Sonochemical Hydrogen Production from Seawater: A Sustainable and Cost-effective Approach

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Priority Topic Area: **Clean Energy and Climate Action**

1 – **Objectives**
Green hydrogen offers the potential to achieve net zero by the hydrogen circular economy. However, current green water splitting technology suffers from a range of challenges, including:

1. The use of ultra-pure water and scarce noble-metals
2. Low efficiency
Sonocatalytic water splitting has the potential:
1. Achieve low-cost setup and operating cost;
2. The use of unprocessed seawater

2 – **Methodology**
A highly efficient sonochemical reactor, that cylindrically converges ultrasound waves, is used to create an intense localised region of high acoustic pressure amplitudes. The region is capable of spontaneously nucleate cavitation and generate hydrogen.

To measure the operating power of the reactor, the voltage and current were monitored. For cavitation noise detection to monitor the cavitation activities, a passive cavitation detector (PCD) was positioned underneath the reaction vial. The noise data was recorded for subsequent data processing.

Cheap, off-the-shelf TiO₂, was used as sonocatalyst to reduce the energy barrier of the reaction, further increasing the sonochemical hydrogen production rate.

3 – **Results**

a) Optimisation of the reactor power and the concentration of TiO₂ catalyst. The threshold for acoustic cavitation was 2.5 W. 0.3 mg/mL TiO₂ had the highest cavitation activity, and hence the sonochemical activity.

b) The presence of TiO₂ catalyst was shown to have a higher H₂ production rate. This is due to the introduction of more bubble nucleating sites on the phase boundaries.

c) The H₂ production rate of different water resources. Natural seawater produced H₂ effectively by sonochemistry.

d) DI water has ~2x H₂ production compared to seawater; due to the presence of salt decreased the gas solubility.

e-f) SEM images of TiO₂ catalyst at 20 mins and 180 mins, they emphasised the recyclability of the catalysts.

4 – **Benefit to society**
The versatility of hydrogen fuel could replace fossil fuels in multiple carbon-intensive sectors of our economy. It is vital that we search for the best hydrogen production approach for the imminent green transition. Sonochemistry offers a cheap and sustainable method for direct green hydrogen generation from seawater, that is previously limited by water electrolysis, the standard green hydrogen production technology. We hope the work will foster development in future industrial-scale green hydrogen production research and contribute to the world net-zero transition.

5 – **Next steps**
A techno-economic model (TEA) and life cycle assessment (LCA) would be carried out to compare the economic and environmental impacts of sonochemical hydrogen production with other existing green water splitting approaches, including electrolysis, photolysis, and thermolysis.

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