ASU School of Molecular Sciences

Arizona State University

SMS Spring 2023 O'Keeffe Lecture

Friday Mar 3 | 3pm | Biodesign Auditorium

Nanoparticles Meet Living Systems

Nanotechnology offers efficient solutions for many areas of science and technology spanning from solar cells to medicine. Owing to rapid development of synthesis and nanofabrication methods we are able to engineer advanced materials with molecular precision and assemble them into functional devices. Integration of inorganic nanoparticles with soft and biological materials results in promising types of hybrids that enable integration of abiotic nanoparticles with living organisms and enable control and manipulation of biomolecules within the living cells. TiO_2 nanoparticles with their extraordinary stability, exceptional photoreactivity and biocompatibility have a special place in biomedical solutions of the future. Reconstructed surfaces of TiO_2 nanoparticles differ from the bulk by the presence of highly reactive under-coordinated surface. Manipulation of the nanoparticle surface was found to alter the way nanoparticles interact with light, enhance their chemical reactivity and improve their optical properties in the visible region. These ligands act as "leads" that bridge the electronic properties of semiconductors to biomolecules to create electroactive biocomposites. Photoinduced charge separation in electroactive biocomposites was employed to control and manipulate processes within the living cells and alter their functioning, thereby establishing new concepts and tools for advanced medical therapies. We have utilized monoclonal anti-EGFR antibodies (C225) for targeting of nanoparticles to the epithelial colon cancer cells. Photoinduced charge separation was than employed to create reactive oxygen species and induce apoptosis in the tumor cells. "Cold light," or bioluminescence, the same property exhibited by fireflies, was also used to develop "light-free" localized therapy that is activated only in cancers, leaving healthy cells intact. The effect of the "cold light" on cancer cell metabolic pathways was investigated both in 2D cell cultures and 3D spheroid model culture. On the other hand, metallic nanoparticles in the form of colloidosomes were used to vectorially pump protons across biomembrane and mimic key biological functions of converting light into chemical energy. Currently, we are developing nanoparticles with spin selected states that hold a promise for sensitive detection of ion flow and signal transduction.

Tijana Rajh, PhD

Professor and Director, Arizona State University

Tijana Rajh began her tenure as the Director of the School of Molecular Sciences on July 15^{th}, 2021. She joined Arizona State University from the Argonne National Laboratory Center for Nanoscale Materials (CNM), one of five DOE Centers for designed to advance scientific and technical knowledge in the areas of nanoscale science. At the CNM she was responsible for conceiving, planning and managing the cross-cutting science and collaborative interdisciplinary research that resulted in several successful programs. She served as Deputy Division Director and worked on identifying and implementing the scientific agenda, the vision for scientific growth, and identifying the areas for strategic thrusts. She has extensive experience in the synthesis and study of colloidal semiconductor nanocrystals and their integration into hierarchical assembly. She conducted some of the earliest research on quantum dots, a scientific area that has grown enormously and is of great current interest and impact. Her early studies involved electron transfer reactions and photoelectrochemistry of colloidal semiconductors and quantum dots, solar energy conversion into chemical fuels and surface modification of nanocrystalline TiO_2 nanoparticles for light-induced chemistries. She developed methods for seamless electronic integration of chelating ligands and colloidal semiconductors creating hybrid properties between nanoparticles and organic molecules. She applied magnetic resonance techniques to investigate spin effects during photoinduced electron transfer in the hybrid structures. She also proposed a first method to control and initiate chemical reactions between semiconductor nanoparticles and biomolecules such as DNA strands and antibodies. Her current work focuses on developing self-adapting nanostructures for energy transduction, conversion and storage as well as hybrid systems for sensing of biomolecules including quantum qubits.

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