Did China Invent Chromium Plating Over 2200 Years Ago?

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Miniature Terra Cotta Warriors at EPCOT Center, Florida; *Photo courtesy of J.H. Lindsay (2009).*

A sign on one display at the terra cotta warrior site in China says that soldiers' swords were chromium plated with a thickness of 10 to 15 microns and that Germans and Americans first used chromium plating in 1937 and 1950, but that China first used it 2,200 years ago. What do you think?

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In 1974, while drilling for water, a peasant farmer in the Chinese province of Shaanxi, thirty-five kilometers east of Xi'an, stumbled across what some folks call the 8th Wonder of the World - Qin Shuang's mausoleum. Seven thousand life-sized terra-cotta warriors and over 40,000 bronze weapons have so far been unearthed in an ongoing excavation at the base of Lishan Mountain. Qin Shuang, China's first Emperor, ordered their construction to protect him in the afterlife. The weapons unearthed include crossbows, hooks, lances, arrowheads, spears

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proof chromium oxide coating on the swords and this consists of 0.6 to 2.0% chromium.[1]

First some background on early technology in China and a good place to start is with Joseph Needham. He is the Editor or Co-editor of S*cience and Civilization in China*, a massive, multi-volume study. He spent more than half a century collecting and compiling evidence that China was the birthplace of everything from chess to cartography, from the stirrup to the suspension bridge, etc. In the process, he probably did more than any other individual to shift the balance of scientific history towards the East.[2] A fascinating book about Needham is Simon Winchester's, *The Man Who Loved China*.[3]

Chromium plated sword at Terra Cotta Warrior exhibit *(Photos courtesy of Don Snyder).*

In Volume 1 of Needhams' *Science and Civilization in China*, he lists a profusion of developments between the 1st and the 18th centuries: "the square-pellet chain-pump, the edge-runner mill and the application of water-power to it, metallurgical blowing-engines operated by water-power, the rotary fan and winnowing machine, the piston-

bellows, the horizontal warp loom, the drawloom, silk reeling, twisting and double machinery, the wheelbarrow, the sailing-carriage, the wagon-mill, the two efficient harnesses for draught-animals, the mastery of cast iron, the segmental arch bridge, the iron-chain suspension-bridge, canal lock-gates, gunpowder and some of its associated techniques, the magnetic compass, paper, printing, and movable-type printing, and porcelain." There are many other examples besides these.[4]

Needham adds, "We must not suppose that the last word has been said on any of these developments, nor that adequate evidence exists in all cases to prove conclusively that the later European uses were derived from the earlier Chinese practice. The feature common to all examples is that firm evidence for their use in China antedates, and sometimes long antedates, the best evidence for their appearance in any other part of the world." This is summarized in Table 1 which shows the approximate lag in centuries from China to the West.

Table 1
Transmission of mechanical and other techniques from China to the West[4]

Item	Approximate Lag in Centuries
Metallurgical blowing-engines, water-power	11
Rotary fan and rotary winnowing machine	14
Silk-handling machinery	3 to 13
Cross-bow	13
Deep drilling	11
Cast iron	10 to 12
Iron-chain suspension bridge	10 to 13
Canal lock gates	7 to 17
Gunpowder	5 to 6
Paper	10
Porcelain	11 to 13

Clearly, scientific innovation in China was highly developed in early times but ground to a halt in the 16th century, just when European science was taking off. Needham was never able to answer the question as to why. This became known as "The Needham Question." Simon Winchester says that Needham never fully worked out the answers, and scholars are still working this issue.[3] One possible explanation comes from Gavin Menzies in his book, *1421: The Year China Discovered America*. Menzies says that in 1421, the newly completed Forbidden City was struck by a lightning bolt just as it opened, and the emperor reacted with horror. He interpreted the lightning as a sign from the gods that the people of the Middle Kingdom had become too dependent on technology, and were not paying enough attention to tradition or to the deities. So the Chinese burned every library, dismantled their fleets, stopped exploring the globe and essentially shut themselves off from the outside world. The result? A downward spiral that lasted for five centuries.[5]

The reason for presenting this information is to show that China was quite technologically advanced, and it brings us back to the subject of chromium plating. If they could do all the things mentioned above, why not chromium plating?

In Needham's treatises, I could find no mention of chromium plating. In his Volume 5, he does state, "Some methods, the results of modern scientific knowledge, can be excluded when medieval procedures are under consideration. For example, electro-plating [sic], with solutions of cyanides of the precious metals.[6]

I've not been able to reach either Williams or Zhang Too so I can't answer the question - if the swords were chromium plated, why is the coating only 0.6 to 2.0% chromium and not 100% chromium?

Williams does report that Frank Walsh, a professor of electrochemical engineering at the University of

Bath in the UK, believes it is unlikely that the swords were chromium plated. As we electroplaters know, conventional chromium plating requires the objects to be placed in a chromic acid solution. Walsh says "it was more likely that chromium was present in the metal mix," and might likely be the result of diffusion processes. Historical records show that during the peasant uprising at the end of the Qin Dynasty, 206 B.C., parts of the mausoleum were plundered and fires that lasted for 90 days were lit. Professor Walsh suggests that the heat from the fires and the presence of carbon would have provided a reducing environment in which chromium atoms could have migrated to the surface of the weapons. There they would oxidize and form a protective coating.[1] Ted Mooney briefly discusses this topic on his web site, pointing out that everything that is shiny isn't chromium plated. He asks, "Is there any metallurgical analysis or metallography demonstrating that they contain chromium or that they are electroplated?"[7]

The answer - none that I know of other than the comment by Zhang Too that the coating is 0.6 to 2.0% chromium. My guess is that chromium plating wasn't used and I favor the analysis of Professor Walsh who suggested a diffusion process.

In March 2010, the History Channel had an hour-long presentation titled "Chrome." They did an excellent job of covering chromium plating and also the use of chromium (they called it "chrome" - my only complaint) in stainless steel. What really caught my attention was the opening segment where they discussed the Terra Cotta Warriors and the "chrome" they had on their swords. They concluded that the "chrome" was there because of diffusion during a high temperature fire.

On top of that, my wife and I recently visited China and had the opportunity to see the Terra Cotta Warriors live and in person. And guess what we found among the exhibits? In a glass case was a "chrome-plated sword," (they also called it "chrome" - I can't win) and the descriptive plaque sitting next to it read:

Chrome-Plating Technology

"Scientific testing reveals that the surface of the sword contains chromium, with a thickness of 10 to 15 micron, which acted as a protected [sic] coating against corrosion. The chrome plating technology was invented by the Germans [and] Americans in 1937 and 1950, but it had emerged in China 2,200 years before. How amazing it is!"

I have since learned that one of our industry's great contributors, my friend Dr. Don Snyder, had also seen

that display when he recently visited China. He concurs, and was kind enough to provide the accompanying photos.

So, at least someone agrees with me. What do you think?

References

1. Robyn Williams, "Weapons in Ancient China," *The Science Show,* Radio National, Australian Broadcasting Corporation, November 22, 2003; http://www.abc.net.au/rn/science/ss/
accessed March 29, 2010).

About the Author

Now retired, but still active, Jack W. Dini worked several decades for Lawrence Livermore Laboratories in northern California, notably as Section Leader, Fabrication Technology in the Materials Fabrication Division. Jack researched and wrote a large volume of papers and texts covering a wide range of metal finishing related subjects, but especially important were articles and texts related to improved methods for the preparation of exotic substrates for accepting electroplated deposits. He is a Past President of the AESF and the 1985 Recipient of the AESF Scientific Achievement Award. He is the author of the well-respected text, Electrodeposition - The Materials Science of Coating and Substrates. Jack is still with us today as a regular columnist in P&SF, with his very popular Fact or Fiction.

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