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Measurements of Vickers Hardness and Refractive Index Properties of Na-Borophosphate Glasses

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Abstract : Microhardness and Refractive Index measurements are performed on x Na_2O (100-X) P_2O_5, (x=25, 30, 35, 40) and 30 Na_2O (70-x) P_2O_5- x B_2O_3, (x = 15, 20, 25, 30) have been investigated to find out the role played by B_2O_3 on the structure of these glasses. These glass samples have been prepared using a conventional melt – quenching method. Microhardness studies revealed that the hardness of the glasses increases with an increase in applied load. Refractive index of the glasses increases with an increase in B_2O_3 content.
Keywords : Vickers hardness, Refractive Index, Melt Quench Method, Glass.

Introduction:

Microhardness is an important parameter often used to define the mechanical properties of a material on a microscopic scale. Hardness of the material is an important solid-state phenomenon. The hardness of a material is defined as the resistance it offers to the motionof dislocations deformation, or damage under an applied stress. Generally, the apparent hardness of the materials varies withapplied load. This phenomenon, known as the indentation size effect (ISE), usually involves a decrease in the micro hardness with increasing applied load[1-4].Phosphate glass usually posses low melting temperature, high thermal expansions coefficient low glass transition coefficient, low glass transition temperature (*Tg*), low softening temperature(*Td*) and are of increasing interest for many application, glass to metal seal [5-7]. In recent years, there has been an increasing interest in the synthesis and characterization of structure and physical properties of heavy metal oxide glasses due to their high refractive index, high density, high non-linear optical susceptibility, high infrared transparency and good radiation shielding for γ-rays [8]. B_2O_3 is one of the most popular and excellent glass formers because of its higher bond strength, lower cation size and smaller heat of fusion, so the structural investigation of boron in these glasses is one of the most attractive points of borate glass formation and related doped systems. In borate glasses, B^{3+} ions are triangularly coordinated by oxygen atoms and the triangle units are corner bounded in a random configuration [9].

Materials and Method:

Preparation of Glasses

Borohosphate glass having composition ,x Na_2O (100-X) P_2O_5, (x=25,30,35,40) and 30 Na_2O (70-x) P_2O_5- x B_2O_3, (x =15,20,25,30) were prepared by conventional melt-quench technique. Analytical grade reagents with no water of crystallization, Na_2O, $NH_4H_2PO_4$, H_3BO_3 are used as a starting material. The required amounts (approximately 25g) in mol% of different chemicals in powder form were weighed using single pan balance having an accuracy of ±0.0001g. The homogenization of the appropriate mixture of the components of

chemicals is effected by repeated grinding using a mortar. The homogeneous mixture is put in an alumina crucible and placed in a furnace at temperature ranging from 900-1000^{0}C depending on composition when the melt was thoroughly homogenized and attained desirable viscosity, it was poured either onto a metal plate. The prepared glass was then annealed at appropriate temperature (Between 300-400^{0}C) for 3 hrs and stored in a desicator prior evaluation.

Results and Discussion:

Refractive Index:

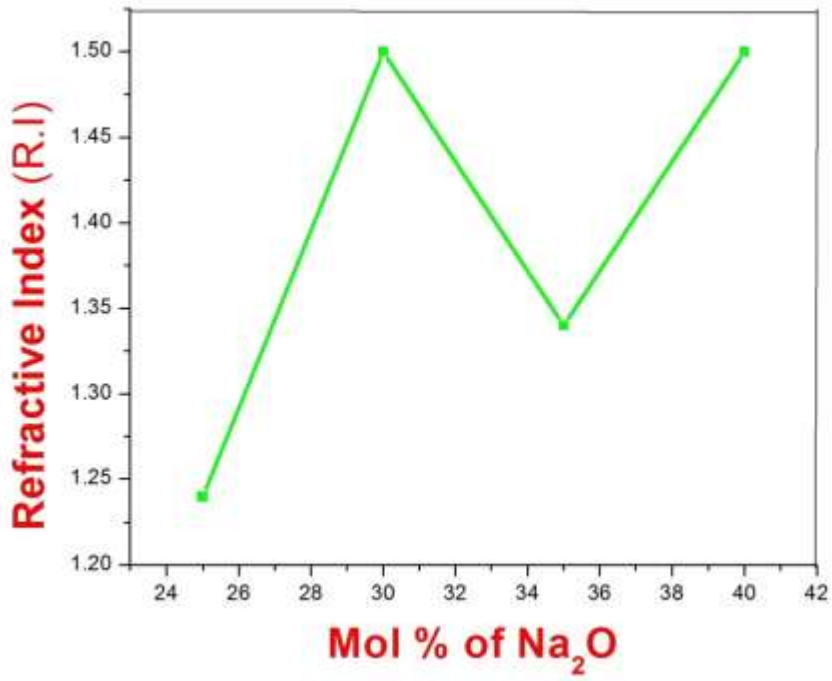

Fig. 1.1Refractive Index ofx Na_2O-(100-x) P_2O_5, (x=25, 30,35,40) glass systems

We have obtained bubble free glass samples in all the cases. Refractive Index measurements are performed on x Na_2O-(100-x) P_2O_5, (x=25, 30, 35, 40) and30 Na_2O (70-x) P_2O_5- x B_2O_3, (x = 15, 20, 25, 30)glass systems have been investigated to find out the role played by B_2O_3 on the structure of these glasses. Refractive Index studies revealed that the refractive index of the glasses increases in the region 1.24 to 1.5 and 1.7 to 1.8 with an increase in B_2O_3 content.

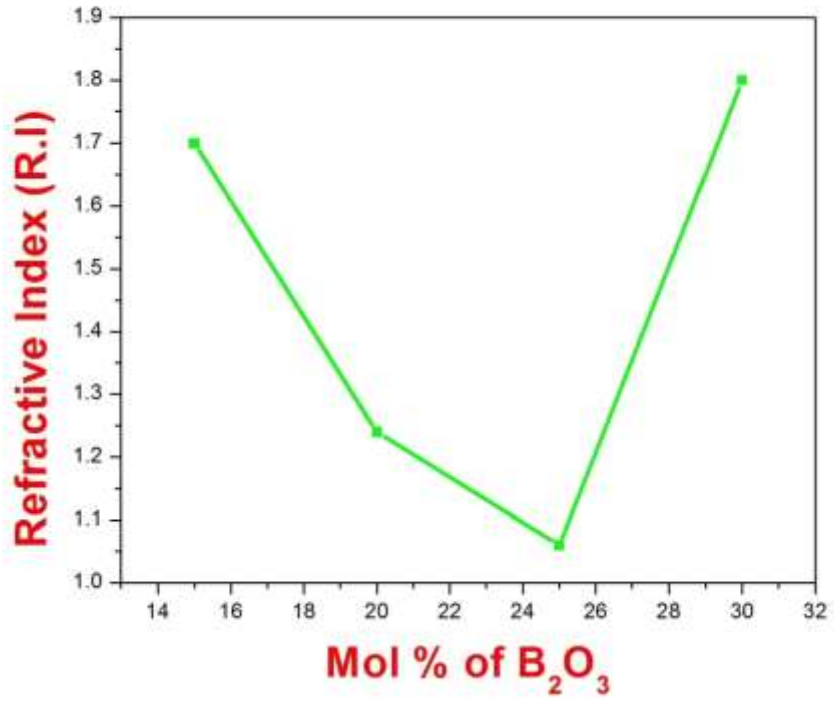

Fig.1.2. Refractive Index of 30 Na_2O-(70-x) P_2O_5-xB_2O_3, (x=15, 20,25,30) glass systems

Microhardness:

Fig.1.3 Vickers indentation image15% of B_2O_3content

Fig.1.4 Vickers indentation imageof25% of B_2O_3content

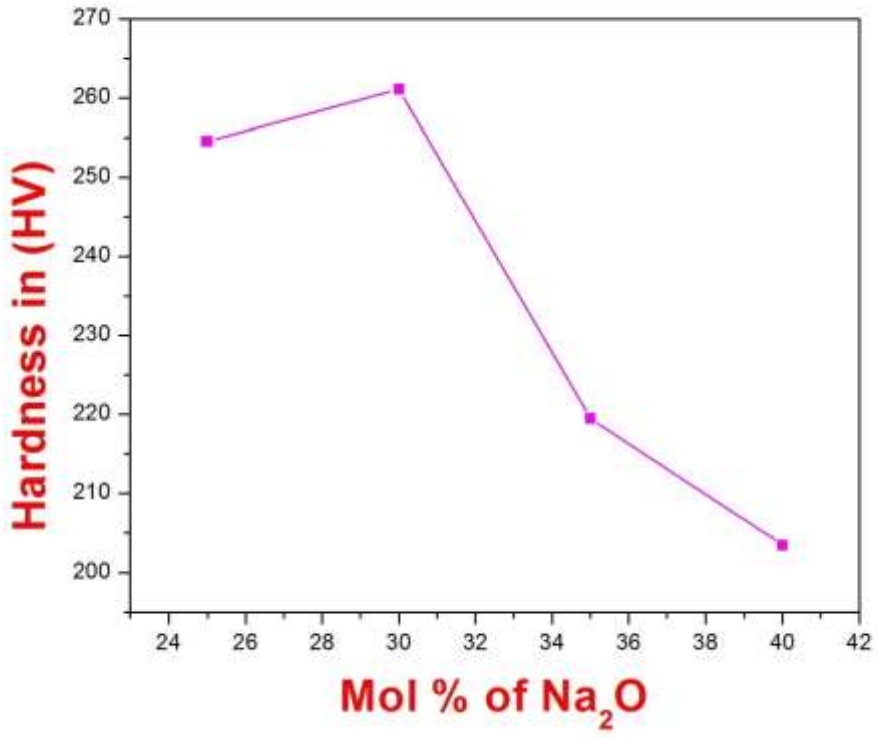

Fig.1.5. Microhardness of x Na_2O-(100-x) P_2O_5, (x=25, 30,35,40) glass systems

The Vickers indentation technique is used for these glasses. Before measurements, the sample was polished with silica carbide paper. We apply 50 gf loads for 10 sec. for indentation. Microhardness value was taken as the average of three values and any crack is not observed.

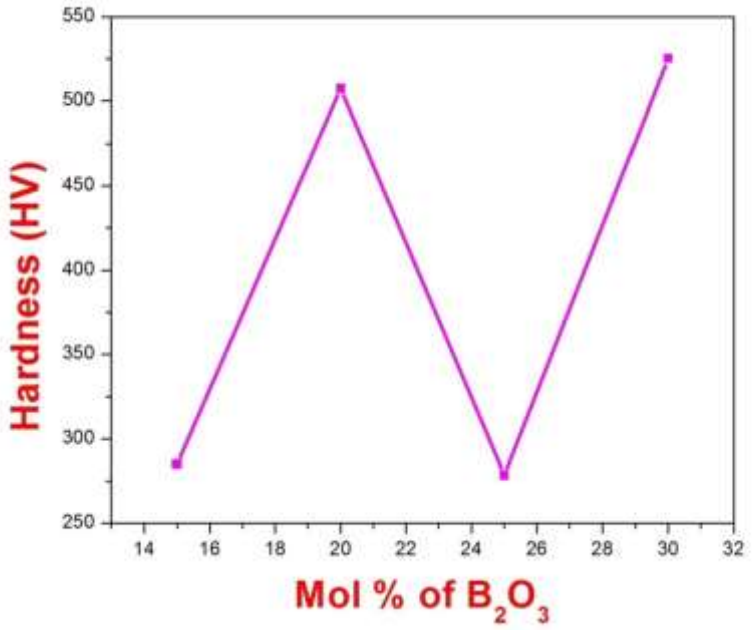

Fig.1.6. Microhardness 30 Na_2O-(70-x) P_2O_5-xB_2O_3, (x=15, 20, 25, 30) glass systems

The microhardness of 30 Na_2O-(70-x) P_2O_5-xB_2O_3, (x=15, 20, 25, 30) glasses is 254.55 GPa for 25% B_2O_3, 261.1GPa for 30% B_2O_3, 219.5GPa for 35% B_2O_3 and 203.5GPa for 40% of B_2O_3 content and the microhardness of 30 Na_2O-(70-x) P_2O_5-xB_2O_3, (x=15, 20, 25, 30) glasses is 285.1 GPa for 15% B_2O_3, 507.5 GPa for 20% B_2O_3, 278.5 GPa for 25% B_2O_3 and 525.5 GPa for 30% of B_2O_3 content. It confirms that the formation of more rigidity structure in present glass samples.

Conclusion:

Homogenous glasses of the sodium borophosphate glasses were prepared successfully by melt-quench method. Analytical grade reagents were used as a starting material. From the refractive index studies it revealed that the refractive index of the glasses increases in the region 1.24 to 1.5 and 1.7 to 1.8 with an increase in B_2O_3 content and obtained more transference in present glass samples. A microhardness measurement confirms in present glass series that the formation of more rigidity structure and obtained bubble free sodium borophosphate samples in all the glass series.

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