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Efficient Dissolution of Waste PVC Using Low-Cost Ionic Liquids for Sustainable Polymer Recycling

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Abstract

Waste polyvinyl chloride (PVC) is a major component of discarded construction and electrical materials, including celestial wires, pipes, and cable insulation. These materials present significant recycling challenges due to their complex composition, often containing plasticizers, fillers, and stabilizers that hinder conventional mechanical recycling. To address this, an integrated approach involving the use of low-cost ionic liquids (ILs) for selective PVC dissolution and separation of additives was investigated. In this study, various waste PVC samples from celestial wires, pipes, and other polymer-rich components were screened for dissolution efficiency using a series of low-viscosity, low-cost ILs. The primary focus was on optimizing the separation of pure PVC from plasticizers, fillers, and other polymer additives commonly found in these materials. Key process parameters, including IL composition, temperature, dissolution time, and particle size, were systematically optimized to maximize PVC recovery. The screening process revealed that ILs with high chloride ion affinity and moderate cation hydrophobicity effectively disrupted the PVC matrix, facilitating rapid polymer dissolution while allowing for the selective separation of plasticizers and inorganic fillers. This approach offers a promising pathway for the recovery of PVC from complex waste streams. Further optimization studies revealed that the dissolution rate can be significantly accelerated by adjusting the IL concentration and incorporating mild co-solvents, effectively reducing energy input. The recovered PVC was further characterized using FTIR, TGA, and SEM to assess its chemical integrity, confirming the successful removal of unwanted additives and preservation of the polymer backbone. Additionally, the separated plasticizers and fillers were identified. This work also involves the complete mass balance study of recovery and reusability study. Providing insights into the complex chemical composition of these waste streams. This approach not only enhances the economic viability of PVC recycling but also supports a circular polymer economy by converting low-value waste into high-purity, reusable chemical feedstocks. The potential for integrating this process into existing industrial recycling infrastructure and its implications for reducing landfill and incineration burdens will be discussed.

Dr. Prashant Kumar is a Research Fellow at RMIT University, Melbourne, specializing advanced engineering material, sustainable systems,development of ionic liquids for polymer recycling. He completed his Ph.D. in 2024 through a joint doctoral program between the Academy of Scientific and Innovative Research (AcSIR), India, and RMIT University, Australia. His research focuses on designing ionic liquids for efficient polymer dissolution and recycling, including polyvinyl chloride (PVC) and other end-of-life plastics, as well as waste oils valorization. Dr. Kumar extensively working on industrial projects on sustainable materials processing and circular economy solutions, contributing to innovative industrial chemical processes.