A Procedure for Design of Crystallization Processes of Multi-Component Electrolyte Systems

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Abstract

Fractional crystallization is a commonly used separation technique for downstream processing of reactor effluent in chemical and biochemical processes. In this work a procedure for design of crystallization processes of multi-component system is described. The procedure consists of three parts; generation of phase diagram, generation of all feasible flowsheet alternatives, and the screening part. As an example, the ionic system of (Na^+, K^+; Cl^-, SO_4^{-2}; H_2O) is considered. This ionic system is related to the process, which is used for the production of K2SO4 and NaCl from Na2SO4 and KCl. The activity coefficients of ions in this system are calculated by the UNIQUAC model. Using these values of activity coefficients in the equilibrium equations, the phase diagrams (thermodynamic part) of the system are generated. These phase diagrams are used to generate a flowsheet for production K_2SO_4 from KCl and Na_2SO_4.

Key words: fractional crystallization; UNIQUAC model; multi-component solutions.

Introduction

Crystallization plays a very important role in the separation and purification of many organic and inorganic materials. Like distillation method for separation of mixtures, it produces pure products. However, compared to the extensive works on multi-component distillation process design, relatively little works are available on multi-component crystallization. This is serious omission because wide applications of multi-component crystallization in the industry. This problem causes that most other chemical processes can be simulated and optimized on computer today, but the same is not true for processes involving crystallization especially for multi-component electrolyte mixtures. Even today graphical methods are being applied for the design of such processes. It is important to note that the worldwide annual production rate of fertilizer chemicals such as ammonium phosphates and ammonium nitrate each exceed one million-ton. The same figure for sodium chloride is 100 million-ton. Some of the above mentioned salts are produced by fractional crystallization, a process in which several salts are separated as pure phases from a multi-component mixture.

Sometimes the precipitation and crystallization of electrolytes is an unwanted side effect which to be avoided. This is for example the case with scaling, the formation of salt layers in boilers, heat exchangers, or reverse osmosis units.

Factional crystallization is used to produce solids from a multi-component