Cyclohexane for cars

It sounds like the ideal environmental compromise: a power source that 'burns' hydrocarbons without emitting carbon dioxide. The latest high performance fuel cell to come out of Japan's Hokkaido University Catalyst Research Centre in Sapporo, may offer precisely that.

The Hokkaido fuel cell uses cyclohexane as a hydrogen source and, the researchers claim, works even more efficiently than the best methanol-based fuel cells which are currently being considered for transport applications.

Fuel cells generate power by performing the electrochemical equivalent of burning H_2 and O_2 (the opposite of the electrolysis of water). The problem with this as a clean alternative to simply burning hydrocarbons is where to get the H_2 from.

Water would be the ideal solution, but it is expensive and would sideline the huge petrochemical infrastructure we currently depend on.

Hydrocarbons are also an excellent source of hydrogen via reformation – except that this increases the size and weight of the fuel cell and involves a modicum of CO_2 emissions. This problem has recently been overcome by using direct proton exchange membrane fuel cells (D-PEMFCs) which electrochemically 'burn' methanol directly, without prior reformation into H_2, and hence produce no CO_2 emissions.

Although high performing and feasible for transport applications, methanol-based D-PEMFCs still have problems: their Pt-based anodes have low electrocatalytic activity and are easily poisoned by the CO produced as a byproduct. In addition, the methanol electrolyte can permeate across the cell to the cathode, reducing its efficiency.

The new Japanese D-PEMFC overcomes these problems by using the dehydrogenation of cyclohexane. This produces benzene as a byproduct that is later hydrogenated back to cyclohexane during recharging, via the electrolysis of water.

Working with an open circuit voltage of 920 mV and a maximum power density of 14–15 mW cm^{-2}, the new fuel cell produces zero CO_2 emissions, while being compatible with the existing petrochemical infrastructure (*Chem. Commun.*, 2003, 690) *Lionel Milgrom*

Understanding how the chemical garden grows

Scatter a few crystals of copper sulphate into a sodium silicate solution and you will get a chaotic, tree-like growth of knobbly tubes made of precipitated copper silicates. This experiment, widely known as a 'chemical garden', has been a favourite in educational demonstrations and children's chemistry kits for many decades.

However, many details of the growth process have remained elusive. Until now, that is.

Oliver Steinbock and his team at Florida State University (Tallahassee) in the US have created a scientifically controlled version of the experiment and worked out the laws of the tube growth (*J. Am. Chem. Soc.*, 2003, 125, 4338).

Instead of letting crystals dispense a column of saturated copper sulphate solution, the researchers introduced a glass capillary in the bottom of their container. This enabled them to inject the salt solution under precisely controlled flow conditions.

They found that the characteristics of the tube growth are mainly determined by the concentration of the copper salt.

At low concentration, very thin, smooth tubes grow steadily. In the middle range (0.1–0.35 M), bubbles of the salt solution wrapped in a thin colloidal membrane detach from the tip of the growing tube and rise to the surface. At higher concentrations, the bubbles burst, nucleating new bubbles, which leads to very irregular growth patterns.

Studying the physics of the oscillatory reaction in the intermediate concentration range, the researchers discovered dynamics very similar to those of a dripping tap. With the low concentration laminar growth, they found that the process can be directed so that the tube grows to connect an entry to an exit hole.

Steinbock and his team believe that a greater understanding of tube growth will enable scientists to create microcapillaries for a range of applications, including lab-on-a-chip devices.

Michael Gross