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Guest columnist

Harnessing hydrogen: The need for further research

Hydrogen is the most abundantly found chemical element in the universe. It is found both all around us and in us—hydrogen accounts for roughly 62% of the atoms in a human body.[1]

Though hydrogen is so abundant, it generally does not appear by itself in nature. Instead, it appears within compounds. For example, hydrogen is so plentiful in the human body because of its existence within water molecules.

Currently, hydrogen is mainly used as a fuel source in the form of hydrocarbons (fossil fuels). When combusted, these compounds of hydrogen and carbon release toxic greenhouse gases into our atmosphere.

If pure hydrogen is used as a fuel, carbon-based greenhouse gases are not formed during combustion. Instead, the only byproduct is water, thus making it a much cleaner source of fuel.

While use of hydrogen fuel is making headway, it is far from simple to obtain. Sourcing hydrogen from coal or other fossil fuels using current technologies often produces more carbon emissions than simply using that fuel for energy directly. Sourcing hydrogen from water through electrolysis is a better option, but only if the process is powered through renewable energy sources.[2]

Once hydrogen is produced, storing and transporting it is another challenge. Hydrogen is usually stored as a liquid because this form has a higher density—and therefore more energy per kilogram—than the compressed gas form. However, liquid hydrogen still takes up a significant amount of space due to hydrogen's low volumetric energy density.* Additionally, cooling hydrogen to its liquid state is challenging because it must reach −252.9°C (−423.2°F). Current cooling and storage solutions are far from perfect, often requiring large amounts of energy for liquefaction and then double-walled vacuum jacketed containers resistant to diffusion for storage.

Many research groups are investigating new designs and materials for storage containers to overcome these challenges. For example, a hydrogen and cryogenics research lab at Washington State University is working on a thin polymer collapsible hydrogen storage bladder that uses origami geometry for aerospace applications (Figure 1).[3] This tool mitigates many of the problems with vacuum jacketed containers, but it is still in the laboratory testing stage. This same lab also developed novel liquid hydrogen containment tanks that are 3D printable.[4]

Finally, actually using hydrogen fuel once it is sourced, transported, and stored faces material challenges. Hydrogen fuel is typically used in two ways: in fuel cells (for vehicles) and in combustion reactions (for industry processes). Work is being done to improve fuel cell safety and efficiency through use of ceramic materials in the anodes, cathodes, and/or electrolytes.[5] As for hydrogen combustion, hydrogen burns hotter and more rapidly than traditional fossil fuels, necessitating the development of new refractory materials within the furnace.[6]

Put simply, research on the production, transport, storage, and use of hydrogen fuel is growing, but it still faces many challenges. As the world transitions toward more renewable and clean energy options, this technology will be crucial for meeting emission targets.

Hydrogen is crucial to life as we know it. It is only fitting that harnessing it is essential to the continuation of this life.

Credit: Bob Hubner, Washington State University

Figure 1. A collapsible hydrogen storage bladder in liquid nitrogen demonstrates its ability to repeatedly bend and fold in cryogenic conditions.

References

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*Hydrogen's low volumetric density is counterbalanced by the fact that hydrogen has a significantly higher specific energy, i.e., energy that can be obtained per unit mass, than any other currently known energy storage options.