

CHAPTER I

INTRODUCTION

1.1 General Introduction

The birth of polymer science started in the mid-nineteenth century [53]. In the 1830s, Charles Goodyear developed the vulcanization process that transformed the sticky latex of natural rubber to a useful elastomer for tire [53]. In 1874, Christian F. Schonbein reacted cellulose with nitric acid to produce cellulose nitrate [53]. This was used as the first man-made thermoplastic namely celluloid. In 1907, Leo Bakeland produced Bakelite (phenol-formaldehyde resin) [53]. In 1912, glyptal (unsaturated polyester-resin) was developed as a protective coating resin by General Electric Company [53].

By the 1930's, Du Pont had produced new polymers including synthetic rubber, nylon and Teflon [53]. In 1838, Dow Chemical Company produced polystyrene [53]. In 1939, low-density polyethylene was made by ICI Company. Ziegler and Natta developed stereospecific transition-metal catalysts in the 1950's that led to the commercialization of polypropylene as a major commodity plastic [53].

Polymer are commercial materials including elastomers and fibers. In general, additives are usually added into polymers. They are added to improve some properties such as the processability, the thermal or

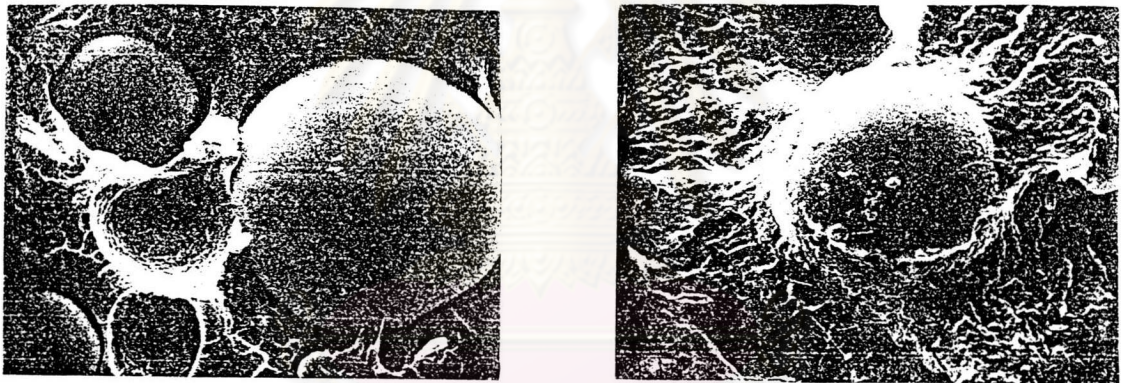
environmental stability and the mechanical properties of the final products.

Filler, a kind of additive was first used in the rubber industry even before the discovery of vulcanisation. Nowadays fillers are used as extenders in vulcanised rubber. It was not until the 1920's that the first carbon black was used [2]. Various types of carbon black were introduced from lamp black to channel black and then to the modern furnace black [13]. Other non-black fillers were introduced from precipitated calcium carbonate, silicas and silicates.

In the plastics industry, phenolic resins had been reinforced with fillers. Wood flour and clay are also used to minimize mold shrinkage. In polyester and epoxy resins, calcium carbonates and clays are used to increase the viscosity of the liquid which tends to cling to the glassfibers in the lay-up stage. In PVC, clays have been used at high loading in flooring sheet, it serves to improve the compression strength resilience of the PVC material. In the field of thermoplastic, the use of fillers had not been widespread until the cost of polymers increased with the rising cost of oil and natural gas. In some cases, mica, talc, glass flakes and glass spheres have been used to make the polymer more rigid, to increase the heat distortion temperature and to decrease the mould shrinkage.

In the early days, surface treatment of fillers in the rubber industry were performed on some fillers such as precipitated calcium carbonate because of its tendency to form aggregates. Hence, it is believed that the use of surface-coatings will give better dispersion of the fillers and thus

there is less tendency to delay the curing process. In the case of plastics, the addition of a high quantity of fillers may result in a loss of strength. This is because the deformation of polymer matrix is more elastic than that of the filler. The failure mechanism of composites acted by the matrix are pulled away from filler and void are formed, as shown in Fig.1.1. Bonding of the filler to the polymer by a coupling agent helps preventing the separation at the interface and thus a stronger material is achieved [57].



(a) No coupling agent. b) One percent silane coupling agent.

Figure 1.1: Fracture surface of glass sphere-filled PA 6.

A further action of the surface coating is used to prevent the formation of filler agglomerates. As a result a better dispersion of the filler is seen in the polymer. In addition, the delamination due to the adsorption of water by the coated glassfiber is reduced [56].

Today, polymeric materials are used in broad areas of applications. For example, a modern automobile contains over 300 pounds (150 kg) of plastics, and this figure has not yet included paint, tire or fiber in tires and upholstery. The new aircraft incorporates increasing amounts of polymer and composites. Transportation industry prefers using plastics and composites whenever possible because of their low weight which consequently reduces fuel consumption. In future, polymers will continue to replace metals in the automotive and aircraft industries. Similarly, the construction industry such as piping, resilient flooring, siding, thermal and electrical insulation, paints and so on.

1.2 The Purposes of the Present Study

This research aims to study the utilisation of mineral in thermoplastics. High density polyethylene (HDPE) is selected to represent commodity thermoplastic in this thesis.

The mineral fillers used in this research are calcium carbonate and talc. In addition, carbon black will also be employed. Interfacial affinities between HDPE and fillers are modified by the use of a coupling agent. Titanate type of coupling agent will be applied in the present study. Silane coupling agent have been developed as effective treatments for siliceous fillers but it is not suitable for non-siliceous fillers such as calcium carbonate which does not generally respond to silanes. Recently titanate coupling agent have been used to improve the affinities between all fillers and polymer matrixes. Hence titanate coupling agents were used in this thesis.

This research will also introduce factorial design method to find factors that really effect and their interaction. The simplest factorial design of two-level full or 2^k factorial design is well suited to deal simultaneously with several factors. The objective of this study was to determine the effect whether five factors which are CaCO_3 with and without coupling agent, talc with and without coupling agent and carbon black, will affect the HDPE. A brief description of the method used in the experimental design and the calculation will be given in Chapter II.



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