Researchers measure single atoms in a graphene 'petri-dish'

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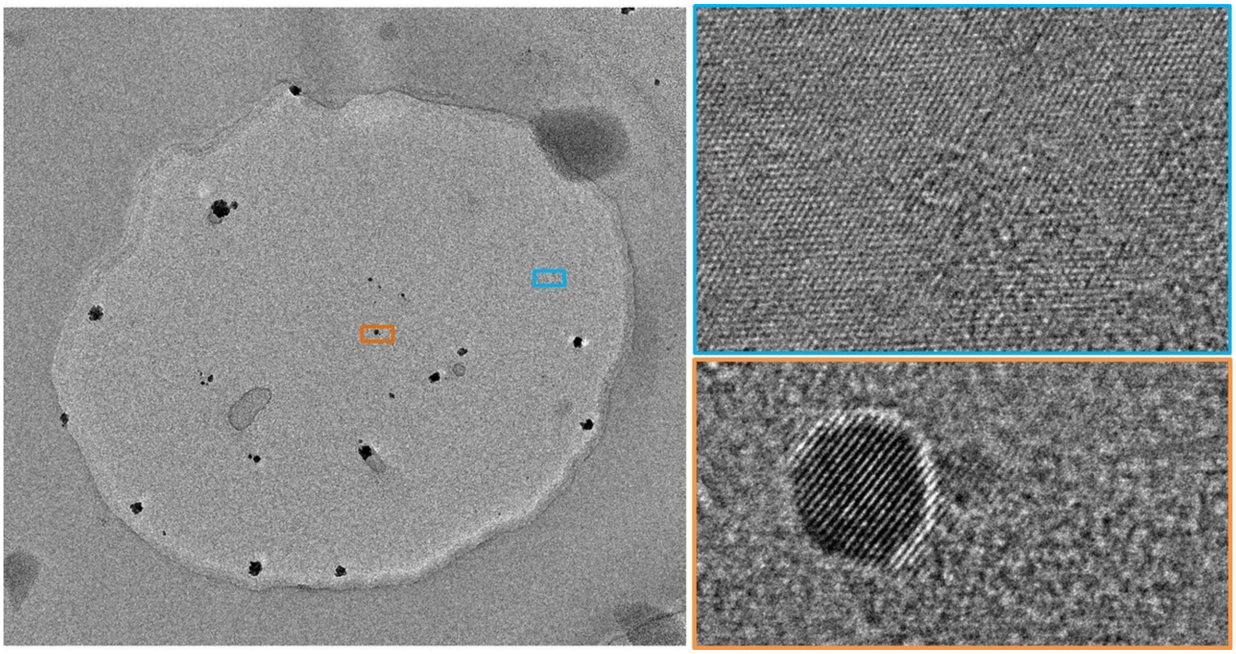

Credit: University of Manchester

Researchers working at The University of Manchester have shown new possibilities for observing nanomaterials in liquids by creating a graphene 'petri-dish'.

New 2-dimensional nanomaterials have the potential to improve efficiencies, reduce costs and provide enhanced performance in a broad range of applications including; better design of nanomaterials for batteries or understanding the degradation of battery materials in order to improve their performance.

The unique properties exhibited by 2-D materials could also lead to functional and antibacterial coatings, bioanalysis, and targeted drug delivery. However, the difficulty of controlling growth and degradation at the atomic scale is currently a hurdle to fully exploiting the potential of these exciting materials.

Scanning / transmission electron microscopy (S/TEM) is one of only few techniques that allows imaging and analysis of individual atoms. However, the S/TEM instrument requires a high vacuum to protect the electron source and to prevent electron scattering from molecular interactions.

Several high profile studies have previously revealed that the structure of functional materials at room temperature in a vacuum can significantly different from that in their normal liquid environment. This could be like trying to study the structure of a dehydrated prune to understand the structure of the original plum.

Publishing in *Nano Letters*, a research team led by Dr. Sarah Haigh and Dr. Roman Gorbachev at the National Graphene Institute and the School of Materials at The University of Manchester have shown that graphene and boron nitride can be combined to create a perfect nano petri-dish. Liquid samples inside the dish can be imaged with single atom sensitivity and it is also possible to measure their elemental composition at the nanometre length scale.

These engineered graphene liquid cells (EGLC) are built from 2-D material-building blocks: They consist of a boron nitride (BN) spacer drilled with holes (where the liquid is contained) and encapsulated with graphene on both sides.

Graphene is the ultimate window material—strong enough to protect the sample from a high vacuum environment, but at the same time thin enough that the resolution of the electron beam is not compromised. Lead author Daniel Kelly said: "Unlike some previous designs our graphene liquid cells allow us to image the atoms for many minutes. We were even able to resolve individual atoms in water and observe them dancing under the electron beam."

The researchers also demonstrated that these new graphene liquid cells enable an order of magnitude improvement in the quality of elemental analysis in liquid cells. They studied the deposition of a 1nm shell of iron on gold to grow core-shell nanoparticles. This new ability to monitor tiny concentrations over such small length-scales is a necessity for the increasingly complex chemical structures of high-performing nanocatalysts.

Mingwei Zhou, the student making these cells, said: "We are getting to understand how to make these more and more reliably, this makes the 2-D petri-dish a promising route to further in situ TEM advancements, including imaging of small biological structures such as proteins."

More information: Daniel J. Kelly et al. Nanometer Resolution Elemental Mapping in Graphene-Based TEM Liquid Cells, *Nano Letters* (2018). DOI: 10.1021/acs.nanolett.7b04713

Provided by University of Manchester

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