Metrological framework for quality control of mass-produced graphene

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Liquid-phase exfoliation (LEP) is considered, among all forms of producing 2D materials, as the most scalable one [1]. However, production scalability, with quality, can only be reached if critical parameters such as temperature, processing time, and energy are optimized. Postprocessing is also important: the proper choice of electrostatic or steric stabilizers can make the suspensions stable. Mass separation through centrifugation is usually employed to improve homogeneity. All these procedures should be monitored, aiming at the requirements that make the material suitable for the target application. However, because LPE usually generates 2D nanosheets with broad distributions of thickness and lateral size, it is hard to find the right parameters that summarize the yielded material. For this purpose, robust statistical analysis is required. In this talk, I will present statistical methods that summarize and provides deep understanding of morphological attributes of mass-produced nanoflakes from 2D materials. The protocol is based on atomic force microscopy (AFM) [2-4], Raman spectroscopy [5,6], and tip-enhanced Raman spectroscopy (TERS) [7] measurements and automated analysis. The information gathered is rarely accessible even in conventional methods considered as statistical ones, such as thermal or spectroscopic analysis. The key factor is that the statistical essence our protocols is not related to the measurement itself but to the large number of nano-objects individually scrutinized, having their morphological parameters extracted one by one. The amount and type of information that can be extracted from this routine indicate that this is the most adequate way to analyze batch produced nanomaterials, in which the size and shape of each individual nano-object matters to the physicochemical properties of the whole.

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