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Rutin-Mediated Synthesis of Zr-Mg@N-rGO Nanocomposites with Potent Antioxidant and Antimicrobial Activities

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In present study, a novel Zr-Mg@N-doped reduced graphene oxide (N-rGO) nanocomposite was synthesized using a green, sustainable approach. Rutin, a natural polyphenolic flavonoid, was employed as a reducing and stabilizing agent, enabling the eco-friendly fabrication of the nanocomposite without the use of harsh chemicals. The synthesized material was thoroughly characterized using multiple techniques. UV-visible spectroscopy confirmed nanoparticle formation and optical properties; FT-IR analysis revealed the presence of functional groups associated with rutin and metal-oxygen bonds; XRD patterns indicated the crystalline nature of ZrO_2 and MgO phases embedded within the rGO matrix; SEM and EDAX analyses confirmed the morphological features and elemental composition, while DLS and zeta potential measurements indicated good colloidal stability and moderate mono dispersity. The nanocomposite exhibited significant bacterial (*Actinomyces israelii*, *Proteus vulgaris*) and fungal (*Candida albicans*, *Trichoderma*) pathogens with increasing inhibition zones observed at higher concentrations. Antioxidant potential was evaluated *via* DPPH, H_2O_2 and NO assays, where the nanocomposite demonstrated dose-dependent free radical scavenging activity, attributed to the presence of rutin and synergistic metal-oxide interaction. Overall, the synthesized Zr-Mg@N-rGO nanocomposite offers a multifunctional platform with potential applications in biomedical, environmental and optoelectronic fields.

Keywords: Doped reduced graphene oxide, Green synthesis, Rutin, Biological activity, Multifunctional properties.