



Processing Guidelines

Cardia Biohybrid™ BL-F

Blown / Cast Film Biohybrid Masterbatch

V2.3 July-2015

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ABOUT THESE PROCESSING GUIDELINES

Cardia Biohybrid™ BL-F is a hybrid resin masterbatch designed to be blended with polyethylene. The product contains a high proportion of thermoplastic starch. Therefore the blended material needs to be processed somewhat different to the conventional film resins of the polyethylene family. This document highlights the areas that are different. If a topic is not discussed in here, then a standard PE film set-up would be an appropriate approach. For further information, any questions, suggestions or comments please contact Cardia Bioplastics' Technical Support.

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PRODUCT DESCRIPTION

Cardia Biohybrid™ BL-F masterbatch is based on a blend of thermoplastic starch (TPS) with polyethylene (PE). This blendable grade is compatibilised to offer a high level of mechanical strength, outstanding elongation properties and toughness. The resin is based on corn starch which is a renewable material. This TPS/PE masterbatch can be blended with a wide range of polyethylene materials to tailor a film with properties perfectly matched to the application.

PRODUCT PROPERTIES

Physical Properties of Cardia Biohybrid™ BL-F Resin

<i>Properties</i>	<i>Test Method</i>	<i>Value</i>	<i>Unit</i>
Melt flow index	ASTM D1238	1.2	g /10 min (2.16 kg/ 190°C/ 374°F)
Density	ASTM D792	1.18	g/cm ³
Melting Temperature Range	ASTM D3418	90 – 100 / 194-212	°C / °F
Moisture Content	Internal	<0.6	%

Physical Properties of a Typical Cardia Biohybrid™ BL-F Film

<i>Properties</i>	<i>Test Method</i>	<i>Value</i>	<i>Unit</i>
Tensile strength at yield	ASTM D883	> 25	MPa
Tensile strength at break	ASTM D883	> 20	MPa
Elongation at break	ASTM D883	> 330	%
Impact Resistance-Dart Test	ASTM D1709	200	g
Tear Resistance	ASTM D1922	130	N

Note: Above film properties are based on a 30 µm blown film made from a blend of 50% BLF, 30% LLDPE and 20% LDPE

Moisture Content

Cardia Biohybrid™ BL-F Resin is sensitive to moisture absorption, due to the hydrophilic nature of its thermoplastic starch component. The process is very slow due to the protective moisture barrier of the PE component. Excessive moisture content in the resin could lead to processing problems such as foaming or phase separation. In the Cardia Bioplastics factory BL-F resins are adjusted to the optimum moisture content and immediately packed and sealed in aluminium foil lined bags. The liner is a perfect barrier and prevents any moisture exchange.

It is important that Cardia Bioplastics resins are processed soon after a new bag is opened. Any open bag should be properly sealed before storage.

PROCESSING OF CARDIA BIOHYBRID™ BL-F RESIN

Cardia Biohybrid™ BL-F resin blends can be processed on standard LDPE or LLDPE blown film equipment. However, due to the different nature of Cardia Biohybrid™ BL-F as part of the blend, the machine set-up and processing

conditions need to be adjusted to ensure a stable process and to optimise quality and output of the product. The following sections discuss these adjustments based on previous successful trials and production campaigns.

Equipment Considerations

The following considerations are based on the conversion of blends with a high BLF content of 50-60 %. At lower addition rates the process conditions are increasingly determined by the processing characteristics of the PE resin component.

Screw Design

Most standard LDPE or LLDPE screw designs with typical L/D ratio between 20 and 32 will plasticate Cardia Biohybrid™ BL-F blends well and should work without any issues. A preferred design would have a length greater than 24D and a distributive mixing head to provide a well homogenised melt.

Very aggressive, high shear screws should be avoided, since they tend to thermally damage the resin from localised overheating.

Smooth barrels are recommended to be used to process Cardia Biohybrid™ BL-F resin blends showing similar effect on processing as applicable to polyethylene. Grooved barrels should be avoided since they can generate significant shear heating which can damage the starch polymer.

The melt channel should be designed to eliminate dead spots or areas of very slow flow to minimise the risk of thermal decomposition due to long residence time and heat exposure of the resin.

Melt Filter

A clean melt filter (60 or 80 mesh) should be used every fresh start-up to ensure small particles do not break/split the bubble.

Die

A die gap of 0.8 - 1.5 mm is recommended for blends with Cardia Biohybrid™ BL-F blends.

Tower

The height from the die surface to the nip roller should be higher than 2.5 m to ensure full cooling and prevent film blocking, unless internal bubble (IBC) is used.

Processing Conditions

Due to differences in machine design and performance the following set-up recommendations are specific to a certain machine and should only be seen as a starting point for further process optimisation. The following recommendations are

based on a 50/50 blend (by weight) of Cardia Biohybrid™ BL-F with a common LDPE with MI of 2.5 (@ 190°C/374°F, 2.16 kg).

Process Temperatures:

Cardia Biohybrid™ BL-F resin is thermally sensitive. Therefore, the processing temperature should be carefully adjusted and monitored to avoid overheating. At no point in the process should the resin be exposed to temperatures above 190°C/374°F.

Overheating can lead to thermal decomposition and degradation of the starch polymer. Signs of degradation are:

- brownish colouring of extrudate
- intensified odour, sweet smell, similar to caramel, as starch degrades into sugars.

Note: During processing the material releases a light starch odour, similar to popcorn, which is perfectly normal.

The following table recommends a starting point for optimisation and a range in which the optimised temperature should be maintained:

Zone	Starting Point Temperature (°C/°F)	Temperature Range (°C/°F)
Hopper	water cooling	water cooling
Feed	135 / 275	120 – 150 / 248 - 302
Compression	160 / 320	140 – 180 / 284 - 356
Metering/mixing	170 / 338	145 – 180 / 293 - 356
Adaptors	170 / 338	145 – 180 / 293 - 356
Die	170 / 338	145 – 180 / 293 - 356

Purging

Before introducing Cardia Biohybrid BL-F™ blends it is recommended to purge the extruder with a standard LDPE of high melt flow (MFI 2-6) and adjust the process temperatures close to the starting point as in the table above. Depending on the design of the extrusion line purging to a clean and streak-free bubble of Cardia Biohybrid™ BL-F blends should take between 20-40 minutes.

Screw Speed / Line Speed

The screw speed should be slow at start-up and then slowly be increased in parallel with the haul-off/line speed.

Blowing a Bubble

The melt of Cardia Biohybrid™ BL-F blends show the beige coloured haze typical for starch based polymers. The higher the BL-F content the less transparent the bubble.

With increasing BL-F content the melt also becomes tackier and shows lower melt strength. The operating window for a stable bubble at high yield can be smaller than that for a pure PE bubble. The process parameters for any new blends need to be carefully optimised for quality of the film and machine output.

The preferred blow-up ratios are between 2.5:1 and 3.5:1. Higher blow-up ratios may lead to bubble instability problems and film creasing.

The cooling air volume should be gradually changed from weak to strong. Cold air is preferred; 10-15 °C (50-59 °F) works best to avoid film blocking problems.

Depending on blend ratios, type of PE, equipment design and process set-up, film thickness between 12 µm and 120 µm can be achieved using Cardia Biohybrid™ BL-F blends.

Purging out Cardia Biohybrid™ BL-F Blends

Following a Cardia Biohybrid™ BL-F blend production run, it is recommended to purge the extrusion line with polyethylene or a similar polymer to minimise the risk of thermal decomposition of the melt. Cardia Biohybrid™ BL-F resin blends should not be left in a hot extruder barrel when the machine is shut down.

Conditioning of Films from Cardia Biohybrid™ BL-F Blends

Films made from Cardia Biohybrid™ BL-F blends, particularly those with high BL-F content (> 30%), achieve their optimum film properties a few days after production. This is the effect of re-absorption of moisture that is required to plasticise the thermoplastic starch polymer. In some circumstances it is recommended to store products for up to 48 hrs unwrapped to allow moisture absorption before the products should be packed and shipped.

ADDITIVES

Cardia Biohybrid™ BL-F resin blends can be coloured using a standard PE based masterbatch.

IN-LINE RECYCLING

The BL-F blend trim waste can be re-processed and recycled as long as it is kept segregated (i.e. not mixed with polyethylene) and kept dry. The film edge trim and bag handle "punch-outs" can be processed through a film re-processing unit (e.g. Erema, PlasMac) into pellets or through an agglomerator or compactor to produce agglomerated/compacted pellets. The regrind pellets can be fed into the main film process at a maximum addition rate of 15 percent.

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