Influence of Sonication Parameters on the Morphology of Nanocellulose Aerogels

Dexter Cox  
*University of Northern Iowa*

Tim Kidd  
*University of Northern Iowa*

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Introduction

The term nanocellulose refers to cellulose on the nanoscale. Cellulose is a fundamental component of plant cell walls and vegetable fibers such as cotton, and is insoluble in water. An aerogel is an ultralight solid material with an extremely low density. Aerogels are produced by replacing the liquid component of a conventional gel with a gas. A common method in the replacement of liquid with a gas is the process of freeze drying.

For this study, nanocellulose aerogels of different concentrations were created and measured. The densities of each aerogel were compared to the expected values to determine the amount of contamination. The purpose of this study was to reduce the contamination of the nanocellulose aerogels by reducing the processing time.

Motivation

Nanocellulose and nanocellulose aerogels have been the interest of many studies due to their unique properties and variety of applications.

Properties

Nanocellulose is very resistant to breaking under tension. Its tensile strength is similar to that of aluminum. The rigidity of nanocellulose is also an important property. Its stiffness is comparable to Kevlar. The strength/weight ratio of nanocellulose is eight times that of stainless steel.

Applications

The food applications of nanocellulose were some of the first to be explored. Nanocellulose can be used as a low calorie substitute for carbohydrate additives used as thickeners and can be used to produce fillings, gravies, puddings, and chips/wafers.

Hydrophobic nanocellulose aerogels have been researched for their use in oil spill recovery. Their properties allow them to reject water and absorb oil and have a potential for use in large ocean oil spills.

Aerogel Creation

The nanocellulose aerogels were created through a mechanical process. A Vibra-Cell™ VC 505 Ultrasonic Processor with a titanium probe attachment was used to break down the microcrystalline cellulose (shown in Figure 2). As a result of this process, nanocellulose particles become suspended in water. This suspension was then frozen with liquid nitrogen and placed under vacuum to maintain its volume. The water component was then removed by freeze-drying the sample with the Labconco FreeZone® 4.5 Liter Freeze Dry Systems (Figure 3).

Methods

Standard

For the standard method of creating the aerogel, the nanocellulose is measured and its mass in grams is added to 100 mL of water. The mass of the nanocellulose added is considered to be the concentration. (1 g added = 1% concentration)

Diluted

For the diluted method of creating the aerogel, a 10% concentration is created and sonicated (10 g NC in 100 mL of water). 10 mL of this concentration is then added to 90 mL of water to create the 1% diluted sample.

Discussion

The main source of aerogel contamination comes from probe wear during the sonication process. Low concentration samples require more processing time in order to create a homogenous mixture. As the probe sonicates and breaks down the microcrystalline cellulose, bits of titanium are broken off into the solution.

In an attempt to reduce the amount of titanium contamination, nanocellulose suspensions were diluted and sonicated to a lower homogenous concentration. Other samples were processed for different durations of time to see whether they would maintain their structure and low density. Although nanocellulose aerogels were successfully created, neither diluting samples nor reducing the sonication period proved as an effective way to reduce titanium contamination.

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