

# Chromium

## A Lustrous, Hard and Brittle Transition Metal

### What is Chromium?

In its more stable trivalent form, chromium (III), the metal does not normally endanger human health. After unstable chromium (VI) enters the body, it quickly reduces to chromium (III). However, cell damage occurs in the process and chromium (VI) is a known carcinogen when inhaled. Metal building products manufactured with chromium (VI) do not generally present a health hazard once in use (*Melton, 2011*). Chromium (VI), hexavalent chromium, is a toxic form of the metallic element chromium and is typically generated through anthropogenic industrial processes. Hexavalent chromium compounds include ammonium dichromate, barium chromate, calcium chromate, chromium trioxide, lead chromate, sodium dichromate, strontium chromate, potassium chromate, potassium dichromate, sodium chromate, and zinc chromate (*National Pollutant Inventory, 2021*). Chromium (VI) is used as an anti-corrosive agent in paint and coatings. It can be present in leather-tanning chemicals (*Melton, 2011*), pigments, dyes (soluble chromates), cement (portland cement), bricks and linings for furnaces (*SafeWork, n.d.*). It is also released during chrome plating, welding and hotworking in stainless steel production and from the smelting of chromite ore (*National Pollutant Inventory, 2021*). Chrome is used to achieve a shiny decorative appearance, provide corrosion resistance, ease cleaning procedures, increase surface hardness and prevent discolouration (*Occupational Safety and Health Administration, n.d.*).

### How Environmentally-Friendly is Chromium?

#### + 100% Recyclable in Theory

Stainless steel is generally chosen for its long life. The main alloying elements (chromium, nickel and molybdenum) are all highly valuable, easily recovered and separated. The amount of recycled stainless steel in stainless steel objects is currently approximately 60% (*British Stainless Steel Association, n.d.*).

#### + A Longer Lasting Version of Steel

Consumer-grade steel is capable of developing rust after only four to five days (*Gorman, 2021*). Rust weakens the structural integrity of buildings (*Jakovljevic, 2019*), bridges and furniture. If steel was to replace stainless steel in the built environment, the frequency at which steel may need to be replaced can create copious amounts of waste. While it may require an initial higher investment, stainless steel's unique properties allow high quality, durable and lightweight structures to deliver long-term performance and economic benefits including minimum downtime, reduced maintenance costs and reduced environmental impacts (*Van Hecke, 2021*).

#### + New Methods to Counteract Pollution

Bioremediation, a new age waste management technology, involves using microbes, whether indigenous or introduced (*South Australia Environment Protection Authority, 2005*), to absorb, degrade and detoxify chromium in the environment (*Bakshi, & Panigrahi, 2022*). Other options, such as biostimulation, bioaugmentation, phytoremediation and vermiremediation, are also cost-effective and environmentally-friendly solutions (*Lacalle, Aparicio, Arretxe, Urionabarrenetxea, Polti, Soto, Garbisu, & Becerril, 2020*).

#### – Raw Material Extraction

Chromium is traded in the form of ferrochromium and ferrochromium production is an electrical energy-intensive process. Much of the electrical power produced today is still coal-based (*Kropschot, Doeblich, 2010*).

#### – Water Contamination

Although contamination is fairly limited to surface water as chromium attaches strongly to soil and is generally contained within the silt layer surrounding groundwater reservoirs, (*Sneddon, 2012*), it has the potential to contaminate supplies of groundwater and drinking water (*Good Environmental Choice Australia, 2019*).

#### – Soil Contamination

Highly solubility chromite ore processing residues are used as fill materials for construction sites and the issue is further compounded by leaching (*Meegoda, & Kamolpornwijit, 2011*).

#### – Acute & Chronic Effects on Humans

Chromium is carcinogenic and leads to detrimental health effects such as allergic reactions, weakened immune system, genetic material alteration (*Sneddon, 2012*), oxidative stress, gastro-intestinal ulcers, dermatitis, kidney and liver failure and even death (*Prasad, Yadav, Kumar, Gupta, Cabral-Pinto, Rezania, Radwan, & Alam, 2021*).

#### – Accumulation in Animal Tissues

Chromium is teratogenic (*Centers for Disease Control and Prevention, 2008*) and prolonged exposure may result in cellular disorganisation, affected muscular activity, lamellar degradation, damaged epithelial cells and increased mortality rates of aquatic organisms (*Prasad, Yadav, Kumar, Gupta, Cabral-Pinto, Rezania, Radwan, & Alam, 2021*).

#### – Toxic to Plant Life

Negatively affects plant metabolic activities, alters physiological processes, increases mutagenesis, impairs photosynthesis, causes nutrient and oxidative imbalances (*Oliveira, 2012*), decreases seed germination, hampers crop growth and yield and reduces vegetable and grain quality (*Prasad, Yadav, Kumar, Gupta, Cabral-Pinto, Rezania, Radwan, & Alam, 2021*).

### The Process of Making Chromium

Chromite deposits are mined by both underground and surface techniques. Much of the ore is rich enough to be used directly for production of ferrochromium. Having a chromium-iron ratio greater than 2:1 is preferred, but ores with a lower ratio and as little as 40% Cr<sub>2</sub>O<sub>3</sub> are also used.

If carbon and Cr<sub>2</sub>O<sub>3</sub> are combined in a molar ratio of 3:1 and subjected to increasing temperatures, a number of oxidation-reduction reactions will ensue that will produce first a series of chromium carbides and finally, at 2,080 °C, pure chromium and carbon monoxide.

Pure chromium is produced either by the thermal reduction of Cr<sub>2</sub>O<sub>3</sub> with aluminum or by the electrolysis of trivalent chromium solutions. Pure chromium is added to nonferrous alloys and is also applied as a corrosion-resistant surfacing for other metals (*Bacon, & Downing, 2013*).



### Emerging Alternatives in Industrial Design:

Polished aluminium is a popular alternative to replicate electroplated chromium's metallic shine with a much lower environmental or health impact. There also appears to be a growing trend for more natural materials, such as timber, in furniture products (*Good Environmental Choice Australia, 2019*).

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