

POLYURETHANE FOAMS FROM PALM OIL AND PALM OIL PRODUCTS

TECHNICAL FIELD

The present invention relates to a process for the production of polyurethane foams (hereinafter referred to as PUFs), and in particular, to a process that can predictably produce various types of polyols from palm oil and palm oil products (hereinafter referred to as POP) to yield tailor made PUFs depending on the choice of raw materials and additives.

10 BACKGROUND ART

The main raw materials used for the production of PUFs are polyols, diisocyanates and blowing agents. More than 90% of the polyols currently used for the production of PUFs worldwide are based on polyethers derived from ethylene or propylene oxides. The structures, molecular weights and functionalities of the polyols play a vital role in determining the properties of the final polyurethane polymer. The characteristics of the polyols used to make flexible and rigid polyurethane foams are as given below.

2-8540738

Characteristics of polyols	Flexible PUF	Rigid PUF
Molecular Weight	1000-6500	150-1600
Functionality	2-3	3-8
Hydroxyl Value	28-160	250-1000

Source: George Woods (1987)

Several aromatic and aliphatic diisocyanates are available. However, more than 95% of the PUFs produced are based on two of them i.e. toluene diisocyanate (TDI) and methylene diphenyl diisocyanate (MDI). Owing to the high volatility of TDI, MDI is gaining in popularity.

Water is added in the polyurethane formulation to react with the diisocyanates to yield carbon dioxide gas which acts as a blowing agent to generate the foam structure. Normally other blowing agents are added to boost the performance. The normal blowing agents added into the polyurethane formulation used to be chlorofluorocarbons (CFCs). However, due to the harmful effects of CFCs to the environment, other blowing agents are being sought after and pentane and cyclopentane are possible alternatives.

Besides these three raw materials, other additives are frequently added to the polyurethane formulation either to increase the rate of reaction, to improve the foam structure/performance, to assist demoulding and/or to retard flammability. Diamines, silicone surfactants, flame retardants and organotin compounds are frequently added into the formulation to increase the rate of reactions, modify the foam structures and reduce flammability. Mould releasing agents are also used for easy removal of the cured PUFs from the moulds.

Except for organotin compounds, all of the above materials are petrochemical-based. There has been interest to find alternative sources for raw materials used in PUF production and materials from renewable resources such as oils/fats which offer interesting possibilities as disclosed in US Patent Nos. 5,075,417, 4,825,004.04 and 3,637,540. The Proceedings of PORIM International Palm Oil Conference, 1993 and US Patent Nos. 4,508,853 and 4,742,087 have indicated that when oil/fats (including palm oil) are epoxidized, they can be reacted with any polyhydric alcohols to yield polyols. These polyols can be reacted or mixed with diisocy-

anates to yield polyurethane prepolymers used mainly in the adhesive fields as disclosed in US Patent Nos. 4,508,853 and 4,742,087.

5 In Malaysia, the interest to produce polyols from palm oil started in the late eighties and early 'nineties. Although there were several technologies available to produce polyols from oils/fats, there were doubts on the suitabilities of these technologies to be used for palm oil since it is semi-solid at room temperature (and not liquid compared to other
10 oils). Early attempts indicated difficulty in getting reproducible PUFs despite the fact that similar raw materials were being fed into the process. In these cases however, the type of POP used was never clearly specified.

DISCLOSURE OF THE INVENTION

15 The present invention comprises a specific combination of process steps, with the aim to produce polyurethane foams of predictable properties from POP based polyols and other non-petrochemical based raw materials.

For the purposes of this invention POP consists of the
20 following:-

a) Crude palm oil which is the oil extracted from the mesocarp of an oil palm fruit;

b) Crude palm olein which is the liquid fraction obtained after fractionating crude palm oil;

5 c) Crude palm stearin which is the solid fraction obtained after fractionating crude palm oil;

d) Refined, bleached and deodorized palm oil which is the product obtained after crude palm oil has been subjected partially or fully to physical or chemical refining. Herein
10 physical refining refers to the process where crude oil is subjected to degumming with phosphoric acid, bleaching with bleaching earth and deodorization under vacuum at high temperature; and chemical refining refers to the process
15 where crude oil is subjected to neutralisation with caustic soda, bleaching with bleaching earth and deodorization under vacuum at high temperature;

e) Refined, bleached and deodorized palm olein is the product obtained after crude palm olein is subjected either

partially or fully to the physical or chemical refining process or it is the liquid fraction obtained when refined palm oil is fractionated.

5 f) Refined, bleached and deodorized palm stearin is the product obtained after crude palm stearin is subjected either partially or fully to the physical or chemical refining process or it is the solid fraction obtained when refined palm oil is fractionated; and

10 g) Palm kernel oil which is oil extracted from the kernel of an oil palm fruit.

The present invention provides a process for preparing polyurethane foam from palm oil or a product thereof, the process comprising:

15 (i) preparing epoxidised palm oil by epoxidation of palm oil;

(ii) reacting the epoxidised palm oil with a monohydric or polyhydric alcohol in the presence of a catalyst to form a polyol;

(iii) mixing with the polyol one or more additives that are conventional in the preparation of polyurethane foams; and

(iv) mixing with the polyol of step (ii) or the polyol mixture of step (iii) with an isocyanate to form a polyurethane foam,

characterised by preparing the epoxidised palm oil in step (i) by reacting palm oil with an acid selected from peroxyacetic acid and performic acid, and by the mole ratio monohydric or polyhydric alcohol to unsaturated groups originally present in the palm oil that has been converted into epoxide rings to form epoxidized palm oil and palm oil products [EPOP] in step (ii) being $\geq 1:3$.

The mole ratio monohydric or polyhydric alcohol to unsaturated groups originally present in the palm oil that has been converted into epoxide rings to form EPOP in step (ii) is in the range of 1:0, 6:1, 5:1, 4:1, 3:1, 2:1, 1:1, 1:2 or 1:3. However the preferred ratios to obtain maximum input are 3:1, 2:1, 1:1, 1:2 and 1:3.

The process as hereinbefore mentioned is preferably carried out at atmospheric pressure.

The epoxidized palm oil and palm oil products [EPOP] according to the invention may be refined, bleached and deodorized palm olein (RBDPOo), refined, bleached and deodorized palm

oil (RBDPO), refined, bleached and deodorized palm stearin (RBDPOs), crude palm oil (CPO), crude palm olein (CPOo) or crude palm stearin (CPOs).

In step (ii) any suitable monohydric or polyhydric alcohols may be utilised. For example, glycerol derived from POP may be used.

It may be appreciated that a wide variety of auxiliary additives may be added to control and modify both the polyurethane foam producing process itself and the properties of the final polyurethane foam product. These additives known from prior art include blowing agents, surfactants, catalysts and flame retardants. In this invention water is the only blowing agent used. Alternatively other suitable blowing agents such as pentane and cyclopentane may be used.

As is already known, the reaction between polyols and isocyanates is the most important reaction for the preparation of polyurethane. In step (iv) the isocyanate of preferred use is 4,4'-diphenylmethane diisocyanate (MDI). Optionally toluene diisocyanate (TDI) may be used.

A publication describes the production of polyurethane prepolymers having excess isocyanates. The forming of this prepolymer is to avoid viscosity increase during the storage of polyols. However, in the present invention the polyol mentioned in step (ii) is produced only prior to its reaction with the isocyanate and subsequent formation of the polyurethane foam in the same pot to overcome said viscosity problems.

Another advantage of this invention is that by selecting the mole ratio between said monohydric or polyhydric alcohols and the degree of unsaturation originally present in the palm oil that has been converted into epoxide rings to form EPOP, and the type and concentration of the additives used, the hydroxyl value of the polyol and thereby the nature of the polyurethane foam may be predictably forecast.

The present invention allows the production of tailor made polyurethane foams for use as thermal insulators, construction materials, furniture and many other varied applications.

5 BEST MODE FOR CARRYING OUT THE INVENTION

In order that the invention may be more readily understood and put into practical effect, the invention will now be described with reference to the accompanying flowchart, tables, figures and specific example.

- 10 The process as hereinbefore described involves initially the formation of EPOP in what is known as the epoxidation process. For this purpose, peroxyacetic acid [PAA] and performic acid [PFA] generated in situ is found to be suitable.

However, PAA gives a better yield and the epoxidation process is better controlled especially at pilot plant scale. In this invention therefore the use of PAA is preferred.

5 The said epoxidation process involves formation of PAA by reacting glacial acetic acid with hydrogen peroxide (35% to 60%) in the presence of a catalyst. A ratio of 2.06:1 glacial acetic acid to hydrogen peroxide (of 30% concentration) in the presence of 1% to 2% catalyst is found to give the highest PAA content. Once the formation of PAA is completed,
10 the catalyst is neutralised with sodium acetate and the actual weight of PAA available in the mixture is calculated/determined.

The iodine value of the oil to be epoxidized is determined by using the AOCS Official Method Da 15-48. The iodine value
15 measures the degree of unsaturation present in the oil. Based on the fact that one mole of PAA will react with one mole of unsaturation, the amount of POP to fully react with the available PAA is calculated [see Method 2], weighed and added to the PAA.

20 PAA reacts with the unsaturated bonds present in the oil to

form epoxide rings. After the epoxidation is completed which is determined by the presence of the oxirane oxygen content [see Method 3] or the reduction in PAA content, the spent acid is removed. The epoxidized oil is then washed until
5 neutral and dried. The product formed during this process is known as epoxidized palm oil and palm oil products [EPOP] (see Table 1(a) and 1(b)).

It may be noted that the higher the degree of unsaturation present in the oil, the higher is the oxirane oxygen con-
10 tent. Therefore due to its higher degree of unsaturation, palm olein is found to produce epoxidized products having the highest oxirane oxygen content as compared to palm oil and palm stearin.

The resulting EPOP is then reacted with pure glycerol (99%)
15 (preferably derived from palm oil and palm oil products), in the presence of boron trifluoride in ether (as catalyst) to yield polyols.

The best characteristic that describes polyols is their hydroxyl values. In this process, depending on the mole
20 ratio between glycerol and the degree of unsaturation origi-

nally present in the palm oil that has been converted into epoxide rings to form EPOP, polyols of various hydroxyl values can be obtained. The hydroxyl value in turn determines the type of polyurethane foam obtained. Since the
5 amount of unsaturation originally present in the oil has been determined, the mole ratio can now be calculated. As a result, the hydroxyl values of the polyols produced can be reliably predicted and so similarly the types of foams to be produced from them.

10 The polyols obtained from EPOP are then allowed to react with 4, 4'-diphenylmethane diisocyanate [MDI] with vigorous stirring. Water is used as the only blowing agent in this process. The polyols react with MDI to form polyurethane polymers while the presence of water helps in the generation
15 of carbon dioxide in situ thus resulting in the formation of cell structures or foams. The production of polyols and PUFs are carried out in one pot. The polyols are prepared just prior to the production of the said foams.

The amount of water added influences the structure and
20 density of foams produced. In this invention, this finding

introduces another parameter which can be varied when aiming for tailormade products (see Table 2).

Other additives such as silicone surfactants (e.g. Tegostab B4-113), triethylene diamine in dipropylene glycol (e.g. A33), diethanolamine (99%) and flame retardants are added to the polyols before the addition of water. The typical examples of foams produced in this invention are given in Table 2.

This process of producing PUFs has been extensively and comprehensively tested using commercially available POP. In all these cases the process has produced predictable results (see Figure 1) allowing the forecast of the types of PUFs to be produced (see Figures 2 to 5).

This predictability allows the production of tailormade foams required for various applications such as insulators, construction materials, furniture etc. depending on the type of raw materials and additives chosen (see Table 2).

In order that this invention may be readily understood, the whole production process as described in this invention is indicated in the flowchart below wherein:

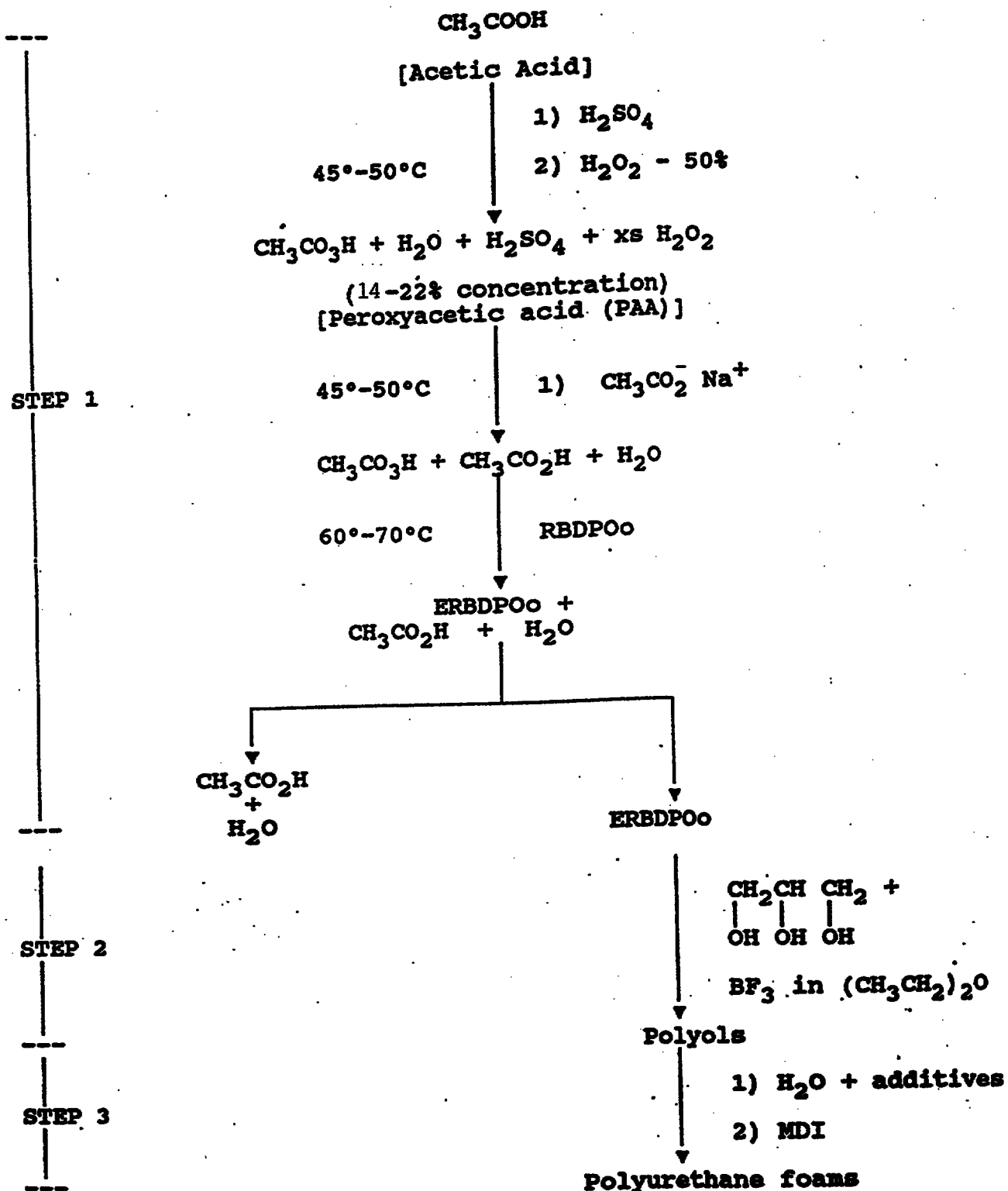
Step 1 indicates the production of epoxidized
palm oil and palm oil products [EPOP]

5

Step 2 indicates the production of polyols

Step 3 indicates the production of
polyurethane foams [PUFs]

THE PRODUCTION PROCESS AS DISCLOSED IN THIS INVENTION



SPECIFIC EXAMPLE USING REFINED, BLEACHED AND DEODORIZED PALM OLEIN (RBDPOo) IN THE PRODUCTION OF POLYURETHANE FOAMS AS INSULATORS

Chemicals Used

1. Glacial acetic acid
2. Hydrogen peroxide (35% - 60%)
3. Concentrated sulfuric acid
4. Sodium acetate (1.5%)
5. Refined, bleached and deodorized palm olein (RBDPOo)
6. Anhydrous sodium sulfate
7. Epoxidized RBDPOo
8. Glycerol 99% pure
9. Boron trifluoride in diethyl ether (48%)
10. 4,4'-Diphenylmethane diisocyanate (MDI)
11. Water
12. Silicone surfactants (e.g. Tegostab B4-113)
13. Diethanolamine 99% pure (DEA)
14. A33 (NIAX catalyst, 33% triethylenediamine and 67% monopropylene glycol, a product of Union Carbide, USA).
15. Flame retardants (e.g. Antimony trioxide or Melamine)
16. Mould releasing agent (preferably water based).

Procedure

In the production of epoxidized refined, bleached and deodorized palm olein (ERBDPOo) using peroxyacetic acid (PAA), glacial acetic acid and 1 to 2% sulfuric acid which is used as a catalyst are mixed together in an apparatus that has been passivated, equipped with a stirrer and condenser. The mixture is stirred for about 30 minutes. The concentration of commercially available hydrogen peroxide ranges from 35% to 60%. Any of these concentrations may be used and a 50% concentration is given as an example in this invention. Hydrogen peroxide is added to the mixture dropwise with continuous stirring. The temperature increases, however, the addition rate is controlled so that the temperature of the reaction is not allowed to exceed 45°C.

After the addition of hydrogen peroxide is completed, the mixture is stirred until a maximum percentage of PAA is formed (measured by using Method 1) or when the hydrogen peroxide has been exhausted. This normally takes about 4 hours. The maximum percentage of PAA obtained ranges from 14% to 22% depending on the concentration of hydrogen peroxide used. Once the maximum percentage of PAA is obtained,

the catalyst is neutralized with an appropriate amount of sodium acetate. It is added to the reaction mixture and stirred for 1 hour.

Based on the percentage of PAA obtained and assuming that one mole of PAA will react with one mole of unsaturation (as indicated by the iodine value) the maximum amount of refined, bleached and deodorized palm olein (RBDPOo) that can react with the available PAA is calculated using Method 2. For a given amount of PAA, the maximum amount of RBDPOo that can be epoxidized will vary depending on the degree of unsaturation present in the oil. The higher the unsaturation the lower the amount.

The RBDPOo is then added to the PAA. Alternatively the PAA may be added to the oil. It is more convenient to add the oil to the PAA when a small amount of sample is being prepared. However, when a large amount of sample needs to be prepared, it is difficult to control the temperature of the reaction due to the reactivity of the oil. In this case it is better to add the PAA to the oil. The PAA is added slowly

to the RBDPOo with continuous stirring. The temperature of the reaction will slowly increase with the addition of PAA. The rate of addition is controlled in such a way that the temperature of the reaction is not allowed to exceed 70°C. A
5 constant rate of addition may be properly controlled if the temperature of the reaction is maintained between 55°C to 60°C.

Once the addition of PAA to the oil or oil to the PAA is completed, the mixture is stirred for an additional 30
10 minutes. The presence of epoxide rings [measured in terms of the oxirane oxygen content using Method 3] indicate that reaction has taken place. The reaction is monitored for the maximum oxirane oxygen content. Once obtained, the stirring is stopped and the epoxidized RBDPOo (ERBDPOo) is allowed to
15 separate from the PAA. The spent PAA is removed and the ERBDPOo is washed several times with water until neutral. The epoxidized oil is then dried using anhydrous sodium sulphate if the amount is small, or a vacuum dryer if the quantity is large. Following this, the mixture has to be

filtered, before the epoxidized oil is used for the production of PUFs.

In the production of a small volume of PUFs (referred to as Procedure 2a in Table 2), an appropriate amount of glycerol is weighed and placed into a heat resistant and non-break-
5 able container. The glycerol is heated to 90°C. After which 1% of total weight (amount of glycerol and 150 g of epoxidized oil) of boron trifluoride in diethyl ether (48%) is added to the glycerol and stirred vigorously (>1000 rpm).
10 150 g of ERBDPOo is added to the glycerol mixture and vigorously stirred for 10 - 15 minutes. The product formed is a polyol. A 100 g of the said polyol while still hot is weighed and added into another heat resistant and non-break-
15 able container. For this purpose a plastic cup that has been cut on one side and resealed with a tape may be used. The said polyol is then mixed with 1g of silicone surfactant, 1g of A33, 1g of DEA, 10g of flame retardant and the desired amount of water. The mixture is vigorously stirred for 3 minutes until all the additives are thoroughly mixed with
20 the polyol. Then 60g of MDI is added and the vigorous

stirring continued until bubbles begin to appear. The stirring is then stopped and the stirrer is removed. The polyurethane foam is allowed to rise freely in the plastic cup and it is allowed to stand until it is fully cured. The tape on the plastic cup is removed, the foam is taken out of the plastic cup by opening the cup at the cut. The polyurethane foam is then cut into cubes and tested for density, thermal insulation characteristics and flame retardant characteristics if necessary (see Table 2 and Figures 2 to 5).

However, it may be noted that the procedure involved in the production of a large volume of PUFs (referred to as Procedure 2b in Table 2) varies slightly from that of a small volume of PUFs. In this procedure, a suitable mould is selected (e.g. 35cm x 35 cm x 4.5cm internal measurement, 45cm x 45cm x 10cm external measurement, aluminium block with cover, 44.3 cm x 44.3 cm x 5cm). The mould is thoroughly lubricated with a suitable releasing agent, preferably water-based (e.g. Acmos 35-3053H). An appropriate amount of glycerol (99% pure) is weighed and added into a heat resistant and non-breakable container. The glycerol is heated to

90°C. An appropriate amount of boron trifluoride in diethyl ether (48%) is added to the glycerol and stirred vigorously for 10 to 15 minutes. An appropriate amount of ERBDPOo is added to the glycerol mixture and vigorous stirring is continued for 10 to 15 minutes. An appropriate amount of silicone surfactant, A33, 99% DEA, the desired amount of water as the blowing agent and the desired amount of flame retardant(s) are added to the polyol. The mixture is vigorously stirred until all additives are thoroughly mixed with the polyol. An appropriate amount of MDI is added and vigorous stirring is continued until bubbles begin to appear. The stirring is stopped and the stirrer is removed. The polyurethane foam is poured into the mould and covered. The polyurethane foam is allowed to cure in the mould (4-5hrs).

METHOD 1

ANALYSIS OF HYDROGEN PEROXIDE AND PEROXYACETIC ACID CONTENT

Chemicals used:-

1. Sample = 0.5 gm
2. H_2SO_4 4N = 50 ml
3. Saturated KI solution = 2 ml
4. KMnO_4 (0.1 N) = x ml
5. $\text{Na}_2\text{S}_2\text{O}_3$ (0.1 N) = y ml
6. Starch indicator

Procedure:-

The 4N sulfuric acid is first cooled to 0°C . - 5°C . After which 50 ml of the said acid is added to the sample. Titration is immediately done with 0.1N KMnO_4 till a pink end-point (x ml) is reached. To the same solution is then added 2 ml of KI solution. The starch indicator is added and the liberated iodine is titrated with 0.1N $\text{Na}_2\text{S}_2\text{O}_3$ (y ml).

Calculation:-

1. Amount of KMnO_4 consumed is equivalent to amount of H_2O_2 left.

$$\% \text{H}_2\text{O}_2 = \frac{1.7 \times \text{ml of } \text{KMnO}_4 \times \text{N of } \text{KMnO}_4}{\text{Weight of sample}}$$

2. Amount of $\text{Na}_2\text{S}_2\text{O}_3$ consumed is equivalent to amount of $\text{CH}_3\text{CO}_3\text{H}$ present.

$$\% \text{PAA} = \frac{76 \times \text{ml of } \text{Na}_2\text{S}_2\text{O}_3 \times \text{N of } \text{Na}_2\text{S}_2\text{O}_3}{20 \times \text{wt. of sample}}$$

METHOD 2

CALCULATION ON THE AMOUNT OF OIL TO BE USED WITH
PEROXYACETIC ACID

5	Let the percentage of the peroxyacetic acid obtained be	A
	Let the total weight in g of the peroxyacetic acid solution be (weight glacial $\text{CH}_3\text{COOH} + \text{H}_2\text{O}_2$)**	B
10	Let the iodine value of palm oil and palm oil products be	$\frac{\text{C g I}_2}{100\text{g sample}}$
	Molecular weight of peroxyacetic acid	76
	Molecular weight of iodine	253.8
	Calculation:-	
15	B g of preformed peroxyacetic acid solution contains g of peroxyacetic acid.	$B \cdot A / [100]$
	This is equivalent to mole of peroxyacetic acid	$B \cdot A / [76 \cdot 100]$
	1 g of oil will consume g of iodine	$C / [100]$
20	This is equivalent to mole of iodine and mole of unsaturation	$C / [253.8 \cdot 100]$
	Assuming that:-	
25	One mole of iodine will react with one mole of unsaturation and one mole of unsaturation will react with one mole of peroxyacetic acid	

Then:-

Mole of unsaturation required to react with
the available peroxyacetic acid is

$$B^*A/[7600]$$

This unsaturation is contained in
g of oil sample

$$\frac{B^*A \times 253.8}{[76^*C]}$$

** The total weight of peroxyacetic acid can be assumed to be equal to the weight of glacial acetic acid + hydrogen peroxide. However, if the PAA solution has to be taken out from the reactor, some loss is expected. In this case, it is better to weigh the available PAA solution exactly.

METHOD 3

DETERMINATION OF OXIRANE OXYGEN CONTENT

Chemicals/solvents used:-

- | | | |
|------|--|-------|
| 1. | Toluene | 10ml |
| 5 2. | Crystal violet indicator | |
| 3. | 0.1N hydrogen bromide
solution 0.1N | x ml |
| 4. | Sample | 0.5 g |

Procedure:-

- 10 0.5g of sample is weighed and placed into an Erlenmeyer flask and dissolved in toluene. The crystal violet indicator is added and titration is done with 0.1N HBr solution till a bluish green end-point that persists for 30 seconds is reached.

15 Oxirane Oxygen Content (%) =
$$\frac{\text{ml of HBr soln} \times \text{N HBr} \times 1.6}{\text{weight of sample used}}$$

TABLE 1A

EXAMPLE OF EPOXIDATION RESULTS

CHEMICALS USED		EXAMPLE 1	EXAMPLE 2
5	Glacial acetic acid	2422 g	1211 g
	Concentrated sulfuric acid	46.5 g	23.5 g
	Hydrogen peroxide (concentration)	50%	35%
	Hydrogen peroxide (amount)	2224 g	1112 g
	Peroxyacetic acid (concentration)	21%	14.2%
10	Sodium acetate	69.7 g	35.5 g
	Refined, bleached and deodorised palm olein (IV = 56.9)	5726 g	1936 g
	Weight of PAA obtained	4646 g	2323 g
15	Procedure	PAA is added to oil	Oil is added to PAA
	Epoxidized RBD Palm Olein*	5000 g	1690 g
	Oxirane oxygen content (%)	3.18	3.15

*Maximum oil loss occurs during the washing step, drying and filtration.

TABLE 1B: CHARACTERISTICS OF EPOXIDIZED PALM OIL
AND PALM OIL PRODUCTS

5	PARAMETERS	EPOXIDIZED CRUDE PALM OIL	EPOXIDIZED REFINED PALM OIL	EPOXODIZED REFINED PALM OLEIN	EPOXIDIZED REFINED PALM STEARIN
	Oxirane Oxygen content (%)	2.53	2.84	3.15	2.37
10	Iodine Value (final)	0.57	0.51	0.44	0.19
	Acid Value	1.33	0.53	1.14	0.32
	Refractive Index (at 20°C)	1.465	1.464	1.466	1.454 (at 50°C)
15	Color (Lovibond)	1R 8Y	1.7R 9Y	1R 4Y	1R 5Y
	Apparent density	0.923 at 50°C	0.921 at 50°C	0.941 at 25°C	0.905 at 60°C

TABLE 2: INSULATORS FROM ERBDPO_o

EXAMPLES INGREDIENTS	3 GUN31	4 GUN21	5 GUN11	6 GUN12	7 GUN13	8 GUN13	9 GUN13
ERBDPO _o (g)	150	150	150	150	150	150	750
GLYCEROL (g)	94.2	62.8	31.4	15.7	10.5	10.5	52.5
BF ₃ In ether (ml)	2.2	1.9	1.6	1.5	1.4	1.4	7.0
POLYOLS (g)	100	100	100	100	100	100	500
WATER (g)	5	10	20	30	40	50	200
SILICONE SURFACTANT (g)	1	1	1	1	1	1	5
DIETHANOL AMINE (g)	1	1	1	1	1	1	5
TRIETHYLENE DIAMINE (g)	1	1	1	1	1	1	5
FLAME RETARDANT (g)	10	10	10	10	10	10	50
MDI	60	60	60	60	60	60	300
PROCEDURE	2a	2a	2a	2a	2a	2a	2b
FOAM-TYPE	semi- rigid	rigid	rigid	semi- rigid	semi- rigid	semi- rigid	semi- rigid
FOAM-STRUCTURE	fine	fine	fine	fine	coarse	coarse	coarse
DENSITY (kg/m ³)	250-265	296-210	186-188	136-185	145-154	171-176	145-154
HEAT LOSS (Δ T/min)	0.208	0.295	0.340	0.223	0.259	0.433	0.259



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CLAIMS:

1. A process for preparing polyurethane foam from palm oil or a product thereof, the process comprising:

(i) preparing epoxidised palm oil by epoxidation of palm oil;

(ii) reacting the epoxidised palm oil with a monohydric or polyhydric alcohol in the presence of a catalyst to form a polyol;

(iii) mixing with the polyol one or more additives that are conventional in the preparation of polyurethane foams; and

(iv) mixing the polyol of step (ii) or the polyol mixture of step (iii) with an isocyanate to form a polyurethane foam,

characterised by preparing the epoxidised palm oil in step (i) by reacting palm oil with an acid selected from peroxyacetic acid and performic acid, and by the mole ratio monohydric or polyhydric alcohol to unsaturated groups originally present in the palm oil that has been converted into epoxide rings to form epoxidized palm oil and palm oil products [EPOP] in step (ii) being $\geq 1:3$.

2. A process according to claim 1, wherein the mole ratio is in the range 1:3 to 6:1.

3. A process according to claim 2, wherein the mole ratio is selected from 3:1, 2:1, 1:1, 1:2 and 1:3.



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4. A process according to claim 1, wherein the epoxidised palm oil is fully saturated.

5. A process according to claim 1, which is carried out at atmospheric pressure.

5 6. A process according to claim 1, wherein the epoxidised palm oil is selected from refined, bleached and deodorised palm olein; refined, bleached and deodorised palm oil; refined, bleached and deodorised palm stearin; crude palm oil; crude palm olein; and crude palm stearin.

10 7. A process according to claim 1, wherein the alcohol used in step (b) is glycerol.

8. A process according to claim 7, wherein the glycerol is derived from palm oil, or a product thereof.

9. A process according to claim 1, wherein the one or
15 more additives are selected from a blowing agent, a surfactant, a catalyst, a flame retardant and mixtures thereof.

10. A process according to claim 9, wherein a blowing agent is mixed with the polyol, the blowing agent being water.



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11. A process according to claim 1, wherein the acid is peroxyacetic acid.

12. A process according to claim 1, wherein the isocyanate is 4,4'-diphenylmethane diisocyanate.

5 13. A process according to claim 1, which comprises selecting said mole ratio and the components, and their amounts, that are used, thereby controlling the hydroxyl value of the polyol and thus the nature of the polyurethane foam.

10 14. A process according to claim 1, which is carried out in one pot.

15. A polyurethane foam obtained by a process according to any preceding claim.

16. Use of a foam as defined in claim 15, as a thermal
15 insulator or a building material.

17. Use of a foam according to claim 15 in furniture.