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Dedicated to the centenary of Academician A.V. Kirsanov's birthday

Cyclocondensation of 1-Tosyl-2,2-dichloroethenyl Isothiocyanate with O-, S-, N-, and C-Nucleophiles

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Abstract–Treatment of 1-tosyl-2,2-dichloroethenyl isothiocyanate with alcohols, thiols, primary and secondary amines, hydrazine and its derivatives, and phosphonium ylides results in addition of the O-, S-, N-, or C-nucleophilic center to the isothiocyanate group, followed by cyclocondensation with elimination of hydrogen chloride and formation of the corresponding 2-functionally substituted 4-tosyl-5-chloro-1,3-thiazoles. Further transformations of these compounds were studied, and a series of previously unknown types of 3-functionally substituted 1,3-thiazole derivatives were prepared.

It was shown recently that readily accessible *N*-(1,2,2,2-tetrachloroethyl)formamide by successive treatments with sodium *p*-toluenesulfinate, phosphorus pentachloride, and thiourea is readily converted into an electrophilic agent, 1-tosyl-2,2-dichloroethenyl isothiocyanate **I** [1]. In this work, we systematically studied the reactions of **I** with various O-, S-, N-, and C-nucleophiles, which proceed by the common scheme.

We found that compound **I** readily reacts with alcohols, mercaptans, and thiophenols in the presence of an equimolar amount of pyridine at 20–25°C. As for cyclization with amines, previously studied with some examples [1], as well as the reaction with hydrazine and its derivatives, it is appropriate to perform this reaction at the molar ratio of the reactants of 1:2. Cyclocondensation of **I** with phosphonium ylides was performed in the presence of triethylamine. In all the above cases, as a rule, the corresponding 2-X-4-tosyl-5-chloro-1,3-thiazoles **II**–**V** [X = AlkO, AlkS, ArS, AlkNH, Alk_2N, ArNH, H_2NNH, PhNHNH, $Ph_3P{=}C(COOCH_3)$, $Ph_3P{=}C(CN)$, and other functional substituents] are formed in good yields (see scheme; Table 1). Their structure was confirmed by

Table 1. Yields, melting points, and elemental analyses of 1,3-thiazole derivatives **II**–**XIII**

Comp. no.	Yield, %	mp, °C (solvent)	Found, %		Formula	Calculated, %	
			Cl	S		Cl	S
IIa	72	119–120 (metanol)	11.70	21.19	$C_{11}H_{10}ClNO_3S_2$	11.67	21.11
IIb	65	110–111 (ethanol)	11.16	20.18	$C_{12}H_{12}ClNO_3S_2$	11.18	20.18
IIc	30	58–60 (ethanol)	10.69	19.48	$C_{13}H_{14}ClNO_3S_2$	10.68	19.33
IIIa	90	128–129 (acetonitrile)	8.60	24.36	$C_{17}H_{14}ClNO_2S_3$	8.95	24.30
IIIb	82	138–139 (ethanol–acetonitrile)	17.26	23.15	$C_{16}H_{11}Cl_2NO_2S_3$	17.03	23.10
IIIc	76[a]	69–70 (methanol)	9.00	24.44	$C_{17}H_{14}ClNO_2S_3$	8.95	24.30
IIId	86	120–122 (ethanol–acetonitrile)	8.00	21.79	$C_{17}H_{13}ClN_2O_4S_3$	8.04	21.82
IIIe	59	93–95 (ethanol)	9.22	24.65	$C_{15}H_{12}ClNO_3S_3$	9.19	24.93
IIIf	96	72–73 (methanol)	15.45	20.95	$C_{18}H_{13}Cl_2NO_3S_3$	15.47	20.99
IIIg	64[b]	94–95 (methanol)	10.83	29.97	$C_{11}H_{10}ClNO_2S_3$	11.08	30.08
IVa	56	178–179 (decomp.) (ethanol)	11.69	21.16	$C_{11}H_{11}ClN_2O_2S_2$	11.71	21.18
IVb	83	139–140 (ethanol)	9.53	17.28	$C_{16}H_{19}ClN_2O_2S_2$	9.56	17.29
IVc	60	175–176 (decomp.) (ethanol)	11.15	20.20	$C_{12}H_{13}ClN_2O_2S_2$	11.19	20.24
IVd	41	115–116 (methanol)	7.51	14.03	$C_{24}H_{21}ClN_2O_2S_2$	7.56	13.67

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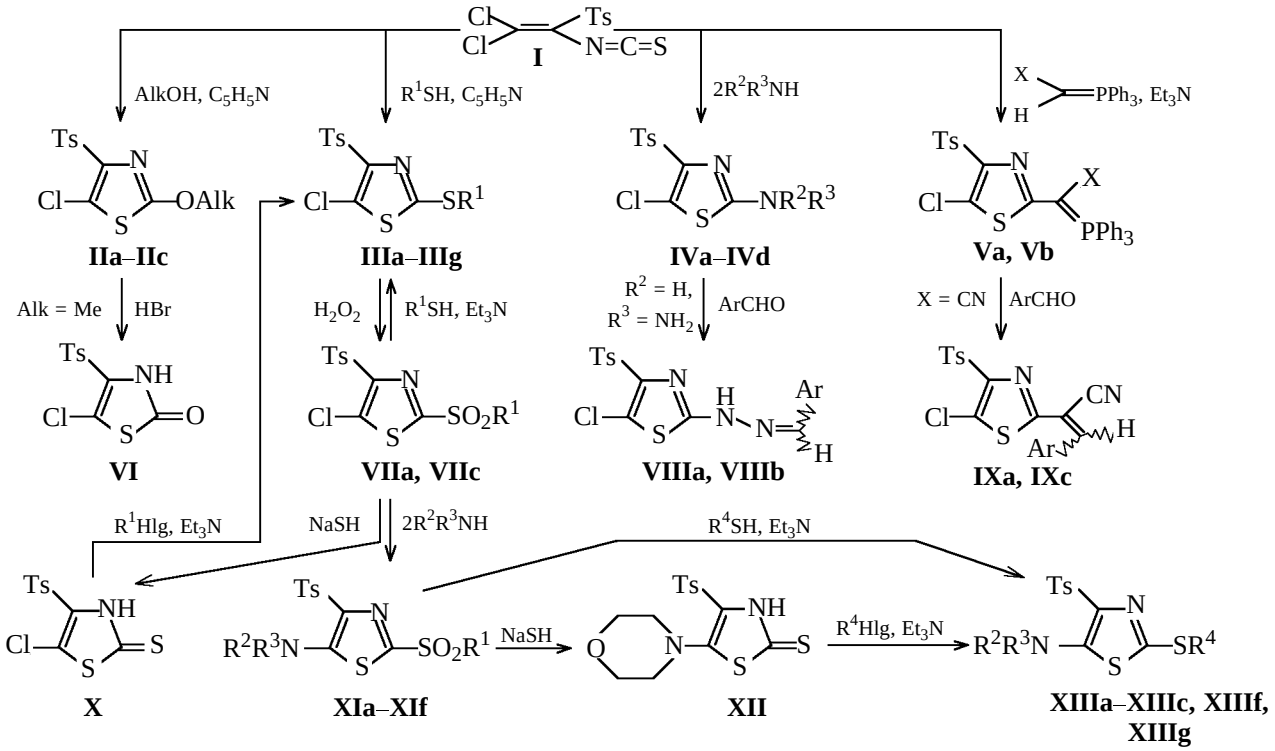
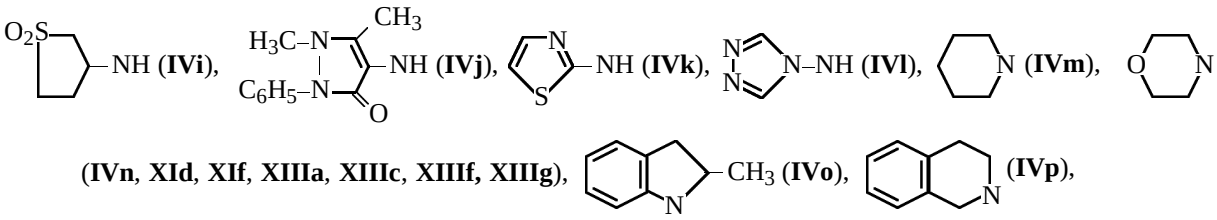
Table 1. (Contd.)

Comp. no.	Yield, %	mp, °C (solvent)	Found, %		Formula	Calculated, %	
			Cl	S		Cl	S
IVe	84	159–160 (ethanol)	9.38	16.90	$C_{17}H_{15}ClN_2O_2S_2$	9.36	16.92
IVf	57	138–139 (ethanol)	9.35	16.91	$C_{17}H_{15}ClN_2O_2S_2$	9.36	16.92
IVg	83	187–188 (ethanol)	17.18	15.54	$C_{17}H_{14}Cl_2N_2O_2S_2$	17.16	15.51
IVh	89	132–133 (ethanol)	9.34	16.90	$C_{17}H_{15}ClN_2O_2S_2$	9.36	16.92
IVi	84	190–191 (acetic acid)	8.82	23.80	$C_{14}H_{15}ClN_2O_4S_3$	8.71	23.64
IVj	97	204–205 (decomp.) (ethanol)	7.48	13.51	$C_{21}H_{19}ClN_4O_3S_2$	7.46	13.50
IVk	73	200–201 (acetonitrile)	9.50	25.84	$C_{13}H_{10}ClN_3O_2S_3$	9.53	25.87
IVl	37	145–147 (decomp.) (methanol)	10.00	18.05	$C_{12}H_{10}ClN_5O_2S_2$	9.96	18.02
IVm	40	150–151 (decomp.) (ethanol)	9.90	17.95	$C_{15}H_{17}ClN_2O_2S_2$	9.93	17.97
IVn[c]	83	186–187 (methanol)	10.02	17.80	$C_{14}H_{15}ClN_2O_3S_2$	9.88	17.87
IVo	98	165–166 (acetonitrile)	8.75	15.81	$C_{19}H_{17}ClN_2O_2S_2$	8.76	15.84
IVp	86	156–157 (acetonitrile)	8.74	15.83	$C_{19}H_{17}ClN_2O_2S_2$	8.76	15.84
IVq	74	154–155 (decomp.) (acetonitrile)	11.63	21.00	$C_{10}H_{10}ClN_3O_2S_2$	11.67	21.11
IVr	70	144–145 (ethanol)	10.63	19.29	$C_{12}H_{14}ClN_3O_2S_2$	10.68	19.32
Va	78	218–220 (decomp.) (acetonitrile)	5.87	10.60	$C_{31}H_{25}ClNO_4PS_2$[d]	5.85	10.58
Vb	77	198–200 (decomp.) (acetonitrile)	6.22	11.22	$C_{30}H_{22}ClN_2O_2PS_2$[e]	6.19	11.19
VI	90	189–190 (ethanol)	12.26	22.15	$C_{10}H_8ClNO_3S_2$	12.24	22.13
VIIa	82	158–159 (acetonitrile)	8.30	22.50	$C_{17}H_{14}ClNO_4S_3$[f]	8.28	22.48
VIIc	76	149–150 (ethanol–acetonitrile)	8.29	22.36	$C_{17}H_{14}ClNO_4S_3$[g]	8.28	22.48
VIIIa	79	204–205 (decomp.) (chlorobenzene)	9.00	16.30	$C_{17}H_{14}ClN_3O_2S_2$	9.05	16.36
VIIIb	85	232–233 (decomp.) (acetonitrile)	8.34	14.71	$C_{17}H_{13}ClN_4O_4S_2$	8.12	14.68
IXa	70	169–170 (ethanol)	8.90	16.07	$C_{19}H_{13}ClN_2O_2S_2$	8.87	16.03
IXc	99	160–161 (ethanol–acetonitrile)	8.00	14.40	$C_{19}H_{12}ClN_3O_4S_2$	7.95	14.38
X	86	155–156 (ethanol)	11.43	31.40	$C_{10}H_8ClNO_2S_3$	11.59	31.45
XIa	86	180–181 (ethanol–acetonitrile)	–	22.71	$C_{18}H_{18}N_2O_4S_3$	–	22.77
XIb	79	191–192 (ethanol–acetonitrile)	–	19.30	$C_{24}H_{22}N_2O_4S_3$	–	19.29
XIc	88	135–136 (ethanol–acetonitrile)	–	22.18	$C_{19}H_{20}N_2O_4S_3$	–	22.03
XId	95	170–172 (ethanol–acetonitrile)	–	20.25	$C_{21}H_{22}N_2O_5S_3$	–	20.10
XIe	87	169–170 (ethanol–acetonitrile)	–	22.10	$C_{19}H_{20}N_2O_4S_3$	–	22.03
XIf	85	184–186 (acetonitrile)	–	19.78	$C_{21}H_{22}N_2O_5S_3$	–	20.10
XII	87	123–125 (decomp.) (ethanol)	–	27.01	$C_{14}H_{16}N_2O_3S_3$	–	26.98
XIIIa	89	141–142 (ethanol)	–	21.50	$C_{21}H_{22}N_2O_3S_3$	–	21.54
XIIIb	56	75–76 (ethanol)	8.30	22.59	$C_{18}H_{17}ClN_2O_2S_3$	8.34	22.63
XIIIc	78	130–131 (ethanol)	7.67	20.63	$C_{20}H_{19}ClN_2O_3S_3$	7.59	20.60
XIIIf	70	118–119 (ethanol)	7.03	18.82	$C_{22}H_{21}ClN_2O_4S_3$	6.96	18.90
XIIIg	80	121–123 (ethanol)	–	26.00	$C_{15}H_{18}N_2O_3S_3$	–	25.96

[a] Yield by method *a*; yield by method *b* 72%. [b] Yield in the transformation **I** → **III**; yield in the transformation **X** → **III** 52%. [c] The compound was synthesized earlier [1]. [d] Found P, %: 5.18. Calculated P, %: 5.11. [e] Found P, %: 5.46. Calculated P, %: 5.40. [f] Found, %: C 47.53; H 3.33. Calculated, %: C 47.71; H 3.30. [g] Found, %: C 47.41; H 3.38. Calculated, %: C 47.71; H 3.30.



Alk = CH_3 (**IIa**), C_2H_5 (**IIb**), *n*-C_3H_7 (**IIc**); R^1 = 4-$CH_3C_6H_4$ (**IIIa, VIIa, XIa**–**XId**), 4-ClC_6H_4 (**IIIb**), $C_6H_5CH_2$ (**IIIc, VIIc, XIe, XIf**), 4-$NO_2C_6H_4CH_2$ (**IIId**),  (**IIIe**), 4-$ClC_6H_4COCH_2$ (**IIIf**), CH_3 (**IIIg**); R^2R^3N = CH_3NH (**IVa, XIa**), $C_6H_5CH_2NH$ (**XIb**),  (**IVb**), $(CH_3)_2N$ (**IVc, XIc, XIe, XIIIb**), $(C_6H_5CH_2)_2N$ (**IVd**), 2-$CH_3C_6H_4NH$ (**IVe**), 4-$CH_3C_6H_4NH$ (**IVf**), 3-Cl-4-$CH_3C_6H_3NH$ (**IVg**), $CH_3(C_6H_5)N$ (**IVh**),



(**IVn**, **XId**, **XIf**, **XIIIa**, **XIIIc**, **XIIIf, XIIIg**), (**IVo**), (**IVp**),

H_2NNH (**IVc**), $(CH_3)_2NNH$ (**IVr**); X = $CH_3OC(O)$ (**Va**), NC (**Vb**); Ar = C_6H_5 (**VIIIa, IXa**), 3-$NO_2C_6H_4$ (**VIIIb**), 4-$NO_2C_6H_4$ (**IXc**); R^4 = 4-$CH_3C_6H_4$ (**XIIIa**), 4-ClC_6H_4 (**XIIIb, XIIIc**), 4-$ClC_6H_4COCH_2$ (**XIIIf**), CH_3 (**XIIIg**).

^{1}H NMR and IR spectroscopy (Table 2), as well as by modification of functional substituents in position 2 of the thiazole ring by a series of transformations: **II** → **VI**, **III** → **VII**, **IV** → **VIII**, and **V** → **IX**.

However, the mobility of the chlorine atom in position 5 of trisubstituted triazoles **II**, **III**, and **V** is low, and it is not substituted with thiols or amines even at prolonged heating in ethanol. However, oxidation of 2-alkyl(aryl)thio-4-tosyl-5-chloro-1,3-thiazoles **III** with hydrogen peroxide gives the corresponding 2,4-disulfonyl-substituted 5-chloro-1,3-thiazoles **VII**, which show marked electrophilicity and react under mild conditions with sodium hydrosulfide and thiophenols in the presence of triethylamine, as well as with highly basic primary and secondary amines. It is of interest that thiols attack mainly the C^2 center in **VII**, which results in the elimination of the alkyl- or arylsulfonyl group (transformations **VII** → **III**, **VII** → **X**), while highly basic amines attack the C^5 center in **VII**, which is accompanied by elimination of the chloride anion: **VII** → **XI**. The regioselectivity of these processes is in conflict with the Pearson's concept; presumably, the reactions with thiols and

sodium hydrosulfide **VII** → **III** and **VII** → **X** are kinetically controlled. Note that, even in those representatives of compounds **XI** where R^2R^3N = $(CH_3)_2N$, $O(CH_2CH_2)_2N$, the C^2 center remains noticeably electrophilic, which makes it possible to perform condensations with sodium hydrosulfide and thiols **XI** → **XII** and **XI** → **XIII** on heating in ethanol.

It is quite possible that introduction of bulky N-substituents in position 5 of the thiazole ring with the tosyl group present at the C^4 center distorts the conjugation between the unshared electron pair of the nitrogen atom in the substituent and the π system of the azole fragment, so that the electrophilicity of the C^2 atom is not fully supressed. At the same time, 5-methylamino-2,4-ditosyl-1,3-thiazole does not react with thiols even on prolonged heating; it seems likely that its inertness is due to the transfer onto the C^2 center of a considerable electron density because of this conjugation.

In conclusion, it should be noted that the majority of transformations described in this work are not only of scientific, but also of practical synthetic interest, since the known routes to 4-tosylthiazole derivatives summarized in the comprehensive monograph [2] and some papers [3–6] do not allow preparation of the twelve types of 3-functionally substituted thiazoles **II**–**XIII** which can be readily prepared from accessible agent **I**.

EXPERIMENTAL

The IR spectra were recorded on a Specord IR-71 instrument in dichloromethane. The ^{1}H NMR spectra of the majority of compounds were taken on a Varian VXR-300 spectrometer, and that of **IVe**, on a Varian Gemini-200 spectrometr with TMS as internal reference.

1-Tosyl-2,2-dichloroethenyl isothiocyanate I. A suspension of 0.14 mol of *N*-(1-tosyl-2,2,2-trichloroethyl)iminodichloromethane [1] and 0.29 mol of thiourea in 250 ml of acetonitrile was refluxed with stirring for 1 h, the precipitate was filtered off, the solvent from the filtrate was removed in vacuo, and the residue was recrystallized from 250 ml of diethyl ether. Yield 77%, mp 94°C (cf. [1]).

2-Alkoxy-4-tosyl-5-chloro-1,3-thiazoles IIa–**IIc.** A mixture of 16.2 mmol of **I**, 10 ml of the appropriate alcohol, and 16.2 mmol of pyridine was stirred for 72 h at 20–25°C; the precipitated product was filtered off and washed with ethanol.

4-Tosyl-2-*p*-tolyl(*p*-chlorophenyl, 2-furylmethyl, methyl)thio-5-chloro-1,3-thiazoles IIIa, IIIb, IIIe, and IIIg. A solution of 16.2 mmol of **I** and 16.2 mmol of pyridine in 35 ml of benzene was saturated with methyl mercaptan or mixed with 16.2 mmol of other liquid or solid thiol, the reaction mixture was stirred for 48 h at 20–25°C, the solvent was removed *in vacuo*, and the residue was washed with water.

2-Benzylthio-4-tosyl-5-chloro-1,3-thiazole IIIc. *a.* To a solution of 15 mmol of **I** in 30 ml of benzene, we added 15 mmol of pyridine and 15 mmol of

Table 2. ^{1}H NMR spectra of 1,3-thiazole derivatives **II**–**XIII**

Comp. no.	δ, ppm
IIb[a]	1.37 t (3H, C*H*$_3$CH$_2$), 2.44 s (3H, C*H*$_3$C$_6$H$_4$), 4.45 q (2H, CH$_2$), 7.35 d (2H, ArH), 7.94 d (2H, ArH)
IIIc[a]	2.45 s (3H, CH$_3$), 4.37 s (2H, CH$_2$), 7.26–7.97 m (9H, ArH)
IVd[b]	2.42 s (3H, CH$_3$), 4.62 s (4H, CH$_2$), 7.21–7.83 m (14H, ArH)
IVe[b]	2.19 s (3H, CH$_3$), 2.42 s (3H, CH$_3$), 7.03–7.85 m (8H, ArH), 9.90 s (1H, NH)
IVi[b]	2.08 m (1H, CH$_2$), 2.41–2.46 m (4H, CH$_2$, CH$_3$), 2.92 m (1H, CH$_2$), 3.12–3.45 m (3H, CH$_2$), 4.35 m (1H, CHN), 7.47 d (2H, ArH), 7.83 d (2H, ArH) 8.63 br.s (1H, NH)
IVl[b]	2.41 s (3H, CH$_3$), 7.46 d (2H, ArH), 7.77 d (2H, ArH), 8.82 s (2H, HtH), 11.65 br.s (1H, NH)
IVo[b]	1.25 d (3H, C*H*$_3$CH), 2.41 s (3H, C*H*$_3$C$_6$H$_4$), 2.75 m (1H, CH$_2$), 3.45 m (1H, CH$_2$), 4.43 m (1H, CHN), 7.00–7.93 m (8H, ArH)
IVg[b]	2.40 s (3H, CH$_3$), 5.24 br.s (2H, NH$_2$), 7.47 d (2H, ArH), 7.80 d (2H, ArH), 9.31 s (1H, NH)
Va[a]	2.35 s (3H, C*H*$_3$C$_6$H$_4$), 3.19 s (3H, CH$_3$O), 6.96–7.64 m (19H, ArH)
VIIa[a]	2.44 s (3H, CH$_3$), 2.46 s (3H, CH$_3$), 7.32–7.91 m (8H, ArH)
VIIc[a]	2.47 s (3H, CH$_3$), 4.64 s (2H, CH$_2$), 7.08–8.01 m (9H, ArH)
VIIIa[b]	2.42 s (3H, CH$_3$), 7.41–7.85 m (9H, ArH), 7.98 s (1H, CH=N), 12.71 s (1H, NH)
IXa[a]	2.45 s (3H, CH$_3$), 7.27–8.02 m (9H, ArH), 8.17 s (1H, CH=C)
XIf[b]	2.42 s (3H, CH$_3$), 3.24 t (4H, CH$_2$N), 3.75 t (4H, CH$_2$O), 4.79 s (2H, CH$_2$SO$_2$), 6.89–7.92 m (9H, ArH)
XIIIa[a]	2.40 s (3H, CH$_3$), 2.44 s (3H, CH$_3$), 3.00 t (4H, CH$_2$N), 3.80 t (4H, CH$_2$O), 7.20–7.94 m (8H, ArH)

Notes: [a] In $CDCl_3$. [b] In DMSO-d_6.

benzyl mercaptan; the mixture was stirred for 48 h at 20–25°C and worked up as described above.

b. A mixture of 1.2 mmol of **VIIa** (see below), 1.2 mmol of benzyl mercaptan, 1.2 mmol of triethylamine, and 5 ml of ethanol was refluxed for 1 h; the precipitate after cooling was filtered off and washed with ethanol. A mixture of the two samples prepared by methods *a* and *b* showed no depression of the melting point.

2-*p*-Nitrobenzyl(*p*-chlorobenzoylmethyl, methyl)thio-4-tosyl-5-chloro-1,3-thiazoles IIId, IIIf, and IIIg. To a suspension of 0.8 mmol of **X** (see below) in 5 ml of ethanol, we added 0.8 mmol of triethylamine and 0.8 mmol of methyl iodide, *p*-nitrobenzyl bromide, or *p*-chlorophenacyl bromide; the mixture was stirred for 48 h at 20–25°C, and the precipitate was filtered off and then washed with water and ethanol.

2-Methylamino(cyclohexylamino, dimethylamino)-4-tosyl-5-chloro-1,3-thiazoles IVa–IVc. To a suspension of 10 mmol of isothiocyanate **I** in 10 ml of ethanol, cooled to 10–15°C, we added 3 ml of 25% aqueous solution of methylamine or 3 ml of 33% aqueous solution of dimethylamine, or a solution of 20 mmol of cyclohexylamine in 5 ml of ethanol; the mixture was stirred for 6 h at 20–25°C, 3 ml of water was added, and the precipitate was filtered off.

2-Dibenzylamino-4-tosyl-5-chloro-1,3-thiazole (IVd). A solution of 20 mmol of dibenzylamine in 5 ml of acetonitrile was added over a period of 10 min with stirring to a suspension of 10 mmol of isothiocyanate **I** in 10 ml of acetonitrile, cooled to 10–15°C; the mixture was stirred for an additional 4 h at 20–25°C, and the precipitate was filtered off. The solvent was removed from the filtrate *in vacuo*, the residue was treated with 5 ml of ethyl acetate, and the precipitate was filtered off.

2-Arylamino(*N*-methylanilino)-4-tosyl-5-chloro-1,3-thiazoles IVe–IVh were prepared similarly to **IVb**.

2-(1,1-Dioxo-λ^6-thiolan-3-ylamino)-4-tosyl-5-chloro-1,3-thiazole IVi. A solution of 20 mmol of 3-aminosulfolane in 5 ml of acetonitrile was added over a period of 10 min with stirring to a suspension of 10 mmol of **I** in 10 ml of acetonitrile, cooled to 10–15°C. The mixture was stirred for an additional 7 h at 20–25°C, 15 ml of water was added, and the precipitate was filtered off.

2-(1,5-Dimethyl-3-oxo-2-phenyl-2,3-dihydro-1*H*-pyrazol-4-ylamino)-4-tosyl-5-chloro-1,3-thiazole IVj. A mixture of 5 mmol of isothiocyanate **I**, 10 mmol of 4-aminoantipyrine, and 10 ml of ethanol was stirred at 20–25°C for 4 h, and the precipitate was filtered off.

2-(1,3-Thiazol-2-ylamino)-4-tosyl-5-chloro-1,3-thiazole IVk. A mixture of 10 mmol of **I**, 20 mmol of 2-amino-1,3-thiazole, and 10 ml of acetonitrile was stirred at 20–25°C for 48 h; the precipitate was filtered off and washed with acetonitrile and water.

4-(4-Tosyl-5-chloro-1,3-thazol-2-ylamino)-4*H*-1,2,4-triazole IVl. A solution of 20 mmol of 4-amino-4*H*-1,2,4-triazole in 5 ml of methanol was added to a solution of 10 mmol of isothiocyanate **I** in 15 ml of benzene; the mixture was kept at 20–25°C for 48 h, and the precipitate was filtered off and washed with methanol.

2-Heteryl-4-tosyl-5-chloro-1,3-thiazoles IVm–IVp were prepared similarly to **IVb**.

2-Hydrazino(*N*',*N*'-dimethyhydrazino)-4-tosyl-5-chloro-1,3-thiazoles IVq and IVr. To a suspension of 30 mmol of isothiocyanate **I** in 30 ml of methanol, cooled to 10–15°C, we added 8 ml of 32% aqueous solution of hydrazine or a solution of 60 mmol of *N*,*N*-dimethylhydrazine in 10 ml of methanol; the mixture was stirred for an additional 4 h at 20–25°C, 10 ml of water was added, and the precipitate was filtered off and washed with methanol.

Methoxycarbonyl(4-tosyl-5-chloro-1,3-thiazol-2-yl)methylenetriphenylphosphorane Va. To a solution of 1.7 mmol of **I** in 6 ml of benzene, we added 1.7 mmol of methoxycarbonylmethylenetriphenylphosphorane and 1.7 mmol of triethylamine; the mixture was kept for 24 h at 20–25°C, the solvent was removed *in vacuo*, 3 ml of ethanol was added to the oily residue to initiate crystallization, and the precipitate was filtered off. IR spectrum, ν, cm^{-1}: 1620 (CO), 1330, 1150 (SO_2).

4-Tosyl-5-chloro-1,3-thiazol-2-yl(cyano)methylenetriphenylphosphorane Vb. To a solution of 3.2 mmol of **I** in 15 ml of benzene, we added 3.2 mmol of cyanomethylenetriphenylphosphorane and 3.2 mmol of triethylamine; the suspension was stirred for 24 h at 20–25°C, and the precipitate was filtered off and washed with water and ethanol. IR spectrum, ν, cm^{-1}: 2170 (CN), 1325, 1150 (SO_2).

4-Tosyl-5-chloro-1,3-thiazol-2(3*H*)-one VI. A mixture of 7.5 mmol of **IIa** and 20 ml of 46% HBr was refluxed for 30 min and cooled to 20–25°C; the precipitate was filtered off and washed with water. IR spectrum, ν, cm^{-1}: 3380 (NH), 1710 (CO), 1340, 1150 (SO_2).

4-Tosyl-2-*p*-tolyl(benzyl)sulfonyl-5-chloro-1,3-

thiazoles VIIa and VIIc. To a solution of 8.4 mmol of **IIIa** or **IIIc** in 30 ml of boiling glacial acetic acid, we added 2 ml of 30% aqueous hydrogen peroxide; the mixture was refluxed for 1 h, and an additonal 1 ml of 30% hydrogen peroxide was added, after which the mixture was refluxed for 1 h and cooled to 20–25°C. The precipitate was filterd off and washed with water.

Aromatic aldehyde *N*-(4-tosyl-5-chloro-1,3-thiazol-2-yl)hydrazones VIIIa and VIIIb. A mixture of 5 mmol of **IVq**, 5 mmol of appropriate aldehyde, 10 ml of ethanol, and 10 ml of acetic acid was refluxed for 2 h with stirring and cooled to 20°C; the precipitate was filtered off.

2-(2-Aryl-1-cyanoethenyl)-4-tosyl-5-chloro-1,3-thiazoles IXa and IXc. A mixture of 0.8 mmol of **Vb** and 3.2 mmol of appropriate aldehyde was heated at 160°C for 4 h and cooled to 20–25°C; 3 ml ethanol was added to the oily residue to initiate crystallization, and the precipitate was filtered off and washed with ethanol.

4-Tosyl-5-chloro-1,3-thiazole-2(3*H*)-thione X. A mixture of 1.4 mmol of **VIIa**, 2.8 mmol of sodium hydrosulfide, and 5 ml of ethanol was refluxed for 5 min, the solution was cooled to 20–25°C, 15 ml of water and 0.3 ml of concentrated HCl were added, and the precipitate was filtered off, washed with water, and dried *in vacuo* over phosphorus pentoxide. IR spectrum, ν, cm^{-1}: 3300 (NH), 1325, 1130 (SO_2).

5-Methyamino(benzylamino, dimethylamino, morpholino)-4-tosyl-2-*p*-tolyl(benzyl)sulfonyl-1,3-thiazoles XIa–XIf. 1.3 mmol of **VIIa** or **VIIc** was mixed with 2 ml of ethanol and 2 ml of acetonitrile, 1 ml of 25% aqueous solution of methylamine or 1 ml of 33% aqueous solution of dimethylamine, or 2.6 mmol of benzylamine, or 2.6 mmol of morpholine was added, and the mixture was refluxed for 1 h and cooled to 20–25°C. The precipitate was filtered off and washed with ether.

5-Morpholino-4-tosyl-1,3-thiazole-2(3*H*)-thione XII. A mixture of 1 mmol of **XId**, 2.1 mmol of sodium hydrosulfide, and 5 ml of ethanol was refluxed for 45 min, the solution was cooled to 20–25°C, and 15 ml of water and 0.2 ml of concentrated HCl were added. The precipitate was filtered off, washed with water, and dried *in vacuo* over phosphorus pentoxide. IR spectrum, ν, cm^{-1}: 3350 (NH), 1325, 1130 (SO_2).

5-Morpholino-4-tosyl-2-*p*-tolylthio-1,3-thiazole XIIIa. A mixture of 0.96 mmol of **XIf**, 1 mmol of *p*-thiocresol, 1 mmol of triethylamine, and 5 ml of ethanol was refluxed for 3 h and cooled to 20–25°C; the precipitate was filtered off and washed with ethanol.

5-Dimethylamino-4-tosyl-2-*p*-chlorophenylthio-1,3-thiazole XIIIb was prepared similarly to **XIIIa** from **XIe** and *p*-chlorothiophenol.

5-Morpholino-4-tosyl-2-*p*-chlorophenylthio-1,3-thiazole XIIIc was prepared similarily to **XIIIa** from compound **XId** and *p*-chlorothiophenol.

5-Morpholino-4-tosyl-2-*p*-chlorobenzoylmethyl-(methyl)thio-1,3-thiazoles XIIIf and XIIIg. To a suspension of 0.6 mmol of **XII** in 5 ml of ethanol, we added 0.6 mmol of triethylamine and 0.6 mmol of *p*-chlorophenacyl bromide or methyl iodide; the mixture was stirred for 48 h at 20–25°C, and the precipitate was filtered off and washed with water and ethanol.

REFERENCES

1. Kharchenko, A.V., Seferov, S.O., Zyabrev, V.S., Chervonyi, V.A., Vdovenko, S.I., and Drach, B.S., *Ukr. Khim. Zh.*, 1993, vol. 59, no. 6, p. 637.
2. *The Chemistry of Heterocyclic Compounds. Thiazole and Its Derivatives*, Metzger, J.V., Ed., New York: Wiley, 1979, part 2, pp. 370, 416.
3. Oldenziel, O.H. and Leusen, A.M. van, *Tetrahedron Lett.*, 1972, no. 27, p. 2777.
4. Leusen, A.M. van and Wildeman, J., *Synth. Commun.*, 1977, no. 7, p. 501.
5. Chervonyi, V.A., Kharchenko, A.V., and Drach, B.S., *Ukr. Khim. Zh.*, 1991, vol. 57, no. 4, p. 415.
6. Rudenko, E.A., Seferov, S.O., Chervonyi, V.A., Kharchenko, A.V., and Drach, B.S., *Ukr. Khim. Zh.*, 1991, vol. 57, no. 5, p. 530.