

At the Interface of Nanomaterials: Challenges and Opportunities in Creating and Utilizing Advanced Nanomaterials

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Nanomaterials are sought after in many fields for their properties. Extensive synthetic pathways exist for preparing nanomaterials, yet challenges and opportunities remain for chemists to improve the performance of nanomaterials in current applications and to enable unexpected future applications of these materials. Furthermore, interfaces control many properties of materials. Chemical stability, electronic properties, ion mobility, electron conduction, and many more properties of materials are dependent on interfacial chemistries. In nanomaterials, where a relatively large percentage of atoms reside at the surfaces of these materials, controlling the interface with their surroundings is critical to both their properties and to their performance, including their durability. Interfacial properties also play a role in the synthesis of nanomaterials, but this discussion will focus on the pursuit of methods to control and tune the surface chemistry of a selection of oxide coatings on nanomaterials including the ability to quantitatively tune the composition of this chemistry. A focus will be given to functionalizing these surfaces through the covalent attachment of molecular species to nanomaterials. It will be demonstrated how this control is enabling the preparation of multifunctional materials with magnetic properties, an enhanced non-linear optical response, an ability to selectively bind species, and to create platforms for on-demand drug delivery or triggered hyperthermia. This discussion will review recent progress towards these goals with examples of custom coatings prepared on a variety of nanomaterials of different core composition. It will also introduce how these methods are helping us to develop additional materials and methods with applications spanning from clean energy technologies (e.g., from fuel cells to water electrolyzers to batteries) to monitoring the health of our environment and protecting workers.