Chapter 5
Role of Doped Nanomaterials in the Synthesis and Characterization of Bio-Organic-Inorganic Composites

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ABSTRACT

The bio-inspired synthesis of organic and inorganic nanomaterials has gained significant attention for creating hierarchical structures. Blending these materials enhances nanocomposite membranes for filtration and sensing, with elements like Co^{2+} and Mn^{2+} improving their properties. Many organisms, such as mollusks and sponges, naturally produce organic-inorganic composites through biomineraliza-

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tion. Biomolecules—proteins, peptides, DNA, RNA, and polysaccharides—guide nucleation, stabilization, and assembly of inorganic frameworks. Proteins aid in forming organized nanostructures, while peptides offer customizable designs for tissue engineering and nanotechnology. Doping is widely used to tailor nanoparticles' electrical, optical, and morphological properties. Doped nanomaterials, like Ag-N-TiO_2 and ZnO composites, exhibit antimicrobial efficacy, while co-doping strategies further enhance microbial inhibition. This review explores biomolecules' synergistic role in nanotechnology for sustainable, multifunctional materials in industry and biomedicine.

INTRODUCTION

Doping is a common method for customizing nanoparticles to continue improving their electrical, optical, and morphological properties. Doping may help boost the antimicrobial effect, according to a few earlier studies (Wei et al., 2011). The doping of nanomaterials provides a multi-functional method of fine-tuning the characteristics of the materials while retaining their high surface areas. Through the doping of various elements, the electronic, optical, photochemical, photo-electrochemical, photocatalytic, and photo-excited relaxation properties can be tuned in the desired direction (Bayne et al., 1998). Semiconductors for particularly sensitive sensing applications can be created by doping with nanoparticles. Now, semiconductor sensors can be made with extremely high accuracy, reliability, and precision by doping with nanoparticles. This article will review the position of several dopant contaminants, including transition metals, rare earth minerals, Co^{2+}, $Ni^{2+,}$ and Mn^{2+} (Drummond & Bapna, 2003).

There are methods by which microorganisms regulate self-gathered hierarchical organic or inorganic frameworks. The protoplasmic surface boundary layer is where cells normally find inorganic materials. Subsequently, the interfacial stress between the cell lines, vesicles, and the ongoing mineralization process helps regulate biomineral formation (Ferracane, 2011). Inorganic materials can obtain structural information directly or indirectly from cellular composition or by modification of their inorganic framework. The use of biomimetic mineralization is broadening into previously unavailable markets, such as the innovation of lithium-ion battery component materials and exquisitely structured composite materials utilizing carbon dioxide gas.

The organisms that generate organic and inorganic bio-composites are equivalent to mollusks that generate nacres or shells with a crystalline state of calcium carbonates (Hosoya et al., 2011). The silica spicules manufactured by marine sponges can grow up to 3 meters in length and have been shown to exhibit light-guiding