

EXECUTIVE Report

Naturally Antimicrobial, Copper Alloys Improve Air Quality

Healthy HVAC Is Goal of New Research

Interest in copper alloys as naturally antimicrobial materials is reaching new heights. At the Society of Automotive Engineers (SAE) 2007 World Congress, two presentations addressed the antimicrobial properties of copper with respect to automotive applications [1,2]. Additionally, the Department of Defense through the U.S. Army Medical Research and Materiel Command recently awarded a Congressionally funded contract to study the antimicrobial effects of copper components in HVAC systems [3]. This large, multiyear research project will involve laboratory and medical facilities as well as several military bases. And that's not all. The Copper Development Association engaged last year a certified independent testing laboratory to undertake the most rigorous experimental testing of antimicrobial copper alloys in history [4]. The results fully support and expand on the antimicrobial claims of earlier research.

This *Executive Report* summarizes the existing science behind the antimicrobial properties of copper alloys, reviewing recent research results as well as ongoing research in this field.

Ancient Wisdom Rediscovered

Long before the germ theory of disease was formulated in the nineteenth century, the ancient Egyptians, Greeks, Romans and Aztecs discovered that water stored in copper or brass vessels is safer to drink than water stored in containers made of other materials. Indeed, Professor Rob Reed, the Head of Biomedical Sciences at the University of Northumbria, U.K., conducted research in the field in India that proves water is purified when stored overnight in traditional copper alloy vessels [5]. The ancients also used copper to sterilize wounds and treat sore throats, boils and eye infections.

Fast forward a couple of millennia: Professor C. William Keevil and his coworkers at the University of Southampton, U.K., demonstrate

by experiments that copper alloys are naturally antimicrobial toward a wide range of pathogens [6-9]. In view of the Southampton research, the International Copper Association and the Copper Development Association funded an extensive series of rigorously controlled experiments by a U.S. EPA-certified Good Laboratory Practices lab to verify these antimicrobial claims and gain acceptance from the EPA to make human health claims related to the use of copper alloys. The tests involved thousands of alloy "coupons" inoculated with various bacteria and studied under carefully controlled conditions. The EPA required that the efficacy of copper alloys to eliminate disease causing bacteria be tested against five pathogens through a rigorous battery of tests. All five have been proved vulnerable to copper.

The copper alloys tested were C11000 (copper), C26000 (brass), C51000 (bronze), C70600 (copper nickel) and C75200 (copper-nickel-zinc). Each of these alloys contains at least 65 percent copper, for maximum antimicrobial efficacy.



Fig. 1: Various HVAC components have been produced using CuproBraze technology.

The International Copper Association, Ltd. (ICA)

is the leading organization for the promotion of the use of copper worldwide. The Association's twenty-nine members represent about 80 percent of the world's refined copper output, and its six associate members are among the world's largest copper and copper alloy fabricators. ICA is responsible for guiding policy, strategy and funding of international initiatives and promotional activities. With headquarters in New York City, ICA operates in 28 worldwide locations through a network of regional offices and copper development associations.

For information about the *CuproBraz*e process or ICA's *CuproBraz*e consulting services, please contact the International Copper Association at: cuprobraz@copper.org. For European inquiries contact: ndc@eurocopper.org.

References

1. Harold T. Michels, SAE 2007 World Congress, "The Antimicrobial Properties of Copper Alloys and Potential Applications in Automobiles," Oral Presentation Only. See also [4].
2. Ulrik Palmqvist, Mattias Liljedahl, and Anders Falkeno, "Copper and its Properties for HVAC Systems," Paper 2007-01-1385. Order from sae.org.
3. "Copper Air Quality Program" (2007) Principal Investigator: Harold T. Michels, The Copper Development Association.
4. Harold Michels, *ASTM Standardization News*, "Antimicrobial Characteristics of Copper," Vol. 34, No. 10, October 2006.
5. P. Tandon, S. Chhibber and H.R. Reed, "Inactivation of *Escherichia coli* and coliform bacteria in traditional brass and earthenware water storage vessels," *Antonie van Leeuwenhoek*, vol. 88, no. 1, pp. 35-48, July 2005.
6. S.A. Wilks and C.W. Keevil, "Improved Work Surfaces to Prevent Cross-contamination and Spread of *Listeria monocytogenes*," Poster presented at the American Society for Microbiology General Meeting, Washington, D.C., May 19, (2003). Available online at www.cuprobraz.com.
7. J.O. Noyce, and C.W. Keevil, "The Antimicrobial Effect of Copper and Copper-base Alloys on Methicillin Resistant *Staphylococcus aureus*," Poster presented at the American Society for Microbiology General Meeting, New Orleans, LA., May 24, (2004). Available online at www.cuprobraz.com.
8. S.A. Wilks, H. Michels and C.W. Keevil, "The survival of *Escherichia coli* O157 on a range of metal surfaces," *International Journal of Food Microbiology* 105 (2005) 445- 454.
9. H. Michels, D.G. Anderson, J.O. Noyce, S.A. Wilks, C.W. Keevil, "The Antimicrobial Properties of Copper Alloys and their Potential Applications," Conference of Metallurgists 2007, Toronto, Ontario, August 25-30 (2007).
10. The Center for Biofilm Engineering, Montana State University - Bozeman. See www.erc.montana.com.
11. "Copper Antimicrobial Research Program, Determining Efficacy of Copper Touch Surfaces to Mitigate Cross-contamination of Infectious Disease" (2007) Principal Investigator: Harold T. Michels, The Copper Development Association.

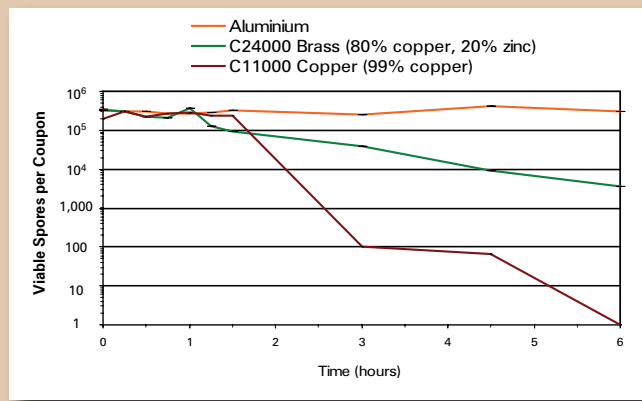


Fig. 2: Recent research shows copper and brass effectively inactivate *Aspergillus niger*. Viable spores are eliminated on the copper surface and reduced by two orders of magnitude on the brass surface, within 6 hours while aluminum has no effect. Similar or better results were also obtained with various species of disease-causing bacteria.

Automotive HVAC

The rediscovery and verification of the antimicrobial properties of copper and brass is exciting news, but what does it mean to the automotive industry? Evaporator odor has been the subject of much research in recent years. As described in a recent SAE paper [2], moisture condensed on an automobile air-conditioner evaporator can trap dust and create an environment where microorganisms thrive. These bacteria and mold gradually form a "slime layer" of polysaccharides. Technically called a "biofilm," this slime-layer has been a focus of much current research in microbiology, as scientists seek to study the natural ecologies of microorganisms, rather than studying colonies of bacteria under artificial laboratory conditions [10].

In the Luvata SAE paper [2], strategies to fight microorganisms on aluminum evaporators are reviewed, and it is remarked that a much more convenient approach is to use a material that is inherently antimicrobial, i.e., copper and brass. Investigations of aluminum evaporators in cars have determined that the microbes found there are of the types that are highly vulnerable to copper. More field experience with copper materials in evaporators is necessary.

Luvata has produced an experimental flat-turbulator evaporator using *CuproBraz*e alloys (Fig. 1). For air conditioners, besides having antimicrobial properties, a hydrophilic surface is desirable so that the contact angle of water droplets on the surfaces of fins can be decreased, allowing for more wetting and better drainage of condensed water in air-conditioner systems. Luvata researchers have performed experiments that have led to the improved wettability of copper fins [2].

Meanwhile, preliminary data from one study at the University of Southampton shows that brass surfaces reduce *Aspergillus niger* (black mold) by about 99 percent within six hours, while traditional aluminum surfaces have virtually no effect (Fig. 2). This result has generated interest in further research, and a five-year project is now underway 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 [3].

This new application of *CuproBraz*e technology could solve a nagging industry problem: bad smells in climate control systems.

Looking Ahead

The antimicrobial properties of copper and copper alloys are now firmly established on a foundation of quantified experimental results.

Ongoing research under the auspices of the Department of Defense should clarify how well copper components in HVAC systems can affect indoor air quality and contribute to its improvement.

A second project, also funded through the Department of Defense, is underway to examine the effect of copper and copper alloys on the bioload on touch surfaces and their capability to combat the cross-contamination of deadly pathogens [11].

Meanwhile, as the automotive industry seeks new strategies for eliminating foul odors from climate control systems, work continues to develop new designs of copper-brass heat exchangers, including components of mobile air-conditioning systems. ■