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Development of PCL/PEG/TIO_2 Composite Membranes for Mitigation of Harmful Algal Blooms: A Preliminary Insight

[Pembangunan Membran Komposit PCL/PEG/TIO_2 untuk Mitigasi Ledakan Alga Berbahaya: Suatu Pandangan Awal]

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Abstract

Harmful algal blooms (HABs) have emerged as a significant environmental issue, threatening aquatic biodiversity, human health, and economic stability. Conventional mitigation methods, such as chemical, physical, and biological treatments, present several drawbacks, including secondary pollutants and ecological disruption. Photocatalytic degradation using titanium dioxide (TiO_2) nanoparticles offers a promising alternative due to its oxidative capability and stability. However, TiO_2 nanoparticles often agglomerate, reducing effectiveness and complicating recovery. To overcome this, immobilizing TiO_2 nanoparticles onto polymeric supports has gained attention. In response to these challenges, this study developed a novel composite membrane by immobilizing

TiO_2 nanoparticles onto a biodegradable polymeric matrix composed of polycaprolactone (PCL) blended with polyethylene glycol (PEG). The composite membranes were fabricated using a modified phase inversion method, and different molecular weights of PCL were evaluated to identify the optimal formulation. The results demonstrated that incorporating PEG significantly improved membrane hydrophilicity, surface porosity, and overall functional performance, enabling effective interaction with algal cells. FTIR analysis confirmed the successful integration of TiO_2 and PEG, maintaining structural integrity. TGA indicated enhanced thermal stability with increasing TiO_2 content, highlighting the contribution of inorganic filler to improved thermal resistance. The optimized PCL/PEG/TiO_2 composite membrane formulation (1:0.2:0.2 ratio) exhibited superior mechanical stability and maintained structural coherence during application. This novel approach provides an environmentally sustainable and efficient solution for HAB management in eutrophic water bodies. © 2026, Penerbit Universiti Kebangsaan Malaysia. All rights reserved.

Author keywords

Harmful algal bloom; polycapolactone; polyethylene glycol; titanium dioxide

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