UV ABSORPTION SPECTRA AND REACTIVITY OF 4-OXO and 4-THIOXO DERIVATIVES OF 1,3-THIAZANE

N. M. Turkevich, E. V. Vladzimirskaya, and L. M. Vengrinovich

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The C=O groups in positions 4 of the molecules of 2-thioxo-1,3-thiazan-4-one and 1,3-thiazane-2,4-dione do not possess ketonic properties. When 2-thioxo-1,3-thiazan-4-one is treated with hydrazine or its derivatives, hydrazinolysis takes place. When these substances react with P_2S_5, the C=O groups are replaced by C=S groups. The compounds formed possess thioketonic properties, which makes it possible to obtain derivatives of 4-imino-1,3-thiazane. The condensation of β-chloropropionic acid with thiourea leads to 1,3-thiazane-2,4-dione and the previously unreported 2-imino-1,3-thiazan-4-one. The UV spectra of the substances synthesized are described.

Derivatives of tetrahydro-1,3-thiazine (1,3-thiazane have recently acquired interest in view of the fact that they include the effective analgesic and sedative substance "Dolitrone." The molecule of one of the modern broad-spectrum antibiotics, namely cephalosporin, constans a dihydro-1,3-thiazine ring. Consequently we set ourselves the task of studying reactivities and UV spectra of some of the most important 1,3-thiazan-4-ones and 1,3-thiazane-4-thiones.

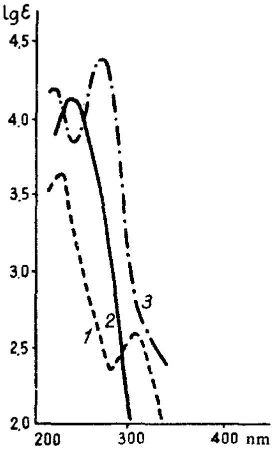
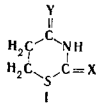


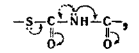
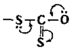
Fig. 1. UV spectra: 1) 1,3-thiazane-2,4-dione; 2) 2-imino-1,3-thiazan-4-one; 3) 2-imino-1,3-thiazan-4-one S-guanylthiohydracrylate.

The unsubstituted thiazanedione (Ia) does not form thiosemicarbazones, semicarbazones, oximes, and other derivatives due to the fact that an NH group is adjacent to the carbonyl groups, in consequence of which the positive charge on the carbon atom is absorbed by the p-electrons of the nitrogen atom

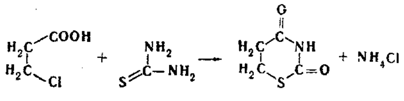


I

a X=Y=O
b X=NH; Y=O
c X=S; Y=O
d X=O; Y=S
e X=Y=S
f X=O; Y=$NNHCSNH_2$
g X=O; Y=$NNHCONH_2$
h X=S; Y=$NNHCSNH_2$
i X=S; Y=$NNHCONH_2$

The molecule of thiazane-2,4-dione contains the complex chromophore , thanks to which two maxima appear in the UV spectra in the 230-nm (log ε 3.60) and 305-nm (log ε 2.63) regions (see Fig. 1). These maxima are displaced bathochromically because of the lengthening of the chain of conjugation as compared with the maxima of the β-alkoxythiocarbonylthiohydracrylic acids [1], which contain the chromophore .

To synthesize the thiazanedione we [2] have proposed to carry out the condensation of thiourea with β-chloropropionic acid in the presence of acetic anhydride. Further investigations show that to obtain reproducible yields it is more convenient to carry out the reaction at 160° C without a solvent or with a small amount of acetic anhydride:



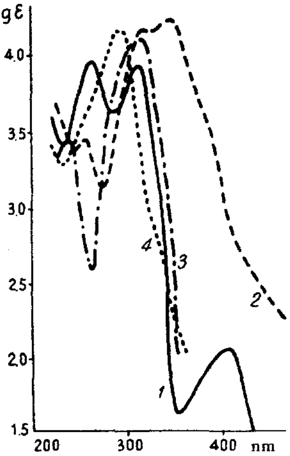
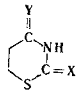


Fig. 2. UV spectra: 1) 2-thioxo-1,3-thiazan-4-one; 2) 1,3-thiazane-2,4-dione; 3) thiocarbonylbisthiohydracrylic acid; 4) 4-thioxo-1,3-thiazanone.

When the condensation was carried out without a solvent, as a by-product the previously unreported 2-iminothiazan-4-one (Ib) was formed, this being characterized by a single absorption maximum at 235 nm (log ε 4.14, see Fig. 1). This substance is also incapable of undergoing the reactions typical for oxo compounds. Its salt with S-guanylthiohydracrylic

1,3-Thiazane Derivatives



Compound	X	Y	Mp, °C	Empirical formula	Found, %		Calculated, %		Yield, %
					N	S	N	S	
Ib	NH · HCl	O	189	$C_4H_6N_2OS \cdot HCl$	17.03	19.36	16.81	19.24	7.8
	NH	O	167	$C_4H_6N_2OS$	21.03	24.69	21.03	24.63	7.8
Ia	O	O	163	$C_4H_5NO_2S$	10.60	24.62	10.68	24.45	22.90; 49.62*
Ih	S	$NNHCSNH_2$	160	$C_5H_8N_4S_3$	25.59	43.43	25.43	43.66	41.1
Ii	S	$NNHCONH_2$	180	$C_5H_8N_4OS_2$	27.16	31.45	27.43	31.61	57.3
If	O	$NNHCSNH_2$	185	$C_5H_8N_4OS_2$	27.41	31.26	27.43	31.39	85
Ig	O	$NNHCONH_2$	162	$C_5H_8N_4O_2S$	17.40	17.07	17.48	17.03	33.3

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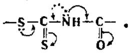
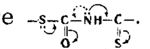
*By the fusion method.

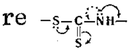
acid, also isolated from the condensation product, has, like the thiazane-2,4-dione, two absorption maxima, in the 223-nm (log ε 4.23) and 274-nm (log ε 4.40) regions (see Fig. 1).

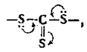
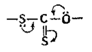
It is known [3] that thiobenzamide is capable of forming an oxime, but 2-thioxothiazan-4-one (**Ic**) [4] does not add nucleophilic reagents, which is undoubtedly due to the presence of an adjacent electron-donating atom in the chromophore  $-S-\underset{\underset{S}{\|}}{C}-\ddot{N}H-\underset{\underset{O}{\|}}{C}-$. It is interesting that the analogous rhodanine does form a 2-oxime [5] and a 2-semicarbazone and 2-thiosemicarbazone [6], which is due to the attraction by the C=O group of the electrons on the sulfur atom through a CH_2 group. At the same time, in the condensation of 2-thioxothiazan-4-one with p-nitrophenylhydrazine or hydrazine, the thiazane ring undergoes hydrolysis with the formation of S-thiocarbamylthiohydracrylic acid p-nitrophenylhydrazide (**III**) or, respectively, bis(S-thiocarbamylthiohydracrylyl)hydrazine (**IV**).

The UV spectra of **Ic** (see Fig. 2) have two high-intensity maxima at 259 nm (log ε 3.98) and 308 nm (log ε 3.93) and also a low-intensity maximum at 404.5 nm (log ε 2.07).

The 4-thioxothiazan-2-one (**Id**) first synthesized by one of us [7] by the reaction of thiazane-2,4-dione with the calculated amount of P_2S_5 in dioxane contains in its molecule the chromophore  $-S-\underset{\underset{O}{\|}}{C}-\ddot{N}H-\underset{\underset{S}{\|}}{C}-$. It may be assumed that the C=S group will exhibit a pronounced ketonic nature in view of the fact that the p-electrons of the adjacent nitrogen atom are attracted by the C=O group to a considerable extent. And, in fact, **Id** readily forms a thiosemicarbazone, semicarbazone, phenylhydrazone, benzoylhydrazone, etc. [8].

The UV spectra of 4-thioxothiazan-2-one have two maxima (see Fig. 2)—one below 220 nm and the second at 290 nm (log ε 4.17). In contrast to the initial thiazane-2,4-dione, thanks to the presence of the thioxo sulfur, the second maximum has a high intensity.

In our further investigations it was established that the reaction of thiazane-2,4-dione or 2-thioxothiazan-4-one with P_2S_5 depends to a considerable extent on the solvent. Thus, when the thiazanedione is boiled with an excess of P_2S_5 in toluene, 4-thioxothiazan-2-one is formed exclusively, while the use of dibutyl ether or dioxane as solvent leads to thiazane-2,4-dithione (**Ie**). The molecule of thiazane-2,4-dithione has the chromophore  $-S-\underset{\underset{S}{\|}}{C}-\ddot{N}H-\underset{\underset{S}{\|}}{C}-$, and, thanks to the presence of the C=S group in position 4, the substance exhibit pronounced ketonic properties and with hydrazine derivatives forms the previously undescribed 4-hydrazinothiazan-2-thione derivatives (**Ih, i**).

The UV spectrum of thiazane-2,4-dithione (see Fig. 2) has four absorption maxima: below 220 nm, at 251 nm (log ε 3.46), at 315 nm (log ε 4.19), and at 340 nm (log ε 4.25). From a comparison of the UV spectra of the thiazanedithione derivatives that we have investigated and of thiocarbonylbisthiohydracrylic acid (see Fig. 2), which has only one pronounced chromophore for the UV region  $-S-\underset{\underset{S}{\|}}{C}-\ddot{S}-$, and also the β-alkoxythiocarbonylthiohydracrylic acids that we have mentioned, with the chromophore  $-S-\underset{\underset{S}{\|}}{C}-\ddot{O}-$ it follows that the absorption maximum in the 274–315-nm region is connected precisely with the monothiocarbonate or dithiocarbonate chromophore.

EXPERIMENTAL

Condensation of β-chloropropionic acid with thiourea. a) A mixture of 1 mole of thiourea and 1 mole of β-chloropropionic acid was fused at 160° C for 30 min. Then the melt was boiled with 1.5 *l* of acetone and the insoluble material (about 69 g) was filtered off. After this, the solid matter was boiled with 350 ml of a mixture of ethanol and benzene (3 : 2), and 33 g of ammonium chloride was filtered off; the filtrate was evaporated to small volume, and 13 g (7.8%) of the hydrochloride of 2-iminothiazan-4-one was filtered off. By triturating the hydrochloride with a saturated solution in $NaHCO_3$ and subsequent filtration, free 2-iminothiazan-4-one (**Ib**) was obtained; it was recrystallized from isopropanol.

The acetone extract was evaporated to dryness and the resulting mass was boiled with 800 ml of xylene and filtered. From the solution in the cold 30 g (22.9%) of the crude thiazan-2,4-dione (**Ia**) crystallized out with mp 136–142° C (after repeated recrystallization from xylene, mp 163° C). The xylene-insoluble residue was triturated with water to give 30 g (21.7%) of crude 2-iminothiazan-4-one S-guanylthiohydracrylate (**II**), mp 209° C (from isobutanol). Found, %: N 19.84; S 22.95. Calculated for $C_4H_6N_2OS \cdot C_4H_8N_2O_2S$, %: N 20.10; S 23.00.

b) A mixture of 1 mole of β-chloropropionic acid, 1 mole of thiourea, and 0.3 mole of acetic anhydride was boiled for 2 hr. The reaction product was extracted with 700 ml of boiling xylene. From the extract 65 g of the thiazane-2,4-dione crystallized. The xylene-insoluble residue was extracted with a mixture of ethanol and benzene (3 : 2), the residue of NH_4Cl (27.3 g) was filtered off, and evaporation of the filtrate yielded 25.0 g (13.5%) of S-guanylthiohydracrylic acid hydrochloride, mp 145° C. Found, %: N 15.30; S 17.48. Calculated for $C_4H_8N_2O_2S \cdot HCl$, %: N 15.17; S 17.36.

Derivatives of 4-imino-1,3-thiazane. A boiling aqueous solution of 1 mM of thiosemicarbazide or semicarbazide was added to a boiling solution of 1 mM of thiazane-2,4-dione [9] or 4-thioxothiazan-2-one [7] in ethanol. The mixture was boiled for 15–30 min, the pronounced evolution of hydrogen sulfide being observed. After cooling, the precipitate that had deposited was filtered off and recrystallized from ethanol.

Hydrazinolysis of 2-thioxothiazan-4-one. An equivalent amount of hydrazine hydrate or p-nitrophenylhydrazine was added to a boiling solution of 0.01 mole of 2-thioxothiazan-4-one in 7.5–20 ml of ethanol. In the first case, the reaction was complete in 1 hr at 50° C, and in the second case it was necessary to boil the mixture for 20 hr. After the evaporation of the reaction mixture, precipitates were obtained which were recrystallized from glacial acetic acid.

S-Thiocarbamylthiohydracrylic acid p-nitrophenylhydrazide: yield 39.8%, mp 206° C. Found, %: N 17.00; S 13.41. Calculated for $C_8H_{14}N_4O_2S_4$, %: N 17.16; S 39.28.

Bis(S-thiocarbamylthiohydracrylyl)hydrazine: yield 86.6%, mp 179° C. Found, %: N 18.70; S 21.30. Calculated for $C_{10}H_{12}N_4O_3S_2$, %: N 18.66; S 21.35.

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L'vov Medical Institute