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One step in the right direction: Manufacture of graphene by electrochemical exfoliation and simultaneous functionalization with metal nanostructures

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Since the ground-breaking article in Science in October 2004 describing the occurrence, isolation and potential significance of graphene, there has been a huge interest in developing industrially scalable methods of manufacture from bottom-up and top-down routes. One such top-down route developed for the mass manufacture of graphene involves electrochemical exfoliation. This can be conducted in anodic (oxidative) and cathodic (reductive) regimens, with the latter more suitable for production of higher quality (containing fewer defects) graphene, but hindered by lower efficiency and yield. This makes the selection of an appropriate electrolyte particularly important. Previous work has shown that graphene prepared by electrochemical exfoliation can be simultaneously functionalized with groups tailored to improve solubility in aqueous systems. In this case, functionalization significantly enhances the specific capacitance of the material when used as an electrode in super capacitors. This presentation details the expansion of this work in two ways.

Firstly, it shows the relative characteristics of different types of electrolyte and suggests a mechanism for the performance in each case. Secondly, it details the use of the preferred electrolyte with appropriate additional reagents in the exfoliation of graphite and simultaneous functionalization of the product graphene with metal nanostructures, specifically various morphologies of gold and cobalt. The metal-functionalized graphene sheets show high catalytic activity and stability when used as electrocatalysts for hydrogen evolution reactions. Other uses of these materials are found in flexible electronics, in biosensing and in biomedicine. The methods demonstrated can be readily extended to functionalize graphene with other metal salts or mixtures of metal salts, further expanding the applicability. Functionalization of graphene with metal nanostructures, gold (top) and cobalt (bottom). The inset pictures show the color change of the electrolyte as electrolysis time increases.

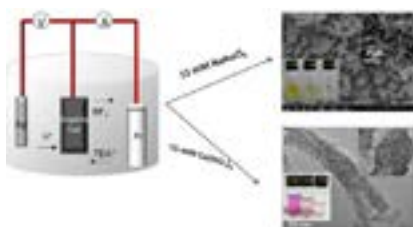


Fig 1: Schematic depicting the electrochemical exfoliation and simultaneous

Biography

Morgan Advanced Materials (LSE: MGAM) is a UK-headquartered global manufacturer of specialized engineered products made from carbon, advanced ceramics and composites. It was the first European strategic partner for the graphene activities at the University of Manchester National Graphene Institute, Morgan being recognized by Manchester for having the product engineering and design expertise required to commercialize the materials developed at the NGI. After being educated as a chemical engineer, Richard Clark has been with Morgan for 30 years, developing and commercializing materials across the spectrum of Morgan's portfolio, most recently focusing on materials related to energy. Richard was part of Morgan's team engaged with the University of Cambridge developing electrolytically produced carbon nanomaterials and has continued his involvement in this field in collaboration with Morgan's team at the Manchester NGI.

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