Surface-Localised Photosensitizer Nanocomposite Hydrogels for Photodynamic Inactivation

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An escalation in antimicrobial drug resistance among pathogens has driven the need to develop alternative treatment methods. Photodynamic inactivation (PDI) is a promising antibiotic-free antimicrobial strategy. Hydrogels have proven their effectiveness as delivery systems for photosensitizers (PS) in antimicrobial PDI. Despite increasing interest, PS-loaded hydrogels encounter several challenges, including limited light penetration, issues with solubility, stability, and bioactivity of many PS under physiological conditions [1]. Moreover, achieving a uniform distribution of photosensitiser (PS) molecules within hydrogels remains a significant challenge during fabrication. Smectites are low-cost, eco-friendly inorganic hosts that have proven to be effective for many photosensitisers (PS) molecules, preserving their fluorescence and photoactivity, improving dye stability, and reducing photodegradation [2]. This study intercalated the photosensitiser phloxine B (PhB) into organically modified synthetic saponite (Sap) with different surfactants as the primary host material. Thin films with a thickness in the micrometre range were subsequently prepared using vacuum filtration. The hydrogel precursor, composed of dissolved poly(vinyl alcohol) (PVA) and glycerol as a crosslinker, was cast onto the freshly prepared film placed in a mould to partially penetrate and swell the organoclay layer. A thin nanocomposite film on the surface of the hydrogel was formed during the crosslinking process, forming surface-functionalised hydrogel [3]. This approach offers greater precision in PS loading and distribution than bulk incorporation, concentrating the active substance at the surface. Absorption and luminescence spectroscopy revealed a direct relationship between PhB loading and absorbance, and an inverse relationship with fluorescence intensity, indicating concentration quenching and molecular aggregation. X-ray diffraction confirmed structural changes upon PhB intercalation and nanocomposite formation, while infrared spectroscopy verified the presence of the components in the composites without significant chemical alteration. This novel approach involving surface-modified hydrogels enables controlled PS loading and distribution through a simple fabrication process, potentially advancing the therapeutic effectiveness of PDI-based hydrogels.

References:

[1] Liu, Shunying, et al. (2024) *Wound Repair and Regeneration* 32.3, 301-313

[2] Bujdák, J. (2018) *Journal of Photochemistry and Photobiology C: Photochemistry Reviews 35*, 108-133.

[3] Skoura, E. et al. (2023) *Applied Clay Science*, *242*, 107037.

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