Probing Copper and Copper-Gold Alloy Surfaces with Space-Quantized Oxygen Molecular Beam

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Abstract

The interaction of O_2 with various metal surfaces induces changes in its chemical stability and reactivity. And the ability to control such processes bears on the chemical economy. Alloying of pristine metals provides one of the simplest and oldest way to do so. Unraveling the stereochemistry of the processes involved would be imperative for understanding the mechanisms behind these interactions. The dynamics of reactant molecules (esp., the orientation and the movement of molecules in 3D space) play an important role in reactions. The small rotational energy excitations involved (ca. less than a few meV) render the reactants susceptible to ***dynamical steering***. This makes direct comparison with theory rather challenging. To directly probe and observe the (polar and azimuthal) orientation dependence of O_2 adsorption on Cu(110) and Cu_3Au(110), we prepared space quantized O_2 molecular beams by sorting the quantum states of the O_2 via ***Richtungsquantelung*** (***space quantization***), as first introduced by the 1922 Stern-Gerlach experiment. We found that chemisorption proceeded rather favorably with the O-O bond axis oriented parallel (vs. perpendicular) to the surface, and the same for O-O bond axis oriented along [001] (vs. along [-110], cf., Fig. 1). Alloying with Au introduced a higher activation barrier to chemisorption. This hinders the surface from further oxidation, and azimuthal anisotropy becomes almost negligible. The presence of Au also prevented cartwheel-like rotating O_2 from further reactions. More details will be presented at the conference.

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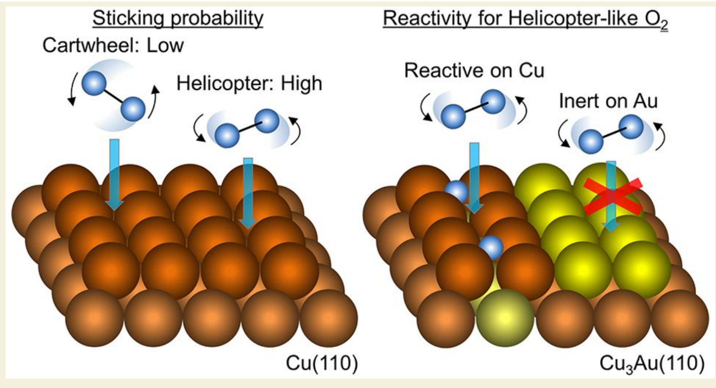

Fig. 1. A depiction of a cartwheel-like rotating O_2 and a helicopter-like rotating O_2 on Cu(110) (**left panel**) and on Cu_3Au(110) (**right panel**). Note the lower sticking for cartwheel-like rotating O_2 as compared to helicopter-like rotating O_2 (cf., **left panel**). The presence of Au on the surface futher hinders the sticking of O_2 (cf., **right panel**). (Taken from Reference [4] of the publication list).

Recent Publications (maximum 5)

[1] T. Makino *et al., Appl. Surf. Sci.* **642** (2024) 158568.
[2] A.A.B. Padama *et al., Chem. Phys.* **573** (2023) 11199916.
[3] S. Yasuda *et al., ACS Nano* **16** (2022) 14362.
[4] Y. Tsuda *et al., JACS Au* **2** (2022) 1839.
[5] T. Kasai *et al., J. Chin. Chem. Soc.* **69** (2022) 630.

Biography(150 word limit)

1999: Doctor of Engineering, Osaka University.
1999-2001: Japan Society for the Promotion of Science (JSPS) Special Invited Foreign Researcher Fellow.
2001-2002: The University of Tokyo, Institute Industrial Science Researcher.
2002-2002: Academia-Industry Collaborative Researcher.
2002-2004: Advanced Computational Science and Technology-Japan Science and Technology Agency (ACT-JST) Researcher.
2004-present: Adjunct Professor, De La Salle University, Philippines.
2004-2005: Specially Appointed Research Asst., Osaka University Nano Center.
2005-2007: Specially Appointed Assoc. Prof., Osaka University Nano Center.
2007-2010: Assoc. Professor, Osaka University, Graduate School of Science.
2010-present: Assoc. Professor, Osaka University, Graduate School of Engineering.
2010-present: Assoc. Professor, Osaka University, Center for Atomic and Molecular Technologies (concurrent)