International Journal of Materials and Chemistry 2015, 5(1): 1-3
DOI: 10.5923/j.ijmc.20150501.01

Study of Thermal Stability of Nitrile Rubber/Polyimide Compounds

Mohaimen Alneamah*, Mohammed Almaamori

Department of polymer engineering, college of materials engineering, University of Babylon, Babylon, Iraq

Abstract Nitrile rubber compounds were prepared by the addition of polyimide (PI). The effect of polyimide on thermal stability of nitrile rubber was studied. Both thermogravimetric analysis (TGA) and dynamic mechanical analysis (DMTA) of the prepared compounds showed much better thermal stability. The onset temperature of nitrile rubber increased from 360℃ to 368.4℃. Also glass transition temperature of nitrile rubber increased from -5℃ to 11.6℃. This proved that the presence of polyimide in nitrile rubber matrix can increase thermal stability.

Keywords Nitrile rubber, Polyimide, Thermal stability

1. Introduction

The measure of thermal stablity of a material is the degree of change in thermal properties with temperature. This change is caused by chemical (bonds scission, oxidation, etc.) or physical changes in polymer structure resulting in a material with different properties (usually worse). The study of thermal stability of polymers and how they react with high temperatures is very important in the design of new and better polymer products.

Nitrile rubber compounds show a limited high temperature stability. Many researches have been made to enhance thermal stability of nitrile rubber either by blending with another rubber [1] or other polymers [2, 3] or by using different additions such as hybrid filler systems [4, 5]. Allows the addition of different kinds of fillers and study its effect on thermal stability of nitrile rubber [6-10]

The aim of the work presented here was to determine the effect of high temperature polymer (polyimide) on thermal stability of nitrile rubber.

2. Experimental

2.1. Materials

Nitrile butadiene rubber (ACN content 45%), zinc oxide, stearic acid, tetramethylthiuram disulfide (TMTD), mercaptobenzothiazole disulfide (MBTS), castor oil, Sulfor, 2,2,4-trimethyl-1,2-dihydroquinoline (TMQ) and Carbon black (N 326) were supplied by Babylon tires company.

* Corresponding author:
mohaimenthamer@gmail.com (Mohaimen Alneamah)
Published online at http://journal.sapub.org/ijmc

Polyimide (aliphatic) was supplied by Taizhou Huangyan Donghai Chemical CO.

2.2. Preparation

Nitrile rubber compounds were mixed by two roll mill according to ASTM D 3182. Table 1 shows the formulation of the prepared NBR compounds. Vulcanization was done in 150℃ for 15 min.

Table 1. Compound formulation details

Ingredients	Phr*
NBR	100
Polyimide	0, 25, 50, 100
Zinc oxide	5
stearic acid	2
TMQ	2
MBTS	1.5
TMTD	0.5
Sulfor	1.5
Carbon black(N320)	40
Castor oil	10

* Phr: Part per hundered rubber

2.3. Characterization

2.3.1. Thermogravimetric Analysis

Thermograms were obtained by means of a thermogravimetric analyzer (TGA/SDTA 851^e Mettler Toledo). The measurements were made under a heating rate of 20 ℃/min at a temperature range 25℃ to 600 ℃. The experiments were done in atmosphere. About 15–16 mg of the sample was used for the analysis.

2.3.2. Dynamic Mechanical Analysis

The dynamic loss factor (tanδ) was measured as a function of temperature with a dynamic mechanical thermal analyzer (METTLER TOLEDO dynamic mechanical thermal analyzer was used) under the tension mode at a frequency of 1 Hz. The strain amplitude in the temperature range of (-50 to 280℃) was 0.1%. The heating rate was 5℃/min.

3. Results and Discussions

3.1. Thermogravimetric Analysis

Thermogravimetric analysis (TGA) curves for the prepared compounds are shown in figure 1. Nitrile rubber compounds present only one thermal degradation step in the temperature range of 25℃-600℃. The incorporation of polyimide in to NBR causes shift towards higher temperatures. Table 2 shows the initial decomposition temperature at weight loss of 5% of NBR compounds. Initial decomposition temperature increased from 360℃ for NBR compound without polyimide to 368.4 ℃ for NBR compound with 100 (Phr) polyimide. Final char residue of the prepared compounds increased from 32 wt% to 36 wt% for NBR with 100 (Phr) polyimide table 2. All this proves that the incorporation of polyimide in to NBR matrix increases thermal stability of NBR.

Table 2. The initial decomposition temperature of NBR and its composites at 5% mass loss and the final char residue at 600 C°

Batch	Initial Decomposition Temperature C°	Final Char Residue Wt%
NBR	360	32
NBR/PI25	360.8	33.7
NBR/PI 50	363.7	35
NBR/PI 100	368.4	36

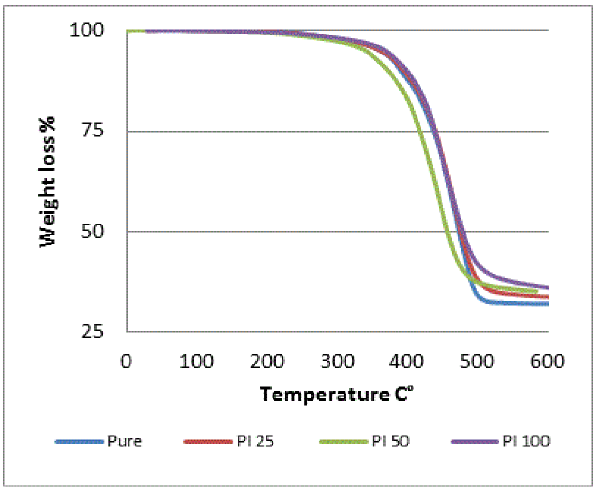

Figure 1. TGA curves of nitrile rubber compounds

3.2. Dynamic Mechanical Analysis

Curves of Dynamic mechanical analysis (DMA) of the prepared compounds are shown in figure 2. Table 3 summarizes the effect of polyimide addition on glass transition temperature (Tg) and loss tangent (tanδ) of nitrile rubber. Tg of NBR increased from -5℃ to 11.6℃.

Table 3. Glass transition temperature and loss tangent of NBR and its composites obtained from DMA analysis

Batch	Glass transition temperature C°	Loss tangent
NBR	-5	1.11
NBR/PI 25	9.5	0.74
NBR/PI 50	10.9	0.55
NBR/PI 100	11.6	0.41

From figure 2 it can be seen that there is only one peak around 9.5℃, the loss tangent of this peak begin to decrease from 0.74 in NBR with 25 (Phr) polyimide to 0.55 in NBR with 50 (Phr) polyimide. Another peak rises in the temperature range 185℃ and its loss tangent increase from 0.25 in NBR with 50 (Phr) polyimide to 0.41 in NBR with 100 (Phr) polyimide, this proves that polyimide increase the damping of NBR at high temperatures.

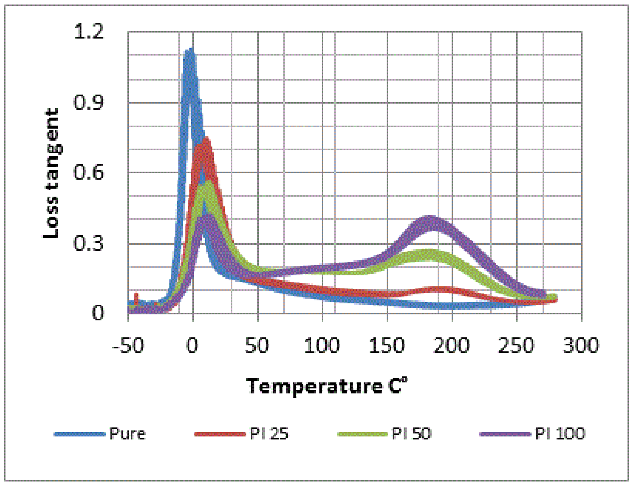

Figure 2. DMTA curves of nitrile rubber compounds

4. Conclusions

NBR compounds were prepared by the addition of polyimide (PI) as a high temperature filler. Thermal stability of NBR compounds was studied. It was found that the initial decomposition temperature at 5% weight loss for NBR compound without polyimide increase as polyimide content increase also high Tg values of the prepared compounds which increase with polyimide content increase are a clear evidence of improving thermal stability of nitrile rubber by the addition of polyimide .

REFERENCES

[1] Marković, G., Marinović-Cincović, M., Vodnik, V., Radovanović, B., Budinski-Simendić, J., & Veljković, O. (2009). Thermal stability of acrylonitrile/chlorosulphonated polyethylene rubber blend. *Journal of thermal analysis and*

calorimetry, *97*(3), 999-1006.

[2] Pruneda, F., Suñol, J. J., Andreu-Mateu, F., & Colom, X. (2005). Thermal characterization of nitrile butadiene rubber (NBR)/PVC blends. *Journal of thermal analysis and calorimetry*, *80*(1), 187-190.

[3] Varghese, H., Bhagawan, S. S., & Thomas, S. (2001). Thermogravimetric analysis and thermal ageing of crosslinked nitrile rubber/poly (ethylene-co-vinyl acetate) blends. *Journal of thermal analysis and calorimetry*, *63*(3), 749-763.

[4] Nugay, N., & Erman, B. (2001). Property optimization in nitrile rubber composites via hybrid filler systems. *Journal of applied polymer science*, *79*(2), 366-374.

[5] Nigam, V., Setua, D. K., & Mathur, G. N. (2001). Hybrid filler system for nitrile rubber vulcanizates. *Journal of materials science*, *36*(1), 43-47.

[6] Albano, C., Ichazo, M. N., Boyer, I., Hernández, M., González, J., Karam, A., & Covis, M. (2012). Study of the thermal stability of Nitrile rubber-coconut flour compounds. *Polymer Degradation and Stability*, *97*(11), 2202-2211.

[7] Janowska, G., Rybiński, P., & Jantas, R. (2007). Effect of the modification of silica on thermal properties and flammability of cross-linked butadiene-acrylonitrile rubbers. *Journal of thermal analysis and calorimetry*, *87*(2), 511-517.

[8] Janowska, G., Rybiński, P., & Jantas, R. (2007). Effect of the modification of silica on thermal properties and flammability of cross-linked butadiene-acrylonitrile rubbers. *Journal of thermal analysis and calorimetry*, *87*(2), 511-517.

[9] Kader, M. A., Kim, K., Lee, Y. S., & Nah, C. (2006). Preparation and properties of nitrile rubber/montmorillonite nanocomposites via latex blending. *Journal of materials science*, *41*(22), 7341-7352.

[10] Kim, J. T., Lee, D. Y., Oh, T. S., & Lee, D. H. (2003). Characteristics of nitrile–butadiene rubber layered silicate nanocomposites with silane coupling agent. *Journal of Applied Polymer Science*, *89*(10), 2633-2640.