

Ingeo™ Based Blown Film for Bags

Ingeo biopolymer can be manufactured into a film suitable for the construction of carrier or t-shirt type bags. An Ingeo blown film can approximate the film properties of HDPE bags when compounded and processed correctly. The resulting bags will be fully compostable in industrial compost as all of the resins used are compostable.

All safety precautions normally followed in the handling and processing of melted thermoplastics should be followed for Ingeo resins. These resins are easily processed in conventional equipment using processing conditions outlined in the NatureWorks LLC Extrusion Processing Guide.

There are two components to manufacturing a Ingeo based film for bags, proper resin selection and proper process conditions. NatureWorks LLC recommends a blend of two commercial grades of resins to achieve a good balance of film stiffness and tear resistance and two processing aids for extrusion output and ant-block. A good starting formulation is shown in the table below:

Recommended Starting Formulation

Ingeo 4043D (%)	68.83
Ecoflex F BX 7011 from BASF (%)	30.00
CESA-extend* from Clariant (%)	0.67
Crodamide EBS from Croda (%)	0.50

**CESA-extend is a 30% masterbatch of Joncryl ADR 4368 from BASF*

Compounding of an Ingeo based formulation can be carried out in traditional twin screw extrusion equipment consisting of a dry blender and gravimetric mixing systems, a co-rotating twin screw extruder with a 32:1 L:D, and feed throat cooling capability. Typical processing conditions are recommended below:

Resin Compounding Conditions

Setpoint in degrees C	
Feed section	20
Zone 1	160
Zone 2	170
Zone 3	180
Zone 4	180
Zone 5	180
Zone 6	180
Zone 7	180
Zone 8	180
Zone 9	180
Zone 10	180
Zone 11	200
Melt Temp	210
RPM	250

The Ingeo based formulation can be processed on standard HDPE blown film equipment, for example a single screw blown film line with a 55 mm screw, a 26:1 L/D, 4 heating zones, a monolayer die, single lip cooling ring (chilled air 18-20°C), and tower height of approximately 4.5 meters. Recommended resin processing conditions for 20 and 35 micron gauge films are offered in the two following tables:

Resin Processing Conditions

Setpoint in degrees C		Setpoint in degrees C	
Zone 1z	170	Zone 1	150
Zone 2	180	Zone 2	160
Zone 3	180	Zone 3	160
Zone 4	190	Zone 4	170
Adapter	185	Adapter	165
Die	180	Die	160
RPM	50	RPM	35
Amps	35	Amps	35
Take Off	21 m/min	Take Off	20 m/min
Film Thickness	35 microns	Film Thickness	20 microns
Rate	53 kg/hr	Rate	50 kg/hr

Gusseted Bag Making Process

Gusseted bags are sealed at the base and at the top. Wrinkles typically do not pose a problem provided proper tension control is employed web handling. The bags can be sealed under the following conditions:

Bag Sealing Conditions

	35 micron	20 micron
Bottom Seal Temp	110	90
Top Seal Temp	290	240
Seal Pressure	5 PSI	5 PSI
Line Speed	60 Bags/min	60 Bags/min

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Ingeo based bags have a stiff feel similar to HDPE bags with typical properties as detailed below:

		35 Micron Gusset Ingeo Bag	20 Micron Gusset Ingeo Bag
	Units	Result	Spec/Result
Printing Criteria			
Tidiness, Definition, Color Strength	N/A	Good	Good
Adhesion and Crock Test	N/A	Good	Good
Film Quality Criteria			
Tensile--MD	N/mm ²	18	10
Elongation--MD	%	210	144
Tensile--TD	N/mm ²	14	6
Elongation--TD	%	228	188
Tear--MD	mN	627	502
Tear--TD	mN	584	144
Puncture	N	45	30
Bag Criteria			
Bag Weight per Piece	g	17.47	10.48
Handle Correct and Equal Width and Depth	N/A	OK	OK
No "V" Cut, Clean Cut	N/A	OK	OK
Perforation Adequate	N/A	OK	OK
Bag Can Open Easily	N/A	OK	OK
Jog Test	@Kg/15min	5kg/30 min	5kg/30 min
Ultimate Load Test	NA	10	15
Sealing Strength--Handle	N/15 min	28/29	11/16
Sealing Strength--Gusset	N/15 min	18/17	13/18
Sealing Strength--Base	N/15 min	9	11

Ingeo based film properties can be varied by altering the content of BASF's Ecoflex resin. An increase in the amount of Ecoflex will generally increase the tear resistance and decrease the stiffness of the finished film.

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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