2020 COVID-19 Coronavirus Ultraviolet Susceptibility

Technical Report · March 2020

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Memo from the Authors
The current global Coronavirus pandemic is of urgent concern with its high transmission rate and rapid spread throughout the world. The current reported death rate is 2-3% and there currently is no antiviral drugs or vaccine available to the public. Structurally, this virus is not unique and is similar to other coronaviruses such as Severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS), and can be addressed with existing disinfection methods such as chemicals and new technologies such as Focused Multivector Ultraviolet (FMUV) from PurpleSun.

Answers to Frequently Asked Questions

1. **How long does COVID-19 Live on Surfaces?**
   6 hours - 9 days on surfaces
2. **What is the difference between a virus and bacteria?**
   Bacteria are self-contained, have cell walls, and can survive and replicate on their own. Viruses are DNA molecules that may be naked or encapsulated and require a host to replicate. They cannot be treated with antibiotics and require a vaccine
3. **What is the biggest issue with this COVID-19 virus?**
   High secondary infection rate, Rapid spread (more rapid than SARS or MERS), Fatality rate (2-3%)
4. **Is ultraviolet light effective against COVID-19?**
   Ultraviolet light destroys DNA of viruses, bacteria, and fung
5. **What is the appropriate Personal Protective Equipment (PPE) for healthcare staff?**
   https://www.cdc.gov/coronavirus/2019-ncov/downloads/COVID-19-PPE.pdf

General Explanation of the Disease
COVID-19 is the respiratory disease caused by the SARS-CoV-2 virus that has caused outbreaks worldwide. The SARS-CoV-2 is a new variant in the betacoronavirus family (Fisher 2020). It transmits by direct contact or contact with fomites and can be suspended in air as well, as are the related betacoronaviruses SARS, MERS, and the four known Human coronaviruses – OC43, 229E, NL63, and HKU1. The majority of infection transmissions are believed to be by droplet spray from coughing and sneezing and by direct contact or contact with fomites.

Confirmation That Ultraviolet is Effective
Ultraviolet light can be an effective measure for decontaminating surfaces that may be contaminated by the SARS-CoV-2 virus by inducing photodimers in the genomes of microorganisms. Ultraviolet light has been demonstrated to be capable of destroying viruses, bacteria and fungi in hundreds of laboratory studies (Kowalski 2009). The SARS-CoV-2 virus has not yet been specifically tested for its ultraviolet susceptibility but many other tests on related coronaviruses, including the SARS coronavirus, have concluded that they are highly susceptible to ultraviolet inactivation. This report reviews these studies and provides an estimate of the ultraviolet susceptibility.

It is estimated that the SARS-CoV-2 virus can survive on surfaces for up to 9 days, based on its similarity to SARS and MERS. Standard disinfectants are effective against SARS-CoV-2 but as an extra level of protection, and to shield against errors in the manual disinfection process, ultraviolet light can be used to disinfect surfaces and equipment after the manual chemical disinfection process is completed. ASHRAE recommends ultraviolet germicidal irradiation as one strategy to address COVID-19 disease transmission (ASHRAE 2020).

COVID-19 is highly contagious and so any residual contamination, no matter how small, can pose a threat to healthcare workers and patients. The PurpleSun E300 Focused Multivector Ultraviolet (FMUV) system with Shadowless Delivery™ (see Figure 1) is an automated system that has proven to reduce surface contamination by 96% and can address contamination left behind by current manual chemical cleaning which was shown to only reduce contamination by 36% (Armellino 2020).

The PurpleSun E300 system has demonstrated elimination of 99%-99.99% of bacteria and fungi as listed in Table 2 in laboratory tests within 90 seconds (Petraitis 2017). Similar reductions could be expected against the COVID-19 coronavirus in 90 seconds as well.

Scientific Rationale

Coronaviruses are members of the Coronaviridae group and contain a single-stranded, positive-sense RNA genome surrounded by a corona-like helical envelope (Ryan 1994). Approximately 100 sequences of the SARS-CoV-2 genome have been published and these suggest there are two types, Type I and Type II, of which the latter came from the Huanan market in China while the Type I strain came from an unknown location (Zhang 2020). The genome consists of 29,751 base pairs (NC_045512.2) and the genome is about 80% homologous with SARS viruses (NCBI 2020, Fisher 2020). Coronaviruses have a size range of 60-140nm, with a mean size of 0.10 microns (Zhu 2020).

Table 1 summarizes the results of studies that have been performed on Coronaviruses under ultraviolet light exposure, with the specific species indicated in each case. The D90 value indicates the ultraviolet dose for 90% inactivation. Although there is a wide range of variation in the D90 values, this is typical of laboratory studies on ultraviolet susceptibility. The range of D90 values for coronaviruses is 7-2410 J/m^2 and the average of all studies is 237 J/m2. However, the study by Walker (2007) is an airborne study and is an outlier in this set of water-based studies. Also, the studies by Weiss (1986) and Darnell (2004) are outliers on the low and high ends. Excluding outliers, the mean D90 is 47 J/m^2, and this should adequately represent the ultraviolet susceptibility of the SARS-CoV-2 (COVID-19) virus.

Two recent studies on SARS-CoV-2 have been added to Table 1 (Inagaki 2020, Bianco 2020). The average value of the D90 is 27 J/m^2, which suggests the average value for all coronaviruses reported above (47 J/m^2) is conservative. Both of these studies indicate tailing in the survival curve above about 3-6 logs of reduction, beyond which the D90 value will not be an accurate predictor (Blatchley 2020).

Table 1: Summary of Ultraviolet Studies on Coronaviruses

Microbe	D_{90} Dose J/m^2	UV k m^2/J	Base Pairs kb	Source
Coronavirus	6.6	0.35120	30741	Walker 2007[a]
Berne virus (Coronaviridae)	7.2	0.32100	28480	Weiss 1986
SARS-CoV-2 (Italy-INMI1)	12.3	0.18670	29811	Bianco 2020
Murine Coronavirus (MHV)	15.0	0.15351	31335	Hirano 1978
SARS Coronavirus (Frankfurt 1)	16.4	0.14040	29903	Eickmann 2020
Canine Coronavirus (CCV)	28.5	0.08079	29278	Saknimit 1988[b]
Murine Coronavirus (MHV)	28.5	0.08079	31335	Saknimit 1988[b]
SARS Coronavirus (CoV-P9)	40.0	0.05750	29829	Duan 2003[c]
SARS-CoV-2 (SARS-CoV-2/Hu/DP/Kng/19-027)	41.7	0.05524	29811	Inagaki 2020
Murine Coronavirus (MHV)	103.0	0.02240	31335	Liu 2003
SARS Coronavirus (Hanoi)	133.9	0.01720	29751	Kariwa 2004[d]
SARS Coronavirus (Urbani)	2410	0.00096	29751	Darnell 2004
Average	**237**	**0.00972**	including all studies	
Average excluding outliers	**47**	**0.04943**	excluding Walker, Weiss & Darnell	
Average for SARS-CoV-2	**27**	**0.08528**	two studies, 90% inactivation	

[a] *(Jingwen 2020)* [b] *(estimated)* [c] *(mean estimate)* [d] *(at 3 logs)*

Table 2: Performance of the FMUV System against Bacteria and Vegetative Fungi

Bacteria (Yellow) or Vegetative Fungi (Green)	D90 J/m^2	Survival (CFU) at Exposure Time, seconds						
		0	5	15	30	60	90	120
Multidrug-resistant Pseudomonas aeruginosa	26	1500	400	0				
Methicillin-resistant Staphylococcus aureus (MRSA)	40	8200	1900	0				
ESBL-producing Escherichia coli	26	18000	1000	10	0			
Candida parapsilopsis	98	2300	300	11	0			
Vancomycin-resistant Enterococcus faecium (VRE)*	120	1800	800	100	0			
Fusarium solani	313	1700	1100	300	0			
Carbapenemase-resistant Klebsiella pneumoniae (KPC)	52	7200	2100	28	4	0		
Acinetobacter baumannii	18	4200	1900	38	10	0		
Candida albicans	374	3000	2800	700	32	0		
Clostridioides (Clostridium) difficile	38	2800	2600	1000	20	0		
Aspergillus fumigatus	560	2700	2700	2200	1200	100	10	0

Figure 1: The PurpleSun E300 FMUV system in PACT configuration for transport or storage (Left), CUBE configuration for surrounding smaller equipment (Center), and RECTAN mode for surrounding larger equipment (Right).

Updated on July 7, 2020 by:

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2015: https://www.researchgate.net/publication/284691618_SARS_Coronavirus_UV_Susceptibility

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