Self-assembling in gelation processes of NIPAAM gel (Soft Matter as Structured Materials)

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Self-assembling in gelation processes of NIPAAM gel

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N-isopropylacrylamide (NIPAAM) gel is a chemical gel and exhibits volume phase transition at 32°C. The dynamics of the volume phase transition is affected by the internal structure in the gels and the formation process of the internal structure is very important. The internal structures or inhomogeneity of NIPA gels strongly depends on the gelation temperature since the poly(NIPAAM)/water system has a lower critical solution temperature type phase diagram with theta temperature being 30.5°C so that the macrophase separation is involved during the gelation process at higher temperature.

Figure 1 shows the time change in the scattered intensity I(q,t) as a function of the magnitude of scattering vector q (=4\pi\theta/\lambda) with \theta being the scattering angle after the onset of temperature jump to 35.0°C, where the turbid gel was formed. At time t=145s, I(q) show q^4 dependence and obeys Porod law, indicating that the macroscopic phase separation has already occur before the completion of the gelation. We found that the scattered intensity during the gelation process can well described by the following equation:

\[ I(q) = Aq^{-4} + \frac{I(0)}{1 + q^2} \]  

where A is proportional to interfacial area density and the square of the magnitude of the amplitude between two phases, I(0) represents the osmotic compressibility of the gel network, and \( q^2 \) is the correlation length of the gel network corresponding to the mesh size of the network. Fig. 2 shows the time changes of A, I(0), and \( q^2 \). From the time changes in these parameters, the gelation process at 35.0°C can be divided into the following two regions:

(i) Region I, t<295s: In this region, all parameters increase with time, indicating that the macrophase separation progresses and the macrophase separation is accelerated by the increase of molecular weight of NIPA gel.

(ii) Region II, 295s< t: In this region, A becomes constant whereas I(0) and \( q^2 \) decreases with time. Invariance of A is due to the fact that the macrophase separation has been pinned down by gelation. The decrease in I(0) and \( q^2 \) is caused by the fact that the networks becomes dense associating with the progress of the gelation.

The results of the gelation process at 19.7°C will be discussed in the meeting.