

# CHAPTER I

## INTRODUCTION

### 1.1 The purpose of the investigation

Natural rubber (NR) latex has been widely used to produce gloves with regard to its excellent physical properties, comfort and feel. Tack and high surface friction of NR gloves are still problems for the quality of the products in the industrial uses and require more attentions for the improvement. In order to reduce the surface friction of rubber film, powder such as talc or cornstarch is traditionally applied. However, the contamination of powdery materials causes problems especially in the electronic and the biomedical applications. Grafting poly(methyl methacrylate) (PMMA) on the NR film surface has been recently developed in order to increase the surface hardness, roughness and, hence, to decrease the friction coefficient of rubber [1-3].

In the rubber industry, besides carbon black, silica is another reinforcing filler used to impart specific properties to rubber compounds. Silica provides a unique combination of tear strength, abrasion resistance, aging resistance and adhesion properties [4]. However, mechanical mixing between silica and rubber is indeed a challenge because silica has a number of hydroxyl groups on the surface, which results in strong filler-filler interactions and adsorption of polar materials by hydrogen bonds. Since intermolecular hydrogen bonds between hydroxyl groups on the silica surface are very strong, the silicas can aggregate tightly. This leads to a poor dispersion of silica in a rubber compound [5]. One of the methods for overcoming these difficulties is to generate silica in the rubber matrix during processing or polymerization. The *in situ* formation of silica is achieved by polymerization of tetraethoxysilane (TEOS) via a sol-gel process. The advantage of the *in situ* generation over the mechanical mixing is that rubber and silica are able to interact more intimately, lowering the agglomeration of each particle. The composite containing *in situ* silica had a higher tensile modulus and tear strength than the composite prepared by conventionally mixing with silica powder [6].

The use of coupling agents is also suggested as an alternative method to improve the rubber–filler interaction, by increasing the adhesion and compatibility of the organic rubber and inorganic fillers. Silane coupling agent contains two different functional groups—one that is attracted or reacting to the polymeric matrix and the other that is absorbed or chemically bonded by the surface of filler. The main role of coupling agents is to promote adhesion which will result in developments in mechanical and electrical properties such as tensile and flexural strength, fracture toughness, tensile modulus, bulk electrical properties, dielectric coefficient, etc. [7]. The first commercially available coupling agents which were the highly reactive 3-mercaptopropyl trimethoxysilane were suggested for sulfur-cured compounds. Vinyltrimethoxysilane and  $\gamma$ -methacryloxypropyl trimethoxysilane ( $\gamma$ -MPS) are for peroxide-cross-linked rubber compounds. With the addition of these silanes, a marked increase in the reinforcement of the silica-filled composite was achieved. The  $\gamma$ -MPS monomer can be incorporated into the polymer chains by conventional free radical copolymerization reaction. Also, the trimethoxysilyl groups in the other end of the chain can undergo hydrolysis/condensation reactions resulting in cross-linking of the hybrid film [8]. In the present work, the graft copolymerization of NR with MMA (NR-g-MMA) was prepared using CHPO/TEPA as a redox initiator system. To reinforce the MMA grafted rubber, *in situ* generation of silica from TEOS was performed. The silane coupling agent,  $\gamma$ -MPS, was also used to improve the adhesion and compatibility of silica/NR-g-MMA composites.

## 1.2 Objective

The aim of this work was to prepare the latex of NR-g-MMA- $\gamma$ -MPS. The latex was subsequently mixed with TEOS, which was heated to activate *in situ* silica formation in the rubber matrix for good grafting efficiency. Besides, silica formation behavior, silica particle size and particle size distribution were also investigated in detail.

### 1.3 Scope of the investigation

The stepwise investigation was carried out as follows:

1. Literature review for methods to prepare *in situ* silica/NR composites.
2. Graft copolymerization of NR with MMA using the mentioned redox initiator system in a latex form.
3. Grafting of  $\gamma$ -MPS in the latex containing NR-g-MMA and TEOS.
4. Preparation of *in situ* silica/NR-g-MMA- $\gamma$ -MPS composites by a sol-gel process of the mixed TEOS.
5. Characterization of the morphology and thermal property of the composites.
6. Summarizing the results and writing the thesis.