

I. Ruiz Salmón, R. Janssens, P. Luis; Membrane crystallization of sodium carbonate in CO₂ capture scenario: mass and heat transfer study. 2016 EMS Summer School on "Membranes and Membrane Processes Design", 26th June –1st July 2016, Bertinoro, Italy. (poster)

Abstract:

Membrane contactors are shown as a promising technology available to be present in many different fields in the current industry. Thus, conventional processes, such as stripping, liquid–liquid extraction operations, crystallization and phase transfer catalysis may be performed with this technology. In fact, traditional equipment as evaporators or crystallizers may be progressively substituted in many cases by membrane configurations because of their advantages: operational flexibility, controlled and known interfacial area, linear scale-up, compact and less energy-consuming. Obtaining crystals with membrane contactors is one of the new areas of research. The membrane's role is to act as a non-selective barrier able to permit the mass transfer between two phases produced by the driving force (difference of concentration, temperature and/or pressure between phases). Crystallization will take place because of the saturation of the feed solution when the water leaves the feed by permeating through the fibers.

Crystallization of Na₂CO₃ using a membrane contactor is proposed in this work as the last stage of a whole integrated membrane system for the capture of CO₂: the general objective is to capture CO₂ from flue gases and to convert it into a valuable product (Na₂CO₃) by using NaCl solution as the only material source. Previous works proved the technical viability of this approach. This work gives a step forward by evaluating membrane distillation-crystallization (MDC) to obtain pure Na₂CO₃ when a temperature gradient and an osmotic solution are involved.

The hollow fiber membrane contactor Liqui-Cel® Extra-Flow 2.5 x 8 (Membrana GmbH, Germany) was used as membrane crystallizer. The feed and osmotic solution presented concentrations from 100 to 200 g/L and 100 to 300 g/L, respectively. Na₂CO₃ and NaCl flowrates ranged from 15 to 500 ml/min and 50 to 1400 ml/min, respectively (counter-current mode). The temperature influence was studied from room temperature up to 40°C.

Results of transmembrane fluxes and mass transfer coefficients allows determining the best operating conditions to minimize the required membrane area and energy consumption. A dichotomy between the efficiency of the overall setup and the performance of the membrane contactor was found and therefore, a deep interpretation based on polarization effects and possible membrane wetting is done. In addition, a comparison between theoretical (resistance-in-series model) and experimental mass and heat transfer analysis was made in order to shed light in this issue which showed the membrane as the main resistance to mass transfer, and the permeate stream to heat transfer. Finally, sodium carbonate decahydrate was obtained with 65.6% of water content.