# UNIVERSITI TEKNOLOGI MARA

# ELASTIC, STRUCTURAL AND OPTICAL STUDIES ON $x$$Na_2O$-(35-$x$)$V_2O_5$-65$TeO_2$, $y$$WO_3$-(40-$y$)$Ag_2O$-60$TeO_2$ AND $z$$Nb_2O_5$-(20-$z$)BaO-80$TeO_2$ TELLURITE BASED GLASS SYSTEMS

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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

Three glass systems with composition $x$$Na_2O$-(35-$x$)$V_2O_5$-65$TeO_2$ ;($x$=5, 10, 15, 20, 25 mol %), $y$$WO_3$-(40-$y$)$Ag_2O$-60$TeO_2$ ($y$=0, 10, 20, 30 mol %) and $z$$Nb_2O_5$-(20-$z$)BaO-80$TeO_2$ (z=0, 5, 10, 15 mol %) were prepared by conventional solid state and melt-quenching methods. Elastic moduli and structural changes were studied by measuring ultrasonic shear and longitudinal velocities using the pulse-echo-overlap technique and Raman spectroscopy, respectively. For $x$$Na_2O$-(35-$x$)$V_2O_5$-65$TeO_2$glass system, both longitudinal ($v_L$) and shear ($v_s$) velocities showed small steady decrease with addition of $Na_2O$ from $x$=5 mol % to $x$=15 mol % followed by large decrease at $x$>15 mol %. Longitudinal modulus ($C_L$), shear modulus ($\mu$), Young's modulus ($Y$), Hardness ($H$) and Debye Temperature ($\theta_D$) also showed similar behavior to the ultrasonic velocities. The decrease in elastic moduli is suggested to be due to weakening of network rigidity of the glass system with increase in formation of non-bridging oxygen (NBO) as revealed by Raman spectroscopy. Additional analysis using bulk compression and ring deformation models showed that ratio between theoretical bulk modulus ($K_{bc}$) and experimental bulk modulus ($K_e$) was around 2.1 for $x$=5-20 mol % before an increase to around 2.4 for $x$>20 mol % indicating that the main compression mechanism was ideal isotropic compression. Meanwhile, optical band gap ($E_{opt}$) showed increase with $Na_2O$ content and this is related to the increase of $TeO_3$ tp formation. For $y$$WO_3$-(40-$y$)$Ag_2O$-60$TeO_2$ glass system, the $v_L$ and $v_s$ showed large increase at $y$=0-20 mol % before dropping with further addition of $WO_3$. Independent moduli ($C_L$ and $\mu$), $K_e$, $Y$ and $\theta_D$ showed similar behaviors to both velocities. The large increase of the elastic moduli at $y$=0-20 mol % is suggested to be due to the increase in $WO_6$ octahedral indicating the increase of bridging oxygen (BO) and also formation of stronger Te-O-W bonds compared to Te-O-Te bonds. On the other hand, for $y$> 20 mol %, the decrease in the elastic moduli was due to increase in NBO as a result of formation of $WO_4$ tetrahedral via breaking of Te-O-W network. Further analysis using bulk compression and ring deformation models showed a slight decrease in the ratio of ideal bulk modulus to experimental bulk modulus ($K_{bc}/K_e$) and average atomic ring size ($l$) for $y$<20 mol % followed by a large increase for $y$>20 mol %. Our analysis also indicates that limited ring deformation takes place and the main compression mechanism in this glass system was mainly ideal isotropic compression. On the other hand, optical band gap ($E_{opt}$) showed small variation for $y$=0-20 mol % but decreased upon higher $WO_3$ content while refractive index ($n$) showed the opposite trend. This optical behavior is suggested to be related to the changes in cross link density and NBO concentration in the glass system. For $z$$Nb_2O_5$-(20-$z$)BaO-80$TeO_2$ glass system, the $v_L$ and $v_s$ steadily increased with $Nb_2O_5$ content and are suggested to be influenced by independent moduli ($C_L$ and $\mu$). Elastic moduli such as $K_e$, $Y$ and $\theta_D$ also showed similar behavior to the $C_L$ and $\mu$. The increase of elastic moduli is suggested to be due to the increase of bridging oxygen (BO) via $TeO_4$ tbp formation. On the other hand, Raman spectra showed increase in intensity of $TeO_4$ tbp and slight increase in $NbO_6$ octahedral.

Analysis on the spectra showed that the increase in BO is prominent compared to NBO. Optical energy gap ($E_{opt}$) was found to decrease with $Nb_2O_5$ which is suggested to be due to smaller difference between HOMO and LUMO states of $TeO_4$ tbp compared to that of $TeO_3$ tp and the averaging effect of $E_{opt}$ of constituent oxides. Meanwhile, Urbach energy ($E_u$) decreased with $Nb_2O_5$ content indicating reduction in disorder of the glass structure.

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