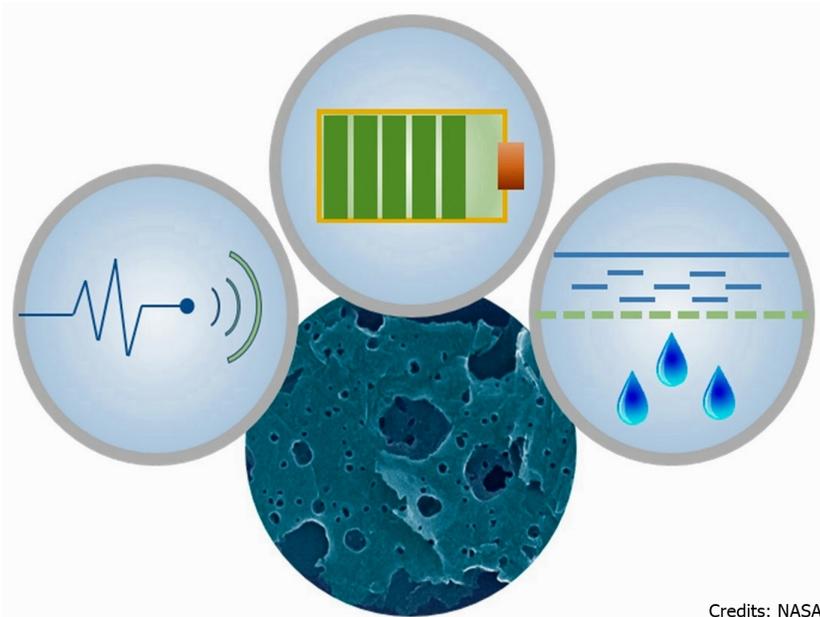




TECHNOLOGY SOLUTION

Materials and Coatings



Credits: NASA

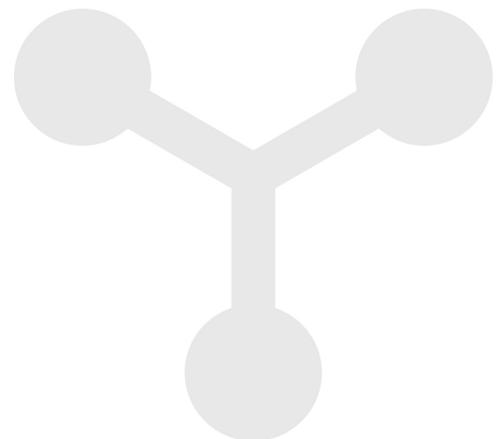
Holey Carbon Allotropes

[Innovative manufacturing methods for bulk preparation of holey graphene and holey carbon nanotubes](#)

Researchers at NASA have developed new methods to manufacture carbon materials (e.g., nanotubes, graphene) with holes through the graphitic surface of the particles. The methods generate materials with increased accessible surface area, increased functional groups at damage sites, and improved through-surface molecular transport properties. The materials generated using these techniques are anticipated to be applicable to a variety of industries, especially energy storage (e.g. super-capacitors and batteries) and separation membranes (e.g. for gas, ions, organics, proteins, etc.).

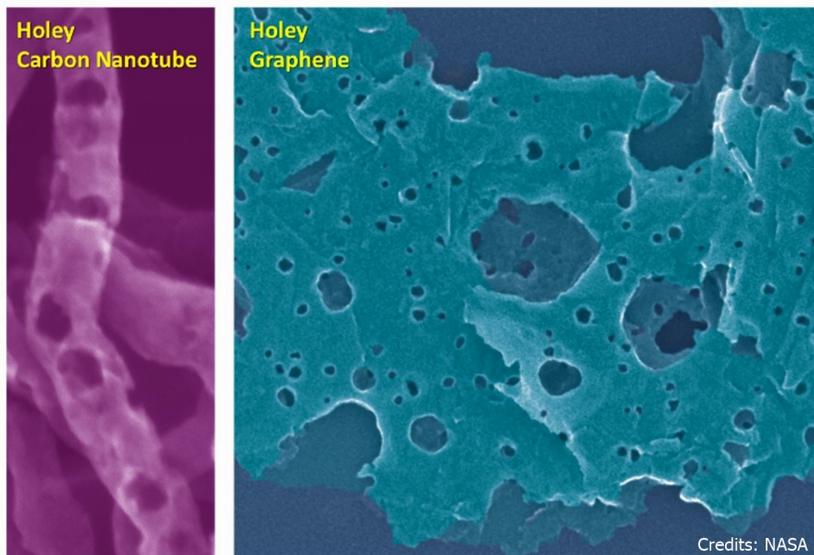
BENEFITS

- Produces carbon nanomaterials with increased surface area, improved electrochemical performance, and through-surface molecular transport properties
- Eliminates need for catalysts, solvents, and flammable gases for processing
- Consistently produces holes with a narrow size distribution, especially in the sub 10-nm ranges
- Allows for control of material properties such as surface area, modulus, thermal conductivity, and thermopower
- Is readily scalable and can be used to generate bulk quantities (only dependent on the availability/cost of pristine materials)



THE TECHNOLOGY

This invention is for scalable methods that allows preparation of bulk quantities of holey nanocarbons with holes ranging from a few to over 100 nm in diameter. The first method uses metal particles as a catalyst (silver, copper, e.g.) and offers a wider range of hole diameter. The second method is free of catalysts altogether and offers more rapid processing in a single step with minimal product work-up requirements and does not require solvents, catalysts, flammable gases, additional chemical agents, or electrolysis. The process requires only commercially available materials and standard laboratory equipment; and, it is scalable. Properties that can be controlled include: surface area, pore volume, mechanical properties, electrical conductivity, and thermal conductivity.



Electron Microscopy Images of Holey Carbon Nanotubes and Holey Graphene

APPLICATIONS

The technology has several potential applications:

- Energy storage (supercapacitors, batteries)
- Membranes for gas separation, water desalination, biomolecular separation
- Gas and drug delivery
- Chemical and biological sensors
- Thermoelectrics
- Coatings

PUBLICATIONS

Patent No: 9,567,225