RESEARCH IN PROCESS

Non-fouling food contact surfaces – prevention of biofilm and surface-mediated cross-contamination

SUMMARY

Post-harvest preventive control is a critical research topic for the produce industry because post-harvest handling is an essential stage in the food supply chain. A practical preventive control will not only impact public health but also the produce industry's long-term profitability. Despite the previous interest in fouling of mainstream FDA-approved food contact substances (FCS), there has not been a comprehensive evaluation of non-fouling properties of any FCS or of the practicality of industrial sanitization procedures for the produce industry. The major aim of this project is to develop an applicable post-harvest preventive control approach to enhance the non-fouling properties of FDA-approved FCS against *Listeria monocytogenes* biofilms. Project outcomes will provide scientific information that will support the sanitary design of packing, holding, and processing equipment/devices, coatings, and coating modifications to simplify cleaning/sanitization, and to prevent pathogen attachment and biofilms on FCS for new and retrofitted equipment.

OBJECTIVES

1. Evaluate the baseline non-fouling properties of existing FDA-approved FCS.
2. Enhance FCS performance by simple and cost-effective physical/topographical modification without altering the chemical composition.
3. Evaluate whether the top-performing FCS are compliant with sanitary designs for the fresh produce industry.
4. Validate the findings at a fresh-cut processing pilot plant.

METHODS

The project will evaluate standard and modified coupons of stainless steel 304 (SS-304) and plastic. Only FDA-approved FCS (approved for multiple uses as substrate coatings) will be evaluated for their non-fouling properties again *Listeria monocytogenes* (*Lm*) biofilm formation.

Topographical modifications are simple and cost-effective approaches to significantly improve the non-fouling properties of a surface without changing its chemical composition. Protocols will be developed, for example by combining chemical and electro-etching of SS-304 to generate topographical roughness for the applied FCS. FDA-approved FCS coatings can be applied on modified SS-304 at suppliers' facilities. Modified SS-304 can also work as the master mold for thermal molding of plastic FCS.

This project also includes an assessment of the non-fouling properties of modified FCS by growing biofilms that contain a cocktail of *Lm*, *E. coli* O157:H7, *Pseudomonas fluorescens* (*Pf*) and/or *Ralstonia insidiosa* (*Ri*), which have been identified as top biofilm formers among microbiota of leafy greens.

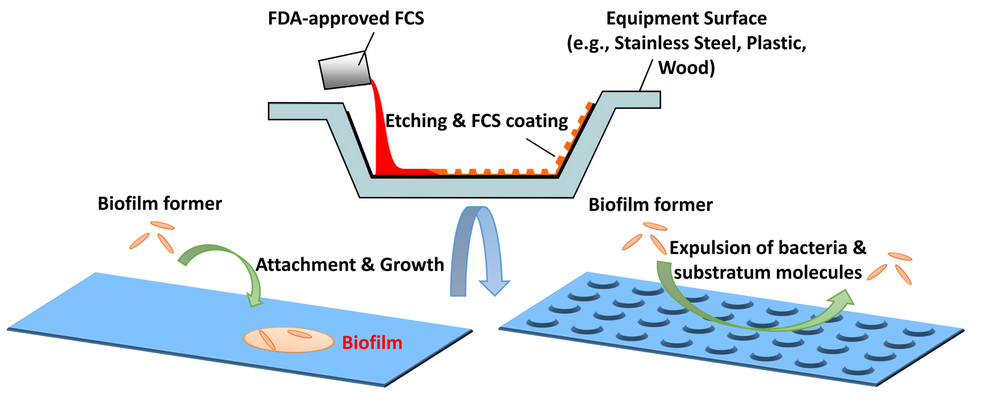

Figure 1. Topographical modification for FCS on a surface, without altering the chemical composition.

RESULTS TO DATE

We developed a protocol that combines chemical and electro-etching of SS-304 to generate roughness, and an FDA-approved FCS can be applied to the topographically modified surface (**Figure 1**).

Biofilm formation was confirmed on blank coupon controls by crystal-violet (CV) staining, and preliminary results show reduced biofilm formation on SS-304 coupons with Dursan® coating (FDA-approved FCS) (**Figure 2**) and on micro-patterned high density polyethylene (HDPE) coupons (**Figure 3)**.

BENEFITS TO THE INDUSTRY

- This project will provide preventive control solutions to suppress fouling of food contact surfaces by bacterial biofilms – this is especially important in mitigating risks in produce operations with *Lm* biofilm formation and cross-contamination.
- Developed coatings could enhance sanitary design by reducing FCS bio-fouling, which will simplify cleaning and sanitization.
- A simple, cost-effective approach to enhance the non-fouling properties of existing FDA-approved FCS, without chemical modification that would require regulatory approval – this approach is significant in that it provides an opportunity to retrofit legacy equipment and improve future equipment design.
- One direct outcome would be mitigating *Lm* biofilm formation in packinghouses and fresh-cut processing facilities. Upon application of the proposed coatings, we anticipate there will be significant reductions in *Lm* biofilm formation.

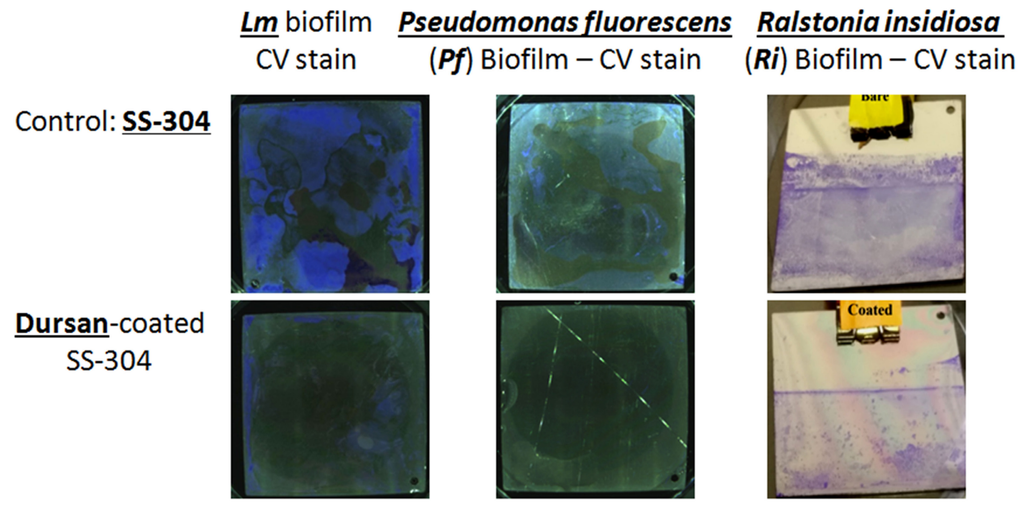

Figure 2. Crystal violet (CV) staining of biofilm formation on control (SS-304) and Dursan-coated SS-304 coupons (6 × 6 cm). Dursan coating significantly reduced biofilm formation.

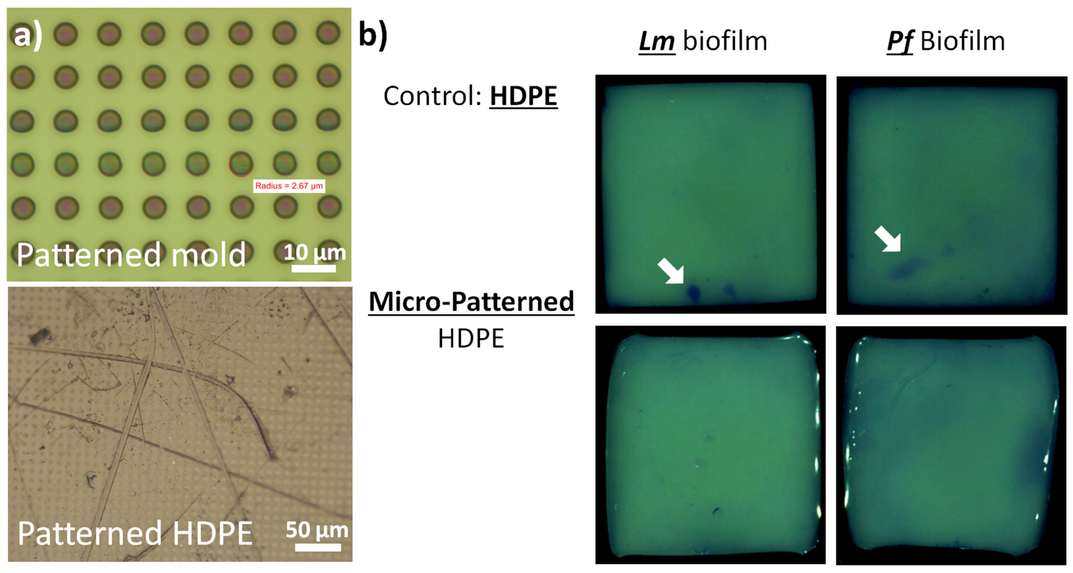

Figure 3. a) Fabricated mold with micropillar patterns (top) and thermal molded HDPE (bottom) coupons (5 × 5 cm). **b)** CV staining of *Lm* and *Pf* biofilm formation on the control

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