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Tensile Properties and Morphology of Epoxidized Natural Rubber/Recycled Acrylonitrile-Butadiene Rubber (ENR 50/NBRr) Blends

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Abstract

Epoxidized natural rubber (ENR 50) has been introduced to the elastomeric group of materials as a modified form of natural rubber. ENR 50 is a modified natural rubber having properties resembling those of synthetic rubbers rather than natural rubber. ENR 50 is miscible with polar rubber such as acrylonitrile-butadiene rubber (NBR). ENR 50 has unique properties such as good oil resistance, low gas permeability, improved wet grip and rolling resistance, as well as high tensile strength. However, the market and applications for ENR 50 is limited. In this research, NBR gloves have been used as recycled NBR (NBRr) which have excellent resistance to punctures, tears and many types of chemicals. Blending ENR50 with recycled NBR is the easiest and cheapest ways to tailor the properties of ENR 50 and at the same time reduce the material cost. ENR 50/NBRr blends were prepared by two-roll mill at five different compositions (i.e., 95/5, 90/10, 85/15, 75/25, and 65/35). Tensile properties such as tensile strength, elongation at break and modulus were carried out to determine the compatibility between ENR 50 and NBRr. Results indicated that blending ENR 50 with NBRr improved all the tensile properties (tensile strength, modulus and elongation at break) compared to the NR/NBRr blends. Scanning electron microscopy (SEM) of tensile fracture surfaces showed a better adhesion between ENR 50 and NBRr such that improved the compatibility of ENR 50/NBRr blends.

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Keywords: ENR 50; NBRr; Tensile properties

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1. Introduction

Malaysia is the world's largest exporter and producer of both nitrile and natural rubber gloves. The world's glove market has been rising recently due to such aspect like emergence of diseases such as H1N1, increase affluence and health awareness of the world population and recession proof industry as glove is a necessity regardless of economic condition. The environmental problems caused by waste rubber have become an important issue in rubber industry. There has been a great deal of interest in the polymer industry about the development of cost effective techniques to convert waste and used rubber into processing form. The practice of recycling has been encouraged and promoted by increasing awareness in environmental matters and the subsequent desire to save the resources. To solve this environmental issue, recycled NBR gloves have been used in rubber application as an effort to create a value added instead of being scrapped [1-6].

Elastomer blends are frequently used in the rubber industry to obtain the best compromise in compound physical properties, processability and cost[7, 8]. Epoxidized natural rubber (ENR 50) has been introduced to the elastomeric group of materials as a modified form of natural rubber. ENR 50 is a modified natural rubber having properties resembling those of synthetic rubbers rather than natural rubber. Instead ENR 50 is miscible with more polar rubber. ENR 50 has unique properties such as good oil resistance, low gas permeability, improved wet grip and rolling resistance, coupled with high strength. However, the market and applications for ENR 50 was found to be limited. As mention above, blending with other rubbers is the easiest and cheapest ways to tailor the properties of ENR 50 and at the same time reduce the material cost[9-12]. Ismail et al. [13] reported that the tensile strength and elongation at break of the blends decrease gradually with % NBR, an observation which is ascribed to the decreasing effect of strain-induced crystallization of SMR L and ENR 50 as NBR content is increased in the respective blends. Ismail and Leong [9] also reported that positive deviation of tensile modulus, hardness and tensile strength indicates that synergism has occurred in the ENR 50/CR and SMR L/CR blends.

Many blends based on ENR and other polymers, like SBR[3], NR[4,6], CR[9], and EVA[10] have been reported. However, no attempt has been made to investigate the effects of ENR 50 blends with recycled NBR. The effects on tensile properties and morphological behaviour of ENR 50/NBRr blends were examined.

2. Methodology

2.1. Materials

Natural rubber (SMR L) was supplied by Rubber Research Institute of Malaysia (RRIM). The recycled NBR glove was supplied by Juara One Resources Sdn. Bhd., Bukit Mertajam, Penang, Malaysia. Epoxidized Natural Rubber (ENR-50) was supplied by Malaysian Rubber Board. Carbon black (N330) was purchased from Malayan Carbon (M) Ltd. The compounding ingredients such as zinc oxide (ZnO), stearic acid, N-cyclohexyl-2-benzothiazolesulfenamide (CBS), N -isopropyl -N'-phenyl-phenylenediamine (IPPD), and sulfur were supplied by Bayer (M) Ltd (Petaling Jaya, Malaysia).

2.2. Preparation of blends

The ENR 50/NBRr blends were prepared at different blend ratios and the formulation is shown in Table 1. Five different compositions were prepared and mixed using a laboratory-sized two-roll mill (160 mm x 320 mm), model XK-160, in accordance with ASTM method D3184-80. Cure characteristics were studied using a Monsanto Moving Die Rheometer (MDR 2000). The samples (approximately 4g) of the respective compounds were tested at the vulcanization temperature of 150^{o}C and the rubber compounds were then compression molded at 150^{o}C using a hot press according to respective cure time, t_{90}.