Tunable magnetoresistance in an asymmetrically coupled single-molecule junction

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Phenomena that are highly sensitive to magnetic fields can be exploited in sensors and non-volatile memories. For example, a change in the electrical conductivity of a substance with magnetic field (i.e. magnetoresistance) is exploited in the read head of hard drives to detect changes in the orientations of the magnetic domains that store binary data. The scaling of such phenomena down to the single molecule level may enable novel spintronic devices. In this work, we report magnetoresistance in a single molecule junction (Fig. 1a,b) arising from a region of negative differential resistance (NDR) – a decrease in current with increasing applied voltage – that, as seen in Fig. 1c,d, shifts in a magnetic field at a rate two orders of magnitude larger than expected Zeeman shifts [1]. This sensitivity to the magnetic field produces two voltage-tunable forms of magnetoresistance, which can be selected via the applied bias. The NDR is caused by transient charging of an iron phthalocyanine (FePc) molecule on a single layer of copper nitride (Cu_2N) on a Cu(001) surface, and occurs at voltages corresponding to the alignment of sharp resonances in the filled and empty molecular states with the Cu(001) Fermi energy. The voltage shift of the NDR with magnetic field, which inherently is on the scale of the Zeeman energy, is enhanced by the asymmetric voltage-divider effect. These results illustrate the impact that asymmetric coupling to metallic electrodes can have on transport through molecules, and highlight how this coupling can be used to develop molecular spintronic applications.

* This work was done in collaboration with Ben Warner, Fadi El Hallak, Henning Prüser, John Sharp, Mats Persson, and Andrew Fisher.

References

[1] B. Warner et al., Nature Nanotechnology 10, 259 (2015)

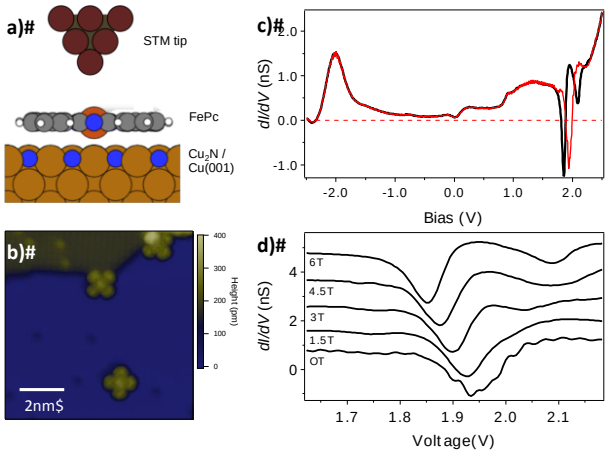

Figure 1. a) Schematic of FePc in an STM junction between the tip and Cu_2N/Cu(001). b) STM topographic image of FePc molecules on Cu_2N. c) Differential conductance spectroscopy measurements taken above the centre of an FePc molecule at 0 T (red) and 6 T (black). The magnetic field only moves features in the NDR region: other features in the spectrum remain constant. d) Same as (c) but with additional magnetic fields and over a smaller voltage range. (After [1])