proceedings

MDPI

Abstract

Synthesis and Antibacterial Efficiency of Chitosan–Copper Oxide Nanocomposites †

Jüri Laanoja [1,2], Mariliis Sihtmäe [1], Maarja Otsus [1], Anne Kahru [1] and Kaja Kasemets [1,*]

[1] Laboratory of Environmental Toxicology, National Institute of Chemical Physics and Biophysics, 12618 Tallinn, Estonia; juri.laanoja@gmail.com (J.L.); sihtmae@gmail.com (M.S.); maarja.otsus@gmail.com (M.O.); anne.kahru@kbfi.ee (A.K.)
[2] School of Science, Tallinn University of Technology, 19086 Tallinn, Estonia
* Correspondence: kaja.kasemets@kbfi.ee
† Presented at the International Conference EcoBalt 2023 "Chemicals & Environment", Tallinn, Estonia, 9–11 October 2023.

Keywords: antimicrobial resistance; bacteria; chitosan; copper; copper oxide; nanocomposites; nanoparticles; nanotechnology

Antimicrobial resistance is among the most serious global healthcare problems today. In Europe, a third of the estimated 8.9 million yearly hospital-acquired infections in 2016 and 2017 were caused by antibiotic-resistant bacteria [1]. One possible source for novel, efficient antimicrobials is nanotechnology. Some metallic nanoparticles (NPs) like silver, CuO, and ZnO are already commercially available for biomedical applications. NPs are often coated with different polymers to improve their characteristics. An intriguing biopolymer to combine with metal NPs is the antimicrobial, biocompatible, and immunomodulating chitosan, presently used in bandages and wound dressings. In this study, novel chitosan–CuO nanocomposites (NCs) were synthesized via the precipitation of copper acetate by sodium hydroxide in the presence of chitosan (50–190 kDa, Sigma Aldrich, Schnelldorf, Germany). Varying copper to chitosan weight ratios (1:0.3, 1:1, and 1:3) were used. The NCs were characterized by DLS, EDX, FTIR, SEM, XPS, and XRD. The minimum bactericidal concentrations (MBC) against clinically relevant gram-negative (*Escherichia coli* ATCC 25922, *E. coli* MG1655, *Pseudomonas aeruginosa* ATCC 27853) and gram-positive (*Staphylococcus aureus* ATCC 6538) bacteria were determined by the Spot test [2]. Flow cytometry and confocal laser scanning microscopy were used to reflect the interactions between NCs and bacteria. The zeta potential of the synthesized NCs was >40 mV. The NCs' hydrodynamic diameter and polydispersity index increased with higher chitosan content, varying within 90–180 nm and 0.24–0.33, respectively. Based on the XRD analysis, the CuO portion of the NCs had a crystalline structure. The NCs were similarly effective against gram-negative and -positive bacteria, displaying MBC values of 0.13–0.25 mg Cu/L after 24 h of exposure. Interestingly, after a 1-h period of exposure, the NCs were more toxic against gram-negative bacteria than Cu ions, suggesting that chitosan may facilitate the interaction of NCs and bacterial cells, enabling the immediate shedding of Cu ions alongside the bacteria. Furthermore, after a 1-h exposure, the NCs with a higher chitosan content were up to two times more biocidal against gram-negative bacteria than NCs with a lower chitosan concentration.

Author Contributions: Conceptualization, J.L. and K.K.; methodology, formal analysis and investigation, J.L., M.S., M.O. and K.K.; writing, J.L.; review and editing, M.S., A.K. and K.K.; supervision, project administration, and funding acquisition, K.K. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Estonian Research Council project PRG749 and conducted using the NAMUR+ core facility (TT13).

Citation: Laanoja, J.; Sihtmäe, M.; Otsus, M.; Kahru, A.; Kasemets, K. Synthesis and Antibacterial Efficiency of Chitosan–Copper Oxide Nanocomposites. *Proceedings* **2023**, *92*, 35. https://doi.org/10.3390/proceedings2023092035

Academic Editors: Monika Mortimer, Ivo Leito, Riin Rebane and Villem Aruoja

Published: 22 November 2023

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors thank Svetlana Vihodceva, Raivis Eglītis, Mairis Iesalnieks, and Inna Juhņeviča from Riga Technical University for their invaluable help.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. European Centre for Disease Prevention and Control. Available online: https://www.ecdc.europa.eu/en/publications-data/infographic-healthcare-associated-infections-threat-patient-safety-europe (accessed on 22 June 2023).
2. Suppi, S.; Kasemets, K.; Ivask, A.; Künnis-Beres, K.; Sihtmäe, M.; Kurvet, I.; Aruoja, V.; Kahru, A. A novel method for comparison of biocidal properties of nanomaterials to bacteria, yeasts and algae. *J. Hazard Mater.* **2015**, *286*, 75–84. [CrossRef] [PubMed]