

# THE SALZBERG CHEMISTRY SEMINAR SERIES



The City College  
of New York



Monday, May 5 2025 @ 12:00 noon – MR1027

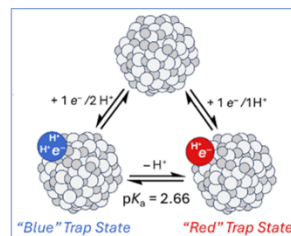
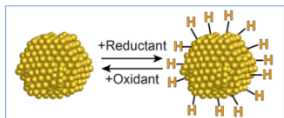
## Proton-Coupled Electron Transfer at Solid/Solution Interfaces Analogies and differences vs. molecular PCET

**James Mayer**

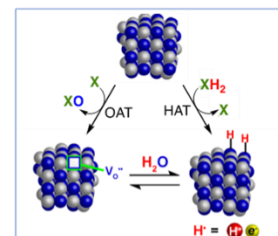
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**Abstract:** Chemical oxidation and reduction (redox) reactions are often described as the transfer of electrons, but protons often play an important role as well. Such proton-coupled electron transfer (PCET) reactions are central to interfacial chemical processes from catalysis to corrosion. To understand these processes, the Mayer lab has focused on stoichiometric reactions of small colloidal nanoparticles (NPs). The colloids have high concentrations of reactive surface and are therefore amenable to techniques used for molecules in solution. For example, changes in the coverage of hydrogen on NPs have been measured by simple optical titration experiments. Because  $\text{H}^\bullet$  is equivalent to  $\text{H}^+$  plus  $e^-$ , transfers of H are PCET reactions and can be studied in diverse ways. The systems examined include aqueous gold, titanium dioxide, and iridium dioxide nanoparticles, cerium oxide and iron carbide nanoparticles in aprotic solvents, nickel oxide films on electrodes, and high surface area cobalt phosphide. The binding energies of H to these materials have been determined by equilibration and/or electrochemically. The surface–H bond strength is not a single value, as for a molecule, but varies with surface coverage. The change in the bond strength can be quite large, up to  $14 \text{ kcal mol}^{-1}$  (0.7 eV), which corresponds to a change in  $K_{\text{eq}}$  of  $10^{10}$ . The kinetics of H-transfer reactions depend strongly on these NP–H bond strengths, following traditional linear free energy relationships (in some ways). Thus, H atoms on NPs at high hydrogen coverages (with weaker NP–H bonds) react more slowly than those at low coverages. Despite the variety of materials and their range of surface structures and electronic structures, common features of their reactions are beginning to emerge. These features are likely to play a central role in interfacial reactivity.



$e^-/\text{H}^+$  trap states in  $\text{TiO}_2$  nanoparticles



O- and H-atom transfers at  $\text{IrO}_x$  nanoparticles

**Biography:** James M. Mayer (Jim) is the Charlotte Fitch Roberts Professor of Chemistry at Yale University. He was born and raised in Manhattan, in New York City, and started doing research in inorganic chemistry just after high school, spending three summers at Hunter College, CUNY, with Edwin Abbott. He earned an A.B. from Harvard University, doing research with William Klemperer. He received his PhD in 1982 from the California Institute of Technology for work with John Bercaw. After two years as a visiting scientist in the Central Research and Development Department of the DuPont Company, he joined the faculty at the University of Washington. In 2014, he moved to Yale. He has mentored over a hundred graduate students and postdoctoral fellows, and almost that many undergraduates have worked in his laboratories. He was a long-serving associate editor of the journal *Inorganic Chemistry*. He is a fellow of the American Chemical Society, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science. Among other honors, he was the recipient of the 2018 ACS award in Inorganic Chemistry and the 2019 Frontiers in Chemical Energy Science Award from the Max Planck Institute for Chemical Energy Conversion. He has given more than 25 named lectures, including the Debye, Dow, E. Bright Wilson, and John C. Bailar lectures. He was elected a member of the US National Academy of Sciences in 2024.

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