What can we learn by watching single molecules in action?

I. Single-nanoparticle catalysis; and II. New mechanisms in transcription regulation

This talk will cover two topics. First, I will present our work in developing single-molecule fluorescence imaging methods to study the catalytic activity and dynamics of metal nanoparticles at the single-particle level, in situ, and with real-time single-turnover resolution and nanometer precision. I will present how we interrogate the catalytic activity, mechanism, heterogeneous reaction pathways, selectivity, and surface-restructuring-coupled temporal dynamics of individual Au nanoparticles. I will also present our latest work in imaging and resolving catalytic reactions on a single nanocatalyst at nanometer resolution, which maps the reactivity of different surface sites and uncovers diverse spatial reactivity patterns at the nanoscale. This spatial resolution of catalysis also enables us to probe communication of catalytic reactions at different locations on a single nanocatalyst, in much relation to allosteric effects in enzymes.

Second, I will present our discovery of new pathways for a MerR-family metalloregulator to turn off transcription. Metalloregulators regulate transcription in response to metal ions. Many studies have provided insights into how transcription is activated upon metal binding by MerR-family metalloregulators. In contrast, how transcription is turned off after activation is unclear. Using single-molecule FRET measurements, we studied the dynamic interactions of CueR, a Cu^{+}-responsive MerR-family metalloregulator, with DNA. We found that CueR can undergo a direct protein substitution pathway and an assisted dissociation pathway to turn off transcription promptly and facilely, and both pathways are unprecedented examples for any transcription factors.