Designing Molecular Machines for Surface Studies and Cancer and Antibacterial Therapies.

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My research goals have been designing and synthesizing artificial molecular machines to better understand and control single-molecule diffusion on surfaces and kill cancer cells and bacteria. We use molecular motors that convert light or electrical impulses into controlled mechanical movements. By working with an extensive collaborative network of microscopists worldwide, we developed and validated imaging and spectroscopic protocols to track and study the molecular machines at the molecular level.

For instance, we reported the first light-induced translation of a motorized nanocar on a metallic surface. We also developed a series of fluorescent motorized nanocars to understand nanocar diffusion on non-conductive surfaces using single-molecule fluorescence microscopy. Later, we designed and synthesized a nanocar that can be oriented and translated on a surface with absolute precision using the electric field of the STM.

In the medical field, we synthesized molecular motors whose rotation irreversibly disrupts the plasma membrane of cancer cells. By incorporating short peptides, the motors can be solubilized in physiological buffers and target specific types of cells. Due to the controlled spatiotemporal action of the molecular machines, this approach is an alternative to conventional chemotherapy, offering higher precision and specificity and decreasing the likelihood of developing drug resistance and side effects. Moreover, we demonstrated that the motors could be activated by two-photon near-infrared light, paving the way for potential *in-vivo* applications. We also developed motors that kill multicellular eukaryotes such as *C. Elegans* worms. Thus, molecular machines could be tailored for a new mode of photodynamic therapy based on mechanical rather than chemical effects.

Interestingly, we showed that hemithioindigo-based motors kill bacteria by oxidative damage rather than mechanical cell wall disruption. So, this opens new opportunities for the design of new molecular machines for fundamental studies in biological environments.