

Graphene and Organic 2D Materials: Grand Challenges and Opportunities

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The discovery of graphene one decade ago has inspired the development of other two-dimensional (2D) materials with periodic network structure and topographical thickness of atomic/molecular level. They have emerged as the new paradigm of materials with enormous potentials, ranging from electronics and optoelectronics to energy technology, membrane, sensing and biomedical applications. However, to transform the fundamental studies of graphene and 2D materials into practical applications, many critical challenges have to be solved. The future research and application of these materials urgently call for the efficient and reliable chemical synthesis and processing, which have to play a key enabling role. In this lecture, our recent efforts on the top-down exfoliation of graphite and bottom-up synthesis of structurally well-defined graphene will be presented. The solution exfoliation of graphite is relying on the smart processing of graphitic precursors at the few-layer thickness level under the electrochemical control. This strategy offers the reliable means to produce high quality, solution-processable graphene on a large scale and at low cost. To introduce a defined bandgap into graphene materials, a bottom-up synthetic strategy is demonstrated, providing structurally defined nanographenes and graphene nanoribbons with tailor-made properties at the atomic level. Towards the synthesis of emerging organic 2D materials, we will present our recent developments on the 2D conducting/conjugated polymers and supramolecular polymers with structural control at the atomic/molecular-level as well as at the meso-scale. The rational processing and assembly of graphene and 2D materials provide the access to novel hierarchical structures and hybrid systems with different complexities. As the result, we will present some prominent applications with using graphene and organic 2D materials as well as their hybrids across the fields of electronics, fuel cells,

supercapacitors and micro-supercapacitors as well as batteries.

References

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