STUDY ON GELATION MECHANISM OF MIXTURE SOLUTION OF KAPPA AND IOTA CARRAGEENANS BY MULTIPLE PARTICLE TRACKING METHOD

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1. Introduction

Carrageenans are p extracted from species of red seaweeds, and are commonly used as gelling or stabilizing agent. A generally accepted model of the gelling process of carrageenan solutions involves a coil-to-helix transition followed by aggregation of helices forming a space-spanning network[1]. Commonly used gelling carrageenans are Kappa (KC) and Iota (IC) types. Several studies shows that mixed KC/IC systems undergo two-step gelation where two independent gel networks are formed and a possible phase separation takes place in the mixed system[2]. This study focuses on the gelation mechanism of KC, IC, and Mixed KC/IC carrageenans through observation of the microscopic rheology.

2. Theory

The mean-squared displacement (MSD) of a particle by Brownian motion is proportional to the diffusion time τ in a homogeneous media. But in an inhomogeneous media with tortuous passway for the diffusion, the particle may exhibit subdiffusive motion as described by the following equation [3]

$$MSD = 4D\tau^{n} \qquad (1)$$

where D corresponds to the diffusion coefficient and n is the diffusive exponent which is related with the tortuosity of diffusion pass in the inhomogeneous media, $0 < n < 1$.

3. Methodology

Sodium-type KC and IC were supplied by MRC Polysaccharide Co. with further dialysis. Solutions added with polystyrene beads and 10Mm KCl were stirred for 30 min at 90°C and the final concentration is 2%. Carrageenan solutions kept at high temperature were viewed using a 100x/1.30 Nikon oil-type objective with stage controlled using a Peltier thermo 0.68° C/min controller with a cooling rate of. 15-20 particles were tracked using a 1.3M CCD camera and images were processed using a free software ImageJ. The particles MSD were calculated using a written Mathematica. When the plots of MSDs showed a monodispersity, averaged MSD was calculated and fitted on equation (1) to give D and n for each temperature. When the MSDs showed a bimodal dispersity, the MSDs were divided into two groups to give two averaged MSDs and the fitting gave two sets of fitting parameters of D and n. The fitting were carried out on the data of τ=1-10s.

4. Results and Summary

From Figure 1a, IC and mixed KC/IC shows a wider variance as gelation proceeds. Both figures at low temperatures, MSDs for particles in the mixture could be divided into two groups to give different Ds and ns as shown two points connected with thin lines. This can be related to a possibility of the phase separation with different rheological properties. It is found that the displacements of embedded particles in the IC gels demonstrated higher diffusivity compared to that of KC gels while mixed system appears to have the lowest diffusivity as this reflects the expected rheology. It is hypothesized that with decreasing temperature, particle diffusion is inhibited due to the corresponding polymer network stiffening. Thus, our observed differences in probe diffusion behaviour can be associated to differences in the gelling mechanisms between the carrageenan isoforms.

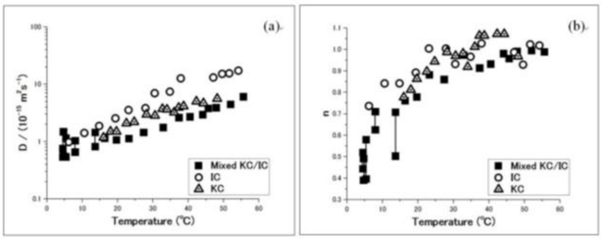

Fig. 1. Temperature dependences of D (a) and n (b). Connected squares refers to a separation of D and n of mixture at low temperature

References

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