Characterization of Biofilms in a Synthetic Rhizosphere Using Hollow Fiber Root Mimetic Systems | Biological Engineering

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Full Abstract

The rhizosphere of a plant is the interface between root and soil that is conditioned by root exudates and inhabiting microbes. Understanding the impact in the rhizosphere of microbial activity, especially beneficial microbes which improve plant health, is important for agricultural production. However, the complexity arising from the dynamic interplay between plant host and colonizing microbes presents a significant challenge in understanding biofilm formation and function. This thesis presents several root mimetic systems (RMSs), with passive and active delivery methods for artificial root exudates (AREs) to support microbial biofilm formation. A well plate assay with fibers immersed into the ARE was developed as a rapid screening method to correlate biofilm formation with ARE composition. A more active method of delivering nutrients to the outside of the fiber by exudation of nutrients through the fiber pores from a lumen fed system was also engineered to control nutrient delivery in a manner mimicking the plant root. The developing biofilms can be monitored in real-time and sampled by sectioning fibers from the RMS for ex-situ analysis with SEM or AFM. The root mimetic systems were constructed from bleach-treated polysulfone polyvinylpyrrolidone (PS/PVP) hollow fiber membranes (HFM). Root colonizer, Pseudomonas chlororaphis O6 (PcO6), was the primary microbe used in these studies as it is a strong biofilm former and beneficial plant microbe. ARE nutrient compositions were varied to explore how different factors, such as the amount of carbon, nitrogen, or phosphate in the ARE, would affect biofilm formation. The PcO6 biofilms formed on the HFM were examined with and without exposure to different levels of nanoparticle (NP) stress. The cell and biofilm were dependent on ARE composition and NP stress. The RMSs developed in these studies provide an abiotic surface for bacterial colonization and studying biofilm formation by a root colonizing bacterium without the complexity of the feedback from active root metabolism.