

A MULTI-SCALE TOOL FOR SIMULATING ELECTRODIALYSIS WITH BIPOLAR MEMBRANES SYSTEMS

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Abstract: In recent years, the global capacity of the desalination industry has increased to address freshwater scarcity, with reverse osmosis established as the leading technology. Brine disposal is a major issue due to the environmental impacts. However, novel brine management methods are oriented by (near) Zero Liquid Discharge strategies towards waste disposal minimization and resource recovery. In this context, ElectroDialysis with Bipolar Membranes (EDBM) can be utilised to valorise and, thus, repurpose the waste brine, thereby producing valuable chemicals, such as acid and base solutions, and recovering desalted water. However, the EDBM system must be carefully designed to meet the process requirements. In this work, we present a mathematical multi-scale model of the EDBM technology¹. Four different scales were integrated in the gPROMS Model Builder environment. The lowest scale predicts the physical properties at the channel level as well as the bipolar membrane transport properties. The middle-low scale simulates the triplets, i.e. the repetitive cells forming the EDBM stack. This level predicts the main electrical variables and the material balances related to transport phenomena. The middle-high scale is devoted to the prediction of shunt currents via manifolds, as well as of the flow distribution and pressure losses across the stack. Finally, the highest scale of simulation integrates the EDBM unit with the external hydraulic circuit including the reservoirs of the electrolyte solutions and other auxiliary components. The model was experimentally validated across varying operating conditions both in the steady-state and dynamic modes of operation, demonstrating a high reliability. The model capability was exploited to conduct a sensitivity analysis of the EDBM performance on the main process variables, computing Specific Energy Consumption, Current Efficiency, and Yield. Favourable process conditions and detrimental phenomena affecting this technology were identified. Finally, this powerful mathematical tool was used to design a pilot-scale EDBM unit.

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References

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