

**Study on the high hydrophobicity and its possible mechanism of textile fabric  
with structural colors of three-dimensional Poly (styrene-methacrylic acid)  
photonic crystals**

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Electronic supplementary

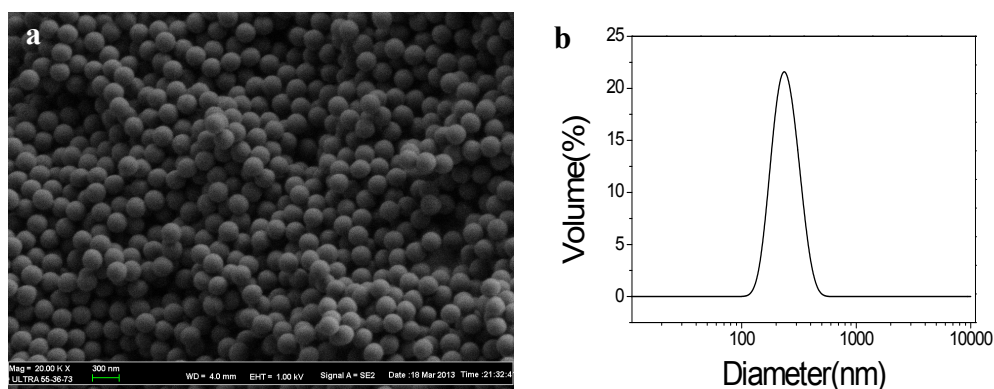
**1. Synthesis of P(St-MAA) colloidal microspheres**

***Figure 1. Schematic diagram of synthesis of P(St-MAA) colloidal microspheres.***

Batches of monodisperse P(St-MAA) microspheres with diameters in the range of 200–400 nm were prepared by soap-free emulsion copolymerization. The size of the P(St-MAA) microspheres produced in this method is highly dependent on the different concentrations of St, MAA, and APS. Syntheses were carried out in a fournecked round-bottom flask equipped with an inlet of nitrogen gas, a reflux condenser, thermometer, and a mechanical stirrer. With one sample as an example, the procedure used was outlined as follows: 20 g St, 3 g MAA, and 195 g H<sub>2</sub>O were added to the

four-necked round-bottom flask. Nitrogen gas was then slowly bubbled through the resulting two-phase system and vigorous mechanical stirring of the mixture commenced. When the mixture was heated to 70 °C, 0.1 g APS dissolved in 5 g H<sub>2</sub>O was introduced into the reactor. The reaction was maintained at 70 °C for 8 h. The whole reaction was carried out in nitrogen atmosphere with mechanical stirring at around 350 rpm. The resulting colloidal suspension of P(St-MAA) microspheres was then filtered through a glass wool plug to remove any large agglomerates and then stored in PET plastic bottles for later use. When the parameters of the polymerization were changed, P(St-MAA) microspheres of different diameters can be prepared.

## 2. Characterization of P(St-MAA) colloidal microspheres

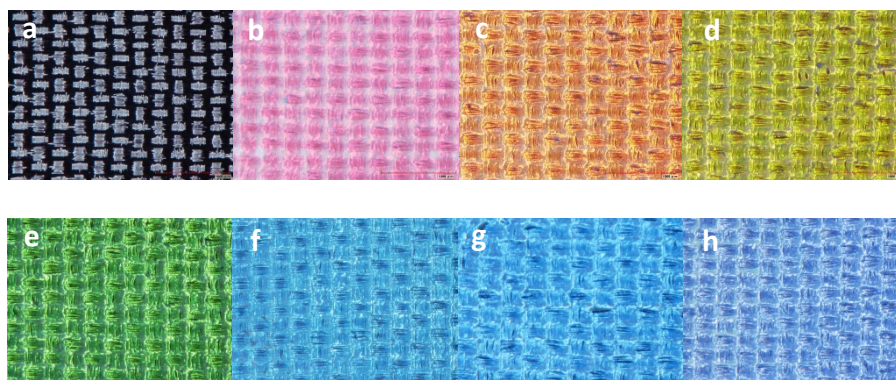


**Figure 2. The morphology of the as-prepared colloidal microspheres and its diameter distribution: (a) is the FESEM micrograph of P(St-MAA) colloidal microspheres with a diameter of 260 nm, prepared by 20 g St, 3 g MAA, and 0.08 g APS; (b) is the diameter distribution of P(St-MAA) colloidal microspheres with a diameter of 260 nm.**

Figure 2(a) shows the surface morphology of P(St-MAA) colloidal microspheres with a diameter of 260 nm. It is clear that each colloidal microsphere has spherical shape, which indicates their potential to fabricate well-organized photonic crystal structure on polyester fabrics. From Figure 2(b), it can be seen that the peak of particle size distribution of P(St-MAA) colloidal microspheres is narrow and sharp. These results indicated that the prepared P(St-MAA) colloidal

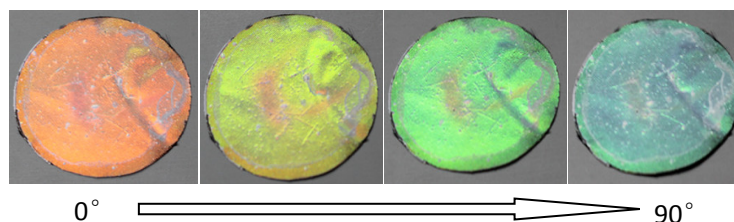
microspheres in our study had excellent monodispersity.

### 3. Structural colors of P(St-MAA) photonic crystals on textile fabrics



*Figure 3. The initial black polyester fabric (a), and the assembled polyester fabrics with P(St-MAA) microspheres of different diameters taken by a three-dimensional video microscope: (b) 304 nm; (c) 286 nm; (d) 265 nm; (e) 255 nm; (f) 222 nm; (g) 206 nm ; (h) 185 nm.*

Figure 3 displays photographs of the as-prepared structural colors on the black polyester fabric taken by a 3D video microscope. It can be seen that the surfaces of black polyester fabrics are completely covered with P(St-MAA) photonic crystals, and present bright and uniform structural colors. The various structural colors of magenta, orange, golden yellow, green, cyan, blue and violet were generated from the photonic crystals fabricated by the P(St-MAA) microspheres with diameters of 304, 286, 265, 255, 222, 206 and 185 nm, respectively. Therefore, it can be confirmed that the structural colors vary with the changes of the microsphere sizes.



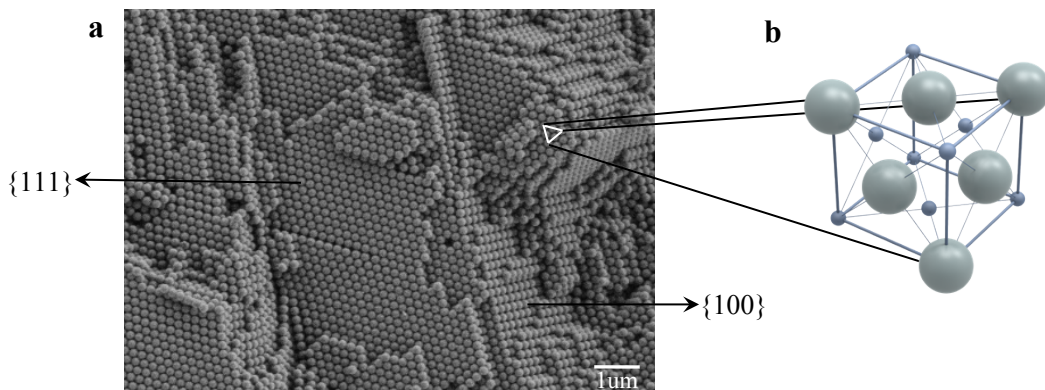
*Figure 4. Photographs of various structural colors on polyester fabrics covered with photonic crystals assembled by the colloidal microspheres with the same diameter*

*of 286 nm, and the photographs taken at different viewing angles increasing from*

*0° to 90° .*

In Fig. 4, the P(St-MAA) photonic crystals on polyester fabrics exhibit different structural colors of orange, golden yellow, emerald green and green at different viewing angles taken by a digital camera from 0° to 90° , which illustrates that the wavelengths of structural colors move to shorter wavelength with increased viewing angles. Generally, the structural colors of photonic crystals look iridescent at different viewing angles due to the light scattering at different orientation of the crystallines.

#### **4. Three-dimensional face-centered cubic structure of P(St-MAA) photonic crystals on textile fabrics**



**Figure 5** *The fcc structure of P(St-MAA) photonic crystals on polyester fabrics. (a) is the cross-sectional morphology; (b) is the fcc lattice used to describe the nanostructure lattice.*

The ordered arrangement of the prepared P(St-MAA) photonic crystals was regarded as a three-dimensional face-centered cubic (fcc) structure through the self-assembly of gravitational sedimentation, as shown in Fig. 5. The cross-sectional image of photonic crystals in Fig. 5 (a) presents the square and hexagon arrangements of P(St-MAA) microspheres, which signifies that the resulting close-packed structure of P(St-MAA) photonic crystals on polyester fabrics is only

compatible with the fcc packing. A square arrangement corresponds to  $\{100\}$  type plane of fcc structure, while a hexagon arrangement corresponds to  $\{111\}$  type plane of fcc structure. The close-packed arrangements in Fig. 5 (a) can be matched to the fcc nanostructure lattice shown in Fig. 5(b), which directly confirmed that the P(St-MAA) photonic crystals on polyester fabrics in our research was in fcc packing.