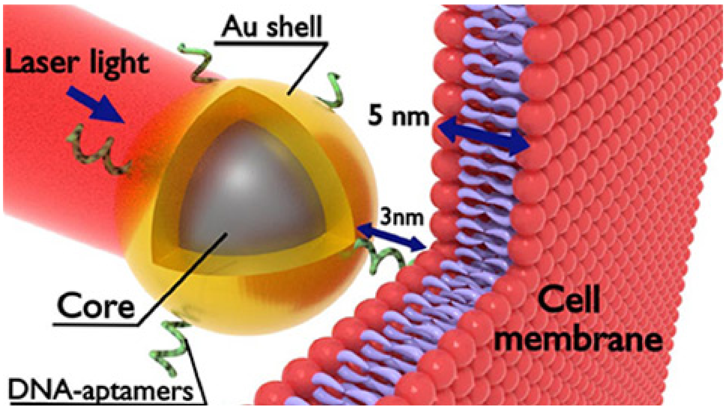
Heatstroke for cancer cells: Scientists Test Nanoparticles to Target the Disease

SibFU Researches within an international research team investigated two types of core-shell nanoparticles with different core materials and gold shell to determine more efficient thermosensitizers for laser antitumor therapy. The researchers report that, according to their opinion, aluminum doped zinc oxide nanoparticles are the most effective. Key findings are published in the Journal of Quantitative Spectroscopy and Radiative Transfer.



Unfortunately, the hopes of the medical society for the universal prospects of radio- and chemotherapy were dashed, as they found several serious contraindications and side effects for these types of cancer treatment. The method of local and selective hyperthermia is considered one of the most promising and actively developing these days. It involves heating tumor cells using various devices and technologies damaging only malignant cells without harming healthy tissues. For local hyperthermia, various physiotherapeutic agents are used (high-intensity focused ultrasound, laser radiation, alternating magnetic fields, etc.). In general, by this method, a high temperature (42–47 ° C) is achieved near the tumor cells, which causes their selective death (especially since malignant cells are more sensitive to high temperatures than healthy cells due to their structural features). Local hyperthermia is now used more often to increase the effectiveness of combined or complex therapy; though, it can also be prescribed as monotherapy in some situations.

> *„Hyperthermia as a method has been actively developing for the last ten to fifteen years. So called Laser induced interstitial thermotherapy (LITT) is a variation of this method, and it has several advantages. For one thing, when using laser thermotherapy, you can continuously monitor the heating processes in real time and visualize temperature changes in the tissues. Furthermore, heating is conducted in a strictly specified volume and considers the configuration of the tumor. An infrared laser is used for LITT: the tumor is heated to 45 °C, which causes irreversible damage in its cells due to changes in the protein structure. Basically, the cells are 'welded' together. The laser operates directly through the patient's skin or laparoscopically, which means that surgical interventions are minimized. To make the heating process directed and to spare healthy tissues, we need thermosensitizers (magnetic or plasmon-resonant nanoparticles, which are injected into the bloodstream or directly into the tumor),"* — said **Artyom Kostyukov**, a graduate student of the School of Engineering Physics and Radio Electronics SibFU.

The researchers explain that these particles bind themselves only to membrane proteins of malignant cells. Their selectivity is based on the employing a target recognition agent (DNA aptamers) attached to the Au surface of the shell. The nanoparticles bound to the membrane absorb laser radiation and release thermal energy that damages the membrane and leads to cell death. This allows reducing the power of laser radiation compared to the direct effect on the tumor. There is also an important option to change the 'settings' of the particles, choosing various materials for their design, as well as sizes, shape, and structure.

“The idea of apply gold nanoparticles to humans to solve therapeutic problems is not new. They can be loaded with drugs and used for targeted delivery of drugs directly to the tumor. Also, we can apply laser irradiation to this peculiar ‘gunners’, that concentrate directly in the transformed cells. These ‘gunners’ absorb optical radiation, create an intense thermal field around them with clear boundaries and kill cancer cells by ‘overheating’. However, a gold nanoparticle absorbs laser radiation at the same wavelength as human hemoglobin. Therefore, we can interfere with healthy tissues and provoke a deterioration in the general condition of the patient. To prevent this, some time ago the American colleagues proposed making ‘composite’ nanoparticles by ‘dressing’ the quartz core in gold. In this case, the particle absorption peak shifts toward the infrared wavelengths, so that hemoglobin becomes relatively ‘transparent’ and does not receive an unnecessary load. We moved beyond that and proposed to improve the transfer of thermal energy from a nanoparticle to cancer cells using the new materials. Calculations showed that nanoparticles with cores of aluminum doped zinc oxide or gallium doped zinc oxide extremely quickly absorb and give off heat compared to the usual quartz ‘counterparts’,”— specified **Sergey Karpov**, a supervisor of the research team, head of the industrial department of photonics and laser technology at the School of Engineering Physics and Radio Electronics SibFU.

Researchers also noted that they came with other methods of testing nanoparticles-thermosensitizer for “suitability”.

“It turned out that nanoparticles should be optimized not by optical properties, but rather by thermal ones. Gold “wrap” has been tested through the years, as gold is hypoallergenic and perfectly compatible with the human body. A check of the core boils down to the question of how quickly it is able to catch and transfer thermal energy,” — noted **Ilia Rasskazov**, SibFU alumnus and postdoc at the Institute of Optics, the University of Rochester.

We can add that the research team also included researchers from Kirensky Institute of Physics SB RAS, Institute of Computational Modeling SB RAS, Reshetnev Siberian State University of Science, and the University of Rochester (USA).

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