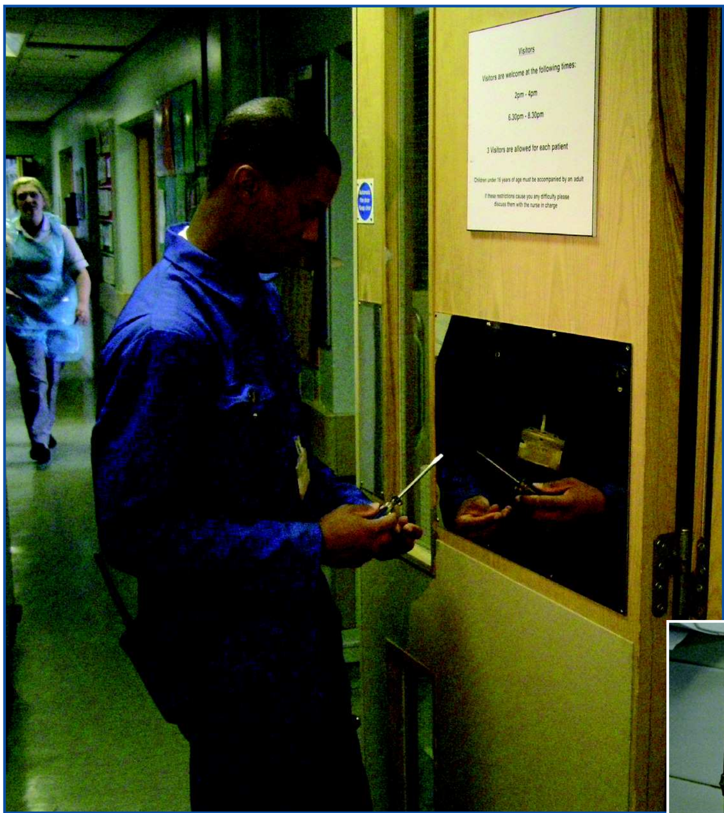
Clinical uses of copper

For environments where contamination is a key issue, **Angela Vessey,** director of the Copper Development Association, reveals why designers and operators should look to exploit the natural antimicrobial properties of man's oldest metal



In ancient times, copper was found useful for its curative powers — largely due to its antibacterial and antifungal properties — in the treatment of wounds and skin diseases.

The ancient Egyptians used copper to sterilise chest wounds and drinking water as early as 2600 BC, Hippocrates used it to treat open wounds and skin irritations around 400 BC, the Romans and Aztecs used copper in the treatment of diseases and the Persians and Indians used it to treat boils, eye infections and venereal ulcers. Forms of copper used for the treatment of disease ranged from metallic copper splinters and shavings to various naturally-occurring copper salts and oxides.

The Egyptians and Romans also used copper and bronze surgical instruments including tools such as needles, surgical knives and vaginal specula. The examples of these, which can be seen in museum collections, are a testament to the longevity of copper alloys.

In the 19th Century, following the discovery of microbes and their association with disease, scientists began to understand the process by which copper served these purposes and there have since been hundreds of scientific papers written on the subject.

Antibacterial copper fittings are about to be trialled at Selly Oak Hospital, Birmingham, UK

Today, the list of copper-based hygiene applications includes fungicides, antifouling paints, oral hygiene products, tissue culture incubator linings and surgical instruments. Following the findings of new research on copper's inhibition of prevalent disease-causing bacteria, this list is set to grow.

Bacterial effects

Recent and ongoing research by Professor Bill Keevil and his team at the University of Southampton tested the effect of copper and copper alloys on survival of various bacteria dried onto their surfaces. One of the first organisms to be tested was *E. coli* O157, an organism occurring in the intestines of healthy cattle which can, during processing, contaminate meat products and also be passed from raw to cooked meat, resulting in human infection.

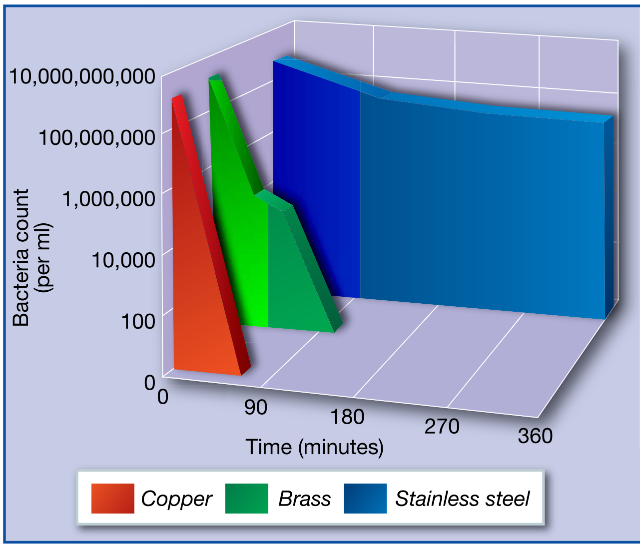
Results showed that copper inactivated extremely high levels of *E. coli* contamination in less than 90 minutes at room temperature. Brass, an alloy of copper and zinc, achieved total inactivation of the bacteria in two hours while the control, stainless steel, remained heavily contaminated, even after the 6-hour duration of the test (see figure. 1).

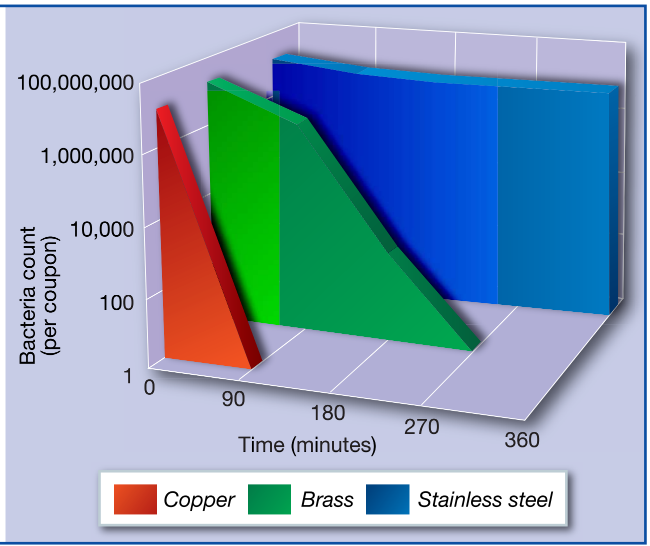
Infections from *E. coli* O157 are serious and life threatening. Preparation of food products requires surfaces that are resilient and easily cleaned to reduce the risk of contamination. Stainless steel, although hard wearing and easily cleaned, is not intrinsically effective at reducing numbers of viable bacteria, which suggests that food-processing environments would benefit from the installation of materials that are inherently antimicrobial.

Copper, and to a lesser extent brass, still demonstrated a significant effect at 4°C, an important consideration for controlling contamination in chill environments.

At the time hospital-acquired infections started emerging as an issue, Keevil put copper to the test on one of the more virulent strains of the antibiotic-resistant Methicillin-resistant *Staphylococcus aureus*, or MRSA.

He showed that MRSA was eliminated after 1.5 hours on copper and after 4.5 hours on brass at 20°C. In contrast, viable organisms were detected on stainless steel





Above left: Fig 1. E. coli survival times on copper, brass and stainless steel
Above right: Fig 2: MRSA survival times on copper, brass and stainless steel

after six hours. At 4°C, complete kill was achieved on copper within six hours. On stainless steel the pathogens can survive unabated (see figure 2).

Further tests, using lower, more typical levels of contamination, show complete elimination of MRSA and *E. coli* in around 20 minutes at room temperature.

Keevil concluded that his results supported the case for using copper as a hygienic material in healthcare applications and this is being put to the test in a copper clinical trial about to start at Selly Oak Hospital, Birmingham, UK. In the test ward, touch surfaces identified by the infection control team as potential reservoirs of infection will be replaced with copper alloy products.

These include door handles, push plates, light switches, toilet flush handles, grab rails, dispensers of all types (soap, alcohol gel, paper towels and aprons), bed heads, bedside cabinets, over-bed tables and doctors' pens.

The trial will monitor contamination levels on the copper surfaces fitted in the test ward and compare them with levels in the control ward. Patient colonisation and infection rates will also be monitored. The trial is planned to last 18 months.

Keevil's work is ongoing and the list of organisms tested and shown to be eliminated by copper reads like a hit list of the 21st century's 'most wanted' pathogens:

- Methicillin-resistant *Staphylococcus aureus* and *Clostridium difficile* (hospital-borne pathogens)
- *E. coli* O157 and *Listeria* (food-borne pathogens)
- *Influenza A* and *Aspergillus niger* (air-borne pathogens).

Testing a range of alloys with different copper contents, Keevil has shown that faster kill times are associated with increased copper content. Hence MRSA, for example, is destroyed faster on 99% pure copper than on an alloy containing 80% copper, and faster on an 80% copper-containing alloy than on a 60% copper-containing alloy. Generally speaking, the best results are seen at copper contents greater than 65%.

Copper alloys

Copper alloys are widely used in many applications, ranging from electrical wiring and connectors to musical instruments, from hi-tech applications including borescopes and industrial cameras to household plumbing tubes and fittings, keys, locks, door knobs, coins and handrails. The list of applications is almost endless.

The wide use of copper alloys is attributable to a long history of successful use, ready availability from a multitude of sources, the attainability of a wide range of physical and mechanical properties and amenability to subsequent processing such as casting, hot and cold forming, machining and joining by a variety of processes including brazing and soldering.

MRSA is killed off after 1.5 hours on copper surfaces compared with 4.5 hours on brass

The properties of copper alloys, which occur in unique combinations found in no other alloy system, include high thermal and electrical conductivity, a wide range of attainable strengths, excellent ductility and toughness, as well as superior corrosion resistance in many different environments.

The major families of alloys are the brasses (copper and zinc), the bronzes (copper and tin), the copper-nickels (copper and nickel) and the nickel-silvers (copper, zinc and nickel).

Earlier this year, a solid body of research was completed by a GLP laboratory in the US to support the registration of copper as the first material to claim that it 'protects human health'. Five alloys were tested against five organisms, including MRSA and *E. coli*, using three test protocols, including a reinfection and wear test.

Testing in the US and Southampton was carried out under conditions representative of the hospital environment with regard to room temperature and ambient humidity. The EPA is currently reviewing the results of the 6,000 tests and a decision is expected in the autumn.

Deceptive looks

There is no doubt that the shiny silver appearance of stainless steel is associated with a clinically clean environment. However, Keevil's work has shown that looks can be deceiving and a surface that appears clean to the naked eye can harbour dangerous pathogens and provide a source of contamination.

Copper alloys change appearance over time and may develop an 'aged' look but, as the research has shown, they eliminate ▶

germs from their surface and so remain hygienic.

Various hypotheses have been put forward to explain copper's effect on microbes and research is ongoing. Microbes actually need copper to survive but, when exposed to a copper surface, their regulatory 'copper pumps' are simply overwhelmed and they cannot survive.

The cost implementing any contamination control measure needs to be weighed against the cost of outbreaks of infection. Hospital-acquired infections are believed to cost the NHS around £1bn a year and the cost in terms of human lives and suffering is incalculable.

Cost-effective manufacture

Copper alloy products are cost-effective to manufacture due to their ease of fabrication, machining and casting. During manufacture, process scrap generated is recycled and this can offset material costs.

Copper alloy products are extremely durable, do not need to be plated or coated and can be recycled at end of life, without any loss of properties. This makes cost of ownership over the service life favourable and contributes to sustainable development.

As durable, homogenous hygienic materials, copper alloys fight infectious organisms 24/7, working away in the background and reinforcing other hygiene measures such as hand washing and cleaning.

So, man's oldest metal can still surprise us and, as a hygienic material, should be considered for those applications where its unique intrinsic antimicrobial properties will benefit human health.

Copper network

The Association's role in this exciting field is taking scientific findings and helping to develop new applications. The Antimicrobial Copper Interest Group has been formed for healthcare professionals, academics, facilities managers, architects, designers, product manufacturers and material suppliers who wish to keep up with the latest research and developments in this field.

Its aims are information dissemination and networking to bring the antimicrobial benefits of copper and its alloys to society. If you are interested in joining the group contact alison.brett@copperdev.co.uk. ■

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