Copper and Copper Alloys as Anti-viral Materials for High-touch Surfaces – Efficacy in a Simulated Public Environment

Analyzing the Effect of Arterial Roadways and Cul-De-Sacs on the Social Interactions of American Children in the Suburbs

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Materials Science and Engineering

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November 27, 2022

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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INTRODUCTION

Communicable diseases create an enormous burden on society. Michaud (2009) estimates that 26.1% of deaths are from infectious causes. This burden extends beyond physical pain for those afflicted and emotional hardship for family and friends. Infectious diseases take a toll on the economy. A bed-ridden hospital patient is not only a large expense for the family, but it also takes away economically productive time. The patient is not at their job producing capital, and the doctor is away from treating other patients. One study estimates the cost for infectious disease to be 6.612 billion USD in 2019 in South Korea alone (Baik et al., 2022). Developing countries are afflicted even more.

Clearly, reducing the spread of communicable diseases is a priority for governments and health organizations. One way to do this is in the reduction of fomite transmission. Fomite transmission is when a disease spreads from a surface to humans. An infected human will contaminate a surface, often through touch. Before the disease dies on the surface, a healthy human will touch the contaminated surface and become infected. One paper estimates that 6.9% of total infectious disease is spread through fomite transmission, a significant amount (Jones et al., 2020).

One way to reduce transmission is to encourage healthy habits. For example, ad campaigns for washing your hands are common. It is ideal if an infected individual can avoid contaminating surfaces, which can be done through a change in behavior. Alternatively, it is important for one to take proper precautions when interacting with high-risk surfaces, such as wearing gloves. We can make our surrounding environment safer by changing the way we act.

However, changing human behavior on a large scale is often a very difficult task. Additionally, fomite transmission can still occasionally occur even when risk reducing steps are

taken. Therefore, it is also important to reduce the lifetime of a disease on the contaminated surface itself (Scully, 2020). Fomite transmission is particularly a problem on high touch surfaces. Research has shown copper alloys can reduce disease counts on surfaces in gyms (Ibrahim et al., 2018). It has also shown they are effective in hospitals (Inkinen et al., 2017). Koniecyzny and Rdzawski (2012) find that this reduction is effective at reducing infections. Therefore, transmission can be reduced by switching them out with a material that is inhospitable for disease. In my research, I hope to further characterize the antibacterial properties of copper surfaces in real-world environments.

TECHNICAL TOPIC

My research aims to find the best metal alloy in killing disease, specifically coronavirus. Copper and copper alloys are the current frontrunners. Diseases have a far shorter half-life on these surfaces due to copper's corrosive properties. Fortunately, copper coatings are just as effective, so it can be used without changing the original bulk substrate (Seo et al., 2022; Sousa et al., 2020). According to Grass, G., Rensing, C., & Solioz, M. (2011), the virus and the solution it lives in induces corrosion of copper. This releases copper ions into the solution. The copper ions then break down the cell walls of the bacteria (ibid). The solubility of these ions impacts their effectiveness (Hans et al., 2016).

However, material selection is more complicated than choosing the alloy with the best kill rate. This is because kill rates vary in different conditions. Is the high touch surface exposed to the outside environment? Does the high touch surface require specific mechanical properties? How is the surface cleaned? How frequently is the surface cleaned? My research aims to partially answer those last two questions. I will look how bleach and glutaraldehyde solutions

alter the antibacterial properties of copper and copper-nickel by forming copper oxides on the surface (Glover et al., 2021). Oxides can reduce the speed that bacteria corrode copper and thus lower its kill rate. This will be done by "cleaning" the copper and the copper alloy "in a hospital environment" for a period of four weeks. There are two purposes of this experiment: 1) To evaluate if bleach or glutaraldehyde has a greater impact on corrosivity and 2) To evaluate if copper alloys are more resistant to oxide build up than pure copper.

After cleaning, the kill rate will be measured using blotch tests of betacoronavirus. A solution of 80% artificial perspiration and 20% assay media, an organic solution that preserves the coronavirus, is optimal (Glover et al., 2022).

After blotch testing, electrochemical tests will be used to characterize the surfaces of the "cleaned" samples. These electrochemical tests will consist of coulometric reduction, cyclic voltammetry, and electrochemical impedance spectroscopy. Coulometric reduction will be used to determine what type of oxides are present (Kies, 1962). Cyclic volumetry will be used to measure the amount of each oxide that is present (Elgrishi et al., 2018). In particular, reduction in Cu(I) oxide formation is particularly effective at improving kill efficiency (Luo et al., 2019). Finally, electrochemical impedance spectroscopy will be used to evaluate the long-term

resilience of the oxide build-up (Lasia, 2002).With the completion of these tests, we hope to better understand how copper and copper alloys react to cleaning products.

KIDS AND CAR DEPENDENCY

While I am interested in high-touch surfaces, I am also passionate about transportation and mobility options. I am particularly interested in the effects of the United States subsidizing and encouraging car infrastructure since the end of WWII. Cars require more space than

alternative transportation choices such as walking, biking, or public transportation. A car occupies more square footage per occupant, requires parking spaces, and can travel at high speeds. This combined with the American dream of owning a house for middle- and upper-class whites spurred a rapid expansion of the suburbs and clearing out of the urban core (Mullen, 2007).

The US sped up this development through funding highways, enforcing Euclidean zoning measures, maintaining lenient safety standards, and providing sweeping tax credits for mortgages. This has resulted in entire regions of a city that are dependent on the car (Frederick, 2016). This means that cul-de-sac (dead-end) neighborhoods are encircled by high-speed, high throughput roadways (arterial roads). However, not everyone can drive an automobile, the largest group being children.

I will be using Wyatt's (2008) framework of technological determinism to look how children are impacted. In short, technological determinism is the belief that technology is the driver of social change. When a new technology is created, it has fundamental impacts on parts of a society. This is a useful lens because I believe car-dependent infrastructure has changed the way kids live. The growth of the technology is "driving" the change. In particular, I will be using methodological technical determinism developed by Heilbroner, Edgerton, and Hughes. Under this, we must analyze a society based on the technologies available to the populace. This is an important method because available technologies are different for kids in suburbia than in the city. For example, suburban kids are unlikely to have the technology of public transportation available to them, but they will have the car and the supporting road infrastructure.

Due to car-dependency, kids are now reliant on a licensed, adult caretaker to get around. While some children are lucky enough to have one or two friends near their single-family home,

the sprawl of the suburbs often means that the majority of their classmates are too far to walk or cycle to practically. Additionally, the disconnected nature of cul-de-sacs can make trips that would otherwise be close become circuitous. Finally, the high-speed nature of arterial roadways surrounding cul-de-sac neighborhoods make some easy, short trips dangerous. For example, when parents were asked why they drive their kids to school, 24% of parents said it was too far while 12% said it was too dangerous (Mackett, 2002).

This dependency on caretakers takes away a critical period of developing self-autonomy and restricts kids to trips that parents find suitable. Want to see that friend at school that your parents disapprove of? Want to join that after school club that conflicts with their schedule? Want to play a 30-minute pick-up game of baseball after dinner? Too bad. Kids are now limited to forming bonds with their peers at school and organized activities.

RESEARCH QUESTION AND METHODS

This leads me to my research question: how have cul-de-sacs and arterial roadways affected social interactions and friend groups for children in US suburbs? It is important because friends influence self-esteem, happiness, and diversity of thought. Additionally, friend groups formed as a child often largely resemble the social networks made as an adult. Therefore, it is important to find an answer not only to help improve a child's quality of life now, but also for their future adulthood.

In order to examine the ramifications of this new style of life, I will interview local urban planners and professors alongside a literature review of American suburbs throughout time. In my interviews, I will ask how urban architecture changes potential interactions between children. I will also question which features of car-dependency have the greatest change in these

interactions. Furthermore, I will conduct an interview with a professor in psychology to determine how and when most friends are made for children. As for the literature review, I will accumulate papers that provide both demographic information about friend groups of children and the location. I will then categorize the papers as a car-dependent or non-car-dependent location. Finally, I will compare the differences in diversity and quantity of friends on average for these two groups. With a sufficient number of papers, I believe these differences can reliably be contributed to car dependency. I believe this data will confirm that friend groups for children are smaller and less socioeconomically diverse than in the past. Additionally, I believe that it will show that young children are less likely to be outgoing due to their continued reliance on their parents.

CONCLUSION

I hope to better determine the viability of copper or copper nickel as a widespread antibacterial surface. This can help reduce the cost of infectious disease and decrease suffering. I believe that characterizing the effect of cleaning solutions is important in choosing viable solutions. Its impact on oxide buildup is critical to optimizing the efficacy of copper alloys.

As for my research in car dependency, I hope I can prove that post-war suburbia is ultimately harmful to kids as well. This is critical because many issues of car dependency are well-known, but demand continues for these places because they are seen as a suitable location for child rearing. Children are the future, and understanding how they interact today is essential to improving it. As a result, we can reduce the number of people who grow up in a socioeconomic bubble.

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