The Lancet Article "Stability of SARS-CoV-2 in different environmental conditions"

A simple explanation of the document.

SARS-CoV-2 at different temperatures

At 4°C, after 14 days around 90% of the virus is still active and infectious. At 70°C it is inactive after 5 minutes.

SARS-CoV-2 on different fabrics and surfaces

All materials were tested at average room temperature of 22°C and 65% humidity.

5 micro litres of virus culture was pipetted on to each surface and left for the time period indicated in the chart.

They soaked, or washed, the virus culture from the surfaces back into a flask for 30 minutes before testing for traces of the virus. So, this detection method (rinsing and reclaiming) doesn't necessarily reflect the potential to pick up the virus from casual contact.

Paper
Nothing detectable after 3 hours.

Cloth (unspecified)
Nothing detectable after 48 hours

Wood
Nothing detectable after 48 hours

Glass
Nothing detectable after 4 days (96 hours)

Bank notes
Nothing detectable after 4 days (96 hours)

Plastic
Nothing detectable after 7 days (168 hours)

Stainless Steel
Nothing detectable after 7 days (168 hours)

Mask, Outer Layer
Virus still detectable after 7 days (168 hours)

This supports the idea that masks should be regularly rotated/replaced and why strict hand washing protocols should be adhered to when removing or **after touching** a mask.

Disinfectants and Hand Soap

Tested by adding 15 micro litres of SARS-CoV-2 culture to 135 micro litres (ratio 1:9) of various disinfectants at working concentration (suggested mix of disinfectant to water). No infectious virus could be detected after 5 minutes at room temperature, with the exception of hand soap. The virus appears to be very stable in a favourable environments but is undetectable after disinfection.

Disinfectants tested -
Bleach; Hand soap; Ethanol (alcohol); Povidone-iodine (eg. Betadine); Chloroxylenol (eg. Dettol); Chlorhexidine (often used in healthcare cleaning & also used in mouthwash; Benzalkonium chloride (used in healthcare cleaning).

Hand soap
It should be noted that hand soap deals with the virus in a different way - by disrupting the lipids in the virus membrane, effectively 'disassembling' the virus.

Two useful articles explaining why washing hands with soap and water is preferable to using alcohol-based gels -
https://www.independent.co.uk/news/science/coronavirus-soap-wash-hands-covid-19-a9406731.html
https://www.theguardian.com/commentisfree/2020/mar/12/science-soap-kills-coronavirus-alcohol-based-disinfectants

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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Chin A W H, Chu J T S, Perera M R A, et al. Stability of SARS-CoV-2 in different environmental conditions. *Lancet Microbe* 2020; published online April 2. https://doi.org/10.1016/S2666-5247(20)30003-3.

Stability of SARS-CoV-2 in different environmental conditions

We previously reported the detection of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in different clinical samples.[1] This virus can be detected on different surfaces in a contaminated site.[2] Here, we report the stability of SARS-CoV-2 in different environmental conditions.

We first measured the stability of SARS-CoV-2 at different temperatures. SARS-CoV-2 in virus transport medium (final concentration ~6·8 log unit of 50% tissue culture infectious dose [$TCID_{50}$] per mL) was incubated for up to 14 days and then tested for its infectivity (appendix p 1). The virus is highly stable at 4°C, but sensitive to heat. At 4°C, there was only around a 0·7 log-unit reduction of infectious titre on day 14. With the incubation temperature increased to 70°C, the time for virus inactivation was reduced to 5 mins.

We further investigated the stability of this virus on different surfaces. Briefly, a 5 µL droplet of virus culture (~7·8 log unit of $TCID_{50}$ per mL) was pipetted on a surface (appendix p 1; ~cm^2 per piece) and left at room temperature (22°C) with a relative humidity of around 65%. The inoculated objects retrieved at desired time-points were immediately soaked with 200 µL of virus transport medium for 30 mins to elute the virus. Therefore, this recovery of virus does not necessarily reflect the potential to pick up the virus from casual contact. 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 detectable level of infectious virus could still be present on the outer layer of a surgical mask on day 7 (~0·1% of the original inoculum). Interestingly, a biphasic decay of infectious SARS-CoV-2 could be found in samples recovered from these smooth surfaces (appendix pp 2–7). 39 representative non-infectious samples tested positive by RT-PCR[3] (data not shown), showing that non-infectious viruses could still be recovered by the eluents.

We also tested the virucidal effects of disinfectants by adding 15 µL of SARS-CoV-2 culture (~7·8 log unit of $TCID_{50}$ per mL) to 135 µL of various disinfectants at working concentration (appendix p 1). With the exception of a 5-min incubation with hand soap, no infectious virus could be detected after a 5-min incubation at room temperature (22°C). Additionally, we also found that SARS-CoV-2 is extremely stable in a wide range of pH values at room temperature (pH 3–10; appendix p 1). Overall, SARS-CoV-2 can be highly stable in a favourable environment,[4] but it is also susceptible to standard disinfection methods.

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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://doi.org/10.1016/S1473-3099(20)30113-4.
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; published online March 16. DOI:10.1101/2020.03.11.20034546 (preprint).
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. DOI:10·1093/clinchem/hvaa029.
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. DOI:10.1056/NEJMc2004973.

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See Online for appendix

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

A) Temperature*

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	-

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
Chloroxylenol (0.05%)	U	U	U
Chlorhexidine (0.05%)	U	U	U
Benzalkonium chloride (0.1%)	U	U	U

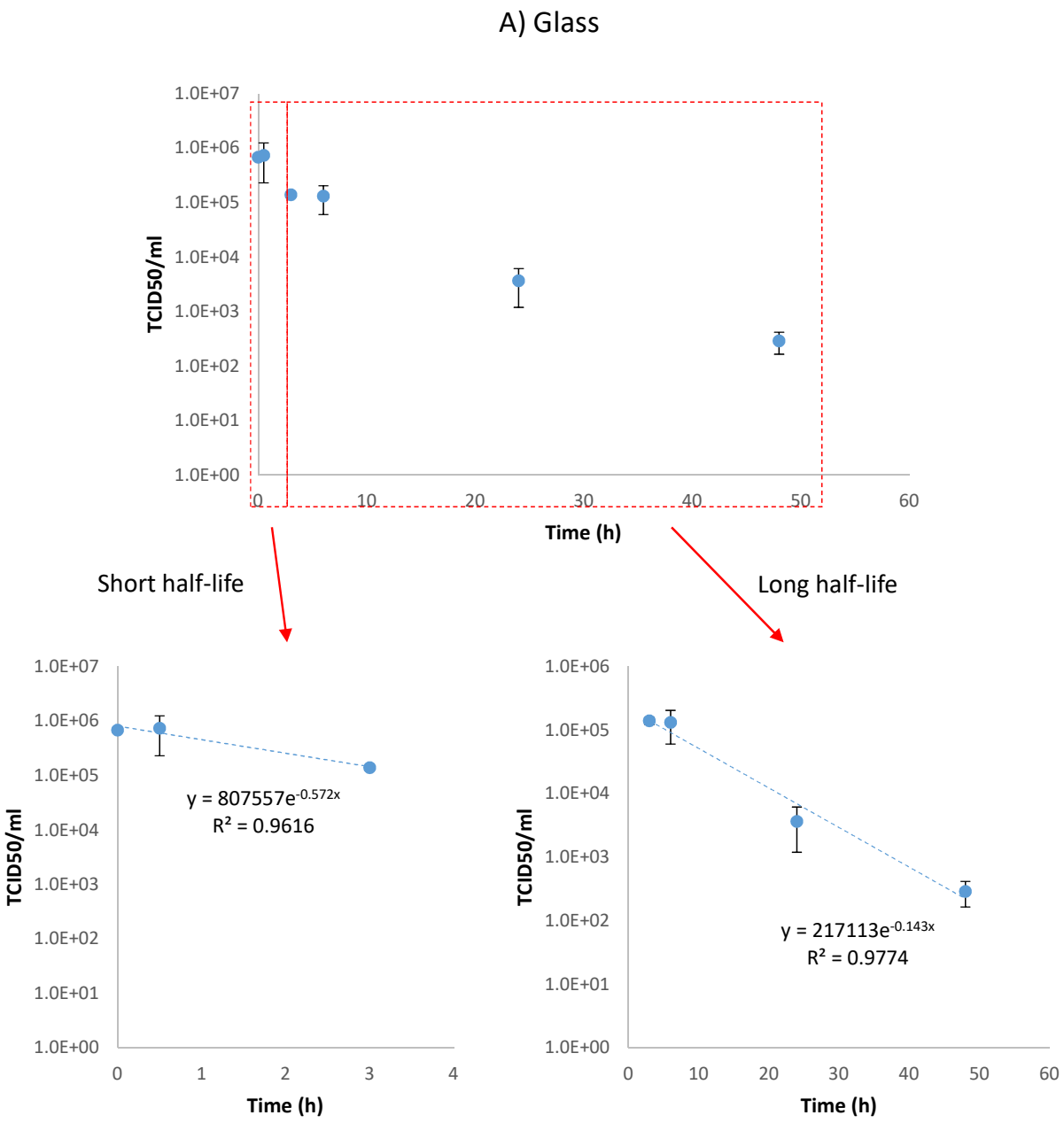
D) pH*

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 $TCID_{50}$ assay is 100 $TCID_{50}$/mL, except reactions containing hand soap/chloroxylenol (detection limit: 10^3 $TCID_{50}$/mL) or reactions containing povidone-iodine/cholorhexidin/benzalkonium chloride; detection limit: 10^4 $TCID_{50}$/mL) because of their cytotoxic effects. N.D.: not done, U: undetectable.

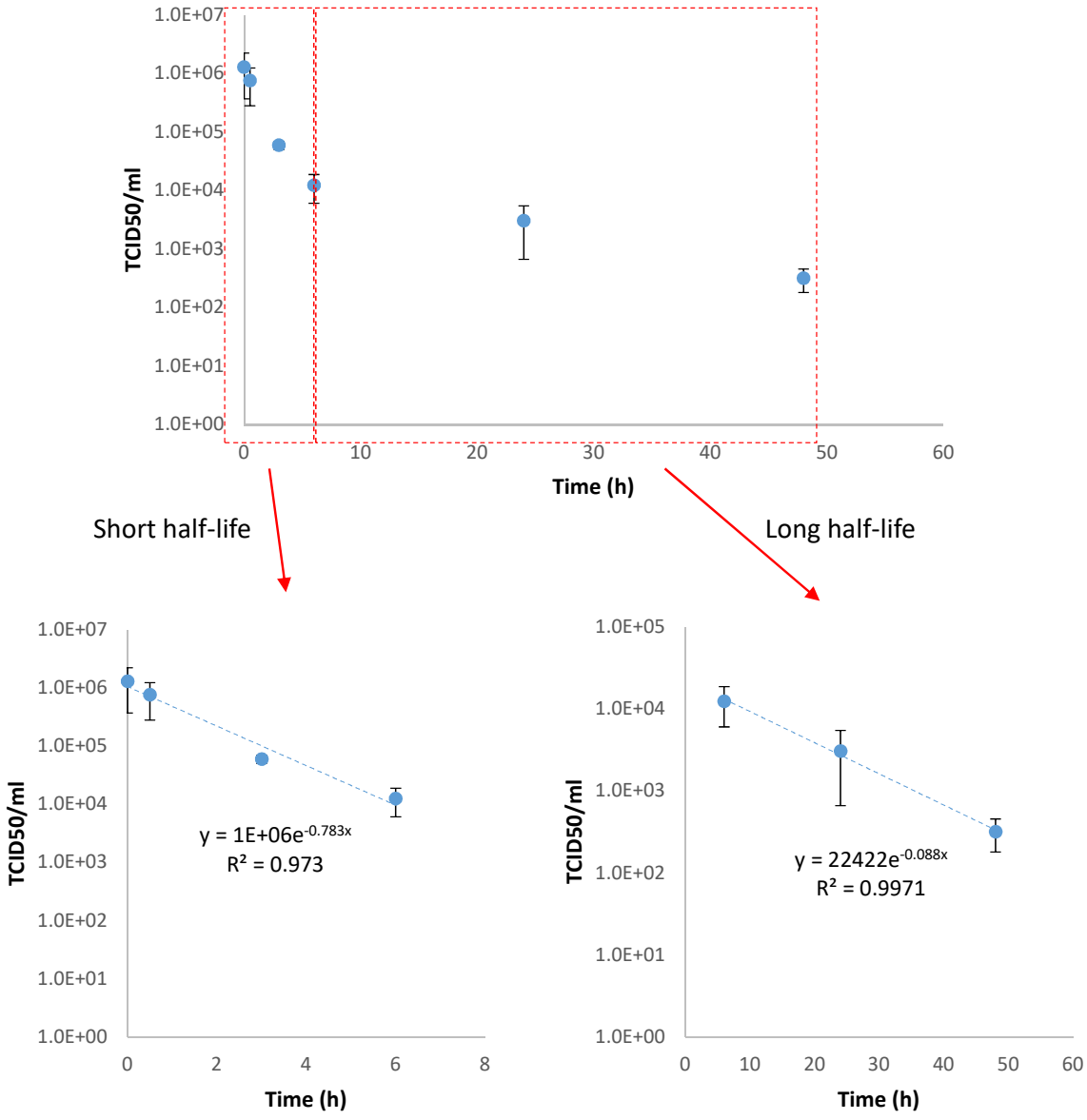
\# Only one of the triplicate reactions was positive in the $TCID_{50}$ assay.

Appendix: Biphasic decay of infectious SARS-CoV-2 population



Half-life of free infectious SARS-CoV-2: 0 - 3 hr, $T_{1/2}$ = 1.2 hr
3 hr - 2d, $T_{1/2}$= 4.8 hr

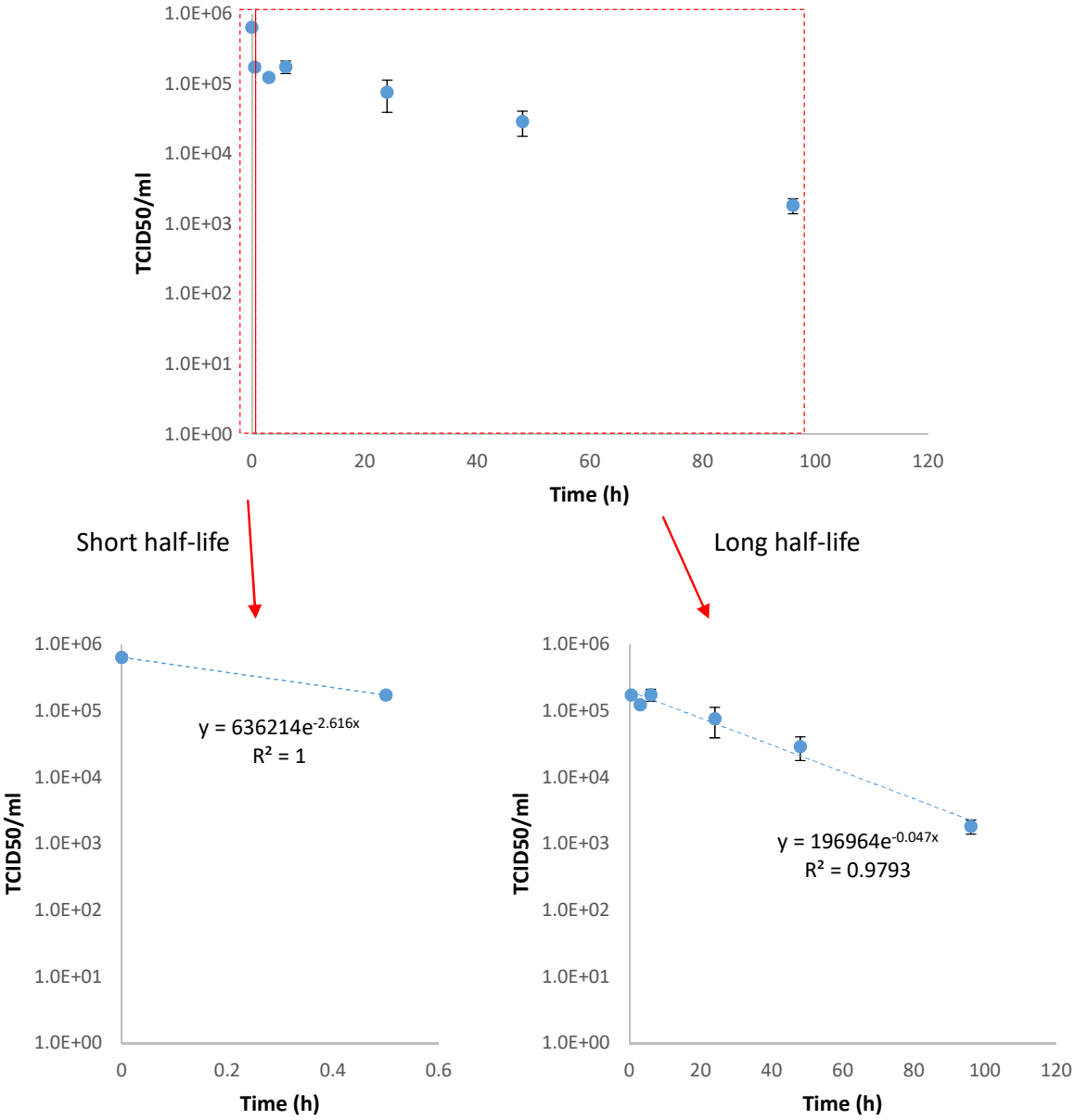
B) Banknote



Half-life of free infectious SARS-CoV-2: 0 - 6 hr, $T_{1/2}$ = 0.9 hr

6 hr - 2d, $T_{1/2}$= 7.9 hr

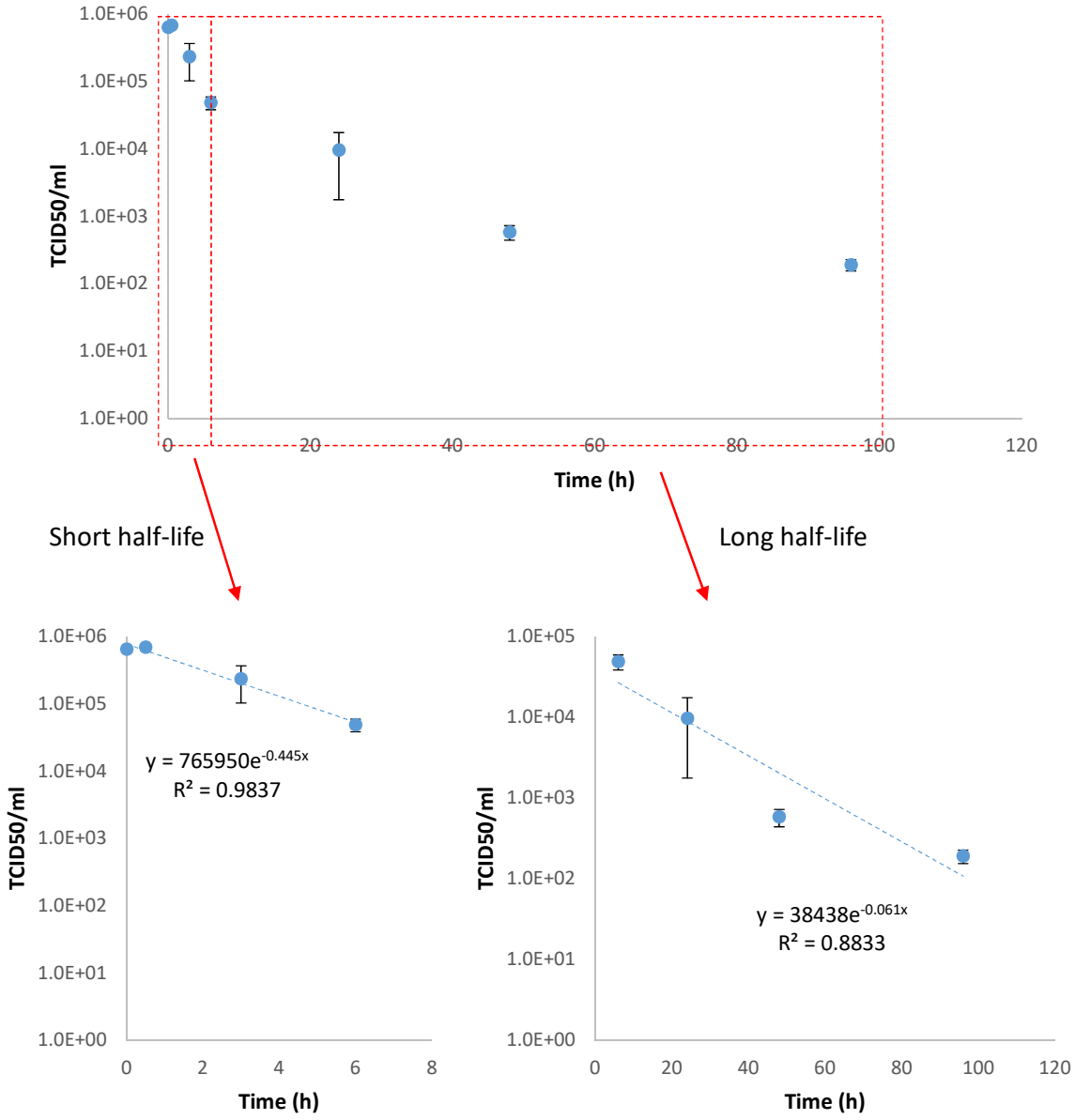
C) Stainless steel



Half-life of free infectious SARS-CoV-2: 0 -30 min, $T_{1/2}$ = 0.3 hr

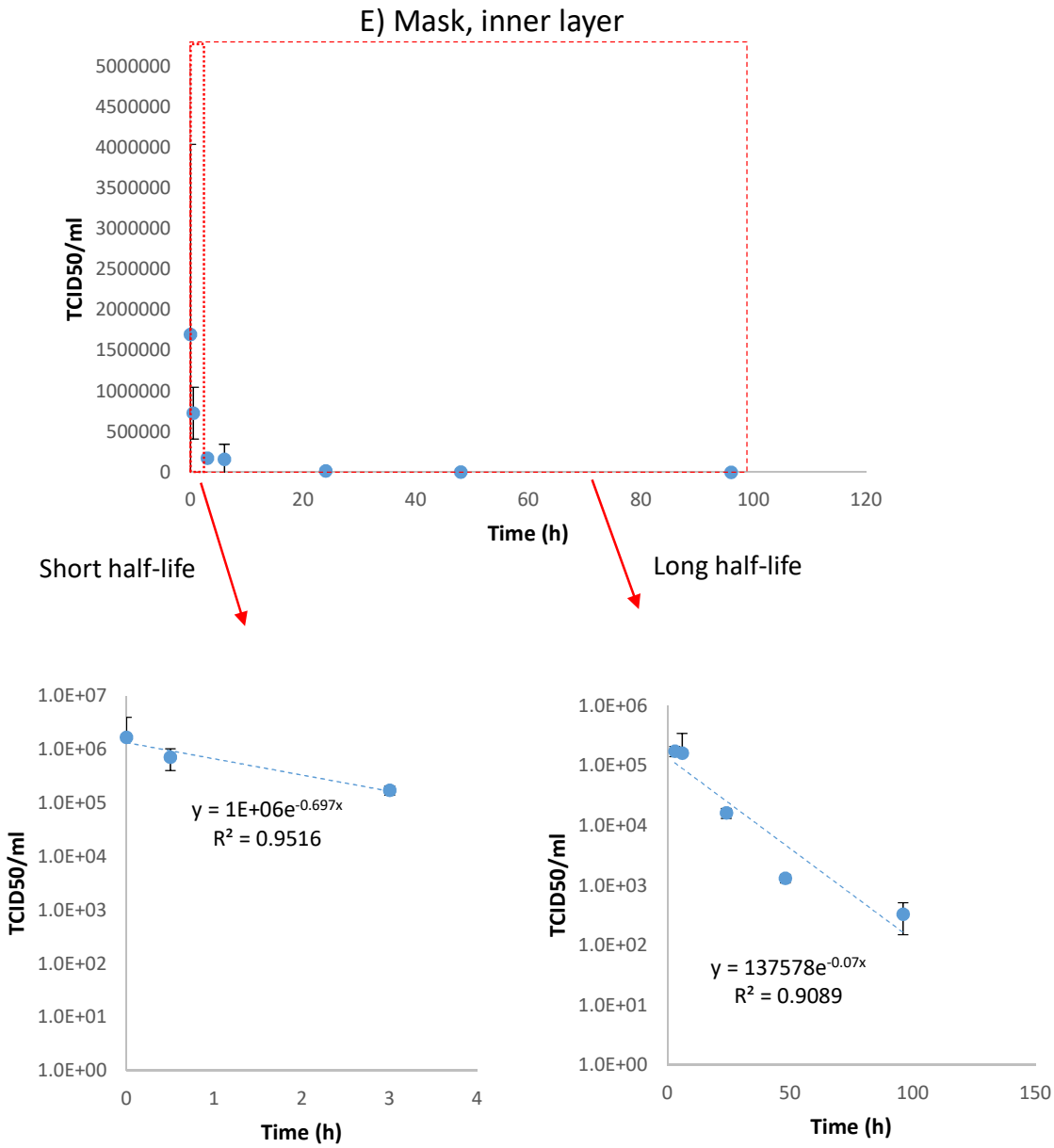
30 min - 4d, $T_{1/2}$= 14.7 hr

D) Plastic



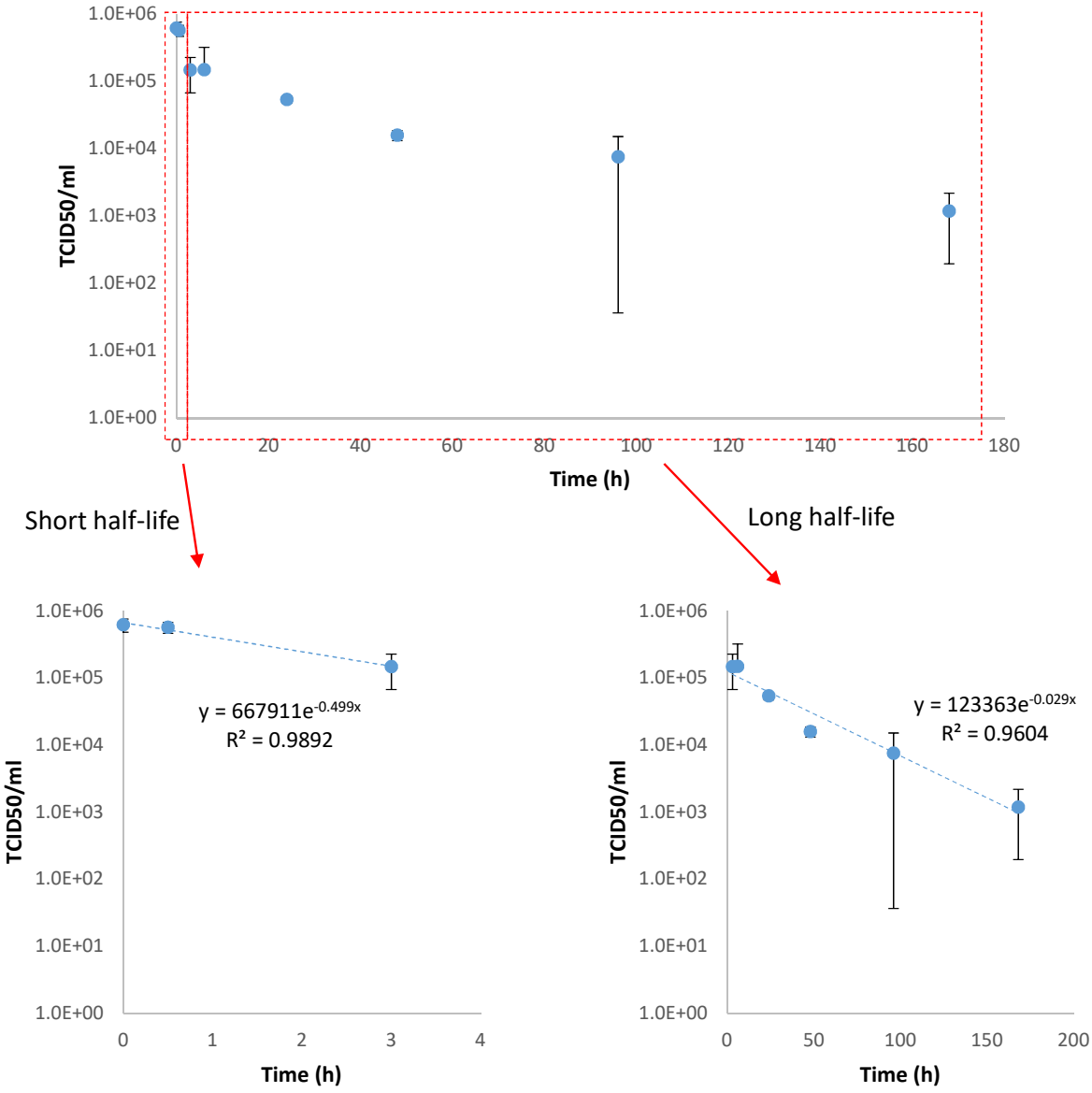
Half-life of free infectious SARS-CoV-2: 0 - 6 hr, $T_{1/2}$ = 1.6 hr

6 hr - 4 d, $T_{1/2}$= 11.4 hr



Half-life of free infectious SARS-CoV-2: 0-3hr, $T_{1/2}$ = 1.0hr
6hr-4d, $T_{1/2}$= 9.9hr

F) Mask, outer layer



Half-life of free infectious SARS-CoV-2: 0 - 3 hr, $T_{1/2}$ = 1.4 hr

3 hr - 7 d, $T_{1/2}$= 23.9 hr