Electro-Rheological Effect of Liquid Crystalline Siloxane Derivatives

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Electro-Rheological (ER) effect is a phenomenon via which the apparent viscosity of a fluid increases with an increase of an applied electric field, and then decreases with a decreasing field. Fluids showing the effect are called ER fluids. Some kinds of liquid crystalline materials show enhanced viscosity when an electric field is applied. In particular, it has been found that side-chain liquid crystalline polymers exhibit large ER effect.

First, a side-chain liquid crystalline polysiloxane derivative, possessing mesogens in which a cyano group and a fluorine atom were included, was synthesized. Then, phase transition behavior and ER effect of the polymer were investigated. Disadvantage in the effect for liquid crystalline polymers is high viscosity and relatively slow response time to an applied electric field. From the viewpoint, we proposed a new method named "pre-shearing". The method accelerates an arrangement of the mesogens to the shearing direction, leading to a reduction in an inherent viscosity. We confirmed that the method played an important role in the measurements of ER effect.

Secondly, side chain liquid crystalline polysiloxane derivatives containing fluorinated mesogens were synthesized in order to study an influence of a dielectric anisotropy of the mesogen on ER effect. A polymer, of which the dielectric anisotropy of the mesogenic group was largest within the samples studied here, showed the largest increment in shear stress by an applied field. It could be noted that a large positive dielectric anisotropy led to larger increment of the shear stress. In addition, the orientation of the mesogens under an applied electric field was one of the main factors to show the ER effect.

Finally, liquid crystalline cyclic-siloxanes were synthesized with varying the length of the spacers and the number of fluorine atoms in the mesogenic groups, taking account into influence of molecular weight of the samples on ER effect. The response time to an electric field was highly desirable, and the shear stress increased instantly by the application of an electric field. This suggests that liquid crystalline cyclic compounds would be useful as one of ER fluids as well as those of liquid crystalline polymers.