

This bulletin is intended for use only as a tool to provide information and help address issues that may pertain to designing of an injection stretch blow molded (ISBM) bottle made from Ingeo biopolymer for water packaging. Since there are many factors to consider with preform and bottle design, development, and manufacturing, an experimental approach may be needed.

The importance of bottle design cannot be overstated. The overall design of the bottle provides many functions that may include:

- Shape and color for consumer appeal and product differentiation
- Ribs that provide structural support to the package, while keeping the overall bottle weight low
- Vacuum panels for use in hot-fill applications
- CSD bottle designs to minimize creep

Ingeo biopolymer 7001D can be manufactured into ISBM bottles using conventional equipment made for PET. There are, however, some aspects about Ingeo biopolymer that should be noted when trying to find the best bottle design.

The first and most important thing to consider is Ingeo biopolymer's barrier properties. Ingeo exhibits higher transport rates for water vapor, carbon dioxide, and oxygen by a factor of 8-10 times than that of PET. A comparison to HDPE is also shown in the table below.

**Permeation Rate\* Comparisons**

Property	WVTR	O <sub>2</sub>	CO <sub>2</sub>
Ingeo	18-22	38-42	170-200
PET	1.0-2.08	3.0-6.1	15-25
HDPE	130-185	0.3-0.4	400-700

\*units: cc-mil/100 in<sup>2</sup> day atm @ 20°C and 0% RH for O<sub>2</sub> and CO<sub>2</sub>; g-mil/100 in<sup>2</sup> day for WVTR

Since Ingeo biopolymer's transmission rate is generally several times higher compared to PET, one should be conscience of bottle design when packaging particular products.

## Design Considerations for Packaging Water in Ingeo Bottles

- The water bottle having reinforcing features, such as ribs, to help alleviate paneling of the sidewall over time
- It is also recommended not to light weight the bottle. Typical weights for a 500ml Ingeo bottle should be 22-25 grams. Too thin of a sidewall will increase the rate of water loss.
- Dosing with nitrogen may help minimize the impact of altitude changes & internal pressure loss in the bottle that can then result in sidewall paneling
- Sharp & aggressive corners in the bottle design should be avoided, as Ingeo biopolymer stretches easier than PET.
- These same issues will need to be address with products containing high water content (e.g. - soaps, shampoos, other beverage drinks, etc.)

Please note that even though one might have sufficient reinforcement on the bottle so that there is not any noticeable implosion, water is still evaporating through the container. Because of this, it is recommended that one overfill the bottle to ensure the consumer gets the advertised volume.

## Physical Properties

The bottle design also plays an important role in providing performance in physical properties. In general, Ingeo biopolymer blown into a bottle designed for PET should perform well in tests such as top-load and drop impact. In order to get adequate physical properties, one will need to get the right material distribution in the base and shoulder in order to pass drop impact and top load testing.

- The preform and bottle designs should have the correct stretch ratio combination in order to obtain a bottle with

adequate polymer orientation, material distribution, and physical properties.

- The finish of the bottle should be thick enough to handle the forces placed upon it by the blow nozzle of the ISBM machine and the torque used to tighten the closure.
- The shoulder of the bottle will need to have an adequate amount of material to meet the top-load requirements.
- An Ingeo bottle that is heavy or thick in the base can have issues with drop impact strength. Material at the base of a bottle is typically unorientated and glassy. If there is too much material, the base can become too brittle and could result in a loss of drop impact strength.

## Resources

NatureWorks LLC has collaborated with Husky Injection Molding Systems and Plastic Technologies, Inc. for technical development purposes specifically related to Ingeo preforms and stretch blow molded bottles. The contacts at either of these companies can be used as a resource for one gaining experience with Ingeo biopolymer with regards to preform and bottle design considerations and processing (see below). The bottle equipment manufacturer is also a good resource to collaborate with on any such product development project.

Plastic Technologies, Inc.  
1440 Timberwolf Drive  
Holland, OH 43528  
Phone: (419) 867-5400

Husky Injection Molding Systems  
500 Queen Street S.  
Bolton, Ontario, Canada L7E 5S5  
Phone: (905) 951-5000

## 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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