Young Scientist Special Session

Genetically engineered culture with reduced EPS production results in improved performance for biofilm reactors

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In this research, we tested the hypothesis that bacteria producing less extracellular polymeric substances (EPS) provide more effective biofilm processes for wastewater treatment. The hypothesis was tested with a membrane-aerated biofilm reactor (MABR) and ultrafiltration membrane reactor (UMR). MABRs are an emerging wastewater treatment technology that have many advantages over conventional activated sludge plant, including a reduced footprint, less stripping of volatile pollutants, and lower energy costs. UMR is a water treatment system that has a smaller footprint and higher-quality effluent than to conventional systems. Both systems produce biofilms on the membrane surface. Reduced EPS production can result in higher-density biofilms, providing greater contamination removal rates in an MABR and reduced biofouling in UMR.

Pseudomonas aeruginosa was selected as a model organism. *P. aeruginosa* produces three main types of EPS: alginate, Pel and Psl. The effect of EPS was studied by comparing the wild type with a genetically modified *P. aeruginosa* with suppressed Pel production (mutant). With reduced EPS production, the biofilm density was expected to increase and the biofilm thickness decrease. This could reduce mass transfer resistance and increase permeability.

For the MABR reactor, at steady state the biofilm thickness for the mutant biofilm was smaller than for the wild type, while the sCOD removals for the mutant biofilm were better than for the wild type. Also, the effluent suspended solids was lower for the mutant biofilm. For ultrafiltration membrane reactor (UMR), there was no significant difference in sCOD between the wild type and mutant biofilms. However, significant biofouling did not occur until much later for the mutant, compared to the wild type.

Our results show the mutant produced a higher cell density biofilm than the wild type. High cell density biofilms can affect the performance and maintenance of biofilm-based systems. The EPS-reduced culture produced thinner biofilms with greater degradation kinetics than the wild type in an MABR. Finally, tests showed that mutant biofilms were mechanically weaker than the wild type. This could make them more vulnerable to sloughing.

This research showed that low EPS production results in improved performance for the MABR and UMR. Further research is needed to determine conditions favoring low EPS production in practice.