MORPHOLOGICAL VARIATIONS AND IMPROVE PROPERTIES ON PP/PA6 BLENDS WITH MODIFIED INTERPHASES BY GRAFTED ATACTIC POLYPROPYLENES COMING FROM INDUSTRIAL BY-PRODUCT

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Abstract
In the present communication the fifty/fifty isotactic-polypropylene (PP) and polyamide (PA6) has been chosen as representative of the thermodynamical incompatibility and then the heterogeneous morphology of an organic polymer blend. It is the most general case when facing a problem of management any fraction of organic plastic wastes coming from big solid waste streams like urban, agricultural or post-consumer out of use organic plastic big parts. The thermodynamical incompatibility between the organic polymers from different structural families, together inefficient processing and/or compounding technologies, it results in deficient set of properties and bad performance. The true possibility to change those morphologies by the presence of different amounts and different kinds of interfacial agents based on atactic polypropylenes grafted with polar groups: Succinic Anhydride (SA) or Succinil-Fluoresceine (SF) moieties is ascertained by the changes in the mechanical and thermal properties of the blends with modified interphase and the morphological changes supported by the optical and emission field scanning electron microscopies (OM and FE SEM).

Keywords: Plastic Wastes; Polymer Blends; Interfacial Agents; Polypropylene; Polyamide 6

INTRODUCTION
Materials as representative of the different ages of the Humankind evolution have been fully involved in the management wastes trends and technologies from early eighties. Indeed the engagement with the sustainable growing principles either in the design of as with materials [1] requires either the reduction of the volume of generated wastes as too the intelligent management of the components of the big waste streams in terms of Ecobalance. It means the coupling between the economic and ecological aspects concerning the materials processing from their early stages as raw materials up to their best available management alternatives once in waste streams [2].

Once identified any plastic waste source, it means: if industrial, agricultural, urban wastes, or any other, the plastic waste management route as material again (if too much degradated its management by the mass, energy or mass&energy recovery routes would be recommended), it requires to optimise the compounding according the properties and performance needed by the new application. It would be reached by chosen the best between the different each time available processing technologies (BAT strategies), from mixing with pristine polymer for the single component case, up to the use of interfacial modifiers at the non single component one, looking for the best performance, passing by the chemical modification options or the combination with additives like: stabilizers (thermal, photo), dies, fillers, reinforcements, etc.

Further the overall aspects involved in the recycling of polymer wastes as polymer blends, polyamides (PA) are a good family of engineering thermoplastics whose moisture affinity constrains their applicability. This is one of the main reason that the combination of polyamides with lower moduli but hydrophobic polymers like polypropylene (PP) have become matters of interest. The first industrial patents concerning polypropylene / polyamide blends to be used as engineering materials were registered four decades ago, and in despice of the thermodynamical incompatibility between the organic polymers from different structural families, polymer blending offers a way to obtain taylor-made materials with a good range of properties, combining those of both homopolymers [3].
EXPERIMENTAL

Homopolymers used in the present work were two commercial grades: Ultramid B3, nylon 6, supplied by BASF (Barcelona, Spain) and Isplen 050, polypropylene, from Repsol Química (Madrid, Spain). Grafted polypropylenes used as interfacial modifiers in PP/PA6 blends were a succinic anhydride grafted polypropylene (a-PP-SA) containing 3.05% (w/w) of grafted groups and a succinil fluoresceine/succinic anhydride grafted polypropylene (a-PP-SF/SA) with 6.2% of attached groups (expressed as succinic anhydride units). Figure 1 shows their structures.

![Figure 1. Chemical structure of the Interfacial Agents coming from an atactic Polypropylene (a-PP), industrial plastic by-product.](image1)

They were obtained in our laboratories by chemical modification of an atactic polypropylene, by-product of industrial polymerization reactors, also supplied by Repsol Química (Madrid, Spain). Physical properties of these polymers, together with those of the atactic polypropylene as raw material and once chemically modified as well the process conditions and experimental procedures were published elsewhere [4 and author’s self-references there enclosed].

The fifty/fifty blends of polypropylene (PP) and polyamide (PA) with and without interfacial agents were prepared following a Box-Wilson worksheet in order to covering the overall amount range. The independent variables were the PP weight percentage in the blend and the interfacial agent amount. Compounding was performed in a Rheomix 600 mixer chamber attached to a Rheocord 90 series from Haake (Barcelona, Spain), working at 240°C and 45 rpm for 5 minutes. Compression molded sheets of about 100 microns thick were obtained in a Dr. Collin (Barcelona, Spain) laboratory press under controlled conditions. From these sheets standardized specimens for mechanical properties were cut. The tensile testing mode was chosen and series of ten specimens for sample were tested in an Instron dynamometer, 4204 model, following the UNE-EN ISO 527-3 standards. Thermal behavior of blends in order to identify the post-processing stability of blend morphologies was determined by DSC measurements on a Perkin-Elmer DSC-7 series using 209 J.g⁻¹ and 190 J.g⁻¹ respectively for fully crystalline i-PP and PA6, as described and discussed elsewhere [4 and author’s self-references there enclosed].

Morphological studies were performed over the same compression molded sheets in a Jenaval optical microscope from Carl Zeiss-Jena (Jena, Germany) under light transmission mode and negative phase contrast. Micrographs as shown in Figure 2 were taken by an automatic video camera printer Sony system.

![Figure 2. PP/PA6 50/50, solid state Blends morphologies by Optical Microscopy. Negative Phase Contrast](image2)

FE SEM observations by a Field Emission Electron Scanning Microscope (FESEM), Jeol JSM-6305F model, were made over the fracture surfaces of tested specimens under the tensile mode, Figure 3. Samples were gold coating by a sputter coater Emitech, K550x model.

RESULTS AND DISCUSSION

FE SEM images are showing the different morphologies of the PP/PA6 fifty/fifty blends original and once modified with the indicated amounts of the a-PP-SA. Similar studies were made for the SF/SA interfacial modifier. Because of the zero shear viscosity ratio between both polymers on the molten
The fifty/fifty composition is indeed the most delicate to compatibilize due to the non existence of a true matrix/dispersed phase morphology but a co-continuous phase distribution, Figures 2, 4 and 5, with poor mechanical performance, Figure 6. Further to improve the polymer blend properties, to get the post-processing stabilization of the new generated morphologies in order to avoid the disperse phase coalescence on further processing would be also necessary. It may be reached if further the interfacial tension changes by the presence of the interfacial modifiers, they are able to yield the optimal number of primary bonds with the main components across the interphase. The control of such capability on the interfacial agents let to optimize the new material performance.

Figure 3. The tensile testing of semicrystalline polymers

Figure 4. FE SEM images of the PP/PA6 binary system and modified by a-PP-SA

Figure 5. FE SEM images of the PP/PA6 binary system modified by different amounts of a-PP-SA
CONCLUSIONS

Together a good processing, the polymer blends usually characterized by the thermodynamical incompatibility between their components and then bad properties, may be conveniently enhanced by the optimization of the interfacial agent amount as well its chemical structure.

REFERENCES