Nanomembranes Could Filter Bacteria

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New nanomaterials research from the University at Buffalo could lead to new solutions for an age-old public health problem -- how to separate bacteria from drinking water.

To the naked eye, both water molecules and germs are invisible -- objects so tiny they are measured by the nanometer, a unit of length about 100,000 times thinner than the width of a human hair.
But at the microscopic level, the two actually differ greatly in size. A single water molecule is less than a nanometer wide, while some of the most diminutive bacteria are a couple hundred.
Working with a special kind of polymer called a block copolymer, a UB research team has synthesized a new kind of nanomembrane containing pores about 55 nanometers in diameter -- large enough for water to slip through easily, but too small for bacteria.
The pore size is the largest anyone has achieved to date using block copolymers, which possess special properties that ensure pores will be evenly spaced, said Javid Rzayev, the UB chemist who led the study. The findings were published online on Jan. 31 in Nano Letters and will appear in the journal's print edition later this year, with UB chemistry graduate student Justin Bolton as lead author.
"These materials present new opportunities for use as filtration membranes," says Rzayev, an assistant professor of chemistry. "Commercial membranes have limitations as far as pore density or uniformity of the pore size. The membranes prepared from block copolymers have a very dense distribution of pores, and the pores are uniform."
"There's a lot of research in this area, but what our research team was able to accomplish is to expand the range of available pores to 50 nanometers in diameter, which was previously unattainable by block-copolymer-based methods," Rzayev adds. "Making pores bigger increases the flow of water, which will translate into cost and time savings. At the same time, 50 to 100 nm diameter pores are small enough not to allow any bacteria through. So, that is a sweet spot for this kind of application."
The new nanomembrane owes its special qualities to the polymers that scientists used to create it. Block copolymers are made up of two polymers that repel one another but are "stitched" together at one end to form the single copolymer. When many block copolymers are mixed together, their mutual repulsion leads them to assemble in a regular, alternating pattern. The result of that process, called self-assembly, is a solid nanomembrane comprising two different kinds of polymers.
To create evenly spaced pores in the material, Rzayev and colleagues simply removed one of the polymers. The pores' relatively large size was due to the unique architecture of the original block copolymers, which were made from bottle-brush molecules that resemble round hair brushes, with molecular "bristles" protruding all the way around a molecular backbone.
The research on nanomembranes is part of a larger suite of studies Rzayev is conducting on bottle-brush molecules using a National Science Foundation CAREER award, the foundation's most prestigious award for junior investigators. His other work includes the fabrication of organic nanotubes for drug delivery, and the assembly of layered, bottle-brush polymers that reflect visible light like the wings of a butterfly do.