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Diffusion Dialysis for HCl and Heavy Metals Separation from Highly Concentrated Pickling Solutions

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Abstract

Disposal of industrial pickling waste solutions strongly affects hot-dip galvanizing industries' economics and environmental footprint. Thus, the recovery of acid is one of the most beneficial steps to enhance the process sustainability. Diffusion dialysis (DD) can be used to separate acids and heavy metals (e.g. iron and zinc) from pickling waters, thus enabling their recovery and reuse promoting the circular use of such raw materials in a sustainable way [1,2].

In the present work, two DD modules equipped with Fumasep FAD anionic exchange membranes were used for the recovery of hydrochloric acid from highly concentrated zinc and iron solutions. In particular, a plate and frame laboratory-scale DD unit (10x10 cm²), operating in a batch configuration [3], and a large-scale DD unit (20x80 cm²), operating in continuous mode, were tested.

Results show that zinc and iron affect HCl recovery in opposite way. In fact, when iron ions are present in solution the acid recovery efficiency can considerably increase thanks to the so-called "salt effect" until over 100%. Conversely, a slight reduction of 10% is observed when both metals are in solution, likely due to the formation of negatively-charged zinc chloro-complexes. All these trends were entirely in agreement with the results obtained in continuous operation.

An already presented mathematical model, with a time and space distributed-parameters structure [3], was further implemented in order to effectively simulate operations also in the presence of zinc ions. The model was thoroughly validated with experimental data for the two units, observing a good fitting between experimental results and model predictions.