# Effect of graphite derivatives on mechanical and functional properties of nitrile rubber nano composite

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## Introduction

The conducting polymers and polymeric composites have attracted considerable attention in recent years because of their breadth applications in advanced technologies, for example, in antistatic coatings, electromagnetic shielding. For all applications, elastomers are reinforced with fillers to promote their performance by incorporating materials such as silica, clay, carbon blacks, etc. Graphite is a layered material with high aspect ratio in its exfoliated state; it is also considered as one of the strongest materials per unit weight and has unique functional properties such as good electrical and thermal conductivities, and good lubricating properties. In other side graphene have recently received significant attention due to its outstanding electronic, mechanical and thermal properties. NBR-based Nano composite was prepared and mechanical and functional properties were studied. The dispersion of the filler in the polymer matrix was studied using the Transmitted light metrological microscope.

## Methodology

Two different experimental trials (Preparation of NBR/Graphite composite and NBR/Graphene Nano composite) with different treatments (Phr levels) were conducted during this study. Nitrile rubber composites were prepared accordance with Brabender Plasticorder (Model: PL-2000; 26 manufacturers: ArtisanTM Technology Group).

Table 01: Formulation used for the filler loading NBR composite and NBR nanocomposite

| Materials (phr)* | Formulation | | | | | | |
|---|---|---|---|---|---|---|---|
| | NBR0 | NBR3 | NBR6 | NBR9 | NBR12 | NBR15 | NBR18 |
| NBR | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Zno | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Stearic acid | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Graphene / Graphite | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| IPPD | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| TBBS | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| TMTM | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Sulphur | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

Phr* - Parts per hundred parts of rubber

## Measurement of Electrical properties of the vulcanizates

Electrical conductivity tests were done with the use of four probe tester, Model 4200-SCS.

**($\sigma = L / RA$)**

### Measurement of Thermal properties of the vulcanizates

Thermal conductivity tests were done with the use of Lee's disc method. The Thermal Conductivity is determined by follows

$$k = \frac{mc\frac{dT}{dt}}{A\frac{(T_2 - T_1)}{x}}$$

### Result and Discussion

Table 02: Physio-mechanical Properties of NBR/Graphene nanocomposite

| Physical Properties | 0 phr | 3 phr | 6 phr | 9 phr | 12 phr | 15 phr | 18 phr |
|---|---|---|---|---|---|---|---|
| Tensile Strength (Mpa) | 3.0 | 3.2 | 4.4 | 4.1 | 5.8 | 6.8 | 6.4 |
| Mean Mod@100% (Mpa) | 1.4 | 1.6 | 1.9 | 2.0 | 2.3 | 2.7 | 3.4 |
| Elongation at break (%) | 301.9 | 331.5 | 314.9 | 329.9 | 363.3 | 382.1 | 309.1 |
| Tear Strength (N/mm) | 8.6 | 9.8 | 12.9 | 14.8 | 13.7 | 19.3 | 25.0 |
| Hardness (IRHD) | 49.1 | 51.6 | 53.5 | 55.7 | 56.9 | 59.0 | 60.1 |
| Abrasion Resistance (mm3) | 55.5 | 49.3 | 55.6 | 75.7 | 50.0 | 49.2 | 50.1 |
| Density(g/cm3) | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 |

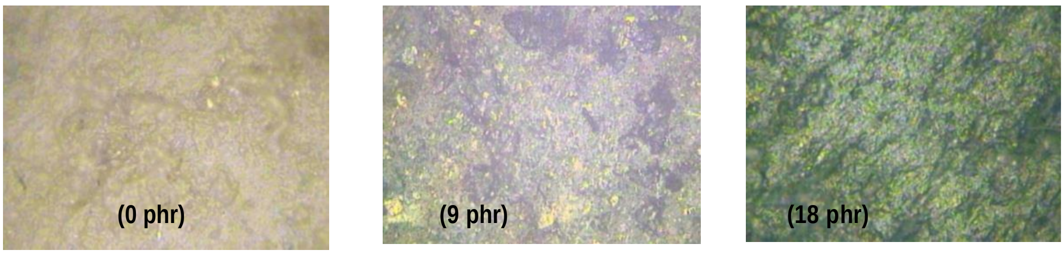


Figure 01: Surface morphology of NBR Nano composites through transmitted light metrological microscope with different graphene powder levels

According to four probe method, no improvement of the electrical conductivity of both NBR composites(4.03x10-8- 5.24 x10-8Scm-1) Considering the images of transmitted light metrological microscope, particle distribution was not uniform, and there was agglomerations of graphite derivatives in the nitrile rubber matrix. Those agglomerations directly affect to the electrical conductivity. Because it reduce the path ways of electrons flowing.

Thermal conductivity of NBR/graphene Nano composite was higher than that NBR/graphite composite. But there was no better improvement to the nitrile rubber. According to literature, the key problem is the scattering of phonons at the interface of the dissimilar phases, the imperfection of particle/particle contacts, may responsible to the observed effects. Usually better results are achieved, if micro- and nano-fillers are combined, where the inter-particle polymer layers may be bridged over by nano-particles. (Minha et al, 2013)

## Conclusions

Effect of graphite and graphene powder content on physical properties of NBR composite and Nano composites was studied. Overall results show that graphene filled Nano composites exhibited higher mechanical properties than graphite filled NBR composites.

Effect of graphite and graphene powder content on electrical conductivity of NBR composite and nanocomposites were studied. According to the results there was no any better improvement of electrical conductivity of graphite derivatives filled nitrile rubber compounds.

Results clearly demonstrated that thermal conductivity of NBR compound was not largely improved. Uneven dispersion of graphite derivatives through the NBR rubber matrix directly affect to the poor improvement of thermal conductivity.

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## References

Minha, S., Lae Lee a, H., Sung-Goo, L., Gak Kim a, B., Kim a, Y.S., Wona, J.C., Choi b, W.J., Lee, D.C., Kim d, J., Yoo, Y. (2013) 'Thermal conductivity of graphite filled liquid crystal polymer composites and theoretical predictions', Composites Science and Technology, pp. 113–119