Metal Oxide Semiconductor Nanoparticles Open the Door to New Medical Innovations

Using metal oxide semiconductor nanoparticles to target and control biological molecules could fuel medical breakthroughs in many areas, including disease treatment, in vivo gene surgery and cellular drug delivery.

Technology Description

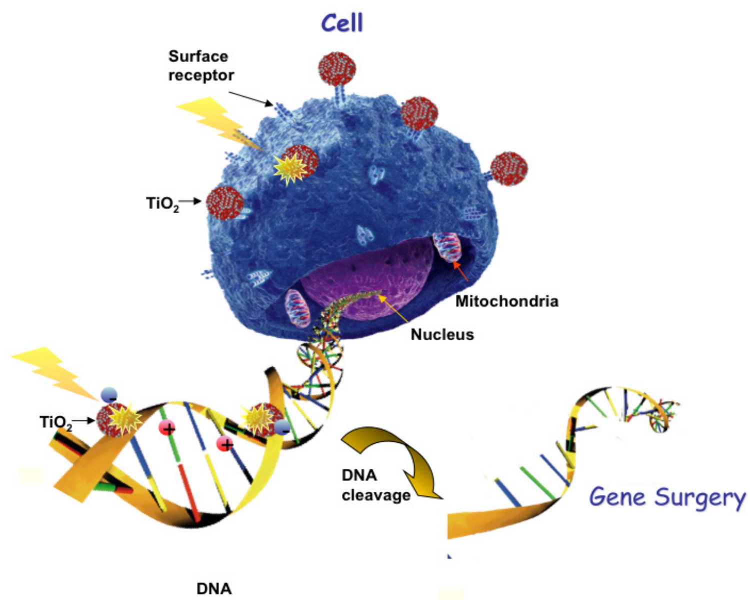
Scientists at Argonne National Laboratory's Center for Nanoscale Materials, led by Tijana Rajh, have developed novel nanometer-sized metal oxide semiconductors that allow researchers to target, initiate and control *in vitro* and *in vivo* chemical reactions in biological molecules, such as DNA, proteins and antibodies. Rajh and her fellow researchers have discovered a technique that can chemically link biomolecules to specially designed inorganic nanoparticles. The unique inorganic-biomolecule interface acts as a "conductive wire," which can initiate chemical changes in the linked biomolecule and any complexes it may have formed with other biological macromolecules.

To demonstrate this technique, modified nanoparticles of the metal oxide semiconductor titanium dioxide (TiO_2) were synthesized and linked to a variety of biological molecules to produce a stable inorganic-biomolecule composite. The ability to create such a stable composite is important; it imparts stability and a high degree of specificity to the TiO_2 nanoparticles, allowing them to target and bind to many biological molecules—including DNA, RNA, proteins and different cell surface receptors.

Once the nanoparticle has bound to its selected biological target, light is used to form a complex, charge separation in the TiO_2 semiconductor. A chemical reaction is then initiated by transferring electrons between the inorganic and biological sides of the nanoparticle via the "conductive wire." This reaction can alter the structural and thermodynamic properties of the complex, affecting its function.

Potential Benefits

The discovery of electronically linking TiO_2 particles with DNA and other biological molecules has opened the doors to many budding medical innovations. The hybrid nanoparticles have several potential commercial applications relating to their controllable dual "locate and destroy" function, including acting as synthetic DNA/RNA endonucleases.



TiO_2 hybrid nanocomposites can "locate and destroy" defective cell lines by using the white light-induced redox chemistry of TiO_2 nanoparticles and recognition properties of biomolecules. When TiO_2 nanoparticles are linked to oligonucleotides, illumination results in DNA scission, enabling programmed gene surgery.

Research has also shown intracellular targeting of these nanoparticles, which could result in a groundbreaking tool for spatially and temporally controlled *in vivo* gene surgery and targeted cell metabolic intervention. Another intriguing application involves using the light-activated chemistries of the hybrid nanoparticles to prevent, control and cure a variety of diseases.

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