

Evaluation of Suitability of Palmyra Fibre as a Replacement for Coconut Fibre in Carbon Black Filled Natural Rubber Composites

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Introduction

Natural rubber (NR) consists of cis 1,4 polyisoprene. It is an example of elastomeric type polymer, where the polymer has the ability to return to its original shape after being stretched or deformed. Fillers are materials that are particulate in nature, which are added to rubber mixes to modify the physical and, to a very smaller extent, the chemical properties, also to improve the processing characteristics and reduce cost (Briggs et al., 2000). Natural fibres are generally lignocellulose in nature, consisting of helically wound cellulose microfibrils in a matrix of lignin and hemicellulose. Palmyra fibre is an inexpensive fibre among the various natural fibres available in the world. It is abundantly available in Sri Lanka, India, like tropical countries and its density is least among all known fibres including coconut fibre. Therefore, the main objective of this study was to replace coconut fibre with palmyra fibre in carbon black filled natural rubber composites

Methodology

The current study was carried out at the Rubber Technology and Development Department, Rubber Research Institute of Sri Lanka (RRISL), Telawala Road, Rathmalana. Compound preparation and laboratory analysis were done at RRISL laboratory. The effect of different amounts of palmyra fibre on physico-mechanical properties of natural rubber compounds was investigated and the properties were compared with those of coconut fibre filled natural rubber compounds. Test pieces were prepared with the rubber compounds to carry out physico-mechanical testing. The cure characteristics and physico-mechanical properties of the rubber composites prepared with different loadings of palmyra fibre were investigated. For comparison purposes, a series of rubber compounds was prepared using coconut fibre, similar to the quantity of palmyra fibre. Two factor factorial Complete Randomized Design (factorial CRD) was conducted and data obtained from cure characteristics and physico-mechanical properties tests were analysed with analysis of variance (ANOVA) with General Linear Model (GLM) procedure of Minitab 16. Significant means of treatments were separated using the Least Significant Difference (LSD) ($P < 0.05$) test.

Results and Discussion

Cure characteristics of rubber compound - cure characteristics were determined for each of the seven rubber compounds in the two types of fibres, palmyra and coconut. The mean of three replicates analyses, for both palmyra fibre and coconut fibre is reported in Table 1 and Fig. 1. Scorch time (ts_2) is an indication of processing safety of rubber compounds. It could be seen from Table 1 that ts_2 increased with increasing loading of palmyra fibre and coconut fibre. Mathew (2009) reported an increase in ts_2 with the increase of natural fibre loading. According to him, the delayed start of cure reaction in the case of fibre would be attributed to possible interaction of the fibre with the accelerators, making it unavailable for cure reaction. There was

a significant difference ($p < 0.05$) in scorch time between S4, S5 and S6 rubber compounds in regard to the fibre types.

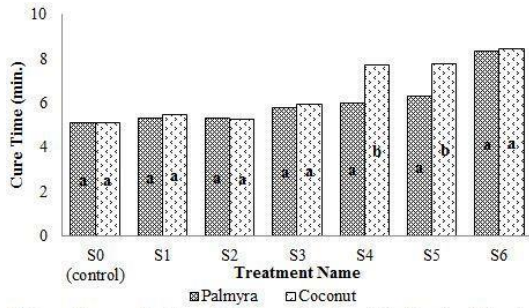
Table 1. Effect of fibre loading on scorch time of rubber compounds.

Scorch Time (min.)		
Treatment Name	Palmyra Fibre	Coconut Fibre
S0 Control (0g fibre + 60g CB)	3.25 ± 0.048 ^a	3.25 ± 0.048 ^a
S1 (10g fibre + 50g CB)	3.28 ± 0.160 ^a	2.96 ± 0.192 ^a
S2 (20g fibre + 40g CB)	3.52 ± 0.240 ^a	3.20 ± 0.112 ^a
S3 (30g fibre + 30g CB)	4.00 ± 0.320 ^a	3.36 ± 0.320 ^a
S4 (40g fibre + 20g CB)	5.04 ± 0.240 ^a	3.76 ± 0.640 ^b
S5 (50g fibre + 10g CB)	5.36 ± 0.640 ^a	4.03 ± 0.192 ^b
S6 (60g fibre + 0g CB)	6.08 ± 0.192 ^a	4.53 ± 0.368 ^b

Value on the same row with the same letter as superscripts is not significantly different at the level of 5%. The values are presented as mean ± SD

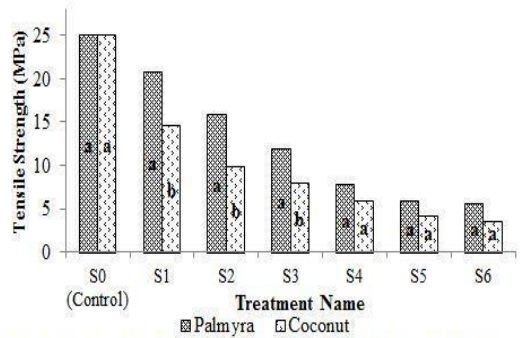
Cure time (T_{90}) is an indication of 90% cure which was taken from rubber compounds. As given in Fig. 1 it was seen that T_{90} increased with increasing loading of palmyra fibre and coconut fibre. Mathew (2009) also reported that increasing filler loading of rubber vulcanizates increased T_{90} . Further he observed, the filler-accelerator interaction was only short term and reversible at elevated temperatures. In the present study, there was a significant difference ($p < 0.05$) in cure time between S4 and S5 rubber composites in regard to the type of fibre.

Mechanical Properties of Rubber Vulcanizates - Mechanical properties of rubber compounds, tensile strength, tensile modulus at 100% and hardness were determined for each of the seven rubber compounds in the two types of fibres. The mean of three replicates analyses for this parameter are presented in Figs.2, 3, and 4. Tensile strength decreased with increasing palmyra fibre loading of composites (Fig 2). Similarly, Ismail et al., (1997) observed a decrease in tensile strength and attributed to poor filler dispersion with filler addition. This behavior can be related to the probable tendency of the filler to form agglomerates. It was observed that, there was a significant difference ($p < 0.05$) in tensile strength between S1, S2 and S3 blends of rubber compound in regard to the fibre types. According to Fig.3 there was an increasing trend in tensile modulus with the increase of fibre loading of both palmyra and coconut compounds. Onyeagoro (2012) also reported an increase in tensile modulus with increasing filler loading, indicating an increase in stiffness of the composites with the incorporation of filler into the rubber matrix. There was a significant difference ($p < 0.05$) in tensile modulus between S1, S3 and S4 blends of rubber compounds in regard to both fibre types. As shown in Fig.4, hardness increased with increasing fibre loading in both palmyra fibre and coconut fibre composites. Similarly, Onyeagoro (2012) observed that hardness increased with increasing filler loading. There was a significant difference ($p < 0.05$) in hardness between S1, S2, S3 and S4 compounds in regard to the two fibre types.



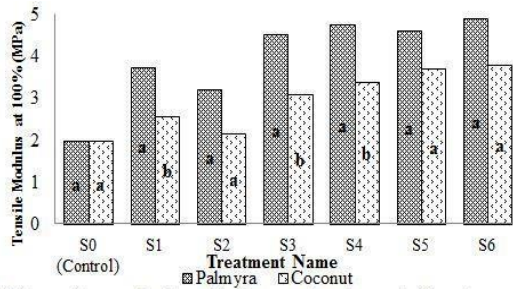
Value on the same bar line with the same letter is not significantly different at the level of 5%.

Figure 1. 90 % Cure time



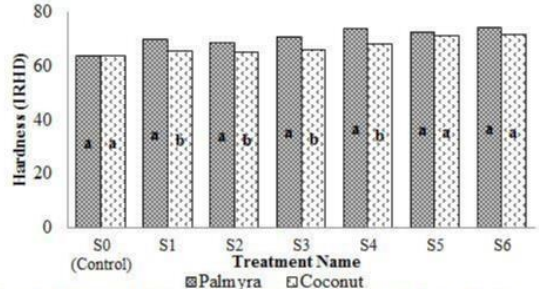
Value on the same bar line with the same letter is not significantly different at the level of 5%.

Figure 2. Tensile strength



Value on the same bar line with the same letter is not significantly different at the level of 5%.

Figure 3. Tensile modulus at 100 %



Value on the same bar line with the same letter is not significantly different at the level of 5%.

Figure 4. Hardness

Conclusions

Arguably the most important conclusion to be drawn from this work is that palmyra fibre composite was suitable as a direct replacement for coconut fibre composite in most applications because of the pattern of reinforcement produced. Further, palmyra fibre composite fulfils the requirements of a middle layer solid tyre compound better than the coconut fibre composite. Out of the palmyra fibre composites, S3 composite is suitable for solid tyre middle layer compounds. Overall, it would be possible to use palmyra fibre as a cost effective reinforcing filler in the solid tyre industry.

References

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