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Green Route Synthesis for ZnO Nanoparticles Using Functionalized Natural Fiber for Wastewater Treatment

Abstract: Nanotechnology is emerging filed and capable to tackle this challenge but facing bigger challenge is the separation of nanoparticle from waste water after treatment. In this regard, our translational novel research focuses on the innovative use of natural materials for wastewater treatment, highlighting the synthesis of engineered nano-functionalized natural fiber membranes. This study presents a novel method for creating large-scale, continuous arrays of zinc oxide (ZnO) nanorods on substrates derived from the leaves of Sansevieria trifasciata. Utilizing a two-step low-temperature hydrothermal growth strategy, we first applied a ZnO nanosol coating onto the fiber through a sol-gel dip-coating technique, followed by a hydrothermal growth process that resulted in vertically oriented, densely packed, and uniform ZnO nanorods with a wurtzite crystal structure. This systematic approach encompasses all stages, from the extraction of natural fibers to their subsequent surface modification, providing a clear pathway for developing high-performance materials. Notably, our method is economical, straightforward, and requires relatively low synthesis temperatures while yielding a uniform distribution of nanorods. The substrate's inherent properties-lightweight, inexpensive, abundant, biodegradable, porous, and environmentally friendly-enhance its appeal for practical applications. Comprehensive investigations into the impact of growth time on the evolution of ZnO nanostructures revealed significant insights into the morphological and structural characteristics of the fibers. The resulting nano-functionalized fibers demonstrated exceptional photocatalytic and self-cleaning capabilities for the degradation of organic dyes, drugs as well as impressive antimicrobial activity against. Moreover, the functionalized membranes exhibited remarkable mechanical strength and excellent recyclability across multiple usage cycles. These ZnO nanomaterial-functionalized fibres will pave the way for a diverse range of applications, including water purification, biomedical uses, flexible electronics, and smart textiles. This work not only addresses critical environmental challenges but also sets the stage for advancements in materials science that prioritize ecological integrity.

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