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Review

Exploring the Amino Acids Behavior in Ionic Liquids: Thermophysical and Biophysical Approach

Pooja Yadav,[†] Swati Arora,[†] Thoti Vasantha,* and Pannuru Venkatesu*

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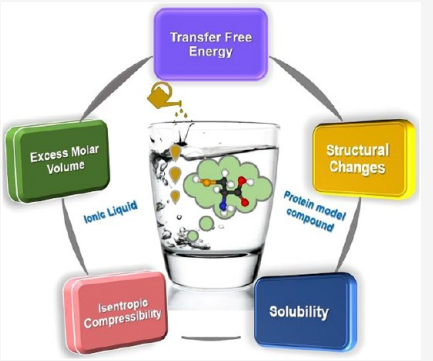
ABSTRACT: The engagement of ionic liquids (ILs) with amino acids (AAs) or peptides establishes a substantial new paradigm for comprehending biomolecular interactions, which is undoubtedly advantageous for the pharmaceutical sector. The comprehension of thermophysical and thermodynamic properties is imperative for elucidating the bimolecular interactions between ILs and AAs. Nevertheless, to this point, no dependable review has been produced to understand the nature of interactions between ILs and AAs. Consequently, this review integrates the results obtained from the analyses regarding the solubility of AAs in ILs and the transfer free energy ($\Delta G'_{tr}$) of AAs from water to aqueous ILs. Furthermore, partial molar volume transfer ($\Delta_{tr}V_{\Phi}^{0}$), apparent molar isentropic compressibility transfer ($\Delta_{tr}K_{\phi,S}^{o}$), and related properties of AAs in ILs have been summarized to understand the biomolecular interactions between solute−solute, solute−solvent, and the alterations in the solute structures within the solution, which are essential for both chemical industries and an academic point of view.



1. INTRODUCTION

Amino acids (AAs) and peptides play pivotal roles in most biological processes. Proteins and enzymes represent biomaterials that possess numerous advantageous characteristics when addressing global challenges, including the advancement of a circular economy and the reduction of environmental repercussions. These substances exhibit biodegradability, can be efficiently sourced from biological systems, are renewable in nature, and have the capability to function as biocompatible scaffolds.[1] As macromolecular substances, they are composed of various combinations of approximately 20 naturally occurring AAs, which serve as the fundamental structural units of proteins. Their capacity for oxidation permits their use by the organism as an energy reservoir. In the pharmaceutical sector, they have been employed in the development of animal feed, alongside applications in the food industry, cosmetic formulations, polymer production, and pharmaceuticals.[2−4]

Ionic liquids (ILs) constitute a class of complex organic salts that have garnered significant interest due to their diverse and compelling characteristics, including low vapor pressure, high ionic conductivity, inflammability, low melting points, as well as enhanced thermal and chemical stability.[5−7] Through various combinations of cationic and anionic species, it is feasible to systematically adjust their physical and chemical properties. ILs have emerged as a highly advantageous category of solvents within a multitude of scientific disciplines and are frequently referred to as innovative green solvents.[8−10] The fundamental principle of green chemistry advocates for the avoidance of toxic and hazardous solvents in both chemical and biochemical methodologies. Correspondingly, the rate of solvent waste generation escalates in conjunction with its application and subsequent remediation efforts.[5] For instance, the production of electric vehicles employs ILs as either solvents or catalysts, thereby stimulating market demand.[6] The advancement of novel ILs characterized by both moisture and temperature stabilities has given rise to an entirely new domain of solvent design.[7−16]

Maintaining the structural integrity and stability of AAs is essential since they are the building blocks of biomolecules, and their side chain type and sequence determine their biological function. Certain AA side chains oversee an enzyme's particular catalytic activity. Analysis of the interactions between cosolvents and AAs indicated that remarkable progress has been accomplished on protein stability by osmolytes, ILs, and other cosolvents.[17−27] Aqueous IL solutions have significant effects on the structure of these AAs or peptides, including their solubility, stability, denaturation, and dissociation into subunits. Little attention has been paid recently to the effect of ILs on the stability of AAs or peptides in aqueous solution ILs. Essentially, it is important to have a clear idea of the solubility, stability, and thermodynamic properties of these biomolecules in ILs.

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