

Sound Absorption of Microporous Processable of Flexible Polyol and Biomonomer

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Abstract. Biopolymer foam was prepared based on vegetable oil and Polyol Flexible with commercial Polymethane Polyphenyl Isocyanate (Modified Polymeric-MDI) with different proportion ratio. This is to determine the acoustic property based on the influence of biomonomer (M) proportion ratio with processable flexible polyol (E). The acoustic property of biopolymer foam was examined by using an impedance tube test according to ASTM E-1050 of sound absorption coefficient (α). Based on the result obtained, the highest ratio of biomonomer to absorb sound is greater than processable flexible polyol namely as M₁₀₀ and E₁₀₀ respectively. The morphology study revealed that M₁₀₀ foam have lower cell sizes compared to other proportion ratio of M with E foams. The smallest averaged cell size is 871 μ m was obtained from M₁₀₀ with sound absorption coefficient (α) of 0.996 at 3796 Hz frequency level. As the conclusion, M its self gives highest α than the combination of both polyol as well as E which gives almost the same results as M but at lowest frequency level.

Introduction

Polymeric foams are important and versatile material due to their outstanding strength-to-weight ratio, resilience, electrical, thermal and acoustic insulating properties, among other characteristics. Polyurethane is one of the largest and most versatile families of polymer [1]. Some notable applications of this foam material include mattresses, upholstery, furniture, footwear and textiles in our homes and office, and as packing, appliances, electronics, machinery and foundry, and as cushioning material in automobiles and in the industries [2].

This is due to the excellence in being lightweight, strength to weight ratio performance, and most importantly, it offers a degree of comfort, protection, and utility not matched by other single material [3]. By proper choice of raw materials, additive and manufacturing technology, the properties of flexible polyurethane (PU) foam can be changed to satisfy desired application. Generally, the characteristic of flexible PU foam can be adjusting via the chemical composition of raw material, in particular polyol and isocyanate.

During the formation of flexible PU foam, polyol and isocyanate are mixed to form polyurethane linkage [3]. However, due to the fluctuation of oil prices, these petro-chemical feed stocks would rise in price and this in fact could influence the production cost of automotive seats [4]. Thus, this research of waste cooking oil conversion process into biomonomer (M) is important in producing biopolymer foam by reacting with different types of crosslinking agent.

Methodology

Raw Materials.

The raw materials for the formation of biopolymer foam: biomonomer based on vegetable waste cooking oil monomer [5-12], flexible isocyanate and Polyol flexible.

Foam Production.

Biomonomer based on waste cooking oil from Small Medium Entrepreneur (SME's) was prepared started with preparation of the catalyst [13-18]. Biomonomer (M) was mechanically mixed with flexible isocyanate for without 15 minute until it homogenous. The mixture was then added with flexible polyol (E) and stirred again for about 6 second to produce dwimatrix of polymer foam. The steps were repeated with six different percentage ratio of E and M as tabulated in Table 1 as show below.

Table 1. Percentage ratio of dwimatrix foam of biomonomer, M with flexible polyol, E

Dwimatrix Foam of M and E	Flexible polyol, E (%)	Biomonomer, M (%)	Flexible Isocyanate
E ₁₀₀	100	0	0.5
EM ₂₀	80	20	0.5
EM ₄₀	60	40	0.5
EM ₆₀	40	60	0.5
EM ₈₀	20	80	0.5
M ₁₀₀	0	100	0.5

Scanning Electron Microscope (SEM).

The top surface of laminated biopolymer foam samples were sputter coated with gold at 25 mA plasma current and 2 Pa of chamber pressure to make a conducting samples. Cellular structure images were examined by using SEM of JEOL-JSM6380LA operates at 15 kV at 30 µm magnifier under high vacuum.

Characterization Fabricated Biofoam.

The fabricated samples were prepared in 100 mm and 28 mm diameter and placed in front of the loudspeaker. The Impedance tube test according ASTM E1050 for horizontally mounted orientation sensitive materials for the frequency range of 100 - 6000 Hz were measured [11]. Impedance tube is used to test sound absorption of the samples at low frequency level by 100 mm sample diameter, while sound absorption at high frequency were determined by using 28 mm sample diameter.

Result and Discussion

SEM and Noise Reduction Coefficient (NRC) analysis of dwimatrix microporous foams; biomonomer, M with flexible polyol, E.

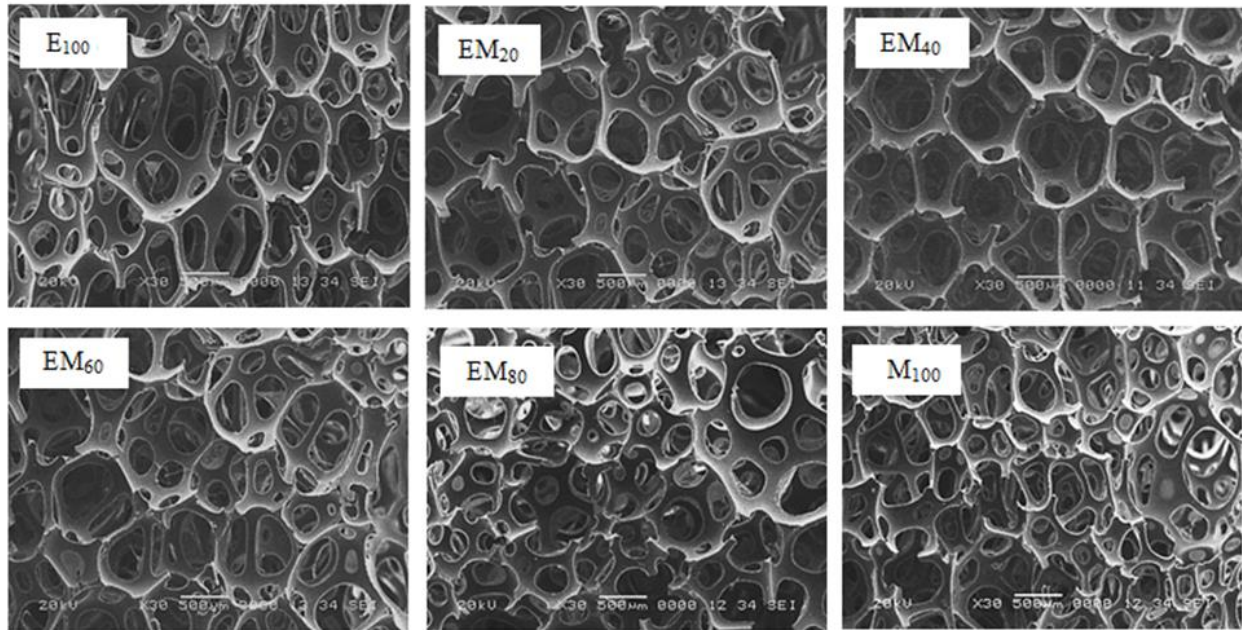


Fig. 1. SEM micrographs of dwimatrix foams; biomonomer, M with flexible polyol, E microporous foams were captured from the surface parallel to the foaming direction

The morphologies of these foam surfaces were investigated. The SEM images of the surfaces are referred to Fig. 1(E₁₀₀) - Fig. 1(M₁₀₀). Referring to the previous researchers, the biopolymer foams were found to have open-cells cellular-structures. The open-cells were formed from cells which contained many small open-windows located on its cell-wall whilst these open-windows formation caused the struts developed throughout the foam system [1-4], the morphology structure of Fig. 1(M₁₀₀) shows open cell which contained many small open-windows (interconnected pores) located on its cell-wall. These open-windows formation caused the struts developed throughout the foam system. This is because of the cell sizes were increase as percentage of flexible polyol, E decrease when it added into biomonomer, M. It was revealed that the mean cell size of M₁₀₀ is smaller than E₁₀₀. Furthermore, the higher the percentage of biomonomer, M influences the non-uniform formation in between the cellular structure of foams and the deceasing size of pore as shown as Fig. 1(E₁₀₀) - Fig. 1(M₁₀₀) [8-20]. These morphological structures will be studies to investigate the performed of sound absorption on samples.

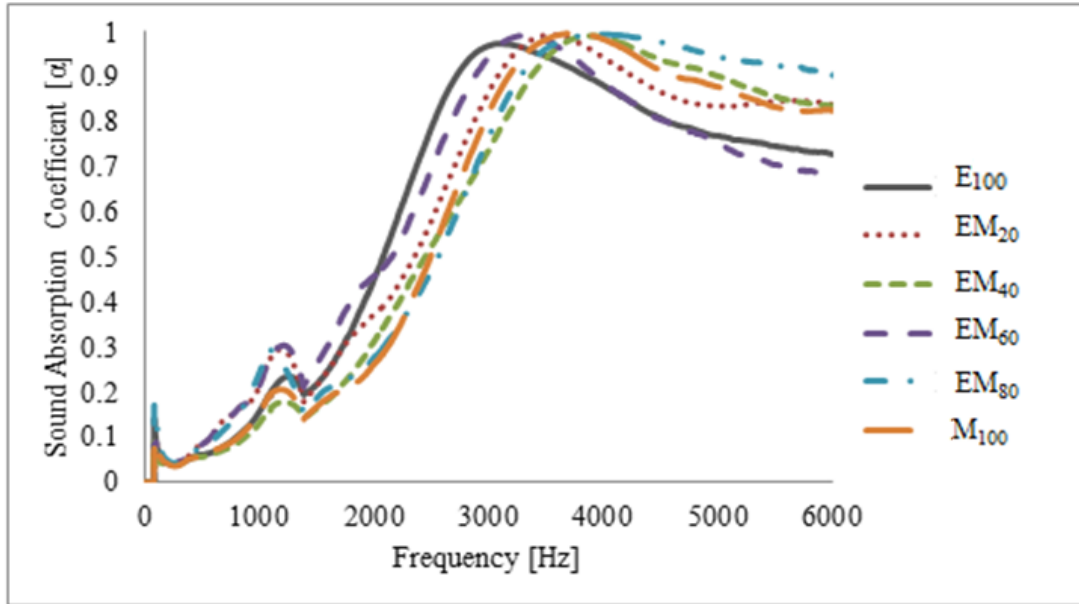


Fig. 2. Sound absorption coefficient $[\alpha]$ of dwimatrix microporous foams; biomonomer, M with flexible polyol, E

Table 2: Average value of sound absorption coefficient $[\alpha]$ versus frequency of dwimatrix microporous foams; biomonomer, M with flexible polyol, E

Frequency [Hz]	Sound Absorption Coefficient $[\alpha]$					
	E ₁₀₀	EM ₂₀	EM ₄₀	EM ₆₀	EM ₈₀	M ₁₀₀
250	0.096	0.089	0.067	0.089	0.150	0.089
500	0.137	0.184	0.112	0.184	0.211	0.134
1000	0.217	0.213	0.163	0.260	0.185	0.167
2000	0.846	0.640	0.566	0.756	0.525	0.571
3000	0.969	0.866	0.737	0.945	0.767	0.819
4000	0.881	0.944	0.984	0.889	0.994	0.988
5000	0.769	0.836	0.903	0.751	0.878	0.995
6000	0.723	0.839	0.837	0.686	0.826	0.904

The results were obtained based on the average value of sound absorption coefficient, α tested from 2 specimens for each percentage. The α value of foam increased in frequency range of 1000 - 4000 Hz when the percentage of M were increased. The result shows similar sound absorption curve as pure flexible polyol (E₁₀₀) microporous foam at the entire frequency range. Based on Fig. 2, M₁₀₀ show highest α of 0.996 at 3796 Hz frequency level. The tabulated average value of α is in Table 2 from low to high frequency of dwimatrix microporous foams; biomonomer, M with flexible polyol, E.

Fig. 3 shows below the Noise Reduction Coefficient (NRC) calculated using the average values of α according to the Eq. 1. The results showed the variations which occurs in NRC between different percentage of M and E. This is influences by the microporous foam sizes as well as cellular-structure which affects the acoustic properties of foams due to different ratio of M and E in dwimatrix polymer. Meanwhile, other characteristic such as porosity, air flow and viscosity [19] of microporous foam will

also influence the the finding. NRC or damping effect may increase by the factor of lower cell sizes and higher cell density [1,20].

$$\text{NRC, \%} = [(\alpha_{250} + \alpha_{500} + \alpha_{1000} + \alpha_{2000}) / 4] \times 100\% \quad (1)$$

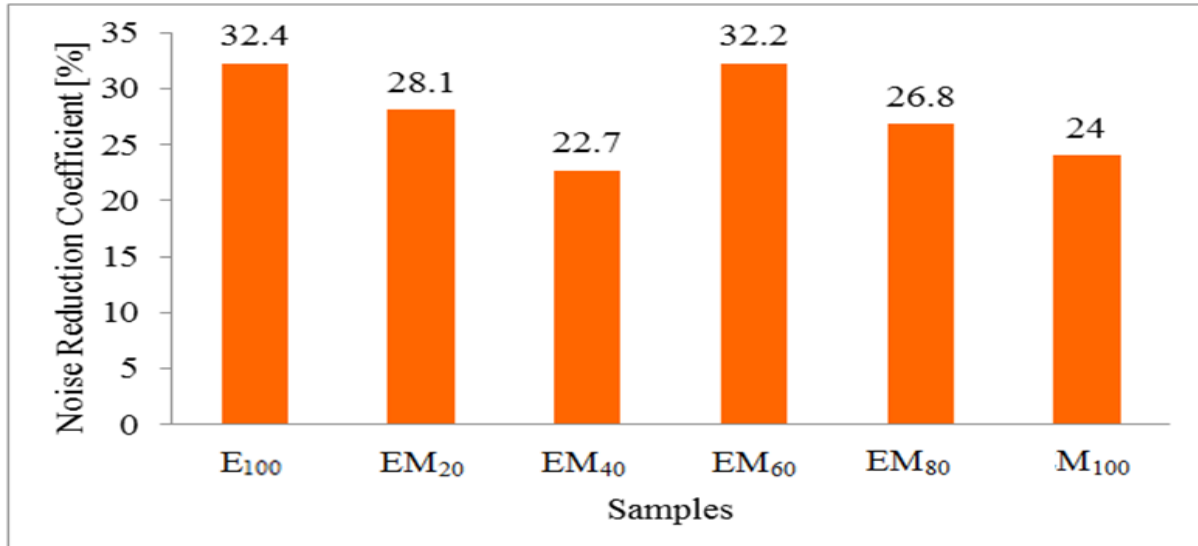


Fig. 3. Noise Reduction Coefficient (NRC) of dwimatrix microporous foams; biomonomer, M with flexible polyol, E

Conclusion

From the research, it was revealed that different proportion ratio of biomonomer, M with flexible polyol, E influences the formation of microporous foam, thus influences the characteristic of sound absorption with different frequency level of maximum absorption. The α of sample M₁₀₀ is 0.996 at frequency of 3796 Hz which smallest cellular pores that is 871 μ m which gives the effective sound absorption than other foam.

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