IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 8, July 2015.
www.ijiset.com
ISSN 2348 – 7968

Synthesis & Characterization of Sodium Phosphate Glasses containing Mn Ions

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Abstract

The present paper reports that the Glasses of the compositional series of xLi_2O – (x-30) Na_2O –40 P_2O_5 -30B_2O_3 (x=5, 10,15, 20, 25) and 20Li_2O – 10 Na_2O – 40P_2O_5 –(x-B_2O_3) xMn (x=0.5, 1, 1.5,2.0, 2.5) have been prepared by melt-quenching technique. The glass samples were characterized using X-ray diffraction (XRD), UV-Vis spectroscopy and Infrared transmission. The X-ray diffraction pattern shows that all the samples are amorphous in nature. The UV-Visible transmittance spectra for Sodium Phosphate Glasses Mn glass samples indicate that the energy band gap decreases. It may due to structural changes that are taking place with introduction of transition metal ions. The strong bands around at 1200–1600 cm^{-1} is due to the asymmetric stretching relaxation of B–O bond of trigonal BO_3 units.

Key words :- Phosphate glass, Transition metal, X-ray Diffraction, UV-Visible spectroscopy, FT-IR spectroscopy

1. Introduction :-

Glass is an amorphous solid which is completely lack of long range and periodic atomic structure. Glasses are important optical materials usually made to be transparent in the visible spectrum[1] phosphate glasses have a wide range of technical is very[2] it is a pure phosphate network is very hygroscopic and it is not stable. It has been demonstrated that the addition of B_2O_3 to a phosphate network improves the chemical durability as well as the thermal & mechanical stability of pure phosphate glass[3,4].

Transition metal oxides dissolve readily in phosphate glass giving characteristic coloration [5,6] which sensitively depends on the oxidation state and the co-ordination of the transition metal and arises mostly from d-d electronic transition. Very few studies on the structure and the physical properties of transition metal doped alkali phosphate glasses [7,8].

2. Experimental procedures :-

Glass preparation:-

The glass samples were prepared from material of Na_2O, P_2O_3 , B_2O_3 and

ISSN 2348 – 7968

Li_2CO_3 according to the composition formula $25Na_2O$-$30P_2O_5$-$25B_2O_3$-$20Li_2O$ doped with 1 mol. % of transition metal (Mn) the corresponding weight of the starting material were weighed by the analytical balance. These chemicals were thoroughly mixed and grind for 30-40 min in a mortar pastel and then the charge (25gm) was melted in alumina crucible using muffle furnace for 3-4 hrs a temperature ranging from 900-1000 ^{0}C. When the melt was thoroughly homogenized and attained desirable viscosity it was poured either onto metal plate. The prepared glass was the annealed at temp between 300-400 ^{o}C for 2 hrs stored in desiccators prior to evolution.

Glasses with compositions,

1) $xLi_2O – (x\text{-}30)\ Na_2O – 40\ P_2O_5\text{-}30B_2O_3$ $(x=5, 10,15, 20, 25)$
2) $20Li_2O – 10\ Na_2O – 40P_2O_5 – (x\text{-}B_2O_3)\ xMn$ $(x=0.5, 1, 1.5,2.0, 2.5)$

3. Result and Discussions

3.1 XRD Study

Figures 3.1 and 3.2 show the XRD pattern of the samples of Sodium Borophosphate Glasses and doped with Mn. Powder X-ray diffraction patterns of all the Sodium phosphate Glasses and doped with Mn samples indicate that the broad peaks, characteristic of glass structure. This is the clear indication of amorphous nature within the resolution limit of XRD unit.

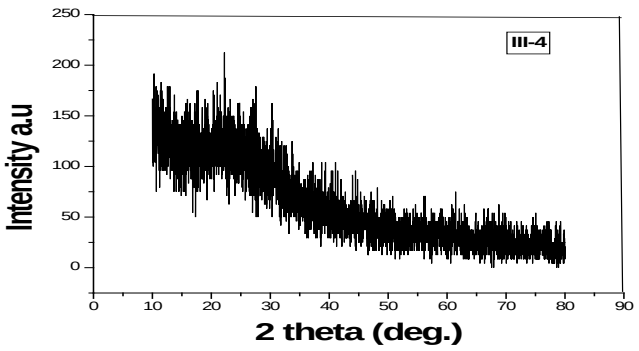

Fig.3.1 XRD pattern of phosphate glass containing Lithium oxide.

3.2 UV- Visible Study:

TMI doping has been characterized with UV visible spectrophotometer and it has shown interesting results. Optical transmission of the investigated glasses in the UV-visible region of the spectrum was measured and recourse in the range 300-500 nm using a

ISSN 2348 – 7968

computerized recording spectrophotometer type (Perkin Elmer 950). The experimental results obtained were recorded in the form of % of transmission as a function of wavelength in nm. Fig 3.2 reveals the transmission spectrum of the base sodium borophosphate glass doped with various composition of Mn. These bands are expected to be due to the presence of Mn ions.

Table 3.1: Band gap of different sodium phosphate glasses doped with Mn.

Sample code	CompositionX mol %	% T	UV Cut off	Band gap in eV
IV-1	0.5	27.67	334.61	3.7087
IV-3	1.5	10.82	345.74	3.589

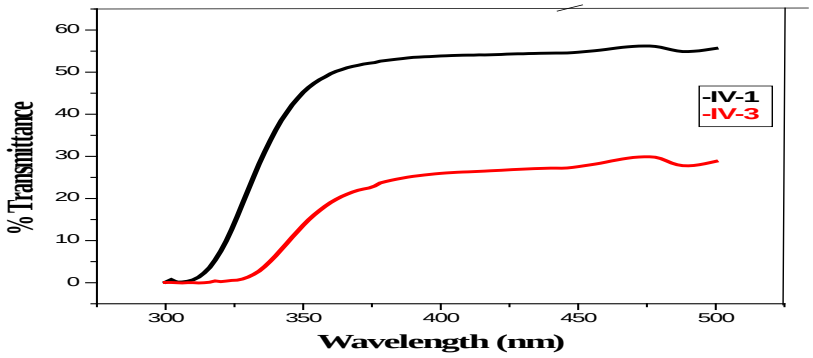

Fig 3.2: Transmittance spectra of a Sodium Phosphate Glasses doped with Mn samples

The wavelength of Sodium phosphate Glasses doped with Mn samples increases with increasing the % of Mn. It was also confirmed that energy band gap decreases with % of Mn increases. The UV cut off point increases, % transmittance is decreases and all these values of Sodium phosphate glasses doped with Mn samples is tabulated in table 3.1. This can be attributed to the structural changes that are taking place with introduction of transition metal ions. It can be observed that UV cut off point increases with increasing doping of Mn ions. The energy band gap of these samples decreases with increasing Mn %.

3.3 FT-IR Study

Infrared spectroscopy is known to provide insights into the interaction between alkali metal ions and phosphate glass network. The room temperature vibration spectra of the glasses were obtained using fine powder technique in the range of 600 to 4000 cm-1. The transmittance spectra of the 5% of Li_2O and 2.5 mol % of Mn samples in the IR region are shown in fig. 3.3 and 3.4. In the infrared spectral region, the irrational modes of the borate network have three regions.

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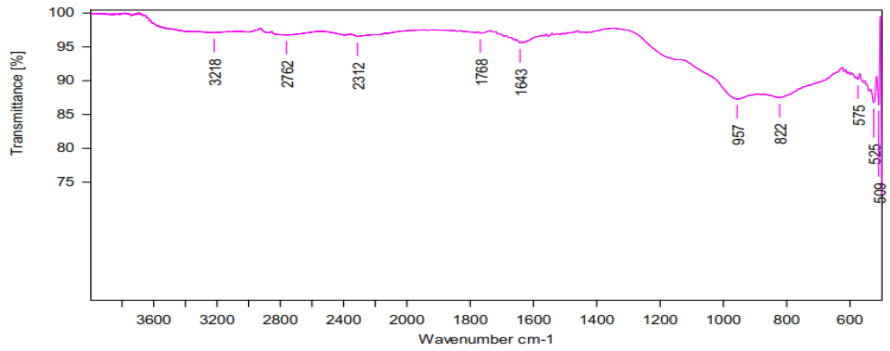

Fig 3.3 I.R Spectra of 5 mol % lithium oxide glasses

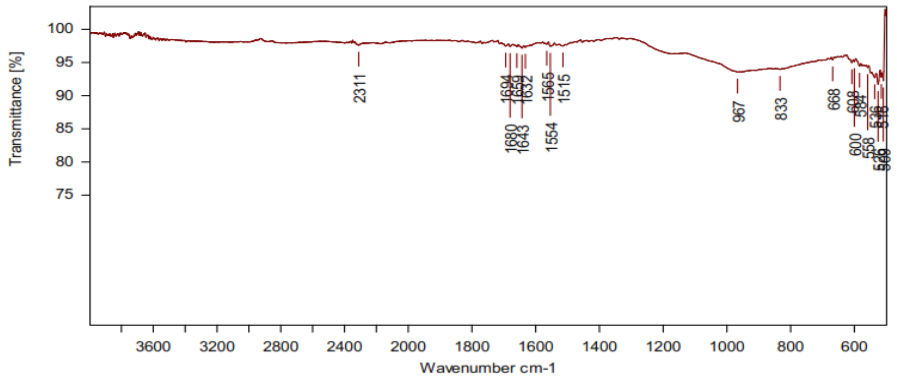

Fig 3.4 I.R spectra of lithium oxide doped with 2.5 mol % of Mn.

The fundamental and strong broad absorption band of glass sample is attributed to P=O asymmetric stretching vibrational mode. In the glass the stretching frequencies are due to the P–O bonds and indicating the depolymerization of phosphate network. These values are similar to the reported literature [9-11].

The vibrational modes of the borate network are mainly due to the asymmetric stretching relaxation of the B-O bonds of trigonal BO_3 units. Bending vibration is due to the vibrations of various borate segments. The observations made in the present investigation agree well with the literature values [12,13].

IR transmission spectra are shown in figs which represent the characteristics of the various phosphate glass samples doped with Mn. The absorption bands appear in the range 700 – 1550 cm^{-1} are mainly due to the phosphate network. The pyrophosphate groups are predominant structure units in all these glasses.

ISSN 2348 – 7968

4. Conclusions:

Sodium phosphate glasses and Sodium phosphate doped with Mn glasses were prepared successfully by melt-quench method. The X-ray diffraction study confirms the amorphous nature of the prepared glasses. The effect of Mn doping on the structural and optical properties are discussed. The energy band gap and % transmittance calculated using transmittance spectra and found that the energy band gap and % transmittance of Sodium phosphate glasses doped with Mn decreases. The pyrophosphate groups are predominant structure units in all these glasses. The absorption bands appear in the range 700 – 1550 cm^{-1} are mainly due to the phosphate network.

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