
**SHORT
COMMUNICATIONS**

Synthesis and Structure of Some Imidazolidine-2-thiones

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Received September 9, 2005

DOI: 10.1134/S1070428006030183

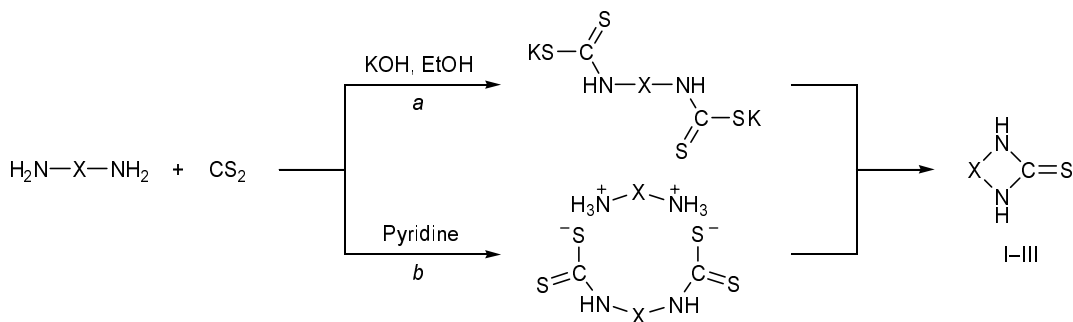
In the recent years much attention was given to the synthesis of fused nitrogen-, sulfur-, and oxygen-containing heterocycles which constitute pharmacophoric fragments of known medical agents or natural biologically active organic compounds [1]. Imidazolidine-2-thiones may be regarded as cyclic analogs of thiourea; interest in these compounds originates from not only their valuable properties but also dual reactivity: depending on the reaction conditions, they could give rise to derivatives of both thione and thiol forms.

With a view to examine the reactivity of heterocyclic compounds related to imidazolidine-2-thiones [2] we synthesized cyclic thioureas **I–III** from some primary diamines according to Scheme 1. The synthesis of compounds **I–III** was performed without isolation of dipotassium bis-dithiocarbamates (method *a*) or diammonium bis-dithiocarbamates (method *b*) formed as primary products of the reaction of diamines with carbon disulfide. For this purpose, the reaction mixture was treated with glacial acetic acid. In both cases, the yield of thioureas **I–III** was 75–95%.

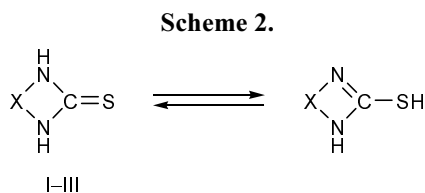
Compounds **I–III** are readily soluble in alkaline solutions and polar organic solvents; cyclic thioureas **I** and **II** are soluble in water. Compounds **I** and **II** were isolated as colorless needle-shaped crystals, and compound **III** was a readily electrifiable yellowish powder. Imidazolidine-2-thiones **I–III** possess a thioureide fragment, and they can exist as thione and thiol tautomers as shown in Scheme 2. Tautomeric equilibrium is usually observed in solution. However, the existence of different tautomers in the crystalline state cannot be ruled out.

The IR spectra of crystalline samples of **I–III** contain absorption bands typical of stretching vibrations of N–H (3500–3100 cm⁻¹), C–H (936–890 cm⁻¹), and C=S bonds (1500–1460 cm⁻¹); the latter band is fairly strong and is characteristic of a thioureide moiety. In the IR spectra of solutions of **I–III** in carbon tetrachloride, apart from the above bands, we observed weak bands which may be assigned to stretching vibrations of S–H (2600–2550 cm⁻¹), C=N (1690–1640 cm⁻¹), and C–S bonds (700–600 cm⁻¹). The

Scheme 1.



I, X = CH₂CH₂; **II**, X = CH(Me)CH(Me); **III**, X = 1,2-C₆H₄.



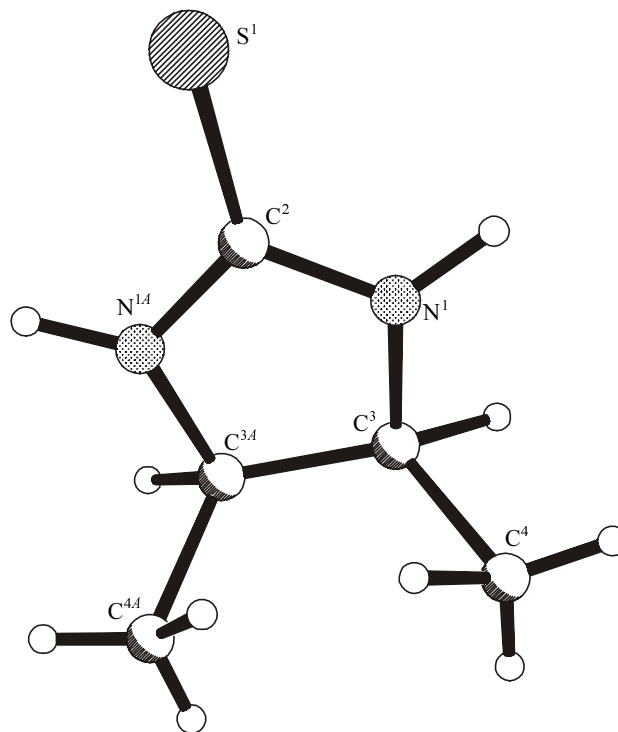
presence of a sulfanyl group in molecules **I–III** is also confirmed by the ^1H NMR spectra recorded in D_2O which contained a singlet in the δ region 3.06–3.13 ppm.

The structure of compounds **I–III** was finally proved by X-ray analysis of 4,5-dimethylimidazolidine-2-thione (**II**). The structure of molecule **II** is shown in figure, and its principal geometric parameters and coordinates of atoms are listed in Tables 1 and 2. The bond lengths and bond and torsion angles in molecule **II** approach the corresponding standard values [3], except for the $\text{C}^2\text{–N}^1$ and $\text{C}^2\text{–N}^{1A}$ bonds. Presumably, these bonds are shortened due to π conjugation between lone electron pairs on the nitrogen atoms and the $\text{S}^1\text{=C}^2$ double bond. The five-membered ring $\text{C}^2\text{N}^1\text{C}^3\text{C}^{3A}\text{N}^{1A}$ is planar within $\pm 0.0185 \text{ \AA}$. The methyl groups in positions 4 and 5 occupy axial positions.

Thus, the IR and ^1H NMR spectra and X-ray diffraction data indicated that compounds **I–III** in crystal have thione structure and that tautomeric equilibrium between the thione and thiol tautomers is possible in solution.

General procedure for the synthesis of compounds I–III. *a.* A mixture of 0.04 mol of ethane-1,2-diamine, butane-2,3-diamine, or benzene-1,2-diamine, 4.48 g (0.08 mol) of carbon disulfide, and 4.2 g (0.08 mol) of potassium hydroxide in 65 ml of ethanol was heated on a water bath for 3–4 h under reflux. Glacial acetic acid, 7.2 g (0.12 mol), was added, and the solution was evaporated to dryness under reduced pressure. The residue was treated with 200 ml of boiling 2.5% aqueous sodium hydroxide containing a few drops of aqueous sodium hydrogen sulfite. The solution was cooled and adjusted to a weakly acidic reaction by adding concentrated hydrochloric acid. The precipitate was filtered off and recrystallized from alcohol.

b. A mixture of 0.01 mol of the corresponding diamine and 2.8 g (0.05 mol) of carbon disulfide in pyridine was heated for 5 h on a water bath. The mixture was poured into water and acidified with glacial acetic acid. The precipitate was filtered off and recrystallized from alcohol.



Structure of the molecule of 4,5-dimethylimidazolidine-2-thione (**II**) according to the X-ray diffraction data.

Imidazolidine-2-thione (I). Yield 3.8 g (93%) (*a*), 0.8 g (80%) (*b*), mp 198–200°C. IR spectrum, ν , cm^{-1} : 1460 (C=S), 936 (NH–C). ^1H NMR spectrum (D_2O), δ , ppm: 4.60 m (1H, NH), 3.06 s (1H, SH), 3.70 m (4H, CH_2). Found, %: C 35.31; H 5.85; N 27.47. $\text{C}_3\text{H}_6\text{N}_2\text{S}$. Calculated, %: C 35.29; H 5.88; N 27.45.

Table 1. Bond lengths (d , Å) and bond (ω , deg) and torsion angles (φ , deg) in the molecule of 4,5-dimethylimidazolidine-2-thione (**II**)

Bond	d , Å	Bond	d , Å
$\text{S}^1\text{–C}^2$	1.692(4)	$\text{C}^2\text{–N}^{1A}$	1.308(3)
$\text{N}^1\text{–C}^2$	1.308(3)	$\text{C}^3\text{–C}^4$	1.504(5)
$\text{N}^1\text{–C}^3$	1.473(4)	$\text{C}^3\text{–C}^{3A}$	1.509(6)
Bond angle	ω , deg	Bond angle	ω , deg
$\text{C}^2\text{N}^1\text{C}^3$	113.6(3)	$\text{N}^1\text{C}^3\text{C}^4$	109.5(3)
$\text{N}^1\text{C}^2\text{N}^{1A}$	108.5(3)	$\text{N}^1\text{C}^3\text{C}^{3A}$	102.03(16)
$\text{N}^1\text{C}^2\text{S}^1$	125.76(17)	$\text{C}^4\text{C}^3\text{C}^{3A}$	119.6(3)
$\text{N}^{1A}\text{C}^2\text{S}^1$	125.76(17)		
Torsion angle	φ , deg	Torsion angle	φ , deg
$\text{C}^3\text{N}^1\text{C}^2\text{N}^{1A}$	5.6(5)	$\text{C}^2\text{N}^1\text{C}^3\text{C}^{3A}$	–3.3(3)
$\text{C}^3\text{N}^1\text{C}^2\text{S}^1$	–175.2(3)	$\text{C}^3\text{N}^1\text{C}^2\text{N}^{1A}$	5.6(5)
$\text{C}^2\text{N}^1\text{C}^3\text{C}^4$	–131.0(4)		

Table 2. Coordinates of atoms (in cell fractions, $\times 10^4$, $\times 10^3$ for hydrogen atoms) in the molecule of 4,5-dimethylimidazolidine-2-thione (**II**)

Atom	<i>x</i>	<i>y</i>	<i>z</i>
S ¹	54(1)	75	-437(5)
N ¹	-145(2)	6262(3)	-351(4)
C ²	-829(3)	75	-343(6)
C ³	-256(2)	662(4)	-109(3)
C ⁴	-3645(4)	5755(7)	-254(4)
HC ^{4a}	-437(5)	591(7)	-142(7)
HC ^{4b}	-351(4)	47(6)	-97(5)
HC ^{4c}	-343(6)	65(7)	6(8)
HN ¹	-109(3)	524(4)	-61(4)
HC ³	-254(4)	567(7)	-276(8)

4,5-Dimethylimidazolidine-2-thione (II). Yield 4.6 g (89%) (*a*), 0.7 g (75%) (*b*), mp 193–195°C. IR spectrum, ν , cm^{-1} : 1480 (C=S), 890 (NH–C). ¹H NMR spectrum (D₂O), δ , ppm: 4.62 m (1H, NH), 3.10 s (1H, SH), 2.70 m (2H, CH), 1.10 d (6H, CH₃). Found, %: C 46.17; H 7.66; N 21.58. C₅H₁₀N₂S. Calculated, %: C 46.15; H 7.69; N 21.54.

Benzimidazolidine-2-thione (III). Yield 5.7 g (95%) (*a*), 1.4 g (93%) (*b*), mp 303–305°C. IR spectrum, ν , cm^{-1} : 1500 (C=S), 900 (NH–C). ¹H NMR spectrum (D₂O), δ , ppm: 4.60 m (1H, NH), 3.13 s (1H, SH), 7.10 m (4H, C₆H₄). Found, %: C 55.98; H 4.01; N 18.65. C₇H₆N₂S. Calculated, %: C 56.00; H 4.00; N 18.67.

The IR spectra were recorded in mineral oil, KBr, or CC1₄ on a AVATAR-320 spectrometer. The ¹H NMR spectra were measured from solutions in D₂O on a DRX500 H1 spectrometer (500 MHz).

X-Ray analysis of compound II. The unit cell parameters and intensities of 689 independent reflections were measured on a Bruker P4 diffractometer (MoK α irradiation, graphite monochromator, $\theta/2\theta$ scanning, $2\theta \leq 52^\circ$). Orthorhombic crystals: $a = 10.8565(10)$, $b = 8.5746(9)$, $c = 7.8680(10)$ Å; $\alpha = \beta = \gamma = 90^\circ$; $V = 732.43(14)$ Å³; $d_{\text{calc}} = 1.181$ g/cm³; $Z = 4$; C₅H₁₀N₂S; space group *Pnma*. The structure was solved by the direct method and was refined by the full-matrix least-squares procedure in anisotropic approximation for non-hydrogen atoms. The positions of hydrogen atoms were determined from the difference synthesis and were refined in anisotropic approximation. In the calculations, 689 reflections with $I > 2\sigma(I)$ were used; the final divergence factors were $R = 0.480$ and $wR_2 = 0.1306$. The calculations were performed using SHELXS-97 and SHELXL-97 programs.

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