Development of Two-Dimensional Nanostructured Virus Filtration Membranes Based on Gemini Smectic Liquid Crystals

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Nanostructured liquid crystals have attracted wide attention because of their ability to form ordered functional nanostructures by self-organization processes. In general, conversion of fluidic liquid-crystalline (LC) materials to solid ordered materials can be achieved by introducing polymerizable moieties into molecules and subsequent in situ polymerization of LC phases. We have developed self-organized nanostructured water treatment membranes based on ionic liquid crystals.[1–4] Uniform size of water channels in the range from sub-nanometer to nanometer scale is achieved by self-assembly of 1D columnar, 2D smectic, and 3D bicontinuous cubic LC monomers, which are preserved by in situ polymerization. The LC nanostructured membranes show selective ion permeation[1,4] and high virus rejection.[2,3]

We here report a new strategy employing gemini smectic liquid crystals exhibiting 2D nanostructures for virus filtration membranes.[5] We synthesized polymerizable gemini ionic amphiphiles, where two monomeric amphiphiles were laterally linked with each other (Figure 1). These gemini amphiphiles showed thermotropic smectic A (SmA) phases with layered nanostructures. The in situ photopolymerization of the SmA liquid crystals allowed for fixation of the LC nanostructures, resulting in the formation of 2D nanostructured crosslinked polymer membranes. The 2D nanostructured membranes removed small viruses in water (>99.99997%) by filtration. Furthermore, the membranes achieved higher water permeation compared to other types of LC nanostructured membranes.

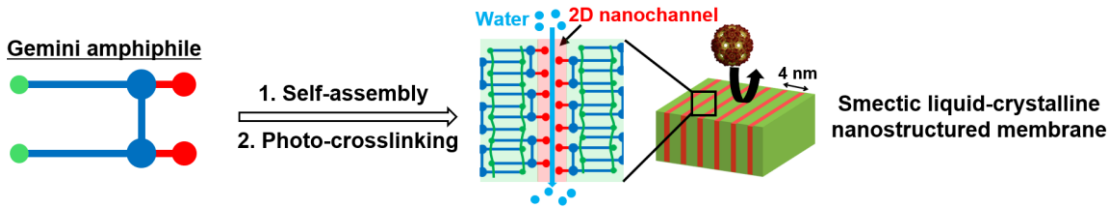

Figure 1. 2D nanostructured membranes based on gemini smectic liquid crystals.

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