SONOCHEMISTRY IN THE FIGHT AGAINST HOSPITAL ACQUIRED INFECTIONS

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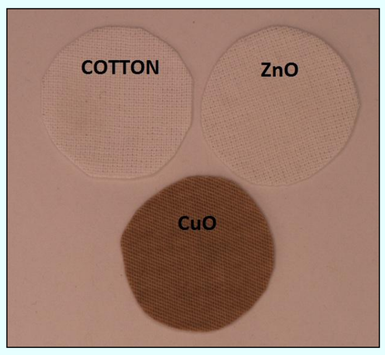
1. Introduction

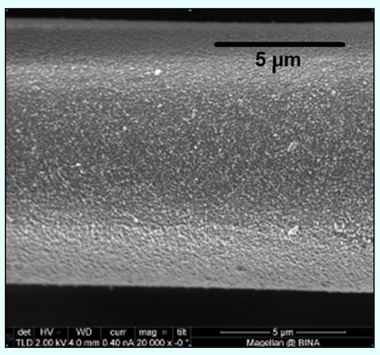
As many as 1 in 10 patients visiting EU hospitals develop hospital acquired infections. As well as being a major cause of morbidity and mortality, these infections are a major financial burden for the European healthcare system.

Antimicrobial fabrics for medical textiles, such as healthcare workers' uniforms, bedding, drapes, gowns and dressings, may provide a useful weapon in the on-going fight against these infections. Although many antimicrobial fabrics have been developed and marketed their uptake has been limited. One of the most common antibacterial additives used is silver. It gives very good levels of antibacterial efficacy but adds significant cost to the fabrics.

The results presented here are from an EU Framework 7 funded project called SONO. The aim of this project is to develop and trial a sonochemical coating system for the production of antimicrobial textiles at a pilot industrial scale. The process uses lower cost metal oxide nanoparticles (NPs) including zinc oxide (ZnO) and copper oxide (CuO) to impart antibacterial activity. The project is a collaboration between 16 partners from 10 different European countries. The partners involved range from fabric manufacturers to medical end users. Further details can be found on the project website at: www.fp7-sono.eu.

Figure 1. Images of Sono fabrics. (*LHS*) Photo of plain white cotton impregnated with ZnO (white) and CuO (brown) (*RHS*) SEM of cotton fibre covered in CuO nanoparticles (~50 nm)





2. Sonochemical Impregnation

The technology is based on a lab scale sonochemical process that was developed at Bar-Ilan University (Abramov *et al*., 2009). It is a one step process in which ultrasonic irradiation causes both the formation of antimicrobial metal oxide nanoparticles and actively impregnates these nanoparticles into textile fibres. A schematic of the impregnation system is shown in Figure 2.

Figure 2. Schematic of sonochemical impregnation system. Fabric (50 cm wide) is fed continuously through a tank containing the reagents required for production of the NPs. An ultrasonic field causes acoustic cavitation (Figure 3) producing the NPs and simultaneously impregnating them on the fabrics.

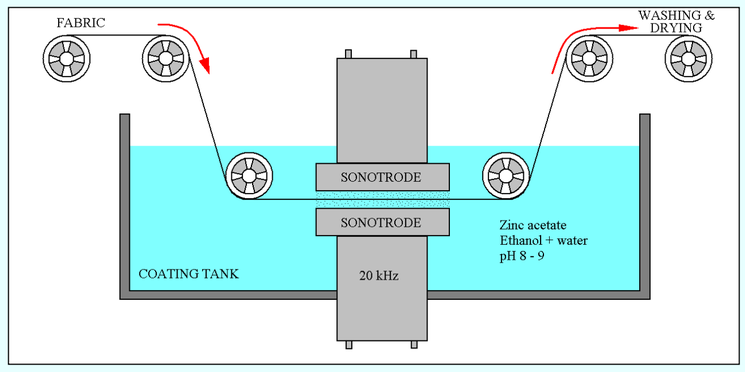
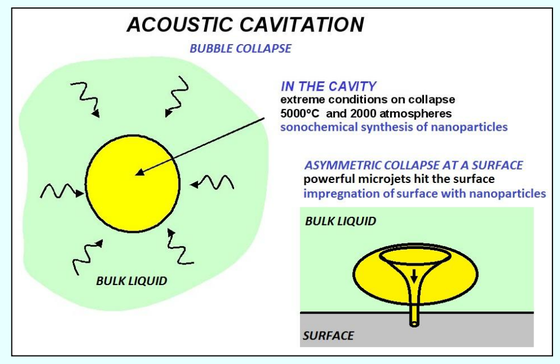


Figure 3. Acoustic cavitation produced under ultrasound. The violent collapse of bubbles produces high temperatures and pressures sonochemically converting the soluble reagents to solid metal oxide nanoparticles. The collapse of bubbles on the surface of the fabric results in the formation of microjets which propel the NPs at high speed in to the fibres.



3. Antimicrobial Efficacy

Antibacterial efficacy testing was carried out according to the absorption method from ISO 20743:2007.

5 x 5 cm pieces of test and control fabric were inoculated with 0.2 ml of bacterial suspension and then incubated overnight at 37ºC. The number of viable bacteria on the samples before and after incubation was determined by agar plate counting. Antibacterial activity values (A) were calculated by comparing the growth on control and test samples (log values).

Table 1. Antimicrobial efficacy testing results for ZnO and CuO impregnated polyester cotton fabric.

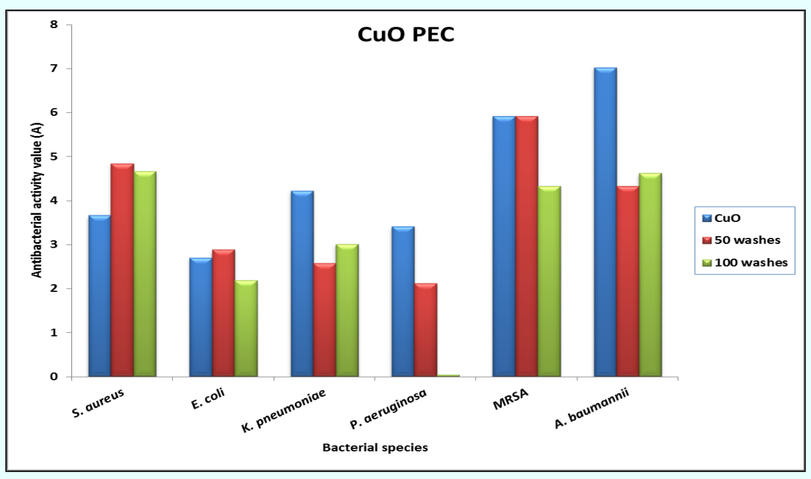
	ZnO	ZnO	CuO	CuO
Antibacterial:	A value [a]	% reduction [b]	A value	% reduction*
Acinetobacter baumannii	5.9	>99	5.3	>99
Escherichia coli	5.6	>99	3.2	>99
MRSA	5.7	>99	5.4	>99
Pseudomonas aeruginosa	5.6	>99	5.7	>99
VRE *Enterococcus faecalis*	3.5	>95	3.6	>99
Antifungal:				
Candida albicans			2.8	

[a] Assessment criteria for A values: <0.5 - no antibacterial activity, ≥0.5 to <1.0 - slight activity, ≥1 to <3 - significant activity, ≥3 strong antibacterial activity

[b] % reduction = ((initial concentration – post incubation concentration) ÷ initial concentration) x 100

Both the ZnO and CuO impregnated fabrics displayed strong antibacterial activity against all the test bacterial strains (Table 1). In durability tests, CuO impregnated fabrics were shown to retain significant antibacterial activity even after 100 wash cycles at 75ºC (Figure 4). In the case of *Pseudomonas aeruginosa,* the antibacterial activity was still high after 50 wash cycles but was lost after 100 wash cycles. The fabrics also retained significant antifungal activity (A > 2) against *C. albicans* after 30 and 60 wash cycles.

Figure 4. Graph showing antibacterial activity values for CuO coated PEC (65/35) after 0, 50 and 100 wash cycles (according to ISO 6330 at 75ºC using a neutral detergent)



4. Summary

Cotton and polyester cotton fabrics impregnated with ZnO or CuO nanoparticles using the Sono process have been shown to be highly active against a range of bacteria associated with hospital acquired infections. It is hoped that the Sono process can be used at an industrial scale to produce antimicrobial fabrics which are cheaper than existing products whilst possessing high activity and long term durability.

The Emergency Medicine Institute (Pirogov) in Sofia, Bulgaria is running a small hospital trial. ZnO impregnated cotton and polyester cotton fabrics have been used to make hospital gowns, pillow cases and bed sheets. Approximately 40 patients will be recruited for the study between June and August 2013. The trial will involve an assessment of the efficacy of the fabrics through regular monitoring of bacterial contamination on the patients and the fabrics. There will also be an assessment of the comfort and safety of the fabrics.

5. References

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