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Photoresponsive liquid crystalline block copolymers: From photonics to nanotechnology

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ABSTRACT

Being one of the most fascinating multi-functional materials, photoresponsive liquid crystalline block copolymers (PLCBCs) have attracted much attention because of their light controllable properties of supramolecularly self-assembled structures. These originate from their unique features combining the advanced function of photoresponsive liquid crystalline polymers (PLCPs) with the inherent property of microphase separation of block copolymers (BCs). Benefiting from recent progresses in materials chemistry, diverse PLCBCs have been designed and synthesized by controlled polymerization using different synthetic routes and strategies. Generally, PLCBCs show different performance depending on their self-organization and molecular composition, with the PLCP blocks in the minority phase or in the majority phase. One of the most important properties of PLCBCs is supramolecular cooperative motion, resulted from the interactions between liquid crystalline elastic deformation and microphase separation, which enables them to self-assemble into regularly ordered nanostructures in bulk films with high reliability. These nanostructures contribute to improving the optical performance of polymer films by eliminating the scattering of visible light, in favor of their photonic applications. With the help of liquid crystal alignment techniques, both parallel and perpendicular patterning of nanostructures has been fabricated in macroscopic scale with excellent reproducibility and mass production, which provides nanotemplates and nanofabrication processes for preparing varieties of nanomaterials. Recent findings about PLCBCs including their synthesis, diagram of microphase separation, structure-property relationship, precise control of nanostructure as well as their applications in photonics to nanotechnology are reviewed.

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1. Introduction

In the past decades, liquid crystalline block copolymers (LCBCs) have aroused a wide range of interests from academic to industry as a novel kind of macromolecules [1–6]. Both the self-organization of liquid crystalline polymers (LCPs) and the inherent property of microphase separation of block copolymers (BCs) are integrated into one organic system of LCBCs. This provides a good opportunity to study the formation and control of the self-organized nanostructure of LCBCs under the influence of more than one driving force. On one hand, the thermodynamically microphase-separated nanostructures of LCBCs show a great effect on LC performances, and vice versa, the feature of LC ordering influences the formation of diverse nanostructures in the supramolecularly self-assembled processes of LCBCs. Such kind of microphase-separated materials has been regarded as one of the emerging topics in macromolecular engineering [3–7].

When one of the blocks of LCBCs is designed as one photoresponsive LCP (PLCP), the light-responsive feature is brought about, endowing the formed hierarchical nanostructures with photocontrollable properties [6–12]. As shown in Fig. 1, photoresponsive LCBCs (PLCBCs) are the outcome of a marriage between photoresponsive chromophore-containing materials and self-organizing soft matter of LCBCs. They generally inherit most of the advanced functions of their father and mother homopolymers of PLCPs, e.g., as photonic materials [7,13–23]. As a result, these PLCBCs often show multi-functions comparing with their homopolymers (PLCPs) composing of only one single component. Firstly, diverse nanostructures due to microphase separation of amorphous BCs has demonstrated their applications in nanotechnology as nanotemplating and nanofabrication materials [24–28]. Secondly, the photocontrollable feature of PLCBCs offers a novel occasion to manipulate supramolecularly self-assembled nanostructures in polymer films and extends their various applications as advanced functional materials

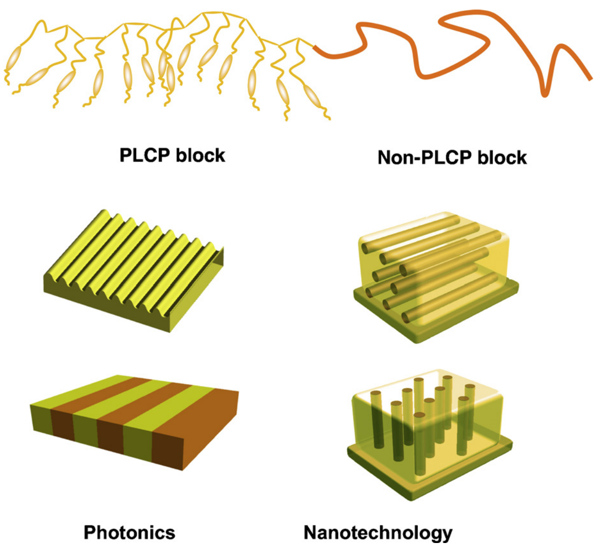

Fig. 1. Scheme of photoresponsive liquid crystalline block copolymers (PLCBCs) and their potential applications from photonics to nanotechnology.