

## Effect of Palm Oil as an Alternative Plasticizer in Tyre Tread Compound

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### Introduction

Raw natural rubber and synthetic rubbers are compounded with other substances to have useful articles. Plasticizers play a major role in rubber compounding and petroleum based mineral oil are mostly used as plasticizers for tyre components. But mineral oil is a nonrenewable resource and some of them have been identified as carcinogenic. Naturally occurring oils from agricultural sources have been investigated as an alternative plasticizer in tyre tread compound for several years but there has been no systematic study of the effect of palm oil with respect to the all three types of mineral oils; aromatic, paraffinic and naphthenic oils. The objective of this work was to study the possibility of using palm oil as a cost effective alternative plasticizer for petroleum based mineral oils in tyre trade compound.

### Methodology

The experiment was carried out in Research and Development section at Samson Compounds (Pvt) Ltd (DSI Group), Bataduwa, Galle, Sri Lanka. Four types of compounds were prepared with aromatic, naphthenic paraffinic and palm oil plasticizers according to the formulation of material. RSS III-75.000, SBR (Styrene Butadiene Rubber)-25.000, Processing oil-10.000, N330- Carbon Black-50.000, TMQ-Antioxidant-2.000, ZnO-5.000, Steric acid-1.500, 6PPD(N-1,3-dimethylbutyl-N-phenyl-P-phenylenediamine)-2.000, CBS (N-cyclohexyl benzthiazyl sulphenamide)-1.300, DPG (N-diphenylguanidine)-0.200, Sulfur-2.300, Wax-2.000 were used to prepare the tyre tread compound .

Mixing was carried out on a laboratory size (160mmx320 mm) two roll mixing mill (Model - COMERI M-89) and the respective cure characteristics were determined using a Monsanto Rheometer (Model 100 FF). Tensile properties and tear strength were tested according to the ISO 37, 1977 using tensile tester (Model TS 1000). Hardness was determined as descri bed in ISO 48, 1979 with a dead load hardness tester. According to the ISO 815, 1991 compression set was tested. Abrasion resistance was measured according to the Din 53516 standards using Abrasion tester (Model GT-7012). Rebound resilience was measured using a Lupke Pendulum according to the ISO 4662-1986 standards. Specific gravity was measured using an Electronic densimeter.

Thermal oxidative aging was analyzed as a measure of tensile properties. Tensile properties were tested for four types of compounds after aging over 22 hrs in 70 C and palm oil based compound was tested for tensile properties as a function over time.

### Results and Discussion

The highest  $M_H$  value, T90 value and second highest scorch time ( $Ts_2$ ) were recorded from the compound with paraffinic oil plasticizer. Compound with palm oil plasticizer indicates the lowest delta cure ( $M_H - M_L$ ). This result signifies the fact that palm oil is a reactive plasticizer sensitive to the sulphur-based vulcanization due to its unsaturated fatty acids (See table 1).

Table 1. Cure characteristics of four types of compounds.

Cure character	Aromatic oil	Paraffinic oil	Naphthenic oil	Palm oil
ML(d Nm) (Minimum torque)	2.987	4.208	3.597	3.597
MH (d Nm) (Maximum torque)	50.838	56.332	53.524	55.355
Ts2(min) (Second highest scorch time)	0.92	1.04	1.05	0.98
T90 (min)	1.6	1.85	1.73	1.71
MH-ML	51.758	52.124	49.927	47.851

Palm oil based compound signified better performance in abrasion resistance, rebound resilience, elongation properties and lowest compression set. Tensile properties of the compound were also in admissible level with respect to other plasticizer based compounds. Tensile properties and tear strength were maximum as cross-linking is increased (Ismail and Ruhaizat, 1997). Abrasion resistance is dependent on the unsaturation content in the backbone chain (Arayaprane & Rempel, 2009). According to the results unsaturated fatty acids in palm oil may affected to the mechanical properties of the compound (See table 2).

Table 2. Mechanical properties of four types of compounds.

Mechanical properties	Aromatic oil	Paraffinic oil	Naphthenic oil	Palm oil
Specific Gravity	1.0620 <sup>a</sup>	1.0958 <sup>a</sup>	1.0848 <sup>a</sup>	1.0737 <sup>a</sup>
Tensile (MPa)	21.371 <sup>a</sup>	21.005 <sup>a</sup>	21.986 <sup>a</sup>	20.915 <sup>a</sup>
300% Modulus	12.094±0.62 <sup>a</sup>	13.449±0.51 <sup>b</sup>	12.846±0.83 <sup>ab</sup>	12.137±0.56 <sup>a</sup>
Elongation(mm)	479.34 ±13.7 <sup>a</sup>	468.31±20.77 <sup>b</sup>	412.76±43.16 <sup>a</sup>	502.46±40.6 <sup>a</sup>
Tear Strength	88.893±3.38 <sup>a</sup>	73.997±6.43 <sup>b</sup>	89.145±4.18 <sup>a</sup>	86.447±5.08 <sup>a</sup>
Hardness	64 <sup>a</sup>	65 <sup>ab</sup>	63 <sup>a</sup>	63 <sup>a</sup>
Compression	31.945±2.62 <sup>a</sup>	23.760 ±1.57 <sup>bc</sup>	26.942±2.41 <sup>b</sup>	21.260±0.93 <sup>bc</sup>
Abrasion loss	120.49±1.45 <sup>a</sup>	109.43±4.71 <sup>b</sup>	104.56±6b <sup>b</sup>	95.12±6.02 <sup>c</sup>
Resilience	40.00±0.82 <sup>a</sup>	51.25±0.82 <sup>b</sup>	43.00±1.7 <sup>c</sup>	45.75±1.87 <sup>c</sup>

(Figures denoted by different letters within a row are significantly different)

Tensile has not demonstrated a significant deviation over the time and 300% modulus seem to be slight increase after heat aging for over 72hrs. The dual coupling interaction of vegetable oil indicated that the polar end of the fatty acid chains could interact with carbon black surface while unsaturation-rich end could interact with NR molecules (Kundu, 2000). Thermal aging may cause destruction of these interactions and buildup new cross links to increase the stiff nature of the compound.

**Conclusions** Palm oil based compound has better performance in abrasion resistance, rebound resilience, lowest compression set and good performance in thermal oxidation at 70 °C. Palm oil indicates the highest elongation properties while maintaining the tensile properties in appropriate level. Therefore palm oil can be used with minimum defects as a cost effective alternative plasticizer, for petroleum based oil plasticizers. Other than the plasticization effect, palm oil can affect on the curing system and the cross linking density of the compound. Therefore co-activator effect of the palm oil is suggested for further investigations.

## **References**

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