

Ingeo™ Biopolymer 6060D Technical Data Sheet

Fiber Melt Spinning

Ingeo biopolymer 6060D, a NatureWorks product, is an amorphous thermoplastic fiber-grade resin derived primarily from annually renewable resources. Available in pellet form, 6060D is designed for extrusion into mechanically drawn staple fibers using conventional fiber spinning and drawing equipment. Ingeo biopolymer 6060D can be used as a low melt binder polymer in a sheath-core configuration. See table at right for typical properties.

Applications

Potential applications for Ingeo biopolymer 6060D include:

- Thermal bonded nonwovens

Processing Information

Ingeo biopolymer 6060D grade will process on conventional extrusion spinning and drawing equipment with thorough cleaning since PLA is not compatible with a wide variety of polymers.

Machine Configuration

General-purpose screws with L/D ratios of 24:1 to 30:1 and 3:1 compression ratios are recommended. However, screws with mixing sections or shallow metering channels may overheat the melt at high screw speeds. Typical melt spinning temperatures are 220 – 240°C. Like PET, Ingeo biopolymer 6060D requires either high filament velocity or drawing and controlled heat setting to control shrinkage.

Drying

In-line drying capabilities are essential to process Ingeo biopolymer 6060D, which is supplied with a moisture content of less than 0.040% (400 ppm). The recommended moisture content to prevent viscosity degradation and potential loss of properties is < 0.005% (50 ppm). Typical drying conditions are 8-12 hours at 40°C [104°F], or to a dew point of –35°C [-30°F], with an airflow rate of greater than 0.5 cfm/lbs per hour of resin throughput. Drying at higher temperatures will cause the pellets to stick together, as they are amorphous. To prevent moisture regain, the resin should not be exposed to atmospheric conditions after drying.

| Typical Material & Application Properties ¹ | | |
|--|-------------|-----------------------------|
| Physical Properties | Ingeo 6060D | ASTM Method |
| Specific Gravity | 1.24 | D792 |
| Relative Viscosity | 3.3 | CD Internal Viscotek Method |
| Melt Index, g/10 min (210°C) | 8-10 | D1238 |
| Melt Density (230°C) | 1.08 | |
| Glass Transition Temperature (°C) | 55-60 | D3417 |
| Crystalline Melt Temperature (°C) | 125-135 | D3418 |
| Typical Fiber Properties | | |
| Denier per Filament | ≥4 dpf | g/9000 m |
| Tenacity (g/d) | 3.5 | D2256/D3822 |
| Elongation (%) | 50 | D2256/D3822 |

(1) Typical properties; not to be construed as specifications.

FDA Status

U.S. Status

This is to advise you that on February 11, 2005 FCN 000475 submitted by NatureWorks LLC to FDA became effective. This effective notification is part of list currently maintained on FDA's website at

This grade of Ingeo biopolymer 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 Ingeo biopolymer formulation meet the applicable sections of the Federal Food, Drug, and Cosmetic Act. The finished polymer is approved for all food types and C-G use conditions.

Migration testing for this product was done using rolled sheet with an approximate thickness of 0.020 inches. Depending on the application, the surface area of a fiber article may differ from the sheet sample tested. It is therefore the responsibility of the manufacturer of the finished food-contact article to determine that the use of a product is safe, lawful, and technically suitable for the intended application. 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.

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European Status

This grade of Ingeo biopolymer complies with Plastics Regulation 10/2011 as amended. No SML's for the above referenced grade exist in Plastics Regulation 10/2011 as amended. NatureWorks LLC would like to draw your attention to the fact that the EU- Plastics Regulation 10/2011, 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 Plastics Regulation 10/2011 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 Plastics Regulation 10/2011. OML testing for this product was done using rolled sheet. Depending on the application, the surface area of a fiber article may differ from the sheet sample tested.

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.

Should you need further clarification, 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.

Safety and Handling Considerations

Safety Data Sheets (SDS) for Ingeo biopolymers are available from NatureWorks. SDS's 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. SDS's are updated regularly; therefore, please request and review the most current SDS's before handling or using any product.

The following comments apply only to Ingeo biopolymers; 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

Ingeo biopolymers 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. Pellets or beads may present a slipping hazard.

No other precautions other than clean, body-covering clothing should be needed for handling Ingeo biopolymers. Use gloves with insulation for thermal protection when exposure to the melt is localized. 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.

Good general ventilation of the polymer processing area is recommended. At temperatures exceeding the polymer melt temperature (typically 175°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 (or goggles) to prevent exposure to particles, which could cause mechanical injury to the eye. If vapor exposure causes eye discomfort, improve localized fume exhausting methods or use a full-face respirator.

The primary thermal decomposition product of PLA is acetaldehyde, a material also produced during the thermal degradation of PET. Thermal decomposition products also include carbon monoxide and hexanal, all of which exist as gases at normal room conditions. These species are highly flammable, easily ignited by spark or flame, and can also

auto ignite. For polyesters such as PLA, thermal decomposition producing flammable vapors containing acetaldehyde and carbon monoxide can occur in almost any process equipment maintaining PLA at high temperature over longer residence times than typically experienced in extruders, fiber spinning lines, injection molding machines, accumulators, pipe lines and adapters. As a rough guideline based upon some practical experience, significant decomposition of PLA will occur if polymer residues are held at temperatures above the melting point for prolonged periods, e.g., in excess of 24 hours at 175°C, although this will vary significantly with temperature.

Combustibility

Ingeo biopolymers 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 option is to recycle into the process 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. Disposal must be in compliance with Federal, State/Provincial, and local laws and regulations.

Environmental Concerns

Generally speaking, lost pellets, while undesirable, are benign in terms of their physical environmental impact, but if ingested by wildlife, 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 environment.

Product Stewardship

NatureWorks has a fundamental duty to all those that 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, and then take

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appropriate steps to protect the environment and the health of our employees and the public.

Customer Notice

NatureWorks encourages its customers and potential users of its products to review their applications 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 literature should be consulted prior to the use of the company's products.

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