LEARNING TOXICOLOGY THROUGH OPEN EDUCATIONAL RESOURCES

Chromium

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CHROMIUM *(Lat. Chromium, Cr)*

= durable metal

Cr occurs naturally in the Earth´s crust, predominantly in the trivalent Cr^{3+} form.

It is ubiquitous in air, water, soil and biological materials.

In foodstufs, Cr is generally considered to be present as Cr^{3+}

Cr^{6+} compounds are essentially anthropogenically produced and do not occur naturally in the environment.

In biological systems, the oxidation of Cr^{3+} to Cr^{6+} never occurs.

The toxicity of chromium depends on the oxidation state:

Cr^{6+} compounds (chromic acid, potassium and ammonium dichromates) are more toxic than Cr^{3+}.

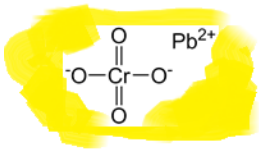
Cr^{3+} is considered an essential element in humans (is a constituent of the glucose tolerance factor, acts as a cofactor in insulin function), is required in glucose and lipid metabolism.

The daily requirement for Cr in humans is approximately 60 µg.

Elemental Cr is nontoxic.

1. Sources and uses:

- Manufacturing batteries, stainless steel
- Electroplating other metals to increase hardness and corrosion resistance
- Paint pigments: chrome yellow = lead chromate = $PbCrO_4$
- Wood preservatives
- Leather tanning: potassium dichromate = $K_2Cr_2O_7$
- Combustion of coal and oil
- Cement works
- Cigarette smoke



2. Fate in the organism:

Absorption:

Cr^{6+} is the more efficiently absorbed in the lungs, GIT and through the skin than Cr^{3+}. Cr^{3+} is poorly absorbed from the GIT. Inhaled chromium particles can remain in the lung for a long time. Water soluble Cr^{3+} salts penetrate the skin but they don´t reach the systemic circulation.

Distribution:

Cr^{3+} : in the blood, 95% is bond to large molecular mass proteins (transferrin).

Cr^{6+} : greater tendency to cross membranes, barriers → greater distribution to all tissues.

Highest Cr concentrations: in the kidney, liver and brain.

Cr^{6+} : unstable in the body reduction to more stable Cr^{3+} (by endogenous reducing agents, e.g. ascorbate and glutathione).

Excretion:

Cr is mainly excreted by the kidneys (about 80% of a chromium dose), elimination through the intestine and in breast milk may also occur.

3. Mechanism of toxicity:

Chromium toxicity results from its ability to penetrate cell membranes, inciting events resulting in cell death.

Cr^{6+} compounds are more toxic:

- oxidizing agents (→ corrosive to the mucous membranes in airways, GIT and skin)
- generation of free radicals → cellular damage
- depletes cellular antioxidants

4. Intoxication:

Cr^{3+} : Chromium dietary supplement (chromium picolinate) ingestions are generally nontoxic

Cr^{6+} : is associated with widespread organ toxicity.

Acute toxicity:

The lethal dose in humans is 2g $K_2Cr_2O_7$ by mouth.

$Na_2Cr_2O_7$ is also extremely toxic, the estimated oral lethal dose is between 1 to 10 g in an adult.

Corrosive nature can cause serious damage to mucous membranes of the respiratory and the gastrointestinal tract and the skin:

- **Ingestion** → esophageal and gastric necrosis, renal tubular necrosis
- **Inhalation** → upper respiratory tract irritation, nasal septum ulceration and perforation, bronchitis, pulmonary edema
- **Eye** → corneal injury
- **Skin** → dermal ulcers (known as „chrome holes“)
  skin burns may enhance systemic absorption

For more see:
http://www.cdc.gov/niosh/topics/skin/occderm-slides/ocderm8.html - slide 38

Chronic toxicity:

Cr^{6+} Cr^{3+} → allergic responses in sensitized individuals (e.g. asthma and contact dermatitis)

e.g. in construction workers – Cr containing cement

Blackjack disease *= contact dermatitis in card players or gamblers caused by exposure to chromium salts used for dyeing green felt or baize, which covers the gambling tables*

Cr^{6+} → human carcinogen (lung cancer, cancer of the larynx, nasal cavity and sinuses). Workers who have been exposed to Cr fumes: an increased incidence of pulmonary cancer, cancer of the larynx, nasal cavity and sinuses with a latent period of about 20 years.

5. Laboratory determination:

Detection in the urine may confirm exposure.
Normal serum chromium concentration is 1µg/l.
Normal urine levels are less than 40µg/l.

6. Treatment: specific drugs and antidotes

- Skin contamination with soluble Cr salts: the area should be immediately rinsed with water, and $CaNa_2$ EDTA in polyglycol solution.
- Cr^{6+} can be transformed into less toxic and poorly absorbed Cr^{3+} by administering ascorbic acid (oral doses of 2 to 4g per 1g of ingested chromium have been recomendeed if there are no symptoms of severe gastroesophageal injury). Larger doses could be harmful because ascorbic acid is a metabolic precursor of oxalate that can cause nephropathy.
- DMPS is recommended as an antidote for Cr poisoning. Chelatation therapy with BAL is not effective.

Share video:
https://www.youtube.com/watch?v=fXF69p2UkVw

Additional reading:
http://www.dovemed.com/diseases-conditions/chromium-toxicity/

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