

Splitting water to create renewable energy simpler than first thought?

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(PhysOrg.com) -- An international team, of scientists, led by a team at Monash University has found the key to the hydrogen economy could come from a very simple mineral, commonly seen as a black stain on rocks.

Their findings, developed with the assistance of researchers at UC Davis in the USA and using the facilities at the Australian Synchrotron, was published in the journal *Nature Chemistry* yesterday 15 May 2011.

Professor Leone Spiccia from the School of Chemistry at Monash University said the ultimate goal of researchers in this area is to create a cheap, efficient way to split [water](#), powered by sunlight, which would open up production of hydrogen as a clean fuel, and leading to long-term

solutions for our renewable [energy crisis](#).

To achieve this, they have been studying complex catalysts designed to mimic the catalysts plants use to split water with sunlight. But the new study shows that there might be much simpler alternatives to hand.

"The hardest part about turning water into fuel is splitting water into hydrogen and oxygen, but the team at Monash seems to have uncovered the process, developing a water-splitting cell based on a manganese-based [catalyst](#)," Professor Spiccia said.

"Birnessite, it turns out, is what does the work. Like other elements in the middle of the Periodic Table, manganese can exist in a number of what chemists call oxidation states. These correspond to the number of oxygen atoms with which a metal atom could be combined," Professor Spiccia said.

"When an electrical voltage is applied to the cell, it splits water into hydrogen and oxygen and when the researchers carefully examined the catalyst as it was working, using advanced spectroscopic methods they found that it had decomposed into a much simpler material called birnessite, well-known to geologists as a black stain on many rocks."

The manganese in the catalyst cycles between two oxidation states. First, the voltage is applied to oxidize from the manganese-II state to manganese-IV state in birnessite. Then in [sunlight](#), birnessite goes back to the manganese-II State.

This cycling process is responsible for the oxidation of water to produce oxygen gas, protons and electrons.

Co-author on the research paper was Dr Rosalie Hocking, Research Fellow in the Australian Centre for Electromaterials Science who

explained that what was interesting was the operation of the catalyst, which follows closely nature's biogeochemical cycling of manganese in the oceans.

"This may provide important insights into the evolution of Nature's water splitting catalyst found in all plants which uses manganese centres," Dr Hocking said.

"Scientists have put huge efforts into making very complicated manganese molecules to copy plants, but it turns out that they convert to a very common material found in the Earth, a material sufficiently robust to survive tough use."

The reaction has two steps. First, two molecules of water are oxidized to form one molecule of oxygen gas (O_2), four positively-charged hydrogen nuclei (protons) and four electrons. Second, the protons and electrons combine to form two molecules of hydrogen gas (H_2).

The experimental work was conducted using state-of-the-art equipment at three major facilities including the Australian Synchrotron, the Australian National Beam-line Facility in Japan and the Monash Centre for Electron Microscopy, and involved collaboration with Professor Bill Casey, a geochemist at UC Davis.

"The research highlights the insight obtainable from the synchrotron based spectroscopic techniques – without them the important discovery linking common earth materials to water oxidation catalysts would not have been made," Dr Hocking said.

It is hoped the research will ultimately lead to the development of cheaper devices, which produce [hydrogen](#).

Provided by Monash University

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