The Hebrew University Center for Nanoscience & Nanotechnology

האוניברסיטה העברית בירושלים

Nano Seminar

Atomic Structure of Copper Surfaces in the Presence of CO, CO2 and Methanol Gases

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Abstract:

Using high pressure scanning tunneling microscopy (HPSTM), we show here that the most compact and stable surfaces of Cu undergo massive reconstructions in the presence of CO at room temperature at pressures in the Torr range, and they decompose into two-dimensional nanoclusters, which is a double effect of low cohesive energy of Cu and the high gain in adsorption energy at the newly formed under-coordinated sites.[i,ii,iii] Here we discuss the atomic structure of the nanoclusters as a function of CO pressure, their energetics for formation, and the growth mechanisms, as well as their importance for heterogeneous catalysis. Whilst 19-atom large hexagonal clusters are the building blocks of larger clusters on the Cu(111) surface, linear clusters form on Cu(100) and Cu(110) surfaces. Surface- sensitive spectroscopy techniques such ambient pressure photoelectron spectroscopy (APXPS) and infrared reflection absorption spectroscopy (IRRAS) are used to corroborate the HPSTM results. The surfaces which are broken up into clusters are more active for water dissociation, a key step in the water gas shift reaction. Such a behavior opens a new paradigm, especially for other soft metals like gold, silver, zinc, etc., and it is clear that we need more of such studies. Similar to CO, Cu(100) surface also breaks up into clusters in the presence of CO_2, however at an order of magnitude higher pressures.[iv] Gas-phase CH_3OH, on the other hand, does not cause the break-up of Cu into clusters because methoxy already adsorbs strongly on Cu terraces.[v]

In the second part of my talk, I will mention my current research plans at the Weizmann Institute of Science in Israel. Although HPSTM made a significant process in bridging this 'pressure gap' between science and technology, two major challenges remain as hurdles. More than 90% of the real catalysts are supported on insulating oxides, which can only be probed with atomic force microscopy (AFM). Our plan is to build an AFM system to operate under reactant gases, and use this experience to later on couple AFM's scanning tip to an infrared laser beam to generate a near-field spectrum. This way, not only a topographical image of an insulating surface will be acquired, but also spectroscopy images with chemical fingerprints in the lower nanometre scale will be generated. In this talk, I will present our current HPAFM design and ideas working with oxides, especially with those interesting for photochemistry.

[i] Eren, B.; Zherebetskyy, D.; Patera, L. L.; Wu, C. H.; Bluhm, H.; Africh, C.; Wang, L.-W.; Somorjai, G. A.; Salmeron M. Activation of Cu(111) Surface by Decomposition into Nanoclusters Driven by CO Adsorption. *Science* **2016**, *351*, 475-478.

[ii] Eren, B.; Zherebetskyy, D.; Hao, Y.; Patera, L. L.; Wang, L.-W.; Somorjai, G. A. Salmeron, M. One-dimensional Nanoclustering of the Cu(100) Surface under CO Gas in the mbar Pressure Range. *Surf. Sci.* **2016**, *651*, 210-214.

[iii] Eren, B.; Liu, Z.; Stacchiola, D.; Somorjai, G. A.; Salmeron, M. Structural Changes of Cu(110) and Cu(110)-(2 × 1)-O Surfaces under Carbon Monoxide in the Torr Pressure Range Studied with Scanning Tunneling Microscopy and Infrared Reflection Absorption Spectroscopy. *J. Phys. Chem. C* **2016**, *120*, 8227-8231.

[iv] Eren, B.; Weatherup, R. S.; Liakakos, N.; Somorjai, G. A. Salmeron, M Dissociative Carbon Dioxide Adsorption and Morphological Changes on Cu(100) and Cu(111) at Ambient Pressures. *J. Am. Chem. Soc.*, **2016**, *138*, 8207-8211.

[v] Eren, B.; Kersell, H.; Weatherup, R. S.; Heine, C.; Crumlin, E. J.; Friend, C. M.; Salmeron, M. Structure of the Clean and Oxygen-covered Cu(100) Surface at Room Temperature in the Presence of Methanol Vapor in the 10 to 200 mTorr Pressure Range. *J. Phys. Chem. B.* **2017**, *accepted.* doi: 10.1021/acs.jpcb.7b04681

Gathering & Refreshments at 10:50

Please contact Alexandra Bannych at 6584919 if you are interested in meeting the lecturer.

Tuesday, May 8th 2018, 11:00 at the Seminar Hall

Los Angeles Building, entrance floor.