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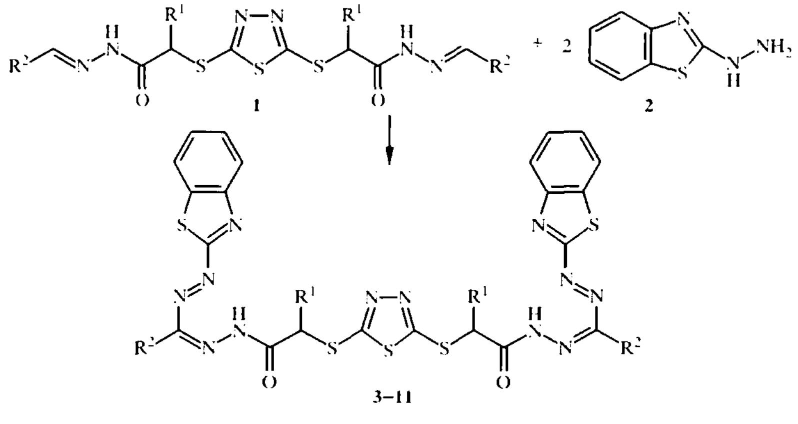
NEW DIFORMAZANES OBTAINED FROM DIHYDRAZIDES OF S,S'-(1,3,4-THIADIAZOL-2,5-DIYL)-BIS(MERCAPTOACETIC) OR -(2-MERCAPTOPROPIONIC) ACIDS

A. Rutavichyus and S. Valyulene

Hetaryldiformazanes have been prepared for the first time as the result of autooxidation of dihydrazones formed in the reaction of bis(arylhydrazones) of S,S'-(1,3,4-thiadiazol-2,5-diyl)bis(mercaptoacetic) or -(2-mercaptopropionic) acid with 2-hydrazinobenzothiazole. Some structural characteristics of these diformazanes were confirmed by IR and ^{1}H NMR spectroscopy.

Keywords: diformazanes, dihydrazone of S,S'-(1,3,4-thiadiazol-2,5-diyl)bis(mercaptoacetic) acid, dihydrazone of S,S'-(1,3,4-thiadiazol-2,5-diyl)bis(2-mercaptopropionic) acid, ^{1}H NMR spectra.

According to the literature [1], hetarylformazanes are highly sensitive and specific reagents for the determination of various metals. In view of the presence in formazanes of a chelating ring capable of bonding with microelements found in the fermentation systems of microorganisms, they may be used as medicinal preparations [2]. Hetarylformazanes prepared from 2-benzothiazolyl-, 2-benzimidazolyl-, 2-benzoxazolyl-, and 2-quinazolylhydrazones have been described in the literature [1, 3, 4].



3, 4 R^1 = H, **5-11** R^1 = Me; **3** R^2 = 4-ClC_6H_4; **4, 5** R^2 = 2,3-$(MeO)_2C_6H_3$;
6 R^2 = 4-$Me_2NC_6H_4$; **7** R^2 = 2,4$(HO)_2C_6H_3$; **8** R^2 = 3-$NO_2C_6H_4$; **9** R^2 = 3,4-(OCH_2O)-C_6H_3;
10 R^2 = C_4H_3O; **11** R^2 = 2-BrC_6H_4

Institute of Chemistry, Vilnius LT-2600, Lithuania; e-mail: lorka@ktl.mii.lt. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 4, 547-550, April, 2000. Original article submitted February 24, 1999; revision submitted September 15, 1999.

In the present work hetaryldiformazanes based on hydrazones of type **1**, formed from bis(arylhydrazones) of S,S'-(1,3,4-thiadiazol-2,5-diyl)bis(mercaptoacetic) or -(2-mercaptopropionic) acid (**1**) and 2-hydrazinobenzothiazole (**2**), have been prepared for the first time. Hetarylformazanes **3-11** are formed as a result of autooxidation of the corresponding dihydrazones **1** with 2-hydrazinobenzothiazole **2** in pyridine in the presence of sodium acetate.

Formazanes can exist either in the form of six-membered chelate rings including an intramolecular hydrogen bond involving proton of the NH group or in the form of an extended structure. The IR spectra of diformazanes **3-11** do not contain ν NH absorption bands in the 3500-3100 cm^{-1} region. By analogy with literature data [4] it may be concluded that the formazanes **3-11** exist in the chelate form. However we have established that they exist in the extended form in solutions. It was established from examination of the ^{1}H NMR spectra in DMSO that the signal of the NH proton is found in the 11-12 ppm region (Table 1). For the chelate structure with an intramolecular hydrogen bond the NH proton signal would appear at weaker field, sometimes reaching 16 ppm for chelate structures [5].

In DMSO solution hetaryldiformazanes **3-11**, like the initial hydrazones [5, 6], exist as mixture of two (*E'*, *Z'*) forms which follows from the doubling of the signals for the protons of the CH_2CO, CHCO, and NH groups (Table 1).

The signal of the NH proton in our diformazanes is, as expected, a doubled singlet except for compound **7** in which the signal is a doubled doublet. Apparently this may be explained, as in the case of the initial hydrazone [5], by the formation of a rigid chelate grouping bonding the unshared electron pair of the nitrogen atom in the azine unit with the proton of the *o*-hydroxy group of phenyl radical.

Diformazanes **3-11** form intensely green colored complexes with zinc, copper, and cobalt salts in water. Solutions of the formazanes in organic solvents change color depending on the nature of the solvent (for example, acetone solutions are deep red while DMSO and DMF solutions are blue). These solutions change to yellow color on the addition of a mineral acid (HCl, H_2SO_4), but this color change is reversible.

The elemental analyses and the increased integral intensity of the aromatic protons in the ^{1}H NMR spectra indicate that, in the solid state, diformazanes **3-11** contain 1 or 2.5 molecules of pyridine. This was confirmed by the IR spectra which contains an absorption band at about 1600 cm^{-1}, characteristic of pyridine. Similar presence of pyridine has been noted for formazanes prepared previously [4].

TABLE 1. ^{1}H NMR Spectra of Diformazanes **3-11**

Compound	Chemical shifts, δ, ppm
3	4.13 and 4.55 (2H, s, CH_2CO); 6.90-8.20 (13H, m, Ar); 11.78 and 11.85 (1H, s, NH)
4	1.57 (6H, d, CH_3O); 4.12 and 4.56 (2H, s, CH_2CO); 6.90-8.20 (12H, m, Ar)
5	0.76 (3H, d, $\underline{CH}_3CH$); 1.55 (6H, d, CH_3O); 4.44 and 5.26 (1H, q, $CH_3\underline{CH}$); 6.80-8.10 (12H, m, Ar); 11.63 and 11.87 (1H, s, NH)
6	1.56 (3H, d, $\underline{CH}_3CH$); 2.97 (6H, s, CH_3N); 4.45 and 5.25 (1H, q, $CH_3\underline{CH}$); 6.80-8.20 (18H, m, Ar); 11.24 and 11.36 (1H, s, NH)
7	1.57 (3H, d, $\underline{CH}_3CH$); 4.44 and 5.18 (1H, q, $CH_3\underline{CH}$); 6.25-8.3 (17H, m, Ar); 9.76 (1H, m, OH); 11.03 (1H, s, OH); 11.39 and 11.83 (1H, d, NH)
8	1.53 (3H, d, $\underline{CH}_3CH$); 4.48 and 5.30 (1H, q, $CH_3\underline{CH}$); 7.00-8.20 (18H, m, Ar); 11.91 and 12.08 (1H, d, NH)
9	1.55 (3H, d, $\underline{CH}_3CH$); 4.46 and 5.26 (1H, q, $CH_3\underline{CH}$); 6.05 (2H, s, OCH_2O); 7.00-8.20 (17H, m, Ar); 11.54 and 11.72 (1H, s, NH)
10	1.56 (3H, d, $\underline{CH}_3CH$); 4.45 and 5.17 (1H, q, $CH_3\underline{CH}$); 6.50-8.20 (17H, m, Ar and furyl); 11.61 and 11.76 (1H, s, NH)
11	1.58 (3H, d, $\underline{CH}_3CH$); 4.46 and 5.28 (1H, q, $CH_3\underline{CH}$); 7.00-8.20 (18H, m, Ar); 11.87 and 12.09 (1H, s, NH)

TABLE 2. Characteristics of Compounds **3-11**

Compound	Empirical formula	Found, % Calculated, %				mp, °C	Yield, %
		C	H	N	S		
3	$C_{34}H_{22}Cl_2N_{12}O_2S_5 \cdot C_5H_5N$	50.19 50.41	2.98 2.85	19.32 19.11	16.66 16.82	209-211	81
4	$C_{38}H_{32}N_{12}O_6S_5 \cdot C_5H_5N$	52.45 52.63	3.91 3.71	18.25 18.13	15.80 15.96	~100 (dec.)	65
5	$C_{40}H_{36}N_{12}O_6S_5 \cdot C_5H_5N$	53.31 53.52	4.19 4.00	17.42 17.64	15.28 15.53	126-128	78
6	$C_{40}H_{38}N_{14}O_2S_5 \cdot 2.5C_5H_5N$	57.22 57.33	4.35 4.44	20.35 20.57	14.91 14.72	130-131	83
7	$C_{36}H_{28}N_{12}O_6S_5 \cdot 2.5C_5H_5N$	53.77 54.02	3.69 3.59	18.20 18.37	14.88 15.02	111-114	86
8	$C_{36}H_{26}N_{14}O_6S_5 \cdot 2.5C_5H_5N$	52.55 52.74	3.55 3.32	20.71 20.50	14.37 14.66	88-90	78
9	$C_{38}H_{28}N_{12}O_6S_5 \cdot 2.5C_5H_5N$	54.80 55.03	3.62 3.51	18.08 17.97	14.51 14.69	85-86	89
10	$C_{32}H_{24}N_{12}O_4S_5 \cdot 2.5C_5H_5N$	53.88 53.75	3.39 3.48	19.77 19.94	16.01 16.31	110-112	80
11	$C_{36}H_{26}Br_2N_{12}O_2S_5 \cdot 2.5C_5H_5N$	49.35 49.66	3.39 3.12	16.98 16.89	13.65 13.81	125-127	72

EXPERIMENTAL

^1H NMR spectra of DMSO-d_6 solutions with TMS as internal standard were recorded on a Bruker AM-300 (300 MHz) spectrometer. IR spectra of KBr discs were recorded on a UR-10 instrument. ^1H NMR spectroscopic data are cited in Table 1.

{5,5'-[1,3,4-Thiadiazol-2,5-di(mercaptoacetyl)]-3,3'-di(4-chlorophenyl)-1,1'-dibenzothiazolyl}diformazane (3). 2-Hydrazinobenzothiazole **2** (0.99 g, 6 mmol), sodium acetate (0.2 g) and water (0.5 ml) were added to a solution of the corresponding hydrazone **1** (1.62 g, 3 mmol) in pyridine (60 ml), the mixture was kept for 4 days, pyridine was partially evaporated, the mixture was diluted with water, the precipitated crystals were filtered off and washed with water.

{5,5'-[1,3,4-Thiadiazol-2,5-di(mercaptoacetyl)]-3,3'-di(2,3-dimethoxyphenyl)-1,1'-dibenzothiazolyl}-diformazane (4) was prepared analogously.

{5,5'-[1,3,4-Thiadiazol-2,5-di(2-mercaptopropionyl)]-3,3'-di(2,3-dimethoxyphenyl)-1,1'-dibenzothiazolyl}diformazane (5). 2-Hydrazinobenzothiazole **2** (0.99 g, 6 mmol), sodium acetate (0.2 g) and water (0.5 ml) were added to a solution of the corresponding hydrazone **1** (1.86 g, 3 mmol) in pyridine (50 ml), the mixture was kept for 5 days, pyridine was partially evaporated, the mixture was diluted with water, the waxy product was triturated in cold water and left for 5 days, after which the crystals were filtered off and washed with water.

{5,5'-[1,3,4-Thiadiazol-2,5-di(2-mercaptopropionyl)]-3,3'-di(4-dimethylaminophenyl)-1,1'-dibenzothiazolyl}diformazane (6), {5,5'-[1,3,4-Thiadiazol-2,5-di(2-mercaptopropionyl)]-3,3'-di(2,4-dihydroxyphenyl)-1,1'-dibenzothiazolyl}diformazane (7), {5,5'-[1,3,4-Thiadiazol-2,5-di(2-mercaptopropionyl)]-3,3'-di(3-nitrophenyl)-1,1'-dibenzothiazolyl}diformazane (8), {5,5'-[1,3,4-Thiadiazol-2,5-di(2-mercaptopropionyl)]-3,3'-di(3,4-methylenedioxyphenyl)-1,1'-dibenzothiazolyl}diformazane (9), {5,5'-[1,3,4-Thiadiazol-2,5-di(2-mercaptopropionyl)]-3,3'-di(furyl)-1,1'-dibenzothiazolyl}diformazane (10), and {5,5'-[1,3,4-Thiadiazol-2,5-di(2-mercaptopropionyl)]-3,3'-di(2-bromophenyl)-1,1'-dibenzothiazolyl}diformazane (11), were prepared analogously.

The characteristics of compounds **3-11** are cited in Table 2.

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