Stability enhanced MXene/polysulfone composite nanofiber membranes for oil-water separation


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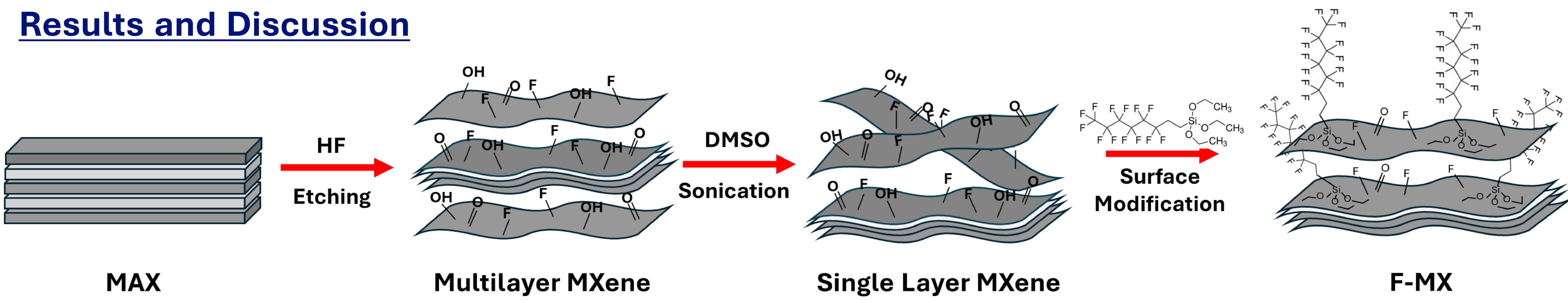
Introduction and Objective

The growing environmental concerns and water pollution have accelerated the need for effective oil–water separation. MXenes (MXs), as promising 2D materials, offer high surface area, tunable nanochannels, and ease of functionalization, making them suitable for nanofiber membrane development[1]. MX-based nanocomposite membranes exhibit high separation efficiency, enhanced mechanical strength, and chemical resistance; however, their hydrophilicity and low stability limit practical applications[1,2]. This study aims to enhance the hydrophobicity of MXene through fluorinated alkyl silane surface modification, confirmed by SEM-EDX, XRD, and zeta potential analyses. F-MX/polysulfone nanofiber membranes were fabricated using the electro-blow spinning method under optimized conditions[3]. Their oil–water separation performance was evaluated using various oils.

Results and Discussion



Scheme 1. Schematic representation of MXene synthesis from Ti_3AlC_2 and surface modification with fluorinated silane.

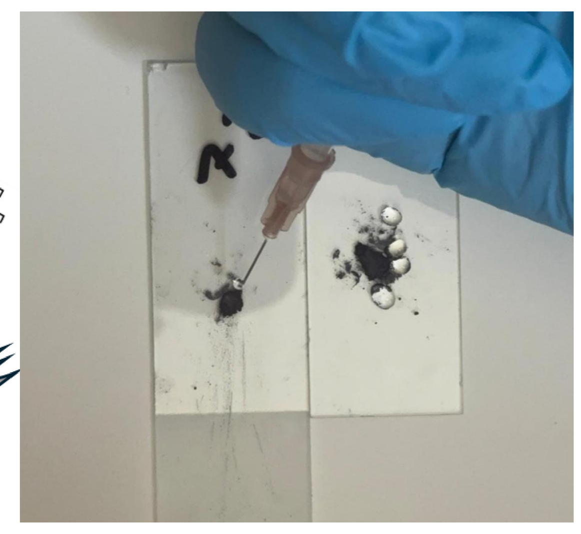
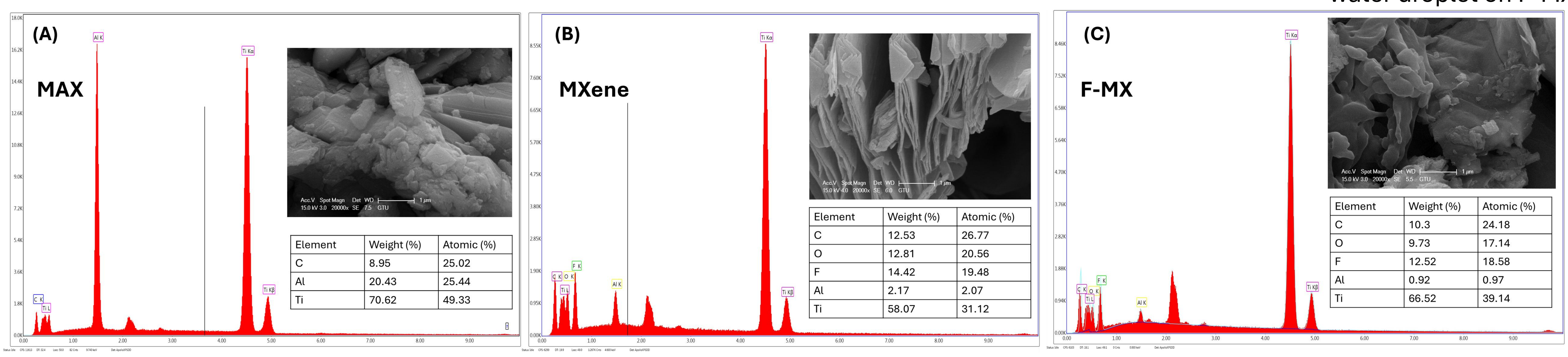


Figure 1. Roll-off of water droplet on F-MX.

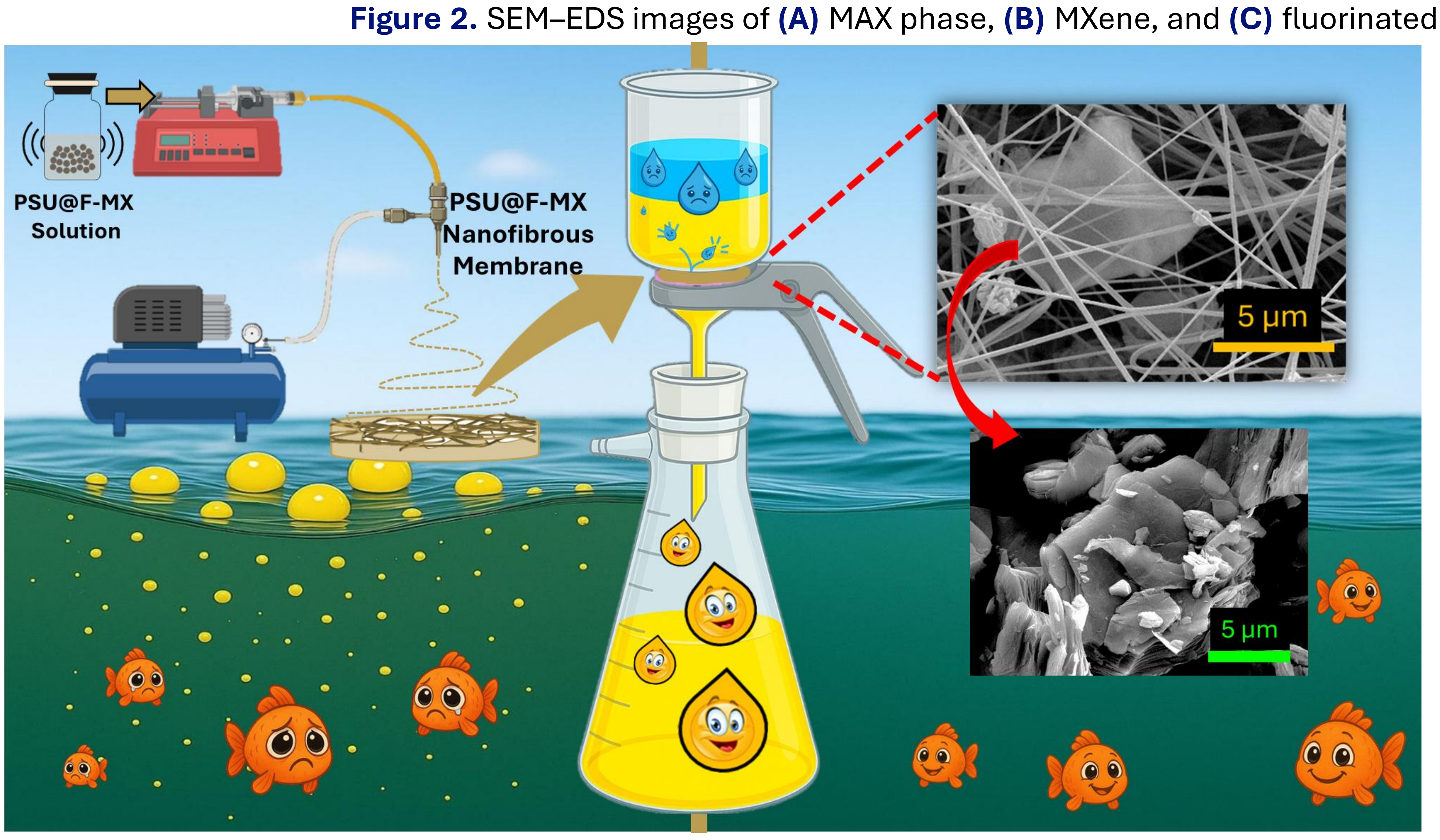


Element	Weight (%)	Atomic (%)
C	8.95	25.02
Al	20.43	25.44
Ti	70.62	49.33

Element	Weight (%)	Atomic (%)
C	12.53	26.77
O	12.81	20.56
F	14.42	19.48
Al	2.17	2.07
Ti	58.07	31.12

Element	Weight (%)	Atomic (%)
C	10.3	24.18
O	9.73	17.14
F	12.52	18.58
Al	0.92	0.97
Ti	66.52	39.14

Figure 2. SEM–EDS images of **(A)** MAX phase, **(B)** MXene, and **(C)** fluorinated MXene (F-MX).



Scheme 2. Overview of electro-blown membrane production, internal MXene layer integration, and symbolic visualization of oil–water separation efficiency through polluted and clean aquatic environments.

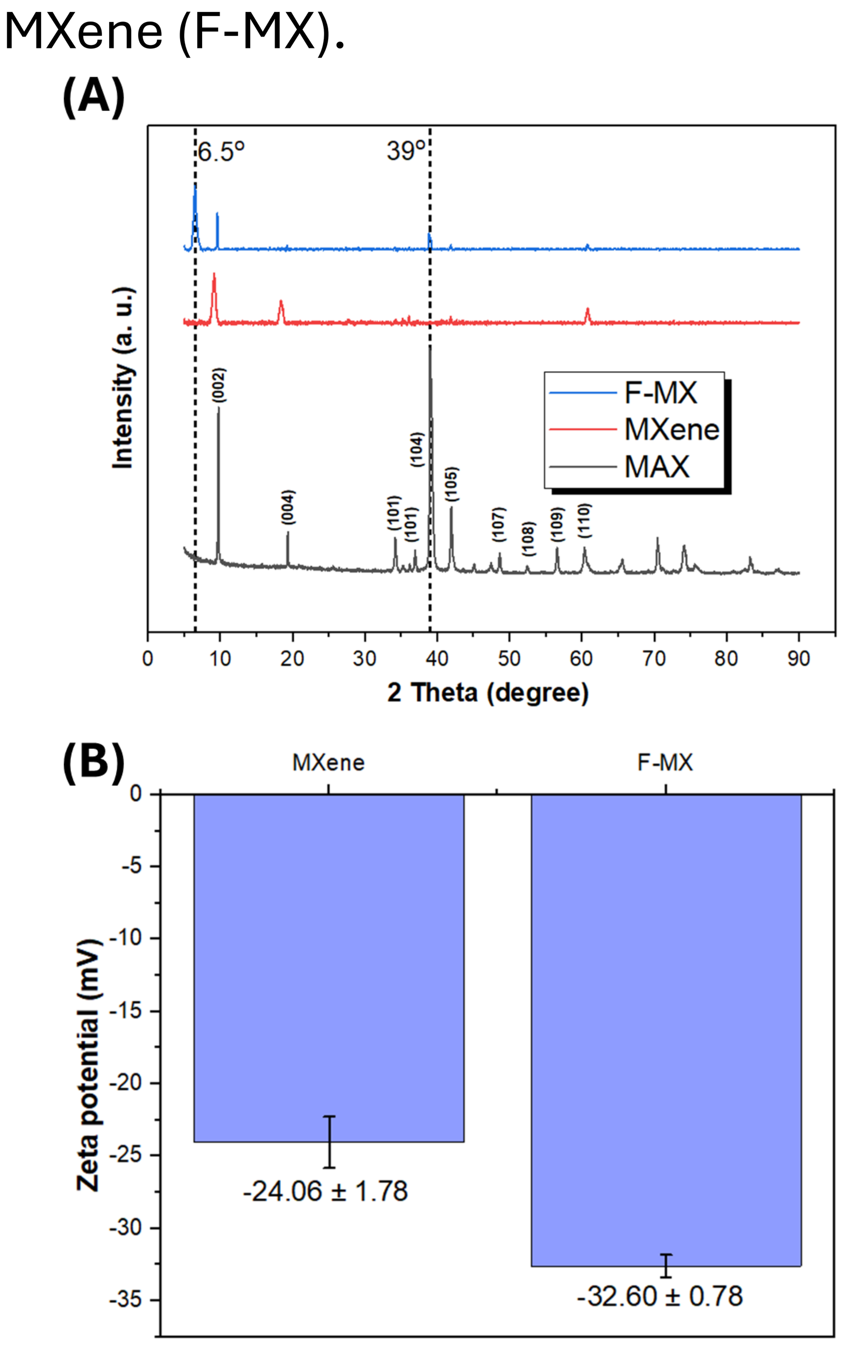


Figure 3. (A) XRD patterns of MAX, MXene, and F-MX; **(B)** Zeta potential values of MXene and F-MX.

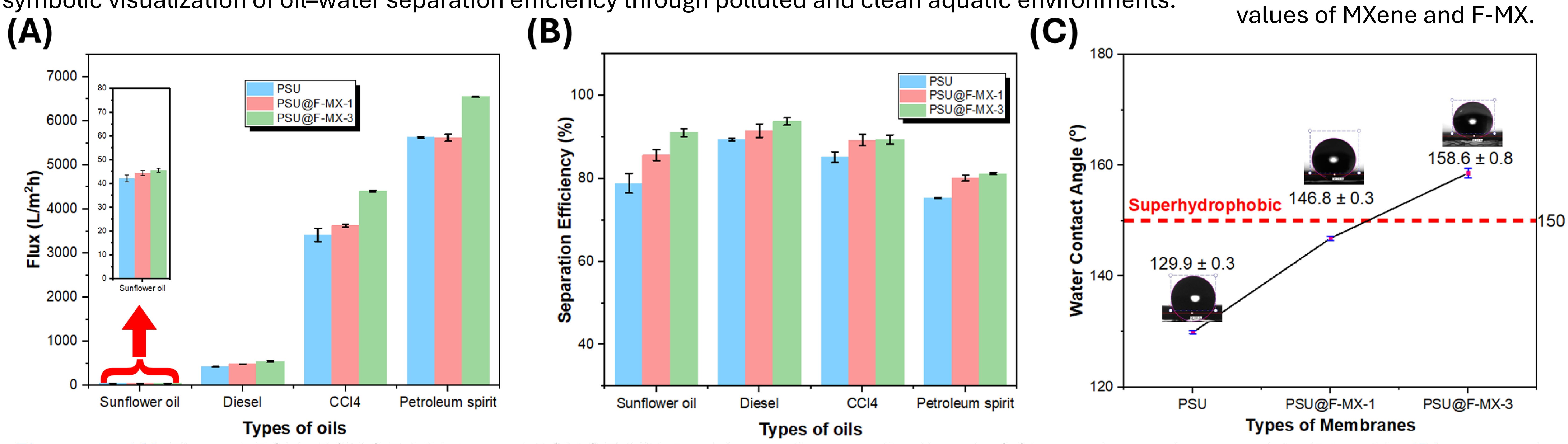


Figure 4. (A) Flux of PSU, PSU@F-MX-1, and PSU@F-MX-3 with sunflower oil, diesel, CCl_4, and petroleum spirit (20 mL); **(B)** separation efficiency with 9:1 oil-water mixtures; **(C)** water contact angles of the membranes.

Conclusions

- Fluorinated MXene (F-MX) was effectively incorporated into the PSU membranes, improving surface hydrophobicity with a water contact angle of 158.6° ± 0.8°.
- The results highlight the potential of F-MX/PSU nanofibrous membranes for practical and sustainable oil–water separation applications.
- Future studies may explore membrane performance under different conditions (acidic, basic, saline, or real wastewater) and with varying F-MX loadings.

Acknowledgments

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References

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