Title: COMPOSITIONS AND METHODS OF MAKING COMPOSITIONS

Two fluid fronts that are opposite. First one side will be immersed than the second side

Standing: Single side / one fluid front

\[ \left/ y \right/ y \times \epsilon \] level of soaking liquid

Two fluid fronts that are perpendicular, standing + flat

Flat: One fluid front

Figure 6: Examples of one or more soaking steps with different soaking directions.

Abstract: A method for obtaining a composition of at least two components, comprising the steps of: providing at least one first fluid component; providing at least one second solid component and processing it so that the first component can diffuse into the second component; and diffusing the first component into the second component. A composition prepared by such a method.
Compositions and method of making compositions

The present invention relates to a method for obtaining a composition/mixture of at least two components. The present invention also relates to compositions/mixtures made by such methods, and devices incorporating such compositions/mixtures.

Ultra High Molecular Weight Polyethylene (UHMWPE) is a versatile material combining high strength and toughness with high wear resistance. As a result, it is used in many industrial applications such as bearings, gearings, liners, chain guides, for example. A problem with processing UHMWPE results from its extremely high melt viscosity (zero shear viscosity > $10^8$ Pa.s), which does not enable for common processing techniques such as injection molding or extrusion. Instead, UHMWPE powder is sintered and then the part is mechanically machined into the desired shape. Since conventional melt-processing and mixing techniques are not applicable, blending of additives is normally done by mixing the UHMWPE powder with the additive followed by sintering. The mixing of the two powders is difficult since the UHMWPE powder has a very low density and is highly porous. If the additive is also a powder, it is difficult to form a homogeneous powder mixture. If the additive is in liquid form, homogeneous distribution of that liquid in the powder having an extremely high surface area is also difficult.

It is known to mix additives with the UHMWPE powder or diffuse them into the UHMWPE powder before the sintering step. It is also known to diffuse the additives into the sintered products.

According to a first aspect of the present invention, there is provided a method for obtaining a composition of at least two components, comprising the steps of:

- providing at least one first fluid component;
providing at least one second solid component and processing it so that the first component can diffuse into the second component; and diffusing the first component into the second component.

5 The first component may comprise at least one liquid.

The first component may comprise at least one gas.

The first component may comprise at least one solid dissolved in the fluid.

10 The second component may be processed so that capillary forces are created or increased when the first component contacts the second component.

The second component may be processed so that capillaries (conduits/channels) are formed to generate or increase capillary forces for the first component that contacts the second component.

The second component may be a powder. The powder may be compacted. The powder may be compacted so that capillary forces are created or increased for the first component that contacts the second component.

The compacted powder block may be soaked in at least one liquid. The liquid may be a pure additive. The liquid may be a solution comprising the additive.

25 The method may further comprise the step of treating the composition so that liquid or gas is removed to produce a solid composition.

The compacted powder block may be treated so that the solvent evaporates leaving the additive in the compacted block.

30 The method may further comprise the step of sintering the composition.
The second component may be a polymer. The polymer may be a co-polymer.

The compacted block may be sintered above the melting temperature of the polymer.

The polymer may be crystalline. The polymer may be semi-crystalline.

The polymer may be selected from the group consisting of polyolefins (polyethylene, polypropylene), polyoxymethylene (POM), polyamides (PA6, PA6.6, PA4.6), PVC, PEEK, PPSU, polytetrafluoroethylene (PTFE) and polyesters (PET, PBT, PEN, PC).

The polymer may be selected from the group consisting of UHMWPE, HDPE, LDPE and LLDPE.

The polymer may be polyethylene having a molecular weight of at least 100,000. The polyethylene may have a molecular weight of at least 300,000. The polyethylene may have a molecular weight of at least 1 million.

The polymer may be amorphous.

The polymer may be selected from the group consisting of polystyrene or modified styrene polymers (SAN, SB, ABS), PMMA, polyacrylates (for example polybutylacrylate), PPO.

The method may further comprise the step of cross-linking the polymer.

The cross-linking may be performed after sintering the composition.
The cross-linking may be performed by irradiation. The cross-linking may be performed using gamma or e-beam irradiation.

The cross-linking may be performed by a chemical species. The chemical cross-linking species may be dibenzoylperoxide.

The first component may comprise a chemical species for cross-linking the polymer.

The first component may comprise an antioxidant.

The first component may comprise at least one Vitamin. The first component may comprise Vitamin E.

The first component may comprise an antibiotic.

The antibiotic may be selected from the group consisting of gentamycin, vancomycin, streptomycin, penicillin and derivatives thereof.

The first component may comprise a foaming agent. That is, a solvent with a boiling temperature above the sintering temperature of the polymer.

The first component may comprise a reactive monomer.

The first component may comprise an initiator to start a polymerization of a monomer.

The reactive monomer may be selected from the group consisting of ethylene, propylene, vinyl chloride, oxymethylene, butylacrylate, methyl methacrylate, and styrene.
The first component may comprise a dye. The dye may be natural. The dye may be synthetic.

The dye may be selected from the group consisting of fuchsin, Sudan red, Sudan black, anthraquinone, azo compounds, sulphuric compounds, natural dyes such as carotene, curcumin (turmeric) or carmine.

The first component may comprise a clarifying or nucleating agent such as sorbitol based compounds (DBS, MDBS, DMDBS), sodium benzoate, talc or thymine.

The first component may be diffused into the second component in at least two stages.

The composition may be sterilised.

The composition may be formed into an artefact.

The artefact may be a medical device.

The medical device may be sterilised.

According to a second aspect of the present invention, there is provided a composition prepared by any of the methods according to the first aspect of the present invention.

According to a third aspect of the present invention, there is provided a composition comprising a compacted powder according to the first aspect of the present invention.
Preferably, the compacted powder is prepared in such a way that capillary forces are created or increased for a fluid component that contacts the compacted powder.

According to a fourth aspect of the present invention, there is provided a composition comprising at least one first fluid component and at least one second solid component according to the first aspect of the present invention, wherein the first component is distributed within the second component.

According to a fifth aspect of the present invention, there is provided a composition comprising a compacted powder and at least one fluid component according to the first aspect of the present invention.

According to a sixth aspect of the present invention, there is provided a composition comprising at least one first fluid component and at least one second solid component according to the first aspect of the present invention, wherein the first component is distributed within the second component, and wherein the composition is sintered.

According to some embodiments of the present invention, the additives are diffused into the compacted body, i.e., into the intermediate state between powder and sintered object. During compaction below the melting temperature, the porous powder particles are deformed into a dense body but since no melting occurs, the particles are not completely fused. Between the deformed particles, there are very narrow channels that support the rapid and uniform fluid absorption due to the capillary forces acting locally. These capillary forces are not present between loose particles or in the sintered and completely fused product. After the additive has been soaked into the compacted body, a final sintering step is done to fuse the particles. Viscous or solid additives can be dissolved to enable soaking into the compacted body. For these embodiments,
the solvent can be evaporated before sintering or it evaporates during the subsequent sintering step.

The sintered materials can be used for medical implants such as total hip or knee replacements. These polyethylene implants containing additives for antioxidative purposes can also be cross-linked after the pre-compaction-soaking-sintering process using gamma or e-beam irradiation. The irradiation doses may vary from 1 to 25 Mrad or more preferably from 3 to 20 Mrad. The medical implants can also be sterilized either using gamma irradiation (2.5 - 4 Mrad) or surface sterilization methods such as ETO or gas plasma treatments.

Solid compositions may be processed from any type of polymer in powder form or from more than one type of polymer. If a polymer is available only in solid bulk or pellet form, the material may be grinded to a powder prior to compaction. The pressure may be chosen between 0 - 50 MPa, more preferably between 0 - 20 MPa and even more preferably between 5 - 15 MPa. The processing temperature is preferably set to a temperature below the melting temperature ($T_m$) of the polymer. If two or more different polymers are processed the temperature is preferably set to a temperature below $T_m$ of the polymer with the lowest $T_m$. More preferably, the temperature is set to $T_m - 30 \, ^{0}\text{C}$, more preferably to $T_m - 20 \, ^{0}\text{C}$ and even more preferably to $T_m - 10 \, ^{0}\text{C}$. The pressure may be applied first followed by heating of the mould. The heating of the mould may be applied first followed by the application of pressure. The compaction time depends on the volume of the solid composition and is preferably between 1 second and 100 hours, more preferably between 1 minute and 24 hours and even more preferably between 30 minutes and 6 hours. All material in the processing mould should reach the desired compaction time. The temperature may be decreased prior to releasing the pressure. The pressure may be released prior to decreasing the temperature. The compaction procedure may be performed in normal air atmosphere, in vacuum environment or in an inert gas atmosphere such as nitrogen or argon.
In those embodiments of the invention comprising polyethylene, compaction of the polyethylene may be performed at a temperature above room temperature and below the melting temperature (25-130°C), at pressures ranging from 0.5-25 MPa (more preferably 1 to 15 MPa, even more preferably 2 to 10 MPa).

Compacted solid compositions are preferably processed from UHMWPE. For example, UHMWPE powder may be filled in a mould at room temperature and subsequently a pressure of about 10 MPa applied and maintained during the whole compaction procedure. Subsequently, the temperature is increased from room temperature to about 120°C. At about 120°C and about 10 MPa, the powder is kept for a period of time to completely heat all of the polymer powder to about 120°C. The period of time depends on the volume of the solid composition, for example around 20 minutes for a composition with the dimensions 4 x 4 x 2 cm, and around 4 hours for a composition with the dimensions 20 x 20 x 5 cm. Subsequently, the temperature is decreased. Below a temperature of about 50°C, the pressure can be released and the solid composition can be removed from the mould.

Reference will now be made, by way of example, to the following drawings and examples, in which:

- Figure 1 shows soaking of a compacted GUR 1020 block in a red isopropanol/fuchsin solution;
- Figure 2 shows soaking of a sintered GUR 1020 block in a red isopropanol/fuchsin solution;
- Figure 3 shows compacted and soaked blocks cut into two pieces (1% curcumin solution in acetone) after drying;
- Figure 4 shows average weight change of the 2 standing blocks as a function of the soaking time;
Figure 5 shows vitamin E concentration profiles in the sintered blocks that were previously compacted and soaked in a Vitamin E-hexane solution; Figure 6 shows examples of one or more soaking steps with different soaking directions; and Figure 7 shows oxidation profiles of Vitamin E soaked and additive-free samples.

**Example 1: diffusion of dyes / colors into compacted UHMWPE bodies**

GUR 1020 UHMWPE powder was compacted in a press at 120°C and a pressure of 10 MPa. A small block (4 cm x 3 cm x 5 cm) was cut from the plate and put into a glass containing 75 ml of isopropanol and 0.04 grams of Fuchsin (Merck). In Figure 1, the soaking behavior at room temperature of the pre-compact ed block is depicted as a function of time. Within seconds, the fluid including the color additive is absorbed and within an hour the body is uniformly colored.

Figure 1 shows soaking of a compacted GUR 1020 block in a red isopropanol/fuchsin solution (left: seconds after immersion; middle: 30 minutes after immersion; right: 1 hr after immersion).

**Comparative example 1:**

A sintered block of GUR 1020 (4x3x5 cm) was put into a glass containing 75 ml of isopropanol and 0.04 grams of Fuchsin (Merck). Figure 2 shows the soaking behavior at room temperature of the block depicted as a function of time (left: seconds after immersion; middle: 30 minutes after immersion; right: 1 hr after immersion).

In the comparative example, the sintered block is not impregnated with the fluid.
Example 2: soaking of natural additives/antioxidants into small compacted blocks

GUR 1020 blocks were compacted below the melting temperature at 120°C in a laboratory scale press for 15 minutes at 10 MPa. Afterwards, the compacted blocks were rapidly cooled to room temperature.

Soaking: 3.8 x 4 x 1.5 cm compacted blocks were soaked at room temperature in a 1% w/w solution of acetone containing curcumin as an additive. After soaking for an hour, the acetone was evaporated in a vacuum oven at 40°C for 24 hr. The compacted and soaked block was cut into two pieces (Figure 3) showing the homogeneous distribution of the yellow curcumin.

Figure 3 shows compacted and soaked blocks cut into two pieces (1% curcumin solution in acetone) after drying. Figure 3 (a) and (b) represent two different blocks, both cut into 2 pieces.

Example 3: soaking of antioxidants - Vitamin E into small compacted blocks followed by sintering

The compaction was done as described in Example 2. After compaction the samples were immersed in a hexane-vitamin E solution (2.8% w/w) and the weight was measured during soaking. 2 compacted blocks were standing in the solution (only lower part of block immersed, see also Figure 1) and 1 block was completely covered with the soaking solution (inside the liquid).

After soaking, the samples were dried to constant weight in a vacuum oven (see example 2) and the weight was measured again to determine the VitE content in the material. Finally, the compacted polyethylene blocks were sintered for 15 minutes in a mold at a temperature of 220°C and a pressure of 5 MPa. The samples were finally cooled rapidly (in 8 minutes) to room temperature.
FTIR measurements were conducted to determine the content of vitamin E in the samples. From the sintered blocks, small portions were cut in regular distances. From these smaller pieces, microtome slices were produced with a thickness of about 300 microns (or 5 times 60 microns). Of these slices, FTIR spectra were recorded with a Bruker Vertex 70 with a resolution of 4 cm⁻¹ and a total of 16 scans.

For a more precise determination of the vitamin E concentration, the measured spectra were normalized and a spectrum of pure UHMWPE was deducted. The 2020 cm⁻¹ peak was chosen as reference peak and its height (relative to the height at 2100 cm⁻¹ and 1980 cm⁻¹) was normalized to an absorbance of 0.05. This is supposed to correspond to a film thickness of 100 microns. Of this normalized spectrum, the spectrum of pure UHMWPE, normalized by the same procedure, was deducted. Then, the height of the C-OH absorption (vitamin E peak) at 1210 cm⁻¹ (relative to the height at 1188 cm⁻¹ and 1231 cm⁻¹) was determined. The concentration of vitamin E (mol/kg) was calculated according to the following equation:

\[ A = \varepsilon \cdot b \cdot C \]

\( A \) = peak absorbance (height of the 1210 cm⁻¹ peak)
\( \varepsilon \): molar absorbivity of the \( \alpha \)-tocopherol -OH in UHMWPE (in kg·cm⁻¹·mol⁻¹).
Experimentally determined = 133 kg·cm⁻¹·mol⁻¹
\( b \) = path length (film thickness) in cm = 0.01 cm for normalized spectra
\( C \) = concentration of \( \alpha \)-tocopherol in UHMWPE in mol·kg⁻¹

In Figure 4, the average weight change of the 2 standing blocks is depicted as a function of the soaking time. Initially there is a fast weight increase within 4 hrs, afterwards, the weight increase levels off. The weight increase is due to the absorption of the hexane-vitamin E solution.

In Figure 5, the concentration profiles of Vitamin E in the blocks are shown after solvent evaporation and subsequent sintering. Figure 5 shows vitamin E
concentration profiles in the sintered blocks that were previously compacted and soaked in a Vitamin E-hexane solution. 2 blocks were standing in the solution, partially immersed in the fluid, and 1 block was completely immersed in the fluid (inside).

The weight% of Vitamin E in the UHMWPE determined from the integrated FTIR spectra and from the gravimetric method are listed below.

<table>
<thead>
<tr>
<th></th>
<th>Gravimetric data</th>
<th>Integrated FTIR data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing #1</td>
<td>3.1%</td>
<td>2.3%</td>
</tr>
<tr>
<td>Standing #2</td>
<td>3.1%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Inside</td>
<td>0.81%</td>
<td>1.15%</td>
</tr>
</tbody>
</table>

This example shows that it is possible to impregnate the compacted body with a solution containing Vitamin E, subsequently evaporate the solvent (hexane) and finally sinter the compacted material. The amount of vitamin E in the block can be tuned by selecting different concentrations of Vitamin E in the solution or by selecting the appropriate soaking procedure.

In accordance with embodiments of the present invention, compacted blocks can be soaked in more than one soaking step. The additive in the fluid during a second or third soaking step may be different from the first soaking step. The additive can also be a chemical cross-linking agent (such as dibenzoylperoxide) or an antibiotic (such as gentamycin) or a reactive monomer (e.g. styrene or methylmethacrylate) or a foaming agent (a solvent with boiling temperature above the sintering temperature of the polyethylene). The foaming agent can have a high boiling temperature at ambient pressure, i.e. after sintering but the foaming agent may also be liquid during sintering at elevated pressures and be in
the gaseous phase upon release of the pressure after sintering. Also the
direction of the soaking can be different as explained in Figure 6, which shows
examples of one or more soaking steps with different soaking directions.

The soaking can be also restricted to a part of the compacted object therewith
creating portions in the block that contain the additive and portions without the
additive. In example 1, if the compacted block was removed from the soaking
fluid (left picture) the sintered product would only be partially colored. This
results in portions of blended and virgin material in the compacted body. Also a
compacted and soaked body with an additive can be placed in a solvent in a
second step to locally extract an additive and create concentration gradients in
the compacted material.

The current invention is not restricted to UHMWPE powders but also powders
from lower molecular weight polyethylenes such as HDPE, LDPE, LLDPE. The
method can also be applied to other polymers such as PMMA, polystyrene,
polypropylene, PVC, polyoxymethylene (POM), PPSU, PPO, PEEK, Polyamides
(PA6, PA 6.6, PA 4.6), other polycrylates (such as poly butylacrylate), PTFE.

Advantages of the present method include the following. For additive mixing
involving powders, the capillary forces acting in the compacted body are not
present between loose particles and therefore it is not possible to get a rapid,
uniform and efficient fluid uptake for fluid additives. For solid additives, the
present method enables a more uniform distribution of the additives by first
dissolving the additive and subsequent soaking. Of course, solid additives
cannot be soaked /diffused into the compacted body without the use of a carrier
liquid.

For additive diffusion into sintered objects, the particles in the sintered objects
are fused and no capillary forces are acting between the particles that enable a
rapid and efficient fluid absorption and diffusion (see comparative example 1).
Therefore, elevated temperatures close to the melting temperature are necessary to stimulate the classical Fick diffusion into the object which is slower and less efficient. In the present invention, additives are soaked into compacted materials at room temperature within minutes/hours which is not possible when using sintered UHMWPE parts.

Example 4: Oxidation of blocks soaked with antioxidant and irradiated with gamma radiation

The oxidation resistance of a block containing antioxidants that was gamma irradiated was determined. A block that was processed according to the method described in Example 3 (soaked with vitamin E prior to sintering) was irradiated with a dose of 14 Mrad (± 10 %) in normal air atmosphere. No post-irradiation thermal treatment was applied.

Cylindrical samples with a length of 40 mm and a diameter of 10 mm were drilled out of the irradiated block. Subsequently, the samples were accelerated aged according to ASTM F 2003 in an oxygen bomb at 5 atm oxygen pressure and 70 °C for 14 days. Oxidation indices of the aged components were determined by means of FTIR according to ASTM F 2102-06. The method for making measurements of the oxidation index according to this standard is as follows: thin slices of the sample are made with a microtome and tested to give a depth profile for the oxidation index. From the micro-slices taken of the sample the infrared spectrum is taken by means of FTIR with a resolution of 4cm⁻¹. The oxidation index is defined as the intensity of the peaks in the region 1680-1 765cm⁻¹, which is associated with carbonyl peaks, divided by the intensity in a reference band which lies between 1330 and 1396cm⁻¹.

In Figure 7, the oxidation profile of a vitamin E soaked and irradiated (gamma in air, 14 Mrad) sample is shown. The oxidation profile is an
average of three individual measurements. As control sample, an UHMWPE without additive, irradiated with 14 Mrad in air (without post-irradiation thermal treatment), is shown. The reduced oxidation of the material that was soaked with vitamin E is clearly demonstrated, as the maximum oxidation index of this material is below 0.02.
Claims

1. A method for obtaining a composition of at least two components, comprising the steps of:
   providing at least one first fluid component;
   providing at least one second solid component and processing it so that the first component can diffuse into the second component; and
   diffusing the first component into the second component.

2. A method according to claim 1, wherein the first component comprises at least one liquid.

3. A method according to claim 1 or 2, wherein the first component comprises at least one gas.

4. A method according to any preceding claim, wherein the first component comprises at least one solid dissolved in the fluid.

5. A method according to any preceding claim, wherein the second component is processed so that capillary forces are created or increased when the first component contacts the second component.

6. A method according to any preceding claim, wherein the second component is a powder that is compacted so that capillaries are formed between particles to generate or increase capillary forces for the first component that contacts the second component.

7. A method according to any preceding claim, further comprising the step of treating the composition so that liquid or gas is removed to produce a solid composition.
8. A method according to any preceding claim, further comprising the step of sintering the composition.

9. A method according to any preceding claim, wherein the second component is a polymer.

10. A method according to claim 9, wherein the polymer is crystalline.

11. A method according to claim 10, wherein the polymer is selected from the group consisting of polyethylene, polypropylene, polyoxymethylene (POM), polyamide, PVC, PPSU, PEEK, PTFE and PET.

12. A method according to claim 11, wherein the polymer is polyethylene having a molecular weight of at least 100,000.

13. A method according to claim 12, wherein the polyethylene has a molecular weight of at least 300,000.

14. A method according to claim 12, wherein the polyethylene has a molecular weight of at least 1 million.

15. A method according to claim 9, wherein the polymer is amorphous.

16. A method according to claim 15, wherein the polymer is selected from the group consisting of polystyrene, polyacrylates, PPO and PMMA.

17. A method according to any of claims 9 to 16, further comprising the step of cross-linking the polymer.

18. A method according to claim 17 when dependent on claim 8, wherein the cross-linking is performed after sintering the composition.
19. A method according to claim 17, wherein the cross-linking is performed by irradiation.

20. A method according to claim 17, wherein the cross-linking is performed by a chemical species.

21. A method according to claim 20, wherein the first component comprises a chemical species for cross-linking the polymer.

22. A method according to any preceding claim, wherein the first component comprises an antioxidant.

23. A method according to any preceding claim, wherein the first component comprises Vitamin E.

24. A method according to any preceding claim, wherein the first component comprises an antibiotic.

25. A method according to claim 24, wherein the antibiotic is selected from the group consisting of gentamycin, vancomycin, streptomycin, penicillin and derivatives thereof.

26. A method according to any preceding claim, wherein the first component comprises a foaming agent.

27. A method according to any preceding claim, wherein the first component comprises a reactive monomer.
28. A method according to claim 27, wherein the reactive monomer is selected from the group consisting of ethylene, propylene, vinyl chloride, oxymethylene, methyl methacrylate, and styrene.

29. A method according to any preceding claim, wherein the first component is an initiator for starting a polymerization of a monomer.

30. A method according to any preceding claim, wherein the first component comprises a dye.

31. A method according to claim 30, wherein the dye is natural or synthetic.

32. A method according to claim 30, wherein the dye is selected from the group consisting of fuchsin, Sudan red, Sudan black, anthraquinone, azo compounds, sulphuric compounds, carotene, curcumin (turmeric) and carmine.

33. A method according to any preceding claim, wherein the first component comprises a clarifying or nucleating agent.

34. A method according to claim 33, wherein the clarifying or nucleating agent is selected from the group consisting of sorbitol based compounds (DBS, MDBS, DMDBS), sodium benzoate, talc or thyme.

35. A method according to any preceding claim, wherein the first component is diffused into the second component in at least two stages.

36. A method according to any preceding claim, wherein the composition is sterilised.

37. A method according to any preceding claim, wherein the composition is formed into an artefact.
38. A method according to claim 37, wherein the artefact is a medical device.

39. A method substantially as hereinbefore described with reference to the drawings.

40. A composition prepared by any of the methods according to claims 1 to 39.

41. A composition comprising a compacted powder according to any of claims 6 to 39.

42. A composition according to claim 41, wherein the compacted powder is prepared in such a way that capillary forces are created or increased for a fluid component that contacts the compacted powder.

43. A composition comprising at least one first fluid component and at least one second solid component according to any of claims 1 to 39, wherein the first component is distributed within the second component.

44. A composition comprising a compacted powder and at least one fluid component according to any of claims 1 to 39.

45. A composition comprising at least one first fluid component and at least one second solid component according to any of claims 1 to 39, wherein the first component is distributed within the second component, and wherein the composition is sintered.

46. A composition substantially as hereinbefore described with reference to the drawings.
Figures

Figure 1: Soaking of a compacted GUR 1020 block in a red isopropanol/fuchsin solution. Left: seconds after immersion; middle 30 minutes after immersion, right 1 hr after immersion.

Figure 2: Soaking of a sintered GUR 1020 block in a red isopropanol/fuchsin solution. Left: seconds after immersion; middle 30 minutes after immersion, right 1 hr after immersion.
Figure 3: Compacted and soaked blocks cut into two pieces (1% curcumin solution in acetone) after drying. a) and b) represent two different blocks, both cut in 2 pieces.

Figure 4: Average weight change of the 2 standing blocks as a function of the soaking time.
Figure 5: Vitamin E concentration profiles in the sintered blocks that were previously compacted and soaked in a Vitamin E-hexane solution. 2 blocks were standing in the solution, partially immersed in the fluid and 1 block was completely immersed in the fluid (inside).

Figure 6: Examples of one or more soaking steps with different soaking directions.
Figure 7: Oxidation profiles of vitamin E soaked and additive-free samples, both gamma irradiated with a dose of 14 Mrad in air (no post-irradiation thermal treatment).
A. CLASSIFICATION OF SUBJECT MATTER

INV. C08J3/00

According to International Patent Classification (IPC) or both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>
| X        | DATABASE WPI Week 200577
Thomson Scientific, London, GB; AN
2005-752230
XP002552037
& JP 2005 276747 A (HITACHI LTD)
6 October 2005 (2005-10-06)
abstract                         | 1-46 |
| X        | US 2004/208902 A1 (GUPTA SHYAM K [US])
21 October 2004 (2004-10-21)
claims 1-19; examples 1-12       | 1-46 |
| X        | WO 2005/121221 A (TICONA LLC [US]; WANG LOUIS C [US]; EHLERS JENS [DE])
22 December 2005 (2005-12-22)
claims 1-19; examples 1-5        | 1-46 |

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T": later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X": document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y": document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

Date of the actual completion of the international search: 23 October 2009

Date of mailing of the international search report: 02/11/2009

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV RIVM
Tel: (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer
Gi omm, Bernhard
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>WO 01/39881 A (ELIPSA GMBH [DE]; ULBRICHT MATHIAS [DE]; SERGEYEVA TATIANA A [UA]; MAT) 7 June 2001 (2001-06-07) claims 1-25; examples 1-16</td>
<td>1-46</td>
</tr>
<tr>
<td>X</td>
<td>WO 00/07702 A (POLY AN GMBH [DE]; ULBRICHT MATHIAS [DE]; PILETSKI SERGIY [UA]; SCHEDL) 17 February 2000 (2000-02-17) claims 1-10; examples 1-10</td>
<td>1-46</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>JP 2005276747 A</td>
<td>06-10-2005</td>
<td>NONE</td>
</tr>
<tr>
<td>WO 2005121221 A</td>
<td>22-12-2005</td>
<td>BR PI0511840 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2561893 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN 1965020 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2008501850 T</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2007510509 T</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2005047467 A2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 2003501 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2397668 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 19959264 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 1244516 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 6670427 B1</td>
</tr>
</tbody>
</table>