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RHEOLOGICAL AND PHYSICO-MECHANICAL PROPERTIES OF HYBRID CARBON BLACK/PALM KERNEL SHELL BIOCHAR (CB/PKSBC) FILLED CARBOXYLATED NITRILE BUTADIENE RUBBER (XNBR) COMPOSITES

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ABSTRACT

Palm oil related industry has been developing and blooming very well nowadays which would lead to abundance of palm oil waste. These palm oil waste especially palm kernel shell (PKS) can be turned into palm kernel shell biochar (PKSBc) and used as a natural filler in rubber composites. PKSBc has the potential to be a co-filler to carbon black (CB). CB is a commercialized reinforcing filler and widely used in the rubber industry, however it is a potential carcinogen and a petroleum-based product which is non-renewable and less sustainable. Hence, in this study, PKSBc is utilized to hybridize with CB (N660) in the efforts of managing and benefiting palm oil waste and finding sustainable way to reduce usage of CB. This research aims to elucidate the effect of hybrid CB/PKSBc at varying loading on the rheological properties and physico-mechanical properties of carboxylated nitrilebutadiene rubber (XNBR). In this study, both CB and PKSBc are incorporated into XNBR and was then cured with sulphur. The compounds were prepared by using a two-roll mill. Different compositions of hybrid CB/PKSBc were incorporated. The rheological properties, crosslink density and physico-mechanical properties such as tensile strength, elongation at break, modulus, morphological analysis, compression set, abrasion resistance, and hardness of the vulcanizates were investigated. Based on the results, as the loading ratio of PKSBc increases, the physico-mechanical properties of XNBR composite decreases except abrasion resistance and hardness where high loading of PKSBc maintains these two properties. Hybridization of CB and PKSBc at optimum ratio of 30/5 phr, the XNBR composite achieved high tensile strength, low elongation at break, high M100 and M300, high reinforcement index, high abrasion resistance (low volume loss), high hardness and low compression set. Therefore, this approach of using eco-friendly filler derived from palm oil agricultural waste (PKSBC) can reduce the abundance of palm oil waste, be a sustainable alternative to act as co-filler in hybrid CB/PKSBc to decrease usage of CB and helps to enhance quality of existing rubber-based products especially for shoe sole application in the footwear industry.

Keywords: *Carbon Black (N660), Palm Kernel Shell Biochar (PKSBc), Carboxylated Nitrile Butadiene Rubber (XNBR), Rheological Properties, Mechanical Properties*

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CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Rubber is a strong, durable, and affordable material which is widely used and preferred in all sorts of industries. Malaysian Rubber Council (MRC) reported that Malaysia's consumption of rubber in 2021 had an increment of about 4.8% where it increased to 1225.8 thousand tons from 1170.1 thousand tons in 2020 [1]. That is just for Malaysia alone. As for the consumption of rubber in the world for the year 2021 in comparison with 2020, an increment of 10.6% was recorded, from 26.9 million tons to 29.7 million tons [1]. As the years go by, these numbers are expected to increase further. Since rubber is a viscoelastic material, rubber has both elastic and damping behaviour [2]. These are so called elastomers which exhibits elastic or viscoelastic behaviour [3].

Ionized groups are introduced into rubbers to help producing and tailoring physical and mechanical properties in a broad range [5]. Such ionomers have the ability to exhibit the behaviour of re-healing properties whenever there is an increase of temperature [6]. An example of ionomer would be carboxylated nitrile butadiene rubber (XNBR) as it contains ionizable carboxylic acid groups with the addition of having acrylonitrile monomers and carbon-carbon double bonds. Since XNBR has highly polar, XNBR is usually used in applications which require resistance to oil such as hoses and seals. It can also be utilized as memory shape material [7-9].

There are many filler types available in the rubber industry and it can either be organic or inorganic [10]. Carbon black, clay, calcium carbonate and calcium silicate are examples of fillers. When filler is added, filler helps to increase the modulus, abrasion and tear resistance of the rubber [11]. In the rubber industry, carbon black plays an important role as a reinforcing filler [12-13]. Carbon black (CB) is widely used and the dominant filler in the rubber industry because of its reduced particle size and has a huge range of grades. Hence, the mechanical properties of rubber are improved. The reinforcement effect of carbon black is also because of the strong interactions between therubber and the surface of CB [14]. However, there are disadvantages of using CB in rubber compounding. CB is known to be a petroleum-based product, hence it is not renewable and sustainable. Once the