Materials for clothes that self-decontaminate may also purify biofuel

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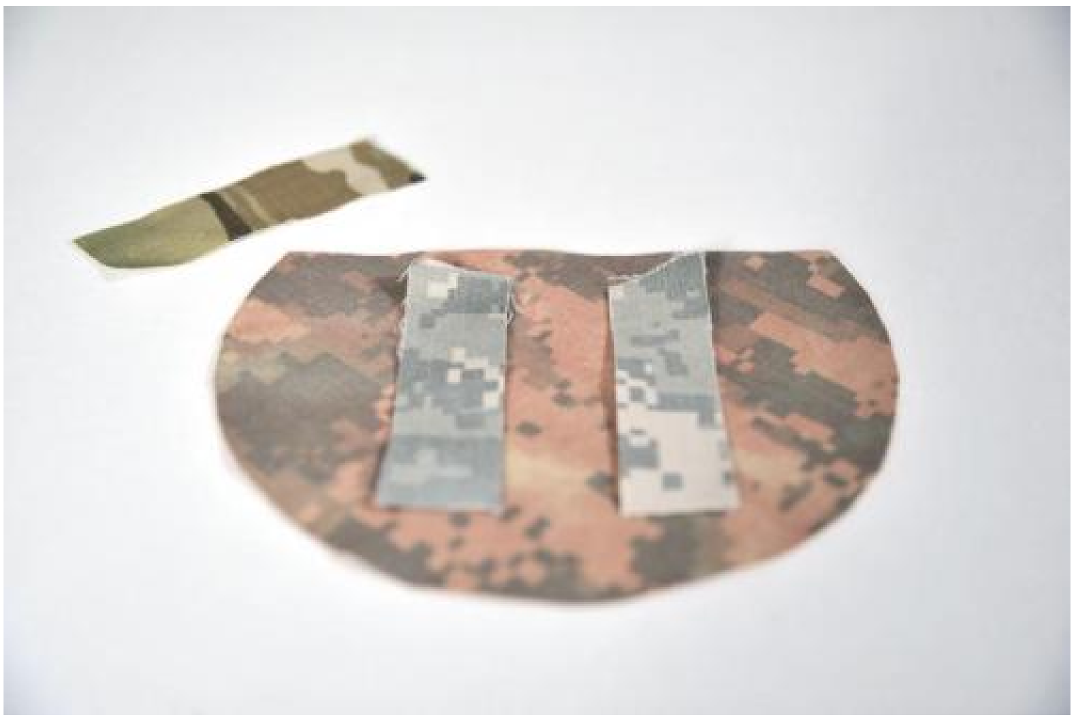


Dr. Brandy White's sorbent-porphyrin materials work for fabrics, and can be coated on hard surfaces or used in sensors. Wet or dry, "I know that you can stick them out in a July sun at 100 degrees for a week and nothing about their performance characteristics changes." She's looking into potential for biodiesel purification. Credit: U.S. Naval Research Laboratory/Jamie Hartman

(Phys.org) —The military wants fabrics that don't just filter out nerve agents and other toxins, but also self-decontaminate. Dr. Brandy White, at the U.S. Naval Research Laboratory (NRL) Center for Biomolecular

Science and Engineering, is making materials that capture entire classes of contaminants, then break them down into something harmless. Her technology is stable and can be used for clothing, air filters, or even coated on windows and vehicles.

Today's filters are carbon—like in your water pitcher at home, or in military suits and gas masks. Carbon is great at capturing and holding contaminants—but they're still there. "You still can't take that suit and go to a populated place. The fabrics that we're talking about with my coating, they grab it and they hold it in just like carbon would, but then they convert it into something else."

As U.S. Marines moved in on Baghdad in 2003, they were wearing hot, unbreathable, full-body suits day and night. When they were finally able to take off their Mission Oriented Protective Posture (MOPP) gear, you can imagine how it felt to have air circulation for the first time in weeks—and then you can just imagine the smell. "If they've actually been exposed to something, then putting on their MOPP gear no longer protects them, they're just trapping it all inside. So the idea behind this type of fabric was it could be used to give them time to get their MOPP gear on."

White's made chemical materials that target a wide range of classes. She's also, at a lab-scale, bonded them to fabrics and powders to verify their potential for military or commercial applications.

White's research complemented efforts by the Defense Threat Reduction Agency (DTRA) to think beyond just clothes. "If you think about air filters," she says, "like for your HVAC system at home, you have those pleated things. That's a fabric." With filters to break down airborne toxins at every air intake, a terrorist couldn't expose an entire building.

Or industry could use such filters to reduce ammonia smells in hospitals and improve air quality around industrial processes. "Air purification technology could be in the ductwork of the building, it could be on stack gases for exhaust from industrial processes."

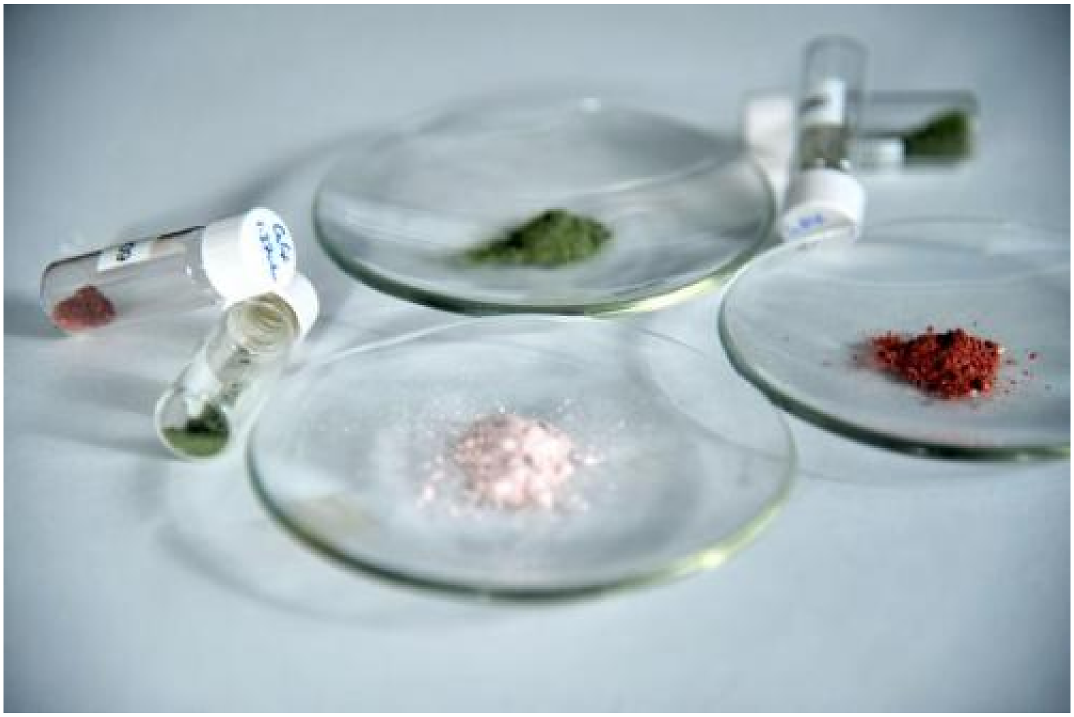
Because her material also works when wet, "You can capture the organics out of your waste stream and make your water safe." She's already proven, with perchlorate, that she could help industry and federal agencies monitor and cleanup water pollutants.

Better than carbon: applications for military and industry

Carbon materials bind both things you care about and things that are totally harmless, then stop working once saturated. White's materials are specific, so "you can use all of your space for the things that you care about and you don't bind things that don't matter, like perfume off the guy standing next to you."

Because her materials also break down targets naturally, they don't become saturated and have to be thrown out. Depending on the target and with a little time, she says, "it can go to complete mineralization, which means you get products like water and CO2 [carbon dioxide] and things like that." In water, the harmless products are released; in air, they move away from the active site so target capture can continue.

She's put these chemical material wonders into useful formats, including a powder that goes into a gas mask; a surface coating for windows or electronics; or "you dip fabric through them, so the material's covalently part of the fabric; not just a coating on the fabric." By dipping fabric through different sorbents, or layering different fabrics, or mixing multiple powders, she can screen for and breakdown multiple target classes.



The porphyrin-functionalized organosilicate sorbents Dr. Brandy White desgined at NRL capture and break TIC/TIM and other targets down into things that are harmless. "Air purification technology could be in the ductwork of the building, it could be on stack gases for exhaust from industrial processes," she says. Credit: U.S. Naval Research Laboratory/Jamie Hartman

She's also working with another group at NRL on a portable sensor, "about the size of a soda can." The sensors quantitatively measure concentrations of a target. She adds, "They will Wi-Fi communicate so you can use them for perimeter monitoring."

The applications for the combat environment are so promising, in part because White's material is washable and stable in extreme conditions. "This is what I know," she says. "I know that you can stick them out in a

July sun at 100 degrees for a week and nothing about their performance characteristics changes. As far as I can tell, the materials are identical to when I stuck them out there." This is true whether they are dry or in water.

The chemistry: a sorbent structure with porphyrin photocatalysts

White's chemistry starts with an organosilica sorbent, which has an organized, very porous structure. "That means that they have solid parts and they have open air parts," she says. "The solid parts give you binding affinity." The open pores give "lots of surface area, [which] means lots of binding sites." With colleague Brian Melde, she designs specific pockets or imprints for the target into the skeleton-like structure.

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To make the structure even better at capturing her target, she adds specific precursors to the sorbent. "The precursor gives you the chemical affinity that you're looking for, so that might be a benzene group or it might be an ethane group or some mixtures of those things."

With a process she's patented, she then couples a porphyrin into the organosilica structure. "The sorbent part captures the material and pulls it in close to where we've immobilized the porphyrins within the material," she says, "and the porphyrin takes light and converts the molecule into something that's less toxic."

"Porphyrins are all of a basic shape that's very similar," she says. "You've got double bonds running around everywhere," which makes them good at photocatalysis. The porphyrins absorb light, then transfer energy to the target to break it down.

Choosing from the library of commercially available porphyrins she keeps in the lab, "I can screen 96 porphyrin variants at a time to look for affinity for the targets that I'm interested in." Adding a coordinated metal can further increases reactivity.

The photocatalysis happens under any light conditions; but, says White, "more blue is better." Without light, the system will eventually stop. "However, you can pass a current through the materials to restart catalysis." And it doesn't have to be a lot. "We're only using 9 volt batteries."

Dr. Brandy White inserts a porphyrin-functionalized, paper sensor surface into a reflectance sensor. NRL is developing sensors that "will Wi-Fi communicate so you can use them for perimeter monitoring." Credit: U.S. Naval Research Laboratory/Jamie Hartman

White's materials are class-specific. "So if I design a material that will bind organophosphonate pesticides, it will also bind sarin and VX [nerve agents] and compounds with a similar structure." She's made sorbent-porphyrin materials for a range of targets, including nerve agents, blister agents (like mustard gas), and nitroenergetics (explosives, like TNT).

She's also made them for toxic industrial chemical (TIC)/toxic industrial material (TIM) targets, as listed by the Department of Defense (DoD) Chemical and Biological Defense Program TIC/TIM Task Force and for first responders by the National Institute of Standards and Technology (NIST). "Industrial waste products in stack gases fall into this class of targets," she says.

"The risk of something is assessed based on how bad it would be if you were exposed to it and how likely it would be that someone could initiate that attack." As an example, "You could breathe some ammonia, you probably do it when you clean your house," says White, "but if you breathe more it can make your lungs uncomfortable, it can start to cause damage to you, and it's really easy for people to get their hands on." VX may be more dangerous; but it's also harder to make and less stable to move around.

White continues to expand the types of targets against which she can defend with a class-specifically designed material. DoD calls emerging threats non-traditional agents. She has the agility, expertise, and resources to ever evolve our defenses. "There's always a new threat. I know how to make materials, I know what they're going to behave like."

White's PhD is in photonics from Oklahoma State, and she's been at NRL since she came as a postdoc in 2004. She credits both the culture and access to federal funding across a wide variety of research areas for her achievements. "The culture at NRL is fantastic, because we all loosely interact within divisions and across divisions." She's also quick to say she's never felt, as a young woman in science, any kind of disadvantage. "If you look at my division, we are more than 50 percent female. It's a special division."

Recently, White began a project to purify biodiesel. "There's been a big push recently within the Navy to switch to alternative fuels," she says. The Navy and Marine Corps already run ships and jets on biofuel blends.

But part of the expense of biofuel is due to the purification process.

White's already shown she can capture nitroenergetics from water. Her idea is to do something similar to purify biodiesel: "To design sorbents to capture the things out of the slurry that impact stability and cold weather performance." Her concept would be more efficient, and reduce waste water associated with the washing process.

"In three years," she says, by the time the project's funding has ended, "I hope to have been able to demonstrate that I can take unprocessed biodiesel and capture out the things that need to be captured so that it will pass the [American Society for Testing and Materials] standard."

Provided by Naval Research Laboratory

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