TECHNICAL BULLETIN: LDPE – LLDPE MIXTURES FOR INDUSTRIAL PACKAGING

POLINTER

1 Introduction

The branched (PEBD) and linear (PELBD) low density polyethylene are normally used mixed in the production of films, in order to achieve the combination of advantages inherent to both resins, such as the excellent mechanical properties of the PELBD and the good processing of the PEBD.

The mixtures can be classified into two categories or domains: mixtures rich in PELBD and rich in PEBD. Depending on the offer levels of each resin, the machinery parks and consumption habits of each regional market, the mixture composition can shift towards each one of the domains. As an example, the European market mainly uses mixtures rich in PEBD (Figure 1) while in North America (Figure 2) dominates the use of mainly PELBD (1).

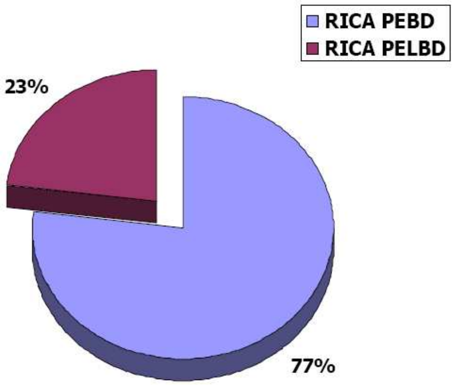

Figure 1. PEBD/PELBD mixtures Consumption in Western Europe (1998).

As new linear have been developed and processing machinery has been modernized, the tendency to use PELBD in greater proportion has also increased. In this sense, 15 years ago the incorporation of PELBD was limited to 30% (2). Nowadays, the use of mixtures in PELBD/PEBD proportions 85/15 or even pure PELBD is more and more frequent (3).

The evolutionary linear development has strengthened attributes such as:

- Superior mechanical properties.
- Excellent appearance (transparency, brightness, low gel level).
- Excellent sealing properties.
- Low production and transformation costs.

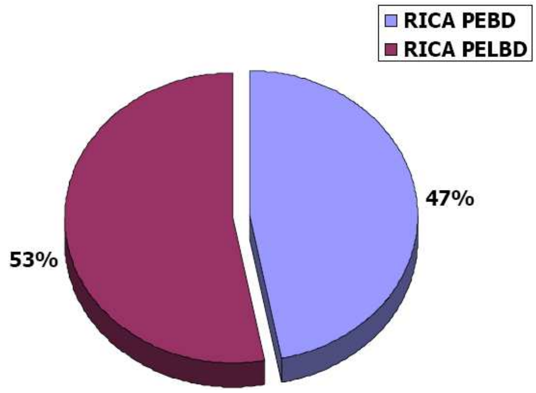

Figure 2. PEBD/PELBD mixtures Consumption in North America (1998).

The benefits brought forth by the PELBD have caused the predominant use of rich linear mixtures in applications such as: high performance bags, cushioning film, tire separator film, industrial liners, elastic films, ice bags, bags for supplemental packaging, and garbage bags.

This bulletin presents the contribution regarding the properties and costs obtained by the use of mixtures rich in PELBD for industrial application products and supplies guides for achieving maximum performance in their processing.

2 Mechanical Properties

The properties of the mixtures shown below were measured in films made with the following products: Venelene® 11F1 (MFI: 0.80 dg/min, density: 0.919 g/cc) and FB-3003 (MFI: 0.27 dg/min, density: 0.922 g/cc), 120 microns thick, extruded under these conditions:

TECHNICAL BULLETIN: LDPE – LLDPE MIXTURES FOR INDUSTRIAL PACKAGING

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Parameter	Assigned Value
Barrel Diameter (mm)	40
L/D Relation	30
Type of screw	Maddock(L/D:2) & Pines(L/D:2)
Compression relation	3:1
Nozzle diameter (mm)	120
Nozzle opening (mm)	1,2
Cooling ring	One release vent.
Blow relation	2,5
Cooling line h (mm)	480 (4D)

Figure 3 represents the values of the tensed elasticity module with respect to the PELBD/PEBD mixture composition. The film elasticity module is a key property for applications in which heavy products (>10 Kg.) will be packed or packaging. While the elasticity module of the material increases, the user may use films with lower thickness without excessively deforming the packaging during the handling, storage and transport operations.

It is evidenced that both in the extrusion direction (MD) as well as in the transverse direction (TD), the module reaches its maximum value when the mixture has a rich PELBD content (80 to 90% of PELBD).

The tendency represented by the module reveals the existence of synergic and conflictive effects of the PELBD/PEBD mixtures that should be taken into consideration when designing them.

Conceptually, we talk about the existence of synergic interactions when the mixture behavior is greater than that which would proportionally be obtained from the pure component properties (dotted lines shown in Figure 3). The existence of synergic interactions in PELBD/PEBD mixtures allows us, in this particular case, to obtain mixtures with 70 to 80% PELBD with elasticity modules superior to the pure linear. A similar situation arises in the region rich in low density (between 10 and 30%) with respect to the pure FB-3003.

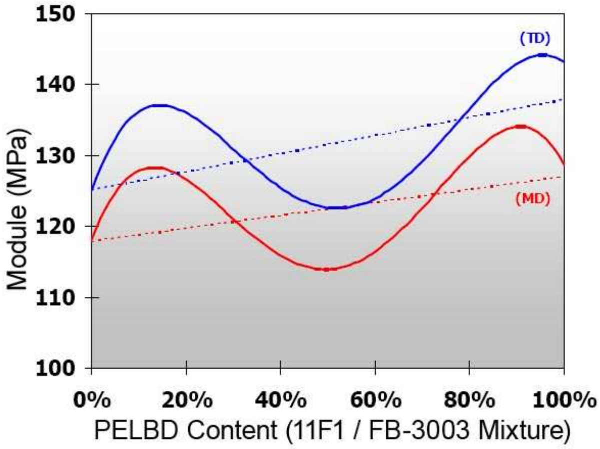

Figure 3. Elasticity modules as a percentage function of PELBD in the mixture.

On the other hand, when the mixture composition is in an area where conflictive interactions take place, the resulting properties are lower than those which would proportionally be obtained from pure components. The existence of conflictive interactions in the area between 30 and 70% PELBD makes the resulting mixture exhibit elasticity modules even lower than those of pure PEBD; this behavior will force the use of a film with greater thickness in order to compensate the deterioration of this property.

The film properties in its rupture point show much more relevant variations than those illustrated for the elasticity module.

Figure 4 shows the noticeable tenacity increase that contributes the incorporation of PELBD to PEBD mixtures.

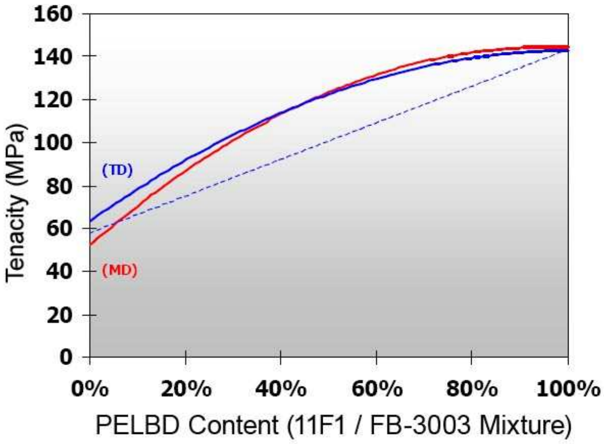

Figure 4. Rupture tenacity as a percentage function of PEBD in the mixture.

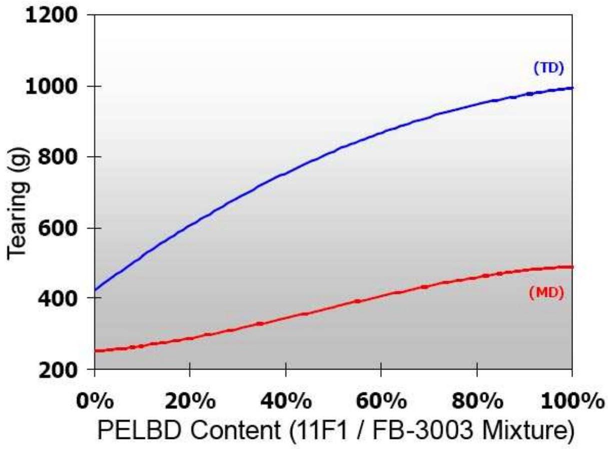

Figure 5. Tear resistance as a percentage function of PELBD in the mixture.

Tenacity is a compound property that represents the ability of the material to absorb applied mechanical energy, transforming it into plastic deformation. Any increase in tenacity means a greater ability of the film to withstand fault processes, such as tear (see Figure 5) and impact.
In regards to tenacity and tear resistance, we can see that the mixture performance is synergic during the entire composition interval.

The combined effect of the improvement of these properties means the possibility of creating films with thickness lower than the one which would be produced with mixtures rich in PEBD, but maintaining or even improving the mechanical properties.

3 Processability

Due to the existing differences regarding branched low-density polyethylene and linear flow properties, both types of resins should be processed under different extrusion conditions.

In order to obtain optimal performance from the transformation equipments, with mixtures major in PELBD, it is convenient to follow the following recommendations:

- Use a greater extrusion temperature and parabolic profiles which benefit the reduction of power consumption, and a low release nozzle temperature that best controls the instability tendency of linear and mixtures with a high content of these (see Figure 6).
- Use nozzles with wider tip openings (between 1.2 and 2.5 mm) and a lower discharge longitude (see Figure 7).
- Us screws with a greater passage or helix angle.

Use cooling rings with double air release vents.

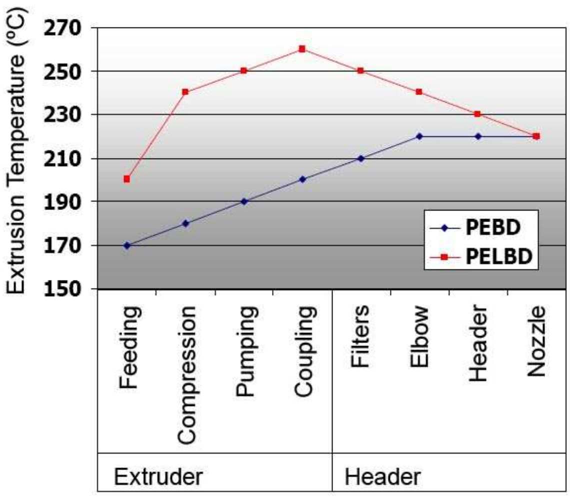

Figure 6. Suggested extrusion temperature profile comparison for mixtures rich in linear or with low density.

Mixtures rich in linear have a greater elastic capacity when cast, which allows achieving greater elastic or thinning relations.

The film elastic relation is obtained by the following equation:

$$\text{Elasticity (MD/TD)} = \frac{\text{Nozzle opening}}{\text{Thickness x (BUR)}^2}$$

For linear resins, this relation must be between 10 and 20 times the index flow; whereas for PEBD it is usually between 2 and 4. Extrusion in these intervals guarantees the maximum bubble stability (4).

The maximum flow that can be achieved in film extrusions with mixtures rich in linear will mostly depend on the restrictions that each component and equipment accessories may exhibit. The following chart shows the most frequent limitations they could exhibit:

Restrictions	Signals of Limitation	Temporary Corrective Measure
Nozzle with an aperture of less than 1.2 mm	Impedes to reach the max. Volume of high-pressure extrusion, scratch, cracking or high consumption.	Increase the temperature of the header and nozzle until pressure reduces or melting crack disappears.
Cooling ring with a single output.	Impedes to use the max. Volume of cooling air due to instability of the bubble.	Use refrigerated air to increase the cooling capacity to a minor volume.
Inadequate design of the extrusion screw	High consumption of power, spotted material, without melting.	Increase extrusion temperature and add anti-oxidizing concentrates to base resin.
Low-power motor	Excessive consumption of power and overheating of engine.	Increase extrusion temperature.

The most adequate extruder component, for the use of mixtures rich in PELBD, with more simplicity and lower cost, is the nozzle.

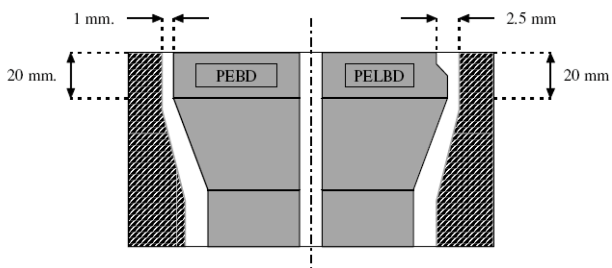

Figure 7. Section of a tubular film extrusion nozzle for PEBD and PELBD.

Nozzles for processing mixtures rich in linear must have not only a wider opening, but also a lower longitude of the discharge area. Figure 7 shows the suggested design and the most widely recommended values in the technical literature.

TECHNICAL BULLETIN: LDPE – LLDPE MIXTURES FOR INDUSTRIAL PACKAGING

Figure 8. Picture of a nozzle for PELBD.

The use of nozzles with the suggested design brings forth the following benefits:

1. Greater extrusion speed limit for reaching the cast material fracture point.

2. Lower extrusion temperature, which contributes to the increase the bubble stability and the reduction of the cooling air flow, both being contributing factors for minimizing thickness deviations.

3. Lower power consumption. As the nozzle pressure fall is reduced, the power that has to be supplied by the engine in order to overcome this restriction is also reduced.

Figure 9 shows the flow variation by Amp used by the extruder engine. This rate gives a very clear comparative reference of the productivity changes generated by the modification of the linear content in the mixture.

The data shown in Figure 9 were obtained for a constant extrusion flow of 30 Kg/h.

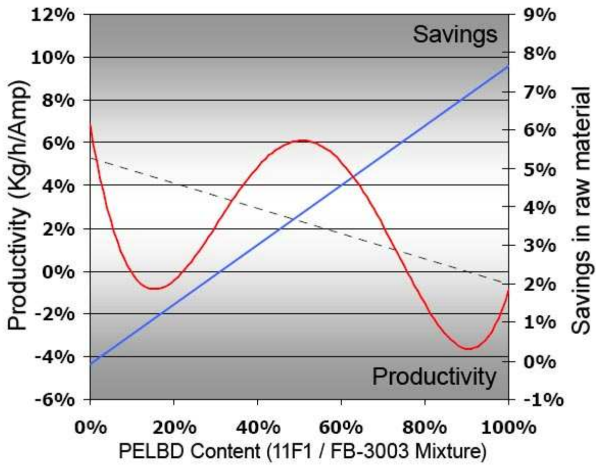

Figure 9. Maximum flow/amperage relation and savings in mixture costs as a percentage function of PEBD in the mixture (at a maximum flow).

The productivity rate shown again reveals the existence of conflictive and synergic phenomena as the ones previously described for the case of the elasticity module.

According to the obtained tendency, mixtures with PELBD content between 75 and 90% show productivity reductions that reach, at the most, 4%; whereas with these doses it is possible to achieve savings in mixture costs of 6 to 7.5%.

The global balance ratifies that the use of mixtures rich in PELBD content for industrial use film production offers important improvements in properties at a better price, without incurring into significant sacrifices in the process. The Processability in major mixtures can be dramatically improved by the use of nozzles with wider openings as well as the use of cooling rings with double release vents, representing a very profitable investment considering the benefits which can be achieved. 🕮

4 References

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This bulletin has been made by the Marketing Department of Polinter with the support of the specialists of Investigación y Desarrollo, C.A. (INDESCA) and by the Technical Services Department of CORAMER. This is intended for all clients and users of the Venelene® resins and we trust that the information contained herein is helpful and useful.

Please contact us at the following email address, info@polinter.com.ve or through our agent: Corporacion Americana de Resinas (CORAMER), with branch offices in Venezuela, Colombia, Peru, Ecuador and Chile (http://www.coramer.com), should you have any suggestions or comments regarding this issue.

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In order to obtain more detailed information of the security aspects regarding the use and disposal of our products we invite you to consult the security pages (MSDS) of the Venelene® Polyethylene.