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# Swelling effects of NR/EPDM filled graphene nanoplatelets (GNPs) in different type of service oils for engine mounting

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**ABSTRACT** – High resistance engine mounting towards corrosive liquid has become one of the hot issues for nowadays. Graphene has been known a new star arising materials with its exceptional properties. In this study, swelling effects for both NR/EPDM blend and NR/EPDM nanocomposite in different types of mediums were investigated. The blends and nanocomposites were prepared via melt compounding by using internal mixer and fabricated by using hot press. The swelling test was performed and further verified by using optical microscope and fourier transform infrared spectroscopy analysis. Brake oil has the highest change in mass (19.2%) followed by engine (10.6%) and gear oil (0.3%) for both blends and nanocomposites.

## 1. INTRODUCTION

Rubbers are usually non-resistant to oils, greases, or fuels and therefore are swollen by them. This causes changes in their physical and mechanical characteristics. [1,2]. The interaction of rubber blend and nanocomposite as an engine mounting with different types of service oils is an important problem from both academic and technological point of views. Crosslinked rubbers brought in contact with different oils during service applications usually exhibit the phenomenon known as swelling. Mostafa et al. [3] stated that, the purpose of measuring the resulting deterioration is to study the swelling rate of rubber exposure to corrosive liquid under definite condition of temperature and time. The swelling properties of rubbers are mainly related to the elasticity of the network, the extend of crosslinking, and the porosity of the rubber as previous study [4]. Kumnuantipa & Sombatsompop [5] found that, the properties of rubbers under swelling are also subjected to dynamic or continuous changes, and sometimes the changes are large enough to cause failure in service.

Many researchers have extensively studied fluid resistance behavior of rubber blend and composites with different filler. However, the study of swelling effect of NR/EPDM rubber in service oils are still scarce. Therefore, the objective of this work is to study the swelling effect of NR/EPDM nanocomposite in different type of service oils for engine mounting.

## 2. METHODOLOGY

Natural rubber (SMR 20) grade and ethylene propylene diene monomer (APDM Buna® EPT 9650) were used in this study. GNPs was treated in a mixture of water/ ethanol (25/75 by volume) 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 GNPS (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 |

Then the NR/EPDM blends and nanocomposites 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 tested for swelling properties according to ASTM D471 into different type of oil mediums which are engine, brake and gear oil at room temperature for 6 days and 9 hours. The change in mass was calculated using Equation (1):

$$\Delta M, \% = \frac{M_2 - M_1}{M_1} \text{ x } 100 \quad (1)$$

Then the sample surfaces were analyzed and validated by using optical microscope and fourier transform infrared spectroscopy.

## 3. RESULTS AND DISCUSSION

### 3.1 Change in mass

Figure 1 shows the change in mass for both NR/EPDM blends and nanocomposites with the maximum changes in gear oil and the minimum changes in brake oil. NR/EPDM nanocomposites are relatively good in term of swelling for three different oils compared to blends. The major changes of mass noticed after immersion of NR/EDPM blends in gear oil (19.2%), followed by engine (10.6%) and brake oil (0.3%). However, NR/EPDM nanocomposites demonstrated a remarkably lower change in mass for all three types of oils. The change could be contributed by the viscosity level of the oils as well as relaxation of polymer chains leading to mass increasing. This indicated the presence of GNPs nanofillers help to increase the interactions between filler and rubber matrix which caused the possibility of more crosslinking to form networks in the nanocomposites. Therefore, it has limited the chain movement and less open chain for the oils to diffuse.

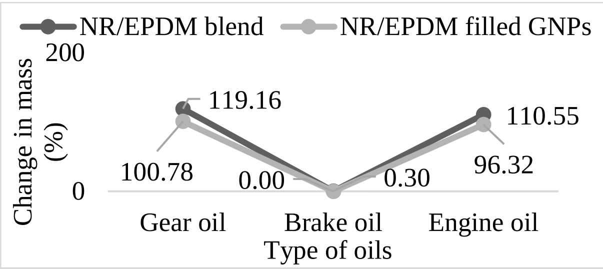


Figure 1 Change of mass when exposed to different types of oils.

### 3.2 Morphological characteristics

Figure 2 displays optical micrograph of swollen surface of NR/EPDM blends and nanocomposites after exposed in gear oil. Based on the figure, NR/EPDM blend experienced huge cracking due to medium flow into the open polymer chain and creates ampoules Some ampoules merged together and forming larger ampoules until it burst and leaving big cracking size within the ampoules parameter. Nonetheless, NR/REPDM nanocomposites shows wrinkles all over the surfaces during deswelling process. The degradation process starts with the attack and penetration by the gear oil beginning to create ampoules and then the formation and propagation of cracking and removal of the base material along its surfaces [6].

### 3.3 Compositional characteristics

Figure 3 depicts the FTIR spectrum for NR/EPDM blends and nanocomposites with three types of oils. The bonding stretch at the wavenumber of 850-900 $cm^{-1}$ indicates C-O-C stretch bond of gear oil and at 1000-1150 $cm^{-1}$. Meanwhile the band around 1445 $cm^{-1}$ corresponds to the $-CH_2$ scissoring vibrations form the propylene unit which remains after swelling. On the other hand, bands around 1530, 1250 and 975 $cm^{-1}$ were observed to faded away after the swelling test due to the broken C=C bonds with other elements from the oils.

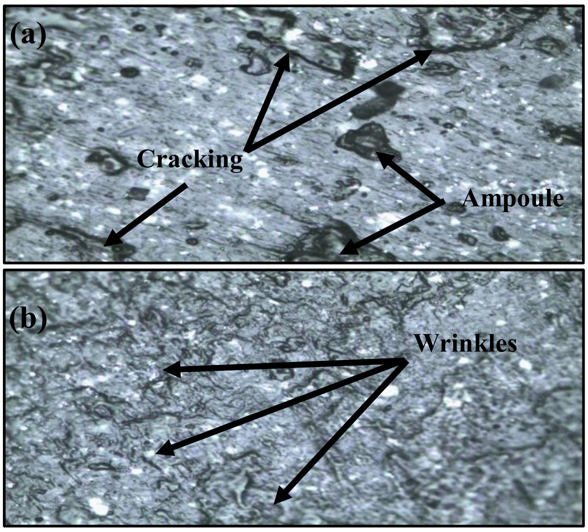


Figure 2 OM micrograph of swollen (a) NR/EPDM blends and (b) NR/EPDM nanocomposites in gear oil.

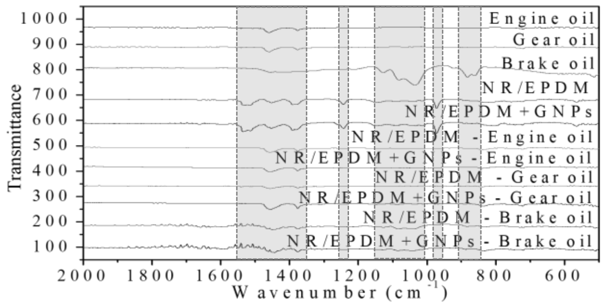


Figure 3 FTIR analysis of swollen NR/EPDM blends and NR/EPDM nanocomposites.

## 4. CONCLUSIONS

NR/EPDM nanocomposites were successfully restrained the oils absorption compared to NR/EPPDM blend. Interaction of gear and engine oils was observed to have higher changes in mass. High viscosity level of oils affected the properties of the elastomer, causing the phenomenon of swelling, cracking and deformation which increase the tendency of rubber degradation. Despite the higher change in mass when in contact with gear and engine oil, application NR/EPDM nanocomposite as an engine mounting was proven having slower degradation process when in contacts with automotive oils.


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