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Abstract

Formulation of a Multifunctional Nanocomposite Hydrogel Based on Natural Polysaccharides, Biogenic Copper Nanoparticles and Essential Oils †

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† Presented at the 3rd International Online-Conference on Nanomaterials, 25 April–10 May 2022; Available online: https://iocn2022.sciforum.net/.

Abstract: Background: Copper nanoparticles are of tremendous interest due to their strong antibacterial properties, thereby having the potential to enhance not only the physical and biochemical characteristics of hydrogels but also their antimicrobial activity. Objective: The goal of this study was to develop a multifunctional hydrogel embedded with copper nanoparticles that were manufactured in an eco-friendly manner. Material and Methods: Copper nanoparticles were biologically synthesized using Cinnamon extract which was mixed with the CuSO4 (pentahydrate copper sulphate) solution (0.1 M) in a 1:5 ratio. The CuNPs suspension was primarily characterized by UV–Visible spectroscopy, the spectrums being recorded from 200 to 800 nm. Xanthan gum, a natural polysaccharide, was used as thickening agent in the formulation of the following hydrogels: control gel, with CuSO4 alone), G1, with biogenic CuNPs and G2 with CuNPs and essential oils (oregano, cinnamon, clove, eucalyptus, thyme, and lavender). The Kirby-Bauer diffusimetric method was used to assess comparatively the antimicrobial activity against Gram-positive, Gram-negative bacteria and fungal species for the formulated gels. Results: The presence of the copper nanoparticles was confirmed by the presence of a surface plasmon resonance (SPR) peak recorded at 234–255 nm. The lowest antimicrobial activity was observed in the case of control hydrogel. Hydrogel G1 showed significantly better antimicrobial activity, especially on Staphylococcus epidermidis and Candida albicans. Hydrogel G2, embedded with biogenic CuNPs and essential oils, presented a higher antimicrobial activity against both Gram-positive and negative bacteria. It also displayed antibiotic activity against MRSA ATCC 33591, a methicillin-resistant Staphylococcus aureus strain with public health significance. Conclusions: When coupled with the specified essential oil blend, copper sulfate demonstrated strong synergistic antibacterial action. Altogether, this work assessed and validated the in vitro antibacterial activity of a polysaccharides-based composite hydrogel comprising biologically synthesized copper nanoparticles and essential oils with potential applications in both human and veterinary medicine.

Keywords: antimicrobial; copper; essential oils; hydrogels; nanomaterials; nanoparticles

Citation: Neculai-Valeanu, A.-S.; Ariton, A.-M. Formulation of a Multifunctional Nanocomposite Hydrogel Based on Natural Polysaccharides, Biogenic Copper Nanoparticles and Essential Oils. *Mater. Proc.* **2022**, *9*, 5. https://doi.org/10.3390/materproc2022009005

Academic Editor: Eleonore Fröhlich

Published: 10 May 2022

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/materproc2022009005/s1.

Author Contributions: Conceptualization, A.-S.N.-V. and A.-M.A.; methodology, A.-S.N.-V.; software, A.-S.N.-V. and A.-M.A.; validation, A.-M.A.; formal analysis, A.-S.N.-V. and AA-M; investigation, A.-S.N.-V. and A.-M.A.; resources, A.-S.N.-V. and A.-M.A.; data curation, A.-S.N.-V. and A.-M.A.; writing—original draft preparation, A.-S.N.-V. and A.-M.A.; writing—review and editing, A.-S.N.-V. and A.-M.A.; visualization, A.-S.N.-V.; supervision, A.-M.A.; project administration, A.-M.A.; funding acquisition, A.-S.N.-V. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by A.S.A.S Heritage Foundation, grant No. 73/25 September 2020.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The author acknowledge the support given by Cristina Rimbu for her technical support in the preparation of the study.

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