

## Injection Molding

Ingeo 3801X, a NatureWorks LLC product is designed for injection molding applications that require high heat and high impact performance. This polymer grade has much more rapid crystallization kinetics than other Ingeo resin grades currently in the market place. The rapid crystallization rate allows for the molding of crystalline parts at competitive cycle times with high heat distortion temperatures.

Ingeo 3801X is designed for injection molding applications where the property requirements are opaque molded parts with heat deflection temperatures between 150°F (65°C) and 285°F (140°C) that do not require food contact approvals.

### Processing Information

Ingeo 3801X resin can be processed on 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 temperature. In order to control melt temperature, it is recommended to balance screw speed, back pressure, and process temperature. Injection speed should be medium to fast. Mold coolant temperature is elevated to an optimal temperature for crystallization, about 194°F (90°C).

### Process Details

#### Startup and Shutdown

Ingeo 3801X is not compatible with a wide variety of other resins, and special purging sequences should be followed:

1. Clean extruder and bring temperatures to steady state with low-viscosity, general-purpose polystyrene or polypropylene.
2. Vacuum out hopper system to avoid contamination.
3. Introduce Ingeo biopolymer into the extruder at the operating conditions used in Step one.

Table 1 – Typical Material & Application Properties <sup>(1)</sup>		
Physical Properties	Ingeo 3801X	ASTM Method
Specific Gravity	1.25	D792
Melt Index, g/10 min (190°C, 2.16kg)	8	D1238
Relative Viscosity	3.1	
Crystalline Melt Temperature (°C)	155-170	D3418
Glass Transition Temperature (°C)	45	D3417
Clarity	Opaque	
Mechanical Properties		
Tensile Modulus, psi (MPa)	432,000 (2,980)	D638
Tensile Yield Strength, psi (MPa)	3,750 (25.9)	D638
Tensile Elongation at Break (%)	8.1	D638
Notched Izod Impact, ft-lb/in (J/m)	2.7 (144)	D256
Flexural Strength, psi (MPa)	6,400 (44)	D790
Flexural Modulus, psi (MPa)	413,000 (2,850)	D790
Heat Distortion Temp. at 66 psi (°C)	65	E2092
Heat Distortion Temp. at 16.5 psi (°C) <sup>(2)</sup>	140	E2092 <sup>(3)</sup>

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

(2) Modified version of E2092 to simulate "light" load

4. Once Ingeo biopolymer has purged, reduce barrel temperatures to desired set points.
5. At shutdown, purge machine with high-viscosity polystyrene or polypropylene.

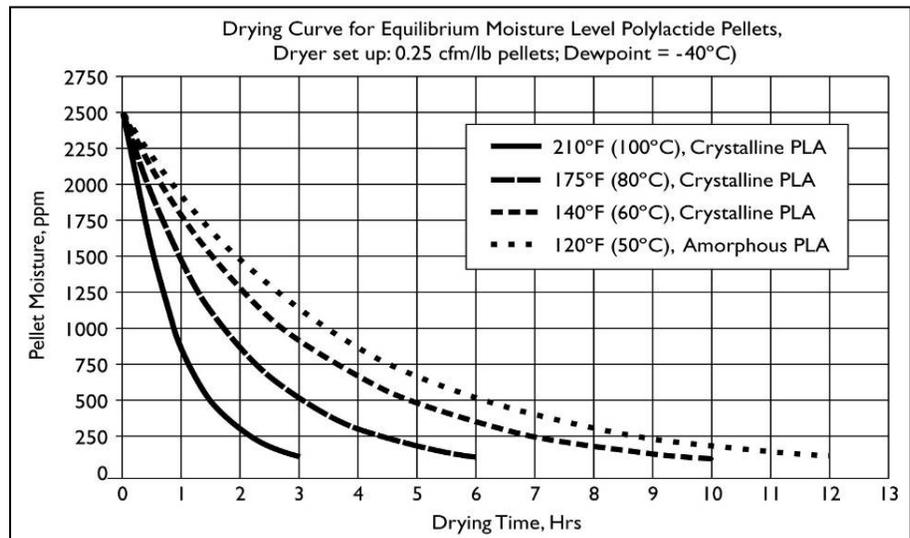
Table 2 - Processing Parameter Profile		
Melt Temperature	370°F	188°C
Feed Throat	75°F	24°C
Feed Temperature	350°F	177°C
Compression Section	370°F	188°C
Metering Section	370°	188°C
Nozzle	370°F	188°C
Mold	185-221°F	85-105°C
Screw Speed	125 rpm	
Back Pressure	250 psi	1.7 MPa
Injection Pressure	4500 - 8000 psi	31-55 MPa
Injection Velocity	2-8 in/sec	51-203 mm/sec
Mold Shrinkage	.012 in/in. +/- .001	.012 mm/mm +/- .001

Note: Process conditions are starting points and may need to be optimized.

## Drying

In-line drying is recommended for Ingeo resins. A moisture content of less than 0.010% (100 ppm) is recommended to prevent viscosity degradation. Polymer is supplied in foil-lined boxes or bags dried to <250 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.

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



## Compostability

Ingeo 3801X is not currently certified for compostability.

## FDA Status

Ingeo 3801X is not certified for food contact.

## Safety and Handling Considerations

Material Safety Data (MSD) sheets for Ingeo biopolymers 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 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. 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 Ingeo biopolymers. Use gloves with insulation 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 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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