Technical and Comparative Data on

Petrothene® Broad Molecular Weight, LLDPE for Blow Molding and Extrusion

lyondellbasell

TECHNICAL AND COMPARATIVE DATA ON PETROTHENE® BROAD MOLECULAR WEIGHT, LINEAR LOW DENSITY POLYETHYLENE FOR BLOW MOLDING AND EXTRUSION

INTRODUCTION

Over the past decade, linear low density polyethylene (LLDPE) has become dominant in many plastics markets once held by low density PE (LDPE), especially that of blown film. However, the narrow molecular weight (NMW) distribution of conventional LLDPE can lead to decreased melt strength and, in some cases, melt fracture. As a result, many LLDPE resins have not been well accepted in blow molding, profile extrusion, sheet extrusion and thermoforming applications, despite their excellent environmental stress crack resistance (ESCR).

To meet the need for both enhanced processability and excellent ESCR in blow molding and extrusion operations, LyondellBasell has developed a family of new broad molecular weight (BMW) distribution LLDPE resins. The first product in this series is Petrothene GA 818-073, which is referred to throughout this brochure. GA 818-073 has a melt index of 0.75 g/10 min. and a density of 0.9205 g/cm^3.

ADVANTAGES OF PETROTHENE BMW-LLDPE

ESCR

LLDPE resins in general have excellent ESCR. ESCR is a measure of the endurance of a polyethylene under stress – such as bending – in the presence of certain liquids, such as detergents and surfactants. The linear nature of their polymer chains gives LLDPE resins enhanced ESCR when compared to branched, conventional LDPE resins. GA 818-073 maintains this excellent ESCR performance, but also exhibits extrudability and melt strength properties superior to most LLDPE resins. These properties are presented in Tables 1, 2 and 3.

Table 1 lists the melt index and density of GA 818-073 and other polyethylene types, including conventional NMW-LLPDE, autoclave LDPE and HDPE.

Table 1. Melt index and density comparisons

Resin Type	Melt Index (g/10 min.)	Density (g/cm^3)
BMW-LLDPE (GA 818-073)	0.75	0.9205
Conventional NMW-LLDPE	1.0	0.918
Conventional Autoclave LDPE	1.2	0.918
Conventional Autoclave LDPE	1.8	0.922
Conventional HDPE	0.3	0.952
High ESCR HDPE	0.2	0.946

In Table 2, several key properties of these resins are compared. The properties include extrudability, ESCR, melt strength, melt fracture resistance and low temperature impact strength. GA 818-073 resin exhibits an excellent balance of properties: the superior ESCR described earlier coupled with good processability, melt strength, resistance to melt fracture and low temperature impact strength. GA 818-073 compares very favorably to other PE types, which can exhibit good performance in some areas but less-than-adequate properties in others.

Table 2. Properties comparison, GA 818-073 and other resins

Resin Type	ESCR Hrs to F_{50}	Extrudability	Melt Strength	Melt Fracture Resistance	Low Temperature Impact Strength
BMW-LLDPE (GA 818-073)	Excellent	Good	Good	Good	Good
Conventional LLDPE	Excellent	Fair	Fair	Fair	Good
Conventional LDPE	Fair	Excellent	Excellent	Good	Good
Conventional HDPE	Fair	Good	Good	Good	Good
High Molecular Weight HDPE	Good	Fair	Excellent	Good	Excellent

Table 3 lists the Bent Strip ESCR (ASTM D-1693) test results for GA 818-073, conventional NMW-LLDPE, two LDPEs and two HDPEs commonly used for blow molding and extrusion applications. Results are reported in hours to failure of 50 percent of the test specimens.

Table 3. Bent strip ESCR test comparisons (ASTM D-1693)

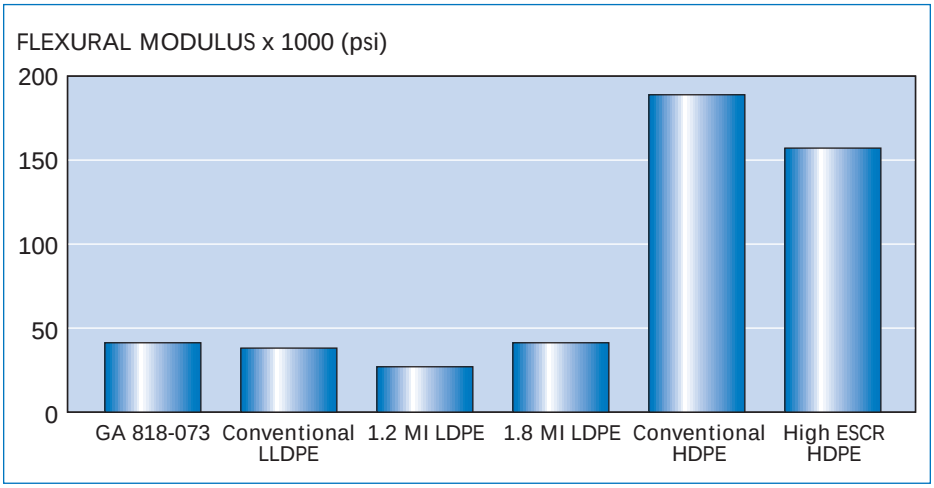
Resin Type	ESCR (Hrs to F_{50})
BMW-LLDPE (GA 818-073)	>1,000
Conventional LLDPE	>1,000
Conventional LDPE, 1.2 MI	8
Conventional LDPE, 1.8 MI	1
Conventional HDPE	48
High ESCR HDPE	>1,000

GA 818-073 has a much higher ESCR than the two high pressure LDPEs used for blow molding and extrusion. Its value is comparable to those of conventional LLDPE and high ESCR HDPE, indicating the versatility of the BMW-LLDPE product.

Flexural Modulus

In Figure 1, the flexural modulus values for the same group of resins are compared. GA 818-073 has a stiffness similar to that of conventional LLDPE and is much more flexible than conventional HDPE. The BMW-LLDPE's stiffness is significantly higher than that of the 1.3 MI LDPE and close to that of the 1.8 MI LDPE. This combination of flexibility and high ESCR opens up many application areas to GA 818-073, including beverage tubing, squeeze bottles and personal care product bottles.

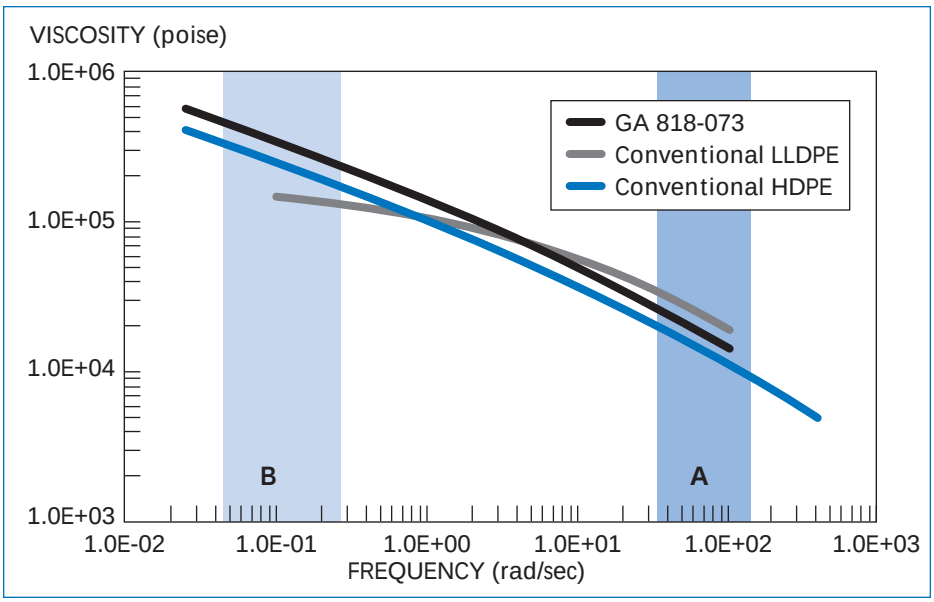
Figure 1. Comparative flexural modulus data (ASTM D-790)



Processability

The broad molecular weight distribution of GA 818-073 also offers certain processing advantages when used in blow molding, profile extrusion, sheet extrusion and thermoforming. These are partially described by the the rheology curves in Figure 2.

Figure 2. Rheology of GA 818-073 vs. conventional LLDPE and HDPE



All polyethylene resins display a phenomenon known as shear thinning. As a resin is pushed faster through an extruder at high shear rates (high frequency), it appears to have a decreasing viscosity. The amount of "shear thinning" that occurs is largely controlled by the breadth of the resin's molecular weight distribution. Broad molecular weight distribution resins display greater shear thinning, which translates into easier extrusion.

Region A in Figure 2 represents the viscosities of three resins – GA 818-073 BMW-LLDPE, a conventional LLDPE and an HDPE – at a high shear (i.e., through an extruder or die). GA 818-073 exhibits a lower viscosity at high shear rates than does the conventional LLDPE. The interpretation: BMW-LLDPE GA 818-073 is easier to extrude. The BMW-LLDPE resin's reduced viscosity under these conditions also means it has less tendency to melt fracture (and produce a rough surface on the extrudate) when compared to conventional NMW-LLDPE.

Region B (low shear rate) represents the melt strength of the same three resins after they have exited a die. Here, GA 818-073 displays a higher viscosity (or greater melt strength), which means a parison made from this resin, dropped from the die, retains its shape better. It also means lower sheet sag during a thermoforming operation. Overall, the flow curve of GA 818-073 closely parallels that of the conventional HDPE tested, a well-accepted, high speed, blow molding resin. This result further supports the excellent performance of GA 818-073 in blow molding applications.

APPLICATIONS

In extrusion blow molding, the broad molecular weight distribution, high melt strength, excellent ESCR, enhanced processability and flexibility of GA 818-073 make it a very good choice for squeeze bottle and tube applications. Its ESCR makes it particularly well suited for containers of aggressive stress cracking agents, such as shampoos, detergents and cosmetics that incorporate fragrances. GA 818-073 can also be used for blow molding large parts and containers, such as drum liners and traffic channelizers, or as an inner layer in a coextruded bottle structure.

Petrothene GA 818-073 can also be extruded as a smooth profile shape. Because of its high ESCR and flexibility, GA 818-073 can be made into tubing that requires force-fittings or clamped fittings. The BMW-LLDPE withstands stresses at the fitting points better than conventional LDPE.

Petrothene GA 818-073 meets the requirements of the Food and Drug Administration, 21 CFR 177.1520. This regulation allows the use of this olefin polymer in "... articles or components of articles intended for use in contact with food." Specific limitations or conditions of use may apply.

SUMMARY

Petrothene GA 818-073 is a broad molecular weight distribution LLDPE with excellent ESCR and low temperature impact strength, good melt strength, resistance to melt fracture under normal processing conditions, flexibility, toughness and extrudability. Occasionally, some problems have occurred in trimming parts blow molded from GA 818-073 because of its toughness and flexibility. However, trimming techniques developed for nylon and polypropylene can be successfully employed with GA 818-073.

LyondellBasell Industries
P.O. Box 3646
Houston, TX 77252-3646
United States

www.LYB.com

6852/0599