JUSTIN WEIBEL, COURTESY OF PURDUE UNIVERSITY

Coated Sponges Could Help Remediate Oil Spills by Absorbing Oil but Not Water

Researchers have discovered that, by immersing a melamine sponge in polydimethylsiloxane, they can create a low-cost, low-energy, and highly effective method for removing oil from water.

BEHOLD THE common household sponge, eminently useful in washing the dishes, mopping the floor, and now—if a team of researchers at Purdue University has its way—cleaning up oil spills in our oceans and along our shorelines.

Suresh V. Garimella, Ph.D., the R. Eugene and Susie E. Goodson Distinguished Professor in the School of Mechanical Engineering at Purdue University and the director of the Cooling Technologies Research Center, part of the National Science Foundation's Industry and University Cooperative Research Program, is working with Xuemei Chen, Ph.D., a postdoctoral research assistant at the center, and Justin A. Weibel, Ph.D., a research assistant professor in the university's mechanical engineering department, to develop a method for separating oil from water using commonly found constituents. The team has coated melamine sponges—the same type used in many households—with a material that renders them both superhydrophobic and superoleophilic so that they absorb oils but not water. The process is both inexpensive and simple and can be replicated on almost any scale.

"Considering that the fabrication of the functionalized sponge is cost effective and scalable, we believe this can be readily adopted for the cleanup of oil spills and industrial chemical leaks," said Garimella in written answers to questions posed by *Civil Engineering*. "Another important class of applications is in oil production."

The Cooling Technologies Research Center has been experimenting with what Garimella calls bioinspired coatings, "primarily related to manipulating fluid behavior on surfaces to enhance the performance of heat exchangers," he said. One method involves coating roughened, textured surfaces with a hydrophobic chemical called polydimethylsiloxane. The textured surface geometry, combined with the coating, produces a surface that is far more water repellent than can be found in nature.

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The team then looked at melamine sponges, which have a unique internal structure comprising tiny ligaments and interconnected pores. Roughly 99 percent of the volume of such sponges is taken up by the pores, but many surfaces along the ligaments are available for coating. "We assumed that if this material could be modified with a hydrophobic coating, as we have done with other surfaces in the past, the sponge would become superhydrophobic," Garimella said.

And the assumption was borne out; the coated sponges were very effective at repelling rather than absorbing water, but they remained very effective at absorbing oil. "Oils have very different characteristics than water; in particular, they have a very low surface tension that allows them to infiltrate into porous surfaces that could not be infiltrated by water," explained Chen, who also replied in writing to questions posed by *Civil Engineering*. "Due to the open, porous nature of the superhydrophobic sponge, it can absorb large quantities of oil while preventing any water from being absorbed," Chen said. "In general, the functionalized sponges can absorb 45 to 75 times their own weight, depending on the density of the oil or other contaminants."

The team members immediately recognized the value of this invention for cleaning up oil spills, separating oil from water in any number of industrial applications, or even drawing usable oil from new, previously unreachable sources. Their research was recently described in a paper, "Continuous Oil-Water Separation Using Polydimethylsiloxane-Functionalized Melamine Sponge," in *Industrial & Engineering Chemistry Research*, a publication of the American Chemical Society.

The sponges that the team worked with were quite small, roughly 1 in. cubes. But there seems to be no limit to how large a sponge the process would work on, according to Weibel, who also responded to questions in writing. The coating process requires little more than commonly available chemicals and a glass container in which to dip the sponges, and only a low concentration of the chemical mixture—3.3 percent by volume—is needed for each sponge. "In order to functionalize the melamine sponge, we stir the chemicals to form a homogeneous solution and then immerse the sponge in the solution for about an hour," Weibel said. The sponge is then removed from the solution, wrung out, and dried in an oven at a high temperature. "We can easily make larger samples, as the fabrication process can easily be scaled up," Weibel said.

In addition to mopping up after oil spills either on land or at sea, the coated sponges could be used to remove oils and oil-based by-products from industrial waste or to absorb hydrocarbons, insulating fluids, pesticides, or even polychlorinated biphenyls (PCBs), carcinogenic compounds that often vex environmental engineers seeking to remediate brownfield sites for redevelopment. And compared with such conventional methods of oil removal as skimming, chemical dispersion, and in situ burning, this method is low tech, requires little energy, and is safe for the environment.

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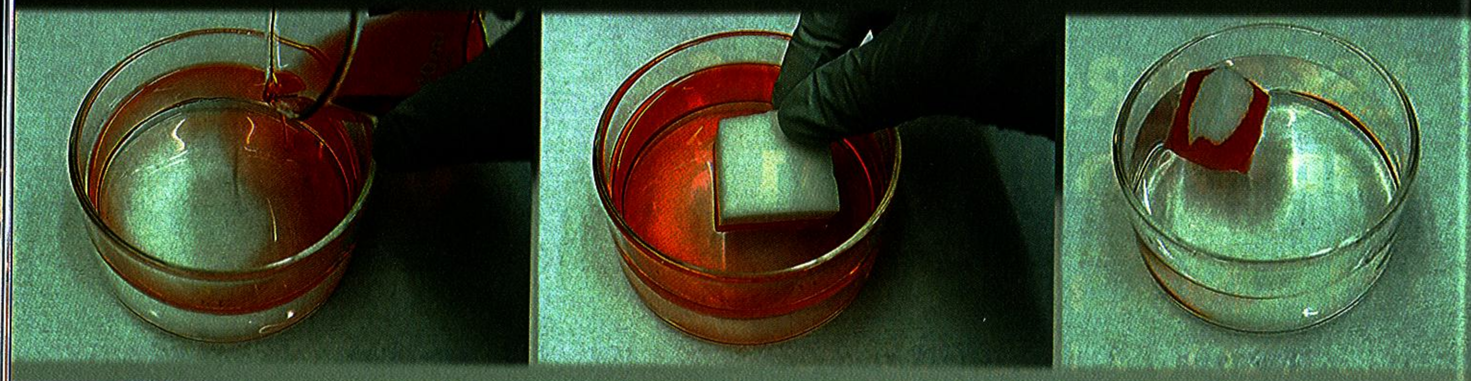
The sponges are also low in cost once an initial investment is made; the team has yet to reach the point at which the sponges cannot be wrung out and reused. "We have demonstrated that the sponge fully retains its functionality after many such absorption-squeezing cycles," Chen said. Alternatively, they can be attached to the end of a low-power suction machine—think of a large sponge on the end of a vacuum hose—so that they can continuously draw oil out of a body of water, for example, without having to be wrung out at all. "The sponge will absorb the contaminants as they are simultaneously pumped out of its porous structure," Chen explained. "In this manner, the sponge never becomes completely saturated and can be used continuously."

Weibel said that the team's next goal is to devise a coating that will work on nanoscale particles. "If similarly facile processes could be developed for functional materials engineered to separate oil-in-water or water-in-oil nanoemulsions," he said, "we could expand to an even broader range of targeted pollutants." —LAURIE A. SHUSTER



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