Pattern Formation at Phase Separation in the Mixture of Liquid Crystals and Polymers

Dept. of Physics, Kyushu Univ. K.Kita[1], K.Tanaka, M.Ichikawa and Y.Kimura

液晶と少量のシリコンオイル(高分子)の混合物をネマチック(N)相から急冷すると、相分離によってシリコンオイルのdropletが液晶中に析出する。等方性液体の相分離の場合とは異なり、この場合には、dropletは特定の大きさになるとその成長を止め、dropletは融合することなく凝集して、高次構造を形成する様子が観察された。droplet間の相互作用測定や凝集体の平均的サイズの時間発展の測定結果をもとに高次構造形成のメカニズムを議論する。

1 Introduction

In recent years, binary mixtures of liquid crystal (LC) and polymer have been intensively studied from fundamental and applicational points of view. In the case of polymer dispersed liquid crystal system (PDLC), the transmittance of light can be controlled by external electric field through varying orientation of LC.

On the other hand, a large spherical particle with normal anchoring in nematic LC accompanies one point defect called hyperbolic hedgehog. Spherical particle interacts with each other mediated by distortion of LC as shown in Fig.1. In this case, the interaction between two particles can be analogically regarded as dipole-dipole interaction of electrostatics. Furthermore, when two particles come closer, an interlayed defect between the particles prevents attachment and coalescence[1].

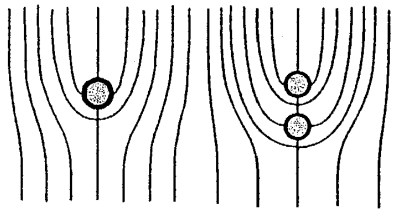

Fig. 1: Director field of LC with spherical particles.

In this paper, we report the dynamics and pattern formation at phase separation in the mixture of LC and polymer at low polymer concentration.

2 Experiment

The system studied is a mixture of TL-203 (LC) and poly-dimethylsiloxane-co-methylphenylsiloxane (silicone oil). Phase diagram of the mixture is shown in Fig.2. This mixture exhibits an uniform nematic (N) phase at low silicone oil concentration (<4w%). In the phase appeared below N phase, silicone oil droplets were randomly formed in nematic host by phase separation.

[1]E-mail: kita8scp@mbox.nc.kyushu-u.ac.jp

We performed temperature quench on this mixture from N phase to N+I phase. The mixture was sandwiched between two glass slides separated by a 20 μm-thick spacer. The surface of the slides have been coated with polyvinylalcohol and been rubbed to yield homogeneous alignment in the N phase.

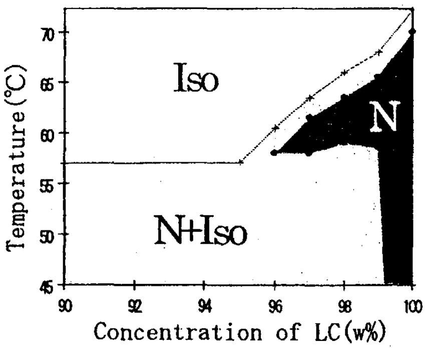

Fig. 2: Phase diagram of the mixture.

3 Result

After quenching from N phase, droplets emerge in the nematic host and attract each other. They grow by coalescing until their sizes reach a certain value. After that, they cease growing and begin to form various kinds of cluster.

Fig.3 shows the process of cluster formation at 2w% concentration of silicone oil after temperature quenching. Droplets form straight chain structure, and it grows monotonously with time. The mean cluster size, $S(t)$, grows as $\propto t^{0.58}$, where t is time elapsed. This result agrees well with the numerical simulation[2]. According to the simulation, cluster with dipolar interaction in an anisotropic liquid grows as $S(t) \propto t^{0.6}$.

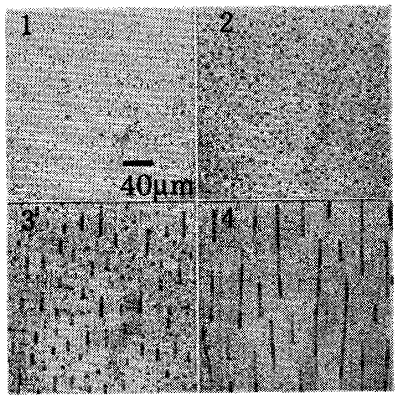

Fig. 3: Process of cluster formation. (Silicone oil 2w%)

When the concentration of silicone oil increases slightly, it is frequently observed that a chain attaches to the side of another chain to form a branched chain structure. Its size grows as $S(t) \propto t^{1.2}$. Although the side of a chain usually exerts repulsive force, some points apparently exert attractive force.

Another type of chain structure is also observed. A chain grows by side-by-side connection as shown in Fig.4. A pair of dipoles pointed to the opposite direction makes this kind of stable structure. Thus, both chains parallel and normal to the direction of director field can be formed in nematic host by self-organization.

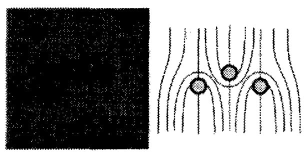

Fig. 4: Chain composed of antiparallel droplets.

References

[1] J.C.Loudet, P.Barois, P.Poulin, Nature **407** (2000), 611.

[2] J.C.Loudet, P.Barois, P.Auroy, P.Keller, H.Richard, P.Poulin, Langmuir **20** (2004), 11336.