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✦ [Editorial Board Members](#)

✦ [Vol. 1 No.1 No.2 No.3](#) (2006)

✦ [Vol. 2 No.1 No.2 No.3 No.4](#) (2007)

- ✚ [Vol. 3 No.1 No.2 No.3 No.4 No.5 No.6 No.7 No.8 No.9 No.10 No.11 No.12 \(2008\)](#)
- ✚ [Vol. 4 No.1 No.2 No.3 No.4 No.5 No.6 No.7 No.8 No.9 No.10 No.11 No.12 \(2009\)](#)
- ✚ [Vol. 5 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21-22 23-24 \(2010\)](#)
- ✚ [Vol. 6 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23-24 \(2011\)](#)
- ✚ [Vol. 7 No.1 2 3 4 5 6 7 8 9 10 11 12 \(2012\)](#)
- ✚ [Vol. 8 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 \(2013\)](#)
- ✚ [Vol. 9 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 \(2014\)](#)
- ✚ [Vol.10 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 \(2015\)](#)
- ✚ [Vol.11 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 \(2016\)](#)
- ✚ [Vol.12 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 \(2017\)](#)
- ✚ [Vol.13 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 \(2018\)](#)
- ✚ [Vol.14 No.1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 \(2019\)](#)
- ✚ [Vol.15 No.1 2 3 4 5 6 7 8 9 10 11 12 \(2020\)](#)
- ✚ [Vol.16 No.1 No.2 No.3 No.4 No.5 No.6 No.7 No.8 No.9 \(2021\)](#)
- ✚ [Special Issues](#)
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[Journals](#) [Contact](#)

[Home](#)

International Journal of Applied Engineering Research (IJAER)

Volume 10, Number 18 (2015)

CONTENTS

[Image Compression, ECG Data Compression and Image Encryption by Binary versions of Discrete Cosine Transform, Haar Transform and Discrete Hartley Transform](#)

pp 38638-38642

P.Ramesh, B.I.Neelgar and B.M.S.Sreenivasa Rao

[An Optimal Weighted Fuzzy Rule Mining Classification On Multidimension Data Stream](#)

pp 38643-38651

P.Velvadivu and C.Duraisamy

[Intelligent Gesture Controlled Automation](#)

pp 38652-38656

Vishesh N Pamadi, Debashish S Sanyal and Gautam Reddy

[Intelligent Placement of Multiple DG's in Distribution Networks for Loss Reduction, Reliability and Voltage Improvement using IPSO](#)

pp 38657-38663

S. Jayalakshmi and V. Balaji

[A Low-Power Sensor Processor with a Approximation-based Fractional Wakeup Timer for Long-Term Sleep of Wearable Sensor Devices](#)

pp 38664-38670

Daejin Park and Jeonghun Cho

[Quality Management in Information System Development Units – An Empirical Study](#)

pp 38671-38678

Murugavel R

[A Novel Approach For Performance Testing On Web Application Services](#)

pp 38679-38683

B.Shyaamini and M.Senthilkumar

[Evaluation of Integrated Hyperbolic Tangent and Gaussian Kernels Functions for Medical Image Segmentation](#)

pp 38684-38689

Nookala.Venu and B.Anuradha

Speaker Identification and Spoken word Recognition in Noisy Environment

pp 38741-38745

Shaik Shafee and Prof. B.Anuradha

Experimental Investigation on Dynamic Characteristics of Unidirectional and Woven Glass Fiber Laminated Composite Plates With and Without Cut-Outs

pp 38746-38752

Manoharan. R

HVOF Spray Parameter Optimization to Obtain Maximum Hardness and Minimum Porosity in WC-Co-Cr Coatings on AISI 304 Stainless Steel

pp 38753-38765

M.S.Sampath Kumar, K.P.Arulshri and C.Thirumoorthy

A Critique on Authentic Materials for Effective ESP Materials Design

pp 38766-38768

A. Rajesh and SarikaTyagi

Network Route Optimization

pp 38769-38773

Anand Kumar and S. Thulasi Krishna

The Thickness and Firing Duration Dependence of Titanium Dioxide (TiO₂) Nanoparticle Against to the Output Power of Dye-sensitized Solar Cell (DSSC)

pp 38774-38777

Muslichin, Amiril Mu'minin, Adabina Husna Yuriz Fridasavema, Muhammad Aulia Rahman Sembiring, Cindy Mutiara Septani and Eka Maulana

Deployment and analysis of Fingerprint Data using cloud services

pp 38778-38784

Harneet Kaur, Sukhjot Singh Sehra and Sumeet Kaur Sehra

Low Power Datapath Architecture for ANN

pp 38785-38789

S N Prasad and S Y Kulkarni

Effects of perceived organizational support on job commitment for research engineer

pp 38790-38793

K. Y. Song and H. Lee

Digital Signed Mash up Security Framework

pp 38794-38797

L.Jibanpriya Devi, Shailendra Kumar Mishra, M.Kalaiarasan and Vijay Albert William

[Analysis on Main Parameters of Fire Service Deployment of 119 Recue Center Using Spatial Information](#)

pp 39024-39029

Ji-Soo Lee, Seung-Yeob Lee and Won-HwaHong

[Construction of a Simplified Software Defined Networking \(SDN\) Test-Bed](#)

pp 39030-39033

Sanjeev Rao Palamand and Shakthipriya P

[Comparison Research on the Characteristics of Architectural Plans per Change in Administrative Clients of Newly-Established Elementary Schools in Sejong City, Korea](#)

pp 39034-39043

Dong-hoon Chang and Jin-ju Jung

[Effects of Engagements of Parents of Disabled Children in Leisure Activities on their Sense of Depression](#)

pp 39044-39047

Gi-Sun Kim and Sung-Je Cho

[Optimization of Honda Algorithm for Rear End Collision Avoidance System with Particle Swarm Optimization](#)

pp 39048-39052

Manjunath K.G and N. Jaisankar

[A Characteristics through the Exterior Space of Mixed-Use Residential Tall Buildings](#)

pp 39053-39057

LeeYong Sung

[Design Optimization of a Pico Linear Permanent Magnet Generator with Novel Shaped Magnet for Wave Energy Conversion using Finite Element Analysis](#)

pp 39058-39065

Aamir Hussain Memon, Taib bin Ibrahim and Perumal Nallagowden

[Study on the Comparative Analysis of Criteria Conformity of Road Facilities and Inconvenience from Them for the Vulnerable and Non-vulnerable](#)

pp 39066-39070

Young-wooLee

[An Algorithm for deskewing a Document Image](#)

pp 39071-39073

Prof Akila Victor, Gurleen kaur brar and Sanyam Seth

[Analysis of the Usability of a Traffic Guide Robot on a Road Work Zone using AHP](#)

pp 39074-39077

Young-wooLee

[Cervical Cancer Detection through Automatic Segmentation and Classification of Pap smear Cells](#)

pp 39078-39084

Sajeena T A and Jereesh A S

[A study on the hierarchy in spatial configuration of outpatient department in general hospital through spatial distinction theory: Focusing on general hospitals located in Korea](#)

pp 39085-39090

Sangwon Oh, Heangwoo Lee and Yongseong Kim

[Graph Based Test Case Generation](#)

pp 39091-39100

V.Vani, G. S. Mahalakshmi and Betina Antony J

[A Study on the Algorithm for Building Envelope Design in accordance with Urban Data by Scattered Data Interpolation](#)

pp 39101-39104

Jinho Park and Woo-HyoungLee

[Boundary Detection in Medical Images Using Bonding Box Based Contour Method](#)

pp 39105-39108

B. Jyothi, Y. MadhaveeLatha and P. G. Krishna Mohan

[A Study on the Block unit architectural plan for Taepyeongdong Housing regeneration-focused on the original part of Seongnam city](#)

pp 39109-39114

Young Lee

[Development Of An Improved Scheduling Scheme For Multicast Traffic Delivery Over Wimax Networks](#)

pp 39115-39121

A.D. Usman, S.M. Sani and Aliu D

[Estimation of Construction Waste Amount Generated by Demolition of Deteriorated Singlefamily Housing](#)

pp 39122-39125

Seung-chan Baek, Young-chan Kim and Won-hwa Hong

[An Enhanced and Productive Technique for Privacy Preserving mining of](#)

Association rules from Horizontal Distributed Database

pp 39126-39130

Sreevidya. B

A Study on Changes of Slate Buildings' distribution in Korea using GIS -Case Study of Gang-won Province-

pp 39131-39137

Su-Young Kim, Young-Chan Kim, Byeung-Hun Son and Won-Hwa Hong

Current ISBN System – Learning & Practicing via Simulation

pp 39138-39144

A.AHMAD, M. A. K. RIZVI, N. MOHANAN and S. AHMAD

Community Space Reflected in Park Taewon's Novel, "Riverside Landscape" on Seoul

pp 39145-39149

Hae-yeon Yoo

Heap Sorting based Node Exchange and Detect Failure Node Recovery in wireless sensor Actor Networks

pp 39150-39156

C. A. Subasini and Chandra Sekar A

Cost Efficiency of Foreign Banks in India with Information Technology (IT) Investments- A Stochastic Frontier Approach (SFA)

pp 39157-39162

S. T. Surulivel, S. Selvabaskar, R.Alamelu and L. Cresenta Shakila Motha and R.Amudha

Availability Evaluation of Unmanned Aerial Vehicle for the Cadastral Confirmation Survey

pp 39163-39167

Joon-Kyu Park and Dae-Wook Park

Solution of Differential Equations by Three Semi-Analytical Techniques

pp 39168-39174

A. A. Opanuga, O. O. Agboola, H. I. Okagbue and J. G. Oghonyon

Application of the Coordinate Transformation for Cadastral Resurvey Project

pp 39175-39178

Joon-Kyu Park and Dae-Wook Park

Energy efficient distributed flooding time synchronization Protocol for Heterogeneous WSN's

pp 39179-39183

Harshjit Singh, Er.Parminder Singh and Er.Vikram Dhiman

[Application of Construction Management using Robotic Total Station and BIM Technology](#)

pp 39184-39187

Joon-Kyu Park and Dae-Wook Park

[The Assistance of Surfactant to Alcohols in Reduction of Soy-Polyurethane's Water Absorbency](#)

pp 39188-39191

F.E. Firdaus

[Availability Evaluation of the Smart Phone Application for the Topographic Surveying](#)

pp 39192-39195

Joon-Kyu Park and Dae-Wook Park

[Preparation and Characterization of Self-Compacting Concrete Containing Lime Stone powder](#)

pp 39196-39200

D. A. Najm, N. Begum and K. N. Ismail

[Time Series Analysis of Land Cover and Land Surface Temperature Change using Remote Sensing Method in Seoul](#)

pp 39201-39207

Joon-Kyu Park and Dae-Yong Um

[Comparison Of Case Based Reasoning And Support Vector Machines Algorithm](#)

pp 39208-39210

Ponni. J and Shunmuganathan. K. L

[Analysis of Change about Reclaimed Land using Landsat Satellite Images of Time Series](#)

pp 39211-39216

Jong-Sin Lee and Hee-Cheon Yun

[A New Chaotic Algorithm For Image Encryption And Decryption Of Digital Color Images](#)

pp 39217-39222

M. Surya Bhupal Rao and V.S. Giridhar Akula

[Analysis of Land Surface Temperature Corresponding to Biotop Index for Eco-friendly Urban Management](#)

pp 39223-39227

Jong-Sin Lee and Hee-Cheon Yun

[Review of Light Fidelity Technology for Wireless Communication](#)

pp 39228-39231

P. G. Kuppusamy, S. Kannan, S. Bharath Kumar and G. Arunraj

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 occurred, 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 occurred 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 occurred 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.

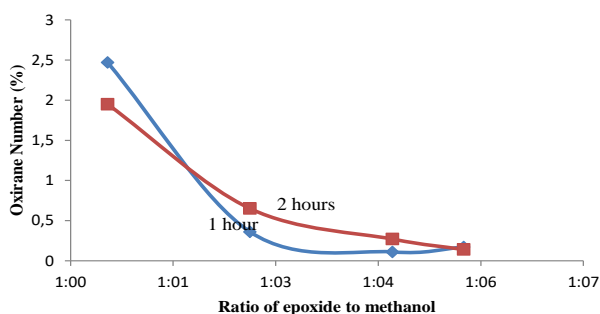


Fig.1. Soy-Polyol Occured Using Methanol

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 .

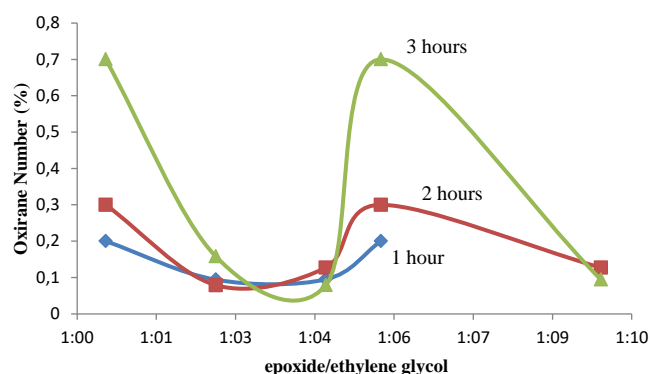


Fig. 2. Soy polyol Occured Using Ethylene Glycol

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	Average 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

$$^a \text{ water absorbency} = \frac{w_0 - w_t}{w_0} \times 100\%$$

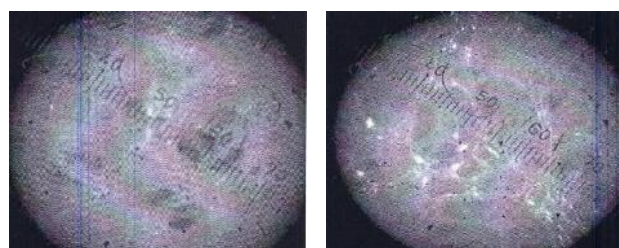
w₀: initial weight

w_t: 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).

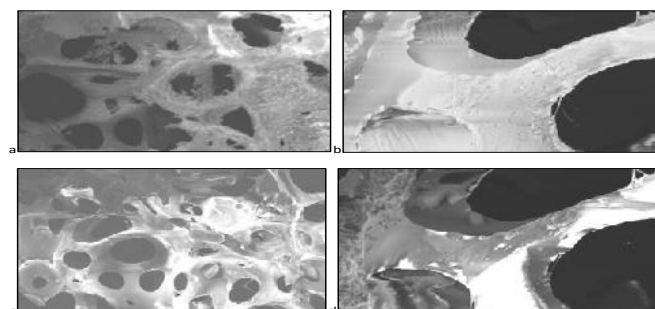


Figure 4. Cell Morphology of polyurethane; a. (PUR 2);40x 500µm b. (PUR 2): 170x 100 µm c. (PUR 1): 40x 500 µm and d. (PUR1): 170x 100µm

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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