4. V. P. Lezina, A. U. Stepanyants, N. I. Golovkina, and L. D. Smirnov, Izv. Akad. Nauk SSSR, Ser. Khim., No. 1, 98 (1980).
5. S. B. Gashev, B. A. Korolev, L. A. Osmolovskaya, and L. D. Smirnov, Khim. Geterotsikl. Soedin., No. 9, 1262 (1983).
6. G. G. Dvoryantseva, M. M. Kaganskii, I. S. Musatova, and A. S. Elina, Khim. Geterotsikl. Soedin., No. 11, 1554 (1974).
7. T. N. Ul'yanova, G. G. Dvoryantseva, L. M. Alekseeva, Yu. N. Sheinker, and A. S. Elina, Khim. Geterotsikl. Soedin., No. 6, 846 (1971).
8. C. D. Johnson, A. R. Katritzky, and S. A. Shapiro, J. Am. Chem. Soc., 91, 6654 (1969).

CYCLIZATION REACTIONS OF NITRILES.

26.* SYNTHESIS, STRUCTURE, AND PROPERTIES OF 2-AMINO-4-METHYLTHIO-5-CYANO-6(1H)-PYRIMIDINETHIONE

Yu. A. Sharanin, A. M. Shestopalov, V. N. Nesterov, V. P. Litvinov, V. Yu. Mortikov, V. K. Promonenkov, V. E. Shklover, and Yu. T. Struchkov

UDC 547.239.2'854.83.07:542.953:548.737

2-Amino-4-methylthio-5-cyano-6(1H)-pyrimidinethione has been prepared via treatment of N-cyanodimethyldithioimidate or 1,1-di(methylthio)-2-thiocarbamoyl-2-cyanoethylene with cyanothioacetamide or cyanamide. The structure of the complex formed between 2-amino-4-methylthio-5-cyano-6(1H)-pyrimidinethione and urea has been studied by x-ray structural analysis. Thieno[2,3-d]pyrimidines and thiazolo[3,2-c]pyrimidinium salts have been synthesized based on the 6(1H)-pyrimidinethione.

The preparation of 5-cyano-6(1H)-pyrimidinethiones based on active methylene nitriles has been described in the literature. Thus, for instance, 2-amino-1-acetylthiocarbamoyl-1-cyanoethylene cyclizes to give 2,4-dimethyl-5-cyano-6(1H)-pyrimidinethione [2]. Related thiones have been synthesized by treatment of ethoxymethylenemalonitriles with thioamides [3]. It was therefore of interest to examine the reactions of alkoxymethylenecyanamide [4] and alkoxymethylenecarbamic acid esters [5] with cyanothioacetamide. The structures and chemical properties of 5-cyano-6(1H)-pyrimidinethiones have received practically no attention until recently.

We have studied the reaction of N-cyanodimethyldithioimidate (I), which is easily accessible, with cyanothioacetamide (II). In ethanol solution in the presence of sodium ethoxide at 45-50°C the reaction proceeds regioselectively to give sodium 2-amino-4-methyl-5-cyano-6-pyrimidinethiolate (III) (method A). The 6-pyrimidinethiolate (III) could also be obtained from cyanamide V and 1,1-di(methylthio)-2-thiocarbamoyl-2-cyanoethylene (IV) in the presence of sodium ethoxide (method B). The formation of salt III in these reactions is accompanied by elimination of methyl mercaptan, which prevents oxidation of the pyrimidinethione to disulfide. 2-Amino-4-methylthio-5-cyano-6(1H)-pyrimidinethione (VI) was isolated after acidification of salt III in ethanol solution with hydrochloric acid.

*For Communication 25, see [1].

T. G. Shevchenko Voroshilovgrad State Pedagogical Institute, Voroshilovgrad. N. D. Zelinskii, Institute of Organic Chemistry, Academy of Sciences of the USSR, Moscow. A. N. Nesmeyanov Institute of Organometallic Chemistry, Academy of Sciences of the USSR, Moscow.
Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 10, pp. 1377-1384, October, 1987. Original article submitted May 21, 1986.

0009-3122/87/2310-1105 $12.50

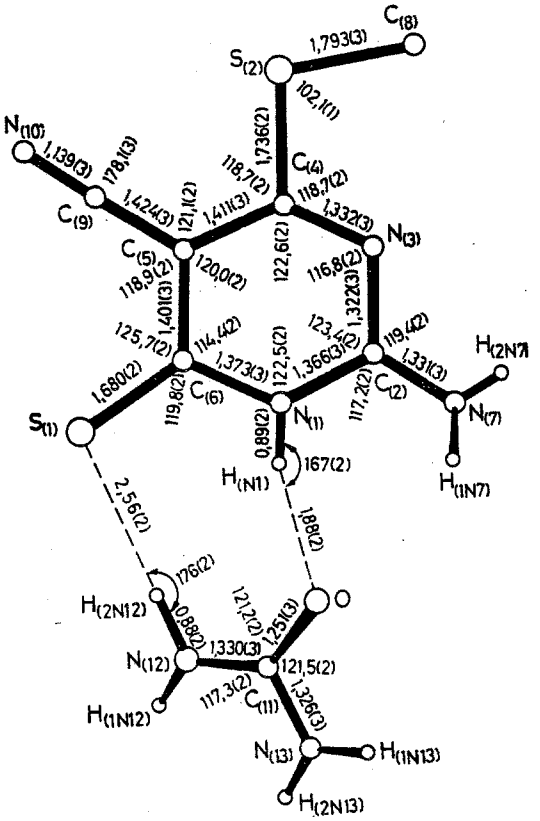
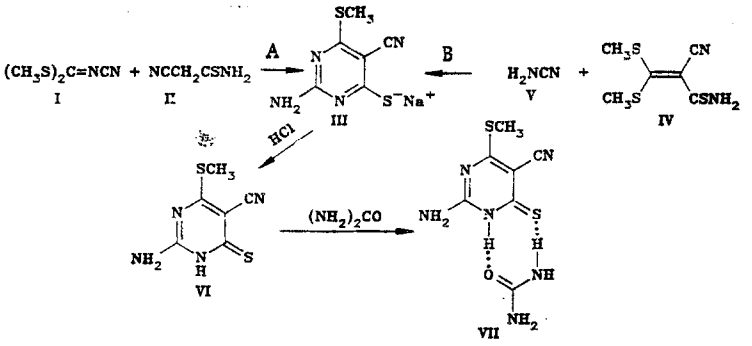


Fig. 1. Mutual orientation of 2-amino-4-methylthio-5-cyano-6(1H)-pyrimidinethione and urea molecules in a crystal of VII. Bond lengths and parameters of $N_{(12)}-H_{(2N12)}\cdots S_{(1)}$ and $N_{(1)}-H_{(N1)}\cdots O$ hydrogen bonds are shown.



The IR spectrum of salt III differs from the spectrum of the pyrimidinethione in that the CN absorption band has been shifted 18 cm^{-1} to lower frequency and its intensity has been simultaneously increased. This is a consequence of the increased degree of conjugation in the N≡C–C–S^- chain III. Comparison of these results with the data obtained in a structural study of 3-cyano-2-pyridinethiolates [6-8] reveals that in compounds III the sulfur atom possesses a formal negative charge. Based on IR and PMR spectroscopic analysis, compound VI exists in the thione form. The PMR spectrum of pyrimidinethione VI contains a broad singlet for the NH group proton signal. The IR spectrum of VI further contains a C=S absorption band in the 1200 cm^{-1} region, which is not present in the IR spectrum of salt III.

Treatment of pyrimidinethione VI with urea gave a complex VII, whose structure was studied by x-ray structural analysis. The atomic coordinates are given in Table 1. In Fig. 1 the bond lengths and bond angles in complex VII are shown. The six-membered ring heterocycle is approximately planar; the atomic deviations from the average plane do not

TABLE 1. Atomic Coordinates ($\cdot 10^5$ for S atoms; $\cdot 10^4$ for O, N, C atoms; $\cdot 10^3$ for H atoms) and Isotropic Equivalent Thermal Parameters for the Nonhydrogen Atoms (isotropic for H atoms) in Complex VII

Atom	x	y	z	B_{iso}^{equiv}, Å²	Atom	x	y	z	B_{iso}^{equiv}, Å²
$S_{(1)}$	16044(11)	21812(3)	32718(6)	3,13(1)	$C_{(8)}$	7941(6)	4193(1)	−358(3)	4,76(8)
$S_{(2)}$	58671(13)	41800(3)	8918(7)	3,82(2)	$C_{(9)}$	2622(4)	3610(1)	2784(2)	3,25(6)
O	5048(3)	777(1)	1487(2)	3,77(5)	$C_{(11)}$	2995(4)	448(1)	1482(2)	2,74(6)
$N_{(1)}$	4967(3)	2104(1)	1560(2)	2,62(5)	$H_{(N1)}$	485(4)	168(1)	164(2)	3,1(5)
$N_{(3)}$	6985(3)	2955(1)	550(2)	2,61(5)	$H_{(1N7)}$	900(4)	204(1)	−32(2)	5,5(6)
$N_{(7)}$	7889(4)	1905(1)	112(2)	3,37(5)	$H_{(2N7)}$	787(4)	150(1)	32(2)	3,8(5)
$N_{(10)}$	1627(4)	3981(1)	3356(2)	4,92(7)	$H_{(1N12)}$	−51(4)	47(1)	186(2)	4,3(6)
$N_{(12)}$	866(4)	678(1)	1941(2)	4,44(7)	$H_{(2N12)}$	97(4)	106(1)	229(2)	4,5(6)
$N_{(13)}$	2825(4)	−136(1)	983(2)	3,68(6)	$H_{(1N13)}$	415(4)	−29(1)	76(2)	4,1(5)
$C_{(2)}$	6628(4)	2335(1)	748(2)	2,52(5)	$H_{(2N13)}$	161(4)	−39(1)	111(2)	4,1(5)
$C_{(4)}$	5620(4)	3363(1)	1186(2)	2,64(6)	$H_{(1C8)}$	794(5)	463(1)	−56(3)	6,5(7)
$C_{(5)}$	3945(4)	3158(1)	2074(2)	2,62(6)	$H_{(2C8)}$	960(6)	403(1)	1(3)	8,4(8)
$C_{(6)}$	3579(4)	2500(1)	2277(2)	2,48(5)	$H_{(3C8)}$	713(5)	392(1)	−95(3)	7,2(8)

exceed 0.019(2) Å. The nonbounded $S_{(1)}\ldots C_{(9)}$, 3.071(2), and $S_{(2)}\ldots C_{(9)}$, 2.995(2) Å, distances lead to deviations of the $S_{(2)}$ and, to a lesser extent, the $C_{(9)}$ atoms from the average plane of the heterocycle of 0.122(1) and −0.048(2) Å, respectively; the $S_{(1)}$ atom, on the other hand, is located exactly within the plane of the ring. The presence of conjugation in the heterocycle is indicated by the partial multiple bond character of bonds within the heterocycle. The endocyclic C–N bond lengths are intermediate in the value between the standard lengths of a single $C_{(sp^2)}$–N bond, 1.426(12) [9], and a double $C_{(sp^2)}$=$N_{(sp^2)}$ bond, 1.27 Å [10]. The C–C bond lengths are also intermediate in value between a standard $C_{(sp^2)}$–$C_{(sp^2)}$ bond, 1.476, and a double $C_{(sp^2)}$=$C_{(sp^2)}$ bond, 1.333 Å [11]. A similar bond length distribution is characteristic of pyrimidine [12] and 2-aminopyrimidine [12, 13], as well. The $C_{(6)}$=$S_{(1)}$ bond length 1.680(2) Å is also increased relative to conventional C=S double bond length values, 1.610(9) Å [14], and is furthermore somewhat larger than the C=S bond length of 1.652(5) Å found in 5H-pyrazolo[3,4-d]pyrimidine-4-thione [15], which has been ascribed to a double bond by the authors. In this regard, it should also be noted that the $C_{(4)}$–$S_{(2)}$ bond length of 1.736(2) Å is shortened relative to a standard $C_{(sp^2)}$–S single bond length, which is 1.77 Å [16]. The $S_{(2)}$–$C_{(8)}$ bond length of 1.793(3) Å is very close to the standard $C_{(sp^3)}$–S bond length value of 1.817 Å [17]. The coordination plane of the trigonal planar $N_{(7)}$ atom (bond angle sum equal to 358°) is approximately coplanar with the heterocycle (corresponding dihedral angle of 15.14°), which is favorable for p–π interaction of the unshared electron pair on the amino group with the π-system of the ring. Conjugation also results in a sharp decrease in the $N_{(7)}$–$C_{(2)}$ bond length to 1.331(3) Å (standard value of an N–$C_{(sp^2)}$ bond is 1.426(12) Å [9]). Conjugation of the NH_2 group with the heterocycle has also been demonstrated in 2-aminopyrimidine [12, 13]. The position of the nitrogen atom strictly within the plane of the heterocycle is also consistent with the presence of conjugation [the deviation of $N_{(7)}$ from the plane of the heterocycle is 0.002(2) Å]. On this basis, therefore, it is concluded that the S and N atoms which are attached to the substituted pyrimidine in this system are also involved in conjugation. The bond lengths and bond angles in the urea molecule in the complex are similar to its conventional values [18].

A crystal of VII also exhibits a developed system of hydrogen bonds (Figs. 1 and 2, Table 2). The $O\ldots H_{(2N7)}$, 2.50(2), $N_{(13)}\ldots H_{(1N13')}$, 2.70(2) Å, distances within the crys-

TABLE 2. Hydrogen Bonds within the Crystal Structure of VII (Fig. 2)

Bond D–H···$A_{x,y,z}$	D–H, Å	D···A, Å	H···A, Å	Angle D–H···A, deg.
$N_{(1)}$–$H_{(N1)}\cdots O_{x,y,z}$	0,89(2)	2,764(2)	1,88(2)	167(2)
$N_{(12)}$–$H_{(2N12)}\cdots S_{(1)x,y,z}$	0,88(2)	3,439(2)	2,56(2)	176(2)
$S_{(1)}\cdots H_{(1N7')}$–$N_{(7')x-1,\ 1/2-y,\ 1/2+z}$	0,81(2)	3,449(2)	2,67(2)	161(2)
$N_{(10)}\cdots H_{(2N13')}$–$N_{(13')-x,\ 1/2+y,\ 1/2-z}$	0,83(2)	3,062(3)	2,23(2)	174(2)
$O\cdots H_{(1N12')}$–$N_{(12')1+x,\ y,\ z}$	0,82(2)	2,964(2)	2,35(2)	133(2)

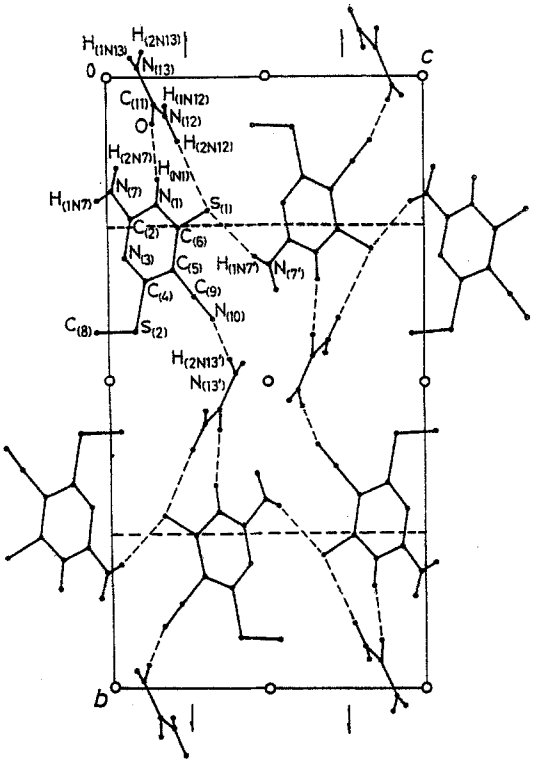
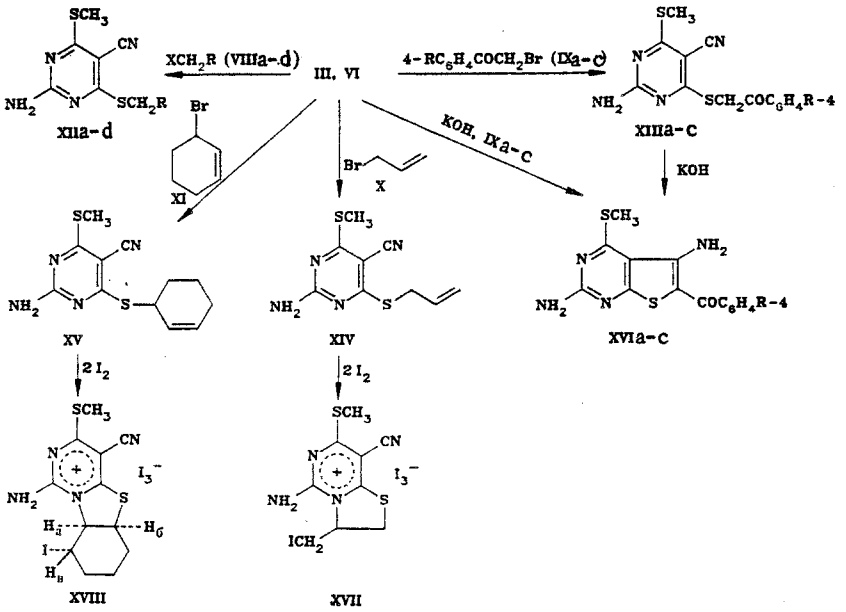


Fig. 2. Projection of the hydrogen bond system within the crystal structure of VII. Dashed lines represent intermolecular hydrogen bonds of the type N–H...S, N–H...O, and N–H...N.

tal are also shortened, and are comparable to the sum of the van der Waals radii for the O and H, or N and H atoms (2.72 and 2.75 Å, respectively [19]).



VIII a,b X=I, c,d X=Br; VIII, XIIa R=H, b R=CH_3, c R=$COOC_2H_5$, d R=$CONH_2$;
IX, XIII, XVI a R=H, b R=Cl, c R=Br

Both the pyrimidinethione VI (in basic media) as well as its salt III are easily alkylated by alkyl halides VIII-XI to give (alkylthio)pyrimidines XII-XV (Table 3), which can be used in the synthesis of annelated pyrimidines. Thus, compounds XIIIa-c cyclize in DMF

in the presence of potassium hydroxide, according to the Torp–Ziegler reaction, to give thieno[2,3-d]pyrimidines XVIa-c in high yields. The IR spectra of compounds XVIa-c contain stretching and bending vibrational absorption bands for the amino groups in the 3143-3438 and 1612-1634 cm^{-1} regions, respectively. The C=O group absorption band is shifted strongly toward lower frequency as a consequence of conjugation and the formation of intramolecular hydrogen bonds with the NH_2 group, and is thus difficult to identify. The PMR spectra data do not contradict the thienopyrimidine structure assignments XVIa-c. The spectra contain, in addition to the proton signals for the CH_3 and RC_6H_4 substituents, broad singlets in the 7.3-7.5 and ~8.0 ppm regions, corresponding to the 3-NH_2 and 6-NH_2 group proton signals, respectively.

Pyrimidines XIV and XV undergo intramolecular quarternization upon treatment with two equivalents of iodine in chloroform to give thiazolo[3,2-c]pyrimidinium triiodides XVII and XVIII, respectively. It should be noted that the triiodides XVII and XVIII were always formed, independently of the amount of iodine introduced into the reaction mixture. In the presence of an iodine deficit unreacted pyrimidine remains in the reaction mixture. Based on their IR and PMR spectra, the positive charge in molecules of XVII and XVIII is delocalized within the pyrimidine fragment. This leads to an increase in the CN vibrational frequency in compounds XVII and XVIII, to 2229-2236 cm^{-1}, as well as to a sharp decrease in its intensity, relative to the starting pyrimidines XIV and XV. The NH_2 group signals in the PMR spectra of triiodides XVII and XVIII are shifted downfield, to 9.80-10.03 ppm, relative to the corresponding signals in compounds XIV and XV.

The intramolecular quaternization of the cyclohexene derivative XV to give XVIII was studied, which permitted certain conclusions to be drawn concerning the stereochemistry of this reaction. Based on PMR spectroscopic data, the cyclization XV → XVIII occurs stereoselectively with trans-quaternization ($J_{H_aH_c}$ = 10.5 Hz) to give a cis-annelated isomer ($J_{H_aH_b}$ = 5.5 Hz).

EXPERIMENTAL

IR spectra were recorded on a Perkin Elmer 457 spectrophotometer using KBr pellets. PMR spectra were recorded on a Bruker WM-250 (250 MHz) spectrometer for DMSO-D_6 solutions.

X-ray Structure Analysis of Compound VII. Crystals of VII are monoclinic: a = 5.103(1), b = 20.804(1), c = 10.704(1), β = 96.179(9)°, V = 1129.8(2) Å, d_{calc} = 1.519 g/cm^3, Z = 4, $P2_1/c$ space group. Unit cell parameters and the intensities of 2107 independent reflections with $I \geq 2\sigma$ were measured on a four-circle automated Hilger-Watts diffractometer at 20°C (λ Mo K_α, graphite monochromator, $\theta/2\theta$ scanning, $2\theta_{max}$ = 60°). Absorption corrections were made using the DIFABS program [20]. The structure was solved by direct methods using MULTAN, which revealed all nonhydrogen atoms, and was refined by full matrix least squares with anisotropic approximations for the nonhydrogen atoms. The hydrogen atoms were revealed by difference synthesis and refined isotropically. The final dispersion factors were R = 0.036 and R_w = 0.034. All calculations were carried out on an Eclipse S/200 computer using the INEXTL program [21].

Sodium 2-Amino-4-methylthio-5-cyanopyrimidine-6-thiolate (III). A. The alkoxide solution prepared from 2.3 g (0.1 mole) sodium and 70 ml absolute ethanol was treated successfully with 10 g (0.1 mole) cyanothioacetamide II and 14.6 g (0.1 mole) N-cyanodimethyldithioimidate I. The reaction mixture was stirred and heated to 45-50°C for 5 min. This resulted in the evolution of methyl mercaptan and precipitation of compound III. The mixture was stirred an additional 3 h at 25°C, the precipitate was filtered and washed with absolute ethanol and hexane. Yield 18.7 g (85%), mp > 350°C. IR spectrum: 1646, 3220, 3343, 3383 (NH_2), 2220 cm^{-1} (C≡N). PMR spectrum: 2.53 (3H, s, CH_3); 7.42 ppm (2H, br s, NH_2). Found, %: C 32.3; H 2.1; N 25.1; S 28.7. $C_5H_5N_4NaS_2$. Calculated, %: C 32.7; H 2.3; N 25.4; S 29.1.

B. A solution of sodium alkoxide (from 2.3 g (0.1 mole) sodium and 70 ml absolute ethanol) was treated successively with 4.2 g (0.1 mole) cyanamide and 20.4 g (0.1 mole) compound IV. The reaction mixture was refluxed for 1 h with stirring and maintained at −4°C for 24 h. The precipitate was filtered and washed with absolute ethanol and hexane. Yield 8.1 g (37%), mp > 350°. The material was identical in its IR spectrum to the pyrimidinethiolate prepared in method A.

TABLE 3. Characteristics of Compounds XIIa-d, XIIIa-c, XIV, XV

Compound	T_{mp}, °C	IR spectrum, absorption bands, cm^{-1}				PMR spectrum (DMSO-D_6) δ, ppm	Found, %				Molecular formula	Calc., %				Yield, %
		ν_{CO}	δ_{NH_2}	$\nu_{C\equiv N}$	ν_{NH_2}		C	H	N	S (Hal)		C	H	N	S (Hal)	
XIIa	208—209		1636	2218	3184, 3297	2,55 [s, $(CH_3)_2$]; 7,73 (s, NH_2)	39,5	3,7	26,3	30,4	$C_7H_8N_4S_2$	39,6	3,8	26,4	30,2	85
XIIb	161—162		1642	2216	3225, 3338	1,28 (t, CH_3C, J=7,5 Hz); 2,51 (s, SCH_3); 3,15 (q, CH_2, J=7,5 Hz); 7,65 (s, NH_2)	42,4	4,3	24,6	28,5	$C_8H_{10}N_4S_2$	42,5	4,5	24,8	28,23	88
XIIc	153—154	1712	1634	2211	3197, 3236, 3424	1,2 (t, CH_3C, J=7,2 Hz); 2,51 (s, SCH_3); 4,05 (q, CH_2, J=7,2Hz); 7,65 (s, NH_2)	41,8	3,9	19,8	22,6	$C_{10}H_{12}N_4O_2S_2$	42,2	4,3	19,7	22,6	94
XIId	229—230	1648	1629	2216	3184, 3298, 3376	2,48 (s, SCH_3); 3,83 (s, CH_2); 7,39 (d, $CONH_2$); 7,68 (s, NH_2)	37,4	3,3	27,7	26,7	$C_8H_9N_5OS_2$	37,6	3,6	27,4	25,1	98
XIIIa	179—180	1692	1625	2200	3224, 3318, 3422	2,53 (s, CH_3); 4,95 (s, CH_2); 7,54—7,68 and 8,05 (m, C_6H_5); 7,79 (s, NH_2)	52,9	3,6	17,9	20,1	$C_{14}H_{12}N_4OS_2$	53,2	3,8	17,7	20,3	92
XIIIb	195—196	1688	1631	2205	3231, 3324, 3417	2,51 (s, CH_3); 4,88 (s, CH_2); 7,58 and 8,03 (d.d, C_6H_4, J=7,8 Hz); 7,65 (s, NH_2)	47,6	3,0	15,8	18,4 (9,8)	$C_{14}H_{11}ClN_4OS_2$	47,9	3,2	16,0	18,3 (10,1)	93
XIIIc	200—202	1690	1627	2208	3230, 3342, 3411	2,50 (s, CH_3); 4,84 (s, CH_2); 7,69 and 7,91 (d.d C_6H_4, J=8,4 Hz); 7,76 (s, NH_2)	42,1	2,6	13,9	16,3 (19,9)	$C_{14}H_{11}BrN_4OS_2$	42,5	2,8	14,2	16,2 (20,2)	83
XIV	162—163		1656	2222	3173, 3345	2,6 (s, CH_3); 3,79 (d, CH_2S, J=7,0 Hz); 5,16 (d, *cis*-CH_2=C, J_{cis}=10 Hz); 5,30 (d, *trans*-CH_2=C, J_{trans}=17,5 Hz); 5,52 (br.s, NH_2); 5,95 (m, CH=C)	45,1	3,8	23,8	26,6	$C_9H_{10}N_4S_2$	45,4	4,2	23,5	26,9	69
XV	207		1644	2214	3115, 3298	1,65, 1,87, 2,0 [m, $(CH_2)_3$]; 2,51 (s CH_3); 4,48 (m, CH—S); 5,73 (m, =CH—C—C); 5,86 (m, =CH—C—S); 7,78 (s, NH_2)	51,4	4,8	20,4	23,2	$C_{12}H_{14}N_4S_2$	51,8	5,1	20,1	23,0	81

TABLE 4. Characteristics of Compounds XVIa-c, XVII, XVIII

Compound	T_{mp}, °C	IR spectrum, absorption bands, cm^{-1}			PMR spectrum (DMSO-D_6), δ, ppm	Found, %					Molecular formula	Calc., %					Yield, %
		δ_{NH_2} and $\nu_{C=O}$	$\nu_{C\equiv N}$	ν_{NH_2}		C	H	Hal	N	S		C	H	Hal	N	S	
XVIa	212—213	1615, 1638		3170, 3280, 3438	2,66 (s, CH_3); 7,31 (s, 3-NH_2); 7,43—7,69 (m, C_6H_5); 7,95 (s, 6-NH_2)	52,8	3,5		17,9	20,0	$C_{14}H_{12}N_4OS_2$	53,2	3,8		17,7	20,3	85 (85)*
XVIb	265—266	1612, 1635		3162, 3282, 3431	2,64 (s, CH_3); 7,31 (s, 3-NH_2); 7,5 and 7,69 (d.d C_6H_4, J=8,1 Hz); 7,96 (s, 6-NH_2)	49,6	3,1	9,7	16,2	18,6	$C_{14}H_{11}ClN_4OS_2$	49,9	3,2	10,1	16,0	18,3	86 (95)
XVIc	263—265	1616, 1634		3143, 3288, 3400	2,78 (s, CH_3); 7,47 (s, 3-NH_2); 7,54 and 7,73 (d.d, C_6H_4, J=7,8 Hz); 8,03 (s, 6-NH_2)	42,3	2,5	19,7	13,8	16,1	$C_{14}H_{11}BrN_4OS_2$	42,5	2,8	20,2	14,2	16,2	91 (94)
XVII	101—103 (dec.)	1650	2229	3080, 3165, 3360	2,63 (s CH_3); 3,41 (m, CH_2I); 3,72 and 3,93 (m, CH_2S); 5,40 (m, CH—N); 9,82 (br.s NH_2)	14,2	1,2	68,4	7,3	8,2	$C_9H_{10}I_4N_4S_2$	14,5	1,4	68,1	7,5	8,6	67
XVIII	141—142	1657	2236	3155, 3190, 3312	1,56, 1,97, 2,35 [m, $(CH_2)_3$]; 2,67 (s, CH_3); 4,72 (m, CHI и CHS); 5,76 (d.d, CHN, J_{trans}=10,5, J_{cis}=5,5 Hz); 9,80, 10,03 (br.d, NH_2)	18,1	1,6	64,9	6,8	7,8	$C_{12}H_{14}I_4N_4S_2$	18,3	1,8	64,6	7,1	8,2	84

*The yield according to method B is given in parentheses.

2-Amino-4-methylthio-5-cyano-6(1H)-pyrimidinethione (VI). A. The reaction mixture prepared as described for the synthesis of pyrimidinethiolate III according to method A was acidified with hydrochloric acid to pH 5 at 25°C. The precipitate was filtered and washed with ethanol and hexane. Yield 17 g (86%), mp 273-275° (dec., from nitromethane).

B. The reaction mixture prepared as described for the synthesis of pyrimidinethiolate III according to method B was acidified with hydrochloric acid to pH 5 at 25°C. Yield 9.2 g (42%); it was identical in its IR spectrum to compound III prepared according to A. IR spectrum: 1200 (C=S), 1635, 3200, 3240, 3298, 3390 (NH, NH_2), 2218 cm^{-1} (C≡N). PMR spectrum: 2.47 (3H, s, CH_3); 7.2 (2H, s, NH_2); 12.34 ppm (1H, br s, NH). Found, %: C 36.2; H 2.8; N 28.4; S 32.4. $C_6H_6N_4S_2$. Calculated, %: C 36.4; H 3.1; N 28.3; S 32.3.

Complex of Pyrimidinethione VI with Urea (VII). A mixture of 0.4 g (2 mmole) pyrimidinethione VI and 0.12 g (2 mmole) urea in 35 ml nitromethane was refluxed for 1 h. The hot solution was filtered. The resulting precipitate was removed, yield 0.48 g (93%); mp 205-208°C (dec., from nitromethane). IR spectrum: 1643, 3173, 3218, 3287, 3385 (NH, NH_2), 1694 (C=O), 2216 cm^{-1} (C≡N). Found, %: C 32.3; H 3.8; N 32.7; S 24.9. $C_6H_6N_4S_2 \cdot CH_4N_2$. Calculated, %: C 32.6; H 3.9; N 32.5; S 24.8.

6-Alkylthio-2-amino-4-methylthio-5-cyanopyrimidines (XII-XV). To a suspension of 10 mmole pyrimidinethione VI in 15-20 ml DMF was added 5.6 ml of 10% KOH in water and 10 mmole of the appropriate alkyl halide VIII-XI; the mixture was stirred for 20-30 min at 25°C. After dilution with 5-10 ml water the mixture was maintained at −4°C for 2-3 h, the precipitate was filtered, and washed with water and dried. Compounds XIV and XV were recrystallized from methanol, compounds XII and XIII from ethanol or benzene (Table 3).

3,6-Diamino-4-(methylthio)thieno[2,3-d]pyrimidines (XVIa-c). A. To a solution of 10 mmole compound XIc-e in 20 ml DMF at 25°C was added 5-6 ml 10% KOH in water solution. The reaction mixture was stirred 1 h, diluted with 10-15 ml water, and the precipitate was filtered and washed with ethanol and hexane. Recrystallized from butanol.

B. To a suspension of 10 mmole pyrimidinethione VI in 10 ml DMF at 25°C was added, with stirring, 5-6 ml 10% KOH solution, 10 mmole of the appropriate phenacyl bromide, and again 5-6 ml 10% KOH solution, successively. The reaction mixture was stirred for an additional 1 h to 1 h 30 min, diluted with 10-15 ml water, and the precipitate was isolated as described above for method A (Table 4).

Substituted Thiazolo[3,2-c]pyrimidinium Triiodides (XVII, XVIII). To a solution of 2 mmole compound XIV or XV in 5 ml dry chloroform was added dropwise with stirring a solution of 1 g (4 mmole) iodine in 15 ml dry chloroform over a 10 min period at 25°C. The reaction mixture was maintained at −4°C for 4 h, and the precipitate was filtered, washed with chloroform, and recrystallized from nitromethane (Table 4).

LITERATURE CITED

1. Yu. A. Sharanin, A. M. Shestopalov, V. P. Litvinov, G. V. Klokol, V. Yu. Mortikov, and A. S. Demerkov, Zh. Org. Khim., in press.
2. S. Rajappa and R. Sreenivasan, Indian J. Chem., 9, 761 (1971).
3. J. L. Soto, A. Loreute, N. Garcia, and L. Jose, An. Quim., C77, 255 (1981).
4. M. A. Perez, J. L. Soto, and J. R. Carrillo, Synthesis, No. 5, 402 (1983).
5. F. J. Cuadrado, M. A. Perez, and J. L. Soto, J. Chem. Soc., Perkin Trans. I, No. 10, 2447 (1984).
6. A. A. Krauze, É. É. Liepin'sh, Yu. É. Pelcher, Z. A. Kalme, I. V. Dipan, and G. Ya. Dubur, Khim. Geterotsikl. Soedin., No. 1, 95 (1985).
7. V. P. Litvinov, V. K. Promonenkov, Yu. A. Sharanin, A. M. Shestopalov, L. A. Rodinovskaya, V. Yu. Mortikov, and V. S. Bogdanov, Izv. Akad. Nauk SSSR, Ser. Khim., No. 9, 2101 (1985).
8. V. N. Nesterov, V. E. Shklover, Yu. T. Struchkov, Yu. A. Sharanin, A. M. Shestopalov, and L. A. Rodinovskaya, Acta Crystallogr., C41, 1191 (1985).
9. International Tables for X-Ray Crystallography, Kynoch Press, Birmingham (1968), Vol. 3, p. 276.
10. M. Burke-Laing and M. Laing, Acta Crystallogr., B32, 3216 (1976).
11. A. I. Kitaigorodsky, Molecular Crystals and Molecules, Academic Press, New York (1973), p. 431.
12. S. Furberg, J. Grogaard, and B. Smedsrud, Acta Chem. Scand., B33, 715 (1979).

13. J. Scheinbein and E. Schempp, Acta Crystallogr., B32, 607 (1976).
14. H. W. Kroto and B. M. Landsberg, J. Mol. Spectrosc., 62, 346 (1976).
15. M. Gadret, M. Goursolle, and J. M. Leger, Acta Crystallogr., B30, 1598 (1974).
16. Gy. Argay, A. Kàlmàn, A. Nahlovski, and B. Ribàr, Acta Crystallogr., B31, 1956 (1975).
17. G. Pepe and M. Pierrot, Acta Crystallogr., B32, 1321 (1976).
18. D. Mullen and E. Hellner, Acta Crystallogr., B34, 1624 (1978).
19. A. Bondi, J. Phys. Chem., 70, 3006 (1966).
20. N. Walker and D. Stuart, Acta Crystallogr., A39, 158 (1983).
21. R. G. Gerr, A. I. Yanovskii, and Yu. T. Struchkov, Kristallografiya, 28, 1029 (1983).

REACTIONS OF AZINIUM CATIONS.

7.* ^{13}C NMR SPECTRA AND ELECTRON STRUCTURE OF NEUTRAL σ-ADDUCTS OF 1,4-DIAZINIUM CATIONS AND METHYLATE ANION

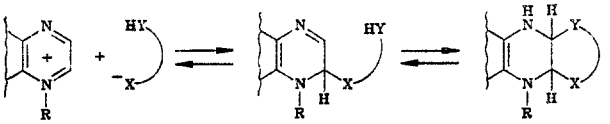
O. N. Chupakhin, V. N. Charushin, I. V. Kazantseva, M. G. Ponizovskii, E. O. Sidorov, P. A. Torgashev, and A. V. Belik

UDC 543.422.25: 547.859'861'863.1

The ^{13}C NMR spectra have been recorded of a number of σ-adducts formed by pyrazinium, quinoxalinium, and pteridinium cations with methylate anion. The experimental data were compared with CNDO/2 calculations of adduct electron structure.

The important role of σ-adducts in the reactions of aromatic and heteroaromatic compounds with nucleophiles has been responsible for the increased attention that has been paid lately to these primary intermediates of nucleophilic aromatic substitution [2-7], ring closure [8, 9], cyclization [8-10], and other conversions. Reviews have been devoted to the structure, stability, and ease of formation of the anionic σ-adducts of azines [2-6]; substantially less attention has been paid to the neutral σ-adducts formed by cationic substrates of the azine series [7, 10, 11].

In a series of papers we have reported on the reactions of 1,4-diazinium cations (I) with bifunctional nucleophiles that give cyclic products (III) in which a tetrahydropyrazine ring is joined to five- and six-membered heterocycles (see reviews [10, 12, 13]).



I II III

The neutral σ-adduct II is considered the probable intermediate; this is the product of the monoaddition of a nucleophile that, however, cannot be recorded under ordinary conditions because of the rapid cyclization II → III. Such an adduct can be observed when substituents are introduced that sensitize the pyrazine system to nucleophilic attack, but only to the extent of monoaddition but not diaddition. Thus, 4-morpholino-8-ethylpteridinium salts react with anions of β-dicarbonyl compounds (acetylacetone, acetoacetic ester) to form products of addition at $C_{(7)}$ that are stable at 20°C [14]. Adducts of similar composition with 1,2-dihydropyrazine structure have been recorded in the reaction of quinoxalinium salts with β-dicarbonyl compounds, but only at lower temperatures (from −40 to −30°C) [15]. Evidently,

*For Communication 6, see [1].

S. M. Kirov Ural Polytechnic Institute, Sverdlovsk 620002; Chelyabinsk State University, Chelyabinsk 454136. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 10, pp. 1385-1391, October, 1987. Original article submitted June 18, 1986.

 0009-3122/87/2310-1112 $12.50