Abstract

The increase of waste from electric and electronic equipment, rich in valuable elements, has pushed the research towards the development of high sustainability treatments for its exploitation. The end-of-life printed circuit boards (PCBs) represent one of the most significant wastes in this category. In addition to their availability, the interest for these scraps is mainly justified by the high Cu concentration (around 25-30% w/w), which makes them a promising secondary resource. Several approaches are developed for PCB treatment and biohydrometallurgical strategies are gaining increasing prominence, for their possibility to decrease the environmental costs, compared to the most traditional hydrometallurgy and pyrometallurgy. Nevertheless, these innovative techniques show the main criticality of the low treated PCB amount, which makes unsustainable the further scale-up. To overcome this issue, the present research introduces an innovative bioleaching process carried out by *At. ferrooxidans*, followed by metal recovery. The developed technology allows to reach high PCB concentration thanks to the high efficiency two-step design, able to reduce the metal toxicity on the bacteria metabolism. The kinetic of the chemical reaction between Cu and Fe^{3+} (added as oxidant agent) has been studied by mathematical models and an activation energy of 18-25 kJ/mol has been estimated. This model has been integrated with two differential equations to describe the bacteria growth and the metabolism rate to study the bioleaching process mechanism. The developed model is consistent with a R^2 higher than 0.97 and its high reliability makes it also an essential tool for the optimization of urban mining processes. The further Cu recovery includes the steps of preliminary Fe precipitation with NaOH (ready for reuse), followed by the Cu cementation with Zn and a final Zn recovery with oxalic acid. The metals show recovery efficiencies and purities higher than 95%. The experimental results are further enhanced by the carbon footprint assessment which has quantified the possible environmental advantages of the developed solution of PCB recycling, able to integrate the circular economy principles.