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Antibacterial paper based on composite coatings of nanofibrillated cellulose and ZnO

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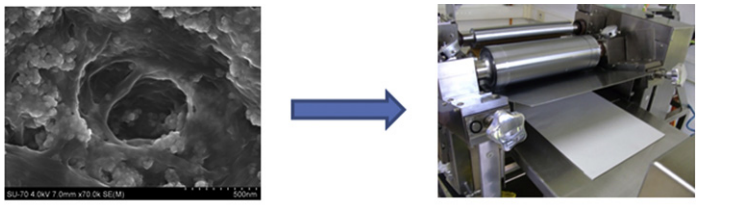
HIGHLIGHTS

- New composites of nanofibrillated cellulose (NFC) and ZnO nanoparticles (NP).
- Assemblies of NFC and ZnO NP using polyelectrolytes as macromolecular linkers.
- Application of NFC/ZnO nanofillers in paper coating formulations.
- Antibacterial activity of NFC/ZnO nanocomposites and derived coated papers.

GRAPHICAL ABSTRACT



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ABSTRACT

New composites of nanofibrillated cellulose (NFC) and ZnO nanoparticles (NP) have been prepared by electrostatic assembly in aqueous medium and using polyelectrolytes as macromolecular linkers. Selected NFC/ZnO systems were employed as fillers in starch based coating formulations for *Eucalyptus globulus*-based paper sheets. Using this method, antibacterial paper with low content of ZnO (<0.03%) and slight improvements in air permeability and mechanical properties were obtained. The antibacterial activity of the ZnO/NFC coatings was investigated namely by submitting paper samples to solar light exposure and dark conditions. In both conditions, the paper samples have shown bacteriostatic and/or bactericidal activity against Gram positive (*Staphylococcus aureus* and *Bacillus cereus*) and Gram negative (*Klebsiella pneumoniae*) bacteria. These results seem to support that the mechanism for ZnO antimicrobial activity is not mediated only by the photoactivity of the semiconductor but also by oxidizing species formed at the particles surfaces.

1. Introduction

The re-emergence of infectious diseases caused by different pathogenic microorganisms and the development of new strains of bacteria resistant to current antibiotics represent a serious threat to public health [1]. A number of those infections occur by contamination with spoiled food or in hospital environments [2]. The search for new antibacterial agents with low toxicity and capable of inhibiting microbial contamination seems imperative, for example in the context of new packaging materials for health care and food applications.

Metal oxide nanoparticles (NP) are receiving increased attention as antimicrobial agents [3–6]. These materials have longer life times as compared to organic antimicrobial agents and are chemically stable in extreme conditions (e.g. high temperature or pressure). Additionally, the development of bacterial resistance is less favored because these nanomaterials attack a broad range of targets in the bacteria [7]. Among the metal oxides, TiO_2 and ZnO

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