Characterization of Microbial Aggregates in Relation to Membrane Biofouling in Submerged Membrane Bioreactors

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Abstract

The purpose of this study was to characterize microbial aggregates and extracellular polymeric substances (EPS) that contribute to biofouling of submerged polymeric microfiltration membranes. Two issues were addressed in this study, 1) the influence operational and recovery cleanings of membranes have on biofouling amelioration and 2) the influence physicochemical properties of microbial flocs have on biofouling.

The experiments in this study employed two pilot scale ZeeWeed™ membrane bioreactors (MBRs). In one MBR, a ZW-10 module was installed to treat secondary municipal wastewater at a sludge retention time (SRT) of 30 days and operated under permeate/relaxation conditions. In the other MBR, two ZW-10 modules were installed to treat secondary municipal wastewater at an SRT of 12 days. One module operated under permeate/relaxation conditions, while the other operated under permeate/backwash conditions. Sludge samples from the MBRs were characterized by measuring the surface charge, hydrophobicity, and EPS composition of the microbial flocs. Membrane fibre samples were collected from each ZW-10 module during permeation and after recovery cleanings. The biofoulant on the membrane was analyzed using confocal laser scanning microscopy (CLSM) after simultaneous staining with the lectins concanavalin A (ConA), wheat germ agglutinin (WGA), and soybean agglutinin (SBA).

The CLSM analysis of the membrane fibres sampled showed that the biofoulant on the membrane was composed of a heterogeneous colonization of microbes and EPS known to contain glucose, mannose, *N*-acetylglucosamine, and galactose. The dominant carbohydrate in the biofoulant was shown to be *N*-acetylglucosamine, which is part of both the cell wall of bacteria and the extracellular matrix. The reversible biofoulant was composed of individual cells, aggregates of cells, and EPS. The major constituent of the irreversible biofoulant was inferred to be EPS, which was observed as a fibrous network of material that remained adhered to the membrane after recovery cleaning the modules with a 2000 ppm hypochlorite solution. By using a permeate backwash rather than relaxation as an operational cleaning method, the rate of biofouling may be reduced. The rate of biofoulant accumulation on hydrophilic membranes may be reduced at higher SRTs because the biomass at higher SRTs has a higher hydrophobicity when compared to the biomass at lower SRTs.