FT-IR and Density Studies on Neodymium Doped Zinc Borotellurite Glass System

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Abstract- Glasses with chemical compositional (50-x)B2O3-45ZnO-05TeO2-XNd2O3 (X=0.5,1.0,1.5 & 2.0) were prepared by conventional melt-quenching technique. The structural properties of the prepared glasses were determined by X-ray diffraction (XRD) analysis and FTIR analysis. The FTIR spectra were recorded at room temperature in the frequency range from 600 to 4000 cm-1. It was confirmed that the prepared glasses are amorphous in nature. The bonding parameters of the glasses were analyzed by using FTIR analysis and were confirmed to be ionic in nature. The density and molar volume of these glasses have been measured and analyzed.

Index Terms- Borotellurite Glass, Melt Quench, XRD, Density, FT-IR.

I. Introduction

Tellurite based glass containing rare earth oxide has received significant attention due their excellent optical properties for future applications. It is well known that these glasses are better competitors for optical transmission studies due to their long infrared (IR) cut-off [1].Among the possible rare earth ions, neodymium is one of the most studied rare earth ions and is also one of the most efficient candidates for photonic devices [2]. Neodymium doped tellurite glasses are suitable candidates to develop waveguide lasers, color display devices, optical fibers and optical amplifiers [3]. In recent years, heavy metallic oxide glasses doped with rare earth ions are very useful material for the better performance of the optical properties [4-5]. There are two types of structural units namely trigonal bipyramid (tbp) and trigonal pyramid (tp) TeO_2 which are responsible for the attractive properties arising from these tellurite based glasses.

II. Materials and Methods

In the present study, the glass samples of composition (50-x) B_2O_3-45ZnO-05TeO_2-XNd_2O_3 (X=0.5,1.0,1.5 & 2.0) have been prepared by the melt quench technique. High purity (99.99%) zinc oxide (ZnO), Tellurium Oxide (TeO_2), Boric oxide (H_3BO_3),Neodymium oxide (Nd_2O_3) were used as starting materials. A batch of 20g of the above high purity chemicals in powder form was weighed, well mixed and melted in a alumina crucible in the temperature range 1100–1200^{0}C for 2 hrs. All the melting processes were done using electric furnace TAIE FY 400. After the melting process, each melt was quenched rapidly into cylindrical stainless steel split mould which had been preheated at 400^{0}C in order to relieve the mechanical stress in sample.

III. Result and Discussions

3.1 XRD Study

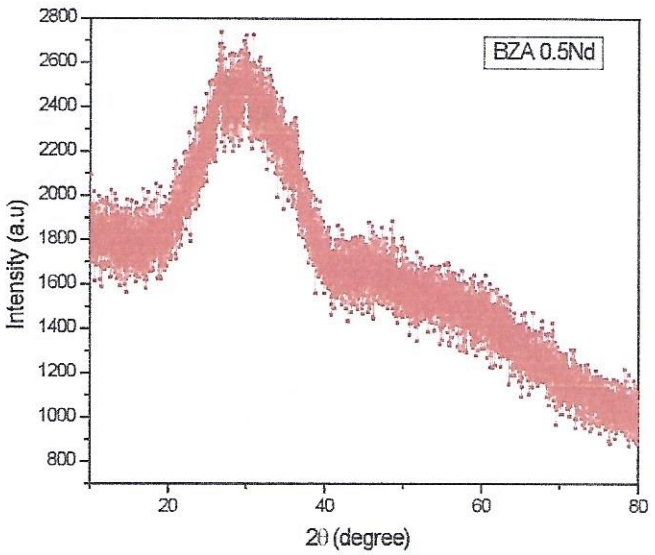

Fig.1. XRD pattern of 0.5% of Neodymium Doped Zinc Borotellurite Glass System.

The glasses were characterized using XRD for their structural study. Powder X-ray diffraction of the (50-x) B_2O_3-45ZnO-05TeO_2-XNd_2O_3 Glass samples showed broad peak as shown in fig.1 the zinc borotellurite doped with neodymium glass samples showed broad peak characterstics of glass structure. Representative XRD pattern is shown in fig.1 confirms the amorphous or glassy nature of the investigated glass samples.

3.2 Density and Molar Volume

The density measurement is considered to be a very important tool to detect the structural changes in the glass network. The density is supposed to change abruptly when the structure of the glass is slightly changed. The density of the prepared glass samples were measured using Archimedes Principle using a sensitive balance with pure xylene as immersion fluid. The density was calculated. The value of density decreases from 1.73 to 1.03 g/cm^3; while the values of

the molar volume increases from 49.04 to 81.49 cc/mol with the gradual increase of the Nd_2O_3 in the zinc borotellurite glasses.

The density and molar volume for (50-x) B_2O_3-45ZnO-05TeO_2-XNd_2O_3 glass system is shown in table 1 and fig.2.

Table 1. Variation of Density and Molar Volume of Neodymium Doped Zinc Borotellurite Glass System

Sr.No.	Glass Code	Glass Composition (mol%)				Molar Mass (gm)	Density (g/cm^3)	Molar Volume (cc/mol)
		B_2O_3	ZnO	TeO_2	Nd_2O_3			
1.	BZT-0.5Nd	49.5	45	05	0.5	84.85	1.73	49.04
2.	BZT-1.0Nd	49	45	05	1.0	81.92	1.37	59.79
3.	BZT-1.5Nd	48.5	45	05	1.5	83.26	1.21	68.80
4.	BZT-2.0Nd	48	45	05	2.0	84.59	1.03	81.49

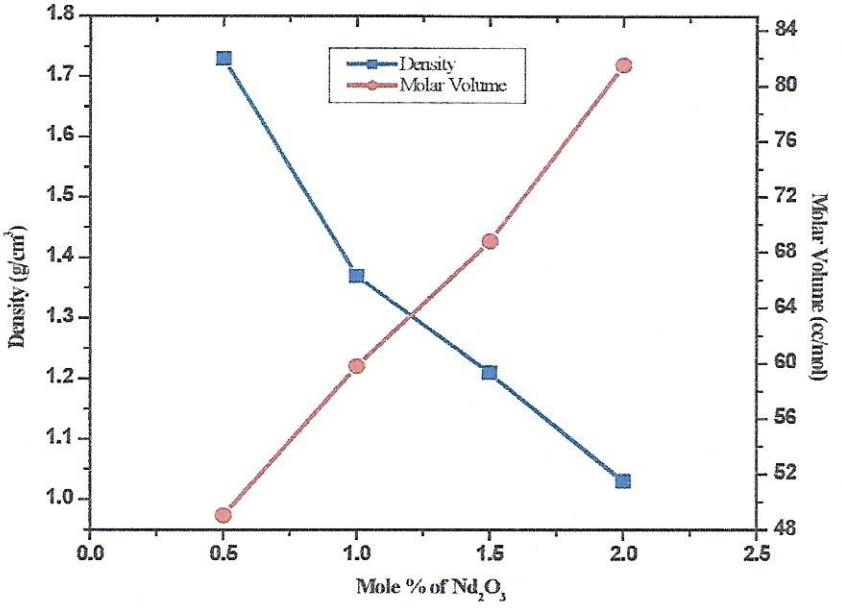

Fig.2. Variation of Density and Molar Volume of Neodymium Doped Zinc Borotellurite Glass Systemwith the Nd_2O_3 content.

3.3 FTIR Analysis

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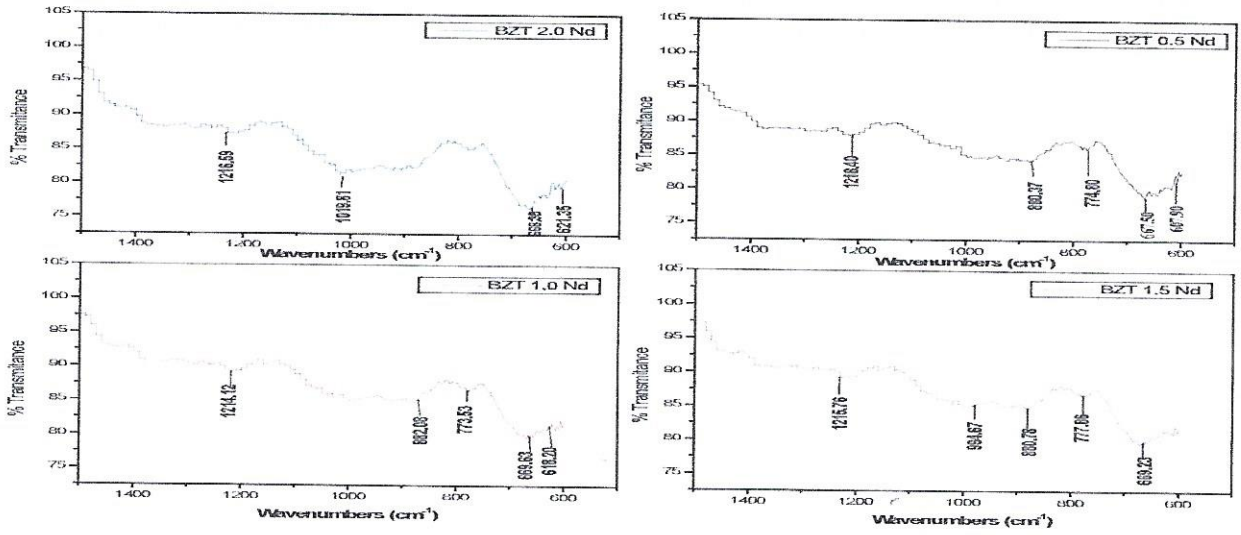

Fig.3. FTIR Spectra of 0.5-2.0% of Nd_2O_3 Doped Zinc

Borotellurite Glass System.

The FTIR spectroscopy is an analysis method which offers structural studies to explore the fundamental and functional fractions in crystalline and non-crystalline matrices. The transmission spectra of the prepared glass samples are recorded in Fig.3 with different composition of Neodymium oxide glass sample recorded in the region 600-4000 cm^{-1}.The characteristics of tellurite oxide structural unit located in the range 600-750 cm^{-1}.After the formation of glass, tellurite oxide finds in two structural units which are trigonal bipyramidal TeO_4 and triagonal pyramidal TeO_3.The first group of band (TeO_4) is located in the range 600-621 cm^{-1} which correlates to the trigonal bipyramidal structural unit. Meanwhile second group of band is located in the region 621-700 cm^{-1} which corresponds to the triagonal pyramidal, TeO_3 structural unit. Pure TeO2 is characterized by an infrared absorption at around 640 cm-1. The formation of borate oxide structural unit located in the region 600-800 cm^{-1} which is attributed to bending vibrations of various borate arrangements. The band located in the range 800-1200 cm^{-1} is due to the B-O stretching of tetrahedral BO_4 units. The band located in the range 1214-1218 cm^{-1} is due to B-O stretching of trigonal BO_3 units [6]. The absorption band at 880-882.08 cm^{-1} could be correspond to B–O stretching vibration of BO_4 units [7]. It can be seen that the band of ZnO does not appear in the spectra which means the zinc lattice is completely broken down [8].

IV. Conclusions

Neodymium doped zinc borotellurite glass system was successfully prepared and characterized. The amorphous nature of the glasses was confirmed by using XRD analysis. The density of the glasses decreased while their molar volume values increases with the increase of neodymium oxide content in borotellurite glasses. FTIR spectra of the glass sample shows the charachterstics of tellurite oxide structural unit were located in the range 600-750 cm^{-1}.

From the IR results, the absorption bands are found to be in the range 667-669 cm^{-1}, 773-778 cm^{-1}, 880-882 cm^{-1}, 994-1019 cm^{-1} and 1214-1218 cm^{-1} which correspond to the stretching and bending vibrations mode. All the above conclusions are in complete agreement with the experimental results obtained.

References

[1] M.Farouk, A. Samir, F. Metawe, M. Elokr, Optical absorption and structural studies ofbismuth borate glasses containing Er^{3+} ions. *Journal of non-crystalline solids*. 14-21. (2013).

[2] P.Chimalawong, J.Kaewjhao , C.Kedkaew., P.Limsuwan.(2010) "Optical and electronic

[3] polarization of Nd^{3+} doped soda-lime silicate glasses"*Journal of Physcics and Chemistry of Solids*.975-970.

[4] M. Reza Dousti, M. Sahar, S. Ghoshal, "Effect of AgCl on spectroscopic properties of erbiumdoped zinc tellurite glass," *Journal of Molecular Structure*. Vol 1035, pp 6-12(2013)

[5] R. Balda, J. Fernadez, A. Mendioroz, M. Al-Saleh. In: S. Jiang, Keys RW (eds.) Rare earth doped materials and devices VI, Proc. SPIE, Vol. 4645, 4/2002, pp 97.

[6] V. K. Rai, L. de S. Menezes, C. B. de Araujo, J. Appl. Phys., 101 (2007)123514.

[7] H.W.Li,Sh.Q.Man,Opt. Commun.282(2009) 1579.

[8] P.Damas, , , J. Coelho, G.Hungerford, &N.S. Hussain,2012. Structural Studies of Lithium Borotelluriteglasses Doped with Praseodymium and Samarium Oxides. *Materials Research Bulletin*. 47(11): 3489-3494.

[9] M. N. Azlan, M. K. Halimah, S. Z. Shafinasand, W. M. Daud, Journal of Nanomaterials, **2013**, 1 (2013).

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