Novel technique achieves 32-fold increase in nanometric bactericide's activity

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In recent decades, research groups in the field of materials science have invested time and resources to answer the following question: Is it possible to develop new techniques to produce silver particles on a nanometric scale (i.e., one billionth of a meter), thus enhancing the optical, catalytic and bactericidal properties of silver? A group of Brazilian investigators reports new developments.

In a research carried out within the Center for Development of Functional Materials (CDMF), the researchers developed a new technological approach to generate silver nanoparticles with 32 times the bactericidal capacity of those currently used in food packaging, orthotics, and hospital and medical materials, among others. The results of the study were published in *Scientific Reports*.

Professor Elson Longo of UFSCar says that CDMF's researchers developed an innovative method of obtaining nanocomposites three years ago. These nanocomposites comprised silver nanoparticles coupled to a silver tungstate semiconductor crystal by transmission electron microscopy.

However, the high cost of transmission electron microscopes limited plans of large-scale production of these materials for real-world applications. "The transmission electron microscope used to obtain this material costs approximately 1.3 million euros," Longo said. The technique involved electron-beam irradiation of silver tungstate, which resulted in promising bactericides whereby the silver tungstate semiconductor attracts bacterial agents that are then are neutralized by silver nanoparticles.

To scale up production of these nanocomposites using a more competitive method, the researchers developed a novel technique consisting of pulsed laser irradiation of a silver tungstate semiconductor, with each pulse lasting only a femtosecond—one millionth of one billionth of a second (10^{-15} s). Analysis of the irradiated samples showed that interaction between the silver tungstate semiconductor and the femtosecond laser gave rise to large numbers of microstructures, which they characterized by transmission electron microscopy and found to be of two different types.

"The new technique we developed resulted both in silver nanoparticles left on the semiconductor and in silver clusters," said the coordinator of the FAPESP-funded research center.

To measure the bactericidal activity of the materials, the researchers placed samples of them in contact with methicillin-resistant strains of Staphylococcus aureus (MRSA), a bacterium that is resistant to numerous antibiotics and is frequently at the root of hospital-acquired infections. Microscopic analysis showed a 32-fold increase in bactericidal activity for the laser-irradiated samples compared with silver nanoparticles produced by electron-beam irradiation.

"The new technique offers the possibility of obtaining high-performance bactericidal compounds that are easy to produce," Longo said.

Potential applications

The researchers have applied for a patent on the new technique and the two new classes of silver nanoparticle obtained by the technique. The idea is to license the technology to Nanox, a spinoff from CDMF based in São Carlos, São Paulo State, and supported by FAPESP's Innovative Research in Small Business Program (PIPE). "Nanox already sells silver nanoparticles worldwide and could benefit a great deal from the new technique for obtaining the material," Longo said.

The researchers plan to evaluate use of the material in dental prosthetics and have begun trials to investigate the action of nanocomposites in cancer cells. Preliminary results of the experiments suggest the nanoparticles can eliminate tumor cells without affecting healthy cells.

More information: Marcelo Assis et al, Towards the scale-up of the formation of nanoparticles on α-Ag_2WO_4 with bactericidal properties by femtosecond laser irradiation, *Scientific Reports* (2018). DOI: 10.1038/s41598-018-19270-9

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