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ORIGINAL PAPER

Preparation and self-assembly of photonic crystals on polyester fabrics

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Abstract Photonic crystals play the vital role in structural color appearance, and they can be fabricated on polymer substrates. In this paper, monodispersed SiO_2 microspheres with the average diameter ranging from 150 to 300 nm were prepared by classical Stöber method. The spherical size of SiO_2 microspheres was regulated by controlling concentrations of ammonia. The tunable structural colors could be changed by modulating the diameters of SiO_2 microspheres or viewing angles, which adhered to the law of the Bragg diffraction. As a kind of polymer fabric, the polyester fabrics, smoother than natural fiber fabrics, exhibited bright structural colors from the well-ordered photonic crystal microstructure by vertical deposition self-assembly of SiO_2 photonic crystals. Moreover, the result indicated that the difference of fabric-woven structure could affect the lightness of structure color, and the lightness on satin fabric was duller than that of plain fabric. Besides, we have also discussed the influence of fabric structure on the lightness of structure color using the theory of thin film interference. It is believed that the structural color could provide a new strategy for related polymer product coloration without chemical dyes and pigments, and has a potential to reduce the pollution in related polymer materials dyeing and printing processes.

Keywords Photonic crystals · SiO_2 microspheres · Vertical deposition · Self-assembly · Fabric

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Introduction

Color is usually caused by either structure coloration or pigmentation [1]. Structural colors in nature can be classified into the following five basic optical processes or their combinations: thin film interference, multilayer interference, diffraction grating effect, photonic crystals and light scattering [2, 3]. Recently, photonic crystals (PCs) have increasingly attracted the attention of researchers owing to their unique structural color properties [4]. The unique properties of structural colors from photonic crystals have fostered a great number of potential applications, for instance, drug release [5], gas sensing [6, 7], inkless printing [8], photonic papers [9], and textile coloration [10–12].

The fabrication of PCs which can generate colors on polymer substrate has been carried out by various methods, including gravitational sedimentation, vertical deposition, electrophoretic deposition and so on [13–15]. Among them, the vertical deposition method has many potential advantages in large scale and low cost production [16]. While it is different from the conventional PCs fabrication on substrates [17, 18], and the textiles have complex rough surface and various woven structure, there is some challenge for PCs on textiles. SiO_2 is an important material for the preparation of photonic crystals, which was extensively used to prepare photonic crystals. Herein, we would focus on the self-assembly of colloidal crystals from SiO_2.

In this paper, monodispersed SiO_2 microspheres were prepared by controlling the concentration of ammonia and were fabricated on a kind of polyester woven fabric. The relationship between the color of photonic crystals and the diameters of microspheres or viewing angles was investigated, which was in great agreement with the Bragg's law of diffraction. Especially, we did experiments and theoretically deduced to explore the influence of fabric-woven