Modelling of large scale Electrodialysis with Bipolar Membranes processes using a multi-scale approach with validation at pilot plant scale

Giovanni Virruso[1], Calogero Cassaro[1], Andrea Culcasi[1], Andrea Cipollina[1], Alessandro Tamburini[1], Giorgio Micale[1]*

[1] Dipartimento di ingegneria, Università degli studi di Palermo, Viale delle scienze ED.6, Palermo, 90128, Italia

* corresponding author: andrea.cipollina@unipa.it

Abstract

Sodium hydroxide and hydrochloric acid represent basic industrial chemicals and their use is widespread in different areas. In many case, they are used as diluted solutions for pH correction, cleaning and regenerative procedures as well as for other applications. These chemicals represent commodities and are produced in large quantity in few places in all over the world. Moreover, these chemicals are hazardous for human health and must be handled with care. Consequently, the cost of transportation account for a large fraction of total cost. In remote areas these issues are exacerbated and it is necessary to find a safety, sustainable and economic way for the *in situ* production of these chemicals. Electrodialysis with bipolar membranes (EDBM) is electro-membrane process capable of producing acid and base streams from the corresponding salt solution, i.g. sodium hydroxide and hydrochloric acid from sodium chloride. This process employs only a brine and some water as feedstock as well as electrical energy for the chemicals production, proving the environmental friendly nature of this process. In the last years, achievements have been in the membranes properties and in new process configuration investigated. Nevertheless, there is still a lack in the modelling of this process on a large scale unit, which results of primary important to design, control and optimize it. These could be helpful to promote the adoption the EDBM technology on an industrial level.

The aim of this work is to modify an already existing model [1] and extend its validity up to real semi-industrial scale, increasing current density range and membrane areas of validity. To this end, a large scale EDBM unit (19.2 m^2 of total membrane area) was used to validate the model in different process configurations (Closed-loop and Feed & Bleed), applying a current density up to 500 A/m^2. The modifications made regard the simulation of a real large scale EDBM stack which foresees two cell packs, adopting an inter staging configuration, with the two cell packs placing in parallel from an electrical point of view (one common anode and two cathodes). Moreover, an *ad hoc* parasitic currents model was developed. to evaluate shunt current as well as current and voltage profiles along the entire stack. Once the model had been validated, a sensitivity analysis was performed, adopting the continuous Feed & Bleed configuration, which has resulted the most promising at high current density [2], varying the current density, the target concentration of acid and base as well as the degree of conversion of the salt.

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