Three-terminal transport through molecular quantum dots

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During the last few years different techniques have become available to study transport through individual molecules. With electromigration, we make nanogaps on an aluminum gate electrode in which single molecules are trapped. Three-terminal measurements on samples with the same molecule (OPV-5, Co4L4 grid molecule, Mn-12, single-metal atom complexes) share common features showing Coulomb blockade and Kondo physics. The junctions form molecular quantum dots and are stable up to temperatures of 200-240 K allowing for temperature-dependent measurements [1]. Of crucial importance is the observation of molecule-specific properties as deduced for example from the interaction between electronic transport and vibrational modes [2] or spin states [3] in the molecule. Other molecule-specific features include a charge-dependent gate and electronic-lead coupling. We have studied in detail [2] transport through a thiol end-capped oligophenylenevinylene molecule with five benzene rings (OPV-5). The measurements show that the spin states, the charging energies and the electronic spectrum are completely renormalized by the presence of the gold electrodes. In case of the doubly charged molecule the data indicate delocalized orbitals with an anti-ferromagnetic ground state and an exchange energy of 1.7 meV. Molecules are provided by Thomas Bjoernholm (OPV-5, single-metal atom complexes), M. Ruben and J.-M. Lehn (Co4L4 grid molecules) and A. Cornia (Mn-12).

[1] M. Poot et al., Nano Lett. 6 (2006) 1031.
[2] E.A. Osorio et al., Adv. Mater. 19 (2007) 281.
[3] H.B. Heersche et al., Rev. Lett. 96 (2006) 206801 (cond-mat/0510732).
[4] E.A. Osorio et al., Nano Lett. 7 (2007) 3336.