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Optical studies of lanthanum oxide doped phosphate glasses

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ABSTRACT

Phosphate glasses are special class of optical glasses composed with metaphosphate of different metals. When rare earth elements are added to glass matrix as dopant, it improves glass melting and also enhances some unique glass properties. Lanthanum oxide doped Phosphate glass system were prepared with melt quenching method. The effect of different concentration (0.5% & 1.5%) of La_2O_3 on electrical, structural and optical properties of phosphate glasses have been studied. The FTIR studies shows, in 0.5% of La_2O_3 doped phosphate glass, sharp peaks were observed with high intensity values. The absence of crystalline structure in the prepared phosphate glasses were confined by both Raman and XRD studies. With the addition of La_2O_3 to P_2O_5, the phosphate glasses alters its structure from cross-linked network to chain network.

The absence of crystalline structure in the prepared phosphate glasses were confined by both Raman and XRD studies. According to the Raman spectra, there is a corresponding decrease in the number of Q_2 units with increasing lanthanum oxide content with the addition of La_2O_3 to P_2O_5, the phosphate glasses alters its structure from cross-linked network to chain network.

1. Introduction

Among various types of oxide glasses, phosphate glasses are more attractive because of its peculiar property of accommodating large volume of active ions without losing its properties. Phosphate glasses exhibits properties like high thermal expansion coefficient, low melting, high ultra violet transmission etc. which makes it superior than borate and silicate glasses [1]. The phosphate glasses are considered for vitrifying certain nuclear wastes they are poorly used for borosilicate glasses [2]. The phosphate glasses are considered for vitrification of certain nuclear waste. The physical and chemical durability of phosphate glasses can be improved by introducing heavy metal oxides into P_2O_5 glass network [3]. The properties of phosphate glasses are determined with the help of their structure. On account of Brow's review, the structure of phosphate glasses are composed of phosphor–oxygen tetrahedrons connected by one or three bridging oxygen atoms (BOs) to form a network [4]. The connectivity of the network is often represented in Q^n notation, where 'n' represents represents the number of bridging oxygen atoms in PO_4 tetrahedron, and this connectivity is affected by glass composition [5]. Phosphate glasses attained particular attention in both in technological and scientific fields because they have low processing temperature (less than 1000 °C) and lower glass transition temperatures [6,7].

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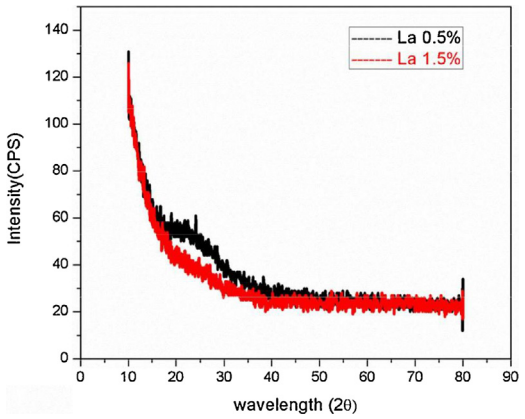

Fig. 1. XRD Pattern of the La_2O_3 doped phosphate glass (series A).

In previous studies, Umakant et al. reported that the chemical properties of glasses can be improved due to the introduction of Zn in the glass [1]. The Lithium carbonate is used as a modifier in the prepared phosphate glasses, helps to lower the melting point. Being Lithium as a component of glasses, these types of glasses offers applications in high energy batteries and other electrochemical applications. Another important key component is Sr_2Co_3, which prevents the X-ray emission. Hence, the prepared phosphate glasses can be suggested for radiation shielding purposes.

The conductivity studies of glasses containing rare earth elements reveal that the conductivity of glasses decreases with increase in the Rare earth ions due to their slow mobility because of their heavy masses [8,9].

The elements including lanthanum to actinium are specially named as Rare earth elements (17 elements) because of its high electrical conductivity. In addition to these 15 Lanthanides, scandium and Yttrium also exhibits 3+ oxidation states. From the different RE elements, we have chosen Lanthanum Oxide as a dopant for the prepared phosphate glasses. Among all rare earth elements La_2O_3 plays a vital role in modification of various physical and chemical properties of glasses and ceramics. It also plays an important role in material for high temperature seals in solid oxide fuel cells [10]. Being a member of Lanthanide group, La_2O_3 improves alkali resistance of the glass, and hence it can be used for making infrared absorbing glasses and camera lenses. These types of glasses have high refractive index. Due to the above mentioned properties La_2O_3 doped glasses had been widely studied in the field of different application like solar cells, laser host materials etc.

In this paper we present the study of Lanthanum oxide doped phosphate glasses prepared by melt quenching method, and characterized by XRD, UV–vis, Fluorescence spectroscopy, FTIR and Raman studies. In the present article, we report the electrical and optical properties of phosphate glasses while using additives in various ratios.

2. Experimental discussion

Lanthanum oxide doped phosphate glass ($59P_2O_5 + 10ZnO + 10Li_2Co_3 + 9Sr_2Co_3 + 10\ H_6NO_4 + 1Y_2O_3 + X\%$ of RE (where X = 0.5% and 1.5%)) was prepared by melt quenching method. All components were taken in powdered form purchased from Sigma Aldrich with 99.9999% of purity. The well mixed batch samples (Pure & doped) were taken in a platinum crucible and heated in electrical furnace at 1160° for 4 h. The melted samples poured into preheated brass dye which was maintained at 400° and annealed for 2 h. After this process, samples were gradually cooled to room temperature. The obtained transparent glasses were utilized for various characterizations.

Two series of Lanthanum doped phosphate glasses have been prepared: series A and series B. In Series A phosphate glasses, Lanthanum oxide of two different compositions 0.5% and 1.5% doped with 0.5% of yttrium oxide (only lanthanum oxide concentration changes). While at the same time, in the other series both yttrium oxide and Lanthanum oxide of same ratio 0.5% and 1.5% were added (concentration of both yttrium and lanthanum oxides change). All the samples prepared by the same method.

3. Results and discussion

3.1. XRD

X-ray diffraction pattern of the phosphate glasses recorded in the range of $0^\circ \leq \theta \leq 80^\circ$ exhibits broad diffusion scattering at lower angles, which defines the lower range of structural disorder of the samples. The XRD characterization confines the amorphous nature of the prepared glass samples. Figs. 1 and 2 represent the XRD pattern of Series A & B Lanthanum oxide phosphate glasses respectively, and they do not reveal any sharp peaks.

While increasing the ratio of both Y_2O_3 and La_2O_3, the resultant graph predicts the amorphous nature of the glass sample.