Transparent Anti-SARS-CoV-2 and Antibacterial Silver Oxide Coatings

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ABSTRACT: Transparent antimicrobial coatings can maintain the aesthetic appeal of surfaces and the functionality of a touch-screen while adding the benefit of reducing disease transmission. We fabricated an antimicrobial coating of silver oxide particles in a silicate matrix on glass. The matrix was grown by a modified Stöber sol–gel process with vapor-phase water and ammonia. A coating on glass with 2.4 mg of Ag₂O per mm² caused a reduction of 99.3% of SARS-CoV-2 and >99.5% of Pseudomonas aeruginosa, Staphylococcus aureus, and methicillin-resistant Staphylococcus aureus compared to the uncoated glass after 1 h. We envisage that screen protectors with transparent antimicrobial coatings will find particular application to communal touch-screens, such as in supermarkets and other check-out or check-in facilities where a number of individuals utilize the same touch-screen in a short interval.

KEYWORDS: SARS-CoV-2, antibacterial, antiviral, antimicrobial, silver oxide, Ag₂O, transparent, coating, COVID-19

1. INTRODUCTION

Pathogenic microbes are responsible for a wide variety of diseases. The routes of transmission vary among microbes and depend on a variety of variables such as temperature and climate. Viruses and microorganisms are known to be transmitted through one or a combination of five main routes: (1) direct contact, (2) airborne, (3) droplet, (4) vehicle-borne including via fomites, and (5) vector-borne. Strategies to reduce pathogen transmission can be used to reduce the prevalence of disease in the community and to reduce healthcare-associated infections (HAIs).

Staphylococcus aureus (S. aureus), methicillin-resistant S. aureus (MRSA), and Pseudomonas aeruginosa (P. aeruginosa), three common infectious bacteria in healthcare settings, cause mild to life-threatening infections that set the stage for maladies such as bloodstream, urinary tract and surgical site infections, sepsis, and pneumonia. These bacteria are considered a major threat to public health and can be transmitted through contaminated fomites.

The coronavirus disease 2019 (COVID-19) pandemic has dramatically increased the need to control pathogen transmission in different settings. By December 2021, COVID-19 had been responsible for the death of almost more than 5 million people and is known to spread more easily than other coronavirus diseases. Although the main transmission route of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes COVID-19, is the inhalation of contaminated respiratory droplets, the transmission modes of this virus are believed to be direct contact, airborne, and contaminated fomites. One modeling study suggested that 25% of transmission is via fomites, and SARS-CoV-2 is known to be stable on a skin model up to 96 h at 22 °C. A recent study showed substantial transfer of this virus from fomites to a skin model.

Hand hygiene is believed to be an effective measure to prevent the microbe transfer through contaminated surfaces, but in a fomite-rich environment, cleaning of hands would need to be very frequent. Therefore, health professionals suggest a combination of hand hygiene and surface disinfection to mitigate the risk of these microbe transfers.

A parallel approach to the reduction of infection from fomites is to implement coatings on common-use surfaces that quickly inactivate microbes between users. SARS-CoV-2 can remain viable on solid surfaces up to 7 days, and the above-mentioned bacteria are stable on surfaces for months, depending on the type of solid and environmental conditions. If these periods were reduced by antimicrobial
coatings on common-touch surfaces, the window of transmission could be shortened and the spread of COVID-19 and other microbial diseases could be reduced.

To this end, coatings have been developed to kill bacteria, viruses and more recently to inactivate SARS-CoV-2. The speed of their action is of great importance; clearly one would like the viability of the surface-adherent microorganisms to be eliminated within minutes or even a shorter time after deposition of the microbe on the solid surface.

Another practical criterion for an antimicrobial coating is retention of the function of the surface after it has been coated. This is our motivation for creating transparent antimicrobial coatings. Transparency is necessary for phone screens, touch-screens at supermarkets and check-in facilities, tablets, windows, etc., and touch-screens are a known pathway for the spread of pathogens. For example, mobile phones are a major pathway for bacteria spread in hospitals and on catheters. No damage, change in morphology, or cytotoxic effect has been observed against L929 fibroblast cells or G292 osteoelastic cells, which are mammalian cells. Because of such low cytotoxicity, Ag2O can be used in wide variety of applications from tooth paste against dental pathogens to its nontransparent coatings for medical implants and on coatings on common-touch surfaces, the window of transmission could be shortened and the spread of COVID-19 and other microbial diseases could be reduced.

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To fabricate the transparent coatings we employed a novel binding method based on the Stöber sol–gel process that utilized vapor-phase reactants so that menisci could form and evaporate and the self-assembly of the particles accordingly. After 2 h, the ethanol was evaporated and samples were transferred to a leveled sealed container in contact with vapors of 8 M DI water in ethanol and 7.62 M ammonia in DI water for 20 h. Next, the samples were heat-treated at 50 °C for 40 min. Lastly, samples were blown with high pressure nitrogen, rinsed upside down in DI water for 10 min, and dried with nitrogen gas. We used cleaned glass and Ag2O-free TEOS-coated samples as controls in the antimicrobial experiments.

2.4. Characterization of Microparticles and Coatings. The X-ray diffraction (XRD) pattern obtained from a Bruker D8 Advance diffractometer (monochromatic Cu Kα X-ray, wavelength = 1.5418 Å) was used to identify the crystal structure of the particles. The X-ray photoelectron spectroscopy (XPS; PHI VersaProbe III with a monochromatic Al Kα source of 1486.6 eV) was employed to assess the chemical composition of the surface of the film. Scanning electron microscopy (JEOL JSM-IT300) and atomic force microscopy (Asylum Research 3D MFP) were utilized to examine the coating morphology and roughness, respectively. ImageJ software was employed to obtain the synthesized particle size distribution through SEM images. Surface composition was assessed using electron-dispersive X-ray spectroscopy (Oxford Instruments Ultim Max 100). Optical absorbance and transmittance were measured using an Agilent model 8453 UV–Vis spectrometer. The wettability of the coatings was assessed from the contact angle (First Ten Angstroms FTA125) of 10 μL of DI water.

2.5. SARS-CoV-2 Assay. We have described the 50% tissue culture infective dose (TCID50) method for SARS-CoV-2 viability tests in detail elsewhere. Briefly, both preparation of the virus stock (Hong Kong index SARS-CoV-2 virus) and assessment of the cytopathic effect utilized Vero E6 cells. These cells were cultured at 37 °C and 5% CO2 in 2% fetal bovine serum and 1% v/v penicillin–streptomycin added to Dulbecco’s modified Eagle medium. The viral transport medium consisted of 0.5% (v/v) bovine serum albumin and 0.1% (v/v) glucose in Earle’s balanced salt solution with a pH of 7.4. Control samples and coatings were disinfected with 70% ethanol in water and then dried in air at 37 °C overnight.

The antiviral properties were assessed by placing a 5 μL droplet containing 7.8 log unit TCID50/mL of SARS-CoV-2 on the test solid at 22–23 °C and 60–70% humidity, and after a predefined time, the sample was eluted in 300 μL of viral transport medium. The viable virus was then measured using the TCID50 assay in quadruplicates. Three independently produced solid surfaces were tested for each time point, and the antiviral activity at each time point was obtained based on the reduction of log (virus titer).

2.6. Antibacterial Assy. Microbial Strains. The microbial strains employed in this study were P. aeruginosa strain DSM-9644, S. aureus strain ATCC no. 6538, and a methicillin-resistant S. aureus (MRSA) strain MA43300 obtained from the Danville Community Hospital (Danville, VA).
Growth of Microbial Strains. Bacterial strains were grown in 5 mL of Tryptic Soy Broth (TSB, BD, Sparks, MD) to midexponential phase at 37 °C with aeration (60 rpm). Following growth, the purity and identity of the cells in the cultures were verified by streaking bacterial cultures on Tryptic Soy Agar (TSA, BD) and incubating at 37 °C for 48 h and examining colonies for species-specific traits (e.g., pigmentation and surface texture).

Preparation of Microbial Strains for Testing. Grown cells were collected by centrifugation (5000g for 20 min), the supernatant medium was discarded, and the cells were suspended in 5 mL of sterile phosphate-buffered saline (PBS) by vortexing for 60 s. Those suspensions were centrifuged (5000g for 20 min), the supernatant was discarded, and the washed cells were suspended in 5 mL of sterile PBS by vortexing for 60 s. The number of colony-forming units (CFU)/mL of each washed suspension was measured by spreading 0.10 mL (in duplicate) of serial dilutions in PBS on TSA plates.

Measurement of Cell Number. Cell number of PBS suspensions of bacteria was measured as colony-forming units (CFU)/mL of suspension. This measures the number of viable cells, i.e., those cells that are able to grow into a colony. A 10-fold dilution series was prepared for each PBS suspension, 0.1 mL of each dilution was spread on TSA in triplicate, and colonies were counted after 48 h of incubation at 37 °C. If no colonies were present for the least dilution, then we rounded this result up to one colony to enable a log transformation. We set this as the detection limit shown in the figures. Any data point at the detection limit is therefore an upper bound for that measurement.

Measurement of Surface Killing. For each microbial strain, a 10 μL droplet of bacterial cells in PBS suspension was placed on each of three individual Ag2O-coated or uncoated glass pieces. Immediately after drying, each glass piece was transferred to a separate sterile 50 mL centrifuge tube containing 5 mL of sterile PBS, vortexed at the highest setting for 10 s, and sonicated for 1 min in a Branson model 12 ultrasonic cleaner (Shelton, CT), and the CFU/mL of the suspension was measured as described above. The process was repeated at each time point. CFU counts, corrected for dilution, are in tables in Supporting Information.

2.7. Robustness of Coatings. The United States Environmental Protection Agency (EPA) has a required procedure for the evaluation of antibacterial coatings. We followed their procedure but with some minor modifications. The procedure is described more fully in Supporting Information, but in brief, it consists of repeatedly translating a wet sponge across the coating with a mass of 0.45 kg using a Gardco model D10 V abrasion 214 tester. The main modification to the EPA procedure was to use ethanol, because our main application was for transparent surfaces, such as electronic displays, that are usually cleaned with alcohol solutions.

We further tested the particle attachment strength by sonicating the coatings for 3 min in ethanol. The absorbance spectra of the resulting suspensions were then obtained using UV–vis to evaluate the detachment of the particles.

2.8. Statistics. All experiments were performed in three independent trials. Effects were considered significant when p was near or below 0.05. Linear regression was performed using Excel or MATLAB.

3. RESULTS

3.1. Characterization of Ag2O Particles. The XRD pattern (Figure 1) of the Ag2O particles is consistent with the known pattern of Ag2O microparticles. The numbers on each peak indicate the Miller indices of the scattering planes. EDS of individual particles shows a 2.5:1 ratio of Ag:O which is similar to a 2:1 ratio expected for Ag2O (Supporting Information, Table S1). The morphology change is mainly complete after about 12 h, that ammonia is necessary for the reaction, and that the heat treatment does not affect the Ag2O morphology.

The static contact angles for a 10 μL water droplet on the Ag2O-coating and the 2xAg2O-coating were 62 ± 7° and 67 ± 5°, respectively (see Figure S7 in Supporting Information). We also examined how firmly the silver particles were attached to the film by exposing the film to ultrasound while immersed in ethanol for 3 min. We were not able to detect any particles that were removed by ultrasound (see Figure S8 in Supporting Information).

3.3. Silver Oxide Coatings Inactivate SARS-CoV-2. The antiviral activity of transparent silver oxide coatings was evaluated by placing a 5 μL droplet containing SARS-CoV-2 on each coating and measuring the viable virus titer at predefined time points. The results in Figure 4 show that silver oxide coatings are able to greatly accelerate the decay of SARS-CoV-2 compared to the uncoated solid. There are two reference points for considering the effectiveness of the coatings: (1) comparison to the input microbe titer in the test droplet, which we call “inactivation” and (2) comparison to the microbe titer on the uncoated glass at the same time, which we call “Reduction”, each of which is defined as follows:
log Inactivation = mean[log_{10}(input titer)] − mean[log_{10}(sample titer)]

(1)

log Reduction = mean[log_{10}(uncoated titer)] − mean[log_{10}(coated titer)]

(2)

% Inactivation = \left(1 - 10^{-\text{log Inactivation}}\right) \times 100

(3)

% Reduction = \left(1 - 10^{-\text{log Reduction}}\right) \times 100

(4)

In eqs 1 and 2, the titers have been made unitless by multiplying by the volume units, so the same volume units must be used for the two means. The TCID_{50} assay does not measure numbers of virions and instead measures the infectious dose of the virus needed to infect 50% of the tissue culture. The experimental Reductions and efficiencies are listed in Table 1. ANOVA (with time and Ag_{2}O loading as factors) showed that both time (p = 7 \times 10^{-19}) and concentration of Ag_{2}O (p = 1 \times 10^{-14}) were significant factors affecting the inactivation of SARS-CoV-2.

We observed a very slow inactivation of SARS-CoV-2 titer on the uncoated glass: the TCID_{50}/mL was decreased by only 66.7% (0.48 log_{10} reduction) after 1 h. In contrast, on the Ag_{2}O and the 2xAg_{2}O-coatings, the virus was inactivated by 95.4% (1.3 log_{10} reduction) and 99.8% (2.6 log_{10} reduction) after 1 h. When we compared the performance of these two transparent coatings with uncoated glass using eq 2 and eq 4, the average Reduction was 86.1% for the Ag_{2}O-coating and 99.3% for the 2xAg_{2}O-coating after 1 h. The 95% confidence interval (one tailed, heteroscedastic) indicated that the Reduction was more than 73.2% on the Ag_{2}O-coating and more than 95.7% on the 2xAg_{2}O-coating compared to uncoated glass after 1 h. The absence of significant Reduction for TEOS-only samples confirmed that silver oxide is the active ingredient for inactivating SARS-CoV-2 (Figure S9 in Supporting Information).

The significance of the silver oxide surface density, \(c\), and time, \(t\), can be determined by a regression analysis. For this analysis we included the zero-Ag_{2}O (TEOS only)-coating, the Ag_{2}O-coating, and the 2xAg_{2}O-coating. We included a cross-term (tc) because we hypothesized that more SARS-CoV-2 would be inactivated over time if there were a greater density...
of Ag<sub>2</sub>O in the coating. The regression equation has the following form:

\[
\log[\text{TCID}_{50}/\text{mL}] = A - Bt - Cc - Dtc
\]

where \(A, B, C,\) and \(D\) are coefficients to be determined by the regression. A regression analysis using 0 and 1 h data points showed that \(p = 0.12\) for the coefficient of concentration, and so this term was deleted and the analysis was rerun with only the \(t\) and \(tc\) terms. For the cross term, \(Dtc\), \(p = 4 \times 10^{-3}\), showing that the loss of viral titer depended on the concentration on the surface density. The half-life of the viral titer is

\[
t_{1/2} = \log 2/(B + Dc)
\]

so the significant value of \(D\) shows that the half-life of SARS-CoV-2 titer decreases with the concentration of Ag<sub>2</sub>O in the coating, a major conclusion of this paper. Values of all coefficients are in Table 2.

### 3.4. Silver Oxide Coatings Kill Bacteria

We tested the Ag<sub>2</sub>O-coating and the 2xAg<sub>2</sub>O-coating against three bacteria strains by placing a 10 µL droplet of bacterial cells on the solid and measuring the CFU after a predefine period of time. Figure 5 shows the antibacterial activity of silver oxide coatings against \(P.\) aeruginosa, S. aureus, and MRSA. Both coatings are extremely effective against all three bacteria as demonstrated by the death of bacteria at 1 h. We quantified the efficacy of the coatings using the following equations:

\[
\log \text{Survival} = \text{mean}[\log_{10}(\text{sample CFU})] - \text{mean}[\log_{10}(\text{input CFU})]
\]

\[
\log \text{Reduction} = \text{mean}[\log_{10}(\text{uncoated CFU})] - \text{mean}[\log_{10}(\text{coated CFU})]
\]

\[
\% \text{ Killing} = (1 - 10^{-\text{Survival}}) \times 100
\]

\[
\% \text{ Reduction} = (1 - 10^{-\text{Reduction}}) \times 100
\]

We use the word survival for simplicity but acknowledge that the CFU assay measures those cells that can reproduce to form a colony. Table 2 lists the survival (in log units) compared to both the input of bacteria, and the Reduction compared to glass at 1 h. Both coatings demonstrated excellent antibacterial activity, and the results indicate that the number of viable bacteria was reduced by at least 1.8 log units (>98.7% Reduction) on the Ag<sub>2</sub>O-coating and at least 2 log units (>99.3% Reduction) on the 2xAg<sub>2</sub>O-coating compared to glass in 1 h. Again, the reduction was greater with more Ag<sub>2</sub>O present in the film, and there was no significant Reduction for TEOS-only coatings (see Figures S10–S12 in Supporting Information), indicating that Ag<sub>2</sub>O is the active ingredient.

The significance of time and Ag<sub>2</sub>O concentration was again determined by a regression analysis using eq 5 (by replacing TCID<sub>50</sub> with CFU). Again, the effect of concentration was insignificant and was omitted in subsequent analysis. In common with SARS-CoV-2, the cross term, \(tc\), shows that a greater density of Ag<sub>2</sub>O in the coating leads to greater inactivation of all three bacteria over time. More precisely, a greater density of Ag<sub>2</sub>O in the coating reduces the half-life of the bacteria.

The 2xAg<sub>2</sub>O-coating also showed a considerable Reduction in comparison to uncoated glass. The Reduction of viable \(P.\) aeruginosa, S. aureus and MRSA on this coating was 99.9% (\(p = 7 \times 10^{-6}\)), 98.3% (\(p = 6 \times 10^{-6}\)), and 96.4% (\(p = 4 \times 10^{-4}\)), respectively, compared to uncoated glass after 1 h (Figure 5).

### 3.5. Ag<sub>2</sub>O-coatings Are Transparent and Retain Touch-Screen Function

The Ag<sub>2</sub>O-coatings are transparent, with about 60–75% of the transmission of glass in the visible range and only small variation in transmission with color (Figure 6A). As a result, the colors of a smart phone screen are retained when a screen protector with the 2xAg<sub>2</sub>O-coating is attached to a smart phone screen (Figure 6B). Importantly, the screen function is retained with the coating in place (see video in Supporting Information).

### 3.6. The Antimicrobial Coatings Are Resistant to Abrasion

We also conducted an EPA abrasion test (slightly modified) on the 2xAg<sub>2</sub>O coating. After abrasion, the antimicrobial properties were unchanged, demonstrating that
the coating was robust (see Figure S13 in Supporting Information).

3.7. Efficacy after Repeated Exposures to Droplets Containing Bacterial Suspension. Although the 2xAg$_2$O coating was very robust against water and ethanol and passed the modified EPA abrasion test, the antibacterial efficacy was diminished after multiple exposures to suspensions of bacteria in droplets. Therefore, we modified the fabrication method to obtain a more robust coating. The principal change was that we increased the amount of silica in the film by increasing the TEOS from 2.8% to 20% (v/v) in ethanol solution. To achieve polymerization of the greater thickness of coating, we increased the time of exposure to the vapor to 60 h and the heat treatment to 75 °C for 40 min. We refer to this modified coating as the M-2xAg$_2$O-coating. The M-2xAg$_2$O-coating was characterized with SEM with XPS (Figure S14), which showed a lower silver content, consistent with some of the silver oxide being covered by the thicker TEOS layer. The visible spectrum showed that the transparency of the 2xAg$_2$O-coating was retained (Figure S15).

We tested the antibacterial performance of the M-2xAg$_2$O-coating against P. aeruginosa and MRSA (Figure 7). After 1 h, the microbial survival was below the detection limit with >99.9% killing, a 99.80% Reduction for P. aeruginosa and 99.97% Reduction for MRSA compared to the uncoated glass. Silver oxide transparent coatings significantly reduced the CFU units of the bacteria compared to uncoated glass (ANOVA p = 7 × 10$^{-15}$).

Figure 5. Log survival in colony forming units (eq 1) over time for (A) P. aeruginosa, (B) S. aureus, and (C) MRSA. Shaded rectangles represent the 95% confidence interval, and × represents the average of the log of the CFU at each time point. The log input titers were 6.08, 6.09, and 6.05 for P. aeruginosa, S. aureus, and MRSA respectively. After 1 h, the average killing percentage of P. aeruginosa, S. aureus, and MRSA were >99.9% on 2xAg$_2$O-coating and >99.3% on Ag$_2$O-coating. Silver oxide transparent coatings significantly reduced the CFU units of the bacteria compared to uncoated glass (ANOVA p = 7 × 10$^{-15}$).

Figure 6. (A) UV−Vis transmission spectrum of glass, Ag$_2$O-coating, and 2xAg$_2$O-coating showing that both films demonstrate more than 60−75% transparency in the visible range (400−700 nm). (B) A smartphone (iPhone 11) with uncoated and 2xAg$_2$O-coated screen protector (Mkeke, Amazon B07HRN9J19, tempered glass). The visual appeal and the touch-screen function are retained with the antimicrobial screen protector in place.
of Ag+ ions into the microbe and damaging the cell membrane. oxidative stress on cells, and (2) the release and penetration of virus and bacteriophage Qβ. Silver oxide particles damage the viral envelope of influenza A virus according which will lead to the killing of bacteria. Silver ions, on the other hand, lead to a loss of cell viability by exerting oxidative stress and damage the cell membrane. Minoshima et al. reported that the superoxide radical was the major form of the reactive oxygen species generated by silver ions, while H2O2 was unlikely to be induced. These reactive oxygen species exert an oxidative stress and damage DNA accordingly which will lead to the killing of bacteria. Silver ions, on the other hand, lead to a loss of cell viability by damaging the cell membrane. Minoshima et al. reported that silver oxide particles damage the viral envelope of influenza A virus and bacteriophage Qβ virus. There is a possibility that the efficacy of Ag2O depends on light. If the bandgap of the particles was in the visible range, light could cause the excitation of electrons to the conduction band, which could then act as reducing agents. We compared the antimicrobial efficacy of the 2xAg2O-coating in visible light and in the dark (see Figure S17 in Supporting Information). A Student’s t-test did not resolve a significant difference between light and dark measurements (p ≫ 0.05), and therefore the silver oxide coating does not require light for its antimicrobial properties.

5. CONCLUSION

We fabricated two silver oxide in silica coatings, Ag2O and 2xAg2O, that inactivate SARS-CoV-2 (95.4% and 99.8% in 1 h) and kill P. aeruginosa, (99.99% in 1 h), S. aureus (99.78% and 99.93% in 1 h), and the antibiotic-resistant strain MRSA (99.33% and 99.98% in 1 h). The coating was fabricated using a modification of the Stöber method to bind silver oxide particles to a glass substrate. The coated glass is transparent, which means that it does not degrade the aesthetic appeal of materials and it can be applied where transparency is important for function. For example, we showed that when a mobile phone screen was coated, both the screen clarity and the function of the touch-screen were retained. The combination of transparency and antimicrobial action means that the coating should find application for multiuser touch-screens, such as check-out facilities in grocery stores.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acsami.1c20872.

Synthesized particle size distribution (Figure S1). AFM images of 2xAg2O coating (Figure S2). Surface elemental analysis of coatings by EDS (Table S1). SEM images of uncoated glass and TEOS-coated glass (Figure S3). Time lapse of the sol–gel reaction (Figure S4). The effect of ammonia on the morphology of silver oxide particles (Figure S5). The effect of heat treatment on the morphology of silver oxide particles (Figure S6). Contact angle images of silver oxide coatings (Figure S7). Test of attachment of particles using ultrasonication (Figure S8). The comparison of SARS-CoV-2 titer log(TCID50/mL) data on TEOS and glass over time (Figure S9). The comparison of log survival of P. aeruginosa on TEOS and glass over time (Figure S10). The comparison of log survival of S. aureus on TEOS and glass over time (Figure S11). The comparison of log survival of MRSA on TEOS and glass over time (Figure S12). The effect of abrasion in the antibacterial properties of the silver oxide coating (Figure S13). Characterization of the M-2xAg2O-coating (Figure S14). UV–Vis transmission spectrum of uncoated glass and the M-2xAg2O coating (Figure S15). The effect of multiple bacteria exposure/sonicating/vortexing/titration/cleaning on the M-2xAg2O coating (Figure S16). The effect of absence of light in the antibacterial properties of silver oxide coating (Figure S17). SARS-CoV-2 TCID50/mL assay results for Figure 4 (Table S2). Pseudomonas aeruginosa CFU assay results for Figure 5 (Table S3). Staphylococcus aureus CFU assay results for Figure 5 (Table S4). MRSA CFU assay results.
for Figure 5 (Table S5). P. aeruginosa CFU assay results for Figure 7 (Table S6). MRSA CFU assay results for Figure 7 (Table S7). P. aeruginosa CFU assay results for Figure S13 (Table S8). P. aeruginosa CFU assay results for Figure S17 (Table S9). MRSA CFU assays results for Figure S17 (Table S10) (PDF)

Retention of screen function with the coating in place (MOV)

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Notes
The authors declare the following competing financial interest(s): W.D. declares part ownership in a startup company that intends to produce surface coatings. The other authors declare no conflict of interest.

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