2D materials beyond graphene: preparation, functionalization and their applications

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Two-dimensional (2D) materials (2DMs), which can be produced by exfoliating bulk crystals of layered materials, display unique optical and electrical properties making them attractive components for a wide range of technological applications. In this context, attaining a full control over the generation of high-quality 2DMs with methods that can be employed for large-scale production of exfoliated nanosheets and inks thereof represents a major challenge of potential technological interest in the numerous fields, even beyond opto-electronics and sensing, such as those associated to energy applications. During this lecture the most recent developments in the production of high-quality 2DMs based inks using liquid-phase exfoliation (LPE) will be discussed,[1] combined with the patterning approaches, highlighting convenient and effective methods for generating materials with controlled thicknesses down to the atomic scale (see Figure 1).

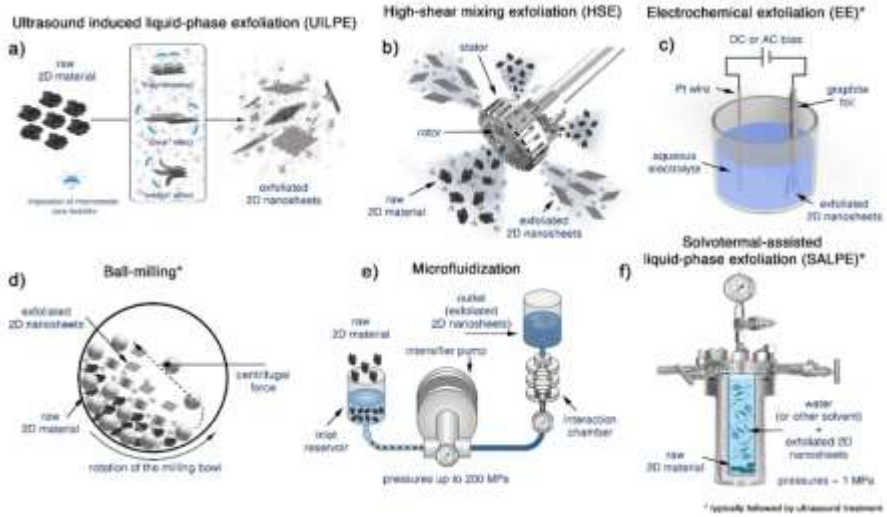

Figure 1: Schematic representation of various liquid phase exfoliation (LPE) based methods such as a) ultrasound induced LPE (UILPE), b) high-shear mixing exfoliation (HSE), c) electrochemical exfoliation (EE), d) ball milling, e) microfluidization and f) solvotermal-assisted LPE (SALPE).

Different processing strategies which can be employed to deposit the produced inks as patterns and functional thin-films will be introduced, by focussing on those that can be easily translated to the industrial scale such as coating, spraying and various printing technologies. By providing insight into the multiscale analyses of numerous physical and chemical properties of these functional films and patterns, with a specific focus on their extraordinary electronic characteristics, this lecture will offer crucial information for a profound understanding of the fundamental properties of these patterned surfaces as the millstone towards the generation of novel multifunctional devices.
The functionalization of 2DMs allows to create foams and coatings integrating novel functions, which comes from the intrinsic design of the molecular units. The second part of this lecture will be devoted to functionalization and the practical use of 2DMs. In particular, molecule–graphene hybrid materials for sensing applications [2] and energy storage [3] will be discussed.

REFERENCES

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