# Coupling System of Ag/BiOBr Photocatalysis and Direct Contact Membrane Distillation for Complete Wastewater Purification

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**Abstract:** A novel photocatalysis-membrane reactor (PMR) is designed by coupling Ag/BiOBr visible-light photocatalysis with thermal driven membrane distillation. Ag/BiOBr films could avoid light-shielding effect from color solution. Meanwhile, Ag-modification promotes the photocatalysis process owing to both the plasma effect and electric conductivity. When the PMR is used for treating wastewater containing picrolonic acid (PC), Ag/BiOBr photocatalyst could thoroughly decompose PC into $CO_2$ and inorganic nitrogen species. Membrane distillation could produce high-quality water on the permeate side as the distillate product. Membrane distillation process also promotes photocatalysis by retarding the decrease of PC concentration by transporting water to the other side.

**Keywords:** Photocatalytic membrane reactor (PMR), visible-light Ag/BiOBr photocatalytic film, direct contact membrane distillation (DCMD).

## 1. Introduction

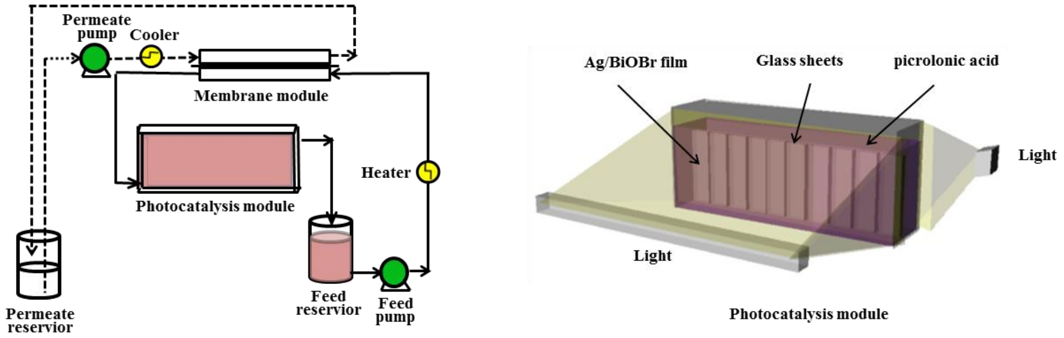
Photocatalysis has been considered as a promising method for wastewater cleaning owing to its advantages of energy-saving and excellent stability.[1] However, photocatalytic degradation of most dye pollutants usually results in inorganic species. Photocatalytic membrane reactor (PMR) that combines photocatalytic degradation with membrane separation could achieve this, and has been an active research topic in recent years.[2] The thermal-driven direct contact membrane distillation (DCMD) could separate organic pollutants and inorganic nitrogen with hydrophobic nature and prevent membrane fouling to achieve the high water flux.[3] However, the synergistic promotion mechanism of photocatalysis and membrane separation during the removal process of organics pollutants had not studied in detail. Herein, we reported a novel PMR by combining photocatalysis approach with Ag/BiOBr film and DCMD process with polytetrafluoroethylene (PTFE) membrane. The Ag/BiOBr films coated on glass substrates could efficiently avoid light-shielding effect from the color solution containing dye-pollutant. Ag/BiOBr exhibited very high activity photocatalytic degradation of picrolonic acid (PC) into $CO_2$ and inorganic nitrogen. The membrane distillation not only acted as a barrier but also produce another pure water stream with high quality. The catalyst film solved the problem of recycling the powder catalysts and the membrane fouling.

## 2. Experimental

Ag/BiOBr film was synthesized according to our previous work [4]. Scheme 1 illustrated the PMR system containing a self-designed rectangular photocatalytic reactor and a DCMD unit. During photocatalysis process, the distillation occurred simultaneously and was driven by temperature-difference in which the permeate stream was controlled at lower temperature ($10 \pm 1.0\ ^{o}C$). The TOC value was measured on a Vario TOC analyzer.

## 3. Results and discussion

Figure 1 showed the removal efficiency of organic pollutant in the PMR. The presence of temperature-difference between two sides of DCMD membrane greatly enhanced the photocatalytic degradation of PC. This could be further confirmed by the phenomena that the PC degradation rate increased gradually with increasing temperature-difference. To explore the role of temperature-difference, we detected the photocatalytic activity of 3.0% Ag/BiOBr in the PC solution with the elevated temperature. Meanwhile, the temperature in pure water side was adjusted to the same as that in the PC solution to avoid the temperature-difference between two sides of DCMD membrane. The TOC value remained constant in the absence of photocatalyst, which clearly demonstrated that the PC degradation mainly occurred through photocatalysis. Both the Ag-nanoparticles on BiOBr and the temperature-difference between two sides of DCMD membrane resulted in the rapid decrease in TOC value, corresponding to the rapid photocatalytic degradation of PC into $CO_2$ owing to their promoting effects as discussed above. No significant TOC value was detected in pure water side. On one hand, the PC could not pass through from wastewater to pure water side during thermal-driven DCMD since the PTFE membrane played the role of selective barrier for the organics and only permitted the water vapor to go through. On the other hand, both the 3.0% Ag/BiOBr and BiOBr photocatalyts exhibited strong oxidation ability, which could rapidly decompose PC into $CO_2$.




(a) (b)

**Scheme 1.** Illustration of (a) PMR and (b) inside photocatalysis module.

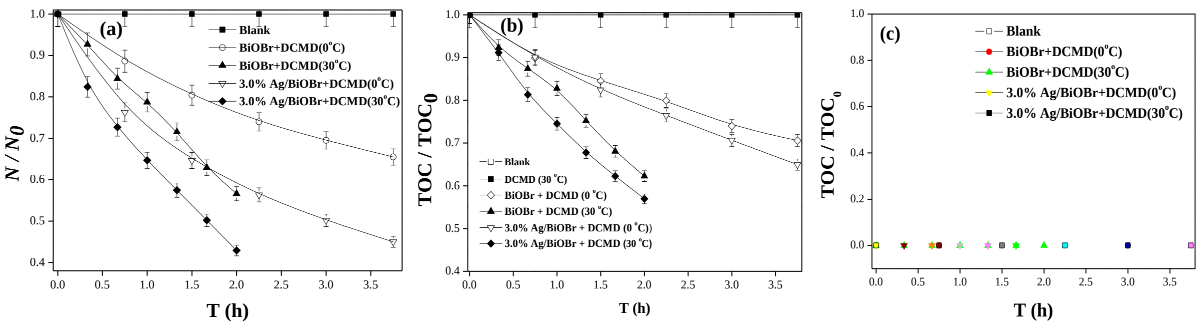



**Figure 1.** (a) Degradation rate of PC and TOC changes (b) during PC degradation and (c) in pure water side in the PMR. Reaction conditions: 25 LED lights (420 nm, 1 W) in each side of the reactor, 550 mL 10 mg/L PC solution, 20 mL/min, temperature of pure water = 10 $^{o}$C, temperature of wastewater was adjusted to achieve the desired temperature-difference comparing that of pure water.

## 4. Conclusions

This work developed a novel PMR by coupling Ag/BiOBr photocatalysis and thermal driven DCMD. The Ag/BiOBr film could decompose PC into $CO_2$ and inorganic nitrogen species under visible light irradiations. The DCMD allowed only water to pass through the PTFE membrane *via* its hydrophobicity. This PMR displayed excellent durability for both photocatalysis and membrane distillation, showing a good potential in complete purification of dye wastewater.

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