# Chapter 1

# The Viscosity of Ionic Liquids

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## ABSTRACT

*This chapter explores the viscosity of ionic liquids (ILs), highlighting its dependence on molecular structure, intermolecular interactions, and external conditions like temperature and pressure. Structural factors, such as cation size, anion nature, and functionalization, significantly impact viscosity, with fluorination, methylation, and branching altering hydrogen-bonding networks. Binary IL mixtures and IL-solvent interactions introduce non-ideal behavior due to solvation and ion-pair dynamics. Temperature and pressure modulate viscosity through ionic diffusion and intermolecular forces. Practical applications include ILs as lubricants, electrolytes, and reaction media, where viscosity is critical. Advances in computational modeling, including machine learning, enhance viscosity prediction and IL design. By integrating experimental and theoretical insights, this chapter provides a compre-*

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*hensive understanding of IL viscosity and its role in next-generation technologies. Deep eutectic solvents and protic ILs offer new strategies for viscosity modulation, expanding IL applications.*

## INTRODUCTION

The resistance of a fluid against flowing is indicated by its viscosity, an elementary physical characteristic. Ionic liquids' (ILs) viscosity is an important variable to identify ILs' suitability for use in many industries. ILs form an all-ion series of organic salts with melting points commonly under 100°C. Their novelty, such as their temperature-varying viscosity, excellent thermal stability, and low volatility, makes them desirable for use in many fields of science and trade. Due to the strong ionic interactions and extensive hydrogen bonding in them, ILs have extremely high viscosities in comparison to other molecular solvents. The property has implications on mass transport, diffusion rates, and overall performance of ILs under real conditions. Some study explores the use of hybrid ionic liquids (ILs) solvents as low viscosity alternatives for biogas upgrading. The thermodynamic and thermal properties of these hybrid solvents were measured using polar soft-SAFT. Results showed that all diluents reduced the solvent's viscosity, but increased isobaric heat capacity, vaporization enthalpy, and solubility. Acetone was found to be a good diluent, increasing CH4 and CO2 solubility while decreasing viscosity and heat of absorption (Alkhatib et al., 2022). The strong ionic conductivity and flexibility of poly(ethylene oxide) (PEO)-based polymer electrolytes make them a viable class of materials for application in lithium-ion batteries. For PEO-based polymer electrolytes, the effects of polymer architecture, such as linear, star, and hyperbranched, and salt (lithiumbis-trifluoromethanesulfonyl)imide (LiTFSI)) concentration on the glass transition (Tg), microstructure, phase diagram, free volume, and bulk viscosity, have been thoroughly investigated. These factors all significantly affect the electrolyte's ionic conductivity. The branching of PEO widens the liquid phase towards lower salt concentrations, resulting in decreased crystallization and improved ion coordination. Ion clustering is common at high salt loadings, but cluster size and distribution are architecture-dependent. Ionic conductivity is maximized at a salt concentration of [Li/EO $\approx$ 0.085] for all architectures, with highly branched polymers showing up to three times higher conductivity. However, salt addition in highly branched architectures accelerates monomeric friction coefficients, potentially enhancing battery performance (Bakar et al., 2023). The rose-window instability (RWI) in silicone oil droplets exposed to corona discharge was investigated. It examines the effects of electrode gap, applied voltage, and viscosity on RWI formation. Increasing the electrode gap leads to an enlarged lattice, while higher voltages accelerate the formation

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