

## Catalysis at Nanoscale and Operando Studies of Catalysts

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Heterogeneous catalysis is crucial for chemical and energy transformation. Our research focuses on the interdisciplinary field of heterogeneous catalysis, nanoscience, materials chemistry, and surface science. We are interested in important catalytic reactions of chemical and energy transformations. The goals of our research projects are to achieve fundamental understanding of important catalytic reactions at molecular level and develop efficient nanocomposite catalytic systems through integration of synthesis, evaluation of catalytic performance, and in-situ and operando characterizations.

We perform in-situ/operando characterization with our laboratory-based ambient pressure photoelectron spectrometer and ambient pressure high temperature scanning tunneling microscope in our group. These studies provide *in-situ* information of nanocatalysts under a reaction condition or during catalysis. More information can be found from group page:

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### Our research projects cover:

- synthesis of nanostructured catalytic materials with controllable composition and structure,
- measurement of catalytic activity, selectivity, and durability
- in-situ/operando characterization of catalytic materials under reaction conditions and during catalysis
- fundamental understanding of catalytic reactions at a molecular level.

### Our specific projects

- *Synthesis and catalysis of shape-controlled early transition metal oxide and mixed transition metal oxide*
- *Preparation and catalysis of singly dispersed metal atoms on oxide (single atom catalyst)*
- *Synthesis and catalysis of singly dispersed bimetallic site catalyst*
- *Catalysis and in-situ studies of shape-controlled bimetallic nanoparticle catalyst*
- *Restructuring surface structure of nanoparticle catalyst toward achieving better catalytic performance*
- *Development of new catalysts for intermediate temperature solid oxide fuel cell technology*
- *Synthesis and in-situ studies of mesoporous metal catalysts*
- *Methane conversion on zeolite anchored with transition metal atoms*
- *Structural evolution of nanoparticle catalysts under reaction conditions or during catalysis*
- *Fundamental studies of surface structure and chemistry of metal and oxide model catalysts in gas phase or during catalysis*
- *Fundamental understanding of surface of photocatalyst and its cocatalysts*
- *Instrumentation for tracking surface of metal or oxide at solid-gas and solid-liquid interfaces*

### References:

1. Zhang, S. ...Tao, F.\*, "Catalysis on Singly Dispersed Bimetallic Sites", *Nat. Commun.*, 2015, 6, 7938. DOI: 10.1038/ncomms8938
2. Tao, F.\*; Shan, J. et al. "Understanding Complete Oxidation of Methane on Spinel Oxides at a Molecular Level", *Nat. Commun.*, 2015, 6, 7798. DOI: 10.1038/ncomms8798
3. Liu, J.; Zhang, S.; Zhou, Y.; Fung, V.; Nguyen, L.; Jiang, D.; Shen, W.; Fan, J.\*; Tao, F., "Tuning Catalytic Selectivity of Oxidative Catalysis through Deposition of Nonmetallic Atoms in Surface Lattice of Metal Oxide", *ACS Catalysis*, 2016, 6, 4218-4228.