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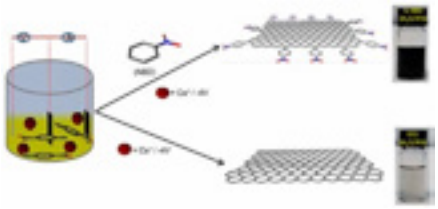
Graphene manufacturing and simultaneous functionalization by electrochemical exfoliation–A winning paradigm or just another mark on an overpopulated IP map

Richard A Clark
Morgan Advanced Materials, USA

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. By mid-2015 the number of international patent applications had already exceeded 10,000 and the annual rate was continuing to accelerate exponentially. Over 11,000 scientific papers (more than one per hour) with graphene in the title were published in 2015. Hundreds of millions of dollars are being invested in such programs as Europe's graphene flagship consortium as well in in many other academic and commercial organizations globally, although this far exceeds the current annual revenue of graphene producers, by an order of magnitude or more. One such top-down route developed for the mass manufacture of graphene involves electrochemical exfoliation. Promising in its own right, this can be performed using diazonium salts at a single applied potential, simultaneously functionalizing the single- or few-layer graphene generated. Not only does this remove the need for the secondary processing step, it is also a particularly effective means of separating the functionalized layers by virtue of the nitrogen generated during the *in-situ* diazonium reduction. Most typically for other top-down methods for production of graphene, functionalization is considered a separate, but necessary operation to permit dispersion, so this method appears to offer some clear economic advantages. Although the method applies to a plurality of diazonium salts, nitrobenzenediazonium (NBD) salts are particularly effective as demonstrated by quantitative assessment of dispersibility and efficacy in improving capacitance at the laboratory scale. This presentation will review the current status of the graphene industry and specifically review the recent progress on electrochemical exfoliation in this context.



Biography

Richard A Clark works at Morgan Advanced Materials (LSE: MGAM), is a UK-headquartered global manufacturer of specialized engineered products made from carbon, advanced ceramics and composites. After being educated as a Chemical Engineer, he 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. He 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.

richard.clark@morganplc.com

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