Emerging Frontiers in Redox-Mediated Electrodialysis: Recent Advances and Future Perspectives

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Abstract

Recently, redox-mediated electrodialysis (redox-ED) has garnered significant attention as an innovative and efficient electrochemical ion separation process for water desalination. By integrating the principles of a redox flow battery with modifications that incorporate intervening channels for water flow, the redox-ED system represents a breakthrough in the field. This system uniquely features multi-channel architecture, which enables the independent management of different flow streams, such as water and redox-active solutions. This design offers several notable advantages over traditional electrochemical ion separation methods like capacitive deionization (CDI) and conventional electrodialysis (ED).

This presentation introduces the foundational principles of the redox-ED system, highlighting recent progress in areas such as cell architecture, electrode development, operational techniques, and strategies for scaling up the technology. Furthermore, it explores the potential applications of redox-ED beyond water desalination, including resource recovery and pollutant removal, demonstrating its versatility as a multipurpose solution. Lastly, the presentation identifies key challenges and opportunities for future research. Topics include improving the durability and performance of redox-active materials, optimizing system design for various scales, and addressing technical and economic barriers to commercialization. This forward-looking perspective aims to inspire further advancements in redox-ED technology and its applications in sustainable water and resource management.