# Valorisation of Tannery Waste and Animal By-Product for Acoustics Applications

by

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## Abstract

Disposal of chromium-containing solid wastes generated from the leather industry poses a major threat to tanners worldwide. Herein, we propose a strategy to utilize chrome shaving waste for sound absorption application by blending it with natural fiber, wool. The composites were prepared at various ratios with different thickness by compression molding method and subjected to characterizations like scanning electron microscope, porosity measurements, and tensile strength analysis. The sound absorption behavior of the composites was evaluated using the two-microphone impedance tube method. The results indicate that the composites with higher thickness show better sound absorption at higher frequencies when compared to the natural wool and composites with lesser thicknesses. Thus, this material can be used as a sound-absorbing material thereby paving the alternative use of leather waste utilization.

## Introduction

Leather making process results in the generation of solid and liquid wastes. From about 100 kg rawhide/skin processed, nearly 75 kg of solid waste is generated with only 25 kg of raw material being converted into leather.[1] Solid waste mainly includes shavings, trimmings, animal hair and fleshing.[2,3] Shavings are one of the chromium-containing tannery solid wastes, generated during the shaving process to obtain an even leather surface.[4] Currently, majority of the chrome shavings waste is landfilled and the once the disposal exceeds the total capacity of the landfilling site, finding a new site becomes difficult. Landfilling also leads to the leaching out of chromium into the soil and ground water. Although chromium(III) has been reported to be an essential nutrient, exposure to high levels via inhalation, ingestion, or dermal contact may cause some adverse health effects.[5] It also causes an environmental threat due to the possible oxidation of Cr (III) to Cr (VI) and Cr(VI) is a well known carcinogen. Thus, unsafe disposal of shaving waste causes environmental impact due to its toxicity and carcinogenic effects.[6] The utilization of chrome shaving solid waste for alternative applications using viable technologies has been researched.[7-9] In the present study, we intend to utilize chrome shaving waste to reduce another type of pollution namely, noise.

Noise pollution is consistently increasing due to urbanization, implementation of industry, machines and vehicles. Noise pollution has a considerable impact on humans and animals.[10] The human hearing sound level ranges from a maximum of 20,000 Hz and a minimum level of 20 Hz.[11] Hearing loss, sleeping disturbance, high blood pressure, headaches, psychological problems, etc., are the adverse effects of noise pollution, which can be controlled by acoustic materials that are capable of absorbing incoming sounds. Hence, the need for acoustic materials is in high demand. Currently, natural and synthetic materials with fibrous and porous nature are being used to make acoustic materials.[12-14] Synthetic fibrous materials like glass fibers and mineral wool are extensively used in sound absorption due to their high surface area and high acoustical performance. However, their usage causes several health effects on humans like skin irritation and lung inflammation. Natural fibers like wool can be used as alternatives for synthetic fibers. Chrome shavings also have fibrous nature with porosity, which enables their usage as sound-absorbing materials.[15-17] In our earlier study, we had explored the use of natural fibers incorporated chrome shavings composite in low and mid frequencies.[18] The solid wastes from tanneries, show disposal difficulties due to the presence of the heavy metal chromium. In this present study, we have prepared sound absorbing materials from chrome shavings by blending with suitable synthetic and natural polymers via compression molding technique. Polypropylene (PP However, those composites did not show better noise absorption properties in the high-frequency range viz., above 2000 Hertz.

In the current study, we intend to explore the sound-absorbing behavior of composites made up of chrome shavings for use in the high frequencies range by combining with another natural fiber, wool. Wool, which is known to have acoustic properties, has been blended with chrome shavings and polystyrene at different ratios and the composite has been prepared using compression molding at two different thicknesses. The sound absorption studies of the prepared composite have been performed through the two-microphone impedance method. The morphological studies, pore size measurements, and tensile strength analysis have been performed for the prepared composites.

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**Table I**

**Preparation of acoustic composite materials of varying ratios**

| Blend composition (100%) (W:Cr) | Wool (g) | Chrome shaving (g) | Polystyrene (g) |
|---|---|---|---|
| 100 | 10 | – | 5 |
| 100 | – | 10 | 5 |
| 70:30 | 7 | 3 | 5 |
| 30:70 | 3 | 7 | 5 |

## Materials and Methods

### Materials

Chrome shavings and sheep wool were collected from the tannery division of Central Leather Research Institute, Chennai, India. The diameter of the wool is 20 μm and the length of wool is approximately 2 mm to 5 mm. Polystyrene was purchased from Fevicol 998FW. Polystyrene was used as a binder.

## Methods

### Preparation of Acoustic Composites

The acoustic materials were prepared with two different thicknesses (2 mm and 5 mm) and by varying ratios of wool and chrome shaving (Table I). The wool and chrome shaving were manually blended for 5 mins with polystyrene to enhance the binding capacity and then compressed in compression molding at room temperature under 50 bar pressure. The whole process was performed under dry conditions. Fixed thickness molding dies were used for the preparation of 2 mm and 5 mm thickness panels. The total weight of the blend composition has been maintained as 10 g for all acoustic panels. The density of each panel was found to be 2 $Kg/m^3$.

### Characterization of Acoustic Materials

The thickness of the acoustic materials was measured using a screw gauge. The sound absorption studies of varying thickness and ratios of wool and chrome shaving acoustic materials were analysed using the two-microphone impedance tube method (BRUEL AND KJAER, Denmark (2716C)). The experiment was performed in triplicates and the average value was taken. The morphology of the acoustic panels was analysed using Scanning Electron Microscope (SEM) (Phenom-World). The pore size of the acoustic panels was characterized using Porous materials incorporation advanced automated humid air porometer HCFP 1100. Instron universal tensile tester machine (AE. Instron, 3369 / J7257.A) was used to study the tensile strength of the acoustic panels according to the ASTM standard (D882-12).

## Results and Discussions

### Morphology

The morphology of the acoustic panels is shown in figure 2 (a-d). It is observed that the chrome shaving acoustic panels showed porous and fibrous structures with agglomerated bundles, whereas neat fiber structures were observed for the wool acoustic panel. The wool and chrome shaving composite panel shows mixed morphology of both wool and chrome shavings and chrome shavings showed fibrous structures with lesser fiber diameter when compared to wool.

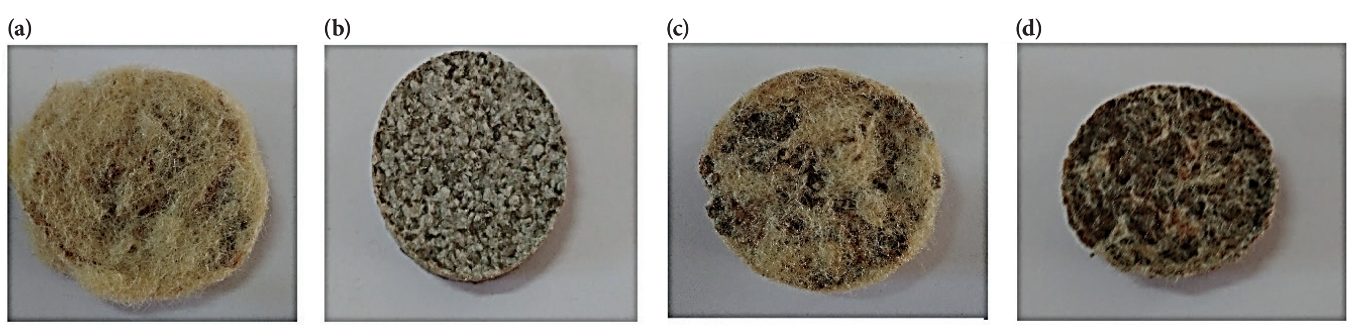


**Figure 1.** Acoustic panels with 5 mm thickness **a)** Wool **b)** Chrome shaving **c)** wool and chrome shaving (70:30) and **d)** wool and chrome shaving (30:70)

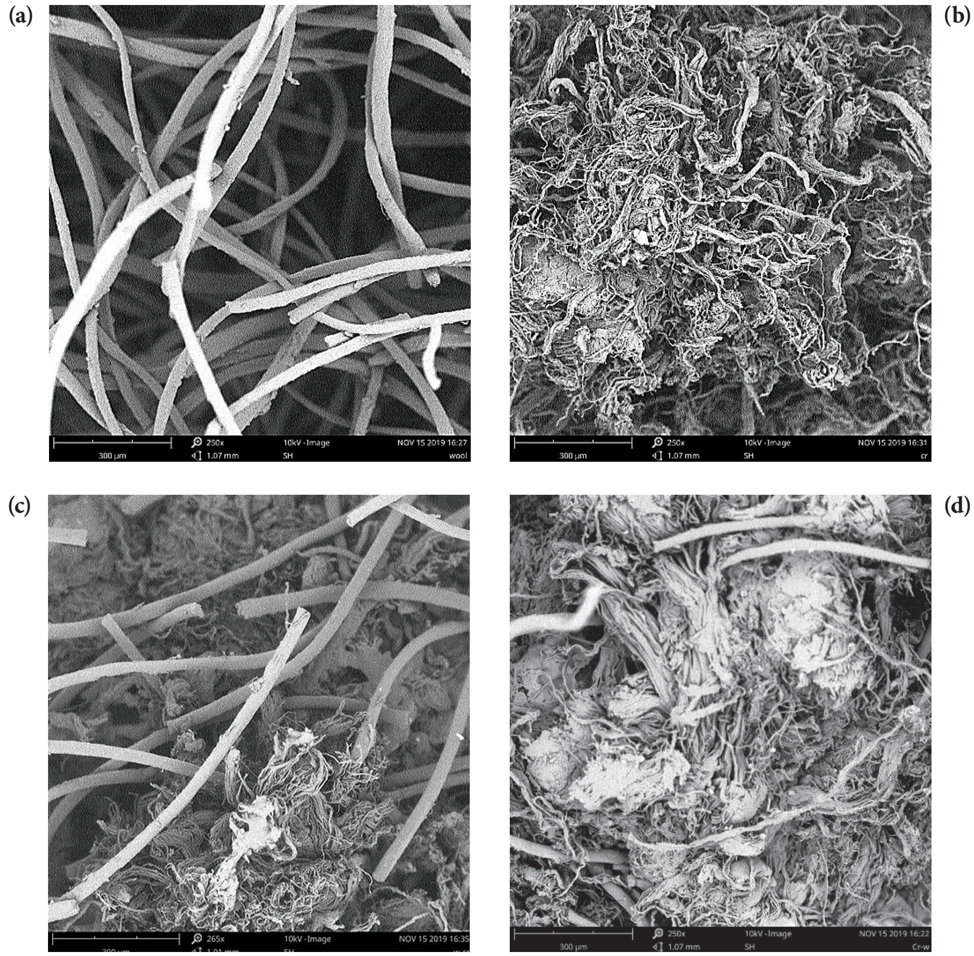


**Figure 2.** SEM images of acoustic panels **a)** Wool **b)** Chrome shaving **c)** Wool and Chrome shaving (70:30) and **d)** Wool and Chrome shaving (30:70)

**Porosity**

Figure 3 shows the bar chart for the pore size of the composite acoustic panels for varying thickness. It is observed that the porosity increases with the increase in chrome shaving content for both 2 mm and 5 mm thickness samples. At the same time porosity increases with increasing thickness of the composite acoustic panels. Enhanced porosity leads to enhanced sound absorption property, which is evidenced from the sound absorption studies. The average pore sizes of wool – chrome shaving (70:30) composite panel for 2 mm and 5 mm were found to be 45 and 60 µm, respectively and for wool – chrome shaving (30:70) composite panel for 2 mm and 5 mm were found to be 48 and 79 µm, respectively.

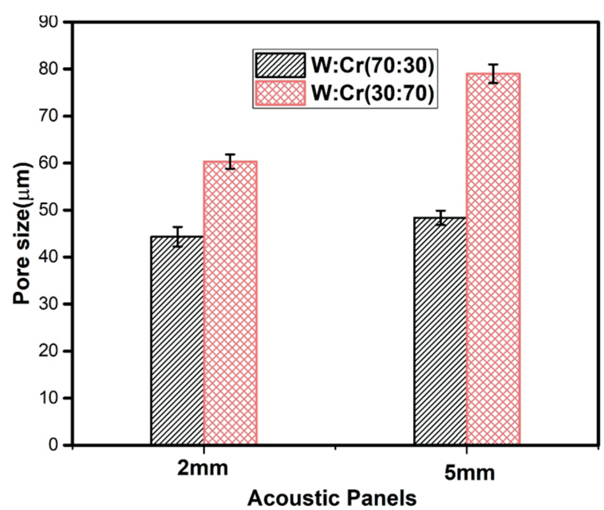


**Figure 3.** Pore size of varying thickness of wool and chrome shaving composite acoustic panels

**Tensile Strength**

The tensile strength for the acoustic composite panels is shown in Figure 4. It is observed that the tensile strength of chrome shaving is higher than the wool. It can also be found that increasing the chrome shavings content in the composite increases the tensile strength. The tensile strength did not show any significant difference with different thicknesses. Since wool is a single fiber with a limited thickness may have a lesser tensile strength when compared to the

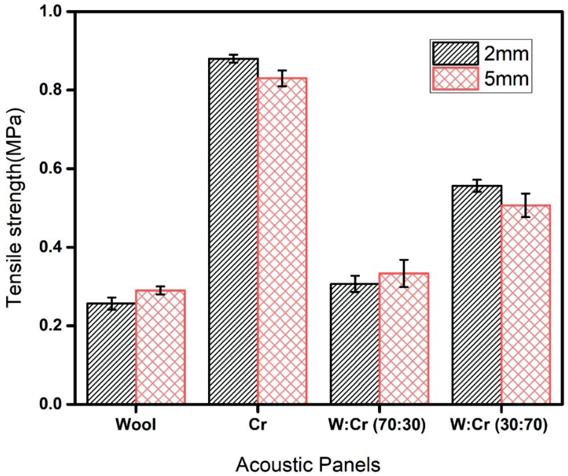


**Figure 4.** Tensile strength of wool (W), chrome shaving (Cr) and wool: chrome (W:Cr) shaving composite acoustic panels

chrome shavings where the collagen fibers are crosslinked by the tanning process, which might have been responsible for the higher tensile strength.

### Sound Absorption Coefficient Studies

The sound absorption coefficient of the acoustic panels has been analysed through the two-microphone impedance tube method.[19] The acoustic panels were tested with the sound frequency level ranging from 16 Hz to 6300 Hz by taking some standard frequency points at 1600 Hz, 2000 Hz, 2500 Hz, 3150 Hz, 4000 Hz, 5000 Hz and 6300 Hz. Figure 5 shows the values of the sound absorption coefficients obtained. It is observed that at 2 mm thickness the sound-absorbing nature of both the composites is higher than the wool at all the frequencies. At the higher frequencies, the composites showed better sound absorption behavior when compared to wool. Thickness plays a major role in enhancing the absorption coefficient. It was found that the sound absorption is better for 5 mm panel than 2 mm for the same ratio (ex. W:Cr 30:70). In a 2 mm panel, after 2500 Hz a slight decrease and saturation was observed, which may be due to less thickness and porosity as against 5 mm panel.

The composite W: Cr (30:70) showed enhanced sound absorption in the higher frequencies. The combined fibrous nature of both the wool and chrome shavings might have increased the sound absorption behavior. Increasing the content of chrome shavings in the composite might have contributed to the presence of more amounts of fibers, which results in enhanced the sound absorption behavior.

## Conclusion

The experimental results indicate the presence of highly fibrous structures with porosity in the composites resulting in good tensile strength. The higher percentage of chrome shavings containing composites show increased sound absorption when compared to the wool at higher frequencies. Thus, this material can be used as a sound-absorbing panel by eliminating the use of synthetic fibers and also this technology can evolve as a proper method of utilization for leather solid waste.

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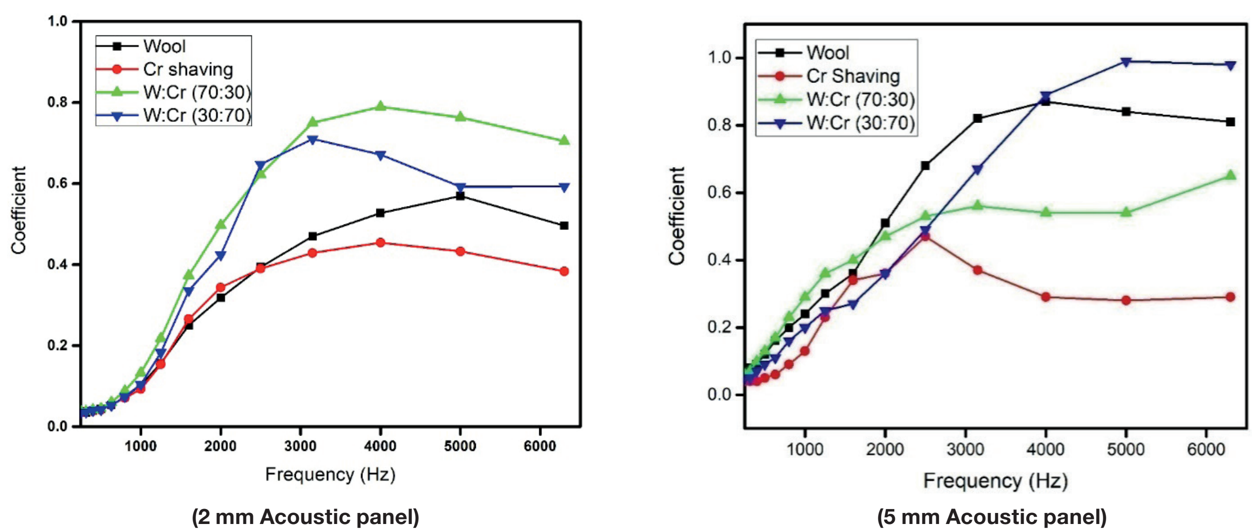


**Figure 5.** Sound absorption co-efficient studies for the acoustic panels of different thickness

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