STUDIES ON BIOSYNTHESIS OF GOLD NANOPARTICLES BY *FUSARIUM OXYSPORUM*

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Abstract
Gold nanoparticles find applications in medicine, catalysis, electronics, and optics owing to their unique properties. Synthesis of gold nanoparticles by *Fusarium oxysporum* was studied as one of the efficient and eco-friendly alternatives. The extracellular fungal extract was analyzed for its bioreduction potential. The effects of changes in concentration of the precursor salt on the nanoparticle properties were investigated. The initial concentration of the gold ions influences the size of the nanoparticles. The results suggest the potential of employing biological extracts to synthesize nanoparticles and to control nanoparticle size and morphology.

Keywords: Nanoparticles, gold, biosynthesis, *Fusarium oxysporum*

1. Introduction

Nanotechnology has revolutionized the modern world due to its various applications in simple domestic products such as toothpastes, clothing, etc., as well as core research areas of biomedical sciences, catalysis, electronics, and optics. One of the biggest challenges in nanotechnology is to develop the technique for the controlled synthesis of metal nanoparticles of characteristic size, shape, and its composition [1]. The limitations of the conventional routes of nanoparticles synthesis are the lack of monodispersity and instability of the resulting nanoparticles which makes it difficult to find useful applications. Other disadvantages include the usage of high temperatures, toxic reducing agents, and organic solvents. So researchers look for an alternative economically viable and ecologically safe procedure that could overcome such limitations. In this context, biological systems can be considered as a favorable option since organisms have the natural tendency to synthesize and/or to organize intricate nanostructures.

Several reports are available on the biosynthesis of nanoparticles. The biological sources employed for synthesizing the nanoparticles encompass a wide variety of organisms (or their extracts) ranging from viruses, bacteria, actinomycetes, yeasts, fungi, plants, etc., Microorganisms provide additional advantages concerning the ease of handling and manipulation of the biomass. Most of the experimental protocols use cells harvested after completion of growth of the microorganisms. Though this method yields nanoparticles of varying shapes and sizes, it is possible to attain better shape- and size-control by varying the microbial system used for the reaction [2], age of cells [1], etc.,

In this research, results are reported on the effect of varying initial concentration of the gold salt on the properties of gold nanoparticles synthesized using the fungal extract of *Fusarium oxysporum*.

2. Materials and methods

Fusarium oxysporum MTCC 284 was obtained from MTCC, IMTECH, Chandigarh, India. The organism was maintained on malt extract agar slants by subculturing at regular intervals. After proper incubation, the organism was transferred into the growth medium aseptically and incubated in a rotary shaker (100 rpm) at 30 ^{o}C. After appropriate growth, cells were separated from the broth by centrifugation. The precursor salt, gold (III) chloride trihydrate, was then added to the cell-free supernatant to get a desired final concentration of gold ions in the solution. The initial concentrations of the gold ions used are in the range of 0.1 mM to 1 mM. A suitable control was included in all sets of experiments to ensure that no other salts present in the growth medium are responsible for the chemical reduction of the gold ions. The mixtures were then incubated in the dark at 30 ^oC. Aliquots of samples were collected at regular intervals and analyzed by UV-visible spectroscopy, HRTEM imaging, and X-ray diffractometry.

UV-vis spectroscopy was performed on an ELICO SL 150 spectrophotometer. HRTEM analysis was carried out on a JEOL 3010 microscope. Samples were spotted on carbon coated copper grids and dried at room temperature. Images were collected at an accelerating voltage of 200 keV. X-ray diffraction analysis was carried out using a Bruker Discover D8 diffractometer. The results were used to account for the extracellular formation of gold nanoparticles obtained by the action of metabolic products secreted into the medium after the growth of cells.

3. Results

The formation of gold nanoparticles in the reaction medium was observed as visible color change from the original pale yellow color of the extract to a vivid purple. Figure 1 is a representative UV-visible spectrum of the reaction mixture (extract from resting cells) containing 1 mM $HAuCl_4 \cdot 3H_2O$. It shows a distinct absorption maximum centered around 540 nm, nearly 12 hours after the start of the reaction, whose intensity increases with time. This characteristic peak is the presumptive test for the formation of gold nanoparticles.

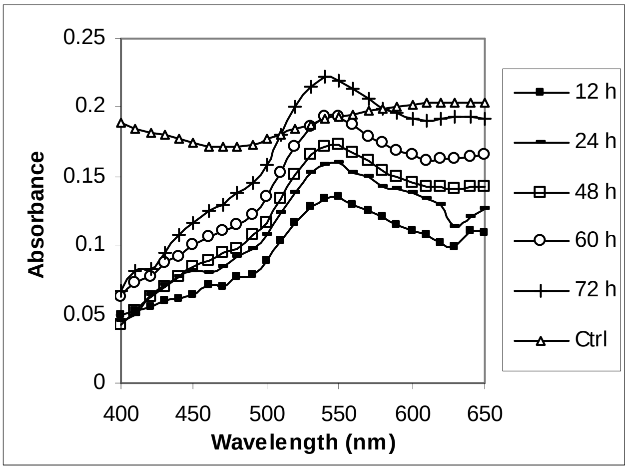

Fig. 1 *UV-visible spectrum of the extract obtained from resting cells of Fusarium oxysporum, exposed to 1 mM* $HAuCl_4$

The gold nanoparticles were further characterized using HRTEM imaging system (Figure 2). Nanoparticles of sizes between 10 nm and 50 nm were obtained using the extract from resting cells when treated with 1 mM $HAuCl_4$. Pentagonal and hexagonal bipyramidal shapes were obtained along with triangular and hexagonal nanoplates. The presence of twin boundaries was evident in some of the bipyramidal shapes as indicated by the arrows.

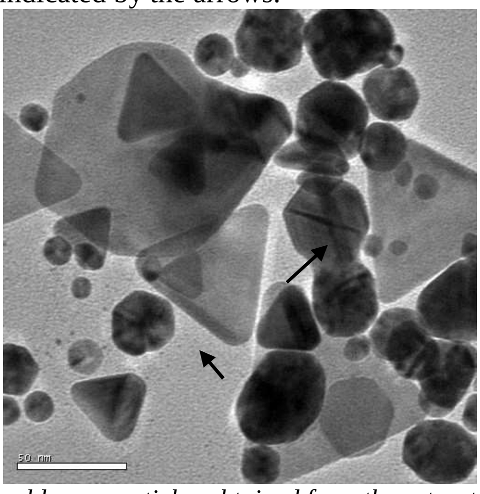

Fig. 2 *HRTEM image of gold nanoparticles obtained from the extract of resting cells exposed to 1 mM* $HAuCl_4$

Initial concentration of gold ions between 0.1 and 0.5 mM shows significant reduction in the sizes of the nanoparticles. The bipyramidal shapes of the nanoparticles were retained in all the cases. The XRD pattern shows the presence of peaks corresponding to facets of face-centered cubic (fcc) structure of gold.

4. Discussion

The change in color of the reaction mixture and the presence of the characteristic absorption peak around 550 nm, due to the surface plasmon absorption of gold nanoparticles, are considered as indications for the formation of gold nanoparticles. Further, HRTEM imaging gave information about the size and shape distribution of the nanoparticles. The particles were highly polydisperse at 1 mM $HAuCl_4$ concentration. Irrespective of the different concentrations of the gold ions, the pentagonal and hexagonal bipyramidal shapes was observed recurrently, which accounts for the reproducibility of the process. The initial concentration of the gold ions used in the experiments was found to be a factor capable of influencing the size of the nanoparticles. The XRD patterns obtained confirm that the nanoparticles are indeed crystalline.

5. Conclusions

We have demonstrated the synthesis of gold nanoparticles by the extracellular extract of resting cells of *Fusarium oxysporum*. With monodispersity still posing a distant goal to attain in the nanoparticles' synthesis protocols, the use of green technology to not only synthesize nanoparticles of unique shapes, but also achieve control over particle size seems to be a viable and convenient option. Furthermore, the unique bipyramidal shapes are known to have interesting properties which can find useful applications in electronics and sensing.

References

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