



## CHAPTER I INTRODUCTION

A composite is a heterogeneous substance consisting of two or more materials in which the components do not lose their basic characteristics. This combination of materials brings about new desirable properties. Composites have many engineering advantages over synthetic polymers and copolymers. The main advantages are reinforcement of the resin resulting in increased tensile strength, flexural strength, compressive strength, impact strength, rigidity, and lightweight. In plastics technology, composite materials are usually two-phase systems consisting of a reinforcing fibrous material, which is usually inorganic, dispersed in a continuous polymeric matrix. The main functions of the reinforcing fiber are to give the composite high strength, stiffness, and toughness. On the other hand, the matrix serves to maintain fiber position and orientation, transmit shear forces, protect the fiber surface and transfer loads to the reinforcement. These functions were achieved in the past by using highly crosslinked thermoset resins. More recently, thermoplastics of high molecular rigidity and/or crystallinity have also been used. Generally, fibrous composites consist of either discontinuous or continuous fibers dispersed in a polymeric matrix resulting in macroscopically homogeneous composites. Glass fiber is the most frequently used reinforcing fiber in modern polymer composites due to its low cost and high tensile strength in fine fiber form. Other advantages of glass fiber include good energy adsorbing characteristics when used in composite form, and good thermal insulation. Polyethylene is often used as a matrix in many applications because of its low cost, high electrical resistance, good thermal insulation and ease of manufacture.

It is well known that the structure and property of the fiber-matrix interface and, particularly, the level of adhesion between polymer matrix and the reinforcing fiber, play a major role in determining the final performance of composite materials. The quality of this interface is strongly dependent on the surface characteristics of both materials. The mechanical properties of high performance composites are often limited by the ability of the interface to transmit the load from the matrix to the fibers. When mechanical stress is applied to the polymeric matrix, it spreads

smoothly through the matrix until it reaches a matrix-fiber interface. If the interface is well bonded, the stress is transferred through it and into the fiber. The stress then spreads rapidly throughout the fiber and eventually exists from the fiber surface at another fiber-matrix interface. If this interface is also well bonded, the stress is transferred again into the matrix. This process continues at each matrix-fiber interface. However, if the interface is weak, causing failure at the fiber-matrix interface, the composite will have low strength.

In many types of composites, particularly those reinforced with glass fiber, the interfacial strength is not inherently high and a number of methods have been developed to improve both the initial and long term interfacial adhesion. Some of these methods include plasma treatment, polymer grafting, deposition of polymer films and application of zirconate, titanate, or silane coupling agents. Silane coupling agents are probably the most common glass surface modifiers, and are widely used commercially. Silane coatings are chemisorbed by being covalently bonded to the surface of the reinforcing fiber.

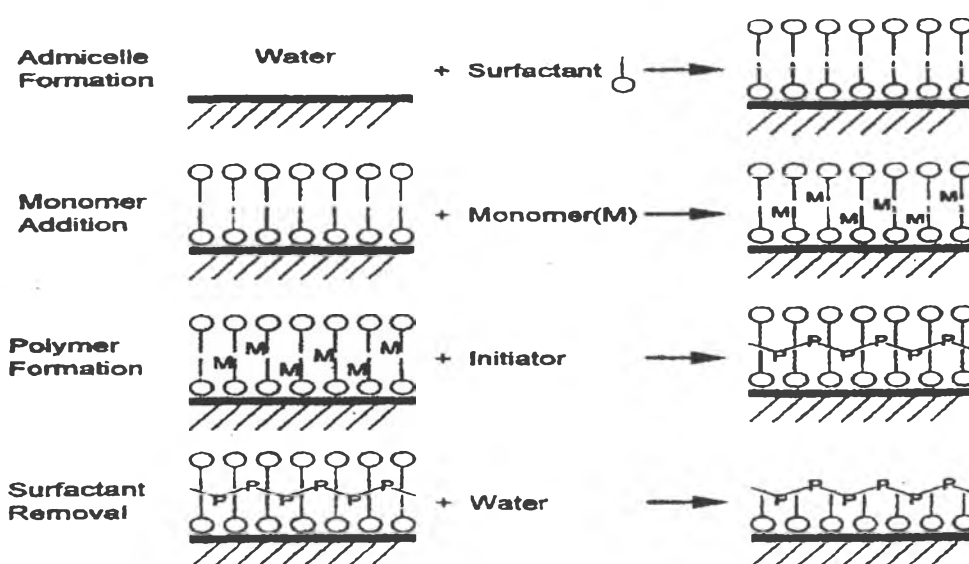
However, probably the most significant commercial disadvantage of silane coupling agents as interface modifiers in composites is their high cost. Therefore, an alternative to silane coupling agents is desirable. One approach to an effective coupling agent is based on the principle that it should be made from the same material as the polymeric matrix of the composite. Since, on the basis of "like dissolves like", the interfacial interaction (adhesion) between polymers of the same type must be considered superior to that of any other type of modified filler surface. One technique that can be used to coat thin film of polymer on a substrate surface is the so-called admicellar polymerization process. Similar to silane coupling agents, adhesion in admicellar-treated systems depends on strong adhesion of the filler/admicellar-treated polymer interface as well as at the admicellar polymer/bulk polymer interface. One significant difference between the two surface modification techniques is that admicellar polymer is not able to covalently bond to the glass surface. One admicellar polymerization technique is based on physically adsorbing surfactant onto the substrate. Nevertheless, the organic thin admicellar layer seems to adhere strongly to the substrate surface.

This research explores the use of the admicellar polymerization technique to form a polymeric thin film on the surface of glass fibers. The purpose of this study is to improve the adhesion between the reinforcing fiber and the polymeric matrix in glass fiber reinforced HDPE composites using admicellar polymerization. Scanning electron microscopy will be used to observe the nature of the polymeric film interface. The mechanical properties of the composites made from modified glass fibers will be compared with those of similar composites manufactured from untreated glass fiber and silane-treated glass fiber.

### 1.1 Theoretical Background of Admicellar Polymerization

The admicellar polymerization method developed from a fundamental understanding of the interactions between surfactants and surfaces. In this type of surface treatment technology an aqueous phase method is used to coat surfaces with polymer.

The conditions of the aqueous solution containing surfactant and suspended inorganic particles can be tailored to favor the formation of a surfactant bilayer on the surfaces of the particles. The thin film polymerization process can be envisioned as occurring in four major steps (Fig 1.1).



**Figure 1.1** The four-step admicellar polymerization process.

Step1: Admicelle formation. The most critical parameter to be manipulated is the solution pH, which is adjusted until the surface exhibits a net surface charge of zero (referred to as the point of zero charge, or PZC). At pH values below the PZC, the surface becomes protonated and more positively charged; above the PZC, the surface is negatively charged. Consequently, the choice of surfactant is influenced by the PZC of the substrate. That is, anionic surfactants, adsorb below the PZC and cation surfactants above the PZC. In this study, glass fibers are used, which typically have a PZC in the acidic range. The amount of surfactant required, which is determined from adsorption isotherms, must be lower than the critical micelle concentration (CMC) to avoid emulsion polymerization from occurring in the supernatant liquid.

Step2: Monomer Adsolubilization. Under conditions favorable for the formation of admicelles on a solid surface and unfavorable for the formation of micelles in the aqueous supernatant, hydrophobic species are deposited on the solid surface, this process being referred to as 'adsolubilization'. Adsolubilization can be defined as the excess concentration of a species on a surface that would not exist in the absence of admicelles. As a prelude to the film forming polymerization reaction (Step3) the hydrophobic monomer adsolubilizes or partitions into the adsorbed surfactant aggregate of Step1. The organic liquidlike environment exhibited by the hydrophobic interaction of the amphiphilic tail renders a favorable region to solubilize the organic monomer.

Step3: In-situ Polymerization of Adsolubilized Monomer. The free radical polymerization reaction is started by the generation of radicals from the initiator. Once the reaction has begun, additional monomer from the bulk solution diffuses into the admicelle. Initiators begin the formation of polymer within the surfactant bilayer, probably by mechanisms similar to that which occur in conventional emulsion polymerization, i.e. within micelles. If the reaction is continued for a sufficient length of time, essentially all of the monomer dissolved in the water will be converted to polymer.

Step4: Surfactant Removal. After polymerization, the glass fibers, presumably coated with a thin polymeric film, must be washed several times using distilled water to rinse off any residual surfactant and monomer from the fiber

surface. The washed fibers are then placed in an oven and heated to remove any excess water and unconverted monomer from the surface of the fibers.