

NatureWorks® PLA Polymer 4032D

Biaxially Oriented Films – High Heat

Film Characteristics

NatureWorks® PLA (polylactide) polymer 4032D, a NatureWorks LLC product, can be converted into a biaxially oriented film with use temperatures up to 300°F (150°C). This film has excellent optics, good machinability and excellent twist and deadfold. Additional properties include barrier to flavor and grease and oil resistance.

Film Characteristics

These properties mentioned above make 4032D film an ideal product for:

- Laminations
- Printed films with higher curing temperatures
- 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. Configure general purpose screws with L/D ratios from 24:1 to 30:1 and compression ratio of 2.5:1 to 3:1. PLA resins will also process on conventional cast tenter equipment. Optimization on specific equipment may require NatureWorks LLC technical support

Process Details

Startup and Shutdown

PLA polymer 4032D is not compatible with a wide variety of polyolefin resins, and special purging sequences should be followed:

1. Clean extruder and bring temperatures to steady state with low-viscosity, general-purpose

Processing Temperature Profile		
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

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.

Drying

In-line drying is required. A moisture content of less than 0.025% (250 ppm) 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 throughout. 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.

Typical Material & Application Properties ^(1,2,3)			
Film Properties		Value	ASTM Method
Density		1.24 g/cc	D1505
Tensile Strength MD		15 kpsi (103.2 MPa)	D882
	TD	21 kpsi (144.5 MPa)	D882
Tensile Modulus MD		500 kpsi (3440 MPa)	D882
	TD	550 kpsi (3784 MPa)	D882
Elongation at Break	MD	180%	D882
	TD	100%	D882
Elmendorf Tear MD		17 g/mil	D1922
	TD	14 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	Melting Point	320° F (160° C)	D1003

⁽¹⁾ Typical properties; not to be construed as specifications. ⁽²⁾ All properties measured on 1.0 mil film.

⁽³⁾ Typical values for a film oriented 3.5x in MD and 5x in TD.

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Compostability

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 Nature-

Works® 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.

European Status

This grade of NatureWorks® PLA complies with Commission Directive 2002/72/EC as amended by 2004/19/EC. No SML's for the above referenced grade exist in Commission Directive 2002/72/EC or as amended by 2004/19/EC. NatureWorks LLC would like to draw your attention to the fact that the EU-Directive 2002/72/EC, which applies to all EU-Member States, includes a limit of 10 mg/dm² of the overall migration from finished plastic articles into food. In accordance with EU-Directive 2002/72/EC the migration should be measured on finished articles placed into contact with the foodstuff or appropriate food simulants for a period and at a temperature which are chosen by reference to the contact conditions in actual use, according to the rules laid down in EU-Directives 93/8/EEC (amending 82/711/EEC) and 85/572/EEC. Please note that it is the responsibility of both the manufacturers of finished food contact articles as well as the industrial food packers

to make sure that these articles in their actual use are in compliance with the imposed specific and overall migration requirements. This grade as supplied meets European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste heavy metal content as described in Article 11. It is recoverable in the form of material recycling, energy recovery, composting, and biodegradable per Annex II point 3, subject to the standards of the local community. Again, for any application, should you need further clarification, please do not hesitate to contact NatureWorks LLC.

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.

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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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