Quantifying impurities in Nanocarbons using ICP-OES

Pedro M. F. J. Costa, Filipa R. F. Simoes, B. H. Warsama, T. F. Yapici, Shashikant P. Patole

Physical Science and Engineering Division, King Abdullah University of Science and Technology, Thuwal 23955-6900, Saudi Arabia
pedro.dacosta@kaust.edu.sa

Abstract
Nanocarbons belong to a class of materials that include the well-known graphene, carbon nanotube and fullerene structures. Much of the interest surrounding Nanocarbons relate to their physical properties some of which are unique (e.g. superlative charge carrier mobility in graphene or unidirectional ballistic transport in nanotubes). However, during the synthesis and/or processing of these materials, it is often the case that non-C impurities are introduced in sample batches. These may be hard to quantify and remove, particularly when in vestigial concentrations (Fig. 1). For a number of technological applications, the presence of contaminants, even at trace levels, will adulterate or eliminate the intrinsic properties of Nanocarbons. Such is the case of devices that rely on the response of a discrete carbon nanostructure (e.g. atom-discriminating resonators, sensors to identify and count biomolecules, etc.).

Developing Metrology and Standardization methods and materials for Nanocarbons is critical to implement accurate quality control at research and industrial production facilities. In view of this, there has been considerable effort to develop Certified Reference Materials (CRM) for Nanocarbons and methods to analyze these. After two decades of intensive work, the first CRMs for Nanocarbons were recently announced by NIST [1], in the US, and NRC [2], in Canada. The availability of these standards opens up a window to routinely and precisely quantify the elemental concentration of elemental impurities in sample batches of Nanocarbons.

Amongst the most reliable, low cost and popular analytical methods to characterize metal impurities in Nanocarbons samples is inductively coupled plasma (ICP) methods. Besides providing vestigial quantification levels (down to ppb) for samples of tenths of mg, the ICP (associated either to optical emission spectrometry, OES, or mass spectrometry, MS) is a staple in laboratories worldwide, academia and industry alike. We have been using the aforementioned CRMs to validate our ICP-OES analyses of Nanocarbons that were either produced in-house or purchased [3]. In the process, new methods for the preparation of ICP-OES analytes are being investigated [4, 5]. Effectively, this is the major roadblock (possibly, the sole) on the way to realize the universal application of ICP-OES as a gold standard analytical tool for chemical quantification of Nanocarbons. In this communication, we will present a novel method of preparing aqueous solutions for ICP-OES that is capable of disintegrating all types of Nanocarbons tested.

References
[1] SRM-2483, Certificate of analysis, National Institute of Standards and Technology, United States of America (November 2011).
[2] SWCNT-1, Certificate of Analysis, National Research Council, Canada (June 2013).
[3] FRF Simoes, NM Batra, BH Warsama, DH Anjum, TF Yapici, SP Patole, PMFJ Costa, (unpublished).
[4] SP Patole, F Simoes, TF Yapici, BH Warsama, DH Anjum, PMFJ Costa, Talanta, **148** (2016) 94.
[5] PMFJ Costa, SP Patole, TF Yapici, USPTO 62/127307, 3 March 2015.

Figures

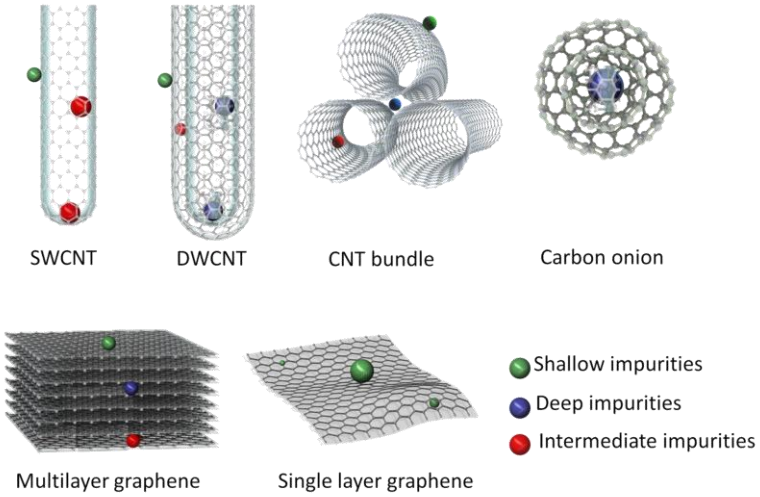

Figure 1. Nanoparticles or atoms may show up in different locations of Nanocarbon samples. Examples include inside fullerene cages, in-between graphene layers or within the interstitial voids of nanotube bundles. While shallow impurities can generally be removed, deep ones are much harder to discard.