Chemical Engineering Dissertation Defense

Novel Process to Recover Ag, Al, Cu, Pb, Si and Sn from c-Si Solar Cells

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Abstract

Metal separation and recovery are a key aspect of silicon solar module recycling. This work contains a comprehensive overview of current methods for solar cell recycling, a detailed analysis on some more potential solutions for hydrometallurgical recycling, and a thorough process to recover all metals at high purity from end-of-life silicon cells.

The capabilities of sodium hydroxide (NaOH), hydrochloric acid (HCl), sulfuric acid(H2SO4), and nitric acid (HNO3) are demonstrated. Based on the initial capabilities of each leaching step, a full 4 step process was investigated. NaOH is used to separate Al from the other metals, H2SO4 was used to leach Cu and Sn, and convert Pb into lead(II) sulfate (PbSO4), and HNO3 was used to leach Ag. Some of the challenges in these leachates led to fundamental studies on the liquid-liquid extraction of tin using di-2-ethyl-hexyl phosphoric acid (D2EHPA), the recovery of Pb through NaOH leaching ofPbSO4 and subsequent electrowinning, and the addition of smoothing aids to improve the morphology of Ag during electrowinning. D2EHPA was able to extract nearly90% of the Sn selectively from the H2SO4 leachate. More than 99.9% of the Pb could be recovered through conversion to PbSO4 and leaching with NaOH. The morphology of Ag was greatly improved through the addition of potassium bitartrate and animal glue, as confirmed by electrochemical impedance spectroscopy and scanning electron microscopy. High purity is demonstrated for all materials recovered. Finally, a process flow diagram is shown for comprehensive chemical recycling of solar cell material. An environmental analysis also shows that the CO2-e emissions associated with recycling the materials of the solar cells are 77% less than the CO2-e emissions associated with producing the raw materials from mining.

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