CHAPTER 7

Summary and Conclusions
Many materials are being used by man for his needs and comfort and, over the years, several new materials have been developed for his technological needs. As the technology becomes more and more sophisticated, the materials used also have to be correspondingly more efficient. Several performance characteristics are also expected from these materials. These new materials should possess better properties, easily available in nature and the method of their preparation should be cost-effective. To meet these ever growing demands, many new materials have been developed that are categorized as copolymers, polymer blends and polymer composites. In the present study, the author proposed to study the polymer blends and composites of unsaturated polyester resin.

A polymer blend, which is the mixture of two or more polymers, continues to be an economical method to obtain new polymeric materials. The final properties of a polymer blend will commonly depend on the properties of its polymeric components, its composition and, mainly, on the miscibility of the polymers. When the blends are miscible, one can make tailor made properties to suit a particular need. When the blends are immiscible, one can convert them into polymer alloys by the addition of suitable compatibilizers.

The study of miscible polymer blends has provoked particular interest, which can be seen from the increasing number of papers in literature, but there are only few
papers concerned with polymer blends of unsaturated polyester resin. Although unsaturated polyester resins due to their low manufacturing costs and high tensile strength, have been widely used as one class of the most important thermosetting plastics in the industry such as glass fiber reinforced polyesters and moulding compounds, only a few researchers concentrate on their blends. Therefore, further investigation of unsaturated polyester polymer blends is of practical significance.

Homogeneous mixing at a molecular scale is a prerequisite for polymer miscibility. There are several methods for blending such as, melt blending, dry blending and solution blending. Since a number of miscible blends are prepared from solution, the study in the solution state is a fundamental importance. The author has selected the solution blending method to investigate the miscibility of unsaturated polyester resin with different thermoplastics. In the present investigation, the miscibility studies of the polymer blends of unsaturated polyester resin (UPR) with poly(methyl methacrylate)(PMMA), polystyrene(PS), polycarbonate(PC), poly(vinyl acetate)(PVAc), cellulose acetate(CA), and poly(vinyl chloride)(PVC) have been carried out by viscosity, ultrasonic velocity, density, and refractive index techniques. These techniques have been selected for the present study as these are inexpensive, simpler and quicker and yield the same information as the other solid-state sophisticated techniques such as spectroscopy, thermal, mechanical, and diffraction techniques. The author also studied the miscibility of the blends by polarized optical microscopy to show that solution and solid-state techniques yield identical results.

Another category of new materials is ‘composites’, which have revolutionized the concept of high strength. A composite is a complex solid material made by
combining two or more dissimilar materials in such a way that the resulting material is endowed with some superior and improved properties. Owing to these superior properties, polymer composites find various applications in our daily life. To meet the specific needs, the polymer composites have to be modified accordingly. The performance of composites depends on the selection of the constituent materials. Reinforcing material or the fiber is one of them. There are two types of fibers that are used as reinforcements: natural and synthetic fibers. A lot of work has been done on the composites based on these fibers. But both these types of fibers have advantages and disadvantages. To minimize their disadvantages, they can be combined in the same matrix to produce hybrid composites, which take full advantage of the best properties of the constituents, and thereby an optimal, superior but economical composite can be obtained. With this view, the author has developed some hybrid composites of short sisal and glass fibers with random orientation. Unsaturated polyester resin was used as the matrix for these composites.

The thesis is divided into seven chapters. In chapter 1, a brief introduction on the history of the polymer blends and polymer composites has been presented. The aim and scope of the work are also presented in this chapter followed by the literature surveyed by the author.

Chapter 2 deals with the materials used in the study of polymer blend solutions. The method of preparation of these blend solutions and the measurements of relative viscosity, ultrasonic velocity, density and refractive index of the polymer
Blend solutions are described in this chapter. The author also explained the optical polarizing microscope technique to probe the miscibility criterion in the polymer blend films and describes the instruments used in the present study.

The results of the miscibility studies are presented in chapter 3. The miscibility of the following blends has been studied.

1. Unsaturated polyester resin (UPR)/poly(methyl methacrylate) (PMMA) in chloroform
2. Unsaturated polyester resin (UPR)/polystyrene (PS) in chloroform
3. Unsaturated polyester resin (UPR)/polycarbonate (PC) in chloroform
4. Unsaturated polyester resin (UPR)/poly(vinyl acetate) (PVAc) in chloroform
5. Unsaturated polyester resin (UPR)/cellulose acetate (CA) in chloroform
6. Unsaturated polyester resin (UPR)/poly(vinyl chloride) (PVC) in tetrahydrofuran

The interaction parameter $\mu$ for the polymer blends of UPR/PMMA, UPR/PS and UPR/PVAc were found to be positive basing on the criterion proposed by Chee [1]. Another interaction parameter, $\alpha$ proposed by Sun et al. [2] was also found to be positive for all the above three blends. From the optical polarizing micrograms of the polymer blends of UPR/PMMA, UPR/PS and UPR/PVAc, a uniform distribution of the components is observed in the blends, as the phase agglomeration is minimum. The $\mu$ and $\alpha$ values for the blends of UPR/PC, UPR/CA and UPR/PVC were found to be negative and the optical polarizing micrograms of these blends showed a non-uniform distribution of the components. Basing on the above results, it is found that
the blends of UPR/PMMA, UPR/PS and UPR/PVAc are miscible whereas the blends of UPR/PC, UPR/CA and UPR/PVC are immiscible. These results have been further confirmed by the density, ultrasonic velocity and, refractive index measurements of the blends.

Chapter 4 deals with the unsaturated polyester composites. The materials used in the preparation of sisal/glass hybrid composites are presented in this chapter. The moulds designed and fabricated by the author to make the test specimens for tensile, flexural, impact, compression, and hardness tests are described in this chapter. The mechanical and chemical resistance test methods are also presented in this chapter.

Chapter 5 describes the mechanical properties of the composites developed by the author. The results of the tensile, flexural, impact, compression, and hardness properties for these composites with varying fiber content are presented in this chapter. A positive hybrid effect has been observed for all these mechanical properties of sisal/glass hybrid composites. A linear increase in properties with increasing glass fiber content in the sisal/glass hybrid composite has been noticed for all the mechanical properties studied. The enhancement in tensile, flexural and impact properties was also observed when the total fiber content of the hybrid composite was increased from 5 vol% to 8 vol%. However, a slight decrease in compressive strength and hardness is observed with the increasing total fiber loading.
As the performance of a composite not only depends on the selection of the constituent materials, but also on the bonding between them, the author studied the effect of a silane treatment and the alkali treatment on the bonding nature. A marginal change in mechanical properties has been observed with the chemical treatment when compared to the properties of untreated fiber reinforced composites.

Chapter 6 presents the results of the chemical resistance tests of the composites developed by the author. These tests are performed in order to probe whether these composites can be used for making articles that are resistant to chemicals. The hybrid samples and the matrix have been tested for various acids, alkalis, and solvents. It is observed from the results that the developed composites are resistant to all the chemicals except carbon tetrachloride.

To conclude, the unsaturated polyester resin can be used for preparing polymer blends and composites, as it is a cheap and easily available material with excellent properties. It is observed that the simpler, quicker and inexpensive techniques such as viscosity, ultrasonic velocity, density, and refractive index can be used to determine the miscibility of thermosetting polymer with different thermoplastics. Based on the miscibility of these polymer blends, one can make tailor made materials by varying the composition of the polymers according to the specific needs. It can also be concluded from the present work that sisal and glass fibers can be combined to produce hybrid composites, which take full advantage of the best properties of the constituents. Almost all the mechanical properties show positive
hybrid effects and hence, these hybrid composites can be used in making various articles such as automobile parts, boats, sports goods, furniture items, water and chemical storage tanks, etc.

References