

Lattice Oxygen Mediated ABO₃-type NdFeO₃ perovskite fabricated over multi-walled carbon nanotubes (MWCNTs) for electrochemical H₂O splitting and photo-induced degradation

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Abstract

The perovskite (PSK) ABO₃-type NdFeO₃ fabricated with multi-walled carbon nanotubes (MWCNTs) is being synthesized to target twin applications of water-splitting and photodegradation. Techniques, such as XRD, FTIR, SEM, TEM, and EDX were used for characterizing nanocomposite. NdFeO₃@MWCNTs has direct band gap energy of 2.8 eV and the indirect band-gap energy (E_g) = 2.2 eV is exposed through UV-Visible spectroscopy. Furthermore, with 5 mg catalyst dose, the pollutant removal rate comes out to be 97.88 %. Additionally, OER was performed in alkaline media using 1M KOH solution. NdFeO₃@MWCNTs electrochemical studies shows its potentiality as an electrocatalyst with an overpotential (η) of 362 mV with a current density of 10 mA/cm², along with low Tafel slope of 112 mV/dec. Moreover, the material owns an electrochemical surface area of (ECSA) of 110 cm² and decreased resistance to charge transfer R_{ct} of 1.5 Ω , and the low R_{ct} is ascribed to faster charge transfer rate. Hence, the low-cost NdFeO₃@MWCNTs nanocomposite compared to noble metals electrodes is not only a promising photocatalyst, but also an electrocatalyst for future applications in H₂ generation.

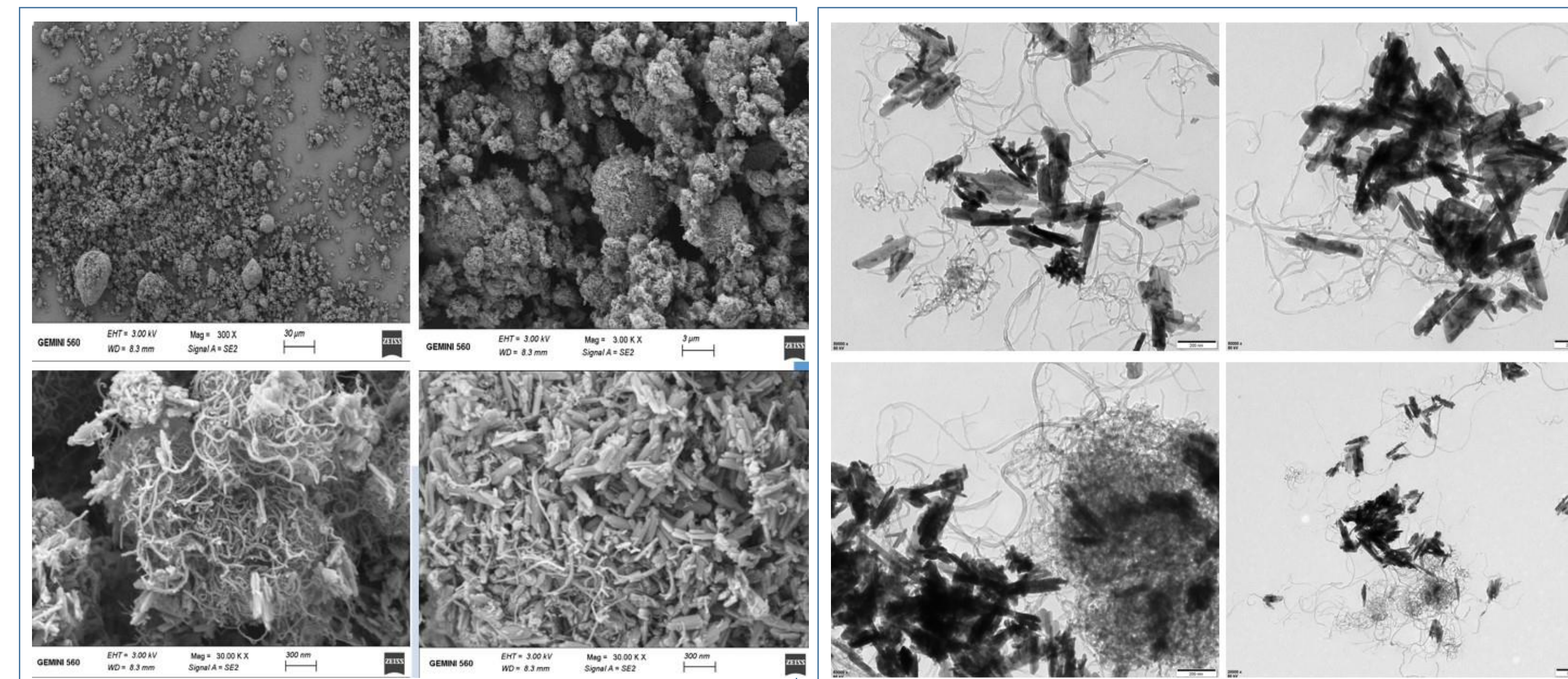
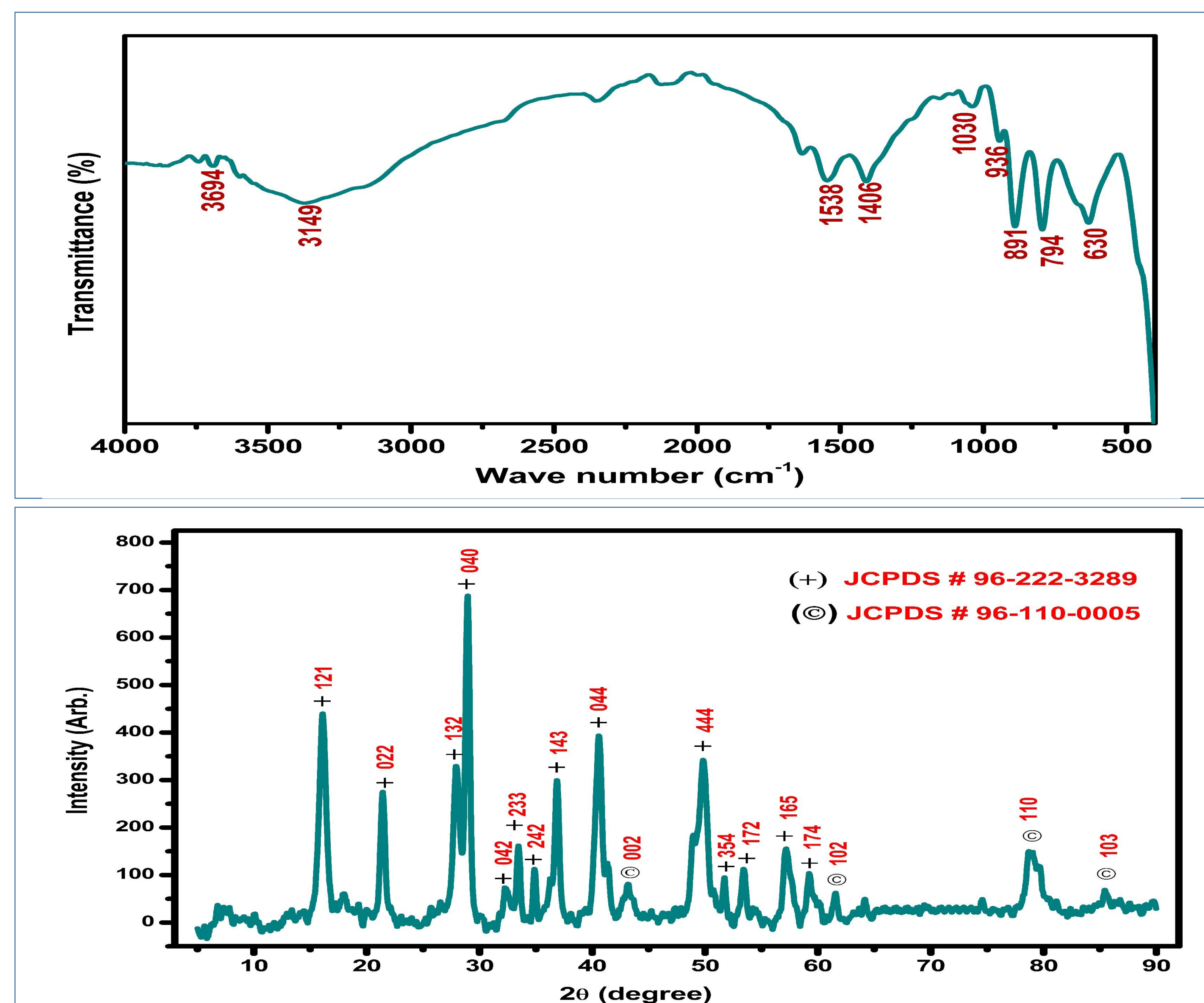
Introduction

Water – the labelled universal solvent – is currently the victim of life-threatening pollution-inducing agents making it ill-suited for consumption. For that, we need a photocatalyst for photodegradation. On the other hand, compelling need of clean and sustainable energy involve researchers to design potent electrocatalyst for carrying out H₂O fission. Hence, the material is also tested for its efficacy in overcoming energy barrier encountered in Oxygen evolution reaction (OER). Hence, ABO₃-type of NdFeO₃@MWCNTs nanocomposite is not only checked for photocatalysis, but also for electrocatalysis. Neodymium – a potent lanthanide – when modified into ferrite, enhances the compound's performance. However, there is an agglomeration of NdFe₂O₄ due to its size. This needs to be tackled. Hence, a dopant is welcomed to tackle aggregation of precursor material. MWCNTs have amazing electronic features, as well as outstanding mechanical tensile strength and is robust for the said application. In the ongoing study, a perovskite material has been designed using facile hydrothermal synthesis route. As a photocatalyst, it demonstrates greater than 95 % degradation proficiency. However, as an electrocatalyst, NdFeO₃@MWCNTs reflects overpotential of just 362 mV at 10 mAcm⁻² is observed. Hence, owing to dual functionality of nanocomposite, it can be served as a future photo-electrocatalyst.

Synthesis

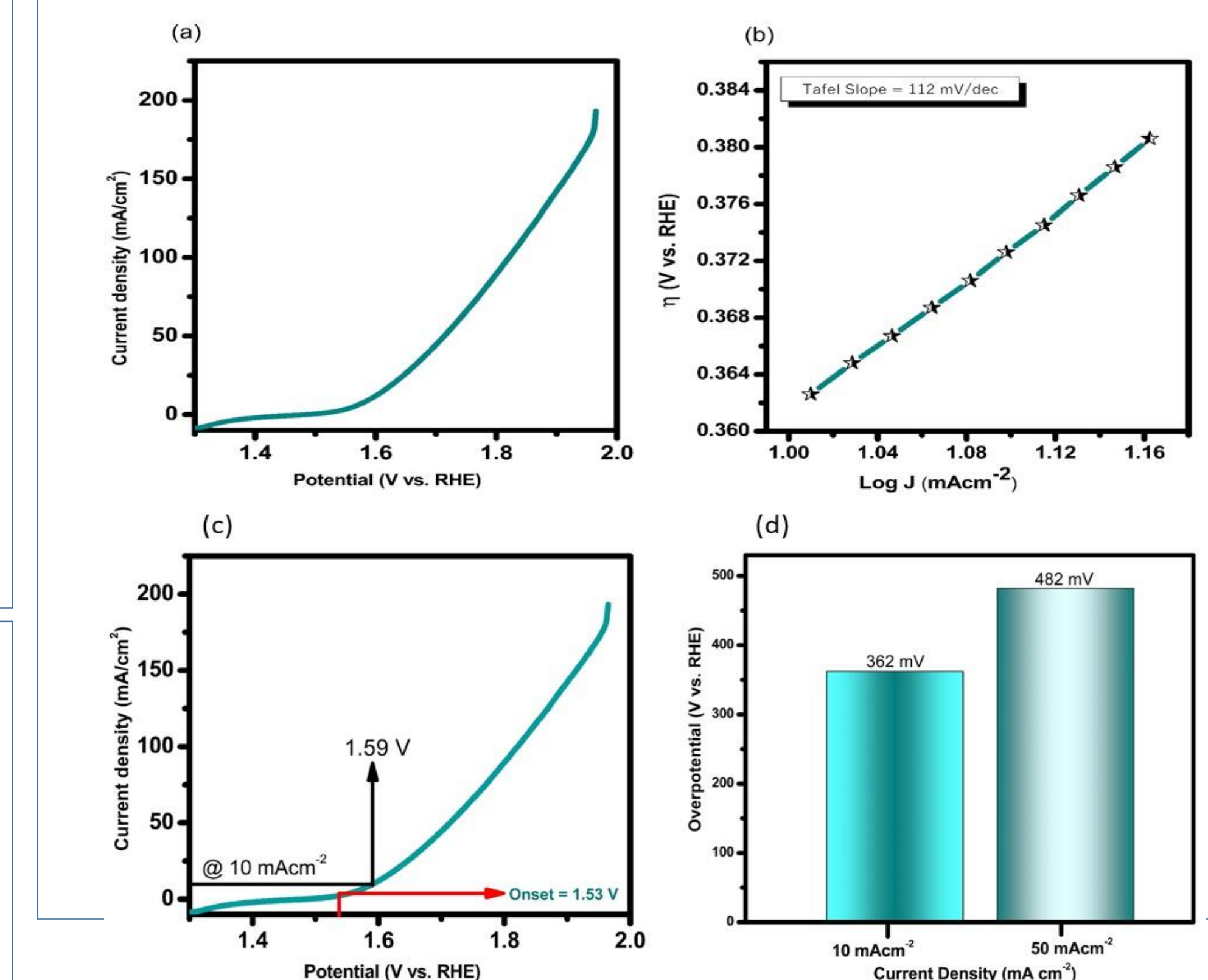


Characterization

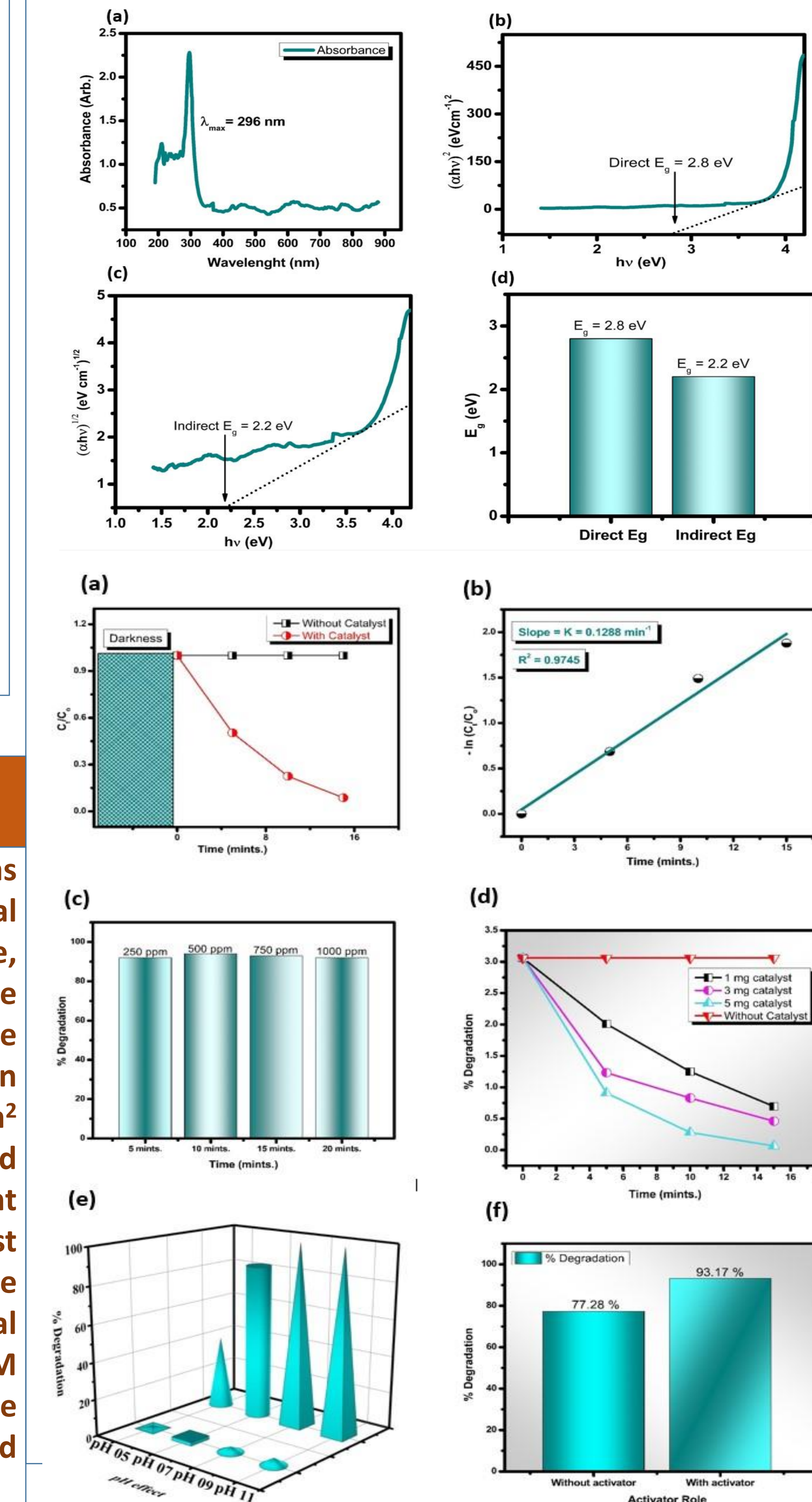


Applications

H₂O Splitting



Photodegradation



Conclusion

In conclusion, the fabricated nanomaterial not only functions as an electrocatalyst, but also as a photocatalyst. Electrochemical properties, such as overpotential (η), tafel slope, electrochemically active surface area (ECSA), and R_{ct} were calculated through different tests for the nanocomposite material. NdFeO₃@MWCNTs shows marvelous OER activity in 1M alkaline KOH environment having η of 362 mV at 10 mA/cm² current density, tafel slope of 112 mV/dec, ECSA of 110 cm², and R_{ct} of 1.5 Ω . Additionally, nanocatalyst demonstrates excellent degradation of 97.88 % with just 5 mg catalyst. The nanocatalyst was taken out through simple hydrothermal route, and the comparative low cost of our catalyst than that of noble metal catalysts makes it a worthy choice for use. XRD FTIR, SEM confirmed the synthesis of NdFeO₃@MWCNTs. Nonetheless, the nanocomposite can be employed as an efficient, durable, and facile electrocatalyst for future green energy generation.

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