

DES-ASSISTED ELECTRODEPOSITION OF ELECTROCATALYSTS FOR GREEN HYDROGEN PRODUCTION

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The growing demand for low-carbon hydrogen calls for scalable, inexpensive and robust electrocatalysts. This work synthesizes and evaluates nickel-based and nickel–ceria composite electrocatalysts fabricated by electrodeposition in deep eutectic solvents (DESs). Electrodeposition in DES media provides a controllable, eco-friendly platform that combines high metal salt solubility with suppressed hydrogen co-evolution during plating, enabling deposition of tailored morphologies, compositions and defect structures that are difficult to obtain from conventional aqueous baths [1].

We systematically varied DES composition and precursor concentrations to tune deposit characteristics. By adjusting Ni(II) and Ce(III) ratios and deposition parameters, we produced a range of coatings from dense nanocrystalline Ni to porous, oxide-rich Ni/NiO_x matrices with dispersed ceria inclusions. These structural variations control the density of active sites, surface area, and the balance between metallic and oxyhydroxide phases – key determinants of electrocatalytic performance.

Electrochemical testing in alkaline media demonstrates that DES-derived deposits achieve lower overpotentials and higher apparent active areas compared with similar materials prepared from aqueous electrolytes. In particular, selected Ni–Ce-based composites show simultaneous enhancement of hydrogen evolution reaction (HER) activity and improved kinetics for oxidation reactions at the anode. We studied urea oxidation reaction (UOR) as an alternative anodic process: UOR proceeds at substantially lower potentials than oxygen evolution, offering a route to reduce overall cell energy consumption when urea is available [2]. DES-deposited films exhibited favorable UOR onset potentials and stable current responses in model alkaline urea solutions, indicating their potential for hybrid urea-assisted electrolyzer configurations.

Practical application requires tolerance to real operating environments. We demonstrate that properly engineered DES-electrodeposited Ni-based surfaces can be conditioned to resist common seawater-related deactivation pathways (chloride attack, rapid passivation), making them compatible not only with conventional alkaline water electrolysis but also with seawater electrolysis scenarios where fresh water access is limited [3].

In conclusion, electrodeposition from DESs is a versatile route to engineer multifunctional Ni-based electrocatalysts for green hydrogen technologies. Continued optimization of bath formulations, composite design and post-deposition treatments, together with long-term stability testing under realistic electrolyzer conditions, will be essential to advance scale-up and integration into hybrid systems (water/urea/seawater electrolyzers).

REFERENCES

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