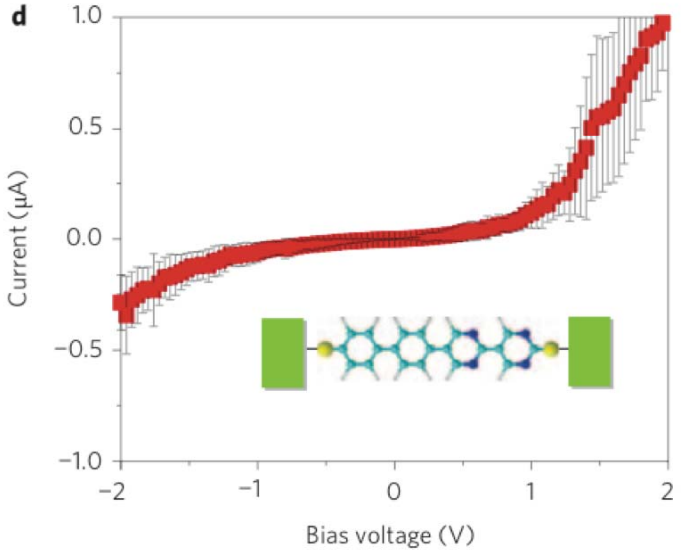
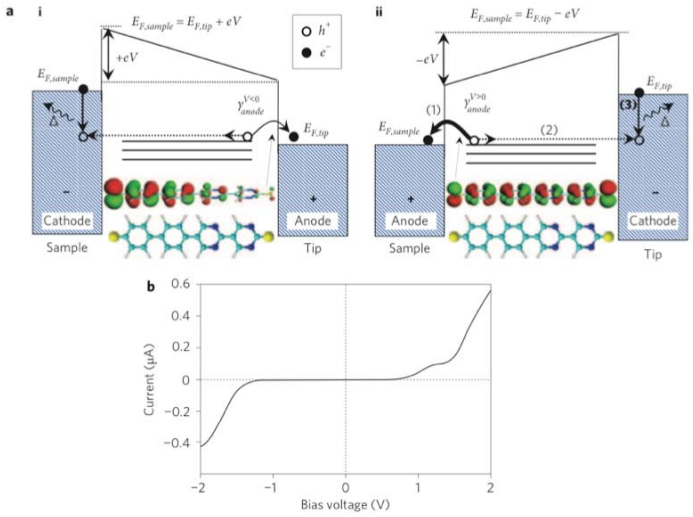
Rectification and stability of a single molecular diode with controlled orientation

Ismael Díez-Pérez[1], Joshua Hihath[1], Youngu Lee[2†], Luping Yu[2*], Lyudmyla Adamska[3], Mortko A. Kozhushner[4], Ivan I. Oleynik[3] and Nongjian Tao[1*]

Nature Chemistry, 1, 635, 2009.



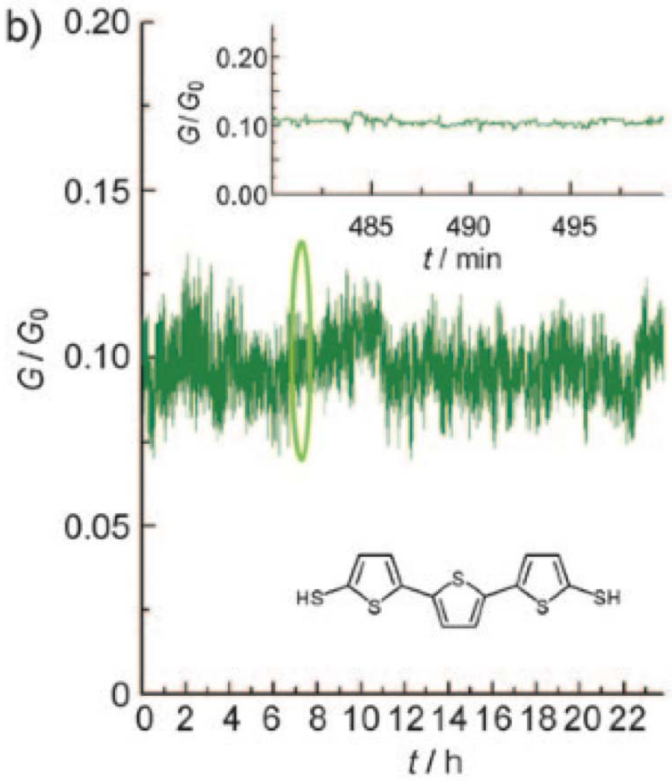


保護基を利用して分子配向を揃えた

Controlled Stability of Molecular Junctions**

*Diana Dulić, Florian Pump, Stephane Campidelli, Pascal Lavie, Gianaurelio Cuniberti, and Arianna Filoramo**

DOI: 10.1002/anie.200902168



横軸単位：hour

Angew. Chem. 48, 1, 2009.

1 week 安定

Single-Molecule Solvation-Shell Sensing

E. Leary,[1] H. Höbenreich,[1] S. J. Higgins,[1] H. van Zalinge,[1] W. Haiss,[1] R. J. Nichols,[1] C. M. Finch,[2] I. Grace,[2] C. J. Lambert,[2] R. McGrath,[3] and J. Smerdon[3]

PRL, 102, 086801, 2009.

A

Molecule	Length (S...S, nm)
1. n = 0	1.99
2. n = 1	2.38
3. n = 2	2.72
4. n = 4	3.47

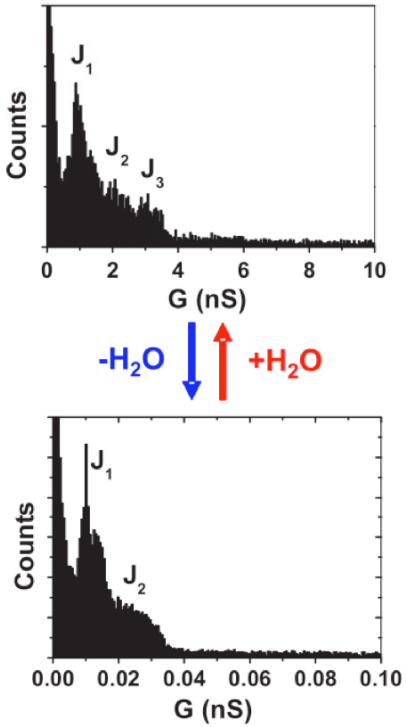
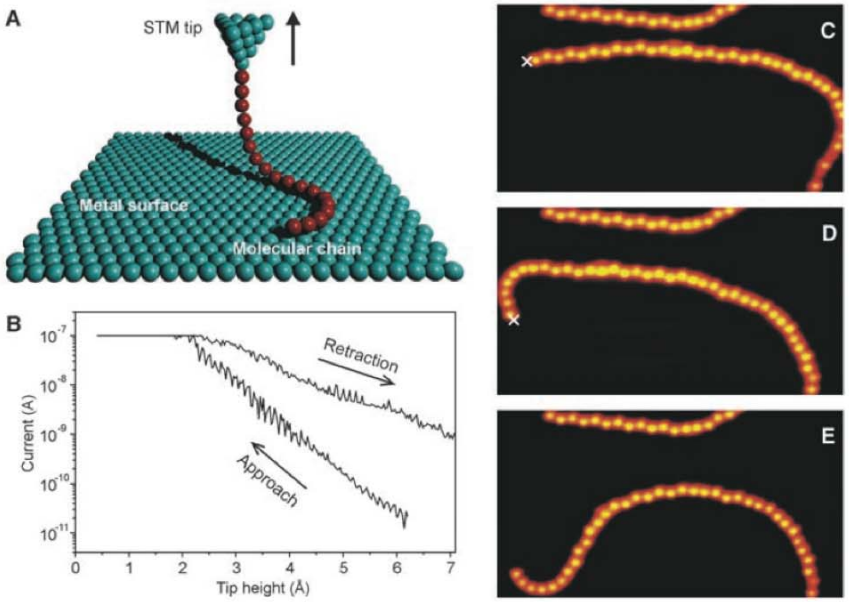


FIG. 2 (color online). Histogram of the characteristic current plateaus [$I(w)$] observed for molecule 3 measured under (lower) dry argon, $U_{tip} = +1$ V, set point current = 7 nA (upper) after subsequent readmission of ambient (wet) air to the STM chamber, same conditions.

水が配位するとコンダクタンス10倍

Conductance of a Single Conjugated Polymer as a Continuous Function of Its Length

Leif Lafferentz,[1] Francisco Ample,[2] Hao Yu,[3] Stefan Hecht,[3] Christian Joachim,[2] Leon



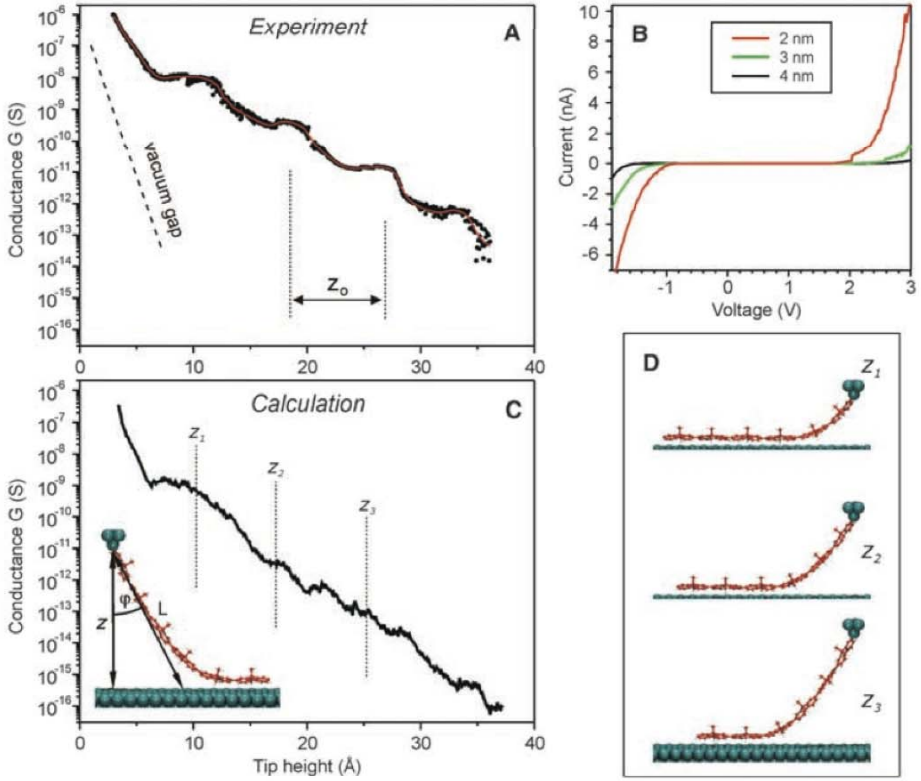


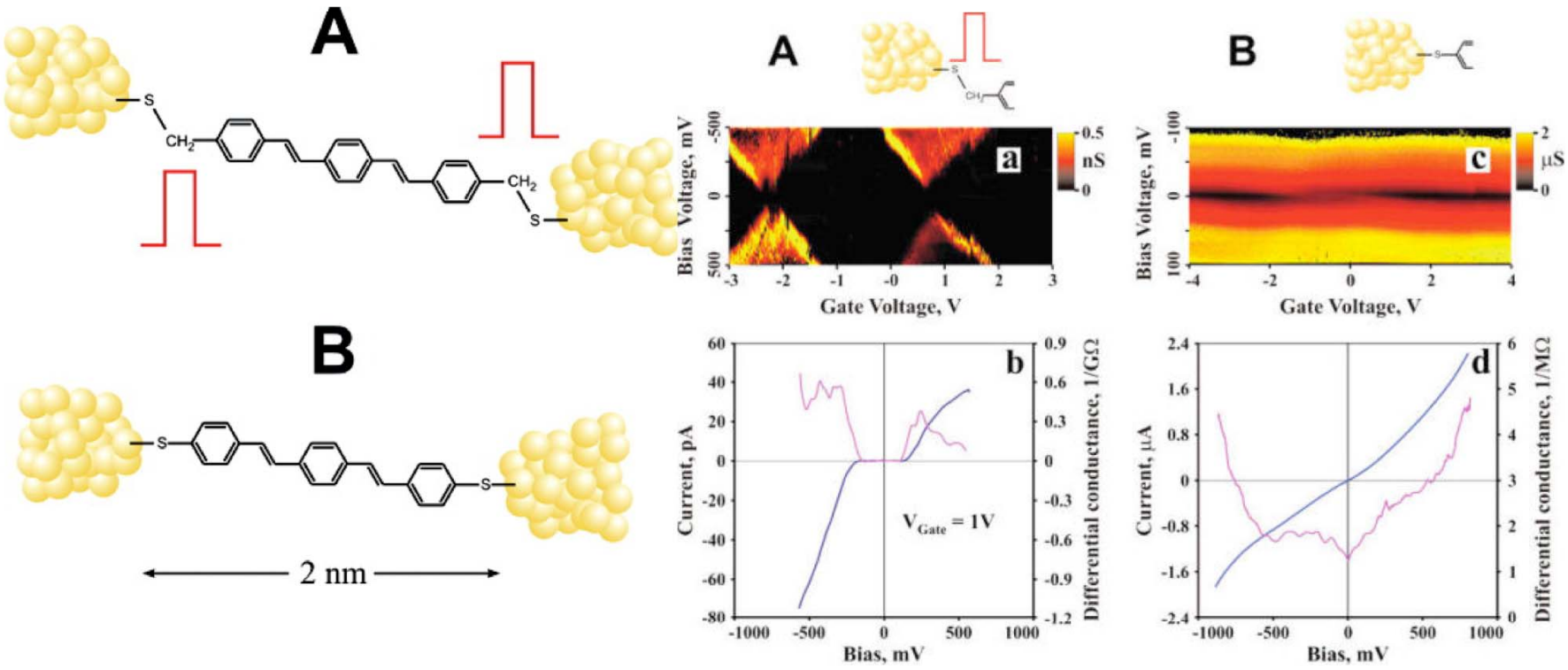
Fig. 3. Conductance as a function of the length of the molecular wire. Experimental (**A**) and calculated (**C**) *G*(*z*) curves (equally scaled), both exhibiting characteristic oscillations with a period of z_o (the decay of a vacuum gap is plotted for comparison). The experimental curve is composed of two data sets from measurements below and above about 20 Å, respectively, using different setups and thus ranges for current detection (each about four orders of magnitude). (**B**) *I-V* curves (of single wires and thus not averaged) at three tip-surface distances (2, 3, and 4 nm). (**D**) Schematic views of characteristic conformations during the pulling process, just before the detachment of another molecular unit (z_1 = 10.2 Å, z_2 = 17.2 Å, and z_3 = 25.2 Å). The inset in (C) shows a sketch with the characteristic parameters *z*, *L*, and φ.

Science, 323, 1193, 2009.

Electronic Transport in Single Molecule Junctions: Control of the Molecule-Electrode Coupling through Intramolecular Tunneling Barriers

Andrey Danilov,[†,‡] Sergey Kubatkin,[‡] Sergey Kafanov,[‡] Per Hedegård,[†]
Nicolai Stuhr-Hansen,[†] Kasper Moth-Poulsen,[†] and Thomas Bjørnholm*[,†]

Nano Lett. 8, 1, 2008.



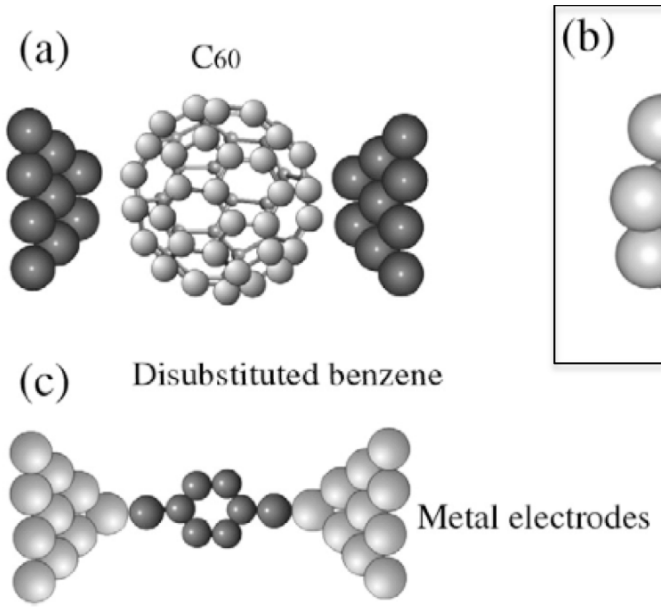
Highly Conductive Molecular Junctions Based on Direct Binding of Benzene to Platinum Electrodes

M. Kiguchi,[1,*] O. Tal,[1] S. Wohlthat,[2,3] F. Pauly,[3] M. Krieger,[1,†] D. Djukic,[1] J. C. Cuevas,[4,3] and J. M. van Ruitenbeek[1]

PRL, 101, 04681,2008.

アンカーを使わずに直接分子を挟む

ベンゼンで ~1G_0



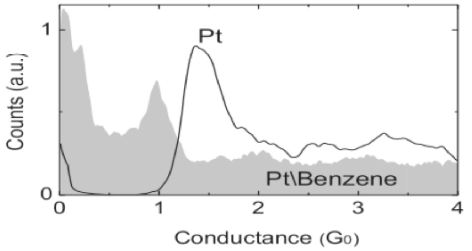
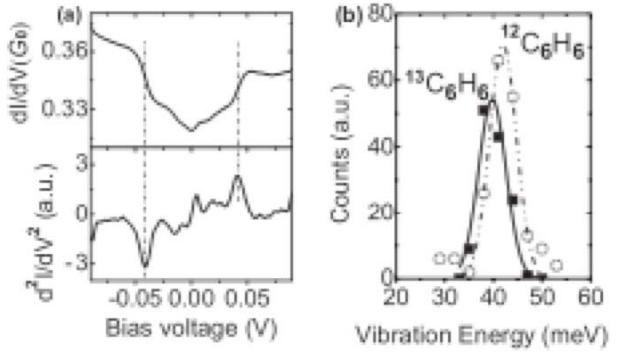


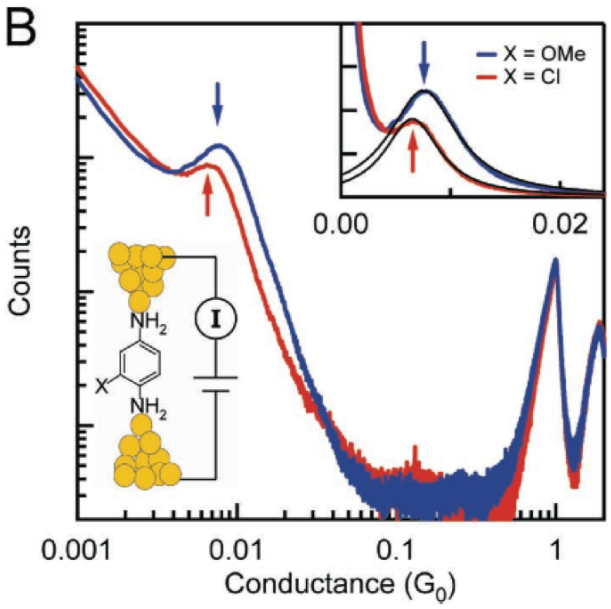
FIG. 1. Conductance histograms (normalized to the area under the curves) for a Pt junction (black), and for Pt after introducing benzene (filled). Each conductance histogram is constructed from more than 3000 conductance traces recorded with a bias of 0.1 V during repeated breaking of the contact.



Electronics and Chemistry: Varying Single-Molecule Junction Conductance Using Chemical Substituents

Latha Venkataraman,*,†,|| Young S. Park,‡,|| Adam C. Whalley,‡,|| Colin Nuckolls,‡,||
Mark S. Hybertsen,§,||,⊥ and Michael L. Steigerwald‡

Nano Lett., 7, 502, 2007.



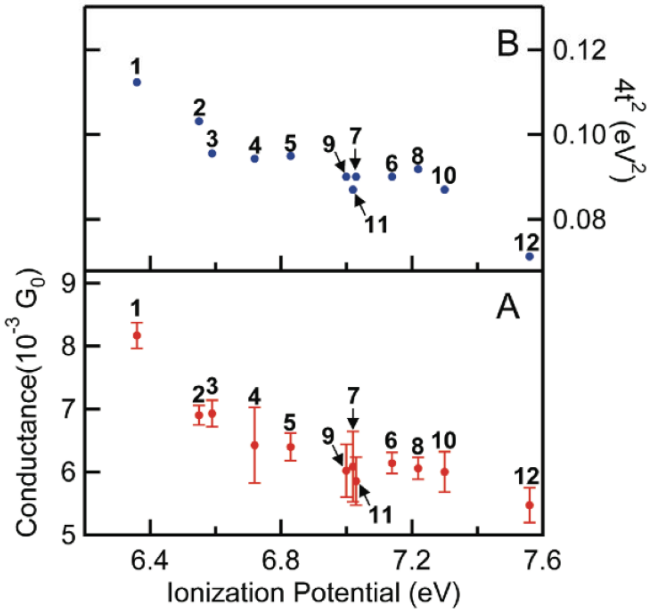
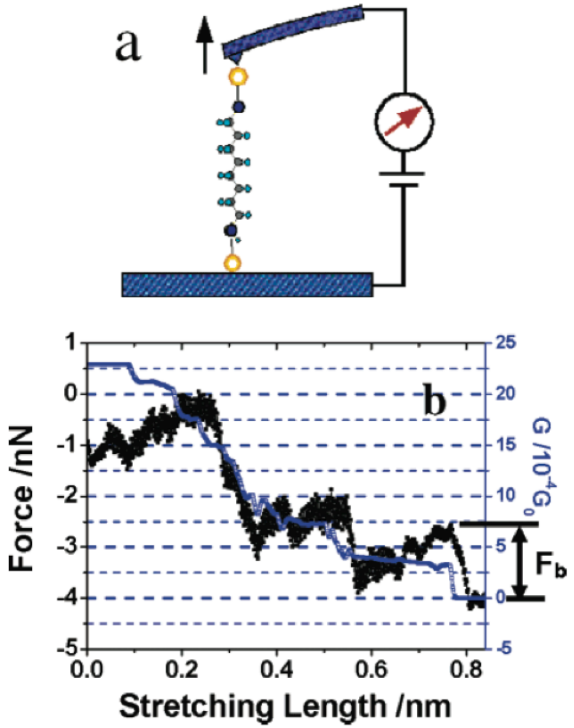


Figure 2. (A) Measured conductance values against the calculated ionization potential for the series of 12 molecules tested. The number of traces measured ranged from 12 000 to 30 000 for different molecules. For each molecule, histograms of 1000 consecutive traces were computed and a Lorentzian was fit to the molecular peak. The mean and standard deviation of the peak positions determined the molecule conductance and the error bar (also listed in Table 1). (B) Square of the calculated tunnel coupling ($4 \times t^2$) against the calculated ionization potential.

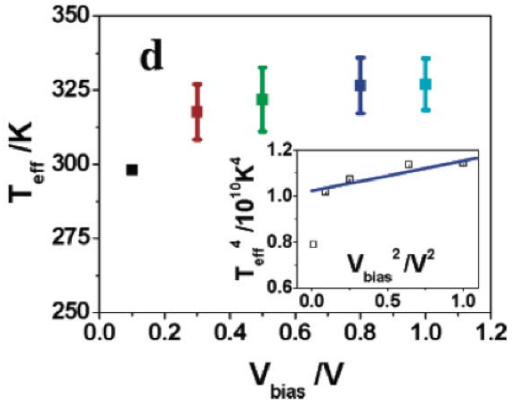
Measurement of Current-Induced Local Heating in a Single Molecule Junction

Zhifeng Huang,† Bingqian Xu,† Yuchang Chen,§ Massimiliano Di Ventra,*,‡ and Nongjian Tao*,†

Nano Lett. 6, 1240, 2006.



AFMで力測定をしながら計測

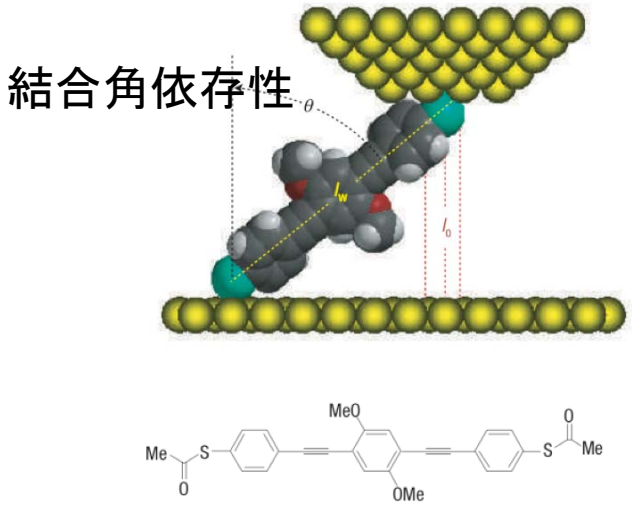


Precision control of single-molecule electrical junctions

WOLFGANG HAISS[1]*, CHANGSHENG WANG[2], IAIN GRACE[3], ANDREI S. BATSANOV[2], DAVID J. SCHIFFRIN[1], SIMON J. HIGGINS[1], MARTIN R. BRYCE[2], COLIN J. LAMBERT[3] AND RICHARD J. NICHOLS[1]

[1]Centre for Nanoscale Science and Department of Chemistry, University of Liverpool, L69 7ZD, UK
[2]Department of Chemistry and Centre for Molecular and Nanoscale Electronics, University of Durham, Durham DH1 3LE, UK
[3]Department of Physics, Lancaster University, Lancaster LA1 4YB, UK
*e-mail: w.h.haiss@liv.ac.uk

結合角依存性



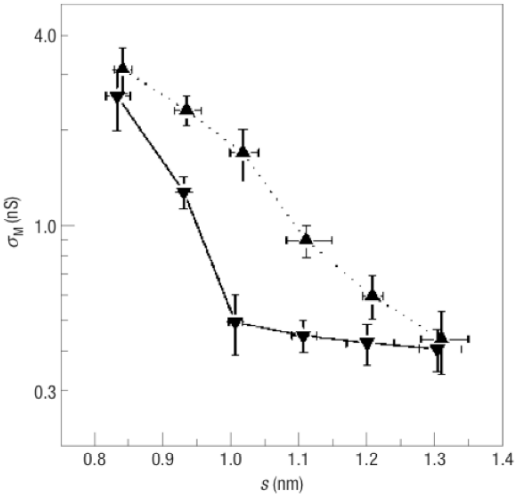


Figure 3 Single-molecule conductance. Nonanedithiol measured at 75 °C (up triangles) and 28 °C (down triangles) in dependence on s at $U_{tip} = +0.6$ V. Error bars represent the standard deviation of group 1 events.

Nature Materials, 5, 995, 2006.

Dependence of single-molecule junction conductance on molecular conformation

Nature, 442, 904, 2006.

Latha Venkataraman[1,4], Jennifer E. Klare[2,4], Colin Nuckolls[2,4], Mark S. Hybertsen[3,4] & Michael L. Steigerwald[2]

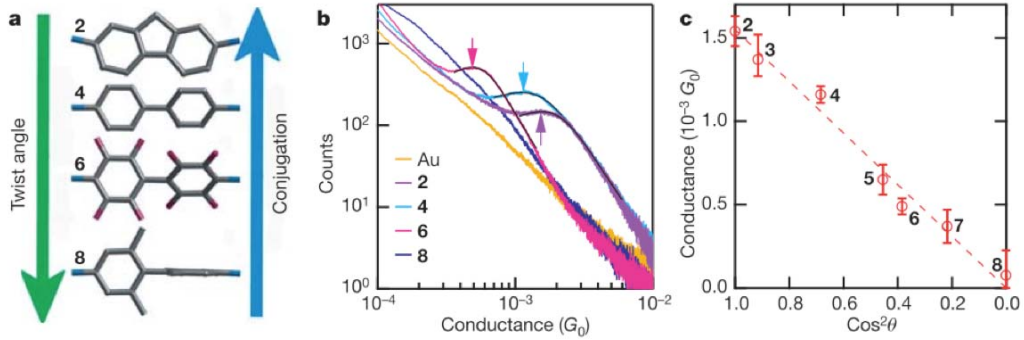


Table 1 | Molecular structure and measured properties

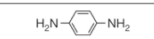
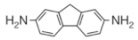
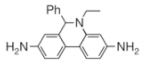
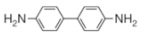
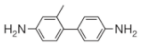
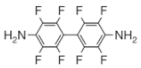
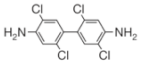
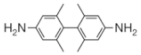
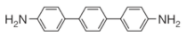
Molecule number	Structure	Conductance (G_0) Measured	Conductance (G_0) Calculated	Peak width*	Twist angle (°)
1		6.4×10^{-3}	6.4×10^{-3}	0.4	–
2		1.54×10^{-3}	2.1×10^{-3}	0.8	0
3		1.37×10^{-3}	2.2×10^{-3}	0.8	17
4		1.16×10^{-3}	1.6×10^{-3}	0.9	34
5		6.5×10^{-4}	1.2×10^{-3}	1.3	48
6		4.9×10^{-4}	7.1×10^{-4}	0.6	52
7		3.7×10^{-4}	5.8×10^{-4}	0.9	62
8		7.6×10^{-5}†	6.4×10^{-5}	NA†	88
9		1.8×10^{-4}‡	3.5×10^{-4}	2.1	–

Table shows molecule structure, measured conductances, calculated relative conductances, relative widths of the histogram peaks (see Supplementary Information for details) and the calculated twist angle, θ.
* Half-width at half-maximum of the lorentzian fit, normalized to the peak value.
† The histogram peak was determined after subtracting the Au histogram from the data, as the raw data could not be fitted with a lorentzian so a width could not be determined.
‡ Determined from actual maximum of the raw data.

ねじれ角依存性

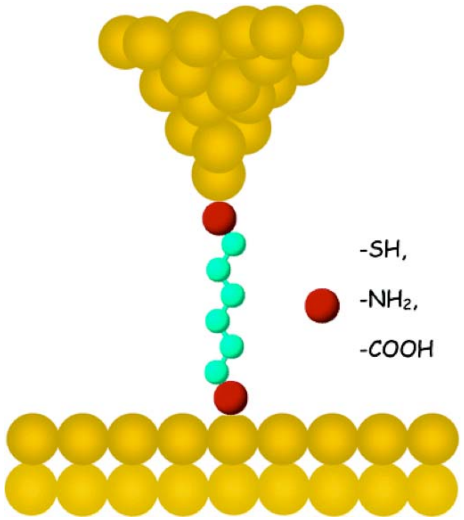
Effect of Anchoring Groups on Single-Molecule Conductance: Comparative Study of Thiol-, Amine-, and Carboxylic-Acid-Terminated Molecules

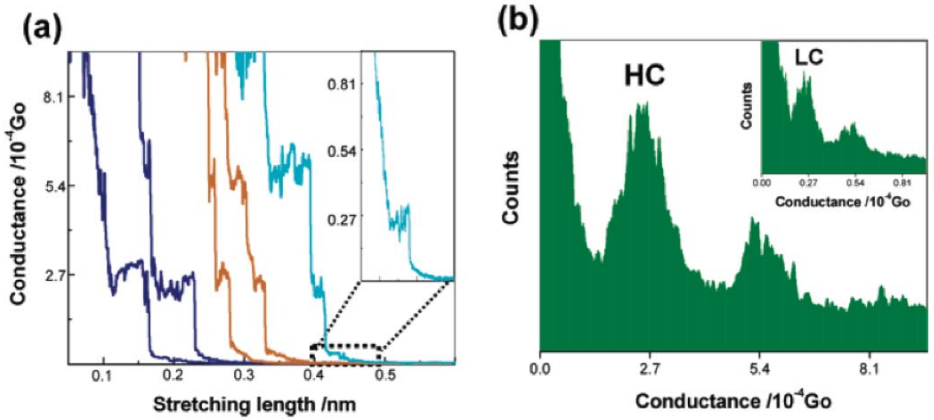
Fang Chen, Xiulan Li, Joshua Hihath, Zhifeng Huang, and Nongjian Tao*

Department of Electrical Engineering & Center for Solid State Electronics Research, Arizona State University, Tempe, Arizona 85287

Received August 11, 2006; E-mail: nongjian.tao@asu.edu

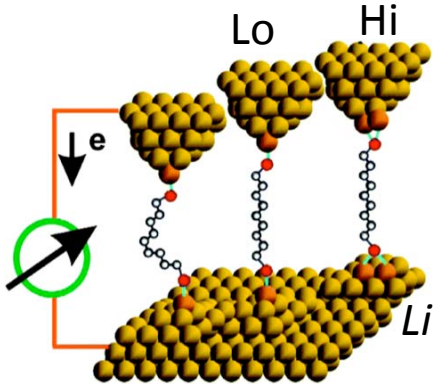
JACS, 128, 15874, 2006.





Hi and Lo conductance states

Contact conductance: Au-S > Au-NH2 > Au-COOH



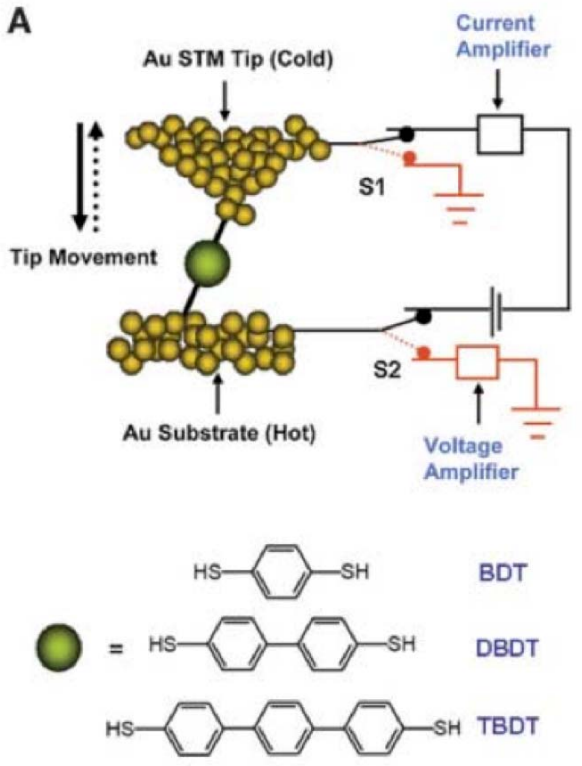
(人によってはさらに小さい値
の三種類があると言っている）

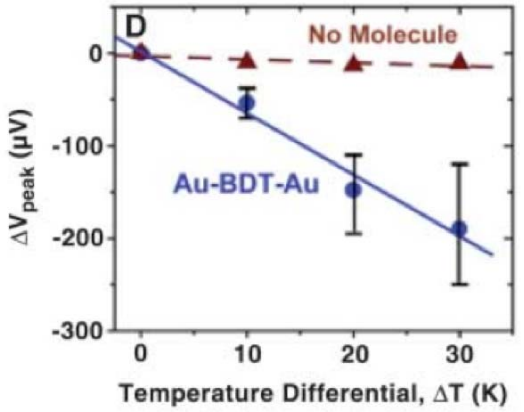
Li et al, J. Am. Chem. Soc., ***2008, 130 (1), pp 318–326***

Thermoelectricity in Molecular Junctions

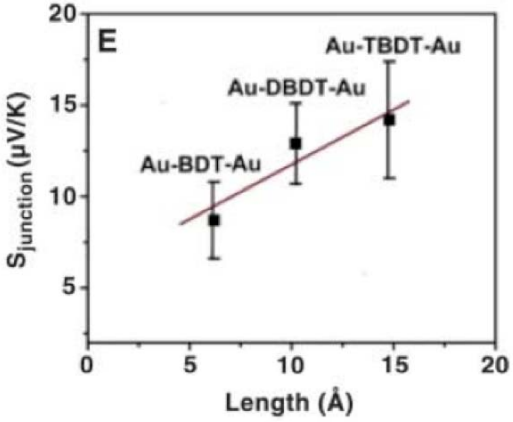
Pramod Reddy,[1]* Sung-Yeon Jang,[2,3]*† Rachel A. Segalman,[1,2,3]‡ Arun Majumdar[1,3,4]‡

Science, 315, 1568, 2007.





熱起電力

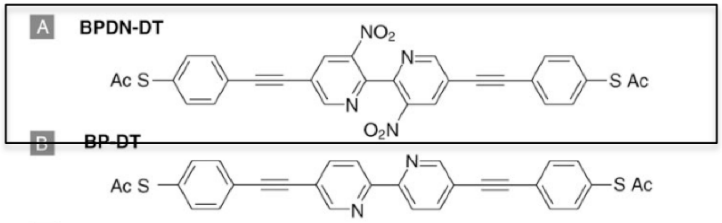


ゼーベック係数

Reversible and Controllable Switching of a Single-Molecule Junction**

*Emanuel Lörtscher, Jacob W. Ciszek, James Tour, and Heike Riel**

small, 2, 973, 2006.



Aはスイッチ挙動を起こし、Bは起こさない。

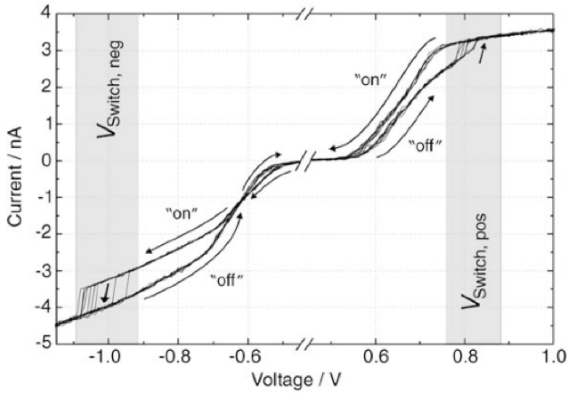


Figure 3. Several repeated switching cycles of the BPDN-DT: If the voltage applied to the metal–BPDN-DT–metal junction exceeds a certain positive threshold value ($V_{Switch,pos}$), the system switches from the initial "off" state to the "on" state. This state is maintained when operating only at voltages above $V_{Switch,pos}$. A negative voltage sweep or a pulse below the negative threshold value ($V_{Switch,neg}$) resets the molecule again to the initial "off" state.

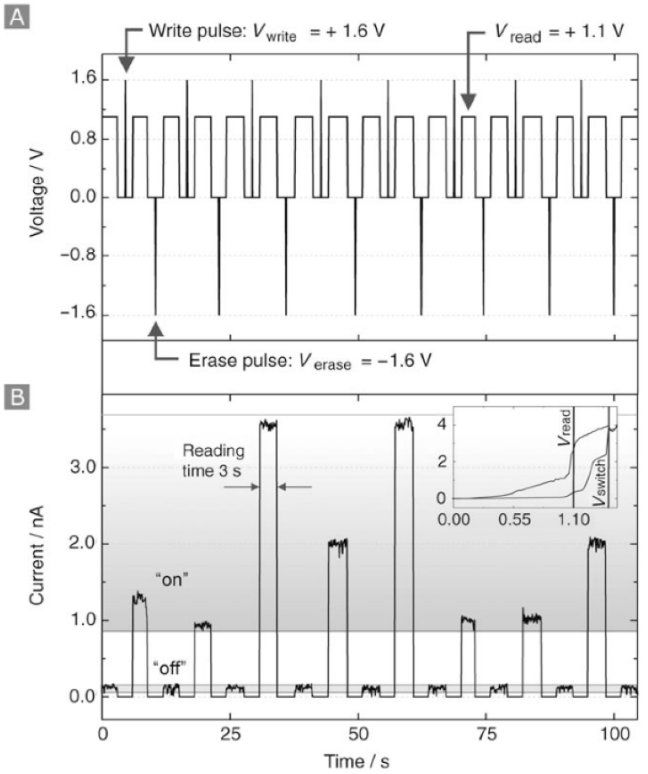


Figure 5. Memory operation of the BPDN-DT system: A) Write, read, and erase voltage pulse pattern applied. B) Resulting switching between "off" and "on" state: I_{off} varies between 0.05 and 0.13 nA, I_{on} between 0.9 and 3.6 nA. Reading times of 3 s display excellent signal stability. The inset shows the corresponding *I–V* curve, indicating switching at 1.4 V and reading at 1.1 V (black lines).

The Kondo Effect in the Presence of Ferromagnetism

Abhay N. Pasupathy,[1] Radoslaw C. Bialczak,[1] Jan Martinek,[2]
Jacob E. Grose,[1] Luke A. K. Donev,[1] Paul L. McEuen,[1]
Daniel C. Ralph[1]*

Science, 306, 86, 2004.

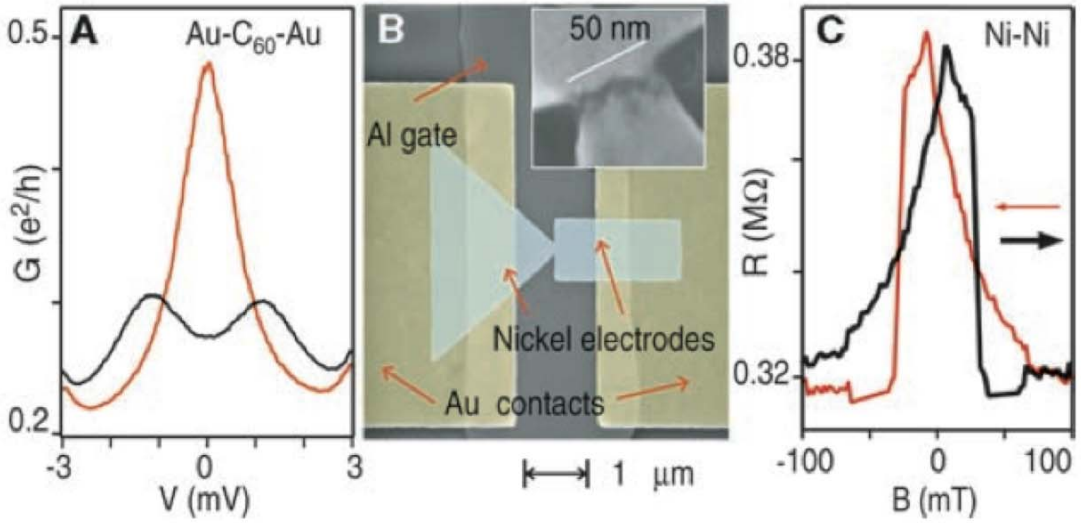


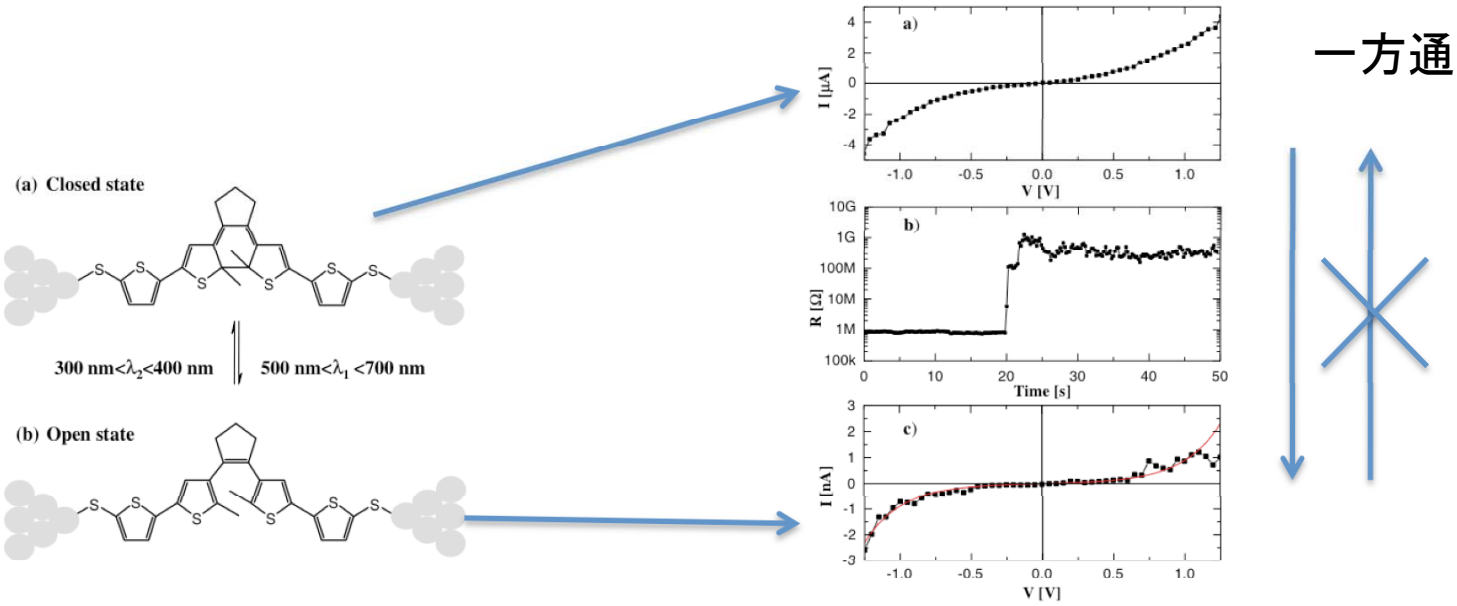
Fig. 1. (**A**) Kondo signal for C_{60} with Au electrodes at T = 1.5 K. At B = 0 (red line), there is a zero-bias peak in $G(V)$ that becomes split for B = 10 T (black line). (**B**) Scanning electron micrograph of a Ni break junction. The magnetic field is applied in the horizontal direction. (**Inset**) Close-up of the junction region after electromigration. (**C**) Tunneling magnetoresistance near V = 0 at T = 4.2 K of a Ni contact after electromigration, with no C_{60} molecule present.

エレクトロマイグレーション

One-Way Optoelectronic Switching of Photochromic Molecules on Gold

Diana Dulić,[1] S. J. van der Molen,[1] T. Kudernac,[2] H. T. Jonkman,[3] J. J. D. de Jong,[2] T. N. Bowden,[2] J. van Esch,[2] B. L. Feringa,[2] and B. J. van Wees[1]

PRL, 91, 207402, 2003.



一方通行

FIG. 3 (color online). MCBJ results. (a) Typical IV of the connected molecule in the closed form and (b) resistance versus time. At $t = 0$ a lamp is turned on ($\lambda = 546$ nm). After approximately 20 s a clear jump is observed (1 V bias). (c) Typical IV of the molecule after switching. The line is a fit to the Stratton formula (for details see text).

Nanotechnology, 16, 695, 2005（別グループ）で可逆スイッチが報告

Single-electron transistor of a single organic molecule with access to several redox states

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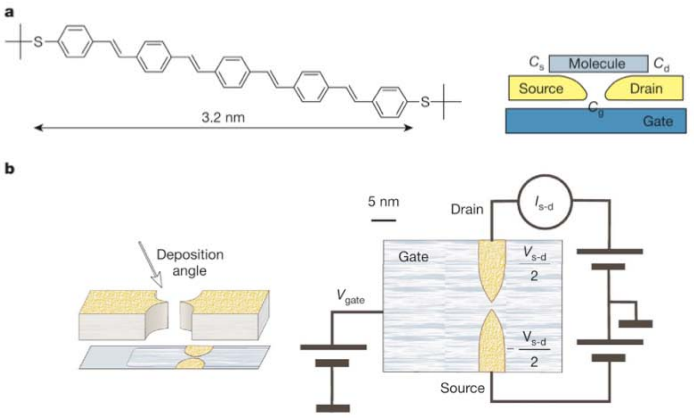
Nature, 425, 698, 2003.



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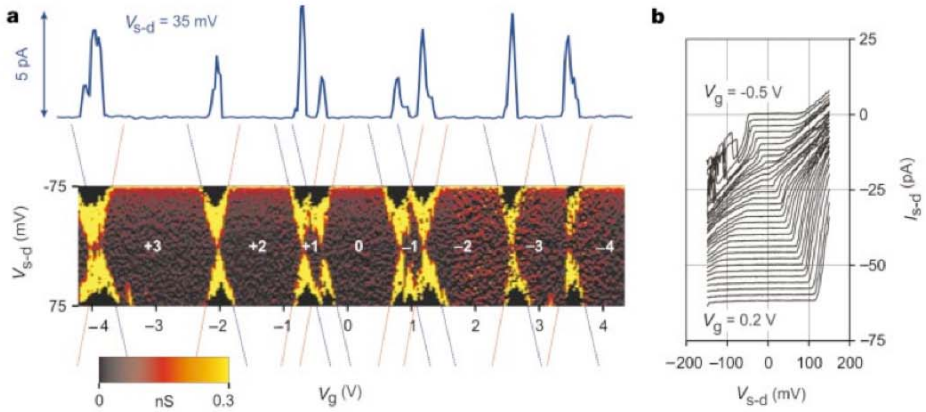

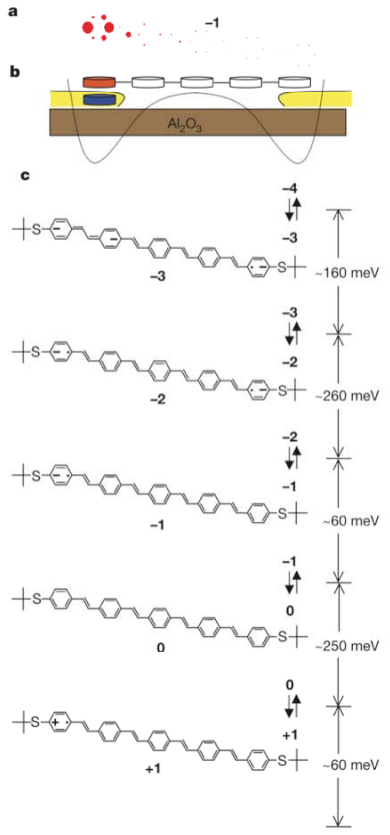

Figure 2 Experimental results. **a**, Measurements of the differential conductance ($dI_{s\text{-}d}/dV_{s\text{-}d}$) as function of $V_{s\text{-}d}$ and V_g. All red lines, and all blue lines, have identical slopes, as discussed in the text. The full solid line at the top of the figure shows a representative $I_{s\text{-}d}$–V_g trace. **b**, Examples of current–voltage curves $I_{s\text{-}d}$–($V_{s\text{-}d}$) fo single OPV5 molecule obtained at different gate potentials V_g (temperature $T = 4$ Curves are shifted vertically for clarity.