Silver-coated polyester fabric: a promising Point-Of-Use disinfection technique against *Escherichia coli*

Sobrinho, R.P.*, Freitas, B.L.S.*, J. A. Byrne **, Fernandez-Ibañez, P.** and Sabogal-Paz, L.P.*

* Department of Hydraulics and Sanitation, São Carlos School of Engineering, University of São Paulo, Avenida Trabalhador São-Carlense 400, São Carlos, São Paulo, Brazil.

** Nanotechnology and Integrated Bioengineering Centre, School of Engineering, Ulster University, Jordanstown, BT37 0QB, Belfast, Northern Ireland, United Kingdom.

Highlights:

- Silver-coated polyester fabrics were efficient for Escherichia coli inactivation.
- Contact time, silver coating percentage and surface area affected the fabric inactivation performance.
- Assays with 100% of silver coating fabric achieved complete bacteria inactivation faster than 4% coating.

Keywords: bacteria; inactivation; drinking water

INTRODUCTION

Silver is recognized as an effective biocide because produces reactive species that interact with microorganisms' enzymes. This inhibits DNA replication and alters cell membrane structure and permeability, leading to respiratory damage and affecting growth, cell division, and cytoplasmic content (Jung et al., 2008). Despite its antimicrobial properties, prolonged exposure to silver ions has been associated with human health issues such as skin and eye disorders (Drake; Hazelwood, 2005).

Research has primarily focused on assessing silver's antimicrobial effects in various treatment contexts, typically involving Ag+ ions and nanoparticles incorporated into diverse substrates like metals, plastics, polymers, and textiles (WHO, 2018). However, due to the specific production and handling requirements of silver nanoparticles, there is interest in investigating alternative silver materials for disinfection purposes.

This study aims to investigate the disinfectant potential of readily available materials, specifically silver fabrics, as a simpler alternative to nanoparticle-based approaches. Additionally, evaluating silver fabrics could offer a practical Point-of-Use (POU) water treatment solution, as their production is widespread, and they are already utilized in various applications such as wound treatment, medical supplies, and electromagnetic protection.

METHODOLOGY

This study aimed to evaluate the effectiveness of two silver-coated polyester fabrics, with coating percentages of 4% and 100%, for *E. coli* (ATCC 11229) inactivation in lab-made water samples (200 mL of distilled water contaminated with up to $7x10^3$ CFU/100mL of *E. coli*).

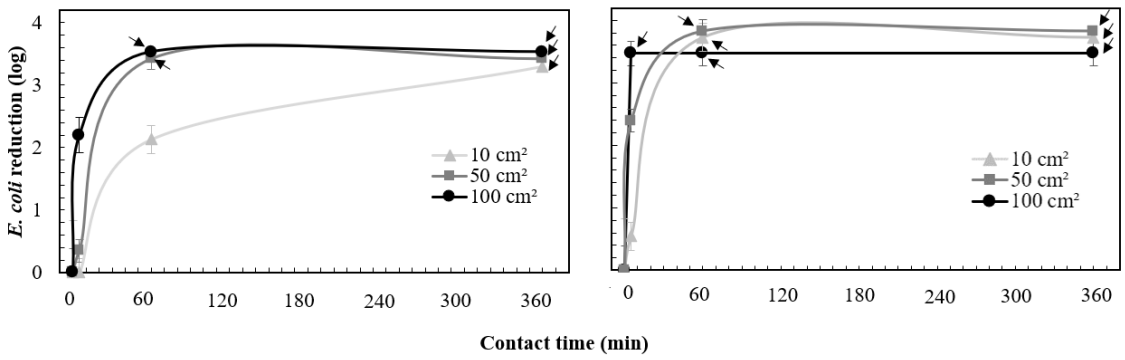
Experimental conditions were delineated by a Factorial Design considering three factors: %Ag coating (4% and 100%), surface area (10, 25 and 100 cm²), and contact time (5, 60 and 360 min) in triplicate. All fifty-four experiments were conducted on a refrigerated shaker under a controlled temperature (25°C) and orbital stirring (38 rpm). Control assays without silver-coated fabric were also performed. No process was implemented to prevent the leaching of silver into the test matrix. Both control and disinfected samples were analyzed for *E. coli* according to APHA et al. (2012).

Statistical analyses were performed using Minitab software, employing Student's t-test and Mann-Whitney U test (95% confidence interval). The effects of silver coating percentage, surface area, and contact time on the *E. coli* inactivation were assessed using Pareto Charts.

RESULTS AND CONCLUSIONS

E. coli reductions using silver-coated polyester fabrics with 4% and 100% coating are shown in Figure 1. As expected, the fabric with a higher silver coating percentages led to more significant bacteria inactivation ($p = 0.17$, Mann-Whitney test). In experiments with 100% coating, seven out of nine conditions achieved complete bacteria inactivation (absence of *E. coli*), compared to five out of nine conditions with 4% coating.

Figure 1 – Performance of silver-coated polyester fabrics with 4 and 100% coating for *E. coli* reduction. Note: arrows indicate absence of *E. coli*



Samples with 100 cm² of 100% silver-coated fabric showed complete *E. coli* inactivation within 5 minutes, while smaller fabric pieces (10 and 25 cm²) required longer exposure times. Conversely, for 4% coated fabric, larger pieces required at least 1 hour of exposure for complete inactivation, with smaller pieces needing up to 6 hours.

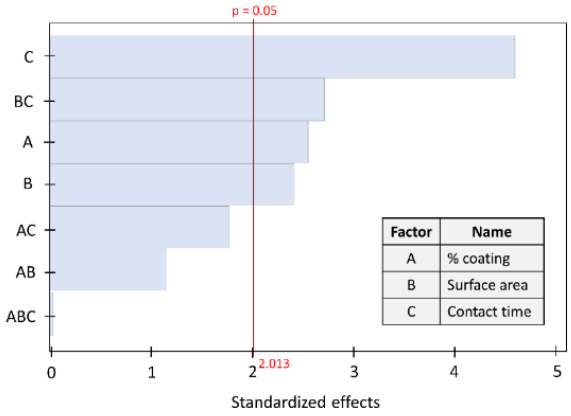
Increasing silver coating from 4% to 100% reduced exposure time for complete inactivation from 1 hour to 5 minutes for fabrics with 100 cm² surface area. Additionally, 10 cm² pieces of 100% coated

fabric exhibited similar performance to 50 cm² pieces of 4% coated fabric (p = 0.89, Student's t-test), indicating higher silver coating percentages maintain efficiency even with smaller areas.

Although silver-coated fabrics showed high bactericidal activity, the acidic pH of the lab-made water used may have enhanced disinfection performance by facilitating silver ion release. Further studies on natural waters are necessary to assess fabric effectiveness as Point-Of-Use technology.

The Pareto Chart highlighted significant positive effects of factors such as contact time, surface area, and silver coating percentage on *E. coli* inactivation (Figure 2). The effects were statistically significant if their respective bars crossed the red line (p = 0.05). As shown, all factors and their combination had positive effects on inactivation performance; however, the only significant ones were the contact time (p < 0.0001), the interaction between surface area and contact time (p = 0.009), silver coating percentage (p = 0.014) and surface area (p = 0.019).

Figure 2 – Pareto Chart for each factor and their combination on *E. coli* inactivation



Jung et al. (2008) also demonstrated the influence of contact time on the *E. coli* reduction in silver laundry machines. They found that silver ions released inside the machine enhanced antimicrobial activities against bacteria every 30 min, reaching the maximum within 2 h of exposure, aligning with our study's findings. The influence of silver quantity (given by the surface area and the silver coating percentage) were also demonstrated by Haase et al. (2017). In their research, the authors achieved antimicrobial activity using silver fabrics with coating percentages ranging from 5 to 30% over a fixed 3-hour exposure period.

The promising results suggest silver-coated fabrics could be viable Point-Of-Use technology, although further studies are needed to evaluate their effectiveness against viruses and protozoa in more challenging waters.

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