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Effect of Ball Milling Parameters on Properties of Attapulgite Filled Natural Rubber Composite

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Abstract

Natural rubber (NR)/attapulgite (ATP) composites was prepared via combination latex compounding and melt mixing. Ball milling method was tailored to improve the ATP dispersion before compounded with latex. The aim of this paper is to investigate the effect of ball milling parameters and operating conditions which were focusing on ball mill size and ball mill ratio on the tensile and morphological properties of NR/ATP composites. Mechanical testing such as tensile test and hardness test were subjected to the samples. The composite was characterized with scanning electron microscopy (SEM) to reveal the effect of ball milling parameters on the morphological properties of the composites. Swelling measurement was done to determine the crosslink density of the composites. A ball to weight ratio (BPR) of 1:5 and large size ball mill were found as the optimized milling parameters for NR/ATP composites.

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1. Introduction

Recently, polymer-layered silicate nanocomposites (PLSN) has become a great attraction to researchers because they show improvements in some properties with only a small amount of filler inserted[1-6]. The dispersion state of silicates in a polymer has tremendous effect on the properties of PLSN. An ideal exfoliated state is one of the

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ultimate aims in the fabrication of PLSN, because it has homogenously dispersed silicate plates in a polymer matrix.

The use of filler in polymeric systems has become worldwide. Fillers help in modifying the properties of polymers and reducing the cost of the composites. In rubber composites industry, the common filler used are carbon black and silica because of their features that improve the product's performances[7]. Researchers have been using a variety of fillers including inorganic types of fillers in order to enhance the mechanical properties of polymers and hence replace the use of carbon black since it is very costly[8]. The properties can be designed by changing the volume fraction, shape, and size of the filler particles [9-11]. A further improvement of the mechanical properties can be achieved by using filler materials with a larger aspect ratio. Fillers with the dimension in nanometres level with larger aspect ratio will have better dispersion and hence improve the mechanical properties performances of the composites. Layered silicates are an example of various filler groups that exhibits those features[11].

In polymer nanocomposites preparation, clay is the most commonly used mineral to incorporate in the polymer matrix. Clay has layered structure and easily disperses in the matrix. However, the dispersion of clay in the polymer is usually poor due to their incompatibility with polymers since the polymer is hydrophobic while the clay is hydrophilic. This is due to the presence of hydroxyl group on the clay surface [12,13] that increases the tendency of agglomeration to occur and influence the dispersion of the particle in the matrix. Moreover, the strength of interactions between the organic and inorganic phases is the most determining factor affecting the properties of the obtained materials. It is because of the differences between the nature of polymer and inorganic fillers which can often cause phase separation[13].

Homogenous distribution and dispersion of clay particles in polymer matrix is very important for the improvement of mechanical properties of polymer matrix composites. An ideal exfoliated state is one of the ultimate aims in fabrication of polymer-layered silicate nanocomposites (PLSN), because it has homogenously dispersed silicate plates in a polymer matrix. In order to get a homogenous dispersion, ball milling technique is used. Shaw et al. (1992), first investigated the possibility application of ball milling to produce polymer matrix composite. They produced polypropylene/SiC composite by ball milling under ambient temperature[13]. Ball milling is a type of grinding method used to grind materials into more fine sizes [14]. Apart from that, it is also one of the most effective and economical methods to produce samples with nanosized structure[15]. During milling, the samples undergone high-energy impacts by balls which result in defects and give rise to nanometer crystallite size and phase transformation[15].

In this study, the mixing process of ATP dispersion using ball milling under ambient temperature was performed and the aim of this work was to investigate the effect of ball milling parameters on properties of ATP filled NR composites.

2. Materials and Experimental

2.1 Materials

Attapulgite, antioxidant, anchoid and calcium chloride were supplied by Sigma Aldrich (M) Sdn. Bhd. while SMR 20, High Ammonia Latex with 60% TSC and some compounding ingredients were supplied by Zarm & Chemical Supplier Sdn. Bhd. Clay dispersion was prepared by stirring vigorously for 2 hours. The dispersion was than ball milled for 48 hours to obtain homogenous suspension. The suspension was compounded with latex. The composites were subjected to mechanical and morphological testings.

2.2 Milling Procedure

Prior milling process, ATP was first mixed together with water, 10% KOH solution and anchoid. Then the mixture was stirred vigorously using a magnetic stirrer for approximately 2 hours to homogenize the dispersion. After 2 hours, the dispersion was put in the ball mill jar and milled up to 48 hours to obtain a homogenous suspension. Frictional forces from edge-to-face particle association caused the dispersion turned into a paste-like clay/water dispersion. The milling process parameters are listed in Table 1.