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COVID-19 Public Transportation Air Circulation and Virus Mitigation Study

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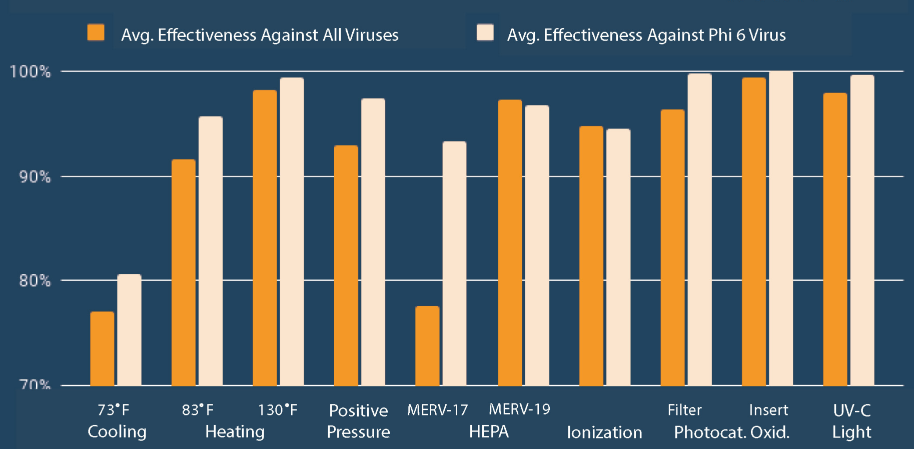
Virus Mitigation Results

from Air



from Surfaces

Positive pressure mitigated all viruses on surfaces by 100%.

Copper foil tape and fabrics with high-percentage of copper mitigated the Phi6 virus by 99.7%. Results were inconclusive with the other two viruses.

Notes: Transit could be safer in winter, since higher HVAC heating temperatures alone mitigate large percentages of the viruses.

These findings could equally be applicable to any confined space with HVAC, such as offices, classrooms, court houses, shops, restaurants, etc.

Introduction

COVID-19 has irrevocably reshaped our world, including the transportation industry. Increased understanding of the virus and how it spreads increases safety for individuals and communities. One important area of investigation is the potential spread of COVID in public transit spaces. Given the limited space and air circulation, potential infections on public transportation could be concerningly high. Accordingly, this study examined air circulation patterns inside the cabins of busses and tested the impact of different technologies in mitigating viruses from the air and on surfaces inside bus cabins.

Study Methods

To study air circulation patterns in busses, the team utilized and implemented different devices, metrics and experiments (including colored smoke; videotaping; anemometers; pressure differentials; particle counts; and 3D numerical simulation models) to understand and quantify air circulation inside different busses, including those with different characteristics, and under different operating conditions (e.g. with bus stationary and in motion, and with windows open and shut).

To test the impact of different technologies, the team utilized three different live prokaryotic viruses: Phi6, MS2 and T7. Various technologies (including positive pressure environment inside the cabin, HEPA filters with different MERV ratings, concentrated UV exposure with charged carbon filters in the HVAC systems, center point photocatalytic oxidation technology, ionization, and surface antiviral agents) were tested to evaluate the potential of mitigating COVID-19 infections via air and surfaces in public transportation. This study tested the effectiveness of these technologies on the three live viruses in both the lab and in buses in the field.

Findings

The results of the air circulation experiments indicated the efficiency of HVAC system designs, where the speed of air spread in bus cabins was consistently much faster than the speed of air clearing. This result indicates the need for additional virus mitigation from the cabin.

Results of the technology impact experiments indicated that photocatalytic oxidation inserts and UVC lights were the most efficient in mitigating viruses from the air. On the other hand, positive pressure mitigated all viruses from surfaces. However, copper foil tape and fabrics with a high percentage of copper mitigated only the Phi6 virus from surfaces. High-temperature heating was also found to be highly effective in mitigating the different viruses from the vehicle cabin.

Finally, limited exploratory experiments to test possible toxic by-products of photocatalytic oxidation and UVC lights inside the bus cabin did not detect any increase in levels of formaldehyde, ozone, or volatile organic compounds.

Photocatalytic oxidation and UVC lights inside the HVAC system mitigated more than 99% of the viruses studied in this project.

Policy/Practice Recommendations

In addition to requiring drivers and passengers to wear PPE, transit operators can implement a number of different methods to reduce the possibility of COVID-19 (and possibly other airborne viruses) infections inside the cabins of buses:

- Installing photocatalytic oxidation and UVC lights inside the HVAC system mitigate; and
- Increasing the positive pressure inside bus cabins.

About the Authors

Aly M. Tawfik, Ph.D., PTP, is an Associate Professor of transportation systems engineering and founding director of the Transportation Institute at California State University, Fresno. His research interests include modeling, simulation and optimization of individual travel behavior and of transportation systems, and he has a particular passion for transportation sustainability and the future of transportation.

Dr. Deify Law is an Associate Professor in the Department of Mechanical Engineering at California State University, Fresno. Dr. Law's research focus is in the area of simulations and measurements of transport phenomena such as two-phase bubbly flows, single-phase fluid flows, and convective heat transfer. Fluids-related applications include building and transportation air ventilation for health and safety and aerodynamic drag reduction for improving fuel efficiency and convective heat transfer enhancement.

Dr. Juris Grasis is an Assistant Professor at UC Merced. He leads a research team focusing on viral metagenomics, systems immunology, microbiome regulation, and viral/antiviral discovery. Dr. Grasis completed his Ph.D. in Adaptive Immunology in 2009, his post-doctoral training in Host-Microbiota Interactions and Viral Metagenomics in 2015, and started his lab at UC Merced in 2018. He teaches undergraduate and graduate-level virology courses and started the HHMI funded SEA-PHAGES course at UC Merced in 2019-2020.

Mr. Joseph Oldham is currently the Transportation Project Developer/Grant Writer for Fresno Metro Ministry in Fresno with a focus on developing sustainable transportation solutions and resources for communities of color. Previously, Mr. Oldham was the Director for the CALSTART San Joaquin Valley Clean Transportation Center; a position he held for five years. Prior to that, Mr. Oldham was the Sustainability Manager for the City of Fresno and is a graduate of California State University, Fresno.

Mr. Moe Salem is the Co-Founder and the CTO of AIR2O Cooling LLC. He holds many patents for the Indirect/Direct Evaporative cooling technology as well as the control Systems for its Hybrid operations. He has over 20 Years of Experience in the HVAC field as well as experience in the sustainable energy saving solutions for HVAC and energy recovery systems. Mr. Salem is one of the pioneers of the outdoor cooling systems.

To Learn More

For more details about the study, download the full report at **transweb.sjsu.edu/research/2036**

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