LEAD CHROMATE

Toxics Link
for a toxics-free world

LEAD CHROMATE

Lead chromate, also called chrome yellow, is an inorganic compound with the chemical formula $PbCrO_4$. It is available naturally as the mineral crocoite and phoenicochroite. It can be produced commercially as well by combining sodium chromate with lead salts such as lead (II) nitrate or by combining lead (II) oxide with chromic acid. Lead Chromate can range in shade from lemon yellow to orange depending upon its particle size and state of hydration i.e., Pb(II) or Pb(IV).[1] Other lead chromate based pigments could produce by the addition of sulfate and molybdate, resulting in "lead sulfochromate" and "molybdate orange" respectively.

Lead chromate is available in trade names: *Cologne yellow, King's yellow, Leipzig yellow, Molybdate Orange, Molybdate Red, Chrome Vermilion, Vynamon Scarlet, Pigment Red 104, Paris yellow, C.I. Pigment yellow 34, C.I. 77600* and many more.

THE MOST IMPORTANT LEAD CHROMATE PIGMENTS ARE:

Primrose chrome - a pale greenish yellow pigment containing 45% - 55% lead sulphate. It has a metastable orthorhombic crystal structure that requires stabilization by the addition of additives.

Lemon chrome - a greenish yellow pigment, but redder than primrose, containing 20% and 40% lead sulphate (the more the sulphate, the greener the shade). It has a monoclinic crystal structure.

Middle chrome - a reddish yellow pigment, typically a pure lead chromate precipitated in the monoclinic structure.

Orange chrome - chemically this pigment is a basic lead chromate and contains no sulphate. It has a tetragonal crystal structure.

Lead chromate molybdate sulphate red - an orange or red crystalline pigment. It is a mixed-phase pigment. Each crystal is containing 69% to 80% lead chromate; 9% to 15% lead sulphate; 3% to 7% lead molybdate ($PbMoO_4$); and possibly 3% to 13% other substances.

APPLICATIONS

Lead chromate pigment is used for of its many advantages such as heat resistance, weather resistance, solvent resistance, bright color, insoluble in water and remarkable shading strength.[2] With these properties lead chromate is used as oxidizing agent, pigment, tanning agent, paints and coatings, etc. [3]

According to a market survey agency 40% of the global lead chromate market is for paints & coatings. The segment is expected to witness growth at a CAGR of 5.4% from 2022 to 2030 on account of growing construction activities in developing countries such as India, China, and Brazil. [4] These paints are also used industrially to protect surfaces and enhance their appearance such as in vehicle original equipment, vehicle refinish coatings, road traffic marking etc.[5]

Besides lead chromate is used as a pigment in paints, inks, and plastics. It is also used in the production of rubber and as a corrosion inhibitor in metal plating. The other major application includes its usage as an oxidizing agent or tanning agent for leather production.

Lead chromate can be used in pyrotechnics for use as a delay composition such as in making detonators for the mining and demolition sectors, to make a firework fire[6] in sequences, inmodel rockets to delay the firing of ejection charges, and to introduce a few seconds of time between triggering a hand grenade and its explosion etc.[7]

Lead chromate pigment has been used for food adulteration to enhance colour to brightly coloured yellow spices such as turmeric, curry powders and paprika.[8]

LEAD IN PAINTS

Lead has been intentionally added to paints as pigments, drying agents, and as anticorrosive agents. It may also present as impurities from raw materials. The commonly used lead pigments are lead chromate, lead oxide, lead molybdate, and lead sulphate. Paints contain driers such as lead octoate to make paints dry faster. Lead compounds such as lead tetroxide are also added to the paints used on metal surfaces to inhibit rust or corrosion.

EXPOSURE ROUTE

Ingestion and inhalation considered as the primary exposure pathways. Studies have reported nano-to micro-sized lead chromate in the atmospheric dust which via inhalation could reach the deepest part of the lungs due to their aerodynamic sizes hence can cause serious health impacts.[9]

Lead Chromate

Applications

- Lead paints
  - Decorative paints
  - Industrial paints
- Plastic & other synthetic polymers
- Printing ink
- Leather industry
- Pyrotechnics
  - Firework
  - Model Rockets
  - Hand granades
  - Detonator
- Ceramic glaze
- Artistic paints

Health impact

- respiratory effect
- neurological effects
- cardiovascular effects
- reproductive effects
- birth defects
- carcinogen
- behavioral and cognitive impairments

During production and use, lead chromate pigments leach into environmental matrices. It has been frequently found in both indoor and outdoor environments, such as roads, playgrounds, gates, and house dust.[10] Household decorative paints, and traffic paints have major contribution to this.

Research studies have reported leaching of lead chromate pigments from microplastics and their toxicological risks to aquatic organisms[11]. Recently high lead chromate in air of Korea was reported due to long-range transportation of PbCrO4 containing aerosols from Chinese industrial cities.[12]

Paints that contain lead chromate pigments are probably the most widespread source of lead exposure in young children. These paints often are used in and around homes, schools, and other places where young children live and play. Painted surfaces always weather, wear, and deteriorate over time. They are also often scraped or sanded prior to repainting. If the paint contains a lead chromate pigment, leaded paint fragments enter indoor dust and outdoor soil. Young children at play will dirty their hands with lead-contaminated dust and soil. They will, typically, put their hands in their mouths and suck on their fingers. When they do this, they ingest lead. Ingesting fragments of deteriorated lead paint is a well-documented, major lead exposure pathway for young children. Other uses of lead chromates are also potential sources of lead exposure.

HEALTH IMPACT

Lead chromate is a toxic chemical that can cause serious health problems on inhalation, ingestion or dermal absorption. Long-term exposure to lead chromate can lead to kidney and liver damage, reproductive problems, and neurological damage. It can also cause skin irritation and respiratory problems.[13]

Effects of short-term exposure:

the substance irritates the respiratory tract.

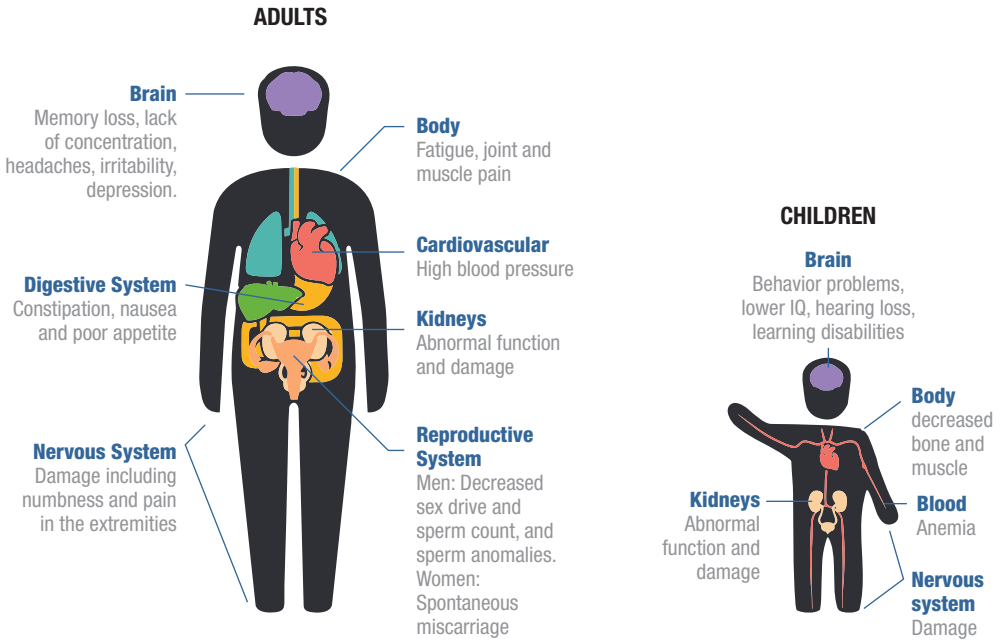
Effects of long-term or repeated exposure:

repeated or prolonged dermal exposure may cause dermatitis, and irritation, chronic ulcers, eczema. Similarly, repeated or prolonged inhalation may cause asthma. Lungs may be affected by repeated or prolonged exposure to dust particles. Once enter the body it may cause tissue lesions in affected organ. Lead chromate shown to have carcinogenic, cytotoxic, and genotoxic properties[14,15].

Both lead and chromium (VI) can accumulate in the body and impacts all the organ systems. Young children and pregnant women are most vulnerable to poisoning even at low concentrations because the nervous system of the child is in a developing stage.

Exposure to high levels of lead can cause severe damage to the brain, blood and kidneys. Children under six are most at risk from lead poisoning. Even low levels of lead exposure have been found to permanently reduce cognitive ability and cause hyperactivity in children.

Health Impacts of Lead



According to WHO there is no level of exposure to lead that is known to be without harmful effects.[16]

Children getting exposed to lead in early childhood are prone to reduction in cognitive abilities, dyslexia, attention deficit disorder and antisocial behavior.[17] Lead exposure can also lead to hypertension, renal impairment, immunotoxicity and toxicity to the reproductive organs. Absorption of large amounts of lead can cause coma, convulsions and even death. Children who survive severe lead poisoning can be left with permanent neurological injury such as deafness and mental retardation. [18]

REGULATION

Lead chromate pigments contain both lead and hexavalent chromium, and as such are defined by EPA as carcinogenic. It is regulated differently across the world and is restricted in some products.

Lead chromate is the main pigment used in paints & coating. Several countries including India has restricted lead concentration in household decorative paints to 90 ppm; however, use of pigment in general is allowed for other uses such as industrial application, road/traffic marking etc.

In the European Union, lead chromate is classified as a substance of very high concern and is subject to authorization for use.[19] Its use in household paints, artists' paint and road marking has been restricted. Lead chromate, lead sulfochromate yellow (CI Pigment Yellow 34) and Lead chromate molybdate sulfate red (CI Pigment Red 104) may not be placed on the market for supply to the general public; however, their use by professionals is allowed (REACH, 2015).

In the United States, the Environmental Protection Agency (EPA) has classified lead chromate as a hazardous air pollutant and has set limits on its emissions. Although there is no direct restriction on lead chromate but the use of lead carbonate and lead sulphate and any other products containing these pigments are prohibited. The regulations prohibit the manufacture, import, distribution and marketing of paints, inks, lacquers and varnishes with a content of lead greater than 600 mg/kg (600 ppm) of dry residue of the paint. (WHO, Global Data, 2023).[20]

In Canada, lead chromate is listed as a toxic substance and is subject to the Canadian Environmental Protection Act. Its use is completely prohibited in cosmetics[21]. Besides house hold paints, Canada Consumer Product Safety Act has also set the migration limits for lead ranging from 0.5 to 4 mg/L for various product categories of glazed ceramics and glassware.[20]

The lead chrome pigments boasts exceptional tinting strength, combined with outstanding opacity and brilliance that acts as a major challenge in the substitution with other yellow pigments in a straightforward 1:1 ratio without sacrificing optical quality. Additionally, cost-competitiveness further compounds the difficulty of addressing the issue, especially within low-to middle-income nations.[22]

However, considering the health impact it is the need of hour to advocate for listing of lead chromate in Rotterdam Convention. If the Rotterdam Convention lists lead chromates and makes them subject to its PIC procedure, governments and others – around the world – will begin to closely scrutinize all the uses of lead chromates.[23]

STATUS IN INDIA

In India, FSSAI has given guidelines to avoid lead chromate in spices[24], and there is a BIS standard on specification for lead chromate for explosive and pyrotechnic compositions; however besides that there is no restriction on use of lead chromate.

Since there is no specific HS code for lead chromate its not possible to estimate actual data on production, export and import. Though, there are several manufacturer in India for lead chromate.

Sona Synthetics Products (Gujarat), Kolor Jet Chemical Pvt. Ltd. (Mumbai), Renu Colour Company (Telangana), Anupam Colours and Chemicals Industries (Mumbai), Vibfast pigments Pvt.Ltd (Gujarat), Swastik Interchem Pvt. Ltd. (Delhi) etc. are some major manufacturers of lead chromate.[25]

To regulate the exposure of lead, the government of India has notified the "Regulation on Lead contents in Household and Decorative Paints Rules, 2016"on 1st November, 2016 which came into force from 1st November, 2017.[26]

ALTERNATIVES

Lately, a great effort has been dedicated globally to substitute lead chromate with eco-friendly and safe options. However, there is no direct countertype is available and therefore each formulation containing lead chromate has to be adjusted with proper alternatives based on its application. Different types of yellow inorganic pigments based on complex metal oxides have been recently synthesized.[27],

These alternatives aim to provide vibrant colors without the harmful effects of lead. Some common alternatives to lead chromate pigments include[28],[29]:

Hansa Yellow (Arylide Yellow): organic pigments that offer a range of bright yellow to orange-yellow hues. They are widely used as alternatives to lead chromate pigments in various applications, including paints, plastics, and inks.

Quinacridone Pigments: organic pigments that come in various shades, including bright yellows and oranges. They are used in paints, inks, and plastics as lead chromate alternatives.

Isoindoline Pigments: organic pigments known for their bright and lightfast colors. They are used in various applications, including plastics and coatings.

Salient features of the regulations are:

Prohibition:
Prohibition of manufacturing, trade, export and import of household and decorative paints containing metallic load in concentration excedding 90 parts per million.

Self-Certification:
Household and decorative paints manufactured or imported after November, 2017 should have the label:
"Lead contents do not exceed 90 parts per million" along the manufacturing/importing data.

Transitory Provision:
A time period of two years had been allotted to paint manufactures before the commencement of the rules to sell off old stock and further comply with the legislations.

Testing:
The manufacturers and importers are also required to get their products tested once a year before putting them in the supply chain. The rules have also identified. The Central Power Research Institute as the authorized testing agency.

Bismuth Vanadate (BiVO4): non-toxic inorganic yellow pigment that provides vibrant yellow to greenish-yellow shades. It can be used in coatings and plastics due to its excellent color fastness and opacity.

Nickel Titanate Yellow (NiTiO3): inorganic non-toxic yellow pigment that can be used as an alternative to lead chromate in some applications.

Mixed Metal Oxides: Various mixed metal oxide pigments have been developed to replace lead chromate pigments. These pigments typically combine different metal elements to achieve the desired color and properties while avoiding the use of toxic lead. For example iron oxide and cadmium sulfide. They can provide yellow and red shades and can be used as alternatives to lead chromate in specific applications.

Strontium Chromate (SrCrO4): inorganic pigment. It is commonly used in aerospace and corrosion-resistant coatings.

ENDNOTES

1 https://training.itcilo.org/actrav_cdrom2/en/osh/ic/7758976.htm

2 Gao H., Li H., Zhou X., Wei J., Qu X., Long T. Effect of low molecular weight organic acids on the lead and chromium release from widely-used lead chromate pigments under sunlight irradiation. Environ Pollut, 2023. 337: 122553. https://doi.org/10.1016/j.envpol.2023.122553.

3 https://mubychem.com/leadchromatemanufacturers.html

4 https://dataintelo.com/report/global-lead-chromate-market/

5 Turner A., Filella M. Lead and chromium in European road paints. Environ Pollut, 2023. 316: 120492

6 Hickey C, et. al. Toxicity of particles emitted by fireworks. Part Fibre Toxicol, 2020. 17(1):28

7 https://ipen.org/sites/default/files/documents/controlling_lead_chromate_pigments_may_2023.pdf

8 Jenna E. Forsyth, et. al. Sources of Blood Lead Exposure in Rural Bangladesh. Environ. Sci. Technol, 2019. 53 (19): 11429-11436

9 Meza-Figueroa D., et.al. Source apportionment and environmental fate of lead chromates in atmospheric dust in arid environments. Sci Total Environ,2018. 630: 1596-1607.

10 Turner, A., Kearl, E.R., Solman, K.R. Lead and other toxic metals in playground paints from South West England. Sci Total Environ, 2016. 544: 460-466.

11 Luo H., Li Y., Zhao Y., Xiang Y., He D., Pan X. Effects of accelerated aging on characteristics, leaching, and toxicity of commercial lead chromate pigmented microplastics. Environ Pollut 2020. 257:113475

12 Lee PK., Yu S., Chang, H. et al. Lead chromate detected as a source of atmospheric Pb and Cr (VI) pollution. Sci Rep, 2016. 6: 36088.

13 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7657991/

14 https://www.epa.gov/sites/default/files/2016-09/documents/chromium-compounds.pdf

15 Singh J, Pritchard DE, Carlisle DL, Mclean JA, Montaser A, Orenstein JM, Patierno SR. Internalization of carcinogenic lead chromate particles by cultured normal human lung epithelial cells: formation of intracellular lead-inclusion bodies and induction of apoptosis. Toxicol Appl Pharm, 1999. 161: 240–248.

16 https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health

17 Daneshparvar M, Mostafavi SA, Zare Jeddi M, Yunesian M, Mesdaghinia A, Mahvi AH, Akhondzadeh S. The Role of Lead Exposure on Attention-Deficit/ Hyperactivity Disorder in Children: A Systematic Review. Iran J Psychiatry, 2016.11(1):1-14.

18 Concerns and challenges of Lead in Paints in India, Toxics Link, 2018

19 https://echa.europa.eu/substance-information/-/substanceinfo/100.028.951

20 https://cdn.who.int/media/docs/default-source/gho-documents/public-health-and-environment/ech-lead-regulations-database-update-31-march-2023---final.xlsx?sfvrsn=8850977f_1

21 https://www.ec.gc.ca/ese-ees/418C7DBB-BF72-42A1-BD7C-27CD8AFE29AD/batch2_1344-37-2_pc_en.pdf

22 Mahmoodi A, Jiryaei Z, Dadras A, Khorasani M, Shi X. A hybrid yellow nanopigment as an environmentally sound alternative to lead chromate pigment for pavement markings. J Clean Prod, 2021. 319: 128733

23 https://ipen.org/sites/default/files/documents/controlling_lead_chromate_pigments_may_2023.pdf

24 https://fssai.gov.in/…/Compendium_Food_Additives_Regulations_29_03_2019.pdf.

25 https://www.benzinga.com/pressreleases/23/09/34251930/basic-lead-chromate-market-trends-industry-analysis-and-growth-projections-through-2030

26 http://www.moef.nic.in/sites/default/files/final%20notification_Lead%20in%20Paints.pdf

27 Elakkiya V., Sumathi S. Low-temperature synthesis of environment-friendly cool yellow pigment: Ce substituted SrMoO4. Mater Lett, 2020. 263: 127246.

28 Ali Mahmoodi, Zahra Jiryaei, Ayda Dadras, Manouchehr Khorasani, Xianming Shi. A hybrid yellow nanopigment as an environmentally sound alternative to lead chromate pigment for pavement markings, Journal of Cleaner Production, 2021. 319: 128733

29 https://wedocs.unep.org/bitstream/handle/20.500.11822/22855/Module%20E%20Lead%20alternatives_FINAL.pdf?sequence=1&isAllowed=y

For more information, please contact:

Toxics Link
E-224, 1st Floor,
East of Kailash
New Delhi – 110065
E: info@toxicslink.org

Supervised by

Piyush Mohapatra; piyush@toxicslink.org

Research and Compiled by

Alka Dubey, alka@toxicslink.org