

Porphyrin electron-transfer reactions observed at the molecular level

August 23 2007

Researchers at Temple University have observed and documented electron transfer reactions on an electrode surface at the single molecule level for the first time, a discovery which could have future relevance to areas such as molecular electronics, electrochemistry, biology, catalysis, information storage, and solar energy conversion.

The researchers have published their findings, “Dynamics of Porphyrin Electron-Transfer Reactions at the Electrode–Electrolyte Interface at the Molecular Level,” in the international scientific journal, *Angewandte Chemie*.

“The simplest chemical reactions are oxidation and reduction,” says Eric Borguet, professor of chemistry at Temple and the study’s main author. “Chemistry is basically all about the transfer of electrons from one atom to another or one molecule to another. Those reactions are called ‘redox’ reactions.”

According to Borguet, one important place where these reactions occur is on an electrode surface. For example, metal corrosion is essentially oxidation. Corrosion can sometimes be reversed by reducing the oxides and reclaiming the metal.

“Most of our studies of oxidation and reduction basically involve measuring the flow of electrons in and out of bulk chemical systems,” he says. “We’ve never really looked at this at the single molecule level, looking at it one molecule at a time. And it wasn’t necessarily clear that

we could do that.”

As part of their research, Borguet and his collaborator were looking on a metal electrode surface at porphyrins, an important class of molecules that are involved in a number of biological processes, and in fact, can act as a catalyst for these processes.

The Temple researchers used scanning tunneling microscopy, in which a sharp metal tip scans the electrode surface and measures the passage of electrons from the tip, through the molecules, to the metal surface. They noted that the chemical state of the molecule changes the ability of the electrons to pass from the metal tip to the electrode.

“We noticed that some of these molecules, under certain conditions, appeared dark while others appeared bright,” noted Borguet. “What we essentially figured out was that the molecules change color and appear dark when we apply a potential to the electrode that begins to oxidize, or essentially pull out an electron from, the molecule. So now it seems that we can see the difference between oxidized molecules—the dark ones—and reduced molecules—the bright ones.”

Borguet says that by gaining a handle on the molecules’ chemical state, researchers now have the ability to identify oxidized and reduced molecules, and to track them individually.

“As researchers, we can now ask questions such as ‘Do molecules oxidize one at a time or do entire domains or areas on the surface oxidize together’,” he says. “Do they oxidize in pairs or in clusters” If one molecule oxidizes, is it going to make the oxidation of a neighboring molecule more or less likely” What is the timescale under which these processes occur and what factors facilitate redox reactions””

Borguet believes the Temple researchers are the first to observe and

understand this interfacial electron transfer process at the single molecule level.

“We think if you look back in the literature and at other peoples’ data there is some evidence for this, but I don’t think they actually recognized that they were observing this process,” he says.

Link: www3.interscience.wiley.com/cgi-bin/jpages/114287533/ABSTRACT

Source: Temple University

Citation: Porphyrin electron-transfer reactions observed at the molecular level (2007, August 23)
retrieved 10 April 2024 from

https://phys.org/news/2007-08-porphyrin-electron-transfer-reactions-molecular_1.html

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