

# **Raman spectroscopy as metrological tool in the study of carbon nanostructures: a tutorial**

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The needs of specific information about the chemical composition of objects, surfaces, solutions, among others, have stimulated the great development of the instrumentation in the last decades, especially in the field of Raman spectroscopy (RS) as its non-destructive and non-invasive characteristics are an extra bonus. The development of cheap and friendly user apparatuses has contributed to further increase the application of RS beyond the research laboratories, arriving at the pharmaceutical industry, hospitals, museums, forensic departments, just to cite a few.

This tutorial will address the basics of RS theory and instrumental aspects, focusing on how Raman spectra acquired by different equipment may present some divergences due to the specific nature of the measurement. The role of each part of the apparatus will be detailed, and the importance of the correct calibration will also be presented. Some other common issues such as fluorescence, sample preparation, stray light and cosmic rays are also on this topic.

The use of RS in the study of carbon nanostructures such as graphene, carbon nanotubes, and fullerene will be presented, focusing on some of the work done at the Materials Metrology Division, in Inmetro (Brazil). RS is the most common technique used to study carbon materials and it is also the most suitable to study the presence of defects and other discordances in such materials. We will see how RS can give not only qualitative but also quantitative information about the structure of those materials, and how this can be used in quality control.