INTERNATIONAL RESEARCH JOURNAL OF PHARMACY
www.irjponline.com
ISSN 2230 – 8407

Research Article

# DEVELOPMENT OF HIGHLOFT NONWOVEN MATERIALS FOR HEALTH CARE ACOUSTICS

Bharanitharan Ramanathan *, K.Thangamani, S. Sundaresan
Department of Textile Technology, Kumaraguru College of Technology, Coimbatore, Tamilnadu, India
*Corresponding Author Email: bharani21@rediffmail.com

Article Received on: 13/08/17 Approved for publication: 19/09/17

**DOI: 10.7897/2230-8407.089165**

**ABSTRACT**

Noise pollution can impart hearing impairment, hypertension, ischemic heart disease, annoyance, and sleep disturbance in human being. Continuous hearing of sound of 90 decibels make fatigue in hearing organs. Equipment sound more than 90 decibels will lead to damage of eardrums. Prolonged sound pollution will lead to permanent hearing disability. It will also create various types of temporary physiological changes, such as hypertension, change of the rate of heart-beat, high respiratory rates, excessive perspiration and vomitary tendency in human beings. This research work has been carried out to investigate the potential of natural material for acoustic applications. The most important factor for noise reduction is mainly based on the type of raw material used and also the structure of the material. In this examination to determine the acoustic performance, jute fibre was processed with STRUTO technology. The highloft structures produced by mixing jute fibre with polyester fibre and low melt bicomponent fibre has been thoroughly studied. The results from various GSM levels also have been analyzed. The highloft materials, which is light weight showed high efficient sound absorbing ability especially with increased GSM. Sound absorption properties of samples were analyzed and the findings were tabulated. These results indicated that high loft textiles produced from jute fibre blends, can be used as a primary raw material for acoustic applications, which is low in cost, light weight and also biodegradable.

**Keywords:** Natural fibre, nonwoven, highloft, sound absorption, impedance tube, Struto technology

## INTRODUCTION

Noise pollution can impart hearing impairment, hypertension, ischemic heart disease, annoyance, and sleep disturbance in human being. Continuous hearing of sound of 90 decibels make fatigue in hearing organs. Equipment sound more than 90 decibels will lead to damage of eardrums. Prolonged sound pollution will lead to permanent hearing disability. It will also create various types of temporary physiological changes, such as hypertension, change of the rate of heart-beat, high respiratory rates, excessive perspiration and vomitary tendency in human beings. This research work has been carried out to investigate the potential of natural material for acoustic applications. The most important factor for noise reduction is mainly based on the type of raw material used and also the structure of the material. The findings of the US Environmental Protection Agency (EPA) during 1970 reveals that noise exposure limit of 55 decibels in a 24-hour period heavily interfere with sleep. A reduction of five decibel noise would reduce the prevalence of high blood pressure by 1.4 percent and coronary heart disease by 1.8 percent. Those who live near busy roadways, airports, and industrial areas are those most likely to be exposed to both noise pollution and air pollution.

Noise pollution can lead to

| | |
|---|---|
| Aggravated depression: 58% | Irritation and annoyance: 54% |
| Hypertension: 87% | Low performance levels: 55% |
| Stress: 65% | Public conflict: 71% |
| Behavioral affects: 59% | Speech interference: 56%. |
| Muscle tension: 64% | Exhaustion: 48% |
| Concentration loss: 93% | Hearing impairment: 69% |
| Cardiovascular issue: 71% | Headache: 74% |

The textile material especially made by using non-woven techniques has a high potential in absorbing the sound. New product can be developed like sound insulation pads, ear muffler, sound barriers which can be used to absorb noise in industry and in domestic places thus by preventing the health hazards caused by noise pollution. This research has been carried out to investigate the potential of natural material for acoustic applications.

## LITERATURE REVIEW

The effect of sound on human depends upon its frequency. Human ear is known to be sensitive to an extremely wide range of intensity varied from 0 to 180 dB. The research work is to know about the various ways of generation of noise, their effects on human, its prevention and control [1]. It has been observed that in industries that the noise levels detected are much above the 80 dB which is more than the specified norms. Because of this majority of the workers in these industries are disturbed from the noise in their workplaces, and few of them were suffering hearing problems [2]. The study conducted using Non-woven composites with activated carbon fiber (rayon precursor) non-woven as a surface layer and cotton, ramie, and polypropylene fiber non-wovens as base layers concluded that the activated carbon fiber composites exhibited an exceptional ability to absorb normal incidence sound waves[3].Acoustic characteristics of structured needle punched floor coverings in relation to fiber fineness, surface effect, punch density, areal density, and chemical bonding process has been studied. It has been found that higher levels of punch density and higher areal density caused the noise reduction coefficient (NRC) of the fabrics[4]. Sound absorbent materials produced using micro-fiber fabrics as reveals that sound absorption is superior to that of conventional fabric with the same thickness or weight[5]. In the case of woven fabric, the surface area of the fabric is directly related to the denier and cross-sectional shape of the fibers in the fabric [6]. Sound absorbency of a novel knitted spacer fabric, which can be used in automotive upholstery and has the potential for greater sound absorbency than a conventional plain knitted fabric and its derivatives[7]. Research work done using samples of woven fabrics having varying structural elements shows that the sound absorption coefficient of woven fabrics is influenced by both density and porosity of fabrics[8].In present scenario noise pollution is a major problem faced globally. Noise pollution affects both health and behavior. The recent growths in population and manufacturing industries have resulted in further increase in noise problems which we all are presently facing [9]. The excessive noise that may harm the activity or balance of human or animal life should be brought down to level that is not harmful to the ears [10]. Noise mitigation is a set of strategies to reduce noise pollution or to reduce the impact of that noise, whether outdoors or indoors. Till now various methods and materials have been used to for sound absorption. Among various techniques used for sound reduction, nonwoven materials are found very successful due to their porous structure and also are capable of absorbing sound and it has been widely accepted as sound absorptive materials [11].The absorption of unwanted noise is mainly based on dissipation of energy of the sound wave due to viscosity and heat conductivity of the medium and also it depends on the fibrous structure. The nature of fibre, length, fineness, the surface characteristics, elasticity of the constituent fibres, the porosity, the fibre orientation, thickness of the assembly and many other several factors determine the sound absorption characteristics of fibre assemblies [12].

The sound absorption coefficient, SAC is a simple way of defining the sound absorption behavior of the surface. Nonwoven material is made up of fibre assemblies, so the fibre characteristics have more significant role in absorbing sound. In practical application, most of the fibrous sound absorbing materials are comprised of synthetic fibres. Due to more awareness related to green technology and usage of biodegradable materials, researchers have been focusing on finding out alternate natural fibres which are ecofriendly than commonly used synthetic fibres[13].Investigators have reported the possibilities of using natural fibres for acoustic treatment in many literatures[14].Fibres extracted from waste tea leaves and their acoustic performance was studied. They produced different woven structures in various thickness using tea fibres and employed them as a back coating on commonly used absorbers. According to their results obtained at frequencies of 500 – 3200 Hz, the acoustic performance of a single layer woven fabric containing the fibres extracted from waste of tea leaves seems to be equal with the case in which six woven fabric layers in double thickness is used for coating the absorber [15]. Highloft nonwovens are defined as low density fiber network structures characterized by a high ratio of thickness to weight per unit area. The fibers may be continuous or discontinuous, bonded or unbonded. Highloft battings have no more than 10% solids, by volume, and are greater than 3 mm (0.13 inches) in thickness [16,17]. Beside this, highloft textiles such as filling materials, precursors for molding processes, thermal insulating materials and sound absorbers are in development. Production of highloft textiles by perpendicular layering carded web and through-air bonding is one of the newest methods in the highloft sector [18-21].

## MATERIAL AND METHOD

STRUTO technology has been used for carrying out the experimental work. The working principle of perpendicular lapper with its parts is shown in Figure 1. Highloft materials from jute and its blends were produced by this STRUTO technology and suitable processing conditions were identified. The upright position of fibers towards the fabric plane is the main characteristics of these materials as shown in Figure 2. Upright position of fibers shows many differences in properties towards materials produced by cross-laid and air-laid textiles, where the fibers are mainly oriented parallel to the fabric plane.

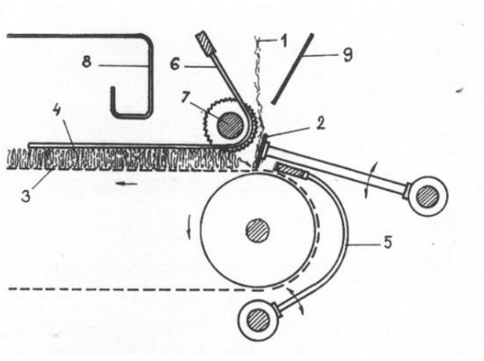


**Figure 1. Perpendicular lapper**
1-carded web, 2- reciprocating comb, 3- conveyor belt, 4- wire grid, 5- reciprocating presser bar, 6, 9- guides, 7- hold back roller.
2-

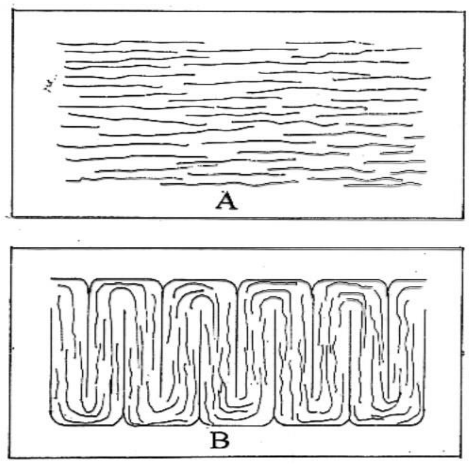


**Figure 2. Typical positions of fibres in cross-laid (a)and perpendicular laid (b) textiles**

Production of perpendicular laid highlofts also consists of carding fiber blend, perpendicular layering of the carded web using a perpendicular lapper and a bonding in the through-air oven. A schematic diagram of production line is shown in Figure 3.

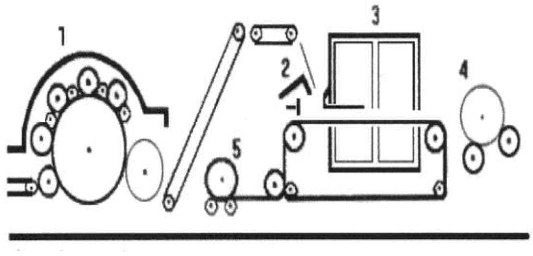


**Figure 3. Production line for perpendicular laid textiles**
**1**-card, 2- perpendicular lapper, 3- through-air thermo bonding oven 4- take-up mechanism, 5- reinforcing backing (optional)

**Materials**

The perpendicular laid highloft samples were produced from tossa jute fibre, white jute fibre, polyester fibre and low melt bicomponent fibre. Jute process mainly needs good opening and carding. In the experiment, carded jute materials, processed to the average staple length of 70 mm. Before carding the jute fibres were sprayed with batching oil and were kept for 24 hours before further opening. Polyester fibre having 6.7 dtex and 65 mm along with low melt bicomponent fibre having 4.8 dtex and 55 mm were used for producing the samples.

**Fibre blends and preparation**

Each nonwoven sample produced contained 20% by weight of bonding fibres (low melt bicomponent), varying jute fibre contents and polyester fibre percentage adjusted to make a total of 100%. In total 5 blends of samples were produced as mentioned in Table 1.

**Table 1. Ratio of fibre components in carded layers**

| Samples | Code | Polyester fibre % | Tossa Jute fibre % | White Jute fibre % | Low melt bicomponent fibre % |
|---|---|---|---|---|---|
| 1 | P80/LM20 | 80 | 0 | 0 | 20 |
| 2 | TJ80/LM20 | 0 | 80 | 0 | 20 |
| 3 | WJ80/LM20 | 0 | 0 | 80 | 20 |
| 4 | TJ60/P20/LM20 | 20 | 60 | 0 | 20 |
| 5 | WJ60/P20/LM20 | 20 | 0 | 60 | 20 |

The fibres were blended by two passes through a laboratory card, the carded web was formed into the batt by a vibrating lapper on the conveyor belt feeding a through air bonding chamber. The batt was then bonded by passing it through the chamber at 160°C for 1 minute. Relatively highloft were produced for 300, 500 and 800 GSM levels.

**TESTING OF SAMPLES**

The samples were tested using the impedance tube method for obtaining the sound absorption and transmission. Noise control materials can be tested in terms of their sound absorption and transmission properties in a plane wave tube to guarantee highly repeatable test conditions. This provides information of materials acoustic properties for validating and calibrating computational methods used to predict the acoustic performance of multi layer systems. Frequency range adopted was 63 to 6300 Hz. Specification for test samples was based on ISO 10534-2, ASTM E 1050 and ASTM E 2611.

**RESULTS AND DISCUSSIONS**

In this investigation highloft structures were produced from different fibre blends. The sound absorption properties of five samples for 300 GSM, 500 GSM and 800 GSM are presented. Tables 2, 3 and 4 gives the results obtained from the impedance tube method for the above mentioned GSM levels. In this study we have considered 63 Hz to 2000 Hz as low frequency, 2000 Hz to 4000 Hz as medium frequency and 4000 to 6300 Hz as high frequency range.

**Table 2. SAC values obtained from 300 GSM**

| FRE (Hz) | Sample-1 P80/LM20 | Sample-2 TJ80/LM20 | Sample-3 WJ80/LM20 | Sample-4 TJ60/P20/LM20 | Sample-5 WJ60/P20/LM20 |
|---|---|---|---|---|---|
| 250 | 0.09 | 0.07 | 0.06 | 0.08 | 0.07 |
| 500 | 0.13 | 0.09 | 0.08 | 0.12 | 0.10 |
| 1000 | 0.18 | 0.12 | 0.08 | 0.15 | 0.12 |
| 2000 | 0.31 | 0.17 | 0.11 | 0.21 | 0.18 |
| 4000 | 0.47 | 0.33 | 0.20 | 0.38 | 0.33 |
| 6300 | 0.52 | 0.45 | 0.30 | 0.49 | 0.43 |

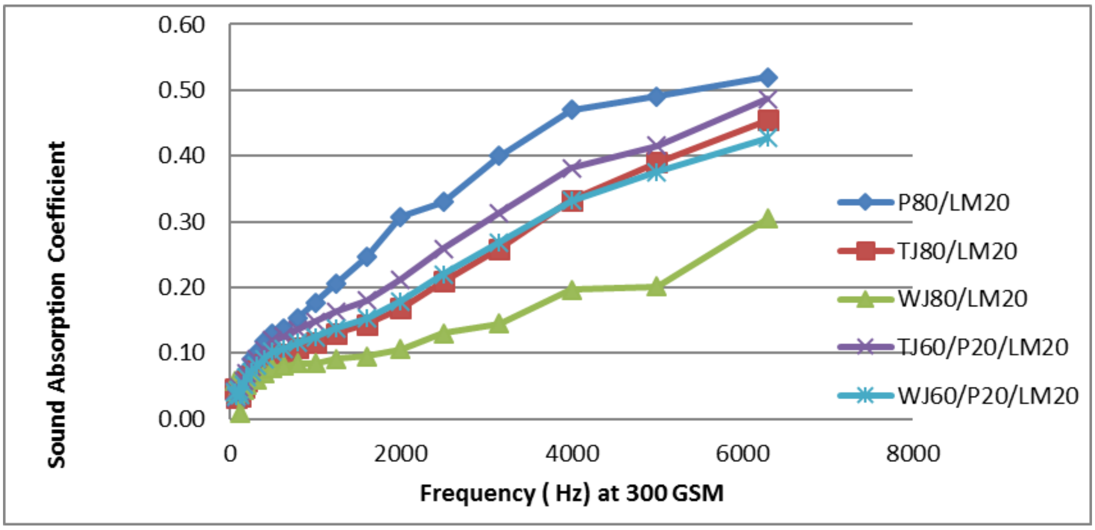


**Figure 4. Sound absorption at 300 GSM for different fibre blends**

**Effect of fibre blend on sound absorption at 300 GSM**

The sound absorption coefficient of P80/LM20, TJ80/LM20, WJ80/LM20, TJ60/P20/LM20 and WJ60/P20/LM20 samples at 300 GSM level is given in figure 4. From the results obtained it is evident that the samples produced from jute fibre blends shows poor sound absorption at low frequencies. The SAC value 0.45 was noticed from TJ80/LM20 sample and SAC value 0.49 was obtained from TJ60/P20/LM20 at 6300 Hz. P80/LM20 sample also showed better SAC value of 0.52 at this range. The sample WJ60/P20/LM20T also exhibited SAC value of 0.49. OnlyWJ80/LM20 sample exhibited very low values, below 0.30 in high frequency range. From this we can understand that the highlofts samples for 300 GSM levels with different fibre blends taken for the study shows better absorption of sound at 6300 Hz range.

**Table 3. SAC values obtained from 500 GSM**

| FRE (HZ) | Sample-1 P80/LM20 | Sample-2 TJ80/LM20 | Sample-3 WJ80/LM20 | Sample-4 TJ60/P20/LM20 | Sample-5 WJ60/P20/LM20 |
|---|---|---|---|---|---|
| 250 | 0.08 | 0.10 | 0.07 | 0.09 | 0.09 |
| 500 | 0.15 | 0.15 | 0.09 | 0.18 | 0.13 |
| 1000 | 0.26 | 0.22 | 0.11 | 0.30 | 0.18 |
| 2000 | 0.47 | 0.32 | 0.17 | 0.44 | 0.30 |
| 4000 | 0.54 | 0.44 | 0.33 | 0.52 | 0.50 |
| 6300 | 0.57 | 0.50 | 0.43 | 0.58 | 0.55 |

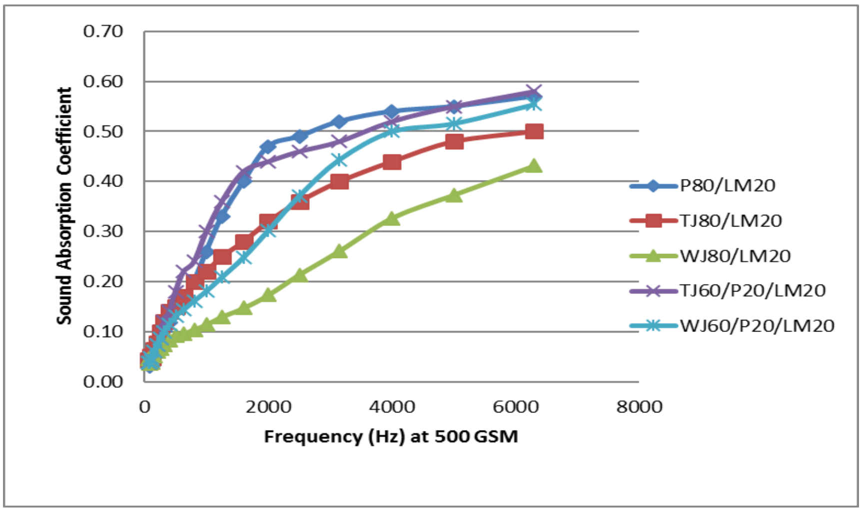


**Figure 5. Sound absorption at 500 GSM for different fibre blends**

**Effect of fibre blend on sound absorption at 500 GSM**

The figure 5 shows the sound absorption coefficient of fibre blends at 500 GSM. Here we could see that at higher frequencies better SAC values 0.50 and 0.58 was noticed for tossa jute fibre blends. White jute blends also showed better absorption rate at higher frequencies with SAC values of 0.43 and 0.55. In low frequencies, less than 2000 Hz, the SAC values were not encouraging for TJ80/LM20,WJ80/LM20, WJ60/P20/LM20. But the sample TJ60/P20/LM20 showed better SAC value of 0.44 from medium frequency range, this is due to the presence of polyester fibre in that blend. Better SAC values, above 0.40 were seen only in high frequency range for the different fibre blends, expect WJ80/LM20 sample which showed SAC value of 0.33 at 4000 Hz and 0.43 at 6300 Hz.

**Table 4. SAC values obtained from 800 GSM**

| FRE (HZ) | Sample-1 P80/LM20 | Sample-2 TJ80/LM20 | Sample-3 WJ80/LM20 | Sample-4 TJ60/P20/LM20 | Sample-5 WJ60/P20/LM20 |
|---|---|---|---|---|---|
| 250 | 0.09 | 0.09 | 0.08 | 0.10 | 0.09 |
| 500 | 0.14 | 0.14 | 0.11 | 0.22 | 0.15 |
| 1000 | 0.21 | 0.18 | 0.14 | 0.38 | 0.23 |
| 2000 | 0.37 | 0.27 | 0.21 | 0.48 | 0.39 |
| 4000 | 0.63 | 0.48 | 0.40 | 0.60 | 0.63 |
| 6300 | 0.68 | 0.57 | 0.51 | 0.68 | 0.64 |

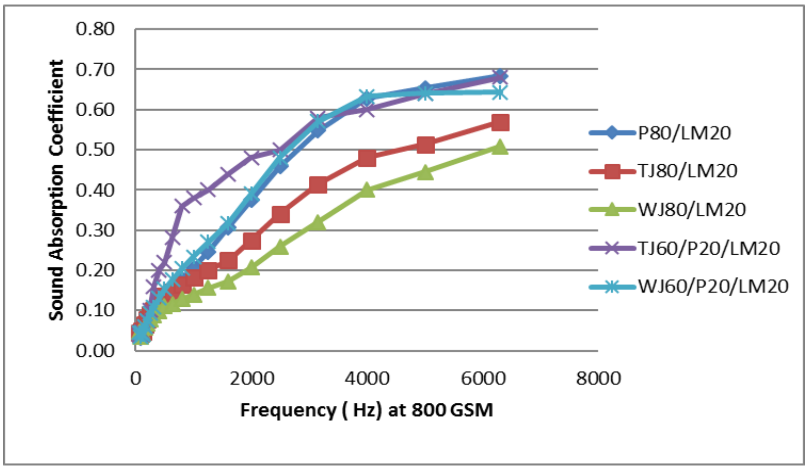


**Figure 6. Sound absorption at 800 GSM for different fibre blends**

## Effect of fibre blend on sound absorption at 800 GSM

The sound absorption coefficient of fibre blends at 800 GSM is shown in figure 6. The SAC value of TJ60/P20/LM20 in low frequency is better when compared to other fibre blends in that range. Also SAC value of 0.48 was noticed at medium frequency level for TJ60/P20/LM20 sample. We could see that the entire fibre blends showed better SAC value in high frequency range. Furthermore both sample TJ60/P20/LM20 and WJ60/P20/LM20 were almost equal to P80/ LM20 sample at high frequency levels. This emphasis, that natural fibers have good sound absorption coefficient at higher frequencies for 800 GSM.

## Effect of GSM on sound absorption

The samples produced with 300 GSM showed, less sound absorption coefficient values at low and medium frequencies. In higher frequency level it was moderate.

In the case of 500 GSM levels the SAC values were excellent from medium to high frequency, that is from 4000 Hz to 6300 Hz within the range of 0.4 – 0.6.

But at 800 GSM levels the P80/LM20 sample showed highest rate of SAC of 0.68 and also TJ60/P20/LM20 sample showed similar value. The highlofts produced with different fibre blends showed better sound absorption values at higher frequency range at 800 GSM. The figure 7 shows the values obtained for sample TJ60/P20/LM20 for the various GSM levels.

It is found that there is direct relationship between weight per square meter and sound absorption. The increase in GSM levels will definitely contribute in achieving maximum SAC values at even lower, medium and higher frequencies.

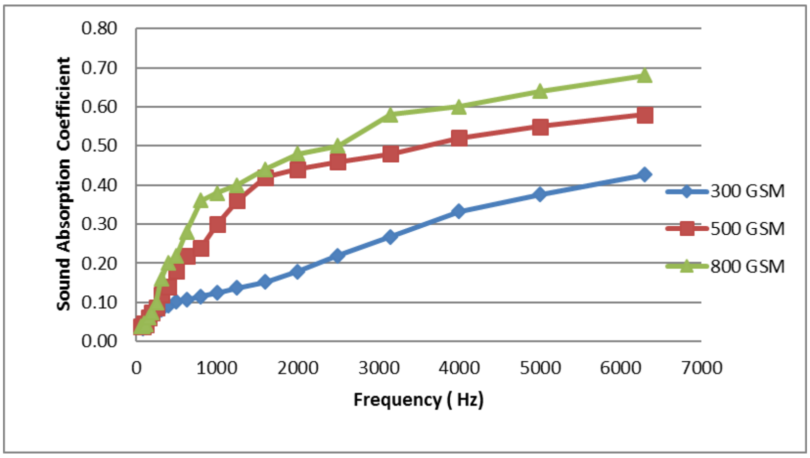


**Figure 7. Sound absorption at various GSM levels**

## CONCLUSION

The highloft nonwoven material with 300 GSM level made by using tossa jute fibre blend (TJ80/LM20), (TJ60/P20/LM20) and white jute (WJ60/P20/LM20) showed better absorption of sound at 6300 Hz range. In the case of 500 GSM better sound absorption coefficient value, above 0.40 were seen only in high frequency range for the different fibre blends, expect WJ80/LM20 sample. Samples made from the blends of tossa jute fibre – Polyester fibre – Low melt bicomponent fibre (TJ60/P20/LM20) and White jute fibre – Polyester fibre – Low melt bicomponent fibre (WJ60/P20/LM20) showed good sound absorption coefficient at higher frequencies for 800 GSM level. From the results we can understand that the tossa jute fibre along with polyester fibre and low melt bicomponent fibres is equally good enough and can be used for sound absorption. There is around 15% difference between sound absorption coefficient for the highloft nonwoven material made from tossa jute and white jute fibre.

The outcome of this study proved that perpendicular laid nonwovens produced using jute fibre possessed better acoustic absorption behavior, especially at higher frequencies, which might be very beneficial for health care applications. It can be concluded that the SAC values drastically improved with the increase in GSM. Installation of noise absorbent barriers produced from jute based highloft nonwoven materials with higher percentage of tossa jute fibre will definitely give permanent solution for acoustic problems faced in health care.

## REFERENCES


1. Savale P. A.“Effect of noise pollution on human being: its prevention and control”, Journal of Environmental Research And Development, Vol. 8 No. 4, April-June 2014 ,pp 1026 - 1036
2. E. Atmaca1*, I. Peker1, A. Altin2 “Industrial Noise and Its Effects on Humans” Polish Journal of Environmental Studies Vol. 14, No 6 (2005), pp.721-726
3. Y Chen, N Jiang “Carbonized and Activated Non-wovens as High-Performance Acoustic Materials: Part I Noise Absorption” - Textile Research Journal, 2007.
4. Shahanietal.“The Analysis of Acoustic Characteristics and Sound Absorption Coefficient of Needle Punched Nonwoven Fabrics” Journal of Engineered Fabrics & Fibers (JEFF) . 2014, Vol. 9 Issue 2, p84-92.
5. YJ Na, J Lancaster “Sound Absorption Coefficients of Micro-fiber Fabrics by Reverberation Room Method”, Textile Research Journal Volume: 77 issue: 5, page(s): 330-335 2007
6. M Tascan, EA Vaughn “Effects of Total Surface Area and Fabric Density on the Acoustical Behavior of Needlepunched Nonwoven Fabrics”, TRJ Volume: 78 issue: 4, page(s): 289-296 April 2008.
7. Tilak Dias, RavindraMonaragala, Peter Needham and Edward Lay “Analysis of sound absorption of tuck spacer fabrics to reduce automotive noise” Measurement Science and Technology, july 2007
8. P Soltani, M Zerrebini “The analysis of acoustical characteristics and sound absorption coefficient of woven fabrics” Textile research Journal, Volume: 82 issue: 9, pp 875-882.
9. Karlinasari, L.,Hermawan,D., &Maduu, A. “Bamboo acoustical properties”,BioResources, Vol.7, pp. 5700 – 5709, 2012.
10. Seddeq, H.S.,“Factors influencing acoustic performance of sound absorptive materials”, Australian Journal of Basic and Applied Science, Vol.3 ,pp. 4610 -4617,2009.
11. Wang, C.N., &Torng,J.H, “ Experimental study of the absorption characteristics of some porous fibrous materials”, Applied Polymer Science Journal, Vol.62, pp. 447 – 459, 2001.
12. Aso, S., & Kinoshita, R, “ Sound absorption characteristics of fiber assemblies”,Journal of the Textile Machinery Society of Japan, Vol.10, pp. 209 – 217,1964.
13. Asdrubali, F.,Schiavoni, S., &Horoshenkov, K.V, “A review of sustainable materials for acoustic applications”, Building Acoustics, Vol.19, pp. 238- 312. 2012.
14. Ersoy, S ., &Kucuk, H,“Investigation of industrial tea – leaf – fibre waste material for its sound absorption properties”, Applied Acoustics, Vol.70, pp. 215 – 220, 2009.
15. Zulkifli, R,“Comparison of acoustic properties between coir fiber and oil palm fiber”, European Journal of Scientific Research, Vol.33, pp. 144- 152, 2009.
16. Nor, M.J.M., Ayub, Md., &Zulkifli, R, “Effect of compression on the acoustic absorption of coir fiber”, American Journal of Applied Sciences, Vol.7 ,pp. 1285 – 1290, 2010.
17. AL- Rahman, L. A., “ Acoustic properties of innovative material from date palm fiber”, American Journal of Applied Sciences, Vol.9, pp. 1390-1395, 2012.
18. Kucuk, M., &Korkmaz, Y, “The effect of physical parameters on sound absorption properties of natural fiber mixed nonwoven composite”, The Textile Research Journal, pp. 1- 11,2012.
19. RadkoKrema "What's new in highloft production? Perpendicular laid fabrics from Czech Republic". Nonwovens Industry. FindArticles.com. 06 Jun, 2012.
20. Krema, R., Jirsak, O. "New Structure in Bulky Nonwovens," Fourth Annual TANDEC Conference, Knoxville, TN, 1994.
21. Krema, R., Jirsak, O., Hanus, J., Macova, I., Plocarova, M. "Perpendicular Laid Bulky Nonwovens," 75th World Conference of the Textile Institute, Atlanta, GA, 1994.



**Cite this article as:**

Bharanitharan Ramanathan *et al*. Development of highloft nonwoven materials for health care acoustics. Int. Res. J. Pharm. 2017;8(9):112-117 http://dx.doi.org/10.7897/2230-8407.089165

Source of support: Nil, Conflict of interest: None Declared