

Proteins stabilize Emulsions and Foams of Food Products

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SCOPE

Many food products are produced in the form of emulsions and foams, and it is necessary to formulate these materials to achieve stability. This is accomplished by arresting coalescence and film drainage, or by minimizing the process of Ostwald ripening. For this purpose, additives such as proteins and biopolymers can be added to either diminish or eliminate these events. Many mechanisms have been proposed to explain the success of these interfacial agents and strong correlations have been observed between their ability to enhance interfacial viscoelasticity and improved stability⁽¹⁾. In this application, the utility of making interfacial rheology measurements is extended to monitoring the influence of processing conditions in multiphase systems.

Products such as salad dressings and mayonnaise are often stabilized through the addition of proteins and biopolymers. These oil-in-water emulsions are thought to be stabilized by an interfacial gelation of the protein that renders the droplet surfaces resistant to rupture and coalescence. In solution, proteins are known to fold into conformations that have the hydrophobic portions of these biopolymers largely shielded from the surrounding water. However, when presented to an oil/water interface, proteins can denature and lower the free energy of the interface by adopting conformations that present the hydrophobic moieties to the oil phase, while leaving the hydrophilic parts of the molecules in the water. This denaturation subsequently exposes disulphide bonds that can crosslink the protein and create a two-dimensional gel at the interface. This process can take considerable time and measure-

ments of surface gelation commonly yield gel times on the order of many hours⁽²⁾. Biopolymers, such as locust bean gum and xanthan gum are also widely used as stabilizers. These molecules can be amphiphilic with a strong propensity to partition to oil/water interfaces and when located at such interfaces can also be subject to strong associations that are not otherwise present in aqueous solution.

Processing conditions can influence the surface gelation and this is investigated in this application note. Denaturation of protein is known to be accelerated by raising temperature. Likewise, molecules forming microcrystals can be encouraged to spread onto interfaces at elevated temperatures. The influence of this variable was examined on a simple oil/water/biopolymer system that is representative of what might be encountered in the food industry.

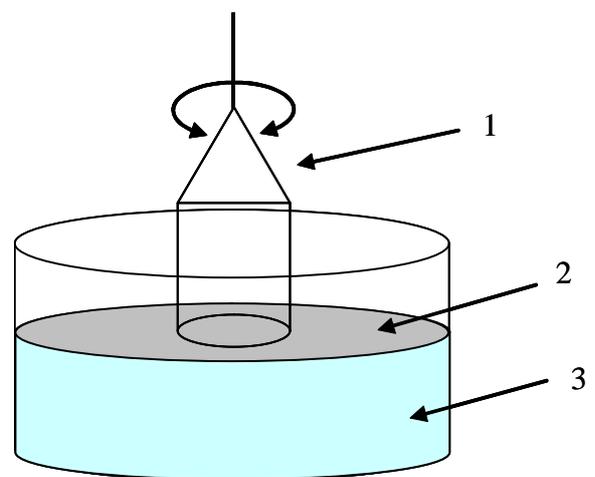


Figure 1: Du Noüy ring used with the AR-G2 rheometer
1. Du Noüy ring, 2. Top interface of sinflower oil, 3. Solution of Polysaccharide

MATERIALS AND METHODS

These experiments investigated the interface between water and sunflower oil. The biopolymer was locust bean gum, which is a galactomannan similar to guar gum. It is polydisperse, consisting of non-ionic molecules made up of about 2000 residues. At low temperatures it crystallizes and it is necessary to heat aqueous solutions of this polysaccharide to induce solubility. The response of locust bean gum was compared to solutions of alginate and carrageen*.

The interfacial viscoelasticity measurements were performed using a TA Instruments AR-G2 rheometer outfitted with a du Nouy ring (Figure 1). The ring was placed in the surface of the aqueous solutions of 0.25 wt% of locust bean gum, alginate or carrageen. At this concentration, *bulk* gelation of the solutions was not observed. The Sunflower oil was added afterwards. With the Du Noüy ring in place at the water/oil interface, the interfacial moduli were monitored at a constant frequency of 1 Hz as a function of time and at various temperatures.

RESULTS

Figure 2 shows the evolution of the interfacial elastic modulus G' as a function of time for a locust bean gum solution beneath sunflower oil as a function of time and at various temperatures. From these data, it is clear that significant interfacial elasticity is only achieved if the solution is first heated to at least 60°C and then cooled down to room temperature. In the absence of heating the solution, the re-

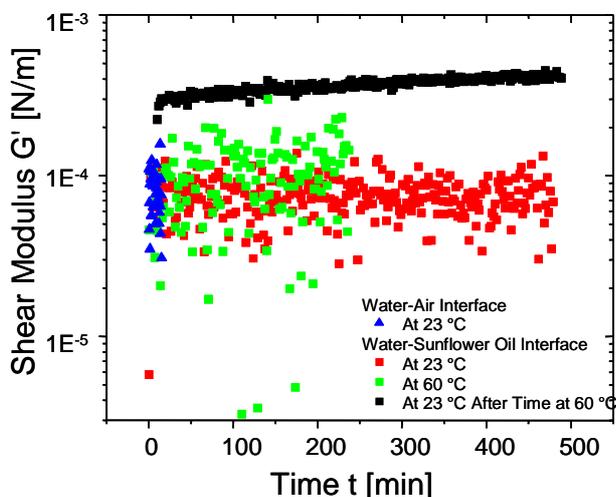


Figure 2: Storage modulus as a function of time for an unfiltered solution of Locust Bean gum (0.25% (w/w) at both water air and water/sunflower oil interface

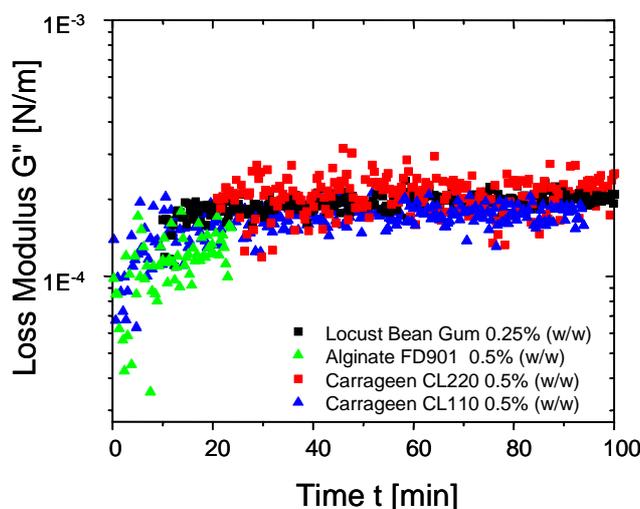
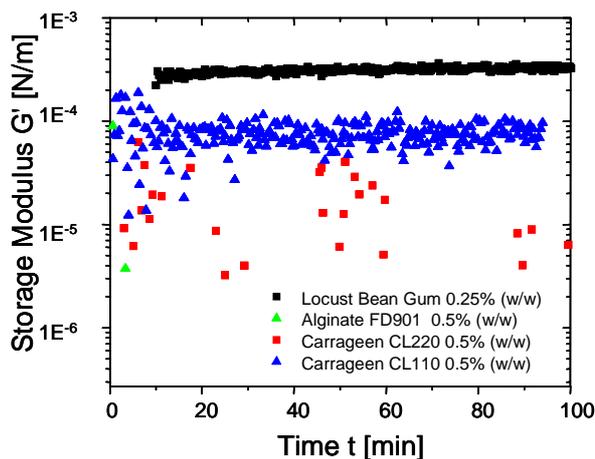


Figure 3: Storage and loss modulus as a function of time for several additives at the water/sunflower oil interface

sulting interfacial properties are similar to a simple air/water interface in the absence of the biopolymer. Surface gelation only occurs after cooling off the previously heated solution. Furthermore, the data reveal a very long surface gelation process for this particular system, which is common to many biopolymer and protein formulations.

The locust bean gum additive is known to be an effective stabilizer in comparison to other possible biopolymers. In Figure 3, the interfacial elastic modulus G' and the storage modulus G'' are shown as a function of time for three different biopolymers, locust bean gum, alginate and carrageen. After heating to 60°C, the sample was allowed to cool, while monitoring the changes over time. Although one form of carrageen was found to display a slight degree of interfacial viscoelasticity, the locust bean gum produced a markedly greater degree of surface gelation, suggesting that it is a superior stabilizer of this oil/water system, if the correct

*These materials were kindly provided by the food rheology group of Professor de Cindio of the University of Calabria.

temperature and processing conditions are used.

CONCLUSION

Proteins, due to their amphiphilic property, can adsorb at the water-oil interface and denature to form an elastic 2-D network, strong enough to resist film rupture - thus stabilizing emulsions from coalescence and foams from film drainage. The shear interfacial dynamic modulus is very sensitive to the changes at the interface. As such the interfacial shear modulus is an ideal monitor to follow variations over time and to study the interfacial phenomena under various conditions.

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