Viscoelastic Phase Separation in Shear Flow

Aichi Gakusen Univ. Tatsuhiro Imaeda

Dept. of Physics, Kyoto Univ. Akira Furukawa, Akira Onuki

シア流下にある高分子溶液の粘弾性相分離について、polymer volume fraction と conformation tensor を gross variables とした TDGL モデルを数値的に解いて得た結果を報告する。

We numerically investigate viscoelastic phase separation in polymer solutions under shear using a time-dependent Ginzburg-Landau model in two dimensions. The gross variables in our model are the polymer volume fraction and a conformation tensor. The latter represents chain deformations and relaxes slowly on the rheological time giving rise to a large viscoelastic stress. Below the coexistence curve, interfaces appear with increasing the quench depth and the solvent regions act as a lubricant. We find steady two-phase states composed of the polymer-rich and solvent-rich regions, where the characteristic domain size is inversely proportional to the average shear stress for various shear rates.

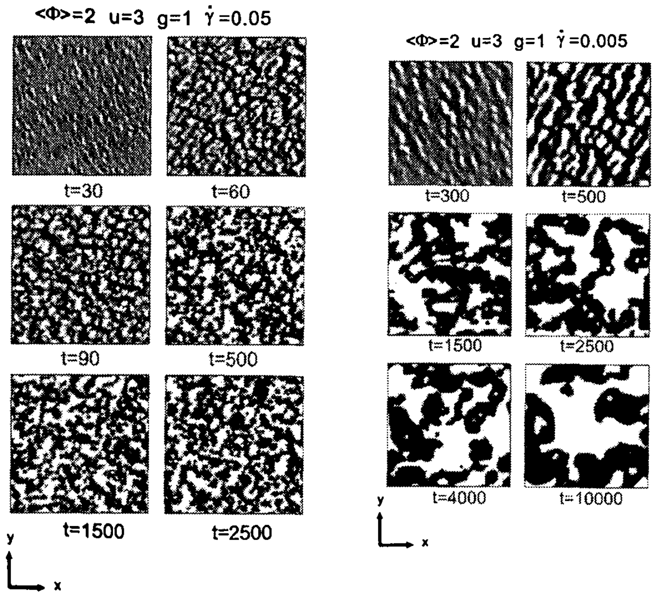

Figure 1: Time evolution of the scaled polymer volume fraction $\Phi(\mathbf{r},t)$ at $\dot{\gamma}=0.05$ (left) and $\dot{\gamma}=0.005$ (right) for $u=3$, $\langle\Phi\rangle=2$, and $g=1$ below the spinodal curve.

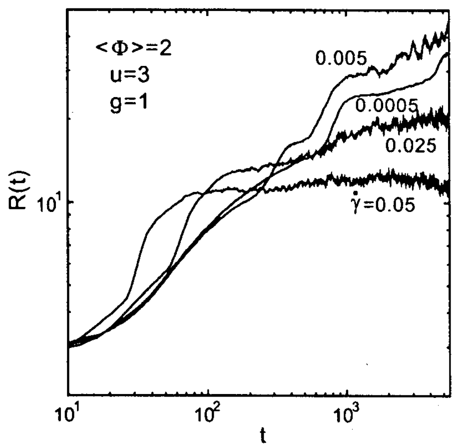

Figure 2: Time evolution of the domain size $R(t)$ below the spinodal curve for $g = 1$, $u = 3$, and $\langle\Phi\rangle = 2$. Here $\dot{\gamma}$ =0.0005, 0.005, 0.025, and 0.05. At small shear rates flow-induced coagulation accelerates the domain growth as demonstrated by the curve of $\dot{\gamma} = 0.005$. For $\dot{\gamma} \gg 0.005$, shear-induced domain breakup becomes dominant and dynamical steady states are realized at smaller domain sizes.

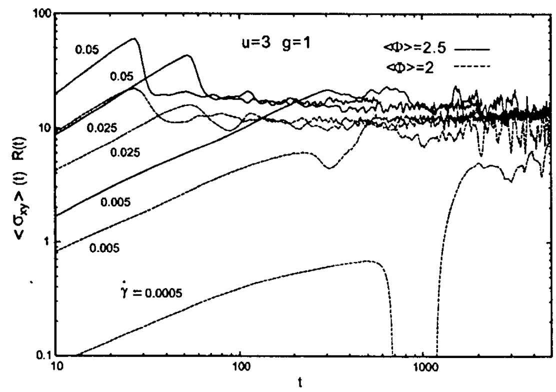

Figure 3: Time evolution of $\langle\sigma_{xy}\rangle(t)R(t)$ below the spinodal curve at various shear rates for $g = 1$ and $u = 3$. Here $\langle\Phi\rangle = 2$ (solid lines) or $\langle\Phi\rangle = 2.5$ (dotted lines).

References

1) T. Imaeda, A. Furukawa, and A. Onuki, Phys. Rev. E (2004), 051503.

2) A. Onuki, *Phase Transition Dynamics*, (Cambridge University Press, Cambridge, 2002).