Ingeo™ Biopolymer 6361D Technical Data Sheet

Specialty Fiber

Ingeo biopolymer 6361D, a NatureWorks LLC product, is a thermoplastic fiber-grade resin derived from annually renewable resources. Available in pellet form, 6361D is designed for specialty fiber products where an amorphous structure is desired. Ingeo biopolymer 6361D can be converted into a broad range of fiber products. See table at right for typical polymer properties.

Applications

Potential applications for Ingeo biopolymer 6361D include:
- Low melt binder fibers/sheath
- Low melt coatings
- Dissolvable / sacrificial fiber components

Processing Information

Ingeo biopolymer 6361D will process on conventional melt spinning equipment with thorough cleaning, since PLA is not compatible with a wide variety of polymers. 6361D can also be used on multi-component fiber spinning systems to produce a wide range of specialty fibers.

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 – 245°C. Extruder feed throat and/or screw cooling is generally required to provide proper pellet feeding.

Drying

In-line drying capabilities are helpful to process Ingeo biopolymer 6361D, which is supplied with moisture content of less than 0.040% (400 ppm). The recommended moisture content to prevent viscosity degradation and potential loss of properties is less than 0.005% (50 ppm). Typical drying conditions are 8-12 hours at 40°C [104°F] with 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.

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. Ingeo biopolymer made of polyactic 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 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 participate in this degradation process. 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 Characteristicis, 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 Ingeo biopolymer (in its resin form) does meet the requirements of these four standards however; it does not currently have certification due to the number of fiber production and downstream processes that can have a significant impact on final fabric performance. Such variables include, but are not limited to, specific fiber geometry, additives incorporated into the fiber, surface

<table>
<thead>
<tr>
<th>Typical Material &amp; Application Properties¹</th>
<th>Ingeo 6361D</th>
<th>ASTM Method</th>
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<tbody>
<tr>
<td>Physical Properties</td>
<td></td>
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<tr>
<td>Specific Gravity</td>
<td>1.24</td>
<td>D792</td>
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<tr>
<td>Relative Viscosity</td>
<td>2.5</td>
<td>CD Internal Viscotek Method</td>
</tr>
<tr>
<td>Melt Index, g/10 min (210°C)</td>
<td>70-85</td>
<td>D1238</td>
</tr>
<tr>
<td>Melt Density (230°C)</td>
<td>1.08</td>
<td></td>
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<tr>
<td>Glass Transition Temperature (°C)</td>
<td>55-60</td>
<td>D3417</td>
</tr>
<tr>
<td>Crystalline Melt Temperature (°C)</td>
<td>125-135</td>
<td>D3418</td>
</tr>
<tr>
<td>Typical Fiber Properties</td>
<td></td>
<td></td>
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<tr>
<td>Denier per filament</td>
<td>1-2 dpf</td>
<td>g/9000 m</td>
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<tr>
<td>Fabric Weight (g)</td>
<td>Various</td>
<td></td>
</tr>
<tr>
<td>Pellet Lubricant</td>
<td>No</td>
<td></td>
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</tbody>
</table>

¹ Typical properties; not to be construed as specifications.
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Please remember it is the responsibility of the end producer to test and certify their final products regardless if the raw material is certified. Should you need further clarification, please do not hesitate to contact NatureWorks LLC.

**European Status**

This grade of Ingeo biopolymer complies with Regulation 10/2011, which applies to all EU member states. Substances used in the manufacturing of this product which are not yet regulated by EU Plastics Directive 2002/72/EC, as amended, are in compliance with appropriate EU national regulations. No SML’s for the above referenced grade exist in Regulation 10/2011. NatureWorks LLC would like to draw your attention to the fact that 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 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 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. While the above referenced NatureWorks LLC product is permitted by the listing of its components in Regulation 10/2011, the finished food-contact article must meet any applicable limitations and specifications described in that legislation.

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.

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. 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
Safety Data Sheets (SDS) for Ingeo biopolymers are available from NatureWorks LLC. 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, such as OSHA (U.S.A.), MAK (Germany), or WHMIS (Canada). SDS’s are updated regularly; therefore, please request and review the most current SDS 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, 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 irritating particles. 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 Ingeo biopolymers. Use gloves withinsulation for thermal protection when exposure to the melt is localized.

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 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 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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