Thin-layer nanofiltration membranes using engineered biopolymers for seawater desalination pre-treatment processes

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Abstract

Nowadays water demand already exceeds supply and water scarcity is a global problem. So it is necessary to develop novel technologies to be able to use poorer quality source waters for drinking water production. Once considered as an expensive, ultimate solution for water supply, desalination is becoming affordable. The two most commonly used seawater desalination methods are Multi-stage Flash Distillation (MSF) and Seawater Reverse Osmosis (SWRO). SWRO is less energy demanding compared to MSF, which makes it economically attractive. However there is no backpulsing of the expensive and delicate reverse osmosis (RO) membranes with air or water, so they are susceptible to fouling, causing the loss of their performance. Therefore cleaning the feed water to the highest level possible by nanofiltration, before it reaches the RO membranes would highly increase the efficiency of the process.

Nanofiltration (NF) as a feed pre-treatment step is a pressure driven membrane separation process that takes place on a selective layer formed by a semipermeable membrane with properties between RO and ultrafiltration. The objective of this project is the developement of highly efficient thin-film composite (TFC) membranes for SWRO pre-treatment processes based on low-fouling cyanobacterial extracellular polymeric substances (EPS). TFC membranes combine high flux and mechanical strenght, and they are expected to be the key components of any water purification technology in the future.

Cyanobacterial EPS are complex heteropolysaccharides with putative antimicrobial and antiviral properties and a particular affinity to bind metal ions [1,2].Within this work, the unicellular N_2-fixing marine cyanobacterium *Cyanothece* sp. CCY 0110 was chosen for RPS production, since it is among the most efficient released polysaccharide (RPS) producers and the polymer has been previously extensively characterised [3]. RPS was produced by growing *Cyanothece* CCY 0110 in 10L bioreactors, in conditions previously defined and the polymer was isolated following the standard methodology [3].

A polyvinyl alcohol (PVA) / cyanobacterial EPS blend nanofibrous membranes were fabricated by electrospinning using polyvinylidene fluoride (PVDF) as a basal membrane, in order to obtain thin-layer composite nanofiltration membranes. The production of the nanofibers using EPS and PVA as plasticizer in different ratios was produced in a NF-103 MECC Nanon electrospinning equipment with an applied electric field between 15 and 25 kV and a flow of 0,2 mL/h.

Morphological, mechanical, chemical and thermal characterization of the electrospun fibers deposited on the basal membranes, were evaluated by atomic force microscopy (AFM), scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS), dynamical and mechanical analysis (DMA), thermogravimetry (TGA) and differential scanning calorimetry (DSC).

The AFM and SEM results show the presence of fibers with dimensions between 54 and 121 nm with low bead formation. In the EDS analysis presence of sulfur elements was observed confirming the inclusion of EPS in the nanofibers. The morphology and diameter of the nanofibers were mainly affected by the concentration of the blend solution and the weight ratio of the blend, respectively. The best PVA/EPS nanofibers were achieved in a ratio of 12 % PVA and 0.4 % EPS. The solution conductivity was ranging 1500 to 3500 µS/cm with a viscosity of about 100 to 500 cP. The DMA results confirmed the miscibility of PVA/EPS blends. The elastic modulus of the nanocomposite mats increased significantly as a consequence of the reinforcing effect of EPS. Thermal and mechanical analysis demonstrated that there were strong intermolecular hydrogen bonds between the molecules EPS-PVA in the blends. The heat-treated electrospun blended membranes showed better tensile mechanical properties when compared with PVA alone, and resisted more against disintegration. A lab-scale

nanofiltration was performed in a bench stainless steel Sterlitech tangential flow stirred cell (200 mL) connected to an air pressure system that allow pressure driven filtration up to 10 BAR.
Bactericidal activity and biofilm formation were tested using *Escherichia coli* and *Sthaphylococcus aureus* as pathogenic microorganisms.

References

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