Controlling In-Plane Helical-Axis Alignment in Chiral Liquid Crystals via Polymer Concentration Gradient Formed by Photogradient Polymerization

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Chiral-nematic liquid crystal (N* LC) forms a one-dimensional helical structure based on helically twisted molecular alignment. This helical structures create a periodic distribution of refractive index along the helical axis. Owing to this periodic distribution of refractive index, N* LC shows the unique optical properties depending on the helical-axis alignment. For instance, N* LC with controlled out-plain helical-axis alignment reflects a light at a wavelength in accordance with their helical pitch. Conversely, N* LC with controlled in-plain helical-axis alignment exhibits the polarized conversion and diffraction property. This is because that the refractive index distribution formed in the material plain due to their helical structures. In both cases, the precise and arbitrary control of helical-axis alignment is necessary to maximize these optical properties.

To control the helical-axis alignment, it is essential to initially control the mesogenic alignment since the helical alignment is perpendicular to the mesogenic alignment. For example, an out-plane helical-axis alignment comes from in-plain mesogenic alignment. The in-plain alignment can be achieved by leveraging the interfacial anchoring forces of an alignment layer such as polyimide that exhibits parallel anchoring ,which leads to the helical-axis alignment in the thickness direction. On the other hand, for the helical-axis alignment in the in-plane direction, mesogens should be aligned in out-plane direction by using the substrate with silane coupling treatment. However, even if out-plain mesogenic alignment can be achieved, uniaxial in-plane alignment of the helical axis is still challenging because the helical axis can be aligned to all directions in the plane of the substrate. Previously, we demonstrated that in-plain uniaxial helical-axis alignment is formed by photopolymerization with light intensity gradient.[1)] In this study, we investigated the formation mechanism of this helical-axis alignment.

The N* LC monomer mixture was injected into a glass cell with silane coupling treatment, which leads to an out-plane mesogenic alignment. We performed the photogradient polymerization by using 4f optical setup with a photomask. Polarized optical microscopy of the resultant N* LC film displayed a striped optical structure. This striped optical structure was aligned perpendicular to the gradient direction of light intensity, indicating that the helical axis was aligned in the gradient direction of light intensity.

1) Y. Shikata, S. Sugiyama, K. Matsumoto, K. Hisano, O. Tsutsumi, *Small Struct.* **2024**, 2400458.