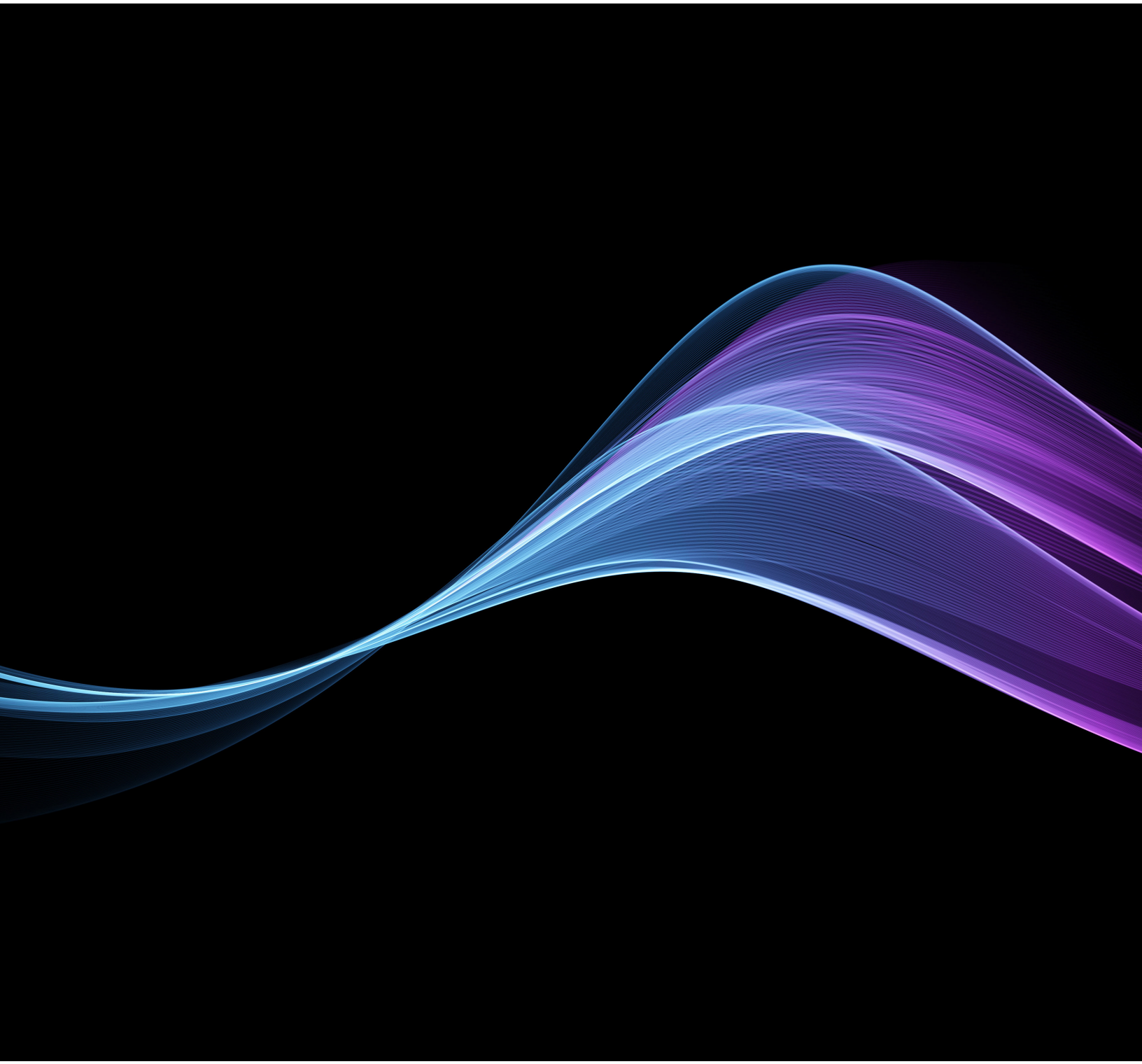
PURO™
UV Disinfection Lighting

DISINFECTION IN A FLASH

The Definitive Guide to UV Light Disinfection



THIS WHITE PAPER IS WRITTEN BY PURO LIGHTING'S TECHNOLOGY PARTNER VIOLET DEFENSE™

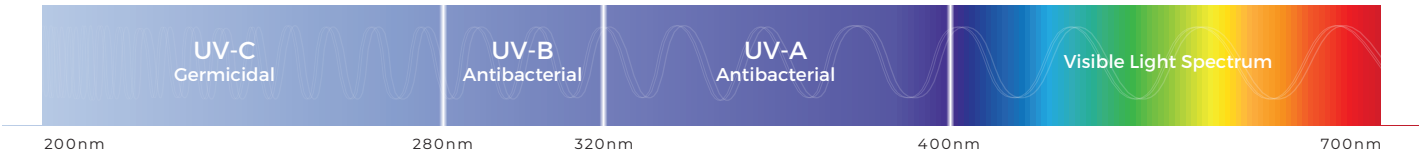
TABLE OF CONTENTS

Introduction

Ultraviolet light is naturally present in sunlight and actually makes up about 10% of the total light generated by the sun. UV is a form of electromagnetic energy with a wavelength from 10 nm to 400 nm, though for germicidal purposes we focus on the wavelengths of UV-A, UV-B, and UV-C light.

The atmospheric ozone absorbs energy of wavelengths less than 290 nm, such that most of UV-C and UV-B is blocked by the planet's ozone.

Weather, geographic region, altitude, and time of year can all impact the amount of UV in a certain location. In areas where there is less atmospheric ozone, such as higher altitudes or during summer months, more UV-B and UV-C are able to make it through.



GLOSSARY OF TERMS

Wavelength: the distance between successive crests of a wave, especially points in an electromagnetic wave.[1] Visible light corresponds to a wavelength range of 400-700 nanometers (nm).

Spectrum: a band of colors, as seen in a rainbow, produced by separation of the components of light by their different degrees of refraction according to wavelength.[1] The ultraviolet spectrum of light consists of wavelengths from 100-400 nm.

Disinfection: the process by which most or nearly all microorganisms are killed through use of chemicals, heat, or ultraviolet rays.[2]

Dose: the measure of how much UV energy is delivered to microbes is the product of intensity of the light times the length of exposure. Different types of organisms require a different dose of UV to be inactivated or killed.

Inactivate: to stop the activity of certain biological substances. As viruses are molecules, it is customary to refer to them as being inactivated rather than killed.

Intensity: the measurable amount of UV energy produced, measured in milliwatts per square centimeter.

Electromagnetic spectrum: the entire spectrum, considered as a continuum, including microwaves, infrared light, ultraviolet light, X-rays, gamma rays, and visible light.

Pathogen: any microbe that can cause infections in humans and animals, including viruses, bacteria, and fungi.

UV-A: light in the UV spectrum from 320-400 nm. Black lights emit UV-A light.

UV-B: light in the UV spectrum from 280-320 nm and is most commonly associated with sunburn or freckling, but also produces germicidal effects.

UV-C: light in the UV spectrum from 200-280 nm known for its germicidal effects.

Violet-blue light: light with wavelengths of 400-470 nm with antibacterial effects.

A Brief History of UV

Violet-blue and UV portions of the light spectrum are able to destroy microorganisms.

It's been 140 years since Downes & Blunt discovered the antibacterial effects of sunlight. They determined that shorter wavelengths of the solar spectrum were more effective at neutralizing bacteria. Just 15 years later, Professor Marshall Ward determined that it was violet-blue and UV portions of the spectrum that are able to destroy microorganisms.

With further validation of the ability of the UV spectrum to kill germs, a variety of applications of this technology began to emerge — ranging from the first UV quartz lamp by Lorch in 1904 to the first overhead UV system for hospitals in 1936. In 1942, the military adopted UV for inclusion in barracks for the protection of soldiers in the Army and Navy.

Studies such as one conducted by Riley in 1957 showed effectiveness in using control for tuberculosis. In spite of the positive adoption rates and studies proving its effectiveness, UV wasn't as widely adopted as would be expected, largely in part due to the rise of the use of antibiotics. Now given the growing concern of antibiotic-resistant strains of "superbugs," UV has tremendous momentum as microbes cannot acquire resistance to the germ-killing power of UV.

In 2000, the Army recommended Ultraviolet Germicidal Irradiation (UVGI) for the isolation of disease and just three years later, the CDC endorsed the use of UVGI in hospitals and FEMA approved the use of bio-defense systems based on UVGI for buildings.

The field of using UV light for germ elimination continues to grow as new ways to deploy this powerful light are discovered.

How UV Works

To understand how UV kills bacteria and viruses, a basic understanding of their structure is needed. DNA and RNA is the genetic material that makes up all living organisms, controlling their growth, development, functioning and reproduction. DNA chains are made up of nucleotides which are comprised of deoxyribose (sugar), phosphate, and nucleotide bases. These bases come in four chemical forms: adenine, cytosine, guanine, and thymine.

DNA and RNA are the blueprint for cellular development. The DNA code gets transcribed to RNA (ribonucleic acid) that carries information or instructions and controls the synthesis of proteins. In some viruses, RNA has the genetic information.

DNA is the most sensitive target of an organism. Radiation at 200 nm is absorbed by molecules of ribose and phosphate while nucleotide bases peak absorption is at the 265 nm wavelength. The UV light actually modifies the genetic material of microorganisms. The electromagnetic energy destroys the ability of microorganisms to reproduce and by causing photo-chemical reactions in nucleic acids. The UV energy triggers the formation of specific thymine or cytosine dimers in DNA and uracil dimers in RNA, which causes the inactivation of microbes by causing mutations and/or cell death as well as failure to reproduce.[1]

UV-B and UV-A light causes oxidation of proteins and lipids causing cell death. Broad spectrum UV lamps have also been shown to inhibit photoreactivation, the process that can result in self-repair of damaged microbes. Furthermore, UV-A light when distributed using pulsed UV systems can cause additional cell wall rupturing from sudden heating. Therefore, pulsed UV systems combine not only the germicidal effects from delivering a lethal UV dose, but also thermal disintegration from the speed and intensity of photonic delivery. [2]

Why Do We Need UV?

21 Million	Average number of cases of norovirus in the United States each year[3]
10 Million	The number of germs found on an average office desk[5]
3 Million	Number of serious infections occurring in assisted living facilities each year[3]
2 Million	Number of people that become infected with bacteria that are resistant to antibiotics each year in the United States[3]
65,000	Number of food safety violations due to food-contact surfaces not being properly cleaned and sanitized in restaurants[4]
10,000	Number of passengers infected on cruise ship outbreaks in the past 5 years[3]

Each year, millions of people acquire illnesses from bacteria and viruses in common places — ranging from restaurants to hospitals to just about any space.

Today, with the worldwide appearance of the SARS-CoV-2 and the resulting COVID-19 pandemic outbreak, the need for quick and effective disinfection of indoor spaces grows exponentially.

While strategies such as hand-washing are a critical part of our defense against getting sick, they are not enough to keep the millions of germs at bay. Many germs, including norovirus can survive on surfaces for weeks. For many years, antibacterial products were prevalent based on people looking for an additional layer of protection.

However, the FDA eventually ruled that products with certain ingredients, such as triclosan, could no longer be marketed as manufacturers had not proven their products to be safe or that they were actually any better than plain soap and water. Some tests have even suggested that chemicals such as these were actually contributing to the antibiotic resistance problem.

Other chemicals that may help clean surfaces are often not used as directed, which can require extended time durations, thus limiting their effectiveness.

The CDC has labeled 18 bacteria as drugresistant threats that require additional prevention and control mechanisms due to their resistance to treatment with antibiotics. Recently, a specific strain of *Klebsiella pneumoniae* was found to be resistant to all 26 antibiotics used in the United States.

Over time, bacteria have changed their structure to resist the antibiotic effects, produce enzymes called beta-lactamases that actually destroy penicillin, or acquire drug resistance from other bacteria.

However, UV can kill all bacteria, including drug-resistant bacteria because UV light is actually attacking the DNA and RNA of microbes. While the amount of UV needed to kill a microbe may vary as there is a relationship between the size of DNA molecules and the effect of UV radiation, there have been no reports of microbes demonstrating an ability to build an immunity to light-based methods.

Finding the Right Solution for You

EASE OF USE

When health and wellness are on the line, it's essential to find a solution that is easy to use to ensure proper usage every time.

PROVEN RESULTS

Not only does the solution need to have proven results, but does it effectively kill the pathogens you are most concerned about and want to target? Look closely at the results, particularly when considering UV solutions to see the distances at which they kill germs.

COST-EFFECTIVE

When selecting a solution, you have to consider not only the initial costs, but ongoing expenses, including labor costs, ongoing supply purchases, and/or maintenance costs.

Alternatives to UV

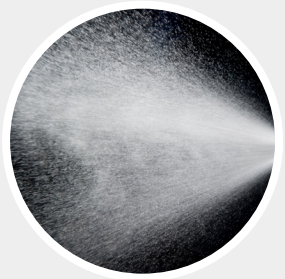
HAND WASHING

Hand washing is among the most common strategies recommended to help fight the spread of germs because so many are spread from touching surfaces or objects and then putting hands in your mouth.

However, many diseases are spread due to people improperly washing their hands. It is recommended that people wash their hands with soap for at least 30 seconds — the bubbles and friction are needed to help remove the pathogens from your hands effectively.

CHEMICALS

Chemicals are one of the most common methods for disinfecting spaces. However, many of the most effective chemicals such as bleach are harmful to humans and the environment. The more eco-friendly and safer chemicals may not be effective against viruses or certain bacteria. For full effectiveness, chemicals also require surfaces to remain wet for 30 seconds to 10 minutes before being wiped down. Research has shown that nearly 70% of hospital surfaces aren't sufficiently disinfected.



AEROSOL MISTING SYSTEMS

Hydrogen peroxide aerosol/misting systems are another alternative, particularly for hospitals when you need a high kill rate. Due to the distribution method, when a room is properly sealed, this method can potentially ensure all surfaces in a room are reached.

However, these systems require extensive room preparation, including sealing all HVAC grilles, doorways, etc. The cycle time can be lengthy requiring up to 120 minutes to operate. These units also produce water as a by-product, which may harm metals, cause rust, as well as be harmful to sensitive electronics.

The PURO Lighting Difference

Helo F1 unit

Powered by Violet Defense technology, PURO Lighting provides a high-quality line of patent- protected products that will meet your needs for safe, effective, germ-killing in everyday spaces. The Helo and Sentry products are designed to integrate into every-day spaces with ease.

INTELLIGENT CONTROL MAKES IT EASY TO USE

PURO Lighting systems feature an intelligent control system that can automatically adapt cleaning cycles to help maintain a level of cleanliness over time. Units can be programmed to deploy in various methods to integrate seamlessly into daily operations of a business. Products include installed fixtures, as well as mobile options.

The units can be programmed to automatically activate when a room is unoccupied. Redundant safety systems are in place to ensure the units de-activate when someone enters the room. The cleaning cycle will automatically resume again when it's safe to do so.

POWERFUL UV YIELDS RESULTS

Helo fixtures and Sentry mobile units are anti-microbial products that utilize powerful, broad spectrum, pulsed Xenon light, including violet-blue, UV-A, UV-B, and UV-C to effectively kill bacteria, fungi, mold, and viruses.

Independent testing has proven that the pulsed Xenon products can kill up to 99.9% of bacteria and viruses, including *E. coli*, Salmonella, MRSA, and Norovirus at distances of up to 3 meters.

COST-EFFECTIVE SOLUTION

Helo fixtures are designed to easily retrofit into existing spaces. Once installed, the units require no ongoing maintenance or labor costs.

References

1 Kesavan, Jana and Jose-Luis Sagripanti. Disinfection of Airborne Organisms by Ultraviolet-C Radiation and Sunlight. Rep. Edgewood Chemical Biological Center, July 2012.

2 Kowalski, Wladyslaw. Ultraviolet Germicidal Irradiation Handbook: UVGI for Air and Surface Disinfection. Springer. 2009

3 Centers for Disease Control & Prevention

4 Florida Department of Business & Professional Regulation, 2015-2016s)

5 "Germs and the Office Equal a Costly, Sickly Mix." B4 Brands. Food Industry, Hand Hygiene, Healthcare, Hotels - Casinos, Office Buildings, Private label, Schools-Education.

ABOUT PURO UV DISINFECTION LIGHTING

Launched in 2019 in Lakewood, Colorado, PURO™ Lighting products, powered by Violet Defense™ technology, have set out to take proven UV light disinfection technology to the next level by making it more powerful, more affordable and most importantly, smaller and easier to utilize. PURO Lighting products can rapidly disinfect any room of any size and at any time using the proprietary miniaturized, pulsed Xenon Light Engine System. Our high intensity broad-spectrum UV disinfection units rapidly kill up to 99.9% of viruses and bacteria and can significantly reduce the growth of fungi such as yeasts and molds. All in remarkably small, yet powerful fixed or mobile units designed for any sized space. For more information, visit www.purolighting.com.

ABOUT VIOLET DEFENSE

Founded in 2012, Violet Defense is on a journey to find new ways to protect people from harmful germs that have grown resistant to traditional forms of cleaning and disinfecting. Its patented technology is the only known Pulsed Xenon UV solution that can be installed into a room full-time, creating continuous way to address disinfection needs of all types of settings, including healthcare and non-healthcare alike. Designed to bring hospital-grade disinfection to everyday spaces, Violet Defense has cost-effective solutions to kill up to 99.9% of bacteria and viruses, including *E. coli*, Salmonella, MRSA, Norovirus and *C. diff.* For more information, visit www.violetdefense.com.

PURO™
UV Disinfection Lighting

Contact Information for PURO Lighting
sales@purolighting.com
12340 W Cedar Dr, Lakewood CO 80228
(877) 452-8785