UV & Application

Ultraviolet (UV) is a general term for radiation with a frequency of 750THz to 30PHz in the electromagnetic spectrum and a corresponding wavelength of 400nm to 10nm. It cannot cause people's visual response. It is invisible light with a higher frequency than blue-violet light.

In 1801, German physicist Ritter discovered that a section outside the violet end of the sunlight spectrum could sensitize photographic films containing silver bromide, thus discovering the existence of ultraviolet light.

E (energy) = h (Planck's constant) × H (frequency)

E (energy)–eV (electron volt)

h (Planck's constant) –6.63×10-34J·s (Joule·second)

k (constant)–1.6×10-19J/eV

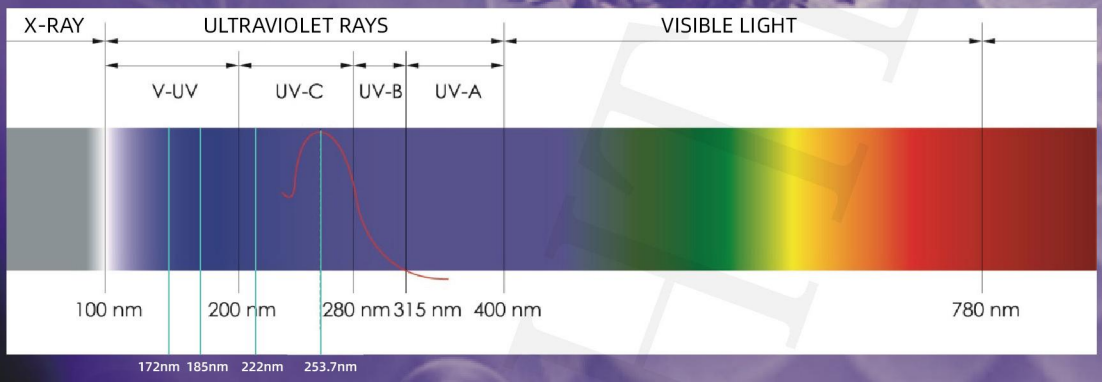
C (speed of light)–3×1017nm/s

λ (wavelength)–nm)

The unit of Planck's constant, joules, needs to be converted into electron volts. The above formula is converted to:

$E = h/k \times C/\lambda = 1240/\lambda$;

$E_{253.7} \approx 4.89$, $E_{185} \approx 6.70$;



Types	Abbr.	Rays range-λ	Photon Energy-ε	UV peak-nm	Main Applicatiop
Low frequency UV/ Long Wave UV	UVA	400nm ~ 315nm	3.10eV ~ 3.94eV	365	Curing, photocatalyst, mosquito trap, tanning, Phototherapy, instrument analysis...
Meidum frequency UV/ Meidum Wave UV	UVB	315nm ~ 280nm	3.94eV ~ 4.43eV	313	Ca. supplement for pets, light supplement for plants, sunburn...
Low frequency UV/ Short Wave UV	UVC	280nm ~ 100nm	4.43eV ~ 12.4eV	253.7	Sterilization & disinfection, photochemistry, AOP, pre-curing, light cleaning...
Near UV	NUV	400nm ~ 300nm	3.10eV ~ 4.13eV		
Medium UV	MUV	300nm ~ 200nm	4.13eV ~ 6.20eV		
Far UV	*FUV	200nm ~ 225nm	5.11eV ~ 6.20eV	222	Healthy Sterilization & disinfection
VUV	VUV	200nm ~ 100nm	6.20eV ~ 12.4eV	172、185	Excimer, optical analysis, photochemistry, Photo cleaning, photo oxidation...
Light UV	LUV	100nm ~ 88nm	12.4eV ~ 14.1eV		
Super UV	SUV	150nm ~ 10nm	8.28eV ~ 124eV		
Extreme UV	EUV	121nm ~ 10nm	10.3eV ~ 124eV		UV lithography

* FUV,According to ISO21348, wavelength range 122-200nm; according to IUVA wavelength range 200-225nm.

Advantages of UV sterilization

HF & instant sterilization | Broad spectrum sterilization | No chemical

More UV dose and higher disinfection efficiency.

The reference table of UV doses for common bacteria, mold, protozoa, viruses, and yeasts (bacteria):

Microorganism	UV dose (μw.s/cm²)	
bacteria	**90% (1log reduction)**	**99% (2log reduction)**
Bacillus anthracis	4520	8700
anthrax spores	24320	46200
Bacillus megaterium	2730	5200
paratyphoid bacilli	3200	6100
Bacillus subtilis spores	11600	22000
Bacillus subtilis	5800	11000
Clostridium tetani	13000	22000
Corynebacterium diphtheriae	3370	6510
Salmonella typhi	2140	4100
Salmonella paratyphi	3200	6100
Salmonella Typhimurium	8000	15200
Escherichia coli	3000	6600
Leptospira-infectious jaundice	3150	6000
Legionella pneumophila	6050	12300
Micrococcus sphaeroides	1000	15400
Mycobacterium tuberculosis	6200	10000
Neisseria	4400	8500
Agrobacterium	4400	8000
Proteus vulgaris	3000	6600
Pseudomonas aeruginosa	5500	7600
Pseudomonas fluorescens	3500	6100
Salmonella Enteritidis	4000	4100
Sarcina luteus	19700	26400
Serratia marcescens	2420	6160
Shigella - dysentery	2200	4200
Shigella flexneri - dysentery	1700	3400
Shigella paradysenteriae	1680	3400
red spirillum	4400	6160
Staphylococcus albus	1840	5720
Staphylococcus aureus	2600	6600
Staphylococcus haemolyticus	2160	5500
Streptococcus lactis	6150	8800
viridans streptococci	2000	3800
Vibrio cholerae	3375	6500
mold	**90% (1log reduction)**	**99% (2log reduction)**
Aspergillus flavus	60000	99000
Gray green mold	44000	88000
Aspergillus niger strains	132000	330000
Mucor racemosa A	17000	35200
Mucor racemosa B	17000	35200
Lactooospora	5000	11000
Penicillium expansum	13000	22000
Penicillium loudi	13000	26400
Penicillium digitata	44000	88000
protozoa	**90% (1log reduction)**	**99% (2log reduction)**
Chlorella vulgaris	13000	22000
nematode eggs	45000	92000
Paramecium	11000	20000
Virus	**90% (1log reduction)**	**99% (2log reduction)**
E coli	2600	6600
infectious hepatitis	5800	8000
influenza	3400	6600
poliovirus	3150	6600
Tobacco mosaic disease	240000	440000
Yeast (bacteria)	**90% (1log reduction)**	**99% (2log reduction)**
beer yeast	3300	6600
Common yeast cake	6000	13200
Saccharomyces cerevisiae	6000	13200
Oval yeast	6000	13200
yeast spores	8000	17600

Iradiation Time by UVC

UV sterilization efficiency against common microorganisms (UV radiation intensity 30mJ/cm²)

Types	Names	Iradiation time(s)	Types	Names	Iradiation time(s)
Fish disease	Fungal disease	1.6	**Fish disease**	Infectious pancreatic necrosis disease	4
	Vitiligo	2.67		viral hemorrhagic disease	1.6
Algae	blue-green algae	10-40	**Algae**	Paramecium	7.3
	Chlorella	0.93		green algae	1.22
	nematode eggs	3.4		Protozoa	4-6.70
Bacteria	Bacillus anthracis	0.3	**Bacteria**	Mycobacterium tuberculosis	0.41
	Diphtheria bacilli	0.25		Vibrio cholerae	0.64
	Tetanus bacilli	0.33		Pseudomonas	0.37
	Clostridium botulinum	0.8		Salmonella spp.	0.51
	Shigella dysenteriae	0.15		Enterobacteriaceae	0.41
	E. coli	0.36		Typhimurium	0.53
	Leptospirillum	0.2		Togella	0.28
	Legionella pneumophila	0.2		Staphylococcus	1.23
	Micrococcus	0.4-1.53		Streptococcus	0.45
Viruses	Adenovirus	0.1	**Viruses**	flu virus	0.23
	bacteriophage virus	0.2		poliomyelitis	0.8
	coxsackie virus	0.08		rotavirus	0.52
	AIKO virus	0.73		tobacco mosaic virus	16
	Echovirus type I	0.75		Hepatitis B virus	0.73
Mold spores	Aspergillus niger	6.67	**Mold spores**	Penicillium	2.93-0.87
	Aspergillus niger	0.73-8.80		Toxigenic Penicillium	2.0-3.33
	fecal fungus	8		Penicillium and other fungi	0.87
	Mucor	0.23-4.67			

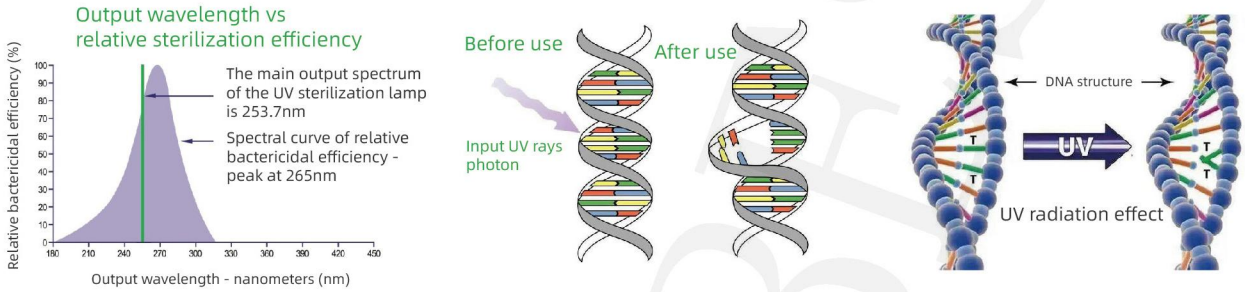
Typical Definition of Lamp Models

L	Ozone-free/253.7nm
VH	Ozone/185nm+253.7nm
G	Germicidal
PH	Preheat
A	Amalgam
V	Vertical
HO	High output,0.8A
HOA	High output,0.8A amalgam
LP	Low pressure
MP	Medium pressure
4P/2P/SP	4-pin, 2-pin,single-pin
T4 T5 T6 T8 T10 T12...	Lamp quartz diameter
C	Coating

Principle of UV Sterilization & Disinfection

UV germicidal lamp emits 90% of the maximum amount of ultraviolet radiation at 253.7nm ultraviolet energy, which is very close to 265nm, which has the strongest sterilization effect on microorganisms. The strongest UV absorption peak of deoxyribonucleic acid (DNA), ribonucleic acid (RNA) and nucleoprotein in bacteria is at 265nm. After bacteria absorb ultraviolet light, it causes the DNA chain to break, causing the cross-linking of nucleic acids and proteins to break, killing the biological activity of nucleic acids, and causing the death of bacteria. It is fast and convenient, and there is no secondary pollution because there is no physical contact.

Commonly used in water treatment, air treatment and surface sterilization and disinfection. UV surface sterilization devices are widely used in food, electronics, semiconductors, liquid crystal displays, plasma TVs, crystal vibrators, precision devices, chemical industry, medicine, health care, biology, beverages, agriculture and other fields. UV light source irradiates the surface of food, materials, etc., and has a fast, efficient, and pollution-free sterilization effect, thereby maintaining the high quality of the product.。



UV Dose

UV dose-D = UV intensity-I * Illumination time-t (D = UV dose-mJ/cm²; I = Irradiation intensity-mW/cm²; t = Irradiation time-s).

The dose of ultraviolet light has a great influence on the inactivation effect of microorganisms.In order to ensure a certain disinfection effect, there are relevant regulations on the dose of ultraviolet light in drinking water and sewage disinfection.The commonly used units are mJ/cm²) or J/m2.

According to relevant research, when the ultraviolet radiation dose of the ultraviolet sterilizer is 15mJ/cm², 99% of bacteria can be killed; when the radiation dose reaches 40mJ/cm², 99.9% of the sterilization effect can be obtained. The minimum dose of UV radiation for drinking water is generally 15~40mJ/cm². The dose for some uses (such as the cosmetics industry) reaches 90~120mJ/cm².

Chinese National UV dose index requirements for ultraviolet sterilizers

Wastewater Sterilization and Disinfection

In order to ensure that the first-level standard A of the hygienic indicators required in GB18918 is achieved, when the SS does not exceed 10mg/L, the UV sterilizer equipment should consider the UV lamp casing structure at the peak flow rate and the end of the UV disinfection lamp operating life. The effective dose of ultraviolet rays that can be achieved after the influence of scale should not be less than 20mJ/cm².

Sterilization and Disinfection of Drinking Water or Purified Drinking Water

When ultraviolet disinfection is used as the main disinfection method for drinking water, the effective dose of ultraviolet rays that can be achieved by the ultraviolet sterilizer at the peak flow rate and at the end of the operating life of the ultraviolet disinfection lamp should not be less than 40mJ/cm² after taking into account the impact of scaling on the ultraviolet lamp sleeve.

Urban Sewage Reuse,Sterilization and Disinfection

When ultraviolet disinfection is used as the main disinfection method for urban miscellaneous water, the effective dose of ultraviolet rays that can be achieved by the ultraviolet sterilizer at the peak flow rate and at the end of the operating life of the ultraviolet disinfection lamp should not be less than 80mJ/cm² after taking into account the impact of scaling on the ultraviolet lamp sleeve.

UV dose regulations for water treatment in other countries

The American National Bureau of Standards and the National Sanitation Foundation stipulate that the lower radiation dose for surface water clarification and filtration is 38mJ/cm².

France and the Netherlands stipulate that the lower radiation dose is 25mJ/cm², Austria stipulates that the lower radiation dose is 30mJ/cm², and Australia stipulates that the disinfection dose of public water supply is 45mJ/cm².

The dose requirements vary according to different water bodies and different disinfection standards, but they basically require a dose higher than 15mJ/cm². That is, it can kill more than 99.9% of microorganisms in water bodies.