SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Accelerating transformative research to deliver Ireland's energy revolution

USEH2 - Using Surplus Energy to generate Hydrogen

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Abstract
A transition to an energy system based upon non-synchronous renewables relies on the storage of large quantities of this energy to cover wind and solar-droughts, demand-peaks, and also for difficult-to-decarbonise sectors. Storage in the form of Green Hydrogen (H_2) is amongst the most promising solutions. However, there are serious questions over the sustainability, cost and availability of precious metal catalysts for H_2 generation. USEH$_2$ investigated the design and synthesis of more sustainable materials to harvest and store solar energy through direct H_2 production in an artificial photosynthesis process. This work aims to promote the role of H_2 in decarbonisation by providing impetus to the development of practical photosynthetic devices.

Research Outcomes
The photocatalysts developed in this project are multicomponent molecular systems, depicted schematically in Fig. 1. The materials developed at DCU, are composed of a photosensitiser (PS) that harvests solar energy. This leads to electron transfer (charge) through a molecular bridge (B) to the catalytic centre where H_2 is produced. Such smart photocatalysts can be anchored onto transparent semiconductor electrodes resulting in practical water splitting devices.

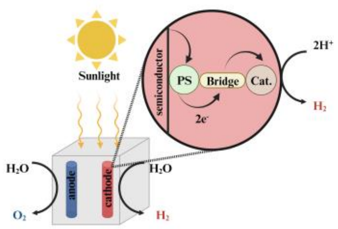

Figure 1: Schematic of photocatalyst and dye sensitised water splitting solar cell.

During the project we: (i) developed new photocatalysts based on organic photosensitisers, therefore moving away from precious metals, (ii) demonstrated the use of inexpensive photosensitising polymers for hydrogen generation, (iii) optimised the anchoring chemistry to permit device integration, and (iv) employed ultrafast spectroscopy techniques to probe the steps (light induced process for e.g., charge transfer) leading to hydrogen (solar fuel) generation. These research outcomes are essential steps in the development of cost-effective and sustainable solar H_2 production technologies.

Recommendations
The government's National Hydrogen Strategy (July 2023) affirms the role of H_2 as part of the future energy landscape. However, policymakers need to be aware of the challenges in producing green H_2 at scale. Through stakeholder engagement we have identified concerns regarding the sustainability of the global electrolyser supply chain both at materials (platinum, iridium, titanium) and systems levels. Significant reductions are required in the production cost of green H_2, with the US targeting a cut of 80% by 2031. These observations point to the need for a continued drive to increase the efficiency of green H_2 production systems, with next generation catalysts offering a route to achieve this. While electrolysis is the most mature technology, it should be noted that renewable electricity accounts for ~60% of the cost of the resulting H_2. By contrast, a photocatalytic H_2 production system, such as that investigated in USEH$_2$, has the potential to eliminate this operating cost, since it is powered by freely available sunlight. It is of further note that advanced molecular catalysts can also be deployed in electrolysers (ongoing research in DCU) and for the conversion of captured CO_2 to commodity chemicals (also demonstrated in USEH$_2$). In summary, the message to policymakers is that while a commitment has been made to hydrogen, it is essential that this is backed-up by continued R&D to ensure the economic viability of this cornerstone of the decarbonised energy future.

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