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Ionic liquids confined in porous matrices: Physicochemical properties and applications

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ABSTRACT

Ionic liquids are emerging as important materials for applications in electrochemical devices, green chemistry etc. For device applications, ionic liquids are generally, either incorporated in polymer matrices or confined in porous matrices (giving rise to an interesting class of materials 'Ionogels'). This review deals with the science and technological applications of ionic liquids confined in nano-pores. A comprehensive overview is given about the experimental studies dealing with the changes in the physico-chemical properties of ionic liquids like thermal phase transition, stability, dynamical behavior, optical properties etc. Recent theoretical studies highlighting the layering and structural hetero-geneity of ionic liquids confined in nano-pores are also discussed. To make the review self-reading, basic ideas about ionic liquids and the phenomena of confinement are also briefly included.

Contents

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1. Introduction

An understanding of the properties of materials confined in constrained geometry is of fundamental and practical interest. The term 'Confined geometry' implies confining any molecular system in the pores of dimensions (at least one dimension) comparable to the size of the molecule being confined. Surface interactions due to spatial restriction and low dimensionality of the "confining matrix" result in the physical and chemical behavior of the "confined systems" much different from the bulk viz. different phase transition behavior, wetting, layering near surface walls as well as shift in glass transition, melting and freezing points. The questions of interest are concerned with how the length scale, dimensionality and surface properties of the walls of the confining matrix modify the dynamics, thermodynamics and structure of the confined molecules compared with their bulk counterparts.

A variety of confined systems like simple organic and inorganic liquids, quantum liquids (helium and hydrogen), inert gases (neon, argon and krypton), molecular gases (oxygen nitrogen etc.), water, polymers and biological systems have been studied widely. Various types of nano-porous matrices have been taken for confinement viz., sol–gel derived silica gelsil/spherosil/Vycor glass/controlled pore glass (CPG), MCM-41, SBA-15, zeolites, carbon nanotubes, reverse micelles, clays, fullerenes, etc. Many unexpected results have been obtained which make this a highly interesting field of study. Rapid advances in technology over the years have also contributed to significant developments leading to the expansion of the frontiers of confined-fluids' research.

Recently, a new class of materials having melting point less than 100 °C, known as ionic liquid (IL), has been discovered which consists of self-dissociated cations and anions (no solvent, like water, is needed to obtain dissociated cations/anions as needed for the conventional electrolytic salt solutions/electrolytes of NaCl, KBr etc.). Ionic liquids have found many industrial and device applications [1–4]. Because of the ionic nature, the types of interaction of such ionic liquids with the confining pore-walls are expected to be entirely different from that in the conventional molecular liquids.