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Notice for the PhD Viva Voce Examination

Ms Rinkoo Rajaram Bhabal, Registration Number: 2170197, PhD Scholar at the Department of Physics and Electronics, School of Sciences, CHRIST (Deemed to be University) will defend her PhD thesis at the public viva-voce examination on Saturday, 13 December 2025 at 10.00 am in Room No. 044, Ground Floor, R&D Block, CHRIST (Deemed to be University), Bengaluru - 560029, Karnataka, India.

Title of the Thesis : **Nanostructured Transition Metal Compound Derived from 2D MOF for H_2 Production by Electrolysis of Alkaline and Urea-Based Water**

Discipline : **Physics**

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The members of the Research Advisory Committee of the Scholar, the faculty members of the Department and the School, interested experts and research scholars of all the branches of research are cordially invited to attend this open viva – voce examination.

Registrar (Academics)

Place: Bengaluru
Date: 04 December 2025

ABSTRACT

Hydrogen production via water and urea electrolysis using renewable energy offers a sustainable pathway for clean energy generation. However, the widespread use of platinum- group metal (PGM) electrocatalysts, due to their high cost, limits large-scale deployment. This thesis focuses on developing low-cost, MOF-derived electrocatalysts based on earth-abundant transition metals for efficient hydrogen generation. In the first study, a CoPBO/Co3O4 composite was synthesized by solvothermal treatment of Co-MOF, followed by pyrolysis and chemical reduction. The catalyst exhibited bifunctional activity with low overpotentials (270 and 67 mV for OER and HER at 10 mA/cm2 in 1 M KOH). Enhanced performance was attributed to hydrogen spillover and oxygen vacancies. It showed good durability over 1000 cycles and maintained stability for 15 hrs. The second study involved introducing a conductive carbon matrix by pyrolyzing Co-MOF under nitrogen, forming a C@CoxOy-B/P composite.

This reduced the OER overpotential to 220 mV while maintaining HER activity (79 mV). Improved conductivity, reduced charge transfer resistance, and better adsorption/desorption kinetics were confirmed. The catalyst-maintained stability for 100 hrs and over 10,000 cycles, and achieved 500 mA/cm2 at 1.72 V with 86% energy efficiency at 60 °C in a zero-gap electrolyzer. The third study employed CoPBO/Co-MOF@NF for urea electrolysis, requiring only 1.32 V for overall splitting and 94 mV for HER at 100 mA/cm2. It outperformed water splitting in both natural cow urine (1.39 V) and synthetic (1.44 V) urine, with high durability and recyclability. In the final study, a bimetallic CoNiPBO/CoNi-MOF@NF catalyst achieved 100 mA/cm2 at 1.27 V for UOR, with water splitting requiring 1.68 V. Ni incorporation improved active site generation and reduced resistance. Overall, these studies demonstrate that MOF-derived catalysts are efficient, stable, and scalable alternatives to PGMs for green hydrogen production.

Keywords: *HER, OER, UOR, Electrochemical kinetics, Metal-organic framework, hydrogen spillover, oxygen vacancy*

Publications:

1. **Bhabal, R.**; Bhide, A.; Gupta, S.; Fernandes, R.; Patel, N. Maximizing Bifunctionality for Overall Water Splitting by Integrating H2 Spillover and Oxygen Vacancies in CoPBO/Co3O4 Composite Catalyst. Small Sci. 4 (2024). https://doi.org/10.1002/smsc.202400343
2. **Bhabal, R.**; Gupta, S. Gupta M.; Fernandes, R.; Patel, N. Bifunctional CoPBO/Co- MOF composite electrocatalyst for energy-efficient hydrogen evolution by urea- assisted water splitting, Int. J. Hydrogen Energy 116 (2025) 299–311.https://doi.org/10.1016/j.ijhydene.2025.03.100