Interfacial Molecular-Scale Investigations of Metal Adsorption onto Graphene-Based Two-Dimensional Materials

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One of the greatest challenges regarding nuclear energy development and implementation is proper containment and disposal of radioactive and heavy metal biproducts. Temporary storage facilities across the country have experienced leaks and spills with catastrophic effects on environment, including groundwater pollution. Filtration of heavy metal ions from water resources is one possible solution for metal remediation and can be used within nuclear waste processing. However, current filtration technology is limited by a lack of fundamental information about ion selectivity and adsorption at water-membrane interfaces. Examination of only the thin interfacial region, spanning only a few nanometers, in between the sorbent material and surrounding solution without considering bulk system properties is experimentally challenging. Obtaining such interface-specific information is critical toward understanding the molecular-level adsorption mechanisms, as dynamics within this small, confined space can greatly differ compared to the bulk and will directly influence membrane performance.

We address these challenges by studying the fundamental surface chemistry of metal adsorption onto functionalized graphene interfaces via specular crystal truncation rod (CTR) and resonant anomalous x-ray reflectivity (RAXR). Both methods are sensitive specifically to the liquid-solid interface of interest. Taken together, these techniques yield direct, molecular-level, element-specific in situ information about ion sorption kinetics and thermodynamics from complex solutions. We consider different functionalized surfaces and vary solution properties, such as pH, to better understand ion adsorption and pave the way toward highly selective membrane development.

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