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Study on physical, optical and luminescence of zinc tellurite glasses doped with bismuth oxide

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Abstract

A series of zinc tellurite glasses of the composition (90-x) TeO_2 – 10ZnO – xBi_2O_3 by (where x = 10, 15, 20, 25 mol%) were synthesized using the conventional melt quenching technique at 1,150 °C for 1 hours 30 minutes. This research the physical, optical and luminescence properties of the glasses by the process just described produced. In order to understand the role of Bi_2O_3 in zinc tellurite glasses systems, the physical, optical and luminescence properties of the glasses were investigated. The result showed that density increased and molar volume increased with increasing Bi_2O_3 concentration. The optical absorption spectra of glasses were measured in the wavelength range of 200 – 1,100 nm for Bi^{3+}. The intensity of absorption also increased with increasing of Bi_2O_3 concentration. The intensity of emission bands at 602 nm increased with increasing Bi_2O_3 concentration. In addition. The luminescence properties of Bi^{3+} -dope TeO_2 – ZnO – Bi_2O_3 glass system were carried out using excitation wavelengths of 302 nm for Bi_2O_3. It was found that the luminescence peaks around 602 nm.

Keywords: Zinc tellurite glass, bismuth oxide, physical property, optical property, luminescence property

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1. Introduction

Glass based on tellurium dioxide possess good thermal and light stability, high refractive index, stable at room temperature, high dielectric constant and low phonon energy. These favorable properties make tellurite glasses as promising materials in the field of optical equipment, laser equipment, signals and telecommunication systems due to Its ability to transmit in broad wavelength region (6 μm). [1] Zinc oxide possess high thermal stability and chemical durability, high refractive index and molten point at low temperature [2-3]. Furthermore, zinc oxide can be used to develop electronic devices and make a laser device. [4] Bismuth oxide has gained a lot of attention in the glass industry because it has nonlinear properties, high refractive index and high density. It is a good choice for optical and laser codecs. [5] The development of technology producing optical materials requires suitable compositions for the manufacture of vitreous products. Concerning, the purpose of this paper was to establish the glassforming in the TeO_2 – ZnO – Bi_2O_3 system and study in physical, optical and luminescence.

2. Experiment

A series of zinc tellurite glasses of the composition (90-x) TeO_2 – 10ZnO – xBi_2O_3 by (where x = 10, 15, 20, 25 mol%) have been synthesized from high purity powder of TeO_2, ZnO and Bi2O3 total weight of 15 g by conventional melt quenching technique at 1,150 °C for 1 hours 30 minutes and annealing at 350 °C for 3 hours. Analysis of physical properties by density and molar volume via Archimedes melted using densitometer HR-200 weighing valance was carried out. The optical measurement sample of 0.3 mm thickness were cut and polished to optical quality. The transmission spectra of the samples prepared were measured using a UV-Visible Spectrophotometer Cary 50 Scan (VARIAN) in the 200-1,100 nm range and the excitation emission spectra were collected by using a Cary Eclipse Fluorescence Spectrophotometer (Agilent Technologies).

3. Results and Discussion

3.1. Physical properties

The result showed that density increased and molar volume increased with increasing Bi_2O_3 concentration by density range of 4.3936 ± 0.0294 to 7296.4

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Table 1. Density and molar volume of the bismuth-doped glasses

Physical Properties	Density (g/cm^3)	Molar Volume (cm^3/mol)
10 mol%	4.3936 ± 0.0294	41.5175
15 mol%	4.6177 ± 0.0047	42.8199
20 mol%	4.7123 ± 0.0124	45.2111
25 mol%	4.7296 ± 0.0083	48.2851

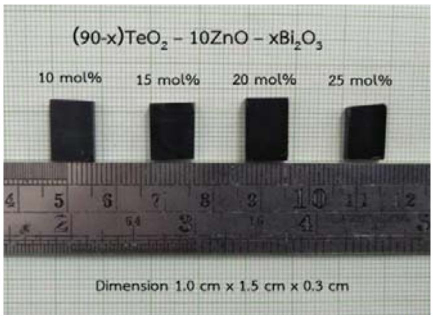

Figure 1: Glass sample of the bismuth-doped zinc tellurite glasses.

± 0.0083 g/cm^3 and molar volume range of 41.5175 to 48.2851 cm3/mol. It is clear that with increasing concentration of Bi_2O_3, the overall molecular weight of the glasses has increased due to its high MW (465.96 g/mol), as a result, the density of bismuth-doped glasses was increased and has shown maximum value 5.732 g/cm^3. That can be explained by high refractive index of individual Bi_2O_3 (≈2.4), and indicates the increase of non-bridging oxygens to bridging oxygens ratio [6].

3.2. Optical properties

The result showed that optical absorption spectra of glasses were measured in the wavelength range of 200 – 1,100 nm for Bi^{3+} the intensity of all absorption bands increased with increasing Bi_2O_3 content by absorption edge of 532, 555, 581 and 646 nm. In fact, measuring cut-off wavelength is a useful factor in order to clearly understand optical transitions and electronic band structure in amorphous solids. From the absorption spectra, within the wavelength range 400–800 nm, absorption coefficient $\alpha(\lambda)$ was calculated for all the glasses with thickness of 'd' using the optical absorbance A, based on the following formula that reported in [7] :

$$\alpha(\lambda) = 2.303\left(\frac{A}{d}\right) \quad (1)$$

The polished glasses thickness was≈ 3.0 mm. In our glasses due to the≈ (3 mm) thickness, we choose absorption coefficient $\alpha(\lambda)$ at ≈ 12 cm^{-1} as a reference similarly as in absorbance A, based on the following formula that reported in [8].

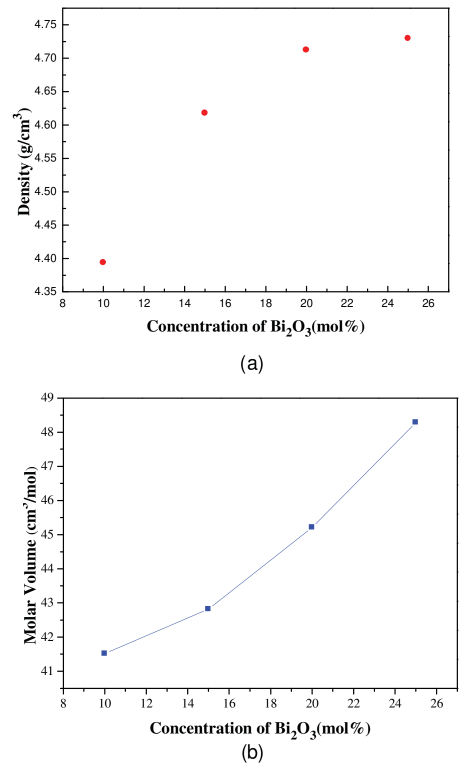

Figure 2: (a) Density of the bismuth-doped glasses (b) Molar volume of the bismuth-doped glasses

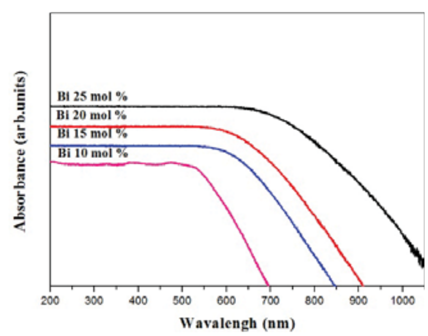

Figure 3: Absorption spectra of the bismuth-doped glasses.

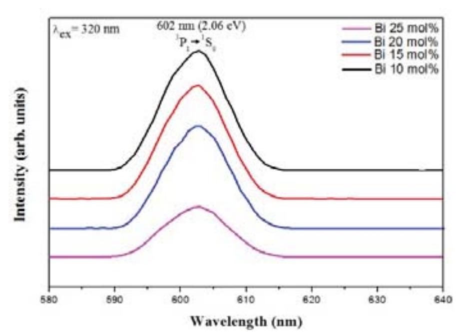

Figure 4: Emission spectra of the bismuth-doped glasses.

3.3. Luminescent

The result showed that Emission spectra of glasses were carried out using excitation wavelengths of 302 nm for Bi_2O_3 the luminescence peaks around 602 nm.

4. Conclusions

The result showed that density increased and molar volume increased with increasing Bi_2O_3 concentration. The optical absorption spectra of glasses were measured in the wavelength range of 200 – 1,100 nm for Bi^{3+} the intensity of all absorption bands increased with increasing Bi_2O_3 content. The intensity of all emission bands increased with increasing Bi_2O_3 contents. In addition, the luminescence properties of Bi^{3+} -dope TeO_2 – ZnO – Bi_2O_3 glass system were carried out using excitation wavelengths of 302 nm for Bi_2O_3 the luminescence peaks around 602 nm.

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