



Synthesis, crystal structure and thermal behavior of a novel oxoborate $\text{SrBi}_2\text{B}_4\text{O}_{10}$

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ABSTRACT

A new compound, $\text{SrBi}_2\text{B}_4\text{O}_{10}$, has been grown by cooling a melt with the stoichiometric composition. It is triclinic, $P\bar{1}$, $a = 6.819(1)$, $b = 6.856(1)$, $c = 9.812(2)$ Å, $\alpha = 96.09(1)$, $\beta = 109.11(1)$, $\gamma = 101.94(1)^\circ$, $V = 416.5(1)$ Å³, $Z = 2$. The crystal structure of the compound has been solved by direct methods and refined to $R_1 = 0.050$ ($wR_2 = 0.128$). The structure contains Bi–O pseudolayers build up from Bi–O chains involving oxocentred OBi_3 triangles. Sr atoms and $[\text{B}_4\text{O}_9]^{6-}$ isolated anions ($4\text{B}:3\Delta\Box < 2\Delta\Box > \Delta$) are located between the Bi–O packages.

The thermal treatment as well as DSC experiment showed that the compound melts above 800 °C presumably according to the peritectic reaction: $\text{SrBi}_2\text{B}_4\text{O}_{10} \leftrightarrow \text{SrB}_2\text{O}_4 + \text{SrB}_4\text{O}_7 + \text{Liquid}$. According to high-temperature X-ray powder diffraction study thermal expansion of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ structure is anisotropic ($\alpha_{11} = 13$, $\alpha_{22} = 9$, $\alpha_{33} = 2$, $\alpha_V = 24 \times 10^{-6} \text{ }^\circ\text{C}^{-1}$).

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1. Introduction

Borates and particularly Bi-contained borates have received great attention of material scientists due to their interesting nonlinear optical properties [1,2]. There is a number of bismuth borates already studied in this connection. In contrast the data on borates containing Bi^{3+} together with other metals are limited although the interest to these compounds rises considerably. Recently the structures of $\text{BaBi}_2\text{B}_4\text{O}_{10}$ [3], BaBiBO_4 [4], PbBiBO_4 [5], $\text{MBi}_2\text{B}_2\text{O}_7$ ($M = \text{Ca}, \text{Sr}$) [6] borates have been determined.

In the Bi_2O_3 – SrO – B_2O_3 system a ternary $\text{SrBi}_2\text{B}_4\text{O}_{10}$ borate was structurally characterized only [6]. Its structure is built of identical neutral layers of corner-sharing BO_3 triangles and SrO_6 trigonal prisms forming six-membered rings in which Bi_2O groups are located. The compound has been prepared using solid-state reactions and its structure has been determined *ab initio* and refined using powder neutron diffraction data in the hexagonal $P6_3$ space group. Triangulation in the Bi_2O_3 – SrO – B_2O_3 system at 600 °C has been proposed in [7]. According to the DTA and heat-treatment investigation two ternary compounds SrBiBO_4 and $\text{Sr}_7\text{Bi}_8\text{B}_{18}\text{O}_{46}$ have been mentioned in the system only, although up to now no crystallographic data have been reported. Here we report synthesis, crystal structure and thermal behavior of

$\text{SrBi}_2\text{B}_4\text{O}_{10}$, another new compound discovered in the Bi_2O_3 – SrO – B_2O_3 system.

2. Experimental

2.1. Synthesis and heat treatment of samples

Single crystals of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ for structure characterization were obtained by cooling down a melt with the stoichiometric composition. The initial mixture of Bi_2O_3 , H_3BO_3 and SrCO_3 was heated at 900 °C during 5 h, rapidly cooled up to 800 °C and then cooled down up to 750 °C with the speed 0.5 °/h. The resulted product contained a mixture of colorless crystals of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ and colored from yellow up to darkbrown crystals of $\text{Bi}_4\text{B}_2\text{O}_9$. Powder $\text{SrBi}_2\text{B}_4\text{O}_{10}$ was prepared by solid-state reaction at 750 °C for 38 h from Bi_2O_3 , H_3BO_3 and preliminary calcinated SrCO_3 . For the treatments pelletized powder sample was placed in a platinum crucible in a furnace and heated consistently (one after another) at 820/12 h, 850/16 h and 950 °C for 6 h. Powder diffraction patterns of treated materials were obtained with a Stoe Stadi P diffractometer ($\text{CuK}\alpha_1$ radiation; $\lambda = 1.5406$ Å, 40 kV/35 mA, transmission mode, PSD detector).

2.2. Crystal-structure study

The colorless crystal selected for data collection was examined under an optical microscope and mounted on a glass fiber. Single

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crystal X-ray experiment was performed using a STOE Imaging Plate Diffraction System (IPDS) (MoK α radiation; $\lambda = 0.71073 \text{ \AA}$, 50 kV/40 mA, frame widths of 2° in ω). The intensity statistics indicated the centrosymmetric space group $P\bar{1}$. The unit-cell dimensions were refined by least-squares method (Table 1). The raw intensities were corrected for Lorentz and polarization effects. The numerical absorption correction was applied taking into account the shape of crystal. For the intensity corrections the Stoe program X-area was used. The structure was solved and refined with SHELX-97 program package [8]. The final model included anisotropic displacement parameters for Bi and Sr only. Attempts to refine anisotropic parameters of O positions resulted in physically unrealistic values. Technical details of the data acquisition as well as some refinement results for the title compound are summarized in Table 1. Final atomic coordinates and displacement parameters are given in Table 2.

2.3. Bond-valence analysis

Bond-valence sums for atoms in the structure of SrBi₂B₄O₁₀ were calculated using the bond-valence parameters for B–O, Bi–O and Sr–O from [9]. The bond-valence sums for B atoms are in the range of 2.97–3.06 v.u. (valence units), for Bi atoms in the range of 2.76–3.05 v.u., for Sr atom 2.24 and for O atoms in the range of 1.71–2.19 v.u. (Tables 2 and 3). All bond-valence sums are in fair agreement with expected formal valences of atoms in the structure.

2.4. High-temperature X-ray powder diffraction study

Thermal expansion of SrBi₂B₄O₁₀ was studied in air by means of high-temperature X-ray powder diffraction data collected using a DRON-3 X-ray diffractometer with a high-temperature KRV-1100 camera. The sample was prepared from heptane's suspension on a Pt plate. The temperature steps were 30–35 °C, average heating rate was about 1–2 °C/min in the range of 20–700 °C. Unit-cell parameters of the compound at different temperatures were

Table 1
Crystallographic data and refinement parameters for SrBi₂B₄O₁₀.

Crystal size (mm ³)	0.07 × 0.06 × 0.1
Formula weight (g/mol)	708.82
Space group	$P\bar{1}$
Z	2
a (Å)	6.819(1)
b (Å)	6.856(1)
c (Å)	9.8118(17)
α (deg)	96.095(14)
β (deg)	109.116(13)
γ (deg)	101.937(14)
V (Å ³)	416.50(13)
μ (mm ⁻¹)	48.572
D _{calc.} (g/cm ³)	5.652
Diffractometer	STOE IPDS II
Radiation wavelength (Å)	0.71073 (MoK α)
θ -Range (deg)	2.24–29.18
Total Ref.	3912
Unique Ref.	2064
Unique F _o ≥ 4 σ_F	1855
R _{int}	0.060
R _{σ}	0.057
R ₁ (2064 Ref.)	0.056
R ₁ (F _o ≥ 4 σ_F)	0.050
wR ₂ (2064 Ref.)	0.132
wR ₂ (F _o ≥ 4 σ_F)	0.128
S	1.101

Note: $R_1 = \sum ||F_o| - |F_c|| / \sum |F_o|$; $wR_2 = \{ \sum [w(F_o^2 - F_c^2)^2] / \sum [w(F_o^2)^2] \}^{1/2}$; $w = 1 / [\sigma^2(F_o^2) + (aP)^2 + bP]$, where $P = (F_o^2 + 2F_c^2) / 3$; $S = \{ \sum [w(F_o^2 - F_c^2)^2] / (n-p) \}^{1/2}$, where n is the number of reflections and p is the number of refined parameters.

Table 2

Atomic coordinates, displacement parameters (\AA^2) and bond valence sums (BVS, v.u.) for SrBi₂B₄O₁₀.

Atom	x	y	z	U iso/eq	BVS ^a
Bi(1)	0.73462(8)	0.63780(7)	0.66350(5)	0.007 ^b	3.05
Bi(2)	0.69872(9)	1.02018(8)	0.40281(6)	0.011	2.76
Sr(1)	0.9646(2)	1.1497(2)	0.83386(13)	0.006	2.24
B(1)	1.587(3)	1.256(3)	0.9039(18)	0.010(3)	3.00
B(2)	1.399(3)	1.204(2)	1.0712(17)	0.007(2)	3.06
B(3)	1.197(3)	0.701(3)	0.8272(18)	0.011(3)	2.97
B(4)	0.850(3)	0.607(3)	0.3703(18)	0.011(3)	3.01
O(1)	0.9202(19)	0.8122(17)	0.3948(12)	0.012(2)	2.09
O(2)	1.3991(19)	1.2331(17)	0.9327(12)	0.012(2)	1.91
O(3)	0.6459(18)	0.8918(17)	0.5895(12)	0.010(2)	2.02
O(4)	1.4134(19)	0.7845(17)	0.8179(12)	0.011(2)	1.94
O(5)	1.0556(18)	0.8182(16)	0.7515(11)	0.010(2)	2.19
O(6)	0.8868(18)	0.5130(16)	0.2492(12)	0.010(2)	2.01
O(7)	0.7523(19)	0.5025(17)	0.4491(12)	0.012(2)	1.71
O(8)	1.7805(18)	1.2919(16)	1.0156(11)	0.010(2)	1.94
O(9)	1.5836(18)	1.2296(17)	0.7633(12)	0.011(2)	1.83
O(10)	1.2113(19)	1.1679(17)	1.0920(12)	0.012(2)	2.08

^a BVS are presented for Bi(1)O₅, Bi(2)O₇, Sr(1)O₉, B(1)O₃, B(2)O₃, B(3)O₄, B(4)O₃ and O(3)Bi₃ polyhedra.

^b Anisotropic displacement parameters: Bi(1) 0.0048(3) 0.0073(3) 0.0079(3) 0.00039(17) 0.00219(19) 0.0004(2); Bi(2); 0.0129(4) 0.0123(3) 0.0093(3) -0.00018(19) 0.0048(2) 0.0023(2); Sr(1) 0.0022(6) 0.0126(6) 0.0047(5) 0.0023(4) 0.0030(4) 0.0032(5).

Table 3

Selected bond lengths in the SrBi₂B₄O₁₀ structure.

Atom	Distance (Å)	BV	Atom	Distance (Å)	BV
Bi(1)–O(3)	2.08(1)	1.02	B(1)–O(9)	1.36(2)	1.02
Bi(1)–O(5)	2.12(1)	0.93	B(1)–O(8)	1.37(2)	1.01
Bi(1)–O(7)	2.26(1)	0.64	B(1)–O(2)	1.38(2)	0.97
Bi(1)–O(10)	2.49(1)	0.34			
Bi(1)–O(6)	2.88(1)	0.12	<B(1)–O>	1.370	3.00
Bi(1)–O(7)	3.04(1)	0.08	B(2)–O(10)	1.34(2)	1.09
Bi(1)–O(9)	3.15(1)	0.06	B(2)–O(4)	1.36(2)	1.03
			B(2)–O(2)	1.39(2)	0.94
<Bi(1) _{III} –O>	2.153	2.59			
<Bi(1) _V –O>	2.367	3.05	<B(2)–O>	1.363	3.06
<Bi(1) _{VII} –O>	2.574	3.19			
Bi(2)–O(3)	2.21(1)	0.72	B(3)–O(5)	1.45(2)	0.81
Bi(2)–O(1)	2.29(1)	0.57	B(3)–O(6)	1.48(2)	0.75
Bi(2)–O(9)	2.30(1)	0.57	B(3)–O(8)	1.49(2)	0.72
Bi(2)–O(3)	2.57(1)	0.28	B(3)–O(4)	1.51(2)	0.69
Bi(2)–O(1)	2.63(1)	0.23			
Bi(2)–O(4)	2.65(1)	0.22	<B(3)–O>	1.480	2.97
Bi(2)–O(5)	2.75(1)	0.17			
Bi(2)–O(7)	3.22(1)	0.05	B(4)–O(1)	1.36(2)	1.04
			B(4)–O(7)	1.35(2)	1.07
<Bi(2) _{III} –O>	2.269	1.86	B(4)–O(6)	1.41(2)	0.90
<Bi(2) _{VII} –O>	2.487	2.76			
<Bi(2) _{VIII} –O>	2.578	2.81	<B(4)–O>	1.373	3.01
Sr(1)–O(10)	2.51(1)	0.34	Sr(1)–O(9)	2.65(1)	0.24
Sr(1)–O(10)	2.56(1)	0.31	Sr(1)–O(8)	2.70(1)	0.21
Sr(1)–O(5)	2.59(1)	0.28	Sr(1)–O(2)	2.71(1)	0.20
Sr(1)–O(1)	2.63(1)	0.25	Sr(1)–O(3)	2.77(1)	0.17
Sr(1)–O(6)	2.65(1)	0.24			
Sr(1)–O(7)	2.642	2.24			

refined by least-square methods. Main coefficients of the thermal expansion tensor including its orientation relatively crystallographic axes were determined using polynomial approximation of temperature dependencies for the unit-cell parameters in the range of 20–700 °C by DTC program [10].

3. Results and discussion

3.1. Cationic polyhedra

Bi-coordination. Two independent Bi atoms in the structure have irregular coordination polyhedra due to the stereoactivity of the $6s^2$ lone pair of electrons on Bi^{3+} cations [11,12]. Both Bi(1) and Bi(2) coordinations are highly asymmetric with three short bonds (2.08–2.30 Å for both Bi atoms) (Table 3) complemented by two longer ones (2.49 and 2.88 Å) for Bi1 and four bonds (2.57–2.75 Å) for Bi(2). Thus Bi(1) is coordinated by five O atoms (2.08–2.88 Å) and Bi(2) by seven O atoms (2.21–2.75 Å). The Bi(1) and Bi(2) minimal polyhedra can be considered as BiO_3 distorted trigonal pyramids formed by short Bi–O bonds (Fig. 2, *black bonds*) with Bi atoms at the apices of the pyramids.

Sr-coordination. There is one symmetrically non-equivalent Sr site (Fig. 1c). According to the calculation of bond valence sum Sr

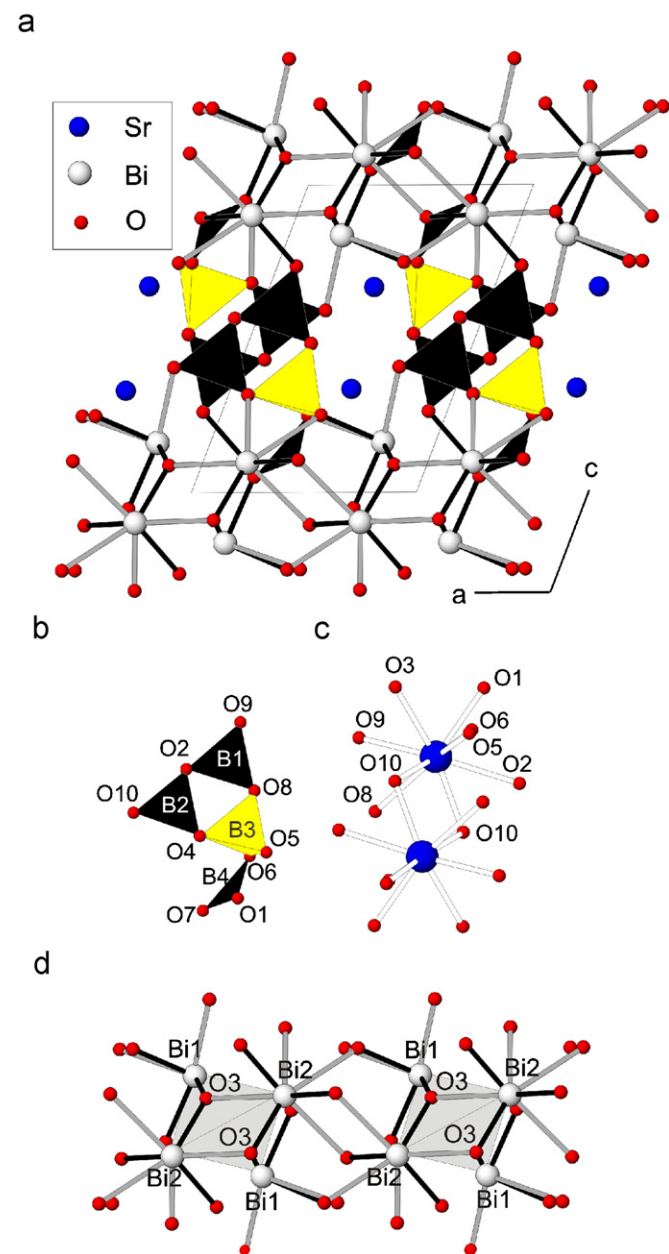


Fig. 1. Crystal structure of $\text{SrBi}_2\text{B}_4\text{O}_{10}$. (a) Projection on ac plane, (b) $[\text{B}_4\text{O}_9]^{6-}$ isolated group, (c) Sr–O coordination, and (d) Bi–O chain.

atom has nine O atoms (2.51–2.77 Å) in its coordination sphere with the average Sr–O bond length of 2.642 Å (Table 3).

B-coordination. There are four symmetrically independent B atoms in the structure of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ (Fig. 1). The B(3) atom is coordinated by four O atoms in a tetrahedral arrangement, whereas the B(1), B(2) and B(4) atoms are coordinated by three O atoms each (Table 3). The average bond lengths for both BO_3 and BO_4 polyhedra as well as ranges of individual B–O bond lengths and O–B–O angles are in good agreement with those reported in [13].

O-coordination. Each of “bridging” O(2), O(4), O(6) and O(8) atoms within the isolated borate anion is coordinated by two B atoms (Fig. 1b). “Non bridging” O(1), O(5), O(7), O(9), O(10) atoms of isolated borate anion have one B and one Bi atoms in their first coordination sphere. The third Bi ligand could be noted for tetrahedral O4, O5 and O6 atoms (Table 3). An “additional” O(3) atom, coordinated by three Bi atoms (2.08, 2.21 and 2.57 Å), has no boron atoms in its first coordination sphere. So the compound belongs to oxoborate class and its structural formula can be assigned as $\text{SrBi}_2\text{OB}_4\text{O}_9$.

3.2. Structure description

Two triangles and tetrahedra sharing corners build up a tetraborate ring $\langle 2\Delta\Box \rangle$. Addition of BO_3 -triangle to the tetraborate ring results in forming a new isolated tetraborate anion (Fig. 1b). Similar tetraborate isolated anion including tetraborate ring decorated by single tetrahedra. According to modern descriptions of borate groups by Burns et al. [14] and Touboul et al. [15], the asymmetric unit is symbolized as $4\text{B}: 3\Delta\Box: \langle 2\Delta\Box \rangle \Delta$ or $4\text{B}: [(3: 2\text{T}+\Delta)+(1: \Delta)]$, respectively, where 4B means four boron atoms composing the asymmetric unit and the BO_4 tetrahedron is denoted as \Box or T, respectively, and the BO_3 triangle is denoted as Δ , in the first notation the $\langle \rangle$ delimiters indicate that borate polyhedra form a ring. Similar tetraborate isolated anion including tetraborate ring decorated by single tetrahedra ($4\text{B}: 2\Delta\Box: \langle \Delta 2\Box \rangle \Box$) is known for urallborite $\text{Ca}_2[\text{B}_4\text{O}_4(\text{OH})_8]$ and hydrochlorborite $\text{Ca}_2[\text{B}_3\text{O}_3(\text{OH})_4][\text{BO}(\text{OH})_3]\text{Cl}\cdot 7\text{H}_2\text{O}$. As far as we are aware $\langle 2\Delta\Box \rangle \Delta$ unit is unknown in borate chains, layers and frameworks [14–18]. Among isolated borate anions another tetraborate group ($4\text{B}: 2\Delta 2\Box: \langle \Delta 2\Box \rangle = \langle \Delta 2\Box \rangle$) is most frequent both in minerals and synthetic borates.

$\text{Bi}(1)\text{O}_5$ and $\text{Bi}(2)\text{O}_7$ polyhedra connecting via apices form approximately along a axis infinite chains including oxocentred triangles $\text{O}(3)\text{Bi}_3$ (Fig. 1a and d, Fig. 2). This chains connected through non bridging oxygen atoms of single triangles BO_3 of isolated B–O anion form pseudolayers approximately parallel (001) plane. Two strontium eight-fold polyhedra sharing edge (Fig. 1c) fill the space between Bi–O pseudolayers together with B–O groups (Fig. 1a).

3.3. Heat treatment, DSC and in situ x-ray high-temperature powder diffraction studies

3.3.1. Melting character

During the heat treatments at 820, 850, and 950 °C tablets of polycrystalline $\text{SrBi}_2\text{B}_4\text{O}_{10}$, prepared by solid-state reaction at 750 °C for 38 h, changed their phase composition, color and microstructure. After heat treatment at 820 °C XRD patterns contained the reflections of $\text{SrBi}_2\text{B}_4\text{O}_{10}$, $\text{Bi}_4\text{B}_2\text{O}_9$, SrB_2O_4 and SrB_4O_7 (Fig. 3). After the treatment at 850 °C for 10 h, the intensity of SrB_2O_4 reflections increased while those of SrB_4O_7 decreased. Correspondingly the color of initially white tablets (750 °C) containing pure $\text{SrBi}_2\text{B}_4\text{O}_{10}$ changed gradually up to dark yellow (850 °C); microstructure became heterogeneous-partial

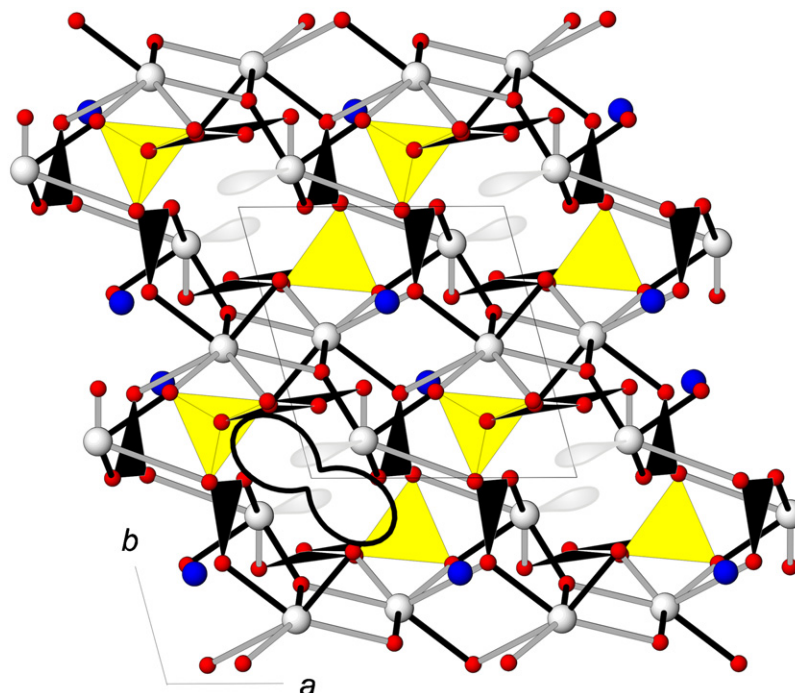


Fig. 2. The crystal structure of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ and pole figure of the thermal expansion coefficients within the (001) plane of maximum anisotropy.

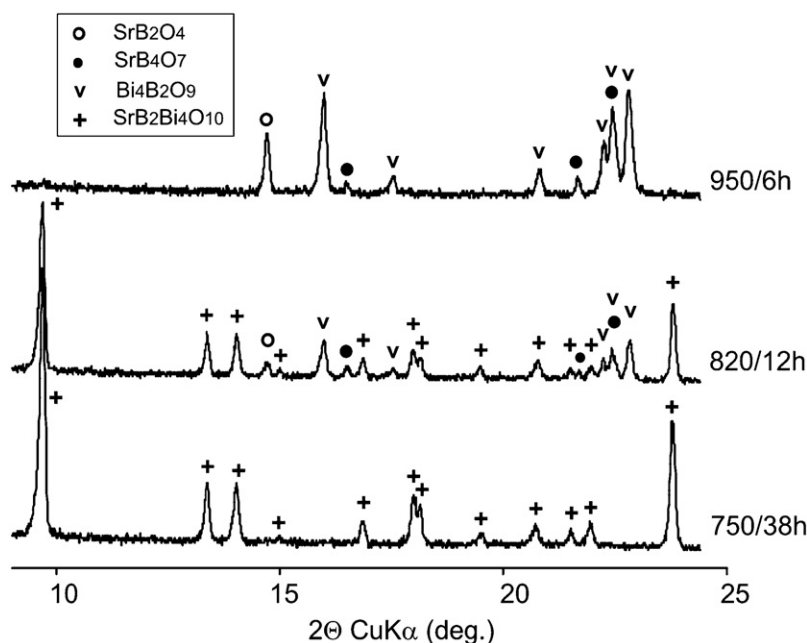


Fig. 3. Fragments of XRD patterns of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ samples after heat treatments.

re-crystallization and melting traces could be seen. In the pattern after the treatment at 950°C for 6 h, there are only the diffraction maxima of $\text{Bi}_4\text{B}_2\text{O}_9$ and two Sr-borates, SrB_2O_4 and SrB_4O_7 ; no more traces of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ were observed (Fig. 3). The great part of re-crystallized tablet was grey-pigmented after this treatment; yellow crystals crystallized from a melt were mostly concentrated at the bottom of the Pt crucible. At further heating ($980^\circ\text{C}/5\text{ h}$) the sample is completely melted. Heat-treatment data are in keeping with the DSC study of initial $\text{SrBi}_2\text{B}_4\text{O}_{10}$ ($750^\circ\text{C}/38\text{ h}$) obtained with NETSCH STA 429. In the DSC curve three endothermic

maxima at 805 , 905 and 970°C were observed (Fig. 4). First maximum can be attributed to the incongruent melting $\text{SrBi}_2\text{B}_4\text{O}_{10}$: $\text{SrBi}_2\text{B}_4\text{O}_{10} \leftrightarrow \text{SrB}_2\text{O}_4 + \text{SrB}_4\text{O}_7 + \text{Liquid}$. In the temperature interval 805 – 905°C three phases, SrB_2O_4 , SrB_4O_7 and a liquid phase, co-exist and above 905°C two phases, SrB_2O_4 and a liquid phase, apparently go together. Last maximum (970°C) corresponds to the full melting of the sample—this is a point of the liquidus curve. In this case, the XRD patterns (Fig. 3) show peaks of $\text{Bi}_4\text{B}_2\text{O}_9$ re-crystallized from a melt on cooling. $\text{SrBi}_2\text{B}_4\text{O}_{10}$ observed at XRD of the samples after 820 and 850°C should be

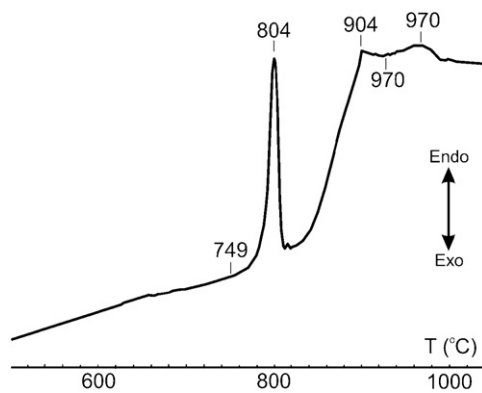


Fig. 4. DSC curve of $\text{SrBi}_2\text{B}_4\text{O}_{10}$.

attributed to the re-crystallization from a melt as well as the traces of SrB_4O_7 in the XRD patterns after the treatment at 950°C since at this temperature the melt has the same fragments of these crystalline phases.

In the latest study of $\text{SrO-B}_2\text{O}_3$ binary system [19], a new compound $\text{Sr}_4\text{B}_{14}\text{O}_{25}$ with a composition intermediate between SrB_2O_4 and SrB_4O_7 was discovered. This compound can be product of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ destruction. However, we did not observe $\text{Sr}_4\text{B}_{14}\text{O}_{25}$ in our experiment.

3.3.2. Thermal expansion

The sample of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ prepared by solid-state reaction at 750°C and contained pure $\text{SrBi}_2\text{B}_4\text{O}_{10}$ was studied *in situ* by high-temperature X-ray powder diffraction in the range from 20 to 700°C . The temperature dependencies of triclinic unit-cell parameters demonstrate that along crystallographic directions a , b , and c the linear expansion of the structure is almost isotropic meanwhile we observed the increase of γ (from 101.9 to 102.3°) angle and insignificant (0.1°) decrease of α and β . The thermal expansion coefficients determined for the main axes of the second-rank tensor showed the distinct anisotropy of thermal expansion of $\text{SrBi}_2\text{B}_4\text{O}_{10}$: $\alpha_{11} = 13$, $\alpha_{22} = 9$ and $\alpha_{33} = 2 \cdot 10^{-6} \text{ } ^\circ\text{C}^{-1}$. The anisotropy of thermal structural deformation is very typical for borates and particularly for Bi-containing borates [3,20]. The plane of the maximal anisotropy of thermal expansion is close to the (001) plane (Fig. 2). The maximal expansion of the structure is directed approximately along the long diagonal of ab parallelogram that is caused by the increase of γ angle. This is so-called shears mechanism of deformations, described in detail in [21]. Correspondingly the increasing of γ angle and expanding along the long diagonal have to be followed by the contraction along the short diagonal of ab parallelogram. This reconstruction accompanied by the general thermal expansion leads to the actual figure of thermal expansion coefficients (Fig. 2). The lone electron pairs of the closest Bi atoms ($\text{Bi}(1)\text{--Bi}(1) = 3.68 \text{ \AA}$) are directed approximately oppositely in the structure (Fig. 2). In [22] it is noted that the lone electron pair distribution could be better defined at low temperatures. If we assume that stereoactivity decreases with temperature and the space occupied by electron pairs decreases, respectively, the neighbor Bi atoms can come closer to each other. Certainly, the hypothesis of lowering of stereoactivity upon heating should be verified.

The volume and linear coefficients (24 and $8 \cdot 10^{-6} \text{ } ^\circ\text{C}^{-1}$, respectively) are relatively low in comparison with other Bi-

contained borates [18,20]. Volume thermal expansion of Bi-borates is about $38 \cdot 10^{-6} \text{ } ^\circ\text{C}^{-1}$.

4. Conclusion

Totally we have been successful in preparation of single crystals as well as powder of $\text{SrBi}_2\text{B}_4\text{O}_{10}$, a new ternary compound in the $\text{SrO-Bi}_2\text{O}_3\text{-B}_2\text{O}_3$ system. The structure solution demonstrated that it contained a novel type of isolated tetraborate anion, $[\text{B}_4\text{O}_9]^{6-}$ $4\text{B}: 3\Delta\Box: \langle 2\Delta\Box \rangle\Delta$, consisting of triborate ring $\langle 2\Delta\Box \rangle$ decorated by single triangle Δ . The compound belongs to a new structure type. The average thermal expansion coefficient of $\text{SrBi}_2\text{B}_4\text{O}_{10}$ is relatively low in comparison with other Bi-containing borates. Maximal anisotropy was observed in the plane approximately parallel (001). In this case, minimal expansion coincides with the direction of bismuth lone electron pair distribution. In accord to the heat-treatment results as well as DSC measurement $\text{SrBi}_2\text{B}_4\text{O}_{10}$ melts incongruently above 800°C : $\text{SrBi}_2\text{B}_4\text{O}_{10} \leftrightarrow \text{SrB}_2\text{O}_4 + \text{SrB}_4\text{O}_7 + \text{Liquid}$.

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