ORIGINAL ARTICLE

Efficiency of coronavirus inactivation on environmental surfaces: A comparison study of two available disinfectants

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ABSTRACT

Background: There are many coronaviruses of significant medical and veterinary concern, all of which are the result of spillover from another species. Disinfection of healthcare and veterinary environments is an important factor in limiting the transmission of coronaviruses. Disinfection agents for coronaviruses use bleach, quaternary compounds, hydrogen peroxide, and sodium hydroxide. Product labels list contact times that range from 10-30 minutes for total inactivation. Decon7 is a combination disinfectant that is currently used in the food and agriculture, medical facilities, and other industries. While Decon7 has been shown to inactivate a variety of pathogens and disrupt biofilms, its effectiveness and rate of coronavirus inactivation has not been evaluated.
Objective: This project sought to evaluate Decon7's effectiveness and rate of coronavirus inactivation.
Methods: This study evaluated the disinfection efficacy of Decon7 (diluted at 1:4) and bleach (diluted at 1:10) after 3 coronaviruses (SARS-CoV-2, HCoV OC43, and HCoV NL63) were inoculated onto up to sixteen environmental surface materials.
Results: A 1:4 dilution of Decon7 inactivated all coronaviruses on all surfaces with 1 minute contact time. A 1:10 dilution of bleach was not effective in inactivating coronaviruses with a contact time of 1 minute on all surfaces.
Conclusions: New technologies and chemistries may offer more efficient inactivation of pathogens on environmental surfaces. These disinfection methods and materials, which require less than 10 minutes contact time, may improve the efficacy of cleaning and disinfecting surfaces in the built environment.

Key Words: Bleach, Coronavirus, Decon7, Disinfection, Environmental surfaces, SARS

1. INTRODUCTION

Coronaviruses (CoVs) pose a significant threat to both human and animal health due to their ability to transmit between different mammalian and avian species. They are classified into 4 genera: alpha, beta, gamma, and delta. Only gamma and delta CoVs infect and transmit between mammals and birds.[1] They are shed from mucous membranes and spread through respiratory droplets and/or feces.[2,3] Bats are con-

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sidered one of the natural reservoirs for CoVs, and they shed large quantities of virus while foraging for food.[4] Additionally, highly pathogenic strains of alpha CoVs have been isolated from humans, cats, pigs, and dogs.[3,5–7] Beta CoVs are significant pathogens for cows and other ruminants, humans, dogs, pigs, and horses.[8–12] Beta CoVs such as SARS, MERS, and SARS-CoV-2 are currently associated with severe human disease and death; additionally, there are dozens of CoVs of significant medical and veterinary concern, all of which are likely the result of spillover from another species.[7] Taken together, CoVs pose a significant threat to human and animal health and pose the potential for the agriculture industry to lose billions of dollars.[13,14]

There are indications that environmental surface material composition plays a role in the transmission of viruses.[15] Studies have shown that environmental surfaces can be heavily contaminated with SARS-CoV-2 and other viruses in hospital rooms, leading to contact transmission and contributing to the spread of SARS-CoV-2 and other infections.[16–23] Research has shown that human CoVs that contaminate surfaces remain infectious from a few hours to up to six days.[15,19,24] Environmental conditions such as higher ambient temperatures and relative humidity increase the rate of decay, limiting transmission capability in the indoor environment.[19,25,26] A recent study comparing sixteen different high- and low-touch materials found that differences in material composition influences the life-span of SARS-CoV-2 virus and contact transmission.[15] Two materials tested, copper and a material with cupric oxide, had no infectious particles by 4 hours, the first tested timepoint.[15] The virus was only detected on three of the remaining materials by 24 hours, suggesting an overall short life-span. Zero infectious particles measured on materials from 4 hours suggests that material composition plays a role in contact transmission.

Many disinfection agents are available for CoV inactivation.[27] Products typically use bleach, quaternary compounds, hydrogen peroxide, and agents containing sodium hydroxide.[28] Labels of the products approved by the United States Environmental Protection Agency (EPA) list contact times ranging from 10-30 minutes for total virus inactivation on surfaces. Sodium hypochlorite, ethanol, and glucoprotamin require a full 10 minutes to inactivate some viruses.[29,30] Hydrogen peroxide may inactivate viruses within 6 to 8 mins, but studies have found mixed results with some indicating a longer contact time.[29] Quaternaries are generally fungicidal, bactericidal, and virucidal against lipophilic viruses but not as effective on hydrophilic viruses.[31] One study showed that quaternary ammonium compounds effectively remove and/or inactivate contaminants (i.e., multidrug-resistant *S. aureus*, *vancomycin-resistant Entercoccus*, *P. aeruginosa*) from computer keyboards with a 5-second application time.[29] Peracetic acid is very effective at rapid inactivation but is unstable and corrosive, indicating that use over time will degrade environmental surface materials, limiting useful life.[31] Disinfectants containing silver dihydrogen citrate were found to not be effective with a 30 minute contact time.[32] Ultraviolet-C radiation is a productive technology for disinfection.[33–41] UV-C has been shown to be effective in eliminating bacteria on contaminated surfaces in line of sight and behind objects in about 15 minutes;[42] however other studies have found that 45-50 minutes were required to get a significant reduction of pathogens.[43,44]

2. MATERIALS AND METHODS

2.1 Cells and viruses

CoVs HCoV-OC43 (NR-52725) and HCoV-NL63 (NR-470) were obtained from BEI Resources. SARS2 Coronavirus (USA-WA1/2020) was obtained from the World Reference Center for Emerging Viruses and Arboviruses SARS-CoV-2 and was maintained in a Biosafety Level 3 laboratory. The virus was grown on Vero CCL81 (ATCC) and titers were determined by plaque assay on Vero E6 cells (Cercopithecus aethiops, Vero 76, clone E6, ATCC CRL-1586). The pathology of the viruses used differ in cell culture thus, HCoV-OC43 and HCoV-NL63 were expanded once in Vero E6 cells and titrated via median tissue culture infectious dose assay (TCID50).

2.2 Description and composition of products

Decon7 (Decon Seven Systems, Dallas, TX) is an EPA registered and patented chemical decontaminant, disinfectant, sanitizer, and cleaning solution currently used in the food and agriculture industries and used in medical and public facilities. It is a combination solution containing surfactants, mild solvents, inorganic salts, a low concentration of hydrogen peroxide ($\sim$3.5%), a hydrogen peroxide activator, and water. The surfactants work to dissolve chemicals into the formulation, where it is neutralized by the hydrogen peroxide.[46] While Decon7 has been shown to inactivate a variety of pathogens,[47,48] studies on its rate of coronavirus inactivation are limited. The germicidal cleaner has 0.65% of the active ingredient, sodium hypochlorite. Sodium hypochlorite, (The Clorox Company, Oakland, CA) is EPA approved for disinfection of healthcare and other facilities working with blood borne pathogens.[49] It is also a common disinfectant used in cleaning indoor surface materials. The recommended dilution for bleach to disinfect indoor surface materials while minimizing corrosion of surface materials is a 1:10 dilution. The manufacturer recommendation for the dilution of Decon7 is 1:4. These are the dilutions used in this study with

a contact time of 1 minute. Sterile, molecular grade water (nuclease free) was used as a control. Materials that are commonly used in a variety of indoor environments such as healthcare, long-term care, education, public spaces, and homes were inoculated and tested.

2.3 Decontamination testing of the OC43 and NL63 coronaviruses

Assays to measure virus inactivation of OC43 and NL63 were modeled after Warnes et al. 2015.[50] Briefly, 2 in. X 2 in. surface swatches were inoculated with 500,000 plaque forming units (PFU) of virus. The pipette tip was used to spread the inoculum over the surface. The swatch was placed in a sterile petri dish and covered for 15 minutes. After 15 minutes, the swatches were sprayed with disinfectant using a standard housekeeping spray bottle set on mist. Disinfectants included a 1:10 dilution of Clorox Healthcare® Bleach Germicidal Cleaner in deionized water, a 1:4 dilution of Decon7 in deionized water, and plain deionized water. After 1 minute, the swatches were rinsed with 4 mL culture media and then the swatches were inverted onto the media. The petri dish was covered and then rocked for 15 minutes, after which, 12-well cell culture plates seeded with Vero E6 cells were inoculated with the media (∼12,500 PFU), incubated at 37°C for 1 week and then viral titration was performed via TCID50. Controls included a no virus plus disinfectant, plus virus with no disinfectant, and no virus no disinfectant. All testing was completed in triplicate.

Four environmental surface materials, Solid Acrylic Surface (SAS), Stainless Steel (SS), Luxury Vinyl Tile (LVT), and Rubber Flooring (RF), were utilized for this study representing "high touch" and low touch" surfaces (see Table 1). Each material is varied in composition and contains properties that have been shown to influence virus viability.[15] SAS is used in many applications in healthcare, veterinary, and community places for both vertical and horizontal applications, but primarily for counter surfaces. SS is a primary material for healthcare and veterinary facilities used for carts, work surfaces, sinks, and other function driven surfaces. Both materials are high touch surfaces. RF and LVT are flooring materials and categorized as low touch. RF is commonly used in healthcare and veterinary facilities while LVT is the resilient environmental surface material specified across all building types. Table 1 provides a description and composition of each material used in this study.

Table 1. Environmental surface materials used for 1 minute disinfection test comparing bleach and Decon7

Material	Composition
Solid Acrylic Surface	Solid, nonporous, homogeneous, composed of acrylic resin and natural minerals.
Stainless Steel, Brushed	Chromium-Nickel (CrNi) austenitic alloy sheet with 18% min. chromium and 10% max. nickel, 18 gauge, grade 304.
Rubber Flooring	Vulcanized rubber (natural, synthetic, recycled) commonly with a polyurethane top layer.
Luxury Vinyl Tile #21	LVT, floating floor installation, flexible PVC core, stabilization layer, cushion backing, waterproof.

2.4 Decontamination testing of SARS-CoV-2

Decon7 was mixed per the manufacturer's instructions. The disinfectant was tested using a 1:4 dilution. The disinfectant was placed in a standard housekeeping spray bottle set to mist. Each material was inoculated with 10,000 PFU of virus in 50 μl of media in duplicate, housed within a petri dish and allowed to dry for 45 min.

Assay controls included a duplicate inoculum onto a petri dish without a material sample. One spray of disinfectant was added to each material and allowed to sit for one minute. After one minute, all fluid was collected by washing with 450 μl of phosphate buffered saline and frozen at -80°C. As a control for viral stability, the inoculum was spread onto 3 petri dishes and allowed to dry, at which time one spray of water only was used. As a control for cell viability, one spray of the disinfectant was used on petri dishes with 50 μl of dried media only (no virus). After one minute, fluid was collected and frozen at -80°C.

To determine the amount of virus surviving after 1 minute of exposure to disinfectant, collected fluid was thawed. Then, 5 μl of the fluid was placed into 5 ml of cell culture media and placed on Vero (E6 or CCL81) cells growing in a T25 flask. Cells were observed for cytopathic effects over a period of 7 days. Additionally, samples were used to create a 10-fold serial dilution and a plaque assay was performed as described above. Sixteen indoor surface materials, a mix of high touch (i.e., stainless steel, solid surface, and high-

pressure laminate) and low touch (i.e., rubber flooring, LVT flooring, and vinyl wall covering) surfaces were inoculated for the experiment. Material composition for each surface material is described in Table 2.

2.5 Data analysis

This experiment, conducted during December 2020 was performed 2 times with three replicates each, and the results were reported as the averages of the replicates in both trials (6 replicates total) $\pm$ the standard error. Univariate analysis using both ANOVA and non-parametric methods (Wilcoxon Rank sum for the overall, Steel-Dwass for all pairwise comparisons) analysis was performed for both the surface and the treatment type. A multivariate ANOVA model including both factors was also fit to further explore the impact of specific combinations of treatment and surfaces. The multivariable model simply highlights results from descriptive analysis due to the nature of the data. Statistical analyses were conducted using Stata version 17.0. Significant differences were presented at a p-value of $\leq .05$.

Table 2. Environmental surface materials inoculated with SARS-CoV-2 for 1 minute contact disinfection with Decon7

Material	Composition
Acrylic Solid Surface	Solid, nonporous, homogeneous, composed of acrylic resin and natural minerals.
Solid Surface w/CuO	Solid, homogeneous, antimicrobial sheet composed of polyester resins, mineral fillers, and pigments. Cupric oxide is added for antimicrobial properties.
Stainless Steel, Brushed	Chromium-Nickel (CrNi) austenitic alloy sheet with 18% min. chromium and 10% max. nickel, 18 gauge, grade 304.
High-Pressure Laminate	Decorative surface papers impregnated with melamine resins pressed over kraft paper core sheets impregnated with phenolic resin.
Copper Sheet	Copper Alloy C71000 (Copper Nickel, CuNi) composed of 78%-84% copper and 19.0-23.0% nickel, 18 gauge.
Quartz	Primarily a natural material with about 7% polyester resin binder and pigment.
Rubber Flooring	Vulcanized rubber (natural, synthetic, recycled) commonly with a polyurethane top layer.
Vinyl, Sheet, Homogeneous	A single layer of PVC with a urethane topcoat.
Wood Laminate Flooring	Laminated layered flooring system utilizing timber veneer backer board, HDF core, and solid wood wear layer; may be finished with a urethane coating. Commercial grade.
Luxury Vinyl Tile #15	LVT, glue down floor installation, flexible PVC core, stabilization layer.
Luxury Vinyl Tile #21	LVT, floating floor installation, flexible PVC core, stabilization layer, cushion backing, waterproof.
Luxury Vinyl Tile #26	LVT, glue down installation, flexible PVC core, no stabilization layer, no cushion backing.
Carpet, Commercial	Nylon 6, 20 OZ, level loop, polyester backing.
Carpet, Residential	PET, 25 OZ, cut pile, jute backing.
Upholstery, Nonwoven	Application for seating, 100% polyurethane nonwoven face with polyester backing. Weight 15 oz. Performance for abrasion 100,000 double rubs.
Vinyl Wall Covering, Type II	Commercial grade wall covering, 20 oz weight, two layers of solid vinyl applied to a woven or nonwoven fabric substrate. Composition includes plasticizers, stabilizers, and pigments. May contain biocides and flame retardants.

3. Results

3.1 Surface type influences virus inactivation with disinfectant

In order to determine if surface type contributed to CoV viability, all disinfection data (water, bleach and Decon7) were combined for each surface type. For the surface type, the ANOVA is statistically significant (p = .0063). The non-parametric Wilcoxon test was borderline significant (p = .053). Further, SS had significantly fewer PFU than any other surface (p = .012) (see Figure 1 and Table 3).

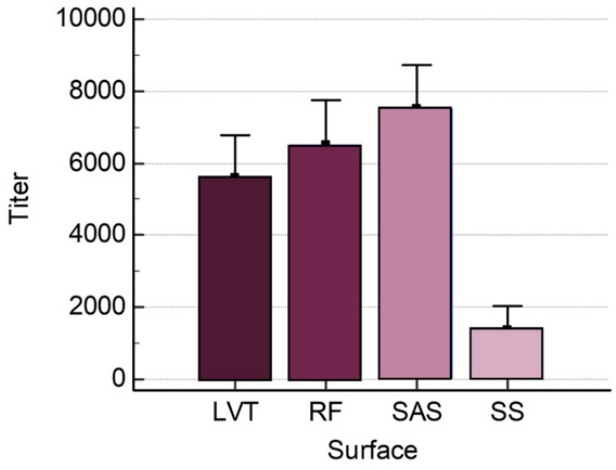

Figure 1. Viability of CoVs on 4 common surfaces figNoteSurfaces were inoculated with HCoV OC43 and HCoV NL63. Disinfectant (H_2O, bleach or Decon7) was applied. Data for recovered PFU was pooled according to surface type. Stainless steel produced significantly fewer PFU than the other surfaces (p = .012)

3.2 Disinfectant type influences virus inactivation

In order to determine if there were differences between disinfectants, all surface data (LVT, RF, SAS, SS) were combined for each disinfectant type (see Figure 2). Parametric and non-parametric methods suggest significant differences (p = .0002, p < .0001) exist between Decon7, bleach, and H_2O with Decon7 inactivating significantly more virus (see Figure 2). Bleach and H_2O were not statistically different in their inactivation of virus after 1 minute contact time (Student's t-test p = .326). Bleach did have less effectiveness with 2,900 more PFU recovered on average than H_2O. The multiple comparisons for Decon7 with bleach and water are statistically significant for both parametric and non-parametric tests while water compared with bleach is not significant (see Table 4).

The multivariate model with both surface and disinfectant as predictors included a significant interaction effect (p < .0001) between the disinfectant and the surface. The interaction term reflects differences in H_2O and bleach effectiveness based on surface. Decon7 eliminated all PFUs on all surfaces. PFUs were essentially completely eliminated on the SS surface by all disinfectants (12.5 units remained with H_2O on average). However, bleach did not eliminate any units on the other 3 surfaces. H_2O similarly did not eliminate units on the other three surfaces except LVT where it eliminated 93% of the units on average.

When Decon7 was applied to surfaces inoculated with SARS-CoV-2, one minute of exposure was sufficient to inactivate all virus at a 1:4 dilution, regardless of the material type tested. Additionally, Decon7 was not damaging to the cells when diluted with cell culture media, allowing accurate detection of viral cells; nor did Decon7 interfere with cell growth, as evidenced by the controls. As expected, samples treated only with water had detectable virus (200,000 PFU/mL upon plaque assay).

3.3 Virus type did not influence inactivation

To determine if inherent differences resultant from virus type impacted the data, we combined all data from surface type and disinfection method for each virus type. The data show (see Figure 3) that nearly equal amounts of virus was recovered from all viruses (p = .973).

Table 3. Pairwise comparisons for surface influence on virus inactivation with disinfectant (univariate model)

Surfaces	Mean Difference	95% Conf. Int. (Tukey HSD)	Tukey HSD	Steel-Dwass
SAS and SS	8329.17	(1488.4, 15170.0)	0.012	0.145
RF and SS	8329.17	(1488.4, 15170.0)	0.012	0.145
LVT and SS	4454.17	(-2386.6, 11295.0)	0.309	0.158
SAS and LVT	3875.00	(-2965.8, 10715.8)	0.429	0.845
RF and LVT	3875.00	(-2965.8, 10715.8)	0.429	0.845
RF and SAS	0.00	(-6840.8, 6840.8)	1.000	1.000

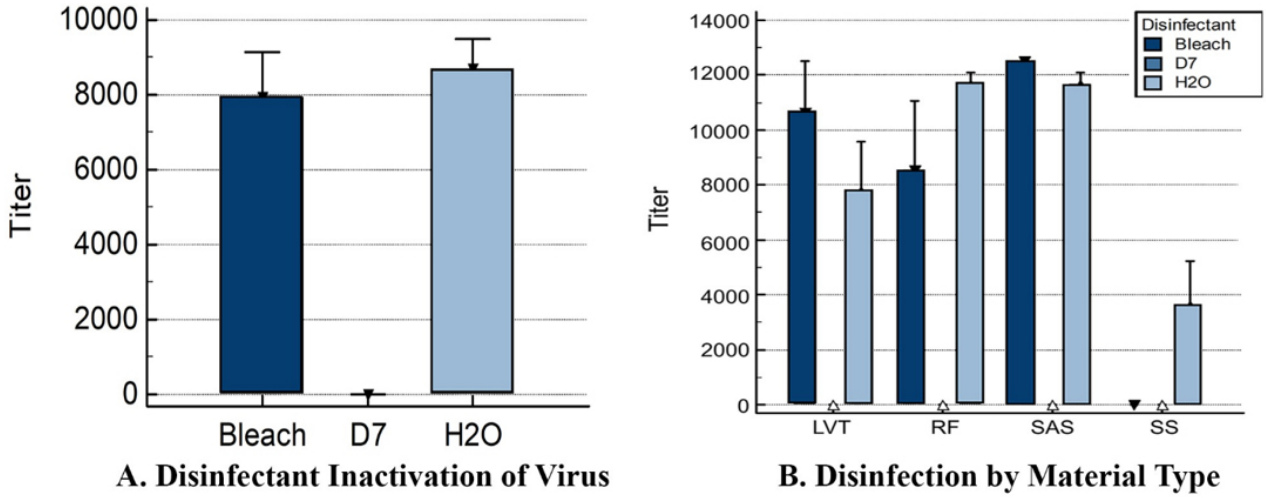

Figure 2. Viability of CoVs following 1 minute contact time with disinefectant figNoteH_2O, bleach, or Decon7 was used to disinfect 4 surfaces that were inoculated with HCoV OC43 and HCoV NL63. A. Disinfectant: data for recovered PFU was pooled according to disinfectant type. Decon7 produced significantly fewer PFU than the other disinfectants (p = .0001 for bleach, p = .0075 for H_2O); B. Decon7 inactivated all virus on all environmental surfaces

Table 4. Pairwise comparisons for disinfectants (univariate model)

Surfaces	Mean Difference	95% Conf. Int. (Tukey HSD)	Tukey HSD	Steel-Dwass
Bleach and Decon7	9,375.00	(4,474.9, 14,275.1)	0.0001	0.0007
H_2O and Decon7	6,471.88	(1,571.8, 11,372.0)	0.0075	< 0.0001
Bleach and H_2O	2,903.13	(-1,997.0, 7,803.2)	0.3259	0.8384

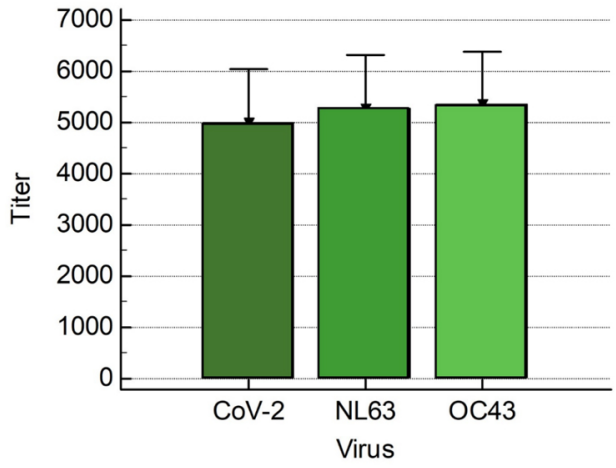

Figure 3. Viability of CoVs following disinfection on 4 surfaces figNoteH_2O, bleach, or Decon7 was used to disinfect 4 surfaces that were inoculated with CoV-2, OC43 and NL63. Data for recovered PFU was pooled according to virus type. All viruses produced similar quantities of PFU following disinfection (p = .961)

3.4 Decon7 inactivates SARS-CoV-2 on 16 surfaces with 1 minute contact time

Sixteen environmental surfaces commonly used in healthcare and other indoor environments were inoculated with SARS-CoV-2 and then treated with Decon7 with a ratio of 1:4 parts H_2O. After 1 minute contact time, all surfaces were free of SARS-CoV-2 while 200,000 PFU/mL of SARS-CoV-2 was recovered from the control samples treated only with H_2O. A variety of indoor finish materials were used, including work surfaces (i.e., solid surfaces, copper sheet, stainless steel, high-pressure laminate, quartz), flooring (i.e., rubber , vinyl, wood laminate, luxury vinyl tiles, residential and commercial grade carpet), and a nonwoven upholstery fabric and type II vinyl wall covering. A previous study[15] found that some indoor finish materials tested for sustained viability of SARS-CoV-2 for 12-24 hours.

4. Discussion

Studies evaluating hospital cleanliness have reported widespread failures in disinfection in clinical and non-clinical

areas, even when bleach was used as a disinfectant.[51] These failures are usually the result of insufficient contact time with the disinfectant.[52] Healthcare facilities, animal clinics, and emergency rooms are challenged with high turnover rates and meeting the required saturation contact times required for appropriate disinfection.[53–55] In many high turnover and high touch areas, housekeeping personnel are given limited time to perform disinfection procedures. Many offices, churches, and clinics (human and animal) do not have professional housekeeping staff or suitable cleaning methods that neutralize viruses or other microbes. Further, ambulatory and non-clinical areas are routinely cleaned only once per day.[56]

Material composition has also been shown to reduce virus viability over time but they may still serve as vectors for transmission when contaminated with CoVs.[15] Of note, surface materials fabricated with copper or containing cupric oxide saw a rapid inactivation of SARS-CoV-2.[15] High touch surfaces can become heavily contaminated and contribute to the spread of CoVs.[21,22] The ability to inactivate the virus in less than the common regulated 10-minute contact time to minimize transmission is compelling. Hypochlorite bleach was first used as an antiseptic in the late 19th century to break the cycle of disease transmission. It is used in the treatment of sewage and the provision of safe drinking water.[57] Even today, bleach plays an important role in reducing cross-contamination of infectious agents via environmental surfaces. However, bleach is corrosive and degrades materials over time, lessoning the intention of the material composition to maintain its integrity.[31,58,59]

Research has shown that 70% ethanol is effective at inactivating some viruses when surfaces remain saturated for at least 2 minutes.[24,60] For ethanol used in hand disinfection, 70% ethanol has been proven to inactivate several types of viruses. However several virus types, including polioviruses, caliciviruses, hepatitis A, and foot and mouth disease virus, require between 80%-100% ethanol with 5 minutes of contact time.[24,61,62] While ethanol on its own is readily available, inexpensive, and not toxic, it is not approved for use in surface decontamination unless augmented with other disinfecting agents by the U.S. Food and Drug Administration (FDA), European Chemicals Agency (ECHA), the Theraputic Goods Administration (TGA) , and the Pharmaceuticals and Medical Devices Agency (PMDA).[29,63,64]

Decon7 does not have the corrosive property of bleach, making it a potential solution that increases life-cycle value of environmental surfaces. Decon7 (EPA Reg 89833-3, 89833-4) has been effectively used in various industries including the military, first responders, medical, and food and agriculture industries.[27] It is effective in a wide range of temperatures, does not require mechanical action, is water soluble and colorfast. It is free of abrasives and has no VOCs of concern. The primary ingredients are hydrogen peroxide, surfactants, and inorganic salts. Thus it does not pose acute or delayed human risks.[65] For immediate discomfort related to exposure, flushing eyes with water, washing skin with soap and water, moving to fresh air for inhalation, and calling for medical advice for ingestion is recommended.[65] In this study, Decon7 was significantly more successful at inactivating CoVs than bleach with 1 minute of contact time. The practical implications of an effective disinfectant with a minimal contact time of 1 minute is substantial. Time constraints and human error may be mitigated to improve overall cleaning and disinfecting of environmental surface materials.

Very few PFUs of HCoV OC43 and HCoV NL63 were recovered from SS regardless of disinfectant. This does not agree with our prior work[15] or that of others that show CoV persists on SS for up to 48 hours.[66] Since the controls worked for the other 3 surfaces, we concluded that there could be an environmental factor contributing to our results. Studies have reported that relative humidity can influence the ability for CoVs adherence to SS.[67,68] Even different CoVs vary in their persistence on SS especially in relation to relative humidity.[67,68] Disinfection studies on SARS-CoV-2 were performed at 45%-50% RH while studies on CoV OC43 and CoV NL63 were performed at 18%-20% RH.

Stainless steel used in indoor environments is typically either polished or brushed. This study utilized brushed stainless steel because it is most used in products and building surface materials in healthcare and veterinary facilities. Future studies should include a comparative analysis of polished and brushed stainless steel to determine if there are significant differences in the properties of stainless steel as currently used. This study, conducted in laboratory conditions, did not use a soil load on the inoculated samples. Supplementing test cultures with an organic soil load, typically in the form of equine or bovine blood serum, simulates moderately "dirty" conditions. The EPA requires a minimum organic soil load of 5% for one-step cleaner/disinfectants.[69] Current evidence suggests that soil load will affect the efficacy of disinfectants.[70,71] A study comparing soil loads found that to develop a realistic soil load, a combination of bacteria, protein, hemoglobin, and total organic carbon may be more suitable than a single material.[70] Future work should include comparing disinfectants with a soil load to determine differences in efficacy.

Even when circumstances allow for a 10-minute contact time, environmental factors can reduce effectiveness. At an aver-

age relative humidity of 45% (for most areas), disinfectant that has been sprayed or wiped onto a surface may not persist for the entire time required for disinfection. In laboratory conditions, disinfectant sprayed on a countertop dried between 41 seconds and 3.19 minutes while countertops wiped with disinfectant wipes dried in 45 seconds to 1.31 minutes. This is not sufficient contact time for most EPA approved disinfectants to inactivate CoVs and other pathogens. Thus, having a product that is effective at 1 minute contact time is more practical in a real-world environment.

5. Conclusions

Decon7 inactivates CoVs within 1 minute, a 90% decrease in time compared to the recommended 10 minute contact time of all other EPA approved disinfectants for CoVs including SARS-CoV-2. A contact time of 1 minute is more practical in a real-world environment where most healthcare facilities, animal clinics, and emergency rooms lose valuable preparation time waiting for 10 full minutes for inactivation. Additional efforts are needed to apply these recommendations to clinical and laboratory settings to improve patient care and safety.

Conflicts of Interest Disclosure

The authors declare they have no conflicts of interest.

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