

Performance and characterization of Ag–cotton and Ag/TiO₂ loaded textiles during the abatement of *E. coli*

T. Yuranova^a, A.G. Rincon^b, C. Pulgarin^b, D. Laub^c, N. Xantopoulos^d,
H.-J. Mathieu^d, J. Kiwi^{a,*}

^a Laboratory of Photonics and Interfaces, Institute of Chemical Sciences and Engineering, Station 6, Lausanne, Switzerland

^b Institute of Chemical Sciences and Engineering, Group of Electrochemical Engineering, Station 6, Lausanne, Switzerland

^c Interdisciplinary Center for Electron Microscopy (CIME), Lausanne, Switzerland

^d Laboratory of Metallurgical Engineering, Materials Department, Swiss Federal Institute of Technology, 1015 Lausanne, Switzerland

Received 22 July 2005; received in revised form 2 December 2005; accepted 19 December 2005

Available online 19 January 2006

Abstract

The bacterial inactivation of *Escherichia coli* on Ag–cotton textiles were investigated under different experimental conditions with novel Ag–nanoparticles fixed on cotton textiles. The evaluation of the bactericide performance of the Ag–cotton was compared with the one observed for Ag–TiO₂–cotton loaded textiles. The procedure used allowed us to prepare highly dispersed Ag–cluster species, 2–4 nm in size, as observed by transmission electron microscopy (TEM). By depth profile analysis, the X-ray photoelectron spectroscopy (XPS) revealed that the Ag profile in the 15 topmost layers remained almost constant before and after *E. coli* inactivation. The cotton loading was fairly low and of the order of 0.10 wt.% Ag/wt. of cotton. By infrared spectroscopy no modification of the Ag–cotton could be detected before or after *E. coli* inactivation due to the small absorption coefficient of Ag and the very low metal loading of Ag on the cotton. The *E. coli* was completely abated on Ag–cotton textiles immediately after the contact took place, due to the strong bacteriostatic effect of the dispersed silver clusters on the cotton surface.

© 2005 Elsevier B.V. All rights reserved.

Keywords: Ag–clusters; *E. coli* decontamination; XPS; IR; Ag–cotton textiles

1. Introduction

Silver solutions and silver clusters have been used for the treatment of infections due to their natural bactericide and fungicide properties [1–4]. Nano-silver particles in solution or supported on appropriate substrates are currently used due to their effective action adversely affecting the cellular metabolism and inhibiting cell growth. The chemistry has revealed that an Ag-deposit is not toxic to human cells in vivo and is reported to be biocompatible [5–8]. Previous work report that Ag as hinders the transport of vital cations in the pores of the microbial cell membranes, affecting the electron transfer system necessary for the basic bacterial metabolism [9–11]. Moreover, it was reported that Ag does not introduce any of the delivery problems encountered with anti-bacterial drugs [12].

Ag–salts and silver solutions have some biological limitations for their practical use as a bactericide. Supported silver clusters prepared using nano-technology seem promising when fixed on adequate supports due to their increased bactericide effect. This is important in wound healing and for the control of inflammations. By decreasing the Ag crystal size the dispersion of the clusters and the active Ag contact area available for chemical reactions is increased. This in turn allows the reactions to proceed over a short time period.

This study investigated the fixation of Ag on cotton (from now on cotton–Ag) that would protect wounds from bacterial contamination and growth. The bacteria existing in the wound exudates in contact with the cotton–Ag, which inhibits the growth and multiplication of bacteria, *Escherichia coli* K-12 taken as a model for this study [13]. Some runs were also tried for Ag–TiO₂ cotton systems to see whether this system under band-gap light irradiation would have a more effective bactericide action on *E. coli* than Ag–cotton alone. Studies of this system in suspensions have been reported [14–16]. Recently the Ag-fixation on healing

* Corresponding author.

E-mail address: john.kiwi@epfl.ch (J. Kiwi).

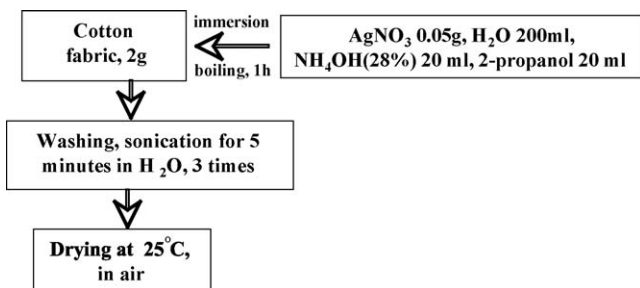


Fig. 1. Schematic of the preparation of the Ag-loaded cotton textiles.

pads by modifying the textile surfaces before the Ag deposition has been reported [17]. During this study we performed a long series of preliminary experiments to find the most suitable conditions in order to attach Ag-clusters on the cotton textile. The bactericide performance of the Ag–cotton was evaluated. Finally, we proceeded to characterize the Ag-clusters on the cotton by electron microscopy (EM), photoelectron spectroscopy (XPS) and infrared spectroscopy (IR).

2. Experimental

2.1. Materials

Reagents like AgNO_3 , ammonia solution, isopropanol, acid and bases were Fluka p.a. and used without further purification.

2.2. Fixation of silver on cotton textiles

Fig. 1 shows schematically the procedure used to fix the Ag-clusters on the cotton textile. The precursor solution was prepared by adding isopropanol to the ammonia aqueous solution of AgNO_3 . The cotton textile was then immersed in this solution and boiled for 1 h. Subsequently, the Ag–cotton sample was removed from the solution, washed with water and sonicated several times before drying at 25°C [18]. This procedure led to loadings of around 0.1 wt.% Ag/wt. cotton as determined by elemental analysis.

The TiO_2 loaded cotton was prepared by immersing the cotton textile sample in a 5 g/l suspension of TiO_2 Degussa P-25, previously sonicated for 30 min in bi-distilled water. The textile was then dried for 1 h and sonicated for 5 min at 75°C to eliminate loosely bound particles. The loading of the cotton was around 1% TiO_2 /wt. on cotton as determined by elemental anal-

ysis. When Ag-clusters were added on top of the TiO_2 on the cotton, the Ag-clusters were fixed as described in the preceding paragraph.

2.3. Bacterial strain quantification

The bacterial strain used *Escherichia coli* K12 was inoculated in the nutrient broth no. 2 (N. Oxoid 2, Switzerland) and grown overnight at 37°C by constant agitation under aerobic conditions. Aliquots of the overnight culture were inoculated into a fresh medium and incubated aerobically at 37°C for 15 h. At a stationary growth phase, bacteria cells were collected by centrifugation at $500 \times g$ for 10 min at 4°C and the bacterial pellets were washed three times with a tryptone solution. Cell suspensions were diluted with Milli-Q water in a glass bottle to the required cell density corresponding to 10^5 to 10^6 colony forming units per millilitre (CFU/ml). Samples were spotted onto plates and spread using standard techniques. Samples were plated on agar PCA (Plate Count Agar) plates. The plates were incubated at 37°C for 24 h for the final bacterial counting. The experimental results reported for *E. coli* inactivation in Fig. 6a–e are the media of four independent runs.

2.4. Photocatalysis experiments with the system Ag– TiO_2 –cotton

At the beginning of the experiments while reactors were kept in the dark (5 min), bacteria were added to a glass bottle and mixed by recirculation of the water to constant concentration throughout the system. All experiments were carried out with Milli-Q water. Then the solar lamp was turned on at an intensity of 100 mW/cm^2 and samples were collected at predetermined times for 3 or 4 h. All experiments were repeated three times and the weighted average was taken to report the data in Fig. 6d to 6e. Samples were also collected at predetermined times (t) in the dark (controls). The experiments were carried out under artificial light using thin film Pyrex glass reactors with an illuminated volume of 25 ml. A peristaltic pump recirculated the water from the recirculation tank to the reactors with a flow rate of 150 ml/min. The total volume of the system (100 ml) is made up by the 25 ml irradiated volume and the dead volume (recirculation tank + connecting tubing). Internal PVC supports were put in the reactors to carry out the irradiation of the bleached cotton with fixed Ag– TiO_2 . The solar simulated Xe-lamp (Suntest, Her-

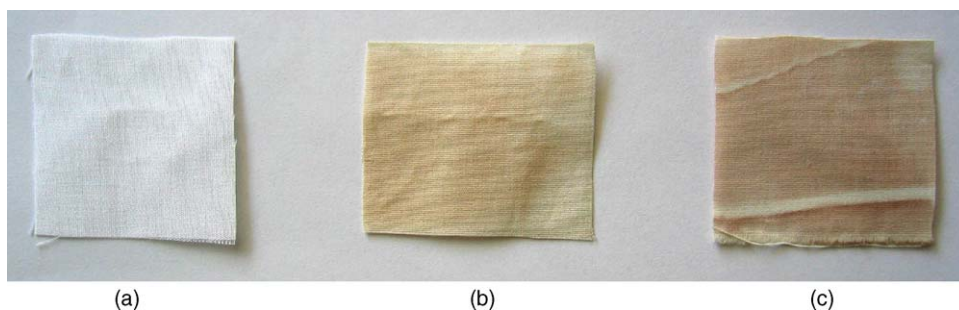


Fig. 2. Cotton pads before Ag-loading (a), after Ag-loading but before being used in *E. coli* inactivation (b) and after their use in *E. coli* inactivation (c).

Download English Version:

<https://daneshyari.com/en/article/28555>

Download Persian Version:

<https://daneshyari.com/article/28555>

[Daneshyari.com](https://daneshyari.com)