Copper: essential for life

European **Copper** Institute

When we think of copper, it is generally in terms of its use in roofing, plumbing and heating, as well as in the power and communications wiring in our homes, places of work and industry. Of all metals, except silver, copper has the best electrical conductivity. It is therefore easy to understand why it is used in so many electrical applications, from the generation through the distribution to the efficient use of electricity. What is less well known is that copper has antimicrobial properties, even though these have been exploited by man for thousands of years.

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.

Then, in the 19th century, came the discovery of the cause-and-effect relationship between germs and the development of disease, allowing scientists to begin to understand the potential of copper's antimicrobial properties. Today, copper is used in applications ranging from antiseptics and anti-fungal products, to medical devices and oral hygiene products by the pharmaceutical industry, as well as in other applications, such as water distribution, ventilation and air conditioning systems.

A solid body of scientific evidence shows that copper has a broad spectrum of antimicrobial efficacy and can inhibit the most important pathogens challenging public health, including meticillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridium difficile* (two organisms causing hospital-acquired infections), *Escherichia coli* (E. coli, the 'burger bug'), as well as *Legionella pneumophila* (the bacteria which cause Legionnaires' disease). Copper has also been shown to inactivate the Influenza A virus and so could even play a part in reducing the risk of a bird flu epidemic. Some of these laboratory findings are now being put to the test in clinical trials in the UK, US, Germany and Japan with initial results showing great promise.

This leaflet explains why copper could have a vital role in reducing the risk of transmission of germs that threaten public health in our hospitals, public buildings and food-processing facilities.

For comprehensive information on copper's antimicrobial properties, including film clips and presentations, visit: **www.copperinfo.co.uk/antimicrobial**

A promising weapon in fighting infection in hospitals

3 million healthcare-related infections in Europe each year result in some 50,000 deaths, according to the EU's Centre for Disease Prevention and Control.[1]

Not all hospital-acquired infections are preventable, but, according to the UK's National Audit Office, the professional consensus is that these could be reduced by at least 15%.

Approximately 80% of infectious diseases are transmitted by contact. Among the micro-organisms most frequently identified in hospital-acquired infections are MRSA, coliforms, such as *E. coli* and *Klebsiella pneumoniae*, as well as *Clostridium difficile*.

These infections, in addition to the very serious risk to the lives of those involved, have a very significant impact on modern healthcare costs. For example, the EU Centre for Disease Protection and Control estimates the cost of one *Clostridium difficile* case to be somewhere between €5,000 and €15,000 in the UK. Assuming the population of the European Union to be 457 million, *Clostridium difficile* could be estimated to potentially cost the European Union €3 billion per annum and this figure is expected to almost double over the next four decades.

[1] http://ecdc.europa.eu

United States Environmental Protection Agency approves registration of copper as an antimicrobial agent

In March 2008, following rigorous tests carried out in the United States, the US Environmental Protection Agency (EPA), announced the registration of copper as an antimicrobial agent to reduce specific harmful bacteria linked to potentially deadly microbial infections. A year of comprehensive testing in an independent US laboratory – following EPA-prescribed protocols – resulted in 275 copper alloys acquiring the right to be marketed in the US as antimicrobial. The tests showed that 99.9% of the bacteria on copper alloy surfaces (with 65% or greater copper content) were eliminated within 2 hours of exposure. These materials exhibit a range of properties – mechanical and aesthetic – that make them ideal for use as antimicrobial surfaces, not only in healthcare and other community facilities, that can become contaminated with bacteria, but also in other environments, such as in the food-processing industry. Copper and its alloys are, in fact, the first solid materials to acquire this status. Typically, this type of registration has been granted to liquids (or aerosols) and gases under the categories of sanitisers and disinfectants.

It should be noted, nevertheless, that the use of copper alloy surfaces is additional to, rather than a substitute for, standard infection control practices.

In the US, a 3-centre Department of Defense-funded clinical trial is under way and has published findings that objects in closest proximity to patients, such as bed rails, call buttons and chairs, have the highest levels of staphylococci, meticillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE). This suggests that touch surfaces in intensive care units serve as reservoirs that could transfer bacteria to patients, healthcare workers and visitors. The next stage of these trials will be the installation and sampling of copper alloy products.

Copper: a solution that is simple yet robust and sustainable

Promising laboratory research results have led to trials in regard to hospital-acquired infections

Laboratory research findings, in 2006, at the University of Southampton, by a team led by Prof. Bill Keevil, on the survival of MRSA on surfaces, confirm that copper may play a key role in combating hospital-acquired infections. Their tests compared survival rates of MRSA deposits in a dry environment on stainless steel (the metal most commonly used in healthcare institutions), with a range of copper alloys.

The results show that the staphylococci are completely deactivated after only 90 minutes on the copper and 4 1/2 hours on brass (an alloy of copper and zinc), whereas they are completely unaffected by stainless steel. This has led Professor Keevil to the important conclusion that 'the use of copper alloys in applications, such as door handles, trolleys, or any other work surface, could considerably reduce the presence of MRSA in hospitals and could thus reduce the risk of cross-contamination between employees and patients in intensive care units'.

Further research has shown that, to achieve a significant antimicrobial effect, copper alloys should have a copper content of more than 65%, meaning that alloys such as bronze and brass would be effective. These alloys have enhanced properties, can be used in different manufacturing processes and also provide a palette of colours. Copper and copper alloy products are homogenous and solid so the antimicrobial effect will last throughout a product's long lifetime, irrespective of how much wear and tear and scratching it sustains. In addition, at the end of their lives, products made from copper and copper alloys are 100% recyclable.

In a ward situation, surfaces could act as reservoirs of infection where healthcare workers, patients and visitors can come into contact with infectious germs. Frequently touched items, such as door handles, light switches, trolleys, bed rails, over-bed tables, bedside cabinets, grab rails and taps are typical examples of such surfaces.

Field trials, led by Prof. Tom Elliott, Consultant Microbiologist and Deputy Medical Director at University Hospitals Birmingham NHS Foundation Trust, have been under way at Selly Oak Hospital in Birmingham, UK, since 2007. Prof. Elliott has considerable expertise and an international reputation regarding the interaction between bacteria and surfaces in the clinical environment. The trial aims to confirm copper's role in reducing environmental contamination and improving patient outcomes as part of a 'care bundle' – a package of measures to fight infection.

Prof. Tom Elliott

If the trial proves to be successful, it is likely that thousands of hospitals across Europe will introduce copper-based fittings, thus offering them yet another means of tackling the spread of healthcare-associated infections. The first results from the trial, presented at the prestigious Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC) in Washington DC, US, in October 2008, show that surfaces made with materials that contain copper kill a wide range of potentially harmful micro-organisms – significantly reducing the number of these organisms that can come into contact with patients, visitors and staff. The study found that, when tested, items made from copper had up to 100 per cent fewer micro-organisms on them, compared with the same items made out of standard materials such as plastic or aluminium.

Prof. Elliott said: "What this must mean is that the risk of picking up an infection is reduced, because we know that one of the vehicles where organisms can spread from one surface to another is by touching them. So the results are very exciting."

"The findings of a 90 to 100 % killing of those organisms, even after a busy day on a medical ward with items being touched by numerous people, is remarkable. So it may well offer us another mechanism for trying to defeat the spread of infection."

The next phase of the trial will see the full range of copper surfaces and their controls tested over a 12-month period to gather more data. In parallel, trials are taking place in the Asklepios Clinic Wandsbek, in Hamburg, Germany. There, aluminium door handles and plastic light switches have been replaced by copper alloy equivalents in one ward and its adjacent bathrooms. The patients in the control ward and the trial ward have similar profiles. The results generated in the first three months of the trial (May – July 2008), that has focused on the total level of contamination in a 'summer' situation and, more specifically on the MRSA bug, reinforce the UK findings. The trial will resume later in 2008 to investigate the 'winter' scenario. The German trial is expected to run for a total of 12 to 18 months.

In addition to the trials in the UK, Germany and the US, testing of copper's potential to fight pathogens is also under way in South Africa and Japan.

Interview with Prof. C. W. Keevil, Head of the Environmental Healthcare Unit at University of Southampton's School of Biological Sciences

Can copper help to stop the epidemic dissemination of diseases?

The prevention of diseases requires multiple barriers for effective control, particularly where resistance to therapeutic antibiotics is increasing. These barriers include preventative measures such as regular contact surface washing (e.g. work surfaces, door handles, push plates), hand washing (particularly the frequent use of alcohol-based handrubs by staff in hospitals to control MRSA spread) and prophylaxis (e.g. vaccination or antibiotic treatment). Unfortunately these measures are not completely effective – so additional barriers are required: the simplest, for example, is installing surfaces with inherent antimicrobial properties that remain effective with standard cleaning agents and procedures. Our work has shown that copper and some of its alloys are able to kill bacteria, fungal and viral pathogens within minutes or hours when they come into contact. By contrast, stainless steel and modern plastics do not show this useful property.

Can you tell us more about the Selly Oak Hospital clinical trial?

The first phase of hospital trials, at Selly Oak Hospital in Birmingham, UK, led by Prof. Tom Elliott, started in 2007. This involved random sampling of some of the copper surfaces at different time points compared to control items.

Phase 2 of the testing involved a change in the design of the trial. The test ward was partitioned to form a *Clostridium difficile* cohort ward to create a real challenge for copper – an infection gradient between this area and the main ward. Door push plates, taps and toilet seats were sampled at 2 time points on one day each week over 5 weeks. After the 5 weeks, the copper and control items were swapped over and tested for another 5 weeks. This unique 'crossover' technique was designed to eliminate potential bias caused by the items being used in different locations and so in different ways. The results – a 90–100% reduction in total contamination on the copper items versus the controls – are most encouraging.

What does the most recent scientific research say about new applications for copper in the healthcare environment?

Further exciting results also suggest a role for copper as an effective control barrier in reducing the spread of bird flu. The experiment consisted of placing 2 million active units of the Influenza A virus (a family to which the H5N1 virus belongs) on a C11000 (99.9% purity) copper sheet, as well as on a S30400 stainless steel sheet. On the stainless steel sheet, the number of infectious virus units fell to 500,000 in 24 hours, a reduction of 75%, whereas on the copper sheet, only 500 infectious virus units survived after six hours, i.e. a reduction of 99.9%. Copper's ability to inactivate the flu virus means that these results are extremely interesting given current interest in curbing a potential bird flu epidemic.

Why copper is used for water distribution and ventilation systems

Copper can help combat the growth of pathogenic organisms in drinking water and ventilation systems. Thanks to its antimicrobial properties, copper inhibits micro-organisms which, from time to time, may be present, such as *Legionella pneumophila*, the bacteria that causes Legionnaires' disease. Although drinking water is generally free of pathogenic organisms, it is possible for viruses, bacteria, fungi and parasites to be present in public drinking water systems. Copper plumbing tube may, therefore, provide some additional protection against the presence of these organisms and the risk of disease.

In today's modern buildings, concerns about exposure to toxic micro-organisms have created a need to improve the hygienic conditions of heating, ventilation and air conditioning (HVAC) systems, which are believed to be factors in over 60% of all so called "sick building situations"[2] (Collet and Associates).

Prominent pathogenic risks in HVAC systems include legionella and moulds, such as *Aspergillus niger* (black mould). Using antimicrobial copper and copper alloys instead of biologically inert materials in heat exchanger tube, fins, filters and condensate drain pans may contribute as a viable and cost-effective means to help control the growth of fungi and bacteria that can thrive in these dark and damp components of HVAC systems. The combination of copper's superior resistance to mould growth and its thermal conductivity can also improve the energy efficiency of the systems in which it is installed.

Due to its mechanical properties, copper tubing is also able to withstand the high temperatures needed to defeat legionella and other pathogenic organisms in thermal disinfection procedures.

The Antimicrobial Copper Interest Group aims to communicate the antimicrobial benefits of copper and its alloys to society.

Contact: bryony.samuel@copperdev.co.uk

[2] For more information on 'sick building' syndrome, see www.nhsdirect.nhs.uk/articles/article.aspx?articleId=336

ECI
168 Avenue de Tervueren b10
1150 Brussels – Belgium
Tel.+32 (0)2 777 70 70
email: eci@eurocopper.org

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