

EFFECTS OF GELATION CONCENTRATION ON CYCLIC DEFORMATION BEHAVIOR OF POLYSACCHARIDE HYDROGELS

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ABSTRACT

Cyclic deformation behavior of κ -carrageenan and agarose hydrogels have been examined to elucidate the relationship between the network structures of polysaccharide hydrogels and their mechanical properties. Regarding the gelation mechanism on the molecular level, it has been commonly reported that these polysaccharides dissolved in water tends to transform the chain conformation from random-coil to helix on decreasing temperature and a piece of hydrogel appears successively by the aggregation of the helical chains to be crosslinks of the gel above a critical concentration. However, there is a decisive difference in the interaction between aggregated helices. In the case of κ -carrageenan, an anionic polysaccharide, the aggregation of the helical chains becomes stable by the shielding effect of counter-cation species on the electrostatic repulsion between anionic helices. On the other hand, helices of agarose, a neutral polysaccharide, aggregates via hydrogen bonding. Hydrogels have been prepared at different gelation concentrations, and then the stress-strain curves during four cyclic deformations have been measured at the same network concentration. It has been found that Young's modulus for κ -carrageenan hydrogels is higher for the gel prepared at 5 gL⁻¹ (C05) compared to that for the gel prepared at 30 gL⁻¹ (C30)¹ and that the relation between Young's modulus and the gelation concentration is opposite for agarose hydrogels. C30 shows almost linear relation between the stress and the strain like an ideal rubber, while a residual strain appears in each cyclic deformation for C05, as shown in Fig.1. The extent of the residual strain depends on the maximum strain and the deformation speed, indicating that C05 deforms plastically to some extent. The residual strain for C05 decreases gradually even after a cyclic deformation and disappears in the case of a small strain as if there were a memory of the structure. Qualitatively-similar difference in the cyclic deformation behavior has been obtained for agarose hydrogels. Optical investigations of the hydrogels have been also carried out to explain the effects of the gelation concentration on the mechanical properties based on the network structure specific to the polysaccharides.

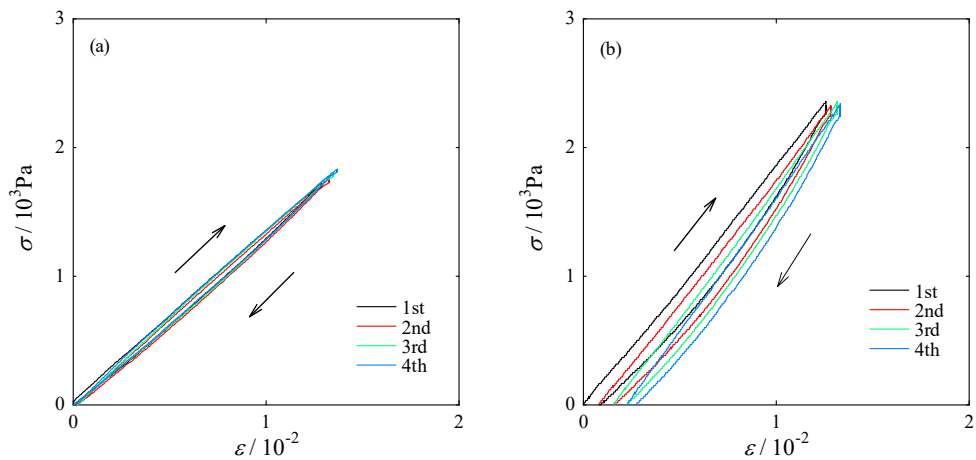


Figure 1: Stress-strain curves of four cyclic deformations for (a) C30 and (b) C05 measured at 1 mm/min up to 1 %. Upper and lower curves of each cycle corresponds to stretching and contraction processes respectively, as guided with the arrows.

REFERENCE

1. Horinaka, J.; Takagaki, H.; Tanaka, T.; Takigawa, T. *Int. J. Biol. Macromol.*, **218**, 634-638, 2022. <https://doi.org/10.1016/j.ijbiomac.2022.07.128>