The Role of Singlet Oxygen Generation from Photodynamic Hydrogels in Infection Control

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Background:

Photodynamic therapy has been used in combination with photosensitisers (PS), light, and oxygen which cause damage to target cells. When the photosensitiser is exposed to the light, it will convert to a singlet excited state ($^1PS^*$), which is transformed by intersystem crossing to the excited triplet state ($^3PS^*$), which reacts with oxygen species (O_2) to produce singlet oxygen ($^1O_2$), a highly reactive oxygen species (ROS). Using light-triggered therapy to treat infectious diseases is called photodynamic antimicrobial therapy (PACT). PACT has been widely shown to have a lethal effect against bacteria, fungi, viruses, and parasites and its impact on different biofilms. PACT has been considered a potential alternative to conventional antimicrobial therapy with a low risk of developing microbial resistance. This study aimed to load a cationic photosensitiser on the surface of the copolymer, capable of reducing the adherence % of bacteria on the material's surface. Cationic photosensitiser have antimicrobial properties that damage the bacterial membrane upon contact. TMPyP is the photosensitiser attached to the copolymer surface with a low amount of leaching from the material to produce singlet oxygen when illuminated by the proper light.

Methods:

Crosslinked copolymers of 90% 2-hydroxyethyl methacrylate (HEMA) and 10% methyl methacrylate (MMA) were synthesized via free radical polymerization and tetrakis(4-N-methylpyridyl) porphyrin) TMPyP) was incorporated onto the surface. photosensitizer loading and the equilibrium water content (EWC) of copolymers were established. TMPyP loading into copolymer was qualitatively and quantitively assessed using Fourier Transform Infrared spectroscopy (FTIR), UV-visible analysis and digital optical microscopic analysis. A white LED array was used as an illumination source to activate the photosensitizer. Microbiological assessments were performed to assess the adherence (%) of *S. aureus* and *E. coli* to the copolymer surface after 120 min of illumination using a white LED array source providing a power of 5.33 mW/cm², integrated between 450-700 nm.

Results:

TMPyP-incorporated copolymers exhibited higher efficacy (23.6±8.4%) against Gram-positive *Staphylococcus aureus* than Gram-negative *Escherichia coli* (94.9±3.15%) after 120 minutes of illumination using white LED array.

Conclusions:

The potential benefits from light-triggered biomaterial were confirmed on *S. aureus.* This material had a higher photosensitiser loading on the surface of p(HEMA-*co*-MMA), rather than penetrating into the inner portion of the copolymer, this surface localisation of TMPyP increased the antimicrobial effect of a photosensitiser. This material can be used in medical devices or as a coating for a device with desirable mechanical properties. This suggests that the TMPyP-incorporated materials could have good persistence of action against bacterial adherence.