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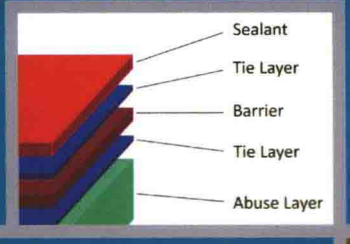
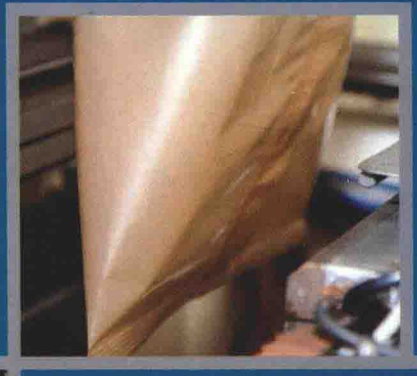
The Science and Technology of Flexible Packaging

Multilayer Films from Resin and Process to End Use





Barry A. Morris

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THE SCIENCE AND TECHNOLOGY OF FLEXIBLE PACKAGING

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Preface

There are many handbooks available that describe plastics and equipment to make multilayer film. While these books provide a good list of what is possible, they often fail to provide the reader the fundamental understanding of why one material is favored over another for a particular application, or how the film or coating process affects the properties. Also, these books do not cover how the product being packaged and the end use affect the film properties.

Similarly, there are handbooks on packaging technology that provide details on the mechanical aspects of packaging equipment and outline film structures currently in use (at least at the time the book was published). These books fail to explain the principles behind packaging equipment from a unit operation's perspective (sealing, thermoforming, and so on). Nor do they give the reader a fundamental understanding of how to design a packaging structure.

There are also a few textbooks that provide an academic analysis of polymer processes. These are typically written at a level beyond the reach or desire of most packaging engineers.

My goal is to create a book that brings the science to the practitioner in a concise and impactful way, bridging the gap between standard handbooks and academic treatises. Using scientific principles, I explore (and debunk) some of the myths that have persisted in our industry. While discussing key challenges in the packaging industry, I provide a critical review of the scientific literature as well as practical explanations and tips on how to deal with the challenge. Too often packaging engineers fail to seek out the scientific literature. One benefit of this book is easy access to this literature, summarized in a meaningful way. Finally, the book provides insight into why things are done the way they are, which makes the work evergreen: the same principles can be applied to new packaging applications with new materials that are sure to come along in the future.

This book is organized into seven parts and two appendices:

1. Introduction
2. Basic processes
3. Material basics
4. Film properties
5. Effect of converting processes on properties
6. End-use considerations
7. Structure Design and Modeling

Appendix A: Writing Guide for Packaging Films and Other Multilayer Structures

Appendix B: Examples of Flexible Packaging Film Structures

The introduction provides a brief history of packaging and its benefits to society. It describes the basic functions of packaging, the packaging value chain, and what is important for each player in the value chain. It also introduces the need for multilayer films to provide the needs along the value chain in the most cost-effective manner.

Part 2 briefly describes the processes involved in the manufacture and use of multilayer films for packaging. Basic differences between technologies and why one may be favored over another for a given application are highlighted. Key unit operations and processing variables are introduced that affect properties, which are described in more detail in subsequent chapters.

Part 3 introduces resins and substrates commonly used in flexible packaging, highlighting important properties, applications, and regulatory issues. Chapters on melt rheology and polymer blending round out the basics.

Part 4 begins the heart of the book, providing detailed descriptions and analysis of the key properties of packaging films from an engineering and

scientific perspective. Drawing from personal knowledge/experiments and the scientific and patent literature, the current state of knowledge around these properties is distilled. Each chapter begins with why the property under discussion is important, how to measure it and typical values. This is followed by a discussion of the science behind how materials influence these properties. Subjects include heat sealing, barrier, physical strength, abuse resistance, adhesion, optical properties, frictional properties, shrinkage, and thermoforming.

Properties of packaging films cannot be thought of in isolation of the process used to make them. Part 5 explores the effect processing has on film properties in tandem with material properties. Three chapters comprise Part 5, the first of which explores the effect of the process on film quality. Flow instabilities and other topics that affect material selection are covered. The second chapter provides examples of how the process directly affects film properties through changes in quench rate and orientation. The final chapter looks at the effect of processing on interlayer adhesion.

How the flexible film is ultimately used—the environment it is subjected to, types of products being packaged—can influence film properties and design. Part 6 discusses the effect of the end-use environment (temperature, humidity, pressure, and irradiation), packaging–product interactions, and aging on package performance. The cost of the package is a predominant factor in any package design. Here both financial costs (film raw material and converting costs, packing line productivity, and waste due to package failure) and environmental costs are considered.

The final section brings together the ideas introduced in earlier parts into a concluding section on structure design. Principles of design, analytical methods to determine what structures are currently in use and modeling approaches are covered.

There are also two important appendices. The first is a system for writing multilayer structures, authored by my longtime colleague at DuPont, Scott Marks. His system provides a coherent method for communicating package design throughout the industry which is used in this book. The second provides some typical packaging structures that have been in use for various applications over the years. The intention is only to provide some examples and not an exhaustive, or even current, list of structures.

Taking on a project like this is a huge endeavor. I have many people to thank, too many to name individually. I want to acknowledge my friends and colleagues at DuPont who have taught me so much over the years about flexible packaging and where most of my knowledge has come from. My longtime association with the Society of Plastics Engineers and TAPPI has also enriched my understanding of polymer processing and film properties.

Finally I would like to thank my family, Kathy, Elizabeth, and Sara, for their encouragement and for putting up with my long hours of writing and editing.

Barry A. Morris
August 10, 2016

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