Current Technologies in Flexible Packaging

Michael L. Troedel, editor

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Foreword

The symposium on Current Technologies in Flexible Packaging was held in St. Charles, Illinois, on 1 Nov. 1984. The event was jointly sponsored by ASTM, through its Committee F-2 on Flexible Barrier Materials, and the Flexible Packaging Association. Michael L. Troedel, General Mills, Inc., presided as chairman of the symposium and also served as editor of this publication.

Related ASTM Publications

Child-Resistant Packaging, STP 609 (1976), 04-609000-11

Adhesion Measurement of Thin Films, Thick Films, and Bulk Coatings, STP 640 (1978), 04-640000-25

Wear Tests for Plastics: Selection and Use, STP 701 (1980), 04-701000-19

Physical Testing of Plastics, STP 736 (1981), 04-736000-19

A Note of Appreciation to Reviewers

The quality of the papers that appear in this publication reflects not only the obvious efforts of the authors but also the unheralded, though essential, work of the reviewers. On behalf of ASTM we acknowledge with appreciation their dedication to high professional standards and their sacrifice of time and effort.

ASTM Committee on Publications

Overview

The symposium on Current Technologies in Flexible Packaging was sponsored by ASTM Committee F-2 on Flexible Barrier Materials and the Flexible Packaging Association. The nine papers in this volume, which were presented at that symposium, review emerging technologies in the flexible packaging industry. The topics include aseptic packaging, test method development, emerging markets for metallized films, new high-barrier film applications, and coextrusion technology.

The paper by *Skodis* discusses the advantages of metallized films, which provide a wide range of options for innovation, consumer appeal, service, and cost savings for the converter and packaging material user.

Samuels stresses that Saran polymers, polyvinylidene chloride (PVDC)/vinyl chloride copolymers, are known for excellent barrier characteristics against both water vapor and oxygen permeation. His paper covers the development of a new high-barrier PVDC copolymer film for lamination use.

Rohn evaluates the benefits of polycarbonate resin as a structural layer in high-barrier coextrusions for flexible packaging. High-temperature performance requirements are examined for hot-fill, retort, autoclave, and ovenable packaging; coextrudable barrier resins and tie layer resins are evaluated; and the benefits of low- and high-moisture barriers are compared in composites.

Stefanovic and Dickerson discuss the removal of hydrogen peroxide from flat packaging material used in aseptic packaging of food. The critical variables are the effective temperature of the drying air, the temperature of the sterilant, and the residence time in the drying zone.

The paper by *Wang and Toledo* addresses inactivation of microorganisms on polyethylene exposed to hydrogen peroxide in air. They state that air saturated with hydrogen peroxide vapor in equilibrium with 35% aqueous hydrogen peroxide solution possesses sporicidal properties suitable for use as a sterilant in aseptic packaging systems.

Baner et al evaluate two test methods developed which provide quantitative and reliable values for the rate of diffusion of organic vapors through polymer membranes.

Richmond and Harte contend that high-performance liquid chromatography (HPLC) is a powerful analytical tool which has application to flexible packaging materials. They state that the technique can be used for qualitative and quantitative evaluation of material components and processing variations, and for physical characterization.

Dunn's paper presents the fundamentals of differential scanning calorimetry (DSC), with particular emphasis on polymer systems used in flexible packaging. The use of DSC techniques to distinguish film properties from the properties of base polymers is also described.

Caimi and Fries describe flexible packaging converters using EPA-complying adhesives in aqueous and 100% solid forms. Aqueous grades are applied with the same direct gravure coating stations used for solvent-borne systems; 100% solid types are applied by offset gravure.

This volume covers a wide range of topics in the area of flexible packaging. It was not intended to be totally comprehensive. It does, however, address major emerging technologies in flexible packaging, as presented by some of the most authoritative investigators in this field.

Michael L. Troedel

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Contents

Lawrence C. Skodis[1]

Merits of Metallized Film Constructions

REFERENCE: Skodis, L. C., **"Merits of Metallized Film Constructions,"** *Current Technologies in Flexible Packaging, ASTM STP 912*, M. L. Troedel, Ed., American Society for Testing and Materials, Philadelphia, 1986, pp. 1-5.

ABSTRACT: This paper discusses the advantages of metallized films, which provide a wide range of options for innovation and consumer appeal and service, along with cost savings, for the alert converter and packaging material user. The vacuum metallizing process is described, uses of metallized films are discussed, and comparisons are made between metallized films and other packaging materials.

KEY WORDS: packaging, flexible packaging, metallized films, vacuum metallizing technology

For converters and end users, metallized films have become not only an attractive but a viable material option. These products have graduated from appeal as essentially "pretty faces" to commercially advantageous functional ingredients in various constructions. Widely utilized in the packaging industry, an assortment of metallized film applications is also increasingly found in such functional applications as insulation, photographic and photocopying processing, electrical conductivity techniques, solar control, aerospace, and a growing list of other uses.

These applications join the essentially decoratively oriented uses that led the way for metallized films—wallcoverings, hot stamping foils, automotive trim, decals and labels, fashion yarns, and others. And these uses, too, are expected to grow as new products and new markets develop.

Packaging, however, continues to be the largest and most rapidly expanding application employing metallized films as a functional component. Food, drug, cosmetic, and industrial packagers are building in the moisture, oxygen, and light barriers that metallization offers to protect their products at an

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increasing rate, while gaining unique aesthetic appeal at the consumer point-of-purchase level. And among these barriers, metallized films in flexible packaging have become the most prevalent.

When evaluating any packaging structure, material, or system, one must remember that the packaging of products involves several manufacturing steps. Collectively, these steps produce a durable, attractive package that suitably protects its product until purchase and use.

The story begins with polymer chemistry laboratories and the producer of the base films. The film first goes to a metallizer where, by means of sophisticated vacuum deposition techniques, a precisely controlled amount of metal is plated onto the surface of the film. Next, at the converter level, follows the printing and combining or laminating of the metallized film with other films, producing the final construction which, in turn, is provided to the packager user. At this stage, the film laminate or composite undergoes forming, filling, and sealing to produce the final package.

Any change in the base film, therefore, produces effects all along the line. Until recently, the base film for metallizing was almost invariably polyester. Biaxially oriented nylon came along, and now biaxially oriented polypropylene and low-density polyethylene. And all this has happened in a relatively short time.

Vacuum Metallizing Technology

Vacuum metallizing equipment has been undergoing constant change and improvement in the last few years as the technology has advanced and the industry itself has been moving from decorative to functional grades, where the uniformity and thickness of the metallic layer are important factors in the performance—as well as appearance—of the end product.

In the vacuum metallizing process, the metal to be volatilized is heated to a temperature at which substantial evaporation occurs. For aluminum, this is about 1200 to 1250°C. The vapor condenses on the surface of the substrate web as it passes directly over the crucibles containing the molten metal. Because the most commonly used metals and their vapors are highly reactive and oxidize rapidly in the atmosphere, the metallizing process must be carried out in the absence of air, that is, under vacuum. The metal evaporation is a surface phenomenon and not a boiling operation, which thus reduces any mechanical transfer or spattering of the metal. The metallic films produced by this process are much thinner and have fewer pinholes than the lightest metal foils. In layman's terms, we are talking about one millionth of an inch deposition, or less than 1% of the weight of aluminum foil.

Metallized Film Versus Foil

Until recently, metallized films had not replaced foil at all but had replaced Saran-coated oriented polypropylene (OPP). The advantages were numerous.

The appearance was great; the barrier was far superior to that of the clear films; the light screening characteristics were desirable in reducing rancidity; and the antistatic properties improved the percentage of good packages coming off the machine and eliminated dust pickup on the shelves. The packaging uses and lamination construction of metallized films are shown in Tables 1 and 2.

Although a great deal of metallized film was being used, it was not until two years ago that the first significant foil was replaced. At that time, a converter proposed to a potato chip manufacturer that, although the savings on materials (metallized versus foil) were small (1.5%), the reduced waste would make significant differences in the overall costs of putting packages on the market. The machine performance tests were run, and the results of 12.5% material savings were proven. The chipper then started shelf life tests. Because the improvement in appearance after shipping was evident, the sales department was eager to change to metallized packages for the product.

The barrier properties of the two packages—OPP/polyethylene/foil/polyethylene and OPP/polyethylene/metallized OPP—were averaged to be somewhat the same coming off the machine. However, there was a difference when both the average and the range were compared after shipping. Some foil packages were successful [moisture vapor transmission rate (MVTR) 0.05]; others were not (MVTR, 3). The difference was the degree of abuse in transportation.

For instance, paper/polyethylene/foil/polyethylene has an MVTR of 0.005 flat and 0.2 after 50 Gelbo flexes. Paper/metallized OPP has an MVTR of 0.11 flat and 0.14 after the same 50 flexes. Similarly, oxygen transmission goes from 0.02 to 380 for foil and from 3 to only 20 for the metallized films.

TABLE 1—*Metallized film use for packaging by structure.*

Structure	Usage, lb[a]	Approximate Cost, ¢/1000 in.^{2} [b]	Major Uses
Lacquer/ink/aluminum polyester (PET)/polyethylene (PI)	7 400 000	20 to 25	snacks, coffee, candy, nuts, cookies
Lacquer/ink/aluminum nylon/PE	3 900 000	20 to 25	coffee
OPP/ink/aluminum OPP/heat seal	3 200 000	18 to 22	snacks
PE/aluminum/PET/PE	2 100 000	14 to 18	bag-in-box
Ink/aluminum/PET/Saran-coated polypropylene	1 100 000	24 to 16	candy bar
PE/ink/aluminum/PE	1 600 000	40 to 45	hosiery
Other	1 100 000	14 to 20	...
Total pounds	20 400 000		

[a]To convert from pounds to kilograms, multiply by 0.4536.
[b]1000 in.^{2} = 6451.6 cm^2.

TABLE 2—*Construction of metallized structures for various end uses.*

End Uses	Lamination Construction
Coffee	48-gage metallized biaxially oriented nylon (BON) (nylon)/ 2-mil low-density (LDPE) polyethylene
Snacks (chips)	75-gage OPP/90-gage metallized OPP (polypropylene)
Condiments	48-gage metallized PET (polyester)/1½-mil MDPE
Wine pouch (bag-in-box)	2-mil surlyn/48-gage metallized PET/3-mil EVA
Cookies	cellophane/metallized 90-gage OPP or OPP/metallized 90-gage OPP
Candy	cellophane/metallized 90-gage OPP
Gelatin mix	60-gage metallized BON/3-mil Sclair
Lidding stock	142-gage metallized PET/heat seal coating
Pancake mix	48-gage metallized BON/3-mil high-density polyethylene (HDPE)
Medical wrap	No. 26 Coated one side paper/90-gage metallized OPP/surlyn
Food coloring pills	white top coat/metallized 90-gage OPP
Weiner wrap/cold cuts	125-gage metallized LDPE/2-mil LDPE or metallized PET/PE
Agricultural products (bags)	No. 25 sulfite paper/metallized LDPE

The foil packages with the most cost-effective performances are those that do not get a great deal of handling or abuse in the manufacturing or distribution cycles. One such package using foil is one for soup mixes. Here, the package is made on equipment that gently puts a single bottom fold in the lamination and then seals the three or four sides of the pouch. The product is shipped in a snug box, so that there is relatively little flexing of the package.

On the other hand, foil is not as well suited to potato chip packages. These are made by forming a cylinder from a flat sheet and pulling and stretching the web over a tortuous forming collar. Foil does not fare well. The results are fractures, tear-offs, and a high degree of waste. Also, a poor looking package is delivered off of the machine. The package must then go through the distribution cycle. A potato chip package is not packed tightly into a carton; instead, it is tossed in loosely. Therefore, the foil has a tendency to fracture, which seriously reduces the barrier characteristics on many of the packages. The bag also takes on permanent dents (because of good deadfold), and so the package becomes shopworn well before its time.

Foil is still economical in the proper packages, and it will continue to play a vital role. But it should be pointed out that foil is a highly energy-intensive product, both in refining and in rolling.

As foil costs increase, new metallized films will compete, even in those applications in which foil has been the traditional choice. New base films will be developed for those applications.

The choice between foil and a metallized film depends on the package type and the product. Currently, bag-type constructions tend to favor metallized materials, while pouches most often are made of foil.

Jack E. Samuels[1]

High-Barrier Flexible Polyvinylidene Chloride Composite Applications

REFERENCE: Samuels, J. E., **"High-Barrier Flexible Polyvinylidene Chloride Composite Applications,"** *Current Technologies in Flexible Packaging, ASTM STP 912*, M. L. Troedel, Ed., American Society for Testing and Materials, Philadelphia, 1986, pp. 6–12.

ABSTRACT: Saran polymers, polyvinylidene chloride (PVDC)/vinyl chloride copolymers, have long been known for excellent barrier characteristics against both water vapor and oxygen permeation.

This paper covers the development of a new high-barrier PVDC copolymer film (HBPVDC) for lamination use. The film is about ten times more resistant to oxygen transmission and about five times better a barrier to moisture passage than regular Saran film.

Laminations including HBPVDC films as the barrier ply offer a transparent alternative to foil and metallized structures. In addition, HBPVDC laminations have excellent flex performance characteristics while maintaining barrier properties.

Structures can be designed for cooking foods in a microwave oven or in retort pouches. Food packages in HBPVDC laminates may also be used in conjunction with metal detectors for tramp metal detection.

Applications of high-barrier laminates include snack food, drug, and pharmaceutical packaging; retort pouches for food and medical packaging; and bag-in-box packaging for liquids and industrial uses.

KEY WORDS: flexible packaging, adhesives, bags, barriers, barrier properties, copolymers, laminates, medical packaging, metallized packaging, pharmaceutical packaging, plastic film, polyurethane, polyvinylidene chloride, retort pouches, seals, shrink-stabilized packaging, package sterilization

The requirement for high-barrier flexible packaging materials for food, drug, pharmaceutical, and medical packaging can be met with a wide array of composite laminate materials, including aluminum foil, metallized films, and transparent plastic barrier films. Saran polymers, chemically known as polyvinylidene chloride (PVDC) vinyl chloride copolymers, have long been

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