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Magnesium Recovery from Brine via Reactive Membrane Crystallization Using Hollow-Fiber Modules

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Drinking water supplies are decreasing in some coastal areas, making it necessary to seek alternative solutions for potable water production. One approach to alternative solutions is the concept of circular economy, which aims at the recycling and regeneration of water resources. One such alternative is seawater desalination using reverse osmosis. However, desalination generates vast amounts of highly concentrated waste streams, known as brine, which are currently discharged back into the ocean. This waste stream contains almost twice the salt concentration of seawater, making it an untapped source of critical raw materials for the European Union. By processing this brine, it would be possible to produce valuable materials while also obtaining clean water. One of these valuable materials is magnesium, which can be separated by reactive crystallization through the addition of a precipitating agent.

Our goal is to separate magnesium from brine using membrane technologies. Membrane crystallization enables the controlled introduction of the precipitating agent without direct contact between the two solutions, resulting in a more easily controllable process. This process employs ion-exchange membranes in the form of hollow fibers. The membrane crystallization was conducted using a membrane module composed of a fiber wounded around a 3D-printed body, which was immersed in a model $MgCl_2$ solution. The experiments were carried out with NaOH as the precipitating agent. The possibilities of increasing the yield after crystallization were investigated through the addition of HCl, osmotic water permeation, and aeration. Subsequently, pilot membrane crystallization experiments were performed using a multi-fiber membrane module, whose construction resembles a shell-and-tube heat exchanger.

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