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Notice for the PhD Viva Voce Examination

Ms Chrisma Rose Babu (Registration Number: 2170204), PhD Scholar at the School of Sciences, CHRIST (Deemed to be University), Bangalore Central Campus will defend her PhD thesis at the public viva-voce examination on Tuesday, 08 April 2025 at 10.30 am in Room No. 044, Ground Floor, R & D Block, CHRIST (Deemed to be University), Bengaluru - 560029, Karnataka, India.

Title of the Thesis	:	**Investigation of Graphene-Transition Metal Oxide Nanocomposites for High Performance Supercapacitors**
Discipline	:	**Physics**
External Examiner - I	:	**Dr Manoj Neergat** Professor Department of Energy Science and Engineering IIT - Bombay Mumbai - 400076, Maharashtra
External Examiner – II	:	**Dr Cyriac Joseph** Professor School of Pure and Applied Physics M G University Kottayam - 686560, Kerala
Supervisor	:	**Dr Anila E I** Professor Department of Physics and Electronics School of Sciences CHRIST (Deemed to be University) Bengaluru – 560029, Karnataka

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: 26 April 2025

ABSTRACT

The rising global demand of reliable and portable power sources leads to the emergence of energy storage devices. Today, electrical energy storage has been solely found in the area of batteries and capacitors. Supercapacitors bridge the functional gap between traditional electrolytic capacitors and rechargeable batteries. They are well suited for applications that expect frequent charge discharge cycles, extreme operating temperatures and rapid discharge of high amount of energy. Presently, supercapacitors are being fabricated using activated carbon as an electrode material due to its large specific surface area, low price, etc. But at high current densities it has low capacitance stability which limits its use at industrial level. For the advancement in energy storage systems, we require an ideal electrode material with high capacitance and wide potential window. Among the two-dimensional materials, graphene and its derivatives are considered as the most desired materials for the futuristic applications. The coupling of graphene with transition metal oxides would effectively improve the specific capacitance, cycling stability, energy and power density of the supercapacitor device. In the current doctoral research, we emphasized on graphene-transition metal oxide nanocomposite as an ideal electrode material with high specific capacitance, cyclic stability and energy density to fabricate the symmetric supercapacitors for an application level use.

The present work investigates the electrochemical properties of prototype symmetric supercapacitor devices using transition metal oxide electrodes and electrodes fabricated using nanocomposites of reduced graphene oxide (rGO) and transition metal oxides (TMOs). The transition metal oxides studied are cobalt oxide (Co3O4), molybdenum trioxide (MoO3), and manganese oxide (Mn3O4), which were synthesized using the hydrothermal method. The metal oxides and their composites were characterized based on their structural, surface, morphological, compositional, and electrical properties. Co3O4 was primarily analysed for its electrochemical activity and thus fabricated a prototype symmetric supercapacitor device. The excellent redox activity of cobalt oxide promotes the practical applications in supercapacitors with their high energy density. The incorporation of rGO into the Co3O4 matrix improved the overall electrochemical performance of the electrode. The specific capacitance (Csp) and energy density (ED) improved from 552.05 Fg-1 and 196.28 W h kg-1 for pure Co3O4 to 821.68 Fg-1 and 292.15 W h kg-1 for the rGO-Co3O4 nanocomposite at a current density of 3 Ag-1. MoO3 is an attractive pseudocapacitive material due to its ability to facilitate the insertion or de-insertion of ions during electrochemical reactions. The electrode made up of MoO3 was studied for understanding the electrochemical behaviour. The introduction of rGO into the MoO3 matrix enhances the properties of the nanocomposites. The Csp and ED for pure MoO3 electrode at 1 Ag-1 were obtained as 290 Fg-1 and 40.27 W h kg-1, respectively. Upon incorporation of rGO, Csp increased to368.99 Fg-1, while ED decreased to 25.62 W h kg-1.

Hausmannite, Mn3O4, has drawn particular attention due to its distinctive structural features along with fascinating electrochemical properties. The incorporation of rGO further enhances the electrochemical behaviour of the composite electrode. The Csp and ED of Mn3O4 (67.26 Fg-1 and 9.34 W h kg-1, respectively) were significantly improved by the addition of rGO reaching 277.27 Fg-1 and 38.5 W h kg-1. In terms of overall performance in aqueous symmetric supercapacitor devices of the current study, the rGO-Co3O4 nanocomposite exhibited superior results demonstrating great potential for practical supercapacitor application.

Keywords: *Reduced graphene oxide, cobalt oxide, molybdenum trioxide, manganese oxide, symmetric supercapacitor, energy density, power density, cyclic stability, specific capacitance.*

Publications:

1. **R. B. Chrisma**, R. I. Jafri, and E. I. Anila, "A review on the electrochemical behavior of graphene–transition metal oxide nanocomposites for energy storage applications", *J. Mater. Sci.*, 2023, doi: 10.1007/s10853-023-08386-7.
2. **R. B. Chrisma**, A. V. Avani, and E. I. Anila, "Effect of pH on the structural and optical properties of cobalt oxide nanoparticles synthesized by hydrothermal method", *Mater. Today Proc.*, no. 3, pp. 0–4, 2023, doi: 10.1016/j.matpr.2022.11.332.
3. **C. R. Babu**, A. V. Avani, S. Shaji and E. I. Anila "Electrochemical characteristics of Co3O4 nanoparticles synthesized via the hydrothermal approach for supercapacitor applications", *J. Solid State Electrochem.*, 2023, doi: 10.1007/s10008-023-05744-y.
4. **C. R. Babu**, A. V Avani, T. S. Xavier, M. Tomy, S. Shaji, and E. I. Anila, "Symmetric supercapacitor based on Co3O4 nanoparticles with an improved specific capacitance and energy density," *J. Energy Storage*, vol. 80, no. August 2023, p. 110382, 2024, doi.org/10.1016/j.est.2023.1103822.
5. **C. R. Babu**, A. V. Avani, and E. I. Anila, "Temperature-Induced variations in the Structural , Morphological and Optical features of Cobalt Oxide Nanoparticles Synthesized via Hydrothermal method," Inorg. Chem. Commun., vol. 167, no. June, p. 112780, 2024, doi: 10.1016/j.inoche.2024.112780.