Polymeric Graphenes & The Case Against Nanocarbons

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The last forty years of carbon nanotechnology can be viewed as a stalled evolution toward the construction of larger-scale, higher-dimensional structures from graphenic lattices. After the discovery of 0D fullerenes in 1985, researchers introduced 1D nanotubes in 1994 and 2D nanosheets in 2004, but for the last two decades the field has struggled with the final step from 2D to 3D. This step is the most critical if graphene's properties— currently confined to the negligible volumes of low-dimensional particle types—are to be extended to larger, more practically useful volumes. Attempts to construct 3D networks from commercially available particle types like nanotubes and nanosheets have produced disjoint assemblies with inadequate density, structural periodicity, and lattice continuity.

Inspired by naturally crosslinked sp^2-hybridized carbons such as soot [1] and anthracite [2] and echoing early theorized graphene foams [3-5], "polymeric graphenes" are a new category of continuous, 3D graphenic networks that represent the final stage of graphene's progression from 0D to architected 3D structures. These networks are orders of magnitude larger and more complex than their nanoscale predecessors. Together, they constitute a broad taxonomy within which the simple, low-dimensional geometries of fullerenes, nanotubes, and nanosheets represent zero-volume limit cases. From a structure-property standpoint, polymeric graphenes eliminate the intrinsic challenges associated with nanoscale graphenic particles (e.g., limited dispersibility, viscosity effects, toxicity concerns, etc.) and invite a critical reassessment of these particles' roles in future applications.

References

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[3] Tománek, et al. *Molecular Crystals and Liquid Crystals* 386.1 (2002): 189-195.
[4] Kawai, et al. *Physical Review B—Condensed Matter and Materials Physics* 72.3 (2005): 035428.
[5] Qin, et al. *Science advances* 3.1 (2017): e1601536.

Figures

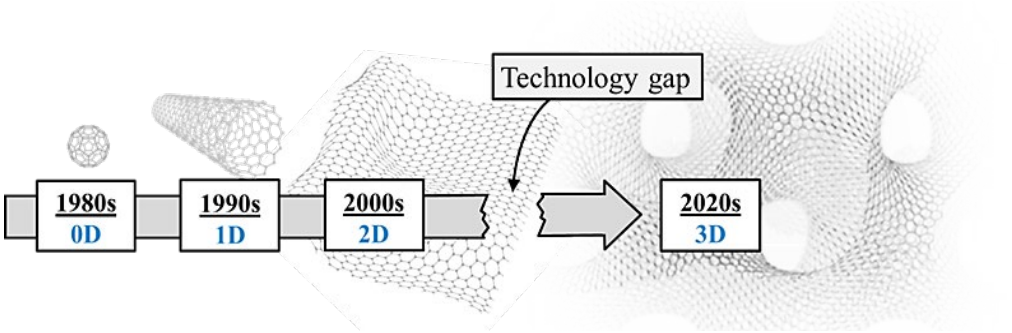

Figure 1: For the last two decades, carbon science has struggled to synthesize 3D graphene lattices. Nanotube and nanosheet supply chains are based on decades-old technology and are at risk of near-term obsolescence due to the emergence of polymeric graphenes, an emerging category of larger-scale, more engineerable graphenic networks.