

Rheological properties of polymer gels based on a polysaccharide network with dynamic cross-links

Shibaev A.V., Smirnova M.E., Muravlev D.A., Kuklin A.I., Gavrilov A.A., Philippova O.E.

Department of Physics, Lomonosov Moscow State University

shibaev@polly.phys.msu.ru

The aim of the work is to synthesize and study the mechanical properties and structure of hydrogels of a polysaccharide – carboxymethyl hydroxypropyl guar – cross-linked simultaneously by two types of cross-linkers – by metal ions and additional dynamic covalent cross-links. A method for obtaining such gels was developed, and their properties were studied by rheometry and freeze-fracture transmission electron microscopy (FF-TEM). It was shown that the mechanical properties of gels with two types of cross-links are higher than for the gels with each type of cross-links taken separately.

Polysaccharides find vast applications as thickeners, e.g. in food industry, consumer goods, oil recovery etc. However, the mechanical properties of the gels are usually not sufficient in order to withstand strong repeated mechanical deformations. In order to increase their strength, several types of cross-links can be simultaneously used, which act differently during deformation – weaker “reversible” cross-links break and recombine and dissipate energy, while stronger cross-links maintain elasticity of the gel. For polysaccharides, mostly multivalent ions are used as cross-linkers, but the recovery of such cross-links after breaking is usually poor. The aim of this work is to synthesize and investigate the rheological properties of polysaccharide gels with two types of cross-links: ionic and reversible covalent bonds.

It was shown that the mechanical properties of the dual-cross-linked gels are enhanced as compared to similar gels with each type of cross-linker taken separately: the increase of the shear and tensile elastic moduli is observed, and the rise of dissipated energy is seen at low deformation frequencies, where the weaker borax cross-links reversibly break and recombine. FF-TEM micrographs show that the gels have microphase separated structure, and the thickness of the “skeleton” of the polymer network increases upon the introduction of the second cross-linker, probably due to higher tendency of the polymer chains for side-by-side aggregation.

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