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Role of transparent exopolymeric particles in membrane fouling: *Chlorella vulgaris* broth filtration

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HIGHLIGHTS

- ▶ The direct role of TEPs on membrane fouling was investigated.
- ▶ Fresh and fractionated broths were filtered using 2 MF and 1 UF membrane.
- ▶ Sample and filtration parameter correlations were assessed by Pearson coefficients.
- ▶ No single dominant sample variable affects fouling.

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ABSTRACT

Recent reports show strong evidence for the involvement of transparent exopolymer particles (TEPs), mainly produced by microalgae in natural environments, in membrane fouling in a wide range of membrane filtration processes. The objective of this study is to fundamentally investigate the direct role of TEPs on membrane fouling by using different *Chlorella vulgaris* broth solutions and different fractions of such broth (the soluble and bound fractions, the cells separated from these fractions and the cells with their bound sugars, separated from the soluble fraction) as filtration feed. The relation between the feed properties and their filterability over three membranes was determined. Scanning electron microscopy and light microscopy showed that the foulant types differed for each broth fraction and confirmed the role of TEPs in the fouling of microfiltration membranes. In addition, this study contributes to the role of TEPs in the filtration of microalgae cultivated for commercial reasons.

1. Introduction

Recent reports show strong evidence for the involvement of transparent exopolymer particles (TEPs) in membrane fouling in a wide range of membrane filtration processes (de la Torre et al., 2010; Villacorte et al., 2009a; Kennedy et al., 2009). Because of the transparent nature of these TEPs, their role in membrane fouling was in the past often overlooked. In addition, they often escaped from standard pretreatments applied prior to membrane filtration because of their gel-like compressibility (Kennedy et al., 2009; Villacorte et al., 2009b). TEPs have natural properties of variable size (0.4–200 μm), a gel-like structure and a high negative charge.

Early indications of the involvement of TEPs in membrane fouling, possibly by inducing colloidal fouling or biofilm formation, or a combination of both, led to a significant research interest in this area. The influence of TEPs was studied in a wide variety of setups, in reverse osmosis (Villacorte et al., 2009b) and ultrafiltration (Berman et al., 2011), as well as in membrane bioreactors (de la Torre et al., 2010). In all these systems, TEPs seemed to play at least a partial role in the fouling process.

In natural environments and in membrane systems, TEPs and TEP precursors can originate from human debris, bacteria or multicellular organisms like macroalgae, oysters or sea snails

Abbreviations: TEPs, transparent exopolymer particles; SEM, scanning electron microscopy; Chla, chlorophyll a; SMP_{CH}, carbohydrate fraction of soluble microbial products; SMP_{PR}, protein fraction of soluble microbial products; EPS_{CH}, carbohydrate fraction of extracellular polymeric substances; EPS_{PR}, protein fraction of extracellular polymeric substances; bTEP, bound transparent exopolymer particles; sTEP, soluble transparent exopolymer particles; $Cells^{EPS}$, algae cells associated with their bound polymeric substances; $PC^{0.1}$, polycarbonate filter with pore size of 0.1 μm; $PC^{0.4}$, polycarbonate filter with pore size of 0.4 μm; PES^{5kDa}, polyethersulfone filter with molecular weight cut-off of 5 kDa; spTEP, soluble particulate transparent exopolymer particles; scTEP, soluble colloidal exopolymer particles; $Total_{CH}$, total carbohydrates; L, permeance; L_{CW}, clean water permeance; SFV, specific filtration volume; TTF, time to filter.

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