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Research Article

Removal of pathogenic bacteria from wastewater using silver nanoparticles synthesized by two fungal species

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Abstract

Nanotechnology are fast advancing and currently became more effective than the conventional technologies used in water treatment that offers safe opportunities for using unconventional water supply sources. Fungi are more versatile in growth and metal tolerance in contrast to bacterial population. This work aims to demonstrate the extracellular synthesis of silver nanoparticle by using two filamentous fungi *Penciillium Citreonigum Dierck* and *Scopulaniopsos brumptii Salvanet-Duval* isolated from Lake Burullus, examine the biosynthesized nano-silver particles by UV–vis spectroscopy, transmission electron microscopy (TEM). The functional group of protein molecules surrounding AgNPs was identified using Fourier transform infrared (FTIR) analysis. Check the antibacterial activity of biosynthesized silver nanoparticles at two concentrations (550.7 and 676.9 mg/l) and interact it with bacteria for different durations (15, 60 and 120 min). Polyurethane foam was used as silver carrier and nano-silver solution for the removal of pathogenic bacteria in polluted water. The synthesized AgNPs showed an excellent antibacterial property on gram positive and gram negative bacterial strains.

Keywords: Nano-silver; Fungi; Antibacterial activity; Polyurethane foam

1. Introduction

The provision of safe drinking water is now a high priority to humanitarian goals and remains a grand global challenge to the 21st century (Qu et al., 2013). There is limited possibility of an increase in the supply of fresh water due to competing demands of various economic sectors. As a result of the shortage of fresh water supply, many countries focus on development of unconventional water sources including desalination, rainfall water harvesting, wastewater

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treatment, and the use of brackish water, (Gikas and Angelakis, 2009). Water borne pathogens [*Escherichia coli*, *Shigella spp.*, *Salmonella spp.*, *Vibrio spp.*, and protozoa (*Cryptosporidium*)] contamination in water resources cause diseases (i.e., diarrhea, gastrointestinal illness) (Lukhele et al., 2010). The WHO recommended that any water intended for drinking non detectable fecal and total coliform counts (Jain and Pradeep, 2005; WHO, 1997).

World Health Organization (WHO) has indicated that the harmful character of organochloro by Chlorination disinfection methods currently used in drinking water treatment which can effectively control microbial pathogens but has urged to find the alternative processes to easily achieve the disinfection of water and the removal of pollutants (WHO, 2008). One of the most important applications of nanotechnology is considered as quick, cheap, free from any toxic chemicals and environment friendly green chemistry method for the synthesis nano-particles (Prashant and Raja, 2011).

Nanotechnology involves the production materials in which at least one dimension is lower than 100 nm (Narayanan and Natarajan, 2010). Conventional methods water/wastewater treatment technologies are still ineffective for providing adequate clean and safe water due to increasing water demand, so there is urgent need to use the advanced and new applications water purification technologies as nanotechnology for achieving affordable solutions for the challenges faced by water/wastewater treatments and provides the opportunity to overcome fresh water shortage by use of unconventional water sources to expand the water supply (Qu et al., 2013). For several decades, nano-materials as., silver, titanium, and zinc have been studied for use in the disinfection of various waterborne disease-causing by microorganisms due to their charge capacity (Amin et al., 2014). Compared with the traditional synthetic chemical and physical methods, biological methods are currently an efficient system of the synthesis of nano-materials (Parashar et al., 2009).

The synthesis of colloidal metals nanoparticles using physical methods include vapor deposition and lithographic processes, on other hand, chemical methods used the popular borohydride and citrate reduction which is environmentally hazardous and result in quick agglomeration of nanoparticles leading to big particles of poor monodispersity (Mukherjee et al., 2008). In comparison to the former methods, Biological methods of nano-particles production have attracted a wide attention as they are safe (not producing toxic compounds during the process), cost effective, requires minimum time and is close to principles of nature (Arya, 2010).

Biomineralization process for the biosynthesis of nano-particles depends on different living organisms such as bacteria, fungi, yeasts, algae and higher plants. These organisms are used to precipitate nano-particles of Silver, Gold, Platinum, Manganese, Selenium, Iron, etc. (Saifuddin et al., 2009; Ali et al., 2011). The fungus *Aspergillus flavus* was capable of the synthesis of extra cellular Ag nano-particles (Vighneshwaan et al., 2007). As a result, researchers have considered the drinking-water treatment by silver nanoparticles as an effective against both gram positive and gram negative bacteria, viruses and other organisms, which is mainly dependent on a high surface area to volume ratio with unique physical, chemical and biological properties, as well as, it can be easily deposited on solid materials (e.g Ag/sand, Ag/zeolite and Ag/fiber) (Duran et al., 2010; Jain and Pradeep, 2005; Nair and Pradeep, 2007; Nangmenyi et al., 2009; Piksova et al., 2009).

Fungi are the best candidate in the synthesis of metal nanoparticles due to their ability to secrete large amount of enzymes, secrete large amount of proteins downstream processing and handling of the biomass would be much simple, economic livability, toleration and metal bioaccumulation capability, moreover, a number of species grows fast and therefore culturing and keeping them in the laboratory are very simple (Sastry et al., 2003; Castro-Longoria et al., 2012; Dhillon et al., 2012). The reduction of Ag^+ to silver nanoparticles Ag° is associated with a (NADH) dependent reductase enzyme produced as secondary metabolite. This was determined in a preliminary protein assay of silver nanoparticle formation by *Fusarium oxysporum* (Ahmad et al., 2003a; Durán et al., 2005).

The present study aims to achieve four-fold objectives (1) demonstrate the extracellular synthesis of silver nanoparticle by using two filamentous fungi *Penciillium Citreonigum Dierck* and *Scopulaniopsos brumptii Salvanet-Duval* isolated from wastewater, (2) examine the biosynthesized nano-silver particles by UV–vis spectroscopy, Fourier transform infrared (FTIR) analysis. (3) Check the antibacterial activity of biosynthesized silver nanoparticles at different concentrations. (4) Use polyurethane foam as silver carriers and nano-silver solution for the removal of pathogenic bacteria from polluted water.