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# Heterocycles from Aroylacetic Aldehydes and SH-Containing Hydrazides

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**Abstract**—Condensation products of aroylacetic aldehydes with hydrazides of thioglycolic, 3-mercaptopropionic and 2-mercaptobenzoic acids exist in cyclic 1,3,4-thiadiazine, 1,3,4-thiadiazepine, or 1,3,4-benzothiadiazepine forms arising at the intramolecular addition of the mercapto group to the C=N bond of the initially formed hydrazone tautomer. The appearance of an alternative 5-hydroxy-2-pyrazoline form is favored by introduction of a strong electron-acceptor substituent into the aromatic ring of the 1,3-ketoaldehyde or by going over to benzoylacetone derivatives. In solutions the derivatives of aroylacetic aldehydes and of benzoylacetone show no tendency to tautomeric transition into linear hydrazine or enhydrazine forms.

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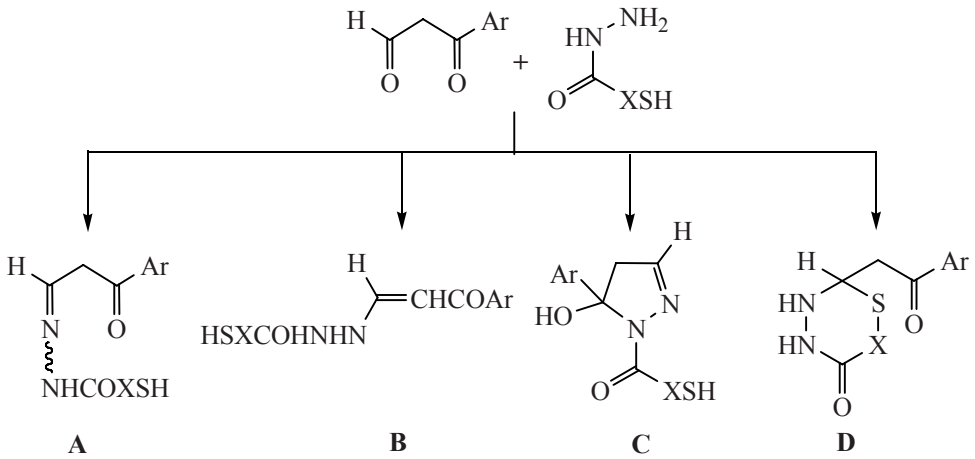
The reaction of 1,3-ketoaldehydes with acylhydrazines proceeding exclusively at the aldehyde function stops at the stage preceding the 1-acylpyrazoles formation [1–8]. The condensation products depending on the structure of the 1,3-dicarbonyl and hydrazine components in the crystalline state may have a hydrazone, conjugated enhydrazine, or 5-hydroxy-2-pyrazoline structure. In solutions they are involved in a number of prototropic and ring-chain equilibria with various combination of the above cited tautomers [7, 8].

In the present study we investigated the reactions of aroylacetic aldehydes with hydrazides of thioglycolic, 3-mercaptopropionic, and 2-mercaptobenzoic acids containing a nucleophilic SH function. Consequently the condensation products of the cited hydrazides with the aroylacetic aldehydes might exist not only in the hydrazone (**A**), enhydrazine (**B**) or **5**-hydroxy-2-pyrazoline (**C**) forms but also in six- or seven-membered cyclic form **D** originating from the attack of the SH function on the C=N bond (Scheme 1).

The reaction of aroylacetic aldehydes **Ia–Ie** with the thioglycolic acid hydrazide (Scheme 2) occurred under mild conditions: by mixing the solutions of equimolar amounts of reagents in anhydrous methanol at cooling the reaction mixture with ice.

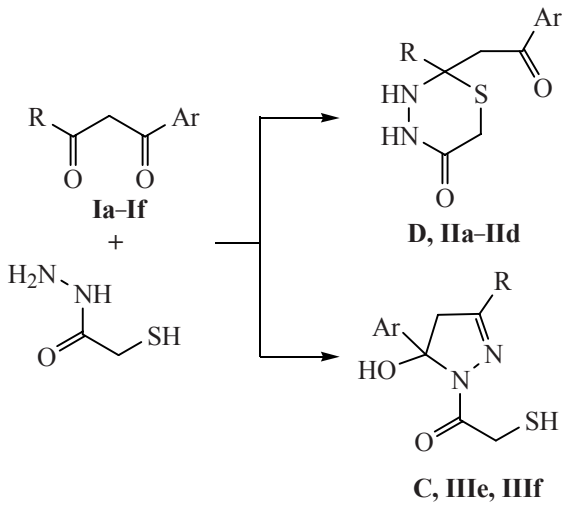
On completion of the reaction determined by TLC monitoring the solvent was removed under a reduced pressure, and the obtained crystalline product was analyzed by $^{1}H$ and $^{13}C$ NMR spectroscopy. In the $^{1}H$ NMR spectra of the condensation products of aroylacetic aldehydes **Ia–Id** recorded just after dissolution a single set of resonance signals was observed (see EXPERIMENTAL). This finding indicated first of all the expected 100% regiodirectional reaction at the aldehyde function. Inasmuch as the spectra were obtained directly after dissolution of the samples when the possible tautomeric and configurational transitions yet not occurred it was presumable that the spectra registered the structure of the derivatives of aroylacetic aldehydes in the crystals. The comparison of these spectra with the spectral data on the previously obtained condensation products of 1,3-ketoaldehydes with acylhydrazines [1–3, 5, 6] made it possible to exclude with confidence the hydrazone (**A**) form (since were absent a doublet proton signal from the methylene group of the 1,3-dicarbonyl moiety in the region 4.0–4.2 ppm and the signal of SH proton in the region 2.2–2.8 ppm) and the enhydrazine (**B**) structure (since

**Scheme 1.**



X = $CH_2$, $(CH_2)_2$, *o*-$C_6H_4$

**Scheme 2.**



R = H, Ar = 4-$XC_6H_4$, X = MeO (**a**), Me (**b**), H (**c**), Br (**d**), $NO_2$ (**e**); R = $CH_3$, Ar = $C_6H_5$ (**f**).

were absent the signals in the region 5.5–6.0 and 7.0–7.5 ppm from the protons at the C=C bond and the signal of SH proton in the region 2.2–2.8 ppm). The choice between the cyclic forms **C** and **D** is somewhat more difficult. Against the 5-hydroxy-2-pyrazoline structure **C** testified the absence of signal of the proton at C=N bond and the proton of the mercapto group. The appeared signals were well consistent with the 1,3,4-thiadiazine structure **D** (see EXPERIMENTAL).

The ultimate choice of the 1,3,4- thiadiazine structure **D** was done with the help of the $^{13}C$ NMR spectroscopy. According to the $^{13}C$ NMR spectra of the condensation products obtained from 1,3-dikrtones and ketoaldehydes with acylhydrazine possessing 5-hydroxy-2-pyrazoline structure the signal from the carbon atom in the position *5* of the ring linked to oxygen and nitrogen atoms appeared at the 92–97 ppm [3, 9, 10]. Obviously, the signal of the corresponding carbon atom should be observed in this region in the spectra of condensation products under discussion produced from 1,3-ketoaldehydes **Ia–Id** and thioglycolic acid hydrazide of they possessed the 5-hydroxy-2-pyrazoline structure **C**.

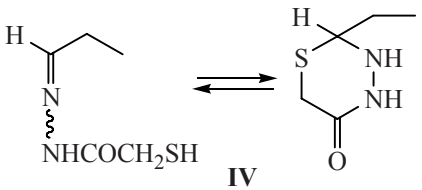
We modeled the 1,3,4-thiadiazine form **D** by the condensation product from propionic aldehyde with thioglycolic acid hydrazide **IV** (Scheme 3).

Compound **IV** in the crystalline state has the cyclic 1,3,4-thiadiazine structure **D,** and in the DMSO-$d_6$ solution is a tautomeric mixture of hydrazone (**A**) and 1,3,4-thiadiazine (**D**) forms, and the content of the latter is no less than 90%.

In the $^{13}C$ NMR spectrum of this compound taken in DMSO-$d_6$ the carbon atoms in positions *2* (linked to sulfur and nitrogen atoms), *5* , and *6* of the ring appeared as signals at δ 66.0, 172.8 and 28.8 ppm.

In the $^{13}C$ NMR spectra of derivatives of aroylacetic aldehydes **IIa–IId** a signal is observed in the region 60–61 ppm. This is an ultimate confirmation of the 1,3,4-thiadiazine structure **D** of compounds **IIa–IId**.

**Scheme 3.**



The $^1H$ and $^{13}C$ NMR spectra of solutions of compounds **IIa–IId** do not change in time. It means that no transition occur into the probable open-chain tautomeric forms **A** and **B** or into the alternative cyclic 5-hydroxy-2-pyrazoline structure **C**.

The condensation product of ketoaldehyde **Ie** bearing a 4-nitrophenyl substituent, compound **IIIe**, takes a special place. The $^1H$ NMR spectra of this compound solutions in $CDCl_3$ and DMSO-$d_6$ also contain a single set of resonance signals, but it corresponds to 5-hydroxy-2-pyrazoline **C**.

In full agreement with the 5-hydroxy-2-pyrazoline structure the $^{13}C$ NMR spectrum contains a signal at δ 95.56 ppm corresponding to the carbon atom in the position *5* of the ring linked to oxygen and nitrogen atoms [2, 3, 9], and lacks the signal in the region 60–61 ppm characteristic as reasoned above of the 1,3,4- thiadiazine structure **D**. The existence of compound **IIIe** in the 5-hydroxy-2-pyrazoline form **C** is due to the effect of a strong electron-acceptor, nitro group, attached to the aromatic ring. It favors the cyclization of the intermediately formed hydrazone by addition of the NH group to the C=O bond. In this compound we also did not observe any tendency to the tautomer transitions; $^1H$ and $^{13}C$ NMR spectra of solutions registered immediately after preparation and after long storage were identical.

We additionally prepared the condensation product of benzoylacetone (**If**) with thioglycolic acid hydrazide **IIIf**. According to the $^1H$ and $^{13}C$ NMR spectra (see EXPERIMENTAL) compound **IIIf** had the structure of 5-hydroxy-2-pyrazoline **C**.

The comparison of compounds **IIc** and **IIIf** shows that the transition from a derivative of 1,3-ketoaldehyde to a derivative of 1,3-diketone favors the formation of 5-hydroxy-2-pyrazoline tautomer **C**. This fact may be understood as follows. In the 1,3,4-thiadiazine form **D** of compound **IIc** at the *chair* conformation of the heterocycle the hydrogen atom in the position *2* takes the axial orientation, and the rest of the 1,3-dicarbonyl component, $CH_2COPh$ moiety, would be in a feasible equatorial position. In a 1,3,4-thiadiazine form of the benzoylacetone derivative **IIIf** either methyl group of the $CH_2COPh$ fragment should be axially oriented. Therefore arise unfavorable *syn*-axial interactions with one of the hydrogens of the methylene group in the position *6* of the heterocycle. This destabilization of the 1,3,4-thiadiazine structure **D** prevents its successful competition with the 5-hydroxy-2- pyrazoline form **C**.

At the use in the reaction with the chosen 1,3-dicarbonyl compounds of 3-mercaptopropionic acid hydrazide we succeeded to isolate in the spectrally pure form only derivatives of ketoaldehyde **Ia** and of benzoylacetone (**If**): compounds **Va** and **VIf** (Scheme 4).

According to the $^1H$ and $^{13}C$ NMR spectra (see EXPERIMENTAL) the condensation prodyct of 1,3-ketoaldehyde **Ia** (compound **Va**) had the 1,3,4-thiadiazepine structure **D**, and the derivative of 1,3-diketone **If** was 5-hydroxy-2-pyrazoline **VIf**.

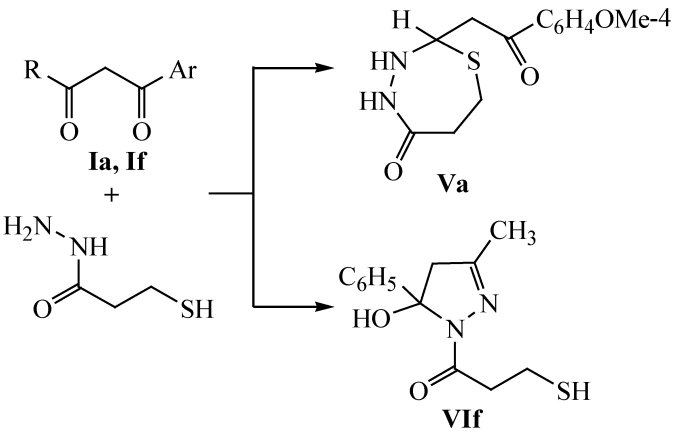
The most significant was the presence in the $^{13}C$ NMR spectrum of the solution of compound **Va** in DMSO-$d_6$ of a signal at δ 72.79 ppm belonging to the carbon atom in the position *2* of the 1,3,4-thiadiazepine ring connected to nitrogen and sulfur atoms. In the $^{13}C$ NMR spectrum of the solution of the derivative of 1,3-diketone (compound **VIf**) was present a signal at δ 93.89 ppm. It can be unambiguously assigned to the carbon atom in the position *5* of the 5-hydroxy-2-pyrazoline ring **C** linked to oxygen and nitrogen atoms.

Regretfully, we failed to obtain in a p;ausible form the derivatives of the other 1,3-ketoaldehydes. Consequently the problem remained unsolved of the effect of the electronic properties of the substituent in the aromatic ring on the direction of the intramolecular cyclization and of the possibility of the existence of tautomeric equilibria.

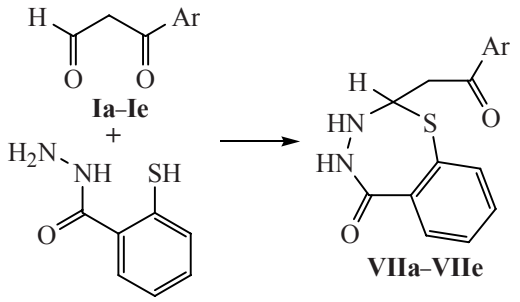
The reaction of aroylacetic aldehydes **Ia–Ie** with 2-mercaptobenzoic acid hydrazide was carried out in an aqueous-alcoholic medium at 50°C (Scheme 5).

The condensation products according to the $^1H$ and $^{13}C$ NMR spectra both in the crystalline state and in solutions in DMSO-$d_6$ have cyclic 1,3,4-benzothiadiazepine structure **VIIa–VIIe** and do not go over in the

**Scheme 4.**



**Scheme 5.**




other possible tautomeric forms (by comparison of spectra registered just after dissolution of the samples and after long storage).

Without detailed discussion of the spectral data we would only like to note that in the $^{13}C$ NMR spectra of com-pounds **VIIa–VIIe** was found a signal in the region 70 ppm. This signal can be duly assigned to the carbon atom in the position *2* of the heterocycle. Note for comparison the results of the study of acetone condensation with 2-mercaptobenzoic acid hydrazide [11]. This compound exists in solutions as a tautomeric mixture of hydrazone and 1,3,4-benzothiadiazepine form. In its $^{13}C$ NMR spectrum the signal of the carbon atom in the position *2* of the cyclic tautomer appears at δ 77.6 ppm.

It should be stated that as soon as the structure of the condensation product of 4-methoxybenzoylacetic aldehyde and 3-mercaptopropionic acid hydrazide (compound **Va**) was established, the existence of the reaction products of 1,3-aroylacetic aldehydes with 2-mercaptobenzoic acid hydrazide in the form of 1,3,4-benzothiadiazepines (compounds **VIIa–VIIe**) was expectable. It is well known that the growing rigidity of the unit connecting the electrophilic and nucleophilic sites in the systems capable of the ring-chain tautomerism essentially favors the formation of the cyclic tautomer [12–14].

It should be mentioned in conclusion that also the thiobenzoylhydrazones of aroylacetic aldehydes have a five-membered cyclic 1,3,4-thiadiazoline structure [15]. The cyclization occurs by the attack of the sulfur atom of the SH function arising in transition of the hydrazone form into the tautomeric azinoenthiol form.

Thus it can be stated that the condensation products obtained from 1,3-ketoaldehydes and hydrazides possessing an additional SH function (even in a latent form, like in the condensation products with thiobenzoylhydrazine) are prone to exist as five-, six-, and even seven-membered heterocycles.

## EXPERIMENTAL

$^1H$ and $^{13}C$ NMR spectra were registered on a spectrometer Bruker DPX-300 at operating frequencies 300.13 and 75.47 MHz respectively. The quantitative composition of isomers and tautomers was determined by integration of intensity of the corresponding signals in the $^1H$ NMR spectra. The measurements error was 3%. The reaction progress was monitored and the purity of compounds obtained was checke by TLC on Silufol UV-254 plates, eluent chloroform.

**2-[2-(4-Methoxyphenyl)-2-oxoethyl]-1,3,4-thiadiazin-5-one (IIa).** A mixture of 0.318 g (3 mmol) of thioglycolic acid hydrazide and 0.534 g (3 mmol) of 1,3-ketoaldehyde **Ia** in 5 ml of anhydrous methanol was kept at 20°C for 2 h. The solvent was removed under a reduced pressure, the separated crystals were filtered off and washed with methanol. Yield 0.591 g (74%), mp 150–151°C. $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm: 3.12 d (1H, $C^6H_B$, $J$ 13.4 Hz), 3.16 d (1H, $C^6H_A$, $J$ 13.4 Hz), 3.37 d.d (1H, $H_B$, $J_{AB}$ 17.4, $J_{BX}$ 8.7 Hz), 3.57 d.d (1H, $H_A$, $J_{AB}$ 17.4, $J_{AX}$ 5.1 Hz), 3.86 s (3H, $OCH_3$), 4.84 br.s (1H, $H^2$), 5.85 br.s (1H, NH), 6.98 d (2H, $H_{arom}$, $J$ 8.7 Hz), 7.90 d (2H, $H_{arom}$, $J$ 8.7 Hz), 8.85 br.s (1H, NHCO). $^{13}C$ NMR spectrum (DMSO-$d_6$), δ, ppm: 28.64 ($C^6$), 45.14 ($CH_2$), 56.08 ($OCH_3$), 60.73 ($C^2$), 114.45, 130.11, 130.99, 164.08 ($C_{arom}$), 173.43 ($C^5$), 195.66 (C=O). Found, %: C 54.22; H 5.26; N 10.38. $C_{12}H_{14}N_2O_3S$. Calculated, %: C 54.12; H 5.30; N 10.52.

Likewise were obtained derivatives **IIb–IId** and **IIIf, IIIe**.

**2-[2-(4-Methylphenyl)-2-oxoethyl]-1,3,4-thiadiazin-5-one (IIb).** Yield 0.323 g (43%), mp 132°C. $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm: 2.42 s (3H, $CH_3$), 3.13 d (1H, $C^6H_B$, $J$ 13.4 Hz), 3.17 d (1H, $C^6H_A$, $J$ 13.4 Hz), 3.40 d.d (1H, $H_B$, $J_{AB}$ 17.4, $J_{BX}$ 8.0 Hz), 3.52 d.d (1H, $H_A$, $J_{AB}$ 17.4, $J_{AX}$ 5.1 Hz), 4.85 m (1H, $H^2$), 5.86 br.s (1H, NH), 7.28 d (2H, $H_{arom}$, $J$ 8.0 Hz), 7.84 d (2H, $H_{arom}$, $J$ 8.0 Hz), 8.84 br.s (1H, NHCO). $^{13}C$ NMR spectrum (DMSO-$d_6$), δ, ppm: 22.03 ($CH_3$), 28.49 ($C^6$), 45.48 ($CH_2$), 60.83 ($C^2$), 128.91, 130.22, 134.63, 144.83 ($C_{arom}$), 173.71 ($C^5$), 197.51 (C=O). Found, %: C 57.49; H 5.63; N 11.04. $C_{12}H_{14}N_2O_2S$. Calculated, %: C 57.58; H 5.64; N 11.19.

**2-(2-Oxo-2-phenylethyl)-1,3,4-thiadiazin-5-one (IIc).** Yield 0.262 g (37%), mp 159–160°C. $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm: 3.11 d (2H, $C^6H_B$, $J$ 13.4 Hz), 3.15 d (1H, $C^6H_A$, $J$ 13.4 Hz), 3.39 d.d (1H, $H_B$, $J_{AB}$ 17.4, $J_{BX}$ 8.1 Hz), 3.51 d.d (1H, $H_A$, $J_{AB}$ 17.4, $J_{AX}$ 5.1 Hz),

4.82 m (1H, $H^2$), 5.73 br.s (1H, NH), 7.30–7.49 m (5H, $H_{arom}$), 9.03 br.s (1H, NHCO). $^{13}C$ NMR spectrum (DMSO-$d_6$), δ, ppm: 28.50 ($C^6$), 45.32 ($CH_2$), 60.72 ($C^2$), 126.02, 128.24, 131.40, 137.58 ($C_{arom}$), 173.54 ($C^5$), 196.83 (C=O). Found, %: C 55.79; H 5.15; N 11.80. $C_{11}H_{12}N_2O_2S$. Calculated, %: C 55.92; H 5.12; N 11.86.

**2-[2-(4-Bromophenyl)-2-oxoethyl]-1,3,4-thiadiazin-5-one (IId).** Yield 0.548 g (58%), mp 133–134°C. $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm: 3.11 d (1H, $C^6H_B$, $J$ 13.8 Hz), 3.17 d (1H, $C^6H_A$, $J_{AB}$ 13.8 Hz), 3.43 d.d (1H, $H_B$, $J_{AB}$ 17.4, $J_{BX}$ 8.0 Hz), 3.53 d.d (1H, $H_A$, $J_{AB}$ 17.4, $J_{AX}$ 5.1 Hz), 4.85 m (1H, $H^2$), 5.86 br.s (1H, NH), 7.66 d (2H, $H_{arom}$, $J$ 8.0 Hz), 7.88 d (2H, $H_{arom}$, $J$ 8.0 Hz), 8.83 br.s (1H, NHCO). $^{13}C$ NMR spectrum (DMSO-$d_6$), δ, ppm: 28.48 ($C^6$), 45.59 ($CH_2$), 60.60 ($C^2$), 128.53, 130.84, 132.44, 132.77 ($C_{arom}$), 173.66 ($C^5$), 197.32 (C=O). Found, %: C 41.98; H 3.47; N 8.78. $C_{11}H_{11}BrN_2O_2S$. Calculated, %: C 41.92; H 3.52; N 8.89.

**1-[5-Hydroxy-5-(4-nitrophenyl)-4,5-dihydro-1*H*-pyrazol-1-yl]-2-sulfanylethan-1-one (IIIe).** Yield 0.177 g (21%), mp 124°C. $^1H$ NMR spectrum ($CDCl_3$), δ, ppm: 2.15 d.d (1H, SH, $J$ 8.7, $J$ 8.0 Hz), 3.03 d (1H, $C^4H_B$, $J_{AB}$ 19.6 Hz), 3.43 d (1H, $C^4H_A$, $J_{AB}$ 19.6 Hz), 3.54 d.d (1H, $H_B$, $J_{AB}$ 13.8, $J_{BX}$ 8.0 Hz), 3.70 d.d (1H, $H_A$, $J_{AB}$ 13.8, $J_{AX}$ 8.7 Hz), 5.0–6.0 br (1H, OH), 7.06 s (1H, $H^3$), 7.59 d (2H, $H_{arom}$, $J$ 8.7 Hz), 8.23 d (2H, $H_{arom}$, $J$ 8.7 Hz). $^{13}C$ NMR spectrum ($CDCl_3$), δ, ppm: 26.82 ($CH_2SH$), 43.30 ($C^4$), 93.56 ($C^5$), 124.52, 127.97, 136.35, 149.20 ($C_{arom}$), 144.23 ($C^3$), 168.71 (C=O). Found, %: C 46.92; H 3.95; N 14.79. $C_{11}H_{11}N_3O_4S$. Calculated, %: C 46.97; H 3.94; N 14.94.

**1-(5-Hydroxy-3-methyl-5-phenyl-4,5-dihydro-1*H*-pyrazol-1-yl)-2-sulfanylethan-1-one (IIIf).** Yield 0.308 g (41%), mp 84–85°C. $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm: 2.02 s (3H, $CH_3$), 2.70 d.d (1H, SH, $J$ 7.3 Hz), 3.00 d (1H, $C^4H_B$, $J_{AB}$ 18.3 Hz), 3.13 d (1H, $C^4H_A$, $J_{AB}$ 18.3 Hz), 3.45 d.d (1H, $H_B$, $J_{AB}$ 14.2, $J_{BX}$ 7.3 Hz), 3.58 d.d (1H, $H_A$, $J_{AB}$ 14.2, $J_{AX}$ 7.3 Hz), 6.85 (1H, OH), 7.33–7.38 m (5$H_{arom}$). $^{13}C$ NMR spectrum ($CDCl_3$), δ, ppm: 16.49 ($CH_3$), 27.45 ($CH_2SH$), 54.95 ($C^4$), 93.89 ($C^5$), 124.33, 126.03, 128.49, 129.10 ($C_{arom}$), 143.51 ($C^3$), 169.48 (C=O). Found, %: C 57.46; H 5.58; N 11.20. $C_{12}H_{14}N_2O_2S$. Calculated, %: C 57.58; H 5.64; N 11.19.

**2-Ethyl-1,3,4-thiadiazin-5-one (IVa).** A mixture of 1.06 g (10 mmol) of thioglycolic acid hydrazide and 0.580 g (10 mmol) of propionic aldehyde in 50 ml of methanol was kept at 25°C for 2 h. The separated crystals were filtered off, washed with ether, and dried. Yield 1.095 g (75%), mp 103–104°C. $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm, *EE'* (6%): 2.67 t (1H, SH, $J$ 7.1 Hz), 3.43 d (2H, $CH_2SH$, $J$ 7.1 Hz), 7.34 t (1H, HC=N, $J$ 5.0 Hz), 11.01 br.s (1H, NH); *EZ2* (3%): 2.84 t (1H, SH, $J$ 7.8 Hz), 3.32 d (2H, $CH_2SH$, $J$ 7.8 Hz), 7.47 t (1H, HC=N, $J$ 5.0 Hz), 11.07 br.s (1H, NH); *ZE2* (<3%): 3.88 d (2H, $CH_2SH$, $J$ 8.8 Hz), 6.72 br.s (1H, HC=N), 11.14 br.s (1H, NH); **D** (90%): 3.12 d (1H, $H_B$, $J_{AB}$ 14.3 Hz), 3.18 d (1H, $H_A$, $J_{AB}$ 14.3 Hz), 4.28 br.s (1H, $H^2$), 5.73 br.s (1H, NH), 8.97 br.s (1H, NHCO). $^{13}C$ NMR spectrum (DMSO-$d_6$), δ, ppm, **D**: 11.00 ($CH_3$), 27.61 ($CH_2$), 28.82 ($C^6$), 66.00 ($C^2$), 172.81 ($C^5$). Found, %: C 40.98; H 6.92; N 19.21. $C_5H_{10}N_2OS$. Calculated, %: C 41.07; H 6.89; N 19.16.

**2-[2-(4-Methoxyphenyl)-2-oxoethyl]-1,3,4-thiadiazepin-5-one (Va).** A mixture of 0.236 g (2 mmol) of 3-mercaptopropionic acid hydrazide and 0.356 g (2 mmol) of 1,3-ketoaldehyde **Ia** in 6 ml of anhydrous methanol was kept at 20°C for 2 h. The solvent was removed at a reduced pressure. Yield 0.180 g (32%), oily substance. $^1H$ NMR spectrum ($CDCl_3$), δ, ppm: 2.68 m (2H, $C^6H_2$), 2.95 m (2H, $C^7H_2$), 3.23 d.d (1H, $H_B$, $J_{AB}$ 18.2, $J_{BX}$ 4.4 Hz), 3.49 d.d (1H, $H_A$, $J_{AB}$ 18.2, $J_{AX}$ 5.8 Hz), 3.85 s (3H, $OCH_3$), 5.59 m (2H, $H^2$, NH), 6.93 d (2H, $H_{arom}$, $J$ 8.7 Hz), 7.64 d (2H, $H_{arom}$, $J$ 8.7 Hz), 7.84 br.s (1H, NHCO). $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm: 2.61 m (2H, $C^6H_2$), 2.92 m (2H, $C^7H_2$), 3.14 d.d (1H, $H_B$, $J_{AB}$ 18.5, $J_{BX}$ 3.9 Hz), 3.34 d.d (1H, $H_A$, $J_{AB}$ 18.5, $J_{AX}$ 4.2 Hz), 3.80 s (3H, $OCH_3$), 5.48 br.s (1H, $H^2$), 5.72 br.s (1H, NH), 7.01 d (2H, $H_{arom}$, $J$ 8.7 Hz), 7.65 d (2H, $H_{arom}$, $J$ 8.7 Hz), 9.30 br.s (1H, NHCO). $^{13}C$ NMR spectrum ($CDCl_3$), δ, ppm: 20.68 ($C^7$), 38.86 ($C^6$), 44.96 ($CH_2$), 55.79 ($OCH_3$), 72.79 ($C^2$), 114.55, 127.34, 128.67, 162.00 ($C_{arom}$), 171.46 ($C^5$), 195.23 (C=O). Found, %: C 55.76; H 5.68; N 9.86. $C_{13}H_{16}N_2O_3S$. Calculated, %: C 55.70; H 5.75; N 9.99.

**1-(5-Hydroxy-3-methyl-5-phenyl-4,5-dihydro-1*H*-pyrazol-1-yl)-3-sulfanylpropan-1-one (VIf)** was similarly obtained. Yield 0.100 g (19%), mp 49–50°C. $^1H$ NMR spectrum ($CDCl_3$), δ, ppm: 2.01 t (1H, SH, $J$ 8.0 Hz), 2.07 s (3H, $CH_3$), 2.80 m (2H, $CH_2CO$), 2.94 d (1H, $H_B$, $J_{AB}$ 18.9 Hz), 3.05 m (2H, $CH_2SH$), 3.29 d (1H, $H_A$, $J_{AB}$ 18.9 Hz), 5.4-6.7 br.s (1H, OH), 7.35–7.40 m (5H, $H_{arom}$). $^1H$ NMR spectrum (DMSO-$d_6$), δ, ppm: 2.01 s (3H, $CH_3$), 2.29 t (1H, SH, $J$ 7.3 Hz), 2.75 m (2H, $CH_2CO$), 3.01 m (2H, $CH_2SH$), 3.25 d (1H, $H_B$, $J_{AB}$ 18.2 Hz), 3.49 d (1H, $H_A$, $J_{AB}$ 18.2 Hz), 6.71 s (1H, OH), 7.32–7.45 m (4H, $H_{arom}$). $^{13}C$ NMR spectrum NMR spectrum ($CDCl_3$), δ, ppm: 16.46 ($CH_3$), 19.94 ($CH_2SH$),

38.82 ($CH_2CO$), 54.66 ($C^4$), 93.98 ($C^5$), 124.31, 128.47, 129.11, 129.18 ($C_{arom}$), 155.17 ($C^3$), 170.83 (C=O). Found, %: C 58.91; H 6.09; N 10.69. $C_{13}H_{16}N_2O_2S$. Calculated, %: C 59.07; H 6.10; N 10.60.

**2-[2-(4-Methoxyphenyl)-2-oxoethyl]-3,4-dihydro-1,3,4-benzothiadiazepin-5(2*H*)-one (VIIa).** To a solution of 0.445 g (2.5 mmol) of 1,3-ketoaldehyde **Ia** in 5 ml of ethanol was added dropwise at stirring a solution of 0.420 g (2.5 mmol) of 2-mercaptobenzoic acid hydrazide in 15 ml of water maintaining the temperature of the reaction mixture at ~50°C. The precipitated crystals were filtered off, recrystallized from ethanol, and dried. Yield 0.460 g (56%), mp 157–158°C. $^1$H NMR spectrum (DMSO-$d_6$), δ, ppm: 3.28 d.d (1H, $H_B$, $J_{AB}$ 16.7, $J_{BX}$ 5.8 Hz), 3.50 br.d (1H, $H_A$, $J_{AB}$ 16.7 Hz), 3.89 s (3H, $CH_3$), 5.21 br.t (1H, $H^2$, $J$ 5.8 Hz), 5.95 br.s (1H, NH), 6.95 d (2H, $H_{arom}$, $J$ 8.7 Hz), 7.42–7.65 m (4H, $H_{arom}$), 7.93 d (2H, $H_{arom}$, $J$ 8.7 Hz), 9.50 br.s (1H, NHCO). $^{13}$C NMR spectrum (DMSO-$d_6$), δ, ppm: 43.09 ($CH_2$), 56.45 ($OCH_3$), 69.42 ($C^2$), 114.85, 127.44, 129.39, 130.25, 131.12, 131.29, 131.91, 134.36, 141.13, 164.23 ($C_{arom}$), 173.93 ($C^5$), 195.63 (C=O). Found, %: C 62.24; H 4.98; N 8.46. $C_{17}H_{16}N_2O_3S$. Calculated, %: C 62.18; H 4.91; N 8.53.

Likewise were obtained derivatives **VIIb–VIIe**.

**2-[2-(4-Methylphenyl)-2-oxoethyl]-3,4-dihydro-1,3,4-benzothiadiazepin-5(2*H*)-one (VIIb).** Yield 0.367 g (47%), mp 166–168°C. $^1$H NMR spectrum (DMSO-$d_6$), δ, ppm: 2.45 s (3H, $CH_3$), 3.31 d.d (1H, $H_B$, $J_{AB}$ 16.7, $J_{BX}$ 5.1 Hz), 3.54 br.d (1H, $H_A$, $J_{AB}$ 16.7 Hz), 5.12 br.s (1H, $H^2$), 5.94 br.s (1H, NH), 7.27 d (2H, $H_{arom}$, $J$ 8.0 Hz), 7.40–7.65 m (4H, $H_{arom}$), 7.84 d (2H, $H_{arom}$, $J$ 8.0 Hz), 9.51 br.s (1H, NHCO). $^{13}$C NMR spectrum (DMSO-$d_6$), δ, ppm: 22.12 ($CH_3$), 43.49 ($CH_2$), 70.13 ($C^2$), 127.89, 129.01, 130.25, 130.36, 130.74, 131.42, 133.53, 134.76, 141.10, 144.77 ($C_{arom}$), 173.64 ($C^5$), 197.54 (C=O). Found, %: C 65.31; H 5.11; N 8.99. $C_{17}H_{16}N_2O_2S$. Calculated, %: C 65.36; H 5.16; N 8.97.

**2-(2-Oxo-2-phenylethyl)-3,4-dihydro-1,3,4-benzothiadiazepin-5(2*H*)-one (VIIc).** Yield 0.239 g (32%), mp 181–182°C. $^1$H NMR spectrum (DMSO-$d_6$), δ, ppm: 3.38 d.d (1H, $H_B$, $J_{AB}$ 16.4, $J_{BX}$ 5.0 Hz), 3.56 d.d (1H, $H_A$, $J_{AB}$ 16.4, $J_{AX}$ 4.2 Hz), 5.11 br.s (1H, $H^2$), 5.96 br.s (1H, NH), 7.30–7.64 m (9H, $H_{arom}$), 9.50 br.s (1H, NHCO). $^{13}$C NMR spectrum (DMSO-$d_6$), δ, ppm: 44.08 ($CH_2$), 70.10 ($C^2$), 125.92, 128.28, 128.32, 130.40, 130.65, 131.39, 131.45, 133.57, 137.54, 140.84 ($C_{arom}$), 173.15 ($C^5$), 196.92 (C=O). Found, %: C 64.51; H 4.70; N 9.34. $C_{16}H_{14}N_2O_2S$. Calculated, %: C 64.41; H 4.73; N 9.39.

**2-[2-(4-Bromophenyl)-2-oxoethyl]-3,4-dihydro-1,3,4-benzothiadiazepin-5(2*H*)-one (VIId).** Yield 0.462 g (49%), mp 172–173°C. $^1$H NMR spectrum (DMSO-$d_6$), δ, ppm: 3.39 d.d (1H, $H_B$, $J_{AB}$ 16.4, $J_{BX}$ 5.1 Hz), 3.57 d.d (1H, $H_A$, $J_{AB}$ 16.4, $J_{AX}$ 4.2 Hz), 5.08 br.s (1H, $H^2$), 5.95 br.s (1H, NH), 7.46–7.61 m (4H, $H_{arom}$), 7.77 d (2H, $H_{arom}$, $J$ 8.7 Hz), 7.88 d (2H, $H_{arom}$, $J$ 8.7 Hz), 9.51 br.s (1H, NHCO). $^{13}$C NMR spectrum (DMSO-$d_6$), δ, ppm: 43.48 ($CH_2$), 69.07 ($C^2$), 128.47, 129.44, 130.93, 131.13, 131.92, 132.44, 132.74, 134.36, 136.27, 141.12 ($C_{arom}$), 173.91 ($C^5$), 196.64 (C=O). Found, %: C 50.87; H 3.47; N 7.49. $C_{16}H_{13}BrN_2O_2S$. Calculated, %: C 50.94; H 3.47; N 7.43.

**2-[2-(4-Nitrophenyl)-2-oxoethyl]-3,4-dihydro-1,3,4-benzothiadiazepin-5(2*H*)-one (VIIe).** Yield 0.318 g (37%), mp 187–188°C. $^1$H NMR spectrum (DMSO-$d_6$), δ, ppm: 3.41 d.d (1H, $H_B$, $J_{AB}$ 16.7, $J_{BX}$ 5.0 Hz), 3.60 br.d (1H, $H_A$, $J_{AB}$ 16.7 Hz), 5.10 br.s (1H, $H^2$), 5.98 br.s (1H, NH), 7.40–7.63 m (4H, $H_{arom}$), 8.17 d (2H, $H_{arom}$, $J$ 8.0 Hz), 8.37 d (2H, $H_{arom}$, $J$ 8.0 Hz), 9.52 br.s (1H, NHCO). $^{13}$C NMR spectrum (DMSO-$d_6$), δ, ppm: 44.12 ($CH_2$), 70.03 ($C^2$), 124.71, 128.49, 128.67, 130.49, 131.22, 133.60, 141.02, 130.72, 138.72, 146.13 ($C_{arom}$), 173.82 ($C^5$), 197.58 (C=O). Found, %: C 55.79; H 3.80; N 12.34. $C_{16}H_{13}N_3O_4S$. Calculated, %: C 55.97; H 3.82; N 12.24.

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