

Synthesis and Characterization of New Amorphous Phases in Bi₂O₃-P₂O₅-SrO System

Zahra RAMZI, Samira TOUHTOUH, M'Hamed TAIBI, Mohammed BETTACH, Abdelwahed HAJJAJI, Wafaa NACHIT, Khalil BENKHOUSA

Abstract— In the present work Bi₂O₃-P₂O₅-SrO glasses have been prepared via melt quenching method. A glass-forming domain is found and studied within Bi₂O₃-P₂O₅-SrO system. The glasses obtained in the system P₂O₅-SrO was investigated by Infrared Spectroscopy. FTIR studies have been performed in these glasses to examine the distribution of different phosphate structural groups. The effect of strontium on these distributions has been examined.

Index Terms— IR Spectroscopy, phosphates, glasses, Bi₂O₃-P₂O₅-SrO System

1. INTRODUCTION

In recent years, glasses are increasingly used as host material for solid state lasers based on rare earth and transition metal ionic transitions [1]. The advantages with glasses are the ease with which large homogeneous pieces can be produced. The nonlinear refractive indices can be made low and the doping concentration can be large [2]. It has been shown that the fluorescence intensity of rare earth ion are enhanced several fold when glass hosts with low phonon energies as example in germanate and telluride are used [2].

Phosphate glasses have received considerable attention in the past few years due to the synthesis of new glass compositions with high chemical stability. The improvement of chemical stability [3–5] stimulated the application of phosphate glasses in several fields of materials science, For example, zinc-calcium borophosphate glasses were investigated for application as glass seals or glass solders due to their low melting temperatures and low viscosities.[6] Alkali and silver borophosphates have been developed for fast-ion-conducting applications such as for preparing electrolytes in solid-state electrochemical cells,[7] and the

addition of niobium or calcium to borophosphate glasses was studied for applications in non-linear optical devices [8].

The present paper reports a preliminary investigation of new phosphate glasses in Bi₂O₃-P₂O₅-SrO system. Elaboration process, vitreous domain, and infrared spectroscopy (IR) will be described successively.

2. EXPERIMENTAL PROCEDURE

The amorphous samples were prepared using high purity commercial materials Bi₂O₃, SrCO₃; NH₄H₂P₀₄ of analytical grade (Aldrich 99.9%). The batches of suitable proportions of starting products were mixed in an agate mortar and then heated in air at 1100°C (2H) for vitreous phases. All of them are quenched to room temperature and identified by infrared spectroscopy.

3. RESULTS AND DISCUSSION

3.1. Glass formation region

A wide range glass system based on the Bi₂O₃-P₂O₅-SrO system was prepared at 1100°C after a series of composition. The vitreous was determined by X-ray diffraction. The glass formation region of the Bi₂O₃-P₂O₅-SrO system is illustrated in the figure 1 indicating a compositional range for glass formation: 50 < P₂O₅ < 100 mol%, 0 < Bi₂O₃ < 30 mol% and 0 < SrO < 50 mol%.

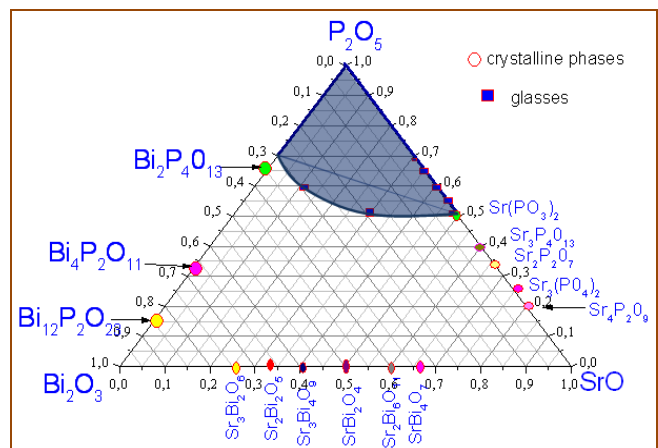


Figure 1: Vitreous domain diagram for the Bi₂O₃-P₂O₅-SrO system and the localized of crystallized phases and glassy phases

Manuscript published on 30 December 2014.

* Correspondence Author (s)

¹E2M_LCCA, Chemistry Department, Faculty of Sciences, UCD University, P.O. Box 20, 24000 El Jadida, Morocco

²ENSA, National School of Applied Sciences, UCD University, P.O. Box 1166, Plateau, 24002 El Jadida, Morocco

³Laboratory of engineering sciences for energy (LABSIPE), UCD University, National School of Applied Sciences, El Jadida

⁴LPCMIO, Université Mohammed V-Agdal, Ecole Normale Supérieure Rabat

⁵LPCM, Chemistry Department, Faculty of Sciences, UCD University, P.O. Box 20, 24000 El Jadida, Morocco

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>

The phosphate glass samples obtained were transparent and showed no sign of devitrification. The photograph image of the studied glass have shown in Figure 2,



Figure 2: Photograph image of glasses $\text{P}_2\text{O}_5\text{-SrO}$

3.2. Infrared Spectra Analysis

Figures 3–5 show FTIR spectra of glasses 70% $\text{P}_2\text{O}_5\text{-30% SrO}$, 65% $\text{P}_2\text{O}_5\text{-35% SrO}$, 60% $\text{P}_2\text{O}_5\text{-40% SrO}$, 55% $\text{P}_2\text{O}_5\text{-45% SrO}$, respectively, in the wave-number range from 400 cm^{-1} to 4000 cm^{-1} .

The absorption band at $1270\text{-}1280\text{ cm}^{-1}$ corresponds to the bonding O-P-O of the type ‘asymmetric stretching vibration mode’, denoted by $\nu_{\text{as}}(\text{PO}_2)^-$ [9,11].

The absorption band at around 1100 cm^{-1} arises from asymmetric stretching vibration of P-O bonding [12]. The absorption band at 920 cm^{-1} is due to asymmetric stretching vibration of P-O-P bonding [12,13]; while those within $725\text{-}770\text{ cm}^{-1}$ arises from symmetric stretching vibration of P-O-P bonding [12,13]. The two bands of P-O-P stretching vibration shift to higher wavenumbers while lower intensity with increasing SrO content.

Figures 3–6 demonstrate that with increasing SrO content, the P=O bonding intensity in the glasses decreases; O-P-O bonding is diminishing, while PO^- bond strength increases. That is to say, contents of Q^3 , Q^2 decrease while contents of Q^1 and Q^0 increase. The reason is that as the ratio

$[\text{P}_2\text{O}_5]/[\text{SrO}]$ decreases, P-O-P bonding is more affected by the modifier thus leading to deterioration of the long phosphate chain and the subsequently to the formation of Q^1 , Q^0 bonding. Formations of P-O-H bonds express the hygroscopic nature of the phosphate glass.

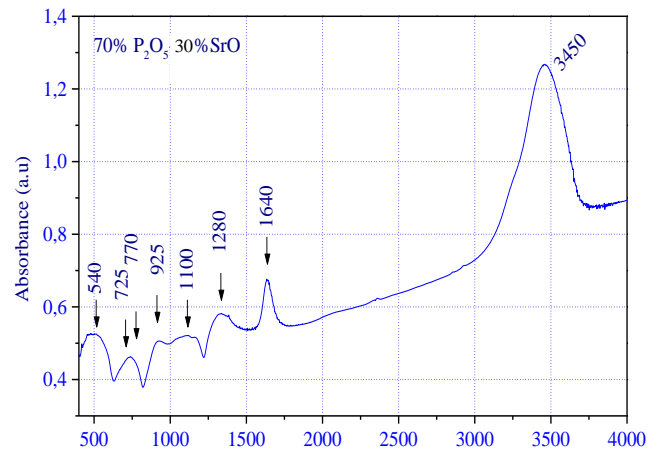


Figure 3: Infrared spectra of 70% $\text{P}_2\text{O}_5\text{-30% SrO}$ glass system

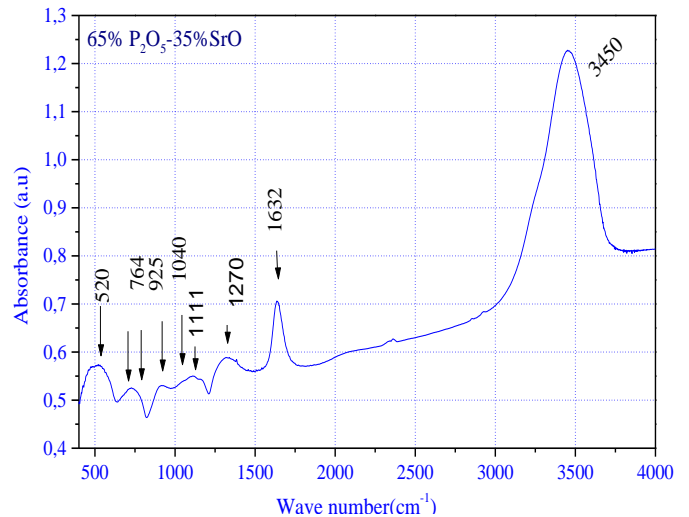


Figure 4: Infrared spectra of 65% $\text{P}_2\text{O}_5\text{-35% SrO}$ glass system

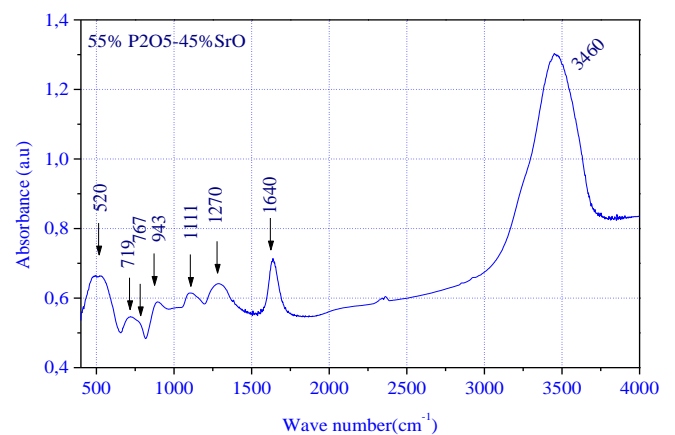


Figure 5: Infrared spectra of 60% $\text{P}_2\text{O}_5\text{-40% SrO}$ glass system

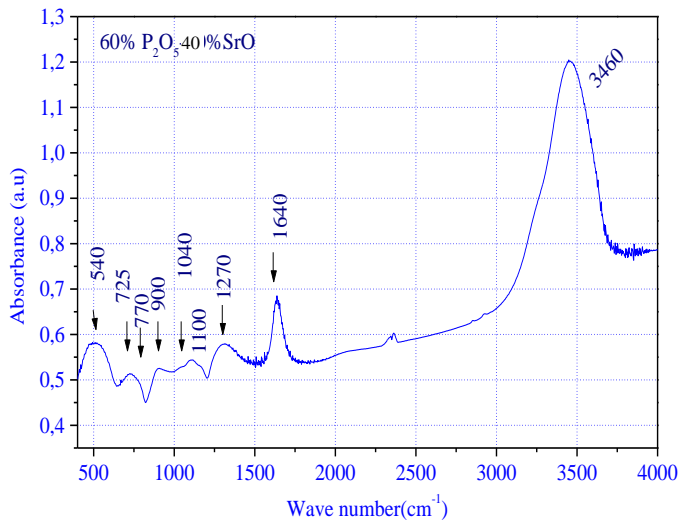


Figure 6 :Infrared spectra of 55% P₂O₅-45%SrO glass system

4. CONCLUSIONS

P=O bonding in the glasses disappears with increasing SrO content, while the O—P—O bonding diminishes with PO⁻ bond strength increases. That is to say, contents of Q³, Q² decrease while contents of Q¹ and Q⁰ increase

ACKNOWLEDGMENT

The research for this paper was financially supported by IRD (Institut de Recherche pour le Développement, France) and CNRST (Centre Nationale pour la Recherche Scientifique et Technique, Maroc). We gratefully acknowledge their support and help.

REFERENCES

- [1] Brian A. Adair and Anthony K. Cheetham, J. Solid State Chemistry, 155 (2000) 451-454
- [2] E. Metwalli, M. Karabulut, D.L. Sidebottom, M.M. Morsi, R.K. Brow, J. Non-Cryst. Solids, 344 (2004) 128-134
- [3] B. C. SALES and L. A. BOATNER, J. Non-Cryst. Solids 79 (1986) 83.
- [4] Y. B. PENG and D. E. DAY, Glass Technol. 32 (1991) 166.
- [5] N. ARANHA, O. L. ALVES, L. C. BARBOSA and C. L. CESAR, in Proc. XVII Int. Congr. Glass, Beijing (1995) Vol. 7, p. 282.
- [6] L. Koudelka, P. Mošner, M. Zeyer, C. Jäger, J. Non-Cryst. Solids. 326-327, 72 (2003).
- [7] A. P. Ahoussou, J. Rogez, A. Kone, J. Non-Cryst. Solids. 353, 271 (2007); Y. K. Park, J. G. Lu, G. Rozgonyi, Electronic Mat. Lett. 6, 1 (2010).
- [8] V. Nazabal, E. Fargin, C. Labrugère, G. Le Flem, J. Non-Cryst Solids 270, 223 (2000); D. H. Kim, B. W. Kim and Y. H Seo, Electronic Mat. Lett. 6, 161 (2010)
- [9] J.J. Hudens, S.W. Martin, J. Am. Ceram. Soc. 76 (1993) 1691–1696.
- [10] K. Meyer, J. Non-Cryst. Solids 209 (1997) 227–239.
- [11] R.K. Brow, D.R. Tallant, S.T. Myers, C.C. Phifer, J. Non-Cryst. Solids 19 (1995) 45–55.
- [12] H.S. Liu, T.S. Chin, S.W. Yung, Phys. Chem. Glasses 50 (1997) 1–10.
- [13] A. Osaka, Y. Miura, T. Tsugaru, J. Non-Cryst. Solids 125 (1990) 87–92