PROCESSES FOR OBTAINING A POLYOL FROM PALM OIL, POLYOLS OBTAINED FROM THE PROCESSES, PRODUCTS DERIVED FROM SUCH POLYOL AND THEIR METHOD OF PREPARATION

FIELD OF THE INVENTION

Synthetic polymers were invented about 60 years ago and from then on much progress has been achieved in the field of their applications. Polyurethane is a polymer obtained through condensation of polyols combined with polyisocyanates. It is subdivided in two major groups: thermostables and thermoplastics. The more usual thermostable polyurethanes are foams frequently used as thermal insulators and as resilient foams, but there are also polyurethanes that are high performance elastomers, adhesives and sealants, paints, fibers, packaging sealants, joints, preservatives, automobile components, elements in the construction industry, furniture industry, and other multiple applications.

Polyols used in the production of polyurethanes are generally compounds with molecular weight in the range of 500 to 5000 g/mol. Depending of the length of the chain of these diols and glycols, the properties of the polyurethanes change. If the polyol has a low molecular weight, it makes rigid plastics, and if it has a high molecular weight it produces flexible elastomers. Polyols are reactive substances, usually liquids, which contain at least two groups that react to isocyanate linked to one molecule. They have a deep effect in the properties of finished polyurethane. The properties of the polymers are associated with the links to isocyanate, but the structure of polyol exercises a direct action on the processing and finishing properties of the polymer.

BACKGROUND OF THE INVENTION

The polyols used in the polyurethane production industry are generally derived from petroleum, but currently there is a trend to use renewable sources such as vegetable oils for production of polyols based on these oils.

The production of polyols from of vegetable oils has been described in several documents in the state of the art:

Patent Application U.S. 20070232816 reveals a process for the production of a polyol monomer which consists of reacting an unsaturated acid fatty or its corresponding triglycerides with a polyhydric alcohol in the presence of a catalyst and an emulsifier in order to prepare a monoglyceride. Said process also comprises an epoxidation stage of

the unsaturated fatty acids of said monoglyceride, and a reaction stage of the epoxidized monoglyceride with a polyhydric alcohol.

Publication W0/2006/012344 provides methods for the preparation of unsaturated polyols based one modified vegetable oils, as well as methods for the production of oligomeric polyols based on modified vegetable oils. This publication shows a method of manufacturing an oligomeric polyol based on a modified vegetable oil, where a mixture is made to react that comprises an epoxidized oil vegetable and a compound that allows the opening of the ring for form an oligomeric polyol based on the modified vegetable oil, where the oligomeric polyol based on the modified vegetable oil comprises at least 20% of oligomers and has a viscosity at 25°C less than approximately 8 Pa s.

Publication W0/2009/058367, as well as Publication W0/2009/058368 refer to methods for obtaining a polyester polyol from natural oils. Such methods comprise the stage of reacting the monohydric fatty acids to the esters with a multifunctional reagent initiator to form the polyester polyol. This document reveals a process where a methanolysis of oils (Sunflower, Soya, Canola) is performed followed by an epoxidation process.

Patent Application U.S. 6,433,121 reveals a method for the production of polyols based on natural oils through the use of a two consecutive-stage process involving epoxidation and hydroxylation. This document mentions in a general manner that palm oil may be used; however, without limitation, the preferred realization of the invention corresponds to the use of soybean oil.

Publication W0/2009/058368 reveals methods for the obtaining a polyester polyol from natural oils. Said method comprises a stage of reacting the hydroxylated fatty acids to the esters with a reagent multifunctional initiator to form polyester polyol. The process revealed in this document performs a methanolysis of oils (Sunflower, Soya, Canola) followed by a process of epoxidation. Additionally, the document mentions in a general way that palm oil could be employed in the process.

In the research published in the Article by G. Ruiz Aviles, "Obtaining and characterizing of a biodegradable polymer from Cassava starch," *Engineering and Science*, Medellin, 2006, a biodegradable polymer is obtained from yucca starch by processing modified starch mixtures with glycerin and water as plasticizers, using an open mill and a single extruder spindle. The variables to control during the extrusion are: temperature, torque and spindle rotation speed profile. The polymer obtained has applications in food packaging and for garbage bags.

On the other hand, the article by H. Yeganeh, P. et al., "Preparation and properties of novel biodegradable polyurethane networks based on castor oil and poly(ethylene glycol)," *Polymer Degradation and Stability* 92, Iran, 2007, reveals a method of preparation of polyurethane with polyols obtained from castor oil and mixtures with polyethylene glycol that were synthesized through the reaction of the prepolymer with 1,6 hexamethylene diisocyanate. The polymer obtained has a rate of biodegradability compatible for be used in biomedical applications.

The article by S. Ahmad, Md, et al., "Urethane modified boron filled polyesteramide: a novel anti-microbial polymer from a sustainable resource," *European Polymer Journal*, 2004 describes a procedure for obtaining an antimicrobial polymer from soybean oil; the polymer is composed of polyesteramide filled with boron that is polymerized for form a polyester amide urethane. The material obtained was evaluated for antimicrobial and antifungal activity, verifying that the different compositions inhibit microbial growth.

Another article, by V. Sharma, et al., "Addition polymers from natural oils: A review," *Prog Polym. Sci.* 31, India, summarizes the theoretical aspects of the production of polymers from renewable sources, especially from vegetable oils, showing the differences in the structure of each oil and its influence on the polymer properties. It poses various alternatives for natural oils such as soy, corn, tung, linseed, castor oil plant and fish oil for the production of polymer materials.

Finally, the article by G. Gunduzb, et al., "Water-borne and air-drying oil-based resins," *Progress in Organic Coatings* 49, Turkey 2003, presents a procedure for the preparation of polyurethane dispersed in water for application as a varnish. The resin is produced for the preparing a maleinised monoglyceride, TDI as isocyanate, silicone, and ethylene diamine. Sunflower oil was used for this development as a renewable resource to produce the monoglycerides.

Palm oil is the second most cultivated vegetable oil in the world following soybean oil. Ninety percent of palm oil produced is exported from Malaysia and Indonesia. Palm oil is derived from the fruits clusters of the palm, is semisolid at environmental temperature due to the combination of triglycerides of high and low fusion points, and has a red-orange color due to its high content of carotenes. It is composed mainly of fatty acids, the amounts typical of these acids being: 45% palmitic, 40% oleic, 10% linoleic and 5% stearic. Thanks to its good resistance to oxidation and to heating at high temperatures, palm oil is employed in diverse industries for its good performance

and economy. In energetic terms palm oil requires less energy than others oils for the production of one ton, such as soy and rapeseed oils.

Initially palm oil production was only used for human consumption, but in view of the overproduction of palm oil of in Malaysia, Thailand and Indonesia, the need to search for alternative uses for the oil has been identified. Some different areas of knowledge have been identified for its use, such as medicine, agriculture development of new materials, civil works, and biofuels, among others.

The production of polyols to from of palm oil, specifically oligomeric polyols, has been described in Publication W0/2007/123637, which discloses oligomeric polyols obtained from palm oil and compositions that comprise these polyols, as well as a process for obtaining an oligomeric polyol based on modified palm oil, which comprises providing an epoxidized composition based on palm oil and making it react with a compound that allows the opening of the ring to form an oligomeric polyol where the oligomeric polyol based on the modified palm oil comprises at least 40% oligomers by weight, has a hydroxyl number of around of 65 mg KOH/g sample or less, an average number of hydroxyl functionality of 2.5 or less, and viscosity at 25°C of less than approximately 4 Pa s.

While the prior art has searched for solutions to the technical problem, which is to provide methods for obtaining "green" polyols, that is, from vegetable oils which include palm oil, as well as obtaining polyurethane foams from of these "green" polyols with properties that allow their application in the different uses mentioned above, none of the documents of the prior art refers to a procedure for obtaining polyols derived from palm for the preparation of polyurethane, in which two methods of preparation are combined to grant a higher functional ty to the final molecular structure. This improves the characteristics of the polyurethane obtained from said polyol, conferring properties such as greater functionality and greater crosslinking.

Although in other inventions polyols have been obtained from vegetable oils, the products prepared from such polyols are brittle due to the concentration of hydroxyl groups at only one end of the carbon chain.

Additionally and in relation to the conditions of operation of the glycerolysis method, the present invention achieved decreasing the reaction temperature for obtaining a polyol with favorable results regarding the decrease in energy costs.

The present invention provides a simple method for its realization, is not expensive, and gives the end result of a product with high technical and functional qualities that

places it above those of conventional type and within the same line found in the prior art, with the advantage of having in its raw materials a polyol from renewable natural sources.

The present invention produces polyols with molecular weights between 314 and 3366 and with a hydroxyl number of between 50 and 450 mg KOH/g sample.

The resulting rigid foams were tested for the density (according to STM C373-88) with results between 0.284 and 0.658 g/cm^3, Young module (according to ASTM 0695-10) with results between 8.94522 and 54.92330 MPa, and maximum effort (according to ASTM 0695-10) with results between 0.92037 and 8.29101 MPa.

The resulting semi-rigid foams were tested for density (according to ASTM C373-88) with results between 0.129 and 0.158 g/cm3, Young module (according to ASTM 0695-10) with results between 0.78727 and 1.54311 MPa, and maximum effort (according to ASTM 0695-10) with results between 0.07012 and 0.09753 MPa.

DESCRIPTION OF THE INVENTION

The present invention is related to the production process of a polyol from palm oil and to rigid polyurethane foams prepared from said polyol derived from palm oil.

On the one hand, the present invention provides a method for obtaining monomeric polyols from palm oil that have a hydroxyl number of between 50 450 mgKOH/g sample.

The polyols of the present application may be obtained by means of a procedure based on the following four mother routes:

- Route 1: maleinization of the fatty acids of palm oil
- Route 2: glycerolysis of palm oil
- Route 3: transesterification of palm oil
- Route 4: epoxidation of unsaturated carbon-carbon bonds in palm oil

Additionally, other modalities of the invention allow the obtaining polyol from the combination of these mother routes.

Specifically, route 1 begins with the alcoholysis of palm oil to obtain fatty acids, which undergo a maleinization process in order to introduce carboxylic groups and from these to extend the glycerin chain and so obtain a polyol from palm oil.

In the mother route 2 of the present invention monoglycerides are prepared from the palm oil but, in contrast to route 1, no maleinization is performed. Rather, polyol is obtained from the palm oil by means of glycerolysis process. The glycerolysis takes place at temperatures between 170 and 280°C, obtaining higher reaction speeds the higher the temperature. It is recommended not to exceed 260°C in any case, provide a good system of agitation (350 to 420 rpm) and use an inert atmosphere (Nitrogen, argon or CO2).

The process of glycerolysis is usually performed in presence of a solvent and a catalyst. The selection of a good catalyst allows using lower temperatures.

The glycerolysis reaction should be carried out under the action of a catalyst that can be homogeneous (acid or base) or heterogeneous. Examples of the catalysts to obtain mono and di glycerides include lead acetate, calcium acetate, lead oxide and lithium ricinoleate, sulfuric acid, hydrochloric acid, sulfonic acid and sodium hydroxide.

Lead and calcium acetates, as well as the lithium ricinoleate, allow obtaining an excellent glycerolysis in the minimum time (40 to 50 minutes) and relatively moderate temperature (235 to 240°C) and, more importantly, using minimum amounts of catalyst.

The mother route 3 of the present invention corresponds to the preparation of a polyol from palm oil modified through transesterification with pentaerythritol, which is useful when a considerable increase in tensile, hardness and resistance to chemical attack properties is required. This is due to a higher degree of crosslinking caused by the increase in the content of hydroxyl groups.

In mother route 4 of the present invention a polyol to from palm oil is produced by double link epoxidation, in which a process of methanolysis of the palm oil is initially performed to obtain of fatty acid methyl esters (FAME), which are submitted to a process of epoxidation with hydrogen peroxide to generate performic acid *in situ*.

In other aspect of the invention polyurethanes are prepared from the polyols obtained through any of the four routes or through a combination of the same. In a modality of the invention, the polyurethanes are produced through the reaction of a mixture of polyol obtained through the present invention, a commercial polyol, a surfactant, a

catalyst and an isocyanate. The polyurethanes may be foams of high density rigid polyurethane.

The specific characteristics, advantages and novel characteristics of this invention will be established in the following section of the description, corresponding to the detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a flow chart exemplifying the production of a polyol from palm oil through Route 1.

Figure 2 shows a flow chart exemplifying the production of a polyol from palm oil through Route 2.

Figure 3 shows a flow chart exemplifying the production of a polyol from palm oil through Route 3.

Figure 4 shows a flow chart exemplifying the production of a polyol from palm oil through Route 4.

Figure 5 shows a flow chart exemplifying the production of a polyol from palm oil through the combination of Route 4 and Route 2.

DETAILED DESCRIPTION THE INVENTION

The present invention relates to a process for the production of a polyol from palm oil and of rigid polyurethane foams with a polyol derived from palm oil mixed with a commercial polyol.

The processes for the production of the polyols based on palm oil will be described by referring to Figures 1 to 5.

Figure 1 describes route 1 in a general manner. Secifically, this route includes two different methods, the first comprising the maleinization of palm oil through heating of the same and its mixture with maleic anhydride. The mixture is later reacted in the presence of reflux condenser and an inert atmosphere, and the reaction happens there during an established period, obtaining the polyol.

The second method corresponds to the maleinization of fatty acids, beginning with a mixture of palm oil and sodium hydroxide and an ethanol-water solution. The mixture obtained is heated and stirred. Subsequently a small amount of concentrated sulfuric acid is added, showing the separation of the organic phase and the aqueous phase.

Then, saturated sodium chloride solution is added. After of the complete separation of the phases, the aqueous phase is eliminated. By means of warming and agitation of the organic phase the fatty acids may be obtained, which are mixed with previously blocked glycerol through an MEK (Methyl ethyl ketone) reaction, carried out with sulfonic toluene acid as a catalyst and toluene as a solvent. The fatty acids then react with the glycerol blocked in the presence of a catalyst, sulfonic toluene acid, and heat. The product of this reaction is evaporated to obtain blocked monoglyceride, which subsequently reacts in a nitrogen and maleic anhydride atmosphere. Sulfuric acid is added to the product of this reaction. The organic phase obtained is washed and submitted to evaporation to finally obtain the polyol.

Now thus, Figure 2 summarizes route 2 which corresponds to the production of polyol from palm oil through glycerolysis. This route comprises the reaction between the palm oil and glycerol, terbutanol as a solvent and sodium hydroxide as a catalyst in the presence of heat. The product of this reaction is neutralized with hydrochloric acid and submitted to evaporation for elimination of the solvent. The phase obtained is separate through the addition of n-hexane, allowing the residual glycerin to be discarded from the polyol finaly obtained.

Figure 3 summarizes route 3, related to the production of polyol from palm oil modified through transesterification with pentaerythritol. This route comprises the reaction between palm oil, pentaerythritol and lead oxide in the presence of heat with continuous agitation and in an inert nitrogen atmosphere. The product of the reaction is treated with n-hexane, allowing formation of two phases: the precipitate that contains glycerol is then discarded and the other phase is submitted to evaporation to obtain the polyol.

On the other hand, route 4 is summarized in Figure 4 and comprises a process of epoxidation of the fatty acid methyl esters of (FAME), which are previously obtained through methanolysis of palm oil. This methanolysis comprises the reaction between the palm oil and methanol in presence of sodium hydroxide. Subsequently the glycerin phase is discarded and the phase of interest is washed with phosphoric acid, discarding the solids formed and neutralizing. The product (FAME) is submitted to evaporation to remove the excess methanol.

In this way, the FAME are made to react with formic acid in the presence of hydrogen peroxide. The reaction is evidenced by the color change from orange to clear yellow. Subsequently, the product is washed with water, sodium bicarbonate and sodium

chloride, neutralizing the solution, which then undergoes evaporation to remove the moisture and allow obtaining the polyol.

Figure 5 describes other modalities of the invention, which correspond to the combination of routes 2 and 4 and are established in more detail below.

One of these modalities allows obtaining polyol from of the olein phase of crude palm oil, using lead oxide as a catalyst. The method is then carried out through the epoxidation of the olein phase of crude palm oil with formic acid, in the presence of heat. Subsequently hydrogen peroxide is added and stirred. The reaction is evidenced by the change of color from orange to clear yellow. The product of the reaction is washed with water, sodium bicarbonate and sodium chloride, discarding the aqueous phase and subjecting the organic phase to glycerolysis (reaction with glycerin) using lead oxide as catalyst to thus obtained the polyol.

Another mode of the invention corresponds to obtaining the polyol from the olein phase of crude palm oil using NaOH as a catalyst. This mode comprises the same steps mentioned for the previous mode, with the difference that the glycerolysis of the organic phase is done in the presence of sodium hydroxide, with a posterior neutralization of the excess catalyst with phosphoric acid.

Yet another mode of the invention allows obtaining polyol from the olein phase of refined, bleached and deodorized palm oil (RBD). For this purpose the same steps are used as for the previous embodiments, using the raw material mentioned and sodium hydroxide as a catalyst in the glycerolysis.

The last mode corresponds to obtaining polyol from of the olein phase of refined, bleached and deodorized palm oil (RBD), but employing lead oxide as catalyst. In the same way, the steps already mentioned above are used, with the exception that the olein phase of RBD is used as raw material and lead oxide as catalyst in the glycerolysis.

The routes and modalities described thus allow obtaining the polyurethane foams through the reaction of the polyols produced with methylene diphenyl diisocyanate (MDI).

For said purpose, the polyol obtained is mixted with a short chain polyol (diethylene 1,6 butanediol), a catalyst (dibutyltin dilaurate, tin octoate, tertiary amine catalysts, water, a surfactant (Silicone or organosiloxane-based), and methylene diphenyl diisocyanate (MDI). The reaction leads to the formation of foam of rigid polyurethane.

Depending on the hydroxyl number obtained for the polyol, flexible, semi-rigid and rigid polyurethane foams may be obtained, as indicated below:

Hydroxyl No.	50	100	150	200	250	300	350	400
Foam Type	Flexible			Semi-rigid			Rigid	

Within of the applications that these types of foam have, the following may be noted:

Polyurethane	**Application**
Rigid	Molded parts, soles for footwear
Semi-rigid	Thermal insulation, soundproofing insulation, waterproofing, floral foam, chairs adapted to the user (mainly for disabled people)
Flexible	Foam for bras, mattresses

EXAMPLES

The following examples is presented with the purpose of illustrating the invention and are in no way a limitation, inasmuch as the person moderately skilled in the matter can recognize the possible variations.

EXAMPLE 1 - Obtaining polyol using the first method of route 1

300 grams of palm oil were laced in the 250 ml reaction flask. Separately, 65.7 grams of maleic anhydride were weighed and were added to the reaction flask. The same was heated to 180°C. Subsequently the reflux condenser was adapted and the reaction flask placed on a heating iron with magnetic agitation to 1300 allowing the reaction to take place during 3 hours in a low nitrogen atmosphere. The product of this reaction is the maleinised oil that was cooled to the 100°C and to which an amount of 30.85 g of glycerol was added. The reaction was allowed to continue and the acidity index tracked every 30 minutes up to a value of 90 mg KOH/g sample, thus obtaining the polyol.

EXAMPLE 2 - Obtaining polyol using the second method of Route 1

150 grams of palm oil were placed in a 1000 ml precipitation glass. Subsequently 33.5 g of NaOH and 100 ml of a 1:1 ethanol-water solution were added. The reaction was carried out at a temperature of 80°C during 30 minutes. The solution was stirred slightly in manual form. Then, drops of concentrated sulfuric acid were added. The separation of the organic phase and the aqueous phase was then observed. To complete the

solution, 100 ml of saturated sodium chloride solution were added. The solution was left at rest while the phases separated. Subsequently the aqueous phase was discarded and is the rest transferred to a separation funnel, washing with hot water. The pH of discarded wash water was measured to verify it was neutral. Separately, the organic phase was transferred to an lateral release Erlenmeyer, the temperature was increased to 80°C, and the phase was stirred continuously; This procedure was carried out in a vacuum. The fatty acids were obtained as a product.

70.83 grams of glycerol were separately weighed and placed in a 500 ml reaction flask. Then 62.90 grams of MEK (methyl ethyl ketone) were added together with 1.8 grams of sulfonic toluene acid and 70 ml of toluene. The reaction was carried out at 90ºC during 2 hours. In this way the blocked glycerol was obtained.

To 40 grams of the fatty acids obtained above, 19.5 grams of blocked glycerol were added in a 500 ml reactor. Subsequently 1.8 grams of sulfonic toluene acid were added and the remaining solution underwent heating at 90ºC with magnetic agitation of 1200 rpm, leaving the reaction to develop for three and a half hours. Then the product of the reaction was moved to a separation funnel, also washing with hot water and measuring the pH of outgoing wash water until it was neutral. The product of this washing is consecutively put under rotoevaporation during 3 hours at a temperature of 90ºC and in vacuum conditions. By these means the blocked monoglyceride was obtained. Afterwards 25 grams of the blocked monoglyceride are taken and placed in a 500 ml reaction flask. Subsequently 9.2 grams of maleic anhydride are added and the reaction is carried out at 200ºC with magnetic agitation during 3 hours in a low nitrogen atmosphere. The product is left to cool to 100°C without stopping the agitation. Four drops of concentrated sulphuric acid are immediately added slowly, dissolved in 3 ml of distilled water, and the reaction is allowed for another hour. A hot water wash is then carried out and the result left decanting throughout the night.

The following day is the aqueous phase was discarded and the organic phase was rotoevaporated at 80ºC during an hour and a half, thus obtaining the polyol.

EXAMPLE 3 - Obtaining polyol using route 2

In a 500 ml reaction flask, coupled with a reflux condenser, a heating surface and a magnetic agitator, 64.5 grams of palm oil were added, along with 40 grams of glycerol, 20 ml of terbutanol and 4.5 grams of sodium hydroxide. The conditions of operation were, temperature: 90ºC, time: 2 hours and agitation: 1300 rpm.

Once the time of reaction had elapsed the mixture was cooled to temperature and the catalyst neutralized with an HCl solution at 10%, verifying the pH with a paper indicator. The glycerin and the residual solvent were then removed and the product of interest was rotoevaporated to ensure the complete elimination of solvent in the solution. The rotoevaporation temperature was 90°C and was carried out during 3 hours.

Finally the phases were separated in a separation funnel, where 60 ml of n-hexane were added with vigorous stirring and constant releasing of pressure. The result was left in repose and the bottom phase discarded, which contained residual glycerin. A polyol was obtained with a hydroxyl number value of 523.23 mg KOH/g sample.

EXAMPLE 4 - Obtaining polyol using route 3

In a 500 ml reaction flask 40.0 grams of palm oil were weighed, along with 4.32 grams of pentaerythritol and 0.02 grams of lead oxide. Subsequently, the flask was placed on a heating surface where the mixture remained in reaction at a temperature of 200°C, with continuous agitation, an inert atmosphere of nitrogen and water reflux condenser during 2 hours. It was then left to cool and 40 ml of n-hexane were added in a separation funnel, stirring and releasing pressure. The phases were allowed to separate to further discard the precipitate and the glycerol. The other phase was submitted to rotoevaporation at 70°C with constant agitation for 3 hours, thus obtaining the polyol, with a hydroxyl number value of 11.86 mg KOH/g sample.

EXAMPLE 5 - Obtaining polyol using route 4

Initially the methanolysis of palm oil was carried out, in a 500 ml reaction flask, taking 500 grams of palm oil, together with 160.8 g of methanol and 9 grams of sodium hydroxide. The mixture was carried out at a temperature of 70°C with agitation of 1000 rpm during 1 and a half hours.

After the reaction time, the product was taken to a separation funnel to discard the glycerin phase that was in the bottom. The phase of interest was then washed with 100 ml of 0,015N phosphoric acid at 60°C, the solids formed were discarded, and repeated the wash was repeated with water at 60°C until the pH was neutralized. The phase of interest was then submitted to rotoevaporation during 3 hours at a temperature of 80°C, for removal of excess methanol. The product obtained corresponds to the fatty acid methyl esters (FAME).

Separately, in a 1000 ml reaction flask, 190 grams of FAME were added along with 7.71 grams of formic acid. The mixture was heated at 40°C and agitated at 800 rpm.

20.85 grams of hydrogen peroxide were then added drop by drop during 1 hour. After the addition of hydrogen peroxide, the reaction continued during 11 hours with constant temperature and agitation. The evidence of the reaction was seen in the change of color from orange to clear yellow. Hot water washes were immediately conducted with until the pH increased to 5. Then a washing with 100 ml of bicarbonate sodium solution at 5% and sodium chloride at 5% was performed. The process ended with hot water washes until completely neutralized.

The resulting mixture was rotoevaporated during 4 hours at 90°C to remove moisture. The polyol was obtained.

EXAMPLE 6 - Obtaining polyol using routes 2 and 4 (epoxidation and glycerolysis) from the olein phase of crude palm oil and using lead oxide as catalyst

200 grams of the olein phase of crude palm oil and 9.97 grams of formic acid were placed in a 500 ml reaction flask, coupled with a reflux condenser, a heating surface to achieve a temperature of 50°C, and magnetic agitation to 800 rpm. The reaction was started and 22,11 grams of hydrogen peroxide were added drop by drop, with agitation constant during 90 minutes. The reaction was allowed to continue during 2 hours. The formation reaction of epoxidized oil was evidenced by a change of color from orange to clear yellow.

Hot water washes were then is conducted until a pH close to 5. A wash was performed with a solution of 5%sodium bicarbonate and with a 5% sodium chloride solution. The aqueous phase was discarded through a separation funnel of and the organic phase transferred to a lateral release Erlenmeyer, drying in a vacuum during 3 hours at 80°C. The glycerolysis was then carried out with 100 grams of epoxidized oil, 25.72 grams of glycerin and 0.03 grams of PbO in a 500 ml reaction flask coupled with a reflux condenser, temperature at 215°C, and agitation of 1300 rpm during 45 minutes. The polyol obtained was analyzed, resulting in hydroxyl numbers of between 60 and 110 mg KOH/g sample.

EXAMPLE 7 - Obtaining polyol using routes 2 and 4 (epoxidation and glycerolysis) from of the olein phase of crude palm oil and using sodium hydroxide as catalyst

200 grams of the olein phase of crude palm oil and 9.97 grams of formic acid were placed in a 500 ml reaction flask coupled with a reflux condenser, a heating surface to reach a temperature of 50°C and magnetic agitation to 800 rpm. The reaction was

initiated and 22,11 grams of hydrogen peroxide were added drop by drop, with constant agitation during 90 minutes. The reaction continued during 2 additional hours. The reaction of formation of epoxidized oil was evidenced by a change of color from orange to clear yellow.

Hot water washes were then carried out up to a pH close to 5. A wash was performed with a of 5% sodium bicarbonate solution and with a 5% sodium chloride solution. The aqueous phase was discarded through a separating funnel and the organic phase was transferred to a lateral release Erlenmeyer, drying in a vacuum during 3 hours at 80°C. Subsequently the glycerolysis was performed with 100 grams of epoxidized oil, 25.72 grams of glycerin and 1 gram of NaOH in a 500 ml reaction flask coupled with a reflux condenser, temperature of 180°C and agitation at 1300 rpm for 45 minutes.

The catalyst was neutralized with drops of phosphoric acid, thus avoiding the formation of soaps. Finally, the polyol obtained was analyzed. It yielded hydroxyl numbers between 400 and 440 mg KOH/g sample.

EXAMPLE 8 - Obtaining polyol using routes 2 and 4 (epoxidation and glycerolysis) from the olein phase of refined bleached deodorized crude palm oil and using sodium hydroxide as catalyst

200 grams of the olein phase of crude palm oil and 9.97 grams of formic acid were placed in a 500 ml reaction flask, coupled with a reflux condenser, a heating surface to achieve a temperature of 50°C, and magnetic agitation to 800 rpm. The reaction was initiated and 22,11 grams of hydrogen peroxide were added drop by drop, with constant agitation during 90 minutes. The reaction continued during 2 additional hours. The reaction of formation of epoxidized oil was evidenced by a change of color from orange to clear yellow.

Hot water washes were then carried out up to a pH close to 5. A wash was performed with a of 5% sodium bicarbonate solution and with a 5% sodium chloride solution. The aqueous phase was discarded through a separating funnel and the organic phase was transferred to a lateral release Erlenmeyer, drying in a vacuum during 3 hours at 80°C. Subsequently the glycerolysis was performed with 100 grams of epoxidized oil, 25.72 grams of glycerin and 1 gram of NaOH in a 500 ml reaction flask coupled with a reflux condenser, temperature of 180°C and agitation at 1300 rpm for 45 minutes.

The catalyst was neutralized with drops of phosphoric acid, thus avoiding the formation of soaps. Finally, the polyol obtained was analyzed. It yielded hydroxyl numbers between 370 and 420 mg KOH/g sample.

Example 9 - Obtaining polyol using routes 2 and 4 (epoxidation and glycerolysis} from the olein phase of refined bleached deodorized crude palm oil and using lead oxide as catalyst

200 grams of the olein phase of crude palm oil and 9.97 grams of formic acid were placed in a 500 ml reaction flask, coupled with a reflux condenser, a heating surface to achieve a temperature of 50°C, and magnetic agitation to 800 rpm. The reaction was initiated and 22,11 grams of hydrogen peroxide were added drop by drop, with constant agitation during 90 minutes. The reaction continued during 2 additional hours. The reaction of formation of epoxidized oil was evidenced by a change of color from orange to clear yellow.

Hot water washes were then carried out up to a pH close to 5. A wash was performed with a of 5% sodium bicarbonate solution and with a 5% sodium chloride solution. The aqueous phase was discarded through a separating funnel and the organic phase was transferred to a lateral release Erlenmeyer, drying in a vacuum during 3 hours at 80°C. Subsequently the glycerolysis was performed with 100 grams of epoxidized oil, 25.72 grams of glycerin and 0.3 grams of PbO in a 500 ml reaction flask coupled with a reflux condenser, temperature of 180°C and agitation at 1300 rpm for 45 minutes.

Finally, the polyol obtained was analyzed. It yielded hydroxyl numbers between 80 and 90 mg KOH/g sample.

EXAMPLE 10 - Preparation of a polyurethane varnish from polyol obtained by route 1 of the first method

The pre-polymer was formed taking 30 g of polyol, 76.92 g surfactant and 20 ml of MEK (Methyl ethyl ketone) in a 250 ml reaction flask at 50°C during 30 minutes. The pre-polymer was then transferred to a precipitate flask of 1000 ml and 14.88 grams of TDI (Toluene diisocyanate) were added, and stirred mechanically for 3 hours maintaining temperature at 70°C. Once the reaction was completed the pre-polymer was cooled to 50°C and 4.96 grams of MEKO (Methyl ethyl ketoxima) were added to block the free NCO groups. This reaction took place during 2 hours. Finally, 2.88 grams of TEA (Triethylamine) were added during 30 minutes with vigorous agitation maintaining the temperature at 50°C. An amount of 50% w/w of water was then added drop by drop to form an emulsion.

EXAMPLE 11 - Preparation of a polyurethane varnish from polyol obtained by route 1 of the second method

The pre-polymer was formed taking 12 g of polyol, 50 g surfactant and 10 ml of MEK (methyl ethyl ketone) in a 250 ml reaction flask at 50°C during 30 minutes. The pre-polymer was then transferred to a precipitate flask of 1000 ml and 12.52 grams of TDI (Toluene diisocyanate) were added, and stirred mechanically for 3 hours maintaining temperature at 70°C. Once the reaction was completed the pre-polymer was cooled to 50°C and 5 grams of MEKO (methyl ethyl ketoxima) were added to block the free NCO groups. This reaction took place during 2 hours. Finally, 2.2 grams of TEA (Triethylamine) were added during 30 minutes with vigorous agitation maintaining the temperature at 50°C. An amount of 50% w/w of water was then added drop by drop to form an emulsion.

EXAMPLE 12 - Preparation of a polyurethane foam from polyol obtained by route 2

13 g of palm polyol were taken and a mixture 50:50 performed with diethylene glycol, placed on a heating surface with magnetic agitation to 800 rpm, and then 0.04 g of surfactant, 0.02 g of DBTL (Dibutilin dilaurate) as catalyst and 0.2 g of water were added. Finally, 3.8 g of TDI (Toluene diisocyanate) were added and rapidly stirred manually. This reaction this is highly exothermic.

EXAMPLE 13 - Preparation of a foam of polyurethane to from of polyol obtained with the route 3

10 g of palm polyol were taken and a mixture 50:50 performed with diethylene glycol, placed on a heating surface with magnetic agitation to 800 rpm, and then 0.27 g of surfactant, 0.19 g of DBTL (Dibutilin dilaurate) as catalyst and 2.69 g of water were added. Finally, 13.2 g of TDI (Toluene diisocyanate) were added and rapidly stirred manually. This reaction this is highly exothermic.

EXAMPLE 14 - Preparation of polyurethane foam from polyol obtained by route 4

10 g of palm polyol and 10 g of DEG (diethylene glycol) were weighed, then 0, 19 g of DBTL (Dibutyltin dilaurate) catalyst were added, followed by 2.69 g of water and 0.27 g of surfactant. This premix was stirred at room temperature for a few minutes and then 13.24 g of MDI were added. This reaction is highly exothermic.

EXAMPLE 15 - Preparation of a polyurethane foam from polyol obtained from example 6

9 grams of polyol and 1 gram of 1,6 butanediol were premixed and submitted to heating in case that the polyol was in a solid state. 0,15 grams of silicone 193C and

0.03 grams DBTL (Dibutyltin dilaurate) were then added and mixed for homogeneity; and finally 1.98 grams of TDI (Toluene diisocyanate) were added and stirred vigorously. The reaction this is highly exothermic.

EXAMPLE 16 - Preparation of rigid polyurethane from polyol obtained in example 7

9 grams of polyol and 1 gram of SDR (Diethylene glycol) are mixed. The mixture, which is solid, is heated. 0.15 grams of silicone 193C and 0.03 grams of DBTL (Dibutyltin dilaurate) were added and mixed to achieve homogeneity, and finally 10.5 grams of polymeric MDI (Methylene diisocyanate) are added and stirred vigorously. The reaction is highly exothermic.

EXAMPLE 17 - Preparation of rigid polyurethane from polyol obtained in example 8

9 grams of polyol and 1 gram of SDR (Diethylene glycol) are mixed. The mixture, which is solid, is heated. 0.15 grams of silicone 193C and 0.03 grams of DBTL (Dibutyltin dilaurate) were added and mixed to achieve homogeneity, and finally 10.5 grams of polymeric MDI (Methylene diisocyanate) are added and stirred vigorously. The reaction is highly exothermic.

EXAMPLE 18 - Preparation of flexible polyurethane from polyol obtained in example 9

8.5 grams of polyol and 1.5 grams of butanediol are mixed. The mixture, which is solid, is heated. 0.15 grams of silicone 193C, 0.1 grams of water, and 0.03 grams of DBTL (Dibutyltin dilaurate) were added and mixed to achieve homogeneity, and finally 4.28 grams of polymeric TDI (toluene diisocyanate) are added and stirred vigorously. The reaction is highly exothermic.

A feature of polyols and of products obtained from these, in view of the previous examples, has yielded the following ranges of properties:

Polyols with molecular weights between 314 and 3366 and with a hydroxyl number between 50 and 450 mgKOH/g sample.

The rigid foams resulting were tested regarding density (according to ASTM C373-88) with results between 0.284 and 0.658 g/cm^3, Young module (according to ASTM 0695-10) with results between 8.94522 and 54.92330 MPa, and maximum effort (according to ASTM 0695-10) with results between 0.92037 and 8.29101 MPa.

The semi-rigid foams resulting were tested regarding density (according to ASTM C373-88) with results between 0.120 and 0.158 g/cm3, Young module (according to ASTM 0695-10) with results between 0.78727 and 1.54311 MPa, and maximum effort (according to ASTM 0695-10) with results between 0.07012 and 0.09753 MPa.

EXAMPLE 19 - Additional experimental runs

Initially we start from the 4 mother routes (Routes 1-4, considering that Route 1 comprises Methods I and II). From these routes other routes are derived in the order below:

Mother Route	Derived Route
1	1
	5
	9
	13
	17
	21
	25
2	2
	6
	10
	14
	18
	22
	26
3	3
	7
	11
	15
	19
	23
	27
4	4
	8
	12
	16
	20
	24
	28

In the following table the different experimental runs are summarized, defined by the following parameters:

- Route Number
- Polyol preparation: reagents

operating conditions

evaluation results

- Preparation of polyurethane: reagents
  operating conditions
  product characteristics
  evaluation results

The abbreviation "NA" indicates that the indicated procedure was not carried out, as it did not become of interest for the inventors.

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
1-Method 1	1	Palm Oil maleic anhydride	Maleinisation: T = 180 ° C; nitrogen t = 3h	0,23 mgKOH/g sample	Prepolymer (polyol), MEKO, TEA, HDI	Isocyanate reaction: t = 3 h, T = 70 ° C. Blocking with MEKO: T = 50 C, t = 2 h. Neutralization with TEA: T = 50 C, t = 30 min, constant stirring.	The varnish is separated into two phases. Silicone varnish intermediately is observed, appears to be in excess. Dark brown initially, but eventually turns light brown. Opaque appearance. Appearance is that of a dispersion (bubbles are observed).	
1-Method 2	1	Palm Oil Maleic anhydride Glycerin (99,5% purity) Sodium Hydroxide Sodium Chloride Sulfuric acid (99,5% purity) Methyl ethyl ketone (MEK) Sulfonic Toluene Acid Toluene maleic anhydride TDI (toluene diisocyanate)	t = 30 min. 2 Rotoevaporation: T = 80 ° C, 800rpm, vacuum conditions. 3. Blocking MEK: T = 90 ° c, t = 2h. 4. Blocked monoglyceride: T = 90 ° C, t = 3.5 h, 200 rpm. 5. Rotoevaporation: T = 80 ° C, 800rpm, vacuum conditions. 6. Maleinization: T = 200°C; nitrogen t = 3h. Rotoevaporation: T = 80°C, 800rpm, vacuum condition, t = 1.5 h.		Pre-polymer (polyol) HDI MEKO TEA	Isocyanate reaction: t = 3 h, T = 70 ° C. Blocking with MEKO: T = 50 C, t = 2 h. Neutralization with TEA: T = 50 C, t = 30 min, constant stirring.		

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Methyl ethyl ketoxime (MEKO, 99.5% purity). Ethanol						
1-Method 1	1	Palm Oil Maleic anhydride	Maleinisation: T = 180 ° C; nitrogen t = 3h		Prepolymer (polyol), MEKO, TEA, HDI	Isocyanate reaction: t = 3 h, T = 70 ° C. Blocking with MEKO: T = 50 C, t = 2 h. Neutralization with TEA: T = 50 C, t = 30 min, constant stirring.	It is a viscous mixture in which the silicone is completely separated. Color dark brown. It contains lots of granules. Freshly prepared separately is much eventually improves the homogeneity of the mixture.	
1-Method 1	2	Palm Oil maleic anhydride	Maleinisation: T = 180 ° C; nitrogen t = 3h	1,32 mgKOH/g sample	NA	NA	NA	NA
1-Method 1	3	Palm Oil maleic anhydride	Maleinisation: T = 180 ° C; nitrogen t = 3h	1,43 mgKOH/g sample	NA	NA	NA	NA
1-Method 2	1	Palm Oil maleic anhydride Glycerin (99,5% purity) Sodium Hydroxide Sodium Chloride Sulfuric acid (99,5% purity)	Maleinisation: T = 180 ° C; nitrogen t = 3h	2,41 mgKOH/g sample	Prepolymer (polyol), TDI MEKO TEA	Isocyanate reaction: t = 3 h, T = 70 ° C. Blocking with MEKO: T = 50 C, t = 2 h. Neutralization with TEA: T = 50 C, t = 30 min, constant stirring.	Smooth varnish. Beige Color. Medium viscosity. Strong odor.	

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Ethyl methyl ketone (MEK)						
		Sulfonic Acid Toluene						
		Toluene						
		Maleic anhydride						
		Toluene diisocyanate (TDI)						
		Methyl ethyl Ketoxima (MEKO, 99.5% purity).						
		Ethanol						
1-Method 2	2	*Palm Oil*	*Maleinisation:* T = 180 ° C; nitrogen t = 3h	27.13 mgKOH/g sample		NA	NA	NA
		Maleic anhydride						
		Glycerin (99,5% purity)						
		Sodium Hydroxide						
		Sodium Chloride						
		Sulfuric acid (99,5% purity)						
		Methyl ethyl ketone (MEK)						
		Sulfonic Toluene Acid						
		Toluene						
		maleic anhydride						
		TDI (toluene diisocyanate)						

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Methyl ethyl Ketoxima (MEKO, 99.5% purity).						
		Ethanol						
1-Method 2	3	Palm Oil	Maleinisation: T = 180 ° C; nitrogen t = 3h	15.03 mgKOH/g sample	NA	NA	NA	
		Maleic anhydride						
		Glycerin (99,5% purity)						
		Sodium Hydroxide						
		Sodium Chloride						
		Sulfuric acid (99,5% purity)						
		Methyl ethyl ketone (MEK)						
		Sulfonic Toluene Acid						
		Toluene						
		maleic anhydride						
		TDI (toluene diisocyanate)						
		Methyl ethyl Ketoxima (MEKO, 99.5% purity).						
		Ethanol						
6	1	Palm Oil	Glycerolysis: T = 90 ° C, t = 2 h. Roto-evaporation at low temperature, according to the volatility of hexane.	19.33 mgKOH/g sample	Diethylene	T, P atmospheric, vigorous manual shaking	Yellow. Solid appearance, it appears greasy. Not observed porous	
		Glycerol			TDI			
		Sodium Hydroxide			Surfactant			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Terbutanol. (20 ml)			Dibutyltin Dilaurate (DBTDL).		Ddid not form a foam.	
		Hydrochloric Acid			water			
		n-Hexane. (40 ml)						
6	2	Palm oil	Glycerolysis: T = 90 ° C, t = 2 h. Roto-evaporation at low temperature, according to the volatility of hexane.		polyethylene glycol	T, P atmospheric, vigorous manual shaking	When reacting remained gritty and when put in the soft mold it becomes soft to the touch, with time it hardened. Its color is pale yellow.	
		Glycerol			TDI			
		Sodium hydroxide			Surfactant			
		Terbutanol (20 ml)			Dibutyltin Dilaurate (DBTDL)			
		Hydrochloric Acid			water			
		n-Hexane. (40 ml)						
20	1	Palm oil	Methanolysis: Temperature: 70 ° C, t = 1.5 h, agitation: 1000 rpm. Rotoevaporation: T = 80 ° C, t = 3 h, vacuum conditions. Epoxidation: • T = 40 ° C, agitation 800 rpm, t = 3h. Rotoevaporation: T = 90 ° C, t = 4 h.		Palm Polyol	T, P atmospheric, vigorous manual shaking	Porous foam. Initially its color was white, but was oxidized and a clear yellow was taken. It is solid but appears liquid on the surface, seems excess reagent, possibly is isocyanate. Feels stiff to the touch.	
		methanol			diethylene glycol			
		Sodium Hydroxide			surfactant			
		Phosphoric acid (H3PO4)			catalyst			
		Hydrogen Peroxide (H202)			water			
		benzene			IPDI			
		diethylene glycol (DEG)						
		Formic acid						
		Sodium Chloride						
20	2	Palm oil	Methanolysis: Temperature:	Palm Polyol	T, P atmospheric		It is a color foam.	

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Methanol Sodium Hydroxide Phosphoric acid (H3P04) Hydrogen peroxide (H202) benzene Diethylene glycol (DEG). formic acid Sodium Chloride	70 ° C, t = 1.5 h, agitation: 1000 rpm. Rotoevaporation: T = 80 ° C, t = 3 h, vacuum conditions. *Epoxidation*: T = 40 ° C. Agitation: 800 rpm, t = 3h. Rotoevaporation: T = 90 ° C, t = 4 h.		surfactant catalyst water IPDI	vigorous manual shaking.	White pores was observed. Wet, it appears a bit greasy. It is a consistent solid.	
2	1	Palm oil. Glycerol Sodium Hydroxide Terbutanol. (20 mi) Hydrochloric Acid n-Hexane. (40 mi)	Glycerolysis: T = 90 ° C, t = 2 h. Roto-evaporation at low temperature, according to the volatility of hexane.		diethylene glycol HDI Surfactant Dilaurate dibutyltin (DBTDL) water	T, P atmospheric, vigorous manual shaking.	Orange. Homogeneous. Played more rigid than others. Initially it looks like a slurry. It takes a little time to become solid.	
2	2	Palm oil Glycerol Sodium Hydroxide	Glycerolysis: T = 90 ° C, t = 2 h. Roto-evaporation at low temperature, according to the volatility of hexane.		Polyethylleneglycol HDI Surfactant	T, P atmospheric, vigorous manual shaking.	The mixture is sandy. Dark yellow. No foam was formed.	

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Terbutanol. (20 ml)			Dilaurate dibutyltin (DBTDL)			
		Hydrochloric Acid			water			
		n-Hexane. (40 ml)						
2	3	Palm oil.	Glycerolysis: T = 90 ° C, t = 2 h. Roto-evaporation at low temperature, according to the volatility of hexane.		polyethylene glycol	T, P atmospheric, vigorous manual shaking	It was prepared using an index of 0.5. It is a weak consistency polymer, orange, it breaks easily. Over time white pieces presented themselvese.	
		Glycerol			HDI			
		sodium hydroxide			Surfactant			
		Terbutanol. (20 mi}			Dilaurate dibutyltin (DBTDL)			
		Hydrochloric Acid.			water			
		n-Hexane. (40 mi)						
2	4	Palm oil.	Glycerolysis: T = 90 ° C, t = 2 h. Roto-evaporation at low temperature, according to the volatility of hexane	23,13 mgKOH/g sample	polyethylene glycol	T, P atmospheric, vigorous manual shaking	It was prepared using an index of 0.8. It is a product a little harder than the 0.5 index, however it is still very fragile. Orange	
		Glycerol			HDI			
		Sodium Hydroxide			Surfactant			
		Tert-butanol (20 ml)			Dilaurate dibutyltin (DBTDL)			
		Hydrochloric Acid.			water			
		n-Hexane. (40 mi)						
2	5	Palm oil	Glycerolysis: T = 90 ° C, t = 2 h. Roto-evaporation at low temperature, according to the volatility of hexane		polyethylene glycol	T, P atmospheric, vigorous manual shaking	It was developed with an index of 1. Orange, it is a product a little stronger than the 0.8 index, however it is even more fragile than expected.	
		Glycerol			HDI			
		Sodium Hydroxide			Surfactant			
		Terbutanol. (20 mi)			Dilaurate dibutyltin (DBTDL)			
		Hydrochloric Acid.			water			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		n-Hexano. (40 mi)						
2	6	Palm oil Glycerol. Sodium Hydroxide Tert-butanol (20 ml) Hydrochloric Acid. n-Hexane. (40 mi)	Glycerolysis: T = 90 ° C, *t* = 2 *h*. Roto-evaporation at low temperature, according to the volatility of hexane		Polyethyleneglycol HDI Surfactant Dilaurate dibutyltin (DBTDL) water	T, P atmospheric, vigorous manual shaking	Made with an index of 12. Orange product, stronger that lower indices, as it consistency is *harder; however*, it is still brittle and does not exhibit the desired rigidity	
2	7	Palm oil Glycerol.	Glycerolysis: T = 90 ° C, t = 2 h. Roto-evaporation at low temperature, *according to the* volatility of hexane	523,23 mgKOH/g sample	NA	NA	NA	NA
2	8	Palm oil Glycerol. Lead Oxide Tert-butanol (20 ml) Hydrochloric Acid. n-Hexane. (40 mi)	Glycerolysis: T = 215 ° C, t = 1 h. Agitation = 1000 rpm. Roto-evaporation at 60°, t = 5 h.					
4	1	Palm oil Methanol Sodium Hydroxide Phosphoric acid (H3PO4)	Methanolysis: T: 70°Cm t = 2.5 h. Agitation 1000 rpm. Rotoevaporation: T= 80°C, *t* = 3*h*., vacuum conditions. Epoxidation: T = 40°		Palm Polyol diethylene glycol Surfactant Catalyst	T, P atmospheric, vigorous manual shaking	White color solid with good homogeneity. Observed as somewhat greasy.	

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Hydrogen Peroxide (H2O2)	C: Agitation: 800 rpm, t = 3 h. *Rotoevaporation*: T = 90°C, t = 4 h.		Water		Liquid on the surface.	
		Benzene			HDI			
		Formic Acid						
		Sodium Chloride						
4	2	Palm oil.	Methanolysis: T: 70°C, t = 1.5 h. Agitation 1000 rpm. Rotoevaporation: T= 80°C, t = 3h., vacuum conditions. Epoxidation: T = 40°C, Agitation 800 rpm, t = 3 h. Rotoevaporation: T) 90°C, t = 4 h.		Palm Polyol	T, P atmospheric, vigorous manual shaking	Clear yellow color. The mixture exhibited good homogeneity. Consistent solid. Creamy to the touch.	
		Methanol			Diethylene glycol			
		Sodium Hydroxide			Surfactant			
		Phosphoric Acid (H3 PO4)			Catalyst			
		Hydrogen Peroxide (H2O2)			Water			
		Benzene			HDI			
		Diethylene glycol (DEG).						
		Formic Acid						
		Sodium Chloride						
4	3	Palm Oil	Methanolysis: T: 70°C, t = 1.5 h. Agitation 1000 rpm. Rotoevaporation: T= 80°C, t = 3h., vacuum conditions. Epoxidation: T = 40°C, Agitation 800 rpm, t = 3 h. Rotoevaporation: T) 90°C, t = 4 h.	2,21 mgKOH/g sample	NA	NA	NA	
		Methanol						
		Sodium Hydroxide						
		Phosphoric Acid (H3PO4)						
		Hydrogen Peroxide (H2O2)						
		Benzene						

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	*Evaluation Results*	*Reagents*	*Operational conditions*	*Product Features*	Evaluation Results
		Diethylene glycol (DEG).						
		Formic Acid						
		Sodium Chloride						
4	4	Palm Oil	Methanolysis: T: 70°C, t = 1.5 h. Agitation 1000 rpm. Rotoevaporation: T= 80°C, t = 3h., vacuum conditions. Epoxidation: T = 40°C, Agitation 800 rpm, t = 3 h. Rotoevaporation: T) 90°C, t = 4 h.		NA	NA	NA	
		Methanol						
		Sodium Hydroxide						
		Phosphoric Acid (H3PO4)						
		Hydrogen Peroxide (H2O2)						
		Benzene						
		Diethylene glycol (DEG).						
		Formic Acid						
		Sodium Chloride						
3	1	Palm Oil	Reaction with pentaerythritol: T= 200°C, inert atmosphere, t=2 h.			T, P atmospheric, vigorous manual shaking	Polymer with a grasslike and brittle consistency. Cream colored. Allows mold flow.	
		PbO						
		Pentaerythritol						
		Tert-butanol (20 ml)						
		Hydrochloric Acid.						
		n-Hexane. (40 ml)						
3	2	Palm oil	Reaction with pentaerythritol: T= 200°C, inert atmosphere, t=2 h.	11.86 mgKOH/g sample	NA	NA	NA	
		PbO						
		Pentaerythritol						
		Tert-butanol (20 ml)						

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Hydrochloric Acid.						
		n-Hexane. (40 mi)						
3	3	Palm oil PbO Pentaerythritol Tert-butanol (20 ml) Hydrochloric Acid. n-Hexane. (40 ml)	Reaction with pentaerythritol: T= 200°C, inert atmosphere, t=2 h.		NA	NA	NA	
5-Method 1	1	Palm oil Maleic Anhydride	Maleinisation: T0 180°C; Nitrogen atmosphere, t = 3h.		Pre-polymer MeKO, HDI, TEA	Reaction with isocyanate: t=3 hr., T=70 °C. MEKO Blockage: T= 50°C, t= 2hr. Neutralization with TEA: T= 50°C, t= 30 min., constant agitation.	This product did not yield varnish, as it became a solid.	
5-Method 2	1	Palm oil Maleic Anhydride Glycerin (99.5% purity) Sodium Hydroxide Sodium Chloride Sulfuric Acid (99.5% purity) Methyl ethyl ketone (MEK) Sulfonic Toluene Acid	Maleinisation: T= 180°C; Nitrogen atmosphere, t = 3h.		Pre-polymer (polyol) MDI Meko TEA	Reaction with isocyanate: t=3 hr., T=70 °C. MEKO Blockage: T= 50°C, t= 2hr. Neutralization with TEA: T= 50°C, t= 30 min., constant agitation.	This varnish exhibits phase separation.	

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Toluene						
		Maleic Anhydride						
		Toluene disiocyanate (TDI)						
		Methyl ethyl Ketoxima (MEKO, 99.5% purity).						
		Ethanol						
7	1	Palm Oil	Reaction with *pentaerythritol*: T= 200°C, inert atmosphere, t=2 h.		Palm Polyol	T, P atmospheric, vigorous manual shaking	Foam with a greasy aspect. Very sticky. Yellow color. Difficult to remove as a whole.	
		PbO			Diethylene glycol			
		Pentaerythritol			Surfactant			
		Tert-butanol (20 ml)			Catalyst			
		Hydrochloric Acid.			Water			
		n-Hexane. (40 ml)			HDI			
7	2	Palm oil	Reaction with pentaerythritol: T= 200°C, inert atmosphere, t=2 h.		Palm Polyol	T, P atmospheric, vigorous manual shaking	This product is a modification of the route initially planned, because the Polyol used iso nly palm oil polyol. Its consistency is a very brittle foam. Clear yellow color. Does not appear greasy and dries more rapidly thatn the product of this route where the polyol	
		PbO			Surfactant			
		Pentaerythritol			Catalyst			
		Tert-butanol (20 ml)			Water			
		Hydrochloric Acid.						
		n-Hexane. (40 ml)			TDI			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
							Combined with the DEG.	
8	1	Palm oil	Methanolysis: T: 70˚C, t = 1.5 h. Agitation 1000 rpm. Rotoevaporation: T= 80˚C, t = 3h., vacuum conditions. Epoxidation: T = 40˚C, Agitation 800 rpm, t = 3 h. Rotoevaporation: T) 90˚C, t = 4 h.		Palm Polyol	T, P atmospheric, vigorous manual shaking	A white foam, appears somewhat porous. Consistent, but appears brittle.	
		methanol			Diethylene glycol			
		Sodium Hydroxide			Surfactant			
		Phosphoric acid (H3PO4)			Catalyst			
		Hydrogen Peroxide (H202)			Water			
		benzene			MDI			
		diethylene glycol (DEG)						
		Formic acid						
		Sodium Chloride						
78	2	Palm oil	Methanolysis: T: 70˚C, t = 1.5 h. Agitation 1000 rpm. Rotoevaporation: T= 80˚C, t = 3h., vacuum conditions. Epoxidation: T = 40˚C, Agitation 800 rpm, t = 3 h. Rotoevaporation: T) 90˚C, t = 4 h.		Palm Polyol	T, P atmospheric, vigorous manual shaking	White color foam. Its appearance is similar to gypsum. Very brittle.	
		methanol			Surfactant			
		Sodium Hydroxide			Catalyst			
		Phosphoric acid (H3PO4)			Water			
		Hydrogen Peroxide (H202)			TDI			
		benzene						
		diethylene glycol (DEG)						
		Formic acid						
		Sodium Chloride						
9	1	Palm oil	Methanolysis: T: 180˚C,		Pre-polymer (polyol)	Reaction with isocyanate:	Coffee-colored varnish.	

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Maleic Anhydride	Nitrogen atmosphere, t= 3 hr.		MEKO, TEA, TDI	t=3 hr., T=70 °C. MEKO Blockage: T= 50°C, t= 2hr. Neutralization with TEA: T= 50°C, t= 30 min., constant agitation.	Easily separated as it does not have low stability, when left in repose two phases are observed and a semisolid layer at the bottom. Pores observed in its interior.	
9-Method 2	1	Palm Oil	Methanolysis: T: 180°C,, Nitrogen atmosphere, t= 3 hr.		Prepolymer (polyol)	Reaction with isocyanate: t=3 hr., T=70 °C. MEKO Blockage: T= 50°C, t= 2hr. Neutralization with TEA: T= 50°C, t= 30 min., constant agitation.	This product did not yield a varnish, as it solidified. Coffee colored solid paste.	
		Maleic anhydride			TDI			
		Glycerin (99,5% purity)			Meko			
		Sodium Hydroxide			TEA			
		Sodium Chloride						
		Sulfuric acid (99,5% purity)						
		Methyl ethyl ketone (MEK)						
		Sulfonic Toluene Acid						
		Toluene						
		maleic anhydride						
		TDI (toluene diisocyanate)						
		Methyl ethyl Ketoxima (MEKO, 99.5% purity).						

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Ethanol.						
5	1. Polyol of crude palm oil using PbO	Palm Oil	Epoxidation:	# OH = 105.52 mg KOH/g sample	Palm polyol	Vigorous agitiation	Rapid growth of the foam which solidified immediately. Rigid foam is not greasy to the touch.	
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarnonate	Agitation: 800 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		*Toluene isocyanate* (TDI)			
		Glycerin	Temp = 215 ˚C					
		Lead Oxide	Time = 45 mins.					
			Agitation: 1300 rpm					
6	1. Polyol of crude palm oil using PbO	Crude palm oil	Epoxidation:	# OH = 202.43 mg KOH/g sample			Reaction with continuous bubbling and release of heat, after a half hour product has not solidified, an excess of isocyanate is observed.	
		Hydrogen Peroxide	Temperature = 50˚C					
		Formic acid	Time: 4 hrs.					
		Sodium Bicarbonate	Agitation: 800 rpm					
		Sodium Chloride	Glycerolysis					
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
7	1. Oil Polyol	RBD Palm Oil	Epoxidation:	# OH = 418.83 mg KOH/g sample	Palm Polyol	Vigorous agitation	Semi-rigid polyurethane, color	

Route	Experiment No. Of RBD NaOH palm.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature	Yellowish, solidified rapidly.	
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
8	1. Polyol of palm oil RBD PbO	RBD Palm Oil	Epoxidation:	# OH = 81.59 mg KOH/g sample	Palm polyol	Vigorous agitation	The product has a grasslike consistence and there was no evience of reaction, such as release of heat.	
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Toluene isocyanate (TDI)			
		Glycerin	Temp = 215 ˚C					
		Lead Oxide	Time = 45 mins.					
			Agitation: 1300 rpm					
Combined 2 and 4	1	Olein Phase of palm oil	Epoxidation:	# OH = 105.52 mg KOH/g sample	Palm polyol	Vigorous agitation	The mixture begins to rise instantly forming a low density foam, it	
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	*Operational conditions*	*Evaluation Results*	*Reagents*	*Operational conditions*	*Product Features*	Evaluation Results
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)		Evidence of a very large pore size and low consistency. This product does not allow flow, nor removal from the mold.	
		Sodium Bicarbonate	Agitation: 800 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Toluene isocyanate (TDI)			
		Glycerin	Temp = 215 °C					
		Lead Oxide	Time = 45 mins.					
			Agitation: 1300 rpm					
	2	Olein Phase of palm oil	Epoxidation:	# OH = 202.43 mg KOH/g sample	Palm Polyol	Vigorous agitation	No evidence of reaction, a viscous yellow liquid pours when emptying the mold. After 1 day it still has not solidified.	
		Hydrogen Peroxide	Temperature = 50°C		Dibutyltin Dilauate (DBTDL)	Ambient temperature		
		Formic acid	Time: 4 hrs.		Silicon 193C			
		Sodium Bicarbonate	Agitation: 800 rpm		Methylene diisocyanate (MDI)			
		Sodium Chloride	Glycerolysis		Water			
		Glycerin	Temp = 215 °C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	3	Olein Phase of palm oil	Epoxidation:	# OH = 418.83mg KOH/g sample	Palm Polyol	Vigorous agitation	Brittle foam that grows rapidly and whose interior is not compact.	
		Hydrogen Peroxide	Temperature = 50°C		Water	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	*Temp = 215 °C*					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	4	Olein Phase of palm oil	Epoxidation:	# OH = 105.52 mg KOH/g sample	Palm Polyol	Vigorous agitation	No evidence of reaction, emptying of the mold yields a viscous yellowish creamy liquid.	
		Hydrogen Peroxide	Temperature = 50°C		Water	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 °C					
		Lead oxide	Time = 45 mins.					
			Agitation: 1300 rpm					
	5	Olein Phase of palm oil	Epoxidation:	# OH = 81.59 mg KOH/g sample	Palm Polyol	Vigorous agitation	A very compact product was obtained but it is very fragile to contact.	
		Hydrogen Peroxide	Temperature = 50°C		Water	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Toluene isocyanate (TDI)			
		Glycerin	Temp = 215 °C					

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Lead oxide	Time = 45 mins.					
			Agitation: 1300 rpm					
	6	Olein Phase of palm oil	Epoxidation:	# OH = 202.43 mg KOH/g sample	Palm Polyol	Vigorous agitation	Material is rigid to the touch, dries quickly, not greasy, pores are smaller than for foams obtained before, medium density. An excess of isocyanate is observed.	
		Hydrogen Peroxide	Temperature = 50°C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 °C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric acid	Agitation: 1300 rpm					
	7	Olein Phase of palm oil	Epoxidation:	# OH = 418.83 mg KOH/g sample	Palm Polyol	Vigorous agitation	Rigid foam, higher density and smaller pore size than the prior one. Color is beige, with a tendency to light yellow.	
		Hydrogen Peroxide	Temperature = 50°C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Toluene isocyanate (TDI)			
		Glycerin	Temp = 215 °C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric acid	Agitation: 1300 rpm					

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
	8	Olein Phase of palm oil	Epoxidation:	# OH = 105.52 mg KOH/g sample	Palm Polyol	Vigorous agitation	Rigid foam, of greater density and lesser pore size than the prior one. Color is beige, with tendency to clear yellow.	
		Hydrogen Peroxide	Temperature = 50°C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 °C					
		Lead oxide	Time = 45 mins.					
			Agitation: 1300 rpm					
	9	Olein Phase of palm oil	Epoxidation:	# OH = 81.59 mg KOH/g sample	Palm Polyol	Vigorous agitation	Rigid foam, medium density and smaller pore size than the prior one. Color is beige, with tendency to clear yellow.	
		Hydrogen Peroxide	Temperature = 50°C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Toluene isocyanate (TDI)			
		Glycerin	Temp = 215 °C					
		Lead oxide	Time = 45 mins.					
			Agitation: 1300 rpm					
	10	Olein Phase of palm oil	Epoxidation:	# OH = 202.43 mg KOH/g sample	Palm Polyol	Vigorous agitation	Rigid sandy polyurethane, good appearance.	
		Hydrogen	Temperature = 50°C		1,6 butanediol (BDO)	Ambient temperature		

Route	Experiment No. 8	*Preparation of polyol*			*Preparation of Polyurethane*			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Peroxide						
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric acid	Agitation: 1300 rpm					
	11	Olein Phase of palm oil	Epoxidation:	# OH = 418.83 mg KOH/g sample	Palm Polyol	Vigorous agitation	A rigid white polyurethane was obtained, very hard. Does not permit agitation because the reaction is very fast.	
		Hydrogen Peroxide	Temperature = 50˚C		1,6 butanediol (BDO)	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric acid	Agitation: 1300 rpm					
	12	Olein Phase of palm oil	Epoxidation:	# OH = 202.43 mg KOH/g sample	Palm Polyol	Vigorous agitation	Beige colored polymer, which exhibited good consistency.	
		Hydrogen Peroxide	Temperature = 50˚C		1,6 butanediol (BDO)	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Sodium Bicarbonate	Agitation: 800 rpm		Silicon 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	*Temp* = 215 °C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric acid	Agitation: 1300 rpm					
	13	Olein Phase of palm oil	Epoxidation:	# OH = 418.83 mg KOH/g sample	Palm Polyol	Vigorous agitation	A white high density foam was obtained, with oval pores, of rigid consistence.	
		Hydrogen Peroxide	Temperature = 50°C		1,6 butanediol (BDO)	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		*Silicon 193C*			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 °C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric acid	Agitation: 1300 rpm					
	14	Olein Phase of palm oil	Epoxidation:	# OH = 32.84 mg KOH/g sample	Palm Polyol	Vigorous agitation	Manually agitated, however no typical features of rection were evidenced (temperature changes, bubbling, and growth of foam), on the contrary, the liquid aspect stayed.	
		Hydrogen Peroxide	Temperature = 50°C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicone emulsion			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
					(MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric acid	Agitation: 1300 rpm					
	15	Olein Phase of palm oil	Epoxidation:	# OH = 88.97 mg KOH/g sample	Palm Polyol	Vigorous agitation	No formation of foam was witnessed.	
		Hydrogen Peroxide	Temperature = 50˚C		1,6 butanediol (BDO)	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Toluene isocyanate (TDI)			
		Glycerin	Temp = 215 ˚C		Ethylenediamine			
		Sodium Hydroxide	Time = 45 mins.		Water			
		Phosphoric acid	Agitation: 1300 rpm					
	16	Olein Phase of palm oil	Epoxidation:	# OH = 88.97 mg KOH/g sample	Palm Polyol	Vigorous agitation	Bubbling was observed, as well as an increase in temperature and the foam that was seen solidifying completely.	
		Hydrogen Peroxide	Temperature = 50˚C		1,6 butanediol (BDO)	Ambient temperature		
		Formic acid	Time: 4 hrs.		Dibutyltin Dilauate (DBTDL)			
		Sodium Bicarbonate	Agitation: 800 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Toluene isocyanate (TDI)			
		Glycerin	Temp = 215 ˚C		Ethylenediamine			
		Sodium Hydroxide	Time = 45 mins.		Water			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	*Operational* conditions	*Product Features*	Evaluation Results
		Phosphoric Acid	Agitation: 1300 rpm					
	17	Olein Phase of palm oil	Epoxidation:	# OH = 401.4 mg KOH/g sample	Palm polyol	Vigorous agitiation	Rigid polyurethane with good consistency although the pore size is big.	
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarnonate	Agitation: 950 rpm		Silicone emulsion			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	18	Olein Phase of palm oil	Epoxidation:	# OH = 401.4 mg KOH/g sample	Palm polyol	Vigorous agitiation	Polymer with a small sized pore and good rigidity properties.	
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarbonate	Agitation: 950 rpm		Silicone emulsion			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	19	Olein Phase of palm oil	Epoxidation	# OH = 437.56 mg KOH/g sample	Palm Polyol	Vigorous agitation	Polymer with a small pore size and	Young module = 33.3293 Mpa

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature	Good properties for rigidity. Chosen for the characterizing range for rigid PU	Maximum effort = 3.1673 Mpa
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarnonate	Agitation: 950 rpm		Silicone emulsion			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	20	Olein Phase of palm oil	Epoxidation:	# OH = 433.08 mg KOH/g sample	Palm polyol	Vigorous agitiation	Presents homogeneity, good pore size, shows good rigidity.	
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarbonate	Agitation: 950 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	21	Olein Phase of palm oil	Epoxidation	# OH = 263.4 mg KOH/g sample	Palm Polyol	Vigorous agitation	Exhibits homogeneity, good pore size and in general good physical appearance.	
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarnonate	Agitation: 950 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 °C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	22	Olein Phase of palm oil	Epoxidation:	# OH = 79.97 mg KOH/g sample	Palm polyol	Vigorous agitiation	It was found that part of the polyol did not react and remained in the lower part, a white foam being found in the upper part. The reaction time was slow.	
		Hydrogen Peroxide	Temperature = 50°C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarbonate	Agitation: 950 rpm		Silicone emulsion			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 °C					
		Sodium Hydroxide	Time = 45 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	23	Olein Phase of palm oil	Epoxidation	# OH = 263.4 mg KOH/g sample	Palm Polyol	Vigorous agitation	This polyurethane presents good features, compared with that of the same Hydroxil number, with DEG, however, its rigidity is less.	
		Hydrogen Peroxide	Temperature = 50°C		1,6 butanediol (BDO)	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium	Agitation: 950 rpm		Silicone 193C			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Bicarbonate						
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 180 ˚C					
		Sodium Hydroxide	Time = 25 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	24	Olein Phase of palm oil	Epoxidation:	# OH = 263.4 mg KOH/g sample	Palm polyol	Vigorous agitiation	This polyurethane exhibts good features, it is a semi-rigid product.	
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarbonate	Agitation: 950 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 180 ˚C					
		Sodium Hydroxide	Time = 25 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	25	Olein Phase of palm oil	Epoxidation	# OH = 263.4 mg KOH/g sample	Palm Polyol	Vigorous agitation	Shows good replicability and is sent for the characterization by density test.	Density = 0.133 g/cm3
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarnonate	Agitation: 950 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Glycerin	Temp = 180 ˚C					
		Sodium Hydroxide	Time = 25 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	26	Olein Phase of palm oil	Epoxidation:	# OH = 263.4 mg KOH/g sample	Palm polyol	Vigorous agitiation	Exhibits good replicability and is sent for the test by characterization of compression.	Young module = 1.32276 Mpa Maximu effort = 0.08760 Mpa
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarbonate	Agitation: 950 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 180 ˚C					
		Sodium Hydroxide	Time = 25 mins.					
		Phosphoric Acid	Agitation: 1300 rpm					
	27	Olein Phase of palm oil	Epoxidation	# OH = 437.66 mg KOH/g sample	Palm Polyol	Vigorous agitation	Polymer with a small pore size and good velocity features. Chosen for the rank of PU characterization by density.	Density = 0.450 g/cm3
		Hydrogen Peroxide	Temperature = 50˚C		Diethylene glycol	Ambient temperature		
		Formic acid	Time: 3 hrs.		Dibutyltin Dilaureate (DBTDL)			
		Sodium Bicarnonate	Agitation: 950 rpm		Silicone 193C			
		Sodium Chloride	Glycerolysis		Methylene diisocyanate (MDI)			
		Glycerin	Temp = 215 ˚C					
		Sodium Hydroxide	Time = 45 mins.					

Route	Experiment No.	Preparation of polyol			Preparation of Polyurethane			
		Reagents	Operational conditions	Evaluation Results	Reagents	Operational conditions	Product Features	Evaluation Results
		Phosphoric Acid	Agitation: 1300 rpm					

CLAIMS

1. A method for the production of polyol from palm oil, characterized by comprising the following steps:

   a. mixing palm oil with maleic anhydride in a reactor at a temperature between 170°C and 190°C

   b. heating and agitating the mixture in step a)

   c. coupling the reactor to a reflux condenser

   d. carrying out the reaction under permanent agitation for 3 hours

2. A method for the production of polyol from palm oil, characterized by comprising the following steps:

   a. mixing, heating and stirring palm oil with sodium hydroxide and a 1:1 solution of ethanol-water

   b. adding concentrate sulphuric acid to the mixture of step a) until the separation of the phases is noted

   c. adding a saturated solution of sodium chloride to the mixture of step b)

   d. discarding the aqueous phase obtained in step c), after the complete separation of the phases

   e. washing with water at a temperature between 70ºC and 80ºC the organic phase left from step d)

   f. heating and shaking the organic phase of step e) and submitting it to evaporation in a vacuum to obtain the fatty acids

   g. mixing the fatty acids obtained in step f) with previously blocked glycerol and a catalyst, heating and shaking

   h. washing with water the mixture of step g) at a temperature between 70°C and 80ºC

   i. separating and discard the aqueous phase obtained in the step h)

j. treating the organic phase remaining from step i) through evaporation in a vacuum to obtain blocked monoglyceride

k. adding maleic anhydride to the blocked monoglyceride from step j), heating and shaking in a low nitrogen atmosphere

l. cooling the mixture from step k) to 100ºC

m. adding sulfuric acid to the product of the reaction in step 1)

n. wash with water to a temperature between 70ºC and 80ºC and decant the product of the reaction obtained in step m)

o. separate the aqueous phase obtained in step m)

p. wash the phase organic obtained in step m)

q. evaporate the organic phase of step n) to obtain the polyol

3. A method in accordance with claim 2 wherein the heating temperature in step a) varies between 75°C and 85ºC and the time of reaction varies between 28 and 32 minutes.

4. A method in accordance with claims 2 and 3 wherein the step of washing e) is performed up to the point where the pH is neutral.

5. A method in accordance with claims 6 to 10 wherein the organic phase of step f) is heated to a temperature between 75°C and 85ºC.

6. A method in accordance with claims 2 to 5, wherein the previously blocked glycerol of step g) is obtained through the following steps:

a. mixing glycerol, MEK (Methyl ethyl ketone), to sulfonic toluene acid as a catalyst and toluene

b. heating the mixture of step a) to a temperature between 85 and 95°C for a time between 110 and 130 minutes to obtain blocked glycerol.

7. A method in accordance with claims 2 to 6, wherein the mixture of step f) is heated to a temperature between 75°C and 85°C, for a time between 2 and 3 hours.

8. A method in accordance with claims 2 to 6, wherein the step of washing h) is is performed until the pH is neutral.

9. A method in accordance with claims 2 to 8 wherein the evaporation of step j) is carried out at a temperature between 85ºC and 95°C and for a period between 3 and 4 hours.

10. A method in accordance with claims 2 to 8 wherein the reaction temperature of step k) varies between 190°C and 210°C and the time of reaction varies between 170 and 190 minutes.

11. A method in accordance with claims 2 to 10 wherein the cooling of step 1) is carried out until the mixture acquires a temperature of 100ºC, without stop the agitation.

12. A method in accordance with claims 6 to 17, wherein in step n) the time of reaction varies between 50 and 70 minutes.

13. A method in accordance with claims 6 to 18, wherein the evaporation of step q) is carried out at a temperature between 75°C and 85ºC and for a period of between 1 and 2 hours.

14. A method for the production of polyol to from palm oil, characterized by comprising the following steps:

a. mix palm oil with glycerol, terbutanol as solvent and sodium hydroxide as catalyst in the presence of heat

b. cooling the mixture of step a)

c. neutralizing the product of the reaction in step a) with hydrochloric acid at 10%

d. removing the glycerol and the residual solvent of the mixture in step c)

e. submitting the product of step b) to evaporation for removal of solvent

f) separating the organic phase obtained in step c) by addition of n-hexane, allowing discarding of the residual glycerin and finally obtaining polyol

15. A method in accordance with claims 14, wherein the reaction temperature of step a) varies between 85ºC and 95ºC and the time of reaction varies between 110 and 130 minutes.

16. A method in accordance with claims 14 or 15, wherein in step b) the mixture is left to cool to ambient temperature.

17. A method in accordance with claims 14 to 16, wherein the evaporation of step e) is carried out at a temperature between 85ºC and 95°C and for a period between 2 and 3 hours.

18. A method for the production of polyol from palm oil, characterized by comprising the following steps:

a. Mixing palm oil, pentaerythritol and lead oxide, in the presence of heat, agitation and an inert nitrogen atmosphere.

b. cooling the mixture of step a)

c. treating mixture of step b) with n-hexane, allowing the formation of two phases, stirring and releasing the pressure.

d. discarding the precipitate obtained in step c) which contains glycerol

e. submitting the organic phase to evaporation for obtaining the polyol

19. A method in accordance with claim 18, wherein the reaction temperature of step a) varies between 195°C and 205°C, and the time of reaction varies between 110 and 130 minutes.

20. A method in accordance with claims 18 or 19, wherein in step b) the mixture is left to cool to ambient temperature.

21. A method in accordance with claims 18 to 21, wherein the evaporation of step e) is carried out at a temperature between 65°C and 75°C and during a period between 2 and 3 hours.

22. Method for the production of polyol from palm oil, characterized by comprising the following steps:

a. producing fatty acid methyl esters (FAME) from the following steps:

- mix palm oil, methanol and sodium hydroxide at a temperature between 65°C and 75°C and agitate during a period between 1 and 2 hours

- discard the glycerin phase that is at the bottom after the previous reaction
- wash the phase of interest obtained in the first step with 0,015N phosphoric acid at a temperature between 55°C and 65°C
- discard solids formed
- wash the product obtained in the previous step with water at a temperature between 55°C and 65°C until the pH this is neutral
- evaporate the product of the previous step (FAME) to remove excess methanol at a temperature between 75°C and 85ºC and during period between 2 and 3 hours.

b. mix FAME obtained in step a) with formic acid in the presence of hydrogen peroxide

c. wash the product obtained in step b) with water at a temperature between 50°C and 60ºC

d. wash the product obtained in step c) with sodium bicarbonate at 5%

e. wash the product obtained in step d) with sodium chloride at 5%

f. wash the product obtained in step e) with water at a temperature between 50°C and 60ºC

g. evaporate the solution obtained in step c) to remove the moisture allowing obtaining the polyol

23. A method in accordance with claim 22, wherein the reaction temperature in step b) varies between 40ºC and 50ºC and the time of reaction varies between 10 and 11 hours, after of the addition of hydrogen peroxide.

24. A method in accordance with claims 22 or 23, wherein the washing step c) is performed until the pH of the solution is 5.

25. A method in accordance with claims 22 to 24, wherein the washing in step f) is performed until the pH is neutral.

26. A method in accordance with claims 30 to 36, wherein the evaporation of step g) is carried out at a temperature between 70ºC and 90ºC and for a period between 3 and 4 hours.

27. A method for the production of polyol from palm oil, characterized by comprising the following steps:

a. mix a source of palm oil with formic acid, in the presence of heat

b. add hydrogen peroxide to the mixture of step a) and shake

c. wash the reaction product of step b) with water, at a temperature between 55°C and 65 ºC

d. wash the product obtained in the step c) with sodium bicarbonate at 5%

e. wash the product of reaction of step d) with water, at a temperature between 55°C and 65ºC

f. wash the product obtained in step e) with sodium chloride at 5%

g. discard the phase aqueous obtained in step f)

h. dry to the empty the phase organic remaining of step f)

i. mix the epoxidized oil obtained in step g) with glycerol and catalyst, in the presence of heat and agitation

28. A method in accordance with claim 27, wherein the source of palm oil in step a) is the olein phase of crude palm oils.

29. A method in accordance with claim 27, wherein the source of palm oil in step a) is the olein phase of refined bleached and deodorized palm oil (RBD).

30. A method in accordance with claims 27 to 29, wherein the catalyst of step h) is lead oxide.

31. A method in accordance with claims 27 to 29, wherein the catalyst of step h) is sodium hydroxide.

32. A method in accordance with claims 27 to 29, wherein the washing of step c) is performed until the pH of the solution is 5.

33. A method in accordance with claims 27 to 32, wherein the reaction temperature of step b) varies between 45°C and 55°C and the time of reaction varies between 1 and 2 hours after of the addition of hydrogen peroxide.

34. A method in accordance with claims 27 to 32, wherein the reaction temperature of step i) varies between 170°C and 190°C and the time of reaction varies between 40 and 50 minutes.

35. A polyol characterized by having a molecular weight between 374 and 3366 and 374, with a hydroxyl number between 50 and 450 mgKOH/g sample.

36. A rigid polyurethane foam characterized by having a density between 0.284 g/cm^3 and 0.658 g/cm^3 , Young module between 8.94522 MPa and 54.92330 MPa and maximum effort between 0.92037 MPa and 8.29101 MPa.

37. Semirigid polyurethane foam characterized by having a density between 0,120 g/cm^3 and 0.158 g/cm^3 , Young modulo between 0.78727 MPa and 1.54311 MPa, and maximum effort between 0.07012 MPa and 0.09753 MPa.