# Ingeo Biopolymer 3D860 Technical Data Sheet

# 3D Printing Monofilament – High Heat and Impact Grade

## Monofilament Applications

Ingeo™ 3D860 is a grade developed for manufacturing 3D printer monofilament. Engineered to deliver improved heat-resistance and high impact strength to 3D printed parts, this formulated grade achieves thermal and mechanical properties similar to ABS while offering an alternative to styrenic-based materials. Monofilaments made with Ingeo 3D860 provide excellent 3D printing characteristics such as precise detail, good adhesion to build plates, less warping or curling, and low odor.

| Typical Material Properties [1] | | |
|---|---|---|
| **Physical Properties** | **3D860** | **ASTM Method** |
| Specific Gravity, g/cc | 1.22 | D792 |
| MFR, g/10 min[2] | 5-7 | D1238 |
| Relative Viscosity[3] | 4.0 | D5225 |
| Peak Melt Temperature, °C | 165-180 | D3418 |
| Glass Transition Temperature, °C | 55-60 | D3418 |
| **Mechanical Properties (crystalline)[4]** | | |
| Tensile Yield Strength, psi (MPa) | 4,760 (33) | D638 |
| Tensile Elongation, % | 2.3 | D638 |
| Notched Izod Impact, ft-lb/in (J/m) | 6.05 (323) | D256 |
| Tensile Strength, psi (MPa) | 4,350 (30) | D638 |
| Tensile Modulus, psi (MPa) | 348,440 (2402) | D638 |
| Heat Distortion Temperature (°C) 66 psi (0.45 MPa) | 80-90 | E2092 |
| Clarity | Opaque | |

(1) Typical properties for injection molded bars; not to be construed as specifications.
(2) 210° C/2.16 kg
(3) RV measured at 1.0 g/dL in chloroform at 30°C
(4) 3D printed part / 100% in-fill, annealed at 110°C/15 min.

## Processing Information

Ingeo 3D860 is available as a formulated pellet. This grade can be used in applications requiring crystalline engineered compounds. Convertors can add process aids, reinforcing agents, etc., to 3D860, per end-use requirements. Drying prior to processing is essential. The polymer is stable in the molten state, provided that the extrusion and drying procedures are followed. Post-annealing in the range of 176-266°F (80-130°C) can be used to promote crystallization and improve the heat deflection temperature of the 3D printed part.

### Machine Configuration

Ingeo biopolymers will process on conventional extruders using general purpose screws with L/D ratios from 24:1 to 30:1 and compression ratio of 2.5:1 to 3:1. Smooth barrels are recommended. Optimization to your specific equipment may require NatureWorks technical support.

| Processing Temperature Profile [5] | | |
|---|---|---|
| Melt Temp. | 410°F | 210°C |
| Feed Throat | 113°F | 45°C |
| Feed Temp. | 355°F | 190°C |
| Compression Section | 375°F | 200°C |
| Metering Section | 390°F | 210°C |
| Adapter | 390°F | 210°C |
| Die | 390°F | 210°C |
| Screw Speed | 20-150 rpm | |
| Filament Diameter Inspection (on-line) | Essential for quality monofilament (+/- 3% max. deviation) | |
| 3D Printing Temp. | 190-230°C | |
| Annealing Temp. | 80-130°C | |
| Print Bed Temp.: | None needed. (or 50-70°C if applicable) | |

(5) Starting points only, and may need to optimized depending on your system.

## Process Details

### Startup and Shutdown

Ingeo 3D860 is not compatible with a wide variety of resins, and special purging sequences should be followed:

1. Clean extruder and bring temperatures to steady state with low-viscosity, general-purpose polystyrene or high MFR polypropylene.
2. Vacuum out hopper system to avoid contamination.
3. Introduce Ingeo polymer into the extruder at the operating conditions used in Step 1.
4. Once Ingeo 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% (250ppm) is recommended to prevent viscosity degradation. Typical drying conditions are 4 hours at 175ºF (80°C) or to a dew point of -30°F (-35°C), with an airflow rate greater than 0.5 cfm/lb. of resin throughput. 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.

## Food Packaging Status

This grade is not certified for food contact applications

## Bulk Storage Recommendations

The resin silos recommended and used by NatureWorks 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 175ºC), 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

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philosophy, by which we assess the health and environmental information on our products and their intended use, and then take appropriate steps to protect the environment and the health of our employees and the public.

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