Characterization of ZnO and Mn-doped ZnO nanoparticles and their antimicrobial activity

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ABSTRACT

Zinc oxide nanoparticles (ZnO NPs) are commonly used in optoelectronic device, pharmaceuticals, food, textile, energy, rubber, electrical engineering, and agriculture applications. This study aimed to study the effect of Mn doping on the physical traits and the antimicrobial activity of ZnO NPs. Five Mn-doped ZnO NPs samples were prepared and characterized with a varied Mn content ranging from 0.01 to 0.09. A low-cost and suitable method for synthesizing Mn-doped ZnO NPs with a semispherical shape is presented without using a surfactant. The antimicrobial activity of the given NPs was determined against pathogenic microorganisms, including Gram-positive bacteria (i.e., *Staphylococcus aureus* and *Bacillus subtilis*), Gram-negative bacteria (i.e., Escherichia coli), and fungi (i.e., *Candida albicans*). The antimicrobial activity was evaluated using the well difusion method, minimum lethal concentrations (MLC) determination, and microbial cell viability assay. X-ray diffraction results confirm that the samples have a single-phase quartzite structure, where the crystal size decreases with an increasing dopant concentration. This decrease occurs due to the small ionic radius of Mn ions compared to Zn ions.

The morphology on the surface shows further that the samples had a spherical shape with an average particle size of 40 nm. The optical bandgap of ZnO NPs decreases with Mn doping, which is attributed to the s–d and p interaction. All tested NPs displayed a higher antimicrobial activity with better efficiency in the case of Mn-doped ZnO NPs compared to standard antibiotics (i.e., cytisoside, fuconazole, and ampicillin). The MLC of ZnO NPs was 160 µg/mL for all tested microorganisms. The best MLC was 40 µg/mL of Zn0.93Mn0.07O, Zn0.95Mn0.05O, and Zn0.91Mn0.09O for E. coli, B. subtilis, and *C. albicans*, respectively. Compared to ZnO NPs, no better effect on MLC was found against Staphylococcus aureus. It is concluded that Mn doping enhanced the antimicrobial activity of Zn1−xMnxO NPs, which could be used as a more efficient antibacterial and antifungal agent compared to pure ZnO NPs.

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