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Hybrid Photocatalytic Ultrafiltration Membranes: A Scalable Solution for CEC Removal

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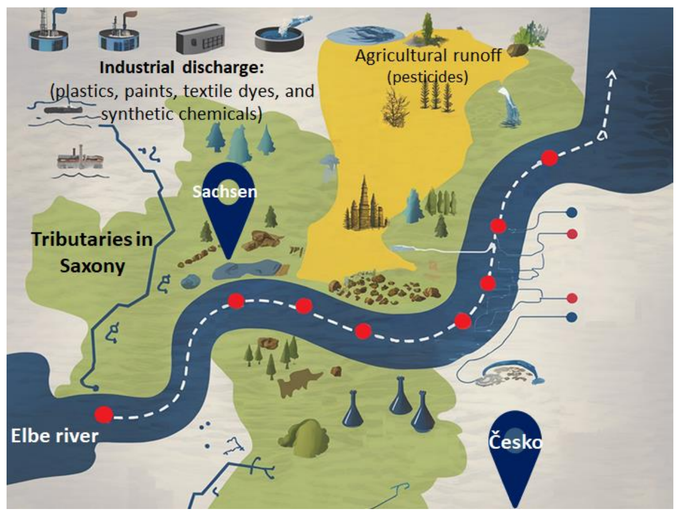
INTRODUCTION & AIM

Aim

- Develop photocatalytic PES ultrafiltration membranes incorporating BiOI and BiOI-ZnO NPs.
- Optimization of the NIPS technique for the highest photocatalytic activity.
- Simultaneous physical filtration and visible light-driven degradation of CECs.
- Provide a scalable, energy-efficient quaternary treatment solution with antimicrobial activity.

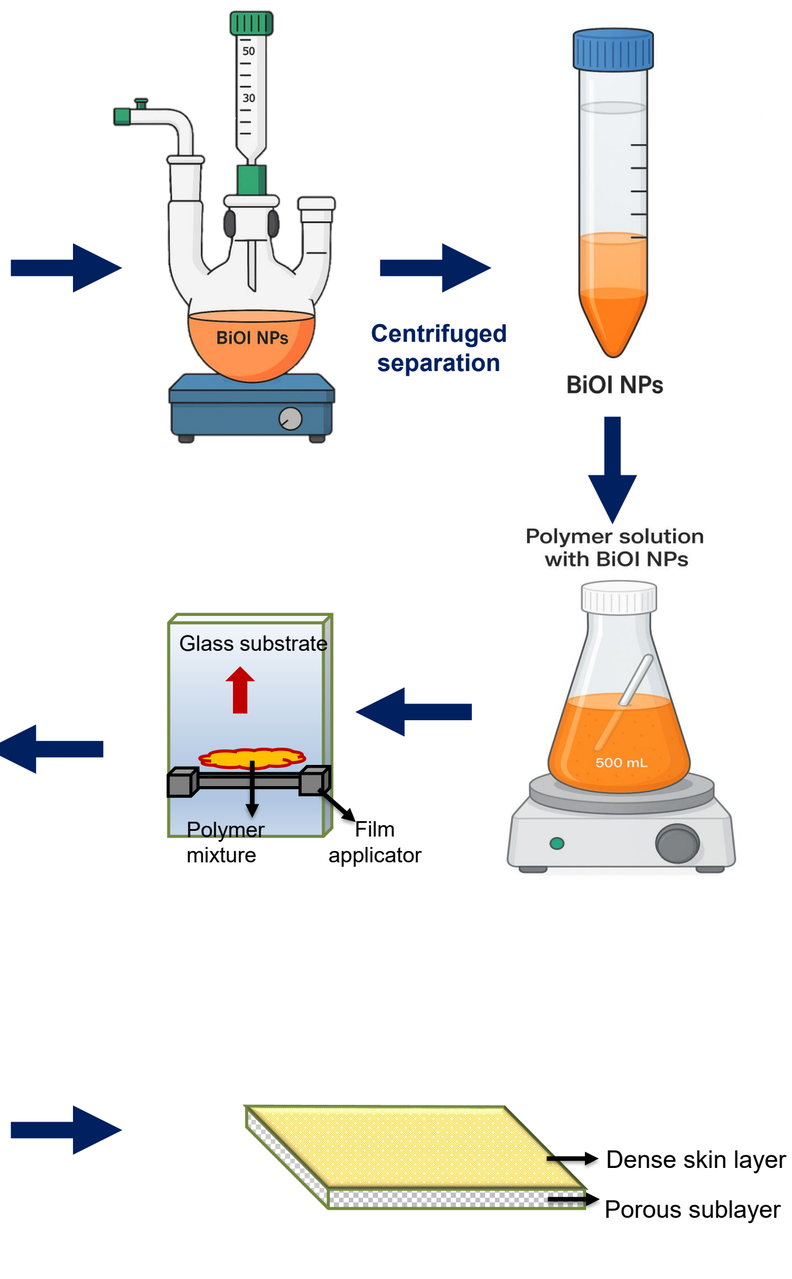
Introduction

- CECs (e.g., pharmaceuticals, dyes, plasticizers) persist in stream water and wastewater in the region due to limitations of conventional treatment.
- Czechia faces notable CEC pollution from textile dyeing and plastics industries, including BPA and RB.
- Hybrid photocatalytic membranes offer a dual function: separation and visible-light-driven degradation of pollutants.
- Such systems enhance contaminant removal and antifouling, supporting sustainable wastewater treatment.



METHOD

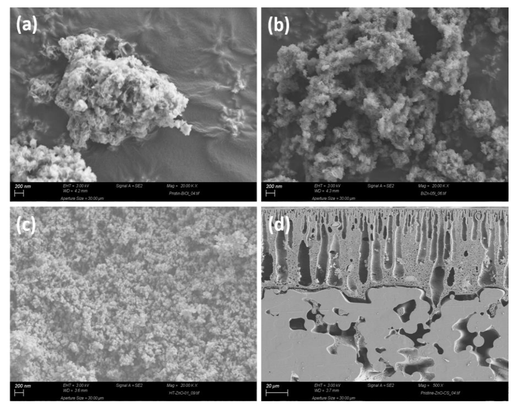
- **Nanoparticle synthesis:** BiOI and BiOI–ZnO NPs prepared via hydro-solvothermal method.
- **Membrane fabrication**: PES flat-sheet nanocomposite membranes produced using NIPS.
- **Characterization:** Structural and surface properties analyzed by SEM, EDX, AFM, and WCA.
- **Performance evaluation:** Photocatalytic degradation of BPA and RB tested under visible light; flux recovery and antimicrobial activity assessed.



RESULTS & DISCUSSION

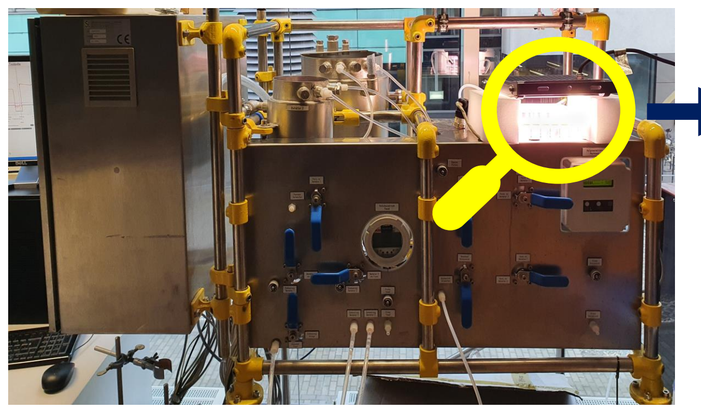
SEM

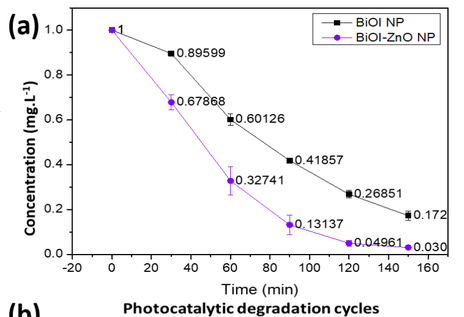
- SEM confirmed the successful synthesis and uniform incorporation of BiOI and BiOI–ZnO NPs within the membrane matrix.
- All fabricated membranes exhibited a characteristic asymmetric structure with only minor differences.
- Even at higher NP loadings, the overall membrane morphology and pore structure remained largely unaffected.

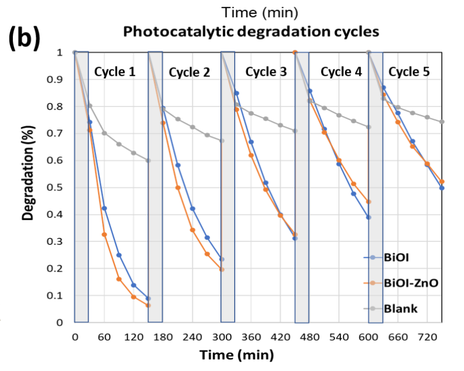


Photocatalytic Performance

- Suspended BiOI and BiOI-ZnO NPs achieved 83% and 97% BPA degradation, respectively, within 2.5 h under visible LED irradiation.
- NP-modified membranes exhibited strong photocatalytic performance, removing 91.1% (BiOI) and 93.7% (BiOI-ZnO) of BPA during the first cycle.
- Submerged membranes retained more than 50% of their initial degradation efficiency after five reuse cycles, demonstrating good stability and reusability.

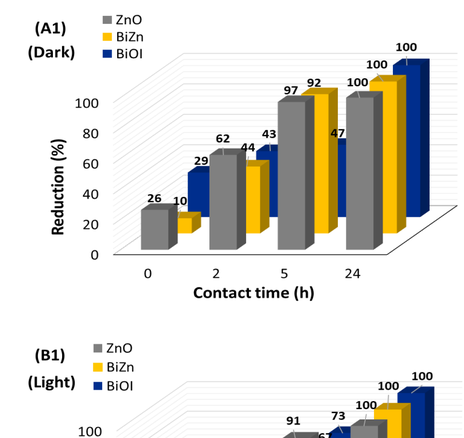


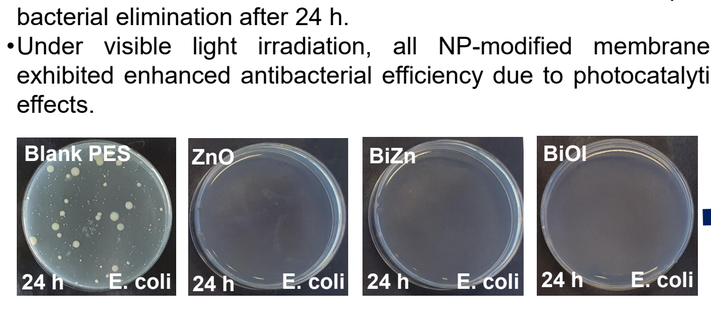


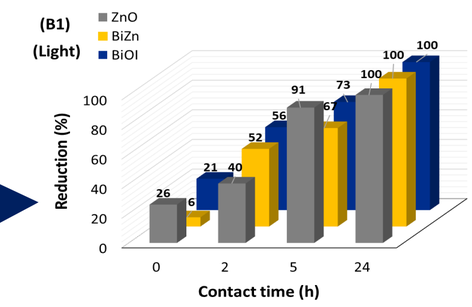


Antibacterial

- Antimicrobial activity was assessed using dynamic contact tests against E. coli on pristine & NP-modified PES membranes.
- Pristine PES membranes showed no antibacterial effect, while BiOI, BiZn, and ZnO-modified membranes demonstrated significant antimicrobial activity, even in dark conditions.
- BiOI-modified membranes achieved 47% bacterial reduction after 5 h and 100% reduction after 24 h in dark conditions.
- BiZn and ZnO-modified membranes also reached complete bacterial elimination after 24 h.
- Under visible light irradiation, all NP-modified membranes exhibited enhanced antibacterial efficiency due to photocatalytic effects.







CONCLUSION

Photocatalytic Performance

- The integration of BiOI and BiOI-ZnO NPs into PES membranes was successfully achieved.
- Both suspended and membrane-embedded NPs demonstrated strong photocatalytic activity for BPA degradation under visible light, with BiOI-ZnO showing superior efficiency.
- The membranes maintained more than 50% of their initial activity after five reuse cycles, confirming their potential for sustainable CEC removal in submerged treatment systems.

ACKNOWLEDGEMENT

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