EFFECT OF CONCENTRATION OF MMT NANOCLAY ON THE MECHANICAL, THERMAL AND ELECTRICAL PROPERTIES OF NBR/PP ELASTOMERIC NANOCOMPOSITES

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ABSTRACT
The effect of montmorillonite (MMT) Nanoclay as an outcome is investigated through experimental work over the characteristics of NBR/PP. Nano-composites samples preparation process adapted in this work belongs to the merger of MMT at diverse types of loadings conditions using the standard melt blending technique using two roll mill. Fourier transform infrared (FTIR) and Thermo gravimetric analyzer (TGA) is used as recent methods to locate the characteristics underneath multiple properties of Nano-composites under concern. The FTIR-based outcome is measured to set up the structural characteristics associations. The thermal stability of Nanocomposites has been evaluated by TGA and it has been established that the highest thermal stability occurs at 3 wt% at the loading of MMT in the polymer matrix. Mechanical properties, for instance, tensile strength, tensile modulus and hardness have been evaluated using a Universal testing machine (UTM). The mechanical characteristics are depicted to intricate investigation associated with elongation, tensile strength hand tensile modulus. It is experiential that these properties are appreciably enhanced by incorporating MMT in the rubber matrix and supportive to uphold the highest assessment at the loading value of 3 phr. Electrical properties consequences how substantial enhancement in dielectric strength& are resistance values when MMT content increases in the blend system.

Keywords: Nano-composites, Tensile Strength, TGA, Dielectric, PP, AFM.

INTRODUCTION
Present-time silicates Nano-composites materials in polymers are attracting an enormous amount of consideration for the reason that they show signs of noteworthy expansion for materials properties activities in the relationship of conventional composites and pure polymers. Such kind of superior presentation supports in giving superior modulus value¹-⁶, higher strength level& improved resistance to be had against heat ⁷, reduced value for gas permeability characteristics⁸-¹², reduced flammability ¹³-¹⁷, with upper level of the eco-friendly character.¹⁸

The performance as a function of (mechanical, thermal, morphological characteristic etc.) the rubber clay Nano-composites extremely depends on the dispersion of the Nano-filler in a matrix & compatibility of these Nano-filler with the rubber matrix. In a variety of types of natural clays, montmorillonite(MMT) is very widespread for layered silicate useful for Nano-composites making process because of the superior value of cation exchange capability, a higher level of the surface area, better reactivity of the surface and surface absorptive. MMT substances have high usage in the oil industries that depends on drilling of mud, processing of the mud slurry in making them highly viscous to maintain drill bit cooling and helps to remove the drilled solids. It has been used as a soil additive for holding the soil water for the soils of drought-prone areas.

Polypropylene (PP) is frequently applied as a polymer globally for the reason of effortless processing and rationally reduced level of cost. They comprise superior mechanical performance and physical


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characteristics never the less they are mediocre in impact strength, poor value UV resistance, brittle nature on lower temperature values for this reason they encompass limitations in the majority of the technology works. Most of the research work is focusing the features of composites of PP/HNT. NBR rubber posses the quality of resistance towards oil, fuels, and many other chemical substances. It has the acceptability of withstanding a very wide temperature range (-40 to 108) °C. This characteristic makes them a very suitable material in the modern day’s automotive.

In this article, efforts are incorporated for preparing such PP/NBR/MMT Nanocomposites under the melt mixing process using two roll mill that can introduce desirable effects for MMT loadings with enhanced performance using developed Nano-composites suitable for morphological, mechanical and thermal properties. Advanced systematic analysis done by FTIR and TGA etc. is applied for validating the improved characteristics of Nano-composites that are developed in this work.

**EXPERIMENTAL**

**Materials**

NBR rubber is taken through M/s. Japan Synthetic rubber, grade JSR 220 with the content of acrylonitrile is 38%. Nitrile rubber (NBR) belongs to a group of a copolymer made up of acrylonitrile and butadiene. PP-ICP (C015EG) grade with the value of MI 1.50 g/10 min is used under this experiment. MMT Nano clay belongs to Sigma-Aldrich and other constituents like Zinc oxide, stearic acid and Sulphur is used in the experimental work are taken from the E. Merk, Germany.

**Sample Preparation**

The compounding of rubber and plastics was done by using an open two-roll mill (Neoplast, TRM 155) of length 300 mm, 170 mm diameter at a slow speed of rolls (18 revolutions/min) & friction ratio of (1.4). The compound was passed 8 to 9 times through the rollers having a tight nip gap of < 1mm. The ingredients were added as per procedure given in the following order: activator, filler, accelerator and curing agents maintaining the roller temperatures between (100-120°C) with the cooling water as a heat removal function. Meanwhile, the different loading of MMT was varied accordingly. Simultaneously the formulations of rubber additives used are tabulated in Table-1. The Nanocomposite thus obtained was then molded in the form of a sheet (12cm x 12cm x 3 cm) at 160°C at 1138 psi or 80 kg/cm² in a compression molding press (made Deepak Poly Plast Pvt Ltd, Delhi, India). All specimens were then cut into the form of testing sheets.

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>NBR (wt%)</th>
<th>PP (wt%)</th>
<th>(ZnO) (wt%)</th>
<th>Stearic Acid (wt%)</th>
<th>Sulphur (wt%)</th>
<th>MMT (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPM-0</td>
<td>50</td>
<td>50</td>
<td>2</td>
<td>1</td>
<td>2.5</td>
<td>0</td>
</tr>
<tr>
<td>NPM-1</td>
<td>50</td>
<td>50</td>
<td>2</td>
<td>1</td>
<td>2.5</td>
<td>1</td>
</tr>
<tr>
<td>NPM-2</td>
<td>50</td>
<td>50</td>
<td>2</td>
<td>1</td>
<td>2.5</td>
<td>2</td>
</tr>
<tr>
<td>NPM-3</td>
<td>50</td>
<td>50</td>
<td>2</td>
<td>1</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>NPM-4</td>
<td>50</td>
<td>50</td>
<td>2</td>
<td>1</td>
<td>2.5</td>
<td>4</td>
</tr>
</tbody>
</table>

**Testing and Characterization of Experiments**

**Measurements of Mechanical Characteristics and Properties**

Mechanical characteristics related to the modulus, tensile strength, and material elongation are figured out through INSTRON 3382 universal testing machine at100KN i.e. peak loading condition. Tensile tests are performed by ASTM-D638 using a different type of composition. Under these tests five times, the measurements are conducted and finally, the average value of modulus and strength are considered. Sample hardness in terms of strength is observed after measuring according to the ASTM D 2240 standards as a testing method for higher accuracy and reliability under this testing method using Durometer 3062 model(type A). Under the five different observed measurements that are precisely recorded the final average value is reported and the hardness is given in the (Shore- A).

**Thermogravimetric (TGA) based Analysis**

TGA gives the measurements of the rate of change in weight concerning the deviation in the temperature. It helps in determining the value of thermal stability and this approach provides consequences for the
kinetics of the specific material decomposition. Underneath these investigation observations based on the thermal studies are performed using a Perkin-Elmer Pyres TGA instrument in temperature range varying from the 50° to 550°C the heating rate is monitored at 10°C/min in the nitrogen atmosphere.

Measurements of Electrical Characteristics and Properties
The dielectric strength is an electric property of materials and its definition is given as the amount of maximum voltage magnitude that can produce a dielectric breakdown measured according to ASTM D 149 standards. Another electrical property is arc resistance. It is defined as the capability of a material as a resistance offered against the application of the high-voltage electric arc. It is commonly expressed as a time duration that requires making a material electrically conductive under conditions of ASTM D 495 standards.

Analysis Parameter for Morphological Characteristics
The morphological features of the surfaces of NBR/PP blends filled with MMT are observed by using the model JEOL (JSM-6490 LV SEM). SEM technique helps to observe the presence of MMT in the composite and the HNT dispersion in the NBR/PP blend matrix. During this measurement before carrying out the SEM analysis, the fractured samples after applying the tensile analysis are coated with gold by using a gold sputtering unit to avoiding the effect of electrical charging and in this way help in enhancing the secondary electrons emission.

RESULTS AND DISCUSSION
Results based on Mechanical Parameters
Mechanical properties results of NBR/PP reinforced with MMT Nanocomposites are offered in Table-2. It is experientially observed through mechanical properties results in outputs that there is a desirable enhancement in the significant values of tensile strength and elongation at break with the effects related to increasing amount of content of MMT based material up to 3% by weight (wt%) loading of the quantity of MMT and the resultant values have been found by observations that it decreases as the percent by weight level of MMT is increased after 4 wt%. The decrease in tensile properties at higher loading is attributed to filler-filler interaction and poor filler dispersion to the polymer matrices. The enhancement in tensile properties may be due to the improvement in interfacial interaction of MMT and rubber molecules and also the higher aspect ratio and surface area of MMT.

The hardness of developed Nanocomposites is increased directly in proportion with an increasing amount of MMT. The hardness values of Nanocomposites are higher as compared to that of NBR rubber and PP blends. This can be due to the strong interaction between MMT Nano clay and NBR/PP blend matrices.

Table-2: Mechanical Properties Results of NBR/PP-MMT Nanocomposites

<table>
<thead>
<tr>
<th>Sample Codes</th>
<th>Tensile Strength (MPa)</th>
<th>Elongation at Break (%)</th>
<th>Hardness (Shore A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPM-0</td>
<td>6.24</td>
<td>1210</td>
<td>65</td>
</tr>
<tr>
<td>NPM-1</td>
<td>6.53</td>
<td>1365</td>
<td>67</td>
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<tr>
<td>NPM-2</td>
<td>6.84</td>
<td>1559</td>
<td>70</td>
</tr>
<tr>
<td>NPM-3</td>
<td>7.22</td>
<td>1670</td>
<td>73</td>
</tr>
<tr>
<td>NPM-4</td>
<td>6.93</td>
<td>1652</td>
<td>73</td>
</tr>
</tbody>
</table>

Thermogravimetric Analysis (TGA)
The results of TGA analysis of the NBR/PP blend reinforced with MMT Nanocomposites have been shown in Fig.-1. The enhancement in thermal stability due to an increase in the MMT loadings verifies the capability of the modern days Nano-filler substances for retardation of the diffusion of the heat in the rubber matrix of the PP/NBR. When the MMT content has been increased beyond 3 wt %, a minute decrease in the weight of residue has been observed. The improvement in thermal stability may be attributed to the incorporation of delay during the process of volatile materials diffusion through the structure of Nano-composites at the condition of 3 wt % loading for the MMT into the PP/NBR matrix. Thus, a conclusion can be drawn by saying that Nano-composites having 3 wt% loadings of MMT possess excellent thermal stability because of better interfacial adhesion Nano-filler and polymer matrix.
Electrical Properties

Table-3 Shows the electrical properties results of NBR/PP reinforced with MMT Nanocomposites. It is observed from the Table-3 dielectric strength and arc-resistant of developed Nanocomposites that there is a remarkable enhancement in dielectric strength and arc-resistant with an increasing amount of MMT up to 3 wt% loading of MMT and the values have been found to decrease as the level of MMT is increased beyond 4 wt%. The decrease in dielectric strength and arc-resistant at higher loading is attributed to filler-filler interaction and poor filler dispersion in the polymer matrices. This can be due to the strong interaction between MMT and polymer matrices shows the dielectric strength and arc-resistant values of Nanocomposites are higher as compared to that of NBR rubber and PP blends systems.
Table-3 Dielectric Strength and Arc-resistant of NBR/PP-MMT Nanocomposites

<table>
<thead>
<tr>
<th>Sample Codes</th>
<th>Dielectric Strength</th>
<th>Arc Resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPM-0</td>
<td>3260</td>
<td>168</td>
</tr>
<tr>
<td>NPM-1</td>
<td>3520</td>
<td>170</td>
</tr>
<tr>
<td>NPM-2</td>
<td>6580</td>
<td>172</td>
</tr>
<tr>
<td>NPM-3</td>
<td>6860</td>
<td>179</td>
</tr>
<tr>
<td>NPM-4</td>
<td>6640</td>
<td>173</td>
</tr>
</tbody>
</table>

Morphological Characterization
Scanning Electron Microscopy (SEM) Figs.-2a, 2b, 2c and 2d indicate the inhomogeneous distribution of dispersants with aggregations in the absence of MMT. Figure 2b depicts the surface morphology after introducing 1 phr MMT in the matrix of compatibilized NBR/PP, no or very less aggregation is observed with homogeneously distributed filler. Figure-2c SEM micrograph for a sample having loading 3 phr, where the uniform distribution of filler is seen. It is evident in the higher magnification image that in all the vulcanizates, the dispersants and stabilizers are dispersed well. The absence of vacuoles in the vulcanizates indicates a higher interaction between the filler and rubber which may result in the improved strength of vulcanizates. Figure-2d is an SEM micrograph for a sample having loading 4 phr, where the fractured surfaces are very rough but demonstrate a homogenous pattern.

Atomic Force Microscopy Studies
As shown in Table-4 and Fig.-3(a-d) surface roughness increases with the loading of fillers. It looks as if surface roughness increases in small magnitude with the increase of MMT loading and reaches its maximum at 3phr. As loading is increased, the presence of fillers at the surface increases surface roughness slightly; it increases further with an increase of MMT loading conforming to the good interfacial bonding between the polymer matrix and the reinforcement.

Table-4: Measured Values of rms Roughness from Topography Images of AFM

<table>
<thead>
<tr>
<th>Sample</th>
<th>RMS Roughness (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 phr</td>
<td>207</td>
</tr>
<tr>
<td>2 phr</td>
<td>211</td>
</tr>
<tr>
<td>3 phr</td>
<td>221</td>
</tr>
<tr>
<td>4 phr</td>
<td>225</td>
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</tbody>
</table>
CONCLUSION

The Nano-composites which are developed in this work has NBR/PP filling at various loading ratio for the MMT Nano-clay prepared through melt mixing procedure by application of two roll mill approach. It is observed in this analysis that MMT-based Nano-clay within polymer matrix found to help in giving prominent effect for improving the performance of Nano-composites polymer because of enhancement in dispersion for the Nano-clay. SEM studies-based analysis in this work is demonstrating improvement in dispersion for the MMT through the matrix because of the high level of interfacial bonding between the rubber matrix and the MMT material. Improvement in the dispersion for the MMT Nano-clay gives the improvement in the thermal, morphological & mechanical characteristics for the Nano-composite at phr for the MMT on comparing to pure blend for the PP/NBR system.

REFERENCES


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