Department of Materials Science and Engineering Seminar Series 2025

Optimization of Extractive Recovery of Sn from Tin Ore while Ta and Nb from Tin Slag

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Date and time: 26th Jan 2026 (2 pm - 4 pm)

Venue: E7-03-06 - Seminar Room 1

Abstract

This research outlines a comprehensive three-project initiative aimed at optimizing the extractive recovery of tin from tin ore while subsequently recovering tantalum and niobium from tin slag, addressing key challenges in modern tin metallurgy and critical metal recovery. The study focuses on fundamental operational improvements in primary tin extraction processes while developing value-added recovery pathways for strategic metals, responding to market demands for efficiency enhancements and critical metal security. This approach integrates tin metallurgy optimization with critical metal recovery.

The first project focuses on improving tin smelting performance in the ISASMELT furnace, a Top Submerged Lance (TSL) technology successfully adapted for tin smelting operations. The main objectives include establishing process control parameters to optimise smelting temperature and tin metal yield, resolving pyrophoric fume formation in filter baghouses, and extending the lifespan of refractory bricks. The experimental approach involves assessing the influence of Sn/Fe ratios in the input materials prior to smelting, moving beyond traditional slag-chemistry control during operation. Initial results from 156 batches of continuous process trials showed that specific Sn/Fe ratio ranges, combined with controlled tin content in fume and tin yield in fume, significantly extended refractory life and enhanced overall smelting performance.

The second project aims to enhance the efficiency of tin smelting in rotary furnaces, which offer high flexibility in processing various feedstocks, making their efficiency comparable to that of ISASMELT furnaces. Key challenges include developing standardized slag chemistry to meet minimum smelting temperature requirements and controlling slag chemistry to produce final slag containing less than 2% tin, while also extending refractory life. The innovative method involves adding sodium carbonate as a flux, leveraging the Na_2O-SiO_2 binary phase diagram to create a liquid slag bath at lower temperatures (800-1000°C). Experimental results showed that using specific Na_2O/SiO_2 ratios and controlling ternary phase diagram parameters (SiO_2-CaO-FeO) allowed operation at reduced operable temperatures (1100-1200°C) with a tin metal yield of 96%, comparable to ISASMELT furnace performance. Additionally, erosion tests showed that slag from the rotary furnace caused significantly less erosion of refractory bricks compared to slag from the ISASMELT furnace, which generally has conventional slag chemistry.

The third project aims to enhance the extraction of tantalum and niobium from tin slag by tackling the challenge of recovering critical metals from low-grade waste streams with greener chemicals. This study explores the potential of deep eutectic solvents (DES) as an environmentally friendly alternative to hydrochloric acid (HCl), which is often considered as a substitute for hydrofluoric acid (HF), for leaching niobium (Nb) and tantalum (Ta) from tin slag. The DES, made from choline chloride (ChCl) and citric acid (CA), was optimized across different molar ratios (2:1, 1:1, 1:2), temperatures (40–80°C), and leaching duration (4 hours), while HCl was tested at concentrations of 2–4 M. Characterisation of the tin slag via EDX and XRD revealed diverse elemental compositions and confirmed the presence of Nb and Ta, mainly in oxide forms. Roasting with NaOH increased leaching efficiency by converting oxides into soluble sodium niobate ($NaNbO_3$) and tantalate ($NaTaO_3$). The best performing DES (1:1 ChCl:CA, 80°C) achieved leaching efficiencies exceeding those of HCl (4 M, 60°C). EDX analysis of the residues post-leaching showed a decrease in Nb/Ta content, confirming successful extraction. The precipitation of both elements with ammonia solution has been studied. At the same time, future work should focus on the optimal precipitation method, the reusability of the DES, and the feasibility of scale-up for industrial applications.

The integration of these three projects represents a holistic approach to tin metallurgy that simultaneously addresses primary extraction efficiency and secondary value recovery.

Biography

Professional Biography

Wong Kin Nyap is the Chief Technology Officer at Malaysia Smelting Corporation Berhad, where he spearheads innovation in tin smelting and mining technologies and develops next-generation extraction methodologies for gold and rare earth elements. An accomplished materials engineer and technology leader, he brings over 15 years of progressive experience in research and development across multiple industrial sectors, with demonstrated expertise in translating advanced technological concepts into production-scale applications.

HOST: Asst Prof Zhao Ming