Defense Announcement

Surface and Molecular Level Characterization of Nanomaterials for Water Treatment and Drug Delivery

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Degree: Ph.D. Environmental Engineering

Date: 05/10/2021 **Time:** 1:00 PM- 3:00 PM

Location: Zoom **Meeting ID:** 925 1895 0956 **PIN:** 802607

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Nanomaterials have versatile applications in a variety of fields, including water treatment applications in environmental engineering and delivery of active ingredients for biomedical or agricultural applications. To explain, predict, and improve the functionality of nanoparticles for these applications, it is essential to provide a detailed and robust characterization of their surface and molecular level interactions. However, the characterization of these nanoscale systems is often challenging. This dissertation contributes toward developing new approaches to characterize and predict the surface chemistry and release behavior of nanomaterials. Specifically, the first section of the dissertation focuses on measuring and predicting competitive adsorption of proteins and natural organic matter onto titanium dioxide nanomaterials for water treatment. This research identified that intermolecular interactions and the kinetics of adsorption are critical to predict the adsorbed layer composition in complex environmental matrices. The following sections focus on developing advanced multi-detector asymmetric flow field – flow fractionation (AF4) methods to characterize the release of active ingredients from polymeric nanoparticles. This research demonstrated that, along with providing more robust and rapid analysis of drug release compared to conventional methods, the unique capability of the AF4 analysis to acquire size-resolved release profiles enables an improved understanding of release mechanisms that is not achievable in bulk time-resolved assays. Overall, the new methods and modeling approaches developed here can be broadly applied to evaluate the surface and molecular interactions of nanomaterials and thereby better predict their functionality and design improved nanomaterials for environmental and health applications.