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Nanoparticle-assisted composite membrane for the multi-scenario recycling of organic wastewater

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1. Introduction

The rapid population growth and revolutionary industrial advancement leads to severe water crisis, which hinders the development of human beings. Thereby, membrane separation technology has accrued and attracted tremendous attention as an effective method for wastewater recycling. However, the commonly used membrane filtration (including dead-end filtration and cross-flow filtration) and distillation are all supported by electric power. It causes great burden to environment, as the electric is still mainly come from thermal power generated from burning non-renewable resource. Herein, we fabricated a dual-mode 2D lamellar composite membrane, which can not only work in cross-flow filtration mode but also in solar-driven evaporation mode. The combination usage of electric power and solar power can decrease the burden of energy crisis and environment pollution, and makes the fabricated composite membrane prospective in generating clean water from sewages.

2. Experimental

Different amounts of MWCNTs-COOK synthesized from MWCNTs were dispersed in 0.2 wt% chitosan solution and then filtered on the base of PTFE membrane (pore size 0.2 μm, diameter 47 mm) by vacuum filtration method. Afterwards, the membranes were furtherly modified by co-deposition of PDA and PVA, which contains DA self-polymerization and PVA crosslinking. The fabricated membranes before and after co-deposition were denoted as CK_x and PCK_x, respectively, where x refer to the mass of MWCNTs-COOK (multiply by 0.1 mg cm^{-2}).

3. Results and discussion

As shown in Fig.1a and b, the highly entangled and bundled MWCNTs-COOK constructed a porous network, which was wrapped by PDA/PVA after co-deposition and the large pores were obviously minimized. When separation 30ppm dyes of Neutral Red (NR), Methylene Blue (MEB) and Methyl Orange (MO) by cross-flow filtration method, the flux decline ratio (FDR) was greatly decreased and flux recovery ratio (FRR) were improved for the charged dyes MEB and MO, especially the FRR which were all over 85% (Fig.1c). It was associated to the size of these two dyes and the electrostatic interaction (Donnan effect) with CNTs, especially the negatively charged MO with a larger size suffered from higher repulsive force and higher steric hindrance from the conductive surface of membrane, which facilitated a better anti-fouling performance during the separation process. For the solar-driven evaporation mode, the average evaporation rate η of PCK_1 membrane reached 1.57 kg m^{-2} h^{-1} after 1 h solar illumination due to the efficient capillary effect and the temperature-dominated vapor pressure, and it still kept 1.52 kg m^{-2} h^{-1} in the last 2 hours during 12 hours long-term working (Fig.1d). Besides, the high rejection of MO over 99% both in cross-flow filtration and solar-driven evaporation mode exhibited high efficiency of the composite membrane.

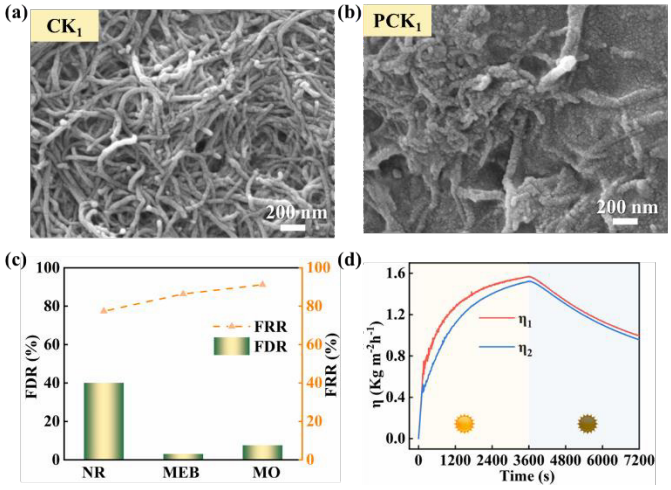

Fig. 1 FESEM images of (a) CK_1 and (b)PCK_1 membranes; (c) FDR and FRR of PCK_1 membrane for different dyes; (d) The average evaporation rate of first 2 hours and last 2 hours during 12 hours long-term working.

4. Conclusion

In summary, a dual-mode functional composite membrane assisted by MWCNTs-COOK and PDA/PVA was successfully fabricated. It exhibited superior water permeability and FRR during fast and short-term cross-flow filtration. Besides, it obtained a high average evaporation rate and excellent stability for long-term solar evaporation. This dual-mode functional design provides a sustainable strategy of hybrid lamellar membranes with cost effective, energy-saving and multiple applications, which is promising for the water shortage crisis.

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