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EFFECTS OF MIXED GLASS FORMER ON AC CONDUCTIVITY, DIELECTRIC AND OPTICAL PROPERTIES OF $70[xTeO_2+(1-x)B_2O_3]+15Na_2O+15K_2O$ GLASSES

SHIMA ASYURAH BINTI SHUHAIMI

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ABSTRACT

Mixed glass former of composition $70[xTeO_2+(1-x)B_2O_3]+15Na_2O+15K_2O$ where $x = 0$ – 0.7 mol% have been prepared by melt quenching method to investigate their structural, AC conductivity, dielectric and optical properties. The variation of conductivity (σ') with TeO_2 showed a non-linear behaviour, where decrease to a minimum value at $x = 0.4$ mol% before increasing for $x > 0.4$ mol%. The minimum is suggested to be due to low migration of Na^+ and K^+ ions caused by the mixed glass former effect (MGFE). Meanwhile, dielectric constant (ε') showed a slight increase for $x \leq 0.4$ mol% followed by a large increase for $x \geq 0.5$ mol% TeO_2. This result is attributed to the formation of TeO_3 give out a larger effect compared to BO_3 and is suggested to be related to MGFE. Structural analysis of the present glass system reveals N_4 reached minima at $x = 0.2$ mol% and 0.4 mol% with addition of TeO_2 which attributed to the structural changes due to the conversion of BO_4 to BO_3 units. Glass transition temperature, T_g exhibited a non-linear increase for $x \leq 0.5$ mol% followed by a large increase at $x > 0.5$ mol%. The conduction mechanism at low frequency region was found to be Inverse – Overlapping Large Polaron Tunnelling (Inverse – OLPT) for $x \leq 0.5$ mol%, while the mechanism transformed to the OLPT model for $x = 0.7$ mol%. The electric modulus of the present glass system showed asymmetric peak of M', that reflected a non-Debye type relaxation. The optical energy gap, E_{opt} for both transition exhibited a minimum at $x = 0.4$ mol%, whereas refractive index, n and Urbach energy, E_u showed a maxima at the same concentration, thereby indicating variation in polarizability due to changes in concentration of bridging and non-bridging oxygen. On the other hand, the large decrease in $\alpha_{O_{2-}}$ and Λ for $x > 0.2$ mol% because of increasing number of bridging oxygen attributed to BO_4 that increase the covalency and decrease the electron donor power. The changes observed showed that the continuous addition of TeO_2 into the glass system influence the properties of this boro-tellurite glasses.

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TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Research Background

Boron oxide-based glasses are very popular especially among researchers and technologists due to its good resistance toward vibration, lower thermal expansion, high toughness, strength and chemical resistance as well as lower viscosity (Sabri, N.S., Yahya, A.K., & Talari, M.K., 2017). Vitreous boron oxide (B_2O_3) consists of boroxol ring while doped B_2O_3 is commonly found in the form of 3-coordinated 'B_3' and 4-coordinated 'B_4' boron units with variety of super structural units such as tri-, penta-, tetra-, di-, pyro- and ortho-borate (Sabri, N.S., Yahya, A.K., & Talari, M.K., 2017). Physical properties of borate glass can be altered through addition of modifiers to the network formers (Saddeek, Y.B., 2004). For example, when alkali oxide was introduces into borate glass, the additional oxygen from alkali oxide causes a conversion from the trigonal boron atom BO_3 into four-fold BO_4 coordinated boron atoms (El-Falaky, G.E., Guirguis, O.W., & Abd El-Aal, N.S., 2012).

On the other hand, tellurium oxide-based glasses are non-hygroscopic and a recognized conditional glass former that require addition of a modifier oxide, such as alkali, alkaline earth, and transition metal oxides or other glass formers (Hisam, R., Yahya, A.K., Mohamed Kamari, H., Talib, Z.A. & Yahaya Subban, R.H., 2016). Tellurite glasses have low melting temperatures, high dielectric constants and relatively good infrared transmission (Dhankhar, S., Kundu, R.S., Parmar, R., Murugavel, S., Punia, R. & Kishore, N., 2015). Tellurite glasses also have high refractive indices, wide optical transmission window and exceptional non-linear optical properties (Kaur, A., Khanna, A., Gonzalez, F., Pesquera, C. & Chen, B., 2016). The basic structure of the tellurite glass consists of TeO_4 trigonal bipyramid (tbp) and TeO_3 trigonal pyramid (tp) unit structure with a lone pair at the equatorial position (Hisam, R. & Yahya, A.K., 2016). Addition of alkali oxide into tellurite glass increases the glass forming tendency and produces non-bridging oxygen (NBO) sites which consequently reduces the average coordination number (Sidkey, M.A. & Gaafar, M.S., 2004). Some examples on the application of tellurite glass are gas sensors, memory switching devices and optical waveguides (Kaur, A. et al., 2016).