Reactive Degradation Kinetics for 2D Materials: A New Approach for High-Throughput Safety Screening and Appropriate Technology Mapping

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Graphene is one member of the broader family of 2D materials, whose rapid pace of development provides strong motivation for systematic study of their biological effects and safe design principles. A major challenge for this effort is the very large number of new materials and their chemical diversity. Recent theoretical work predicts that many 2D materials are non-equilibrium structures that will be susceptible to reactive degradation phenomena in the natural environment and in biological tissue. Recent experimental work on a few selected materials has supported these predictions, often through observations of oxidative attack and structural alteration upon exposure to the atmosphere in dry, humid, or aqueous environments. Early knowledge of degradation kinetics can inform and guide hazard assessment for 2D materials, but is also key for mapping materials onto appropriate, promising biomedical technologies, which typically require either long-term stability or alternatively, controlled bioresorbability.

This talk describes a new approach for high-throughput safety screening and technology mapping for 2D materials. The approach is based on biodissolution kinetic studies in reactive media specially chosen for each material to match chemically feasible degradation pathways, either oxidative, reductive, or hydrolytic. Reactive dissolution and in vitro toxicity tests on the nanosheets and their degradation products allow grouping of materials into four classes: A, potentially biopersistent; B, slowly degradable; C, biosoluble with potentially hazardous degradation products; and D, biosoluble with low-hazard degradation products. The talk will develop and justify the framework needed to apply this classification system, and will present specific material case studies that cover the oxidative, reductive, and hydrolytic degradation pathways.