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Switchable Solvents for Hypersaline Brine Desalination using Low-Grade Thermal Energy

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Abstract Switchable solvents are liquids that reversibly and drastically shift physical properties in response to an external stimulus, such as temperature change. In this talk, we present a radically different approach for hypersaline desalination, termed temperature swing solvent extraction (TSSE) using thermally-switchable amines. Hypersaline brines are of growing environmental importance but are technologically under-served by today's desalination methods. We demonstrate the potential of TSSE to desalinate hypersaline brines with exceptional salt removal and high water recovery yields up to zero liquid discharge (ZLD) operation. Fundamental changes in hydrophilicity of the switchable amines in response to thermal stimuli are studied using the Kamlet-Taft polarity scale. We then show that the thermoresponsive polarity of the solvents governs the partitioning behaviors of the three components of water, salt, and solvent in the aqueous-organic biphasic systems. To probe the intra- and inter-molecular interactions, advanced atomistic measurement technique of atomic pair distribution function were integrated with in-silico molecular dynamic simulations and further complemented with small-angle x-ray scattering analysis and bulk-phase phenomenological characterizations. Lastly, the prospects of broader application of switchable solvents for aqueous environmental separations are discussed.

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