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Journal of Materials Chemistry C top picks web collection: the many faces of carbon

Q3

Nazario Martín

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EDITORIAL

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With the advent of 0D fullerenes, the ''so-called'' third allotropic form of carbon, in 1985, a new scenario was opened for the scientific community and for the study of carbon-based materials. This important finding, which was awarded the Nobel Prize in 1996, was followed by another major development with the discovery of the 1D multiwall tube-like carbon nanotubes (MWCNT) in 1991 and single wall carbon nanotubes (SWCNT) in 1993.

Although these important scientific events afforded important carbon materials for the emerging field of nanotechnology, a major breakthrough occurred Q4 when A. Geim and K. Novoselov first reported in 2004 the isolation of 2D graphene from lumps of graphite by using sticky tape to peel atomically thin layers of carbon.

Since then, the study of graphene by the scientific community has experienced tremendous development, becoming one of the most studied materials with great expectations for practical purposes. Graphene is the thinnest (one atom thickness) and strongest (100 times stronger than steel) material known so far, exhibiting remarkable properties such as huge conductance of heat and electricity, and a surface area close to 2600 m^2 g^{-1}. These and other important properties of this material stem from the atomically thin mesh of carbon atoms arranged in a honeycomb pattern resulting in an extremely high strength-to-weight ratio.

Graphene exhibits an electron mobility 100 times that of silicon and, therefore, it is an appropriate material for high-tech applications. Considering the availability and low price of the starting graphite, graphene could probably surpass silicon for a variety of applications and many companies are working on transferring these appealing properties of graphene to market.

Whereas the initial efforts in the study of graphene were devoted to the development of reliable methods to exfoliate graphite (namely the use of organic solvents, mechanical cleavage and epitaxial and chemical vapor deposition) and produce single-layer honeycomb carbon sheets, the bottom-up chemical approach has also produced a variety of carbon nanoribbons in a controlled manner. Although efforts are still dedicated to new and more efficient exfoliation procedures, the study of graphene is currently focused on its rich chemical reactivity as well as on finding new potential applications.

Chemical functionalization opens the invaluable opportunity of combining the properties of the carbon-based materials with those of other types of molecular building blocks for many potential applications. This is also the case for the so-called graphene oxide where the presence of multiple oxygen containing functional groups, including epoxides, alcohols, ketones and carboxylic groups, mostly at the graphene edges but also in the basal plane, is responsible for its high reactivity and for the observed catalytic behavior.

Furthermore, suitably functionalized graphene derivatives either covalently or supramolecularly connected to a variety of photo and/or redox active building blocks resulted in the observation of photoinduced energy and/or electron transfer processes, evolving from their excited species, thus mimicking natural photosynthesis and revealing the great possibilities of these carbon-based materials for photovoltaic applications.

Graphene quantum dots (GQDs) represent a new type of small graphene flakes, typically less than 10 nm in diameter, which in contrast to pristine graphene, exhibit fluorescence properties, thus paving the way to optical sensing,

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bio-imaging and photovoltaics applications, to name a few. Interestingly, experimental and theoretical calculations reveal that the photoluminescence of a GQD can be finely tuned depending on its size, shape, edge configuration, presence of functional groups or doping heteroatoms, as well as chemical defects. This new class of carbon-based material is currently undergoing rapid development in the search for reliable chemical methods able to control the synthesis as well as the morphological and electronic features of the obtained GQDs.

Analogously to GQDs, carbon quantum dots (CQDs, C-dots or CDs) are another novel type of carbon nanomaterial with sizes below 10 nm. Although Q5 these carbon-based materials have been known since 2004 when they were formed during the preparative electrophoresis of SWCNTs, only recently have they been considered an important material with outstanding perspectives provided by their abundance and low production cost.

Thus considering the aforementioned features of GQDs and CQDs, and particularly their electronic and optical properties, biocompatibility and low toxicity, they appear as new rising stars among the many nanoforms of carbon. In particular, they are revealed as promising materials for applications in bioimaging and medical diagnosis, photovoltaics and catalysis. Very recently, chiral properties have also been reported for GQDs, thus extending the use of these carbon nanoforms for materials and bio-medical applications.

This top picks web collection (***URL link to web collection to be inserted here***) highlights *Journal of Materials Chemistry C*'s most outstanding papers in the synthesis, preparation, characterization, and applications of some of the most recent and appealing nanoforms of carbon-based materials, namely graphene and graphene oxide, graphene quantum dots and carbon quantum dots. The papers gathered in this web collection clearly show the tremendous and rapid development experienced by these singular nanoforms of carbon, which will certainly catch the attention of both the specialized and general scientific communities.