IEOM

11th Annual International Conference on Industrial Engineering and Operations Managment

Singapore

March 7 - 11, 2021

Host University

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SINGAPORE UNIVERSITY
OF SOCIAL SCIENCES

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Welcome to the 11th Annual International Conference on Industrial Engineering and Operations Management, Singapore

To All Conference Attendees:

On behalf of the IEOM Society International, we would like to welcome you to the 11th Annual **International Conference on Industrial Engineering and Operations Management,** March 7-11, 2021. This unique international conference provides a forum for academics, researchers and practitioners from many industries to exchange ideas and share recent developments in the fields of industrial engineering and operations management. This diverse international event provides an opportunity to collaborate and advance the theory and practice of major trends in industrial engineering and operations management. There were more than 600 papers/abstracts submitted from 60 countries, and after a thorough peer review process, approximately 900 have been accepted. The program includes many cutting-edge topics of industrial engineering and operations management. The theme of the conference is "*Operational Excellence in the era of Industry 4.0*".

This conference will address many of the issues concerning continuous improvement for quality and service. Our keynote speakers will address some of these issues:

Dr. Mario Fargnoli, Technical Director, Italian Ministry of Agriculture and Contract Professor at Faculty of Civil and Industrial Engineering , Sapienza University of Rome, Italy

Dr. Hamid R. Parsaei, Professor, Dept. of Industrial and Systems Engineering, Texas A&M University, College Station, Texas, USA

Alex Teo, Vice President & Managing Director – South East Asia, Siemens Digital Industries Software, Singapore

Dr. Chung Piaw TEO, Provost's Chair Professor, Executive Director, Institute of Operations Research and Analytics (IORA), NUS Business School, National University of Singapore

Dr. Benny Tjahjono, Professor of Supply Chain Management, Sustainable Production & Consumption Research Cluster, Centre for Business in Society, Coventry University, UK

Dr. Lu ZHEN, Dean and Professor, School of Management, Shanghai University, Shanghai, China

Dr. Victoria Jordan, Vice President – Quality, Emory Healthcare, Atlanta, Georgia, USA

Dr. Koh Niak Wu, CEO and CTO, Cosmiqo International, Singapore

Dr. Ir. Wahyudi Sutopo, Professor, Dept. of Industrial Engineering and Vice Dean, Universitas Sebelas Maret, Surakarta, Indonesia

Dr. Ruth Banomyong, Professor and Dean, Thammasat Business School, Thammasat University, Thailand

Dr. Alessandro ROMAGNOLI, Associate Professor, School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore

Dr. Robert de Souza, Executive Director, The Logistics Institute – Asia Pacific (TLI – Asia Pacific), Singapore

Dr. Jenson Goh, Chief Information and Learning Officer, Monde Nissin Singapore Pte Ltd., Singapore

Dr. Hoong Chuin LAU, Professor of Information Systems and Director of the Fujitsu-SMU Urban Computing and Engineering Corporate Lab, Singapore Management University (SMU), Singapore

Dr. Murphy Choy, Director of Operations and Technology, SSON Analytics, Singapore

Dr. Noordin Mohd. Yusof, Professor, Department of Materials, Manufacturing and Industrial Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia (UTM), and Former Dean of Faculty of Mechanical Engineering at UTM, Malaysia

The 21st IEOM Society Global Engineering Education session will feature distinguished speakers who will discuss the workforce readiness and engineering education challenges and opportunities. The Industry 4.0 will showcase major topics including IoT, AI, data analytics, iCloud, cybersecurity, automation, digital manufacturing and MSV. Industry Solutions will showcase best industry practices as well as shared experiences. Six panel sessions have been planned. They are: Industry 4.0, Global Engineering Education, Supply Chain and Logistics, Lean Six Sigma, Women in Industry and Academia and Healthcare Improvement.

The IEOM Society would like to express our deep appreciation to our sponsors, university partners, organization partners, exhibitors, authors, reviewers, keynote speakers, panelists, track chairs, advisors, the local committee and the many volunteers who have given so much of their time and talent to make this unique international conference an overwhelming successful event.

SUSS, conference host, welcome all participants. The IEOM Society Conference Planning Committee hopes you will enjoy Singapore conference. Lastly, our sincere best wishes to you all for a successful conference.

Enjoy the conference!

Associate Professor Tan Yan Weng
CONFERENCE CHAIR
Head, Logistics and Supply Chain
Management Programme, School of Business
Singapore University of Social Sciences

Dr. Robert de Souza
HONORARY CHAIR
Executive Director / CEO
The Logistics Institute - Asia Pacific
Singapore

Dr. Ahad Ali
CONFERENCE CO-CHAIR
Associate Professor and Director of Industrial
Engineering Programs, Lawrence
Technological University, Southfield, MI, USA

Panel Speaker III

Panel Speaker IV

2:00 – 3:45 pm, MONDAY   Sustainable Manufacturing   Room 3

Session Chair: Christopher COX, Kimmel School of Construction Management, Western Carolina University, Cullowhee, NC, USA

ID 261   Comparing Concrete construction using Modular and Individual Panel System (IPS) methods
Ali Tighnavard Balasbaneh, Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, Parit Raja, Johor, Malaysia
Mohd Irwan Juki and David Yeoh, Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, Parit Raja, Johor, Malaysia

ID 299   Development of Performance Measurement Framework for Biomass Smokeless Charcoal Production
Pornthip Jaiinphon, Graduate Program in Logistics Engineering and Supply Chain Management, Industrial Engineering Department, Faculty of Engineering, Chiang Mai University, Chiang Mai, 50200, Thailand
Salinee Santiteerakul, Excellence Center in Logistics and Supply Chain Management, Industrial Engineering Department, Faculty of Engineering, Chiang Mai University, Chiang Mai, 50200, Thailand

ID 192   Do All the Green Manufacturing Adoption Drivers have the same Influence? (Survey Study of Indonesian Batik Textile SMEs)
Ira Setyaningsih, Wakhid Slamet Ciptono, Nurul Indarti, and Nofie Iman Vidya Kemal, Magister Doctoral Faculty of Bussiness, Universitas Gadjah Mada, Yogyakarta, Indonesia

ID 327   Fabrication of Soy-Based Polyurethane and Identification Failures from Processing Pathway
Flora Elvistia Firdaus, Donna Imelda, Lubena, and Rinnette Visca, Department of Chemical Engineering, Jayabaya University, Jl Pulomas Selatan Kav 23 Jakarta-13210, Indonesia

ID 328   The Manufacturing of Low Loading Phosporic Based Polyurethane Application from Edibles Epoxide Conversion
Flora Elvistia Firdaus*, Donna Imelda, Lubena,and Rinnette Visca, Department of Chemical Engineering, Jayabaya University, Jl Pulomas Selatan Kav 23 Jakarta-13210, Indonesia

ID 1065   Student Learning Interest in Covid-19 Pandemic Age by Blended E-Learning (Asynchronous and Synchronous)
Harlindah Harniati Arfan, STIE NOBEL Makassar, Indonesia
Geminastiti Sakkir, Universitas Negeri Makassar, Indonesia
Nungky Puspita, Universitas Pancasila, Indonesia
Zarina Akbar, Universitas Negeri Jakarta, Indonesia
Misnawati, Sekolah Tinggi Ilmu Hukum Pengayoman, Makassar, Indonesia
Asriadi, Yusriadi Yusriadi, Sekolah Tinggi Ilmu Administrasi Puangrimaggalatung, Makassar, Indonesia

ID 1043   Project Risk in the Age of AI: A Meta-network Assessment of Behavior Centric Intangible Risks
Christopher COX, Kimmel School of Construction Management (August 2021), Western Carolina University, Cullowhee, NC 28723, USA
Hamid PARSAEI, Wm Michael Barnes'64 Department of Industrial and Systems Engineering, Texas A&M University, College Station, TX, USA

2:00 – 3:45 pm, MONDAY   Operations Management   Room 4

Session Chair: Eneng Tita Tosida, Universitas Pakuan, Bogor, Indonesia

ID 684   Estimated Spline in Nonparametric Regression with a Generalized Cross Validation and Unbiased Risk Approach
Agustini Tripena and Agung Prabowo, Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Jenderal Soedirman, Indonesia
Yosita Lianawati, Sekolah Tinggi Ilmu Komputer Yos Sudarso, Purwokerto, Indonesia
Abdul Talib Bon, Department of Production and Operations, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia

ID 685   The Variant of Magic Square in Javanese Tradition
Agung Prabowo, Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Jenderal Soedirman, Indonesia
Hasriati, Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Riau, Indonesia
Sukono, Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Indonesia
Mustafa Mamat, Faculty of Informatics and Computing, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300, KualaTerengganu, Terengganu, Darul Iman, Malaysia
Abdul Talib Bon, Department of Production and Operations, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia

ID 732   Poverty Level Analysis in Indonesia Using the Stochastic Restricted Maximum Likelihood Approach Method
Riaman, Sudradjat Supian, and Sukono, Department of Mathematics, FMIPA, Padjadjaran University, Jatinangor 40363, Indonesia
Abdul Talib Bon, Department of Production and Operations, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia

ID 735   Increasing Labor Insurance Participation with the Agency System
Fredi Andria, Salmah, and Mirna Rahayu, Department of Management, Faculty of Economics Pakuan University, Bogor Indonesia
Abdul Talib Bon, Department of Production and Operations, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia
Abdul Talib Bon, Department of Production and Operations, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia

ID 755   Financial Distress Analysis Using Altman (Z-Score), Springate (S-Score), Zmijewski (X-Score), and Grover (G-Score) Models in the Tourism, Hospitality and Restaurant Subsectors Listed on the Indonesia Stock Exchange Period 2015-2019

Fabrication of Seed Oil-Based Flexible Polyurethane and Identify Failures from the Processing Pathway

Flora Elvistia Firdaus*, Donna Imelda, Lubena, Rinette Visca
Department of Chemical Engineering, Jayabaya University
Jl. Pulomas Selatan Kav 23 Jakarta-13210, Indonesia
flora_elvistia@yahoo.com
deimelda18@gmail.com, lubena2013@gmail.com, viscairsyad96@gmail.com

Abstract

The preparation of polyurethane (PU) foam using green-based polyol from soybean oil as an alternative for petroleum-based polyurethane. The polyurethane was fabricated by using the prepolymer method following the two steps namely epoxidation and alcoholysis reaction. The FTIR, hydroxyl numbers were used to monitor the process of the synthesized polyol and determined the physicochemical properties. Choosing a suitable method for the processing of polyurethane foam soy-based became a major to the success of the production. Temperatures of operation, reactants, were not the only to be focuses dealing with organics the length of the reaction should also be considered. The research aimed to focus on the optimized fabrication of soy-polyol as intermediate to flexible foam polyurethane. Identify the use of the length of reaction to epoxidation reaction, and hydroxylation, and evaluates the correlation to the physical property of the foam product.

Keywords
Fabrication, flexible polyurethane foam, length of the reaction, foam physical property, soybean oil

1.Introduction
Polyurethane (PU) production from bio-based feedstock is being pursued to increase the renewable material fraction in foams. PU globally is consumed in the form of foams (Ionescu, 2016). Isocyanates and polyols are petroleum feedstocks as two major components in polyurethane (PU) production. The amount of isocyanate is greatly affected to the PU foams' performances (Javni, Zhang, & Petrović, 2003);(Pechar et al., 2006);(Guo, Javni, & Petrovic, 2000), include compressive strength. Altering the amount of isocyanate in the foam formula the mechanical property could be modified, where the excess of isocyanate results in more rigid PU foams because of a more complete conversion of OH groups in polyols.

2.Literature Review
The side reactions that occur during the polyurethane production may have intense effects on the final properties, the products were temperature-dependent equilibrium with reactants (Lee, 1985).

Isocyanate groups like TDI and TEA taking part in the growth of particles, where free isocyanates react with the hydroxyl functionality of polyol. The reaction was not closely controlled so it results in an undesirable property. The presence of secondary hydroxyl end groups in big amount in polyol medium unstabilized particle and emerge large size distribution. The idea of using seed oils in the formula provides an intrinsic hydroxyl functionality which suited to cost-competitive feedstocks (Firdaus, 2016).

The reactiveness of isocyanates relatively slow with hydroxyl at room temperature, this was reflected in the incompatibility of nonpolar to denser isocyanate and polar to less dense polyol of hydroxyl even though a surfactant and catalysts were applied.

The tertiary amine (R_3N) as catalyst drives reactions other than urethane formation (Tillet, Boutevin, & Ameduri, 2011);(Van Maris, Tamano, Yoshimura, & Gay, 2005), where the catalytic activity forming urethane bonds were

commonly known as gelling reaction tied in the rapid growth of molecular weight and increased viscoelasticity. The activity of isocyanates catalyzation and water resulted in a blow reaction to the formation of carbon dioxide as a result of blow reaction and forming a frothed morphologies (Sonnenschein, 2014);(Firdaus, 2011a).

The R_3N catalyst reacted with hydroxyl and isocyanates, the presence of water drives the blow reaction where it has higher efficiency than the gelling reaction. Referred to some research findings, there was a heat formation the value depends on the type of alcohol and isocyanate structure (Wang, Wang, He, Mao, & Sun, 2013).

At elevated temperature, the urethane bond can revert to isocyanate and hydroxyl functionality (Okrasa, Czech, Boiteux, Méchin, & Ulanski, 2008);(Mohammed & Sankar, 2011);(Yang, Zhu, Li, Xia, & Li, 2010), where the revert occurred as a function of the urethane structure stability (Firdaus, 2011b). The structure contributes to urethane thermal stability. The aliphatics are more thermally stable than aromatics, where delocalization of aromatics stabilizes the activated states of reversion results. It was found the urethanes synthesized from aromatic alcohols exhibit low thermal stability. Phenol somewhat often considered as aromatic alcohols where more acidic than aliphatic alcohols, has been widely used for protecting isocyanates to be available at elevated temperatures (>100 °C) (Kothandaraman, Nasar, & Lakshmi, 1994);(Wicks & Wicks, 1999).

The formation of urethane in the absence of a change in stoichiometry upon cooling exceedingly unaffected to the change of overall molecular weight (Koberstein, Gancarz, & Clarke, 1986). As the nucleophilicity increased it influenced the reactivity of an active hydrogen compound. It is well understood steric factor affected the reactivity of the isocyanate structure in NCO, where the electrophilic attack increased the negative charge density of the isocyanate oxygen which increased reactivity (Figure 1).
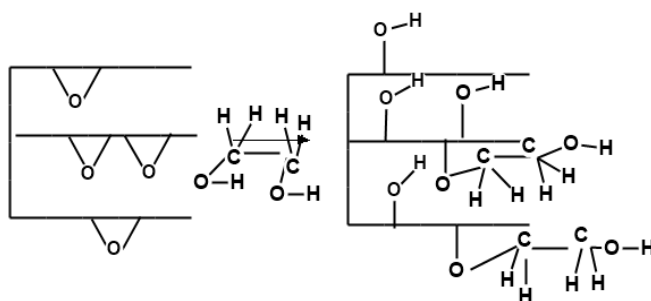

Figure 1. Scheme of Polyol using 1,2 ethanediol

Based on the reference above, it was stated the success of the polyurethane production was generally affected by temperature, the reaction endurance during the process was abiding. The research aimed to focus on the optimized fabrication of soy-polyol as intermediate to flexible foam polyurethane. Identify the use of the length of reaction to epoxidation reaction, and hydroxylation, and evaluates the correlation to the physical property of the foam product.

3.Methods

The soybean oil was purchased from the local store commonly known as cooking oil. It was produced by Sione Darby Singapore. The epoxide and polyol were synthesized in stoichiometry calculation. The epoxidation reaction was done by using peracetic (acetic acid and peroxide acid) to modify the unsaturated C=C triglycerides of soybean oil. The ratio of CH_3COOH/ H_2O_2 was done 1:4; 1:5.4; 1:6, 1.6.1; 1:6.4; 1:6.9; and 1:7.1 (mol/mol) with temperature 60°C using hot plate. The oxirane number was determined. The next step was preparing for a hydroxylation reaction of soy epoxide. It was done by using soy epoxide and 1,2 and ethanediol with the ratio of 1:3, 1:5; and 1:10 (%, v/v). The oxirane number and hydroxyl value were determined. The experiments were carried out in a 500 mL three-necked, round-bottomed flask equipped with a thermometer and a mechanical stirrer. The whole apparatus was placed in a water bath to maintain a temperature of 110°C ± 5°C (Arniza et al., 2015).

3.1 Characterization of the product
- The acid number was used for quality control to ensure uniformity, it was also used as a correction factor for the true hydroxyl number. The reagents used were ethanol, toluene dry, and Phenolphthalein. The titrant concentration

used was KOH = 0.1 mol/L dissolved in alcohol either ethanol or methanol with a concentration of 50% (v/v), then have it neutralized previous the addition of 0.3 mL phenolphthalein/100 mL and KOH.

$$Ac_N = \frac{C_F\,[KOH]\,V_T\,M_{W\ KOH}}{S} \qquad\qquad (1)$$

Where

Ac_N	: acid number (mg KOH/ g)
V_T	: titrant (mL) for first endpoint
C_F	: correction factor
$M_{W\ KOH}$	: 56.11 (g/mol)
S	: sample (g)

- The hydroxyl value directly correlates to the number of polyols it was an important characterization according to ASTM E1899. The hydroxyl value was given in mg KOH per g sample to know the degree of esterification of the sample. 60 mL deionized water is added to approximately 180 mg Potassium hydrogen phthalate (KHP). The mixture was then stirred for about one minute to let the KHP dissolved, titrated until it reached the first equivalence point using Tetrabutylammonium hydroxide (TBAOH) as [TBAOH] = 0.1 mol/L. An appropriate amount of was weighed dissolved in 10 mL acetonitrile, the mixture solution stirred with the rate 8 for 30 seconds, 10.0 mL Toluene-4-sulfonyl-isocyanate (TSI) were added and covered, stirred with the rate 4. Then 0.5 mL deionized water was added, closed again, and stirred with a rate of 4 for another 60 seconds. The solution 40 mL acetonitrile was added and then titrated until outreached the second endpoint with [TBAOH] = 0.1 mol/L.

$$Ms = \frac{40}{OHV_{expected}} \qquad\qquad (2)$$

Where

Ms	: sample size in g
OHV	: expected hydroxyl value

- FTIR measurements were aimed to characterized organic compounds both qualitative and quantitative. There were two characteristic absorptions of the oxirane ring in the range between 4000 cm⁻¹ and 400 cm⁻¹. The first one, at 915 cm⁻¹, was attributed to the C-O deformation of the oxirane group.

4. Result and Discussion

Production of soy epoxide, it was found that the ratio of CH_3COOH / H_2O_2 1: 6.4 (mol/mol) was the best, as evidenced by the highest oxirane number was 6.8, exceeding the previous average value of oxirane in the range 4.5-5.6 mg KOH/g (Figure 2).
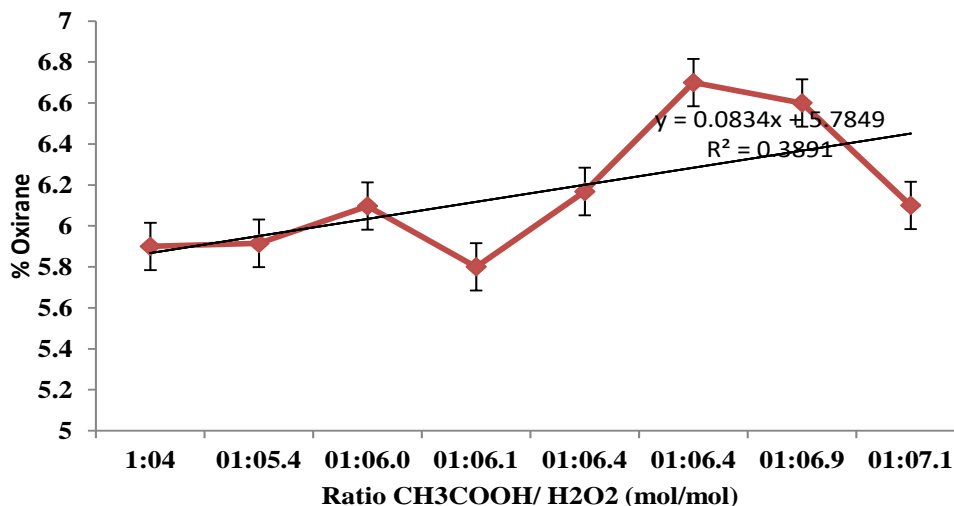

Figure 2. The optimized of Soy-epoxide with the length of reaction 90 minutes
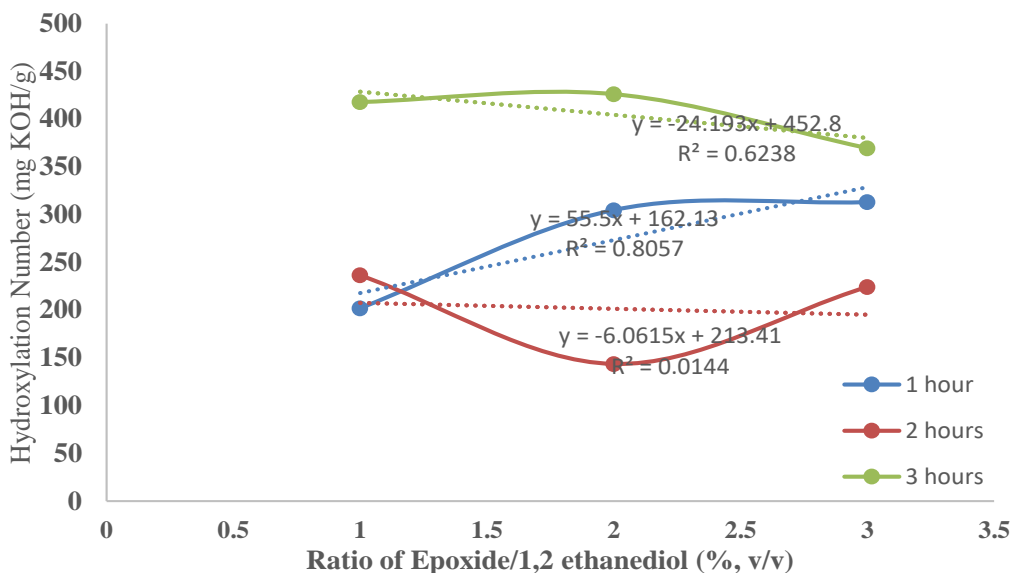
Figure 3. The optimized of soy-polyol

The duration of the reaction will lead to better results (Firdaus, 2014). For the manufacture of polyols, it can be seen that the reaction time of three hours was the best, where the hydroxyl numbers were the highest compared to one and two hours (Figure 3).
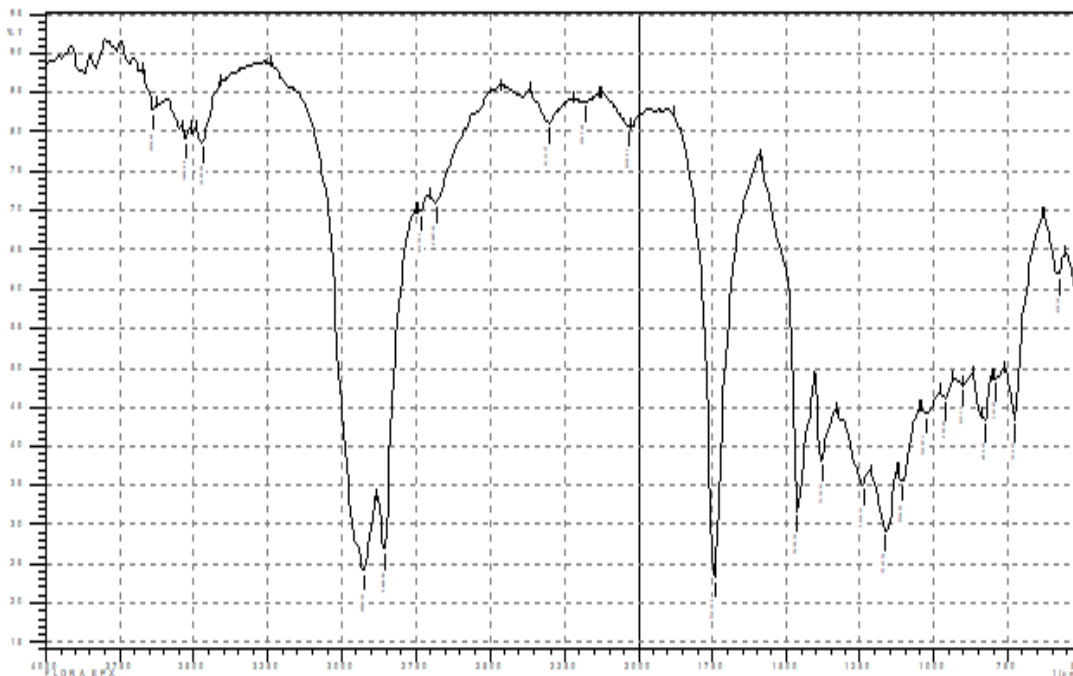

Figure 4. FTIR images of Soy epoxide

Indeed it was proven by the R^2 value. The FTIR spectrum of soybean epoxides was shown by the loss of epoxy groups at 825 cm⁻¹, 845 cm⁻¹ and the appearance of hydroxyl groups at 3450 cm⁻¹ was clear from soy-based polyols showing a characteristic signal at 1050 cm⁻¹ indicating the presence of ester groups (Firdaus, 2011b).
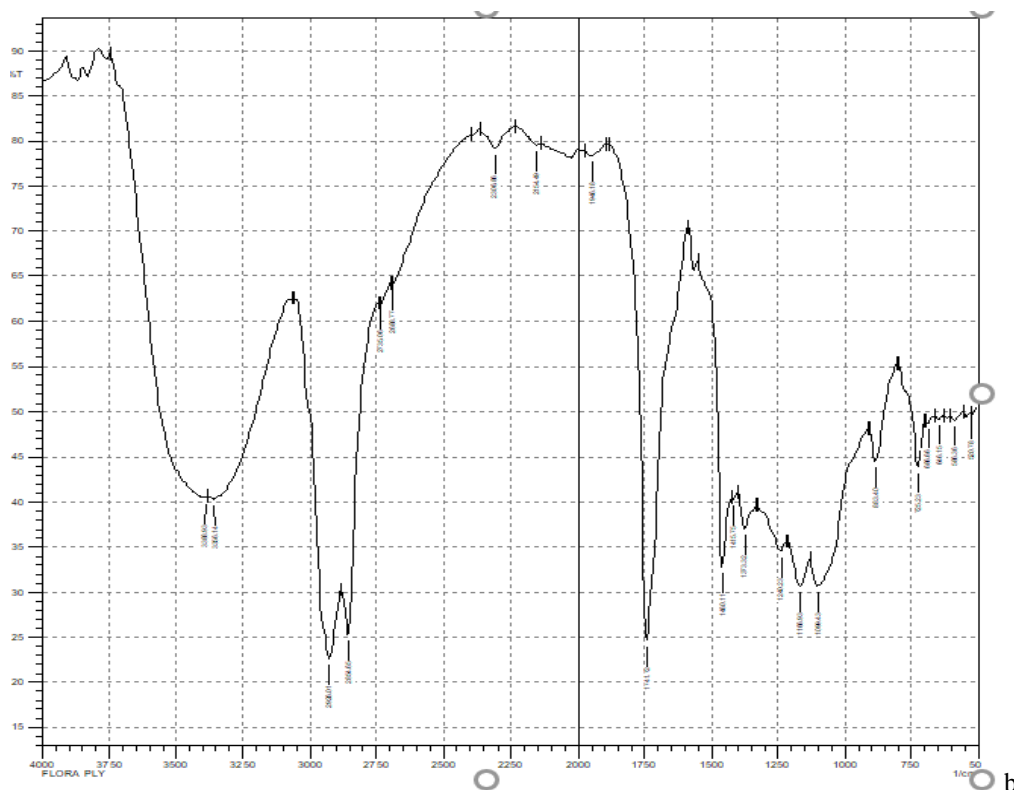
Figure 5. FTIR images of Soy -Polyol

In making polyurethane using the prepolymer method. The mixture of peracetic acid reagent (CH_3COOH with H_2O) was intended to oxidize the unsaturated C = C bond in soybean oil triglyceride, namely the ratio of CH_3COOH and H_2O_2: 1 / 5.962; 1 / 6.219; 1 / 7.25; 1 / 7.255; and 1: 7.8 (mol/mol). The temperature applied was 55 ^{0}C, and 60^{0}C, the length of the reaction was 90; 120; 150; and 180 minutes (Figure 4) and (Figure 5).
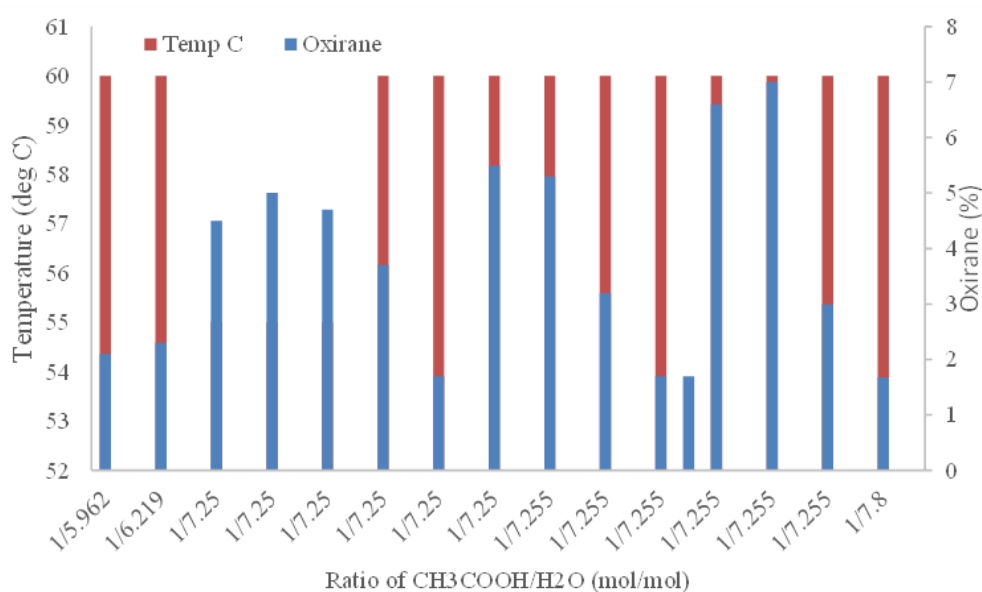

Figure 6. The Effect of temperature and ratio of peracetic to the oxirane number

Each formula was made in Duplo form. At a ratio of 1/7.25 (mol/mol), the reaction time of 150 minutes and with an operating temperature of 60 ^{0}C has resulted in an oxirane number of 5.5%. If applied the same ratio and reduce the reaction time to 120 minutes, the oxirane number obtained was also low were 1.7%. If the temperature was lowered to 55 ^{0}C with the reaction time was 150 minutes, the resulting oxirane number slightly improved to 4.7% if the time above was shortened to 90 minutes, the oxirane number increased if the time reaction was increased to 120 minutes (Figure 6).

From the above results, it can be concluded the epoxidation was considered to affect the oxirane number, in other words, the completion of the reaction depended on the length of the reaction which has to modify the unsaturated C=C. This was adjusted to the composition of the C = C double bond present in the soybean oil triglycerides. The temperature and the reactants were not the only points to be considered, but the length of the reaction also become major to the success of the process. The increased peracetic ratio to 1/7.8 with the operating temperature at 60 ^{0}C where the time was also extended to 180 minutes, this does not make the oxirane number increased. The best provisional conclusion was 150 minutes and an operating temperature of 60^{0}C with a ratio of peracetic was 1/7.25. But the resulting acid number was 8.9 which was still quite high. Likewise, at 1/7.25 with the temperature was 60^{0}C and the reaction time was 150 minutes the acid number was 7.8, the same thing also happened to the ratio of 1/7.8 at 60 ^{0}C and the reaction time was 180 minutes acid number was 8.9. These high acid numbers can be done by neutralization using distilled water until the acid number range (AN) was obtained $0 \leq AN \leq 1$. Based on laboratory work the twice neutralization was sufficient in reducing the acid number to within the threshold. Overall, the percentage of water in the epoxide was quite small in the range of 0.0004 to 0.46 (%) (Figure 7).
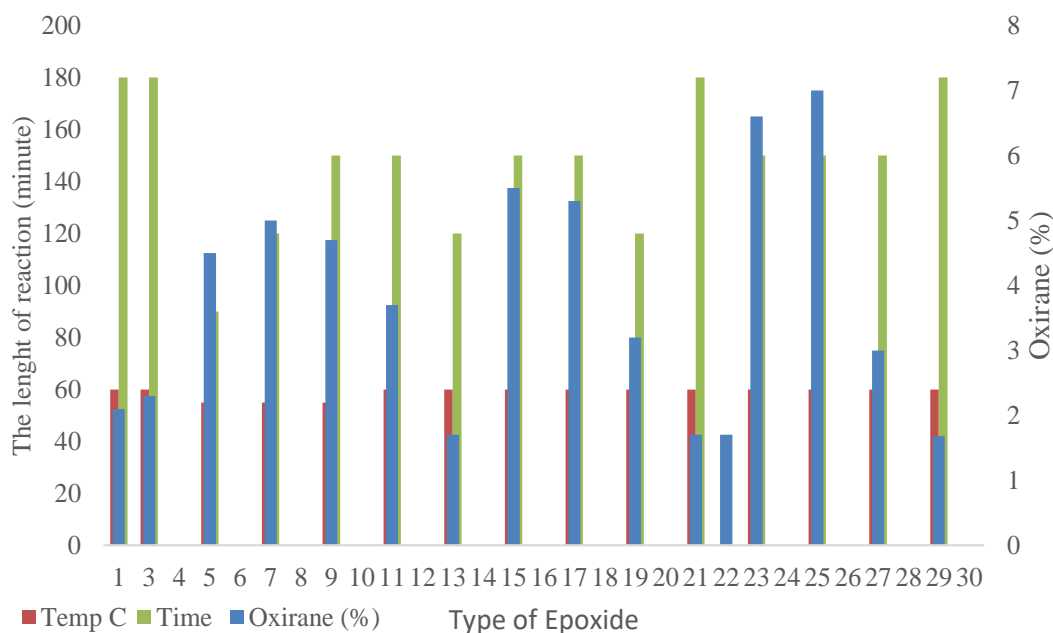

Figure 7. The Effect of Length of the reaction and Type of Epoxide to Oxirane Number

The polyols from renewable-based oil were significantly different from polyols derived from petroleum, the hydroxyl of vegetable oil for example was located at the center of the polyol chain. Compared to most polyols derived from petroleum, it has primary hydroxyl and secondary hydroxyl with only one covalent bond was lost from the petroleum chain, while in vegetable oil there was the possibility of 5-8 covalent bonds was lost, this was expressed as a disadvantage for natural polyols concerning the gelling reaction (Figure 8).
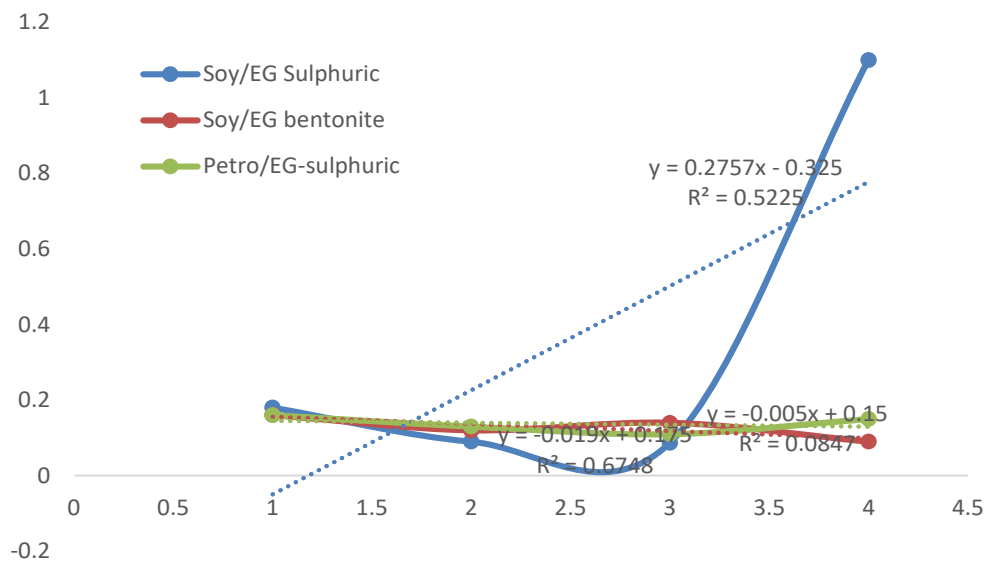
Figure 8. Comparing the Density to Petro based Polyol

The main ingredients for manufacturing the polyurethane foam are isocyanates, polyols, equipped with a catalyst. Water was important enough for the foam to expand properly. Several other additives such as chain extender, crosslinker, plasticizer, etc can be added if the resulting product has certain desired properties (Firdaus, 2011a). There are several conditions contributes to the failure of the foaming process. Such as water became major co-reagant for the foam to expand where it found the best range was 2.22 to 2.78% for foam to rise in maximum. One other thing should be concerned was the concentration of surfactant, it was fairly in the concentration 3% from the whole formula of polyurethane, where the polyol from the previous as intermediates should also have a good hydroxyl value from the reaction product which takes into account the reaction process duration (Figure 9).

Figure 9. The Failure of Polyurethane Foam in the absence of expanding reagent

Conclusion

The success of polyurethane production was determined apart from the materials used and the formula used, it determined by the processing include the length of the reaction. The chemical structure of polyols synthesized from renewable materials has a significant difference from polyols from petroleum materials. This of course will give an ultimate differentiation of mechanical properties. The tactic that can be done was to modify the unsaturated chain of

the triglyceride chain by observing the reaction time. From the results, it was found that this will affect the oxirane number and hydroxyl value as an intermediate to a polyurethane product. The formation of polyurethane was influenced by a perfectly swelling process, the absence of water causes the foam to fail to expand because it does not form CO_2.

Reference

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Biography

Flora Elvistia Firdaus, is an Associate Professor at the Department of Chemical Engineering at Jayabaya University Jakarta, Indonesia. Research interest; polymer production, environmental engineering, and material composite.

Donna Imelda, is a lecturer at Department of Chemical Engineering at Jayabaya University Jakarta, Indonesia. Research interest; polymer production, environmental engineering, and oelochemical.

Lubena is a lecture at Department of Chemical Engineering at Jayabaya University Jakarta, Indonesia. Research interest; corrosion engineering, environmental engineering, and oelochemical.

Rinette Visca is a lecturer at Department of Chemical Engineering at Jayabaya University Jakarta, Indonesia. Research interest; polymer production, environmental engineering, and oelochemical.