Consumer-Minded Development & Production of Compostable Flexible Films

Abstract

Flexible films represent a large portion of the waste stream that cannot be readily recycled, separated or otherwise diverted from landfill disposal. As regulations tighten and disposal costs rise, having a viable compostable packaging alternative is critical. Previous attempts at biodegradable/compostable packaging films forced consumers to sacrifice performance and cost, the two most critical factors in their purchasing decisions. With innovative new technologies and new production methods, a new family of compostable packaging is entering the market offering consumers superior performance and cost effectiveness that was previously unattainable.

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The focus of most of the recent innovations in the flexible film package production has been on increased performance, cost reduction and shelf-appeal. Simultaneously, there has been an increased consumer awareness of the impact flexible films have on the environment when they are disposed of. This awareness has resulted in an evolution of life-cycle analysis, increased taxes, import duties, and "take-back" laws. Agencies of the federal government have also been forced to purchase biobased materials, including packaging, whenever they are feasible as described in Farm Bill 2002.

This combination of consumer demand and industry regulations has created explosive market potential for packaging films that offer cost-effective performance and environmentally benign disposal. Previous attempts at biodegradable films have had only limited success. The new generation of films offer unparalleled market penetrability at a time when the demand for these products is growing exponentially.

Brief History

One of the first degradable plastic films used in the United States relied on a technology where an additive was incorporated into polyethylene. While polyethylene is not readily degradable on its own, the additive was thought to accelerate the breakdown of the long carbon chain that makes up the polyethylene molecule under some conditions. Although the manufacturers of these products had multiple test reports showing degradation, the conditions required for even a five year degradation curve were next to impossible to mimic with existing disposal infrastructure.

Nearly a decade later, a new technology was developed in Europe that was specifically designed to biodegrade rapidly in commercial compost facilities. In Europe, composting infrastructure was developed sufficiently to allow these films to actually be processed and diverted from landfills and incinerators. The technology used incorporated high levels of starch into biodegradable petroleum-derived polyester. The resultant films would convert into carbon dioxide and water well within six months. While these products met the goals of realistic and rapid biodegradation, even years later they are mostly used only in direct-to-disposal applications such as organic waste collection bags.

While the manufacturers of the starch-polyester films market the content of starch, it is this starch component that has limited the market penetrability of these products. As soon as the starch-polyester products are manufactured, their physical properties begin weakening. These films and bags are weaker than non-degradable polyethylene even immediately after production and are

susceptible to moisture, humidity and temperature. These substandard properties have forced consumers to sacrifice performance and have limited the market potential of this technology.

Standards and Definitions

Shortly after the development of the starch-polyester technology, communities, industries and nations began developing definitions and standards to avoid misleading the consumers given the negative response earlier additive films had received. Some of the resultant definitions and standards are described below.

ASTM D 6400-99 was established only a few years ago, but is based on years of intensive laboratory and real-world testing of biodegradable and degradable films. This standard mimics methods used by **Din Certco** in Europe and others in Asia. The general criteria for these standards include rapid biodegradation under commercial compost conditions, no negative effect on plant growth, and no contamination due to water-soluble intermediates. These standard methods do not include criteria of usefulness, strength or durability. They focus solely on the disposal phase of the products.

Degradable films refer to those products where a catalyst (in the form of an additive) is used to cause the *eventual* degradation of the polyethylene products under specific conditions, which most often include ultraviolet light exposure, heat or mechanical strain. While these products do not meet the time criteria required in ASTM D 6400-99, some of the manufacturers have achieved degradation rates of around 60 months. However, there is growing concern that the most common catalysts used may have toxicity issues due to their heavy metal content.

Biodegradable films are commonly referred to as *compostable* films in the industry as the conditions required for biodegradation are commercial compost conditions—relatively high heat, moisture and concentration of microorganisms. Biodegradable film products are typically polyester-based, however additional components include starch, polylactic acid and others. The concept behind biodegradable films is fairly simple. When the film is exposed to compost conditions, the microorganisms ingest the film as a food source and release carbon dioxide and water. Therefore, a compostable/biodegradable film must not harm the microorganism (toxicity), interrupt the composting process (time) or contaminate the water for animals or humans.

Biobased flexible film products utilize the highest level of annually-renewable raw materials as currently feasible for that type of product. Much as a "water-based" product is not 100% water, a biobased product does not need to be 100% derived from annually-renewable sources. Biobased also does not equate to biodegradability, although in many cases biobased products are also biodegradable.

Development of Value-Added Compostable Films

The most recent biodegradable/compostable flexible films to enter the market were designed by Cortec Corporation specifically to bridge the gap between performance and biodegradability. These new technologies offer strength properties up to 300% greater than even non-degradable polyethylene, but strictly adhere to domestic and international standards of compostability. This combination has allowed compostable films to enter both niche and commodity markets far greater than starch-polyester products ever had.

Cortec Advanced Films Division has recently introduced four families of products. All four film families offer the consumer performance and biodegradability as well as application-specific

benefits as described below. A key factor of the development was the ability to use these products on existing production, converting and packaging equipment.

The first product is a high performance polyester film that is 300% stronger than low-density polyethylene in terms of tensile, puncture and tear. Additionally, the unique film remains stable even at extremely high and low temperatures allowing the resultant film products to be used in cryogenic, frozen food and harsh industrial applications. With minor modification in temperature settings, it can be processed into bag-on-roll, in-line automated pouches and packages, laminates and fold-over commercial packs.

The second family builds on the polyester technology mentioned above by incorporating various amounts of polylactic acid, commonly referred to as PLA. The resultant PLA-polyester blend resembles high-density polyethylene, but with improved barrier and strength properties. PLA is derived solely from corn, so it is biodegradable *and* biobased. When PLA comprises at least 25% of the formulation, the finished product meets the standards of biobased plastic products proposed by the United States Department of Agriculture. In its pure form, PLA is a very rigid plastic suitable for clamshell containers, cups, cutlery and similar items. Using proprietary extrusion techniques, Cortec has pioneered the incorporation of PLA into flexible films. Where the biobased starch component in starch-polyester blend products *decreases* the strength and usability of the products, the biobased PLA component actually *improves* the strength and usability.

Again building on the previous two technologies, the third family incorporates performance enhancing, functional additives into both polyester and PLA-polyester films. The resultant products offer corrosion protection, static dissipation and barrier protection while in use, but convert into carbon dioxide and water within 45 days of commercial disposal. Corrosion inhibiting films are widely used in metal processing industries, while anti-static and electrostatic dissipative films are required for the shipping and storage of electronic hardware.

Finally, with additional processing the formulations above are combined with either a multi-layer extrusion technique or secondary coating operation. In either case, one or two sides of the film have cling properties. The cling properties can be adjusted to offer permanent non-destructive properties, as used in tapes and stretch film, or temporary cling as used in food wraps or release films. The high elasticity and strength of these formulations exceed those of non-degradable stretch and masking films.

Market Penetrability

As the above product descriptions show, biodegradable and compostable films are ideally suited for existing and newly created flexible film markets. Described below are some common applications

An agricultural customer wraps hay, straw, alfalfa and similar crops with stretch film for containment during transport and protection during storage. After evaluating the strength properties and usefulness of Cortec's compostable tensioning film as a replacement for their 160 gauge multi-layer stretch film, a 100 gauge film was selected and required only two wraps as opposed to three. The yield per roll was increased by 60% and the $1.25 per pallet disposal charge was eliminated entirely. Although the per pound cost of the compostable tensioning film was higher per pound, the customer realized a 10% reduction in overall cost.

An office building implemented a waste diversion program for all tenants on seven different floors and including a large cafeteria. The waste diversion program required organic materials

including food from the cafeteria, contaminated paper from the office sections and hot coffee grounds from break areas to be source separated. Cortec's polyester bags met all the required strength properties, including temperature and moisture stability, without needing to be removed at the processing facility as the bags biodegrade at the same rate as their contents.

A manufacturer of premium blankets and throws had previously used a poly-vinyl chloride zipper bag. For the introduction of a new fiber that was derived entirely from corn, the manufacturer selected the PLA-polyester version due to its corn content and rigidity. This film not only performed as needed, but added crucial marketing benefits. Customers apt to buy the blankets would certainly take notice of the sustainable packaging selected.

Automobile manufacturers are using parts suppliers from all over the world. These parts are manufactured and then preserved with oil to prevent corrosion. When the parts are received at the assembly plant, the rust preventative oil is removed and disposed of. By specifying the corrosion-inhibiting polyester film, the supplier need not use any preservative oil and the assembly plant simply removes the part from the biodegradable bag and installs the part. Not only is there a labor savings, but also the cost of oil, cost of cleaners and cost of disposal are eliminated completely.

A food manufacturer designed an outer box and inner pouch for a dry-goods food item. There are essentially three components in the finished design—the food, the pouch and the box. As is, two of the three components are already compostable. By converting the inner pouch to the PLA-polyester blend, the entire package is not only biodegradable, but biobased. Product rejects that are already packaged, can therefore be sent to a compost facility without manual sorting.

While there are countless other opportunities for biodegradable flexible packaging films, the above five show how diverse the application potential really is. Other films developed, including non-degradables, cannot offer the unique benefits of these new products.

Summary

There is a tremendous need for producers and consumers to decrease the quantity of flexible films sent to landfills or incinerators. Increased cost and strict regulatory guidelines have forced companies to frantically search for biodegradable and biobased packaging alternatives. Many degradable and biodegradable films have entered the market over the past 20 years, however these products failed to deliver either the performance while in use or the rapid biodegradation after disposal. While the market for these materials has grown substantially, it was only recently that the films offered both key properties. Consumers and producers can now comply with regulations at a lower cost without lowering the quality of their package.