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Nanopores That Can Recognize, Separate Proteins and Small Molecules

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Nanopores, holes less than one-thousand the width of a human hair, are capable of isolating strands of DNA or therapeutic drugs from a solution, based mostly on the size of the pores. Now, a chemist at the University of Massachusetts Amherst has created nanopores that can recognize and interact with certain molecules, actively controlling their movement across synthetic membranes. Results were published online Feb. 3 in *Nature Nanotechnology*.

By lining their internal cavities with various polymers, S. "Thai" Thayumanavan and his students Elamprakash Savariar and K. Krishnamoorthy of the UMass Amherst department of chemistry have developed a method for creating nanopores that can separate small molecules and proteins based on size, charge and how strongly they are repelled by water. The method could be used in many applications including diagnostic medical tests, DNA sequencing and fuel-cell membranes.

"Modifying the internal cavities of nanopores with polymers allows them to interact with molecules moving through the pores. By using different polymers, we can control how the molecules will react with the nanopore and this allows us to identify them as they pass through," says Thayumanavan. "This process may be especially suitable for sensors, since the presence of a single molecule can produce changes in the electrical properties of the nanopore that we can detect and measure."

Thayumanavan views this process as a platform technology that could be used by researchers in many fields. “At UMass Amherst, we are researching the use of this method in sensors and separations, as well as addressing some fundamental questions about fuel-cell membranes as part of the Center for Fueling the Future funded by the National Science Foundation.”

To create these functional nanopores, Thayumanavan immersed a membrane containing nanopores in a tin solution, causing tin ions with a positive charge to adhere to the inside of the pores. Filtering a negatively charged polymer solution through the membrane caused tin ions to attract molecules of the polymer like a magnet and hold them in place, where they can easily react with other molecules in the confined space of the nanopores.

This process has many advantages over current methods. “Using polymer molecules allows you to precisely control the size of the nanopores at the same time that you are altering them to perform specific functions,” says Thayumanavan. “It can also be done quickly, usually in a few minutes. This method also results in a uniform layer inside the nanopore that behaves in a predictable way.”

Testing performed by Thayumanavan showed that using different types of polymers could create nanopores of almost any size, which translates to efficient separation of molecules based on their size.

Nanopores lined with polymers were also able to separate molecules based on their charge. “We found that nanopores with negatively charged interiors would allow positively charged molecules to move through the membrane more quickly,” says Thayumanavan. “Conversely, nanopores decorated with positively charged interiors would favor negatively charged molecules.”

In additional experiments, Thayumanavan lined the nanopores with polymers that were hydrophobic, or strongly repelled by water, and found that they would allow other hydrophobic molecules to pass more easily through the membrane. A final test revealed that the membranes could be used to separate proteins based on electrical charge.

Future research will focus on using different polymers with different functional groups to find out how specific the process can be made. “This method is limited only by the ability of chemists to place chemically reactive functional groups in polymer chains,” says Thayumanavan.

Source: University of Massachusetts Amherst

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