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Unrevealing Alterations and Disturbances in Bacterial Outer Layers in Response to Metallic Nanoparticle Stress

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Extended Abstract

The rapid advancement of nanotechnology contributed to revolutionising science, technology and industry in the 21st century. Inorganic nanoparticles (NPs), due to their unique physicochemical properties, have become attractive materials for various commercial and technological applications. Using metal NPs is most commonly associated with implementing their bactericidal and bacteriostatic properties. Unfortunately, the progressive production and use of nanoproducts with such amenities significantly increase the risk of their release into the environment, where they may threaten non-target microorganisms. Unfortunately, the lack of appropriate tools makes it impossible to distinguish NPs of anthropogenic origin from those naturally occurring in the environment and perform a full risk assessment. Therefore, extensive toxicological studies using both model microorganisms and environmental strains to evaluate the biological effects of NPs are of utmost importance. The mechanisms responsible for the biocidal activity of metallic NPs are still not fully understood due to their variety and non-specific mechanisms of action. However, the response of microorganisms to NPs is believed to be mediated by numerous cellular phenomena and processes. Firstly, NPs act on the bacterial cell's outer layers, interacting with the surface structures and leading to changes in cell membrane integrity and permeability [1,2]. The discrepancy and inconsistency of findings on this subject and the diverse impact of NPs on individual microorganisms require further advanced research and thorough explanation.

This study deciphered the effect of four commercial metallic NPs, including Ag-NPs (cat. no. 576832, Sigma- Aldrich, <100 nm), Cu-NPs (cat. no. 774081, Sigma-Aldrich, 25 nm), TiO_2-NPs (cat. no. US1019F, US Research, 20 nm) and ZnO-NPs (cat. no. 677450, Sigma-Aldrich, <50 nm) on the disruption and alterations in the structure and functioning of *Escherichia coli* (ATCC® 25922™) and *Staphylococcus epidermidis* (ATCC® 12228™) outer layers. The performed work included the following measurements: cellular ATP levels, ATPase activity, cell membrane permeability and the contents of various groups of fatty acids [3].

The obtained data showed a differentiated effect of tested NPs on bacterial strains, creating a unique toxicity profile for each type of NPs. Nevertheless, the Gram-negative *S. epidermidis* proved to be more sensitive to the stress caused by NPs than *E. coli*. Furthermore, the exposure of both strains to Cu-NPs induced the most significant alternations in measured parameters. Changes in the energy carrier ATP level were correlated with changes in ATPase activity. Similarly, distinctive modifications in selected groups of fatty acids were distinguished, reflected in the enhanced permeability of the cell membrane. Undoubtedly, this study confirmed the negative impact of NPs on the outer layers' integrity, providing innovative results in nanotoxicological research. An optimised methodology for similar future nanotoxicology studies was also presented [3].

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