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Effective Inactivation of airborne noroviruses using platinum nanoparticles on cloth masks

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ABSTRACT

There is no vaccine for norovirus. This paper shows spraying platinum nanoparticles on masks can inactivate airborne noroviruses. Feline calicivirus F-9 strain was used as a surrogate for human norovirus to verify the effectiveness of inactivation under JIS L 1922 and ISO 18184 for testing the ability of textiles to kill virus. The result achieved an R-value = 0.9, which is equivalent to 87.4 % reduction of infectious norovirus.

There is no vaccine for norovirus [1,2]. Noroviruses are among the most important causes of acute gastroenteritis [3]. Norovirus spreads through coughing, talking, sneezing, sharing food and utensils and via the mothers' breast tissue [4]. In other words, it is able to reduce norovirus by 87.4 % and repel it. To repel norovirus means to inactivate or disinfect the norovirus, thereby preventing it from causing an infection.

Inactivating airborne noroviruses on masks is crucial for public health for several reasons:

1) **Mitigating Disease Transmission:** Norovirus, due to its highly infectious nature, can be rapidly disseminated via minuscule airborne particles. The correct usage of masks can serve as a barrier against inhaling these particles.
2) **Safeguarding At-Risk Populations:** Individuals with conditions such as cardiovascular diseases, autoimmune disorders, immunosuppression, or kidney diseases are more susceptible to prolonged bouts of diarrhea and extended periods of viral shedding. These individuals are at an elevated risk and require additional protection.
3) **Healthcare Setting Precautions:** In healthcare environments, it's crucial to minimize exposure to vomit or diarrhea. Patients exhibiting symptoms aligned with norovirus gastroenteritis should be isolated in a single-occupancy room and placed under Contact Precautions.

This paper examines the effectiveness of airborne noroviruses with 10-ppm sprayed platinum nanoparticles on masks whether they are inactivated. The animal deodorant spray contains a 10-ppm platinum nanoparticle solution. Wearing a mask can reduce airborne viral infections. According to the CDC [5], cloth masks can reduce the use of masks by 56 %, surgical masks by 66 %, and respirators (N95) by 83 %.

It is extremely difficult to locate and identify the density distribution of platinum nanoparticles on mask. Ceramics Craft Co. Ltd., a company based in Japan, is responsible for the production of platinum nanoparticles. Their website can be found here: [http://www.ceraft.co.jp]. They have achieved a breakthrough in Japan by successfully purifying platinum nanoparticles, eliminating the need for colloidal membranes, and using platinum nanocolloids as the primary material [6]. They have secured the patent for a unique method that allows for the direct production of platinum nanoparticles from platinum via liquid-phase laser ablation [6]. The size of the platinum nanoparticles is controllable, but the distribution remains undetermined in a liquid solution.

Rise, accessible at [https://rise-pt.jp/], offers spray bottles containing a 10-ppm solution of platinum nanoparticles from ceraft.co.jp which are marketed as animal deodorizers. While there are currently no masks embedded with platinum nanoparticles available for purchase, one can find spray bottles filled with a 10-ppm solution of platinum nanoparticles for protection against COVID-19.

There is no platinum nanoparticles binder on the mask. The spray bottles are filled with a solution that has a concentration of 10-ppm of platinum nanoparticles. It may be a negligible amount for harming human health. A comprehensive review of the safety of platinum nanoparticles was conducted to examine the platinum nanoparticles safety.

Czubacka et al. conducted a review examining the safety of platinum nanoparticles in relation to human health [7]. They have found extensive applications not only in various industries but are particularly

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Table 1
result of antiviral activity test.

Test sample		Control logarithm average of infectivity titer (PFU/vial)		Reduction value (M)	Antiviral activity value (Mv)
Control specimen		Immediately after inoculation lg (Va)	6.62		
		After contacting for 4 h lg(Vb)	6.16	0.5	
Bonded-fiber fabric made adhere to platinum nano particles	original	After contacting for 4 h lg(Vc)	5.70		0.9

Table 2
result of control test.

Test sample		Cytotoxic effect	Cell sensitivity to virus Common logarithm average of infectivity titer (PFU/ml)	Judgement of control test
Control specimen		negative	2.69	
Bonded-fiber fabric made adhere to platinum nanoparticles	original	negative	2.65	satisfied

prevalent in the fields of medicine and diagnostics. In other words, platinum nanoparticles have been utilized as safe materials in the medical field for the betterment of human health.

Brown et al. have confirmed that up to 15 mg/kg of platinum or a 15-ppm solution is safe and showed no cytotoxic effects [8]. In other words, a 10-ppm solution of platinum nanoparticles is safe for human health.

The Scientific Committee on Consumer Safety of the European Commission has deemed platinum nanomaterials, when used in leave-on cosmetic products, to be safe [9]. These cosmetic products may contain up to 10-ppm of platinum nanomaterials. To put it differently, the 10-ppm platinum nanomaterials solution can be used as safe materials in cosmetic products.

According to US FDA regulations, when used only as a surface coating, the platinum content should not exceed 200 ppm [10]. The 10-ppm solution of platinum nanoparticles satisfies the regulation.

This paper will examine the effect of the cloth mask with 10-ppm platinum nanoparticles against norovirus using the animal deodorant.

Feline calicivirus F-9 strain [11] was used as a surrogate for human norovirus to verify the effectiveness of inactivation under JIS L 1922 and ISO 18184 for testing the ability of textiles to kill virus. The JIS L 1922 and ISO 18184 test standards are harmonized methods between the Japanese Industrial Standard (JIS) and International Organization for Standardization (ISO) organizations. The JIS L 1922 is designed to test the ability of textiles and other similar materials to kill virus. 4 h of exposure time was used in this experiment. In other words, the JIS L 1922 is the identical test method to ISO 18184 and uses improved textile products to obtain better antiviral properties.

Feline calicivirus is often used as a surrogate for human noroviruses because human noroviruses, a major cause of acute gastroenteritis worldwide, cannot be readily cultured in laboratory [12].

Antiviral Activity Test for Textile Products is composed of the following 7 steps: 1) preparation of test virus inoculum, 2) inoculate the Feline calicivirus suspension on the surface of CRFK cells in the flask, 3) put the flask in the COz incubator to multiply the Feline calicivirus, 4) centrifuge the multiplied virus suspension by using the centrifuge, 5) take the supernatant suspension from the centrifugal tube after the centrifugation, 6) the virus suspension was proceeded with 10-fold dilution using distilled water as diluent, and 7) the concentration of the virus suspension for the test after 10-fold dilution should be adjusted to a titer of 1×10^7 PFU/ml to 5×10^7 PFU/ml. This is to be the test Feline calicivirus inoculum.

Antiviral evaluation was performed at the Japan Textile Products Quality and Technology Center using plaque assay (Japanese Industrial Standard JIS L 1922), which corresponds to ISO 18184. As a procedure for experimentation, we first put the test piece (0.4 g) and test virus solution (0.2 ml) in a vial and incubated them at 25 °C for 4 h. Feline calicivirus was used as a test strain.

For cytotoxicity verification, three steps were conducted: 1) put control specimens and antiviral test specimens in the vial containers, 2) add 20 ml of wash-out solution in all containers, then put caps on the containers and agitate them by Vortex mixer for 5 s and 5 times, and 3) observe if cells damage or not by plaque assay.

For verification of cell sensitivity to virus and inactivation of antiviral activity, six steps were conducted: 1) put control specimens and antiviral test specimens in the vial containers, 2) add 20 ml of wash-out solution in all containers, then put the caps on the containers and agitate them by Vortex mixer for 5 s and 5 times, 3) take 5 ml of washing-out solution to new tubes, 4) add 50 μl of virus suspension prepared to be a concentration of 5.9×10^4 PFU/ml into the tubes, 5) keep them at 25 °C for 30 min, and 6) determine virus infective titer by plaque assay.

Plaque forming unit (PFU) is a measure used in virology to describe the number of viral particles that can form a plaque per unit volume. Table 1 shows the result of antiviral activity test of this experiment. The cotton 100 % woven fabric without fluorescent brightness or other finish sources from JTETC is used for control specimen.

Antiviral activity value is given: (Mv) = lg(Va)-lg(Vc).

Reduction value is given: (M) = lg(Va)-lg(Vb).

For judgement of test effectiveness is given: M≤1.0.

Table 1 shows that the test is effective since M = 0.5 which satisfied M ≤1.0. The antiviral activity value is 0.9 which is equivalent to reducing 87.4 % noroviruses.

It is calculated by the following: $(1–10^{-0.9}) = 0.874$. The result shows that the cloth mask with 10 ppm platinum nanoparticles is better than any existing masks on infection protection against noroviruses.

The result of control test is shown in Table 2. Test virus, Feline calicivirus, Strain: F-9 ATCC VR-782 was used. Test virus suspension is 5.0×10^4 PFU/ml. In conditions for control test, Cytotoxic effect is negative.

Cell sensitivity to virus is satisfied as follows:

lg(infectivity titer (PFU/ml) of control specimen) – lg(infectivity titer (PFU/ml) of treated specimen).

= 2.69–2.65 = 0.04 ≤ 0.5.

In Tables, "M" represents reduction value such as 0.5. "Va" represents control logarithm average of infectivity titer (PFU/vial) immediately after inoculation without platinum nanoparticles. "Vb" represents control logarithm average of infectivity titer (PFU/vial) after contacting for 4 h without platinum nanoparticles. "Vc" represents control logarithm average of infectivity titer (PFU/vial) after contacting for 4 h with platinum nanoparticles.

The results of this experiment showed that the animal deodorizer containing a 10-ppm platinum nanoparticle solution on a cloth mask was able to reduce norovirus by 87.4 % and repel it. The supplemental material-certificate of this experiment is attached with this manuscript.

The method proposed can be applied to other infectious diseases, including COVID-19. The results of the study are currently being prepared for possible submission.

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CRediT authorship contribution statement

Yoshiyasu Takefuji completed this research and wrote this article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Certificate of this experiment on data is attached.

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