Chapter 5

Structure–Property Relations in Polymers and Polymer Blends Using X–Ray Diffraction Technique

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ABSTRACT

This chapter discusses about the synthesis and characterization of polymers, polymer blends, polymer composites, and polymer nanocomposites. Electrically conductive blends polyaniline dodecyl benzene sulphon acid (Pani:DBSA)/Styrene Butadiene Styrene (SBS) block copolymer have been prepared by melt mixing and using in situ polymerization method. The microstructural parameters were computed using wide angle X-ray scattering (WAXS) and Small angle X-ray scattering (SAXS). Bimodal distribution method has been studied for SBS, DCH32 cotton fiber and Pure Mysore multi-voltine silk (PMS) samples using Line profile analysis.

INTRODUCTION

Materials have become a symbol of the progress of human civilization. Human society has experienced the Stone Age, Bronze Age and Iron Age. In the 20th century high performance plastics and polymer composites became the substituent for traditional materials. Polymer composites exhibit superior properties to those of individual component materials. This is obviously the driving force for the development of composites.

The properties of polymer composites like weight reductions, corrosion resistant, high specific mechanical properties, superior stiffness and improved fatigue life leads to the production of many new
materials from low cost plastics to experience emerging materials. These tailored materials are useful in transportation, medical field, construction sectors etc...

Classification of composites can be polymer-polymer blends, fibre inforced composites, polymer-matrix composites (PMCs), polymer-nanocomposites, polymer electrolytes etc.

Materials are generally classified as insulators, semiconductors, conductors and superconductors based on their electrical properties. A material with conductivity less than $10^{-7}$ S/cm is regarded as an insulator. Metals have conductivity larger than $10^{3}$ S/cm whereas the conductivity of a semiconductor varies from $10^{-4}$ to 10 S/cm depending upon the degree of doping. It was generally believed that plastics (polymers) and electronic conductivity were mutually exclusive and the inability of polymers to carry electricity distinguished them from metals and semiconductors. As such, polymers were traditionally used as inert, insulating and structural materials in packaging, electrical insulations and textiles where their mechanical and electrically insulating properties were paramount. In fact, any electrical conduction in polymers was generally regarded as an undesirable phenomenon.

The evolution of conducting polymers began in 1975 with the discovery of a linear conjugated organic polymer, polyacetylene by Shirakawa (Shirakawa. H, et al., 1977). However, the material showed metallic properties only after its oxidation by iodine, which was reported two years after its discovery (Shirakawa. H, et al., 1977; Skotheim. T J, et al., 1998; Chandrashekar. P, et al., 1999). The 2000 Nobel Prize in Chemistry, recognized the discovery of conducting polymers after over 25 years of progress in this field (MacDiarmid. A G, 1999; N. Hall, 2003). In recent years, there has been growing interest in research on conducting polymer since they combine the advantages of organic conductors with low-dimensional systems and therefore create interesting physicochemical properties and potentially useful applications (Sailor. M J, et al., 1994; Neves. S, et al., 2004; Gangopadhyay. R, et al., 2004; Wallace. G G, et al., 2004; Epstein. A J, et al 2001; Martin. C R, 1995). Traditionally, an advantage of polymeric materials is that they can be synthesized and processed on a large scale at relatively low cost. Many of the applications (sensors, functional coatings, catalysts, etc.) of conducting polymers indeed need bulk quantity materials. Therefore, developing bulk syntheses for conducting polymers would be especially important for practical reasons. It has been found that the nanofibers significantly improve the processability of polyaniline and its performance in many conventional applications involving polymer interactions with its environment. This leads to much faster and more responsive chemical sensors, new inorganic/ polyaniline nanocomposites, and ultra-fast non-volatile memory devices.

Among the family of conjugated polymers, polyaniline is one of the most useful since it is air- and moisture-stable in both its doped, conducting form and in its de-doped, insulating form (Huang. W S, et al., 1986; MacDiarmid. A G, 1997; MacDiarmid. A G, et al., 1985). It has a great variety of potential applications including anticorrosion coatings, batteries, sensors, separation membranes, and antistatic coatings (Skotheim. T J, et al., 1998; Chandrashekar. P, et al., 1998). Conventional polyaniline synthesis is known to produce particulate products with irregular shapes. Therefore, many methods have been developed to make nanostructures of polyaniline (with diameters smaller than 100 nm) by introducing structural directing agents during the chemical polymerizing reaction. A great variety of such agents have been reported in the literature, and these include: surfactant, (Zhang. X, et al., 2004; Yu. L, et al., 2003; Michaelson. J C, et al., 1994; Li. G C, et al., 2004).
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