ANTI-BIOFILM TECHNOLOGIES

PATHWAYS TO PRODUCT DEVELOPMENT

January 29—30, 2025

Crystal Gateway Marriott Hotel

Executive Abstracts

CENTER FOR BIOFILM
CBE
ENGINEERING

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SESSION 1: Healthcare Associated Infections

Keynote Presentation

Wastewater environment as a complex reservoir for AMR-causing hospital acquired infections and mitigation strategies

Shireen Kotay
Research Scientist, Div. of Infectious Diseases & Int'l Health, School of Medicine, University of Virginia

Due to time constraints abstract not available

Needleless connector design and infection risk: Confirming the in vitro through publicly reported surveillance data

Jason Battle
Senior Clinical Specialist, Research, ICU Medical

Purpose of this Research:
To correlate the in vitro evaluation of design characteristics of commercially available needleless connectors (NC) to publicly available CLABSI surveillance data.

Methods and Results:
Assessment of an in vitro model of different needleless connectors' design elements predicted significant differences in biofilm and bacterial transfer. Leveraging this model, the predicted effect of the design was tested using a publicly available infection reporting database. Analysis of the hospital groups using the Clave NC group demonstrated statistically significant in CLABSI risk and SIR.

Next Steps:
This work provides a model for a method of in vitro evaluations of biofilm and bacterial transfer to be verified via publicly available infection data. These data sets may be used to evaluate other infection related data such as CAUTI, Sepsis, Etc.

Industrial Relevance:
ICU Medical manufactures the NCs (Clave) which were among the best-performing groups in the in vitro evaluation and were evaluated in comparison to all other data for the public surveillance evaluation. This data may provide clinicians and industry guidance on the best design elements for NCs and other vascular access related devices.

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Antimicrobial silver

Garth James
PI, Medical Biofilms Laboratory, CBE; Assoc. Research Professor, Chemical and Biological Engineering, MSU

Purpose of this Research:
This presentation reviews the usage of silver as an antimicrobial. The history, antibacterial mechanisms, and bacterial resistance are all discussed.

Methods and Results:
A literature review was conducted.

Next Steps:
We will continue to monitor silver-related publications and regulations.

Industrial Relevance:
Silver is an antimicrobial agent that is often integrated into medical devices. This presentation reviews the antibacterial mechanisms of silver and how bacteria resist silver.

Navigating the medical device regulatory landscape: From concept to market

Jeanne Lee
Vice President of Quality, Clinical and Regulatory Affairs - Next Science, LLC

Purpose of this Research:
How are regulatory affairs involved in the various steps in the lifecycle of a medical device?

Methods and Results:
Establish a regulatory strategy early on. Seek agency advice and execute it.

Next Steps:
N/A

Industrial Relevance:
Directly relevant to medical device companies developing new products and relatable to other regulated industries such as pharma.

Enzymes, antibiotics, and bacteriophage: Creating combinations to disperse and kill biofilms of antibiotic-resistant bacteria

Kristi Frank
Associate Professor, Microbiology & Immunology, Uniformed Services University of the Health Sciences
Due to time constraints abstract not available

Mimicking bacterial contamination in the surgical operating room

Matt Libera
Professor, Chemical Engineering and Materials Science, Stevens Institute of Technology
Due to time constraints abstract not available

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SESSION 2: Current and Emerging Needs in Surface Disinfection

Keynote Presentation

What might volatile metabolites tell us?

Jane E. Hill
CEO, Shirley Diagnostics; Associate Professor, University of British Columbia

Purpose of this Research:
We aim to identify, characterize, and use biomarkers derived from microbial systems (abiotic and biotic) in practical applications.

Methods and Results:
To explore a system's volatilome and link it to phenotype or identity, we use a combination of study design, multidimensional chromatography coupled to mass spectrometry, knowledge of an organism and its ecosystem, as well as advanced chemometrics.

Next Steps:
1. We have a few clinical applications we are moving toward FDA consideration for disease diagnostics for humans and animals, with a focus on bacteria such as *Pseudomonas, Staphylococcus, Mycobacteria*, and multi-drug resistant organisms.
2. We are always exploring the profiles of new organisms in a variety of contexts and considering phenotypes of interest.

Industrial Relevance:
1. Rapid clinical tests (using breath, for example) to detect pathogens of interest in humans or animals
2. Beyond clinical tests, there are many possible applications!

Dry biofilms

Liz Sandvik
Research Engineer, CBE

Purpose of this Research:
Dry biofilms exist in environments with intermittent wetting, high humidity, or equipment shutdown that allows for the survival of the microorganisms. Minimal research has been done to explore how organisms survive in dried biofilms and respond to antimicrobials. This presentation will show preliminary results of how multiple strains respond to drying and biocide applications.

Methods and Results:
Three studies will be presented illustrating the dry biofilm phenomenon. The first shows the survival of a multidomain water system biofilm after one year of dry out. In a second, dried biofilm tolerance is tested against 20 individual bacterial species. In the third, biocide tolerance of dried Pseudomonas and Staphylococcus biofilms to chlorine treatment will be reported.

Next Steps:
Future work will expand testing from dried biofilms to other types of dry biofilms and characterize biofilm features. More extensive testing will be done to define the different levels of “dry” for biofilms and processes for creating the varied conditions of dry out and biocide application will be evaluated.

Industrial Relevance:
An industrial need for standard methods to study dry biofilms has been identified. The goal of these preliminary studies is to better characterize dry biofilms and develop methods for testing antimicrobial responses.

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Dual-species biofilm formation by bacterial pathogens and their removal by sanitizers

Jitu Patel
Lead Scientist, US Department of Agriculture

Purpose of this Research:
Research was conducted to evaluate the role of hydrodynamic shear force and surface topography on dual-species biofilm formation by pathogens. Efficacy of sanitizers in biofilm removal in the presence of promotor bacteria was investigated.

Methods and Results:
Bacterial biofilms were grown in the CDC bioreactor at different shear forces and their removal by sanitizer was investigated using the Bio in-line reactor. Shear force influenced biofilm formation and its removal by sanitizer. Surface parameters other than roughness had a pronounced effect on biofilm. Hyperspectral fluorescent imaging revealed differences in bacterial biofilms.

Next Steps:
Neural network-based image spectrum will be employed in biofilm detection. Further, predictive modeling will be developed for biofilm mitigation studies.

Industrial Relevance:
Surface topography should be considered in equipment selection to minimize biofilm formation. Peroxyacetic acid-based sanitizers are superior to chlorine in biofilm removal.

Biofilm love in the subsurface: New methods and insights

Birthe V. Kjellerup, Professor, Civil and Environmental Engineering, University of Maryland at College Park

Due to time constraints abstract not available

The impact of test variability on regulatory decisions on hand hygiene

Al Parker
Biostatistician, CBE

Purpose of this Research:
Since 2014, US EPA has been setting regulatory performance standards for hospital-level antimicrobials that minimize Type I (false positive = pass-error) and Type II (false negative = fail-error) error rates based on multi-lab study data. This talk applies the same statistical approach to assess performance standards that FDA has set for hand hygiene products used by healthcare workers.

Methods and Results:
The error rates are driven by ASTM test method variability which in turn is a function of the tested product's efficacy. Depending on the sources of variability, some study designs (cross-over vs parallel groups) are better than others (i.e., have lower pass- and fail- error rates).

Next Steps:
More multi-lab study data are needed to better understand hand hygiene test method variability.
Industrial Relevance:
Producers of antimicrobial products can find an efficient study design to generate product efficacy data for submission to FDA.

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Keynote Presentation

***Pseudomonas aeruginosa* initiates a rapid and specific transcriptional response during surface attachment**

Chris Jones
Research Professor, Biofilm Science & Technology, Chemical & Biological Engineering, MSU, CBE

Purpose of this Research:
Chronic biofilm infections by Pseudomonas aeruginosa are a major contributor to the morbidity and mortality of patients. The formation of multicellular bacterial aggregates, called biofilms, is associated with increased resistance to antimicrobials, immune clearance, and the persistence of infections. Biofilm formation is dependent on bacterial cell attachment to surfaces, and therefore, attachment plays a key role in chronic infections. We hypothesized that bacteria sense various surfaces and initiate a rapid, specific response to increase adhesion and establish biofilms. RNA sequencing (RNA-Seq) analysis identified transcriptional changes of adherent cells during initial attachment, identifying the bacterial response to an abiotic surface over a 1-h period. Subsequent screens investigating the most highly regulated genes in surface attachment identified 4 genes, pfpI, phnA, leuD, and moaE, all of which have roles in both metabolism and biofilm formation. In addition, the transcriptional responses to several different medically relevant abiotic surfaces were compared after the initial attachment.

Methods and Results:
Surprisingly, there was a specific transcriptional response to each surface, with very few genes being regulated in response to surfaces in general. We identified a set of 20 genes that were differentially expressed across all three surfaces, many of which have metabolic functions, including molybdopterin cofactor biosynthesis and nitrogen metabolism. This study has advanced the understanding of the kinetics and specificity of bacterial transcriptional responses to surfaces. It suggests that metabolic cues are important signals during the transition from a planktonic to a biofilm lifestyle.

Next Steps:
Future work will expand on this report to identify mechanisms of biofilm initiation with the aim of identifying bacterial factors that could be targeted to prevent biofilms.

Industrial Relevance:
Bacterial biofilms are a significant concern in many aspects of life, including chronic infections of airways, wounds, and indwelling medical devices; biofouling of industrial surfaces relevant for food production and marine surfaces; and nosocomial infections. The effects of understanding surface adhesion could impact many areas of life. This study utilized emerging technology in a novel approach to address a key step in bacterial biofilm development. These findings have elucidated both conserved and surface-specific responses to several disease-relevant abiotic surfaces.

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SESSION 3: Methods in Action

Creating pathways to drive biofilm innovation: Building consensus on biofilm regulatory decision making

Darla Goeres
Coordinator of Industrial Development, Research Professor of Regulatory Science, CBE

Due to time constraints abstract not available

Purpose of this Research:
While every country has its own defined pathway for regulatory approval, all regulators rely on regulatory science tools to make decisions as to whether a product may enter the commercial market and what label claim the company who sells the product may make.

Methods and Results:
COST Action CA23152 will bring together teams of researchers to update the equipment, models, and methods used by regulatory, industrial, and clinical stakeholders for improved decision making with the intent of providing laboratory data that translates into regulatory decisions that protect public health and the environment.

Next Steps:
Optimal *E. coli* concentration for *Acanthamoeba* cyst excystment and recovery will be incorporated into a developing protocol for contact lens care disinfection procedures and ring tested across multiple laboratories to determine its robustness and repeatability.

Industrial Relevance:
Regulatory science encompasses the development and application of scientific methods, research equipment, reference materials and model systems that enable informed decision making on antimicrobials, processes and devices that require regulatory approval. As part of their decision making, regulators must consider how the product improves public health and its impact on the environment.

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Acanthamoeba, biofilms, and pathways toward standardization of contact lens care products

William Domm Ph.D.
Senior Research Scientist, Vision Care Research & Development, Bausch + Lomb

Purpose of this Research:
Acanthamoeba are ubiquitous throughout nature, often utilizing biofilms as a reservoir, and a causative agent of a devastating corneal infection often leading to vision loss. Standardization and optimization of disinfection testing methodologies for contact lens care products may increase protection for contact lens wearers from *Acanthamoeba keratitis*.

Methods and Results:
Existing in two life forms, the trophozoite and cyst, *Acanthamoeba* requires multiple independent industry standards to be developed. In disinfection protocols *Acanthamoeba* cysts need to undergo excystment prior to growth and recovery. Here, experiments were undertaken to determine the optimal concentration of *E. coli* needed to promote cyst excystment and recovery.

Next Steps:
Optimal *E. coli* concentration for *Acanthamoeba* cyst excystment and recovery will be incorporated into a developing protocol for contact lens care disinfection procedures and ring tested across multiple laboratories to determine its robustness and repeatability.

Industrial Relevance:
Acanthamoeba in comparison to other microorganisms remains poorly understood. Research into *Acanthamoeba* encystment, excystment, and biofilm interactions will lead to further discoveries that can protect patients from infection.

Regulatory science and biofilms: Methods for biofilm soil formation on reusable stainless steel medical device material

Bruno Haas
Scientific Group Leader, Infection Prevention Technologies R&D, STERIS

Purpose of this Research:
Use of existing published standard methods for biofilm formation and assess their applicability for evaluation in the context of reusable medical devices.

Methods and Results:
CDC biofilm reactor and Drip-flow biofilm reactor were used to grow Pseudomonas aeruginosa biofilm on stainless steel surfaces. Surface scraping and vortex-sonic can be used to harvest the biofilm from the surfaces. Biofilm was quantified using CFU, protein and TOC as analytes. Only one extraction was needed.

Next Steps:
Determine if TOC and protein are sensitive enough to quantify a post-treatment biofilm level.

Industrial Relevance:
Industry needs FDA-recognized methods to market products with biofilm claims. This work shows that the methodology can be used to form and quantify a high biofilm contamination from a stainless-steel surface.

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Biofilms in manufacturing environments

Charles Pettigrew
Research Fellow, Arxada

Purpose of this Research:
We share a case study where a consumer goods manufacturer requested technical support for an ongoing microbial contamination issue in a laundry detergent product.

Methods and Results:
A plant hygiene audit of the manufacturing process identified microorganisms of concern and the corresponding root cause involving bacterial biofilms. A plan of action implemented the use of industrial hygiene corrective measures in parallel to the development of a new biocidal package recommendation. Temporal monitoring of the production batches over a 10-month period that spanned pre- and post-corrective actions demonstrated a significant improvement in microbial resistance of the end formulation after the incorporation of new holistic strategies.

Next Steps:
N/A

Industrial Relevance:
We also share an industrial cooling tower case study where a stable multispecies biofilm model was developed. *Legionella pneumophila* was incorporated into the multispecies biofilm, enabling future bench-scale evaluations of treatment, removal, and prevention technologies.

Models for wound infection research

Erin Gloag
Assistant Professor, Microbiology, Virginia Technological University
Due to time constraints abstract not available

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