Chapter 6
Biological Synthesis of Silver Nanoparticles and their Functional Properties

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ABSTRACT

A nanoparticle is defined as a small object between 1 and 100 nanometer in size and has a large surface to volume ratio. Silver nanoparticles (AgNPs) could be synthesized using various chemical and physical processes. However, these methods lead to hazardous by-products. In the recent past, AgNPs are produced by biological means. The size, shape and composition of AgNPs have significant effect on their biological applications. Aqueous solution of AgNP is not stable and rapidly undergoes agglomeration which is prevented by electrostatic or steric stabilization techniques with the help of capping or protective agents. The biologically synthesized nanoparticles are now favoured because it is a green alternative, mild, and does not need toxic chemicals and solvents. The scope of this review is to provide an overview of the various biological means researched for the synthesis of AgNPs, different techniques and chemicals used to develop stable solution, various techniques for their characterization, and their biological. The future research directions in this subject area are also dicussed.

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1. INTRODUCTION

Nanoparticles are popular because of their small size and enormous applications. Unlike bulk materials, they have characteristic physical, chemical, electrical, mechanical, electronic, magnetic, thermal, dielectric, optical and biological properties (Daniel & Astruc, 2004; Schmid, 1992). Their distinct properties including optoelectronic, physicochemical and electronic properties are determined by their size, shape and crystallinity. The synthesis of nanoparticle of varying size is a challenge. Although various physical and chemical means are extensively researched, the use of toxic chemicals leads to enormous pollution load. This drawback is overcome when biological means of synthesis is opted. More-over, the increasing need to develop high-yield and low-cost synthesis procedure adds significance to the biological approach. But the draw backs in biological means of synthesis include it is a time consuming process and, lack of control over size distribution, shape and crystallinity. These drawbacks could be overcome by optimizing the culture conditions including, pH, temperature, time, concentration of metal ions and the amount of biological material (Knoll & Keilmann, 1999). The design of a synthesis method in which the size, morphology, stability and properties are controlled has become a major field of interest (Wiley et al., 2007). These approaches have paved the way for large scale preparation for commercial use.

Various bacteria, fungi and plants are used for nanoparticle synthesis. Biosynthesis of nanoparticles is carried out by several microorganisms. They grab the target ions from the solution and then accumulate the reduced metal in their reduced form through enzymes generated in situ. The synthesis might either be intracellular or extracellular depending upon the location where the nanoparticles are formed. The former method involves transporting ions into the microbial cell to form the nanoparticles in the presence of enzymes. The latter synthesis consists of trapping the metal ions on their surfaces and reducing the ions in the presence of enzymes. Different techniques are used for the analysis of the silver nanoparticles during their various stages of synthesis as well as after synthesis.

The extremely small sizes of nanoparticles lead to their large surface area allowing them to easily interact with microorganisms thereby increasing their antimicrobial efficiency. Silver nanoparticles are known to act on various types of microorganism including bacteria, fungi, virus and drug resistant pathogens. In addition they can be used in various applications including wound healing treatments, in retinal therapies and as anti-cancer agent.

This chapter provides a brief overview on the biological means of synthesis of nanoparticles, functionalization and stabilization of nanoparticles, various techniques involved in the analysis of nanoparticles and their biological applications.

2. BACKGROUND

The size-controlled synthesis of nanoparticle remains a challenge in material science (Reddy et al., 2009). The size and shape are critical factors that decide the biological activity and specificity. Several factors contribute to the controlled synthesis of AgNPs like, the concentration of $AgNO_3$ used; the media components, pH and temperature. (Gurunathan et al., 2009; Huang et al., 2007). Although this is an important aspect, there is very little literature available on the controlled synthesis of AgNPs. This chapter will focus on the various means in which controlled synthesis could be made possible. Since nanoparticles have high surface energy, they are less stable leading to agglomeration. The use of stabilizer will result in stable nanoparticles. This chapter will also focus on the different means in which stable nanoparticles could be produced. The use of biosurfactants is one possible green alternate for the synthesis and stabilization of nanoparticles (Kiran et al., 2010).

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