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Intramolecular Heterocyclization of α,β-Unsaturated Ketone Thiosemicarbazones

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Abstract—Intramolecular heterocyclization of thiosemicarbazones derived from α,β-enones under acid activation of one nucleophilic center afforded previously unknown 2-(2-arylethenyl)-2,3-dihydro-1,3,4-thiadiazoles. The transformation involves the thiol tautomer of thiosemicarbazone without participation of the conjugated carbon–carbon double bond.

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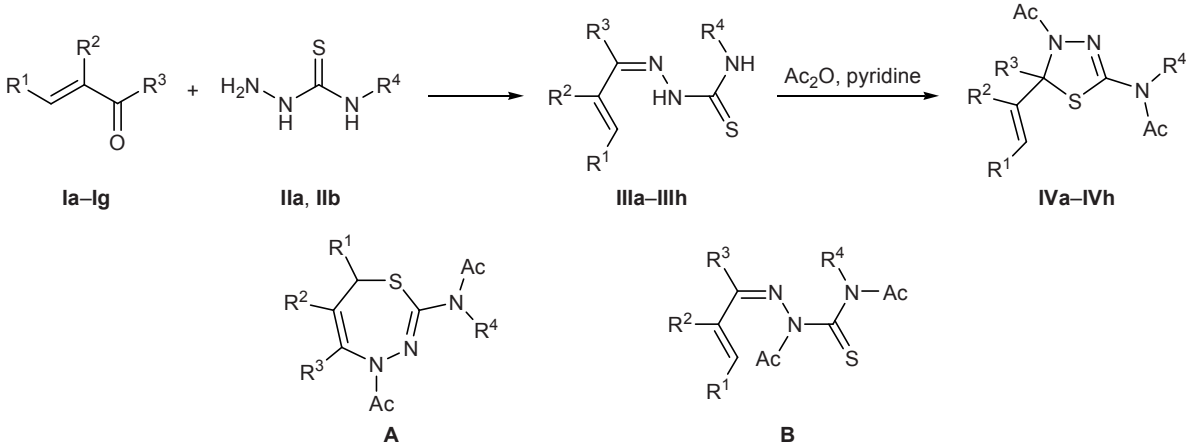
Dihydro-1,3,4-thiadiazoles exhibit a broad spectrum of biological activity, including antimicrobial, antiviral, and fungistatic [1]. Convenient starting compounds for the synthesis of dihydro-1,3,4-thiadiazoles are aldehyde and ketone thiosemicarbazones. However, published data on heterocyclizations of thiosemicarbazones are fairly scanty and are concerned mainly with thiosemicarbazones derived from aromatic, fatty–aromatic, and saturated acyclic carbonyl compounds [2, 3]. We previously described the synthesis of thiourea derivatives of carbo- and heterocyclic carbonyl compounds [4, 5]. Nether the use of multicenter conjugated substrates nor mechanistic or preparative aspects of heterocyclization of thiosemicarbazones were reported.

In the present work we examined intramolecular heterocyclization of multicenter α,β-enone thiosemicarbazones with a view to extend preparative potential of this reaction and obtain previously unknown dihydro-1,3,4-thiadiazoles which may be promising from the viewpoint of their antibiotic activity.

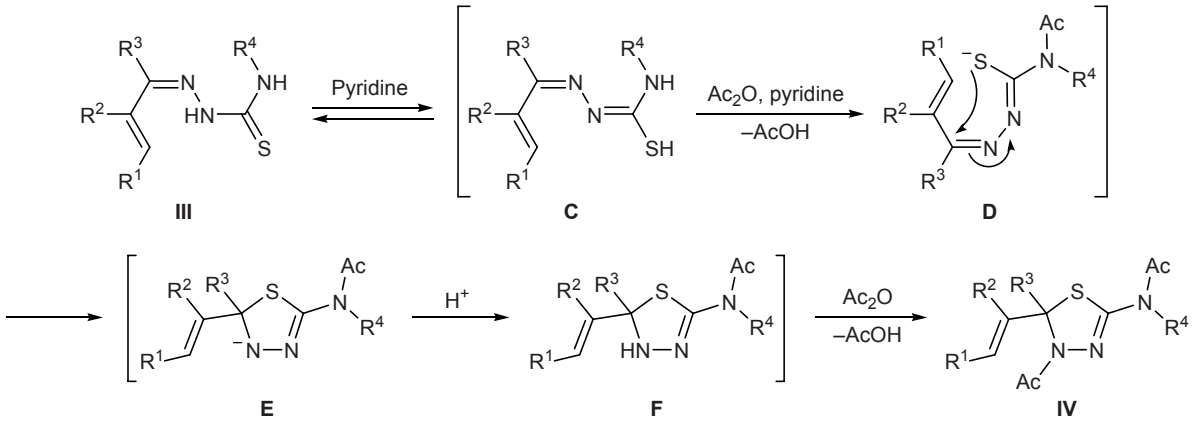
As substrates we used arylmethylidene(furfurylidene)methyl ketone thiosemicarbazones **IIIa**–**IIIh** which were prepared from the corresponding α,β-unsaturated ketones **Ia**–**Ig** and thiosemicarbazides **IIa** and **IIb** (Scheme 1). Heterocyclization of thiosemicarba-

Scheme 1.



I, R^1 = 2-furyl: R^2 = H, R^3 = Me (**a**); R^2R^3 = $(CH_2)_4$ (**b**), $(CH_2)_3$ (**c**), $(CH_2)_5$ (**d**); R^2R^3 = $(CH_2)_4$, R^1 = Ph (**e**), *o*-ClC_6H_4 (**f**), *p*-$MeOC_6H_4$ (**g**); **II**, R^4 = H (**a**), Ph (**b**); **III**, **IV**, R^1 = 2-furyl, R^2 = R^4 = H, R^3 = Me (**a**); R^4 = H, R^2R^3 = $(CH_2)_4$ (**b**), $(CH_2)_3$ (**c**), $(CH_2)_5$ (**d**); R^4 = H, R^2R^3 = $(CH_2)_4$, R^1 = Ph (**e**), *o*-ClC_6H_4 (**f**), *p*-$MeOC_6H_4$ (**g**); R^1 = 2-furyl, R^2 = H, R^3 = Me, R^4 = Ph (**h**).

Scheme 2.



zones **IIIa**–**IIIh** was performed in pyridine in the presence of acetic anhydride as acylating agent. Under these conditions, several alternative reaction pathways are possible: (1) cyclocondensation to give five-membered dihydro-1,3,4-thiadiazole derivatives **IVa**–**IVh**, (2) heterocyclization involving the conjugated C=C bond with formation of 1,3,4-thiadiazepine system (structure **A**), and (3) acylation of the NH groups in **III** with formation of *N*,*N*′-diacetyl derivatives like **B**.

Analysis of the spectral parameters of the isolated products showed that they have the structure of 2-(2-arylethenyl)-2,3-dihydro-1,3,4-thiadiazoles **IVa**–**IVh**. The reaction involves regioselective intramolecular attack by the nucleophilic sulfur atom on the carbon atom in the azomethine fragment, while the double C=C bond remains intact. Compounds **IVa**–**IVh** were formed in up to 82% yield. The IR spectra of thiadiazoles **IVa**–**IVh** contained absorption bands in the region 1610–1600 cm^{-1} due to stretching vibrations of the double C=C bond conjugated with the aromatic ring. Analogous absorption band is present in the spectra of the initial ketones. In the ^1H NMR spectra of thiadiazoles **IVa**–**IVh** we observed singlets at δ 5.75–5.79 ppm from the vinylic protons (compound **IVa** displayed two doublets from the vinylic protons at δ 6.18 and 6.24 ppm, J = 6.55 Hz), which excludes formation of seven-membered heterocyclic system **A**. In the ^{13}C NMR spectra of **IVa**–**IVh**, the C^2 atom in the thiadiazole ring resonated at δ_C 60.0–85.5 ppm, signals from the acetyl carbonyl carbon atoms were located at δ_C 168.1–170.4 ppm, the C^5 signal appeared at δ_C 135.8–142.1 ppm, and double-bonded carbon atoms in the substituent on C^2 had chemical shifts in the δ_C ranges 112.0–113.1 and 150.1–153 ppm. The ^{13}C NMR spectra of **IVa**–**IVh** lacked downfield signal at about δ_C 190 ppm, which is typical of thiocarbonyl group; therefore, alternative linear thiosemicarbazone structure **B** may be ruled out.

A probable reaction mechanism is illustrated by Scheme 2. It involves tautomeric transformation of the thionic form of thiosemicarbazone **III** into thiol **C** which undergoes acylation at the primary amino group to give intermediate **D** having activated nucleophilic sulfur center and two electrophilic centers: C=N carbon atom and β-carbon atom at the conjugated double bond. Attack by the sulfur atom on the C=N carbon atom gives structure **E** which is stabilized by addition of proton, and the subsequent acylation yields final dihydrothiazole **IV**.

To conclude, we were the first to effect heterocyclization of α,β-unsaturated ketone thiosemicarbazones. The cyclization is regioselective, and the products are substituted dihydro-1,3,4-thiadiazole derivatives (including those spiro-fused to a carbocycle) having unsaturated substituents.

EXPERIMENTAL

The ^1H and ^{13}C NMR spectra were recorded from solutions in DMSO-d_6 on a Bruker MSL-400 spectrometer (400 and 100 MHz, respectively); the chemical shifts were measured relative to tetramethylsilane as internal reference. The IR spectra were recorded in KBr on a Specord M-80 instrument. The progress of reactions and the purity of products were monitored by TLC on Silufol UV-254 plates using hexane–ethyl acetate–chloroform (2:2:1) as eluent; spots were visualized by treatment with iodine vapor.

Thiosemicarbazones IIIa–IIIh (*general procedure*). A solution of 0.05 mol of the corresponding ketone and 0.06 mol of thiosemicarbazide in 60 ml of isopropyl alcohol was heated for 4 h under reflux.

When the reaction was complete (TLC), the mixture was cooled to room temperature and kept for 30 min, and the precipitate was filtered off, washed with isopropyl alcohol, and recrystallized from the same solvent.

4-(2-Furyl)but-3-en-2-one thiosemicarbazone (IIIa). Yield 87%, mp 143–145°C. IR spectrum, ν, cm^{-1}: 3362, 3340 (NH_2), 3220 (NH), 3150–3100 (=CH), 3180–3140 (C–H, Fu), 2980–2860 (CH_3), 1605 (C=C), 1200 (C=S). ^{1}H NMR spectrum, δ, ppm: 1.89 s (1H, NH), 2.12 s (3H, CH_3), 6.19 d (1H, 3-H, J = 6.55 Hz), 6.74 d (4-H, J = 6.55 Hz), 6.79–6.83 m (2H, 3′-H, 4′-H), 7.29 s (1H, 5′-H), 10.53 s (2H, NH_2). Found, %: C 51.55; H 5.28; N 20.35. $C_9H_{11}N_3OS$. Calculated, %: C 51.65; H 5.30; N 20.08.

2-Furfurylidenecyclohexan-1-one thiosemicarbazone (IIIb). Yield 75%, mp 173–175°C. IR spectrum, ν, cm^{-1}: 3330, 3150 (NH_2); 3400 (NH); 3100–3100 (=C–H); 3170–3150 (C–H, Fu); 2940–2860 (CH_2); 1600 (C=C); 1200 (C=S). ^{1}H NMR spectrum, δ, ppm: 1.55 s (1H, NH), 2.12–2.42 m (8H, CH_2), 6.18 s (1H, =CH), 6.79–6.86 m (2H, 3′-H, 4′-H), 7.31 s (1H, 5′-H), 9.56 s (2H, NH_2). ^{13}C NMR spectrum, δ_C, ppm: 22.7, 22.9, 23.1, 41.1 (CH_2); 129.5 (=CH); 128.0 ($C^{4'}$); 134.4 ($C^{3'}$); 142.8 ($C^{2'}$); 148.4 ($C^{5'}$); 142.8 (=C); 154.8 (C=N); 184.5 (C=S). Found, %: C 57.57; H 6.23; N 19.97. $C_{12}H_{15}N_3OS$. Calculated, %: C 57.81; H 6.06; N 19.85.

2-Furfurylidenecyclopentan-1-one thiosemicarbazone (IIIc). Yield 68%, mp 190–191°C. IR spectrum, ν, cm^{-1}: 3200, 3110 (NH_2); 3390 (NH); 3120–3000 (=C–H); 3165–3140 (C–H, Fu); 2945–2864 (CH_2); 1665 (C=C); 1193 (C=S). ^{1}H NMR spectrum, δ, ppm: 1.85 s (1H, NH), 2.10–2.31 m (6H, CH_2), 6.33 s (1H, =CH), 6.78–6.86 m (2H, 3′-H, 4′-H), 7.35 s (1H, 5′-H), 9.67 s (2H, NH_2). ^{13}C NMR spectrum, δ_C, ppm: 24.6, 25.1, 46.8 (CH_2); 129.7 (=CH); 128.4 ($C^{4'}$); 135.1 ($C^{3'}$); 141.6 ($C^{2'}$); 149.1 ($C^{5'}$); 151.3 (=C); 149.5 (C=N); 181.7 (C=S). Found, %: C 57.57; H 6.23; N 19.97. $C_{11}H_{13}N_3OS$. Calculated, %: C 57.81; H 6.06; N 19.85.

2-Furfurylidenecycloheptan-1-one thiosemicarbazone (IIId). Yield 55%, mp 175–177°C. IR spectrum, ν, cm^{-1}: 3240, 3150 (NH_2); 3350 (NH); 3100–3012 (=C–H); 3195–3130 (C–H, Fu); 2935–2856 (CH_2); 1671 (C=C); 1195 (C=S). ^{1}H NMR spectrum, δ, ppm: 1.75 s (1H, NH), 2.05–2.41 m (10H, CH_2), 6.31 s (1H, =CH), 6.79–6.87 m (2H, 3′-H, 4′-H), 7.41 s (1H, 5′-H), 10.17 s (2H, NH_2). ^{13}C NMR spectrum, δ_C, ppm: 23.2, 24.9, 25.9, 26.4, 49.1 (CH_2); 129.9 (=CH); 128.3 ($C^{4'}$); 136.2 ($C^{3'}$); 141.1 ($C^{2'}$); 148.2 ($C^{5'}$); 156.4 (=C); 150.9 (C=N); 184.3 (C=S). Found, %: C 58.97; H 6.74; N 15.95. $C_{13}H_{17}N_3OS$. Calculated, %: C 59.29; H 6.51; N 15.96.

2-Benzylidenecyclohexan-1-one thiosemicarbazone (IIIe). Yield 65%, mp 154–156°C. IR spectrum, ν, cm^{-1}: 3250, 3145 (NH_2); 3210 (NH); 3180–3050 (=C–H); 3090–3010 (C–H_{arom}); 2935–2870 (CH_2); 1691 (C=C), 1205 (C=S). ^{1}H NMR spectrum, δ, ppm: 1.67 s (1H, NH), 2.32–2.52 m (8H, CH_2), 6.21 s (1H, =CH), 7.03–7.49 m (5H, H_{arom}), 10.06 s (2H, NH_2). ^{13}C NMR spectrum, δ_C, ppm: 22.3, 22.7, 23.3, 40.5 (CH_2); 127.8 (=CH); 121.2, 123.5, 123.7, 123.9, 124.5, 125.1 (C_{arom}); 149.5 (=C); 153.5 (C=N); 183.1 (C=S). Found, %: C 64.51; H 6.64; N 16.52. $C_{14}H_{17}N_3S$. Calculated, %: C 64.83; H 6.61; N 16.20.

2-(2-Chlorobenzylidene)cyclohexan-1-one thiosemicarbazone (IIIf). Yield 69%, mp 158–159°C. IR spectrum, ν, cm^{-1}: 3310, 3150 (NH_2); 3215 (NH); 3070–3045 (=C–H); 3095–3005 (C–H_{arom}); 2940–2825 (CH_2); 1690 (C=C); 1195 (C=S). ^{1}H NMR spectrum, δ, ppm: 1.69 s (1H, NH), 2.31–2.55 m (8H, CH_2), 6.15 s (1H, =CH), 7.12–7.51 m (4H, H_{arom}), 10.16 s (2H, NH_2). ^{13}C NMR spectrum, δ_C, ppm: 25.1, 27.7, 28.3, 39.6 (CH_2); 127.5 (=CH); 121.1, 122.9, 123.1, 123.8, 124.8, 135.2 (C_{arom}); 147.5 (=C); 154.1 (C=N); 185.8 (C=S). Found, %: C 57.61; H 5.61; N 14.52. $C_{14}H_{16}ClN_3OS$. Calculated, %: C 57.23; H 5.49; N 14.30.

2-(4-Methoxybenzylidene)cyclohexan-1-one thiosemicarbazone (IIIg). Yield 73%, mp 161–163°C. IR spectrum, ν, cm^{-1}: 3321, 3148 (NH_2); 3217 (NH); 3095–3053 (=C–H); 3091–3011 (C–H_{arom}); 2960–2820 (CH_2); 1685 (C=C); 1204 (C=S). ^{1}H NMR spectrum, δ, ppm: 1.71 s (1H, NH), 1.91–2.45 m (8H, CH_2), 3.75 s (3H, CH_3O), 6.21 s (1H, =CH), 6.98–7.19 m (4H, H_{arom}), 10.12 s (2H, NH_2). ^{13}C NMR spectrum, δ_C, ppm: 25.4, 27.9, 28.4, 38.1 (CH_2); 60.3 (CH_3O); 121.3, 123.2, 123.4, 123.5, 124.8, 135.2 (C_{arom}); 131.4 (=CH); 139.6 (=C); 149.1 (C=N); 183.9 (C=S). Found, %: C 57.61; H 5.61; N 14.52. $C_{15}H_{19}N_3OS$. Calculated, %: C 57.23; H 5.49; N 14.30.

4-(2-Furyl)but-3-en-2-one 4-phenylthiosemicarbazone (IIIh). Yield 51%, mp 191–193°C. IR spectrum, ν, cm^{-1}: 3320 (NH), 3227 (NH), 3096–3061 (=C–H), 3090–3006 (C–H_{arom}), 2965–2819 (CH_3), 1693 (C=C), 1203 (C=S). ^{1}H NMR spectrum, δ, ppm: 1.73 s (1H, NH), 1.31 s (3H, CH_3), 6.21 d (1H, 3-H, J = 6.55 Hz), 6.25 d (1H, 4-H, J = 6.55 Hz), 6.71–6.82 m (2H, 3′-H, 4′-H), 6.98–7.19 m (5H, H_{arom}), 7.3 d (1H, 5′-H), 10.19 s (2H, NH_2). Found, %:

C 63.59; H 5.15; N 14.69. $C_{15}H_{15}N_3OS$. Calculated, %: C 63.13; H 5.30; N 14.73.

1,3,4-Thiadiazoles IVa–IVh (*general procedure*). A solution of 0.015 mol of thiosemicarbazone **IIIa–IIIh** and 0.03 mol of acetic anhydride in 30 ml of pyridine was stirred for 4 h at 50°C. The mixture was cooled and concentrated under reduced pressure, and the precipitate was filtered off, washed with ethanol, and recrystallized from ethanol.

3-Acetyl-5-acetylamino-2-methyl-2-[2-(2-furyl)-ethenyl)]-2,3-dihydro-1,3,4-thiadiazole (IVa). Yield 63%, mp 160–162°C. IR spectrum, ν, cm^{-1}: 3150 (NH), 1690 (amide I), 1610 (C=N), 1520 (amide II), 3180–3140 (C–H, Fu), 1650–1625 (C=C). ^{1}H NMR spectrum, δ, ppm: 1.52 s and 2.15 s (3H each, $COCH_3$), 2.21 s (3H, CH_3), 6.20 d (1H, 2-CH, J = 6.55 Hz), 6.63 d (1H, =CH, J = 6.55 Hz), 6.67–6.89 m (2H, 3′-H, 4′-H), 7.32 s (1H, 5′-H), 9.6 s (1H, NH). Found, %: C 54.10; H 5.50; N 13.96. $C_{13}H_{15}N_3O_3S$. Calculated, %: C 53.61; H 5.15; N 14.34.

1-Acetyl-3-acetylamino-6-furfurylidene-4-thia-1,2-diazaspiro[4.5]dec-2-ene (IVb). Yield 62%, mp 187–190°C. IR spectrum, ν, cm^{-1}: 3140 (NH), 1680 (amide I), 1615 (C=N), 1540 (amide II), 3180–3140 (C–H, Fu), 1660–1630 (C=C), 740–710 (δCH). ^{1}H NMR spectrum, δ, ppm: 1.22–2.32 m (8H, CH_2), 1.92 s and 2.45 s (3H each, $COCH_3$), 5.8 s (1H, C=C), 6.71–6.82 m (2H, 3′-H, 4′-H), 7.32 s (1H, 5′-H), 8.29 s (1H, NH). ^{13}C NMR spectrum, δ_C, ppm: 26.8, 28.7, 31.4, 56.2 (CH_2); 85.1 (C_{spiro}); 36.3, 38.2 (CO**C**H_3); 129.5 (=CH); 128.1 ($C^{4'}$); 134.5 ($C^{3'}$); 141.5 ($C^{2'}$); 149.1 ($C^{5'}$); 142.1 (C=N); 144.1 (CH=**C**); 178.9, 179.8 (C=O). Found, %: C 57.35; H 5.63; N 12.60. $C_{16}H_{19}N_3O_3S$. Calculated, %: C 57.69; H 5.74; N 12.60.

1-Acetyl-3-acetylamino-6-furfurylidene-4-thia-1,2-diazaspiro[4.4]non-2-ene (IVc). Yield 59%, mp 167–169°C. IR spectrum, ν, cm^{-1}: 3390 (NH), 1680 (amide I), 1600 (C=N), 1500 (amide II), 3180–3140 (=C–H), 1664–1633 (C=C). ^{1}H NMR spectrum, δ, ppm: 1.22–1.72 m (6H, CH_2), 1.52 s and 2.15 s (3H each, $COCH_3$), 6.1 s (1H, =CH), 6.72–6.82 m (2H, 3′-H, 4′-H), 7.29 s (1H, 5′-H), 8.8 s (1H, NH). ^{13}C NMR spectrum, δ_C, ppm: 27.9, 30.3, 59.2 (CH_2); 83.2 (C_{spiro}); 39.3, 44.2 (CO**C**H_3); 129.1 (=CH); 128.3 ($C^{4'}$); 134.9 ($C^{3'}$); 141.2 ($C^{2'}$); 149.7 ($C^{5'}$); 141.9 (C=N); 150.6 (CH=**C**); 173.9, 179.1 (C=O). Found, %: C 56.44; H 5.37; N 13.96. $C_{15}H_{17}N_3O_3S$. Calculated, %: C 56.41; H 5.37; N 13.16.

1-Acetyl-3-acetylamino-6-furfurylidene-4-thia-1,2-diazaspiro[4.6]undec-2-ene (IVd). Yield 56%, mp 152–155°C. IR spectrum, ν, cm^{-1}: 3480 (NH), 1685 (amide I), 1600 (C=N), 1490 (amide II), 3200–3150 (C–H, Fu), 1630–1625 (C=C). ^{1}H NMR spectrum, δ, ppm: 1.32–2.22 m (10H, CH_2), 1.75 s and 2.25 s (3H each, $COCH_3$), 5.9 s (1H, =CH), 6.77–6.85 m (2H, 3′-H, 4′-H), 7.3 s (1H, 5′-H), 8.9 s (1H, NH). ^{13}C NMR spectrum, δ_C, ppm: 26.8, 28.7, 28.6, 31.4, 56.2 (CH_2); 84.7 (C_{spiro}); 38.1, 45.4 (CH_3); 127.2 (=CH); 128.6 ($C^{4'}$); 133.9 ($C^{3'}$); 142.1 ($C^{2'}$); 148.9 ($C^{5'}$); 139.9 (C=N); 145.9 (CH=**C**); 175.9, 177.1 (C=O). Found, %: C 58.34; N 6.01; N 12.01. $C_{18}H_{21}N_3O_3S$. Calculated, %: C 58.77; N 6.09; N 12.09.

1-Acetyl-3-acetylamino-6-benzylidene-4-thia-1,2-diazaspiro[4.5]dec-2-ene (IVe). Yield 64%, mp 170–171°C. IR spectrum, ν, cm^{-1}: 3350 (NH), 1650 (amide I), 1600 (C=N), 1500 (amide II), 3180–3140 (C–H_{arom}), 1640–1635 (C=C). ^{1}H NMR spectrum, δ, ppm: 1.23–2.38 m (8H, CH_2), 1.32 s and 1.95 s (3H each, $COCH_3$), 6.2 s (1H, =CH), 7.25–7.89 m (5H, H_{arom}), 8.9 s (1H NH). ^{13}C NMR spectrum, δ_C, ppm: 26.9, 28.6, 32.1, 57.8 (CH_2); 87.3 (C_{spiro}); 35.2, 39.1 (CH_3); 126.7 (=CH); 122.1, 123.4, 123.9, 124.1, 125.1, 126.4 (C_{arom}); 140.5 (C=N); 143.9 (CH=**C**); 175.3, 177.6 (C=O). Found, %: C 62.34; H 6.16; N 12.21. $C_{18}H_{21}N_3O_2S$. Calculated, %: C 62.95; H 6.16; N 12.23.

1-Acetyl-3-acetylamino-6-(2-chlorobenzylidene)-4-thia-1,2-diazaspiro[4.5]dec-2-ene (IVf). Yield 51%, mp 167–169°C. IR spectrum, ν, cm^{-1}: 3410 (NH), 1690 (amide I), 1600 (C=N), 1500 (amide II), 3180–3140 (C–H_{arom}), 1650–1645 (C=C). ^{1}H NMR spectrum, δ, ppm: 1.25–1.78 m (8H, CH_2), 1.42 s and 1.85 s (3H each, $COCH_3$), 6.3 s (1H, =CH), 7.15–7.49 m (4H, H_{arom}), 9.1 s (1H, NH). ^{13}C NMR spectrum, δ_C, ppm: 26.8, 28.5, 32.4, 58.5 (CH_2); 80.6 (C_{spiro}); 31.6, 35.8 (CH_3); 127.1 (=CH); 122.3, 123.6, 124.1, 125.1, 125.8, 129.3 (C_{arom}); 136.2 (C=N); 137.6 (CH=**C**); 174.9, 178.1 (C=O). Found, %: C 57.34; H 5.49; N 11.21. $C_{18}H_{20}ClN_3O_2S$. Calculated, %: C 57.21; H 5.33; N 11.12.

1-Acetyl-3-acetylamino-6-(4-methoxybenzylidene)-4-thia-1,2-diazaspiro[4.5]dec-2-ene (IVg). Yield 56%, mp 170–172°C. IR spectrum, ν, cm^{-1}: 3380 (NH), 1685 (amide I), 1600 (C=N), 1480 (amide II), 3190–3110 (C–H_{arom}), 1650–1645 (C=C). ^{1}H NMR spectrum, δ, ppm: 1.23–2.39 m (8H, CH_2), 1.42 s and 2.14 s (3H each, $COCH_3$), 6.5 s (1H, =CH), 7.15–7.69 m (4H, H_{arom}), 9.2 s (1H, NH). ^{13}C NMR spectrum, δ_C, ppm: 25.9, 29.1, 32.5, 57.9 (CH_2); 86.3 (C_{spiro}); 37.4, 39.6 (CH_3); 60.3 (CH_3O); 125.3 (=CH); 122.4, 122.7, 123.3, 123.7, 124.9, 134.2 (C_{arom}); 135.8

(C=N); 138.1 (CH=**C**); 174.8, 177.4 (C=O). Found, %: C 61.34; H 6.31; N 11.21. $C_{19}H_{23}N_3O_4S$. Calculated, %: C 61.10; H 6.21; N 11.25.

3-Acetyl-5-[acetyl(phenyl)amino]-2-[2-(2-furyl)-ethenyl]-2-methyl-2,3-dihydro-1,3,4-thiadiazole (IVh). Yield 49%, mp 160–162°C. IR spectrum, ν, cm^{-1}: 3380 (NH), 1685 (amide I), 1600 (C=N), 1480 (amide II), 3190–3110 (C–H_{arom}), 1650–1645 (C=C). ^{1}H NMR spectrum, δ, ppm: 1.71 s and 2.09 s (3H each, $COCH_3$), 2.07 s (3H, NCH_3), 6.05 d (1H, 2-CH, J = 6.55 Hz), 6.12 d (1H, 2-CH=C**H**, J = 6.55 Hz), 6.75–6.83 m (2H, 3′-H, 4′-H), 7.32 s (1H, 5′-H), 7.2–7.6 m (5H, H_{arom}), 9.4 s (1H NH). Found, %: C 62.27; H 5.05; N 10.94. $C_{19}H_{19}N_3O_3S$. Calculated, %: C 61.77; H 5.18; N 11.37.

REFERENCES

1. Martins Alho, M.A., Moglioni, A.G., Brousse, B., Moltrasio, G.Y., and D'Accorso, N.B., *Arkivoc*, 2000, part (iv), p. 627.
2. Ueda, Y., Toyooka, F., Kazuichi, F., Kouhei, T., and Shibuya, M., *J. Org. Chem*., 1980, vol. 45, p. 1476.
3. Andreae, S., Schmitz, E., and Seeboth, H., *J. Prakt. Chem*., 1986, vol. 328, p. 205.
4. Sazonov, A.A., Frantsuzov, A.A., and Klochkova, I.N., *Izv. Vyssh. Uchebn. Zaved., Ser. Khim. Khim. Tekhnol*., 2005, vol. 48, p. 127.
5. Klochkova, I.N., Sazonov, A.A., Anis'kov, A.A., Voronov, I.I., and Frantsuzov, A.A., *Izv. Saratov. Univ., Ser. Khim. Biol. Ekol*., 2006, no. 6, p. 35.