Relationship between morphology and rheology of immiscible polymer blends

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1. INTRODUCTION

In rheology, immiscible liquid blends exhibit many interesting behaviors, which are intimately related to changes in morphology. When subjected to a shear flow, they undergo complex changes. In addition, application of electric fields brings about more complicated morphological changes and viscosity change, when the blends have a mismatch of electrical properties such as permittivity and conductivity between the two polymers. We demonstrate that detailed observations can be made by using a confocal scanning laser microscope (CSLM), and investigate the relation between the structure and the shear stress in the evolution process from droplet-dispersed state to network one on the basis of the interface tensor.

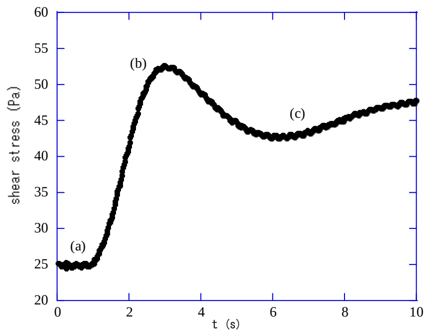

Fig. 1 Transient shear stress to a step electric field.

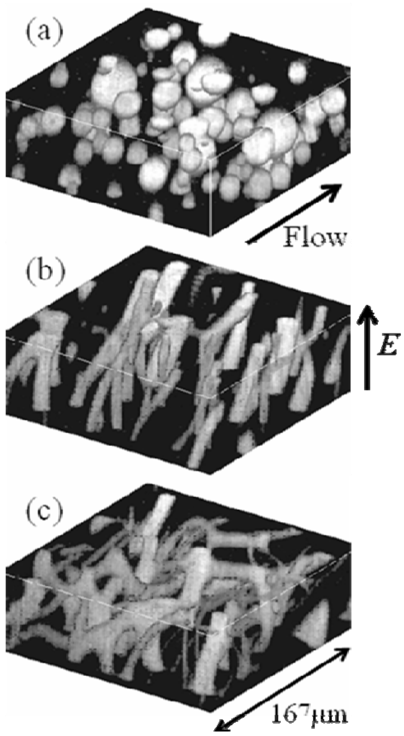

Fig. 2 3-dimensional images corresponding to Fig. 1.

2. EXPERIMENTAL AND RESULTS

In the experiment, we used a liquid crystalline polymer (LCP) and a polyisobutylene (PIB). The experiment was done at 25 °C, where the LCP was in the isotropic phase. To observe the structure clearly and to distinguish LCP and PIB, a small amount of fluorescent dye was doped into LCP before mixing LCP and PIB. They were mixed in the weight ratio of LCP:PIB=1:6. Figures 1 and 2 show, respectively, the transient shear stress to an ac electric field of $E_0 = 3$ kV/mm applied at $t = 0$ under a shear flow of $\dot{\gamma} = 1\ \mathrm{s}^{-1}$ and the corresponding structural change. Before applying the field, droplets of LCP are dispersed in the matrix of PIB, as seen in Fig. 2 (a). When subjected to the field, the droplets are elongated along the field to make slant bridges between the upper and lower plates (Fig. 2 (b)), and then the bridges coalesce and break up, resulting in a network structure (Fig. 2 (c)). As shown in Fig. 1, the shear stress steeply increases due to the bridge formation and then attains a maximum followed by a slight decrease. After passing the maximum a network structure begins to be formed.

The stress increase may be brought about by the interfacial tension and the Maxwell stress. They will be discussed in detail on the basis of the interface tensor obtained from images.