



Synthesis of Ni-foam supported bifunctional electrocatalyst based on transition metals for electrochemical water splitting

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Introduction

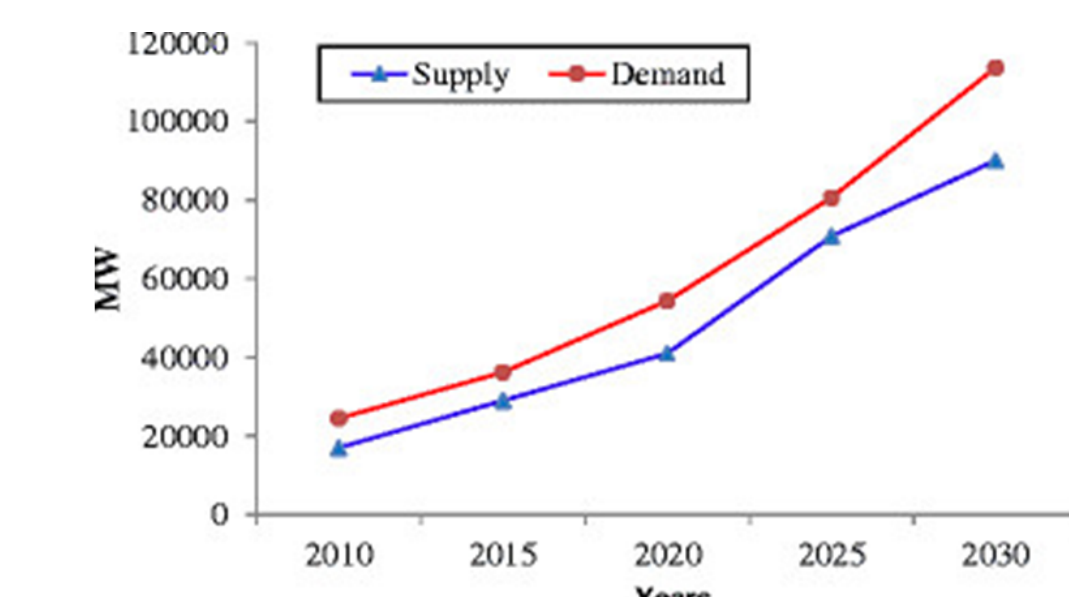
In modern economies, energy security is a serious concern. Increased depletion rates of fossil fuels, as well as rising greenhouse gas emissions associated with the combustion of fossil fuels, and anthropogenic activities, have urged humanity to realign on primary energy sources.¹ The ultimate goal is carbon neutrality, which could be achieved by developing energy-efficient transition technologies that reduce carbon footprints.² The emerging technology for the production of green hydrogen is electrochemical water splitting, which is anticipated to be a cheap fuel source in years to come. Continuous efforts have been made to replace Pt-based electrocatalysts with transition metal and chalcogenides-based electrocatalysts for hydrogen evolution reactions (HER) and oxygen evolution reactions (OER).³ Transition metal (Nickel and Iron) based electrocatalysts have gained immense attention due to metals' natural abundance, lower cost, and efficient water-splitting activities.⁴⁻⁷ Herein, Ni and Fe-based electrocatalysts supported over nickel foam were synthesized by simple and efficient methods, as bi-functional electrocatalysts for complete water electrolysis in alkaline medium.

Problem Statement

Acute Shortage of Electricity
Industries and households are facing frequent power shutdown

Rising fuel prices
Hefty petroleum import bills cause inflation, worsening the economic crisis

High vulnerability climate change impacts
Pakistan remains top 10 climate-affected countries of the world
(Germanwatch's Global Climate Risk Index 2021)



Raheem, Abdul, et al. "Renewable energy deployment to combat energy crisis in Pakistan." *Energy, Sustainability and Society* 6.1 (2016): 1-13.

Domestic fuel prices to rise amid Russia-Ukraine crisis
Sources say petroleum prices may increase by Rs12.33 per litre from Feb 16

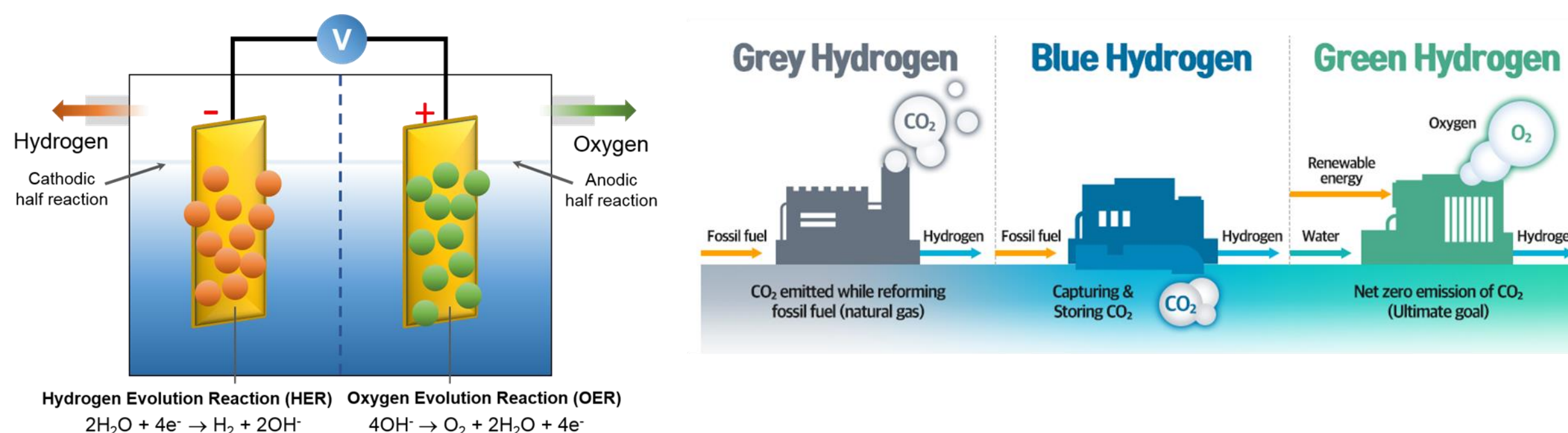
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Major Challenges regarding Hydrogen Energy

Low-cost Production
To make hydrogen production cost-competitive with conventional fuels; current electrocatalysts are based on Platinum Group Metals (PGM)

Clean Production
To establish technologies for blue and green hydrogen production

Safe handling & storage
To establish safe hydrogen storage and transport technologies



Hydrogen: A clean, Flexible Energy Carrier

Emissions Control

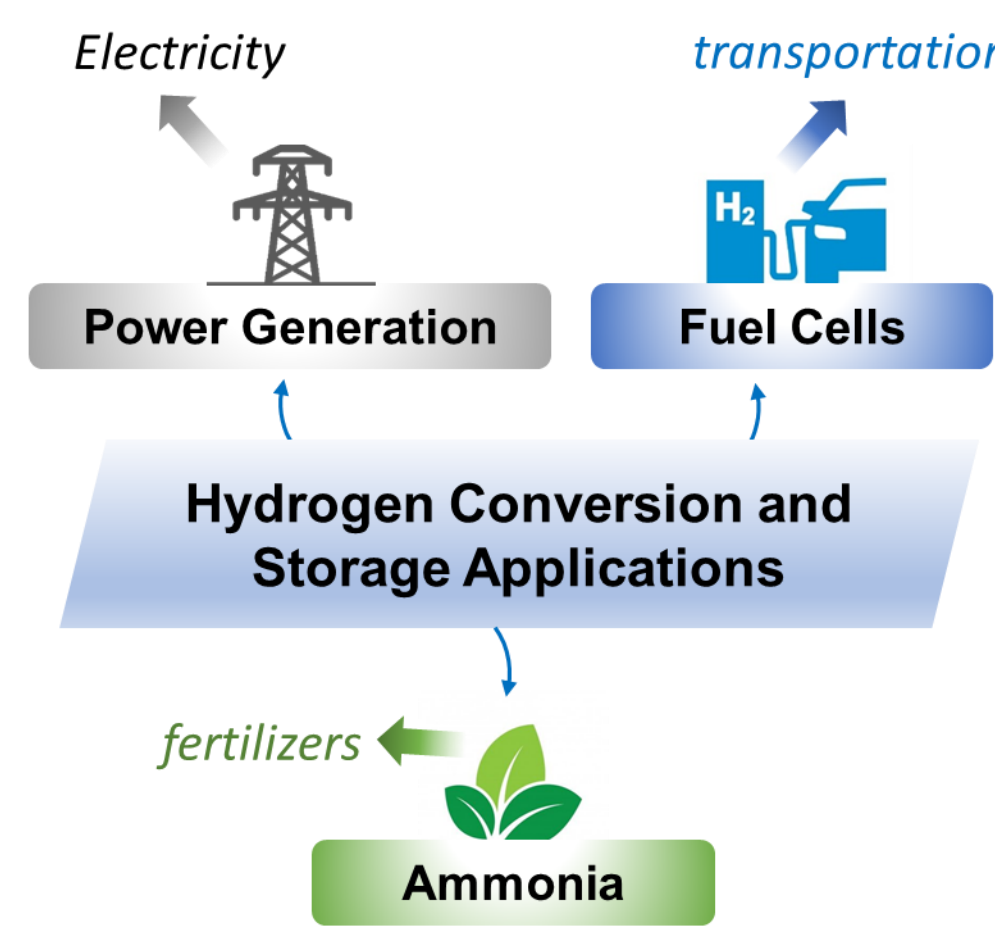
Due to a zero- or near zero-emissions operation, hydrogen fuel can effectively reduce greenhouse gas emission

Broad Range of Applications

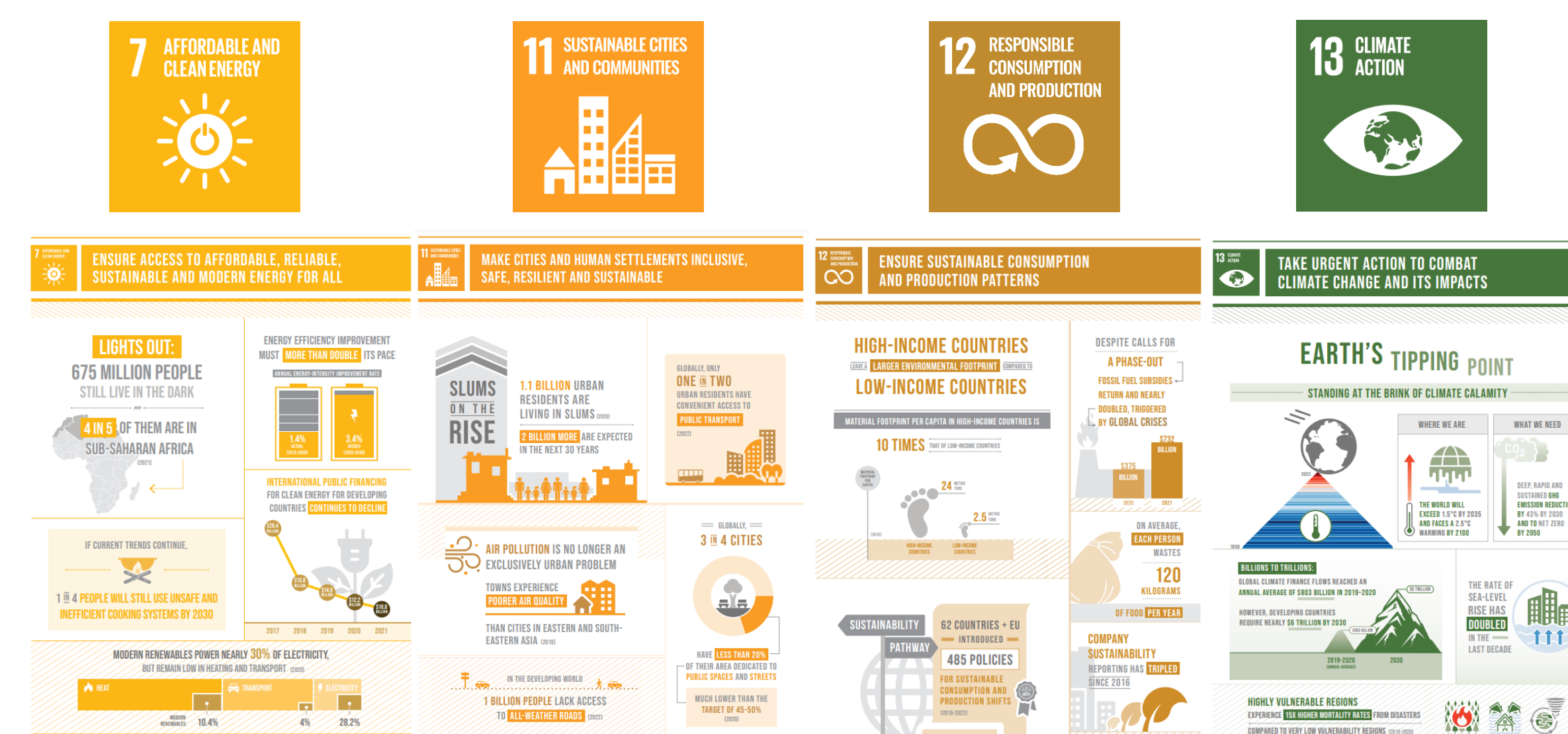
Energy applications across all sectors — transportation, commercial, industrial, residential, and portable.

Industrial Support

Cheap hydrogen supply for petroleum refining and fertilizer production



Research Related SDGs



Synthesis Protocol and Material Characterization



Figure 1: Systematic diagram for preparation of NiFe/NF via reflux method

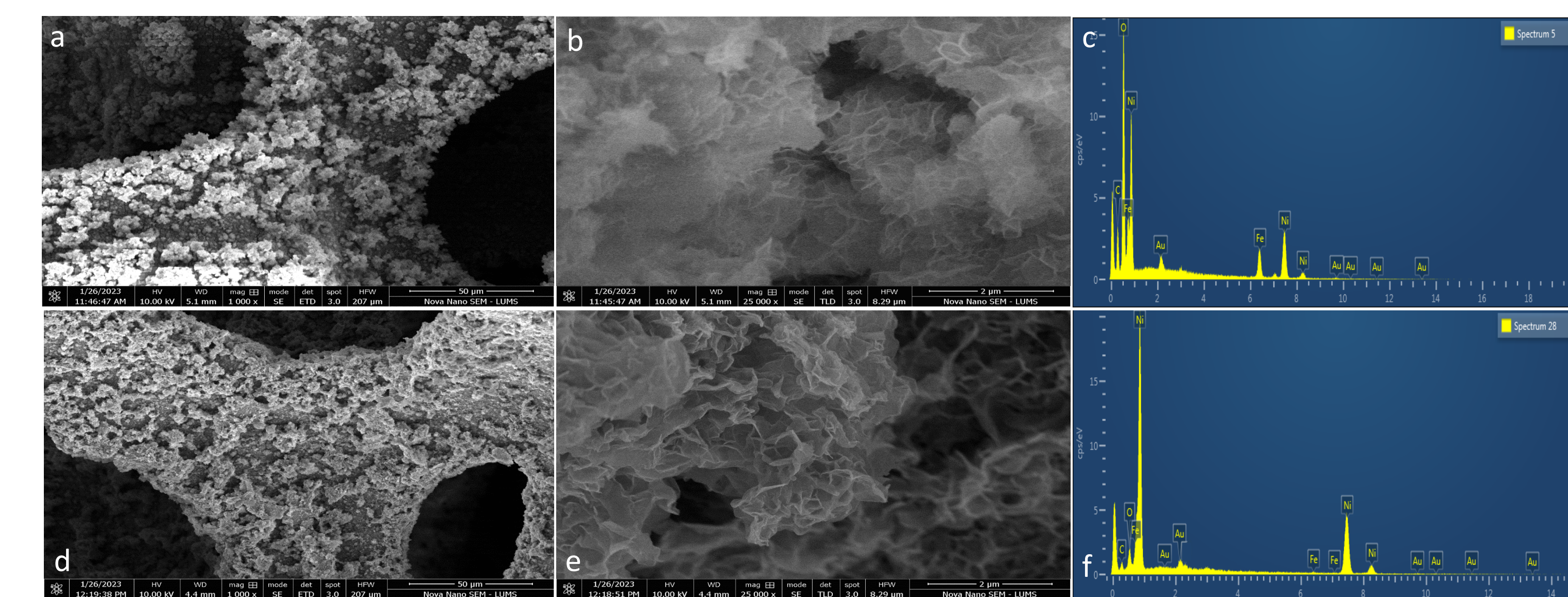


Figure 2: SEM-EDX of NiFe/NF synthesized via (a-c) hydrothermal process (d-f) reflux method

Electrochemical Water Splitting (HER and OER)

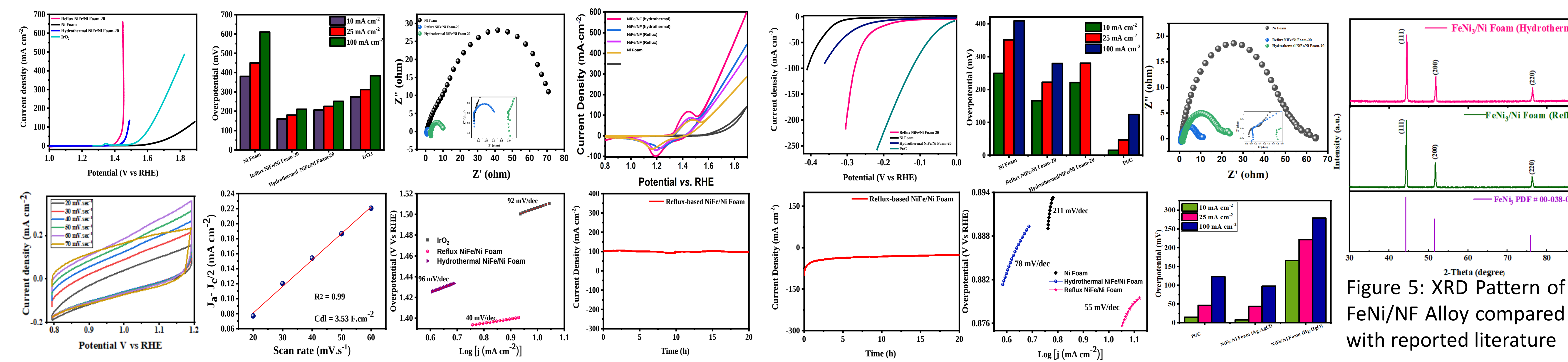


Figure 3: Graphical representation of Alkaline water splitting for Oxygen evolution reaction (OER) using 1M KOH as alkaline medium and Hg/HgO as reference electrode. Catalyst activity was tested over 1cm² area of Nickel foam substrate

Figure 4: Alkaline water splitting for Hydrogen evolution reaction (HER) using 1M KOH as alkaline medium and Hg/HgO as reference electrode. Catalyst activity was tested over 1cm² area of NF substrate

Conclusion

The as-synthesized electrocatalysts were characterized by X-ray diffraction spectroscopy (XRD) and Scanning electron microscopy coupled with energy-dispersive X-ray (SEM/EDX). Electrochemical analysis results showed the low onset potential, high current density, and over potential along with great long-run stability for HER and OER. The catalysts showed efficient and robust electrochemical activities due to large exposed active sites available on the Ni-foam surface. Its intrinsic activities are facilitated by the synergic effect of Ni and Fe, which resulted in outstanding catalyst performances.

Acknowledgment

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References

1. Axon, C.; et. al. 2021, 27, 1195-1204
2. Kurniawan, T. A.; et. al. 2023, 332, 117429
3. Hota, P.; et. al. 2023, 48 (2), 523-541
4. Zhang, R.; et. al. 2023. 25 (3), 35-43
5. Li, J.; et. al. 2023, 1-35
6. Zhang, X.-Y.; et. al. 2022, 430, 132312