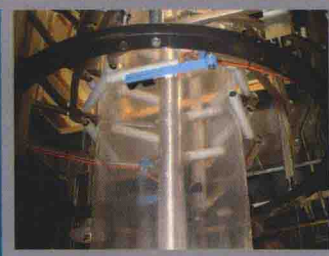
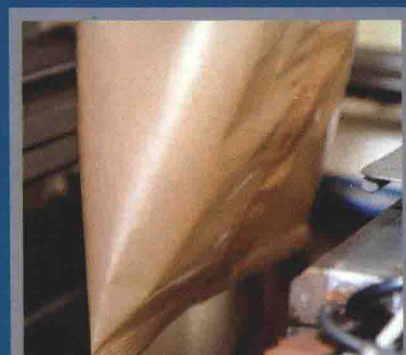


The Science and Technology of Flexible Packaging

Multilayer Films from Resin and Process to End Use



Barry A. Morris

THE SCIENCE AND TECHNOLOGY OF FLEXIBLE PACKAGING

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to End Use

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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

Contents

Preface	xv
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PART I Why Multilayer Films?

1 Introduction	3
1.1 History of Packaging	3
1.2 Benefits of Packaging	7
1.3 Consumption Patterns	9
1.4 Packaging Value Chain	11
1.5 Needs Along the Value Chain	13
1.5.1 Consumer Needs	13
1.5.2 End-User Needs	13
1.5.3 Converter Needs	14
1.6 Assembling a Package: Benefits of Multiple Layers	15
1.7 Packaging Trends in the Context of the Value Chain	18
References	19

PART II Basic Processes

2 Converting Processes	25
2.1 Extrusion	25
2.2 Film Converting	29
2.2.1 Blown Film	29
2.2.2 Cast Film	36
2.3 Coating and Lamination	40
2.3.1 Extrusion Coating and Lamination	40
2.3.2 Adhesive Lamination	42
2.4 Orientation	44
2.4.1 Tenter Frame	45
2.4.2 Double Bubble	45
2.4.3 Machine Direction Orientation	46
2.5 Printing	46
2.5.1 Gravure Printing	46
2.5.2 Flexographic Printing	47
References	47
3 Packaging Equipment	51
3.1 Brief Description of Packaging Equipment	51
3.1.1 Pouch Machines	51
3.1.2 Horizontal Thermoform Fill Seal	53

3.1.3	Tray Sealer	54
3.1.4	Aseptic Packaging	54
3.1.5	Retail Packaging	54
3.2	Unit Operations	56
3.2.1	Registration	57
3.2.2	Thermoforming	58
3.2.3	Filling	58
3.2.4	Gas Flush/Modified Atmosphere Packaging	59
3.2.5	Heat Sealing	60
	References	65

PART III Material Basics

4	Commonly Used Resins and Substrates in Flexible Packaging	69
4.1	Resin and Substrate Function	69
4.2	Commonly Used Resins in Flexible Packaging	72
4.2.1	Polymer Chemistry as It Relates to Packaging Performance	72
4.2.2	Polyethylene	78
4.2.3	Polypropylene	84
4.2.4	Specialty Polyolefins	85
4.2.5	Polyamides	86
4.2.6	Polyvinyl Alcohol	87
4.2.7	Ethylene Vinyl Alcohol	87
4.2.8	Polyvinylidene Chloride	88
4.2.9	Polychlorotrifluoroethylene	89
4.2.10	Tie Resins and Adhesives	89
4.2.11	Polyester	89
4.2.12	Polystyrene	91
4.2.13	Polyvinyl Chloride	91
4.2.14	Biobased Polymers	91
4.2.15	Additives	94
4.3	Commonly Used Substrates in Flexible Packaging	104
4.3.1	Oriented Polypropylene	104
4.3.2	Aluminum Foil	104
4.3.3	Oriented Polyester	105
4.3.4	Metallized Film	105
4.3.5	Cellophane	106
4.3.6	Paper and Paperboard	106
4.4	Material Specifications	108
4.5	Regulatory Considerations	110
4.5.1	Food Packaging Regulatory Compliance in the United States	111
4.5.2	Food Packaging Regulatory Compliance in the European Union	112
4.5.3	Health-Care Packaging	113
	References	113
5	Rheology of Polymer Melts	121
5.1	Basic Terms	121
5.2	Importance of Rheology in Flexible Packaging	123

5.2.1	Extrusion and Film Fabrication	124
5.2.2	End Use	130
5.2.3	Polymer Characterization	130
5.3	Rheological Measurements	131
5.3.1	Melt Index or Melt Flow Rate	131
5.3.2	Solution Viscosity	132
5.3.3	Capillary Melt Shear Viscometry	133
5.3.4	Cone and Plate Viscometry	135
5.3.5	Dynamic Rheology Measurements	135
5.3.6	Extensional Measurements	136
5.4	Factors Influencing Polymer Rheology	138
5.4.1	Strain and Rate of Strain	138
5.4.2	Temperature	138
5.4.3	Pressure	139
5.4.4	Time	139
5.4.5	Molecular Factors	139
5.5	Relaxation, Creep, and Constitutive Equations	141
5.5.1	Stress Relaxation	141
5.5.2	Creep/Recovery	142
	Further Reading	144
	References	144
6	Polymer Blending for Packaging Applications	149
6.1	Introduction	149
6.2	Why Blend?	149
6.3	Blending Processes	150
6.3.1	Pellet Premixing	151
6.3.2	Melt Blending	152
6.4	Physics of Blending	155
6.4.1	Thermodynamics	157
6.4.2	Morphology Development in Immiscible Blends	160
6.5	Morphology Development in Blown Film	169
6.6	Dispersion of Rigid Particles and Nanocomposites	169
6.7	Rheology of Polymer Blends	171
6.8	Conclusion	172
	References	173
PART IV Film Properties		
7	Heat Seal	181
7.1	Why It Is Important	181
7.2	How to Measure	182
7.2.1	Seal Strength of Packages: The Peel Test	182
7.2.2	Laboratory Heat Seal Tests	183
7.2.3	Laboratory Hot Tack Measurement	184
7.2.4	Relating Lab Results to Packaging Line Studies	188
7.3	Typical Values	188
7.3.1	Heat Seal Curves	188
7.3.2	Hot Tack Curves	190

7.4	Factors That Influence Heat Seal Performance.....	191
7.4.1	Heat Seal Operation.....	191
7.4.2	Film Fabrication and Package Design.....	193
7.5	Science of Heat Sealing.....	198
7.5.1	Early Theories of Auto Adhesion.....	199
7.5.2	Bonding at the Interface	200
7.5.3	Diffusion at the Interface.....	200
7.5.4	Interfacial Bond Strength and Crystallization.....	205
7.5.5	Hot Tack.....	207
7.5.6	Fracture Mechanics.....	210
7.6	Modeling Heat Seal and Hot Tack	212
7.6.1	Heat Seal.....	212
7.6.2	Hot Tack.....	216
7.6.3	Squeeze Flow	219
7.7	Easy-Open Seal Technology.....	230
7.7.1	Introduction.....	230
7.7.2	Examples.....	231
7.7.3	PB-1 Blends	232
7.7.4	Lidding Films.....	235
7.8	Reclosable Seal Technologies	238
7.9	Ultrasonic Sealing.....	239
7.10	Failure Analysis and Troubleshooting.....	242
7.10.1	Types of Seal Failures.....	242
7.10.2	Common Causes of Failure	242
7.10.3	Analytical Techniques.....	247
7.10.4	Troubleshooting Checklist.....	247
7.11	Selecting Sealant Resins.....	248
	References.....	253
8	Barrier.....	259
8.1	Why It Is Important	259
8.2	How to Measure.....	261
8.2.1	Definitions.....	261
8.2.2	Gas Permeation	266
8.2.3	Moisture Vapor Transmission Rate	268
8.2.4	Permeation of Organic Molecules	269
8.3	Typical Permeation Values	269
8.3.1	Gas Barrier	269
8.3.2	Moisture Vapor Barrier	272
8.3.3	Grease and Oil Resistance	274
8.3.4	Organic Molecules.....	277
8.3.5	Chemical Resistance	278
8.3.6	Light Barrier	278
8.4	Science of Permeation	278
8.4.1	Permeation Through Polymer Films	278
8.4.1.1	Permeation Through Multilayer Films.....	280
8.4.1.2	Factors that Affect Permeability Through Polymer Films.....	281

8.4.2	Permeation Through Defects, Pinholes, and Perforations	290
8.4.2.1	Permeation Through Pinholes: High Barrier Packaging.....	290
8.4.2.2	Permeation Through Perforations or Channels	292
8.5	Emerging Technologies	293
8.5.1	Oxygen Scavenging	293
8.5.2	Layer Multiplication	294
8.5.3	Nanocomposites	297
8.5.4	Advanced Coatings	299
	References.....	300
9	Strength, Stiffness, and Abuse Resistance	309
9.1	Why It is Important	309
9.1.1	Strength	309
9.1.2	Stiffness	309
9.1.3	Abuse Resistance	310
9.2	How to Measure.....	311
9.2.1	Mechanical Properties.....	311
9.2.2	Stiffness.....	313
9.2.3	Tear Strength.....	314
9.2.4	Puncture and Impact Resistance.....	315
9.2.5	Scratch and Abrasion Resistance	316
9.2.6	Flex Fatigue	317
9.2.7	Shipping Tests for Package Durability.....	317
9.3	Typical Values.....	318
9.4	Engineering Principles for Multilayer Films.....	318
9.4.1	Mechanical Properties.....	318
9.4.2	Bending Stiffness	323
9.4.3	Puncture, Scratch, and Abrasion Resistance	327
9.4.3.1	Puncture Resistance of Polyethylene Films	327
9.4.3.2	Puncture Resistance of Laminates.....	328
9.4.3.3	Scratch Resistance	332
9.4.3.4	Abrasion Resistance.....	334
9.4.4	Tear Resistance	335
9.4.4.1	Polyethylene Films	336
9.4.4.2	Directional Tear Technology	340
9.4.4.3	Multilayer Films	342
9.4.5	Essential Work of Fracture	343
9.4.6	Microlayer Technology.....	344
	References.....	345
10	Adhesion	351
10.1	Why Adhesion is Important.....	351
10.2	How to Measure Adhesion	352
10.2.1	Peel Test.....	352
10.2.2	Adhesion of Coatings	354
10.2.3	Fracture Mechanics Analysis of Peel Test	354

10.3	Fundamentals	360
10.3.1	Thermodynamics of Adhesion.....	361
10.3.1.1	Surface and Interfacial Tension.....	361
10.3.1.2	Wetting and Work of Adhesion.....	363
10.3.1.3	Practical Guidelines	363
10.3.2	Mechanical Interlocking	365
10.3.3	Diffusion	366
10.3.4	Chemical Interaction.....	367
10.3.5	Boundary Layer	370
10.4	Tie Resin Technology	371
10.4.1	Extrusion Coating and Lamination.....	371
10.4.1.1	Substrate.....	371
10.4.1.2	Polymer	373
10.4.1.3	Examples From the Literature.....	374
10.4.1.4	Choosing a Coating Adhesive Resin	375
10.4.2	Coextrudable Adhesives	378
10.4.2.1	Coextrudable Tie Resin Technology	378
10.4.2.2	Factors Affecting Peel Strength in Coextrusion.....	380
10.4.2.3	Choosing a Coextrudable Tie Resin.....	392
	References.....	396
11	Thermoforming, Orientation, and Shrink.....	401
11.1	Thermoforming	401
11.1.1	Thermoforming Part Testing	401
11.1.2	Material Properties and Testing.....	402
11.1.3	Factors that Affect Thermoforming.....	405
11.1.3.1	Material Parameters	405
11.1.3.2	Film Structure	405
11.1.3.3	Film Temperature.....	406
11.1.3.4	Processing Parameters	409
11.1.3.5	Interlayer Adhesion After Forming	410
11.1.4	Modeling	410
11.2	Orientation and Shrink.....	411
11.2.1	Why It Is Important	412
11.2.2	How to Measure.....	413
11.2.2.1	Orientation	413
11.2.2.2	Shrink and Shrink Force.....	413
11.2.3	Factors that Affect Orientation and Shrink	415
11.2.3.1	Polymer Characteristics	415
11.2.3.2	Processing	416
11.2.4	Oriented Multilayer Films	420
11.2.4.1	Laminations.....	420
11.2.4.2	Base Films.....	420
11.2.4.3	Multilayer Barrier Shrink Film and Bags	420
11.2.4.4	Multilayer Nonshrink Barrier Films.....	421
11.2.4.5	Shrink Films and Labels.....	424
11.2.4.6	Stretch and Cling Films	426
11.2.4.7	Adhesion	428
	References.....	429

12 Frictional and Optical Properties.....	435
12.1 Frictional Properties.....	435
12.1.1 Why Frictional Properties Are Important	435
12.1.2 How It Is Measured	436
12.1.2.1 Coefficient of Friction	436
12.1.2.2 Blocking	437
12.1.3 Additive Technology.....	437
12.1.3.1 Why Friction Arises and How Additives Work	437
12.1.3.2 Migrating Additives	439
12.1.3.3 Nonmigrating Additives (Slip and Antiblock)	440
12.1.4 Migratory Slip Additive Performance Factors	441
12.1.4.1 Polymer Surface.....	441
12.1.4.2 Migration of Slip Additives	442
12.1.4.3 Amide Structure	446
12.1.4.4 Film Fabrication.....	447
12.1.4.5 Film Thickness and Additive Level	447
12.1.4.6 Storage Temperature	449
12.1.4.7 Effect of Other Additives	449
12.1.4.8 Coextrusion and Multilayer Structures.....	450
12.1.4.9 Problems With Too Much Slip	451
12.1.4.10 Tips and Classic References	452
12.2 Optical Properties	453
12.2.1 Definitions and Measurement	453
12.2.2 Haze and Transparency.....	454
12.2.2.1 Monolayer Polyethylene Film	454
12.2.2.2 Coextrusion	455
12.2.2.3 Other Factors.....	456
12.2.3 Gloss.....	458
12.2.4 Specialty Microlayer Films	458
References.....	458

PART V Effect of the Converting Process on Properties

13 Effect of Processing on Quality	465
13.1 Thermal Stability	465
13.2 Die Drool	467
13.3 Moisture-Related Issues.....	470
13.4 Flow Maldistribution and Instability Issues	470
13.4.1 Sharkskin and Extrudate Distortion	470
13.4.2 Draw Down Instabilities in Extrusion Coating/Lamination and Cast Film	472
13.4.3 Bubble Instability in Blown Film.....	479
13.4.4 Layer Rearrangement in Coextrusion.....	483
13.4.5 Interfacial Instabilities	486
13.5 Curl.....	494
13.5.1 Causes	494
13.5.2 Strategies for Reducing Curl	497
13.5.3 Modeling	502
References.....	508
Appendix: Two-Layer Curl Model.....	513

14 Effect of Process on Properties.....	515
14.1 Stress—Strain History in Blown Film.....	515
14.1.1 Monolayer Blown Film.....	516
14.1.2 Coextrusion Blown Film.....	519
14.2 Air- Versus Water-Quench Blown Film	525
14.3 Development of Blend Morphology in Blown Film.....	530
14.3.1 Material Characteristics.....	532
14.3.2 Processing Factors	533
References.....	534
15 Effect of Processing on Interlayer Adhesion.....	539
15.1 Adhesion to Substrates in Extrusion Coating	539
15.1.1 Extruder and Die.....	539
15.1.2 Air Gap.....	540
15.1.2.1 Oxidation.....	542
15.1.2.2 Stress and Orientation.....	554
15.1.2.3 Cooling.....	559
15.1.2.4 General Guidelines	565
15.1.3 Nip.....	566
15.1.3.1 Time in Nip and Solidification	567
15.1.3.2 Other Examples.....	569
15.1.4 Case Study: Effect of Coating Thickness on Peel Strength	573
15.1.4.1 Porous Substrates	576
15.1.4.2 Nonporous Substrates	582
15.1.4.3 Analysis of Peel Test	588
15.2 Interlayer Adhesion in Coextrusion.....	594
15.2.1 Initial Process Time Studies	594
15.2.2 Time, Temperature, and Area Creation.....	598
15.2.3 Process Time Master Curve.....	603
15.2.4 Flow Accelerated Reaction Rate	608
References.....	609
Appendix: Relating Stress to Process Control Variables.....	612

PART VI End Use Considerations

16 End-Use Factors Influencing the Design of Flexible Packaging	617
16.1 Environmental Effects on Package Performance	617
16.1.1 Temperature	617
16.1.2 Humidity	619
16.1.3 Pressure	621
16.1.4 Irradiation.....	621
16.2 Packaging—Product Interactions	623
16.2.1 Loss of Package Integrity	623
16.2.1.1 Peel Strength and Delamination	624
16.2.1.2 Environmental Stress Cracking	628
16.2.2 Organoleptics	628
16.2.2.1 Impartation.....	628
16.2.2.2 Scalping.....	630

16.2.3 Active Packaging	633
16.2.3.1 Odor Scavenging.....	633
16.2.3.2 Antimicrobial	634
16.3 Aging.....	636
16.4 General Considerations.....	640
16.5 Cost	640
16.5.1 Financial Costs.....	640
16.5.2 Environmental Costs.....	642
References.....	649

PART VII Structure Design and Modeling

17 Analytical and Modeling Tools for Structure Design and Process Optimization.....	657
17.1 Identification of Packaging Structures	657
17.1.1 Microscopy.....	657
17.1.2 Fourier Transform Infrared Spectroscopy	658
17.1.3 Differential Scanning Calorimetry	659
17.1.4 Other Techniques	660
17.2 Modeling	660
17.2.1 Types of Modeling.....	661
17.2.1.1 Attribute Models	661
17.2.1.2 Empirical and Statistical Models.....	661
17.2.1.3 Theoretical/Fundamental Models	665
17.2.2 Examples of Models and Their Use in Flexible Packaging	666
17.2.2.1 Package Design	666
17.2.2.2 Processing/Converting	671
17.2.3 Case Study	673
References.....	681
Appendix A: Writing Guide for Packaging Films and Other Multilayer Structures.....	685
Appendix B: Examples of Flexible Packaging Film Structures.....	697
Index	711

