2C2T Centre for Textile Science and Technology
Universidade do Minho Escola de Engenharia
P1.090
Frontiers in polymer science
29 May - 1 June 2023 | Gothenburg, Sweden
materialstoday Connecting the materials community

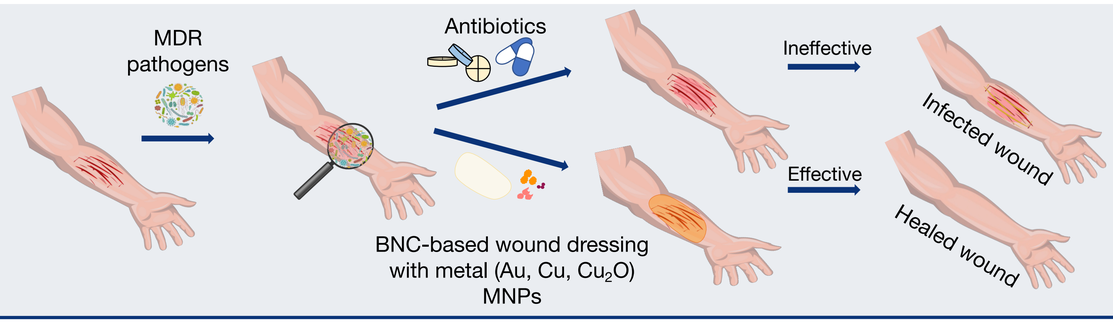
Antibacterial properties of bacterial nanocellulose functionalized with metal nanoparticles via *in situ* synthesis

Liliana Melro[1], Behnaz Mehravani[1], Gracinda Silva[2], Ana Isabel Ribeiro[1], Talita Nicolau[1], Fernando Dourado[3], Miguel Gama[3], Jorge Padrão[1] and Andrea Zille[1]

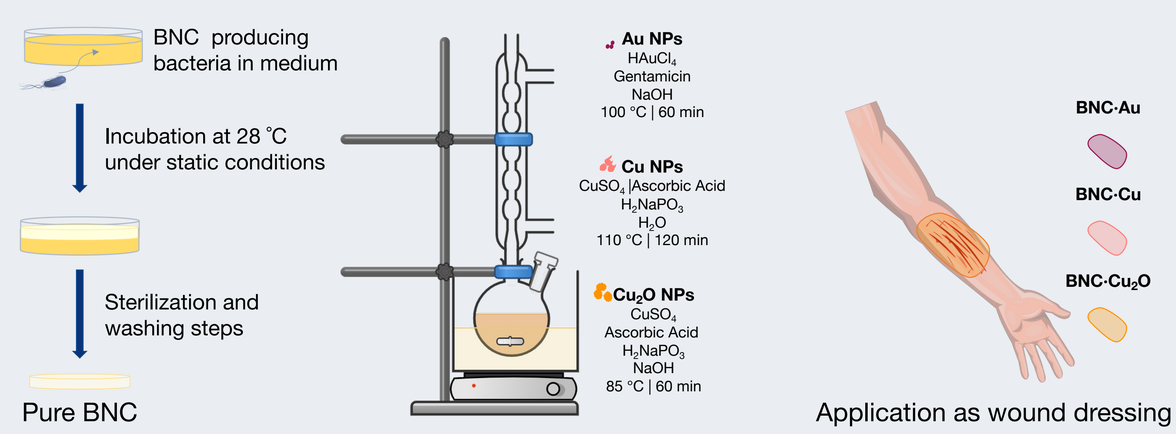
[1]Centre for Textile Science and Technology (2C2T), University of Minho, Guimarães, Portugal; [2]Department of Textile Engineering, University of Minho, Guimarães, Portugal; [3]Centre of Biological Engineering (CEB), University of Minho, Braga, Portugal
azille@2c2t.uminho.pt

Introduction

Wound infections are generally caused by pathogens and multidrug-resistant (MDR) strains that render the administration of antibiotics ineffective. An alternative is to treat infected wounds at the initial stage using a fibrous bionanopolymer, bacterial nanocellulose (BNC), functionalized with antimicrobial metal nanoparticles (MNPs). BNC is a highly promising wound dressing due to its very high-water retention capacity (> 99 %) and high porosity. Such properties enable the absorbance of exudates, whilst maintaining the environment moist allowing the exchange of air. However, BNC is absent of antibacterial properties, thus gold (Au), copper (Cu), and copper oxide (Cu_2O) NPs were incorporated within the nanofibrous structure of the biopolymer via *in situ* synthesis.



Methodology



In situ synthesis of MNPs in the presence of BNC

Results

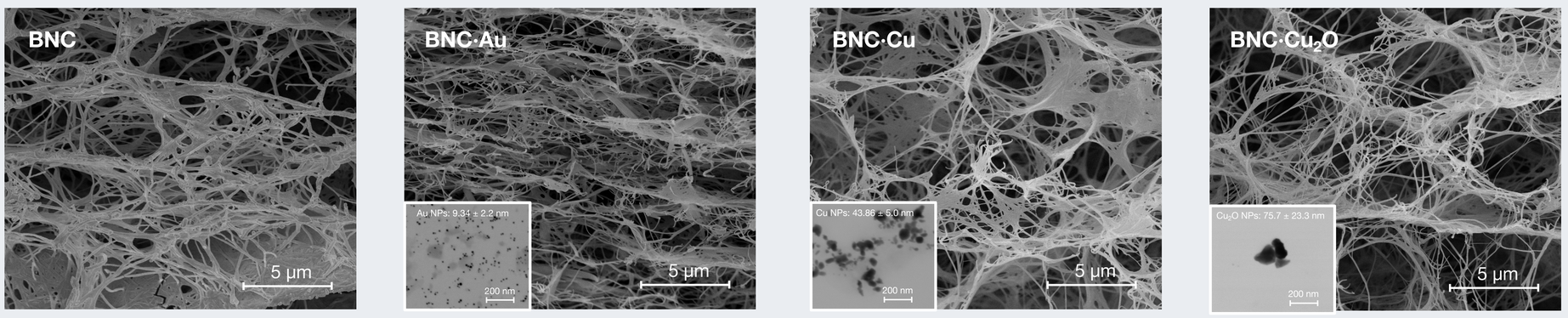


Figure 1. Analyses performed on BNC functionalised with MNPs (Au, Cu, and Cu_2O) to assess their influence on the intrinsic properties of BNC: Scanning Electron Micrographs (SEM) cross-section (magnification 15000 x) with inset of Scanning Transmission Electron Microscopy (STEM) images of the NPs.

SEM/STEM

- No apparent alteration to the fibrous structure of the BNC with the addition of MNPs.

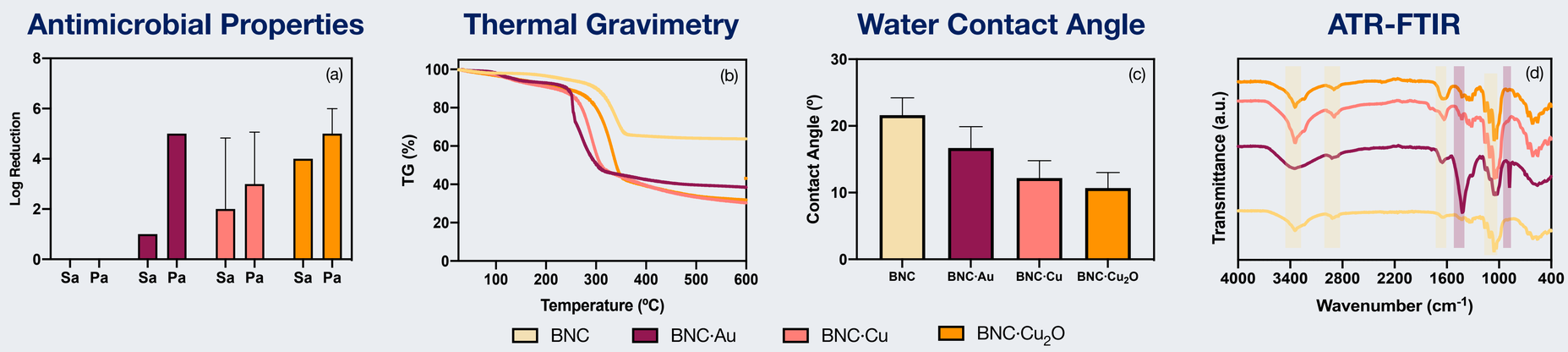


Figure 2. Analyses performed on BNC functionalised with MNPs (Au, Cu, and Cu_2O): (a) Antimicrobial Activity against *Staphylococcus aureus* (Sa) and *Pseudomonas aeruginosa* (Pa); (b) Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) spectra indicate the establishment of the nanocomposite; (c) Water Contact Angle measurements show superhydrophilic properties; (d) Thermal Gravimetry spectra indicate slight decrease on the degradation temperatures.

Antimicrobial Properties

- Moderate to strong disinfectant properties of functionalized BNC against *Pseudomonas aeruginosa* (Pa);
- Weak decontaminant properties of BNC·Au and BNC·Cu and moderate decontaminant of BNC·Cu_2O against *Staphylococcus aureus* (Sa);

Thermal Gravimetry

- Smaller metal NPs lead to lower degradation temperatures of BNC between 50-100 °C, suggesting a slight alteration to its structure;

Water Contact Angle

- Highly hydrophilic surface of all functionalized BNC, in particular for BNC·Cu and BNC·Cu_2O, possibly caused by the stronger polarity that is felt in the copper ions that cover the surface of the nanofibers;

ATR-FTIR

- Typical BNC peaks at around 3340, 2900, 1640, and 1050 cm^{-1} remain unchanged in the presence of Cu and Cu_2O NPs;
- Very sharp peaks at 1410 and 879 cm^{-1} from BNC·Au confirm the formation of the nanocomposite.

Conclusions

The functionalisation of BNC with MNPs led to:

- Changes in the BNC fibrous structure according to thermal degradation and ATR-FTIR analyses, particularly for BNC·Au, likely due to a better incorporation within the BNC fibrous structure given their smaller size;
- Excellent bacterial activity for all NPs functionalised BNC against the two most common bacteria responsible for wound infection: *Staphylococcus aureus* and *Pseudomonas aeruginosa*;
- Increase in hydrophilicity, beneficial to keep the moist in wounds;

Metal NPs functionalised BNC proved to be an excellent alternative as wound dressing.

Acknowledgements

This research was funded by FEDER funds through the Operational Competitiveness Program–COMPETE, under the project , and by National Funds through PTDC/CTM-TEX/1213/2020. Fundação para a Ciência e Tecnologia (FCT), under the project UID/CTM/00264/2020. Liliana Melro, Behnaz Mehravani, Ana Isabel Ribeiro, and Talita Nicolau acknowledge FCT, MCTES, FSE and UE PhD grants 2020.04919.BD, 2022.13094.BD, SFRH/BD/137668/2018, 2022.15386.BD. The authors would also like to acknowledge Ana Cristina Rodrigues for the samples liophilization, and Marta Fernandes for the thermal characterisation.