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The vegetable oil in the production of polymers and plastics; an effort of creating green products

Flora Elvistia Firdaus

Jayabaya University, Jl. Pulomas Selatan Kav. 23 Jakarta Timur 13210 Indonesia

*flora_elvistia@yahoo.com

Abstract. Manufacturing of polymers and plastics derived from petroleum feedstocks are called synthetic products. The existing of synthetics throughout the plastic series of process is detrimental to the environment. Polyurethane is classified as a family of plastics. Vegetable oil is the potential of producing polyurethane in the presence of unsaturated chain in triglyceride, is being considered intermediates of polymers product. An effort of replacing petroleum with green resources is urgently required of its cheap price, and abundantly available. The vegetable now is not just a cooking oil but turned into various polymeric products. This research is aimed to identify the vegetable oil content in polyurethane's formula with comprehensive low production cost and potentially resulted in the best polyurethane product properties.

1. Introduction

Plastics are polymeric materials, the global production and consumption of plastic have grown rapidly to a commercialized desire product from household to industrial scale. The plastic littering has become big issues of worldwide which essentially fulfil the modern life style. The impact of its non-biodegradable properties is worried, has the burden of exceedingly of earth carrying capacity without knowing when is destroyed. Plastics are actually a shortened form of thermoplastic, the materials can be shaped and reshaped by heating. The production of synthetic polymers globally has dominated by polyolefins, polyethylene, and polypropylene.

According to Jambeck *et. al*, the estimated plastic world consumption is approximately 335 million metric tonnes (MMT) in 2016. It confirmed and upward trend over the past years. Indonesia is the world second-ranked mass of mismanaged plastic waste after China [1].

Plastics are polymeric materials is made from petroleum feedstocks. Reducing the plastics amount in a series of processes or replaced to green materials are possibly step to save the environment. The economic losses and crisis of petroleum shortages have created serious innovative findings which have to fuel the growing interest of worldwide researcher on using renewable resources [2]. Despite the lack of limitations to suitably fabricate plastics, the proper method can solve and established a sustainable environment [3][4][5].

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Triglyceride for Polyurethane

Polyurethane is one class of plastics. Green resources are renewables, the availability if served as the main ingredient in plastic fabrication is much promising besides it saved the environment. It should be part of upstream into downstream of the process. Triglycerides in vegetable are typically contained 10 or more different fatty acids, it can either be saturated or unsaturated. The triglyceride has the answered for the world awareness to the environment, the functional groups at least one unsaturated fatty acid to be introduced to a desired of soy-polyol. The name and structure of fatty acid are illustrated in Table 1.

Table 1. Fatty acid of Vegetable Oils

Name	Structure
Myristic acid	$CH_3(CH_2)_{12}COOH$
Palmitic acid	$CH_3(CH_2)_{14}COOH$
Palmitolec acid	$CH_3(CH_2)_5CH=CH(CH_2)_7COOH$
Stearic acid	$CH_3(CH_2)_{16}COOH$
Oleic acid	$CH_3(CH_2)_7CH=CH-CH_2-CH=CH(CH_2)_7COOH$
Linolenic acid	$CH_3CH_2CH=CHCH_2CH=CHCH2CH=CH(CH_2)_7COOH$
α-Eleostearic acid	$CH_3(CH_2)_3CH=CHCH=CHCH=CH(CH_2)_7COOH$
Ricinoleic acid	$CH_3(CH_2)_4CHCHCH_2CH=CH(CH_2)_7OHCOOH$

The soybean oil contains carbon-carbon double bonds with no hydroxyl groups, the epoxidation reaction will form reactive group oxirane rings is an intermediate to fabricated fatty acid derivatives [6]. Soybean oil has in the majority the unsaturated fatty acid chains which are approximately 85%, the reactivity of fatty acid depend on the amount of carbon double bond, the structure of a triglyceride, in general, is depicted in Figure 1.

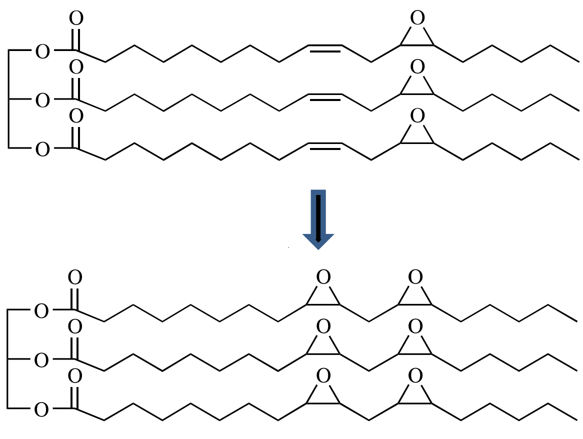

Figure 1. Triglyceride is a Major Substituent in Vegetable Oils

The polymerization by epoxidation reaction of three carbon-carbon π-bond of linolenic acids, linoleic (18:2) and oleic (18:1) [7][8]. The soy epoxidized is one of the raw material, the ring opening has made the epoxides transformed into polyols which is the meat of foam formulation, the ingredients bind to forming the molecular chain of polyurethane [9].

Methylene diisocyanate (MDI) is the material reacts with polyol forming chemical reaction and builds the complex shape of polyurethane flexible foam. The hydroxyl functionality of polyol is used to increase isocyanates reactivity. The carbon chain before and after the hydroxyl acted as a plasticizer to improved properties of polyurethane and reduce rigidity [10]. High hydroxyl values can be caused by high production costs because of the high isocyanates requirement. The number of reactive hydroxyl groups per polyol molecule ultimately control the degree of cross-linking between molecules, this effected to mechanical properties of polyurethane. The maximum content of vegetable oils for petroleum replacement is approximately 15-20% of the polyol content. The mechanism reaction of polyurethane can be seen in Figure 2.

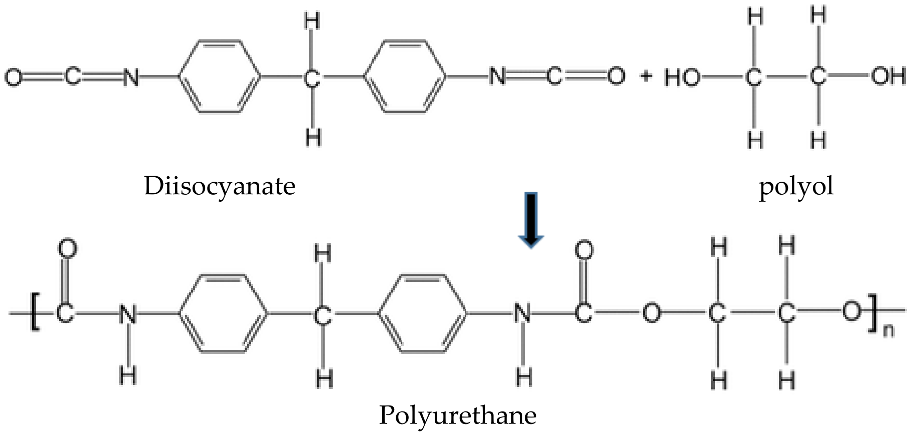

Figure 2. Mechanism Reaction of Polyurethane from Polyol and Diisocyanate

2. Methods

Polyurethane is manufactured by spontaneously cell opening. The molding method can catalyze to the perfect blowing of foam. The properties possessed are from flexible to rigid. In the series of the process, the petrochemicals are partially reduced.

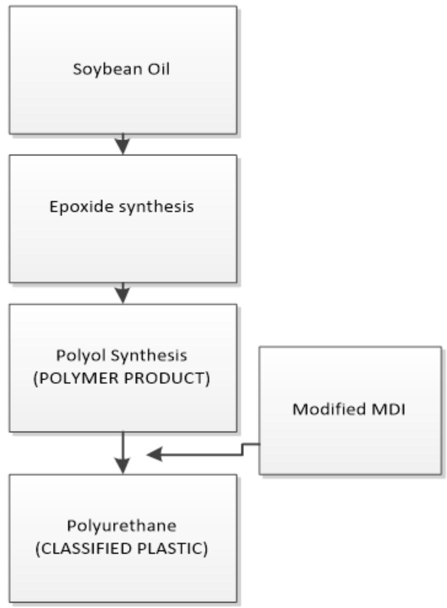

Figure 3. Fabrication of Polymers and Classified Plastic from Soybean Oil

The material used is soybean oil from Variatama with the specification of iodine value of 53.89 gram Iod/100 gr sample, viscosity 65.5278 cps, and acid value 0.024 mgr KOH/sample.

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Environmental set-up
The vegetable used in this research is soybean oil, it contains triglycerides of long chain saturated and unsaturated carboxylic acids, the triglycerides are charged to peracetic acid using a sulfur acid catalyst. The concentration of catalyst is designed 1%, 2%, and 3% (v/v), temperature is maintained 60± 0.50C. The flow diagram of the research is depicted in Figure 3. Polyols are synthesized by blending of soy epoxide to ethylene glycol in stoichiometric calculation into 1% (v/v) acid catalyst at 1170C. The producing of polyurethane is using the molding method.

3. Results and discussion

The stepwise of the research is meant to find the optimized conditions. The oxiranes values are measuring the unsaturated fatty acid. The best oxirane number occurred is by 1% (v/v) sulfur acid was 6.7% and 7.3%; while 2% (v/v) of the acid catalyst the oxirane number was 3.9% and 4.6% and 3% (v/v) of sulfur acid was 3.3% and 4.5%. The optimized result is the catalyst 1% (v/v) as can be seen in Figure 4, this condition can fasten the reaction with a low concentration of catalyst where it considered reduce the production cost.

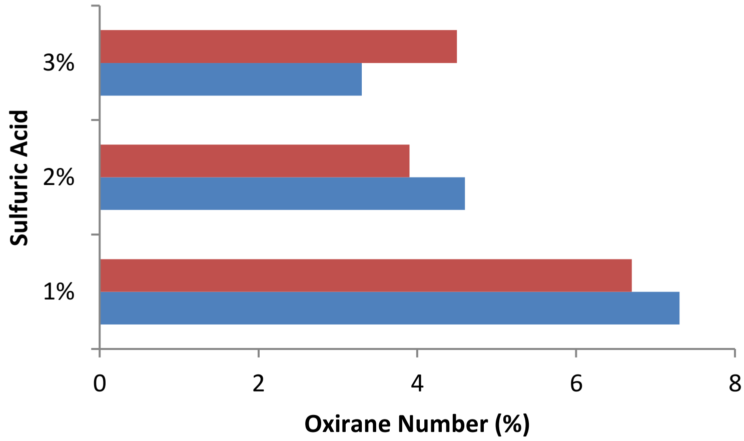

Figure 4. Optimization of the Epoxidation catalyst

The time reaction is other factors to be considered because it related to cost-effectively of polyol product. The polyol creates hydroxyl sites to be linked into MDI which resulted in polyurethane. The steady increase of hydroxyl number may be attributed to the continued breaking of the ester bond. The high hydroxyl number is achieved from partially of epoxidized and ethylene glycol, the high hydroxyl number will require high MDI.

The 1 hour of reaction and 1:3 (mo/mol) the lowest concentration of epoxide/EG in the designated formula as illustrated in Figure 5, is fairly produce polyurethane in the range of flexible properties. The flexibility of polyurethane is mainly the focus of the work as if it uses a blending of synthetic polyol and soy polyol 4:1 (v/v) as the optimized the concentration which resulted in elasticity 86.66% and resilience 13.34 %, while using 100% soy polyol resulted in elasticity 71.42% and resilience 28.58%. The polyurethane from soy-based also has good compressive strength with 3.3 x 10^{-3} MPa in 10% deformation.

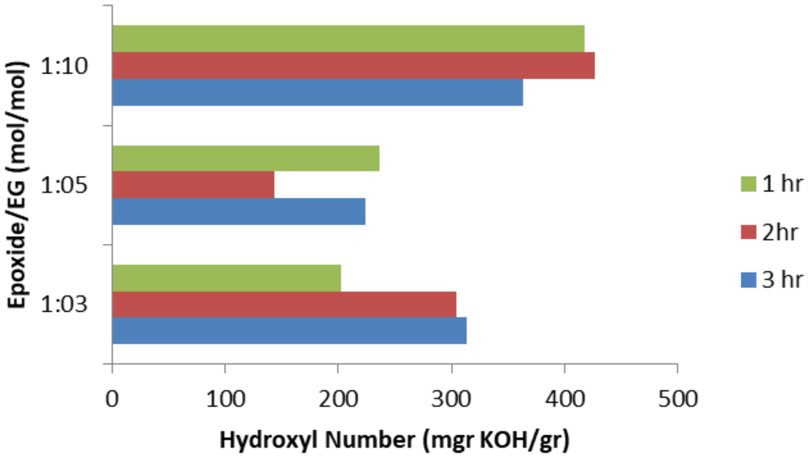

Figure 5. The Effect of Time reaction to Hydroxyl Number of Soy Polyol-Synthetic Ethylene Glycol (EG)

The appearance of polyurethane can be seen in Figure 6.

Figure 6. The polyurethane of Soybean oil based

4. Conclusions

The shortages of petroleum fuel feedstock have rising focuses of world researches on using vegetable oil as renewable resources for a variety of polymer products. The unsaturated chain in triglyceride is a functional site of vegetable oil conducted to resulted polymers and its derived in the form of classified plastic. The polyol is taking part in the process, is the only candidate from green resources in polyurethane formula for petroleum replacement. Polyol soybean-based are represented as one amongst vegetable oils, are viable, and has most an economic point of view.

Acknowledgments

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