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Enhancing biomass and waste valorization through paired electrolysis with nickel and copper foam-modified electrodes.

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Introduction

With the growing global emphasis on the urgent need for an energy transition towards sustainable and environmentally friendly solutions, electrochemical processes for hydrogen (H₂) production have attracted considerable attention. Among these processes, the electrooxidation of urea represents a promising avenue for clean energy production[1]. However, a major challenge in urea electrooxidation is the concomitant production of carbon dioxide (CO₂), which hinders its viability in a carbon-conscious world. In this study, we propose a novel approach to mitigate the CO₂ emissions associated with urea electrooxidation by coupling this reaction with glycerol to simultaneously yield H₂, a clean energy carrier, and glycerol carbonate, a chemical with multiple applications and environmental benefits. . In this context, our work contributes to the ongoing energy transition by providing a way to improve the sustainability and economic viability of electrochemical processes by optimising the use of electricity in coupled electrolysis[2].

Materials and Methods

Synthesis of modified electrodes and characterization

Copper and nickel foam modified electrodes were prepared by a simple one-step hydrothermal method. The modification involved the incorporation of Ni_{0.8}MO_{0.2} nanoparticles into the support surface, where M = Rh, Cu, Co and Mo.

The size, shape and distribution of the nanoparticles were observed by scanning electron microscopy (SEM). Cyclic and linear sweep voltammetry were used to investigate the electrochemical behaviour of the modified electrodes in our system. The effective electrochemical surface area (ECSA) was estimated by measuring the double layer capacitance (Cdl) and then dividing it by the specific capacitance (Cs).

Electrolysis

Electrolysis experiments were carried out in an H-type reactor with compartments separated by an anion exchange membrane. Fourier transform infrared spectroscopy (FTIR) was used to monitor changes in chemical composition during the electrochemical processes.

Results and Discussion

The successful construction of Ni_{0.8}MO_{0.2}/MF modified electrodes was achieved by a single step hydrothermal reaction. Table 1 shows the double layer capacitance values for these electrodes, providing insight into their electrochemical characteristics. Notably, Ni_{0.8}Rh_{0.2}/NF on nickel foam exhibited the lowest onset potential and the smallest Tafel slopes for the Hydrogen Evolution Reaction (HER) (Fig.1), indicating its superior electrocatalytic activity compared to other electrode compositions..

In Figure 2, the Fourier Transform Infrared Spectroscopy (FTIR) spectrum provides a visual representation of the anodic compartment at two time points: at t=0 and after 4 hours of

electrolysis at 550 mV vs. SCE. In particular, the spectrum shows a notable change in chemical composition as evidenced by a reduced ratio of the peaks at 1045 (C-O stretching) and the peak at 1590 (C=O stretching). This change in peak ratios indicates significant chemical transformations during the electrochemical process and warrants further investigation into the underlying reactions and their implications.

Table 1. Cdl of modified electrodes

Support	Nps	Cdl μFg ⁻¹
Copper	Ni	89.5
	Ni _{0.8} Co _{0.2}	96.5
	Ni _{0.8} Cu _{0.2}	105.5
	Ni _{0.8} Mo _{0.2}	55.0
	Ni _{0.8} Rh _{0.2}	220.5
Nickel	Ni	32.0
	Ni _{0.8} Co _{0.2}	44.0
	Ni _{0.8} Cu _{0.2}	42.5
	Ni _{0.8} Mo _{0.2}	23.0
	Ni _{0.8} Rh _{0.2}	175.5

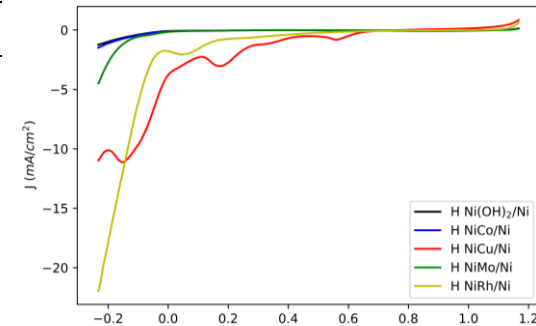
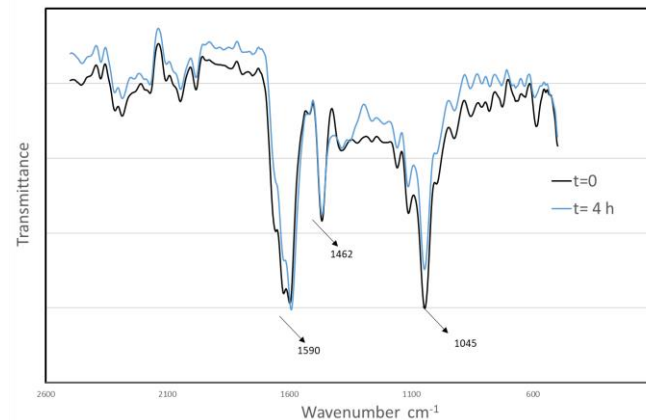


Fig. 1 Polarization curves of modified nickel foam electrodes in KOH 1 M.



Significance

In summary, this work has the potential to drive innovation in both industry and academia, in line with the global push towards sustainability and cleaner energy solutions.

References

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