(12) UK Patent Application (19) GB (11) 2551190 (13) A

(43) Date of A Publication 13.12.2017

(21) Application No: **1610138.8**

(22) Date of Filing: **10.06.2016**

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(51) INT CL:
A41D 13/05 (2006.01) ***A63B 71/12*** (2006.01)

(56) Documents Cited:
WO 2010/103186 A2
WO 2006/027763 A2
US 20140259324 A1
US 20120090068 A1
JP H09676

(58) Field of Search:
INT CL **A41D, A63B**
Other: **Online: EPODOC, WPI**

(54) Title of the Invention: **Sports protection device**
Abstract Title: **Sports protection device**

(57) A sports protection device (such as a shin pad) comprises a lining layer for facing the wearer's body with an opposing composite layer superimposed on the lining layer. The composite layer comprises wood particles set within a thermoplastic polymer matrix. The lining and composite layers are shaped to substantially match the contour of the portion of the wearer's body for which it is to offer protection. The flexibility of the shin pad may be maintained by the provision of a hinge portion, or by the series of incisions in the composite layer. The application also describes a mouldable blank for forming a sports protection device, and a method of manufacturing the device or the mouldable blank.

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SPORTS PROTECTION DEVICE

Field of the Invention

The present invention relates to a device for providing protection to an individual's body whilst participating in sports and/or recreational activities. In particular, the present invention relates to a customizable sports protection device that is moldable to fit a portion of the individual's body to provide shock, impact and friction protection during sporting/recreational activities.

Background of the Invention

Many sporting or recreational activities such as soccer, American football, baseball, hockey, skateboarding, cycling and skiing present opportunities for an individual to sustain injury through inadvertent contact either with the ground, sporting equipment and/or other individuals. Such injuries typically include bruising/contusion, abrasions, lacerations and bone fractures.

It is known to provide sports protection equipment for use during sporting/recreational activities to protect vulnerable areas of the body. For example, it is known to provide protective pads/guards for shins, elbows, wrists and knees. It is obviously a requirement for such protective pads that they are both lightweight and highly shock absorbent. Such protective pads are typically formed of layers of fibreglass, foam rubber, polyurethane and nylon. Many individuals find the known protective pads to be too bulky and thus an impediment to their sporting performance.

Many known protective pads are provided in standard sizes/shapes devised to fit an average individual. Straps or integrated socks are provided to maintain the position of the protective pads. Such standard protective pads typically provide an imperfect fit for the majority of individuals thus leading to discomfort and compromised protection/sporting performance.

It is known to provide customizable sports protection pads/guards that can be heat moulded to provide an improved fit. For example, it is known to provide heat moldable mouth guards.

It is also known from US2012/0090068 to provide heat-moldable shin guards that include a moldable thermoplastic layer comprising ethylene vinyl acetate. In order to impart shock resistance and rigidity to the shin guards, the thermoplastic layer is sandwiched between two layers of carbon fibre-reinforced plastic, Kevlar™ or fibreglass.

There is a need for protective devices for use in sporting/recreational activities that are moldable to fit the individual and that have a simple, lightweight construction whilst retaining high shock absorbency.

Summary of the Invention

In a first aspect, the present invention provides a sports protection device for protecting a portion of a wearer's body, the sports protection device comprising:

a lining layer for facing the wearer's body; and

an opposing composite layer superimposed on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

the lining and composite layers being shaped to substantially match the contour of the portion of the wearer's body.

In a second aspect, the present invention provides a moldable blank for forming a sports protection device for protecting a portion of a wearer's body, the moldable blank comprising:

a lining layer for facing the wearer's body; and

an opposing composite layer superimposed on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

the lining and composite layers being moldable to substantially match the contour of the portion of the wearer's body.

The present inventors have found that a composite layer comprising a thermoplastic polymer and wood particles can be used to provide a sports protection device and a moldable blank for forming a sports protection device having a high shock absorbance whilst being lightweight and unbulky. Combined with a liner layer facing the wearer's body, the present invention provides a comfortable, customizable, highly effective sports protection device which can be formed from a moldable blank or can be provided pre-formed.

Optional features of the invention will now be set out. These are applicable singly or in any combination with any aspect of the invention.

The term "sports protection device" is intended to cover a device worn by an individual to maintain their safety and prevent injury arising from sport/recreation.

The lining layer may be formed of a textile material. The textile material may be formed by weaving, knitting, crocheting, knotting, bonding or felting natural fibres such as cotton, hemp, jute, flax or artificial fibres such as polyester, polyamide, polyurethane, polynitrile, ABS, polyolefin (such as polypropylene) fibres.

Performance/technical fabrics including such as COOLMAX®, DRYROAD®, DRI-FIT® or CLIMACOOL® i.e. fabrics that wick moisture away from the wearer's skin are particularly preferred.

The lining layer may be formed of a 3D spacer fabric such as those manufactured by Baltex or Apex Mills which provide effective heat and moisture transfer. A 3D spacer fabric typically comprises a three-dimensional knitted/woven fabric comprising two knitted/woven substrates separated by spacer yarns. The spacer yarns allow air and moisture flow through the fabric between the knitted/woven substrates. The 3D spacer fabric may be formed of polyester, polyamide of polypropylene for example.

The lining layer e.g. the 3D spacer may have a thickness of between 1 – 5 mm e.g. around 3 mm.

The lining layer e.g. the 3D spacer fabric may have a weight of between 200 -500 g/m^2 e.g. around 350 g/m^2.

The lining layer may comprise a foam. The foam may be provided instead of or as well as the textile material described above. The foam may be provided between the textile material and the composite layer. The foam may be a shock-absorbing foam such as a polyurethane foam e.g. Poron ® XRD® foam.

The foam may have a thickness of between 1-20 mm e.g. between 3-8 mm depending on how much shock absorption is required from the sports protection device.

The lining layer e.g. the 3D spacer fabric and/or the foam may comprise an anti-bacterial and/or anti-odour composition. The composition may be coated onto or impregnated into the fabric/foam. For example, the lining layer may comprise silver ions e.g. such as those provided in Polygiene® or Microban®.

The material used to form the composite layer may be as described in WO2010/103186 herein incorporated by reference.

The thermoplastic polymer is preferably a biodegradable polymer (only) but also non-biodegradable polymers may be utilized.

Examples of polymers include polyolefins, e.g. polyethylene (HD or LD), polypropylene, and polyesters, e.g. poly(ethylene terephthalate) and poly(butylenes terephthalate), polystyrene homopolymer and copolymers including acrylonitrile-butadiene-styrene (ABS), polycarbonates, polyethers, polyetheresters, polyamides e.g. nylon, lactic or butyric acid derivativesm polybenzimidazole (PBI), polyethersulfones (PES), polyvinyl alcohols (PVA), ethyl vinyl acetates (EVA), polyether ether ketones (PEEK), polyetherimides (PEI), polyphenylene oxide (PPO), polyphenylene sulphide (PPS), polyvinyl chloride (PVC) and acrylic polymers. Copolymers, blends and mixtures of polymers may also be used.

The thermoplastic polymer may also be any cross-linked polymers manufactured prior to processing or in situ during the compounding process for example by means of ionizing radiation or chemical free-radical generators. Examples of such polymers are cross-linked polyesters, such as polycaprolactone (PCL).

Generally, the weight ratio of biodegradable polymer to any non-biodegradable polymer is 100:1 to 1:100, preferably 50:50 to 100:1 and in particular 75:25 to 100:1.

The thermoplastic polymer may comprise a biodegradable polymer i.e. a polymer which can degrade into natural by-products such as carbon dioxide, nitrogen, water, biomass and inorganic salts. By using a biodegradable polymer in combination with the wood particles for the composite layer, the sports protection device can be made substantially biodegradable offering environmental advantages after disposal.

For example, the thermoplastic polymer may be a thermoplastic polyester e.g. a biodegradable thermoplastic polyester. Suitable examples for the thermoplastic polymer are polylactide, polyglycolide, polycaprolactone (PCL), mixtures/blends thereof and copolymers thereof.

The thermoplastic polymer may comprise a mixture/blend of 5-99 wt%, in particular 40 to 99 wt%, of a caprolactone homopolymer and 1-95 wt%, in particular 1 to 60 wt%, of another thermoplastic polymer e.g. another biodegradable or non-biodegradable thermoplastic polymer.

Copolymers of caprolactone include copolymers formed with caprolactone, lactic acid and/or glycolic acid monomers. The copolymer may contain at least 80 % by volume of (epsilon) caprolactone monomer, in particular at least 90 % by volume and in particular about 95 to 100 % epsilon caprolactone monomer. The copolymer may contain 5 to 99 wt% and especially 40 to 99 wt% of repeating units derived from (epsilon) caprolactone monomer with 1 to 95 wt% and especially 1 to 60 wt% of repeating units derived from another polymerisable monomer.

The thermoplastic polymer (e.g. the polycaprolactone polymer) may have a molecular weight of between 60,000 g/mol and 500,000 g/mol. For example, the thermoplastic polymer may have a molecular weight between 65,000 – 300,000 g/mol, preferably above 70,000 g/mol such as between 75,000 g/mol and 100,000 or 200,000 g/mol. This has been found to be advantageous both in terms of resultant properties and cost.

The thermoplastic polymer is preferably selected such that it softens when it is heated to a temperature of approximately 50 to 70 °C, after which the blank can be molded directly on the wearer to create a form that closely matches the anatomical contours of the portion of the wearer's body.

PCL has a unique melting behavior: The polymer crystals only start melting when a temperature of approximately 60 °C is reached yet the polymer crystals start re-forming when temperature is decreased down to 37 °C. This hysteresis property together with insulating wood particles in the composite layer of preferred embodiments enables a molding time for the blank which facilitates use in “field situations” and by users without any special competence working with materials.

The molding properties of the present invention can be determined by the average molecular weight (Mn) of the polymer, such as epsilon caprolactone homo- or copolymer. A particularly preferred molecular weight range for the Mn value of PCL is from about 75,000 to about 100,000 g/mol, e.g. around 80,000 g/mol.

The number average molar mass (Mn) and the weight average molar mass (Mw) as well as the polydispersity (PDI) were measured by gel permeation chromatography. Samples for GPC measurements were taken directly from the polymerization reactor and dissolved in tetrahydrofuran (THF). The GPC was equipped with a Waters column set styragel HR(1, 2 and 4) and a Waters 2410 Refractive Index Detector. THF was used as eluent with a flow rate of 0,80 ml/min at a column temperature of 35°C. A conventional polystyrene calibration was used. In determination of the water content of the monomer at different temperatures a Metroohm 756 KF Coulo meter was used.

The properties of moldability of the present composition can also be determined by the viscosity value of the polymer. For an epsilon caprolactone homopolymer: when the inherent viscosity (IV) -value of PCL is less than 1 dl/g the composite is sticky, flows while formed and forms undesired wrinkles while cooling. When PCL having IV-value closer to 2 dl/g is used the composite maintains its geometry during molding on the wearer and it may be handled without adhesive properties. Thus, IV values in excess of 1 dl/g are preferred, values in excess to 1.2 dl/g are preferred and values in excess of 1.3 dl/g are particularly suitable. Advantageously the values are in the range of about 1.5 to 2.5 dl/g, for example 1.6 to 2.1 dl/g. Inherent Viscosity values were determined by LAUDA PVS 2.55d rheometer at 25 °C. The samples were prepared by solvating 1 mg of PCL in 1 ml chloroform (CH_3Cl).

The viscosity of the thermoplastic polymer may be relatively high, typically at least 1,800 Pas at 70 °C, 1/10 s. The viscosity can be of the order of 8,000 to 13,000 Pas at 70 °C, 1/10 s (dynamic viscosity, measured from melt phase).

The modulus (Young's modulus) at ambient temperature of the thermoplastic polymer component may be greater than 300 MPa. By compounding the thermoplastic polymer with the wood particles, the modulus will increase to about 350 to 2000 MPa for the composite material.

The thermoplastic polymer may have a melt flow index of between 0.3 to 2.3 g/min (at 80^{o}C; 2.16 kg).

The thermoplastic polymer may be present in the composite layer in an amount of 5 to 99 wt% (based on the amount of thermoplastic polymer and wood particles). It may be present in an amount between 40 to 99 wt%.

In some preferred embodiments showing particularly good shock absorption, the thermoplastic polymer is present in an amount of around 60 wt% i.e. the weight ratio of wood particles to thermoplastic polymer in the composite layer may be 2:3.

Preferably, the wood particles have a granular or a generally plate-like structure. Typically, the wood particles are greater in size than a powder.

Particulate or powdered material is characterised typically as material of a size in which the naked eye can no longer distinguish unique sides of the particle. Plate-like particles are easily recognizable as one dimension is recognizable by the naked eye as being larger than another. Granular particles, while having substantially equal dimensions, are of such dimension that their unique sides can be determined by the naked eye and oriented.

More particularly, particulate or powdered materials are of such a small or fine size that they cannot be easily oriented with respect to their neighbors. Granular and plate-like particles are of such a size that their sides are recognizable and can be orientated.

The wood particles orientate in two dimensions in the thermoplastic polymer matrix and provide a self-reinforcement effect. As a result, the composite layer of the sports protection device provides a good dimensional stability, good shock absorbance and good puncture resistance.

The wood particles may be present in the composite material forming the composite layer in an amount of 1 to 95 wt% (based on the amount of thermoplastic polymer and wood particles). They may be present in an amount between 1 to 70 wt% or 1 to 60 wt% or 10 to 60 wt% or 20 to 60 wt%.

In some preferred embodiments showing particularly good shock absorption, the wood particles may be present in an amount of around 40 wt% i.e. the weight ratio of wood particles to thermoplastic polymer in the composite material forming the composite layer may be 2:3.

The wood particles may be present in the composite material forming the composite layer in an amount of 15 to 50 % (based on the volume of thermoplastic polymer and wood particles). They may be present in an amount between 25 to 50 %, by volume.

Before the wood particles are mixed with the thermoplastic polymer they can be surface treated, e.g. sized, with agents, which modify their properties of hydrophobicity/-hydrophobicity and surface tension. Such agents may introduce functional groups on the surface of the wood particles to provide for covalent bonding to the matrix. The wood particles can also be surface treated with polymer e.g. PCL.

The wood particles can be also coated or treated with anti-rot compound e.g. vegetable oil to improve its properties against aging and impurities.

The wood particles can be dehydrated to make them lighter before mixing with thermoplastic polymer. The mechanical and chemical properties of the wood particles can be improved with heat treatment, which is known to decrease swelling and shrinkage.

The size and the shape of the wood particles may be regular or irregular. Typically, the particles have an average size (of the smallest dimension) in excess of 0.02 mm, advantageously in excess of 0.1 mm, 0.4 mm or 0.5 mm, for example in excess of 0.6 mm or

1 mm, suitably about 0.6 to 40 mm, in particular about 1.2 to 20 mm, preferably about 1.5 to 10 mm, for example about 1 to 7 mm. For the plate-like wood particles having a length, width and thickness, the smallest dimension will be the thickness.

The length of the particles (longest dimension of the particles) can vary from a value of greater than 0.6 mm (e.g. greater than 0.75 mm or 1 mm or 1.8 mm or 3mm) to value of up to about 200 mm, for example up to about 50 mm or 21 mm.

The wood particles can be granular i.e. having a substantially cubic shape, plate-like or a mixture of both. Wood particles considered to be granular have a cubic shape whose ratio of general dimensions are on the order of thickness : width : length = 1 : 1 : 1. In practice it is difficult to measure each individual particle to determine if it is a perfect cube. Therefore, in practice, particles considered to be granular are those where one dimension is not substantially different than the other two.

Wood particles considered to be plate-like means that they have generally a plate-shaped character. The ratio of the thickness of the plate to the smaller of the width or length of the plate's edges is generally 1:2 to 1:500 or 1:100 or 1:20 such that the thickness of the plate-like particles is smaller than the width/length.

The plate-like wood particles may have at least two dimensions greater than 1 mm and one greater than 0.02 mm (e.g. greater than 0.1 mm), the average volume of the wood particles being generally at least 0.02 mm^3 (e.g. at least 0.1 mm^3 or at least 1 mm^3). Suitable wood particles have typical dimensions of 2mm x 2mm x 1mm, for example.

The specific weight of the wood particles may be between 180-200 kg/m^3.

"Derived from platy wood particles" designates that the wood particles may have undergone some modification during the processing of the composition. For example, if blending of the thermoplastic polymer and wood particles is carried out with a mechanical melt processor, some of the original plate-like wood particles may be deformed to an extent.

Typically more than 70 % and preferably up to 100% of the wood particles are greater in size than powder, which particles may be granular or platy.

The wood species can be freely selected from deciduous and coniferous wood species alike: beech, birch, alder, aspen, poplar, oak, cedar, Eucalyptus, mixed tropical hardwood, pine, spruce and larch tree for example.

The wood particles can be derived from wood raw-material typically by cutting or chipping of the raw-material. Wood chips of deciduous or coniferous wood species are preferred.

The desired composition of the wood particles can be achieved by sifting wood particles through one or more meshes having one or more varying qualities. The desired composition can also be accomplished by other well-known techniques in the art for sorting and separating particles in to desired categories. The desired composition may be the resultant composition of one sifting or separating process. The desired composition may also be a mixture of resultant compositions from several sifting or separation processes.

A particularly interesting raw-material comprises wood particles, chips or granules, of any of the above mentioned wood species having a screened size of greater than 0.6 mm up to about 3.0 mm, in particular about 1 to 2.5 mm on an average.

In addition to wood particles and thermoplastic polymer, the composite layer can contain reinforcing fibrous material, for example cellulose fibers, such as flax or seed fibers of cotton, wood skin, leaf or bark fibers of jute, hemp, soybean, banana or coconut, stalk fibers (straws) of hey, rice, barley and other crops and plants including plants having hollow stem which belong to main class of Tracheobionta and e.g. the subclass of meadow grasses (bamboo, reed, scouring rush, wild angelica and grass).

In addition, inorganic particulates or powdered materials such as mica, silica, silica gel, calcium carbonate and other calcium salts such as tricalcium orthophosphate, carbon, clays and kaolin may be present or added.

In some embodiments, the composite layer further comprises an elastic or soft polymer. Such a polymer can be homogenously distributed within the composite layer or can be concentrated within regions of the composite layer. For example, the elastic/soft polymer may be provided at a hinge portion of the sports protection device.

This improves the fit and comfort of the sports protection device.

"Soft" when used in the context of a polymer means that the polymer, either a thermoplastic or thermosetting polymer, has Shore D hardness 27 or less at ambient temperature. "Ambient temperature" stands for a temperature of about 10 to 30 °C, in particular about 15 to 25 °C.

"Region" when used in connection of elasticity or softness of the composite layer denotes a portion of the composite layer. The region may extend only to a limited depth of the composite layer or it may extend through the composite layer in at least one dimension. The region may comprise an elongated, essentially integral area. The region may also comprise one or several isolated portions of, for example, material different from the material surrounding the isolated portion(s). "Region" may also be a portion evenly distributed throughout the composite layer. Thus, a soft or elastic polymer can be homogeneously blended or mixed with the thermoplastic polymer to extend the region of elasticity or softness to cover essentially the whole superficial area of the sports protection device formed by the composite layer.

A property of "elasticity" or "softness" can be measured by a ring stiffness test, and such a property will be manifested in a greatly reduced stiffness. Typically the stiffness will be at least 20 % lower, preferably at least 30 % lower than for a corresponding material, wherein the same (± 10 %) volume as taken up by the soft or flexible polymer is formed by the thermoplastic polymer, for example and typically by the thermoplastic polyester or other polymer having melting point or softening point below 70 °C and higher or equal to about 55 °C.

The elastic/soft polymer is a different polymer than the thermoplastic polymer. The elastic/soft polymer can be thermoplastic or thermosetting polymer. The elastic/soft polymer can be used to partly replace the thermoplastic polymer to maintain the total volume of polymer in the composite layer at least essentially unaltered.

In a sports protection device/blank having a longitudinal and lateral axis, the soft (or elastic) polymer rich regions are generally unidirectional either along the longitudinal or lateral axis. The soft (or elastic) polymer rich regions can also be in form of a grid, mesh or web.

Typically, the soft/elastic polymer is a polymer having a Shore D hardness of 27 or less, in particular 25 or less, at ambient temperature or a thermoplastic elastomer.

Other examples of soft polymers include polymers exhibiting Shore A of 0 to 70 and Shore OO of 0 to 90.

The soft/elastic polymer can be formed by a polymer selected from the group of thermoplastic polyolefin blends; polyurethanes; co-polyesters; polyamides; unsaturated or saturated rubbers, including natural rubber, silicone, and copolymers of olefins; and natural or synthetic soft material, including soft gelatin, hydrogels, hydrocolloids and modified cellulose.

The elastic or soft polymer does not need to have melting range in same range as the thermoplastic polymer. Typically, the soft/elastic polymer has a melting range outside that of the thermoplastic polymer, in particular the melting point of the soft/elastic polymer is higher than the melting point of the thermoplastic polymer.

In one embodiment, the soft/elastic polymer is miscible with thermoplastic polymer forming a homogenous matrix when processed at elevated temperatures. In another embodiment, the soft/elastic polymer is immiscible with the thermoplastic polymer forming phase-separated zones or regions within the thermoplastic polymer.

Based on the above, in one embodiment, the composite material comprises:

- 10 to 70 parts by weight of thermoplastic polymer e.g. a biodegradable polyester;

- 25 to 60 parts by weight of wood particles; and

- 5 to 40 parts by weight of a soft or elastic polymer.

Preferably the soft or elastic polymer together with the thermoplastic polymer (e.g. biodegradable polyester) make up a majority of the composite layer (i.e. more than 50 % by weight of the total weight of the composite layer).

In a particular preferred embodiment, the soft or elastic polymer together with the thermoplastic polymer (e.g. biodegradable polyester) make up at least 53 % and up to 70 %, for example 55 to 70 %, by weight of the total weight of the composite layer. The soft or elastic polymer generally forms 5 to 50 %, in particular 10 to 40 %, for example 15 to 30 %, by weight of the total weight of the thermoplastic polymer (e.g. biodegradable polyester) together with the soft or elastic polymer.

It is possible to incorporate further polymers into the composite layer. In one embodiment, the composition comprises 3 to 30 parts by weight, of a further polymer comprising a thermoplastic polymer different from that of the first and the soft/elastic polymer. Such a component can be used for achieving improved mechanical properties of the composite layer. It is also possible to use a fourth polymer to modify the surface properties (for example properties of adhesion) of the composition.

Suitable polymers for the soft/elastic polymer and the further polymer are as described in WO2015/059354.

The composite and lining layers be affixed directly to one another with no interposing layer.

They may be affixed directly to one another by bonding e.g. bonding using an adhesive. For example, the lining layer may be pre-impregnated with adhesive prior to affixing to the composite layer.

The lining layer may be affixed to the composite layer by heat bonding i.e. by pressing the lining layer onto the composite layer when the composite layer is tacky due to heating e.g. during extrusion of the composite layer.

The lining layer may be affixed to the composite layer by stitching or mechanical locking.

The sports protection device or blank may further comprise an edging layer which may extend at least partly (and preferably entirely) around the peripheral edges of at least composite layer and preferably both the lining/composite layers. The edging layer may provide a smooth edge to the sports protection device or blank to prevent irritation of the portion of the wearer's body against which the sports protection device fits.

The edging layer may be formed of a textile material or textile string e.g. a fleece material. The textile material may have a width of between 2-6 mm e.g. around 3 mm. It may have a thickness of between 0.5-3 mm, e.g. around 1.5mm.

The edging layer may be joined around the peripheral edges of the composite layer or the lining/composite layers using adhesive e.g. adhesive that is pre-impregnated into the edging layer.

The edging layer may be stitched around the peripheral edges of the composite layer or lining/composite layers.

The composite layer may a thickness of about 1 to 50 mm, in particular about 1.5 to 30 mm, for example 1.5 to 20 mm. The composite layer may have a thickness greater than 1.5 mm.

A typical thickness is about 2 to 6 mm, for example between 2 and 4 mm.

With a typical thickness of the composite layer being 2-4 mm and a typical thickness of the lining layer being 1-5 mm, the typical thickness of the sports protection device is around 3-9 mm making the sports protection device considerably less bulky than the known sports protection devices e.g. the known shin pads.

The thickness of the composite layer may vary over the sports protection device/blank. For example, the composite layer may be increase in thickness from its periphery to its centre. For example, the composite layer may have a thickness of between 4-6 mm e.g. around 4 mm at its centre decreasing to between 2-4 mm e.g. around 2 mm at its peripheral edges.

The length and the width of the sports protection device and the blank for forming the sports protection device can vary in the range of about 1 to 150 cm (length) and 1 to 50 cm (width). The length and width will vary depending on the body portion requiring protection.

A typical length for a shin pad will be around 10-50 cm, e.g. 15-40 cm in length. A typical width for a shin pad will be around 10 to 20 cm. For example, a shin pad according to the present invention may have a length of around 18 cm and/or a width of around 13 cm. Another embodiment of a shin pad (e.g. for use in baseball) may have a length of around 32 cm and a width of around 14.5 cm.

The blank may have a substantially planar profile i.e. it may be in the form of a plate or sheet. The plate or sheet may have, for example, a rectangular, square, triangular or I-shaped profile. Any apices may be rounded.

The blank and/or the sports protection device may have at least a portion having a substantially curved profile. For example, where the blank or sports protection device is for use against the wearer’s shins, the blank and/or sports protection device may have a substantially U-shaped curved profile. The curvature may be constant or may vary along its length. For example, the curvature may decrease along its length.

The composite layer may comprise at least one region of non-rigidity to provide for flexibility and/or aeration in the sports protection device. For example, the composite layer may comprise a region of non-rigidity at a hinge portion.

The or each region of non-rigidity may be formed by perforations in the composite layer for example in the form of incisions, in particular unidirectional incisions.

By introducing lengthwise/longitudinal incisions in regions of the composite layer, aeration and flexibility can be achieved by merely widening the composite layer in widthwise direction e.g. during the formation of the sports protection device from the blank.

The incisions are located such that they are kept "closed" in the areas of the sports protection device requiring maximum strength so as not to impair mechanical strength.

Typically the areas requiring maximal strength are subjected to longitudinal forces, i.e. forces which act along the length of the device. Thus, in one preferred embodiment, the incisions are longitudinally directed, and they will therefore not be opened by the action of such longitudinal force. By orientating the incisions longitudinally, the incisions will remain closed under the influence of longitudinal forces, and the material will exhibit mechanical strength and rigidity directly derivable from the structure of the composite layer.

Wearer comfort is improved by providing some flexibility of the material, to allow for some movement, and the composite layer can yield to forces perpendicular to the general orientation of the incisions by opening the closed incisions.

In the context of the present technology, the pattern and the shape of the incisions in the composite material have been studied in particular for planar composite materials having a thickness in the range of 2 to 4 mm.

The incisions studied are formed by straight (linear) incisions or cuts. Preferably there are lines formed with a plurality of incisions. In particular there is a plurality of such lines, which preferably are parallel.

In a particular embodiment, the incisions in adjacent lines are off-set such that no two adjacent incisions are located along the same transversal line. Examples of suitable perforations are shown in WO2015/059355.

When subjected to the stretching laterally, the incisions will form apertures. Typically, the perforated composite layer will allow stretching at least 5 %, typically up to 75 %, in particular about 10 to 50 %.

During stretching, the non-rigid region of the composite layer will have pore area which is 2x to l00x, typically 2.5x to 15x greater that than pore area of the corresponding non-stretched, non- incised composite layer. The pore area can be about 2.5 to 30 % of the total area of the non-rigid region, for example about 3 to 20 %, for example about 5 to 15 %.

It has been found that incisions having a length of generally more 20 mm may cause tearing of the material when exposed to strong twisting and strain. On the other hand, incisions which are less than 5 mm in length do not sufficiently open during molding the material onto the human limb to allow for proper aerating.

Further, the space between each incision in longitudinal direction must exceed 5 mm to avoid tearing of the material and be less than 20 mm to achieve sufficient level of aerating.

The space between each incision line transversally to the linear incision must exceed 10 mm to avoid tearing and be less than 25 mm to achieve sufficient level of aerating. The incisions may be manufactured into the composite profile with an incision device, examples of suitable equipment include a rolling cylinder or a press equipped with blades, water jet, and laser cutting.

Typically, the incisions have a width of 0.1 to 1 mm, preferably 0.3 to 0.8 mm, and a length of 4 to 20 mm.

The incisions can be made with a blade, the surface area of which incisions being on the blade ingoing side about 1 to 10 mm^2, preferably 2.5 to 8 mm^2. The number of incisions per 10 cm^2 may be generally 20 to 100, preferably 30 to 70.

The particular advantage of incorporating incisions into the composite layer is that upon forming the sports protection device e.g. by molding the blank, the incisions will yield openings which give the composite layer properties of breathability and flexibility in the non-rigid region(s) e.g. at a hinge portion.

The shape of the openings or apertures formed by stretching of the incisions can be, for example, round, rectangular, square, diamond, hexagonal, oval, slot or ornamental perforation. The surface area of one hole should be generally about 3 to 30 mm^2 and the number of the holes is kept between 20 holes / 10 cm^2 and 100 holes / 10 cm^2. The total open area is less than 10 percentage of the whole surface area.

In a third aspect, the present invention provides a method of manufacturing a sports protection device for protecting a portion of a wearer's body, the method comprising:

providing a lining layer for facing the wearer's body;

superimposing a composite layer on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix, shaping said layers to substantially match the contour of the portion of the wearer's body.

In a fourth aspect, the present invention provides a method of manufacturing a moldable blank for forming a sports protection device for protecting a portion of a wearer's body, the method comprising:

providing a lining layer for facing the wearer's body;

superimposing a composite layer on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix.

The lining layer and composite layer may be as described above for the first and second aspects.

The composite layer can be manufactured by mixing the thermoplastic polymer with the wood particles. The thermoplastic polymer may be provided in the form of pellets.

The method may comprise the steps of mixing together 10 to 100 parts, preferably 50 to 100 parts by weight of the thermoplastic polymer and 1 to 100 parts, preferably 10 to 50 parts, by weight of wood particles. In some embodiments, the method comprises mixing together the thermoplastic polymer and wood particles in a ratio of 3:2 (by weight).

The thermoplastic polymer (pellets) and wood particles may be mixed using melt mixing/processing e.g. in a heatable vessel having a mechanical stirrer.

The mixing can be melt mixing carried out at a temperature sufficient for melting the thermoplastic polymer, e.g. at about 50 to 150 °C. Alternatively, the temperature can be in the range of about 80 to 190 °C, preferably about 100 to 150 °C.

The uniformity of the composite layer can be increased by using an extruder, kneader or any device suitable for mixing thermoplastic polymers.

By using an extruder mixing apparatus, two hoppers, each containing one of the two components of the composite layer, can deposit the desired amount of each component (thermoplastic polymer and wood particles) in to the mixing chamber of the apparatus. Alternatively, the wood chips and polymer granules may mixed to form a uniform blend before pouring into the feed hopper of an extruder. Then, by way of the stirrer/agitator in the mixing apparatus, there is formed a homogeneous mixture of the thermoplastic and wood particles prior to the formation of the composite layer.

One advantage to the material being formed by such a homogeneous mixture of the components is that the forces necessary to form a substantially homogeneous material are reduced. Therefore, little or no compression force is necessary to facilitate mixing of the components in a material formation step. The importance of this factor is that, by way of the homogeneous mixture, larger particles of each component can be used which would otherwise have been destroyed when subjected to high compression forces.

The composite layer can be formed, for example, by extruding the mixture of thermoplastic polymer and wood particles using an appropriate nozzle e.g. to form a sheet or plate. The extruder may be a single screw extruder. The nozzle is selected to give the desired thickness and profile of the composite layer including a composite layer of varying thickness as described above.

In the compounding process the profile of the extruder screw is preferably such that its dimensions will allow relatively large wood chips to move along the screw without crushing them. Thus, the channel width and flight depth are selected so that the formation of excessive local pressure increases, potentially causing crushing of the wood particles, are avoided. The temperature of the cylinder and the screw rotation speed are also selected such as to avoid decomposition of wood chip structure by excessively high pressure during extrusion. For example a suitable barrel temperature can be in the range of about 110 to 150 °C from hopper to die, while the screw rotation speed may be between 25-50 rpm. These are, naturally, only indicative data and the exact settings will depend on the actual apparatus used.

The molten thermoplastic polymer containing the wood particles can be subjected to tensile forces to achieve a desired orientation of the thermoplastic polymer and, in particular, the wood particles.

The desired 2D profile for the composite layer for the sports protection device/blank can be obtained from the extruded sheet or plate with e.g. laser cutting, water jet cutting, eccentric pressing or with any tool capable for producing regular shape profiles.

The composite layer with the appropriate 2D profile can also be formed by compression molding, injection molding, die-casting, pressure die-casting or manual shaping.

A particular advantage of the present invention is that the composite layer and lining layer forming the blank can be cut to its 2D profile using scissors i.e. without any specialist cutting tools.

Other features of the steps of manufacturing the composite layer may be as described in WO2010/103188 incorporated herein by reference.

At least one region of non-rigidity can be provided e.g. at a hinge portion of the sports protection device by forming incisions or by using polymer mixtures with more elasticity as described above. The incisions can be formed into the composite layer during or subsequent to extrusion of the composite layer e.g. using a rolling cylinder or a press equipped with blades, water jet or laser cutting.

The composite and lining layers be affixed directly to one another with no interposing layer. They may be affixed before or after the formation of the sports protection device/blank into the desired 2D profile.

They may be affixed directly to one another by bonding e.g. bonding using an adhesive. For example, the lining layer may be pre-impregnated with adhesive prior to affixing to the composite layer.

The lining layer may be affixed to the composite layer by heat bonding i.e. by pressing the lining layer onto the composite layer when the composite layer is tacky due to heating e.g. during extrusion of the composite layer.

The lining layer may be affixed to the composite layer by stitching or mechanical locking.

The method may further comprise affixing an edging layer which may extend at least partly (and preferably entirely) around the peripheral edges of the layers. The edging layer may provide a smooth edge to the sports protection device or blank to prevent irritation of the portion of the wearer’s body against which the sports protection device fits. The edging layer may be affixed using adhesive and/or stitching, for example.

To form the 3D profile of the sports protection device of the first aspect and/or to mold the blank according to the second aspect, the composite/lining layers are heated to the desired operating temperature by a heating device.

Once the composite/lining layers are heated to the desired temperature, then the layers can be formed into the desired profile. For example, the blank can be placed on the wearer in the desired location to form the sports protection device. The advantage of the present material is that it can be handled by hand without any protective requirement such as gloves. Equally important is that the material can be formed directly against the wearer's skin. The wood particles form insulating regions within the thermoplastic polymer (which is moldable at low temperature) such that the composite layer is comfortable to touch with bare hands.

With the composite material still pliable and moldable, it can be contoured to fit the wearer's body part nearly or exactly. Additionally, if the initial placement is not desirable, the blank can be moved while still moldable to a more desirable location. If the composite layer has lost its desired moldability, then it can be reheated and likewise moved to the new location. A blank formed of PCL and wood particles typically remains moldable for up to 5 minutes. One of the particular advantages of the present material is that it can be heated and cooled many times without degrading its mechanical properties.

When the blank is located properly and molded to the desired form, then it can be allowed to cool to a temperature where it can be removed but maintain its shape. The cooling may be accomplished by allowing the ambient conditions to reduce the temperature of the material or the cooling may be aided by spraying the material with water or another chemical to speed up the cooling. Additionally, solid cooling means can be used to cool the material such as a cold pack or ice place directly against the composite material.

The sports protection device may be contoured or the blank may be moldable to fit against the wearer’s limb.

For example, the sports protection device may comprise or the blank may be moldable to form a shin pad, an elbow pad, a knee pad, an ankle guard, a shoulder pad/guard or a wrist guard. In these embodiments, the sports protection device may be contoured/dimensioned to only partly encircle the wearer’s limb so that weight of the device is minimised and ease of fitting is optimised.

For example, a shin pad may have a substantially U-shaped profile. A blank for a shin pad may have a substantially rectangular shape that is moldable into a U-shaped profile. The curvature of the U-shaped profile may be constant or may vary along its length. For example, the curvature may decrease along its length.

The blank may have a cut-out portion at one end – this cut-out portion may provide for flexing of the wearer's ankle once the blank has been moulded into the shin pad.

A typical length for a shin pad will be around 10-50 cm, e.g. 15-40 cm in length. A typical width for a shin pad will be around 10 to 20 cm. For example, a shin pad according to the present invention may have a length of around 18 cm and/or a width of around 13 cm. Another embodiment of a shin pad (e.g. for use in baseball) may have a length of around 32 cm and a width of around 14.5 cm.

In another example, a blank for an elbow guard may have a planar substantially triangular shape optionally with rounded apices. The triangular shape may be an isosceles triangle with a width of around 190-250 mm (e.g. 200 or 230 mm) and a height of around 110-160 mm (e.g. 125 mm or 145 mm).

In another example, a blank for a wrist guard (e.g. for use in baseball) may have a planar substantially square shape with optionally rounded apices. One side of the square shape may be convex whilst the opposing side may be concave. The sides may be around 75-90mm. The convex/concave sides may be shorter than the adjoining sides. For example, in one embodiment, the adjoining sides may be around 85 mm whilst the concave/convex sides may be around 77.5 mm. The blank is moldable into a U-shaped profile the fit the wearer's wrist.

In another embodiment of a wrist guard (e.g. for use in fighting sports), the wrist guard has a substantially planar elongated portion for contacting the upper surface of the wearer's wrist with curled central edges for partially encircling the wearer's wrist, the curled central edges tapering to the planar portion at the opposing lateral ends of the planar portion. The length of the planar elongated portion may be around 100-250 mm with a width of around 150-190mm. The height of the curled edges may be around 125-160 mm.

In other embodiments, the sports protection device may be contoured or the blank may be moldable to fit against the wearer's face/head (e.g. nose/forehead), groin, chest or back.

A blank for a nose guard may have a planar substantially I-shaped profile with two opposing horizontal portions (for molding over the root and tip of the nose) separated by a vertical web (for molding over the bridge of the nose). The upper horizontal portion (for molding over the root of the nose) may have a greater extension (from the web) than the lower horizontal portion (for moulding over the tip of the nose). For example, the upper horizontal portion may have a total extension (width) of around 120 mm. The height of the blank (from the upper edge of the upper horizontal portion to the lower edge of the lower horizontal portion) may be around 90 mm.

In some embodiments, the sports protection device may comprise at least one fastener for affixing the sports protection device to the portion of the wearer's body. The at least one fastener may comprise a strap e.g. a strap that is securable to a further strap or to the sports protection device using a hook/loop connection (e.g. Velcro™).

In other embodiments, the sports protection device may not include any fastener. For example, the composite layer has been found to have a sufficiently rough surface (owing to the presence of wood particles) that it can frictionally engage with the wearer's clothing e.g. socks, to maintain its position against the portion of the wearer's body e.g. shin. This provides for secure affixing of the sports protection device without the need for fasteners (which complicate the manufacturing process).

In a fifth aspect, the present invention provides a shin pad for protecting a wearer's shin, the shin pad comprising:

a lining layer for facing the wearer's shin; and

an opposing composite layer superimposed on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

the lining and composite layers being shaped to substantially match the contour of the wearer's shin.

In a sixth aspect, the present invention provides a moldable blank for forming a shin pad for protecting a wearer's shin, the moldable blank comprising:

a lining layer for facing the wearer's shin; and

an opposing composite layer superimposed on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

the lining and composite layers being moldable to substantially match the contour of the wearer's shin.

The lining layer and composite layers may be as described above and may be joined as described above. The shin pad/blank may further comprise the edging layer as described above.

The shin pad/blank may be manufactured as described for the third and fourth aspects respectively.

With a typical thickness of the composite layer being 2-4 mm and a typical thickness of the lining layer being 1-5 mm, the typical thickness of the shin pad is around 3-9 mm making it considerably less bulky than the known shin pads.

A typical length for a shin pad will be around 10-50 cm, e.g. 15-40 cm in length. A typical width for a shin pad will be around 10 to 20 cm. For example, a shin pad according to the present invention may have a length of around 18 cm and/or a width of around 13 cm. Another embodiment of a shin pad (e.g. for use in baseball) may have a length of around 32 cm and a width of around 14.5 cm.

The blank and/or the shin pad may have at least a portion having a substantially curved profile. For example, the blank and/or shin pad may have a substantially U-shaped curved profile. The curvature may be constant or may vary along its length. For example, the curvature may decrease along its length (e.g. towards a lower end).

Alternatively, the blank may have a substantially planar e.g. planar rectangular shape for molding into the curved profile.

The blank and/or the shin pad may have a cut-out portion at the lower end for molding around and allowing flexing of the wearer’s ankle.

The blank/shin pad is preferably dimensioned such that it only partially encircles the wearer’s leg i.e. it encircles the wearers shin but not their calf.

The shin guard may comprise at least one fastener for affixing the shin guard to the wearer’s shin. The at least one fastener may comprise a strap e.g. a strap that is securable to a further strap or to the sports protection device using a hook/loop connection (e.g. Velcro™).

In other embodiments, the shin pad may not include any fastener. For example, the composite layer has been found to have a sufficiently rough surface (owing to the presence of wood particles) that it can frictionally engage with the wearer’s clothing e.g. socks, to maintain its position against the wearer’s shin. This provides for secure affixing of the shin pad without the need for fasteners (which complicate the manufacturing process).

The shin pad may comprise an ankle guard extending from the composite layer. The ankle guard may be formed of padded, elastic material and may be detachable from the composite layer

Example - Comparative Shock absorption test

Test specimens with dimensions of 50 mm x 50 mm were cut from the plastic shell of three commercially available shin guards (after separation of the shell from the associated foam/textile layers). Additionally three sets of 50 mm x 50 mm test samples were cut from a composite layer having a thickness of 4 mm and a composite layer having a thickness of 2 mm. The composite layer was formed from a 3:2 ratio of PCL and wood particles. The wood particles were aspen wood particles having an average size of 2 x 2 x 1 mm. The PCL had an Mn of 80,000g/mol.

The composite layers were heated and formed to have identical shape as the comparative shin guard specimens to exclude the effect of shape in results. The thickness of each test specimen was measured with calliper at both ends of the specimen, to calculate average thickness.

A blunt impact test set up was used to assess the impact absorbing properties of the test specimens and composite layer samples by dropping a 2.5 kg mass from 47 mm distance, positioned vertically over the top of the test specimen/samples. The amount of force that was transmitted through the guard onto the flat anvil was measured (Kistler9065) and recorded. The lower the transmitted force the better the shock absorption property of the sample.

Three measurements were performed for each test specimen/sample.

Transmitted force averages and standard deviations were calculated for each test specimen/sample. An independent paired two-tailed t-test was used to test the hypothesis that there is a difference between two materials. A value of $P < 0.05$ indicates a statistically significant difference between the two materials.

The transmitted force values (averages from three measurements) are shown in Table 1.

Material	Thickness (mm)	Transmitted Force k(N) (average - stdev)
Test specimen 1	3.2	4.57 +/- 0.13
Composite layer 4 mm	4.2	2.90 +/- 0.09
Composite layer 2 mm	2.2	3.98 +/- 0.16
Test specimen 2	2.9	5.97 +/- 0.27
Composite layer 4 mm	4.3	2.97 +/- 0.19
Composite layer mm	2.2	4.24 +/- 0.11
Test specimen 3	3.0	5.02 +/- 0.51
Composite layer 4 mm	4.2	3.73 +/- 0.19
Composite layer 2 mm	2.1	4.26 +/- 0.05

Table 1

The 4 mm composite layer clearly provides the best shock absorption amongst the specimens/samples tested. The 2 mm composite later has only approximately 2/3 of the thickness of the test specimens, however the shock absorption property was either higher (Test specimen 1; P=0.009 and Test specimen 2; P=0.048) or around the same level (Test specimen 3; P=0.171), in this test.

The composite layer can be used to provide a sports protection device having high shock absorbance but with a narrow profile, reduced bulkiness and lower weight compared to known products. The lining layer provides comfort for the wearer.

The 3D moldability of the composite layer in the blanks according to the second and sixth aspects further improves comfort and shock absorbency.

While the invention has been described in conjunction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the spirit and scope of the invention.

All references referred to above are hereby incorporated by reference.

CLAIMS

1. A sports protection device for protecting a portion of a wearer’s body, the sports protection device comprising:

a lining layer for facing the wearer’s body; and

an opposing composite layer superimposed on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

the lining and composite layers being shaped to substantially match the contour of the portion of the wearer’s body.

2. A moldable blank for forming a sports protection device for protecting a portion of a wearer’s body, the moldable blank comprising:

a lining layer for facing the wearer’s body; and

an opposing composite layer superimposed on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

the lining and composite layers being moldable to substantially match the contour of the portion of the wearer’s body.

3. A device or blank according to claim 1 or 2 wherein the lining layer is formed of a 3D spacer fabric.

4. A device or blank according to any one of the preceding claims wherein the lining layer has a thickness of between 1 – 5 mm.

5. A device or blank according to any one of the preceding claims wherein the lining layer comprises an anti-bacterial and/or anti-odour composition.

6. A device or blank according to any one of the preceding claims wherein the thermoplastic polymer is a polyester.

7. A device or blank according to any one of the preceding claims wherein the thermoplastic polymer is polycaprolactone.

8. A device or blank according to any one of the preceding claims wherein the wood particles are plate-like or granular and have at least two dimensions greater than 1 mm and one greater than 0.02 mm.

9. A device or blank according to claim 8 wherein the wood particles are plate-like and have dimensions or around 1mm x 2mm x 2mm.

10. A device or blank according to any one of the preceding claims wherein the composite layer contains around 40 wt% wood particles.

11. A device or blank according to any one of the preceding claims comprising at least one region of increased flexibility.

12. A device or blank according to claim 11 wherein the region of increased flexibility is provided at a hinge portion.

13. A device or blank according to claim 11 or 12 wherein said composite layer further comprises a soft or elastic polymer in the region of increased flexibility.

14. A device or blank according to claim 13 wherein the soft or elastic polymer is selected from the group of thermoplastic polyolefin blends; polyurethanes; co-polyesters; polyamides; unsaturated or saturated rubbers, including natural rubber, silicone, and copolymers of olefins; and natural or synthetic soft material, including soft gelatin, hydrogels, hydrocolloids and modified cellulose.

15. A device or blank according to any one of claims 11 to 14 wherein said composite layer further comprises incisions in the region of increased flexibility.

16. A device or blank according to claim 15 wherein said incisions are spaced in a series of longitudinal parallel lines.

17. A device or blank according to any one of the preceding claims wherein the composite and lining layers are affixed directly to one another with no interposing layer.

18. A device or blank according to any one of the preceding claims further comprising an edging layer extending at least partly around the peripheral edges of the composite layer.

19. A device or blank according to any one of the preceding claims wherein the composite layer has a thickness of between 2 to 6 mm.

20. A device or blank according to any one of the preceding claims wherein the composite has a central portion that is thicker than a peripheral portion.

21. A device or blank according to any one of the preceding claims having at least a portion having a substantially curved profile.

22. A method of manufacturing a sports protection device for protecting a portion of a wearer's body, the method comprising:

providing a lining layer for facing the wearer's body;

superimposing a composite layer on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

shaping said layers to substantially match the contour of the portion of the wearer's body.

23. A method of manufacturing a moldable blank for forming a sports protection device for protecting a portion of a wearer's body, the method comprising:

providing a lining layer for facing the wearer's body;

superimposing a composite layer on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix.

24. A method according to claim 22 or 23 comprising mixing the thermoplastic polymer with the wood particles in a melt mixing apparatus to produce a compounded melt mixture and extruding the melt mixture.

25. A method according to any one of claims 22 to 24 comprising affixing a lining layer formed of a 3D spacer fabric to said composite layer.

26. A method according to any one of claims 22 to 25 wherein the thermoplastic polymer is polycaprolactone.

27. A method according to any one of claims 22 to 26 wherein the wood particles are plate-like or granular and have at least two dimensions greater than 1 mm and one greater than 0.02 mm.

28. A method according to any one of claims 22 to 27 comprising mixing around 40 wt% wood particles with said thermoplastic polymer.

29. A method according to any one of claims 22 to 28 comprising providing at least one region of increased flexibility at a hinge portion.

30. A method according to any one of claims 22 to 29 comprising mixing a soft or elastic polymer with the thermoplastic polymer in the region of increased flexibility.

31. A method according to any one of claims 22 to 30 comprising providing incisions in the region of increased flexibility.

32. A method according to any one of claims 22 to 31 wherein the composite and lining layers are affixed directly to one another with no interposing layer.

33. A method according to any one of claims 22 to 32 further comprising applying an edging layer extending at least partly around the peripheral edges of the lining/composite layers.

34. A shin pad for protecting a wearer's shin, the shin pad comprising:

a lining layer for facing the wearer's shin; and

an opposing composite layer superimposed on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

the lining and composite layers being shaped to substantially match the contour of the wearer's shin.

35. A moldable blank for forming a shin pad for protecting a wearer's shin, the moldable blank comprising:

a lining layer for facing the wearer's shin; and

an opposing composite layer superimposed on said lining layer, the composite layer comprising wood particles within a thermoplastic polymer matrix,

the lining and composite layers being moldable to substantially match the contour of the wearer's shin.

36. A shin pad or blank according to claim 34 or 35 wherein the lining layer is formed of a 3D spacer fabric.

37. A shin pad or blank according to any one of claims 34 to 36 wherein the lining layer has a thickness of between 1 – 5 mm.

38. A shin pad or blank according to any one of claims 34 to 37 wherein the lining layer comprises an anti-bacterial and/or anti-odour composition.

39. A shin pad or blank according to any one of claims 34 to 38 wherein the thermoplastic polymer is a polyester.

40. A shin pad or blank according to any one of claims 34 to 39 wherein the thermoplastic polymer is polycaprolactone.

41. A shin pad or blank according to any one of claims 34 to 40 wherein the wood particles are plate-like or granular and have at least two dimensions greater than 1 mm and one greater than 0.02 mm.

42. A device or blank according to claim 41 wherein the wood particles are plate-like and have dimensions or around 1mm x 2mm x 2mm.

43. A shin pad or blank according to any one of claims 34 to wherein the composite layer contains around 40 wt% wood particles.

44. A shin pad or blank according to any one of claims 34 to comprising at least one region of increased flexibility.

45. A shin pad or blank according to claim 44 wherein the region of increased flexibility is provided at a hinge portion.

46. A shin pad or blank according to claim 44 or 45 wherein said composite layer further comprises a soft or elastic polymer in the region of increased flexibility.

47. A shin pad or blank according to claim 46 wherein the soft or elastic polymer is selected from the group of thermoplastic polyolefin blends; polyurethanes; co-polyesters; polyamides; unsaturated or saturated rubbers, including natural rubber, silicone, and copolymers of olefins; and natural or synthetic soft material, including soft gelatin, hydrogels, hydrocolloids and modified cellulose.

48. A shin pad or blank according to any one of claims 44 to 47 wherein said composite layer further comprises incisions in the region of increased flexibility.

49. A shin pad or blank according to claim 48 wherein said incisions are spaced in a series of longitudinal parallel lines.

50. A shin pad or blank according to any one of claims 34 to 49 wherein the composite and lining layers are affixed directly to one another with no interposing layer.

51. A shin pad or blank according to any one of claims 34 to 50 further comprising an edging layer extending at least partly around the peripheral edges of the lining/composite layers.

52. A shin pad or blank according to any one of claims 34 to 51 wherein the composite layer has a thickness of between 2 to 6 mm.

53. A shin pad or blank according to any one of claims 34 to 52 wherein the composite has a central portion that is thicker than a peripheral portion.

54. A shin pad or blank according to any one of claims 34 to 53 having at least a portion having a substantially curved profile.

55. A sports protection device substantially as any one embodiment described herein.

56. A blank substantially as any one embodiment described herein.

57. A method substantially as any one embodiment described herein.

Intellectual Property Office

Application No:	GB1610138.8	**Examiner:**	Mr Philip J. Roe
Claims searched:	1-57	**Date of search:**	29 September 2016

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-54	WO 2006/027763 A2 (FASTFORM RESEARCH LIMITED) see whole document, especially page 28 lines 6-9, page 9 lines 12-21, and page 27 lines 17-23.
X	1-54	WO 2010/103186 A2 (ONBONE OY) see whole document, especially page 6 lines 1-10, page 4 lines 9-22, and page 5 lines 13-34, page 19 lines 24-31.
A	-	US 2012/0090068 A1 (GLASS et al) see whole document
A	-	US 2014/0259324 A1 (BEHREND et al) see whole document.
A	-	JP H09676 A (MOLTEN CORP) see WPI Abstract Accession No. 1997/113197 and all figures.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A41D; A63B

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

Intellectual Property Office

International Classification:

Subclass	Subgroup	Valid From
A41D	0013/05	01/01/2006
A63B	0071/12	01/01/2006