Investigation of the mechanism of the CO$_2$ induced gelation of biopolymers towards aerogel production

Master thesis (deutsch/english)

Introduction

Aerogels are lightweight solid materials with high interconnected porosity, large specific surface area, and low density. Aerogels can be produced based on biopolymers to obtain non-toxic, biodegradable aerogels for food or life science applications. The production of biopolymer-based aerogels consists of 3 main steps: 1) gelation, 2) solvent exchange, 3) supercritical drying. Properties like large specific surface area can be influenced strongly by the gelation step itself. A comparable new method of gelation is CO$_2$ induced gelation where pressurized CO$_2$ is applied to biopolymer solutions. Gelation mechanisms depend strongly on biopolymer characteristics. Nevertheless, with some slight modifications combination of gelation methods can be applied to wide range of biopolymer solutions.

It was shown that CO$_2$ induced gelation have some advantageous over other methods like more homogeneous and stable hydrogels, which can be dried then supercritical to aerogels. Further CO$_2$ induced gelation needs less time than other gelation methods (like acid or thermal induced gelation).

The mechanism of CO$_2$ induced gelation of pectin with additional calcium carbonate as cross-linker consists of 5 main steps:

1) Dissolution of CO$_2$ in the aqueous biopolymer solution
2) Reaction of CO$_2$ with water and formation of carbonic acid
3) Drop of the pH value
4) Dissolution of calcium carbonate particles
5) Cross-linking of pectin molecules with calcium ions (gelation)

To understand the whole gelation process, the single steps should be elucidated and modeled.

To understand the gelation mechanism of pectin solutions with applied pressurized CO$_2$ single steps should be studied. First, the dissolution of CO$_2$ into the biopolymer solution and impact of different solution and process parameters. Second, a “gel point” should be defined via viscosity measurements and be connected to already observed dissolution of calcium carbonate particles and drop of the pH value. Obtained results are connected to earlier made in-situ measurements of the gelation process. Further, they should be used to integrate a theoretical (and empirical) model of the gelation process. These models should be used to transfer the knowledge to other gelation systems and enable the process set-up and optimization in industry.

Methods

High pressure CO$_2$ induced gelation, magnetic suspension balance, viscosity measurements, UV-vis spectroscopy

Contact:

M.Sc. Imke Preibisch, room 1.019, phone: +49 (0) 40 42878 2132; email: imke.preibisch@tuhh.de,