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Sticky mussels inspire biomedical engineer yet again

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Mussels are delicious when cooked in a white wine broth, but they also have two other well-known qualities before they're put in a pot: they stick to virtually all inorganic and organic surfaces, and they stick with amazing tenacity.

Northwestern University biomedical engineer Phillip B. Messersmith already has developed a material that mimics the strength of the bonds; now he has produced a versatile coating method that mimics the mussels' ability to attach to a wide variety of objects.

Messersmith and his research team, in a study to be published in the Oct. 19 issue of the journal *Science*, report that a broad variety of materials can be coated and functionalized through the application of a surface layer of polydopamine.

Potential applications of the simple and inexpensive method include flexible electronics, such as bendable and flexible displays, biosensors, medical devices, marine anti-fouling coatings, and water processing and treatment, such as removing heavy metals from contaminated water.

Key to the coating method is the small molecule dopamine, commonly known as a neurotransmitter. Dopamine, it turns out, is a good mimic of the essential components of mussel adhesive proteins, and the researchers use it as a building block for polymer coatings. (Dopamine itself is not found in mussels.) So, like a mussel, Messersmith's coating sticks to anything.

"This is an astonishingly simple and versatile approach to functional surface modification of materials," said Messersmith, professor of biomedical engineering at Northwestern's McCormick School of Engineering and Applied Science, who led the research. "We dissolve dopamine, which we buy at low cost, in a beaker of water exposed to air. We adjust the water's pH to marine pH, about 8.5, put in an object and several hours later it's coated with a thin film of polydopamine. That's it."

Solid objects of any size and shape can be immersed in the solution. (The dopamine solution is very dilute -- only two milligrams of dopamine per one milliliter of water.) At marine pH, there are chemical changes in the dopamine molecule that result in polymerization of the molecules together to form a polymer, polydopamine, which coats the object. The polymer is fairly similar to what is found in the mussel adhesive protein.

And to make things more interesting, the polydopamine coating, in turn, provides a very chemically reactive surface onto which the researchers can deposit a second coating. And because the surface is so reactive in so many different ways, a wide variety of second coatings can be applied.

"We take advantage of that reactivity to apply the second layer," said Messersmith. "As a simple example, I could put an iPod in the dopamine solution, and a thin polydopamine coating would form. Then I could take it out and put it in a metal salt solution and form a coating of copper or silver."

This second coating, depending on what it is, promises to take researchers and industry in multiple directions as far as applications go. In addition to cladding objects with metal coatings, this includes inhibiting biofouling of materials (such as for medical devices), engineering surfaces to support biospecific interactions with cells (such as for culture and expansion of stem cells) and applying self-assembled monolayers to nonmetal surfaces (such as for biosensors).

Messersmith and his colleagues tested the two-step process on 25 different substrate materials (but not an iPod) with a wide range of characteristics representing all major classes of materials, from hydrophobic to hydrophilic, from inorganic to organic, as well as the traditionally difficult material Teflon, all with positive results. They then demonstrated deposition of metal and organic coatings and self-assembled monolayers onto the polydopamine coating.

“Existing methods for modifying material surfaces are fairly restricted to specific materials -- what works well on glass would not work well on gold,” said Messersmith. “Our method is a much more general strategy for a variety of surfaces. We haven’t found a material to which we can’t apply polydopamine.”

Source: Northwestern University

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