

Description

The present invention relates to particulate hydroperoxidized poly-n-vinyl lactam, a method of preparing the same, and the use thereof in the preparation of graft copolymers with at least one hydrophobic monomer or hydrophilic monomer, and optionally a crosslinking agent. The resulting copolymers possess unexpectedly low extractibles and good mechanical properties and are useful in various biomedical applications, including contact lenses, medical surgical devices such as heart valves, vessel substituted, mouth guards and denture liners, as semipermeable membranes, and as films or fibers, e.g. for textile uses or as burn and wound dressings.

Polyvinyl pyrrolidone and its use in the preparation of graft or block copolymers with hydroxyethyl methacrylate finding applications for a variety of purposes, including contact lenses, is described in U.S.-A-3, 621,079.

U.S.-A-3,639,524 discloses the graft or block copolymerization of polyvinyl pyrrolidone with N-vinyl pyrrolidone and a monomeric methacrylate, optionally in the presence of a crosslinking agent and a catalyst, to prepare a crosslinked xerogel which can be machined into contact lens replicas and swollen in water to form a hydrated contact lens.

U.S.-A-3,894,129 discloses the graft or block copolymerization of polyvinyl lactams with a hydroxyalkyl methacrylate monomer in the presence of a polymerization initiator at low temperatures and containing not more than 0.7% alkyl dimethylacrylate crosslinker, followed by a post polymerization heat treatment in the manufacture of contact lenses. This patent stresses the exclusion of oxygen from the polymerization reaction mixture on the grounds that oxygen inhibits polymerization and can cause uneven degrees of polymerization and monomer vaporization.

U.S.-A-4,138,408 discloses the graft or block copolymerization of a polyvinyl lactam with a mixture of hydrophilic and hydrophobic polymerizable monomers and a divinyl benzene or divinyltoluene crosslinking agent in the manufacture of contact lenses.

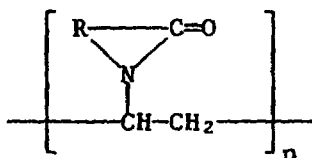
Unfortunately, due to the incomplete incorporation of polyvinyl lactam into the polymer network, such graft or block copolymers of the prior art, upon swelling with an aqueous medium, characteristically exhibit a relatively high degree of water soluble extractibles, comprising polyvinyl lactam containing residual products. Over a period of time, the mechanical properties of contact lenses made of such materials can degrade. Moreover, tinted lenses containing such extractibles can fade over an extended period of time.

It is thus an object of the present invention to provide an improved modified poly-n-vinyl lactam of increased reactivity with hydrophobic and hydrophilic monomers, and copolymers resulting therefrom.

It is a further object of the invention to provide crosslinked copolymers with a significantly reduced degree of extractibles.

According to one aspect of the present invention, there is provided particulate hydroperoxidized poly-N-vinyl lactam useful in the preparation of graft or block copolymers with hydrophilic and/or hydrophobic monomers. A further aspect of the present invention relates to copolymers therefrom containing reduced water soluble extractibles as compared to non-hydroperoxidized poly-N-vinyl lactam derived copolymers. In a further aspect of the present invention there is provided a method of preparing such hydroperoxidized poly-N-vinyl lactams.

One embodiment of the invention relates to a particulate hydroperoxidized derivative of a poly-N-vinyl lactam containing units of the formula



wherein R is alkylene of 2 to 8 carbon atoms and n is between about 40 and about 4000, and mixtures thereof.

Generally, the polymers of formula I contain from 3 to 7 carbon atoms in the heterocyclic ring thereof, including the carbonyl carbon atom, and preferably contain from 4 to 6 carbon atoms in the heterocyclic ring.

Some poly-N-vinyl lactams falling within the scope of formula I include, for example, poly-N-vinyl pyrrolidone, poly-N-vinyl-2-piperidone, poly-N-vinyl-2-caprolactam, poly-N-vinyl-3-methyl-2-caprolactam, poly-N-vinyl-3-methyl-2-piperidone, poly-N-vinyl-4-methyl-2-piperidone, poly-N-vinyl-4-methyl-2-caprolac-

tam, poly-N-vinyl-3-ethyl-2-pyrrolidone, poly-N-vinyl-4, 5-dimethyl-2-pyrrolidone, and the like. Most preferred is polyvinylpyrrolidone.

The average value of n is preferably between about 50 and about 3600, most preferably between about 100 and about 800.

5 The starting material polymers according to formula I are known, per se, or can be prepared by methods well known in the art. For example, the corresponding N-vinyl lactam can be polymerized under moderate to elevated temperatures, e.g. between about 20 and 160°C, optionally in the presence of a catalytic amount of a polymerization catalyst, such as azo-bis(isobutyronitrile), or a peroxide, such as hydrogen peroxide, di-tertiary butyl peroxide or t-butyl peroctoate, in the presence or absence of an inert
10 diluent, such as water, and optionally in the further presence of a base, such as ammonia or an amine, to inhibit hydrolysis. As the artisan can appreciate, the reaction conditions can be adjusted to vary the degree of polymerization. Upon recovery of the polymer, it can be dried if necessary and comminuted, for example, powdered.

The particle size of the poly-N-vinyl lactam can vary widely, but conveniently is between about 0.01 and about 200 μm , preferably between about 0.1 and about 100 μm , and most preferably between about 0.5
15 and about 50 μm . Poly-N-vinyl lactams are widely available commercially. For example, polyvinyl pyrrolidone is generally commercially available over a wide average molecular weight range. Thus, the GAF Corporation supplies powdered polyvinyl pyrrolidone having an average molecular weight of about 10,000 (PVP K-15) to about 360,000 (PVP K-90). A convenient polyvinyl pyrrolidone of GAF Corporation is
20 Plasdone C Grade having a number molecular weight of about 37,000 and a molecular weight range of about 25,000 - 50,000. Also convenient is PVP K-30, having an average molecular weight of about 40,000, supplied by GAF Corporation.

The hydroperoxidized poly-N-vinyl lactam of the present invention generally contains an average of between about 0.5 to about 20 hydroperoxy (-OOH) mole equivalents per mole of poly-N-vinyl lactam.
25 Preferably the polymer contains an average of between about 1 and about 15 mole equivalents of hydroperoxy groups per mole of poly-N-vinyl lactam, most preferably between about 1 and about 10 mole equivalents of hydroperoxy groups per mole of poly-N-vinyl lactam.

In another embodiment of the invention, hydroperoxy groups can be conveniently introduced into the polymer by subjecting the particulate polymer according to formula I to ozone (O_3), for example, by simply
30 intimately contacting the particulate polymer with an ozone containing gaseous carrier, such as ozonated air or ozonated oxygen, for a period of time sufficient to result in the requisite uptake of ozone into the polymer to form the desired hydroperoxidized polymer derivative. The reaction temperature is generally not critical, and the reaction can be conducted over a wide temperature range, e.g. between 0° and 100°C, preferably under ambient conditions.

35 In order to facilitate the reaction between the polymer and ozone to form the hydroperoxidized derivative, it may be desirable to insure that the ozonation is conducted in the presence of a small amount of moisture. Generally, the poly-N-vinyl lactam contains, under ambient conditions, sufficient adsorbed water, e.g. 5-9 weight percent in the case of polyvinyl pyrrolidone, to facilitate the hydroperoxidation. If desired, moisture can be added, for example by adjusting the humidity or moisture content of the carrier
40 gas to between about 20 and about 90 percent of saturation.

Ordinarily ozone can conveniently be prepared in admixture with a carrier gas by passing an oxygen containing gas, such as air or oxygen, through a standard ozone generator. In the case of air, generally about 2 % ozone by weight is produced; in the case of pure oxygen gas, about 4 % ozone by weight is characteristically produced.

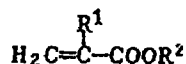
45 As stated above, moisture may be introduced into the reaction mixture by controlling the humidity of the ozone containing gas. However, attempts to hydroperoxidize polyvinyl lactams in aqueous solutions are to be avoided, since under such conditions, the polyvinyl lactam is characteristically degraded into low molecular weight products, presumably due to chain scission.

The ozone containing gas may be contacted with the particulate polymer according to various methods,
50 such as passing the gas over a shallow layer of the particulates, or through a packed column containing the polymer particulates, and preferably by passing the ozone containing gas through a fluidized bed of particulate polymer.

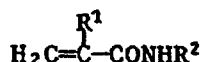
The resulting hydroperoxidized poly-N-vinyl lactam can be polymerized with at least one hydrophobic or hydrophilic monomer, or mixtures thereof, optionally in the presence of a crosslinking agent, to obtain
55 graft copolymers possessing unexpectedly low amounts of extractibles coupled with good mechanical properties, the useful in a wide variety of applications, including contact lenses, medical surgical devices such as heart valves, vessel substitutes, mouth guards and dental liners, semipermeable membranes the films or fibers, e.g. for textile uses or as burn and wound dressings.

Suitable hydrophilic copolymerizable monomers include generally water soluble conventional vinyl monomers such as:

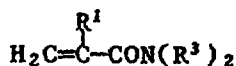
acrylates and methacrylates of the general structure



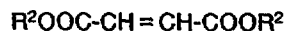
wherein R¹ is hydrogen or methyl and R² is hydrogen or is an aliphatic hydrocarbon group of up to about 10 carbon atoms, e.g. an alkyl group, substituted by one or more water solubilizing groups such as carboxy, hydroxy, amino, loweralkylamino, di-loweralkylamino, a polyethyleneoxide group with from 2 to about 100 repeating units, or substituted by one or more sulfate, phosphate, sulfonate, phosphonate, carboxamido, sulfonamido or phosphonamido groups, or mixtures thereof; acrylamides and methacrylamides of the formula



where R¹ and R² are as defined above; acrylamides and methacrylamides of the formula



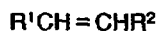
where each R³ is lower alkyl of 1 to 3 carbon atoms and R¹ is as defined above; maleates and fumarates of the formula



wherein R² is as defined above; vinyl ethers of the formula



where R² is as defined above with the proviso that R² is other than hydrogen; aliphatic vinyl compounds of the formula



where R¹ is as defined above and R² is as defined above with the proviso that R² is other than hydrogen; and vinyl substituted heterocycles, such as vinyl pyridines, piperidines and imidazoles and N-vinyl lactams, such as N-vinyl-2-pyrrolidone. Hereinbefore and hereinafter the term "lower" defines groups having up to 7 carbon atoms, if not defined otherwise.

Included among the useful water soluble monomers are:

2-hydroxyethyl-; 2- and 3-hydroxypropyl-; 2,3-dihydroxypropyl-; polyethoxyethyl-; and polyethoxypropyl-acrylates, -methacrylates, -acrylamides and -methacrylamides; acrylamide, methacrylamide, N-methyl acrylamide, N-methyl methacrylamide, N,N-dimethyl acrylamide, N,N-dimethyl methacrylamide; N,N-dimethyl- and N,N-diethyl-aminoethyl acrylate and methacrylate and the corresponding acrylamides and methacrylamides; 2- and 4-vinylpyridine; 4- and 2-methyl-5-vinylpyridine; N-methyl-4-vinylpiperidine, 2-methyl-1-vinylimidazole; N,N-dimethyl allylamine; dimethylaminoethyl vinyl ether; N-vinylpyrrolidone; acrylic and methacrylic acid; itaconic, crotonic, fumaric and maleic acids and the lower hydroxyalkyl mono- and diesters thereof, such as the 2-hydroxyethylfumarate and maleate, sodium acrylate and methacrylate; maleic anhydride; 2-methacryloyloxyethylsulfonic acid and allylsulfonic acid.

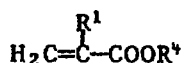
Preferred water soluble monomers include 2-hydroxyethylmethacrylate, N,N-dimethylacrylamide, acryl-

ic acid and methacrylic acid, and most preferably 2-hydroxyethylmethacrylate.

Suitable hydrophobic copolymerizable monomers include water insoluble conventional vinyl monomers such as:

acrylates and methacrylates of the general formula

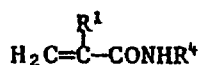
5



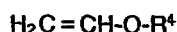
10 where R^1 is as defined above and R^4 is an aliphatic, cycloaliphatic or aromatic group having up to 20 carbon atoms which is unsubstituted or substituted by one or more alkoxy, alkanoyloxy or alkyl of up to 12 carbon atoms, or by halo, especially chloro or preferably fluoro, or C_3 - C_5 polyalkyleneoxy of 2 to about 100 units;

acrylamides and methacrylamides of the general formula

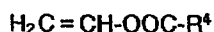
15



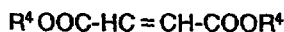
20 where R^1 and R^4 are as defined above;
vinyl ethers of the formula



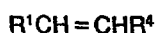
25 where R^4 is as defined above;
vinyl esters of the formula



30 where R^4 is as defined above;
maleates and fumarates of the formula



35 where R^4 is as defined above;
and vinylic substituted hydrocarbons of the formula



40 where R^1 and R^4 are as defined above.

Useful hydrophobic monomers include, for example:

methyl-, ethyl-, propyl-, isopropyl-, butyl-, ethoxyethyl-, methoxyethyl-, ethoxypropyl-, phenyl-, benzyl-, cyclohexyl-, hexafluoro-isopropyl- or n-octyl-acrylates and -methacrylates as well as the corresponding acrylamides and methacrylamides;

45 dimethylfumarate, dimethylmaleate, diethylfumarate, methyl vinyl ether, ethoxyethyl vinyl ether, vinyl acetate, vinyl propionate, vinyl benzoate, acrylonitrile, styrene, alpha-methyl styrene, 1-hexene, vinyl chloride, vinyl methyl ketone, vinyl stearate, 2-hexene and 2-ethylhexyl methacrylate.

Generally, the copolymers are prepared by graft reacting a polymerizable mixture containing

a) from about 1 to about 80 weight percent of the hydroperoxidized poly-N-vinyl lactam,

50 b) optionally up to about 5 weight percent of a crosslinking agent preferably e.g. about 0.1 weight percent, and

c) from about 99 to about 20 weight percent of one or more hydrophilic or hydrophobic monomers or mixtures thereof. If desired the reaction mixture may contain a catalytic amount of a conventional catalyst characteristically employed in polymerizing compounds having ethylenic unsaturation, and preferably a

55 free radical catalyst. Of particular interest are conventional peroxide and azo catalysts, such as hydrogen peroxide, benzoyl peroxide, tert.butyl peroctoate, or azobis(isobutyronitrile). In many cases, an initiator is not needed, due to the reactivity of the hydroperoxidized N-vinyl lactam. If desired or appropriate, the polymerization may be, at least in part, conducted in the presence of actinic radiation, with or without the

presence of a photoinitiator.

The graft polymerization can generally be carried out at temperatures between about 20° and about 150° C, for a period between about 1 and about 24 hours. It is understood that the time and temperature in such a reaction are inversely related. Thus, temperatures employed in the upper end of the temperature range will generally provide reaction times near the lower end of the time range and vice versa.

Depending upon the nature of the polymer mixture, it may be desirable for the copolymers obtained from such polymerizations to be post cured, e.g. at a somewhat elevated temperature such as between about 60° C and about 150° C.

For the preparation of contact lenses, the polymer mixture may be cast directly in the shape of the lens, or the polymerization may be carried out in a mold having a shape convenient for further processing, such as in the shape of small cylinders or "buttons", which can then be machined.

In a preferred embodiment of the invention, at least 50 weight percent of the monomer c) component is a hydrophilic monomer, preferably a mono ester of acrylic or methacrylic acid and a polyhydroxy alcohol, and most preferably hydroxyethyl methacrylate. Especially preferred are hydrophilic polymers capable of swelling in aqueous media to absorb between about 20 % and about 80 % water or other physiologically acceptable aqueous medium by weight, based upon the total hydrogel composition.

Suitable crosslinking agents are diolefinic monomers such as: allyl acrylate and methacrylate; alkylene glycol and polyalkylene glycol di-acrylates and -methacrylates, such as ethylene glycol dimethacrylate, and propylene glycol dimethacrylate; trimethylol propane triacrylate; pentaerythritol tetraacrylate, divinylbenzene; divinyl ether; divinyl sulfone; bisphenol A diacrylate or methacrylate; methylene bisacrylamide; diallyl phthalate, triallyl melamine; and hexamethylene diacrylate and dimethacrylate.

Of particular importance is the fact that the instant hydroperoxidized poly-N-vinyl lactam may be employed in conventional graft polymerization processes to produce useful articles of commerce in substantially the same manner as when employing poly-N-vinyl lactams, to obtain graft polymers quite similar to appearance to conventional poly-N-vinyl lactam graft polymers, but unexpectedly possessing unexpectedly low extractibles.

Accordingly, the hydroperoxidized particulate poly-N-vinyl lactam of the present invention may advantageously be employed in the preparation of graft copolymers as described in U.S. 3, 621,079; U.S. 3,700,761; U.S. 4,123,407; and U.S. 4,123,408, for the uses described therein.

The following examples are presented for the purposes of illustration only and are not to be construed to limit the nature and scope of the instant invention. All parts are by weight unless otherwise disclosed. Temperatures are given in degrees Centigrade.

Example 1: 27 g of poly-N-vinyl pyrrolidone, containing about 2 to 3 percent by weight absorbed water, having a weight average molecular weight of about 40,000 (K-30 from GAF Corporation) and an average particle size of about 5 μ m, are placed in a 100 ml cylindrical fluidized bed containing a frit on the bottom through which ozonized oxygen gas, having a concentration of 6 % ozone, prepared by passing O₂ through an ozone generator, is passed upwardly through the particulate poly-N-vinyl pyrrolidone at a rate of about 1 liter per minute gas for a period of 40 minutes at a temperature of about 18° C. The resulting poly-N-vinyl pyrrolidone is found to contain approximately 3 hydroperoxy mole equivalents per mole equivalent of poly-N-vinyl pyrrolidone.

Example 2: As a comparative example, 18 g of poly-N-vinyl pyrrolidone having a weight average molecular weight of about 40,000 (K-30 from GAF Corporation) are dissolved in about 204 g of water, and ozonized oxygen gas, having a concentration of 4 % ozone, is passed through the solution at a rate of about 1 liter per minute of gas at a temperature of about 18° C. After about 1 minute the solution turns clear and degrades, as evidenced by a marked reduction in viscosity, illustrating scission of the poly-N-vinyl pyrrolidone under the reaction conditions.

Example 3: 2.0 g of the peroxidized poly-N-vinyl pyrrolidone according to example 1 are dissolved in a mixture of 9.3 g of hydroxyethyl methacrylate, 0.15 g of ethyleneglycol dimethacrylate and 0.7 g water, the solution is mixed to insure uniformity, degassed by placing the mixture in a vacuum, placed under a nitrogen blanket and subjected to ultraviolet radiation under ambient room temperature conditions. The solution polymerizes within 30 minutes to afford a clear crosslinked product suitable for use as a hydrophilic contact lens upon machining the product into a lens replica and swelling the machined lens replica with water.

Example 4: In a manner identical to example 3, 2.0 g of the peroxidized poly-N-vinyl pyrrolidone are dissolved in 9.3 g hydroxyethyl methacrylate and 0.7 g water, and the solution polymerizes within 30 minutes to afford a clear polymerization product suitable for use as a hydrophilic contact lens material.

Example 5: 5.0 parts of ozonized poly-N-vinyl pyrrolidone prepared according to example 1 are

dissolved in a solution containing 19.5 parts hydroxyethyl methacrylate, 0.15 parts ethyleneglycol dimethacrylate, 0.05 parts benzoin methyl ether, 0.3 parts methacrylic acid and 1.2 parts water, degassed by subjecting the mixture to a vacuum, placed under a nitrogen blanket and poured into a contact lens replica mold. The solution in the mold is then subjected to ultraviolet radiation for two hours. The lens replica, upon equilibration with an isotonic saline solution, contains about 55.6 % water and possesses superior clarity coupled with good mechanical properties. Upon subjecting a dried lens to exhaustive soxhlet extraction with methanol, only a 4.6 % total loss of extractibles occurs. Similarly, upon subjecting a test lens prepared in accordance with the above to boiling water for a period of three days, only about a 3 % reduction in weight, on a dry basis, occurs.

Example 6: In order to show the increased reactivity of the instant ozonated poly-N-vinyl pyrrolidone as compared with unaltered poly-N-vinyl pyrrolidone, two solutions are prepared. Solution A contains 2.0 g of ozonized poly-N-vinyl pyrrolidone prepared in accordance with example 1 dissolved in 8.0 g hydroxyethyl methacrylate. Solution B contains 2.0 g of non ozonized poly-N-vinyl pyrrolidone, identical to the starting material of example 1, dissolved in 8.0 g of hydroxyethyl methacrylate. Both solutions are purged with nitrogen and subjected to ultraviolet light under identical conditions. Within 15 minutes, solution A polymerizes whereas no evident polymerization occurs with solution B.

Example 7: To further show the increased reactivity of the instant ozonized poly-N-vinyl pyrrolidone, solutions A and B are prepared according to example 5. When solution A, containing 2.0 g ozonated poly-N-vinyl pyrrolidone, dissolved in 8.0 g hydroxyethyl methacrylate, is heated to a temperature of 80° C for a period of about 2 hours, the solution polymerizes into a hard polymeric mass. Solution B, containing non-ozonated poly-N-vinyl pyrrolidone, but otherwise identical, does not polymerize. This illustrates that ozonized poly-N-vinyl pyrrolidone auto-initiates polymerization in the absence of added catalyst or ultraviolet radiation.

Example 8: Data from lenses prepared under conditions of example 4 are compared to lenses using non-hydroperoxidized polyvinyl pyrrolidone as the substitute. The lenses are fully molded.

Lens parameter	non-hydroperoxidized polyvinyl pyrrolidone lenses	hydroperoxidized polyvinyl pyrrolidone lenses
Colour	yellowish	clear
Feel	slimy	reduced slimy
Extractibles: methanol	9 - 12 %	4 - 5 %
Modulus [dynes/cm ²]	69 x 10 ⁵	100 x 10 ⁵
Max. Stress [dynes/cm ²]	37 x 10 ⁵	35 x 10 ⁵
Max. Strain	75 %	49 %
Expansion	27 %	28.3 %
Water content	52 %	53 %

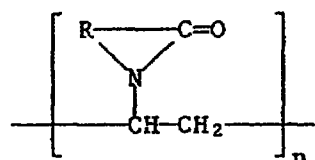
Example 9 : Data from lenses prepared under conditions of example 4 are compared to lenses using non-hydroperoxidized polyvinyl pyrrolidone as the substitute. The polymer is cured in rod form. Buttons are prepared and lathed into lenses, extracted and characterized as summarized below:

Lens parameter	hydroperoxidized polyvinyl pyrrolidone lenses	non-hydroperoxidized polyvinyl pyrrolidone lenses
Colour	Crystal clear	Yellowish
Visible Light Transmission	100 %	≥ 98 % (spec.)
Feel	Non-slimy	Non-slimy
Extractibles: via MeOH	2.4 %	~ 8 %
Expansion	27.4 %	26 % to 29 % (spec.)
Water content	53.3 %	55 % ± 4 % (spec.)
Refractive Index	1.4158	1.4076 to 1.4222 (spec.)
Modulus [dynes/cm ²]	90 x 10 ⁵	64 x 10 ⁵
Maximum Stress [dynes/cm ²]	40 x 10 ⁵	41 x 10 ⁵
Maximum Strain	50 %	67 %

Claims

Claims for the following Contracting States : BE, CH, DE, FR, GB, IT, LI, NL, SE

1. A particulate hydroperoxidized derivative of a poly-N-vinyl lactam containing units of the formula



where R is alkylene of 2 to 8 carbon atoms, n is between about 40 and about 4000, and wherein said derivative contains an average of about 0.5 to about 20 hydroperoxy mole equivalents per mole of poly-N-vinyl lactam.

2. A particulate hydroperoxidized derivative according to claim 1, being the result of the process comprising contacting a particulate polymer having units of formula I with ozone.
3. A particulate hydroperoxidized derivative according to claim 1, wherein said derivative possesses a particle size between about 0.01 and about 200 μm .
4. A particulate hydroperoxidized derivative according to claim 1, possessing a particle size between about 0.1 and about 100 μm .
5. A particulate hydroperoxidized derivative according to claim 1 wherein the average value of n is between about 50 and about 3600.
6. A particulate hydroperoxidized derivative according to claim 1, wherein the average value of n is between about 100 and about 800.
7. A particulate hydroperoxidized derivative according to claim 1, containing an average of between about 1 and about 15 mole equivalents of hydroperoxy groups per mole of poly-N-vinyl lactam.

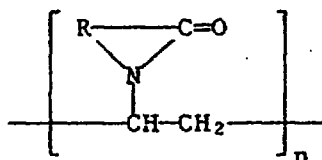


Lens parameter	hydroperoxidized polyvinyl pyrrolidone lenses	non-hydroperoxidized polyvinyl pyrrolidone lenses
5 Colour	Crystal clear	Yellowish
Visible Light Transmission	100 %	≥ 98 % (spec.)
Feel	Non-slimy	Non-slimy
10 Extractibles: via MeOH	2.4 %	~ 8 %
Expansion	27.4 %	26 % to 29 % (spec.)
15 Water content	53.3 %	55 % ± 4 % (spec.)
Refractive Index	1.4158	1.4076 to 1.4222 (spec.)
Modulus [dynes/cm ²]	90 x 10 ⁵	64 x 10 ⁵
20 Maximum Stress [dynes/cm ²]	40 x 10 ⁵	41 x 10 ⁵
Maximum Strain	50 %	67 %

Claims

Claims for the following Contracting States : BE, CH, DE, FR, GB, IT, LI, NL, SE

1. A particulate hydroperoxidized derivative of a poly-N-vinyl lactam containing units of the formula



where R is alkylene of 2 to 8 carbon atoms, n is between about 40 and about 4000, and wherein said derivative contains an average of about 0.5 to about 20 hydroperoxy mole equivalents per mole of poly-N-vinyl lactam.

2. A particulate hydroperoxidized derivative according to claim 1, being the result of the process comprising contacting a particulate polymer having units of formula I with ozone.
3. A particulate hydroperoxidized derivative according to claim 1, wherein said derivative possesses a particle size between about 0.01 and about 200 μm.
4. A particulate hydroperoxidized derivative according to claim 1, possessing a particle size between about 0.1 and about 100 μm.
5. A particulate hydroperoxidized derivative according to claim 1 wherein the average value of n is between about 50 and about 3600.
6. A particulate hydroperoxidized derivative according to claim 1, wherein the average value of n is between about 100 and about 800.
7. A particulate hydroperoxidized derivative according to claim 1, containing an average of between about 1 and about 15 mole equivalents of hydroperoxy groups per mole of poly-N-vinyl lactam.



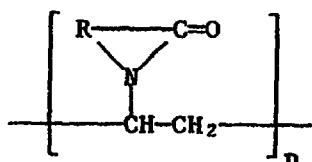
8. A graft copolymer formed from about 1 to about 80 weight percent of a hydroperoxidized poly-N-vinyl lactam according to claim 1, from about 99 to about 20 weight percent of one or more hydrophilic or hydrophobic vinylic monomers, or mixtures thereof, in the further presence or absence of up to about 5 weight percent of a crosslinking agent.

9. A graft copolymer according to claim 8, wherein at least 50 weight percent of said vinylic monomer is a hydrophilic monoester of acrylic or methacrylic acid and a polyhydroxy alcohol.

10. A graft copolymer according to claim 9, wherein said hydrophilic monoester is hydroxyethyl methacrylate.

11. A transparent contact lens formed of a hydrogel composition consisting essentially of (A) a graft copolymer, wherein said copolymer is formed from about 1 to about 80 weight percent of a hydroperoxidized poly-N-vinyl lactam according to claim 1, from about 99 to about 20 weight percent of one or more hydrophilic or hydrophobic vinylic monomers, with the proviso that at least one-half of said vinylic monomer is a hydrophilic monomer, in the further presence or absence of up to about 5 weight percent of a crosslinking agent, and (B) swollen with a physiologically acceptable aqueous medium, such that the amount of (B) is between about 20 and 80 weight percent of the total of (A) and (B).

12. A process for the manufacture of a particulate hydroperoxidized derivative of a poly-N-vinyl lactam containing units of the formula

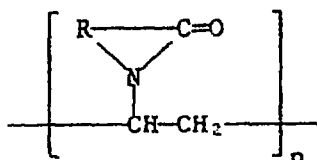


where R is alkylene of 2 to 8 carbon atoms, n is between about 40 and about 4000, and wherein said derivative contains an average of about 0.5 to about 20 hydroperoxy mole equivalents per mole of poly-N-vinyl lactam comprising contacting a particulate polymer having units of formula I with ozone.

13. Use of a particulate hydroperoxidized derivative according to claim 1 for the manufacture of a contact lens according to claim 11.

Claims for the following Contracting States : AT, ES

1. A process for the manufacture of a particulate hydroperoxidized derivative of a poly-N-vinyl lactam containing units of the formula I



where R is alkylene of 2 to 8 carbon atoms, n is between about 40 and about 4000, and wherein said derivative contains an average of about 0.5 to about 20 hydroperoxy mole equivalents per mole of poly-N-vinyl lactam comprising contacting a particulate polymer having units of formula I with ozone.

2. A process for the manufacture of a particulate hydroperoxidized derivative according to claim 1, wherein said derivative possesses a particle size between about 0.01 and about 200 μm .
3. A process for the manufacture of a particulate hydroperoxidized derivative according to claim 1, possessing a particle size between about 0.1 and about 100 μm .

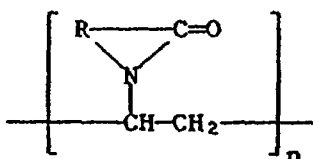


4. A process for the manufacture of a particulate hydroperoxidized derivative according to claim 1 wherein the average value of n is between about 50 and about 3600.
5. A process for the manufacture of a particulate hydroperoxidized derivative according to claim 1, wherein the average value of n is between about 100 and about 800.
6. A process for the manufacture of a particulate hydroperoxidized derivative according to claim 1, containing an average of between about 1 and about 15 mole equivalents of hydroperoxy groups per mole of poly-N-vinyl lactam.
7. A process for the manufacture of a graft copolymer formed by conventional copolymerization from about 1 to about 80 weight percent of a hydroperoxidized poly-N-vinyl lactam according to claim 1, from about 99 to about 20 weight percent of one or more hydrophilic or hydrophobic vinylic monomers, or mixtures thereof, in the further presence or absence of up to about 5 weight percent of a crosslinking agent.
8. A process according to claim 7, wherein at least 50 weight percent of said vinylic monomer is a hydrophilic monoester of acrylic or methacrylic acid and a polyhydroxy alcohol.
9. A process according to claim 8, wherein said hydrophilic monoester is hydroxyethyl methacrylate.
10. A transparent contact lens formed of a hydrogel composition consisting essentially of (A) a graft copolymer, wherein said copolymer is formed from about 1 to about 80 weight percent of a hydroperoxidized poly-N-vinyl lactam according to claim 1, from about 99 to about 20 weight percent of one or more hydrophilic or hydrophobic vinylic monomers, with the proviso that at least one-half of said vinylic monomer is a hydrophilic monomer, in the further presence or absence of up to about 5 weight percent of a crosslinking agent, and (B) swollen with a physiologically acceptable aqueous medium, such that the amount of (B) is between about 20 and 80 weight percent of the total of (A) and (B).
11. Use of a particulate hydroperoxidized derivative according to claim 1 for the manufacture of a contact lens according to claim 10.

Revendications

Revendications pour les Etats contractants suivants : BE, CH, DE, FR, GB, IT, LI, NL, SE

1. Dérivé hydroperoxydé en particules d'un poly-N-vinyl lactame contenant des unités de formule I

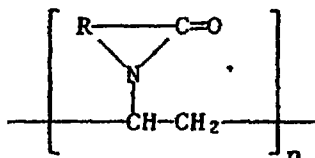


- où R est un radical alkylène ayant de 2 à 8 atomes de carbone, n est compris entre environ 40 et environ 4000, et où ledit dérivé contient une moyenne d'environ 0,5 à environ 20 équivalents molaires de groupes hydroperoxy par mole de poly-N-vinyl lactame.
2. Dérivé hydroperoxydé en particules selon la revendication 1, résultat du procédé comprenant la mise en contact d'un polymère en particules ayant des unités de formule I avec de l'ozone.
3. Dérivé hydroperoxydé en particules selon la revendication 1, dans lequel ledit dérivé possède une taille de particules comprise entre environ 0,01 et environ 200 μm .
4. Dérivé hydroperoxydé en particules selon la revendication 1, possédant une taille de particules comprise entre environ 0,1 et environ 100 μm .
5. Dérivé hydroperoxydé en particules selon la revendication 1, dans lequel la valeur moyenne de n est



entre environ 50 et environ 3600.

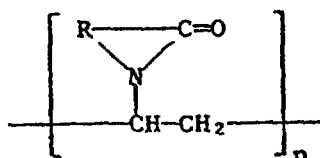
6. Dérivé hydroperoxydé en particules selon la revendication 1, dans lequel la valeur moyenne de n est entre environ 100 et environ 800.
7. Dérivé hydroperoxydé en particules selon la revendication 1, contenant une, moyenne d'environ 1 à environ 15 équivalents molaires de groupes hydroperoxy par mole de poly-N-vinyl lactame.
8. Copolymère greffé formé à partir d'environ 1 à environ 80 pour cent en poids d'un poly-N-vinyl lactame hydroperoxydé selon la revendication 1, d'environ 99 à environ 20 pour cent en poids d'un ou plusieurs monomères vinyliques hydrophiles ou hydrophobes ou leurs mélanges, en présence en outre ou en l'absence d'au plus environ 5 pour cent en poids d'un agent de réticulation.
9. Copolymère greffé selon la revendication 8, dans lequel au moins 50 pour cent en poids dudit monomère vinylique est un monoester d'acide acrylique ou méthacrylique et un alcool polyhydroxylé hydrophiles.
10. Copolymère greffé selon la revendication 9, dans lequel ledit monoester hydrophile est le méthacrylate d'hydroxyéthyle.
11. Lentille de contact transparente formée d'une composition d'hydrogel consistant essentiellement en (A) un copolymère greffé, dans lequel ledit copolymère est formé à partir d'environ 1 à environ 80 pour cent en poids d'un poly-N-vinyl lactame hydroperoxydé selon la revendication 1, d'environ 99 à environ 20 pour cent en poids d'un ou plusieurs monomères vinyliques hydrophiles ou hydrophobes, avec la condition qu'au moins la moitié dudit monomère vinylique soit un monomère hydrophile, en présence en outre ou en l'absence d'au plus environ 5 pour cent en poids d'un agent de réticulation, et (a) gonflée avec un milieu aqueux physiologiquement acceptable, de telle sorte que la quantité de (B) soit comprise entre environ 20 et 80 pour cent en poids du total de (A) et (B).
12. Procédé pour la production d'un dérivé hydroperoxydé en particules d'un poly-N-vinyl lactame contenant des unités de formule I



- où R est un radical alkylène ayant de 2 à 8 atomes de carbone, n est compris entre environ 40 et environ 4000, et où ledit dérivé contient une moyenne d'environ 0.5 à environ 20 équivalents molaires de groupes hydroperoxy par mole de poly-N-vinyl lactame, comprenant la mise en contact d'un polymère en particules ayant des unités de formule I avec de l'ozone.
13. Utilisation d'un dérivé hydroperoxydé en particules selon la revendication 1 pour la production d'une lentille de contact selon la revendication 11.

Revendications pour les Etats contractants suivants : AT, ES

1. Procédé pour la production d'un dérivé hydroperoxydé en particules d'un poly-N-vinyl lactame contenant des unités de formule I





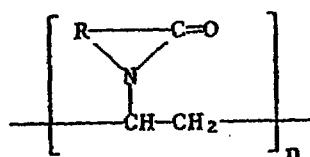
où R est un radical alkylène ayant de 2 à 8 atomes de carbone, n est compris entre environ 40 et environ 4000, et où ledit dérivé contient une moyenne d'environ 0,5 à environ 20 équivalents molaires de groupes hydroperoxy par mole de poly-N-vinyl lactame, comprenant la mise en contact d'un polymère en particules ayant des unités de formule I avec de l'ozone.

2. Procédé pour la production d'un dérivé hydroperoxydé en particules selon la revendication 1, dans lequel ledit dérivé possède une taille de particules comprise entre environ 0,01 et environ 200 μm .
3. Procédé pour la production d'un dérivé hydroperoxydé en particules selon la revendication 1, possédant une taille de particules comprise entre environ 0,1 et environ 100 μm .
4. Procédé pour la production d'un dérivé hydroperoxydé en particules selon la revendication 1, dans lequel la valeur moyenne de n est entre environ 50 et environ 3600.
5. Procédé pour la production d'un dérivé hydroperoxydé en particules selon la revendication 1, dans lequel la valeur moyenne de n est entre environ 100 et environ 800.
6. Procédé pour la production d'un dérivé hydroperoxydé en particules selon la revendication 1, contenant une moyenne d'environ 1 à environ 15 équivalents molaires de groupes hydroperoxy par mole de poly-N-vinyl lactame.
7. Procédé pour la production d'un copolymère greffé formé par copolymérisation classique à partir d'environ 1 à environ 80 pour cent en poids d'un poly-N-vinyl lactame hydroperoxydé selon la revendication 1, d'environ 99 à environ 20 pour cent en poids d'un ou plusieurs monomères vinyliques hydrophiles ou hydrophobes ou leurs mélanges, en présence en outre ou en l'absence d'au plus environ 5 pour cent en poids d'un agent de réticulation.
8. Procédé selon la revendication 7, dans lequel au moins 50 pour cent en poids dudit monomère vinylique est un monoester d'acide acrylique ou méthacrylique et un alcool polyhydroxylé hydrophiles.
9. Procédé selon la revendication 8, dans lequel ledit monoester hydrophile est le méthacrylate d'hydroéthyle.
10. Lentille de contact transparente formée d'une composition d'hydrogel consistant essentiellement en (A) un copolymère greffé, dans lequel ledit copolymère est formé à partir d'environ 1 à environ 80 pour cent en poids d'un poly-N-vinyl lactame hydroperoxydé selon la revendication 1, d'environ 99 à environ 20 pour cent en poids d'un ou plusieurs monomères vinyliques hydrophiles ou hydrophobes, avec la condition qu'au moins la moitié dudit monomère vinylique soit un monomère hydrophile, en présence en outre ou en l'absence d'au plus environ 5 pour cent en poids d'un agent de réticulation, et (B) gonflée avec un milieu aqueux physiologiquement acceptable, de telle sorte que la quantité de (B) soit comprise entre environ 20 et 80 pour cent en poids du total de (A) et (B).
11. Utilisation d'un dérivé hydroperoxydé en particules selon la revendication 1 pour la production d'une lentille de contact selon la revendication 10.

Patentansprüche

Patentansprüche für folgende Vertragsstaaten : BE, CH, DE, FR, GB, IT, LI, NL, SE

1. Teilchenförmiges hydroperoxidiertes Derivat eines Poly-N-vinylactams, das Einheiten der Formel

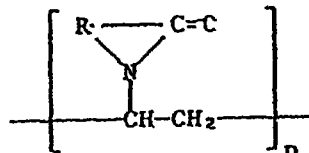


enthält, worin R Alkylen mit 2 bis 8 Kohlenstoffatomen ist, n zwischen etwa 40 und etwa 4000 ist und



worin das Derivat durchschnittlich etwa 0,5 bis etwa 20 Hydroperoxy-Moläquivalente pro Mol Poly-N-vinylactam enthält.

2. Teilchenförmiges hydroperoxidiertes Derivat nach Anspruch 1, welches das Ergebnis des Verfahrens ist, welches das Inkontaktbringen eines teilchenförmigen Polymers, das Einheiten der Formel I hat, mit Ozon umfaßt.
3. Teilchenförmiges hydroperoxidiertes Derivat nach Anspruch 1, worin das Derivat eine Teilchengröße zwischen etwa 0,01 und etwa 200 μm aufweist.
4. Teilchenförmiges hydroperoxidiertes Derivat nach Anspruch 1, das eine Teilchengröße zwischen etwa 0,1 und etwa 100 μm aufweist.
5. Teilchenförmiges hydroperoxidiertes Derivat nach Anspruch 1, worin der Durchschnittswert von n zwischen etwa 50 und etwa 3600 beträgt.
6. Teilchenförmiges hydroperoxidiertes Derivat nach Anspruch 1, worin der Durchschnittswert von n zwischen etwa 100 und etwa 800 beträgt.
7. Teilchenförmiges hydroperoxidiertes Derivat nach Anspruch 1, das durchschnittlich zwischen etwa 1 und etwa 15 Moläquivalente Hydroperoxygruppen pro Mol Poly-N-vinylactam enthält.
8. Pfcopolymers, das gebildet wird aus etwa 1 bis etwa 80 Gew.-% eines hydroperoxidierten Poly-N-vinylactams nach Anspruch 1, etwa 99 bis etwa 20 Gew.-% von einem oder mehr hydrophilen oder hydrophoben vinylischen Monomeren oder Mischungen davon in Gegenwart oder Abwesenheit von bis zu etwa 5 Gew.-% eines Vernetzungsmittels.
9. Pfcopolymers nach Anspruch 8, worin wenigstens 50 Gew.-% des vinylischen Monomers ein hydrophiler Monoester von Acryl- oder Methacrylsäure und Polyhydroxyalkohol ist.
10. Pfcopolymers nach Anspruch 9, worin der hydrophile Monoester Hydroxyethylmethacrylat ist.
11. Transparente Kontaktlinse, geformt aus einer Hydrogel-Zusammensetzung bestehend im wesentlichen aus (A) einem Pfcopolymers, worin das Copolymers hergestellt ist aus etwa 1 bis etwa 80 Gew.-% eines hydroperoxidierten Poly-N-vinylactams nach Anspruch 1, etwa 99 bis etwa 20 Gew.-% von einem oder mehr hydrophilen oder hydrophoben vinylischen Monomeren, mit der Maßgabe, daß zumindest die Hälfte des vinylischen Monomers ein hydrophiles Monomer ist, weiters in Gegenwart oder Abwesenheit von bis zu etwa 5 Gew.-% eines Vernetzungsmittels, und (B) gequollen mit einem physiologisch annehmbaren wäßrigen Medium, so daß die Menge (B) zwischen etwa 20 und etwa 80 Gew.-% der Summe von (A) und (B) beträgt.
12. Verfahren zur Herstellung eines teilchenförmigen hydroperoxidierten Derivats eines Poly-N-vinylactams, das Einheiten der Formel

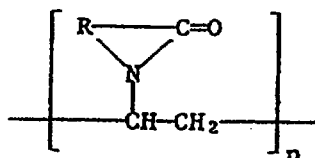


enthält, Worin R Alkylen mit 2 bis 8 Kohlenstoffatomen ist, n zwischen etwa 40 und etwa 4000 beträgt und worin das Derivat durchschnittlich etwa 0,5 bis etwa 20 Hydroperoxy-Moläquivalente pro Mol Poly-N-vinylactam enthält, umfassend das Inkontaktbringen eines teilchenförmigen Polymers, das Einheiten der Formel I hat, mit Ozon.

13. Verwendung eines teilchenförmigen hydroperoxidierten Derivats nach Anspruch 1 für die Herstellung einer Kontaktlinse nach Anspruch 11.


Patentansprüche für folgende Vertragsstaaten : AT, ES

1. Verfahren zur Herstellung eines teilchenförmigen hydroperoxidierten Derivats eines Poly-N-vinylactams, das Einheiten der Formel



enthält, worin R Alkylen mit 2 bis 8 Kohlenstoffatomen ist, n zwischen etwa 40 und etwa 4000 ist und worin das Derivat durchschnittlich etwa 0,5 bis etwa 20 Hydroperoxy-Moläquivalente pro Mol Poly-N-vinylactam enthält, umfassend das Inkontaktbringen eines teilchenförmigen Polymers, das Einheiten der Formel I hat, mit Ozon.

2. Verfahren zur Herstellung eines teilchenförmigen hydroperoxidierten Derivats nach Anspruch 1, worin das Derivat eine Teilchengröße zwischen etwa 0,01 und etwa 200 µm aufweist.

3. Verfahren zur Herstellung eines teilchenförmigen hydroperoxidierten Derivats nach Anspruch 1, das eine Teilchengröße zwischen etwa 0,1 und etwa 100 µm aufweist.

4. Verfahren zur Herstellung eines teilchenförmigen hydroperoxidierten Derivats nach Anspruch 1, worin der Durchschnittswert von n zwischen etwa 50 und etwa 3600 beträgt.

5. Verfahren zur Herstellung eines teilchenförmigen hydroperoxidierten Derivats nach Anspruch 1, worin der Durchschnittswert von n zwischen etwa 100 und etwa 800 beträgt.

6. Verfahren zur Herstellung eines teilchenförmigen hydroperoxidierten Derivats nach Anspruch 1, das durchschnittlich zwischen etwa 1 und etwa 15 Moläquivalente Hydroperoxygruppen pro Mol Poly-N-vinylactam enthält.

7. Verfahren zur Herstellung eines Pfropfcopolymers, das aus etwa 1 bis etwa 80 Gew.-% eines hydroperoxidierten Poly-N-vinylactams nach Anspruch 1, etwa 99 bis etwa 20 Gew.-% von einem oder mehr hydrophilen oder hydrophoben vinylischen Monomeren oder Mischungen davon in Gegenwart oder Abwesenheit von bis zu etwa 5 Gew.-% eines Vernetzungsmittels durch herkömmliche Copolymerisation gebildet wird.

8. Verfahren nach Anspruch 7, worin wenigstens 50 Gew.-% des vinylischen Monomers ein hydrophiler Monoester von Acryl- oder Methacrylsäure und Polyhydroxyalkohol ist.

9. Verfahren nach Anspruch 8, worin der hydrophile Monoester Hydroxyethylmethacrylat ist.

10. Transparente Kontaktlinse, geformt aus einer Hydrogel-Zusammensetzung bestehend im wesentlichen aus (A) einem Pfropfcopolymer, worin das Copolymer hergestellt ist aus etwa 1 bis etwa 80 Gew.-% eines hydroperoxidierten Poly-N-vinylactams nach Anspruch 1, etwa 99 bis etwa 20 Gew.-% von einem oder mehr hydrophilen oder hydrophoben vinylischen Monomeren, mit der Maßgabe, daß zumindest die Hälfte des vinylischen Monomers ein hydrophiles Monomer ist, weiters in Gegenwart oder Abwesenheit von bis zu etwa 5 Gew.-% eines Vernetzungsmittels, und (B) gequollen mit einem physiologisch annehmbaren wäßrigen Medium, so daß die Menge (19) zwischen etwa 20 und etwa 80 Gew.-% der Summe von (A) und (B) ist.

11. Verwendung eines teilchenförmigen hydroperoxidierten Derivats nach Anspruch 1 für die Herstellung einer Kontaktlinse nach Anspruch 10.