Bioinspired Chitin Layer-by-Layer Films
Brushed vs Dipped Approaches for Bactericidal Performance

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CONTEXT

Biofilm & Hospital-acquired infections

- 80% of the chronic infections are due to biofilm formation
- Financial and healthcare issues worldwide
- Nature-inspired surfaces kill or repel bacteria through nanoscale topography but require costly, energy-intensive fabrication.
- There is a need for effective, low-cost, and biosourced antimicrobial surfaces.

Layer-by-Layer films to prevent bacterial growth

Simple method at room temperature
Tuneable film properties
Decher, G. Science 1997, 277, 1232

Contact-killing LbL films
Séon et al. Langmuir 2015, 31, 12856

Local release-killing tannic acid based films
Iqbal et al. ACS Appl. Mater. Inter. 2020, 12, 2295

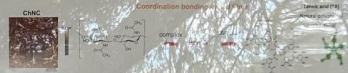
OUR STRATEGY

Antibacterial coatings with contact killing properties

Bioinspiration from Nature: Cicada Wing Nanostructures

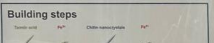
Pseudomonas aeruginosa bacteria penetrated by the nanopillars, leading to cell death.
Ivanova, E. P. Small 2012, 8, 2489

Biosourced Materials for Antibacterial Surfaces

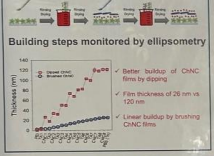


FILM BUILDUP

Building steps

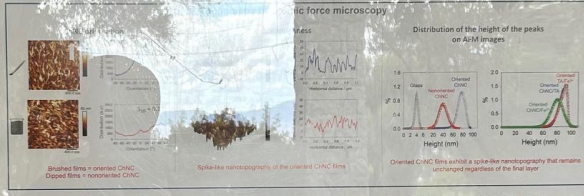


Building steps monitored by ellipsometry



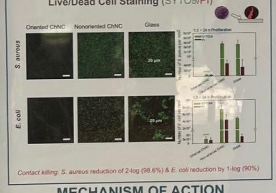
TOPOGRAPHY

Atomic force microscopy



ADHERENT BACTERIA

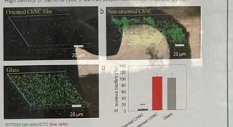
Live/Dead Cell Staining (SYTO9/PI)



Contact killing: S. aureus reduction of 2-log (98.6%) & E. coli reduction by 1-log (90%)

BACTERIA BIOFILM

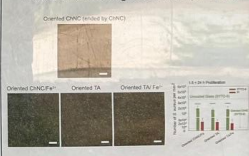
Cell Staining (SYTO9/CTC) and Safranin Staining for Biofilm Quantification



Antibiofilm: S. aureus biomass reduced on Oriented CNHC by 96% vs glass

INFLUENCE OF THE ENDING LAYER

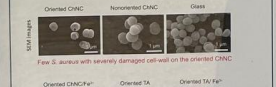
Live/Dead Cell Staining of *S. aureus* (SYTO9/PI)



Dramatic effect of the ending layer: crucial role of CNHC layer for the bactericidal effect

MECHANISM OF ACTION

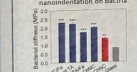
Morphology of adhered bacteria



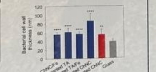
Few S. aureus with severely damaged cell wall on the oriented CNHC

S. aureus exhibited severely damaged cell walls on the oriented films, yet a higher number of cells compared to the oriented CNHC ending films

Mechanical properties of bacteria using AFM nanoindentation on bactria



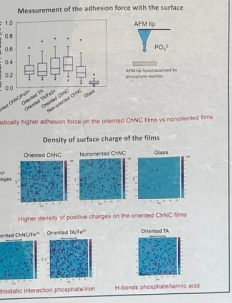
Thickness evaluation on SEM images



Stiffer bacteria on the oriented CNHC films due to the thickening of the bacterial cell-wall => bacteria under stress

CHEMICAL CHARACTERIZATION

Chemical force microscopy: characterization of the surface charge of the films



CONCLUSION

- ✓ Oriented ChNC films show strong contact-killing and antibiofilm activity
- ✓ Bacterial cell walls become severely damaged and thickened => This effect is caused by spike-like nanotopography and a high density of positive surface charges
- ✓ The developed antibacterial coating is bioinspired, sustainable, and based on an FDA-approved compound.

Iqbal et al. Applied Materials Today 2023, 32, 101816

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