UNIVERSITY of HOUSTON

CULLEN COLLEGE of ENGINEERING

Department of Civil & Environmental Engineering

CIVE 6111 Graduate Seminar

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Heterogeneous Nucleation and Growth of Nanoparticles under Environmentally Relevant Conditions

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2:45PM-3:45PM
Classroom Business Building (CBB) Room 122

Abstract

Scientific research on nanoparticles is intense, because they existed ubiquitously in our environment and have many potential applications in medicine, physics, optics, and electronics. In natural and engineered systems, nanoparticles can form in solution as homogeneous precipitation and on substrates (e.g., rocks, membranes, equipment and facilities) as heterogeneous precipitation. Nanoparticle precipitation starts with nucleation with subsequent particle growth. The homogeneous and heterogeneous covalently-bonded ferrihydrite ($Fe(OH)_3$) nucleation and growth processes of nanoparticles controls the fate and transport of various aqueous contaminants (e.g., heavy metals, organic pollutants, and arsenic). Using synchrotron-based grazing-incidence small angle X-ray scattering technique (GISAXS), homogeneous (in solution) and heterogeneous (on quartz) nucleation and growth of ferrihydrite ($Fe(OH)_3$) were quantified for the first time in 10^{-4} M Fe^{3+} solution in the presence of EPA priority heavy metals Cu^{2+}, Pb^{2+}, or Cr^{3+} under acid mine drainage conditions (pH = 3.8 ± 0.1). The interfacial interactions among aqueous ions, substrate surfaces, and nanoparticles were explored with quartz crystal microbalance dissipation (QCM-D) and dynamic light scattering (DLS). Pb(II) was significantly enriched on Fe hydroxide surfaces, thus inhibited particle growth. Aqueous Cr(III)/Fe(III) ratios were found to control the chemical composition (x) of $(Fe_x, Cr_{1-x})(OH)_3$ precipitates, and affect their homogeneous and heterogeneous precipitation rates in different ways. The heterogeneous nucleation and growth of $BaSO_4$, as a representative sparingly-soluble salt whose bonding between constituent ions is dominantly ionic, were also studied. Ionically-bonded barite ($BaSO_4$) mineral scale formation affects the safety and efficiency of many subsurface operations (e.g., oil production, geologic carbon sequestration, managed aquifer recharge) and membrane water treatment processes. Using GISAXS, $BaSO_4$ nucleation and growth at organic-water interfaces were quantified under varied aqueous saturation and Ba/SO_4 ratios. QCM-D, DLS, and FTIR were utilized to explore the controlling mechanisms, which were partly different from those of covalently-bonded Fe hydroxide.

About the speaker:

Chong Dai is currently a Ph.D. candidate under the guidance of Dr. Yandi Hu, assistant professor in the Department of Civil & Environmental Engineering at University of Houston. Chong Dai obtained her B.S. in Environmental Engineering from Southwest University in China. She obtained her M.S. in Environmental Engineering at Lehigh University (PA, United States). Since August 2013, she has been starting her doctoral research focusing on nucleation and growth of iron hydroxide, barite, and lead phosphate nanoparticles, which are related to heavy metal immobilization at acid mine drainage, scale control during oil production, and Pb immobilization in lead pipes. She has utilized the state-of-the-art synchrotron X-ray techniques at Argonne National Laboratory (APS) to conduct her research. She has published four papers as first author on top journals, and several other papers as co-authors. Chong also received several awards. In 2017, she won the American Chemical Society (ACS) Environmental Chemistry Graduate Student Award. The prestigious honor with national competition is awarded up to 25 students each year. In 2016, she was awarded the 3rd prize in student presentation competition of Texas Water. In 2015, she was fully supported by US Department of Energy (DOE) to attend 17th National School on Neutron and X-ray Scattering, a workshop held at Argonne National Laboratory (IL) and Oak Ridge National Laboratory (TN), which taught the most out-of-art techniques and their applications in the world.