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4-1-2019

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Recommended Citation

Morey, Kinsey; Morey, Tucker; Neria, Brooks; Siam, Khamis; and Kahol, Pawan K., "Almond Based Electrocatalyst for Fuel Cell Applications" (2019). *Posters*. 42.

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Almond based Electrocatalyst for Fuel Cell Applications

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Background

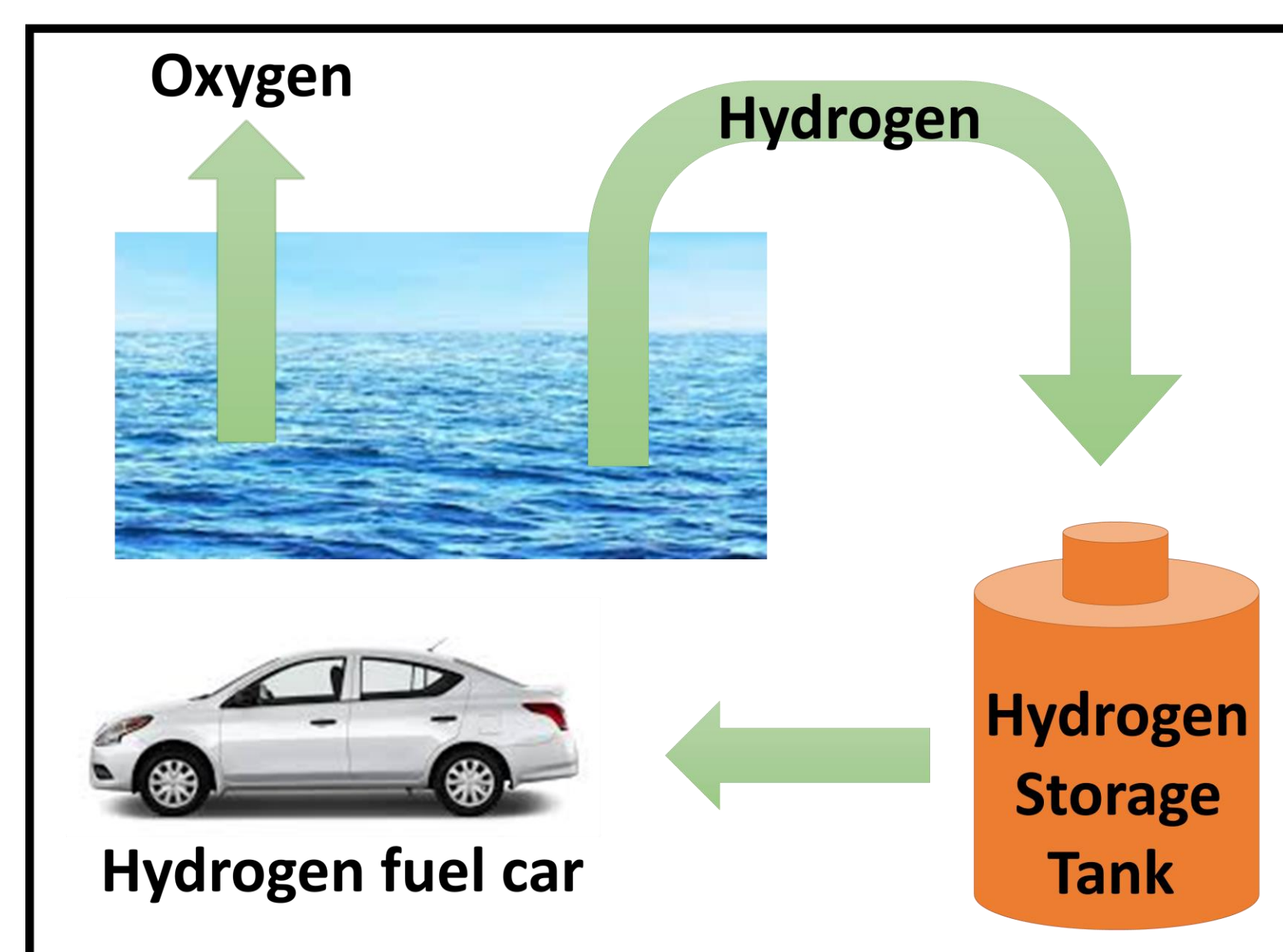
- The rapid depletion of fossil fuels and growing environmental concerns have created an enormous worldwide demand for alternative clean energy technologies.
- Hydrogen has a potential to be one of the most effective clean energy sources due to its high energy density of 141.86 MJ/kg and clean combustion.
- Water electrolysis via photochemical and photoelectrochemical are the promising pathways for sustainable hydrogen production.
- The water splitting reaction can be expressed chemically as:
Total reaction $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$ (1.23V)

Challenges

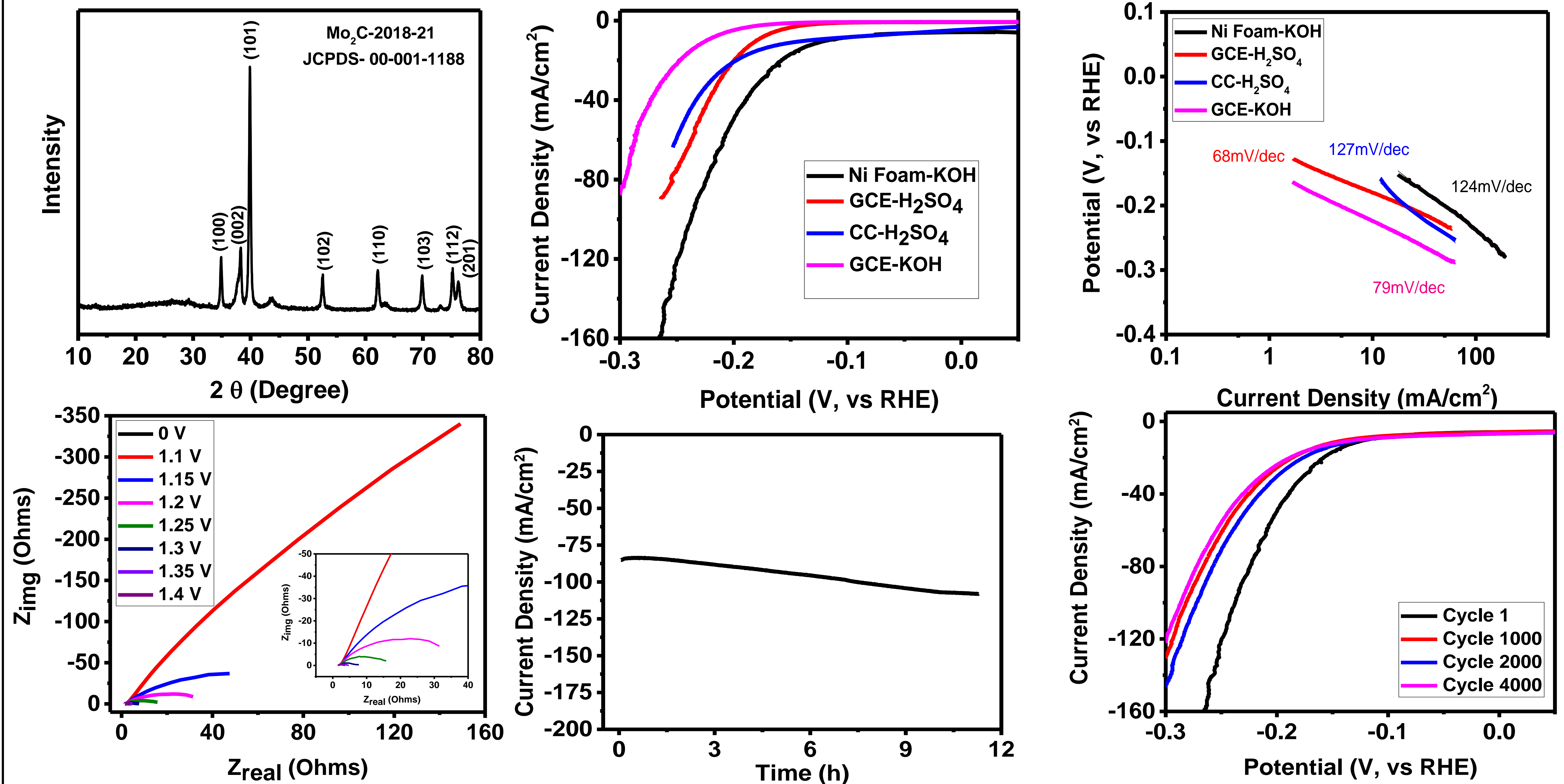
- Regardless of the media in which water splitting takes place, the thermodynamic voltage of water splitting is 1.23 V at 25 °C and 1 atm. However, in fact, we must apply voltages higher than the thermodynamic potential (overpotential) value to achieve electrochemical water splitting.
- An ideal electro-catalyst should provide high current density at a lower overpotential.
- Platinum is one of the most efficient electro-catalyst for hydrogen evolution, however, its high cost and limited availability has curtailed its use for hydrogen production.

Solution through this research

- Replacement of Pt with inexpensive, earth-abundant electrocatalysts would be significantly beneficial for clean and efficient hydrogen evolution.
- We have used earth-abundant materials such as Mo_2C as an alternative to platinum electrocatalyst for hydrogen evolution.



Results and discussion



- We have prepared Mo_2C as a cost effective and biorenewable electrocatalyst capable of performing in both alkaline and acidic media.
- Mo_2C on nickel foam produces higher current densities (122 mA/cm² at -0.25 V) compared to the Mo_2C on GCE in acidic media (75 mA/cm² at -0.25 V) and Mo_2C on GCE in alkaline media (22 mA/cm² at -0.25 V).
- Molybdenum carbide showed an overpotential of 117 mV and 180 mV in alkaline and acidic media, respectively to achieve a current density of 10 mA/cm²
- The long-term stability of the Mo_2C was studied using chronoamperometry and cyclic voltammetry measurements. The performance of Mo_2C is very stable up to about 12 hours of measurement.

Summary

- Mo_2C was synthesized using a facile method.
- The excellent electroactivity of Mo_2C is due to its high conductivity, high electroactive surface area, and pure phase structure.
- Mo_2C on nickel foam in basic media, Mo_2C on GCE in basic media and Mo_2C on GCE in acidic media showed Tafel slopes of 124, 79 and 68 mV per decade, respectively.
- Mo_2C could be a promising cheap electrocatalyst for hydrogen evolution reaction due to its high electroactivity and durability.

Future work & Acknowledgement

- We are working to develop multifunctional (energy storage and generation) materials using cost effective method.
- We plan to use other bio-waste materials for the synthesis of electrocatalysts.
- Sincere acknowledgment to the Polymer Chemistry Program, PSU and KINBRE (Grant # P20GM103418) for providing financial and research support.