This thesis investigates the dielectric and electrical properties of binary liquid mixtures of n-Hexanol + N, N-Dimethylformamide (DMF) and n-Octanol + DMF. Using dielectric relaxation spectroscopy across a wide frequency range, the study explores molecular interactions, relaxation mechanisms, and the impact of concentration and temperature variations. Acoustic and physico-chemical analyses complement these findings, providing insights into solute-solvent interactions, molecular structures, and hydrogen bonding. Empirical models are tested for properties like dielectric constant, refractive index and ultrasonic velocity, offering a understanding of the dynamic behavior of these systems. This research has implications for industrial applications in areas such as chemical engineering, material science, and pharmaceutical development.

Chapter 1 This chapter introduces the study of molecular interactions in binary liquid mixtures, emphasizing their importance in chemical, biological, and industrial applications as well literature surveys. It focuses on the significance of alcohols and amides, such as n-Hexanol, n-Octanol and DMF, due to their hydrogen-bonding capabilities and high polarity. The objectives include analyzing the dielectric, acoustic, and physico-chemical properties of these mixtures to understand solute-solvent interactions and structural dynamics.

Chapter 2 The chapter provides a theoretical framework for understanding dielectric materials, polarization mechanisms (electronic, ionic, orientation, and space-charge), and their frequency-dependent behaviors. It explains the Debye relaxation model, relaxation time, and the distinction between static and dynamic permittivity, laying the foundation for interpreting experimental results.

Chapter 3 This chapter describes the materials, experimental setup, instrument calibration, and data analysis methods. Binary mixtures of n-Hexanol + DMF and n-Octanol + DMF were analyzed using an LCR meter and VNA for dielectric measurements, alongside techniques for measuring ultrasonic velocity, viscosity, density, and refractive index. Calibration ensured accurate results, and empirical models were used to analyse the data and interpret molecular interactions.

Chapter 4 This chapter explores the dielectric and electrical properties of binary mixtures of n-Hexanol and N, N-Dimethylformamide (DMF) over a broad frequency range (20 Hz to 2 MHz and 200 MHz to 20 GHz) and at varying temperatures (293.15 K, 303.15 K, 313.15 K). Using dielectric relaxation spectroscopy (DRS), key parameters such as static dielectric constant, loss tangent, relaxation times, electrical

modulus, conductivity, and impedance are analyzed to investigate the effects of frequency, temperature, and composition. The study also delves into the molecular interactions, including hydrogen bonding and dipole-dipole effects, and evaluates excess properties like permittivity and viscosity. The findings offer valuable insights into the solute-solvent dynamics of the mixtures, contributing to a deeper understanding of their molecular behavior and thermodynamic characteristics.

Chapter 5 This chapter presents the results of the dielectric relaxation spectroscopy (DRS) study conducted on binary mixtures of n-Octanol and N, N-Dimethylformamide (DMF) over a broad frequency range (20 Hz to 2 MHz and 200 MHz to 20 GHz) at different temperatures (293.15 K to 313.15 K). The complex permittivity spectra of the mixtures were analyzed to investigate various dielectric and electrical properties, including complex permittivity ($\varepsilon^*(\omega)$), loss tangent ($\tan\delta$), complex electric modulus ($M^*(\omega)$), and complex conductivity ($\sigma^*(\omega)$). Key parameters, such as electrode polarization relaxation time (τ_{EP}), ionic conductivity relaxation time ($\tau\sigma$), and DC conductivity (σdc), were calculated, and complex impedance spectra were fitted to an RC equivalent circuit model. The study also explores the temperature and concentration dependence of these properties and discusses the dielectric behavior using the Cole-Cole model, highlighting the impact of concentration on dipole-dipole interactions and molecular dynamics within the mixtures.

Chapter 6 This chapter investigates the ultrasonic velocity (u), density (ρ) and viscosity (η) of binary mixtures of n-Hexanol and N, N-Dimethylformamide (DMF) across a temperature range of 293.15 K to 313.15 K. Key physico-chemical parameters, including molar volume, adiabatic compressibility, intermolecular free length, acoustic impedance, and relaxation time, were calculated. Excess values of these parameters were fitted using the Redlich-Kister polynomial. The results indicate significant temperature and concentration dependence, suggesting strong intermolecular interactions, primarily due to dipole-dipole and hydrogen bonding. Fourier Transform Infrared (FTIR) analysis confirms the role of DMF in facilitating molecular association. The findings highlight the nature of intermolecular forces and provide insights into the molecular interactions within the binary mixtures.

Chapter 7 reports the experimentally measured ultrasonic velocity (u), density (ρ), and viscosity (η) for binary mixtures of n-Octanol and N, N-Dimethylformamide (DMF) at temperatures of 293.15 K, 303.15 K, and 313.15 K. From these measurements, various physico-chemical parameters such as molar volume, adiabatic compressibility,

intermolecular free length, and relaxation time were calculated to explore molecular interactions. The Redlich-Kister equation was applied to excess and deviation functions, revealing concentration-dependent behavior and the influence of temperature. Thermodynamic analysis shows Arrhenius-type behavior with specific intermolecular interactions, including hydrogen bonding, and provides insights into the molecular dynamics within the mixtures.

Chapter 8 investigates the refractive index (n) and density (ρ) of binary mixtures of n-Hexanol and N, N-Dimethylformamide (DMF) across various concentrations and temperatures (293.15 K, 303.15 K, 313.15 K). Key refractometric parameters such as molar volume, molar refraction, atomic polarization, polarizability, molecular radii, and internal pressure were calculated, with deviations analyzed using the Redlich-Kister polynomial. The results show good agreement with literature values for refractive index and density. The excess refractive index and molar volume exhibited negative deviations, suggesting weak molecular interactions likely due to hydrogen bond disruption between DMF and n-Hexanol. Temperature increases weakened these deviations. The Lorentz-Lorentz relation provided the most accurate predictions for the refractive index, while Nomoto's relation performed best for ultrasonic velocity at lower temperatures. The Arrhenius-Eyring relation yielded the most accurate viscosity predictions, confirming the reliability of the models used to describe molecular dynamics in the mixtures.

Chapter 9 Deals with the summary of the work presented in the thesis and future scope of work.