

Measurement and modeling of solid - liquid equilibrium in the system fructose + glucose + ethanol + water.

Adrian Flood

Department of Chemical Engineering, Suranaree University of Technology
Muang District, Nakhon Ratchasima, 30000, Thailand.
adrianfl@ccs.sut.ac.th

ABSTRACT

Measurement and modeling of the solubility, and determination of preferred crystalline phases under different solvent and temperature conditions is essential information required at the beginning of crystallizer design. However this information is rarely available in the scientific literature, particularly for mixed solute and mixed solvent solutions. This paper describes methods and results for measuring and modeling solid-liquid equilibrium in the quaternary system fructose + glucose + ethanol + water at 30 and 40 °C. Experiments covered a range of solvent (ethanol + water) compositions from 40 weight percent ethanol to 80 weight percent ethanol. This range is suitable for determining solubilities under conditions likely to be found in alcoholic crystallization from high fructose syrups (HFS). The solubility results showed that addition of ethanol greatly reduces the solubility of both sugars over the entire range of compositions, as would be expected from the ternary systems glucose + ethanol + water and fructose + ethanol + water. The solubility also increases significantly with increasing temperature for all solvent compositions. The fructose + glucose + water system displays two invariant points, and thus three crystalline phases (glucose monohydrate, anhydrous glucose, and anhydrous fructose) over the range of solute compositions; however the system fructose + glucose + ethanol + water displays only one invariant point, where the preferred crystalline phase changes from anhydrous glucose to anhydrous fructose. It is believed that the ethanol in solution stabilizes the presence of water in the liquid phase with respect to the solid phase. The activity coefficient of the sugars in the solid phase could be determined from rigorous thermodynamic methods for both hydrated and anhydrous forms. The availability of solid-phase activity coefficients and solubility measurements at two temperatures allowed the system to be modeled using a UNIQUAC-type model.