

## Detection and Manipulation of Spin state of Single Molecule Magnet: Kondo resonance and ESR–STM

T. Komeda, H. Isshiki, Y. F. Zhang, K. Katoh,\* Y. Yoshida,\* M. Yamashita,\*  
H. Miyasaka,\* B. K. Breedlove\*

IMRAM, Tohoku University, komeda@tagen.tohoku.ac.jp,

\*Department of Chemistry, Graduate School of Science, Tohoku University

Molecular spintronics has attracted attentions, which combines molecular electronics with the spin degree of freedom in electron transport. Among various molecules as candidates of the molecular spintronics, single molecule magnet (SMM) is one of the most promising material. SMM molecules show a ferromagnetic behavior even as a single molecule and hold the spin information even after the magnetic field is turned off.

Here in this report, we show the spin behavior of SMM molecules adsorbed on the Au surface by combining the observation of Kondo peak in the STS and ESR–STM measurement. Kondo resonance state is formed near the Fermi level when degenerated spin state interacts with conduction electrons. ESR–STM detects the Larmor frequency of the spin in the presence of a magnet field. The sample include  $MPC_2$  and  $M_2Pc_3$  molecules ( $M = Tb^{3+}$ ,  $Dy^{3+}$ , and  $Y^{3+}$  Pc=phthalocyanine) whose critical temperature as a ferromagnet reaches 40 K. A clear Kondo peak was observed which is originated from an unpaired electron in the ligand of the molecule, which is the first demonstration of the Kondo peak originated from electron observed in the STS measurement. We also observed corresponding peaks in ESR–STM spectra. [1]

In addition we found that the Kondo peak intensity shows a clear variation with the conformational change of the molecule; namely the azimuthal rotational angle of the Pc planes. This indicates that the Kondo resonance is correlated with the molecule electronic state. We examined this phenomena by using STM manipulation technique, where pulse bias application can rotate the relative azimuthal angle of the Pc planes. The result indicates that an application of  $\sim 1V$  pulse to the bias voltage can rotate the Pc plane and the Kondo peaks shows a clear variation in intensity by the molecule's conformational change.

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## References

- [1] Katoh, K.; Yoshida, Y.; Yamashita, M.; Miyasaka, H.; Breedlove, B. K.; Kajiwara, T.; Takaishi, S.; Ishikawa, N.; Isshiki, H.; Zhang, Y. F.; Komeda, T.; Yamagishi, M.; Takeya, J. *J. Am. Chem. Soc.* 2009.