MECHANICAL ENGINEERING COLLOQUIUM SERIES 2015-2016

Mechanical Engineering Lecture in Energy

Accelerating the Catalysis of Oxygen Reduction

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Oxygen reduction is one of the most studied electrochemical reactions in the field of electrochemistry: it occurs in batteries, fuel cells, and enzymes in nature. I will present a series of model investigations, where we specifically aim to improve the catalysis of this ubiquitous reaction.

The slow kinetics of the oxygen reduction to H_2O impose a bottleneck against the widespread uptake of low temperature fuel cells in automotive vehicles. High loadings of platinum are required to catalyse the reaction; its short supply limits the extent to which fuel cell technology could be scaled up. The most widely used strategy to decrease the Pt loading is to alloy Pt with other late transition metals, in particular Ni or Co. However, these materials degrade via dealloying. At our laboratory, we have developed a different class of catalyst for oxygen reduction: alloys of Pt with rare earths, such as Y or Gd. The strong interaction between Pt and the rare earth elements should make these compounds inherently less prone towards dealloying. We first demonstrated the high activity of Pt_3Y and Pt_5Gd on smooth bulk surfaces. However, we have more recently shown that model, size-selected nanoparticles of these materials show equally superior performance. Our efforts are now aimed towards the large scale synthesis of these catalysts, so that they can be implemented in fuel cells and tested for their long term stability.

In most fuel cell applications, H_2O_2 is an unwanted side-product in the reduction of O_2, to be avoided at all cost. However, it is a very useful chemical in its own right, with an annual global production exceeding 3 million tons. At present, H_2O_2 is synthesised by the anthraquinone route, a complex, batch process, conducted in large scale facilities. The electrochemical production of H_2O_2 would enable small scale production of hydrogen peroxide, closer to the point of consumption. The viability of the process is contingent on a catalyst that is active, stable and selective for H_2O_2 production. We recently discovered a set of electrocatalysts that showed an unprecedented combination of all three of these desired properties: alloys of Pt, Ag or Pd with Hg.

Our studies incorporate electrochemical measurements, ultra-high vacuum based surface science methods, electron microscopy, synchrotron based spectroscopy and density functional theory calculations.

Refreshments will be served before the seminar.
Please contact Tony Pulsone at pulsone@mit.edu with any questions.

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