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How judicious selection and application of d block metal ions in electrochemical exfoliation of graphite can help transition graphene production from the laboratory to commercial use in energy storage

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Since the groundbreaking 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 previously considered more suitable for production of higher quality (containing fewer defects) graphene, but hindered by lower efficiency and yield. Generating a high-quality graphene product using an anodic process would therefore be of huge value in potential commercialization. Previous work has shown that graphene prepared by electrochemical exfoliation can be simultaneously functionalized with groups tailored to improve solubility in aqueous systems and with metal nanostructures, specifically various morphologies of gold and cobalt, which show high catalytic activity and stability when used as electrocatalysts for hydrogen evolution reactions. This presentation shows how, using selected transition metal ions such as cobalt (Co^{2+}) and iron (Fe^{3+}), high-quality (low oxygen, more conductive and with few layers) graphene can be produced using an anodic electrochemical exfoliation route. Additionally, it shows how other transition metal ions such as ruthenium (Ru^{3+}) and manganese (Mn^{2+}) can be used as metal oxide decorators. Certain hybrid structures can be uniformly grown on the graphene sheets in a single process and the product is an efficient electrocatalyst for water splitting and a high-performance electrode for supercapacitors (specific capacitance demonstrated over 520 Fg^{-1}). This method also provides an elegant means of utilizing the pseudocapacitance of ruthenium dioxide (RuO_2).

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 (NGI), 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 over 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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