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Title: Harnessing and Manipulating Light for the Control of Pathogens in the Natural and Built Environment

Abstract: Acutely emphasized by the coronavirus pandemic, the global disease burden associated with viral infections is undoubtedly high. Rotavirus the leading cause of childhood severe acute diarrhea, is responsible for over 500,000 deaths annually; while norovirus is the leading cause of gastroenteritis worldwide. Human travel patterns and increased interaction with wildlife make the emergence of new zoonotic viruses and their rapid global transmission only more likely. Understanding light induced inactivation is key to predicting the fate of viral pathogens in the environment, while engineered light-based treatment systems provide opportunities to develop sustainable, practical and effective methods for controlling viral pathogens. In this talk, I will discuss processes and technologies that harness solar energy for disinfection, including biocidal sunlight, photocatalysts, photovoltaics, and photothermal nanomaterials. Recently, we developed a novel nanomaterial enabled system for sustainable solar photothermal disinfection, leading to the first demonstration of direct solar nanoparticle-enhanced thermal inactivation of bacteria and viruses in drinking water. We further optimized this approach through the development of fluorescent techniques to quantitatively measure spatially resolved temperatures in photothermal devices, and the fabrication of prototype reactors from immobilized photothermal films for application in flow-through validation tests. Additionally, I will discuss the use of a genome-wide PCR approach to study photodamage in the genomes of bacteriophage MS2 and human norovirus. In contrast to previous work indicating that UVC inactivation occurs primarily through the formation of pyrimidine dimers which render the viral genome non-replicable after a single photon absorption event, we found that the single-hit inactivation assumption is invalid under simulated solar radiation. This highlights the need for further mechanistic analysis of photoproducts in viral genomes under environmentally relevant conditions.