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A Novel Approach to Recycle Footwear Industry Wastes

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Abstract: Foot wear industry generates a lot of wastes every year which requires technological interventions for the safe guarding of environment. Ethylene vinyl acetate (EVA) is a commonly used polymer in footwear industry. It generates a big quantum of wastes worldwide. These wastes must be recycled or re-utilized otherwise it creates lot of environmental problems. Natural rubber (NR) is an elastomer available plenty in Kerala having many industrial applications. It's cost is increasing up significantly (10 times in 10 year). Natural rubber product developing units are facing a big problem in terms of cost and quality. This work is to examine the feasibility of introducing EVA waste into natural rubber in a technologically viable way without sacrificing the basic qualities of NR. Different samples are prepared by varying the Phr (parts per hundred of rubber) of EVA waste in NR matrix. Rheological examination wascarried out to determine the optimum cure time. Mechanical properties of the system are studied. Differential scanning calorimetry (DSC) analysis was carried out to evaluate the performance of blend in terms of glass transition temperature and crystallization temperature. Morphology of specimen is studied using scanning electron microscopy (SEM). Development of a product from optimized formulation shall be tried.

Key words: EVA · Phr · Natural rubber · Blend · Mechanical properties · Glass transition temperature

INTRODUCTION

The environmental pollution produced by industry residues is one of the largest concerns of human society [1, 2, 3, 4]. Polymers play a vital role in this regard, since the demand of polymeric products increased over the last decades due to their many industrial applications. As synthetic polymers do not decompose easily, their residues constitute a serious problem to the environment. Ethylene vinyl acetate is a polymer used as a substitute for leather in footwear industry [5]. It is used for making the insoles and innersoles of shoes. More than 17 billion pair of shoes are produced worldwide every year. This creates enormous amount of wastes. These wastes must be recycled or re-utilized otherwise it creates lot of environmental problems [6, 7, 8] Natural rubber is an elastomer available plenty in Kerala having many industrial applications. The major uses for natural rubber are for vehicle tires and conveyor belts, shock absorbers and anti-vibration mountings, pipes and hoses. It also serves some other specialist applications such as in pump housings and pipes for handling of abrasive sludge, power transmission belting, water lubricated bearings, etc. It's cost is increasing up significantly(10 times in 10 year). Natural rubber product developing units facing a big problem in terms of cost and quality. This project is to examine the feasibility of introducing EVA waste into natural rubber in a technologically viable way without sacrificing the basic qualities of NR

MATERIALS AND METHODS

EVA waste used here for the test is collected from nearby footwear industry. Sulphur with zinc oxide and stearic acid are used as vulcanizing agents. MTBS and TMTD are the activators used for vulcanization. The optimized formulation for mixing NR and EVA is found out by trial and error method. First NR and EVA waste are pressed separately between two rollers mixing mill and then they mixed each other with the formulations shown in Table 1. Curing characteristics is determined in a rheometer which is shown in Table 2. Diffrent samples are prepared by varying the concentrations EVA waste. Samples are named as N100, NE30. NE40, NE50, NE60,

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Table 1: Formulations used for vulcanization in Phr (parts per hundred of rubber)

Saple Name/Ingradient	N100	Ne30	Ne40	Ne50	Ne60	Ne100
Nr	100	100	100	100	100	100
Eva Waste	0	30	40	50	60	100
Sulphur	2	2	2	2	2	2
Zinc Oxide	5	5	5	5	5	5
Stearic Acid	1.5	1.5	1.5	1.5	1.5	1.5
Mtbs	1	1	1	1	1	1
Tmtd	1	1	1	1	1	1

Table 2: Cure time characteristics of selected samples at temperature of 150°C

Cure time characteristics	NR100	NE60
Cure time, T_{90} (min)	3	3.2
Scorch time(min)	2.5	2.5
Maximum torque(Nm)	5.2	3
MH-ML(Nm)	5	2.8

NE100. Where N stands for natural rubber and E stands for EVA waste. Samples are taken into injection moulding machine for pressure vulcanization. This process involves heating the mix in a mould under pressure of 2000pounds/square inches at a temperature of 150°C and kept it for a time equal to curing time. The cured samples are taken out to perform various testing.

Testing for Mechanical Properties: Mechanical tensile test and tear test is carried out in universal testing machine at a test speed of 500mm per minute as per ASTM standard D3574. The test temperature was 18°C and humidity was 50%. Six samples were tested. The mechanical properties obtained are tensile strength, young's modulus, elongation at break and tear strength. All the properties are plotted against Phr of EVA waste.

Diffraction Scanning Calorimetric Analysis: DSC analysis is carried out in DSC apparatus (DSC Q20 V24.10 Build 122) to evaluate the performance of blends in terms of glass transition and crystallization. Samples selected for DSC analysis are EVA60, EVA30 and NR100.

Scanning Electron Microscopy: SEM observations were performed on selected samples to study the morphological features.

RESULTS AND DISCUSSION

Mechanical Properties: Table 3 presents experimental data obtained from tension and tear test performed on six samples. The result shows that tensile strength, tear strength, percentage elongation and young's modulus increases with increasing Phr of EVA wastes in the NR matrix and it is maximum around 60 Phr of EVA waste. If we go for 100 Phr EVA waste it is again decreases but not below that of NR100. The increase in properties is due to the formation of more cross linking between polymer layers. That means.EVA waste act as filler. Considering the influence of EVA waste on properties one can say that optimum value of EVA waste for better result is around 60 Phr. The important properties needed for rubber products like Shock absorbing capacity, creep resistance, tensile strength and tear strength are increased significantly due to the introduction EVA waste into NR.

DSC Analysis: Figure 1 shows the DSC of NR100 and Figure 2 is the DSC of NE60. The graphs shows that glass transition occurs at -59.48°C and -58.1°C respectively for NR100 1nd NE60. This result indicates that introduction

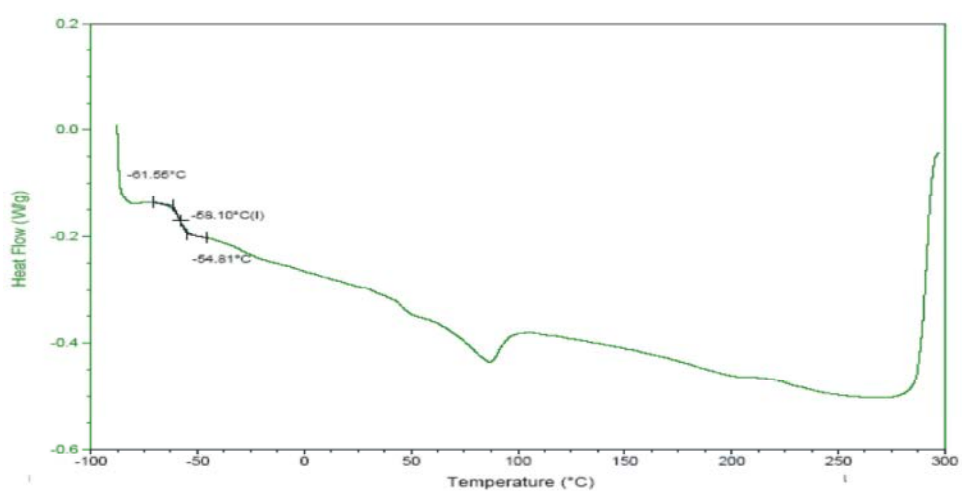

Fig. 1: Dsc Of NE60

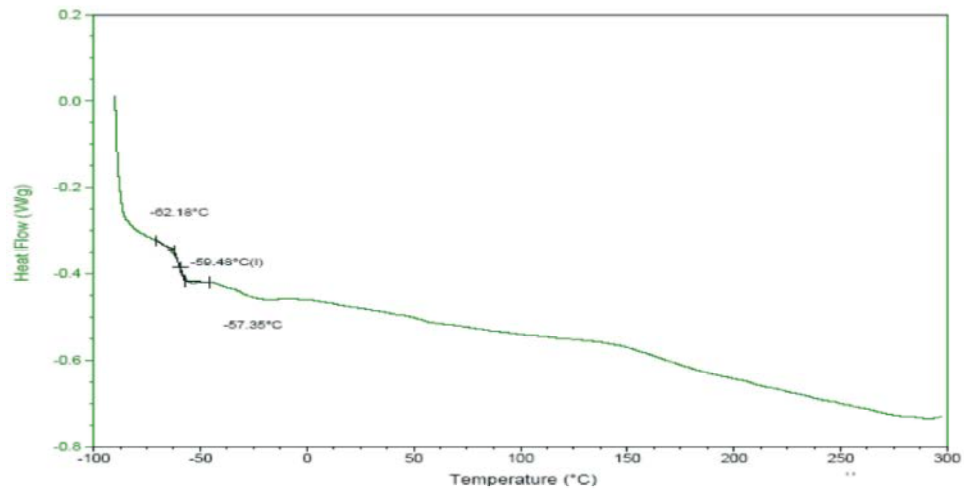

Fig. 2: DSC of NR10

Table 3: Mechanical properties at a glance

Sample name/property	N100	NE30	NE40	NE50	NE60	NE100
Tensile strength(Mpa)	10	11	15	16	18.5	9.10
Young's modulus(Mpa)	7	8.3	9	7.68	8.15	6.5
% of elongation at break	635	460	450	434	500	350
Tear strength(N/mm)	3.46	4.43	4.84	5.31	5.41	1.48

of EVA into NR matrix has not that much influence on glass transition temperature. All products manufactured with natural rubber can also be made with NR/EVA blend as both will give required flexibility in almost same manner. Also crystallization occurs for NE60 blend in temperature range of 75°C to 100°C.

CONCLUSIONS

The experimental results show that introducing EVA waste into natural rubber is not only a good option for recycling EVA wastes but also a cost effective alternative to rubber for the elastomeric product manufacturing units. The EVA/NR blends developed shows excellent mechanical, rheological and processing characteristics. Comparison of these heterogeneous blend systems with existing mathematical models is to be done. Further research is needed to study the feasibility of developing elastomeric blend with other types polymeric waste

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