โครงการ

การเรียนการสอนเพื่อเสริมประสบการณ์

ชื่อโครงการ ผลของสมบัติทางกายภาพขององค์ประกอบในวัสดุเส้นใยซับเสียงต่อประสิทธิภาพการดูดซับเสียง
Effect of physical property of non-woven materials to sound absorption performance

ชื่อนิสิต นายธนาวิทย์ นิยมนา **เลขประจำตัว** 5933050023

ภาควิชา เคมี

ปีการศึกษา 2562

คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ผลของสมบัติทางกายภาพขององค์ประกอบในวัสดุเส้นใยซับเสียงต่อประสิทธิภาพการดูดซับเสียง

Effect of physical property of non-woven materials to sound absorption performance

โดย

นายธนาวิทย์ นิยมนา

รายงานนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตร

ปริญญาวิทยาศาสตรบัณฑิต

ภาควิชาเคมี คณะวิทยาศาสตร์

จุฬาลงกรณ์มหาวิทยาลัย

ปีการศึกษา 2562

Project Title Effect of physical property of non-woven materials to sound absorption performance

By Mr.Thanawit Niyomna

Accepted by the Faculty of Science, Chulalongkorn University in Partial Fulfilment of the Requirements for the Bachelor of Science degree

SENIOR PROJECT COMMITTEE

1. Associate Professor Dr. Sumrit Wacharasindhu, Ph.D.	Chairman
2. Associate Professor Dr. Apichat Imyim, Ph.D.	Examiner
3. Assistant Professor Dr. Varawut Tangpasuthadol, Ph.D.	Project Advisor
4. Ms. Wirawan Bangcharoenpornphong	Special Co-Project Advisor

This report was approved by head of department of Chemistry

.... Wirawan B. ....

(Assistant Professor Dr. Varawut Tangpasuthadol, Ph.D.)
Project Advisor

(Ms. Wirawan Bangcharoenpornphong)
Special Co-Project Advisor

....

(Associate Professor Vudhichai Parasuk, Ph.D.)
Head of Department of Chemistry
Date 23...... Month December Year 2019

ชื่อโครงการ ผลของสมบัติทางกายภาพขององค์ประกอบในวัสดุเส้นใยซับเสียงต่อประสิทธิภาพการดูดซับเสียง

ชื่อนิสิตในโครงการ นายธนาวิทย์ นิยมนา เลขประจำตัว 5933050023

ชื่ออาจารย์ที่ปรึกษา ผู้ช่วยศาสตราจารย์ ดร. วราวุฒิ ตั้งพสุธาดล

ภาควิชาเคมี คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย ปีการศึกษา 2562

บทคัดย่อ

ในปัจจุบันนี้วัสดุดูดซับเสียงถูกนำมาใช้ลดปัญหามลภาวะทางเสียง วัสดุดูดซับเสียงที่ได้รับความนิยมในการใช้งานคือวัสดุประเภทเส้นใย เนื่องจากสามารถเปลี่ยนแปลงรูปร่างไปใช้ในพื้นที่ต่าง ๆ ได้ ในงานวิจัยนี้ วัสดุที่นำมาใช้ทดสอบคือวัสดุประเภทเส้นใยที่ทำจากพอลิเอสเทอร์และพอลิโพรพิลีน การทดสอบสมบัติการดูดซับเสียงทำได้โดยนำวัสดุดูดซับเสียงที่มีขนาดเส้นผ่านศูนย์กลางของเส้นใยและความหนาแน่นของเส้นใยในวัสดุ มาทดสอบด้วยท่ออิมพีแดนซ์ตามมาตราฐานการทดสอบ ASTM E1050 ในการศึกษาผลของขนาดเส้นผ่านศูนย์กลางของเส้นใยพบว่า วัสดุที่มีขนาดเส้นใยเล็กกว่าสามารถดูดซับเสียงได้ดีกว่าวัสดุที่มีขนาดเส้นใยที่ใหญ่ ในการศึกษาผลของความหนาแน่นของเส้นใยในวัสดุพบว่า เมื่อวัสดุมีความหนาแน่นเพิ่มมากขึ้น ประสิทธิภาพการดูดซับเสียงในช่วงความถี่ต่ำจะสูงขึ้น แต่ประสิทธิภาพการดูดซับเสียงในช่วงความถี่สูงจะลดลง และพบว่า วัสดุที่มีองค์ประกอบเป็นพอลิโพรพิลีนบริสุทธ์มีประสิทธิภาพการดูดซับเสียงสูงกว่าวัสดุที่มีองค์ประกอบเป็นพอลีเอสเทอร์

คำสำคัญ: วัสดุดูดซับเสียง, ท่ออิมพีแดนซ์, มาตราฐานการทดสอบ ASTM E1050

Project Title Effect of physical property of non-woven materials to sound absorption performance

Student Name Mr. Thanawit Niyomna Student ID 5933050023

Advisor Name Assistant Professor Dr. Varawut Tangpasuthadol, Ph.D

Department of Chemistry, Faculty of Science, Chulalongkorn University, Academic Year 2019

Abstract

Nowadays, absorptive material is one of interest material for noise reduction. Fibrous material is among the most popular absorptive material because it is flexible in shape and that can be applied in variety of application area. The mix of polyester and polypropylene fibers is investigated in this study. The physical properties of absorption materials (Fiber diameter, density of material and type of material) is evaluated by using Impedance tube refer to ASTM E1050 standard. The smaller fibers in diameter show higher acoustic absorption performance. The increase of the density of fibers show the better absorption performance at lower frequency, while the absorption performance decreasing at high frequency. By comparing between polyester and polypropylene, polypropylene has higher acoustic absorption performance.

Keywords: absorptive material, Impedance tube, ASTM E1050 standard

Acknowledgments

First of all, I am also grateful to Siriporn Jiwpanich, Preedara Thamsavate, WirawanBangcharoenpornphong, Nattawat Issarapakdee and Patra Warunyuta for their insightful comments and encouragement, but also for the hard question which incented me to widen my research from various perspectives. My sincere thanks also go to Asst. prof. Dr. Varawut tangpasuthadol who for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I would like to express my gratitude to my parents for their love and for always supporting me. A special thanks to 3M CTC team for giving many suggestions, my lab mates, Pitchaya Srijulangkul for their kindness and assistance through this seven month (internship time).

Next, I would like to thank the support from 3M Thailand Limited for the best opportunity and every take care.

Last but not least, I gratefully acknowledge the Department of Chemistry, Faculty of Science, Chulalongkorn University to give me the best opportunity and financial support.

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

Hz	Hertz
W/cm^2	Watts per square centimeter
dB	Decibel
µm	Micrometer
%w/w	Percent weight by weight
m^2	Square meter
mm.	Millimeter
g	Gram
g/m^2	Gram per square meter

Chapter 1

Introduction

1.1. Statement of the problem

Nowadays, noise disturbance from car engines is considered as one of major problems in passenger car. One of interest solution is to use sound-absorbing materials installed in a car. In principle, there are various types of materials that can absorb sound at different frequencies. Therefore, sound frequency must be taken into consideration in order to choose the right sound-absorbing materials. For example, acoustic barrier material is a good solution for low-frequency sound (less than 500 Hz),[1, 2] whereas porous material is better in absorbing high-frequency noise (above 500 Hz).[1, 3.] This is because of the characteristic of porous materials , such as foam and fibers allow air to pass through. The sound absorption efficiency depends on the friction during sound passing through the material.[4] This can be small effect on absorbing sound in the low-frequency range.[5] To reduce noise in vehicle during driven, the porous material should be chosen because the noise occur in a passenger car is greater than 500 Hz. Moreover, the car main body made from steel at which it can act as a resonance absorbent insulation to help cut off the low frequency noise. Therefore, in this study, the interest physical factors of high-frequency sound-absorbing materials in the form of non woven fibers were investigated. The effects of sizes, densities, and types of fibers on sound absorption performance were studied.

Objective of the research is to study factors of non woven fiber that may affect sound absorption performance.

1.2. Literature review, theory and concept

1.2.1. Definition and properties of sound

Definition: Sound is a disturbance of mechanical energy (vibration) which produced by vibrating object. The medium molecule around vibrating object was disturbed and made to vibrate like the vibrating object. The vibrating molecule transfer their vibration to next molecule that make the sound propagate away from the source. When the vibration molecule reaches to receiver, they make receiver vibrate.[6]

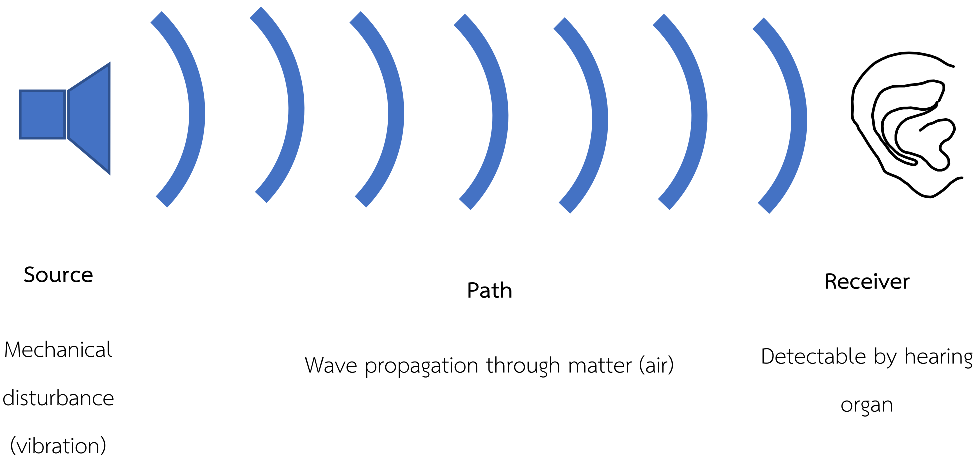

Figure 1.1 Sound transmission form source to receiver[6]

In propagation of sound, the medium between source and receiver is the main key factor. In propagation of sound in the air, the disturbance makes the air compressed as the pressure increases and expanded when the pressure drops. These compresses and expand are simply deviations in the density of the air from the average value. The variations in density are equivalent to pressure changes.

Two important properties of sound are intensity, which is determined by magnitude of compression and expansion in the propagation medium, and frequency which is determined by how often the compression and expansion occur. Frequency is measured in cycle per second, which is designated by the unit hertz after the scientist Heinrich Hertz. The symbol for this unit is Hz. (1 Hz¼1 cycle per second.)

The motion of the medium can be highly complex, but it is useful to study properties of wave in term of simple sinusoidal vibration by setting up a vibrating tuning fork. The sound pattern is called a pure tone. When pure tone propagates through the medium, the pressure variation is in form of sinusoidal.

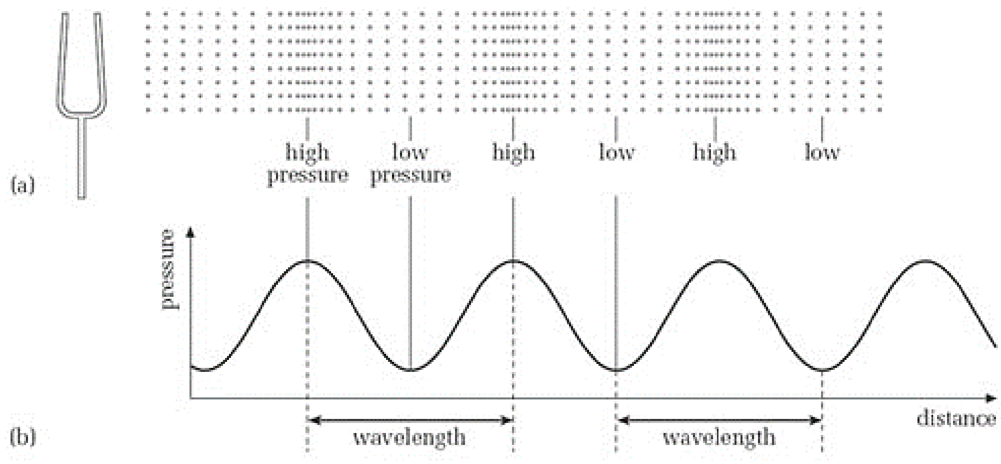

Figure 1.2 The pressure variation in form of sinusoidal.[7]

If the sound propagation in the air was illustrated, it would exhibit the compression band and expansion band in a punctuation. The distance between the two bands is called as wavelength λ.[6]

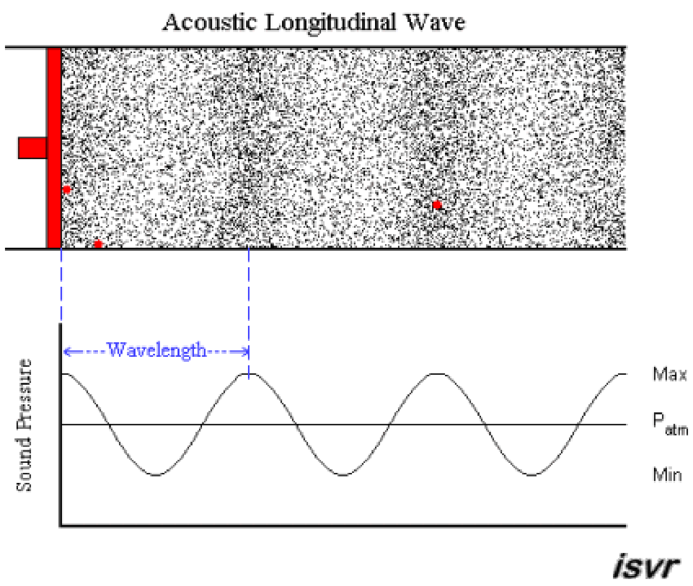

Figure 1.3 Condense and expand of the air[8]

The speed of sound propagation (v) depends on the properties of the medium, In air at 20°C, the speed of sound is about 3.3 x 10^4cm=sec, and in water, it becomes 1.4 x 10^5cm=sec. The relation between the speed of sound propagation, wavelength, and frequency is given by the follow equation:

$$V = \lambda f$$

This equation always true for all types of wave motions

The changing of pressure due to the propagating sound are superimposed on the surrounding air pressure, Thus, the total pressure in the path of a sinusoidal sound wave is of the form

$$P = P_a + P_o \sin 2\pi ft$$

Where P_a is the ambient air pressure, P_o is the maximum pressure change due to the sound wave, and f is the frequency of the sound.

The sound energy, which propagates in form of sinusoidal per unit time through each unit area and vertical to the direction of sound propagation, is called the intensity I. The equation is shown below.

$$I = \frac{P_0^2}{2\rho v}$$

Where ρ is the density of the medium, and v is the speed of sound propagation.

1.2.2. Type of sound

In general. The type of sound divided by type of medium into two main types: structure-Borne sound, and airborne sound.

1.2.2.1. Structure-Borne Sound

Structure borne noise or structure borne sound is defined as noise that occurs from the impact of an object hitting a surface, like heavy footsteps falling against a floor. The impact causes both sides of the inflicted surface to vibrate and generate sound waves. For example, if your upstairs neighbor drops a book onto the floor, the collision will vibrate from the floor up into their space as well as down the other side, through the ceiling of your space.

The key to reducing structure-borne noise is weakening the vibrations created from the noise source. While, it is impossible to eliminate all structure-borne noise but there are several ways to greatly reduce it.

1.2.2.2. Airborne sound

Airborne noise or airborne sound is defined as any sounds that are transmitted through the air, such as music or speech. Sound waves are picked up and carried by air until they crash into something solid, like a wall. The collision sends vibrations through the wall and into the space beyond it. Therefore, you’re able to hear your neighbor’s dog barking as if it were inside your home; the sound waves created are carried by air until they reach your walls and vibrate through them.

While it is impossible to eliminate all airborne noise, there are several ways to greatly reduce it,

1.2.3. Intensity and Loudness

Because the responds of ear to sound intensity is too wide range. At 3000 Hz, the lowest intensity that the human ear can detect is about 10 x 16 W/cm^2. The loudest tolerable sound has an intensity of about 10 x 4 W/cm^2. These two extremes of the intensity range are called the threshold of hearing and the threshold of pain, which intensity above the threshold of pain may cause permanent damage to the eardrum and the *ossicles*.

Because of the nonlinear response of the ear and the large range of intensities involved in the process of hearing, it is convenient to express sound intensity on a logarithmic scale. On this scale, the sound intensity is measured relative to a reference level of 10 x 16 W/cm^2 (which is approximately the lowest audible sound intensity). The logarithmic intensity is measured in units of decibel (dB) and is defined as

$$\text{Logarithmic intensity} = 10\ \frac{\mathbf{logSound\ intensity\ in\ W/cm^2}}{\mathbf{10^{-16}\ W/cm^2}}$$

At one time, it was believed that the ear responded logarithmically to sound intensity. Referring to Table 1.1, a logarithmic response would imply. Although it has been shown that the intensity response of the ear is not exactly logarithmic, the assumption of a logarithmic response still provides a useful guide for assessing the sensation of loudness produced by sounds at different intensities.

Table 1.1 Sound Levels Due to Various Sources (representative values)

Source of sound	Sound level(dB)	Sound level(W/cm^2)
Threshold of pain	120	10^{-4}
Riveter	90	10^{-7}
Busy street traffic	70	10^{-9}

Ordinary conversation	60	10^{-10}
Quiet automobile	50	10^{-11}
Quiet radio at home	40	10^{-12}
whisper	20	10^{-14}
Rustle of leaves	10	10^{-15}
Threshold of hearing	0	10^{-16}

1.2.4. Sound transmission through barriers

To reduce over acoustic, barrier and absorption materials are often used to attenuate the acoustic energy. When the acoustic wave is incidentally on the object, the energy of wave is reflected, some converted in to heat and attenuated due to friction and viscous resistance, which is defined as sound absorption, and some are transmitted through the object as shown in Figure 1.4, E_i, E_r, E_a, and E_t are incident acoustic energy, reflected energy, absorbed energy, and transmitted energy, respectively.[6]

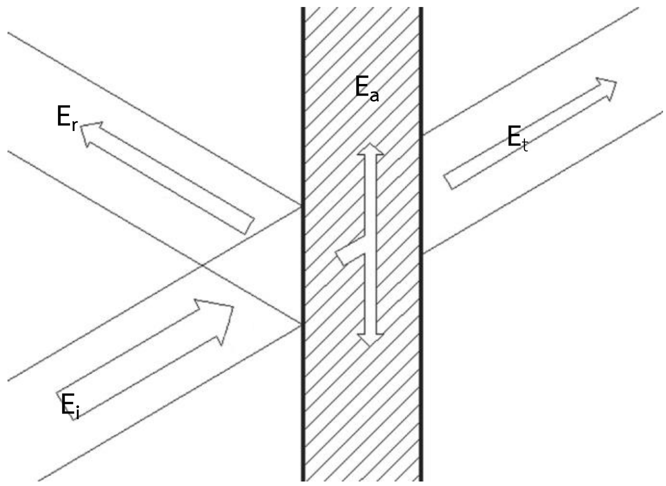

Figure 1.4 Sound transmission through barriers

1.2.5. General solution to reduce the over sound

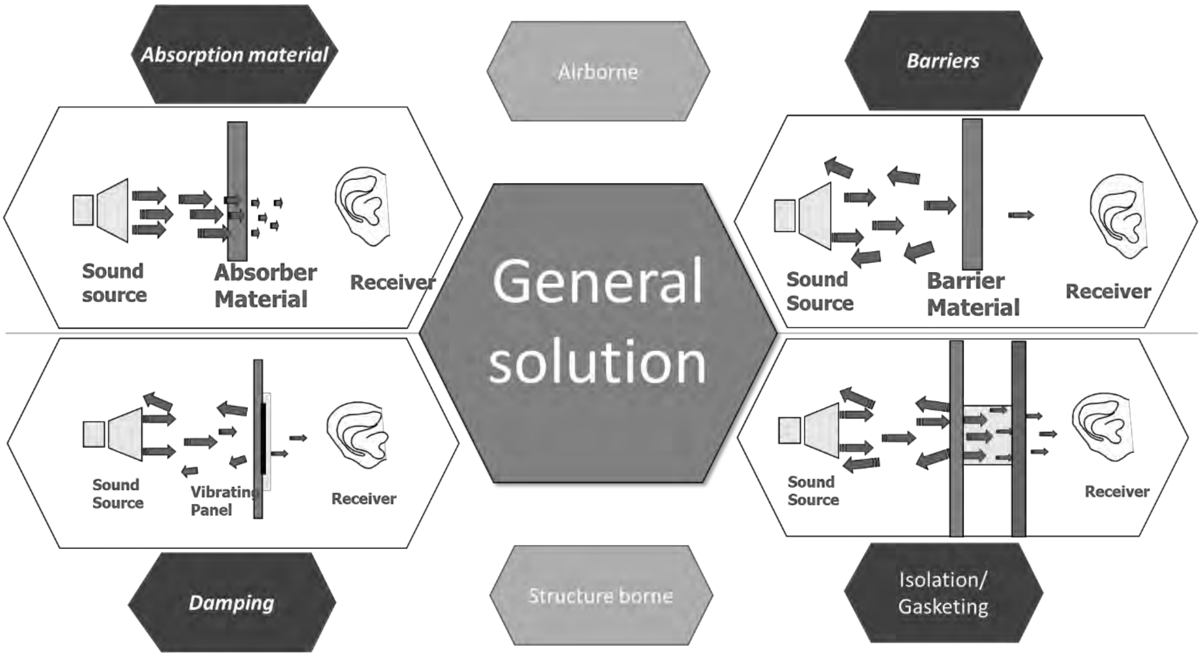

Figure 1.5 General solution to reduce the sound[9]

1.2.5.1. Absorption material:

A good candidate will "soak up" airborne sound-energy waves by changing the wave energy into heat as it passes through the absorption medium. Absorption materials are generally either fibrous or cellular. Common fibrous material is fiberglass, mineral wool, and ceramic. These are applied as a blanket or semi rigid sheets which can be cut to shape. Generally, they are film faced or bagged to prevent the fibers from being dislodged and causing problems in air-handling systems or rotating machines when bearings or other components could prematurely wear out if they became contaminated.

1.2.5.2. Barriers:

There are two types of barriers -- those that already exist (walls, cabinets, enclosures, etc.) and supplemental barriers. Supplemental barriers are those which you add if the existing enclosure wall is not thick enough. In this case, mass is the key to controlling noise. The mass law for homogeneous materials gives a rough approximation of the amount of noise that can be reduced given a specific material mass.

1.2.5.3. Damping:

All materials have a natural frequency. When they are excited by some source at this natural frequency, they will vibrate. This causes the air surrounding the material to vibrate and produce noise. This type of noise can be controlled by damping. Properly applied damping materials will only work if the metal or plastic to which they are applied is vibrating at or near their resonant frequency. If a mechanically driven plate is vibrating, damping will not stop it. And it should be noted that all damping materials are temperature sensitive, so they must be selected both for their temperature range and the operating temperature of the material to which they are applied.

1.2.5.4. Gasketing:

Although this is a subject that generally receives little attention, it is essential to achieving the full potential of a cabinet enclosure. Gasketing materials are generally soft, pliable foamed vinyl, urethanes, or neoprenes, although other materials are used.[9]

1.2.6. Method assessment

1.2.6.1. Sound absorption coefficients (α)

Definitions: The sound absorption coefficient is used to evaluate the sound absorption efficiency of materials. It is the ratio of absorbed energy to incident energy and is represented by α. If the acoustic energy can be absorbed entirely, then α = 1.

1.2.7. Sound absorption measurement

The acoustic absorption properties of material can be characterized by an acoustic absorption coefficient. An acoustic absorption coefficient can be measured in three method: standing wave tube method, transfer function method, and the reverberation room method.

1.2.7.1. Standing wave tube method

A standing wave tube is plastic or metal straight pipe, of which the absorptive material is fixed on one side and a loudspeaker is fixed on the other side. A single frequency wave is generated by loudspeaker and is magnified by an amplifier. Sound wave propagate in the tubes. A standing wave is contributed by incident wave and reflected wave. And the maximum and minimum sound pressure values are distributed alternately from material surface. The difference between the maximum value and the minimum value can be measured by a moving microphone, and the absorption coefficients are calculated. This method is described in standard GB/T 19696.1-2004.

1.2.7.2. Transfer function method

In 1980, Chung and Blaser proposed an absorption coefficient measuring approach in the transfer function method using impedance tubes with two microphones. The transfer function method is also conducted in sonic tubes like the standing wave method, while the sliding microphone is replaced by two microphones fixed on the tube wall. The sound source generates plane waves in the tubes. Sound pressure is tested by two microphones closed to the test sample, and the sound propagation function of two microphone signals can be obtained. Normal incident absorption coefficient and surface impedance are derived from complex calculation. The transfer function method is more convenient and advanced compared with the standing wave method. The measurement method is stated in standard ISO10534-2 and GB/T18696.2-2002.

1.2.7.3. Reverberation room method

The acoustic absorption coefficient measurement is estimate form the decay sound. The volume of reverberation is no less than 150 m^3. The area of the tested material is about 10-12 m^2. The reverberation time, which characterizes the rate of sound decay, of the room is measured before the sample is mounted. Acoustic absorption coefficient of the surface of reverberation room can be calculate according to the Sabine reverberation formula.

In general, standing wave methods and transfer function method is popular because sample size required in the both method is small and the experiments are low cost and easy to carry out while result are close to actual situation.[9]

1.2.8. Impedance tube kits

Impedance tube kit consists of testing tube that are equipped with a microphone and a sound source. Material are inserted into the tube. A loudspeaker is placed in the tube then emits precisely quantified sound. The microphone measures sound pressure level at a specific location in the tube. Brüel & Kjær program is used to calculate the incident acoustic properties of the material based on frequency response the various measurement location (also known as Transfer function method)

These kits help to determine sound absorption coefficient by making measurements and calculations that followed by standard ASTM E 1050-12.[10]

1.3. Expected benefits

To understand the relationship between material physical properties and sound absorption efficiency at the frequency of 0-6300 Hz. The understanding of the effect of material physical properties can lead to new material improvement for sound absorbance.

Chapter 2

Experimental

2.1. Instruments

Table 2.1 list of instruments

Instruments	Brand and Model
Hydraulic press	Manas, SWING ARM 25T
Microscope	Olympus, BX51M
Transmission loss and impedance tube kits	Brüel & Kjær, type 4206

2.2. Sample

In this investigate, there are 17 samples which different in weight, component ratio, and fiber diameter (less than 50 μm.)

2.3. Procedure

2.3.1. Sample preparation

Each raw sample was made as full width sheet that has different characters. Referring to figure 2.1, raw sheet was cut into 2 sizes and 7 pieces per size namely size A and size B. Sample size A has diameter 29 mm Sample type B has diameter 100 mm (Figure 2.2).

Figure 2.1 Raw sheet of sample

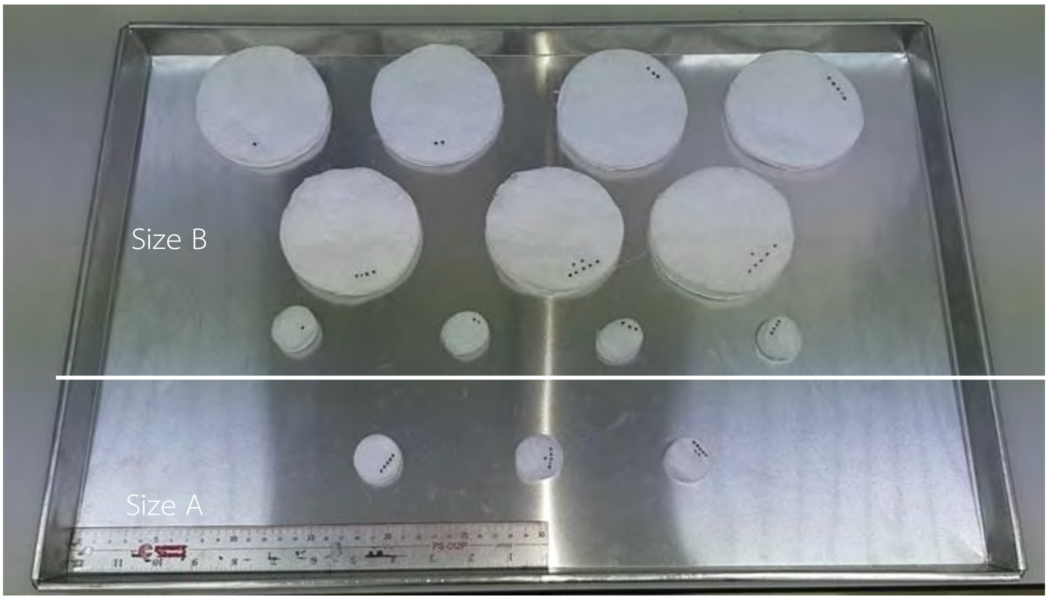

Figure 2.2 Prepared samples

Table 2.2 surface areas of each sample size

Sample	Surface area (cm^2)
Size A	10
Size B	80

2.3.2. Identifying physical characteristics of fibers

2.3.2.1. Weight

Measure the weight of each sample 2 decimals and convert unit from gram to gram/meter^2 by divided with surface area in Table 2.2

2.3.2.2. Fiber sizes

A microscope was used to observe and take a picture of fiber. The size of polypropylene is selected for this study while size of polyester is controlled. The size of fiber was measured from 5 random positions of the circular specimens with the aid of microscope (50c magnification).

2.3.3. Testing of Acoustic absorption

The acoustic absorption coefficient was measured by impedance tube kit that followed the standards ASTM E1050.

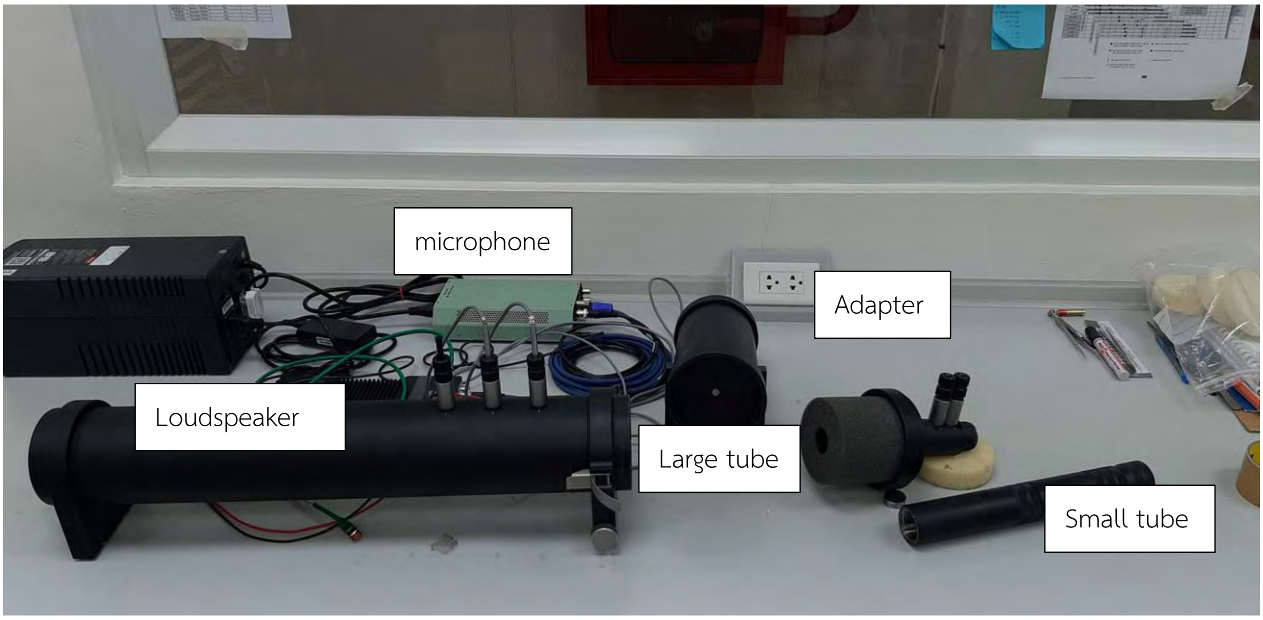

Figure 2.3 Impedance tube kit

2.3.3.1. Testing of Acoustic absorption in high frequency

For sample size A, each piece was set at specific thickness for each factor (referring to table 2.3). The sample was mounted into small tube, then a loudspeaker was assembled with small tube and adapter (Figure 2.4).

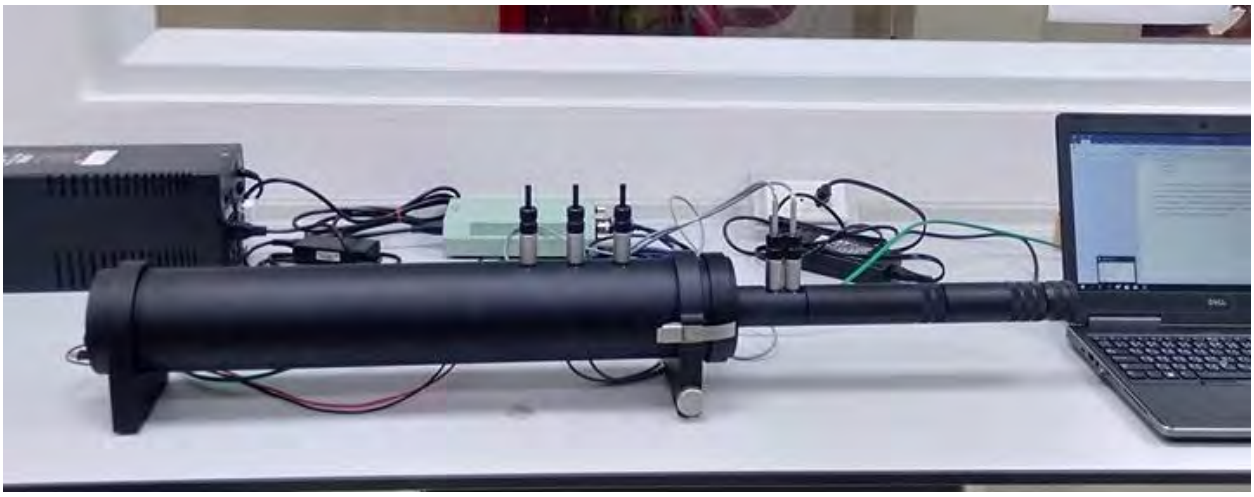

Figure 2.4 Impedance tube kit with small tube

2.3.3.2. Testing of Acoustic absorption in low frequency

For sample size B, each piece was set a specific thickness for each factor. Referring to Table 2.3. After that, sample was mounted into large tube. Then, A loudspeaker was assembled with large tube.

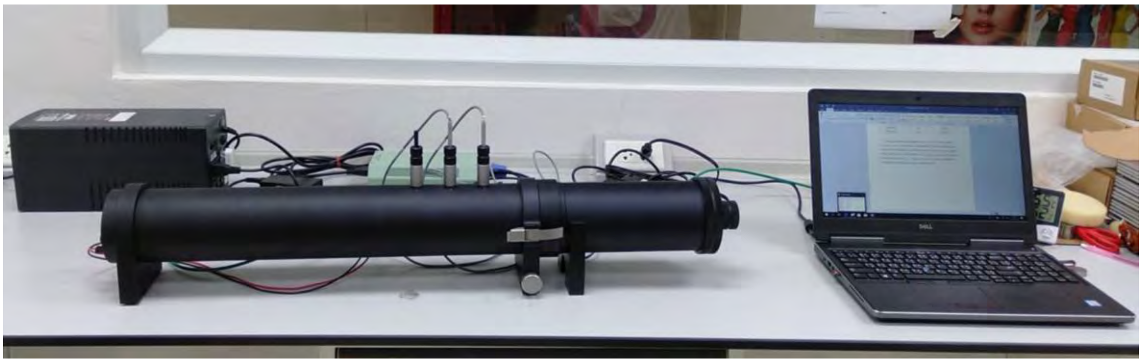

Figure 2.5 Impedance tube kit with large tube

Table 2.3 list of thickness

Samples	Thickness (mm.)
Sample 1, 2, 17	12
Sample 3, 4, 5, 6, 13, 14, 15, 16	21
Sample 7, 8, 9, 10, 11, 12	10

2.3.4. Reporting data

After measuring the acoustic absorption in both ranges (125-1600 Hz and 125-6300 Hz). The data was averaged, combined, and extracted by Brüel & Kjær programs before exporting to excel format.

First, the acoustic absorption coefficient in each sample size (seven data per size of each sample) is averaged to 1 data. After averaging, the averaged data in each sample (two averaged data sample) is combined to 1 data. The combine data has frequency in 125-6300 Hz. After combining, the data in each sample (one combined data sample) is extracted to 1/3 octave band. The data has frequency in 125-6300 Hz as the same but have less point of frequency causing data more easily analysis. The data is exported to excel programs showing in a line graph.

Chapter 3

Result and discussion

3.1. Physical characteristic of fiber

3.1.1. Weight of sample

Table 3.1 Weight of sample

		Sample (g)								Weigh/Area	Avg.
		1	2	3	4	5	6	7	Avg.	(g/m^2)	(g/m^2)
Sample 1	Large	4.84	4.56	4.64	4.66	4.48	4.77	4.65	4.66	582.14	575.03
	Small	0.46	0.36	0.38	0.40	0.39	0.39	0.43	0.40	567.92	
Sample 2	Large	4.94	5.26	5.58	4.98	5.02	4.98	4.65	4.49	560.89	585.63
	Small	0.46	0.46	0.43	0.42	0.40	0.43	0.42	0.43	610.36	
Sample 3	Large	1.29	1.26	1.27	1.32	1.16	1.20	1.37	1.27	158.39	157.01
	Small	0.10	0.12	0.09	0.15	0.10	0.11	0.10	0.11	155.62	
Sample 4	Large	1.50	1.42	1.77	1.52	1.41	1.54	1.45	1.52	189.46	178.61
	Small	0.09	0.12	0.13	0.11	0.11	0.13	0.14	0.12	167.75	
Sample 5	Large	1.84	1.60	1.63	1.60	1.82	1.95	1.59	1.72	214.82	226.65
	Small	0.15	0.15	0.15	0.18	0.17	0.19	0.19	0.17	238.49	
Sample 6	Large	2.21	2.65	2.53	2.45	2.29	2.31	2.50	2.42	302.50	315.97
	Small	0.24	0.22	0.20	0.24	0.28	0.23	0.22	0.23	329.44	
Sample 7	Large	0.92	0.76	0.80	0.92	0.82	0.73	0.80	0.82	102.68	105.91
	Small	0.09	0.07	0.09	0.07	0.06	0.07	0.09	0.08	109.14	
Sample 8	Large	1.28	1.20	1.17	1.26	1.45	1.07	1.20	1.23	154.11	157.90
	Small	0.11	0.11	0.11	0.12	0.13	0.09	0.13	0.11	161.69	
Sample 9	Large	1.42	1.40	1.56	1.60	1.64	1.48	1.80	1.56	194.64	198.38
	Small	0.14	0.11	0.20	0.09	0.15	0.15	0.16	0.14	202.11	
Sample 10	Large	2.40	2.32	2.37	2.38	2.33	2.27	2.15	2.32	289.64	295.39
	Small	0.21	0.23	0.16	0.24	0.22	0.23	0.20	0.21	301.14	
Sample 11	Large	3.51	2.97	3.31	3.17	3.54	3.02	3.07	3.23	403.39	396.73
	Small	0.29	0.25	0.23	0.23	0.27	0.33	0.33	0.28	390.07	
Sample 12	Large	4.56	4.55	4.07	4.76	4.58	4.63	5.05	4.60	575.00	573.48

	Small	0.40	0.38	0.37	0.41	0.45	0.42	0.40	0.40	571.96	
Sample 13	Large	2.20	2.20	2.31	2.43	2.28	1.94	2.20	2.22	277.86	270.30
	Small	0.17	0.16	0.17	0.23	0.21	0.17	0.19	0.19	262.74	
Sample 14	Large	2.91	3.09	3.17	3.01	2.92	2.88	3.03	3.00	375.18	370.50
	Small	0.21	0.30	0.34	0.26	0.25	0.23	0.22	0.26	365.81	
Sample 15	Large	3.66	3.78	3.73	3.75	4.20	3.78	3.76	3.81	476.07	478.54
	Small	0.32	0.35	0.30	0.33	0.36	0.39	0.33	0.34	481.02	
Sample 16	Large	5.30	5.08	5.44	5.56	5.06	5.17	5.30	5.27	659.11	675.16
	Small	0.47	0.46	0.48	0.56	0.47	0.50	0.48	0.49	691.21	
Sample 17	Large	3.50	3.17	3.12	2.99	3.04	3.41	3.55	3.25	406.79	203.39
	Small	0.29	0.26	0.26	0.31	0.28	0.26	0.24	0.27	384.00	

3.2. Fiber diameter

Table 3.2 Fiber diameter

Sample	fiber diameter (μm)					
	1	2	3	4	5	Avg.
sample 1	6.22	5.37	5.37	7.01	5.91	5.99
sample 2	9.92	7.52	10.30	9.02	8.70	9.09
sample 3	4.61	5.53	4.12	4.26	5.39	4.78
sample 4	5.61	6.74	3.61	4.51	4.21	4.94
sample 5	3.77	4.68	4.76	4.57	6.15	3.63
sample 6	4.66	4.18	4.85	5.73	5.35	4.95
sample 7	4.07	3.91	4.57	4.94	4.60	4.42
sample 8	4.24	4.29	5.64	4.57	3.74	4.50
sample 9	5.38	4.79	4.90	4.26	4.49	4.77

sample 10	5.23	4.88	4.78	4.97	4.95	4.96
sample 11	4.51	4.11	4.21	5.57	3.77	4.44
sample 12	4.44	4.30	5.29	5.12	3.40	4.51
sample 13	3.91	5.20	4.49	4.18	5.14	4.58
sample 14	4.35	4.63	3.85	5.92	4.57	4.66
sample 15	4.74	4.81	4.05	4.24	4.87	4.55
sample 16	5.14	4.76	4.99	4.87	4.26	4.80
sample 17	14.01	13.24	13.50	14.80	14.50	14.01

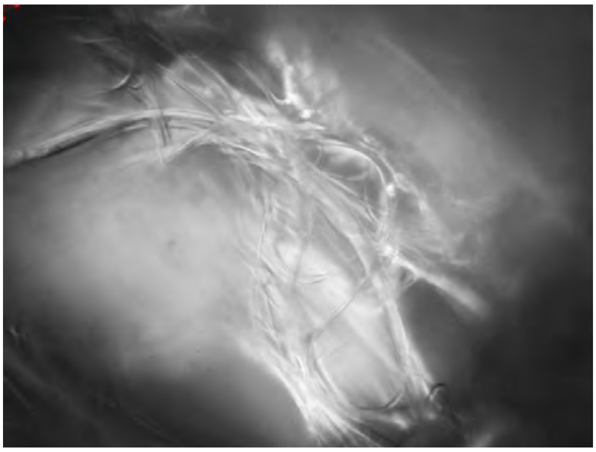

Figure 3.1 Fiber image of sample 1

Figure 3.2 Fiber image of sample 2

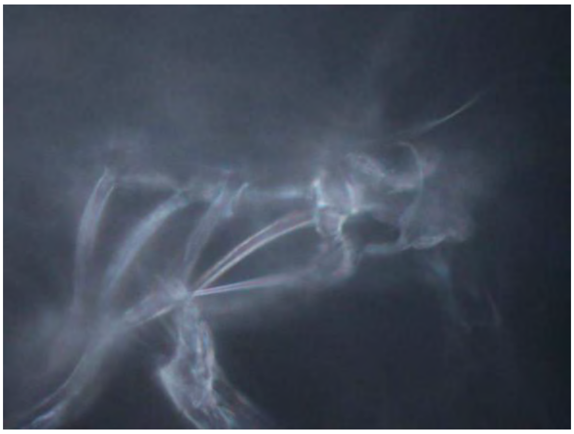

Figure 3.3 Fiber image of sample 3

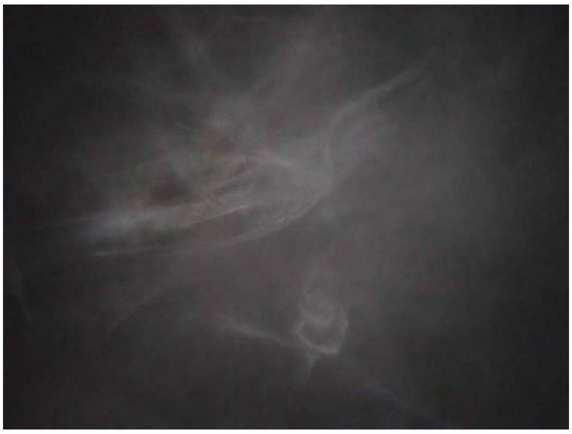

Figure 3.4 Fiber image of sample 4

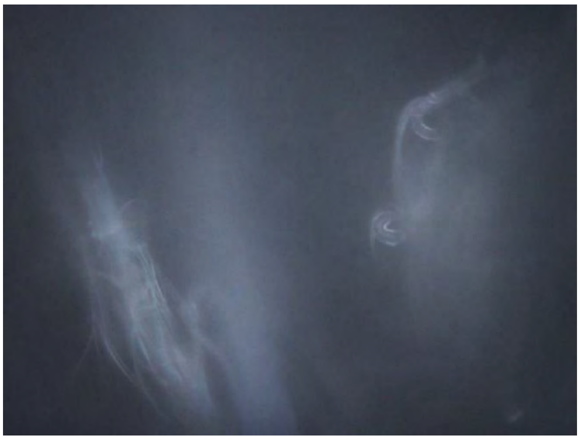

Figure 3.5 Fiber image of sample 5

Figure 3.6 Fiber image of sample 6

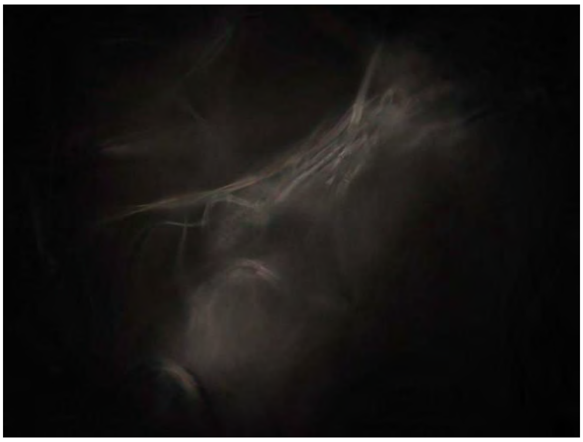

Figure 3.7 Fiber image of sample 7

Figure 3.8 Fiber image of sample 8

Figure 3.9 Fiber image of sample 9

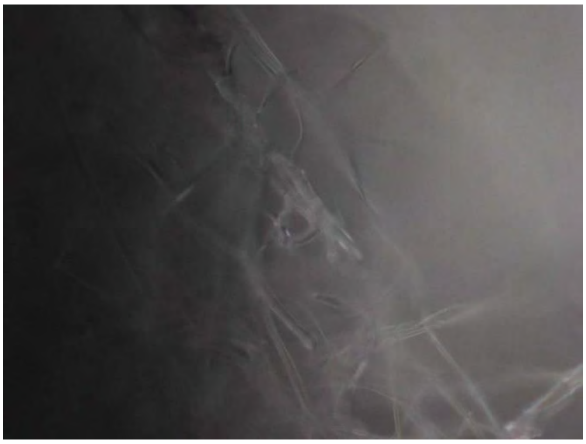

Figure 3.10 Fiber image of sample 10

Figure 3.11 Fiber image of sample 11

Figure 3.12 Fiber image of sample 12

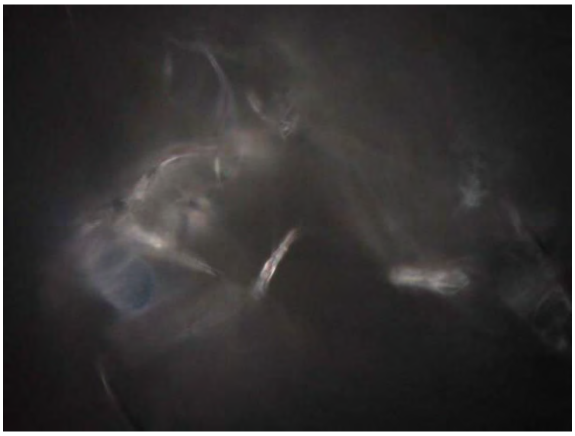

Figure 3.13 Fiber image of sample 13

Figure 3.14 Fiber image of sample 14

Figure 3.15 Fiber image of sample 15

Figure 3.16 Fiber image of sample 16

Figure 3.17 Fiber image of sample 17

3.3. Effect of fiber diameter

Fiber diameter of sample 1 and 2 is observed by microscope at 50x. According to figure 3.1 and 3.2, Both of fiber are non-woven fiber. Sample 1 has smaller fiber diameter (6um), while sample 2 has fiber diameter about 9 um, but sample 2 has more uniform in size and higher in packing density

Sample 1 and 2 measures by impedance tube for acoustic absorption coefficient (Figure 3.18)

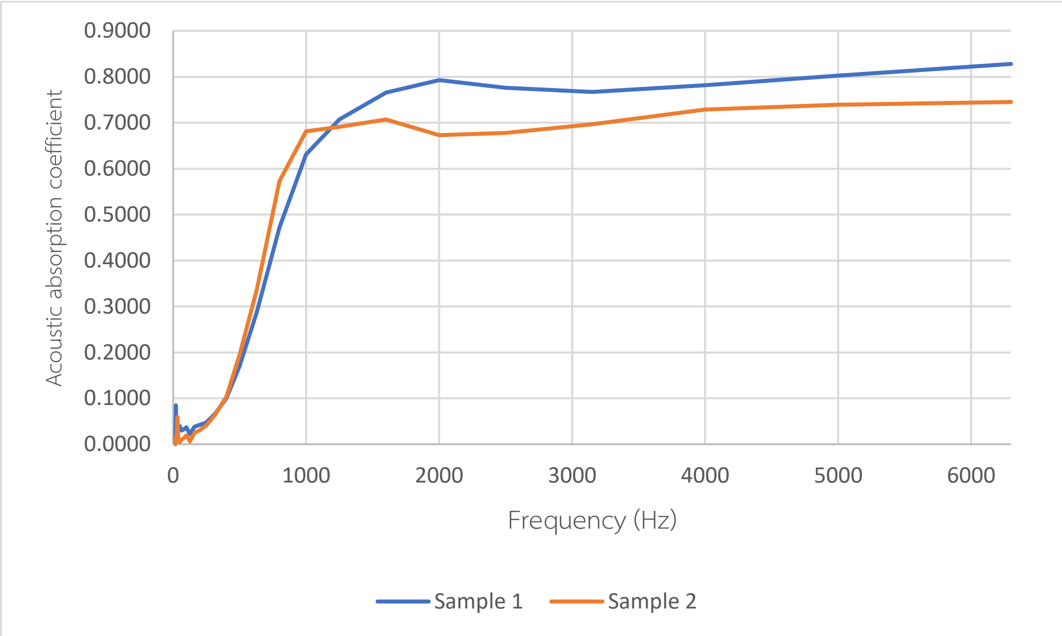

Figure 3.18 Acoustic absorption coefficient of sample 1 and 2

According to figure 3.18, both of sample has good acoustic absorption performance in range above 600 Hz. The sample 1 has more acoustic absorption coefficient because of small diameter of fiber causing more surface area compared to other sample fibers at the same weight. Because one factor that affects acoustic absorption performance of Absorptive material is the friction occurred between air and fiber surface. Sound energy can be lost through the friction energy. Trend of sample 2 has a little shift to low frequency because its fiber is in closed packing where it can reduce the air flow in the sample and create more barrier causing reflection of sound energy at higher frequency. However, sound energy at low frequency can be absorbed by fiber vibration.

3.4. Effect of density to acoustic absorption

Sample 3-16 was divided into 3 group by ratio of polypropylene, group 1 have more amount of polypropylene and follow by group 2 and group 3, respectively. In each group. Sample have different weigh that affect each sample have different density, density increase when sample number increase.

Each group of samples is measured by impedance tube for acoustic absorption coefficient (Figure 3.19-3.21)

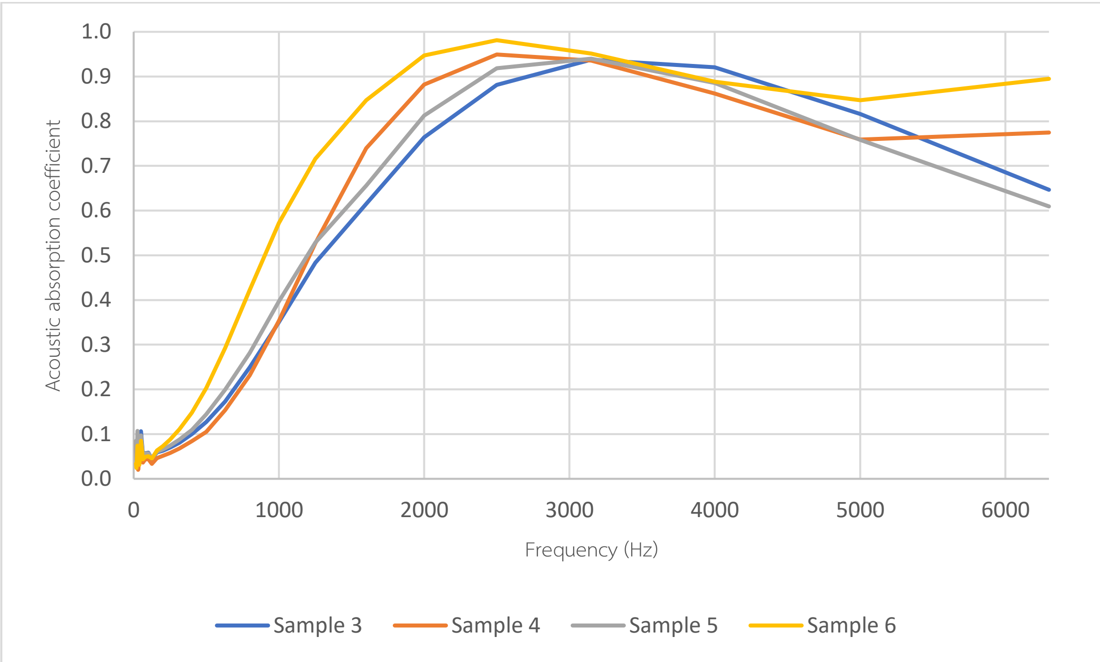

Figure 3.19 Acoustic absorption coefficient for sample group 1

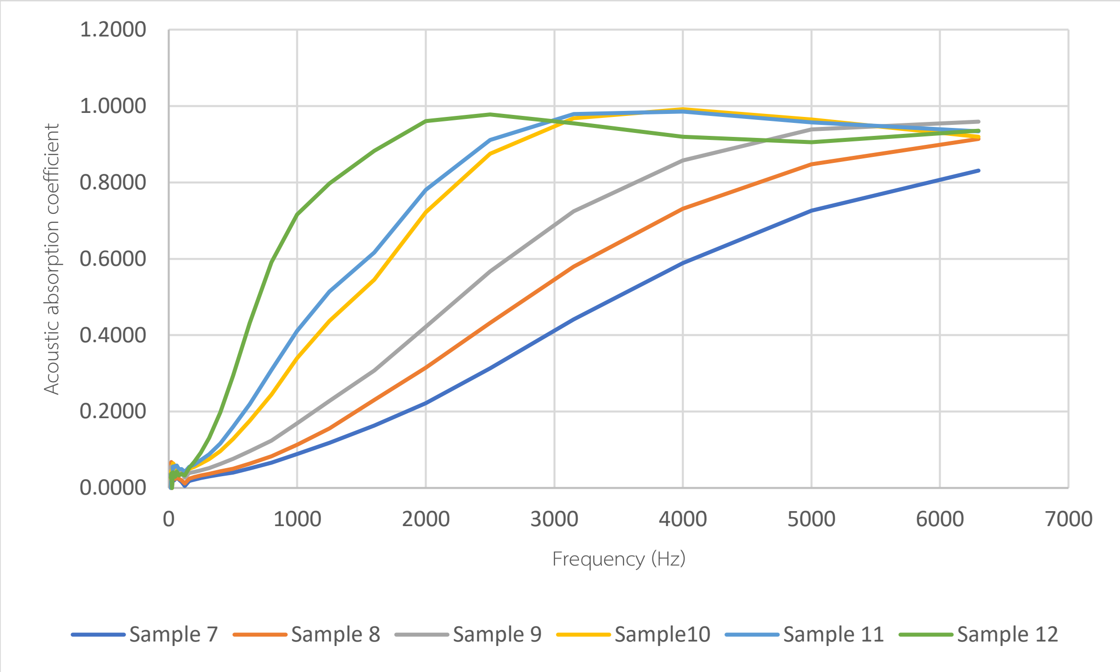

Figure 3.20 Acoustic absorption coefficient for sample group 2

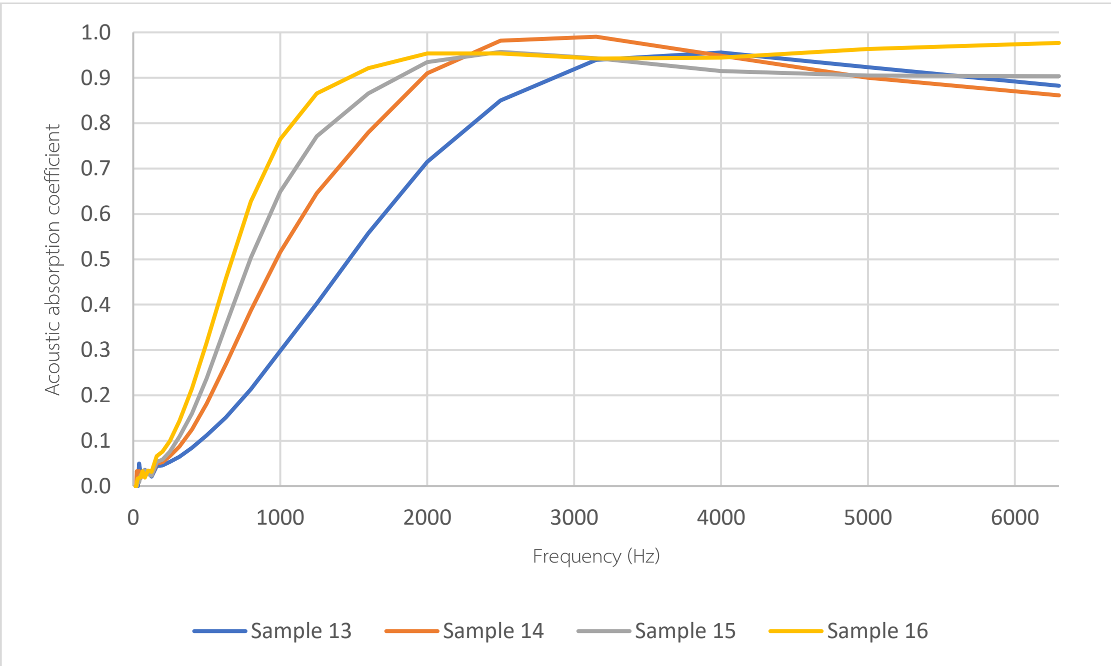

Figure 3.21 Acoustic absorption coefficient for sample group 3

According to Figure 3.19-3.21, Trend of all three groups of samples show similar shift in the direction of low frequency by the increase of fiber density. This is because when density is increase, air volumn in sample is decrease and that makes sample transform from the

absorption material to the barriers causing most of sound wave cannot passes through. The sound-energy cannot change into different energy form when it passes through or contact with fiber surface; in the contrast, it reflects sound energy easily than absorption. Moreover, the sound energy at low frequency has more ability to lose their energy through vibrate object or fiber. Therefore, the acoustic absorption coefficient has trend to be increase at lower frequency when fiber density increase. In addition, the lowest weight sample in each sample group exhibits lower peak of acoustic absorption coefficient. This is because of the void in fiber mesh at the control thickness is dramatically high and that let the sound pass through with less contact to fiber, so energy lost
efficiency is reduced.

3.5. Effect of fiber type

Sample 1 and 17 measures by impedance tube for acoustic absorption coefficient

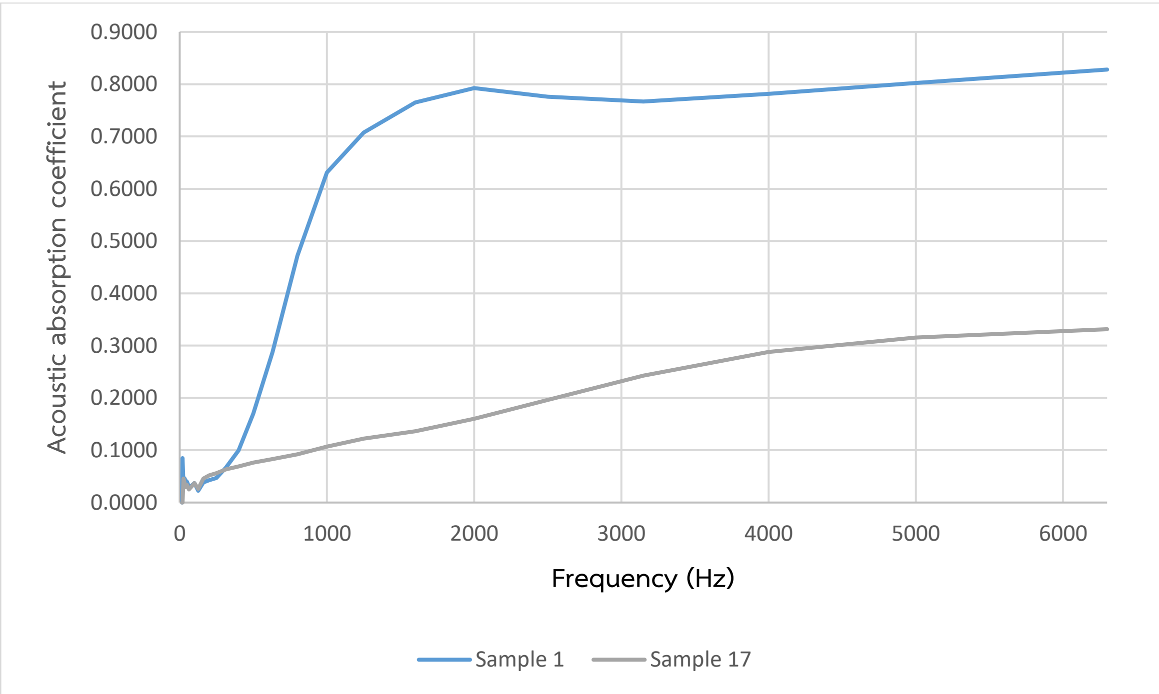

Figure 3.22 Acoustic absorption coefficient for sample 1 and 17

According to figure 3.22, Sample 1 has higher acoustic absorption coefficient compared to sample 17. This is because the character of both sample surface is different. The sample 1 is more rough and tight packing allowing the sound energy lost due to friction. While the character of sample 17 fiber is loose packing and has smooth and glossy surface, the reduction of sound energy of this sample by friction is less impact.

Chapter 4

Conclusion

4.1. Conclusion

Acoustic absorption materials containing the mix of polypropylene and polyester has a good performance in sound absorption performance to reduce the noise in the range of frequency more than 500 Hz.

In this study, the physical factors including fiber size, density, and fiber type show impact to sound absorption performance.

i) The effect of diameter size; the small fiber diameter has more performance than the larger fiber diameter.

ii) The effect of density; the density of fiber and air flow volumn in sample impact to acoustic absorption performance and this factor must be considered together with range of frequency. More density of fiber has a trend to be good at low frequency. If the density is decreasing. Acoustic absorption coefficient peak will drop.

iii) The effect of fiber type and its surface; the surface of fiber is one of the factors that impact to acoustic absorption performance. The rougher surface has better performance due to the sound energy lost.

4.2. Suggestion

1. For study the effect of size of diameter; Difference between size and amount of size should be investigated more

2. For study effect of the effect of density; Airflow resistant should be tested

3. For study effect of type of fiber; Type of fiber should be more and airflow resistant should be test for friction between air and fiber.

4.3. Obtain benefit

Relation between physical property and sound absorption property

REFFERENCE

1. XiaoningTang, XiongYan, Acoustic energy absorption properties of fibrous materials: A review, Composites Part A, 101(2017), pp. 360-380
2. X.B. Cai, Q.Q. Guo, G.K. Hu, J. Yang, Ultrathin low-frequency sound absorbing panels based on coplanar spiral tubes or coplanar Helmholtz resonatorsAppl Phys Lett, 105 (12) (2014)
3. M. Zakriya, G. Ramakrishnan, N. Gobi, N.K. Palaniswamy, J. Srinivasan, Jute-reinforced non-woven composites as a thermal insulator and sound absorber – a review, J Reinf Plast Compos, 36 (3) (2017), pp. 206-213
4. Q.B. Ao, J.Z. Wang, A.J. Li, H. Zhi, J. Ma, H.P. Tang, Sound absorption properties of fibrous porous metals, Rare Met Mater Eng, 46 (2) (2017), pp. 387-391
5. X. Tang, X. Yan, Multi-layer fibrous structures for noise reduction, J Text Inst (2017), pp. 1-11
6. Paul Davidovits. Chapter 12 - Waves and Sound, Physics in Biology and Medicine (Fifth Edition) 2019: 173-192
7. Dojo University, Understanding Harmonics—Part 1. Retrieved form. https://learn.dojouniversity.com/understanding-harmonics-part-1/ (access 25.07.19)
8. Institute of Sound and Vibration Research, basic sound. Retrieved form. http://resource.isvr.soton.ac.uk/spcg/tutorial/tutorial/Tutorial_files/Web-basics-nature.htm?fbclid=IwAR3OdcbgDFfuDrEUeeFOziIop6dvLwA-Vb0ooh_ydZEfldIa383hxH64-yo (access 25.07.19)
9. Machine Design, Noise Control Materials. Retrieved form. .https://www.machinedesign.com/basics-design/noise-control-materials (access 25.07.19)
10. ref: Brüel & Kjær , Transmission loss and impedance tube kits. Retrieved form. https://www.bksv.com/en/products/transducers/acoustic/Acoustic-material-testing-kits/transmission-loss-and-impedance-tube-kits-4206 (access 25.07.19)

VITA

Mr. Thanawit Niyomna was born on October 27, 1997, in Trat, Thailand. He graduated from the Pibulwittayali School, Lopburi in the academic year 2015. He pursues a Bachelor of Science degree at Department of Chemistry, Faculty of Science, Chulalongkorn University, Bangkok, Thailand. His current address is 60/5, Patan, Mueang Lopburi, Lopburi, 15000 and an email is notza55511@hotmail.com