a very weak band at 1632 cm^{-1} , probably characteristic of C=N vibrations of an amino structure ring. In the NH valence vibrations region the NH bands are accompanied by acetyl radical vibrations (3120 and 3000 cm^{-1}), as well as by a series of considerably less intense bands of harmonics in the high frequency region. In the spectrum of VI, the carbonyl absorption bands are displaced towards the region of lower frequencies, e. g. by 50 cm^{-1} , and have the values 1675 and 1640 cm^{-1} . The NH group vibration bands vanish. Wide and very intense bands in the region 3000 and 3200 cm^{-1} characterize vibrations of the group NH_3^+ of the hydrochloride VII.

Consideration of the IR spectra of 2-iminothiazolidin-4-one derivatives VIII, IX, and X (Fig. 2) enables a hypothesis to be framed about the effect of substi-

Elementary Analytical Data

Compound	Name	Mp, °C	Formula	Found, %		Calculated, %	
				Cl	S	Cl	S
I	2-Iminothiazolidin-4-one	247 (decomp)	$\text{C}_8\text{H}_4\text{N}_2\text{OS}$		27.45		27.59
II	Thiazolidin-2,4-dione	128	$\text{C}_3\text{H}_2\text{N}_2\text{O}_2\text{S}$		27.16		27.34
III	3-Phenylthiazolidin-2,4-dione	148	$\text{C}_9\text{H}_7\text{N}_2\text{O}_2\text{S}$		16.31		16.57
IV	Di-silver derivative of I	215 (decomp)	$\text{C}_8\text{H}_2\text{N}_2\text{OSAg}_2$		9.87		9.70
V	2-N-Acetaminothiazolidin-4-one	245	$\text{C}_8\text{H}_6\text{N}_2\text{O}_2\text{S}$		20.18		20.25
VI	Silver derivative of V	212—213	$\text{C}_8\text{H}_5\text{N}_2\text{O}_2\text{SAg}$		11.72		12.08
VII	2-Iminothiazolidin-4-one hydrochloride	229—230	$\text{C}_8\text{H}_4\text{N}_2\text{OS} \cdot \text{HCl}$	20.28		20.25	
VIII	2-Phenylaminothiazolidin-4-one	178	$\text{C}_9\text{H}_8\text{N}_2\text{OS}$		16.42		16.66
IX	2-p-Tolyliminothiazolidin-4-one	191	$\text{C}_{10}\text{H}_{10}\text{N}_2\text{OS}$		15.36		15.53
X	2-Benzyliminothiazolidin-4-one	212	$\text{C}_{10}\text{H}_{10}\text{N}_2\text{OS}$		15.48		15.53
	Hydrochloride X	205—207	$\text{C}_{10}\text{H}_{10}\text{N}_2\text{OS} \cdot \text{HCl}$	14.71		14.64	

tients at the exocyclic nitrogen atom on its tautomerism. In the region of vibration of double bands in the spectrum of VIII, there are bands of frequencies 1680, 1636 cm^{-1} , and in the spectrum of IX, belonging respectively to vibrations of C=O and C=N bonds. The intense wide band frequency 1500 cm^{-1} , along with aromatic absorptions, possibly characterizes absorption by the imino form skeleton, or is connected with deformation vibrations of the ring NH group (the above-mentioned band is also present in the IR spectrum of I).

The IR spectrum of X differs from the spectra of VIII and IX. It has only an absorption band due to vibrations of the group C=O, frequency 1697 cm^{-1} , and a C=N bond absorption band is absent (the ring C=N bond gives very weak bands); a series of bands in the 1500–1600 cm^{-1} region can obviously be assigned to aromatic absorption and to deformation vibration of the secondary amino group NH.

Chemical investigation of VIII and X showed the latter to have basic properties; it gave a hydrochloride resistant to hydrolysis. VIII and X behaved differently to acid hydrolysis, X remained unaltered when heated for 3–4 hr with concentrated hydrochloric acid (elementary analytical data and IR region spectroscopic studies), while heating VIII with dilute hydrochloric acid gave thiazolidin-2,4-dione.

From what has been said above, it follows that data of IR spectroscopic investigations and results of chemical studies enable it to be postulated that the absence of basic properties for VIII, as well as the capacity of its exocyclic C=N bond to undergo hydrolysis to form thiazolidin-2,4-dione, is obviously connected with its existing in the imino tautomeric form, while X exists in the amino form. It can be assumed that the existence of the benzyl derivative X in the amino form is connected with the higher electronegativity of the exocyclic nitrogen atom in it, due to $\rho\sigma$ coupling at the exocyclic nitrogen atom, which in conjunction with the lower polarizability of the σ bond as compared with the π bond ($\rho\pi$ coupling for VIII and IX), is less clearly manifest. The latter facilitates migration of a proton from position 3 to position 2 of the thiazolidine ring, accompanied by rearrangement of double bonds to give amino forms.

EXPERIMENTAL

The 2-iminothiazolidin-4-one derivatives, mentioned in this paper, were prepared by reacting thiourea or a monoarylthiourea (phenyl, p-tolyl, benzyl) with chloroacetic acid in absolute EtOH, in the presence of fused NaOAc (table) [3, 12–18].

Silver derivatives IV and VI were prepared by the action of an ammoniacal solution of an equimolecular quantity of AgNO_3 on aqueous ethanolic solutions of compounds I and V.

Acid hydrolysis of X. 1.03 g (0.005 mole) X was heated in a flask with a reflux condenser with 30 ml conc HCl for 4 hr. The solution was then evaporated on a water bath, the viscous residue treated with ether, and then recrystallized from absolute EtOH. Mp 205–206°, undepressed mixed mp with VII. X was obtained by treatment with aqueous ammonia. Mp 210°, mass 0.87 g (84%) (undepressed mixed mp with X, and the IR spectra of the two identical).

Acid hydrolysis of VIII. 1.92 g (0.001 mole) VIII was heated with 50 ml dilute HCl (1:2) for 4 hr then the contents of the flask evaporated to dryness under vacuum, and the residue recrystallized repeatedly from EtOH, to give 0.78 g II (68%), mp 127°. Found: C 30.51; 30.46; H 2.24; 2.32%, calculated for $\text{C}_3\text{H}_3\text{NO}_2\text{S}$: C 30.51; H 2.56%.

REFERENCES

1. H. Najer, R. Giudicelli, J. Menin, and J. Loiseau, *C. r.*, **254**, 2173, 1962.
2. C. F. Howell, M. A. Quinones and R. A. Hardy, *J. Org. Chem.*, **27**, 1686, 1962.
3. A. M. Comrie, D. Dingwall and J. B. Stenlake, *J. Chem. Soc.*, 5713, 1963.
4. F. C. Brown, *Chem. Rev.*, **61**, 463, 1961.
5. A. M. Comrie, *J. Chem. Soc.*, 3478, 1964.
6. J. A. Durden, H. A. Stasbury and W. H. Catlette, *J. Am. Chem. Soc.*, **81**, 1949, 1959.
7. H. Najer, R. Giudicelli, C. Morel and J. Menin, *Bull. Soc. Chim, France*, 1022, 1963.
8. N. A. Borisevich and N. N. Khovratovich, *Opt. i spektr.*, **10**, 589, 1961.
9. L. J. Bellamy, *Infrared Spectra of Complex Molecules* [Russian translation], IL, Moscow, 1963.
10. N. B. Colthup, *J. Opt. Soc. Am.*, **40**, 397, 1950.
11. M. E. Baguley and J. A. Elvidge, *J. Chem. Soc.*, 709, 1957.
12. G. Finzi and C. Angelini, *Ann. Chim, (Rome)*, **43**, 832, 1953.
13. R. P. Rao, *J. Indian Chem. Soc.*, **38**, 786, 1961.
14. T. Ueda, S. Kato, and S. Toyoshima, *Japanese patent 7811: C. A.*, **64**, 4620i, 1960.
15. A. J. Speziale, *J. Org. Chem.*, **23**, 1231, 1958.
16. G. N. Mahapatra and M. K. Rout, *J. Indian Chem. Soc.*, **33**, 17, 1956.
17. K. S. Das and M. K. Rout, *J. Indian Chem. Soc.*, **31**, 617, 1954.
18. M. Z. Vasa, J. J. Trivedi, and K. S. Kshatriya, *J. Indian Chem. Soc.*, **36**, 648, 1959.

25 December 1965

Lenin Belorussian State University, Minsk
Institute of Physical Organic Chemistry AS Belorussian SSR, Minsk