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## **SOME PROPERTIES OF BLENDS BASED ON HIGH DENSITY POLYETHYLENE GRAFTED WITH DI-2-ETHYL-HEXYL FUMARAT**

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### **ABSTRACT**

Blends based on high density polyethylene (MFI=0.3 g/10 min) and low density polyethylene grafted with di-2-ethyl-hexyl fumarate are presented.

These blends were obtained through component homogenization, in different proportions, on a Berstorff laboratory roll-mill, for 10 minutes at 180°C.

Low density polyethylene (MFI=2.0 g/10min) grafting was carried out in polymer melt, through radicalic initiation, in the presence of organic peroxides, at a temperature of 140-160°C. The content of the monomer grafted on polymer chain was determined through IR absorption spectrophotometry using the absorption band of 1735 cm<sup>-1</sup>.

From the experimental, obtained blends plates, 1 mm thick, were manufactured with the purpose of determining the main tensile properties.

For the respective blends melt flow index evolution were followed.

The modification of the crystalline structure due to the presence of grafted polymer in the studied blends were followed through optical microscopy.

## INTRODUCTION

Polymer blends still remain in the attention of many researchers due to their importance from the theoretical and practical points of view [1-3].

Many blends with both compatible and incompatible components were studied in the literature.

Polyolefins without polar groups cannot give miscible blends through mixing. Low density polyethylene/high density polyethylene blends crystallize independently with a minimum interaction between crystalline phases [4]. Bataerd showed that for diphase systems the interaction between phases has an important influence upon the physical properties of the obtained blend [5]. In this way, it was suggested that the careful studying and the interface modification could lead to the improvement of the properties of blends made from two immiscible polymers.

Recent research upon different immiscible polymer blends resulted in finding new techniques to improve the component compatibility and to obtain the best possible properties for the studied blends. Among these, the most useful found consisted of the chemical modification of blend components or the adding of some compatibility agents.

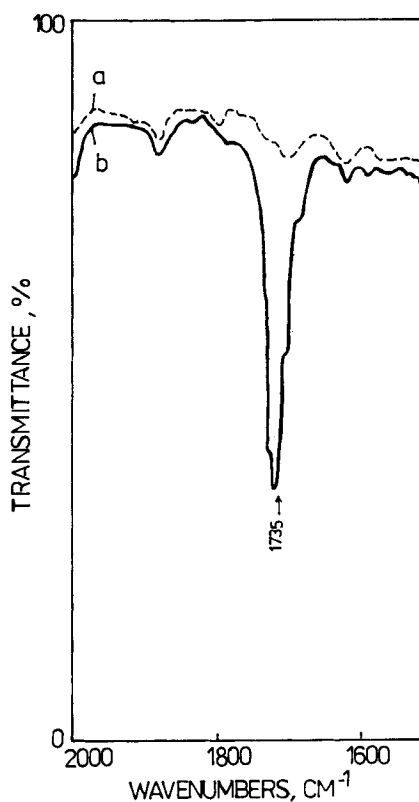
Chemical modification of blend components could be achieved by introducing polar functional groups on a polyolefin chain. The result is the disturbance of crystalline structure of polyolefin which determines the improvement of the main properties as well as of the compatibility with different polymers.

This study presents research carried out on some blends based on high density polyethylene and low density polyethylene grafted with di-2-ethyl-hexyl fumarate.

## EXPERIMENTAL

Blends based on high density polyethylene (HDPE), having MFI = 0.3 g/10 min. and grafted low density polyethylene (LDPEg) were obtained through component homogenization, in different proportions (95/5; 85/15; 75/25), on a Berstorff laboratory roll-mill, for 10 minutes at 180°C.

LDPEg was obtained through radicalic grafting of low density polyethylene (MFI = 2.0 g/10 min) with di-2-ethyl-hexyl fumarate. The reaction was carried out

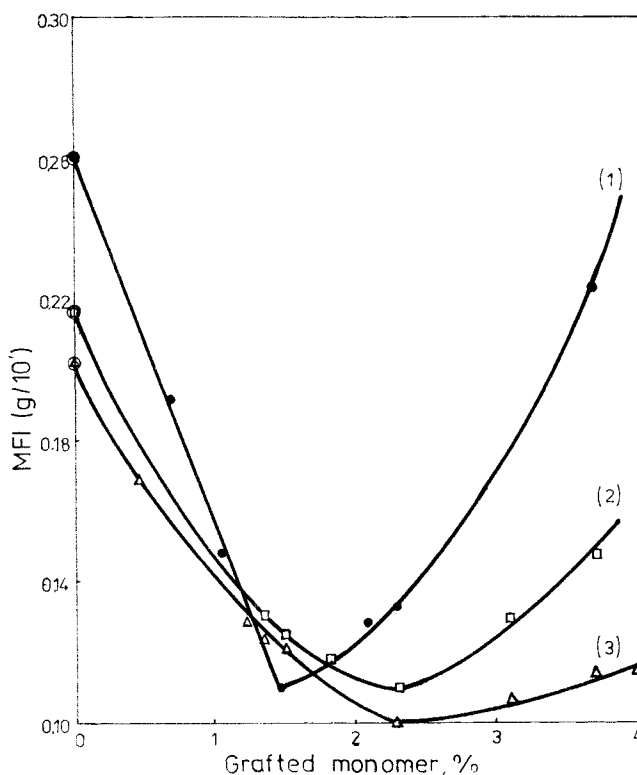


**Figure 1.** IR spectra of LDPE (a) and LDPE g (b).

in polymer melt, through radicalic initiation, at a temperature of 140-160°C and a different reaction time. The obtained grafted polymer was purified through extraction in a plant of Soxhlet type, for 27 hours, using a proper solvent (diethyl ether) for taking off the unreacted monomer.

From the purified polymer, plates 1 mm thick were manufactured through pressing, at a temperature of 180°C and a pressure of 300 bars with the purpose of determining the tensile properties.

At the same time, grafted polyethylene was purified through repeated solvation and precipitation, with the purpose of taking off the eventual traces of unreacted monomer. The polymer purified in this way and then dried at constant weight was pressed in the shape of films 0.1-0.2 mm thick used with the purpose of structural characterization of LDPEg through IR absorption spectrophotometry. The recordings were achieved using films with the above mentioned thickness and 3x4 cm dimensions. A spectrophotometer of Specord IR 75 type was used, the



**Figure 2.** MFI versus grafted monomer content for HDPE/LDPEg blends.

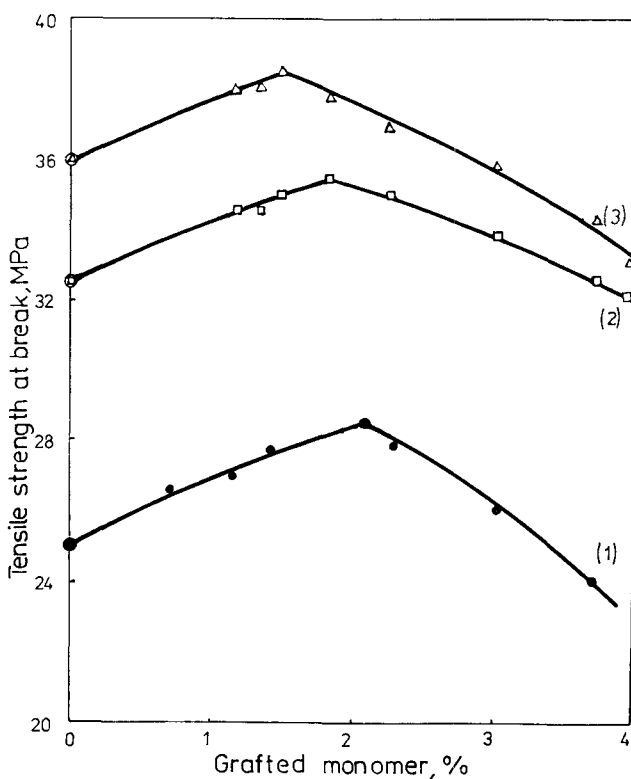
1. ●—● HDPE/LDPEg (75/25)
2. □—□ HDPE/LDPEg (85/15)
3. △—△ HDPE/LDPEg (95/5)

measuring range being  $2200\text{--}400\text{ cm}^{-1}$ . The purpose of the main absorption bands was presented in a previous paper [6].

The content of the grafted monomer on low density polyethylene was determined through IR absorption spectrophotometry using the characteristic band of  $1735\text{ cm}^{-1}$  as the analytical band. The experimental data are in the area ranging from 0.5 to 4.0 gr%.

## RESULTS AND DISCUSSIONS

The melt flow index measurement for the obtained blends was performed according to ASTM 1238-89; the MFI evolution is indicated in Figure 2.

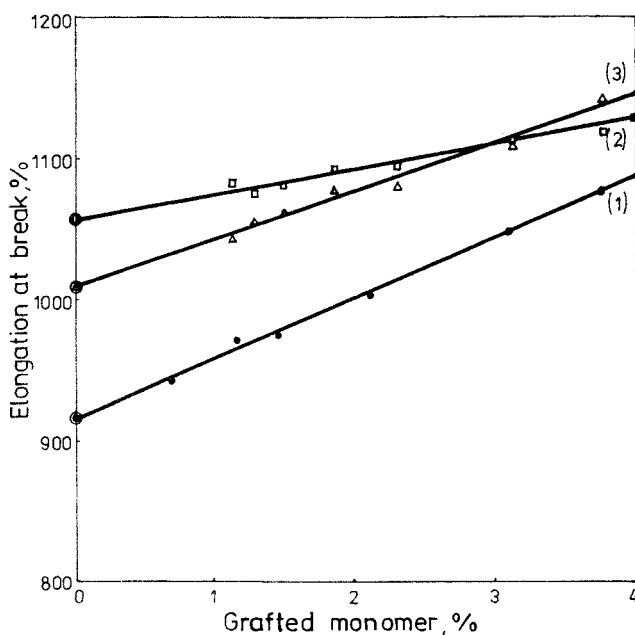


**Figure 3.** Tensile strength at break versus grafted monomer content for HDPE/LDPEg blends.

- 1. ●—● HDPE/LDPEg (75/25)
- 2. □—□ HDPE/LDPEg (85/15)
- 3. △—△ HDPE/LDPEg (95/5)

It is obvious that a small amount of grafted fumaric diester significantly modifies the melt flow index of the respective blends. First of all, MFI decreases rapidly to a minimum value according to an amount of grafted monomer (1.5-2.3%), then it increases. This behavior is more pronounced for HDPE/LDPEg (75/25) blend (curve 1); blends with a smaller amount of LDPEg show a slower increase of MFI after the achievement of the minimum value (curves 2 and 3).

For the same blends, tensile strength at break and percentage elongation at break were determined according to ASTM D638-76; the data are presented in Figures 3 and 4.



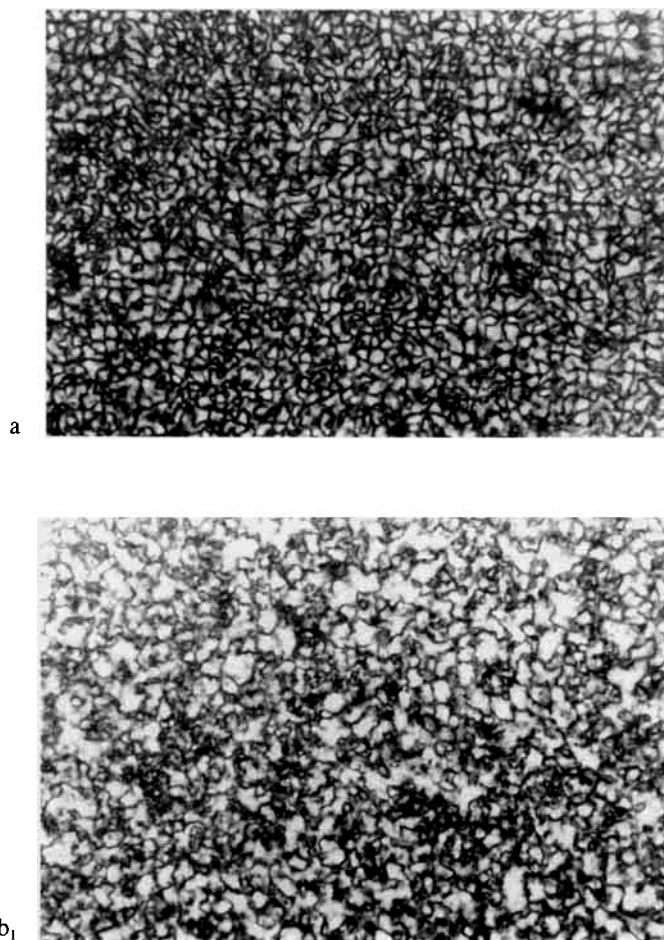
**Figure 4.** Elongation at break versus grafted monomer content for HDPE/LDPEg blends.

1. ●—● HDPE/LDPEg (75/25)
2. □—□ HDPE/LDPEg (85/15)
3. △—△ HDPE/LDPEg (95/5)

The results emphasize the increase of tensile strength at break with the content of grafted diester until values of 1.5-2.0%; afterwards, the values of this characteristic decrease. This behavior indicates the compatibility improvement between HDPE and LDPE grafted with fumaric diester. The experimental results were found to agree with some data reported in the literature [7].

At the same time, the increase of percentage elongation at break for those blends which contain grafted monomer on the macromolecular chain was emphasized; the increase being more pronounced for those whose composition is enriched in LDPEg component (Figure 4, curve 1).

In the enclosed photos, we make a comparison among the morphology evolution of HDPE, LDPE, LDPEg and the above mentioned HDPE/LDPEg blends.

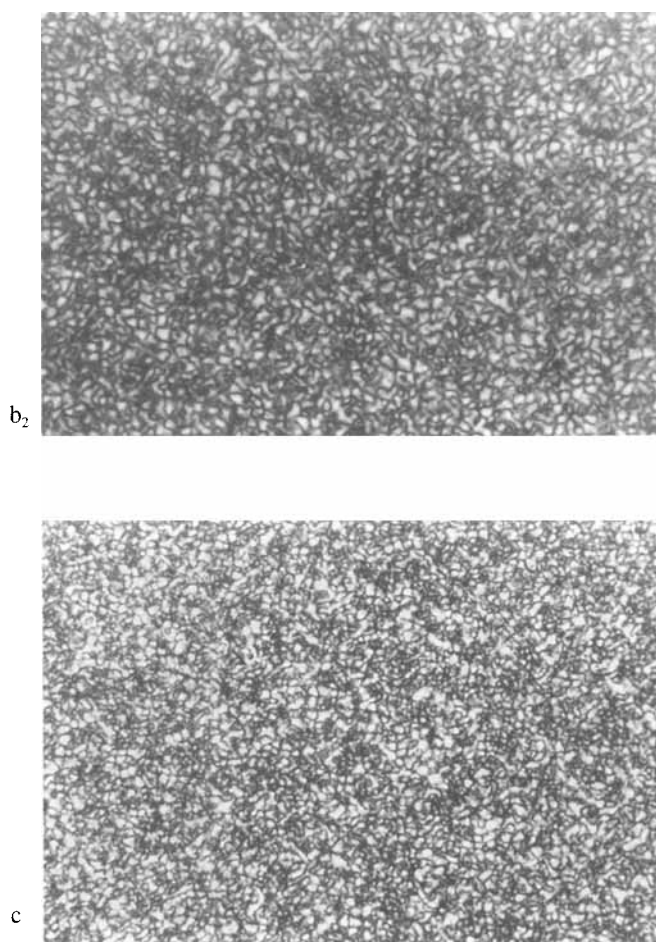


**Figure 5.** Transmitted light micrographs for:

- 5a - LDPE
- 5b<sub>1</sub> - LDPEg (grafted monomer content 2.09%)
- 5b<sub>2</sub> - LDPE grafted monomer content 3.99%)
- 5c - HDPE
- 5d - HDPE/LDPE (75/25) blend
- 5e<sub>1</sub> - HDPE/LDPEg (75/25) blend  
(grafted monomer content 2.09%)
- 5e<sub>2</sub> - HDPE/LDPEg (75/25) blend  
(grafted monomer content 3.7%)

*(continued)*





**Figure 5.** Continued

Figure 5 shows the photos corresponding to LDPE (Figure 5a), LDPEg (Figure 5b<sub>1,2</sub>), HDPE (Figure 5c), HDPE/LDPE blend (Figure 5d), and HDPE/LDPEg blend (75/25) (Figure 5e<sub>1,2</sub>); these photos were obtained in polarized light using an ORTHOLUX lab microscope with a magnification of 900x.

The images presented in Figures 5a and 5b allow us to say that through LDPE grafting with fumaric diester the number and size of the spherulites are modified according to the content of grafted monomer.

The images presented in Figures 5c, 5d and 5e also emphasize a modification of the number and size of the spherulites.

We also notice a better homogeneity of the spherulites with the content growth of grafted monomer.

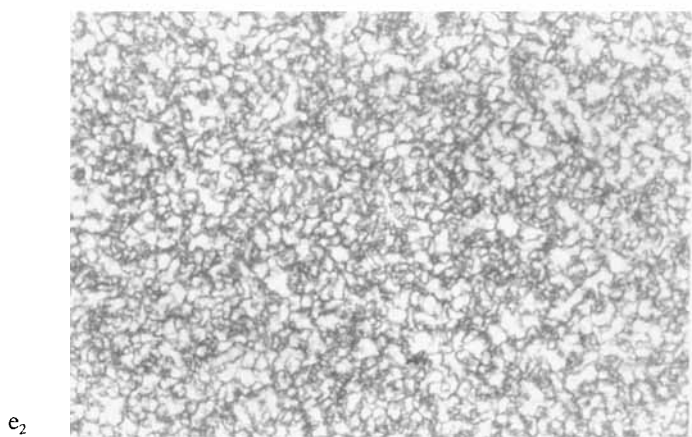
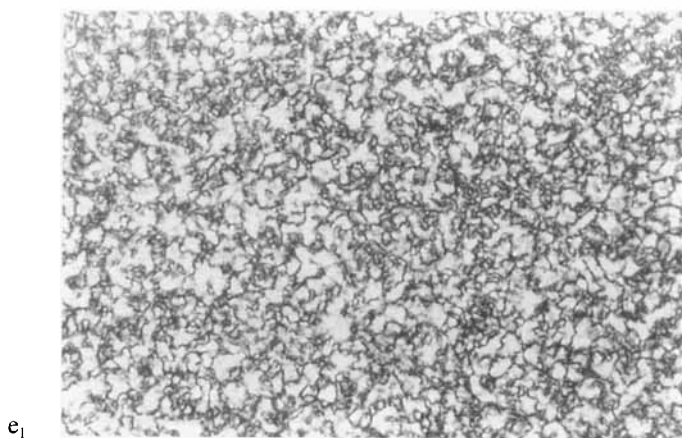
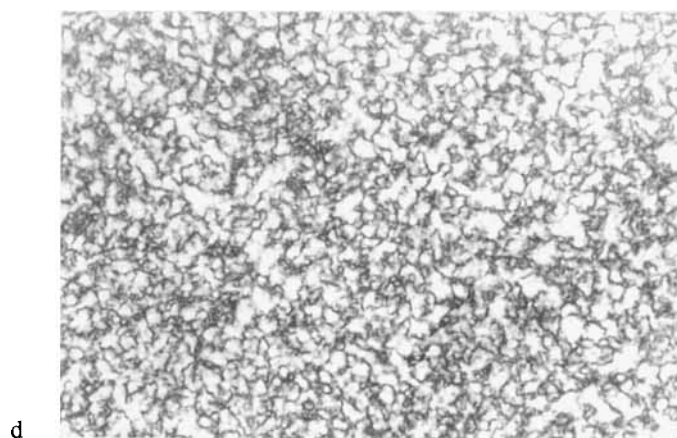


Figure 5. Continued

We have to specify that the modifications which take place in polymer morphology are observed in HDPE/LDPEg blends (85/15 and 75/25), while HDPE/LDPEg blend (95/5) shows unimportant modifications.

The morphology modification for HDPE/LDPEg blends agrees with the tensile properties evolution.

The main characteristic evolution of the studied blends allows for the outline of some utilization proposals.

## CONCLUSION

High density polyethylene (HDPE)/low density polyethylene grafted with di-2-ethyl-hexyl fumarate (LDPEg) blends were obtained through component homogenization, in different proportions (HDPE/LDPEg = 95/5; 85/15 and 75/25), in preestablished experimental conditions. LDPEg was obtained through low density polyethylene grafting with di-2-ethyl-hexyl fumarate, in polymer melt, using radicalic initiation; the content of grafted monomer determined through IR absorption spectrophotometry was 0.5-4.0%.

Fumaric diester grafted on low density polyethylene chain determines the modification of melt flow index of the studied blends. Tensile properties of the respective blends also changed.

Tensile strength at break growth emphasizes the compatibility improvement of HDPE and LDPE due to the LDPE grafting with polar monomers.

Morphology modification of both LDPEg and blends, followed by optical microscopy, also explains tensile properties variations and determines the improvement of component compatibility.

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