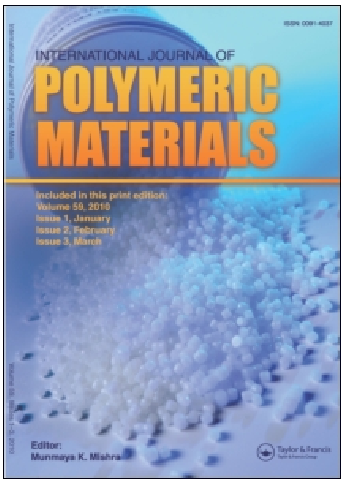

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The Effects of Palm Oil Fatty Acid Additive (POFA) and Commercial Processing Aids on the Properties of Carbon Black Filled Natural Rubber Compounds

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The effects of palm oil fatty acid additive (POFA 2) and commerical processing aids on the properties of carbon black filled natural rubber compounds were studied. Incorporation of POFA 2 reduces the scorch time while aromatic processing oil and peptizer show retardation effect. Both POFA 2 and commercial processing aids reduce the Mooney viscosity of the rubber compounds. This shows that POFA 2 can act as a processing aid to improve the processibility of the rubber compounds. However at a similar concentration, aromatic processing oil gives lowest Mooney viscosity followed by peptizer and POFA 2. Results also indicate that at a similar concentration, POFA 2 gives better mechanical properties viz tensile strength, tear strength and hardness compared to two others commercial processing aids.

Keywords: Palm oil fatty acid additive; processing aids; mechanical properties; carbon black; natural rubber

1. INTRODUCTION

In our previous work [1], the preparation and application of palm oil fatty acid additives (POFAs) in carbon black (CB) filled natural

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rubber (NR) compounds were studied. The incorporation of POFA's was found to improve mechanical properties of CB filled NR compounds especially below concentration of 2 phr. Scanning electron microscopy indicates that POFA's improved filler dispersion while swelling measurement test shows that POFA's had some effects on crosslink density.

In this study, the effects of one type of these POFA's called POFA 2 and two commercial processing aids, aromatic processing oil and peptizer on the mechanical properties of carbon black filled natural rubber compounds were evaluated.

2. EXPERIMENTAL

2.1. Compounding Ingredients and Formulations

SMR 10 grade natural rubber was obtained from Rubber Research Institute of Malaysia (RRIM). The filler used was carbon black, N550 obtained from Malayan Carbon (M) Ltd. Other chemicals such as sulphur, zinc oxide, stearic acid, N-isopropyl-N-phenylenediamine (IPPD), N-cyclohexyl-2-benzothiazole-2-sulphenamide (CBS), tetramethylthiuram disulphide (TMTD), aromatic processing oil (Dutrex R) and peptizer (Renacit 11) were all purchased from Bayer (M) Ltd. All materials were used as supplied and recipes used throughout the study are shown in Table I. POFA 2 was synthesised in our laboratory as reported in our previous work [1].

TABLE I Different levels of POFA2, aromatic oil and peptizer in carbon black filled natural rubber compounds

Materials	*Phr*
SMR 10	100.0
Carbon black (N550)	50.0
Zinc oxide	3.0
Sulphur	0.4
Stearic acid	1.0
IPPD[a]	2.0
CBS[b]	2.0
TMTD[c]	1.0
POFA2/aromatic oil/peptizer	0.0, 1.0, 2.0, 3.0, 5.0

[a] N-isopropyl-N-phenylenediamine.
[b] N-cyclohexyl-2-benzothiazole-2-sulphenamide.
[c] Tetramethylthiuram disulphide.

2.2. Sample Preparation

Mixing was carried out on a laboratory size (160 mm×320 mm) two roll mixing mill (Model XK-160) in accordance to the method described by the American Society for Testing and Materials (ASTM), designation D 3184-80. The respective cure times at 140°C indicated by t_{90} were then determined using a Monsanto Rheometer, model MDR 2000. The scorch times, torque, elastic modulus etc. can also be determined from the rheograph. The determination of Mooney scorch time, cure index and Mooney viscosity using Mooney Viscometer MV 2000 at 140°C were also carried out.

2.3. Measurement of Mechanical Properties

The various rubber compounds were compression moulded at 140°C according to their respective t_{90}, into test specimen sheets. Dumb-bell and crescent test pieces according to ISO 37 and ISO 34 respectively were then cut out. Tests were carried out on Monsanto Tensometer, T 10 according to BS 903: Part A2 and BS 903: Part A3, respectively at 500 mm/min cross-head speed. The test for hardness was carried out by using the Shore type A Durometer according to ASTM 2240. All tests were conducted at room temperature (25°C).

2.4. Scanning Electron Microscopy

Examination of the fracture surface was carried out using a Scanning electron microscope (SEM) model Leica Cambridge S-360. The fracture ends of the tear specimens were mounted on aluminium stubs and sputter coated with a thin layer of gold to avoid electrical charging during examination.

3. RESULTS AND DISCUSSION

3.1. The Comparison Effect of POFA 2, Aromatic Processing Oil and Peptizer on Mooney Scorch Time and Mooney Viscosity

Figure 1 shows the comparison effect of POFA 2, processing oil and peptizer on Mooney scorch time of carbon black filled natural rubber

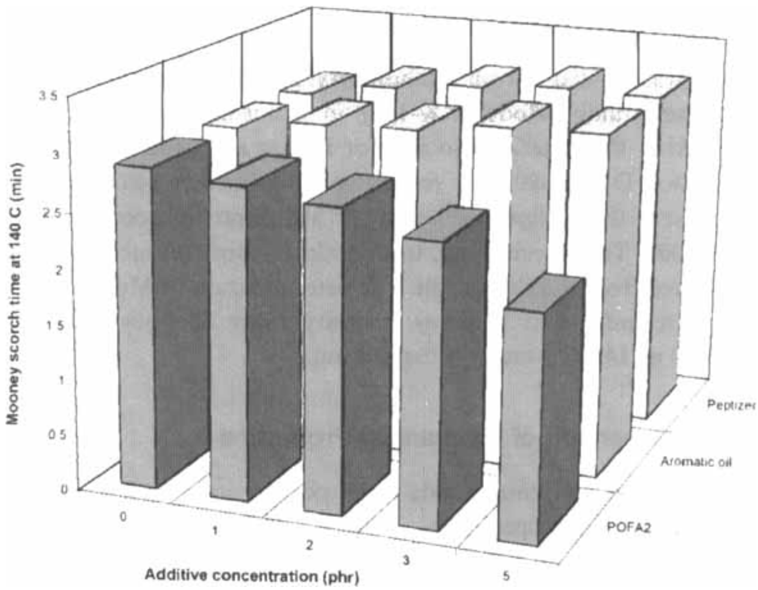


FIGURE 1 Relationship between Mooney scorch time and concentration of POFA 2, processing oil and peptizer of the carbon black filled natural rubber compounds.

compounds. It can be seen that Mooney scorch time decreases with increasing POFA 2 concentration. In our previous work [1], POFA's was found to enhance the cure rate and cure state of the rubber compounds. Diamine as a result of POFA dissociation at temperature ~100°C would act as a cure accelerator and is responsible for the reduction of the scorch and cure times of the compounds.

However the incorporation of aromatic processing oil and peptizer exhibit different trend. Mooney scorch time of the rubber compounds increases with increasing concentration of aromatic processing oil and peptizer. Crowther [2] also reported that the scorch time, t_5 and cure time, t_{90} increased with increasing concentration of various processing aids and plasticizers in the natural rubber compounds.

The use of processing oils, plasticisers and processing aids in rubber compounding is well known [3]. The processing oils and plasticizers are used in proportion of 1 part of oil per 10 parts of reinforcing filler. Processing aids which are more expensive are used in smaller proportion, viz 1 – 5 phr. These additives are added to rubber compounds to improve the flow and general processability of the rubber [4].

The addition of POFA 2, aromatic processing oil and peptizer decrease the Mooney viscosity of the rubber compounds (See Fig. 2). This shows that these additives can act as processing aids to improve the flow properties of the rubber compounds. However at a similar concentration, aromatic oil exhibits lowest Mooney viscosity followed by peptizer (Renacit 11) and POFA 2. It is interesting to note that beside acceleration of vulcanization, POFA 2 also imparts to rubber compounds a combination of good flow during processing and good release from mill rolls and mould release.

3.2. The Comparison Effect of POFA 2, Aromatic Processing Oil and Peptizer on Mechanical Properties

Figures 3, 4 and 5 show the concentration effect of POFA 2, aromatic processing oil and peptizer on tensile strength, tear strength and hardness of the carbon black filled natural rubber compounds. All figures indicate that POFA 2 filled rubber compounds have better

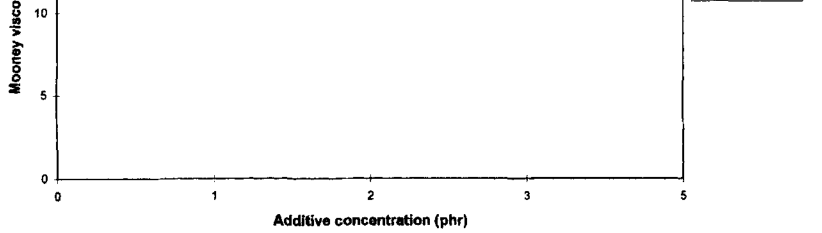


FIGURE 2 The concentration effect of POFA 2, processing oil and peptizer on the Mooney viscosity of the carbon black filled natural rubber compounds.

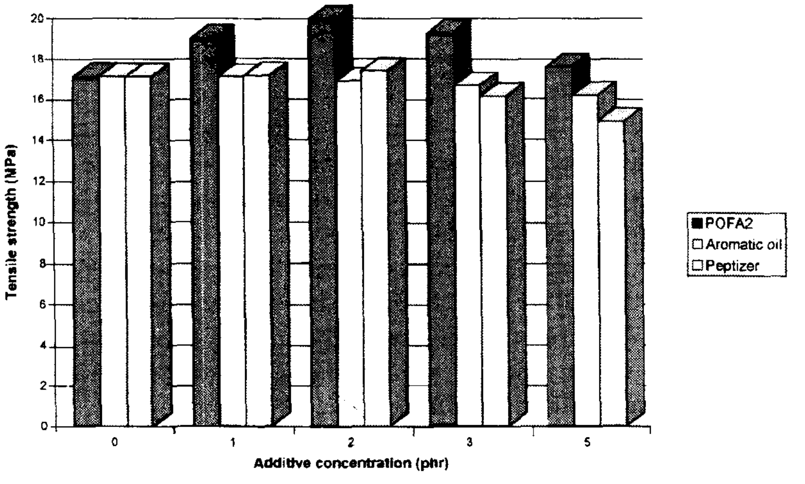


FIGURE 3 The concentration effect of POFA 2, processing oil and peptizer on the tensile strength of the carbon black filled natural rubber compounds.

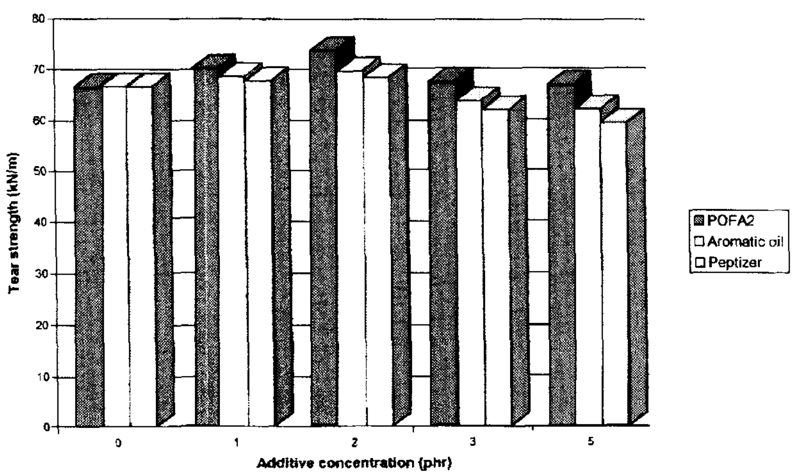


FIGURE 4 The concentration effect of POFA 2, processing oil and peptizer on the tear strength of the carbon black filled natural rubber compounds.

mechanical properties compared to similar compounds with aromatic processing oil and peptizer. At a similar concentration, POFA 2 gives better properties than the other two processing aids. The enhancement of these properties was due to better filler dispersion and higher

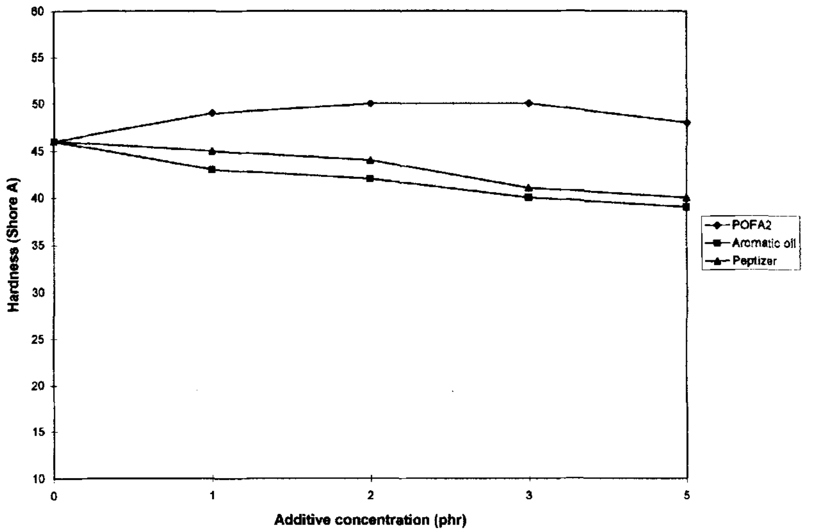


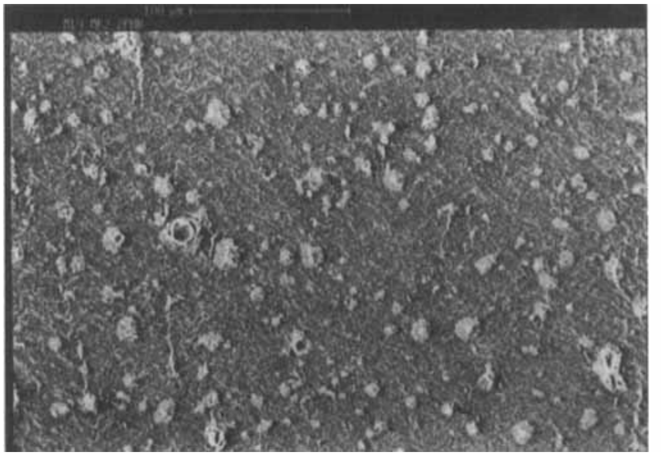
FIGURE 5 The concentration effect of POFA 2, processing oil and peptizer on the hardness of the carbon black filled natural rubber compounds.

crosslink density when the POFA was incorporated in the rubber compounding [1]. For aromatic processing oil and peptizer, the properties viz. tensile strength, tear strength and hardness did not change significantly at low concentration (1 phr) and deteriorate with increasing concentration of these additives. Although the processing aids were added into rubber compounds to improve processability, generally physical and elastic properties were not impaired by their presence and may even be improved if filler dispersion problems were overcome in their use [4].

Figure 6 shows the SEM micrographs fracture surface of the carbon black filled natural rubber vulcanizates with 2 phr of POFA 2 (Fig. 6a), aromatic processing oil (Fig. 6b) and peptizer (Fig. 6c) at a magnification of 300X. The fracture surface of POFA 2 displays a smooth surface with many discontinuous stick-slip tear lines and a few long tear lines with path deviation. This unique feature is indicative of the high energy requirement to cause failure. The smooth surface of the POFA 2 vulcanizate also indicates homogeneous microdispersion of carbon black as a result of incorporation of POFA 2. The fracture surface of aromatic processing oil vulcanizate displays a rough surface

TABLE V Mechanical and electrical properties of galss-reinforced poly(urea-imide)s Va – j

PUIs Sample	*Chemical Resistance percent change in*		*Density*	*Flexural strength*	*compressive strength*	*Impact strength*	*Hardness*	*Electrical Strength*
	Thickness	*Weight*	(g/cm^3)	*(MPa)*	*(MPa)*	*(MPa)*	*(R)*	*(in air) (kV/mm)*
V_a	1.1	1.5	1.31	445	392	401	76	22.4
V_b	1.2	1.2	1.46	359	470	467	71	21.3
V_c	1.4	1.4	1.51	452	464	469	76	24.6
V_d	1.3	1.1	1.55	375	336	341	90	26.0
V_e	1.0	1.2	1.40	382	312	319	64	25.2
V_f	1.2	1.3	1.59	425	373	362	69	23.8
V_g	1.1	1.6	1.44	398	387	365	54	20.2
V_h	1.3	1.1	1.38	406	392	370	55	19.8



c

FIGURE 6 (Continued).

ingredients and consequently reduced the tear strength and other mechanical properties.

4. CONCLUSIONS

Palm oil fatty acid additive (POFA 2) and commercial processing aids viz aromatic processing oil and peptizer were found to improve the processability of the rubber compounds by reducing the Mooney viscosity. Compared to control compound (without POFA 2), the mechanical properties were enhanced by the addition of POFA 2. For aromatic processing oil and peptizer the mechanical properties i.e. tensile and tear strengths did not change significantly at their lower concentration. However as their concentration increases, the mechanical properties start to deteriorate.

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