

CHAPTER I

INTRODUCTION

Any material consisting of more than a single phase can justifiably be described as a “composite material”. In plastics technology the term is usually reserved for two-phase systems consisting of a reinforcing fibrous material, which is usually inorganic but which may be polymeric, dispersed in a continuous polymeric matrix (Cope, 1992).

Conventional composites science and engineering has concentrated upon making products of high rigidity, strength, impact strength (resistance to mechanical shock) and often resistance to high temperature as well. To do this, scientists first select a polymeric matrix of high rigidity and heat resistance. Originally highly crosslinked thermoset resins were used but now thermoplastics of high molecular rigidity and/or crystallinity are also used.

They next select a reinforcing fiber, which they disperse throughout the polymeric matrix to increase its rigidity and strength still further, and especially to add impact strength, which is often lacking in such rigid matrixes. Among the several glass-forming compositions used to manufacture reinforcements for composites, E-glass is the most industrially important.

The high performance of such composites results from the unique interaction between polymeric matrix and reinforcing fiber. When mechanical stress is applied to the composite, it spreads uniformly through the matrix until it reaches a matrix-fiber interface. If the interface is well bonded, the stress is transferred across it into the fiber, and then spreads rapidly throughout the fiber. When it exits from the fiber surface at another fiber-matrix interface, if it is well bonded, the stress is again transferred to the matrix, and the process continues in this way. On the other hand, if the fiber/matrix interface is weak, the composite will have low strength and be worthless.

The composite then is seen to consist of very strong fibers embedded in a polymeric matrix. The purpose of the fibers is to enhance the low stiffness and strength of the polymeric matrix while the matrix serves to maintain fiber position and orientation, transmit shear force, protect the fiber surface and transfer loads to the reinforcement. For these reasons fiber-matrix adhesion is essential.

Thus great research efforts have been expended to ensure that the matrix-fiber interface is as strong as possible. Whilst some of these interface systems have enough natural affinity due to polar, hydrogen bonding, electronic attraction, or actual primary covalent bonding, in most systems it is necessary to use a coupling agent at the interface to create a strong bond and therefore confer good stress transfer across the fiber/matrix interface and thus prevent part failure.

Therefore, improving the adhesion between a polymer matrix and a reinforcing fiber in fiber-reinforced composites is very important since good adhesion is necessary for good mechanical properties. This work uses a technique termed “admicellar polymerization”, which uses nanoscale chemistry, to coat a layer of polyethylene onto glass fiber reinforcement in order to improve the interfacial adhesion between the polymeric matrix (HDPE) and reinforcing fibers (glass fiber).

Theoretical Background of Admicellar Polymerization

In admicellar polymerization, a very thin layer of polymer is formed in the hydrophobic region of a surfactant bilayer adsorbed on the surface of a particle suspended in water. The most significant advantage of admicellar polymerization relative to other methods used to improve polymer-filler adhesion is cost; both the ingredients and processing methods used for admicellar polymerization are inexpensive.

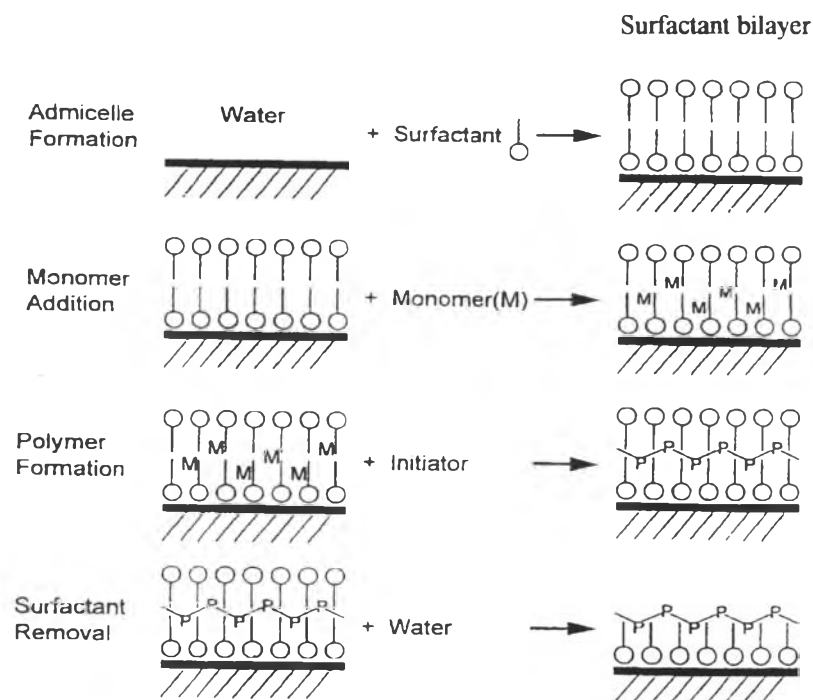


Figure 1.1 The four-step admicellar polymerization process.

The thin-film polymerization process can be envisioned as occurring in four major steps as illustrated in Figure 1.1. The various steps are as follows:

Step 1 Admicelle formation.

The aggregation of surfactants at solid/liquid interfaces to form bilayers (admicelles) through adsorption from an aqueous solution is a well-known phenomenon. To obtain admicelle formation, the most critical parameter to be manipulated is the solution pH, such that 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, i.e. more positively charged; above the PZC, the surface becomes negatively charged. Consequently, anionic surfactants adsorb below the PZC and cationic

surfactants above the PZC. The concentration of surfactant used in the admicelle formation step must be lower than the critical micelle concentration (CMC) in order to avoid emulsion polymerization occurring in the supernatant liquid.

Step 2 Monomer adsolubilization.

Under conditions favorable for the formation of admicelles on a solid surface but unfavorable for the formation of micelles in an aqueous solution, monomer becomes concentrated at the hydrophobic bilayer interface in a phenomenon called adsolubilization. Formally, adsolubilization can be defined as the excess concentration of monomer at an interface that would not exist in the absence of admicelles. The organic environment exhibited by the hydrophobic interaction of the amphiphilic tails of the surfactant molecules renders a favorable region to solubilize the hydrophobic monomers.

Step 3 In-situ polymerization of adsolubilized monomer.

In addition to concentrating the monomer at the surface of the substrate, the admicelles function as reaction loci or two-dimensional reaction solvent for polymerization. Initiators begin the formation of polymer within the surfactant bilayer, probably by mechanisms similar to that which occurs in conventional emulsion polymerization, i.e. within micelles.

Step 4 Surfactant removal.

After polymerization, the treated substrate, presumably coated with a thin polymeric film, must be washed using distilled water to rinse off any residual monomers and surfactants from the adhering film.