Tensile properties of degraded NR/EPDM nanocomposites in different automotive oils

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ABSTRACT – In this study, the tensile properties of NR/EPDM blends and NR/EPDM nanocomposites were compared after immersed in different types of automotive oils (brake oil; engine oil; gear oil) for 6 days 9 hours. The tensile properties of the swollen rubber were measured and degraded fracture surfaces were validated under optical microscope. NR/EPDM blend and NR/EPDM nanocomposites in brake oil have the lowest reduction in tensile strength followed by engine and gear oil. Nonetheless, within both rubbers, the reduction of tensile strength of NR/EPDM nanocomposites is lower for all types of oil of 19.92% in brake oil, 3.26% in gear oil and 0.27% in engine oil compared to NR/EPDM blends respectively.

1. INTRODUCTION

Natural rubber (NR) undergoes strain-induced crystallization that accounts for the large increase in modulus at high deformation because the crystallites act as additional cross-links in the network. Despite having attractive range of properties, excellent mechanical strength and elasticity, as well as good processing characteristics, the NR is highly unsaturated and is chemically reactive [1]. Hence, NR is highly susceptible to degradation and is very sensitive to environmental factors such as oxygen attack by ozone, light, moisture, humidity, radiation and heat [2,3]. Ethylene propylene diene monomer (EPDM) in contrast, which has an attractive balance chemical, electrical thermal, and mechanical properties [4], weathering, oxidation, heat, oil, and chemical resistance, which are suitable characteristics for outdoor applications [5]

For engine mounting application, it always exposed to oil during service, hence this method is used to simulate service condition. Thus, the aim of this work is to study the tensile properties of degraded NR/EPDM filled graphene nanoplatelets (GNPs) in different type of automotive oils.

METHODOLOGY

Natural rubber (SMR 20) grade and ethylene propylene diene monomer (EPDM Buna® EPT 9650) were used in this study. GNPs KNG-G2 was treated in a mixture of water/ ethanol using vibration sonicator for 2 hours before dried at 60 °C until it reaches the moist bulk form. The compounding was performed according ASTM D 3192 using Haake Internal Mixer using the formulation recipes as summarized in Table 1.

Table 1 NR/EPDM formulation recipe.

Ingredients	Rubber blend (phr)	Rubber nanocomposite (phr)
NR (SMR 20)	70	70
EPDM	30	30
GNPs	0	3
ENR-50	10	10
Zinc oxide	5.0	5.0
Stearic acid	2.0	2.0
Sulphur	1.5	1.5
MBTS[a]	1.0	1.0
TMTD[b]	0.3	0.3
6PPD[c]	2.0	2.0

[a] 2,20-dithiobis (benzothiazole)
[b] Tetramethylthiuram disulphide
[c] *N*-(1,2-Dimethylbutyl)-*N'*-phenyl-*p* phenylenediamine

Then the NR/EPDM blends and nanocomposite were filled into mold cavity and compressed using GT7014-A hot press. The samples were prepared under compression of 1800 kg/cm^2. Next, both of the rubbers were vulcanized with 1 mm thickness with a hot press at 150 °C. The samples were cut into rectangular-shaped of 25 x 50 mm. The samples were immersed into different type of oil mediums which are engine, brake and gear oil at room temperature for 6 days and 9 hours. Next the swollen sample were tested for tensile properties according to ASTM D1822. The fracture surfaces were validate using optical microscopy analysis.

RESULTS AND DISCUSSIONS

3.1 Mechanical properties

The effect of swollen NR/EPDM blends and nanocomposite on tensile strength is shown in Figure 1. The result shows that the reduction tensile strength of swollen NR/EPDM blend and nanocomposite are the

highest strength in gear oil followed by engine oil and brake oil. This is due to the lower solubility of gear oil thus make it difficult for oil molecules to penetrate into the rubber molecules [6]. However, swollen NR/EPDM nanocomposite in all three types of automotive oils illustrate lower reduction in tensile value in comparison of NR/EPDM blend of 39.54% in brake oil, 3.36% in gear oil and 0.27% in engine oil. This is due to GNPs succeed to support the stress transferred from NR/EPDM rubber matrix. The good adherence in the filler-matrix would give drop the formation of matrix both in the interphase and interface, which would decrease the mechanical properties of the NR/EPDM filled GNPs compared to unfilled NR/EPDM. Tensile comparison between brake and both gear and engine oil are due to the deterioration of the material is accentuated when the concentration of gear and engine oil is higher than brake oil [7]. When molecule of oil transport into the rubber network decreasing in molecular cohesion which lowering in tensile strength [8].

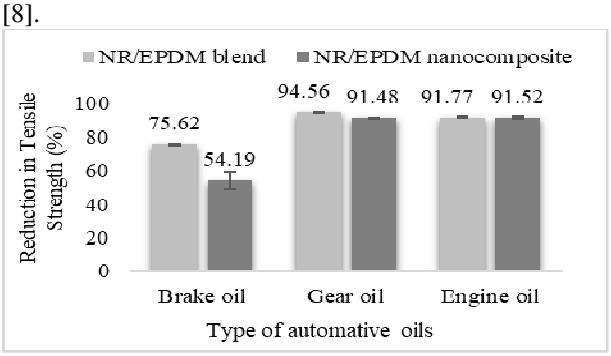

Figure 1 Reduction of tensile strength in different types of automotive oils.

3.2 Morphological Characteristics

Figure 2 depicts the OM swollen surface images of NR/EPDM (a) blend and NR/EPDM nanocomposite (b) after immersed in gear oil. NR/EPDM blend shows rougher fracture surface (high toughness) of the swollen NR/EPDM blend indicated sharp tearing. Whereas, NR/EPDM nanocomposite shows smoother fracture surface (high stiffness) of swollen NR/EPDM nanocomposite indicated blunt tearing due to lower swelling percentage when added with GNPs [9].

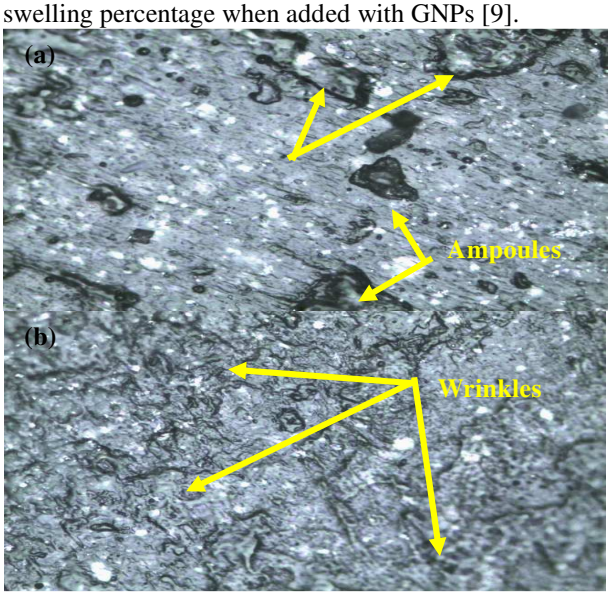

Figure 2 OM of (a) NR/EPDM blend in gear oil, and (b) NR/EPDM nanocomposite in gear oil at 200x mag.

CONCLUSIONS

The incorporation of GNPs into the NR/EPDM was observed to resist the automotive oils better compared to NR/EPDM blends during the immersion process. Although the decreasing in tensile strength in gear and engine oil is higher, yet due to difficulties of the molecules in brake oil to penetrate into the NR/EPDM nanocomposites network resulting lower swelling percentage which lowering the reduction in tensile strength. OM analyses validate the swollen surface of both rubbers.

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