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ORIGINAL PAPER

# Biochemical changes in microalga *Porphyridium cruentum* associated with silver nanoparticles biosynthesis

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## Abstract

For the first time, the microalga *Porphyridium cruentum* was tested for its ability to produce silver nanoparticles. To characterize formed silver nanoparticles UV–vis Spectrometry, Scanning Electron Microscopy, Energy-dispersive analysis of X-rays and X-ray diffraction were used. It was shown that after biomass exposure to silver nitrate solution the extracellular formation of spherical-like nanoparticles took place. Functional groups responsible for metal binding were determined by Fourier-transform infrared spectroscopy. The complex of biochemical tests was used for biomass characterization and assessment of the changes of its main components (proteins, lipids, carbohydrates, and phycobilin) during nanoparticle formation. Obtained data indicate a significant decrease of proteins, carbohydrates, phycobiliproteins, and lipids content as well as antiradical activity of biomass. The obtained results show the necessity of determination of optimal conditions for obtaining *Porphyridium cruentum* biomass enriched with silver nanoparticles for its further application in the pharmaceuticals industry

**Keywords** Silver · Nanoparticles · *Porphyridium cruentum* · Biochemical analysis

## Introduction

Nowadays, metal nanoparticles are gaining a reputation as multifaceted materials exhibiting novel or advanced characteristics compared to bulk materials (Patel et al. 2015). From a wide range of nanoparticles produced, noble metal nanoparticles are being widely used in different fields of industry as well as medicine (Prathna et al. 2011). Of the noble metal nanoparticles, silver is of particular interest because of properties, such as good electrical conductivity, chemical stability, catalytic and antimicrobial activity (Prathna et al. 2011; Siddiqi et al. 2018; Anandaradje et al. 2020; Xu et al. 2020).

Silver nanoparticles can be produced using a variety of chemicals and physical methods, including ball milling, chemical reduction, photochemical and electrochemical reduction, thermal vaporization, sol–gel process, chemical solution, and vapor deposition (Kuppusamy et al. 2016; Arunachalam et al. 2013; Xu et al. 2020). Physical and chemical methods are characterized by high cost and use of chemical reductants and stabilizing agents, which may pose environmental risks. In contrast, synthesis of nanoparticles through biological methods corresponds to the principles of green chemistry: use of natural resources, rapidness, eco-friendliness, and benignancy (Raja et al. 2017; Prathna et al. 2011; Anandaradje et al. 2020). Biologically synthesized metal silver nanoparticles could have a wide application, especially in medicine. Presently, bio-organisms from simple prokaryotic cells to eukaryotic ones and even live plants are applied for nanoparticles production (Sanghi and Verma 2009; Siddiqi et al. 2018; Cepoi et al. 2015; Hosseini-Abari et al. 2013; Anandaradje et al. 2020).

Among microorganisms, microalgae attract special attention since they have the ability to bioremediate toxic metals, subsequently converting them to more amenable forms (Patel et al. 2015; Hamouda et al. 2019; Abdel-Raouf et al. 2019). Besides application for the environment bioremediation and nanoparticles production microalgae are the source

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