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Graphitic materials decorated with bio-based silver nanoparticles as antiviral filters for face masks

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ABSTRACT

Silver nanoparticles (AgNPs) have well known antimicrobial properties against various pathogens, while graphitic materials are acknowledged for their excellent mechanical and thermal properties. The present research focused on the fabrication of antiviral filters for face masks based on graphitic materials, cellulose nanofibers and bio-based silver nanoparticles.

INTRODUCTION

Silver nanoparticles (AgNPs) have well known antimicrobial properties against various types of human, animal, and plant pathogens, such as virus, bacteria, and fungi [1]. In parallel, graphitic materials are acknowledged for their excellent mechanical and thermal properties [2].

The present research focused on the fabrication of antiviral filters for face masks based on graphitic materials (graphene oxide – GO or expanded graphite – EG), cellulose nanofibers (CNF), and bio-based silver nanoparticles (BB-AgNPs).

EXPERIMENTAL PROCEDURE

The proposed fabrication method is efficient and low-cost, with the fabricated materials being sustainable since they employ biodegradable components prepared through a clean and energy-efficient process.

Hesperetin (HST) was dissolved in sodium hydroxide solution (0.005 mol L^{-1}) to a final HST concentration of 1 mmol L^{-1}. $AgNO_3$ was dissolved in deionized water in a concentration of 1 mmol L^{-1}. The solutions were mixed in a ratio of 1 to 1 (v/v) by drop wise addition of reduction reagent into Ag(I) solution (Fig. 1a). The formation of bio-based silver nanoparticles, was monitored using UV/Vis measurements and Plasmon band at 404 nm.

GO and EG suspensions were obtained by submitting the materials to ultrasound for 10 to 15 minutes. Subsequently, the 10%-CNF (Fig. 1b) suspension in 7% of NaOH was added into the GO or EG suspensions and then the CNF-GO or CNF-EG co-suspensions were filtered, leading to the fabrication of freestanding composite sheets. The BB-AgNPs were added to the suspensions and submitted to ultrasound before filtering (Fig. 1c) or sprayed/drop casted onto the recently obtained layers.

The fabricated freestanding films as well as their individual components were characterized using Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and challenged in antiviral tests.

RESULTS AND DISCUSSION

TEM characterization indicates that bio-based silver nanoparticles (BB-AgNPs - Fig. 1a), having mean diameter size of ~22 nm and Zeta potential of -40 mV were formed,

SEM images showed that by simple sonication process for ~4 minutes the GO and EG material can be uniformly decorated with bio~-based silver nanoparticles (Fig. 1c).

The obtained filters (GO-CNF@BB-AgNP and EG-CNF@BB-AgNP) showed excellent physical appearance, mechanical properties (hardness and elasticity) and were efficient in fighting viruses, such as SARS-CoV-2. Cellular toxicity was low or absent in the developed filters.

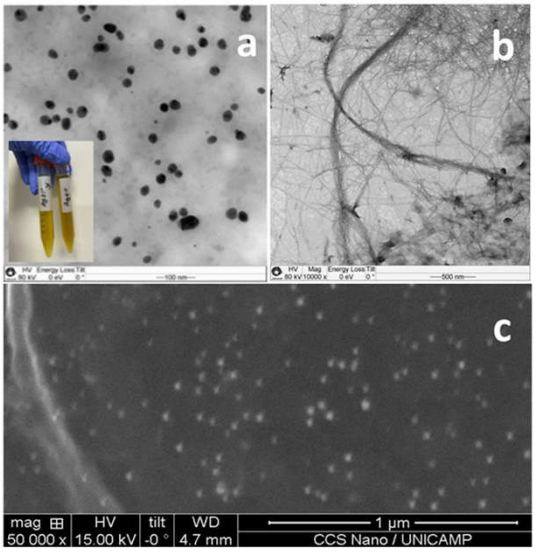

Figure 1: TEM images of BB-AgNPs (a) and cellulose nanofibers (b); SEM images of a GO sheet decorated with bio-based silver nanoparticles (c). The inset in (a) show the picture of BB-AgNP suspensions

CONCLUSIONS

Altogether, the GO- or EG-based CNF@BB-AgNP filters might be used for fabrication of face mask due to their highly water absorbable materials (CNF), antimicrobial properties, and low resistance to breathing and sneezing, thus protecting the users from infections.

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