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Synthesis, Characterization and Antimicrobial Activity of Poloxamer-Assisted Copper Nanoparticles: Investigating the Effects of Different Concentrations of Poloxamer 407

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The development of copper nanoparticles (CuNPs) with antimicrobial activities shows high potential for various clinical applications. We herein synthesized Poloxamer(P407)-assisted CuNPs with improved oxidative stability using a simple process that included environment friendly Vitamin C (ascorbic acid) as a reducing agent and nontoxic P407 polymer as a stabilizing agent. To optimize the reducing agent, the effect of the molar ratio of ascorbic acid-to-Cu^{2+} salt was investigated through fluorescence measurements. The UV-Visible spectrum presented that the inclusion of P407 improved the efficiency of CuNPs synthesis. In addition, DLS demonstrated that when the concentration of P407 was increased, the particle size of CuNPs was reduced. According to the XRD patterns, all the CuNPs are fcc-structured and crystalline. The FE-SEM and EDX images indicated the cubic morphology and the absence of any oxides of copper. The synthesized CuNPs have different particle sizes, showing strong antimicrobial activities against Gram-negative and Gram-positive bacteria as well as funguses. Our findings suggest that P407-assisted CuNPs could be a new way to fight both human and plant pathogens.

Introduction

Nowadays, nanoparticles are being employed in a variety of domains such as biology, physics, chemistry, engineering, and so on..[1,2] The key benefit of nanoparticles is that their characteristics differ significantly from those of bulk materials of similar composition. Nanoparticles' properties can easily be modified by altering their shape, size, and chemical conditions.[3] Nanoparticles, especially metal nanoparticles (MNPs), have been getting a lot of attention from scientists because they can be used in a lot of different ways, from catalysis to nanofluids, to thermal conductors to optical compounds, and magnetic devices to environmental remediation.[4–6] When compared to metallic gold and silver nanoparticles, copper's natural abundance, inexpensive, and multiple practical and easy ways of synthesizing Cu-based nanoparticles, as well as their economic viability, make CuNPs especially attractive. Micro emulsion, thermal decomposition, vapour decomposition, sol-gel, precipitation, laser ablation, electrochemical, electrospinning, aqueous chemical reduction, and microwave-assisted techniques have already been reported as physical and chemical ways for the synthesis of CuNPs.[7–14] CuNPs can be used in many different ways because of their unique chemical and physical properties.[15,16] CuNPs have been extensively applied as trace elements, fungicides, algaecides, insecticides, and herbicides in agriculture, as well as disinfectants in animal husbandry.[17] Many reviews have been reported on the synthetic pathways of CuNPs and their various newer applications, reporting optimal features such as good electrical conductivity,[18] lubricating thermal,[19] and excellent antimicrobial activities.[20] Because of their large surface area-to-volume ratio (SA:V) and crystalline structure, CuNPs have been shown to have a better antimicrobial effect than typical copper salts.[21] CuNPs show potent antifungal and inhibitory activities against a wide range of fungi.[22–24] The use of CuNPs is restricted due to Cu's high sensitivity to oxidation. Hence, fabricating pure and stable CuNPs is quite a difficult task. Many efforts have been made to develop synthesis paths and help materials that improve the stability of CuNPs through modifying their sensitivity towards water, chemical entities, and oxygen.[25–27] To avoid oxidation, the reactions were carried out in an inert atmosphere employing reducing agents and capping agents for the reduction of copper salt.[28–30] In the chemical reduction method, the reduction of metal ions to zero-valent metal has been done with conventional, costly, and hazardous reducing agents. To keep away the toxic reaction, we have used Vitamin C (ascorbic acid) as a reducing agent, which also behave as a protecting agent to terminate the oxidation reaction.[31] The task of synthesizing CuNPs with significant biological effects and better media stability is clearly essential. The nanoparticles that are in a colloidal solution are very different from those that are in a biological media. When nanoparticles are placed into such biological medium, they are likely to undergo chemical and physical changes that diminish, if not eliminate, its effects. Natural and synthetic polymers or proteins are used

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