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Chemical Degradation Study of Sodium Borophosphate Glasses

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Abstract

Sodium borophosphate glasses of the series of $30Na_2O – (70-x) B_2O_3 – xP_2O_5$ (x=15, 20, 25, 30, 35,..) have been prepared by melt-quench technique. The glass samples were characterized using X-ray diffraction (XRD) and chemical degradation (corrosion) techniques. The X-ray diffraction pattern confirms the amorphous nature of the glass samples. Chemical degradation studies of the glass samples were carried out in 10% HCl and 10% NaOH. The dissolution rate was seen to be higher in acidic medium as compared to alkaline medium.

Keywords: Sodium borophosphate glasses, XRD, chemical degradation, glass composition, glass former.

Introduction

In the material science literature, there is a wealth of information on glass degradation. Boron oxide (B_2O_3) usually occurs in the glassy from which is virtually in capable of direct crystallization. Pure boron trioxide (B_2O_3) is a very good glass former, covalently bonded with interesting physico chemical properties. It exhibit unique structural features and attracts because of it simple composition which consists of planar BO_3 triangle[1,2]. Glasses having P_2O_5 as one of the major component are called phosphate glasses. Phosphorous pentaoxide is used as a glass former. Pure P_2O_5 has a melting point of 560^0C and a boiling point of 605^0C. Phosphate glasses have poor durability which often limits their practical applications, that is generally overcome by adding certain oxides to the phosphate glasses, such as PbO, Al_2O_3 and Fe_2O_3. In phosphate network the addition of alkali ions depolymerizes the phosphate network and decreases the connectivity. A similar increase was observed in Na_2O, SiO_2 glasses with the addition of Al_2O_3 [3]. The pure phosphate glasses are highly hygroscopic. However, the alkali oxides and other additives modified phosphate glasses were reported to stable and durable[4].

The non linear optical properties of semiconductor doped glasses, in which the semiconductor microcrystal from quantum dots has been a topic of recent theoretical[5,6] and practical interest[7,8]. Phosphate glasses have high IR transmission nearly up to 8 mm[9], because of low thermo-optical coefficients and large emission they are more suitable for high power lasers[10]. Phosphate glasses have many applications in optics and other areas. Researchers have studied wide variety of phosphate glass compositions. P_2O_5 is main glass former gives with (Na_2O) sodium oxide modifier gives phosphate glasses with good physical properties and high UV transmission. Alkali borophosphate glasses are of interest for fast ion conducting applications.

Material and Methods

Glass preparation: The Sodium borophosphate glasses of various compositions were prepared by melt quench technique. The chemicals were use $NaNO_3$, H_3BO_3 and $(NH_4)_2HPO_4$ of analytical grade. These chemicals were thoroughly mixed and ground for 30-40 min in a mortar pastel and then the charge 30g was melted in alumina crucible using muffle furnace for 4-5 hrs at temperature ranging from 900-1100°C depending on composition. Glasses with compositions $30Na_2O – (70-x) B_2O_3 – xP_2O_5$ (x=15, 20, 25, 30, 35,..)

XRD- Analysis: Prepared glasses were characterized by X-ray diffraction technique to check amorphous nature of glasses, using X-ray diffractometer with Cu-Kα radiation. The XRD patterns were recorded in the 2θ range 20-80 degree with scanning rate 1^0/mint.

Chemical Degradation: The result of the corrosion test for the polished samples of sodium borophosphate glasses were carried out in 10% NaOH and 10% HCl solutions at room temperature for 1hrs to 6hrs of exposure are monitored.

Results and Discussion

XRD Analysis: Prepared glasses were characterized by X-ray diffraction technique. Figure 1 shows the XRD pattern of the samples of sodium borophosphate glasses indicate that the broad peaks, characteristic of glass structure. This is the clear indication of amorphous nature within the resolution limit of XRD instrument.

Chemical Degradation: The result of the corrosion test for the polished samples of sodium borophosphate glasses were carried out in 10% NaOH and 10% HCl solutions at room temperature for 1hrs to 6 hrs of exposure are shown in table 1 and table 2.

The dissolution rate was seen to be higher in acidic medium as compared to alkaline medium. In 10% HCl solution, the rate of dissolution of for glass II-3 i.e. $30Na_2O$-$45B_2O_3$-$25P_2O_5$ is maximum and for glass II-1 i.e. $30Na_2O$-$55B_2O_3$-$15P_2O_5$ is less in all the studied glass samples of sodium borophosphate glasses.

In 10% NaOH solution, the dissolution rate is very slow, for II-1 glass than the II-2 and II-3. From the studies of chemical degradation it came to notice that the rate of dissolution of II-1 glass in both i.e. in 10% HCl and in 10% NaOH is low in comparison to other investigated sodium borophosphate glasses.

In 10% HCl solution, the rate of dissolution of for glass II-3 i.e. $30Na_2O$-$45B_2O_3$-$25P_2O_5$ is maximum and for glass II-1 i.e. $30Na_2O$-$55B_2O_3$-$15P_2O_5$ is less in all the studied glass samples sodium borophosphate glasses.

The investigated glasses contain group I (Periodic Table) fluxes i.e. Na and glass former B_2O_3, which help to improve the chemical resistance hence the rate of dissolution in NaOH solution is slower than in HCl. Plot of weight loss versus P_2O_5 content at various time of exposure in 10% HCL is shown in figure 2 and the Plot of weight loss versus P_2O_5 content at various time of exposure in 10% NaOH is shown in figure 3.

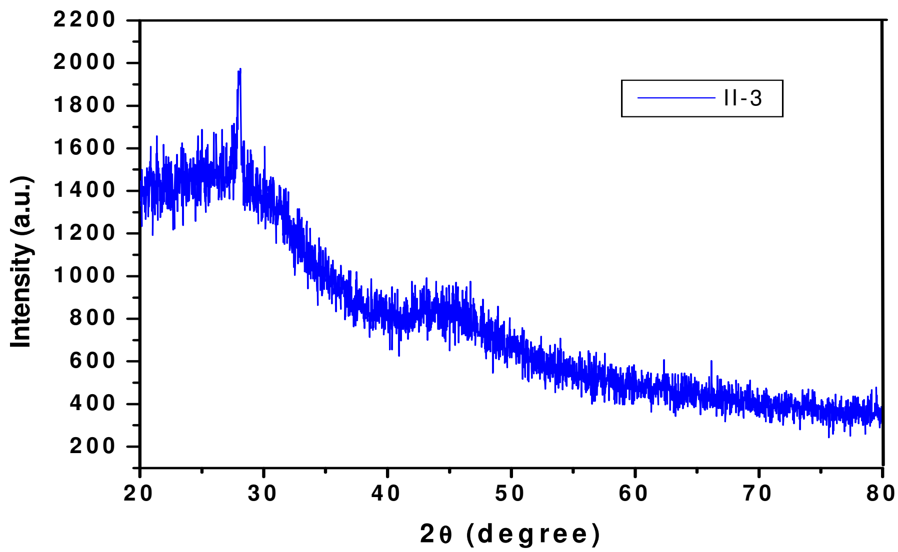

Figure-1
X-ray diffraction patterns for typical sample II-3 (X=25%)

Table-1
Weight loss observed in 10% HCl for 1 to 6 hrs of exposure of $30Na_2O$ – (70– x) B_2O_3 – xP_2O_5 glasses

Sr. No	Glass Code	Composition X mole% of P_2O_5	Wt. loss in 10% HCl g/cm^2					
			1 hrs	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs
1	II-1	15	0.31	0.58	0.79	0.92	0.97	0.90
2	II-2	20	0.40	0.59	0.81	0.93	0.99	0.94
3	II-3	25	0.38	0.58	0.82	0.88	0.94	0.91

Table-2
Weight loss observed in 10% NaOH for 1 to 6 hrs of exposure of $30Na_2O$ – (70– x) B_2O_3 – xP_2O_5 glasses

Sr. No.	Glass Code	Composition X mole% of P_2O_5	Wt. loss in 10% NaOH g/cm^2					
			1 hrs	2 hrs	3 hrs	4 hrs	5 hrs	6 hrs
1	II-1	15	0.08	0.012	0.019	0.031	0.042	0.038
2	II-2	20	0.010	0.014	0.022	0.040	0.048	0.045
3	II-3	25	0.014	0.017	0.030	0.039	0.051	0.048

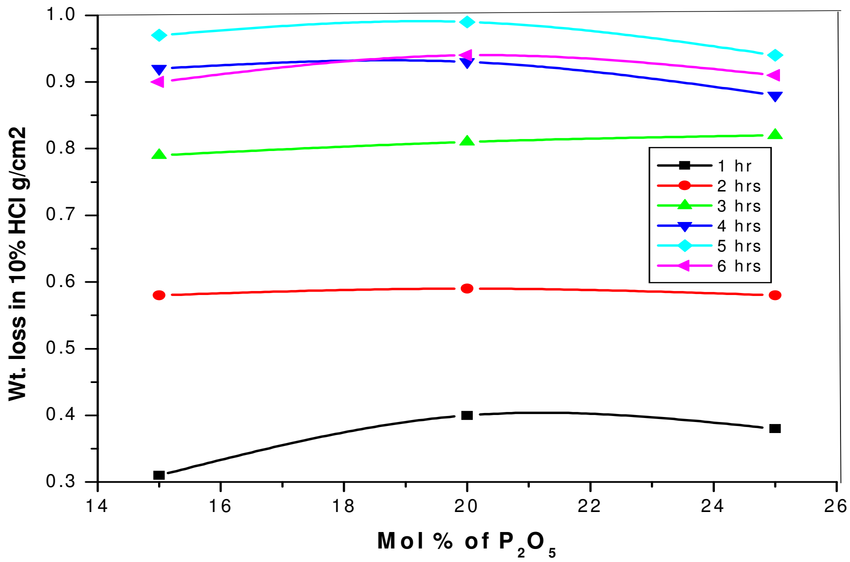

Figure-2
Plot of weight loss versus P_2O_5 content at various time of exposure in 10% HCl.

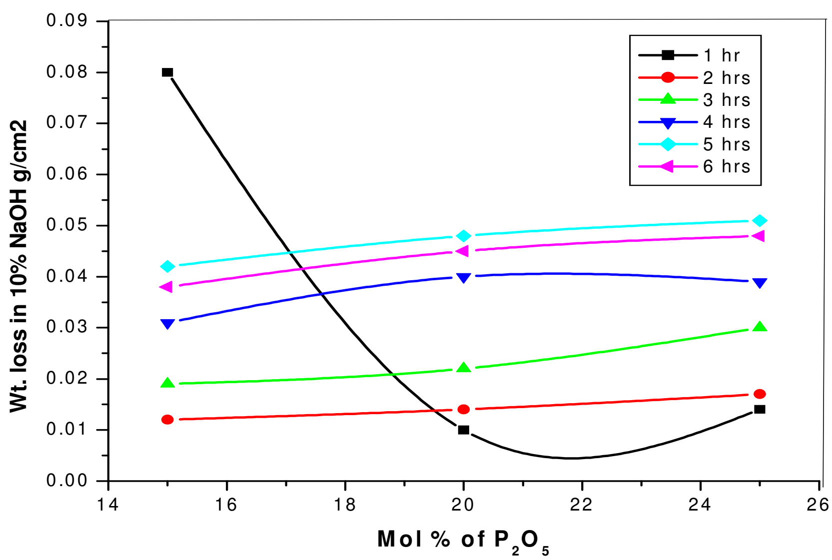

Figure-3
Plot of weight loss versus P_2O_5 content at various time of exposure in 10% NaOH

Conclusion

The XRD pattern of various Sodium borophosphate glasses confirms the amorphous nature of glasses. The investigated glasses contain Na and glass former B_2O_3, which help to improve the chemical resistance hence dissolution rate was seen to be higher in acidic medium as compared to alkaline medium at room temperature. In alkaline medium percentage of P_2O_5 increases dissolution rate also goes on increases.

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