Fouling mitigation in ultrafiltration for wastewater treatment using zinc oxide nanoparticles

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Short Introduction

Natural organic matter (NOM) is a common organic material present in natural water. NOM fouling is a main concern in membrane processes. This could be attributed to the gel layer formation on membrane surface and pore blocking. NOM is hard to be removed by chemical cleaning or backwashing and tend to cause irreversible fouling (Yamamura et al., 2014). Recent development of nanomaterial has shown a great potential of advanced treatment technology in wastewater treatment. Hybrid adsorption-membrane process has been introduced to be a reliable process in membrane fouling mitigation in wastewater treatment. Potential of zinc oxide (ZnO) nanoparticle as nano-absorbent in hybrid adsorption-membrane process has been studied in this work. ZnO has advantages over conventional absorbent such as powdered activated carbon due to their regenerable properties (Liqiang et al., 2004). ZnO nanoparticle (0.5 g/l) is well-mixed with the targeted natural organic pollutant surrogate - flower soil (FS) extract (1:500 dilution) - and was used as feed solution. Three ultrafiltration (UF) membranes with different nominal molecular weight cut-off (MWCO) (4 kDa, 5 kDa and 10 kDa) were used in a low pressure cross-flow ultrafiltration membrane system. The main objective in this work is to assess the membrane performance and fouling propensity when dealing with organic pollutant with or without the adsorption by ZnO. Further, this work also acts as a preliminary study prior to the fouling mitigation under UV irradiation.

Materials and Methods

Flower soil (B1 Blumenerde) was obtained from Toom Baumarkt. The flower soil extraction technique is based on standard procedures of inge watertechnologies AG. ZnO nanoparticles (CAS No. 1314-13-2) and UF membranes used in this work were supplied by Evonik Industries and MICRODYN-Nadir GmbH, Germany, respectively. The properties of membranes used are shown in Table 1 (Information provided by manufacturer). A fluorescence spectrophotometer (RF-6000, Shimadzu, Japan) and UV/VIS spectrometer (Lambda 20, Perkin Elmer) were used to investigate the major components and organic matter in the feed and permeate samples. Total organic carbon (TOC) of samples was measured using TOC analyzer (TOC-L CPN, Shimadzu, Japan).

Results and Discussion

Fig. 1 illustrates the membrane performance and fouling propensity of UP005P membrane with different feed solutions. It can be clearly seen that feed solution with only FS causes a very drastic TMP increment compared to the colloidal suspension of FS and ZnO nanoparticles. Fouling with ZnO nanoparticles as adsorbent was low and could be attributed to the FS pollutants that have been adsorbed by ZnO and then effectively retained on the surface of the membrane. In this situation, less dense fouling layer was found as shown in Fig.2 (a). Similar phenomenon also was also previously reported by Kim et al. using powdered activated carbon (Kim et al., 2008).

Table 1. Properties of UF membranes

Membrane type	UH004P	UP005P	UP010P
Membrane material	PESH	PES	PES
Nominal MWCO (kDa)	4	5	10
Thickness (µm)	210-250	210-250	210-250

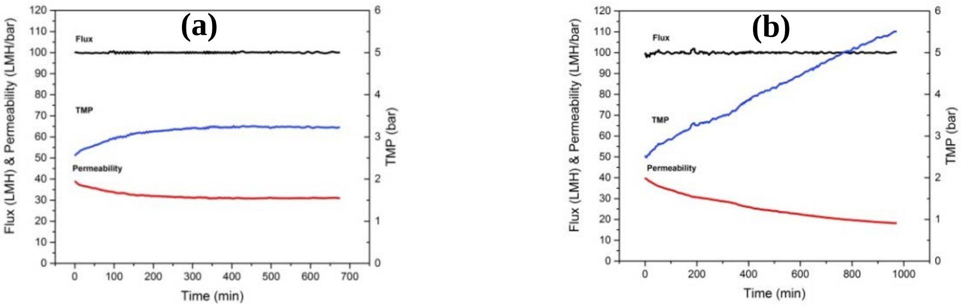

Figure 1. UP005P membrane performance: (a) 1:500 dilution FS and ZnO, (b) 1:500 dilution FS

Figure 2. UP005P membrane morphology: (a) 1:500 dilution FS and ZnO, (b) 1:500 dilution FS

Conclusions

This work studied the potential of ZnO in membrane fouling mitigation. The interaction between ZnO and FS resulted in less dense fouling layer on membrane surface. ZnO can be easily removed from the membrane surface with less fouling.

References

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