TerranearPMC Safety Share

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Week of October 29, 2018 – Hexavalent Chrome

Hexavalent chrome? How's that different from regular chrome? First of all, Chrome – or chromium - is a chemical element with the symbol Cr and atomic number of 24. It is the first element in group 6 in the periodic table, making it a refractory metal, of which molybdenum (Mo), tungsten (W), and seaborgium (Sg) are also in this group. Refractory metals are extremely resistant to heat and wear. As a transition metal, chromium's atomic structure has a partially filled *d* sub-shell, which means it can easily become a cation (a positively charged ion).

Chromium has many uses as it is able to be highly polished while resisting tarnishing. Chromium is also the main component of stainless steel, and as a refractory metal, it has the property of being highly reflective. Even simple polished chromium reflects almost 70% of the visible spectrum, with almost 90% of infrared light waves being reflected.

The name, chromium, is derived from the Greek word meaning color, as many chromium compounds are intensely colored. During the 1800s, chromium was primarily used as a component of paints and in tanning salts. Chromium has been used for electroplating (due to easily transitioning into a cation) as early as 1848, and today has become widespread with the development of improved industrial processes.

But what about hexavalent chrome? Where does this material come from? Hexavalent chromium, or Cr(VI), is generally produced by industrial processes, such as when performing "hot work" such as welding on stainless steel or melting chromium metal. In these situations, the chromium is not originally hexavalent, but the high temperatures involved in the process result in oxidation that converts the chromium to a hexavalent state.

While Cr(VI), is prevalent in industrial processes, this material is a well-established occupational carcinogen which has been associated with lung cancer as well as nasal and sinus cancer. The National Institute for Occupational Safety and Health (NIOSH) considers all Cr(VI) compounds to be occupational carcinogens. In 1989, the International Agency for Research on Cancer (IARC) has concluded that "there is sufficient evidence in humans for the carcinogenicity of chromium[VI] compounds as encountered in the chromate production, chromate pigment production and chromium plating industries." Cr(VI) compounds were reaffirmed as an IARC Group 1 carcinogen (lung) in 2009 while the National Toxicology Program (NTP) identified Cr(VI) compounds as carcinogens in its first annual report on carcinogens in 1980. Nonmalignant respiratory effects of Cr(VI) compounds include irritated, ulcerated, or perforated nasal septa. Other adverse health effects, including reproductive and developmental effects.

It is estimated that 558,000 workers are potentially exposed to Cr(VI) in the United States and occur mainly in the following areas:

- Welding and other types of "hot work" on stainless steel and other metals that contain chromium
- Use of pigments, spray paints and coatings
- Operating chrome plating baths

In 2006, OSHA promulgated a hexavalent chromium standard for general industry as 29 CFR 1910.1026, Construction 29 CFR 1926.1126, and for Shipyards as 29 CFR 1915.1026. Through these regulations, a revised permissible exposure limit (PEL) was established at 5 micrograms per cubic meter (μg/m^3) measured as an 8-hour time-weighted average (TWA). In addition, an action level (AL) was established at 2.5 μg/m^3 which is intended to trigger certain requirements; most notable is the requirement for continued employee exposure sampling. Industrial hygiene (IH) sampling is not required should initial IH assessments confirm employee exposures are within the AL. However; if IH sampling indicates exposures are greater than the AL, IH sampling needs to continue every six months and can only stop after two sampling events (no less than 7 days apart) confirms both sampling events are within the AL. Otherwise the employer must continue with a monitoring program.

Employee exposures exceeding the PEL will require further controls to be implemented. Recommended controls should be based on the conventional approach of the *Hierarchy of Controls*. Thus, first consideration should be substitution. That is if possible, operations that involve Cr(VI) should be reexamined for the possibility to use another, less toxic material. If that is not feasible, engineering (e.g. Ventilation) needs to be employed. And if controls such as ventilation are not possible, the next controls to be considered are administrative and work practices (e.g. training, establishing procedures and setting up regulated areas). A popular work control has always been the incorporation of work rotations. This is a method by which persons work only part of a full shift in a contamination environment. Thus, employees would not be subject to 8-hour work shift exposures. However, in the recently promulgated OSHA regulations, this practice is NOT an acceptable approach to control workplace exposures to Cr(VI)(29 CFR 1910.1026(f)(2)). The last resort is always to control worker exposures by personal protective equipment (ex. respiratory protection).

Recently, the American Conference of Governmental Industrial Hygienists (ACGIH) has revised its threshold limit value (TLV) for Cr(VI) in their 2018 edition of the *TLVs for Chemical Substances and Physical Agents* from 10 μg/m^3 to 0.2 μg/m^3, and therefore, considerably lower than the OSHA PEL (both ACGIH TLVs and OSHA PELs are based on an 8-hour exposure period). And while OSHA PELs are enforceable by law, ACGIH TLVs are guidelines and therefore, are not (generally) supported through regulatory compliance. However, when working at a DOE facility, the DOE Worker Safety and Health Program (10 CFR 851) mandates that employers working at DOE sites need to follow whichever occupational exposure limit is "…lower (more Protective) …" (10 CFR 851.23). And while the 2018 TLV for Cr(VI) is the lower value, 10 CFR 851.23 recognizes the 2016 TLV publication where the TLV is 10 μg/m^3. therefore, due to this technicality, the OSHA PEL takes precedence.

Not only is Cr(VI) considered to be an occupational health contaminant but it is also a public health concern as Cr(VI) has been detected in groundwater samples throughout the country. This has been brought to the forefront most notably, in the movie "Erin Brockovich" where Cr(VI) has been shown to be present in drinking water sources.

The education of young people in science is at least as important, maybe more so, than the research itself - Glenn T. Seaborg