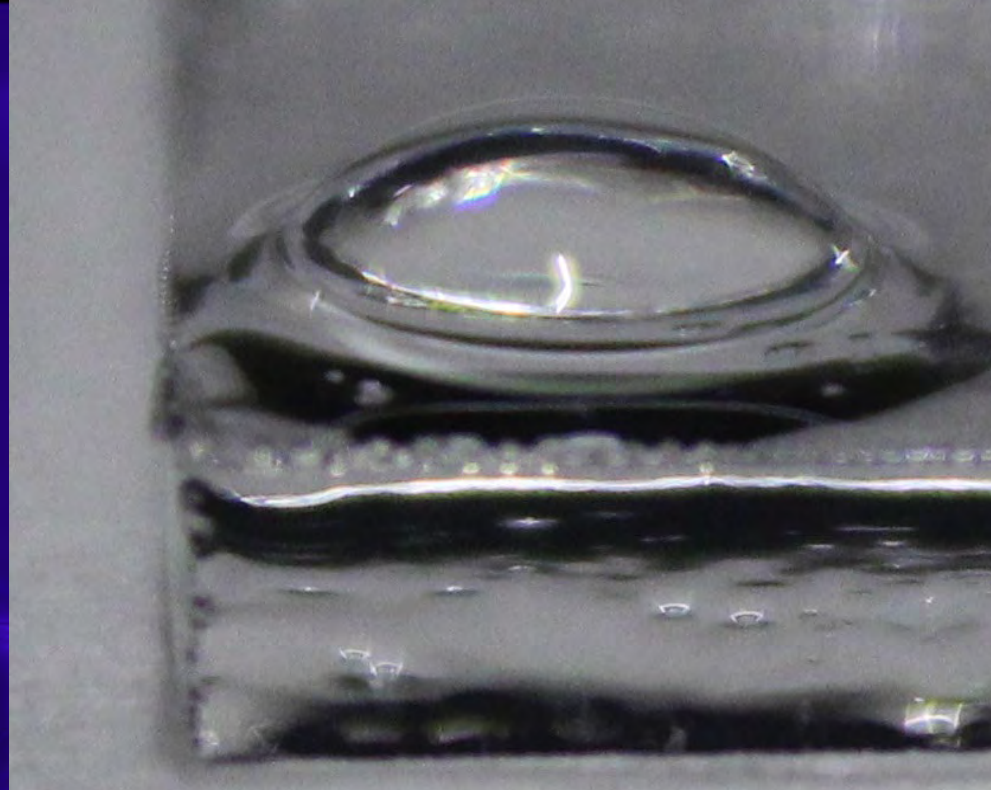
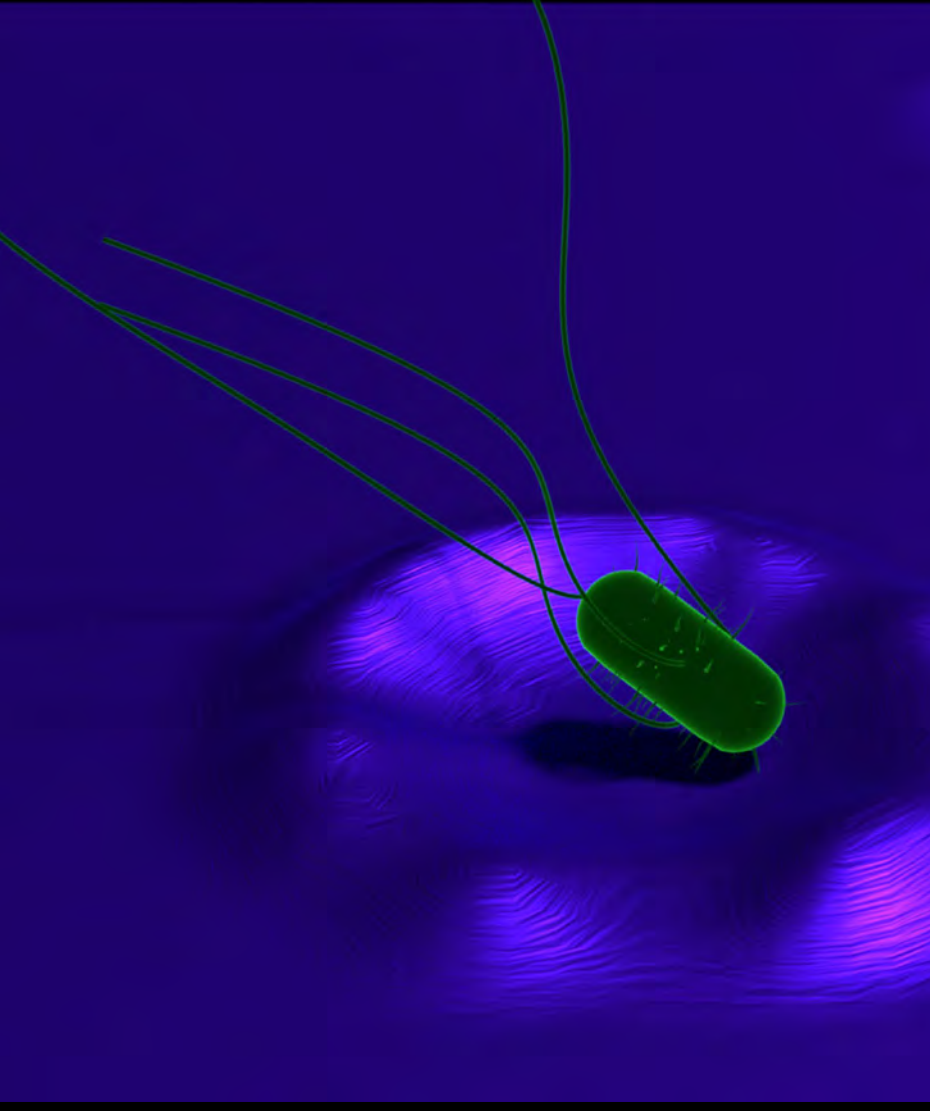


# Bio-inspired liquid-infused surfaces for reducing bacterial adhesion in catheters



Caitlin Howell

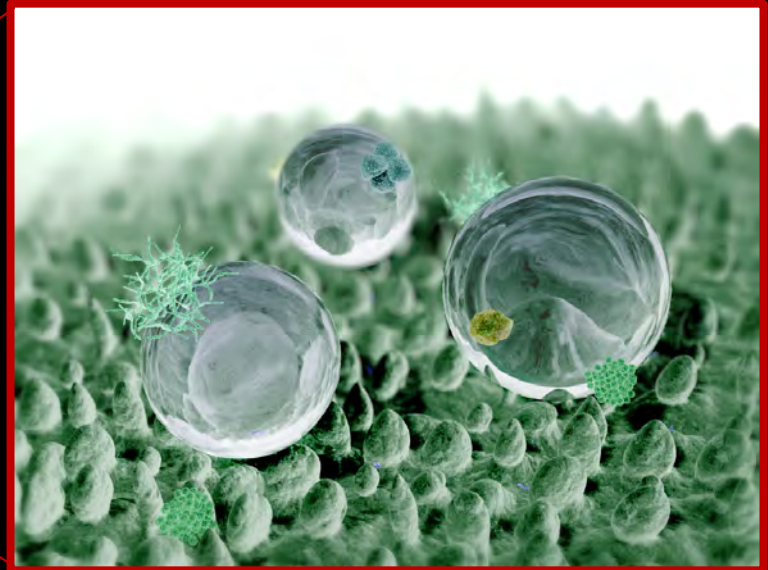
Assistant Professor Biomedical Engineering  
Department of Chemical and Biological Engineering  
Graduate School of Biomedical Science and Engineering,  
University of Maine, Orono, ME, USA



# Self-Cleaning Surfaces

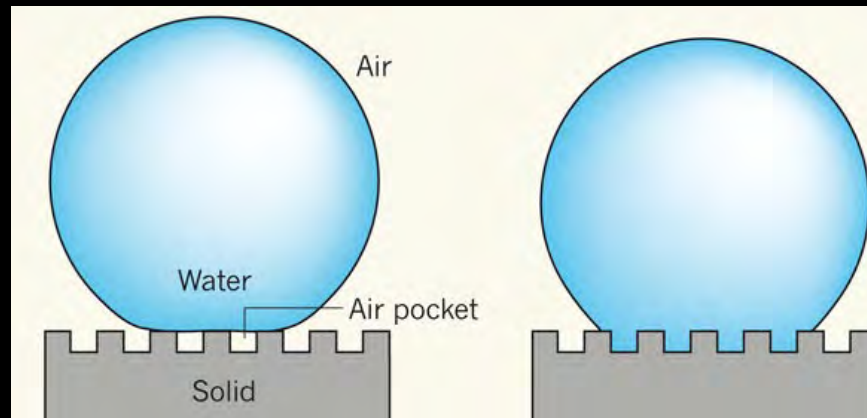


Wikimedia Commons

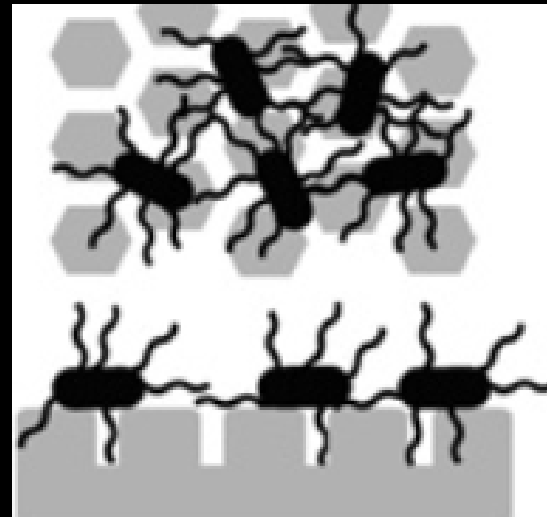
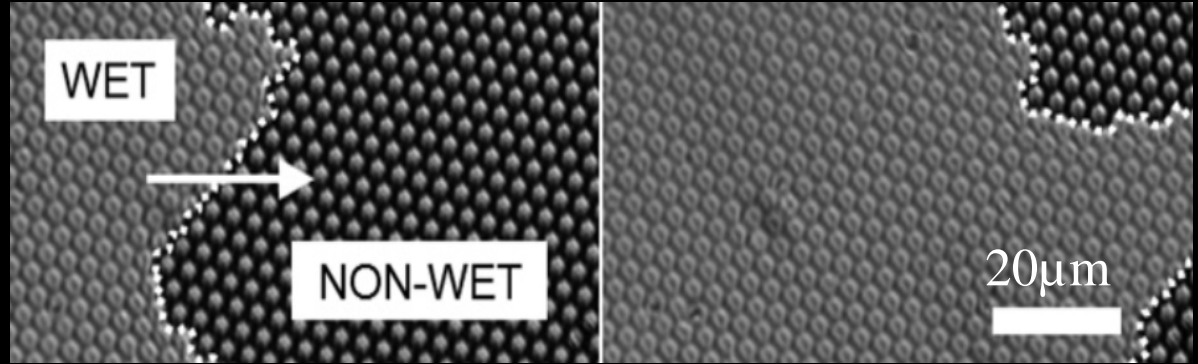
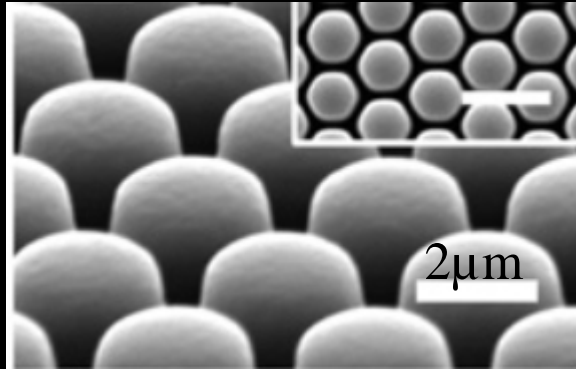


Cassie-Baxter State

Wenzel State



# Microorganisms: Adaptive Foulants



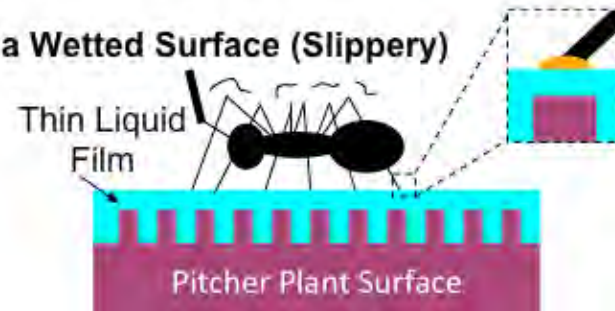
# Bio-Inspired Slippery Surfaces



On a Dry Surface



On a Wetted Surface (Slippery)



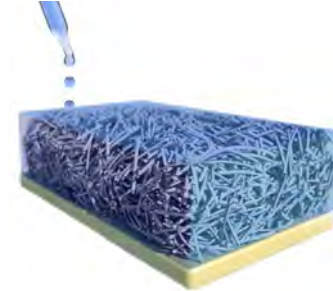
# Slippery Liquid-Infused Porous Surfaces (SLIPS)



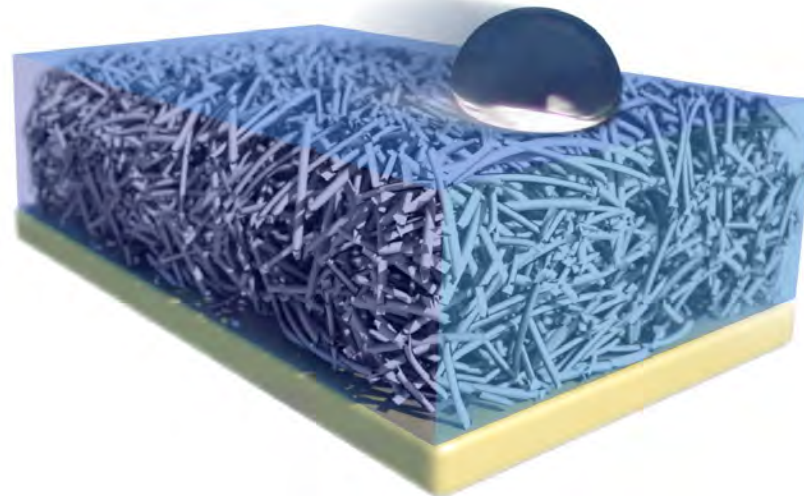
1. Roughening



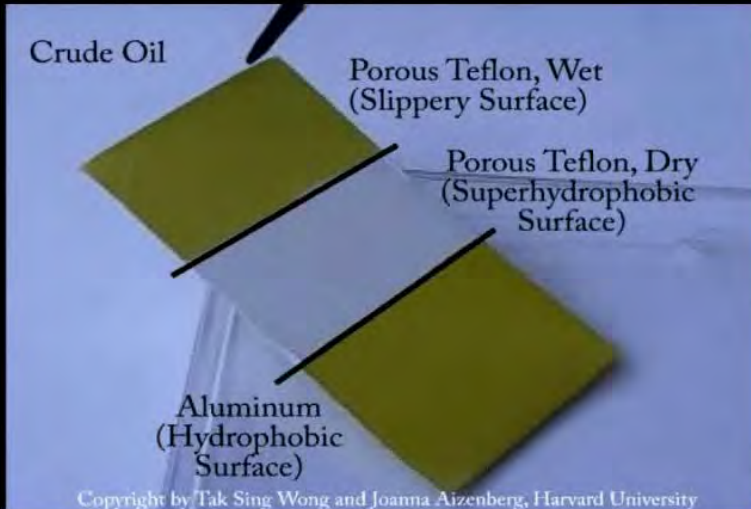
2. Functionalization



3. Lubricant Addition



# SLIPS



**Recipient: R&D 100  
Award 2012**

**Start-up Company in  
2014**



Adv. Funct. Mat. **2014**, 24, 6658-6667  
Nanotech. **2013**, 25, 014019  
Nature Comm., **2013**, 4, 2167-2177  
Appl. Phys. Lett. **2013**, 102, 231603

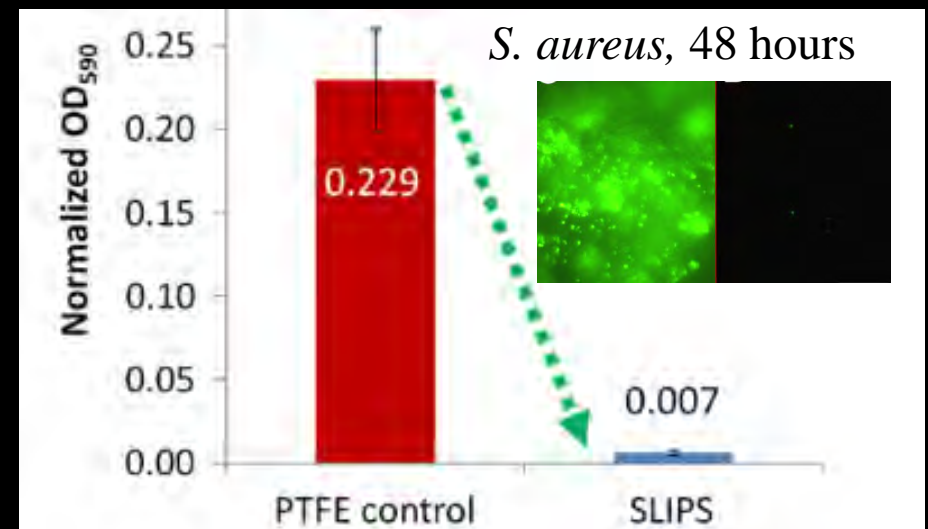
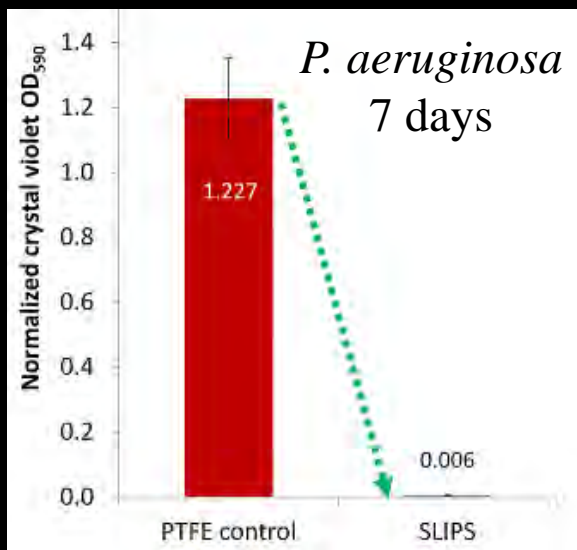
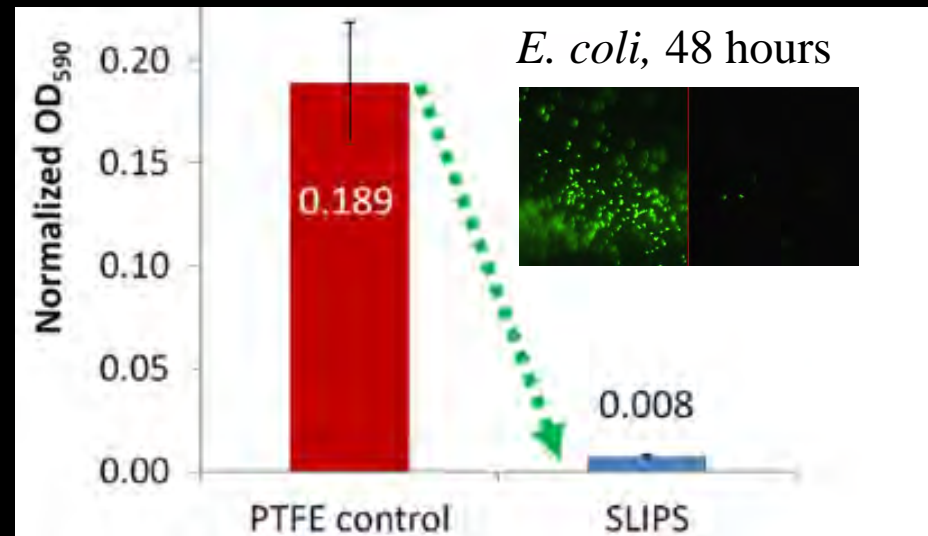
Nano Lett. **2013**, 13, 1793-1799  
Phys. Chem. CP **2012**, 15, 581-585  
ACS Nano **2012**, 6, 6569-6577

# In vitro bacterial resistance

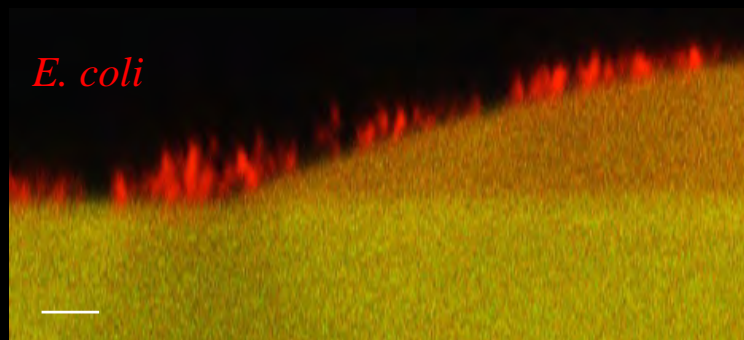
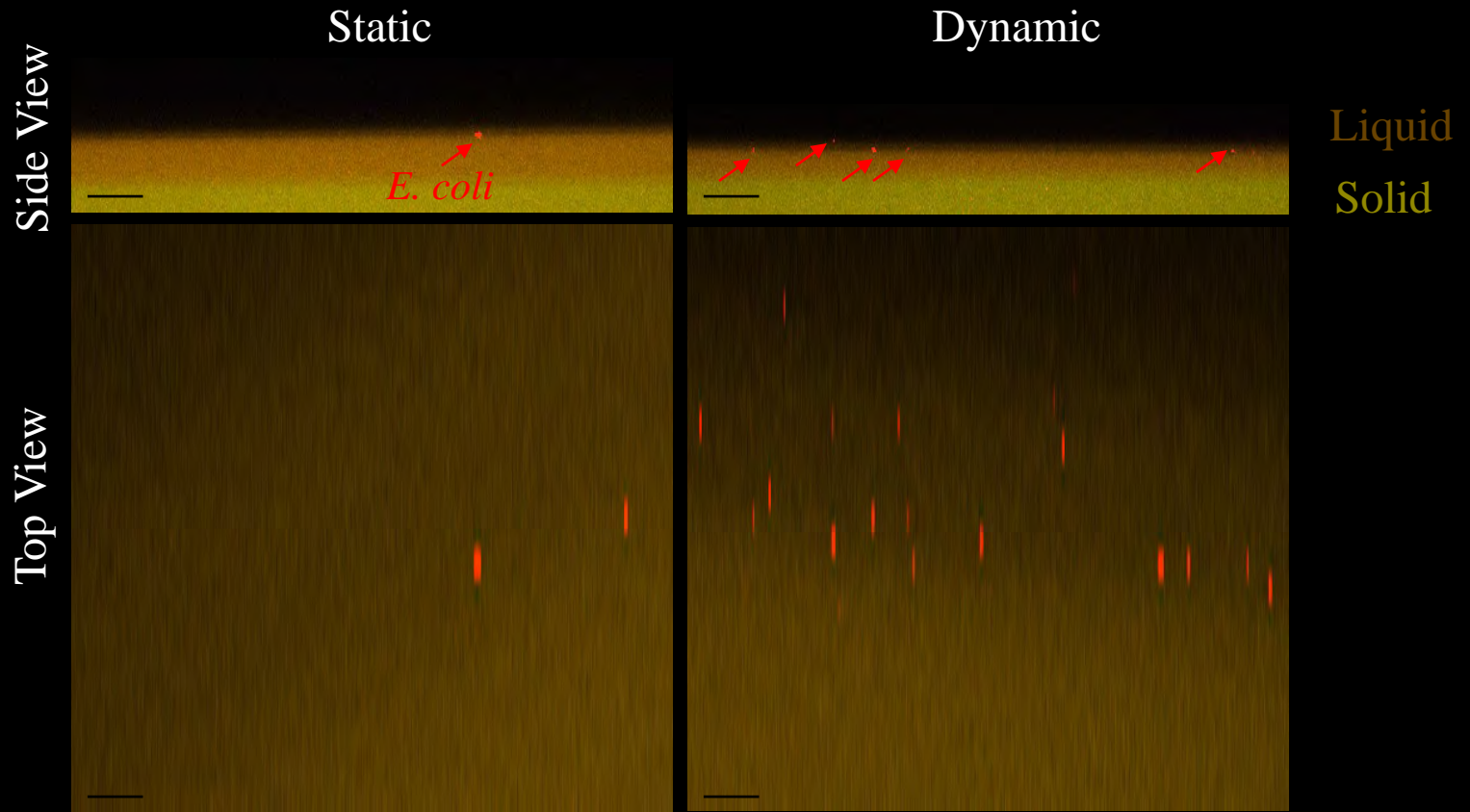
4x Playspeed



*Pseudomonas aeruginosa*  
After 24 hrs of Incubation



# Liquid as a Physical Barrier





# Customizable Platform Technology



## Solid Material:

### Plastics



- PET
- PS
- PVC
- ...

### Metals



- Steel
- Titanium
- Aluminum
- ...

### Rubbers

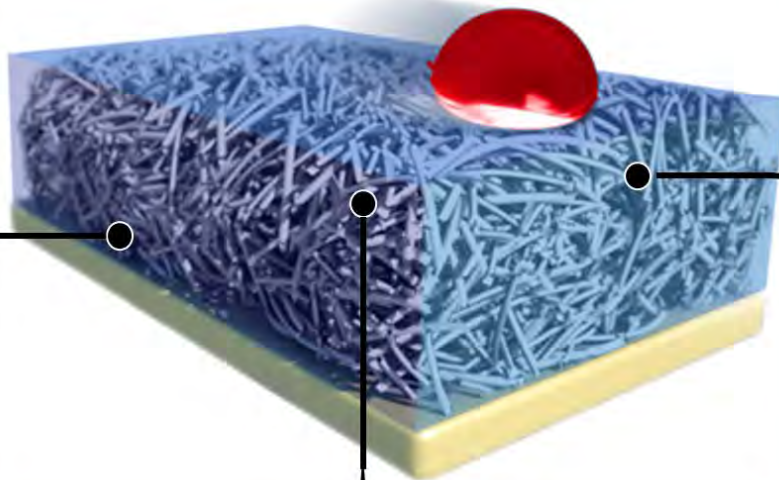


- Silicone
- Fluoroelastomers
- EP
- ...

### Other



- Glass
- Enamel
- Hydrogels
- ...



## Liquids:

### Pharmaceutical Grade



Perfluorodecalin



Perfluoroperhydrophenanthrene

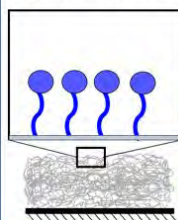


Silicone oils

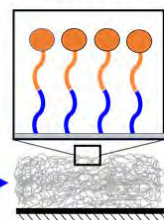
### Others...

## Surface Functionalization:

### Intrinsic

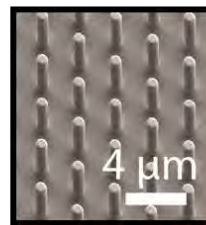


### Added

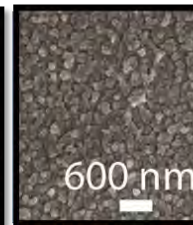


## Surface Structure:

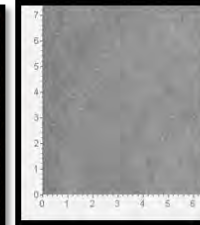
### Micro Scale



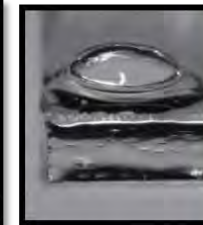
### Nano Scale



### Flat



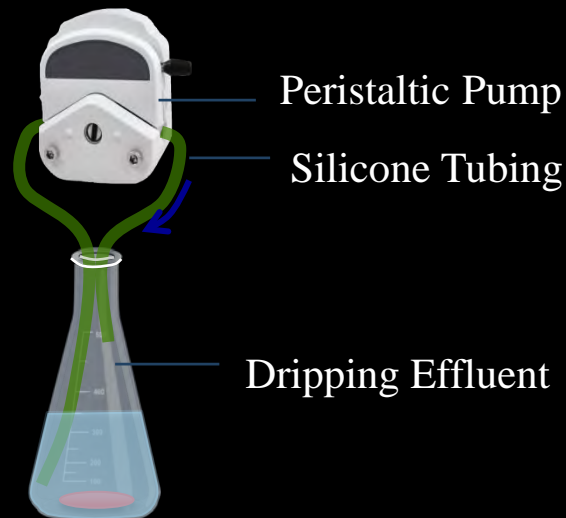
### Infused



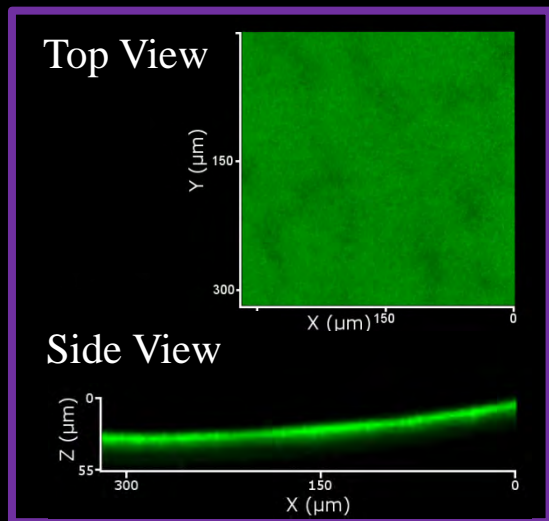
# Biofilm Resistance Under Laminar Flow



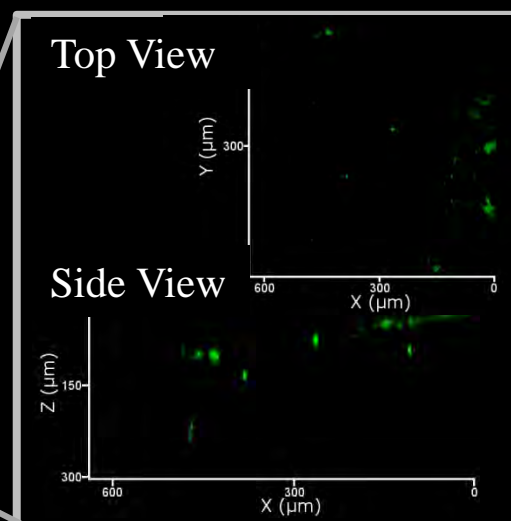
*P. aeruginosa*



## Untreated



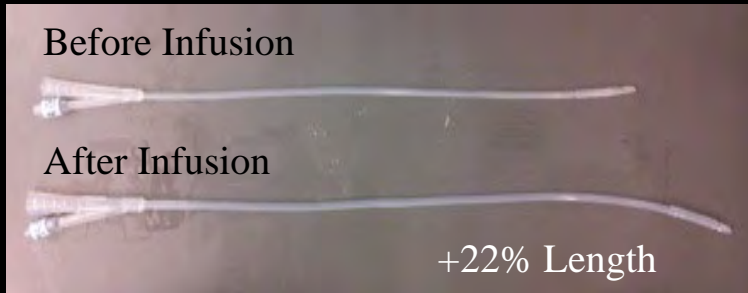
## Liquid Surface



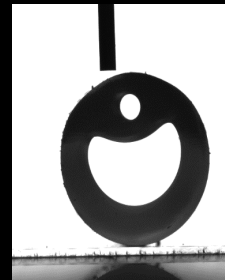
# Treatment of Foley Catheters

## Silicone

Length



Cross-Section



Before



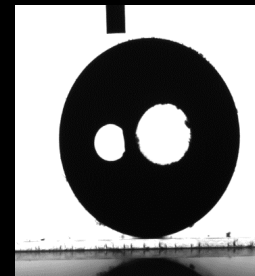
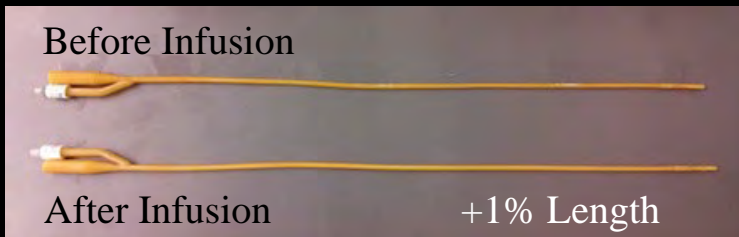
After

+24% ID

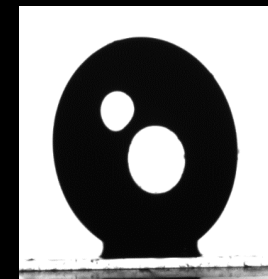
Additional Cost

\$0.47

## Silicone-Coated Latex



Before



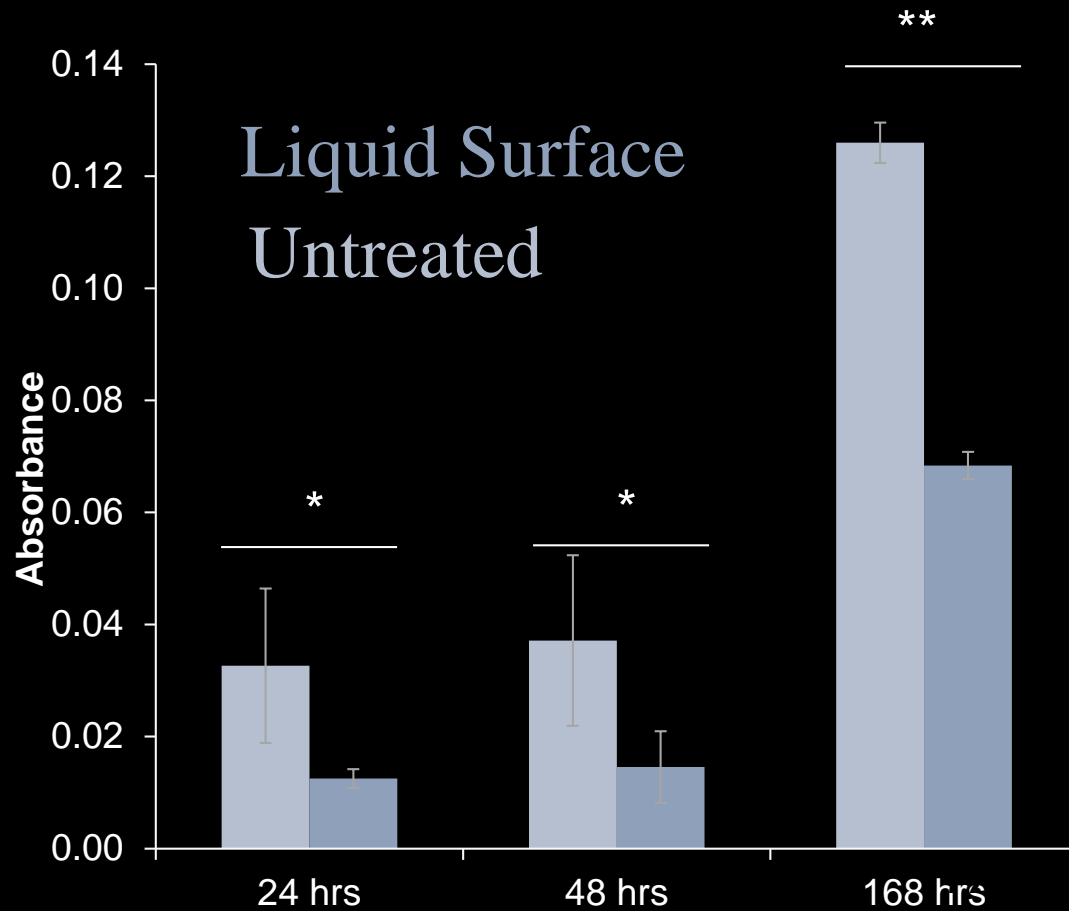
After

+3% ID

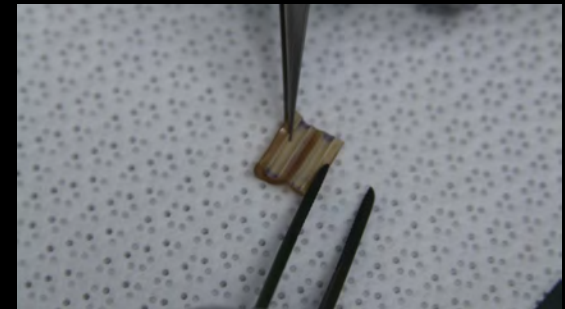
\$0.02

# Biofilms on Foley Catheters

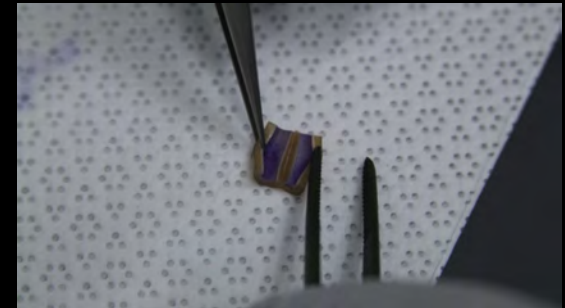
*P. aeruginosa*



Liquid Surface

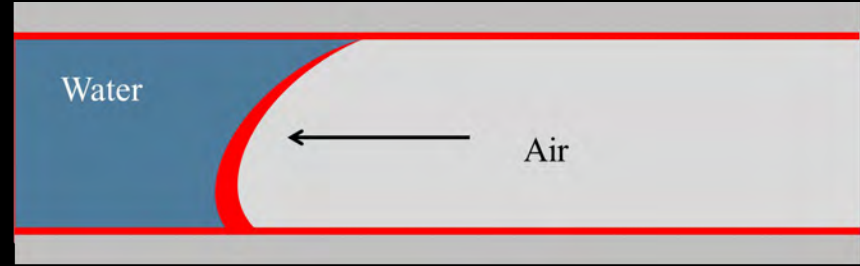
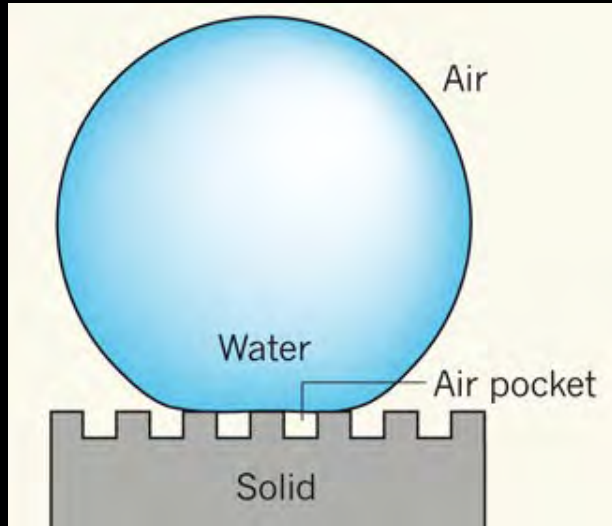


Untreated



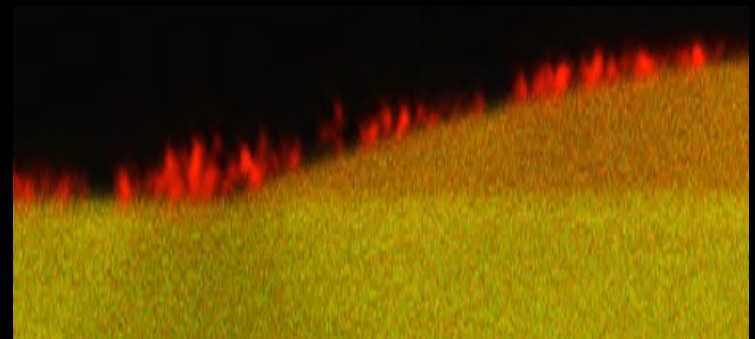
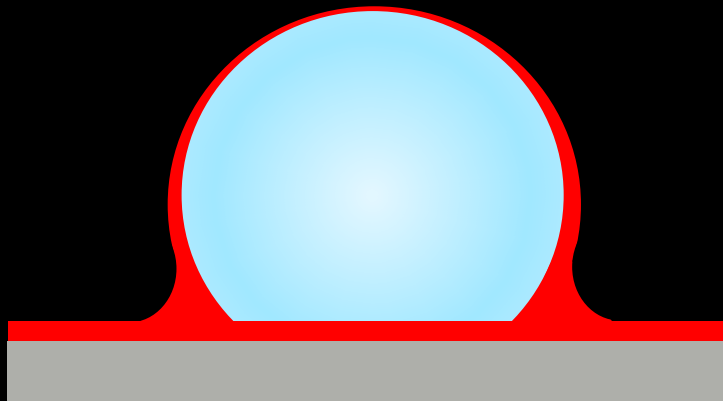
# Rethinking our approach: Physics Working for Us

## 3-Phase Contact



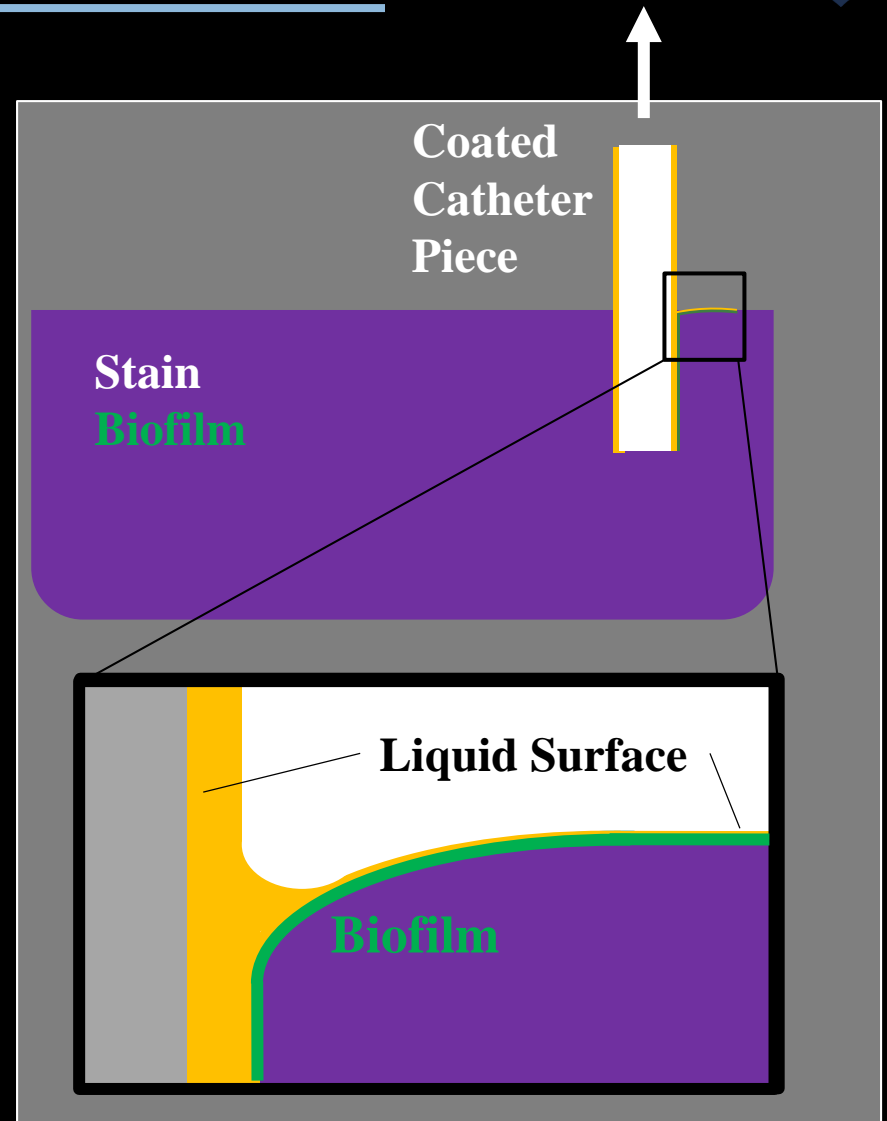
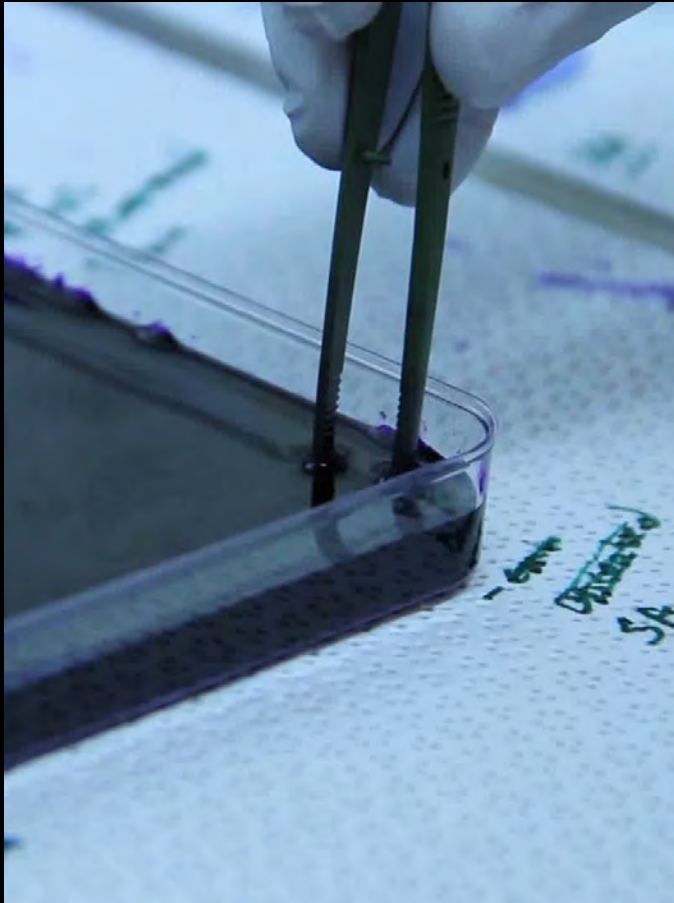
Chemistry of Materials **2015**, 27, 1792-1800

### 3-Phase Contact



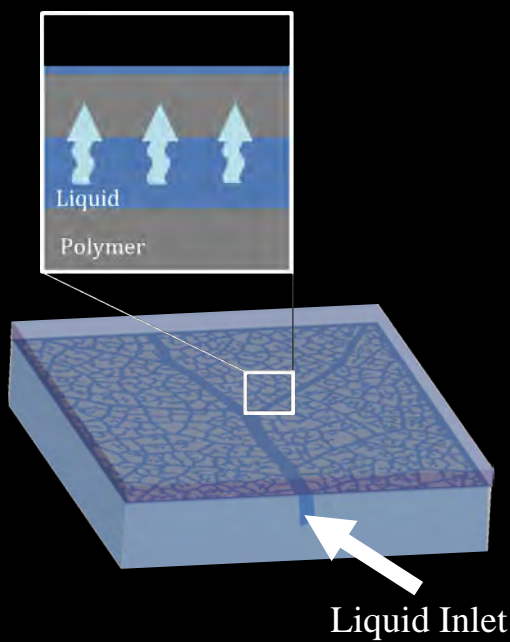
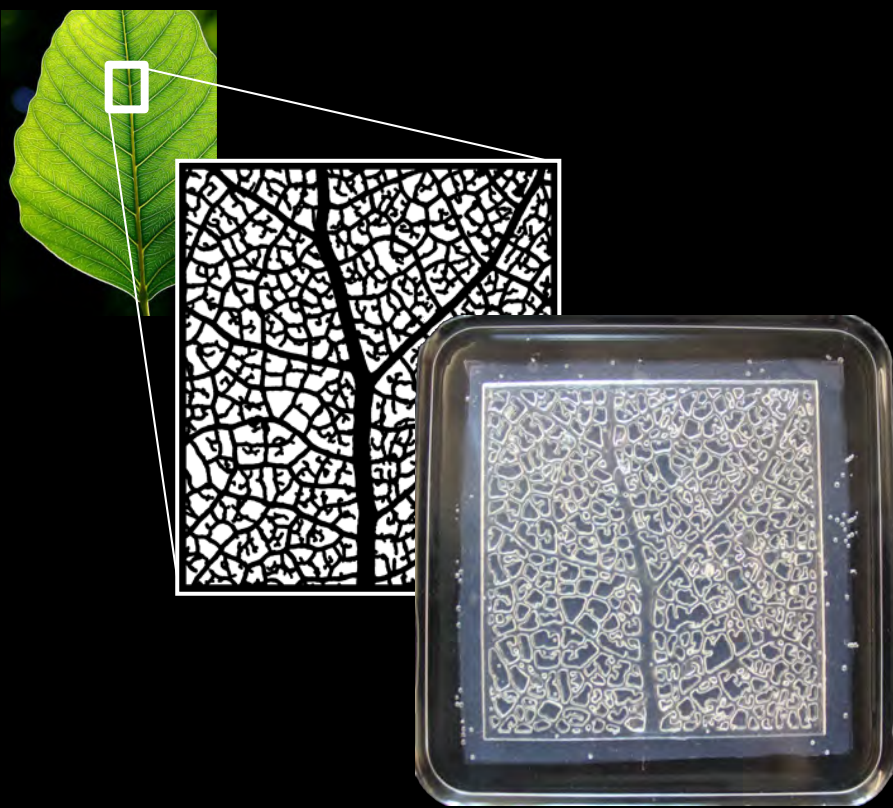
Advanced Healthcare Materials **2017**, 1600948

# Spontaneous Biofilm Stripping

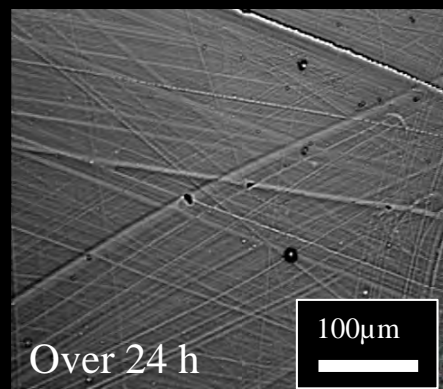


# Rethinking our approach: Physics Working for Us

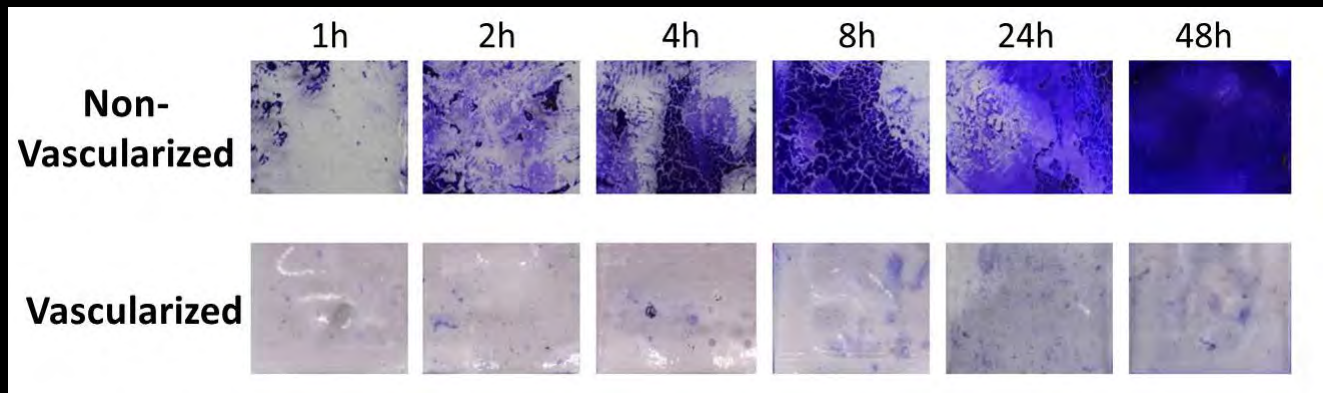
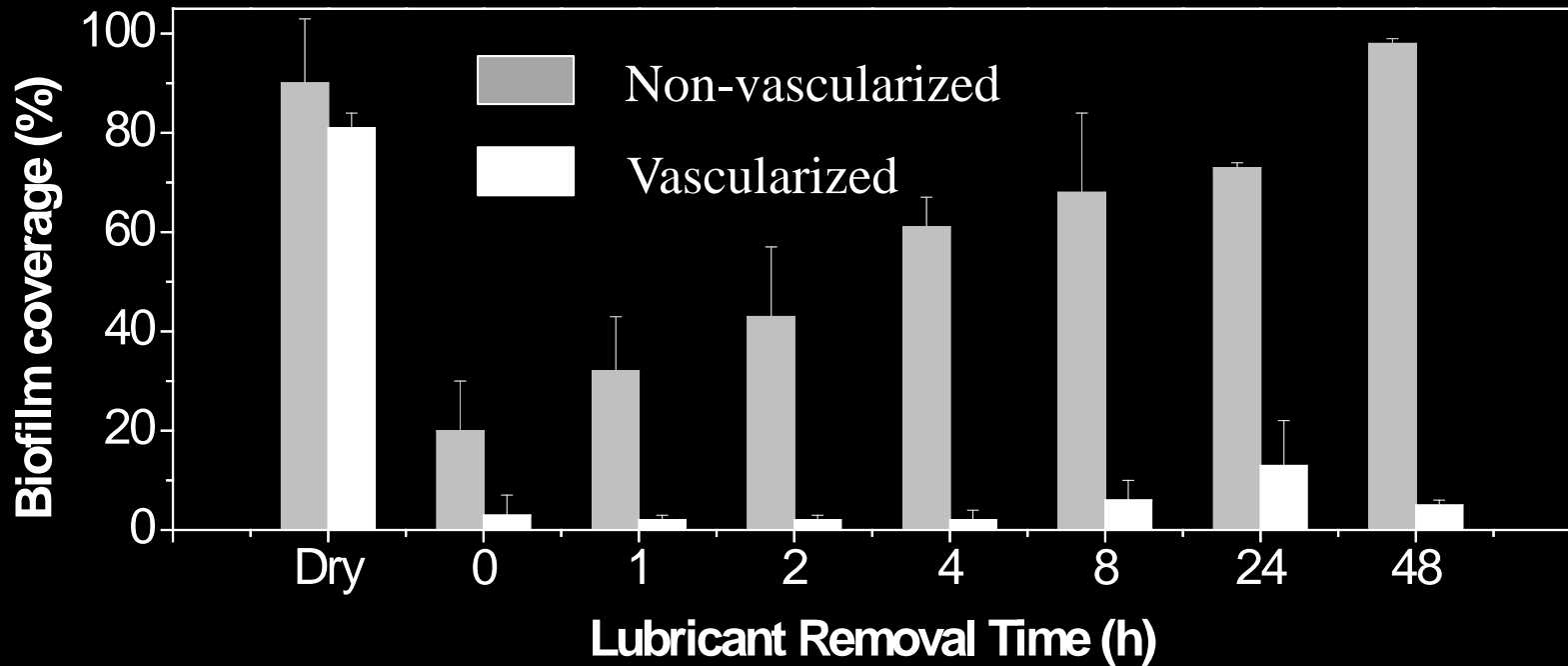
## Diffusion



### Surface liquid replenishment



# Vascular systems for continuous resistance







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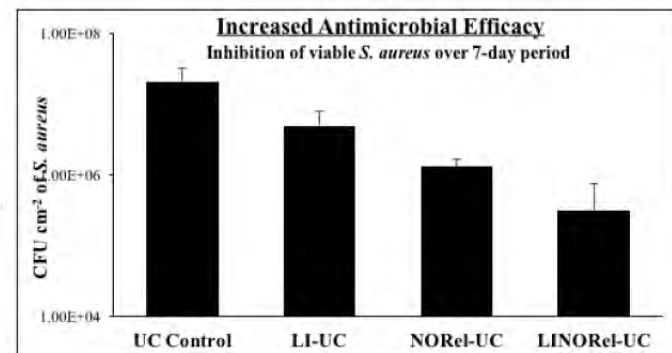
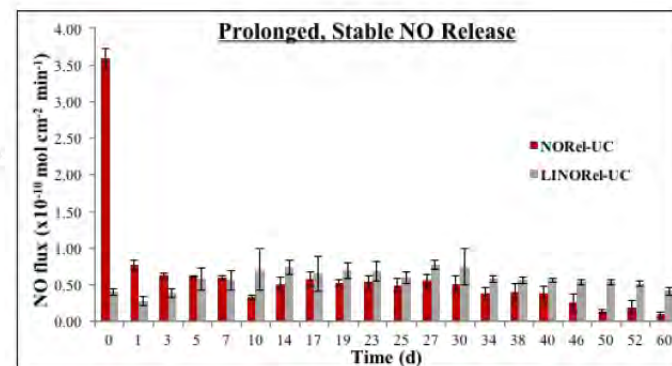
## Applications and Health

### Liquid-infused nitric oxide-releasing silicone Foley urinary catheters for prevention of catheter-associated urinary tract infections

Katie Homeyer, Marcus Goudie, Priyadarshini Singha, and Hitesh Handa

ACS Biomater. Sci. Eng., Just Accepted Manuscript • DOI: 10.1021/acsbiomater.3c01000 • Publication Date (Web): 05 Feb 2023

Downloaded from <http://pub>



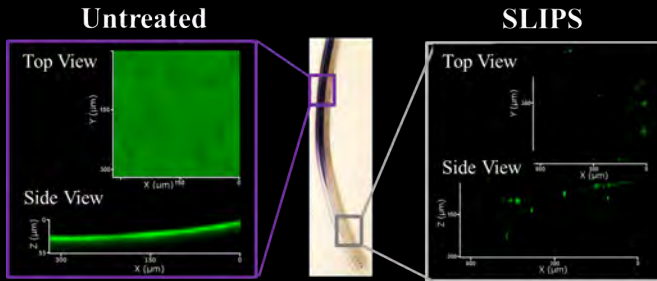
# Summary

- Bio-inspired slippery liquid surfaces



*A non-solid* paradigm shift in anti-biofouling materials and interfaces

- Resist bacterial adhesion
- Straightforward application to catheters
- Potential platform for new approach to anti-adhesive surfaces



# Acknowledgements

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