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Regeneration of a Liquid Desiccant Using Membrane Distillation to Unlock Coastal Desert Agriculture Potential

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Abstract : In Gulf Cooperation Council (GCC) countries, domestic agriculture is hindered by a lack of freshwater, poor soil quality, and ambient temperatures unsuitable for cultivation resulting in a heavy reliance on imported food. Attempts to minimize the risk of food insecurity by growing crops domestically creates a significant demand on limited freshwater resources in this region. Cultivating food in a greenhouse allows some of these challenges, such as poor soil quality and temperatures unsuitable for cultivation, to be overcome. One of the most common methods for greenhouse cooling is evaporative cooling. This method cools the air by the evaporation of water and requires a large amount of water relative to that needed for plant growth and air with a low relative humidity. Considering that much of the population in GCC countries live within 100 km of a coast and that sea water can be utilized for evaporative cooling, coastal agriculture could reduce the risk of food insecurity and water demand. Unfortunately, coastal regions tend to experience both high temperatures and high relative humidity causing evaporative cooling by itself to be inadequate. Therefore, dehumidification is needed prior to utilizing evaporative cooling. Utilizing a liquid desiccant for air dehumidification is promising, but the desiccant regeneration to retain its dehumidification potential remains a significant obstacle for the adoption of this technology. This project studied the regeneration of a magnesium chloride ($MgCl_2$) desiccant solution from 20wt% to 30wt% by direct contact membrane distillation (DCMD) and explored the possibility of using the recovered water for irrigation. Two 0.2 µm hydrophobic PTFE membranes were tested at feed temperatures of 80, 70, and 60°C and with a permeate temperature of 20°C. It was observed that the permeate flux increases as the difference between the feed and coolant temperature increases and also as the feed concentration decreases. At 21wt% the permeate flux was 34,17, and 14 L m^{-2} h^{-1} for feed temperatures of 80, 70, and 60°C, respectively. Salt rejection decreased overtime; however, it remained greater than 99.9% over an experimental time span of 10 hours. The results show that DCMD can successfully regenerate the magnesium chloride desiccant solution.

Keywords : agriculture, direct contact membrane distillation, GCC countries, liquid desiccant, water recovery
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