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Green Synthesis of Silver-Decorated Magnetic Particles for Efficient and Reusable Antimicrobial Activity

Sachin V. Otari [1], Vipin Chandra Kalia [1], Aarti Bisht [1], In-Won Kim [1,2] and Jung-Kul Lee [1,*]

1 Department of Chemical Engineering, Konkuk University, Seoul 05029, Korea; sachinotari169@gmail.com (S.V.O.); vckalia@gmail.com (V.C.K.); aartibisht94@gmail.com (A.B.); inwon@konkuk.ac.kr (I.-W.K.)
2 Institute of SK-KU Biomaterials, Konkuk University, Seoul 05029, Korea
* Correspondence: jkrhee@konkuk.ac.kr; Tel.: +82-2-450-3505

Abstract: Metal and metal hybrid nanostructures have shown tremendous application in the biomedical and catalytic fields because of their plasmonic and catalytic properties. Here, a green and clean method was employed for the synthesis of silver nanoparticle (Ag NP)-SiO_2-Fe_2O_3 hybrid microstructures, and biomolecules from green tea extracts were used for constructing the hybrid structures. The SiO_2-Fe_2O_3 structures were synthesized using an ethanolic green tea leaf extract to form Bio-SiO_2-Fe_2O_3 (BSiO_2-Fe_2O_3) structures. Biochemical studies demonstrated the presence of green tea biomolecules in the BSiO_2 layer. Reduction of the silver ions was performed by a BSiO_2 layer to form Ag NPs of 5–10 nm in diameter in and on the BSiO_2-Fe_2O_3 microstructure. The reduction process was observed within 600 s, which is faster than that reported elsewhere. The antimicrobial activity of the Ag-BSiO_2-Fe_2O_3 hybrid structure was demonstrated against *Staphylococcus aureus* and *Escherichia coli*, and the nanostructures were further visualized using confocal laser scanning microscopy (CLSM). The magnetic properties of the Ag-BSiO_2-Fe_2O_3 hybrid structure were used for studying reusable antimicrobial activity. Thus, in this study, we provide a novel green route for the construction of a biomolecule-entrapped SiO_2-Fe_2O_3 structure and their use for the ultra-fast formation of Ag NPs to form antimicrobial active multifunctional hybrid structures.

Keywords: hybrid structure; green synthesis; antimicrobial activity

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1. Introduction

For the last seven decades since the discovery of antibiotics, their uncontrolled use has led to a generation of antibiotic-resistant strains that are unresponsive to currently available conventional antibiotics, creating a major concern for the health sector [1,2]. More new-generation antibiotics have been introduced in the field of medicine; however, the toxicity and adverse effects of these antibiotics are worrying factors for implementation [3,4]. Therefore, alternate therapeutic strategies have been studied for the last two decades, and several types of nanomaterials have been tested for their antimicrobial activity that is nontoxic to human and nonhuman hosts [5–7]. Silver nanoparticles (Ag NPs) have been extensively studied because of their effective antimicrobial activity known since ancient times [8]. A detailed study of the antimicrobial activity of Ag NPs against a wide range of pathogenic microorganisms was performed; it was demonstrated that the Ag NPs act by releasing Ag+ ions, which act on bacteria through reactive oxygen species [8]. The antimicrobial activity of the Ag NPs decreases with aggregate formation, where Ag NPs form a bulky material that makes it difficult for them to act on small bacteria and viruses [9–11]. In addition, Ag NPs are not only toxic to the bacteria but also to mammalian cells, which is a major concern for the therapeutic use of Ag NPs [12]. Therefore, several functionalizations or immobilization procedures have been used to enhance their antimicrobial efficiency and avoid the aggregation and toxicity of Ag NPs before release into the environment [13]. Currently, extensive research is ongoing for the