Vibrational exfoliation - a scalable, sustainable method for producing graphene

A new method for producing conductors, semiconductors and electronic insulators uses vibrational energy to split and peel off molecular-thin layers of material.

BIRMINGHAM, UNITED KINGDOM, April 28, 2026 /EINPresswire.com/ -- Researchers have demonstrated a new technique for creating 2D materials that runs at room temperature and increases production rates tenfold over current methods, without using toxic solvents.

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> Our work shows a new way of making 2D materials that overcomes the production capacity issues of current methods, while simultaneously embedding sustainable manufacturing practices.”
> *Dr Jason Stafford, University of Birmingham, UK*

Scientists led by Dr Jason Stafford from the Department of Mechanical Engineering demonstrated the method can produce nanosheets of conductors, semiconductors and insulators, which are the building blocks of all digital devices and technologies produced today. The research published today in the journal Small.

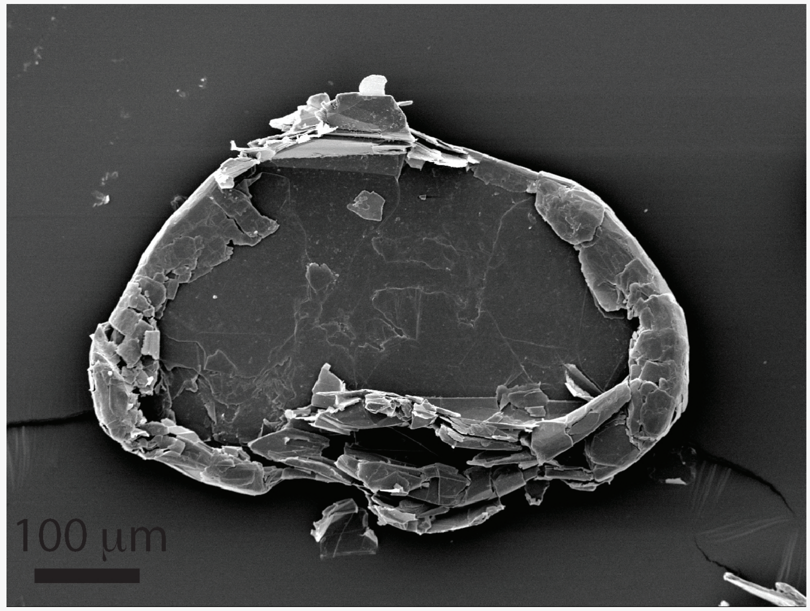
Dr Stafford said: “Our work shows a new way of making 2D materials that overcomes the production capacity issues of current methods, while simultaneously embedding sustainable manufacturing practices."

2D materials are ultra-thin materials that consist of a few layers of atoms. They have unique electronic, thermal, and mechanical properties that differ significantly from their 3D counterparts, and are ideal components for next-generation electronics, energy and sensor technologies.

Although these materials can be made in the laboratory, the same methods are inefficient for industrial scale.

Shear mixing, a high energy process that uses intense mechanical force, and requires long run times, and sonication, which uses ultrasound waves to fracture a precursor material into nanosheets, work at relatively low concentrations of material, so have low production rates and high solvent waste. Ball-milling is a low-solvent option and high yields have been reported, but the method has long processing times, carries the risk of contamination from the milling medium, and can introduce defects into the structure of nanomaterial.

Manufacturing graphene has proved particularly challenging, with high production costs, inconsistent material quality, technical barriers to large-scale production and reliance on critical and non-renewable raw materials.   Higher production rates and sustainable, green manufacturing methods are needed to meet large-scale industrial demand.



Vibrational motion causes graphite particles to fold at the edges, before splitting into thinner layered materials, peeling off the parent particle, and finally undergoing high strain rates to form atomically thin sheets of graphene.

Scientists from the Birmingham Centre for Mechanochemistry and Mechanical Processing demonstrated the use of high intensity vibrations as a novel mechanical method for synthesising graphene and other 2D materials including the electronic insulator hexagonal boron nitride, and semiconductors molybdenum disulfide and tungsten disulfide, which are used in optoelectronics.

Dr Stafford said: “By creating alternate, more sustainable synthetic routes for these exciting materials, we have an opportunity to lower the barrier for industrial translation. This will help facilitate future electronic devices, composites, and catalysts, while also avoiding unintended environmental consequences as production is scaled up.”

They found that liquid is required for the vibrational technique to work, but rather than using toxic solvents, the researchers chose to demonstrate the method using water and tannic acid, due to its high sustainability and low cost.

Their published work combined experiments, materials characterisation, and computer simulations to show how materials are transformed from raw ‘bulk’ materials to few-layer nanosheets.

The work on graphene combined electron microscopy and multiphase computational models to confirm that vibrational motion causes graphite particles to fold at the edges, before splitting into thinner layered materials, peeling off the parent particle, and finally undergoing high strain rates in the liquid phase to form atomically thin sheets of graphene.

Experimental work showed the vibrational method functions at substantially higher concentrations, and therefore delivers a higher production rate, than either sonication or shear mixing. The earliest stages of graphene production, where the precursor folds at the edges prior to splitting, were detected as early as five minutes, and spectroscopic analyses showed the vibrational exfoliation approach does not introduce defects into the graphene nanosheets.

Dr Jason Stafford is a co-inventor on 20 patents, and the main inventor on a patent application filed by University of Birmingham Enterprise for a high throughput method for 2D and nanomaterial processing. The researchers are interested in speaking to commercial companies who wish to licence the patent or collaborate in further development and optimisation of either technique.

Ruth Ashton
University of Birmingham Enterprise
r.c.ashton@bham.ac.uk
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