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(54) **Új bioanyagok, eljárás előállításukra elektromos szálképzéssel és alkalmazásuk biogyógyászati és sebészeti területen**

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(54) **NEW BIOMATERIALS, THEIR PREPARATION BY ELECTROSPINNING AND THEIR USE IN THE BIOMEDICAL AND SURGICAL FIELD**

NEUE BIOLOGISCHE STOFFE, IHRE HERSTELLUNG DURCH ELEKTROSPINNEN UND IHRE VERWENDUNG IN DER BIOMEDIZIN UND CHIRURGIE

NOUVEAUX BIOMATÉRIAUX, LEUR PRÉPARATION PAR ÉLECTROFILATURE, ET LEUR UTILISATION DANS LES DOMAINES BIOMÉDICAL ET CHIRURGICAL

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(56) References cited:
WO-A-93/11803

- **UM I C ET AL: "Electro-Spinning and Electro-Blowing of Hyaluronic acid" BIOMACROMOLECULES, ACS, WASHINGTON, DC, US, vol. 5, no. 4, 5 July 2004 (2004-07-05), pages 1428-1436, XP002483474 ISSN: 1525-7797 [retrieved on 2004-07-05]**
- **WEE-EONG TEO, WEI HE, SEERAM RAMAKRISHNA: "Electrospun scaffold tailored for tissue-specific extracellular matrix" BIOTECHNOLOGY JOURNAL, vol. 1, no. 9, September 2006 (2006-09), pages 918-929, XP002522630 ISSN: 1860-6768**
- **ULRICH BOUDRIOT, ROLAND DERSCH, ANDREAS GREINER, JOACHIM H. WENDORFF: "Electrospinning Approaches Toward Scaffold Engineering?A Brief Overview" ARTIFICIAL ORGANS, vol. 30, no. 10, October 2006 (2006-10), pages 785-792, XP002522631 ISSN: 0160-564X**

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Description

Field of the invention

[0001] The present invention relates to the field of biomaterials produced for biomedical use, in particular of non-woven fabric, wherein fibres obtainable by the electrospinning technique are used.

State of the art

[0002] As is known, hyaluronic acid (HA) is a heteropolysaccharide composed of alternating residues of D-glucuronic acid and N-acetyl-D-glucosamine.

[0003] It is a linear chain polymer with molecular weight that may range between 50,000 and 13 x 10^6 Da, according to the source it is obtained from and to the methods of preparation used.

[0004] It is found in nature in pericellular gels, in the fundamental substance of the connective tissue of vertebrate organisms (of which it is one of the main components), in vitreous humor and in the umbilical cord.

[0005] Hyaluronic acid is one of the main molecules constituting the cartilaginous matrix but it also represents the major non-proteinic component of the synovial fluid. Being a highly hydrophile viscoelastic molecule, it imparts lubricating properties to the synovial fluid and for these reasons, for over 30 years HA has been used in the pathology of ostheoarthrosis, especially for treating the pain associated therewith (Ghosh P. et al., Semin Arthritis Rheum, 2002, 32: 10-37).

[0006] In fact, at an articular level the hyaluronic acid contained in the synovial fluid also serves as a viscous lubricant during slow movements while during quick movements, with its elastic properties it absorbs any traumas or microtraumas that may affect the articulation; in pathological situations both the concentration of HA and its mean molecular weight decrease considerably, altering the physiological features of the synovial fluid.

[0007] It has also been proved that HA plays a fundamental role in the tissue healing process both from the structural point of view (in the extracellular matrix organization and in the control of its hydration) and as stimulating substance for a large number of processes wherein it intervenes either directly or indirectly (clotting, phagocyte activity, fibroblast proliferation, neovascularization, riepitelization, etc.) (Weigel P. et al., J Theoretical Biol, 1986:219-234; Abatangelo G. et al., J Surg Res, 1983, 35:410-416; Goa K. et al., Drugs, 1994, 47:536-566).

[0008] Such widely recognized properties have long been used for preparing dressings used for treating wounds, ulcers and skin wounds of various origin.

[0009] HA therefore plays an important role in the biological organism both as structural and mechanical support of tissues, and as active component in the physiology of tissue cells such as skin, tendons, muscles and cartilage.

[0010] Hyaluronic acid esters are, among the derivatives of HA, particularly important in the process of forming new engineered tissues, since they can be processed into different shapes for making biomaterials usable for tissue reconstruction. The use of HA derivatives for making fibres (EP 0618817 B1) is in fact known, which processed as non-woven, make up a biomaterial in the form of three-dimensional matrix (free from cellular component) usable in the dermatological field; moreover, the above three-dimensional structures may be charged with mesenchymal cells and kept *in vitro* for a time required for favoring the proliferation and/or the partial differentiation thereof (EP 0863776 B1), for forming new artificial tissue to be implanted *in vivo.*

[0011] The above biomaterials have particular biocompatibility features totally matching those of hyaluronic acid as is, but having a different biodegradability and so, when implanted *in vivo,* the residence time *in situ* is considerably higher than that of unmodified HA, thus allowing the reconstruction of the damaged tissue (Campoccia D. et al., Biomaterials, 1998, 19: 2101-2127).

[0012] The so-called Electrospinning technique is known, which allows making ultra-thin fibres through the stretching carried out by an electrical field.

[0013] A polymer solution is obtained according to this technique, using a polar solvent that may therefore make the solution conductive.

[0014] A drop of the polymer solution is introduced, generally by a needle connected to earth, inside a very strong electrical field obtained by placing a screen with a large potential difference in front of the needle itself. The drop is attracted in the form of many small drops towards the screen and a very fine spray is formed, but under certain condition of surface tension and viscosity of the solution, the drop is stretched and an immediate evaporation of the solvent occurs by the effect of the large surface it takes on, thus obtaining polymer fibres having a nanometric diameter (even 50 nanometres).

[0015] It should be noted that while the literature on this technique is very large, to date it has found poor application in the industry. UM IC ET AL: "Electro-Spinning and Electro-Blowing of Hyaluronic acid",BIOMACROMOLECULES, ACS, WASHINGTON, DC, US, vol. 5, no. 4, 5 July 2004 (2004-07-05), pages 1428-1436, discloses non-woven fabric materials comprising electrospun fibres of hyaluronic acid having diameter smaller than 1 micron.

[0016] WO 93/11803 A discloses non-woven fabric materials comprising fibres of hyaluronic acid benzyl ester with

diameter of tens of microns. The fibres are produced by wet extrusion in DMSO.

Brief description of the Figure

[0017] Figure 1 shows the growth data of fibroblasts on the non-woven fabric according to the invention compared to a control biomaterial.

Summary of the invention

[0018] Objects of the invention are new biomaterials in the form of fibres, tissues and non-woven fabric materials comprising fibres of hyaluronic acid benzyl ester with a % of esterification comprised between 50 - 100% having diameter smaller than a micron.

Detailed description of the invention

[0019] It has now been surprisingly found that by subjecting solutions composed of HA benzyl ester with a % of esterification comprised between 50 - 100% to electrospinning it is possible to obtain fibres with a diameter below a micron that allow making biomaterials in the form of non-woven fabric or woven fabric. The fibres may be composed of hyaluronic acid benzyl ester with a % of esterification comprised between 50 - 100% associated with esters of alginic acid or other natural, semi-synthetic or synthetic polymers. The woven fabric and the non-woven fabric prepared by the electrospinning technique may contain a single type of fibre or it may consist of different fibres consisting of various polymers. Therefore, the subject biomaterials may comprise fibres consisting of at least an HA benzyl ester with a % of esterification comprised between 50 - 100% in combination with another polymer, or woven and non-woven fabrics with fibres at least 1 % made of HA benzyl ester with a % of esterification comprised between 50 - 100% and for the rest consisting of other polymers.

[0020] Natural polymers that may be selected as components of the new biomaterial comprise collagen, hyaluronic acid, cellulose, chitin, chitosan, pectin, pectic acid, agar, agarose, gellan, alginic acid, starch, natural gum and polyglycan.

[0021] Semi-synthetic polymers comprise cross-linked collagen and hyaluronic acid, and chemically modified derivatives of the natural polymers listed above.

[0022] Synthetic polymers comprise polylactic acid, polyglycolic acid, copolymers of polylactic and polyglycolic acid, polycaprolacton and polyurethane.

[0023] According to the invention, by esters of hyaluronic acid it is meant esters of hyaluronic acid with benzyl ester (Hyaff 11) with a % of esterification comprised between 50 and 100%, preferably benzyl ester with a % of esterification comprised between 50 - 75% and 80 - 100%.

[0024] A further object of the present invention is the improvement of the process of preparation of the new biomaterials by electrospinning of Hyaff 11 derivatives having a % of esterification comprised between 50 - 75%, in fact the powders of said derivatives are insoluble in the hereinafter reported solvents and therefore the Hyaff esterified from 50 - 75% would be not usable for the preparation of biomaterials by electrospinning. However the Applicant surprisingly found that it is possible to solubilise, and therefore to stretch/work in an electric field, mixtures comprising Hyaff esterified 50-75% when the Hyaff is mixed up with polyvinylpirrolidone (PVP) in a w/w rate of 80:20 and preferably 87/13.

[0025] Moreover it is possible to prepare solutions comprising Hyaff 11 esterified 80 - 100% without mixing with PVP since they are perfectly soluble in the hereinafter reported solvents. The advantages in using Hyaff 11 partially esterified are various, in particular they give the possibility of working a polysaccharide in the wanted form of biomaterial, choosing the preferred degradation time *in vivo,* and therefore the time of permanence *in situ*, in a way dependent on the kind of tissue which must be reconstructed: a longer time for cartilaginous or bone tissues and shorter for skin tissues.

[0026] Solvents for preparing the solutions to be subjected to electrospinning according to the invention are normally selected from 1,1,1,3,3,3-hexafluoro-2-isopropanol and mixtures in all proportions of dimethyl sulfoxide and 1,1,1,3,3,3-hexafluoro-2-isopropanol and dimethylformamide (DMF) in admixture with 1,1,1,3,3,3-hexafluoro-2-isopropanol.

[0027] The concentrations of the solutions preferably of hyaluronic acid ester, according to the invention, are normally comprised between 0.01 and 200 g/L, preferably between 10 and 50 g/L, more preferably between 15 and 30 g/L.

[0028] The fibres are manufactured starting from the above solutions as described above in the comment to the state of the art.

[0029] Preferably, according to the invention the distances between the polymer source and the fibre collection plane is comprised between 1 and 50 cm, preferably between 10 and 15 cm, and the high voltage values are comprised between 1 and 160 kV, preferably between 40 and 60 kV.

[0030] The fibres thus obtained normally have a diameter comprised between 0.01μm and 1.0μm, preferably of 0.1μm.

[0031] Woven and non-woven fabric sheets are prepared with the fibres thus made essentially according to the prior art. Moreover it is possible to coat synthetic devices in order to increase their bio-compatibility *in vivo.*

[0032] In particular, the fibres are evenly and randomly laid on the collection plane thanks to the strength of the electrical field received, and the make thereof takes place in the same electrical field. The fibres make a non-woven fabric thanks to the adherence of the fibres to each other and to the possible presence of traces of residual solvent that afterwards are eliminated. The fibres deposited according to a predefined drawing allow to obtain a bio-material in the form of woven fabric.

[0033] The collection is made on a plane, connected to earth, which may either be stationary or rotating, and with different shapes.

[0034] The new biomaterials object of the present invention substantially differ from the woven fabrics and non-woven fabrics according to the prior art for the reasons listed below:

1. triple increase of the contact surface area with the *in vivo* tissue treated, the weight of the subject biomaterial being equal to that of reference/control according to the prior art;
2. greater compactness and thus smaller volume, the surface unit being equal compared to the reference/control biomaterial;
3. considerable increase of wettability (up to 5 times) compared to the reference/control biomaterial;
4. bi-dimensional cell growth;
5. considerable increase of cellular proliferation compared to a control growth carried out on reference material, consisting of the same derivative processed in the shape of a membrane for ensuring a bi-dimensional proliferation like the new subject biomaterials.

[0035] To prove what stated, the Applicant has run comparative tests (described below) using a non-woven fabric based on a benzyl ester of HA having 100% esterification produced with an electrospinning technique, compared to the biomaterial called Hyalomatrix®, composed of benzyl ester of HA with 100% esterification, also processed as a non-woven fabric, and Laserskin®, holey membrane of benzyl ester of HA with 100% esterification. Hyalomatrix® is a three-dimensional matrix used by the man skilled in the art especially for the absorption of the exudate present in burns and/or in skin wounds, whereas Laserskin® is a known bi-dimensional support used for the growth of fibroblasts in the bioengineered regeneration of derma/skin.

[0036] Comparison of the absorption and wettability properties of the new non-woven fabric produced with the electrospinning technique with Hyalomatrix®

[0037] The test is run on a number of 5 pieces for each product and for each test required.

[0038] The test is run with the same surface of the two products (2X2 cm) and for surface unit with the same weight of the product.

[0039] The solvent for running the test is a sterile saline (sodium chloride 0.9%).

[0040] The results are shown in the table.

	Absorption with the same surface	Absorption with the same weight	Wettability
Hyalomatrix®	1st test: 9 fold the dry weight 2nd test: 8 fold the dry weight 3rd test: 10 fold the dry weight 4th test: 10 fold the dry weight 5th test: 9 fold the dry weight	1st test: 10 fold the dry weight 2nd test: 10 fold the dry weight 3rd test: 9 fold the dry weight 4th test: 11 fold the dry weight 5th test: 9 fold the dry weight	1st test: 2 fold the dry weight 2nd test: 2 fold the dry weight 3rd test: 2.5 fold the dry weight 4th test: 2 fold the dry weight 5th test: 2.5 fold the dry weight
Non-woven fabric (produced with the electrospinning technique)	1st test: 8 fold the dry weight 2nd test: 8 fold the dry weight 3rd test: 9 fold the dry weight 4th test: 8 fold the dry weight	1st test: 9 fold the dry weight 2nd test: 9 fold the dry weight 3rd test: 8 fold the dry weight 4th test: 9 fold the dry weight	1st test: 8 fold the dry weight 2nd test: 8 fold the dry weight 3rd test: 9 fold the dry weight 4th test: 10 fold the dry weight

(continued)

	Absorption with the same surface	Absorption with the same weight	Wettability
	5th test: 9 fold the dry weight	5th test: 8 fold the dry weight	5th test: 9 fold the dry weight

[0041] The tests run on the wettability of materials follow a procedure that requires the placement of the material inside a container (Petri dish) and adding a known amount of saline. The products should not be moved for any reason.

[0042] For the absorption test, applying the same sample treatment procedure as described for wettability, the sample may be moved for favoring the imbibition thereof.

[0043] Results: while for the new non-woven fabric object of the present invention the absorption values match those of wettability, for the Hyalomatrix® non-woven fabric, which represents the state of the art, it is clear that wettability tests are about 4 times lower than both the Hyalomatrix® absorption values and the wettability test of the new biomaterial. Moreover, it is important to point out that the product weight being equal, the new non-woven fabric has a contact surface area 3 times larger than that of the known product.

[0044] This datum is very important since, the dry weight of the product being equal, an absorbing surface is obtained that is 3 times larger that allows, for example, a greater absorption of the exudate of a burn and/or skin wound than the products known in the art, without the need of compressing the wound with the selected dressing.

[0045] Example: non-woven fabric from electrospinning: dry weight: 30mg, surface: 6 cm^2, absorption for wettability (without compression): 8 to 10 fold the dry weight, therefore: 240-300mg.

[0046] Hyalomatrix® non-woven fabric: dry weight: 30mg, surface: 3 fold less than the above, thus: 2 cm^2, absorption for wettability (without compression): 2 to 2.5 fold the dry weight, therefore: 60-75g. End result: the dry weight being equal, the new dressing absorbs an amount of exudate 4 times higher with a surface 3 times larger without compression of the wound or of the burn treated.

[0047] Assessment of the cellular viability of human fibroblasts seeded on the new non-woven product made with the electrospinning technique compared to Laserskin®, holey membrane of benzyl ester of HA

Experimental rationale: Human fibroblasts were seeded at a density of 500,000 cell/cm^2 on 1 cmX1 cm pieces of tested materials.

[0048] At 7 days the samples were subject to MTT test for assessing the cellular viability.

Materials and methods

Fibroblast preparation

[0049] Dermic fibroblasts were collected, upon informed consent, from subjects undergoing a surgery that had no alterations of the connective tissue. The isolated fibroblasts from biopsies were grown in DMEM containing 10% FCS. Fibroblasts between the third and the sixth step were seeded at a density of 500.000 per cm^2 of the biomaterials described above. The above biomaterials were kept for 7 days at 37°C in an atmosphere of 95% air and 5% CO2.

[0050] The culture medium is added with ascorbic acid 50 μg/ml. Test MTT: tetrazolium salt subject to redox reaction only by the mitochondrial enzymes of vital fibroblasts (Dezinot F. et al., J Immunol Methods, 1986, 22(89): 271-277).

[0051] Briefly, the cells are incubated with a solution MTT 0.5 mg/ml for 3 hours. At the end of the incubation, the dye is extracted from the cells by an extraction solution (90% isopropanol, 10% DMSO) for the readout at 540nm/660 nm.

[0052] Results: Figure 1 shows the considerable increase (more than 30%) of the growth of fibroblasts on the new non-woven fabric compared to the control biomaterial. Proliferation, for the compactness of the new substrate, takes place in two dimensions, whereas the non-woven fabric Hyalomatrix®, known in the art, only shows a three-dimensional proliferation and for this reason a membrane, Laserskin®, wherein the cell proliferation takes place in two dimensions, was used as control/comparison matrix. Thanks to the compactness of the new biomaterial, related to the thickness of its fibres, it was possible to prepare non-woven fabrics that appear like porous surfaces whereon the fibroblasts can "anchor" better than a smooth surface like that of a Laserskin® membrane, the substrate normally used by the man skilled in the art for the proliferation of skin cells. Therefore, the material produced according to the electrospinning technique will better favor the skin regeneration in the case it is used as treatment for skin wounds.

[0053] The new biomaterials in the form of fibre, woven fabric or non-woven fabric of the present invention may advantageously be used in various types of micro-surgeries in dermatology, odontology, stomatology, otorhinolaryngology, orthopaedics, neurosurgery and in the surgery of internal organs, wherein it is necessary to use a substance that may be metabolized by the organism and which is capable of facilitating the flap-take, the riepitelization of membrane mucosa, the stabilization of grafts and cavity filling. Moreover, they may advantageously be used as buffer means in

nose and inner ear surgery, for forming/regenerating new bioengineered tissues either in association or not with differentiated or undifferentiated cells, and finally for making new advanced dressings to use in the *management* of burns and skin wounds (comprising ulcers of various etiology, surgical wounds and abrasions) since, as proved above, they favor the exudate absorption and skin regeneration.

[0054] The invention shall be more and better understood in the light of the following examples.

EXAMPLE 1

[0055] A solution of ester of hyaluronic acid HYAFF 11 prepared at 15 g/L in 1,1,1,3,3,3-hexafluoro-2-isopropanol is spun in an electrical field at 54kV voltage. The fibres are formed in the space between the source and the revolving collecting cylinder, connected to earth, where afterwards they are laid for making the non-woven fabric. In this case, the distance is 15 cm.

EXAMPLE 2

[0056] A solution of ester of hyaluronic acid HYAFF 11/p75 at 30 g/L in 1,1,1,3,3,3-hexafluoro-2-isopropanol was prepared under light stirring. The obtained solution is added with polyvinylpirrolidone (PVD) in order to increase the solubility in the solvent. The preferred ratio HYAFF/PVD is 87:13.

[0057] The solution thus obtained is spun in the electrical field at a voltage value of 42 kV and a distance of 12 cm.

EXAMPLE 3

[0058] A solution of ester of hyaluronic acid HYAFF 11/p80 at 40 g/L in 1,1,1,3,3,3-hexafluoro-2-isopropanol was prepared under light stirring.

[0059] The solution thus obtained is spun in the electrical field at a voltage value of 40kV and a distance of 12 cm.

EXAMPLE 4

[0060] A solution of ester of hyaluronic acid HYAFF 11 at 50 g/L in 1,1,1,3,3,3-hexafluoro-2-isopropanol was prepared under light stirring.

[0061] The solution thus obtained is spun in the electrical field at a voltage value of 50kV and a distance of 12 cm.

Claims

1. Biomaterials in the form of woven or non-woven fabric comprising fibres having diameter smaller than a micron of hyaluronic acid derivatives made of hyaluronic acid benzyl ester with a % of esterification comprised between 50 - 100% obtained by electrospinning technique.

2. Biomaterials according to Claim 1 wherein said fibres have diameter comprised between 0,01 μm and 1,0 μm.

3. Biomaterials according to Claim 2 wherein said fibres have diameter of 0,1 μm.

4. Biomaterials according to Claim 1 wherein said derivatives are used in combination or associated with esters of alginic acid or other natural, semi-synthetic or synthetic polymers.

5. Biomaterials according to claims 1 - 4 consisting of a unique kind of fibres or fibres consisting of various polymers.

6. Biomaterials according to claim 5 comprising fibres consisting of at least fibres of HA benzyl ester with a % of esterification comprised between 50 - 100% in combination with another polymer or fibres consisting of at least 1% of HA esters and for the rest of natural, semi-synthetic or synthetic polymers.

7. Biomaterials according to claims 4 and 6 wherein said natural polymers are chosen among: collagen, hyaluronic acid, cellulose, chitin, chitosan, pectin, pectic acid, agar, agarose, gellan, alginic acid, starches, natural gums, polyglycans.

8. Biomaterials according to claims 4 and 6 wherein said semi-synthetic polymers are chosen among: cross-linked collagen and hyaluronic acid and chemically modified derivatives of the polymers according to claim 6.

9. Biomaterials according to Claims 4 and 6 wherein said synthetic polymers are chosen among: polylactic acid, polyglycolic acid, copolymers of polylactic and polyglycolic acid, polycaprolacton and polyurethane.

10. Fibres having diameter smaller than a micron of hyaluronic acid derivatives made of HA benzyl ester with a % of esterification comprised between 50 - 100% obtained by electrospinning technique.

11. Biomaterials and fibres according to claims 1 - 10 for the preparation of coatings, medication tools and/or bioengineered biomaterials.

12. Biomaterials and fibres according to Claims 1 - 10 for use in a method of absorption of the exudate present in burns and/or in skin wounds or for the growth of fibroblasts in the regeneration of derma/skin.

13. Biomaterials and fibres according to Claims 11-12 for use in dermatology, odontology, stomatology, otorhinolaryngology, orthopaedics, neurosurgery and in the surgery of internal organs

14. Biomaterials and fibres according to Claims 11-12 for use as tampons in the surgical treatment of nose and ears.

15. Biomaterials accordig to Claim 1 wherein said % of esterification is comprised between 50 - 75%.

16. Biomaterials according to claim 1 wherein said % of esterification is comprised between 80 - 100%

17. Process for the preparation by electrospinning of biomaterials and fibres wherein:

- a hyaluronic acid benzyl ester with a % of esterification comprised between 50 - 75% is mixed up with polyvinylpirrolidone (PVP) in a w/w rate of 80:20, preferably 87:13;
- the mixture is solubilised in the appropriate solvent;
- the solution is submitted to electrospinning.

Patentansprüche

1. Biomaterialien in Form von gewebten oder nicht gewebten Textilien, die Fasern aus Hyaluronsäurederivaten mit einem Durchmesser von unter einem Mikrometer aufweisen, die aus Hyaluronsäure-Benzylester, mit einem Veresterungsgrad zwischen 50 und 100%, und durch die Technik des Elektrospinnens hergestellt werden.

2. Biomaterialien gemäß Anspruch 1, wobei die Fasern einen Durchmesser zwischen 0,01 μm und 1,0μm aufweisen.

3. Biomaterialien gemäß Anspruch 2, wobei die Fasern einen Durchmesser von 0,1 μm aufweisen.

4. Biomaterialien gemäß Anspruch 1, wobei die Derivate in Kombination oder in Verbindung mit Estern aus Alginsäure oder anderen natürlichen, teilsynthetischen oder synthetischen Polymeren verwendet werden.

5. Biomaterialien gemäß den Ansprüchen 1 bis 4, die aus einer einzigen Art von Fasern oder aus Fasern verschiedener Polymere bestehen.

6. Biomaterialien gemäß Anspruch 5, die Fasern aufweisen, die zumindest Fasern aus Hyaluronsäure-Benzylester mit einem Veresterungsgrad zwischen 50 und 100% in Kombination mit einem anderen Polymer enthalten, oder Fasern, die zumindest aus 1% Hyaluronsäureester und als Rest aus natürlichen, teilsynthetischen oder synthetischen Polymeren bestehen.

7. Biomaterialien gemäß den Ansprüchen 4 bis 6, wobei die natürlichen Polymere ausgewählt werden aus: Kollagen, Hyaluronsäure, Cellulose, Chitin, Chitosan, Pektin, Pektinsäure, Agar, Agarose, Gellan, Alginsäure, Stärke, Pflanzengummi, Polyglycanen.

8. Biomaterialien gemäß den Ansprüchen 4 bis 6, wobei die teilsynthetischen Polymere ausgewählt werden aus: quervernetztem Kollagen und Hyaluronsäure und chemisch modifizierten Derivaten von Polymeren gemäß Anspruch 6.

9. Biomaterialien gemäß den Ansprüchen 4 bis 6, wobei die synthetischen Polymere ausgewählt werden aus: Polylactidsäure, Polyglycolidsäure, Copolymeren von Polylactidsäure und Polyglycolidsäure, Polycaprolacton und Polyurethan.

10. Fasern mit einem Durchmesser von unter einem Mikrometer, die aus Hyaluronsäure-Benzylester, mit einem Veresterungsgrad zwischen 50 und 100%, und durch die Technik des Elektrospinnens hergestellt werden.

11. Biomaterialien und Fasern gemäß den Ansprüchen 1 bis 10 zur Bereitstellung von Auflagen, medizinischen Behandlungswerkzeugen und / oder biotechnischen Biomaterialien.

12. Biomaterialien und Fasern gemäß den Ansprüchen 1 bis 10 zur Verwendung in einem Verfahren der Absorption von Exsudat bei Verbrennungen und / oder Hautwunden oder beim Fibroblastenwachstum bei der Regenerierung der Derma / Haut.

13. Biomaterialien und Fasern gemäß den Ansprüchen 11 bis 12 zur Verwendung in Dermatologie, Odontologie, Stomatologie, Otorhinolaryngologie, Orthopädie, Neurochirurgie und der Chirurgie der inneren Organe.

14. Biomaterialien und Fasern gemäß den Ansprüchen 11 bis 12 zur Verwendung als Tampons bei der chirurgischen Behandlung von Nase und Ohr.

15. Biomaterialien gemäß Anspruch 1, wobei der Veresterungsgrad zwischen 50 und 75% liegt.

16. Biomaterialien gemäß Anspruch 1, wobei der Veresterungsgrad zwischen 80 und 100% liegt.

17. Verfahren zur Bereitstellung von Biomaterialien und Fasern durch Elektrospinnen, wobei:

    - ein Hyaluronsäurebenzylester, mit einem Veresterungsgrad zwischen 50 und 75%, mit Polyvinyl-Pirrolidon (PVP) in einem Gewichtsverhältnis von 80 : 20, vorzugsweise von 87 : 13 gemischt wird;
    - die Mischung in einem geeigneten Lösungsmittel gelöst ist;
    - die Lösung dem Elektrospinnen zugeführt wird.

Revendications

1. Biomatériaux sous forme d'étoffe tissée ou non tissée comprenant des fibres ayant un diamètre inférieur à un micron de dérivés d'acide hyaluronique réalisées en ester de benzyle d'acide hyaluronique avec un % d'estérification compris entre 50 et 100 % obtenues par une technique de filage électrostatique.

2. Biomatériaux selon la revendication 1, dans lesquels lesdites fibres ont un diamètre compris entre 0,01 μm et 1,0 μm.

3. Biomatériaux selon la revendication 2, dans lesquels lesdites fibres ont un diamètre de 0,1 μm.

4. Biomatériaux selon la revendication 1, dans lesquels lesdits dérivés sont utilisés en combinaison ou associés à des esters d'acide alginique ou d'autres polymères naturels, semi-synthétiques ou synthétiques.

5. Biomatériaux selon les revendications 1 à 4, constitués d'une sorte unique de fibres ou de fibres constituées de divers polymères.

6. Biomatériaux selon la revendication 5, comprenant des fibres constituées au moins de fibres d'ester de benzyle d'AH avec un % d'estérification compris entre 50 et 100 % en combinaison avec un autre polymère ou des fibres constituées d'au moins 1 % d'esters d'AH et pour le reste de polymères naturels, semi-synthétiques ou synthétiques.

7. Biomatériaux selon les revendications 4 et 6, dans lesquels lesdits polymères naturels sont choisis parmi : le collagène, l'acide hyaluronique, la cellulose, la chitine, le chitosan, la pectine, l'acide pectique, l'agar-agar, l'agarose, la gellane, l'acide alginique, des amidons, des gommes naturelles, des polyglycanes.

8. Biomatériaux selon les revendications 4 et 6, dans lesquels lesdits polymères semi-synthétiques sont choisis parmi : le collagène réticulé et l'acide hyaluronique et des dérivés chimiquement modifiés des polymères selon la revendi-

cation 6.

9. Biomatériaux selon les revendications 4 et 6, dans lesquels lesdits polymères synthétiques sont choisis parmi : le polyacide lactique, le polyacide glycolique, des copolymères de polyacide lactique et de polyacide glycolique, la polycaprolactone et le polyuréthane.

10. Fibres ayant un diamètre inférieur à un micron de dérivés d'acide hyaluronique réalisées en ester de benzyle d'AH avec un % d'estérification compris entre 50 et 100 % obtenues par une technique de filage électrostatique.

11. Biomatériaux et fibres selon les revendications 1 à 10 pour la préparation d'enrobages d'outils de médication et/ou de biomatériaux de bioingénierie.

12. Biomatériaux et fibres selon les revendications 1 à 10 destinés à être utilisés dans un procédé d'absorption de l'exsudat présent dans des brûlures et/ou des plaies cutanées ou pour la croissance de fibroblastes dans la régénération de derme/peau.

13. Biomatériaux et fibres selon les revendications 11 à 12 destinés à être utilisés en dermatologie, odontologie, stomatologie, oto-rhinolaryngologie, orthopédie, neurochirurgie et dans l'opération d'organes internes.

14. Biomatériaux et fibres selon les revendications 11 à 12 destinés à être utilisés comme tampons dans le traitement chirurgical du nez et des oreilles.

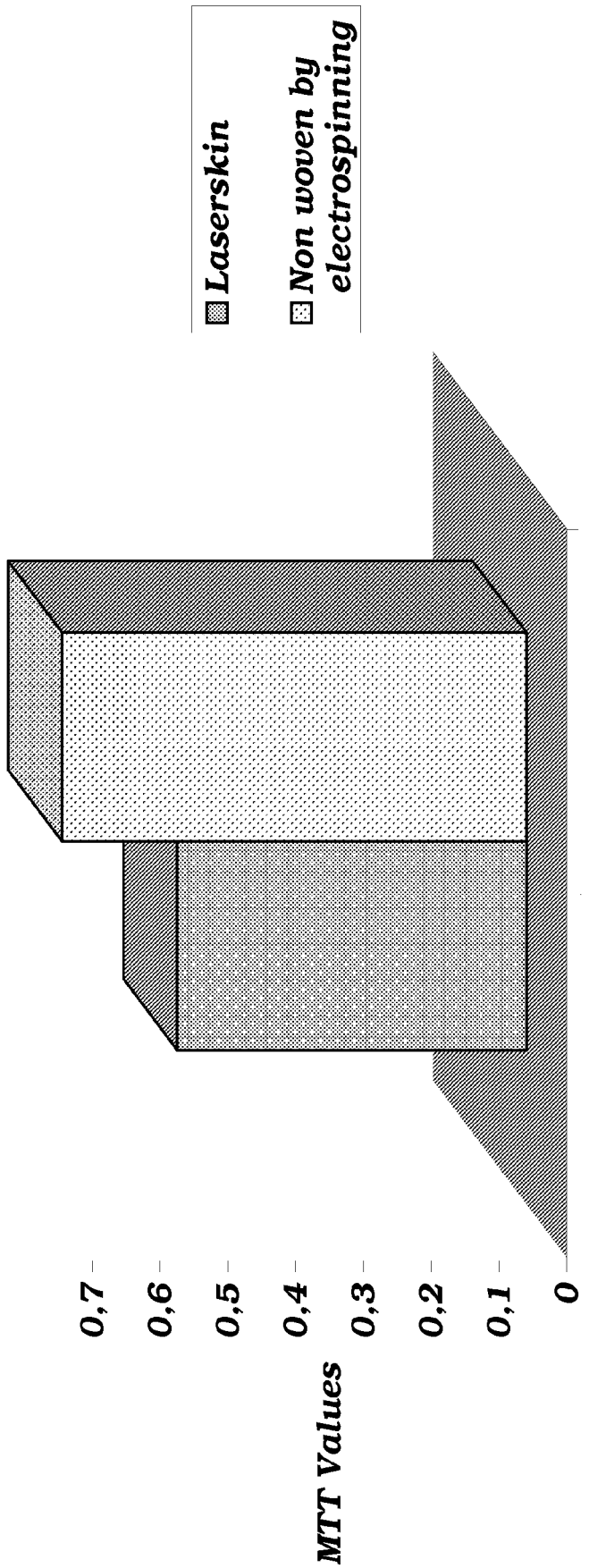
15. Biomatériaux selon la revendication 1, dans lesquels ledit % d'estérification est compris entre 50 et 75 %.

16. Biomatériaux selon la revendication 1, dans lesquels ledit % d'estérification est compris entre 80 et 100 %.

17. Procédé pour la préparation par filage électrostatique de biomatériaux et de fibres dans lequel :

    - un ester de benzyle d'acide hyaluronique avec un % d'estérification compris entre 50 et 75 % est mélangé avec de la polyvinylpyrrolidone (PVP) dans un rapport p/p de 80:20, de préférence 87:13 ;
    - le mélange est solubilisé dans le solvant approprié ;
    - la solution est soumise à un filage électrostatique.

Growth of fibroblasts on new non-woven fabric compared to Laserskin membane



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0618817 B1 **[0010]**
- EP 0863776 B1 **[0010]**
- WO 9311803 A **[0016]**

Non-patent literature cited in the description

- **GHOSH P. et al.** *Semin Arthritis Rheum,* 2002, vol. 32, 10-37 **[0005]**
- **WEIGEL P. et al.** *J Theoretical Biol,* 1986, 219-234 **[0007]**
- **ABATANGELO G. et al.** *J Surg Res,* 1983, vol. 35, 410-416 **[0007]**
- **GOA K. et al.** *Drugs,* 1994, vol. 47, 536-566 **[0007]**
- **CAMPOCCIA D. et al.** *Biomaterials,* 1998, vol. 19, 2101-2127 **[0011]**
- Electro-Spinning and Electro-Blowing of Hyaluronic acid. **UM IC et al.** BIOMACROMOLECULES. ACS, 05 July 2004, vol. 5, 1428-1436 **[0015]**
- **DEZINOT F. et al.** *J Immunol Methods,* 1986, vol. 22 (89), 271-277 **[0050]**

Szabadalmi igénypontok

1. Bioanyagok szőtt vagy nemszőtt anyag formájában, amelyek tartalmaznak elektromos szálképzési eljárással kapott, egy mikronnál kisebb átmérőjű, hialuronsavból és benzil-észterből készült, 50-100% észterezési %-kal rendelkező hiauronsav-származék szálakat.

2. Az 1. igénypont szerinti bioanyagok, ahol a szálak átmérője 0,01 μm és 1,0 μm közötti.

3. A 2. igénypont szerinti bioanyagok, ahol a szálak átmérője 0,01 μm.

4. Az 1. igénypont szerinti bioanyagok, ahol a származékokat alginsav-észterekkel vagy más természetes, félszintetikus vagy szintetikus polimerekkel kombinálva vagy társítva használjuk.

5. Az 1-4. igénypontok szerinti bioanyagok, amelyek egyféle szálakból vagy különféle polimerekből álló szálakból állnak.

6. Az 5. igénypont szerinti bioanyagok, amelyek tartalmaznak szálakat, amelyek legalább HA-benzil-észter szálakból állnak, melyek észterezési %-a 50-100%, egy másik polimerrel vagy szálakkal kombinációban, amelyek legalább 1%-ban HA-észterekből állnak, és a maradék természetes, félszintetikus vagy szintetikus polimerből áll.

7. A 4-6. igénypontok szerinti bioanyagok, amelyekben a természetes polimereket a következők közül választjuk: kollagén, hialuronsav, cellulóz, kitin, kitozán, pektin, pektinsav, agar, agaróz, gellán, alginsav, keményítők, természetes gumik, poliglikánok.

8. A 4-6. igénypontok szerinti bioanyagok, amelyekben a félszintetikus polimereket a következők közül választjuk: térhálósított kollagén és hialuronsav, valamint a 6. igénypont szerinti polimerek kémiailag módosított származékai.

9. A 4-6. igénypontok szerinti bioanyagok, amelyekben a szintetikus polimereket a következők közül választjuk: politejsav, poliglikolsav, politejsav és poliglikolsav kopolimerei, polikaprolakton és poliuretán.

10. Elektromos szálképzési eljárással kapott, egy mikronnál kisebb átmérőjű, HA-benzil-észterből készült, 50-100% észterezési %-kal rendelkező hiauronsav-származék szálak.

11. Az 1-10. igénypontok szerinti bioanyagok és szálak bevonatok, orvosi eszközök és/vagy biotechnológiával előállított bioanyagok előállítására.

12. Az 1-10. igénypontok szerinti bioanyagok és szálak égési sebekben és/vagy börsérülésekben jelen levő izzadmány abszorbeálására irányuló eljárásban történő alkalmazásra, vagy a derma/bőr regenerációja során a fibroblasztok növesztésére.

13. A 11-12. igénypontok szerinti bioanyagok és szálak börgyógyászatban, fogászatban, sztomatológiában, fül-orr-gégészetben, ortopédiában, idegsebészetben és belső szervek sebészetében történő alkalmazásra.

14. A 11-12. igénypontok szerinti bioanyagok és szálak orr és fül sebészeti kezelésében tamponként történő alkalmazásra.

15. Az 1. igénypont szerinti bioanyagok, amelyekben az észterezési % 50 - 75%.

16. Az 1. igénypont szerinti bioanyagok, amelyekben az észterezési % 80 - 100%.

17. Eljárás bioanyagok és szálak elektromos szálképzéssel történő előállítására, amelyben:

- 50-75% észterezési %-kal rendelkező hiauronsav-benzil-észtert polivinilpirrolidonnal (PVP) elegyítünk 80:20, előnyösen 87:13 tömegarányban;

- az elegyet a megfelelő oldószerben szolubilizáljuk;

- az oldatot elektromos szálképzésnek vetjük alá.