World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:18, No:08, 2024

Synthesis and Luminescent Properties of Barium-Europium (III) Silicate Systems

Authors : A. Isahakyan, A. Terzyan, V. Stepanyan, N. Zulumyan, H. Beglaryan

Abstract : Previous studies have shown that the involvement of silica hydrogel derived from serpentine minerals $(Mg(Fe))_6[Si_4O_{10}](OH)_8$ as a source of silicon dioxide in SiO_2–NaOH–$BaCl_2$–H_2O system results in precipitating via one-hour stirring of boiling suspension such intermediates that on heating up to the temperature of 800 °C crystallize into the product composed of barium ortho- Ba_2SiO_4 and metasilicates $BaSiO_3$. Taking into account the fact that the suggested precipitation method based on the silica hydrogel mentioned allowed avoiding a number of drawbacks related with tetraethoxysilane $Si(OC_2H_5)_4$ frequently used in sol-gel routes, this approach has been decided to be adapted to inserting europium (III) Eu^{3+} ions into the structure of the synthesized compounds. A series of experiments was performed for the investigation of optical properties evolution observable in the final samples. Intermediates previously precipitated in $SiO_2 \cdot H_2O$ (silica hydrogel)–NaOH–$BaCl_2$–$Eu(NO_3)_3$ system via stirring for 60 min at room temperature underwent one-hour heat-treatment at different temperatures (600–1200 °C). When the silica hydrogel was metered, SiO_2 content in the silica hydrogel that is 5.8 % was taken into consideration in order to guaranty the molar ratios of both SiO_2 to BaO and SiO_2 to Na_2O equal to 1:2. $BaCl_2$ and $Eu(NO_3)_3$ reagents were weighted so that the formation of appropriate compositions was guaranteed. A number of samples including various concentrations of Eu^{3+} ions (1.25, 2.5, 3.75, 5, 6.35, 8.65, 10, 17.5, 18.75 and 20 mol%) has been synthesized by the described method. Luminescence excitation, emission spectra of the final products were recorded on the Agilent Cary Eclipes fluorescence spectrophotometer (scanning rate = 30 nm/min, slit width = 5 nm, and Voltage = 800 V) as the excitation source. X-ray powder diffraction (XRPD) measurements were made on the SmartLab SE diffractometer. Emission spectra recorded for all the samples at an excitation wavelength of 394 nm exhibit peaks centered at around 536, 555, 587, 614, 653, 690 and 702.5 nm. The most intensive emission peak is observed at 614 nm due to 5D0 →7F2 of europium (III) ions transition. Luminescence intensity achieves its maximum for Eu^{3+}17.5 mol% and heat-treatment at 1200 °C. The XRPD patterns revealed that the diffraction peaks recorded for this sample are identical to $NaBa_6Nd(SiO_4)_4$ reflections. As Nd-containing reagents were not involved into the synthesis, the maximum luminescent intensity is most likely to be conditioned by $NaBa_6Eu(SiO_4)_4$ formation whose reflections are not available in the ICDD-JCPDS database of crystallographic 2024. Up to Eu3+2.5 mol% the samples demonstrate the phases corresponding to Ba_2SiO_4 and $BaSiO_3$ standards. Subsequent increasing of europium (III) concentration in the system leads to $NaBa_6Eu(SiO_4)_4$ formation along with Ba_2SiO4 and BaSiO3. $NaBa_6Eu(SiO_4)_4$ share gradually increases and starting from 17.5 mol% and more $NaBa_6Eu(SiO_4)_4$ phase is only registered. Thus, the variation of europium (III) concentration in silica hydrogel–NaOH–$BaCl_2$–$Eu(NO_3)_3$ system allows producing by the precipitation method the products composed of europium (III)-doped Ba_2SiO_4 and $BaSiO_3$ and/or $NaBa_6Eu(SiO_4)_4$ distinguished by different luminescent properties. The work was supported by the Science Committee of RA, in the frames of the research project № 21T-1D131.

Keywords : europium (III)-doped barium ortho- Ba2SiO4 and metasilicates $BaSiO_3$, $NaBa_6Eu(SiO_4)_4$, luminescence, precipitation method

Conference Title : ICLMLS 2024 : International Conference on Luminescent Materials and Luminescence Science

Conference Location : Venice, Italy

Conference Dates : August 15-16, 2024