



Introduction to 'Chemistry of 2D materials: graphene and beyond'

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Introduction to ‘Chemistry of 2D materials: graphene and beyond’

The isolation and in-depth investigations on the fundamental physical and chemical properties of 2-dimensional (2D) materials like graphene have undoubtedly represented a corner stone in materials sciences and nano-science. The unprecedented electrical, mechanical, thermal, optical, electrochemical and catalytic properties of 2D materials, often coexisting in a single material, have triggered a major scientific revolution with unparalleled efforts devoted towards their syntheses, functionalization and processing. The ultimate goal is to exploit 2D materials in a multitude of disruptive technologies, in particular to address the challenges our society is nowadays facing. Soon after the pioneering works of Geim and Novoselov on mechanically exfoliated graphene, the scientific interest was branched out to both graphene produced using other top-down and bottom-up approaches, and to other 2D materials which exhibited diverse properties. For example, alongside the atomically thick semimetal graphene, mechanically robust and chemically stable 2D dielectrics (h-BN), semiconductors (unipolar such as black phosphorous and MoS₂, and ambipolar like WSe₂) and superconductors (NbSe₂) could be generated. MXenes (metal carbides and nitrides) represent another robust class of emerging 2D materials with notable electronic and electrochemical properties which can be achieved by the top-down delamination of bulk MAX phase. While the properties of pristine 2D materials are undoubtedly outstanding, they are hardly tuneable. In this regard, the chemical approach via their covalent and non-covalent functionalizations opens numerous opportunities as a powerful route to modulate their physical and chemical properties. It simplifies their processing in particular in liquid media, and it enables to realize hierarchical composites and hybrid structures which not only combine “the best of two worlds” but also enable the emergence of new characteristics which are absent in the components themselves. More recently, chemical approaches to 2D materials expanded beyond the simple grafting of molecules to pre-existing nanosheets, achieving also the synthetic 2D covalent organic frameworks and 2D metal organic frameworks as bottom-up grown crystalline monolayers with chemical compositions and structures at will. This represented another compelling way to develop atomically thick materials with properties on-demand.

This theme issue on “Chemistry of 2D materials: graphene and beyond” is focussed on the controlled functionalization of 2D materials in order to harness their fundamental properties and enhanced performance in applications in the fields of opto-electronics, energy, catalysis, biomedicine and sensing. It highlights some of the most enlightening approaches on the production of 2D materials (e.g. via electrochemical exfoliation), their processing, printing and manipulation, their covalent and supramolecular functionalization, and their application for energy generation and storage (supercapacitors and batteries), water filtration, optoelectronics, biosensing,

This theme issue provides clear evidence of the interdisciplinary nature of the chemistry of 2D materials, interesting not only for the fundamental understanding on the modulable properties that can be achieved via a chemical approach, but also for its immense potential for technological breakthroughs. We hope the readers will find these contributions inspiring.

We are most grateful to all contributing authors for their effort in highlighting and addressing the key questions in this highly dynamic interdisciplinary field of nanoscience where the chemical approach, at its interface with physics and engineering, offers a notable step forward.

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