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Research Article

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Investigation on the swelling characteristics of NR/BR rubber blends

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ABSTRACT

The Polymer stability investigation in different media is of a great practical importance to understand their characteristics for many industrial applications. The investigation on the swelling characteristics of rubber under different solvents is of more significant. The current paper presents a thorough overview of swelling of NR/BR blended rubber having many industrial applications at the present. The swelling of rubber induces self healing and increase in volume when in contact with certain fluids. The swelling test has been carried out upon interaction with fluids like oil and toluene and the swelling results in change of geometry, density, hardness. The swelling of the rubber blend depends on the temperature, pressure and fluid composition. Moreover high swelling taken place during the stage of adsorption by toluene than Aromatic Rubber Process oil (Mahathol), leading to an increase in dimension. The change in dimension of the toluene swelled sample is around 1.5 to 2 times than the oil swelled one. The Toluene swelled sample is almost weak and during the wear test they showed high wear rate when compared with Oil swelled samples.

Key words: swelling, wear, volume, rubber blends, slip

INTRODUCTION

Blending of two or more types of polymer is a useful technique for the preparation and developing materials with properties superior to those of individual constituents [1]. Natural rubber has been studied and reported on extensively because of its superior performance in tire applications [2]. It is well known that elastomers do not display all of the characteristics that are required and thus the additives are included to avail the desired properties. Elastomer blends are used for many purposes such as lowering the compound cost [3]. The complex shaped product may be more easily fabricated during production. The elastomer blends are frequently used in the rubber industry to obtain the best compromise in compound physical properties, processability and cost [4]. The Natural rubber (NR) and Poly Butadiene rubber (BR) have been blended for a long time for these reasons. A lot of studies have demonstrated that the mechanical properties of such blends can be significantly improved by adding suitable agents [5].

The investigation also concentrated on the wear characteristics of swelled samples and presented here. Wear is a process of the gradual removal of a material from surfaces of solids subject to contact and sliding. The damages of contact surfaces are the results of wear. The abrasion or wear rate is the dominant factor that controls the service life of all these components. Abrasion or wear rate are therefore important factors in determining how fast a material is removed from the surface, for determining its life [6]. Therefore good abrasion resistance is of high priority for most elastomer components. The wear test was conducted in the DIN Abrader for estimating the wear of samples by abrassion.

EXPERIMENTAL SECTION

When the rubber comes into contact with any liquid hydrocarbons, generally mass transfer takes place [7]. Depending on the nature of the polymer, the amount of the liquid adsorbed varies and also the change in dimension of the sample varies [8]. In this investigation the process of adsorption in NR/BR blended rubber blocks on different mediums has been studied. This test was performed to determine the swelling behavior (volume and thickness change) of elastomer samples when immersed in different mediums kept at identical temperatures for a total time of 240 hours. Disc shaped samples were used to study the swelling response of free (unconfined) elastomer. Thickness and volume of each specimen was measured before swelling and periodically after swelling. Rubber vulcanizates were tested for wear characteristics in the DIN abraded. An approach was made in this research work to understand the mechanism of wear behavior of blocks under standard abrasion test. The DIN abrader is a device used for estimating the wear of vulcanizates, following DIN standard (DIN 53516).

COMPOUNDING

The raw rubber was first masticated on the laboratory open two roll mill for five minutes. Zinc oxide, stearic acid and other rubber additives were added sequentially in masticating rubber blend. The mixing mill was cooled by cold water circulation during the mixing of all rubbers and rubber additives. The compounds were prepared as per formulation given in **Table 1** According to ASTM method D 3182.

Table1. Rubber Formulation

Ingredients	phr
Natural Rubber NR	80.00
Poly-Butadiene Rubber BR	20.00
6PPD[a]	2.00
Zinc oxide	5.00
Stearic acid	2.00
N330, HAF black	(variable 15,35,45,60)
Process oil (Aromatic)	5.00
Micro crystalline Wax	1.00
TBBS[b]	1.50
Sulphur	1.50

a- N(1,3-dimethyl-butyl)-N'-phenyl-p-phenylenediamine
b- N-Tertiarybutyl-2-benzothiazole sulfennamide

MOULD DESIGN AND SAMPLE PREPARATION

It is necessary to use more precisely designed and well constructed steel moulds, suitably hardened and finished for moulding the samples. In this investigation, the samples were prepared using the compression moulding process. The figure 1 presents the mould used for sample preparation. The mould was designed with three pieces including top and bottom platen. The moulds used in are made of die steel, and fabricated by using the wire cut Electrical Discharge Machining (EDM) process to ensure good dimensional accuracy. Adequate care was taken in designing the mould for getting almost flash free samples. All the samples were made identical, in terms of mass and volume.

Figure1. Mould for Sample preparation

The test pieces were prepared directly by moulding in the hydraulic press. The properties of the test samples and hence the test results obtained depends on the processing methods. It is highly desirable to standardize the sample preparation procedure, so that a comparison can be made from the test pieces produced under identical conditions. The dimensions of the samples play a critical role as it is very likely to influence the results. As the test results are sensitive to the geometry of the test piece, they are prepared very carefully. The Figure 2 shows the samples used in the investigation with different aspect ratios. The cylindrical samples with aspect ratios (a/h) ranging from 0.5 to 1 are analyzed with and without the CB filler. The samples have been prepared from specifically designed moulds and are investigated for swelling and wear characteristics.

Figure2. Samples of different Aspect ratios

Swelling Test

The Swelling test was performed according to ASTM D3616. This test was performed to determine the swelling behavior (volume and thickness change) of elastomer samples when immersed in different testing mediums [9]. Disc shaped cylindrical samples were used to study the swelling response. Swelling behavior was determined by the change in mass using the following method. The rubber vulcanized test pieces of known weight (*W*2) were immersed in toluene and oil in diffusion test bottles and kept at room temperature for 24, 48, 144, 240 hours. Samples were removed from the bottles and the wet surfaces were quickly wiped using tissue paper and re-weighted (*W*1). The test samples of the blends were further dried in an oven cooled in a desiccator and immediately weighed (*W*3). The swelling parameters of blends were calculated by the following relation.

The Swelling index (SI) was calculated by,

SI = (W1-W2/W2) x100 %

Where: W2 = Initial Weight/dry weight & W1 = Swollen Weight

Wear Test

The abrasion or wear rate is the dominant factor that controls the service life of all these components [10]. Abrasion or wear rate are therefore important factors in determining how fast the material is removed from the surface for determining a component's life. As good abrasion resistance has become a high priority for most elastomer components, wear studies were performed on the swollen and un-swollen vulcanizates.

RESULTS AND DISCUSSION

In the present paper, blends of natural rubber and Poly-Butadiene Rubber have been blended as per the recipe given in the table 1 and swelling, wear characteristics were studied. The diffusion of toluene, an aromatic solvent, through the blends has been investigated and the mechanism of adsorption through the blends was determined. The S1, S2, S3, S4 are variably carbon black loaded sample. The Carbon black loading value varied from 0, 45, 67.5 and 90 PHR for the samples S1 to S4 respectively. Figure 3 depicts the Hardness plot for Toluene swelled samples with variable Carbon black (CB) loading. For the toluene swelled samples the value was determined using Shore A hardness. For the gum compound (0 Phr CB) to the highly CB loaded samples the change in hardness was almost showed gradual decrement. The change in hardness values found to be negligible in the course of time variation. Figure 4 depicts the Hardness plot for Oil (Mahathol) swelled samples with variable CB loading. There found a rapid change in the hardness value at the initial stage and thereafter found to be negligible. The toluene swelled samples when compared to oil swollen have shown higher variation in the hardness vales in the test period.

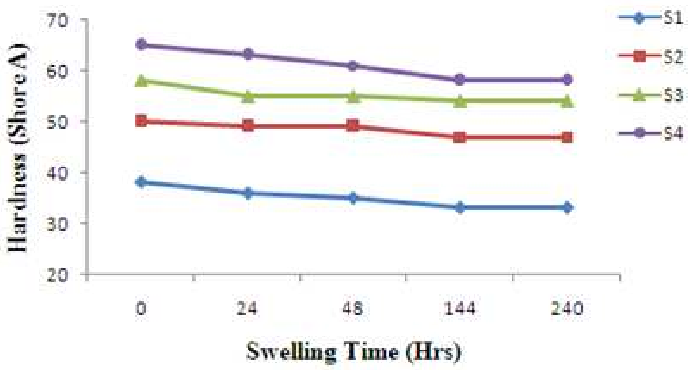

Figure 3 Hardness plot for Toluene swelled samples with variable CB loading

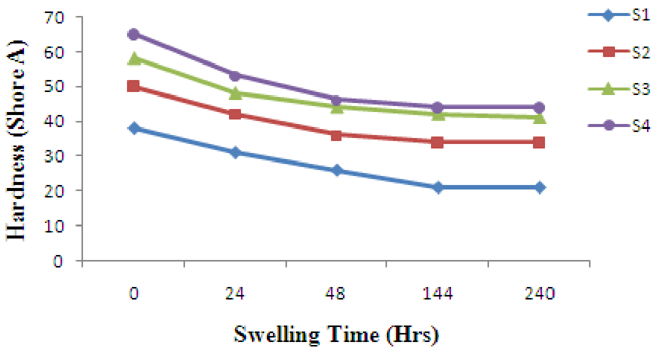

Figure 4 Hardness plot for Oil swelled samples with variable CB loading

Abrasion is an important factor to determining how fast a material is removed from the surface for determining its life. A gradual removal of a material from surfaces has been carried out in the DIN Abrader for estimating the wear characteristics. Figure 5 presents the Mass loss for Oil (Mahathol) swelled samples with variable CB loading. The mass loss for the gum compound was very high than the CB filled Vulcanizates. The vulcanizates with high carbon black loaded shown good resistance to wear comparatively. The wear debris found to be larger in sizes having granular shapes. The wear of debris of un-swollen samples found to be powdery in normal case. The wear rate was high initially and gradually decreased in both the oil and toluene swelled samples.

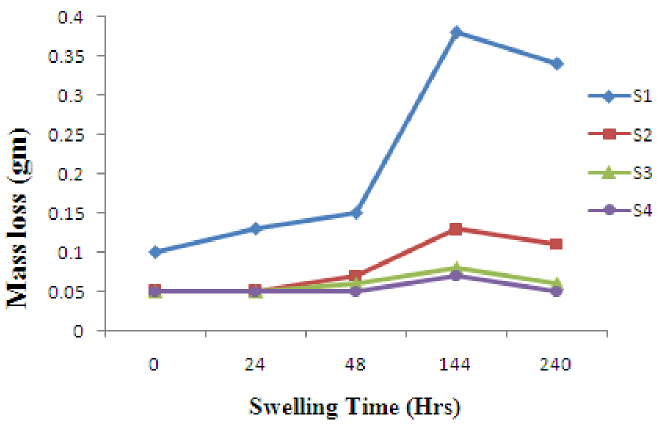

Figure 5 Mass loss for Oil swelled samples with variable CB loading

Figure 5 presents the Mass loss for Oil (Mahathol) swelled samples with variable CB loading. The test was carried out similarly in the DIN abrader and the mass loss was quantified. The wear debris found to be powdery and also they are very soft. This shows the toluene swelling makes the rubber material to become weaker by affecting the cross linking of the polymer. The rate of wear was also comparatively high than the oil swelled samples. The oil swollen samples shown better resistance and the reason might be due to slip at the interfacial during abrasion.

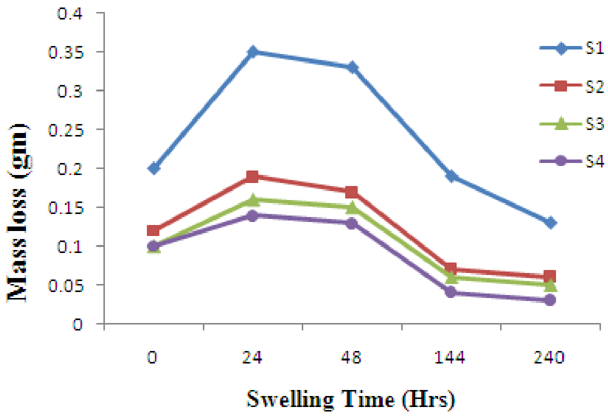

Figure 6 Mass loss for Toluene swelled samples with variable CB loading

CONCLUSION

The investigation on the swelling characteristics of rubber in different solvents is of more significant for their industrial applications. The current paper analyzed the swelling and wear characteristics of NR/BR blended rubber blocks. The change in hardness values found to be negligible in the course of time variation for both the toluene and oil swelled samples. There found a rapid change in the hardness value initially and was almost negligible finally. The hardness values of the oil swelled samples even though with higher CB loading shown decrease in hardness values for longer duration. The wear rate of the swollen and un-swollen samples is more significant to understand their behavior under operating environments. The wear particles found to be very soft and almost even in size for toluene swelled. Comparatively the debris is of granular shape agglomerate with oil. Also the oil swelled samples also shown resistance to wear which might be due to slip in the contact surfaces. The wear rate is extremely high for toluene swelled samples rather the oil swelled samples.

REFERENCES

[1] F Findik ; R Yilmaz ; Keoksal, *Materials and design*, **2004**,25, 269-276.
[2] SC George; KN Ninan; G Greonincks; S Thomas, *J. of Appl Polym Sci.*, **2000**, 78(6), 1280–1303.
[3] J Anuar; M Mariatti; H Ismail, *Polymer-Plastics Technology and Engineering*, **2007**, 46(12), 1201-1206.
[4] Hanfi Ismail; HM Hairunezam, *European Polymer Journal*, **2001**, 37, 39-44.
[5] A Mostafa; A Abouel-Kasem; MR Bayoumi; MG El-Sebaie, *Materials and Design*, **2009**,30,1561-1568.
[6] NSM El-Tayeb; R Nasir, *Wear*, **2007**, 262, 350-361.
[7] K Azaar; ID Rosca; JM Vergnaud, *Polymer*, **2002**, 43, 4261-4267.
[8] T Pervez; SZ Qamar ; RA Siddiqui; M van de Velden, *Archives of Materials Science and Engineering*, **2009**, 37(2),**2009**,77-84.
[9] Khalil Ahmed, Shaikh Sirajuddin Nizami, Nudrat Zahid Raza, Khaula Shirin, *Adv in Materials Physics and Chem.*, **2012**, 2, 90-97.
[10] AH Muhr; AD Roberts, *Wear*, **1992**,158, 213-228.