UNIVERSITI TEKNOLOGI MARA

ELASTIC AND STRUCTURAL STUDIES OF TeO_2-Nb_2O_5-ZnO AND TeO_2-Nb_2O_5-ZnO-Er_2O_3 TELLURITE GLASS SYSTEMS

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ABSTRACT

Ternary (90-x)TeO_2-10Nb_2O_5-(x)ZnO, x = 0 – 15 mol% and 75TeO_2-(10-y)Nb_2O_5-15ZnO-(y)Er_2O_3, y = 0.0 – 2.5 mol% glass systems have been prepared by melt-quenching method. Elastic properties together with structural properties of the glasses were investigated by measuring sound velocity using the pulse-echo-overlap technique and Fourier Transform Infrared (FTIR), respectively. For (90-x)TeO_2-10Nb_2O_5-(x)ZnO glass, ultrasonic velocities, related elastic moduli and Debye temperature were observed to drop at x = 5mol% but increased back at x > 5 mol%. The former is suggested to be due to increase in non-bridging oxygen (NBO) ions as a direct effect of TeO_2 reduction while the latter occur is suggested due to increase in bridging oxygen (BO) ions which improved the glass network rigidity. For 75TeO_2-(10-y)Nb_2O_5-15ZnO-(y)Er_2O_3 glass, shear velocity, shear modulus, Young's modulus and Debye temperature were observed to initially decrease at y = 0.5 mol% but remained constant between x = 1.0 mol% to y = 2.0 mol%, before increasing back with Er_2O_3 addition at y = 2.5 mol%. The initial decrease of shear velocity and related elastic moduli are suggested to be due to increase in NBO ions. This was followed by competition between BO and NBO ions in the glass network between y = 0.5 to 2.0 mol%, where BO seems to be more dominant compared to NBO when Nb_2O_5 content reached 2.5 mol% replacement with Er_2O_3. FTIR analysis on infrared (IR) absorption peak of NbO_6 octahedral, TeO_3 trigonal pyramid (tp), TeO_4 trigonal bipyramid (tbp) and ZnO_4 tetrahedral indicates variation of BO and NBO in the glass network and this supports the explanation for the elastic properties given for both glasses. The combined results of ultrasonic velocity and IR absorption spectra revealed that each structural compound, TeO_2, Nb_2O_5, ZnO and Er_2O_3 play significant roles in formation of both BO and NBO and modifications of the glass network structure.

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CHAPTER 1

INTRODUCTION

1.1 Background

Glass is an amorphous (non-crystalline) solid usually formed by the solidification of a melt without crystallization. Compared with crystals, the structure of glass is devoid of a regular arrangement with no long range order of atoms in a reciprocal lattice (Zallen, 1998 and Scholze, 1991).

In the last decades, TeO_2-based glasses have been the subject of scientific and technological interest (Saddeek, 2005) due to their good mechanical strength and chemical durability (Rolli *et al.*, 2001, Lin *et al.*, 2004 and Desirena *et al.*, 2008), non hygroscopicity (Sidkey *et al.*, 1997 and El-Mallawany, 1998), low melting temperature (Lin *et al.*, 2004), high refractive indices (Afifi and Marzouk, 2003, Lakshminarayana *et al.*, 2009 and Yakhkind, 1966) and good infrared (IR) (Sidkey *et al.*, 1997 and Saddeek, 2005) and visible wavelength transmission (Vogel *et al.*, 1991, Takebe *et al.*, 1994 and Kalampounias *et al.*, 2006). These properties make tellurite (TeO_2) glasses good candidates for development of optical devices (Rolli *et al.*, 2001 and Ozdanova *et al.*, 2007) and photonic applications such as optical window and laser materials (El-Mallawany, 1992 and Shen *et al.*, 2007).

Tellurium oxide (TeO_2) under normal conditions does not have the ability to form glass without a modifier like alkali, alkaline earth and transition metal oxide or other glass modifiers (Sharaf El-Deen *et al.*, 2008, Neov *et al.*, 1979 and Bale *et al.*,2008). Binary zinc-tellurite glasses have been extensively studied (Burger *et al.*, 1992, Jaba *et al.*, 2005, Shaaban *et al.*, 2006, Surendra Babu *et al.*, 2007 and Sahar *et al.*, 2008) and can be considered as a choice for superheavy optical flint glasses (El-Mallawany,