PHOTOACTIVE HYDROGEL-BASED THERAPY FOR BIOFILM DISRUPTION IN CHRONIC WOUND INFECTIONS

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Chronic wound infections are a major healthcare challenge due to the persistence of biofilms formed by multidrug-resistant pathogens. Conventional treatments often fail due to the protective nature of biofilms, necessitating innovative therapeutic approaches. This study presents a novel methylene blue (MB)-loaded photoactive hydrogel (HG1MB1) designed for antimicrobial photodynamic therapy (aPDT) to enhance biofilm eradication. The hydrogel's gel-like structure improves MB penetration into biofilms, allowing enhanced interaction with extracellular polymeric substances (EPS) and promoting biofilm disruption. Upon light activation, HG1MB1 generates reactive oxygen species (ROS), leading to oxidative damage and microbial inactivation.

We evaluated HG1MB1 against Candida albicans, Pseudomonas aeruginosa, and Staphylococcus aureus biofilms. Results demonstrated significant biofilm reduction following aPDT, with log reductions of 3.42, 4.97, and 5.42 for C. albicans, P. aeruginosa, and S. aureus, respectively ($p < 0.0001$). EPS reduction reached up to 72%, correlating with increased ROS generation and enhanced oxidative stress within biofilms. Notably, fibroblast viability remained unaffected, confirming the hydrogel's biocompatibility.

This study highlights HG1MB1 as a promising alternative to conventional treatments, offering a targeted, safe, and effective strategy for biofilm-related infections. By overcoming biofilm resistance mechanisms, this photoactive hydrogel has the potential to improve chronic wound management and reduce reliance on traditional antimicrobials.

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