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Editorial: Women in Carbon Science and Technology-"The Many Shades of Carbon"

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Editorial on the Research Topic
Women in carbon science and technology

This Research Topic features work presented by women principal and lead authors, established and internationally recognized in the field of carbon science and technology, as well as early career investigators, and captures the spirit of collaboration and interdisciplinary nature of carbon-related research.

The advent of carbon nanomaterials in their diverse dimensionalities, from carbon dots and fullerenes to single- or multi-walled carbon nanotubes (SWCNTs or MWCNTs), graphene (single or few-layered) and graphene derivatives (graphene oxide, graphyne, or graphane), has introduced a myriad of new opportunities for both fundamental and applied scientific research and sparked industrial applications (De Volder et al., 2013). Indeed, carbon nanotubes and graphene possess a unique set of impressive mechanical, optical, electrical, and thermal properties (Geim and Novoselov, 2007), which make them ideal building blocks for the next-generation of technologies. At the same time, the recent discovery of intensely fluorescent and eco-friendly carbon nanoparticles in the visible range offers numerous applications in sensing, bio-imaging, energy conversion, electronics, and nanomedicine (Liu et al., 2020).

Because carbon is one of the most versatile materials, it can be processed from a variety of sources, both naturally and synthetically, and added to other materials, heterostructures, and matrices to fabricate novel carbon-based composites with enhanced and/or tailored properties.

This Research Topic of articles presents several original works as well as a review article, which describe and address challenges associated with carbon nanomaterials, in the ways they are synthesized or processed, as well as their uses in a wide range of applications, from flexible sensors to biomedical devices to sustainable water treatments, just to name a few. With reference to this latter application field, by carbon nanotubes/nanofibers were synthesized on an ultrabasic rock, such as serpentinite, to obtain a composite material for removing organic pollutants, such as sulfentrazone, from water (Diogo et al.). Also, other forms of carbon materials were shown to be an effective water treatment remedy, and the mechanisms by which multidimensional graphene nanostructures adsorb a common contaminant like paracetamol were elucidated (Matos et al.).

One main trust related to graphene applications is its efficient dispersion in solutions; this is often addressed by the use of graphene derivatives, such as graphene oxide (GO), which offers an exciting opportunity to be efficiently mixed with other materials, such as polymers, due to the presence of several functional groups. To this end, GO was shown to be incorporated into PEDOT:PSS and PEDOT for the production of conductive inks, later used as active layers in flexible methanol sensor devices (Neves et al.). New fabrication processes involving GO reinforced polymers, for example, ultrahigh molecular weight polyethylene (UHMWPE), were shown to be scalable and, therefore, compatible with industrial settings (Amurin et al.).

In general, to tune the properties of carbon nanomaterials, including their ability to be successfully interfaced with other materials, their chemical structure has to be modified by proper functionalization strategies, which can be investigated through theoretical and experimental approaches. For example, the theoretical investigation of the electronic properties, such as the band structure and the spatial distributions of the electronic states in quantum corrals resulting from fractal architectures of carbon atoms, can guide the synthesis of novel fractal nanostructures, highlighting new functionalization possibilities (Late and Latgé). Additionally, the structure of GO contains oxygenated functional groups that can act as anchor points for various species, such as biomolecules or medicines, through different synthetic approaches, as reported by Gonçalves et al.. In general, the biomedical and medical fields can significantly benefit from the applications of carbon nanomaterials, because of their intrinsic biocompatibility. For example, carbon dots can be directly incorporated into polyvinyl alcohol (PVA) to produce fluorescent films for wearable bio-chemical sensors or therapeutic remedies (Silva et al.). They could serve as both colorimetric pH sensors to monitor pH changes characterizing wound healing processes or as antioxidants in the wound treatment for developing bioactive dressings. On the other hand, understanding the potential toxicity of carbon nanomaterials, heterostructures, and other derivatives, is an area of intense investigation because they are, often, interfaced with human body and biological samples. In this respect, researchers investigated the behavior of normal and cancer affected cells, their viability and spreading on the bed of SWCNTs and heterostructures of SWCNTs and ZnO nanowires (Luc et al.). While both materials were biocompatible, the concentration of released Zn^+ ions indicated to play a critical role. In a different study, the biodistribution of polyethylene glycol-functionalized SWCNTs was analyzed after intravenous delivery to assess their capability to cross biological membranes and reach specific rat brain sites, such as brain cortex parenchyma, without acute toxic effects (Bruch et al.).

In this Research Topic, the diversity of carbon nanomaterials and their wide-ranging applications reflect the dynamic nature of the field. The innovative research presented here not only advances fundamental science but also opens new avenues for technological and biomedical applications. We hope this body of work continues to inspire collaboration and progress in carbon-based research and technology.

This Research Topic is dedicated to Professor Mildred Dresselhaus (1930–2017), whose lifelong commitment to science and technology, pioneering work in the field of carbon research, and inspiring mentorship and support of women in science have earned her a loving attribute of "Queen of Carbon" (Chung, 2017).

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