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Ionic liquids serve as versatile green solvents with unique physicochemical properties for chemical processes

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Abstract

Ionic liquids are salts that remain in liquid form at relatively low temperatures and possess remarkable properties such as negligible vapor pressure, high thermal stability, and excellent solvation ability. These characteristics make them attractive alternatives to conventional organic solvents in chemical synthesis, extraction, catalysis, and electrochemistry. Their tunable structure allows customization for specific applications. This article discusses the structure, properties, synthesis, and applications of ionic liquids in modern chemical science.

***Keywords:** Ionic liquids, Green solvents, Low volatility, Solvent extraction, Catalysis, Electrochemistry, Sustainable chemistry, Imidazolium salts, Reaction medium, Chemical processes*

Introduction

Ionic liquids are composed entirely of ions, typically bulky organic cations paired with various anions, which prevent them from forming solid crystal lattices at room temperature and keep them in liquid form [1]. Unlike conventional solvents, ionic liquids exhibit negligible vapor pressure, meaning they do not evaporate easily and reduce atmospheric pollution. This property makes them attractive in the context of green chemistry. The structure of ionic liquids can be tuned by altering the combination of cations and anions, allowing chemists to design solvents with specific polarity, viscosity, and chemical reactivity. Imidazolium-based ionic liquids are among the most widely studied due to their stability and versatility [2]. Their ability to dissolve a wide range of organic and inorganic compounds enhances their usefulness in chemical reactions. Ionic liquids serve as effective media for catalysis because they can stabilize reactive intermediates and improve reaction selectivity. Their high thermal stability allows reactions to occur at elevated temperatures without solvent degradation [3]. They are also used in solvent extraction processes for separating metals and organic compounds from mixtures. Electrochemical applications benefit from the ionic conductivity and stability of ionic liquids, making them suitable electrolytes in

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batteries and supercapacitors. Their non-flammable nature further enhances safety in such systems [4]. Despite their advantages, considerations regarding cost, recyclability, and environmental impact are important. Research continues to develop biodegradable and less toxic ionic liquids to enhance sustainability. Ionic liquids thus represent a significant advancement in solvent chemistry, linking green chemistry principles with practical industrial and laboratory applications [5].

Conclusion

Ionic liquids function as versatile green solvents with unique physicochemical properties suitable for synthesis, extraction, catalysis, and electrochemistry. Their tunable structure and low volatility make them promising alternatives to traditional solvents. Continued research into sustainable and cost-effective ionic liquids will further expand their role in modern chemical processes. Through advanced membranes, catalysts, and electrolytes, fuel cells provide sustainable and clean power solutions. Continued development of durable and cost-effective materials will expand the role of fuel cells in future energy systems.

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