Recovery of valuable heat sensitive products and concentrates by eutectic freeze crystallization

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Motivation

Eutectic freeze crystallization (EFC) is a newly developed crystallization technique that operates at subzero temperatures. The eutectic point of an aqueous solution is the concentration and temperature where both the solvent as the solute start to crystalize simultaneously[1], see figure 1. Due to the density difference between the solvent and solute, separation by gravity is possible. A pure stream of ice and solute can then be extracted, the remaining liquid can be separated further or recycled again into the process. See figure 2.

In comparison with other separation technologies like evaporation, EFC has a low energy requirement and has the ability of complete conversion of feed into water and solidified solutes. In addition there is no thermal degradation of the product because of the low temperatures used.

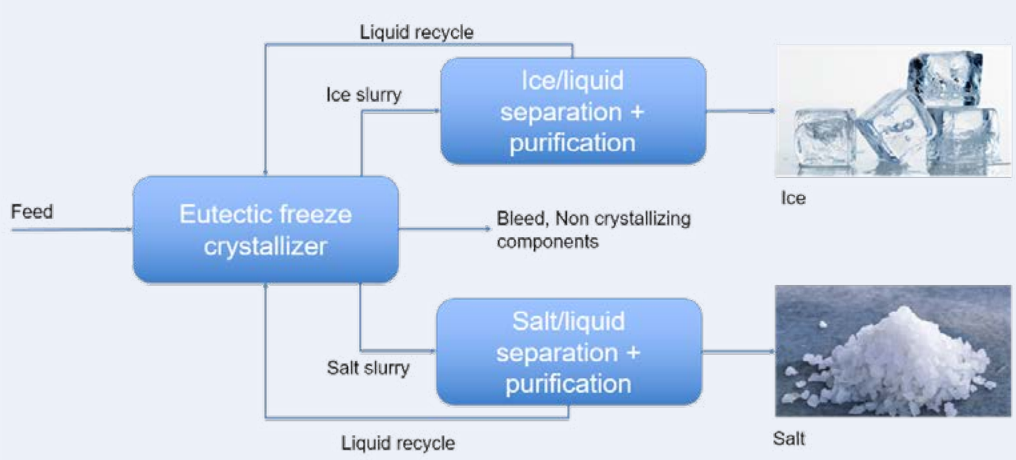

Fig. 2 process description of an EFC process

Technological challenge

Previous research has shown that it is possible to separate brines into ice and salt with a high purity. In theory however it is possible to separate both organic and inorganic aqueous solutions.
This research focuses on the recovery of heat sensitive products and concentrates in the agro and food industry by EFC. The first part of this research will look at the recovery of lactose from delactose whey permeate (DLP), which is a byproduct created during cheese and protein production.
DLP contains minerals, acids, residual proteins, residual lactose and water [2]. As DLP is difficult to process with conventional methods it is currently only used for low value application like cattle feed [3]. EFC could be used for treating this waste streams by concentrating and extracting minerals and lactose. It is currently unknown if it is possible to treat DLP with EFC: if it is possible to concentrate and extract different components without simultaneous crystallization. Furthermore it is unknown what the effect will be of low temperature crystallization on the rate, quality and quantity of lactose crystals.

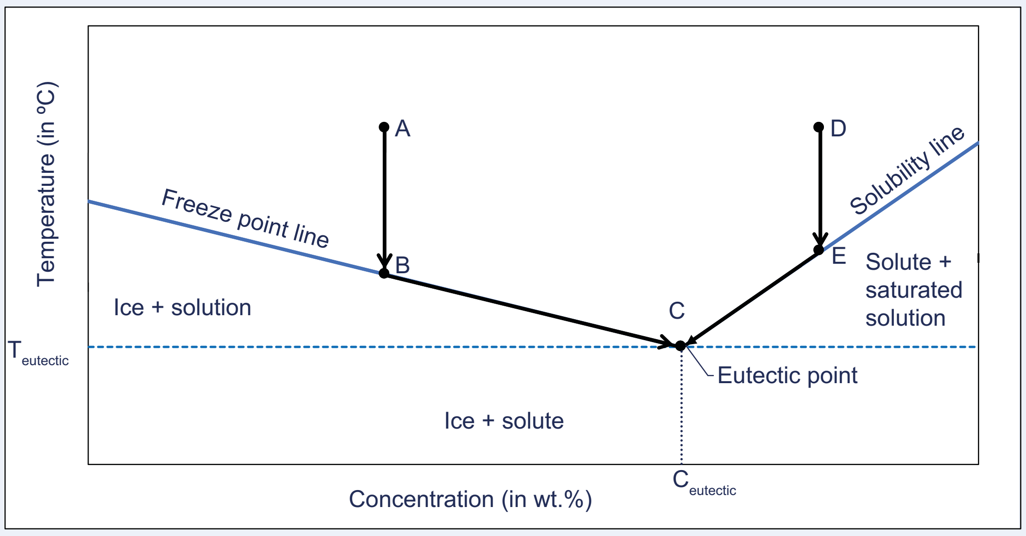

Fig. 1 Typical binary phase diagram of salt-water solution, the arrows show the two routes an EFC process can take(A-B-C or D-E-C)

Research goals

To test the effectiveness of EFC for food an agricultural streams the following parameters will be investigated:

- Crystal size and morphology
  - Solid-liquid separation
  - Effect of impurities
- Quality of product and ice
- Crystal nucleation and growth rate

After the initial experiments an investigation will be made of scaling up the process: a conceptual design of a reactor will be made and a economic evaluation as well as an energy and mass balance of an EFC process will be investigated.

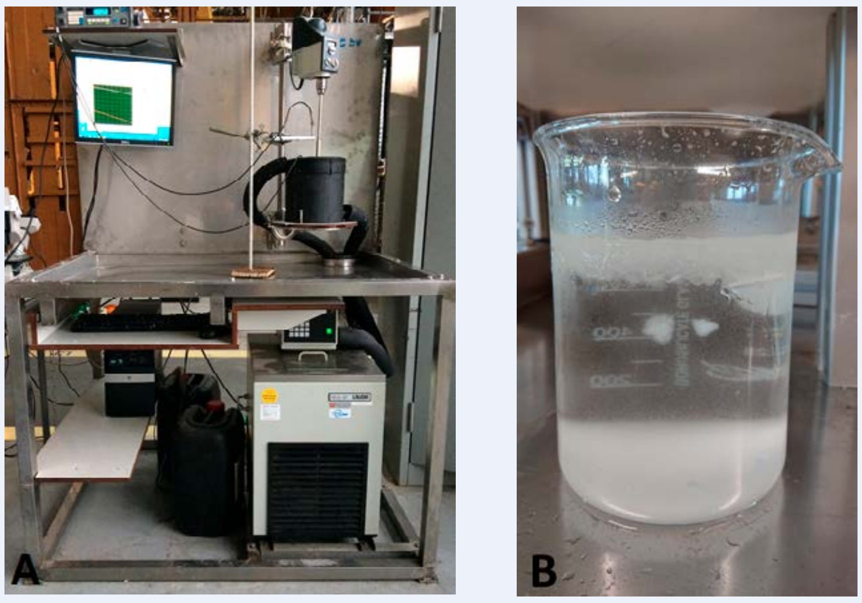

Fig. 3 (A) 1 L setup at laboratorium in Wetsus, (B) MgSO4-solution at eutectic conditions

References
[1] Ham et al., "Eutectic freeze crystallization simultaneous formation and separation of two solid phases," (1999), J. Cryst. Growth.
[2] Liang et al., "Effect of composition on moisture sorption of delactosed permeate,",(2009), Int. Dairy J.
[3] Wong et al., "Crystallization in Lactose Refining—A Review,", (2014), J. Food Sci.

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