Strategic Science Investment Fund (SSIF) Case Study 2019-20
Platform 3 – Isotope & Nuclear Sciences

Unlocking the potential of green hydrogen

MBIE SSIF funding is contributing to GNS's research focus on the development and application of new materials that enable New Zealand to meet its future energy needs. By identifying and developing new materials, our research aims are enabling technologies to increase the use of renewable energy and drive greater energy usage efficiency. This will result in new processes and products that will increase industry revenue, consolidate/improve export of New Zealand products, and open new markets for export. For example, this year we have demonstrated the potential of our unique surface modification technologies to improve the energy efficiency of heat exchangers. With a doubling of the heat transfer coefficient of a plate heat exchanger in the lab, these surfaces can significantly reduce energy consumption of appliances such as refrigerators and heat pumps. This saving was estimated at ~10% of the energy usage for the best-selling Fisher & Paykel Appliances fridge which equates to a potential ½ to 1 energy star rating. These promising results were obtained in partnership with the New Zealand Product Accelerator and the University of Auckland.

As Aotearoa New Zealand looks for new fuels and technologies to enable the transition to a low-emission energy system, hydrogen is fast emerging as one of the potential solutions. Our Materials Team is playing a key role in this transition by applying its world-leading capabilities to help make hydrogen production a more efficient and less expensive process – for instance, applying the synergistic use of physical and chemical techniques to modify the surface properties of materials to develop novel technologies and materials (graphitic carbon nitride) for energy storage.

When produced from renewably-generated electricity, hydrogen becomes a zero-emission energy carrier known as green hydrogen. Green hydrogen can improve the resilience of a renewable energy dominant energy system as it can be produced and stored when there is excess renewably-generated electricity - the excess electricity is used to split water into its component elements of hydrogen and oxygen, which is then used to produce electricity during peak demand.

With many countries hungry for low-emission energy solutions, green hydrogen is a compelling option. It can be used to power our heavy vehicle fleet, or as an export commodity. As well as its potential as a fuel, it would also help to create new industries and jobs.

However, there are a number of daunting technological and economic barriers that work against the large-scale uptake of green hydrogen. One of these issues that the team is focusing on is the catalytic material used to split water efficiently: current catalyst materials use precious metal, such as platinum, that are scarce, expensive and difficult to deposit onto the ion exchange membranes required to separate hydrogen from oxygen.

Along with our research collaborators in New Zealand and internationally, including Boston University in the USA, the University of Würzburg in Germany, and the University of Newcastle in Australia, GNS Science is working on a lower-cost alternative to platinum using ruthenium iridium oxide, tungsten carbide, and Bismuth Vanadate ($BiVO_4$). The aim is to develop new materials that can replace platinum. This world-leading approach represents radical technological changes.

Developing processes and methods for new, high-performing, materials is not enough however, as we need to also ensure that these methods can be used at large scale. Based on designs developed in this research project, we are currently building a prototype that will apply catalytic materials, such

as those developed in our research, onto membranes in a single step at large scales (square meters, as opposed to lab prepared square centimeters).

Current catalysts are attached to powder carriers using chemical means. The resulting composite particles are then “glued” on the membranes. Preparing the catalyst, attaching it to the carrier, stabilising the resulting powder and attaching it to the membrane are all expensive, time-consuming processes. In parallel with our research to find alternatives to precious metals as catalyst materials, we are also working on two approaches to resolve these manufacturing barriers: 1/ cutting down the chemistry involved in fixing the catalyst on its carrier by using our ion beam process; 2/ Removing the carrier altogether and directly depositing the catalyst materials on the membrane.

To support our new research on catalytic materials for hydrogen production, we have commissioned new electrocatalysis materials characterisation equipment as well as installing our first electrolysers performance measurement system. This is helping us in evaluating key performance metric of our materials in relevant application conditions. We are working closely with industry players such as First Gas, Ballance Agri-Nutrients, Hiringa Energy and Gallagher Fuel Systems, who are keen to help shape the way our research evolves to ensure the results are of maximum value to end users.

We want our research initiatives to inform and improve Aotearoa New Zealand's policies and plans for energy and environmental management, resulting in sustainable economic growth from our energy, land and water resources. The changes to energy production are expected to show increased resilience to pressures on the environment from human activity, and new R&D investment in high-value materials that will assist the transition to a low-carbon future is expected as a result of our research. All this will enable us to fulfil our international commitments with regard to greenhouse gas reduction and contribute to worldwide efforts to decarbonise.

Our research in this area is funded by SSIF (approximately 80%) and the KiwiNet Pre-seed Accelerator Fund (approximately 20%).

End-user Commentary

“First Gas believes GNS’ hydrogen objectives align with a key research need for New Zealand as we seek to decarbonise this country’s energy mix. It also addresses some important questions for our company as we consider the options for reducing emissions in our own operations and providing an energy delivery service based on renewable fuels.”

Iwan Bridge
Chief Operating Officer, First Gas Limited, New Plymouth

“As a player in the national hydrogen transformation agenda, Gallagher Fuel Systems is looking forward to actively working with GNS Science to define and refine the areas where GNS’s talent base can most appropriately break the impasses that the state of the art in hydrogen technology presents us. We are turning a corner, for Gallagher Fuel Systems, for the nation, and for the planet.”

Arnim Littek
Technical Advisor, Hydrogen, Gallagher Fuel Systems Limited, Marton