The Role of Surfactant Inhibits Water Absorbency of Soy-Based Polyurethane

Flora Elvistia Firdaus

Abstract**—**Flexible polyurethane foam obtained from reaction of soybased polyol with TDI:MDI (80:20), and surfactant. The goal of this research is to determined the optimal conditions of using monol and diol chain extenders; Methanol and Ethylene Glycol; EG in polyurethane synthesis. The optimized of polyol were occurred by ratio of epoxide/methanol were 1:6 (mol / mol), and epoxide/ethylene Glycol 1:3 (mol / mol). It was found the absorbency ability of polyurethane made from soy polyols is bigger than polyurethane petroleum-based. This can be solved by Silicone inclusion into polyurethane formula.

Keywords**—**Soy polyurethane, surfactant, water absorbency.

I. 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. 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 [3]-[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 is constituted 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]-[12].

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 [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 [14].

Based on the previous research the optimized oxirane number were obtained in value of 6.7% [15]. The optimized formulation were then implemented on proceed steps. This research were conducted an assessment of different polyurethane foam products synthesized from combinations of two low molecular weight alcohols; methanol represented as monol, and ethylene glycol represented as diol with a surfactant inclusion. Furthermore, studied its value if as applied in a wet media, and whereas verified to polyurethane petroleum-based.

II. EXPERIMENTAL PROCEDURES

A. Materials

Polyols were synthesized in a 500 ml three-neck flask which equipped with reflux condenser. A 10 ml prepared sample categorize into two intermediate products; a) soy-epoxide to methanol and b) soy-epoxide to ethylene glycol. The reaction were catalized by acid catalysis with the concentration of catalyst 1% v/v. The reaction temperature was designated at 117^0C. The products obtained were 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.

B. 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

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In making use of two types of polyurethane polyols, namely the reaction of epoxides soybean with chain extender methanol (monol) is referred as (P1) and epoxide soybean with chain extender ethylene glycol (diol) is referred as (P2). Each (P1) and (P2) were optimized before being used as base for the manufacture of polyurethane named (PU1) and (PU2).

III. RESULTS AND DISCUSSION

A. Synthesis of Polyol

The optimized oxirane number of epoxide along with its optimum condition were carried out as based oil formulation which were used for theproceed based reaction. Polyol 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 will result the best characterization of polyurethane products.

The expected oxirane number in polyol synthesis is the lowest among other compositions, which were conducted in triplo in a stable average number. The oxirane were occured 0.14 mgr KOH/ gr at the ratio of methanol/ epoxide 1:6 (mol/mol) at 2 hour reaction and as shown in Fig. 1.

The role of chain extender as source of OH, so polyols will have more hands to bind isocyanate ions (SCN-). Polyol products will formed a reduction of oxirane numbers which increases active centers for polyurethane synthesis.

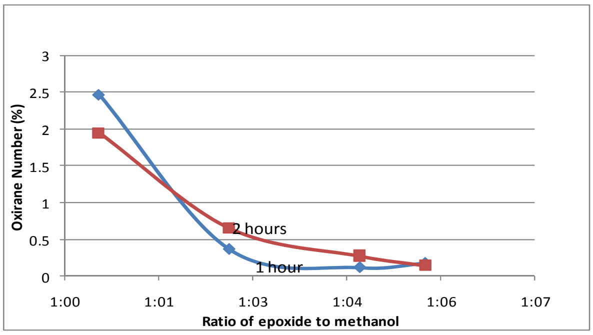


Fig. 1 Soy polyol with chain extender methanol

While the optimum synthesis conditions for the manufacture of polyols using ethylene glycol is at the ratio of epoxide/ ethylene glycol 1:3 (mol / mol), whereas the oxirane number was 0.079% by 2 hours which is shown in Fig. 2.

B. Curing Time of Polyurethane

Type of alcohols are suitable for the reaction which can affected to polyurethane curing time; is the phase of polyurethane which perfectly developed, it still takes a couple of minutes to being dried completely and safe to be appointed from the molding.

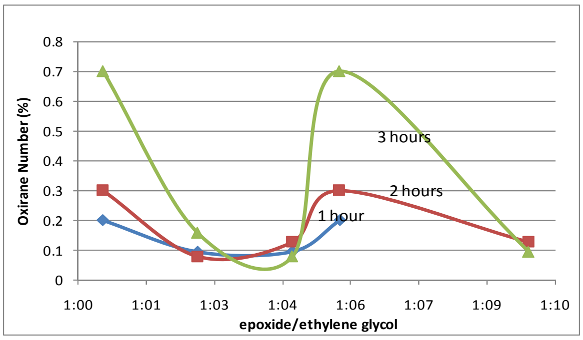


Fig. 2 Soy polyol with ethylene glycol

Evidently have found there are no significant differences of curing time between polyurethane using methanol to ethylene glycol. Empirically proofed active sites of polyols ethylene glycol-based are larger than polyols methanol-based. This condition was considered to be as time efficiency in case it would realized to be manufacture in up-scaling or maybe in industrial scale.

TABLE I
THE CURING TIME OF POLYURETHANE

No	Curing Time (minute)	
	Methanol (P1)	EG (P2)
1	22.3	20
2	20.1	20.2
3	23.15	21
4	22	21.1
5	23.3	21.35
6	23	21.4
7	23.5	21.3
Average	22.47	20.9

This research finding was verified from previous study, with physical properties as can be seen in Table II below [15].

TABLE II
CHARACTERISTIC OF OPTIMIZED POLYOL

Polyol Properties	Methanol	EG
Hidroxyl Number (mgr KOH/gr)	578.9	308.5
Oxirane (%)	0.11	0.08
Viscosity (cps)	23.8	18.8
Functional	1	2
Colour	Pale Yellow	Light Brown

Source: Firdaus (2010)

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

C. Pore Absorbency to Water

These observations using 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 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 inclusion into polyurethane synthesis, this method is much effected in lowering foam absorption ability to water. The pores are narrower inline with its open cells percentages as shown in Table III below.

TABLE III
WATER ABSORBENCY

Type of sample	Foam Weight (gram)	Percentage of Absorbency	Percentage of Average
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	

The absorbency of soy-based polyurethane if compared to petroleum based as shown in Table IV below.

TABLE IV
CHARACTERIZATION OF FLEXIBLE POLYURETHANE FOAM

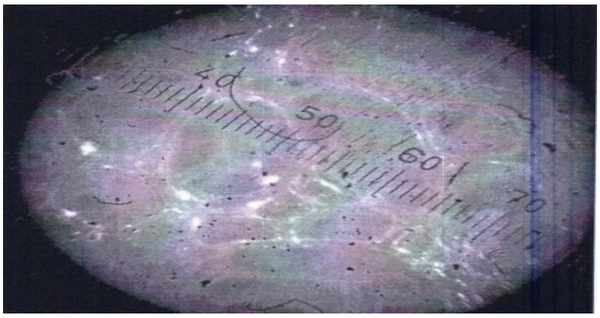
Observation	Polyurethane synthesized from		
	Methanol	EG	Synthetic
[a]Water Absorbency	86.76	98.46	14.54
Density (gr/cm3)	0.0992	0.1156	0.1295
Pore Diameter (ml)	7.8	5	0.2

[a] water absobency = $\frac{w0-wt}{w0}$ x 100%
w0: initial weight
wt: weight after soaked
Methanol (PU1); EG (PU2)

D. Surface images of polyurethane

Polyurethane surface characterization were using Light Microscope with magnification of 3 (three) times. Visible cavities (void) generated by the surface of polyurethane (PU2) which is larger and comparable to polyurethane (PU1). This is not significant to density, whereas PU2 is greater than PU1 this can be indicate the reaction were at the backbone of hydrocarbon which is in the bulk of the system.

Methanol (PU1)



Ethylene Glycol (PU2)

Fig. 3 Surface images of Polyurethane

F. Cell Morphology

SEM micrograph was used to take images of cured solid polyurethane foams. Polyurethane (PU2) synthesized using ethylene glycol, has slightly imperfect form of cell morphology compared to foams polyurethane (PU1).

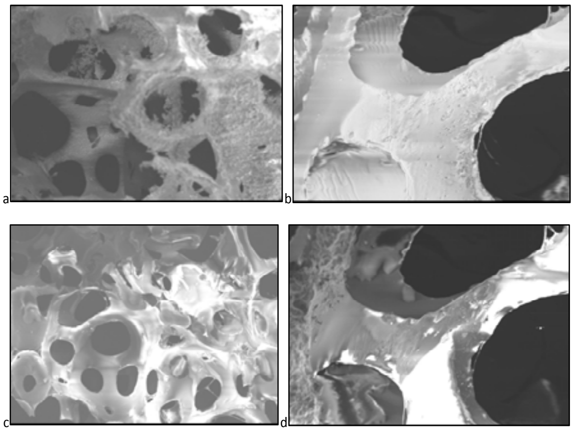


Fig. 4 Cell Morphology of polyurethane; a. (PUR 2);40x 500µm b. (PUR 2): 170x 100 µm c. (PUR 1): 40x 500 µm and d. (PUR1): 170x 100µm

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.

IV. CONCLUSION

It clearly proofed the polyurethane soy-based implemented in wet media still meet much weaknesses. Though inclusion of substances into reaction can improve properties. However this can be assignment to researchers to find methods to minimize the threat and let this material be accepted in a wide spectrum.

ACKNOWLEDGMENT

The author gratefully acknowledge the support of the Indonesia Department of higher education as funding the research

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