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Review

Design, preparation, and application of ordered porous polymer materials

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HIGHLIGHTS

- Breath figures involve polymer casting under moist ambience.
- Hard template employs monodisperse colloidal spheres as a template.
- Soft template utilizes the etched block in copolymers as template.

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ABSTRACT

Ordered porous polymer (OPP) materials have extensively application prospects in the field of separation and purification, biomembrane, solid supports for sensors catalysts, scaffolds for tissue engineering, photonic band gap materials owing to ordered pore arrays, uniform and tunable pore size, high specific surface area, great adsorption capacity, and light weight. The present paper reviewed the preparation techniques of OPP materials like breath figures, hard template, and soft template. Finally, the applications of OPP materials in the field of separation, sensors, and biomedicine are introduced, respectively.

1. Introduction

Ordered porous materials, which were developed rapidly in 1990s, are a kind of materials with ordered nano-structure. Emergence of ordered porous materials attracted a great deal of attention from the field of physics, chemistry, and materials, at the same time, ordered porous materials developed rapidly into one hot research focus [1]. Generally, ordered porous materials can be classified into ordered porous inorganic (OPI) materials and ordered porous polymer (OPP) materials. The preparation and application of OPI materials are becoming mature, whereas OPP materials still have huge development space in the preparation techniques and application fields.

OPP materials have a series of advantages like light weight, ordered alignment of pores, high specific surface area, great adsorption capacity, uniform pore size, and tunable pore size, and this type of materials have great application prospects in the field of biomedicine [2–4], biological film [5,6], bioreactor [7], adsorption [8,9], catalyst supports [10,11], separation [12,13], and growth templates of nanomaterials with specific shapes [14]. Therefore, preparation and application of OPP materials have has drawn much interest of researchers and scientists in the field of polymer materials. Up to now, OPP materials can be classified into two types: OPP membrane and OPP monoliths. The term “monolith” refers to unibody structures composed of interconnected repeating cells or channels [15]. Since Nakahama et al. firstly prepared ordered porous polystyrene (PS) membranes via microphase separation of polystyrene-*b*-polyisoprene and ozonolysis, the last two decades have witnessed the great progress of OPP membrane in the synthetic routes, and in selective separation and photonic application [16].

The development of etching techniques made the preparation of OPP monoliths with thickness of a few millimeters possible. Compared to traditional polymer materials with continuous pore size distribution, OPP monoliths have uniform pores with large aspect ratio. Buchmeiser think this type of materials possess

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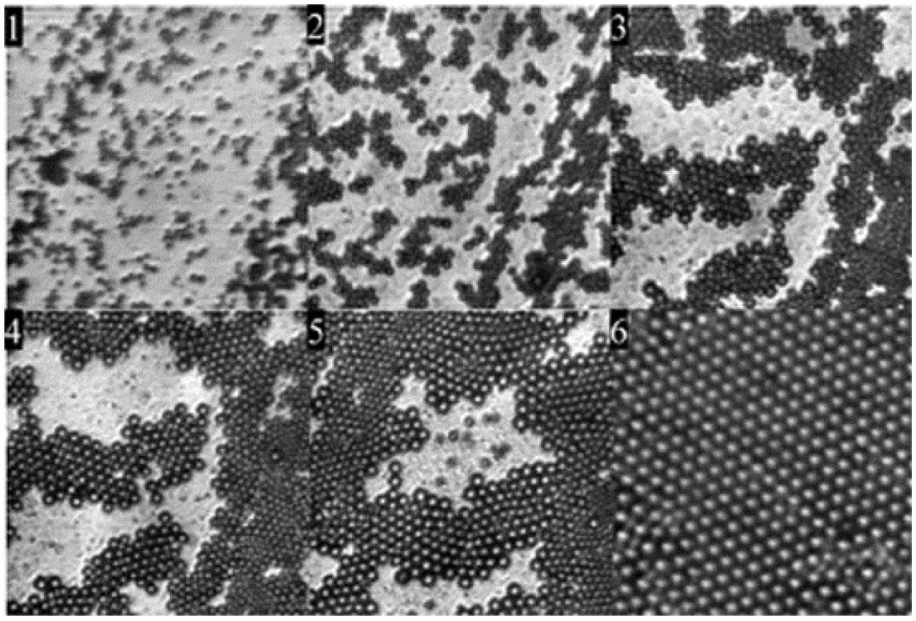

Fig. 1. Sequence of images depicting the growth and aggregation of water droplets near the surface of an evaporating polymer solution. The time interval between frames 1 and 5 is 50 s [22].

enormous potential as "advanced materials" for many high-tech application such as microelectrophoresis, bioseparation, and bioreactor [17]. Hillmyer et al. suggest that OPP monoliths have two special advantages in the template synthesis [18]. One is the preparation of nanomaterials with large aspect ratio ($>10^4$); and the other is that functional groups left on the pore wall during etching block copolymers can meet special template synthesis. Moreover, the functional groups can be transferred into the other groups, which further widen the application field of OPP monoliths. The present review attempts to introduce the preparation routes of OPP membrane and monoliths in the next sections. The application of OPP membrane and monoliths is also covered in the third section. Finally, a short summary and prospect on the field of OPP materials is provided at the end of this review.

2. Preparation techniques

2.1. Breath figures

Breath Figures derived from almost 100 years ago had not drawn extensive attention until Widawski et al. [19] applied this method to prepare porous polystyrene-*b*-polyparaphenylene film with

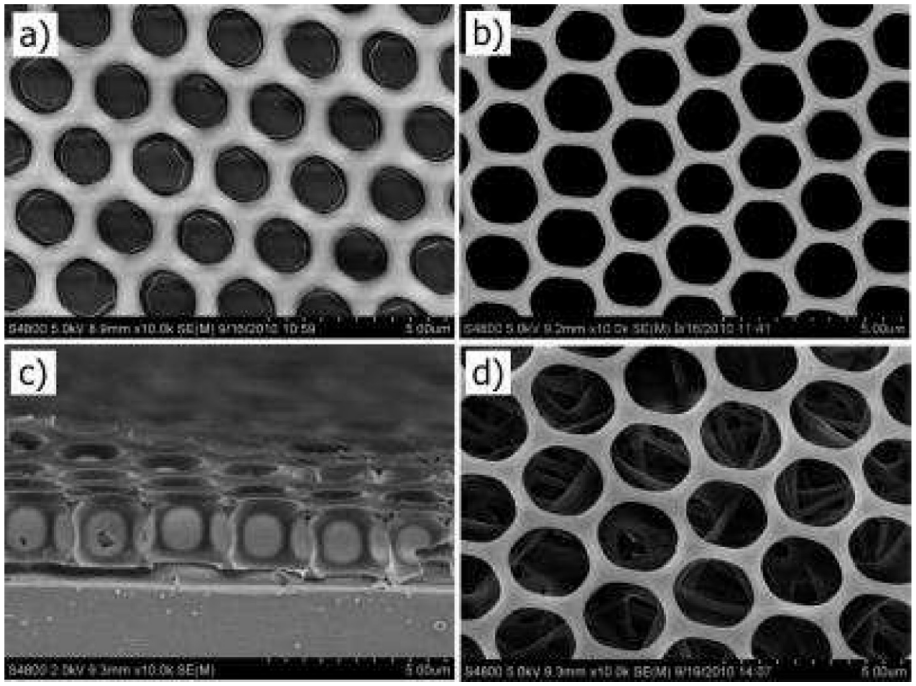

Fig. 2. SEM images of ordered PS-b-PDMAEMA membrane with through-pores. (a) Top, (b) bottom, and (c) cross section. (d) The membrane transferred onto a piece of dense nanofiber mesh [27].