

Stability of SARS-CoV-2 in different environmental conditions

Alex W.H. Chin, Julie T.S. Chu, Mahen R.A. Perera, Kenrie P.Y. Hui, Hui-Ling Yen, Michael C.W. Chan, Malik Peiris, Leo L.M. Poon*

School of Public Health, LKS Faculty of Medicine, The University of Hong Kong, Hong Kong Special Administrative Region, China.

* Corresponding authors:

- Leo Poon, School of Public Health, LKS Faculty of Medicine, The University of Hong Kong, Hong Kong SAR, China. E-mail: llmpoon@hku.hk

To the Editor,

We previously reported the detection of SARS-CoV-2 in different clinical samples¹. This virus can be detected on different surfaces in a contaminated site². Here, we report the stability of SARS-CoV-2 in different environmental conditions.

We first determined the stability of SARS-CoV-2 at different temperatures. SARS-CoV-2 in virus transport medium (VTM; final concentration: ~ 6.8 log TCID₅₀/mL) was incubated for up to 14 days and then tested for its infectivity (Table A). The virus is highly stable at 4°C, but sensitive to heat. At 4°C, there was only ~ 0.7 -log unit reduction of infectious titre on Day 14. With the incubation temperature being increased to 70°C, the time for virus inactivation was reduced to 5 minutes.

We further investigated the stability of this virus on different surfaces. In brief, a 5- μ L droplet of virus culture (~ 7.8 Log unit of TCID₅₀/mL) was pipetted on a surface (Table B; $\sim 1\text{cm}^2$ per piece) and left at room temperature (22°C; Relative humidity: $\sim 65\%$). The inoculated objects retrieved at desired time points were immediately soaked with 200 μ L of VTM for 30 minutes to elute the virus. No infectious virus could be recovered from printing and tissue papers after a 3-hour incubation, whereas no infectious virus could be detected from treated wood and cloth on Day 2. By contrast, SARS-CoV-2 was more stable on smooth surfaces. No infectious virus could be detected from treated smooth surfaces on Day 4 (glass and banknote) or Day 7 (stainless steel and plastic). Strikingly, a significant level of infectious virus could still be detected on the outer layer of a surgical mask on Day 7 ($\sim 0.1\%$ of the original inoculum). Interestingly, a biphasic decay of infectious SARS-CoV-2 could be found from samples recovered from these smooth surfaces (Appendix). Representative negative samples were tested positive by RT-PCR³ (N=39; data not shown), demonstrating that non-infectious viruses could be recovered by the eluents.

We also tested the virucidal effects of disinfectants by adding 15 μ L of SARS-CoV-2 culture (~ 7.8 Log unit of TCID₅₀/mL) to 135 μ L of various disinfectants at working concentration (Table C). With the exception of a 5-min incubation with hand soap, no infectious virus could be detected after a 5-minute incubation at room temperature. In addition, we also found that

SARS-CoV-2 is extremely stable in a wide-range of pH values at room temperature (pH3-10; Table D)

Overall, SARS-CoV-2 can be highly stable in a favourable environment⁴, but it is also susceptible to standard disinfection methods.

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References:

1. Pan Y, Zhang D, Yang P, Poon LLM, Wang Q. Viral load of SARS-CoV-2 in clinical samples. *Lancet Infect Dis* (2020) published online Feb 24. [https://www.thelancet.com/journals/laninf/article/PIIS1473-3099\(20\)30113-4/fulltext](https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30113-4/fulltext)
2. Ye G, Lin H, Chen L. et al. Environmental contamination of the SARS-CoV-2 in healthcare premises: An urgent call for protection for healthcare workers. *medRxiv* 2020.03.11.20034546; doi: <https://doi.org/10.1101/2020.03.11.20034546>
3. Chu DKW, Pan Y, Cheng SMS, et al. Molecular Diagnosis of a Novel Coronavirus (2019-nCoV) Causing an Outbreak of Pneumonia. *Clin Chem* (2020) published online Jan 31. <https://academic.oup.com/clinchem/advance-article/doi/10.1093/clinchem/hvaa029/5719336>
4. van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *N Engl J Med* (2020) published online March 17. https://www.nejm.org/doi/full/10.1056/NEJMc2004973?query=featured_home

Table. Stability of SARS-CoV-2 at different environmental conditions.

Time	Virus titre (Log TCID ₅₀ /mL)									
	4°C		22°C		37°C		56°C		70°C	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
1 min	N.D.	N.D.	6.51	0.27	N.D.	N.D.	6.65	0.1	5.34	0.17
5 mins	N.D.	N.D.	6.7	0.15	N.D.	N.D.	4.62	0.44	U	-
10 mins	N.D.	N.D.	6.63	0.07	N.D.	N.D.	3.84	0.32	U	-
30 mins	6.51	0.27	6.52	0.28	6.57	0.17	U	-	U	-
1 hr	6.57	0.32	6.33	0.21	6.76	0.05	U	-	U	-
3 hrs	6.66	0.16	6.68	0.46	6.36	0.19	U	-	U	-
6 hrs	6.67	0.04	6.54	0.32	5.99	0.26	U	-	U	-
12 hrs	6.58	0.21	6.23	0.05	5.28	0.23	U	-	U	-
1 day	6.72	0.13	6.26	0.05	3.23	0.05	U	-	U	-
2 days	6.42	0.37	5.83	0.28	U	-	U	-	U	-
4 days	6.32	0.27	4.99	0.18	U	-	U	-	U	-
7 days	6.65	0.05	3.48	0.24	U	-	U	-	U	-
14 days	6.04	0.18	U	-	U	-	U	-	U	-

A) Temperature*

B) Surfaces*

Time	Virus titre (Log TCID ₅₀ /mL)									
	Paper		Tissue paper		Wood		Cloth		Glass	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
0 min	4.76	0.10	5.48	0.10	5.66	0.39	4.84	0.17	5.83	0.04
30 mins	2.18	0.05	2.19	0.17	3.84	0.39	2.84	0.24	5.81	0.27
3 hrs	U	-	U	-	3.41	0.26	2.21"	-	5.14	0.05
6 hrs	U	-	U	-	2.47	0.23	2.25	0.08	5.06	0.31
1 day	U	-	U	-	2.07"	-	2.07"	-	3.48	0.37
2 days	U	-	U	-	U	-	U	-	2.44	0.19
4 days	U	-	U	-	U	-	U	-	U	-
7 days	U	-	U	-	U	-	U	-	U	-

Time	Banknote		Stainless steel		Plastic		Mask, inner layer		Mask, outer layer	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
0 min	6.05	0.34	5.80	0.02	5.81	0.03	5.88	0.69	5.78	0.10
30 mins	5.83	0.29	5.23	0.05	5.83	0.04	5.84	0.18	5.75	0.08
3 hrs	4.77	0.07	5.09	0.04	5.33	0.22	5.24	0.08	5.11	0.29
6 hrs	4.04	0.29	5.24	0.08	4.68	0.10	5.01	0.50	4.97	0.51
1 day	3.29	0.60	4.85	0.20	3.89	0.33	4.21	0.08	4.73	0.05
2 days	2.47	0.23	4.44	0.20	2.76	0.10	3.16	0.07	4.20	0.07
4 days	U	-	3.26	0.10	2.27	0.09	2.47	0.28	3.71	0.50
7 days	U	-	U	-	U	-	U	-	2.79	0.46

C) Disinfectants*

Disinfectant (Working concentration)	Virus titre (Log TCID ₅₀ /mL)		
	5 mins	15 mins	30 mins
Household bleach (1:49)	U	U	U
Household bleach (1:99)	U	U	U
Hand soap solution (1:49)	3.6"	U	U
Ethanol (70%)	U	U	U
Povidone-iodine (7.5%)	U	U	U
Chloroxylonol (0.05%)	U	U	U
Chlorhexidine (0.05%)	U	U	U
Benzalkonium chloride (0.1%)	U	U	U

D) pH*

pH (60 mins)	Virus titre (Log TCID ₅₀ /mL)	
	Mean	±SD
3	5.55	0.25
4	5.67	0.36
5	5.73	0.04
6	5.75	0.08
7	5.58	0.22
8	5.70	0.14
9	5.54	0.44
10	5.51	0.11

* All the virus titres were titrated using Vero-E6 cells. All experimental studies were done in three independent triplicates. Detection limit of a typical TCID₅₀ assay is 100 TCID₅₀/mL, except reactions containing hand soap/chloroxylonol (detection

limit: 10^3 TCID₅₀/mL) or reactions containing povidone-iodine/chlorhexidin/benzalkonium chloride; detection limit: 10^4 TCID₅₀/mL) because of their cytotoxic effects. N.D.: not done, U: undetectable.
Only one of the triplicate reactions was positive in the TCID₅₀ assay.