

## CHAPTER I

### INTRODUCTION

Polymer blending is one of the most popular methods used in developing new materials with desired combinations of properties. This is probably the cheapest and fastest route to develop new plastics (Uptal *et al.*, 1996). Griffin and his coworker proposed the idea of incorporating natural polymer like starch fillers for thermoplastics in 1973. Starch is composed of 1,4- $\alpha$ -D-glucopyranosyl repeating units. The addition of starch into polymer matrix is expected to lead to a decrease in solid-waste ( Bhattacharya *et al.*, 1995). In addition to starch, there has also been work concerned with other biopolymers such as cellulosic materials. Maldas *et al.* (1987) reported that improvements in tensile modulus and tensile strength of sawdust wood fiber-filled polystyrene blends could be achieved by treating the fibers with isocyanate coupling agent. Moreover, the addition of treated fiber at 30% filler content gave the best result in both of tensile strength and tensile modulus of the blends. Devi *et al.* (1988) studied the effect of fiber content and fiber treatment on the mechanical properties in terms of tensile strength, tensile modulus, flexural strength, flexural modulus and impact strength of pineapple leaf fiber (PALF)-reinforced polyester composites. All of the mechanical properties of the composites were improved when the silane-treated fibers were blended with the polystyrene matrix. In addition, all cases of mechanical properties of treated PALF-reinforced polystyrene composites increased as fiber content increased.

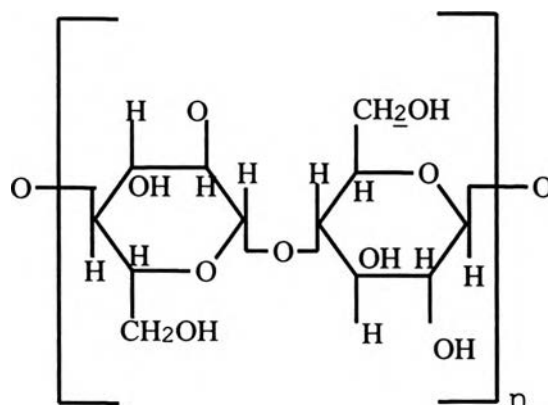
Thailand produces rice as a major agricultural product, not only for domestic consumption but for also exporting. Rice milling processes generate large amounts of by-products (approximately 100 million tones per year) which are rice husk and bran.

Rice husk is the outermost layer of paddy, and is usually in a fibrous form that consists mostly of cellulose. Depending on the species of paddy, the husk represents 20 to 25% of the paddy weight most of which is undesired waste (Ruiten., 1979). Cellulose is a long chain polymer of  $\beta$ -D-glucose linked together by 1,4 glycosidic bonds. Its structure is quite similar to starch structure, and it also shows interesting potential as filler for thermoplastics (Joseph *et al.*, 1996; George *et al.*, 1998). Application of cellulosic material in thermoplastic composite is highly beneficial, since the strength and toughness of the plastics can be improved (Devi *et al.*, 1997; Sreekala *et al.*, 1997; Rozman *et al.*, 1998; Matuana *et al.*, 1998). Moreover, cellulosic raw materials are very cheap, highly available and renewable.

High density polyethylene (HDPE) is a widely used polymer because of its high mechanical properties, strong chemical resistance and low water absorption. However it has some disadvantages because it can not degrade in nature and plastic wastes cause environmental problems. In order to decrease plastic waste as well as adding value to rice husks, the present work investigates the use of two types of rice husk, i.e., treated rice husk and burning husk, as a filler for HDPE. Blends containing rice husk are then investigated in terms of mechanical properties, microstructure and water absorption as compared to the blend containing tapioca starch.

### **1.1 Cellulose**

Cellulose is a long chain polymer of  $\beta$ -D-glucose in the pyranose form linked together by 1,4 glycosidic bond to form cellobiose residues that are the repeating units in the cellulose chain. Figure 1.1 illustrates the structure of cellulose.



**Figure 1.1** The repeating unit of cellulose.

Cellulose is a highly crystalline material, with extended chains and are large degree of intermolecular hydrogen bonding. However cellulose consists not only of highly ordered crystalline regions, but contains disordered or amorphous regions as well. These different regions do not have clearly defined boundaries, but rather blend into each other. In plant cell, there are hemicelluloses that are closely associated with cellulose. But they differ from cellulose in that they consist for the most part of sugars other than glucose, both pentoses and hexoses, are usually branched and have much lower degrees of polymerization.

The most remarkable property of cellulose is its insolubility in water despite the fact that is a polymer of glucose. Hydrogen bonding between cellulose chains is so intense that water can not disrupt it by forming bond with the hydroxyl groups of glucose unit. Moreover hemicelluloses are also water insoluble, but can dissolved in strong alkali. Hence, it is a reason why the solubility in water of cellulose is a significant important property. We also consider another properties of celluloses such as mechanical property that is rather high in relation of their weight.

Furthermore, if we consider the source of celluloses that obtain from woody plant in which 40-50% of the plant consist of cellulose. Therefore these plentiful materials should continue to be relatively inexpensive.

## 1.2 High Density Polyethylene (HDPE)

High Density Polyethylene (HDPE) is defined by ASTM D 1248-84 as a product of ethylene polymerization with a density of 0.940 g/cm<sup>3</sup> or higher. HDPE is a linear polymer with the chemical composition of polyethylene, (CH<sub>2</sub>)<sub>n</sub>. Its name, polyethylene, reflects the principal method of production ethylene polymerization by various processes.

The properties of HDPE are significantly controlled by its melt flow index and molecular weight distribution values. The effects of changes in molecular weight, density and molecular weight distribution (MWD) are as follows (Whelan, 1994).

Property	Effect of increasing:		
	MFR	Density	MWD
Tensile strength at yield		Increase	
Elongation at break	Decrease	Decrease	
Impact strength	Decrease	Slight decrease	Decrease
Modulus		Increase	

HDPE is a highly crystalline, nonpolar thermoplastic, which has excellent chemical resistance to most household and industrial chemicals. The polymer does not absorb moisture and provides good water vapor barrier. Moreover HDPE offers superb impact resistance at ambient conditions and even at temperatures as low as -40 ° F. For all of the above reason, HDPE is one of the top volume thermoplastics used in the world today.

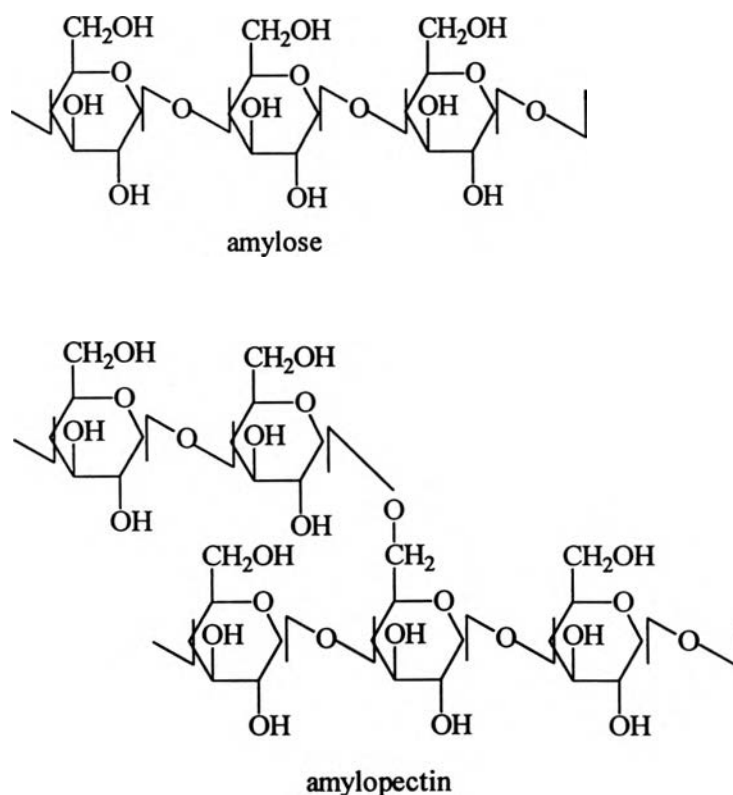
A major use for HDPE is in blow molding applications. Large container, drums and car component are typical applications. HDPE is used in such applications because of its high impact strength and because it can retain its properties at low temperatures.

General uses of HDPE include injection-molded beverage cases, bread trays and dunnage trays as well as films. Another interesting application is extruded sheet that is subsequently thermoformed into such articles as canoes and pickup truck bed liners. In sum, HDPE is a versatile thermoplastic enjoying many successful applications that maximize its properties.

### **1.3 Starch**

The main reserve food of plants, starch constitutes two-thirds of the carbohydrate caloric intake of most human. Commercial starches are obtained from seeds, particularly corn, wheat and rice, and from tubers or roots particularly potato, sweet potato and tapioca.

Starch is an abundant, inexpensive, natural raw material that permits the development of products recyclable to atmospheric CO<sub>2</sub> when biodegraded or incinerated. Starch consists of two major components: amylose, a mostly linear  $\alpha$ -D-(1,2)-glucan and amylopectin, an  $\alpha$ -D-(1,4)-glucan which has  $\alpha$ -D-(1,6) linkages at the branch point. The linear amylose molecules of starch have a molecular weight of 0.2-2 million, while the branched amylopectin molecules have molecular weight as high as 100-400 million.



**Figure 1.2** The structure of starch.

In nature, starch is found as crystalline beads of about 15-100 microns in diameter, in three crystalline modifications designated A (cereal), B (tuber) and C (smooth pea and various beans). Starch can be used as a natural filler in traditional plastics and particularly in polyolefins. When blended with starch beads, polyethylene films biodeteriorate on exposure to a soil environment. The microbial consumption of starch component, in fact, leads to increased porosity, void formation and the loss of integrity of the plastic matrix. Generally starch is added at fairly low concentrations (6-15%). However thermoplastic-starch blends are sensitive to humidity, which makes them unsuitable for most applications.

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## 1.5 Mechanical Properties

The mechanical properties, among all the properties of plastic materials, are often the most important properties because virtually all service conditions and the majority of end-use applications involve some degree of mechanical loading. In this study, tensile, flexural and impact property are mentioned.

### 1.5.1 Tensile Property Testing

Tensile elongation and tensile modulus measurements are among the most important indications of strength in a material and are the most widely specified properties of plastic materials. Therefore different types of plastic materials are often compared on the basis of tensile strength, elongation and tensile modulus which can be calculated as follow:

$$\text{Tensile strength} = \frac{\text{Force (load) (lb)}}{\text{Cross section area (sq.in.)}}$$

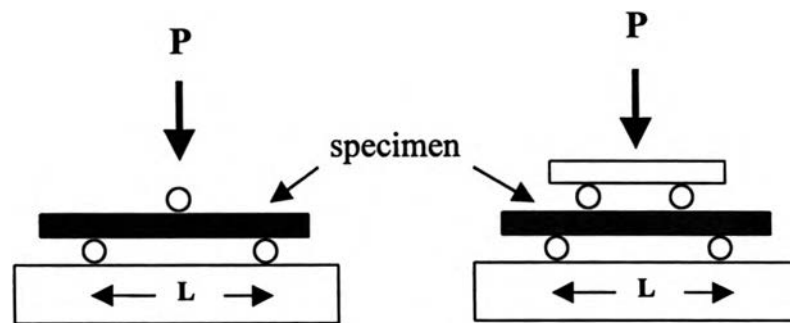
$$\text{Elongation} = \text{Strain} * \text{Original length}$$

$$\text{Tensile modulus} = \frac{\text{Difference in stress}}{\text{Difference in corresponding strain}}$$

### 1.5.2 Flexural Property Testing

Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis.

Flexural properties are reported and calculated in term of the maximum stress and strain that occur at the outside surface of the test bar. There are two basic methods that cover the determination of flexural properties of plastics. Method I is a three-point loading system utilizing center loading on a sample supported beam. While method II is a four-point loading system utilizing two load points of one-third of the support span. The pictures of both three-point and four-point bending are shown in Figure 1.3.



**Figure 1.3** Types of flexural testing equipment.

The maximum stress is related to the load and sample dimensions and is calculated using the following equation 1.1

$$S = \frac{3P \cdot L}{2b \cdot d^2} \quad (1.1)$$

where: S is stress (Psi)

P is load (lbs)

L is the length of span (in.)

b is the width of specimen (in.)

d is the thickness of specimens (in.)



While the maximum strain in the outer surface is calculated via equation 1.2

$$r = 6D*d/L^2 \quad (1.2)$$

Where: r is strain

D is the deflection (in.)

d is the thickness of specimen (in.)

L is the length of span (in.)

### 1.5.3 Impact Property Testing

The impact properties of the polymeric materials are directly related to the overall toughness of the material that indicates the ability of the polymer to absorb applied energy. An impact test can be divided into six major classes as

- Pendulum impact test
- High-rate tension test
- Falling weight impact test
- Instrumented impact test
- High-rate impact test
- Miscellaneous impact test

However in this study the Pendulum impact test is only mentioned. Especially for the Izod impact test that is expressed in term of kinetic energy consumed by the pendulum in order to break the specimen. The specimen used in the test is usually notched to provide a stress concentration area that promotes a brittle rather than a ductile failure. The Izod test requires a specimen to be clamped vertically as a cantilever beam. The specimen is struck by a swing of a pendulum released from a fixed distance from the specimen lamp.