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From waste cooking oil to a green compatibilizer for HDPE/PA6 recycling

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Introduction

Around 13 Mt of plastic debris ends into the oceans every year of which 20 % derives from marine activities. Discarded, lost, and abandoned fishing nets constitute an important part of the sea pollutants. Giving new economic value to end-of-life fishing nets could encourage their recovery through an appropriate logistic collection system. Nets recycling would contribute both to circular economy directives and reducing marine pollution.
As high-density polyethylene (HDPE) and polyamide-6 (PA6) are the most common polymers used for nets, the present work aimed at recycling fishing nets producing HDPE/PA6 blends. To improve the compatibility between the polar polyamide and the non-polar polyethylene a compatibilizer is required. Different kinds of compatibilizers are available on the market. In this study, a compatibilizer precursor, also coming from waste materials, was synthesized by epoxidation of treated wasted vegetable oil (WVO) derived from household and catering activities. In this work, discarded fishing nets were collected, washed, cut, and preliminarily characterized to determine their chemical composition and thermo-physical properties. The analysis confirmed that nets were made of HDPE and PA6. HDPE/PA6 blends were produced using different weight ratios and a few percentages of compatibilizer precursor (EWVO). A commercial compatibilizer was also tested for comparison. All the blends were characterized from a morphological, thermal, rheological, and mechanical point of view.

Experimental

Blends of HDPE/PA6 75/25, 85/15, and 25/75 with different amounts of compatibilizer precursor were prepared. Thermal, and chemical analysis were carried out on all the samples by differential scanning calorimeter (DSC), infrared spectroscopy (FT-IR), thermogravimetric analysis (TGA), scanning electron microscopy (SEM), and polarized optical microscopy (POM). The rheological behavior of the blends was investigated at 240°C by an MCR rheometer equipped with a plate-plate geometry. Tensile tests were performed on dog-bone specimens to evaluate the mechanical properties of the materials.

Results and Discussion

Epoxy groups, during the blending, were expected to react with the end-groups of the polyamide (Figure 1), and the vegetable oil grafted to the polyamide, moving to the interphase, should reduce the interfacial tension between HDPE and PA6 phases similarly to the well-known polymeric compatibilizer. In the case of samples HDPE/PA6/EWVO 75/25/2 and 85/15/2, analysis confirmed the compatibilizing effect of EWVO. Moreover, the thermal, rheological, and mechanical analysis pointed out a plasticizing effect due to the addition of EWVO to the blends. The effect was clearly visible from the mechanical results. The more enhanced plasticizing effect of EWVO than the commercial compatibilizer could be related to its lower molecular weight. On the contrary, blends with polyamide as a matrix showed crosslinking during the blends' preparations, highlighting that the compatibilizer remains in the matrix phase and fails to migrate to the interface.

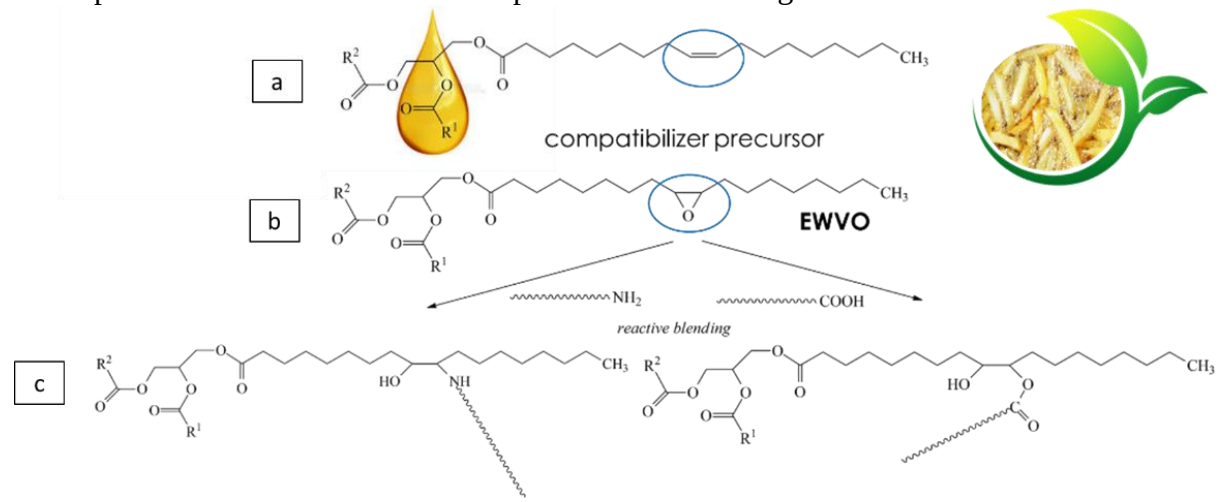

Figure 1. a) waste vegetable oil, b) compatibilizer precursor, and c) compatibilizer obtained during reactive blending.

Conclusions

EWVO could be used as a compatibilizer of HDPE/PA6 blends in the case of the HDPE matrix, with the advantage of a great increase in plasticity. On the contrary, the different reaction mechanism of EWVO compared to a standard di-block compatibilizer prevents its application in the case of the PA6 matrix as during the blending crosslinking occurred.

Biography

Miriam Cappello is a Chemical Engineering graduate of the University of Pisa. She got a PhD in Industrial Engineering (Chemical and Material Engineering). She is working on recycling and reusing of waste materials. Her research is focused on synthesis and compatibilization of polymeric materials, and sorbent materials for VOCs abatement. Previous works concerned the durability and rejuvenation of bituminous materials for civil engineering applications. She had also a long experience in the synthesis and characterization of polymeric materials, energetic polymers, and metal hydrides for solid propellant formulation. She is an Assistant Professor of Chemical Fundaments of Applied Technologies at the Department of Civil and Industrial Engineering, University of Pisa.