

Pattern Formation of Polymer Droplets Phase separated in Nematic Liquid Crystal

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一様なネマチック液晶中のコロイドは、界面で生じる歪みを打ち消すために、いくつかの粒子一欠陥対の形態をとり、粒子間に双極子または四重極子類似の相互作用を及ぼしあう。本研究では、ネマチック液晶とシリコンオイルの混合系において、このような液晶の弾性を介した相互作用による相分離パターン形成メカニズムの詳細を報告する。

1 Introduction

It is well known that colloidal particles in nematic LC deform director field near the particles and induce a discontinuous point or line called a *topological defects* and a *disclinations* near them.

In case of a colloid with normal anchoring in nematic LC itself becomes a point defect called a radial hedgehog. It accompanies an additional defect near-by to minimize the elastic deformation of LC, and they form colloid-defect pair. Such colloid-defect pairs interact with each other in different ways depending on their configurations. There are two typical configurations of the colloid-defect pair respectively called *dipole* (Fig.1(a)) and *saturn-ring* (Fig.1(b)).

At the phase separation of LC-polymer mixtures in the LC-rich system, the self-assembled pattern of polymer droplets reported has two structural features (Fig.2(a)) [1]; (i) They are quite straight chains like ones in electro- or magnetorheological fluids, (ii) The chain consists of droplets with a uniform size. However, we found different patterns such as branched chains (Fig.2(b)) and antiparallel chains (Fig.2(c)) in our experiments.

In this paper, we have studied the process of the phase separation and the transformation of droplet-defect configuration in details by using silicone oil with high viscosity.

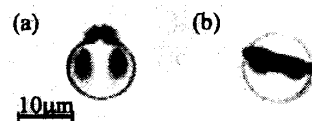


Figure 1: Two typical droplet-defect pairs

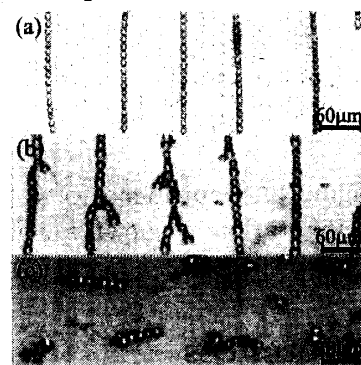


Figure 2: Self-assembled pattern observed in the study

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2 Experiment

The system studied is the mixture of nematic LC (TL203, Merck Ltd.) and silicone oil (viscosity 500, Fluka). This mixture shows a uniform nematic (N) phase at low silicone oil concentration (≤ 4 w%). We mixed the silicone oil and TL-203 at the temperature region of the isotropic phase. The mixture was injected into a glass cell whose thickness is about $20 \mu\text{m}$ at the uniform N phase. Both surfaces of the cell were coated with polyvinylalcohol and rubbed to yield homogeneous alignment of LC. We quenched the mixture from N phase (about 60°C) to N+Iso phase (room temperature).

3 Result and Discussion

A droplet retains the saturn-ring configuration (Fig.2(b)) in early stage of the phase separation. The saturn-rings fuse diagonally each other and grow monotonously in their size. It is observed that the disclination ring in the saturn-rings break immediately before fusing. When the size of droplet reaches a critical value, the saturn-ring configuration becomes unstable by its large line energy of a disclination ring and spontaneously transforms into the dipole configuration. In addition, we found the rubbing direction of the cell controls the direction of dipole formed by spontaneous transformation. However in some cases, the transformation of configuration is induced by the near-by another droplet. This breaks the monodispersity of size of droplets and leads size distribution in chains. Lubensky *et al.* [2] have predicted theoretically that the interaction energy between two droplets at r and r' is written as

$$U(R) = 4\pi K [pp'V_{PP} + \frac{2}{3}(cp' - c'p)V_{pc} + \dots],$$

V_{pp} : dipole – dipole interaction energy V_{pc} : dipole – quadrupole interaction energy

where $R = r - r'$, p and p' are dipole-moments, c and c' are quadrupole moments. The interaction between the same-size dipoles is simple dipole-dipole one. Result, They form quite straight chains like ones in electro- or magnetorheological fluids (Fig.2(a)). The interaction between the particles in dipole configuration with different size is not simple dipole-dipole one but also includes dipole-quadrupole term. Therefore, chain branches along the direction where asymmetrical attractive dipole-quadrupole interaction is largest (Fig.2(b)).

References

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- 2) T.C.Lubensky, D.Pettey, N.Curier, *Phys. Rev. E* **57** (1998), 610.