SASOL CHEMICALS

Technology Tip

Improvement of film properties by blending
Low Density Polyethylene (LDPE) and
Linear Low Density Polyethylene (hLLDPE)

Overview

SASOL AT A GLANCE

Sasol is an international integrated chemicals and energy company that leverages technologies and the expertise of our 30 400 people working in 36 countries. We develop and commercialise technologies, and build and operate world-scale facilities to produce a range of high-value product streams, including liquid fuels, chemicals and low-carbon electricity.

SASOL CHEMICALS

Sasol Chemicals is a producer and marketer of a range of commodity chemicals based on the Fischer Tropsch (FT) and natural gas value chains including chemical feedstocks of ethane, ethylene, propylene and ammonia. Final products include polymers, explosives, fertilisers, mining reagents (caustic soda, sodium cyanide), and a range of alcohols, ketones, acrylate monomers, and other oxygenated solvents.

Final products marketed through the Polymers division include low density polyethylene (LDPE), hexene linear low density polyethylene (hLLDPE), polypropylene (PP), and polyvinyl chloride (PVC) as well as propylene and ethylene monomers. Through this product portfolio we offer polymer solutions for a broad range of applications and industries.

Our polymers are marketed throughout Sub-Saharan Africa, Europe, Americas and Asia and we are active in over 75 countries globally.

Our Polymer Technology Services Centre in Johannesburg provides expertise and technical service support to external customers and also undertakes polymer-related applications research and development applicable to the Polymers division.

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Optimisation of film properties by blending LDPE and LLDPE

1. INTRODUCTION

Blends of linear low density polyethylene (hLLDPE) and low density polyethylene (LDPE) (typically up to 30% w/w) are used by converters to optimise film properties and to reduce the overall cost of a formulation. Blending can result in the production of a film with properties that cannot be achieved by the individual polymers. Blending, is therefore, a valuable tool for optimising film properties. Blending must however, be carried out using the correct formulating principles.

The processing, mechanical and optical properties of hLLDPE and LDPE resins are significantly different. hLLDPE resins generally have excellent mechanical properties, including good tear and impact strength, but they are however, more difficult to process than LDPE grades. The optical properties (haze and gloss) of LDPE resins are significantly better than those of hLLDPE. The mechanicals however, are inferior.

2. THE MAIN TECHNICAL DRIVERS FOR BLENDING LDPE AND LLDPE

There are several technical drivers for the blending of LDPE and hLLDPE:

1. Enhance optical properties (haze, gloss and clarity) of hLLDPE by blending in LDPE
2. Enhance the mechanical properties of LDPE by blending in hLLDPE
3. Manipulate the shrink properties of a formulation
4. Improve processing and bubble stability by adding LDPE
5. Down-gauging of a formulation using hLLDPE

3. EFFECT OF BLENDING ON THE PERFORMANCE PROPERTIES OF PE FILMS

Blending may affect several performance properties, including:

1. Processing performance

2. Optical properties
- Haze
- Gloss
- Clarity

3. Mechanical properties
- Tensile properties
- Tear properties
- Impact properties

4. Shrink properties

These properties will be considered individually and discussed in light of work carried out at the Polymer Technology Services Centre (PTSC).

3.1. Processing performance

The melt pressure in an extruder is a function of several parameters, including the type of polymer, screw speed and the die gap. The polymer properties, especially the molecular weight distribution, will have a significant influence on the melt pressure, because LDPE typically, has a broad molecular weight distribution (MWD) and hLLDPE a narrow MWD. When adding LDPE to hLLDPE, the distribution will broaden, resulting in a blend that is more prone to shear thinning.

In the study carried out at Polymer Technology Services Centre (PTSC) a significant increase in the melt pressure was observed when hLLDPE was added to LDPE using a die gap of 1,4 mm. For the 50/50 blends, a die gap of 2,2 mm was selected. This resulted in a decrease in the melt pressure, compared to a 75% LDPE/25% hLLDPE blend. When starting with 100% LLDPE, the addition of LDPE will generally cause a broadening of the overall molecular weight distribution, resulting in a decrease in the melt pressure. This was found for the hLLDPE rich blends with the 1 and the 2 MI resins as the LDPE blending partners (Figure 1).

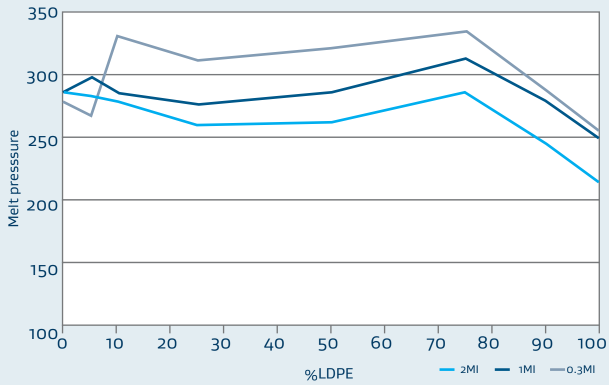

Figure 1: Effect of blending on melt pressure

3.2. Optical properties

The optical properties of a polymer can be characterised by the haze, gloss and clarity values. Haze is defined as the percentage of light, which, on passing through a sample, deviates from the incident beam by more than 2.5º. The gloss of the sample is a measure of the amount of light which is reflected by the surface of the film at an angle of 45º or 60º from the incident beam. Generally, a smoother surface will result in a higher gloss value.

3.2.1. Effect of blending on the haze values

In the above PTSC study, the addition of LDPE to hLLDPE resulted in a significant improvement in the haze properties of the film. With the addition of 5% tubular LDPE to the hLLDPE grades, a 4 - 5% decrease in the haze values was experienced. The optimum reduction in haze of hLLDPE was obtained at between 10 and 25% LDPE addition. The addition of hLLDPE to LDPE resulted in an increase in the haze value. This increase in haze was, however, much more gradual than for the hLLDPE rich blends, and generally, the addition of 25% hLLDPE to LDPE resulted in a 1 unit increase in haze (Figure 2).

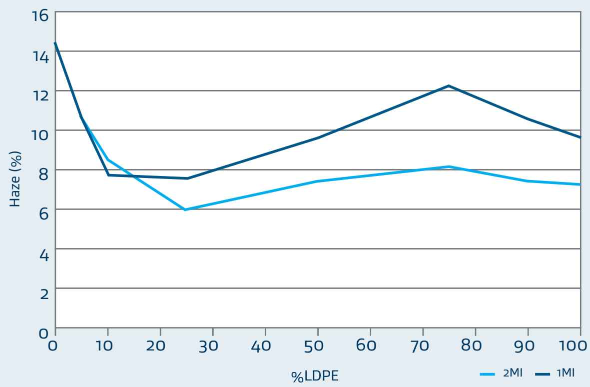

Figure 2: Effect of blending on haze

3.2.2. Effect of blending on the gloss values

The addition of small quantities of tubular LDPE (typically between 10 and 15%) to hLLDPE resulted in a significant improvement in the gloss values. When more than 25% LDPE was added, the effect was less pronounced and the addition of more LDPE resulted in a small increase (or even a decrease) in the gloss values. The addition of hLLDPE to LDPE resulted in a small change in the gloss value, and at 25% hLLDPE addition, the gloss changed by less than 4 units (Figure 3).

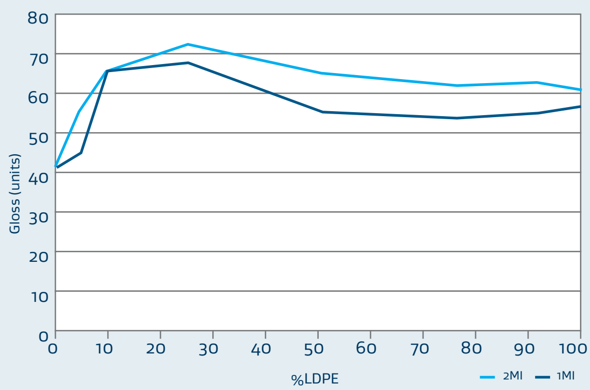

Figure 3: Effect of blending on gloss

3.3. Effect on break strength

The ultimate break strength of a sample is dependent on the molecular weight and the initial degree of entanglement. The machine direction (MD) and transverse direction (TD) break strength of LDPE can be significantly improved by the addition of hLLDPE. The results indicate that there was an almost linear increase in the MD and TD break strength (Figure 4) with the addition of hLLDPE to LDPE.

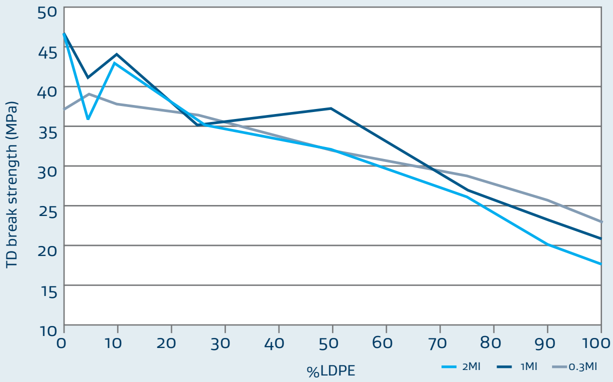

Figure 4: Effect of blending on the TD break strength

3.4. MD and TD elongation at break

The elongation at break of a polyethylene sample depends on its molecular structure and the initial orientation. The effect of blending on the MD and TD elongation was:

3.4.1. MD elongation

The draw-down ratios of the LDPE base resins are lower than the corresponding hLLDPE blending partners. The addition of hLLDPE to LDPE resulted in a significant increase in the MD elongation performance. Similarly, the addition of LDPE to hLLDPE resulted in a significant decrease in the MD elongation (Figure 5).

3.4.2. TD elongation

The addition of hLLDPE to LDPE resulted in an increase in the TD elongation (Figure 6).

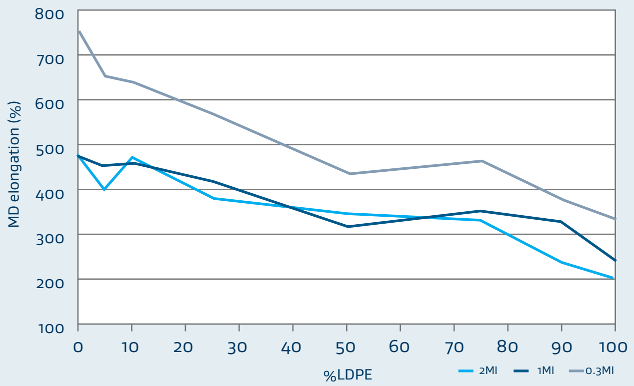

Figure 5: Effect of blending on the MD elongation at break

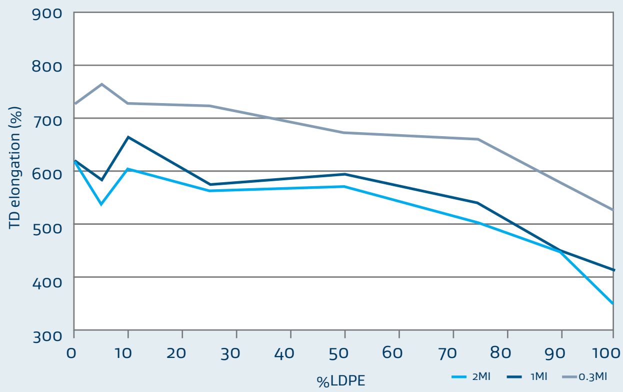

Figure 6: Effect of blending on the TD elongation at break

3.5. Effect of blending on the tear strength

3.5.1. MD tear strength

The MD elongation is influenced significantly by the processing conditions (e.g haul-off speed). With hLLDPE rich blends, adding LDPE to hLLDPE resulted in a decrease in the MD tear strength.

3.5.2. TD tear strength

The addition of hLLDPE to the tubular LDPE grades resulted in an almost linear increase in the TD tear strength. However, at high concentrations of hLLDPE, the effect reached a plateau and at more than 75% hLLDPE the TD tear strength decreased (Figure 7).

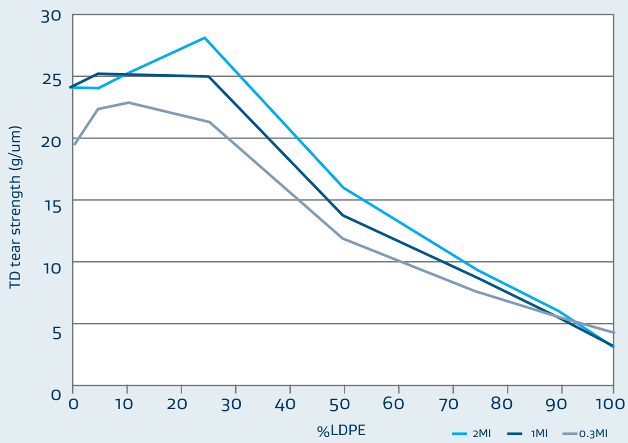

Figure 7 : Effect of blending on the TD tear strength

3.6. Impact strength

The impact strength is a measure of the toughness of polyethylene and is primarily influenced by the degree of crystallinity of the material (density). The impact strength generally decreases with an increase in the crystallinity (density). The addition of LDPE to hLLDPE (between 0 and 50%) generally resulted in a drop in the impact properties. The addition of between 10 and 25% hLLDPE to LDPE did not result in a significant improvement in the impact properties, except for the 0.3 MI resin, where the addition of HF101 resulted in a significant improvement in the mechanicals (HF 101 has a significantly higher impact strength than the 0.3MI tubular LDPE resin). The addition of LDPE to hLLDPE resulted in a significant drop in impact properties (Figure 8).

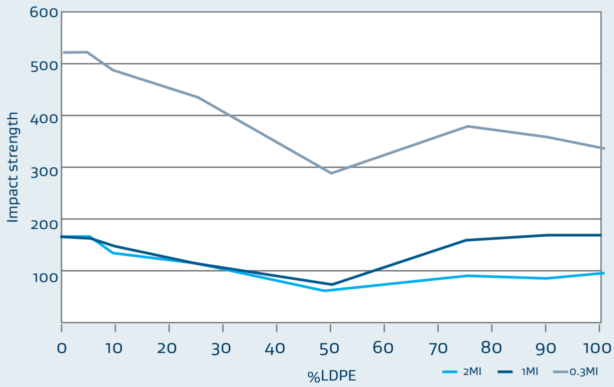

Figure 8: Effect of blending on impact strength

3.7. Shrink performance

The shrink properties of a formulation can be affected significantly by the blending of LDPE and hLLDPE. This must be taken in account when a formulation is optimised.

3.7.1. MD shrink performance

The addition of low levels (< 25%) of hLLDPE to tubular LDPE resulted in a significant reduction in the MD shrink performance (Figure 9).

3.7.2. TD shrink performance

The addition of hLLDPE to LDPE resulted in a decrease in the TD shrink performance. At 50% or more addition of hLLDPE to LDPE, there was virtually zero or negative TD shrink (Figure 10).

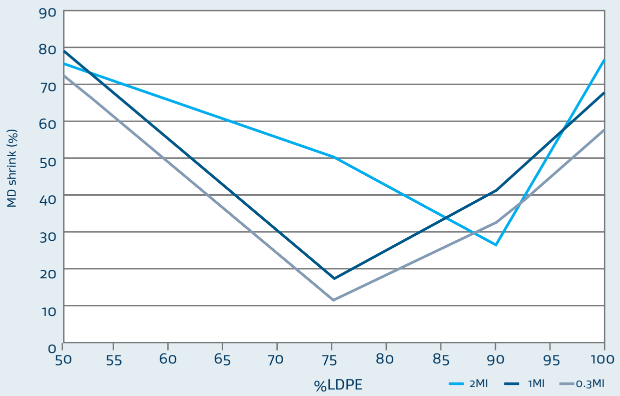

Figure 9: Effect of blending on the MD shrink performance

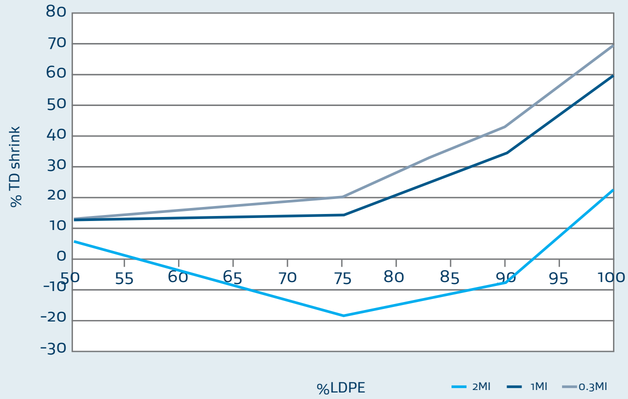

Figure 10: Effect of blending on the TD shrink performance

4. CONCLUSIONS

The addition of between 10% and 25% hLLDPE to tubular LDPE resulted in a significant improvement in the mechanical properties of the tubular base resins. Significant improvements were achieved in the TD tear strength, MD and TD break strength, and MD and TD elongation at break. The haze and gloss values were both affected by the addition of hLLDPE, but this effect was minimal at 10% addition (typically less than 1 haze unit increase and a small change in gloss).

The addition of small quantities (between 5 and 10%) tubular LDPE to hLLDPE improved the optical properties of the hLLDPE to a significant extent. The haze decreased and the gloss increased significantly. The addition of small quantities LDPE also resulted in a decrease in the melt pressure at the same die gap.