# Enhanced system design to reduce the $SO_2$ crossover to the cathode in $SO_2$ Depolarized Electrolyser (SDE)

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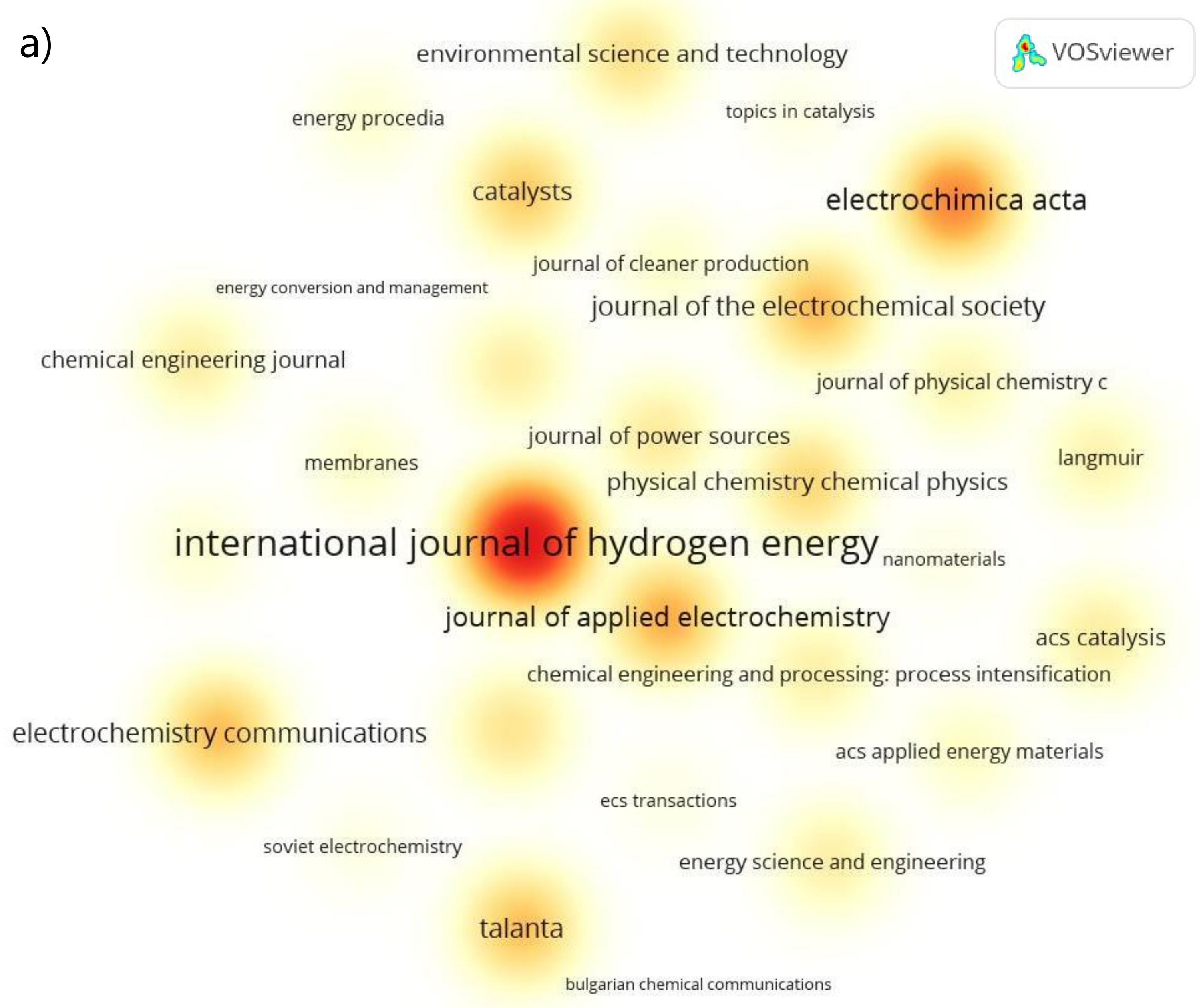
## Introduction

The $SO_2$ Depolarized Electrolyser (SDE) is a major breakthrough in the production of hydrogen on a large scale. SDE has the potential to produce hydrogen with lower energy requirements and less environmental impact. However, SDE can produce sulfur-based contaminants at the cathode, which can reduce the quality of the hydrogen produced. The goal is to develop SDE into a viable technology for producing green hydrogen on a large scale.

## Results of bibliometric analysis

a)




b)

| Sno. | Country | Number of documents | Citations | Average citations |
|---|---|---|---|---|
| 1 | USA | 21 | 467 | 22.2 |
| 2 | China | 10 | 70 | 7 |
| 3 | South Korea | 9 | 43 | 4.8 |
| 4 | Spain | 6 | 42 | 7 |
| 5 | Finland | 5 | 54 | 10.8 |

*Figure 1: Results of bibliometric analysis: a) citation analysis by source;; b)Top 5 most productive countries*

## Future Suggestions

- SDE is a promising technology for green hydrogen production, but it needs more research to overcome the challenges of leaks, corrosion, and membrane selectivity.
- The gas analysis system used in previous research is not accurate enough to measure the gases produced in the cathode compartment of an SDE cell.
- A new gas analysis system is proposed that uses gas chromatography-mass spectrometry (GC-MS) / micro-GC to detect all the gases in the mixture (Fig no. 2).
- A gas flow meter is also needed to measure the amount of gas being produced.

## Conclusion

- The bibliometric analysis shows that USA leads in SDE research with highest number of publications, citations and Finland shows higher impact
- Proposal of a new gas analysis and circulation system for SDE
- Pourbaix diagram shows pH closer to 7 prevents S and $H_2S$ formation

## Working principle

- The process involves the oxidation of $SO_2$ from +4 to +6 oxidation state to produce Protons ($H^+$) and Sulfate ions ($SO_4^{2-}$) at the anode [2] (Fig no. 2).
- The protons flow through a polymer electrolyte membrane (PEM) and reduce at the cathode to produce $H_2$.
- The process has a lower standard reversible voltage, $E^0$ of 0.158V [3], compared to a conventional water electrolyser with $E^0$ = 1.23V.

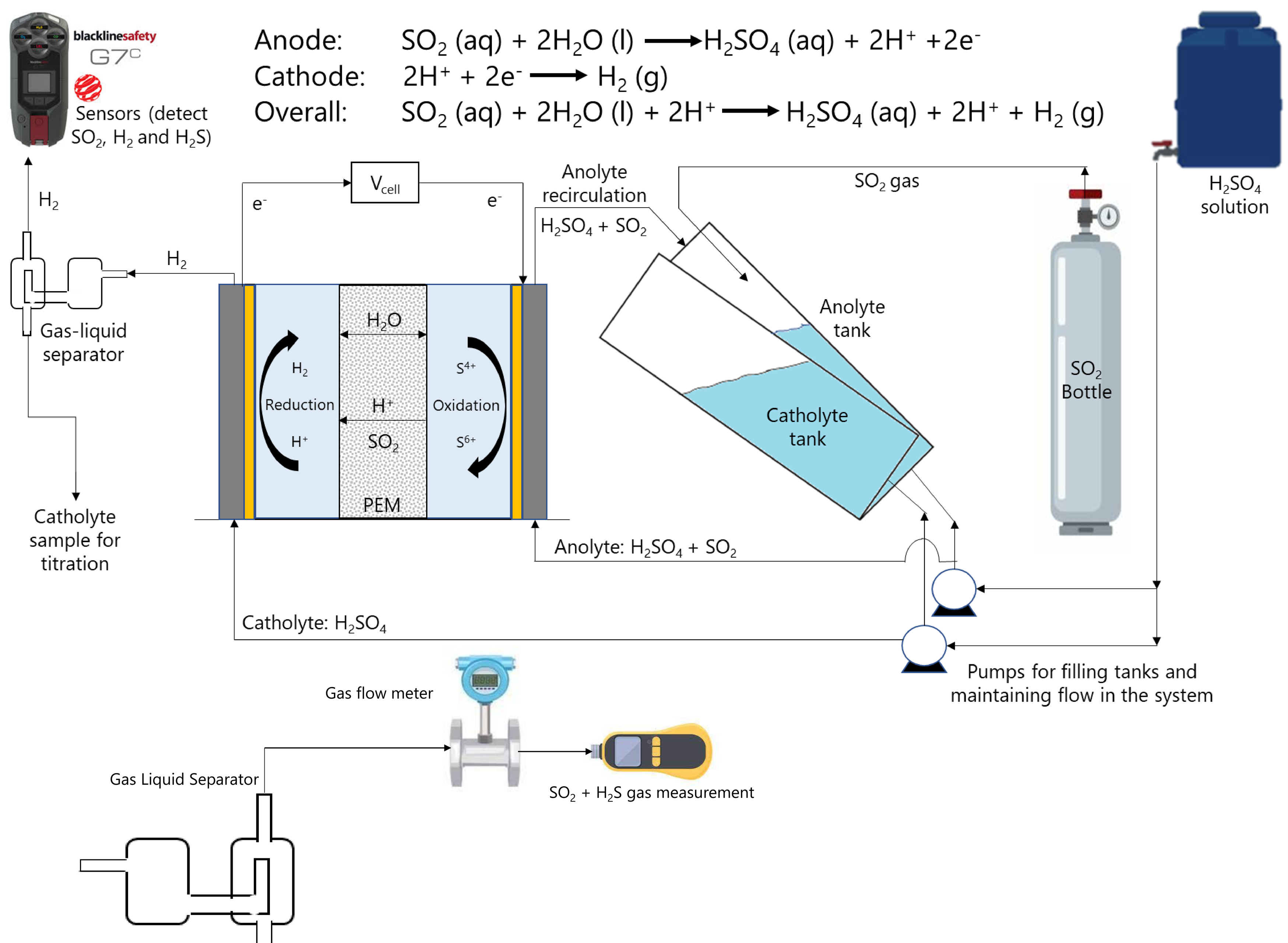



*Figure 2: Setup and basic working principle of SDE; Gas analysis system*

## Effect of pH on the production of hydrogen

- The main limitation of SDE is the formation of Sulphur on the cathode side due to reduction of $SO_2$ (crossover) [1]. This reduces the efficiency of the system.
- To overcome this, a Pourbaix diagram (Fig no. 3) was drawn using the HSC Chemistry 10 program. This diagram shows that a pH closer to 7 would prevent the formation of Sulphur (S) and Hydrogen Sulphide ($H_2S$).

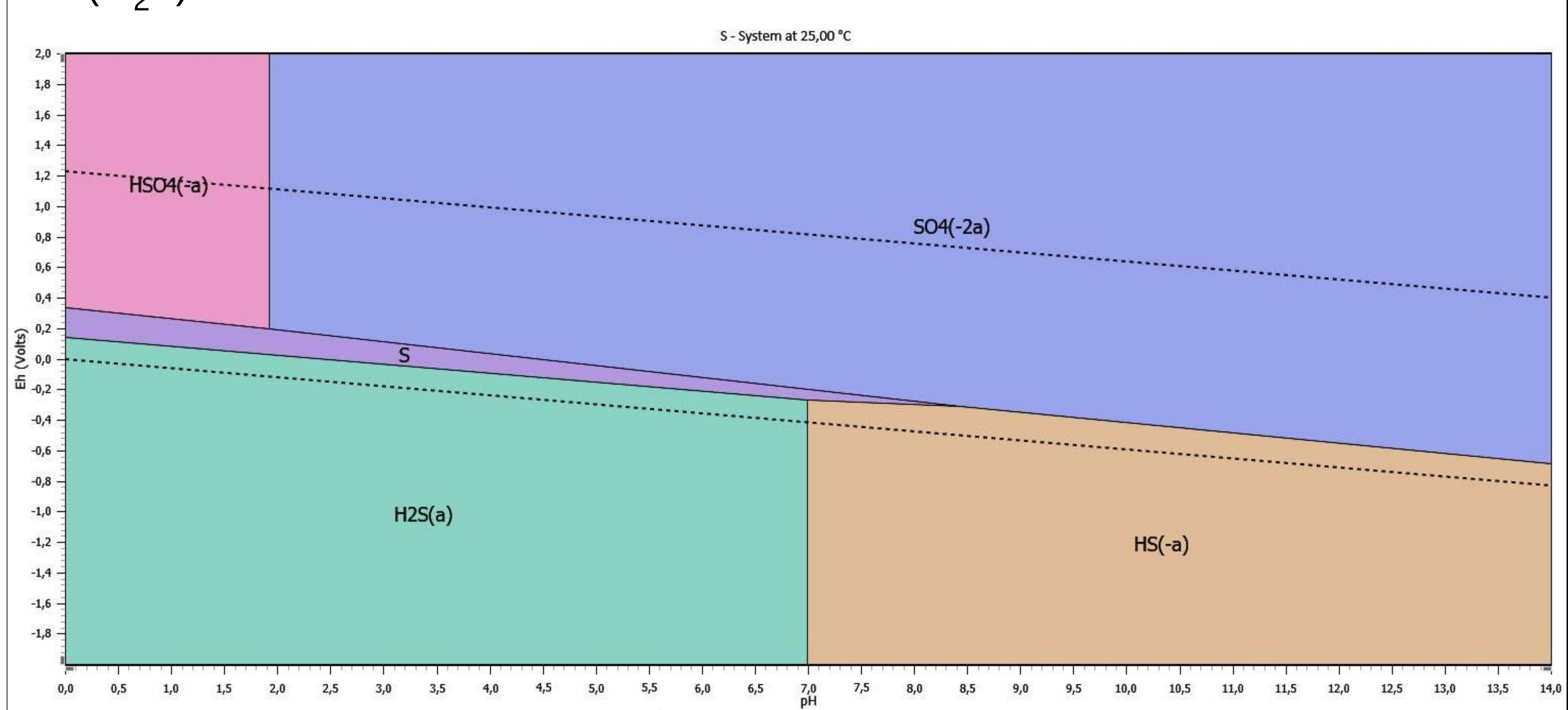



*Figure 3: Thermodynamic calculations of possible products in S-H2O system at 25 °C in SDE by HSC Chemistry 10 program.*

### References

(1) Santasalo-Aarnio, A.; Virtanen, J.; Gasik, M., SO 2 Carry-over and sulphur formation in a SO 2-depolarized electrolyser. Journal of Solid State Electrochemistry 2016, 20, 1655-1663. https://doi.org/10.1007/s10008-016-3169-8

(2) Sattler, C., et al., Solar hydrogen production via sulphur based thermochemical water-splitting. Solar Energy, 2017. 156: p. 30-47.

(3) Gorensek, M.B., et al., A thermodynamic analysis of the SO2/H2SO4 system in SO2-depolarized electrolysis. international journal of hydrogen energy, 2009. 34(15): p. 6089-6095.

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