Sulphur dioxide Depolarized Electrolysis for Hydrogen production: Approaches and applications

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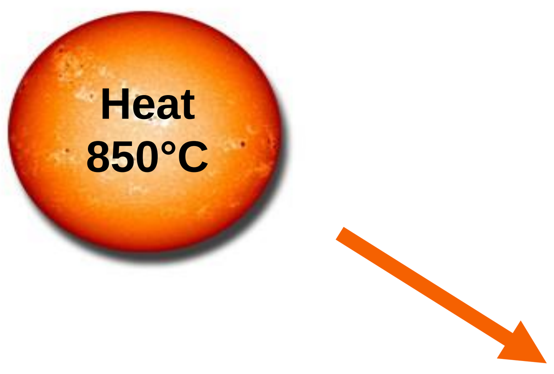
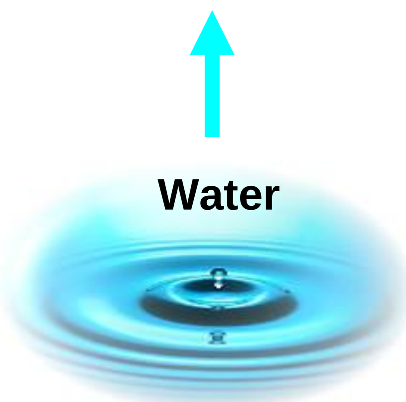
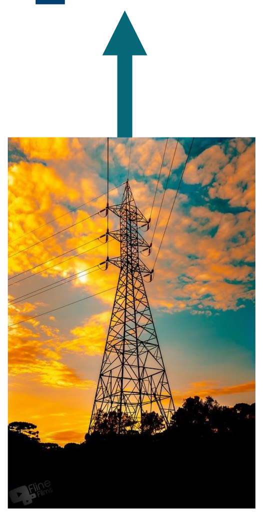


Thermal step: $H_2SO_4 \leftrightarrows \frac{1}{2} O_2 + H_2O + SO_2$

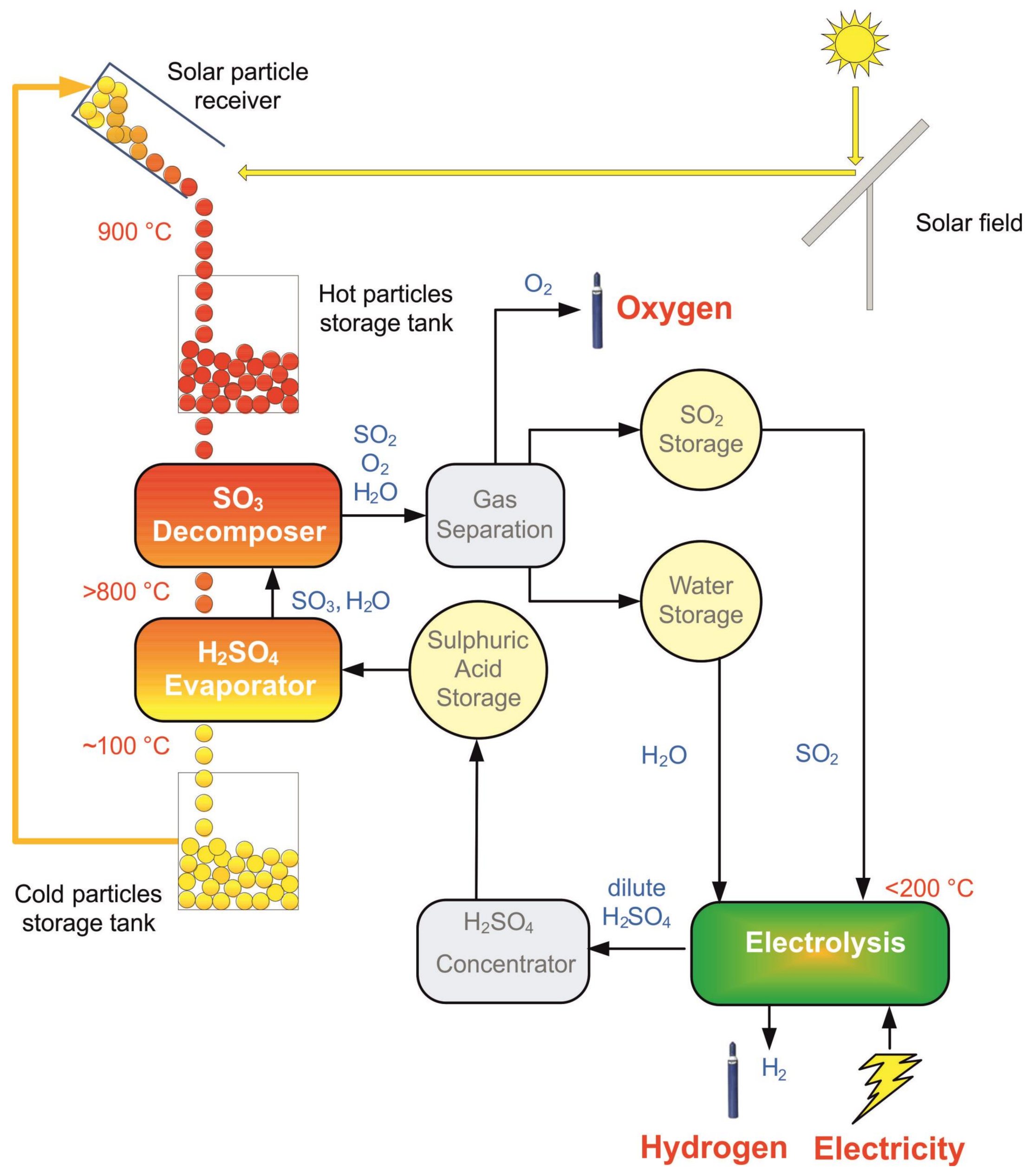
Electrochemical step: $2\ H_2O + SO_2 \leftrightarrows H_2SO_4 + H_2$





Electricity

Solar Hybrid Sulphur Cycle

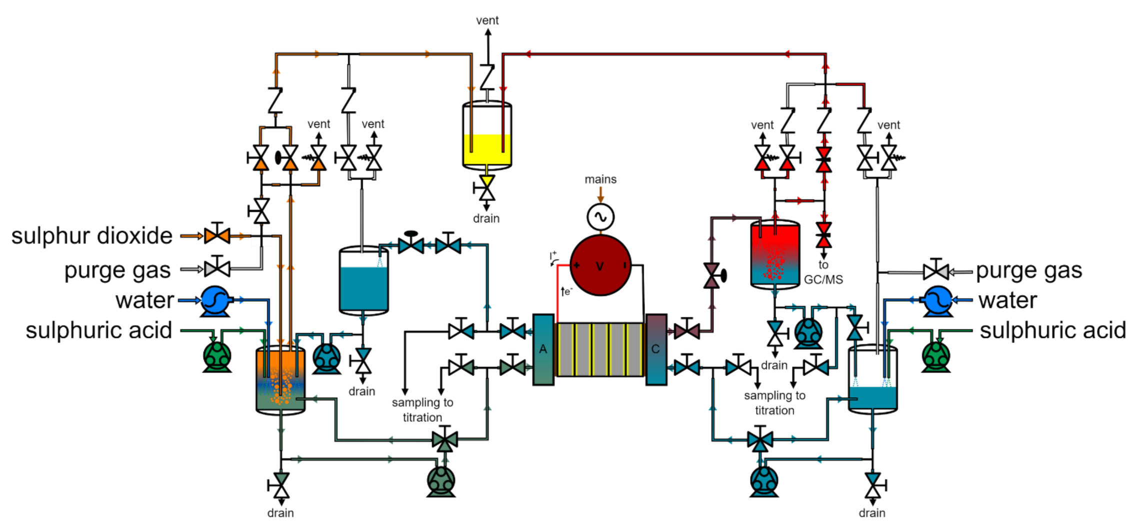


Schematic of the Solar HyS

Introduction

What is Sulphur dioxide (SO_2) Depolarized Electrolysis – SDE

- Alternative to PEM water electrolysis
- **Only 14% electricity demand of conventional water electrolysis** [1]
- Adding SO_2 to the anode to produce hydrogen and sulphuric acid
- SDE is the electrochemical part of the solar Hybrid Sulphur Cycle – HyS
- HyS: two step process
  1. High temperature solar reactor
  2. SDE electrolyser
- Annual solar to hydrogen efficiency of HyS is 22% compared to 11% for PV and alkaline electrolysis[2]



Flow chart of DLR SDE lab set-up

Problems addressed

Water electrolysis by renewable energy

- EU transition to a hydrogen-based economy
- Limitations with multi-MW electrolysers & battery storage systems:
  critical materials - platinum group metals - commercialization
- Proposal: direct solar-to-hydrogen pathways:
  Sulphur cycles
  Sulphur dioxide Depolarized Electrolysis

Pathway to green hydrogen and green sulphuric acid

Research focus

- SDE based on PEM technology, modified for corrosive environment
- Catalysts
  Conventional PEM catalysts
  Au/C
  Fe-N
- Membrane
  Nafion®: ban on PFAs
  PBI
- Automation
- Long-term operation
- Goal: 0.5A/cm² at 0.6V with a concentration of produced sulphuric acid of 65 wt% [3]

Electrochemical Details

Overall:

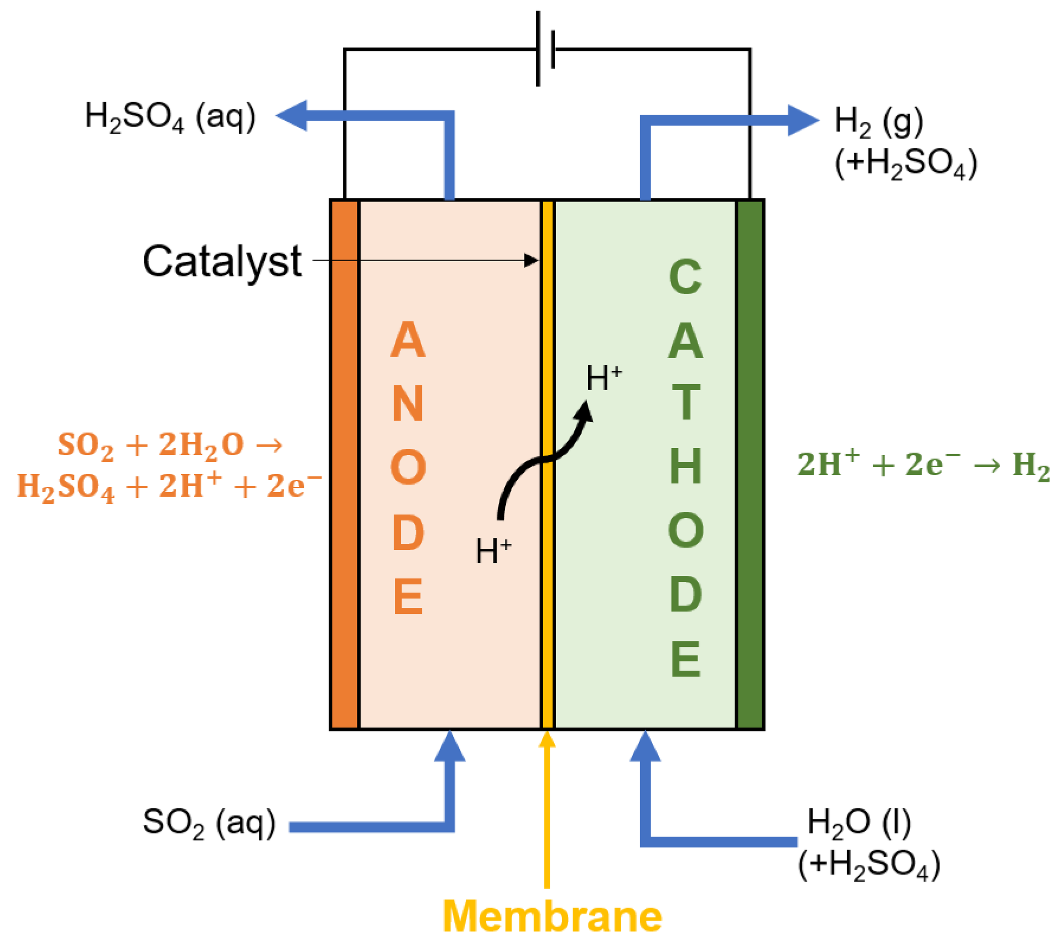
$$SO_2 + 2H_2O \leftrightarrows H_2SO_4 + H_2$$

Anode:

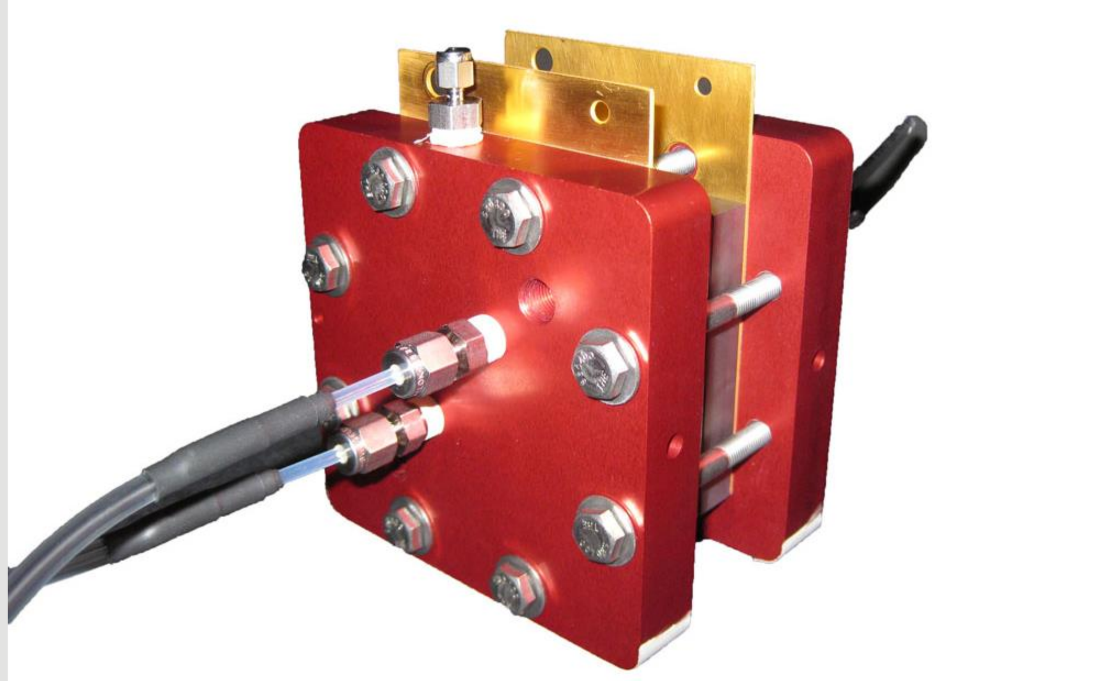
$SO_2 + 2H_2O \leftrightarrows 2H^+ + 2e^- + H_2SO_4$ -0.158V[4]

Cathode:

$2H^+ + 2e^- \leftrightarrows H_2$ 0V



Schematic of the SDE



Corrosion resistant cell hardware ©Scribner Associates Inc.®

References

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