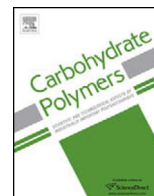




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Impregnation of silver nanoparticles into polysaccharide substrates and their properties

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ABSTRACT

A method to impregnate silver nanoparticles (AgNPs) into different polysaccharides substrates (cellulose powder (CP), microcrystalline cellulose (MCC), carboxymethyl cellulose (CMC) and chitosan (Chit)) by using glucose as reducing agent, is presented. X-ray diffraction analyses of polysaccharides coated with AgNPs showed the formation of silver particle sizes in the range of 3.7–5.6 nm and have almost spherical shape. The entire prepared composite shows antimicrobial effect. The antibacterial activity of polysaccharides loaded with silver nanoparticles was evaluated against Gram-negative *Escherichia coli* (*E. coli*) and Gram-positive *Staphylococcus aureus* (*S. aureus*) bacteria. The results suggest excellent antibacterial activity.

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1. Introduction

Silver has been known since it was used in ancient times for water purification, dental alloy, jewellery, etc. In recent years, it has been noticed that, a solution of silver nitrate effectively inhibits the growth of both Gram-positive and Gram-negative bacteria (Panáček et al., 2006). This phenomenon was studied on a deeper level to disclose that silver ions works against bacteria in a number of ways; ionic silver (Ag^+) or its oxide (AgO) disrupt the DNA replication in bacteria by causing an increase in osmosis and silver ions interact with the thiol groups of enzymes and proteins that are important for bacterial respiration (Ousey & McIntosh, 2009). Silver does not react with oxygen in the air under normal conditions. However, it reacts slowly with sulfur compounds in the air to end up with silver sulfide (Ag_2S), a black compound. Losing lustre that develops over time on silverware and other silver-plated objects is silver sulfide.

Over the last few decades, much attention has been paid to Ag nanoparticles (Ag-NPs) because of its excellent antimicrobial properties for its high surface area to volume ratio, which can provide better contact with microorganisms. Such Ag-NPs have utilized in a wide range of applications such as, medical textiles, management of open wounds, and water filters in swimming

pool (Liz-Marzán & Lado-Touriño, 1996; Su, Wei, Hu, & Tang, 2011; Valodkar, Bhadoria, Pohnerkar, Mohan, & Thakore, 2010; Vigneshwaran, Nachane, Balasubramanya, & Varadarajan, 2006). Therefore, several approaches have been used to prepare Ag-NPs by using wide range of reagents (El-Rafie et al., 2011; Hebeish, El-Shafei, Sharaf, & Zaghloul, 2011; Ibrahim, Eid, & El-Batal, 2012; Liz-Marzán & Lado-Touriño, 1996; Panáček et al., 2006; Su et al., 2011; Venediktov, Ganiev, & Padokhin, 2010; Vigneshwaran et al., 2006). Perhaps, one of the most controversial issues concerning silver colloid nanoparticles is the colour of the finished colloidal silver product. Colour is affected by both the size of the mineral particles to which the silver ions attach and the level of electrolyte in the solution at the time of the electrolysis process. Colours pans from yellow to brown as long as there is little mineral electrolyte in solution; and from milky white, to grey when the mineral electrolyte in solution is higher. Add to that, a distinguished character of spherical silver nanoparticles is that surface plasmon resonance (SPR) peak wavelength which can be tuned from 400 nm to 530 nm by changing the particle size.

Chemical reduction of silver nitrate to produce Ag-NPs is one of the most commonly ways used in wet processing industry. However, freshly reduced Ag-NPs are unstable and tend to aggregate into large clusters and in order to preserve the antimicrobial properties, Ag-NPs should be protected from aggregation. Much has been done for that purpose by using different auxiliaries such as, surfactants, natural or synthetic polymers, biological reagents, and dendrimers. However, impregnation of Ag-NPs into polysaccharides fibres represents a novel approach to achieve the reduction

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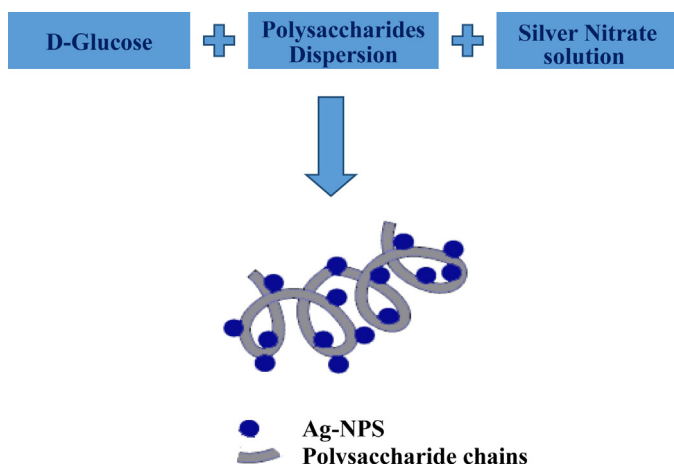


Fig. 1. D-Glucose mediated biological process for the impregnation of AgNPs into polysaccharides.

and the stability conditions in one step to produce a new composite with antimicrobial activities (Gao, Wei, Yan, & Xu, 2011).

The present research is aimed to impregnate AgNPs into different polysaccharides namely, chitosan (Chit), cellulose powder (CP), carboxymethyl cellulose (CMC) and microcrystalline cellulose (MCC), using glucose as the reducing agent at ambient conditions which can be regarded as a green process, and to study its antimicrobial properties.

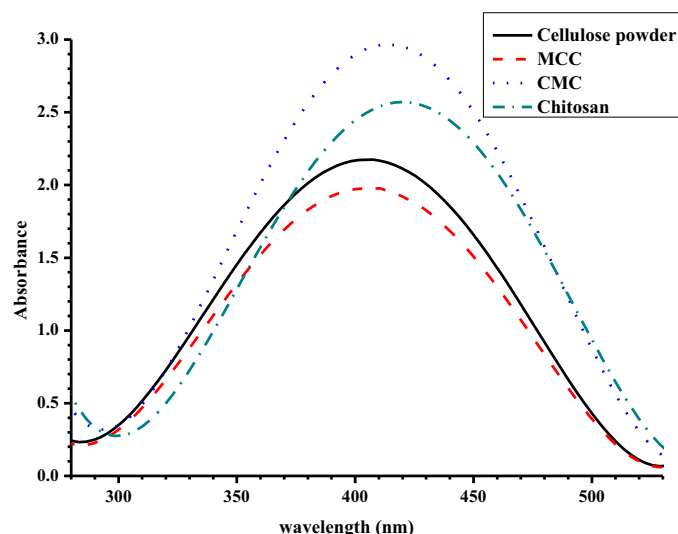


Fig. 2. Plasmonic UV-vis spectra of Ag-NPs impregnated into different polysaccharides.

2. Experimental

2.1. Materials

D-Glucose monohydrate were obtained from (ADWIC), carboxymethyl-cellulose (CMC) in the name of Tylose® C 1000,

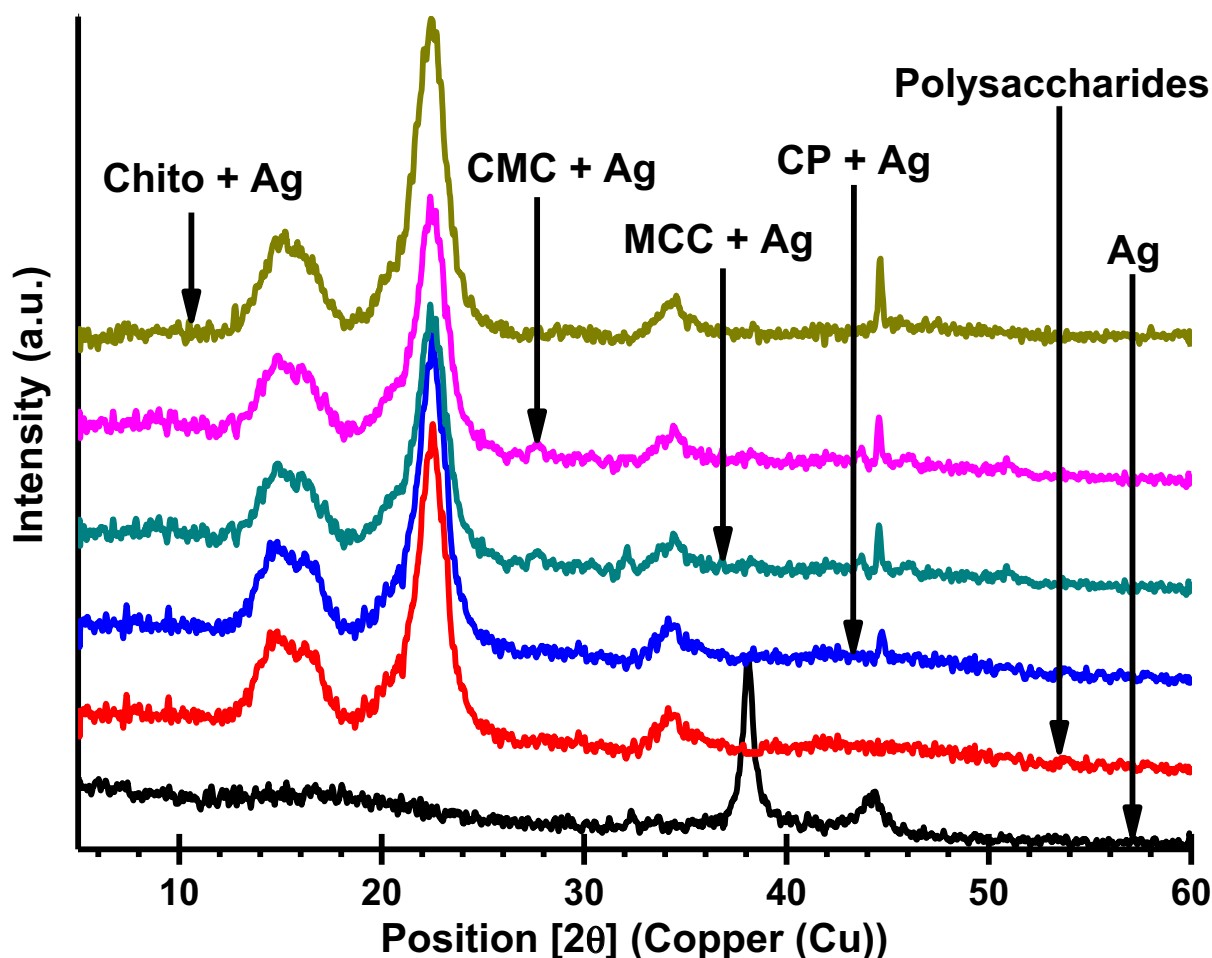


Fig. 3. XRD analysis of silver nanoparticles, polysaccharide and AgNPs impregnated polysaccharides (CP, CMC, MCC and Chito).

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