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High performance ordered nanoporous membranes from block copolymers

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Among the different strategies to prepare nanoporous materials, block copolymer (BCP) self-assembly has shown remarkable potential towards preparation of highly ordered nanoporous film templates.[1] In a self assembling process, covalently connected, chemically dissimilar polymer blocks phase separate into ordered nanostructures with length scales on the order of tens of nanometres. Selective removal of the minor phase from self-assembled polymer thin films leads to self-standing nanoporous membranes. By selecting the right combination of template materials, several factors such as pore size, pore density and pore shape can be easily controlled in a resulting membrane. Pore size in block copolymer membrane is defined by the size of the removed minor component. The unique pore size pattern and their uniform distribution makes these nanoporous materials advantageous over conventionally prepared asymmetric membranes. The morphology depends on the composition of the copolymer and volume fraction of one of the constituent blocks.

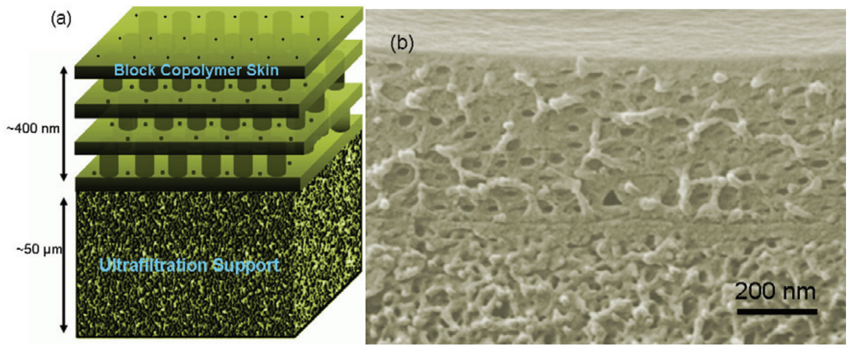

Figure 1. (a) Schematics of block copolymer coated asymmetric membrane and (b) SEM cross section of asymmetric PI-BCP membrane.

We explore block copolymers, polystyrene-*block*-polymethyl methacrylate [PS-*b*-PMMA] made into nanoporous membranes in a process called collective osmotic shock[2] (COS) to a range of contaminated wastewater treatment. The COS process allows the generation of nanopores that can be an order of magnitude smaller than the template nanostructures from which they are formed. Using a polyimide ultrafiltration (PI-UF) membrane support, thin film of block copolymer (~400 nm) skin layers were coated and further processed to selectively remove of one block (PMMA); thereby well ordered pores were induced as shown in Figure 1a. Among several advantages, collective osmotic shock induces asymmetric pore structure with tiny pores (1-2 nm) on top of underlying larger pore channels that help high permeate fluxes. As prepared membranes (Figure 1b) were then tested for removal of range of contaminant feeds including aqueous solutions of dye, urea, salt and organic solvent filtration applications. Contaminants from aqueous solutions have shown greater rejection performances while maintaining high permeate fluxes. High solute rejection at low pressure operations makes these membranes commercially viable and attractive.

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