WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 3, Issue 5, May., 2022

STUDY OF THE INFLUENCE OF SALT CATIONS ON THE RHEOLOGICAL STATUS OF GELLAN GUM BEFORE GEL FORMATION

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Abstract

The work is devoted to the study of the influence of cations, such as calcium chloride and ferrous sulfate, on the rheological status of gellan gum before gelation and the suitability of flow models for their characterization. Gellan gum was used as a gelling agent .

Keywords: Viscosity, gels, pH, temperature, rheogram.

Introduction

Understanding the behavior of sol flows prior to gel formation is important for the development of nutrient-enriched gels. The effect of cations such as $CaCl_2$ (0.05 and 0.1%, wt./wt .) and $FeSO_4$ (0.05 and 0.1%, wt./wt .) on the rheological properties of 1% gellan sol (wt ./ wt .) before gelling. The apparent viscosity reported at a shear rate of 100 s-1 showed that the gellan dispersion without any cation had lower values compared to other samples containing various cations. The cross model provided the best fit ($0.97 \leq r \leq 0.99$, $p \leq 0.01$) compared to the moderate force law model ($0.94 \leq r \leq 0.98$). Among various cross-model parameters, zero shear viscosity (η_o) increased with the addition of $CaCl_2$ and $FeSO_4$ and as their concentrations increased. The viscosities of the embryos were 0.46 for gellan sol, 0.79 for gellan with 0.05% (w / w) $CaCl_2$, 1.41 for gellan with 0.1% $CaCl_2$, 3.85 for gellan with 0 05% $FeSO_4$ and 4.33 for gellan with 0.1% $FeSO_4$. Increasing the concentration of cations from 0.05 to 0.10% (w / w) slightly increased the relaxation time (λ), indicating the development of harder characteristics in the ash.

The importance of rheological characterization lies in process and product development, flow system design, scaling and modeling in addition to understanding transport, flow and deformation behavior. For a liquid food product such as a hydrocolloid dispersion, the generation of a wide range of shear rate/shear stress/apparent viscosity data helps to understand the behavior of the material, which is useful for many practical applications, including those associated with sensory features.

Food gels based on hydrocolloids are gaining popularity as attractive confectionery products. These specialty gels offer special benefits including an attractive appearance and texture as well as enjoyment while eating. However, the judicious selection of hydrocolloids and other additives, as well as the control of appropriate gel formation conditions such as temperature, pH, concentration, and time, are equally important in order to obtain a hydrocolloidal gel with desired objective and subjective characteristics.

hydrocolloids are used in the food system . Among these hydrocolloids used in food preparations, gellan gum has several advantages including product development with sparkling viscosity. It is an anionic polysaccharide obtained by Sphingomonas elodea , formerly Pseudomonas elodea . Commercially, it is produced through a fermentation process. This polysaccharide is widely used in the food and biotechnology industries because it forms a relatively warm and acid resistant gel compared to other polysaccharide gels. The exact gelation properties depend critically on the cation present. Gellan also has several advantages such as easy and fast setting to create a highly clear gel. Multi-component or mixed gels containing gellan can be combined with another hydrocolloid to offer special features that may not be possible using a single gelling agent alone have determined the textural signatures of gellan gels formed by mono- and divalent cations.

Binary gels using a mixture of gellan and other hydrocolloids have been reported that the concentration of gellan gum has a pronounced effect on the textural properties of the resulting gel. The characteristics of viscoelastic (vibrational properties) of gellan sols were determined at low concentrations (0.005-0.05%). They noted that strengthening of network structures occurs with increasing concentration of gellans , which ultimately leads to more elastic gels, well confirmed by the rheology of the systems.

Divalent cations are more effective gel formers than monovalent cations. Marginally soluble calcium salts such as calcium sulfate, calcium chloride and calcium citrate have been reported to form crosslinks in gels. Experiments have suggested that gellan gum dispersions with sufficient divalent cations form solid gels when cooled below the gel setting temperature. This behavior differs markedly from that of thermoreversible gels formed with gellan resin alone or in the presence of monovalent cations. In this context, it may be possible to use divalent sources of iron and calcium to be used in conjunction with gellan , so that the designed gels can serve as a good source of these nutrients. Therefore, there is an area for the development of gellan gels incorporated with divalent ions, where the characterization of the sol is indispensable to understanding its flow behavior. The usefulness of such research lies in the selection and development of a flow system for processing gellan sols prior to the preparation of gels that are beneficial to health.

It was prepared in distilled water by hydrating the resin powder in a magnetic stirrer for 15 min, followed by heating in a water bath, maintained at a temperature of 90°C for 20 min. Concentrations of 0.05 and 0.10% (w / w) for $CaSO_4$ and $FeSO_4$ were adjusted by adding these solids only at the end of the gellan gum heating period followed by good mixing using a mechanical stirrer. The concentration of 0.15% (wt./wt .) was difficult, since the formation of the gel began immediately upon addition.

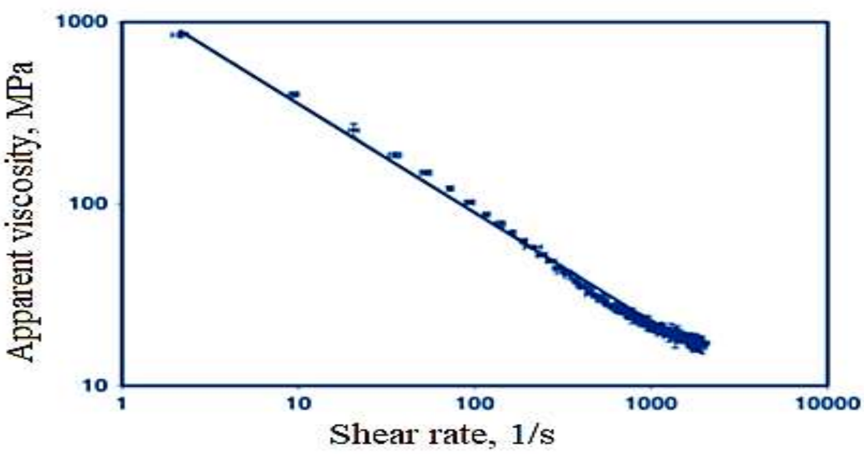

Figure 1. Sample plot showing apparent viscosity versus shear rate for 1% gellan dispersion

rheogram (plot of apparent viscosity vs. shear rate) for a 1% gellan or sol dispersion (w / w) (Figure 1) shows non-Newtonian shear thinning characteristics as a logarithmic linear decrease occurs as shear rate increases. The phenomenon of shear thinning is often found in food systems, which is believed to be associated with the disruption of particles existing as agglomerates in dispersions. It has been shown that the force law model can adequately describe the flow behavior and viscosity values at low and medium shear rates for dilute gellan dispersions near the sol-gel transition. In the present study, the Cross model can provide an excellent fit ($0.97 \leq r \leq 0.99$, $p \leq 0.01$) (Figure 1) compared to a moderate fit of the force law model ($0.94 \leq r \leq 0.98$). The increase in zero shear viscosity (η_o) and infinite shear viscosity (η_∞) of the Cross model occurs with increasing cation concentration (Figure 2). Zero shear viscosity reflects the undisturbed status of the sample and is important in storage; this indicates rheological status at an extremely low shear rate, as in a collision. An increase means that the system is more stable during storage and does not leak. Infinite shear viscosity occurs at high shear rates and represents the rheological state of a sample that is subjected to a high degree of disturbance such as spraying, mixing and pumping. However, the values of infinite shear viscosity are much smaller than their corresponding zero shear viscosity, and therefore this term can be neglected compared to η_o . The power index of the Cross model (n) reflects the characteristic behavior of the sample; a high value of n reduces the apparent viscosity of the system. In the range of present experimental conditions, n values are between 0.38 and 0.86.

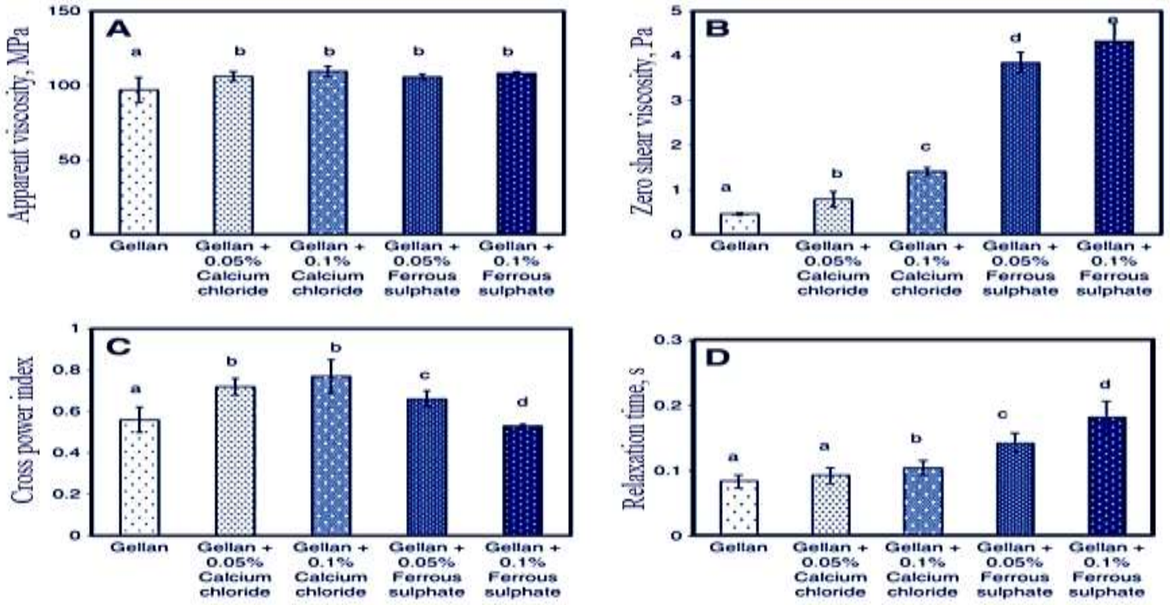

Figure 2. Influence of different cations: A - on apparent viscosity at a viscosity shear rate of 100 s-1, B - zero shear viscosity, C - Cross power index and D - relaxation time of gellan dispersions .

The effect of cations on various flow parameters is shown in Figure 2. The apparent viscosity reported at a shear of 100 s-1 indicates that the gellan sol without any cation has a lower apparent viscosity compared to other samples containing various cations; the latter samples do not differ statistically ($p \leq 0.01$) from their apparent viscosity (Fig. 2A). Among various Cross Model parameters , zero shear viscosity (ηo) increases with the addition of $CaCl_2$ and FeSO4 and with their respective concentrations (Fig. 2B). The power index (n) of the Cross model is a dimensionless constant that reflects the characteristics of the dispersions. An increase in n values is expected to decrease the apparent viscosity of the system. In the present study, it varies depending on the type and concentration of cations (Fig. 2C). However, there is no clear trend in n values with cations. It is possible that the non-linear analysis method used in this paper (to calculate n values) cannot detect small changes occurring in n values. The relaxation parameter (λ) is a measure of the time taken for the material to relax to 1/4 of the initial stress. A low value indicates the predominant characteristics of the liquid, while a high value indicates a solid behavior; the liquid offers instant relaxation when allowed to relax and has a value close to zero. In contrast, a solid sample takes a significant amount of time to relax, while viscoelastic samples offer intermediate values between an ideal fluid and an ideal solid. Increasing the cation concentration from 0.05 to 0.10% (wt / wt) increases the λ values, especially for FeSO4 sol samples, which means the development of harder characteristics before gelation. The sol containing 0.10% (wt./wt .) $FeSO_4$ has a prominent solid characteristic, as evidenced by the highest value of λ 0.83 (Fig. 2D).

Calcium salts such as calcium sulfate, calcium chloride and calcium citrate have been reported to attempt to crosslink in gels. The formation of such cross-links increases the viscosity of the system. Previous research done suggests that gellan gum dispersions with sufficient divalent cations can form solid gels when cooled below a given temperature. This behavior differs from that of thermoreversible gels formed with gellan gum alone or in the presence of monovalent cations. The gelling properties of the gellan sol depend critically on the cation present. For gellan gum, it is necessary to create a sufficient amount of divalent cations to form a solid gel in different zones of the connection with different thermal stability. In the present work, an increase in the concentration of cations increases the apparent viscosity of the ash system. Divalent cations contribute to the formation of more stable bonding zones than monovalent cations. For example, the temperature increases from about 71 to 80°C as the calcium concentration increases from 2 to 80 mM . A similar increase is also observed with an increase in the concentration of sodium or potassium from 10 to 200 mM . High acyl gellan gum is capable of forming self-supporting gels at concentrations above about 0.2% gum.

Gellan dispersions behave like non-Newtonian fluids and exhibit shear thinning characteristics. The presence of cations such as CaCl2 and FeSO4 changes the rheological status of the sol to gelation. The Cross model is suitable for explaining the relationship between shear rate and shear stress. The change in the dispersion relaxation time depends on the level and type of cations.

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