New chemical sponge has potential to lessen the carbon footprint of oil industry

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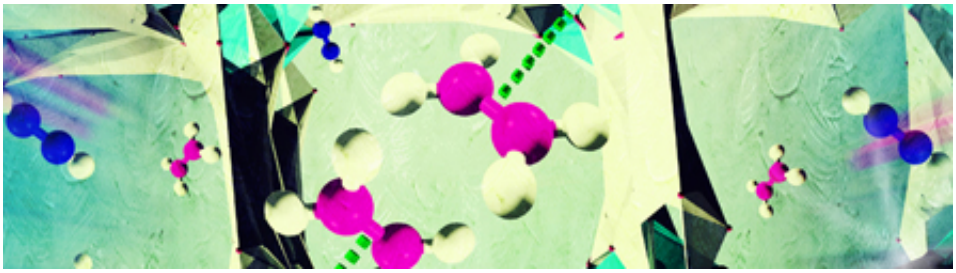

UK scientists have discovered a ground-breaking technique with the potential to dramatically reduce the amount of energy used in the refinement of crude oil.

Professor Martin Schröder and Dr Sihai Yang from The University of Nottingham have led a multi-disciplinary team of scientists from Nottingham, the Science and Technology Facilities Council's (STFC) ISIS Neutron Facility, Oak Ridge National Laboratory, and Diamond Light Source, to discover a porous material that works like a chemical sponge to separate a number of important gases from mixtures generated during crude oil refinement.

The existing industrial process uses huge amounts of energy to separate and purify these gases, so the new technique has the potential to revolutionise the oil industry by significantly reducing carbon emissions

and making the process more environmentally friendly.

Commercially useful

Crude oil is a raw material that is refined to produce fuel for cars, to heat homes, and to create polymers and other useful materials. It is made up of a complex mixture of hydrocarbons (chemical compounds that contain only hydrogen and carbon), of which certain components are especially commercially useful.

One industrial process used to achieve hydrocarbon separation is called "cryogenic distillation". It is operated at enormous scales worldwide and uses vast amounts of energy to generate the high pressures and cryogenic temperatures required to ensure efficient separation of hydrocarbon mixtures into pure components.

However, an innovative solution may have come in the form of a novel chemical sponge. This porous material, a metal-organic framework, was developed by the same team at Nottingham just two years ago. Now, in research published in *Nature Chemistry*, for the first time, scientists have proved that it can be used to separate hydrocarbon mixtures without the need for high pressures or very low temperatures.

Reusable materials

Made from cheap organic materials, aluminium nitrate salt and water, the porous material, called NOTT-300, is able to adsorb different gases found in mixtures of hydrocarbons at different rates, making it possible to separate them and extract the most useful ones. NOTT-300 requires less energy to function than existing methods, as it operates at ambient temperatures and normal pressures. The gases that are adsorbed into NOTT-300 can be removed without a significant energy input and

therefore the material can be easily reused.

The team of scientists from Nottingham used Diamond, the UK's synchrotron science facility, as well as STFC's ISIS Neutron Facility and Oak Ridge National Laboratory, the UK's and USA's world-leading neutron facilities respectively, to prove that the sponge works under real life conditions.

Professor Martin Schröder, Dean of the Faculty of Science at Nottingham says: "It is a very important to be able to separate different hydrocarbons effectively and efficiently with low energy consumption. Porous solids, such as the metal-organic framework system studied here, represent important materials for the future development of low energy separation technologies. We are most grateful to our collaborators at ISIS Neutron Facility, Oak Ridge National Laboratory, and Diamond Light Source in bringing this work to fruition."

Significant impact on oil industry

Dr A.J. Ramirez-Cuesta, senior scientist and group leader of chemical neutron spectroscopy at ORNL, said: "Access to the high-performance Titan supercomputer at ORNL proved essential to perform the electronic structure and dynamics calculations that, together with neutron scattering allowed the elucidation of the mechanism of interaction between molecules and NOTT-300."

Dr Sihai Yang, the winner of Diamond Young Scientist and BTM Willis Prize, is a Senior Research Fellow at Nottingham. He led the project together with Professor Martin Schröder. Dr Yang says: "With the help of advanced central facilities like Diamond, ISIS, and ORNL, we have developed a new separation technique which can potentially reduce the energy usage associated with oil, petroleum, and chemical industries which require the separation of raw hydrocarbons from crude oil.

"The next step is to launch in-depth collaborations with materials engineers and R&D from industries. The current research shows promise in that direction and we're confident that this exciting work will attract new collaborators."

The discovery of the exciting new material, NOTT-300 could have a significant impact on the oil industry by removing the necessity for some energy-intensive refinement processes.

More information: Selectivity and direct visualization of carbon dioxide and sulfur dioxide in a decorated porous host, *Nature Chemistry* 4, 887–894 (2012) DOI: 10.1038/nchem.1457

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