Nanodiamond and 2D Transition Metal Carbides (MXenes): Chemistry and Applications

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Nanomaterials hold tremendous potential enabling new unexpected applications and pushing the horizons of attainable properties and environments amenable to exploration to the extreme limits. Graphene (2D), carbon nanotubes (1D), and fullerene (0D) are commonly known, but the nanomaterials world has many more treasures to offer. The talk will discuss our recent progress in nanodiamond (0D sp^3 carbon) and MXenes (2D transition metal carbides/nitrides).

Nanodiamond powder made of ~5nm diamond particles with large accessible surface and tailorable surface chemistry delivers extreme optical, mechanical, electronic, and thermal properties of diamond on the nanoscale. It is being developed for many applications ranging from lubrication to advanced composites, to drug delivery and biomedical imaging. The superior mechanical and thermal properties of diamond core, its stability in harsh environments on one hand, as well as rich and tailorable surface chemistry on the other, make nanodiamond the material of choice for design of super-strong composites, where the nanodiamond particles in effect become part of the molecular structure of the matrix. Properties, purification, characterization, de-aggregation, and chemistry of nanodiamond, as well as its applications in composites will be discussed in detail.

MXenes is the largest family of 2D materials discovered in 2011. It is extremely rare when an entirely new family of materials is discovered, moreover one that shows as useful and tunable properties at such early stages of exploration as the MXenes do. MXenes offer great diversity in composition, layer thickness, electronic, magnetic, thermoelectric, mechanical, and other properties – all within one family of 2D materials. Not surprisingly, the interest to these materials grows quickly in different research communities. In particular, the advantages of MXenes are now being harnessed for energy storage, composites, and electronic materials. Recent results on the synthesis, structure, properties, chemistry, computational modeling, and potential of MXenes for Li ion batteries, supercapacitors, and advanced composites will be discussed.