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Development of Biomorphic Magnesium-Zinc Oxide Nanofibrous Using Eggshell Membrane as Bio-template: A Review

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Structured Abstract

Background: Zinc oxide (ZnO) nanomaterials are widely studied due to their excellent photocatalytic, antibacterial, and electronic properties. By altering the bandgap and improving charge carrier behavior, magnesium doping has been shown to significantly improve ZnO's optical and functional performance. However, high temperatures, hazardous chemicals, and energy-intensive procedures are common in conventional synthesis methods, raising questions about sustainability and the environment. Utilizing natural bio-templates, biomorphic synthesis has recently surfaced as a viable green substitute. A proteinaceous biowaste material with a three-dimensional fibrous shape, eggshell membrane (ESM) has great potential as a natural scaffold for the creation of metal oxide nanostructures. This study evaluates ESM-assisted biomorphic synthesis for magnesium-doped zinc oxide (Mg-ZnO) nanofibrous structures.

Methods: The study adopts a theoretical, review-based methodology through a critical analysis of peer-reviewed journal articles published between 2020 and 2024. The use of green or biomorphic synthesis techniques such as the usage of eggshell membrane as a bio-template, and the documented structural, morphological, and functional characteristics of ZnO and Mg-ZnO nanomaterials were taken into consideration when choosing appropriate literature. The synthesis conditions, morphology, and material performance as documented in the literature were the main areas of comparison between biomorphic synthesis pathways and traditional fabrication methods.

Results: The reviewed studies indicate that ESM-assisted synthesis successfully produces nanofibrous ZnO and Mg-ZnO structures with high surface area and well-defined morphology, as demonstrated through SEM and TEM analyses. Magnesium was successfully incorporated into the ZnO-lattice without changing the crystal structure, according to XRD data published in the literature. Bandgap tuning in Mg-ZnO, which improves photocatalytic performance, is further revealed by optical experiments. When compared to traditional synthesis methods, biomorphic synthesis delivers lower energy consumption, less environmental impact, and better sustainability, according to comparative data from earlier studies displayed in tables and figures.

Conclusion: In conclusion, the findings from the reviewed literature demonstrate that the eggshell membrane is an effective and sustainable bio-template for the biomorphic synthesis of Mg-ZnO nanomaterials. This method improves structural and functional qualities while promoting the development of green nanotechnology. For upcoming experimental validation and application-focused research employing waste-derived bio-templates, the study offers a solid theoretical basis.

Keywords: Magnesium-doped zinc oxide, Eggshell membrane, Biomorphic synthesis, Green nanotechnology, Nanofibrous structures

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