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(72) Inventeurs/Inventors:

Frische, Rainer, DE;
Volkheimer, Jurgen, DE;
Wollmann, Klaus, DE;
Schomann, Hermann, DE;
Schneider, Judith, DE;
Ach, Alexander, DE;
Gross-Lannert, Renate, DE;
BEST, BERND, DE

(73) Propriétaire/Owner:

Dr. Frische GmbH, DE

(74) Agent: KIRBY EADES GALE BAKER

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(54) Title: FATTY-ACID-BASED PLASTICS

(57) **Abrégé/Abstract:**

The present invention relates to plastics that can be obtained by reacting unsaturated and/or hydroxyl-group-containing fatty acids or their esters or mixtures of various such fatty acids and esters with bifunctional ester- and/or amide-forming compounds and, if necessary, subsequently converting any possibly existing ethylenic double bonds, to give difatty acid diamides, difatty acid diesters, difatty acid amide esters, monofatty acid amide amines or monofatty acid amide alcohols as monomer components which contain at least two functional groups suited for linkage to give polymers, in particular ethylenic double bonds, hydroxyl groups, epoxy groups or amino groups, and by linking the said compounds in the known way via a second group of bifunctional compounds that are capable of reacting with these free functional groups to give the desired plastics.

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ABSTRACT

The present invention relates to plastics that can be obtained by reacting unsaturated and/or hydroxyl-group-containing fatty acids or their esters or mixtures of various such fatty acids and esters with bifunctional ester- and/or amide-forming compounds and, if necessary, subsequently converting any possibly existing ethylenic double bonds, to give difatty acid diamides, difatty acid diesters, difatty acid amide esters, monofatty acid amide amines or monofatty acid amide alcohols as monomer components which contain at least two functional groups suited for linkage to give polymers, in particular ethylenic double bonds, hydroxyl groups, epoxy groups or amino groups, and by linking the said compounds in the known way via a second group of bifunctional compounds that are capable of reacting with these free functional groups to give the desired plastics.

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New, Fatty-Acid-Based Plastics

The present invention relates to a new group of plastics based on fatty acids that can be obtained from natural oils and fats.

Natural oils and fats serve not only as initial substances for producing a multitude of technically important basic materials; under certain conditions, they can also be used to a substantially increased extent to produce polymers, in particular plastics. At present, the production of polymers from fats and oils is based essentially on three possibilities.

The first possibility makes use of the observation that polyunsaturated fats and fatty acids tend to polymerise when heated or exposed to atmospheric oxygen. These properties are of importance, for example, in the production of linoleum and in the curing of lacquers and varnishes (oil paints) as well as of sealing compounds, e.g. glazier's putty. The field of application in this case is naturally limited to oils with a high content of polyunsaturated fatty acids, so-called drying oils such as linseed oil, wood oil or nut oil.

A second possibility is to use oils and fats which, because of their composition, predominantly contain two or more alcohol groups per triglyceride molecule, and to process them with appropriate reactive compounds, e.g. diisocyanates, to give polymeric structures. Suitable substances for such reactions are, for example, castor oil or hydrogenated castor oil, which can be used directly as triglycerides. However, the range of application of the method in this case is also limited by the available oils and fats and, in addition, the direct use of triglycerides normally permits only such polymers to be produced that are cross-linked and therefore cannot be processed thermoplastically.

The third possibility is to break down the fatty acids contained in oils and fats into diactive fatty acid splitting products such as dicarboxylic acids by splitting reactions, e.g. ozonolysis, the reactive groups, e.g. carboxylic acid groups, being attached to both ends of the hydrocarbon chains. According to this method, it is possible to produce azelaic acid from oleic acid on an industrial scale. The dicarboxylic acids subsequently can be reacted with diamines to give polyamides or with diols to give polyesters. Splitting of ricinoleic acid (from castor oil) and reacting one of the splitting products to give 11-amino-undecanoic acid as well as its polycondensation to give Polyamide 11 (RilsanTM) are also carried out in the chemical industry. Although thermoplastic polymers as well can be produced via these or other diactive fatty acid splitting products, this method has decisive drawbacks, too. On the one hand, splitting the fatty acids into diactive splitting products is relatively complicated and involves major losses, and on the other hand considerable amounts of various by-products are formed, especially aliphatic monocarboxylic acids, the chain length of which is less interesting from the technical point of view, and the subsequent purifying operations are therefore difficult.

The above examples already show the basic interest of the plastics industry in using natural fats and oils.

The object of the present invention therefore was to make available in an advanced manner the fatty acids which are contained especially in natural fats and oils and have functional groups such as double bonds or hydroxyl functions and which are suitable for the reaction to give polymers accessible in an advanced manner, and thus to extend the range of application of fats and oils in the plastics industry. The present invention was based on the idea that molecules with at least two reactive groups, e.g. double bonds or hydroxyl groups, can be reacted via other appropriate bifunctional compounds, e.g. diisocyanates, to give linear polymers. It must be ensured that two reactive groups react per each monomer. If fewer groups per molecule react, chain termination occurs; reaction of more than two groups per molecule results in cross-linking.

According to one aspect of the invention there is provided a thermoplastic linear polymer obtained by a process of preparing and reacting a monomer containing two reactive groups comprising steps for: (a) reacting at least one natural fatty acid or ester selected from the group consisting of unsaturated fatty acids or esters and hydroxyl-group containing fatty acids or esters with an equimolar amount of a bifunctional ester-forming compound, a bifunctional amide-forming compound, or a bifunctional ester and amide-forming compound to produce a monomer component, comprising at least one difatty acid diamide, difatty acid diester, difatty acid amide ester, monofatty acid amide amine or monofatty acid amide alcohol, having only two groups reactive with a second bifunctional compound to produce a thermoplastic linear polymer said reactive groups including ethylenic double bonds, hydroxyl groups, epoxy groups or amino groups; and (b) subsequently reacting said monomer component with an equimolar amount of said second bifunctional compound selected from the group consisting of disulfur dichloride, diisocyanate, dicarboxylic acid and activated dicarboxylic acid.

To produce plastics according to the invention, unsaturated and/or amino- and/or hydroxyl-group-containing fatty acids, preferably with chain lengths of 10 to 24 carbon atoms, or their derivatives such as esters are required. As a rule, natural fats and oils will be used as initial substances, which have a particularly high content of such a fatty acid, e.g. oleic acid, linoleic acid, linolenic acid or ricinoleic acid. If these fats and oils contain fatty acids with one or several double bonds, the hydroxyl or amino groups can also be obtained subsequently, the hydroxyl groups, for example, by oxidising the initial substance with peracetic acid or performic acid, whereby the range of fatty acids for further reaction can be greatly extended. Oils that are

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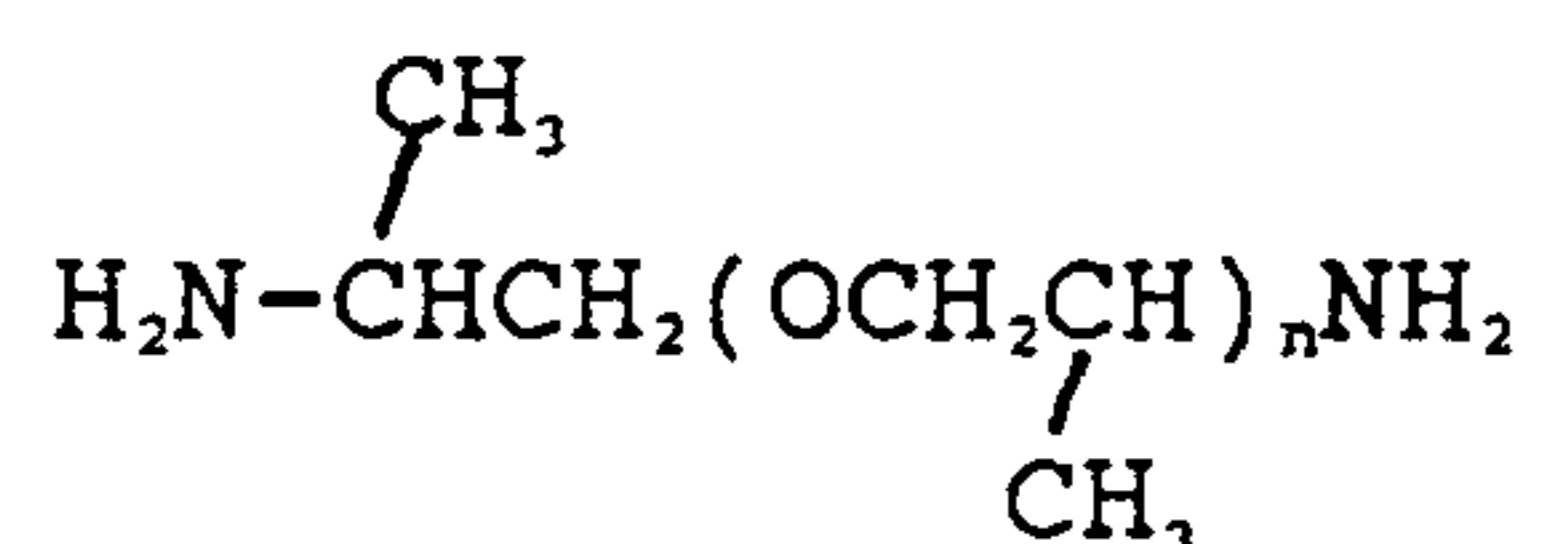
particularly well suited for the method according to the invention are, for example, the oil from the seeds of *Euphorbia lathyris*, olive oil, linseed oil, castor oil and hydrogenated castor oil, sunflower oil that is rich in linoleic acid or oleic acid, in particular sunflower oil of the "high-oleic" species, rapeseed oil, especially of the high-erucic-acid species, the oil of *Jatropha curcas* or the oils of marine animals, e.g. fish or whale oil.

The initial substance is directly reacted with the bifunctional ester-forming or amide-forming substances. Appropriate bifunctional compounds include diols, diamines or amino alcohols. Instead of the diols, it is also possible to use the corresponding thio compounds in which one or both OH groups have been substituted by SH groups. For the reaction with diols, it is recommended to use the initial substance in pre-purified form. As described in the simultaneously filed German Patent Application DE 40 19 089 A 1, published January 3, 1991, using crude oils and fats for the reaction with diamines or amino alcohols does not present any problems either.

Diols that can be used in the method according to the invention are, for example, primary and secondary aliphatic, cyclo-aliphatic, aliphatic-aromatic and aromatic diols, preferably with 2 to 44 carbon atoms. Preferably used substances are 2-butyne-1,4-diol, 2-

butene-1,4-diol, 1,5-pentanediol, 1,6-hexanediol, neopentyl glycol, N,N-diethylaminopropanediol-2,3 or hydroxypivalic acid neopentyl glycol ester. Particularly preferred are 1,4-butanediol, 1,2-propanediol, 1,10-decanediol and glycol. An appropriate thio compound is, for example, 2-mercaptoethanol.

Appropriate diamines or amino alcohols are primary and secondary aliphatic, cyclo-aliphatic, aliphatic-aromatic and aromatic diamines or amino alcohols, preferably with 2 to 44 carbon atoms. This includes, among others, dimeric fatty acids from natural fats and oils. Between the two amino functions of the diamines, additional structural elements or further functional groups, e.g. ether groups, diamide groupings, amino groups, keto groups or sulfone groups, may be arranged in the hydrocarbon chain or attached to the cycloaliphatic or aromatic group. Preferably used diamines are 1,2-diaminoethane, 1,3-diaminopropane, 1,6-diaminohexane, 1,8-diaminooctane, piperazine, diethylenetriamine, 4,7,10-trioxatridecane-1,13-diamine, 3,3'-diaminodiphenyl sulfone, 3,3'-dimethyl-4,4'-diaminodicyclohexylmethane and commercial ether diamines of the following formula:



where n is an integral number from 1 to 2000. 1,2-diaminoethane and 1,6-diaminohexane are particularly preferred. Preferred amino alcohols are 2-aminoethanol and 3-aminopropanol.

If difatty acid diesters, difatty acid diamides or difatty acid amide esters are to be obtained as reaction products, the diols, diamines and amino alcohols are preferably reacted in stoichiometric mixing ratios, so that a single amino or alcohol group can react per fatty acid carboxylic group. In the case of the diamines, the mixing ratio is not so critical, however, because the monoamide surprisingly forms only at a very great excess of amino functions.

Desirable products of the reaction with amino alcohols or diamines to give monoamides include the monofatty acid amides of the said fatty acids, because in such compounds the OH group of amino

alcohol or the free amino group of the reacted diamine may act, in addition to the functional group of the fatty acid, as a second coupling group which permits linking the monomers to give polymers. If an excess of amino alcohol is used, monofatty acid amides are obtained almost exclusively as a result of the higher reactivity of the amino function. As outlined above, monofatty acid amide amines also result when a great excess of diamines is used.

In order to ensure a homogeneous course of reaction, the reaction may also take place in an appropriate solvent. Depending on the kind of reaction to be performed, polar as well as non-polar solvents can be used, particularly methanol, ethanol, propanol, butanol, toluene, xylene or petroleum ether.

The reaction can occur at temperatures between 20 and 300°C, but the temperature range between 50 and 200°C is preferred, because the reaction times in this temperature range are sufficiently short.

As a precaution the reaction is carried out in a closed system, e.g. an autoclave. It requires no complicated procedure, but an inert gas atmosphere, e.g. of argon or nitrogen, possibly also the solvent atmosphere, is preferred because this provides more protection against undesired side-reactions such as oxidation of the initial substance.

If necessary, catalysts such as ammonium chloride or p-toluene-sulfonic acid can be added to the reaction mixture. In addition, it is possible to add further auxiliary materials and additives such as polymerisation inhibitors and antioxidants, e.g. ascorbic acid or glucose.

After completion of the reaction, and possibly after removal of the solvent, the reaction products can be separated by simple or fractionated crystallisation and, if necessary, subsequently be recrystallised from appropriate solvents. Both polar and non-polar substances can be used as solvents for crystallisation. Recrystallisation is preferably done with methanol or ethanol. A simple washing process is possibly sufficient for obtaining pure

reaction products. In specific cases it is advantageous to subject the reaction mixture to a hot vapour extraction process to obtain the reaction products in pure form.

Unless the fatty acids with epoxy or hydroxyl groups were already contained in the natural fats and oils, or if they were produced by oxidation or another kind of reaction of the initial substance, the intermediate products resulting from the above-described method - provided they contain double bonds - can still be turned into appropriate functional compounds either before or after a possible purification step. In this case it is also interesting to form epoxy groups as reactive groups for further reaction.

Monomers that can be obtained according to this method, and that are of special interest for the production of plastics, are in particular the diesters, diamides and amide esters of those derivatives of fatty acids, especially of stearic acid, which contain one or more double bonds, epoxy, amino or hydroxyl groups as close to the chain end as possible, usually near the carbon atoms 9 to 16. Such derivatives are, for example, oleic acid, ricinoleic acid, 9-, 10- or 12-hydroxystearic acid, 9,10-epoxystearic acid, linoleic acid, linolenic acid and erucic acid, as well as the mono- and oligohydroxy or mono- and oligoepoxy compounds that can be derived from the said acids, especially 9,10-dihydroxystearic acid. The diesters, diamides and amide esters need not have a symmetrical structure, but may consist of different fatty acids. Further interesting substances are the monofatty acid amides of the said substituted acids which can be obtained by reaction with amino alcohols or diamines.

The monomers that can be obtained according to this method have at least two functional groups; as in the case of diamides, diols or amide esters, these may either both belong to the fatty acid residue or, as in the case of the monofatty acid amides obtained by reaction with the amino alcohols or diamines, one of them may come from the fatty acid and the other from the amino alcohol or diamine. Under the known appropriate conditions, such monomer compounds can be linked to give linear polymers by using suitable difunctional compounds.

According to the invention it is possible, for example, to react the diamides, diols and amide esters of fatty acids that contain several double bonds in the fatty acid residues, e.g. oleic acid compounds such as dioleic acid ethylenediamide, with disulphur dichloride to give linear polymers.

Monomers which contain at least two hydroxyl functions or one amino group and one hydroxyl group can be reacted with diisocyanates as are known in plastics production, e.g. with hexamethylene diisocyanate, methylenediphenyldiisocyanate (MDI) or with the diisocyanates that are available under the trade names Desmodur E14TM and T80TM. Other difunctional compounds suitable for reacting this monomer class are activated dicarboxylic acids or dicarboxylic acid derivatives such as acid chlorides, esters, anhydrides, azides or nitriles, corresponding thio acids or the diketenes. Preferably used representatives of such bifunctional compounds are phthalic acid dichloride, adipic acid dichloride, maleic acid dichloride or phosgene.

A further very interesting class of polymers is obtained when the epoxy compounds of diamides, diesters or amide esters are reacted with diols, e.g. 1,4-butanediol, or the respective thio compounds. In this case the respective monomers are linked together via ether or thioether groups that are located close to a hydroxyl group. In addition, the epoxy compounds can be linked via dicarboxylic acids or via amino alcohols or diamines.

In the embodiments of the diesters, diamides and amide esters according to the invention, the fatty acids in the monomers are linked head-to-head via the carboxyl group. This is a completely new structural principle of polymers, in particular in the case of the hydroxyl-group-containing diamides combined with diisocyanates as monomer-linking reagents, and leads to the novel category of plastics: polyamide urethanes. The kind of linkage results in a particularly strong polar interaction between the polymer chains in this case, without impairing the thermoplastic properties of the plastic material. An example is the reaction of bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide with

hexamethylene diisocyanate. Similarly interesting plastics of the same structure, polyamide esters, are obtained when the diisocyanate compound is replaced by activated dicarboxylic acids, e.g. adipic acid dichloride.

The individual components are reacted according to the conventional methods which are used in plastics production and with which persons skilled in the art are familiar. Related to the functional groups to be reacted, the individual components are introduced in equimolar amounts, and the reaction is performed at a temperature between 20 and 180°C, preferably in the melt and, for precautionary reasons, in an inert gas atmosphere, e.g. of nitrogen.

The special advantage of the method according to the invention consists in the multitude of possibilities provided by this system of varying the properties of the plastics. The properties can be influenced either by the component which links the fatty acids via the carboxyl function, i.e. the diamines, diols or amino alcohols, or by the choice of the fatty acid, and finally by the bifunctional linking component with which the monomers are reacted, e.g. the diisocyanate or the acid dichloride. In addition, it is possible to react mixtures of different monomers such as bis-ricinoleic acid-1,2-N,N'-ethylenediamide and bis-ricinoleic acid-1,6-N,N'-hexamethylenediamide or bis-ricinoleic acid-1,2-N,N'-ethylenediamide and bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide, to give polymers, whereby the resultant plastics properties can be influenced further. Generally speaking, the rules of classical polymer chemistry must be observed in this connection. Thus, it should be noted that the flexibility of the plastics will increase as the chain length increases and that the same is true for the length of the various bifunctional compounds that act as linking elements. Since the fatty acids of natural fats and oils, which will probably be mainly used as initial substances for producing the plastics according to the invention, usually carry their functional groups approximately in the middle of the fatty acid chain (ricinoleic acid, for example, carries the OH group at C₁₂, and oleic acid carries the double bond between C₉ and C₁₀), the linked polymer chains always contain more or less long-chained aliphatic residues. Such aliphatic residues in polymers not only

render the plastic material hydrophobic but also act as internal plasticisers. Therefore, their presence can be used to advantage for obtaining flexible plastics. Vice versa, the polar types of bonds that may occur in this plastic system may counteract this plasticising effect by hydrogen bridge linkages or by the formation of allophanate or else, this possibly undesired effect of the side chains may be compensated by choosing appropriate bifunctional linking elements. How extremely important these linking elements are due to their variability is best exemplified by the dimers of ricinoleic acid, which can be used only to a limited extent in polyester production, for example, because of the inevitable plasticising effect of the aliphatic side chains on the backbone of the polymer structure.

Because of the favourable adhesive properties that are associated with it, the polarity of the bonds makes the plastics obtained in this way particularly useful for glass-fibre-reinforced composites, the low processing temperature representing another advantage of this system.

Generally speaking, the described possibilities of variation thus permit plastics to be produced that are perfectly tailored to the respective requirements. It is possible to produce plastic materials which can be processed thermoplastically, used for injection moulding and are suitable for extrusion into sheets or films. Other properties such as tensile strength, stretchability, impact strength, softening point or crystallinity can also be varied within wide limits. On the other hand, thermosetting plastics can also be obtained in this way.

Another advantage of the present invention is that the initial fatty acid molecules that are linked via the carboxyl function are already relatively large compared with the monomers that are normally used for the production of plastics; thus, the further reaction with bifunctional reactive compounds needs only comparatively few linkage reactions to give linear polymers of sufficient chain length.

Surprisingly it was also found that even if there is a relatively great portion of chain-terminating compounds among the carboxyl-group-linked fatty acids, i.e. compounds which normally result from the reaction of a fatty acid that contains no functional group in the aliphatic chain, and which therefore have only a single functional group available for further reaction, it is still possible to obtain plastics with astonishingly good properties. As, furthermore, compounds without functional groups cannot lead to chain termination but rather behave like normal additives, it may even be superfluous to purify and isolate the resultant monomers if oils and fats are used that have a sufficiently high content of fatty acids containing functional groups.

In addition, the carboxyl-linked fatty acid components can also be incorporated in other plastics systems where they may act as plasticisers for example. Thus, reacting 1,4-butanediol as alcohol component with hexamethylene diisocyanate yields hard and brittle plastics. If part of the butanediol is replaced in this reaction by bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide, the resultant plastics are much more flexible and elastic.

As outlined above, the use of fats and oils as initial substance for the plastics industry has so far been limited by the following facts: Direct use of triglycerides containing fatty acids with appropriate functional groups results only in thermoset plastics, or else, it is necessary to split the fatty acids by oxidation, which involves loss of a major portion of the available fatty acid material. The invention for the first time provides a method which permits a wide variety of plastics with very different properties or combinations of properties to be produced from fats and oils without prior splitting of the fatty acid residues. What is more, these plastics are in fact polymers that can be obtained, at least in part, from biological sources, so that it can be expected that these products will be easier to decompose and, in the long run, more environmentally compatible than the majority of conventional plastics.

The present invention is exemplified in the following.

Example 1

Preparation of bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide

153 g hardened castor oil and 15 g ethylenediamine are stirred for 5 hours in an autoclave in a nitrogen atmosphere at 140°C. The reaction product is recrystallised from hot methanol.

(Melting point: 142-45°C; yield: 106.5 g)

Example 2

Preparation of bis-12-hydroxystearic acid-1,6-N,N'-hexamethylene diamide

5.1 g hardened castor oil and 0.97 g hexamethylenediamine are stirred for 5 hours in an autoclave in a nitrogen atmosphere at 150°C. The reaction product is subjected to hot vapour extraction with methanol.

(Melting point: 135-136°C; yield: 3.7 g)

Example 3

Preparation of bisricinoleic acid-1,2-N,N'-ethylenediamide

1.5 g castor oil and 0.5 g 1,2-diaminoethane are stirred for 5 hours in a nitrogen atmosphere at 120°C. The product is recrystallised from methanol.

(Melting point: 83-85°C; yield: 2.6 g)

Example 4

Reaction of bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide with hexamethylene diisocyanate

3 g of the product obtained according to Example 1 is melted in a nitrogen atmosphere and heated up to 155°C. 0.79 ml hexamethylene diisocyanate is added to this substance and thoroughly stirred. The reaction mixture is kept at 150°C for 45 minutes and then cooled down to room temperature. The resultant polyurethane amide is thermoplastic.

Example 5

Reaction of bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide with Desmodur E14TM

0.83 g bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide and 3.22 g Desmodur E14TM are kept for 2 hours in a nitrogen atmosphere at a temperature of 150°C. The resultant product is thermoplastic.

Example 6

Reaction of bis-12-hydroxystearic acid-1,6-N,N'-hexamethylenediamide with Desmodur T80TM

6.8 g bis-12-hydroxystearic acid-1,6-N,N'-hexamethylenediamide is melted and heated up to 160°C in a nitrogen atmosphere. 1.74 g Desmodur T80TM (aromatic diisocyanate) is added. The reaction mixture then is kept for 4 hours at 160°C. The resultant polyurethane amide is thermoplastic.

Example 7

Reaction of bisricinoleic acid-1,2-N,N'-ethylenediamide with hexamethylene diisocyanate

2.00 g bisricinoleic acid-1,2-N,N'-ethylenediamide is melted and heated up to 100°C in a nitrogen atmosphere. Then 0.54 g hexamethylene diisocyanate is added. The solution is kept at 100°C for 4 hours. The resultant plastic can be pressed into sheets or films at 110°C.

Example 8

Reaction of bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide with 1,4-butanediol and hexamethylene diisocyanate

2.45 g of the product obtained according to Example 1 and 0.54 g 1,4-butanediol is heated up to 150°C. In a nitrogen atmosphere, 1.68 g hexamethylene diisocyanate is added. The reaction mixture

is kept at 150°C for 1 hour. The resultant polyamide urethane is thermoplastic and stretchable. This polyamide urethane is pressed into a film at 200°C. The film is placed between two glass plates. The glass plates are heated up to 190°C and slightly pressed together. After cooling, the two glass plates are tightly bonded.

Example 9

Reaction of bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide with 1,10-decanediol and hexamethylene diisocyanate

1.88 g bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide and 0.35 g 1,10-decanediol are heated up to 145°C. Then, 0.84 g hexamethylene diisocyanate is added in a nitrogen atmosphere. The reaction mixture is kept at 145°C for 35 minutes. The resultant polyamide urethane is thermoplastic and stretchable.

Example 10

30 g bis-12-hydroxystearic acid-1,2-N,N'-ethylenediamide, 120 ml 6N sodium hydroxide solution and 350 ml methanol are stirred for 5 hours in an autoclave in a nitrogen atmosphere at 180°C. The methanol is drawn off, and the residual product is dried over P₂O₅. The dried product is poured into boiling 2N H₂SO₄ and stirred for 2 hours. After cooling to room temperature, the wax-like product is dissolved in chloroform. The chloroform phase is twice extracted with water and then dried. Subsequently, the chloroform is drawn off and 12-hydroxystearic acid is obtained.

Example 11

0.60 g 12-hydroxystearic acid and 0.34 g hexamethylene diisocyanate are heated up to 150°C. Foaming occurs at once. The foam is stable and elastic.

Claims:

1. A thermoplastic linear polymer obtained by a process of preparing and reacting a monomer containing two reactive groups comprising steps for:
 - (a) reacting at least one natural fatty acid or ester selected from the group consisting of unsaturated fatty acids or esters and hydroxyl-group containing fatty acids or esters with an equimolar amount of a bifunctional ester-forming compound, a bifunctional amide-forming compound, or a bifunctional ester- and amide-forming compound to produce a monomer component, comprising at least one difatty acid diamide, difatty acid diester, difatty acid amide ester, monofatty acid amide amine or monofatty acid amide alcohol, having only two groups reactive with a second bifunctional compound to produce a thermoplastic linear polymer said reactive groups including ethylenic double bonds, hydroxyl groups, epoxy groups or amino groups; and
 - (b) subsequently reacting said monomer component with an equimolar amount of said second bifunctional compound selected from the group consisting of disulfur dichloride, diisocyanate, dicarboxylic acid and activated dicarboxylic acid.
2. The thermoplastic polymer as set forth in claim 1, wherein said natural fatty acids or esters comprise unsaturated hydroxyl-group-containing fatty acids or fats and oils with unsaturated hydroxyl-group-containing fatty acids in their fatty acid composition.
3. The polymer as set forth in claim 1, wherein said fatty acids or esters comprise euphorbia oil, olive oil, linseed oil, castor oil or hydrogenated castor oil, sunflower oil, rapeseed oil, oil of Jatropha curcas, or oil from seeds of Euphorbia lathyris.

4. The thermoplastic polymer as set forth in claim 1, wherein said amide-forming bifunctional compound comprises an aliphatic, cycloaliphatic, aliphatic-aromatic or aromatic diamine.
5. The thermoplastic polymer as set forth in claim 1, wherein said amide-forming bifunctional compound comprises a 1,2-diaminoethane or 1,6-diaminohexane.
6. The thermoplastic polymer as set forth in claim 1, including the bifunctional ester and amide-forming compound wherein the bifunctional ester and amide-forming compound comprises an aliphatic, cycloaliphatic, aliphatic-aromatic or aromatic amino alcohol.
7. The thermoplastic polymer as set forth in claim 6, wherein said ester-forming and amide-forming bifunctional compound is 2-aminoethanol or 3-aminopropanol.
8. The thermoplastic polymer as set forth in claim 1, wherein the reaction with ester-forming or amide-forming bifunctional compound is carried out at temperatures between about 20° and 300°C.
9. The thermoplastic polymer as set forth in claim 8, wherein the reaction with ester-forming or amide-forming bifunctional compound is carried out at temperatures between about 50° and 200°C.
10. The thermoplastic linear polymer set forth in claim 1, wherein said second bifunctional compound is disulfur dichloride.
11. The thermoplastic linear polymer set forth in claim 1, wherein said second bifunctional compound is a diisocyanate.

12. The thermoplastic linear polymer set forth in claim 1, wherein said second bifunctional compound is a dicarboxylic acid.
13. The thermoplastic linear polymer set forth in claim 1, wherein said second bifunctional compound is an activated dicarboxylic acid.
14. The process for preparing a thermoplastic linear polymer as defined in claim 1, wherein said natural fatty acid or ester in step (a) is an unsaturated fatty acid or ester without hydroxyl groups.
15. The process for preparing a thermoplastic linear polymer as defined in claim 14, including first reacting said unsaturated fatty acid or ester to obtain a hydroxyl-group containing fatty acid or ester and then reacting said hydroxyl-group containing fatty acid or ester to yield at least one difatty acid diamide, difatty acid diester, difatty acid amide ester, monofatty acid amide amine or monofatty acid amine alcohol.