NANO-HIGHLIGHT:

Wiring single molecules into electronic circuits

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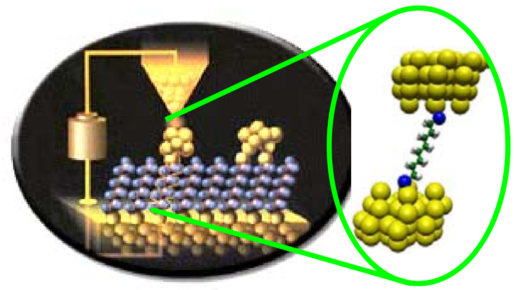
NSF NIRT Grant ECS01101175



The smallest possible electronic component would be made from a single molecule connected at two, or more places into conventional, conducting metallic wires. The flexibility of organic chemistry might allow many such types of device to be synthesized: switches, memories, amplifiers and chemical and biological sensors. Despite these possibilities, and despite much active research, controversy surrounds the field of molecular electronics. Results are often difficult to reproduce and they can disagree markedly from the predictions of detailed calculations. For example, experimental results published in prestigious journals show that the molecule DNA is an insulator, semiconductor, metallic conductor and superconductor! The problem turns out to be that the electrical properties of molecules depend critically on how they are attached to metal electrodes. Every aspect of the atomic arrangement of the environment around the molecule is important. Recently, we have obtained highly reproducible current-voltage using a combination of chemical-self-assembly and atomic force microscopy (see figure). A molecule with reactive sulfur atoms at each end is inserted end-on into a hole in an otherwise highly ordered layer of molecules (fixed to the metal surface by a reactive sulfur group at just one end). The result is a well-ordered matrix supporting a few isolated molecules reacted with the underlying electrode at one end and with a reactive sulfur exposed on the top surface. The exposed sulfurs are located, and connected to, by reacting this film with a suspension of tiny gold crystals – small enough to be suspended in solution, but big enough to make good electrical contacts. These nanocrystals explore the surface by random thermal motion, eventually finding, and then sticking to, the top end of the inserted molecules. An atomic force microscope with a conducting probe is used to locate these top contacts. The probe is then pushed into the nanocrystal to connect a molecule into a macroscopic electrical circuit. Data from devices like these is being used to explore the mechanisms of charge transport in molecules, and to test candidate molecules for switching properties, negative differential resistance and optoelectronc behavior.