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56. OGÓLNOPOLSKA KONFERENCJA MIKROBIOLOGICZNA

Unveiling the influence of inorganic nanoparticles on bacterial cell membrane: structure, properties, and functionality

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The unique physicochemical and biological properties of nanomaterials have garnered significant attention in the contemporary world. The dynamic development of nanotechnology has revolutionised every dimension of life, giving new technological and industrial applications. The increasing use of engineering nanomaterials, particularly metallic nanoparticles (NMs), serves various advantageous purposes, notably their antibacterial properties [1,2]. On the other hand, there is a concern regarding the potential uncontrolled release of these NMs into the environment, which could lead to the exposure of microbial populations and subsequent risks of their potentially toxic effects. Nowadays, despite the extensive research conducted to comprehend the impact of NPs on bacterial cells and their effects on the membrane properties and functioning, many issues remain unexplained [3].

Aim of study

Hence, the objective of this study was to investigate the multifaceted effects of commonly used Ag-NPs, Cu-NPs, TiO_2-NPs, and ZnO-NPs on the structure and functionality of cell membranes in representative bacterial species, including *Escherichia coli*, *Bacillus cereus* and *Staphylococcus epidermidis*.

Materials and methods

This study was performed using the following bacterial strains: *Escherichia coli* (ATCC® 25922™), *Bacillus cereus* (ATCC® 11778™) *and Staphylococcus epidermidis* (ATCC® 12228™). The proposed experiments assessed:

1) the permeability of outer cell layers using a crystal violet [4, 5] and cytoplasmic leakage focuses on the changes in the content of nucleic acids and proteins released from microbial cells after the disruption of bacterial outer layers. [6, 7],
2) fatty acid profiling isolated from bacteria according to the procedure by [8],
3) SEM analysis to elucidate the interactions of individual NPs with bacterial cells upon NPs exposure [9].

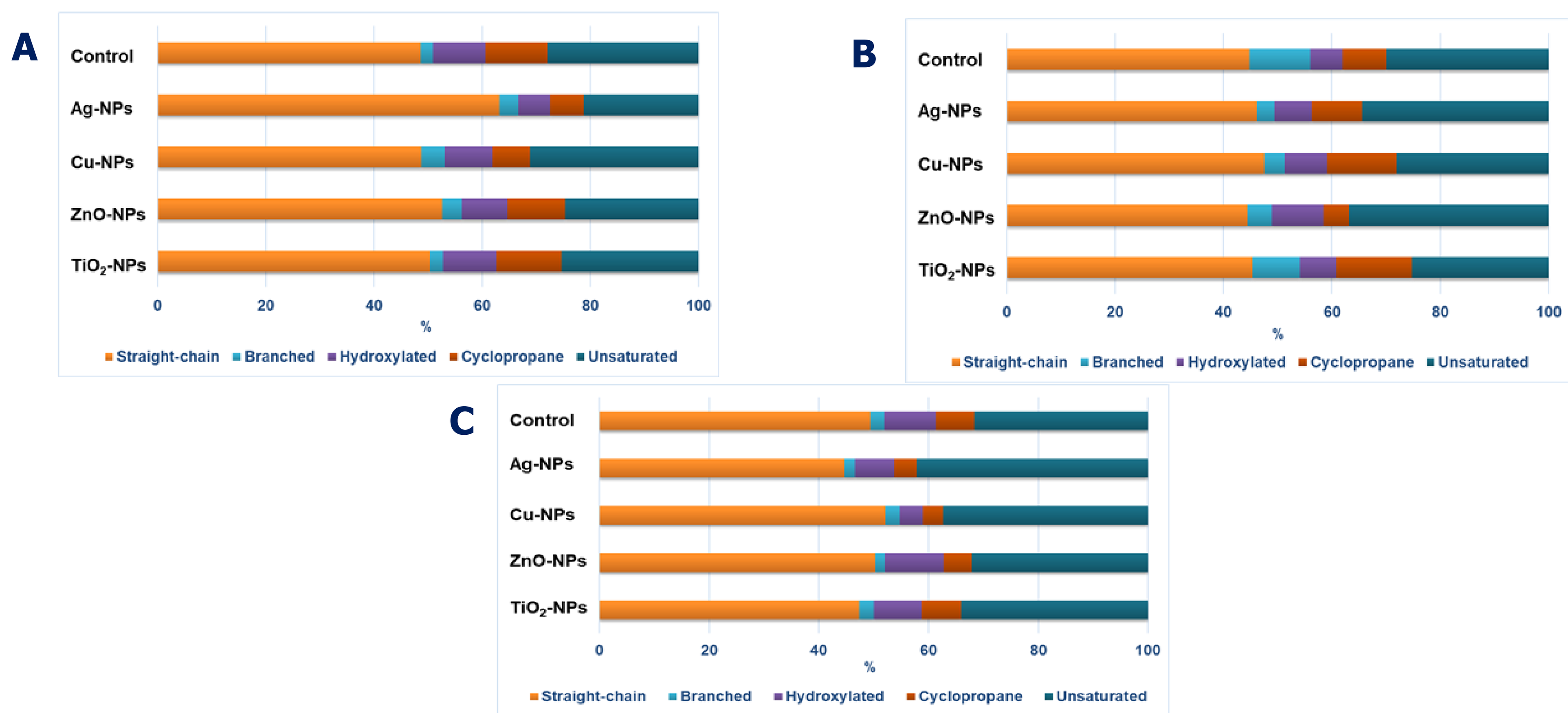

Fig. 3. Percentages of straight-chain, branched, hydroxyl, cyclopropane and unsaturated acids in FAME profiles of *E. coli* (**A**), *B. cereus* (**B**) i *S. epidermidis* (**C**) strains treated with NPs at IC_{50}.

Results

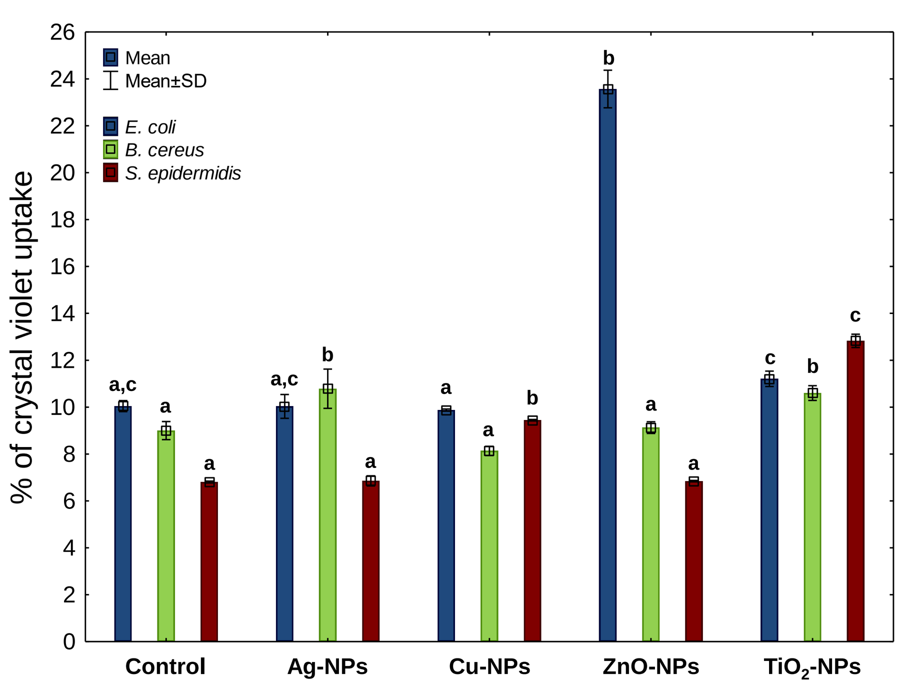

Fig. 1. Changes in membrane permeability of *E. coli*, *B. cereus* and *S. epidermidis* cells treated with NPs at IC_{50}.

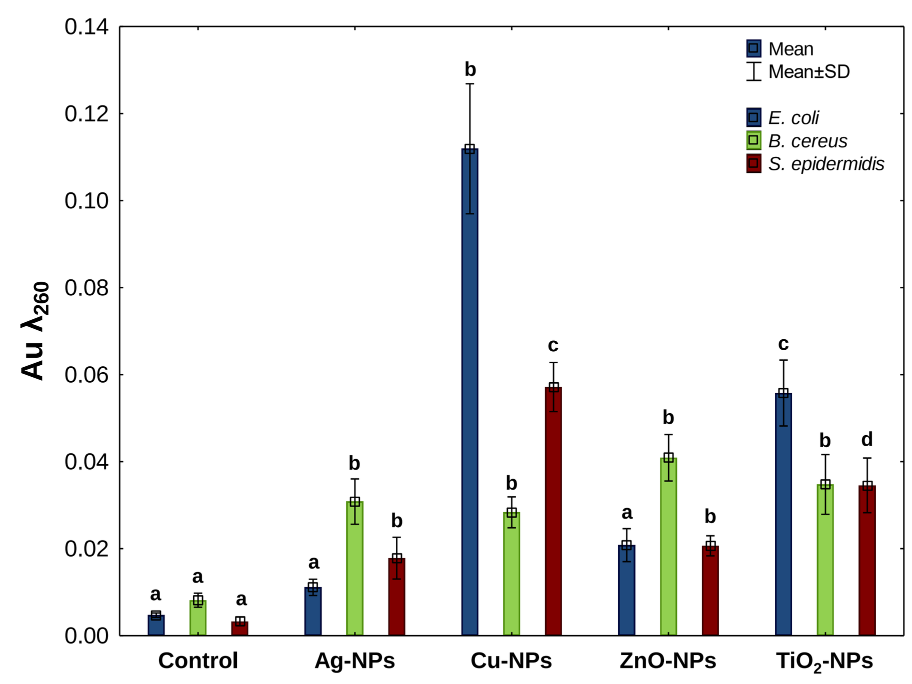

Fig. 2. Changes in cytoplasmic leakage from *E. coli*, *B. cereus* and *S. epidermidis* cells treated with NPs at IC_{50}.

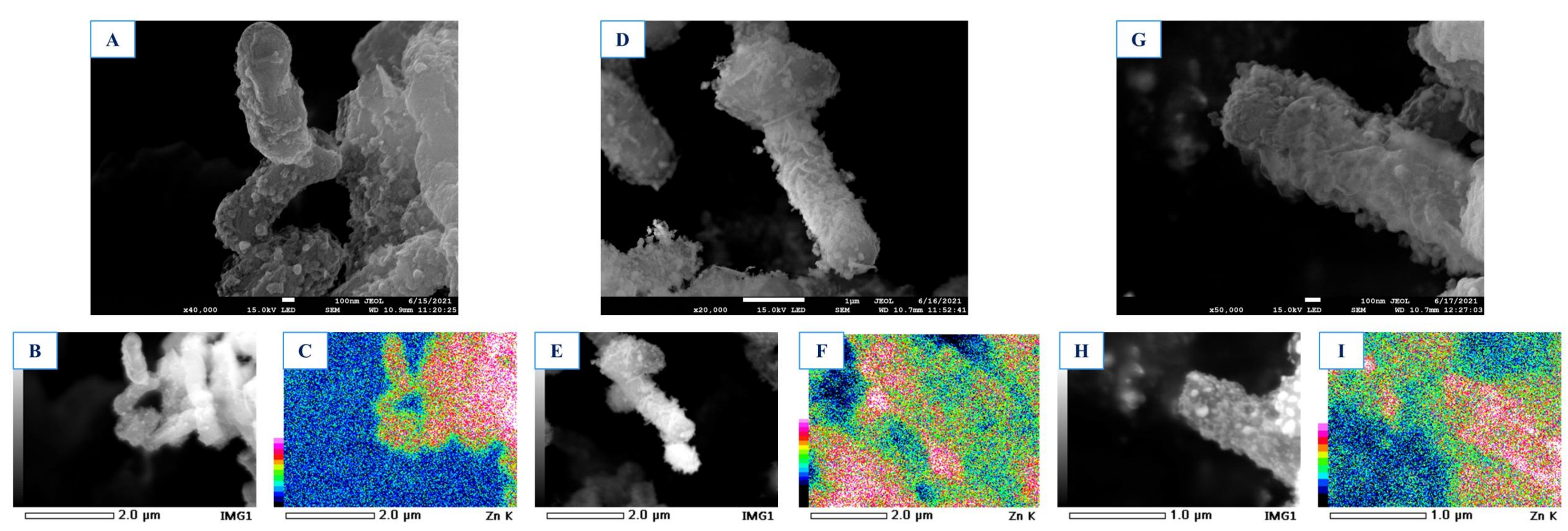

Fig. 4. Scanning electron micrographs of *E. coli* (**A,B**), *B. cereus* (**D,E**) and *S. epidermidis* (**G,H**) cells exposed to ZnO-NPs at IC_{50} concentration. EDS micrographs of Zn element (**C,F,I**).

Conclusions

1. The results clearly showed differences in the impact of individual NPs on the measured parameters.
2. The enhanced membrane permeability exhibited a strong correlation with increased cytoplasmic leakage.
3. The fatty acid profile demonstrated strain-specific characteristics for each bacterial strain, highlighting significant changes in the proportions of hydroxyl, cyclopropane, branched, and unsaturated fatty acids.
4. Conclusively, *E. coli* exhibited higher susceptibility to alterations than *B. cereus* and *S. epidermidis*.
5. Moreover, the presented results may contribute to a better understanding of the effects of inorganic NPs on various species of bacteria, concerning Gram-negative and Gram-positive bacteria.

Acknowledgments

This research was entirely funded by the National Science Centre, Poland, grant number 2021/41/N/NZ9/02506. The research activities was co-financed by the funds granted under the Research Excellence Initiative of the University of Silesia in Katowice.

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