RHEOLOGICAL ASPECTS OF POLYSACCHARIDES

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1. Introduction

Polysaccharides are natural polymers, or biopolymers with broad spectrum of applications due to their capability of modifying the solution properties by thickening, gelation, emulsification, stabilization, encapsulation, flocculation, swelling and gel formation [3].

They have many industrial applications, for example in food, chemical, pharmaceutical, cosmetic, textile, paint, oil industry, medicine and much more [2]. For all of these applications, the key parameter to manipulate is the product structure which mainly influences the mechanical and rheological properties of the material [1], which consequently determine the functionality of products made of polysaccharides.

2. Experimental methodology and materials

The purpose of the research was to examine how aging of polysaccharide samples modifies their mechanical properties, and hence the functionality of final products. The analysis of viscoelastic moduli, obtained experimentally by rheological tests, enabled us to understand the structural characteristics of examined materials. Besides, we used rheological experiments to test the material stability.

The materials, used in our research, are listed in Tab. 1.

Material	Type	Serial no.	Producer
Gellan	Kelcogel	8I0043A	Monsanto
Welan	K1A96	24046K	Monsanto
Xanthan	FNCS	2503647	Jungbunzlaver
HPMC	K4M	UF3052	Methocel
CMC	/	C-5013	Sigma

Tab. 1. List of tested materials.

Each sample was prepared in a way that biopolymer powder was weighed in a glass beaker, distilled water was added, and the solution was stirred well by glass rod. Samples of five materials were prepared as 1 wt. % water solution, stored in refrigerator at 5 °C. Before each test samples were left for 10 min at room temperature, and during tempering the solution was stirred to assure homogeneous substance.

For measuring rheological properties within a linear viscoelastic response of tested materials we used rheometer Anton Parr, Physical MCR 301. The experiments were performed at 20±0.1°C. The steady temperature during complete test was kept by using glass lid which prevented also other influences from surrounding of instrument. Dynamic shear storage modulus G' and dynamic shear loss modulus G" as functions of oscillation frequency ω in a range from 0.1 to 100 rad/s were measured on all five materials.

3. Results and discussion

Fig. 1 shows frequency dependent behavior of dynamic shear moduli for water solutions of (a) gellan, welan and xanthan, and (b) HPMC and CMC. For water solutions CMC and HPMC shear loss modulus G" exceeds shear storage modulus G' in the whole frequency range examined (see Fig. 1b), which characterizes more pronounced viscous behavior. Both moduli increase by increasing frequency, with G" increasing slowly than G', and at higher frequencies both tend to the same value.

For samples of gellan, welan and xanthan both moduli G' and G" (see Fig. 1a) change with the frequency much less. They exhibit more pronounced elastic properties, reflecting in elastic shear modulus G' exceeding viscous shear modulus G" in the whole frequency range examined. Such characteristic response is typical for weak gels [3]. In the whole frequency range both moduli of gellan, welan and xanthan exhibit much higher values that in the case of CMC and HPMC samples. The values of dynamic shear moduli for gellan and welan are almost a decade higher than in a case of xanthan.

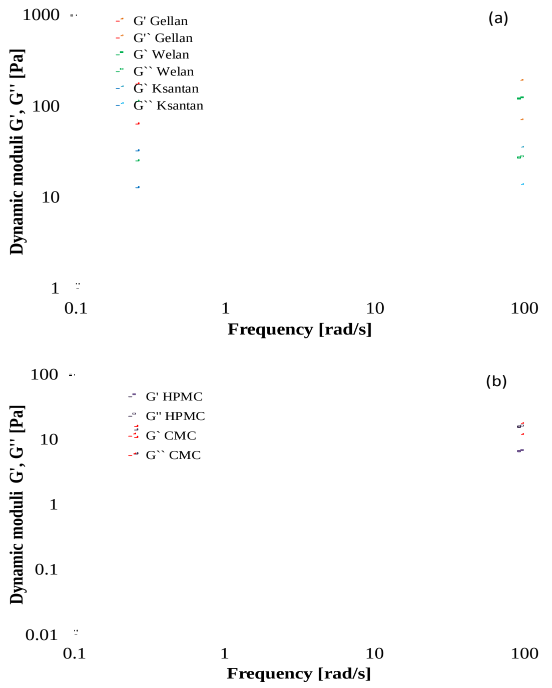
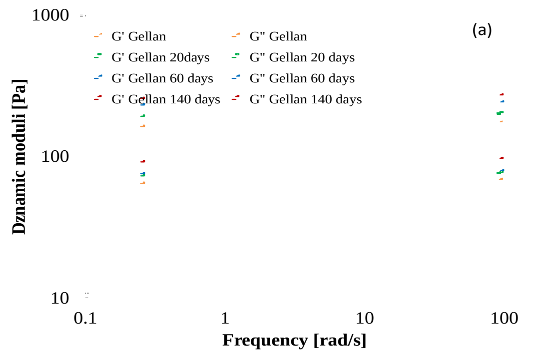


Fig. 1. Shear storage modulus G′ and shear loss modulus G″ as a function of shear frequency.

The influence of aging on the viscoelastic behavior of all five materials was examined by analysing rheological tests, performed after 20, 60 and 140 days. The results of rheological tests for welan, xanthan, HPMC and CMC were repeatable, but for gellan we observed changes in rheological properties already after 20 days. We noticed that the sample didn't form the final structure during sample preparation; probably the process of forming network was not completed. Fig. 2a shows the results of frequency tests for gellan, made after different stages of aging. It is shown that the values of both components of response, viscous and elastic, increases with aging.

The measurements of shear deformation as a function of time, recorded with creep and recovery tests, are shown in Fig. 2b.



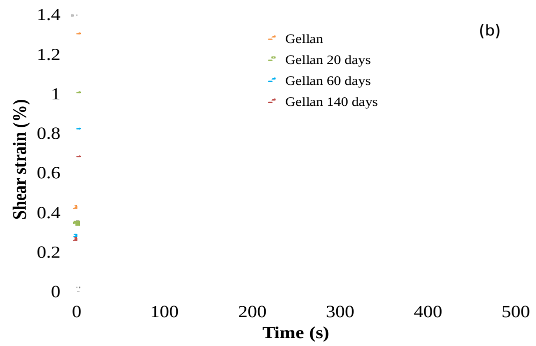


Fig. 2. (a) Frequency dependence of shear storage modulus G′ and shear loss modulus G″ for aged gellan samples, (b) Shear strain, determined with creep and recovery tests for aged gellan samples.

Differences in response at different stages of aging show that the structure of gellan samples changes with aging. The sample becomes more elastic with aging, which is noticed in shear deformation, being the lowest for the sample, tested after 140 days of aging.

4. Conclusions

The frequency tests confirmed that gellan, welan and xanthan in water exhibit more pronounced elastic properties than HPMC and CMC. Such behavior is characteristic for weak gels. For CMC and HPMC solutions shear loss modulus G'' prevails over shear storage modulus G' in the whole frequency range examined, which shows more pronounced viscous character of materials.

The analysis of rheological tests showed that the behavior of welan, xanthan, HPMC and CMC in water doesn't change after aging, while the differences in behavior of gellan appear already after 20 days.

References

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