Arsenic The Old ‘Poudre De Succession’

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Some 300 years or more ago, the expression *poudre de succession*—or “inheritance powder”—was the comfortingly euphemistic way the French used to describe poison. It was, you see, a convenient (and often very swift) way to secure that inheritance.

While it remains a matter of debate as to whether arsenic was the original *poudre de succession*, it has been satisfactorily used for that purpose from times immemorial.

Back in the Roman days, Agrippina (Nero’s mother) proved an adept dispenser of lethal doses of white arsenic, or arsenic trioxide (AsO_3). In this way, she saw off at least two husbands, one husband’s former wife and a stepson.

Many years later, the Borgia siblings, Cesare and Lucrezia, took a leaf out of Agrippina’s book, using arsenic cocktails to dispatch a number of their father’s enemies. Unfortunately, Cesare also more than likely finished off his father, Pope Alexander VI, when the latter quaffed someone else’s poisoned vino.

More Modern Uses

Although these days, arsenic may have given way to more exotic poisons, it’s still used for purposes of assassination, including ricin (victim—Georgi Markov), polonium-201 (victim—Alexander Litvinenko) and TCDD (victim—Viktor Yushchenko).

As a toxin, arsenic continues to be used both in herbicides and insecticides. And back in the days before penicillin, arsenic was used in Salvarsan, the cure for syphilis developed in 1907 by Nobel Prize-winner Paul Ehrlich.

These days, particularly in the US (the world’s largest arsenic consumer), the main use of arsenic (from AsO_3) is in the production of chromated copper arsenate (CCA), a wood preservative and anti-pest treatment.

In addition, AsO3 has, for some time, been used to make various arsenical compounds added to chicken feed “to promote growth, kill parasites that cause diarrhea, and improve pigmentation of chicken meat.” Indeed, back in 2007 it was reported that one such compound, Roxarsone, was “mixed in the diet of about 70 percent of the 9 billion broiler chickens produced annually in the U.S.” With concerns continuing as to the wisdom of feeding arsenic to chickens, Congress has very recently introduced legislation seeking to ban the practice.

Historically, arsenic has also been (and still is) used as both a decoloring agent and bubble dispersant in the manufacture of glass. It was also used as a pigment in paints.

In its metallic form, arsenic serves a number of disparate purposes. As an additive to lead, it is used in lead-acid batteries. And when used together with miniscule amounts of antimony, arsenic helps harden lead bullets, especially in small arms ammunition. Arsenic is also used along with antimony (see Antimony: A Metal?), in creating the Babbitt metals employed in low-friction bearings.

Along with these well-established and somewhat low-tech uses, arsenic is also currently used in a number of somewhat higher-tech ways. In the world of electronics, arsenic is combined as a compound of both gallium (see Gallium: A Slippery Metal) and indium, which is used in the semiconductors found (albeit in miniscule amounts) in anything from mobile phones to optoelectronic applications, to solar cells.

Arsenic Is A Metal

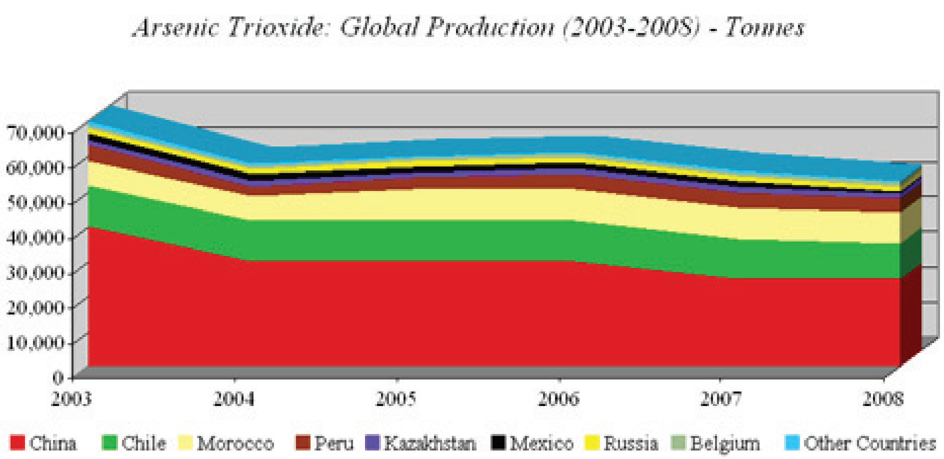
Similar to antimony, arsenic has a number of allotropes, including black and gray arsenic (both metalloids) and yellow arsenic (non-metalloid). Thus arsenic is more properly categorized as a metalloid, or "sort of" metal. Other members of the category include: antimony, boron, germanium (see Germanium: Winkler's Metal), polonium, silicon and tellurium (see Tellurium And Garlic).

Arsenic is most commonly found in nature in the mineral known as mispickel, more formally known as arsenopyrite (FeAsS), and the minerals orpiment (As_2S_3) and realgar (AsS).

Commercially, however, the metal, in the form of arsenic trioxide (from which all the world's supply of arsenic metal is produced by chemical reduction), is most usually produced by recovering the element from either the dusts or residues resulting from the processing of non-ferrous metals—in particular, copper and lead.

In China, arsenic is also produced as a by-product of gold mining, from orpiment and realgar, according to the U.S. Geological Survey (USGS). Perhaps not surprisingly, as one of the world's top producers of both non-ferrous metals and gold, China is also the world's largest producer of arsenic.

Currently, neither any AsO3 nor any arsenic metal is produced domestically in the U.S. Indeed, none has been since ASARCO closed its copper smelter in Tacoma, Wash., in 1985.



Source: USGS

Arsenic trioxide is produced in a few spots elsewhere in the world, such as Canada, Iran, Japan and Portugal. In Chile, the old El Indio mine, once owned by Canada's Barrick Gold, used to sell a major amount of the world's arsenic trioxide (some 30 percent back in 2000), but the mine has now closed. It is probably safe to assume that CODELCO is now one of Chile's major producers (if not *the* major producer) of arsenic trioxide.

In Peru, Doe Run Peru offers the oxide for sale, out of its La Oroya complex, as does Managem (Bloomberg Ticker - MNG:MC) out of Morocco.

Figures on who else might produce arsenic trioxide are well-nigh impossible to discover.

Prospects For Arsenic

Following the wood preservative industry's voluntary reduction in its use of (CCA) (leading, it is expected, to its final elimination as a wood preservative in the domestic sector), the trade in arsenic, particularly in the U.S., has diminished substantially. Arsenic metal, however, *appears* set to continue to be used for some time yet in both the manufacture of lead bullets and lead-acid batteries, as well as in the small lead weights attached to automobile wheels to balance them.

However, it is in electronics for the alternative energy sector that there may actually be future growth in arsenic's use. With the continuing expansion and development of solar cells, the use of arsenic in gallium arsenide semiconductors may offer some hope of a steady (and, perhaps, rising) need for metal.

That said, given the constant advances taking place in semiconductors, the dominant position of no single type of semiconductor, whatever its application, ever appears guaranteed for too long. It may only be a matter of time, therefore, before a semiconductor (or semiconductors) for cheap solar cells using different chemical compounds excluding arsenic is on the rise.

Toxic To A Degree

There is absolutely no denying the toxicity of arsenic—or its ability to "hang about." A paper in the September 2007 edition of Science of the Total Environment discussed the inspection of the topsoil in the fields near Verdun, examined more than 80 years after arsenical chemical shells had been burned during World War I. The findings: "[e]levated concentrations of As were found in all soil horizons up to a depth of 2 m and also in the leachate [the liquid that leaches from a landfill]" and "[t]he main hazard of the site is the severe arsenic contamination and the transfer of this carcinogen by leachate, surface runoff and probably by wind."

While this may be a strictly local anthropogenic problem with arsenic, the effects of naturally occurring arsenic can be devastating. According to "Venomous Earth: How Arsenic Caused The World's Worst Mass Poisoning" by Andrew Meharg (Macmillan Science, 2005), in India and particularly Bangladesh, "...between forty and eighty million people are at risk of consuming too much arsenic from well water that might have already caused one hundred thousand cancer cases and thousands of deaths." And a recently reported study of river sediments in the Ganges-Brahmaputra-Meghna delta suggests that the situation may only get worse, with further groundwater contamination.

In Southeast Asia, a similar situation exists with the Mekong River. According to a 2007 UN report, "[a]rsenic contamination of the Mekong River and groundwater is putting millions of residents at risk of severe illness due to arsenic poisoning."

In both cases, blame for the crises can be attributed as much to the ill-considered drilling of wells as the toxicity of arsenic itself. And, indeed, arsenic's poor reputation, including its membership in "The Toxic Trio" (arsenic, cadmium and mercury), are in no small part attributable to the patent disregard with which its toxicity has been (and still so often is) treated, whether the arsenic is in gold mine tailings, animal feed or coal ash.

An especially contemporary example of this disregard involves the arsenic in so-called "e-scrap": old computers, electronic devices, mobile phones, etc. If not recycled or disposed of appropriately, such waste can also prove hazardous and lethal. (As evidence of the growing importance of the whole issue of e-scrap, there are now annual e-scrap conferences in the U.S., the most recent of which took place in Florida at the end of last month.)

Opportunities In Arsenic

Since arsenic is predominantly a by-product of other mining activities, there are no "pure" plays in the metal. (Even China's encouragingly named China Arsenic Industries, Co., Ltd, Zuhai, sells silicon as well as arsenic.) Indeed, with total global production of arsenic trioxide in 2008 valued at probably less than $26 million,[1] it is hardly that attractive from an investment perspective.

However, when it comes to technologies for mitigating arsenic's toxicity, there could be some interesting opportunities out there, or at least the potential for such opportunities. Whoever develops the cheapest, most efficient, way of recycling the toxic, precious and heavy metals from e-scrap has the potential to make a deal of money.

Companies, like Molycorp, that have developed simple, effective ways of filtering arsenic (and other contaminants) from water (in this case, by using rare earth metals—see Mark Smith: Why Rare Earth Metals Matter), are creating the opportunity to participate in a big market, as may those be who eventually corral and commercialize an "arsenic-eating super-bug," the discovery of which The Australian reported early last year.

Opportunities may even extend to those who are able to successfully exploit the Chinese ladder fern, *Pteris villata*, which "absorbs arsenic to the extent of 5 percent of its dry weight" (John Emsley, "Nature's Building Blocks," Oxford University Press, 2002).

Finally, it is very likely that *anyone* who can provide a cheap, efficient and easy way to clean up all the arsenic that we have already dumped—and continue to dump—in the earth will find a ready market.

In reality, though, arsenic isn't just a minor metal; it can now only be truly described as a "minor minor metal." Perhaps there may be future breakthroughs in semiconductors using arsenic, but even then they will only use miniscule amounts. And there will probably never be a remake of "Arsenic and Old Lace."

Endnotes

1. This figure is based on a USGS estimated global production figure of 53,500 tonnes of TO3 for 2008, and a price of $454-483 per tonne (from Metal-Pages for 99 percent Chinese TO3) as of mid-September 2009.

Resources

U.S. Geological Survey (USGS)