Assessment and Development of Antimicrobial Coated Steels for Indoor Use

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1. Introduction:

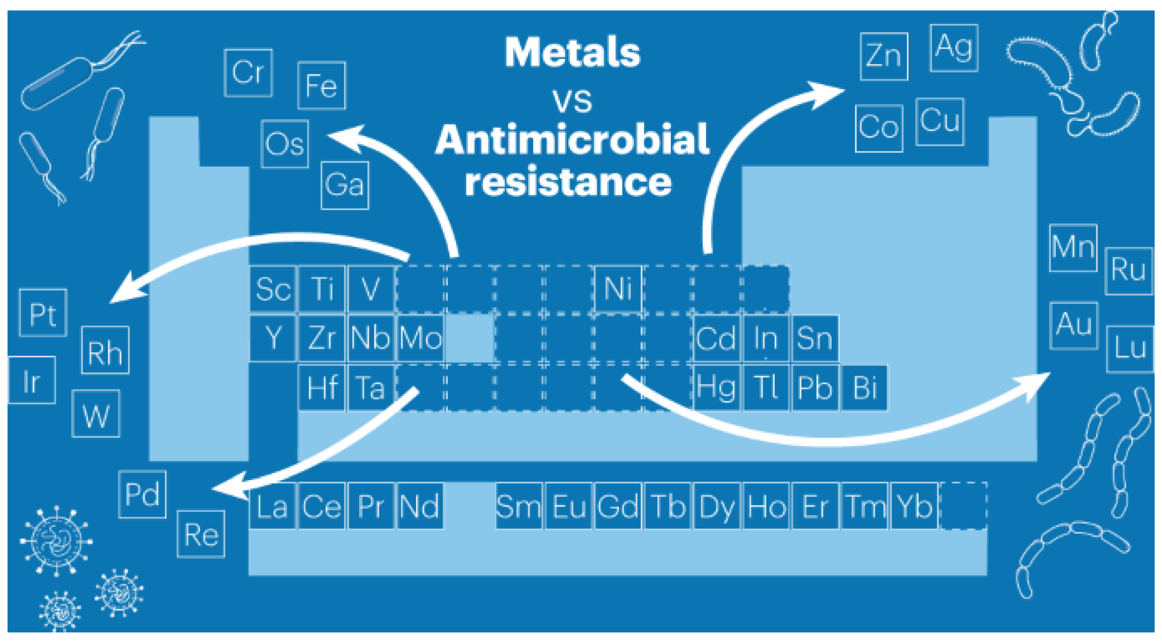
- Antimicrobial resistance was already a public health concern, and the COVID-19 pandemic has sparked a heightened interest in reducing transmission[3]
- Studies have shown there is a link between contaminated surfaces and infection transmission rates, with some bacteria surviving for months at a time.
- Antimicrobial coatings offer a cost-effective solution to aid with the prevention of, and protection from, infection-causing microbes[1]
- Safer to both humans and the environment compared with disinfectants[2]
- Paint-based steel coatings are a robust and well used material combination found in many sectors including healthcare. i.e. medical apparatus such as panelling on cabinets, doors etc.
- Within the global antimicrobial coatings market, an estimated incremental growth of £552.31M is expected between 2019 and 2024[4]

2. Aims

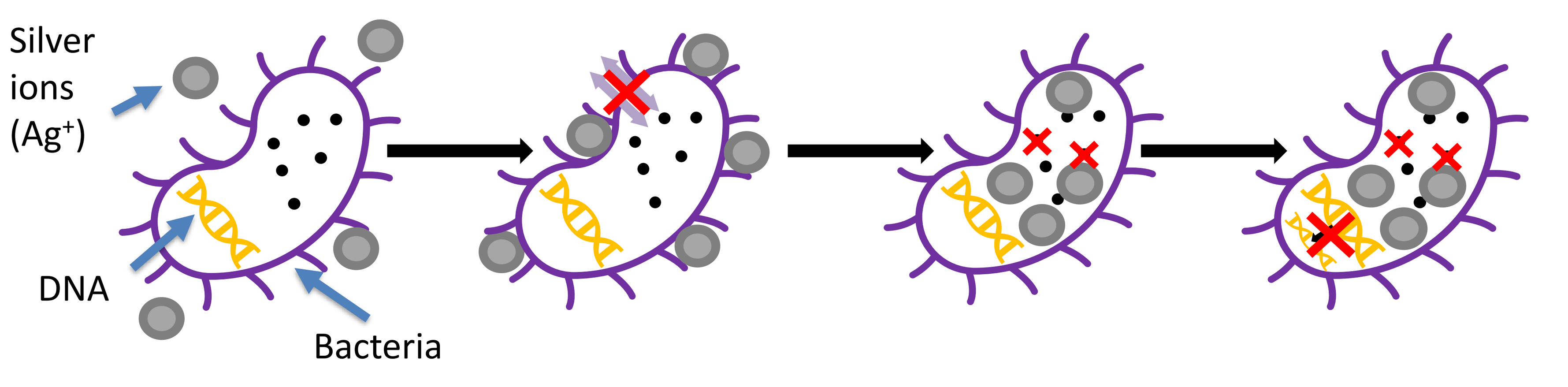
- To determine and test suitable metals/ metal complexes to be embedded into a paint-based coating.
- To determine the impact of cleaning products and hand sanitizers on antimicrobial coatings

3. Why metals?

- Elemental metals, such as copper, silver and zinc are well known to have antibacterial properties, in both their solid state, as well as in salts and metal complexes



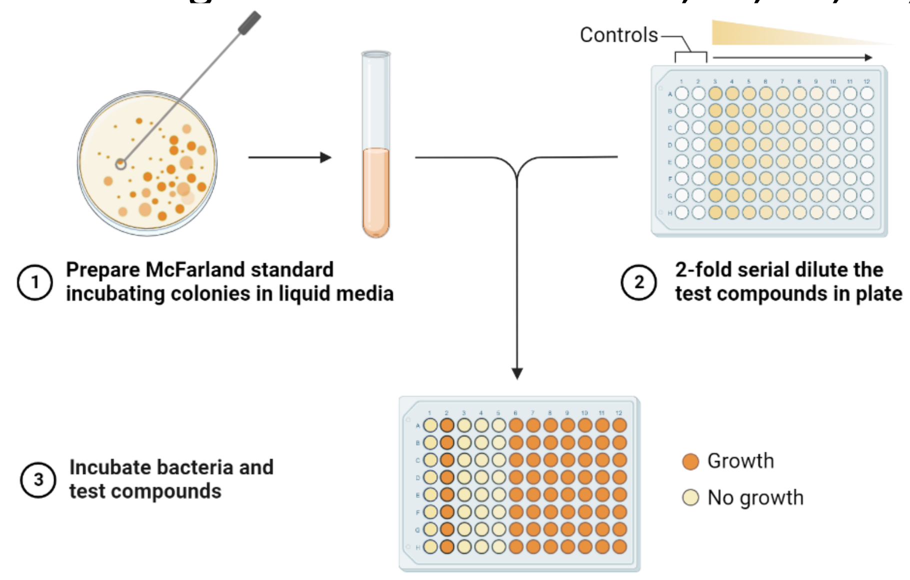
- Many metals are even known to have multiple mechanisms of action, which makes it hard for bacteria to gain resistance, which readily can occur with antibiotics.
- Lesser used metals such as ruthenium and bismuth are now at the forefront in antimicrobial research and are researched at in different forms such as nanoparticles, to develop next generation antibiotics.



Bacteria lands on a silver-based coating. | Silver ions bind to the bacterial cell wall and blocks transport in and out of the cell. | Silver ions migrate into the cell and stop the respiratory system and energy production. | Bacterial cell division and replication is inhibited, by silver ions binding to DNA.

4. Testing for antibacterial properties

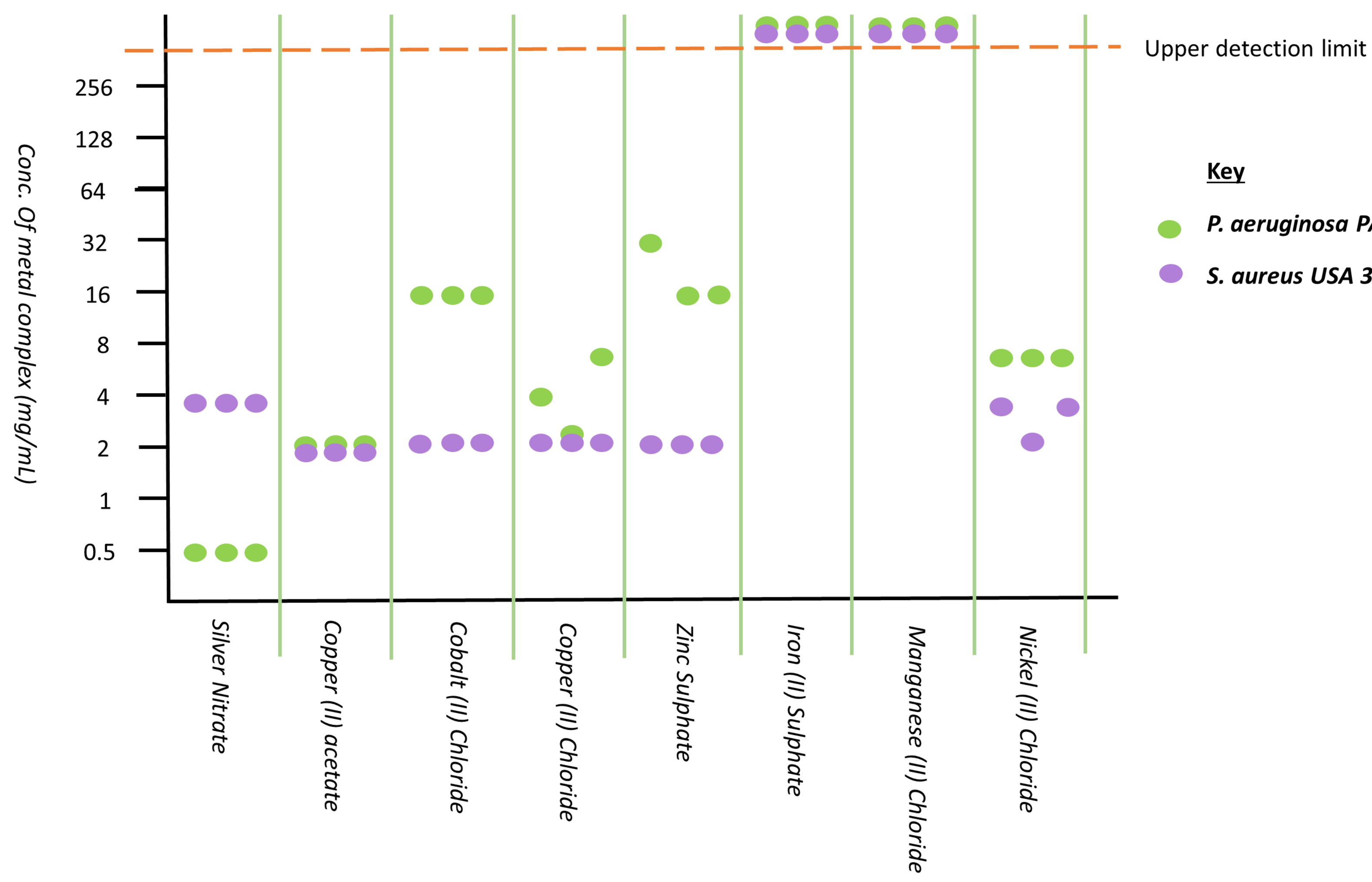
- Initially a library of 25 metals and metal-based compounds were collected, including elements such as: Cu, Ni, Zn, Fe, Ag, Li, Cs, Mn, and more.



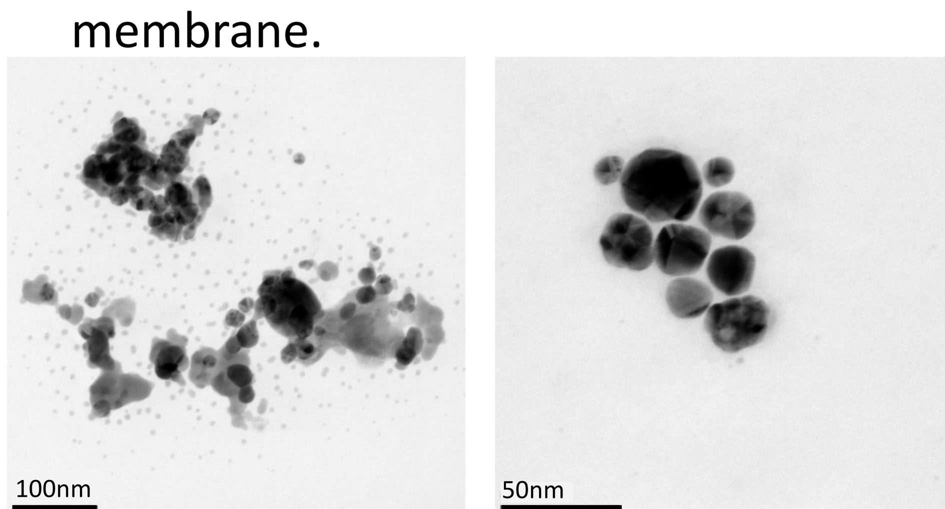
- Compounds were then screened for their minimum inhibitory concentration (MIC)
- After the MIC, compounds will be further selected based compound toxicity and cost.
- Biofilm growth for both bacteria will be determined and then used to determine the antibiofilm properties.

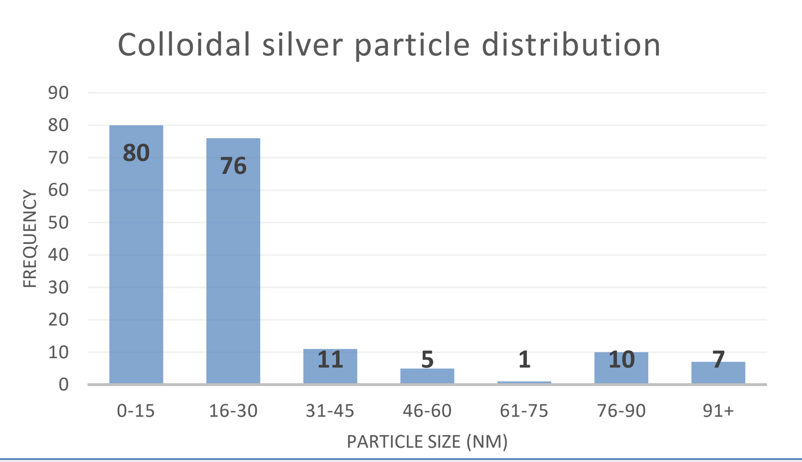
5. Results

- Ten metal complexes were tested for their antibacterial efficacy.
- Six have shown to have antibacterial properties as seen below, but both iron (II) sulphate and manganese (II) chloride did not have any effect on bacterial growth within the concentrations tested.
- Silver nanoparticles and colloidal silver were also shown to have no antibacterial properties, but it is likely the concentration of the silver nanoparticles were a limiting factor (highest conc. 0.01mg/mL).



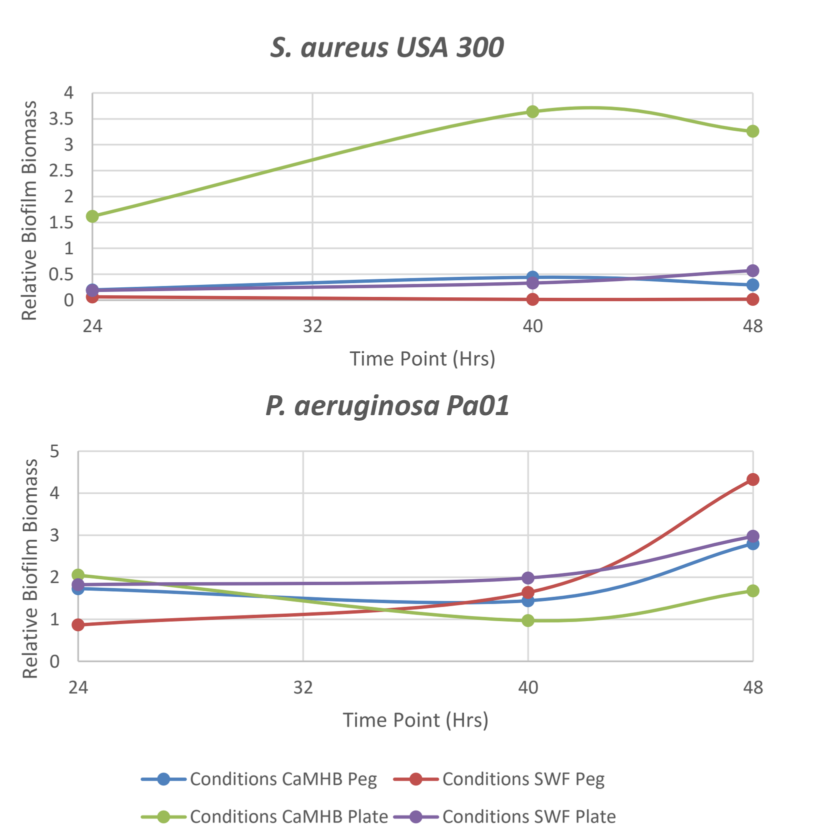
- Colloidal silver was further investigated using an electron microscope (TEM) to investigate why no effect was seen.
- As seen below, there was large agglomeration of the colloidal silver, with particle sizes ranging from 1-130 nm. Over half of the particles measured were above 15nm and could contribute to why no antibacterial effect was seen within this project, as this is likely too large to pass through the bacterial membrane.





6. Future work:

- As the concentration of commercially available silver nanoparticles were the limiting factor, synthesising our own will allow us to effectively test the known antibacterial effects of silver nanoparticles. The remaining library of metal complexes will be screened and then narrowed down using the above data, toxicity and cost of the compounds to take on to further testing.
- Using the biofilm growth curves established (on the right), we will use this data to determine how the chosen compounds will affect biofilm formation at the highest time point.
- Metal complexes will also be tested against fungi and viruses to determine antimicrobial properties
- Successful compounds will then be screened in a variety of paints before being applied on to steel substrates to determine parameters such as durability against cleaning products and industrial testing (ISO 22196/21702) to further highlight antibacterial properties of the coated steel.



7. References:

1) Pochtovyi, A. A.; Vasina, D. V.; Kustova, D. D.; Divisenko, E. V.; Kuznetsova, N. A.; Burgasova, O. A.; Kolobukhina, L. V.; Tkachuk, A. P.; Gushchin, V. A.; Gintsburg, A. L. Contamination of Hospital Surfaces with Bacterial Pathogens under the Current COVID-19 Outbreak. *Int J Environ Res Public Health* **2021,** *18* (17).
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4) Size, F., Size, F. and WIRE, B., 2022. *Antimicrobial Coatings Market Worth USD 682.06 Million by 2024, Growing at a CAGR of over 11% - Global Market Analysis and Industry Forecasts | Technavio*. [online] Businesswire.com. Available at: <https://www.businesswire.com/news/home/20201103005552/en/Antimicrobial-Coatings-Market-Worth-USD-682.06-Million-by-2024-Growing-at-a-CAGR-of-over-11---Global-Market-Analysis-and-Industry-Forecasts-Technavio> [Accessed 8 September 2022].