

Chapter 4

Natural Rubber and Rubber Blend Nanocomposites: Reinforcement of Natural Rubber with Polymer–Encapsulated Inorganic Nanohybrid Particles

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ABSTRACT

Natural rubber (NR) is representative biomass polymer and the effective uses are strongly contributed to sustainable society. This chapter presents the innovative and advanced rubber nanocomposites with polystyrene-encapsulated silica nanohybrids (PS- $n\text{SiO}_2$) subsequently used as a nanofiller for NR and NR/styrene butadiene rubber (NR/SBR). The PS- $n\text{SiO}_2$ were prepared via ‘in situ’ differential microemulsion polymerization. The core-shell nanohybrids of PS- $n\text{SiO}_2$ were achieved with an average diameter of 40 nm using a smaller amount of surfactant, compared to microemulsion polymerization method. Moreover, the effects of the NR and NR/SBR filled with PS- $n\text{SiO}_2$ nanohybrids on the mechanical properties, thermal stability, flammability and morphology are also discussed. The results indicated that the encapsulation of $n\text{SiO}_2$ with PS can provide not only the well-dispersion of nanoparticles in the rubber matrix but also the synergistic properties of two components from the polymer and the inorganic nanoparticles by improving mechanical properties, thermal stability and flammability of rubber nanocomposites.

INTRODUCTION

Natural rubber (NR) is an outstanding natural bio-based polymer that widely utilize in many applications. NR is known to exhibit numerous excellent properties; however, reinforcing fillers are necessarily added into NR in order to enhance the appropriate characteristics for a variety of the applications. Generally, the activity of reinforcing fillers depends on their primary particle size (Hewitt, 2007). Therefore, reinforcing nanoparticles play an important role to improve the NR properties for example, the large

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surface area, which leads to the high interfacial adhesion between NR and nanoparticles. However, Most of reinforcing fillers contains a large number of hydroxyl groups (-OH groups) on their surface and causes the strong filler-filler interactions, leading to the reinforcing particle aggregation. Moreover, the acidity (-OH groups) of the fillers results in the adverse effect on the NR curing system. This is due to the interaction between -OH groups on the surface of nanoparticles and basic accelerator in sulphur curing system (Choi, 2001). In order to enhance dispersability of nanoparticles and interaction between nanoparticles and rubber matrix, inorganic nanoparticles are usually encapsulated by polymer molecules such as polystyrene (PS) (Chuayjuljit & Luecha, 2011) and poly(methyl methacrylate) (PMMA) (Chuayjuljit, Sukasem, & Boonmahitthisud, 2014). Besides the enhanced dispersibility of nanoparticles, the polymer-encapsulated inorganic nanohybrid materials may exhibit the synergistic effects of polymer encapsulating onto nanoparticle and give the potential for preparing advanced engineering materials with specific and enhanced properties. Among various polymerization methods, 'in situ' differential micro-emulsion polymerization method is an advanced technology to prepare nanosized encapsulation fillers.

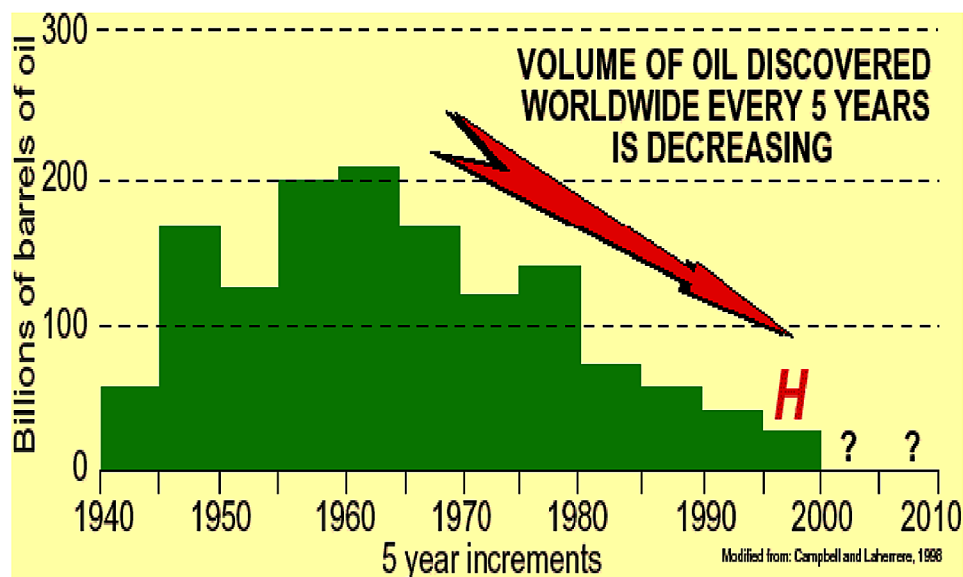
In this chapter, the author presents the novel technique to synthesize polymer-encapsulated silica nanohybrid particles with small average diameter below 50 nm by means of 'in situ' differential micro-emulsion polymerization for applying as a reinforcing nanofiller in rubber nanocomposites.

BACKGROUND

The rapidly increasing human population growth caused an increasing demand on the limited resources of petroleum. While the demand for world crude oil is growing at 2 percentages each year, the volume of a newly discovered oil has decreased dramatically every five years since the early 2000s (Figure 1). This has caused the impending world oil shortage and facing the rising oil price (Lindgren, 2003).

Figure 1. The volume of oil discovered worldwide during 1940-2000

Source: Lindgren, 2003



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