

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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