

The University of West Florida
Department of Chemistry

William D. Smart Seminar
Series in Chemistry

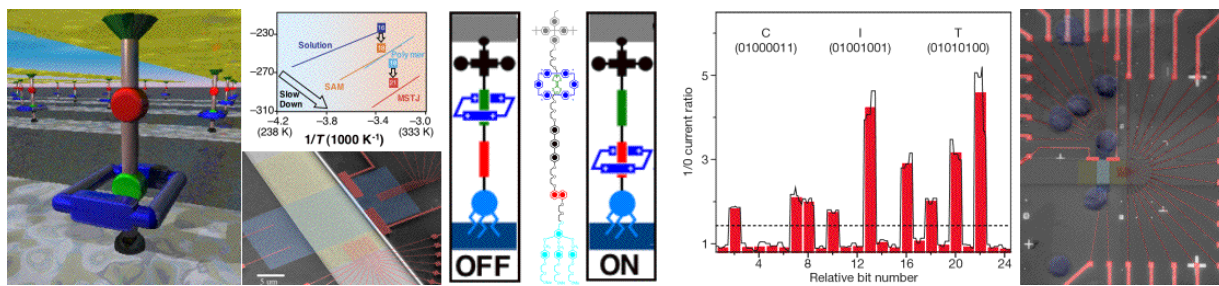


Speaker: Dr. Fraser Stoddart, Board of Trustees Professor
Northwestern University
Date: Friday, October 24th
Location: UWF, Main Campus
Time: 3:00 PM, 58/101

**Seminar Title: Chemistry and Molecular Nanotechnology in
Tomorrow's World**

Abstract

The development of molecular electronic devices (MEDs) for memory and logic applications in computing presents one of the most exciting contemporary challenges in nanoscience and nanotechnology. The lecture will highlight how the concepts of molecular recognition and self-assembly (template-directed synthesis) have been pursued actively during the production of two families of redox-controllable mechanically interlocked molecules—namely, bistable catenanes and bistable rotaxanes—which can be incorporated into a device setting in the form of a two-terminal molecular switch tunnel junction (MSTJ) wherein the bistable molecules can be switched electrically between high- and low-conductance states. In the case of a two-terminal MSTJ, the objective is to design and make a bistable molecule that, collectively in the device at a specific voltage, switches from a stable structure (isomer) to another metastable isomer with a different conductivity. The molecule needs to remain in the metastable state until either another voltage pulse is applied or thermal fluctuations cause a return to the starting state. The two states of the molecule correspond to the ON and OFF states of the switch and the finite stability of the metastable state leads to a hysteretic current/voltage response that forms the basis of the switch. Molecular random access memory (RAM) can be created by fabricating many MSTJs simultaneously into a crossbar type of architecture in a MED. The lecture will conclude with the description of a 160,000-bit molecular electronic memory circuit based on a bistable [2]rotaxane and fabricated at a density of 100,000,000,000 bits per square centimeter—that is, roughly analogous to the density of a DRAM circuit projected to be available by 2020. The entire 160,000-bit crossbar is smaller than the cross-section of a white blood cell.



Arguably, chemical systems are at their best when they are robust and smart. Imagine a device for the specific delivery of an anticancer drug targeted to breast cancer cells that involves a rugged nanoscale

container, endowed with nanoscale antennae and associated machinery. The containers we are using consist of mesoporous glass nanoparticles (200–500 nm in diameter) adorned with antennae to seek out diseased cells in preference to healthy ones and interspersed on the surface of the nanoparticles with different models of nanomachinery that can be actuated chemically (pH change), biochemically (enzyme action), or photophysically (light). Alongside a wide variety of drug delivery systems that include polymers, in many different guises, mesoporous silica nanoparticles have several highly attractive features that commend them for use in the delivery of chemotherapeutic agents. The nanoparticles can be made with complete control being exercised, not only on their diameters, but also on the dimensions of the cylindrical cavities that characterize the mesoporous glass in a periodic (often hexagonal) manner. Since the nanoparticles are made of glass they are not only robust and innocuous but they are also biocompatible and nontoxic. They have large surface areas and their porous interiors can be employed as reservoirs for storing (hydrophobic) drugs, usually introduced quite simply under a concentration gradient. The pore sizes can be rather accurately and tightly controlled during the synthesis of the mesoporous glass nanoparticles, while their size and shape can be tuned to maximize their uptake by cells. The lecture will describe the progress we are making in our research with these mechanized nanoparticles.

- 'A 160-kilobit molecular electronic memory patterned at 10^{11} bits per square centimeter', *Nature* **2007**, *445*, 414–417.
- 'Designing bistable [2]rotaxanes for molecular electronic devices', *Phil. Trans. R. Soc. London Ser. A* **2007**, *365*, 1607–1625.
- 'Nanovalves', *Adv. Funct. Mater.* **2007**, *17*, 685–693.
- 'Versatile supramolecular nanovalves reconfigured for light activation', *Adv. Funct. Mater.* **2007**, *17*, 2101–2110.
- 'Mesostructured silica supports for functional materials and molecular machines', *Adv. Funct. Mater.* **2007**, *17*, 2261–2271.
- 'pH-Responsive supramolecular nanovalves based on cucurbit[6]uril pseudorotaxanes', *Angew. Chem. Int. Ed.* **2008**, *47*, 2222–2226.
- 'Enzyme-responsive snap-top covered silica nanocontainers', *J. Am. Chem. Soc.* **2008**, *130*, 2382–2383.