

## INNOVATIVE TEXTILE TECHNOLOGY: PRELIMINARY TESTS ON ANTIMICROBIAL PROPERTIES OF UPEC MICROORGANISMS

### Hypothesis / aims of study

The prevalence of Urinary tract infections (UTI) and the problem of antibiotic resistance prompts innovative strategies to bacterial containment. Antiseptic and disinfectant substances are getting increasing interest because of their use in clinical practices to prevent and/or treat localized infections. The usage of textiles with antiseptic properties can be an interesting solution for the containment of colonizing microorganisms. The purpose of this study is to verify whether the innovative Nexus Energy Fiber® (Italy) has an *in vitro* antimicrobial effect compared to conventional pure cotton fabrics. Tests are realized both in direct contact and in close proximity with cultures of microorganisms responsible for urinary tract infections.

### Study design, materials and methods

We verified the antimicrobial activity of Nexus Energy Fiber® comparing it to not treated, pure cotton fabric which was used as a control tissue. Activity is related to a far infrared radiation composition having excellent static-eliminating properties, containing a silver compound as an essential component for the antibacterial effect. On top, its antimicrobial activity is evaluated on microorganisms responsible for urinary tract infections. Particularly, clinical strains of *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterococcus faecalis* and *Staphylococcus saprophyticus* isolated from urine cultures of hospitalized patients in different clinical wards and previously identified by the Microbiology Laboratory were considered. The reference microorganisms belong instead to the collection of ATCC (*American Type Culture Collection*) reference strains: *Staphylococcus aureus* ATCC 6538 and *Klebsiella pneumoniae* ATCC 4352. The analytical procedure is performed in accordance with the standardization document "ASTM E-2180-07"[1]. Specifically, the test took place in two rounds. Round 1 (direct contact): evaluation of the antimicrobial effect when the fabrics were in direct contact with microbial cultures in their exponential phase of growth in the slurry agar to verify an antimicrobial effect. Round 2 (remote conditions): the fabrics were placed 0.5 - 1 cm away from the microbial culture. For both tests, positive and negative controls were set up to verify the reliability of the media and to exclude possible contaminations. All tests were performed in triplicate. The antimicrobial effect was verified for different incubation times and assessment times: 0, 6, 24, 48 hours. The antimicrobial effect was estimated by comparing the different decline in the CFUs between growth on pure cotton and direct-contact and remote tests on Nexus Energy Fiber®, respectively.

### Results

The percentages of the geometric means for the treated tissue effect (Nexus Energy Fiber®) versus conventional pure cotton were calculated according to paragraph 9 of the ASTM E-2180-07 [1] and results are reported in tables 1 and 2 for direct contact and remote conditions experiments, respectively.

### Interpretation of results

Direct-contact tests proved that Nexus Energy Fiber® has no antimicrobial effect against wild strains of *E. faecalis* and *S. saprophyticus* at any contact time. It instead presented a bactericidal effect against *P. aeruginosa* strain after 48 hours, while no effect was observed for shorter contact times. Significantly, it showed an almost total killing of *S. aureus* after a 6-hours long contact. However, this effect disappeared if the contact time is increased up to 48 hours. A progressive increase of the antimicrobial effect against *K. pneumoniae* as a function of contact time is also observed. The results about *E. coli* clinical strain were similar: however, a peak of bactericidal power after a contact time of 24 hours was observed. Distant experiments showed an increase in the antimicrobial effect with the contact time against all the investigated microbial strains: compared to the direct-contact cases, longer contact times were however required before it became measurable. Particularly, 48 hours were needed to obtain a 100%-effective antimicrobial effect against *K. pneumoniae* and *E. coli*. For shorter contact times, no effect was observed. Lastly, the fabric started showing an antimicrobial effect against *S. aureus* and *P. aeruginosa* strains after 24 hours only and it increased after 48 hours. Interestingly enough, reduced or no antimicrobial effects was observed for the same contact times in most of direct-contact experiments.

### Concluding message

Nexus Energy Fiber® has a bactericidal effect on most of the tested microbial strains. Both the contact times and the distance play a significant role: in direct-contact conditions, shorter contact times are required to measure an antimicrobial effect, but a decrease of that effect is observed at longer times for some strains (*S. aureus* and *E. coli*). On the contrary, remote condition experiments show antimicrobial effects only at longer time with always a relationship of direct proportionality. These very preliminary results are encouraging: antibacterial properties of Nexus Energy Fiber® deserve to be further tested.

Table 1: Direct-contact conditions experiments: antimicrobial effect of Nexus Energy Fiber® versus conventional pure cotton.

MICROORGANISMS	Antimicrobial effect (%) in function of time			
	0 hours	6 hours	24 hours	48 hours
<i>Klebsiella pneumoniae</i> ATCC 4352	4.3%	22%	49%	99%
<i>Staphylococcus aureus</i> ATCC 6538	86%	91%	0%	0%
<i>Escherichia coli</i>	13%	35%	51%	37%
<i>Enterococcus faecalis</i>	0%	0%	0%	0%
<i>Staphylococcus saprophyticus</i>	0%	0%	0%	0%
<i>Pseudomonas aeruginosa</i>	0%	0%	0%	21%

Table 2: Remote conditions experiments: antimicrobial effect of Nexus Energy Fiber® versus conventional pure cotton.

MICROORGANISMS	Antimicrobial effect (%) in function of time			
	0 hours	6 hours	24 hours	48 hours
<i>Klebsiella pneumoniae</i> ATCC 4352	0%	0%	0%	100%
<i>Staphylococcus aureus</i> ATCC 6538	0%	0%	24%	100%
<i>Escherichia coli</i>	0%	0%	0%	70%
<i>Pseudomonas aeruginosa</i>	0%	0%	23.73%	75%

#### References

1. ASTM E-2180-07 (Reapproved 2012) Determining the activity of incorporated antimicrobial agents in polymeric or hydrophobic Vol.11.08 "Pesticides Antimicrobials, and Alternative Control Agents; Hazardous Substances and Oil Spill Response". ASTM Internat., West Conshohocken, PA, USA

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