New technology could stamp out bacteria in persistent wounds

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(PhysOrg.com) -- Using an advanced form of a rubber stamp, researchers have developed a way to adhere an ultra-thin antibacterial coating to a wound.

The active ingredient, silver, "has been used to prevent and treat infections for ages," says first author Ankit Agarwal, a postdoctoral fellow in chemical and biological engineering at the University of Wisconsin-Madison. "But silver can also kill skin cells, and therefore we need to develop materials that deliver antibacterial but nontoxic levels of silver to wounds."

In a study just published in the journal Advanced Functional Materials, Agarwal, chemical and biological engineering professor Nicholas Abbott, and colleagues described a process for creating a transparent ultra-thin polymer coating carrying precise loads of extremely fine silver nanoparticles.

The coating, just a few molecules thick, was assembled on a flexible piece of rubber and then rubber-stamped onto a piece of cadaver skin that simulated a wound in the experiment.

To test the activity against bacteria, the researchers treated skin samples with two bacteria that commonly infect wounds. Using a silver dosage that had not harmed skin cells in previous tests, the bacteria were undetectable within 12 hours, Agarwal says.

Persistent wounds are a major cause of pain, expense and disability. Approximately two million people in the United States seek hospital care for burns each year, and another six million people have chronic wounds from other causes.

"Chronic wounds are a major national burden," says Michael Schurr, a collaborator on the study who is a professor of surgery at UW-Madison. "If you look at the coming epidemic of diabetes, foot ulcers are very common in diabetes, and they often lead to amputation. Despite all the advances in surgery and medicine, the wound care we are providing now is much the same as what we offered 20 or 50 years ago."

Contact printing with stamps is widely used in industry to apply precise coatings to metal and glass, Agarwal says, but the researchers had to invent a method to transfer the polymer layer to softer skin. "We found, serendipitously, that if we introduce certain micrometer-sized beads in the films, it greatly enhances the transfer of films to soft materials," says Agarwal.

The technology, developed in collaboration with Charles Czuprynski of UW-Madison and Christopher Murphy, who is now at the University of California, offers many benefits, says Agarwal. First, it places the silver nanoparticles directly in the wound, allowing nontoxic silver doses (up to 100 times lower than what is used in commercial silver dressings) to have antibacterial activity. Second, chemical engineers should be able to make a sustained-release version to reduce the need for repeated applications and painful dressing changes.

Furthermore, while bacteria can efficiently evolve resistance to antibiotics, they virtually never develop resistance to silver. "The silver works by damaging bacterial cell membranes and interfering with metabolic functions of the microbes," says Agarwal. Silver can also kill fungi and yeast and inactivate viruses.

The films containing silver nanoparticles are composed of hundreds of individual layers and take several hours to prepare on a robotic machine on campus. But none of this chemistry needs to be done near the patient, Agarwal says, and the stamping process itself takes just 30 seconds. In the lab, the stamps are impressed onto cadaver skin using a handheld roller like those artists use to make woodcut prints.

Preliminary studies have shown that the films and stamping process do not impair healing of wounds in diabetic mice, Agarwal says. Further studies, directed by Jonathan McAnulty of the UW-Madison School of Veterinary Medicine, are investigating the antibacterial effect of silver-nanoparticle films in infected wounds in mice and pigs.

The process could be used more generally, says Abbott. "This method is applicable to a range of soft materials and could incorporate a variety of molecules onto the tissue surface that could influence fundamental cell behaviors involved in healing."

If and when the technology passes its animal trials, it will be time to prepare human trials. "We have a multidisciplinary team of veterinary scientists, chemists, surgeons, chemical engineers and material scientists who have experience taking medical devices through the Food and Drug Administration," Agarwal says. "The need is great, but it can take another few years before the treatment is available to patients."

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