Synergistic Ce/Ag/N-doped ZnO-MWCNT Nanocomposites for Efficient Photocatalytic Wastewater Remediation with Visible Light

Manisha Dagar[1], Suresh Kumar[1], Amit Jain[2,], Anil Vohra[1], Manohar Singh[3], Jasvir Dalal [4, *], Sanjeev Kumar[5], Sandeep Kaushal[6]*

[1] Department of Electronic Science, Kurukshetra University Kurukshetra-136119, India
[2] Department of Electronics, Rajdhani College, University of Delhi, Delhi-110015, India
[3] Department of Physics, Motilal Nehru College, University of Delhi, Delhi-110021, India
[4] Department of Physics, Rajdhani College, University of Delhi, Delhi-110015, India
[5]Department of Physics, Chandigarh University, Gharuan, Mohali, 140413, India
[6]Regional Institute of Education, NCERT, Ajmer, Rajasthan, India

2. Experimental detail

2.1 Photocatalytic Activity Measurement

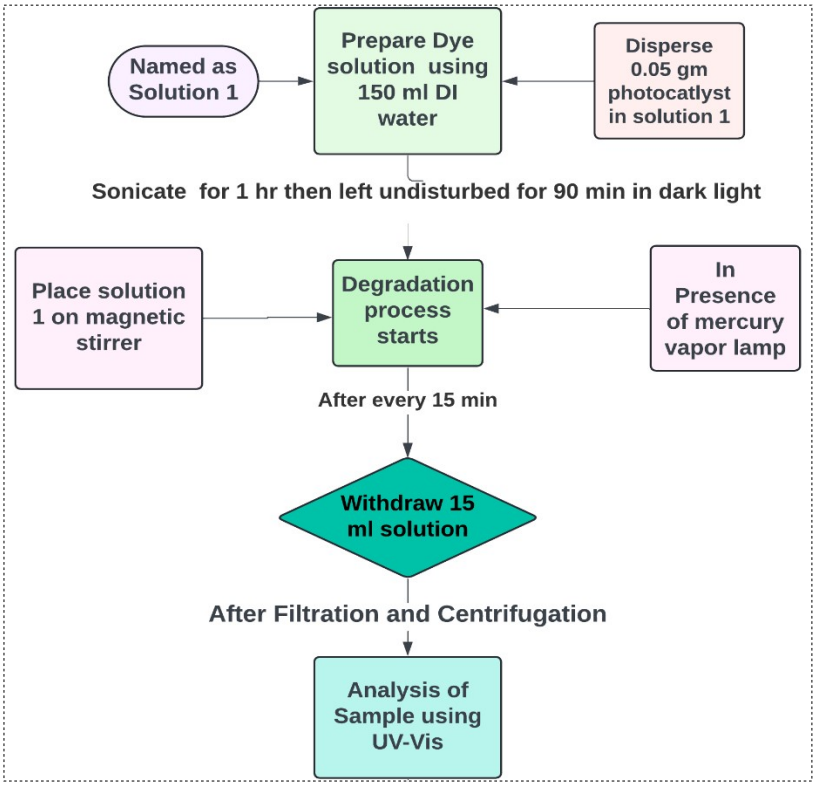

Figure S1: *Flowchart depicting the experimental procedure for photocatalytic degradation of Congo Red and Methylene Blue dyes.*

2.2 Characterizations techniques

* Corresponding Authors Email: jasvirdalal2012@gmail.com (J. Dalal), amitjainudsc@gmail.com (A. Jain)

The Ag/Ce/N-doped ZnO-MWCNT nanocomposites were characterized using various advanced analytical techniques. Field Emission Scanning Electron Microscopy (FE-SEM, Zeiss EVO40) provided high-resolution images to examine the surface morphology. The crystallographic properties were studied through X-ray Diffraction (XRD, PANalytical X'pert PRO), confirming the phase purity and crystallite size. Optical properties were assessed using UV-Vis Diffuse Reflectance Spectroscopy (UV-Vis DRS, Perkin Elmer Lambda 20) to determine the bandgap and visible light absorption, while Photoluminescence (PL) Spectroscopy (Perkin Elmer LS55) analyzed the charge carrier recombination rates, indicating enhanced photocatalytic activity. The surface area and porosity of the nanocomposites were measured using Brunauer-Emmett-Teller (BET) analysis (Quantachrome NovaWin), confirming a mesoporous structure with increased surface area. Energy Dispersive X-ray Spectroscopy (EDX, PANalytical Epsilon 5) was utilized to map the elemental composition and distribution of Ag, Ce, N, Zn, O, and C, ensuring homogeneity in doping across the nanocomposites. These techniques collectively provided a detailed understanding of the structural, optical, and surface characteristics of the synthesized nanocomposites.