MODELLING AND EXPERIMENTAL INVESTIGATION OF A NOVEL ION EXCHANGE MEMBRANE CRYSTALLIZER FOR MAGNESIUM RECOVERY

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Abstract: The selective transport properties of ion exchange membrane has recently raised a significant interest towards the development of processes here a selective passage of ions between solutions can be the key of success for the obtainment of a desired product. Within this context, reactive crystallisation processes often require the addition of ionic species into a reacting environment, yet limiting as much as possible the direct mixing of feed solutions.

On the basis of the above idea, a novel ion exchange membrane crystallizer (CrIEM[1]) was developed for the valorisation of saline natural or industrial waste streams by means of magnesium and other valuable minerals recovery.

In particular, in a CrIEM reactor, the presence of an Anion Exchange Membrane, separating a brine and an alkaline solutions, allows the passage of hydroxyl ions from the alkaline to the brine compartment, where crystallization of magnesium hydroxide occurs, yet avoiding a direct mixing between the solutions feeding the reactor. This enables the use of low-cost reactants (e.g. $Ca(OH)_2$) without the risk of co-precipitation of by-products and contamination of the final crystals.

An experimental campaign was carried out treating two types of feed solutions, namely: 1) Mediterranean seawater, collected from North Sicilian coast (Italy), and 2) a waste industrial brine from the Bolesław Śmiały coal mine in Łaziska Górne (Poland). The Mg^{2+} concentration in the feed solutions ranges from 0.7 to 3.1 g/L. The CrIEM was tested in two configurations: batch and feed & bleed.

Interestingly, a magnesium hydroxide purity between 95 and 99% can be obtained, while the anionic membrane has not suffered performance drops throughout the 80 hours of operation. Furthermore, a mathematical model was purposely developed to simulate the performance of the crystallizer, based on the Donnan Dialysis equilibrium and transport mechanism. The model was implemented using Python and numerical simulations of the experimental runs were successfully carried-out, thus providing a good validation of the modelling tool.