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Short Communication

Microbial Mechanisms for Heavy Metal Resistance and Detoxification in Genetically Modified Organisms

Khalif Khun*

Department of Pharmacy, Isfahan University of Medical Sciences, Isfahan, Iran

DESCRIPTION

The application of Genetically Modified Organisms (GMO) is a fascinating scientific area based on green chemistry and cleans technology principles, as it has great potential for Heavy Metal (HM) removal and nanomaterial biosynthesis. Various nanomaterials and nanostructures can be fabricated using Genetically Engineered Organisms (GEO) containing stabilizers, reducing agents and capping agents. Synthesis of bio-inspired nanomaterials using GEO offers advantages in simplicity, cost-effectiveness and eco-friendly properties compared to conventional methods consisting of toxic/hazardous materials and labor-intensive processes [1]. I have shown some advantages in points. In this context, GEO is capable of bio-recovery and bio-reduction of HM ions, offering excellent opportunities for HM removal [2,3]. These bio-factories with great potential for bio-reduction of metal ions depend on their bioaccumulation/ biotransformation, biosynthetic capacity, and reaction conditions.

The nanomaterials production capacity of organisms can be enhanced by detailed cellular reprogramming, offering ease of manipulation and downstream processing by application of GEOs for the synthesis of eco-friendly NPs at ambient temperature and pressure. However, scalability and industrial applications with a precise attitude towards potential toxicity and biosecurity issues are of great importance and should be evaluated analytically [4,5]. The exploration of relevant nanoparticle synthesis pathways and HM removal mechanisms, as well as responsible enzymes/proteins and metabolic pathways, will lead to engineered systems with properties tailored for specific purposes, especially through clean and sustainable technologies. It should be a high priority in research to acquire it.

Various nanotechnology advances have been inspired by nature, and as a result, researchers are looking for smart, nature-inspired systems with a range of promising environmental potentials [6]. There are still concerns about the commercialization and large-scale applicability of organisms for the purposes of bioremediation and nanoparticle synthesis. Therefore, investigations should focus on technical organisms with high competence and industrialization standards to obtain detailed optimization strategies/techniques, surface functionalization of manufactured NPs, and analytical/ characterization procedures. To identify the genes involved in NP synthesis, several studies were considered using gene silencing processes and identifying genes predicted for synthesis. We introduced candidate gene clusters into other organisms to test their ability to initiate NP production [7,8].

Bioremediation is an environmentally friendly and cost-effective strategy that can be used to clean up complex industrial tannery wastewater containing HM, which poses a significant threat to ecological pollution [9]. In particular, the toxicity of metals is a major concern due to their bioaccumulation and non-biodegradability in nature. Several factors, such as reaction conditions, chemical composition of HM, redox potential and nutritional status, can affect the efficiency of his GEO-based bioremediation. Biotransformation, oxidative stress response, metal regulation and transport cell surface engineering can play important roles in HM repair synthesis by these organisms. For phytoremediation by transgenic plants, the selection of appropriate plant species, plant-microbe interactions, translocation processes, resistance mechanisms, metal properties, and environmental conditions have major implications [10].

CONCLUSION

Molecular modifications have been deployed for the displaying metal binding proteins at the cell surfaces through overexpression of genes and introduction of exogenous DNA to produce transgenic algae with high selectivity and efficacy for HM adsorption; however, these modifications are variable and more elaborative studies are necessary for clarifying the underlying mechanisms and solving possible limitations and challenges. On the other hand, significant HM concentrations and poor competitiveness may restrict the application of these organisms, but the efficacy can be enhanced by improving their bio-reduction and bioaccumulation potential. In this, active transportation of metal ions, intracellular and extracellular appropriation, and metal ions bio-reduction capability should be considered. Configuration of microbial cell walls and ionization

Correspondence to: Khalif Khun, Department of Pharmacy, Isfahan University of Medical Sciences, Isfahan, Iran, E-mail: khun123@gmail.com

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of chemical entities on the cell walls affects the bioremediation by GEOs. Microbes have shown several mechanisms for interacting and surviving in toxic metal environment such as extrusion, biotransformation, enzymatic processes, exopolysaccharide formation, and metallothioneins production. Bacteria exhibited metal resistance and detoxification potentials through ion exchange, surface complexation, precipitation, reaction to metals in the environment. Specifically, bacterial HM resistance includes methylation/demethylation, formation of metal chelators, metal efflux pumps, and extra/intracellular metal acquisition and removal *via* permeability barriers, metal ligand destruction, organometallic complex formation, and metal oxidation.

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