Turning CO2 into fuel

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With new fossil fuel power stations being built every week, and the idea of burying CO_2 [carbon sequestration] regarded by many scientists as unproven or even unworkable, coming up with an alternative solution to what to do with CO_2 is more pressing than ever.

What chemists dream about is turning CO_2 from a dangerous greenhouse gas into a useful fuel. But to make this dream a reality will take more than clever chemistry.

That's why a team at Oxford University is bringing together expertise in chemistry, materials science, engineering and the social sciences to tackle one of the grand challenges of the 21st Century.

Peter Edwards of Oxford University's Department of Chemistry, one of the leaders of this team, starts by telling me about the simplest recipe for turning CO2 into fuel: just add hydrogen, then inject some energy from sunlight and you can produce methanol - a versatile feedstock that can be made into all kinds of fuels.

It's a nice idea, but there's a big problem. 'Where do you get the hydrogen from?' Peter asks. In fact, he explains, 98 per cent of the world's hydrogen comes from another fossil fuel, methane: and not only is this a finite resource but turning methane into hydrogen takes additional energy and emits more CO2.

'Back in the 1990s chemists had a thought: what if we could bypass hydrogen and make methane and CO2 react to produce methanol,' he tells me, an idea given a further green boost by the growing resources of sustainable biomethane, especially in India and China.

The new recipe would see this biomethane added to the CO2 that otherwise would be sent up the power station chimney and would harness the existing heat of this CO2-rich 'flue gas' to help make the reaction more energy-efficient.

'It's all about the energy balance,' Peter says, 'if we can use natural gas or biomethane in this process rather than just burning it we're winning in terms of the energy we get out and the emissions we eliminate.' Now we're cooking!

Yet while this sort of chemical recipe was already shown in the 90s to work with a 'pure' gas, the sort of emissions that come from a fossil fuel power station are typically full of impurities.

'Real flue gas is made up of nitrogen oxide (NOx), nitrogen, and oxygen as well as CO2,' Peter tells me. Up until now dealing with this sort of realistically 'dirty' chemical cocktail of gases has been an almost impossible hurdle - especially as scrubbing out the impurities would use up more energy and generate more CO2 emissions.

And if that wasn't bad enough NOx is a poisonous pollutant that it takes a lot of effort to remove.

Yet the Oxford team - Peter, Tiancun Xiao and Zheng Jiang (the first-ever John Houghton Fellow at Oxford) and colleagues - believe the key to making their CO2-into-fuel dreams a reality lies in new catalyst technology and a different way of thinking.

Instead of getting rid of the NOx the team believe they can use it as a catalyst to help power the reaction. They also cite the fact that the latest technology makes it possible to work with the sort of 'dirty' nitrogen-rich gas mix produced in a power station.

To be able to turn the CO2 in this mixed gas and methane into methanol in a power station without an accumulation of carbon causing everything to grind to a halt will take a new generation of nanoscale-structured magnetic catalysts.

Because such catalysts, based on metallic compounds like cobalt oxide, are magnetic they can be moved around by strong magnetic fields, agitating or 'stirring' them to ensure that the reaction is more efficient and doesn't snuff itself out. It's a novel approach that will require new research in materials science, chemistry and physics to work.

In the end though, even overcoming these challenges will come to nothing if the new approach isn't economically viable and environmentally beneficial.

'There are a lot of broader questions we need answers to: such as, how much natural gas or biomethane is there in the world? And can our solution have a real impact on overall carbon emissions?' Peter tells me.

But, the team feel, this is where Oxford has an advantage calling on the expertise of the Department of Engineering Science, Begbroke Science Park, the Smith School of Enterprise and the Environment, and RAL, as well as partners in the UK and China.

The Oxford team believe that by working on the whole challenge - not just the scientific or technological aspects - they can help to crack one of the world's biggest and most intractable problems: how to make the CO2 we produce work for us and the planet.

Provided by Oxford University