

# Influence of Colloidal Particles and NOM on Membrane Fouling and DOC Removal in Combined Photocatalysis/Microfiltration Systems for Drinking Water Treatment

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## 1. Introduction

Surface water contains colloidal particles and natural organic matter (NOM) which covers a wide range of size from a few nanometers to a few micrometers. Removal of NOM and colloids is an important issue in drinking water treatment [1]. NOM is not of direct concern in drinking water, but it affects the quality of treated water due to disinfective by products formation. Pressure-driven membrane processes, such as microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO), become more and more popular in water treatment to meet stringent regulations [2]. MF and UF processes can be an alternative to conventional treatment, but they are still limited in NOM removal. Another issue in the use of these low pressure membrane processes is fouling, which arises from specific interactions between the membrane and various components in the raw water [3-5]. Recently, it was demonstrated that conjunctive use of membrane filtration and heterogeneous photocatalytic degradation enhanced NOM removal [6-7].

In this research, a lab-scale photocatalyst-membrane hybrid reactor was developed for drinking water treatment. To improve NOM removal efficiency and reduce membrane fouling, the microfiltration (MF) membrane was modified by coating of iron oxide particles (IOPs). The influence of colloidal particles and NOM in the raw water was investigated using bare and IOP-coated systems in terms of membrane fouling and NOM removal. The effect of IOP coating layers formed on the MF membrane surface on membrane fouling, cake layer formation,

and NOM removal efficiency was also evaluated.

## **2. Materials and methods**

### **2.1. Raw water and materials**

Raw water used in the experiments was taken from the Nakdong River. TiO<sub>2</sub> particles (Degussa P25, Germany) were used as photocatalyst, which had an average aggregate particle diameter of 3 μm and a surface area of 50 m<sup>2</sup>/g. IOP (i.e., ferrihydrite) was prepared in the laboratory and used for membrane coating. The microfiltration (MF) membrane used was made of polyethylene with a nominal pore size of 0.4 μm and an effective surface of 60 cm<sup>2</sup> (KMS, Korea).

### **2.2. Experimental setup**

The photocatalytic membrane reactor with a working volume of 700 mL was composed of an UV lamp (Sankyo Ultraviolet, Japan) and a submerged MF membrane, as shown in Fig. 1. Peristaltic pumps (Cole Parmer, USA) were used for feeding and suction with MasterFlex tubings. Air sparging was provided using an air diffuser underneath the membrane to supply oxygen to the reactor and prevent membrane fouling.

### **2.3. Analytical methods**

Solution pH was measured using a calibrated portable pH meter (pH 330i, Germany) and dissolved oxygen (DO) was measured by a DO meter (Oxi 330i, Germany). The UV absorbance at 254 nm (UV<sub>254</sub>) was determined using a UV-VIS spectrophotometer (DR/4000U, HACH, USA), while the total organic carbon (TOC) concentration was measured by a TOC analyzer (Model 820, SIEVERS, USA). Transmembrane pressure (TMP) was monitored to evaluate the degree of membrane fouling. Turbidity of raw water and filtered water was determined by a turbidimeter (2100, HACH, USA).

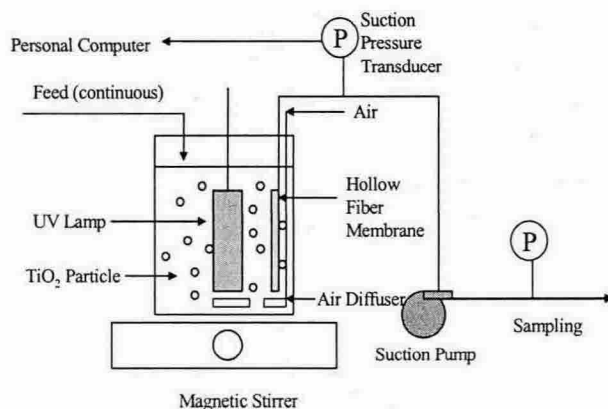


Fig. 1 Schematic of a photocatalysis/microfiltration system.

### 3. Results and discussion

In order to evaluate the influence of IOP layers on membrane fouling and NOM removal, bare and IOP-coated membranes were compared for different qualities of water. The variation of TMP and DOC concentration under different conditions are shown in Fig. 2 and 3, respectively. With filtered water, membrane fouling for the two membranes was nearly the same, while with raw water containing colloidal particles the IOP-coated membrane showed higher TMP values during MF. It could be related to the interactions among colloidal particles, NOM, IOP and a membrane. In the presence of colloidal particles in feed water, the IOP layer may be blocked more seriously compared to the bare membrane. In terms of NOM removal, shown in Fig. 3, the IOP-coated membrane always achieved higher removal efficiencies. It could be attributed to the adsorption capacity of NOM on IOP, that is, the desorbed NOM from the  $\text{TiO}_2$  surface during photocatalysis might be adsorbed onto IOP again. For the unmodified system, NOM would pass through the membrane or be adsorbed onto the membrane, resulting in the lower DOC removal efficiency or higher membrane fouling. As the NOM concentration in the raw water was relatively low, it was hard to discriminate the influence of NOM for membrane fouling and NOM removal for the two membranes. Different amounts of humic acid was added to the water to increase the DOC concentration, but colloidal particles were removed by  $0.45\text{-}\mu\text{m}$

prefiltration. Membrane fouling and DOC removal efficiency with different DOC concentrations of 5 mg/L, 8 mg/L, and 11 mg/L for bare and IOP-coated membranes are shown in Fig. 4 and 5. It was obvious that membrane fouling for modified one decreased significantly with the high DOC content, as shown in Fig. 4. For the NOM removal efficiency, the IOP-coated membrane still worked better than the bare membrane, especially at the DOC concentration of 11 mg/L.

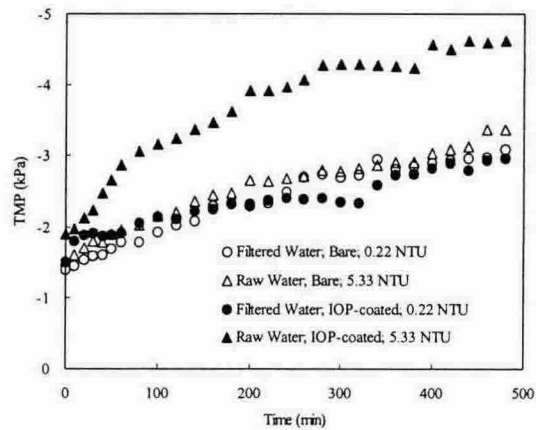


Fig. 2. Variation of TMP with different qualities of water:  $\text{TiO}_2$  dose, 0.5 g/L; flux, 50 LMH.

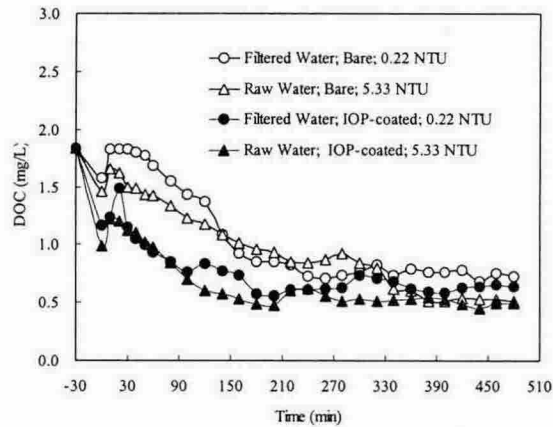


Fig. 3. Variation of DOC removal with different qualities of water:  $\text{TiO}_2$  dose, 0.5 g/L; flux, 50 LMH.

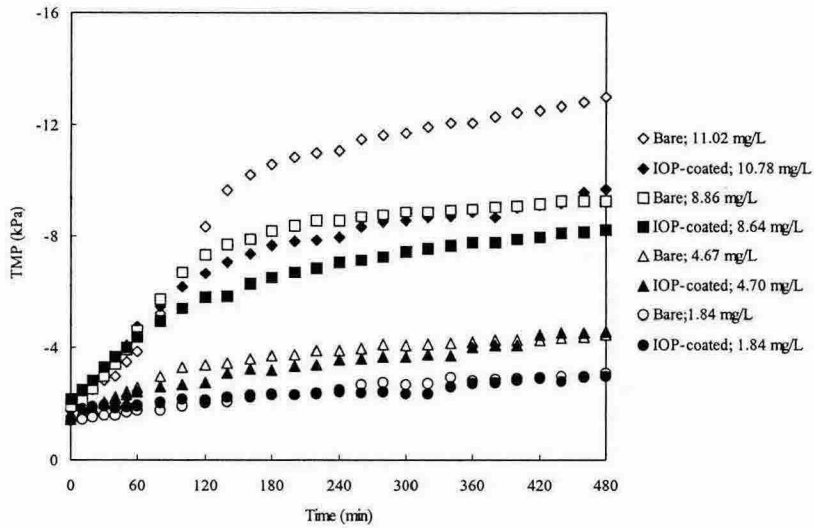


Fig. 4. Variation of TMP with different qualities of water: TiO<sub>2</sub> dose, 0.5 g/L; flux, 50 LMH.

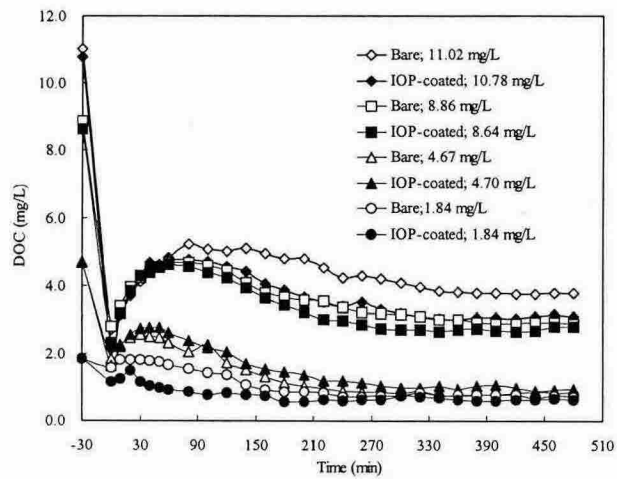


Fig. 5. Variation of DOC with different qualities of water: TiO<sub>2</sub> dose, 0.5 g/L; flux, 50 LMH.

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