



AENSI Journals

Advances in Environmental Biology

Journal home page: <http://www.aensiweb.com/aeb.html>



Characterization and Mechanical Properties of Biomass Polyurethane

¹M.A.Nur Azni, ²A.A.Sinar, ³Z.Firuz and ⁴A.G. Supri

^{1,2,3,4}School of Materials Engineering, Universiti Malaysia Perlis, Kompleks Pusat Pengajian Jejawi 2, Taman Muhibah, 02600 Arau, Perlis, Malaysia.

ARTICLE INFO

Article history:

Received 11 September 2013

Received in revised form 21

November 2013

Accepted 25 November 2013

Available online 3 December 2013

Key words:

Polyurethane, turmeric, henna, free rise density, compression

ABSTRACT

In this work, turmeric (*Curcuma Longa*) and henna (*Lawsonia inermis*) has been used as filler to rigid polyurethane (PU) foam. Characterization and mechanical properties of biomass polyurethane has been investigated using free rise density and compression test. The percentages of fillers were varied from 2 to 10% by weight. PU foam was prepared by reaction of natural oil polyol and isocyanate with a ratio of 1 to 1.1 by weight. The mixture was stirred with 2000 rpm and was poured into the mould when mixture starting to expand. Free rise density (FRD) by stirring polyol and isocyanate in paper cup according to ASTM standard. FRD of foam will be increase when increasing filler loading. Mechanical properties of foams were evaluated using uniaxial compression test to determine compression strength of composites. Compression strength of PU/henna(H) shows the highest strength while PU/turmeric(T) is the lowest. PU/H have highest compression when filler loading increase to 6 percent and decrease with next formulation which is 8 and 10 percent due to agglomeration. Eventhough PU/T have low compression strength, the trend of compression strength is vary from PU/T which showing the optimum strength at 2 percent of filler loading.

© 2013 AENSI Publisher All rights reserved.

To Cite This Article: M.A.Nur Azni, A.A.Sinar, Z.Firuz and A.G. Supri., Characterization and Mechanical Properties of Biomass Polyurethane. *Adv. Environ. Biol.*, 7(12), 3696-3699, 2013

INTRODUCTION

Polyurethanes (PU) are versatile engineering materials which have wide range of applications because of their properties can be tailored for desired type and composition [1]. Polymeric foam has a polymer matrix with either air bubbles or air tunnels which is also known as closed-cell or open-cell structure. Closed-cell foams are normally more rigid, while open-cell foams are typically flexible [2]. Rigid polyurethane foams are synthesis from evaporation of a liquid that act as blowing agent which is added as a solution to one of the components. Alternatively, it is possible to use a gas with a boiling point well below room temperature. The gas is dissolved under pressure in one of the components and subsequently comes out of solution when the mixed components are depressurized [3]. Composites have attractive commercial properties such as low apparent density and good mechanical strength. The natural fibres and nanofibres were also used for the modification of polymer matrix. The results show that the addition of fibres increases composite's stiffness and strength [4].

Experimenta:

Material:

The material that had been used in this research is polyol and isocyanate from palm oil based that purchased from Maskimi Polyol Sdn. Bhd. Polyol that had been used containing amine catalysts, water and surfactant, which will react with isocyanate to form polyurethane. Filler that had been used are henna and turmeric. The formulation of PU foam composites is shown in Table 1 :

Table 1: Physical and chemical properties of polyol and isocyanate

Material	Polyol	Isocyanate
Physical	Yellow liquid	Dark brown liquid
Density (25°C)	1.10 ± 0.05 g/cm ³	1.24g/cm ³
Viscosity (25°C)	250 ± 50 cps	200 – 300 cps

Corresponding Author: M.A.Nur Azni, School of Materials Engineering, Universiti Malaysia Perlis, Kompleks Pusat Pengajian Jejawi 2, Taman Muhibah, 02600 Arau, Perlis, Malaysia.
E-mail: azni.azizan89@gmail.com

Water content	1.40 ± 0.02 % wt.	-
Solubility in water	Soluble in water	Not soluble in water

Filler Preparation:

The first step plant part was cut into small pieces. Plant part that had been cut was dried naturally under sunlight to remove the excessive water from cleaning process and removed water. The process continued by dry plant part in the oven at 60 °C for 1 day to remove excess water. The plant part was grinded using grinder and sieved with 63 micron siever.

Synthesis of PU/ Foam Composite:

Polyurethane/plant based foams were prepared by mixing filler with one monomer, which is polyol by a stirrer at 2000 rpm speed. Polyol and isocyanate ratio was 1 :1.1, while the percentages of plant based were varied from 2 to 10 percent. Excess isocyanate was used to assure the complete reaction of polyol. The mixture was pour into the mould and left for one hour in compress mould. The sample was heated in oven for two hour in 80°C temperature for post cure process. The composite that had been cured was cut with band saw with dimension 5cmx5cmx5cm for compression test. Formulation of polyurethane composites is given in Table 2 :

Table 2: Formulation of polyurethane composites and description

Material	Quantity	Description
Polyol and isocyanate	Ratio 1 :1.1	Polyol and isocyanate from palm oil based that purchased from Maskimi Polyol Sdn. Bhd.
Henna and turmeric	2 to 10 percent	The filler had been made by using 100 percent of natural source.

Testing Procedure:

FRD test had been done following ASTM D7487-08 for Polyurethane Foam Cup Test which covers the determination of cream time, fiber time, tack free time and rise time. Compression test had been done under ASTM D1621-10 for Compressive Properties of Rigid Cellular Plastics that describes a procedure for determining the compressive properties of rigid cellular materials, particularly expanded plastics.

RESULT AND DISCUSSION

The important part of foaming processing is the rapidity of foaming that influence condensed properties of the foam in a mould. Table 1 shows the foaming time properties of polyurethane composites foam at various properties. Foaming time of PU/H composites is higher than PU/T composites eventhough the composition is the same. From the foaming time, the increasing of filler loading will effecting the foaming time by slightly increasing the cream and fiber time but increase the tack free and rise time in wide gap. The different of foaming time had affected by dispersion of filler which means the reaction between filler and matrix will affecting foaming time. Addition of filler loading percentages can weigh up the viscosity of mixture, thus the slower the reaction between isocyanate and water which will decelerate the production of carbon dioxide gas [5].

Table 3: Foaming time of polyurethane composites

Percentage (%)	Cream Time (s)	Fiber Time (s)	Tack Free Time (s)	Rise Time (s)
Pu 0wt%	39	94	175	190
Pu/Turmeric 2wt%	40	97	190	210
Pu/Turmeric 4wt%	41	98	195	220
Pu/Turmeric 6wt%	41.5	100	200	230
Pu/Turmeric 8wt%	42	110	205	240
Pu/Turmeric 10wt%	42	115	210	250
Pu/Henna 2wt%	40	99	185	200
Pu/Henna 4wt%	41	110	225	240
Pu/Henna 6wt%	43	111	226	250
Pu/Henna 8wt%	45	113	229	260
Pu/Henna 10wt%	46	115	235	270

Core Density is important to determine the strength of the polymer foam. the addition of filler had increase the density of polymer composites. This is probably due to exfoliation of plant based filler into cell wall of polyurethane foam that causing the foam becoming more dense. As can be seen in Fig.1, core density of PU/T and PU/H increase when increasing filler loading but decrease when the composition reach its optimum filler loading. PU/H composites have higher core density comparing with PU/T which have optimum filler loading at 0.0586 g/cm³ at 6 percent of henna.

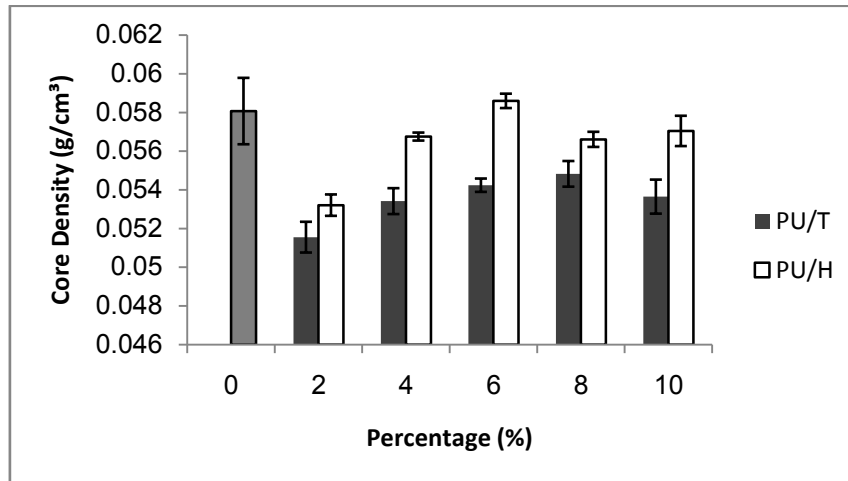
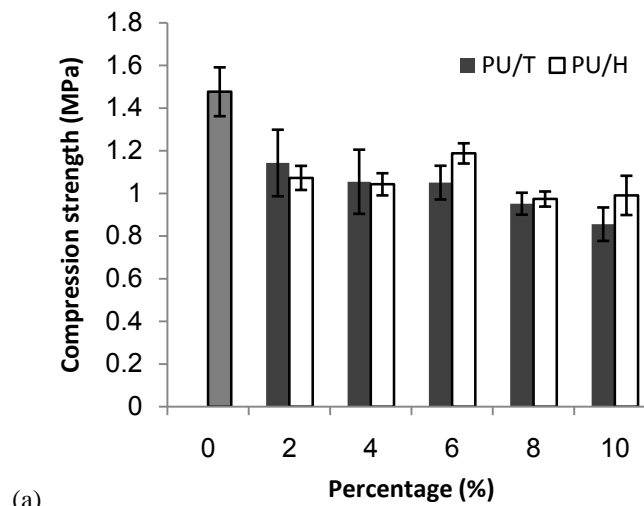
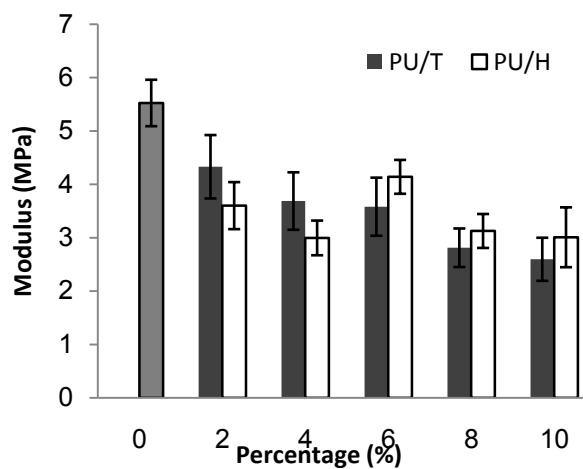


Fig. 1: Effect of filler loading to core density

In order to study the effect of filler loading to PU foam composites, PU foam composite with different filler loading was prepared and tested with compression test under ASTM D1621. Fig. 2 shows compression strength and modulus of PU/H and PU/T composites. Compression strength of PU/H exhibit higher compression strength and modulus if comparing to PU/T.



(a)



(b)

Fig. 2: Effect of filler loading to; (a) compression strength, (b) modulus of compression strength

Compression strength of PU decrease when increasing filler loading. For addition of turmeric filler, first formulation had decrease the compression strength from 1.477 MPa to 1.143 MPa and continue with decending value which were 1.055 MPa, 1.051 MPa, 0.952 MPa and 0.856 MPa. Modulus also exhibit decending value which mean proportional with compression strength. Compression strength for PU/H have different trend when comparing to PUT which were compression strength decrease to 1.073 MPa and 1.043 MPa at 2 and 4 percent filler loading but increase at 6 percent of filler loading. More addition of filler loading had make the composites tend to become crystalline and have low compression strength.

Conclusion:

Foaming time of PU/H composites is higher than PU/T composites eventhough the composition is the same. From the foaming time, the increasing of filler loading will effecting the foaming time by slightly increasing the cream and fiber time but increase the tack free and rise time in wide gap. density of PU/T and PU/H increase when increasing filler loading but decrease when the composition reach its optimum filler loading. PU/H composites have higher core density comparing with PU/T which have optimum filler loading at 0.0586 g/cm³ at 6 percent of henna. Compression strength for PU/H have different trend when comparing to PU/T which were compression strength decrease to 1.073 MPa and 1.043 MPa at 2 and 4 percent filler loading but increase at 6 percent of filler loading. More addition of filler loading had make the composites tend to become crystalline and have low compression strength.

ACKNOWLEDGEMENT

The authors would like to thank Ministry of Science, Technology and Innovation for financial support through Science Fund 9005-00055.

REFERENCE

- [1] Hakima, A.A., M. Nassara, A. Emamb and M. Sultan, 2011. Preparation and Characterization Of Rigid Polyurethane Foam Prepared from Sugar-Cane Bagasse Polyol. Faculty of Science, Suez Canal University, Egypt. Material Chemistry and physic, Elsevier.
- [2] Sivertsen, K., 2007. Polymers Foam: 3.063 Polymer Physics, pp: 1-17.
- [3] Eaves, D., 2010. Handbook of Polymer Foams, Smithers Rapra, pp: 69.
- [4] Kuranska, M., A. Prociak, 2012. Porous Polyurethane Composites with Natural Fbres, Department of Chemistry and Technology of Polymers, Cracow University of Technology, Poland.
- [5] Firuz, Z., A. Sahrim, R. Rozaidi and S.A. Syed Nuzul Fadzli, 2010. Preparation and Characterizations of Palm Oil Based Rigid Nanocomposite Polyurethane Foam. Materials Science Programme, School of Applied Physics, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Selangor.