

**Figure 2: Surface migration of PB-1**

The idealized surface migration layer diagram (Figure 2 above) shows no die degradation or swell buildup as experienced with many other additives. This patent demonstrates that throughput of metallocene polyethylene (in particular octene-based) can be increased by 40% to 50% by 2.5-5.0 wt% PB-1.

Originally developed and patented by a major oil company, Direct Addition Technology has been gifted to the University of Southern Mississippi Research Foundation. Through Noetic Technologies, Inc., the Research Foundation is seeking a commercial partner to bring this promising technology to market.

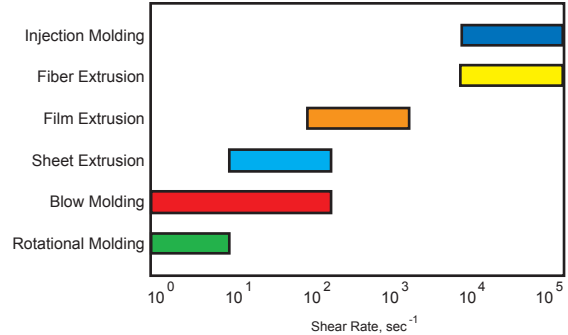
**PROCESSING AND TECHNOLOGY BENEFITS**

The PB-1 Process Aid technology has multiple processing and performance benefits. In general, the benefits of using a processing aid include:

- Minimization of Melt Fracture
- Increased Throughput
- Cost Reduction
- Reduced Die Buildup
- Improved Surface Appearance
- Reduced Cycle Times
- Lower Operating Temperatures

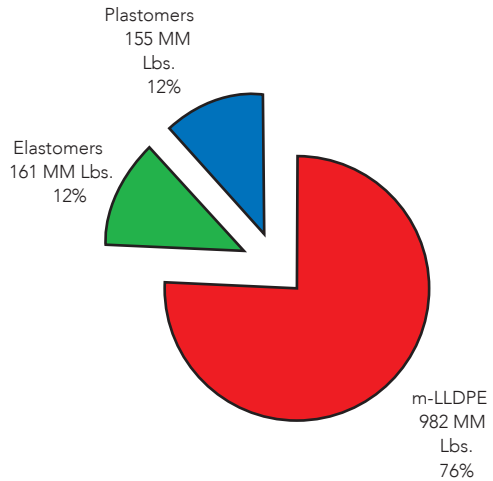
With the advent of metallocene-based elastomers, plastomers and LLDPE, improving processability while retaining their inherently high mechanical and optical properties has become an industry target.

Because of its narrow MWD and higher melt viscosity, m-LLDPE resins are more prone to melt fracture, resulting in irregular surface appearances and lower throughputs. As shear rate requirements increase, the more difficult it is to process metallocene resins without the use of processing aids.



**Figure 3: Shear Rate Maxima Experienced by Polymers During Processing**

The potential market size of this technology is significant. Taken at the low end of the blending curve (2.5 wt%) rate, and 2003 figures for m-PE demand, the PB-1 requirement could be over 30 million lbs/year. This is a significant business base in its own right to say nothing of the collateral benefits gained directly in metallocene products. This is for North America quantities ONLY; world wide outlook is several times greater.



**Figure 4: Metallocene PE Market in North America**

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- Increased throughput for metallocene polyethylene processing
- Improved performance and reduced cost compared to other process aids

## INTRODUCTION

Very low density polyethylene resins via metallocene catalysts were first commercialized in 1991 by Exxon Chemical Company followed shortly by the Dow Chemical Company. The demand for metallocene polyolefins has increased steadily, though not perhaps at rates first predicted when they were commercialized. Commercialization lagged forecasts for many reasons, among them (1) premium prices of resins, (2) unique processability problems of these new resins and (3) limited number of suppliers.

In 1996, Shell Chemical filed US Patent 5,889,121 that outlines a new method of reducing metallocene based polyethylene processing deficits by the addition of minor quantities of poly-1-butene (2-5 wt%) – “PB-1”.

In 2004, this entire patent and intellectual property base became the property the University of Southern Mississippi Research Foundation. This technology is now available for licensing from Noetic Technologies, Inc.

## PROCESSING METALLOCENE PE (m-PE)

The primary mechanism by which this process patent serves to increase the processability of host polymers is by surface migration and establishing a film layer to lubricate the host polymer across the die and/or through the extruder barrel.

In typical testing, the lubricated metallocene host resin **processability is increased significantly** over processing the host resin alone.

Metallocene-based polyethylenes, by virtue of their narrow MWD, evince low shear viscosity at low shear rates and high shear viscosity at high shear rates. selectivity of desired products through recycle.

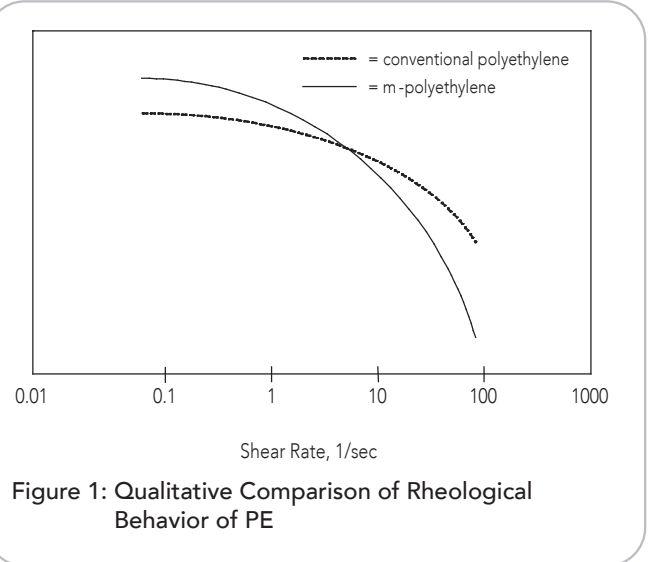


Figure 1: Qualitative Comparison of Rheological Behavior of PE

These rheological characteristics are plotted in Figure 1. Polyethylene processing equipment evolved for several decades around the rheological properties of resins with broad MWDs, so converters are still learning to process metallocene-based polyethylenes.

## TECHNOLOGY ANALYSIS

Patent Title: Process for Improving the Processability of Thermoplastics

○ Patent Number	US 5,889,121
○ Date Filed:	October 4, 1996
○ Date Issued:	March 30, 1999
○ Region:	United States

This patent covers technology related to blends of poly-1-butene (PB-1) with m-LLDPE in the range of 0.1 to 15 wt% to improve processability of the host polymer. The patent affords a method of increasing the processability of metallocene-based polyethylene by blending minor quantities of PB-1 (2-5 wt%). Due to incompatibility with the host resin, PB-1 lubricates the polymer melt by migrating to the surface of the blend to form a film between the host melt and processing equipment die face or internal void channel.