

NatureWorks® PLA Polymer 7000D

Injection Stretch Blow Molded Bottles

NatureWorks® PLA polymer 7000D— a NatureWorks LLC product—is a bottles grade resin designed for injection stretch blow molded applications, using conventional ISBM equipment. PLA polymer 7000D typically processes at lower temperatures than PET and can retain a greater level of detail on conventional equipment.

Applications

Injection Stretch Blow Molded, or ISBM Bottles for 1:2 stage operations. Ideal for applications such as:

- Fresh Dairy
- Edible Oils
- Fresh Water

Preform Design

Preform design is critical in getting a container with good clarity and physical properties. Designing a preform for use as a PLA container is, to an extent, specific to the blow mold equipment, bottle design, and mold tooling. As a starting point, however, designing a preform with an areal (axial x hoop) stretch ratio (SR) of 8-11, an axial SR of 2-3, and a hoop SR of 3-4, should allow for the blow molding of the desired container. A preform designed with a thinner endcap might also be desired in order to prevent excess material accumulating in the base of the blown container.

Injection Molding of Preforms

A general-purpose screw designed to minimize residence time and shear is recommended.

Re-heating of Preforms

The heating of the preforms is critical in getting a container with good clarity and material distribution. Normal preform temperatures for running on a 2-step process have been between 80-100°C. This temperature may be lower or higher depending on the preform design, bottle design, and re-heating equipment that is being used.

Typical Material & Application Properties ⁽¹⁾		
Physical Properties	PLA Polymer 7000D	ASTM Method
Specific Gravity	1.24	D792
Melt Density (230°C)	1.08-1.12	D1238
Glass Transition Temperature	130-140°F (55-60°C)	D3417
Crystalline Melt Temperature	295-310°F (145-155°C)	D3418
MFR (210°C) 5-15	5-15	D1238A and B
Blowmolding Specifications		
Preform Temperature	80-100C	
Stretch Rod Speed	1.2-2 m/second	
Blow Mold Temperature	70-100F (21-38°C)	

Blow Molding Container

The base of any given bottle has a thicker material distribution than the sidewall. This thick area in the bottle needs to be distributed well and cooled quickly. This helps keep the base from deforming because the material is still warm in this area. A base design that includes ribs and a high pushup for reinforcement is recommended.

Process Details

Startup and Shutdown

PLA polymer is not compatible with a wide variety of resins, and special purging sequences should be followed:

1. At normal operating temperatures for current polymer in injection molder, purge with polypropylene (PP) or polyethylene (PE), preferably starting with a low MI (high viscosity) PP, switching to a high MI (low viscosity) PP.
2. Bring injection molder to steady state at normal operating temperatures for PLA (listed on reverse side) while running PP.
3. Vacuum out hopper system and any other potential points where

contamination could occur.

4. Introduce PLA resin into the injection molder at the recommended operating temperatures—see operating temperatures, listed on reverse side.
5. It will be obvious when pure 7000D is being extruded, as it gives a clear, steady melt.
6. At shutdown, purge machine with a high-viscosity resin, such as PP.

Note: If transitioning from PET to PLA polymer, it is advised to first transition from these materials to a low melt index (higher viscosity), PP or PE. Follow this transition with one to a higher MI (lower viscosity) PP or PE. Next, lower temperatures to those for PLA before transitioning to PLA.

NatureWorks® PLA-Polymer 7000D



Nominal Processing Parameters		
Melt Temperature	390-430°F	200-220°C
Feed Throat	70°F	20°C
Feed Section	355°F	180°C
Compression Section	410°F	210°C
Metering Section	410-430°F	210-220°C
Nozzle	410-430°F	210-220°C
Mold	70-100°F	21-38°C
Back Pressure	100-200psi	
Mold Shrinkage	0.004 in/in.+/-0.001	

* Note: These are starting points and may need to be optimized. It is very important to optimize back-pressure, process temperature, mold temperature, and injection speed such that the cycle time and the internal stresses in the finished part are kept to a minimum. This will help keep the shrinkage of the preform upon re-heating to the lowest level possible while keeping preform production as high as possible. Using a hot runner system in the injection-molding step is also recommended to help keep shear stress and preform shrinkage to a minimum.

Drying

In-line drying capabilities are essential to process PLA 7000D, which is supplied with a moisture content of less than 0.025% (250 ppm). The recommended moisture content to prevent viscosity degradation and possible lactide reformation is less than 0.010% (100ppm). Typical drying conditions are 4 hours at 212°F (100°C) or to a dew point of -40°F (-40°C), air-flow rate of greater than 0.5 cfm/lbs per hour of resin throughput. The resin should not be exposed to atmospheric conditions after drying. Transfer lines and hoppers should be sealed or padded with inert gas. Keep resin package sealed until ready to use and promptly reseal packages of unused material.

Compostability

PLA polymer 7000D has been shown to biodegrade similarly to paper under simulated composting conditions (ASTM D5338 @ 58°C (135°F)) and passes proposed European composting certification standards. Composting is a method of waste disposal that allows organic materials to be recycled into a product that can be used as a valuable soil amendment. PLA is made primarily of polylactic acid, a repeating chain of lactic acid, which undergoes a 2-step degradation process. First, the moisture and heat in the compost pile attack the PLA polymer chains and split them apart, creating smaller polymers, and finally, lactic acid. Microorganisms in compost and soil consume the smaller polymer fragments and lactic acid as nutrients. Since lactic acid is widely found in nature, a large number of organisms metabolize lactic acid. At a minimum, fungi and bacteria are involved in PLA degradation. The end result of the process is carbon dioxide, water and also humus, a soil nutrient. This degradation process is temperature and

humidity dependent. Regulatory guidelines and standards for composting revolve around four basic criteria: Material Characteristics, Biodegradation, Disintegration, and Ecotoxicity. Description of the requirements of these testing can be found in the appropriate geographical area: DIN V 54900-1 (Germany), EN 13432 (EU), ASTM D 6400 (USA), GreenPla (Japan). This grade of NatureWorks® PLA meets the requirements of these four standards with limitation of maximum layer thickness of 1650 µm and for coating layers up to 37 µm thick.

FDA Status

U.S. Status-

This is to advise you that on January 3, 2002 FCN 000178 submitted by NatureWorks LLC to FDA became effective. This effective notification is part of list currently maintained on FDA's website at <http://www.cfsan.fda.gov/~dms/opa-fcn.html>. This grade of NatureWorks® PLA may therefore be used in food packaging materials and, as such, is a permitted component of such materials pursuant to section 201(s) of the Federal, Drug, and Cosmetic Act, and Parts 182, 184, and 186 of the Food Additive Regulations. All additives and adjuncts contained in the referenced NatureWorks® PLA formulation meet the applicable sections of the Federal Food, Drug, and Cosmetic Act. The finished polymer is approved for all food types and B-H use conditions. We urge all of our customers to perform GMP (Good Manufacturing Procedures) when constructing a package so that it is suitable for the end use. Again, for any application, should you need further clarification, please do not hesitate to contact NatureWorks LLC.

NatureWorks® PLA Polymer 7000D

Safety and Handling Considerations

Material Safety Data (MSD) sheets for PLA polymers are available from NatureWorks LLC. MSD sheets are provided to help customers satisfy their own handling, safety, and disposal needs, and those that may be required by locally applicable health and safety regulations, such as OSHA (U.S.A.), MAK (Germany), or WHMIS (Canada). MSD sheets are updated regularly; therefore, please request and review the most current MSD sheets before handling or using any product. The following comments apply only to PLA polymers; additives and processing aids used in fabrication and other materials used in finishing steps have their own safe-use profile and must be investigated separately.

Hazards and Handling Precautions

PLA polymers have a very low degree of toxicity and, under normal conditions of use, should pose no unusual problems from incidental ingestion, or eye and skin contact. However, caution is advised when handling, storing, using, or disposing of these resins, and good housekeeping and controlling of dusts are necessary for safe handling of product. Workers should be protected from the possibility of contact with molten resin during fabrication. Handling and fabrication of resins can result in the generation of vapors and dusts that may cause irritation to eyes and the upper respiratory tract. In dusty atmospheres, use an approved dust respirator. Pellets or beads may present a slipping hazard. Good general ventilation of the polymer processing area is recommended. At temperatures exceeding the polymer melt temperature (typically 170°C), polymer can release fumes, which may contain fragments of the polymer, creating a potential to irritate eyes and mucous membranes. Good general ventilation should be sufficient for most conditions. Local exhaust ventilation

is recommended for melt operations. Use safety glasses, if there is a potential for exposure to particles, which could cause mechanical injury to the eye. If vapor exposure causes eye discomfort, use a full-face respirator. No other precautions other than clean, body-covering clothing should be needed for handling PLA polymers. Use gloves with insulation for thermal protection when exposure to the melt is localized.

Combustibility

PLA polymers will burn. Clear to white smoke is produced when product burns. Toxic fumes are released under conditions of incomplete combustion. Do not permit dust to accumulate. Dust layers can be ignited by spontaneous combustion or other ignition sources. When suspended in air, dust can pose an explosion hazard. Firefighters should wear positive-pressure, self-contained breathing apparatuses and full protective equipment. Water or water fog is the preferred extinguishing medium. Foam, alcohol-resistant foam, carbon dioxide or dry chemicals may also be used. Soak thoroughly with water to cool and prevent re-ignition.

Disposal

DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. For unused or uncontaminated material, the preferred options include recycling into the process or sending to an industrial composting facility, if available; otherwise, send to an incinerator or other thermal destruction device. For used or contaminated material, the disposal options remain the same, although additional evaluation is required. (For example, in the U.S.A., see 40 CFR, Part 261, "Identification and Listing of Hazardous Waste.") All disposal methods must be in compliance with Federal, State/Provincial, and local laws and regulations.

Environmental Concerns

Generally speaking, lost pellets are not a problem in the environment except under unusual circumstances when they enter the marine environment. They are benign in terms of their physical environmental impact, but if ingested by waterfowl or aquatic life, they may mechanically cause adverse effects. Spills should be minimized, and they should be cleaned up when they happen. Plastics should not be discarded into the ocean or any other body of water.

Product Stewardship

NatureWorks LLC has a fundamental duty to all those that make and use our products, and for the environment in which we live. This duty is the basis for our Product Stewardship philosophy, by which we assess the health and environmental information on our products and their intended use, then take appropriate steps to protect the environment and the health of our employees and the public.

Customer Notice

NatureWorks LLC encourages its customers and potential users of its products to review their applications for such products from the standpoint of human health and environmental quality. To help ensure our products are not used in ways for which they were not intended or tested, our personnel will assist customers in dealing with ecological and product safety considerations. Your sales representative can arrange the proper contacts. NatureWorks LLC literature, including Material Safety Data sheets, should be consulted prior to the use of the company's products. These are available from your NatureWorks LLC representative.

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