



BLENDS OF LLDPE AND LDPE FOR FILM

Important benefits can be achieved with the processability and end use properties of LDPE and LLDPE. (including metallocene LLDPE) by blending the polymers together in various proportions.

Alkatuff LLDPE, Alkamax mLLDPE and Alkathene LDPE are normally compatible. Linear-rich blends or LDPE-rich blends are widely used in film applications. Blends containing 40 – 60% LDPE are not so common.

Addition of LDPE to LLDPE or mLLDPE improves several properties, including processing and optical properties. Such linear rich blends have rheological properties intermediate between those of the two polymers and their processing performance is modified sufficiently to improve the film processing with little loss in the desirable mechanical properties.

In particular, a small addition of LDPE to LLDPE makes the LLDPE less sensitive to disturbances and significantly decreases the tendency for bubble instability.

The blending of a small amount of LDPE into LLDPE also gives a considerable improvement to the gloss and haze of the film.

As would be expected, the properties of the linear-rich blends are modified slightly away from those of LLDPE or mLLDPE towards those of LDPE but generally this is not a serious disadvantage. At the other end of the scale, small amounts of Alkatuff LLDPE or Alkamax mLLDPE (less than 40%) blended into Alkathene LDPE improve processability, with enhanced tensile properties, stiffness, puncture resistance and heat sealability which may allow the benefits of down gauging.

Blends of LDPE and LLDPE show two major melting peaks when tested using the Differential Scanning Calorimeter (DSC). This indicates that the two polymers exist as separate phases within the blend. The relative sizes of the two peaks can often be used to estimate the composition of the blend.

PROCESSING PROPERTIES

Blends of LDPE and LLDPE have shear viscosities intermediate between those of the two component polymers. This is illustrated in Figure 1 (on page 2) for blends of an MFI 2.5 *Alkathene* LDPE and an MFI 1.0 *Alkatuff* LLDPE. The blends have a lower shear viscosity at any shear rate than the base LLDPE polymer, and the log shear viscosity is approximately a linear function of the blend composition.

This means that these blends will require less power to extrude than straight LLDPE, will give lower melt temperatures and lower pressure and, as a consequence, the output rate from any extruder will be less restricted. Extrusion may be possible without resorting to wide die gaps.

Addition of small amounts of LDPE to LLDPE gives significant increases in the extensional viscosity and imparts some strain-hardening characteristics. Such blends are less sensitive to disturbances than straight LLDPE and hence significantly decrease the tendency for bubble instability. LLDPE containing a small amount of LDPE will be less prone to show surface melt fracture effects than the straight polymer. This is one solution used in overcoming this extrusion problem.

In summary, significant processability benefits can be readily achieved with LLDPE or mLLDPE by using linear-rich blends containing, for example, 5 to 20% LDPE.

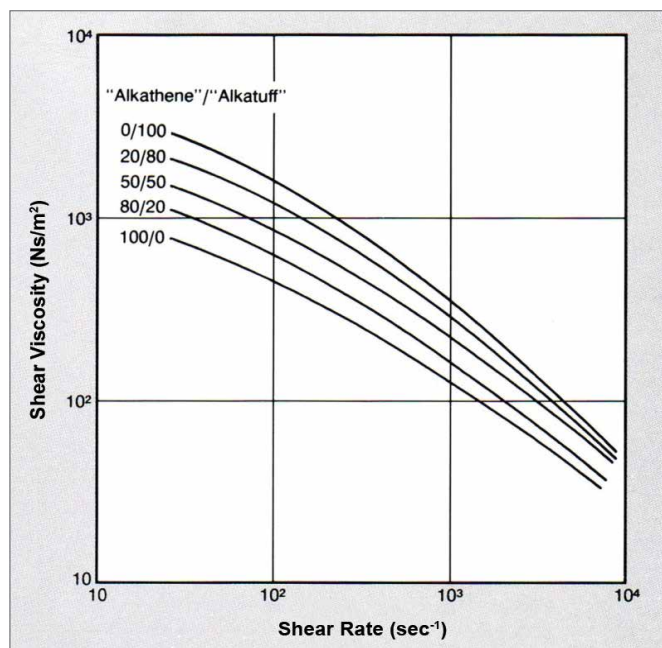


Figure 1: Shear Viscosity vs. Shear Rate for Blends of *Alkathene* LDPE (MFI 2.5, Density 0.922 g/cm³) and *Alkatuff* LLDPE (MFI 1.0, Density 0.920 g/cm³) at 190°C

PHYSICAL PROPERTIES

The physical properties of a series of LDPE/LLDPE blends for blown film have been investigated. The blends evaluated were based on an MFI 0.45, density 0.922 g/cm³ *Alkathene* LDPE and contained various levels (20%, 40%, 60%, and 80%) of LLDPE. Three LLDPEs were used: a butene-based copolymer made by the gas-phase process (MFI 1.0, density 0.920 g/cm³), a hexene-based (*Alkatuff* type) copolymer made by the gas-phase process (MFI 1.0, density 0.920 g/cm³) and an octene-based copolymer made by a solution process (MFI 1.0, density 0.921 g/cm³).

The effects of blending of these LLDPEs with the *Alkathene* LDPE on the mechanical properties of nominally 50 micron film were determined and these results are presented graphically in Figures 2 to 8. In general, the film properties of the blends with the higher alpha-olefin copolymer LLDPEs (hexene- and octene based) were quite similar and much superior to those obtained with the butene-based LLDPE blends.

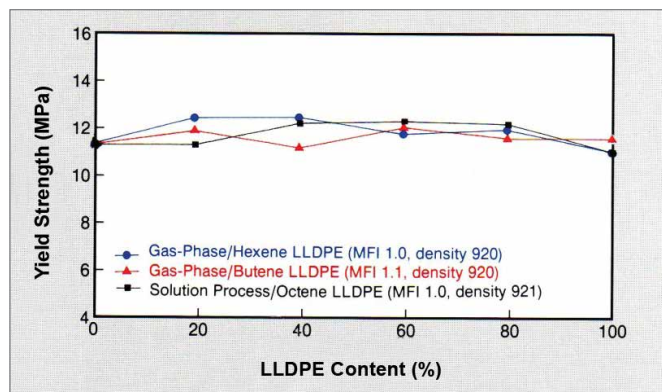


Figure 2: Yield Strength in Machine Direction for LDPE/LLDPE Film Blends, based on MFI 0.45, Density 0.923 g/cm³ (Film Thickness 50 micron)

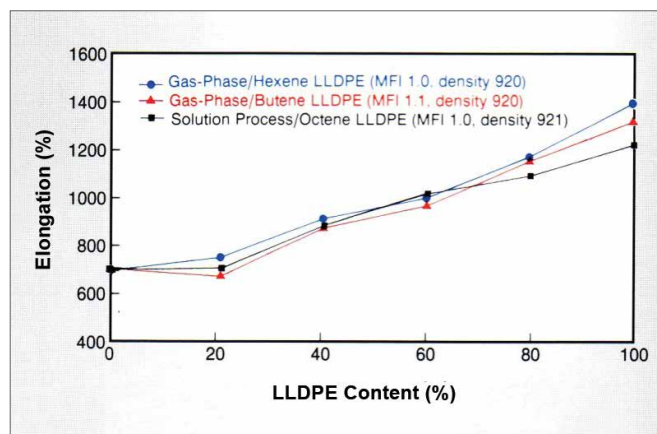


Figure 3: Elongation in Machine Direction for LDPE/LLDPE Film Blends (based on MFI 0.45, Density 0.923 g/cm³ (Film Thickness 50 micron)

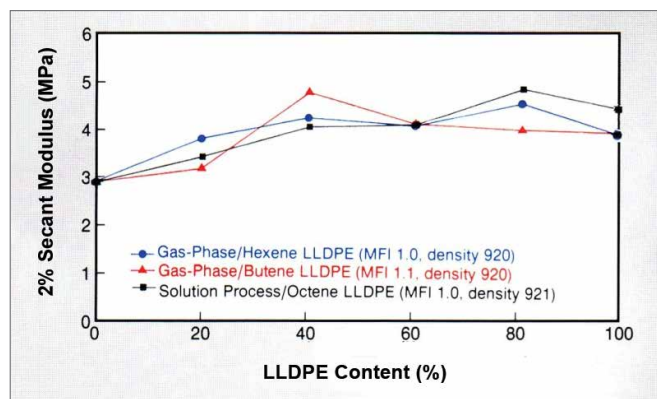


Figure 4: 2% Secant Modulus for LDPE/LLDPE Film Blends (based on MFI 0.45, Density 0.923 g/cm³ (Film Thickness 50 micron)

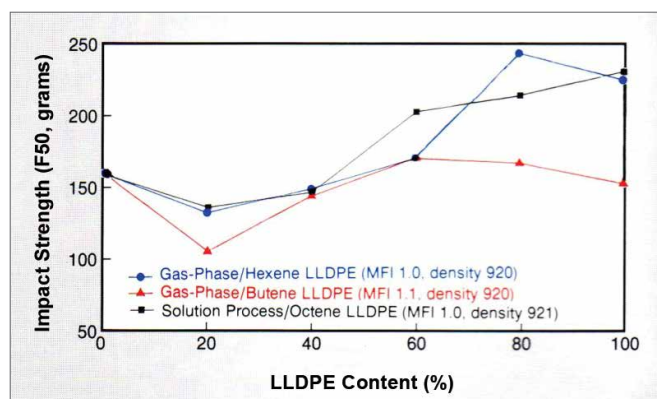


Figure 5: Impact Strength of LDPE/LLDPE Film Blends (based on MFI 0.45, Density 0.923 g/cm³ (Film Thickness 50 micron)

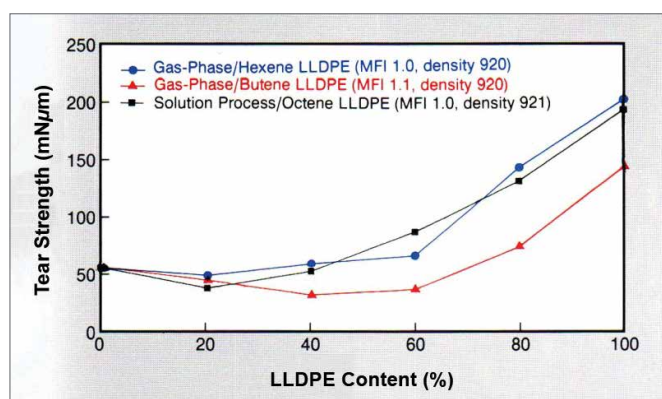


Figure 6: Machine Direction Tear Strength for LDPE/LLDPE Film Blends (based on MFI 0.45, Density 0.923 g/cm³ (Film Thickness 50 micron)

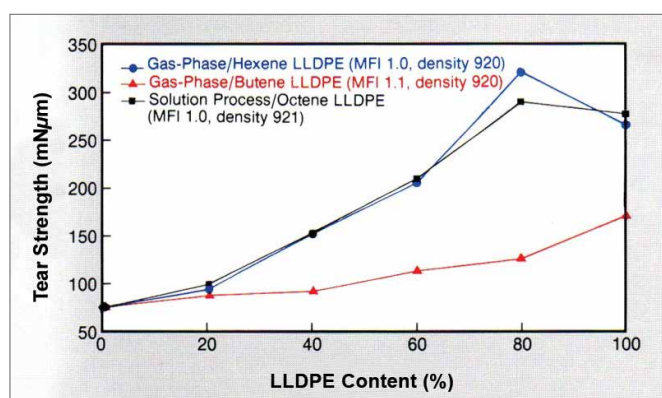


Figure 7: Transverse Direction Tear Strength for LDPE/LLDPE Film Blends (based on MFI 0.45, Density 0.923 g/cm³ (Film Thickness 50 micron)

Tensile Properties: Yield strength in both the machine and transverse directions was relatively unaffected by the blending, as shown in Figure 2. There was a small yield strength benefit by adding about 20% LDPE to the LLDPE. Yield strength is essentially influenced by density and all the polymers used in this investigation had very similar densities.

Ultimate strength increased approximately linearly with the LLDPE content in the blends. The ultimate strength results demonstrated the poorer properties of the blends with the butene-based LLDPE.

Elongation increased roughly linearly with the LLDPE content, the increase being much greater (double) in the machine direction (see Figure 3) than in the transverse direction.

Film stiffness was assessed by measuring the 2% secant modulus. This property increased with increasing LLDPE content (see Figure 4).

Falling Dart Impact Strength: Addition of the LLDPE to the *Alkathene* LDPE grade significantly improved the impact strength of the film (see Figure 5).

Elmendorf Tear Strength: Small additions of LLDPE (about 20%) to the *Alkathene* LDPE grade gave small decreases in the MD tear strength but increases in the TD tear strength (see Figures 6 and 7).

Optical Properties: Addition of 20 to 40% *Alkathene* LDPE to the LLDPEs significantly improved their haze and gloss results.

Heat Sealing: Hot tack sealing measurements on these film blends using an IDM Hot Tack Tester (Figure 8) showed that the hot tack strength increased as the LLDPE content increased, with the linear-rich (80% LLDPE) blend performing quite well, especially at higher sealing temperatures.

Puncture Resistance: Blending LLDPE into conventional LDPE polymer results in a significant increase in puncture resistance.

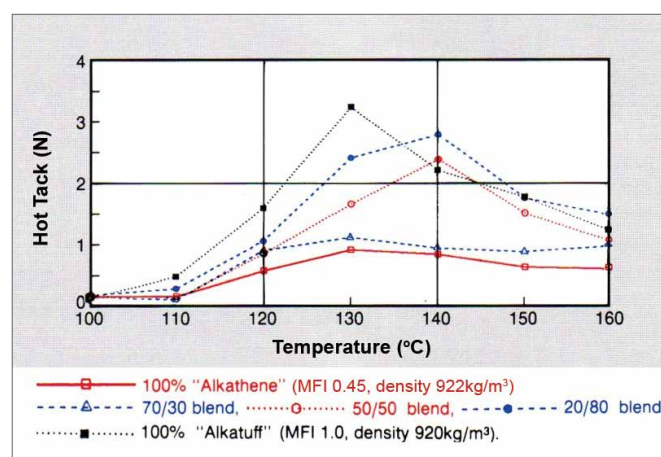


Figure 8: Hot Tack Sealing of *Alkathene* LDPE/*Alkatuff* LLDPE Blend Films (IDM Hot Tack Tester, Seal Pressure 275 kPa, Seal Time 0.5 sec, Delay Time 0.2 sec, Peel Speed 250 mm/sec, Film Thickness 50 micron)



THE ADDITION OF LDPE TO LLDPE OR MLLDPE IMPROVES SEVERAL PROPERTIES, INCLUDING PROCESSING AND OPTICAL PROPERTIES.



TROUBLESHOOTING GUIDE: RELATING TO BLENDS

The causes and potential solutions listed in this troubleshooting guide are only related to blending. Please refer to the Film Extrusion Technical Guide for a full list of possible causes and solutions to these and other issues.

Problem/Issue	Causes	Potential Solutions/Actions
Blocking	Formulation susceptible to blocking	Consider metallocene resins or higher density resins
Low output	Unstable bubble	Refer to “Unstable bubble” section
Melt fracture	Formulation not optimum	Add or increase level of LDPE Consider a different grade of LLDPE
	Output rate too high	Reduce output rate
Poor optical properties	Formulation not optimum	Consider lower density resins Consider higher melt index resins Add or increase level of LDPE
Poor shrink properties	Incorrect resin or formulation for application	Adjust level of LLDPE/HDPE or alter grade of LDPE
Poor sealing	Formulation not optimum for conditions	Adjust formulation (will depend on failure type)
Unstable bubble	Melt strength too low	Reduce melt temperature Use material with lower MFI Add or increase level of LDPE

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