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E-waste Recycling: Development of Integrated Process for Metal Recovery and Energy Production

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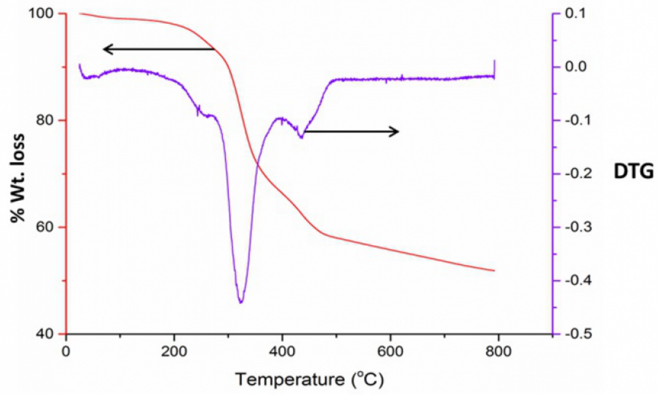
PURPOSE OF THE ABSTRACT

Rapid technology development in the field of electrical and electronic industry and consumers urge to use advanced technology leads to the foreshortened life of the electrical and electronic equipment. Therefore, the generation of waste electrical and electronic equipment has been increased at a significant rate and it becomes the fastest growing waste stream with an annual growth rate of 3-5% [1]. The study by United Nations University reported that electronic waste (e-waste) is expected to increase to 52.2 Mt by 2021 as compared to 44.7 Mt in 2016 [2]. E-waste contains various toxic substances and therefore unregulated accumulation may lead to a serious threat to human health and the environment. However, e-waste with their high content of base and precious metals, is regarded as a potential secondary resource of metals while plastic present can also be converted into valuable products. Metals and plastic are the major components of e-waste with a share of 61% and 21% respectively [3]. Therefore, this study aims at the development of sustainable technology for e-waste management by conversion of e-waste plastic into valuable product followed by separation of different metals for further reuse. The Waste Printed Circuit Board (WPCB) of the desktop computer has been used in this study. The integrated process can be divided into three parts viz. (1) shredding of WPCB, (2) pyrolysis of WPCB and (3) individual metal recovery. The adopted methodology involves the shredding of WPCB followed by the pyrolysis of WPCB. The pyrolysis of WPCB was carried out for the recovery of metal and conversion of WPCB plastic into the gaseous product. The effect of different process parameters such as temperature and time on the pyrolysis of WPCB has been investigated. The temperature and time were varied from 200 to 600 °C and 10 to 60 min respectively. Solid (metal-carbonaceous material mixture) and gases were obtained as the product after the pyrolysis of WPCB. The pyrolysis at 400 °C for 20 min found to be optimum for metal recovery. The gaseous product obtained after the pyrolysis was the mixture of CH_4, H_2, CO, CO_2, and C1-C5 hydrocarbons. This gaseous product can be used for the production of energy. The WPCB and the solid product obtained after the pyrolysis has been characterized using different characterizing techniques such as Microwave Plasma Atomic Emission Spectroscopy (MP-AES), Thermogravimetric Analysis (TGA), Fourier Transform Infrared Spectroscopy (FTIR), and an elemental analyzer. The metal fraction has been separated from the metal-carbonaceous material mixture and efficiency of metal fraction separation is around 90%. This metal fraction can be directly used by metal industries for the formation of different alloys or/and recovery of individual metal. Efforts have also been made in this study for the recovery of Cu and Ni using H_2SO_4-$CuSO_4$-NaCl system from the metal fraction. The effect of time was studied on the recovery of Cu and Ni by varying time from 1 to 5 h. Around 100% recovery of Cu and Ni was achieved within 4 h and other reaction conditions used were: 0.5 M H_2SO_4, 7.5 g/L Cu, 46.6 g/L Cl^-, 1/20 (g/mL) solid to liquid ratio, 70°C temperature, and 700 rpm stirring speed. The said process provides a viable solution for the sound management of e-waste. However, this process also provides an added advantage of gaseous product formation and metal recovery.

FIGURES



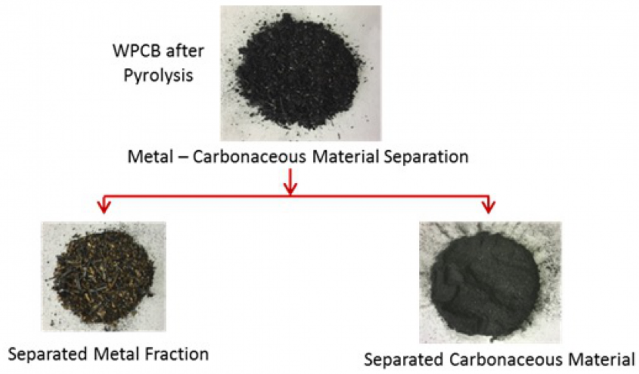


FIGURE 1

TGA of Waste Printed Circuit Board

It can be seen from the TGA and DTG plot that the most of the plastic present in WPCB converts to gaseous product between 250-400°C. This supports the experimental results which showed 400°C as the optimum pyrolysis temperature.

FIGURE 2

Separation of metal fraction

This figure show the separation of metal fraction from pyrolysed WPCB. More than 90% of metals present in WPCB have been successfully recovered in this metal fraction.

KEYWORDS

E-waste | WPCB | Pyrolysis | Metal Recovery

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