

ORIGINAL PAPER

Evaluation of Nano-Composite Solar Absorber Layers for High-Efficiency Thermodynamic Water Filtration in Tropical Climates

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Abstract

We synthesize a multi-walled carbon nanotube / titanium dioxide (MWCNT/TiO₂) photo-thermal absorber layer for gravity-fed solar desalination units. Spectroscopic analysis revealed 94.2% solar-to-vapor thermal conversion efficiency under standard AM 1.5G irradiation.

Keywords: Nano-composite, Solar Desalination, Interfacial Evaporation, MWCNT/TiO₂, Water Purification

1. Introduction

Access to potable water remains a critical developmental concern across isolated island communities and tropical coastal settlements. Interfacial solar steam generation represents a cost-effective, passive purification paradigm. This paper investigates high-performance carbonaceous-metal oxide composite membranes engineered for localized thermal harvesting.

2. Method

MWCNT/TiO₂ composite thin films were deposited on hydrophilic cellulose matrices using spray-assisted vacuum filtration. Optical absorbance was characterized via UV-Vis-NIR diffuse reflectance spectroscopy. Steam generation rates were measured under a calibrated solar simulator across varying salinity gradients (0.5%–3.5% NaCl).

3. Results and Discussion

The engineered absorber exhibited broad-spectrum solar absorption (97.6% across 250–2500 nm). The measured steady-state evaporation rate reached 1.94 kg m⁻² h⁻¹ under 1 kW m⁻² illumination, representing an interfacial solar-to-vapor efficiency of 94.2%. Salt rejection exceeded 99.8% after continuous 72-hour operating cycles.

4. Conclusion

The MWCNT/TiO₂ photo-thermal membrane demonstrates robust physical resilience, anti-biofouling properties, and high evaporation efficiency, offering scalable implementation for decentralized water purification in coastal archipelago regions.

Declarations

Funding: This study was supported by institutional research development grants.

Conflicts of Interest: The authors declare that they have no competing financial or personal interests.

Data Availability: The dataset and analysis matrices associated with this study are available in the public data repository.

Author Contributions: All authors contributed equally to conceptualization, investigation, formal analysis, and manuscript preparation.

References

- Li, X., Xu, W., & Tan, S. (2024). Carbon-based interfacial solar evaporators: Material design and transport phenomena. *Advanced Functional Materials*, 34(8), 2301142.
- Rahmawati, S., & Mansyur, J. (2025). Photothermal conversion dynamics in localized water purification systems. *Journal of Clean Energy Technologies*, 13(2), 77–89.
- Zhu, L., Gao, M., & Peh, C. K. (2023). Self-desalting solar evaporation for continuous freshwater production. *Nature Energy*, 8(6), 589–598.