SUSTAINABLE NICKEL-DOPED NITROGEN-ENRICHED BIOMASS-DERIVEDCARBON CATALYSTS FOR HYDRAZINE FUEL CELLS

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The growing demand for sustainable and efficient energy conversion technologies has led to increasing interest in biomass-derived carbon materials as cost-effective and environmentally friendly catalysts [1,2]. Biomass-based carbons, unlike traditional carbon materials, provide a renewable and abundant alternative enriched with inherent heteroatoms (e.g., N, P, S), which contribute to enhanced catalytic performance. In particular, nitrogen-doped carbon materials have demonstrated significant potential for electrochemical applications due to their improved conductivity and active sites. The incorporation of transition metals (Co, Cu, Ni, Fe, etc.) can further enhance catalytic activity, making these materials suitable for direct hydrazine fuel cells (DHFCs) [3-5]. Hydrazine (N_2H_4) is a promising liquid fuel for fuel cells due to its high energy density and carbon-free oxidation, offering a clean and efficient power source for next-generation energy systems.

In this study, we present a straightforward synthesis of non-noble metal-doped nitrogen-enriched biomass-based activated carbon catalysts for alkaline fuel cell applications. Activated wood carbon (AWC) was derived from birch wood and doped with Ni and nitrogen in a one-step synthesis using 10 % Ni^{2+} ions relative to AWC, along with dicyandiamide (DCDA) in dimethylformamide (DMF). After solvent evaporation, the mixture was subjected to pyrolysis at 800 °C for 60 minutes. The obtained catalysts were comprehensively characterized using ICP-OES for elemental composition, XRD for crystalline structure, XPS for surface chemistry, SEM-EDS for morphology and elemental distribution, BET analysis for surface area, and Raman spectroscopy for structural integrity. The AWC-Ni-N catalyst contained 1.12 at. % Ni and 98.88 at. % C. The catalytic performance of the AWC-Ni-N catalyst was assessed in DHFCs operating with 1 M N_2H_4 + 1 M KOH as the fuel and 5 M H_2O_2 + 1.5 M HCl as the oxidant, employing AWC-Ni-N as both the anode and cathode catalyst. Peak power densities of up to 10.8 mW cm^{-2} were achieved at 25 °C with the AWC-Ni-N catalyst. The AWC-Ni-N catalyst demonstrated excellent electrocatalytic activity, stability, and power output, highlighting its potential as an efficient electrode material for sustainable fuel cell technologies.

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