Reducing the Risk of Healthcare Associated Infections

The Role of Antimicrobial Copper Touch Surfaces

CDA Publication 196

2010

Antimicrobial Copper Cu+™

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Contents

1. Executive Summary

There is now substantial laboratory and clinical evidence to support the replacement of frequently touched equipment and fittings in the healthcare environment with those incorporating antimicrobial copper to reduce bioburden and therefore reduce the risk of transmission of infection.

Copper and its alloys are easy to form into long-lasting equipment and fittings suitable for service in the healthcare environment. Whole life costs are comparable with other materials and products are fully recyclable and therefore contribute to sustainable design. Alloys that look like stainless steel are available although the distinctive golds and bronzes can provide a highly visible statement that an additional measure is being taken to reduce the risk of HCAIs. The supply chain is primed to supply.

The use of copper for touch surfaces is not a substitute for standard hygiene practices and products should be cleaned according to standard procedures, using standard agents. Some surface change will take place and, in the Selly Oak trial, this has been acceptable to all users.

Some guidelines have been developed for specifying copper and copper alloy products and information and training are available for all stakeholders.

The UK clinical trial at Selly Oak Hospital was the first in the world to publish results demonstrating copper's efficacy in reducing microbial contamination in a clinical setting and other countries are looking to the UK to lead in the implementation of copper products in the healthcare environment. Adoption of antimicrobial copper touch surfaces as an additional measure in the fight against HCAIs has already started in hospitals and care homes in the UK and Ireland.

2. Introduction

Well before micro-organisms were discovered, the Egyptians, Greeks, Romans and Aztecs used copper-based preparations to treat sore throats and skin rashes, as well as for day-to-day hygiene. Copper was also used to ward off infection in battlefield wounds.

In the 19th century, with the discovery of the cause-and-effect relationship between germs and the development of disease, scientific evidence started to be gathered. In the last few decades, work has been done on the antimicrobial properties of copper and its alloys against a range of micro-organisms threatening public health in food processing, healthcare and air conditioning applications. A summary of the main results is presented here and references are provided.

3. Recent Scientific Evidence

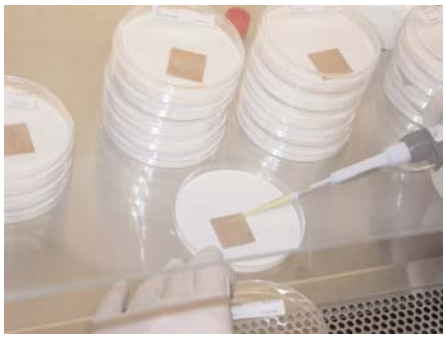
Laboratory Studies

Research has been carried out to determine the survival of different micro-organisms on copper and copper alloy surfaces. Much of this work since 1994 has been carried out by Prof Bill Keevil, Director of the Environmental Healthcare Unit at University of Southampton and the results have been repeated in laboratories around the world. Efficacy against the following key organisms has been shown:

- *Acinetobacter baumannii*
- Adenovirus
- *Aspergillus niger*
- *Candida albicans*
- *Campylobacter jejuni*
- *Clostridium difficile* (including spores)
- *Enterobacter aerogenes*
- *Escherichia coli O157:H7*
- *Helicobacter pylori*
- Influenza A (H1N1)
- *Legionella pneumophila*
- *Listeria monocytogenes*
- Meticillin-resistant *Staphylococcus aureus* (MRSA, including E-MRSA)
- Poliovirus
- *Pseudomonas aeruginosa*
- *Salmonella enteritidis*
- *Staphylococcus aureus*
- Tubercle bacillus
- Vancomycin-resistant enterococcus (VRE)

Protocol

Small coupons of each alloy were inoculated with bacteria and incubated at either 20°C or 4°C for various time periods. Standard microbiological techniques were used to culture, recover and enumerate the viable bacteria and *in situ* microscopy methods were used to assess membrane integrity and respiration.

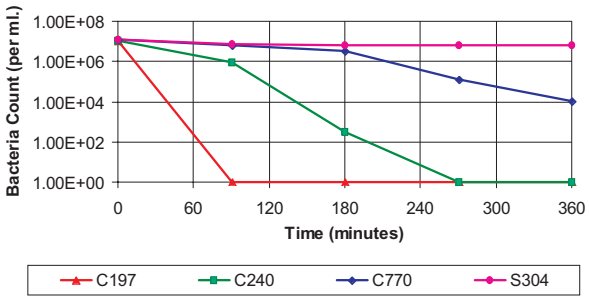


Antimicrobial efficacy testing

Results

The following graphs show sample data for efficacy of different materials (copper, copper alloys and silver-containing materials) against MRSA. Stainless steel is used as the control. General conclusions for all organisms tested are summarised below.

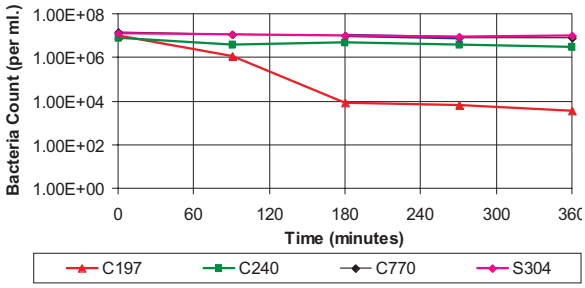
MRSA Viability on Copper Alloys and Stainless Steel at 20°C



Indicates p=<0.05 compared to zero time controls

Survival of MRSA on stainless steel (S304), Cu 99% (C197), Cu 80% (C240) and Cu 55% (C770) at 20°C

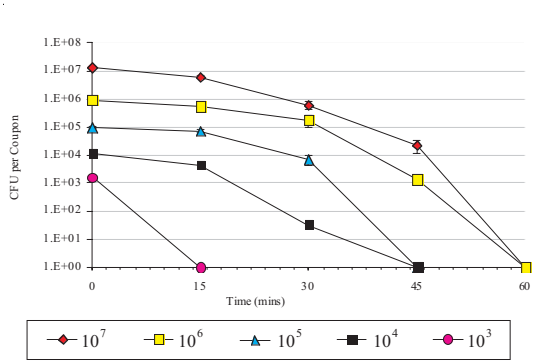
MRSA Viability on Copper Alloys and Stainless Steel at 4°C



Indicates p=<0.05 compared to zero time controls

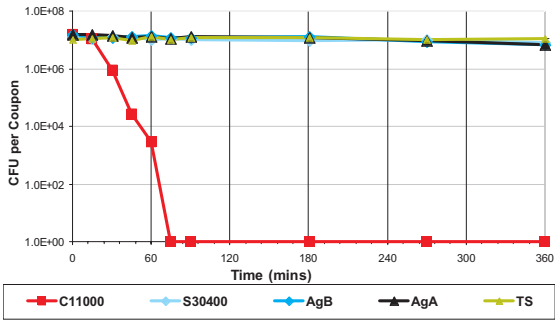
Survival of MRSA on stainless steel (S304), Cu 99% (C197), Cu 80% (C240) and Cu 55% (C770) at 4°C

MRSA Viability on Copper at 20°C - Reduced Inoculum



At reduced inoculum challenges, more typical of clinical environments, copper rapidly eliminated MRSA e.g. 10^3 CFU in 15 minutes.

MRSA Viability on Copper, Silver- and Triclosan-coated Materials and Stainless Steel at Room Temperature and Humidity



Under typical indoor conditions, silver coatings (AgA, AgB) and the triclosan coating (TS) behave as the stainless steel control (S30400) - i.e. they show no antimicrobial activity. Copper (C1100) is effective under these conditions, eliminating 10^7 MRSA in 90 mins.

- Results show that bacteria survive on stainless steel for days and are eliminated on 99% copper in less than 60 minutes (10^7 cfu/coupon).
- The effect is slower at 4°C but still significant.
- Greatest efficacy is seen at copper contents >60%.
- Reduced inoculum testing shows that, at levels of bacterial challenge typically encountered in the clinical environment (10^3 cfu/cm^2), kill times were as rapid as 15 minutes.
- Silver- and triclosan-containing coatings behaved as the stainless steel control i.e. showed no antimicrobial efficacy at room temperature and humidity.

Efficacy Testing

ISO 22196, based on the Japanese standard JIS Z2801, is most commonly used in the certification of antimicrobial efficacy of hard surfaces, yet this test is carried out at elevated temperature and humidity and so is not an appropriate indicator of efficacy under typical indoor conditions for touch surface applications. The more appropriate US Environmental Protection Agency approved test, carried out at room temperature and humidity, is being developed into a standard by ASTM and also as a British Standard.

Conclusions

Laboratory research on the antimicrobial efficacy of copper has been carried out and verified at institutions around the world, including the UK (Aston University, University of Southampton, Kingston University), US, South Africa, Germany and Japan. Results have been peer reviewed and published.

Kill times vary according to organism, strain, level of challenge, copper content of alloy and temperature - being more rapid at 20°C but still with a considerable effect at 4°C.

Copper exhibits efficacy under typical indoor conditions (humidity and temperature). Silver-containing materials (from two manufacturers) and triclosan behaved as the stainless steel control i.e. showed no antimicrobial efficacy under these conditions.

There is now a solid body of laboratory and clinical evidence to demonstrate the antimicrobial efficacy of copper against the most important pathogens challenging public health. It has been demonstrated that bacteria, viruses and fungi cannot survive on copper surfaces.

US EPA Registration

The Keevil efficacy test was adapted for a US Environmental Protection Agency (EPA)-approved protocol to substantiate claims on antimicrobial efficacy to allow marketing of antimicrobial copper products in the US. Tests were conducted at an EPA-approved GLP (Good Laboratory Practice) Laboratory.

Key features

Three test protocols were established to assess:

- efficacy as a sanitiser
- residual self-sanitising activity
- continuous reduction of bacterial contaminants.

Staphylococcus aureus, *Enterobacter aerogenes*, *Escherichia coli* O157:H7, *Pseudomonas aeruginosa*, MRSA and Vancomycin-resistant *Enterococcus faecalis* (VRE) were deposited on alloys ranging from 60% to 100% copper from two or three separately manufactured batches of each alloy.

Registered claims

Laboratory testing has shown that when cleaned regularly (bacterial claims relate specifically to the organisms tested and to 282 specified alloys with copper content > 60%):

- Antimicrobial copper alloys continuously reduce bacterial contamination, achieving 99.9% reduction within two hours of exposure.
- Antimicrobial copper alloy surfaces kill greater than 99.9% of Gram-negative and Gram-positive bacteria within two hours of exposure.
- Antimicrobial copper alloy surfaces deliver continuous and ongoing antibacterial action, remaining effective in killing greater than 99.9% of bacteria within two hours, even after repeated wet and dry abrasion and re-contamination.
- When cleaned regularly, antimicrobial copper alloy surfaces kill greater than 99.9% of bacteria within two hours, and continue to kill more than 99% of bacteria even after repeated contamination.
- Antimicrobial copper alloy surfaces help inhibit the build up and growth of bacteria within two hours of exposure between routine cleaning and sanitising steps.

The EPA requires that the following statement be included when making public health claims related to the use of antimicrobial copper alloys:

The use of a Copper Alloy surface is a supplement to, and not a substitute for, standard infection control practices; users must continue to follow all current infection control practices, including those practices related to cleaning and disinfection of environmental surfaces. The Copper Alloy surface material has been shown to reduce microbial contamination, but it does not necessarily prevent cross contamination.

Conclusions

In the US, antimicrobial products marketed with public health claims must be registered with the EPA. Copper is the first solid material to be registered. Outside of the US, this registration represents an independent, official recognition of the laboratory data presented and provides the quantified efficacy claims applicable to all registered alloys for the organisms tested.

Mode of Action

There are several theories for the mechanism by which copper kills bacteria, including:

- Causing leakage of potassium or glutamate through the outer membrane of bacteria
- Disturbing osmotic balance
- Binding to proteins that do not require copper
- Causing oxidative stress by generating hydrogen peroxide.

Clinical Research

In 1983, a US physician, Dr Phyllis Kuhn, published a hospital study showing copper's effectiveness in lowering the *E. coli* count on brass doorknobs.

In December 2005, Keevil presented his laboratory findings to the Department of Health and the conclusion was that that the evidence was compelling and the next step should be a trial to demonstrate efficacy in a clinical environment. Copper Development Association (CDA) provided an education grant to University Hospitals Birmingham NHS Foundation Trust where Prof Tom Elliott developed a copper clinical trial. CDA worked with the supply chain to provide copper products for the trial and also provided liaison with other clinical trial groups around the world.

Kitasato University Hospital study, Japan

In 2005, selected surfaces on a dermatology ward and the neonatal intensive care unit (NICU) at Kitasato University Hospital in Tokyo were wrapped with copper or brass foil and levels of contamination were monitored on these and control surfaces. It was found that copper alloys had a superior sanitising effect in the hospital environment.

Selly Oak clinical trial, UK

From March 2007 onwards, surfaces identified as 'frequently touched' on a general medical ward were replaced with copper-containing items and the contamination on their surfaces compared to control items on the same ward.

The copper-containing items introduced included grab rails, door handles, door push plates, light switches, taps, over-bed tables, sink traps and toilet seats (see images below and table of components and alloy compositions on page 7).

In the first phase of this study, three items were sampled - taps, door push plates and toilet seats. Sampling took place once a week for five weeks and then copper and control products were swapped over to compensate for any bias of use and sampling continued for a further five weeks. The results show that there was a reduction in contamination of between 90 and 100% on the copper-containing items compared to the controls.

Further products were introduced (including trolleys, light pulls, flush handles, over-bed tables, dressings trolleys and commode chairs) and these were sampled for two three-month periods, with a crossover at the midway point. Results are expected to be published in late 2010.

To note:

There are currently no data to show reduced infection rates where antimicrobial products are installed. The Department of Health estimates a sample size of 300,000 beds would be needed to assess the impact of a single intervention with absolute confidence. They are therefore working on a suitable model.

In the larger-scale US study (see page 6), infection rates are being monitored. It is generally accepted that reducing environmental bioburden reduces the risk of infection.

Selly Oak pen audit

A smaller-scale trial was set up to compare the contamination on copper vs stainless steel pens used by healthcare workers at different time points at the end of a shift. The results of a pilot study show that copper pens have reduced contamination and are actually free of contamination after twelve hours. The study is being repeated with a larger sample size.

Below: Installed copper products at Selly Oak Hospital, Ward B4

Other ongoing clinical trials

US

The Department of Defense is funding a large-scale 3-centre trial. The current status is as follows:

- Established bioload in intensive care units of three hospitals and determined most highly contaminated surfaces - bed, chair, and nurse's call device.
- First results on bioload were published at ICAAC in October 2008 - 'contamination is highest closest to the patient'.
- Copper objects (bed rails, tray tables, chair arms, call buttons, monitors, and IV poles) were placed into 3 randomly selected MICU rooms and were sampled weekly for 9 weeks. Similarly, these same non-copper objects were sampled in 3 other randomly selected control MICU rooms over the same time period.
- The first results, presented at the 5th Decennial International Conference on Healthcare-Associated Infections, Atlanta, in March 2010, showed that the continuous antimicrobial activity of copper was apparent and effective in significantly reducing the total mean microbial burden by 87.4% in ICU patient care rooms as well on many individual objects within those rooms.
- MRSA and VRE were frequently isolated from non-copper objects but were never isolated from copper objects over the study period.

Germany

At Asklepios Hospital, Hamburg, a ward for geriatric medicine was equipped with copper alloy light switches and door handles. These were sampled for a period of 26 weeks and compared to the same surfaces on a control ward. Initial findings show a significant reduction in contamination on the copper compared to the control components.

Finland

A trial conducted at a nursing home, in conjunction with the Helsinki University Department of Public Health, compared contamination on copper vs standard items in patient rooms, bathrooms and communal areas. Copper components included dressing trolleys, door handles, grab rails, handrails, shower drains and push buttons. The first results show higher levels of contamination on the non-copper items and presence of faecal and urinary bacteria, (*Staphylococcus aureus*, *E. coli* and *Candida albicans*) only on stainless steel, plastic and chromium components. On copper and copper alloy surfaces, only Gram-positive bacilli and cocci and normal environmental and skin flora were found.

Others

Trials are under way in South Africa (led by Prof Shaheen Mehtar, University of Stellenbosch) and Greece and also in Chile, where the first results confirm the Selly Oak and US findings.

Conclusions

Teams around the world are leading clinical trials to assess copper's role in reducing bioburden in the clinical environment and any associated improvement in patient outcomes.

The first published results from the Selly Oak clinical trial show a 90-100% reduction in the contamination on the copper vs control surfaces. These results have been confirmed by trials in other parts of the world.

4. Practical Aspects of Implementation

Range of Alloys

The materials chosen for clinical trial are those already in common use for other purposes and are readily available to equipment manufacturers supplying healthcare components. They represent a range of compositions broadly in line with the EPA registered alloys.

Fabricability, Durability and Appearance

Copper alloys, especially brass, have become an industrial standby due to their ease of use and durability. Much equipment is manufactured in these materials and subsequently lacquered or chrome or nickel-plated. Brass is readily cast, is considered the 'gold standard' in terms of machining and is easy to manipulate by bending and pressing. Moreover, the alloys are very malleable, which has the potential to allow designers to provide interesting as well as practicable equipment. Components are familiar, easy to install and have long service lives.

Copper forms an alloy with a number of other elements such as iron, zinc, nickel and aluminium, providing a practical family of alloys with material characteristics that are readily understood by engineering designers. The alloys exhibit a range of colours, again allowing expression of design as well as practicality. Because they are notably different they can potentially provide a mark of change and innovation in healthcare.

Cleaning

The alloys installed for the clinical trials have been subject to the normal day-to-day range of cleaning processes and formulations used throughout the hospitals, including toilet and spillage cleaning. In the case of Selly Oak, apart from the expected mild surface oxidation, there has been no severe corrosion observed over the course of the last 24-36 months.

It has been observed that, if a component is left uncleaned for more than a week, under certain conditions, the surface will change appearance, allowing a visual assessment of cleanliness to be made.

Deep cleaning, with hydrogen peroxide techniques, merely accelerates the usual patination of the alloys, leaving a slight oxide 'bloom' on newly installed equipment.

From recent observations of long-installed brass hardware elsewhere (especially taps and wastes, which have seen the most aggressive environmental and cleaning regimes) the brass shows greater longevity than chrome or nickel plating.

Details of copper and copper alloy components installed in the Selly Oak Clinical Trial.

Area/fixture	Item/comment	Material	% Copper
Cubicle door bolt	Heavily plated zinc alloy	CuOF	99.95
Electrical socket	Back plate	CuDHP	99.9
Grab rails	Brass handle, steel plates	CuZn30	70
Light switch	Back plate and switch	CuDHP	99.9
Main door handle	Lever handle	CuSn8	92
Main door handle	Back plate and lock	CuETP	99.95
Overbed table	Work surface	CuDHP	99.9
Pens	All-metal ballpoint	CuZn15	85
Pull handle	Long: x 420 mm	CuSn8	92
Pull handle	Short: x 230 mm	CuZn39Pb3	58
Push plate - main ward door	Large push/kick plates	CuZn30	70
Push plate - vertical/horizontal	Small: 75 x 300 mm	CuOF	99.95
Push plates - cohort ward	Large push/kick plates	CuZn37	63
Sinks	All mixer taps	CuZn40	60
Sluice	Single hot and cold taps	CuZn40	60
Toilet seat	Sprayed coating	CuOF composite	70 approx.

Reactions from HCW, Patients and Visitors

From our own interviews at Selly Oak, the nursing staff are interested and very willing to explain to patients why the ward has copper alloy fittings; they say they are proud to be associated with the trial. Likewise the patients readily accept that the fittings should be considered and treated as normal. There is no evidence of changed behaviour from these individuals.

Cost

Copper and its alloys are used throughout industry because they offer good value. Most component cost comes not from the intrinsic material value, but a combination of fabrication and fitting costs. The fitting costs are broadly the same for any given component - unless it fails and has to be replaced. Copper alloys are widely used for complex components, like a tap or a lock, because they are so easy to fabricate, by casting, rolling, machining and then polishing. They therefore represent a comparable capital cost to other widely used materials. Installation of a key 'ward set' is relatively easy and can be accomplished without major disruption on the ward.

Sustainability

Copper is 100% recyclable without loss of properties. 'Scrap' from manufacturing has value and there is a very well developed infrastructure for collecting and recycling it. In Europe, over 40% of copper needs are met through the recycling route and almost all the brass produced comes from recycled stock.

Design

Copper alloys are considered by many designers as traditional and component designs often reflect a focus on a nostalgic market. In fact, they provide a fantastic opportunity to design out infection through the use of modern manufacturing technology. The UK still plays an important part in the global industry, providing designs that can be best made using skills and equipment relevant to any country's supply chain. The clean, straight stainless steel design forms that have become so ubiquitous have arisen largely because the early steels were difficult to fabricate.

Availability

Copper alloys are widely available throughout the UK from both primary manufacturers and stockists. Manufacturers of components have access to a wide variety of material forms and good selection advice from these sources, as well as the support of Copper Development Association and its global network of corresponding offices. Globally, there are thousands of suppliers of both raw materials and semi-finished products.

Conclusions

Copper and its alloys are easy to form into durable equipment and fittings suitable for service in the healthcare environment. Components are familiar, easy to install and have long service lives. Products made from solid materials will remain effective in killing germs throughout their lives, even if scratched.

Alloys are available which look like stainless steel, as well as the distinctive golds and bronzes which can provide a highly visible statement that an additional measure is being taken to reduce the risk of HCAIs.

Whole life costs are comparable with other materials and products are fully recyclable and therefore contribute to sustainable design. The supply chain is primed to supply.

5. Accelerating Adoption

Acceptance

The Department of Health's (DH) fast track initiatives for HCAI control measures are aimed at individual products but not appropriate for endorsing an inherent property of a material. However, DH have reviewed the scientific evidence and accept that copper can reduce contamination on touch surfaces in a clinical setting. CDA is working with DH to progress the evaluation of copper's potential in healthcare.

The first hospital and care home projects to exploit antimicrobial copper touch surfaces are already taking place, in the UK and Ireland.

A cystic fibrosis unit for young adults, at Northern General Hospital, Sheffield, has specified antimicrobial copper door furniture to meet the unit head's requirement for 'the gold standard in infection control' for these vulnerable patients.

Specifying Copper and Copper Alloy Products

Currently, neither Health Technical Memoranda nor Health Building Notes have been developed for antimicrobial copper touch surface components. However, CDA is working with material suppliers and product manufacturers to develop specifications. The first set, covering door furniture, is now available.

As the global industry representative, the International Copper Association (ICA) has developed the Antimicrobial Copper brand to ensure it addresses its stewardship with regard to the deployment of copper and copper alloys in the field. The use of the Antimicrobial Copper brand and logo indicates that ICA has verified that organisations understand the underlying technology and promote and advise on it in line with existing research, regulatory and legislative requirements.

Learning More

CDA is able to offer support by providing speakers and advisors for team meetings, seminars and other events, covering both the science and practical application of antimicrobial copper. All information resources are also accessible online. See back cover for contact and website details.

6. Background Information

Copper Voluntary Risk Assessment

The copper industry initiated a Voluntary Risk Assessment for copper. The assessment process was agreed with the Italian Government's Istituto Superiore di Sanità, acting as the review country on behalf of the European Commission and the EU Member States. The risk assessment has now been completed and one of the main conclusions, accepted by the European Commission and EU Member State experts, is 'the use of copper products is in general safe for Europe's environment and the health of its citizens.'

About Copper Development Association (CDA)

CDA is a not-for-profit, membership-based organisation which supports and promotes the correct and efficient use of copper and its alloys through the provision of technical support and impartial information to professionals, end users and students. CDA is part of a global network of 28 Copper Centres with a regional office in Brussels, European Copper Institute, and headquarters in New York, International Copper Association, Ltd.

CDA provided an education grant to University Hospitals Birmingham NHS Foundation Trust where Prof Tom Elliott developed a clinical trial. CDA worked with the supply chain to provide copper products for the Selly Oak trial and also provides liaison with other clinical trial groups around the world.

International Copper Association, Ltd, has funded the research at University of Southampton.

7. Key Recent References

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Copper Voluntary Risk Assessment

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