2nd Conferences on Applications of Nanotechnology in Sciences, Engineering and Medicine (NTC2011)

16-17 May 2011 Mashhad - Iran

Islamic Azad University Mashhad Branch

MECHANICAL BEHAVIORS OF SMR RUBBER REINFORCED WITH NANO- PRECIPITATED CALCIUM CARBONATE

S. Dabaghi[a], A. Ahmadpour[a,*], M. Shiva[b]

[a] *Department of Chemical Engineering , Ferdowsi University of Mashhad, Mashhad, Iran.*

[b] *Department of Chemical Engineering , University of Sistan & Baluchestan, Zahedan, Iran.*

* *Corresponding Author's E-mail: ahmadpour@um.ac.ir*

ABSTRACT

In this study, we have used nano-$CaCO_3$ particles as modified filler to prepare Standard Malaysian Rubber (SMR)/ nano-$CaCO_3$ composites. By adding different mass fraction of nano-$CaCO_3$ to SMR rubber, the mechanical properties of product such as tensile strength, elongation at break and hardness were investigated. The experimental results showed that by increasing small mass fraction of nano-$CaCO_3$ up to 5wt%, elongation at break and tensile strength of the SMR/nano-$CaCO_3$ composites were enhanced, but they have decreased above this quantity. Hardness was also increased since nano-particles filled the cavity of SMR rubber.

KEYWORDS: *Nano-$CaCO_3$, Mechanical properties, Rubber.*

INTRODUCTION

Currently, developing nanocomposites based on polymers and nano-sized fillers has been an attractive approach to enhancing properties [1]. They show superior physical and mechanical behavior over their conventional microcomposites [2]. Various nano-size particles such as clay, nano-$CaCO_3$, nano-SiO_2, and nano-Al_2O_3 have been added as toughening agents [3]. Nano-$CaCO_3$ has reinforcement function and also additional advantages of a low aspect ratio and a large surface area [4]. Several researchers have studied the preparation and mechanical properties of nano-$CaCO_3$-reinforced rubber composites [5–7]. In this paper, we briefly report the mechanical properties of SMR rubber reinforced with nano-$CaCO_3$.

EXPERIMENTAL

MATERIALS AND SAMPLE PREPARATION

The nano-sized calcium carbonate (nano-$CaCO_3$) used in this study with 30 nm mean particle size and 40 m^2/g specific surface area was obtained from Merck. SMR was used with the additives namely stearic acid, zinc oxide, sulfur and OBTS. The compounding formulations are summarized in Table 1. The nano-$CaCO_3$ content of the rubber was varied from 5 to 20 wt%. Mixing of the rubber, ZnO and stearic acid was first performed using a two-roll mill (MCCIN 152 X 305 R-E) at 60°C for 5min. The nano-$CaCO_3$ was also added and mixed using the mill at 60°C for 15min. Then, after 24hr, sulfur and accelerator were added in the same manner at 60°C for 10min. After all, the resulting rubber sheets were pressed and vulcanized using a Vacuum Vulcanizer at 155°C.

MEASUREMENTS

The cured sheets were subjected to conditioning for 24hr. The tensile strength and elongation at break were measured at 23°C and relative humidity of 50%, using a dinamometer according to the ASTM-D-624 method. Hardness was also tested by using durometer according to ASTM-D-2240. All the mechanical property values were obtained by averaging three experimental values.

Table1 Compounding Formulation.

Ingredient	Loading (phr)[a]
SMR rubber	100
Zinc oxide	5
Stearic acid	1.5
Accelerator[b]	2
Sulfur	5

[a] Part Per Hundred of Rubber.

[b] *N*-(Oxydiethylene)-2-benzothiazolesulfenamide.

RESULTS AND DISCUSSION

The tensile strength of a material quantifies how much stress the material will endure before suffering permanent deformation. This is very important in applications that rely upon a polymer's physical strength or durability. For example, a rubber band with a higher tensile strength will hold a greater weight before snapping. In general, tensile strength increases with polymer chain length and also crosslinking of polymer chains. The tensile strength and elongation of the composites as a function of nano-$CaCO_3$ content are shown in Fig1. As observed, these mechanical properties were enhanced by the addition of nano-$CaCO_3$ up to 5 wt% loading. These results can be attributed to the fact that nano-$CaCO_3$ was finely dispersed in the rubber matrix, thereby increasing the intermolecular interactions between the rubber chains and the $CaCO_3$ surfaces. The decrement of mechanical properties above 5wt% of nano-$CaCO_3$ content, might be due to the agglomeration of filler nanoparticles [8,9].

The hardness of an elastomer is measured based on the depth of indentation. The hardness is obtained by comparing the difference between a small initial force and a much larger final force. Fig2 shows that the hardness increases by enhancing the filler due to dispersion of filler in matrix, which brings chains of matrix closer to reduce the free volume.

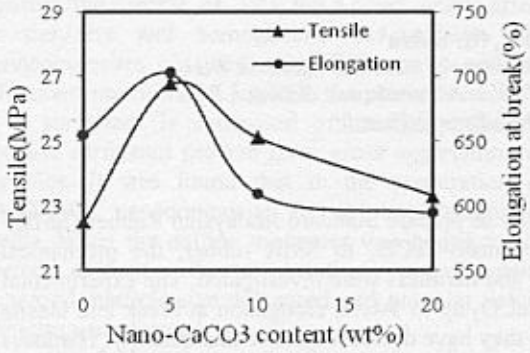

Fig1: Tensile strength and elongation of BR/nano-$CaCO_3$ composites as a function of nano-$CaCO_3$ content.

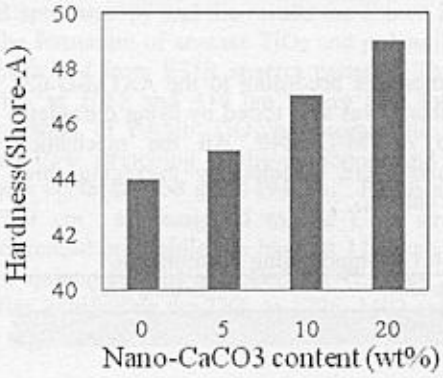

Fig2: Dependency of the hardness to nano-$CaCO_3$ content.

CONCLUSION

Through the experimental results, we have observed that tensile strength and elongation at break of the SMR/nano-$CaCO_3$ composites are increased. Although, there was continuous increment in hardness with increasing nano-$CaCO_3$ content, maximum enhancement was observed up to 5wt% loading due to uniform dispersion of these nanoparticles into rubber matrix. The results indicate that nano-$CaCO_3$ is a good candidate to use as a SMR rubber-reinforcing agent.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Kavir Tire Company for giving facilities to carry out this work.

REFERENCES

[1] A. A. Bakari, N. N. M. Rosli, *Jurnal Teknologi*. 45 (2006) 83-93.

[2] J. T. Kim, T. S. Oh, D. H. Lee, *Polym. Int*. 52 (2003) 1058-1063.

[3] F. L. Jin, S. J. Park, *Mater. Sci. Eng. A*. 478 (2008) 406–408.

[4] C. H. Chen, C.C. Teng, S.F. Su, W.C. Wu, C.H. Yang, *J. Polym. Sci. Part B: Polym. Phys*. 44 (2006) 451.

[5] C. M. Deng, M. Chen, N. J. Ao, D. Yan, Z. Q. Zheng, *J. Appl. Polym. Sci*. 101 (2006) 3442.

[6] X. Su, Y. Hua, J. Qiao, Y. Liu, X. Zhang, J. Gao, Z. Song, F. Huang, M. Zhang, *Macromol. Mater. Eng*. 289 (2004) 275.

[7] S. Mishra, S. H. Sonawane, N. Badgujar, K. Gurav, D. Patil, *J. Appl. Polym. Sci*. 96 (2005) 6.

[8] S. Mishra, N. G. Shimpi, *J. Sci. Ind. Res. India*. 64 (2005) 744–751.

[9] Q. Wang, F. Yang, Q. Yang, J. Chen, H. Guan, *Mater. Des*. 31 (2010) 1023–1028.