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Study of Sole Durability from Poly Vinyl Chloride (PVC) Injection and Extrusion Grades Blends

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Abstract*— Utilization of recycling a plastic waste for manufacture of footwear sole is the aim of this work. Injection grade and extrusion grade of PVC (Poly Vinyl Chloride) waste were blended with three different formulations. Mechanical properties of the experimental footwear sole, such as tensile strength and hardness were evaluated. Density test have been determined as a physical test. The result showed that, the optimum composition of PVC blends (extrusion/injection; 70/30) provided good mechanical and physical properties of sole.

***Index Terms*— PVC; PVC Blend; durability; sole; Footwear.**

I. INTRODUCTION

The polymer used to make the sole is chosen depending on the type of footwear, design, long life, features of resistance and cost. The most common materials are: SBR, SBS, PVC, EVA, PU and TPR.

Based on A.J. Harvey (1992) over the last 60 years there has been a major change in soling materials used in the footwear trade. Leather has been the traditional soling materials for footwear, but in 1980, only 5% of shoes have leather soles. Nowadays, most soles are made of rubber or plastic, which are classed as synthetic soling materials. [1]

The advent of PVC as an injection moulded material for soles in the early 1960's was rapidly adopted by the footwear trade as an alternative to vulcanized rubber. It is suitable for direct moulding on to shoe bottoms or can be used to produce a wide variety of moulded unit soles. R.G. Miller, (2013) state fairly soft grades of P.V.C are used so that a good bond and good wearing properties (similar to that of medium grade rubber) can be obtained. PVC needs to have a patterned surface to overcome a tendency to slip [2]

The issue of plastic waste management is a complex process and there is no simple solution for reducing this waste. Incineration, recycling, and land filling are some of the traditional methods for handling plastic waste. However, these methods are costly and often create new environmental difficulties. The best solution according to many scientists in the world like Rajashree Patil et al (2012) is a combination of solutions that includes use of biode-gradable plastic, plastic recycling, and bioremediation of plastic waste.[3]

According to G. Menges, (1996) PVC recyclate can be successfully marketed or not will depend on its price, its quality and its availability and also on the demand for it. These factors, in turn, are interlinked. The aim must therefore be to achieve a recyclate with precisely defined properties that can be fed into an existing processing cycle again with the fewest possible problems, since existing production capacity is essentially tailored to the characteristic properties of virgin PVC [4].

The objective of this study to evaluate the mechanical properties and physical property of the footwear sole produced from PVC waste.

II. MATERIALS AND METHODS

Materials

Two different grades of PVC waste were used in this work to manufacture PVC footwear sole. The waste of PVC Injection grade from shoes products mixed with PVC extrusion waste from tube products. The blend prepared from extrusion and injection according to the following compositions ratio: 70/30, 60/40 and 50/50 to

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make up a total of 3Kg blend. The injection molding machine used to produce the PVC sole from the experimental blend. **Table 1** shows the different percentage of materials used.

Table1. Composition percentage of PVC injection grade and PVC extrusion grade blends

No	Materials	
	PVC injection grade (Wt %)	PVC extrusion grade (Wt %)
A	50	50
B	40	60
C	30	70

Testing Methods

Tensile strength test

The tensile measurements were carried out by using a Tensile Tester Machine. In this analysis, tensile strength and elongation at break were carried out.[5] The maximum force and the length of the specimen at break are recorded. Tensile strength in MPa and elongation at break as % are calculated.

Density

Density is one of the important parameter that must be analyzed. The sample was taken in any shape with a volume to find out mass and volume and then calculating density using the formula. [5]

Hardness

The measured penetration is converted into International Rubber Hardness Degree (IRHD). The harder materials will give higher reading. Then the hardness sample is checked with the standard only by acceptance or rejection. [6] The hardness of the samples was measured using Shore A.

III. RESULTS AND DISCUSSION

Three samples from each blend were tested and average is calculated. The mechanical and physical properties were evaluated.

Tensile Strength (N/mm^2)

The tensile strength of the different blends composites PVC were evaluated and result for experimental footwear sole (**Table 2**)

Table 2. Tensile strength of different composites

No / Samples	Specimen 1	Specimen 2	Specimen 3	Mean
Standard	13.5	13.5	13.5	13.5
A	19.18	17.16	17.38	17.91
B	15.23	16.81	17.79	16.61
C	14.1	17.55	16.94	16.18

Elongation %

The elongation of the different blends composites PVC were evaluated and result for experimental footwear sole (**Table 3**)

Table3. Elongation of different composites

No / Samples	Specimen 1	Specimen 2	Specimen 3	Mean
Standard min.	300	300	300	300
A	210	182	176	189
B	166	184	194	181
C	152	184	160	165

Hardness test

The hardness test results were evaluated for experimental footwear sole (**Table 4**)

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Table 4. Hardness of different composites

No Samples	Specimen 1	Specimen 2	Specimen 3	Mean
Standard Max.	74	74	74	74
A	85.7	82.7	87.5	85.3
B	83.8	86.4	84.2	84.8
C	84.6	82.6	82.5	83.3

Density (g/cm^3)

The density of the experimental footwear sole from different composites was evaluated (**Table 5**)

Table 5. Density of different composites

No Samples	Specimen 1	Specimen 2	Specimen 3	Mean
Standard	1.2	1.2	1.2	1.2
A	1.13	1.4	1.22	1.25
B	1.33	1.18	1.15	1.22
C	1.08	1.13	1.28	1.16

The importance of tensile strength and breaking load per unit cross-sectional area in soling specification depends on the soling. The specimens shows in (**Fig.1**) increased tensile strength so that indication of stiffness and overall poorer wear performances.

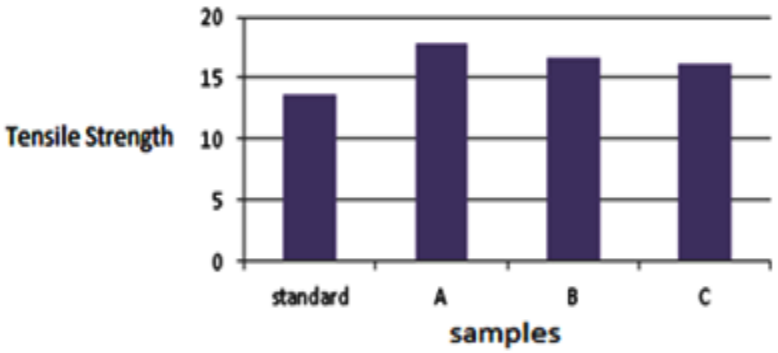

Fig 1: The Comparison of Tensile Strength in different composites

The tensile strength is above the range so the elongation will be less than the range, all the composites were less than the range of PVC sole i.e. 300(**Fig. 2**)

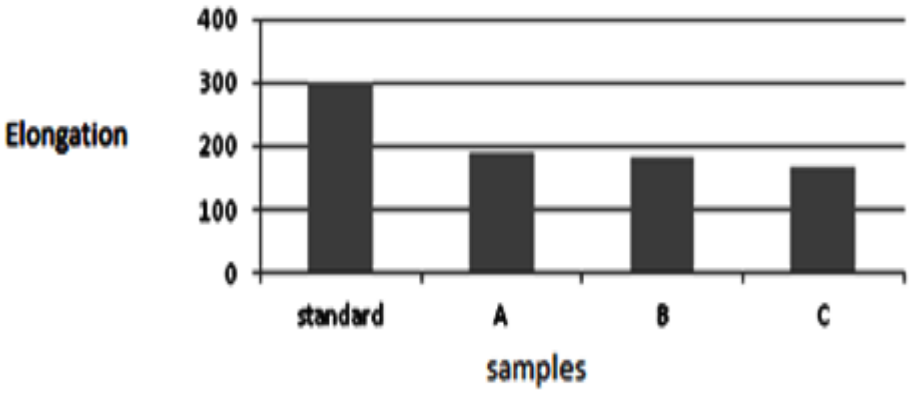

Fig 2: The Comparison of Elongation in the different composites

The hardness values of different composites were above the normal hardness range of PVC sole i.e. 58-74 (**Fig. 3**)

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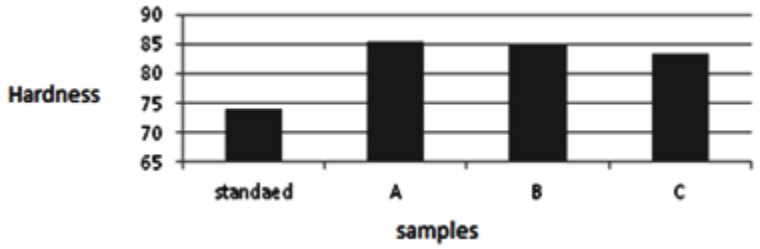

Fig 3: The Comparison of hardness in the different composites

The density of different composites PVC blend sole were evaluated A and B above range and the C less than range with the normal 1.2 g/cm3. (**Fig. 4**).

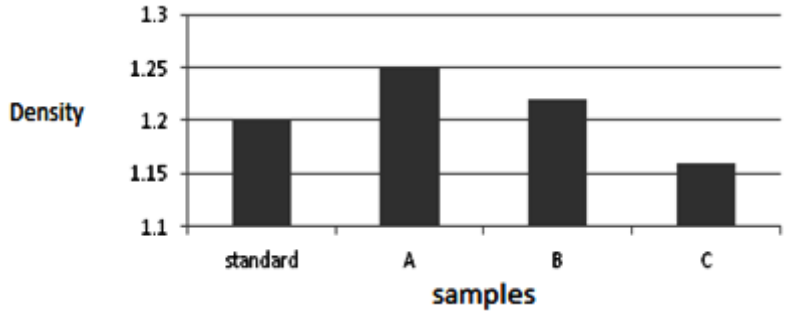

Fig 4: Comparison of density in the different composites

VI. CONCLUSION

The PVC injection grade and PVC extrusion grade blends were useful for manufacture footwear sole and improve the durability. Three different composites of PVC blend were investigated. The optimum composition of PVC grades blends were evaluated i.e. (extrusion/injection 70/30). This blend provided good mechanical and physical property.

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