(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 December 2010 (16.12.2010)

PCT

(10) International Publication Number
WO 2010/142774 A1

(51) International Patent Classification:
C08L 77/02 (2006.01) *C08L 77/04* (2006.01)
C08J 5/04 (2006.01) *C08L 97/02* (2006.01)

(21) International Application Number: PCT/EP2010/058186

(22) International Filing Date: 10 June 2010 (10.06.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0909958.1 10 June 2009 (10.06.2009) GB

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

[Continued on next page]

(54) **Title**: COMPOSITE MATERIAL

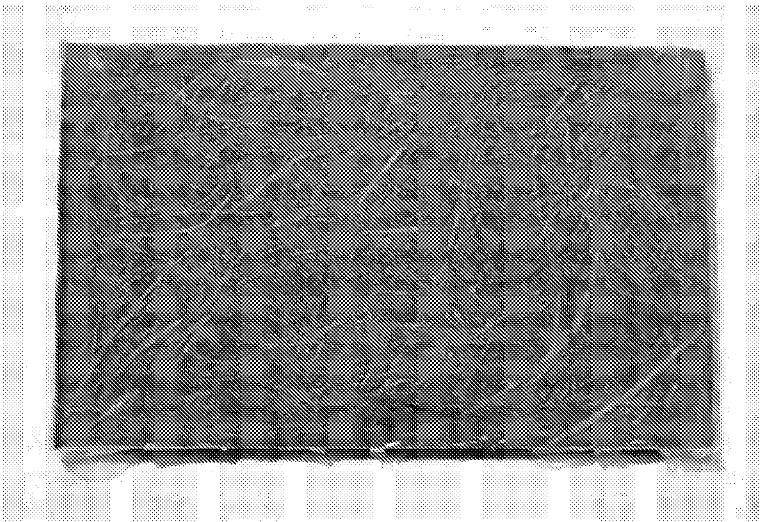

Figure 14

(57) **Abstract**: A composite material comprises a matrix material and natural fibres extracted from Castor Plant. Preferably, the matrix material is a bio-plastic.

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

COMPOSITE MATERIAL

FIELD OF THE INVENTION

The present invention relates to a composite material. In particular, the invention relates to fibre reinforced composite materials.

BACKGROUND OF THE INVENTION

Composite materials typically comprise a reinforcing material, for example a fibre, which is surrounded and supported by a matrix material, for example a resin.

Composite materials are used extensively in aerospace applications. Increasingly composite materials are being utilised for airframe structures. Additionally, composite materials have been used extensively for many years in aircraft cabin interiors. Such interiors are made of materials that are predominantly fibre reinforced polymer composites which are applied due to their high stiffness and strength to weight ratios. These ratios result in a high light weight potential.

Cabin interiors can be separated in two application categories. The first category includes panel parts, which are typically floor and ceiling panels, cargo liners, window surrounds, panels and parts of food and drink trolleys. In addition to these classical panel parts, stowage bins, galleys, lavatory modules and class dividers or bulkheads may also belong to this group, since they are commonly made from similar materials. Typically these parts may be made from sandwich structures with Nomex (RTM) honeycomb being a common core material. Carbon Fibre/Epoxy or Carbon Fibre/Phenolic face sheets may be used for high load bearing applications. For most interior panel applications Glass Fibres/Phenolic sheets may be used. Such phenolic resin based composites may make up 80-90% of the interior furnishing of an aircraft. In the future there may be a move away from phenolic resin based systems due to the free formaldehyde and phenol in the systems. Thermoplastics have been introduced to replace the thermosetting face sheets in some applications like the new stowage bins of the Airbus A380 made from Polyetherimide (PEI).

The second category of aircraft interior application includes load introduction parts like the seat rails, pedestals, brackets and hinges. These parts are still predominately made from metallic materials, such as aluminium, but have the potential to be replaced with polymer or composite materials.

The combined market volume for new and aftermarket interior materials are estimated to be more than 6000 tons per year. Since cabin interiors have a short service life of in comparison to the airframe (for example three to seven years versus an aircraft life of 20 years). With a relatively turnover of cabin interior materials it is desirable to utilise materials which have a low environmental impact, for example materials with a low lifetime CO2 impact and/or materials from sustainable sources. One possible source of materials that meet this aim are biobased materials such as natural fibre composites. Natural fibre composite can offer environmental advantages such as reduced dependence on non-renewable energy or material sources, lower emissions, enhanced energy recovery and end-of-life biodegradability of components.

SUMMARY OF THE INVENTION

A first aspect of the invention provides a composite material comprising a matrix material and natural fibres extracted from Castor Plant.

The Castor Plant (Ricinus Communis) has been identified as a promising natural fibre material source as it is a very fast growing plant which can be grown in a wide range of habitats, which span a wide range of climate zones ranging from cool temperate steppe to tropical rainforest, with moist warm temperate to tropical zones being the most suitable for commercial cultivation. Furthermore the Castor plant produces large amount of biomass (measured in terms of yearly yield) compared to other plants such as Sunflower, Flax, Corn or Cotton. Castor Plant seeds contain 35-55% oil and are the only parts of the plant of current commercial interest. The current yearly production of Castor oil exceeds one million tons

The fibres may, for example, be reinforcement fibres. Depending on the desired application the fibres may be unidirectional or multidirectional. Preferably the matrix surrounds and supports the fibres. Preferably, the fibres are embedded within a matrix. The matrix is preferably substantially homogenous.

The matrix material is preferably a bioplastic. A bioplastic is a plastic derived from a biomass source. For example, a bioplastic may be derived from vegetable oil, corn starch, pea starch or microbiota. Preferably the matrix material is a biopolymer, most preferably a polyamide.

In a particularly preferred embodiment the matrix material is derived from castor oil, for example the matrix material is Polyamide 11. This provides the potential advantage of providing a composite material which is substantially entirely (for example at least 90%, preferably 99%) sourced from a single plant.

A further aspect of the invention provides a method of manufacturing a composite material as claimed in any preceding claim, the method comprising:

(i) providing a mould;

(ii) providing Polyamide 11 powder and castor plant fibres

(iii) applying heat and/or pressure to the mould.

The composite material is particularly suited for the manufacture of aircraft components, for example aircraft cabin interior components.

BRIEF DESCRIPTION OF THE DRAWINGS

Preliminary experiments and analysis were carried out to evaluate the effectiveness of embodiments of the Castor plant fibres embedded within a composite material.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows the Tensile/Strain Curve of the Castor Fibre samples at 5mm/sec testing speed;

Figure 2 shows a Castor Fibre at 20x magnification;

Figure 3 shows the Tensile Strength of the Castor Fibres and known reference materials;

Figure 4 shows the Young's Modulus of the Castor Fibres and reference materials;

Figure 5 shows the density of the Castor Fibres and reference materials;

Figure 6 shows eco-profile of each manufacturing process of PA11;

Figure 7 shows the CO2 emission and global warming potential in 100 years of PA11 and reference matrix materials;

Figure 8 shows the average density of PA11 and reference materials;

Figure 9 shows the average tensile strength of PA11 and reference materials;

Figure 10 shows the average modulus of elasticity of PA11 and reference materials;

Figure 11 shows the average cost of PA11 and reference materials;

Figure 12 shows the cross section of a castor plant stem;

Figure 13 shows visible fibres in a broken Castor plant stem;

Figure 14 shows a sample of multidirectional castor fibre reinforced PA11 in accordance with an embodiment of the invention;

Figure 15 shows a polished cross section of a unidirectional castor fibre reinforced PA11 in accordance with an embodiment of the invention;

Figure 16 shows the flexural strength measured in a three point bending test of a composite in accordance with an embodiment of the invention and reference materials;

Figure 17 shows the three point bending failure load of a composite in accordance with an embodiment of the invention and reference materials having the same weight;

Figure 18 shows the Young's Modulus measured in a three point bending test of a composite in accordance with an embodiment of the invention and reference materials;

Figure 19 shows the Limiting Oxidation Index of PA11 resin and reference resin materials;

Figure 20 shows the Carbon Footprint of Raw materials for use in embodiments of the invention and other reference materials; and

Figure 21 shows the Carbon Footprint of composites in accordance with embodiments of the invention and reference composites;

DETAILED DESCRIPTION OF EMBODIMENT(S)

Experiments and analysis were performed to demonstrate that natural fibres can be extracted from the Castor plant (Ricinus Communis) and embedded as reinforcement in a matrix material such as the polyamide PA11.

1. CASTOR FIBRES

The Castor fibres can be produced from the bast of the plant. The fibres produced from the Castor plant for verification were tested to determine their tensile strength, density, and temperature resistance (TGA). The Castor fibre properties were compared with literature values from other reinforcing fibres. The process of fibre making is explained in detail below. During the fibre production we were easily able to produce thin fibre bundles with a length greater than 30cm. This length is enough to convert the fibres to woven fibre mats or other semi finished textile products.

The tensile strength was determined using standard procedures for fibre testing. The stress/stain curves can be seen in Figure 1. The large scatter is typical for natural fibres due to "defects" based on their biological origin. Therefore normally a strength range is given instead of a single value.

To calculate the tension from the load/strain curve, the area of the cross section was measured in advance by using imaging microscopy as seen in Figure 2.

The tensile strength and Young's Modulus of the Castor plant fibres is given in Figure 3 and Figure 4 and compared to the tensile strength of flax, sisal, jute and glass fibres. The skilled person in the art will appreciate that the measured Castor fibres are not optimized or improved by any procedure. Therefore a significant potential of improvement can be assumed.

The density of the Castor fibre was determined from laminate specimens (see below). Based on a fibre volume fraction of 30% and the known density of the PA11 the density of the fibres were estimated by measuring the weight and volume of the samples manufactured. The estimated average density of Castor fibre is 1.48kg/m3. Figure 5 shows the density of the Castor, Flax, and Glass and Carbon fibre.

2. CASTOR OIL

Castor oil consists of around 90% Ricinoleic acid, a monosaturated 18 carbon-fatty acid. In contrary to many other seed oils Ricinoleic has a hydroxyl function group on the twelfth carbon in the chain. This leads to an unusually polar oil, which allows chemical derivatisation that is not practical with most other seed oils. Castor oil and its derivatives have applications in the manufacturing of soaps, lubricants, hydraulic and brake fluid, paints, inks, plastics, waxes and pharmaceuticals to name only a few.

The most commonly used Polyamides are Polyamide 6/6 (PA66) and Polyamide 6 (PA6). However, they are produced from fossil fuel derivate. Different to PA6/6 and PA6, PA11 can be produced from the sustainable material, the Castor oil. According to the predicted oil and natural gas shortages, it is foreseen that PA11 may have a promising future in a growing range of applications. Figure 6 shows the eco-profile of each manufacturing process of PA11. One can see that the cultivation state compensates for some of the CO2 equivalent of the subsequent processes resulting in a positive CO_2 balance in comparison with other polymer materials as seen in Figure 7.

The physical properties of PA11 are comparable to common thermoplastic composite matrix materials. Figure 8 shows the average density of aluminium, PA11, PA66, epoxy resin and Polyetheretherketone (PEEK). PA11 used as a matrix material has a very low density and therefore an excellent lightweight potential. Figures 9 and 10 show the average tensile strength and modulus of elasticity of PA11, PA66, epoxy resin and PEEK. The average tensile strength is comparable with other matrix materials. The drawback of the lower modulus of elasticity can be somewhat compensated by its low density as discussed below. As shown in figure 11, the costs of PA11 are approximately three times higher than epoxy resin, but significantly lower than most of the high performance thermoplastics like PEI or PEEK.

3. CASTOR COMPOSITE MANUFACTURE

Test samples of composite materials in accordance with embodiments of the invention were produced to demonstrate the capability of the material.

Stems were harvested from Castor plants which were approximately 1.5 - 2.0 meter tall and roughly three months old.

The fibre containing bark was removed from the Castor Plant stems, shown in cross section in figure 12. Figure 13 shows the visible fibres present in the bark of a broken stem section of Castor Plant. Extracting fibres from the bark required vast manual effort. Therefore, the bark was soaked in fresh water for several days. This soaking process, known as retting, was found to enable release of the fibres from the bark with less mechanical impact. Advantageously, the retting process also resulted in longer fibres exceeding 30 cm. The skilled person will appreciate that other retting processes are known and may be utilised in embodiments of the invention. For example, dew retting, double retting or tank retting.

A complete bio-based thermoplastic composite laminate in accordance with an embodiment of the invention was manufactured using the matched-die moulding method. The raw materials, PA11 powder (Rilsan, Es Naturelle) and the Castor Plant fibres were placed into a female mould. The fibres were either placed in a unidirectional or multidirectional alignment. A hydraulic press was preheated to 250°C and the mould was placed between the press platen. A male die was provided on top of the female mould. The mould was heated above the melting point of the PA11 under a pressure of two MPa and held for two minutes. Fibre volume fracture of the resulting unidirectional (Figure 14) and multidirectional (Figure 15) Castor fibre reinforced composite laminates produced in accordance with embodiments of the invention was determined by image processing of polished micrography sections. The fibre volume fraction was found to be between 30-40%. The skilled person will appreciate that the fibre volume content of small test samples will vary due to the difficulty in arranging fibres homogenously in a small mould.

To compare the Castor composite with known Aircraft cabin interior materials, the composite samples in accordance with embodiments of the invention were tested for their flexural strength according to the ASTM International three point bending standard ASTM D790. The test coupons' width and length were 13 mm and 28 mm, respectively with a thickness of 1.5 mm to 2.2 mm. The supporter span of the three point bending jig was 25.41 mm, resulting in a span to thickness ratio of 11.6 to 17.9. The testing speed was 0.5 mm/s. Figure 16 shows the determined flexural strength of pure PA11, PA11/Glass and PA11/unidirectional Castor fibre. For comparison Figure 16 also shows the flexural strength of know cabin interior materials, specifically a bidirectional phenolic/glass composite with a fibre volume content of 30% and an aluminium alloy. Thus, the skilled person will appreciate that these samples demonstrate the suitability of the flexural strength of Castor composite materials in accordance with embodiments of the invention. The skilled person will further appreciate that the samples were manufactured with a non-optimised manufacturing process such that composite materials in accordance with other embodiments of the invention may exhibit significantly improved properties.

Figure 17 shows the three point bending failure loads of three composite (PA:PA11/Castor, Phenol:Phenolic/Glass, Al:Al 6013 T6) specimens with the same width, length and weight but with different thicknesses due to various densities are shown. The values given base on a one millimetre thick aluminium plate. It will be appreciated that this shows a clear lightweight potential as the PA11/Castor composite withstands a 40% higher load then the Phenolic/Glass composite and even a 140% higher load then the specimen made from aluminium.

The modulus of elasticity was determined of pure PA11 and PA11/Glass and PA11/UD Castor fibre composite with the average slope of the load/deflection curve. In addition Young's modulus of pure phenol and a bidirectional phenol/E-Glass composite are shown in figure 18. The dashed area above the measured PA11/Castor fibre composite signifies the modulus which is theoretically achievable with a fibre volume content of 60%. To calculate this value, the measured average modulus of elasticity of the fibres and of PA11 was used in the rule of mixture. This shows that a sufficient stiffness is achievable. Summarising all obtained values of the Castor fibre and composite are given in Table 1 below.

Fibre Properties		
Density	1.4	kg/m^3
Tensile Strength	760-1350	MPa
Young's Modulus	18-47	GPa
Matrix Properties		
Density	1.0	kg/m^3
Tensile Strength	55.2	MPa
Young's Modulus	1.2	GPa
Composite Properties		
Density	1.2	kg/m^3
Flexural Strength	143.2	MPa
Young's Modulus	9.8	GPa

Table 1

In addition to excellent weight specific material properties, aircraft cabin interior materials must meet very stringent fire, smoke and toxicity requirements (FST). A comprehensive overview over the fire testing can be found in the FAA handbook Aircraft Materials Fire Test Handbook or the Airbus directive ABD0031. A thermo gravimetric analysis (TGA) was conducted of the composite in accordance with embodiments of the invention, the Castor fibres and the pure PA11 resin. An indication that PA11 as a resin material that can fulfil the FST requirements is given by the modified PA11 resin FR-106 from Advanced Laser Materials, which has passed all the FAR 25 fire retardant requirements. A commercially available bio-based PA11 fire retardant grade, Rilsan (RTM) MB 3000, is available from Arkema (RTM) also offers the with the lowest UL94 flammability index (V-O) and a high oxygen index of 33% in comparison with other resin materials such as Melanine, Phenolic, Polyimide and Epoxy (as shown in Figure 19).

A TGA was conducted to determine the weight loss over temperature. The Castor fibre, PA 11 Powder and the composite in accordance with an embodiment of the invention were evaluated separately. All samples were tested a heat rate of 15°C/min in a nitrogen atmosphere. PA11 was found to lose no weight at temperature up to 400°C whilst the Castor fibres start losing mass at 230°C. The first small drop in mass is due to moisture in the fibres and highlights the importance of well dry fibres before processing. The composite in accordance with an embodiment of the invention retained 97% of its weight up to 250°C, indicating no generation of smoke up to this temperature.

4. Environmental Impact

The environmental impact of composite materials in accordance with embodiments of the invention was analysed using the Model of the Eco-costs/Value Ratio (EVR) approach proposed by the Delft University of Technology. Of the three indicators used, carbon footprint or CO2 equivalence was chosen since it is the most commonly used indicator and hence data is readily available which facilitates the analysis at this early stage. The Life Cycle Analysis (LCA) includes all stages of the product life cycle from the material processing, all the way trough to the recycling. The values are obtained from the eco-cost 2007 data collection available free of charge [20]. It should be noted that all the values are rough estimates and small differences (<20%) may not render indicative. In distinction to a standard LCA, where the carbon footprint is calculated weight specific (Kg/Kg), the carbon footprint for this analysis was calculated volume specific (ton/m3). Using the volume specific approach, comparison of the different solution becomes more convenient, since structural performance properties are volume and not weight related. Six scenarios were derived, reflecting common or promising composite combinations for aircraft interiors.

Four matrix raw materials were considered: PEEK, Epoxy Resin, Phenolic Resin and PA11 from Castor Oil. Three fibre raw materials were considered: Glass fibre, Carbon Fibre and Castor Fibre. As shown in figure 20, in the primary production state both PA11 and the Castor fibres show the lowest CO_2 equivalent of all materials considered. A composite in accordance with embodiments of the invention which combines these raw materials outperforms all other combinations (as shown in Figure 21). The resulting CO_2 emission reduction in comparison is around 10.7 ton/m3 when compared to a Phenol/Carbon fibre composite.

Embodiments of the present invention using thermoplastic resins such as PA11 have further advantages at the end of life stage of their life cycle. It is difficult to efficiently recycle fibre reinforced thermosets. For thermoplastic matrix materials the recycling process is more favourable. There are two main ways of recycling a thermoplastic composite. One possibility is to separate the fibre from the matrix, with the advantage of ending up with fibre and matrix material in near pure quality (Melt-Fibre Recycling). The disadvantage of this approach is the high energy consumption of the recycling process which may be unprofitable for low matrix material and fibre prices and low CO2 equivalence in primary production. A second more economic way is to chop the composite and reuse the obtained recyclate for parts of lesser quality, with possible applications of the recyclate being for example in consumer goods or automotive applications.

Further environmental advantages of embodiments of the invention arise from the fact that the fibre is extracted from an existing by product of the Castor oil production. This significantly increases the net value created per area of Castor plantation and creating two sources of income for farmers. Furthermore, the proposed composite is to 99% made from renewable sources. In addition to the improved CO2 balance this also provides the opportunity to reserve fossil fuel resources.

The skilled person will appreciate that the above example embodiment shows that the Castor fibre is very competitive in comparison with common natural fibres. Due to the low density of the Castor fibre the weight specific properties are superior to E-Glass fibres. The skilled person will also appreciate that the obtained values illustrate the application and effectiveness of the invention but have the potential to be improved significantly through normal process optimisation (for example, parameters such as fibre orientation, heat or cool rate and moulding pressure, could be optimised improving the properties further). Microscopy images of composite in accordance with embodiments of the invention show good fibre impregnation which could be further improved if the fibres were sized. These results are underlined by the flexural test of the composite in accordance with an embodiment of the invention showing up to 110% increase in flexural strength in comparison with the pure PA11. These results suggest that no, or very little, degradation of the fibre occurs during the manufacturing process.

Claims

1. A composite material comprising:

   a matrix material; and

   natural fibres extracted from Castor Plant.

2. A composite material as claimed in claim 1, wherein the matrix material is a bio-plastic.

3. A composite material as claimed in claim 1, wherein the matrix material is a polyamide bio-plastic.

4. A composite material as claimed in claim 2 or 3, wherein the matrix material is derived from castor oil.

5. A composite material as claimed in any preceding claim, wherein the matrix material comprises Polyamide 11.

6. A composite material as claimed in any preceding claim, wherein the matrix material comprises a fire retardant additive.

7. A composite material as claimed in any preceding claim, wherein the natural fibres are formed into a textile product prior to being embedded into the material.

8. A composite material as claimed in any preceding claim, wherein the material is a laminate material.

9. An aircraft component comprising a composite material as claimed in any preceding claim.

10. An aircraft component as claimed in claim 9, wherein the component is an aircraft cabin interior component.

11. A method of manufacturing a composite material as claimed in any preceding claim, the method comprising:

(i) providing a mould;

(ii) providing bio-plastic powder and castor plant fibres

(iii) applying heat and/or pressure to the mould.

12. A method of extracting fibres for forming a composite material the method comprising:

(i) removing the bark form the Castor Plant stem

(ii) retting the bark

13. The method of claim 12, further comprising:

(iii) mechanically extracting fibres from the bark after retting.

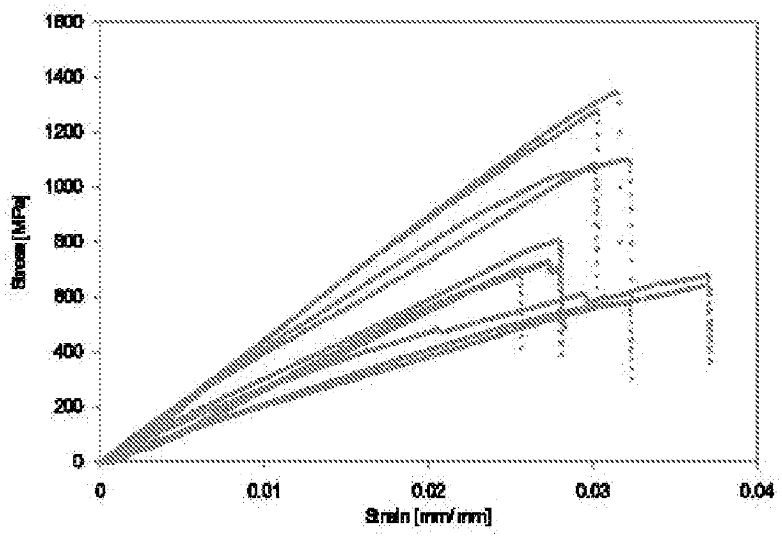

Figure 1

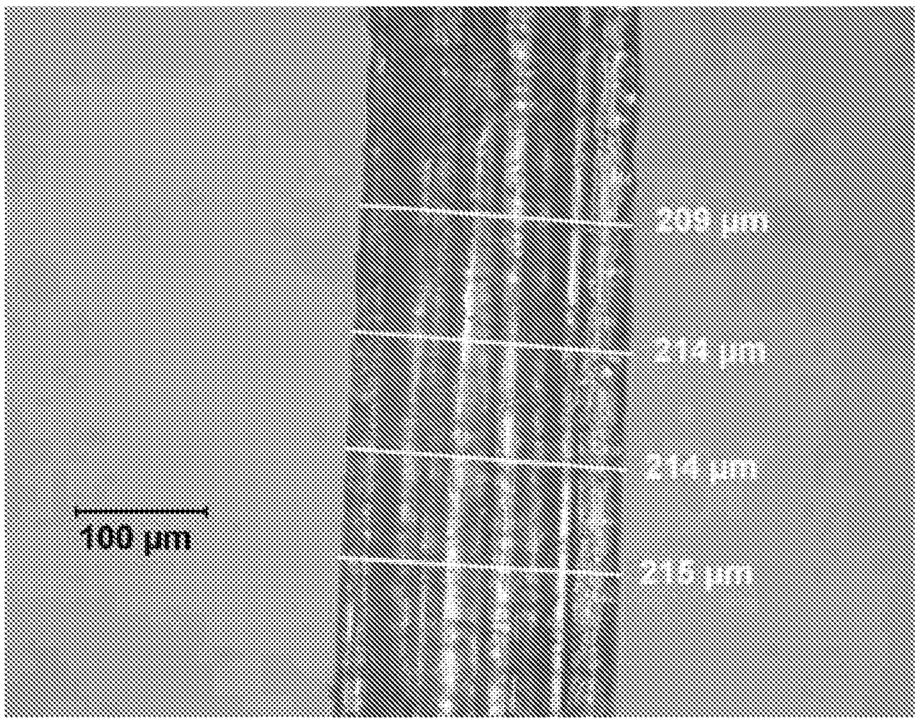

Figure 2

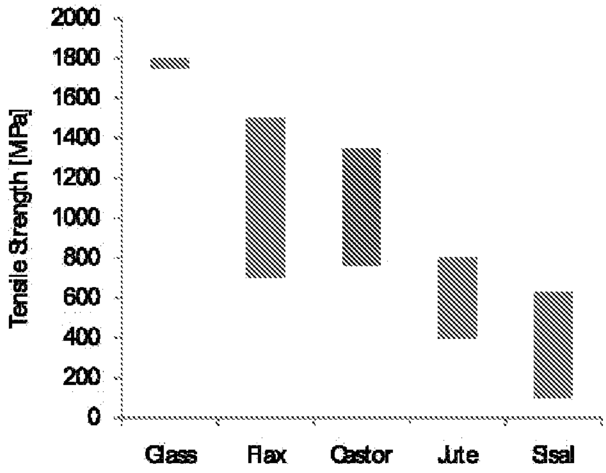

Figure 3

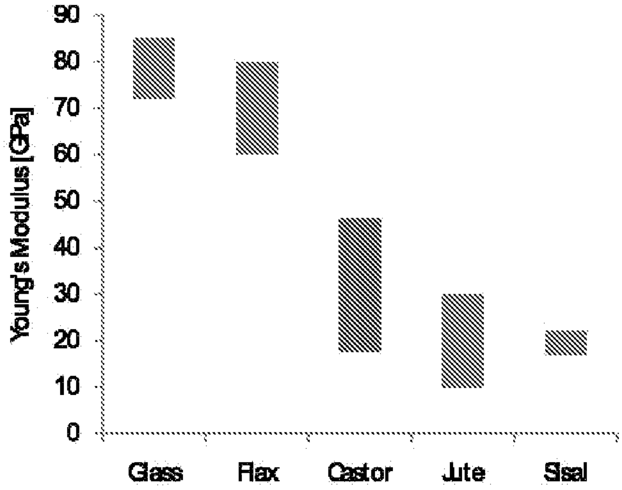

Figure 4

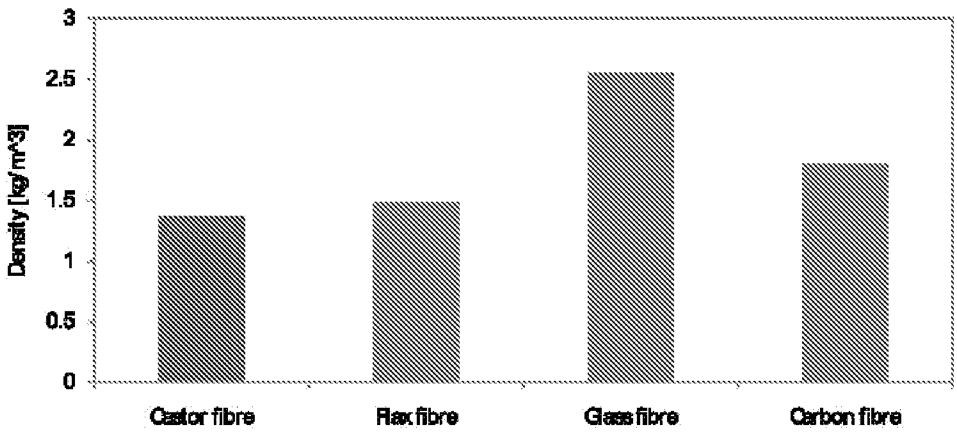

Figure 5

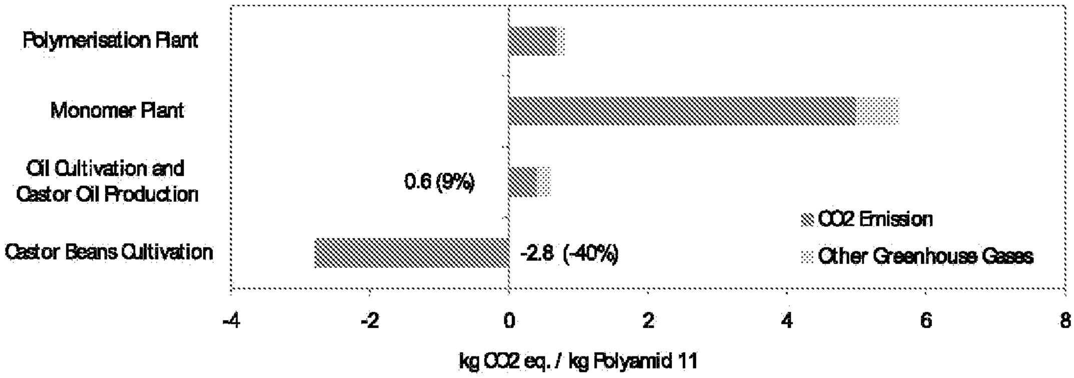

Figure 6

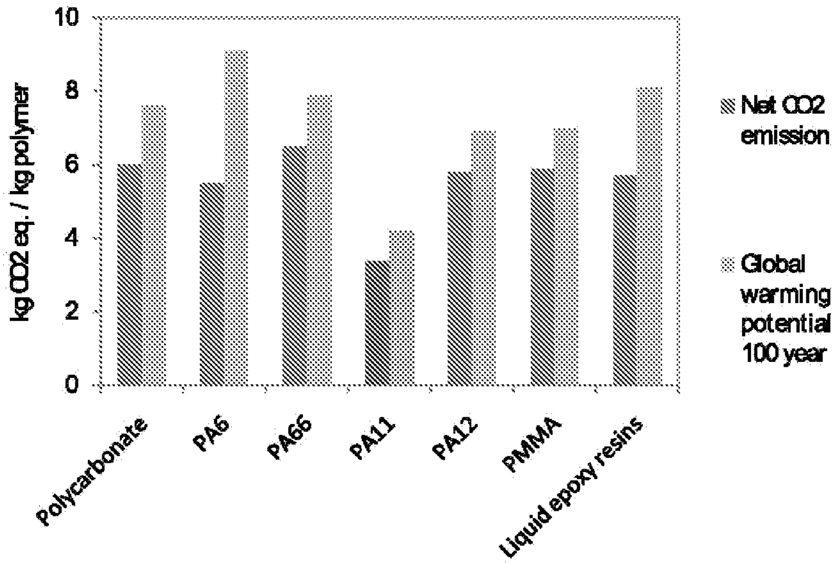

Figure 7

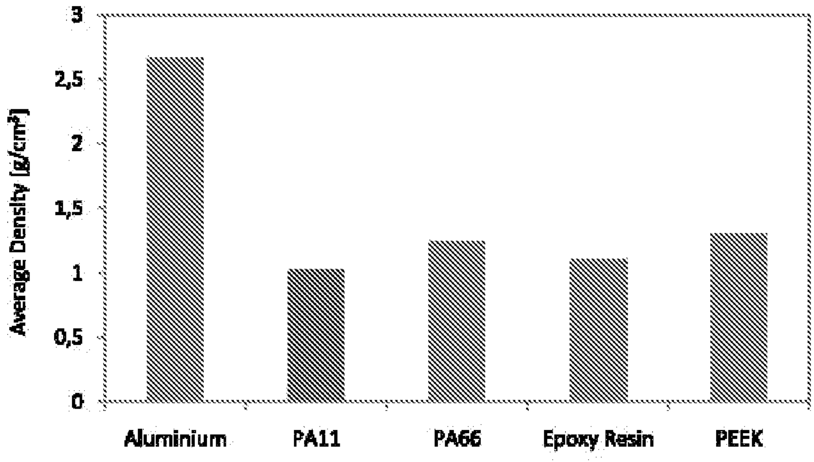

Figure 8

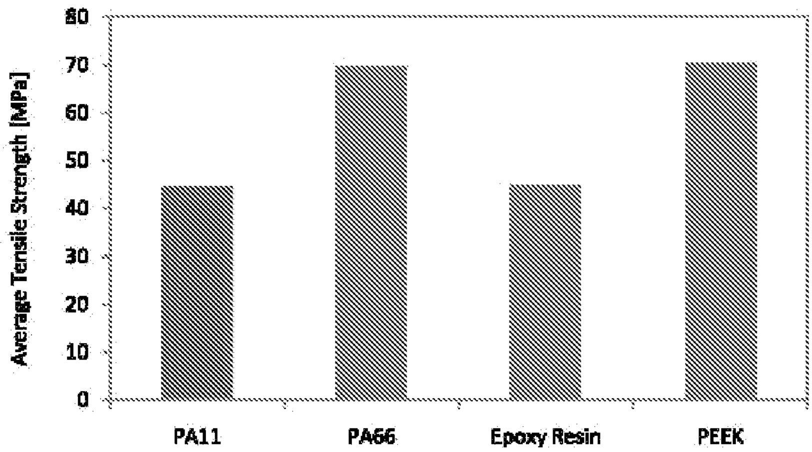

Figure 9

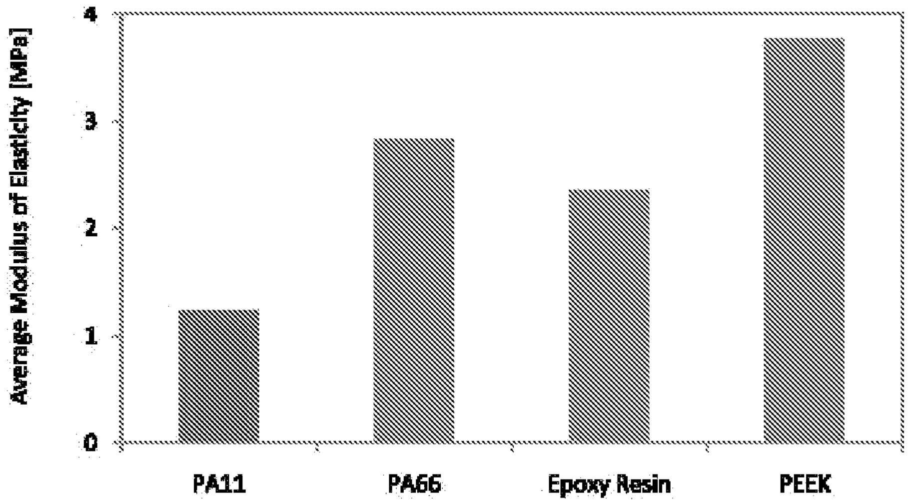

Figure 10

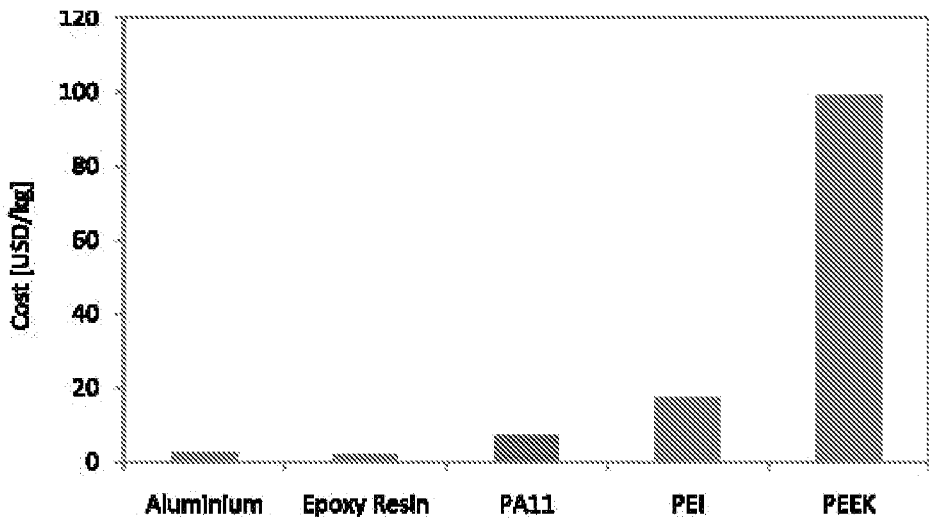

Figure 11

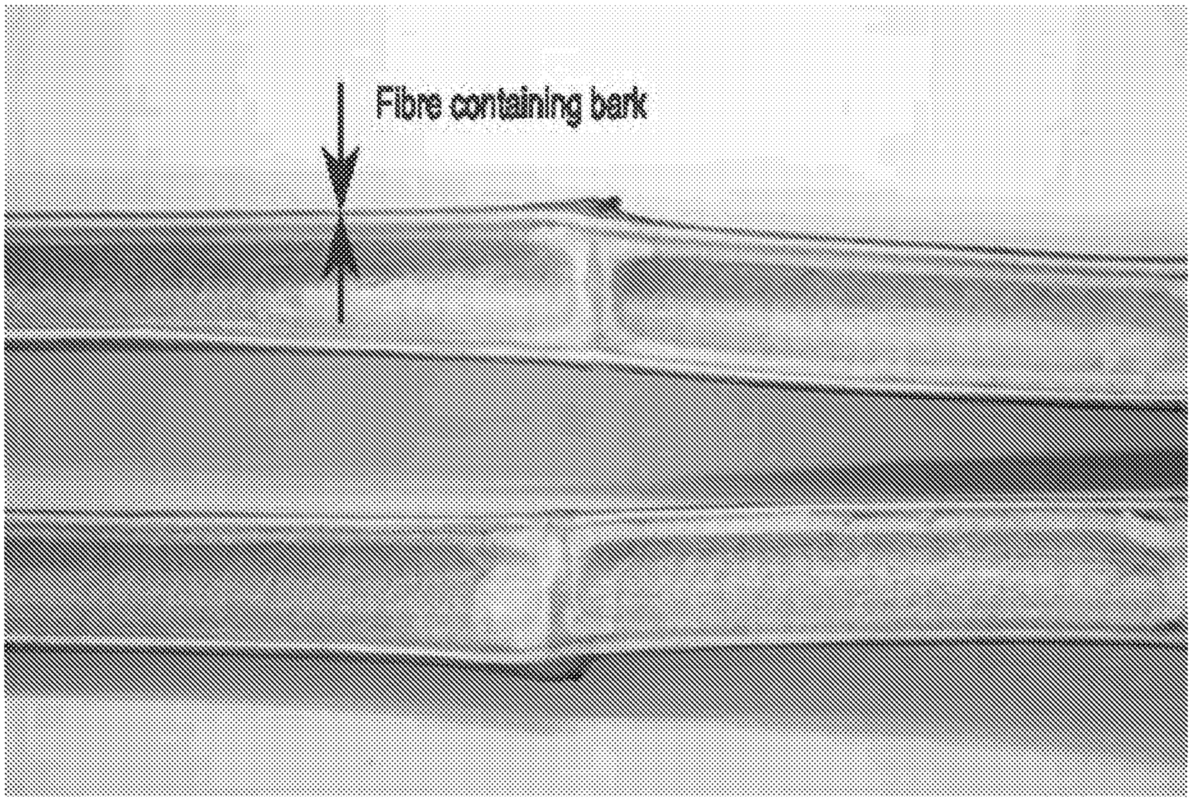

Figure 12

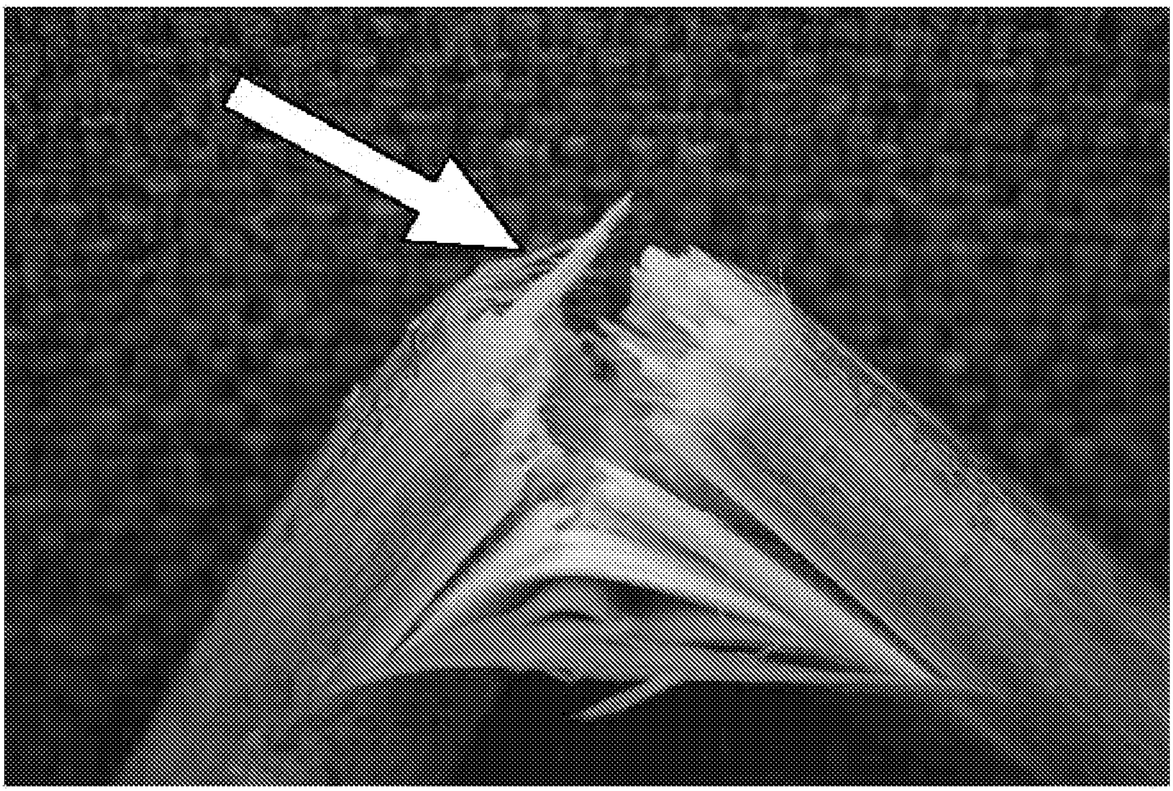

Figure 13

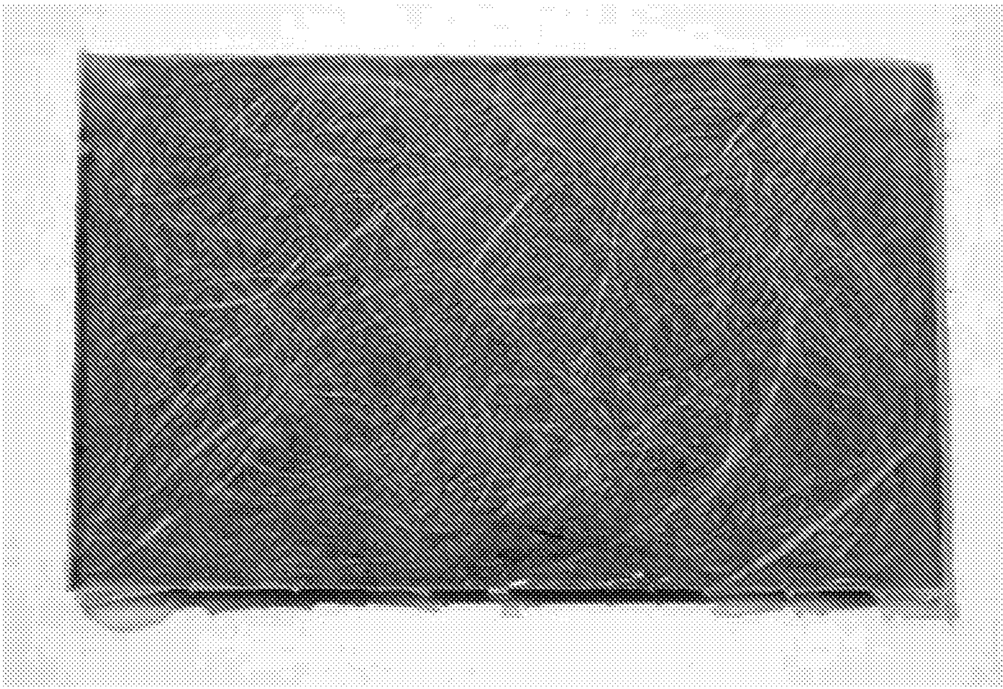

Figure 14

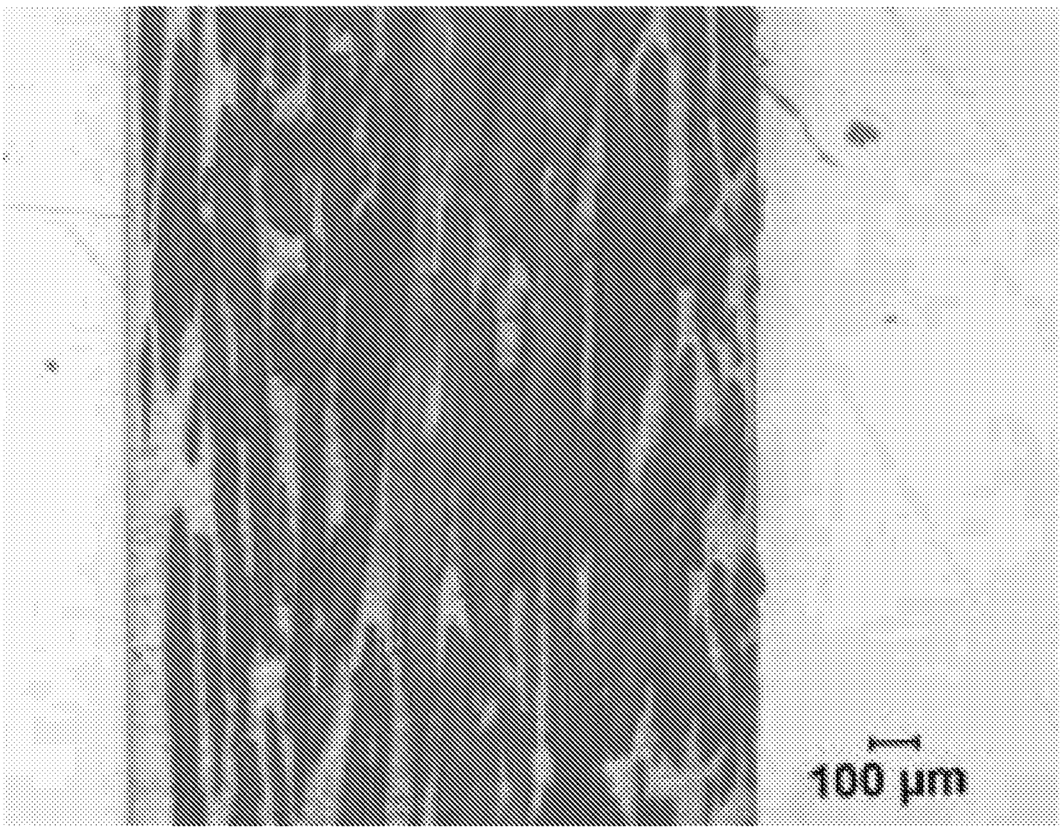

Figure 15

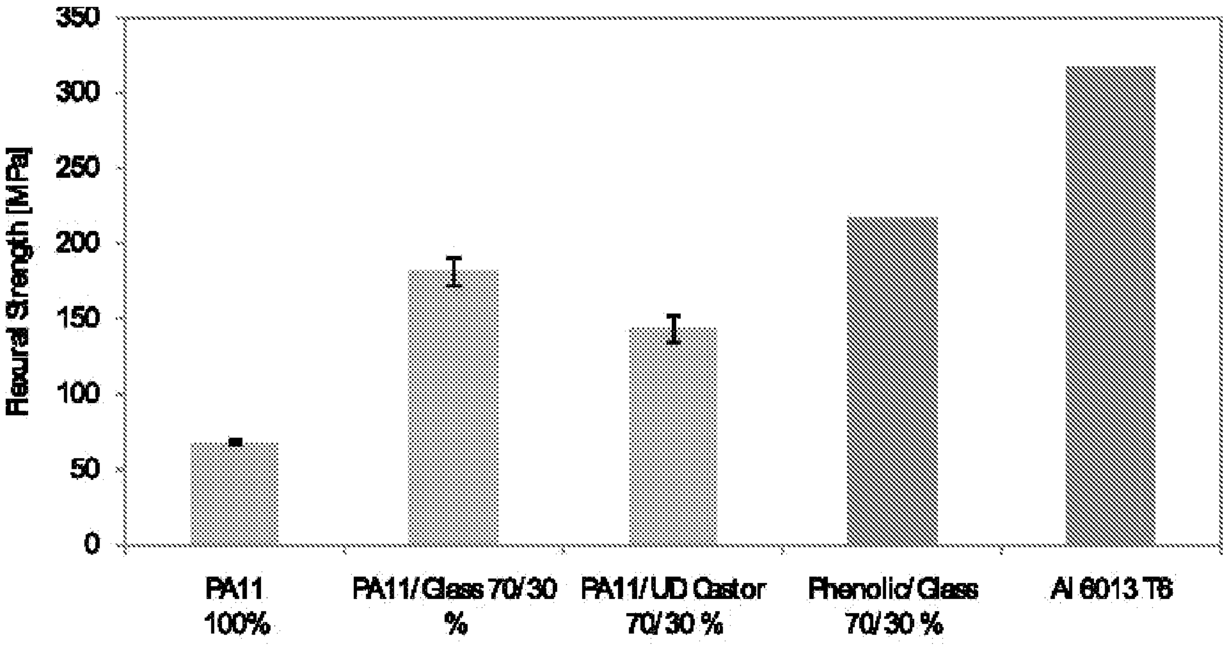

Figure 16

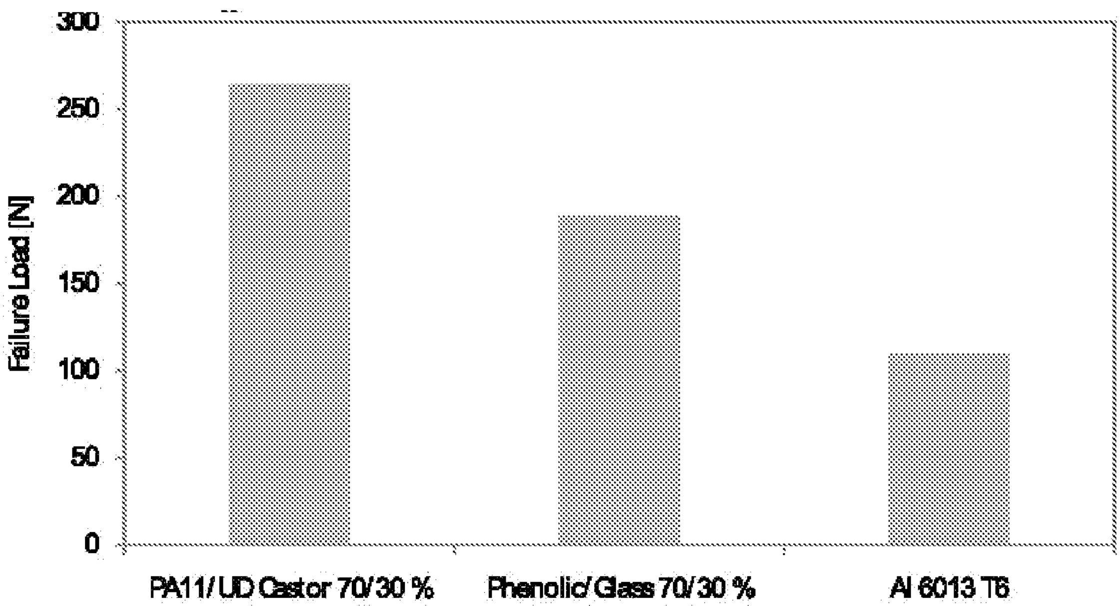

Figure 17

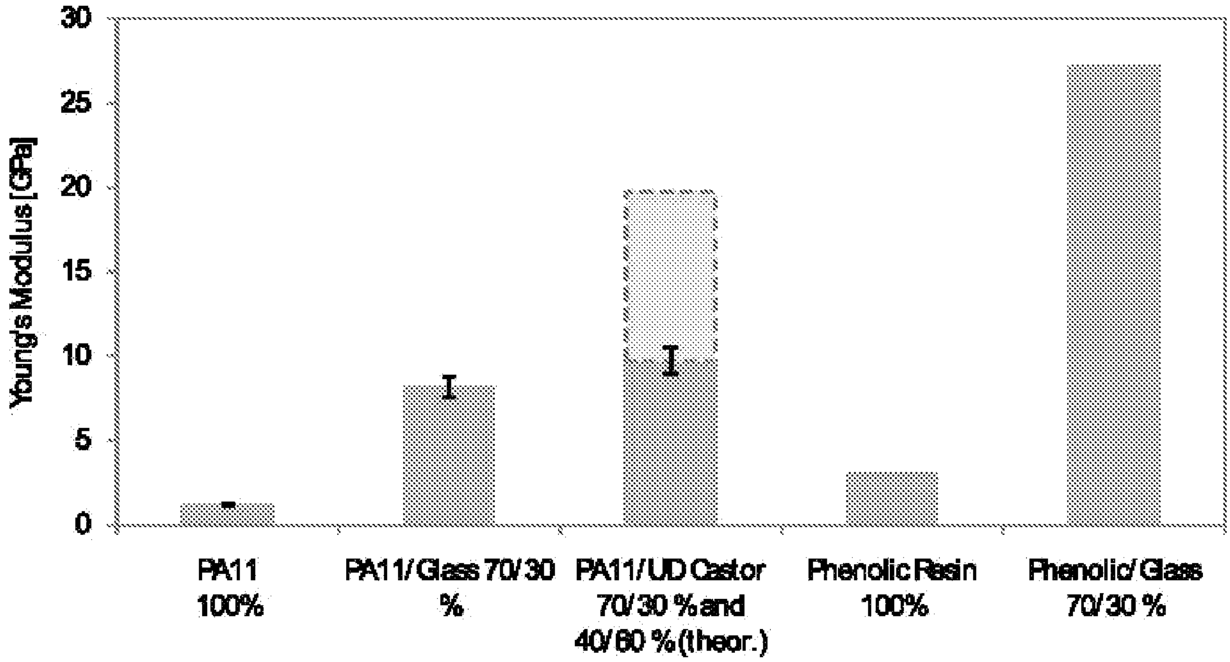

Figure 18

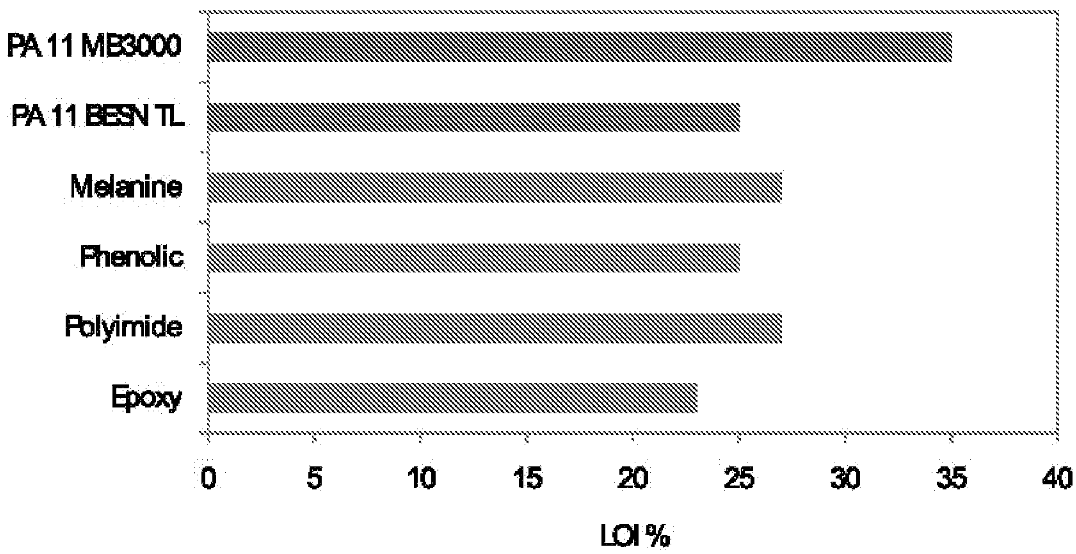

Figure 19

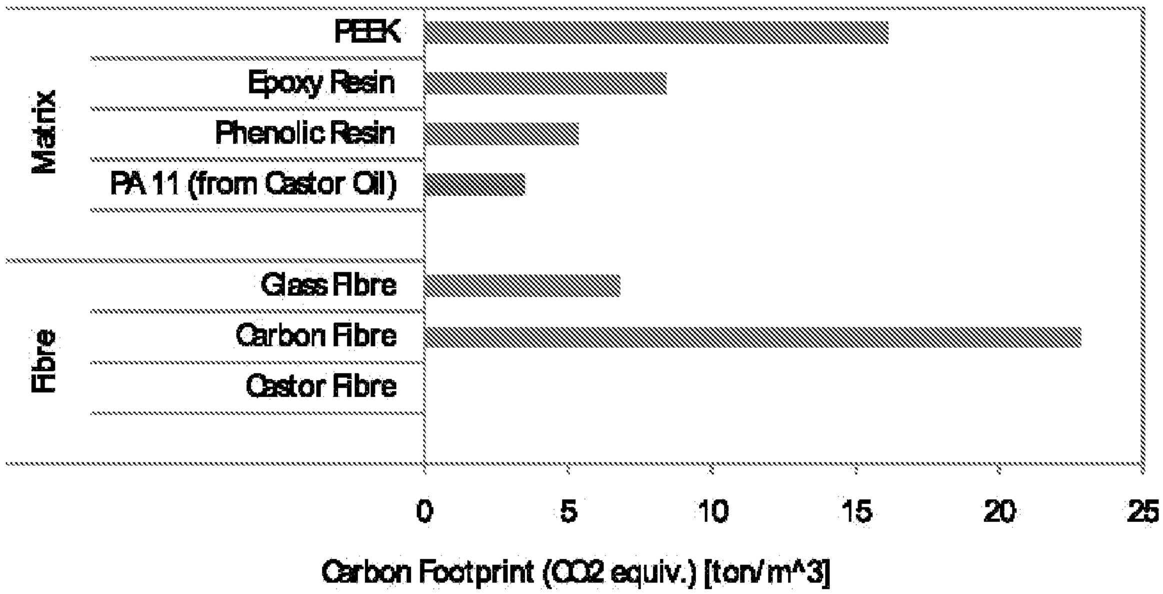

Figure 20

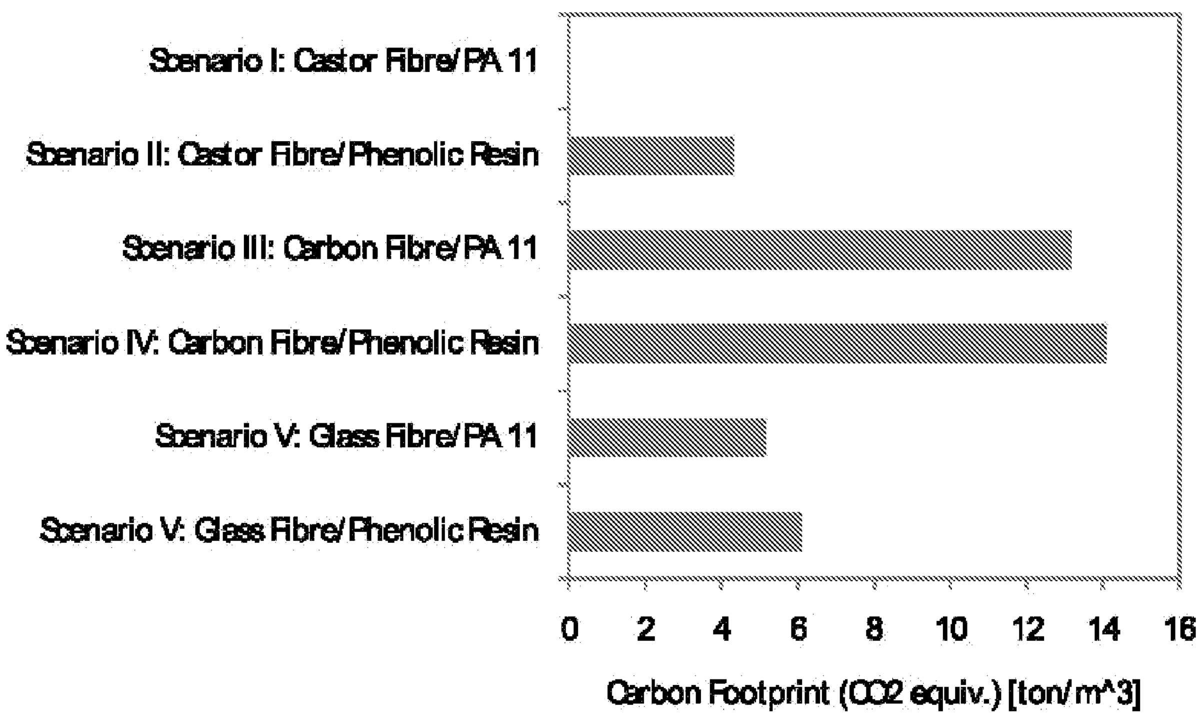

Figure 21

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/058186

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08L77/02 C08J5/04 C08L77/04 C08L97/02

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08L C08J

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GRIGORIOU A. H.: "The potential use of Ricinus communis L. (Castor) stalks as a lignocellulosic resource for particleboards" INDUSTRIAL CROPS AND PRODUCTS, vol. 13, 20 April 2001 (2001-04-20), pages 209-218, XP002595510 DOI: 10.1016/S0926-6690(00)00078-9	1,8-11
Y	pages 210-212; tables 2,6	2-7
Y	DE 198 34 048 A1 (COGNIS DEUTSCHLAND GMBH [DE]) 3 February 2000 (2000-02-03) page 2, line 50 - page 3, line 18 page 4, lines 20-42; claims 1, 12, 13; examples 4, 6	2-4,6,7

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 August 2010	25/10/2010

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

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 197 05 280 C1 (DAIMLER BENZ AG [DE]) 5 March 1998 (1998-03-05) page 2, lines 7-16, 48-56 page 3, lines 14-31	2-6
X,P	DATABASE WPI Week 201017 10 February 2010 (2010-02-10), Thomson Scientific, London, GB; AN 2010-C41078 XP002595509 "Urea formaldehyde resin adhesive mid-density fiber plate, has castor oil plant stalk fiber" & CN 101 642 925 A 10 February 2010 (2010-02-10) abstract	1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2010/058186

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-11

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-11

A composite material

1.1. claims: 1-8

A composite material comprising a matrix material and natural fibers extracted from Castor plant

1.2. claims: 9, 10

An aircraft component comprising a composite material according to claim 1-8

1.3. claim: 11

A method for manufacturing a composite material according to claims 1-8

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2. claims: 12, 13

A method for extracting fibers from a Castor plant

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/058186

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
DE 19834048	A1	03-02-2000	AT	234888	T	15-04-2003
			AU	5038899	A	21-02-2000
			CA	2339106	A1	10-02-2000
			WO	0006632	A1	10-02-2000
			EP	1102804	A1	30-05-2001
			JP	2002521542	T	16-07-2002
DE 19705280	C1	05-03-1998	WO	9836024	A1	20-08-1998
			EP	0859031	A2	19-08-1998
			EP	0960162	A1	01-12-1999
			JP	3336493	B2	21-10-2002
			JP	10219000	A	18-08-1998
			JP	2000512928	T	03-10-2000
			US	6184272	B1	06-02-2001
			US	6375881	B1	23-04-2002
CN 101642925	A	10-02-2010	NONE			