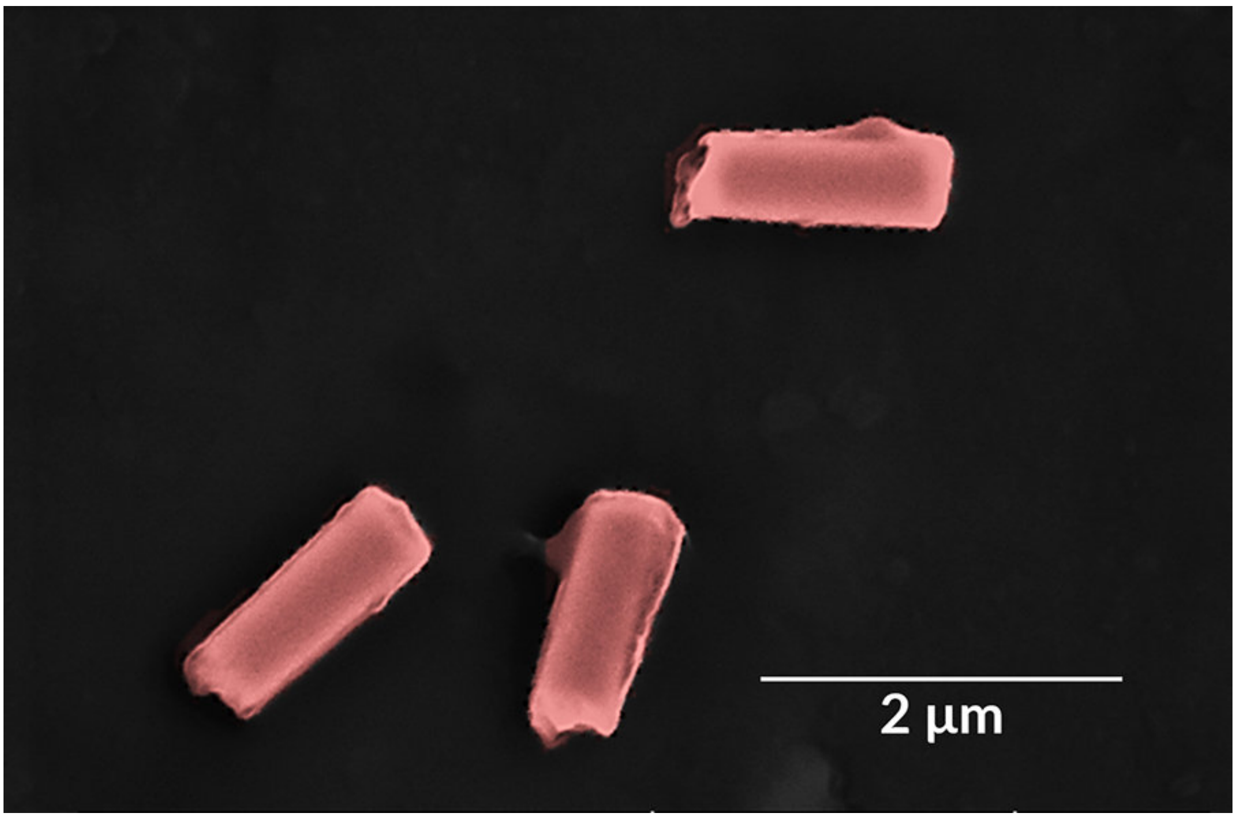
Cell-like nanorobots clear bacteria and toxins from blood

May 31 2018, by Liezel Labios



Colored SEM image of nanorobots coated in hybrid platelet/red blood cell membranes. Credit: Esteban-Fernández de Ávila/Science Robotics

Engineers at the University of California San Diego have developed tiny ultrasound-powered robots that can swim through blood, removing harmful bacteria along with the toxins they produce. These proof-of-concept nanorobots could one day offer a safe and efficient way to detoxify and decontaminate biological fluids.

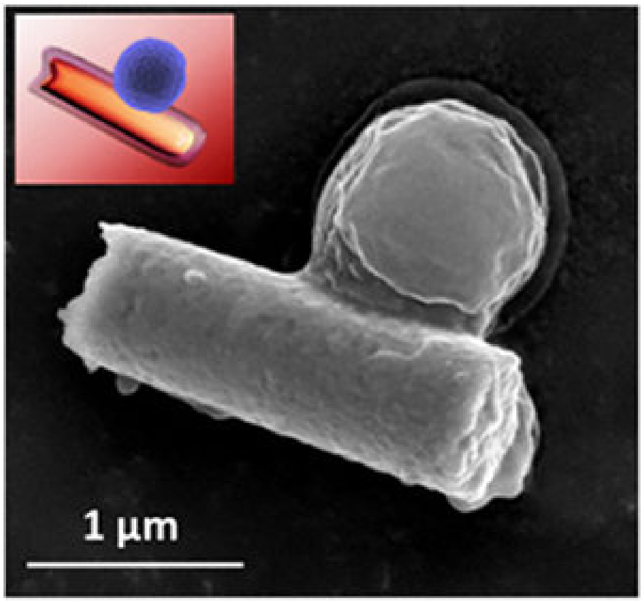
Researchers built the nanorobots by coating gold nanowires with a hybrid of platelet and red blood cell membranes. This hybrid cell membrane coating allows the nanorobots to perform the tasks of two different cells at once—platelets, which bind pathogens like MRSA bacteria (an antibiotic-resistant strain of Staphylococcus aureus), and red blood cells, which absorb and neutralize the toxins produced by these bacteria. The gold body of the nanorobots responds to ultrasound, which gives them the ability to swim around rapidly without chemical fuel. This mobility helps the nanorobots efficiently mix with their targets (bacteria and toxins) in blood and speed up detoxification.

The work, published May 30 in *Science Robotics*, combines technologies pioneered by Joseph Wang and Liangfang Zhang, professors in the Department of NanoEngineering at the UC San Diego Jacobs School of Engineering. Wang's team developed the ultrasound-powered nanorobots, and Zhang's team invented the technology to coat nanoparticles in natural cell membranes.

"By integrating natural cell coatings onto synthetic nanomachines, we can impart new capabilities on tiny robots such as removal of pathogens and toxins from the body and from other matrices," said Wang. "This is a proof-of-concept platform for diverse therapeutic and biodetoxification applications."

"The idea is to create multifunctional nanorobots that can perform as many different tasks at once," said co-first author Berta Esteban-Fernández de Ávila, a postdoctoral scholar in Wang's research group at UC San Diego. "Combining platelet and red blood cell membranes into each nanorobot coating is synergistic—platelets target bacteria, while red blood cells target and neutralize the toxins those bacteria produce."

The coating also protects the nanorobots from a process known as biofouling—when proteins collect onto the surface of foreign objects and prevent them from operating normally.



SEM image of a MRSA bacterium attached to a hybrid cell membrane coated nanorobot. Credit: Esteban-Fernández de Ávila/Science Robotics

Researchers created the hybrid coating by first separating entire membranes from platelets and red blood cells. They then applied high-frequency sound waves to fuse the membranes together. Since the membranes were taken from actual cells, they contain all their original cell surface protein functions. To make the nanorobots, researchers coated the hybrid membranes onto gold nanowires using specific surface chemistry.

The nanorobots are about 25 times smaller than the width of a human hair. They can travel up to 35 micrometers per second in blood when powered by ultrasound. In tests, researchers used the nanorobots to treat blood samples contaminated with MRSA and their toxins. After five minutes, these blood samples had three times less bacteria and toxins than untreated samples.

The work is still at an early stage. Researchers note that the ultimate goal is not to use the nanorobots specifically for treating MRSA infections, but more generally for detoxifying biological fluids. Future work includes tests in live animals. The team is also working on making nanorobots out of biodegradable materials instead of gold.

Paper title: "Hybrid biomembrane-functionalized nanorobots for concurrent removal of pathogenic bacteria and toxins." Co-authors include joint co-first authors Pavimol Angsantikul and Doris. E Ramirez-Herrera, Fernando Soto, Hazhir Teymourian and Diana Dehaini, Yijie Chen, all at UC San Diego.

More information: Berta Esteban-Fernández de Ávila et al. Hybrid biomembrane–functionalized nanorobots for concurrent removal of pathogenic bacteria and toxins, *Science Robotics* (2018). DOI: 10.1126/scirobotics.aat0485

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