Nanostructured Materials for Sustainable Hydrogen Generation

María Giménez-López*, Melanie Guillén-Soler, Lucía Vizcaíno-Anaya, Ahmad Tayyebi, Jose M. Vila-Fungueiriño

[1]Centro Singular de Investigación en Química Biolóxica e Materiais Moleculares (CiQUS), Universidade de Santiago de Compostela, Spain,

E-mail corresponding autor: maria.gimenez.lopez@usc.es

INTRODUCTION

The coupling of the hydrogen evolution reaction (HER)[1] with the urea oxidation reaction (UOR)[2] in electrolyzers represents an efficient alternative for hydrogen production, as it significantly reduces the operating voltage compared to water oxidation. Additionally, this strategy allows for the valorization of urea-rich waste from wastewater streams. However, the sluggish kinetics of the UOR and the high cost of noble metals highlight the need for stable, efficient, and low-cost electrocatalysts. In this work, sulfur-doped nanocomposites are presented as versatile platforms for stabilizing active metal nanoparticles for HER and UOR.

EXPERIMENTAL/THEORETICAL STUDY

Sulfur-doped supports were synthesized and modified through a multi-step process involving chemical functionalization and thermal treatment. The resulting materials were characterized using a range of spectroscopic and microscopic techniques to assess their structural and compositional properties. These platforms were subsequently hybridized with transition metal species to develop electrocatalysts for both hydrogen evolution and urea oxidation reactions. Tailored thermal protocols were applied to promote the formation of mixed metal and metal oxide/sulfide phases with enhanced electrocatalytic activity.

RESULTS AND DISCUSSION

After electrochemical activation, the doped hybrid HER catalysts showed a significant enhancement in activity, with notable improvements in overpotential and reaction kinetics. For the UOR, materials prepared through optimized thermal processing demonstrated the best electrocatalytic behavior, along with high efficiency and long-term operational stability. A two-electrode electrolyzer device incorporating these electrocatalysts achieved efficient hydrogen production at reduced cell voltage, outperforming conventional water-splitting systems.

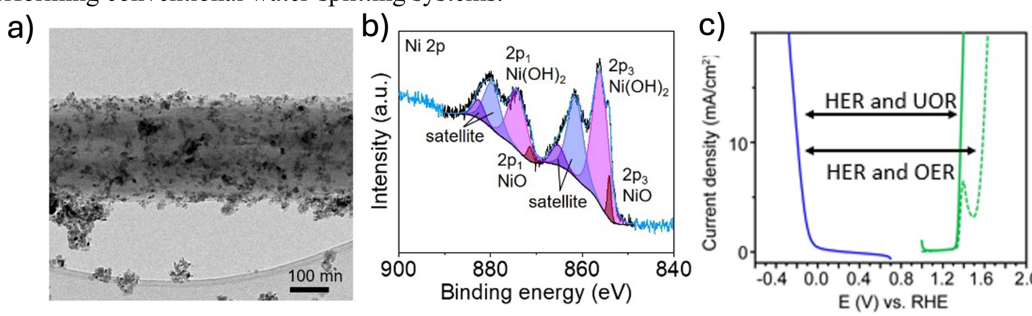

Fig. 1 a) An example of sulfur-doped nanocomposites of a nickel using a novel route, b) High-resolution XPS spectra of Ni 2p, c) LSV curves for the HER/UOR catalyst in comparison with an OER catalyst.

CONCLUSION

This study highlights the potential of sulfur-doped nanostructured supports as versatile platforms for the development of electrocatalysts with different functionalities in alternative electrolysis systems. The materials tested demonstrated high catalytic activity, good stability, and excellent energy efficiency. These findings open new avenues for advancing clean and sustainable hydrogen production technologies.

REFERENCES

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