Evaluation of the NoviSphere UV-C Duct Unit Removal Efficiency of Coronavirus in Aerosols

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Control technologies to efficiently inactivate airborne viruses are in need during the ongoing SARS-CoV-2 pandemic, and to guard against future pandemics where airborne transmission is important route of infection. Ultraviolet light in the 100-280 nm range (UV-C light) is an established technology for virus inactivation applicable to both surfaces, and to viruses in aerosols. Prior work reveals that UV-C is particularly efficacious towards the inactivation of single-stranded RNA viruses, such as coronaviruses.

We have tested the efficacy of virus inactivation for a NoviSphere LLC, duct UV-C flow tube unit, which can be incorporated into HVAC ducts, or into standalone air purification systems. First, we demonstrated that the sealed, UV-C flow tube reactor can be operated at flow rates from 684 – 2439 L min^{-1}, with fluences near 252 +/- 1 nm of 13.9 – 49.6 mJ cm^{-2}. We used nebulized porcine respiratory coronavirus (PRCV) aerosol as a surrogate for SARS-CoV-2 and other coronaviruses, through testing in a custom built 3.86 m long wind tunnel housed in a biosafety level class II facility. Aerosolized viruses were sampled upstream and downstream of the UV-C duct unit using the 0, 5, and 6 stages of an Andersen impactors operated at 90 liters per minute sampling flow rate. Using virus titration assays of swabbed samples from the impaction plates, we showed the log reduction of active coronavirus is in excess of 2.2, corresponding to 99.4% removal efficiency at a flow rate of 2439 L min^{-1} and in excess of 3.7, corresponding to 99.98% removal efficiency at 684 L min^{-1}. Because virus titers resulting from sampling downstream of the unit were below the limit of detection of the applied virus titration method, the true log reduction and removal efficiencies are likely even higher than we are able to measure, i.e. beyond 4.0 (above 99.99% efficient) at the lowest flow rate, and likely all tested flow rates. Furthermore, because of the high fluences (more than an order of magnitude higher than many other tested units), the device can likely enable efficient coronavirus inactivation at flow rates up to an order of magnitude higher than tested here.

In addition to measuring virus titers, we determined log reductions based upon reverse transcriptase quantitative PCR and measurement of fluorescein concentrations (doped into the nebulized aerosol). Comparison of log reductions from these assays to the virus titration assay revealed that the reduction in viable PRCV is primarily due to UV-C based inactivation, as opposed to physical collection of virus within the unit (fluorescein and PCR based log reductions, which correspond to physical virus removal, were less than 1.0). The results presented in this study suggest the NoviSphere UV-C flow tube reactor can enable efficient inactivation of coronaviruses through incorporation into HVAC ducts or recirculating air purifiers.