Self-Powered 3D Membrane Water Filtration (#8268)

Novel polymer composites for a wide range of industrial, medical, and environmental applications

This 3D filtration innovation is based on novel core-shell polymer composites (CSPCs), where the shell provides selective permeability and the core is a hydrogel network that can absorb approximately 50 times its weight in water. Unlike conventional flat (1D) or curved cylinder-like (2D) membrane filtration processes, which usually require some kind of external driving force, the core in Georgia Tech's technology provides the driving force for the filtration through absorption.

This innovative technology enables extra versatility and control in separation processes at different scales via membrane filtration in discrete 3D core-shell absorbers suspended in a system. With significant chemical and physical flexibilities of the polymers and the dynamic 3D configuration, the CSPCs and this filtration strategy have enormous potential for use in industrial, medical, and environmental separation processes.

Benefits/Advantages

- **Self-powered**: Eliminates the need for an external power source
- **Versatile**: Presents opportunities for hydrogel tuning and selective layer modification, leading to ultrahigh water flux, reversibility, and multi-functionality
- **Flexible**: Supports hydrogel cores of different water absorbency and biodegradability and PA shells of various morphology and mechanical properties
- **High performance**: Exhibits high-capacity and selective water absorption

Potential Commercial Applications

Georgia Tech's innovative filtration system can be leveraged in a number of industrial, medical, and environmental applications, including:

- Municipal wastewater purification
- Bioprocessing
- Environmental monitoring

Background/Context for This Invention

Membrane filtration plays a critical role in a variety of industries, including water purification, gas separation, bioprocessing, and chemicals manufacturing. The tradeoff between membrane permeability and selectivity remains a crucial problem to be addressed as novel high-performance membranes are developed.

Specifically, configuration of filtration processes and strategies are lagging behind the development of advanced membranes.

In Georgia Tech’s innovation, the composite core is a spherical hydrogel network of sodium polyacrylate (SPA) crosslinked with polyacrylamide (PAM). A polyamide (PA) coating—as thin as 7 nm—serves as the separating shell and provides reverse-osmosis-level selectivity.

When a CSPC is immersed in an aqueous solution, water molecules diffuse into the hydrogel channels, expanding the hydrophilic network. The vacuum pressure created by the volumetric swelling of the hydrogel drives water absorption until the equilibrium between absorption and osmotic flow is reached. The PA shell acts as a screen, rejecting salt ions along the water absorption process. Georgia Tech researchers have demonstrated that the CSPCs achieve a salt rejection of 99.8 percent at an initial water flux of 84.1 LMH.

In the case of water purification, the technology primarily targets municipal wastewater. The CSPCs can extract pure water from the target and the swollen gels containing purified water can be used as a water source for hydroponic gardening or farming.

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More Information

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Publications

Self-Driven Membrane Filtration by Core-Shell Polymer Composites, Journal of Materials Chemistry A, August 21, 2020

For more information about this technology, please visit:
https://licensing.research.gatech.edu/technology/self-powered-3d-membrane-water-filtration

Images:

The automated sequential delivery of multiple fluids. A varying number of delay gates imprinted in the branches are shown in the figure.

COVID-19 and flu saliva test on paper: (A) The automatic sequential delivery of multiple reagents required for virus test; (B) Water pouring into the device triggers the virus assay, allowing the presence of SARS-CoV-2 and influenza A & B viruses to be visually identified by the color changes in the corresponding detection spot