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Disrupting Desalination: Temperature Swing Solvent Extraction for Hypersaline Brines

Abstract

Hypersaline brines, e.g., produced water from oil and gas extraction, inland desalination concentrate, landfill leachate, and flue gas desulfurization wastewater, are of growing environmental importance but are technologically under-served by today's desalination methods. In this talk, we present a radically different approach for hypersaline desalination, termed temperature swing solvent extraction (TSSE). The technology utilizes a low-polarity solvent that is immiscible with aqueous solutions to extract water from hypersaline brines. Because water solubility of the solvent is highly temperature-sensitive, a mild temperature swing causes the aqueous phase to demix from the solvent, yielding product water. We demonstrate the potential of TSSE to desalinate hypersaline brines up to 235,000 ppm TDS ($\approx 7\times$ seawater salinity) with exceptional salt removal of $> 98\%$. High water recovery of $> 50\%$ was demonstrated for TSSE desalination of 1.5 M NaCl brine in semibatch experiments with multiple extraction cycles. Importantly, as only moderate temperatures $< 80\text{ }^\circ\text{C}$ are needed, the heat input can be supplied by inexpensive or free low-grade thermal sources. Lastly, the prospects and challenges of implementing TSSE for the desalination and dewatering of industrial high-salinity streams are discussed. The development of energy-efficient technologies can offer more sustainable solutions for the intensifying environmental concerns of hypersaline brines.

Bio

Ngai Yin Yip is an Assistant Professor of Earth and Environmental Engineering at Columbia University. He received his doctoral degree in Chemical and Environmental Engineering from Yale University, where his dissertation work on novel membrane technologies for the sustainable production of energy and water earned the CH2M Hill/AEESP Outstanding Doctoral Dissertation Award in 2014. Prior to Columbia, he pursued postdoctoral research at the Singapore Centre for Environmental Life Sciences Engineering. He completed his Civil and Environmental Engineering BEng degree in Nanyang Technological University of Singapore. His current research is focused on advancing technologies and innovations for environmental challenges at the nexus of water and energy, including energy-efficient desalination, sustainable resource recovery from waste streams, and novel membrane materials for water purification.

