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Manufacturing of Thermal and Acoustic Insulation From (Polymer Blend/Recycled Natural Fibers)

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K E Y W O R D S

Polymer Blend, Recycled Natural Fibers, Acoustic Insulation, Thermal Conductivity, Hemp Fibers, Cornhusk Fibers

A B S T R A C T

These works study the characterization of thermal and acoustic insulation behavior of Polymer Blend/Recycled Natural Fibers. Acoustic insulation is an important property in design criterion in buildings and used to avoid the damage caused by the sounds of the explosion of rockets and bombs. This work is done through reinforcing 80% epoxy resin EP with 20% polycarbonate PC with two different recycled natural fiber RNF (hemp fiber H.F., cornhusk fiber C.H.F) at various weight fractions of (2,4,6) %, the samples, were formed by hand lay-up then the acoustic and thermal insulation tests carried out. The results show that altering both kinds of RNF can improve acoustic insulation. Also, it could be noticed that sound insulation efficiency can improve with increasing RNF weight fraction. Finally, the optimum results got at 6% hemp composite that shows better acoustic insulation than cornhusk composites. The thermal conductivity improved by increasing the fiber weight fraction. The maximum value of thermal conductivity for composite samples with (H.F., C.H.F) fibers at (6% wt) equal to (0.71609W/m. K°) and (0.73686W/m. K°), respectively. The composite samples with C.H.F. fibers have slightly higher thermal conductivity value than composite samples with H.F.

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1. INTRODUCTION

Sound absorption counts as one of the significant prerequisites for the humans, relief, these days. Acoustic insulation, requirement in-vehicle, manufacturing environments, and equipment, that produced a, higher sound, pressure drives the need to develop, more efficient productive and conservative, ways, for creating sound absorption, materials. Industrial applications of sound insulation generally, include the uses of, material, such as glass wool, foam, mineral fibers, and their composites,[1]. Present-day composite materials comprise a wide, extent of the engineering material market ranging, from every day, products to sophisticated, specialty, application [2].

Nowadays, composites, development trend that changed, from using "synthetic fibers" to " natural fibers" as a reinforced phase. This is because the composites with synthetic, fibers such as glass, fibers are not environmentally, friendly, leading to problems of waste glass fiber, which can't be decomposed by nature [3]. Natural, fibers composites, for their outstanding acoustic absorption properties, and they become a good competitor for the sound absorption structure comparative with synthetic fibers [4].

Sérgio et al., 2015studies the characteristic of acoustic, insulation, behavior for hybrids-sandwich composites panels for application in the modular house construction, which is given characteristic natural filaments structure impregnated, (EP) [5]. Lee et al., 2016, measured the sound absorption properties of flax/ EP composites and subsequently comparing them with glass-fiber/ EP composites. The results showed that flax/EP composites have very excellent acoustic properties also show promising as environmentally safe, reasonable substitutions for glass/ EP systems [6]. Weidong and Yan, 2012 studied the behavior of sound-insulation properties of natural fibers, and their reinforced composites, i.e., flax, jute, and ramie fibers and their composites that measured through 2 microphone transfer functions technique in the impedance tube and compared with "synthetic fibers" and their composites. It's found that both types of natural fibers and their composites have the premium ability to reduce the noise [4]. Hussain et al., 2011. Investigated on natural composites of "jute" and "white feature" as there (raw material) for getting the thermal conductivity, it has been concluded that the increase in the volume fraction of natural fiber leads to decrease the thermal-conductivity [7]. Hussain et al., 2012. studies the thermal conductivity of "bamboo fiber" reinforced composite by different volume-fraction, it's concluded that the fiber-length increase in the volume fraction of fiber makes the thermal-conductivity decreases [8].

This work aims to study the influence of adding natural fibers on the thermal conductivity and the acoustic insulation of the polymeric blend composites.

2. MATERIALS AND METHODS

I. Materials

The matrix materials, which used in this work, are Epoxy resin, (produced by Quick mast 105 made in Jordan), compose of two-part (uncured epoxy and hardener), and polycarbonate, (manufactured by teijin human chemistry–japan company), (model :PC/L-1250Y), with particle (size: 60 meshes).

Natural fibers such as hemp fibers (H.F) and Cornhusk fibers (CH.F) a reinforcing phase of the composite.

II. Methods

1) Natural Fibers Preparation

The RNF was cleaned with water to remove dirt and impurity then dried in the sun for three days to eliminate the excess water. Fibers in this study were cutting manually (2 mm) length and different weight fractions (2, 4, and 6) wt.% of both types of fibers are used. Figures 1and 2 show hemp, corn husk fibers respectively.

Figure 1: (a) hemp fibers as resaved before cutting, (b) hemp after cutting.

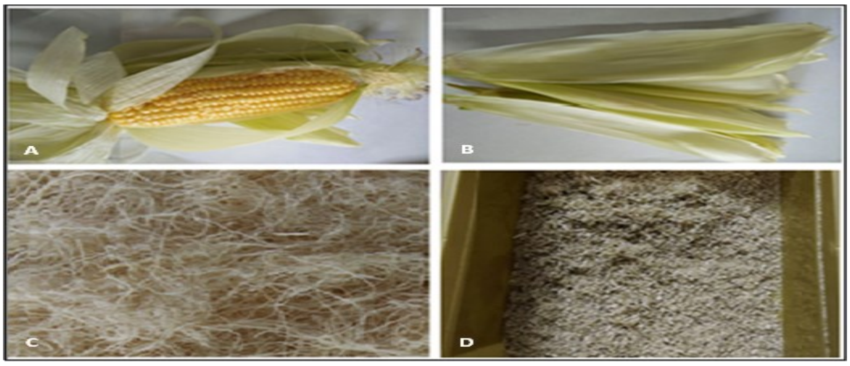

Figure 2: (a) Corncob, (b) Cornhusk, (c) Cornhusk fibers, (d) Corn Husk Fibers after cutting.

2) Samples Preparation

Blending of EP resin with 20% wt. PC powder had been performed after several experimental trials to dissolve PC powder and get a homogenous mixture, where the best results had got after (15) minutes of manual mixing. Next, the blend of 20% PC has reinforced by two types of natural fibers (hemp fiber, cornhusk fiber) at different weight fraction of (2,4, and 6) wt.% by using the role of mixture theory to prepared the samples. The fibers add gradually to the polymer blend (EP and PC) then mixed for 10 minutes to ensure good distribution of fiber into the blend matrix. Then adding EP hardener to the mixture, (3 parts of epoxy: 1 part of hardener) in weight fraction. Then the mixture was poured into glass mold, have cavities coated with Vaseline (wax) to help 'releasing' the samples have a dimension of (25×25×1.5) mm^3 (according to Acoustic insulation test), after (24) hours, specimens removed from the mold and heat-treated by ordinary oven at (50) °C for 2 hours. The same procedure was carried out except the mixture poured in silicone mold with a circular shape (50mm diameter and 3 mm thickness).

3) Acoustic Insulation Test

The acoustic insulation is done according to the American standers (ASTM - E336) by using a locale-made device composer from a wood box within wave generator, loudspeaker, wave receiving, and amplifier as shown in Figure 3 [9]. The test begins once the sound waves are generated from the waves generator and amplified then transport to the loudspeaker which is attached to the wood box, the sample placed in the center of the frame box. Once the box closed the waves generated with a different frequency (15) HZ the generated waves reached the audio receiver.

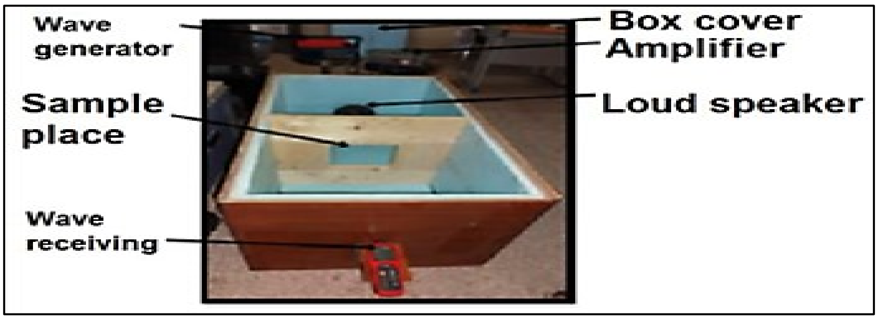

Figure 3: Aquatic Insulation device.

4) Thermal Properties Test

The Conduction will take place by the existing temperature gradient. "Lee’s disc method" as shown in figure 4, that used for good and bad conductors of heat, respectively. The experimental setup for Lee’s Disc method is simple and involves the use of two metal discs (it's usually brass), a sample for measuring, and two thermometers to measure the temperature gradient. The thermometer measures the sample temperature and the temperature of the brass base T_2. In this way, the temperature difference across such a thin disc of the sample can be accurately measured [10].

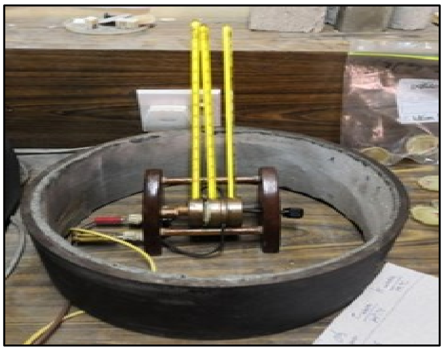

Figure 4: Lee’s disc method.

3. Results and Discussion

Figures 5 and 6 illustrated the relationship between the acoustic level and the frequency of the samples that made of polymer blend composite reinforced with H.F. at different (2, 4, and 6) wt.%, it can be seen in the figure below that the acoustic level decrease with increasing the weight fraction of H.F. by (0.3, 0.5, and 2) %. Respectively. While figure (6) represents a polymer blend of reinforced with C.H.F.at (2, 4, and 6) wt.% they also decreased by (0.1, 0.3, and 1.8) %. The decrease in acoustic level leads to an increase the acoustic insulation for both types of fibers because natural fibers have hollow structures that could convert acoustic energy into mechanical, and heat energy efficiently that makes them better acoustically absorbents materials because of their hollow structures [11]. 6 wt.% composite sample hemp has the value of the height of sound insulation with other composites samples because of the increase in density of sample result in an increase in the sound absorption in different frequency regions because increasing in the numbers of fibers per the unit area, the density of the sample increases. As a result, the energy loss of sound waves increases due to increasing surface friction, leading to an increase in the performances of the sound absorption [12]. In Figures 7- 9, it is clear that the polymeric blend (P.B) with H.F. has the highest acoustic insulation at (2, 4 & 6) wt.% than the (P.B) with C.H.F.

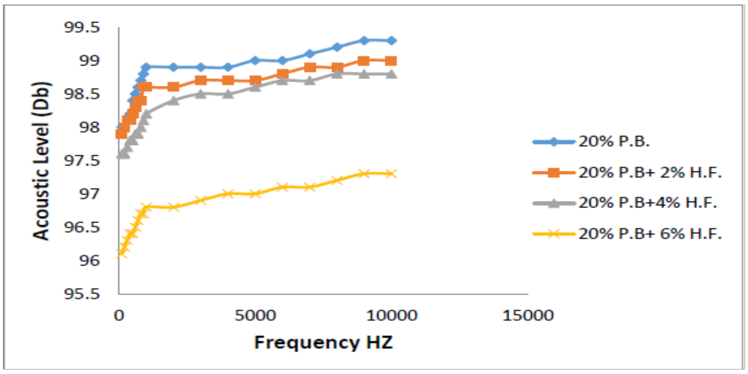

Figure 5: Acoustic level with a frequency with Weight Fraction of 20% P.B. reinforcing with hemp fibers (H.F.).

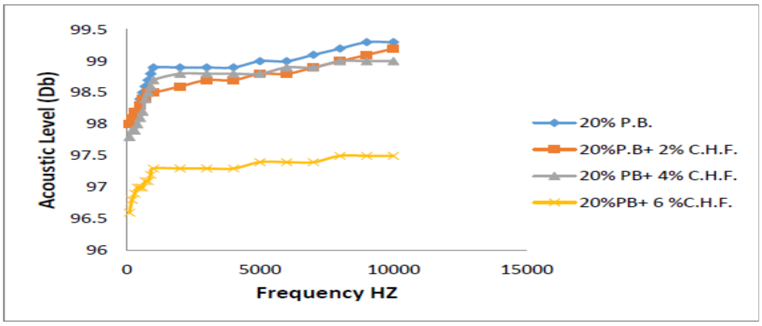

Figure 6: Acoustic level with a frequency with Weight Fraction of 20% P.B. reinforcing with hemp fibers (CH.F.).

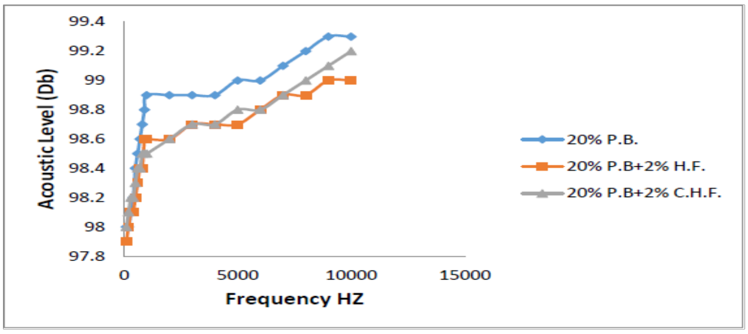

Figure 7: Acoustic level with a frequency with Weight Fraction of 20% P.B reinforcing with 2% (hemp fibers H.F., cornhusk fibers C.H.F).

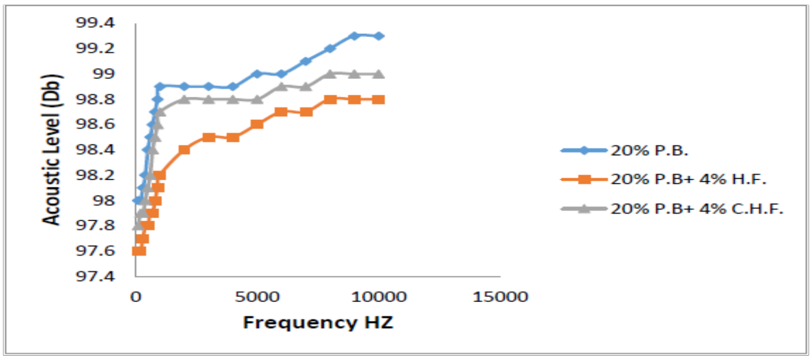

Figure 8: Acoustic level with a frequency with Weight Fraction of 20% P.B reinforcing with 4% (hemp fibers H.F., cornhusk fibers C.H.F.).

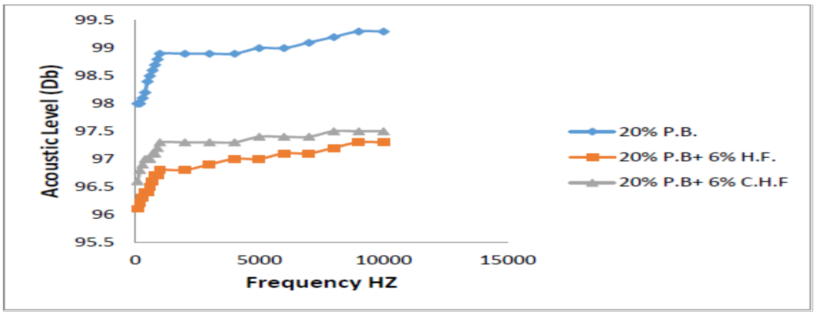

Figure 9: Acoustic level with a frequency with Weight Fraction of 20% P.B reinforcing with 6% (hemp fibers H.F., cornhusk fibers C.H.F.).

The thermal conductivity of natural fiber insulation materials depends on the effective density of the fiberboard, and on the fiber network (orientation of the fibers, number of fiber-fiber contacts, fiber size distribution, and tortuosity), which form a consequence of the manufacturing process [13]. Figures 10- 11 show that once increasing the weight fraction of H.F., the thermal conductivity of the composite samples increase. The thermal conductivity of (20% P.B.) reinforced with (2, 4 & 6) wt.% of HP increased by (4, 16, and 32)% respectively, while P.B. reinforced by C.H.F.(2, 4 & 6) wt.% increased by(5, 21 & 36)%. This is because fibers have higher thermal conductivity than 20% PC blend matrix. The presence of short fibers can improve the thermal conductivity considerably. The composite samples with cornhusk fibers have a slightly higher thermal conductivity value than composite samples with hemp fibers.

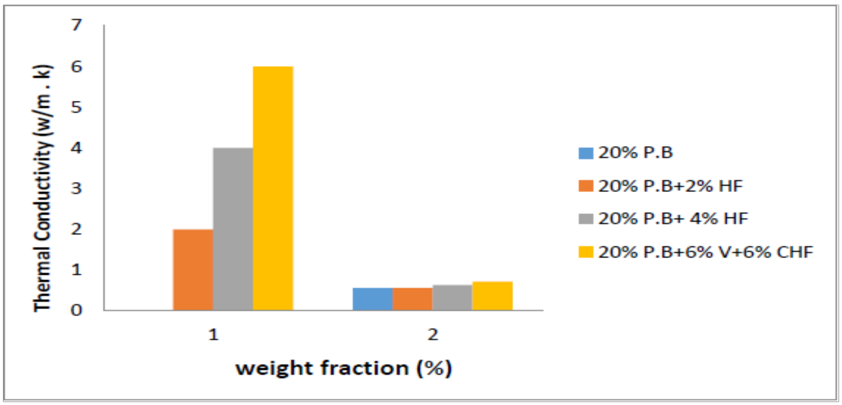

Figure 10: Thermal conductivity with Weight Fraction of 20% P.B reinforcing with hemp fibers (H.F.).

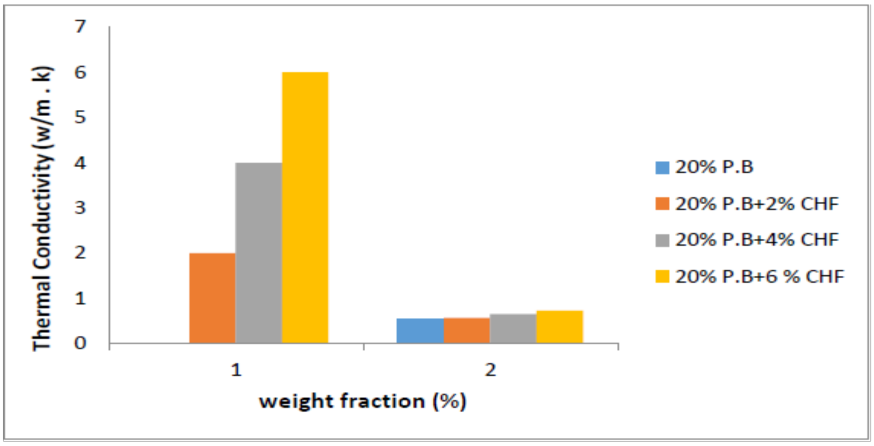

Figure 11: Thermal conductivity with Weight Fraction of 20% P.B reinforcing with corn husk fibers (C.H.F).

4. CONCLUSIONS

1) Ep resin / 20 wt.% polycarbonate can be blended successfully by using the mixing technique at room temperature.
2) The acoustic insulation of polymeric blend composites with both kinds of fibers (cornhusk, hemp) was higher than that of the parent polymer blend(20% PC).
3) Increasing the volume fraction in both cases(cornhusk and hemp fibers) in composite material led to improve acoustic insulation properties of prepared composites.
4) The polymeric blend composite sample with 6% hemp fibers have the highest acoustic insulation.
5) Thermal conductivity increase by increasing fiber percentage it is raised by 32% for polymeric composite reinforced by 6% and increased to 36% at 6% cornhusk fiber.

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