



# Processing Bio-Based / Biodegradable Poly hydroxybutyric acid Copolymer (PHA) with conventional Thermoplastic Process Equipment



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# What is Mirel™ PHA

- Mirel is a family of bio-based Biodegradable polymers.
- Mirel is an aliphatic polyester.
- Mirel is produced through a proprietary fermentation and recovery process that converts corn sugar into plastic.
- Specific grades of Mirel are design for specific property sets and for specific conversion methods.



# Commercial grades of Mirel™

- There are three grades of Mirel available today.
- P1003 is specifically designed for injection molding
- P4001 is specifically designed for sheet extrusion
- P5001 is specifically design for both blown and cast film





# Material Handling and Process Setup



# Material Handling

- Mirel is supplied ready to process.
  - Mirel should be stored in a cool dry place in its original packaging until it is ready to be processed.
- Mirel should be dry before processing.
  - P1003 and P4001 should be 0.1% or less moisture.
  - P5001 should be less than 0.05% moisture.
  - Material that is not dry should be dried in desiccant drier at 80 C for 4 hours



# Before You start to Process Mirel

- Purging
  - Mirel process below the melt temperature of most polymers
  - It is necessary to purge out all other plastics with LDPE before setting the processing conditions for Mirel.
- Waterbath, Chilled rolls and Injection Mold temperatures.
  - Mirel crystallizes at a higher rate at elevated temperatures
  - Molds, waterbath and chilled rolls should be set at 60 C.
  - Small deviations in this temperature has a significant impact on line speeds and cycle times.
- If a machine is going to left idle for more than 15 minutes it is necessary to purge out the Mirel material with PE while any repairs or modification are performed.



# Adding Color

- Color concentrates must be based in Mirel™
- Using other carrier resins effects both processing and biodegradation.
- Established a partnership with Teknor Color to provide color concentrates for Mirel™ based in Mirel™.





# Injection Molding Mirel™ P1003



# Injection Molding Mirel

- Mirel P1003 can be molded on conventional molding equipment.
- General purpose screw
- Standard ball check ring
- Shot size to barrel capacity ratio should be between 2:1 and 4:1
- A reverse temperature profile.
  - 180, 170, 165 C
- Slow Injection speeds
  - Between 12 and 50 mm/sec



# Mirel Injection Mold Design

- Mirel is not corrosive to traditional mold materials.
- Mirel can be molded using conventional gate designs.
- Vents should be 0.005 to 0.02 mm deep.
- Flow balancing is critical.
  - Family tools are difficult due to the differences in the cavities.
- Mirel replicates mold surfaces (textures) very well.
- Mirel works in cold and hot runner systems
- Insulated runners are not recommended.



# Common Mirel Injection Molding Problems

- Flash
  - Too fast of an injection speed
  - Too much hold pressure
  - Poor tool balance
- Too slow of a molding cycle
  - Melt temperature too high
  - Mold temperature either too hot or too cold
- Voids
  - Mold is too cold
  - Inadequate packing pressure/time



# Sample Injection Molding Conditions

Injection Molding Conditions: 2 ISO Tensile bars	
Mold Temperature	140 F
Nozzle Temperature	160 C
Front Barrel Temperature	160C
Middle Barrel Temperature	165 C
Rear Barrel Temperature	175 C
Injection Speed	1.0 in/sec
Injection Time	1.25 sec
Injection Pressure	1048 psi
Hold Time	10.0 sec
Hold Pressure	576 psi
Screw Speed	55 rpm
Back Pressure	75 psi
Cooling time	10.0 sec
Total Cycle Time	25.4 sec



# Sheet Extrusion of Mirel™ P4001



# Mirel Sheet Extrusion

- P4001 can be extruded using conventional extrusion equipment.
- Typical extruder with an L/D ration of 24:1 are recommended
- Low shear screw designs
  - Low shear barrier screws
  - General purpose screw with compression ration of 2.5:1 to 3:1
- Low surface energy first rolls
- Controlled roll temperatures.
  - The first and second rolls need to be controls to keep the surface of the sheet leaving the roll at 60 C



# Mirel Sheet Die Design

- Low volume sheet dies work best
- Choker bars should be avoided
- Well balanced “coat hanger” dies and parabolic dies work best.
- Die lip gaps should be 0.035 mm bigger than the sheet thickness.





# Blown and Cast Film Extrusion with Mirel™ P5001



# Mirel Film Production

- P5001 is design for both blown and cast film.
- Mirel can be converted to film down to about 25 microns in thickness.
- Typical film lines with either 24:1 or 30:1 L/D ratios can be used.
- Low shear barrier screw work best.
- Reverse temperature profile
  - 175, 170, 165 C



# Mirel Blown Film

- Spiral mandrel dies.
- Draw down ratio should be 10:1 or less.
- Dual lip air ring.
- No internal bubble cooling.



# Mirel Cast film

- Low volume film dies work best
- Choker bars should be avoided
- Well balanced “coat hanger” dies and parabolic dies work best.
- Die lip gaps should be 0.4 to 0.65 mm to produce a 0.07 mm film.
- Mirror pocket or other low energy surface finish should be used for the casting roll
- Casting roll should be 60 C



- Advances continue to be made with Mirel™ PHA product development that make more processes possible.



**Thank you for your attention**