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INDUSTRIAL CADMIUM USE

What is cadmium?

Cadmium is a soft, bluish-white metallic element that occurs naturally in the earth's crust.[1] Found as an impurity in many ores, cadmium is often recovered as a byproduct during the processing of those ores. Because zinc ore is the most abundant source of cadmium, cadmium production has increased with the demand for zinc.[2]

PBTs

Persistent, bioaccumulative toxins (PBTs) threaten human and environmental health even when released in small, legally allowed quantities. Once released into the environment, these toxins do not break down; instead, they remain there indefinitely. In the environment, they build up in the food chain because they remain in the tissues of living animals when these organisms consume PBT-contaminated foods. These toxins also increase in concentration as they move up the food chain, reaching dangerous levels in "top feeding" carnivores.

Because the use of cadmium by industry has greatly increased, the amount of pure cadmium we are exposed to via air, water, and soil has increased to the extent that it has become a hazard to public health. It is estimated that 679 tons of cadmium were incorporated into products in 2001.[3] This figure does not include the many cadmium-containing products imported into the US that year. Many of these goods eventually end up in landfills or incinerators, further increasing the amount of pure cadmium exposure to the general public.[4]

What properties make cadmium useful and what do we use it for?

Cadmium has many chemical and physical properties that make it desirable for industrial and consumer applications: resistance to corrosion and chemicals, tolerance for high temperatures, a low melting point, and excellent electrical conductivity.[5] These properties make cadmium suitable for use in alloys, pigments, coatings, stabilizers, and rechargeable nickel-cadmium (Ni-Cd) batteries.[6]

How are we exposed to cadmium?

Cadmium is released into the environment through mining and smelting operations (primarily zinc, lead, copper, and cadmium), fuel combustion (in coal-, wood-, and oil-fired boilers or in vehicle engines), incineration of municipal waste and sewage sludge, the spreading of sewage sludge, the disposal of metal-containing products, and the application of phosphate fertilizer. Cadmium can also be released naturally through volcanic eruptions, forest fires, and soil erosion.

Cadmium particles travel in the form of dust or fall from the atmosphere in rain and settle, entering into our water supplies, soil, and crops. For the general population, the most common routes of cadmium exposure are contaminated food and cigarette smoke.[7] Crops for human consumption, particularly grains and cereal products—including rice, potatoes, root vegetables, leafy vegetables, and tobacco—take up cadmium from the soil.[8] Drinking water often contains a small amount of cadmium (average 1 part per billion); public notification is required when a water supply contains more than 5 parts per billion.[9] Cadmium from improperly regulated hazardous waste sites, factories, or incinerators can escape as dust or contaminate food and water supplies, exposing people who live nearby to elevated levels of cadmium.[10] Occupational exposure can occur in any facility that smelts or refines metals produced from ores that contain cadmium compounds, or it can occur in factories that manufacture cadmium products.[11]

Why should we be concerned about cadmium?

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Cadmium is a toxin that is harmful to human health. Once it enters the body, it tends to remain there long term.[12] Many factors determine whether exposure to cadmium will be harmful, including the dose (how much), the duration (how long), the form of cadmium, and how contact with it was made.[13] For example, cadmium fumes created during industrial processes that involve heat are more toxic than cadmium dust.[14]

Low-dose exposure to elevated levels of cadmium over a long period of time has different health consequences than a single high dose exposure. Acute health effects, such as flu-like symptoms, intestinal tract ailments, and lung irritation, can be caused by intense short-term exposure.[15]

Long-term effects of cadmium exposure can be severe and include kidney disease,[16] weakened bones,[17] and damage to the lungs.[18] The US Environmental Protection Agency (EPA) now classifies cadmium as a known human carcinogen,[19] and cadmium is recognized as a developmental toxicant[20] and reproductive toxicant.[21]

In which products and industries is cadmium used?

Due to environmental concerns, industrial cadmium use in the US fell by 35 percent between 2001 and 2005. Even with this downward trend, industry consumed roughly 430 tons of cadmium in 2005.[22] High production of nickel-cadmium (Ni-Cd) batteries ensures the continuing demand for cadmium products in the US market, even as traditional uses for cadmium in pigments, plating, and stabilizers decline.

Cadmium in Products in the US, 2001	
Nickel-cadmium batteries	75.0%
Pigments	12.0%
Plating	8.0%
Stabilizers	4.0%
Other*	1.0%

* Alloys, photoconductors, photoelectric solar cells, automobile tires, control rods in nuclear reactors, solar batteries, and dental amalgams.
Source: S. Boehme and M. Panero, eds., "Pollution Prevention and Management Strategies for Cadmium in the New York/New Jersey Harbor," New York: New York Academy of Sciences, December 2003, available at http://www.nyas.org.

Are there alternatives to Ni-Cd batteries?

Although no environmentally benign battery is currently available, some alternatives to Ni-Cd batteries are far less toxic. Finding substitutes for cadmium is important because Ni-Cd batteries account for 75 percent of the cadmium released from product disposal.[23] Ni-Cd batteries frequently end up in landfills or are incinerated, which releases cadmium into the environment.

Nickel-metal hydride (Ni-MH) batteries operate on the same voltage, possess similar power, and charge as quickly as Ni-Cd batteries. Also, because Ni-MH batteries do not rely on cadmium for their power source, they contain fewer toxic constituents than Ni-Cd batteries.[24] Cheaper ways of manufacturing Ni-MH batteries are being explored, and prices should go down as demand increases.

Lithium-ion batteries offer another cadmium-free alternative to Ni-Cd batteries.[25] Although lithium rechargeable batteries have many advantages, such as the highest energy density among commercial batteries and low self-discharge, some disadvantages need to be overcome, including the high cost of manufacture.[26]

Do products currently on the market use the more environmentally friendly battery types?
Not all products use environmentally friendly batteries. Since 1994, computer equipment generally comes with lithium-ion batteries installed as a backup power source.[27] However, Ni-Cd batteries are still found in many products, including but not limited to cordless power tools, flashlights, remote control devices, pagers, two-way radios, boom-box radios, children's toys, electric toothbrushes, penlights, cordless and cellular phones, cordless vacuums, and certain kitchen appliances.

How is cadmium used in the coating and electroplating industry?
Ferrous metals such as steels, iron, aluminum, and brass are often given a protective coating of cadmium. This application accounts for 8 percent of the cadmium incorporated in products.[28] For example, the electronic and electrical industries use cadmium plating on silver-cadmium contacts and switches,[29] and the automotive industry uses cadmium plating to protect springs and other brake parts.[30]

Are there alternatives to cadmium that can be used for coating and electroplating?
Yes. The basic alternative for cadmium plating is zinc plating. In recent years, zinc-nickel alloys have become popular in the US, and they are currently used in the automotive and defense industries, among others. These alloys have been more widely used in Europe and Japan over the past 10 years. Zinc-nickel alloys have been found to possess all of the attributes of cadmium for coating and plating, with the added benefit of environmental safety.[31]

Other plating alternatives include tin alloys[32] and aluminum vapor deposition.[33] Aluminum vapor deposition coating has been used primarily on high-strength steels in the aerospace industry and in marine applications. Aluminum vapor coating is still too expensive for many applications, and it has some functional shortcomings making inappropriate for many applications.[34]

How does the plastics industry use cadmium? Are there alternatives?
Approximately 4 percent of the cadmium found in products is used as a stabilizer for polyvinyl chloride (PVC) plastic.[35] Cadmium, which helps stabilize the plastic during the manufacturing process, remains in small amounts in the finished product (typically no more than 0.2 percent of a product).[36] In the US, cadmium is primarily used as a PVC stabilizer in window frames.[37]

Although PVC and other plastics are inexpensive, their continued use presents costly health and environmental dangers beyond those associated with cadmium.[38] A variety of construction and manufacturing materials that do not contain PVC plastic are available for most purposes. (For more information about PVC-free alternatives, see http://www.healthybuilding.net/pvc/alternatives.html.)

How is cadmium used in pigments? Are there alternatives?

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Cadmium-based pigments account for 12 percent of the cadmium incorporated in products.[39] Cadmium is typically used to produce shades of yellow, orange, red, and maroon. Cadmium is primarily used to color plastics, but it is also used in pigments for ceramics, glass, textiles, printing, inks, rubber, lacquers, and specialty paints.

Alternatives to cadmium-based pigments are available.[40] Solaplex Pigments™ have a new chemistry (that relies on CI pigment yellow 216) and are cadmium and lead free.[41] They offer the bright yellow and orange shades for artist's oil- and water-based paints that traditionally contain cadmium.

Recommendations

Manufacturers are strongly encouraged to take environmental concerns into account when assessing their business plans. As the long-term human and environmental health impacts of chemicals and heavy metals become increasingly well documented, purchasing agents in large states and institutions will continue to demand a wider range of safer products that are cost competitive, are readily available, and meet performance expectations. Manufacturers who can supply the next generation of safer products will have a marketing edge.

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