Scanning Wave Photopolymerization Directs Three-dimensional Molecular Alignment Patterns in Liquid-crystalline Polymer Films as an Alignment Layer

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The control of molecular alignment, which enhances nanoscale molecular functions to macroscale material ones, is crucial for developing high-performance materials and devices.[1] The simple and practical method for the alignment control using mechanical stress enables the fabrication of one-dimensional alignment over large areas. On the other hand, a photoalignment method has drawn much attention due to its clean and non-contact process.[2] With conventional photoalignment methods, a liquid-crystalline (LC) film containing photoresponsive dyes is irradiated with spatiotemporally uniform linearly polarized light, and the molecular alignment is controlled via the interaction between the dipole of dyes and the polarization axis of the incident light. However, the fine control of microscopic three-dimensional molecular alignment remains a challenge in this method. Recently, we have reported a new photoalignment method based on a concept of scanning wave photopolymerization (SWaP).[3] In this study, we fabricated the LC polymer films with three-dimensional alignment patterns by optimizing the photopolymerization conditions and explored the functionality of the polymer films as an alignment layer for LCs.

A sample mixture composed of an anisotropic monomer, an anisotropic crosslinker and a photoinitiator was spin-coated on an ozone-treated glass substrate. Subsequently, SWaP process was conducted to the sample by scanning a slit UV light for fabricating molecularly aligned polymer films. As a result, SWaP successfully induced the homeotropic and pretilt alignment with control of photopolymerization temperature and incident light intensity. Next, a glass cell was prepared by adhering two glass plates with the aligned polymer films. Low-molecular-weight LC molecules doped with a small amount of a dichroic dye were injected into the glass cell. Polarized optical microscopy and polarized UV-visible absorption spectroscopy revealed that both LC molecules and dyes were aligned in the same direction along the alignment direction of the LC polymers. These results indicate that the three-dimensionally aligned polymer films fabricated by SWaP enable the control of homeotropic, tilted and homogeneous alignment of LC molecules, acting as a three-dimensional alignment layer.

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