

**STUDIES ON ELECTRICAL TRANSPORT AND ION  
KINEMATICS PHENOMENA IN SOME OXIDE  
GLASSY SYSTEMS**

Synopsis Submitted by

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# **SYNOPSIS**

In recent times, glassy nanocomposite systems are the most significant materials because of their wide range of applications, compositional versatility and adaptable qualities. The remarkable electrical, chemical, and physical characteristics of such glassy nanocomposite materials have recently attracted a lot of attention from the research community. The combination of their glassy and nanocomposite properties leads to improved electrical conductivity, dielectric characteristics, mechanical strength, and thermal stability.

The specific study objective of this work is to explore the transport processes of the charge carriers, such as ions or polarons, in the environment of various glassy systems. This thesis examines how the structural and compositional characteristics affect the mobility and interactions of charge carriers as they move across various glassy systems. This research intends to promote fields like energy storage, optoelectronics, and solid-state ionics by investigating the mechanisms driving charge transport and offering insights into the basic behaviours of these carriers in disordered materials.

The research goal has been accomplished by carrying out the following steps. The first step is to use reagent-grade chemicals (Sigma Aldrich make) to produce some novel and useful glassy nanocomposites (ionic and semiconducting). The second step is to examine the samples' physical characteristics and correlate them with their structures. Exploration of the samples' electrical and dielectric characteristics is the next step of this thesis. Finally, efforts have been given to propose the area of application field where the prepared materials could be utilized.

This thesis is organized into the following chapters:

In the first chapter, amorphous materials, glasses, and glass-nanocomposites are introduced, along with some specific definitions that are pertinent to this discussion. In this regard, a literature review part regarding relevant works by other researchers is also included. In addition, it offers many models of AC and DC conduction in glassy systems. Lastly, it outlines the specific goals of the current work.

An overview of the preparation of various glass-nanocomposite materials is provided in Chapter 2. It elaborates the preparation of the as-developed samples and the experimental methodologies of all the studies that are conducted in the experimental laboratory. The studies include measurement of Density and Molar volume, X-Ray Diffraction of powder sample (PXRD), Fourier Transform Infrared (FT-IR) Spectroscopy, Scanning Electron Microscopy (SEM),

Electrical and Dielectric measurements.

The chapter 3 discusses about the preparation of the glassy system  $x\text{AgI} - (1-x)(0.1\text{CdO} - 0.3\text{V}_2\text{O}_5 - 0.4\text{P}_2\text{O}_5 - 0.2\text{ZnO})$  for  $x=0, 0.05, 0.1, 0.2, 0.3$  and  $0.4$  using melt-quenching method. The structural, electrical and dielectric studies that have been carried out on the as-developed glassy systems have been conversed here extensively. The results of PXRD and SEM examinations have shown the development of different nanophases and the presence of different bands in the glass-nanocomposites. The study has shown that the as-developed glassy system exhibits mixed conduction i.e. both polaronic and ionic conduction depending on the concentration of AgI salt. It has been established that the current glassy systems' conductivity and dielectric characteristics are thermally triggered.

The mixed former effects on the ion dynamics of the as-developed  $0.2\text{AgI} - 0.8(0.1\text{CdO} - y\text{V}_2\text{O}_5 - z\text{P}_2\text{O}_5 - 0.2\text{ZnO})$  system has been investigated in chapter 4 for different values of  $y$  and  $z$ . The study emphasizes on the important role that glass-forming oxides play in altering the structural framework. The study has shown that the mixed formers have a great positive impact on electrical conductivity of the glassy systems.

The preparation and structural, electrical and dielectric study on  $x\text{CdI}_2 - (1-x)(0.3\text{Ag}_2\text{O} - 0.3\text{V}_2\text{O}_5 - 0.3\text{P}_2\text{O}_5 - 0.1\text{ZnO})$  glassy system for  $x=0.1$  and  $0.2$  have been addressed in chapter 5. The goal of this work has been achieved as it has been demonstrated that the addition of a new metal halide,  $\text{CdI}_2$ , greatly improves the conductivity behavior of oxy-salt glassy systems. The study concludes that when the  $\text{CdI}_2$  level increases, more  $\text{Cd-Ag}$  ion exchanges may occur, which encourages  $\text{Ag}^+$  ion migration and increases the DC conductivity. The study has inferred that this enhanced ionic mobility is due to structural modifications caused by  $\text{CdI}_2$  doping. The results of this study significantly enhance the potential of oxy-salt glassy systems in technological applications.

A comprehensive study on the  $\text{CdI}_2$  doped glassy system, already discussed in chapter 5, has been continued in chapter 6 with the incorporation of two different network modifiers. For the purpose of study, the glassy systems  $0.3\text{CdI}_2 - 0.7(0.3\text{Ag}_2\text{O} - 0.3\text{MoO}_3 - 0.3\text{P}_2\text{O}_5 - 0.1\text{ZnO})$  and  $0.3\text{CdI}_2 - 0.7(0.3\text{Ag}_2\text{O} - 0.3\text{TeO}_2 - 0.3\text{P}_2\text{O}_5 - 0.1\text{ZnO})$  are made using the melt quenching process. Along with the alteration in the network modifier, the ratio of  $\text{Ag}_2\text{O}$  to  $\text{P}_2\text{O}_5$  has also been increased gradually. The study has shown that the  $\text{MoO}_3$ -doped system shows a significant rise in electrical conductivity when the  $\text{Ag}_2\text{O}:\text{P}_2\text{O}_5$  ratio rises. Conversely, as the  $\text{Ag}_2\text{O}:\text{P}_2\text{O}_5$  ratio increases in a  $\text{TeO}_2$ -doped system, a decrease in electrical conductivity is observed, which can be attributed to

several structural and compositional factors. However, the TeO<sub>2</sub>-doped system has shown greater conductivity than the other system at a particular temperature. Additionally, this system has higher dielectric constants and dielectric losses compared to MoO<sub>3</sub>-doped system, suggesting that they may find application in fields where electrical energy storage is crucial.

Applications and future prospects of glass nanocomposites are described in Chapter 7. Oxide glassy systems and their nanocomposites have been identified as promising candidates for their usage in a variety of devices in recent years.

The current study aims to create new glass nanocomposites and improve our basic knowledge of the behaviour and characteristics of these glassy nanocomposite systems so that, on the one hand it can provide a solid background and progress to the research community regarding the current state-of-knowledge on this topic, and on the other hand it can also tell them what the highlights of the present thesis in comparison with the progresses about other glassy states. It also has the potential to contribute to the field of great technological importance.

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