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Development of ZIF-8/Polyacrylonitrile Nanofibrous Membrane for Efficient Coalescence Separation of Oil-in-Water Emulsion

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1. Introduction

Oil-in-water (O/W) emulsions are widely found in industrial wastewater, and effective O/W separation is imperative to meet stringent environmental standards [1]. Coalescence separation represents an energy-efficient approach for the separation and subsequent reutilization of oil from O/W emulsions [2]. Nonetheless, conventional coalescers face challenges in efficiently separating emulsions containing fine oil droplets smaller than 10 μm. To address this limitation, nanofiber membranes have been used for highly efficient separation of emulsified oil droplets. Our research focuses on nanofiber membranes, aiming to develop an emulsion coalescence separation system capable of effectively treating even minute oil droplets of 10 μm or less.

2. Experimental

The polyacrylonitrile (PAN) nanofiber membranes was fabricated by electrospinning method and zeolitic imidazolate framework-8 (ZIF-8) was fabricated on the PAN nanofiber surface through an in-situ growth method. Comprehensive characterization of the ZIF-8/PAN membranes was conducted. To create the O/W emulsion, dodecane was added into ultrapure water and subsequently emulsified using a homogenizer. For the O/W separation experiments, a continuous separation system with steady flow rates was employed to ensure the stable permeation flux. During the experiments, pressure drops and separation ratios were measured at predetermined intervals, allowing for a comprehensive evaluation of the separation performance of the nanofibrous membranes.

3. Results and Discussion

The ZIF-8/PAN membrane was successfully fabricated, and the ZIF-8 particles were distributed on the surface of nanofiber, which was confirmed by scanning electron microscope (SEM) as shown in Fig. 1. The successful synthesize of ZIF-8 was also confirmed by x-ray diffraction (XRD), and x-ray photoelectron spectroscopy (XPS). Subsequently, the separation performance of the ZIF-8/PAN membrane was evaluated for O/W emulsion. With an oil concentration of 1,300 ppm and a flow rate of 120 mL/min (equivalent to a permeation flux of 21,177 L m^{-2} h^{-1}), the continuous separation achieved a steady state. The separation ratio exceeded 99.9%, significantly surpassing previous membrane coalescer. The remarkable separation performance was attributed to its complex pore channel structure and functional ZIF-8 particles, which effectively disrupting the interfacial film of the emulsified oil droplets.

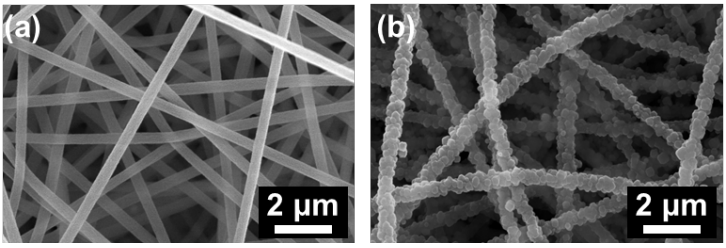

Figure 1 SEM images of (a) PAN, and (b) ZIF-8/PAN nanofibrous membrane

References
1) Liu Y, Lu H, Li Y, Yang Q, et al., *Sci. Total Environ.*, **775**, 145485 (2021).
2) Hu D, Li L, Li Y, Yang C, *Ind. Eng. Chem. Res.*, **55**, 11809–11817 (2016).

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