The Dynamics of Solvent Evaporation from Polymer Solutions with Lyotropic Capability: Hydroxypropylcellulose/Methanol

CARL L. ARONSON[1], JOHN C. CATALOGNA[1]
AND WILLIAM D. WEBSTER[2]
*[1]Department of Science and Mathematics and
[2]Department of Mechanical Engineering
Kettering University, Flint, Michigan 48504*

Presentation in
Conductive Polymers & Electro-Optics
Technical Program

or

Structure Development in Polymer
Processing Technical Program

Polymer Processing Society Annual Meeting
PPS-20

Akron, Ohio

June 20-24, 2004

The Dynamics of Solvent Evaporation from Polymer Solutions with Lyotropic Capability: Hydroxypropylcellulose/Methanol

Carl L. Aronson[1], John C. Catalogna[1] and William D. Webster[2]
[1]Department of Science and Mathematics and [2]Department of Mechanical Engineering, Kettering University, Flint, Michigan 48504 USA.

ABSTRACT

An important area of polymer physics research at the present time is the observation and prediction of lyotropic liquid crystalline phase behavior (*i.e.* orientational and/or positional molecular ordering in one or two dimensions) resulting in phase separation due solely to variations in polymer concentration at constant temperature. Lyotropic capability has become a convenient route to lower a polymer's processing temperature while taking advantage of its rheological characteristics in the liquid crystalline state. Furthermore, calculation of the solvent's diffusion coefficient is necessary for optimizing the degree of orientation and minimizing processing time in the production of electrically oriented polymer thin films from lyotropic solutions. Here a small amount of hydroxypropyl cellulose (HPC)/methanol (MeOH) solution was confined between a microscope slide and a cover slip and observed using polarized optical microscopy techniques. Thin films of HPC/MeOH solution were juxtaposed against air in a diffusion couple geometry at room temperature and the solvent was allowed to diffuse away and evaporate from the solution in a controlled manner. The diffusion couple geometry produced a thin, uniform film for optical assessment of liquid crystalline potential between crossed polarizers. After an induction period, a stable microstructure developed in which the interior of the sample remained isotropic followed by a cholesteric liquid crystalline band, with characteristic disclination defects and texture, followed by a crystalline band nearest to the external surface. The width of the characteristic birefringent band was measured over time and provided information concerning the dynamics and trajectory of solvent transport and evaporation from the cover slip edge. The apparent solvent diffusion coefficient for the HPC/MeOH system was measured at room temperature as a function of initial concentration. Crank-Nicholson predictor-corrector one-dimensional finite differences mathematical techniques were employed to solve the partial differential diffusion equation given both the observed concentration dependence for diffusion and appropriate boundary conditions. Diffusion couple optical microscopy data are compared to both experimental rheology as well as diffusion data calculated from mathematical modeling in order to validate the observed concentration dependence.