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DYNAMIC PROPERTIES OF NEW PROCESS NATURAL RUBBER BY DYNAMIC MECHANICAL THERMAL ANALYSIS AND GABO FLEXOMETER

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ABSTRACT

Malaysian Rubber Board has developed a new grade of rubber using a new process and technique for production of field coagulum grades. Research showed that the new process natural rubber (NPR) has low gel content, better processability, low modulus and similar recovery behaviour and physical properties compared to commercial Standard Malaysian Rubber (SMR). Further research is carried out to determine the dynamic properties of NPR by Dynamic Mechanical Thermal Analysis (DMTA) and Gabo flexometer. The DMTA measures the tan delta values of material when exposed to temperatures from -70°C to 80°C at constant deformation. The Gabo flexometer machine can be used to determine heat build-up and viscoelastic properties of rubber undergoing rapid cyclic deformations at certain frequency or over a range of frequencies. The cyclic deformation behavior of rubber is important in products such as an indication of tyre performance, bearing, v-belts, and cable pulley insert rings etc. which are subjected to dynamic flexing in service. The dynamic properties of NPR are compared with commercial grades SMR 10 and SMR CV 60. DMTA results show that the vulcanizates give almost similar curves and values at both 0°C and 60°C indicating little differences in the compound's wet grip and rolling resistance properties for the three grades of rubber. The Gabo flexometer machine determined heat build-up and viscoelastic properties of rubber. The results indicate that the NPR generates the lowest heat build-up value and low tan delta as compared to SMR 10 and SMR CV60. As a general conclusion, NPR could be advantages as an alternative material for tyre applications.

Keywords: DMTA; Gabo flexometer; heat build-up; viscoelastic properties; tan delta

INTRODUCTION

New process natural rubber (NPR) is a new grade of rubber developed recently by Malaysian Rubber Board (MRB) using a new process and technique for production of field coagulum grades[1]. The NPR was compared with Standard Malaysian Rubber SMR 10 and SMR CV60. All grades of rubber were prepared from the same clonal rubber coagulum collected from the same field in RRIM Research Center, Sungai

The most widely used natural rubber (NR) in tyre applications is SMR 20, which is prepared from the conventional process of SMR production from field coagulum grades. However, due to the high quality of SMR rubber produced by MRB, SMR 10 has been used in this study. The SMR CV60 is latex based grade which are selected in order to see the effect of rubber grades on the same properties. The dynamic properties of the vulcanisates are important to be evaluated especially in analyzing the heat generated by materials for tyre applications. The dynamic instruments such as dynamic mechanical thermal analysis and gabometer are important parameters to predict the rate of heat generated by the rotation of tyre on the road surface when subjected to rapidly oscillating compressive stresses or strain. DMTA measured the changes in tan delta of material with increases the temperature. Gabometer measured a heat build-up or to measure the rate of heat generated by the rubber vulcanisates when subjected to rapidly oscillating compressive stresses or strain under controlled conditions[2]. This test is very important especially for several types of rubber products such as tires, transmission belts, and vibration isolators[3].

EXPERIMENTAL DETAILS

Dynamic Mechanical Thermal Analyser (DMTA)
Dynamic mechanical properties were measured using a Rheometric Scientific Dynamic Mechanical Thermal Analyser (DMTA) IV according to ISO 4664[4]. The test specimen was 5 mm x 50 mm x 2 mm which was cut from vulcanized slab. The instrument was operated by setting the sample gap at 20 mm and a frequency of 10 Hz with 0.1% strain. Sample was cooled to -70°C and the measurement was made during warming-up at a heating rate of 2°C/min.

Heat Build-up
In this heat build-up test, the Gabometer® 2000 in the compression (constant strain mode) according to ISO 4666/3[3] is used to determine the temperature rise of the sample on the surface and inside the sample. It allows the monitoring of changes in tan delta depending on the sample temperature during the heat build-up process. The test specimen with dimension 25mm length and 17.8mm diameter was placed in between upper and lower compression platen. A needle thermocouple is injected into test specimen to measure temperature inside the test specimen. The test was conducted for 25 minutes at set temperatures of 55°C or 100°C, frequency of 30Hz and dynamic amplitude (stroke) of 4.46 mm.

RESULTS AND DISCUSSION

The dynamic properties based on DMTA and heat build-up measurements were performed as they are important parameters to predict the behavior of compounds especially for tyre applications. For DMTA measurement, tan δ is the important property; its value at 50-60°C is used an indicator of tyre rolling resistance and tan δ at -

5 to +5°C is used as an indicator of the compound's wet grip. The ideal tyre has low tan δ at 60°C for low rolling resistance and high tan δ at 0°C for good wet grip. The DMTA results of vulcanisates are as shown in Figure 1.

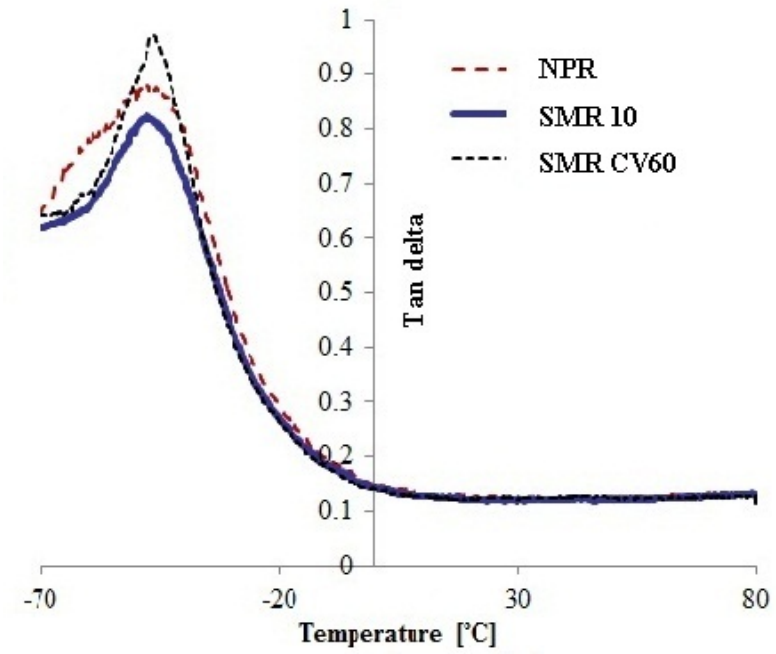

Figure 1: Dynamic properties of vulcanisates by DMTA

The vulcanizates give almost similar curves and values at both 0°C (0.15, 0.14 and 0.14 for NPR, SMR CV60 and SMR 10 respectively) and 60°C (0.13, 0.12 and 0.12 for NPR, SMR CV60 and SMR 10, respectively) indicating little differences in the compound's wet grip and rolling resistance properties for the three grades of rubber. The tan delta did not show significant effect due to rubber grade.

Energy losses within tyre materials produce heat as they are deformed during service. In this study, the Gabometer® 2000 heat build-up equipment is used to determine the temperature rise inside the sample specimen. Figures 2 and 3 show the effect of temperature rise in the inner part of the sample with test duration at 55°C and 100°C, respectively. It can be observed that the temperature rose sharply to maximum values after about 8 minutes, and then decreases slightly with increasing test duration. The rise in temperatures is lower for NPR compared to SMR 10 and SMR CV60 and more pronounced when tested at 55°C. Similarly the NPR shows a lower increment in temperature compared to SMR 10 and SMR CV60 after the testing was completed where the drop in temperature of the sample is more significant for samples tested at 55°C (Figure 2). The low increment indicates of low heat build-up (hysteresis) during the rotation of tyre. High heat accumulation gained for the first 8 minutes is due

to high internal friction. Prolong heating caused reduction in internal friction due to the increase in the distance between the molecules.

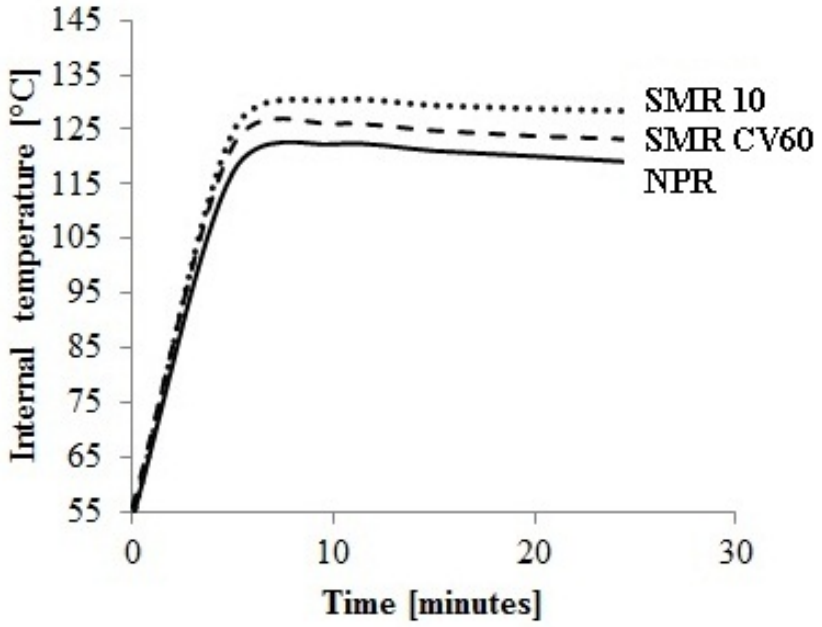

Figure 2: Effect of test duration on temperature (internal sample) tested at 55°C

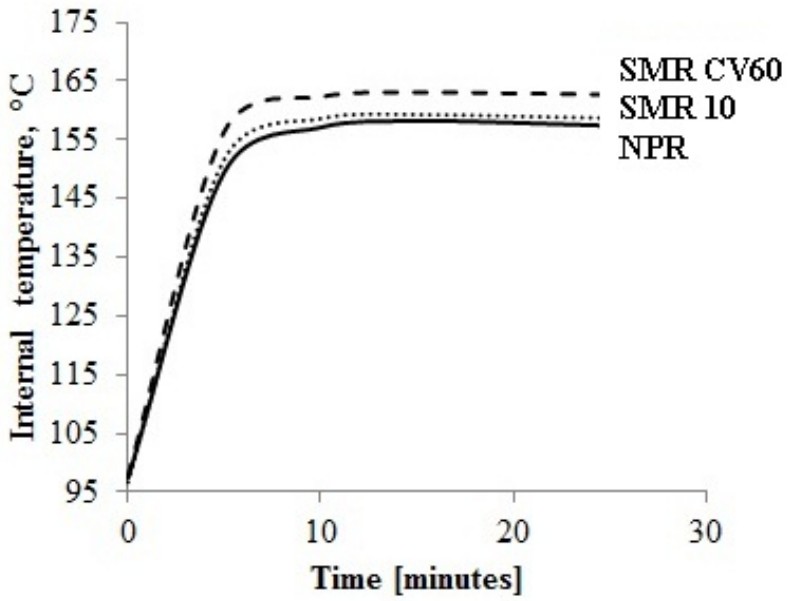

Figure 3: Effect of test duration on temperature (internal sample) tested at 100°C

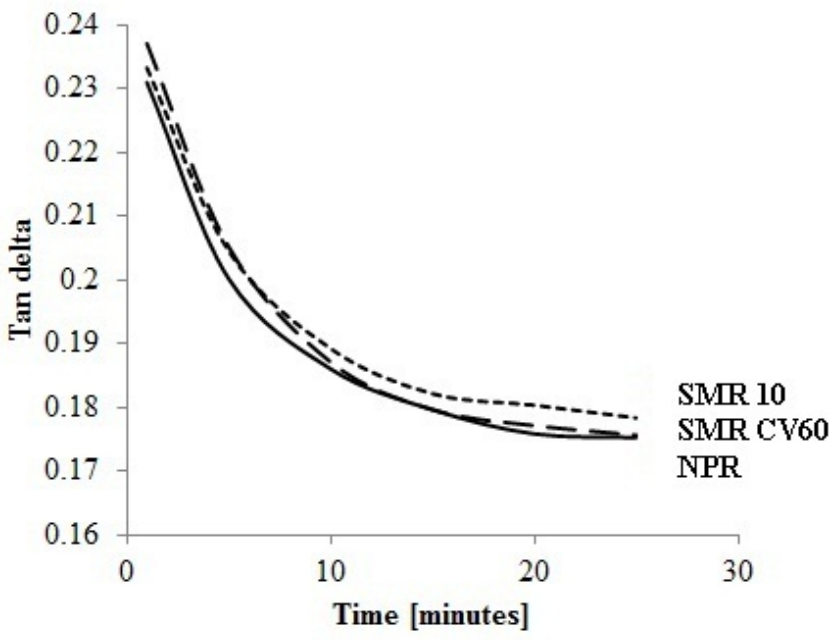

Figure 4: Effect of test duration on tan delta tested at 55°C

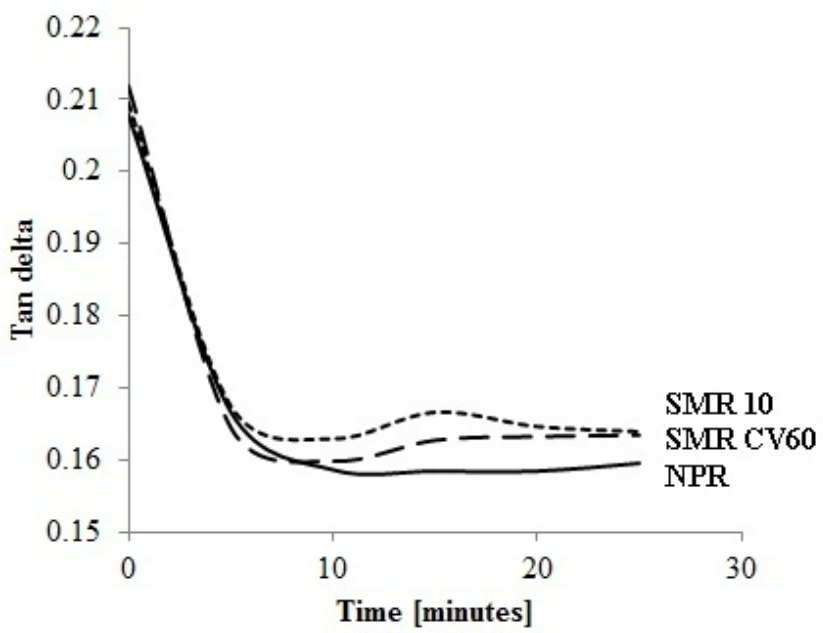

Figure 5: Effect of test duration on tan delta tested at 100°C

Figures 4 and 5 show the effect of test duration on tan delta at 55 and 100°C, respectively. It can be seen from Figure 4 that the tan delta drastically decreases and becomes slightly linear after 15 minutes. At initial test time (0-8 minutes), the curve did not show significant difference on tan delta. The NPR shows the lowest tan delta from

the starting point until after 25 minutes compared with SMR 10 and SMR CV60. Same phenomenon happened as tested at 100°C. Tan delta value is higher when tested at 55°C.This is because during the test, the distances between molecules are closed packed and generate a high internal friction. Lower tan delta specifies lower hysteresis which is small amount of heat will be generated during tyre rotation. It can be seen that the processability behaviour of SMR CV60 is close to NPR than SMR 10 in term of heat generated at 100°C and easier processing at 55°C as represented by tan delta.

CONCLUSION

The DMTA results showed that NPR has a similar curves and values at both 0°C and 60°C for NPR, SMR CV60 and SMR 10 respectively indicating little differences in the compound's wet grip and rolling resistance properties for the three grades of rubber. The heat build-up test results show that NPR displays the smaller increment in temperature compared to SMR 10 and SMR CV60 which indicates of low heat build-up during the rotation of tires. These attributes are expected to be advantages in tyre applications such as tyre treads. The order in the increment rate of temperature (internal sample) at 100°C is

SMR CV60 > SMR 10 > NPR

While at 55°C, the order in the increment rate of inside temperature is

SMR 10 > SMR CV60 > NPR

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