Journal of Hospital Infection 106 (2020) 633–634

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

Letter to the Editor

Rapid SARS-CoV-2 inactivation by commonly available chemicals on inanimate surfaces

Sir,

The emergence of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has become a global health concern with over 7.5 million confirmed cases (as of June 2020 [1]). Due to a lack of specific therapies, preventing the spread of SARS-CoV-2 via droplets, contaminated hands or surfaces is the primary intervention. Stability of the virus on surfaces for days demands rigorous hygiene measures [2,3]. The ingredients of commercially available hand disinfectants revealed virucidal activity against SARS-CoV-2 in suspension tests [4]. However, less is known about surface disinfection for SARS-CoV-2 under realistic surface contamination [5].

To address this gap, we evaluated single components of disinfectants and household cleaning agents against SARS-CoV-2 on various surfaces. Seventy percent ethanol (EtOH) and 70% isopropanol (IPA) are based on World Health Organization formulations I and II for disinfectants (although lower concentrations were chosen [1]), 0.1% hydrogen peroxide (H_2O_2) is also based on WHO formulations I and II for disinfectants [1] and is present in more aggressive household cleaning agents, and 0.1% sodium laureth sulphate (SLS) is a surfactant present in almost all household cleaning/hygiene agents (e.g. dishwashing liquid, hand soap and shampoo).

The tested surfaces – stainless steel, plastic [e.g. polyethylene terephthalate (PET)], glass, polyvinyl chloride (PVC), cardboard and cotton fabric – represent materials with increased exposure during daily life and especially during the SARS-CoV-2 pandemic. Plastic (e.g. PET) represents the worst case for SARS-CoV-2 persistence [3] and, like glass and PVC, is used for protective (face) shields. During lockdown, increased use of delivery services was observed. Thus, exposure to cardboard was increased. Interestingly, SARS-CoV-2 persistence for up to 24 h was documented for cardboard [3]. Furthermore, due to the current recommendation/liability to wear mouth/nose masks, many people have started to use self-made mouth/nose masks made of cotton fabric.

In this study, surfaces were challenged with SARS-CoV-2, allowed to dry for 1 h and subsequently treated with 70% EtOH, 70% IPA, 0.1% H_2O_2 or 0.1% SLS for 30 s and 60 s. The treatment was neutralized with cell culture media at a dilution showing neither toxicity nor significant interference. For each sample, the 50% tissue-culture infectious dose per mL ($TCID_{50}$/mL) was determined on Vero clone PH-2 with 16 technical replicates. Additionally, expanded volume testing was performed for final virus inactivation samples (60 s time point) to estimate titres for samples with low viral loads more accurately (for details, refer to online supplementary material). The reduction in viral infectivity for each treatment condition was calculated as the difference between the titre of the sample without treatment (0 s treatment) and with 30 s or 60 s treatment. Combinations of surfaces and chemical agent treatments were based on surface compatibility and realistic estimates of expected cleaning habits. Replicates were derived from three individual experiments.

SARS-CoV-2 remained viable on all surfaces throughout the 1h dehydration period with $\leq$0.5 log_{10} $TCID_{50}$/mL titre reduction (Table A.1, see online supplementary material). The surface stability of SARS-CoV-2 is in alignment with previous studies [3]. Interestingly, there was no significant loss of infectivity on cotton fabric, indicating SARS-CoV-2 persistence.

SARS-CoV-2 was highly susceptible to 70% EtOH, 70% IPA, 0.1% H_2O_2 and 0.1% SLS treatment (Table I). For EtOH and IPA, complete viral inactivation to the limit of detection was observed within 30 s of treatment. Although the titre was greatly reduced, viable SARS-CoV-2 could be detected after 30 s of treatment with H_2O_2 and SLS. After 60 s, effective SARS-CoV-2 inactivation with logarithmic reduction of viral infectivity by more than 4.0 log_{10} was documented for all tested chemicals. No differences in SARS-CoV-2 inactivation were found between the different surfaces. Although SARS-CoV-2 is more stable on stainless steel and plastic [4], it can be inactivated rapidly by all tested chemicals, independent of the contaminated surface.

This study found that SARS-CoV-2 can be inactivated effectively by 70% EtOH, 70% IPA, 0.1% H_2O_2 and 0.1% SLS within 60 s of exposure on various surfaces. Alcohols as well as H_2O_2 are used for disinfection, including in healthcare settings. This study showed that detergents present in commonly available household cleaning agents are also able to inactivate SARS-CoV-2 rapidly. These data, covering various surface materials including cotton fabric, may be considered relevant for settings beyond health care to limit the spread of SARS-CoV-2 by contaminated surfaces. Furthermore, we would like to highlight that SLS, present in many household cleaning agents and in commonly available hand soap, is also able to inactivate SARS-CoV-2 effectively. Thus, hand hygiene using soap may also act as a contributing factor to limit the spread of SARS-CoV-2, potentially reducing the need for the use of disinfectants in settings with limited availability.

https://doi.org/10.1016/j.jhin.2020.09.001

Table I
Inactivation of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) by 70% ethanol (EtOH), 70% isopropanol (IPA), 0.1% hydrogen peroxide (H_2O_2) and 0.1% sodium lauryl sulphate (SLS) on various surfaces

Reduction of viral infectivity (log_{10})	Time (s)	Stainless steel	Plastic (PET)	Glass	PVC	Cardboard	Cotton fabric
70% EtOH	30	≥4.1	≥4.1	≥3.8	≥4.0	≥3.8	-
	60	≥5.0	≥5.0	≥4.7	≥4.9	≥4.7	-
70% IPA	30	≥4.1	≥4.1	≥3.8	≥4.0	≥3.8	-
	60	≥5.0	≥5.0	≥4.7	≥4.9	≥4.7	-
0.1% H_2O_2	30	2.4±0.3	-	2.3±0.4	2.4±0.5	-	-
	60	≥4.8	-	≥4.5	≥4.7	-	-
0.1% SLS	30	3.1±0.4	≥3.6	≥3.3	≥3.5	-	≥3.1
	60	≥4.9	≥4.9	≥4.6	≥4.8	-	≥4.4

PET, polyethylene terephthalate; PVC, polyvinyl chloride; -, not measured.
Surfaces were challenged with SARS-CoV-2 and subjected to treatment with various chemical agents for 30 s and 60 s. The experimental approach was identical for all tested disinfectants, except for neutralization due to varying toxicity and interference of the chemical agents with the cell culture test system. As a control, surfaces were left untreated (0 s treatment). The table summarizes the results of three independent replicates. The logarithmic reduction of viral infectivity for each treatment condition was determined by comparing the total SARS-CoV-2 load in the input (0 s treatment) with that in the final output sample (60 s treatment). If complete virus inactivation was observed, the titre equals the limit of detection, and the logarithmic reduction of viral infectivity factor is reported as '≥'. In this case, the largest logarithmic reduction of viral infectivity factor of all replicates is reported with no standard deviation of the mean. In the case that one or more of the replicates did not show complete virus inactivation, the mean logarithmic reduction of viral infectivity factor and the standard deviation of the mean is reported. The limit of detection is determined by the tested sample volume. In the case of 60 s treatment, expanded volume testing was performed to achieve a lower limit of detection. For details, see the methods section in the online supplementary material.

Acknowledgements

The authors would like to thank Gerhard Hopp for excellent technical assistance.

Conflict of interest statement
None declared.

Funding sources
None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2020.09.001.

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M. Gerlach[a,*]
S. Wolff[a]
S. Ludwig[b]
W. Schäfer[a]
B. Keiner[a]
N.J. Roth[a]
E. Widmer[a]
[a]*CSL Behring GmbH, Global Pathogen Safety, Marburg, Germany*

[b]*Westfaelische Wilhelms-University Muenster, Institute of Virology, Muenster, Germany*

* Corresponding author. Address: CSL Behring GmbH, Global Pathogen Safety, Emil von Behring Str. 76, 35041 Marburg, Germany. Tel.: +49 6421 39 2740.
E-mail address: Michaela.Gerlach@cslbehring.com (M. Gerlach)

Available online 9 September 2020