Could the humble sea urchin hold the key to carbon capture?

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A chance discovery that sea urchins use Nickel ions to harness carbon dioxide from the sea to grow their exoskeleton could be the key to capturing tonnes of CO2 from the atmosphere.

Experts at Newcastle University, UK, have discovered that in the presence of a Nickel catalyst, CO2 can be converted rapidly and cheaply into the harmless, solid mineral, calcium or magnesium carbonate. This discovery, which is published today in the academic journal *Catalysis Science & Technology*, has the potential to revolutionise the way we capture and store carbon enabling us to significantly reduce CO2 emissions – the key greenhouse gas responsible for climate change.

Dr Lidija Šiller, a physicist and Reader in Nanoscale Technology at Newcastle University, says the discovery was made completely by chance. "We had set out to understand in detail the carbonic acid reaction – which is what happens when CO2 reacts with water – and needed a catalyst to speed up the process," she explains.

"At the same time, I was looking at how organisms absorb CO2 into their skeletons and in particular the sea urchin which converts the CO2 to calcium carbonate. "When we analysed the surface of the urchin larvae we found a high concentration of Nickel on their exoskeleton. Taking Nickel nanoparticles which have a large surface area, we added them to our carbonic acid test and the result was the complete removal of CO2."

At the moment, pilot studies for Carbon Capture and Storage (CCS) systems propose the removal of CO2 by pumping it into holes deep underground. However, this is a costly and difficult process and carries with it a long term risk of the gas leaking back out - possibly many miles away from the original downward source.

An alternative solution is to convert the CO2 into calcium or magnesium carbonate. "One way to do this is to use an enzyme called carbonic anhydrase," explains Gaurav Bhaduri, lead author on the paper and a PhD student in the University's School of Chemical Engineering and Advanced Materials.

"However, the enzyme is inactive in acid conditions and since one of the products of the reaction is carbonic acid, this means the enzyme is only effective for a very short time and also makes the process very expensive. "The beauty of a Nickel catalyst is that it carries on working regardless of the pH and because of its magnetic properties it can be re-captured and re-used time and time again. It's also very cheap – 1,000 times cheaper than the enzyme. And the by-product – the carbonate – is useful and not damaging to the environment.

"What our discovery offers is a real opportunity for industries such as power stations and chemical processing plants to capture all their waste CO2 before it ever reaches the atmosphere and store it as a safe, stable and useful product." Each year, humans emit on average 33.4 billion metric tons of CO2 - around 45% of which remains in the atmosphere. Typically, a petrol-driven car will produce a ton of CO2 every 4,000 miles.

Calcium carbonate, or chalk, makes up around 4% of the Earth's crust and acts as a carbon reservoir, estimated to be equivalent to 1.5 million billion metric tons of carbon dioxide.

It is the main component of shells of marine organisms, snails, pearls, and eggshells and is a completely stable mineral, widely used in the building industry to make cement and other materials and also in hospitals to make plaster casts.

The process developed by the Newcastle team involves passing the waste gas directly from the chimney top, through a water column rich in Nickel nano-particles and recovering the solid calcium carbonate from the bottom.

Dr Šiller adds: "The capture and removal of CO2 from our atmosphere is one of the most pressing dilemmas of our time.

"Our process would not work in every situation – it couldn't be fitted to the back of a car, for example – but it is an effective, cheap solution that could be available world-wide to some of our most polluting industries and have a significant impact on the reduction of atmospheric CO2."

The team have patented the process and are now looking for an investor to take it forward.

More information: "Nickel nanoparticles catalyse reversible hydration of carbon dioxide for mineralisation carbon capture and storage" Gaurav Bhaduri and Lidija Šiller. Catalysis Science & Technology, Royal Society of Chemistry. February 2013. DOI: 10.1039/c3cy20791a

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