The importance of international standards for the graphene community

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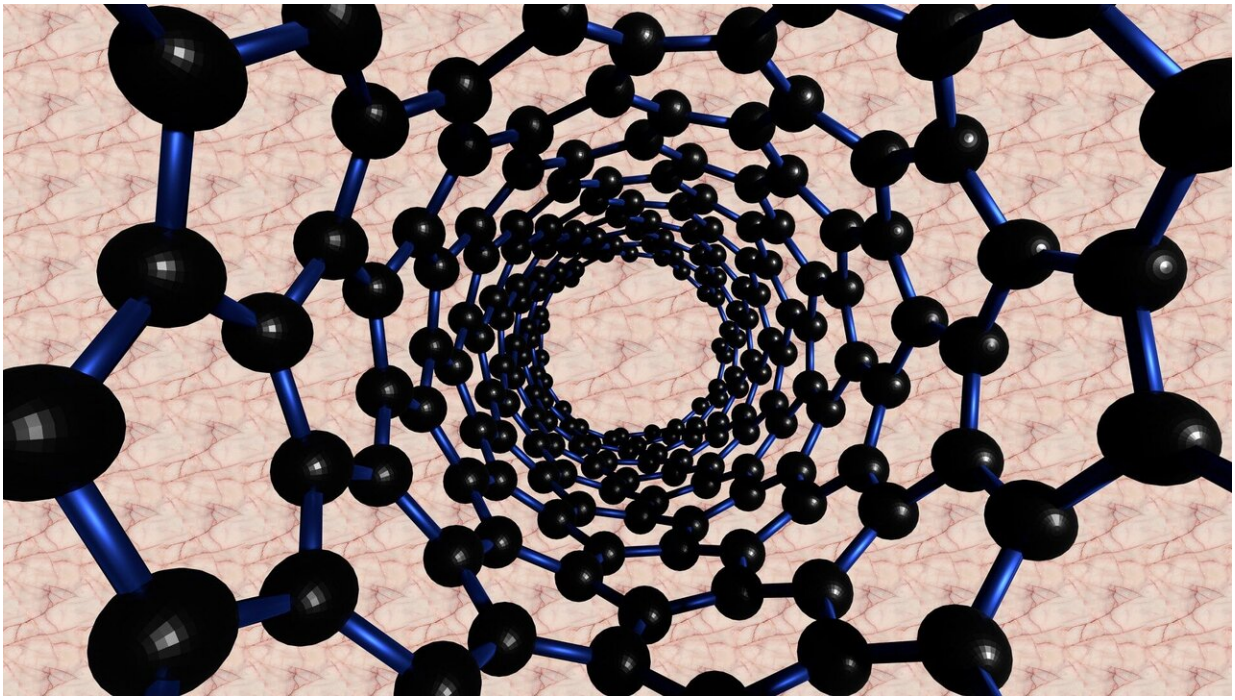

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NPL, in collaboration with international partners, has developed an ISO/IEC standard, ISO/TS 21356-1:2021, for measuring the structural properties of graphene, typically sold as powders or in a liquid dispersion. The ISO/IEC standard allows the supply chain to answer the question 'what is my material?" and is based on methods developed with The University of Manchester in the NPL Good Practice Guide 145.

Over the last few years, graphene, a 2D material with many exciting properties and just one atom thick, has moved from the laboratory into real-world products such as cars and smartphones. However, there is still a barrier affecting the rate of its commercialisation, namely, understanding the true properties of the material. There is not just one type of material, but many, each with different properties that need matching to the many different applications where graphene can provide an improvement.

With hundreds of companies across the globe selling different materials labeled as "graphene," and manufacturing it in different ways, end users who want to improve their products by incorporating few-layer graphene flakes are unable to compare and subsequently select the right material for their product.

Through standardized methods to enable the reliable and repeatable measurement of properties, such as the lateral flake size, flake thickness, level of disorder and specific surface area, industry will be able to compare the many materials available and instill trust in the supply chain. In conjunction with the international ISO/IEC terminology standard led by NPL, ISO/TS 80004-13:2017, it will be possible for commercially available material to be correctly measured and labeled as graphene, few-layer graphene or graphite.

As the UK's National Metrology Institute, NPL has been developing and standardizing the required metrologically-robust methods for the measurement of graphene and related 2D materials to enable industry to use these materials and realize novel and improved products across many application areas.

The continuation of the NPL-led standardization work within ISO TC229 (nanotechnologies) will allow the chemical properties of graphene related 2D materials to be determined, as well as the structural

properties for different forms of graphene material, such as CVD-grown graphene. This truly international effort to standardize the framework of measurements for graphene is described in more detail in *Nature Reviews Physics*, including further technical discussion on the new ISO graphene measurement standard.

Dr. Andrew J Pollard, science area leader at NPL said: "It is exciting to see this new measurement standard now available for the growing graphene industry worldwide. Based on rigorous metrological research, this standard will allow companies to confidently compare technical datasheets for the first time and is the first step towards verified quality control methods."

Dr. Charles Clifford, senior research scientist at NPL said: "It is fantastic to see this international standard published after several years of development. To reach international consensus especially across the 37 member countries of ISO TC229 (nanotechnologies) is a testament both to the global interest in graphene and the importance of international cooperation."

James Baker, CEO of Graphene@Manchester said: "Standardization is crucial for the commercialisation of graphene in many different applications such as construction, water filtration, energy storage and aerospace. Through this international measurement standard, companies in the UK and beyond will be able to accelerate the uptake of this 21st Century material, now entering many significant markets."

More information: Charles A. Clifford et al. The importance of international standards for the graphene community, *Nature Reviews Physics* (2021). DOI: 10.1038/s42254-021-00278-6

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