Electrochemical Removal of Bacteria and Biofilms Formed on Metal Substrates

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Biofilms are highly complex, three dimensional communities of microorganisms encased in extracellular polymeric substance. Biofilms form on the surfaces of equipment in food and dairy industries, waste water treatment facilities, marine vessels, chemical, petrochemical and pharmaceutical industries. Formation of biofilms in different industrial settings results in clogged pipelines, reduced plant run times, corrosion of metal surfaces, reduced heat transfer in heat exchangers and reduced separation efficiency in membranes.

Biofilms are extremely hard to eradicate requiring the use of harsh chemical or mechanical treatments which, aside from being costly, rarely result in the complete removal of the biofilm. The cells remaining on the surface will thus act as nuclei for the formation of new biofilms. Furthermore, the release of detached biofilm cells into the surrounding medium can compromise the safety and quality of the final product. In addition, these treatments can lead to corrosion of materials and machinery, endangering the health of workers and imposing negative impact on the environment.

This presentation will outline our results on the use of an electrochemical method for biofilm removal. The method is based on the production of hydrogen gas on the biofilm-covered surface, which results in detachment (lifting off) of the biofilm.

We implemented this approach to remove single species bacterial biofilms of *Pseudomonas aeruginosa* (Gram -) and *Staphylococcus aureus* (Gram +). The effect of electrode potential on biofilm removal kinetics was investigated. It was determined that 10-day old biofilms of *P. aeruginosa* formed on stainless steel surfaces can be effectively and very quickly removed by the electrochemical polarization method. Figure 1 shows that only 2.5 minutes of the treatment results in a biofilm free surface. Furthermore, the efficiency of the electrochemical biofilm removal method was investigated by re-formation-and-removal of the biofilm for four cycles, and it was observed that the repeated application of the electrochemical removal method does not affect the subsequent biofilm removal kinetics.

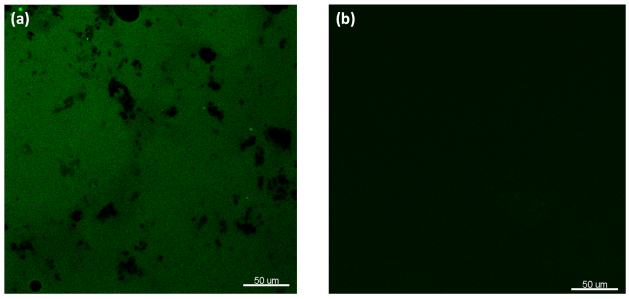

Figure 1. (a) 10 day old biofilm of *P. aeruginosa* cells on a stainless steel surface. (b) Biofilm-free stainless steel surface after 2.5 min electrochemical biofilm removal at -4.0 V vs. Ag/AgCl reference electrode.