The potential for the application of metallic copper surfaces as a method for preventing surface and airborne microbial contamination in military healthcare facilities, food handling operations, and other occupational settings

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Introduction: Controlling hospital-acquired infections, microbial food contamination, and indoor air quality are constant public health challenges. The microorganisms that cause these problems can survive on common surfaces for extended periods of time. Copper and copper alloys (metals such as brass and bronze) have the intrinsic ability to kill microorganisms within hours. These materials are registered with the U.S. Environmental Protection Agency as antimicrobial public health products and are the only solid materials with such registration[1].

Background: Microbial contamination of surfaces is the root cause of numerous public health issues. Pathogenic organisms can be transferred from surfaces to humans via direct touch transfer or airborne dissemination and subsequently cause infections. Traditional surface materials have no inherent ability to kill these organisms.

Within hospitals, Healthcare Associated Infections (HAI) are a growing concern that continue to challenge infection control programs throughout the world. In the U.S. alone, the Centers for Disease Control and Prevention (CDC) estimates that HAIs account for 100,000 deaths annually and increase healthcare costs between 35 and 45 billion dollars annually[2].

HVAC system components operate in warm, dark, humid environments that are ideal for fungal, bacterial and viral growth and distribution. Pathogenic organisms breeding in air handling systems are disseminated through ductwork into office spaces, classrooms, and homes and significantly deteriorate Indoor Air Quality (IAQ) , often causing serious building related illnesses (BRI) such as Legionnaire's disease, Pontiac Fever, and Humidifier Fever, and less serious non-specific acute symptoms categorized as sick building syndrome (SBS)[3]. Poor IAQ is also a leading cause of lost productivity in the workplace.

According to the CDC, each year 48 million illnesses associated with contaminated food are reported in the United States, which result in 128,000 hospitalizations and 3,000 deaths[4]. Many outbreaks can be directly attributed to microbial contamination of work surfaces in the food production chain.

Copper is an intrinsically antimicrobial material. Humanity has utilized the antimicrobial properties of copper for thousands of years, but it wasn't until recently that the use of copper and copper alloys has been thoroughly evaluated to combat microbial contamination on surfaces. Groundbreaking research conducted by scientist from across the world provided keen insight into this phenomenon. Copper alloys were found to kill a wide range of pathogenic bacteria, fungi and inactivate viruses within a short period of time. In 2008, an unprecedented registration with the U.S. Environmental Protection Agency (EPA) permitted this class of materials to make public health claims against six disease causing bacteria: *Staphylococcus aureus*, MRSA (Methicillin-resistant *Staphylococcus aureus*), Vancomycin-resistant *Enterococcus* (VRE), *Escherichia coli* 0157:H7, *Enterobacter aerogenes* and *Pseudomonas aeruginosa*[5-10].

Method: Review of recent research on antimicrobial efficacy of copper metal surfaces against a range of pathogenic microorganisms.

Results: A wide body of technical literature indicate that copper alloys demonstrate antimicrobial efficacy against a broad range of pathogenic microorganisms including Methicillin-resistant *Staphylococcus aureus, Vancomycin-resistant Enterococci, Clostridium difficile* (both spores and vegative form), *Influenza A* (H5N1), *Escherichia coli* O157:H7, *Staphylococcus aureus, Enterobacter aerogenes, Pseudomonas aeruginosa, Acinetobacter baumanii, Listeria monocytogenes, Candida albicans, Klebsiella pneumonia, Mycobacterium tuberculosis, Salmonella enteric, Salmonella Typhi, Vibrio cholerae* and *Campylobacter jejuni,* and more. With the exception of *C. difficile* spores, copper killed concentrations as high as 100 million Colony Forming Units of these organisms within approximately two hours[5-12]. A concentration of 1,000,000 C. difficile spores was completely killed within 24 hours. Most of these organisms can survive for days on common surfaces, while *C. difficile* spores can survive for months[12].

Conclusion: There is potential for application of copper surfaces as a preventive agent in military healthcare and food processing facilities and in HVAC systems. Planned defense-funded research will investigate environmental bacterial loads, infection rates, and impact on cross-contamination in military healthcare, operational, training, and occupational environments.

Microbial contamination of surfaces is the root cause of many public health issues

- Healthcare: Hospital-acquired infections affect 2 million people each year, cause 100,000 deaths, and instigate an additional $35 to 45 billion in healthcare costs annually[2].
- Indoor Air Handling Systems: microbes frequently contaminate system components, leading to poor indoor air quality.
- Food processing: contaminated food causes 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths each year[4].

A number of defense-related environmental and occupational health research projects are currently being planned to investigate the use of antimicrobial copper in operational and non-operational settings.

- Shipboard applications
- Training facilities
- Military treatment facilities
- Barracks and office environments
- Food service establishments and food handing operations
- Analytical laboratory applications

Copper and copper alloys have been registered with the U.S. Environmental Protection Agency as antimicrobial products that kill pathogenic* organisms. They are the only class of solid materials with this registration[1].

- 355 copper alloys registered
- Materials tested per three EPA test protocols:
  1. Efficacy as a Sanitizer - Kills organisms within 2 hours
  2. Residual Self-Sanitizing Activity- Standard wear/cleaning will not impede efficacy
  3. Continuous Reduction of Bacterial Contaminants- Kills organisms after repeated contaminations
- Sample Public Health Claim:
  "Laboratory testing shows that when cleaned regularly, Antimicrobial Copper kills more than 99.9% of bacteria* within two hours, and continues to kill more than 99% of bacteria* even after repeated contamination"

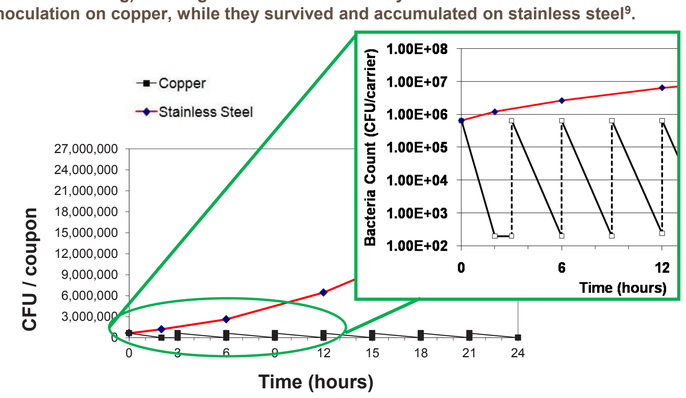
* Testing demonstrates effective antibacterial activity against Vancomycin-resistatn *Enterococcus faecalis*, *Staphylococcus aureus*, *Enterobacter aerogenes*, Methicillin-Resistant *Staphylococcus aureus*, *Escherichia coli* O157:H7, and *Pseudomonas aeruginosa*

Testing was conducted per internationally accepted Good Laboratory Practices guidelines. More than 99% of bacteria were killed in all tests, with more than 99.9% being killed in 174 out of 180[9].

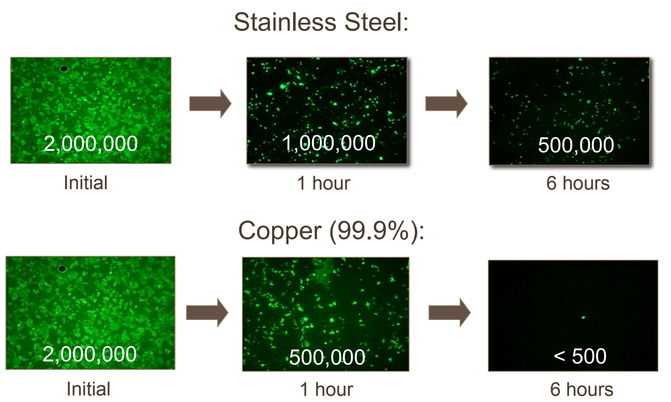
Average Percent Reduction of Bacterial Contamination

	Group	Alloy	% Cu	*S. aureus*			*E. aerogenes*			MRSA			*P. aeruginosa*			E. coli O157:H7			VRE	
Efficacy as a Sanitizer	I	C110	99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	II	C510	94.8	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	III	C706	88.6	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	IV	C260	70.0	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	V	C752	65.0	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	VI	C280	60.0	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
Residual Self-Sanitizing	I	C110	99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	II	C510	94.8	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	III	C706	88.6	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	IV	C260	70.0	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	V	C752	65.0	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	VI	C280	60.0	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
Continuous Reduction of Bacterial Contaminants (Results at 24 Hr)	I	C110	99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	II	C510	94.8	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	III	C706	88.6	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	IV	C260	70.0	99.3	99.7	99.7	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	99.9	
	V	C752	65.0	>99.9	99.6	99.6	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	VI	C280	60.0	99.7	99.7	>99.9	>99.9	>99.9	>99.9	>99.9	99.8	>99.9	>99.9	>99.9 *	>99.9	>99.9	>99.9	>99.9	>99.8	

MRSA on copper vs. stainless steel – copper and stainless steel coupons were inoculated 8 times with approximately 1,000,000 CFUs of MRSA over a 24 hour period (without cleaning). The organisms were reduced by more than 99.9% after each inoculation on copper, while they survived and accumulated on stainless steel[9].



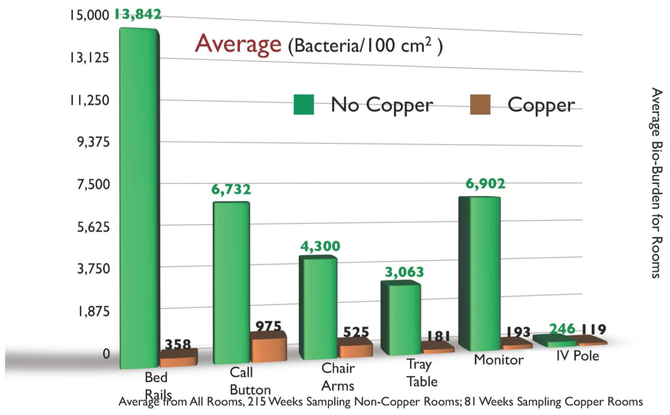
Influenza A on copper vs. stainless steel[11]



DoD funded clinical trials are currently underway in three hospitals under the aegis of the Telemedicine and Advance Technology Research Center (TATRC) and managed through the Advanced Technologies Institute. The trials have confirmed the antimicrobial performance in real world settings.

- Memorial Sloan-Kettering Cancer Center , New York, N.Y.
- Medical University of South Carolina, Charleston
- Ralph H. Johnson VA Medical Center , Charleston S.C.

Results demonstrated that copper surfaces reduce bacterial contamination by more than 90% compared to non-copper equivalents[13].



The Copper Air Quality Program, also funded by DoD through TATRC, has confirmed the ability of copper surfaces to reduce the incidence of airborne biological contaminants through two complementary studies.

Field Trials – Barracks at Ft. Jackson, S.C.

- Replaced aluminum heat exchangers with copper equivalents
- Placed new aluminum heat exchangers on adjacent barrack
- A significant reduction in the aerial fungal loads of buildings with copper heat exchangers vs. buildings with aluminum heat exchangers

Laboratory Trials – University of South Carolina

- Pilot scale air-handling system, precise parameter control
- Side-by-side branches with aluminum or copper components
- Significant reduction of bio-load on copper

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