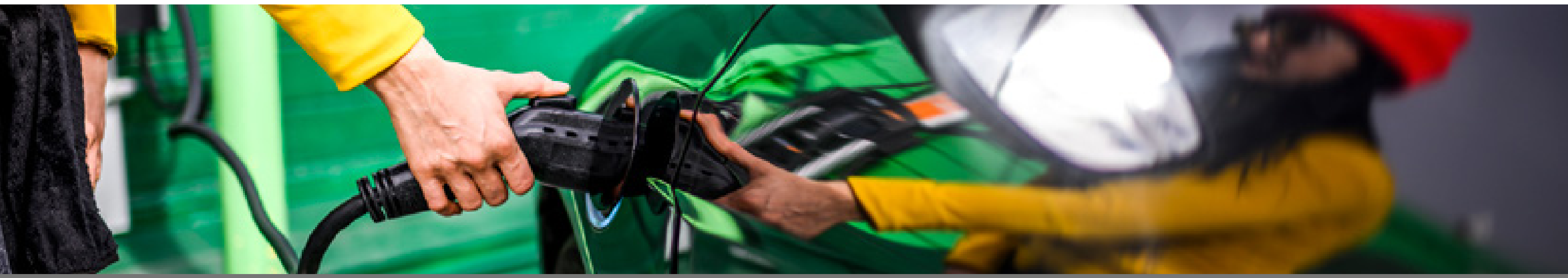
HENRY ROYCE INSTITUTE

ADVANCED MATERIALS RESEARCH & INNOVATION

MATERIALS CHALLENGES TO ENABLE HYDROGEN DEPLOYMENT AT SCALE BY 2050

Challenge: Materials led solutions for cost effective, conformable hydrogen tank storage in fuel cell vehicles.



CONTEXT

The main options available for decarbonising the transport sector include the use of direct electrification with battery electric drivetrains, biofuels (likely to be relatively limited due to resource constraints and demands for biofuels in other sectors), and the use of renewable hydrogen and hydrogen-derived synthetic fuels. Each option has pros and cons, with some better suited to certain applications and duty cycles than others. There is a strong focus on direct electrification of transport as the primary means of achieving emissions reduction in the short term. Based on current technology, battery electric solutions cannot provide a like-for-like replacement for all transport modes. It is accepted that a portfolio of technologies is likely to be required to achieve full decarbonisation of the transport sector, including hydrogen fuel cell options for heavy duty or long range transport.

Hydrogen-powered vehicles currently use gaseous hydrogen stored at 350 or 700 bar pressure in cylindrical vessels. Hydrogen storage tanks are the most expensive component in current hydrogen fuel cell cars and add significant weight. Cylindrical shapes are used to achieve a more uniform distribution of forces, allowing the storage of high-pressure gas while minimising the risk of cracks and failures. The low packing efficiency of this shape creates challenges to achieve the required hydrogen storage in a limited space. Materials led solutions offering more conventional fuel tank shapes would allow optimal use of on-board space and greater flexibility in vehicle design.

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MATERIALS RESEARCH CHALLENGE

Current hydrogen vehicles use either type III tanks, which are made from a metal liner wrapped by a composite material to provide strength, or type IV tanks, made from a plastic liner with a composite wrap. Alternative materials such as new polymers or resins, as well as different approaches to manufacturing, could reduce the cost of gaseous storage tanks. In particular large scale manufacture of gaseous hydrogen storage tanks will reduce cost further through economies of scale from streamlining and automation of manufacturing, reducing the cost of materials and components through large-scale procurement, and other efficiencies. The life cycle of the storage tanks also needs to be considered.

Research on hydrogen tank materials needs to be aligned with manufacturing of the overall storage system, to ensure that fittings are compatible with hydrogen and the new tank materials developed. Beyond type IV tanks, the mass and cost of storage tanks may be improved by removing the liner, use of resins, reinforcements, additive technologies, and filament winding and braiding technologies.

Further work will be required to support the development of materials for low-cost, conformable hydrogen tanks; in particular the development of UK testing capability, a standardised approach to lifecycle analysis, standardised testing and inspection protocols, and end-of-life treatment.

UK CREDENTIALS AND WAY FORWARD

The UK has significant expertise in composites through institutions such as Imperial College and the National Composite Centre, which could be exploited to develop lower cost conformable composite tanks.

A cross industry/academic group is currently developing a more detailed proposal outlining the research challenges, resources and capabilities required to achieve a breakthrough in this area to enable widescale hydrogen deployment by 2050. This proposal will be available by the end of July for consideration for inclusion in the November spending review.

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