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Standards for

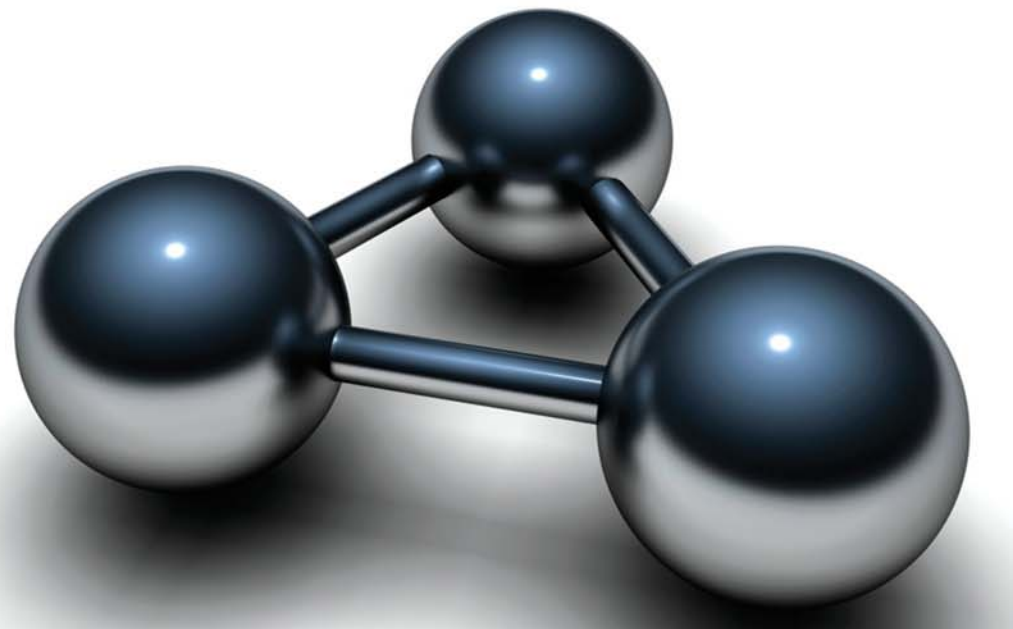
Metals

Use of Standards at Nippon Steel

Antimicrobial Characteristics of Copper

Permanent Magnets

New Titanium Grade



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October FROM THE EDITOR'S DESK

Killer Copper

Having become familiar over many (I will not say just how many) years with the varied uses of the metals that ASTM International standardizes, I was a little surprised to see copper, for one, in a whole new light — as a killer. This is not a problem for you unless you're a microbe, but if you are, copper is a distinctly inhospitable environment.

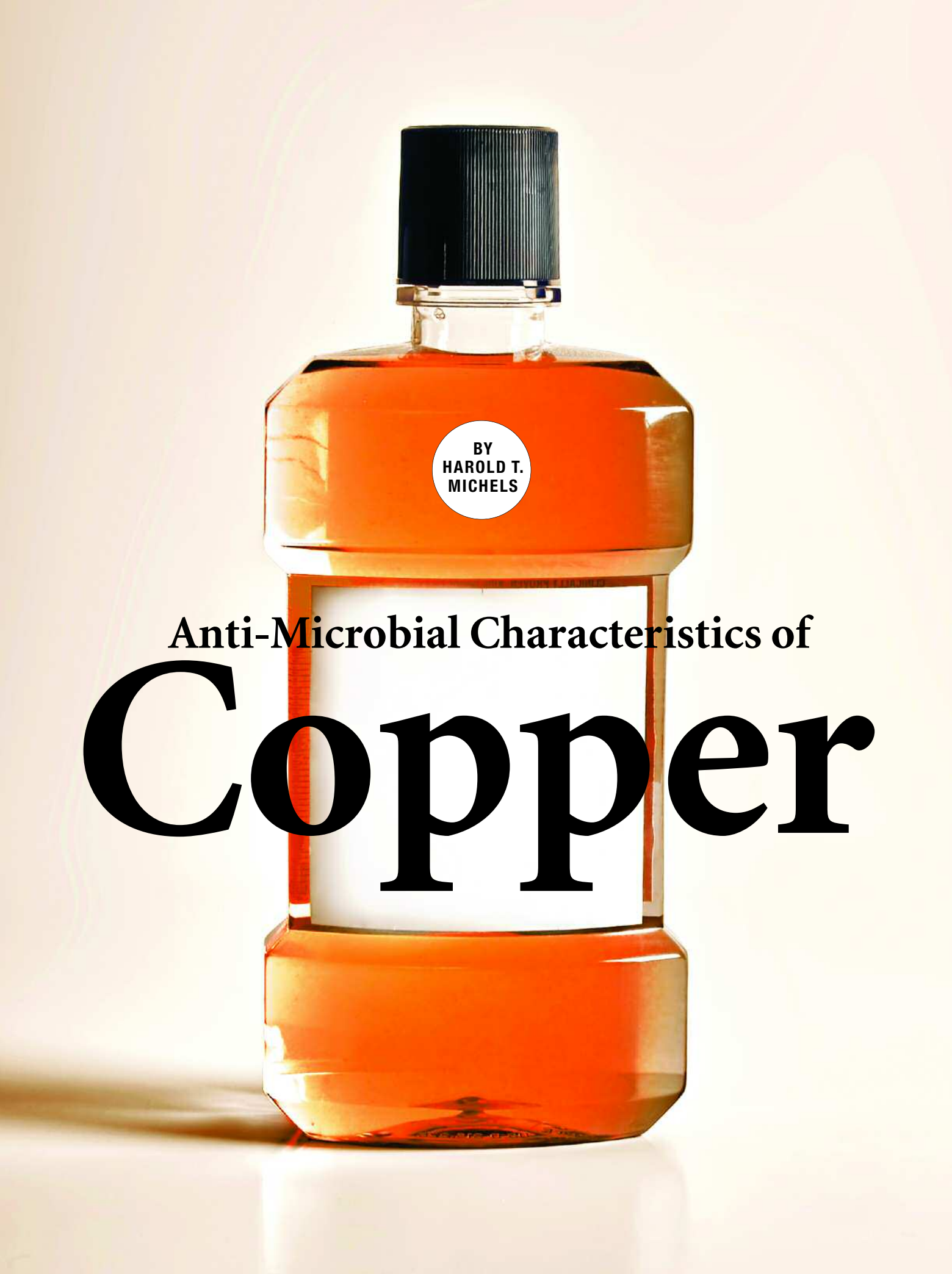
This is most graphically depicted in the epifluorescence image on page 29, which shows the prevalence of *E. coli* after it's been sitting on copper for 90 minutes, or rather, the non-prevalence of *E.coli* — it's virtually eliminated. This is important information for people like hospital administrators, who need tools in their fight against infections such as methicillin-resistant *Staphylococcus aureus,* better known as MRSA, a difficult-to-treat and potentially deadly bacterium that can thrive in hospital environments, but which also perishes on copper. Using copper for touch surfaces such as door hardware, bedrails, faucets and so on can go a long way toward reducing the incidence of MRSA and other infections in healthcare facilities.

Heating, ventilation and air-conditioning systems are also prime candidates for the copper cure. *Aspergillus niger* (black mold), commonly found in HVAC systems, is eliminated by mere contact with copper in six hours, strongly suggesting that designing these systems with copper components could reduce the need for maintenance where mold and fungi are concerned.

Interestingly, our ancestors seem to have instinctively known what we can prove today with complex imaging procedures. According to the feature in this issue by Harold T. Michels of the Copper Development Association, copper was used by ancient civilizations to sterilize drinking water and wounds and to treat sore throats, boils, and eye infections. With current U.S. headlines featuring another tragic outbreak of *E. coli* infections from the food supply chain, the appearance of Michels' article is well-timed, and we would do well to put copper on the front lines of our modern attempts to reduce the suffering caused by microbial infections.

Maryann Gorman
Editor in Chief

Letters to the editor can be e-mailed to mgorman@astm.org or can be sent to Standardization News, ASTM International, 100 Barr Harbor Dr., PO Box C700, West Conshohocken, PA 19428. Letters may be edited for clarity or space limitations.



BY
HAROLD T.
MICHELS

Anti-Microbial Characteristics of Copper

Before anyone recognized that microorganisms existed, the Egyptians, Greeks, Romans and Aztecs used copper compounds for good hygiene and to treat disease. Egyptians used copper to sterilize drinking water and wounds. Hippocrates treated open wounds and skin irritations with copper. The Romans catalogued numerous medicinal uses of copper for various diseases. The Aztecs treated sore throats with copper, while people in Persia and India applied copper to treat boils, eye infections and venereal ulcers.

In the 19th century, scientists discovered microbes and the germ theory of infection that linked bacteria and other microorganisms to infection and disease. They then began to understand how we could capitalize on copper's antimicrobial properties to provide additional benefits. Over the past centuries, we have continually expanded the antimicrobial uses of copper to include fungicides, antifouling paints, antimicrobial medicines, oral hygiene products, hygienic medical devices, antiseptics and a host of other useful applications.

CAN COPPER CONTROL INFECTIOUS DISEASE?

This long history of the antimicrobial applications of copper metals has given rise to current efforts to determine their effectiveness in stemming infectious disease in healthcare and public facilities, the food processing industry, and heating, ventilation and air conditioning applications.

Recent studies sponsored by the Copper Development Association Inc. and the International Copper Association, Ltd., have shown that uncoated copper and copper alloys can inactivate common disease-causing bacteria, such as *E. coli* (Figure 1), *streptococcus* and *staphylococcus.* Copper alloy surfaces have even proven effective against one of the more virulent strains of antibiotic-resistant bacteria associated with hospital-acquired infections, such as methicillin-resistant *Staphylococcus aureus,* known as MRSA (Figure 2). The studies were conducted by Drs. William Keevil, Sandra Wilks and Jonathon Noyce at the University of Southampton, U.K.

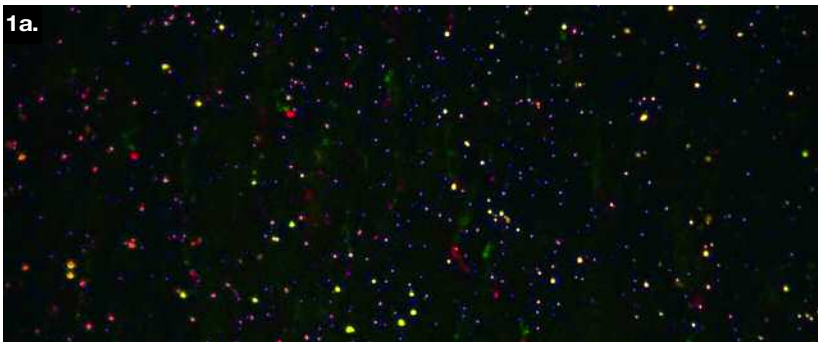
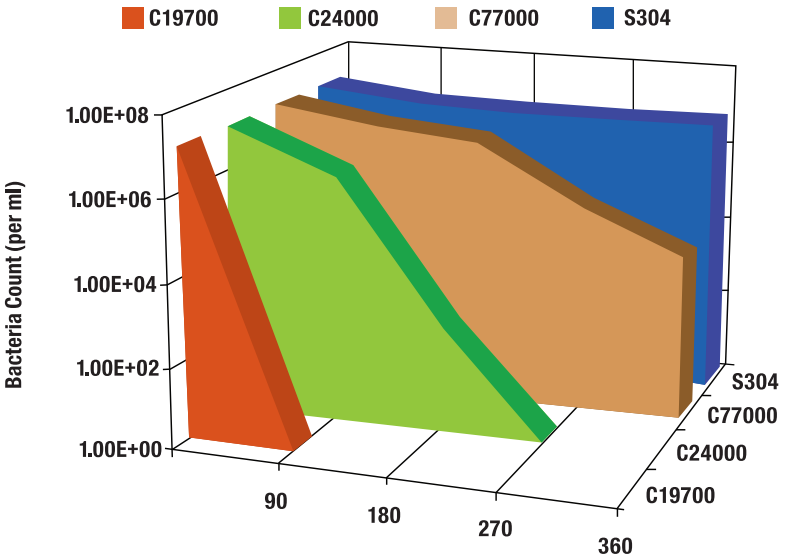


Figure 1a—Epifluorescence image after staining with fluorophore of *E. coli* on S30400 after 90 minutes at 20°C

Figure 1b—Epifluorescence image after staining with fluorophore of *E. coli* on C10200 after 90 minutes at 20°C

MRSA was eliminated in laboratory studies on brass surfaces in 4.5 hours, and on pure copper in just 1.5 hours. Brass surfaces also inactivated the often deadly *E. coli* O157:H7 in less than two hours. On stainless steel, used for typical hospital and food-processing hardware, the pathogens can survive unabated for more than 30 days. The study also shows that the higher the

Figure 2—MRSA Viability on Copper Alloys and Stanless Steel at 20°C (68°F)



MRSA bacteria thrive on stainless steel (blue) but die off quickly on copper (red) and copper alloy surfaces.

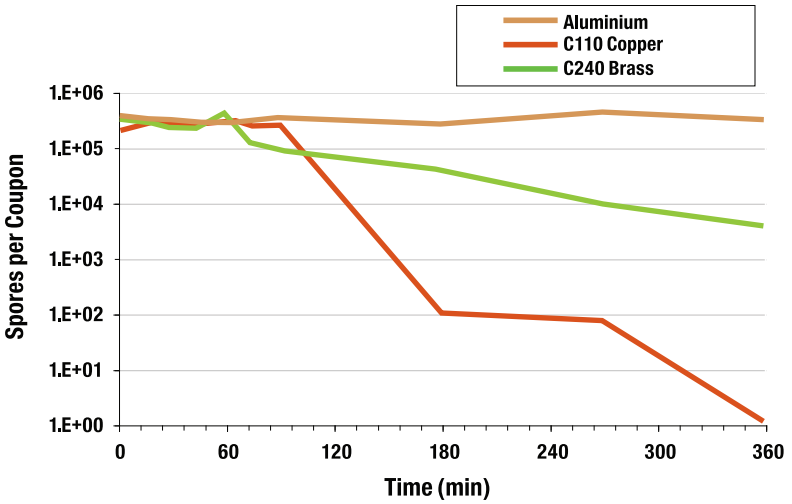


Figure 3—The viability of *Aspergillus niger* on surfaces of aluminum, C24000 (brass) and C11000 (copper) at 20°C

copper content of the alloy, the more quickly bacteria die.

CDA recently conducted independent laboratory testing of five alloys on five different pathogens. These laboratory results were presented to the U.S. Environmental Protection Agency in July as part of the process to obtain registration for health claims under the Federal Insecticide, Fungicide and Rodenticide Act. The formal application for registration will be submitted this fall. EPA is expected to respond within 270 days. If successful, copper will become the first and only metal to be granted a health claim from EPA.

The potential for the copper industry is great. It may expand existing markets and open the door to new ones. Included among possible applications are doorknobs and handles, push plates, countertops and work surfaces, railings, grab bars, sinks, condenser coils, evaporator pans, heat fins, and food-processing equipment.

TOUCH SURFACES

A 2000 Centers for Disease Control and Prevention report estimates hospital-acquired infections such as MRSA to be more than 2 million per year in the United States, resulting in nearly 90,000 deaths annually. The report also estimates that resistant infections cost health facilities about $5 billion per year. Community-acquired infections are also on the rise. Surfaces in such facilities as nursing homes, locker rooms, gymnasiums, barracks, transportation depots, schools, prisons and the like are of great concern.

Prescribed hygienic practices for the sterilization of touch surfaces along with hand-washing are the first lines of defense but often go unheeded. The continuing rise in hospital-acquired infections suggests they are also inadequate. Adding to the problem is that there are few prospective antibiotics in the pipeline to combat evolving and resistant microbial strains. Consequently, medical, military and public communities are ill-prepared to protect patients and personnel. Meanwhile, little attention has been paid to the touch surfaces themselves, which are a continual source of cross-contamination.

In healthcare facilities, surfaces in proximity to patients are of the most concern. Items such as door and furniture hardware, bed rails, railings, intravenous unit stands, medical monitoring equipment, faucets, sinks and work surfaces are identified as the most critical to sanitize on a regular basis. Disinfectants and even antimicrobial coatings have finite efficacy, at best. Identifying and employing surface materials that can provide continual antimicrobial protection, accommodate the demands of everyday use, and require a minimum of maintenance would help stem infections induced by cross-contamination.

Congress has approved funds for clinical trials to prove that the use of copper metals for touch surfaces will provide a continual, proactive means to help reduce and/or preempt microbial pathogens in healthcare and other public environments. It is expected that, together with a concurrent program of good hygienic practice, the need for antimicrobial drugs and the fostering of drug-resistant microbial strains will be significantly reduced and that infection rates will decline.

COPPER COULD HELP CONTAIN FLU

Other recent studies at the University of Southampton show that Influenza A viruses are virtually eradicated within six hours on copper surfaces. The findings are being prepared for submission for peer-reviewed publication later this year. Influenza A viruses cause an average of 200,000 hospitalizations and 36,000 deaths a year in the United States alone.

The researchers placed 2 million plaque-forming units of influenza A (H1N1) on coupons of C11000 copper (common, pure copper sheet metal) and on S30400 (common stainless steel) at room temperature and then came back periodically to determine the survival rates of the samples. On the stainless steel, the pathogen declined to 1 million after six hours and to 500,000 after 24 hours. Meanwhile, the copper surface achieved a reduction to 500,000 after only one hour and inactivated all but 500 — a 99.99% reduction — after just six hours.

The H1N1 strain tested is nearly identical to the H5N1 (avian) strain and the effectiveness of copper's antimicrobial properties should be nearly identical as well. While vaccines stimulate host antibodies to target specific exposed cell surface structures (epitopes), copper's antimicrobial action probably attacks the overall structure of the virus and, hence, has a broad-spectrum effect. Indeed, other work has shown the viricidal activity of copper to the unrelated adenovirus type 40.

HEATING, VENTILATION AND AIR CONDITIONING

Fungi and pathogenic bacteria that are great threats to public health thrive in moist, dark HVAC environments, such as those found in offices, schools, hotels and the like. Studies have found high concentrations of different species on heat exchanger fins, cooling coils and evaporator pans.

A second Congressional appropriation is slated for studies to show that replacing aluminum and steel components with those made of copper or copper alloys would mitigate harmful bacteria and fungi, eliminating or reducing the need for any maintenance. Preliminary data from one study at the University of Southampton show that brass surfaces reduce *Aspergillus niger* (black mold) by about 99 percent within six hours; copper completely eliminates the mold within six hours; while traditional aluminum surfaces have virtually no effect (Figure 3).

FOOD PROCESSING

Copper's antimicrobial properties are a potential solution to help prevent cross-contamination and subsequent human infections emanating from the food-processing industry. Chief among the pathogens of concern are *Listeria* and *E. coli,* which affect beef, pork and poultry products. In 2002, there were 66 major recalls related to more than 60 million pounds of contaminated food products. And the problem is growing. Those numbers are a threefold increase from the preceding year. The U.S. Department of Agriculture cites more than 62,000 cases of infection from *E. coli* O157:H7 each year, incurring an annual cost impact of nearly $660 million. An estimated 1,600 cases of Listeriosis cause more than 400 deaths annually.

CDA studies demonstrate the efficacy of copper and copper alloys to inactivate food-borne microbes at room and chill temperatures. They show that stainless steel, the most common touch surface material in the food-processing industry,

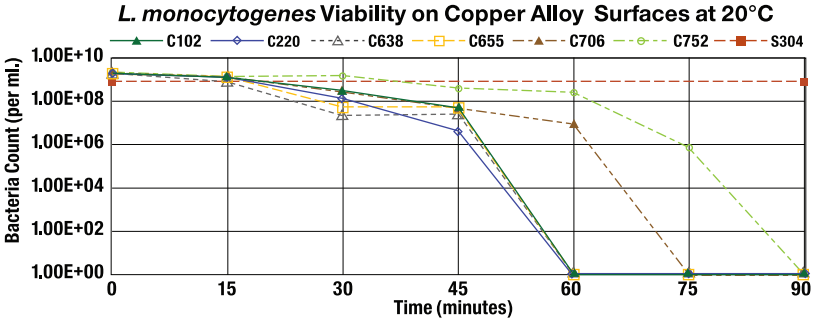


Figure 4—The viability of *Listeria monocytogenes* on the surfaces of alloys UNS C10200, C22000, C63800, C70600, C75200 and S30400 at 20°C

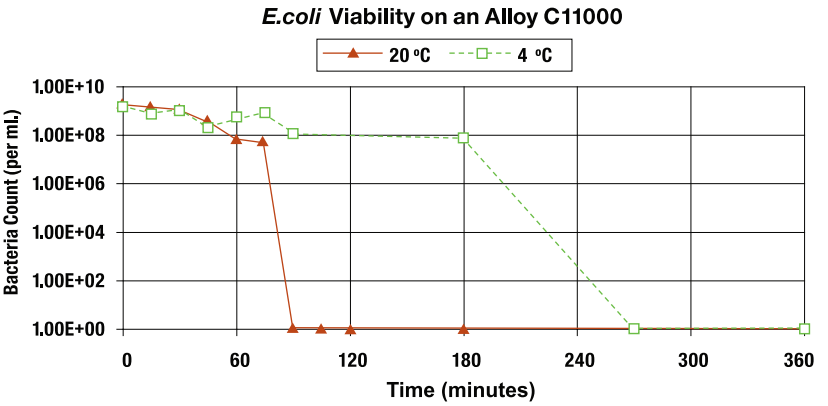


Figure 5—*E. coli* O157:H7 viability on alloy UNS C11000 Surfaces at 20°C and 4°C

has little or no efficacy in combating contamination (Figures 4 and 5).

BOTTOM LINE

The challenge now is to engage health authorities, equipment manufacturers, regulators and other stakeholders in taking the next steps to continue their research and pursue product development using the most compatible copper alloys for appropriate applications. This will require balancing the antimicrobial efficacy of copper alloys with other required attributes, such as formability, durability, ease of fabrication, aesthetic appeal, surface finishes, corrosion resistance, tarnish resistance and reactivity to foods, disinfectants and cleaning solutions. By this time next year, we expect there will be a solid base upon which to put man's oldest metal to work on metal surfaces throughout the world to help protect us from infectious disease. //

Harold T. Michels, Ph.D., vice president, technical and information services, Copper Development Association, will be conducting the following workshop:

Workshop on Antimicrobial Properties of Copper and Copper Alloys and Their Applications Wednesday, Oct. 25, 2006; Hyatt Regency Atlanta; Atlanta, Ga.; October 2006 Committee Week

HAROLD T. MICHELS, Ph.D., is vice president of technical and information services for the Copper Development Association. He has authored numerous technical papers and holds several U.S. patents. He holds a Ph.D. in materials science, an M.S. in metallurgy from New York University and a B.S. in mechanical engineering from City College of New York, and is a licensed professional engineer in New York and California.

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Antimicrobial Characteristics of Copper

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