Chromates and dichromates (insoluble): Human health tier II assessment

02 March 2018

Chemicals in this assessment

Chemical Name in the Inventory	CAS Number
Chromic acid (H2CrO4), strontium salt (1:1)	7789-06-2
Chromic acid (H2CrO4), barium salt (1:1)	10294-40-3
Chromic acid (H2CrO4), iron(3+) salt (3:2)	10294-52-7
Chromate(1-), hydroxyoctaoxodizincatedi-, potassium	11103-86-9
Chromic acid (H2CrO4), zinc salt (1:1)	13530-65-9
Chromic acid (H2CrO4), calcium salt (1:1)	13765-19-0
C.I. Pigment Yellow 36	37300-23-5
Chromium zinc oxide	50922-29-7

Preface

This assessment was carried out by staff of the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) using the Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework.

The IMAP framework addresses the human health and environmental impacts of previously unassessed industrial chemicals listed on the Australian Inventory of Chemical Substances (the Inventory).

The framework was developed with significant input from stakeholders and provides a more rapid, flexible and transparent approach for the assessment of chemicals listed on the Inventory.

Stage One of the implementation of this framework, which lasted four years from 1 July 2012, examined 3000 chemicals meeting characteristics identified by stakeholders as needing priority assessment. This included chemicals for which NICNAS already held exposure information, chemicals identified as a concern or for which regulatory action had been taken overseas, and chemicals detected in international studies analysing chemicals present in babies' umbilical cord blood.

Stage Two of IMAP began in July 2016. We are continuing to assess chemicals on the Inventory, including chemicals identified as a concern for which action has been taken overseas and chemicals that can be rapidly identified and assessed by using Stage One information. We are also continuing to publish information for chemicals on the Inventory that pose a low risk to human health or the environment or both. This work provides efficiencies and enables us to identify higher risk chemicals requiring assessment.

The IMAP framework is a science and risk-based model designed to align the assessment effort with the human health and environmental impacts of chemicals. It has three tiers of assessment, with the assessment effort increasing with each tier. The Tier I assessment is a high throughput approach using tabulated electronic data. The Tier II assessment is an evaluation of risk on a substance-by-substance or chemical category-by-category basis. Tier III assessments are conducted to address specific concerns that could not be resolved during the Tier II assessment.

These assessments are carried out by staff employed by the Australian Government Department of Health and the Australian Government Department of the Environment and Energy. The human health and environment risk assessments are conducted and published separately, using information available at the time, and may be undertaken at different tiers.

This chemical or group of chemicals are being assessed at Tier II because the Tier I assessment indicated that it needed further investigation.

For more detail on this program please visit:**www.nicnas.gov.au**

Disclaimer

ACRONYMS & ABBREVIATIONS

Grouping Rationale

The chemicals in this group all contain chromium in the hexavalent, i.e. VI, oxidation state, and are sparingly soluble to insoluble (solubility <5 g/L). All chemicals in this group have similar end uses, typically in the paint and pigment industries. The chemicals in this group are expected to have similar toxicity which is primarily due to the chromate anion. They share similar physico-chemical properties including density and melting points. Chromium zinc oxide (CAS No. 50922-29-7) and zinc yellow (CAS No. 37300-23-5) are listed as forms of zinc chromate (Wiley Publications, 2012); they are therefore included in this group despite having unspecified molecular compositions.

Import, Manufacture and Use

Australian

The following Australian industrial uses were reported under previous mandatory and/or voluntary calls for information.

Some chemicals in this group have reported domestic uses including:

- in paint manufacturing—strontium chromate (CAS No. 7789-06-2); and
- as colouring agents—strontium chromate (CAS No. 7789-06-2); barium chromate (CAS No. 10294-40-3).

Some chemicals in this group have reported commercial uses including:

- as corrosion inhibitors—strontium chromate (CAS No. 7789-06-2); zinc chromate (CAS No. 13530-65-9); and
- electroplating—barium chromate (CAS No. 10294-40-3).

International

The following international uses have been identified through European Union Registration, Evaluation and Authorisation of Chemicals (EU REACH) dossiers; the Organisation for Economic Cooperation and Development Screening information data set International Assessment Report (OECD SIAR); Galleria Chemica; Substances and Preparations in the Nordic countries (SPIN) database; the European Commission Cosmetic Ingredients and Substances (CosIng) database; United States (US) Personal Care Product Council International Nomenclature of Cosmetic Ingredients (INCI) Dictionary; and eChemPortal: OECD High Production Volume chemical program—OECD HPV, the US Environmental Protection Agency's Aggregated Computer Toxicology Resource—ACToR, and the US National Library of Medicine's Hazardous Substances Data Bank—HSDB.

The majority of chemicals in this group have reported domestic uses including:

- as colouring agents;
- in fillers;
- in paints, lacquers and varnishes;
- as pigments; and
- in surface treatment.

The majority of chemicals in this group have reported commercial uses including:

- as corrosion inhibitors; and
- in adhesives and binding agents.

The majority of chemicals in this group have reported site-limited uses including:

- as intermediates; and
- as laboratory reagents.

Some chemicals in this group have the following reported commercial uses:

- electroplating;
- chrome plating;
- pyrotechnics;
- battery depolarisation; and
- ignition control devices.

Restrictions

Australian

The chemicals in this group are listed in the *Poisons Standard—the Standard for the Uniform Scheduling of Medicines and Poisons* (SUSMP, 2018) in Schedule 6:

"Chromates (including dichromates) **except** in paints or tinters containing 5 per cent or less of chromium as the ammonium, barium, calcium, iron, potassium, sodium, strontium or zinc chromate calculated on the non-volatile content of the paint or tinter."

Schedule 6 chemicals are labelled with 'Poison'. These are substances with a moderate potential for causing harm, the extent of which can be reduced by using distinctive packaging with strong warnings and safety directions on the label (SUSMP, 2018).

The chemicals in this group (including strontium chromate) are included under the following entry for "First Group" paints under "**Controls on Medicines and Poisons: Section Seven Paint or Tinters**" (formerly known as the *Appendix I, The uniform paint standard*) (SUSMP, 2018).

Controls on Medicines and Poisons (Section Seven/Appendix I: Paint or Tinters)

The following applies to paints containing 'chromium as chromates of ammonia, barium, potassium, sodium, strontium or zinc" at >5 % (the proportion of a substance for the purposes of this Group is calculated as a percentage of the element present in the non-volatile content of the paint)' (SUSMP, 2018).

"(1) A person must not manufacture, sell, supply or use a First Group Paint for application to:

(a) a roof or any surface to be used for the collection or storage of potable water; or

(b) furniture; or

(c) any fence, wall, post, gate or building (interior or exterior) other than a building which is used exclusively for industrial purposes or mining or any oil terminal; or

(d) any premises used for the manufacture, processing, preparation, packing or serving of products intended for human or animal consumption.

(2) A person must not manufacture, sell, supply or use a paint or tinter containing more than 0.1 % Lead (the proportion of Lead for the purposes of this section is calculated as a percentage of the element present in the non-volatile content of the paint).

(3) A person must not manufacture, sell, supply or use a paint for application to toys unless the paint complies with the specification for coating materials contained in Australian/New Zealand Standard AS/NZS ISO 8124.3:2012 entitled *Safety of toys Part 3: Migration of certain elements* (ISO 8124-03:2010, MOD).

(4) A person must not manufacture, sell, supply, or use a paint or tinter containing a pesticide except a fungicide, algaecide, bactericide or antifouling agent" (SUSMP, 2018).

International

The risk of exposure to chromium(VI) and related compounds has been recognised internationally and has resulted in broad restrictions regarding occupational and public exposure.

Chromium(VI) compounds appear on the following (Galleria Chemica):

- Health Canada list of prohibited and restricted cosmetic ingredients (The Cosmetic Ingredient 'Hotlist');
- the EU Cosmetic Directive 76/768/EEC Annex II—List of substances which must not form part of the composition of cosmetic products (except barium chromate (CAS No. 10294-40-3)); and

- the New Zealand Cosmetic Products Group Standard—Schedule 4: Components cosmetic products must not contain.

Existing Worker Health and Safety Controls

Hazard Classification

Compounds related to zinc chromate, specifically zinc potassium chromate (CAS No. 11103-86-9), zinc chromate (CAS No. 13530-65-9) and zinc yellow (CAS No. 37300-23-5), are classified as hazardous with the following risk phrases for human health in HSIS (Safe Work Australia):

- Carc. Cat. 1; R45 (Carcinogenicity—may cause cancer);
- Xn; R22 (Harmful if swallowed); and
- R43 (May cause sensitisation by skin contact).

Strontium chromate (CAS No. 7789-06-2) and calcium chromate (CAS No. 13765-19-0) are classified as hazardous with the following risk phrases for human health in HSIS (Safe Work Australia):

- Carc. Cat. 2; R45 (Carcinogenicity—may cause cancer); and
- Xn; R22 (Harmful if swallowed).

The remaining chemicals in this group, apart from barium chromate, as 'Chromium (VI) compounds, with the exception of barium chromate and of compounds elsewhere specified' are classified as hazardous with the following risk phrases for human health in the Hazardous Substances Information System (HSIS) (Safe Work Australia):

- Carc. Cat. 2; R49 (Carcinogenicity—may cause cancer by inhalation); and
- R43 (May cause sensitisation by skin contact).

Exposure Standards

Australian

Compounds related to zinc chromate, specifically zinc potassium chromate (CAS No. 11103-86-9), zinc chromate (CAS No. 13530-65-9) and zinc yellow (CAS No. 37300-23-5), are listed in HSIS as 'Zinc chromate (as Cr)' and have an exposure standard of 0.01 mg/m³ time weighted average (TWA) (Safe Work Australia).

The remaining chemicals in this group are listed in HSIS as 'Chromium(VI) compounds (as Cr), certain water insoluble (h)' and have an exposure standard of 0.05 mg/m³ time weighted average (TWA) (Safe Work Australia).

International

The following exposure standards are identified (Galleria Chemica):

Some chemicals in this group have exposure limits (TWA) of 0.0005–0.05 mg/m³ in different countries such as USA (California), Canada (Alberta, British Columbia), Denmark, the United Kingdom and Iceland.

Some chemicals in this group have exposure limits (STEL) of 0.0015–0.3 mg/m³ in different countries such as Canada (Saskatchewan), Sweden and Poland.

Health Hazard Information

Common to all chemicals in this group is the chromate anion, containing chromium(VI), which is expected to be the main hazard for human health effects. The cation components are not expected to contribute significantly to the toxicity of the chemicals. Bioavailability of the chromate anion will affect the toxicity of the chemicals in this group (compared with other chemicals containing the chromate or dichromate anion) as they are sparingly soluble to insoluble. The hazards of this group of chemicals can generally be considered to be the same on an available chromate equivalent basis.

Toxicokinetics

Toxicokinetic data in dogs, rats, mice, rabbits, and hamsters generally correlate well across species. Animal data also correlate well with human data (ATSDR, 2012).

Chromium(VI) and related compounds can be absorbed after oral, inhalation and dermal exposure. Absorption is greater through the lungs than through the gastrointestinal tract. Gastrointestinal absorption is estimated to be approximately 10 % of the ingested dose. Ingested chromium(VI) is not well absorbed because the acidic environment of the stomach reduces it to the less readily absorbed chromium(III), also known as trivalent chromium. Chromium(VI) can partly penetrate human skin; insoluble chromium(VI) compounds are absorbed less readily than soluble forms and chromium(VI) is much more readily absorbed than chromium(III) (ATSDR, 2012).

Absorbed chromium(VI) is distributed to, and accumulated in, red blood cells (RBCs) and is also distributed to almost all tissues, with the highest concentrations found in the kidneys, lungs and liver. Long-term chromium retention also occurs in bones. Sparingly soluble or insoluble chromium(VI) compounds that are inhaled or instilled intratracheally have a longer retention time in the lungs than soluble chromium(VI) compounds (ATSDR, 2012). The chromate ion is very reactive, and for the most part will not persist in the body beyond the point of contact.

Chromium(VI) can enter cells via sulfate-ion transport channels; once this occurs it is rapidly reduced to chromium(III). The reduction of chromium(VI) to chromium(III) involves glutathione, ascorbic acid, or cytochrome P450. Chromium(III) binds to haemoglobin and other ligands. The chromium-haemoglobin complex is relatively stable and remains within the RBC for the cell's lifespan (ATSDR, 2012).

Once absorbed, chromium is excreted rapidly. Urinalyis of industrial workers exposed to chromium(VI) indicated that chromium(III) is the major form excreted. Chromium is usually excreted in the urine as it is processed by the kidneys following absorption. However, in the case of oral exposure the majority of the ingested chromium is excreted in faeces due to poor intestinal absorption of chromium(VI). Chromium may also be excreted via sweat, hair and nails. Chromium(VI) has been shown to cross the placental and mammary barriers (ATSDR, 2012).

Acute Toxicity

Oral

Some chemicals in this group are classified as hazardous with the risk phrase ‘Harmful if swallowed’ (Xn; R22) in HSIS (Safe Work Australia):

- strontium chromate (CAS No. 7789-06-2);
- calcium chromate (CAS No. 13765-19-0);
- zinc potassium chromate (CAS No. 11103-86-9);
- zinc chromate (CAS No. 13530-65-9); and
- zinc yellow (CAS No. 37300-23-5).

Based on the physico-chemical similarity of the group members, this hazard classification is supported for all of the chemicals in this group.

Strontium chromate (CAS No. 7789-06-2) and calcium chromate (CAS No. 13765-19-0) were of moderate acute toxicity in animal tests following oral exposure. The median lethal dose (LD50) values in rats for these chemicals are 327–811 mg/kg bw.

Male and female Sprague Dawley (SD) rats were administered calcium chromate by oral gavage. The LD50 was calculated as 327 mg/kg bw in female rats and 746 mg/kg bw in male rats. An LD50 of 811 mg/kg bw was calculated for strontium chromate in male rats when administered by oral gavage (ATSDR, 2012; REACH). The studies indicate that female rats are more sensitive to the toxic effects of chromium(VI) than male rats (ATSDR, 2012).

Dermal

The chemicals in this group are not classified as acutely toxic from dermal exposure in HSIS. Sparingly soluble and insoluble chromates are expected to be of low acute dermal toxicity.

Soluble chromates are recommended to be classified as 'Harmful in contact with skin' (Xn; R21) (NICNAS) although they have an identified dermal absorption of <1% (REACH). Soluble chromates are corrosive on dermal contact, which can increase the absorption of the compound and lead to systemic toxicity (ATSDR, 2012). However, insoluble chromium(VI) compounds are not corrosive and also have lower dermal absorption than soluble forms (ATSDR, 2012). On this basis, no classification for acute toxicity from dermal exposure is supported.

Inhalation

The chemicals in this group are not classified as acutely toxic by inhalation in HSIS. The available data support an amendment to this classification (refer to **Recommendation** section) to reflect the findings reported below. Based on the information available, and the physico-chemical similarity of the group members, the chemicals in this group should be classified as hazardous with the risk phrase 'Toxic by inhalation' (T; R23).

Strontium chromate (CAS No. 7789-06-2) was of high acute toxicity in animal tests following inhalation exposure. The median lethal concentration (LC50) in rats is 0.27–0.51 mg/L (REACH).

Strontium chromate was administered as an aerosol through the nose to male and female albino Wistar rats (5/sex/dose) at 0.27, 0.51 and 0.81 mg/L for four hours. In the lowest dose group, a mortality rate of 2/10 animals occurred within four days. A mortality rate of 8/10 animals occurred in the 0.51 and 0.81 mg/L dose groups, with the remaining two animals in both groups euthanised on day eight due to severe body weight loss. Observed sublethal effects included tachypnoea (abnormally rapid breathing) and ruffled fur at all dose levels. Gross pathology showed treatment-related changes including dark red lung discolouration and/or incompletely collapsed lungs in the higher dose groups, as well as hardened and pale lungs in the lowest dose group (REACH).

These results support the conclusion that inhalation exposure to insoluble chromium(VI) compounds damages the lower respiratory tract (ATSDR, 2012).

Corrosion / Irritation

Skin Irritation

One of the chemicals in this group produced no skin irritation in studies performed in accordance with OECD Test Guideline (TG) 404. The available data do not support a classification for skin irritation.

Strontium chromate (CAS No. 7789-06-2) (0.5 g) was applied to the dorsal flank of three New Zealand White rabbits for four hours semiocclusively. No oedema or erythema was reported; there was some yellow discolouration of the skin. Based on the results, the chemicals in this group are not irritating to the skin (REACH).

Eye Irritation

One of the chemicals in this group is reported to be a slight eye irritant in animal studies. The available data do not support a classification for eye irritation.

Strontium chromate (CAS No. 7789-06-2) was administered to the eyes of three New Zealand White rabbits. Low-grade conjunctival redness and chemosis were observed; these effects were transient and resolved during the study. Based on the effects, the chemicals in this group are not irritating to the eyes (REACH).

Sensitisation

Skin Sensitisation

All of the chemicals in this group, with the exception of barium chromate (CAS No. 10294-40-3), are classified as hazardous with the risk phrase 'May cause sensitisation by skin contact' (R43) in HSIS (Safe Work Australia).

Based on the information available this hazard classification is supported for all of the chemicals in this group, including barium chromate. Although no animal data were available, the evidence from human studies indicates that chromium(VI) is a skin sensitiser.

Observation in humans

Patch testing has identified chromium(VI)-sensitised workers in the printing and lithography industry, in automobile factories (where assemblers handled nuts, bolts, and screws), and in wet sandpapering of primer paint (where workers were exposed to zinc chromate). Other sources that resulted in chromium sensitivity included manufacturing match heads (which may contain barium chromate) (ATSDR, 2012).

Direct skin contact with chromium compounds results in an allergic response that is characterised by eczema or dermatitis. Chromium-induced allergic contact dermatitis is usually isolated to areas at the site of contact. The acute response phase lasts between a few days and a few weeks; it is characterised by erythema, oedema, and small and large blisters. The chronic phase is similar and may also include thickened, scaly, and fissured skin. Oral exposure to chromium(VI) has been shown to exacerbate dermatitis in sensitive individuals (ATSDR, 2012).

Several studies have attempted to estimate the exposure level required to elicit a dermal response in chromium-sensitised individuals, with exposure levels of 4–25 ppm producing sensitisation and leading to chromium-induced allergic dermatitis. However, it is anticipated that the exposure level required to elicit a dermal response in sensitised individuals could be highly variable (ATSDR, 2012).

Repeated Dose Toxicity

Oral

No data are available. Given the low gastrointestinal absorption of insoluble chromium(VI) chemicals, and moderate acute oral toxicity, the chemicals in this group are not expected to be toxic by repeated oral exposure.

Dermal

No data are available. Given the low skin penetration of insoluble chromium(VI) chemicals, and the lack of acute dermal toxicity, the chemicals in this group are not expected to be toxic by repeated dermal exposure.

Inhalation

The chemicals in this group are not classified by Safe Work Australia as toxic by inhalation following prolonged exposure. The available data support an amendment to this classification (refer to **Recommendation** section) to reflect the findings reported below.

Based on the information available, the chemicals in this group should be classified as hazardous with the risk phrase 'Harmful: Danger of serious damage to health by prolonged exposure through inhalation' (Xn; R48/20) given the lowest observed adverse effect level (LOAEL) of 0.129 mg/L for calcium chromate.

In a non-guideline study (summary only) C57BL/6 mice were exposed to 0.043 mg/L of chromium(VI) as calcium chromate dust for 18 months (five days/week for 5.5 hours/day). The LOAEL was determined to be 0.043 mg chromium(VI)/L (0.129 mg/L calcium chromate) based on epithelial necrosis and marked hyperplasia of the large and medium bronchi, with numerous openings in the bronchiolar walls (ATSDR, 2012; REACH). A no observed adverse effect level (NOAEL) could not be determined as only one concentration level of the chemical was studied.

Effects that may be indicative of altered immune function (altered white blood cell counts and cytokine levels in bronchoalveolar lavage—BAL fluid) were observed in rats exposed to 0.0036 mg chromium(VI)/L as barium chromate for 2–4 weeks. However, results of this study are difficult to interpret, since effects were not clearly adverse, only one exposure level of the chemical was studied, and histopathological assessment of respiratory tissues (or other tissues) was not conducted (ATSDR, 2012).

Many chronic exposure studies relating to exposure through inhalation of insoluble particulate chromium(VI) compounds do not clearly identify adverse effects or are older studies that do not report sufficient experimental details to make a definite classification (ATSDR, 2012).

Given the effects reported and their similarity to effects seen following acute toxicity by inhalation, a hazard classification is warranted. Sparingly soluble and insoluble chromium(VI) compounds that are inhaled take longer to clear the lungs than soluble chromium(VI) compounds (ATSDR, 2012); the risk of adverse effects from repeated exposure increase when a chemical accumulates in the organ. It is also noted that soluble chromates are recommended to be classified as 'Toxic: danger of serious damage to health by prolonged exposure through inhalation' (Xn; R48/23) (NICNAS).

Genotoxicity

The data indicate that the chemicals in this group are unlikely to have mutagenic or genotoxic potential in humans. The available data do not support a classification for genotoxicity.

Most soluble chromium(VI) chemicals are classified as hazardous with the risk phrase 'May cause heritable genetic damage' (T; R46) in HSIS (Safe Work Australia).

The genotoxicity of chromium(VI) compounds is clearly established, although there is little data to show in vivo genotoxicity of the chemicals in this group. The systemic genotoxicity of chromium(VI) compounds is directly related to their solubility and therefore to their bioavailability. The chemicals in this group are not expected to be systemically distributed due to poor bioavailability and any genotoxic activity will be resticted to the site of contact. The chemicals in this group are not expected to cause germ cell mutations.

Carcinogenicity

Chemicals related to zinc chromate, specifically zinc potassium chromate (CAS No. 11103-86-9), zinc chromate (CAS No. 13530-65-9) and zinc yellow (CAS No. 37300-23-5) are classified as hazardous as Category 1 carcinogenic substances with the risk phrase ‘May cause cancer’ (T; R45) in HSIS (Safe Work Australia). The available data support this classification.

The following chemicals in this group are classified as hazardous as Category 2 carcinogenic substances with the risk phrase ‘May cause cancer’ (T; R45) in HSIS (Safe Work Australia).

- strontium chromate (CAS No. 7789-06-2); and
- calcium chromate (CAS No. 13765-19-0).

The remaining chemicals in this group, with the exception of barium chromate (CAS No. 10294-40-3), are classified as hazardous as Category 2 carcinogenic substances with the risk phrase ‘May cause cancer by inhalation’ (T; R49) in HSIS (Safe Work Australia).

The available data support an amendment to these classifications (refer to **Recommendation** section) to reflect the findings reported below.

Based on the available information (epidemiological human data and animal test data on inhalation carcinogenicity along with animal data on other routes of exposure), all chemicals in this group should be classified as Category 1 carcinogens (given sufficient evidence in humans and experimental animals) with the risk phrase 'May cause cancer' (T; R45) in HSIS.

Insoluble and slightly soluble chromium(VI) compounds have been tested for carcinogenicity in several species and strains of animals by multiple routes of exposure (IARC, 1990). The carcinogenic potential of insoluble chromates by the inhalation route is expected to be greatest due to the low distribution beyond the point of contact.

Calcium chromate administered to mice by inhalation at 4.3 mg/m³ resulted in a 2.8 fold increase in lung tumour incidence compared with controls (ATSDR, 2012), and induced local tumours following intramuscular administration (IARC, 2012). In rats, calcium chromate caused lung tumours (adenoma, squamous cell carcinoma, or adenocarcinoma) when administered intratracheally or intrabronchially; bronchial carcinomas or squamous cell carcinomas after intrabronchial administration; and local tumours after intrapleural or intramuscular administration (IARC, 2012).

In rats, zinc chromates caused bronchial carcinomas when administered intrabronchially and local tumours when given intrapleurally, subcutaneously or intramuscularly. Strontium chromate also caused bronchial carcinomas when implanted intrabronchially, and local sarcomas when administered intrapleurally and intramuscularly in rats (IARC, 2012).

There are no available data for carcinogenicity following dermal exposure.

Occupational exposure to chromium(VI) has been associated with increased risk of respiratory system cancers, specifically in chromate production and chromate pigment production and use. Retrospective studies of chromate pigment production workers indicated elevated risks of lung cancer in nearly all the cohorts and subcohorts reported. A recent meta-analysis estimated an overall standardised mortality ratio of 1.41 for lung cancer among 47 studies of workers with possible chromium(VI) exposure (IARC, 2012).

Workers in chromate pigment production and spray painting were likely to have been exposed to lead and zinc chromates resulting in high risks. Workers in chromate production may have been exposed to calcium chromate (along with multiple soluble chromates) and were at the highest and most consistent excess risks. There were increased risks in diverse industries that involved exposure to multiple chromium(VI) compounds ranging from insoluble to highly soluble, which supports a general carcinogenic effect of chromium(VI) (IARC, 2012).

The International Agency for Research on Cancer (IARC) has classified chromium(VI) (without exception) as ‘Carcinogenic to humans’ (Group 1), based on sufficient evidence for carcinogenicity in humans and in animal testing (IARC, 2012).

Reproductive and Developmental Toxicity

The chemicals in this group are not expected to be systemically available due to poor bioavailability, which may explain the lack of reliable data on reproductive and developmental toxicity. Toxicologically significant amounts of insoluble chromium(VI) are unlikely to be transported to reproductive organs or developing foetuses as the compounds are poorly absorbed and tend to act at the site of exposure.

In repeated dose toxicity studies (described above), the treatment showed no significant effect on the weight or histology of reproductive organs.

Based on the limited information available, the chemicals in this group do not show specific reproductive or developmental toxicity. The available data do not support a classification for reproductive and developmental toxicity.

Other Health Effects

Neurotoxicity

Human exposure to high levels of airborne chromium(VI) in occupational and environmental settings produced symptoms of dizziness, headache, and weakness when the workers were over the chromate tanks. Additional studies are needed to provide conclusive information regarding the effect of chromium(VI) compounds on human neurological and behavioural changes (ATSDR, 2012).

Risk Characterisation

Critical Health Effects

The critical health effects for risk characterisation include systemic long-term effects (carcinogenicity, predominantly by inhalation), systemic acute effects (acute toxicity by inhalation exposure) and local effects (skin sensitisation). The chemicals in this group may also cause harmful effects following repeated exposure through inhalation, and harmful systemic effects following a single exposure from oral exposure.

Public Risk Characterisation

The chemicals in this group are currently listed on Schedule 6 of the SUSMP for preparations containing chromates. Barium, strontium and zinc chromates are excepted from the schedule when present in paints or tinters at at concentrations less than 5 % of the non-volatile content. A number of warning statements, first aid instructions and safety directions relating to the chemicals in this group apply. The chemicals in this group (barium, strontium and zinc chromates—CAS Nos 7789-06-2, 10294-40-3, 11103-86-9, 13530-65-9, 37300-23-5 and 50922-29-7) are also listed in the Uniform Paint Standard. The use of these chemicals in paints, which may be exposed to the public (see **Restrictions** section), at concentrations greater than 5 % is not permitted.

The current controls are considered adequate to minimise the risk to public health posed by domestic and cosmetic products containing the chemicals listed above, therefore, those chemicals are not considered to pose an unreasonable risk to public health.

Although the Schedule 6 entry for some chemicals in this group is appropriate, the schedule should be amended to align the restrictions on iron and calcium chromates with those of the other chemicals in this group. An amendment to *Appendix I—Uniform Paint Standard* is also supported to include iron and calcium chromates at concentrations greater than 5 % in the first Schedule. Both of these chemicals have similar or identical toxicity and solubility ranges to the chemicals currently listed, and notably both have potential use as pigments in the paint industry.

Occupational Risk Characterisation

During product formulation, dermal, ocular and inhalation exposure of workers to the chemicals may occur, particularly where manual or open processes are used. These may include transfer and blending activities, quality control analysis, and cleaning and maintenance of equipment. Worker exposure to the chemicals at lower concentrations may also occur while using formulated products containing the chemicals. The level and route of exposure will vary depending on the method of application and work practices employed.

Given the critical health effects (systemic long-term, systemic acute and local); the chemicals may pose an unreasonable risk to workers unless adequate control measures to minimise dermal, ocular and inhalation exposure are implemented. The chemicals should be appropriately classified and labelled to ensure that a person conducting a business or undertaking (PCBU) at a workplace (such as an employer) has adequate information to determine appropriate controls. The data available support an amendment to the hazard classification in HSIS (refer to **Recommendation** section).

NICNAS Recommendation

Further risk management is required. Sufficient information is available to recommend that risks to public health and safety from the potential use of the chemical in cosmetics and/or domestic products be managed through changes to poisons scheduling, and risks for workplace health and safety be managed through changes to classification and labelling.

Assessment of the chemical is considered to be sufficient provided that risk management recommendations are implemented and all requirements are met under workplace health and safety and poisons legislation as adopted by the relevant state or territory.

Regulatory Control

Public Health

Products containing the chemicals should be labelled in accordance with state and territory legislation (SUSMP).

It is recommended that an amendment to the current listing of the chemicals in the SUSMP be considered. Given the risk characterisation, it is recommended that:

- the inclusion in Schedule 6 and Appendix I be retained; and
- iron and calcium chromates be added to the list of exemptions in Schedule 6 and to the list of chromium compounds contained in the first Schedule of Appendix I.

Work Health and Safety

The chemicals in this group are recommended for classification and labelling under the current approved criteria and adopted GHS as below. This assessment does not consider classification of physical hazards and environmental hazards.

Note: It is proposed that the following hazard classifications be applied to all of the chemicals in this group. Some of the chemicals in this group have existing hazard classifications for certain endpoints (as per the table below).

Hazard	Approved Criteria (HSIS)[a]	GHS Classification (HCIS)[b]
Acute Toxicity	Harmful if swallowed (Xn; R22)* Toxic by inhalation (T; R23)	Harmful if swallowed - Cat. 4 (H302) Toxic if inhaled - Cat. 3 (H331)
Sensitisation	May cause sensitisation by skin contact (Xi; R43)*	May cause an allergic skin reaction - Cat. 1 (H317)
Repeat Dose Toxicity	Harmful: danger of serious damage to health by prolonged exposure through inhalation (Xn; R48/20)	May cause damage to organs through prolonged or repeated exposure - Cat. 2 (H373)
Carcinogenicity	Carc. Cat 1 - May cause cancer (T; R45)*	May cause cancer - Cat. 1A (H350)

[a] Approved Criteria for Classifying Hazardous Substances [NOHSC:1008(2004)].

[b] Globally Harmonized System of Classification and Labelling of Chemicals (GHS) United Nations, 2009. Third Edition.

* Existing Hazard Classification. No change recommended to this classification

Advice for consumers

Products containing the chemicals should be used according to label instructions.

Advice for industry

Control measures

Control measures to minimise the risk from oral, dermal and inhalation exposure to the chemicals should be implemented in accordance with the hierarchy of controls. Approaches to minimise risk include substitution, isolation and engineering controls. Measures required to eliminate or minimise risk arising from storing, handling and using a hazardous chemical depend on the physical form and the manner in which the chemical is used. Examples of control measures which may minimise the risk include, but are not limited to:

- using closed systems or isolating operations;
- using local exhaust ventilation to prevent the chemicals from entering the breathing zone of any worker;
- health monitoring for any worker who is at risk of exposure to the chemicals if valid techniques are available to monitor the effect on the worker's health;
- air monitoring to ensure control measures in place are working effectively and continue to do so;
- minimising manual processes and work tasks through automating processes;
- work procedures that minimise splashes and spills;
- regularly cleaning equipment and work areas; and
- using protective equipment that is designed, constructed, and operated to ensure that the worker does not come into contact with the chemical.

Guidance on managing risks from hazardous chemicals is provided in the *Managing risks of hazardous chemicals in the workplace—Code of practice* available on the Safe Work Australia website.

Personal protective equipment should not solely be relied upon to control risk and should only be used when all other reasonably practicable control measures do not eliminate or sufficiently minimise risk. Guidance in selecting personal protective equipment can be obtained from Australian, Australian/New Zealand or other approved standards.

Obligations under workplace health and safety legislation

Information in this report should be taken into account to assist with meeting obligations under workplace health and safety legislation as adopted by the relevant state or territory. This includes, but is not limited to:

- ensuring that hazardous chemicals are correctly classified and labelled;
- ensuring that (material) safety data sheets ((m)SDS) containing accurate information about the hazards (relating to both health hazards and physicochemical (physical) hazards) of the chemicals are prepared; and
- managing risks arising from storing, handling and using a hazardous chemical.

Your work health and safety regulator should be contacted for information on the work health and safety laws in your jurisdiction.

Information on how to prepare an (m)SDS and how to label containers of hazardous chemicals are provided in relevant codes of practice such as the *Preparation of safety data sheets for hazardous chemicals— Code of practice* and *Labelling of workplace hazardous chemicals—Code of practice*, respectively. These codes of practice are available from the Safe Work Australia website.

A review of the physical hazards of the chemicals has not been undertaken as part of this assessment.

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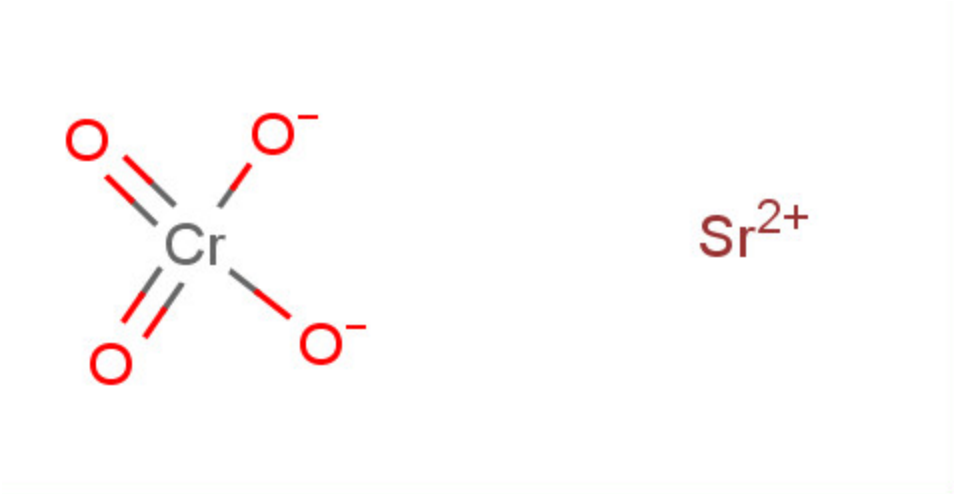
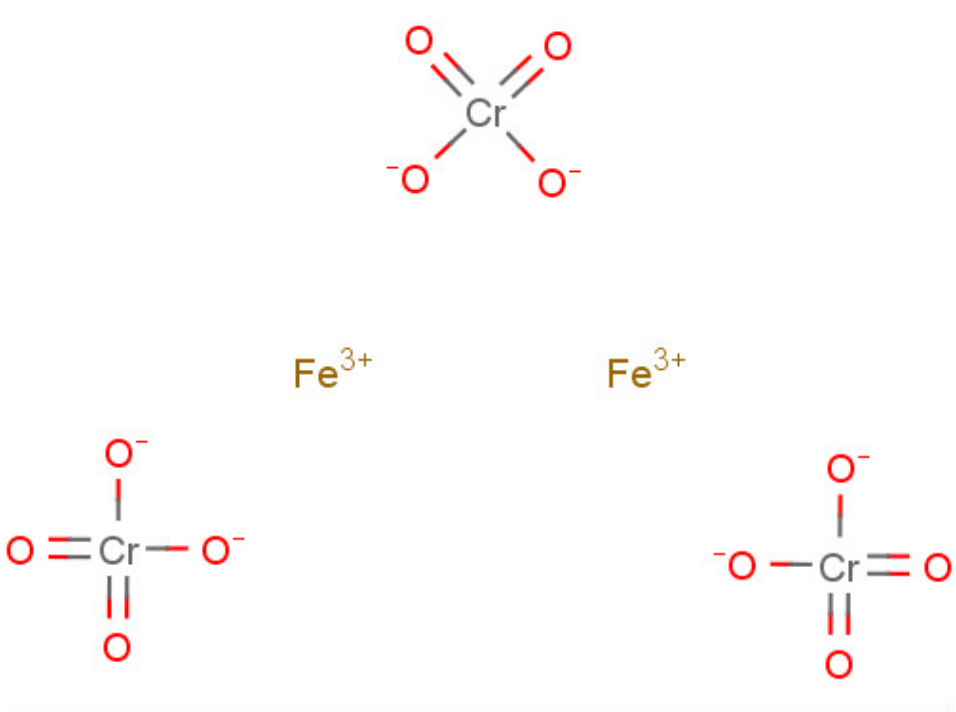
Last Update 02 March 2018

Chemical Identities

Chemical Name in the Inventory and Synonyms	**Chromic acid (H2CrO4), strontium salt (1:1)** Strontium chromate C.I. Pigment Yellow 32 Strontium yellow Strontium chromate(VI) Deep Lemon Yellow
CAS Number	7789-06-2
Structural Formula	

	
Molecular Formula	CrH2O4.Sr
Molecular Weight	203.61

Chemical Name in the Inventory and Synonyms	**Chromic acid (H2CrO4), barium salt (1:1)** Barium chromate Barium chromate(VI) Barium chromium oxide (BaCrO4) C.I. Pigment Yellow 31 CI 77103
CAS Number	10294-40-3
Structural Formula	
Molecular Formula	Ba.CrH2O4
Molecular Weight	253.32

Chemical Name in the Inventory and Synonyms	**Chromic acid (H2CrO4), iron(3+) salt (3:2)** Iron(III) chromate C.I. Pigment Yellow 45 Ferric chromate Diiron tris(chromate)
CAS Number	10294-52-7
Structural Formula	
Molecular Formula	CrH2O4.2/3Fe
Molecular Weight	459.67

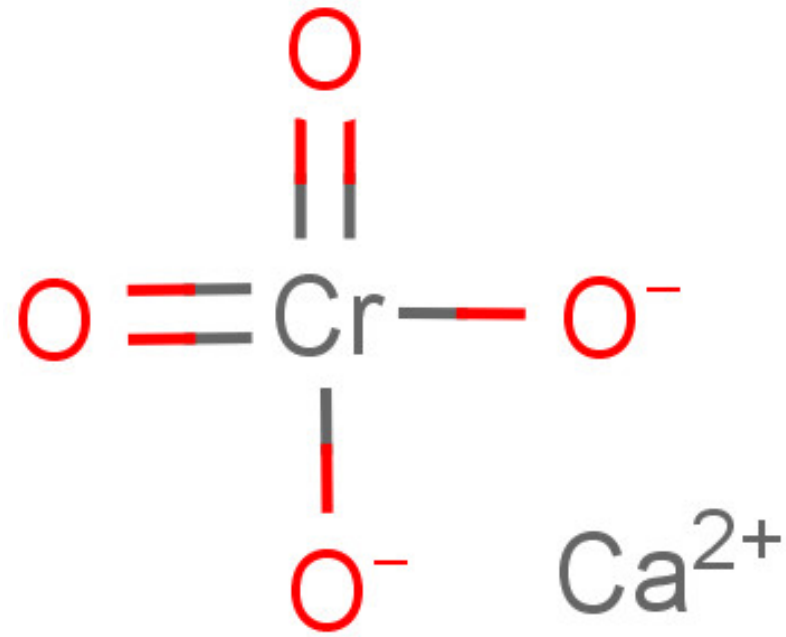
Chemical Name in the Inventory and Synonyms	**Chromate(1-), hydroxyoctaoxodizincatedi-, potassium** Zinc potassium chromate Potassium zinc chromate hydroxide Chromic acid, potassium zinc salt (2:2:1) Potassium zinc chromate hydroxide (KZn2(CrO4)2(OH))
CAS Number	11103-86-9
Structural Formula	

	
Molecular Formula	CrO4.HO.K.Zn
Molecular Weight	418.87

Chemical Name in the Inventory and Synonyms	**Chromic acid (H2CrO4), zinc salt (1:1)** Zinc chromate Zinc chromate(VI) hydroxide C.I. 77955 Zinc chromium oxide (ZrCrO4)
CAS Number	13530-65-9
Structural Formula	

	
Molecular Formula	CrH2O4.Zn
Molecular Weight	181.38

Chemical Name in the Inventory and Synonyms	**Chromic acid (H2CrO4), calcium salt (1:1)** Calcium chromate Calcium Chrome Yellow Calcium chromium oxide (CaCrO4) C.I. Pigment Yellow 33 Calcium chromate(VI)
CAS Number	13765-19-0
Structural Formula	

	
Molecular Formula	Ca.CrH2O4
Molecular Weight	156.07

Chemical Name in the Inventory and Synonyms	**C.I. Pigment Yellow 36** Zinc Yellow Chromic acid, zinc salt, compound with zinc hydroxide and chromium oxide (9:1) Zinc chromate Zinc potassium chromate hydrate Coprecipitated calcium and zinc chromates
CAS Number	37300-23-5
Structural Formula	

	No Structural Diagram Available
Molecular Formula	Unspecified
Molecular Weight	

Chemical Name in the Inventory and Synonyms	**Chromium zinc oxide** Basic zinc chromate Chromic acid, zinc salt, basic Chromium zincate Zinc chromite
CAS Number	50922-29-7
Structural Formula	**No Structural Diagram Available**
Molecular Formula	Unspecified
Molecular Weight	

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