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H-09-P

GREEN SYNTHESIS OF SILVER NANOPARTICLES USING *BACILLUS LICHENIFORMIS* STRAIN

D. Jakovljević[1] , J. Stefanović[1], D. Ilić[2], G. Gojgić-Cvijović[1], M. Vrvić[1,2]

[1]IChTM - Department of Chemistry, University of Belgrade, Njegoševa 12, P.O. Box 473, 11000 Belgrade, Serbia (djakovlj@chem.bg.ac.rs)
[2]Faculty of Chemistry, University of Belgrade, Studentski trg 12-16, P.O. Box 51, 11158 Belgrade, Serbia

Abstract

The development of eco-friendly technologies in different areas, as well as in nanotechnology, is of great importance to the expansion of the many biological applications of microrganisms. In this work, the synthesis of silver nanoparticles by the reduction of aqueous Ag^+ ions using the non-pathogenic bacterial strain *B. licheniformis*, under mild conditions, was investigated. The synthesized nanoparticles were characterized by UV–Vis spectroscopy, scanning electron microscopy (SEM), and electron diffraction spectroscopy (EDX).

Introduction

Nanoparticles usually can be synthesized by physical, chemical and biological methods. Nowadays, important segment of nanotechnology is the synthesis of nanoparticles with well-defined chemical composition, size, shape and polydispersity by different microorganisms [1]. In this way the process of obtaining the metal nanoparticles is usually a part of the defense mechanism of microorganisms from highly reactive metal ions. The synthesized nanoparticles are used in many areas, such as catalysis, biosensors or drug delivery systems. Silver nanoparticles have important applications as an antibacterial agent, and also show excellent biocompatibility which makes them suitable for use in nanoimmunology and nanomedicine [1].

The aim of the presented work was the synthesis of silver nanoparticles through a eco-friendly process, by the non-pathogenic *B. licheniformis* strain isolated from petroleum sludge sample taken from Oil Refinery Novi Sad [2].

Experimental

B. licheniformis strain was grown on nutrient broth by incubation at 200 rpm for 24 h at 28 ^oC. After 24 h, the culture was centrifuged at 15,000 rpm for 15 min. Wet biomass (2 g) was washed with phosphate buffer (pH 7.0), mixed with 1 mM $AgNO_3$ (3 ml) and incubated for 24 h at 200 rpm followed by sonication (5min, 40 KHz, 20 ^oC) and centrifugation (10,000 rpm; 30 min) [3]. The culture supernatant was used for the characterization of silver nanoparticles. UV-VIS spectra were obtained using spectrophotometer GBC Cintra 40. Further characterization of particles was performed through analysis of dried sample (obtained by evaporation

of water at 50 °C) by using scanning electron microscope (SEM), Model JEOL JSM-6610LV, that equiped with energy dispersive X-ray spectrometry (EDX).

Results and Discussion

The aqueous silver ions were reduced to metallic silver on exposure to the bacterial biomass. The UV-VIS spectrum of culture supernatant showed a strong, broad absorption maximum at 430 nm (Fig. 1.) characteristic of silver nanoparticles due to its surface plasmon resonance [4].

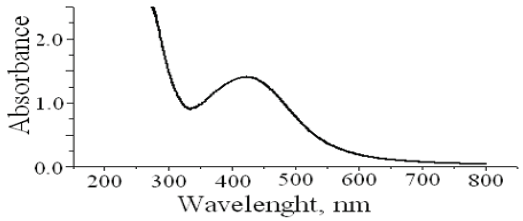
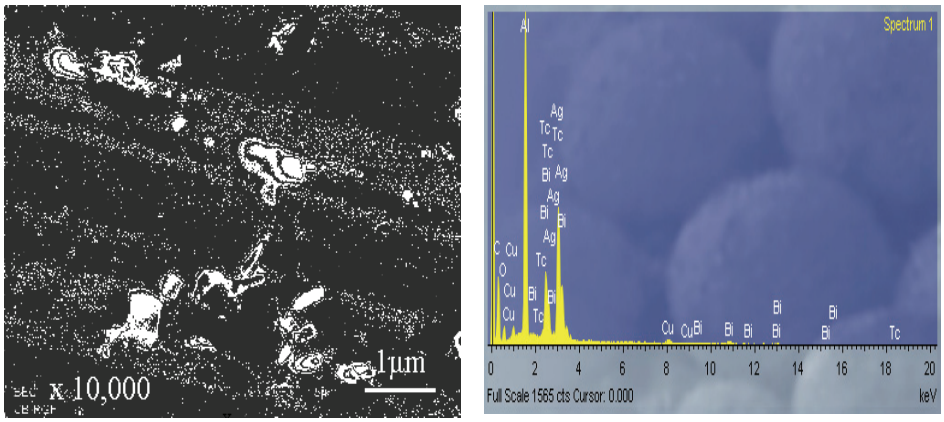


Figure1. UV-VIS spectrum of silver nanoparticles synthesized by *B. licheniformis* strain.

Their formation was confirmed visually too, by solution color change from colorless to brown. The nano particles formed were polydisperse and some of them were self-assembled into larger aggregates (Fig 2.a).



(a) (b)

Figure 2. SEM micrograph (a) and EDX spectrum (b) of the dried sample nanoparticles produced by *B. licheniformis* cells with the treatment of 1×10^{-3} M silver nitrate.

The enzyme involved in this synthesis is likely the nitrate reductase, present in *B. licheniformis*. This nitrate inducible enzyme reduces Ag^{+} ions to metallic silver [5].

Presence of silver was confirmed by EDX spectrum (Fig. 2b). Sharp signal in the silver region confirmed the formation of silver nanoparticles (Fig 2). Metallic silver nanocrystals generally show typical absorption peak approximately at 3 keV due to surface plasmon resonance.

Conclusion

The results present in this work showed a route for the production of silver nanoparticles from aqueous solution of $AgNO_3$ by *B. licheniformis* strain. The synthesis of these particles was confirmed by UV-VIS, SEM and EDX data. The production of nanoparticles by microrganisms is considered to be clean, nontoxic, and environmentally acceptable "green chemistry" procedures.

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References

[1] V. Deepak, K. *Kalishwarlal*, S. R. K. Pandian, S. Gurunathan, in M. Rai, N. *Duran* (Eds), *Metal Nanoparticles in Microbiology,* 2011, 17-37.
[2] G. D. Gojgic-Cvijovic, J. S. Milic, T. M. Solevic, V. P. Beskoski, M. V. Ilic, L. S. Djokic, T. M. Narancic, M. M. Vrvic, Biodegradation, 2012, 23, 1-14.
[3] K. Kalimuthu, R.S. Babu, D. Venkataraman, M. Bilal, S. Gurunathan, *Colloids Surf. B: Biointerface*, 2008, *65*, *150*-153.
[4] M. Sastry, K.S. Mayya, K. Bandyopadhyay, Colloids Surf. A, 1997, 127, 221-228.
[5] M. Sastry, V. Patil, S.R. Sainkar, J. Phys. Chem. B, 1998, 102, 404-1410.