

Measurement of Concentration Dependence of Mutual Diffusion Coefficient in Polymer Solution Using the Soret Forced Rayleigh Scattering Method

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The mass diffusion coefficient in polymer solutions is important for the analysis of polymer film processing. In the film casting process, the concentration of the polymer solution drastically changes as a function of time. Since the mass diffusion coefficient of a polymer-solvent system is a function of concentration, the analysis of the film casting process requires reliable data on the concentration dependence of the mass diffusion coefficient in polymer solutions. However, advances in the measurement method have been slowed due to the difficulty in making measurements caused by the high viscosity and low diffusivity of concentrated polymer solutions.

In the present paper, novel optical techniques for measurements of mass diffusion coefficients for polymer film materials, namely the Soret forced Rayleigh scattering method (S-FRSM), have been developed. In this method, an interference of laser beams heats a sample, and the Soret effect induces a concentration distribution. This concentration distribution decays exponentially after the short heating, and the mass diffusion coefficient can be determined by analyzing the time constant of the attenuation process. The S-FRSM is one technique to measure not only the self diffusion coefficient, but also the mutual diffusion coefficients of polymer solutions in wide ranges of concentration.

By using the S-FRSM, the mass diffusion coefficient of cellulose acetate butyrate in methyl ethyl ketone with polymer concentrations from 5 to 50 wt. % at room temperature was measured. To avoid the influence of scattering light, the interference fringe space was optimized from 10.75 μm to 4.18 μm . Considering the experimental settings, the uncertainty in this measurement was less than 1.83 %. The mass diffusion coefficient significantly increased with the rise of concentration from 5 to 30 wt. %. The slow decrease of the mass diffusion coefficient in 30 to 50 wt. % was measured. This concentration dependence of the mutual diffusion coefficient was successfully revealed by the S-FRSM. This result indicates the availability of the S-FRSM for concentration dependence measurements of mass diffusion coefficients for the improvement of the film casting process.