

## 2.\* COMPOUNDS OF THE THIAZOLO[3,2-a]PYRIDINIUM 3-OXIDE SERIES

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It was recently shown [1-3] that the product formed when (2-pyridylthio)acetic acid is heated in acetic anhydride is not thiazolo[3,2-a]pyridinium 3-oxide (IIa), as assumed previously in [4], but rather is a compound with a dimeric structure, viz., 2-[(2'-pyridylthio)acetyl]thiazolo[3,2-a]pyridinium 3-oxide (IIIa). Thus, up until now, thiazolo[3,2-a]pyridinium 3-oxide (IIa) has remained unknown. It seemed of interest to attempt to obtain and investigate the properties of this compound.

We have established by spectrophotometry that a new substance that differs from IIIa is formed when (2-pyridylthio)acetic acid is heated briefly in acetic anhydride at 40-50°C rather than at 100-140°C or when it is allowed to stand in acetonitrile in the presence of dicyclohexylcarbodiimide at 0-10°C. During its formation in the latter case, one can observe the disappearance of the absorption of the starting acid at 251 and 293 nm and the appearance of new maxima at 260 and 390 nm (Fig. 1). At the instant that the maximum optical density at 390 nm is reached the amount of liberated dicyclohexylurea is 90% of the theoretical amount, but the results of thin-layer chromatography (TLC) indicate the complete absence of (2-pyridylthio)acetic acid in solution. The compound formed is stable only in dilute solutions; when such solutions are heated or concentrated, it is converted to IIIa. The course of this conversion can also be followed by spectrophotometry (Fig. 1). In solutions the substance is stable with respect to organic bases (no change is observed when triethylamine is added); however, it is hydrolyzed to starting acid Ia under the influence of mineral acids.

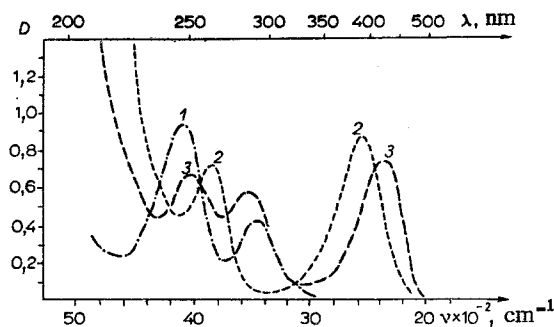


Fig. 1. Absorption spectra in methanol:  
1) Ia ( $1 \cdot 10^{-4}$  mole/liter); 2) IIa; 3)  
IIIa ( $5 \cdot 10^{-5}$  mole/liter).

\*See [3] for communication 1.

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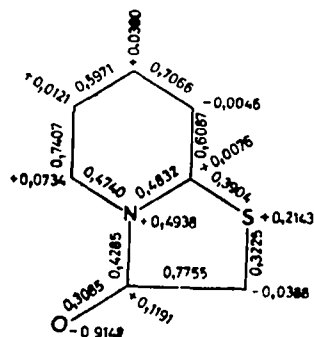
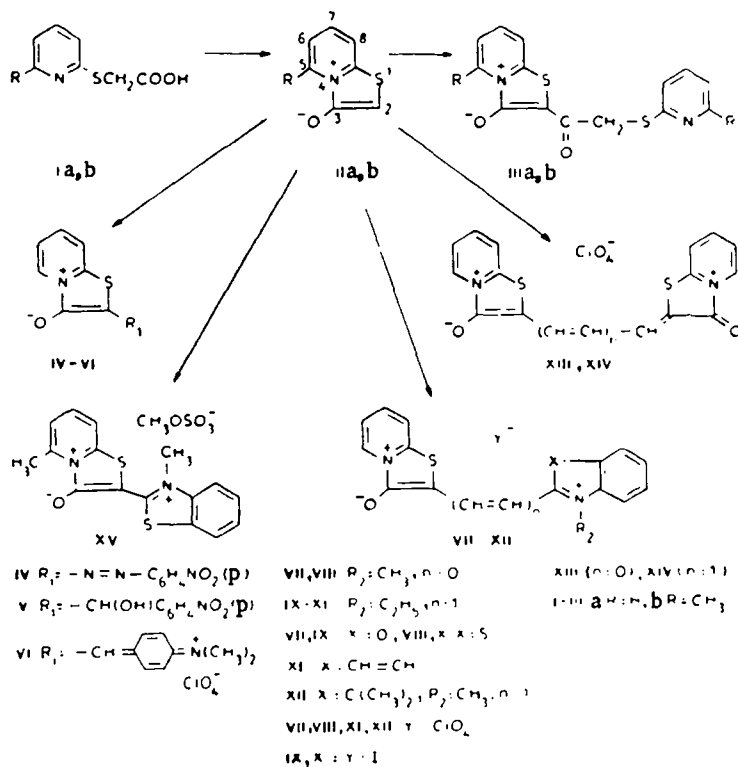


Fig. 2. Distribution of the  $\pi$  charges and bond orders in the thiazolo[3,2-a]pyridinium 3-oxide molecule.



The results obtained make it possible to assume that thiazolo[3,2-a]pyridinium 3-oxide (IIa), which cannot be isolated from solution, is formed under mild conditions from (2-pyridylthio)acetic acid. However, the presence of this compound in solutions is confirmed by the isolation of the products of its condensation with various electrophilic agents. For example, azo dye IV was obtained by reaction with p-nitrobenzenediazonium tetrafluoroborate. Substituted benzaldehydes add to IIa to give carbinols, which on treatment with acids give the corresponding 2,3-dihydro-3-hydroxythiazolo[3,2-a]pyridinium derivatives. Carbinol V and styryl VI were synthesized via this pathway.

Thiazolo[3,2-a]pyridinium 3-oxide (IIa) reacts with the intermediates used for the synthesis of cyanine dyes. Thus dyes VII and VIII were obtained with 3-methyl-2-methylthiobenzoxazolium or -benzothiazolium salts, IX-XII were obtained with 2- $\omega$ -acetanilidovinyl-substituted derivatives of quaternary salts of nitrogen heterocycles, and XIII and XIV, respectively, were obtained with ethyl orthoformate and malonaldehyde dianil hydrochloride.

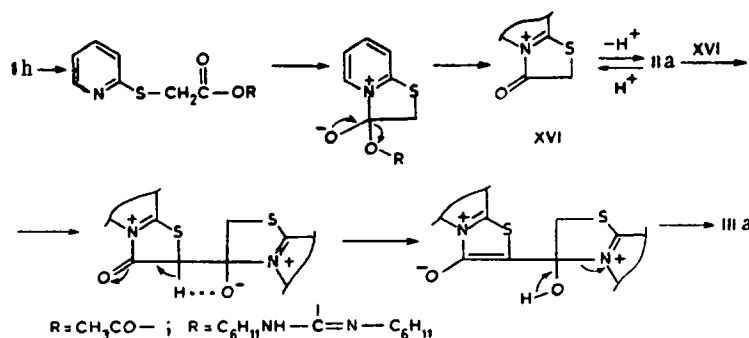
In contrast to dimeric product IIb, in which the methyl group in the 5 position is sufficiently active for reactions with electrophilic agents [3], the 2 position in IIb is more active. Thus dye XV is formed in the reaction of IIb with 3-methyl-2-methylthiobenzothiazolium methylsulfate.

TABLE 1. Thiazolo[3,2-a]pyridinium 3-Oxide Derivatives (IV-XV)

Compound	mp, °C *	$\lambda_{\max}$ , nm (lg $\epsilon$ ) in CH <sub>3</sub> CN	Found, %		Empirical formula	Calc. %		Yield, %
			N or (Cl)	S		N or (Cl)	S	
IV	248—249	510 (4,44)	18,6	10,6	C <sub>13</sub> H <sub>8</sub> N <sub>4</sub> O <sub>3</sub> S	18,7	10,7	30
V	116—117	430 (4,03)	9,3	10,6	C <sub>14</sub> H <sub>10</sub> N <sub>2</sub> O <sub>4</sub> S	9,3	10,6	32
VI	228—229	585 (4,73)	(9,1)	8,2	C <sub>16</sub> H <sub>15</sub> ClN <sub>2</sub> O <sub>5</sub> S	(9,3)	8,4	48
VII	277—280	435 (4,39)	7,4	8,4	C <sub>15</sub> H <sub>11</sub> ClN <sub>2</sub> O <sub>5</sub> S	7,3	8,4	55
VIII	287—288	453 (4,48), 470 (4,40)	(9,0)	16,0	C <sub>15</sub> H <sub>11</sub> ClN <sub>2</sub> O <sub>5</sub> S <sub>2</sub>	(8,9)	16,1	51
IX	223—225	525 (4,75), 545 (4,71)	6,3	7,2	C <sub>18</sub> H <sub>15</sub> IN <sub>2</sub> O <sub>5</sub> S	6,2	7,1	71
X	260—262	553 (4,73), 574 (4,72)	5,9	13,5	C <sub>18</sub> H <sub>15</sub> IN <sub>2</sub> O <sub>5</sub> S <sub>2</sub>	6,0	13,7	83
XI	243—244	562 (4,78), 580 (4,81)	(8,2)	7,2	C <sub>20</sub> H <sub>17</sub> ClN <sub>2</sub> O <sub>5</sub> S	(8,2)	7,4	61
XII	233—234	550 (4,76), 576 (4,76)	(7,0)	6,5	C <sub>20</sub> H <sub>19</sub> ClN <sub>2</sub> O <sub>5</sub> S · CH <sub>3</sub> COOH	(7,2)	6,5	36
XIII	281—283	568 (4,65), 608 (4,79)	7,0	15,5	C <sub>15</sub> H <sub>9</sub> ClN <sub>2</sub> O <sub>5</sub> S <sub>2</sub>	6,8	15,5	46
XIV	219—220	640 (4,75), 685 (4,98)	6,2	14,3	C <sub>17</sub> H <sub>11</sub> ClN <sub>2</sub> O <sub>5</sub> S <sub>2</sub>	6,4	14,6	60
XV	216—218	460 (4,50), 477 (4,45)	6,7	23,0	C <sub>17</sub> H <sub>16</sub> N <sub>2</sub> O <sub>5</sub> S <sub>2</sub>	6,6	22,6	59

\*The compounds were crystallized: IV, VII, X, XI, XIII, and XIV from CH<sub>3</sub>NO<sub>2</sub>, VI, VIII, and XV from CH<sub>3</sub>CN, IX and XII from CH<sub>3</sub>COOH, and V from iso-C<sub>3</sub>H<sub>7</sub>OH.

The ability of thiazolo[3,2-a]pyridinium 3-oxide to react with electrophilic agents follows from its molecular diagram calculated by the MO LCAO method within the Pariser-Parr-Pople (PPP) approximation (Fig. 2). It is apparent from Fig. 2 that the carbon atom in the 2 position in IIa should have considerable nucleophilicity, whereas the carbon atom in the 3 position has considerable electrophilicity; this also evidently explains the tendency of the compound to undergo dimerization. The formation of II and its dimerization probably proceed via the scheme



Compounds VI-XIV can be regarded as heteroanalogs of thionaphthene derivatives, viz., merocyanines VI-XII and oxanines XIII and XIV [5]. A comparison of the long-wave absorption bands of merocyanines VIII and IX and oxanines XIII and XIV (Table 1) with the absorption bands of their 3-hydroxythionaphthene derivative analogs shows that the dyes that are thiazolo[3,2-a]pyridinium 3-oxide derivatives are more deeply colored (20-30 nm). The absorption bands of the synthesized nullo- and dimethylidynemerocyanines contain two distinctly expressed maxima, of which the short-wave maximum is more intense for a number of the compounds. The nature of this form of the bands requires further study. It is important to note that the dimethylidynemerocyanines that are thiazolo[3,2-a]pyridinium 3-oxide and 3-hydroxythionaphthene derivatives display opposite types of solvatochromism. Thus, whereas the maximum of the absorption of dye IX is shifted from 591 to 572 nm on passing from a solution in the less polar dichloroethane to a solution in the more polar methanol, the absorption maximum is shifted from 544 to 559 nm in the case of the hydroxythionaphthene analog of this dye under the same conditions. Other thiazolo[3,2-a]pyridinium 3-oxide derivatives such as 2-[2'-pyridylthio)acetyl]thiazole[3,2-a]pyridinium 3-oxide (IIIa) [3] also display negative solvatochromism [6]. In contrast to 3-hydroxythionaphthene derivatives, their

structures probably approach polar structures more closely. The latter is probably due to the polarizing effect of the positively charged nitrogen atom in the molecules of these dyes.

#### EXPERIMENTAL

The electronic spectra of solutions of the compounds in acetonitrile were measured with a specord spectrophotometer. Thin-layer chromatography (TLC) was carried out on Silufol-254 in a chloroform-methanol system (9:1).

2-(p-Nitrophenylazo)thiazolo[3,2-a]pyridinium 3-Oxide (IV). A solution of 0.6 g (3 mmole) of dicyclohexylcarbodiimide in 2 ml of acetonitrile was added to a cooled (to 5-10°C) solution of 0.51 g (3 mmole) of (2-pyridylthio)acetic acid in 15 ml of acetonitrile. After 5 min, the dicyclohexylurea was removed by filtration, 0.69 g (3 mmole) of p-nitrobenzene-diazonium tetrafluoroborate and 0.3 g (3 mmole) of triethylamine were added to the filtrate, and the resulting precipitate was removed by filtration and washed with alcohol and ether. Data on the properties of the synthesized compounds are presented in Table 1.

2-Thiazolyl[3,2-a]pyridinium(p-nitrophenylcarbinol) 3-Oxide (V). A 0.45-g (3 mmole) sample of p-nitrobenzaldehyde was added to an acetonitrile solution of IIa obtained by the method described above, and the resulting precipitate was removed by filtration and washed with alcohol.

2,3-Dihydro-3-(p-dimethylaminobenzylidene)thiazolo[3,2-a]pyridinium 3-Oxide Perchlorate (VI). A 0.34-g (2 mmole) sample of (2-pyridylthio)acetic acid was added to a solution of 0.3 g (2 mmole) of p-dimethylaminobenzaldehyde in 4 ml of acetic anhydride, and the mixture was heated at 50°C for 30 min. The solution was cooled and treated with 0.6 ml of 42% perchloric acid, and the resulting precipitate was removed by filtration and washed with ether.

2-(3'-Methylbenzoxazolio-2-yl)thiazolo[3,2-a]pyridinium 3-Oxide Perchlorate (VII), and 2-(3'-Methylbenzothiazolio-2'-yl)thiazolo[3,2-a]pyridinium 3-Oxide Perchlorate (VIII). A 0.17-g (1 mmole) sample of (2-pyridylthio)acetic acid was added in three portions at 50°C to a solution of 1 mmole of the corresponding 2-methylthio derivative in 7 ml of acetic anhydride, and the mixture was heated for 40 min. The dye was removed by filtration and washed with ether.

2-(3'-Ethylbenzoxazolio-2'-vinyl)thiazolo[3,2-a]pyridinium 3-Oxide Iodide (IX), 2-(3'-Ethylbenzothiazolio-2'-vinyl)thiazolo[3,2-a]pyridinium 3-Oxide Iodide (X), 2-(1'-Ethylquinolino-2'-vinyl)thiazolo[3,2-a]pyridinium 3-Oxide Perchlorate (XI), and 2-(1',3',3'-Trimethyl-3H-indolo-2'-vinyl)thiazolo[3,2-a]pyridinium 3-Oxide Perchlorate (XII). A 0.17-g (1 mmole) sample of (2-pyridylthio)acetic acid was added at 50°C to a solution of 1 mmole of the corresponding 2-acetanilidovinyl derivative in 20 ml of acetic anhydride, and the mixture was maintained at this temperature for 1 h. The dye was removed by filtration and washed with ether.

2-(2'-Thiazolyl[3,2-a]pyridino-3'-oxide-2'-methylene)-2,3-dihydro-3-ketothiazolo[3,2-a]pyridinium Perchlorate (XIII). A mixture of 0.17 g (1 mmole) of (2-pyridylthio)acetic acid, 0.14 g (1.3 mmole) of ethyl orthoformate, and 4 ml of acetic anhydride was heated at 60°C for 5 min, 0.17 g (1 mmole) of (2-pyridylthio)acetic acid was added, and the mixture was maintained at the same temperature for 10 min. The solution was cooled, and 1 ml of 42% perchloric acid was added dropwise. The dye was removed by filtration.

2-(2'-Thiazolyl[3,2-a]pyridino-2'-allylidene)-2,3-dihydro-3-ketothiazolo[3,2-a]pyridinium 3'-Oxide Perchlorate (XIV). A 0.34-g (2 mmole) sample of (2-pyridylthio)acetic acid was added to portions at 50°C to a solution of 0.26 g (1 mmole) of malonaldehyde dianil hydrochloride in 10 ml of acetic anhydride, and the mixture was maintained at this temperature for 2 h. The resulting precipitate was removed by filtration and dissolved in 5 ml of acetonitrile, and 1 ml of 42% perchloric acid was added to the solution. The dye was removed by filtration and washed with acetonitrile.

5-Methyl-2-(3'-methylbenzothiazolio-2'-yl)thiazolo[3,2-a]pyridinium 3-Oxide Methylsulfate (XV). This compound was similarly obtained from (6-methyl-2-pyridylthio)acetic acid [1].

# LITERATURE CITED

1. L. T. Gorb, N. N. Romanov, E. D. Sych, and A. I. Tolmachev, Dokl. Akad. Nauk Ukr. SSR, No. 10, 895 (1978).
2. K. T. Potts and D. R. Choudhary, J. Org. Chem., 13, 2700 (1978).
3. L. T. Gorb, E. D. Sych, A. I. Tolmachev, and I. S. Shpileva, Khim. Geterotsikl. Soedin., No. 8, 1066 (1979).
4. A. R. Katritzky and A. J. Boulton, Advances in Heterocyclic Chemistry, Vol. 19, Academic Press, New York-San Francisco-London (1976), p. 3.
5. N. N. Sveshnikov and I. I. Levkoev, Zh. Obshch. Khim., 10, 274 (1940).
6. A. I. Kiprianov, Usp. Khim., 29, 336 (1960).
7. E. Koinigs and H. Geisler, Ber., 57, 2076 (1924).

## SMILES REARRANGEMENT OF TETRACHLOROPYRIDYL METHYL-HYDROXYPHENYL SULFONE

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In the present work we have investigated the Smiles rearrangement [1] for compounds which contain as activated aromatic system a tetrachloropyridyl residue bonded to a benzene ring by a sulfide or sulfonyl bridge. To prepare compounds of this type, we investigated the reaction of 2,3,5,6-tetrachloropyridyl-4-sulfonyl chloride (I) with p-cresol and p-chlorophenol. In the IR spectrum of the compound obtained as a result of the condensation with p-cresol, an absorption band in the  $3500\text{ cm}^{-1}$  region was detected (OH group), which unequivocally demonstrates that the attack of the sulfonyl chloride I is directed to one of the carbon atoms of the benzene ring, namely, to the ortho position to the hydroxyl group, whose donor properties exceed those of the methyl group, as a result of which 2,3,5,6-tetrachloropyridyl 4-(2'-hydroxyl-5'-methylphenyl)sulfide (IIa) is formed. Replacement of the methyl group in p-cresol by the electronegative chlorine atom considerably retards the reaction rate.

In the action of aqueous or alcoholic alkali on the sulfides IIa and IIb, the solution rapidly acquires a stable bright-yellow coloration ( $\lambda_{\text{max}} = 390\text{ nm}$ ), which indicates the formation of the spiro Meisenheimer complex (A). It should be noted that ionization of the hydroxyl group can be effected only with the aid of a sufficiently strong base, for example, sodium hydroxide or potassium hydroxide, or alkali metal alcoholates. In the presence of triethylamine or piperidine, complex A is not formed [2].

Upon the action of hydrochloric acid or dimethyl sulfate on the complex A, there are formed, respectively, the sulfides IIa and b, or 2,3,5,6-tetrachloropyridyl-4-2'-methoxy-5'-methyl(or chloro)phenyl sulfides (IIIa, b). In spite of the higher nucleophilicity of the sulfur atom as compared with oxygen, opening of the oxathiolane ring of complex A under the action of electrophiles takes place, not at the C-S bond, but at the C-O bond. This is apparently explained by the stability of the phenolate anion [3], as a result of which the reaction inverse to the formation of complex A takes place easily. At  $50^\circ$  the orange coloration of complex A disappears, and cyclization products separate from the solutions; in the UV spectra of these an absorption band at 296 nm is detected, and in the IR spectra hydroxyl group absorption is absent. In the mass spectra of the cyclization products peaks for molecular ions at 317 and 337 are observed, respectively. If cyclization takes place with involvement of an oxygen anion (compound B), which attacks the 3-position, the reaction products will be the corresponding 3-azaphenoxathines (IVa and b). In the case of a preliminary Smiles rearrangement, the formation of isomeric 2-azaphenoxathines is possible. We suggest that, thanks to the insufficient stability of the spiro-complex A, and by analogy with polynitrobenzene derivatives [3], we obtained the isomers IV.

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