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Safety issues of Carbon Nanomaterials: a focus on Graphene Oxide and a Safer-by-design strategy to mitigate its potential impact on Health and the Environment

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Carbon nanomaterials, and especially Carbon Nanotubes (CNTs) and Graphene have been among the most studied nanomaterials due to their exceptional combination of physical properties which have led to applications in almost all fields. Unfortunately, in the case of graphene, the large-scale production of good quality samples (low number of layers (less than five, what is called "few-layer graphene", FLG), lateral dimensions exceeding one micrometer, good structural quality) still represents a challenge despite the regular advances described in the literature. A simpler alternative consists in preparing graphite oxide, easy to exfoliate into graphene oxide (GO), for example by simple ultrasonic treatment. GO is hydrophilic and much easier to disperse (solvent, matrix) than FLG, which is very hydrophobic. GO is an electrical insulator, while FLG is a good electronic conductor. When electrical conductivity is one of the desired properties, it is required to reduce GO (decrease its oxygen content) to obtain "reduced GO" (rGO), supposed to be equivalent to FLG, but still presenting many structural defects. As the oxygen content decreases, the electrical conductivity is progressively restored but as a counterpart the stability of the dispersion in a solvent or a matrix decreases.

Regarding safety issues, we have evidenced the toxicity and genotoxicity of GO both in vitro and in vivo [1, 2], but also the possibility to suppress these adverse effects by thermal reduction [3]. The aim is to find a compromise between the ease of use of GO on the one hand, and its negative impacts on humans and the environment on the other. This strategy, which aims to identify the most suitable experimental conditions allowing a compromise between the absence of (geno)toxicity and the preservation of its ease of use, is part of the "safer by design" approach.

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