UNIVERSITI TEKNOLOGI MARA

ELASTIC, STRUCTURAL AND OPTICAL PROPERTIES OF (80-x)TeO_2-xBaO-20ZnO AND $x$$Ag_2O$-(35-$x$)[0.5$MoO_3-0.5V_2O_5$]-65$TeO_2$ GLASSES

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This project has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

In this study, two series of tellurite based glass with composition $(80-x)TeO_2$-20ZnO-xBaO (x = 0 mol% to 20 mol%) and $x Ag_2O-(35-x)[0.5MoO_3-0.5V_2O_5]-65TeO_2$ (x = 0–25 mol%) glasses were prepared using melt-quenching method to investigate their elastic, structural, thermal and optical properties. For $(80-x)TeO_2$-20ZnO-xBaO glass samples, BaO addition resulted in a decrease in ultrasonic velocities and independent elastic moduli; this result indicated that the rigidity of the glass network weakened possibly because non-bridging oxygen increased. Thermal analysis results showed that glass transition temperature (T_g) increased as BaO content increased because of the stabilizing effect of Ba^{2+} on the glass network. Additional analyses using bulk compression and ring deformation models revealed that the ratio between theoretical bulk modulus and experimental bulk modulus increased; this result indicated that the compression mechanism mainly involved isotropic ring compression. Furthermore, the increase in non-bridging oxygen formation with BaO addition caused a decrease in optical energy gap (E_{opt}) and an increase in refractive index (n). An increase in Urbach energy (E_u) indicated that the degree of disorder in the glass system also increased. For $x Ag_2O-(35-x)[0.5MoO_3-0.5V_2O_5]-65TeO_2$ glass, ultrasonic velocities showed nonlinear behaviors, wherein the velocities increased for $x \leq 10$ mol% and then decreased beyond x = 10 mol%. Independent elastic moduli and other related moduli, and T_g also showed similar nonlinear behaviors with maxima at x = 10 mol%. This result coincided with the electronic-to-ionic transition region as previously reported. A large decrease in elastic moduli beyond x = 10 mol% indicated a decrease in stiffness, thereby enabling ionic conductivity. Although Ag_2O addition weakened the glass network, the presence of MoO_3 played an important role as an additional glass former at $x \leq 10$ mol% apart from V_2O_5. Analysis of bulk compression and ring deformation models showed a large decrease at $x \leq 10$ mol% followed by near constancy with increased Ag_2O content. These results showed that ring deformation was reduced in the electronic region, but limited ring deformation took place in the ionic region, and that the main compression mechanism was mainly isotropic ring compression. The E_{opt} and n showed a slope change at x = 10 mol%, which confirmed the effect of mixed electronic-ionic conductivity on optical properties.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF RESEARCH

Among oxide glasses, tellurium oxide (TeO_2)-based glasses are receiving increased attention because of their optical and non-optical properties [1, 2], high refractive index [1, 3-5], good infrared transmission [6], high dielectric constant and electrical conductivity [7-9], good mechanical strength and chemical durability [10-12] and non-hygroscopic property compared to phosphate and borate glasses [13, 14]. These properties make TeO_2-based glasses suitable for various applications such as optical devices [15, 16], sensor system [17, 18], and CD memory devices [19]. TeO_2 glass consists of TeO_4 trigonal bipyramids (tbp) and TeO_3 trigonal pyramid (tp) unit structures with a lone electron pair in the equatorial position [1, 2, 11, 20, 21]. TeO_2 is known as a conditional glass former that requires the addition of modifier oxide, such as alkali, alkaline earth, and transition metal oxides, or another glass former to form a glass with different structural units and oxide contents [10, 22]. The addition of modifiers or formers to the TeO_2 network causes the structural modification of Te, which transforms TeO_4 tbp to TeO_3 tp [2, 21-25].

ZnO addition in binary zinc-tellurite glass provides good glass-forming ability and improves glass transition temperature (T_g); ZnO addition also influences mechanical, optical, and structural properties of glass systems [26-34]. Studies on binary xZnO-$(1-x)$$TeO_2$ glass systems have revealed that ZnO behaves as a former at $x \leq 20$ mol% [26, 34-36]. In the case of ternary glass, the presence of heavy metal oxides, such as Nb_2O_5 in $(90-x)TeO_2$-$10Nb_2O_5$-xZnO, allows ZnO to act as a network modifier at $x \leq 5$ mol%; however, ZnO becomes a network former at $x > 5$ mol% [27]. Similar findings have been observed in $80TeO_2$-$(20-x)$ZnO-xFe_2O_3 [32] and $(80-x)TeO_2$-20ZnO-xEr_2O_3 [37] glass systems. Interestingly, addition of alkali oxides, such as Na_2O, as a third component in ternary Na_2O-ZnO-TeO_2 glass systems is unlikely to induce Na_2O to act as a modifier immediately. At $x \leq 10$ mol%, addition of Na_2O in $10Na_2O$-15ZnO-$75TeO_2$ glass increases stability and resistance to