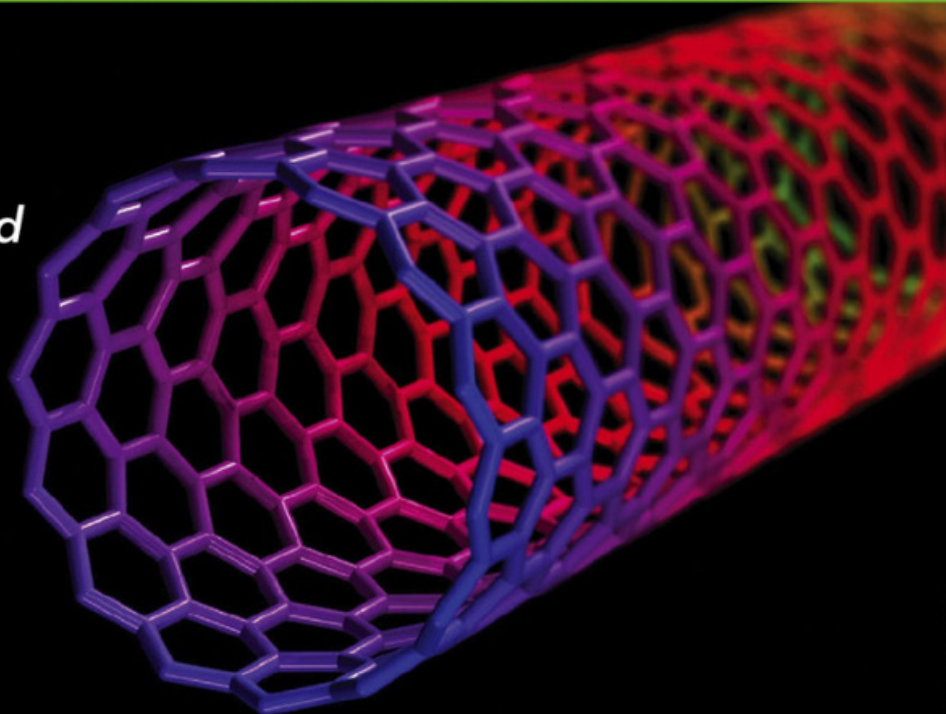


Advances in graphene and carbon nanotubes are driving progress towards industrialisation and new thermoplastic applications. Jennifer Markarian reports on the latest developments



Graphene and carbon nanotubes hit the market

Nano-scale additives used in plastics, as well as in other materials, include graphene (of various forms) and carbon nanotubes (CNTs). These additives promise to reduce weight and improve properties at a different level than traditional reinforcing additives.

Graphene is a form of carbon in a single layer, two-dimensional honeycomb lattice that provides exceptional mechanical strength, electrical conductivity and thermal performance, along with other benefits, explained manufacturer Black Swan Graphene. Various forms of graphene with different numbers of layers and functional groups have different advantages.

Haley Marie Keith, CEO and Co-founder of **Mito Materials**, which has a patented additive technology that functionalises substances such as graphene oxide, said that the company is working with specialty compounders who are incorporating graphene in thermoplastics. She said that graphene is continuing an upward trajectory in commercial use cases and adoption. "For the compounders, we hear value in processing and handling; from component producers, we see improvements in torsional stability, flex, and tensile, at much lower loadings than other additives. It's exciting to see graphene deliver on its promises in this market," said Keith.

While graphene had previously been targeted

for high-value, niche applications, the additive is becoming competitive in general applications, added Tom Eldridge, Director of Business Development at graphene manufacturer **Hydrograph Clean Power**. "Previously, multifunctional benefits from graphene were often needed to justify its use as a premium additive. Now graphene is becoming competitive in more mainstream applications, with emphasis on fulfilling specific functional roles."

Eldridge added that graphene is able to help products be thinner, lighter, and more durable. "Companies are under pressure to do more with less material while maintaining or improving performance. Compounds with graphene offer a compelling path to achieving these goals," he said.

Graphene can also help companies achieve the goal of moving away from multilayer, multimaterial packaging that can be challenging to recycle. Furthermore, graphene can be an enabler to upgrade recycled material. "We're currently focused on applications to both upcycle plastic waste, and also to integrate our graphene into closed loop recycling systems to enable product circularity," Eldridge said.

"Our graphene can be used in packaging applications - both industrial and consumer - where it can reduce wall thickness to save weight and cost, and enhance barrier performance to improve

Main image:
Small loadings
of carbon
nanotubes lead
to performance
benefits in
polymer
compounds



IMAGE: HYDROGRAPH

Above: HydroGraph uses tensile testing machines (pictured) to validate the effectiveness of Fractal Graphene, certify partner performance, and provide engineering-grade proof to OEMs and manufacturers in demanding industries

produce shelf life," he said. "In automotive components, it can be used in applications for structural parts where weight reduction directly impacts fuel efficiency. There are applications in fibres for strength improvement to carry additional loads, and also bearings and seals where durability improvements extend service life and reduce maintenance costs for equipment. The common thread across all these applications is the drive to use less material while achieving better performance."

Seeking partners

HydroGraph said that its Fractal Graphene is characterised by its 99.8% carbon purity and consistent morphology, and that its structure enables performance at addition rates 10 to 100 times lower than conventional graphene nanoplatelets. "Our Fractal Graphene typically achieves 20-30% increases in tensile strength and stiffness at only 0.05 wt% loading levels, enabling lighter thinner parts. Toughness can be increased from 50-70% with loading levels from 0.1%. We also see 20-30% wear reduction from 0.01% to 0.1% loading, leading to longer lasting components and products. This kind of reinforcement efficiency is dramatically superior to conventional additives and even other graphene products. Our ultra-low loading levels also preserve processability and in some cases enhance processing," Eldridge reported.

The company launched a Compounding Partner Program in July this year seeking to certify compounders to make compounds using the company's Fractal Graphene to support customers who are testing formulations in end uses including

automotive and packaging.

"This initiative effectively builds supply availability of graphene compounds for the market by providing end customers with a vetted supply chain for sourcing graphene-enhanced compounds with confidence," said Eldridge. "Early partners are already piloting new formulations across automotive and packaging sectors, supporting our mission to make graphene reinforcement accessible for mainstream commercial applications."

He said that HydroGraph has also been scaling up its manufacturing capabilities. "We established a strategic relationship with a leading North American industrial gas supplier, which provides us access to high-purity acetylene - a critical feedstock for our patented detonation synthesis process. This partnership ensures continuous, high-quality supply that enables increased production volumes without compromising our industry-leading product consistency. We've also signed a lease for a new 20,000-square-foot headquarters facility in Austin, Texas, representing nearly a 100% size increase from our current operations, with operations expected to begin by February 2026," he reported.

Industrialising graphene

Black Swan Graphene is focusing on a cost-effective process to facilitate industrialisation of graphene as an additive for materials such as concrete and polymers by making graphene nanoplatelets that are five or more layers. The company partners with compounders to provide trademarked Graphene Enhanced Masterbatch (GEM) polymer masterbatches for the plastics industry. Black Swan has partnered with masterbatch producers **Hubron International**, **Broadway Colours** and **Modern Dispersions** and said that it is working through the GEM qualification process with other global masterbatch and compounding companies. The company said that since the launch of several GEM products in mid-2024, they are working on more than 40 joint projects.

"We are incredibly excited to see our efforts and investments culminating in significant progress toward commercialisation as our graphene gains traction in the industrial sector," said Michael Edwards, Chief Operating Officer of Black Swan. "As for many innovative products, the initial commercialisation is paramount, as progress with prospective customers and production activities can provide supply security for eventual customers. As volumes expand, not only will the company be able to compete more effectively in higher-volume applications, but lower production costs open doors to more price-sensitive markets. The path to

commercialisation success is now clearly within reach."

GEM has shown performance benefits in a range of polymers, Black Swan reported. For example, in thermoplastic polyurethane (TPU), a 1% loading of GEM allowed an approximately 20% weight reduction and a stronger part, which is now in commercial use. In polypropylene (PP), 0.2% GEM showed more than 20% higher impact resistance. In polylactic acid (PLA), less than 1% GEM improved barrier properties, with a more than 40% reduction in water vapour transmission. In a PET film, 0.2% GEM resulted in a more than 35% reduction in oxygen transfer rate, as well as increased stiffness and tensile strength.

GEM is being tested in North America to enhance the strength and barrier properties of agricultural films used in crop protection (eg greenhouse films, mulch films, silage storage). The company said that it is collaborating with a number of packaging companies to use GEM to improve barrier properties of PET. Black Swan is also seeking food contact notification from the US FDA and is currently in the application process with a leading partner, the company said. Other projects are seeking to incorporate graphene into PLA to improve barrier properties for packaging as well as vehicle components. The GEM approach allows customers to try graphene in a low-cost format to see if it will succeed in their application, said Edwards.

"We are achieving exactly

what we set out to prove: with the right dispersion and the right loading, our graphene products can unlock properties that matter at industrial scale. These partner-led trials validate the strength of our GEM model confirming that we can provide a reliable pathway for global manufacturers to integrate graphene seamlessly into existing production processes.

Importantly, the results demonstrate not only technical performance, but also commercial viability, positioning Black Swan to capture significant near-term opportunities as we advance toward high-volume production," said Simon Marcotte, President and CEO of Black Swan.

On the manufacturing side, Black Swan announced in June that it is undertaking

an expansion to increase its production capacity to 140 tonnes/yr, which will more than triple its current capacity. An additional unit will be installed at the company's existing Thomas Swan facility in the UK.

Black Swan recently entered a distribution agreement with Ferro South Africa to distribute and resell GNPs and GEM solutions in South Africa to



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Above: Shrink wrap for commercial and industrial sectors is being evaluated as a possible application for graphene by Nova Graphene and TufWrap Australia. The colour of the graphene-enhanced sheeting is anticipated to be darker than the traditional sheeting pictured here but is expected to stay cooler due to enhanced thermal conductivity

better vibration control than concrete-based ties," explained Beasant. "We are working on optimising the formulation and scaling up."

Asbury Carbons has received US EPA approval to introduce its novel Edge-Oxidised Graphene (EOG) into commercial applications. The company

explained that EOG (ie Edge-Functionalised Graphene), is a few-layer, lightly oxidised graphene made through a patented mechano-chemical process, resulting in a cost-efficient, high-performing material at an industrial scale. It provides the processability of graphene oxides with the performance of graphene and can benefit various applications.

The company said it can currently provide high-volume quantities (metric tonnes) of EFG in the form of active powder, dispersions (aqueous and solvent) and polymer masterbatches. A new, 17,000-square-foot facility in South Plainfield, New Jersey is being brought on-line to complement its existing R&D centre in Asbury, New Jersey.

"We are open to exploring any collaboration in high-volume applications requiring improved mechanical strength, barrier properties, flame retardancy, thermal/electricity management, flame retardancy and anti-corrosive properties in both masterbatch and slurry forms," said Daniel Tsai, Vice-President of Business Development.

Tom Nosker, Principal Investigator at the **AMIPP Advanced Polymer Center at Rutgers**, the State University of New Jersey, was recently awarded a



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