New hull coatings for Navy ships cut fuel use, protect environment (w/Video)

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New hull coatings being developed by the Office of Naval Research are showing promise in reducing the build-up of marine crustaceans - namely barnacles - on ships' hulls, optimizing vessel performance and dramatically reducing fuel costs.

Marine growth adds weight and increases drag reducing a vessel's fuel efficiency - not good in an era of soaring fuel costs. The practical problem for ships is simply that biofilm can add up to 20 percent drag and barnacles over 60 percent. This increases fuel consumption and green house gas emissions. ONR-sponsored biofouling prevention coatings provide an environmentally safe alternative for protecting naval ship hulls, which could also benefit the commercial shipping industry.

"The ultimate solution is to stop the barnacle settlement process before it happens," says Steve McElvany, Ph.D., program manager for ONR's Environment Quality program. "We are really trying to look very far forward to get the ultimate solution that's good for the U.S. Navy and the oceans."

The Naval Surface Warfare Center at Carderock estimates that biofouling reduces vessel speed by up to 10 percent. Vessels can require as much as a 40 percent increase in fuel consumption to counter the added drag. For the Navy, that translates into roughly one billion dollars annually in extra fuel costs and maintenance to keep its ships free of barnacles, oysters, algae and other debris.

High-performance naval warships and submarines rely on critical design factors such as top speed, acceleration and hydroacoustic stealth. Previous biofouling prevention methods used toxic coatings, or biocides, to clear barnacle colonies from the ship exteriors. Although effective in the short-term, biocides exact a heavy environmental burden.

By studying the environment, researchers are learning from nature how it beats the "crusty fouler" naturally. And that's where ONR's investment in biofouling prevention technologies has made significant gains.

On the East Coast, ONR is funding research at the University of Florida where Anthony Brennan, Ph.D., professor of material science and engineering, has been investigating why some marine animals, such as whales, harbor barnacles and others, such as sharks, stay relatively clean. Brennan discovered that the unique pattern of shark skin contributed to its ability to fend-off microorganisms.

With this insight, Brennan started modeling shark skin patterns in his lab. The idea led to the development of a new biomimetic technology called Sharklet, which has shown extremely positive results in inhibiting marine growth. The significance of his work really hit home during a visit to Pearl Harbor.

"I saw a Navy ship going by ... flowing with green algae," Brennan said. "I thought that's why we are doing this research, to stop that biofouling … to give our Navy the ability to perform at a higher level."

The biodiversity of different ocean environments also creates unique challenges. So, across the country on the West Coast, ONR is working with Dr. Shaoyi Jiang, Boeing-Roundhill Professor at the University of Washington, on biofouling prevention coatings that incorporate zwitterionic or mixed-charge compounds.

"The marine environment is very complicated," said Jiang. "It is as complex as the human body."

Zwitterionic compounds are stable, alternating perfectly between positive and negative charges, and easy to handle in both laboratory and field tests. They've shown excellent resistance to the attachment of biomolecules and microorganisms. The result is that naturally occurring proteins, bacteria, algae, barnacles and tubeworms do not bind to this unique surface.

ONR's innovation in hull coatings will optimize ship performance with an eye toward environmental stewardship. Inventive biofouling prevention systems will help conserve fuel, minimize the Navy's carbon footprint, reduce the risk of transporting invasive aquatic species and prevent toxic biocides from entering surrounding environments.

While both the Sharklet pattern and zwitterionic coating inhibit the settlement of barnacles, they also inhibit the growth of bacteria. This unique attribute has applications in hospitals and high-touch areas in healthcare where it is critical to inhibit the survival and transference of bacteria to protect patients from infections. As Brennan says, "this technology spreads beyond the hull of the ship … there is a great opportunity to extend this technology to the public."

Jiang and Brennan acknowledged the open environment and multidisciplinary research approach that the Office of Naval Research and its program managers encourage from principal investigators.

"The ONR program provides an excellent environment and infrastructure for collaborations," said Jiang.

Brennan added, "ONR has brought together biologists, geneticists, chemists, material engineers, chemical engineers, physicists and we end

up sharing. It says a lot of our Navy to have that forethought to reach beyond what everybody sees in front of them and go for something new and innovative that will help the Navy and benefit the world."

Source: Office of Naval Research