

# Investigation of Sound Properties of High Density Polyethylene / Styrene Butadiene Rubber Polymer Composites

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**Abstract.** Polymers are used in many areas today and able to produce specially with enhanced features. For this reason, Polymer Industry has developed several polymers composite. Some features of polymer composites are examined in determining areas and to improve these properties such as mechanical, thermal, electricity and morphological. One of the important features of the sound characteristics of a material that can help identifies the areas where the material is used. Provide strength and comforts of used materials are very important in transportation technologies such as rail vehicles, automotive and aircraft. In this study High Density Poly Ethylene (HDPE) with Styrene Butadiene Rubber (SBR) polymer with elastomeric composites with properties were determined of the sound. Firstly, a sound absorption material composed of blends of HDPE with SBR developed. After then HDPE/SBR composite's sound absorbing characteristics were investigated in an impedance tube, according to transfer function method. Measurements show that HDPE ratios have a significant effect on the acoustic absorption performance of the blend due to their microstructures and physical features. Furthermore, a polymer blend of High Density Poly Ethylene and Styrene Butadiene Rubber was tested in order to quantify its sound properties such as sound absorption and impedance ratio. There was sound absorption in the frequency range between 100 and 6400 where is high frequency range. All the data was filtered via MATLAB numeric analyses program. In the light of all these data, it was seen that SBR contribution leads to property of acoustics behaviors.

## 1. Introduction

Present day technology requires materials with combination of properties that cannot be met by the convertible classes of material metals, ceramics and polymers. As a result engineers are compelled to search for alternative materials to meet the complex service requirements for today's applications. Amongst the desired material properties requirement are: low density, strong, abrasion and impact resistant and are not easily corroded [1, 2].

Many researchers have focused on studying and developing polymer sound absorption materials, among which polyurethane, polyacrylic ester, polystyrene, and polyvinyl chloride have been used to prepare sound absorption materials.

Sound absorption constitutes one of the major requirements for human comfort today. Sound insulation requirements in automobiles, manufacturing environments, and equipment, generating higher sound pressure drive the need to develop more efficient and economical ways of producing sound absorption materials. Industrial applications of sound insulation, generally includes the use of materials such as glass wool, foam, mineral fibers and their composites. A porous laminated composite material manufactured by lamination, preheating and molding of premix, exhibits a very high sound absorption property in the frequency range 500–2000Hz [3].

Park has generated to materials that is compose from thermoplastic foam. Polymer foam matrix preferably made of a thermoplastic foam, such as low-density polyethylene, a high melt strength polypropylene, or a blend of PP and LDPE, optionally containing a cell size enlarging agent such as glycerol mono-stearate, an antioxidant, carbon black and/or flame retardant additives, using a volatile

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organic compound, e.g. isobutene, as blowing agent [4].

Ulug et al. [5] studied sound absorption and impedance ratio of SBR=HIPS polymer blends. Sound absorbing characteristics of SBR/HIPS polymer blends were investigated in the impedance tube, according to the transfer function method. They found that the sound absorption coefficients were generally above 0.2 with the maximum of 0.5. It was revealed that soft blends have good sound absorption ability in 4000Hz frequency range.

Taşdemir et al. studied sound absorption properties of some polymer composites SIS/HIPS/CaCO<sub>3</sub>. With the increased amount of HIPS in SBR/HIPS polymer blends, hardness and Izod impact strength values of the resultant material increased. Because of rigid structure of the HIPS, these values were increased. With addition of SIS rubber to the HIPS, the adhesion and distribution of the present phases were considerably enhanced as well. These composites structure were tested for acoustic absorption at high frequencies [6].

Ersoy and others study on sound absorption properties of SBR/HIPS polymer blends. In this study, the addition of HIPS to a SIS based material was investigated in order to quantify its effects on the mechanical, acoustical and morphological. SIS/HIPS/CaCO<sub>3</sub> polymer composites were subjected to analysis in order to quantify their sound absorption, impedance ratio and hardness. Furthermore, the structure and properties of the blends are characterized using a scanning electron microscopy (SEM). Taking the structure of the materials into consideration, it is observed that sound propagation characteristic declines, while the ratio of HIPS, which is a hard material increases. The range where the impedance ratio reaches to the highest level is the range of 1000–3400. It is understood that all materials show a steady and stable sound propagation characteristic after 4000Hz [7].

Ersoy and others study on sound absorption properties of reinforced with multi-axial E-glass fabrics and Hazelnut's rind composites. This composite structure was tested for acoustic absorption in high frequency [8].

In this study, the effect of HDPE on the mechanical sound absorption and impedance ratio properties of SBR type elastomeric based material was investigated. SBR/HDPE polymer blends were subjected to examinations to obtain their sound absorption and impedance ratio and hardness.

## 2. Experimental

**Compositions and Materials:** HDPE and SBR polymer used for polymer blends. And then five different polymer blends (given in Table 1) were prepared by using the following materials: HDPE, known as Petilen YY (I 668 UV) was obtained from Petkim A.Ş., Turkey. Styrene butadiene block copolymer (SBR) (calprene 411) was supplied by Dynasol Elastomers (Houston, TX-USA). Its specific gravity is 0.938g/cm<sup>3</sup>, melt flow rate (190oC/5.0kg) is 1.0g/10min. First step, these were mixed, and then mechanical premixing of solid compositions was done using a LB-5601 liquid-solids blender (The Patterson-Kelley Co., Inc. Stroudsburg, USA) brand batch blender at 10min.

HDPE/SBR polymer blends were produced between 180-220oC at 20-30bar pressure, and a rotation rate of 30rpm, with a Microsan co-rotating twin-screw extruder (Microsan Instrument Inc. Kocaeli - Turkey). L/D ratio is 30, Ø: 25mm. This process is repeated 2 times. These polymer blends were prepared the samples for mechanical tests; the following injection conditions were used: Injection temperature was 180-220oC, injection pressure was between 110-130bar, dwelling time in mold was 10s, and screw rotation was 20rpm, Polymer blends were also dried in vacuum oven at 105oC for 24 hours after extrusion

Blend specimens were conditioned at 23oC and 50% humidity for 24h before testing (ASTM D618). Tensile tests were prepared according to the ASTM D638 standards by using a Zwick Z010 (Ulm-Germany) testing machine with a load cell capacity of 10kN at a cross-head speed of 50mm/min. The hardness test was done according to the ASTM D2240 method with Zwick hardness measurement equipment. To investigate fracture behavior, Izod impact test (notched) was done at room temperature according to the ASTM D256 method with Zwick B5113 impact test device (Ulm, Germany). Five samples were tested in each set and the average value was reported.

**Table 1.** Composition of the different polymer blend formulations.

Groups	HDPE (wt %)	SBR (wt %)
1	100	-
2	90	10
3	80	20
4	70	30
5	60	40

### 3. Test Procedure

Sound properties measurement the acoustic measurements were based via two microphone transfer-function method. These operations are performed according to ISO 10534-2 and ASTM E1050-98 international standards which are the appropriate standards for horizontally mounted orientation-sensitive materials. These test devices were part of a complete acoustic material testing system. This system which is a small-tube setup was used to measure different acoustical parameters for the frequency range of 50-6400Hz.

Parentheses and numbers in equations must be not Italic. It is important to ensure that all notations in text and figures must be of the same style.

Small impedance tube kit from Brüel & Kjaer Type 4206 was consisted of a 29mm diameter tube (small tube), sample holder and an extension tube at the same diameter. A frequency-weighting unit is also provided within the tube, in which different types of weighting are available; high-pass, for high frequency measurements in the small tube, linear for measurements in the large tube, and low-pass for additional measurement accuracy below 100Hz.

At one end of the tube, a loudspeaker is situated to act as a sound source. At the other end of the tube, the test material is placed to measure sound absorption properties, as seen in Figure 2 [15]. For proper fitting of samples into the measurement tube, an aluminum rod was machined to a length of 40mm and a diameter of 29mm, and it was utilized to push the material into a pre-adjusted depth. For each thickness of the material, three different sample measurements were made and the average of the measured data was presented here.

Three samples from each group were manufactured. These samples were subjected to sound absorption test in impedance tube for high-frequency. The results obtained from samples in each sample were averaged. These results are by filtration by MATLAB and presented comparatively via Graph.

### 4. Results

Materials which were obtained by the addition of HDPE into the SBR of sound absorption properties is indicate in figure 1. These were observed a stable behavior in the low frequency. Therefore, we did not consider necessary to test the low-frequency. The high frequency test results are presented at figure 1.

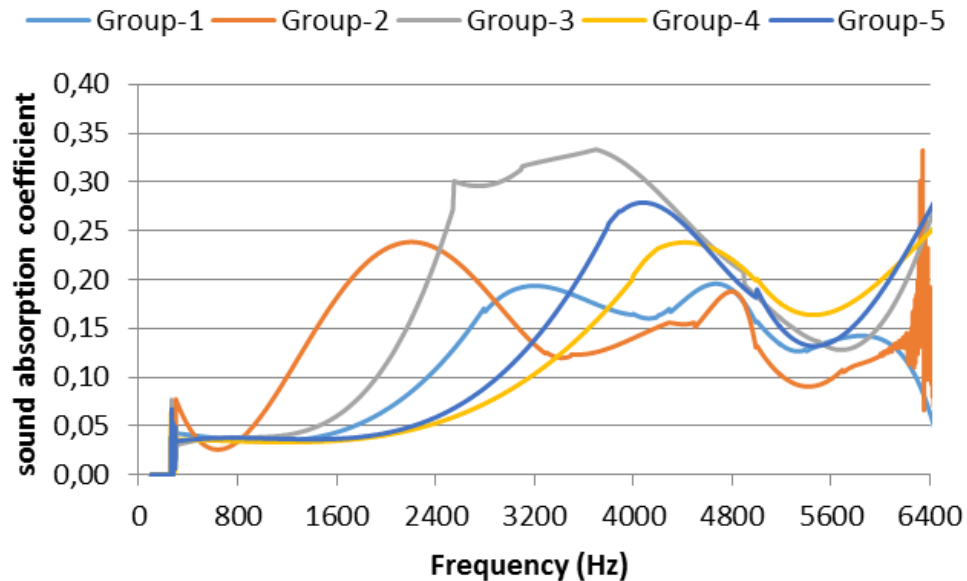
Sound absorption of Polymer blends range between 100 and 6400Hz were examined. The behaviors of this mixture were within the range 0-250Hz. is quite uncertain. The results were not clearly n this point. Results are analyzed from this point, we can see that, SBR rate did not cause to linear and stable effect on sound absorption coefficient.

Analysis of pure HDPE sound absorption property, we can see that the sound absorption coefficient was stable (0.05). The highest sound absorption coefficient was seen between 3200-4800Hz, where the values was 0.15.

At contribution of 10% of SBR, there is an increase of 800-2000Hz. The high value was seen at 3200Hz. There is the value was 0.22 sound absorption coefficient. After this point, a stable value can be seen. 4800Hz and then followed a fluctuating behavior can see.

When we consider that 20% wt SBR, in all groups, the highest sound absorption coefficient (0.34) was seen at 4000Hz in this blend. In this mixture between 2400-4000Hz was the high-sound feature

absorption. After the 4000Hz, in parallel with the increase in frequency, sound absorption coefficient decrease was seen.



**Figure 1.** Impedance ratio of HDPE / SBR polymer blends.

30% wt SBR addition was indicate that sound absorption coefficient was stable till 2400Hz. And then the value was rising due to increase of frequency. The highest value was seen at 4200Hz where the coefficient reach to peak (0.274). However, after this point, the behavior was fluctuating.

Lastly, 40% wt SBR loading indicate that the increase of sound absorption coefficient was depend to frequency increase. The highest value was 0.27 at 4000Hz. From this point, the sound absorption behavior was undulated.

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