VIDEO ARTICLE

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Antimicrobial Materials for Infection Prevention in Hospital Environments

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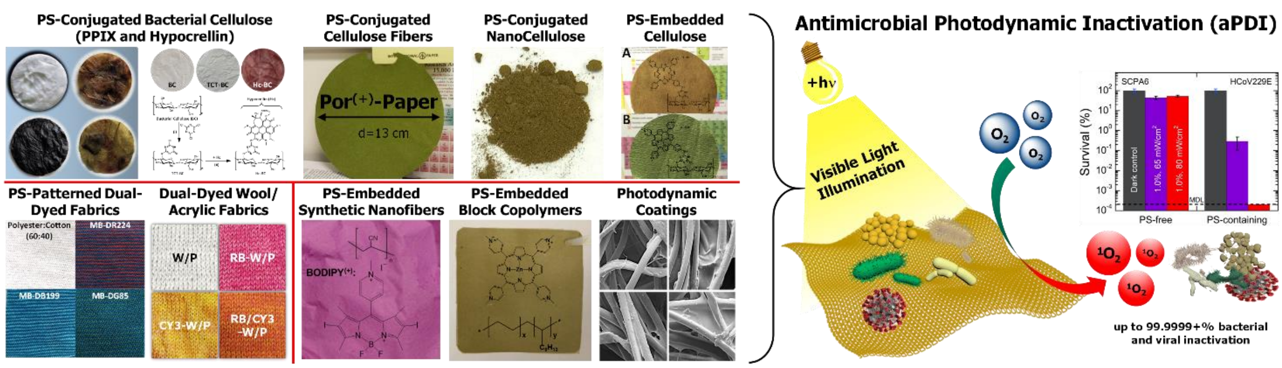
Graphical Abstract



Photosensitizer-modified materials are capable of the visible-light promoted inactivation of a broad range of pathogens, including drug-resistant bacteria as well as enveloped and non-enveloped viruses, by up to 99.9999%, yet themselves are harmless to the user and can be made from sustainable and environmentally friendly materials.

Abstract

Efforts to control hospital acquired infections (HAIs) have been hampered by the emergence of drug-resistant pathogens, necessitating the pursuit of advanced functional materials that are capable of the self-disinfection of such microbes in hospital environments. To that end, we have explored the feasibility of antimicrobial photodynamic inactivation (aPDI) of bacteria and viruses using photodynamic materials. *In vitro* aPDI studies employing photosensitizer-embedded or conjugated nanofibrillated cellulose, **[1]** polyacrylonitrile or nylon nanofibers, **[2]** dual-dyed wool/acrylic blended fibers, **[3]** olefinic block copolymers **[4]** and spray coatings **[5]** were performed against bacteria and viruses. Pathogens were cultured, deposited onto the materials, and subsequently illuminated with visible light (400–700 nm, 65-80 mW/cm^2, 5-60 min), and their survivability was determined via colony counting or plaque assay methods. For natural polymer scaffolds, cellulose-porphyrin conjugates (either as nanocrystals, nanofibers, or paper sheets) were found to be highly effective against a broad spectrum of pathogens: our best results demonstrated that *S. aureus*, *A. baumannii*, *P. aeruginosa* and *K. pneumoniae* all exhibited photodynamic inactivation by 99.99+%,

as well as inactivation of dengue-1 virus (>99.995%), influenza A (~99.5%), and human adenovirus-5 (~99%). As an alternative strategy, non-covalent approaches to photodynamic materials using artificial polymers were also explored: i) using electrospinning, cationic porphyrin and BODIPY photosensitizers were embedded into polyacrylonitrile and nylon nanofibers, and the resultant nonwoven materials possessed both antibacterial and antiviral activities; ii) using melt-pressing, we developed a photosensitizer-embedded olefinic block copolymer that exhibited excellent antimicrobial properties against a range of microbes, including Gram-positive and Gram-negative drug-resistant bacteria, as well as against enveloped and non-enveloped viruses. Most recently, we have explored photodynamic coatings on polymer microfibers for pathogen inactivation and have demonstrated population reductions of >99.9999 and 99.6% for *S. aureus* and antibiotic-resistant *E. coli*, respectively, after exposure to visible light for 1 h. In response to the current COVID-19 pandemic, we also confirmed that these coated fibers can inactivate a human common cold coronavirus serving as a surrogate for the SARS-CoV-2 virus. Together, these results demonstrate that photodynamic materials may have widespread applicability for non-specific pathogen disinfection, and further research may lead to their application in hospitals and healthcare-related industries where novel materials with the capability of reducing the rates of transmission of a wide range of bacteria, viruses, and fungi, particularly of antibiotic resistant strains, are desired.
Keywords: Antimicrobial; bacteria; hospital-acquired infections; photodynamic inactivation; viruses.

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