The Effect of Different Amounts of ZnO on Structural Properties of Aluminosilicate Glasses

Zahra Kahrobaee[1] Sajad Azghandirad [2]
Javad NaeemAbadi[3] Masoud Tavakolian Akbari[4]
Sahar Mollazadeh beidokhti[5]
Mohammad Mazinani[6]

1. Introduction

The demands for aesthetics have put the dentists under the pressure to use new tooth-colored dental materials with a more natural look. New restorative dental materials are bioactive and biocompatible exhibiting a biological effect in addition to their main function in restoring decayed or fractured teeth. Aluminosilicate glasses, as a new generation of the dental restorative materials, have acceptable toughness and strength. Zinc oxide is known to be helpful in culturing bone tissue and is also vital to correct functioning of immune system. Addition of Zinc oxide to aluminosilicate glasses can result in decreasing their glass transition temperature, T_g. Limited number of studies have been conducted regarding the effect of the variation in the content of zinc oxide on the microstructures of the aluminosilicate glasses. In this investigation, the variation of zinc oxide content has been examined on the physical properties of an aluminosilicate glassy system.

2. Materials and methods

The glass samples were prepared from reagent grade powders, i.e., alumina, quartz, calcium fluoride, mono ammonium phosphate, calcium carbonate, zinc oxide, potassium carbonate, and sodium carbonate. The weighed samples were melted in an electrically heated furnace in alumina crucibles with a heating cycle consisting of heating from room temperature (20 °C) to 1450 °C with the heating rate of 10 °C/min and holding for another 2 hours at 1450°C. The glass samples were labeled according to their approximate ZnO content. Differential thermal analysis *(*DTA) was conducted for all the glass samples using NETZSCH Geratebau test machine with the heating rate of 10 °C/min in order to evaluate the effect of ZnO content on the structure of frits produced in the process and to determine the glass transition temperature (T_g) and crystallization temperature (T_c). Characterization of the crystalline phases was done using X-Ray Diffraction (XRD) analysis by means of X’ Pert PW 3040/60, Philips, and the analysis software of X'pert Highscore plus.

3. Result and discussion

The results of DTA analysis of four glass samples are shown in Figure 1. The first peak in all four DTA curves represents the T_g temperature for each test sample. The second and third peaks show the first and second critical temperatures, i.e., T_{c1} and T_{c2}, correspond to the crystallization of Apatite and Anorthite phases, respectively, according to the XRD patterns obtained for these samples. It is assumed that the sharpest temperature peak at lower temperatures represents a better crystallization behavior in a glass system. As can be observed in Figure 1, both the critical temperatures T_{c1} and T_{c2} have increased with increasing the ZnO content up to 1.8 wt.% in the system, i.e., the crystallization behavior has become less significant suggesting that glass viscosity is higher and mechanical properties are improved. The results in Table 4 show that the sample with no ZnO (0%ZnO-g) has the lowest hardness value (677 Vickers) and the hardness increases with the addition of ZnO to the sample up to 1.8wt.% (i.e., the maximum hardness is obtained in 2%ZnO-g sample with the hardness value of 816 Vickers) and hardness decreases when a greater amount of ZnO (2.6wt.%) is added to the sample (i.e., 3%ZnO-g sample with the hardness value of 793 Vickers).

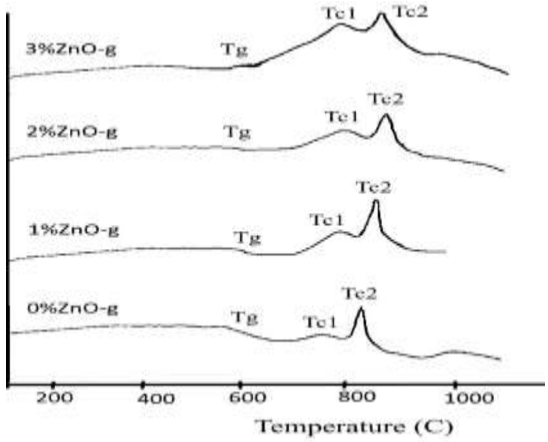

Figure 1. The results of DTA analysis for four glass samples investigated.

[1] M.Sc. Student, Department of Materials Engineering, Faculty of Engineering, Ferdowsi University Of Mashhad.
[2] Masters, Student, Department of Materials Engineering, Faculty of Engineering, Ferdowsi University Of Mashhad.
[3] Masters, Student, Department of Materials Engineering, Faculty of Engineering, Ferdowsi University Of Mashhad.
[4] Masters, Student, Department of Materials Engineering, Faculty of Engineering, Ferdowsi University Of Mashhad.
[5]Corresponding author: Assistant Professor, Department of Materials Engineering, Faculty of Engineering, Ferdowsi University of Mashhad. Email: mollazadeh.b@um.ac.ir.
[6] Associate Professor, Department of Materials Engineering, Faculty of Engineering, Ferdowsi University Of Mashhad.

Table 4. The Vickers microhardness values for all glass samples in this investigation

Sample	0%ZnO	1%ZnO	2%ZnO	3%ZnO
Average Microhardness	677	770	816	793

4. Conclusion

Results reveal that increasing ZnO up to 1.8 wt. % in the glass system shows a transformation in DTA extracted peaks. The Apatite and Anorthite crystallization temperature were increased from 750°C to 785°C and form 825°C to 875°C respectively, which can be contributed to a more condense glass system. Hence, a better mechanical property was expected. Vickers micro hardness of glass particles varied from 677 to 816 Hv which could be a representative for the better mechanical properties.