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RESEARCH PAPER

Mechanistic approach for fabrication of gold nanoparticles by *Nitzschia* diatom and their antibacterial activity

Hemant P. Borase[1] · Chandrashekhar D. Patil[1] · Rahul K. Suryawanshi[1] · Sunil H. Koli[1] · Bhavana V. Mohite[1] · Giovanni Benelli[3] · Satish V. Patil[1,2]

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Abstract The problem of chemically synthesized nanoproducts motivated scientific community to explore ecofriendly methods of nanosynthesis. Diatoms belong to a group of aquatic, unicellular, photosynthetic microalgae have been scarcely investigated as a source of reducing and capping agents for nanosynthesis of pesticides and antibiotics. The present study reports a novel ecofriendly method for the fabrication of bioactive gold nanoparticles using locally isolated *Nitzschia* diatoms. The diatom-fabricated gold nanoparticles show characteristic ruby red colored with sharp absorbance peak at 529 nm. Electron microscopy confirmed irregular shape of gold nanoparticles, with average size of 43 nm and zeta potential of −16.8 mV. The effects of gold nanoparticles on diatom viability were investigated using light and electron microscopy. The mechanistic approach to shed light on how diatoms reacted after exposure to gold metal salt revealed that exposure to gold chloride triggers elevated levels of catalase and peroxidase (12.76 and 14.43 unit/mg protein, respectively) to relieve reactive oxygen species (ROS) stress induced by gold salt exposure. Investigation studies on mechanisms behind *Nitzschia*-mediated gold nanoparticles fabrication outlined the role of diatom proteins, polysaccharides in reduction, and stabilization of nanoparticles as confirmed by FT-IR analysis. Bioactivity of gold nanoparticles was accessed by coupling them with antibiotics (penicillin and streptomycin), which increased their antibacterial activity compared to individual nanoparticles and antibiotics (*Escherichia coli*, *Pseudomonas aeruginosa,* and *Staphylococcus aureus*). Overall, the present novel phyco-nanotechnological approach is a promising tool to be used as sustainable strategy in green nanotechnology as well as to reduce use of antibiotics in microbial control.

Keywords Catalase · Green nanosynthesis · Peroxidase · Reactive oxygen species · Antibacterial activity

Introduction

Diatoms belong to a group of aquatic, unicellular, photosynthetic microalgae found in river biofilms and have unique structural features [1]. Cell wall of diatoms is made up of nanostructured amorphous polymerized silicic acid termed "frustule" generated by bio-mineralization of silica [2]. *Nitzschia* is dominant genus of diatom found in colder (fresh) water, as well as in marine environments, including tropical areas are also observed in water bodies with heavy organic pollution. Diatoms are found to be useful in several areas such as ecological monitoring, biofuel, and CO_2 sequestration [3].

Gold nanoparticles (AuNPs/GNP) possess peculiar properties such as small size, high surface-to-volume ratio, biocompatibility, and ability to attach different molecules on its surface (i.e., functionalization), biocidal potential, and low toxicity [4, 5]. Above properties made gold

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✉ Satish V. Patil
satish.patil7@gmail.com

[1] School of Life Sciences, North Maharashtra University, Post Box 80, Jalgaon 425001, Maharashtra, India

[2] North Maharashtra Microbial Culture Collection Centre (NMCC), North Maharashtra University, Post Box 80, Jalgaon 425001, Maharashtra, India

[3] Department of Agriculture, Food and Environment, University of Pisa, Via del Borghetto 80, 56124 Pisa, Italy

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