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Bimetallic Transition-Metal Supported Biomass-Derived Carbon Catalyst for Efficient Hydrazine Oxidation

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INTRODUCTION & AIM

- Direct hydrazine fuel cells (DHFCs) have emerged as highly promising next-generation energy systems for sustainable hydrogen production; however, their practical advancement requires low-cost, highly active, and durable non-noble-metal electrocatalysts for the hydrazine oxidation reaction (HzOR).
- Recently, biomass-derived nitrogen-doped carbon (N–C) materials have gained significant attention as sustainable catalyst supports due to their porous structure, excellent conductivity, and enhanced electrocatalytic performance.
- **Research Objective:** In this work, cost-effective Fe/N–C and MnFe/N–C electrocatalysts were synthesised via hydrothermal synthesis using birchwood-derived nitrogen-doped carbon supports, and their electrocatalytic performance toward HzOR in alkaline medium was evaluated using cyclic voltammetry (CV) for enhanced DHFC applications.

METHODS

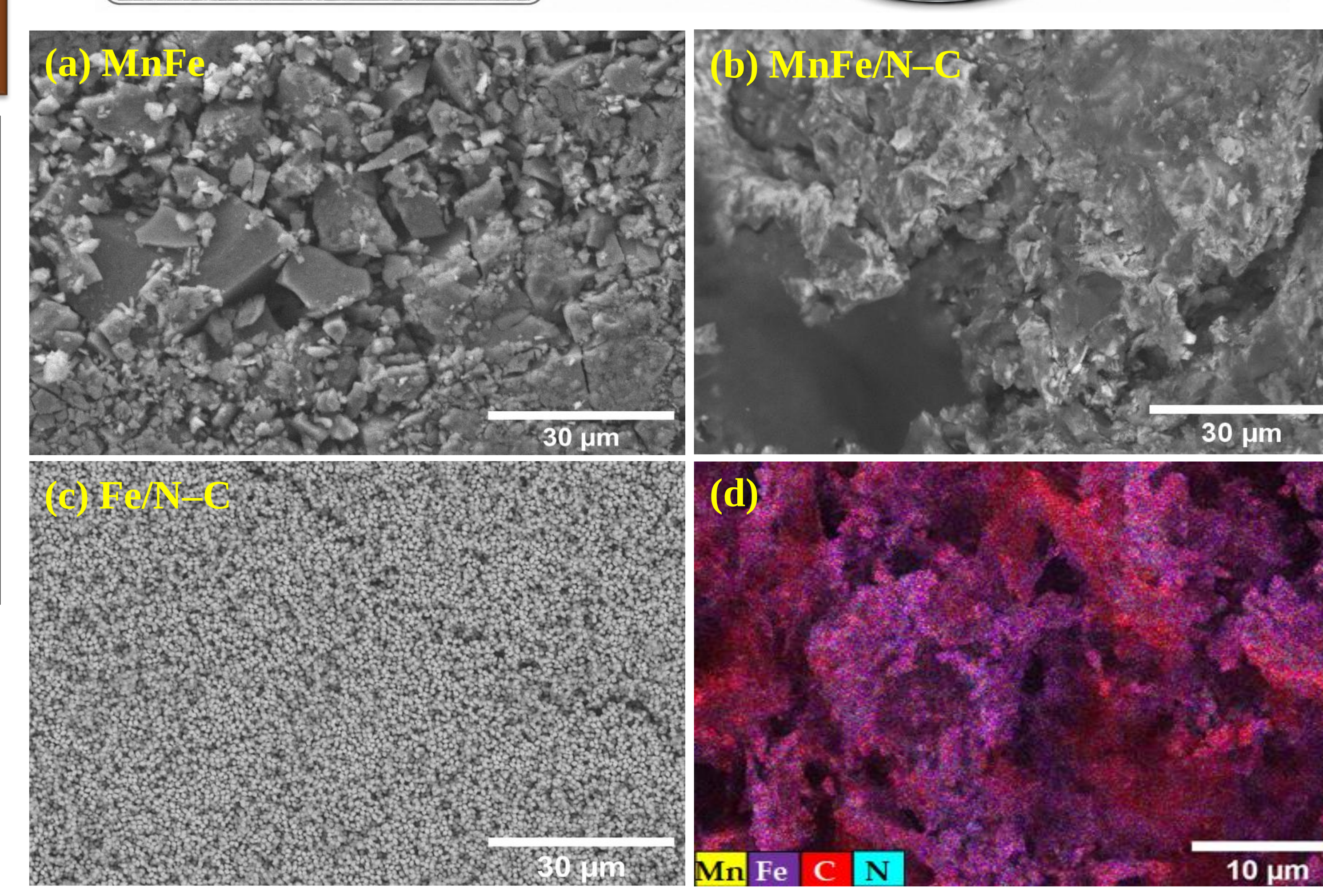

Fig. 1. SEM images of the MnFe (a), MnFe/N–C (b), and Fe/N–C (c) catalysts, along with the elemental mapping of the MnFe/N–C catalyst (d).

Table 1. Surface composition of the catalysts determined by EDS analysis.

Catalyst	Element, at%			Molar Ratio, at%
	Mn	Fe	O	Mn:Fe:O
MnFe	6.74	33.60	59.65	1:5:8.9
MnFe/N–C	4.92	29.50	65.58	1:6:13.3
Fe/N–C	–	47.80	52.20	0:1:1.1

RESULTS & DISCUSSION

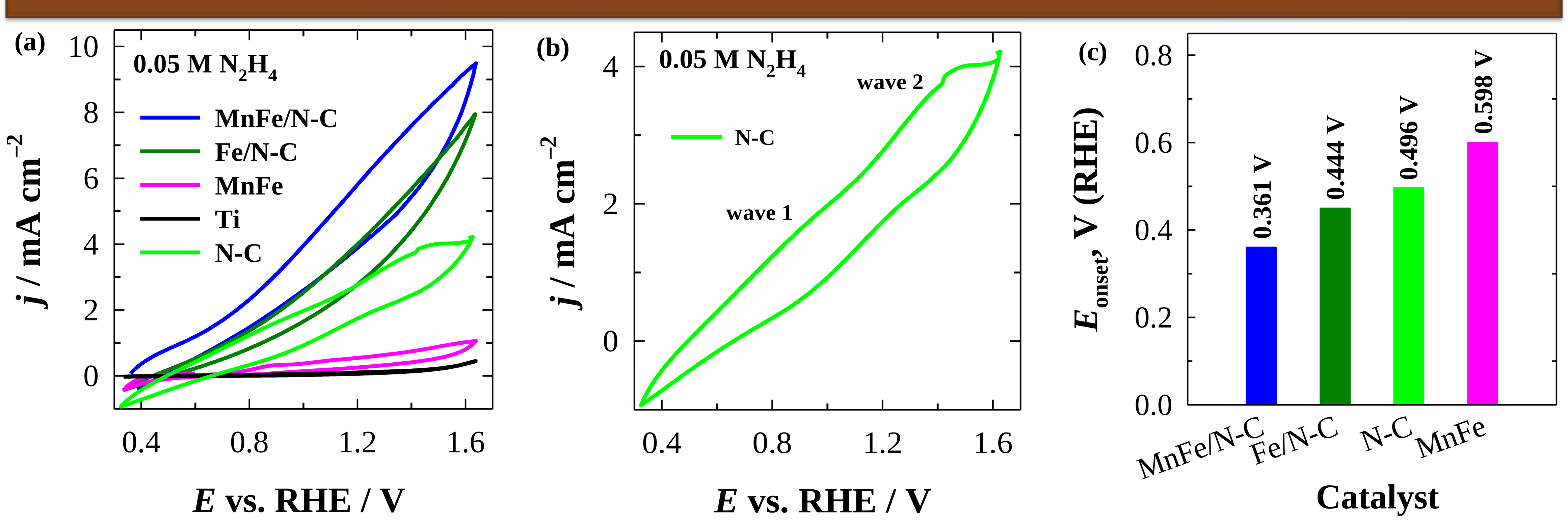

Fig. 2. Comparison of CV curves **(a)** and onset potentials **(c)** recorded for the MnFe/N–C, MnFe, Fe/N–C, N–C, and bare Ti catalysts in a 0.05 M N_2H_4 + 1 M KOH solution at a scan rate of 50 mV s^{-1}. CV recorded on N–C in the 0.05 M N_2H_4 + 1 M KOH solution **(b)**.

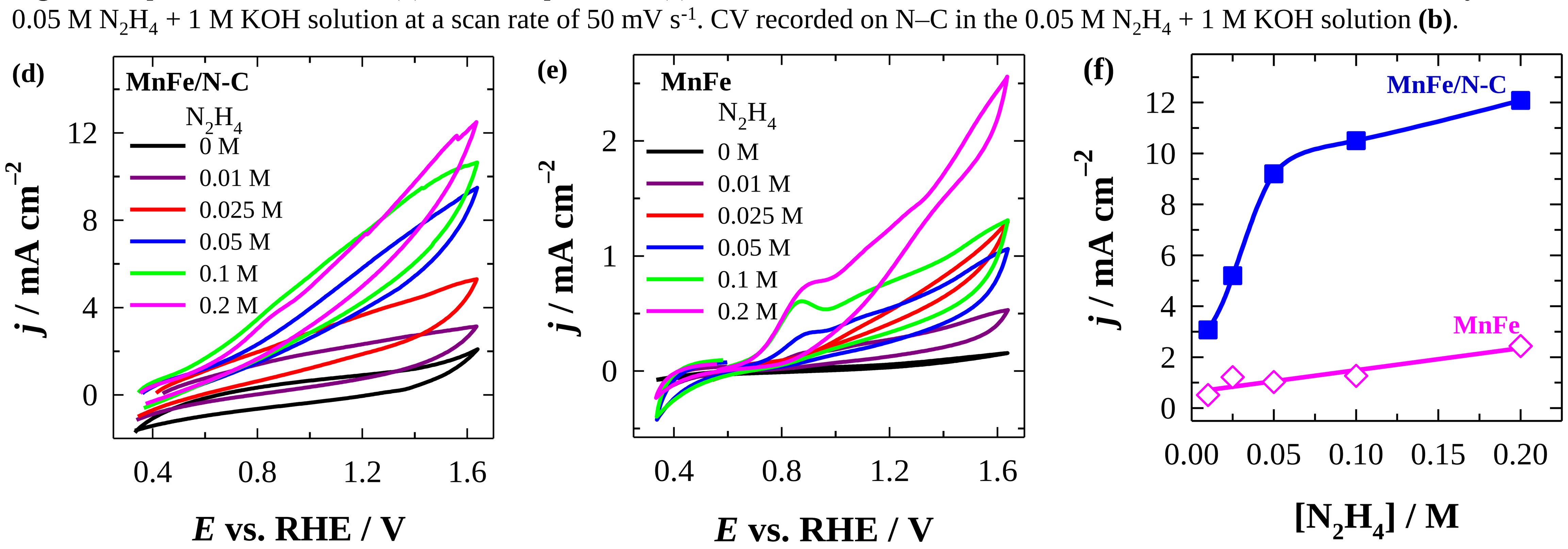

Fig. 3. CV curves recorded on MnFe/N–C **(d)** and MnFe **(e)** catalysts in a 1 M KOH solution containing different N_2H_4 concentrations at 50 mV s^{-1}. Dependence of the N_2H_4 oxidation current densities at MnFe/N–C and MnFe at +1.6 V on N_2H_4 concentration **(f)**.

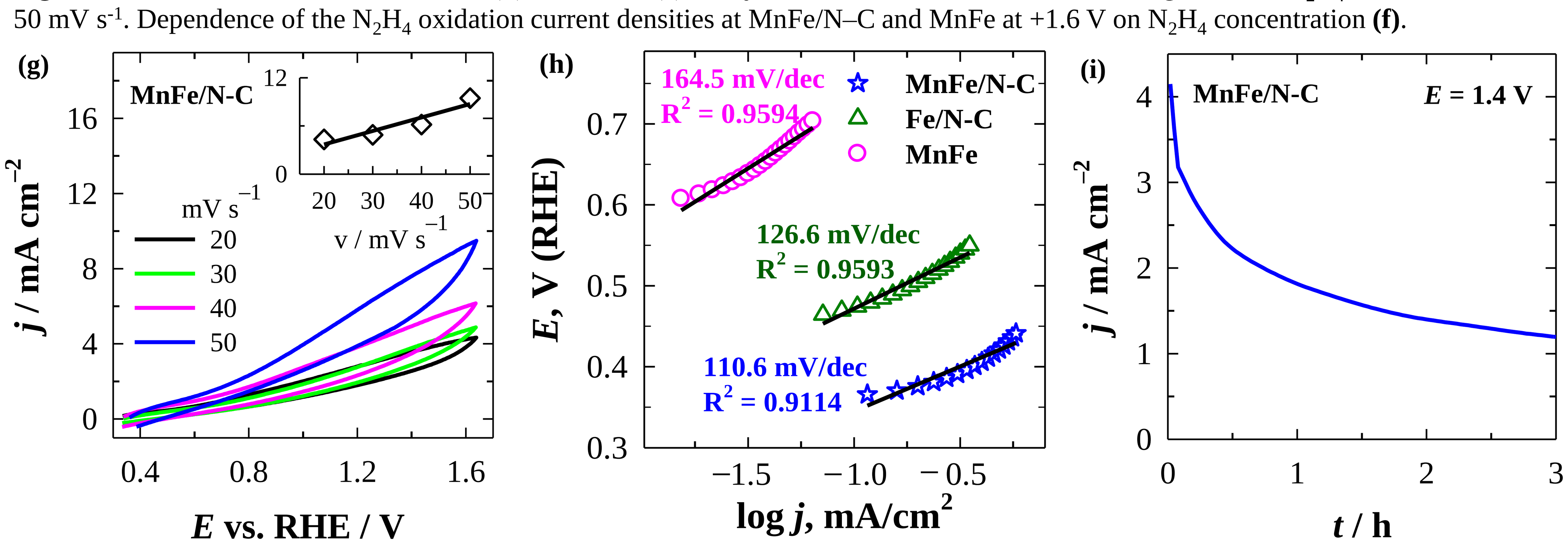

Fig. 4. CVs recorded on the MnFe/N–C catalyst at different scan rates in the 0.05 M N_2H_4 + 1 M KOH solution. The inset represents the dependence of current density at +1.6 V on scan rate **(g)**. Corresponding Tafel plots of investigated catalysts **(h)**. Chronoamperometric stability curve of MnFe/N–C catalyst at a constant potential of +1.4 V in a 0.05 M N_2H_4 + 1 M KOH solution **(i)**.

CONCLUSION

- Electrochemical analysis demonstrated that MnFe/N–C exhibited significantly enhanced hydrazine oxidation activity compared to other catalysts under study, due to the strong synergistic interaction between Mn, Fe, and the nitrogen-doped carbon framework.
- Concentration-dependent CV, Tafel, and scan-rate studies revealed accelerated reaction kinetics, improved charge-transfer behaviour, and excellent electrocatalytic efficiency toward the HzOR.
- Chronoamperometric measurements confirmed the outstanding electrochemical stability and durable catalytic performance of the MnFe/N–C electrocatalyst in alkaline hydrazine electrolyte.
- These results suggest that the MnFe/N–C catalyst is a highly promising non-noble-metal anode material for the HzOR in DHFCs. Moreover, the sustainable synthesis strategy presented in this work provides a simple, environmentally friendly, and cost-effective approach for developing highly efficient electrocatalysts for advanced DHFC applications.

REFERENCES

1) Vjūnova, K., Amber, H., Šimkūnaitė, D., Mockus, Z., Volperts, A., Plavniece, A., Dobele, G., Zhurinsh, A., Tamašauskaitė-Tamašiūnaitė, L. & Norkus, E. Manganese–Iron-Supported Biomass-Derived Carbon Catalyst for Efficient Hydrazine Oxidation. *Molecules* 2026, *31*(2), p.354.

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