Efficacy of Bioshell Calcium Oxide Water as Disinfectants to Enable Face Mask Reuse

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Bioshell calcium oxide (BiSCaO) is derived from scallop shells and after heat treatment exhibits broad microbicidal activity. BiSCaO Water is a disinfectant prepared by collecting the aqueous layer after adding BiSCaO powder to water, is colorless and transparent, and has a pH of 12.8. We compared the utility of commercially available BiSCaO Water, ethanol, sodium hypochlorite, hypochlorous acid and hydrogen peroxide solutions as sterilization agents to enable the reuse of surgical and N95 face masks. The microbicidal efficacy of each disinfectant was evaluated using pieces of surgical and N95 face masks contaminated with normal bacterial flora. The results suggest that BiSCaO Water has excellent disinfection activity toward contaminated polypropylene masks and has minimal adverse effect on the structure of non-woven masks.

Key words: non-woven mask / reuse / bioshell calcium oxide / microbicidal activity / sterilization.

INTRODUCTION

Respiratory viruses cause more deaths globally than any other infectious agent, as exemplified by the pandemic caused by SARS-CoV-2. Animal coronaviruses have “host jumped” to humans, leading to severe infections with high mortality, such as severe acute respiratory syndrome, Middle East respiratory syndrome (Geller et al., 2012), and coronavirus disease 2019 (COVID-19) (Hirschmann et al., 2020; Kampf et al., 2020). Single use filtering face masks are critical personal protective equipment for health care workers treating patients with suspected upper respiratory tract pathogens such as COVID-19. Face mask use prevents airborne viral transmission, reduces the likelihood of droplet infection, and prevents the user from touching their mouth and nose (Kampf et al., 2020; Rubio-Romero et al., 2020). However, single use masks can be in short supply globally during a pandemic. Although decontamination by hydrogen peroxide (H₂O₂) vapor treatment is approved by the United States Food and Drug Administration for the reuse of masks, this technique requires special equipment, limiting its widespread application (Liao et al., 2020; Rubio-Romero et al., 2020). Other sterilization methods, including autoclaving, bleach, and alcohol (Boskoski et al., 2020; Geller et al., 2020) can damage the filtration layer of masks made of melt-blown polypropylene. This filtration layer determines the pore size of a face mask and thus its effectiveness (Boskoski et al., 2020; Geller et al., 2020). A simple and effective decontamination method that does not compromise the function of a mask is thus required to allow their reuse.

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Scallop shells are naturally derived inorganic materials and are used as a food additive. Most scallop shells are currently considered industrial waste and thus accumulate on the shores of harvesting districts in Japan. Harmful materials leaching from the shells have caused serious problems, such as offensive odors and soil pollution (Sawai, 2011; Hiruma et al., 2020). The main component of scallop shells is calcium carbonate (CaCO₃). When heated above 800 °C, the resultant heated scallop shell powder is composed mainly of calcium oxide (CaO). We call this material bioshell calcium oxide (BiSCaO) and have shown it to have broad antimicrobial activity (Watanabe et al., 2014) against avian influenza virus (Thammakarn et al., 2014), various pathogenic bacteria (Sawai, 2011; Watanabe et al., 2014), heat-resistant bacterial spores (Sawai et al., 2003), fungi (Xing et al., 2013), and biofilms (Kubo et al., 2013; Sawai et al., 2013; Shimamura et al., 2015). In addition, the use of this material as a food additive prolongs the shelf life of food products (Sawai, 2011).

The mechanisms underlying the disinfection action of BiSCaO involve the strong basicity of calcium hydroxide (Ca(OH)₂) produced by the hydration of CaO. The disinfection activity of BiSCaO is higher than that of Ca(OH)₂ or sodium hydroxide (NaOH) solutions at the same pH, suggesting other mechanisms are also involved (Fukuda et al., 2020; Sato et al., 2019A). BiSCaO suspensions have been used to clean contaminated wood and pig skin pieces to remove both total viable bacterial cells (TC) and coliform bacteria (CF) (Fukuda et al., 2020; Sato et al., 2019A). Moreover, treating Pseudomonas aeruginosa-infected wounds on hairless rats with BiSCaO suspension (Takayama et al., 2020A) or BiSCaO-ointment (Takayama et al., 2020B) once daily for 3 days using chitin-nanofiber sheets as wound dressings significantly decreased the bioburden and enhanced healing (Ishihara et al., 2015; Nguyen et al., 2014).

Despite the huge potential of BiSCaO, its disadvantage for some applications is its poor water-solubility under strongly alkaline conditions (pH > 12.3); spraying high concentration aqueous suspensions of BiSCaO results in precipitation, causing significant loss of BiSCaO and plugged spray nozzles (Fukuda et al., 2020; Sato et al., 2019A). We previously reported strategies for preventing the precipitation of BiSCaO by adding phosphate compounds such as sodium phosphate (Na₃HPO₄) or polyphosphate sodium (Na-polyPO₄) or polyphosphate calcium (Ca-polyPO₄) producing a BiSCaO dispersion (Sato et al., 2019B) and colloidal dispersion (Sato et al., 2019C), respectively. Interestingly, the dispersion and colloidal dispersion exhibited higher deodorization and microbicidal activity compared to BiSCaO suspension without the phosphate compounds.

Commercially available BiSCaO Water is another BiSCaO-based disinfectant with high deodorization and bactericidal activity, as well as virucidal activity to both enveloped and non-enveloped viruses (Nakamura et al., 2020). BiSCaO Water is prepared by adding BiSCaO powder to water, then gently collecting the aqueous layer. BiSCaO Water is transparent, has a pH > 12.7, and contains small nanoparticles (100-200 nm) that aggregate into larger particles (400-800 nm) (Nakamura et al., 2020). We recently demonstrated that spraying BiSCaO Water onto surfaces of various materials or rat skin is safe, despite the strong alkalinity of fresh BiSCaO Water, because the high pH rapidly decreases upon the generation of CaCO₃ by interaction between Ca²⁺ in BiSCaO Water and CO₂ in the air (Ishihara et al., 2020). The present study evaluated BiSCaO Water as a sterilization agent to allow the reuse of face masks and was compared with ethanol, sodium hypochlorite (NaClO), hypochlorous acid (HClO) and H₂O₂ solutions.

MATERIALS AND METHODS

BiSCaO Water and other disinfectants

BiSCaO powder with an average particle diameter of 6 µm and BiSCaO Water were purchased from Plus Lab Corp., Kanagawa, Japan. According to the manufacturer, the BiSCaO powder was heated at 1450 °C for 4 h and had a CaO content > 99%. BiSCaO Water was prepared by adding 100 g of BiSCaO to 1100 mL chilled water (< 10 °C), gently mixing, and leaving for 30 min. The aqueous layer (1000 mL) was collected and transferred to a tank. Another 1000 mL chilled sterile water was added to the BiSCaO and the aqueous layer was transferred to the tank. This process was repeated 100 times. Ethanol (99.5%) and H₂O₂ (30%) were purchased from FUJI FILM Wako Pure Chemical Corp., Osaka, Japan. The NaClO (5000 ppm, pH 9.8) was purchased from Yoshida Pharmaceutical Co. Ltd., Saitama, Japan. The pH of the HClO solution was adjusted to 6 by adding 1 N HCl.

Change in pH of BiSCaO Water sprayed on surgical and N95 face masks

Approximately 1 mL of BiSCaO Water was sprayed onto pieces (2 × 2 cm) cut from surgical masks (surgical mask ST; Utsunomiya Seisaku Co. Ltd., Osaka, Japan) and N95 face masks (GIKO 1400, NIOSH N95, Fitlife Corp., Tokyo, Japan). The pH of each wet surface was measured every minute for 20 min using a pH bench meter (LAQUA pH meter, F-74, HORIBA, Ltd., Kyoto, Japan) equipped with a Micro Tough electrode (9618S-10D; HORIBA, Ltd.).

Microbicidal efficacy against highly contaminated
mask surfaces

The microbicidal efficacies of variously diluted solutions of BiSCaO Water against contaminated pieces of surgical and N95 face masks were measured and compared with those of ethanol, NaClO, HClO and H₂O₂. Suspensions contaminated with normal bacterial flora were prepared by incubating bathtub water with 10% Dulbecco’s Modified Eagle’s Medium (DMEM) and 0.1 wt% bovine serum albumin (BSA) at 37 °C for 24 h (Fukuda et al., 2020; Sato et al., 2019A; Sato et al., 2019B; Sato et al., 2019C). Contaminated pieces of each mask type were prepared by adding 40 mL of the contaminated suspension to each piece of mask (1.2 cm × 1.2 cm, n = 10) and incubating at 37 °C for 3 h with gentle rotary mixing, followed by rinsing with sterile water. For the disinfection assay, each piece of mask was placed in 5 mL of non-diluted, 2-fold-diluted, 4-fold-diluted and 8-fold-diluted BiSCaO Water, or in ethanol (99.5%), NaClO (200 ppm, pH 10.0), HClO (200 ppm, pH 6.0) or H₂O₂ (1%), then rotary mixed for 15 min. TC and CF were released from the contaminated pieces by adding 10 mL of sterile water and vigorously vortexing for 2 min.

To count the number of colony-forming units (CFU), 1 mL of each mixture was gently poured into individual Petri dishes containing pre-aliquoted portions of Simple and Easy Dry Medium for TC or CF (Nissui Pharmaceutical Co., Ltd., Tokyo, Japan) (Fukuda et al., 2020; Sato et al., 2019A; Sato et al., 2019B; Sato et al., 2019C). The plates were incubated for 24 h in a 37 °C incubator (A1201; IKUTA Sangyo Co., Ltd., Ueda, Nagano, Japan), followed by plating and counting as a set of 4 technical replicates (n = 4).

Sterilization using BiSCaO Water sprayed on surgical mask surfaces

A suspension contaminated with 2.7 ± 0.7 (×10⁶) CFU/mL of TC and 7.2 ± 2.5 (×10⁷) CFU/mL of CF (100 μL) was inoculated and dried for 30 min at room temperature on a round area (2 cm diameter) of the surface of a surgical mask. “Pre-spray” was conducted by spraying about 1 mL of non-diluted BiSCaO Water, ethanol (80%), NaClO (200 ppm, pH 10.0), HClO (200 ppm, pH 6.0) or H₂O₂ on the round area and drying for 3 h at room temperature, then inoculating with TC and CF. “After-spray” involved spraying about 1 mL of BiSCaO Water, ethanol, NaClO, HClO or H₂O₂ on the inoculated round area and drying for 3 h at room temperature. The inoculated area of each mask was cut out, then the TC and CF were released from the contaminated sections into 10 mL of sterile water by vigorous vortexing for 2 min. To count the CFU, 1 mL of each mixture was gently poured into individual Petri dishes containing pre-aliquoted portions of Simple and Easy Dry Medium for TC or CF. The plates were incubated for 24 h in a 37 °C incubator, followed by plating and counting as a set of 4 technical replicates (n = 4).

Adverse effects on the structure of non-woven (surgical and N95) masks

Adverse effects on structure of non-woven (surgical and N95) masks were evaluated by submerging four pieces cut from the inner layer (1.5 × 1.5 cm) of both masks into 40 mL of non-diluted BiSCaO Water, 80% ethanol, 200 ppm NaClO (pH 9.5), 200 ppm HClO (pH 6.0) or 1% H₂O₂ for 30 min twice each day for 5 days (a total of 10 times). Scanning electron microscopy (SEM) samples were prepared by osmium metal coating of treated and untreated surgical and N95 mask pieces using a neo-osmium coater (Neoc-STB; Meiwafosis Co., Ltd., Tokyo, Japan). The structure of each inner mask surface was observed using a field emission scanning electron microscope (JSM-6340F; JEOL Ltd. Tokyo, Japan) at an accelerating voltage of 5 kV.

RESULTS

Changes in the pH of BiSCaO Water sprayed on surgical and N95 masks

BiSCaO Water was sprayed onto the outside surfaces of surgical and N95 face masks, then the pH of each wet surface was measured for the next 20 min. For all tested surfaces, the pH immediately after spraying was 12.7 ± 0.03, slightly lower than the pH of BiSCaO Water (pH 12.8). The pH of the surfaces of both masks fell below 12 after 3 min and decreased to below 11 after 5 min, and after 10 and 15 min was below 10 and 9.5 (Fig. 1). The pH decreased faster when a researcher breathed on each mask (data not shown).
Incubation of bathtub water with DMEM and BSA at 37 °C for 24 h resulted in the TC and CF values increasing from 84 ± 15 and 31 ± 7 CFU/mL to 7.5 ± \(10^7\) and 1.7 ± \(10^7\) CFU/mL, respectively.

Ten pieces (1.2 cm × 1.2 cm) of surgical and N95 masks were incubated with 40 mL of the contaminated suspension for 3 h at 37 °C with gentle rotary mixing, then rinsed with sterile water. The TC and CF values of contaminated pieces of surgical and N95 masks were 1.2 ± 0.3 \(10^6\) and 2.3 ± 0.2 \(10^5\), and 9.2 ± 1.2 \(10^5\) and 9.8 ± 1.1 \(10^5\), respectively.

For surgical masks, the CFU/mL for both TC and CF following treatment for 15 min with BiSCaO Water (non-diluted, 2-fold-diluted and 4-fold-diluted), ethanol (non-diluted and 2-fold-diluted), NaClO (non-diluted), HClO (non-diluted and 2-fold-diluted) or H\(_2\)O\(_2\) (non-diluted) were below the detection limit (< 10 CFU/mL), whereas the log\(_{10}\)CFU reductions of TC and CF with 8-fold-diluted BiSCaO Water, ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 4.8 and 4.4, 0.4 and 0.6, 1.2 and 1.6, 0.7 and 0.9, and 0.6 and 0.5, respectively. The log\(_{10}\)CFU reductions of 4-fold-diluted ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 3.2 and 3.3, 0.2 and 0.3, 2.2 and 2.7, 2.1 and 2.1, and 0.2 and 0.3, respectively. The log\(_{10}\)CFU reductions of TC and CH with 4-fold-diluted BiSCaO Water, ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 3.2 and 3.3, 0.2 and 0.3, 2.2 and 2.7, 2.1 and 2.1, and 0.2 and 0.3, respectively. The log\(_{10}\)CFU reductions of TC and CH with 8-fold-diluted BiSCaO Water, ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 4.8 and 4.4, 0.4 and 0.6, 1.2 and 1.6, 0.7 and 0.9, and 0.6 and 0.5, respectively. The log\(_{10}\)CFU reductions of 4-fold-diluted ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 3.2 and 3.3, 0.2 and 0.3, 2.2 and 2.7, 2.1 and 2.1, and 0.2 and 0.3, respectively. The log\(_{10}\)CFU reductions of TC and CH with 8-fold-diluted BiSCaO Water, ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 4.8 and 4.4, 0.4 and 0.6, 1.2 and 1.6, 0.7 and 0.9, and 0.6 and 0.5, respectively.

For N95 facial masks, the CFU/mL for TC and CF following treatment for 15 min with BiSCaO Water (non-diluted and 2-fold-diluted), ethanol (non-diluted), NaClO (non-diluted and 2-fold-diluted), HClO (non-diluted and 2-fold-diluted) or H\(_2\)O\(_2\) (non-diluted) were below the detection limit (< 10 CFU/mL), whereas the log\(_{10}\)CFU reductions of TC and CF with 8-fold-diluted BiSCaO Water, ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 4.8 and 4.4, 0.4 and 0.6, 1.2 and 1.6, 0.7 and 0.9, and 0.6 and 0.5, respectively. The log\(_{10}\)CFU reductions of 4-fold-diluted ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 3.2 and 3.3, 0.2 and 0.3, 2.2 and 2.7, 2.1 and 2.1, and 0.2 and 0.3, respectively. The log\(_{10}\)CFU reductions of TC and CH with 4-fold-diluted BiSCaO Water, ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 3.2 and 3.3, 0.2 and 0.3, 2.2 and 2.7, 2.1 and 2.1, and 0.2 and 0.3, respectively. The log\(_{10}\)CFU reductions of TC and CH with 8-fold-diluted BiSCaO Water, ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 4.8 and 4.4, 0.4 and 0.6, 1.2 and 1.6, 0.7 and 0.9, and 0.6 and 0.5, respectively. The log\(_{10}\)CFU reductions of 4-fold-diluted ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 3.2 and 3.3, 0.2 and 0.3, 2.2 and 2.7, 2.1 and 2.1, and 0.2 and 0.3, respectively. The log\(_{10}\)CFU reductions of TC and CH with 8-fold-diluted BiSCaO Water, ethanol, NaClO, HClO and H\(_2\)O\(_2\) were 4.8 and 4.4, 0.4 and 0.6, 1.2 and 1.6, 0.7 and 0.9, and 0.6 and 0.5, respectively.
Sterilization by BiSCaO Water sprayed on surgical mask surfaces.

The CFU/mL of TC and CF released from the inoculated and dried sections of surgical masks into sterile water by vigorous vortexing were $1.2 \pm 0.2 \times 10^7$ and $6.2 \pm 1.2 \times 10^6$, respectively. The log$_{10}$CFU reductions of TC and CF by pre-spray with BiSCaO Water, ethanol, NaClO, HClO or H$_2$O$_2$ were 1.7 and 2.0, 0.3 and 0.3, 0.4 and 0.4, 0.6 and 0.5, and 0.7 and 0.8, respectively. In contrast, the log$_{10}$CFU reductions of TC and CF by after-spray with BiSCaO Water, ethanol, NaClO, HClO or H$_2$O$_2$ were 4.6 and 4.7, 3.8 and 4.2, 4.3 and 4.4, 4.4 and 4.5, and 4.6 and 4.6, respectively. The log$_{10}$CFU reductions of TC and CF by pre- and after-spray were almost identical to those in after-spray (Fig. 4). Thus, pre-spray with BiSCaO Water, ethanol, NaClO, HClO or H$_2$O$_2$ had minimal sterilization effects for surgical mask surfaces.

Adverse effect on structure of non-woven masks

Pieces of surgical and N95 masks were submerged in BiSCaO Water, ethanol (80%), NaClO (200 ppm), HClO (200 ppm) or H$_2$O$_2$ (1%) for 30 min twice a day for 5 days (a total of 10 times) and then dried. SEM images of the front (Fig. 5) and inside (Fig. 6) surfaces of masks treated with BiSCaO Water were identical to that of the control, suggesting that BiSCaO Water did not damage either mask. In contrast, the front and inner surfaces of both masks appeared to significantly melt following treatment with ethanol. In addition, H$_2$O$_2$, HClO, and NaClO-treatments seemed to cause formations of minor damaged holes and corruptions of nonwoven fabric (Figs. 5 and 6).

DISCUSSION

Studies of previous respiratory virus epidemics to date suggest that surgical and N95 face masks have significant efficacy. The protective effects of both masks are especially powerful when used in combination with other protective measures such as hand washing, eye protection, gowns, and gloves. In emergency situation such as the COVID-19 pandemic, the use of N95 face masks by the general public and non-high-risk medical staff should be limited and rather reserved mainly for high-risk healthcare personnel working with airborne virus outbreaks. Surgical and N95 face masks remain effective even when used for extended periods, although wearing a single mask for longer than 4 hours should be avoided because it can lead to discomfort (Boskoski et al., 2020; Rubio-Romero et al., 2020). Moreover, disposable surgical and N95 face masks are generally not approved for routine decontamination and reuse as a standard of care.

Although the reuse of masks after sterilization is a promising strategy, the treatments may adversely affect the masks. Disinfection with an alcohol such as ethanol structurally deforms non-woven polypropylene (Grinshpun et al., 2020; Rubio-Romero et al., 2020). In this study, SEM observations of the inner surfaces of surgical and N95 face masks treated with 80% ethanol showed significant structural deformation in inside of masks with melting (Fig. 6). Furthermore, formations of minor damaged holes and corruptions of nonwoven fabric were observed with H$_2$O$_2$, HClO, and NaClO-treatments. Thus, BiSCaO Water did not change the structures of nonwoven fabric facial masks (Figs. 5 and 6). However, filtration efficiency test is required to demonstrate a function maintenance of BiSCaO Water-treatment (Hirschmann et al. 2020; Liao et al. 2020). We plan to evaluate the filtration efficiency of each-treated masks.

NaClO solution (pH > 8) is a disinfectant with strong

![FIG. 4](image-url). Sterilization of surgical mask surfaces by spraying BiSCaO Water. Surgical mask pre- and after-spray, and after-spray alone, of each disinfectant had a strong sterilization effect, whereas pre-spray alone resulted in minimal sterilization. Plating and counting were performed as a set of 4 technical replicates ($n = 4$) and error bars represent means ± S.D.
oxidizing properties and is widely used for sanitation and decontamination in various fields, including healthcare and food processing, because of its antimicrobial activity and low cost (Ardizzoni et al., 2009; Fukuzaki et al., 2006; Hao et al., 2013; Horiuchi et al., 2015). However, the antimicrobial activities of NaClO are relatively poor against some microorganisms, such as Aspergillus oryzae, bacterial spores, poliovirus, and norovirus. While high concentrations (> 1000 ppm) of NaClO are generally used in clinical settings to inactivate microorganisms in spilled body fluids such as blood and feces, reactions of NaClO with organic molecules can produce carcino gens and poisonous compounds. Although the present study showed that NaClO disinfects contaminated face masks, harmful compounds might be produced.

HClO solution (pH 6) exhibits higher antimicrobial activity against a broad range of microorganisms compared to NaClO (Horiuchi et al., 2015) but it is less stable: for example, various organic compounds and inorganic ions rapidly decrease the HClO concentration thorough oxidation reactions (Ishihara et al., 2017). Furthermore, here we showed that the inner surfaces of surgical and N95 face masks treated with either NaClO or HClO showed minor damage and structural deformation of non-woven polypropylene.

The addition of phosphate compounds to BiSCaO or BiSCa(OH)$_2$ suspensions results in stable dispersions (Sato et al., 2019B), and the addition of NapolyPO$_4$ as a flocculation agent generates BiSCaO and BiSCa(OH)$_2$ colloidal dispersions (Sato et al., 2019C). In contrast,

**FIG. 5.** SEM images of the front surfaces of surgical and N95 masks without and with disinfectant treatment.
BiSCaO Water is prepared by collecting the aqueous layer after adding BiSCaO powder to water, is colorless and transparent, and has a pH of 12.8. BiSCaO Water can easily be sprayed and dried on smooth metal or plastic surfaces, providing a white powder coating. The dried white powder was previously shown to be CaCO$_3$ by X-ray diffraction analysis (Nakamura et al., 2020).

Serious concerns have been raised regarding the safety of BiSCaO Water for use on living tissues because its pH is above 12.7. We showed that BiSCaO Water, when sprayed onto surgical and N95 masks, had an initial pH of 12.6 ± 0.02, which is lower than the pH of BiSCaO Water (pH 12.8). The pH values of the mask surfaces decrease to below 10 within 15 min (Fig. 1) and are below pH 11 after 5 min. The decrease in pH was faster when the masks were breathed upon (data not shown), possibly due to a higher supply of CO$_2$ from breath.

The results of this study suggest that spraying BiSCaO Water onto the surfaces of face masks is safe, despite the strong alkalinity of fresh BiSCaO Water: the high pH of BiSCaO Water rapidly decreases on the surfaces of masks, generating CaCO$_3$ through the interaction between Ca$^{2+}$ ions in BiSCaO Water and CO$_2$ in the air (Ishihara, M. et al. 2020). CaCO$_3$ powder is used as a gastric antacid (Chen et al., 2019), an anti-erosive agent (Scandiffio, et al., 2018), and a plant fertilizer (Royse et al., 2003). Thus, the ingestion of a small amount of BiSCaO Water will not cause problems, given that the resulting CaCO$_3$ powder will be converted...
to safe and soluble calcium bicarbonate (\(\text{Ca}(\text{HCO}_3)\)) upon further interaction between \(\text{CaCO}_3\) and \(\text{CO}_2\) (Ishihara et al., 2020). The characteristics of BiSCaO Water, including its apparent safety and virucidal activity against enveloped viruses (Nakamura et al., 2020), make BiSCaO a promising approach for enabling face mask reuse to combat the spread of respiratory viruses such as SARS-CoV-2.

Disclosure statement
Declarations of interest: none.

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