THE EFFECT OF KENAF LOADING AND HYBRIDIZATION OF KENAF WITH EMPTY FRUIT BUNCH FIBERS OR HALLOYSITE NANOTUBE ON PROPERTIES OF NATURAL RUBBER LATEX FOAM

SITI NURUL IZZATI BINTI KUDORI

UNIVERSITI SAINS MALAYSIA

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by

SITI NURUL IZZATI BINTI KUDORI

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LIST OF SYMBOLS

°C	Degree celcius
μm	Micron meter
g	Gram
g/cm^3	Gram per cubic centimeter
mm	Milimeter
mm/min	Millimeter per minute
Mm^2	Cubic milimeter
MPa	Megapascal

LIST OF ABBREVIATIONS

CFC	Chlorofluorohydrocarbons
CO	Carbon monoxide
CO_2	Carbon dioxide
DPG	Diphenylguanidine
DRC	Dry rubber content
E_b	Elongation at break
EFB	Empty fruit bunch
EPDM	Ethylene propylene diene monomer
HCN	Hydrogen cyanide
HDPE	High density polyethylene
HFC	Hydrofluorocarbon
HNT	Halloysite nanotube
NRLF	Natural Rubber Latex Foam
M_{100}	Modulus at 100% elongation
PC	Polycarbonate
PE	Polyethylene
PP	Polypropylene
PS	Polystyrene
PU	Polyurethane
PVC	Polyvinyl chloride
SEM	Scanning electron microscopy
SSF	Sodium silicofluoride
TSC	Total solid content
UV	Ultraviolet

ZDEC	Zinc diethyldithiocarbamate
ZMBT	Zinc 2-mercaptobenzothiolate

KESAN PEMBEBANAN KENAF DAN PENGHIBRIDAN KENAF DENGAN GENTIAN TANDAN KOSONG KELAPA SAWIT ATAU TIUB NANO HALOISIT KE ATAS SIFAT-SIFAT BUSA LATEKS GETAH ASLI

ABSTRAK

Penyebatian kenaf di dalam busa lateks getah asli (NRLF) telah disediakan melalui kaedah Dunlop. Morfologi, sifat-sifat tegangan, ketumpatan busa, pemampatan kekerasan dan penuaan terma NRLF terisi kenaf telah dianalsis dalam kajian ini. Kandungan kenaf 'core' dan 'bast' yang berbeza (0,1,3,5,7 phr) telah dikaji. Kekuatan tegangan, pemanjangan pada takat putus (E_b) dan kekuatan mampatan NRLF terisi 'core' atau 'bast' berkurang dengan peningkatan pembebanan kenaf. Walaubagaimanapun, modulus pada pemanjangan 100% (M_{100}), kekerasan dan ketumpatan NRLF telah meningkat dengan peningkatan pembebanan kenaf. Penambahan kenaf 'core' ke dalam NRLF telah meningkatkan peratusan pembengkakan dan peratusan retensi penuaan berbanding kenaf 'bast'. Keputusan pengimbasan mikroskop electron (SEM) menunjukkan yang kenaf 'bast' bergentian mempunyai lekatan kuat berbanding kenaf 'core' zarahan menghasilkan kekuatan tegangan, E_b dan kekuatan mampatan yang lebih tinggi. Kesan perbezaan saiz kenaf 'bast' (97, 144, 200 µm) terisi NRLF juga telah dikaji. Keputusan menunjukkan saiz kenaf yang lebih kecil didalam NRLF meningkatkan kekuatan tegangan, kekuatan mampatan, set mampatan dan kekerasan pada kandungan kenaf yang sama. Saiz tetingkap sel meningkat apabila saiz pengisi meningkat. Penghibridan kenaf/tandan kosong kelapa sawit (EFB) telah menunjukkan bahawa saiz tetingkap sel menjadi lebih besar dengan peningkatan kandungan EFB menyebabkan pengurangan di dalam sifat-sifat mekanik. Untuk penuaan terma, NRLF terisi EFB mempunyai

peratusan retensi kekuatan regangan dan M_{100} lebih tinggi berbanding NRLF terisi kenaf. Penggantian tiub nano haloisit untuk NRLF terisi kenaf menggalakkan tetingkap sel untuk bergabung antara satu sama lain dan meningkatkan lagi pembentukan tetingkap sel yang lebih besar.

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ABSTRACT

Natural rubber latex foam (NRLF) become great interest to the society due to its function in various applications. However, the usage of natural filler in NRLF from previous literature are do not perform very well. The aim of this research was to produce NRLF with different component of kenaf and hybridization of kenaf with Empty Fruit bunch (EFB) and Halloysite Nanotube (HNT) in order to provide good mechanical and physical properties. The incorporation of kenaf in natural rubber latex foam (NRLF) was prepared by using Dunlop method. Morphology, tensile properties, density, compression, hardness and thermal aging of kenaf filled NRLF were analysed in this work. The different loading of kenaf core or bast (0,1,3,5,7 phr) was studied. The tensile strength, elongation at break (E_b) and compressive strength of kenaf core or bast filled NRLF samples decreased as the loading of kenaf was increased. However, the modulus at 100% elongation (M_{100}), hardness and density of NRLF increased with increasing kenaf loadings. The addition of kenaf core into NRLF increased the swelling percentage and retention percentage of aging compared to the kenaf bast. Scanning electron microscope (SEM) results indicated that the fibrous kenaf bast had strong adhesion compared to the particulate kenaf core, resulting higher tensile strength, E_b and compression strength. The effect of different size of kenaf bast (97, 144, 200 μm) filled NRLF was also studied. It revealed that the smaller size of kenaf filled NRLF showed higher in tensile properties, compression strength, compression set and hardness at the same kenaf loading. The

size of the window cell increases as size of the filler increased. The hybridization of kenaf/ EFB showed that the size of cell window become larger with increasing EFB loading resulting in reduction of mechanical properties. For thermal aging, EFB filled NRLF has higher retention percentage of tensile strength and M_{100} compared to kenaf filled NRLF. The substitution of halloysite nanotube in kenaf filled NRLF promotes the cell window to coalesce each other and increase the formation of larger cell window.

CHAPTER 1

INTRODUCTION

1.1 Background

Foam is a porous structure that made by trapping a solid and gas phase (Sivertsen, 2007). Over the past few decades, foam has attracted increasing attention and has been considered for applications such as automotive parts, acoustic absorbent, and sporting equipment (Mohebbi et al., 2015). Foam has its own advantages as compared to the other types of materials which is lightweight product and low cost. Foam can comes from different types of materials like metal, polymer and ceramic. In addition, 10% of the foam production comes from the polymer materials. (Ariff et al., 2008).

Generally, polymeric foam is made up from the combination of gaseous in the solid polymer matrix. Polymeric foam can be either in thermoplastic, thermoset, cellular elastomers or expanded rubber. Polymer foam was taking place in the industry in early 1914 as sponge rubber (Frisch, 1981). The polymeric foam has brought some development in foam technology. Enormous amount of polymeric foam product are being used in our daily life like disposal packaging, cushioning and furniture. Polymeric foam can be classified into two kinds; closed cell and open cell. Closed cell foam has an enclosed wall and the cells do not interconnecting between one another and it is more rigid. It usually used for noise or thermal insulation, lightweight structure purpose and sealing (Dalongeville et al., 2017). While, for the open cell foam, the cells are broken and thus allowing the air to fill the spaces within. It also gives a unique characteristic to the foam which it can return to its original state after forces are being applied.

Thermoplastic foam is the biggest contributor to the polymer foam production. Thermoplastic is made from petroleum-based, and being categories as non-renewable product. Various types of thermoplastic are commonly used in the foam production like polystyrene (PS), polyurethane (PU), polypropylene (PP), polyvinyl chloride (PVC) and polycarbonate (PC) (Gama et al., 2018). The production of polyurethane foam is higher as compared to the other types of foam. It was approximately 11.5 million tonnes of polyurethane production in 2014 and it estimated to be over 15.5 million tonnes in 2019 (Agrawal et al., 2017). Unfortunately, the growth of the thermoplastic foam brings a greater attention in the environmental sustainability as the world now is facing depletion of the petroleum oil at an alarming rate (Bergeret and Benezet, 2011).

Today, in the growth of environmental awareness, development of green and natural products has become an interesting research topic. Natural rubber latex foam (NRLF) is one of the products that comes from the natural rubber. It can be obtained when a stable dispersion of natural rubber latex (NRL) and chemicals are being converted into a porous solid material. The production of moulded latex foam was founded by the Dunlop Rubber company in 1930 (Lim and Amir-Hashim, 2011). In the 1950s, after recovery from the World War II, 70% of global productions of rubber latex were used to make latex foam. The combination of natural fibers in polymer promotes the development of engineering green materials as it comes from natural or renewable resources.

In early 2010, kenaf was planted in large scale in Malaysia as an alternative crop to replace the tobacco plantation due to reduction in the tobacco price and its import duty (Basri et al., 2014). Kenaf (*Hibiscus cannabinus*) is a tropical plant of

Malvaceae family that yields a fiber resembling jute that can be used for the production of textile and cordage. Every parts of kenaf become crucial in their respective as it is a renewable materials and environmental friendly.

1.2 Problem Statement

These days, commercial foam originated from the oil based item like polyurethane (PU) foam, polyethylene (PE) foam, and polycarbonate (PC) foam. Oil is a inexhaustible asset that we have to moderate as it faces a genuine exhaustion issue. The usage of NRLF act as a promising green foam as it comes from the rubber trees which are renewable resources. The NRLF is indeed an excellent choice for having high level comfort capability and extra durability as compared to the synthetic or blended latex. The NRLF has been used in the bedding and furniture industries for manufacturing mattresses, pillows and automobile products like car seats, cushions and insulation materials (Lim and Amir-Hashim, 2011). Recently, many researchers have been carried out to study the properties of NRLF by using various kinds of fillers. The usage of natural fibers as a filler in NRLF was extensively explored due to their sustainability and renewability characteristics.. Ramasamy et al. (2013) studied the aqeous dispersion of rice husk powder in NRLF. The physical properties of NRLF with different type of filler like rice bran, longan shell and organic fertilizer has been explored by Pornprasit and Aiemrum, (2018). Abdul Karim et al. (2016) reported on the kenaf filled NRLF, however the different loading of kenaf effects on the properties of NRLF. The NRLF with higher loading of kenaf do not perform very well. The previous works have not comprehensively considered the different component of kenaf to be incorporated with NRLF. The incorporation of different components of kenaf in NRLF is another approach for selecting the best properties of different components of kenaf in NRLF.

In this study, different loading of kenaf core or bast was used as a filler in NRLF. This is considered as the fundamental parameter to assess the best component and loading of kenaf filled NRLF. There are several factors that effect on the properties of NRLF like structure, dimension, shape and chemical composition. Moreover, one of the important parameters that affecting the properties of NRLF is the size of the fillers. The particle size has great influence on the reinforcement ability of the fillers (Nourbakhsh and Karegarfard, 2010). However, kenaf had some unfavourable effect on the adhesion and compatibility with the NRLF. This was due to the nature kenaf, which is hydrophilic, as they are derived from lignocellulose. Therefore, employing combinations of different type of filler is one of the approach in order to improve the properties of final product.

The hybridization of kenaf and empty fruit bunch (EFB) from the oil palm waste are being used as filler in the production of NRLF in order to promote green foam product with a great polymeric sponge material for various application like sound absorbance, oil absorbance, upholstery product, pillow and mattress. The EFB waste generated from the industry is estimated to be about $8x10^6$ tons per year (Rozman et al., 2000) The usage of natural fibers from empty fruit bunches could help the oil palm industry in Malaysia to reduce the by-product waste of palm oil (Suzana and Ahmad, 2012). Furthermore, the possibility of utilizing high loading of EFB with kenaf in NRLF will reduce the cost of final product.

Nanofiller has drawn many attentions and be considered as high potential filler materials for improving mechanical and physical properties of polymer matrix. The combination of nanofiller with natural filler will reduce the water absorption