Introduction

Ultraviolet light (UV) has two levels of radiation, ionizing and non-ionizing, which are separated by the length of waves they emit. Non-ionizing radiation ranges from 40-400 nanometers and is the most common form of UV radiation being used in biomedical and microbiological research laboratories. The ranges of non-ionizing UV can be charted into three types base on wavelength:

Band	Wavelength	Hazard Rating	Main Visual Hazard	Other Visual Hazards	Other Hazards
UV-A (Black Light)	315-400nm	Lowest		cataracts of lens	skin cancer, retinal burns
UV-B (Erythemal)	280-315nm	Mid to High	corneal injuries	cataracts of lens, photokeratitis	erythema, skin cancer
UV-C (Germicidal)	100-280nm	Highest	corneal injuries	photokeratitis	erythema, skin cancer

Hazards

The biological effects of UV radiation depend on the wavelengths concerned. Sources emitting radiation with wavelengths longer than 200 nm are serious health hazards. Since UV radiation has such low penetrating power, the effects are confined mainly to the eyes and the skin.

The effects on skin are two types, acute and chronic. Acute effects appear within a few hours of exposure while chronic effects are long lasting, cumulative and may not appear for years. Acute effects of ultraviolet radiation are similar to sunburn; the redness of the skin called erythema. Chronic effects include accelerated skin aging and skin cancer.

The eye is very sensitive to UV where main effects are due to exposure to UV-B and UV-C, namely conjunctivitis and photokeratitis. In conjunctivitis the membranes lining the insides of the eyelids and covering the cornea become inflamed resulting in discomfort as if there was sand in the eyes. Photokeratitis manifests as an aversion to bright light. The severity of these conditions depends on the duration, intensity and wavelength of exposure. Symptoms may appear 6 to 12 hours after exposure and may subside after 24 to 36 hours with no permanent damage. Unlike the skin, the eyes do not develop a tolerance to repeated exposure to ultraviolet. The absorption of UV-A radiation in the lens of the eye is thought to produce progressive yellowing with time and may contribute to the formation of cataracts, causing partial or complete loss of transparency.

Sunlight falls into the UVA region, which is known to be the most common form of UV. The Earth's Ozone layer intercepts all of the UVC and between 97-99% of the UVB, varying by geographical regions. Most of the natural UV should be avoided by use of personal protection such as a hat, sunblock, and sunglasses. However, UV radiation from laboratory equipment is in a more concentrated form which poses a greater threat to personnel. If no personal protection equipment is used, tissue damage may occur in only a few seconds.

Laboratory Equipment Emitting Non-Ionizing Ultraviolet Wavelengths

Typical laboratory equipment with the capacity to emit non-ionizing UV wavelengths includes: transilluminator boxes, handheld UM lights and biological safety cabinets (BSCs). The BSCs usually contain a UV lamp used to help maintain a sterile environment. Transilluminator boxes are used to observe gels susceptible to electrophoresis and contain nucleic acids.

Control Measures

Protection against exposure may be achieved by a combination of engineering, administrative control measures and personal protective equipment. Emphasis should always be placed on engineering and administrative control measures to minimize the need for personal protective equipment.

Engineering control measures include enclosures, screens or filters used to contain the UV radiation or devices such as interlocks to allow safe temporary access to a hazardous area. Reflective surfaces should be avoided and surfaces should be painted in a dark, dull color.

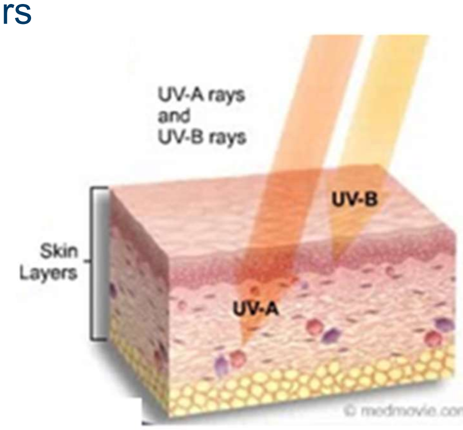
Administrative controls consist of warning signs, limitation of access and exposure time and the provision of information on the nature of the hazard and the precautions to be taken. The PI should decide what measures are necessary to limit access to the source and to make personnel aware of its presence. It may be necessary to install warning signs and/or lights and to limit exposure time.

After these steps have been taken it should be determined whether it is necessary to provide protection for the face, eyes or skin and what type of Personal Protective Equipment (PPE) is needed. PPE may consist of gloves, laboratory coat, UV protecting goggles and or face shield.

Exposure and Hazards of UV

Exposure to UV light poses a serious threat to both the eye and skin. Diagnosis of exposure may vary but are commonly set into two categories, photokeratitis (eye injury) and erythema (sunburn). Photokeratitis is an inflammation of the cornea (outer protective coating of the eye) that is caused by exposure to ultraviolet radiation. Eye injury can occur due to very brief exposure or with just a flash of intense UV. Erythema is sunburn of the skin and can occur within a few seconds of exposure to a concentrated form of UV. Prolonged exposure to ultraviolet light also causes premature aging and cancer of the skin.

UV Affects Both the Epidermis and Dermis Skin Layers



Ultraviolet Radiation is absorbed by the epidermal skin layer and usually proceeds via photochemical and thermal reactions into the dermal skin layers. UVB rays have a short wavelength that reaches the outer layer of your skin (the epidermis). UVA rays have a longer wavelength that can penetrate the middle layer of your skin (the dermis).

Exposure usually results in erythema, which is commonly called sunburn. Symptoms are comparable of normal sunburn and include redness, swelling, pain, blisters and peeling on the burned area. Severe sunburn can lead to headache and nausea like conditions. Variables for this intensity are mostly genetic factors but can be exaggerated by photosensitization from certain foods (e.g., celery root), drugs (e.g., tetracycline) and other chemical agents. Being at the cutaneous level, the cornea of the eye is also very susceptible to UV radiation and is extremely vulnerable because of its lack of thickness. UV exposure can cause lesions of the cornea and ultimately cause photokeratitis. Symptoms are described as a sensation of sand in the eye that may last for several days. Other symptoms of an overexposed eye may occur within a few hours and include sensitivity to light, unexplained tearing, and a burning or painful sensation in the eye.

The eyes are most sensitive to UV radiation from 210 nm to 320 nm (UV-C and UV-B). Maximum absorption by the cornea occurs around 280 nm. Absorption of UV-A in the lens may be a factor in producing cataract (a clouding of the lens in the eye).

Exposure Limits

There is no Occupational Safety and Health Administration (OSHA) standard for exposure to ultraviolet light, but the National Institute for Occupational Safety and Health (NIOSH) recommends that the time of exposure to an intensity of 100 microwatts per square centimeter at wavelength 254 nanometers not exceed 1 minute. When averaged over an eight-hour work day, this value is 0.2 microwatts per square centimeter.

The American Conference of Governmental Industrial Hygienists (ACGIH) has issued Threshold Limit Values (TLVs) for occupational exposure to UV. These TLVs refer to ultraviolet radiation in the spectral region between 180 and 400 nm and represent conditions that nearly all workers may be repeatedly exposed without adverse health effects. The TLVs for occupational exposure to UV incident upon skin or eye are based on the irradiance and time of exposure. Broad band sources are weighted to determine the effective irradiance compared with the spectral effectiveness curve at 270 nm. Refer to current "Threshold Limit Values for Chemical Substances and Physical Agents" published by ACGIH for values.

Personnel must take adequate steps to shield themselves and in some cases limit the duration of exposure. Environmental Health and Safety (EH&S) office can provide assistance in measuring UV emissions and evaluating personal protective equipment.

Laboratory Safety Precautions

As a common rule, never allow your eyes or skin to be exposed to UV light in the laboratory. This "laboratory UV light" is heavily concentrated and can cause severe damage with very short exposure periods. Always wear personal protective equipment (PPE) such as gloves, face shields, and lab coats (long sleeves) when using UV light. Thick nitrile gloves are recommended.

Biological Safety Cabinets (BSCs) are never to be occupied while the UV lamp is activated. Always lower sash and keep away from escaping rays. Mechanical safety devices should be standard on most new cabinets. If there is no safety shield or safety switch, these must be retro-installed in such a way as to prevent exposure and not interfere with the operation of the apparatus. Transilluminators are never to be used without the protective shield in place. A face shield, thick nitrile or double latex gloves along with a lab coat are the recommended PPE. Crosslinkers are not to be used if the door safety interlocking mechanism is not working properly.

Label Equipment Properly

Overexposure of UV radiation usually occurs because of inadequate education with regard to hazards when using UV emitting equipment. All equipment should be obviously and specifically labeled pertaining to UV emission. Properly labeled equipment will decrease the likeliness of an accident involving exposure to the eyes and/or skin. If you need proper UV Hazard labeling, contact EH&S.

Although UV is effective against most microbes, it requires an understanding of its abilities and limitations. The 253.7-nm wavelength emitted by the germicidal lamp has limited penetrating power and is primarily effective against unprotected microbes on exposed surfaces or in the air. It does not penetrate soil or dust. The intensity or destructive power decreases by the square of the distance from the lamp. Thus, exposure time is always related to the distance. The intensity of the lamp diminishes over time. This requires periodic monitoring with a UV meter. The intensity of the lamp is drastically affected by the accumulation of dust and dirt on it. The bulbs require frequent maintenance. In addition, there are safety hazards associated with the use of UV that require personal protective equipment or other safety devices to protect users. UV lights in biosafety cabinets require the cabinet be decontaminated prior to performing maintenance on the system. Experience has proven that good techniques in conducting experiments are highly effective in preventing contamination. The use of UV radiation does not eliminate the necessity for using good practices and procedures.

Transilluminators

UV-transilluminators are used in molecular biology labs to view DNA (or RNA) that has been separated by electrophoresis through an agarose gel. During or immediately after electrophoresis, the agarose gel is stained with a fluorescent dye which binds to nucleic acid. Exposing the stained gel to a UVB light source causes the DNA/dye to fluoresce and become visible. This technique is used wherever the researcher needs to be able to view their sample, for example sizing a PCR product, purifying DNA segment after a restriction enzyme digest, quantifying DNA or verifying RNA integrity after extraction.

Signage

Access to rooms must be controlled by closing the door and posting a warning sign on the door stating the instrument is in use. The warning sign should include -Caution: High Intensity Ultraviolet Energy. Protect Skin and Eyes.

Personal Protective Equipment

Individuals working with the equipment must wear personal protective equipment while the transilluminator is operating. The PPE must protect the eyes and skin and include gloves, lab coat with no gap between the cuff and the glove, and a UV resistant face shield.

Germicidal Lamps in Biosafety Cabinets

These are used for disinfecting the interior surfaces of a biosafety cabinet prior to and after use. The germicidal properties of ultraviolet light are used in addition to routine chemical disinfection and must not be relied on as the sole method of disinfection.

Signage

Access to the interior of the biosafety cabinet while the lamp is operating is controlled by closing the sash. Some cabinets are equipped with an interlocking switch that deactivates the UV lamp when the fluorescent lamp is activated; however, personnel must ensure that the UV light is off prior to working at the cabinet. Placing labels that fluoresce when exposed to UV inside the biosafety cabinet should be considered if the UV lamp is not interlocked with the fluorescent lamp. The warning sign should include - Caution: High Intensity Ultraviolet Energy. Protect Skin and Eyes.

Personal Protective Equipment

The personal protective equipment must protect the eyes and skin and include gloves, lab coat with no gap between the cuff and the glove, and a UV resistant face shield.

Maintenance/Monitoring

Since ultraviolet light is not used as a sole method of disinfection for the interior of biosafety cabinets, routine monitoring or the lamp's output is unnecessary. Bulbs should be wiped off on a monthly basis with a soft cloth dampened with ethanol. The bulb must not be operating and must be cool to the touch prior to wiping. Bulb replacement should proceed according to manufacturer's instructions based on the amount of use. Collect bulbs for disposal. Do not throw them in trash. UV lamps often operate at pressures below or above atmospheric and may produce a risk of explosion particularly during lamp replacement or maintenance work.

Hand-held UV Lights

Frequently used in research laboratories for visualizing nucleic acids following gel electrophoresis and ethidium bromide staining as well as contamination survey.

Signage

Access to rooms must be controlled by closing the door and posting a warning sign on the door stating the instrument is in use. The warning sign should include - Caution: High Intensity Ultraviolet Energy. Protect Skin and Eyes.

Personal Protective Equipment

Individuals must wear personal protective equipment while the hand-held UV unit is operating. The PPE must protect the eyes and skin and includes gloves, lab coat with no gap between the cuff and the glove, and a UV resistant face shield.

Responsibilities

The Principal Investigator (PI) or Lab Manager is responsible to ensure that employees working with UV producing equipment are properly trained about the safe use of equipment, have access to appropriate PPE and don it when working with it. New personnel should be provided with a copy of this policy and fully explained about the safe use of UV emitting equipment prior to start of work.