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Single Molecule Junctions from metal-complex molecules: Long range charge transport, stability and I/V characteristics

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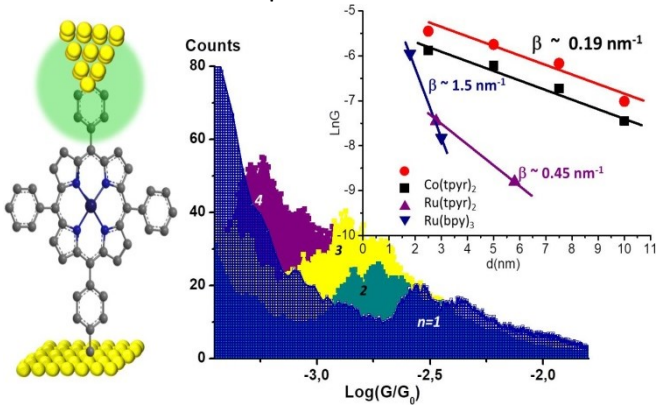
Abstract:

The research of single molecule junction (SMJ) aims to miniaturize the molecular electronics in size and to optimize the charge transports in efficiency. A SMJ is formed when a single molecule is connected between two conducting electrodes. We have recently studied SMJs, based on two types of organometallic oligomers. They are deposited as ultrathin layers on an ultraflat gold bottom electrode and are contacted by an STM tip used in various modes (STM-break junction or I(t) mode).

The first systems are based on Au-[metal-$(tpy)_2$]n-Au (n = 1–4). Highly efficient long range transport is observed from Au-$[Co(tpy)_2]_n$-Au SMJs where the conductance (~10^{-3} G_0) shows very weak length dependence. An extremely low attenuation factor (β~0.19 nm^{-1}) is obtained which indicates that resonant charge transport is the main transport mechanism. By varying the SMJ metal center from Co to Ru, the conductance decreases by 1 order of magnitude. In Au-$[Ru(tpy)_2]_n$-Au and Au-$[Ru(bpy)_3]_n$-Au SMJs, a charge transport transition from direct tunneling to hopping is evidenced from the length-dependent β-plot in the right figure. Three different transports mechanisms are observed with clear molecular signature. (1)



In a second system, Au-[metal-porphyrine]$_n$-Au SMJ is studied on both their transport properties and their stability by recording the SMJ life time, namely the G(t) measurements. Au-[NH_2-CoTPP]n-Au SMJs show random telegraph G(t) signals first then stabilize with a surprisingly long lifetime around 10s.(2) By adding an extra NH_2 anchoring group, Au-[NH_2-CoTPP-NH_2]n-Au SMJs are recorded to stabilize with a life time as long as 1 min. Thanks to the high stability, intensive I(V) measurements at a single molecule level are easily feasible. The I/V characteristic from different SMJs indicates that, the applied bias voltage decreases the attenuation factor and drives the device toward resonant tunneling. (3)

We have therefore obtained SMJs with unprecedented stability and studied their transport properties using three complementary characterizations: the STM-bj G(d) histogram, the stability from G (t) and the voltage dependent conductance G(V) measurements. The observed unprecedented stability is likely due to a combined contribution: the diazonium grafting covalently immobilizes molecules and impedes molecule movements; the anchoring groups optimize the top molecule-tip contact.

References:

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(3) X. Yao, M. Vonesch, J. Weiss, X. Sun*, J. C. Lacroix*, *to be submitted.*