UNIVERSITI TEKNOLOGI MARA

STRUCTURAL, ELASTIC, DC CONDUCTIVITY, AND OPTICAL PROPERTIES OF (74-x)TeO_2-$x$$V_2O_5-5Al_2O_3-20Na_2O-0.5Er_2O_3-0.5Ho_2O_3$ MIXED IONIC-ELECTRONIC GLASS SYSTEM

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ABSTRACT

Glass system of composition (74-x)TeO_2-$x$$V_2O5-5Al_2O_3-20Na_2O-0.5Er_2O_3-0.5Ho_2O_3$ ($0 \leq x \leq 2.0$ mol%) were prepared by melt-quenching technique to investigate the effects of V_2O_5 on structural, elastic properties, DC conductivity, optical and photoluminescence properties of the glass system. These studies are driven by the ambiguity in MIE glasses in terms of structural, elastic, DC conductivity mechanism and optical properties that can change depending on the role of vanadium. The broad hump in the XRD spectra proves the amorphous structure of the glass system. FTIR spectroscopy revealed that the relatively high TeO_3 indicates that the environment of the glass system is NBO-rich despite the increase in BO attributed, that is attributed by V_2O_5. The DC conductivity study of glass system revealed that the introduction of vanadium ions into the glass system has resulted in a general decrease of σ_{DC} due to blocking effect by vanadium ion, impeding the ionic conductivity. Meanwhile, the increase of σ_{DC} until maximum at $x = 1.0$ mol% was suggested to be due the increased polaronic hopping due to increased availability of V^{4+} ions and V^{5+} by V_2O_5. On the other hand, the elastic parameters including the longitudinal, shear, bulk and Young Modulus have exhibited a general increasing trend that was accompanied by a slope change at $x = 1.0$ mol% due to the competition between BO and NBO which has altered the structural properties, that is related with MIE effect. The K_{bc}/K_e revealed a maximum at $x = 1.0$ mol% that was suggested to be due to the surge of NBO that creates an increased ring deformation. Analysis on optical absorption edge by Tauc's plot revealed that $E^d_{0\text{pt}}$ and $E^i_{0\text{pt}}$ decreases generally due to the prevalence of NBO in the glass system while the increasing trend of the E_U indicates an increase of the state of structural disorder in the glass network. The Judd-Ofelt oscillator strength, f_{exp} increases accompanied with an anomalous drop at $x = 1.0$ mol% due to the competition between BO and NBO that has altered the covalency and asymmetry of the Er^{3+} with the local environment ligand. Meanwhile, the Judd-Ofelt parameter Ω_2 decreases generally suggesting that the glass system has underwent some structural modification due to the increase in BO in the host matrix contributed by the VO_5. Photoluminescence spectra revealed three dominant emissions in the green region (525 nm; $^2H_{11/2} \rightarrow {}^4I_{15/2}$, 532 nm; $^5F_4 + {}^5S_2 \rightarrow {}^5I_8$, 547 nm; $^4S_{3/2} \rightarrow {}^4I_{15/2}$,) and 2 emissions in the red region (659 nm; $^5F_5 \rightarrow {}^5I_8$, 662 nm; $^4F_{9/2} \rightarrow {}^4I_{15/2}$). The decrease in photoluminescence intensity observed is due to the role of V_2O_5 that has resulted in the concentration quenching between V^{4+} and Ho^{3+}.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Oxide glasses have been thoroughly studied and widely commercialized due to their potential applications. Oxide glasses have been showing great values because they possess high chemical durability and thermal stability (Jóna, Nemčeková, Plško, Ondrušová, & Šimon, 2004; Vikas, Jayasimhadri, & Haranath, 2024) and having excellent insulating and optical properties allowing them to be utilized as components for telecommunications, sensors, and medical application (Alzahrani, Alrowaili, Eke, Olarinoye, & Al-Buriahi, 2023; Hasanuzzaman, Rafferty, Sajjia, & Olabi, 2016; Vogel, 1994). Among the number of existing glass hosts, such as borate, germanate, silicate and antimony, tellurite glasses are well recognized for its wide transmission region, high glass stability, high refractive index, great rare earth ions solubility, good resistance to corrosion and relatively low phonon energy when compared to other oxide glasses (Burtan et al., 2011; Hasanuzzaman et al., 2016; Syam Prasad & Venkateswara Rao, 2018; Vogel, 1994). Thus, tellurite glasses are extensively used for optical devices and photonic applications such as optical windows and laser components. (R. Hisam & Yahya, 2019).

The structural units of tellurite glass were found to be TeO_4 trigonal bipyramid (tbp) and TeO_3 trigonal pyramid (tp) (Brand, Anjos, & Bell, 2023). The TeO_4 (tbp) group has two axial and two equatorial oxygen atoms, where an electron pair occupies the third equatorial position of the orbital. (Grelowska et al., 2016). Similar to other network former glass, tellurite glass is conditional network former which needs the presence of modifier ion in order to form to glassy state easily. (Nazrin et al., 2018) The basic structure contained in tellurite glasses are susceptible to alteration once modifier is added to the system. For example, with the presence of modifier, the TeO_4 trigonal bipyramid (tbp) which are the basic coordination polyhedron can be transformed into TeO_3 trigonal pyramid (tp) through an intermediate polyhedral TeO_{3+1}. (Grelowska et al., 2016; Neov, Gerassimova, Krezhov, Sydzhimov, & Kozhukharov, 1978).