Study of the early stage of phase separation in polymer solutions (poster presentation, Soft Matter as Structured Materials)

Author(s): Koyama, Takehito; Tanaka, Hajime

Citation: 物性研究 (2005), 84(6): 884-885

Issue Date: 2005-09-20

URL: http://hdl.handle.net/2433/110319

Type: Departmental Bulletin Paper

Textversion: publisher
Study of the early stage of phase separation in polymer solutions

Institute of Industrial Science, The University of Tokyo
Takehito Koyama 1 and Hajime Tanaka

A novel form of phase separation, viscoelastic phase separation (VPS) [1] can occur in binary mixtures. VPS is induced by a strong dynamic asymmetry between the two components, such that the relaxation timescales of the components are well separated. Examples include polymer solutions, colloidal dispersions, protein solutions and micelle dispersions. In the case of polymer solutions, the small solvent molecules relax very much faster the larger polymer 'macromolecules'. The key feature of VPS is that the slower-molecule-rich phase shrinks in early time and transiently forms network-like structures even if it is the minority phase. These characteristics are fundamentally different from ordinary fluid phase separation. The reason for these characteristics is thought to be that the transient gel is formed by the slower component and has a strong impact on the morphology. Therefore we seek to measure the viscoelastic stress emerged by transient gel formation and to understand the effect of the stress on phase separation process.

To measure the stress formed during VPS, we observed phase separation in polymer solution (polystyrene (PS) and diethyl malonate (DEM)) by VH-scattering (crossed nicole) of time resolved static light scattering. Molecular weight $M_w$ of PS is $3.86 \times 10^6$ and concentration of the solution was 2.0 wt% PS. The power-spectrum image we detected was a four-leaf clover pattern (Figure 1). This pattern means that the mechanical stress acted on the polymers and we could

---

1 E-mail: tkoyama@iis.u-tokyo.ac.jp
detect birefringence due to the stress on the polymers. Therefore we directly detected the stress that spontaneously arose as a result of stress-diffusion coupling. Furthermore the pattern means that the direction of the stress is random and the spatial distribution of the stress is isotropic. We confirmed that the pattern appeared upon phase separation (at the critical concentration).

Figure 2 shows temporal change of the peak wave number \( q_p \) and peak intensity \( I_p \) of scattering function of VV- and VH-scattering. The early stage of phase separation emerged by about 4 second. It is found that there are two processes in the early stage. The dashed line in the figure refers to a transitional time dividing the two processes. Particularly, after the transitional time, the temporal change of both \( I_p \) of VV and of VH accelerates. It seems that diffusion of PS strongly couples with mechanical stress produced spontaneously on the PS upon network formation. We believe that the second processes is related to transient gelation of PS. Furthermore, to clarify the behavior of this new process we carried out the same experiment using another \( M_w \) of PS solution. In the presentation, we will explain the details about the experimental results and discuss the relation between the two processes and the transient gelation of PS.

References