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(54) Nonwovens obtained from banana plant outer sheath fibre

(57) A nonwoven which comprises grinded banana plant outer sheath fibre, thermoplastic fibre and cellulosic fibre, in which the grinded banana plant outer sheath fibre content is at least 70% weight/weight, the thermoplastic fibre content is at least 5% weight/weight and the cellulosic fibre content is at least 5% weight/weight.

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Description

Field of the invention

[0001] This invention refers to fabrics comprising grinded banana plant outer sheath fibres, as well as their use as reinforcement for composite materials and their obtaining by means of wet laid technology.

Background of invention

[0002] The growing use of nonwovens in a broad field of applications such as personal hygiene, medicine and household products, among others, has made them a target of continuous study and development.

[0003] Nonwovens are classified mainly based on their weight per unit area, their web formation and their consolidation system. As regards their classification based on their web formation, three different processes can be distinguished: dry laid, wet laid and molten laid. In the wet laid process the fibres are suspended in an aqueous medium and then deposited on a conveyor belt, where the web is formed, carrying the film to a consolidation station.

[0004] The main advantage of wet laid technology is the absence of chemical products, as well as the reuse of the water used during the process. In addition, it offers greater productivity and has a broader range of application than the case of dry laid and molten laid procedures. On the contrary, it has the disadvantage that the length of the fibres to be treated needs to be short (commonly less than 15 mm) and, therefore, the mesh structure formed is stiffer and weaker than those obtained based on longer fibres using dry processes.

[0005] On the other hand, natural fibres are now being used increasingly instead of synthetic fibres, mainly because these natural fibres produce wovens (and nonwovens) that maintain their natural properties and are 100% biodegradable and renewable.

[0006] As such, for example, this fact is contained in Assembling Technologies for Functional Garments, Indian Journal of Fibre & Textile Research, vol. 36, December 2011, pages 380-387, which reports the increase in the number of natural fibres currently used in functional garments. Among these fibres are those from bamboo and banana, among others.

[0007] Described in Development of Natural Fibre Nonwovens for Application as Car Interiors for Noise Control, Journal of Industrial Textiles 2010, 39: 267 is the use of nonwovens based on natural fibres such as banana, bamboo and jute for use in car interiors to absorb noise, the main advantage of these being their biodegradability, unlike the materials used commonly, such as glasses and foams.

[0008] European Patent 0992338B1 describes three ply structures with two external layers composed of synthetic fibres and an intermediate layer composed of natural fibres that find use in the field of wipes and hospital gowns.

[0009] Document JP2010095805A describes a procedure for manufacturing fabrics and nonwovens, for use in garments, from banana fibres.

[0010] Document IN201302979P2 describes absorbent items, such as sanitary towels, which use banana pulp as the absorbent material.

[0011] Although it is true that the use of natural fibres has increased substantially, it is also true that the items obtained from them are mainly limited to wipes, hospital clothing, garments such as hats, etc., i.e. products with limited mechanical strength are obtained in general. It would, therefore, be desirable to obtain products which, in addition to having the advantage of being biodegradable, offer high mechanical strength, so that the field of application is broader than indicated above.

[0012] In addition to this, it must be borne in mind that in some cases, as in the specific case of banana plants, the treatment of the large amount of wastes these plants generate represents a serious problem. It is estimated that around 20% of the bananas consumed in Europe come from Canary Island plantations and these plantations generate approximately 25 tons of banana waste annually. The "banana plant outer sheath", also called sometimes "badana", is the dry, burnt ochre coloured part of the banana leaf that wraps around the outside of the plant pseudostem. This "outer sheath" is composed of a collection of natural fibres that, although it used to be used in the past as fodder for cattle and goats, went on to accumulate in gullies as biological filler (aside from being used sparingly for some types of decorative handicrafts) after decomposition, when the farms started to feed their animals using pre-digested fodder.

[0013] Therefore, taking into account the previously mentioned need to find products that, as well as having the advantage of being biodegradable, offer high mechanical strength, it would be desirable to be able to take advantage of these wastes to meet this need.

Summary of the invention

[0014] The objective of this invention is aimed at nonwovens comprising banana plant outer sheath wastes, as well as their production using wet laid technology and their use, among others, as reinforcement material for composite materials. The fact of using nonwovens as reinforcement materials instead of using the grinded fibre as a filler for a plastic leads to materials being obtained with a higher percentage of fibre and, therefore, a higher ecological value, among other advantages.

Brief description of the figures

[0015]

Figure 1: Variation in tensile strength, in the longitudinal and transverse directions, for prototype nonwovens 3 to 7 with the compositions shown in Table 1.
Figure 2: Variation in elongation at maximum force, in the longitudinal and transverse directions, for prototype nonwovens 3 to 7 with the compositions shown in Table 1.
Figure 3: Variation in tensile strength for the composite materials obtained from prototype nonwovens 3 to 7 with the compositions shown in Table 1.
Figure 4: Variation in elongation at maximum force for the composite materials obtained from prototype nonwovens 3 to 7 with the compositions shown in Table 1.
Figure 5: Variation in the maximum strength observed in the flexural tests for the composite materials obtained from prototype nonwovens 3 to 7 with the compositions shown in Table 1.

Detailed description of the invention

[0016] As indicated previously, one of the objectives of the invention is aimed at nonwoven composites from grinded banana plant outer sheath fibre, as well as obtaining them using wet laid technology and their use, among others, to obtain composite materials.

[0017] Wet laid technology enables the use of both synthetic and natural fibres, the length of which do not exceed approximately 15 mm. Given that banana plant outer sheath fibre occurs in the form of dry leaves longer than 15 mm, it needs to be treated beforehand. To do this, it is first grinded in a conventional grinding machine so as to obtain a particle size in the 0 to 10 mm range, suitable for proper processing.

[0018] In wet laid technology the grinded fibres are suspended in an aqueous medium and are subsequently deposited on a conveyor belt on which the web is formed. From the conveyor belt, the sheet of randomly oriented fibres goes to the roller pressing system, where part of the excess water contained in the sheet is removed, which is recovered for subsequent use. The sheet is then led to the consolidation station where the material is dried further. The procedure is summarised in Diagram I.

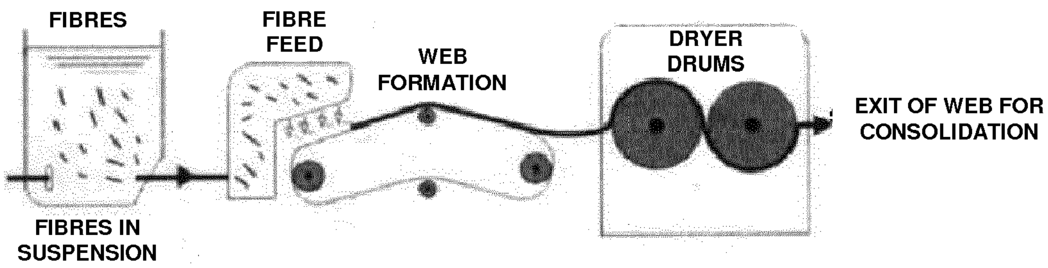

Diagram I. Wet laid process procedure

[0019] The aqueous solution of banana plant outer sheath fibres also contains cellulosic fibres and thermoplastic fibres. The cellulosic fibres are added, advantageously, to obtain nonwoven web formation and the thermoplastic fibres are used in preferred embodiments as binders to consolidate nonwovens. In embodiments, the cellulosic fibres used are viscose fibres and in the case of thermoplastic fibres, polylactic acid (PLA) fibres and polypropylene (PP) fibres have been used.

[0020] As such, as a first aspect, the invention is aimed at a nonwoven which comprises grinded banana plant outer sheath fibre, at least one thermoplastic fibre and at least one cellulosic fibre, characterised in that the grinded banana plant outer sheath fibre content is between 70% and 90% weight/weight, the thermoplastic fibre content is at least 5% weight/weight and the cellulosic fibre content is at least 5% weight/weight.

[0021] As a second aspect, the invention is aimed at a method of manufacturing a nonwoven material that comprises banana plant outer sheath fibre, including the stages of:

a) grinding the banana plant outer sheath fibres to a length no larger than 15 mm, and suspending them in an aqueous medium;
b) depositing the suspension of grinded banana plant outer sheath fibres on a conveyor belt, on which it forms a sheet of randomly oriented fibres;
c) pressing the sheet of randomly oriented fibres using rollers, where part of the excess water contained in the sheet is removed; and
d) drying the sheet of pressed fibres.

[0022] After obtaining nonwovens in the way explained above, processing takes place using thermocompression technology with a hot plate press to obtain composite materials (composites). The details of the procedure are included in the example section.

[0023] And, as a third aspect, the invention is aimed at a use of the nonwoven comprising banana plant outer sheath fibres in the manufacture of furniture, transport crates and as thermal insulation for walls and floors.

Examples

Obtaining nonwovens

[0024] As indicated previously, the banana plant outer sheath fibre occurs in the form of dry leaves the length of which exceed 15 mm (which is the maximum length to ensure correct processing using wet laid technology). Therefore, it is grinded in a conventional grinder machine so as to obtain a particle size in the 0 to 10 mm range. The fibres so obtained are placed in a conventional rotary mixer where, in an aqueous solution, the fibres are opened and mixed with thermoplastic fibres and cellulosic fibres.

[0025] The thermoplastic fibres are used as binders to consolidate the nonwovens. Polylactic acid (PLA) 260 fibre, supplied by TREVIRA, at a length of 6 mm, with a melting point of 160°C under the title 1.7 dtex and polypropylene (PP) fibre PP 2,8/6 supplied by STW, of 6 mm in length, with a melting point of 160°C and under the title 2.8 dtex, have been used as the thermoplastic fibres.

[0026] In the initial prototypes obtained (see Table 1), only grinded banana plant outer sheath fibres and thermoplastic fibres were used and it was noted that very weak nonwovens were obtained that broke easily. For this reason, cellulosic fibres were added, which have been shown to be suitable for sheet formation. Viscose fibre ZW gl 1,0/6T has been used, as supplied by STW, of 6 mm in length, with heat resistance of 120°C and a decomposition point of 175°C under the title 0.9 dtex.

[0027] With the objective of making maximum use of grinded banana plant outer sheath fibre, the development of nonwovens with the maximum percentage of it was sought. To do this, nonwoven formation starts at a grinded banana plant outer sheath fibre percentage lower than the final material will contain, together with the thermoplastic binder fibres, and the amount of grinded fibre is increased progressively to be able to form a fully functional nonwoven that contains up to the maximum amount of grinded banana plant outer sheath fibre possible.

[0028] The mixture of fibres is deposited on a conveyor belt, where the sheet is formed (Fourdrinier), carrying the sheet formed, after passing through a double tier drying system, to the nonwoven consolidation station. The technical data for the pilot plant and the drying system are as follows:

Pilot plant:

- Production width: ≈ 500mm
- Inclination: 20°
- Production speed: 1-10 m/min

[0029] Dryer:

- Conveyor belt width: 510 mm
- Dryer length: ≈ 5 m
- Maximum drying temperature: 250°C

[0030] En realizaciones preferidas, los no tejidos comprenden fibra de badana triturada en un porcentaje entre 70 - 90% peso/peso, más preferiblemente entre 70-80% peso/peso, y lo más preferiblemente alrededor de 70% peso/peso. Igualmente, la fibra termoplástica se encuentra presente preferiblemente en un porcentaje entre el 5% y el 30% peso/peso, más preferiblemente entre el 5% y el 20%, y lo más preferiblemente entre el 5% y el 10%. Además, la fibra celulósica se encuentra presente preferiblemente en un porcentaje entre el 5% y el 20% peso/peso, y más preferiblemente entre 10% y 20%. Todos estos intervalos pueden ser combinados entre si en cualquier combinación de los mismos.

[0031] In preferred embodiments, the nonwovens comprise banana plant outer sheath fibres in a range between 70-90 wt/wt%, more preferably between 70-80 wt/wt%, and most preferably around 70% wt/wt%. Likewise, the thermoplastic fibres are present preferably in a percentage between 5-30 wt/wt%, more preferably between 5-20 wt/wt%, and most preferably between 5-10 wt/wt%. Also, the cellulosic fibres are preferably present in a percentage between 5-20 wt/wt%, and more preferably between 10-20%. All these ranges can be combined with each other in any combination.

[0032] Table 1 shows the different prototypes of nonwovens obtained in line with the aforementioned procedure.

Table 1. Composition and weight per unit area of the banana plant outer sheath waste nonwovens

Nonwoven No.	Components	Composition % (weight/weight)	Weight per unit area (g/m^2)
1	Grinded banana plant outer sheath fibre	70	200
	PLA	30	
2	Grinded banana plant outer sheath fibre	80	200
	PLA	20	
3	Grinded banana plant outer sheath fibre	70	200
	PLA	10	
	Viscose	20	
4	Grinded banana plant outer sheath fibre	80	200
	PLA	10	
	Viscose	10	
5	Grinded banana plant outer sheath fibre	90	200
	PLA	5	
	Viscose	5	
6	Grinded banana plant outer sheath fibre	80	200
	PP	10	
	Viscose	10	
7	Grinded banana plant outer sheath fibre	90	200
	PP	5	
	Viscose	5	
8	Grinded banana plant outer sheath fibre	70	500
	PP	10	
	Viscose	20	
9	Grinded banana plant outer sheath fibre	80	500
	PLA	10	
	Viscose	10	
10	Grinded banana plant outer sheath fibre	90	500
	PLA	5	
	Viscose	5	

[0033] In prototypes numbers 1 and 2 the nonwoven obtained was seen to leave the dryer in pieces. Therefore, it was considered appropriate to add to the mixture of grinded banana plant outer sheath fibre and thermoplastic fibre acting as a binder, a cellulosic fibre (viscose) to facilitate the grinded banana plant outer sheath fibre processing.

[0034] Prototypes 3, 4 and 5 are mixtures of grinded banana plant outer sheath fibre, PLA and viscose where the minimum banana plant outer sheath content is 70%. The sheet mass for the production of the nonwovens was 200 g/m^2. In the three cases nonwovens were obtained which were visually homogeneous, could be calendered easily and could be handled to carry out the tests described below.

[0035] In order to study whether there were differences between the mechanical properties of the nonwovens as a consequence of the use of different thermoplastic fibres, prototypes 6 and 7 were prepared (also with a sheet mass of 200 g/m^2), which were equivalent to prototypes 4 y 5 respectively, but replaced the polylactic acid (PLA) fibre with polypropylene (PP) fibre. The nonwovens obtained were also perfect, visually homogeneous and could be calendered easily.

[0036] Finally, prototypes 8, 9 and 10 were studied. The composition of these was the same as prototypes 3, 4 and 5 respectively, but a sheet mass of 500 g/m^2 was used instead of 200 g/m^2. In the three cases, although the speed of the conveyor belt was increased from 1 m/min to 1.5 m/min, overflowing of the water occurred and development of the nonwoven web was not achieved.

Characterisation of the nonwovens

[0037] In order to characterise the prototype nonwovens indicated above, tests were carried out to determine sheet mass, tensile strength, elongation at failure and thickness.

Sheet mass testing

[0038] This test was carried out according to the UNE-EN 29073-1:1993 standard for the determination of mass per unit area of nonwovens.

[0039] To carry this out, a die to cut a test specimen with a minimum area of 50,000 mm^2 and a balance capable of determining the mass of a test specimen with a precision of $\pm$ 0.1% were used. Measurements were carried out at a temperature of (20$\pm$2)°C with a relative humidity of (65$\pm$4)%.

[0040] The mass per unit area of the nonwoven samples contained in Table 1 was verified (only those prototypes which resulted in the formation of a perfect nonwoven, i.e. prototypes 3 to 7, were studied). The results obtained are shown in Table 2.

Table 2. Mass per unit area values for prototype nonwovens 3 to 7 with the compositions shown in Table 1.

Prototype	Sheet mass (g/m^2)
3	244.26
4	206.15
5	198.80
6	215.48
7	195.47

[0041] Based on this data, it can be concluded that the weight per unit area obtained coincides with that set theoretically in the processing equipment (200 g/m^2), with this being only slightly higher than the latter in prototype number 3, which may be due to a nonhomogeneous distribution of the material in some areas of the nonwoven.

Tensile strength and elongation at failure testing

[0042] This test was carried out in accordance with the ISO 9073-3:1989 standard. The tensile characteristics (force necessary to produce failures) and elongation experienced by the samples at the time of failure were determined.

[0043] The equipment used was an INSTRON dynamometer. Measurements were carried out at a temperature of (20$\pm$2)°C and a relative humidity of (65$\pm$4)%.

[0044] As in the previous section, prototypes 3 to 7 were subjected to testing. The results obtained, both in the longitudinal and transverse directions, are presented in Table 3.

Table 3. Tensile strength and elongation at maximum force values for prototype nonwovens 3 to 7 with the compositions shown in Table 1.

Prototype	Direction	Tensile strength (N)	Elongation at maximum force (%)
3	Longitudinal	146	3.0
	Transverse	130	4.0
4	Longitudinal	84	1.4
	Transverse	73	2.2
5	Longitudinal	25	1.6
	Transverse	35	1.6
6	Longitudinal	78	3.2
	Transverse	80	2.2
7	Longitudinal	27	1.8
	Transverse	23	2.4

[0045] The tensile strength and elongation at maximum force values in the longitudinal and transverse directions are presented in Figures 1 and 2 respectively.

[0046] Based on the tensile strength data presented in Table 3 and Figure 1, it can be concluded that there are no differences between the transverse and longitudinal behaviours for all the prototypes. It can also be concluded that the use of PLA or PP as a thermoplastic fibre does not lead to differences in tensile strength (see prototypes 4 and 6 and 5 and 7 which have the same composition, differentiated only by the binder material). Finally, it can be highlighted that the prototype with the best tensile properties is prototype number 3, which has the lowest percentage of grinded banana plant outer sheath fibre of all the series analysed and the highest percentage of thermoplastic/viscose fibre (specifically with 70% weight/weight of grinded banana plant outer sheath fibre, 20% weight/weight of viscose fibre and 10% PLA). This result is surprising and unexpected, as from the review of documents on prior art it could be predicted that the higher the banana plant outer sheath fibre content the higher the mechanical strength of the material.

[0047] As regards elongation at maximum force, based on the data in Table 3 and Figure 2, it can be concluded that although different values can be seen for elongation at maximum force in the longitudinal and transverse directions, no significant difference can be considered to exist in the behaviour in the two directions. As in the case of the tensile characteristics presented above, it is prototype number 3 (70% weight/weight of grinded banana plant outer sheath fibre, 20% weight/weight of viscose fibre and 10% PLA) which has the highest elongation at maximum force. As regards differences deriving from using different binder fibres (PLA or PP), it can be concluded that although prototypes 4 and 6 show slight differences, giving higher elongation at maximum force values in the prototype containing PP as the binder fibre, these differences cannot be considered significant.

<u>Test to determine thickness</u>

[0048] This test was carried out in accordance with the UNE-EN ISO 9073-2 standard, establishing a method for determining the thickness of nonwovens on which a certain pressure is applied.

[0049] The equipment used was a SODEMAT thickness gauge. Measurements were carried out at a pressure of 0.5 KPa, a temperature of (20 ± 2)°C and a relative humidity of (65 ± 4)%.

[0050] From the thickness values obtained (shown in Table 4), it can be concluded that there is no difference in thickness of the nonwovens as a consequence of the different percentages of fabric, or as a consequence of the use of different binder fibres (as indicated above, the differences between prototypes 4 and 6 and 5 and 7 derive solely from the use of different binder fibres).

Table 4. Thickness values for prototypes 3 to 7 with the compositions shown in Table 1.

Prototype	Thickness (mm)
3	0.665
4	0.718
5	0.642
6	0.659
7	0.725

Obtaining composite materials based on nonwovens of grinded banana plant outer sheath fibre

[0051] Based on the prototype nonwovens successfully obtained (i.e. prototypes 3 to 7), these were processed using thermocompression technology using a hot plate press to obtain composite materials.

[0052] Firstly, the reels of nonwovens were die cut to dimensions of 80x80 mm. Once all the layers of nonwoven materials were die cut, all the layers were inserted in the hot plates of the thermocompression equipment, without the need to use a mould. A sheet of Teflon was placed between the two hot plates to prevent sticking. The temperature was then raised to the corresponding temperature for each binder fibre (PLA or PP, see Table 5), with the application of 6 tonnes for 10 minutes. The thermoforming process parameters are shown in Table 5.

Table 5. Thermoforming process parameters

Composite material obtained from prototype No.	Temperature (°C)	No. of layers	Time (min)	Pressure (Tonnes)
3	165	15	10	6
4	165	15	10	6
5	165	20	10	6
6	165	15	10	6
7	165	15	10	6

Characterisation of composite materials from nonwovens of grinded banana plant outer sheath fibre

[0053] In order to characterise the composite materials indicated above, tests were carried out to determine sheet mass, tensile strength, elongation at failure, flexural properties and thickness.

Tensile strength and elongation at failure testing

[0054] This test was carried out in accordance with the UNE-EN ISO 527-4 standard, which specifies the test conditions for determining the tensile properties of isotropic and orthotropic fibre reinforced plastic composites.

[0055] The measuring equipment was an IBERTEST dynamometer. Measurements were carried out at a temperature of (20±2)°C and a relative humidity of (65±4)%.

[0056] The tensile characteristics (force necessary to produce failure) and elongation experienced at failure were determined for the sample composite materials obtained in the previous section. Table 6 shows the results obtained for the two parameters. Figures 3 and 4 show the variation in the maximum force (tensile strength) and the variation in elongation at maximum force, respectively.

Table 6. Tensile strength and elongation at maximum force values for composite materials obtained from prototype nonwovens 3 to 7 with the compositions shown in Table 1.

Composite material obtained from prototype No.	Tensile strength (N)	Elongation at maximum force (%)
3	19.77	4.44
4	17.44	3.17
5	8.19	1.93
6	11.23	4.00
7	4.90	3.46

[0057] Based on the data on the maximum force required to break the composite materials contained in Table 6 and Figure 3, it can be concluded that the composite material that requires the greatest force to break it is that obtained from prototype number 3, which is the material with the lowest percentage of grinded banana plant outer sheath fibre of the five prototypes obtained (70% weight/weight of grinded banana plant outer sheath fibre, 20% weight/weight of viscose fibre and 10% PLA). It should also be emphasised that the materials obtained from prototypes that used PLA as a binder had better tensile properties (prototypes 4 and 5 compared to 6 and 7 respectively).

[0058] As regards elongation at maximum force, based on the data contained in Table 6 and Figure 4, it can be concluded that the composite material with the greatest elongation at maximum force is that obtained from prototype number 3, which is the one with the lowest percentage of grinded banana plant outer sheath fibre of all those obtained. In terms of the differences deriving from the use of different binder fibres, it can be highlighted that the materials containing PLA had lower elongation at maximum force (prototypes 4 and 5 compared to prototypes 6 and 7, respectively).

[0059] Once again the conclusion obtained from these tests is that there is a maximum in the banana plant outer sheath content in the resulting material of the order of 70 - 80% at which the material strength is highest, which is a surprising and unexpected result.

<u>Flexural testing</u>

[0060] This test was carried out in accordance with the UNE-EN ISO 178 standard, which specifies the test conditions for determining the flexural properties of rigid or semi-rigid plastics.

[0061] The measuring equipment was an IBERTEST dynamometer. Measurements were carried out at a temperature of (20±2)°C and a relative humidity of (65±4)%.

[0062] The flexural characteristics were determined for the composite materials obtained from nonwoven prototypes 3 to 7. Table 7 shows the results of the ultimate flexural breaking strength for the aforementioned composite materials. Figure 5 shows these results graphically.

Table 7. Ultimate flexural breaking strength values for composite materials obtained from prototype nonwovens 3 to 7 with the compositions shown in Table 1.

Composite material obtained from prototype No.	Ultimate flexural breaking strength (MPa)
3	31.64
4	31.84
5	18.60
6	21.54
7	18.50

[0063] Based on these results, it can be concluded that it is prototypes 3 and 4 that give the best flexural properties, giving ultimate flexural strength considerably higher than those seen in the rest of the composite materials. As regards the composite materials obtained from nonwovens that vary only in terms of the binder fibre used (prototypes 4 and 6 and 5 and 7), a large difference was seen in those in which the proportion of grinded banana plant outer sheath fibre was 80% weight/weight and the proportion of PLA or PP was 10% weight/weight (prototypes 4 and 6), with the flexural breaking strength being much higher where the binder fibre was PLA. On the contrary, in prototypes 5 and 7, both of which contain 90% weight/weight of grinded banana plant outer sheath fibre and are differentiated by the binder fibre added (PLA in prototype 5 and PP in prototype 7), no differences were seen in flexural properties.

Test to determine thickness

[0064] This test was carried out in accordance with the UNE-EN ISO 9073-2 standard, as indicated above.

[0065] Of the thickness values obtained (shown in Table 8), it can be concluded that there is no difference in the thickness of the composite materials obtained from the banana plant outer sheath nonwovens as a consequence of the different percentages of fabric or as a consequence of the use of different binder fibres. It can simply be highlighted that the composite material obtained from the nonwoven with the lowest grinded banana plant outer sheath fibre content (i.e. prototype 3) is slightly higher than the rest.

Table 8. Thickness values for composite materials obtained from prototype nonwovens 3 to 7 with the compositions shown in Table 1.

Composite material obtained from prototype No.	Number of nonwoven layers	Thickness (mm)
3	15	4.12
4	15	3.41
5	20	3.32
6	15	3.55
7	15	3.47

Determination of thermal resistance and conductivity

[0066] To carry out this test, the composite materials with the best mechanical properties were selected, i.e. the composite materials prepared from nonwoven prototypes numbers 3 and 4 were selected.

[0067] The UNE-EN 12667:2002 standard was followed. This specifies the testing principles and procedures for determining, by means of data from guarded hot plate or heat flow meter methods, the thermal resistance of the test materials.

[0068] The material is considered to be thermally insulating if:

Thermal conductivity < 0.060 W/mK
Thermal resistance > 0.25 K/W

[0069] The test method used was a heat flow meter in accordance with the ISO 8301:1991 standards and the apparatus was a single sample flow meter, in the horizontal position and with a hot plate in the top part.

[0070] Composite materials were prepared with 10 layers of nonwovens from prototypes 3 and 4, giving the following thermal resistance and conductivity values (Table 9).

Table 9 - Thermal resistance and thermal conductivity values for composite materials obtained from prototype nonwovens 3 and 4 with the compositions shown in Table 1.

Composite material obtained from prototype No.	Thermal resistance (m^2°K/W)	Thermal conductivity (W/m°K)
3	0.3456	0.0385
4	0.2471	0.04909

[0071] Based on these data, it can be concluded that both composite materials have thermal insulation properties, with the most insulating the one obtained from prototype number 3. This may be due to the higher weight per unit area shown by prototype 3 (see Table 2) and, therefore, its greater thickness, which would indicate that materials with higher thermal resistance can be obtained if more nonwoven layers are used.

Claims

1. A nonwoven which comprises grinded banana plant outer sheath fibre, at least one thermoplastic fibre and at least one cellulosic fibre, **characterised in that** the grinded banana plant outer sheath fibre content is between 70% and 90% weight/weight, the thermoplastic fibre content is at least 5% weight/weight and the cellulosic fibre content is at least 5% weight/weight.

2. The nonwoven according to claim 1, in which the thermoplastic fibre is polylactic acid (PLA) and its content is between 5% and 30% weight/weight.

3. The nonwoven according to claim 1, in which the thermoplastic fibre is polypropylene (PP) and its content is between 5% and 10% weight/weight.

4. The nonwoven according to any of claims 1 to 3, in which the cellulosic fibre is viscose and its content is between 5% and 20% weight/weight.

5. The nonwoven according to any of the preceding claims, in which the weight/weight percentage of grinded banana plant outer sheath fibre is between 70% and 80%.

6. The nonwoven according to any of the preceding claims, the composition of which is 70% banana plant outer sheath, 10% PLA and 20% viscose.

7. The nonwoven according to any of the claims 1 to 5, the composition of which is 80% banana plant outer sheath, 10% PLA and 10% viscose.

8. The nonwoven according to any of the preceding claims 1 to 5, the composition of which is 80% banana plant outer sheath, 10% PP and 10% viscose.

9. An article, product, composite, piece or part comprising the nonwoven of any one of previous claims 1 to 8.

10. A method for manufacturing the nonwoven according to any of the preceding claims 1 to 8, comprising the steps of:

    a) grinding banana plant outer sheath fibres to a length no larger than 15 mm, and suspending them in an aqueous medium;
    b) depositing the suspension of grinded banana plant outer sheath fibres on a conveyor belt, on which it forms a sheet of randomly oriented fibres;
    c) pressing the sheet of randomly oriented fibres using rollers, where part of the excess water contained in the sheet is removed; and
    d) drying the sheet of pressed fibres.

11. The method according to claim 10 in which the water obtained in step c) is recovered at least partially for subsequent

reuse in step a).

12. A use of the nonwoven according to any of the preceding claims 1 to 8 in the manufacture of furniture.

13. A use of the nonwoven according to any of the preceding claims 1 to 8 in the manufacture of transport crates.

14. A use of the nonwoven according to any of the preceding claims 1 to 8 as thermal insulation for walls and floors.

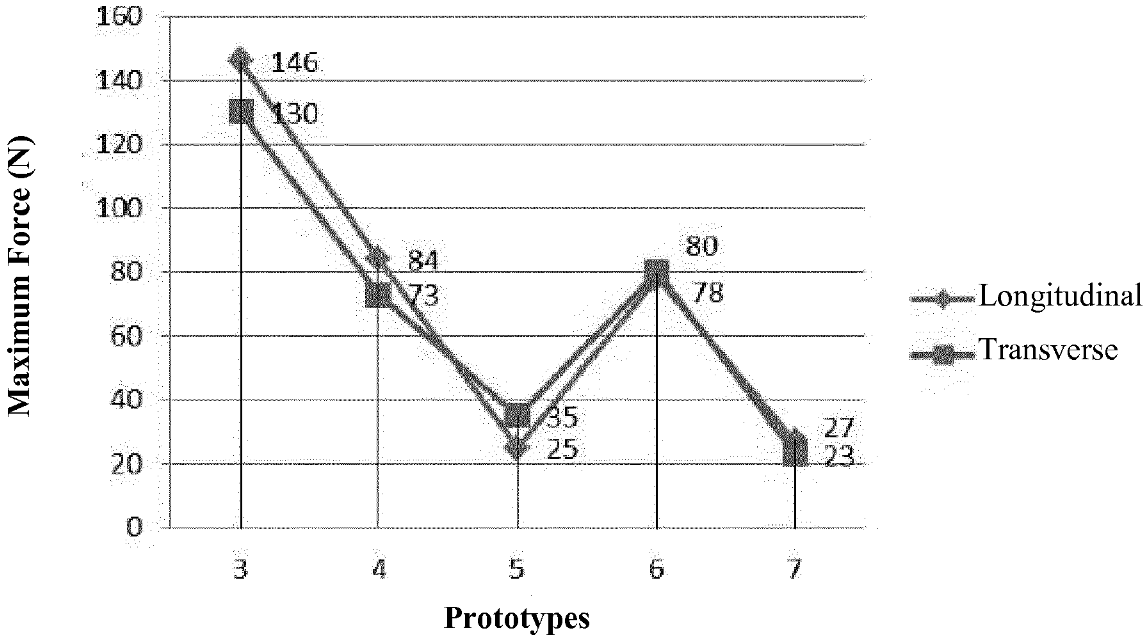
Maximum Force (N)
160
140
120
100
80
60
40
20
0
146
130
84
73
35
25
80
78
27
23
3
4
5
6
7
Prototypes
Longitudinal
Transverse

Figure 1

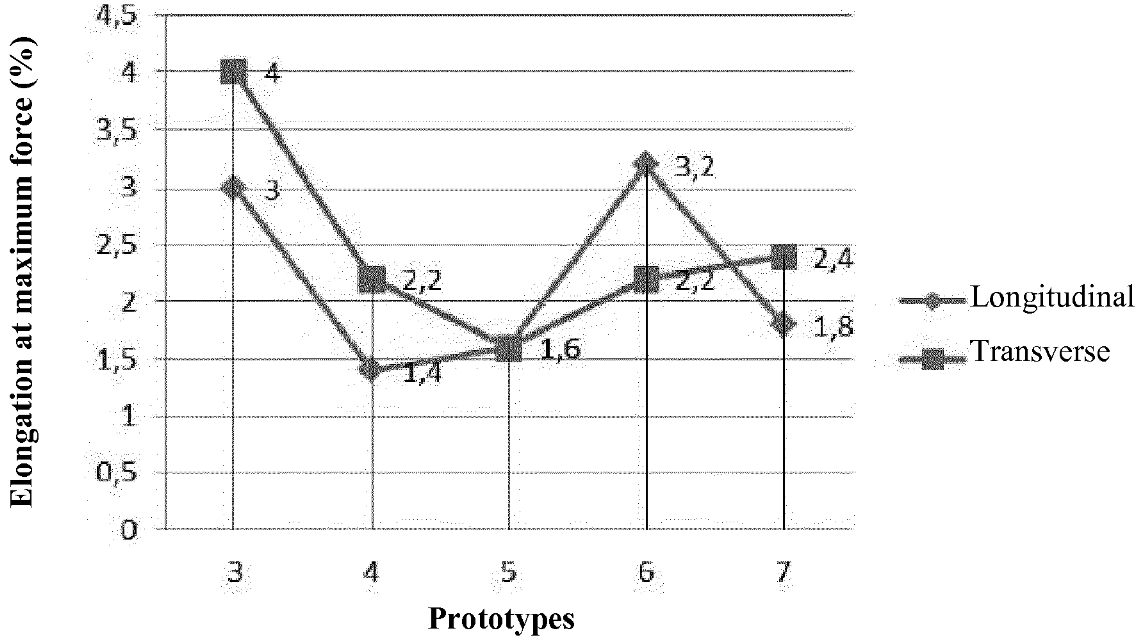
Elongation at maximum force (%)
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
4
3
2,2
1,4
1,6
3,2
2,2
2,4
1,8
3
4
5
6
7
Prototypes
Longitudinal
Transverse

Figure 2

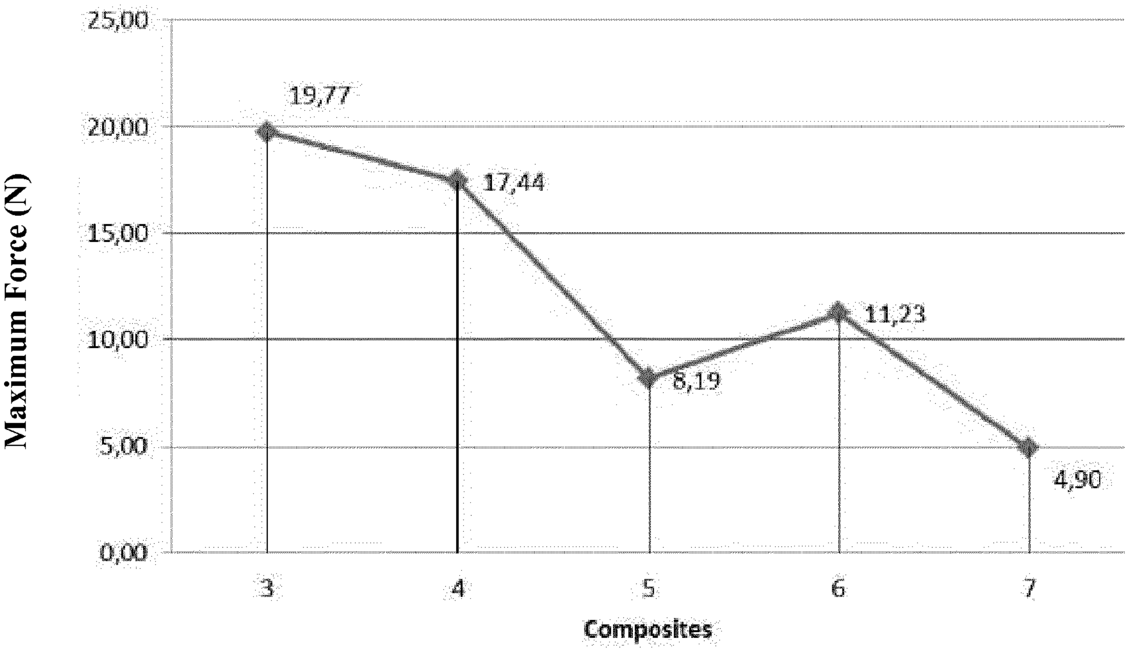
25,00
20,00
15,00
10,00
5,00
0,00
Maximum Force (N)
19,77
17,44
8,19
11,23
4,90
3
4
5
6
7
Composites

Figure 3

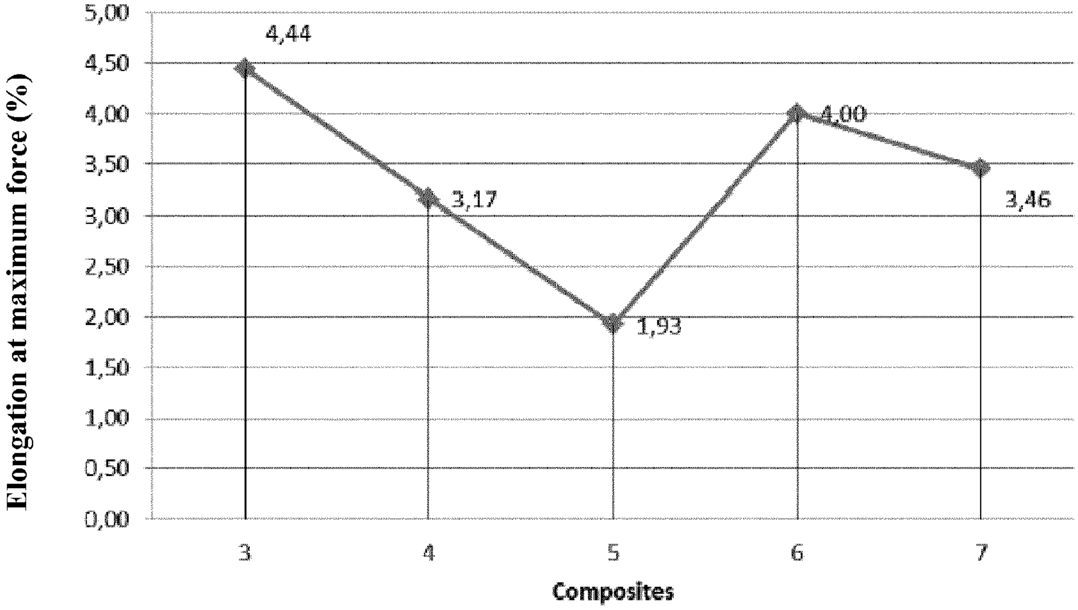
Elongation at maximum force (%)
5,00
4,50
4,00
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
4,44
3,17
1,93
4,00
3,46
3
4
5
6
7
Composites

Figure 4

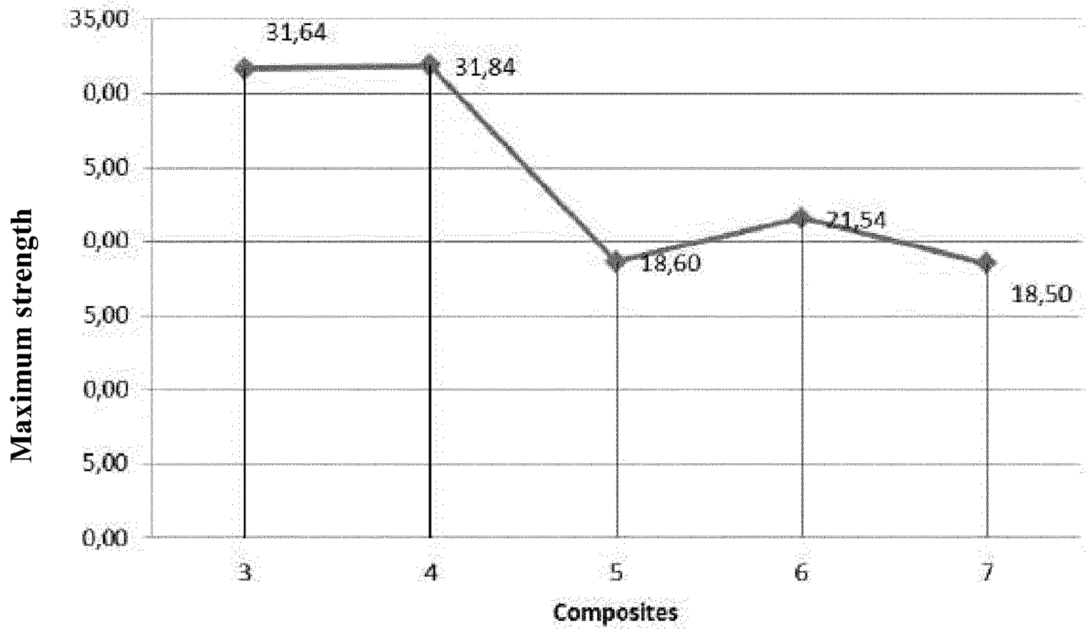
35,00
0,00
5,00
0,00
5,00
0,00
5,00
0,00
31,64
31,84
18,60
21,54
18,50
Maximum strength
3
4
5
6
7
Composites

Figure 5

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EUROPEAN SEARCH REPORT

Application Number
EP 14 38 2328

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	JP 2010 095805 A (NISSHINBO HOLDINGS INC; TOYO SENI KK) 30 April 2010 (2010-04-30) * paragraph [0001] * * paragraph [0032] - paragraph [0034] * * paragraph [0038] * -----	1-14	INV. D04H1/4266
A	JP 2004 052176 A (NISSHIN SPINNING) 19 February 2004 (2004-02-19) * paragraph [0027] - paragraph [0028] * -----	1-14	
A	US 2013/105746 A1 (CARPANZANO FABRICE [FR] ET AL) 2 May 2013 (2013-05-02) * paragraph [0001] * * paragraph [0020] * * paragraph [0042] * * paragraph [0061] - paragraph [0062] * -----	1-14	
A,D	EP 0 992 338 A2 (FORT JAMES CORP [US] GEORGIA PACIFIC CONSUMER OPERA [US]) 12 April 2000 (2000-04-12) * paragraph [0011] - paragraph [0012] * * paragraph [0025] * -----	1-14	TECHNICAL FIELDS SEARCHED (IPC)
A	WO 2014/039361 A1 (GEORGIA PACIFIC CONSUMER PROD [US]) 13 March 2014 (2014-03-13) * paragraph [0009] * * paragraph [0014] * * paragraph [0048] * * paragraph [0053] - paragraph [0054] * -----	1-14	D04H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	24 February 2015	Demay, Stéphane

CATEGORY OF CITED DOCUMENTS

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24-02-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2010095805 A	30-04-2010	NONE	
JP 2004052176 A	19-02-2004	CN 1472372 A	04-02-2004
		HK 1061875 A1	03-04-2009
		JP 4125065 B2	23-07-2008
		JP 2004052176 A	19-02-2004
		KR 20040010138 A	31-01-2004
		TW 200407470 A	16-05-2004
US 2013105746 A1	02-05-2013	AU 2011251882 A1	13-12-2012
		CA 2797745 A1	17-11-2011
		CN 103003504 A	27-03-2013
		EP 2569491 A1	20-03-2013
		FR 2960010 A1	18-11-2011
		KR 20130119325 A	31-10-2013
		SG 185527 A1	28-12-2012
		US 2013105746 A1	02-05-2013
		WO 2011141644 A1	17-11-2011
EP 0992338 A2	12-04-2000	AT 371535 T	15-09-2007
		CA 2285113 A1	09-04-2000
		DE 69936962 T2	15-05-2008
		EP 0992338 A2	12-04-2000
		EP 1775116 A2	18-04-2007
		ES 2291009 T3	16-02-2008
		US 6110848 A	29-08-2000
WO 2014039361 A1	13-03-2014	AU 2013313126 A1	19-02-2015
		US 2014066872 A1	06-03-2014
		WO 2014039361 A1	13-03-2014

EPO FORM P0459

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Patent documents cited in the description

- EP 0992338 B1 **[0008]**
- JP 2010095805 A **[0009]**
- IN 201302979 P2 **[0010]**

Non-patent literature cited in the description

- Assembling Technologies for Functional Garments. *Indian Journal of Fibre & Textile Research,* December 2011, vol. 36, 380-387 **[0006]**
- Development of Natural Fibre Nonwovens for Application as Car Interiors for Noise Control. *Journal of Industrial Textiles,* 2010, vol. 39, 267 **[0007]**