Issue 96
January 2020
Division of Technical Resources
Office of Research Facilities
National Institutes of Health
Technical News BULLETIN

UV Lighting Part I – Fundamentals

Introduction

Ultraviolet (UV) radiation is naturally occurring electromagnetic radiation that comprises approximately 10% of sunlight at ground level. There are four types of UV radiation, which are classified based on the wavelength range measured in nanometers (nm): vacuum-UV (VUV) with a wavelength between 100-200 nm, UV-C with a wavelength between 200-280 nm, UV-B with a wavelength between 280-315 nm, and UV-A with a wavelength between 315-400 nm. In addition to UV electromagnetism, the Sun's spectral composition also emits X-rays, visible light, and infrared radiations. Figure 1 shows the electromagnetic spectrum from the Sun which includes various types of UV and other electromagnetic radiations.

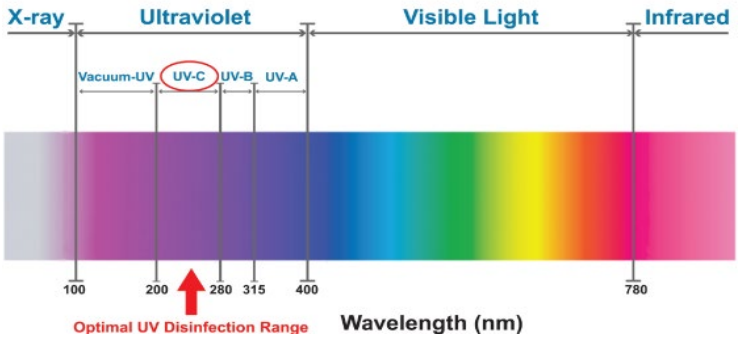

Figure 1 - The Electromagnetic Spectrum

Ultraviolet (UV) Irradiation Effects on Human

UV radiation can be harmful or beneficial to humans, depending on the wavelength, range of the radiation, and duration of exposure. Approximately 95% of the UV radiation that reaches earth is UV-A, which is hazardous for humans because it can penetrate deep into the skin and have harmful effects. In contrast, UV-B cannot penetrate the skin any further than the surface layer, and instead works with the skin to generate vitamin D3. UV-C, although harmful to humans, is filtered by the atmosphere and does not reach the earth's surface. Vacuum UV (VUV) also does not reach earth's surface because it is absorbed by the oxygen in the atmosphere.

What is UVGI

Ultraviolet germicidal irradiation (UVGI) uses UV-C to deactivate microorganisms, rendering them harmless. By changing the DNA structure of microorganisms, UV-C kills or deactivates them, making them incapable of performing vital functions including respiration, reproductive functions, and absorption of nutrients. Figure 2 graphically represents the direct effects of UVGI on the DNA of the microorganisms. Combined with an appropriate filtration system, UVGI is utilized for water treatment as well as for air disinfection applications in hospitals, health care facilities, research facilities, water treatment plants, and commercial and food industry. In each of these applications, it is important to remember that adequate support systems shall be in place when UVGI is used to prevent UV-C exposure, due to its effects on humans.

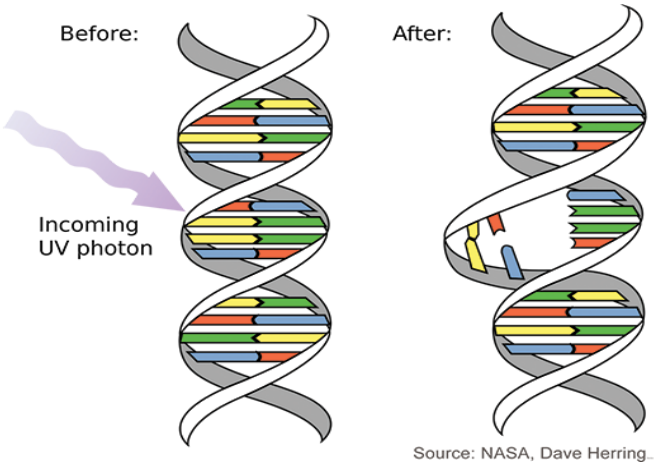

Figure 2 - Germicidal Effect on DNA

UVGI General Applications

Water Treatment Basics: When UVGI is used for water treatment, its effectiveness is heavily dependent on the turbidity (small particulates or colloidal material suspended in the water) and the efficacy of the UV source used. UVGI uses UV light with an optimal wavelength of 254 nm. A water filtering system will be required to remove particulate matter such as heavy metals, salt, etc., for disinfection; the removal of chemicals such as chlorine should also be evaluated. By physically removing particles with the use of filters, the UV light can spread freely and reach the microbes. UVGI is used in HVAC systems to control microorganism growth on coil surfaces, condensate drain pans, and associated drain lines as well as other components exposed to UVGI. UVGI is also used in reverse osmosis (RO) systems. UVGI systems are an important component of research laboratories, boiler water systems, water treatment facilities, and aquatic research facilities, because they will ensure that any microbes that remain after passing through properly selected filters are irradiated with UVGI.

Air Disinfection Basics: The UVGI system is also widely applied in various forms to improve Indoor Air Quality (IAQ) through the HVAC system by neutralizing harmful airborne bacteria. In an HVAC system, just like in water treatment, the use of UVGI must be accompanied by a properly designed and selected filtration system. Air disinfection using UVGI also has many other applications outside of the HVAC system. For instance, in the health care industry, UVGI is being used in hospitals and many non-NIH research laboratories for disinfection of localized unoccupied areas, such as hospital rooms and ambulances interiors.

Part 2 will review further UVGI applications in detail. General design and maintenance considerations will also be addressed.

Reference for Further Reading

1. Analysis of Efficacy of UVGI Inactivation of Airborne Organisms Using Eulerian and Lagrangian Approaches
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2. Solving Office Complex IAQ Issues Through Ultraviolet-C Technology
https://www.achrnews.com/articles/142371-solving-office-complex-iaq-issues-through-ultraviolet-c-technology
3. The History of Ultraviolet Germicidal Irradiation for Air Disinfection
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2789813/
4. Ultraviolet germicidal irradiation and the INTERSUN Programme
https://www.who.int/uv/faq/whatisuv/en/index2.html