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Doctoral Dissertation Defense
Chem & Bio Eng. - Center for Biofilm Eng.
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9:00am - 10:00am
Reid Hall, 201 and via Microsoft Teams

Material coatings and strategies for biofilm mitigation in spacecraft water systems

Abstract:
Biofilms are diverse microbial communities that can be attached to surfaces or present in liquid as floating aggregates. Previously, biofilms in the International Space Station (ISS) water recovery system have caused clogs that required part replacement. As spaceflight missions become longer and travel farther from Earth, it will no longer be feasible for biofilm-related issues to be treated with part replacement. To improve spaceflight sustainability and permanence of humans in space, water recovery systems in future spacecraft must be more robust to biofilms and their related issues. The goal of the research in this dissertation is to explore methods of biofilm control for implementation in spacecraft water systems. This was achieved by examining multiple material coatings for their ability to reduce viable biofilm accumulation in normal gravity benchtop experiments. Once it was determined that material coatings offer promise for reducing biofilm accumulation at normal gravity and with a single-species biofilm, additional methods of biofilm control– nutrient limitation and biocide dosing– were incorporated. As the research progressed, the experiments became more accurate to modeling the water recovery system of the ISS by incorporating a consortium of four direct isolates from the system, a medium designed to simulate the fluid present in the wastewater tank, and eventually, simulated microgravity. The coating tested most thoroughly effectively delayed biofilm accumulation for at least 3 days in normal gravity experiments, and its effect was bolstered by the removal of phosphorus (a key nutrient) from the growth medium and daily dosing of silver fluoride biocide. These combined strategies resulted in a 99.9999% reduction in viable biofilm accumulation compared to the experiments without methods of biofilm control. Following the normal gravity experiments, the biofilm control methods were evaluated in a novel simulated microgravity biofilm reactor. With all three methods of control implemented in simulated microgravity, no viable biofilm was recovered from the surfaces nor were viable biofilm aggregates recovered from the bulk fluid in the reactor. These results show that simultaneously using three methods of biofilm control may be promising for managing microbial growth in future spacecraft water recycle systems.