DOI: http://doi.org/10.21698/simi.2020.ab31

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT – PROCESSING AS THERMOPLASTIC COMPOSITES

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Keywords: *melt processing, recycling, thermoplastic composites, WEEE*

Introduction

In the last decades, the waste electric and electronic equipment (WEEE) has increased substantially due to an accelerated development of the economy, the life time of the electronics, or the diversified supply of these products. Proper initiatives regarding the energy consumption, the reduction of disposed solid and wastewater by e-waste recycling, etc. can reduce the environmental impact.

Taking into account the aspects regarding the waste separation into individual polymers, the majority polystyrene fraction of WEEE can be recycled by melt compounding as elastomer modified compounds. The method can bring significant economic and technical advantages with obtaining performance composites.

The 10% share of waste printed circuit boards (WPCB) from WEEE can be also recycled, but the high content of epoxy or phenolic thermosetting resins makes it difficult to be used in a conventional melt processing method. Presently, the profitability is due to the metals and glass fiber recovery. Hence, several proposed applications of non-metallic WPCB have been comprehensively examined. One method includes its use as filler in thermoplastic composites.

The research was focused on processing by extrusion and injection molding some compositions containing WEEE. The amount of waste was selected based on the processability and mechanical properties of WEEE based compounds with different percent of the polystyrene fraction and WPCB, respectively, obtained by melt compounding. The characteristics were tested after modifying the polystyrene fraction of WEEE with styrene-butadiene block-copolymer. For waste printed circuit boards, recycled polypropylene was used as continuous phase.

Materials and methods

Collected plastic waste from monitor enclosures and central units, keyboards, mouse cases, parts of central drives from recovered computer and telecommunication equipment was found to have the following composition: PS 10%, ABS 70%, HIPS 15%, and polar components 5% (especially PET, PC, and PA).

The non-metallic powder with dimensions below 1 mm was obtained by leaching the WPCB using a simple mild oxidation system. Copper was removed from the grounded boards using sulfuric acid, copper sulphate and sodium chloride. After desolvation, a light blue-green powder was obtained. As matrix for WPCB embedding, recycled polypropylene (rPP) as grind material (of about 0.05 x 0.6 mm) from industrial transport shuttles was used.

As compatibilizers, a styrene-butadiene block-copolymer (SBS) was used as an impact modifier for compounds and a hydrogenated and maleinized styrene-butadiene (SEBS-g-MAH) was used for increasing the compatibility between components.
The composites were obtained by melt compounding the components on a Brabender plastometer, and then processed by extrusion and injection. The tensile properties were measures using a FPZ 100 Testing Machine and the IZOD impact strength was achieved on notched samples using a Zwick-Roell HIT 5.5P Impact Tester Pendulum.

Results and conclusions

The study regarding the recycling of non-metallic WEEE fraction showed that impact-strength polystyrene composites can be obtained by both an impact modifier and a compatibilizer using during the melting process. Adding 5% of the block-copolymer with polar groups to all SBS modified composites ensures the compatibility of the matrix with polyolefin and polar polymeric impurities. The increased interphase adhesion due to the MAH groups improves thus the transfer of the mechanical energy to the dispersed phase, the tensile strength decreasing less pronouncedly, the elongation at break and the impact strength increasing significantly compared to the samples modified only with SBS. It can be assumed that the obtained WEEE composites are close to commercial high-impact polystyrene (HIPS) and can be used in various applications like covers, packaging, small automotive parts, and so forth.
The compatibility between the ethylene-butylene blocks from SEBS-MA and polypropylene and the MA groups and the functionalities of WPCB led to improved mechanical properties of the recycled PP composites. By adding the elastomers, especially the malenized block-copolymer, a three times increased impact strength was obtained compared to rPP filled with the same dosage of WPCB. The effect of the thermoplastic elastomers with high elasticity on the recycled polypropylene matrix is reflected in a significant increase in the elongation at break of the materials, the composites, initially brittle, becoming ductile. The improvement of impact strength and elongation at break is obtained in detriment of tensile strength. The obtained rPP elastomeric composites containing WPCB can be used for various technical applications and industrial packaging.
The processability of the waste composites was verified by obtaining in suitable conditions of extruded and injected items. Their aspect was homogeneous, with surface defects and with high mechanical properties.

Acknowledgement

This work was supported by a grant of the Romanian Ministery of Research and Innovation, PCCCDI – UEFISCDI, project number 84 PCCDI/2018, within PNCDI III.