LIBERTY UNIVERSITY

Exploring Soap Thickeners: A Comparative Study of Sodium Chloride to the Alternate Benefits of Carrageenan and Xanthan Gum

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Background

Soap viscosity is an important factor in customer consumption. Low viscosity soaps are difficult to apply to the hands without losing product and consequently having to dispense more. [1] This brings forward the use of soap thickening agents. These agents are formulated into soap products to make the soap spreadable and holdable for cleaning hands. Among many soap products, sodium chloride, is the most abundant and common additive in formulations across many soap products. Sodium chloride can dry the skin and cause irritation to those with sensitivities. [2] To combat this, alternative thickening agents can be substituted into the formulation. Alternative thickeners may also have additional benefits without the downside of skin dryness.

Sodium chloride is only a thickener in special cases such as soap due to its ingredients and structure, however the polysaccharides carrageenan and xanthan gum can thicken water by themselves. [3] Carrageenan is derived from a red seaweed plant (Figure 6) and xanthan gum is a powder (Figure 7) that comes from the fermentation of carbohydrates. [4] Viscosity is one way that these additives can be compared. There are many ways to measure viscosity. One example is with a Zahn cup (Figure 9) primarily used in the paint industry where the cup drains and is timed to see how long it takes for the liquid to leave the cup from a bottom opening. [5] Another is a rotational viscometer where the rotational torque is used to determine viscosity based on the amount of force it takes to rotate an object. [6] A third way is with a falling sphere viscometer where a ball is dropped into the liquid and timed to see how long it took to reach the bottom of the container.

Research Question

How do the alternate thickeners carrageenan and xanthan gum compare to the most common soap thickener sodium chloride in terms of viscosity and skin benefits?

Methods

The main methods of research were through CAS Scifinder^{n}, Science Direct, and Google Scholar. Literature searches about the topic tuned over many results. When searching “polysaccharide thickeners and soap” through Scifinder as seen in Figure 3, the results of articles were over 400. Changing the search to each of the specific additives brought much narrower results. These included keywords such as sodium chloride, carrageenan, xanthan gum, and soap. Additional searches to find information regarding each additives structure and function was conducted. . An additional Biblical search was carried out in which there were 128 total mentions of “washing”. [7]

The following experiments may be proposed: (1) test each thickener in increased concentrations to measure the viscosity of each solution; (2) test soap formulation to observe the lathering properties of each.

Future Work

Additional future work would be to conduct the proposed experiment to test and observe the differences in thickeners through viscosity measurements. Other possible future work may include research and testing of additional alternative thickeners for further comparison.

Market Data

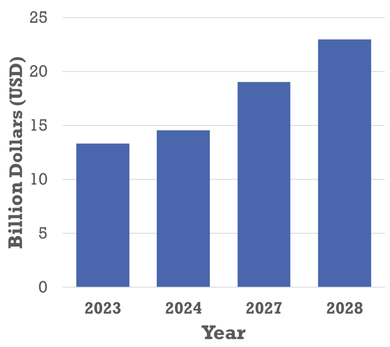

Figure 1: Expected Market Value Per Year

Micelle Structures

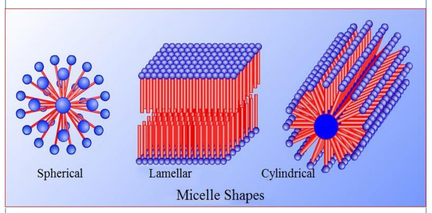

Figure 2: Micelle Shapes [20]

CAS Scifinder^{n} Search Results

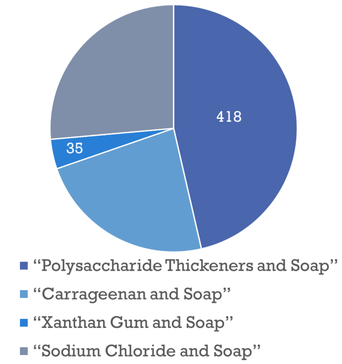

Figure 3: Search Results

Alternative Thickener 1

Figure 4: Carrageenan [21]

Alternative Thickener 2

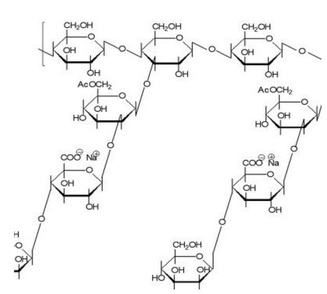

Figure 5: Xanthan Gum [22]

Red Seaweed

Figure 6: Red Seaweed of which carrageenan is derived [23]

Xanthan Gum

Figure 7: Xanthan Gum Powder [24]

Sensitive Skin Soap

Figure 8: Sodium Chloride Free Soap [16]

Viscometer

Figure 9: Zhan Cup Set [5]

Results and Conclusions

Researching the structures, it was found that soap formulations contain micelles which is a spherical structure that forms by aggregating surfactant molecules. [8] Sodium ions in sodium chloride cause the micelle charge density to lower. [9] This causes more micelle agglomeration which can ultimately lead to lamellar structures forming a thicker solution. Surfactant concentrations may appear in different shapes (Figure 2) based on its concentration with lamellar being one of the variants. [8] The structure of xanthan gum in Figure 5 shows negatively charged carboxyl groups on the side chains. These groups are responsible for the increase in viscosity through their ability to form hydrogen bonds with water molecules. [10] In water, the molecules of xanthan gum form ribbon-like bonded spiral copolymers that coil to create a thicker solution. [11] Carrageenan works in a similar manner as it form matrices that wrap around each other and other water molecules to immobilize each other, thus thickening the solution. [12] K^{-} and I^{-} carrageenan involves helix formation on cooling from a hot solution together with gel-inducing and gel-strengthening K^{+} or Ca^{2+} cations. [13] The structure is shown in Figure 4.

Carrageenan [14] and xanthan gum [15] provide moisturizing properties that may be more beneficial substitutes to sodium chloride to soothe the skin. When researching soaps, many sodium chloride free soaps were marketed as natural or for those with sensitive skin such babies. (Figure 8) Some soaps found included xanthan gum and carrageenan in these formulations. [16] Other products use different thickeners, [17] or no thickener at all. [18]

In addition to the literature search on the research question, the market data for soap was found to be very large. The hand wash market size will grow from $13.31 billion in 2023 to $14.54 billion in 2024. [19] (Figure 1) The industry is expected to continue to grow for the next few years. This growth is heavily influenced by the rise in infectious disease such as the COVID-19 and flu viruses.

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