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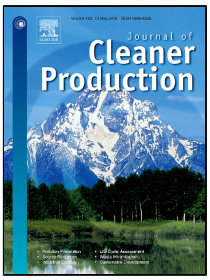

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ACCEPTED MANUSCRIPT

Recycling of bare waste printed circuit boards as received using an organic solvent technique at a low temperature

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Abstract

High recycling rate is considered the main challenge to close the loop of circular economy for the million tons of Waste Printed Circuit Boards (WPCBs) due to their complex structure. In order to achieve this goal, the current work aims to recover all metal foils and woven fiberglass layers from bare Waste Printed Circuit Board (WPCBs) "as received" through dissolution of Brominated Epoxy Resin (BER) by solvent Dimethylformamide (DMF) at low temperature (50˚C) with recycling rate >99%. To avoid the losses of materials in form of dust and fly ash that occur during shredding and milling of WPCBs, the experiment was carried out on a full-size waste video card. A traditional ultrasonic bath was used as a reactor after several modifications; the modifications included glass vessel (reaction chamber) containing DMF and video card, fixation system to install the reaction chamber inside the bath constrained by flexible flotation in the vibrating fluid under the effect of sound waves in order to reduce the dissolution time. In addition, cover and suction system were installed to prevent any leakage of harmful fumes. Metal foils and woven fiberglass layers were separated after 16 hours, then a rotary decompression evaporator was used to extract BER and regenerate used DMF. Also, economic assessment of the developed technique was performed in terms of power consumption. Ultraviolet-visible spectroscopy, Fourier transform infrared spectroscopy, Nuclear magnetic resonance spectroscopy, metallographic microscope, SEM and EDX were used to examine the structure of recovered BER and composition of fiberglass and metal. The results showed that the new technique is efficient enough to be applied on an industrial scale, especially in the countries having a warm climate.

Key words: Recycling; Waste Printed Circuit Boards (WPCBs); Dissolution; Dimethylformamide (DMF); Woven fiberglass; Brominated Epoxy Resin (BER).

1. Introduction

Currently, according to the Solving the E-Waste Problem (StEP) initiative, about 65.4 million tons of e-waste are predicted to be generated in 2017 around the world (Yoshida et al., 2016). In this material stream, Waste Printed Circuit Boards (WPCBs) represent relatively small

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