BP
Future Perspectives
Unlocking the Gas Economy

Commentary

Our society has a huge demand for fuels and products derived from petrochemicals, and increasingly for ones that are cleaner and cheaper. Several alternatives to oil are being developed, but in the shorter term none is as attractive as methane or natural gas.

And methane would be even more attractive if it could be easily converted into a liquid. It would not only be readily transportable - large volumes of natural gas are often found in remote areas – but convertible into other products such as fuels and chemicals. It would then form the basis of a new gas economy.

Title: Future Perspectives – Unlocking the Gas Economy

Many of the current processes for turning gas into liquids, like the one used at BP's Nikiski plant in Alaska, are based on what is known as the Fischer-Tropsch process. In this process, methane and steam are turned into syngas.

The syngas is then converted to paraffins, which are treated with hydrogen and upgraded to diesel and other fuels. These are cleaner than the more conventional hydrocarbon fuels, produce less greenhouse gases and can also be easily transported.

But as effective as Fischer-Tropsch is, it hasn't yet unlocked the gas economy. It is a complex multi-stage process that consumes large amounts of energy. Hence the establishment of the Methane Conversion Co-operative, or MC Squared.

Sponsored by BP and based at the California Institute of Technology and the University of California Berkeley, MC Squared is a science research partnership that is setting out to revolutionise the conversion of methane gas to liquids, and go beyond Fischer-Tropsch to produce methanol in one step...

Professor Harry Gray: The fundamental work is trying to understand the basic steps. The basic steps when a methane molecule hits a catalyst. The simple reaction of methane to methanol is simply inserting an oxygen atom into a carbon hydrogen bond. It sounds really easy, but believe me it is very, very difficult to do this without oxidising the gas all the way to carbon dioxide, which is what we want to avoid.

Professor Jonas Peters: What we typically are doing in our laboratory, and that's true of other laboratories with the team, is we're making molecules that we would call, quote unquote, catalysts ideally, although they're not always catalytic.

And we're trying to study fundamental issues of the reactivity of methane with the molecules we're making, ideally so that we can learn how to get methane to react with these complexes at low temperature in solution and then to undergo subsequent oxidation.

Bernie Bulkin: There are parts of this programme, substantial parts of this programme, which challenge conventional wisdom and say well, you've always been able to do these reactions only at 800 degrees Celsius or very high temperatures, we think we could do them at 200 degrees, let us try it here.

And for BP, well this is a high risk situation but we think it's a worthwhile, one because the pay-off if it ever was accomplished would be great. Not just for us in terms of proprietary products, but in changing the whole way people think about the chemistry of methane.

Commentary: **Three years into this ten year project, the experimentation work at both Caltech and Berkeley is already showing progress in several areas…**

Student 1: I'm working on methane selective oxidation, which is basically trying to take methane, a natural gas,

and convert it into an oxygenated form. Basically just any condensed form which can be taken from remote locations and transported to markets as a useful molecule. So we aim for formaldehyde because formaldehyde is the easiest oxygenated product to make.

Student 2: We're working to try and make a catalyst, and thereby understand the processes that are going on. So one of the fundamental goals of the BP project as I understand it is we want to understand how for example alkane oxidation occurs using a metal complex. And once we understand those basic guiding principles, we're going to be much more effective in making catalysts to do specifically what we want.

Student 3: The fundamentally difficult part, and interesting part, is the CH bond breaking step which happens at the metal centre. And that's the step that gives rise to the selectivity for methane versus methanol. So understanding the mechanism of that step, the thermodynamics of that step, and having a very clear descriptive picture is where our interests lie.

Student 4: We're definitely making breakthroughs, particularly in breaking down what has been in the literature and trying to break down the fundamentals of the activation of methanol over copper catalysts, which hasn't been done. It's been done more generally, but we're trying to piece it all together and put together a full story.

Professor Enrique Inglesias: This programme has been around for three years. The programme has already resulted in what I think are remarkable accomplishments. The work has also turned out some very good people that now know a lot more about methane conversion than they did when they came to Berkeley. And these are people that ultimately for both mankind, Berkeley and BP will be very useful. And they're certainly a significant contribution in my view.

Professor Harry Gray: You shoot for the moon in fundamental work. You really go for really big-time stuff. You make little incremental progress. But there comes a time, and you don't know when that time is, but there comes a time when you make a big breakthrough. And that's why fundamental work is so important, because you never know when that's going to be. But it's sure as shooting it's going to be there some time.

Bernie Bulkin: We have some of the greatest chemists in the world working for us here at Caltech and Berkeley, and I think we have the possibility of cracking what is really going on in these processes and then allowing us to step out beyond the incremental advances that people have been making for the last 40 years into really new processes, really new chemicals.

Professor Jonas Peters: What's actually been surprising and wonderful at the same time is that not only was BP excited to let us do what we want, we find the scientists at BP are interested in the same kinds of fundamental issues that we're interested in. So it's a relationship that works.

Professor Harry Gray: You can talk about the human genome project , you can talk about all the stuff that's in the news of how we're going to revolutionise biology. You can talk about nano science and nano machines. You can talk about all this gee-whiz stuff. But there's one thing that's for sure. If we do not solve the energy problem, our planet will not survive this century. This is a must-do project.

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