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Electrocatalytic hydrogen generation

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Introduction

Electrocatalysis rationale:

Thermodynamic potential to split water: 1.23 V_{RHE}

Significant overpotentials are observed in practice

Electrocatalyst at electrodes surfaces can decrease these overpotentials by decreasing the activation energy of water splitting

Requirements:

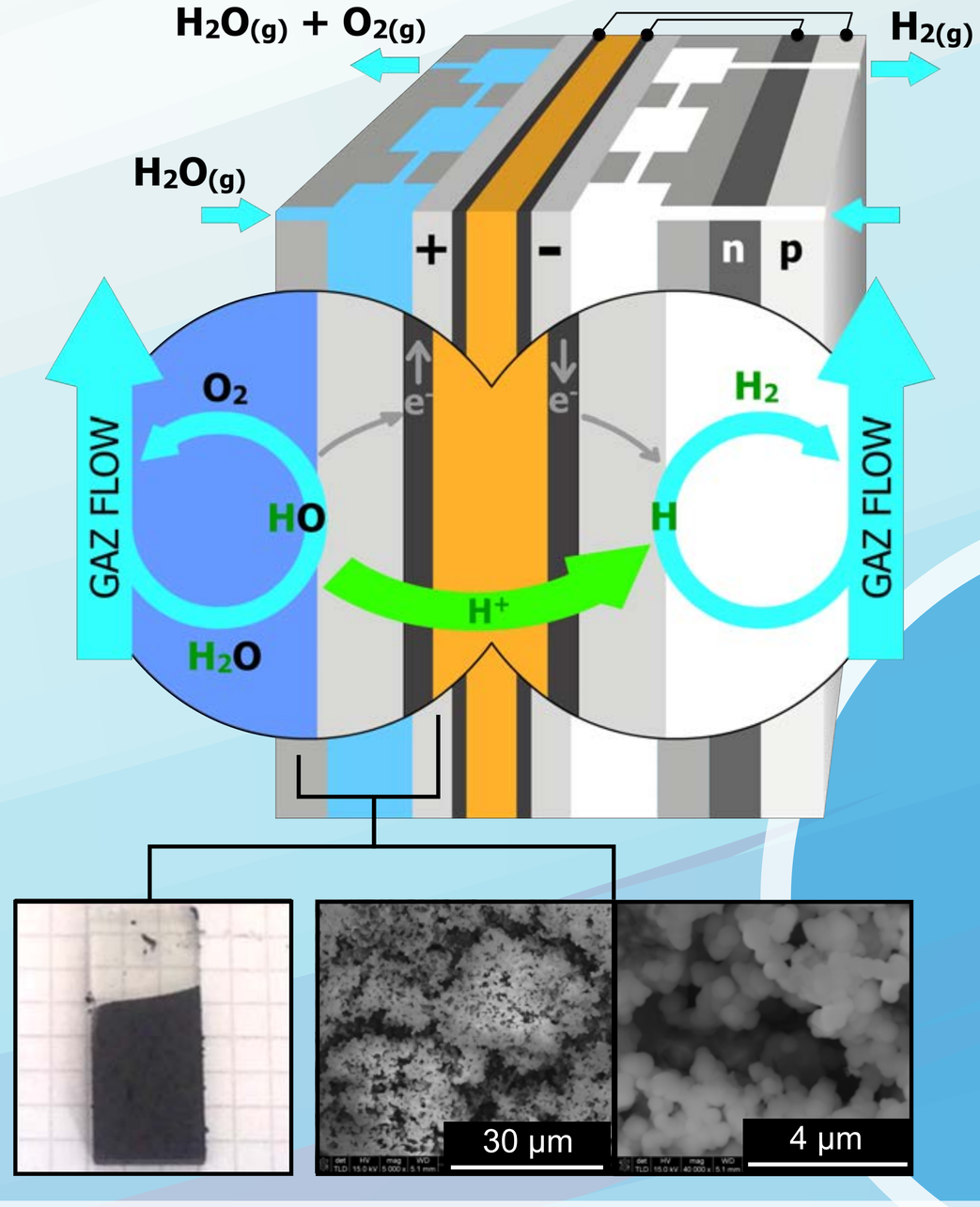
- Earth abundant material
- Highly active catalytic site and selectivity
- Stable in acidic and basic medium
- Environmentally friendly
- Water vapor sensitive

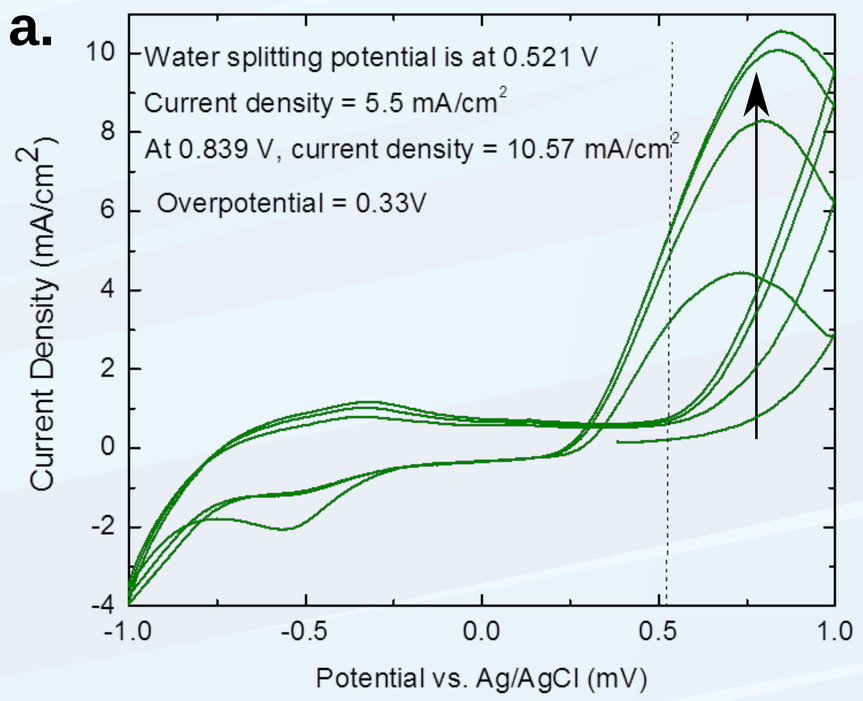
Candidates materials:

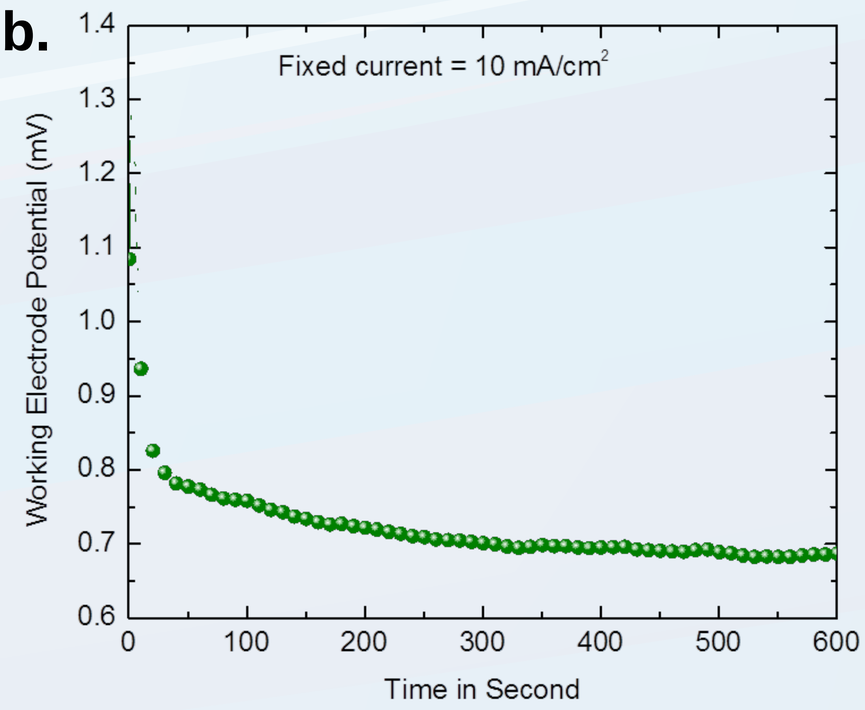
- *Water oxidation catalysts:* NiO, NiFeOx, MnOx, Co3O4, NiO- hematite, Molecular POM cluster
- *Water reduction catalysts:* mesoporous Pt, NiFe, CuO2

NiO ?

NiO: highly active water oxidation catalyst in the presence of Fe, shows water oxidation current of 10.57mA/cm^2







Results

The catalyst is constituted of Ni particles dispersed in a carbon support. It was dip coated on a conductive substrate (FTO glass). This assembly constitutes a planar anode (see photograph above) and can be characterized electrochemically.

Electrochemical measurements were performed in a normal electrochemical cell (three electrode configuration). The electrolyte was a 1M PBS buffer solution (pH = 7.2). A neutral pH was chosen to simulate.

Cyclic voltametry was performed (Figure a.): over time a strong current peak is rising at 0.84V vs Ag/AgCl, 10.57mA/cm^2 is the maximum current peak at this potential. Significant water splitting currents are still obtained for potentials as low as 0.521 V vs Ag/AgCl.

The extra current observed at 0 V might be evolved from oxidation of carbon support. Some amount of current also evolves from oxidation of Ni itself.

Note that the Ni particles here are intentionally oxidized to NiO which acts as a water oxidation catalyst. Therefore the current taking off at 0.52 V should be linked mainly to water oxidation. Chronopotentiometric study of this electrode shows its stability (Figure b.), which adds credit to the hypothesis that most of the observed current comes from the oxygen evolution.

Conclusions

- Ni / C anode shows high current density (10.52 mA/cm^2)
- Significant water splitting current density (5.5 mA/cm^2) obtained at low overpotentials
- Electrode load potential is fairly stable for 10 mA /cm^2 fixed current

Outlooks

- Electrode kinetics will be studied using Tafel and Butler Vullmer model
- Nature of evolved gas has to be determined
- The planar electrode assembly will be upscaled to 5 x 5 cm^2

Integration Considerations