Chapter 2

Thermophysical Properties of Ionic Liquids

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ABSTRACT

Ionic liquids (ILs) represent a promising new material group showing distinct thermophysical features that lead to significant applications in industrial sectors. The chapter explores ILs through molecular structure examination & classifying mechanisms while assessing their thermophysical features regarding density, viscosity, thermal conductivity, and phase behaviour. IL properties transform in response to specific cation-anion pair selection yet maintains systematic management of material characteristics. It examines IL applications in energy storage & heat transfer operations & their usage in green chemistry processes & pharmaceutical development before showing their better performance than conventional

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solvents. The study discusses how industrial uses and environmental examinations of ILs occur through an assessment of scaling issues and management limitations and toxicity challenges. The chapter concludes with a summary of recommended research approaches to resolve current limitations and improve the use of ILs in developing technological fields.

INTRODUCTION

Ionic liquids (ILs) form when salts maintain a liquid state at or near room temperature, thus having melting points below 100°C. ILs use bulky organic cations like imidazolium and pyridinium together with organic or inorganic anions to form a unique ion-based structure which gives them exceptional physicochemical traits absent in conventional molecular solvents (Shukla et al., 2023). The scientific study of ILs formally started in 1914 when researchers discovered ethyl ammonium nitrate. The advancement of air-stable 1-ethyl-3-methylimidazolium ([EMIM])-based ILs took place during the 1980s under the development work of John Wilkes. The development of room-temperature ILs with adjustable hydrophobicity and acidity properties occurred in 1992 which drove their extensive adoption for various applications. The manufacturing sector embraced ILs as industrial materials during the early 2000s after Chevron implemented its ISOALK™ process which used chloroaluminate IL catalysts to produce alkylate fuels (Greer et al., 2020).

ILs demonstrate distinctive properties during transformation which separate them from conventional solvents. The volatile character of these materials remains below 1 Pa as their vapour pressure makes them highly effective at lowering environmental release and breathing hazards (Shukla et al., 2023). The resistance of ILs to high temperatures can extend to 400°C which makes them suitable for industrial applications (Greer et al., 2020). The pairing ability of specific cations and anions in ILs enables precise control of polarity and acidity and solubility performance characteristics for various applications (Shukla et al., 2023). The main benefits of ILs surpass volatile organic solvents like dimethylformamide (DMF) and acetone because ILs possess reduced vaporisation while being fire-resistant and able to dissolve diverse substances and attain high recycling rates greater than 90% (Greer et al., 2020). The industrial research on ILs includes various applications across green chemistry fields together with pharmaceuticals energy storage and catalysis. A study from 2016 illustrated that Indole alkylation resulted in a 75% IL recovery rate yet yielded products at 62% when compared to traditional method yields of 85% (Greer et al., 2020). The pharmaceutical industry uses Dual Active ILs with medicinal components including lidocaine docusate to improve bioavailability and also enables 98% pure extraction of artemisinin from Artemisia annua (Shukla et al.,

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