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A Critical Review on Nanoparticle Synthesis: Physical, Chemical, and Biological Perspectives

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Abstract: Nanoparticles (NPs) are ultra-small particles ranging from 1 to 100 nanometers, exhibiting unique physicochemical properties such as high reactivity, enhanced strength, stability, and increased surface area. These properties make nanoparticles highly valuable across diverse fields, including medicine, environmental sustainability, agriculture, industry, and pollution remediation. Nanotechnology has emerged as a pivotal multidisciplinary field, driving advancements in nanomaterial synthesis. Various synthesis methods are employed, primarily categorized into physical, chemical, and biological (green) approaches. Traditional physicochemical methods often raise environmental concerns due to toxic byproducts and the necessity of reducing and stabilizing agents. In contrast, biological synthesis methods utilizing plant extracts, bacteria, fungi, and yeast offer a more eco-friendly alternative. This review provides an in-depth comparison of physical, chemical, and biological nanoparticle synthesis techniques, highlighting their advantages, limitations, and potential applications.

Keywords: Nanoparticles, Nanotechnology, Physical Synthesis, Chemical Synthesis, Green Synthesis



