UVC-BASED STERILIZATION UNITS AND OTHER INITIATIVES

Prof. Ambarish Kunwar
Department of Biosciences and Bioengineering
Indian Institute of Technology Bombay

akunwar@iitb.ac.in

http://www.bio.iitb.ac.in/~akunwar/

Routes of exposure to infectious agents

- Inhalation of infectious aerosols.
- Contact of the agent with the skin, eyes or mucous membrane.
- Inoculation by contaminated sharps.
- Bites from infected animals or contact with their body fluids.
- Ingestion of infectious agent through mouth pipetting or contaminated hands.

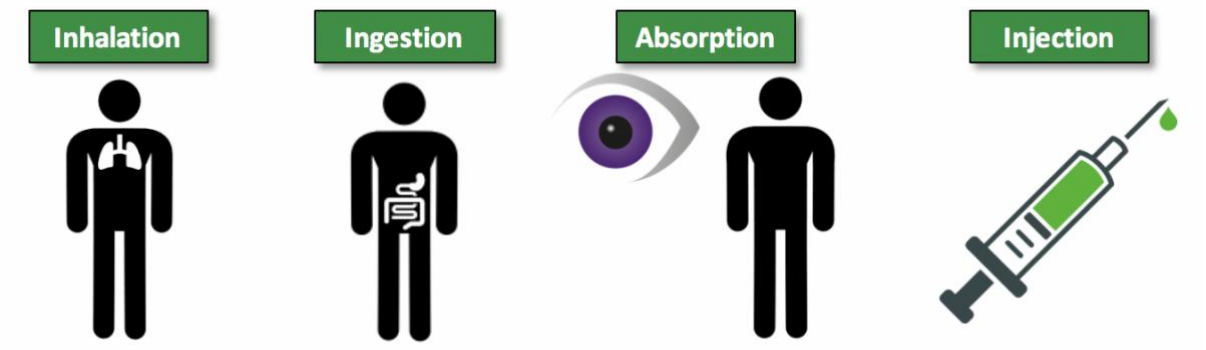


Figure Source: https://riskmanagement.unt.edu/hcs-ghs-module2

Routes of exposure to infectious agents: Aerosols and fomite

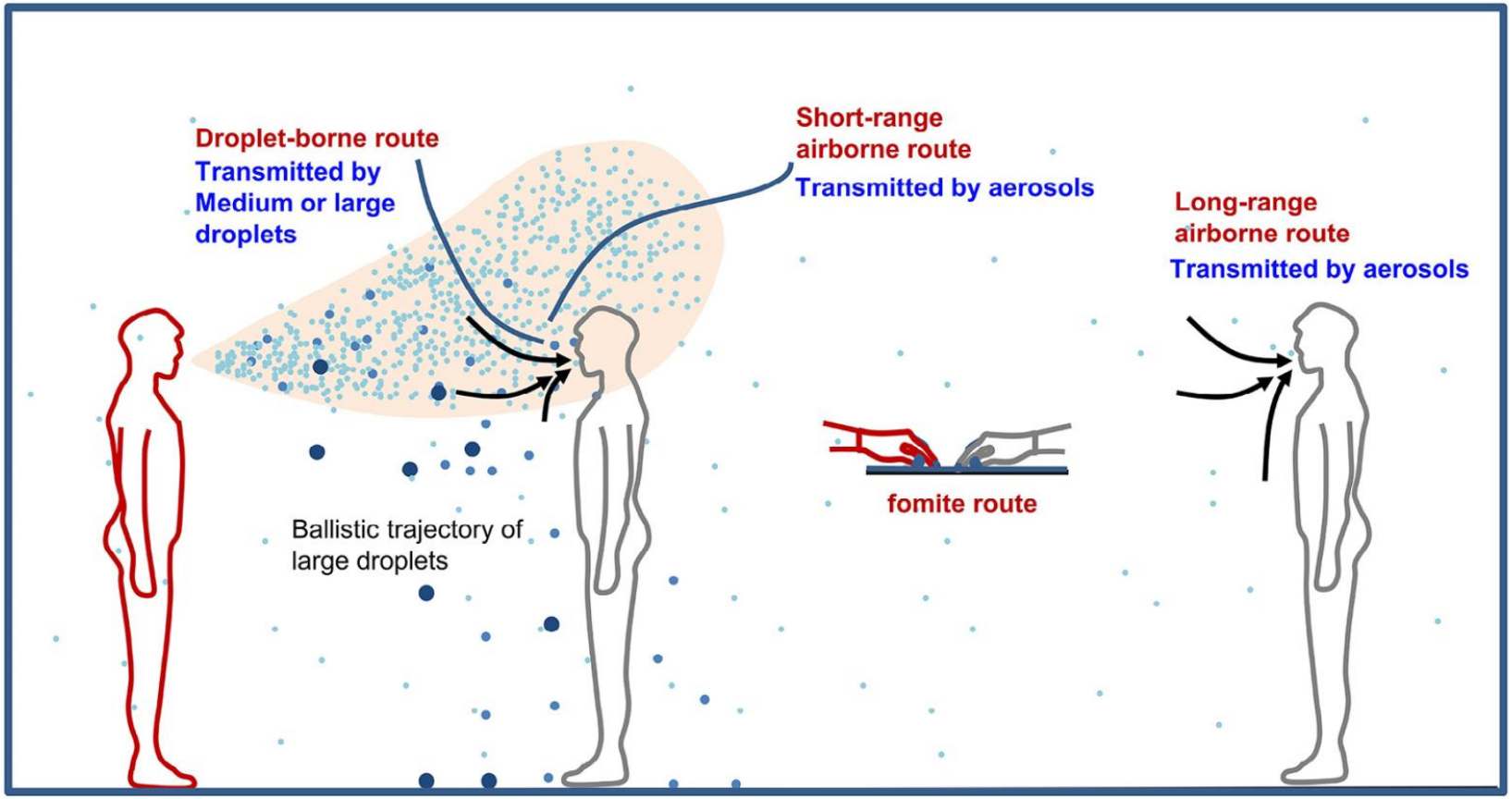
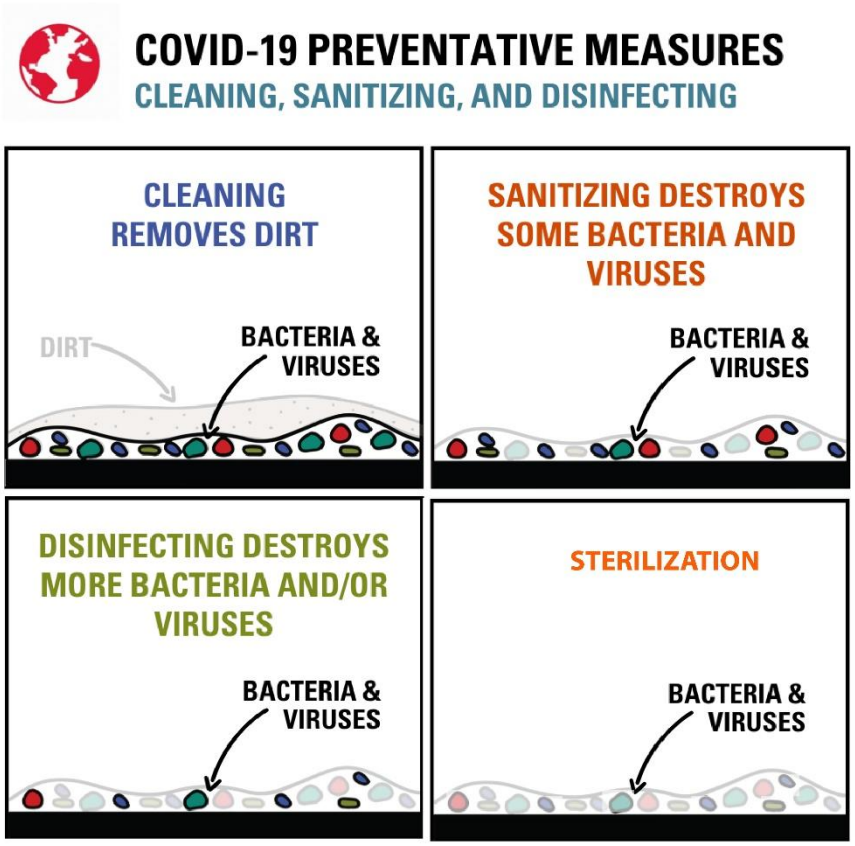


Figure Source: J. Wei, Y. Li / American Journal of Infection Control 44 (2016) S102-S108

Cleaning, Sanitization, Disinfection and Sterilization



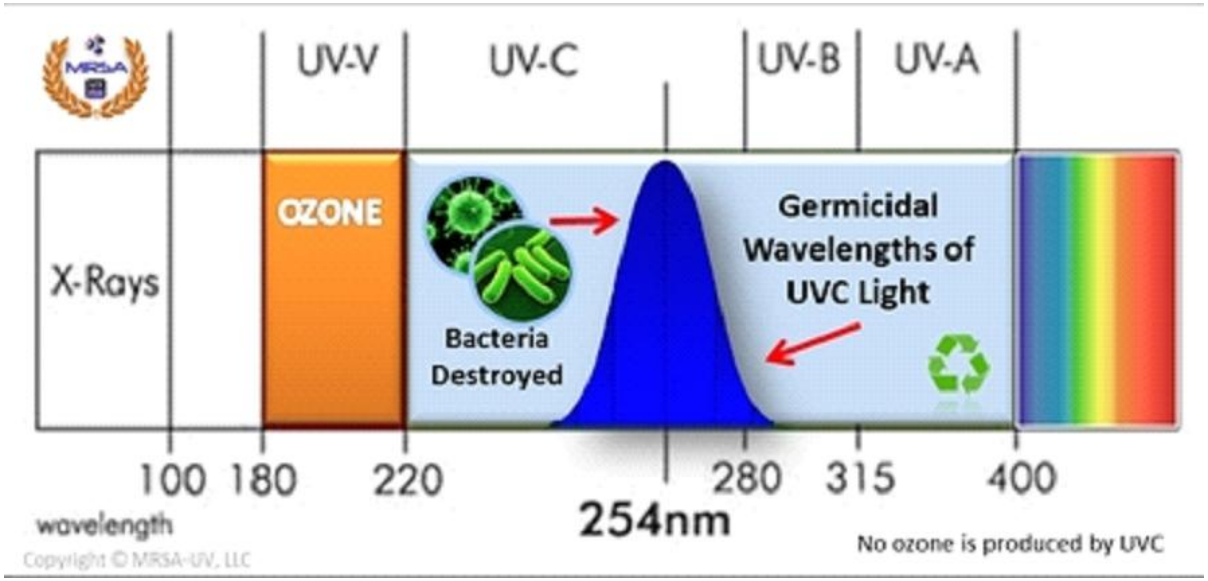
Adapted from: https://foodsafety.ces.ncsu.edu/2020/04/cleaning-and-disinfecting/

Methods of Sterilization

- Dry Heat Sterilization

- Steam Sterilization –autoclaves
- Chemical Sterilization-Alochol, Bleach, Sodium Hypochorite etc.
- Filtration
- Gas Sterilization-Ozone, Hydrogen Peroxide Vapour etc.
- Sterilization via ionizing radiation – Gamma radiation, X-ray
- Sterilization via non-ionizing radiation- UV radiation

UV radiation



UV-A (long-wave)	from 315 to 400 nm
UV-B (medium-wave)	from 280 to 315 nm
UV-C (short-wave)	from 100 to 280 nm

Germicidal action of UV radiation

- The mechanism of UVC inactivation of microorganisms is to damage the genetic material in the nucleus of the cell or nucleic acids in the virus.
- The UV damage to the DNA and RNA of a microorganism often results from the dimerization of pyrimidine molecules. In particular, thymine (which is only found only in DNA) produces cyclobutane dimers.

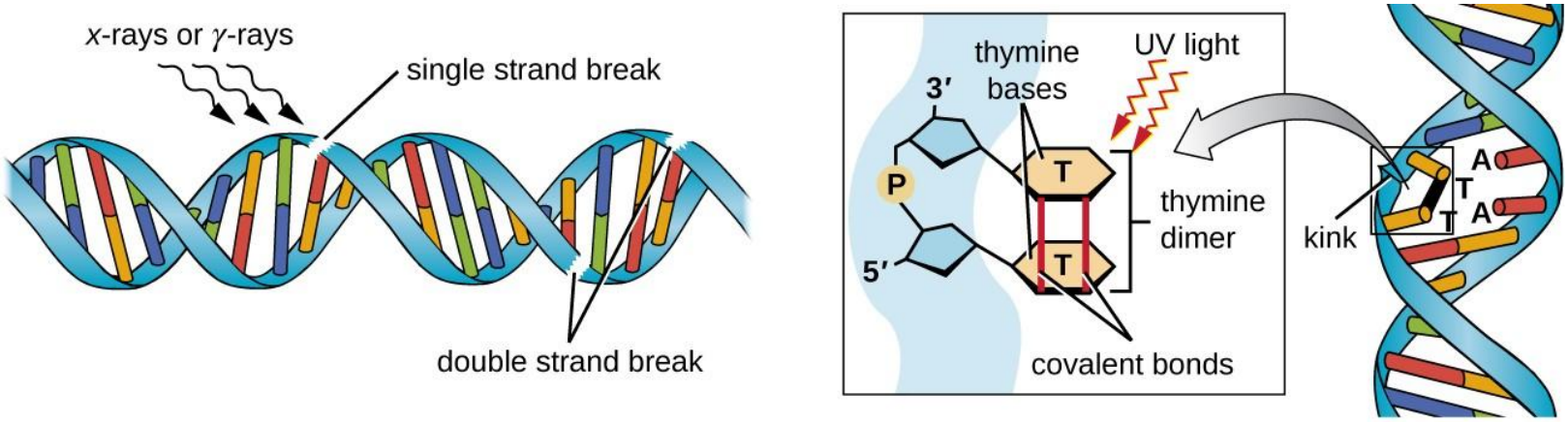
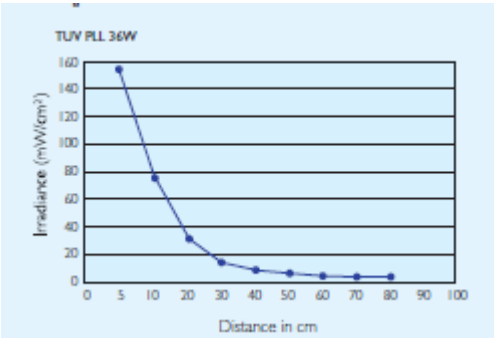


Figure Source: https://courses.lumenlearning.com/microbiology/chapter/mutations/

UV Dose and Log Inactivation

UV Dose = Irradiance x time

joule/ m^2 watt/m^2 sec



Log Inactivation = log N(0)/N(t)

1 log inactivation = 90% killing

2 log inactivation = 99% killing

3 log inactivation = 99.9% killing

4 log inactivation = 99.99% killing

5 log inactivation = 99.999% killing

Figure Source: https://www.assets.signify.com/is/content/PhilipsLighting/Assets/philips-lighting/global/20200504-philips-uv-purification-application-information.pdf

UV Dose (1 log inactivation)

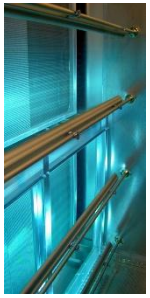
Bacteria	Dose	k
Bacillus anthracis	45.2	0.051
B. megatherium sp. (spores)	27.3	0.084
B. megatherium sp. (veg.)	13.0	0.178
B. parathyphosus	32.0	0.072
B. suptilis	71.0	0.032
B. suptilis spores	120.0	0.019
Campylobacter jejuni	11.0	0.209
Clostridium tetani	120.0	0.019
Corynebacterium diphteriae	33.7	0.069
Dysentery bacilli	22.0	0.105
Eberthella typhosa	21.4	0.108
Escherichia coli	30.0	0.077
Klebsiella ternifani	26.0	0.089
Legionella pneumophila	9.0	0.256
Micrococcus candidus	60.5	0.038
Micrococcus sphaeroides	100.0	0.023
Mycobacterium tuberculosis	60.0	0.038
Neisseria catarrhalis	44.0	0.053
Phytomonas tumefaciens	44.0	0.053
Pseudomonas aeruginosa	55.0	0.042
Pseudomonas fluorescens	35.0	0.065
Proteus vulgaris	26.4	0.086
Salmonella enteritidis	40.0	0.058
Salmonella paratyphi	32.0	0.072
Salmonella typhimurium	80.0	0.029
Sarcina lutea	197.0	0.012
Seratia marcescens	24.2	0.095
Shigella paradysenteriae	16.3	0.141
Shigella sonnei	30.0	0.077
Spirillum rubrum	44.0	0.053
Staphylococcus albus	18.4	0.126
Staphylococcus aureus	26.0	0.086
Streptococcus faecalis	44.0	0.052
Streptococcus hemoluticus	21.6	0.106
Streptococcus lactus	61.5	0.037
Streptococcus viridans	20.0	0.115
S.entertidis	40.0	0.057
Vibrio chlolerae (V.comma)	35.0	0.066
Yersinia enterocolitica	11.0	0.209

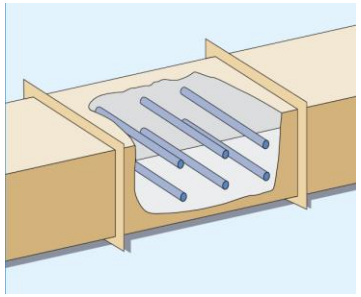
Yeasts	Dose	k
Bakers' yeast	39	0.060
Brewers' yeast	33	0.070
Common yeast cake	60	0.038
Saccharomyces cerevisiae	60	0.038
Saccharomyces ellipsoideus	60	0.038
Saccharomyces sp.	80	0.029
Mould spores		
Aspergillus flavus	600	0.003
Aspergillus glaucus	440	0.004
Aspergillus niger	1320	0.0014
Mucor racemosus A	170	0.013
Mucor racemosus B	170	0.013
Oospora lactis	50	0.046
Penicillium digitatum	440	0.004
Penicillium expansum	130	0.018
Penicillium roqueforti	130	0.018
Rhizopus nigricans	1110	0.002
Virus		
Hepatitis A	73	0.032
Influenza virus	36	0.064
MS-2 Coliphase	186	0.012
Polio virus	58	0.040
Rotavirus	81	0.028
Protozoa		
Cryptosporidium parvum	25	0.092
Giardia lamblia	11	0.209
Algae		
Blue Green	3000	0.0008
Chlorella vulgaris	120	0.019

Figure Source: https://www.assets.signify.com/is/content/PhilipsLighting/Assets/philips-lighting/global/20200504-philips-uv-purification-application-information.pdf

Applications of UV disinfection

Water
Domestic water
Ultra pure water
Waste water
Process water
Industrial drinking water
Fish ponds
Aquaria
Swimming pool
Agricultural recycling
Air
Space/upper air
Forced air/airco
Cooling coils
Dish dryer etc.
Surfaces
Food processing
Packaging





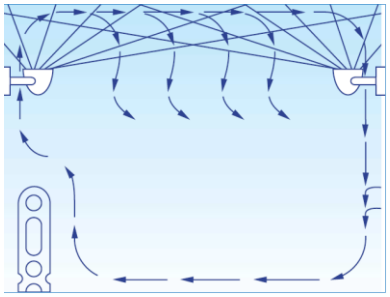


Figure Source: https://www.assets.signify.com/is/content/PhilipsLighting/Assets/philips-lighting/global/20200504-philips-uv-purification-application-information.pdf

UVC-based Sterilization Solutions developed at IIT Bombay

- Existing liquid based method: soap solutions, alcohol based sanitizer, beach solution, steam are not suitable due to presence of various delicate materials/electronics and time/error involved in manual disinfection

- The germicidal effect of UV-C light is well recognized and it kills various types of pathogenic bacteria and viruses including emerging viruses such (SARS-CoV), Crimean-Congo haemorrhagic fever virus (CCHFV) and Nipah virus (NiV).

Similar articles

Inactivation of Ebola virus and Middle East respiratory syndrome coronavirus in platelet concentrates and plasma by ultraviolet C light and methylene blue plus visible light, respectively.

Eickmann M, Gravemann U, Handke W, Tolksdorf F, Reichenberg S, Müller TH, Seltsam A.

Transfusion. 2018 Sep;58(9):2202-2207. doi: 10.1111/trf.14652. Epub 2018 May 6.

PMID: 29732571

Reduction of Zika virus infectivity in platelet concentrates after treatment with ultraviolet C light and in plasma after treatment with methylene blue and visible light.

Fryk JJ, Marks DC, Hobson-Peters J, Watterson D, Hall RA, Young PR, Reichenberg S, Tolksdorf F, Sumian C, Gravemann U, Seltsam A, Faddy HM.

Transfusion. 2017 Nov;57(11):2677-2682. doi: 10.1111/trf.14256. Epub 2017 Jul 17.

PMID: 28718518

Inactivation of yellow fever virus in plasma after treatment with methylene blue and visible light and in platelet concentrates following treatment with ultraviolet C light.

Faddy HM, Fryk JJ, Hall RA, Young PR, Reichenberg S, Tolksdorf F, Sumian C, Gravemann U, Seltsam A, Marks DC.

Transfusion. 2019 Jul;59(7):2223-2227. doi: 10.1111/trf.15332. Epub 2019 May 3.

PMID: 31050821

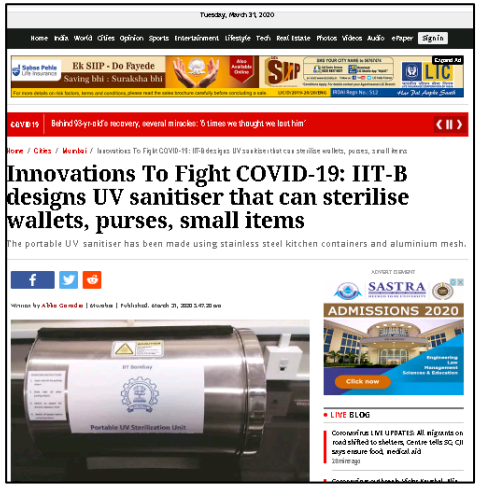
Portable UV Sterilization Unit

- Portable UV sterilization unit is cylindrical unit with approximate diameter 25 cm and length 36 cm. It uses one single germicidal UV tube.

- Portable UV sterilization unit provides > 4 log inactivation of MS2 Phase for UV exposure of 90 seconds

Collaborators: Prof. Kiran Kondabagil and Prof. P. Kumaresan
Financial Support: IRCC, IIT Bombay

Portable UV Sterilization Unit


Tuesday, March 31, 2020

Innovations To Fight COVID-19: IIT-B designs UV sanitiser that can sterilise wallets, purses, small items

The portable UV sanitiser has been made using stainless steel kitchen containers and aluminium mesh.

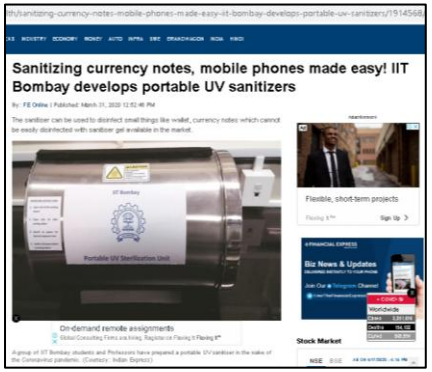

hindustantimes

Covid-19: IIT-b makes prototype of uv sanitisers for phones, wallets


Burials to be allowed, with riders

IIT-B develops mask for staff, portable sanitiser

Schools can't ask for fees until lockdown


Sanitizing currency notes, mobile phones made easy! IIT Bombay develops portable UV sanitizers


कोरोना: आईआईटी बॉम्बे ने बनाया पोर्टेबल यूवी सैनिटाइजर, जानें- खासियत

- Product is available for non-exclusive licensing
- Non-exclusive license has been given to one company so far

Germicidal UV Cabinet

- This cabinet has approximate volume of 45cm X 45 cm X 35 cm.
- Experiment conducted in our lab using MS2 phage with this sterilization unit shows that 3 minutes second of exposure completely eliminates them (> log 7 inactivation)

Collaborators: Prof. Kiran Kondabagil
Financial Support: IRCC, IIT Bombay

Germicidal UV Cabinet

- Prototype is being used by IIT Hospital
- Product is available for non-exclusive licensing
- Non-exclusive license has been given to one company so far

Wheeled sterilization Unit for large areas

- This unit can be used in empty rooms/area by an outside operator using proper safety guidelines.
- Experiment conducted in our lab with this sterilization unit shows that 900 second of exposure completely eliminates using MS2 phage within 1 meter radius.

Collaborator: Prof. Kiran Kondabagil

Wheeled sterilization Unit for large areas

IIT मुंबई ने विकसित किया यूवी सैनिटाइजर

बड़े क्षेत्रों को संक्रमण रहित करने में मिलेगी मदद

रोबोट संस्करण विकसित करने की योजना

लोकसत्ता

निर्जंतुकीकरणासाठी आयआयटीचं नवं उपकरण!

रिमोटवर चालणारं

सॅनिटाइझेशन यंत्र

आयआयटीच्या विद्यार्थ्यांनी केलं संशोधन

- Prototype is being used by IIT Hospital
- Product is available for non-exclusive licensing
- Non-exclusive license has been given to one company so far

Wheeled sterilization Unit for large areas

IIT मुंबई ने विकसित किया यूवी सैनिटाइजर

बड़े क्षेत्रों को संक्रमण रहित करने में मिलेगी मदद

रोबोट संस्करण विकसित करने की योजना

लोकसत्ता

निर्जंतुकीकरणासाठी आयआयटीचं नवं उपकरण!

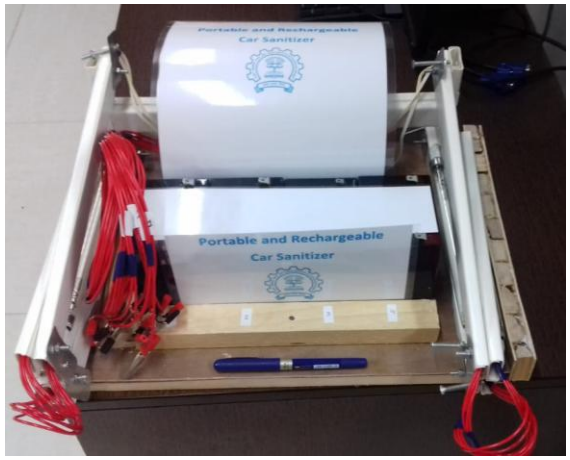
रिमोटवर चालणारं

सॅनिटाइझेशन यंत्र

आयआयटीच्या विद्यार्थ्यांनी केलं संशोधन

- Prototype is being used by IIT Hospital
- Product is available for non-exclusive licensing
- Non-exclusive license has been given to one company so far

Portable and Rechargeable Car Sanitizer



- This car sanitizer is currently powered via four 12V rechargeable batteries and total run-time depends on the battery's capacity.

- This prototype provides 9 log inactivation (99.9999999% inactivation) of MS2 Phage samples kept under directly illuminated zones inside the car in 35 minutes.

Collaborator: Prof. Kiran Kondabagil

Safe Biohazard Transporter

- This safe biohazard transporter is powered by single 12V rechargeable battery.
- The transporter can be used for inactivation, transport as well as safe disposal of solid and some liquid biohazards.
- This prototype is currently being used by proteomics lab to bring inactivated COVID samples from hospital.

Collaborator: Prof. Kiran Kondabagil

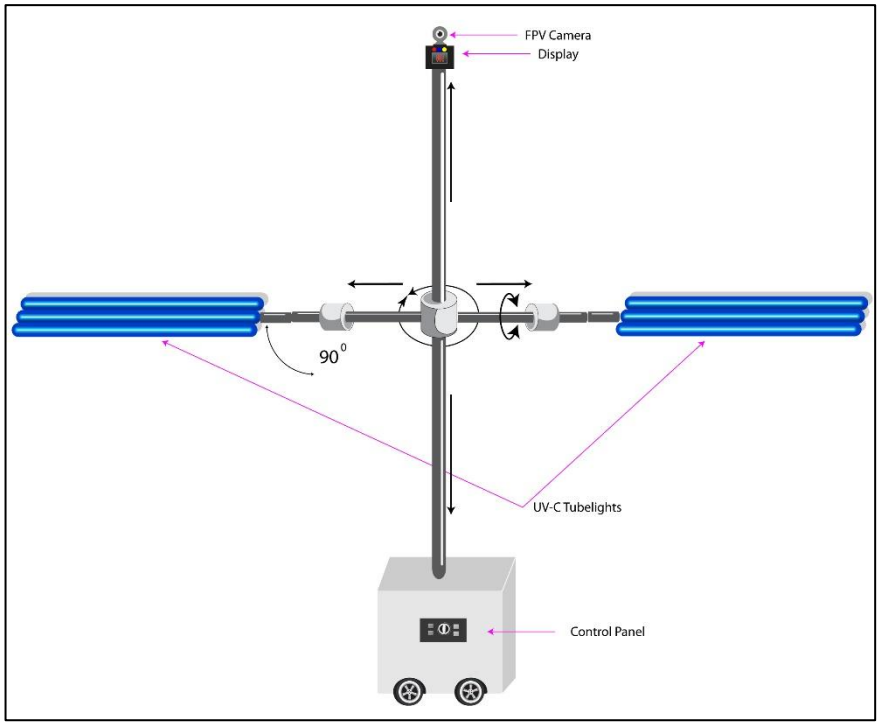
Expertise related to UVC Sterilization

- Consultancy project for UVC sterilization units
- Calculation of UVC dose via modeling
- Measurement of UVC dose
- Inactivation of pathogens (bacterial, virus and spores)

Collaborator: Prof. Kiran Kondabagil

Ongoing Project: Robotic UVC Sterilization Unit

Construction and Validation of Robotic UVC Sterilization Unit for Inactivating Coronavirus and Other Pathogens inside public transport system and hospital rooms



Collaborators: Prof. Leena Vachhani, Prof. Anirban Guha and Prof. Kiran Kondabagil

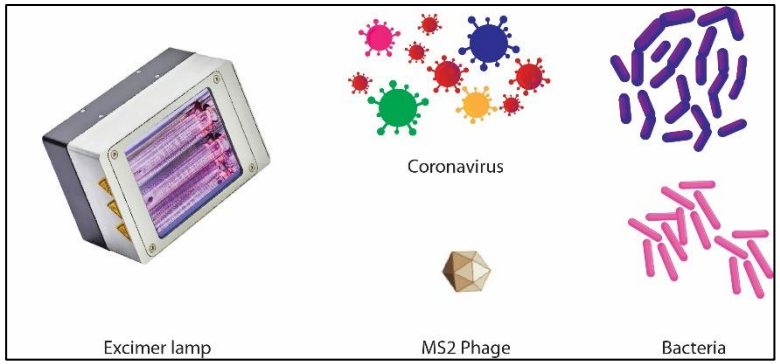
Funding: Wadhwani Research Centre for Bioengineering IIT Bombay

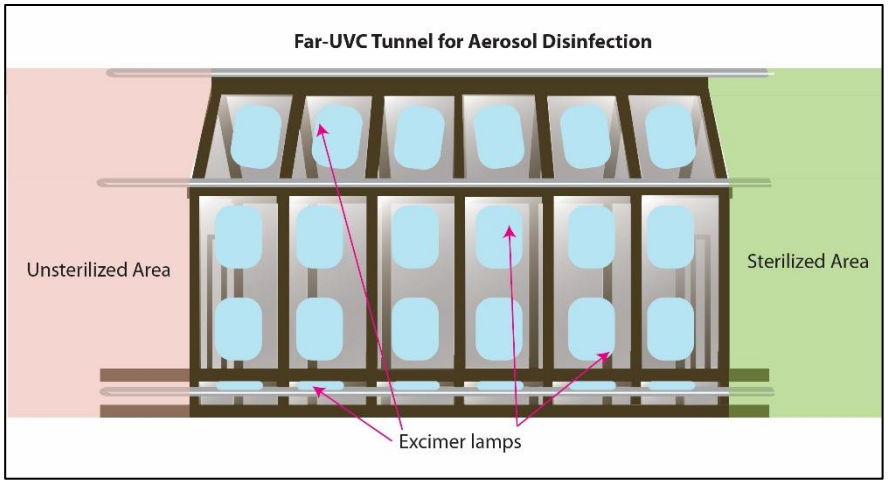
Other initiatives: Using Far-UVC radiation for sterilization

- Far-UVC radiation is emitted by excimer lamps
- It has been shown that far-UVC could kill pathogens without damaging mammalian skin. Far-UVC light is very unlikely to be a human health hazard as it penetrates through the outer dead-cell layer of human skin or the tear layer in the eye.
- It has been shown that far-UVC light 207-222 nm efficiently inactivates bacteria without harm to exposed mammalian skin.
- Besides, it has been also shown that far-UVC efficiently inactivates the aerosolized H1N1 influenza virus and human coronaviruses.
- Long-term effects of far-UVC lamps on mice suggest that far-UVC light produces DNA lesions only in the uppermost layer of the epidermis.

Future Directions: Using Far-UVC radiation for sterilization

LoI entitled "***Construction and Validation of Far-UVC Tunnels for Inactivating Coronavirus and Other Pathogens in Public Places***" submitted under COVID-19 Research Consortium call to BIRAC has successfully cleared the rigorous technical evaluation process and is **Recommended for support subject to financial, IP and legal clearances.**





Collaborator: Prof. Kiran Kondabagil and Prof. Shamik Sen
Industry Partners: Arklite and Litex

Other initiatives : Bio-safety Training

o TEQIP-II Course “Technical Skills for Non-teaching Staff Members“, March 20-23, 2017, IIT Bombay

o QIP Course “Laboratory and Ergonomics Safety For Engineers“, June 12-16, 2017, IIT Bombay

o QIP Course “Laboratory and Ergonomics Safety For Engineers“, June 11-15, 2018, IIT Bombay

o QIP/CEP Course “Laboratory and Ergonomics Safety For Engineers“, June 10-14, 2019, IIT Bombay

o CEP Course “Laboratory and Ergonomics Safety For Engineers“, August 05-09, 2019, IIT Bombay

Other initiatives : Bio-safety Training

Conducted webinar titled "**Achieving Bio-safety in COVID-19 times**" for employees of Bank of Baroda under "**Bank of Baroda-IIT Bombay innovation centre**"

https://www.youtube.com/watch?v=rpqg2GSUKGM

https://www.youtube.com/watch?v=LRy5PWvc_oE

Faculty: Prof. Neeta kanekar, Prof. Kiran Kondabagil and Prof. Ambarish Kunwar

THANK YOU