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FORMATION AND STUDY OF HYDROGELS BASED ON GELLAN

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Abstract
This work is devoted to the creation of new materials based on gellan, which have the prospect of being used as a packaging material and as a matrix for incorporating functional particles .

Keywords: gellan , chloride, macromolecules, swollen particles, polysaccharide, hydrogels.

Introduction

The possibility of obtaining hydrogels from gellan polysaccharide was investigated. Dissolution of gellan in distilled water at room temperature led to the formation of suspensions in which gellan was in the form of swollen particles. When the suspension is heated up to 80° Gellan dissolved and clear solutions formed. It was seen that with an increase in the concentration of gellan, an increase in the viscosity of the solutions occurs.

Figure 1 shows the dependence of rheological parameters on the concentration of gellan.

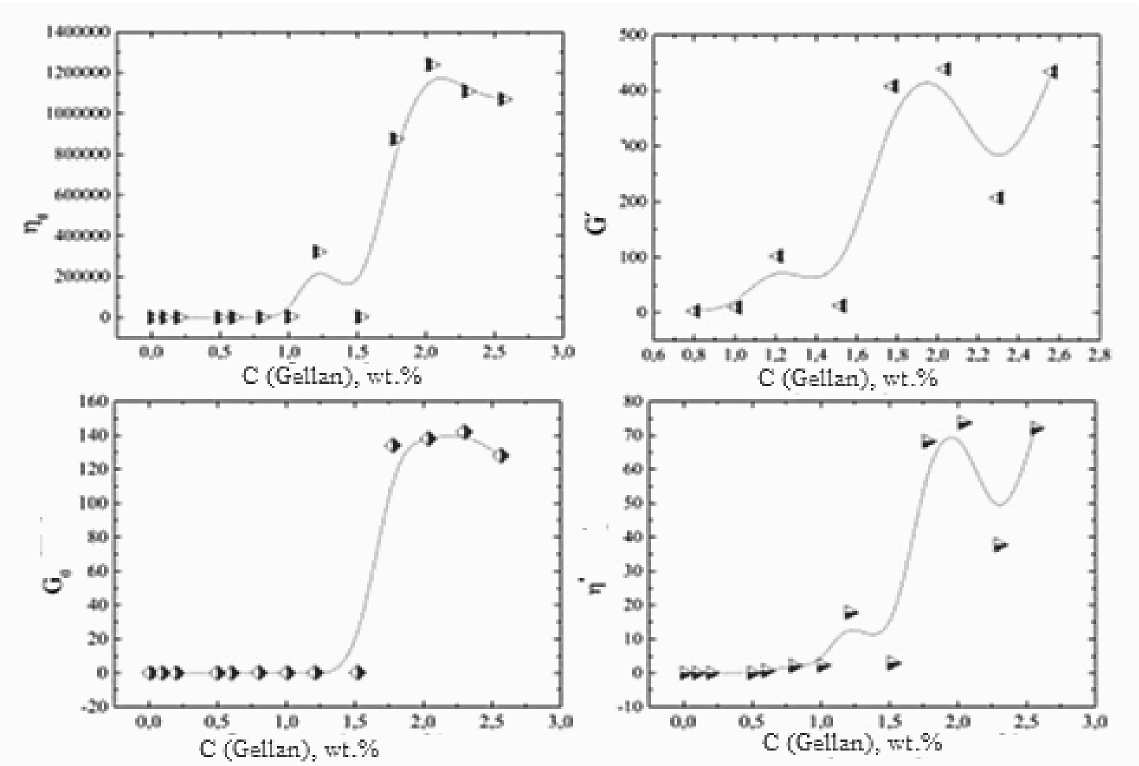

Figure 1. Dependence of static viscosity (η_0), storage modulus G', plateau modulus (G_0) and complex viscosity (η *) on gellan concentration

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With an increase in the concentration of gellan , an increase in all rheological parameters occurs. Moreover, upon reaching a concentration of 1.5 wt.%, their sharp increase is observed, which indicates a solution-gel phase transition.

A study of the phase behavior showed that at a gellan concentration of 1.2 wt %, gellan solutions stop flowing, turning into a gel. The gelation time decreases, which indicates an increase in the speed of the process.

The introduction of divalent metal salt solutions into cold gellan solutions leads to the formation of heterogeneous gels in the form of clots. The reaction proceeds instantly. When they are introduced into hot gellan solutions, homogeneous hydrogels are formed. As their concentration increases, the phase behavior of hydrogels changes. Figure 2, using the calcium chloride salt as an example, shows the dependence on the phase behavior and gelation time . With the introduction of small amounts of calcium chloride up to 0.01 mol / l, transparent hydrogels are formed, with an increase in concentration, opalescence appears, which intensifies with the formation of cloudy systems.

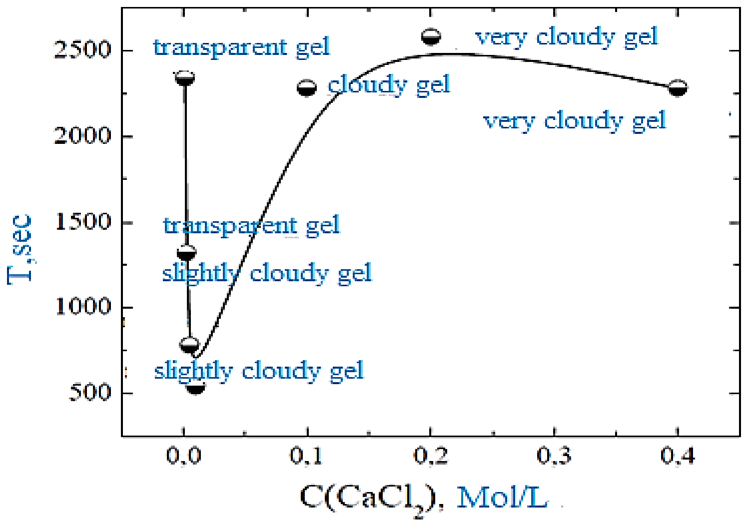

Figure 2 . Dependence of the gelation time and phase behavior of hydrogels on the concentration of calcium chloride. Composition: 0.6 wt.% gellan, calcium chloride

As can be seen from the figure, the gelation time with an increase in the concentration of calcium chloride first decreases, and then increases and practically does not change. This behavior can be associated with phase transitions in the system.

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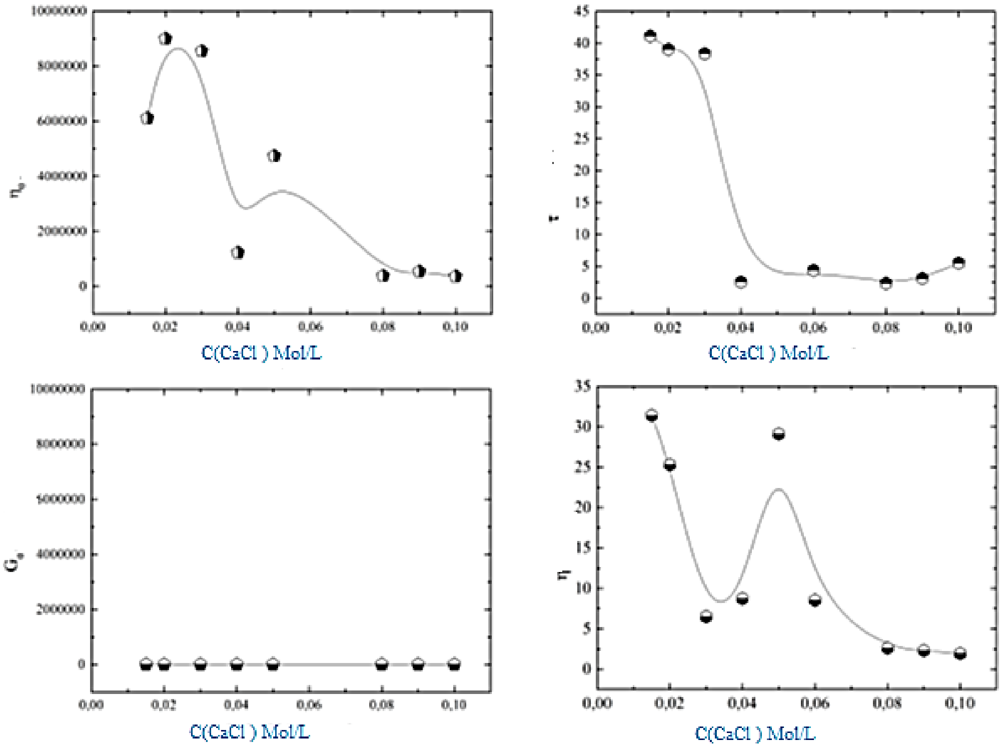

Figure 3. Dependence of static viscosity (η_0), critical shear stress (τ), plateau modulus (G0) and complex viscosity (η *) on calcium chloride concentration. Composition: 0.6 wt . % gellan calcium chloride

Studies of the mechanical properties of hydrogels are presented in Figure 3. As can be seen from Figure 3, with an increase in the concentration of calcium chloride, a decrease in rheological characteristics occurs. This indicates that the hydrogels are becoming more brittle. Gellan macromolecules lose their elasticity due to multiple cross-links with calcium cations. According to gellan solutions macromolecules are in the form of coils. The introduction of divalent cations leads to the formation of ionic bonds with carboxyl groups. Due to this, double helices are formed, which aggregate with an increase in the concentration of cations, which contributes to an increase in the rigidity of the structure. Therefore, at a lower load, the destruction of such systems occurs.

Studies of the surface morphology of hydrogels explain this nature of the dependences. Figure 4 shows images of hydrogels made using a scanning electron microscope. As can be seen from Figure 4 , in the absence of calcium chloride (Figure 4, a), the hydrogel is a fibrous structure of orderly intertwined gellan macromolecules .

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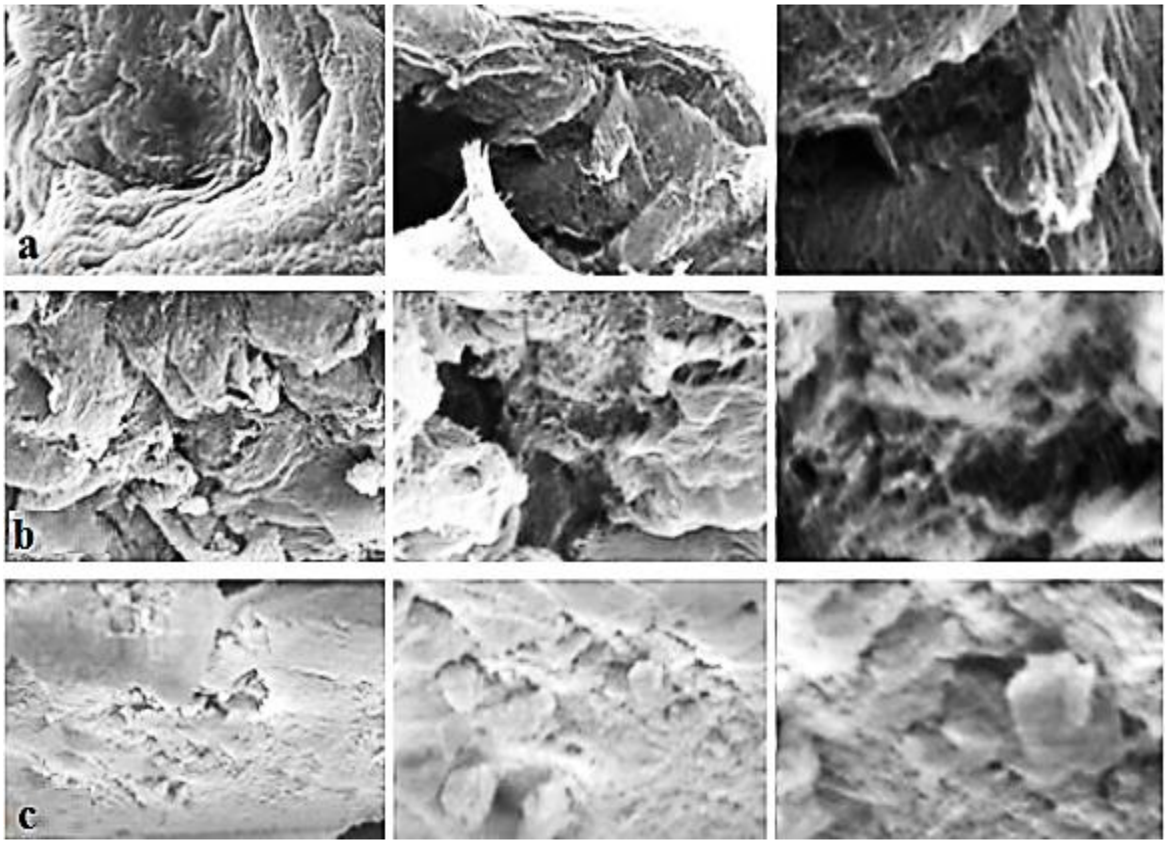

Figure 4. Images of hydrogels obtained using a scanning electron microscope. Sample composition: gellan 0.25 wt . %, calcium chloride a - 0 mol/l, b - 0.0026 mol/l; c – 0.4 mol/l

The introduction of small concentrations of calcium cations during the formation of gellan hydrogels leads to a change in the surface morphology. As can be seen from Figure 4 (b), the structure is compacted, but individual gellan macromolecules are visible .

With an increase in the concentration of calcium chloride (Figure 4, c), the structure becomes amorphous and porous, therefore, more fragile.

The study of syneresis of hydrogels is presented in Figure 5. As can be seen from the figure, almost all hydrogels undergo syneresis, but the amount of liquid released was small, at the level of the experimental error for its determination. It turns out that hydrogels based on gellan and calcium chloride practically do not decrease in volume when they stand. It should be noted that for hydrogels without the addition of calcium chloride, the phenomenon of syneresis is not typical.

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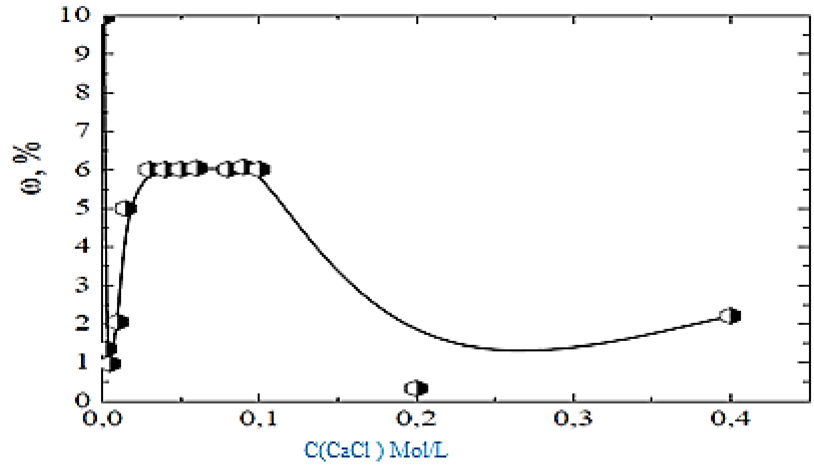

Figure 5 . Dependence of the maximum amount of liquid (ω, %) released from hydrogels on calcium chloride concentrations. Composition of hydrogels: 0.6 wt .% gellan , calcium chloride. Standing time of gels 3 days

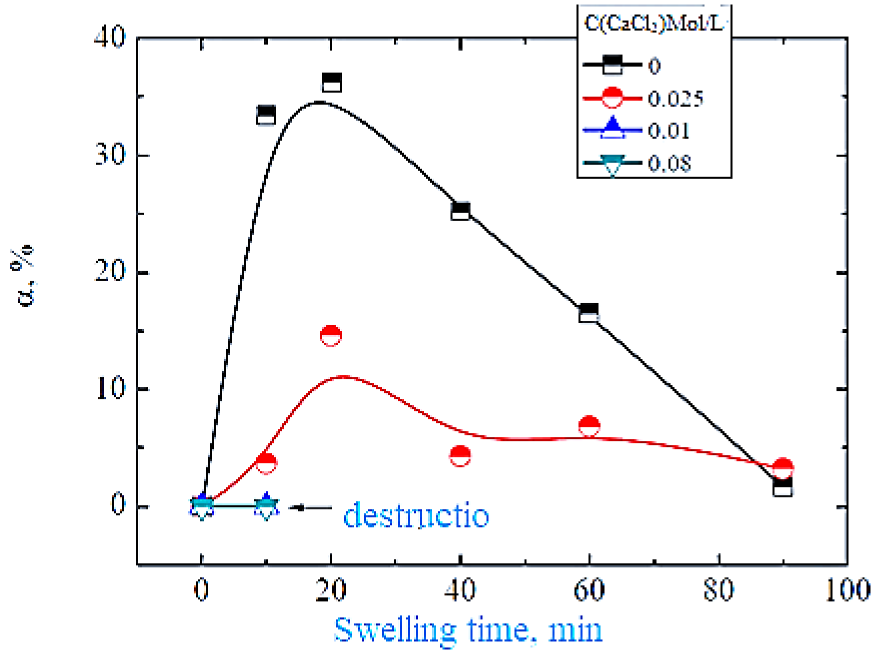

Figure 6 . Kinetics of swelling of hydrogels in distilled water depending on the concentration of calcium chloride. Ingredients: gellan 0.25 wt %, calcium chloride

The study of swelling of materials is an important characteristic in their operation. The swelling of hydrogels in distilled water was studied. Figure 6 the kinetics of swelling of hydrogels in distilled water is presented. As can be seen from the figure, the swelling of hydrogels is unlimited. After 20 minutes, and in some cases even earlier, destruction occurs.

Conclusion With an increase in the concentration of calcium chloride reduces the "lifetime" of hydrogels. According to rheological and morphological studies, an increase in the concentration of calcium chloride makes the samples more brittle and amorphous.

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