ANNALS OF THE ORADEA UNIVERSITY
Fascicle of Management and Technological Engineering
ISSUE #1, MAY 2013, http://www.imtuoradea.ro/auo.fmte/

STUDY OF THE MECHANICAL PROPERTIES OF ACRYLONITRILE BUTADIENE STYRENE – HIGH IMPACT POLYSTYRENE BLENDS WITH STYRENE ETHYLENE BUTYLENE STYRENE

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Abstract**—** A binary blend Acrylonitrile Butadiene Styrene – High Impact Polystyrene (ABS-HIPS 50% wt) was prepared on a twin-screw extruder at 190-210 ºC. The different mechanical properties were then analyzed using tensile strength and impact tests. The analysis of mechanical properties showed a decrease in elongation at break and impact strength. On the other hand, we have prepared ternary blends of ABS-HIPS- Styrene Ethylene Butylene Styrene (SEBS), varying the percentage of SEBS from 10 to 30 %wt using a twin screw extruder at 190-210ºC. The addition of SEBS to the binary system (ABS-HIPS) allowed us to increase the ductile properties (elongation at break and impact strength).

Keywords**—** Additive, blend, compatibility, extrusion, thermoplastic.

I. INTRODUCTION

According to Meireles, Dawson, Olabisi, and Weber et al. the study of mixtures of polymer materials has been the subject of a great deal of intense research in the last few decades [1]-[2]-[3]-[4]. However, in spite of this study, there are still many problems associated with production of these materials which need to be studied and analyzed in order to find a solution. The current economic crisis has meant that, more than ever, companies need to optimize their production processes and make the maximum possible reductions in their costs in order to become more competitive. Cost reduction includes minimizing the losses due to waste in production processes or alternately creating new value from this waste at low cost.

According to Rejewski, one of the principal sources of materials for companies that operate in the polymer recycling area is the waste generated by public consumption [5]. As the economic crisis has seen a reduction in consumption, recycling companies are facing a huge reduction in their supply of raw material.

All of this has meant that, in order to prevent stoppages in production, the material used in the production line has to be changed more frequently. This has been one of the problems in recovery processes of materials such as styrene waste, where HIPS and ABS are the most common materials according to Brennan and Hosseini et al.[6]-[7]-[8].

The economic viability of polymer waste recovery processes rests on recovery of a large quantity of waste material, and given the great variety of polymers in existence it is not possible to have separate production lines for each type of material, so each line must be used for a range of polymers. This recovery process configuration produces a significant quantity of mixed material that has no commercial value. During styrene waste recovery processes, a mixture of ABS - HIPS is often produced which cannot be sold or used as either HIPS or ABS, but which must be commercialized as a blend with particular characteristics.

Following on from this, the objective of this study is to characterize ABS – HIPS blends and then to use SEBS to add value to these blends, according to Jiang, Cataño, Equiza, and Rek et al., it is a frequently used compatibilization strategy between polymers [9]-[10]-

[11]-[12]. Optimization of the production process requires that the recycling production line does not stop for a moment, and for this reason, when there is a change of material (from HIPS to ABS or vice versa) a certain quantity of each is lost. This change in material in fact means a change from 100 % ABS to 100 % HIPS, but in reality, the sum of the wasted material is made up of 50% of each, Fig 1.

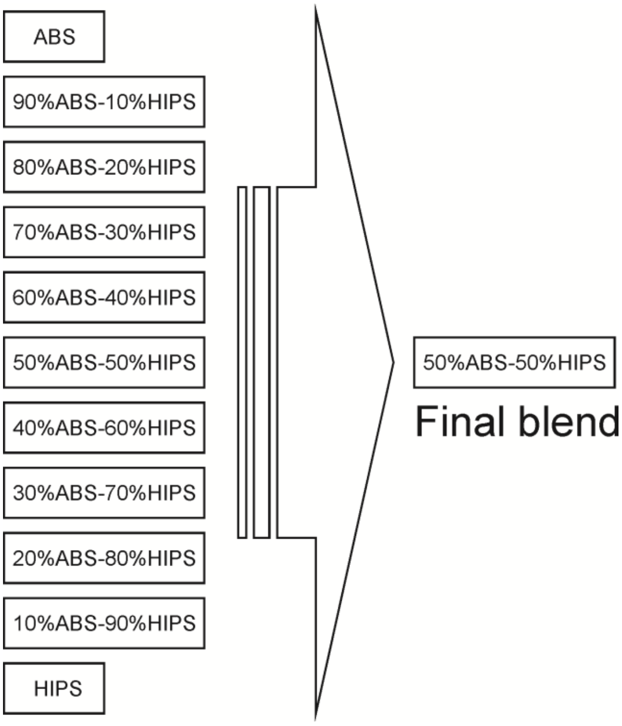

Fig. 1. Graphic representation of the transformation from 100 % ABS to 100 % HIPS during changes in material in extruder which leave production waste which is 50 % of each.

II. Experimental

A. Material

The HIPS, ABS, and SEBS used in the experiment are commercial products HIPS (PS Impact 6541; Total petrochemical, Belgium), ABS (Terluran® GP22, BASF, Germany), and SEBS (Megol® TA, Applicazioni Plastiche Industriali, Italy). Table I shows fresh material used in this study.

TABLE I
Mechanical Characterization Values of the Virgin ABS, Virgin HIPS and Virgin SEBS

Material	ABS	HIPS	SEBS
Tensile strength (MPa)	44	20	6.0
Elongation at break (%)	12	45	600
Charpy notched impact strength (kJ•m-2)	19	9.5	-
Hardness	75	-	50
Source	BASF	Total Petrochemical	API

B. Sample preparations

A binary blend (50%ABS – 50%HIPS wt) was conducted on a conventional twin-screw extrusion machine, at 190 – 195 – 200 – 210 ºC extrusion temperatures. Finally, ternary blends were prepared by varying the SEBS content, from 0% to 30 % (wt %), at the same conditions of ABS-HIPS blends.

C. Mechanical properties measurement

The mechanical properties of the samples were evaluated using an ELIB 30 electro-mechanical universal testing machine made by Ibertest (S.A.E. Ibertest, Madrid, Spain), with a load cell of 5 kN. All tests were carried out following the UNE-EN ISO 527 standard, at a speed of 50 mm min-1.

Impact strength was determined by using the Charpy impact machine (S.A.E. Ibertest, Madrid, Spain) according to ISO-179.

The values of all the mechanical parameters were calculated as averages over 5 specimens for each composition.

III. Results and Discussion

A. ABS-HIPS System.

The mechanical properties of any material are fundamental for its use in any particular application. Traction and impact tests are extremely important because they allow us to understand properties such as tensile strength, elongation at break and impact strength.

In the study carried out on the ABS-HIPS system, the graph showing tensile strength for the virgin (ABS and HIPS) and the 50% blend show a linear evolution of the values, where the 50% by weight blend has values that fall between those of virgin ABS and HIPS. This result indicates the compatibility between the elements that form the blend (Fig. 2).

However, the values for elongation at break and impact strength of the 50% blend are very low; even lower than those of virgin material. While the elongation at break values indicate a clear compatibility of the compounds, the properties related to ductility show they are not completely compatible (Fig. 3) and (fig. 4).

According to Brennan et al., this behaviour has been observed when they are analyzing the properties of the blend obtained from recovery of waste materials from the electrical and electronic sectors [6].

B. ABS – HIPS – SEBS System.

Having obtained the results from the ABS – HIPS blend, we analyzed the addition of Styrene-Ethylene-Buthylene-Styrene (SEBS) to the blend, with the aim of improving the blend's ductile properties.

According to Jiang, Rek, Jazani, Jelcic and Jazani et al. SEBS has been used as an element to achieve compatibility between polymers [8]-[9]-[12]-[13]-[14]-[15], often with excellent results, thus the option of using SEBS with the HIPS – ABS system has real promise.

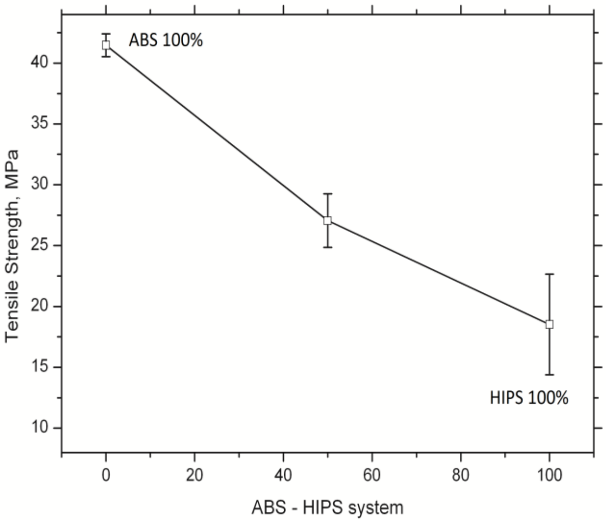

Fig. 2. Tensile strength for the virgin (ABS and HIPS) and the 50% blend.

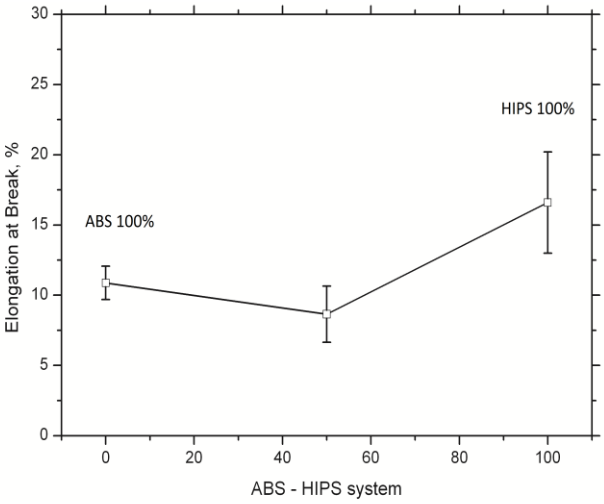

Fig. 3. Elongation at break strength for the virgin (ABS and HIPS) and the 50% blend.

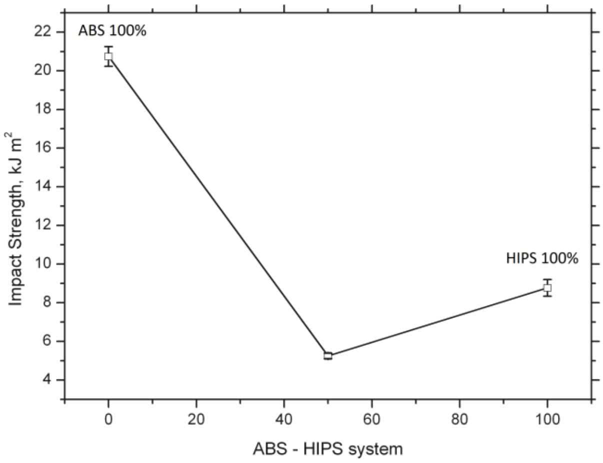

Fig. 4. Impact strength for the virgin (ABS and HIPS) and the 50% blend.

The incorporation of a new element in the blend could have two effects: the new polymer could act as an interface between the HIPS and the ABS and thus improve the overall properties of the initial mixture, or, it could have the complete opposite effect, causing a general loss of properties due to a lack of interaction between the components of the original system.

Before carrying out any mixing processes, we proposed the following hypothesis:

According to Agari et al., HIPS is compatible with SEBS [16], and ABS is compatible with SEBS, then there are the strong probability that SEBS acts as an agent of compatibility between ABS and HIPS.

The elastic character of SEBS must bring improved ductile properties to the ABS – HIPS system. One of the first effects that can be observed in the mechanical properties Fig. 5 is a decrease in tensile strength as the percentage of SEBS increases. This decrease is lighter for a SEBS content of 10%, and after this the tensile strength declines more rapidly reaching a loss of 60% for a 30% SEBS content.

Although there is a loss in tensile strength, the recovery of high elongation at break and impact strength values more than compensate for this loss Fig. 6 and Fig. 7.

On analyzing the results from the addition of SEBS to the ABS – HIPS blend, we conclude that the ideal percentage of SEBS is 10%, which causes a 10% decrease in tensile strength but a 50% increase in both elongation at break and impact strength values.

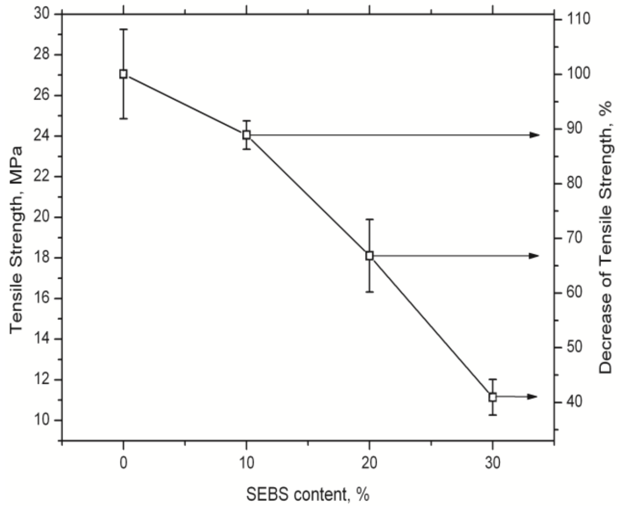

Fig. 5. Tensile strength for the ABS – HIPS - SEBS blend.

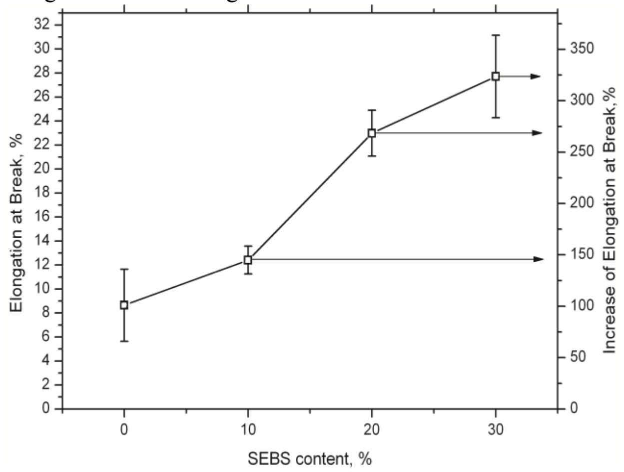

Fig. 6. Elongation at break strength for ABS – HIPS - SEBS blend.

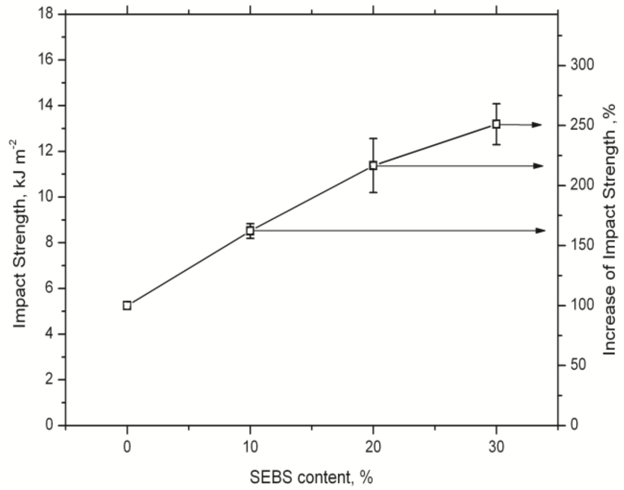

Fig. 7. Impact strength for the ABS – HIPS –SEBS blend.

IV. Conclusions

Our results suggest that the compatibility between ABS and HIPS is only partial and that a significant loss of ductile properties is produced in the 50% by weight blend of the two materials. The addition of SEBS allows us to recover the ductile properties of the ABS – HIPS blend, with some loss of tensile strength.

V. Acknowledgment

We would like to thank the Vice-Directorate of Research, Development and Innovation of the Polytechnic University of Valencia for the help granted to the project: “Ternary systems research applied to polymeric materials for the upgrading of waste styrene”, Ref: 20091056 within the program of First Projects of Investigation (PAID 06-09) where this work is framed.

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