Recycling Bromine and Antimony from Acrylonitrile Butadiene Styrene (Waste Plastics Containing Brominated Flame Retardants)

Electronic waste plastics often contain bromine, and this makes it difficult to recycle these plastics. If bromine can be recovered, it can be repurposed to make valuable new products. So, the present study aims to understand what reactions take place during bromine removal by calcium hydroxide to develop a viable process for recycling these plastics. This work studied the effects of the final reaction temperature and heating rate, and the reaction residue was analysed. Calcium successfully captured 88 % of the total bromine present. Continued research is necessary to completely remove the remaining bromine.

Abstract

Electronic waste plastics often contain brominated flame retardants (BFR) with antimony trioxide used as a synergist. The presence of Br and Sb hinders the recycling of BFR-laden plastics. If Br and Sb are recovered, they can be repurposed to make valuable new products. As a result, the present study investigates the mechanism of the BFR debromination under controlled conditions, in the presence of Sb_2O_3 and $Ca(OH)_2$, to develop a viable process for recycling these plastics.

The experimental equipment comprised a thermogravimetric apparatus for determining the debromination kinetics of decabromodiphenyl ethane with and without Sb_2O_3 and $Ca(OH)_2$. The TGA-DSC also produced the solid residue used for quantitative experiments and characterisation. We characterised the char by powder x-ray diffraction, x-ray photoelectron spectroscopy, transmission electron microscope, electron probe microanalysis and vibrational spectroscopy.

The Kinetics of the pyrolysis of DBDPE is characterised by activation energies of approximately 150 kJ mol^{-1}. Sb_2O_3 increases the activation energy, reflecting the formation of strong Sb-O-Br bonds. XRD results indicate the presence of antimony oxybromides at 500 °C. The presence of antimony induces the formation of anthracene indicating the removal of Br by an Sb-mediated coupling reaction. The application of calcium hydroxide readily decomposes the BFR forming $CaBr_2 \cdot 6H_2O$ and mixed salts with antimony. Calcium hydroxide removes 88 % of Br from the BFR, indicating complete removal could occur with an increased quantity of the additive. The results indicate the versatility of calcium hydroxide in fixing Br and Sb and propose a method for emission control during waste treatment.