I BET YOU DID'T KNOW...

How to clean water using a molecular sieve!

Prof. Dudley Shallcross, PSTT CEO, links **cutting edge research** with the **principles of primary science**

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In many parts of the world, clean water is a major issue and drinking unclean water can lead to a wide range of illnesses and even death. Ironically, many people live near the sea but despite the closeness to water, it is undrinkable.

(Do our primary school children know this? Have they tasted salty water? Why is drinking salty water so bad for humans?)

There are many ways that water can be cleaned, and it would be ideal for children to try some of these in the classroom, but it turns out that removing salt from water is quite tricky. The salt is present as charged particles called ions and that makes it hard to remove. However, a simple idea is to use a sieve to remove the unwanted salt.

We can ask our primary school children how they might remove salt from seawater, and it would be interesting to hear their answers. Salt water could be left out in the sun or near a heater and eventually the water would evaporate leaving the salt behind, which is ok if you want the salt but not if you want the water. There are many potential opportunities for the children to explore questions surrounding changes of state here. Some specific questions that could be explored include: How does temperature affect the rate of evaporation? Does the amount of water or concentration of salt matter? Does salt dissolve in other liquids and can these be evaporated in the same way? Ideally, we want children to have as much chance to explore their own ideas as possible.

So how does a sieve work? We can demonstrate this (and experiment with this) with a normal sieve (or set of sieves) that we might use in cooking. We could try different mixtures of solids or solids and liquids and see if the sieve can separate them. If possible, set a challenge for children to form their own sieve simply from a sheet of paper, and use this to separate given mixtures of solids – this will help them to appreciate that sieves can be formed from many materials and that size matters.

We could try filter paper to see if that can separate out mixtures. The paper is also a sieve. What have the children discovered? Children should be able to explain that the size of the spaces in the sieve determine whether or not is it possible to separate the mixtures. In the case of salt and water, the materials available to them would make separation impossible. **Could we scale up any of these ideas so that they could make lots of fresh water from salt water or another water mixture?**

Scientists at the University of Manchester have taken a form of carbon called graphene and modified it so that it acts like a molecular sieve and can separate the salt particles (remember these are ions and have positive (sodium) and negative (chlorine) charges) from the water. Graphene is similar to the graphite that we find in a lead pencil. It is relatively cheap and could be a significant step forward in allowing the desalination (removal of salt from water) to take place.

What is graphene? These are sheets of carbon atoms that can be folded to make tubes and a wide range of other shapes. Hexagonal netting (such as chicken wire) is the perfect example of a model of graphene, but you could use jelly babies and cocktail sticks to make hexagons and stacking these will give the idea behind a molecular sieve (see Figures 1 and 2). The researchers have reacted the graphene with oxygen and made a graphene oxide layer. Their research shows if you can make the graphene oxide tubes with the correct size (i.e. make the right sized sieve) then the charged salt particles (sodium and chlorine ions) cannot pass through the graphene oxide layer, whilst the water can (Figure 3).

In the classroom, it would be possible for children to create models of this concept and use them to explain their understanding to others. Mesh bags (such as those in which oranges or marbles are purchased) or other mesh fabrics and bird netting, for example, are easily sourced. Can the children find appropriately-sized objects to represent the salt ions (this will vary, depending on the mesh of course)?

Although there is some way to go to make a workable pipe, the idea that you can flow salt water through a pipe made of this graphene oxide, and the salt is separated and removed so it becomes pure water is very exciting.

Can we make other structures with our models and discuss what applications these may have?

Figure 2: The structure of graphene resembles chicken wire

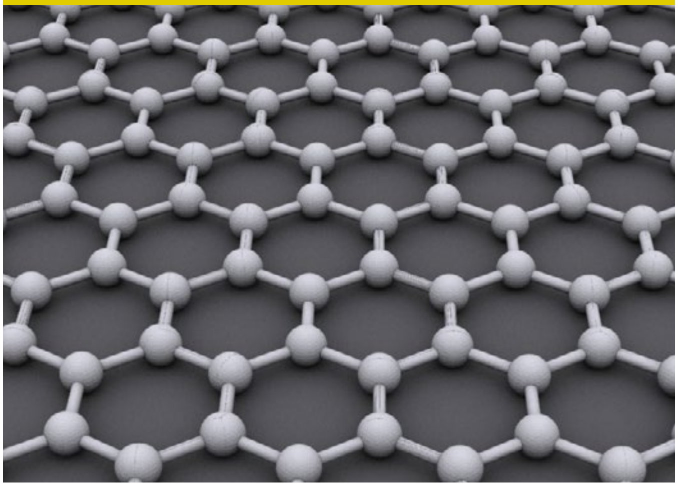


Figure 1: Modelling graphene in the classroom

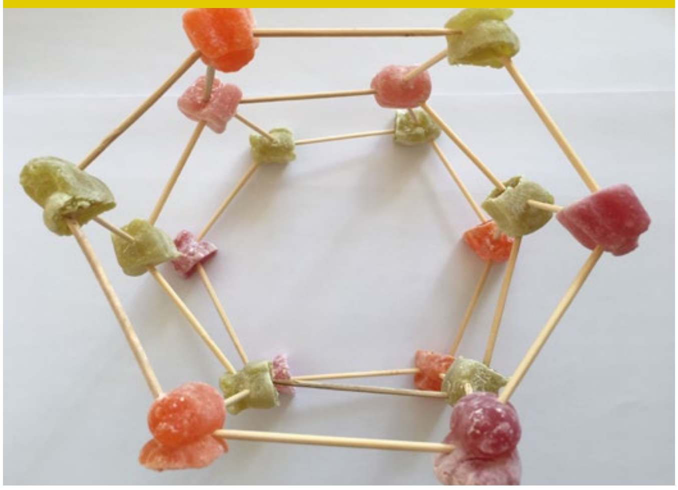
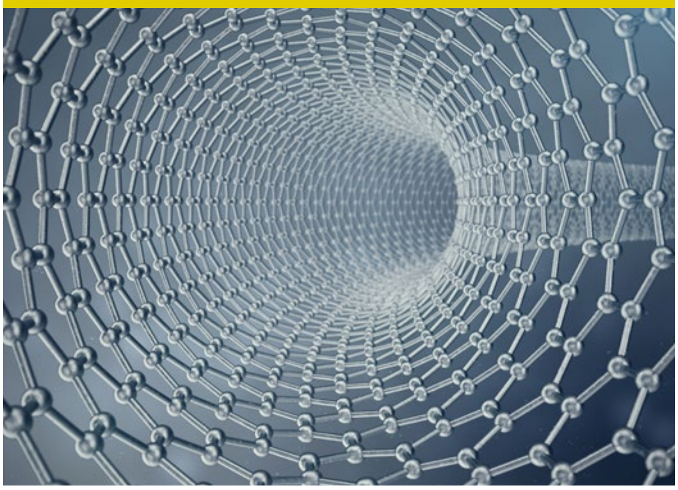


Figure 3: Graphene can be shaped to form a tube



The research paper that generated this work was:

Tuneable sieving of ions using graphene oxide membranes

By: Jijo Abraham,[1,2,3] Kalangi S. Vasu,[1,2] Christopher D. Williams,[2] Kalon Gopinadham,[3] Yang Su,[1,2] Christie T. Cherian,[1,2] James Dix,[2] Eric Prestat,[4] Sarah J. Haigh,[4] Irina V. Grigorieva,[1] Paola Carbone,[2] Andre K. Geim[3] and Rahul R. Nair.[1,2]

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All the researchers are from the University of Manchester.

Discuss these questions with the children:

Why are there so many different people from different departments in the University working on this project? How did they manage to work together on this project?