



STUDY ON THE ROLE OF MANGANESE IONS ON PHYSICAL AND STRUCTURAL PROPERTIES OF ALUMINO-PHOSPHATE GLASSES BY MEANS OF SPECTROSCOPIC ANALYSIS

Kassa Belachew¹, Eyob Daniel¹, Mengesha Ayene¹ and Laxmikanth C^{2*}

¹Department of Physics, Wollo University, Dessie, Ethiopia

²Department of Physics, Osmania University, Hyderabad, India

ARTICLE INFO

Article History:

Received 11th May, 2018

Received in revised form 7th

June, 2018 Accepted 5th July, 2018

Published online 28th August, 2018

Key words:

Phosphate glass, manganese ion doping, optical properties, EPR Studies, IR Studies and glass forming ability parameter.

ABSTRACT

39CdO–10Al₂O₃–(51-x) P₂O₅: xMnO (x=0,0.1, 0.2, 0.3 and 0.4 wt.%) glasses were synthesized by melt quenching technique. Various physical parameters of these glass materials were calculated and presented. Amorphous nature of these materials was confirmed from XRD and DTA studies. Various stability factors were calculated and presented from DTA analysis; from the results, the stability of the glass network is observed to increase with MnO concentration from 0.1 to 0.4 wt. %. IR spectral analysis of these glasses exhibited several symmetrical and asymmetrical bands due to phosphate groups; the observed change in these band intensities with increase in MnO concentration from 0.1 to 0.4 wt. % shows an increase in stability of the glass network. Optical absorption studies of these glasses exhibited an absorption bandwidth shifting its band position from 500 to 488 nm with MnO concentration from 0.1 to 0.4 wt. %, which is an indicative of gradual conversion of Mn²⁺ ions into Mn³⁺. EPR spectra of these glasses characterized by two signals due to Mn²⁺ and Mn³⁺ ions; observations on these signal intensity variations revealed an increase in stability of the glass network from 0.1 to 0.4 wt. % of MnO concentration.

Copyright © 2018 Kassa Belachew et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Phosphate glass is a class of optical glasses composed of metaphosphates of various metals. Phosphate glasses are useful for applications such as bone transplantation, containment of radioactive wastes, fast ion conductors, laser host materials etc. They exhibit very important physical properties such as low melting temperature, high thermal expansion coefficient, high ultra-violet transmission, low glass transition temperature, low softening temperature, high ionic conductivity and bio compatibility [1-6]. Despite their solubility, the lower processing temperature has led these glasses to be used in applications such as glass to metal seals, low temperature enamels for metals and for optical elements etc. [7-11]. The main component in the phosphate-based glasses, phosphorus pentoxide (P₂O₅) is highly hygroscopic and shows relatively poor chemical durability; this problem can be addressed by replacing some proportion of phosphorus in the form of stable oxides like Bi₂O₃, Al₂O₃, Fe₂O₃ etc. [12-16]. In the present study, the conditional glass former Al₂O₃ is used to improve the stability of the glass network. CdO is used as a glass modifier; addition of it breaks up the continuous phosphate network and introduces dangling bonds/non-bridging oxygen's (NBOs) [17].

Manganese, is a class of transition metal, ion is an interesting one because it exists in different valence states in different glass matrices, for example as Mn³⁺ in borate glass with octahedral coordination whereas in silicate and germanate glasses it exists in Mn²⁺ state with both octahedral and tetrahedral coordination [18]. Further, among different manganese ions, Mn²⁺ and Mn³⁺ are well known paramagnetic ions, Mn²⁺ and Mn⁴⁺ ions are identified as luminescence activators [19, 20]. The content of manganese in different forms in different valence states exist in the glass depends on the quantitative properties of modifiers and glass formers, size of the ions in glass structure, their field strength, mobility of the modifier cation etc. Manganese ions have been frequently used as paramagnetic probes for exploring the structure and properties of vitreous systems [21]. Hence, the connection between the state and the position of the manganese ion and the physical properties of the glass is expected to be highly interesting. In view of this, it is aimed in this work to establish the valence and the structural role of the manganese ions by means of optical and EPR studies in the glass matrix composed of CdO-Al₂O₃-P₂O₅.

Experimental

In the present study, the glasses were prepared by the melt-quenching technique. The starting materials CdO, Al₂O₃, P₂O₅ and MnO that used for the preparation of the present glass

*Corresponding author: Laxmikanth C

Department of Physics, Wollo University, Dessie, Ethiopia

systems were with analar grade (larger than 99.9% purity). The chemical composition of these series of glasses is listed below.

| Glass Name | Glass Composition |
|------------|--|
| CAPM_0 | 39CdO-10Al ₂ O ₃ -51P ₂ O ₅ |
| CAPM_1 | 39CdO-10Al ₂ O ₃ -50.9P ₂ O ₅ ; 0.1MnO |
| CAPM_2 | 39CdO-10Al ₂ O ₃ -50.8P ₂ O ₅ ; 0.2MnO |
| CAPM_3 | 39CdO-10Al ₂ O ₃ -50.7P ₂ O ₅ ; 0.3MnO |
| CAPM_4 | 39CdO-10Al ₂ O ₃ -50.6P ₂ O ₅ ; 0.4MnO |

The melting temperature of all the glass samples were in the range of 1160-1200 °C. The density *d* of the glasses was determined by the standard principle of Archimedes with an accuracy of 0.001 g/cm³, by using O-xylene as working liquid at room temperature. The refractive indices *n_d* of the optically polished glasses was measured using sodium vapour lamp (λ=589.3nm) on a precession Abbe's refractometer. The non-crystalline phases of the glasses were confirmed by XRD-7000S. The differential thermal analysis was recorded by differential thermo Gravity (DTG) of model DTG-60H with heating rate of 10 °C per minute in temperature ranges from 25 to 900 °C. FT-IR spectrum was recorded by 8400S model infrared spectroscopy in the wavelength ranging from 400-4000 cm⁻¹ with a resolution of 4 cm⁻¹ by using BEWTeKi Raman plus spectrometer and ESR spectra of the samples were recorded at room temperature by E11Z Varian X-band (ν =9.5 GMZ) ESR Spectrometer. The optical absorption spectra of the glasses were recorded by 8400S UV-VIS spectrometer at room temperature in wavelength ranging from 300 to 700nm.

RESULTS AND DISCUSSION

Physical Parameters

Various physical parameters of the glasses were determined and presented in Table 1. The density *d* of the glass samples was determined at room temperature by using Archimedes principle using O-xylene as the immersion liquid. The concentration of manganese ions *N_i* was calculated from the known densities and compositions of the respective glasses. The refractive index *n_d* of the glass was measured with an Abbe Refractometer at sodium wavelength (589.3 nm). From the obtained values of *N_i*, the inter-ionic distance *r_i* and the Polaron radius *r_p* of dopantions can be evaluated by the following equations [22-24]:

$$\text{Inter-ionic distance } r_i (\text{\AA}) = \left[\frac{1}{N_i} \right]^{1/3} \quad (1)$$

$$\text{Polaron radius } r_p (\text{\AA}) = \frac{1}{2} \left[\frac{\pi}{6N_i} \right]^{1/3} \quad (2)$$

Table 1 Various physical parameters of CdO-Al₂O₃-P₂O₅: MnO glasses.

| Physical Parameters | CAP M 0 | CAPM 1 | CAPM 2 | CAPM 3 | CAPM 4 |
|---|---------|---------|---------|---------|---------|
| Average molecular weight, <i>M̄</i> | 125.481 | 125.418 | 125.368 | 125.351 | 125.312 |
| Density, <i>d</i> (g/cm ³) | 5.351 | 5.360 | 5.362 | 5.371 | 5.382 |
| Molar volume, <i>V_M</i> | 23.449 | 23.398 | 23.379 | 23.338 | 23.283 |
| Refractive index, <i>n_d</i> | 1.553 | 1.572 | 1.605 | 1.643 | 1.692 |
| Manganese ion concentration <i>N_i</i> (x10 ¹⁹) | - | 0.672 | 1.345 | 2.017 | 2.691 |

| | | | | | |
|--|-------|-------|-------|-------|-------|
| ion/cm ³) | | | | | |
| Inter ionic distance, <i>R_i</i> (Å) | - | 1.141 | 0.905 | 0.791 | 0.718 |
| Polaron radius, <i>R_p</i> (Å) | - | 0.352 | 0.444 | 0.509 | 0.560 |
| Electron polarizability, <i>α_e</i> (x 10 ⁻¹⁹ ion/cm ³) | - | 0.117 | 0.061 | 0.043 | 0.034 |
| Dielectric constant, ε | 2.40 | 2.464 | 2.560 | 2.689 | 2.856 |
| Reflection loss, <i>R</i> | 0.046 | 0.049 | 0.053 | 0.058 | 0.065 |
| Molar refractivity, <i>R_M</i> | 3.601 | 3.721 | 3.892 | 4.083 | 4.332 |

The field strength (*F_i*) of dopantion in the glass network was described through the oxidation number *Z* and the polaron radius *r_p* of the transition metal ions by:

$$\text{Field strength } F_i (\text{cm}^{-2}) = \frac{Z}{r_p^2} \quad (3)$$

The theoretical dielectric constant (ε) was calculated from the refractive index of the glass using $\epsilon = n_d^2$ (4)

The reflection loss from the glass surface was computed from the refractive index by using the Fresnel's formula:

$$R = \left[\frac{(n_d - 1)}{(n_d + 1)} \right]^2 \quad (5)$$

The molar refractivity *R_M* for each glass was evaluated using the formula:

$$R_M = \left[\frac{(n_d - 1)}{(n_d + 2)} \right] V_m \quad (6)$$

The molar volume of the glass samples was calculated using the formula:

$$V_m = \frac{\bar{M}}{d} \quad (7)$$

The electronic polarizability *α_e* was calculated using the formula:

$$\alpha_e = \frac{3(n_d^2 - 1)}{4\pi N_i (n_d^2 + 2)} \quad (8)$$

where *N_i* is the number of manganese ions per unit volume.

XRD studies

Fig.1 represents X-ray diffraction patterns of MnO doped CdO-Al₂O₃-P₂O₅ glasses. XRD patterns of powder samples were recorded at room temperature using Phillips X-ray generator (Model XRD-7000 S) in 2θ ranges from 10° - 80°. In all glass samples, the observation shows that, the broad peaks (absence of sharp peaks), is characteristics of glass structure with in the resolution limit of the XRD.

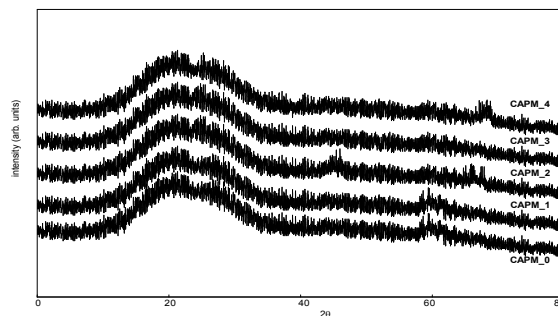


Figure 1. XRD patterns of CdO-Al₂O₃-P₂O₅: MnO glasses.

DTA studies

Fig. 2 represents differential thermal analysis (DTA) traces of pure and MnO doped CdO-Al₂O₃-P₂O₅ glasses recorded in the temperature range 30-1000 °C. DTA traces show an inflection due to the glass transition temperature T_g in the region from 492 to 524°C followed by a well-defined exothermic effect due to crystallization temperature T_c between 698 to 750 °C and melting temperature T_m due to endothermic effect ranging from 945 to 956 °C. From the data of DTA traces various stability parameters were calculated and presented in Table 2. The difference between crystallization temperature T_c and transition temperature T_g is an indication of thermal stability of glasses against crystallization. The variation of parameters T_g/T_m , $(T_c-T_g)/T_g$, $(T_c-T_g)/T_m$ and Hrubby's parameter $K_{gl} = (T_c-T_g)/(T_m-T_c)$, which give information on the stability of the glass, with the concentration of MnO is plotted as an inset in the Fig. 2. All the traces show an increasing trend from 0.1 up to 0.4wt. % of MnO; suggesting an increase in stability of the glass network.

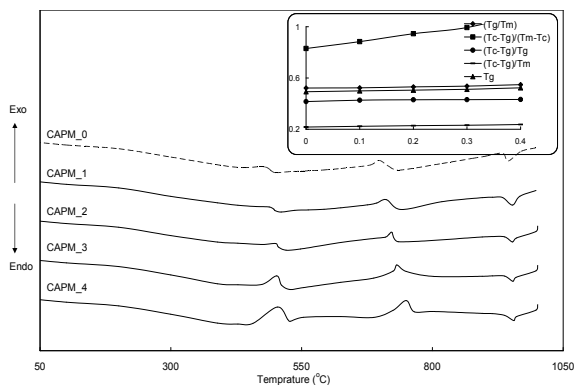


Figure 2. IR spectra of CdO-Al₂O₃-P₂O₅: MnO glasses. Inset shows the variation of T_g/T_m , K_{gl} , $(T_c-T_g)/T_g$, $(T_c-T_g)/T_m$ and T_g with MnO concentration.

Table 2 Data on DTA analysis of CdO-Al₂O₃-P₂O₅: MnO glasses.

| Glasses | T_g (°C) | T_c (°C) | T_m (°C) | T_g/T_m | $(T_c-T_g)/(T_m-T_c)$ | $(T_c-T_g)/T_g$ | $(T_c-T_g)/T_m$ |
|---------|------------|------------|------------|-----------|-----------------------|-----------------|-----------------|
| CAPM_0 | 493.0 | 698 | 945 | 0.522 | 0.829 | 0.415 | 0.216 |
| CAPM_1 | 499.0 | 712 | 953 | 0.524 | 0.883 | 0.426 | 0.223 |
| CAPM_2 | 505.5 | 723 | 953 | 0.530 | 0.945 | 0.430 | 0.228 |
| CAPM_3 | 511.5 | 732 | 954 | 0.536 | 0.993 | 0.431 | 0.230 |
| CAPM_4 | 523.6 | 750 | 956 | 0.547 | 1.099 | 0.432 | 0.236 |

IR spectral studies

Fig.3(a) represents the room temperature recordings of IR spectra of the pure and MnO doped CdO-Al₂O₃-P₂O₅ glasses. The glass matrix with increasing concentration of MnO exhibits different IR bands corresponding to phosphate and aluminate structural groups. The observed band positions in this work are almost similar to those reported in literature [25-29]. The data on various band positions from the IR spectra of these glasses was presented in Table 3.

Table 3 Data on various band positions from the IR spectra of CdO-Al₂O₃-P₂O₅: MnO glasses.

| Glasses | O-P-O Units Band 1 (cm ⁻¹) | PO ₄ ³⁻ Units Band 2 (cm ⁻¹) | P-O-P Units Band 3 (cm ⁻¹) | AlO ₄ units (cm ⁻¹) |
|---------|--|--|--|--|
| CAPM_0 | 1214 | 995 | 896 | 726 |
| CAPM_1 | 1210 | 1005 | 903 | 726 |
| CAPM_2 | 1207 | 1020 | 907 | 726 |
| CAPM_3 | 1204 | 1033 | 911 | 726 |
| CAPM_4 | 1198 | 1047 | 915 | 726 |

For this specific network of glasses, the IR transmission spectra recorded for glasses (Fig. 3) exhibit the following conventional bands due to:

- The O-P-O symmetric stretching vibrations in the region of 1198-1214 cm⁻¹(band 1).
- The asymmetrical stretching of PO₄³⁻ groups in the region between 995-1047 cm⁻¹ (band 2).
- The asymmetrical bending vibrations of P-O-P groups in the region between 896-915 cm⁻¹ (band 3).
- The vibrations of AlO₄ groups in theregionbetween700-750 cm⁻¹.

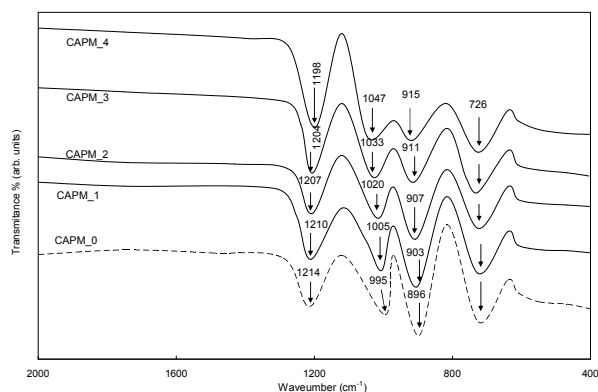


Figure 3 (a). IR spectra of CdO-Al₂O₃-P₂O₅: MnO glasses.

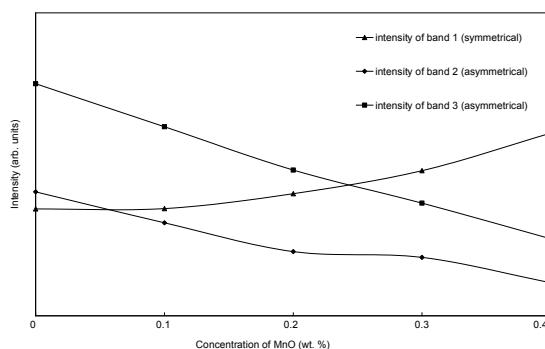
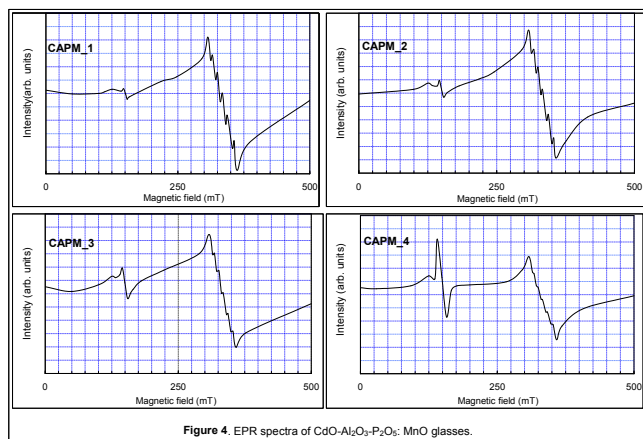


Figure 3(b). Variation of symmetrical and asymmetrical band intensities for pure and MnO doped CdO-Al₂O₃-P₂O₅ glasses.

From the IR-Spectra, it has been observed that, with increase of MnO concentration from 0.1 to 0.4 wt. % in the glass matrix, the frequency of the band 1 (symmetrical band) shifts towards lower frequency with increase in intensity. Whereas bands 2 and 3 (symmetrical bands) shift towards higher frequency with decrease in intensity; indicating a decrease in the degree of asymmetric stretching and increase in symmetrical stretching in phosphate units, which further shows an increase in polymerization/stability of the glass network. However, there is no observed change in the band position of AlO₄ groups at any concentration of MnO in the glass network. Fig. 3(b) shows the variation of symmetrical and asymmetrical band intensities for pure and MnO doped CdO-Al₂O₃-P₂O₅ glasses.

EPR studies

Fig. 4 shows the EPR spectra of CdO-Al₂O₃-P₂O₅:MnO glasses recorded at room temperature. The spectra are characterized by two intense resonance signals; one of them is centered at around $g = 2.01$ (signal 1) with six line hyperfine pattern, which is a characteristic of isolated Mn²⁺ ions, and the other is centered at $g = 4.3$ (signal 2), which is a characteristic of isolated Mn³⁺ ions.


 Figure 4. EPR spectra of CdO-Al₂O₃-P₂O₅: MnO glasses.

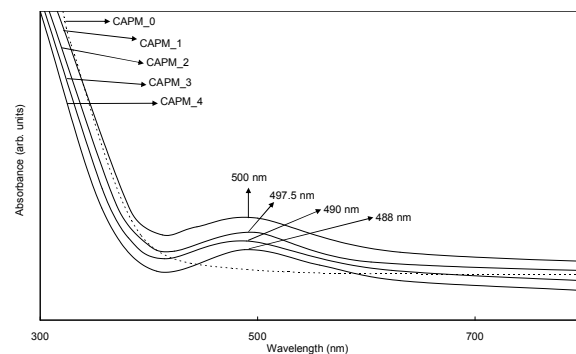
The observed spectra of these samples are similar to those reported for manganese ions doped in various glass systems [30-36]. With the increase of MnO concentration from 0.1 to 0.4 wt. %, the intensity of the signal 2 is found to increase at the expense of the intensity of the signal 1, which is an indicative of the conversion of Mn²⁺ ions into Mn³⁺ ions. The EPR spectra of Mn²⁺, in general, can be analyzed using the spin-Hamiltonian of the form:

$$H = \beta(g_{xx}B_xS_x + g_{yy}B_yS_y + g_{zz}B_zS_z) + (A_{xx}S_xI_x + A_{yy}S_yI_y + A_{zz}S_zI_z) + (DS_z^2 - \frac{1}{3}S(S+1)) + E(S_x^2 - S_y^2). \quad (9)$$

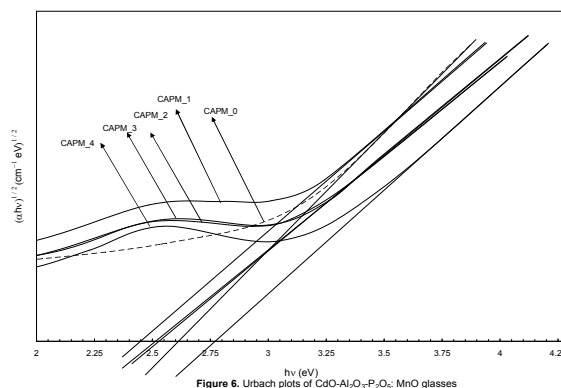
Where g is the isotropic factor, β is the Bohr magneton, B is the external magnetic field, S is the vector operator of the electron spin momentum and A is the hyperfine interaction parameter, I is the vector operator of nuclear spin momentum and D is the zero field splitting parameter. Most Mn²⁺ complexes are octahedral, and have a high spin arrangement with five unpaired electrons. The d^5 electronic configuration has a ${}^6S_{5/2}$ ground state in the free atom and possesses zero orbital angular momentum and hence an ESR signal is expected with g value very close to the free electron value 2.0023 [36]. Signal at $g \sim 2.01$ due to Mn²⁺ ions shows an octahedral symmetrical environment with the nature of the bonding is dominantly ionic [37, 38]. The probable local structure to occur for Mn³⁺ in these glasses is as a MnO₆ octahedron entwined with a PO₄ tetrahedron MnPO₉, where all the oxygen's are bridging and charge compensated by a pair of Cd²⁺ ions. The presence of such complexes obviously increases the stability of the glass network possibly with covalent environment. In the present glass system, with increase of MnO concentration from 0.1 to 0.4 wt. %, there is an observed conversion of Mn²⁺ ions into Mn³⁺ ions, which is an indicative of increased covalent nature over that of ionic. Further, this suggests that the glass polymerization increases with improved stability with increase in MnO concentration from 0.1 to 0.4 wt. % in the glass matrix.

Optical absorption studies

Fig. 5 represents optical absorption spectra of CdO-Al₂O₃-P₂O₅: MnO glasses. The spectra of MnO doped glasses exhibit two absorption bands resulted from Mn²⁺ transition (around 500 nm) ${}^6A_{1g}(S) \rightarrow {}^4T_{1g}(G)$ and Mn³⁺ transition (around 490 nm) ${}^5E_g \rightarrow {}^5T_{2g}$.


 Figure 5. Optical absorption spectra of CdO-Al₂O₃-P₂O₅: MnO glasses.

The band at 500 nm is arises from intra-configurational transitions due to Mn²⁺ ions [39, 42]. These detected bands due to Mn²⁺ ions were obscured, beyond 0.1 wt. % of MnO concentration, with a presence of a new broad absorption band with a maximum at about 490 nm due to Mn³⁺ ions [43, 44]. With increase of MnO concentration from 0.1 to 0.4 wt. %, there is an observed shift of band positions from 500 to 488 nm; indicating the gradual conversion of Mn²⁺ ions into Mn³⁺ ions. Fig. 6 presents Urbach plot of CdO-Al₂O₃-P₂O₅: MnO glasses.


 Figure 6. Urbach plots of CdO-Al₂O₃-P₂O₅: MnO glasses

The optical band gap E_{opt} can be determined from the Urbach plot $(\alpha hv)^{1/2}$ versus hv , which is related by the equation.

$$\alpha(v) = \alpha_0 \left[\frac{hv - E_{opt}}{hv} \right]^2. \quad (10)$$

Where, α_0 is a constant related to the extent of the band tailing, and E_{opt} is the optical band gap energy [45]. The absorption coefficient, $\alpha(v)$, can be determined near the absorption edge of different photon energies for all glass samples. With increase of MnO concentration from 0.1 to 0.4 wt. %, the optical band gap is observed to increase, whereas the Urbach energy is found to decrease; is an indicative of improvement in the insulating character and hence the stability of the glass network. Table 4 presents the data on optical absorption, calculated optical band gaps, and Urbach energies of CdO-Al₂O₃-P₂O₅: MnO glasses. Finally, the observed band positions and the calculated optical band gaps show an improvement in the glass network and an insulating character with increase in MnO concentration from 0.1 to 0.4 wt. %. A similar trend was also observed from DTA, IR, and EPR studies of CdO-Al₂O₃-P₂O₅: MnO glasses.

Table 4 Data on various band positions from the optical absorption spectra of CdO-Al₂O₃-P₂O₅: MnO glasses.

| Glass | Band edge λ (nm) | Band position λ (nm) due to Mn ²⁺ transitions ⁶ A _{1g} (S)→ ⁴ T _{1g} (G) | Band position λ (nm) due to Mn ³⁺ transition ⁵ E _g → ⁵ T _{2g} | Optical band gap energy E_{opt} | Urbach energy ΔE (eV) |
|--------|--------------------------|--|---|-----------------------------------|-------------------------------|
| | | | | | |
| CAPM_0 | 320.5 | - | - | 2.56 | 0.61 |
| CAPM_1 | 315.7 | 500 | - | 2.44 | 1.03 |
| CAPM_2 | 308.0 | 497.5 | - | 2.52 | 0.89 |
| CAPM_3 | 301.5 | - | 490 | 2.53 | 0.67 |
| CAPM_4 | 300 | - | 488 | 2.75 | 0.55 |

CONCLUSIONS

The conclusions drawn from the study of various physical and spectroscopic properties of CdO-Al₂O₃-P₂O₅: MnO glasses are summarized as follows:

- i. Study on the DTA traces recorded in the temperature range 30-1100 °C indicate an improved glass network with increase of MnO concentration from 0.1 to 0.4 wt. %.
- ii. The IR spectra recorded at room temperature exhibited an increase in intensity of symmetrical band (band 1) at the expense of intensities of asymmetrical bands (bands 2 and 3) with increase in MnO concentration from 0.1 to 0.4 wt. %; the observed trend shows an increase in the stability of the glass network.
- iii. Study on the EPR spectra recorded at room temperature revealed a gradual conversion of Mn²⁺ ions into Mn³⁺ with increase in MnO concentration from 0.1 to 0.4 wt. %, which indicates an increased covalent environment of manganese ions and further shows an increase in the stability of the glass network.
- iv. Study on optical absorption spectra revealed an increase in the optical bandgap and an increase in accumulation of Mn³⁺ ions at the expense of Mn²⁺ ions with increase in MnO concentration from 0.1 to 0.4 wt. %; the observed trend shows an increase in insulating character and further the stability of the glass network.
- v. Finally, the results from various studies made on CdO-Al₂O₃-P₂O₅: MnO glasses reveal an improved stability of the glass network with increase in MnO concentration 0.1 to 0.4 wt. %.

References

1. A.C. Wright, Chemical bonding in phosphate glasses, *Eur. J. Glass Sci. Technol.* B 55 (2014) 193–195.
2. M. R. Ahsan and M. G. Mortuza, "Spectroscopic analysis of the effect of P₂O₅ in the 3:2 cadmium oxide silica glass", *J. Phys. Chem. Glasses* 42(2001) 1-5.
3. T.H. Campbell and T.I. Saratwala, *J. Non-Cryst. Solids* (2000) 263-264.
4. Babita Tiwari, Anupam Dixit, V.Kothiyal, M. Pandey, and S. K. Deb., "Preparation and characterization of phosphate glasses containing titanium", *Barc Newsletter*, 285 (2007) 167-173.
5. Doris Ehrhart, *Eur. J. Glass Sci. Technol.* B 54 (2013) 65–75.
6. B. Erariah, *Bull. Mater. Sci.*, 33 (2010) 391-394.
7. R. El-Mallawany, M. Dirar Abdalla and I. Abbas Ahmed, *Mater. Chem. Phys.*, 109 (2008) 291-296.

8. L. Koudelka, L. Rosslerrova, Z. Cernosek, P. Mosner, L. Montagne, B. Revel, G. Tricot, *Eur. J. Glass Sci. Technol.* B 53 (2012) 245–253.
9. R. El Mallawany, H.M. Diab, *J. Int. Meas. Conf.* 46 (2013) 1722-1725.
10. M. Szumera, I. Walawska, *J. Therm. Anal. Calorim.* 108 (2012) 583 - 588.
11. M. Kayhan, A. Yilmaz, *J. Alloys Compd.* 509 (2011) 7819 - 25.
12. R. P. Sreekanth Chakradhara, K. P. Ramesha, J. L. Raob, J. Ramakrishnaa, *J. of Phys. and Chem. of Solids*, 64 (2003) 641–650.
13. A. Terczynska-Madej, K. Cholewa-Kowalaska, M. Laczka, the effect of silicate network modifiers on colour and electron spectra of transition metal ions. *Optical Material* 32 (2010)1456-1462.
14. E. A. Abou Neel, D. M. Pickup, S. P. Valappil, R. J. Newport & J. C. Knowles., Bioactive functional materials: a perspective on phosphate-based glasses. *Journal of Materials Chemistry*, 19 (2009) 690-701.
15. R. K. Brow, R. J. Kirkpatrick, & G. L. Turner, The Short-Range Structure of Sodium-Phosphate Glasses. *Mas Nmr-Studies. Journal of Non-Crystalline Solids*, 116 (1990) 39-45.
16. K. Franks, I. Abrahams, G. Georgiou & Knowles, J. C., Investigation of thermal parameters and crystallization in a ternary CaO- Na(2)O-P(2)O(5)-based glass system. *Biomaterials*, 22 (2001) 497-501.
17. Jae-Yeop Chung, Jong-Hwan Kim, Su-Yeon Choi, Hyun-Joon Park, Moon- Kyung Hwang, Yoon-Ki Jeong, and Bong-Ki Ryu, 52 (2015)128 -132.
18. K. Linganna, M. Rathaiah, N. Vijaya, C. Basavapoornima, C. Jayasankar, S. Ju, W. T. Han, V. Venkatramu, *Ceram. Int.* 41 (2015) 5765–5771.
19. B. R. Judd, *Phys. Rev.*, 127 (1962) 750.
20. A.V. Ravi Kumar, Ch. Srinivasa Rao, N. Narasimha Rao, V. Ravi Kumar, I.V. Kityk, N. Veeraiah, *J. Non-Cryst. Solids* 358 (2012) 1278–1286.
21. R.P. Sreekanth Chakradhara, K.P. Ramesha, J.L. Raob, J. Ramakrishnaa, *Journal of Physics and Chemistry of Solids* 64 (2003) 641–650.
22. S. Sreehari Sastry¹, S.Vedavyas, B. Rupa Venkateswara Rao, Vol. 3, Issue 4, April 2014.
23. M. Elisa J. Optoelectron. Adv. Mater., 4 (2010) 1301.
24. Aliff Rohaizada, Rosli Hussina, Nur Aimi Syaqliah Aziza, Royston Uninga and Nur Zu Ira Boharia, *J. Teknologi.*, 62 (2013) 119.
25. G. Le Saout, P. Simon, F. Fayon, A. Blin and Y. Villas, *J. Raman. Spectrosc.*, 33 (2002) 740.
26. L. Montagne, G. Palavit and G. Mairesse, *Phys. Chem. Glasses*, 37 (1996) 206.
27. D.K. Durga, N. Veeraiah, *Journal of Physics and Chemistry of Solids* 64 (2003) 133–146.
28. Y. Cheng, W. Zhongqing, H. Xi, W. Tengyan, Z. W. Wei, *J. Rare Earths* 32 (2014) 1154–1161.
29. J. H. Simmons, C.A. Simmons and R.O. choa Fluoride glass structure in Fluoride Glass Fibre Optics (eds I.D. Aggarwal and G. Lu), Academic Press, London, ch 2 (1991) 1–33.
30. Y. Masaru, Y. Zhidong, M. Yoshinobu, U. Yasushi, K. Kohei and Y. Tetsuo, *J. Non-Cryst. Solids*, 333 (2004) 37.

31. L.D. Bogomolova, V.A. Yachkin, N.A. Krasil'nikova, V.L. Bogdanov, F.B. Fedorushkova and V.D. Khahlev, *J. Non- Cryst. Solids* 125 (1990) 32.
32. R. V. S. S. N. Ravikumar, K. Ikeda, A. V. Chandrasekhar, Y. P. Reddy, P. S. Rao and Jun Yamauchi, *J. Phys. Chem. Solids*, 64 (2003) 2433.
33. I. Ardelean, M. Peteanu, V. Simon, S. Simon and M. Flora, *Phys. Chem. Glasses*, 41 (2000) 153.
34. D. Viviani, F. Faivre, C. Levelut and M. Smihi, *J. Phy. Chem. B.*, 110 (2006) 7181.
35. M. R. Chialanza, J. Castiglioni, L. Fornaro, *J. Mater. Sci.* 47 (2012) 2339-2344.
36. J. D. Lee, *Concise Inorganic Chemistry*, (Blackwell science , Oxford, 1996).
37. G. Giridhar, M. Rangacharyulu, R. V. S. S. N. Ravikumar and P. Sambasiva Rao, *IOP Conf. Series: Mater. Sci. Eng.* 2 (2009) 012058.
38. Dana Toloman, A. R. Biris, Adriara Popa, Oana Raita, L. M. Giurgiuand and I. Ardelean, *J. phys. Conference series*, 182 (2009) 012032.
39. A.Srinivasa Rao, B. Sreedhar and S.V.J. Lakshman, *J. Non-Cryst. Solids*, 144 (1992)169.
40. R.Stefan and S.Simon, *Mod.Phys.Lett.*, 3 (2000) 111.
41. I. Ardelean, S. Simon and C. Bob, *Mater. Lett.*, 39 (1999) 42.
42. R. Durny, *J.Non-Cryst.Solids*, 41(1980) 273.
43. F.Albert Cotton and G. Wilkinsin, *Adv. Inorganic Chemistry*, (Wiley. New Delhi), 1976.
44. D.K.Durga and N.veeraiah, *J.Phys.Chem.Solids* 2002 (Accepted).
45. Van Die, A., Leenaers, A.C.H.I., Blasse, G., and Van Der Weg, W.F., "Germanate Glasses as Hosts for Luminescence of Mn²⁺ and Cr³⁺ ", *J. Non- Cryst. Solids*, 99 (1988) 32-44.

How to cite this article:

Kassa Belachew *et al* (2018) 'Study on the Role of Manganese Ions on Physical And Structural Properties of Alumino-Phosphate Glasses By Means of Spectroscopic Analysis', *International Journal of Current Advanced Research*, 07(8), pp. 15054-15059. DOI: <http://dx.doi.org/10.24327/ijcar.2018.15059.2748>
