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THE 13TH INTERNATIONAL INNOVATION, INVENTION & DESIGN COMPETITION 2024

EXTENDED ABSTRACTS e-BOOK

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TURNING WASTE TO WEALTH: NANO ACTIVATED PALM KERNEL SHELL FROM OIL PALM INDUSTRY AS A FEEDSTOCK FOR SUSTAINABLE BIO-FILLER PRODUCTION

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ABSTRACT

Malaysia generates a significant quantity of oil palm wastes such as palm kernel shell (PKS) and empty fruit bunch (EFB). These wastes cause pollution and have a negative effect on the environment. Conversion of PKS into activated palm kernel shell (APKS) could change the performance of PKS to a value-added additive. APKS was transformed into nano particle size and the potential of nano-APKS as a sustainable bio-filler was investigated in this research. Different loadings of n-APKS ranging from 0 phr to 10 phr were incorporated in natural rubber (NR) and several testings were conducted such as swelling, hardness, compression set and abrasion resistance. Nano-activated palm kernel shell filled NR compounds were prepared using a two-roll mill. The incorporation of n-APKS in NR matrix has increased the crosslink density by referring to the lower swelling index and compression set values, hardness and ARI. The overall mechanical properties were enhanced due to the homogeneous dispersion and better mechanical interlocking between n-APKS and NR phases until the optimum n-APKS loading which was 5 phr (F4).

Keyword: Activated palm kernel shell, nanoparticles, bio-filler, mechanical properties.

1. INTRODUCTION

Palm oil production is vital to the Malaysian economy as reported by Parveez et al.,[1] where the statistic of production was slightly higher in 2022 compared to 2021 due to the oil palm industry gaining momentum from Covid-19 pandemic to endemic in April 2022. Due to the large production of oil palm, oil palm generates large amounts of waste by-product biomass such as palm kernel shell (PKS) that need to be handled properly to avoid any environmental issues such as serious disposal, pollution and global warming effects. Many approaches have been made to transform PKS into an activated palm kernel shell via pyrolysis. Syawani et al., reported that micron sized APKS particles have a potential to be used as a semi-reinforcing filler and the ability to improve the properties of XNBR [2]. In this study, nano-APKS (n-APKS) was used as a bio-filler and incorporated into the NR matrix for exploring the performance of n-APKS. Different n-APKS loadings from 1 phr to 10 phr were introduced in the NR matrix and the properties of n-APKS filled NR vulcanizates were investigated by conducting swelling measurement, hardness, compression set, and morphological analysis.

2. METHODOLOGY

2.1 Preparation of n-APKS filled NR compounds

Nano Activated Palm Kernel Shell (n-APKS) filled natural rubber (NR) was prepared using a two-roll mill and the formulations were summarized in Table 1.

Table 1 Formulations of n-APKS Filled Compounds

	Formulation					
Ingredient	**1**	**2**	**3**	**4**	**5**	**6**
NR	100	100	100	100	100	100
n-APKS	0	1	3	5	7	10
ZnO	3	3	3	3	3	3
HST	2	2	2	2	2	2
Dispersing agent	2	2	2	2	2	2
Processing oil	5	5	5	5	5	5
TMQ	0.8	0.8	0.8	0.8	0.8	0.8
Accelerator	2.75	2.75	2.75	2.75	2.75	2.75
S	1.3	1.3	1.3	1.3	1.3	1.3

2.2 Testing

Swelling measurement was performed in toluene according to ASTM D3616. Cured test pieces for each formulation were cut and weighed. The samples were immersed in toluene for 5 days and the weights of the swollen samples were taken every day. Swelling index (SI) was calculated. Hardness was measured according to ASTM D2240 by using a Wallace Dead Load Hardness Tester. The compression set test followed the procedure described in ASTM D395B and was performed at 25% compression at 70ºC for 24 h. The compression set was then calculated. Abrasion resistance measurement was conducted according to ASTM D5963 and the abrasion resistance index (ARI) was calculated.

3. FINDINGS

3.1 Swelling Properties

The swelling Index (SI) of n-APKS filled NR vulcanizates is shown in Figure 1. The addition of n-APKS led to reduced SI values till F4 (5 phr) and then increased as the n-APKS loadings were further increased. The decreasing trend of SI is due to better and more interaction between n-APKS and rubber phases resulting in high resistance of toluene to penetrate. On the other hand, the decreasing of the SI is related to the dispersion of n-APKS in NR matrix which contributes to better interfacial interaction between both phases [3].

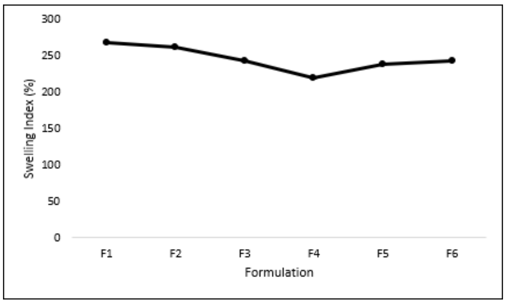

Figure 1 Swelling index of n-APKS filled NR vulcanizates

3.2 Hardness and Compression Set

The results of the hardness and compression set are presented in Figure 2. As can be seen, the hardness is inversely proportional to the compression set. F4 shows the highest and the lowest of hardness and compression set, respectively. This can be explained by the SEM image (Figure 3) which shows that a better dispersion of n-APKS in the NR matrix can enhance mechanical interlocking between both phases thus reducing the compression set [2].

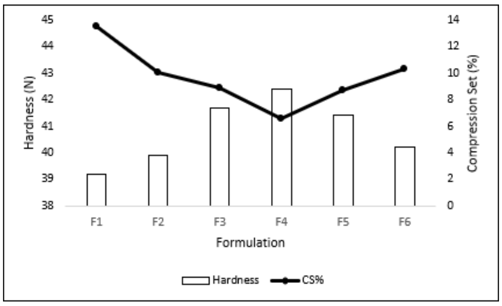

Figure 2 Hardness and compression set of n-APKS filled NR vulcanizates.

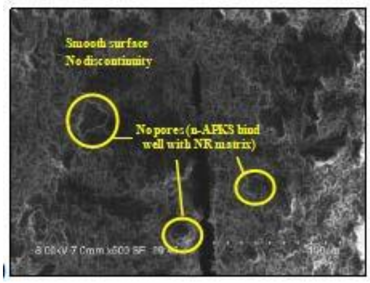

Figure 3 Interfacial interaction between n-APKS and NR phases

3.3 Abrasion Resistance

Figure 4 depicts abrasion resistance index (ARI) of n-APKS filled NR vulcanizates. F4 shows the highest ARI which indicates higher resistance to abrasion. The homogeneous dispersion of n-APKS particles into the NR matrix contributes to a better interfacial interaction between n-APKS and NR phases thus, increasing ARI [2].

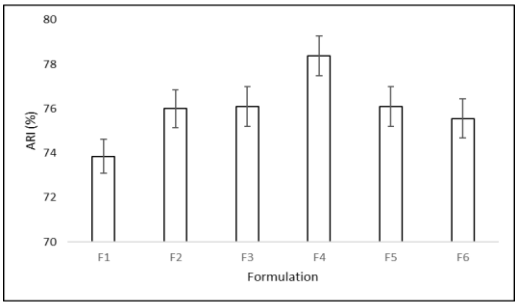

Figure 4 ARI of n-APKS filled NR vulcanizates.

4. CONCLUSION

In conclusion, n-APKS has the potential to be used as a bio-filler in NR. The incorporation of the n-APKS into NR matrix reduced the swelling index and it is indicated that n-APKS particles have a good interfacial interaction with NR phases which restrict the mobility of toluene into vulcanizates. As the optimum loading of n-APKS reached 5 phr, the hardness and the abrasion resistance increased. Beyond the optimum loading, the properties of n-APKS filled NR vulcanizates deteriorated and this might be due to the formation of filler-filler interaction.

REFERENCES

[1] Parveez, G. K. A., Rasid, O. A., Ahmad, M. N., Taib, H. M., Bakri, M.A.M., Hafid, S. R. A., Ismail, T.M.N.T., Loh, S. K., Abdullah, M. O., Zakaria, K. & Idris, Z. (2023). Oil Palm Economy Performance in Malaysia and R&D Progress in 2022, Journal of Oil Palm Research, 35(2), 193-216.

[2] Zainal, S. A., Mamauod, S. N. L., Zainal, N. H, Ismail, H. & Mamauod, M. L. (2024). Preparation and Characterisation of Activated Palm Kernel Shell/Carboxylated Nitrile Butadiene Rubber (APKS/XNBR) Vulcanizate. Journal of Mechanical Engineering, 21(1), 217-235.

[3] Zainal, Z. A., Mamauod, S. N.L., Romli, A. Z., Sarkawi, S. S & Zainal, N. H. (2023). Synergistic Effect of Partial Replacement of Carbon Black by Palm Kernel Shell Biochar in Carboxylated Nitrile Butadiene Rubber Composites, Polymers, 15(943), 1-13.

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