

Communications

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Brief Survey of Chromium Toxicity

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I recently read some information in the pyrotechnic literature^[1] about chromium toxicity, which, unfortunately, was not completely correct. Since there are some serious health concerns regarding chromium, this brief article has been written to present a survey of some of what is known.^[2-4]

Chromium (Cr) is probably the most complicated of the metals in terms of toxicity. To consider the toxicity of chromium compounds, the very first thing you have to do is look at the valence state of the chromium ion

Carcinogenicity by Valence State

Cr⁰ metal, Cr(II) and Cr(III) have airborne threshold limit values (TLVs) of 0.5 milligrams per cubic meter (mg/m³) and are *not* considered carcinogens. Here the TLV is set to avoid irritation, sensitivities, etc.

Cr(VI) compounds generally have a TLV of 0.05 mg/m³ and *are* carcinogens. This group includes the chromates, dichromates, chromic acid, and chromium trioxide. However, some Cr(VI) compounds have been assigned even lower TLVs:

1) Insoluble Chromates

Certain insoluble chromates such as fume from stainless steel welding and byproducts of manufacture of chromate compounds are much more carcinogenic based on epidemiological studies. Therefore, a separate TLV is set for these compounds:

Insoluble Cr(VI) compounds: 0.01 mg/m³

2) Individual Chromates with Separate TLVs

Various individual chromates have their own TLVs based on pretty solid data. Included are:

Calcium chromate: 0.001 mg/m³

Lead chromate: 0.05 mg/m³ for the lead,
0.012 mg/m³ for the Cr

(This means that there can be no more than 0.05 mg of Pb per cubic meter, and no more than 0.012 mg of Cr per cubic meter, if these elements are present as PbCrO₄.)

Zinc chromate: 0.01 mg/m³

In addition, one particular chromate, strontium chromate, is one of the most potent animal carcinogens ever tested. It has its own very special TLV:

Strontium chromate: 0.0005 mg/m³

No one really knows exactly why this strontium compound is so toxic. Most strontium compounds are of very low toxicity, and there are no TLVs for them at all.

Sensitization Caused by Chromium

All the chromium compounds and the chromium metal appear to be skin sensitizers with the more soluble usually being more sensitizing. These compounds cause a well-known occupational disease called "chrome ulcers" (which I have had). I developed my chromium sensitivity from working with chrome compounds in pottery and now have to avoid chrome even in the metal jewelry I wear, or I will get dermatitis and/or a chrome ulcer on the site of contact. These ulcers can take up to 6 months to heal.

Sensitization of the respiratory system by chromium metal, chromium containing alloys and chromium compounds is even more relevant to pyrotechnics. Fumes from the metallic salts (which would be produced in a pyrotechnic effect containing chromium compounds) are capable of inducing bronchial reactivity (e.g.,

asthma) even in previously non-allergic individuals. Once sensitized to chromium, people usually will have allergic reactions to all forms of chromium for the rest of their lives. It is even likely they will react to smaller and smaller amounts over time. While no one should inhale pyrotechnic smoke containing chromium, it can be especially hazardous to these pre-sensitized individuals.

Other Aspects

Chromium in many forms can damage the skin and mucous membranes. This effect can range from stuff that will eat holes in you like chromic acid to stuff that will ulcerate your nasal passages like potassium dichromate. While the chromium VI compounds usually are the most damaging, some chrome III and IV compounds and even chrome metal dust will cause irritation of the nasal mucosa. Many of the compounds also stain the skin and may be a factor in causing certain adverse kidney effects.

Chromium is also essential for glucose metabolism. It is needed in *trace* amounts, as Cr(III). (Chromium is only one of many elements that are needed in the diet, but that are toxic at higher doses. Other examples include cobalt and manganese.)

Ongoing studies of chromium compounds are expected to deepen and alter our understanding of their toxicity and carcinogenicity. For example, some experts think there are circumstances under which chromium(II) and (III) compounds can be altered to the cancer causing chromium(VI) forms in the body. In any case, it is wise for us to use prudent chemical handling procedures to avoid exposure to all chromium chemicals that can be inhaled, ingested, or contact the skin in liquid or fine particulate form.

References

- 1) T. I. Perigrin, "Chemical Risks", *American Fireworks News*, No. 202 (1998) pp 2–3.
- 2) *Documentation of Threshold Limit Values and Biological Exposure Indices*, American Conference on Governmental Industrial Hygienists (ACGIH) (1997).
- 3) Guide to Occupational Exposure Values—2000, ACGIH, 1330 Kemper Meadow Dr, Cincinnati, OH 45240-1634, USA
<http://www.acgih.org>
- 4) *Patty's Industrial Hygiene and Toxicology*, Vol. II, Part C, 4th ed., Wiley Interscience, pp 1973–1985.