



Environmental Product Statement for Algae Fuel

Introduction

This Environmental Product Statement (EPS) provides a comparative quantitative description of the environmental performance of 3D Fuel's line of Solaplast algae-blended bio-resins. Solaplast has a third party conducted full Life Cycle Assessment (LCA) from which this EPS is based. The full LCA report can be provided upon request.

This EPS describes the production of Solaplast resins from a 'cradle to gate' perspective - from resources extraction, raw material manufacturing up to the Solaplast resin production. Data provided in this EPS offer detailed comparable insight of Solaplast resin versus some of the conventional plastic materials it is comparable to. This document is designed to inform the user of Solaplast Algae Fuel products on the improvement of environmental impacts associated with the blending algae with plastics. This study presents algae blended with PolyLactic Acid (PLA) compared to the virgin base resin (PLA) being used alone.

The Company/ About Us

SOLAPLAST is a green technology company committed to the production of sustainable plastic composites. Through an uncompromising work ethic, innovation and life cycle thinking, we empower our customers to address the needs of today without compromising the needs of tomorrow. Our process allows us to provide a wide variety of environmental, economic, and humanitarian benefits.

Solaplast is a subsidiary company of ALGIX. ALGIX is committed to Life Cycle Thinking and further improving our products in order to produce more with less and to ensure sustainable resource use while alleviating the stress on the environment. Various life cycle analyses support the better performance of biobased rigid packaging, in particular in the impact categories of human health, ecosystems, climate change and fossil resources. For more information, visit www.algix.com.

The Materials

At Solaplast, we offer a variety of algae-based resin formulations. Algix processes algae biomass, harvested from aquaculture ponds and other sources, to be blended with plastics such as and polystyrene (PS), to create a blended plastic filler that reduces the amount of petroleum-based plastics needed. The Algix product can also be blended with biodegradable plastics, such as poly lactic acid (PLA) to make them more cost competitive since the algae biomass is also biodegradable and cost competitive with conventional and bio-based plastics.

The use of algae and other bio-based materials instead of fossil resources in the plastics industry can help reduce Green House Gas (GHG) emissions, since the bio-based composition uses the atmospheric CO₂ absorbed by algae during the photosynthesis rather than carbon from fossil-based resources. Reducing GHG remains a driver for the increase seen in bio-based content of engineering materials. Solaplast not only provides a more sustainable plastic product but, dependent on the resin, in some aspects they provide improved material specifications and product performance. We accomplish all of this through our in house Custom Compounding and Research and Development activities.

Generally, Solaplast formulations typically consist of either a durable polymer or a biodegradable bio-based polymer combined with algae. Solaplast resins can be used in a vast number of ways and in a variety of applications such as packaging, agriculture/horticulture, consumer electronics, material handling, automotive, consumer goods & household appliances, personal care, and construction.

Solaplast resins often provide a drop-in replacement for thermoplastic compounds and offers the manufacturer improved mechanical properties, a more sustainable product, eligibility for government incentive programs, process cost reductions and a buffer to crude oil price fluctuations.

The Products

Solaplast resins are comprised of a base resin (PLA) and algae at 45% algae loading level. Solaplast resins are sold as plastic resin pellets ready to be processed in injection molding, extrusion, blown films, blown molding, foaming and sheet extrusion/ thermoforming processes. Solaplast products can be sold in 50 pound foil bags, 1,500-2,000 pound cardboard Gaylords boxes or super sacks, as well as rail car upon special request. Typical mechanical properties are provided in our Technical Data Sheets for each product which can be found on our website at <http://algix.com/products-services/solaplast-resin-grades/>

The Life Cycle Assessment study compares the cradle-to-gate environmental impacts when the algae, sourced from aquaculture ponds and targeted algae blooms, is blended with polylactic acid (PLA, a bio-based plastic) to the respective base resin.

Health and Safety Information

Solaplast resins are polymeric materials not classified as hazardous for human health or the environment according to Directive 1999/45 and Regulation 1271/2008. Substances of Very High Concern (SVHC) or Substances of the 'Candidate List of Substances of Very High Concern for Authorisation' (SVHC candidate list published by the European Chemical Agency (ECHA) following REACH Regulation are not purposely used for the product of Solaplast.

Renewable Content

The renewable content for Solaplast resins is calculated by the weight of the algae biomass added to the formulation. Solaplast resins are comprised of up to 55% algae, and if being blended with a biodegradable base resin, they can be up to 100% bio-based materials. In filament form, the algae content may be reduced to 15-20% by weight. This study evaluates the resins at the masterbatch level at 55% and does not consider a let-down of algae concentration for filament production.

Production Process

Upstream Processes

Upstream processes include the growing and harvesting of renewable, bio-based, algae resources, the extraction of non-renewable resources for the durable base resins (e.g. operation of oil platforms), the production of intermediate polymers including transport within the upstream process.

Core Processes

Core processes include the formulation by means of micronization of the algae biomass and extrusion compounding of the bio-based and fossil-based polymers along with any additives to form the final Solaplast resin pellets.

Downstream Processes

Downstream processes include the distribution from the production facility to the place where the conversion takes place, the conversion process, the use phase and the packaging.

Environmental Data – LCA/ Charts

The Algix process includes harvesting from an algae pond, dewatering, milling and compounding the algae with plastic, resulting in the masterbatch. The masterbatch consists of roughly 50% dry algae and 50% petroleum-based (or bio-based) plastic. The masterbatch is then combined with additional plastic at a 50:50 ratio before it is extruded into film or sheet and thermoformed. The amount of algae blended into the plastic is referred to as the loading level. For the resin comparison, 50% algae loaded is used for comparison to the virgin base resin. The final algae content in 3D printer filament may be in the 15-20% range.

The inputs to the Algix process include:

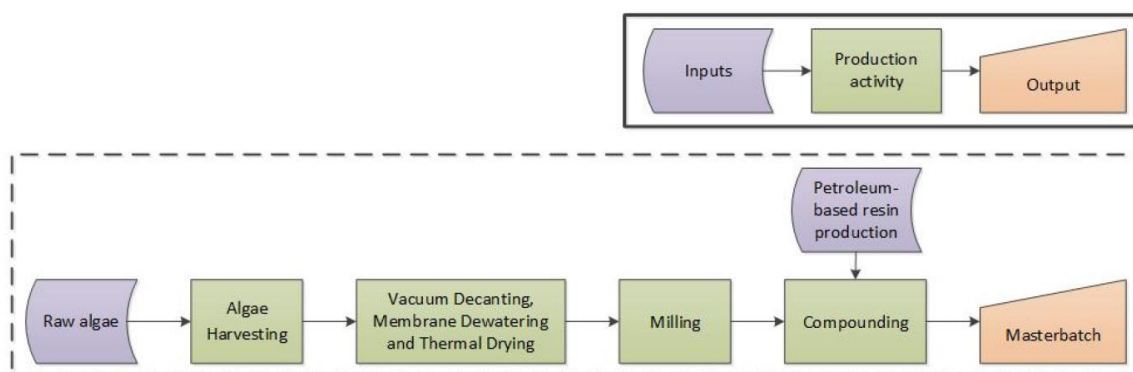
- Raw algae
- Material inputs for harvesting
- Electricity
- Material inputs for milling and compounding
- Water
- Base plastic resin

The outputs from the Algix process include:

- Masterbatch resin
- Plastic scrap from extrusion
- Water evaporation
- Wastewater

The life cycle's examined are "Cradle-To-Gate" Analysis. The boundary conditions for this analysis are shown below:

Figure 1: Cradle to Gate:



Solaplast 2000 Series resin versus Poly Lactic Acid

The results shown in Figure 3 indicate with a high level of certainty that the algae blended masterbatch with PLA has fewer impacts than PLA in human health, ecosystems, climate change and water. The results are uncertain in resources and cumulative energy demand, therefore the comparative results for these categories are not provided. In the PLA comparison, the Solaplast 2000 resin used less water than the virgin resin despite similar electrical consumptions compared to other formulations. This is due to the large quantities of water used in the growth of corn production process for PLA. Figure 4 shows the quantified impacts of Solaplast 2000 series compared to pure PLA.

Figure 3: Solaplast 2000 series resin compared to Poly Lactic Acid

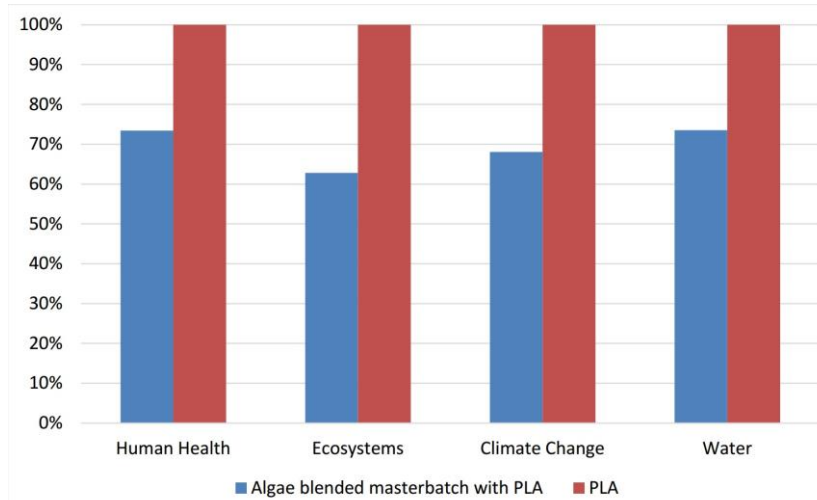


Figure 4: Comparison of quantified impacts for each impact category.

Impact category	Unit	Algae/ PLA	PLA
Ecosystems	species.yr	1.86E-08	2.96E-08
Resources	Econ Units	7.29E-02	8.19E-02
Climate Change	kg CO ₂ eq.	1.60E+00	2.36E+00
Water	m ³	1.83E-02	2.50E-02

Figure 11: Overview of Impact categories used in LCA Analysis.

Ecosystems	Species * yr	Assessed in units of species * yr, or the number of species that may disappear due to the impact times the area over which they are affected times the duration that the species are affected.
Resources	Economic units	Puts a future value on resources which will be unavailable since we are using them today.
Climate change	kg CO ₂ eq.	Measures global warming potential due to greenhouse gas emissions such as carbon dioxide, methane and nitrous oxides. Based on the 100 year time horizon.
Water	m ³	Counts the amount of water consumed, in all processes, including electricity production. Does not show impact. Used for benchmarking only.

By analyzing the milled algae and masterbatch algae blended plastic, this study provides useful insight regarding the environmental impacts of Algix's operations, as well as how the algae blended plastic compares to petroleum and bio-based plastics. The LCA results also identified where the largest impacts are occurring so that Algix can make further improvements to the production system in order to continue to optimize and improve the life cycle footprint of the Solaplast product lines.

ALGIX is committed to Life Cycle Thinking and further improving our products in order to produce more with less and to ensure sustainable resource use while alleviating the stress on the environment. Various life cycle analyses support the better performance in the impact categories of human health, ecosystems, climate change and fossil resources.