Concentration of Liquid Food Extracts Based on Process-Controlled Gas Hydrate Formation

SUTTER R. (1), HARTMANN C. (1), MEUNIER V. (1)
1 Institute of Material Sciences, NestlResearch Lausanne, Lausanne, Switzerland

CO_2 gas hydrates can be observed in aqueous systems at elevated pressure and temperatures above 273 K. They offer prospect to increased energy efficiency and concentration at low thermal load for liquid food extracts, such as fruit juice, sugar cane juice or coffee. The aim of the current contribution was to study the formation of CO_2 gas hydrates in a batch autoclave system for pure water and reconstituted soluble coffee in a theoretical and experimental approach.

CO_2 gas hydrates were formed in a batch autoclave system with pure water and reconstituted soluble coffee at different concentrations. The influence of the coffee concentration was evaluated based on the induction time, i.e., the time required for the first gas hydrates to form. Moreover, different process conditions with varying initial concentration, pressure and temperature settings were tested, with focus on their influence on macroscopic hydrate structures.

Once stable hydrate conditions were reached after process initiation, instantaneous hydrate formation in both pure water and reconstituted coffee was highly reproducible, with a success rate of over 90 %. The coffee concentration was shown to influence the induction time for hydrate formation. In some cases, hydrate formation with induction times so close to zero were observed, that they could not be quantified.
Every process, when illustrated as a trajectory in a p-T-diagram, evolved in the hydrate stable region, for all chosen process conditions. Varying temperature and pressure levels resulted in different gas hydrate morphologies, ranging from highly dispersed gas hydrate crystals (characteristic length: 1 mm) in coffee slurry, to ordered and topologically simple, large-scale, continuous structures (characteristic length: 10 cm). Within latter structure, an anisotropic distribution of gas hydrates was observed.

CO_2 gas hydrate formation can be triggered in pure water and reconstituted coffee solutions at different concentrations. Both the concentration and the chosen process conditions influence the morphologies of the formed hydrates. The formation of large-scale continuous structures with simple morphologies offers prospect to efficient separation of the solid gas hydrate phase from the remaining liquid, even at ambient conditions. Ultimately, the liquid concentrate can be obtained with minimized coffee loss at low energy input.