

Ingeo™ Biopolymer 3100HP Technical Data Sheet

Injection Molding

Ingeo 3100HP is a medium viscosity product from NatureWorks LLC, designed for medium flow injection molding applications. It is designed to crystallize during processing, leading to higher heat deflection temperatures in opaque applications. See Table 1 for properties.

Applications

The variety of products made with 3100HP is widely varied and growing. Applications include disposables such as cutlery, cups, plates, cosmetic packaging, and durables such as electronics housings and semi-durable building materials.

Processing Information

3100HP is intended for use in crystalline engineered formulations; however it is sold as neat resin. The formulator or compounder will need to add nucleating agents, impact modifiers, reinforcing agents, etc. to meet the requirements of their application (consult with your NatureWorks representative for recommendations and masterbatch suppliers). 3100HP biopolymer can be processed on most conventional injection molding equipment. The material is stable in the molten state, provided that the drying procedures are followed. Mold flow is highly dependent on melt and mold temperatures. It is recommended to balance screw speed, back pressure, and process temperature to control melt temperature. Injection speed should be medium to fast. Mold temperature is generally elevated in the range of 80-130°C, depending on the formulation characteristics.

Machine Configuration

Ingeo biopolymer 3100HP will process on conventional injection molding machinery. A general purpose screw designed to minimize residence time and shear works well. One should size the machine for minimum residence time in the barrel. Please refer to the Ingeo Injection Molding Guide for more information.

Table 1 - Typical Material & Application Properties ⁽¹⁾

Physical Properties	Ingeo Resin	ASTM Method
Specific Gravity	1.24	D792
MFR, g/10 min (210°C, 2.16kg)	24	D1238
Relative viscosity ⁽²⁾	3.1	D5225
Mechanical Properties, molded amorphous with 26°C mold temperature		
Tensile Yield Strength, psi (MPa)	9,400 (65)	D638
Tensile Elongation, %	3.4	D638
Notched Izod Impact, ft-lb/in (J/m)	0.34 (18.2)	D256
Flexural Strength, psi (MPa)	16,200 (112)	D790
Flexural Modulus, psi (MPa)	520,000 (3585)	D790
Heat Distortion Temperature (°C) 66 psi, (0.455 MPa)	54	E2092
Molded Linear Shrinkage, %	0.2-0.4	
Clarity	Transparent	
Mechanical Properties, molded crystalline with 120°C mold temperature⁽³⁾		
Tensile Yield Strength, psi (MPa)	9,300 (64)	D638
Tensile Elongation, %	2.2	D638
Notched Izod Impact, ft-lb/in (J/m)	0.6 (32)	D256
Flexural Strength, psi (MPa)	15,700 (108)	D790
Flexural Modulus, psi (MPa)	632,000 (4357)	D790
Heat Distortion Temperature (°C) 66 psi, (0.455 MPa)	149	E2092
Molded Linear Shrinkage, %	1.7-1.8	
Clarity	Opaque	
Peak crystalline melting point (°C)	165-180	

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

(2) RV measured at 1.0 g/dL in chloroform at 30°C

(3) Formula included 1wt% nucleating agent (LAK-301 from Takemoto Oil & Fat)

Processing Temperature Profile

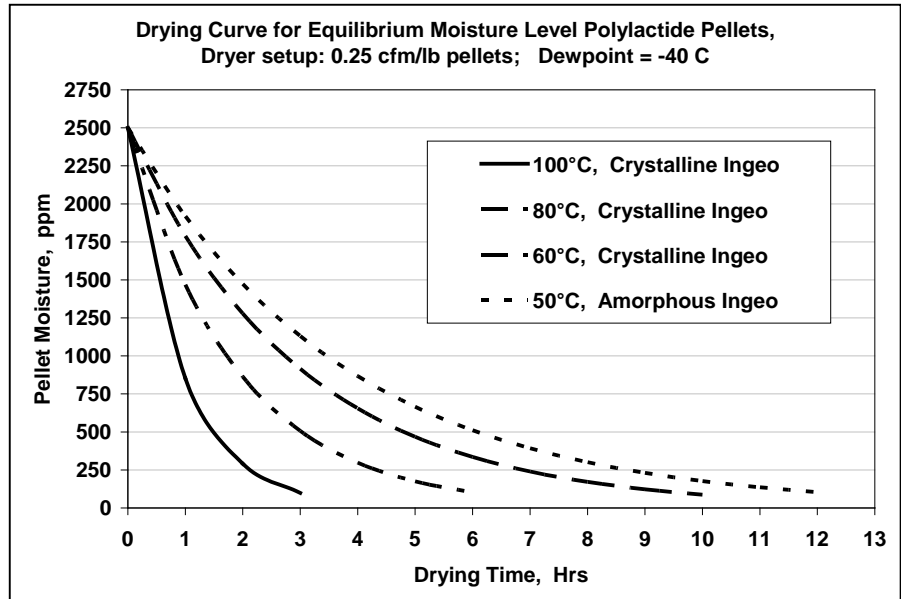
Melt Temperature	390°F	200°C
Feed Throat	70°F	20°C
Feed Temperature	365°F	185°C
Compression Section	383°F	195°C
Metering Section	392°F	200°C
Nozzle	392°F	200°C
Mold	248°F	120°C
Screw Speed	200 rpm	
Back Pressure	250 psi	
Mold Shrinkage	.017 in/in. +/- .001	

Note: These are starting points and may need to be optimized. For thin walled parts temperatures up to 450F may be needed.

Process Details

Startup and Shutdown

1. 3100HP is not compatible with a wide variety of resins and special purging sequences should be followed:
2. Clean extruder and bring temperatures to steady state with low-viscosity, general-purpose polystyrene or polypropylene.
3. Vacuum out hopper system to avoid contamination.
4. Introduce Ingeo polymer into the extruder at the operating conditions used in Step 1.
5. Once Ingeo polymer has purged, reduce barrel temperatures to desired set points.
6. At shutdown, purge machine with high-viscosity polystyrene or polypropylene.



Procedures) when constructing a package so that it is suitable for the end use.

Drying

In-line drying is recommended for Ingeo resins. A moisture content of less than 0.025% (250 ppm) is recommended to prevent viscosity degradation. Polymer is supplied in foil-lined boxes or bags dried to <400 ppm. The resin should not be exposed to atmospheric conditions after drying. Keep the package sealed until ready to use and promptly dry and reseal any unused material. The drying curves for both amorphous and crystalline resins are shown to the right above.

Note: Amorphous polymer must be dried below 120F (50C).

Food Packaging Status

U.S. Status

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.fda.gov/food/ingredientpackaginglabeling/packagingfcs/notifications/default.htm>

This grade of Ingeo biopolymers 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 biopolymers 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

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.

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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