ELECTROCHEMICAL FIXATION AND CONVERSION OF NITROGEN INTO AMMONIA BY $ZnMn_2O_4$ SPINEL DERIVED FROM SPENT BATTERY

IITM Technology Available for Licensing

Problem Statement

- In instance, the development of efficient catalyst for electrochemical synthesis of ammonia is a **great challenge** because of the rate of **ammonia formation and conversion efficiency** is **not satisfactory** due to competing hydrogen evolution reaction.
- Various catalysts have been explored for electrochemical ammonia synthesis by NRR,
- but most of the reported catalyst suffers in the selectivity for NRR.
- Hence, there is a need to address the issues.

Technology Category/ Market

Technology: Preparation of $ZnMn_2O_4$ through hydrothermal synthesis; **Industry & Application:** Material Science, Catalysts;
Market: The global **zinc oxide** market is projected at a **CAGR** of **5.7%** during 2024-**2030**

Technology

- Present invention describes a **method of electrochemical fixation** and **conversion of nitrogen into ammonia by spinel $ZnMn_2O_4$ derived** from spent **primary zinc carbon batteries.**
- Said method comprises a few steps explained hereinbelow:

Step 1

i)preparing spinel $ZnMn_2O_4$ from primary battery waste by hydrothermal route;

Step 2

ii)preparing $ZnMn_2O_4$ ink by ultrasonically dispersing 10 mg of $ZnMn_2O_4$ from step (i) 5 into a solution containing 1 mL of dimethylformamide (DMF) and 10µL of 1 wt.% PVDF binder;

Step 3

iii)drop-casting the obtained ink from step (ii) onto polished glassy carbon electrode (GCE);

- Further, the derived **$ZnMn_2O_4$** from primary battery waste acts as an **electrocatalyst** to increase the selectivity of the **nitrogen reduction reaction (NRR)** to yield ammonia at **low negative potential (<- 0.6 V)** by **suppressing** the **hydrogen** evolution reaction.
- The spinel **$ZnMn_2O_4$** derived from primary **zinc carbon batteries** prepared by a simple thermal route with calcination & filtration.

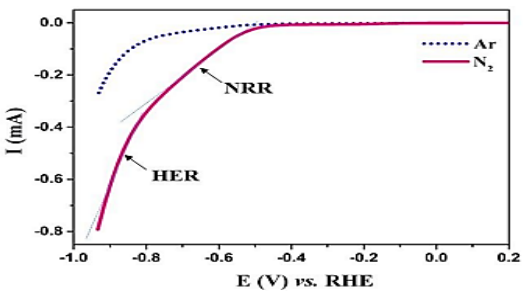

Fig.1 depicts LSV curves of the $ZnMn_2O_4$ catalyst on GCE measured in Ar and N_2 saturated 0.05 M H_2SO_4 (100 mV s-1)

Intellectual Property

IITM IDF Ref. 2211; Patent No:502600;

TRL (Technology Readiness Level)

TRL-4, Proof of concept tested in Lab;

Research Lab

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Key Features / Value Proposition

❖ *Technical Perspective:*

- ❖ $ZnMn_2O_4$ derived from the primary battery waste divulged to be a promising electrocatalyst for NRR, **achieving an NH_3 yield rate of 13.5µg h-1 mgcat-1** and with conversion efficiency **of ~ 51% at -0.5 V vs RHE.**
- ❖ $ZnMn_2O_4$ electrocatalyst derived from spent zinc-carbon battery is **highly active and selective for N_2 fixation.**
- ❖ Further, the **residue** collected by centrifugation is **dried at ~80 °C for 16h.** Later, it is **calcinated at 400 ºC for 6h with a 20 heating/cooling rate of (5°/min)** to obtain **$ZnMn_2O_4$**, wherein **570 µg/cm² of $ZnMn_2O_4$** is coated on glassy carbon electrode.
- ❖ Obtained **$ZnMn_2O_4$** are **mesoporous in structure.**
- ❖ Catalyst employs a dissociative method to produce **electrochemical ammonia** by nitrogen reduction.
- ❖ $ZnMn_2O_4$ can effectively suppress the **hydrogen evolution reaction** to increase the selectivity of the NRR at **low negative potential region (<-0.6 V)**.

❖ *Industrial Perspective*:

- ❖ The proposed process is **eco-friendly** and provides **efficient e-waste management** by obtaining $ZnMn_2O_4$ derived from the primary battery waste.
- ❖ Applicable in the field of **Material Science**.

Image

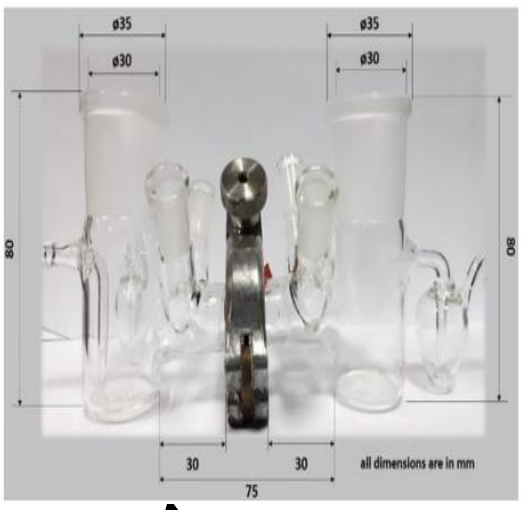

FIG 2: Illustrates H-cell showing dimensions in nm used for chronoamperometry study;

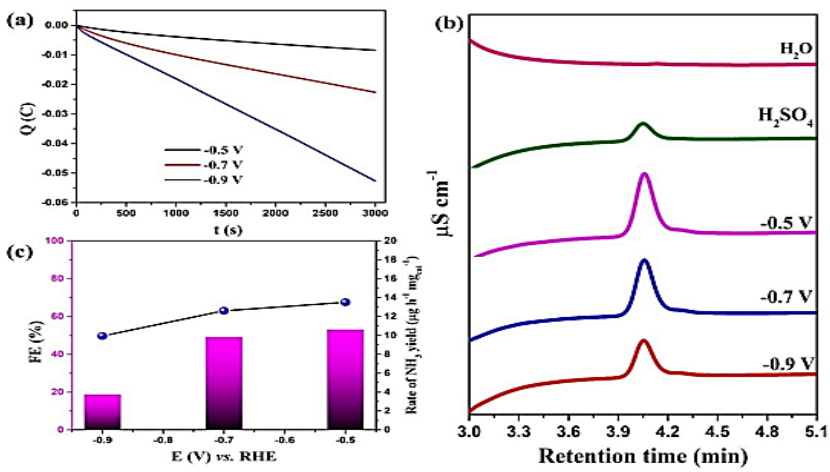

FIG. 3 shows (a) Q vs t plot of the ZnMn2O4 catalyst on GCE in N_2-saturated 0.05 M H_2SO_4 at various potentials; (b) IC of post electrolyte solutions and blank; (c) NH_3 yield rates and Faradaic efficiencies of the $ZnMn_2O_4$ catalyst on the GCE measured in N2-saturated 0.05 M H_2SO_4 electrolyte at different potentials.

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