

DTA traces of Lead Gallium Phosphate Glasses doped with tungsten ions

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ABSTRACT: Lead scandium phosphate glasses (PbO-Sc₂O₃-P₂O₅) containing different concentrations of tungsten oxide (WO₃) ranging from 0 to 5 mol% were prepared. A differential thermal analysis (DTA) have been carried out. The results of DTA indicated the highest glass forming ability for the glass containing 5 mol % of WO₃.

KEYWORDS: PbO, Ga₂O₃, P₂O₅ glasses, Tungsten ions.

I. INTRODUCTION

P₂O₅ glasses are well-known due to their high thermal expansion coefficients (~ 20 to $27 \times 10^{-6}/^{\circ}\text{C}$) [1], low melting and softening temperatures and high ultra-violet and far infra red transmission [2,3]. Interest on these glasses was simulated by their use in a variety of industrial applications, including sequestering agents for hard water treatments and dispersants for clay processing and pigment manufacturing [4]. They are also the materials of choice particularly for high power laser applications [5]. In recent years there has been an enormous amount of research on improving the physical properties and the chemical durability of phosphate glasses by introducing a number of glass formers and modifiers such as Al₂O₃, MoO₃, Ga₂O₃, Cr₂O₃, Ta₂O₃, Sb₂O₃, As₂O₃, etc., into P₂O₅ glass network [6,7]. The addition of heavy metal oxides like PbO to the phosphate glasses is expected to improve the thermal stability of the glasses to a large extent. The addition of heavy metal oxides like PbO to the phosphate glasses is expected to improve the thermal stability of the glasses to a large extent. A considerable amount of work has been reported on PbO based glasses in the recent years [8,9]. The property of phototropism of WO₃ mixed glasses, they are proposed as promising candidates for application in information display devices of high memory [10,11]. WO₃ containing host materials are also widely used in smart windows to control solar input of buildings or related to large area displays [12,13]. The aim of the present study is to explore the structural influence of WO₃ on PbO- Sc₂O₃-P₂O₅ glass system, by a systematic study of DTA.

II. EXPERIMENTAL METHODS

Within the glass forming region of lead scandium phosphate glasses doped with tungsten ions, a particular composition 40PbO-(10 - x)Ga₂O₃-50P₂O₅:xWO₃ (with x ranging from 0 to 5mol %) is chosen for the present study. We labelled them as PGPW0, PGPW1, PGPW2, PGPW3, PGPW4, and PGPW5 for x = 0, 1, 2, 3, 4, and 5 mol% of WO₃. The starting materials to obtain the glass were (NH₄)₂HPO₄, PbO, Ga₂O₃, and WO₃ of reagent grade purity. The samples were prepared by weighing suitable proportions of the components; the powder was mixed thoroughly in an agate mortar and melted in a thick-walled platinum crucible at 1050–1200°C in an automatic temperature controlled furnace for about 1 h until a bubble free transparent liquid was formed. The resultant melt was then poured in a brass mould and subsequently annealed from 300°C with a cooling rate of 1°C/min. The amorphous state of the glasses was checked by X-ray diffraction. Differential thermal analysis (DTA) was carried out using STA 409C, Model DTATG instrument with a programmed heating rate of 10°C/min, in the temperature range 30–850°C to determine the glass transition temperature and other glass forming ability parameters.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 7, July 2016

III. RESULTS AND DISCUSSION

Figure 1 shows the DTA traces of the glasses in study. The glass transition temperature (T_g) is described as the change in temperature in which a reversible transition occurs in amorphous materials from a hard and relatively brittle state to a molten or rubber-like state. An amorphous material below its T_g (glassy state) behaves like a brittle solid but without a crystalline structure and only has short-range order [14]. It is the temperature at which glass physical properties change. As the temperature increases, an amorphous solid will become less viscous. At some point the molecules may obtain enough freedom of motion to spontaneously arrange themselves into a crystalline form. This is known as the crystallization temperature (T_c). This transition from amorphous solid to crystalline solid is an exothermic process. The DTA traces of these glasses demonstrate an endothermic effect due to the glass transition temperature T_g between 395 and 426°C, the glass transitions temperature is observed to increase with the increasing content of WO_3 in the glass matrix. This is due to the decrement in the non-bridging oxygens (NBO). In the region, 787–825°C, an exothermic peak due to crystallization is observed in the traces of all the glasses. The increase in the augmented cross-link density of various structural groups and the reduction in the closeness of packing are accountable for the increase of these parameters in these glasses. These results manifest that, with the increase in the concentration of WO_3 in the glass matrix, tungsten ions regularly occupy network forming positions, increase the cross-link density, and enhance the mean bond strength.

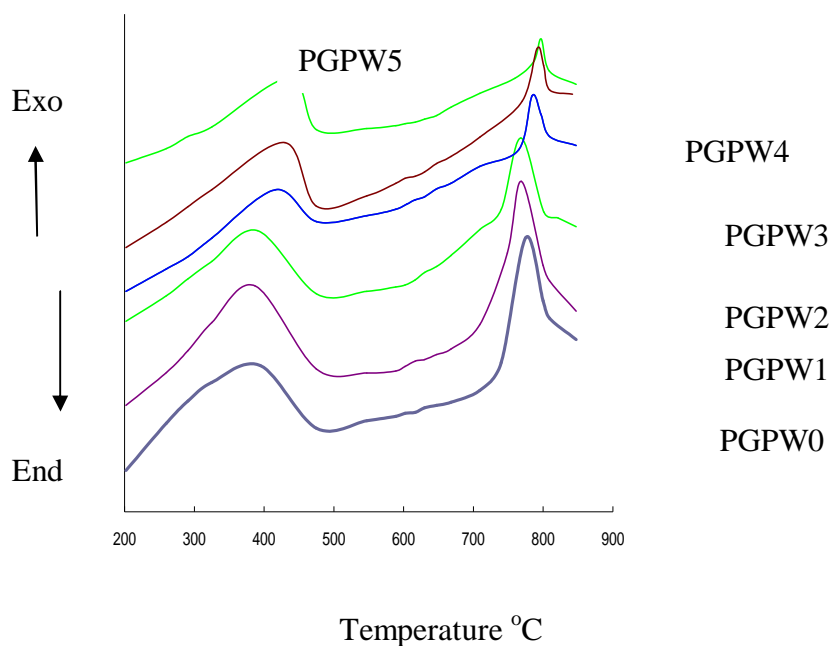


Fig. 1. DTA traces of PbO–Ga₂O₃–P₂O₅:WO₃ glasses.

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Vol. 5, Issue 7, July 2016

V. CONCLUSION

The study of the outcome of DTA indicated that the glass forming ability is high for the glass W5, that is, the glass containing 5 mol% of WO₃.

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