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**Effect of metals and brominated flame retardants on the thermal degradation kinetics of waste printed circuit board**

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**Abstract**

Waste printed circuit board (WPCB) is the most vital part of any waste electrical and electronic equipment. It is a complex mixture of metals, glass fibers and polymers. Pyrolysis is a promising technology for material recovery from WPCB. It can enhance metal concentration by eliminating the organic materials and converts into valuable liquid and gas fractions. However, the presence of brominated flame retardants (BFRs) in the polymer matrix leads to the formation of brominated compounds in the product fractions; which are precursor to the formation of dioxins and furans. Hence it is essential to remove the BFRs prior to pyrolysis. In this work, TGA based kinetic study was performed to understand the effect of metals and BFRs on the pyrolysis process. Hence, the sample was sorted into (a) RW (raw WPCB), (b) NM (non-metallic WPCB), (c) RWBFR\_ext (raw WPCB without BFR) and (d) NMBFR\_ext (non-metallic WPCB without BFR). The presence of metals has reduced the offset temperature from 375 ℃ for non-metallic WPCB to 341 ℃ for the raw WPCB at 5 ℃/min. Additionally, the presence of BFR caused slight delay in onset temperature from 259 ℃ for non-metallic WPCB without BFR (NMBFR\_ext) to 273 ℃ for non-metallic WPCB (NM). The average activation energies obtained for RW using Isoconversional methods of Friedman, FWO, KAS, and Starink were found to be 143.7, 146.3, 135.5, and 136.0 kJ/mol, respectively. The reaction mechanism determined from Criado master plot for RW followed F1 model, while for non-metallic WPCB followed F2 ( = 0.05 to 0.5), and F1 ( = 0.55 to 0.95) reaction models. The pre-exponential factor values estimated using the concept of compensation effect showed average values for RW, NM, RWBFR\_ext, and NMBFR\_ext as 5.1×1011, 7.87×1012, 1.62×1012, 5.90×1013 min-1, respectively. The kinetic triplets obtained were also validated by reconstruction of the conversion profiles using MATLAB. The best fit was showed by Starink with average R2 values of 0.9946, 0.995, 0.9822, and 0.995 for the RW, NM, RWBFR\_ext, and NMBFR\_ext samples, respectively. On comparison of the average activation energies for the raw WPCB and the non-metallic WPCB, maximum reduction in activation energy of 38 kJ/mol at  = 0.95 was obtained. Hence the current study suggests that the pyrolysis of WPCB without removing the in-situ metals is beneficial as it consumes lesser energy.

**Keywords:** Waste printed circuit board, Isoconversional methods, Activation energy, Brominated flame retardants