Polymer Nanotube Ensembles for Separation and Sensing

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Presentation

Abstract: We have developed a method to rapidly manufacture nanoporous membranes that are capable of separating small and large biomolecules. In this method, nanoporous membranes are modified with amphiphilic homopolymers that are developed in our lab, to impart selectivity to these membranes. The uniqueness of our polymers is that it comprises hydrophilic and hydrophobic functionalities in each repeat unit of the polymer. These polymers form micelle type assemblies in polar solvents and inverse micelle type assemblies in apolar solvents. We have also synthesized polymers having two hydrophilic functionalities in each repeat unit of the polymer. These polymers have been found to form vesicle type assemblies in water. The possibility of utilizing these micelle and vesicle type assemblies in separation of small molecules and large biomolecules are explored. We hypothesized that high throughput separation is feasible, if we convert the micelles and vesicles into nanotubes. Towards this objective, the nanopores of polycarbonate membranes are decorated with amphiphilic polymer micelles and vesicles. We anticipated that the vesicle type assemblies will functionalize the nanopores and concurrently reduce the pore diameter of the polycarbonate membranes. Such functionalization preferably results in the formation of polymer nanotubes upon its adherence on the pore walls. The functionalization was carried out by treating the commercially available polycarbonate membrane with $SnCl_2$, which imparted positive charge on the membrane surface. Then, a solution containing vesicle type assemblies was filtered through the membrane. To find out whether the filtration process modified the nanopores, the polycarbonate template was dissolved to liberate the nanostructures. TEM images of the liberated nanostructures were found to be polymer nanotubes. The inner diameter of the polymer nanotubes were measured by diffusion of water through the polymer nanotubes embedded in the polycarbonate membranes. By carrying out ion transport experiments using the functionalized polycarbonate membranes, we could ascertain the charge of the polymer nanotubes' interior. Further, by filtering a polymer with complementary charge through the polymer nanotubes, we could modulate the pore size as well as the interior charge of the polymer nanotubes. Such modified membranes were used to separate small molecules based on size, charge and hydrophobicity. We also demonstrated that the amphiphilic polymer functionalized membranes can separate biomolecules such as proteins, based on size and pI.