

ABSTRACT

The present study deals with an experimental investigation for $(76\text{V}_2\text{O}_5-24\text{P}_2\text{O}_5)_{1-x}(\text{Li}_3\text{PO}_4)_x$ glass to follow up some of their physical properties.

The glass samples $(76\text{V}_2\text{O}_5-24\text{P}_2\text{O}_5)_{1-x}(\text{Li}_3\text{PO}_4)_x$ (where $x=0.0, 0.01, 0.02, 0.01$ and 0.15) have been prepared by quenching the melt to room temperature.

Characterization of the glasses has been done using X-ray diffraction and differential thermal analysis (D.T.A). X-ray diffraction study for all samples illustrated the amorphous nature of glasses. Differential thermal analysis (D.T.A.) reveals that the characteristic glass transition temperature of the samples glass (T_g) shifts toward higher temperature with increasing the lithium phosphate content.

The dc electric conductivity of the glass samples was studied over a temperature range from room temperature to 593K. The general behavior shows two regions, one at relatively low temperature range and the other one at the higher temperature range. At the high temperature range (above $\theta_D/2$), the conduction mechanism is explained according to the hopping of small polaron to the nearest empty sites. In the temperature range below $\theta_D/2$, the conduction process could be explained as a contribution of two processes. The first is the electron hopping between filled and empty localized states which dominate at low temperature range and the second is due to small polaron hopping.

An increase of the activation energy with increasing Lithium Phosphate was obtained which was attributed to :

- 1) An increase of the phosphate group in the glass matrix which reduces the vanadium fraction and subsequently the electrical conductivity .
- 2) The glass hydration which leads to a contribution of protons in conduction process in the glasses .
- 3) The increase of lithium ion conduction in the glass.

The current – voltage ($I - V$) characteristic of the glasses has been studied as a function of both temperature and Lithium phosphate content . The $I - V$ characteristic exhibits threshold switching with differential negative resistance . It is found that the threshold voltage (V_{th}) decreases and the threshold current (I_{th}) increases with increasing temperature , while they vary inversely with increasing lithium phosphate content . The behavior of the Off – state region is analyzed according to Pool – Frenkel effect besides the joule heating . The switching to the negative resistance region has been discussed according to the electrothermal model . The conduction process in the negative resistance region are interpreted according to the activation of charge carrier under the influence of the high field ,the joule heating, and the self generation of a.c signal in the conduction path filament .

The total conductivity (σ_{tot}) of the glasses are studied in the frequency range (0.2 – 100 kHz) and the temperature range (290 – 493 K) .The conductivity – frequency dependence relation is divided into two regions ; One at low frequency while the other appears at relatively higher frequency range . The low frequency conductivity region refers to the d.c conductivity and is found to be strongly dependent on temperature . The relatively higher

frequency conductivity region obeys a power law relation , $\sigma = A \omega^s$. The obtained values of the power s lie in the range $(0.5 \leq s \leq 1)$ in the case of vanadium phosphate glass sample and that of low of lithium phosphate content $(0.01, 0.02)$ which confirms the electron hopping between V^{4+} and V^{5+} ions .The values of s for the glass sample of the higher lithium phosphate content , the values of s less than 0.5 confirm the domination of ionic conductivity in the investigated glasses .

The frequency and temperature dependence of the dielectric constant ϵ' , the dielectric loss ϵ'' and the dielectric loss tangent . Are studied the dielectric constant and the dielectric loss decrease as the frequency was increased for all glass samples . A slight decrease is observed at low frequency range while a strong dependence appears at higher frequency range . The dielectric constant increases slightly with increasing temperature . The effect of frequency assists electron hopping between V^{4+} and V^{5+} ions , while increasing temperature causes the glassy network relaxes from which the ionic motion becomes easier .

The bulk conductivity of the glasses is obtained by the complex impedance technique . It increases with increasing temperature obeying Arrhenious relation :

$$\sigma_B T = \sigma_{B0} \exp (- E_B / k_B T)$$

The obtained values of the activation energy E_b lie in the range $(0.348 - 0.467 \text{ eV})$. In addition the bulk conductivity is found to decrease with increasing lithium phosphate content .