The Chemical Company

Compostable Multilayer Food Packaging

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Compostable Multilayer Food Packaging

In 2011 BASF Biodegradable Polymers group successfully made a completely compostable multilayer food packaging structure with high barrier properties, This packaging structure meets the barrier requirements for a large number of consumer packaged goods and allows, for the first time, these packaging wastes to be diverted from landfill and sent to industrial composting instead. Because current multilayer packaging is neither recyclable nor compostable, use of the BASF compostable multilayer packaging structures will result in higher landfill diversion rates for Zero Waste programs throughout the United States. BASF has taken packaging destined for landfill and redesigned the materials so that the packaging can now be composted, which creates end-of-life value far beyond putting materials in a landfill.

This technology is not eligible for the small business award or the academic award.

The project focus area of this technology is the design of greener chemicals.

Production of the films, inks, adhesives and primers were done in the United States, along with the conversion of raw materials into the finished structure.

Abstract: Most conventional food packaging consists of a multi-layer film structure which is comprised of polyolefin or polyamide resins and adhesives. The only disposal option for conventional packaging consisting of these materials is disposal in a landfill because it is neither recyclable nor compostable. The multilayer packaging is needed to provide barriers, colorful print and necessary adhesives to bond all the layers together. These materials are not easily separated for disposal, thus making recycling problematic and are made from chemicals that are not compostable in industrial compost sites.

Landfill diversion is critically important today as waste is being generated at a substantial rate. BASF has taken packaging destined for landfill and redesigned that material so that it can be composted at industrial compost sites, creating value from the product's end-of-life packaging.

Composting and the subsequent use of compost produce beneficial factors for the environment and resource management. It turns what would otherwise be landfill waste into usable, valuable, product. When organic material goes into a landfill it degrades over time releasing methane gas and carbon dioxide, known as Landfill Gas (LFG). Less than 30% of the landfills in the US collect LFG, so the majority of organic material disposed of in a landfill eventually creates gases that are pollutants to the environment. If food packaging can be diverted from landfills they can then be used in the generation of compost which has useful benefits. One of the benefits of organic waste diversion is increasing the landfill lifespan, reducing the waste input, allowing for a "right size" landfill (a landfill designed for exactly what will be needed). This will lead to less environmental impact from the reduced need to build new landfills or expand existing ones as often, which in turn reduces the energy consumed, emissions to water and air pollutants from building new landfills.

Compostable Multilayer Packaging

Since 1998 BASF has been producing Ecoflex®, a compostable bioplastic product, which is a co-polyester polymer and is fully biodegradable under industrial composting conditions. Ecoflex® is able to be blended with multiple renewable materials allowing for use in compost bags and liners, mulch films, paper coating, foams, and more.

In 2006 BASF introduced Ecovio®. Ecovio® is a compound of Ecoflex® and polylactic acid (PLA) which is produced from corn. PLA is an annually renewable raw material that is also biodegradable and compostable. Ecovio® has been designed to work as a film, paper coating, shrink film, foam, and rigid packaging. Its structure is determined by the blend of PLA and Ecoflex®, allowing it to be used in specific applications. Ecoflex® and Ecovio® products are the main materials used in the BASF compostable multilayer food packaging.

Both Ecoflex® and Ecovio® molecules have a structure similar to naturally occurring polymers and are biodegraded by microorganisms and their enzymes. Microorganisms therefore process Ecoflex® and Ecovio® molecules, just like naturally occurring macromolecules, into carbon dioxide, water and biomass. This can best be done in an industrial composting plant because this is where optimum conditions are to be found. Ecoflex® complies with European standard EN 13432 on the compostability of materials and with the Japanese GreenPla standard and American standard ASTM 6400. Both Ecoflex® and Ecovio® are FDA and EU food compliant.

BASF has designed the food packaging to be only 6 layers, a reduction in the number of layers for the same application. Commonly polypropylene-based multilayer structures for food packaging have up to 11 layers or more. This allows them to achieve the necessary barriers, print quality, and sealing capabilities for a given application. They usually consist of an outer web where printing is applied, a tie layer in the middle which bonds the other two layers together, and an inner web consisting of a metalized layer with polypropylene. Polypropylene does not seal to itself so a sealant layer is needed on both sides. Polypropylene is also usually layered with polyethylene or some other barrier material such as EVOH (Ethyl Vinyl Alcohol copolymer) or PVdC (Polyvinylidene Chloride). This new packaging by BASF does not require additional sealant layers since Ecoflex and Ecovio readily seal to themselves and also the structure has done away with the need for a tie layer between the outer and inner webs. This is an advantage for BASF packaging since the most sustainable materials are ones that reduce the amount of materials used.

The compostable food packaging film structure is a six layer film (see Figure 1). The outer layer is the print web which is a mix of 75% Ecoflex®, 19% Ecovio®, 3% Silica AB masterbatch, and 3% AB masterbatch. The second layer is the printing ink layer which uses a BASF Joncryl SLX water-based resin. The third layer is the adhesive coating which is Epotal® P 100 ECO. The fourth layer is a metallization layer at a 3 optical density (OD). The fifth layer is the pre-met primer which is Versamid® resin system. The last layer, or inner layer, is the sealant web whose composition is the same as

the outer print web layer. The innovative design of the packaging and its materials allows for the entire structure to be composted.

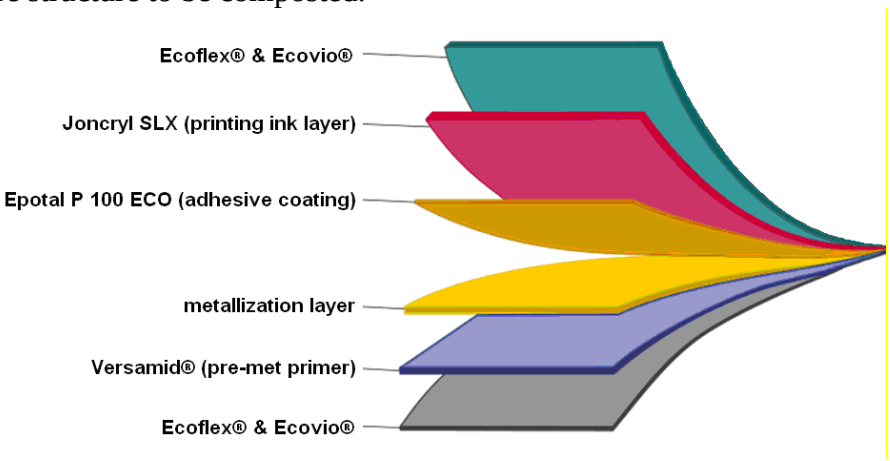

Figure 1: Compostable Food Packaging Layers

Figures 2 and 3 below show example graphics of the BASF compostable packaging structures developed. They have the potential of being used for breakfast and snack bars, candy wrappers, peanut bags, chip bags, and much more. The graphics depict the individual film layers as described before, all being 100% compostable.

Figure 2: Peanut Bag Graphic

Figure 3: Breakfast Bar Graphic

The Case for Composting

Landfills have helped keep waste contained and out of the broader environment but increased wastefulness is becoming a problem. It is inaccurate to state landfills have never had use or value. Before landfills, waste was an unsanitary issue affecting the environment. The use of landfills has helped contain harmful materials that would have before ended up in the environment by being disposed of improperly, affecting ecology and producing unhealthy living conditions. The technology behind landfills has improved over time allowing for better safety barriers and the improved design of landfills has established better waste disposal practices. However, the amount and kinds of materials that are being placed in the landfill are wastes that do not need to be disposed of in a landfill. We have entered into a time when single use plastic packaging has become

standard and most of it has only one place to go at end of life, to a landfill. While overall space for landfills is not an issue in the U.S., The amount of lost resources and costs associated with landfills has become increasingly more apparent.

According to multiple waste diversion studies done around the country, at least 40% of materials that go to a landfill are organic and have the potential of being used for compost. Less than 9% of these are actually being diverted from the landfill and used for compost. Every year approximately 30 million tons of plastics are discarded in landfills in the United States according to the EPA. If an average landfill in the U.S. has a capacity of 8 million tons, almost 4 landfills per year could be reduced. If you consider the average lifespan of a landfill is 20 years, diversion of this material could increase the lifespan to over 33 years. One benefit of diverting the organic waste from landfill is the reduction of LFG generation. Organic waste in landfills creates LFG which is methane and Carbon dioxide and, according to the EPA, less than 30% of landfills in the United States collect this LFG. This means that more than 70% of landfills filled with 40% organic waste are polluting the atmosphere with methane and carbon dioxide both of which are greenhouse gases.

Composting is host to many beneficial environmental and resource attributes. A 40,000 ton capacity compost facility has a lifespan of 50 years and unlike a landfill, compost will not keep piling up, so smaller capacity facilities can be built. Compost is also a useful resource able to be sold and utilized for landscaping, agriculture, and bio-remediation projects. Compost as a fertilizer returns nitrogen, phosphorous, and potassium back to the soil, increases the water retention of the soil, as well as prevents top soil loss and erosion. The greatest environmental benefits for composting are; reduced resource consumption, fewer emissions, reduced energy use, and reduction in potential occupational illnesses and working accidents. Proper composting also kills many harmful pathogens present in some organics.

Multilayer food and food service packaging make up a large portion of products that cannot be recycled and do not possess materials that can be composted, nor are they designed to be reused in any capacity. They are products specifically designed to go to landfill after one use. They could also go to waste-to-energy through incineration but incineration use is limited in the U.S. and the benefits to the environment and waste reduction are debatable. BASF's compostable multilayer packaging aims to take those packaging structures destined for landfill and has redesigned them to be composted, diverting waste material from landfill and creating a usable resource.

Real Life Example

BASF has partnered with the Seattle Mariners in their zero waste initiative through the Green Sports Alliance, which is a collection of over 50 sports teams and venues representing 9 professional sports teams across America. The goal of the Green Sports Alliance is to help sports teams, venues, and sports leagues enhance their environmental performance through waste diversion and greener practices. The Mariners have switched to a recycle and compost bin system instead of trash bins in their stadium and BASF has helped to provide compost compatible service-ware. Most of these items are compostable

paper-based products. An ongoing issue is the candy wrappers, peanut bags and similar plastic packaging brought in by fans or sold by vendors that cannot be composted or recycled. The improved compostable packaging structure from BASF could be integrated in with the other compostable organic and paper materials thus doing away with a significant portion of waste.

The lack of compost facilities and infrastructure available across the country is the main hurdle for general use of composting. Most composting is done by only a select few cities, stadiums, and other institutions where compost waste streams have been established. California is the current leader in developing composting through state-wide waste diversion initiatives. With the help of waste diversion programs and new innovative compostable materials like BASF's multilayer food packaging, composting use will grow exponentially across the country.

Eco-Efficiency Analysis

The term "eco-efficiency" was developed in 1992 by The World Business Council for Sustainable Development (WBCSD). In general, eco-efficiency means creating more goods (products) while consuming fewer resources and generating less waste and pollution. BASF uses this methodology to compare the relative ecological impacts and economic efficiencies of alternative products. As an objective and science based, state of the art life cycle assessment tool, the BASF Eco-Efficiency analysis methodology has been 3rd party reviewed and validated by two recognized standards organizations throughout the world: NSF International and TÜV. This independent review provides both credibility and transparency to the Eco-Efficiency methodology. NSF International, a not-for-profit, non-governmental organization, develops national standards and provides third-party conformity assessment services.

The BASF Eco-Efficiency portfolio was developed to graphically depict both economic and environmental results on a single 2x2 matrix as shown in Figure 4 below. The normalized values from the Environmental Fingerprint are weighted and aggregated into a single relative environmental impact through relevant and societal factors and plotted against a normalized cost. The data used for the determination of the weighting factors comes from independent, third-party environmental surveys in the U.S. as well as data collected from governmental (DOE, EPA, US Department of Agriculture, US Dept. of the Interior) and other organizations (United Nations, WRI etc.).

Eco-Efficiency looks at the advantages of composting by comparing four cases of organic diversion. The first case is if no organic diversion was being done, in other words 100% of organic material is going to landfill. The second case is what is currently being done in organic diversion. The third case looks at what if the organic diversion was 50% more than it is currently. The last case looks at what if 100% of organics were diverted from landfill. Figure 4 shows the general results from the comparison through the environmental impact and the costs. The more organic diversion is done the impact to the environment and the cost decreases. Top right on the chart corresponds to a higher eco-efficiency.

There is a clear reduction in the environmental impact when more organic diversion is being implemented as well as reduced costs. This is primarily caused by the reduction in costs and ecological effects from not needing to build new landfills or expand currently maintained ones as frequently over time. The major benefits of composting are the savings in materials and energy from organic waste being placed in the landfill and by extending the lifespan of landfills. The lifespan extension produces the ability to "right size" the landfill, building landfills to match the exact need.

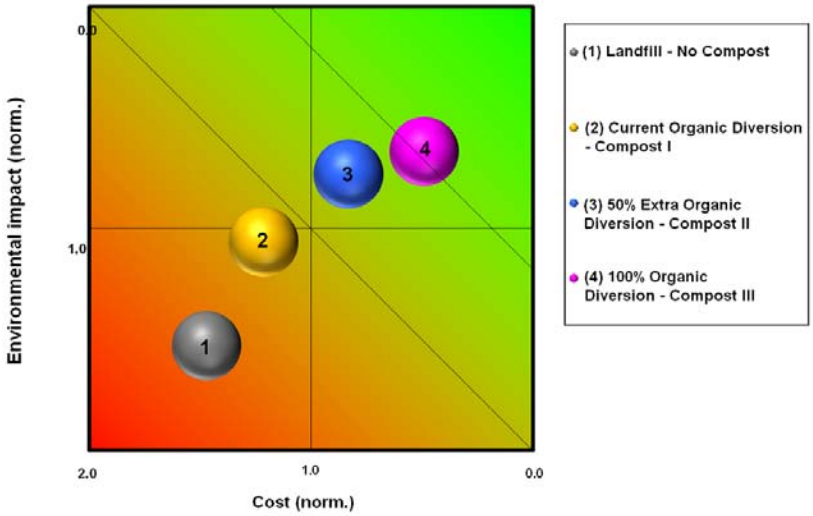

Figure 4: Eco-Efficiency Portfolio

The result of organic diversion from the aspects of each of the 6 key environmental elements is shown in Figure 5. The alternative with the greatest environmental impact in each category is given the value of 1.0. All other alternatives are normalized based on this maximum value with a value approaching 0.0. The closer to the origin (0) an alternative is, the more favorable it is. The axes are mutually independent so that an alternative that, for example, does well in energy consumption can perform less favorably in the emissions category. As the amount of organic waste diversion increases the more favorable the environmental elements become. In this compared data, every key element becomes more favorable as the amount of organic diversion increases.

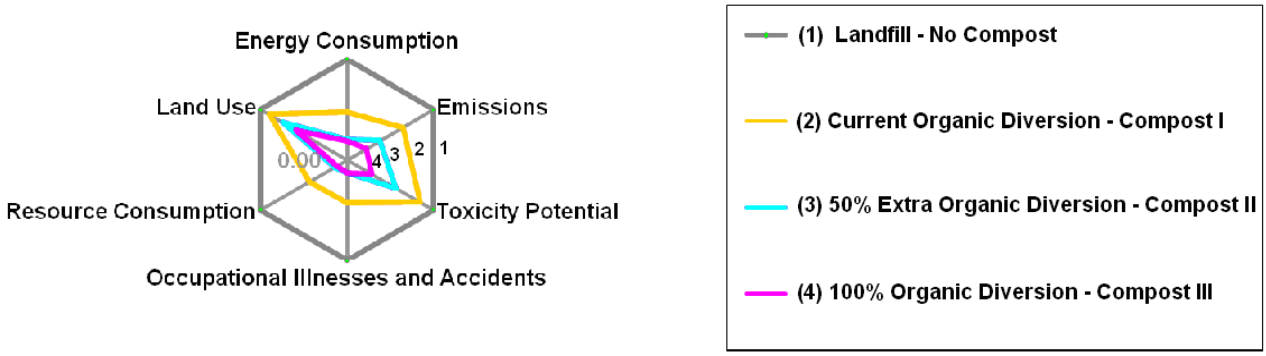

Figure 5: Ecological Footprint

The more organic diversion taking place the lower the potential for toxicity. The main driver in reducing toxicity comes from the agricultural benefits of compost. Because fertilizer is needed in agricultural applications, compost generated and used in farming reduces the amount of synthetic fertilizer needed. The generation and use of compost reduces the fertilizer use, thus less exposure to humans and aquatic animals from run-off in agricultural applications. Figure 6 shows the toxicity potential in relation to the organic waste diversion. A great deal of fertilizer material is put into the ground, much of it washing through the soil and into the environment. Compost puts nutrients and minerals back into the ground naturally.

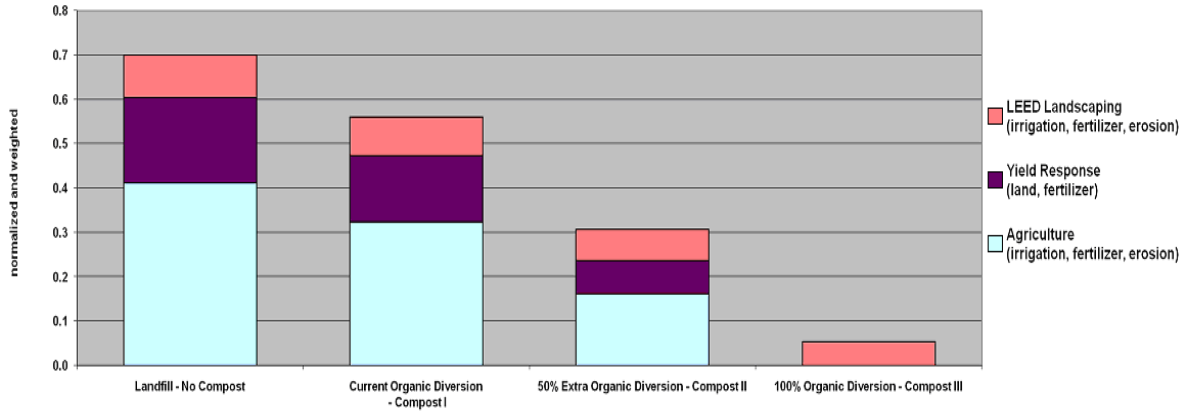

Figure 6: Toxicity Potential

Summary:

BASF has taken packaging destined for landfill and redesigned it so that it can be composted, creating value from the product's end-of-life packaging. The use of BASF's Ecoflex® and Ecovio® material in packaging allows the disposable packaging to turn what would be landfill waste into usable product. When organic material goes into a landfill it degrades over time releasing methane gas and carbon dioxide, with little or no value. Diverting waste to compost however has multiple environmental benefits such as increasing the life of the landfill, reducing the amount of methane and carbon dioxide gas emitted into the atmosphere and physical benefits from the use of compost in several applications. If food packaging can be diverted from landfills they can then be used in the generation of compost which has tremendous attributes.

References:

Tom Laginess, BASF Corporation *Eco-Efficiency Analysis: Compost Value*, quantifies the differences in life cycle environmental impacts and total life cycle costs of composting waste and the value of the compost. November 12, 2010

BASF Corporation, Ecoflex® & Ecovio® Brochure, *Biodegradable polymers-Inspired by nature*, *Ecoflex®*, *Ecovio®*, BASF Ecovio® product information website www.bioplastics.basf.com/ecovio