Industry Day Theme #3: Sustainable Environment

IIT DELHI INDUSTRY DAY 2019

A Review of Alternate Production Approaches for Indian Chromate Industries towards Reducing Chromite Ore Processing Residue (COPR)

Shiva Kumar Gummadivalli, Arvind K. Nema*

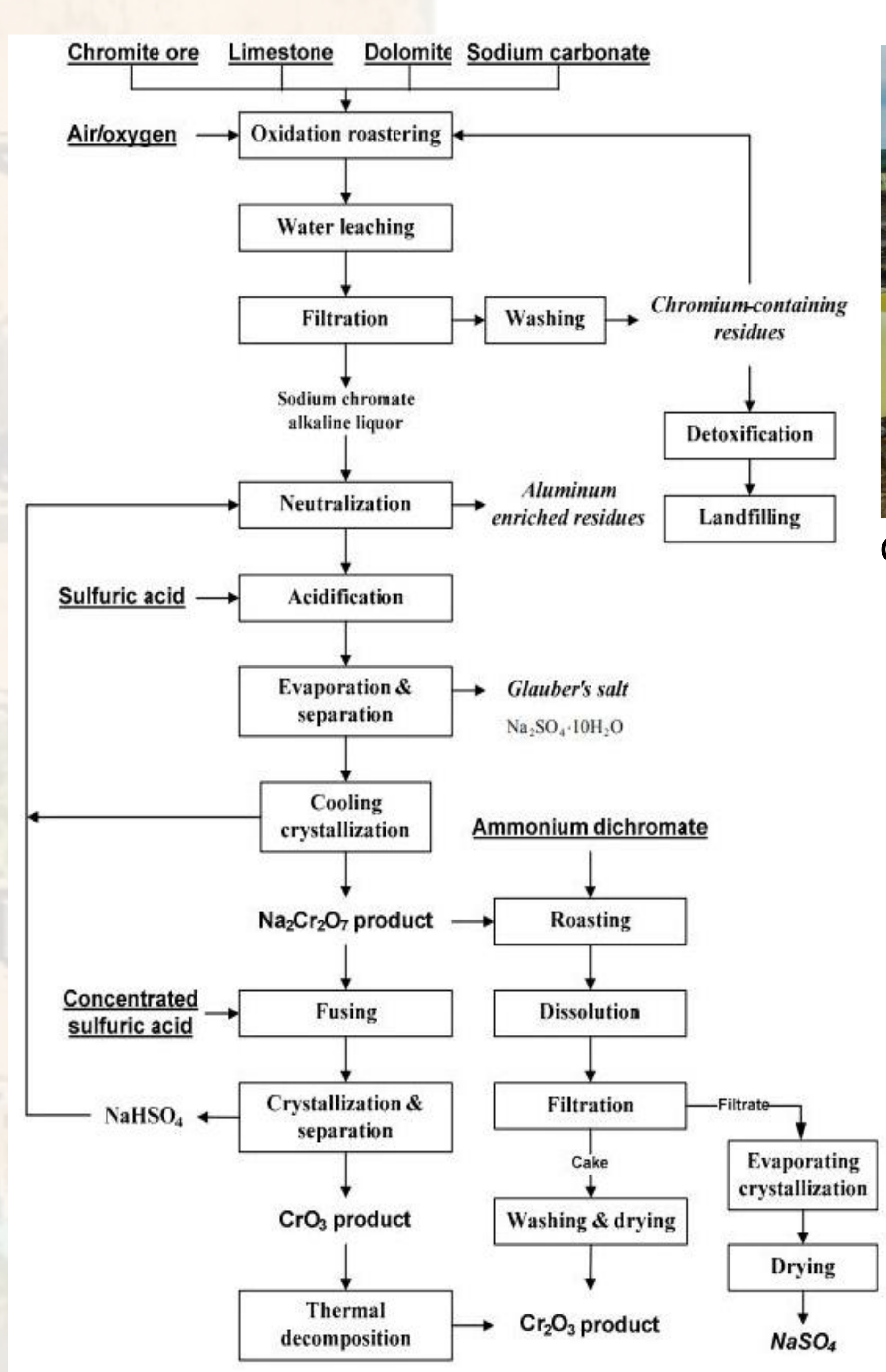
Department of Civil Engineering, IIT Delhi

Abstract

Current methods for processing chromite ore for manufacture of Chromates, Chromic Oxide or other Chromium-containing compounds present an extremely serious set of environmental problems associated with waste management and disposal. In comparison to traditional pyrometallurgical processes (i.e. Soda-ash alkaline roasting), many hydrometallurgical methods yield higher chromate yields with decreased quantities of hexavalent chromium in Chromite Ore Processing Residues(COPRs); and hence, should be implemented as environmentally friendly alternatives of conventional operations. Widespread implementation of these new methods can help in drastically decreasing the amount of COPR generated, while enhancing the range of Chromium recovery/conversion/leaching efficiency (from ore to product) from existing values of 74-76% to ≥ 97%. Instead of being a toxic waste and an environmental burden, The COPR produced in some of these new methods (like pressure oxidative leaching) can have an economic value. Furthermore, these methods are highly clean, relatively cheap to implement, less energy intensive and remarkably resource efficient compared to the traditional technologies. The policy interventions should be altered such that the decision-making authorities, regulatory bodies and other involved stakeholders should gradually shift towards complete implementation of these hydrometallurgical methods, while also focusing the inclusive concepts of industrial ecology and industrial symbiosis.

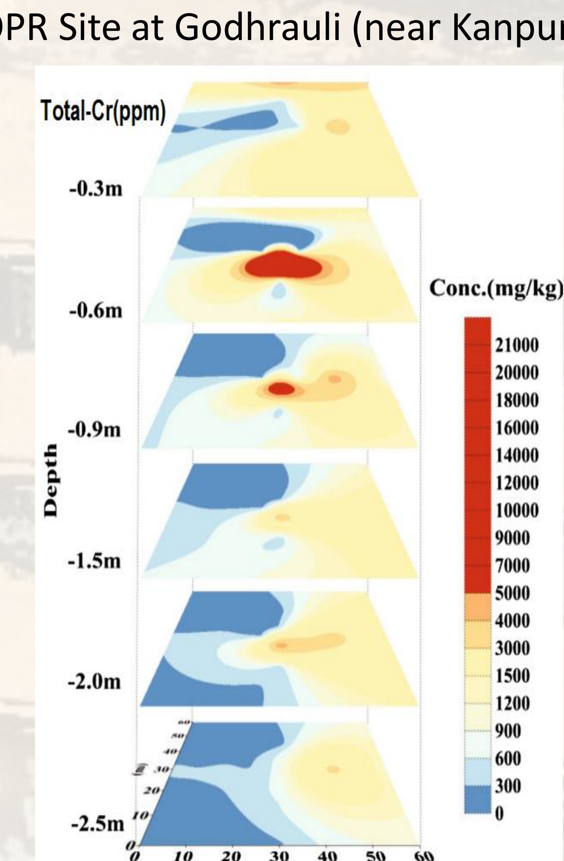
Introduction

Conventionally, In Indian Scenario, Chromite Ore Processing Residue (COPR) is a by-product of the chromite ore high-temperature lime-based roasting process, which was widely used to isolate and extract soluble chromate (CrO_4^{2-}). Limestone and Dolomite were added to chromite ore which is processed by roasting with sodium carbonate in a rotary kiln at 1200°C. The discharge of large amount of chromium-containing gases and dusts creates serious pollution and health risk. The process yields only ~75% of Cr in the ore, with the COPR quantities being 2.5-3.0 tons discharged per ton of chromate product. Furthermore, hexavalent chromium (that causes significant environmental pollution) is present in COPR at significantly high concentrations. These toxic chromium-containing residues are difficult to be detoxify. Another problem with the process is the production of by-products that are not valuable. The chromium-containing Glauber's salt and sodium bisulfate produced are of little use and constitute a pollution source.



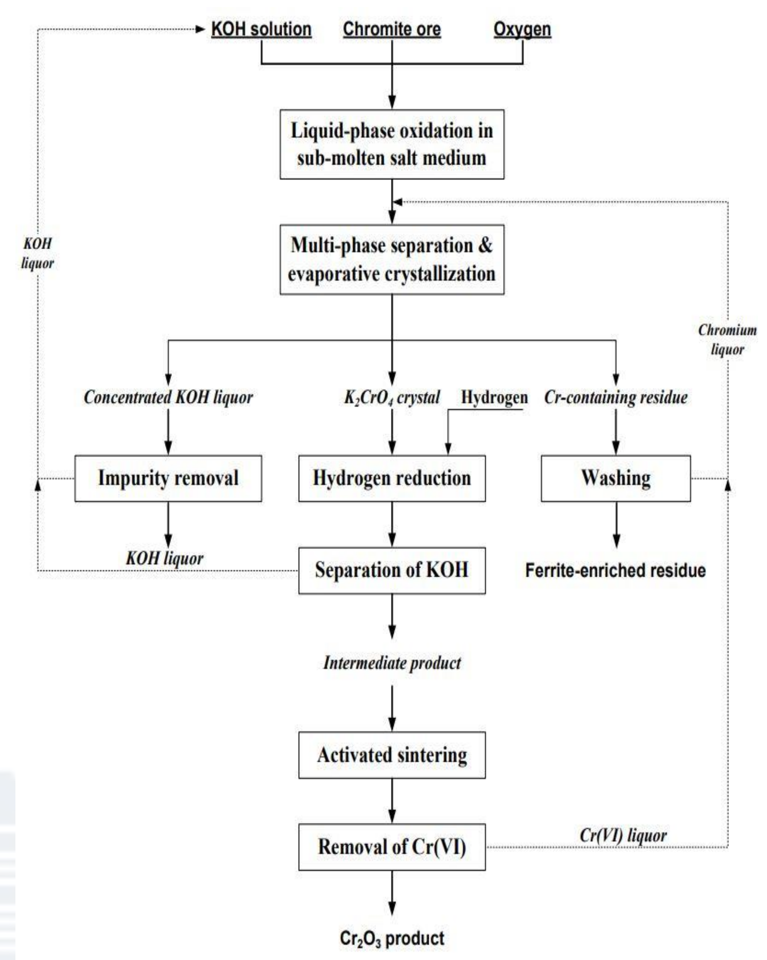
Traditional Production Process for Chromium Compounds

COPR Site at Godhrauli (near Kanpur), India

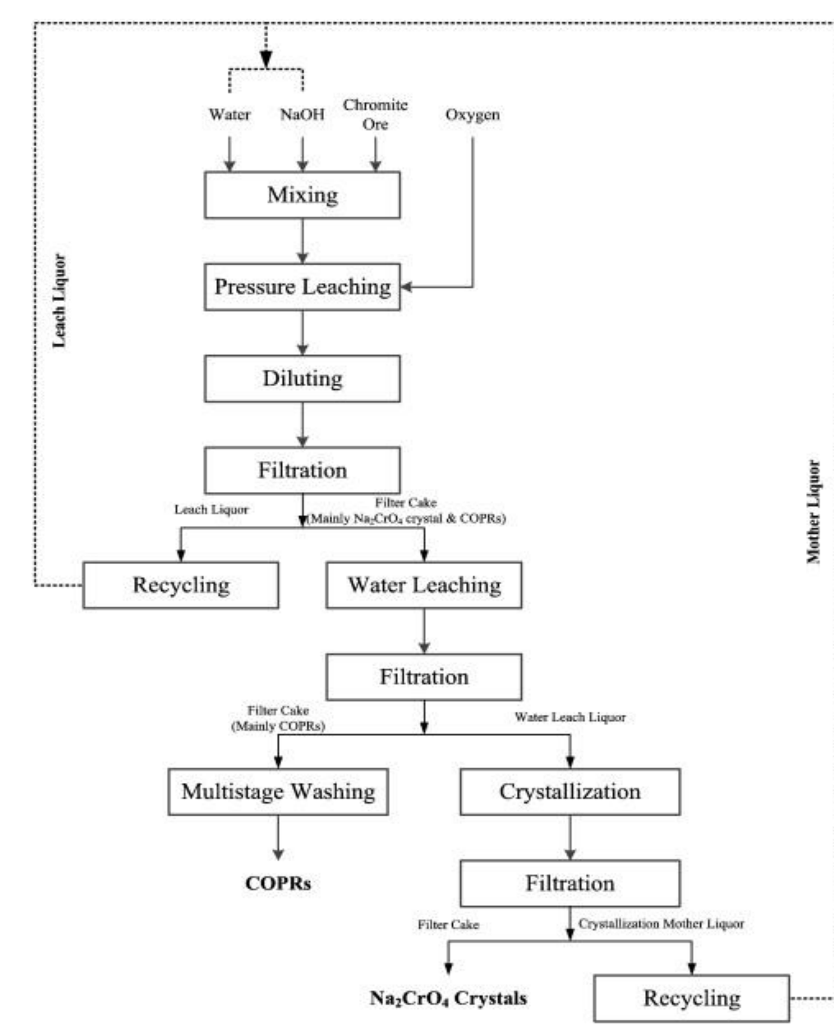


Vertical Cr distribution — Yunnan, China *(Zhou et al., 2017)*

Methods



Clean Production Process of Chromic Oxide that include liquid-phase oxidation in Sub-Molten Salt (SMS) medium (Zhang et al., 2008)



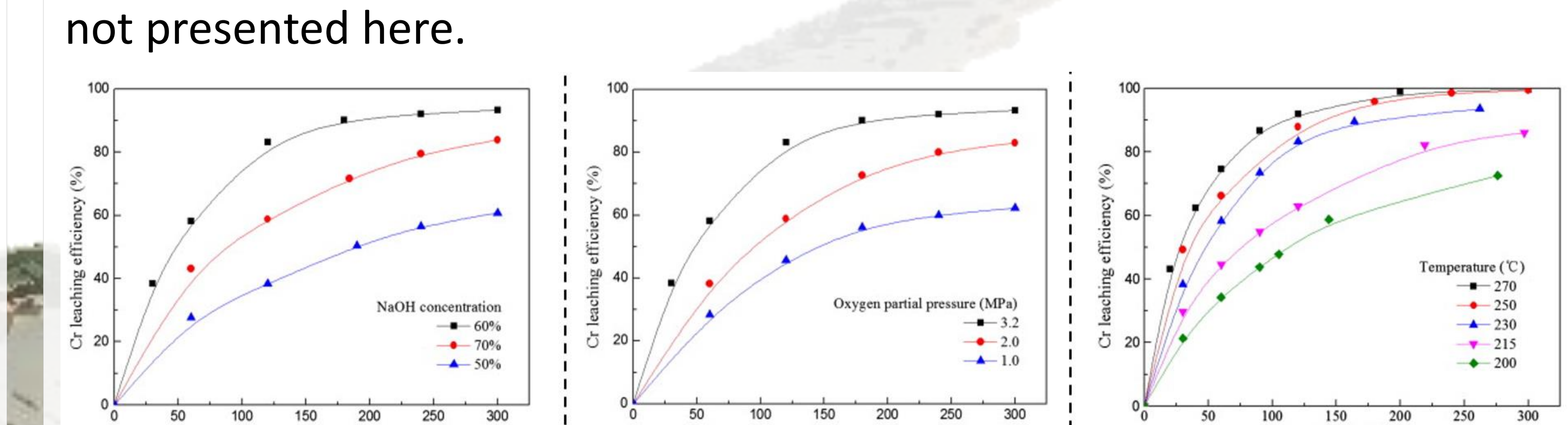
Process flowchart for the preparation of Na_2CrO_4 products on the basis of the pressure oxidative leaching process (Zhang et al., 2014)

The results corresponding to the underlying kinetics with equilibrium calculations, mineral morphology, lab-scale experimentations, thermodynamic analysis, energy and resource efficiency, and COPR characterization have been presented in detail by Zhang et al., 2008; Zhang et al., 2014.

Item	Traditional Process	Clean process proposed by Zhang et al., 2008	Clean process proposed by Zhang et al., 2014
Chromium conversion, %	75	98	99
Reaction temperature, °C	1200	300~350	250
Resource utilization, %	15	90	—
Chromium-containing residue amount, t/t	2.0	0.5-0 (final zero emission)	0.5-0 (Ferrite enriched residue)
Energy consumption	—	Decreased by 20%	—
Production cost	—	Decreased by 17%	—
O_2 Partial Pressure	Atmospheric	—	3.2 MPa

Results

The results for the method proposed by Zhang et al., 2014 on Indian Chromite are presented below. The results f the Zhang et al., 2008 are not presented here.



Industrial Significance

- The methods presented here are economical and sustainable while providing environmental compliance for chromate and chromium industries

Technology Readiness Level:

- A demonstration plant with an annual production capability of 2,000 tons of chromic oxide has been built in China with the technology presented by Zhang et al., 2008

References

- Zhou, G., Yin, X., Zhou, J., & Cheng, W. (2017). Speciation and spatial distribution of Cr in chromite ore processing residue site, Yunnan, China. Acta Geochimica, 36(2), 291-297
- Zhang, Yi., Zuo-hu LI, Hong-bin XU, Shi-li ZHENG, Tao QI. (2008). A Clean Production Process of Chromic Oxide. AIChE. The 2008 Annual Meeting Philadelphia. Industrial Innovation in Process Design (10A02). https://pdfs.semanticscholar.org/2864/3c5d3b8a87312c0b83208d8efefda23e6b2d.pdf
- Zhang, H., Xu, H. B., Zhang, X., Zhang, Y., & Zhang, Y. (2014). Pressure oxidative leaching of Indian chromite ore in concentrated NaOH solution. Hydrometallurgy, 142, 47-55