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STUDY OF PHYSICAL PROPERTIES OF VANADIUM BORATE GLASSES MIXED WITH ALUMINUM OXIDE

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Abstract: *The glasses of various composition $(70-x)V_2O_5$-$30B_2O_3$-XAl_2O_3 (Where X-0,5.10,15,20) have been prepared by using melt quenching technique. The density and molar volume was measured by Archimedes principle using benzene as immersion liquid. It has been observed that density of glass increases and molar volume decreases with increase in mole percent of aluminum oxide. Hopping distance and polaron radius were calculated by density measurement. The results are correlated to composition of material.*

Key words: Density. Molar volume, Glass composition.

Introduction: Structural properties of borate glasses are very important for application in various fields. Density of solids is mostly the simplest physical property that can be measured. However, it would be a highly informative property if the structure of material could be well defined. Density can be used for finding out the structure of different types of glasses. Some workers considered that density of the glass is additive and can thus be calculated on the basis of the glass composition [1-6]. Several formulas have been derived to correlate the glass density to the glass composition [7-9]. Jen and Kalinowski [10] suggested a model for describing the bridging to non-bridging oxygen ratio as a function of the glass composition and the calculated values of glass density based on this model, were excel-lent agreement with the experimental

values. The glass structure can be explained in terms of molar volume rather than density, as the former deals the spatial distribution of the ions forming that structure. The change in the molar volume with the molar composition of an oxide indicates the preceding structural changes through a formation or modification process in the glass network [11-13].

Experimental and Measurement:

The Vanadium borate glass samples of various composition $(70\text{-}X)V_2O_5\text{-}30B_2O_3\text{-}XAl_2O_3$ (where X = 0,5,10,15,20) were prepared by melt quenching technique. The glass samples were prepared for different former ratio by using following formula.

$$\textbf{Former Ratio} = \frac{V_2O3}{V_2O5 + Al_2O_3} \qquad \ldots\ldots\ldots (1)$$

The starting material Vanadium oxide, boric acid and aluminum oxide of GR grade purchased from Merc laboratory were used. A homogeneous mixture of different composition has melted in ceramic crucible by keeping it into Muffle furnace equipped with digital temperature controller. The materials were melted at 800^0C for two hours with heating rate 20^0C/min and molted material is quenched in copper mould at room temperature (26^0C). The samples were annealed at 200^0C for 2Hrs in hot air oven. The sample was ready for measurement.

The density of glass samples were measured by Archimedes's principle with pure benzene as the immersion fluid. All the measurement were made using K-Roy mono pan balance with accuracy 0.0001gm.. The experiment was repeated five times to get accurate value of density. The density was calculated according to known formula.

$$D_{exp} = \frac{Wa \times d_b}{(Wa - W_b)} \qquad \ldots\ldots\ldots\ldots \quad (2)$$

Where, Wa is the weight of sample in air, Wb is the weight of sample in benzene and d_b is density of buoyant (benzene) at room temperature.

Molar volume is calculated by the formula.

$$Vm = \frac{M}{D_{exp}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where, M is the molecular weight of sample.

Table 1: Density and Molar volume of Vanadium borate glass sample.

Sample No	Mole Percent Al_2O_3	Mole percent V_2O_5	Mole Percent B_2O_3	Density D_{exp} (cm^3)	Molar Volume V_m	Hopping Distance (Å)	Polaron radius (Å)
1	0	70	30	2.21	57.24	3.34	1.35
2	5	65	30	2.34	54.64	3.33	1.345
3	10	60	30	2.54	53.47	3.32	1.341
4	15	55	30	2.65	53.03	3.31	1.338
5	20	50	30	2.71	51.79	3.30	1.326

RESULTS AND DISCUSSION

The calculated values of density (ρ) and molar volume (Vm) for all samples are displayed in Table 1. Variation of density (ρ) and molar volume (Vm) with Al_2O_3 mole% for all glass samples is shown in Figure 1.

The following could be concludes from the obtained results that the value of density increased from 2.21 to 2.71 g/cm3; while the values of the molar volume decreased from 57.24 to 51.79 cm3 with the gradual increase of the mole percent of Al_2O_3 in the glasses. The variation of density and molar volume is found as shown in Fig.1.

Win Kelman and Scott [1] have proved that the additive calculation of glass density is possible by multiplication of a suitable factor of various oxide percentages in the glass. The density is in close connection with the volume and is expressed in cm^3. For simple oxide glasses, the value of

the volume is always higher than that for the crystalline modifications of the corresponding oxides [5-6]

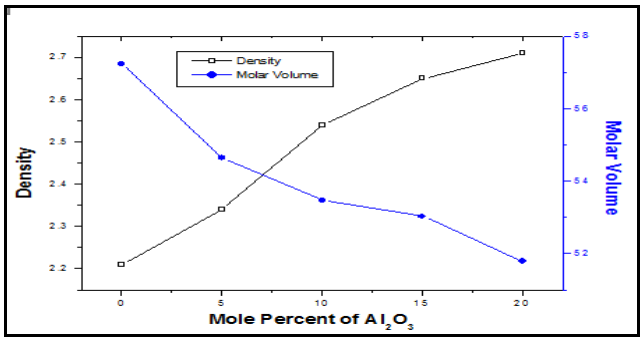

Fig.1: Variation of D_{expt} and V_m with mole percent of Al_2O_3

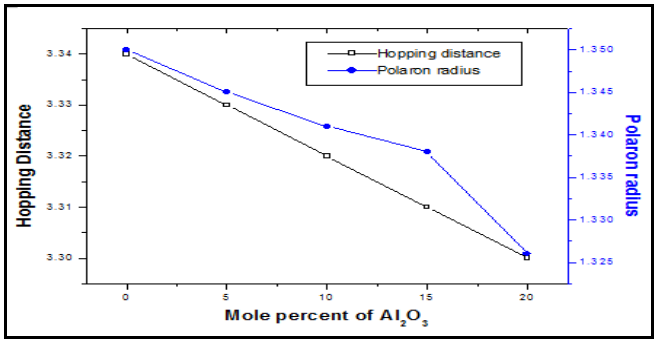

Fig 2. Variation of hopping distance and polaron radius

The density of the glass is the volume of the constituent ions and it depends on nature, the number of ions and the way by which ions can enter the glass structure. The variation in density and molar volume has been observed due substitution of Al ion in the structure. Fig 2.shows the variation of hopping distance and polaron radius. It is observed that these two parameters changed due to change in the former of glasses.

CONCLUSION:

The density of the glasses increased while their molar volume values decreases with the increase of aluminum oxide content in vanadium glasses. All the above conclusions are in complete agreement with the experimental results obtained.

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