Proceedings of International Conference on Technology and Social Science 2017
KEYNOTE

The FTIR Analysis of Nd_2O_3 Substitution on (35-x)CuO-xNd_2O_3-65P_2O_5 glasses

Agus Setyo Budi [1, a], Dewi Mulyati[1, b], Hadi nasbey[2, c] and Iwan Sugihartono[1, d],

[1] State University of Jakarta, Jalan Rawamangun muka no.1, Jakarta, INDONESIA

[2] Division of Mechanical Science and Technology, Faculty of Science and Technology, Gunma University, 1-5-1 Tenjin-cho, Gunma, 376-8515, JAPAN

[a]<abihuda123@yahoo,com>,[a]<dmuliyati@gmail.com>,[a]<t15806008@gunma-u.ac.jp>,

[a]< isugihar@hotmail.com >

Keywords: social safety, privacy protection, network camera, Internet of Things, social infrastructure, e-JIKEI Network, e-JIKEI Network Camera

Abstract. Melt quenching technique (MQT) has been used to prepare the series of (35-x)CuO-xNd_2O_3-65P_2O_5 ($0 \leq x \leq 10$ mol%) glasses, The thermal properties and structure of those glasses were investigated. The glass transition temperature increases as the Nd_2O_3 is substituted for CuO. This behaviour indicates that the replacement of CuO by Nd_2O_3 improves the strength of the cross-links between the phosphate chains of the glasses. The analysis of the infrared spectra of the studied glasses reveals that the increase of Nd_2O_3 content decreases the formation of the end groups in phosphate chain structure.

1. Introduction

Phosphate glasses offer several advantages over silicate and borate glasses [1,2]. Compared with conventional oxide glasses, phosphate glasses are technologically important materials because they posses some superior physical properties such as high thermal expansion coefficients, low melting temperature, low softening temperature, low transition temperature and high electric conductivity. These glasses have considerable potential for application in optical data transmission, solid state batteries, sensing and laser technology. The study of glasses by means of the analysis of the optical absorption edge provides a simple method for explaining some features concerning the band structure of the materials [3]. The optical absorption in this region depends strongly on the electronic structure and involves interactions between the incoming radiations and the electronic state of the glasses under consideration. The electronic states depend on the glass composition. The absorption depends on how tightly the electrons are bound in the microstructure. The electrons in the excited states usually occupy their lowest energy level with the emission of photons. The principle involved is that the photons with energies greater than the band gap energy are absorbed and the less energetic photons are transmitted [4]. The aim of this work was to study the structure and properties of CuO-Nd_2O_3-P_2O_5 glasses in terms of the substitution of CuO by rare earth oxide neodymium.

2. Experimental

2.1. Preparation of Sample.

The glasses were prepared by melting dry mixtures of neodymium oxide (Nd_2O_3), cuprum oxide (CuO) and phosphate (P_2O_5) in silica crucible with composition $[Nd_2O_3]_{(x)}$-$[CuO]_{(35-x)}$-$[P_2O_5]_{(65)}$, where $0 \leq x \leq 10$ mol %. To react the constituents, the mixed powders were heated in an electrical furnace at 350 ^{0}C for 1h, and then melted in another furnace at 1200 ^{0}C . To ensure proper mixing and homogeneity, the molten liquid was shaken frequently and vigorously. After being checked, the melt was cast by pouring as fast as possible into a hot steel split mould to quench it to form a glass. The glass was immediately transferred to an annealing furnace at 350 ^{0}C where it was kept for 3 h to relieve any residual stress which could cause embrittlement. At the end of this annealing process, the furnace was switched off and the glass left to cool down to the room temperature gradually by controlled thermal treatment at cooling rate of 0.5^{0}C/min. The sample were selectively cut, ground, and polished. After preparation, samples were stored in plastic containers in a dessicator until the FTIR and DTA measurement was performed. The amorphous nature of the samples was checked by X-ray diffraction.

2.2. Measurement of DTA

The equipment used to carry out the thermal measurement was a Perkin-Elmer DTA 7 Series system, which was operated under standard atmospheric conditions. The maximum temperature that could be reached by the instrument was approximately 1400^{0}C. The same weight of fine standard and sample (± 5-20 mg) were loaded in an alumina crucibles and were heated at a rate of 10 ^{0}C/min for all samples. With the combination of built-in computer and UNIX operating system. It was possible to obtained DTA curves and the required data for analysis.

2.3. Measurement of IR spectra

A Perkin Elmer 1600 Fourier Transform infra red (FTIR) have been used to investigate to all sample prepared using the KBr pellet technique. Typically around 2 mg of the finely ground sample is mixed with 200 mg of KBr powder and the mixture then pressed for 4 minutes, in evacuable die under 10 tons of pressure to give a transparent disk with a surface area of 1 cm^3. The FTIR spectra were recorded in the spectral range of 4000 – 400 cm^{-1} resolution and 64 scans to ensure a good signal to noise ratio.

3. Results and discussion

Composition, density, molar volume and glass transition temperature for all the samples are listed in Table 1.

Table 1. Data for CuO-Nd_2O_3-P_2O_5 glasses, batch composition (mol%), density (g/cm^3), D, molar volume (cm^3/mol), V_m and glass transition temperature T_g (^{0}C) of the studied samples.

Batched			D	V_m	T_g
CuO	Nd_2O_3	P_2O_5			
35	-	65	2.725	44.07	314
33	2	65	2.759	45.39	315
31	4	65	2.777	46.94	316
29	6	65	2.808	48.26	317
27	8	65	2.831	49.68	318
25	10	65	2.861	50.95	319

3.1. Glass transition temperature

As shown in the Fig. 2, the replacement of CuO by Nd_2O_3 increases T_g from 31^{0}C for Nd_2O_3 = 0 mol% to 319 ^{0}C for 10 mol% Nd_2O_3. This is attributed to the lower field strength of the Cu^{2+} than of the rare earth ion Nd^{3+}. A similar trend in variation of properties in the rare earth copper phosphate glasses has been observed by Arzeian et.al [5].

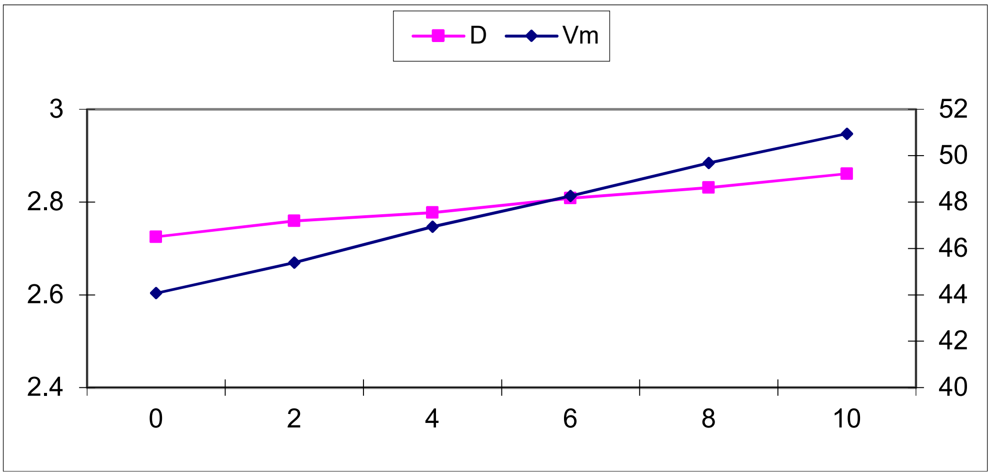

Fig. 1. Density and molar volume of (35-x)CuO-xNd_2O_3-65P_2O_5 glasses

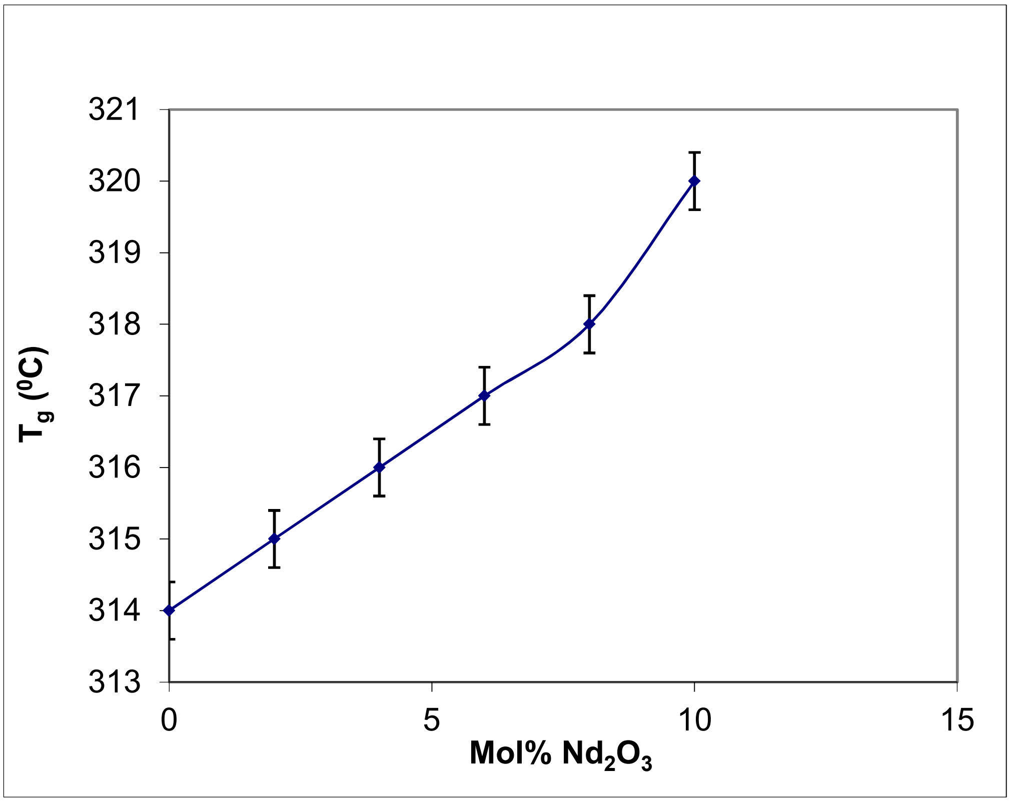

Fig. 2. Glass transition temperature of (35-x)CuO-xNd_2O_3-65P_2O_5 glasses.

3.2. FTIR

The Fourier Transform Infra Red (FTIR) absorption spectra of neodymium copper phosphate glasses are shown in Figure 3.

The infra-red spectrum of neodymium copper phosphate glasses lies in the region of 4000 cm^{-1} to 200 cm^{-1}. The majority of the resonant vibrational frequencies are present in this region and can be seen in Table 2. There are six important absorption bands within the frequency range from 3428 cm^{-1} to 470 cm^{-1}. For Nd_2O_3-CuO-P_2O_5 glasses, the measurements of the infra-red absorption spectra in many respects are similar to the one obtained by Hogarth and Moridi [6]. However, absorption peak for CuO, which appear at 620 cm^{-1} has not appeared in these glasses. This band seems to be completely broken down as a consequence of the P-O-Cu stretching vibrations being modified by P-O-Cu-O-Nd bands.

The addition of very small amount of Nd_2O_3 also affects the absorption band positions compared with ternary copper phosphate glass. A very slight shift in the position of some band is observed. The absorption band at 470 cm^{-1} has shifted to 476 cm^{-1} as the rare-earth content is changes from sample to sample.

Table 2: Infrared spectra of xNd_2O_3-(35-x)CuO-$65P_2O_5$ glasses

Sample	Peak positions (cm^{-1})							
S_1	470.55	506.91	755.65	945.62	1066.50	1262.5	-	3406.6
S_2	473.55	-	783.66	941.93	1110.46	1260.5	2912.6	3405.6
S_3	472.61	-	750.23	938.14	1075.56	1264.5	-	3428.6
S_4	475.29	504.66	761.29	941.93	1080.60	1270.5	2925.6	-
S_5	476.65	-	782.72	-	1072.58	1261.5	-	-
S_6	476.63	-	779.71	-	1070.55	1263.5	-	-

The absorption band observed in this study at 770 cm^{-1} would seem to be attribute to the P-O-P ring frequency, which is in close agreement with other results [7,8]. The strong broad band at 938 $cm^{-1}$to 1270 cm^{-1} are assigned to P-O^- stretching in CuO-P_2O_5. Two absorption bands were observed in Nd_2O_3-CuO-P_2O_5 network at about 2925 cm^{-1} to 3406 cm^{-1}. These weak bands are probably associated with water trapped in the glass.

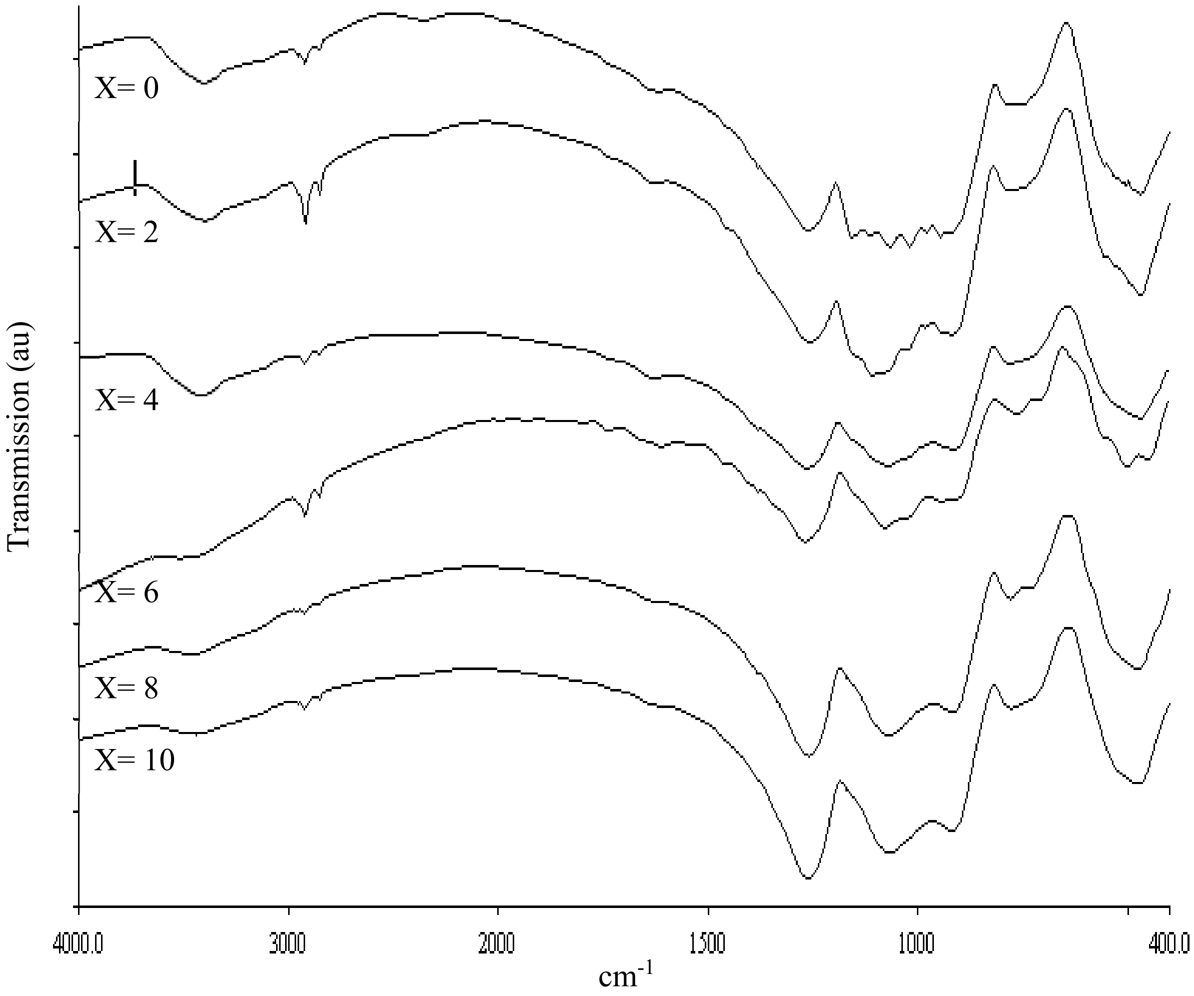

Fig. 3: IR spectra of $(Nd_2O_3)_x$-$(CuO)_{35-x}$-$(P_2O_5)_{65-x}$, with, $0 \leq x \leq 10$

4. Conclusions

The infra red spectroscopy of these glasses showed that the dominance of the phosphate tetrahedral in lattice vibrations. The strong broad band at 938 cm^{-1}to 1270 cm^{-1} are assigned to P-O$^-$ stretching in CuO-P_2O_5. Two absorption bands were observed in Nd_2O_3-CuO-P_2O_5 network at about 2925 cm^{-1} to 3406 cm^{-1}.

Acknowledgements

We wish to thank to the Physics Department of Universitas Indonesia for research facility

References

[1]. T. Minami, K. Imazawa, M. Tanaka , “Formation region and characterization of superionic conducting glasses in the systems $AgI\square Ag_2O\square M_xO_y$”, ***Journal of Non-Crystalline Solids***,Vol. Issues 1–3, pp. 469-476, 1980.

[2]. JB. Wagner, C. Wagner, “Electrical conducticity measurements on cuprous halides”, ***The Journal of Chemical Physics***, 26, 1957.

[3]. M.M. Ahmed, R. Harani, C.A. Hogarth, “The optical energy gap in praseodymium phosphate glasses”, ***J. Material Science Letters,*** 3, 1055-1057, 1984.

[4]. M. Hafid, T. Jermoumi, N. Toreis, T. Ghailassi, “Structure of $(45-x)\ Na_2O–xBaO–5ZnO–50P_2O_5$ glasses studied by DSC and infrared spectroscopy”, ***Materials Letters***, Vol. 56, No.4, pp.486-490, 2002.

[5]. J.M. Arzeian, C.A. Hogarth, “Some structural, electrical and optical properties of copper phosphate glasses containing the rare-earth europium”, ***Journal of materials science***, Vol. 26, No.19, pp 5353-5366, 1991.

[6]. GR Moridi, CA Hogarth, “Infra-red absorption spectroscopy of copper-calcium-phosphate glasses”, ***International Journal of Electronics***, Vol. 37, No.1, pp. 141-143, 1974.

[7]. JJ Hudgens, SW Martin,” Glass transition and infrared spectra of low-alkali, anhydrous lithium phosphate glasses”, ***Journal of the American Ceramic***, Vol. 76, No.7, pp. 1691-1696, 1993.

[8]. D. Ilieva, B. Jivov, D. Kovacheva, Ts. Tsacheva, Y. Dimitriev, “FT–IR and Raman spectra of Gd phosphate crystals and glasses”, ***Journal of Non-Crystalline Solids***, Vol. 293-295, pp. 562-568, 2001.