TECHNOLOGY WATCH: MEDICAL POLYMERS

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http://www.PURpatents.com

Introduction.

This "Essenscia Technology Watch" is about polymeric materials used for medical applications. Because there is an enormous amount of medical research going on all over the world, this report does not even attempt to be complete but only highlights some of the main topics and trends that stand out from the recent patent literature. The following topics and trends are discussed from a *materials science & -technology point-of-view:*

- Adhesives
- Bioresorbable materials
- Coatings
- Composites
- Foams
- Hydrogels
- Nanofibers
- Nanoparticles
- Shape memory materials

Each topic is concisely discussed and a table with examples of recent patent applications given. The patent application numbers are linked to 'Free Patents Online' (http://www.freepatentsonline.com) from where the complete text can be downloaded.

Bioadhesives

Adhesives are used in a number of medical application like tissue fixation, attachment of wound dressings, adhesion of drug delivery devices etc. replacing some older technologies like sutures,staples, screws and the like.

Medical grades of 'conventional adhesives like **cyanoacrylates**, **polyurethanes** and **silicones** can be used as bioadhesives. For example WO/2014/026672 discusses two component polyurea systems. Silicone adhesives discussed in WO/2013/103537 comprise silicone ionomers to improve hydrophilicity and moisture transport. Water-based adhesives made from **polysaccharides**, in this case **hyaluronic acid** and **collagen** solutions are discussed in WO/2012/175563.

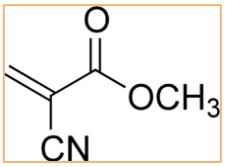

FIGURE 1: METHYL CYANOACRYLATE

Bioadhesives can also be in the form of hydrogels, like in WO/2010/118284 which teaches an adhesive hydrogel made from a oxidized polysaccharide crosslinked with a multi-arm polyamine.

A special type of adhesive is bone cement, which is used in in orthopedic surgery. Bone cement is often in the form of a powder of **acrylic** particles, as for example in WO/2014/168565 and WO/2015/148759.

An interesting development are bioadhesives which exploit the key components of the natural marine mussel: the **mussel adhesive proteins** (MAPs). These adhesives are remarkable for the ability to work under water. Peptides that mimic natural adhesive proteins in their composition and adhesive properties can be coupled to a polymer chain, and provide adhesive properties to synthetic polymers. Examples of this technology are given in WO/2012/009664 and WO/2014/062901.

The table below is a small selection of recent bioadhesive patent applications:

TABLE 1: BIOADHESIVES

Document No.	Title	Assignee
WO/2014/081391	New photoactive bioadhesive compositions	NANYANG TECH UNIV

WO/2012/175563	Biocompatible adhesive and method for the production thereof	CHARITE UNIVERSITAETSMEDIZIN
WO/2012/009664	Bioadhesive compounds and methods of synthesis and use	KNC NER ACQUISITION SUB INC
WO/2014/062901	Negative-swelling and exceptionally robust adhesive hydrogels	UNIV NORTHWESTERN
WO/2011/003172	Controlled nitric oxide delivery from aqueous s-nitrosothiol conjugated polymers and their complexes	UNIV TORONTO
WO/2010/118284	Hydrogel tissue adhesive having reduced degradation time	DUPONT
WO/2014/026672	Bioreabsorbable adhesives and use thereof in the medical sector	BESS PRO GMBH
WO/2012/028842	Double- sided adhesive silicone gel -coated wound dressing	SYSTAGENIX WOUND MANAGEMENT
WO/2013/103537	Silicone adhesive compositions	MOMENTIVE PERFORMANCE MAT INC
WO/2014/168565	Acrylic cements for bone augmentation	
WO/2015/148759	Acrylic bone cement having a delayed release polymerization inhibitor such as an anti-oxidant for increased working time	DEPUY SYNTHES PRODUCTS LLC
WO/2011/103268	Polymeric bone defect filler	DOCTORS RES GROUP
WO/2013/160917	Self-hardening bioactive cement compositions with partially deacetylated chitin as bone graft substitutes	GENIS EHF
WO/2011/120002	Thermal-responsive polymer networks, compositions, and methods and applications related thereto	UNIV MASSACHUSETTS
WO/2013/064059	Biodegradable medical adhesive and preparation method and use thereof	INST PHARMA & TOXICOLOGY AMMS
WO/2012/030821	Terpolymer blends and their use as pressure-sensitive adhesives	SURMODICS PHARMACEUTICALS

Bioresorbable materials

Bioresorbable or bioabsorbabale implants degrade over time and are safely absorbed and excreted by the body. They are used in the areas of drug delivery (e.g. drug-releasing implants), bone augmentation, temporary fixation (screws, pins), and tissue regeneration and replacement. Bioabsorbable implants preserve the structure of tissue at the early stage of the healing, after that, the implant decomposes, and stress are gradually transferred to the healing tissue

Most bioresorbable polymers discussed in recent patent literature are polyester-based, often made from **poly(lacticacid)** (PLA), **polyglycolic acid** (PGA) and **polycaprolactons** (PCL). Other developments are DSMs **polyesteramides** (PEAs) WO/2016/020545 and **phenolic** materials based on tyrosol: WO/2013/116804. Also thermoset and **thermoplastic polyurethane** (TPU) can be made bioresorbable, e.g. WO/2013/052739 and WO/2014/004333 .

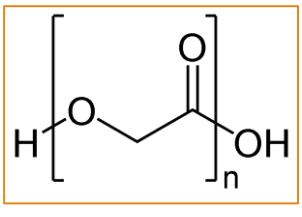

FIGURE 2 POLYGYCOLIC ACID

TABLE 2: BIORESORBABLES

Document No.	Title	Assignee
WO/2011/059408	Biodegradable thermoplastic elastomers	NANYANG TECH UNIV
WO/2012/040316	Bioabsorbable polymeric compositions, processing methods, and medical devices therefrom	ETHICON INC
WO/2013/052739	Bioresorbable thermoset polyester/urethane elastomers	480 BIOMEDICAL INC

WO/2016/037871	Biodegradable hybrid polymers usable in medical technology or in biology, starting silanes therefor, and preparation processes therefor and uses thereof	FRAUNHOFER GES FORDERUNG
WO/2014/004333	Method for identifying bioabsorbable polymers	LUBRIZOL ADVANCED MATERIALS
WO/2012/120139	Implantable bio-resorbable polymer charged with fragile macromolecules	OCCLUGEL; CENTRE NAT RECH SCIENT CNRS
WO/2011/029867	Implantable bio-resorbable polymer	OCCLUGEL
WO/2015/172212	Reabsorbable hybrid device for guided tissue regeneration	
WO/2013/116804	Polymeric biomaterials derived from phenolic monomers and their medical uses	RUTGERS UNIV
WO/2015/075397	Resorbable biomimetic prosthetic ligament	LARS LABORATOIRE D APPLIC ET D
WO/2015/130602	Sustained release composition using biobased biodegradable hyperbranched polyesters	MICHIGAN MOLECULAR INST
WO/2013/015685	Biodegradable, semi-crystalline, phase separated, thermoplastic multi block copolymers for controlled release of biologically active compounds	INNOCORE TECH BV
WO/2016/020545	Reduction sensitive biodegradable polyesteramides	DSM IP ASSETS BV
WO/2012/175746	New biodegradable polyesteramide copolymers for drug delivery	DSM IP ASSETS BV
WO/2014/053542	Drug delivery composition comprising proteins and biodegradable polyesteramides	DSM IP ASSETS BV
WO/2012/131104	Biodegradable compositions suitable for controlled release	INGELL TECH HOLDING BV
WO/2014/179615	Biodegradable copolymers, forming and using same	
WO/2011/014859	Biocompatible polymers for medical devices	RUTGERS UNIV
WO/2015/066173	Resorbable, amino acid-based poly(ester urea)s scaffold for vascular graft tissue engineering	UNIV AKRON
WO/2013/187988	Bioresorbable polymer peripheral scaffolds made from block copolymers of poly(l-lactide) and hydrophilic polymers	ABBOTT CARDIOVASCULAR SYSTEMS
WO/2016/005991	Thin strut stent from bioabsorbable polymer with high fatigue and radial strength and method to manufacture thereof	MERIL LIFE SCIENCES PVT LTD
WO/2014/057349	Biodegradable cross-linked polymer, vascular stent and manufacturing methods therefor	MICROPORT MEDICAL SHANGHAI CO

Coatings

Different types coatings are used for medical devices like lubricous-, antimicrobial-, hydrophilic-, and drug -releasing coatings amongst others.

Lubricous coatings are for example made from crosslinked **polyethyleneglycols** (PEGs) WO/2015/085040, from **fluoropolymers** WO/2012/006135 or from **polyethylene** (PE) **and cyclic olefin copolymers** (COCs): WO/2013/189672.

Bioresorbable coatings based on **polyetheresteramides** (PEAs) are shown in WO/2014/004512 .

Hydrophilic coatings can be made from **polyurethane** WO/2012/160053, polyurethane-polyurea WO/2011/032650 or silane functional polymers as in WO/2011/082296.

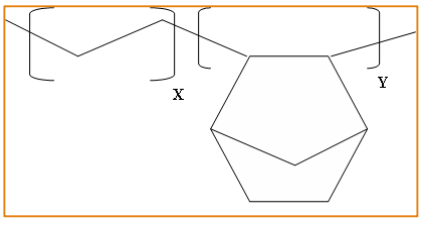

FIGURE 3 CYCLYC OLEFINE COPOLYMER

An example of an anti-bacterial coating is given in WO/2014/085275 which teaches biofilm-preventing coatings that release salicyclic acid.

TABLE 3: COATINGS

Document No.	Title	Assignee
WO/2015/085040	cross-linked peg polymer coating for improving biocompatibility of medical devices	MEDICAL SURFACE INC
WO/2016/035830	fluorine-containing highly-branched polymer, and biomolecule adsorption-suppressing surface	KYUSHU UNIV NATIONAL UNIV
WO/2012/006135	fluorinated polymers and lubricious coatings	SURMODICS INC
WO/2014/004512	bioerodable poly(etheresteramides) and medical article uses	SURMODICS INC
WO/2016/022796	article coatings including oligomerized polyphenol layer and biological methods of use	SURMODICS INC
WO/2012/160053	hydrophilic layer composite for medical equipment	BAYER INTELLECTUAL PROPERTY
WO/2011/032650	cyclohexanedimethanol-based hydrophilic polyurethane urea	BAYER MATERIALSCIENCE AG
WO/2014/012080	slippery self-lubricating polymer surfaces	HARVARD COLLEGE
WO/2010/012836	biocompatibility layer, and coated objects	FRAUNHOFER GES FORDERUNG
WO/2014/164469	wear resistant and biocompatible coatings for medical devices and method of fabrication	KETTERING UNIV
WO/2014/060591	osteoconductive coating of implants made of plastic	
WO/2016/032720	lubricious one-part hydrophilic coatings	BOSTON SCIENTIFIC SCIMED
WO/2011/082296	silyl ether-modified hydrophilic polymers and uses for medical articles	SURMODICS INC
WO/2014/085275	multi-functional surface coating of implants	UNIV MASSACHUSETTS MEDICAL
WO/2012/028305	coating for medicinal implants and coated medicinal implants	HELMHOLTZ ASSOCIATION; MEDIZINISCHE HOCHSULE HANNOVER; UNIV HANNOVER
WO/2016/013700	temperature sensitive adhesion prevention composition and use thereof	MEDYTOX INC
WO/2014/122631	tissue substitute material with biologically active coating	LACERTA TECH INC
WO/2015/181826	crystalline coating and release of bioactive agents	YISSUM RES DEV CO
WO/2011/156488	medical devices and polymers therefor having ptfe surfaces modified with nitric oxide-releasing polymers	MEDTRONIC INC
WO/2014/143521	bioabsorbable stent with hydrothermal conversion film and coating	MEDTRONIC INC
WO/2010/027683	medical devices having fluorine-containing polymer coatings with improved adhesion	BOSTON SCIENTIFIC SCIMED
WO/2013/189672	material composition having reduced friction coefficient used for medical tubes	BIOTRONIK SE & CO KG
WO/2016/014755	self-lubricating polymer composition	BECTON DICKINSON & CO
WO/2013/180940	hydrophilic and non-thrombogenic polymer for coating of medical devices	BIOCOAT INC
WO/2012/032283	lubricious coatings for medical devices	BIOINERACTIONS LTD
WO/2015/103023	functionalized lubricious medical device coatings	BOSTON SCIENTIFIC SCIMED

Composites

Composites can be used in many medical applications like implants, prostheses, splints etc.

An interesting development are bioceramic-polymer composites like **polyaeryletherketones** (PAEK) reinforced with bioactive glass WO/2010/043900. These composites can also have a bioresorbable polymer matrix exemplified in WO/2013/176734 which is about a composite from **poly-4-hydrozybutyrate** (P4HB) and bioceramic. These composites are useful for implants among other things.

Bionanocomposites from **poly(vinylalcohol)** (PVA), PU and hydroxyapatite can be used for bone restoration according to WO/2014/194392. Other nanocomposites, using **carbon nano-tubes** (CNT) can make the composite thermally and electrically conductive allowing for electrical heating. Examples are **chitosan** +CNT WO/2013/000049 and thermoplastic **polyurethane** (TPU) + CNT WO/2012/117349.

An unexpected medical composite is a **wood-plastic** composite made from a biodegradable polyester and wood particles, ans is claimed to be useful for splints: WO/2015/059354.

Composites can also be made based on two types of polymers: a bio-inert 'load bearing' polymer from **polyurethane**, co-continuous with a bioresorbable polymer from **polylactic acid** or **starch** for example: WO/2013/131499.

TABLE 4: COMPOSITES

Document No.	Title	Assignee
WO/2011/005535	Ceramic-polymer composites	DOW GLOBAL TECH LLC
WO/2014/194392	Bionanocomposite for bone recovery	UNICAMP
WO/2015/143258	Bioactive "smart" dental composite materials	UNIV MICHIGAN
WO/2013/176734	Resorbable bioceramic compositions of poly-4-hydroxybutyrate and copolymers	TEPHA INC
WO/2010/043900	Polymeric materials	INVIBIO LTD
WO/2013/000049	Biocomposite for facilitating organic tissue recovery	AWAD SHIBLI JAMIL
WO/2012/117349	Sheet-like carbon nanotube-polymer composite material	ORFIT IND
WO/2015/059354	Novel materials	ONBONE OY
WO/2015/116045	Elastic stent graft	GORE & ASSOCIATES WL
WO/2014/049190	Biodegradable bioglass - polymer composite having improved thermal stability	UNIV PAIS VASCO
WO/2013/131499	Polymeric composite with co-continual structure, especially for the preparation of implants with the increased bio-compatibility	TOMAS BATA UNIV IN ZLIN

Foams

Medical-grade soft **polyurethane** foams are well known, especially for wound dressings. Bayer is very active in this field and have many recent (and old) patent applications on the subject. For example: WO/2011/083144, WO/2013/000910, WO/2012/150224.

Silicone foams are also studied for negative pressure wound therapy - a technique in which a vacuum is applied to a wound dressing, for example: WO/2011/072840.

Rigid porous materials are mostly used for implants and scaffolds in tissue engineering. These can be made from bio-stable materials like **poly(etherether keton)** (PEEK) WO/2011/076971 or e.g. **polytetrafluoroethylene** (PTFE) WO/2013/029142.

WO/2010/052582 claims a porous polymeric implantable device where the polymer is biosynthesised by bacteria, the polymer is 'bacterial' **cellulose**.

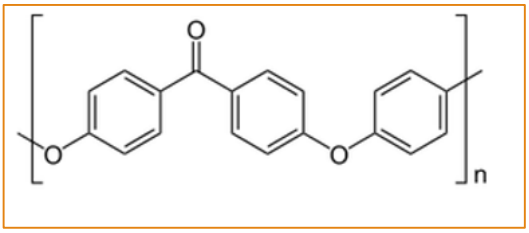

FIGURE 4 PEEK

TABLE 5: FOAMS

Document No.	Title	Assignee
WO/2015/175270	Articles including a porous elastomeric material with an integrated elastomeric material and methods of making same	3M INNOVATIVE PROPERTIES
WO/2014/004160	In-situ forming foams for treatment of aneurysms	ARSENAL MEDICAL INC
WO/2015/002786	Antimicrobial foams and methods of making same	3M INNOVATIVE PROPERTIES
WO/2010/139192	Polyurethane useful for orthopedics external fixing system in complex environment and preparation method thereof	
WO/2011/159663	Open-cell surface foam materials	ALLERGAN INC
WO/2012/097381	At least partially resorbable reticulated elastomeric matrix elements and methods of making same	BIOMERIX CORP
WO/2011/094155	Open celled foams, implants including them and processes for making same	ALLERGAN INC
WO/2010/112658	Macroporous or meso/macroporous polymer materials produced in concentrated and highly concentrated emulsions	CONSEJO SUPERIOR INVESTIGACION
WO/2011/144731	Nanoporous foamed, active ingredient-containing preparations on the basis of pharmaceutically acceptable thermoplastically processable polymers	BASF CORP
WO/2015/162523	Foamed polyurethane polymers for the regeneration of connective tissue	FONDAZIONE FILARETE PER LE BIOSCIENZE
WO/2015/148775	Compositions and methods for growing autologous biological tissue	UNIV TEXAS
WO/2013/173906	Collagenous foam materials	UNIV KINGSTON
WO/2013/000910	Composite foam for wound dressings	BAYER INTELLECTUAL PROPERTY
WO/2011/083144	Hydrophilic, aliphatic polyurethane foams	BAYER MATERIALSCIENCE AG
WO/2010/000400	Layer composite, suitable as a wound dressing, comprising a polyurethane foam layer, an absorber layer and a cover layer	BAYER MATERIALSCIENCE AG
WO/2012/032032	Method for producing hydrophilic polyurethane foams	BAYER MATERIALSCIENCE AG
WO/2011/161048	Method for producing hydrophilic, aliphatic polyurethane foams having low bulk density	BAYER MATERIALSCIENCE AG
WO/2010/022894	Method for producing shaped polyurethane foam wound dressings	BAYER MATERIALSCIENCE AG
WO/2010/031509	Wound dressing having a polyurethane foam layer and a cover layer made of thermoplastic polymer	BAYER MATERIALSCIENCE AG
WO/2012/150224	Hydrophilic polyurethane foam with low volume swelling	BAYER INTELLECTUAL PROPERTY
WO/2014/096654	Novel hydrophilic polymer foam comprising maltodextrin	LABORATORIES URGO
WO/2013/045403	Fast-setting alkoxysilane spray foams	BAYER INTELLECTUAL PROPERTY
WO/2011/072840	Device for negative pressure wound therapy	HARTMANN PAUL AG

WO/2010/046095	Polyurethane gel foams	HARTMANN PAUL AG
WO/2011/076971	Porous peek element as an implant	FUNDACION INASMET
WO/2010/052582	Medical devices with definable porosity produced by bacterial polymer bio-synthesis	SOFRADIM PRODUCTIONS SAS
WO/2014/013121	Composite material of hyaluronic acid and at least one acrylic polymer for biomedical applications	UNIV POLITECNICA DE VALENCIA
WO/2011/143206	Porous materials, methods of making and uses	ALLERGAN INC
WO/2013/029142	Dental implant, vascular implant and tissue implant made of porous three-dimensional structure of polytetrafluoroethylene	
WO/2014/186336	Release of biologically active agents from polymeric composite particles	3M INNOVATIVE PROPERTIES
WO/2013/183976	Patch for tissue regeneration, comprising fibrous porous three-dimensional scaffold	EWHA WOMANS UNIV

Hydrogels

A polymeric gel is a system of a (physically or covalently) crosslinked polymer wherein a liquid is dispersed. When the liquid is water, the gel is called a hydrogel. Hydrogels can be used as wound care, implants, scaffolds, coatings, contact lenses amongst others.

Medical hydrogels can be made from different hydrophilic polymers like crosslinked **poly(vinylalcohol)** (PVA) WO/2014/185825, **polyurethane** WO/2014/076336, **poly(ethylene glycols)** (PEGs) WO/2012/018718, **polycaprolactones** (PCL) WO/2011/047486 etc.

A lot of recent research however seems to be about hydrogels based on **polysaccharides**, especially **hyaluronic acid** for example WO/2012/014180 and WO/2015/169849 and **chitosan** WO/2014/005471.

WO/2013/045729 is about **cyclodextrin** nanogels. "Nanogels" are nanoparticles composed of a hydrogel and are useful for drug release. Another nanogel application is WO/2012/165953.

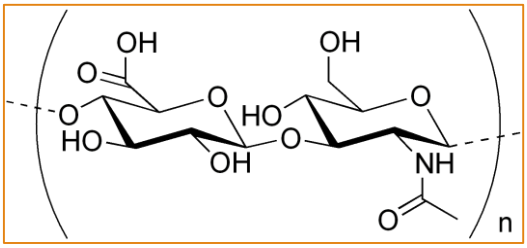

FIGURE 5 HYALURONIC ACID

Hydrogels can also be 'smart' materials, meaning that they can respond to external stimuli like pH, temperature or light. For example a thermoreversible hydrogel is described in WO/2014/095915, and self-healing hydrogels in WO/2012/159106 and WO/2013/123946

TABLE 6: HYDROGELS

Document No.	Title	Assignee
WO/2013/045729	Cyclodextrin nanogels	UNIV SANTIAGO COMPOSTELA
WO/2012/014180	Hyaluronic acid based hydrogel and use thereof in surgery	NOVAGENIT SRL
WO/2015/169849	Hydrogels of methacrylic hyaluronic acid derivatives for oral enzyme therapy in celiac disease	NEMYSIS LTD
WO/2014/072330	Glucose responsive hydrogel comprising pba-grafted hyaluronic acid (ha)	CENTRE NAT RECH SCIENT CNRS
WO/2016/018145	Durable hydrogen bonded hydrogels	SUPRAPOLIX B V
WO/2011/088562	Nanocomposite hydrogel and method for preparing it, for industrial and medical applications	FPINNOVATIONS
WO/2014/203075	Nanocrystalline cellulose hydrogels for inhibition of bacterial adhesion	UNIV ALBERTA

WO/2014/203075	Nanocrystalline cellulose hydrogels for inhibition of bacterial adhesion	UNIV ALBERTA
WO/2013/174982	Micro-engineered hydrogels	UNIV DE MONS
WO/2012/107385	Biodegradable prepolymers	BAYER MATERIALSCIENCE AG
WO/2013/112381	New class of anti-adhesion hydrogels with healing aspects	BVW HOLDING AG
WO/2010/099818	Thermoreversible polysaccharide hydrogel	AO TECH AG
WO/2014/121378	Conductive biomaterial for enhancement of conduction in vitro and in vivo	UNIV HEALTH NETWORK
WO/2014/039607	Hyaluronic acid/collagen- based dermal filler compositions and methods for making same	ALLERGAN INC
WO/2014/185825	Hydrogel material based on cross-linked polyvinyl alcohol	LLC RES & PRODUCTION CENTER AMPHION
WO/2013/186747	Process for preparing objects made of biocompatible hydrogel for uses thereof in the medical field, and more particularly in ophthalmology	
WO/2012/018718	Absorbable peg-based hydrogels	ADVANCED TECHNOGIES & REGENERATIVE MEDICINE
WO/2012/162840	Polysaccharide-based hydrogel polymer and uses thereof	
WO/2014/056926	Hydrogel prodrugs	ASCENDIS PHARMA AS
WO/2014/005471	Thermosensitive injectable chitosan hydrogel product and use thereof	DALIAN CHEMICAL PHYSICS INST
WO/2013/091001	A peptide-hydrogel composite	UNIV SYDNEY
WO/2013/068397	Production of hydrogels by means of diels-alder reaction	UNIV REGENSBURG
WO/2011/111067	A biodegradable polymeric hydrogel composition	COUNCIL SCIENT IND RES
WO/2015/177540	Apertured hydrogel compositions and wound dressings	FIRST WATER LTD
WO/2013/112875	Wound dressings with enhanced gas permeation and other beneficial properties	UNIV AKRON
WO/2010/132028	Composition for manufacturing a scaffold for tissue engineering, and a method of making it	NANYANG TECH UNIV
WO/2015/110097	Biodegradable hydrogel with controlled lifetime and method of preparation thereof	VYSOKE UCENI TECHNICKE V BRNE
WO/2016/014158	Resilient polysaccharide foams and uses thereof	ARTHROCARE CORP
WO/2014/076336	Dressing for compromised wound healing	CONSEJO SUPERIOR INVESTIGACION
WO/2011/047486	Biodegradable thermoresponsive hydrogels	UNIV ALBERTA
WO/2013/123946	Multi-responsive self-healing polymer and gel compositions	UNIV AARHUS
WO/2012/159106	Ph responsive self-healing hydrogels formed by boronate-catechol complexation	UNIV NORTHWESTERN
WO/2012/059820	Temperature sensitive hydrogel and block copolymers	UNIV HEALTH NETWORK
WO/2014/095915	Chain-extending poloxamers, thermoreversible hydrogels formed by them which include biological materials, and medicinal applications of same	POLYMATERIALS AG

Nanofibers

Nanofibers are usually made by electrospinning and are used to make scaffolds for tissue engineering. Some examples of recent applications: WO/2012/134086, WO/2015/120465, WO/2015/048224.

The can be made from a range of materials, notably from **polysaccharide** like hyaluronic acid derivatives: WO/2015/074632.

TABLE 7: NANOFIBERS

Document No.	Title	Assignee
WO/2014/109379	Nanofiber having self-heating properties and biologically active substance release properties, production method for same, and nonwoven fabric having self-heating properties and biologically active substance release capabilities	NAT INST FOR MATERIALS SCIENCE
WO/2012/134086	Three-dimensional nanofiber scaffold for tissue repair and preparation method thereof	KYUNGHEE UNIV
WO/2015/120465	Polymer nanofiber scaffolds and uses thereof	UNIV CASE WESTERN RESERVE
WO/2015/183228	Nano fiber cover for wounds and ambustions with an additive containing natural antiseptic	
WO/2012/141938	Chemically modified cellulose fibrous meshes for use as tissue engineering scaffolds	UNIV MASSACHUSETTS MEDICAL
WO/2015/048224	Fiber scaffolds for use creating implantable structures	
WO/2014/066297	Nonwoven fiber materials	UNIV NORTH CAROLINA STATE
WO/2015/132639	Nanoreinforced polymeric material	UNIV PONTIFICIA BOLIVARIANA
WO/2015/074632	Nanofibers containing photocurable ester derivative of hyaluronic acid or its salt, photocured nanofibers, method of synthesis thereof, preparation containing photocured nanofibers and use thereof	CONTIPRO BIOTECH SRO
WO/2013/144206	Nonwoven membrane as a drug delivery system	UNIV POLYTECNICA DE CATALUNYA
WO/2013/009253	Microfibrillated cellulose films for controlled release of active agents	CHALMERS TEKNISKA

Nanoparticles

Nanoparticles are used in medicine as drug delivery vehicles. Some nanoparticles can target specific organs or tumors and are sometimes called 'stealth particles': WO/2012/071452

Drug releasing nanoparticles can be made from polysaccharides like **starch** WO/2010/084060 and **cellulose** WO/2012/103634 but also from synthetic polymers like **poly(vinylbenozoate)** WO/2012/068476, or WO/2014/191502 which is about stealth particles made from **poly(alkyl cyanoacrylate)**.

TABLE 8: NANOPARTICLES

Document No.	Title	Assignee
WO/2014/093343	Multistage nanoparticle drug delivery system	MASS INST OF TECH MIT
WO/2012/071452	Stealth polymeric particles for delivery of bioactive or diagnostic agents	HOWARD UNIV
WO/2015/081310	Stretch release drug delivery materials	BOSTON UNIV
WO/2016/025770	Anti-microbial foams containing polymer-stabilized silver nanoparticles	ESSENTRA POROUS TECH CORP
WO/2013/137755	Process for the preparation of polysaccharide nanoparticles	NANOVELOS SP Z OO
WO/2012/103634	Cellulose-based nanoparticles for drug delivery	ONTARIO INST FOR CANCER RES
WO/2012/068476	Poly(vinyl benzoate) nanoparticles for molecular delivery	UNIV SOUTH FLORIDA

WO/2010/084060	Starch copolymers and nanoparticles thereof for drug delivery systems	BASF CORP
WO/2010/084088	Starch nanoparticles for drug delivery systems	BASF CORP
WO/2012/078831	Smart polymeric nanoparticles which overcome multidrug resistance to cancer chemotherapeutics and treatment-related systemic toxicity	UNIV JOHNS HOPKINS
WO/2014/130994	Nanoparticles for controlled release of anti-biofilm agents	UNIV ROCHESTER
WO/2013/127004	Polymeric nanoparticles useful in theranostics	UNIV TORONTO
WO/2011/123591	Injectable dendrimer hydrogel nanoparticles	UNIV WAYNE STATE
WO/2011/020294	Magnetic nanoparticles having novel core-shell structure and ph responsiveness, and use thereof	INST PHARMA & TOXICOLOGY AMMS
WO/2012/165953	Nanogels	UNIV TWENTE
WO/2013/160773	Polymeric nanoparticles and process of preparation thereof	NANOGEN PHARMACEUTICALS
WO/2014/191502	Process for preparing stealth nanoparticles	SINVENT AS
WO/2012/175538	Bioresorbable microparticles	FERRING

Shape Memory materials

Shape memory materials can return to their original shape when subjected to an external stimulus like heating. In medicine most shape memory materials are metallic alloys often used for implants like stents.

Medical shape memory materials can also be produced from polymeric materials which may be easier to make bioresorbable and drug-releasing. Some examples are WO/2013/164782 which is about implantable shape memory materials made from polysaccharides, especially **hyaluronic acid** and **chitosan** crosslinked with polyfunctional epoxy and WO/2011/085847 which is about polyester **polyurethane** shape memory material with anisotropic properties which is said to be useful for scaffolds.

TABLE 9: SHAPE MEMORY MATERIALS

Document No.	Title	Assignee
WO/2012/019145	Radiopaque shape memory polymers for medical devices	ENDOSHAPE INC
WO/2014/124225	Radiopaque polymers for medical devices	ENDOSHAPE INC
WO/2011/115582	Biodegradable and biocompatible shape memory polymers	AGENCY SCIENCE TECH & RES
WO/2013/050775	Medical devices containing shape memory polymer compositions	SMITH & NEPHEW INC
WO/2015/051186	Photo-active and radio-opaque shape memory polymer - gold nanocomposite materials for trans-catheter medical devices	UNIV COLORADO
WO/2013/164782	Shape-memory cross-linked polysaccharides	MEDICAL & BIOTECHNOLOGICAL SERVICES
WO/2010/145741	Radio-opaque shape memory polymers	MERCK PATENT GMBH; ADOLF PFAFF DR KARL FRIEDRICH REICHENBACH GBR
WO/2016/048985	Implantable medical device with shape memory polymer filter layer	BOSTON SCIENT SCIMED INC
WO/2011/084536	Multi-fiber shape memory device	ENDOSHAPE INC; UNIV COLORADO
WO/2014/085827	Medical fabric with integrated shape memory polymer	UNIV COLORADO
WO/2012/034126	Medical fabric with integrated shape memory polymer	UNIV COLORADO

WO/2011/085847	Molded foam body having anisotropic shape memory properties, method for manufacturing same and article comprising the molded foam body	HELMHOLTZ ZENTRUM GEESTHACHT ZENTRUM FOR MATERIAL & KUESTENFORSCHUNG
WO/2011/144257	Amorphous resorbable polymeric network materials with shape memory	UNIV GRONINGEN; ACADEMISCH ZIEKENHUIS

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