

# Scalable and Integrated Membrane Processes for Industrial Resource Recovery

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Industrial operations generate large volumes of saline wastewaters and by-products that are costly to manage and often lead to the loss of valuable resources. This plenary lecture presents an integrated membrane-based technology platform that converts such streams into marketable products — including high-purity solid salts, regenerated chemicals, and reusable water — while substantially reducing energy demand and residual waste. The work is focused on commercial applications with measurable economic benefits and resource recovery within a circular economy framework.

Presented will be a newly developed process that builds on the well-known ability of electrodialysis to concentrate aqueous solutions and integrates this effect into a membrane-based route for the recovery of sparingly soluble salts, without reliance on chemical additives or energy-intensive evaporation. The approach enables recovery of target salts as a high-purity product, with substantially improved energy efficiency and environmental performance compared to conventional alternatives, while also generating a reusable water stream suitable for minimal or near-zero liquid discharge concepts. Laboratory and pilot-scale validation demonstrate a step-change reduction in energy consumption and operating costs compared to conventional thermal or chemical routes, with ongoing pilot operation under real industrial conditions confirming scalability and robustness.

Beyond this flagship technology, the lecture will summarize key results in membrane-based recovery of salts and chemicals from industrial wastewaters, including electrodialysis with bipolar membranes (EDBM) for on-site regeneration of acids and bases from spent ion-exchange streams. These solutions close chemical loops, significantly reduce waste volumes, and are currently being piloted in industrial environments. Together, the presented results outline a coherent pathway from membrane research through pilot validation to industrial deployment and commercialization, delivering tangible environmental and economic advantages for water-, energy-, and chemical-intensive industries.