THE OXIDATIVE-ADDITION REACTIONS OF TRI(META-TOLYL)ANTIMONY AND TRI(ORTHO-TOLYL)ANTIMONY WITH 5-NITROFURFURALDOXIME IN THE PRESENCE OF PEROXIDES. THE MOLECULAR STRUCTURES OF \( \mu_2\text{-Oxo-Bis}[5\text{-Nitrofurfuraldoximato}]\text{Tri(Meta-Tolyl)Antimony} \) AND \( \mu_2\text{-Oxo-Bis}[5\text{-Nitrofurfuraldoximato}]\text{Tri(Ortho-Tolyl)Antimony} \)

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The interaction of tri(m-tolyl)antimony and tri(o-tolyl)antimony with 5-nitrofurfural oxime in the presence of an oxidizing agent (hydrogen peroxide or tert-butyl hydroperoxide) leads to the formation of bis(5-nitrofurfuraldoximato)tri(m-tolyl)antimony (1), \( \mu_2\text{-Oxo-Bis}[5\text{-Nitrofurfuraldoximato}]\text{Tri(Ortho-Tolyl)Antimony} \) (2), bis(5-nitrofurfuraldoximato)tri(m-tolyl)antimony (3) and \( \mu_2\text{-Oxo-Bis}[5\text{-Nitrofurfuraldoximato}]\text{Tri(Ortho-Tolyl)Antimony} \) (4). The molecular structures of complexes 2 and 4 have been determined by X-ray diffraction analysis.

**Keywords:** tri(m-tolyl)antimony, tri(o-tolyl)antimony, 5-nitrofurfuraldoxime, tert-butyl hydroperoxide, hydrogen peroxide, oxidation, bis(5-nitrofurfuraldoximato)tri(m-tolyl)antimony, \( \mu_2\text{-Oxo-Bis}[5\text{-Nitrofurfuraldoximato}]\text{Tri(m-Tolyl)Antimony} \), \( \mu_2\text{-Oxo-Bis}[5\text{-Nitrofurfuraldoximato}]\text{Tri(o-Tolyl)Antimony} \), molecular structures, X-ray diffraction analysis.

**Introduction**

It is known that some pentavalent antimony derivatives are biologically active compounds. For example, triphenyl- and trimethylantimony dioximates and dicarboxylates were observed to have bactericidal and antitumor activity [1-6]. One of the methods allowing such compounds to be synthesized is the oxidative synthesis. It is interesting to note that two types of triaryltantimony dioximates \( \text{Ar}_3\text{SbX}_2 \) or \( \text{Ar}_3\text{SbX}_2\text{O} \) \( \text{(Ar} = \text{Ph, } p\text{-Tol, } o\text{-Tol; } X = \text{ONCHR, ONCRR'}) \) can be obtained, depending on the oxime nature and the reaction conditions [7–10].

Oximes that contain two donor atoms (O and N) are amplydentate ligands. However, according to X-ray diffraction data, the ligands of such antimony derivatives as \( \text{Ar}_3\text{Sb(ONCRR')}_2 \) and \( \text{(Ar}_3\text{SbONCRR')}_2\text{O} \) are usually bound to the antimony atom only via the oxygen atom. In this case, short distances between the antimony atom and the nitrogen atoms of iminoxy-groups, which do not lead to the significant distortion of the trigonal-bipyramidal central atom coordination, are observed [11].

Sometimes the oxime ligand coordination method can be dependent on the nature of the aryl radicals at the antimony atom. For example, furfuraldoxime or 2-hydroxybenzaldoxime performs various structural functions in the derivatives of triphenyl- [8] and tri \( (o\text{-tolyl}) \) antimony [10] or triphenyl- and \( \text{ris}(5\text{-bromo-2-methoxyphenyl)antimony} \) [9], respectively.

Obviously, the oxidative-addition reactions of triaryltantimony with oximes and the structure of the obtained products require further study.

The present work concerns the investigation of the interaction between tri(m-tolyl)- or tri(o-tolyl)antimony and 5-nitrofurfuraldoxime in the presence of an oxidizing agent (hydrogen peroxide or \( t \)-butyl hydroperoxide) and the establishment of the product molecular structures.
Experimental

Synthesis of bis(5-nitrofururaldioxidomato)tri(m-tolyl)antimony (1).

100 mg of tri(m-tolyl)antimony (0.25 mmol) and 79 mg (0.5 mmol) of 5-nitrofururaldioxidime were dissolved in the mixture of diethyl ether (15 mL) and heptane (15 mL), then 28 mg of 30 % aqueous solution of hydrogen peroxide (0.25 mmol) were added. The mixture was kept for 24 hours at 20 °C. After the solvent evaporation, the light-yellow crystals of 1 were obtained (m = 0.132 g (78 %), MP = 78 °C). IR spectrum, ν, cm⁻¹: 3155, 3138, 3049, 2957, 2922, 2860, 1558, 1520, 1475, 1456, 1377, 1348, 1300, 1244, 1097, 1016, 970, 937, 810, 773, 739, 706, 689, 545, 505, 474, 426.

Synthesis of µ₂-oxo-bis(5-nitrofururaldioxidomato)tri(m-tolyl)antimony (2).

a) 100 mg of tri(m-tolyl)antimony (0.25 mmol) and 39 mg (0.25 mmol) of 5-nitrofururaldioxidime were dissolved in the mixture of diethyl ether (25 mL) and heptane (5 mL), then 22 mg of 70 % aqueous solution of hydrogen peroxide (0.25 mmol) were added. The mixture was kept for 24 hours at 20 °C. When the solvent was evaporated, the yellow crystals of 2 were obtained (m = 0.134 g (96 %), MP = 143 °C).

b) 100 mg of tri(m-tolyl)antimony (0.25 mmol) and 39 mg (0.25 mmol) of 5-nitrofururaldioxidime were dissolved in the mixture of diethyl ether (15 mL) and heptane (15 mL), then 28 mg of 70 % aqueous solution of tert-butyl peroxide (0.25 mmol) were added. The mixture was kept for 24 hours at 20 °C. After the solvent evaporation, the yellow crystals of 2 were obtained (m = 0.127 g (91 %), MP = 144 °C).

Synthesis of bis(5-nitrofururaldioxidomato)tri(o-tolyl)antimony (3).

a) 100 mg of tri(o-tolyl)antimony (0.25 mmol) and 79 mg (0.5 mmol) of 5-nitrofururaldioxidime were dissolved in diethyl ether (40 mL), then 28 mg of 30 % aqueous solution of hydrogen peroxide (0.25 mmol) were added. The mixture was kept for 24 hours at 20 °C. When the solvent was evaporated, the fine-crystalline precipitate was crystallized from benzene with the addition of heptane (5:1 vol.) to give light-yellow crystals of 3 (m = 0.139 g (83 %), MP = 154 °C, with destr.). IR spectrum, ν, cm⁻¹: 1576, 1560, 1526, 1477, 1456, 1375, 1348, 1298, 1242, 1205, 1180, 1159, 1123, 1018, 964, 924, 864, 837, 808, 746, 737, 704, 683, 631, 582, 548, 507, 480, 436, 412.

b) 100 mg of tri(o-tolyl)antimony (0.25 mmol) and 79 mg (0.5 mmol) of 5-nitrofururaldioxidime were dissolved in diethyl ether (40 mL), then 22 mg of 70 % aqueous solution of tert-butyl peroxide (0.25 mmol) were added. The mixture was kept for 24 hours at 20 °C. When the solvent was evaporated, the fine-crystalline precipitate was crystallized from benzene with the addition of heptane (5:1 vol.) to give light-yellow crystals of 3 (m = 0.139 g (83 %), MP = 154 °C, with destr.).

Synthesis of µ₂-oxo-bis(5-nitrofururaldioxidomato)tri(m-tolyl)antimony (4).

a) 100 mg of tri(o-tolyl)antimony (0.25 mmol) and 39 mg (0.25 mmol) of 5-nitrofururaldioxidime were dissolved in heptane (40 mL), then 28 mg of 30 % aqueous solution of hydrogen peroxide (0.25 mmol) were added. The mixture was kept for 24 hours at 20 °C. After the solvent evaporation, the colorless crystals of 4 were obtained (m = 0.138 g (99 %), MP = 164 °C, with destr.). IR spectrum, ν, cm⁻¹: 1587, 1570, 1550, 1473, 1377, 1352, 1304, 1242, 1206, 1178, 1155, 1121, 1031, 1013, 982, 968, 943, 860, 822, 808, 798, 748, 723, 698, 674, 665, 542, 503, 471, 438, 409.

b) 100 mg of tri(o-tolyl)antimony (0.25 mmol) and 39 mg (0.25 mmol) of 5-nitrofururaldioxidime were dissolved in heptane (40 mL), then 22 mg of 70 % aqueous solution of tert-butyl peroxide (0.25 mmol) were added. The mixture was kept for 24 hours at 20 °C. After the solvent evaporation, the yellow crystals of 4 were obtained (m = 0.138 g (99 %), MP = 164 °C, with destr.).

IR spectra of compounds 1–4 were recorded on a Shimadzu IRAffinity-1S FTIR spectrometer (pellets with KBr; 4000–400 cm⁻¹).

X-ray diffraction analysis of crystalline substances 2, 4 was performed on Bruker D8 QUEST automatic four-circle diffractometer (Mo Kα emission, λ = 0.71073 Å, graphite monochromator).

Data collection and editing, the refinement of unit cell parameters, and correction for absorption were carried out in SMART and SAINT-Plus software [10]. All calculations aimed at solving and refining the structures of 2, 4 were performed in SHELXL/PC software [11]. The structures of 2, 4 were...
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determined using direct methods and refined with LS method in the anisotropic approximation for non-
hydrogen atoms. The selected crystallographic data and the structure refinement results are listed in
Table 1. Selected bond lengths and bond angles are summarized in Table 2.

The full tables of atomic coordinates, bond lengths, and bond angles were deposited with the
Cambridge Crystallographic Data Centre (CCDC 1048763, 1048167, 1048131 for compounds 2 and 4,
respectively; deposit@ccdc.cam.ac.uk; http://www.ccdc.cam.ac.uk).

| Crystallographic data and the experimental and structure refinement parameters for compounds 2, 4 |  
| --- |  
| Parameter | Value |  
| 2 | 4 |  
| Empirical formula | C$_{26}$H$_{43}$N$_{2}$O$_{9}$Sb$_{2}$ | C$_{26}$H$_{43}$N$_{2}$O$_{9}$Sb |  
| Formula weight | 1116.44 | 558.22 |  
| $T$, K | 273.15 | 273.15 |  
| Crystal system | monoclinic | monoclinic |  
| Space group | P2$_{1}$/c | C2/c |  
| a, Å | 22.472(2) | 20.529(11) |  
| b, Å | 13.139(11) | 10.1119(6) |  
| c, Å | 21.165(18) | 27.9617(15) |  
| $\alpha$, deg | 90.00 | 90.00 |  
| $\beta$, deg | 110.646(3) | 91.075(2) |  
| $\gamma$, deg | 90.00 | 90.00 |  
| V, Å$^3$ | 5848.3(9) | 5803.5(6) |  
| Z | 4 | 8 |  
| $\rho$(calcd.), g/cm$^3$ | 1.268 | 1.278 |  
| $\mu$, mm$^{-1}$ | 0.974 | 0.981 |  
| $F$(000) | 2248.0 | 2248.0 |  
| $\theta$ Range of data collection, deg | 6.5–38.12° | 7–49.5° |  
| Range of refraction indices | –20 $\leq$ h $\leq$ 20, –12 $\leq$ k $\leq$ 12, –19 $\leq$ l $\leq$ 19 | –24 $\leq$ h $\leq$ 19, –11 $\leq$ k $\leq$ 11, –32 $\leq$ l $\leq$ 31 |  
| Measured reflections | 32451 | 9023 |  
| Independent reflections | 4701 | 4648 |  
| $R_{int}$ | 0.0476 | 0.0428 |  
| Refinement variables | 610 | 307 |  
| GOOF | 1.117 | 1.078 |  

| $R$ factors for $F^2 > 2\sigma(F^2)$ | $R_f = 0.0738, wR_f = 0.2106$ | $R_f = 0.0792, wR_f = 0.2043$ |  
| $R$ factors for all reflections | $R_f = 0.0906, wR_f = 0.2430$ | $R_f = 0.1291, wR_f = 0.2323$ |  
| Residual electron density (min/max), e/Å$^3$ | 1.54/–0.41 | 1.05/–0.47 |  

| Selected bond lengths and bond angles in the structures of compounds 2, 4 |  
| Bond | $d$, Å | Angle | $\alpha$, deg |  
| --- | --- | --- | --- |  
| 2 |  |  |  |  
| Sb(1)–C(1) | 2.156(17) | O(1)Sb(1)O(2) | 176.5(4) |  
| Sb(1)–C(11) | 2.107(19) | C(11)Sb(1)C(1) | 121.5(7) |  
| Sb(1)–C(21) | 2.051(16) | C(21)Sb(1)C(11) | 118.3(7) |  
| Sb(1)–O(1) | 1.971(9) | C(1)Sb(1)C(21) | 119.7(7) |  
| Sb(1)–O(2) | 2.130(10) | N(1)O(2)Sb(1) | 107.1(9) |  
| O(2)–N(1) | 1.409(17) | O(2)N(1)C(35) | 108.2(13) |  
| O(6)–N(3) | 1.332(17) | Sb(1)O(1)Sb(2) | 146.0(5) |  
| N(1)–C(35) | 1.267(19) | N(3)O(6)Sb(2) | 116.3(8) |  
| N(3)–C(75) | 1.206(17) | O(6)N(3)C(75) | 113.9(12) |  

Table 1

Table 2
Results and Discussion

We have studied the reactions of tri(m-tolyl) - and tri(o-tolyl)antimony with 5-nitrofururaloximate at various molar ratios in the presence of an oxidizing agent. It has been found that at molar ratio 1:2 of triarylantimony and 5-nitrofururaloximate the product of the reactions, regardless of the nature of the oxidant, is bis(5-nitrofururaloximato)triarylantimony: m-Tol₃Sb[ON=CH₃H₂O(NO₂-5)]₂ (1) or o-Tol₃Sb[ON=CH₃H₂O(NO₂-5)]₂ (3):

\[
\text{Ar₃Sb} + 2 \text{HON=CH₃H₂O(NO₂-5)} + \text{ROOH} \rightarrow \text{Ar₃Sb[ON=CH₃H₂O(NO₂-5)]₂} + 2 \text{ROH}
\]

Ar = m-Tol, o-Tol; R = H, Bu-t

At the equimolar ratio of the reagents, in the presence of both hydrogen peroxide and tert-buty1 hydroperoxide, \( \mu \text{-oxo-bis(5-nitrofururaldehydoximato (m-Tol₃Sb[ON=CH₃H₂O(NO₂-5)]₂)O (2) or } \mu \text{-oxo-bis(5-nitrofururaldehydoximato (o-Tol₃Sb[ON=CH₃H₂O(NO₂-5)]₂)O (4) is formed:} \)

\[
2 \text{Ar₃Sb} + 2 \text{HON=CH₃H₂O(NO₂-5)} + 2 \text{ROOH} \rightarrow [\text{Ar₃SbON=CH₃H₂O(NO₂-5)]₃O + 2 \text{ROH} + \text{H₂O}}
\]

Ar = m-Tol, o-Tol; R = H, Bu-t

Compounds 1–4 are crystalline substances, which are resistant to the effect of moisture and air oxygen and freely soluble in aromatic and aliphatic hydrocarbons.

The synthesized triarylantimony dioximates have been identified by infrared spectroscopy and X-ray diffraction analysis.

In the IR-spectrum of compounds 1–4 there are intensive absorption bands, which characterize nitro group vibrations. Thus, the absorption band due to NO₂-group asymmetric vibrations is at 1520, 1522, 1526 and 1516 cm⁻¹, while the band, corresponding to NO₂-group symmetric vibrations appears at 1348, 1350, 1348 and 1352 cm⁻¹ in the spectra of 1–4, respectively. The C–NO₂ vibrations are characterized by the bands at 810, 810, 808 and 808 cm⁻¹. In addition, there are bands at 426, 426, 436 and 438 cm⁻¹, which have been attributed to the Sb–C(Ar) vibration of the C₃-symmetric [12] SbC₃ fragment. The characteristic bands at 1558–1587 cm⁻¹ (C=N bonds), 964–970 cm⁻¹ (N–O bonds) have also been found.

According to the X-ray diffraction analysis data, the antimony atoms in the molecules of compounds 2 and 4 have distorted trigonal-bipyramidal coordination with oxygen atoms in axial positions (Fig. 1–2). Molecule 4 is centrosymmetric. In binuclear molecules 2, 4 the Sb (1) and Sb (2) atoms are connected by the bridging oxygen atom, Sb(1)O(1)Sb(2) bond angles are equal to 146.0(3)° and 180.0(0)°, respectively. The oximate ligands in molecules 2, 4 are monodentate as in the case of \( \mu \text{-oxo-bis([furfuraldehydoximato(tri(o-tolyl)antimony)] [10].} \)
The sums of CSbC bond angles are equal to 358.9(7)°, 358.8(6)° (2), 359.4(6)° (4), at that the values of the individual angles differ from the theoretical angle not more than by 6°. The Sb atoms are shifted from the correlated planes [C₃] at 0.002 Å (1), 0.091, 0.098 Å (2), 0.052 Å (3). The axial OSbO angles are equal to 176.5(4)°, 176.1(3) (2), 173.6(2)° (4). The OSbC angles vary within the ranges 92.8(7)°−94.8(5)°, 91.0(5)°−96.6(4)° (2), 91.4(4)°−95.1(3)° (4).

The lengths of Sb–C bonds lie within the ranges of 2.051(16)−2.156(17) Å, 2.088(13)−2.119(15) Å (2), 2.097(10)−2.116(16) Å (4). The Sb–O bridging bond lengths in 2 (1.971(9), 1.975(8) Å) are longer in comparison with the same characteristic in 4 (1.960(8) Å), which correlates with the previously discovered pattern for the molecules with the similar structure: the closer the angle SbOSb is to linear, the shorter the Sb–O bond is [11]. The lengths of the Sb–O terminal bonds are 2.130 (10), 2.127 (9) Å (2), and 2.195 (8) Å (4). It should be noted that the values of angles for the antimony atom in molecule 4 are approximately equal to the corresponding values in the fragment of the molecule of μ₂-oxo-bis[(furfuraloxime)tri(α-tolyl)antimony], where the Sb–O–Sb fragment is linear, but the internuclear distances Sb–C and Sb–O in these molecules are different. Thus, the bonds Sb–O (1.9706 (3), 2.112 (6) Å [10]) in the latter compound are shorter than in 4, which can be explained by the presence of the nitro group in the furan ring of its oximate ligand.

In molecules 2, 4 the Sb···N distances between the Sb atom and N atoms of iminoxy groups [2.88(8), 2.97(1) Å (2), 2.95(1) Å (4)] are considerably less than the sum of Van der Waals radiuses of
the Sb and N atoms (3.8 Å [15]). Obviously, there is no correlation between the Sb–O bond lengths and strength of Sb···N contacts. Thus, in the molecule of μ₂-oxo-bis[(furfuraloximato)tr(o-tolyl)antimony], the distance Sb···N (2.951(1) Å [10]) coincides with the comparable distance in 4. The decrease of the Sb···N distances does not result in the expected N–O bond lengthening [1.409(17), 1.332(17) Å (2), 1.335(11) Å (4)].

The structure organization of crystals 2, 4 is due to weak intermolecular O···H hydrogen bonds between the oxygen atoms of nitro groups and the hydrogen atoms of methyl groups or aromatic rings, as well as due to C–H···π interactions.

Conclusions

The structure of the products of the reactions of tri(m-tolyl)- and tri(o-tolyl) antimony with 5-nitrofururaldoxime depends on the molar ratio of the reactants. Regardless of the nature of the oxidant, the reaction of triarylantimony with 5-nitrofururaloxime at molar ratio 1:2 leads to the formation of tritolylantimony dioximates. At the stoichiometric ratio of the reagents the antimony-organic product with the bridging oxygen atom is formed.

The structure of molecules is determined by the aryl radical nature, thus, the μ₂-oxo-bis[(5-nitrofururaloximato)tr(m-tolyl)antimony molecule] has the angular structure of the central fragment, and the μ₂-oxo-bis[(5-nitrofururaloximato)tr(o-tolyl) antimony] molecule is centrosymmetric and has a linear structure. The oxime ligands are monodentate in both cases; they are bound to the antimony atom via the oxygen atom.

References

1. Bajpai K., Srivastava R.C. [Synthesis and Reactions of O-triorganoantimony Dioximates]. Synth. Inorg. Met.-Org. Chem, 1981, vol. 11, no. 1, pp. 7–13. DOI: 10.1080/00945718108059270.
2. Yu L., Ma Y.-Q., Li J.-S. [Synthesis and Biological Activity of Some Triarylantimony Dipyrazolecarboxylates]. Heteroatom Chemistry, 2002, vol. 13, no. 4, pp. 299–301. DOI: 10.1002/hc.10033.
3. Yu L., Ma Y.-Q., Wang G.-C., Li J.-S. [Synthesis and in Vitro Antitumor Activity of Some Triarylantimony Di(N-phenylglycimates)]. Heteroatom Chemistry, 2004, vol. 15, no. 1, pp. 32–34. DOI: 10.1002/hc.10208.
4. Khosa M.K., Mazhar M., Ali S., Shahid K., Malik F. [Synthesis and Spectroscopic Characterization of Biologically Active Triarylantimony (V) Carboxylates Containing Germanium] Turkish Journal of Chemistry, 2006, vol. 30, no. 3, pp. 345–354.
5. Handong Y., Li Q., Linwei L. [The Molecular and Crystal Structure Determination of Bisanthydroalthiomycin by the X-ray Diffraction Method]. Inorganic Chemistry Communications, 2008, no. 11, pp. 1121–1124. DOI: 10.1016/j.inoche.2008.06.017.
6. Islam A., Da Silva J.G., Berbet F.M., da Silva S.M., Rodrigues B.L., Beraldo H., Melo M.N., Frézard F., Demicheli S. [Novel Triphenylantimony (V) and Triphenylbismuth (V) Complexes with Benzoic Acid Derivatives: Structural Characterization, in Vitro Antileishmanial and Antibacterial Activities and Cytotoxicity Against Macrophages]. Molecules, 2014, vol. 19, no. 5, pp. 6009-6030. DOI: 10.3390/molecules19056009.
7. Dodonov V.A., Gushhin A.V., Gor'kaev D.A., Fukin G.K., Starostina T.I., Zaharov L.N., Kurski Ju.A., Shavyrin A.S. [Synthesis and Structure of Triphenylantimony Oximates]. Russian Chemical Bulletin, 2002, no. 6, pp. 1051–1057. DOI: 10.1023/A:1019634307064.
8. Sharutin V.V., Sharutina O.K., Molokova O.V., Pakusina A.P., Bondar' E.A., Krivolapov D.B., Gubajdullin A.T., Litvinov I.A. [Synthesis and Structure of μ-Oxo-bis(triphenyl(furfuraloximato)antimony)]. Russian Journal of General Chemistry, 2001, vol. 71, no. 9, pp. 1426–1430. DOI: 10.1023/A:1013910120594.
9. Sharutin V.V., Sharutina O.K. [Specific Features of the Reaction between Tris(5-bromo-2-methoxyphenyl)antimony and 2-Oxybenzaldoxime: Structure of Bis(μ₂-2-oxoxyzanolzoximato-O,O,N)-(μ₂-oxo)-bis(5-bromo-2-methoxyphenyl)diomantimony]. Russian Journal of Inorganic Chemistry, 2014, vol. 59, no. 11, pp. 1263–1267. DOI: 10.1134/S0036023614110229.
10. Sharutin V.V., Molokova O.V., Sharutina O.K., Smirnova S.A. [Oxidative Addition Reactions of Tri(2-Methylphenyl)Antimony]. Russ. J. Inorg. Chem., 2012, vol. 57, no. 9, pp. 1334–1340.
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11. Sharutina O.K., Sharutin V.V. [Molekulyarnye Struktury Organicheskikh Soedineniy Sur'my (V): Monografiya]. Chelyabinsk: SUSU, 2012, 395 p.
12. Bruker (2000) SMART. Bruker Molecular Analysis Research Tool, Versions 5.625 Bruker AXS, Madison, Wisconsin, USA.
13. Bruker (2000) SAINT Plus Data Reduction and Correction Program Versions 6.02a, Bruker AXS, Madison, Wisconsin, USA.
14. Doak G.O., Long G.G., Freedman L.D. [The Infrared Spectra of Some Phenylsubstituted Pentavalent Antimony Compounds]. J. Organomet. Chem., 1965, vol. 4, no. 1, pp. 82–91. DOI: 10.1016/S0022-328X(00)82370-0.
15. Batsanov S.S. [The Atomic Radii of the Elements]. Russian Journal of Inorganic Chemistry, 1991, vol. 36, no. 12, pp. 1694–1706.

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ОСОБЕННОСТИ ВЗАИМОДЕЙСТВИЯ ТРИ(МЕТА-ТОЛИЛ)СУРЬМЫ И ТРИ(ОРТО-ТОЛИЛ)СУРЬМЫ С 5-НИТРОФУРУРФУРАЛЬДОКСИМОМ. МОЛЕКУЛЯРНЫЕ СТРУКТУРЫ $\mu_2$-ОКСО-БИС[(5-НИТРОФУРУРФУРАЛЬДОКСИМАТО)ТРИ(МЕТА-ТОЛИЛ)СУРЬМЫ] И $\mu_2$-ОКСО-БИС[(5-НИТРОФУРУРФУРАЛЬДОКСИМАТО)ТРИ(ОРТО-ТОЛИЛ)СУРЬМЫ]

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Взаимодействием три(мета-толил)сурьмы и три(орто-толил)сурьмы с 5-нитрофурфуральдокси мом в присутствии окислителя (пероксида водорода или третбутилгидропероксида) синтезированы бис(5-нитрофурфуральдоксимиato)три(мета-толил)сурьма (1), $\mu_2$-оксо-бис(5-нитрофурфуральдоксимиato)три(мета-толил)сурьма (2), бис(5-нитрофурфуральдоксимиato)три(орто-толил)сурьма (3) и бис(5-нитрофурфуральдоксимиato)три(орто-толил)сурьма (4). Соединения 2, 4 охарактеризованы методом рентгеноструктурного анализа.

Ключевые слова: три(м-толил)сурьма, три(о-толил)сурьма, 5-нитрофурфуральдоксимиato, третбутилгидропероксид, пероксид водорода, окисление, бис(5-нитрофурфуральдоксимиato)три(м-толил)сурьма, $\mu_2$-оксо-бис(5-нитрофурфуральдоксимиato)три(м-толил)сурьма, бис(5-нитрофурфуральдоксимиato)три(о-толил)сурьма, $\mu_2$-оксо-бис(5-нитрофурфуральдоксимиato)три(о-толил)сурьма, молекулярные структуры, рентгеноструктурный анализ.

Литература
1. Bajpai, K. Synthesis and reactions of o-triorganoantimony dioximates / K. Bajpai, R.C. Srivastava // Synth. Inorg. Met. – Org. Chem. – 1981. – V. 11, № 1. – P. 7–13.
2. Li, J.S. Synthesis and biological activity of some triarylantimony dipyrrazolecarboxylates / Y.-Q. Ma, L. Yu, J.-S. Li // Heteroatom Chemistry. – 2002. – V. 13, № 4. – P. 299–301.
3. Synthesis and in vitro antitumor activity of some triarylantimony di(N-phenylglycinates) / L. Yu, Y.-Q. Ma, G.-C. Wang et al. // Heteroatom Chemistry. – 2004. – V. 15, № 1. – P. 32–34.
4. Synthesis and spectroscopic characterization of biologically active triarylantimony (V) carboxylates containing germanium / M.K. Khosa, M. Mazhar, S. Ali // Turkish Journal of Chemistry. – 2006. – V. 30, № 3. – P. 345–354.
Артемьева Е.В., Макерова М.С., Шарутина О.К. Особенности взаимодействия три(мета-толили)сульфида с 5-нитрофуранфуралдиксимом и три(орто-толили)сульфида с 5-нитрофуранфуралдиксимом... 5. Handong, Y. Synthesis, spectroscopic and structural aspects of triphenylandimino(V) complex with internally functionalized acetylferroceneoxime: Crystal and molecular structures of [C₅H₅FeC₆H₆(C₂H₅)=NO]₂SbPh₃ and C₅H₅FeC₆H₆(C₂H₅)=NOH / Y. Handong, Q. Li, L. Linwei // Inorganic Chemistry Communications. – 2008. – № 11. – Р. 1121–1124.

6. Novel triphenylandimino (V) and triphenylbisnuth (V) complexes with benzoic acid derivatives: structural characterization, in vitro antileishmanial and antibacterial activities and cytotoxicity against macrophages / A. Islam, J.G. Da Silva, F.M. Berbet et al. // Molecules. – 2014. – V. 19. № 5. – P. 6009-6030.

7. Синтез и строение оксиматов трифенилсурьмы / В.А. Додонов, А.В. Гущин, Д.А. Горькаев и др. // Изв. РАН. Сер. хим. – 2001. – Т. 71, вып. 9. – С. 1507–1510.

8. Шарутина, В.В. Особенности взаимодействия три(мета-толили)сульфида с 5-нитрофуранфуралдиксимом. Строение бис(μ₂-оксибензальдоксимато-О,О',N)- (μ₂-оксо)-бис(5-бром-2-метоксифенил)дисурьмы / В.В. Шарутина, О.К. Шарутина // Журн. неорган. химии. – 2014. – Т. 59, № 11. – С. 1507–1511. DOI: 10.7868/S0044457X14110221.

9. Реакции окислительного присоединения три(мета-толили)сульфида / В.В. Шарутина, О.В. Молокова и О.К. Шарутина // Журн. неорган. химии. – 2012. – Т. 57, № 9. – С. 1334–1340.

10. Молекулярные структуры органических соединений сурьмы (V): монография / О.К. Шарутина, В.В. Шарутина. – Челябинск: Издательский центр ЮУрГУ, 2012. – 395 с.

11. Bruker. SMART. Bruker molecular analysis research tool, Versions 5.625 Bruker AXS, Madison, Wisconsin, USA, 2000.

12. Bruker. SAINT Plus data reduction and correction program versions 6.02a, Bruker AXS, Madison, Wisconsin, USA, 2000.

14. Doak, G.O. The infrared spectra of some phenylsubstituted pentavalent antimony compounds / G.O. Doak, G.G. Long, L.D. Freedman // J. Organomet. Chem. – 1965. – V. 4. № 1. – Р. 82–91.

15. Бацанов, С.С. Атомные радиусы элементов / С.С. Бацанов // Журн. неорган. химии. – 1991. – Т. 36, вып. 12. – С. 3015–3037.

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