Metal hydrides hold the key to green energy

Hydrogen could be an ideal ecological fuel once researchers have found the right material in which to store it

>> KLAUS YVON

Cutting grass with Professor Yvon's own hydrogen-powered lawnmower is child's play

For several decades, people have been exploring alternative fuels to petroleum that could be used to provide power. Hydrogen is one possibility. It is environmentally friendly, burning in an internal combustion engine to produce only water. It is also possible to extract hydrogen from water (H_2O) with electricity made, say, with solar energy.

Hydrogen has one big snag, however. As a gas, it takes up a large volume and is very explosive, so is difficult to store and handle. Fortunately, there are a range of metal alloys (based on copper, manganese and titanium, for example) that can soak up huge amounts of hydrogen gas, which is then released on gentle heating. They provide a safe, effective way of storing and transporting hydrogen.

The hydrogen-storage materials tested so far are expensive and rather heavy, so our research team in Geneva is investigating alternatives which are lighter and can absorb even more hydrogen. These are the so-called complex metal hydrides which may contain up to four times as much hydrogen as the conventional hydrogen-absorbing alloys. In fact, two of our compounds, the barium-rhenium and magnesium-iron complexes shown below, hold the world record for hydrogen absorption. However, the complex hydrides studied so far have disadvantages too. They do not release their hydrogen easily but require heating to 300°C, which is commercially uneconomic; the barium-rhenium compound does release its hydrogen at just above room temperature but is too heavy and expensive.

We haven't yet found the ideal storage material, but neutron experiments play an important part in our search by helping us to characterise the compounds we make and predict more effective ones.

High resolution at ILL

Neutron diffraction is ideal for investigating the crystal structures of metal compounds containing light elements like hydrogen which scatter neutrons strongly but are almost invisible to X-rays. Nevertheless, our polycrystalline complex hydrides, which are analysed using ILL's powder diffraction instruments (see p.4), present a formidable challenge. The smallest repeating unit of each crystal (unit cell) contains many atoms, resulting in very crowded, overlapping diffraction patterns. The ILL neutron source is the only facility in the world that provides an intense-enough neutron beam to resolve these patterns and pinpoint the location of the atoms.

On the practical side, several car companies have been experimenting with hydrogen-fuelled vehicles employing metal hydrides. In Switzerland, we have been demonstrating the technology at home! I have been using a hydrogen-powered lawnmower for 10 years, and an architect, Markus Friedli, has equipped his house in central Switzerland with solar panels to generate the electricity for recovering hydrogen from water. This is then used to power the family van.

So far, none of the applications of hydrogen gas storage materials has been commercialised. This is partly because we are still searching for that 'miracle material'. However, we have barely started to look at all possible combinations of elements, and neutron experiments will continue to make a significant contribution. ■

The neutron diffraction patterns and structures for (A) magnesium iron hydride (Mg_2FeH_6) and (B) barium rhenium hydride ($BaReH_9$). Note that the magnesium-iron compound contains twice the density of hydrogen atoms (150 grams per litre) compared with that in liquid hydrogen (70 grams per litre). The barium-rhenium compound contains 4.5 hydrogen atoms per metal atom, which is greater than the ratio of hydrogen to carbon in natural gas, methane (CH_4)