DESIGN OF LIGHT-ACTIVATED BIOACTIVE NANOSCALE MATERIALS

by

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ABSTRACT

Light-activated generation of reactive oxygen species (ROS) is being actively researched as a method to target pathogens in Photodynamic Therapy (PDT). In my thesis work, we have explored the use of light for the degradation of various pathogens as well as for the manipulation of protein function at the cellular level. We have designed antimicrobial nanocomposites by conjugating multi-walled carbon nanotubes (MWNTs) and Protoporphyrin IX (PPIX) that are highly effective against *Staphylococcus aureus* and Influenza A virus upon irradiation with visible light. *S. aureus* infections can lead to life-threatening situations, especially when caused by antibiotic-resistant strains. Influenza spreads around the world in seasonal epidemics, resulting in thousands of deaths every year, up to millions in some pandemic years. While porphyrins like PPIX are known to be potent biocidal agent (due to the generation of ROS in the presence of light), we decided to use carbon nanotubes as scaffolds because of their ease of recovery from a solution through simple filtration, and their ability to form large area coatings.

We found that MWNT-PPIX was effective against *S. aureus* and Influenza virus at very low concentrations and within a very short duration of time. We demonstrated the fabrication of large area films using MWNT-PPIX which showed potent bactericidal activity. We also demonstrated that MWNT-PPIX can be recoverd from an aqueous solution and reused atleast three times before it starts losing activity partially. This work provides a facile approach to incorporate porphyrins into coatings and make them re-usable which may lead to their more widespread use as antibacterial and antiviral agents/coatings.

Extending the use of ROS for pathogen decontamination, we developed porphyrin based formulations to target *Bacillus* spores. *Bacillus anthracis* is one of the deadliest known pathogens and an ideal biowarfare agent being the causative agent of anthrax. We demonstrated that a mixture of germinants and porphyrins can cause a 4.5 log reduction in the survival percentage of *B. anthracis.* Apart from using light as an effective tool for decontamination we have also explored the use of light and nanomaterials to gain control over protein function. The work presented in this thesis work may pave the way for

developing light-activated materials which can be used as components of antimicrobial coatings, reusable water-based decontaminants, and sporicidal agents.