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INVESTIGATION OF NANOFILTRATION FOULANTS IN A DRINKING WATER PRODUCTION UNIT BY ATR/FTIR SPECTROSCOPY AND LECTIN-BINDING ANALYSIS

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ABSTRACT

The application of membrane filtration in the food industry, and particularly nanofiltration (NF) in the drinking water industry, has attracted increasing interest in recent years. The main problem of membrane techniques is the reduction of permeate flux with time due to membrane fouling. To have a better understanding of the fouling mechanisms in a French drinking water production unit, we investigated the nanofiltration foulants composition and organisation between February and September 2005 by the combination of attenuated total reflection Fourier transform infrared (ATR/FTIR) spectroscopy, lectin analysis, epifluorescence microscopy and confocal laser scanning microscopy (CLSM). NF membranes were extracted from the filtration unit, one cm^2 fragments were cut, and analysed. The comparison of ATR/FTIR spectra of clean and fouled NF membranes revealed a qualitatively homogenous deposition of biological matter onto the surface of the used membranes, high heterogeneity in the composition of the foulant matter but high temporal stability of this composition. Characteristic signals of mainly polysaccharides (900-1200 cm^{-1}) and proteins (1300-1700 cm^{-1}) were observed. CLSM analysis revealed that the stained part of the foulant layer varied in depth between 6 and 27 μm. Fluorescence microscopy observations after nucleic acid staining with DAPI and polysacharides staining with lectins labelled with FITC or TRITC indicated high spatial heterogeneity inside the foulant matter. Some microbial cells were localised in the superficial layer of the foulant material and were mainly organised as microcolonies interspersed on the membrane surface. The greater part of the microbial community was composed of bacteria but algae were also present. Lectin staining was non-homogenous, not only concentrated in areas where microcolonies were present but also extended in areas devoid of microbial cells, indicating staining of extra cellular structures. High staining with *Arachis hypogaea* and *Bandeiraea simplicifolia* lectins revealed high occurrence of galactosides residues in the polysaccharide component of the foulant matter. The *Bandeiraea simplicifolia* lectin staining pattern indicated a high degree of spatial organisation with the observation of long and tangled up fibers. *Triticus vulgaris* lectin staining showed short fibers and cloud stained areas. *Arachis hypogaea* and Concanavalin A lectins staining were more interspersed. In conclusion, the combination of ATR/FTIR spectroscopy with lectin analysis was efficient in studying the composition and spatial organisation of the foulant matter on the surface of a NF membrane. The NF foulant material was mainly composed of bacteria and extracellular biological molecules (proteins and polysaccharides) forming a highly complex and heterogeneous matrix. The next step of our study will be to check the sensitivity of this biofouling layer to digestion by several enzymes with different specificities.