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Acoustic Behavior of Polymer Foam Composite of *Shorea leprosula* after UV-Irradiation Exposure

Anika Zafiah M. Rus, S. Shafizah

***Abstract*—**This study was developed to compare the behavior and the ability of polymer foam composites towards sound absorption test of *Shorea leprosula* wood (SL) of acid hydrolysis treatment with particle size <355µm. Three different weight ratio of polyol to wood particle has been selected which are 10wt%, 15wt% and 20wt%. The acid hydrolysis treatment is to optimize the surface interaction of wood particle with polymer foam matrix. In addition, the acoustic characteristic of sound absorption coefficient (α) was determined. Further treatment is to expose the polymer composite in UV irradiation by using UV-Weatherometer. Polymer foam composite of untreated *Shorea leprosula* particle (SL-B) with respective percentage loading shows uniform pore structure as compared with treated wood particle (SL-A). As the filler percentage loading in polymer foam increases, the α value approaching 1 for both samples. Furthermore, SL-A shows better α value at 3500-4500 frequency absorption level (Hz), meanwhile α value for SL-B is maximum at 4000-5000 Hz. The frequencies absorption level for both SL-B and SL-A after UV exposure was increased with the increasing of exposure time from 0-1000 hours. It is therefore, concluded that the α for each sound absorbing material, with or without acid hydrolysis treatment of wood particles and it's percentages loading in polymer matrix effect the sound absorption behavior.

Keywords—Polymer foam composite, sound absorption coefficient, UV-irradiation, wood.

I. Introduction

In recent years, a number of studies have been carried to develop new materials and technologies improving the sound absorption properties [1], [2]. The sound of an industrial waste developed by using processed bamboo and oil palm frond has been tested for its sound absorption properties [3], [4]. Sound absorbing materials absorb most of the sound energy striking them and reflect very little. Therefore, sound-absorbing materials have been found to be very useful for the control of noise [5]; Materials that have high value of sound absorption coefficient are usually porous [6].

Bio-polymeric materials are well known materials suitable for many industrial applications and intensively studied for foams [7], [8]. The absorption coefficient is a useful concept when using geometrical acoustic theory to evaluate the growth and decay of sound energy in a room [9].

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From previous study, polyurethane foams composites made from palm oil were synthesized, crosslink and doped with eco natural filler of rubber waste or sawdust powder [10], [11]. As natural resources become scarce, many researchers and industries are beginning to investigate and utilize various renewable resources such as the abundant and cheap vegetable oils, which represent a major potential source of chemicals [12], [13].

Shorea leprosula wood (SL) was used because its abundant sources of the furniture manufacturing. The acoustical properties (sound absorption coefficient) of the composite were determined to investigate the possibility of untreated and treated SL as filler of polymer composite foams. Wood was chosen as raw material because of its availability. The remaining wood after hydrolysis treatment containing acidic cellulose-lignin and before acid hydrolysis treatment was tested as filler.

Attempts have been made to study the effect of UV irradiation on the surface properties of some common polymers. Their stability against weathering is important and one of the greatest factors in the weathering of polymer foam is ultraviolet (UV) radiation [14], [15].

In this present study, a comparison of untreated and treated before and after acid hydrolysis of SL as filler of composite foam to measure the sound absorption ability and the quality of fibrous material as composite polymer foam. The analysis of the wood composition is still in progress to seek the influence of percentage loading of wood particle which is inconsistent throughout the analysis.

II. Methodology

A. Preparation of Samples

Wood with <355 µm in size, untreated and treated with acid hydrolysis named as SL-B and SL-A with percentage of 10wt%, 15wt% and 20wt% respectively were used as filler in polymer foam composites. Fig. 1 shows the morphological structure of SL wood. As comparison, the treated SL wood as shown in Fig. 1 (a) has higher pore surface structure due to chemical reactions of acid on the SL wood surfaces. Thus, the penetration of the acid hydrolysis (SL-A) samples provide groovy surfaces and open pore as observed and compared to Fig. 1 (b). However, by applying chemical treatment, the hydrophilic nature of wood filler is reduced for better dispersion of the filler into the polymer matrix.

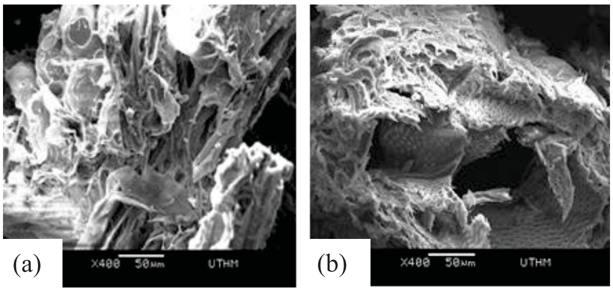


Fig. 1 (a) SL-A; (b) SL-B

The pore size and structures of composites during the cross linking with polyol and isocyanate was also monitored. Specific designed of close mold with 100mm diameter and 28 mm diameter was used to fabricate the samples. The polyol was crosslink with flexible isocyanate with correct proportion, 1:0.5 (w/w %) ratio. The SL wood was makes with uncured polyol, stirred and cast into mold. Figs. 2 (a) and (b) show SL polymer foam composite.

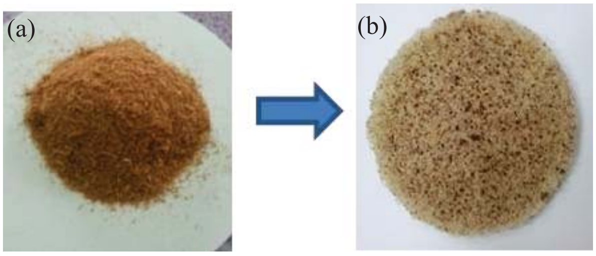


Fig. 2 (a) SL (A-B) wood; (b) SL (A-B) polymer foam composite

B. Scanning Electron Microscope (SEM)

The surface of SL-B and SL-A polymer foam composite samples were gold coated at 25 mA plasma current and 2 Pa of chamber pressure to make them conducting samples. Cellular structure images were examined by using SEM of JEOL-JSM6380LA operates at 15 kV at 30 µm magnifier under high vacuum.

C. Acoustic Property by Impedance Tube Test

The impedance tube consists of an adjustable filter, propagation tube, large and small sample tube of 100 mm and 28 mm diameter respectively of two-microphone method. This is a digital frequency analysis system for the measurement of normal incidence sound absorption coefficient and normal specific acoustic impedance ratios of materials. The samples of SL-B and SL-A were tested by using impedance tube test according ASTM E1050 for horizontally mounted orientation sensitive materials for the frequency range of 100-6000 Hz.

D. UV Irradiation of Polymer Foam Composite

The SL-B and SL-A polymer foam composite were placed on a rack with a rack holder in the UV-Weatherometer chamber at 50°C with different exposure time at 250, 500, 750, 1000 hours. The UV accelerated weathering test was conducted according to ASTM D 4587-Standard practice for fluorescent UV-condensation exposures. The UV-Weatherometer used UV irradiation was carried out using an array of UV fluorescent lamps emitting light in the region from 280 to 320 nm with a tail extending to 400 nm.

III. Results & Discussions

A. Scanning Electron Microscopy, SEM

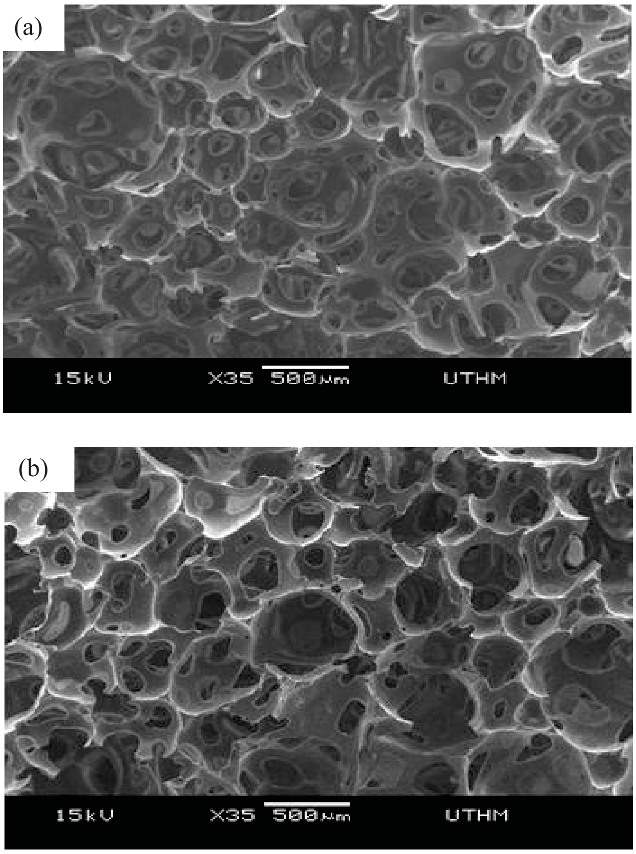


Fig. 3 (a) SL-B-filler polymer foam composites; (b) SL-A-filler polymer foam composites

In Fig. 3 (b), the SL-A was compounded in polyol shows even pore structure as compared to Fig. 3 (a), this might be due to better dispersion of the filler into the polymer matrix resultant in homogenous pore structure. SL-B was loaded in polymer foam composite gives bigger pore size of the foam, whereby the homogenous large size of porous cell increases the absorption coefficient at low frequency level [16] indicated through Fig. 3 (b). The interconnected pore of these polymer porous materials was another important parameter to control the acoustic behavior.

Fig. 3 showed the open porous cell structures with different cell sizes. The lighter part corresponded to the pore shape whereas the darker part was related to the interconnected pore.

B. Acoustic Analysis of Polymer Foam Composite

As refer to Fig. 4 (a), the higher the percentage of SL-B in the polymer foam, the higher the frequency absorption level (Hz). The shifted of frequency absorption level (Hz) is from 4000 Hz up to 4900 Hz for SL-B polymer foam composite with highest frequency absorption level contributed by the 20% SL-B loading in polymer matrix. Meanwhile, by referring to Fig. 4 (b), as the percentage loading of SL-A increases, the frequency absorption level (Hz) is shifted to lower frequency range from was 3500 to 3000 Hz of minimum SL-A loading at 10% and 15% (w/w%) only.

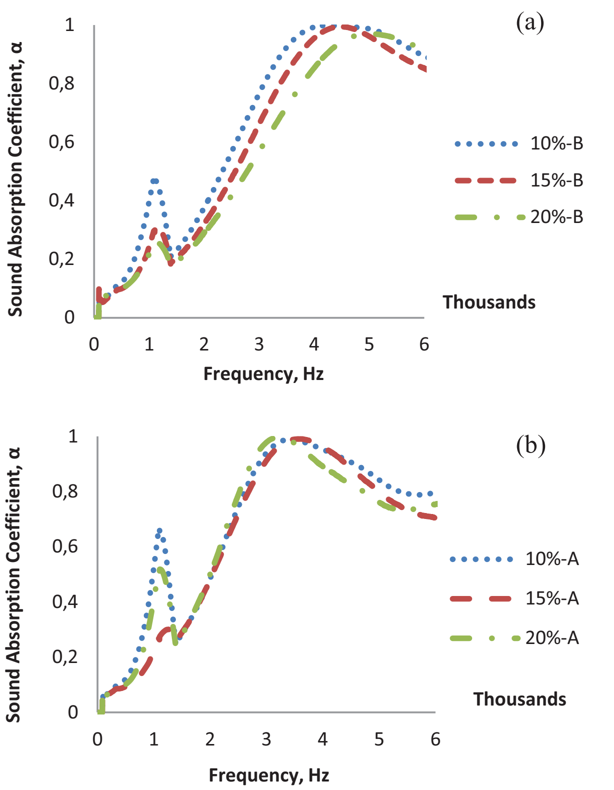
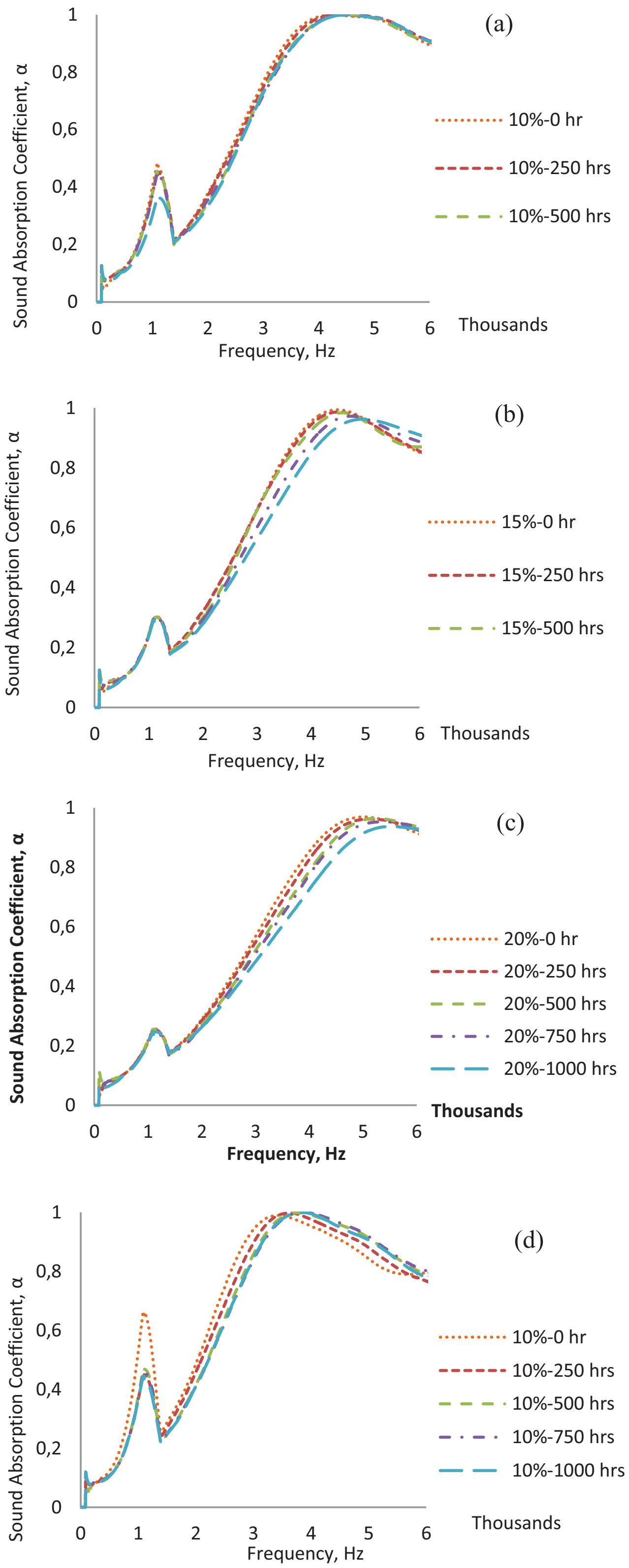


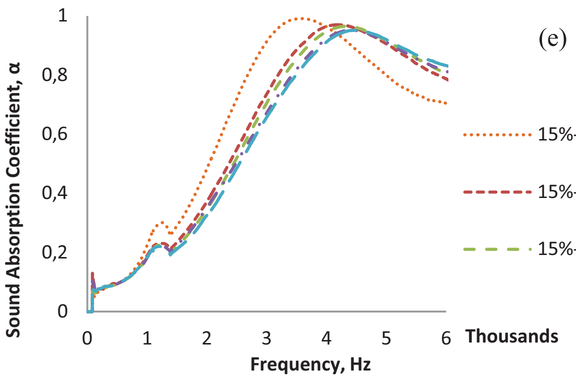
Fig. 4 Sound absorption coefficient of different conditions and ratio of the (a) SL-A and (b) SL-B polymer foam composites

The acoustic behavior of treated and untreated SL wood may be vary due to the changes of wood pores structure after acid treatment which affects the size of porosity. Chemical treatment facilitated the interaction between SL fillers-polymer. This leads to better dispersion and foam formation of polymer composites. The differences among the foams in sound absorption behavior can therefore be attributed to the effect of pore size [17].

C. Acoustic Analysis of SL-B and SL-A Polymer Foam Composite after UV Irradiation

Figs. 5 (a)-(f) show the SL polymer foam composite after UV irradiation from 0-1000 hours in UV-Weatherometer. Figs. 5 (a)-(c) represent SLB-Uv polymer foam composite meanwhile (d)-(f) represent SLA-Uv polymer foam composite with 10%, 15% and 20% (w/w%) of filler loading respectively of UV-irradiation up to 1000 hours. The frequency is shifted towards higher frequency absorption level (Hz) and slightly decreasing in sound absorption coefficient value. From past academic studies on the effect of the higher-energy UV radiation have shown that irradiation promotes chemical reaction in foam, some of which are detrimental to the foam structure [18]. This has proved that exposure to UV light gives minimal impact on the physical properties of the foam. The changes of pores cell structure after UV exposure has allowed the sound absorption to absorb at higher frequency.





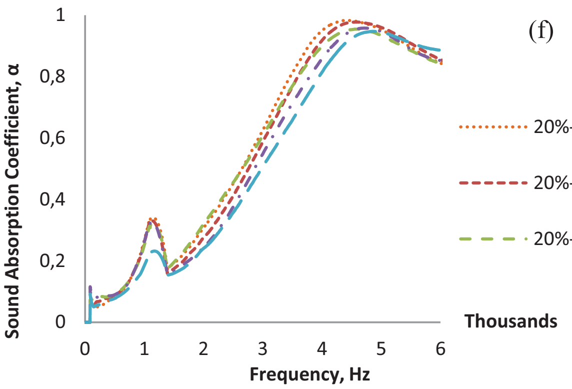


Fig. 5 Sound absorption coefficient of the ratio of the wood filler-polymer foam composites after UV irradiation; (a) 10% SLB-Uv, (b) 15% SLB-Uv and (c) 20% SLB-Uv; (d) 10% SLA-Uv, (e) 15% SLA-Uv and (f) 20% SLA-Uv

IV. Conclusions

The SL polymer foam composite were studied. Treated wood polymer foam composite shows uniform pore structure as compared to untreated. Both of untreated and treated wood gives different result in sound absorption coefficient at different frequency level. The wood polymer foam composite gives variety value of α which approaching to 1. This SL polymer composite shows high photo-stability of UV irradiation exposure which is suitable to be used or applied for cushion, sound-proof wall or building structure.

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