Flexible Packaging: Innovations and Developments

Erin Hoppe
University of Wisconsin-Stout

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Abstract

Since the creation of flexible films, the packaging industry has been propelled to astonishing heights. Through the development and utilization of these films, manufacturing practices, and continual innovations, the field of packaging has been able to grow and evolve to adapt to the needs of products around the globe. Due to flexible film's many desirable characteristics, the implementation of various manufacturing methods and polymer additions provides the means to increase appeal to a broad spectrum of products. Flexible films have an illustrated history in packaging, and there are continually enhancements and improvements, as well as new products being marketed.

In this paper, the history, manufacture, and recent innovations of flexible films will be addressed, as well as the importance and impact flexible films has had on the packaging industry as a whole, and what the packaging future holds for flexible films.

INTRODUCTION

With the United States commanding $135 billion in the worldwide packaging industry (Flexible Packaging Association), the flexible packaging industry is the second largest sector of the business—with flexible packaging offering consumers extensive desirable characteristics, it is easy to see why. From ease of handling and storage, overall cost savings, and convenience, flexible packaging has cemented itself in the packaging world, and has undoubtedly been a key contributor to packaging's continued success.

The popularity of utilizing flexible packaging and films for packaging is largely based on the numerous technical developments that have been made in the field. Flexible packaging and film possess good barrier properties on their own, but with the aid of coatings, film types, and manufacturing methods, the positive attributes skyrocket.

HISTORY

While there are many polymers utilized in the flexible packaging industry, the most common are polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), polyethylene terephthalate (PET), and biaxially oriented polypropylene (BOPP) (Anyadike).

Polyvinyl Chloride (PVC)

Though initially created in 1872, PVC was not patented until 1913 by Friedrich Klatte. When PVC was plasticized in 1926, it was not long after that it began to widely gain popularity in packaging. With good cling and barrier properties, along with good heat-seal properties; PVC is often used in the manufacture of films for meats and produce as well as being a popular choice for blisterpacks. In recent years, PVC has received negative attention from environmentalists, and very little growth is expected in the future (Anyadike).

Polyethylene (PE)

In 1933, PE was discovered by E.W. Fawcett and R.O. Gibson at the British company Imperial Chemical Industries. After a reaction occurred between ethylene and benzaldehyde, the substance that was left behind ultimately became polyethylene (The History of Plastic). Polyethylene later progressed to become three variations of itself—high density polyethylene (HDPE), low density polyethylene (LDPE), and linear low density polyethylene (LLDPE). HDPE, LDPE, and LLDPE are used in flexible packaging applications due to their flexibility, good low-temperature performance, durability, high moisture-barrier, and ability to seal to itself without any coating. PE is by far the most used plastic film material that is used in flexible packaging, and its growth (in Europe) is around 1.5% a year (Anyadike).

Polyethylene Terephthalate (PET)

With 1941 came PET. At the Calico Printer's Association in Manchester, England, Rex Whinfield and James Dickson furthered research that had previously been done by Wallace Carothers (Bellis). PET possesses excellent high-temperature properties, high strength and clarity, and has high oxygen and carbon dioxide barrier properties. Often used for medical application pouches, boil-in-bag applications, meat, snack, and baked goods, PET is an important player in the field of flexible packaging.

Polypropylene (PP)

The 1950's brought forth the introduction of PP. Paul Hogan and Robert Banks, both of whom were working for Phillips Petroleum, were ultimately credited with the invention of PP (A Plastics Explosion-Polyethylene, Polypropylene, and Others). After finding that modification of their original catalyst of nickel oxide to include chromium oxide, the chromium produced a material—polypropylene. PP is commonly used in moisture-proof wrapping, fat-resistant films, and in the manufacture of medical packaging due to its low-moisture absorption, high chemical resistance, and low permeability to moisture.

MANUFACTURING PROCESSES

Just as there are many different types of film materials, there are various forms of manufacturing processes and technologies. Each having its own pros and cons, it is important to distinguish between them, and know the impact that they will ultimately have on the film. With every combination of resin type, and processing method, a unique set of characteristics will be produced.

Blown Film

Blown film manufacturing involves using a jet of air to blow the (melted) plastic polymer through a circular blown film die. The melted plastic then forms a continuous tube, which is inflated, flattened by rollers, and cut to length—resulting in double-thickness film. Blown film is one of two main processes that are used in the manufacture of film products since it is efficient (little polymer is needed to produce a lot of film) and used in a wide variety of applications.

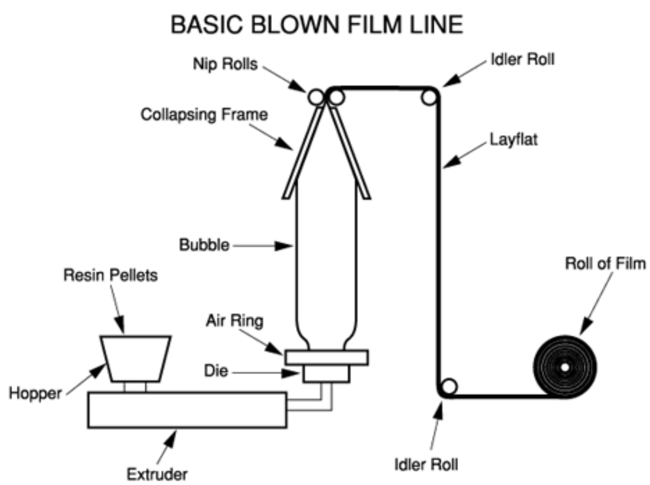


Figure 1. Blown Film Manufacturing Diagram
(PlasticsDome)

Cast Film

Cast film is manufactured by extruding the melted polymer through a flat die or slot—forming a thin sheet or film. After extrusion, it is attached to the surface of a chilled (rotating) roller so that it is cooled extremely fast. It is the surface of the rotating roller that gives cast film its characteristic smooth and clear appearance. While cast film can be produced at much higher line speeds, there is higher waste along with little orientation in the cross direction (Anyadike).

Coextrusion

Barrier packaging would not be what it is today had it not been for the discovery of the multilayer structure (MLS). Prior to the development of coextrusion technology, multilayer films were produced by laminating thin plastic layers together. While this process of lamination worked, it was found to be slow and not very efficient. Coextrusion involves combining two or more layers of melted plastic into a single extruded web (Anyadike).

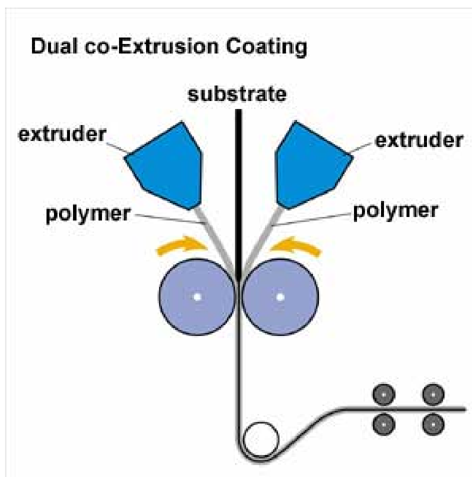


Figure 2. Coextrusion Manufacturing Diagram (PlasticsDome)

Coextrusion provides the unique opportunity to combine desired properties of various polymers to ultimately form one material that would otherwise be impossible to achieve by using a single polymer alone. Barrier packaging introduced additional benefits to the flexible packaging industry and since its premier in the packaging world; MLSs have been the catalyst for numerous innovations to come.

INNOVATIONS AND ADVANCEMENTS

Along with the continual development and demand for new, different, and desirable characteristics and properties of film types has come the creation of new polymers to fill these needs. From adding additional sought-after characteristics that some products demand, creating environmentally-friendly alternatives, or simply producing a film for consumer pleasure, the advancements that have been, and continue to be made in the field are numerous.

Metalized Films

One of the more popular innovations that has taken place in the recent past is the introduction of metalized films. With the application of a layer of aluminum to a polymer's surface, the finished product proves to be more resistant to both water and oxygen transmission as well as providing a metallic and glossy appearance—much like that of aluminum foil. The ability to provide some of the key properties possessed by aluminum foil, for a considerably lower cost and tare weight makes metalized films a popular choice in the food and confectionary fields.

Modified Atmosphere Packaging

Modified atmosphere packaging (MAP) can be credited with providing the food packaging industry with increased shelf-life of minimally-processed foods. By modifying the internal environment of the package, the natural deterioration of the product is slowed down—preserving its fresh state for a longer period of time. Since different products will have different reactions and respiration rates, different quantities in the package, and different ultimate storage temperatures, making sure that the MAP system correctly maintains an environment that will extend the shelf-life (as opposed to one that will enable faster spoilage) is a difficult task. Controlling the transmission rate of oxygen and carbon dioxide as well as the quantity of oxygen both inside and outside of the package is key in the success of a MAP system (Anyadike).

Table 1. Comparison of Products Packaged with Non-MAP vs. MAP
(Coextruded Plastic Technologies, Inc.)

Shelf-life Extension with MAP		
Numbers represent days of refrigerated shelf-life		
Product	**Non-MAP**	**MAP**
Fresh red meat (high O2)	2-3	6-10
Fresh red meat (low O2)	2-3	21
Fresh sausage	4-5	15-16
Fresh processed poultry	3-10	12-18
Cooked poultry	5-16	21-30
Cooked/cured meats	1	30-45
Cheese	7	180+
Fresh Pasta	3	60+

Through the development of MAP, consumers have access to food with an extended shelf-life, wider variety, increased visual appeal, and a reduction in many food-related health hazards.

Active Packaging

Along with the incorporation of additives into a flexible packaging film, active packaging also employs moisture absorbers, temperature control packaging, preservative releasers, oxygen-scavenging, and carbon dioxide absorbers. Used in the food industry, active packaging is able to both control and react to events that occur inside of the package (Anyadike). The main role of food packaging is to ultimately protect the food product from a variety of outside influences; light, water, oxygen, and microbial or chemical contamination. Through active packaging, it is possible to address, and even eliminate, many of these variables.

Edible and Soluble Films

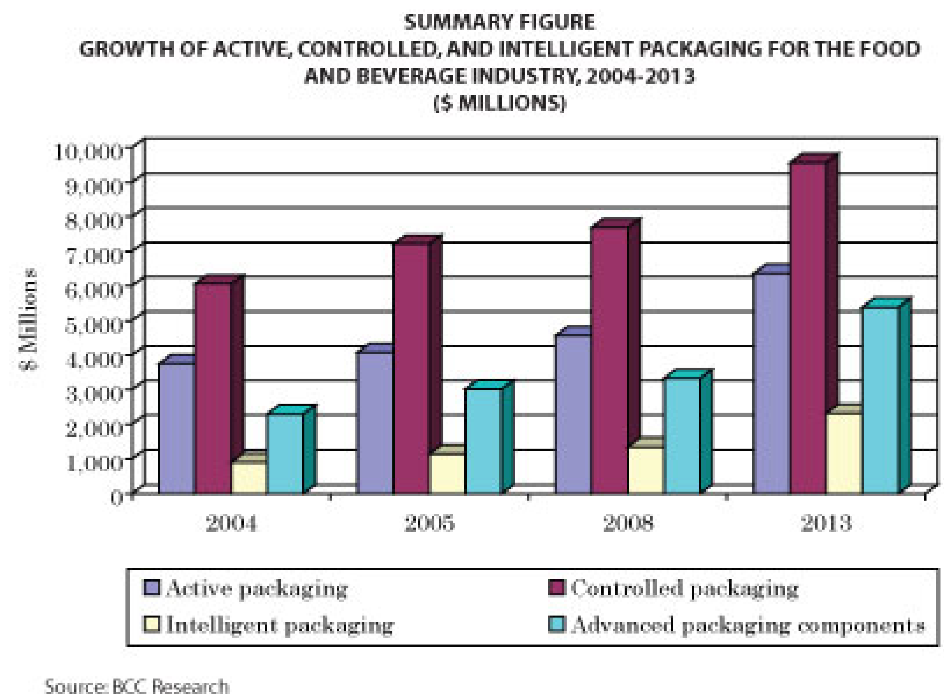
One of the more “trendy” advancements to fall under the active packaging category involves edible and soluble films. Combined with the continual demand for environmentally friendly materials and the ongoing trend of minimizing packaging materials, Pira predicts that the demand for edible and water-soluble films could increase over the next few years (Anyadike). Edible films and coatings enhance the quality of food products through extending their shelf live and improving food's safety by protecting them from threats such as chemical, biological, and physical deterioration (Han). While edible films have been produced using cellulose before, recently there have been advancements using whey proteins (a component of milk). Whey is able to provide advantages that cellulose was not; whey is able to be processed to make films that are either water-soluble or water-resistant, whey offers high oxygen and aroma barriers, and whey is glossy, transparant, and gives off no strong smell or taste (Incredible Edible Films). Whey's use as an edible/soluble film is continuing to be researched while improvements and developments continue to be made. Whether or not this is a sector of flexible packaging that will prove to be highly successful has yet to be determined.

Intelligent Packaging

Another example of emerging technology in the packaging industry is intelligent packaging. Intelligent packaging involves a 'smart' material that is capable of detecting a change in its environment through any combination of indicators, sensors, and processors. Upon the detection of a change, an automatic response takes place—resulting in neither the product, package, or consumer being compromised. In the flexible film field, there have been steps taken to create, continually develop, and implement intelligent packaging in films. While the polymers that are utilized in packaging applications are immune to attack by algae, bacteria, and fungi, microbial growth is still possible (Coles). Antimicrobial films that are capable of controlling the growth of microorganisims in food have recently been researched and developed due to higher demand for extended shelf life and food safety. Companies such as Mitsubishi and Maxwell Chase Technologies (Fresh-R-Pax) have made huge strides in developing films to help protect consumers against microbial threats (Anyadike). Currently, there are antimicrobial films using additives such as silver and naringanase (an enzyme-derived fungus (Anyadike)) in developmental stages.

Along with antimicrobial films, there has been research done on conductive polymers and the light-emitting properties they possess. With additional research and development, it could be possible for the film to produce advertisements or signal lights. In the year 2011, active and intelligent packaging demand in the United States alone is expected to exceed $1.1 billion (Nair).

Table 2. Past, Present, and Future Predictions for the Growth of Active, Controlled, and Intelligent Packaging for the Food and Beverage Industry
(LoPrinzi)



While it is an industry that is still relatively new, both active and intelligent packaging are providing the flexible film future with ideas and possibilities that could ultimately change the face of packaging.

FUTURE INNOVATIONS

Looking to the future of flexible films, there are already foreseen consumer and development trends as well as continuing innovations in the field. An ongoing trend in the packaging market is the development of materials which posses high-barrier properties. There is continuing research regarding biodegradable/compostable films (there have been launches of biodegradable films such as the bio-based film released by Alcan in early 2008) and the push to make them more widely available and utilized. A recent application of "food-grade flavor molecules" added to polymer structure has resulted in the development of a film that releases odors/aromas on the inside or outside of a package (Byrne). The flexible film industry has been the center of revolutionary developments and innovations, both of which will not cease anytime soon.

CONCLUSION

Commanding $25.6 billion in the United States (Flexible Packaging Association), the flexible packaging industry is the second largest packaging segment. From the start of the creation of popular modern polymers, to the manufacturing practices used to create plastic films, to the ongoing developments in the field, flexible films have been able to continually grow, expand, and provide packaging engineers with endless possibilities.

With the constant continual research and development surrounding flexible films, it is safe to assume that there will contine to be modifications to the existing materials as well as innovational additions to the already expansive flexible film field. It is through these innovations that we, as packaging engineers, are able to fulfill what we set out to do: protect, preserve, and present.

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