

## ANTIMICROBIAL, NANO-SIZED SILVER SALT CRYSTALS ENCAPSULATED IN A POLYMER COATING.

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Silver-based antimicrobial coatings are progressively used for different finishing/coating processes in medical device, textile, filtration, paper, and packaging industries. For example, in the technical/ functional textile business unit, antimicrobial fabrics find many applications in medical, hygiene, protection (bio-hazard protective clothings), sport, health care, personal care, filtration, and other markets. Some popular products include high value silver-coated fabrics for use as wound dressings.

Silver is a well known antimicrobial metal capable to inhibit and kill bacteria and fungi. Today, many different forms of silver are proposed such as metallic silver nanoparticles, silver-oxide nanoparticles, silver-complex zeolites, soluble silver salts and slightly soluble silver salts. Silver at the nanoscale or silver-based nanoparticles have the main advantage of providing a greater surface area than microparticles; then, nanoparticles provide higher availability of biocidal silver ions for improved antimicrobial effect. While these nanoparticles are used to control or limit the growth of bacteria or fungi (inhibition), most of them do not provide sufficient silver ions to kill effectively and, therefore, to act as a biocide. In addition, for many applications, nanoparticles must be encapsulated in order to provide durability of antimicrobial properties. The encapsulation process must be carefully chosen and optimized in order to obtain durability of antimicrobial properties and provide sufficient silver ions to achieve significant kill rates.

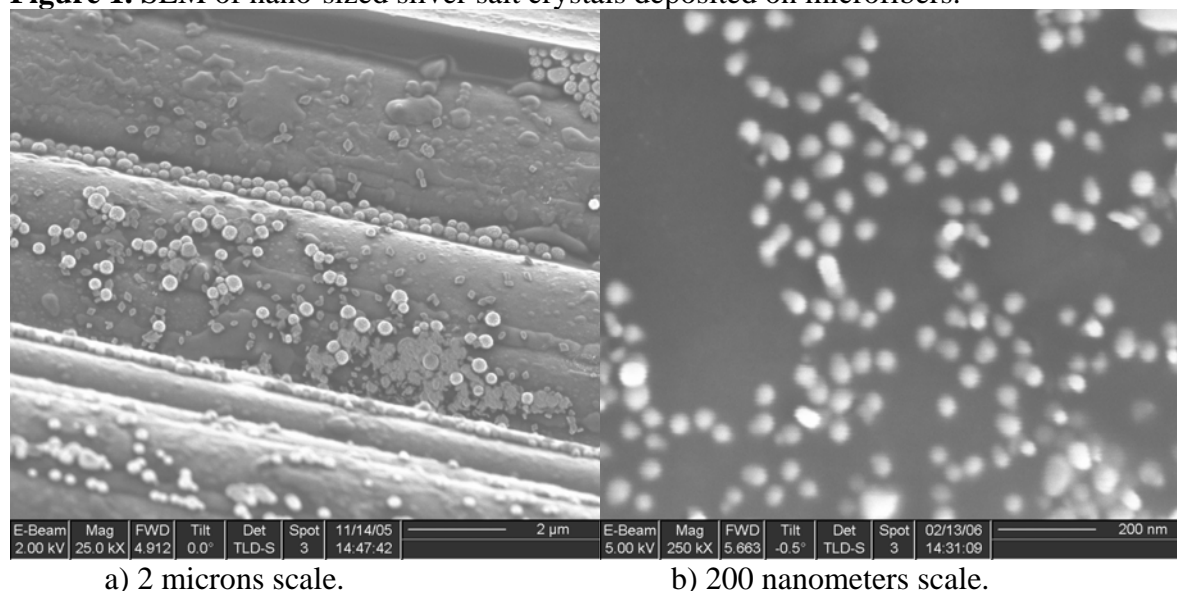
This paper presents a new, non-toxic, antimicrobial silver solution made of nano-sized, slightly soluble, silver salt crystals which can be applied in different finishing/coating processes such as spraying, dip-coating, padding and thin film deposition to form a durable antimicrobial/ biocidal polymer coating. Figure 1 presents SEM image of these nano-sized silver salt crystals deposited on a fabric made of microfibers. The dimension of such nanoparticles varies between 20 and 150 nm approximately.

Figure 2 shows kill rate against *Clostridium Difficile* (*C. Difficile*) on polycotton and polyester fabrics (PC-GRSC and PE-GRSC respectively) [1]. The nano-silver salt treatment allows to kill 99.99% of *C. Difficile* very rapidly, within 1 min. In addition, Figure 3 shows cytotoxicity agar overlay (cellular damage or cytopathics effects) test results [2]. GLP-Cytotoxicity test was conducted for USFDA (21 CFR PART 58) certification. The silver-treated sample has an average score of 2, which meets the requirement for acceptability. Therefore, this test result demonstrates the non-toxicity of the treatment resulting from the application of nano-sized silver salt crystals.

**References:**

- [1] American Association of Textile Chemists and Colorists, AATCC Test Method 100-1999: Antibacterial finishes on textile materials, assessment of. In AATCC Technical Manual, 149-151, 2001.
- [2] ISO 10993-5: Cytotoxicity –Agar overlay, In ISO 10993-2003, Biological evaluation of medical devices, Part 1: Evaluation and testing, 2003.

**Figure 1.** SEM of nano-sized silver salt crystals deposited on microfibers.



**Figure 2.** C. Difficile kill rate test results (AATCC 100) with different fabrics treated by silver salt crystals encapsulated in a polymer coating.

Sample identification	Bacterial counts of sample ioculated at t=0 (UFC/ sample)	Bacterial counts of sample ioculated at t=1 minute (UFC/ sample)	Bacterial counts of sample ioculated at t=1 hour (UFC/ sample)	Bacterial counts of sample ioculated at t=24 hours (UFC/ sample)	% reduction after 1 hour
PC-GRSC	4,6 x 10 <sup>6</sup>	1,6 x 10 <sup>6</sup>	<100	<100	>99,99
PE-GRSC	4,6 x 10 <sup>6</sup>	1,0 x 10 <sup>6</sup>	<100	<100	>99,99
Control	4,6 x 10 <sup>6</sup>	4,6 x 10 <sup>6</sup>	6,0 x 10 <sup>6</sup>	---	0

**Figure 3.** Cytotoxicity agar overlay test results for virgin and nanosilver-treated fabrics.

Sample identification	Score #1	Score #2	Score #3	Average
Negative control	0	0	0	0
Positive control	4	4	4	4
1135-8-01 (virgin)	0	0	0	0
1135-8-02 (treated)	2	2	2	2

Legend: 0 –No damage to cells; 1 –Some damaged cells under sample; 2 –Damage limited to area under sample; 3 –Damage extend 0.5 to 1.0 cm beyond sample; 4 –Damage greater than 1.0 cm in extension from sample.