OXIDATION AND REDUCTION OF SOME DERIVATIVES OF BENZO-2,1,3-THIADIAZOLE

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In the reduction of 4-hydroxy-7-phenylazobenzo-2,1,3-thiadiazole and of 4-hydroxy-7-nitrobenzo-2,1,3-thiadiazole with sodium hydrosulfite, 7-amino-4-hydroxybenzo-2,1,3-thiadiazole is obtained. The reduction of 4-hydroxybenzo-2,1,3-thiadiazole leads to 2,3-diaminophenol which forms 5-hydroxyquinoxaline with the bisulfite derivative of glyoxal. The oxidation of 4-hydroxy- and 4-aminobenzo-2,1,3-thiadiazoles with potassium dichromate in an acid medium has yielded 4,7-dioxo-4,7-dihydrobenzo-2,1,3-thiadiazole, which has been converted into 4,7-dihydroxybenzo-2,1,3-thiadiazole and 4,7-di(hydroxyimino)-4,7-dihydrobenzo-2,1,3-thiadiazole.

Azophenol derivatives based on benzo-2,1,3-thiadiazole are dyes for polyester and polyamide fibers [1]. Nevertheless, the structure of the products obtained from diazotized aromatic amines and 4-hydroxybenzo-2,1,3-thiadiazole (I) has not been established [1, 2]. The present work was devoted to an investigation of the products of the azo coupling and the oxidation and reduction of (I). The azo coupling of (I) with diazotized aniline forms 4-hydroxy-7-phenylazobenzo-2,1,3-thiadiazole (II). On reaction with sodium hydrosulfite the latter gives 7-amino-4-hydroxybenzo-2,1,3-thiadiazole (III), which was characterized in the form of the diacetyl derivative (IV). Compound (IV) proved to be identical with a substance obtained from (III) the structure of which has been established in the following way.

The reaction of (I) with dimethyl sulfate formed 4-methoxybenzo-2,1,3-thiadiazole (V). The latter was readily nitrated by sodium nitrate in concentrated sulfuric acid, giving a mixture of 5-nitro and 7-nitro derivatives of (V), which were separated by a published method [3]. 4-Methoxy-7-nitrobenzo-2,1,3-thiadiazole (VI) was hydrolyzed with a 1% solution of caustic soda to 4-hydroxy-7-nitrobenzo-2,1,3-thiadiazole (VII) [4]. On reaction with sodium hydrosulfite, compound (VII) formed (III).

Thus, in the azo coupling of 4-hydroxybenzo-2,1,3-thiadiazole with diazotized aromatic amines the azo group enters position 7.

The oxidation of (I) with potassium dichromate in an acid medium at room temperature gave a mixture of substances from which it was possible to isolate about 5% of 4,7-dioxo-4,7-dihydrobenzo-2,1,3-thiadiazole (VIII). The latter proved to be identical with the compound obtained by the oxidation of (III) and of 4,7-diaminobenzo-2,1,3-thiadiazole (IX) [5].

The oxidation of 4-aminobenzo-2,1,3-thiadiazole (X) also gave a mixture of substances, from which it was possible to isolate about 5% of (VIII). The latter was readily reduced by sodium hydrosulfite to 4,7-dihydroxybenzo-2,1,3-thiadiazole (XI), and on reaction with hydroxylamine hydrochloride in ethanol it gave 4,7-di(hydroxyimino)-4,7-dihydrobenzo-2,1,3-thiadiazole (XII).

The reduction of (I) with stannous chloride in hydrochloric acid led to 2,3-diaminophenol, which with the bisulfite derivative of glyoxal formed 5-hydroxyquinoxaline (XIII) [6].

The compound (I) required for the present investigation was synthesized by means of the Bucherer reaction. The method described previously [7] was improved in the present work, which led to an increase in the yield of (I) and to a reduction in the time of synthesis.

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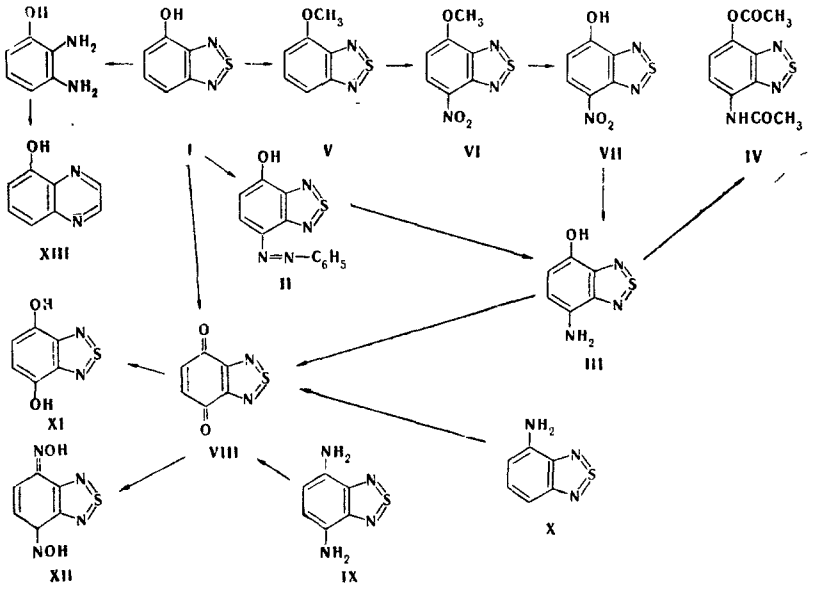

EXPERIMENTAL

4-Hydroxybenzo-2,1,3-thiadiazole (I). A mixture of 25 g (165 mmoles) of 4-aminobenzo-2,1,3-thiadiazole [8], 600 ml of water, and 100 g (525 mmoles) of sodium metabisulfite was boiled for 10 h and was cooled. The product was worked up as described in the literature [7]. In this process it was necessary to use: 150 ml of water for washing out traces of the starting material, 500 ml of 10% caustic soda for making the mixture alkaline, and 300 ml of concentrated sulfuric acid + 900 ml of water for acidifying the reaction mixture. The yield of (I) was 21.4 g (85.6%), mp 128°C (from gasoline) [9] or 114-115°C (from water) [9].

4-Hydroxy-7-phenylazobenzo-2,1,3-thiadiazole (II). At 0-5°C, 8.2 g (119 mmoles) of sodium nitrite in 60 ml of water was added dropwise to a solution of 10.2 g (110 mmoles) of aniline in 20 ml of concentrated hydrochloric acid and 40 ml of water. The diazonium solution obtained was kept at room temperature for 10 min and was then added to a solution of 15.2 g (0.1 mole) of (I), 32 g (0.3 mole) of sodium carbonate, and 900 ml of water at 0-2°C. After the end of the addition, the mixture was kept at the same temperature for 10-15 min and was then acidified to pH 2-3 and filtered. The residue on the filter was washed with water to neutrality and dried. This gave 25 g (98.7%) of a bright-red substance readily soluble in organic solvents and sparingly soluble in water with mp 178-179°C (from ethanol). Found, %: N 21.6; S 12.4. $C_{12}H_8N_4OS$. Calculated, %: N 21.9; S 12.5.

7-Amino-4-hydroxybenzo-2,1,3-thiadiazole (III). a) A mixture of 10 g (39 mmoles) of (II) and 100 g (475 mmoles) of sodium hydrosulfite was added to 700 ml of water heated to 85-90°C, and the mixture was boiled for 1-2 min. Then it was filtered and the precipitate that separated out when the hot filtrate was cooled was filtered off and dried. Weight 2.7 g. The mother solution was extracted three times with ether. Elimination of the ether gave another 0.3 g of product. Total weight 3 g (45%). Bright-red substance readily soluble in organic solvents and in 10% caustic soda solution, and giving a brown coloration with an aqueous solution of ferric chloride; mp 224-226°C (decomp., from toluene). Found, %: N 25.2; S 19.2. $C_6H_5N_3OS$. Calculated, %: N 25.1; S 19.1.

b) A mixture of 3 g (15.2 mmoles) of (VII) and 30 g (143 mmoles) of sodium hydrosulfite was added to 210 ml of water heated to 85-90°C, and the mixture was boiled for 1-2 min. The product was worked up as in method (a). The total yield was 1.2 g (47.25%), mp 224-226°C (decomp., from toluene).

4-Acetoxy-7-acetylaminobenzo-2,1,3-thiadiazole (IV). A mixture of 1 g (6 mmoles) of (III) obtained by method (a) and 5 ml of acetic anhydride was boiled for 1 h, and then the reaction mixture was poured into 50 ml of water and the resulting mixture was boiled for 1-2 min and was filtered. The compound (IV) that deposited when the filtrate was cooled was filtered off, washed with water, and dried. Weight 0.6 g. From the filtrate chloroform extracted a further 0.45 g of the substance. The total weight of (IV) was 1.05 g (70%), mp 164-165°C (from ethanol), giving no depression of the melting point with the diacetyl derivative obtained from (III) (b). Found, %: N 16.4; S 12.9. $C_{10}H_9N_3O_3S$. Calculated, %: N 16.7; S 12.8.

4-Methoxybenzo-2,1,3-thiadiazole (V). A mixture of 9 g (59.2 mmoles) of (I), 2.4 g (60 mmoles) of caustic soda, 8.4 g (60.8 mmoles) of potassium acetate, and 120 ml of water was heated to 60-65°C, and

then 15 ml (158.5 mmoles) of dimethyl acetate was added. Then the reaction mixture was heated in the boiling-water bath for 1 h and was cooled and poured into 400 ml of 25% ammonia solution. The precipitate that deposited was filtered off, washed with water to neutrality, and dried. The weight of precipitate was 7.5 g, and chloroform extracted another 0.5 g from the filtrate. The total yield was 8 g (81.5%), mp 66-68°C (from ethanol), giving no depression of the melting point with a sample of (II) obtained by a published method [10].

4-Methoxy-7-nitro- and 4-Methoxy-5-nitrobenzo-2,1,3-thiadiazoles. At room temperature, 3.32 g (39.1 mmoles) of sodium nitrate was added to a solution of 6.5 g (39.1 mmoles) of (V) in 65 ml of concentrated sulfuric acid (the temperature of the reaction mixture gradually rose to 40°C). Then the reaction mixture was kept for 30 min and was poured onto ice; the precipitate that deposited was filtered off, washed with water to neutrality, and dried. The weight of the mixture of nitro derivatives was 7.2 g (87%). This mixture was treated with ether, and the product insoluble in ether, weighing 3.6 g, consisted of (VI), mp 204-206°C (from ethanol). According to the literature [3], (VI) has mp 206°C. The ethereal filtrate was evaporated, giving a residue of 3.5 g of 4-methoxy-5-nitrobenzo-2,1,3-thiadiazole which, after distillation with steam, melted at 91-93°C.

4-Hydroxy-7-nitrobenzo-2,1,3-thiadiazole (VII). This was obtained as described by Dal Monte et al. by boiling 3.16 g (15 mmoles) of (VI) with 180 ml of a 1% solution of caustic soda for 5 min. Yield 2.6 g (88.2%), mp 218-219°C [benzene–ethanol (9 : 1)] [according to the literature [4]: yield 86%, mp 220°C (benzene–ethanol; 9 : 1)].

4,7-Dioxo-4,7-dihydrobenzo-2,1,3-thiadiazole (VIII). a) A solution of 3.6 g (12.2 mmoles) of potassium dichromate in 48 ml of water was added to a mixture of 1.2 g (7.2 mmoles) of (III), 2.5 ml of concentrated sulfuric acid, and 10 ml of water. The mixture was stirred at room temperature for 2-5 min and was then filtered and the residue was washed with water. The product was extracted from the filtrate with chloroform. After the elimination of the solvent, 0.9 g (75%) of (VIII) was obtained; it dissolves readily in acetone, benzene, and chloroform, and crystallizes from isopropanol. Mp 169-170°C. Found, %: N 17.0; S 19.4. $C_6H_2N_2O_2S$. Calculated, %: N 16.9; S 19.3.

b) A solution of 2.4 g (8.2 mmoles) of potassium dichromate in 32 ml of water was added to a mixture of 0.8 g (4.8 mmoles) of (IX) [5], 1.6 ml of concentrated sulfuric acid, and 7 ml of water. The subsequent procedure was the same as in method (a). This gave 0.25 g (34%) of (VIII); after recrystallization from isopropanol, mp 169-170°C (sealed capillary). It gave no depression of the melting point with the substance obtained by method (a).

c) A mixture of 10 g (66 mmoles) of (I), 40 ml of concentrated sulfuric acid, and 400 ml of water was cooled to room temperature and to it 28 g (95 mmoles) of potassium dichromate in 300 ml of water was added dropwise. After 3-5 min, the precipitate was filtered off and washed with water, and the filtrate was repeatedly extracted with chloroform. After the filtration of the chloroform extracts and the elimination of the solvent, 0.5 g (4.58%) of (VIII) was obtained, and this was crystallized from isopropanol, mp 169-170°C (sealed capillary), giving no depression of the melting point with the substances obtained by methods (a) and (b).

d) Compound (X) (10 g, 66 mmoles) was oxidized as described in method (c). This gave 0.5 g (4.55%) of (VIII). After crystallization from isopropanol, it melted at 169-170°C (sealed capillary) and gave no depression of the melting point with the substances obtained by methods (a), (b), and (c).

4,7-Diaminobenzo-2,1,3-thiadiazole (IX). This was obtained as described previously [5] by the reduction of 4-amino-7-nitrobenzo-2,1,3-thiadiazole with sodium hydrosulfite in 5% caustic soda solution. Yield 65%, mp 128-130°C (from water).

4,7-Dihydroxybenzo-2,1,3-thiadiazole (XI). A mixture of 1.9 g (11.4 mmoles) of (VIII) and 19 g (109 mmoles) of sodium hydrosulfite was poured into 130 ml of water at a temperature of 90°C and after being boiled for 2-3 min the hot mass was filtered and the mother solution was cooled and extracted with ether, and then the elimination of the ether gave 0.9 g (47.4%) of (XI), readily soluble in methanol and ethanol and almost insoluble in benzene and petroleum ether. Mp 183-185°C (sealed capillary, from toluene). Found, %: 17.1; S 19.1. $C_6H_4N_2O_2S$. Calculated, %: N 16.7; S 19.1.

4,7-Di(hydroxyimino)-4,7-dihydrobenzo-2,1,3-thiadiazole (XII). A mixture of 1 g (6 mmoles) of (VIII), 2 g (30 mmoles) of hydroxylamine hydrochloride, and 30 ml of ethanol was boiled for 2 h. Then it was cooled, and the precipitate was filtered off, washed with a small amount of ethanol, and dried. Weight

0.65 g (55%). It was purified by reprecipitation from dimethylformamide with water, and decomposed at 263-270°C. Found, %: N 28.4; S 16.1. $C_6H_4N_4O_2S$. Calculated, %: N 28.6; S 16.3.

5-Hydroxyquinoxaline (XIII). A mixture of 70 g (368 mmoles) of stannous chloride, 16 ml of concentrated hydrochloric acid, and 8 g (52.6 mmoles) of (I) was heated in the boiling water bath for 6 h. Then the mixture was cooled, diluted with 200 ml of water, and filtered. The filtrate and the precipitate were extracted with chloroform. Elimination of the solvent gave 3.5 g of the initial (I). A current of hydrogen sulfide was passed into the filtrate after the extraction with chloroform until the tin sulfide had deposited completely. This was filtered off and washed with water, and then the 400 ml of filtrate was made alkaline with 10% caustic soda solution to pH 6. It was filtered again and the precipitate was washed with 300 ml of water. The filtrate, with a volume of 700 ml, was heated to 60°C, and 10 g of the bisulfite derivative of glyoxal was added. The temperature of the solution was kept between 50 and 60°C for an hour, after which it was left overnight. Then the reaction mixture was filtered, and the filtrate was brought to pH 8 with sodium carbonate and extracted with ether. Elimination of the solvent gave 1.2 g of 5-hydroxyquinoxaline (27.7% calculated on the hydroxy compound that had reacted). Mp 100-101°C. According to the literature [6], mp 101-102°C. Found, %: N 19.1. $C_8H_6N_2O$. Calculated, %: N 19.2.

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