

## PUBLICATIONS

Pettinger, N. W.; Williams, R. E. A.; Chen, J.; Kohler, B., Crystallization kinetics of cerium oxide nanoparticles formed by spontaneous, room-temperature hydrolysis of cerium(IV) ammonium nitrate in light and heavy water. *Physical Chemistry Chemical Physics* **2017**, *19* (5), 3523-3531.

## PRESENTATIONS

Pettinger, N. W.; Chen, J.; Kohler, B., "The Photoreduction of Ce(IV) in Aqueous Solution", Optec Conference, Bozeman, MT, Aug. 17, 2012 (poster).

Pettinger, N. W.; Chen, J.; Kohler, B., "Ultrafast Photoreduction of Cerium Oxide Nanocrystals and Precursor Complexes in Aqueous Solutions", Pacific Conference on Spectroscopy and Dynamics, Asilomar, CA, Jan. 29-31, 2014 (poster).



Department of Chemistry and Biochemistry

**Master of Science  
in Chemistry**

## DISSERTATION DEFENSE

**Ms. Natasha Pettinger**

B.Sc., B.A. Montana State University, Bozeman, MT (2014)

Tuesday, June 20, 2017 – 9 am

*Byker Auditorium*

Department of Chemistry and Biochemistry

**“The Non-Classical Nucleation of CeO<sub>2</sub> Nanoparticles”**

### **Graduate Committee**

Dr. Bern Kohler (Research Advisor)

Dr. Pat Callis (Chair)

Dr. Erik Grumstrup

## ABSTRACT

Over the past couple of decades, new *in situ* characterization techniques such as liquid-cell TEM have revitalized efforts to understand the mechanisms of crystal formation. The spontaneous, room-temperature crystallization of CeO<sub>2</sub> from mM concentrations of cerium(IV) ammonium nitrate (CAN) in water was studied using UV-Vis absorption spectroscopy, transient absorption spectroscopy, x-ray diffraction, and high-resolution transmission electron microscopy. Characterization of the final nanoparticles revealed several nm polycrystalline CeO<sub>2</sub> nanoparticles that are stable from aggregation over a period of months. Crystallization is accompanied by a large change in absorption which can be modeled by the presence of just two species. These species are argued to be an amorphous, hydrated intermediate that is converted to nanocrystalline CeO<sub>2</sub> over a period of minutes to hours. The rate-limiting step of the amorphous to crystalline transition involves a proton transfer reaction, as evidenced by a solvent kinetic isotope effect of ~10. Ultrafast transient absorption measurements show a drastic difference between the optical properties of the crystalline nanoparticles and the amorphous precursors. This system is an excellent model system for studying non-classical crystallization because the minutes-to-hours time scale and the small sizes of the nanoparticles and precursors allow for *in situ* observation of crystallization using steady-state absorption spectroscopy. This system would also lend itself well to characterization by other techniques such as liquid-cell TEM or x-ray absorption spectroscopy.

## BIOGRAPHICAL NOTES

### **Academic Preparation:**

2010-2014 Montana State University, Bozeman, MT  
Bachelor of Arts in Modern Languages and Literatures (Honors, Summa cum Laude)  
Bachelor of Science in Chemistry (Honors, Summa cum Laude)

### **Graduate Studies**

Field of Study: physical chemistry

### **Teaching and Outreach Activities**

2009 Kohler Lab Outreach (Jan–Dec)  
2014 General Chemistry Lab TA, Montana State University (Jan–May)  
2015 Physical Chemistry Lab TA, Massachusetts Institute of Technology (Sep–Dec)  
2016 Montana Science Olympiad (Nov)

### **Awards**

2010-2014 MSU Achievement Scholarship  
2010-2014 President's List  
2012 Governor's Energy Research Program Grant  
2012-2013 Undergraduate Scholars Program Grant  
2012-2013 Kekulé Award for Organic Chemistry  
2013 Swager Summer Research Award  
2013-2014 Goldwater Scholarship  
2013-2014 Dr. Arthur and Lois Fry Award  
2014 NSF GRFP Honorable Mention  
2014 Outstanding Senior Award, MSU  
2015-present NSF GRFP Fellowship, MSU