Leaving the islands: Desorption of oxygen molecules from silver surface visualized

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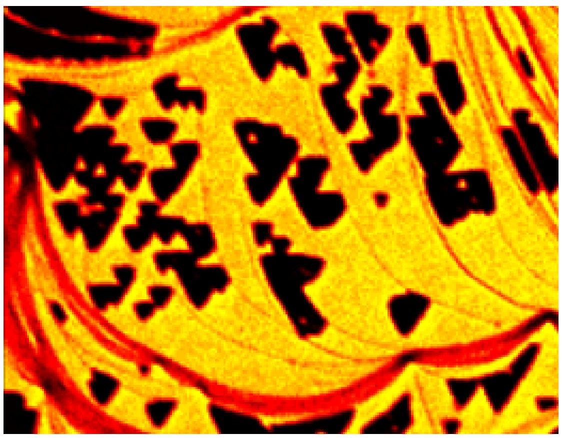

Visualization of the desorption of oxygen molecules from a silver surface

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In heterogeneous catalytic reactions, which take place at the boundary layer between a solid and the gas phase, the products finally have to desorb from the surface of the solid. This happens, for example, in the catalytic exhaust converters in automobiles. A research team led by Professors Joost Wintterlin (LMU Munich), Sebastian Günther (TU Munich) and Dr. Andrea Locatelli (Syncrotron Elettra, Trieste) has now, for the first time, imaged such a desorption process in microscopic detail. As they report in *Nature Communications*, their results explain why conventional calculations of desorption rates are often incorrect.

In heterogeneous catalysis, the catalyst is a solid, e.g., a metal or metal oxide, to which the reactants adsorb. The catalytic reaction takes place on the surface, and the products then spontaneously desorb. Unlike the complicated processes that occur on the surface during the catalytic reaction itself, the process of desorption was thought to be relatively simple: The reactants gain thermal energy from the solid surface, and desorb as soon as this energy exceeds the binding energy to the surface. This picture suggests that desorption is a purely statistical process that only depends on the number of molecules. "However, in many cases, the desorption rates calculated using this model do not agree with the experimentally determined values," says Joost Wintterlin.

Imaging with nanometer resolution

The experiments carried out by Günther, Wintterlin and their colleagues reveal that not only the number of adsorbed molecules but their spatial distribution on the surface is important. In their study, the team employed low-energy electron microscopy (LEEM), which allows one to image solid surfaces with nanometer resolution, to follow what goes on during the course of temperature-induced desorption. LEEM works similarly as conventional electron microscopy. The only difference is that the energetic electrons that form the beam are decelerated just before they hit the surface of the sample. With the help of this technique, the researchers were able to monitor desorption of oxygen from a silver surface.

"It turned out that, during desorption, the layer of absorbed molecules breaks up into many isolated islands, and desorption takes place exclusively from the edges of these islands," says Sebastian Günther. Moreover, the size distribution of the islands depends on the pretreatment of the silver surface. "Together, these effects account for the discrepancies between theoretical predictions and experimental measurements of desorption rates reported in earlier studies. They probably play a role in many other processes involving desorption from surfaces, and could change our concepts of the processes on catalytic surfaces," Günther adds.

More information: Paper: www.nature.com/ncomms/2014/140 … full/ncomms4853.html

Provided by Ludwig Maximilian University of Munich