

Synthesis and Characterization of Silver-Chitosan Nanoparticles on Textiles

Behnaz Mehravani¹, Majid Montazer², Andrea Zille^{1(*)}

¹2C2T - Centre for Textile Science and Technology, University of Minho, Azurem Campus, Portugal 4800-058

²Amirkabir University of Technology (Tehran Polytechnic), Hafez Avenue, Tehran, Iran

(*) Email: azille@2c2t.uminho.pt

INTRODUCTION

Silver nanoparticles (AgNPs) are known to exhibit inhibitory and bactericidal effects. AgNPs were previously applied onto polyester fabric by exhaustion method [1,2]. However, very few researchers have studied and demonstrated the effects of silver-chitosan nanoparticles on polyester fabric [3]. XRD, EDS and SEM analysis have been used for characterizing and proving the presence of silver nanoparticles on the fabric. Application of silver-chitosan nanoparticles on polyester fabric have shown positive results when tested the fabric sample against Gram-negative *E. coli* and Gram-positive *S. aureus* bacteria. The good results of washing fastness demonstrate a potential application in biomedical industry.

MATERIALS AND METHODS

AgNPs were synthesized using exhaustion method in presence of different amount of chitosan, silver nitrate, citric acid and sodium hypophosphite (Table 1). The steps for the above procedure involved dissolving chitosan in citric acid, addition of sodium hypophosphite at 50 °C, addition of silver nitrate and fabric at the boiling temperature. Antimicrobial test was performed using the AACTCC100-2004 standard. Cytotoxicity test was performed using fibroblasts.

Table 1. Synthesis Conditions of AgNPs with Different Weight Percentage

SAMPLE	SILVER NITRATE w/v %	CHITOSAN w/v %	CITRIC ACID w/v %	SODIUM HYPOPHOSPHITE w/v %
1-AG+CHIT	0.002	0.1	0.5	0.3
2-CHIT	-	0.1	0.5	-
3-AG	0.002	-	0.5	0.3

RESULTS AND DISCUSSION

XRD analysis confirms the presence of silver in metal state with crystallite size of 12 nm. XPS elemental analysis confirm the presence of AgNPs and its distribution was confirmed in the EDX mapping analysis (Figure 1).

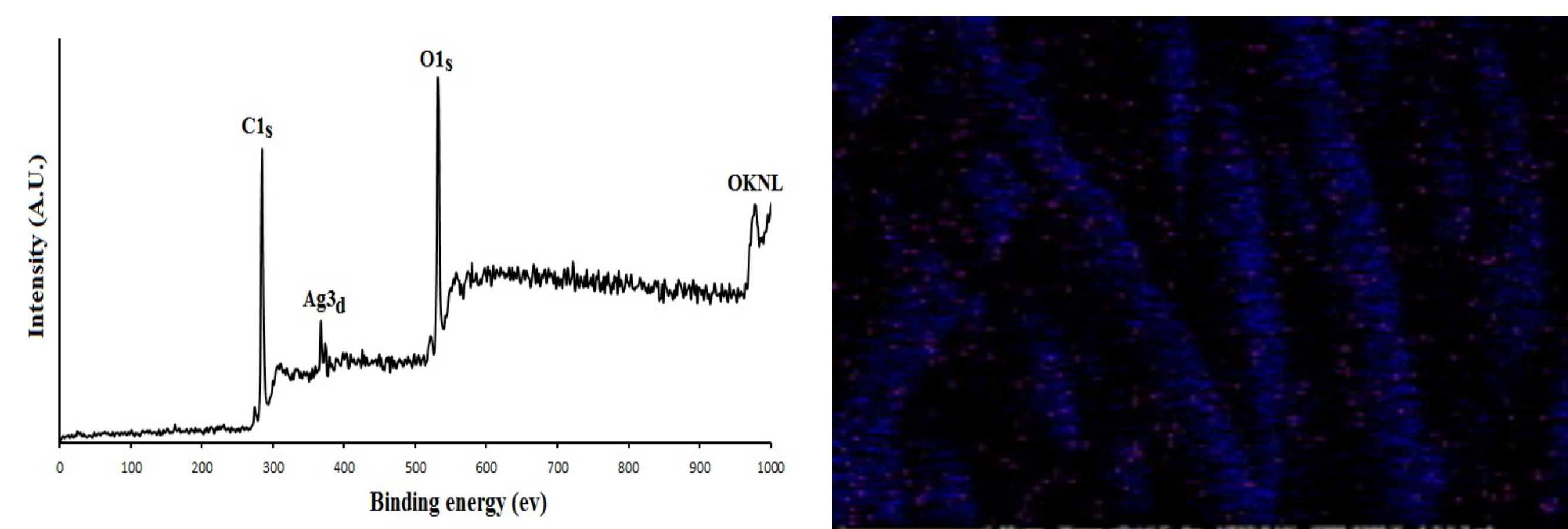


Figure 1. XPS and EDX mapping Analysis

The SEM analysis (Figure 2) of the silver-chitosan sample confirm that AgNPs are uniformly scattered on the fibre surface.

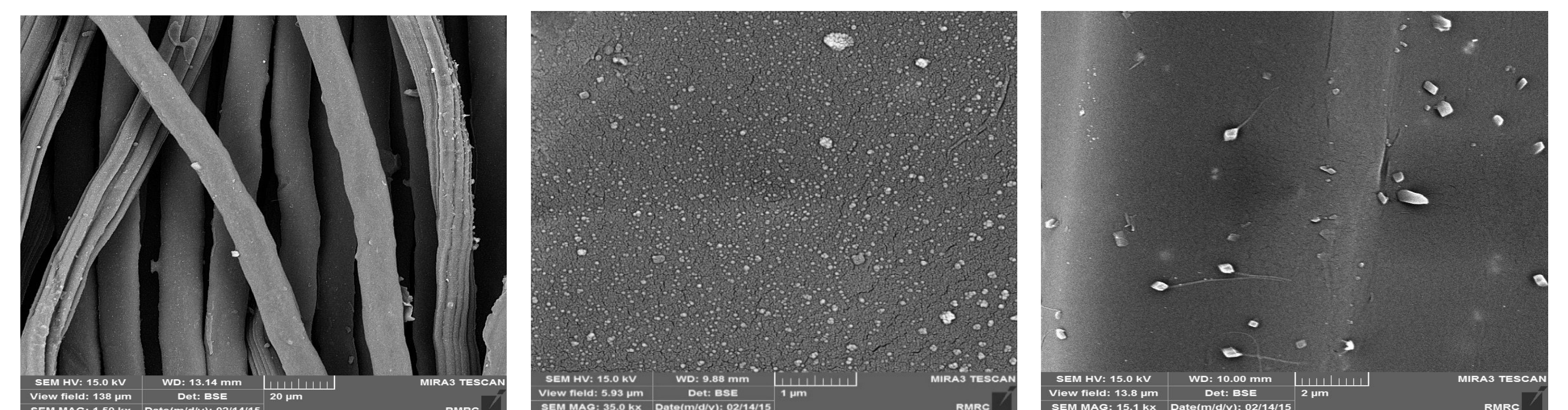


Figure 2. SEM Images of polyester and Silver-Chitosan sample

The antimicrobial effect of the AgNPs was determined by testing them against Gram-negative bacteria *Escherichia coli* and Gram-positive *Staphylococcus aureus*. From the results (Table 2) it can be concluded that the chitosan nanoparticles show positive effect against both bacteria. After 10 washing cycles the samples with only silver or chitosan showed a slight decrease in antimicrobial efficacy while the sample with the chitosan-silver nanoparticles did not show any loss in the antimicrobial efficiency. The samples show no cytotoxicity.

Table 2. Antimicrobial activity before and after washing and Cytotoxicity results

SAMPLE	S. AUREUS	E. COLI	S. AUREUS AFTER WASH	E. COLI AFTER WASH	CYTOTOXICITY
1-AG+CHIT	99.9	99.9	99.9	99.9	0
2-CHIT	99.9	98.1	99.9	67.3	0
3-AG	99.9	99.9	99.9	98.3	0

CONCLUSION

Synthesis of silver-chitosan nanoparticles in acidic media was performed successfully by using exhaustion method. The XPS elemental analysis and EDX analysis has confirmed the presence of silver nanoparticles on the samples and the images from SEM have displayed the uniform distribution of the AgNPs on the fabric. The silver-chitosan nanoparticles have demonstrated improved antimicrobial efficacy against Gram-positive and Gram-negative bacteria when compared to the control samples. The samples show no cytotoxicity.

REFERENCES

- Thomas, V., Bajpai, M., & Bajpai, S. K. (2011). In situ formation of silver nanoparticles within chitosan-attached cotton fabric for antibacterial property. *Journal of Industrial Textiles*, 40(3), 229-245.
- Ilić, V., Šaponjić, Z., Vodnik, V., Potkonjak, B., Jovančić, P., Nedeljković, J., & Radetić, M. (2009). The influence of silver content on antimicrobial activity and color of cotton fabrics functionalized with Ag nanoparticles. *Carbohydrate Polymers*, 78(3), 564-569.
- Ali, S. W., Rajendran, S., & Joshi, M. (2011). Synthesis and characterization of chitosan and silver loaded chitosan nanoparticles for bioactive polyester. *Carbohydrate Polymers*, 83(2), 438-446.

Acknowledgments

This work was also funded by FEDER funds through the Operational Competitiveness Program—COMPETE and by National Funds through Fundação para a Ciência e Tecnologia (FCT)—under the projects PTDC/CTM-TEX/28295/2017 and UID/CTM/00264/2019.