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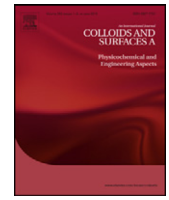

Improvement on solvent resistance of photonic crystals by surface modification

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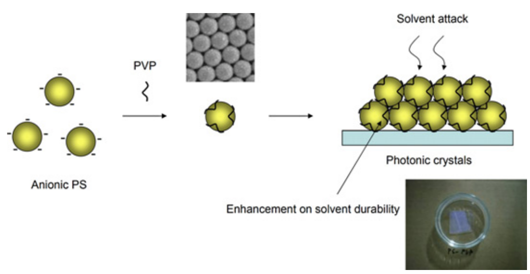
HIGHLIGHTS

- ► Artificial photonic crystals have a very weak solvent resistance.
- ► A facile method to significantly improve the solvent resistance was developed.
- ► The improvement on solvent resistance by the thermal treatment was limited.
- ► PVP-modification spheres revealed excellent solvent durability.

GRAPHICAL ABSTRACT



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ABSTRACT

In this study polystyrene (PS) spheres were synthesized by emulsifier-free emulsion copolymerization of styrene with methacrylic acid for the fabrication of photonic crystals. A facile method to significantly improve the solvent resistance of photonic crystals was developed through surface modification of PS spheres by poly(vinyl pyrrolidone) (PVP). We used an ethanol soaking test to evaluate the solvent resistance of photonic crystals prepared by pristine, thermal-treatment, and PVP-modification methods. The crystal structure and the absorption band of the photonic crystals before and after the soaking test were investigated. Experimental results revealed that the photonic crystals prepared from the unmodified PS spheres have a very weak resistance to ethanol, resulting in impossibility of carrying out inverse opal photonic crystals. The improvement on solvent resistance by the thermal-treatment method was limited due to the weak bonding or the mergence of PS spheres. We found the photonic crystal prepared from the PVP-modification PS spheres maintains its integrity very well in the ethanol solution after 5-h soaking. Moreover, the photonic crystal and the corresponding inverse opal photonic crystal revealed excellent structure and optical properties.

1. Introduction

Artificial photonic crystals have received increasing attentions over the past two decades due to their potential applications in optical waveguides, sensors, light filters, optical integrated circuits, low-threshold telecommunication lasers, and so on [1–5]. Artificial photonic crystal structures can be easily accomplished by virtue of using monodisperse spheres to be face-centered-cubic packing, called an opal structure. Especially, an inverse opal structure, that is, air sphere array in solid matrix, is more desirous due to occurrence of a complete photonic band gap at a refractive index contrast of 2.8 or higher [6], which incident wavelengths are forbidden for every state of polarization and propagation direction [7,8]. Numerous methods have been reported to achieve the close-packed array, such as gravitational sedimentation [9], horizontal deposition [10], vertical deposition [11,12], vertical deposition with a temperature gradient [13], centrifugation [2,14], physical confinement [15–17], electrophoresis deposition [18], and forced array [19,20]. However, the opal photonic crystals prepared by these methods have a very weak mechanical strength due to the weak attraction force between spheres. The drawback results in the fabrication of inverse opal photonic crystals are difficultly carried out by infiltration of a

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