Controlling Chemical Reactions at the Single-molecule Level using Scanning Probe Microscopy

Project Leader
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1. Objective

This project is aimed at:

Tracking single-molecule chemical reactions as well as identifying their atomic structures and compositions is important in the step-by-step understanding of their microscopic elementary processes, which provides valuable information to synthesize nano-materials with desired functionalities. This project aims to control single-molecule chemical reactions and their direct imaging, using scanning probe microscopy (SPM). SPM is a powerful tool since it enables us not only to image and analyze surface atomic structures, but also to manipulate single atoms/molecules. By making best use of such SPM capabilities, we will try to induce chemical reactions of single organic molecules locally in a controlled way, and observe their structural/electronic responses, and thus investigate the detailed reaction mechanism.

2. Project Outline

To that end, the project will consist of the following phases:

(a) Controlling chemical reactions of single organic molecules using single-atom/molecule manipulations.
(b) In situ SPM imaging of photo-chemical reactions of single organic molecules.
(c) Imaging chemical reactions of single organic molecules at room temperature.

3. Expected Performance

In this project, the successful candidate would be expected to:

(a) Make a research plan and define the research term to achieve the purpose.
(b) Work independently in experimental preparation, work, and data analysis.
(c) Work actively and cooperatively (including communication skill) with Lab members.

4. Required Skills and Knowledge

The successful candidate for this project will have the following knowledge and skills:

(a) Basic knowledge of surface science and organic chemistry.
(b) Knowledge and skills for operating ultra-high vacuum (UHV) system, scanning tunneling microscopy (STM), and ultra-short laser pulses.
(c) Knowledge of LabVIEW and programming skills (C++, python etc.).

References

[1] "Controlled Deposition Number of Organic Molecules Using Quartz Crystal Microbalance Evaluated by Scanning Tunneling Microscopy Single-Molecule-Counting", E. Inami, M. Yamaguchi, T. Yamaguchi, M. Shimasaki, and T. K. Yamada, Anal. Chem. 90 (2018) 8954.
[2] "Room temperature stable film formation of π-conjugated organic molecules on 3d magnetic substrate", E. Inami, M. Shimasaki, H. Yorimitsu, and T. K. Yamada, Sci. Rep. 8 (2018) 353.
[3] "Room-temperature concerted switch made of a binary atom cluster", E. Inami, I. Hamada, K. Ueda, M. Abe, S. Morita, and Y. Sugimoto, Nat. Commun. 6 (2015) 6231.

[4] "Formation of sp^3-bonded carbon nanostructures by femtosecond laser excitation of graphite", J. Kanasaki, E. Inami, K. Tanimura, H. Ohnishi, and K. Nasu, Phys. Rev. Lett. 102 (2009) 087402.

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