Ryerson University Faculty of Science

Biomedical Physics
January 2017

Medical Devices & Biofilms: Exploring a New Synergistic Treatment

Medical devices like catheters, artificial joints, pacemakers and synthetic heart valves have revolutionized health care. But these devices are also prone to a pesky problem – biofilms.

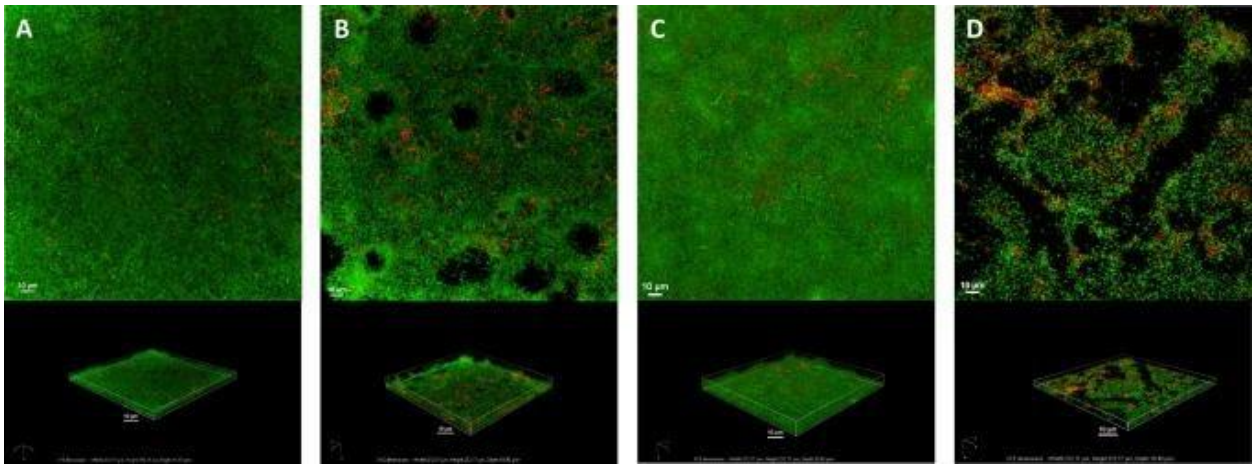
“Biofilms occur when microbes attach to surfaces in a matrix of self-produced slime,” says Evan Ronan, currently a PhD student in Ryerson’s Environmental Applied Science and Management Program. “They’re also notoriously difficult to eradicate,” he adds. “This is of particular concern when biofilms form on medical devices implanted in the human body – at least one half of all hospital-acquired infections can be attributed to biofilm growth.”

Jointly supervised by Drs. Gideon Wolfaardt and Otini Kroukamp in the Department of Chemistry and Biology, and Dr. Raffi Karshafian from the Department of Physics, Ronan recently managed a fascinating interdisciplinary project. The study’s goal was to investigate the potential synergistic effect of a novel simultaneous treatment for biofilms.

Up to now, two methods are common in treating implant-associated infections: antibiotics and replacement of medical devices. Ronan notes each method has drawbacks. “Even in cases when symptoms are alleviated by antibiotics,

future flare-ups can occur if the biofilm was not completely destroyed during treatment." And while removing and replacing a device with a new sterile device is the most effective route, Ronan says, "There is still no guarantee the new device will remain sterile during and after implantation."

Given such challenges, Ronan and his team identified an urgent need to improve antibiotic efficacy here. They set out to investigate the potential synergistic effect of a unique method they developed: treating biofilms simultaneously with aminoglycoside antibiotics and ultrasound. Ronan says, "Both treatments were also carried out in the presence of lipid-coated microbubbles, which burst to create shockwaves and microjets when placed in a strong ultrasonic field."



This is a figure showing confocal laser scanning micrographs of Pseudomonas aeruginosa PAO1 biofilms. Propidium iodide stain was added so that dead cells would appear red, while all others would appear green due to the presence of green fluorescent protein in these cells. Biofilms were subjected to either no treatment (A), ultrasound and microbubble (USMB) (B), gentamicin (C), or concurrent treatments of gentamicin and USMB (D). For each type of treatment, a top-down maximum intensity projection as well as a three-dimensional volume rendering is shown.

Encouragingly, when researchers measured changes in biofilm structure and metabolism, they found treatment was "successful in removing large portions of biofilm, and significantly impacted overall biofilm respiration." In fact, they were surprised at the how pronounced the changes were. Says Ronan: "The large craters in the biofilm, which formed as a result of microbubble disruption, resembled the surface of the moon."

Recently, Ronan, and fellow researchers Narbeh Edjiu, Kroukamp, Wolfaardt and Karshafian published their findings in the journal, Ultrasonics, in an article called "USMB-induced synergistic enhancement of aminoglycoside antibiotics in biofilms."

With further research, Ronan envisions even greater success with synergistic treatment – and ultimately, that this technology could be used in clinical practice. But he sees other applications for the technique too – for example, in industrial water systems, where biofilm-associated biofouling is a major concern.

Ronan, who also earned his MSc at Ryerson, is currently devoting his doctoral studies to wastewater treatment technologies, with a focus on biological nitrogen removal. Speaking to his Ryerson experience, he says, "I really enjoy the collaborative and interdisciplinary aspect of the work I carry out at Ryerson. As a microbiologist, I have had the opportunity to work on a number of projects with physicists, chemists, and engineers. Not only has this allowed

me to gain valuable experience in a number of areas outside my own field; it has also exposed me to a range of different perspectives when it comes to identifying effective solutions to real-world problems.”

Ronan’s research was partially funded by an NSERC Engage Grant, and this particular project was carried out in collaboration with the manufacturing company MD Precision Inc.