LITERATURE CITED

1. T. É. Bezmenova, R. A. Dorofeeva, and A. Ya. Bezmenov, Zh. Org. Khim., 3, 778 (1967).
2. T. É. Bezmenova, D. I. Kurlyand, A. F. Rekasheva, T. D. Zaika, and T. S. Lutsii, Khim. Geterotsikl. Soedin., No. 8, 1067 (1975).
3. T. É. Bezmenova, A. F. Rekasheva, T. S. Lutsii, and R. A. Dorofeeva, Khim. Geterotsikl. Soedin., No. 9, 1200 (1974).
4. Takanashi, L. A. Cohen, H. K. Miller, and E. L. Peake, J. Org. Chem., 36, 1205 (1971).
5. T. J. Crowell, R. T. Kemp, R. E. Lutz, A. A. Wall, J. Am. Chem. Soc., 90, 4638 (1968).
6. L. R. Fedor and W. R. Clave, J. Am. Chem. Soc., 93, 985 (1971).
7. B. Loev, J. Org. Chem., 26, 4394 (1961).
8. H. S. Harned and L. D. Fallon, J. Am. Chem. Soc., 61, 2374 (1939).
9. N. M. Émanuel' and I. G. Knorre, Course in Chemical Kinetics [in Russian], Moscow (1969), p. 157.

REACTION OF 3-PHENYLSULFONYLBENZOTHIAZOLONE WITH AMINES

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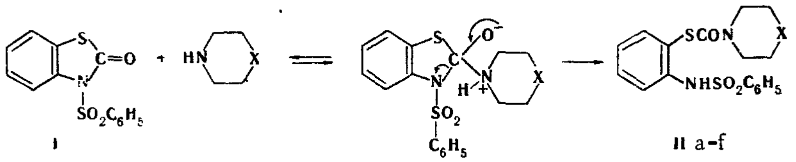
A phenylsulfonyl group in the 3 position accelerates and changes the direction of aminolysis of benzothiazolone and leads to the formation of 2-phenylsulfonylamino-S-phenyl esters of N-substituted thiocarbamic acids. 2,2'-Bis(phenylsulfonylamino)diphenyl disulfide and the corresponding symmetrical ureas were obtained in the reaction with several primary amines.

In our preceding studies [1, 2] we established that the corresponding 2,2'-bis(3-alkylureido)diphenyl disulfides are formed in the reaction of benzothiazolone and some of its benzene-substituted derivatives with primary and secondary amines at 100°C. This sort of decyclization is realized more readily in the case of the benzothiazolone analog benzoxazolone [2, 4].

In the present research we investigated the effect of an electron-acceptor substituent attached to the $N_{(3)}$ atom on the course and rate of the above-indicated reaction. In this connection, we studied the reaction of 3-phenylsulfonylbenzothiazolone (I) with several primary and secondary amines in ethanol.

The reaction with cyclic amines such as piperidine, pyrrolidine, morpholine, 1-methylpiperazine, 1-(β-hydroxyethyl)piperazine, and 1-benzylpiperazine leads to the production of the previously unknown 2-phenylsulfonylamino-S-phenyl esters of N-substituted thiocarbamic acids (II) in 45-75% yields.



II a $X=CH_2$, c $X=O$; d $X=NCH_3$, e $X=NCH_2CH_2OH$; f $X=NCH_2C_6H_5$;

II b- pyrrolidine derivative

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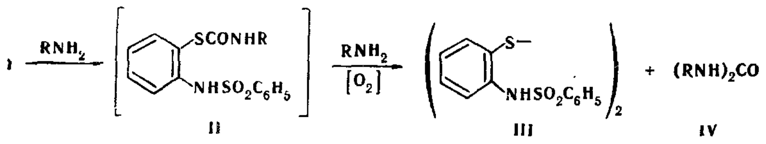
In conformity with the literature data for thiocarbamates [5], the intense band of a carbonyl group is observed at 1660-1670 cm^{-1} in the IR spectra of II. The absorption band of NH stretching vibrations and two intense bands at 1330-1340 and 1150-1175 cm^{-1}, which correspond to the asymmetrical and symmetrical vibrations of SO_2, also appear in the spectra; this confirms the presence of a sulfonamido group. In fact, the same three characteristic bands corresponding to the phenylsulfonylaminophenylsulfide fragment are observed in the IR spectrum of 2,2'-bis(phenylsulfonylamino)diphenyl disulfide (III) [6].

Two signals with an integral intensity of 8 proton units, which belong to the hydrogen atoms of the methylene groups of the heteroring, appear in the PMR spectrum of IIc at 3.58-3.65 ppm (the signal of the imine proton is probably overlapped by the signals of the aromatic protons, since a multiplet with an integral intensity of 10 proton units is found at 6.95-8 ppm).

The results of the studies indicate a new trend of aminolysis of benzothiazolone in the presence of an N-phenylsulfonyl group. The latter, as a strong electron acceptor, changes the ratio of the polarities of the nitrogen—carbon and sulfur—carbon bonds in the heteroring of benzothiazolone as compared with unsubstituted compounds, and the nitrogen—carbon bond in 3-phenylsulfonylbenzothiazolone become more labile. It should be noted that the cleavage of the heteroring of 3-phenylsulfonylbenzothiazolone is effected more readily than in the case of benzothiazolone itself and some of its ring-substituted derivatives [1, 2]. This is probably promoted both by the considerable polarization of the nitrogen—carbon bond and the additional reduction of the electron density at the $C_{(2)}$ reaction center under the influence of the phenylsulfonyl group.

The reaction of 3-phenylsulfonylbenzothiazolone with cyclic amines also seems of interest for the synthesis of phenyl esters of cyclic thiocarbamic acid containing a substituted sulfonamido group.

As a result of experiments with amines such as n-butylamine, isobutylamine, cyclohexylamine, and benzylamine, we obtained the corresponding symmetrical ureas IV and 2,2'-bis(phenylsulfonylamino)diphenyl disulfide (III) in up to 65% yield, depending on the reaction conditions. When primary amines are used, the reaction probably proceeds in the same way as in the case of cyclic amines with the production of the ester of an S-substituted thiocarbamic acid (II). However, as a result of additional attack of the amine on the carbonyl group of this ester, the reaction proceeds further, and compounds III and IV are therefore isolated.



IV a $R = n\text{-}C_4H_9$; b $R = iso\text{-}C_4H_9$; c $R = CH_2C_6H_5$; d $R = C_6H_{11}$

We were unable to isolate esters (II) of thiocarbamic acid in the case of primary amines: the reaction does not take place at low temperatures or leads immediately to the production of III and IV in lower yields. Steric factors probably have more of an effect than the basicity of the amines on the ratio of the rates of the two steps of the reaction, since thiocarbamic acid esters are isolated only when the ring of the cyclic amines opens.

In addition, to the products of the reaction of II and IV, benzothiazolone is isolated in the reaction of 3-phenylsulfonylbenzothiazolone with any of the amines under various conditions as a result of a side reaction involving transamination. Benzothiazolone was identified during the reaction by thin-layer chromatography (TLC) and was isolated from the reaction in up to 33% yield.

EXPERIMENTAL*

The IR spectra of chloroform solutions of the compounds were recorded with a UR-10 spectrometer. The PMR spectrum of a deuterochloroform solution of IIc was recorded with a Tesla B 487C spectrometer (80 (MHz) with tetramethylsilane as the internal standard. The

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TABLE 1. 2-(Phenylsulfonylamino)-S-phenyl Esters (II) of N-Substituted Thiocarbamic Acids

Compound	Reaction time, h	mp, °C*	Empirical formula	Found, %			Calc., %			IR spectra, cm^{-1}	Yield, %
				C	H	N(S)	C	H	N(S)		
IIa	1	126—128	$C_{18}H_{20}N_2O_3S_2$	58,0	5,4	7,6	57,5	5,4	7,4	3330, 1665 1340, 1175	70
IIb	1	138—139	$C_{17}H_{18}N_2O_3S_2$	56,4	5,0	7,8	56,4	5,0	7,7	3330, 1665 1340, 1170	75
IIc	5	160—161	$C_{17}H_{18}N_2O_4S_2$	54,3	4,8	(16,8)	54,0	4,8	(16,9)	3340, 1670 1340, 1175	63
IId	3,5	141—143	$C_{18}H_{21}N_3O_3S_2$	55,4	5,3	11,0	55,2	5,4	10,7	3335, 1670 1340, 1175	52
IIe	3,5	138—140 (from water)	$C_{19}H_{23}N_3O_4S_2$	—	—	10,0	—	—	10,0	3610, 3470 (νOH) 3330, 1665 1330, 1155	57
IIf	3,5	112—114	$C_{24}H_{25}N_3O_3S_2$	61,9	5,7	9,2	61,7	5,4	9,0	3335, 1660 1330, 1150	45

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*The substances were recrystallized from ethanol—water (1:1).

TABLE 2. Reaction of 3-Phenylsulfonylbenzothiazolone with Primary Amines

I/Amine (molar ratio)	Heating time, h	Method used to work up the reaction mixture	Reaction products, yield, %		
			III	IV, R	benzothiazolone
I/Isobutylamine (1:2)	2,5	A	53	47 R=i-C_4H_9	30
I/Cyclohexylamine (1:2)	5	B	46	46 R=C_6H_{11}	26
I/Cyclohexylamine (1:4)	5	B	60	64 R=C_6H_{11}	22

course of the reaction and the purity of the products were monitored by TLC on SI-F (Riedel) plates in a benzene—ethyl acetate system (5:1) and development in UV light or with iodine vapors. Chromatographically pure 3-phenylsulfonylbenzothiazolone was used in the study.

S-(2'-Phenylsulfonylaminophenyl)piperidine-1-carbothionate (IIa). A 1.7-g (0.02 mole) sample of piperidine was added to 1.45 g (0.005 mole) of benzothiazolone I [6] suspended in 20 ml of ethanol, and the mixture was stirred at 25-30° for 1 h, during which it became homogeneous. It was then neutralized with 5% HCl, and the mixture was worked up to give 1.3 g (70%) of ester IIa with mp 121-124°. Crystallization from ethanol—water (1:1) gave colorless crystals with mp 126-128°.

Water was added to the filtrate from the preparation of IIa, and the resulting precipitate (0.45 g) was found to be a mixture of four substances. Separation of the mixture by means of preparative TLC on Kieselgel F-254 (Merck) in a benzene—ethyl acetate system (5:1) yielded the following compounds (in percent ratio relative to the mixture): ~50% IIa, ~25% benzothiazolone, 20% 1-phenylsulfonylpiperidine [IR spectrum: 2950, 2860, 1440, 1345 (ν_{as} SO_2), and 1160 (ν_s SO_2) cm^{-1}], and 5% benzothiazolone I. Compounds IIb and IIe were similarly obtained.

S-(2'-Phenylsulfonylaminophenyl)morpholine-1-carbothionate (IIc). A 1.75-g (0.02 mole) sample of morpholine was added to 1.45 g (0.005 mole) of benzothiazolone I suspended in 20 ml of ethanol, after which the mixture was stirred for 5 h and worked up to give 1.2 g (63%) of ester IIc.

Compounds IId and IIf were similarly obtained. Data on IIa-f are presented in Table 1.

2,2'-Bis(phenylsulfonylamino)diphenyl Disulfide (III) and Symmetrical Ureas (IV) (see Table 2). A) A 0.73-g (0.01 mole) sample of n-butylamine was added to a suspension of 1.45 g (0.005 mole) of benzothiazolone I in 10 ml of ethanol, and the mixture was stirred at 50-55° for 2 h, during which it was converted to a solution. At the end of the reaction, the mixture was neutralized with 5% HCl and worked up to give 0.72 g (55%) of disulfide III with mp 161-163° [ethanol—water (2:1)]. IR spectrum: 3325, 1345, and 1175 cm^{-1}. Found: C 54.4; H 4.1; N 5.3%. $C_{24}H_{20}N_2O_4S_4$. Calculated: C 54.5; H 3.8; N 5.3%.

The identical character of III and 2,2'-bis(phenylsulfonylamino)diphenyl disulfide [6] was proved by means of their melting points and their IR spectra.

The filtrate was acidified with 5% HCl, the ethanol was removed by distillation, and the aqueous solution was extracted with chloroform. Extraction of the chloroform solution with 5% NaOH yielded 0.34 g (40%) of N,N'-di-n-butylurea (IVa) with mp 70-72° (from aqueous ethanol). Products IVa was identical to N,N'-di-n-butylurea (mp 71° [7]).

Acidification of the alkaline extract with 5% HCl precipitated benzothiazolone mixed with a certain amount of disulfide III. Recrystallization yielded 0.25 g (33%) of benzothiazolone.

B) A 1.1-g (0.01 mole) sample of benzylamine was added to 1.45 g (0.005 mole) of benzothiazolone I suspended in 10 ml of ethanol, and the mixture was stirred at 50-55° for 3.5 h, during which it gradually became homogeneous, after which a precipitate began to form. Neutralization of the mixture with 5% HCl yielded 1.57 g of a mixture of disulfide III and N,N'-dibenzylurea (IVc). This mixture was treated in the cold with 5% NaOH, and the insoluble IVc was worked up to give 0.62 g (52%) of a product with mp 166-168° (from aqueous ethanol) (mp 167° [1, 7]). No melting-point depression was observed for a mixture of IVc and N,N'-dibenzylurea [1].

The ethanol was removed by distillation from the filtrate after separation of the mixture of III and IVc, the precipitate was treated with 5% NaOH, and the mixture was worked up to give an additional 0.12 g (10%) of urea IVc. Acidification of this alkaline filtrated yielded 0.20 g (26%) of benzothiazolone.

LITERATURE CITED

1. D. Simov and A. Antonova, Compt. Rend. Acad. Bulg. Sci., 20, 881 (1968).
2. D. Simov and A. Antonova, Dokl. Bolgarsk. Akad. Nauk, 23, 1493 (1970).
3. D. Simov and V. Kalcheva, Compt. Rend. Acad. Bulg. Sci., 17, 825 (1964).
4. V. Kalcheva and D. Simov, Khim. Geterotsikl. Soedin., No. 10, 1333 (1971).
5. R. Nyquist and W. Potts, Spectrochim. Acta, 17, 679 (1961).
6. H. Zinner and W. Nimmich, J. Prakt. Chem., 14, 139 (1961).
7. T. Davis and K. Blankchard, J. Am. Chem. Soc., 45, 1816 (1923).