CHAPTER I

INTRODUCTION

1.1 The purpose of the investigation

Natural rubber latex is used to produce thin film products such as gloves and condoms, which require high elongation and excellent resilience. Nevertheless, NR has some weak characteristics, such as low tensile strength and modulus. One of the techniques to improve the properties of natural rubber products is the reinforcement by silica particles. Silica reinforcement is conventionally achieved by mixing fine silica powder with solid rubber or by mixing aqueous slurry of silica with NR latex [1]. However, in the mixing process, silica particles tend to aggregate and agglomerate due to intermolecular hydrogen bonding between the hydroxyl groups on the silica surface. This often results in poor particle dispersion in the rubber matrix and high viscosity during mixing [2]. The silica can also adsorb or react with curing agents and accelerators on its surface which results in the reduction of curing efficiency [3]. The other important difficulty is the incompatibility of inorganic silica with the organic rubber.

A method for overcome these problem is to generate silica particles within the NR matrix. *In situ* silica formation is achieved by the sol–gel process of a silica precursor, such as tetraethoxysilane (TEOS), within the latex. The success use of TEOS was reported in many latex systems, such as styrene butadiene rubber (SBR) and nitrile rubber [4], and NR [5-7]. However, the silanol groups of silica particles remain on surface. These groups are highly polar and thus they are incompatible with the natural rubber matrix.

Alkyltrialkoxysilanes were introduced as an alternative way to improve the compatibility with NR matrix. The compounds carry three alkoxy groups, required for bonding with silica, and one alkyl substituent, designated for *bonding* or *interacting* with rubber matrix. Alkyltrialkoxysilanes are used to chemically modify silica surfaces by hydrolysis and condensation, in order to improve the filler dispersion and prevent adsorption of curing agents on the silica surface. Some functional groups such

as alkyl, amine, and vinyl groups can be introduced by selecting the right choice of alkyltrialkoxysilanes [8, 9].

Earlier the uses of TEOS and alkylalkoxysilanes in natural rubber latex were reported [5-7]. The composite containing *in situ* silica had higher tensile modulus and tear strength than the composite prepared by conventionally mixing with silica powder. Bis-(3-triethoxysilylpropyl)tetrasulfide (TESPT) were mixed with TEOS into natural rubber latex for the formation of silica inside the rubber matrix. The presence of TESPT resulted in an increase of mechanical properties and sulfur curing rates [5]. Vinyltriethoxysilane (VTOS), ethyltriethoxy-silane (ETOS), and i-butyltriethoxysilane (BTOS) were reportedly used to generate *in situ* silica. Among the three alkyltriethoxysilanes, VTOS seemed to be the most promising silane that was able to enhance the tensile modulus and resistance to tear of the rubber vulcanizates. However, it was possible that mixing of rubber and other chemicals by a two-roll mill before curing could cause silica aggregation that affect to the reinforcing efficiency [7].

In this work, the focus was to generate the NR films reinforced by *in situ* silica. The films were prepared by dipping process. TEOS were used in combination with three types of alkyltrialkoxysilanes to prepare the *in situ* silica with alkyl group on its surface or *alkylated* silica. It was hypothesized that the *in situ* alkylated silica particles can improve the dispersibility and mechanical properties of the NR/silica dipped films.

1.2 Objectives

The aim of this research was to reinforce dipped NR films by *in situ* alkylated silica particle. The use of TEOS and three alkyltrialkoxysilanes; VTOS, ETOS, and methacryloxypropylmethoxysilane (MPS) as precursor were studied. Morphology, thermal property, and mechanical properties of the NR/silica dipped films were analyzed.

1.3 Scopes of the investigation

Stepwise investigation was carried out as follows:

1. Determination of a standard procedure to prepare NR/silica dipped films with the emphasis on the mixing procedure and degree of conversion of alkoxysilanes in the rubber latex.

2. Characterization of the morphology, thermal property, and mechanical properties of the NR/silica dipped films.

3. Summarizing the results and writing the thesis.