OPPORTUNITY 46

SCOPE TRANSITIONAL

UNCERTAINTIES

Technology, Nature

MEGATRENDS

Materials Revolution

TRENDS

Artificial intelligence
Immersive technologies & wearables
New Materials
Nanomaterials
Transforming energy

SECTORS IMPACTED

Agriculture & Food
Automotive, Aerospace & Aviation
Chemicals & Petrochemicals
Communication Technologies & Systems
Consumer Goods, Services & Retail
Digital Goods & Services
Education
Energy, Oil, Gas & Renewables
Financial Services & Investment
Government Services
Health & Healthcare
Immersive Technologies
Infrastructure & Construction
Insurance & Reinsurance
Logistics, Shipping & Freight
Manufacturing
Materials & Biotechnology
Art, Media & Entertainment
Metals & Mining
Professional Services
Real Estate
Sports
Travel & Tourism
Utilities

What if graphene were mass produced?

FINALLY GRAPHENE

By unlocking solutions for mass production, graphene could transform energy storage, hydrogen fuel efficiency, air filtration, water desalination, sensor technologies, and healthcare, particularly in drug delivery and personalised medicine.

WHY IT MATTERS TODAY

Graphene is useful for everything from healthcare and energy to supercomputers and building materials, including batteries, solar cells, and sensors

The thinnest material known, graphene is a layer of carbon atoms arranged in a hexagonal matrix. It is also a superconductor,[929] lightweight,[930] strong (200 times stronger than steel),[931] flexible, and nearly transparent.[932] These invaluable properties mean graphene is useful for everything from healthcare and energy to supercomputers and building materials,[933] including batteries, solar cells, and sensors.[934]

Even though it was discovered 20 years ago,[935] it has yet to be adopted in mass manufacturing as it remains expensive to produce graphene that, beyond small flakes,[936] is both defect free and in single layers.[937] Nevertheless, some companies assert their ability to mass produce good quality graphene layer, e.g. 2DCarbon in China,[938] and graphene flakes, e.g. Avadain in the United States.[939]

In 2013, the European Union launched a decade-long, $1.1 billion[R] Graphene Flagship project that has led to 83 patents, over 5,000 publications, and 17 spin-off companies.[940] Abu Dhabi's Khalifa University of Science and Technology and the University of Manchester (where graphene was first produced) have partnered to jointly explore areas where graphene can make an impact, including water filtration and energy storage.[941]

The global graphene market was valued at $175 million in 2022 and is expected to grow at a CAGR of 46.6% from 2023 to 2030.[942] Graphene's global market potential is projected to reach $190 billion by 2030.[943]

Graphene membranes have also been shown to boost the efficiency of air filtration by 55%–65%, and the efficiency of graphene-enhanced solar desalination increases by 70%–90%.[944] Graphene also has the potential to make desalination a more sustainable solution for usable water and, as the need for more sensitive sensors grows, graphene, which has been shown to have increased the sensitivity of a fibre-optic sensor by 50%,[945] could replace silicon and, for example, boost the efficiency of solar cells and conductivity in semiconductors.

From drug delivery to cancer treatment, as one of the most adaptable nanocarriers potentially available and with its ability to directly engage with the immune system,[946] graphene may transform the way we approach healthcare and personalised medicine.

[R] Based on EURUSD exchange rate on 30 December 2023.

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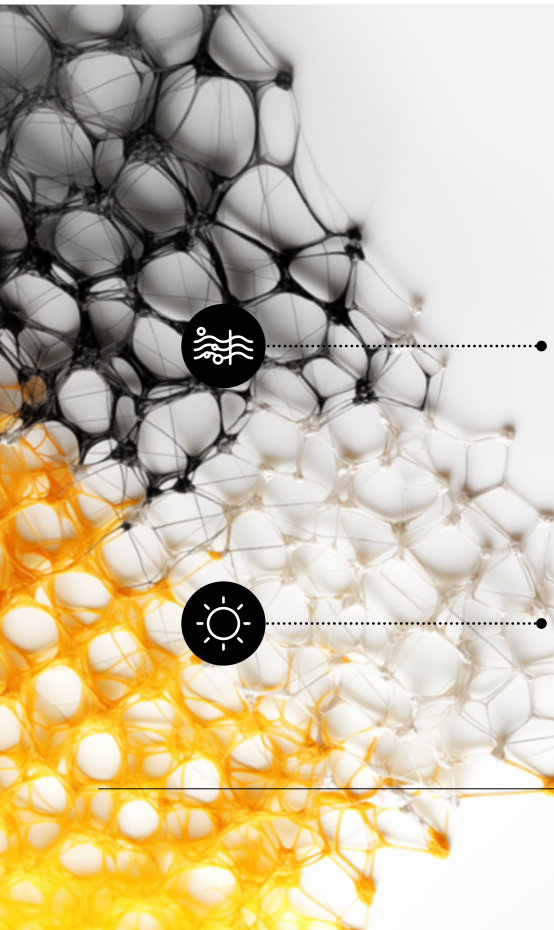
With advanced machine intelligence, the mass production and application of graphene may become a reality with many applications owing to graphene's flexibility, conductivity, and high surface area[947] – from water treatment[948] and wearable sensors[949] to e-skins[950] and energy storage technologies, enhancing batteries, supercapacitors, and solar cells.[951] As graphene has also been shown to boost hydrogen fuel cell efficiency,[952] its application could accelerate the future potential of hydrogen in aviation[953] such that 40% of European flights could be powered by hydrogen before 2050,[954] earlier than currently expected.

BENEFITS

Thanks to its strong, stretchy, conductive, and atom-thin properties, graphene disrupts entire value chains, transforming everything from batteries to water and air purification, healthcare, wearables, and electronics.[955]

RISKS

Graphene's disruptive impact may affect jobs, with its toxicity posing health risks[956] and creating new challenges in environmental sustainability.[957]



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