Scientists have created nanoparticles that cure cancer harmlessly

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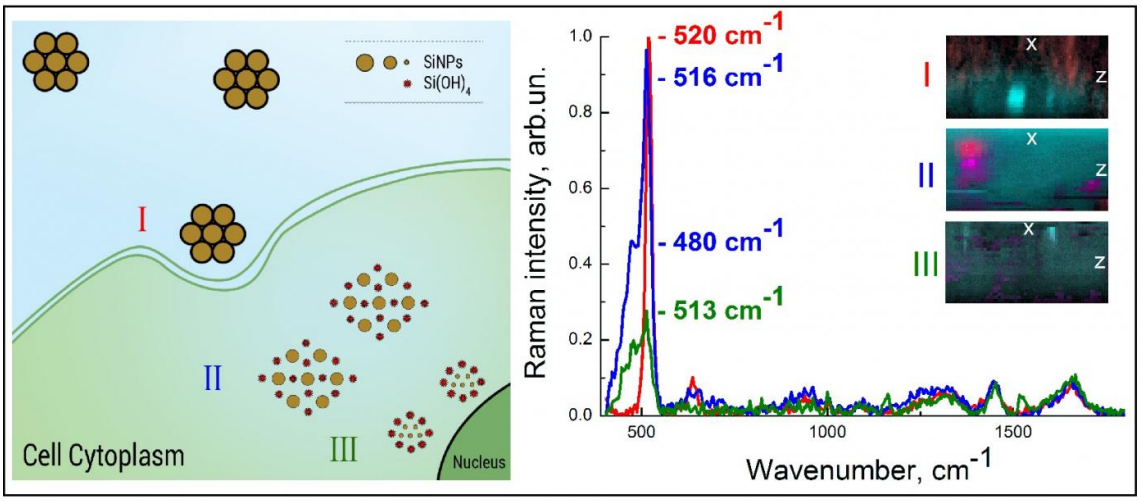

Left: Schematic representation of silicon nanoparticles (SiNPs) biodegradation processes: (I) localization of SiNPs on the cell membrane; (II) penetration of SiNPs in the cytoplasm with partial solubility of the nanoparticles; (III) strong dissolution of SiNPs after 10-13 days within the cell body.Right: Raman spectra of SiNPs for different incubation times: 9 h, 48 h and 13 days of incubation depicted in red, blue and green, respectively. Inset: corresponding xz-cross-section of Raman spectroscopy images of MCF-7 cells cultivated with SiNPs. Credit: Lubov Osminkina

Lomonosov Moscow State University researchers, in collaboration with German colleagues, have applied silicon nanoparticles to diagnose and

cure cancer. For the first time, scientists have demonstrated the ability of particles to penetrate into diseased cells and dissolve completely after delivering therapeutic drugs. The details of the research are presented in an article published in the latest issue of *Nanomedicine: Nanotechnology, Biology and Medicine*.

The scientific direction of the team is called "theranostics," a portmanteau of "therapy" and "diagnostics," denoting the process of simultaneous detection and treatment of the disease. One of its applications is spotting a range of oncologic diseases with the help of nanoparticles carrying medicine for targeted delivery into a cancer cell. Many nanoparticles do not currently meet the requirement of biocompatibility. According to one of the researchers, Liubov Osminkina, some of the nanoparticles can act quickly, deliver the drug accurately and cure a number of diseases, but cause liver, kidney, lung pain, or even headaches months later.

"The reason is that gold, silver, titanium oxide, cadmium selenide and other nanoparticles are not completely excreted," Liubov Osminkina explains. "When nanoparticles reach the bloodstream, they can get stuck in internal organs and after a while, they begin to harm the organism due to prolonged toxic effects."

Seeking not only biocompatible, but also bio-degradable transportation for targeted drug delivery, scientists studied porous silicon. They believed these nanoparticles would do no harm while helping the patient, as the result of their dissolution is silicic acid, vital for bones and connective tissues.

Using Raman spectroscopy, scientists scan the contents of a living cell and compare the spectra obtained of what is located inside a cell. "That's when I came up with an idea to conduct a study of nanoparticle biodegradation using Raman micro-spectroscopy," the scientist says.

"This technique makes it possible not only to locate the nanoparticles in the cell, but also to watch the process of their disintegration. The latter was possible because the Raman spectrum of silicon nanoparticles depends on their size—the smaller they are, the broader the spectrum becomes, shifting to lower frequencies."

The essence of Osminkina's new study was incubating the breast cancer cells with 100 nm silicon nanoparticles and then using a Raman micro-spectrometer to observe what happens in the cells during different periods of time from five hours to 13 days. They saw how during the first five to nine hours, nanoparticles localize on the cell membranes and penetrate into the cell over the next day and then begin to biodegrade, as evidenced by a decrease in signal amplitude, spectral broadening and the appearance of the peak of the amorphous silicon phase. It was shown that on the 13th day, the nanoparticles dissolve completely and the signal disappears.

"Thus, for the first time, we have shown that porous silicon nanoparticles could be completely harmless theranostics agents for many types of cancer. They easily penetrate into the diseased cell, and when filled with a drug, emit it while dissolving. I believe that the results of our work are of great importance in the long term as the basis for creating drugs based on biocompatible and biodegradable silicon nanoparticles," Lubov Osminkina says.

More information: Elen Tolstik et al, Studies of silicon nanoparticles uptake and biodegradation in cancer cells by Raman spectroscopy, *Nanomedicine: Nanotechnology, Biology and Medicine* (2016). DOI: 10.1016/j.nano.2016.04.004

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