Slovak Society of Chemical Engineering
Institute of Chemical and Environmental Engineering
Slovak University of Technology in Bratislava

PROCEEDINGS

52nd International Conference of the Slovak Society of Chemical Engineering SSCHE 2026

Hotel SOREA TRIGAN
Štrbské Pleso, Slovakia
May 26 - 29, 2026

Editors: Assoc. prof. Mário Mihaľ

ISBN: 978-80-8208-177-3, EAN: 9788082081773

Published by the Faculty of Chemical and Food Technology, Slovak University of Technology in Bratislava in Slovak Chemistry Library for the Institute of Chemical and Environmental Engineering; Radlinského 9, 812 37 Bratislava, 2026

Fehér, J., Tvrzník, D., Václavíková, N., Bobák, M., Pindroch, O.: Electrodialysis for Zero Liquid Discharge: From Concept to Industrial Scale, Editors: Mihaľ, M., In *52nd International Conference of the Slovak Society of Chemical Engineering SSCHE 2026*, Štrbské Pleso, Slovakia, 2026.

Electrodialysis for Zero Liquid Discharge: From Concept to Industrial Scale

Jakub Fehér[1], David Tvrzník[1], Natália Václavíková[1], Marek Bobák[1], Ondrej Pindroch[1]

[1]*MemBrain s.r.o., Pod Vinicí 87, Stráž pod Ralskem 471 27, Czechia*

e-mail: jakub.feher@membrain.cz

Key words: ZLD, electrodialysis, homogeneous, ion-exchange membranes,

Increasing environmental pressures, stricter regulatory frameworks, and rising costs of wastewater disposal are accelerating the adoption of advanced treatment technologies across industrial sectors. Zero Liquid Discharge (ZLD) has emerged as an effective strategy for minimizing wastewater generation while maximizing water reuse and resource recovery, particularly in the European Union, where environmental policies promote sustainable water management and reduced industrial emissions.

Among available technologies, membrane processes, especially electrodialysis, offer an energy-efficient alternative to conventional thermal methods for desalination and concentration of industrial streams. However, operation at high concentrations remains challenging due to reduced concentration gradients, back diffusion, scaling risks, membrane damage (burning), and decreased current efficiency caused by parasitic currents.

This work presents the development of an industrial-scale electrodialysis module tailored for ZLD applications. Based on laboratory evaluation of ion-exchange membranes, FUJI Type 12 membranes were selected due to their superior performance in achieving high concentrations. Analysis of their properties and module geometry showed that, to maintain current efficiency above 75%, a conventional single-stage design would be limited to approximately 150 membrane pairs, which is insufficient for industrial-scale operation.

To address this limitation, a multi-stage module was designed, consisting of four electrically and hydraulically independent stages separated by intermediate plates with bipolar electrodes. This configuration enables improved current distribution and reduction of parasitic losses. Experimental results demonstrated stable operation, achieving a maximum concentration of 230 g/L Na_2SO_4 with a current efficiency of 87%, confirming the suitability of the proposed design for ZLD applications.

Acknowledgement: This work was carried out in the frame of the IP project (Decision Nr. 6/2023) supported by the Czech Ministry of Industry and Trade. The project utilizes Membrane innovation centre infrastructure.