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Organic fouling on ZrO_2 ceramic membrane in the ultrafiltration of synthetic water and wastewater treatment plant effluent

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Adsorption of organic matter on ceramic membrane can lead to hydraulic-irreversible fouling, which decreases the permeate flux and the cost-efficiency of membrane devices. In order to optimize the filtration process, it is necessary to study the organic fouling mechanisms on ceramic membranes. In this study, dead-end filtration experiments with synthetic water (humic acid (HA) and HA-tryptophan mixture) and secondary effluent of a wastewater treatment plant (WWTP) were conducted on a planar ZrO_2 ceramic membrane.

The results show that HA can be adsorbed on ZrO_2 membrane and cause permeate flux decline; and that HA-tryptophan mixture, at the same DOC level, promoted the filtration flux decline. DOC removal in the case of HA-tryptophan was lower than that of HA alone. It seems that hydrophilic organics with low molecular weight has some specific contribution to the organic fouling of the ZrO_2 membrane. It was supposed that tryptophan molecules were preferentially adsorbed on the membrane in the initial phase of filtration, exposing the hydrophobic sides which would further adsorb HA from the feed water. During the filtration of WWTP effluent, protein-like substances (mainly tryptophan-like) were also preferentially adsorbed on the membrane compared with humic-like ones in the initial few cycles of filtration. More humic-like substances were adsorbed in the following filtration cycles due to the increase of membrane hydrophobicity.

A significant rise in hydraulic-irreversible flux decline was observed when the

pH was decreased from near the pH_{pzc} of the membrane, suggesting that a positively charged surface is preferred for HA adsorption. The increase ionic strength did not influence the filtration of HA, but lessened the hydraulic-irreversible flux decline in HA-tryptophan filtration. Therefore, HA adsorption on the membrane is mainly caused by an outer-sphere interaction between the organic and the membrane, while the HA-tryptophan adsorption can be attributed to an inner-sphere interaction between them.

Pre-ozonation of HA reduced its hydraulic-reversible fouling towards the membrane, but not the hydraulic-irreversible one. A similar phenomenon was also observed for ozone-pretreated WWTP effluent. Flux decline was observed in both the filtration of pre-ozonated HA and pre-ozonated WWTP effluent. It was confirmed that smaller hydrophilic molecules have a stronger affinity to the ZrO_2 membrane and tend to cause hydraulic-irreversible fouling.

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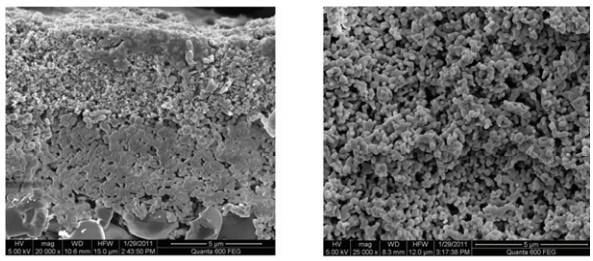

Fig. 1 SEM images of the planar ZrO_2 ceramic membrane

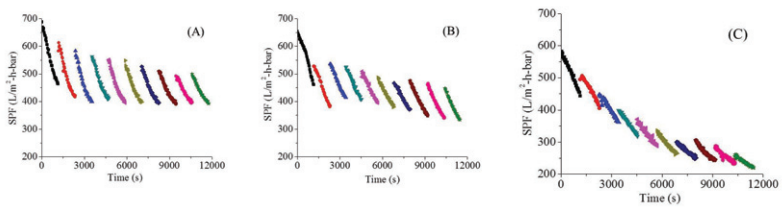

Fig. 2 Evolution of the specific permeate flux (SPF) of the ZrO_2 membrane in the filtration of HA (A) and HA-tryptophen ((B) and (C)) synthetic water at the same DOC.

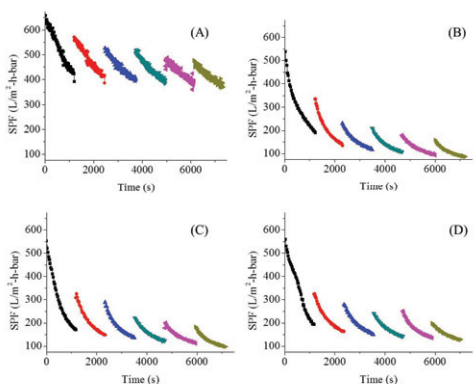

Fig. 3 Evolution of the specific permeate flux (SPF) of the ZrO_2 membrane in the filtration of HA synthetic water at difeferent pHs.

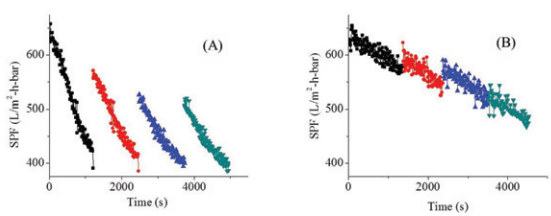

Fig. 4 Evolution of the specific permeate flux (SPF) of the ZrO_2 membrane in the filtration of HA synthetic water without (A) and with (B) pre-ozonation.

Keywords: organic fouling, ceramic membrane, Effluent of WWTP, ozonation