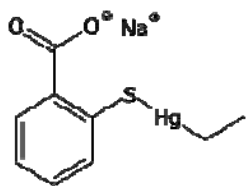
Mysterious Mercury

By Lisa Alexander

This month's article will focus on mercury, the metal – some history, uses, recent studies and legal happenings worldwide.

Quicksilver

In early December 2012, reading about the coming ban on certain incandescent light bulbs, and the push to get people to switch to compact fluorescent light bulbs (or "CFLs"), I wondered, why *is* mercury in CFLs anyway? And why, when this toxic metal is being phased out of so many other products, are consumers being encouraged to bring mercury *into* their homes via energy efficient bulbs? The bulbs are often given for free by energy auditors and utility companies, trying to help customers save money and energy.



Meanwhile, coincident with the seasonal flu "epidemic," health officials were advising people to take advantage of free flu shot clinics. Mercury (as thimerosal, $C_9H_9HgNaO_2S$) has been abandoned as a preservative in most personal care products and vaccines now – *except* for seasonal flu vaccines. It seems difficult to completely eliminate use of this toxic metal! I had heard that burning coal released mercury to the atmosphere, but why, and how much? Were there other sources? Surely the metal doesn't exist as a liquid in the environment, so how was it discovered?

I put my research on hold, and just when I was getting back to it, mercury was in the news. On January 9, 2013, Derrick Jackson wrote in *The Boston Globe* that "All of Earth [is] Now a Mercury Hotspot" (regulatory note: this is not the MCP definition of "hotspot," and it does not change the need to evaluate mercury "background" concentrations by the MCP definition). Another author proclaimed that the "whole planet" was in danger of being "poisoned" by mercury; a third called for more education and public health awareness. I soon discovered that the focus on mercury was related to a *2013 Global Mercury Assessment* report that had just been released by the United Nations, coinciding with a push for a "worldwide mercury treaty" attempting to address emissions from all sources including coal burning, dentistry, chlorine and PVC production and small scale or "artisanal" gold mining.

The week ended with a horoscope email purporting to contain my "Mercury forecast." What an odd synchronicity, especially since it is the only metal named for a planet. I began to jokingly wonder if mercury had consciousness. Apparently, John Worrell Keely, a self-proclaimed pioneer of "free energy" from the 1800s seemed to think so. While more research revealed that Keely, himself, suggested his epitaph should read "world's greatest humbug," there were others who claimed his work inspired such writers as Jules Verne and H.P. Lovecraft and quite a number of other interesting characters, including Nikola Tesla.

The original Greek name for mercury was “hydrargyrum” – meaning “watery silver,” hence the chemical abbreviation Hg. It was later renamed “quicksilver” by English speakers. Mercury was already well known to the Chinese and Indians before 2000 BC, and also to the Maya in South America. Some sources say cinnabar, or mercury sulfide, found as a soft red crystal, was mined as far back as the Neolithic Era (10,200 BC to 4,500 BC). When cinnabar was heated in a closed vessel, the red mineral broke down, vaporizing the mercury until it cooled and re-formed as liquid mercury. It must have seemed quite magical.

Liquid mercury was found in Egyptian tombs dating to 1500 BC. It was known from at least 500 BC to dissolve and bind gold and silver for mining and gilding purposes. Mercury is still used in some “artisanal” gold panning operations: liquid mercury is used to collect tiny gold particles. The mixture is then heated to vaporize the mercury, leaving the gold in the pan. Some of the vaporized mercury can be recovered and reused, but there are many negative health effects for those using this process and to the nearby environment.

When I visited China in 1999, I learned for the first time that there were legends that the first Emperor of China (Qin Shi Haung) was buried in a pyramid shaped tomb under a hill the size of a city block, not far from the Terra Cotta Warriors. Rumor had it that inside the tomb was a miniature version of China, using gemstones for stars and liquid mercury for the rivers, but that it would remain closed indefinitely due to fear of the first Emperor’s curse. It has been documented that Emperor Qin ingested mercury and crushed jade in pursuit of immortality, but more likely contributing to his early demise. While the Terra Cotta Warriors have undergone extensive excavation, the tomb remains closed to this day. Preliminary investigations have taken place since 2010 and do appear to confirm the presence of very high mercury levels.

Mercury *is* rather fascinating. I imagine most readers of this article had access to a blob of liquid mercury at one time or another from an old thermometer. It was a favorite of alchemists and charlatans alike, undoubtedly for its unique liquid metal form. A search for images of the solid, crystalline form of mercury sulfide that occurs in nature, reveals many beautiful specimens – from deep pink markings in a white mineral matrix (Myrickite) to “opals” infused with reds and oranges, to deeply colored, but soft, blood-red crystals. All manner of mystical qualities were assigned to the cinnabar and to mercury, and naturally, “uses” were found for it shortly thereafter. Cinnabar is often found near hot springs and in coal and other rock formations. The largest known cinnabar mine, in operation since the Roman Empire and still in production today, is in Almaden, Spain. Prisoners and slaves that were sent to work the mine seldom lived more than a year. Romans loved the red color so much they sometimes used it as make up and as body paint for celebrations.

The US Geological Survey estimates that volcanoes worldwide release some 6,000 tons of mercury vapors per year, or about “half” of all atmospheric emissions. The other natural sources of mercury emissions are forest fires and evaporation of mercury from the surface of the ocean. Like the hydrologic cycle, the “hydragyric” cycle means these atmospheric emissions will eventually oxidize and return to the earth as inorganic mercury unless or until bacteria convert them into methylmercury. Coal burning reportedly accounts for about 50% of man-made emissions (US EPA). Outside coal burning, (unless one counts forest fires), man-made sources of mercury emissions include gold production and other metal

smelting processes, cement production, incineration (including cremation), production of chlorine, caustic soda and polyvinyl chloride (PVC), as well as certain batteries.

Early experiments with mercury led to discoveries still relevant to modern chemistry and physics today, including superconductivity. Historic uses of mercury range from the mundane and well known (thermometers, barometers, certain batteries, neon lights and the hat felting industry) to the somewhat surprising (coatings on certain antique mirrors, preservatives in medical vaccines, contact lens solutions and mascara, fungicide in latex paints, coolants in early nuclear reactors and production of chlorine) to the strange (medicines, infant teething powders, skin lightening creams, and weapons: mercury secretly applied to enemy planes in World War II could reportedly quickly disintegrate aluminum parts leading to structural failures) to uses that still sound like science fiction: coolants in early nuclear reactors, specialized liquid mirror telescopes used in astronomy, and, as propellants in the ion engines of early electric space propulsion systems.

Mercury has been used for the better part of two centuries to bind strongly with gold and silver with other metals (e.g., copper and tin) and used to form dental amalgams. In 2009, the US Food and Drug Administration and the American Dental Association (ADA) reiterated their safety statements on mercury amalgam dental fillings as being safe “in most cases” since exposures of greater concern are primarily attributable to inhalation of mercury *vapors* which depends on a number of variables besides quantity of fillings and the mass of mercury present. Nevertheless, the ADA has issued additional precautions for dentists handling the material, and amalgam fillings are being phased out altogether in some other countries. One of the UN sources said that dental amalgam production currently accounted for about 10% of all worldwide mercury industrial “consumption” (between 300 and 400 metric tons per year).

Although mercury is bound to the other metals in the amalgam fillings, I wondered how many “silver” fillings a person had to have to approach, say, the BWSC cleanup concentrations for soil with potential for direct contact (20 micrograms mercury per gram of soil). At 50% mercury in the mix, my own quick attempt to calculate this suggested that it was about 1.5 to 2 cubic centimeters of fillings in a 200 pound person (a volume our Office of Research and Standards concurred with, albeit with the aforementioned caveats about mercury vapors).

As for the mercury vapor that is used in compact fluorescent bulbs? Electricity causes the mercury vapor to discharge ultraviolet radiation which then excite the phosphorescent coating on the inside of the bulb and causes the phosphor to radiate light. The trade off, according to the US EPA, is that the efficiency of the bulbs means significantly less burning of coal for the life of the bulb, ultimately leading to less mercury released to the environment from coal burning electric plants, particularly if the bulbs are recycled at the end of their lives.

Personally, I’m starting to convert to mercury-free LED bulbs and non-amalgam fillings. In the meantime, there is still quite a bit of mercury around, something to consider when cleaning up older industrial sites in Massachusetts where mercury may have been used in one process or another. But all of earth is not a mercury “hotspot.”

To read more on mercury:

http://www.epa.gov/hg/about.htm: US EPA fact sheet about mercury in coal.

http://www.unric.org/en/latest-un-buzz/28158-governments-at-un-forum-agree-on-legally-binding-treaty-to-curb-mercury-pollution: UN information about the mercury treaty.

http://www.clu-in.org/download/contaminantfocus/mercury/geologic-studies-of-mercury-c-1248.pdf: USGS paper.

http://clu-in.org/contaminantfocus/default.focus/sec/mercury/cat/Overview/: EPA paper.

http://www.worldandi.com/subscribers/feature_detail.asp?num=23870: article with notes on mercury's historic value in understanding chemistry and the nature of matter, plus interesting sidebar on health effects, reviewed by a mercury specialist at USGS.

http://www.unric.org/en/latest-un-buzz/28158-governments-at-un-forum-agree-on-legally-binding-treaty-to-curb-mercury-pollution: UN website information about the "Minimata treaty," signed by 140 nations, including the US, on January 21, 2013 (to be formally ratified this fall in Japan).

http://www.prnewswire.com/news-releases/un-treaty-on-mercury-expected-to-phase-down-amalgam-globally-draws-praise-from-consumer-and-environmental-groups-187293121.html: estimates dental amalgams represent about 10% of mercury "consumption" worldwide, or between 300 to 400 metric tons per year.

http://www.google.com/search?q=cinnabar%20images&ie=utf-8&oe=utf-8&aq=t&rls=com.frontmotion:en-US:unofficial&client=firefox-a&source=hp&channel=np: some images of cinnabar.