Recommendations to Transition a Melt Process from an Incumbent Polymer to Ingeo™ Biopolymer

Purging recommendations can and should be tailored to the process needs of each transition event. In this document, hypothetical transitions are proposed, and recommendations are given to transition to Ingeo biopolymer in an efficient manner.

Ingeo biopolymer is incompatible with most polymer systems, and cross contamination usually results in loss of transparency or inclusions of unmelt. Ingeo biopolymer is relatively low in viscosity and in addition loses viscosity and even degrades severely at high extrusion temperatures making it often inefficient at pushing the previous extrusion product out of the line. These features and needs cause challenges transitioning from the previous production product to Ingeo biopolymer.

The starting condition is a process that delivered a clean melt with the incumbent process material. These recommendations will be recognized by many as standard practices. The key features are to:

1. At the onset, purge at the process temperatures and rates of the prior product
2. At the end, purge at the process temperatures of the subsequent product
3. Higher viscosity products resist purging with low viscosity products, so manage the viscosity transition as well as the temperature transition
4. Purging takes time and material flow through the system. Seven average residence times is frequently comparable to about 30 minutes. For the processes below, purge time suggestions assume 7 residence times will be proportionately divided over a 30 minute or longer time period.
5. Finally, sometimes the purging process is more effective when the screw speed is jogged up and down a few times to disrupt any laminar flow patterns that could occur which prevent effective mixing and purging.

In addition to purging, it is necessary to thoroughly clean the raw material (solids) conveying and handling equipment so that there are no residues of the previous polymer system left behind that could be inadvertently added to the melt stream once the full system is brought back on line. Ensure that the feeding and blending equipment is free from dust and contamination, and all metal magnets have been wiped clean. Ensure that all hang-up areas such as elbows, transitions and slide gates have all dust and granules completely removed.

1.0 Transitioning the melt process from APET to Ingeo 2003D

APET and Ingeo biopolymer are process temperature incompatible. Amorphous APET will crystallize in the extrusion system having Ingeo set points, and crystalline PET will not melt. One purging scenario follows:

Process Step	Material	Extrusion Temp	Purge Time
Initial condition	APET	500 - 530°F (260 - 275°C)	time zero
Start purging	blend APET and PETG	500 - 530°F (260 - 275°C)	3 residence times
Reduce viscosity	PETG	500 - 530°F (260 - 275°C)	4 residence times
Reduce temperature	PETG	420°F (215°C)	4 residence times
Reduce viscosity	Blend PETG and Ingeo	420°F (215°C)	3 residence times
Introduce Ingeo	Ingeo	420°F (215°C)	4 residence times
Possible rest	Ingeo	420°F (215°C)	Pausing (to allow the temperature to drop) and then restarting a purge can be beneficial. Use this pause to assure APET and PETG dust, flake and stray pellets have not remained in the solids handling system.
Complete purging	Ingeo	420°F (215°C)	3 residence times

Thoughts: APET used in thermoforming applications is frequently 0.80 to 0.85 IV. The PETG envisioned is Eastman Eastar 6267 or an equivalent material used for blister packaging and having an IV of about 0.70. Eastar 6267 PETG is an amorphous grade that is processable at melt temperatures from 380 to 525F. It is temperature compatible with both PET and Ingeo biopolymer. As all three are polyesters, there is a natural synergy in polarity that assists in transitioning between the grades. Since Ingeo is relatively low in viscosity, it is helpful that this envisioned PETG is lower in viscosity than typical APET thermoforming grades. Frequently we see more contamination the second day of a trial when we restart – pausing after Ingeo has been introduced is an attempt to draw that residue out sooner.

When transitioning the melt process from Ingeo biopolymer back to PET, it will again be necessary to transition through a polymer system which is temperature compatible with both products. Either PETG or a 2 MFR GPPS would be recommended as a transitioning polymer system.

2.0 Transitioning the melt process from Polystyrene to Ingeo 2003D

Polystyrene and Ingeo biopolymer are processed at similar melt temperatures. There is a significant difference in polarity that does not permit PS to be solublized by PLA. More importantly, with any amount of shear heating, Ingeo will be much less viscous than PS.

Process Step	Material	Extrusion Temp	Purge Time
Initial condition	HIPS	450°F (230°C)	time zero
Start purging	Blend HIPS (or OPS grade ~2 MFR) and 10 MFR grade of GPPS	450°F (230°C)	3 residence times
Reduce viscosity and adjust temperatures	10 MFR grade GPPS	420°F (215°C)	4 residence times
Reduce viscosity	Blend 10 MFR grade GPPS and Ingeo	420°F (215°C)	3 residence time
Introduce Ingeo	Ingeo	420°F (215°C)	4 residence time
Possible rest	Ingeo	420°F (215°C)	Pausing and then restarting a purge can be beneficial. Use this pause to assure polystyrene dust, flake and stray pellets have not remained in the solids handling system.
Complete purging	Ingeo	420°F (215°C)	3 residence times

Thoughts: Typical grades of PS used in manufacturing OPS or HIPS sheet are quite viscous and non-polar both of which make it desirable to try and purge with a higher flow GPPS prior to introducing Ingeo biopolymer. It may be that stopping flow for a while will let Ingeo bring out more material trapped in the extruder. Frequently we see more contamination the second day of a trial when we restart – pausing material flow after Ingeo has been introduced is an attempt to draw that residue out sooner.

3.0 Using polystyrene to transition a melt process from APET to Ingeo 2003D

Process Step	Material	Extrusion Temp	Purge Time
Initial condition	APET	500 - 530°F (260 - 275°C)	time zero
Start purging	blend APET and 2 MFR GPPS	500 - 530°F (260 - 275°C)	3 residence times
Purge with GPPS	2 MFR GPPS	500 - 530°F (260 - 275°C)	4 residence times

Reduce viscosity	Blend 2 MFR GPPS and 10 MFR GPPS	500 - 530°F (260 - 275°C)	3 residence times
Reduce temperature	Blend 2 MFR GPPS and 10 MFR GPPS	420°F (215°C)	4 residence times
Reduce viscosity	10 MFR GPPS	420°F (215°C)	4 residence times
Introduce Ingeo	Ingeo	420°F (215°C)	4 residence times
Possible rest	Ingeo	420°F (215°C)	Pausing and then restarting a purge can be beneficial. Use this pause to assure APET and PS dust, flake and stray pellets have not remained in the solids handling system.
Complete purging	Ingeo	420°F (215°C)	3 residence times

APET and Ingeo biopolymer are process temperature incompatible. Polystyrene serves as a transition product that can be processed for brief periods at APET conditions and also can be processed at PLA conditions. The APET processing temperatures are sufficiently hot that GPPS is preferred to HIPS for better thermo-oxidative stability. There is also a visual clue that purging is progressing well. A mixture of PET and GPPS, or GPPS and Ingeo will be white, but in pure forms all three products are transparent. As polystyrene is non-polar relative to APET and PLA, it does not solubilize the polyesters and purging is difficult. This is the reason for working with both temperature and molecular weight to improve purging efficiencies.

When transitioning the melt process from Ingeo biopolymer back to PET, it will again be necessary to transition through a polymer system which is temperature compatible with both products. Either a 2 to 3 MFR GPPS, or PETG would be recommended as a transitioning polymer system.

4.0 Transitioning a Melt Process from Polypropylene to Ingeo 2003D

Polypropylene and Ingeo biopolymer are processed at similar melt temperatures. There is a significant difference in polarity that does not permit PP to be solublized by Ingeo. PP is available in fiber grades as well as OPP or sheet grades so PP with a viscosity lower than Ingeo can be readily available.

Process Step	Material	Extrusion Temp	Purge Time
Initial condition	PP (2-3 MFR)	450°F (230°C)	time zero
Start purging	Blend PP with a 10-20 MFR grade of PP	450°F (230°C)	3 residence times
Reduce viscosity and adjust temperatures	10-20 MFR grade PP	420°F (215°C)	4 residence times
Introduce Ingeo	Ingeo	420°F (215°C)	4 residence times
Possible rest	Ingeo	420°F (215°C)	Pausing and then restarting a purge can be beneficial. Use this pause to assure PP dust, flake and stray pellets have not remained in the solids handling system.
Complete purging	Ingeo	420°F (215°C)	3 residence times

Thoughts: Typical grades of PP used in manufacturing OPP film or PP sheet are quite viscous and non-polar both of which make it desirable to try and purge with a higher flow PP prior to introducing Ingeo biopolymer. It may be that stopping flow for a while will let Ingeo bring out more material trapped in the extruder.

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.

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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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