Synthesis of Janus graphene for energy storage

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Chemical functionalization of graphene is a promising approach for the controlled engineering of its structural and electric properties.[1, 2] The grafted functional groups can also act as spacers, modifying the stacking distance of graphene layers, forming truly 3D nanostructures made of graphene and organic molecules with possible applications in electronics, biosensors, composite materials and energy storage.

The graphene nanosheets shall be chemically tailored before assembling, to tune the interlayer spacing and the intercalation properties.[3] The enlarged interlayers distance can be used as example for hydrogen gas storage by physical adsorption, or for electrochemical energy storage in supercapacitors and batteries.

Such "chemical" approach yields stacked nano-composites significantly different from the most conventional ones obtained by assembling different monoatomic materials (graphene, BN, MoS_2 etc.).[4]

Here we describe the production of layered structures of high-quality graphene grown by chemical vapour deposition (CVD), where both the number of layers and their spacing can be controlled by chemical processing (Figure 1). To precisely control the interlayer distance, we functionalized each sheet with rigid chemical moieties before the assembling. This method gives a great versatility of fabrication, allowing in principle to have a different, asymmetric functionalization for each layer in the same stack (JANUS graphene). These materials can then be used as an ideal test model to study, in real time, the intercalation of different ions suitable for battery applications. The increased interlayer distance allows fast intercalation of cations and anions, an essential process for electrochemical energy storage. The results obtained indicate that the surface chemistry and interlayer engineering are efficient strategies to control the electrochemical energy storage of chemically functionalized 2D materials.

References

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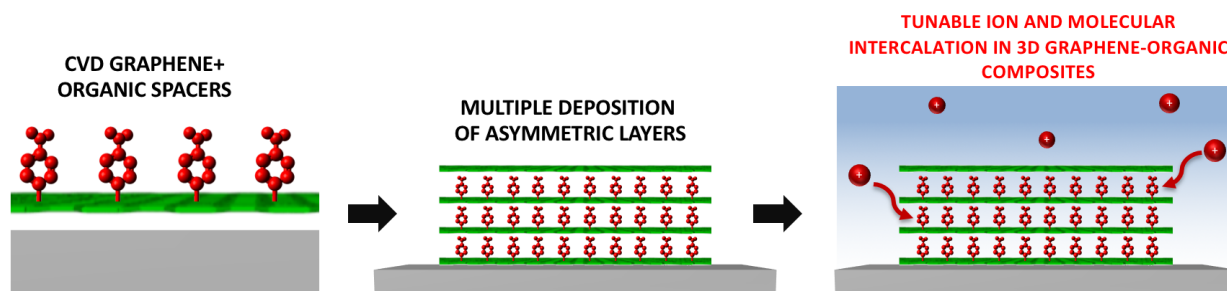[4] K.S. Novoselov, et al., **Science**, 353 (2016), 9439.

Figure 1: Scheme of covalently functionalized multilayer CVD graphene.