How algal caused ultrafiltration fouling depends on type and growth phase of algae

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Short Introduction

Depending on algae's type and concentration, algae often have undesirable effects on water treatment procedures like ultrafiltration (UF) membrane processes, especially during algae blooms (Henderson et al., 2008). The presence of algae and algae by-products can cause severe fouling and cake deposition on the membrane due to its accumulation (Babel & Takizawa, 2010). In surface water, the typical algal condition can be found in the three states lag phase, exponential phase, stationary phase and death phase in diverging portions. Various types of algae produce different amount of algal organic matter (AOM) and also cause different fouling behaviour in UF membrane applications. This research work focused on the comprehensive comparison between the two cell samples, "intact-living" (mostly present in exponential phase) and "lysed" (mostly present in death phase), in terms of membrane fouling potential, hydraulic backwash-ability, and chemical enhanced cleaning ability.

Material and Methods

Three types of marine algae in "intact-living" or "lysed" condition were used as model water for filtration process: Chlorella Sorokiniana (a spherical single cell green microalga) and Arthrospira Platensis (a filamentous helical blue-green microalga), both as representative for fresh water algae and Thalassiosira Rotula (a cylinder diatom), as representative for sea water algae. Chlorophyll-a concentration was measured as a control parameter for presence of intact cells. Particle size distribution analysis in terms of particle number and particle volume was used to inspect and differentiate the physical morphology of the algae in both intact and lysed condition. The disruption of cells algae was conducted using ultrasound. Inside/out dead-end mode process of UF capillary Multibore® membranes made from polyethersulfone (PES) with a pore size of approximately 0.02 µm and active surface area of 0.051 m^2 were used for this series of experiments. The experiments have been conducted minimum 3 times for each type condition of algae. Feed solutions were prepared with extraordinary high chlorophyll-a concentration in order to accelerate fouling (200 µg/L for Chlorella, and 25-60 µg/L for Arthrospira and Thalassiosira, in which results for 25 µg/L each are presented in figure 1). Intensive cleaning (CIP) after each experiment was done with alkaline chlorine solution at room temperature (pH 12, 100 ppm Cl_2) for 15 minutes. In case first CIP was not sufficient a second CIP with pH 12.5 and 200 ppm Cl_2 successfully recovered the performance completely.

Results and Discussion

Results in figure 1 show that “lysed” Chlorella Sorokiniana cells can cause much more severe fouling compared to “intact” cells and hydraulic backwash of the membranes was much more effective in restoring the permeability in case of “intact” cells compared to “lysed” cells. This might be due to the intracellular material in the algal organic matter pool after cell disruption. Adhesion of these substances which might behave like sticky colloids on the membrane surface and into the pores could lead to strong exacerbation of the membrane performance. Similarly, in case of Thalassiosira Rotula, a more severe fouling was observed in “lysed” cells compared to “intact” cells. However, the permeability reduction was less strong compared to that in case of Chlorella Sorokiniana. This could be explained by the difference in the nature of the produced sticky colloids after cell disruption due to difference between the nature characteristic of these two algae cells (diatom and green algae). Different fouling behavior was found in the case of Arthrospira Plantesis. Here, “intact” cells caused slightly stronger fouling compared to ”lysed” cells. The likelihood of this phenomenon might be a result of the disintegration of the cells from a filamentous form into smaller particle size cells with a more regular shape due to ultrasound.

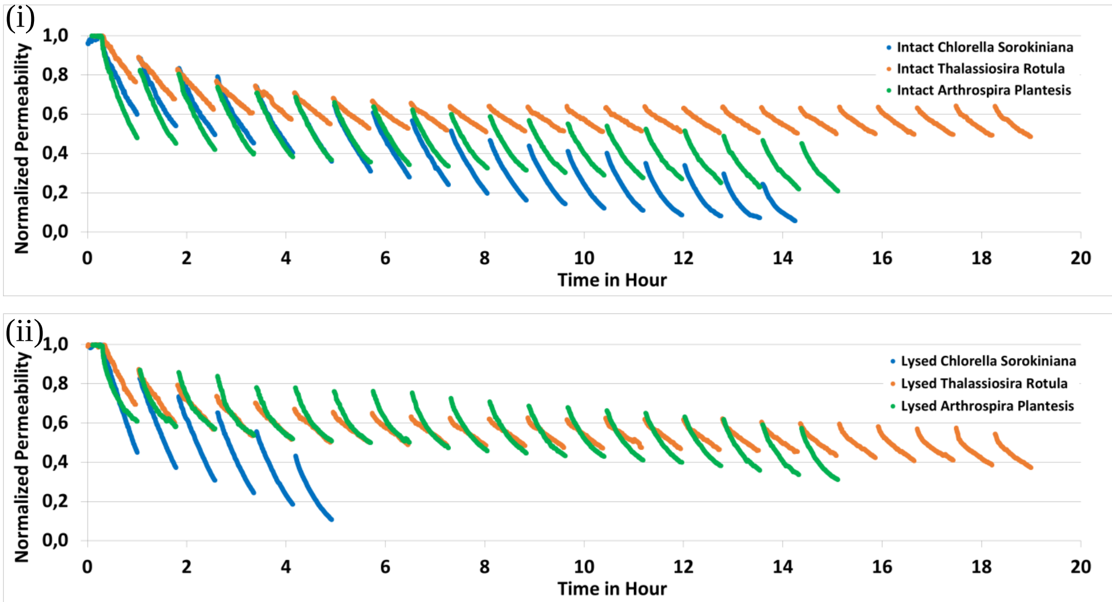

Figure 1. Permeability decline comparison during filtration of Chlorella Sorokiniana, Thalassiosira Rotula, and Arthrospira Plantesis in ‘intact’ (i) and ‘lysed’ (ii) condition of algae cells

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