"Nanobombs" shock cancer cells

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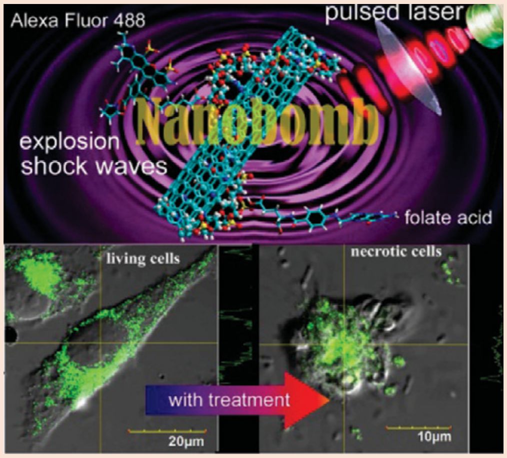
In the realm of science fiction, the idea of tiny nanorobots that can enter the human body and seek out and destroy unwanted elements has been prevalent. This idea has been made a reality by a research team led by Bin Kang and Yaodong Dai at Nanjing University and the Georgia Institute of Technology [Kang, *et al.*, *Small* (2009), doi: 10.1002/smll.200801820]. They have used what is called the photoacoustic effect of carbon nanotubes (CNTs) to make what are essentially nanogrenades that can target and destroy cancer cells. Says Professor Dai, "Under the irradiation of a Q-switched millisecond pulsed laser, the acoustic wave generated in a nanotube solution is so strong that it can trigger a micro-explosion at the nanoscale. So we had a good idea: if the nanotube in solution can explode at the nanoscale like a bomb, why don't we try to use this nanobomb to kill cancer?"

To make these weapons of minute destruction, they start with carbon nanotubes that are functionalized with folate acid, which causes them to be selectively absorbed into cancer cells which have an overabundance of folate receptor. Once inside the cancer cell, the nanotube grenade is "detonated" using a short millisecond pulse of energy from a 1054 nm laser. The nanotubes absorb very strongly in the near infrared range, while most biological species are transparent in this region (control studies showed cells without nanotubes are undamaged by the laser). The nanotubes absorb the laser energy, causing severe local heating and non-linear transfer of heat into the surrounding cell, a process that generates a shock wave that reaches upwards of 100 MPa in magnitude, and destroys the cell in a matter of milliseconds. Using this technique, they showed that 85% of cells with nanotube uptake were destroyed within 20 seconds, while 90% of cells without the nanotubes survived. Professor Dai claims that this photoacoustic method of cell destruction using carbon nanotubes is superior to previous photothermal methods because it uses hundreds of times less energy, and does not cause excessive heating, which could lead to damage of the surrounding tissue. Professor Dai says that the next step in this research will be to attempt this cancer treatment on mice. If that works they "will try bigger animals such as rabbits or dogs." They warn that eventual human clinical treatments using this technique have "a long-long way to go".



Cancer cells are selectively destructed by the strong shock wave explosion of nanotubes inside cells.

David Hecht

Nanoparticles deliver the goods and leave without a trace

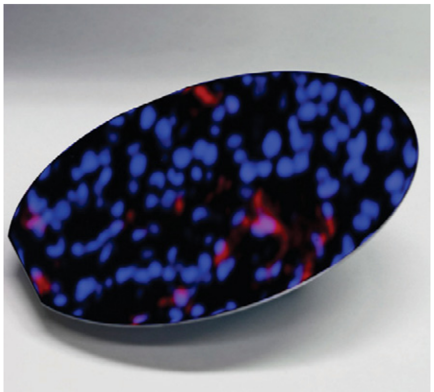
NANOMEDICINE

Researchers from California and Massachusetts have come up with a new type of non-toxic nanoparticle (NP) that is efficiently broken down and excreted by the kidneys once it has delivered its drug cargo to the target organ [Park, *et al.*, *Nat. Mater.* (2009), doi: 10.1038/nmat2398].

There is already a significant amount of research on drug delivery using NPs, but some of these systems suffer from major drawbacks, such as the body's immediate rejection of NPs before they can deliver their payload, or biodegradability and toxicity of the NPs or their by-products. However, the use of NPs for drug delivery remains of major interest because these small bodies have some exceptional properties. NPs have a large specific capacity for loading drugs, they are easily detected while they are in the body, and they are retained by the blood stream long enough for them to reach their target and offload the drug.

The new 126 nm luminescent porous Si NPs (LPSiNPs) are fabricated by electrochemical etching of single-crystal Si wafers, followed by ultrasonication and filtration to obtain NPs with 5-10 nm pore diameters. Silicon oxide grown onto the surface of LPSiNPs gives them an intrinsic photoluminescence at 650-900 nm. This makes them suitable for in vivo applications as organs and tissues exhibit very low adsorption in this region and any photoluminescence can be attributed to the LPSiNPs. The luminescent material is much more photostable than fluorescein or cyanin fluorophores and has a quantum yield comparable to other water-soluble luminescent silicon-silica NPs.

In vivo tests have been carried out by the researchers who incorporated an anti-cancer drug – doxorubicin – into LPSiNPs (DOX-LPSiNPs) and injected the DOX-LPSiNPs into mice. Photoluminescence indicates that the DOX-LPSiNPs reach the tumor, where they build up. Histology of the tissues also confirms the presence of the drug together with LPSiNPs inside the tumor. The LPSiNPs then break down, most probably into soluble silicic acid and are completely eliminated from the body by renal clearance within 1-4 weeks of injection, without any signs of toxicity in the major organs of the mice.


Luminescent Silicon nanoparticles

Katerina Busuttil