Graphene nanopores separate gas

Providing a new source of sought after helium-3

Scientists in New Zealand, the US and Germany have developed a way of using tiny pores in a graphene sheet to separate different isotopes of helium. By creating nanoscale holes in the material, the researchers calculated that it should be possible to alter the permeability of graphene to allow helium-3 isotopes to tunnel through, while heavier helium-4 isotopes cannot. This approach has potential applications in the production of helium-3 for scientific research as well as for the separation of gases in other scientific and industrial contexts.

Helium-3 is present in the Earth's atmosphere in a ratio of 1.4 parts of helium-3 to a million parts of helium-4. It also exists as a primordial nuclide in the Earth’s mantle, created by nucleosynthesis during the Big Bang. It is used extensively in fusion research and low temperature chemistry, though most helium-3 used by researchers and industry comes from the radioactive decay of tritium. However, demand for helium-3 has risen considerably in recent years and supply has been unable to keep pace with demand. Harvesting helium-3 from terrestrial sources of helium would help to plug this gap.

Using quantum chemistry calculations and potential energy simulations, the researchers found that removing rings from a perfect graphene sheet reduced the energy barrier of the material, which determines its permeability. However, this approach was not sufficiently sensitive to achieve the specific potential required to permit tunnelling of helium-3 while excluding helium-4. Functionalising the nanopores with nitrogen enabled the researchers to fine tune the tunnelling barrier, which could one day allow the efficient separation of the two isotopes at an industrially acceptable gas flux.  

In addition to potentially providing a new source of helium-3, this approach could provide a novel way of separating other gases. ‘Graphene is a relatively inert material. If it is possible to achieve the specific potential required to permit tunnelling of helium-3 while excluding helium-4, functionalising the nanopores with nitrogen enabled the researchers to fine tune the tunnelling barrier, which could one day allow the efficient separation of the two isotopes at an industrially acceptable gas flux.’

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Targeting organs with therapeutic CO

Gel delivers gaseous signalling molecule

Scientists in the US have created a gel that can be used to deliver therapeutic carbon monoxide gas to selected organs in the body. CO has a role in the body as a neurotransmitter and a blood gas that can be poisonous, and the CO cannot be targeted to any organs other than the lungs.

More recently, small molecule CO-releasing molecules (CORMs) have been developed as an injectable targeted delivery method. However, the molecules - metal carbonyls, and more recently polymeric micelles, are commonly used - have short half-lives and are not retained in tissues, which limits their use.

Samuel Stupp from Northwestern University, and colleagues, who previously developed self-assembling peptide-based materials to deliver another biological signalling molecule - NO - have now turned their attention to the problem of delivering CO. His team combined a peptide amphiphile (PA) designed to self assemble into a fibrous gel with a ruthenium carbonyl complex similar to a known CORM. They reacted the resulting compound with sodium methoxide to generate the CO-releasing PA. The PA self-assembled into nanofibres 8.2nm in diameter.

The CO release performance of the soluble PA gave a similar half-life to known CORMs. The PA was, however, designed to form a gel, which was achieved by adding CaCl2 to the solution. ‘Gel formation slowed down CO release dramatically, from a half-life of 2.1 minutes for the soluble peptide to 17.8 minutes after gelation,’ says Stupp. This prolonged release could significantly improve the utility of CO therapy. ‘This work will add to the regenerative medicine toolbox by enabling researchers to modulate biological signalling through the delivery of a very simple diatomic gas,’ says Stupp.