Technology offers path to 'clean, safe' chemical production

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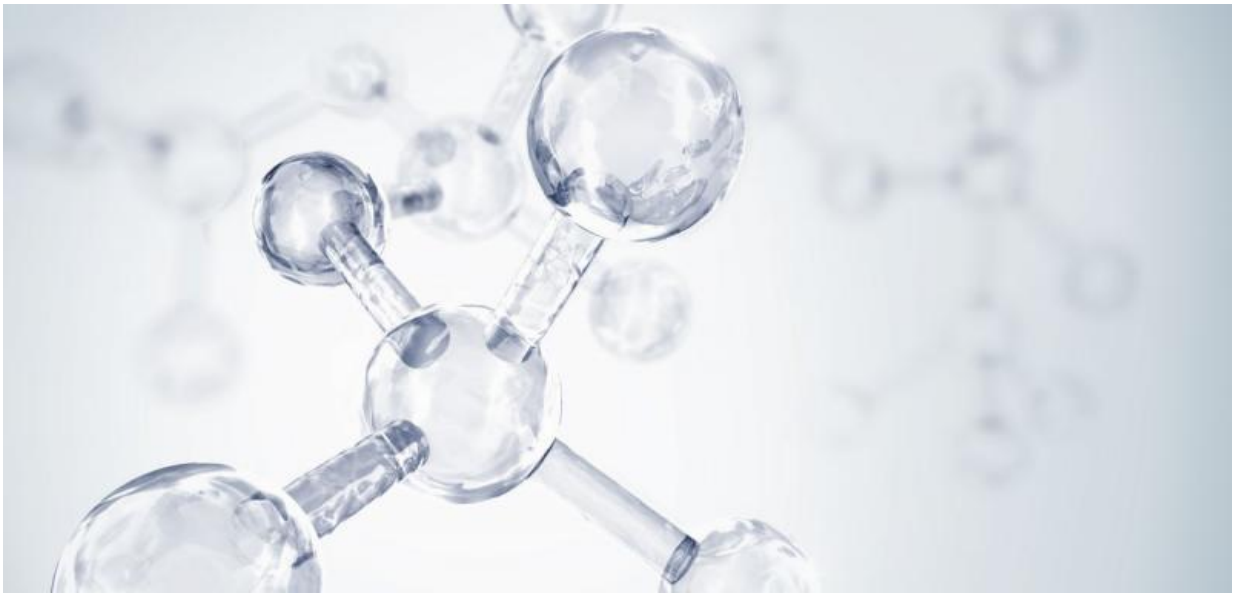

From fragrances and food flavourings to the building blocks of pharmaceutical drugs, fine chemicals – complex chemicals produced in small quantities to a high degree of purity – play a major role in our daily lives.

But producing these chemicals can come at a cost, both in monetary terms and the large amount of waste generated.

A new technology called HydRegen is being developed by Professor Kylie Vincent and her team in the Department of Chemistry at the University of Oxford that promises to make the production of fine chemicals 'cheaper, faster, safer and cleaner'.

The project was recently awarded an Innovate UK/EPSRC grant worth £2.9 million and was the overall winner of the Royal Society of Chemistry's Emerging Technology competition in 2013.

Dr Holly Reeve, co-investigator and manager of the HydRegen project – which takes its name from the use of hydrogen to regenerate a key molecule involved in the process – told Science Blog about this award-winning technology.

In a nutshell, what is HydRegen?

'The HydRegen technology has the potential to make the production of fine chemicals such as pharmaceuticals, flavours and fragrances cheaper, faster, cleaner and safer. Chemists increasingly turn to nature to find clever ways of making complex chemicals using enzymes isolated from the cells of bacteria and other organisms. The HydRegen technology offers a completely new way of harnessing the incredible selectivity of these enzymes and will allow enzyme pathways to be implemented into existing chemical synthesis strategies much more easily.'

What are some of the problems with manufacturing fine chemicals at present?

'Many of the traditional methods for making fine chemicals suffer from a lack of selectivity and generate large quantities of waste. These problems mean that expensive purification strategies are usually required to obtain the desired chemical with the level of purity required by the

fine chemicals industries.

'One method for increasing the selectivity and decreasing the waste associated with a chemical processes is using a catalyst which not only speeds up a reaction but, if designed correctly, allows generation of only the desired product. In industry, metal catalysts are often used; however, these metals tend to be very expensive, highly toxic and are in finite supply. Tuning the selectivity of these metal catalysts is still a considerable challenge for this area of research.

'Fine chemicals companies are starting to rely on biological catalysts (enzymes), which can be extracted from cells grown in the laboratory and which catalyse reactions with near-perfect selectivity. Enzymes catalyse these reactions under mild, and therefore less energy intensive, conditions.

'However, complicated strategies are required to allow enzymes to function outside of cells because they often require an additional biological "helper" molecule to be able to work. At present, carbon-intensive methods are required to sustain enzyme catalysis by recycling the expensive helper molecule.'

How does the HydRegen technology aim to solve these problems?

'HydRegen uses hydrogen gas to regenerate the helper molecule required for biocatalysis. The technology allows enzymes to be handled in a similar way to the metal catalysts which are currently used for hydrogen addition reactions (hydrogenations). The overall reactions are 100% atom efficient, meaning that there is almost no waste produced.

'We can carry out these reactions in pure water and therefore avoid using

harsh solvents. We also use the enzymes immobilised on carbon supports, which means they can be easily removed from solution and re-used, both increasing product purity and decreasing costs associated with enzyme production.'

What types of chemicals are you focusing on?

'We are focusing developments of the HydRegen technology towards the fine chemicals industries (pharmaceuticals, flavours and fragrances) as these industries benefit most from an increase in selectivity and highly pure products.

'In particular, the HydRegen technology facilitates the addition of dihydrogen to a molecule to generate a "reduced" product. These kinds of reactions are essential to the production of the active ingredients in pharmaceuticals. We have also demonstrated other reaction classes of interest to the flavour and fragrance industries.

'Overall, this technology will play a part in making the fine chemicals industry more environmentally and economically sustainable.'

What are the next steps for HydRegen?

'The technology has been demonstrated for a range of key reaction steps, but only on a very small scale (