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Synthesis and structure of novel dithioderivatives of 3-pyrrolin-2-one

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Abstract

Unsaturated γ-lactams (3-pyrrolin-2-ones) are an important class of five-membered nitrogen-containing heterocycles that play a significant role as structural motifs in numerous natural products and synthesized compounds with a wide range of biological activities. These motifs are also successfully used as intermediates in organic transformations and allow access to more diverse compounds and previously inaccessible structures. In this work, method for the synthesis of two types of novel heterocyclic compounds containing an unsaturated γ-lactam ring and two sulfur atoms was developed. Reactive and easily available substrates of 5-methoxy-2(5*H*)-furanone series were involved into the reactions with ammonia and benzylamine and converted into the corresponding dithioderivatives of 5-hydroxy-3-pyrrolin-2-one, difficult to access by other methods. The molecular and crystal structures of four novel sulfur-containing compounds were characterized by single-crystal X-ray diffraction. These heterocyclic systems are promising candidates for further functionalization and biological screening.

Key findings

- Novel dithioderivatives of 3-pyrrolin-2-one were obtained from the reactions of the corresponding 5-methoxy-2(5*H*)-furanones with ammonia or benzylamine.
- Molecular and crystal structure of novel heterocycles, containing γ-lactam ring and two sulfur atoms was characterized by single crystal X-ray diffraction.
- 5-Alkoxyfuranone based method is attractive for the synthesis of different heterocycles, possessing lactam ring, difficult to access by other methods.

Accompanying information

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Supplementary information
Supplementary materials: READ
Transparent peer review: READ

Sustainable Development Goals
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1. Introduction

Nitrogen-containing heterocyclic compounds have garnered considerable attention due to their abundance in nature, great medical and biological importance and numerous applications in various fields ranging from medicinal chemistry to material science [1,2]. α,β-Unsaturated γ-lactams (1,5-dihydro-2*H*-pyrrol-2-ones, also referred to as 3-pyrrolin-2-ones) have occupied a prominent place among five-membered *N*-heterocycles by virtue of their diverse medicinal values [3–5]. Derivatives of 3-pyrrolin-2-one exhibit an impressive repertoire of biological activities, including antimicrobial, anti-inflammatory, antitumor, analgesic, antiviral, nootropic, antiaggregant, and many others. In addition, 3-pyrrolin-2-one functional derivatives are widely used as versatile scaffolds for organic synthesis and development of novel biologically active compounds [6].

To date, a number of methods have been proposed for the synthesis of pyrrolinones using different precursors,

such as acetylene, allene, ketene, pyrrole, furanone, azirine, azetine, aldehyde and keto acids, amino alcohols, amides, imides, enamines, and imines [4,7–9]. In this series, reactions of various 2(5*H*)-furanone derivatives with nitrogen-containing nucleophiles provide a simple, convenient and versatile way to obtain structurally similar 3-pyrrolin-2-ones [7,10–12]. The formation of lactam ring in these reactions is achieved under mild conditions, and a broad range of amino compounds can be involved as reactants into the interaction with furanones, namely, ammonia, primary aliphatic and alicyclic amines, amino alcohols, amino acids, alkylarylamines, and hetarylamines.

In our recent studies, we applied a facile approach for the synthesis of 1-benzyl and 1-(4-methylbenzyl) derivatives of 3-chloro- and 3-bromo-5-hydroxy-1,5-dihydro-2*H*-pyrrol-2-ones, possessing arylsulfanyl [13–17] or 4-phenyl-1,2,3-triazolyl [18] group in the fourth position of the lactam ring, based on the interaction of the corresponding 4-substituted 5-methoxy-2(5*H*)-furanones with benzyl-type amines. Thioethers of *N*-substituted 5-hydroxy-3-pyrrolin-2-ones have shown the ability to form a wide range of stereochemically different phases during crystallization, including examples of spontaneous resolution of enantiomers [14,15,17,18]. The available literature on the synthesis and properties of pyrrolinone thioethers [19–23] and sulfur heterocycles, containing γ-lactame ring [24,25] remains scan.

In this work, we aimed to expand on furanone based approach to obtain novel sulfur-containing derivatives of 3-pyrrolin-2-one, possessing two sulfur atoms. Here, we show that reactive and easily available starting materials of 5-methoxy-2(5*H*)-furanone series can be successfully converted by the treatment with ammonia or benzylamine into the corresponding derivatives of 5-hydroxy-3-pyrrolin-2-one, difficult to access by other methods.

2. Experimental

2.1. General

Benzylamine and 1,2-ethanedithiol (all Aldrich) were used as received without further purification. All solvents were purified and distilled by standard procedures. IR spectra were recorded on a Bruker Vertex 70 FTIR spectrometer fitted with a Pike MIRacle ATR accessory. NMR spectra were measured on a Bruker Avance III 400 spectrometer at 400.17 MHz (^{1}H) and 100.62 MHz (^{13}C) at 20 °C, Bruker Avance III HD 700 spectrometer at 700.13 MHz (^{1}H) and 176.06 MHz (^{13}C) at 25 °C in acetone-d_6. The chemical shifts (δ) are expressed in parts per million (ppm) and are calibrated using residual undeuterated solvent peak as an internal reference (acetone-d_6: δ_H 2.05; δ_C 29.8). Analytical thin layer chromatography (TLC) was carried out on Sorbfil PTLC-AF-A-UF plates using UV light (254 nm) as the visualizing agent. The melting points were measured on a Boetius hot stage and were not corrected.

2.2. X-ray structure determinations

Single crystal X-ray diffraction analysis was performed on a Bruker Kappa Apex automatic four-circle diffractometer at a temperature of 296(2) K: graphite monochromator, λ[Mo Kα] = 0.71073 Å, ω/ϕ scanning mode with a step of 0.5°. Data collection and indexing, determination, and refinement of unit cell parameters for crystals were carried out using the *APEX3* software package. Spherical absorption correction was performed using the *SADABS* software [26]. Using *OLEX2* [27], structures were solved by direct methods using the *SHELXT* program [28] and refined by full-matrix least-squares on *F2* using the *SHELXL* program [29]. Non-hydrogen atoms were refined anisotropically. Positions of H(N/O) hydrogen atoms were determined from difference electron density maps and refined isotropically. The remaining hydrogen atoms were refined using a riding model. Figures and analysis of intermolecular interactions were performed using *MERCURY* [30] and *PLATON* [31] programs. The crystal data, data collection, and structure refinement details are summarized in Table S1.

The crystallographic data for the structures **6**–**9** have been deposited in the Cambridge Crystallographic Data Centre and are freely available on request on the website www.ccdc.cam.ac.uk/data_request/cif. X-Ray diffraction data were obtained in the Collective Spectro-Analytical Center of FRC Kazan Scientific Center of RAS.

2.3. Chemical Synthesis

7-Hydroxy-2,3-dihydro[1,4]dithiino[2,3-*c*]furan-5(7*H*)-one (**2**) [32], 7-methoxy-2,3-dihydro[1,4]dithiino[2,3-c]furan-5(7*H*)-one (**3**) [33], 3,4-dichloro-5-methoxy-2(5*H*)-furanone (**4**) [34] and 4,4'-(ethane-1,2-diyldisulfanediyl)*bis*(3-chloro-5-methoxyfuran-2(5*H*)-one) (**5**) [32] were synthesized according to the knowns methods.

2.3.1. 7-Hydroxy-2,3,6,7-tetrahydro-5*H*-[1,4]dithiino[2,3-c]pyrrol-5-one (6)

Cooled aqueous ammonia solution (25%, 3 mL, 40 mmol) and a 1:2 mixture of ethanol and diethyl ether (3 mL) were added to a compound **3** (0.25 g, 1.2 mmol). The reaction mixture was stirred at −13 ÷ −10 °C for 24 h (monitored by TLC). A precipitate formed during the reaction was filtered off, washed with ether and recrystallized from ethanol to afford heterocycle **6** as colorless solid. Yield 91% (0.21 g), m.p. 162–163 °C. R_f 0.11 (acetone-toluene, 1:2). IR, ν, cm^{-1}: 3000–3500 (OH, NH), 1662 (C=O), 1568 (C=C). ^{1}H NMR (acetone-d_6, 400 MHz, ppm): δ 3.12–3.40 (m, 4H, SCH_2), 5.27 (d, 1H, OH_B, $^3J_{AB}$ = 9.8 Hz, $^4J_{BX}$ = 0.0 Hz), 5.45 (dd, 1H, C(7)H_A, $^3J_{AB}$ = 9.8 Hz, $^3J_{AX}$ = 1.6 Hz), 7.57 (br s, 1H, NH_x). ^{13}C{^{1}H} NMR (acetone-d_6, 100 MHz, ppm): δ 25.9, 27.4 (SCH_2), 82.0 (C(7)), 121.9 (C(4a)), 144.4 (C(7a)), 168.5 (C(5)). Found (%): C, 38.18; H, 3.85; N, 7.27; S, 34.04. $C_6H_7NO_2S_2$. Calculated (%): C, 38.08; H, 3.73; N, 7.40, S, 33.89.

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2.3.2. 6-Benzyl-7-hydroxy-2,3,6,7-tetrahydro-5*H*-[1,4]dithiino[2,3-c]pyrrol-5-one (7)

A solution of benzylamine (0.33 mL, 3.0 mmol) in diethyl ether (10 mL) was added dropwise to a stirred mixture of compound **3** (0.41 g, 2.0 mmol) and ether (10 mL). The reaction mixture was refluxed for 26 h. After cooling to room temperature, the precipitate was filtered off, washed with ether and recrystallized from a mixture of benzene and tetrachloromethane (10:1) to give heterocycle **7** as colorless solid. Yield 71% (0.40 g), m.p. 166–167 °C. R_f 0.31 (acetone-toluene, 1:4). IR, ν, cm^{-1}: 3000–3500 br (OH), 1656 (C=O), 1580 (C=C$_{lact}$), 1498 (C=C$_{arom}$). ^{1}H NMR (acetone-d_6, 400 MHz, ppm): δ 3.21–3.28 (m, 2H, SCH_2), 3.28–3.36 (m, 2H, SCH_2), 4.29, 4.84 (both m, 1H each, AB quadruplet, CH_2N, $^2J_{HH}$ = –15.2 Hz), 5.18 (d, 1H, C(7)H, ^3J = 9.9 Hz), 5.55 (d, 1H, OH, ^3J = 9.9 Hz), 7.17–7.41 (m, 5H, H$_{arom}$). ^{13}C{^{1}H} NMR (acetone-d_6, 100 MHz, ppm): δ 26.1, 27.5 (SCH_2); 43.3 (CH_2N); 84.0 (C(7)); 122.0 (C(4a)); 128.1, 128.9, 129.4, 138.9 (C$_{arom}$); 142.6 (C(7a)); 166.2 (C(5)). Found (%): C, 55.81; H, 4.62; N, 5.08; S, 22.93. $C_{13}H_{13}NO_2S_2$. Calculated (%): C, 55.89; H, 4.69; N, 5.01, S, 22.95.

2.3.3. 4,4'-(Ethane-1,2-diyldisulfanediyl)*bis*(3-chloro-5-hydroxy-1,5-dihydro-2*H*-pyrrol-2-one) (8)

Cooled aqueous ammonia solution (25%, 6 mL, 80 mmol) and a 1:2 mixture of ethanol and diethyl ether (3 mL) were added to a compound **5** (0.39 g, 1.0 mmol). The reaction mixture was stirred at –13 ÷ –10 °C for 24 h (monitored by TLC). At first a precipitate of *meso* isomer **8a** was formed during the reaction, which was filtered off, washed with acetone and dried. Evaporation of the mother liquor to about half-volume, and cooling for 24 h, gave a mixture of two diastereomers **8**. The total yield 73% (0.27 g).

Mixture of diastereomers 8. Colorless solid. Yield 30% (0.11 g), m.p. 158 °C (decomp.). IR, ν, cm^{-1}: 3000–3500 br (OH, NH), 1694 (C=O), 1592, 1578 (C=C$_{lact}$). ^{1}H NMR (acetone-d_6, 700 MHz, ppm): δ 3.48–3.72 (m, 8H, SCH_2), 5.71 (dd, 2H, OH$_B$, $^3J_{AB}$ = 10.1 Hz, $^4J_{BX}$ = 1.3 Hz), 5.73 (dd, 2H, OH$_B$, $^3J_{AB}$ = 9.5 Hz, $^4J_{BX}$ = 1.4 Hz), 5.84 (dd, 2H, C(5)H$_A$, $^3J_{AB}$ =10.1 Hz, $^3J_{AX}$ = 1.8 Hz), 5.85 (dd, 2H, C(5)H$_A$, $^3J_{AB}$ = 9.5 Hz, $^3J_{AX}$ = 1.7 Hz), 7.92 (br s, 4H, NH$_X$). ^{13}C{^{1}H} NMR (acetone-d_6, 176 MHz, ppm): δ 31.52 (SCH_2); 79.98, 80.04 (C(5)); 122.69, 122.81 (C(3)); 151.86, 151.92 (C(4)); 165.19, 165.24 (C(2)).

Meso-isomer 8a. Colorless solid. Yield 43% (0.16 g), m.p. 159 °C (decomp.). IR, ν, cm^{-1}: 3000–3500 br (OH, NH), 1695 (C=O), 1594 (C=C$_{lact}$). ^{1}H NMR (acetone-d_6, 700 MHz, ppm): δ 3.47–3.71 (m, 4H, SCH_2), 5.71 (d, 2H, OH$_B$, $^3J_{AB}$ = 10.0 Hz), 5.84 (d, 2H, C(5)H$_A$, $^3J_{AB}$ =10.0 Hz), 7.92 (br s, 2H, NH$_X$). ^{13}C{^{1}H} NMR (acetone-d_6, 176 MHz, ppm): δ 31.5 (SCH_2), 80.0 (C(5)), 122.8 (C(3)), 151.9 (C(4)), 165.2 (C(2)). Found (%): C, 33.54; H, 2.80; Cl, 19.78; N, 7.63; S, 17.93. $C_{10}H_{10}Cl_2N_2O_4S_2$. Calculated (%): C, 33.62; H, 2.82; Cl, 19.85; N, 7.84, S, 17.95.

2.3.4. 4,4'-(Ethane-1,2-diyldisulfanediyl)*bis*(1-benzyl-3-chloro-5-hydroxy-1,5-dihydro-2*H*-pyrrol-2-one) (9)

Cooled solution of benzylamine (0.23 mL, 2.1 mmol) in a 2:1 mixture of diethyl ether and ethanol (7.5 mL) was added dropwise to a stirred mixture of compound **5** (0.27 g, 0.7 mmol) and ether (4 mL). The reaction mixture was stirred at –13 ÷ –10 °C for 3 days (monitored by TLC). The precipitate was filtered off, washed with ether and recrystallized from ethanol to give bis-thioether **9** as a mixture of diastereomers. Colorless solid. Yield 68% (0.26 g), m.p. 163–165 °C (decomp.). R_f 0.49 (acetone-toluene, 1:2). IR, ν, cm^{-1}: 3100–3450 br (OH), 1695 (C=O), 1590, 1499 (C=C$_{lact}$, C=C$_{arom}$). ^{1}H NMR (acetone-d_6, 700 MHz, ppm): δ 3.46–3.60 (m, 8H, SCH_2), 4.36, 4.81 (both m, 2H each, AB quadruplet, CH_2N, $^2J_{HH}$ = –15.4 Hz), 4.36, 4.82 (both m, 2H each, AB quadruplet, CH_2N, $^2J_{HH}$ = –15.4 Hz), 5.58, 5.61 (both d, 2H each, C(5)H, ^3J = 9.5 Hz), 5.88 (d, 4H, OH, ^3J = 9.5 Hz), 7.21–7.35 (m, 20H, H$_{arom}$). ^{13}C{^{1}H} NMR (acetone-d_6, 176 MHz, ppm): δ 31.42, 31.53 (SCH_2); 44.25 (CH_2N); 82.41, 82.45 (C(5)); 122.60, 122.75 (C(3)); 128.18, 128.84, 128.86, 129.40, 138.42 (C$_{arom}$); 150.16, 150.29 (C(4)); 163.39 (C(2)). Found (%): C, 53.72; H, 4.06; Cl, 13.15; N, 5.17; S, 11.91. $C_{24}H_{22}Cl_2N_2O_4S_2$. Calculated (%): C, 53.63; H, 4.13; Cl, 13.19; N, 5.21; S, 11.93.

3. Results and Discussion

Two types of sulfur-containing compounds of 2(5*H*)-furanone series were considered as promising precursors for the synthesis of the corresponding dithioderivatives of 3-pyrrolin-2-one. The interaction of mucochloric acid **1** with 1,2-ethanedithiol in the presence of triethylamine resulted in the formation of fused bicyclic compound **2** [32], which was further converted into a methoxy derivative of dithiinofuranone **3** (Scheme 1). *Bis*-thioether **5**, which combines two 2(5*H*)-furanone moieties, bridged through their carbon atoms C(4) by the 1,2-ethanedithiol fragment, was obtained from mucochloric acid **1** in two steps by initial reaction with alcohol under acidic catalytic conditions, followed by thiilation of furanone **4** by the use of dithiol in the presence of a base [32].

Bicycle **3** and *bis*-thioether **5** were involved in the reaction with nitrogen-containing nucleophiles to afford the corresponding dithioderivatives of 3-pyrrolin-2-one **6–9**, possessing a hydroxy group at the saturated carbon atom of the γ-lactam ring (Scheme 2). Reactions were carried out under cooling by mixing compounds **3** and **5** with aqueous ammonia solution or benzylamine in diethyl ether-ethanol medium. The structure of novel synthesized compounds **6–9** obtained as stable colorless solids was confirmed by IR, ^{1}H and ^{13}C{^{1}H} NMR spectroscopy, and single crystal X-ray diffraction (Figures S1–S8, Table S1).

Characteristic features of the IR spectra of pyrrolinones **6–9** are a broad band of medium intensity in the range of 3000–3500 cm^{-1} assigned to the stretching vibra-

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tions of the hydroxy (for **6**–**9**) or both OH and NH groups (for the *N*-unsubstituted compounds **6** and **8**), and a strong band at 1656–1695 cm^{-1} corresponding to the lactam carbonyl group (Figures S6–S8).

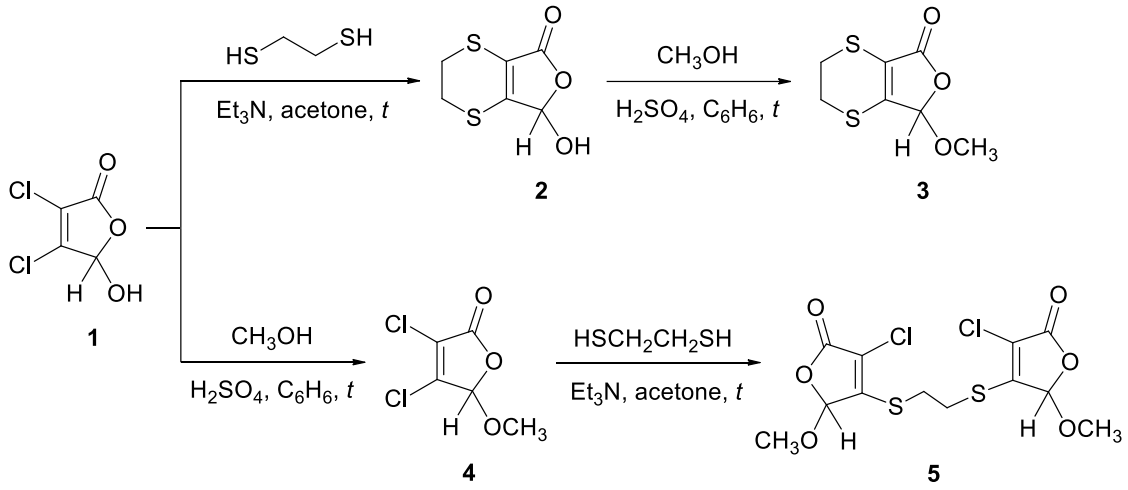
The ^{1}H NMR spectra of compounds **6**–**9** recorded in the deuterated acetone contain signals for the methine proton at the saturated carbon atom of the lactam ring (δ 5.18–5.85 ppm), the proton of the hydroxy group (δ 5.27–5.88 ppm) and a multiplets in the range of 3.12–3.72 ppm, characteristic for the methylene protons of the –SCH_2CH_2S– moiety (Figures S1–S5). The signal for the NH proton appeared as a broad singlet in the range of 7.57–7.92 ppm in the ^{1}H NMR spectra of compounds **6** and **8**.

In the case of *bis*-thioethers **8** and **9**, a doublet signal set in the ^{1}H and $^{13}C\{^1H\}$ NMR spectra evidenced the formation of two diastereomers (*meso* and *dl*) of these products. The less soluble *meso* isomer **8a** was obtained in pure form and characterized by spectral methods (Figures S4, S7b) and single crystal X-ray diffraction.

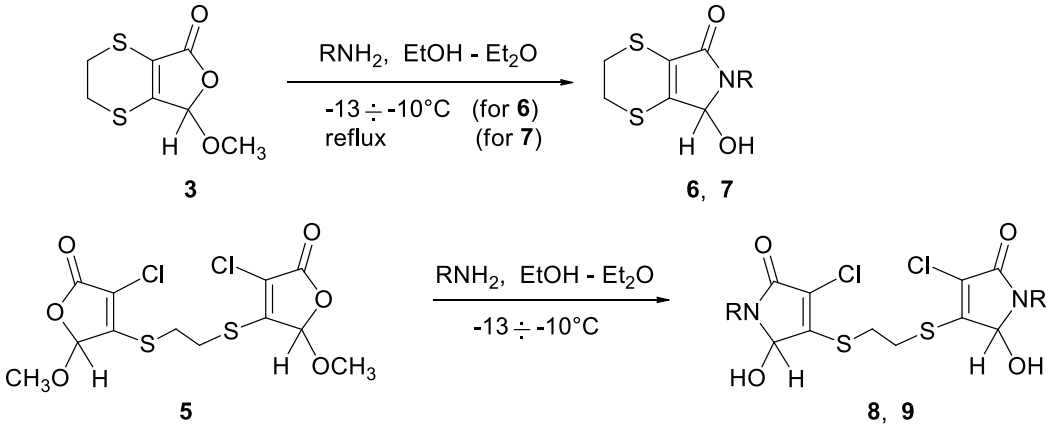
It should be noted, that similar to heterocycles **6** and **7** other fused bicyclic compounds were synthesized earlier in two steps from 5,6-dihydro-1,4-dithiine-2,3-dicarboxylic anhydride and amines followed by reduction using sodium borohydride [24,25]. To the best of our knowledge, compounds **8** and **9** are first representatives of *bis*-thioethers with a dithiol linker joining the two lactams together through their C(4) atoms.

Ammonolysis or amination of 5-methoxy-2(5*H*)-furanone derivatives represent a simple and convenient method for the synthesis of bicycles **6**, **7** and *bis*-thioethers **8**, **9**. One can expect the formation of unsubstituted at the nitrogen atom N(1) compounds **6** and **8** upon direct thiilation of 5-hydroxy-3,4-dichloro-3-pyrrolin-2-one [35]. However, we have shown that the interaction of this pyrrollinone with ethane-1,2-dithiol in the presence of a base (triethylamine or aqueous potassium hydroxide solution) gave a complex inseparable mixture of several products. Apparently, it is difficult to synthesize compounds **6** and **8** by direct thiilation of 3,4-dichloro-3-pyrrolin-2-one in used reaction conditions.

The structure of bicycle **6** was determined by single crystal X-ray diffraction using colorless crystals obtained from a deuterated acetone solution. According to the X-ray data, the six-membered ring of the molecule **6** in the crystal has a half-chair conformation: the five-atom fragment S(1)C(3)C(4)S(2)C(7) is planar, the C(6A) and C(6B) atoms deviate from this plane by –0.683(4) Å and 0.625(11) Å, respectively (Figure 1).



Scheme 1 Synthesis of dithioderivatives of 2(5*H*)-furanone **3** and **5**.



R = H: **6** (91%), **8** (73%); R = $CH_2C_6H_5$: **7** (71%), **9** (68%)

Scheme 2 Synthesis of dithioderivatives of 3-pyrrolin-2-one **6**–**9**.

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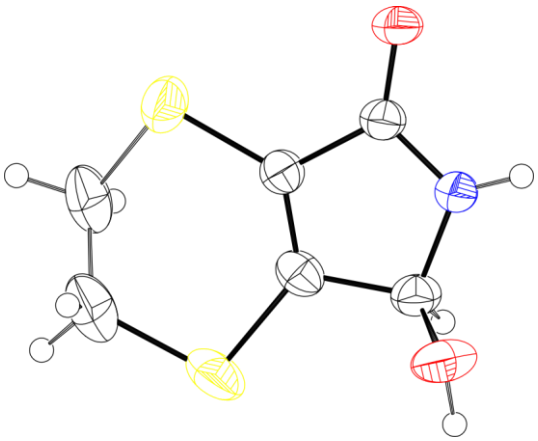

Figure 1 Molecular structure of heterocycles **6** in the crystal.

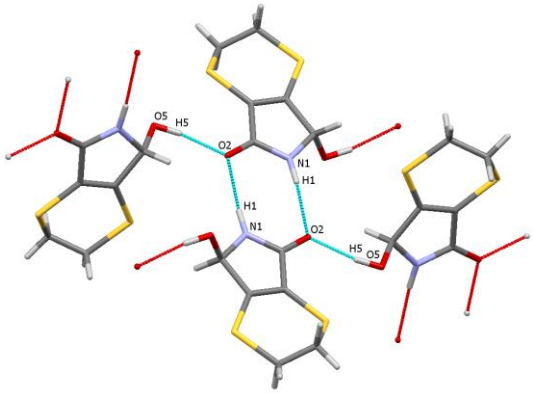

Figure 2 Intermolecular interactions in the crystal of compound **6**.

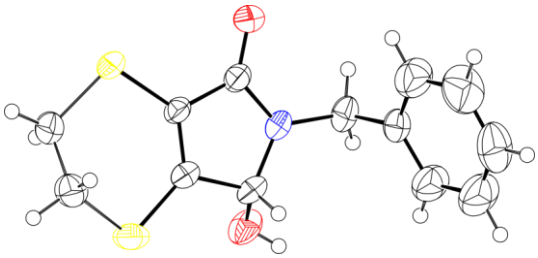

Figure 3 Molecular structure of bicycle **7** in the crystal.

In the crystal, neighboring molecules **6** form centrosymmetric dimers through a hydrogen bond between the hydrogen atom of the amino group and the oxygen atom of the carbonyl group (the N(1)...O(2) distance is 2.938(7) Å). These dimers, in turn, are linked to each other by the interaction of the hydrogen atom of the hydroxy group and the oxygen atom of the carbonyl group (the O(5)...O(2) distance is 2.705(6) Å) (Figure 2).

The X-ray crystallographic analysis revealed that the six-membered cycle of the molecule **7** is characterized by the half-chair conformation (Figure 3). The S(1)C(3)C(4)S(2) fragment is planar, the deviation of C(13A) and C(14A) atoms from the plane is 0.416(16) Å and –0.383(14) Å, correspondingly. The atoms C(13B) and C(14B) deviate from the plane by –0.357(7) Å and 0.449(6) Å, respectively.

The molecules of **7** in the crystal form infinite chains via classical hydrogen bonds between the hydrogen atom of the hydroxy group and the oxygen atom of the carbonyl group (the O(5)...O(2) distance is 2.726(2) Å) (Figure 4).

The obtained individual *meso* diastereomer **8a** crystallizes as a solvate with two DMSO molecules (Figure 5). The molecules of compound **8a** are linked to the solvent molecules through hydrogen bonds between the hydrogen atom of the hydroxy group and the oxygen atom of DMSO. In the crystal, the molecules of *bis*-thioether **8a** are linked to each other by hydrogen bonds between the hydrogen atoms of the amino groups, on the one hand, and the oxygen atom of the carbonyl group, on the other (Figure 6, Table S2).

Recrystallization of the obtained mixture of isomers **9** from ethanol gave crystals of *meso* form **9a** as verified by X-ray crystallography. The molecules of *meso* form **9a** in the crystal were in the special position in the center of symmetry (Figure 7).

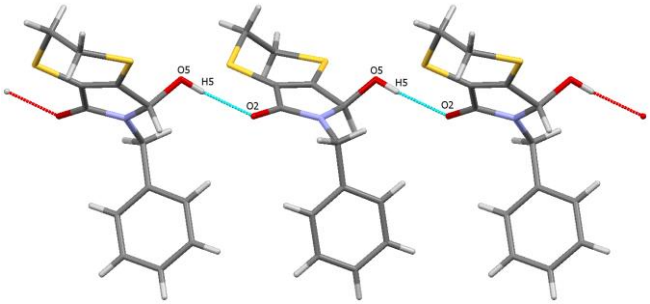

Figure 4 Intermolecular interactions in the crystal of bicycle **7**.

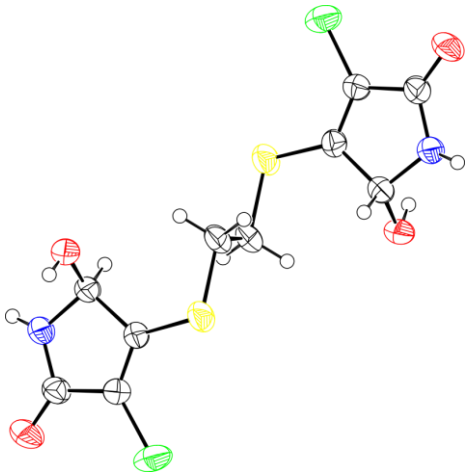

Figure 5 Molecular structure of *meso* isomer **8a** in the crystal.

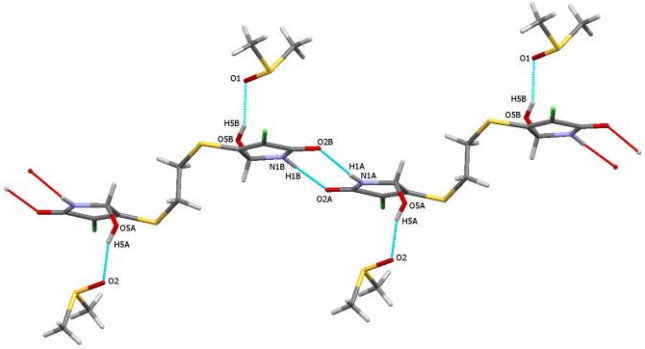

Figure 6 Intermolecular interactions in the crystal of *meso* isomer **8a**.

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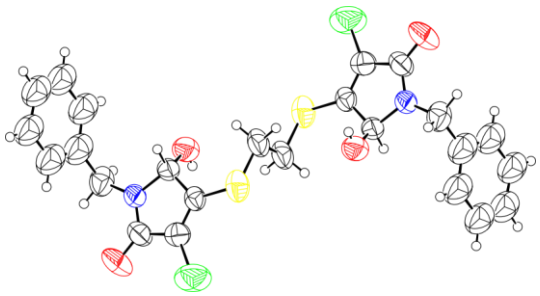

Figure 7 Molecular structure of *meso* isomer **9a** in the crystal.

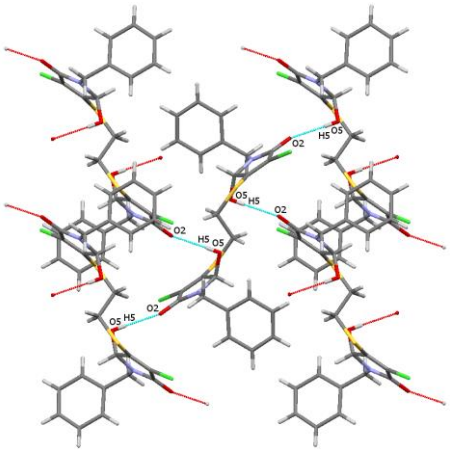

Figure 8 Intermolecular interactions in the crystal of compound **9a**.

The connecting fragment –SCH_2CH_2S– adopts a *transoid* conformation, similar to the studied earlier *meso* isomers of furanone *bis*-thioethers [32]. In the crystal, O(5)–H(5)...O(2) hydrogen bonds with an O(5)...O(2) distance of 2.683(8) Å are observed between the molecules **9a** (Figure 8).

Thus, for all single crystals studied here, hydrogen bonding is a key factor in the formation of compounds structure. In most cases, hydrogen bonds between the hydrogen atom of the hydroxy or amino groups and the oxygen atom of the carbonyl group determine the crystal lattice architecture, forming dimers (*N*-unsubstituted compounds **6** and **8a**) or infinite chains (*N*-benzyl derivatives **7** and **9a**). Interactions with the solvent further stabilize the structure and form special packing motif in the crystal structure of compound **8a**.

4. Limitations

There were some difficulties associated with poor solubility of the synthesized compounds **6**–**9** in most organic solvents, especially it relates to *bis*-thioether **8**.

5. Conclusions

In this study, we successfully applied the synthesis method, based on the interaction of ammonia and benzylamine with corresponding thioethers of 5-methoxy-2(5*H*)-furanone to the synthesis of novel sulfur-containing derivatives of 3-pyrrolin-2-one, possessing two sulfur atoms. New representatives of fused bicylic compounds of 2,3,6,7-tetrahydro-5*H*-[1,4]dithiino[2,3-c]pyrrol-5-one series and *bis*-thioethers with a dithiol linker connecting two unsaturated γ-lactams through their C(4) atoms, were synthesized and characterized by spectral methods and single crystal X-ray diffraction. 5-Alkoxy-furanone based method can be effectively utilized for the construction of such and more complex heterocyclic systems, possessing lactam ring, difficult to access by other methods.

Supplementary materials

This manuscript contains supplementary materials, which are available on the corresponding online page.

Data availability statement

The data that supports the findings of this study are available in the supplementary material of this article.

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None.

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Conflict of interest

The authors declare no conflict of interest.

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