

Oxidative Removal of Thallium(I) from Wastewater by Recycled Aluminum Beverage Cans

Recycled aluminum beverage can powder facilitates oxidation-precipitation of thallium(I).

Thallium (Tl) is an emerging environmental pollutant. The research group of Yu-Ting Liu (National Chung-Hsing University) used recycled aluminum (Al) beverage cans to remove Tl(I) from wastewater and determined the removal mechanism using X-ray absorption spectroscopy at TPS 44A.¹ Because of the low solubility of Tl(III), oxidation-precipitation is regarded as a promising method for the Tl(I) removal. Recycled Al beverage can powder (AICP) was applied as the substitute for zero-valent Al (ZVAI) to catalyze a Fenton-like reaction for Tl(I) oxidation. The system was subsequently alkalized to a pH of 9.5 to induce the precipitation of Tl(III) (Fig. 1).

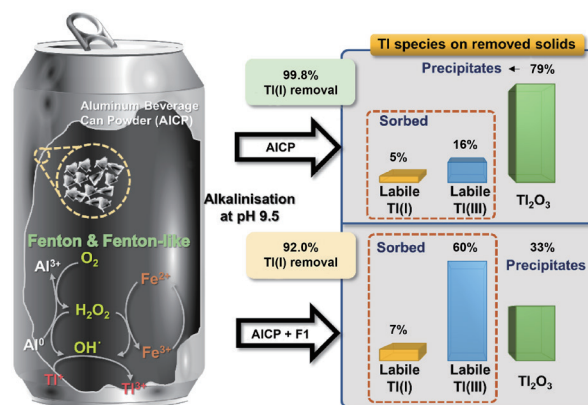
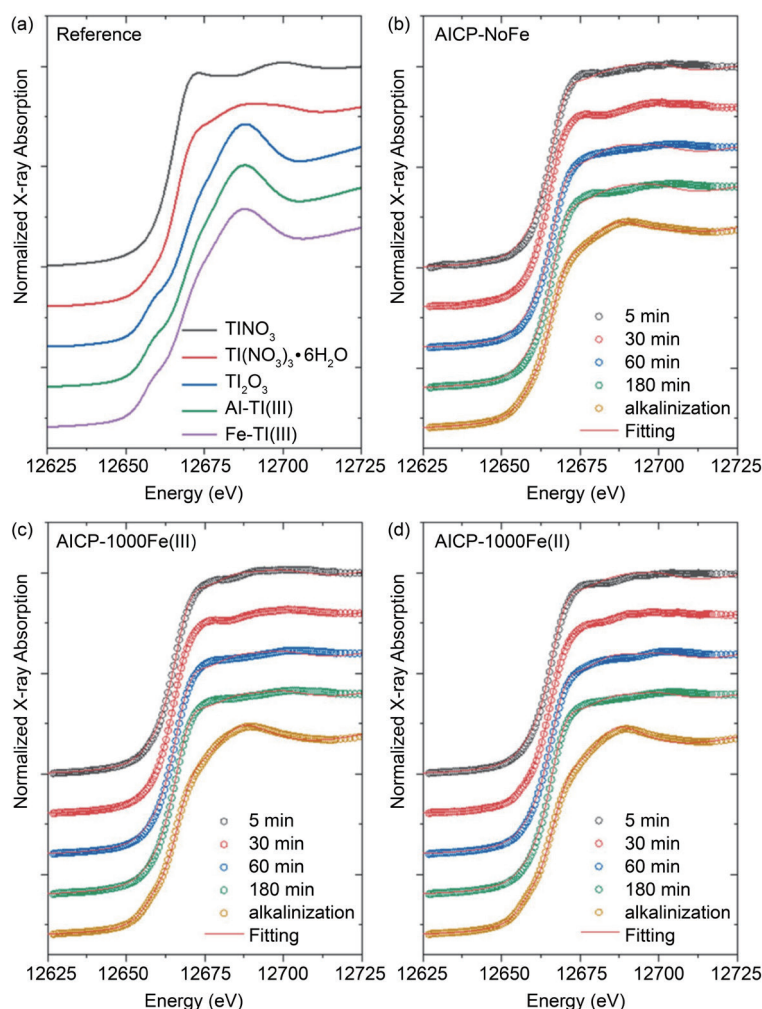


Fig. 1: Schematic illustration for the mechanism underlying Tl(I) removal and the chemical species of Tl on solids precipitated upon alkalization. [Reproduced from Ref. 1]

In the oxidation process, the addition of Fe(III)/Fe(II) into the AICP system increased Tl(I) oxidation as compared with that of pure AICP; however, Fe was detrimental to Tl removal during alkalization. The highest Tl(I) removal efficiency of the AICP/Fe(III)/Fe(II) system was approximately 92%, whereas that of pure AICP was 99.8% (Fig. 1). To clarify the removal mechanism, Tl L₃-edge X-ray absorption near edge structure (XANES) data were acquired to investigate the distribution of Tl chemical species on the removed solids (Fig. 2). The XANES results indicated that although Tl(III) dominated the Tl inventory (92–95%) on all solids obtained upon alkalization, it was prone to precipitate as stable Tl₂O₃ in

Fig. 2: Normalized Tl L₃-edge XANES spectra for (a) references, including labile Tl(I) (TlNO₃), labile Tl(III) [Tl(NO₃)₃·6H₂O], Tl(III) precipitates: Tl₂O₃, Al/Tl(III) coprecipitate [Al-Tl(III)], and Fe/Tl(III) coprecipitate [Fe-Tl(III)]. The Tl-XANES data for solids obtained during the incubation (5–180 min) of 100 μM Tl(I) in oxic and acidic (pH 1.0) suspensions containing (b) only 8 g L⁻¹ AICP (AICP-NoFe) and (c,d) both AICP and 1,000 μM Fe(III)/Fe(II) [AICP-1000Fe(III)/Fe(II)] as well as for that collected upon alkalization are showed as open circles along with the linear combination fitting results showed as solid lines. [Reproduced from Ref. 1]



the pure AICP system but occur as labile Tl(III) in the AICP/Fe(III)/Fe(II) system. Such labile Tl(III) may be sorbed on the precipitated Al (hydr)oxides and is subject to reduction and further dissolution, accounting for the lower removal efficiency for Tl(I) in the presence of Fe(III)/Fe(II).

With the combination of Tl speciation for both dissolved and solid phases, this study shed light on the oxidative removal mechanisms of Tl(I) by means of the ZVAI-based Fenton-like reaction. The comparable Tl(I)-removal efficiency between AICP and other state-of-the-art (nano) composites provides a niche opportunity to co-benefit the hazard remediation and waste reduction/reuse. (Reported by Yu-Ting Liu, National Chung-Hsing University and Liang-Ching Hsu, NSRRC)

This report features the work of Yu-Ting Liu and her collaborators published in *Chem. Eng. J.* **427**, 130846 (2022).

TPS 44A Quick-scanning X-ray Absorption Spectroscopy

- Quick-scanning X-ray Absorption Spectroscopy
- Environmental and Earth Sciences, Materials Science, Chemistry

Reference

1. K.-Y. Chen, Y.-M. Tzou, L.-C. Hsu, J.-W. Guo, Y.-L. Cho, H.-Y. Teah, Y.-C. Hsieh, Y.-T. Liu, *Chem. Eng. J.* **427**, 130846 (2022).

Accumulation of Gallium in Paddy Rice

Gallium (Ga) released from the semiconductor industry may accumulate in soil and eventually in rice plants. X-ray absorption spectroscopy helps elucidate the translocation of Ga in soil-rice systems.

Shan-Li Wang (National Taiwan University) and his colleagues recently elucidated gallium (Ga) speciation in soils and its accumulation in rice plants (*Oryza sativa* L.) grown in Ga-contaminated soils. Ga released from the semiconductor industry is an emerging environmental contaminant. The presence of Ga has been detected in primary staple crops, such as rice and wheat, grown in Ga-contaminated soils. Therefore, humans are at the risk of Ga exposure through staple crops. However, our understanding of the fate of Ga in soil-plant systems and the potential risk of Ga contamination of soils remains limited. To elucidate the mechanisms underlying the uptake and accumulation of Ga in rice plants, Wang's team used X-ray absorption spectroscopy (XAS) at **TLS 17C1** to explore Ga speciation in three types of soil, acidic clay (Pc), acidic sandy loam (Tn), and alkaline clay (Tk), treated with varying amounts of Ga. The roots, shoots, and grains of rice plants grown in these soils were collected at different phases of rice cultivation and analyzed to determine the corresponding Ga concentrations. The Ga concentrations of the roots of rice plants grown in Pc, Tn, and Tk soils treated with 1.0 mmol kg^{-1} Ga were, respectively, 74.1, 149.3, and 39.0 mg kg^{-1} on day 45, and 25.1, 55.6, and 24.5 mg kg^{-1} on day 100 (**Fig. 1(a)**). The Ga concentrations of the shoots were 3.8–15.9 and 2.5–23.4 mg kg^{-1} on days 45 and 100, respectively (**Fig. 1(b)**). Furthermore, the Ga concentration of the grains of rice grown in the three soils was 0.3–1.9 mg kg^{-1} (**Fig. 1(c)**). The results revealed that the highest proportion of the total Ga absorbed by rice plants was accumulated in the roots, and only a small proportion was translocated to the shoots and then to the grains. The grains of rice grown in Tn soil exhibited the highest Ga concentration and thus were selected to investigate the spatial distribution of Ga in rice grains by using laser ablation

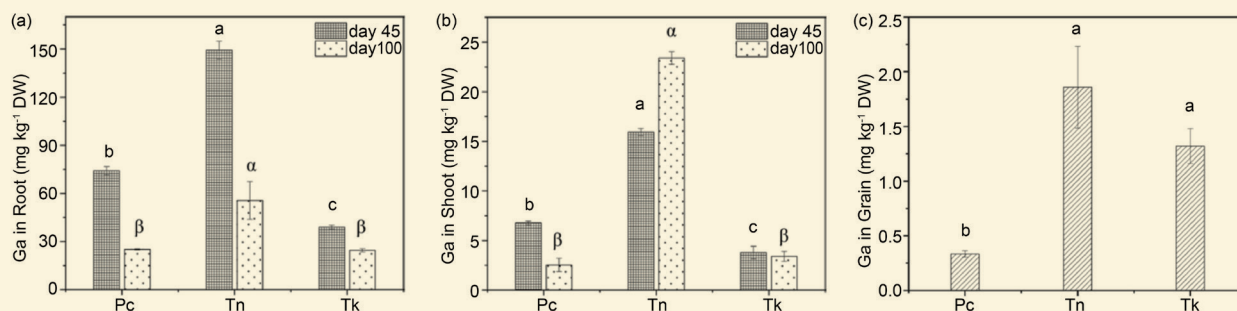


Fig. 1: Ga concentrations in the (a) roots, (b) shoots, and (c) grains of rice plants grown in three soils (Pc, Tn, and Tk) treated with a Ga concentration of 1.0 mmol kg^{-1} for 45 and 100 days. The mean values are the average of data obtained from three experimental replicates. Error bars represent the standard error of the mean values. Different letters indicate significant intragroup differences ($P < 0.05$). [Reproduced from Ref. 1]