2023「中技社科技獎學金」
2023 CTCI Foundation Science and Technology Scholarship
境外生研究獎學金
Research Scholarship for Overseas Students

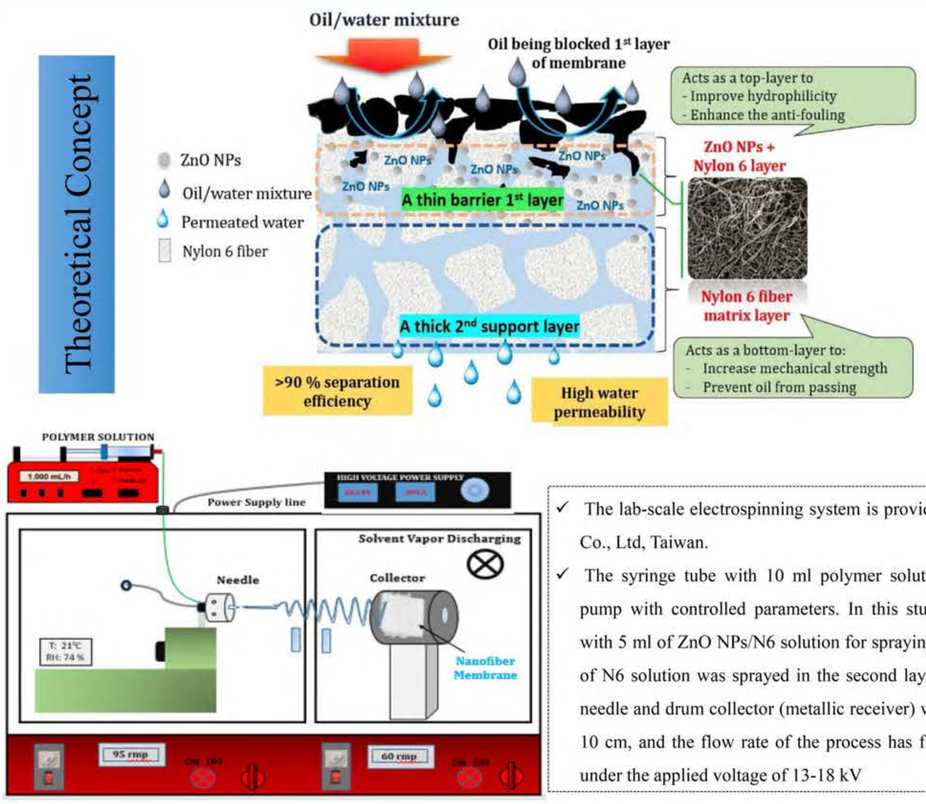
A novel ZnO nanoparticle blended Nylon 6 in double layers membrane for the used engine oil wastewater treatment
新興聚己內酰胺混合氧化鋅奈米顆粒雙層膜用於廢機油廢水處理

3rd year Ph.D. student: Nguyen Thi Xuan Quynh *Advisor: Prof. Shiao-Shing Chen*
Institute of Environmental Engineering and Management, National Taipei University of Technology

Abstract

Separating water from oily wastewater using membranes is a big challenge because of serious membrane fouling and low separation efficiency. So, for the first time, Nylon 6 (N6) membranes blended with ZnO nanoparticles with a N6 support layer by the electrospinning technique were fabricated, where the N6 layer enhanced the mechanical strength and ZnO NPs formed a strong barrier on the N6 membrane to reduce membrane pore-clogging. The micron pore size membranes created by hydrophilic ZnO NPs on electrospun Nylon 6 fiber-matrix structures contributed to the hydrophilicity and fouling resistance of the membranes. The presence of ZnO NPs in the N6 membrane also exhibited excellent anti-fouling properties with the flux recovery ratio of 52.5 % and water flux of 405.6 LMH/bar, which was much better than those of a pristine N6 membrane, indicating the microfiltration membranes developed in this study were reasonably resistant to fouling to ensure high effluent water quality and the fabricated N6/ZnO NPs membrane is feasible in treating oil-containing wastewater.

Theoretical Method



- ✓ The lab-scale electrospinning system is provided by Falco Tech Enterprise Co., Ltd, Taiwan.
- ✓ The syringe tube with 10 ml polymer solution is placed in the syringe pump with controlled parameters. In this study, two layers were formed with 5 ml of ZnO NPs/N6 solution for spraying in the first layer, and 15 ml of N6 solution was sprayed in the second layer. The distance between the needle and drum collector (metallic receiver) wrapped in the steam paper is 10 cm, and the flow rate of the process has fluctuated from 0.5–2.5 mL/h under the applied voltage of 13-18 kV

Fig 1. The lab-scale electrospinning machine

Table 1 . Composition and content of dope solution for the electrospraying.

Membrane type	Abbreviation	N6 w.t%	Formic acid w.t%	ZnO w.t%	HCl w.t%
N6/FA	M0	42	58	-	-
N6/FA/ZnO(5)/HCl	M1	40	45	5	10
N6/FA/ZnO(2.5)/HCl	M2	40	52.5	2.5	5
N6/FA/ZnO(1.25)/HCl	M3	40	53.75	1.25	5
N6/FA/ZnO(0.5)/HCl	M4	40	54.5	0.5	5

Research publications

1. **Thi Xuan Quynh Nguyen***, Shiao-Shing Chen, Hau-Ming Chang, Ngoc Dan Thanh Cao, Randeep Singh "Effects of polyethylene glycol and glutaraldehyde cross-linker on TFC-FO membrane performance". Environmental Technology & Innovation, 2020, 10105.

2. **Nguyen, Thi Xuan Quynh*,** Shiao-Shing Chen, M. Pasawan, Huy Quang Le, Hau-Ming Chang, and Nguyen Cong Nguyen. "Separation of used automobile oil/water mixture by Nylon 6/ZnO nanoparticles electrospun membrane." Separation and Purification Technology (2022): 121578.)

3**. Thi Xuan Quynh Nguyen*,** Shiao-Shing Chen, M Pasawan, Hau-Ming Chang. Enhanced photocatalytic activity of g-C3N4–n-p type flower-like ZnO/BiOBr heterojunction for hexavalent chromium and dye wastewater degradation. Environmental Technology & Innovation, 31, 103154. (2023)

Results

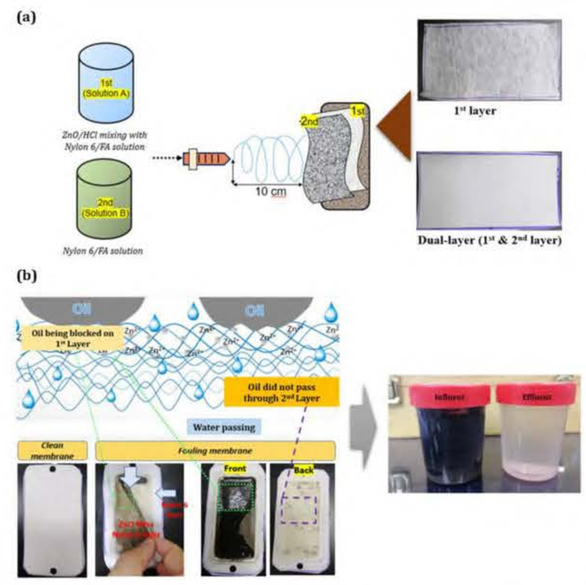
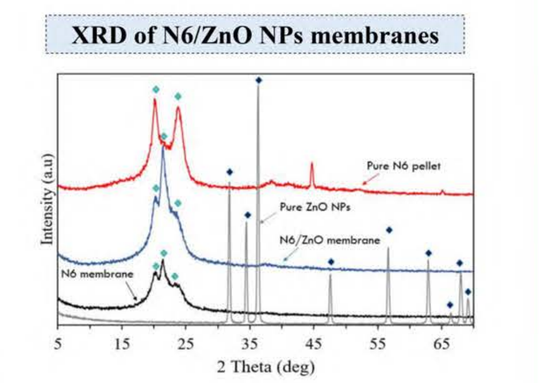
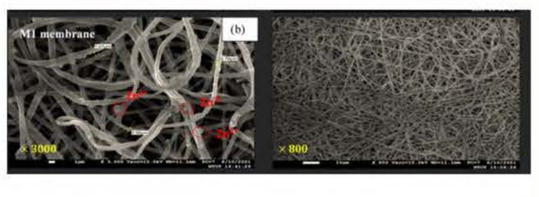


Fig. 2. (a) The N6 dual-layer membrane blended with ZnO NPs was synthesized by the electrospinning technique (b) Schematics showing the anti-fouling mechanism of N6 membrane with the addition of ZnO NPs and permeated water quality with using M2 membrane.





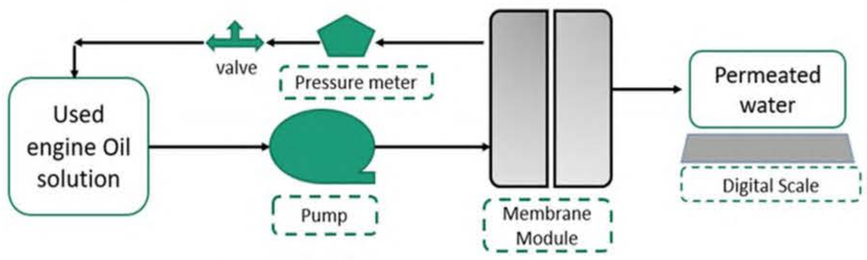


Fig.3 . Schematic of the cross-flow microfiltration system in oil/water separation.

Table 2 : The effluent quality of different membrane types when using influent as 2.5% v/v oil and parameter limits of effluent of environmental quality from the industries, 2019

Parameter	Influent 2.5% v/v oil	Effluent					Limits of effluent
		M0	M1	M2	M3	M4	
Oil and grease (mg/L)	1183.244	48.75	113	90	102	105	10
COD (mg/L)	9570	282	69	50	125	102	100
TSS (mg/L)	11680	1120	840	710	300	240	118-310
Turbidity (NTU)	1183	179	4.78	2.29	1.92	0.54	265-749

The result

Compared to the N6 membrane, modified N6/ZnO NPs membranes exhibited excellent separation efficiency in terms of the permeated flux and effluent water quality after the microfiltration process. The study discovered that the distribution of ZnO NPs in the N6 structure increased the permeated flux by creating a strong barrier layer that reduced membrane fouling on the N6 membranes. Our results indicated that the N6 membrane with 2.5 w.t% ZnO NPs exhibited the optimum separation performance. The optimized M2 membrane in this empirical work was accomplished with 215.14 LMH/bar specific flux after 3 hours separation using 0.1% v/v oil concentration of influent wastewater.