NatureWorks LLC

Ingeo™ Bottle Packaging Technical Bulletin

Using Co-Injection and Multilayer Technology for PLA Bottles

This document is designed to provide an overview of PLA bottles and using multilayer technology in these types of packages. This information is intended to be used only as a guide and because production of preforms and bottles is a complex process, an experimental approach may be required to achieve desired results.

Besides monolayer bottles being made by injection stretch-blow molding (ISBM) and extrusion blow molding (EBM) processes, bottles can also be made using these similar processes where the cross-section of the bottle is composed of layers of different polymer materials. For example, the layers could be in various structural or compositional configurations such as "ABA," or "ABBA," or "ABCBA," etc. where each letter designates a different polymer type or system. These polymer systems and/or layers in the bottle cross-sectional construction could include base polymer resins in neat form or with various polymers and/or additives which impart a certain property, such as better barrier improvement, layer adhesion, physical properties, or unique visual/optical properties.

This layering construction is accomplished during the preform injection molding step for ISBM and during the extrusion and in the parison die for EBM. In both systems, separated extrusion systems are typically used to deliver the different polymer or additives to create the different layers. The amount and thickness of these different layers can also be controlled. Using a co-injection or co-extrusion melt delivery system to make multilayer preforms and bottles is not uncommon in the plastics industry, and this technology has been demonstrated and shown for PLA bottles.[1-3]

NatureWorks has demonstrated making multilayer preforms using, for example, Kortec's co-injection equipment integrated to an injection molding press. These preforms were then made into multilayer bottles. As an example and shown in Figure 1, active and/or passive barrier materials have been used in the middle layer of multilayer PLA preforms to create a bottle that could help better protect the packaging contents from water, carbon dioxide, oxygen, or other gases that may either escape or enter through the bottle sidewall. Barrier improvement results from such work are shown in Table 1.

Co-injection technology could also be used to create unique, visually different bottles which could improve identification in a plastic or multi-sort recycle stream for separation and/or collection purposes. This could be accomplished using a color marker in such a multilayer structure to help minimize or prevent contamination of a certain type of plastic from the others. A toner, dye, or other additive identification marker could be introduced in one of the cross-sectional layers of the bottle, such as the "B" layer in an "ABA" configuration. The dye, toner, or marker additive would be delivered via the melt extrusion process, where it is introduced in

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one of the extruders which feed one of the layers. For example, a toner or dye could be introduced in the "B" layer via the "B" melt extruder. The additive could either be solid or liquid in form and could be a color or any other example which would help to easily identify the bottle either visually or optically using either manual and/or automated sorting equipment.

As shown in Figure 2, the toner or dye marker could also be distributed or placed at only certain locations along the lengthwise direction of the bottle, such as the base of the bottle, or only at the cap or thread portion of the bottle. This control of placement where the dye, toner, or identification marker goes would help enable a converter to tailor the location of the identification marker to the needs of the bottle design or needs/wants of the application or customer, whether that is based on certain fit-for-use requirements or aesthetics or both.

The color could also be placed in the middle layer of the bottle which has a barrier material which would improve the barrier properties of the bottle. However, the color could only be distributed along the whole length of the bottle sidewall, as typically this is how the barrier material is used in a multilayer bottle to get optimum and improved barrier performance through good material distribution. This may affect the uniqueness of the graduated color effect, and thus would result in making the bottle not look much different from other bottles that are completely colored.

By using markers, co-injection and multilayer technology and its application could potentially help to identify certain bottle types from one another by visual or optical identification. This is especially the case in recycling systems where the use of manual or hand sortation is employed, and less so by automated optical equipment since PLA's unique chemistry can already be distinguished by near-infrared technology (NIR).[4] For cases using NIR sortation, black dyes/toners/colorants may or may not be the best choice to use to help distinguish the bottle, as black can be more difficult to pick up by near-infrared automatic sortation devices. Other colors may be better choices. An experimental approach should be taken to confirm the effectiveness and efficiencies using automated optical sortation devices, such as near-infrared.

Figure 1 – PLA multilayer preforms with barrier resin in middle layer

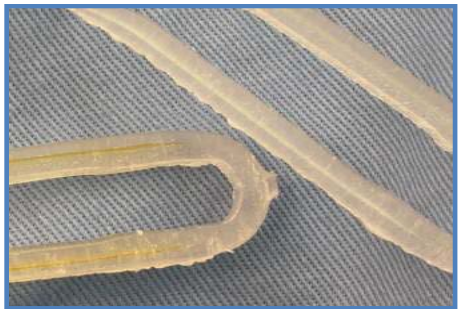

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Table 1 – Barrier improvement factors for PLA multilayer bottles[2, 3]

	Barrier Improvement Factor (BIF)*			
Polymer	O_2	CO_2	WVTR (23°C/50%RH)	WVTR (40°C/80%RH)
PLA	1.0	1.0	1.0	1.0
EAA	0.7	0.7	3.7	1.9
PP	0.7	0.9	4.5	3.6
PE	0.8	0.8	6.5	3.6
Ticona COC	-	-	13.9	5.6
Honeywell Aegis, nylon nanocomposite	8.1	-	1.2	-
Honeywell Aegis, nylon nanocomposite with O_2 scavenger	46.2	-	1.3	-
Mitsubishi Gas, MXD6	13.0	-	1.8	-

*All multi-layer bottles contain ~8-9% by weight barrier polymer in a three-layer structure. Barrier improvement factors calculated using base PLA as reference.

Figure 2 – PLA multilayer bottles with graduated toner/colorant

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References:

1. Toyoda et al, *Lactic Acid-Based Polymer Laminated Product and Molded Product.* United States Patent No. 6,248,430 B1, Jun. 19, 2001.

2. Vanyo, T., *Barrier Enhanced NatureWorks PLA Bottles for Extended Shelf-life Applications,* Nova Pack Americas 2006 conference proceedings. NatureWorks LLC, Feb. 7, 2006.

3. NatureWorks LLC Multi-layer technical bulletin. NatureWorks website, www.natureworksllc.com

4. NatureWorks LLC website, www.natureworksllc.com

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