

NatureWorks® PLA Polymer 4042D

Biaxially Oriented Films – General Purpose

Film Characteristics

NatureWorks® PLA (polylactide) polymer 4042D, a NatureWorks LLC product can be converted into a biaxially oriented film with use temperatures up to 265°F (130°C). This film has excellent optics, good machinability and excellent twist and deadfold. Additional properties include advantageous barrier to flavor and grease and superior oil resistance.

Applications

These properties mentioned above make 4042D film an ideal product for:

- Candy twistwrap
- Salad and Vegetable bags
- Window Envelope film
- Lidding film
- Label film
- Other packaging applications

Processing Information

PLA polymer is available in pellet form. Drying prior to processing is essential. The polymer is stable in the molten state, provided that the extrusion and drying procedures are followed.

Machine Configuration

PLA polymers will process on conventional extruders using general purpose screws with L/D ratios from 24:1 to 30:1 and compression ratio of 2.5:1 to 3:1. Smooth barrels are recommended. PLA resins will also process on conventional cast tenter equipment that has been designed for OPS or OPET with minimal modifications. Optimization on specific equipment may require NatureWorks LLC technical support.

Process Details ⁽¹⁾

Startup and Shutdown

PLA polymer 4042D is not compatible with a wide variety of polyolefin resins, and special purging sequences should be followed:

Processing Temperature Profile ⁽⁵⁾		
Melt Temperature	410 ±15°F	210 ±8 °C
Feed Throat	113°F	45°C
Feed Temperature	355°F	180°C
Compression Section	375°F	190°C
Metering Section	390°F	200°C
Adapter	390°F	200°C
Die	390°F	200°C
Screw Speed	20-100 rpm	
MD Draw Temp.	140-160°F	60-70°C
TD Draw Temp.	160-175°F	70-80°C
Heat Set Oven	250-285°F	120-140°C

(5) Processing guide for Biaxially oriented Films is available from NatureWorks LLC

1. Clean extruder and bring temperatures to steady state with low-viscosity, general-purpose polystyrene or high MFR polypropylene.
2. Vacuum out hopper system to avoid contamination.
3. Introduce PLA polymer into the extruder at the operating conditions used in Step 1.
4. Once PLA polymer has purged, reduce barrel temperatures to desired set points.
5. At shutdown, purge machine with high-viscosity polystyrene or polypropylene.

In-line drying is required. A moisture content of less than 0.025% (250ppm) is recommended to prevent viscosity degradation. Typical drying conditions are 4 hours at 175°F (80°C) or to a dew point of -30°F (-35°C), with an airflow rate greater than 0.5 cfm/lb (0.032 m³/min per kg) of resin throughput (1.85 m³/hr kg resin). The resin should not be exposed to atmospheric conditions after drying. Keep the package sealed until ready to use and promptly reseal any unused material.

⁽¹⁾ Detailed Purging recommendation available at www.natureworkslc.com

Drying

Typical Material & Application Properties ^(2,3,4)			
Film Properties		Value	ASTM Method
Density		1.24 g/cc	D1505
Tensile Strength MD		16 kpsi (110.1 MPa)	D882
	TD	21 kpsi (144.5 MPa)	D882
Tensile Modulus MD		480 kpsi (3302 MPa)	D882
	TD	560 kpsi (3852 MPa)	D882
Elongation at Break	MD	160%	D882
	TD	100%	D882
Elmendorf Tear MD		15 g/mil	D1922
	TD	13 g/mil	D1922
Spencer Impact		2.5 joules	
Transmission Rates	Oxygen	550 cc-mil/m ² /24 hr atm	D1434
	Carbon Dioxide	3,000 cc-mil/m ² /24 hr atm	D1434
	Water Vapor	325 g-mil/m ² /24 hr atm	E96
Optical Characteristics	Haze	2.1%	D1003
	Gloss, 20°	90	D1003
Thermal Characteristics	Glass Transition Temperature	125-136°F (52-58°C)	D3418
	Melting Point	302°F (150°C)	D1003

⁽²⁾ Typical properties; not to be construed as specifications. ⁽³⁾ All properties measured on 1.0 mil film.

. O₂ and CO₂ at 23°C; 50% RH; H₂O at 38°C 90% RH ⁽⁴⁾ Typical values for a film oriented 3.5x in MD and 5x in TD.

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Bulk Storage Recommendations

The resin silos recommended and used by NatureWorks LLC are designed to maintain dry air in the silo and to be isolated from the outside air. This design would be in contrast to an open, vented to atmosphere system that we understand to be a typical polystyrene resin silo. Key features that are added to a typical (example: polystyrene) resin silo to achieve this objective include a cyclone and rotary valve loading system and some pressure vessel relief valves. The dry air put to the system is sized to the resin flow rate out of the silo. Not too much dry air would be needed and there may be excess instrument air (-30°F dew point) available in the plant to meet the needs for dry air. Our estimate is 10 scfm for a 20,000 lb/hr rate resin usage. Typically, resin manufacturers specify aluminum or stainless steel silos for their own use and avoid epoxy-lined steel.

*All NatureWorks LLC Product Stewardship information including global food contact compliance, global chemical registration, and other information pertaining to this product can be found in our product stewardship bulletin (PROST-001). Our job is to maintain an effective product stewardship program to ensure that our customers involved with our product receive sufficient information and training to store, use, and dispose of our product with no harm to human health or the environment. If you need further information regarding the toxicology or safe handling of our material please feel free to give us a call

For additional information in the U.S. and Canada, call toll-free 1-877-423-7659
In Europe, call 31-(0)35-699-1344
In Japan, call 81-33-285-0824

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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