ISSN: 0976-3031

International Journal of Recent Scientific Research

Impact factor: 5.114

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Volume: 6

Issue: 10

THE PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH
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International Journal of Recent Scientific Research
Vol. 6, Issue, 10, pp. 6587-6590, October, 2015

International Journal of Recent Scientific Research

ISSN: 0976-3031

RESEARCH ARTICLE

THERMAL AND ELECTRICAL PROPERTIES OF VANADIUM PHOSPHATE GLASS CONTAINING DIFFERENT OXIDES

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ARTICLE INFO

Article History:

Received 16th July, 2015
Received in revised form 24th August, 2015
Accepted 23rd September, 2015
Published online 16st October, 2015

Key words:

ABSTRACT

60% P_2O_5– 30%V_2O_5–10%X where X is Li_2O, Na_2O, K_2O, and BaO glass system were prepared by the melt-quenching technique. The produced glass were checked by x-ray to ensure the glassy state. Glass transition temperature, crystallization temperature, glass thermal stability, glass forming ability and electrical conductivity were measured and calculated. All the above mentioned properties decreases with increasing the ionic radius of the doped oxides. The results suggested the modifier position of the dopped oxides.

INTRODUCTION

Considerable research has been done on vanadium phosphate glasses due to its interesting semiconducting properties and their applicability in electronic devices. The hopping mechanism between different states of transition metal ions were used to explain the electrical properties of vanadium phosphate glasses and the effect of heat treatment on crystallization also discussed(1). Magnetic susceptibility, x-ray diffraction, infrared, electrical conductivity and structural studies were done on vanadium phosphate glasses (2-9).The electrical conductivity were discussed according to hopping mechanism between two different ion states v^{4+} and v^{5+}. Magnetic susceptibility were explained in relation to paramagnetic behavior of v^{4+} and diamagnetic behavior of v^{5+}. Infrared studies confirms the presence of both v^{4+} and v^{5+}. The main separated phase on crystallization process of vanadate glasses was V_2O_5. Differential thermal analysis (DTA) is a technique for determining the temperatures of the phase transitions like melting point, solidification, re-crystallization and evaporation temperature .DTA curves can record the transformations where the heat is either absorbed or released (dehydration, decarbonation, burning of materials, ordering etc. (10). Glass transition temperature (TG) of silver phosphate glasses undoped and doped with transition metal halides were studied (11). TG of doped glasses are higher than those undoped glasses. The increasing of TG with increasing Cd/Zn halides concentration were attributed to the increasing of cross link density. TG of doped glasses with Cadmium halides are higher than those glasses doped with Zinc halides. TG values of silver phosphate glasses doped with Cd and/or Zn halides follow the decreasing order ($Cl > Br > I$). The decreasing order were explained on basis of ionic size, the increasing size of halide ions ($I^- > Br^- > Cl^-$) loosen the glass structure to greater extent and thereby the TG values are lowered as ne goes from Chloride to Iodide. DTA studies of PbO-PbF_2-B_2O_3 glass system doped with V_2O_5 was studied (12). The good homogeneity of the prepared glasses were proved by the presence of one TG and one crystallization temperature. The change of TG, crystallization temperature (TC), glass forming ability K_{gl} and glass thermal stability (GTS) values were attributed to the variation of valance state of vanadium ions and its position in the glass network. The GTS of 20CaO-10ZnO-59.9P_2O_5-10Pb_3O_4-1x, (x= V_2O_5, Cr_2O_3, MnO and CuO) were studied (13). DSC curves shows endothermic and exothermic changes due to TG and TC. The calculation of GTS shows that glass containing vanadium oxide is most stable one. DTA of $(MnO)_x\cdot(P2O5)_{40}\cdot(ZnO)_{60-x}$ glass system were studied (14). The presence of one single peak attributed to the TG indicates the homogeneity of the prepared glasses and TG is not affected by ZnO addition. The GTS, K_{gl} decreases while the fragility index increases with increasing manganese oxide. Thermal

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properties of oxy-chloride bismuth-borate glasses doped with vanadium oxide were studied (15). The higher TG and GTS the higher density of the studied glasses. DTA of glasses with composition (30- x) $Li_2O\cdot xV_2O_5\cdot 20Bi_2O_3\cdot 50B_2O_3$(x=15, 10, 5) has been carried out in order to study the effect of replacing the Transition Metal Oxide with alkali oxide (16). The TG, the TC and K_{gl} decreases with replacing alkali oxide with transition metal oxide of the glasses which confirms that the glass become more fragile.

Experimental

Glass system with molar composition (60% P_2O_5– 30%V_2O_5– 10%X) where X is Li_2O, Na_2O, K_2O, and BaO was prepared from reagent grade chemicals (99% purity). Vanadium pentoxide (V_2O_5), ammonium dihydrogen orthophosphate ($NH_4H_2PO_4$), lithium carbonate (Li_2CO_3), sodium carbonate (Na_2CO_3), potassium carbonate (K_2CO_3), and barium carbonate ($BaCO_3$) were thoroughly mixed in a porcelain crucible and melted at 1200 °C for 3 h in a muffle furnace until a homogeneous melt was obtained. The melt was then quickly quenched to room temperature. Powder X-ray diffraction was performed on samples and the results showed that they were purely non-crystalline. The DC electrical conductivity measurements were carried out using Keithely 617 electrometer with range from 10 to 10^{-16} A. Discs about 2 mm thickness were used. The parallel surfaces were coated with silver paste to serve as electrodes. The thermal behavior of glass samples was carried out using a PerkinElmer TG/DTA 6300 thermal analyzer under Ar gas atmosphere. About 20mg of bulk glass was heated in Pt-holder with another Pt-holder containing -alumina as a reference material. The DTA traces were recorded at heating rates 10 ◦C/min.

RESULTS AND DISCUSSIONS

In previous work (17) the density, the molar volume, the IR spectra, temperature dependence on electrical conductivity and magnetic susceptibility of the same glass system were carried out. The electrical conductivity results shoes semiconducting behavior and were explained according to non-adiabatic hopping mechanism of small polaron hopping conduction. The density and magnetic susceptibility decreases while the molar volume increases with increasing ionic radius of doped oxides. The hopping distance is given by (18)

$$R = (4\pi N/3)^{-1/3} \qquad (1)$$

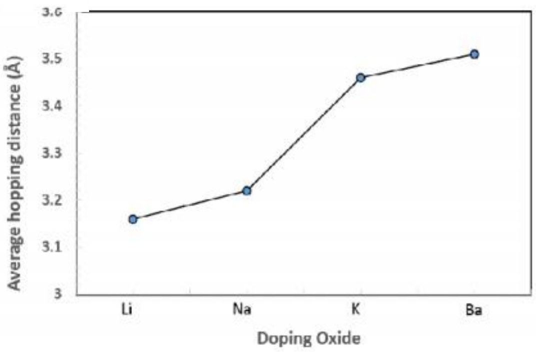

Figure 1 The dependence of average hopping distance on doped oxides.

Where N is the number of transition metal ion per unit volume. The hopping distance and electrical conductivity at room temperature are shown in figs (1, 2).

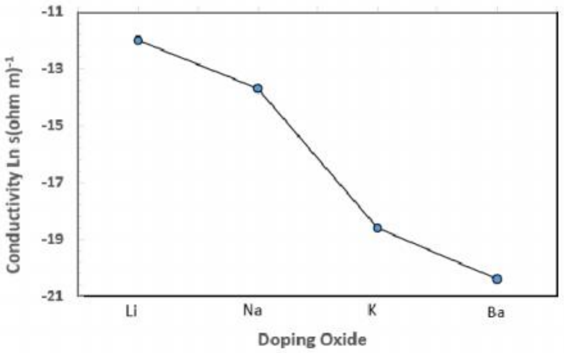

Figure 2 Dependence of electrical conductivity on doped oxides.

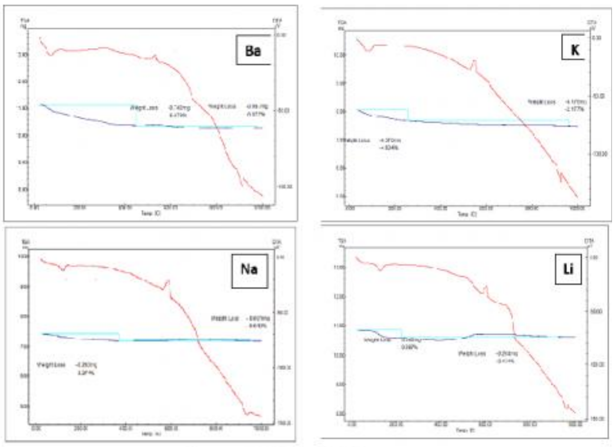

Figure 3 DTA, TGA curves.

The conductivity decreases while the hopping distance increases with increasing ionic radius of doped oxides, which confirms the modifier position of doped oxides, and the expansion of the glass network depends on the ionic radius of the doped oxides. These results are in agree with molar volume results (17). DTA and TGA results are shown in fig (3) and summarized in table 1. DTA curve exhibits three peaks (two endothermic peaks according to GT, melting temperature (TM) and exothermic peak according to TC). Presence of one peak of each temperature confirms the homogeneity and one phase of the prepared glasses (12, 14). The weight loss at the first stage can be attributed to the evaporation and dehydration of water on the sample surface, while the weight loss at the second stage may be attributed to combustion of residual organics probably predisposes to crystallization process and to the decomposition of the samples during crystallization process (14, 19). The glass transition temperature is given by (13)

$$GTS = TC - TG \qquad (2)$$

Dependence of GT, TC and GTS on doping oxides are shown in figs (4, 5, 6). Thermal stability of glasses is an important property both fundamentally and technologically. It is a measure of degree of disorder of glassy state. In all curves one can see the decreasing of all measured and calculated parameters. This decreasing may be attributed to decreasing of oxygen packing density in the glass network, compactness of the samples, decreasing of cross link density, decreasing the number and strength of the cross-link between the cation and the oxygen atom and creating voids in the structure (15, 17, 20, 21). The decrease in the above mentioned parameters are confirmed by the decreasing of the density and increasing of the molar volume in previous study (17). Fig (7) shows the dependence of doping oxide on K_{gl}, which given by

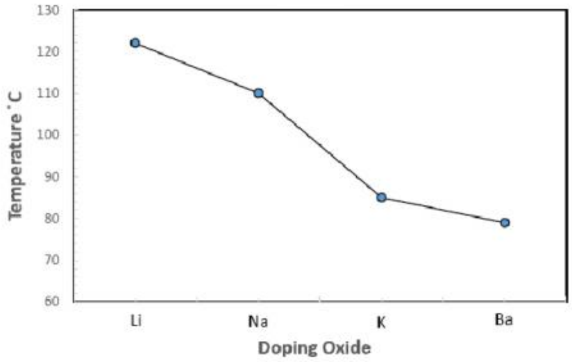

Figure 4 Dependence of glass transition temperature on doping oxides.

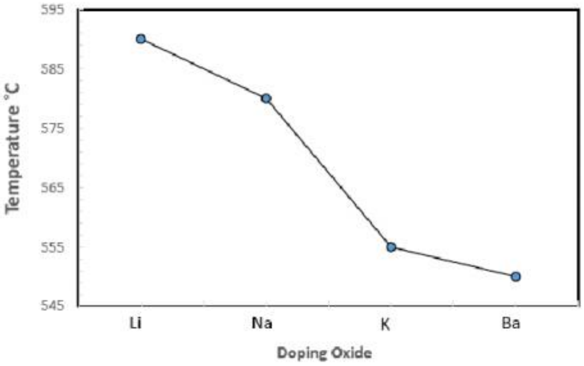

Figure 5 dependence of crystallization temperature on doping oxides.

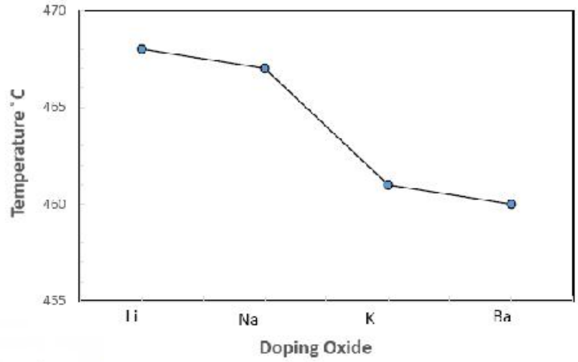

Figure 6 Dependence of Glass stability on doped oxides.

$$K_{gl} = \frac{T_c - T_g}{T_m - T_c} \qquad (3)$$

The higher value of ($T_c - T_g$) delay the nucleation process and devitrification of the glass while the higher value of ($T_m - T_c$) increases the nucleation and enhance the crystallization of glasses (22, 23). Glass-forming ability can be determining in order to compare devitrification tendency of the glass. The decreases of the thermal stability and the glass-forming ability with increasing ionic radius of doping oxide suggests high tendency of crystallization and the glasses become more fragile with increasing ionic radius(16, 20). Our results (the decreasing of all measured and calculated parameters except the hoping distance which increased) are in good agreement with the results carried out by Yang LI.*et.al* and H. Desirena.*et.al* (24, 25). They concluded that the decreasing of thermal parameters are related to the field strength of cation ions. The cation field strength increase with decreasing the ionic radius, which in turn increase the cross link density, and the glass network became stronger. This mechanism of compactness the glass network decrease all measured and calculated thermal parameter.

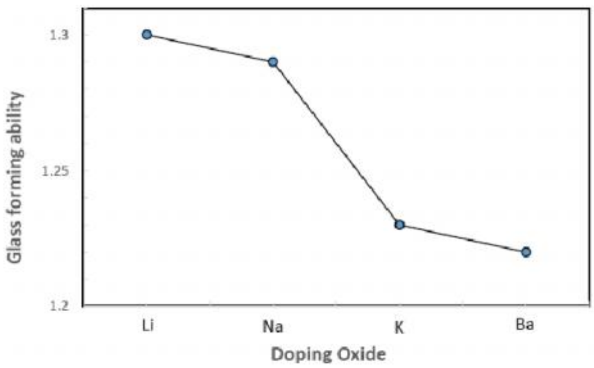

Figure 7 Dependence of glass forming ability on doped oxides.

Table 1 Thermal parameters of prepared glasses,

Element	TG	TC	T_M	TC-TG	K_{gl}	Weight loss%
Li	122	590	950	360	1.3	-2.4
Na	110	580	940	360	1.29	-3.1
K	85	555	930	375	1.23	-5.2
Ba	79	550	925	375	1.22	-6.1

CONCLUSIONS

The decreasing of all measured and calculated properties except the hoping distance ,which increases, with increasing ionic radii confirms the modifier position of the different oxides in the glass network. This behavior is attributed to the decreasing of cation field strength, density and increasing of molar volume.

References

1. I. Kashif, H. Farouk, S. A. Aly, A. A. Abdel Rahman, A. M. Sanad, E. E. Assem, Materials Science and Engineering. B10 [1991] 1.
2. I. Kashif, H. Farouk, S. A. Aly, A. M. Sanad, M. H. El-Kottamy, E. E. Assem, *Journal of Materials Science: Materials in Electronics*. 3 [1992] 144.
3. I. Kashif, H. Farouk, A. M. Sanad, S. A. Aly, E. E. Assem, Journal of Materials Science. 27[1992] 122.
4. I. Kashif, H. Farouk, S. A. Aly, E. E. Assem, A. M. Sanad, Physics and Chemistry of Glasses. 31 [1990] 156.
5. I. Kashif, H. Farouk, S. A. Aly, A. M. Sanad, E. E. Assem, *Journal of Materials Science: Materials in Electronics*. 3[1992] 48.
6. E. E. Assem, Key Engineering Materials Vol. 280 (2005) pp.327-332.
7. E.E. Assem, PHYSICA B. 406 (2011) 421-425.
8. G.D. Khattak, A. Mekki, L.E. Wenger, *Journal of Non-Crystalline Solids* 355 (2009) 2148.
9. M. A. Salim, G.D. Khattak, P. S. Fodor, L.E. Wenger, *Journal of Non-Crystalline Solids* 289 (2001) 185.
10. Grega Klančnik, Jožef Medved, Primož Mrvar, RMZ – Materials and Geoenvironment, 57(2010) 1, 127.

11. S.S.Das, P.B.Paranwal, C. P. Gupta, Punita Singh, Indian *Journal of Engineering& Materials Sciences*, 12(2005)58.
12. P. Bhavani, T.V. Nagalakshmi, A.W. Iqbal and K.A. Emmanuel, *Chemistry Journal* 3(2013) 75.
13. S. Sreehari Sastry, B. Rupa Venkateswara Rao, , 4(2015) 18681.
14. Petru Pascuta, Maria Bosca, Gheorghe Borodi, Eugen Culea, *Journal of Alloys and Compounds* 509 (2011) 4314.
15. M.S. Dahiya, S. Khasa, A. Agarwal, J. Asian Ceram. Soc. (2015), http://dx.Doi.org/10.1016/j.jascer.2015.02.006
16. S. Khasa, M. S. Dahiya and A. Agarwa, AIP Conference Proceedings 1591, 796 (2014); doi: 10.1063/1.4872759.
17. E.E. Assem, I.Elmehasseb, *Journal of material Science*.46 (2011) 2071.
18. G.B. Devidas, T. Sankarappa, B.K. Chougule, G. Prasad, J Non Cryst Solids 353 (2007) 426.
19. M. PrzeVniak-Welenc, M. AapiNski, T. Lewandowski, B. KoVcielska, L. Wicikowski, and W. Sadowski, *Journal of Nanomaterials Volume* 2015, Article ID 418024, 8 pages, http://dx.doi.org/10.1155/2015/418024.
20. I. Kashif, A. Abd El-ghany, A. Abd El-Maboud, M.A. Elsherbiny, A.M. Sanad, *Journal of Alloys and Compounds* 503 (2010) 384.
21. E E Assem, K R Mahmoud, T Sharshar and C Siligardi, J. Phys. D: Appl. Phys. 39 (2006) 734.
22. N. Mehta, R.S. Tiwari, A. Kumar, Mater. Res. Bull. 41 (2006) 1664.
23. V. Kumar, S. Sharma, O.P. Pandey, K. Singh, Solid State Ionics 181 (2010) 79.
24. Yang LI, Jianhu YANG, Shiqing WANG, Lili HU, J. Mater.Sci.Technol.21 (2005)391.
25. H. Desirena , A. Schülzgen , S. Sabet , G. Ramos-Ortiz , E. de la Rosa , N. Peyghambarian, Optical Materials 31 (2009) 784.

How to cite this article:

Assem E.E., Ashour A and Aljaier A.M.2015, Thermal and Electrical Properties of Vanadium Phosphate Glass Containing Different Oxides. *Int J Recent Sci Res.* 6(10), pp. 6587-6590.

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International Journal of Recent Scientific Research

ISSN 0976-3031

9 770976 303009