Antimicrobial surface activation using cold atmospheric plasma technology

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Motivation: in EU around 88 million tons of food waste are generated annually with associated cost of 143 billion euros (FUSIONS, 2016).

Introduction

The ambition of the BIOSMART (H2020) project is to develop smart and self-active packages from bio-based source to increase the shelf life of the product while being industrially compostable.

Scope of the study

To enhance the food preservation, antimicrobial activation is performed using Cold Atmospheric Plasma (CAP) technology. The antimicrobial substance used within this project are bio-surfactant lipopeptides produced by *Bacillus subtilis*. A focus is made onto surfactin and mycosubtilin.

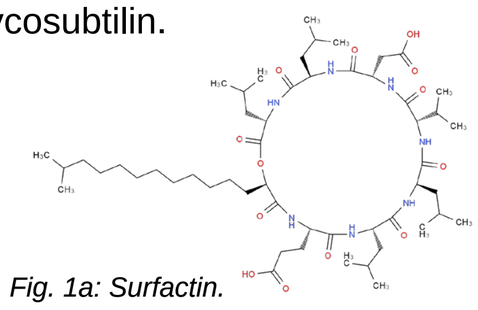

Fig. 1a: Surfactin.

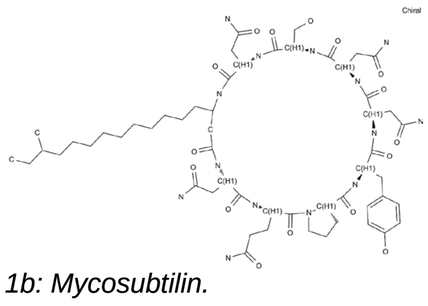

Fig. 1b: Mycosubtilin.

Cold atmospheric plasma treatment

The aim of CAP treatment is to bind lipopeptide chemically to polymer surfaces such as PE and PLA. Glass substrate is used as a reference surface and MMA as a reference precursor.

Process description

A continuous plasma flow of nitrogen, argon or helium is generated between a central and an outer electrode. Precursors are pushed towards the surface within the plasma afterglow which generates functional groups and radicals on the substrate surface (without altering the bulk). This serve as anchoring point for precursors. The main parameters are the power at which the plasma is generated, the treatment time and the concentration of the precursor.

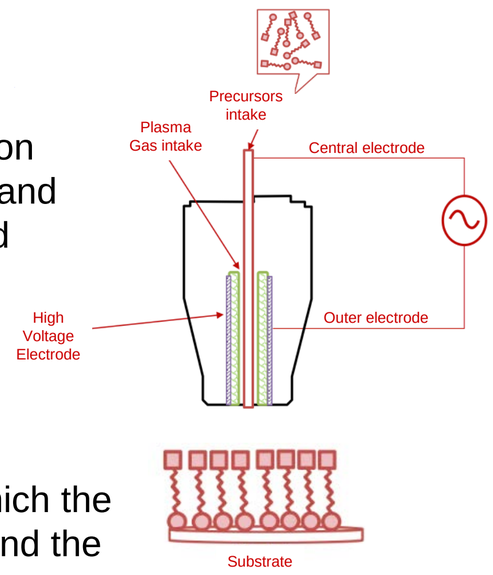

Fig. 2: Plasma process.

Results and discussion

To determine the change in surface tension after CAP treatment using lipopeptides, the contact angle between a 2µL droplet and a solid substrate is measured. A significant change in WCA is observed for samples treated with surfactin. This effect is more pronounced for hydrophobic surfaces such as PE *(Fig. 3a)*, than for quite hydrophilic surfaces such as PLA *(Fig. 3b)*. This is due to the conformation of the lipopeptide.
Chemical surface composition is determined using ATR-FTIR spectroscopy. Amide I stretching resonances are observed around 1652cm^{-1} *(Fig. 3c).* The presence of these bands indicates that surfactin is deposited on the surface.

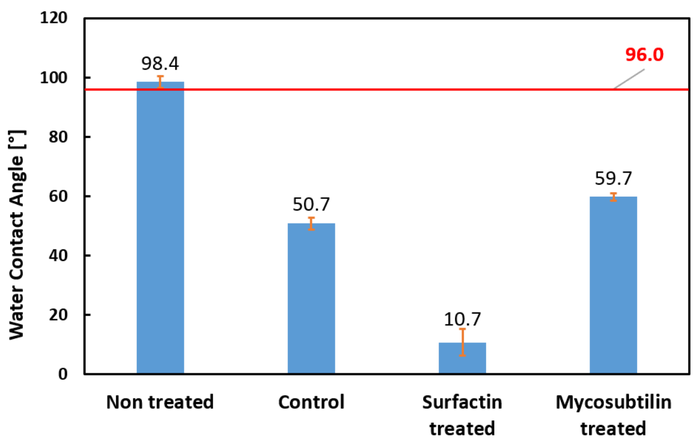

Fig. 3a: PE treated at 250W with antibacterial lipopeptides.

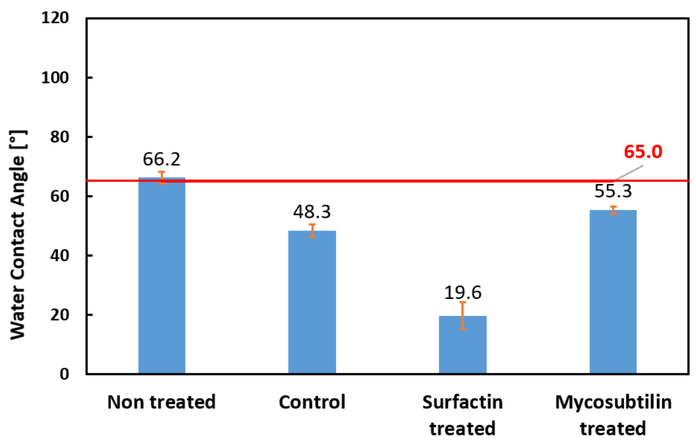

Fig. 3b: PLA treated at 250W with antibacterial lipopeptides.

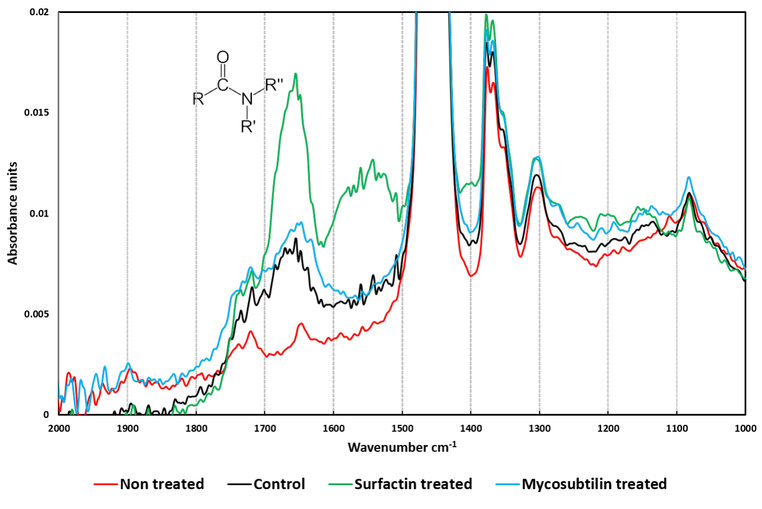

Fig. 3c: PET treated at 250W with antibacterial lipopeptides.

Power influence on precursor deposition

Increasing the power increase the resistance of MMA coatings to solvent, but etch (erode) more the surface *(Fig 4)*.

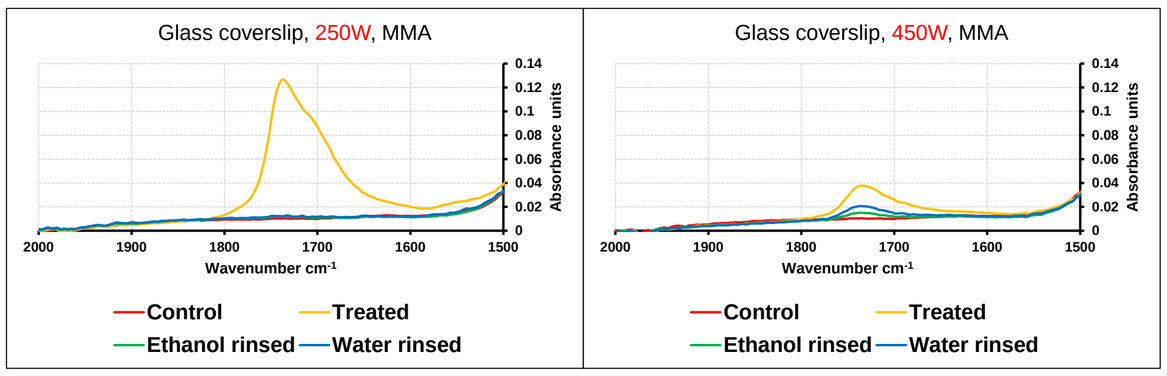

Fig. 4: Glass coverslip treated at 250 and 450W with MMA.

Conclusion

- After CAP treatments, substrates exhibit different surface properties and changes in their chemical composition. This suggests the effective deposition of antimicrobial lipopeptides.
- This first study shows the potential to graft antimicrobial lipopeptide using CAP treatment while keeping their surfactant properties intact.

Next steps

- Surface topography measurement using AFM have to be conducted in order to confirm that the change in WCA is only due to a different surface composition.
- Ellipsometry and Scanning Electron Microscopy have to be done to measure the thickness of the lipopeptide layer.
- Rinsing has to be carried to assess the lipopeptide stability and its chemical interaction with the substrate.
- Hemolytic and antimicrobial test have to be conducted to control that the antibacterial lipopeptide remains active after CAP deposition.

Acknowledgments

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