Imaging the Nucleation and Growth of Nanoparticles in Solution

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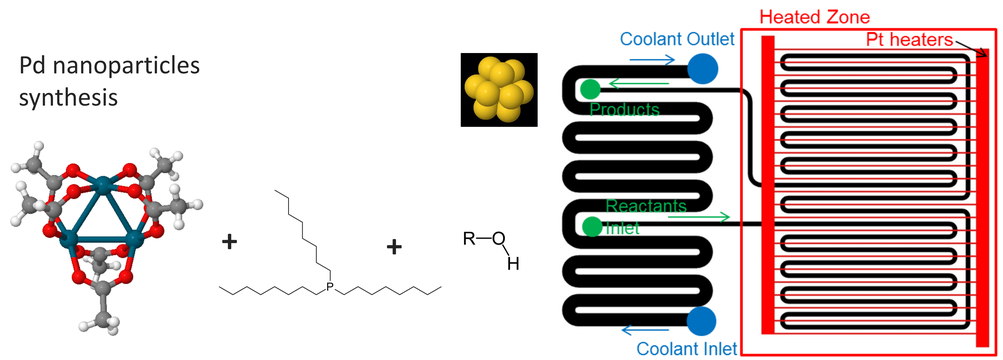
Purpose

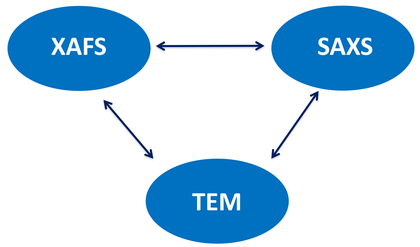
- Image the nucleation and growth of nanoparticles in solution to enable the controlled synthesis and study of nanomaterials of well-defined size, shape, and surface facets
- Develop high spatial and time resolution in situ tools for that purpose

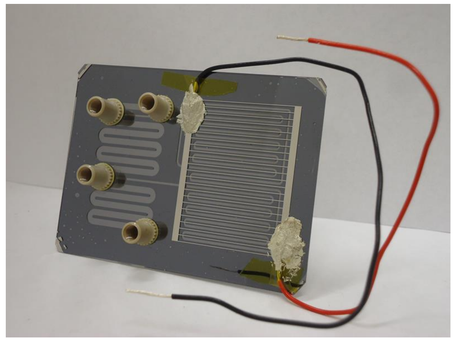
Key Successes

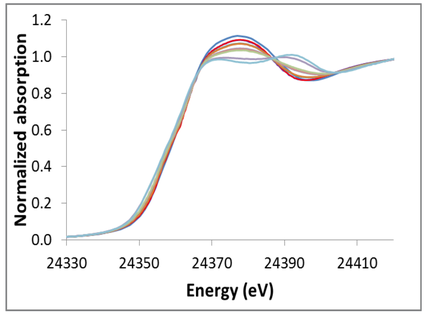
- Determined growth mechanism of Pd nanoparticles supported on carbon by environmental transmission electron microscopy (ETEM)
- Demonstrated millisecond-hour time resolution during in situ X-ray absorption fine structure (XAFS) study in microfluidic reactor
- Revealed Pd nanoparticles nucleation and growth mechanisms in solution by correlating time-resolved XAFS and small-angle X-ray scattering (SAXS)

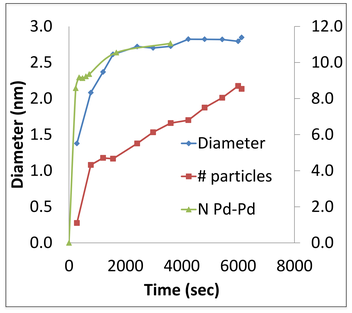
Research Accomplishments

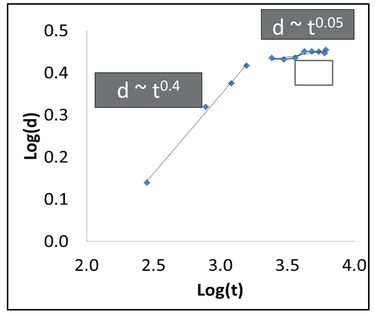


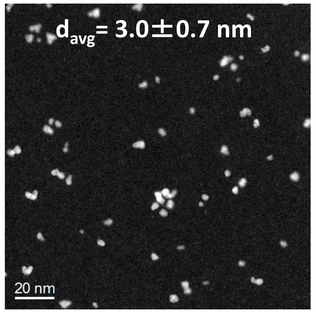




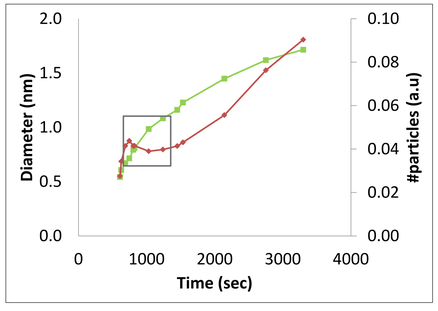


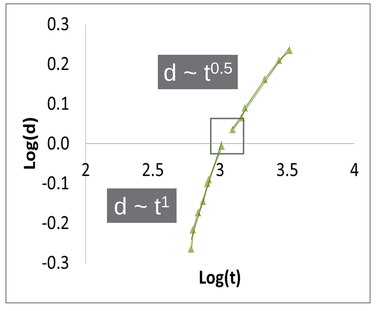


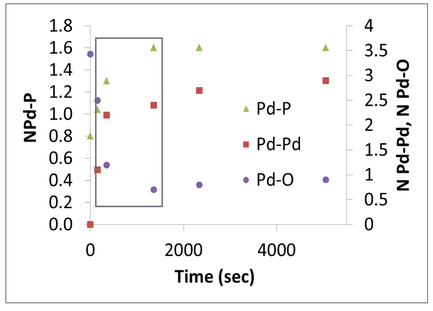




In situ XANES, EXAFS, and SAXS during Pd nanoparticles synthesis. Top: Oleylamine/Pd = 1 reduced with methanol at 60° C. Bottom: Trioctylphosphine/Pd = 1.5 reduced with hexanol at 100° C. The continuous increase in number of particles indicates slow nucleation. Fast growth in the early times suggests the precursor reduction is autocatalytic.







- Slow nucleation indicated by continuous particle formation
- Fast growth autocatalyzed by Pd
- Slower growth caused by increased coverage by capping agent
- Pd-capping agent bond strength dictates final nanoparticle size
- Manuscript in preparation

Next Steps

- Materials Synthesis and Simulation Across Scales (MS^3) Initiative
- Droplet flow synthesis of Pt nanoparticles and correlate in situ XAFS/SAXS with in situ TEM