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Green synthesis and characterization of silver sulfide nanoparticles using *Bacillus safensis* strain GMS10 isolated from contaminated soil of gold mine

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Introduction

Nanotechnology creates enormous commercial possibilities on the production and usage of structures and systems by manipulation of individual atoms and molecules at the nanoscale. ***Silver sulfide*** (Ag_2S) nanoparticles are increasingly applied in various fields, including solar ***cell batteries,*** infrared detectors, novel ***thermoelectric*** temperature ***sensors, and*** antimicrobial therapy, due to their unique Optical, chemical, mechanical and electrical properties. This study aimed to isolate and identify the ***silver-resistant bacteria and investigate on their potential in the biological synthesis of*** silver sulfide nanoparticles (***Ag_2SNPs).*** Also, optimization of reaction parameters for obtaining Ag_2SNPs in nanometer size was ***investigated.***

Materials & Methods

Soil samples were collected from contaminated soil of gold mine in the city of *Qorveh* in Kurdistan *Province* and were used as the source material for bacterial isolation. The samples were serially diluted in sterile 0.85 % NaCl and then plated onto Luria Bertani agar (LB) media supplemented with 0.5 mM *silver sulfate* (Ag_2SO_4) solution with shaking at *200 rpm and temperature 25˚ C.* Tolerance pattern was *determined using* the *agar dilution method.* The bacterial isolate with the highest tolerance to silver sulfate was selected as the potent bacterial isolate for green synthesis of Ag2SNPs under the resting cell strategy. *Preliminary* characterization of the Ag_2SNPs was *carried out* using visual observations and *UV–Visible spectroscopy. Scanning Electron Microscopy* (SEM) with Energy Dispersive *X-Ray Analysis* (EDX) *was used* to *determine size, morphology* and *elemental analysis of the nanoparticles. Fourier-transform infrared spectroscopy (FTIR) analysis was performed to determine* the *functional groups involved* in the *bioreduction of silver sulfate into Ag_2SNPs. The bacterial isolate* was identified using 16S rRNA gene sequence analysis, morphological and biochemical characteristics.

2/ In vitro evaluation of the effect of the organic adsorbent on the reduction of mycotoxin zearalenone

Results & discussion

Among the 18 bacterial isolates (GMS1-GMS10 and SW01-SW08) purified from soil samples using enrichment culture, ***strain GMS10*** showed the highest tolerance to the Ag_2SO_4 stock solution (5.25 mM) and was selected for the study and was found to have the ability to form Ag_2SNPs as observed by change in colour of the reaction from pale yellow to ***blackish-brown under resting cell culture.*** The colour change observed for the extracellular biosynthesis was further confirmed by UV–Vis spectral analysis as part of primary confirmation. Ag_2SNPS are known to have an intense absorption peak in UV absorption spectra at around ***332 nm*** due to its surface plasmon excitation. The Selected Ag_2SNPs-producing strain GMS10 was further subjected to molecular identification by 16S rDNA sequencing-based method. The sequence data were subjected to BLAST analysis and the result showed its maximum identity of 99 % to various *Bacillus* sp. mainly *Bacillus safensis.* The 16S rDNA sequence of the isolate was submitted to NCBI under the accession number MW362307. Effect of reaction parameters on the yield, shape and size of the synthesized Ag2SNPs, including initial Ag_2SO_4 concentration (05, 1, 1.5, 2, 2.5 mM), bacterium biomass concentration (5, 10, 15, 20, 25 g/l), and incubation time (12, 24, 36, 48, 60, 256 h) was assessed under resting cell strategy. The results showed *Bacillus safensis* strain GMS10 with highest tolerance to silver sulfate (50 mM) was able to synthesize ***spherical*** shape of Ag_2SNPs with an ***average size*** diameter of 22.2 nm ***under optimized conditions (1 mM silver sulfate, 15 g/L biomass) after 36 h incubation. This study is the first report on the synthesis of Ag_2SNPs using*** *B. safensis.*

Conclusion

The isolation of and characterization *silver sulfate* resistant *bacterial* strains from the contaminated soils of gold mine show that the new native ecosystems of Iran can have countless capabilities for microbial species. In this study, a new species of *Bacillus* was introduced, which *has* been considered to be potential candidate for synthesis of Ag_2SNPs. The Ag_2SNPs formed by the strain GMS10 was found to be stable with average size diameter 22.2 nm which indicate its potential applications.

Keywords: *B. safensis, Biosynthesis, Characterization, Silver sulfide nanoparticle, Soil*

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Declaration of conflict of interest:

The authors declare that there is no conflict of interest.