Applied Biosafety, *11*(4) pp. 228-230 © ABSA 2006

Position Paper on the Use of Ultraviolet Lights in Biological Safety Cabinets

Jyl Burgener

Eli Lilly and Company, Indianapolis, Indiana

Purpose

The purpose of this paper is to review information available on the use, risks and benefits of using Ultraviolet (UV) lights in Biological Safety Cabinets (BSC) and set forth a position based on the risk and benefits.

Background

Ultraviolet (UV) radiation is a form of nonionizing radiation and behaves in accordance with the laws and principles of geometric optics. Electromagnetic radiation can be described as a "wave" that consists of an electric field and a magnetic field. Electromagnetic radiation is usually characterized by wavelength and frequency or photon energy. The term wavelength refers to a distance in a line of advance of a wave from any point to a like point on the next wave; it corresponds to the distance traveled by the wave during one cycle. A wavelength is usually measured in angstroms or nanometers (nm).

The International Commission on Illumination (CIE) has divided the UV spectrum into three wavelength bands, primarily due to biological effects. The 315-400 nm wavelength band is designated as UV-A. 280-315 nm is designated as UV-B, and 100-280 nm as UV-C. Wavelengths below 180 nm are of little practical biological significance since the atmosphere readily absorbs them. Sources of UV-A are used for dentistry and tanning, UV-B is used for fade testing and photocuring of plastics, and UV-C (100-280 nm) is used for germicidal purposes. All wavelengths less than 320 nm are actinic, meaning they are capable of causing chemical reactions. The mechanism of the germicidal effect involves these chemical reactions and so effectiveness varies by composition of the target organism in addition to physical variables.

Effects of Overexposure to Humans

Biological effects from UV radiation vary with wavelength, photon energy, and duration of exposure. In general, adverse effects are limited to the skin and eyes. Erythema (e.g., reddening of the skin in sunburn) is the most commonly observed effect on the skin. Erythema is a photochemical response to the skin normally resulting from overexposure to wavelengths in the UV-C and UV-B bands. Exposure to UV-A alone can produce erythema, but only at very high radiant exposures. Chronic exposure to UV radiation may accelerate the skin aging process and increase the risk of developing skin cancer. The National Toxicology Program's (NTP's) Report on Carcinogens classifies broad-spectrum UVR as a known human carcinogen and UVA, UVB, and UVC individually as probable (reasonably anticipated to be) human carcinogens. (http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s183uvrr.pdf).

Elevated exposure of UV-B and UV-C radiation may adversely affect the eye and cause photokeratitis and/or conjunctivitis. A sensation of "sand in the eyes" and reddening of facial skin usually occurs within 6-12 hours of the exposure, with the symptoms and discomfort lasting up to 48 hours. UV radiation exposure rarely results in permanent ocular injury, although cataracts have been produced in animals by exposure to UV radiation in the UV-B and UV-A bands.

UV radiation exposure to eyes and skin is typically quantified in terms of an irradiance E (Watts/meter^2) for continuous exposure, or in terms of a radiation exposure H (Joules/meter^2) for time-limited exposure.

Regulations and Guidelines

The Occupational Safety and Health Administration (OSHA) do not have a permissible exposure limit for UV radiation. Guidelines on UV radiation exposure have been established by the International Radiation Protection Association (IRPA) and adopted by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH does have a threshold limit value (TLV) table for UV radiation and relative spectral effectiveness, which is published in the Threshold Limit Values (TLV) booklet annually. Refer to the most current "Threshold Limit Values for Chemical Substances and Physical Agents" published by ACGIH for values.

Using the current guidelines, it is expected that repeated exposure at or below the current guideline would not cause adverse health effects. However, it should be emphasized that UV radiation is implicated in both skin cancer and cataracts in humans. These values apply to all UV radiation sources except UV lasers. These values do not apply to UV radiation exposure of photosensitive individuals or individuals concomitantly exposed to photosensitizing agents. It should be emphasized that many individuals who are exposed to photosensitizing agents (ingested e.g., aspirin or topically applied chemicals) probably will not be aware of their heightened sensitivity.

Boettrich performed a study evaluating UV light exposure from six biological safety cabinets. He evaluated permissible exposure times using a research radiometer photometer equipped with a UV actinic band sensor. Permissible exposure times were established within:

1. Thirty-two minutes to 1.4 hours at general eye level in the center of the room;
2. Thirteen to 24 minutes for eye level exposures while seated at the cabinet; and
3. Twenty-eight to 44 seconds for hand level exposures at the cabinet face.

Boettrich also evaluated potential exposures around biological safety cabinets with 253.7 nm UV bulbs. Overexposures at the face of the cabinets (outside sash) could occur within 1.3-6.7 minutes.

Limitations of UV Light in Biological Safety Cabinets

The activity of UV lights for sterilization/decontamination purposes is limited by a number of factors including:

Penetration—In a dynamic air stream (e.g., biological safety cabinet): UV light is not penetrating as particles do not come close enough to the UV source to be affected for a sufficient period of time. Microorganisms beneath dust particles or beneath the work surface are not affected by the UV irradiation. UV irradiation can cause erythema that may damage both the skin and eyes because UV does not penetrate deeply into tissue. These effects are generally not permanent but can be quite painful.

Relative Humidity—Humidity adversely affects the effectiveness of UV. Above 70% relatively humidity, the germicidal effects drops off precipitously.

Temperature and Air Movement—Optimum temperature for output is 77-80°F. Temperatures below this optimum temperature result in reduced output of the germicidal wavelength. Moving air tends to cool the lamp below its optimum operating temperature and therefore results in reduced output.

Cleanliness—UV lightbulbs should be cleaned weekly with an alcohol and water mixture as dust and dirt block the germicidal effectiveness of the ultraviolet lights.

Age—UV lamps should be checked periodically (approximately every six months) to ensure the appropriate intensity of UV light is being emitted for germicidal activity (UV C). The amount of germicidal wavelength light emitted from these bulbs decreases with age and bulb ratings (hours of use) may vary by manufacturer.

Overuse—UV lights are routinely left on for extended periods of time (overnight or longer) in an effort to increase efficacy. This practice can result in the germicidal wavelength no longer being produced. Often sashes are left up or partially raised which increases the likelihood of exposure. UV lights in biosafety cabinets if not properly maintained can lead to a false sense of security regarding disinfection efficacy.

Performance Standards for UV Light in Biological Safety Cabinets

The National Sanitation Foundation (NSF) Standard 49, the U.S. industry testing standard for all biohazard cabinetry, does not provide performance criteria for UV lighting and specifically states in section 5.25.2 "UV lighting is not recommended in class II (laminar flow) biohazard cabinetry."

As it is possible to produce ozone levels from UV wavelengths below 250 nm sufficient to affect rubber or other polymer made materials, low or no ozone UV light bulbs are commercially available.

Recommendations

Due to the short time for UV overexposure to occur, it is recommended that neither laboratory nor maintenance personnel work in a room where UV lights are on. The CDC, NIH, and NSF agree that UV lamps are neither recommended nor required in Biological Safety Cabinets (BSC). There are no criteria available from NSF to evaluate the performance of the UV lights within a biological safety cabinet. Numerous factors affect the activity of the germicidal effect of UV light, which require regular cleaning, maintenance, and monitoring to ensure germicidal activity.

Retrofitting any equipment (e.g., UV lights) into a biological safety cabinet may alter the air flow characteristics of the cabinet and invalidate the manufacturer warranty and is not recommended.

This author agrees with the NSF that UV lights are not recommended for use in Biological Safety Cabinetry. Furthermore, expenses required to test and establish consistent UV germicidal performance for the agents in question may prove prohibitive to resolving this issue given that less expensive high-level disinfectants are in common use with good results. In the opinion of this author, the risks of using UV lights outweigh the benefits and effective alternative methods of disinfection are available and in common use.

References

American Conference of Governmental Industrial Hygienists. (2000). *Threshold Limit Values for Chemical Substances and Physical Agents and Biologic Exposure Indices* (TLVs and BEIs) ACGIH Worldwide, Cincinnati, OH.

Boettrich, E. P. (1990). *Hazards Associated with Ultraviolet Radiation in Academic and Clinical Laboratories*. Paper presented at the American Industrial Hygiene Conference, Orlando, Florida, May 13-18, 1990.

Keene, J. (1999). *Certification and Use of Biosafety Cabinets (BSCs)*. Biohaztec Associates, Inc., Midlothian, VA.

National Toxicology Program (NTP) Report on Carcinogens substance profiles. Available at http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s183uvrr.pdf. Accessed online September 12, 2006.

Noll, M. L. (1995). *Ultraviolet Radiation Exposures in Biomedical Research Laboratories. Applied Occupational and Environmental Hygiene, 10*(12), 969-972.

NSF International Standard, American National Standard: NSF/ANSI 49-2004A: *Class II (Laminar Flow) Biohazard Cabinetry*. The NSF Joint Committee on Biohazard Cabinetry.

Personal Dosimetry of UV Radiation Publication CIE 98-1992. Available at www.hike.te.chiba-u.ac.jp/ikeda/CIE/home.html. Accessed online 2001.

U.S. Department of Health and Human Services, Public Health Services, CDC, and NIH. (1995). *Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets*, Washington, DC: U.S. Government Printing Office.