ELECTRICAL PROPERTIES OF TELLURIUM OXIDE BASED GLASSES

THESIS SUBMITTED BY

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FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN THE
DEPARTMENT OF PHYSICS
UNIVERSITY OF PERADENIYA
PERADENIYA
SRI LANKA

DECEMBER 1996 DEPARTMENT OF PHYSICS

ABSTRACT

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In this work, studies on preparation, characterization and electrical properties of some selected ionically and mixed conducting tellurium oxide based glass systems were carried out. The glass samples were prepared by an air quenching technique and their amorphous state was confirmed using XRD. Glass transition temperatures of all the samples were measured using DSC or DTA. Electrical conductivity measurements were carried out using ac impedance technique.

Glasses in the xNa_2O-$(1-x)TeO_2$ binary system were synthesized for $0.18 \leq x \leq 0.33$. The glass transition temperature of these glasses were found to decrease slowly with Na_2O content from 260 °C to 220 °C. The density of glasses was measured by picnometry using toluene. The density decreased with increasing TeO_2 content. In the glass forming region, ionic conductivity was found to vary over two orders of magnitude ranging from 3.0×10^{-9} to 3.2×10^{-7} S cm^{-1} at 200 °C when the total concentration of sodium cations was varied only by a factor of two. Conductivity data showed an Arrhenius type behaviour with the same pre-exponential term, in agreement with the interstitial pair mechanism for ion transport.

Glasses in the ternary system $0.33Na_2O$ $0.66[xB_2O_3$ $(1-x)Te_2O_4]$, which can be described as a solution of sodium metaphosphate with sodium tellurate were synthesized for $0 \leq x \leq 1$. For all compositions, the glasses were transparent and appeared homogeneous. Nevertheless, for compositions near x=0.4 glassy materials were observed to be heterogeneous in SEM. Glass transition temperatures for all the compositions were between 220 °C and 310 °C. Conductivity data obtained in the 100-250 °C temperature range obeyed an Arrhenius relationship with a composition-independent pre-exponential term A. The value of $\log A \approx 4.8$ is in agreement with the indirect interstitial mechanism model for sodium cation migration. Variation of electrical conductivity with x under isothermal conditions showed a maximum in conductivity near x=0.7. This behaviour, apparently caused by the mixed network former effect,

could be explained by assuming an endothermic mixture between sodium phosphate and sodium tellurate.

Glasses in the ternary system $0.5Na_2O\ 0.5[xP_2O_5\ (1\text{-}x)Te_2O_4]$ were prepared for $0 \leq x \leq 1$. It appeared from the SEM studies that the most of these glasses were heterogeneous. Glass transition temperatures remained almost constant near 270 °C for $0 < x \leq 0.5$ and increased linearly to 475 °C for $0.5 < x \leq 1$. As in the case of ternary and binary systems, the conductivity data showed an Arrhenius behaviour, throughout the whole composition range, and the pre-exponential term was observed to be composition-independent with a mean value of $\log A \approx 4.5$.

Li^+ conducting glasses with a macromolecular network made of PO_4 tetrahedra and TeO_4 bipyramids were synthesized and characterized by ionic conductivity measurements. Glass pellets, based on the formula $0.4Li_2O\ 0.6[xP_2O_5\ (1\text{-}x)Te_2O_4]$, were prepared for $0.4 \leq x \leq 0.8$. Glass transition temperatures of these materials were found to be between 240 °C and 320 °C. Ionic conductivity values followed an Arrhenius relationship with a pre-exponential factor A, essentially constant with a value of $\log A \approx 4.3 \pm 0.6$. At constant temperature, the conductivity was found to increase with x showing a peak at x=0.6.

Glasses in the $2Te_2O\ xNa_2O(1\text{-}x)V_2O_5$ and $3Te_2O\ xLi_2O(1\text{-}x)V_2O_5$ systems were synthesized for $0 \leq x \leq 1$. Conductivity data followed an Arrhenius type behaviour for temperatures ranging from room temperature up to their glass transition temperatures. Values of activation energies and pre-exponential factors in the V_2O_5 rich region were low compared to those in the alkali oxide (Na_2O or Li_2O) rich region, implying that the conductivity mechanisms in these two regions were different. Experimental data suggest that a polaron hopping mechanism could be operative in the electronically conducting domain of $0 \leq x < 0.5$ and an interstitial pair mechanism operative in the ionically conducting domain of $0.5 < x \leq 1$.