Why are we doing this?

Hydrogen sulfide or H₂S is produced in large quantities in waste water treatment plants and refineries after hydrodesulfurization processes to remove sulfur from oil. 64 million tonnes are processed as sulphur every year in the world. H₂S is a toxic, corrosive and smelly gas. H₂ is the fuel of the future.

Solar energy suffers from intermittency and low yields. Energy storage is an issue that needs to be solved in order to consider the sun as an effective source of energy. Hydrogen is considered as a promising alternative for chemical energy storage.

How do we do it?

It is very challenging to find an inexpensive semiconductor, able to split hydrogen sulfide efficiently without decomposing. Also, it is recommended to be environmentally benign. Heavy metals such as cadmium and lead should be avoided.

Where is the catch?

Experimental data was compared with finite element model predictions (Comsol Multiphysics) of spatial distributions of potential and photocurrent densities.

The main aim is to optimize geometrical parameters such as distance and size of perforations in the anode in order to reduce ohmic drops and recombination losses. Also, this will help to see how this affects hydrogen yields, which is related to the achieved photocurrent.

Which materials have been tested?

- Pyrite (FeS₂): Difficult synthesis, low efficiency
- Bismuthinite (Bi₂S₃): Low efficiency
- Cobalt sulfide (Co₃S₄): Not photovoltaic

Hematite (α-Fe₂O₃) is thermodynamically unstable in sulfide solution, but its kinetics of decomposition are very slow. (a) Higher current densities and (b) efficiencies were achieved compared to conventional water splitting. Also, (c) photocurrent with time is stable at moderate potentials.

Reactor modelling

Surface: Total interface current density (A/m²)

Conclusions

- Hydrogen sulfide splitting is a feasible process and less energy intensive if a suitable semiconductor is found.
- Hematite performed better than most of mineral sulfides. However, an electrical bias must be applied because of mismatching of band edges.
- Current densities are homogeneous for medium scale reactors (0.01m²). However, that is not the case when its size exceeds 0.3 m.
- Model predictions and experimental results agreed.

References