Antimicrobial Efficacy and Durability of Copper Products on Public Transportation Vehicles

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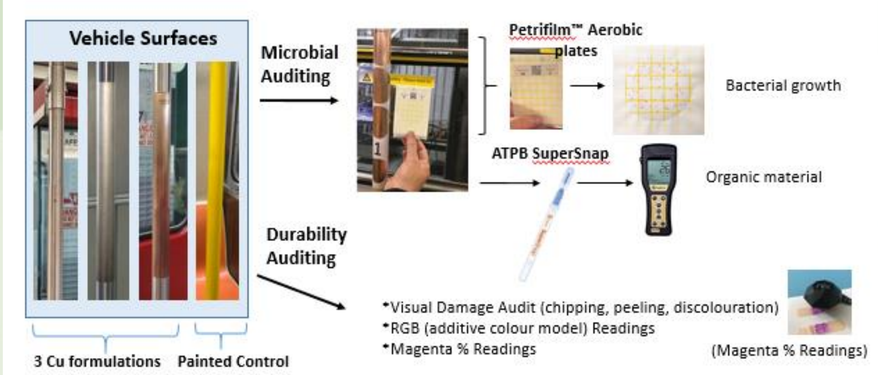
Background and Objectives

Public transport is often the primary and only means of transportation for people. Furthermore, transit spaces are small, contained areas that have a high turnover of users and have many frequently touched surfaces. Copper (Cu), with its well-documented antimicrobial action, could reduce the risk of pathogen exposure on highly touched surfaces for transportation riders [1-3]. Following a Phase 1 pilot study with Translink (TL) in 2020, as part of their COVID-19 response, Phase 2 of the study was launched in late 2021 with TL and Toronto Transit Commission (TTC) to determine if Cu installed on transit high touch surfaces will maintain its durability and antimicrobial efficacy over 12 months of use.

Objective: To evaluate the antimicrobial efficacy and durability of three formulations of Cu products on transit vehicles in Vancouver and Toronto after one year of use.

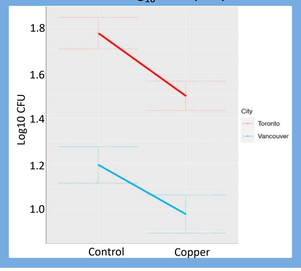
Methods

- Three different formulations and applications of Cu products were randomly installed on 110 stanchions on three buses and four skytrain cars in Vancouver; and three buses, two subway cars and two streetcars in Toronto. Each Cu product had a mirrored non-copper control directly opposite. All audits were performed on transit vehicles after peak morning rush-hour traffic and prior to cleaning.
- **Microbial (bi-monthly):** 3M™ Aerobic Count Petrifilm™ surface testing (*in triplicate*) and ATP bioluminescence assay
- **Durability (monthly):** Colourimeter measurement, Waterloo test for Cu concentration and visual inspection. At 6 and 12 months, ex-situ microscopy used to assess Cu product durability.

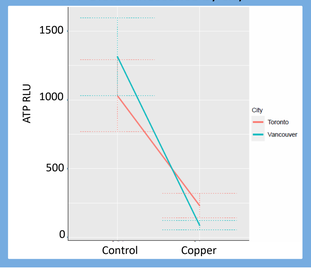


Antimicrobial Results

Effect of the Group (Control vs Copper) on Log_{10}CFU by city



Effect of the Group (Control vs Copper) on ATP Bioluminescence by city



Descriptive Table of overall mean (standard deviation) and median (range) of averaged log CFU (at stanchion level over triplicates) by Group at Month 12

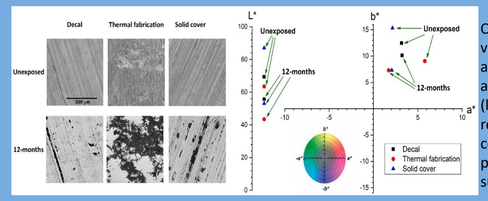
CONTROL			COPPER		
Number stanchions	Mean sd. log CFU	Median range log CFU	Number stanchions	Mean sd. log CFU	Median range log CFU
110	1.451 (0.497)	1.434 (0.201, 2.447)	110	1.209 (0.487)	1.219 (-0.1, 2.332)

Descriptive Table of overall mean (standard deviation) and median (range) of ATP by Group at Month 12

CONTROL			COPPER		
Number stanchions	Mean sd. ATP (RLU)	Median range ATP	Number stanchions	Mean sd. ATP (RLU)	Median range ATP
111	1188.441 (1033.239)	926 (36, 6770)	111	151.559 (236.9)	75 (0, 1330)

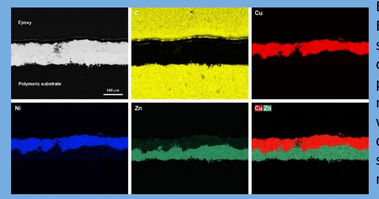
Results analyzed by UBC Department of Statistics

Durability Results



Changes in surface morphology of the stanchions via SEM and colourimetric analyses. Surface appearance is described by the three coordinates, a* (red/magenta-green), b* (yellow-blue) and L* (lightness−black to white) in the CIE Lab colour reference space. LEFT: dirt or corrosion products concentrate in surface asperities over time. RIGHT: products become tarnished and duller due to surface oxidation as time progresses.

The three Copper applications on transit stanchions - showing surface darkening after 12 months of use.



Example of SEM-EDS cross-sectional analysis of one of the Cu products after 6-months. Minimal wear and minimal copper loss was seen across all materials.

Discussion and Conclusion

One of the challenges of conducting a year long study on transit vehicles during the COVID-19 pandemic was that conditions on vehicles were not typical: ridership was lower, transit users avoided touching surfaces and wore masks and gloves, and vehicles were cleaned more frequently. These conditions served to reduce contamination on all surfaces; this was noted particularly by the lower than normal bacterial counts on control surfaces [4]. Overall results after 12 months:

- Cu (compared to SS) exhibited a significant 43% reduction in the mean colony forming units (CFU) (0.573 (CI95%: 0.453, 0.726), p-value<0.001.
- Mean ATP Bioluminescence in relative light units (RLU) (ATP RLU) exhibited a significant 87% reduction for all three Cu products combined compared to that of the Controls at (0.129 (CI95%: 0.059, 0.285, p.value<0.001).
- Ex-situ microscopy confirmed very little surface deterioration and change in surface copper concentrations/alloying.
- Macroscopic observations confirmed a dulling of Cu surfaces due to tarnishing/oxidation.
- Colourimetric data confirmed changes in the brightness of the surface towards browner colours.

Conclusion: Despite the challenges described above due to the pandemic and the observed dulling and colour changes in Cu surfaces over the one year period, copper concentrations were maintained, there was minimal wear in products and we were able to see significant antimicrobial activity for Cu compared to control surfaces.

References

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