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Separation and purification of gas or liquid mixtures via gas hydrate technology

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Chemical separation methods such as distillation and evaporation are energy intensive and are often not suitable as they can alter the properties of the chemicals within the mixture. Evaporation is the traditional and commonly used method for juice concentration; however, the juice can be very sensitive to heat which can alter its colour and flavour. In the processing of sugar cane to produce sugar crystals, the clarified juice is concentrated in a multi-effect evaporator train to 60% (m/m) sucrose. The separation of xenon from a gaseous mixture of xenon, krypton and argon remains a difficult and costly industrial process. Although cryogenic distillation, adsorption and membranes are established methods for the separation of these gases, the drawbacks include high energy consumption when using cryogenic distillation, and a low adsorption capacity for the selected adsorbents which makes these options uneconomical. Initial studies within our research unit have reported the dissociation data for the systems mentioned and the proposed separation process via the hydrate method. Gas hydrate separation is an emerging technology which concentrates the mixture by trapping a hydrate former, the gaseous molecule within a lattice cage created by the water molecules. Similarly, a separation is affected within a gaseous mixture when a selective gas component is enclosed in the hydrate clathrate. A gas hydrate reactor vessel, with two viewing windows, and with good agitation of the cell contents was designed to investigate the effect of juice concentration, and separation of gas mixtures. Other design features include sample removal for the gaseous mixture. Hydrate dissociation measurements and kinetic studies performed determine the hydrate boundary condition, the induction time, crystal size, as well as rate of hydrate formation. In this study, the separations via gas hydrate method will be reported and discussed, and its feasibility will be compared to the traditional methods for separation.

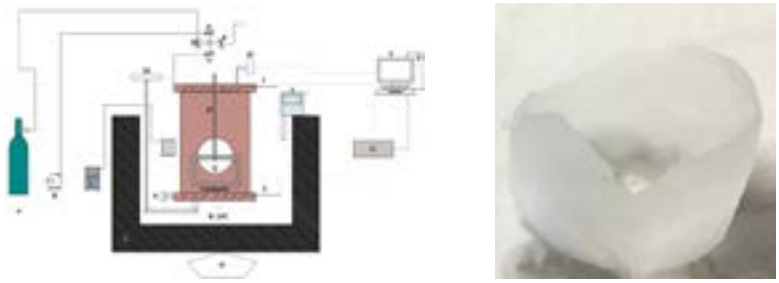

Figure 1: Schematic of the hydrate reactor and a photograph showing hydrate formation of sucrose solution.

Recent Publications

1. Nelson W M, Naicker S, Naidoo P, Ramsuroop S and Ramjugernath D (2018) Experimental phase equilibrium for the binary system of n -pentane +2-propanol using a new equilibrium cell and the static total pressure method. Journal of Chemical and Engineering Data 63(3):732–740.
2. Tumba K, Mohammadi A H, Naidoo P and Ramjugernath D (2016) Assessing hydrate formation as a separation process for mixtures of close-boiling point compounds: a modeling study. Journal of Natural Gas Science and Engineering 35:1405–1415.
3. Smith A, Babaee S, Mohammadi A H, Naidoo P and Ramjugernath D (2016) Clathrate hydrate dissociation conditions for refrigerant + sucrose aqueous solution: experimental measurement and thermodynamic modelling. Fluid Phase Equilibria 413:99–109.
4. Babaee S, Hashemi H, Mohammadi A H, Naidoo P and Ramjugernath D (2016) Experimental measurement and thermodynamic modeling of hydrate phase equilibrium for krypton + tetra-n-butyl ammonium bromide aqueous solution. Journal of Supercritical Fluids 107:676–681.

5. Babaee S, Hashemi H, Mohammadi A H, Naidoo P and Ramjugernath D (2015) Experimental measurements and thermodynamic modeling of hydrate dissociation conditions for the xenon + tbab + water systems, J. Chem. Eng. Data 60:1324–1330.

Biography

Paramespri Naidoo is the Co-Director of the Thermodynamics Research Unit, at the University of KwaZulu-Natal. This research unit specializes in phase equilibrium studies (high-low pressure-temperature measurements and modeling), vapour-liquid, liquid-liquid and solid-liquid equilibrium. She has been specializing in this area, developing new equipment to extend the range and versatility of the experimental capabilities within the research unit. This research is supported by local chemical process industries, and in collaboration with several internationally recognized research groups in the field of Chemical Thermodynamics and Separation Studies.

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