The properties of zinc sodium phosphate glass system with the various concentration of chromium oxide doped

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Abstract. In this research, we investigate the properties of zinc sodium phosphate glass system with the various concentration of chromium oxide doped. The glass system was synthesized using the melt quenching technique — the concentration of chromium oxide varying from 0.5% to 2.5%. The chromium oxide presence makes the range value was smaller for the density and the molar volume thus making its the structure of this glass system more stable. We perform the Vicker Hardness test using 980 mNewton pressure. The test results show the concentration of chromium oxide effect to the hardness scale of glass system. We also perform FTIR test for knowing the relationship between the wavenumber and percentage of transmittance.

1. Introduction

The wide application of phosphate glass includes as a waveguide substrate [1,2], a solid laser source [3,4], optical fiber [5-7], battery [8-11], and variously applied biomaterials [12,13]. The extent of this application cannot separated from its characteristics and characteristics such as a coefficients of high thermal expansions [14], the low of melting points [6, 15], the low temperatures of glass transition [16], having a high refractive index [15], the low dispersion [15], and the structure varies to accept some exchange of cations or anions [17]. Also, phosphate glass is also relatively easy to make and has the possibility of a wider area of glass composition mixture [18]. However, it has a weak resistance to chemicals, high hygroscopic properties, and volatile [19]. Therefore other compounds are needed in the manufacture of glass phosphate systems.

Zinc oxide is an inorganic powder form white to white to brass which is odorless. When it heated will turn yellow and white on cooling. This powder is widely used as an additive in material products, such as plastics, ceramics, glass, cement, rubber, paint, and others. ZnO is an amphoteric oxide that is almost insoluble in water and alcohol. However, it dissolves and decomposes in strong acids. Addition of ZnO to phosphate glass will increase the resistance of glass to chemicals. ZnO can act as a modifier because it can prevent hydration reactions and can make connections between phosphate anions with ionic conductivity [20].

Previous research on the composition of zinc sodium phosphate glass system and its properties refers to the arrangement between zinc, sodium, and phosphate with various refractive index values. This paper proposed the influence of Cr_2O_3 in making glass against hardness properties and its transmittance while FTIR tested.

2. Methods

The composition of each glass samples shown in Table 1. The glass compositions mixed into the alumina crucible and then furnaced 30 minutes at a temperature 1100°C till completely melted. In order of the mixture being crystals, the mixture was poured into a steel mold with time as fast as possible. Then the samples are transferred into the furnace 3 hours at a temperature 300°C for annealing process to prevent the crack. The last method is cooling the sample at room temperature (cooling down procedure). Melt quenching.

Table 1. The composition of glass samples.

Sample ID	Cr_2O_3 (%mol)	Glass Composition (%mol)
ID1	0.5	$14.5ZnO\text{-}30Na_2O\text{-}55P_2O_5\text{-}0.5Cr_2O_3$
ID2	1.0	$14.0ZnO\text{-}30Na_2O\text{-}55P_2O_5\text{-}1.0Cr_2O_3$
ID3	1.5	$13.5ZnO\text{-}30Na_2O\text{-}55P_2O_5\text{-}1.5Cr_2O_3$
ID4	2.0	$13.0ZnO\text{-}30Na_2O\text{-}55P_2O_5\text{-}2.0Cr_2O_3$
ID5	2.5	$12.5ZnO\text{-}30Na_2O\text{-}55P_2O_5\text{-}2.5Cr_2O_3$

3. Result and Discussion

3.1. Hardness Test

The Vicker hardness test is shown in Table 2. The most substantial average value of the results of this measurement on the ID1 sample.

Table 2. The hardness test with 980 mNewton pressure.

ID of Sample	1st Test	2nd Test	3rd Test	4th Test	Average
ID1	298	251	393	363	326.25
ID2	310	313	338	277	309.5
ID3	323	314	255	246	284.5
ID4	240	244	215	389	272
ID5	258	298	298	234	272

3.2. FTIR Test

We perform FTIR test for wavenumber 4000 to 500 cm^{-1}. The FTIR pattern is shown in Figure 1-5. Each sample ID has different FTIR pattern, but for every sample, have some pattern peak about 1700 to 500 cm^{-1} wavenumber.

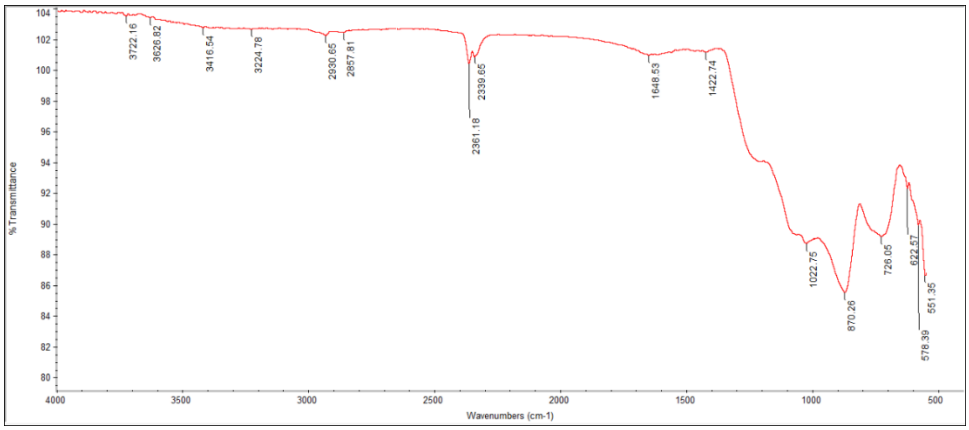

Figure 1. FTIR pattern of 0.5%Cr_2O_3 doped in glass systems.

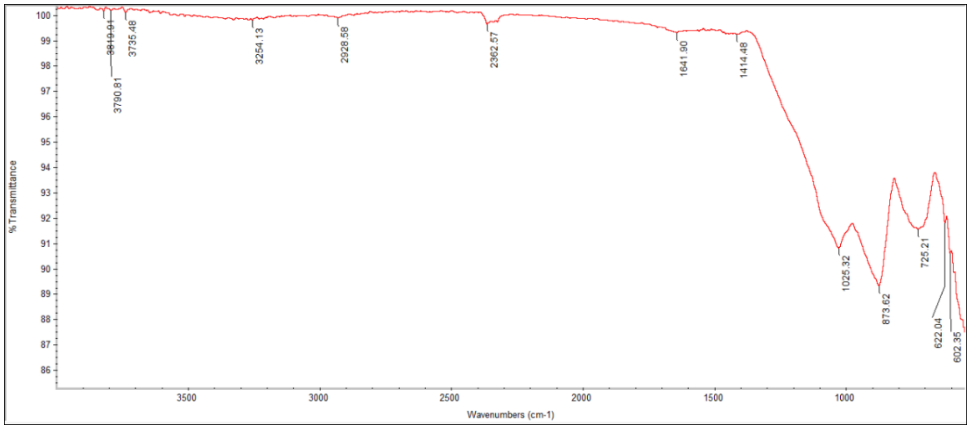

Figure 2. FTIR pattern of 1.0%Cr_2O_3 doped in glass systems.

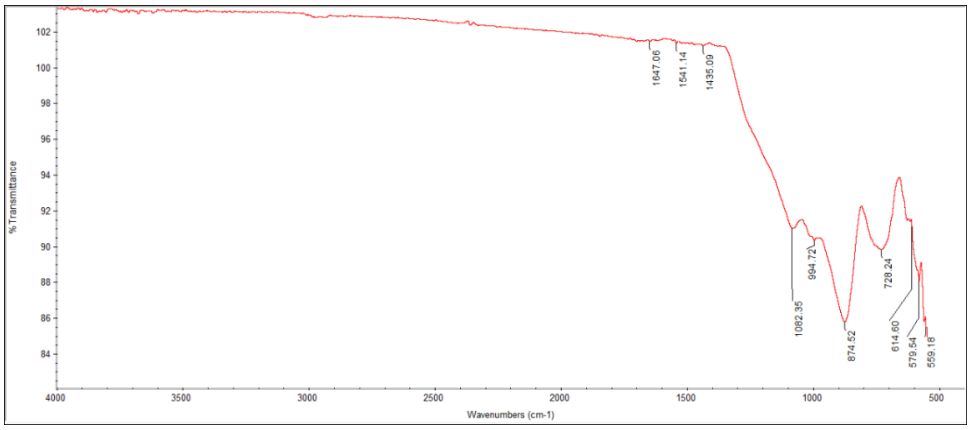

Figure 3. FTIR pattern of 1.5%Cr_2O_3 doped in glass systems.

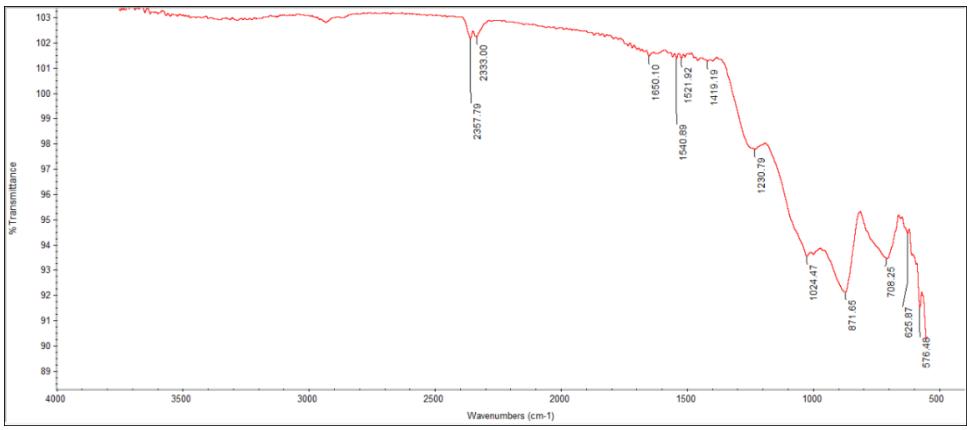

Figure 4. FTIR pattern of 2.0%Cr_2O_3 doped in glass systems.

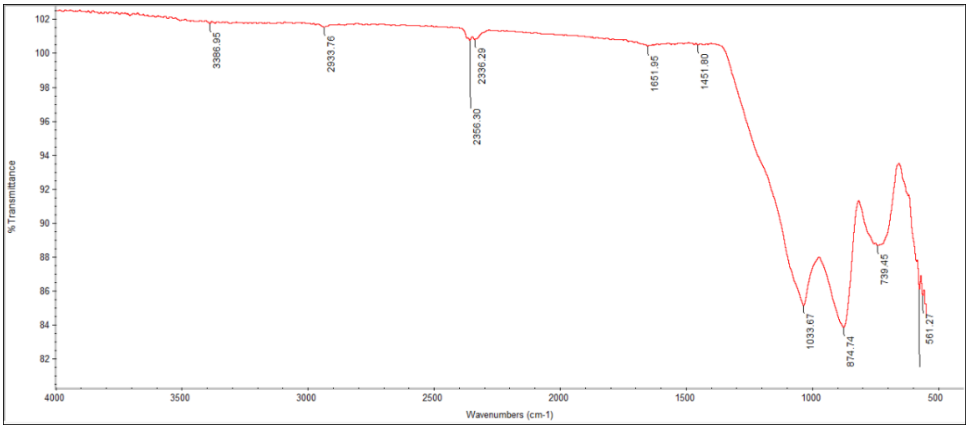

Figure 5. FTIR pattern of 2.5%Cr_2O_3 doped in glass systems.

All samples show a strong vibration in the region around 1082 – 551 cm^{-1}. The first sample shows the main vibration on 1022.75 cm^{-1}, 870.26 cm^{-1}, 726.05 cm^{-1}, and 551.35 cm^{-1}. These values shifted depends on the concentration of chromium oxide. The two peaks other, at around 662.57 cm^{-1} and 578.59 cm^{-1}, disappear in FTIR pattern for sample ID5.

4. Conclution

The study of the zinc sodium phosphate glass system of properties investigation with a various concentration of chromium oxide doped has been successfully performed using melt quenching technique — the concentration of chromium oxide varying from 0.5% to 2.5%. We deliver the Vicker Hardness test using 980 mNewton pressure. The test results show the concentration of chromium oxide effect to the hardness scale of glass system. The FTIR test showed the relationship between the wavenumber and the percentage of transmittance for each sample ID. Future work investigates these properties for different applications glass system.

5. References

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