Self-assembled haloalkanes on a semiconductor surface: charge corralling and electronic switching.

P.A. Sloan and J.C. Polanyi

Department of Chemistry, University of Toronto
80 St. George Street, Toronto (ON) M5S-3H6 – Canada.
E-mail: psloan@chem.utoronto.ca

In 1993 Donald Eigler's group at IBM showed that synthetic 'atoms' could be made by capturing surface-electrons within an atomic fence termed a 'corral'. The electrons of these designer-atoms had tailored energy-states. The corrals were fabricated one-atom-at-a-time on smooth metallic surfaces at liquid helium temperatures. We have employed a novel approach to the construction of corrals employing the spontaneous self-assembly of long-chain halocarbons on a semiconductor surface.

We show that haloalkane molecules, e.g., 1-chlorododecane, physisorbed on Si(111)-(7x7) self-assemble to form dimers stable to 100ºC which corral silicon adatoms [1]. Corral size is shown to be governed by the haloalkane chain-length. Isolation of a labile pre-cursor points to a model for corral formation which combines mobility with immobility; monomers diffusing in a mobile vertical state meet and convert to the immobile horizontal dimers constituting the corrals. Spectroscopic and theoretical evidence shows that haloalkane dimers on the Si(111)-(7x7) surface can induce electron transfer to a corralled adatom, shifting its energy levels by ~1 eV.

Moreover, we have observed switching of STM current-flow to silicon adatoms, enclosed within a bistable dimeric corral of self-assembled chlorododecane molecules [2]. These thermally-activated oscillations amounted to an order of magnitude change in the tunnelling current.
Theory showed that small changes in molecular configuration could cause alterations in the corralled adatom's electronic energy by as much as 1 eV, accounting for the observed current-switching

[1] S. Dobrin, K.R. Harikumar, R.V. Jones, N. Li, I.R. McNab, J.C. Polanyi, P.A. Sloan, Z. Waqar, J. (S.Y.) Yang, S. Ayissi and W. A. Hofer. Surf. Sci. Lett. In press, doi:10.1016/j.susc.2005.12.044

[2] K.R. Harikumar, J.C. Polanyi, P.A. Sloan, S. Ayissi and W.A. Hofer. In preparation.