Control of Helical Nanostructures of Chiral-Nematic Liquid Crystals in Monodispersed Polymeric Particles

Tomoki Shigeyama,[a] Kyohei Hisano,[a] Osamu Tsutsumi[a]
[a]*Department of Applied Chemistry, College of Life Sciences, Ritsumeikan University.*
E-mail: tsutsumi@sk.ritsumei.ac.jp

Liquid crystalline polymers (LCPs) show advanced optical and mechanical functionalities depending on their molecular alignment. For example, chiral-nematic phase forms helical nanostructure of molecular alignment and shows Bragg reflection. The molecular alignment can be reversibly controlled by external stimuli, so LCPs can be used as soft-sensors and actuators. Since these functionalities appear when the LCP is aligned over a relatively long range (> 1 µm), the development of alignment control methods is important for the application of LCPs. In general, low-molecular-weight liquid crystals can be easily aligned over a long range. On the other hand, LCPs easily form very small domains (~ 100 nm) because the alignment is inhibited by the main chain. Therefore, to achieve alignment control of LCPs, polymerization of aligned liquid crystalline monomers have been employed. In this method, the monomers must exhibit liquid crystalline phase. Thus, it is difficult to fabricate an aligned LCPs from monomers that exhibit liquid crystalline phase only after polymerization. Thus, a versatile method to control molecular alignment in LCPs is required.

In this study, we achieved to control molecular alignment in LCPs by dispersion polymerization which is a versatile and simple method to synthesize the polymer particles. In the dispersion polymerization, monomers, a stabilizer, and an initiator are dissolved in the poor solvent for the produced polymer. As a result, the produced polymer precipitates and micro-sized particles can be obtained. We fabricated monodispersed chiral-nematic LCP particles with the size of 2.6 ± 0.1 µm (Figure 1a). Transmission electron microscopy (TEM) observation of the cross-section revealed stripe pattern arising from helical nanostructure of chiral-nematic LCP (Figure 1b). From this uniform stripe pattern, we concluded that LCP was aligned over a long-range during dispersion polymerization. We expect that this alignment was formed during the nucleation-growth process of LCP precipitation. Actually, the growth of molecular alignment can be observed by tracing the particle growth process during dispersion polymerization. This method can be applied to wide range of monomers as long as they are soluble in the polymerization solvent. We expect this method will be a versatile control method of molecular alignment in LCPs.

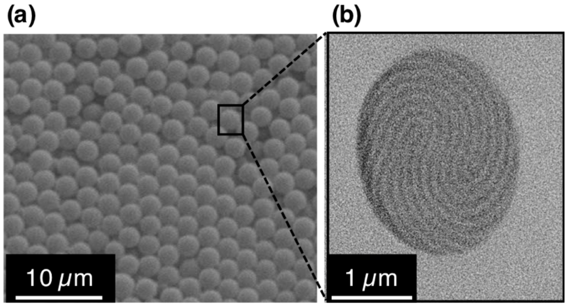

Figure 1. (a) Scanning electron microscope image and (b) TEM image of a chiral-nematic LCP particle of this study.

We also investigated the optical functionality of chiral-nematic LCP particles. Figure 2 shows the characters drawn utilizing the chiral-nematic LCP particle dispersed in resin. Because of the centrally symmetric nanostructures, our chiral-nematic LCP particles showed angular-independent reflection. This result supports that our method has a potential to develop the applications of LCPs, such as reflective coating.

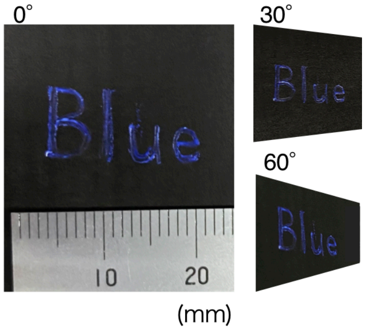

Figure 2. Image of reflective coating patterned with chiral-nematic LCP particles and viewing-angle independence of reflection color.