Polymer Blends and Composites

Chemistry and Technology

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Preface

The emerging area of polymer blends and composites allows choosing a suitable combination of polymers and tailoring them for a desired performance. Although polymer blends and composites are relatively independent, history has shown that the interplay of new methods and ideas results in advancements in the development of new materials via properties and multifunctional approaches.

As part of the significant progress of science, engineering, and technology, it is highly gratifying that polymer blends and composites continue to advance at such a rapid pace. Today, continuously changing environmental aspects and natural resources dictate what is not allowed in the manufacture of new polymeric materials. Hence, blends and composites provide a powerful means of expanding new product development as well as new concepts in applications.

Today's challenge for material scientists is to develop technologies that can produce blends and composite products with extended lifetime, increased safety and perhaps with little or no maintenance. Therefore a technical reference is needed to help address this challenge, with text that provides the necessary value-added information to the reader. Consequently, an important motivation behind this book was to provide information that ultimately leads to advances in blends and composites. This along with the structure-property relationships in blends and composites are presented in order to achieve a new level of understanding of the area, resulting in the synergistic outcome of new materials.

The main objectives of this book are to present state-of-the-art preparation of novel materials, and to discuss their performance and application potentials. The wide scope of material covered provides a high-level of knowledge on polymer blends and composites. At the same time, the book gives young scientists the opportunity to understand areas of blends and composites and to develop professionally as quickly as possible. In addition, this book will encourage scientific and technological investigators to expand their knowledge of commercially relevant blends and composites.

I thank Mrs. Himachala Ganga, Mr. Venkatasubramanian and Mr. Sailesh for providing the encouragement to get the job done and help bring this book to fruition. Special thanks also to Mr. Martin Scrivener, Ms. Jean Markovich and to my professors. Above all, I thank the almighty Nataraja for bringing me into this wonderful earth to complete this work.

Dr. Muralisrinivasan Natamai Subramanian
Madurai
January 1, 2017

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Introduction

Polymers are considered as matrix materials in blends and composites. These polymers, which are a result of the mixing of two or more polymers, enable the production of blends and composites with required properties. As the performance requirements of polymers become more demanding, their physical properties through the use of blends and composites has become increasingly important.

Polymers have recently been used more frequently as blends and composites, resulting in good technological qualities of each of the components. Polymer blend processing has emerged as an inexpensive and versatile route to control the microstructural characteristics of polymers and enhance their properties [1–4].

Polymers are macromolecules and are insoluble material. The physical properties of the material dictate the complex structure of polymer by their ability to establish a structure-property relationship that predicts various physical properties. With the introduction of food packaging, the use of polymers has grown greatly, particularly the use of thermoplastic polymers such as high- and low-density polyethylene (HDPE and LDPE), polypropylene (PP), polyethylene terephtalate (PET), polyvinyl chloride (PVC), and polystyrene (PS). Polymers have been widely used

as a route to develop a combination of desired properties by blending or by composites.

1.1 Polymer Blends

Polymer blends have become a broad field that aims to tailor polymer functionality. The blending of polymers is an inexpensive route to the modification of various polymer properties. It is a viable and versatile way to control the performance of polymeric materials with available polymers [5]. There has been a significant increase in the use of polymer blends to obtain new high-performance organic materials without any synthesis, resulting in a new polymeric material. Polymer blends are composed of two or more polymers with or without compatibilizer, depending on the composition and viscoelastic properties of individual components. They have complicated properties which display elasticity and viscosity at different strain rates and temperatures [6, 7].

Polymer blending is a relatively simple process and cheaper than polymer synthesis. The blending of conventional polymers has been extensively employed to develop new polymeric materials. Polymer blends have become a traditional method for producing new, high-performance polymeric materials. Mechanical, optical and electrical properties of polymer blends depend on their morphological characteristics [8]. They are produced in order to achieve improvements in properties such as thermal stability, mechanical properties or chemical resistance [9]. Many important polymer blends are incompatible polymers [4]. Due to its utility and simplicity, blending is currently a feasible method for improving polymer surface properties [10, 11]. Polymer blends and composites improve product performance by combining different polymers with specific properties in order to combine as one material.

1.2 Polymer Composites

Polymer matrix composite is a material with at least two phases, a continuous phase as polymer and a dispersed phase as filler or fiber. The continuous phase is responsible for filling the volume and transferring loads to the dispersed phase. The dispersed phase is responsible for enhancing one or more properties of the composite.

Polymer matrix composites, due to their outstanding mechanical properties, are widely used as special engineering materials in applications

for aerospace, automotive and civil engineering structures. Therefore, it is of great interest to have knowledge of the durability of these materials [12, 13]. Polymer composites are controlled by the reinforcing material content present in them. Volume fraction and orientation of reinforcing material decides the properties such as stiffness, strength, thermal conductivity, and other properties of composites. Instead of synthesizing new polymers, composites have several features in comparison with metallic and other products.

Composites have been developed to meet several industrial requirements such as the need for easier processing and broadening of the range of properties, either by varying the type, relative amounts or morphology of each component. These materials can be prepared so as, for example, to combine their high mechanical strength to a better dimensional stability and thermal resistance. Sometimes a higher stiffness is also attained with the use of reinforcing fillers [14–16]. Most of the composites target an enhancement of mechanical properties such as stiffness and strength, but other properties may be of interest such as density, thermal properties, etc.

One of the key parameters in controlling the successful design of polymer matrix composites is the efficient control of the interface between the continuous phase (polymer) and the discontinuous phase (reinforcement). The greatest advantage of composite materials is that they offer the possibility of tailoring their properties by playing with the volume fraction of the discontinuous phase, dimension of the particles (particularly when in fiber form), and their orientation [17].

1.3 Blends and Composites – Advantages

Polymers have been widely used as routes to develop a combination of desired properties by blending or by composites. Polymer blends and composites with useful combinations have increased considerably and rapidly. There has been a long practice of tailoring specific processing and performance requirements which combine both physical and mechanical properties of the existing polymers depending on the composition and level of compatibility of the materials.

Blends and composites are relatively

- Low cost;
- Light weight, thereby easily transported;
- Easy to fabricate using extrusion, injection molding, compression molding, etc.;