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Letters to the Editor

Synthesis of 1,3-thiazetidin-2-imines from 3*H*-1,2-dithiol-3-imines

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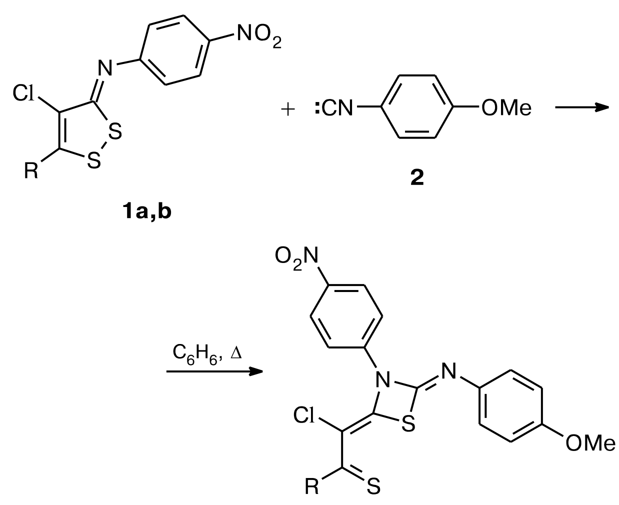
Earlier,[1,2] we have shown that the reaction of 3*H*-1,2-dithiole-3-thiones with isonitriles at room temperature leads to imino-1,3-dithietanes. The reaction was found to be reversible, and at elevated temperatures the equilibrium favors starting compounds.[2] At the same time, 3*H*-1,2-dithiol-3-ones in the reaction with these reactants unexpectedly are converted to 2-iminothiophen-3(2*H*)-ones.[3] This fact can be explained by addition of the isonitrile molecule to the 1,2-dithiole ring with the formation of 1,3-oxothietane, which easily loses the isothiocyanate molecule, that afterwards leads to the final thiophenone. In continuation of our research on reactions of 1,2-dithioles with isonitriles, we studied a reaction of 3*H*-1,2-dithiol-3-imines **1** with isonitriles **2**. Before we started our work, it was impossible to predict whether the reaction would stop in the stage of formation of 1,3-thiazetidin-2-imines **3** or the compounds formed would undergo further transformations.

We studied a reaction of *N*-[(3*Z*)-3*H*-1,2-dithiol-3-ylidene]anilines **1** containing an electron-donating (methyl) or electron-withdrawing (nitro) groups on the aromatic ring. Arylimines **1** containing a nitro group on the aromatic ring have proved reactive. We for the first time have shown that 1,2-dithiol-3-imines **1** react with 4-methoxyphenylisocyanide **2** upon reflux in benzene for 18—20 h to form 1,3-thiazetidines **3** in moderate yields (Scheme 1).

Scheme 1



3a (43%), **3b** (47%)

R = Cl (**a**), PhO (**b**)

The structure of the unreported in the literature 1,3-thiazetidin-2-imines **3** was confirmed by elemental analysis, ^{1}H and ^{13}C NMR spectroscopy, IR spectroscopy, and mass spectrometry. Thus, the elemental analysis data correspond to the 1 : 1 addition product of isonitrile **2**

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to dithiolimine **1**. We suppose that the addition proceeds similarly to the reaction with 1,2-dithiole-3-thiones[2] to form a four-membered ring, in this case thiazetidine one. The ^{1}H and ^{13}C NMR spectroscopic data are consistent with such a structure, and a signal in the region δ 200 characteristic of the fragment C=S is observed in the ^{13}C NMR spectrum. At the same time, no absorption bands characteristic of an isonitrile group (2150—2110 cm^{-1}) are found in the IR spectrum.[4]

Elevation of the reaction temperature (reflux in toluene or xylene) causes decomposition of thiazetidines, and isolation of individual compounds from the reaction mixtures becomes impossible. Less reactive aromatic isonitriles containing no donor substituents on the benzene ring (phenylisocyanide and its 4-nitro derivative) or containing nonaromatic substituents at the isonitrile group (CH_2Tos, CH_2CO_2Et, and Bn) do not react with 1,2-dithiol-3-imines **1** neither at room temperature, nor upon reflux in benzene; the starting compounds were recovered from the reaction mixture almost quantitatively.

Only several methods are described in the literature concerning synthesis of such 4-ylidene-1,3-thiazetidin-2-imines, they use poorly available starting compounds such as ketene imines,[5] thioketenes,[6] and dimethyl dithiono oxalate.[7] The known method are successfully complemented by the approach suggested by us.

^{1}H and ^{13}C NMR spectra ($CDCl_3$) were recorded on a Bruker AM-300 spectrometer, using signals for the residual protons of the solvent as a reference. Melting points were determined on a Kofler heating stage and were not corrected. Mass spectra were recorded on a Finnigan MAT INCOS 50 instrument (EI), IR spectra were recorded on a Specord M80-2 spectrometer in KBr pellets. Reaction mixtures were monitored by TLC on Sorbfil plates, using UV light and iodine vapors for visualization.

Synthesis of 1,3-thiazetidines 3 (general procedure). A mixture of 1,3-dithiol-3-imines **1a,b** (1 mmol) and isonitrile **2** (1 mmol) in benzene (10 mL) was refluxed with stirring until either 1,2-dithiol-3-imine or isonitrile disappeared (TLC monitoring). The reaction mixture was concentrated and subjected to chromatography on a column with silica gel (Silicagel Merck 60, eluent light petroleum—CH_2Cl_2).

(2*E*)-Chloro[(4*Z*)-4-[(4-methoxyphenyl)imino]-3-(4-nitrophenyl)-1,3-thiazetidin-2-ylidene]ethanethioyl chloride (3a). The yield was 43%, brown crystals, m.p. 179—180 °C, R_f 0.38 (CH_2Cl_2—light petroleum (2 : 1)). ^{1}H NMR (300 MHz, $CDCl_3$), δ: 3.80 (s, 3 H, OMe); 6.65—7.03 (m, 6 H, Ar); 8.21 (d, 2 H, Ar, J = 9.2 Hz). ^{13}C NMR (75 MHz, $CDCl_3$), δ: 55.6 (OMe); 114.9, 117.8, 124.0, 124.9 (8 CH); 121.9, 138.8, 141.4, 143.6, 153.2, 157.3, 160.3 (7 C (sp^2)); 201.6 (C=S). MS (EI, 70 eV), m/z ($I_{\rm rel}$ (%)): 310 [M + 4-CNC_6H_4OMe]$^+$ (12), 308 [M + 2-CNC_6H_4OMe]$^+$ (62), 306 [M – CNC_6H_4OMe]$^+$ (100), 133 [CNC_6H_4OMe]$^+$ (4). IR, ν/cm^{-1}: 3069, 2934, 2842 (CH); 1586; 1564; 1533 (C=N); 1501; 1344; 1261; 1160 (C=S); 1108; 1028; 963; 834; 752. Found (%): C, 46.51; H, 2.60; Cl, 16.15; N, 9.49; S, 14.47. $C_{17}H_{11}Cl_2N_3O_3S_2$. Calculated (%): C, 46.37; H, 2.52; Cl, 16.10; N, 9.54; S, 14.56.

***O*-Phenyl (2*E*)-chloro[(4*Z*)-4-[(4-methoxyphenyl)imino]-3-(4-nitrophenyl)-1,3-thiazetidin-2-ylidene]ethanethioate (3b).** The yield was 47%, yellow crystals, m.p. 133—134 °C, R_f 0.77 (CH_2Cl_2). ^{1}H NMR (300 MHz $CDCl_3$), δ: 3.80 (s, 3 H, Me); 6.89, 7.03, 7.63, 8.35 (all d, 2 H each, 2 C_6H_4, J = 8.8 Hz); 7.06—7.12 (m, 2 H, Ph); 7.28—7.37 (m, 1 H, Ph); 7.41—7.49 (m, 2 H, Ph). ^{13}C NMR (75 MHz, $CDCl_3$), δ: 55.6 (OMe); 114.9, 122.2, 123.2, 124.1, 127.7, 129.8 (12 CH, Ar); 126.9 (CH, Ph); 102.2, 136.8, 139.6, 146.9, 149.0, 153.9, 154.3, 158.2 (8 C (sp^2)); 200.7 (C=S). MS (EI, 70 eV), m/z ($I_{\rm rel}$ (%)): 364 [M + 2-CNC_6H_4OMe]$^+$ (4), 364 [M – CNC_6H_4OMe]$^+$ (11), 223 (72), 133 [CNC_6H_4OMe]$^+$ (84), 77 [Ph]$^+$ (100). IR, ν/cm^{-1}: 3036, 2920, 2836 (CH); 1700; 1604; 1580 (C=N); 1520; 1504; 1488; 1344; 1260; 1252; 1228 (C=S); 1080; 932; 824; 748; 684. Found (%): C, 55.59; H, 3.48; Cl, 7.23; N, 8.16; S, 12.73. $C_{23}H_{16}ClN_3O_4S_2$. Calculated (%): C, 55.47; H, 3.24; Cl, 7.12; N, 8.44; S, 12.88.

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