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The Assistance of Surfactant to Alcohols in Reduction of Soy-Polyurethane's Water Absorbency

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Abstract- Polyurethane foam are obtained by using soy- polyols, TDI: MDI (80:20), and surfactant. Soy-polyol is made using a low molecular weight of alcohol; methanol and ethylene glycol. The responses of ethylene glycol and methanol to silicon surfactant has produces a unique polyurethane. With the ability minimized water absorbency. The goals of this study is to determine the optimal conditions of using of methanol and ethylene glycol in soy-polyol synthesis as based substance for polyurethane formula. From this work we found a relation between foam reduction absorption to its morphology and the voids occured, the shape of the surface of the foam, and the curing time of foaming. Optimal conditions of polyol synthesis is found at the ratio of epoxide/methanol is 1: 6 (mol/mol), and epoxide/Ethylene Glycol 1: 3 (mol/mol).

Keywords: Soy- polyurethane, surfactant, water absorbency

Introduction

Fears of supply of non-renewable natural resources has urged to using renewables material. Some research has explored and used various technological innovations as an effort to save environment [1]-[2].

Polyurethane has range of wide spectrum of polymer product from straight-chain polymers to thermosetting plastics. Structure and properties of polyurethane depends on density, hard and soft segments, and chemical compositions [3]. Previously synthesis of polyurethane were prepared from petroleum based-polyol. Due to the dwindling of oil supplies which affected to increasing prices and also increasing production cost [4]-[7], switching the raw materials into vegetable oil; a natural abundant resources and a promising material which can replace petroleum. Some advantages are having low toxicity, soluble, and high purity [8]-[10].

Unsaturated fatty acids in vegetable oil are plays an important role from the intermediates to final product. Fatty acid in soybean oil are constitute of palmitic acid 11%, stearic acid 4%, oleic acid 23%, linoleic acid 54%, and linolenic 8%. The combination of polyols, di isocyanate, and low molecular chain extender gives a multitude forms which suitable for extremely different practical applications [11]. Advantages possessed of using vegetable oils, because are easily to be reshaped and tailormade, which can be made according to market needs. Flexible properties owned by soft segmented with the percentages is higher than hard segment. It occured when ratio of polyol to isocyanate is greater than 1. Polyols will perform as soft segment while isocyanates forming hard segment.

The flexible foam can be made as necessary by adding a chain extender, polyol derived from a short chain polyhydroxy defined as low molecular hydrocarbons, if not using chain extenders it can be added polyhydroxy initiator [12]-[13].

Chain extender are generally low molecular weight of reactant which produces hard segment in polyurethane, this believed as the result from an increased intermolecular association or bonding induced. Based on the previous research the optimized oxirane number were 6.7% [14]. The optimized formulation were then implemented to the proceed steps.

This research were conducted an assessment of different polyurethane foam products synthesized from combinations of two low molecular weight alcohols; methanol is represented as monol, and ethylene glycol is represented as diol, where both type of alcohols are performed as chain extender in the syntesis with the assistance of surfactant. Furthermore, studied its value if as applied in a wet media, and whereas compared to polyurethane petroleum-based.

Experimental Procedures

Materials

Polyols were synthesized in a 500 ml three-neck flask which equipped with reflux condenser. Two samples of are prepared for intermediate products; a) 85 mL of epoxide using methanol and b) 45 mL of epoxide using ethylene glycol.

The reaction respectively are catalyzed by acid catalyst with the concentration of 1% v/v.

The reaction temperature are designated at 1170C. The products obtained then neutralized, decantated, and filtered. Polyurethane were made by mixing polyols, TDI: MDI (80:20), surfactants, and blowing agent; distilled water. The mixture is then poured into the glass mold.

Method of Analysis

- Numbers oxirane; specify a group of oxirane oxygen obtained from the titration using HBr in glacial acetic acid.
- Water absorbency test: a sample that has been made in certain dimensions, dropped into a container soaked in distilled water for 20 minutes, then weighed.
- Density test: the sample that had been prepared in a particular dimension were weighed using an analytical balance, and then calculate the volume of dimension.
- Curing time: the time of polyurethane passing cream time phase, it expands until reached a stable form, then after minutes is observed

In making use of two types of soy-polyols, the product occured from using methanol is referred as (P1) and using ethylene glycol (diol) is referred as (P2). Each (P1) and (P2) which then become as polyurethane (PU1) and (PU2).

Results and Discussion

Synthesis of Polyol

The optimized oxirane number of soy-epoxide were carried out as based oil which then used for proceed reaction for polyol synthesis. The synthesis were taken in two designated time of reaction; 1 hour and 2 hours. Overall this determination is to identify which of these two chain extenders, and surfactant at certain time reaction are resulted the best property of polyurethane products.

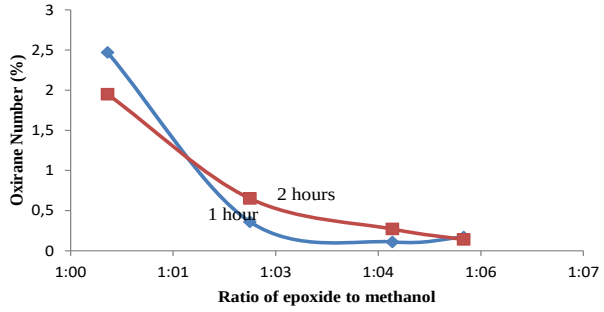


Fig.1. Soy-Polyol Occured Using Methanol

The expected oxirane number for polyol synthesis is the lowest among compositions. Each formula were conducted in triplo until it reached the stable average number. The best value of oxirane for methanol based were 0.14 mgr KOH/ gr at the ratio of epoxide/methanol 1:6 (mol/mol) at 2 hour reaction, as shown in fig. 1.

Polyol products will formed a reduction of oxirane numbers which increases active centers for polyurethane synthesis The alcohols perform as chain extenders, it also sources of OH's which can elevate hydroxyl value; polyols will have more hands to bind isocyanate ions (SCN-). The optimum condition for polyol synthesis using ethylene glycol, is the ratio of epoxide/ethylene glycol 1:3 (mol / mol), whereas the oxirane number was 0.079% with 2 hours which is shown in Fig. 2 .

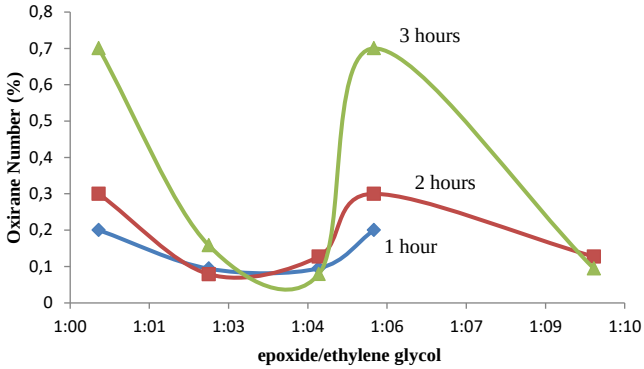


Fig. 2. Soy polyol Occured Using Ethylene Glycol

B. Curing time of polyurethane

The collaborative reaction of alcohols and surfactant bring out suitable condition, the outcome of foaming process of polyurethane product are read as curing time; is the phase of foam are perfectly developed, it may be takes a couple of minutes to being completely dried and safely to be appointed from the molding.

Evidently on this founding there is no significant differences of curing time of using methanol to ethylene glycol. Empirically proofed active sites of polyols ethylene glycol-based is larger than polyols methanol-based. As in average the curing time of methanol–based (P1) was 22.47 minutes, and ethylene glycol based (P2) was 20.9 minutes. This condition were considered to be as time efficiency in case it would realized to be manufacture in up-scaling or maybe in industrial scale.

The composition of unsaturated fatty acids accumulated in soybean triglycerides can affected to elasticity and foam deployment process. This research

finding were verified from previous study, with physical properties as can be seen in table 1.

Table 1. Characteristic of optimized polyol

Polyol Properties	Methanol	EG
Hdroxyl Number (mgr KOH/ gr)	578.9	308.5
Oxirane (%)	0.11	0.08
Viscosity (cps)	231.8	18.8
Functional	1	2
Colour	Pale Yellow	light brown

Source: (Firdaus, F.E, 2010)

Pore absorbency to water

These observations used polyurethane petroleum based as control. It was found the absorbency ability of polyurethane made from soy polyols is bigger than polyurethane petroleum-based. Overall pores of

Table 2. Water abosorbency

Type of sample	Foam Weight (gram)	Percentage of Absorbency	Averge of Percentage
The synthesis without Surfactant			
Methanol	0.68	91.44	86.75
	0.59	81.44	
	0.58	87.4	
	0.54	86.7	
EG	0.52	86.01	89.46
	0.45	89.52	
	0.49	85.52	
	0.65	96.8	
The synthesis with surfactant 1 % (v/v)			
Methanol	0.27	26.71	14.12
	0.27	0.03	
	0.3	9.23	
	0.31	20.5	
EG	0.29	27.19	18.42
	0.26	19.4	
	0.33	13.52	
	0.26	13.56	

polyurethane foam soy- based is more larger and visible than polyurethane petroleum-based. This can be the weaknesses. This problem can be solved and improved by silicone surfactant into polyurethane synthesis.

The inclusion of 1% (v/v) of silicone compared to without using silicone to polyol methanol based, are able lowering the foam absorbency to water 83% of reduction. As with ethylene glycol based is 79.4 % of reduction. With this method the foam ability to absorb water can be minimize. The cells percentages of absorbency are shown in Table 2. The absorbency of soy-based polyurethane if compared to petroleum based as shown in table 3.

Table 3. Characterization of Flexible Polyurethane

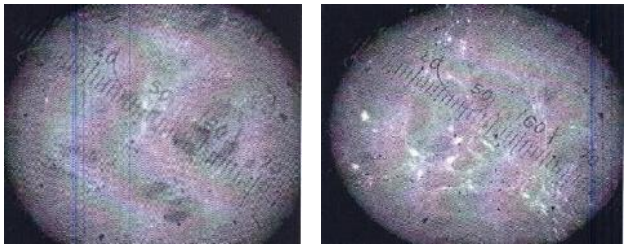
Observation	Polyurethane		
	Methanol	EG	Synthetic
[a]Water Absorbency (%)	86.76	98.46	14.54
Density (gr/cm3)	0.0992	0.1156	0.1295
Pore Diameter (ml)	7.8	5	0.2

[a] water absobency = $\frac{w0-wt}{w0}$ x 100%

w0: initial weight
wt: weight after soaked
Methanol (PU1); EG (PU2)

Polyurethane Surface Images

The polyurethane surface were characterized using Light Microscope with the magnification of three times. Visible cavities (void) generated by the surface of polyurethane (PU2) is much larger and comparable to polyurethane (PU1). This is not significant to density, whereas PU2 is greater than PU1, indicated the reaction were at the backbone of hydrocarbon which is in the bulk of the system.



Methanol Based (PU1) Ethylene Glycol Based (PU2)

Figure 3. Surface images of Polyurethane

Cell Morphology

The cellular were used to take images of cured solid polyurethane foams using SEM micrograph. Polyurethane (PU2) has slightly imperfect form compared to foams polyurethane (PU1).

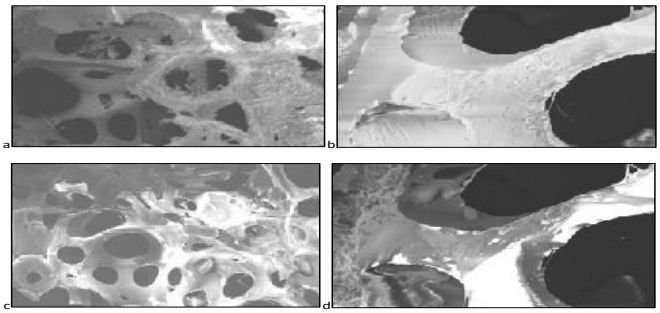


Figure 4. Cell Morphology of polyurethane; a. (PUR 2);40x 500µm b. (PUR 2): 170x 100 µm c. (PUR 1): 40x 500 µm and d. (PUR1): 170x 100µm

As visually can be seen the open cell of PU2 ethylene glycol-based the size of its open cell is larger than PU1 methanol- based. In PU1 the open cell is more narrower but great in numbers.

Conclusion

The soy-polyurethane if implemented in wet media still meet much weaknesses. The inclusion of silicone surfactant substances into the polyurethane formula can minimize water uptake. The responses of methanol based to silicone is much greater in reduction compared to ethylene glycol as obeying the properties desired.

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