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Thermoplastic and Rubber Compounds

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Preface

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All commercial polymers are compounds that have additives primarily intended as stabilizers. These additives protect the polymer from oxygen, heat, and other aspects of the environment. Many available polymer products are compounds that involve a wide range of ingredients, including commercial products such as polypropylene-based thermoplastic elastomers, polyvinyl chloride pipes, mineral-filled polypropylene, and pneumatic tire components. These compounds contain not only stabilizers but also other polymers, fillers, oils, curatives, accelerators (for curatives), and other ingredients.

The compounding of polymers is not a new technology. It dates back to the beginnings of the rubber industry in the first half of the nineteenth century. Compounding is discussed extensively in the memoirs of Charles Goodyear and Thomas Hancock, both published in 1855–1857. These early efforts were almost entirely empirical. Today, roughly 150 years later, there is a sound scientific understanding of most modern additives' mechanisms in their intended applications.

As the polymer products industry developed and became increasingly large in this period, compound recipes became much more complex and sophisticated. Separate compounding cultures developed for individual polymer types, such as elastomers, polyvinyl chloride, polyolefins and thermoplastic elastomers. Indeed, sub-cultures, such as tire rubber compounds, specialty elastomer compounds, polyethylene compounds, and polypropylene compounds, have come into existence. The rubber industry has also in large part separated and become isolated from the thermoplastics industry.

Recipes have generally been designed on the basis of considering each active ingredient independently and presuming these ingredients do not interact. This often turns out not to be the case. When the number of components becomes three or more, unexpected consequences often result. A polar solvent or additive introduced into a binary polymer blend will incorporate itself preferentially into the more-polar polymer rather than the less-polar polymer. An additive previously compounded into a particular polymer can migrate into a second polymer during mixing as the number of components in a blend increases.

It is our purpose in this book to describe the components and composition of major types of polymer compounds used in both the thermoplastics and rubber industries. We will describe the intended mechanisms of these additives and their sometimes unintended various interactions with one another.

This book is divided into nine chapters. Chapter 1 describes the composition of polymer compounds and the chemical nature and physical properties of ingredients. Chapters 2 through 5 describe binary compounds of polymers with solid particles (Chapter 2), solvents (polymer solutions) (Chapter 3), additives such as stabilizers and curatives (Chapter 4), and a second polymer (blends) (Chapter 5). We turn to ternary compounds in Chapters 6 and 7. Chapter 6 discusses polymers with two low molecular weight liquids, two polymers with one low molecular weight substance, and three polymers including compatibilized polymer

blends. Chapter 7 considers the combination of polymer, solid particles, and low molecular weight additives including curatives and accelerators. Chapter 8 considers multicomponent compounds and the component interactions. Chapter 9 considers the mixing machinery and mixing cycles used for preparation of compounds. We discuss both the technology and basic mechanisms of the major commercial batch and continuous mixers, as well as related areas such as reactive mixing.

For readers with special interest in rubber and rubber compounding, we recommend especially sections 1.3 to 1.9; 2.4; 3.3, 3.8 to 3.10; 4.2 to 4.4, 4.7, 4.11; 5.2 to 5.6; 6.2, 6.4, 6.5, 6.8; 7.2 to 7.5; 8.3, 8.5; 9.2 to 9.4.

For readers with special interest in thermoplastics we recommend especially sections 1.3, 1.4, 1.6, 1.7; 2.4; 3.3 to 3.5, 3.11; 4.2, 4.3, 4.5 to 4.11; 5.1 to 5.11; 6.3 to 6.9; 7.2 to 7.4; 8.4, 8.6; 9.3 to 9.5.

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