Using cold atmospheric plasma treated-air for disinfection in cold-chain environment

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As an important part of global logistics, cold-chain transport has been suggested to be an important means for the cross-regional transmission of SARS-CoV-2[1]. In addition, many other pathogenic microorganisms can also be transmitted across countries via cold-chain transport. Efficient cold-chain sterilization technology is urgently needed to curb the spread of infectious diseases, but so far there is no mature technology and only a few studies have been published related to this subject.

In recent years, cold atmospheric plasma (CAP) has been widely studied for biomedical applications, and it is proven to have an excellent sterilization capability. However, whether CAP can effectively inactivate microorganisms in the cold chain environment remains to be further studied. We used surface discharge plasma-treated air to deactivate pseudoviruses with the SARS-CoV-2S protein as a model virus of COVID-19 in cold-chain environment[2]. As shown in Figure 1, the plasma treated-air can inhibit the capability of infection of either the dried or the wet COVID-19 pseudovirus, regardless of whether it is attached to flakes of plastic or copper. This indicates that cold atmospheric plasma has substantial potential to be developed as a new technology for cold-chain sterilization, but further studies are needed to enhance its efficiency to meet the practical application requirements.

In view of this, a novel plasma technology by the combination of NO_x mode and O_3 mode air discharges (mode-combination method), was proposed for the sterilization in cold chain environment. This method has been proven to be an effective way for producing plasma-activated water with a strong bactericidal efficiency[3]. However, in a cold-chain environment, the water around microorganisms turns into ice, so it remains to be seen whether the mode-combination method can still have high bactericidal efficiency. As shown in Figure 1, the mixed gas can effectively inactivate *Salmonella typhimurium* and *Staphylococcus aureus* in 1-4 mm thick ice layers at different temperatures (-20/-40/-80 ℃) within 10 min, which is a significantly stronger effect than that of the effluent gas of either the NO_x mode or the O_3 mode discharge alone. This can be attributed to the high-valence reactive nitrogen species such as N_2O_5. Considering the large volume of the container in the actual cold chain transportation, we kept trying to increase the volume of the treatment chamber in the experiment. At present, the effective treatment volume has reached 1 m^3. Our findings provide a promising sterilization strategy to curb the spread of infectious diseases in cold-chain environments.

References

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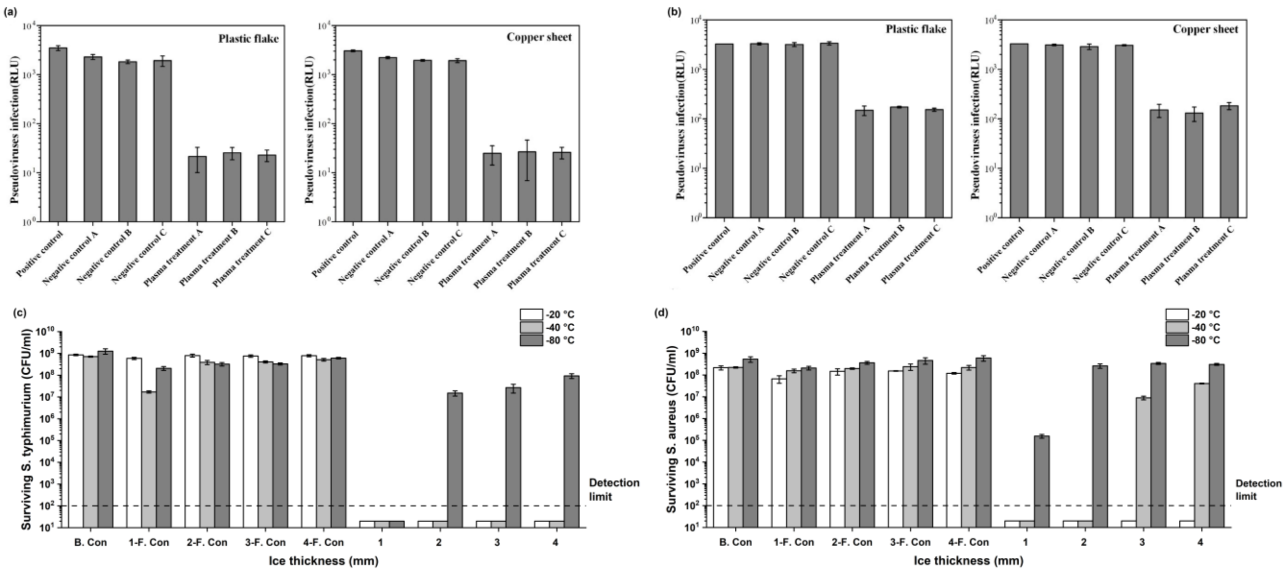

Figure 1. (a) Infection of untreated and plasma-treated dried pseudovirus on hACE2-HEK-293T cells, (b) infection of untreated and plasma-treated wettish pseudovirus on hACE2-HEK-293T cells, and sterilization effects of mixed gas on (c) *S. typhimurium* and (d) *S. aureus* in ice with different thicknesses at different temperatures.