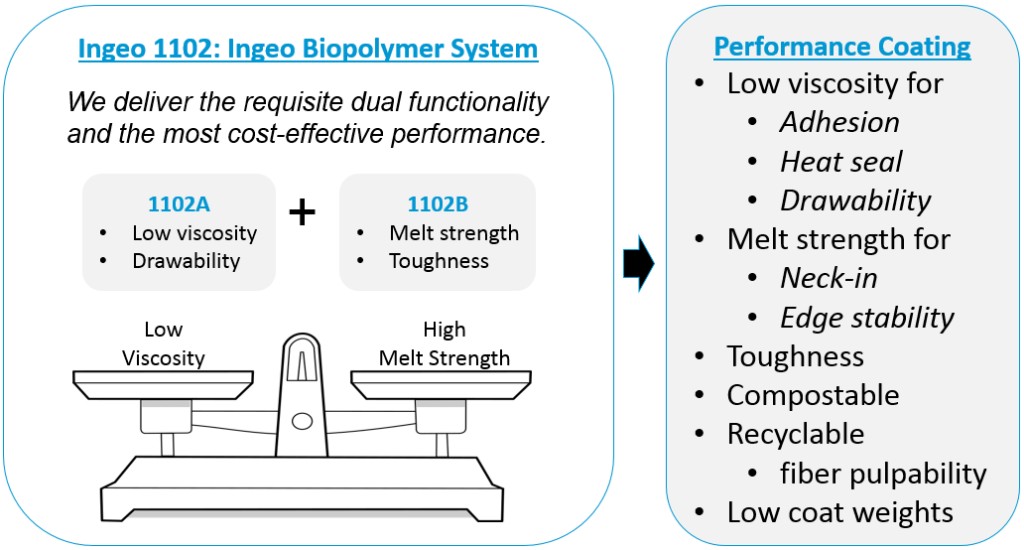
NatureWorks LLC

Ingeo™ Biopolymer 1102 Technical Data Sheet

Two-Component System for Extrusion Coating on Paper and Paperboard

Applications

Ingeo 1102 is a biopolymer system from NatureWorks LLC designed to be extrusion coated on paper and paperboard suitable for food contact applications. This product consists of two resin components, 1102A and 1102B, which provide excellent adhesion, melt strength, and heat seal performance when combined in an extrusion coating line. Ingeo 1102A, the primary component, delivers low viscosity and high drawability for improved adhesion, stronger heat seal, and lower coat weights. Ingeo 1102B, the second component, delivers high melt strength and toughness for reduced neck-in and greater edge stability in the melt curtain. Through this system customers can fine tune their process to optimize key performance attributes at a lower cost for coated substrate and articles made therefrom.



PHYSICAL PROPERTIES	INGEO 1102A	INGEO 1102B	INGEO 1102(2)	ASTM METHOD
Density, g/cm^3	1.24	1.17	1.23	D1505
MFR, g/10 min(1)	6	2	5.4	D1238

(1) 190°C; 2.16 kg; (2) Recommended loading of 85% 1102A + 15% 1102B

Characteristics

Ingeo is available in pellet form. The resin is amorphous and starts to become tacky at 45°C. Drying prior to processing is essential. The polymer is stable in the molten state, provided that the extrusion and drying procedures are followed.

Process Information

Ingeo 1102 will not process like LDPE, but may be processed on conventional extrusion coating equipment engineered for LDPE for initial trials and market development work. The combination of high compression ratio screws, excessive shear, a significantly higher melt density, and a need to be processed at cooler temperatures results in having insufficient power and excessive heat generation when processing Ingeo on these lines.

PROCESSING TEMPERATURE PROFILE		
Melt Temperature	445ºF	230ºC
Feed Throat	110F	45ºC
Feed Temperature	355ºF	180ºC
Compression Section	390ºF	200ºC
Metering Section	435ºF	225ºC
Adapter	435ºF	225ºC
Die	445ºF	230ºC

Ingeo has a significantly higher specific gravity than LDPE and therefore a higher bulk density of the feed pellets. Most LDPE extrusion lines have been optimized for the maximum output and therefore, the screw has been designed to feed the highest possible volume of pellets that the drive motor can supply power to melt. Converting to a higher density feed material puts a greater demand on the power required from the drive system and therefore many LDPE extrusion lines do not have the required torque to process Ingeo. A NatureWorks technical representative should be consulted to ensure any extrusion coating line has adequate torque to melt process Ingeo.

Capital investment plans should be created for optimal commercialized product processing considering:

- In-line desiccant drying would be required.
- A new screw design would be desired.
- A new die design to minimize the effects of neck-in should be investigated.

The extrusion coating temperatures used for LDPE are incompatible with the requirements for processing Ingeo. A maximum melt processing temperature of 480°F (250°C) is recommended with resin dried to 50 ppm moisture content. Higher melt processing target temperatures are not recommended. Minimize back pressure settings to minimize residence time and associated thermal and hydrolytic degradation.

Ingeo has a higher density than LDPE. The same coating thickness will have a 34% higher coating weight. A 0.75 mil (19 µm) coating of LDPE will be 10.8 lb/ream (17.6 g/m2), but for Ingeo will be 14.5 lb/ream (23.6 g/m2).

Machine Configuration

A fume/vent hood over the die is required. Excessive fuming may indicate a degradation process called depolymerization which may be caused by processing temperatures in excess of 250°C, especially if the resin is not adequately dried.

To improve adhesion, conditions are set to maximize heat retention of the web at the nip point, in contrast to techniques used with LDPE that enhance oxidation prior to the nip point.

- Continue pre-treating the paper with corona or flame treatments.
- A production rate of 8-10 lb/hr.in of die (0.14-0.18 kg/hr.mm of die) is recommended. For a die 100 inches wide, this is 800-1000 lb/hr production rate. For thinner coatings, faster rates may be necessary to achieve the same adhesion.
- Minimize the air gap to 5 inches or 125 mm, if possible.
- Maximize nip pressure.
- Set chill roll to be warm but not sticking (80°F / 27°C)

To improve draw down capability, minimize the die gap. At the draw down limit, expect to see draw resonance (which is sometimes misidentified as surging).

There will be more neck-in than compared to LDPE. Consider overcoating, edge pinners, or even an encapsulating die.

Optimization to your specific equipment may require NatureWorks LLC technical support.

Process Details

Startup and Shutdown

Ingeo 1102 is not compatible with a wide variety of commodity resins. Special purging sequences should be followed for typical paperboard coating lines:

1. At conclusion of running 4-5 MI LDPE resin, introduce 12-16 MI LDPE extrusion coating resin to purge out the more viscous resin at the elevated LDPE temperatures.
2. Stop extruder and reduce temperatures to settings for Ingeo 1102. When cool, purge briefly with the low viscosity 12-16 MI LDPE resin. Stop pellet flow and continue extruding into waste carton until screw is empty.
3. Vacuum out hopper system to avoid trace LDPE content.
4. Introduce Ingeo biopolymers into the extruder at the operating conditions established in Step 2.
5. Once Ingeo biopolymer has purged the LDPE, optimize barrel temperatures as needed.
6. At shutdown, purge machine with LDPE resin at the low Ingeo temperatures before re-setting to standard LDPE settings.

Drying

In-line drying is required. A moisture content of less than 0.005% (50 ppm) is recommended to prevent viscosity degradation. Typical drying conditions are 4 hours at 110°F (45°C) or to a dew point of -30°F (-35°C), with an airflow rate at least 1.0 cfm/lb of resin throughput. The resin should not be exposed to atmospheric conditions after drying. Keep packages sealed until ready to use and promptly reseal any unused material.

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 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

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 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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