Production of Ingeo™ Film on Blown Film Equipment Designed for Low Density Polyethylene (LDPE) Film

NatureWorks LLC

The increased market acceptance of products made from biopolymers has led to a renewed interest in making films normally produced from polyolefins from Ingeo resins . Unfortunately, there are a significant number of differences between Ingeo biopolymers and olefinic materials. These differences in basic engineering proprieties and rheology make it difficult to convert a conventional blown film line to a line capable of producing Ingeo film.

It is important to note that this document refers to the production of standard Ingeo grades only, not blends of Ingeo with other polymers and additives that may be available in the marketplace and are better suited to production on blown film equipment.

Raw Material Handling

Almost no LDPE, LLDPE or HDPE manufacturing line is equipped with desiccant bed dryers designed to dry down to less than 250 ppm of moisture. In addition, and perhaps more importantly, once the material is dried, it needs to be conveyed to the extruder with dry air to keep the resin from regaining moisture. All the blending and holding hoppers also need to be sealed to keep a dry environment for the resin. Drying of Ingeo resin is necessary before extrusion of any grade.

Extrusion

While not ideally suited for melting Ingeo resins, a small percentage of extruders designed for processing polyolefins would be able to melt and process Ingeo at some level with acceptable performance. The remaining extruders will typically be limited by excessive power consumption. That is because of the significant density difference between the polymer families. Ingeo biopolymer has a specific gravity (density) of 1.24-g/cc. While polyolefin densities vary depending upon the grade and blend, they typically are in the range of 0.91 – 0.96-g/cc. This represents an increase of between 30 and 35%. Considering all other factors such as feeding properties, heat capacity and rheology equal, this would require the motor to supply a minimum of 30 – 35% greater energy at an equal screw speed. Therefore, if a particular line running LLDPE was already drawing 85 – 90% of the available power from the drive, it is extremely unlikely that it would have enough power to process Ingeo.

A second consideration is the screw design. Most of the commercial lines have extruder screws that have been optimized to run olefin resins at the maximum output for the diameter of the screw. To do this, they need to design for the specific melt flow properties (rheology) of the resin. Ingeo biopolymers have a significantly different rheology than olefin materials. They do not shear thin as readily and therefore typically require additional power input from the drive. This additional power input manifests itself as an excessive increase in melt temperature. Quite often, if the drive has enough power to process Ingeo resin, it will be screw speed limited (and hence rate limited) by excessive melt temperature.

Melt Strength

Ingeo biopolymer is a highly linear molecule which inherently has very poor melt strength. This low melt strength will hinder bubble formation and subsequent bubble stability. Depending upon the melt temperature, it could also limit the overall rate or maximum gauge film that could be produced.

Collapsing Frame

By its nature, Ingeo film is quite a stiff film. As it has a glass transition temperature (Tg) greater than room temperature, it is stiff and glassy compared to a olefin material which has a Tg less than room temperature. The table below lists the modulus (a measure of stiffness) of an Ingeo film compared to a typical LDPE film. The Ingeo film is significantly stiffer film.

Material	Secant Modulus MD / TD (kpsi)
Ingeo Film	500 / 700
LDPE	30 / 35

In addition, the elongation of an Ingeo film is very low as it is in its glassy state compared to a LDPE film that has elongations of 200 – 300%.

These two facts make it very difficult to collapse a bubble of Ingeo film without creating a significant amount of wrinkles in the web. As Ingeo has excellent dead fold properties, these wrinkles will remain in the film and make further downstream converting difficult.

Web Handling

Unoriented Ingeo film has low elongation, poor tear initiation strength and poor tear propagation strength. These properties make handling of an unoriented Ingeo web difficult at best. The tension control through the web path must be excellent and all idler driven rolls must be maintained in top working condition. If the web is edge trimmed or slit, rotary shear trimming wheels are required to prevent web breaks.

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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 170ºC), 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.

For additional information please contact NatureWorks via our website on the tab called FAQ's or by clicking here.

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