The Impact of Antimicrobial Light

MEETS THE INTERNATIONAL STANDARD FOR CONTINUOUS AND UNRESTRICTED USE AROUND HUMANS

EOS
ENERGY OPTIMIZATION SERVICES

EOS PROVIDES

Antimicrobial Lighting solutions in many industries, including: healthcare, food safety and preparation, pharmaceutical and biotech manufacturing, consumer products and services, travel and hospitality, athletics and agriculture, to name a few. The patented single-diode white violet light technology applies the power of 400-420nm (non-UV) light to be used in combination with traditional intermittent cleaning in hospitals, homes, public spaces, and workplaces. The technology multi-tasks to effectively and continuously prevent the growth and spread of microorganisms (bacteria, fungi, yeast, mold and mildew) on surfaces while also illuminating the space.

Introduction

The use of visible light is an effective new approach to prevent the growth and spread of bacteria and other microbes.

Concerns about efficacy and safety are always appropriate when exploring new approaches and technologies. Working with our research partners, accreditation bodies and customers, we have demonstrated a positive results in four specific areas of concern:

- Ultra Violet (UV) Radiation
- Blue Light Hazard
- Antibiotic-Resistant "Superbugs"
- "Good" Bacteria

Current cleaning and disinfection procedures—whether ad hoc or regularly scheduled (hourly, daily or weekly) do not provide adequate protection against harmful bacteria, fungi, yeast or mold. Current approaches are effective at and around the time of cleaning, but once anything new enters that environment, the cycle of contamination begins again. This is the case in virtually every environment from our homes to the workplaces and factories to any interior public space.

This technology works non-stop, around the clock and in between routine cleaning activities, continuously eliminating microorganisms exposed to our light. Our technology harnesses specific wavelengths of visible light that target molecules exclusively within microbes and pathogens. This ultimately creates an inhospitable environment for bacteria, mold, yeast and fungi to grow.

The Differences between This Technology and Ultraviolet (UV) Light

This technology harnesses its microbial killing power from within the visible light spectrum, which ranges from the frequencies of 380-750nm. The visible light spectrum is comprised of the colors we can see, such as the colors within a rainbow. The discovery of visible light's antimicrobial power was originally made in the late 1800s, where experiments with colored filters were used with natural sunlight to initially demonstrate its impact.
LED technology engineered to produce an abundance of light in the 400-420nm range, which has been acknowledged to kill bacteria, fungi, yeast and mold/mildew.

It's killing action is completely different. It works by activating particular types of porphyrin molecules that are present specifically in microbial cells, but not in humans.

Certain spectrum of ultraviolet light works by attacking the cell's DNA, making it harmful to humans by penetrating our skin and our eyes, potentially causing cancerous cells to form and eye disease to be initiated. This light's killing action is completely different. It works by activating particular types of porphyrin molecules that are present specifically in microbial cells, but not in humans, plants or animals. When activated, the porphyrins produce excessive Reactive Oxygen Species (ROS), such as singlet oxygen, hydrogen peroxide, and hydroxyl groups. Once these ROS build up, they become toxic to the cell, causing the destruc-tion of multiple structures within the cell and ultimately leading to cell death. Because the types of porphyrin molecules found in humans and other animals are not photoactivated by light in the 400-420nm range, this light technology has no negative impact.

Multiple scientific, peer-reviewed studies have exposed mammalian and human cells to these wavelengths and have shown that antimicrobial ir-radiance levels do not cause damage to them[1-5]. In addition, all of these studies were also conducted at much higher intensities of light than our products and their applications typically produce, without impacting facility operations or surface materials within the environment.

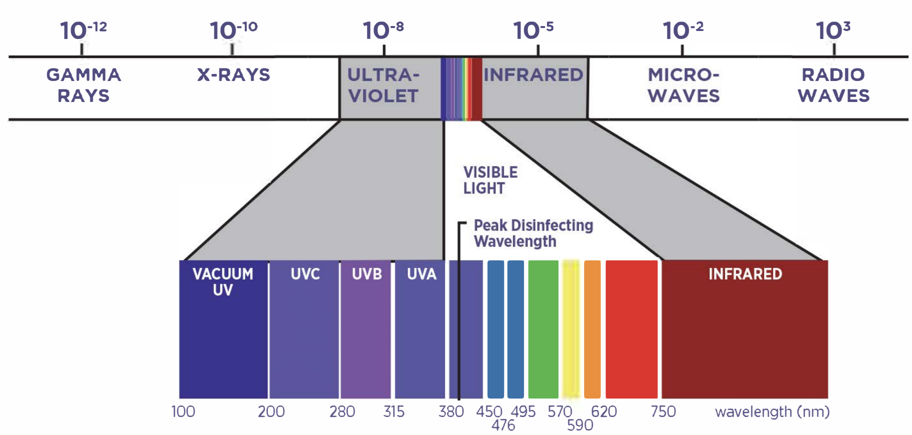

Figure 1. **UV Light occurs from 100-380nm—Visible Light occurs from 380-750nm.**

By contrast, UV occurs in the 100-380nm range The wavelengths that are most germicidal and therefore most commonly used for sterilization or disinfection occur from 200-280nm, which is known as UV-C.

Certain spectrum of UV-C light works as a disinfectant by penetrating much further into the nucleus of microbes, destroying nucleic acids and therefore disrupting their DNA. The DNA damage accumulates leaving cells unable to per-form vital functions and causing cell death. Because humans also have DNA in our cells, and because that DNA is damaged by certain spectrum of UV-C wave-lengths, most spectrum of UV-C light at disinfecting or sterilizing doses is not safe for human exposure. Most UV-C can only be used when the area to be exposed is not occupied, or in spaces that are enclosed and have no risk of human exposure. Equally important when it comes to certain materials, certain spectrum of UV light breaks down the chemical bonds in plastics, gaskets, insulation, and similar materials. EOS' Antimicrobial Light does not have any impact on these materials, making it ideal for applications where the caustic effects of harmful spectrum of UV are undesirable or impractical.

In summary, EOS' Antimicrobial Light technology is not ultraviolet (UV). It is within the visible light spectrum and acts using a completely different killing mechanism than UV.

The wavelengths that are most germicidal and therefore most commonly used for sterilization or disinfection occur from 200-280 nm, which is known as UV-C.

ATTRIBUTES	ANTIMICROBIAL TECHNOLOGY	UV-C TECHNOLOGY
Wavelength	400-420nm	200-280nm
Mechanism of Action	Unique Porphyrin Activation	DNA Damage
Effects on Materials	No effect	Degradative
How Often to Use	Continuously	Intermittently
Type of Clean	Sanitation/Prevention depending on application	Disinfection/Sterilization depending on application

Table 1. **Comparison of EOS' Antimicrobial Light technology and UV-C technology.**

EOS' Antimicrobial Light has been tested to the international IEC photobiological standard and meets the exempt category for continuous and unrestricted use around humans

The International Electrotechnical Commission (IEC) prepares and publishes the primary international standards for electrical, electronic and related technologies. Underwriter's Laboratories (UL) conducts photobiological safety assessments using IEC standards. UL tested these fixtures against IEC 62471—Photobiological Safety of Lamps and Lamp Systems. This new technology met every standard for continuous and unrestricted exposure for humans.

IEC 62471 is focused on safety of the skin and eyes in eight areas related to UV hazard, blue light hazard, temperature hazard and infrared hazard. The specific categories are:

1. Actinic UV hazard exposure limit for the skin and eye
2. Near-UV hazard exposure limit for the eye
3. Retinal blue light exposure limit
4. Retinal blue light hazard exposure limit—small source
5. Retinal thermal hazard exposure limit
6. Retinal thermal hazard exposure limit—weak visual stimulus
7. Infrared radiation hazard exposure limit for the eye
8. Thermal hazard exposure limit for the skin

Based on these assessments, products with EOS' antimicrobial light technology have shown to be in what the IEC calls the "Exempt Group (RG 0), where no optical hazard is considered reasonably foreseeable, even for continuous, unrestricted use."

This Technology Does Not Risk Creating “Superbugs”

Antibiotic-resistant bacteria-often called "superbugs"-have been identified by the World Health Organization as "one of the biggest threats to global health, food security, and development today"[11] We are confident that our technology does not and will not contribute to this global threat, and instead can provide additional layers of protection against the spread of these powerful germs.

In the simplest of terms, antibiotics and these fixtures work in very different ways, with antibiotics affecting a single "target" and EOS' Antimicrobial Light affecting multiple "targets" within a microorganism Microbes have proven effective at mutating to resist aggression toward a single target, but not multiple targets.

Antibiotics operate by targeting a singular molecule or function within a cell: a component of either DNA synthesis; cell wall synthesis; or pro-tein synthesis. Bacteria are then able to generate one of four resistance mechanisms: antibiotic inactivation, target modification, altered per-meability, or the bypass of that part of the metabolic pathway[7] These mechanisms become effective because resistance is needed against only the single target within the cell.

By contrast, this new technology impacts bacteria through the photoactivation of the ubiquitous and critical building blocks of the cell, specifically, unique microbial porphyrin molecules, which then produce reactive oxygen species (ROS) These ROS cause irreparable damage intracellularly by affecting numerous targets simultaneously, including DNA, RNA, proteins, and lipids[6] It would be very difficult for microbes to produce enough mutations that did not kill the cell to generate viable resistance.

This dynamic has been demonstrated in several studies that look at the potential for the development of resistance to antimicrobial light technology by targeted microorganisms[5,8,9]. Each of these studies tested different bacterial strains, including MRSA and *E. coli.* The bacteria cells were exposed to the light's wavelengths and the surviving cells were collected, re-grown to higher amounts, and re-exposed to the lights This was repeated for as many as 20 cycles, and none of the species tested showed any development of resistance by the end of the longer-term exposures This lack of resistance after repeated exposure shows that the development of resistance to the antimicrobial light is not likely to occur, especially on surface environments.

Impacts on "Good Bacteria"

In 2016, a group of seven North Carolina-based physicians led by William A. Rutala, PhD, MPH found that the 400-420nm wavelength is effective at killing microbes and does not distinguish between microbes. All species currently tested that are impacted by the technology contain the unique porphyrin molecules; there is no difference in molecules between bacteria that are beneficial and those that are pathogenic to humans. Human flora can be found all over the body, including skin, gut, respiratory tract, and more.

The Gut

The gut has the largest number of microbes and the largest variety relative to any other area on or in the human body. Because antimicrobial light penetrates only the first few layers of the epidermis, bacteria in the gut are not exposed to its effects.

The Skin

Since most of our body surface is covered by clothing most of the time, only a small percentage of our skin is likely to be exposed to antimicrobial light at any one time, most frequently the face and hands. Therefore, only microbes on exposed skin have any chance of being affected, and these areas are quickly repopulated from covered areas, or from the environment, through the normal course of human activity. This is like what we experience while showering, washing hands, or using antibacterial gels.

The fixtures have been tested by UL to meet the standards set by the IEC as safe for continuous exposure to the skin, and there is no evidence of and no reason to suspect any negative effects on skin flora from this lighting technology.

Conclusion

Our primary mission is to create and deliver a distinctive new class of antimicrobial lighting solutions that are healthy for us and our planet in the cleanest and simplest way. Again, the four areas of concern related to this technology have been thoroughly investigated:

- Ultra Violet (UV) Radiation
- Blue Light Hazard
- Antibacterial Resistant "Superbugs"
- So-called "Good" Bacteria

Working with our research partners, accreditation bodies and customers, and backed by our own and independent research and scientific and clinical studies, we have demonstrated a positive and healthy profile in each of these areas.

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