S1.5.1 - Methods to Assess the Removal and Inactivation of Airborne Coronaviruses using Surrogate Viruses for SARS-CoV-2

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The emergence of SARS-CoV-2, the virus responsible for causing the COVID-19 pandemic has led to considerable public attention on methods to mitigate viruses that transmit through aerosols. There is evidence that SARS-CoV-2 can transmit through aerosols, thus the need to develop methods to assess whether SARS-CoV-2 can be inactivated or removed by technologies that can remove or inactivate airborne viruses. Evaluating technologies effective against SARS-CoV-2 applicable to real-life conditions require testing methods capable to operate at relatively high airflows. However, because SARS-CoV-2 is a BSL-3 pathogen and methods that test virus removal and inactivation require relatively high volumes of virus at high concentrations, use of SARS-CoV-2 is not practical or desirable. Instead, there are animal coronaviruses that can be used as surrogates of SARS-CoV-2 because of their morphologic, pathologic and transmission similarities. In this study, we will present methods using two animal coronaviruses, porcine respiratory coronavirus (PRCV) and bovine coronavirus (BCoV) used as surrogates for SARS-CoV-2 that have been used to assess various air purification technologies on their ability to remove and/or activate the viruses. The testing uses a single pass newly developed biosecure custom-

designed wind tunnel that ensures proper mixing of aerosolized viruses and that is capable to operate at flows up to 80 cfm. Both non-infectious particle and viable virus penetration tests were performed. The tested unit control technologies included a UV-based technology and a technology that incorporates a minimum efficiency reporting value-16 (MERV-16) based filter laminate with a photoelectrochemical oxidation (PECO) layer exposed to UV-A light during operation to drive the oxidation of incoming particles and vapor phase species. For virus testing, the wind tunnel system was housed within a Biosafety level II facility, and procedures were approved by the University of Minnesota Institutional Biosafety Committee. Both, PRCV and BCoV were grown to titers of 10^7 TCID50/ml (tissue culture infectious disease) and aerosolized using a large volume particle nebulizer fed with a syringe pump for a total of 90 ml per replicate. Upstream and downstream air sampling was carried out using an Anderson Cascade Impactor operated at 90 lit/min for 30 minutes in triplicate for each test virus, both in the presence and absence of the air control technology unit in the wind tunnel. Samples were tested to assess the presence of viral genetic material using RT-PCR (reverse transcriptase-polymerase chain reaction) and viability using cell culture methods specific for each of the viruses. Physical collection efficiency was quantified as a function of size as the penetration (1-collection efficiency), while virus removal was quantified via log reduction (based 10 log of the upstream to downstream concentration ratio). For the UV-based technology, we reported a virus log reduction in excess of 4.0 for PRCV (BCoV was not tested). For the filter/PECO-based technology we reported a 3.0 log reduction for BCoV, and 2.5 for PRCV, and a removal efficiency up to 99.9% for both viruses. In summary, our work describes a suite of test methods that can be used to rigorously evaluate the efficacy of air purification technologies.

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