Bactericidal Efficiency and Mechanism of High-intensity Narrow-Wavelength Light Based Disinfection Technology

By

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Abstract

Each year, hospital acquired infections (HAIs) take countless lives worldwide. Of all these infections, a large proportion can be attributed to multi drug resistant organisms (MDROs). MDROs can be resistant to one or more classes of antibiotics and have evolved as a response to the abuse of antibiotics. At present there are more than 15 classes of antibiotics, for all of which resistance mechanisms evolved. Multi drug resistant S.aureus, vancomycin resistant enterococcus, carbapenem resistant Escherichia coli, multi drug resistant Pseudomonas aeruginosa, are the most common and harmful MDROs, requiring strict control. The survivability of MDROs on surfaces is long and cross contamination plays an important role in the transmission of these pathogens.

Although there are many guidelines regarding the cleaning and disinfection of the exposed surfaces of medical equipment, infections still break out at times. To confront the high morbidity and mortality of these infections, many methods of disinfection are under development. The most popular method used in local healthcare setting is 1:49 bleach. However disinfection technologies using light, which leaves no residual chemicals, are also used.

Blue LEDs emitting continuous light at wavelengths of 405nm and 470nm exhibit desirable bactericidal activity against S.aureus, P.aeruginosa, MRSA and MRPA, but the bactericidal efficiency in substantially increased using pulsed blue LEDs with same exposure dosage. Pulsed UVC provides remarkable bactericidal effects at lower dosages and energy consumption. A light disinfection device combining the three wavelengths of light was assembled and evaluated. The resulting light disinfection device showed outstanding disinfection effects against MDROs on different surfaces including plastic, glass, agar, liquids and porous material.

The bactericidal mechanisms of 405nm, 470nm blue LEDs and light disinfection device all result from reactive oxygen species (ROS) created during exposure, but the specific action modes are different, as the oxidation effects of ROS are non-specific. Exposure to 405nm blue LEDs affects the bacterial plasma membrane resulting in bacterial death, while exposure to 470nm blue LEDs is genotoxic. The light disinfection device used not only these two disinfection modes but also increases the membrane deconstruction effect and genotoxicity of each wavelength of light.

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