Journal of Material Science and Mechanical Engineering (JMSME)
Print ISSN: 2393-9095; Online ISSN: 2393-9109; Volume 2, Number 9; April-June, 2015 pp. 9-11

http://www.krishisanskriti.org/jmsme.html

Studies on Thermal and Mechanical Properties of NBR/Montmorillonite Nanoclay Nanocomposites

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Abstract—*Acrylonitrile co-butadiene /montmorillonite (NBR/MMT) rubber nanocomposites have been prepared using melt mixing process by two roll mill. The influence of MMT content on mechanical, thermal, and morphological properties of the nanocomposites are investigated .Mechanical properties such as tensile strength, tensile modulus & hardness were tested. Thermo gravimetric analyzer (TGA) analysis is carried out to analyze the thermal stability of the nanocomposites. The mechanical property result shows that tensile strength, elongation at break and tensile modulus has increased significantly with increase at 5 phr loading of MMT. TGA analysis demonstrates that there is remarkable enhancement in thermal stability of developed nanocomposite at 5 phr loading of MMT. The morphological properties of fractured surface of NBR/MMT nanocomposite have been studied with the help of SEM. The morphological study reveals that there is homogenous dispersion of MMT nanoclay inside the NBR matrix. This might be the reason for the tremendous improvement in thermal and mechanical property of developed nanocomposites.*

Keywords*: NBR, TGA, Nanoclay.SEM, Mechanical properties.*

1. INTRODUCTION

Polymer nanocomposites are commonly defined as the combination of a polymer matrix and additives that have at least one dimension in the nanometer range. [1,2] The additives can be one-dimensional (examples include nanoclay, nanotubes and fibres), two-dimensional (which include layered minerals like clay), or three-dimensional (including spherical particles).[3,4] Over the past decade, polymer nanocomposites have attracted considerable interests in both academia and industry, owing to their outstanding mechanical properties like elastic stiffness and strength with only a small amount of the nanoadditives.[5-7] This is caused by the large surface area to volume ratio of nanoadditives when compared to the micro- and macro-additives. Other superior properties of polymer nano-composites include barrier resistance, flame retardancy, scratch/wear resistance, as well as optical, magnetic and electrical properties. [8,9] Elastomers were reinforced with fillers to improve their performance by incorporating conventional fillers. The resulting polymer nanocomposites thus comprise nano fillers embedded in a polymerized medium that can be subsequently cross-linked, to obtain vulcanized rubber nanocomposites. Nanocomposites made out of nano fillers had shown to afford remarkable property enhancements compared to conventional micro composites that were made using conventional filler [10-12].

In the present study, nanocomposites based on NBR/MMT nanoclay have been prepared with the help of two roll mill by melt mixing technique. Nanocomposite and their properties studies like mechanical, thermal and morphological properties. The stability of developed nanocomposites by Thermo gravimetric analysis (TGA).

2. EXPERIMENTAL

2.1 MATERIALS

The following ingredients were used in the present work:

Acrylonitrile-co-butadiene (NBR)

NBR rubber was obtained from M/s. Japan Synthetic Rubber, grade JSR 220 having acrylonitrile content of 38%. Nitrile rubber (NBR) is a copolymer of acrylonitrile and butadiene.

MMT Nanoclay: Organo modified montmorillonite (OMMT) clay: Nanomer® 1.31 PS, montmorillonite clay surface modified with 15-35 wt. % octadecylamine and 0.5-5 wt. % aminopropyl triethoxy silane supplied from Sigma Aldrich, (USA),was used as reinforcing agent to prepare the nanocomposites.

Fillers: Zinc oxide, Stearic acid, Sulphur were obtained were obtained from E. Merk, Germany.

PREPARATION OF NANOCOMPOSITES: NBR and other curing agent were masticated separately and then mixed together along with other ingredients (Table 1.).

Table 1: Sample codes and compounding formulation of NBR/MMT nanocomposites.

Sample Codes	NBR	Sulphur (phr)	ZnO (phr)	Steric acid (phr)	MMT (phr)
A	100	4	2	3	-
B	100	4	2	3	1
C	100	4	2	3	3
D	100	4	2	3	5
E	100	4	2	3	7

Mixing was carried out in a conventional laboratory by two roll mill (150 x 330 mm) at 90-100°C. NBR was masticated for 5 min and blended with MMT. After homogenization of the rubber blend for about (5 min), the other ingredients were added. The processing time after each component addition was about 5 min. The compound rubber was allowed to stand overnight before vulcanization. The compounds blends were molded to obtain sheet (3.5 mm) thickness using an electrically manually hydraulic press (Poly plast, Ahmadabad) at 150°C for 10 min at a pressure of 2400 Psi. These cured sheets were conditioned before testing (24 h maturation at 25°C).

3. EVALUATION OF PROPERTIES

MECHANICAL PROPERTIES Mechanical properties such as tensile strength, tensile modulus and elongation at break were measured by using a universal testing machine of the INSTRON model 3382; USA with the maximum load capacity 100 KN.. It has also been observed that both tensile modulus and elongation at break increases. The unit of hardness is expressed in Shore-A Durometer as per ASTM D 2240.

4. THERMO GRAVIMETRIC ANALYSIS (TGA)

Thermal stability of nanocomposites has been analyse by TGA. Thermal gravimetric analyzer studies has been conducted by using a Perkin-Elmer Pyres TGA, in the temperature range of 50-650^{o}C under a constant heating rate of 10^{o}C/min in nitrogen atmosphere for thermal stability studies of the developed nanocomposites.

5. RESULTS AND DISCUSSIONS

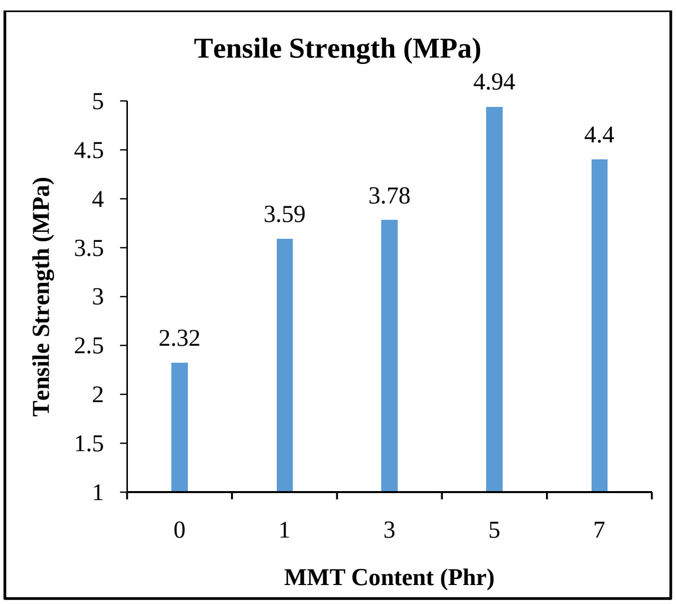

Fig. 1: Effect of MMT content on Tensile strength of NBR/MMT rubber nanocomposites.

MECHANICAL PROPERTIES: The mechanical properties of developed nanocomposites are shown in Figures 1-4. It is interesting to note that there is a significant improvement in the tensile properties of NBR/MMT nano-composites. Incorporation of MMT in NBR matrix leads to an increase in tensile strength. In fact, at higher loading of MMT, the tensile strength increases significantly. The increase in tensile strength, especially at high at 5 phr loadings of MMT.

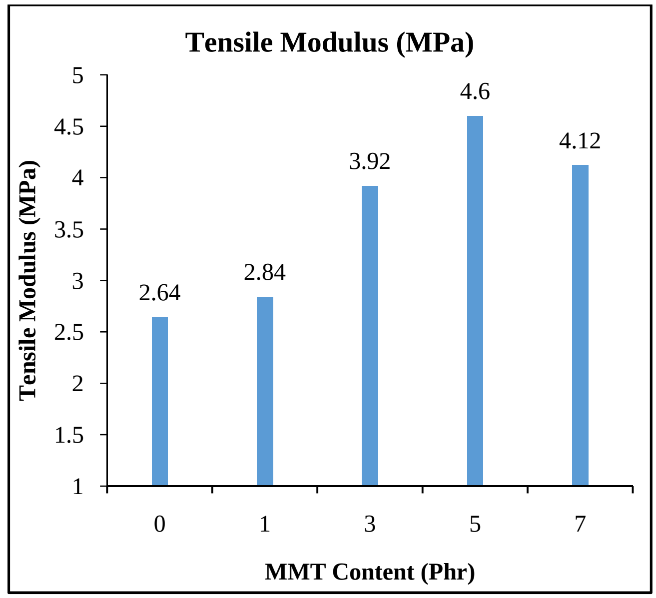

Fig. 2: Effect of MMT content on Tensile Modulus of NBR/MMT rubber nanocomposites.

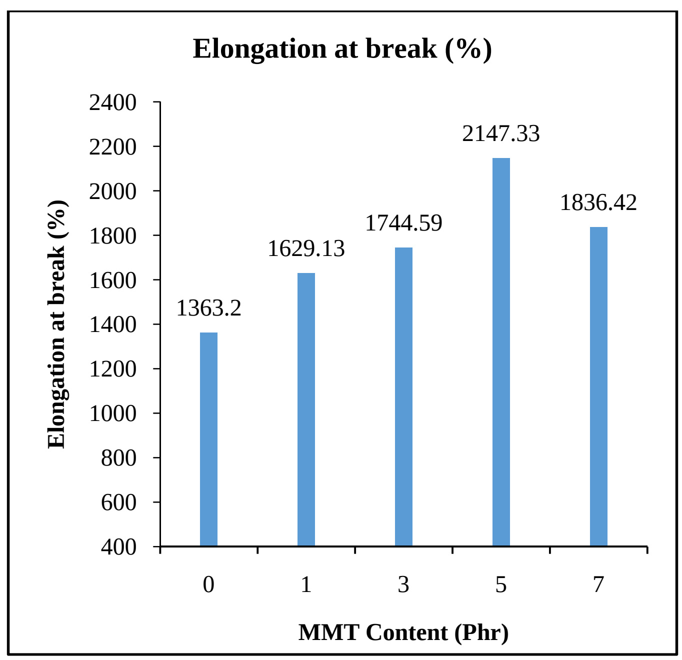

Fig. 3: Effect of MMT content on Elongation at break of NBR/MMT rubber nanocomposites.

The mechanical properties decrease at higher loading of MMT due to developed more agglomeration in side matrix. The hardness is increasing continuously at higher loading of MMT which is seen in Fig. 4.

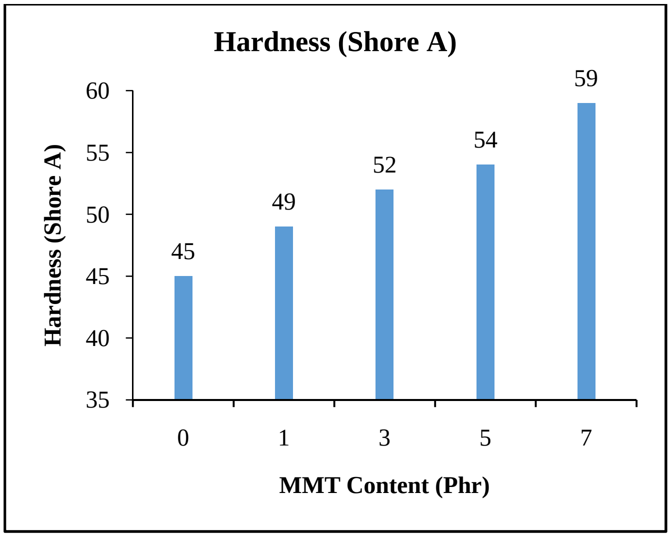

Fig. 4: Effect of MMT content on Hardness of NBR/MMT rubber nanocomposites.

THERMO GRAVIMETRIC ANALYSIS (TGA): It is depicted from TGA results that the thermal stability of NBR/MMT nanocomposites is enhanced with the incorporation of MMT as compared to virgin NBR as shown in Fig. 5.

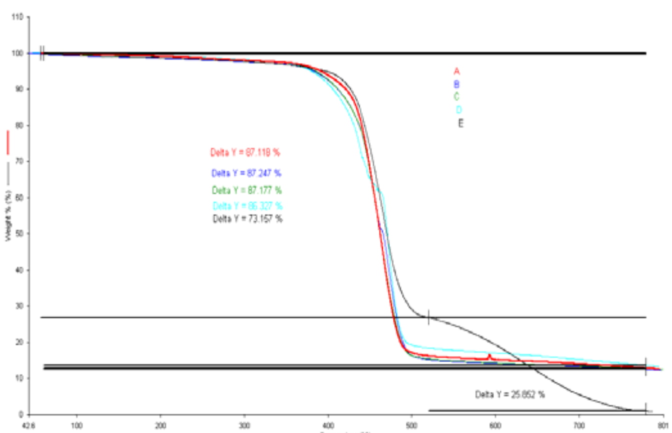

Fig. 5: TGA thermogram of NBR/MMT rubber nanocomposites.

It is clear from Fig. 5, that highest thermal stability has been achieved at 5 phr loading of the nanofiller. This remarkable effect of nanocomposite is likely to be due to reduction of chain mobility of NBR matrix by providing a large number of restriction sites which has resulted in reducing the thermal vibration of active bonds. Thus, we can say that the developed nanocomposite is in need of much more thermal energy for the decomposition of NBR matrix which enhances the thermal stability. Better thermal stability of developed nanocomposite results from entrapment of degradation product of NBR based nanocomposites, resulting in effective delay in mass transport and significantly increased thermal stability of NBR/MMT nanocomposite.

6. CONCLUSIONS

The nanocomposites based on acrylonitrile co-butadiene rubber filled with various loadings of MMT nanoclay have been prepared in two roll mill by melt mixing process. It has been found that MMT nanoclay in the polymer matrix shows the prominent effect at 5 phr loadings of MMT. The performance of polymer nanocomposites, due to better dispersion of nanoclay. Better dispersion of MMT results in the enhancement of thermal and mechanical properties of nanocomposites when compared to pure NBR rubber matrix.

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