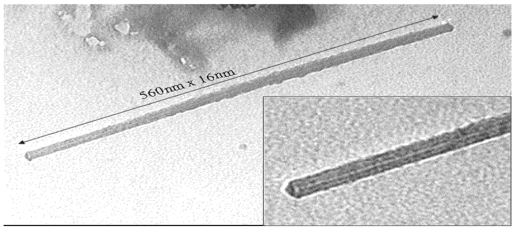
Carbon Nanotube Production from Plant Materials

Technology ID: 2008-31

Status: Patented (US 8632744 B2, US 8080227 B1)



Introduction: Significant investment currently exists in the industrial application of carbon nanotubes to a wide range of fields, such as energy storage and medical devices, due to this material's superior physical properties. The traditional methods used to manufacture carbon nanotubes (e.g., arc discharge, chemical vapor deposition, and laser ablation) have several issues that lead to decreased yields, high costs, and challenging process control.

Invention: The inventions describe novel processes that utilize the nanoscale arrangement of plant cell wall components to produce carbon nanotubes via controlled cyclic heating or flash-heating processes in an oxygen-limited atmosphere. Both single-walled carbon nanotubes (SWNT's) and multi-walled carbon nanotubes (MWNT's) can be produced from cellulosic plant fibers. These methods allow for lower process temperatures than those of traditional methods. The lower energy costs combined with the inexpensive starting material provide greater potential for scalability, which is especially important for applications that require bulk quantities of nanotubes, such as composite materials.

Advantages:

- Lower process temperatures
- Inexpensive starting material
- Potential scalability

Possible Applications:

- Energy storage
- Solar energy production
- Composite materials
- Medical devices
- Military applications

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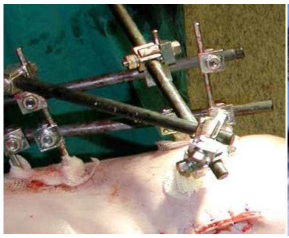
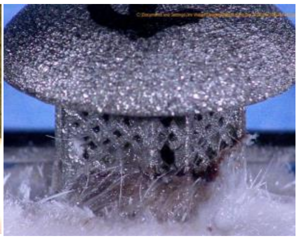
Reduced Infections with Porous Transcutaneous Implants

Technology ID: 2013-12

Status: Patent Pending

Introduction:

Surgical realignment of bones following skeletal fractures requires external hardware to fix the bone in place until the bone heals and is self-supporting. Such transcutaneous hardware includes metal rods that are affixed to the bone, protrude through the skin and are attached to an external hardware system. As the rods remain in place for weeks, the site where a rod passes through the skin and soft tissue can often become infected. At least 16% of orthopedic external fixation patients contract such infections, requiring additional hospitalization and resulting in an estimated annual health care cost of over $1billion. Reducing such infections is of significant importance.

Invention: Experts at The University of Maine have developed a biocompatible 3D printed and highly porous implant for use in place of a smooth metal surface at the transcutaneous site. The high porosity promotes in-growth of surrounding cells, creating a biological seal at the tissue-implant interface. This seal prevents pathogenic entry at the site, thereby reducing or eliminating infection. Further, as the skin eventually fuses to the porous fixator pin, scar tissue is not generated. Thus, upon removal, a fresh wound would be generated which could potentially allow quicker healing times with reduced complications and scarring.

Advantages:

- Reduces infection rates and hospital stay
- Animal studies successful - no infection/rejection, clear in-growth and vascularization, soft tissue attachment in under 1 week
- Aging population increases relevant patient population (rheumatoid arthritis, osteoarthritis)

Possible Applications: To reduce infection rates at orthopedic external fixation sites.

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Composite Building Products Bound with Cellulose (No Added Formaldehyde Wall Board)

Technology ID: 2013-13

Status: Patent Pending

Introduction: Wood composite products are commonly used as building products and for consumer goods such as furniture, shelving, and toys. Typically, the panels are constructed by binding wood chips, flakes, sawdust, or pulp using a resin binder under pressure and heat. The result is a durable, lightweight, and versatile panel made of renewable material. However, because the resins traditionally used for such products are urea-formaldehyde based due to their low cost and fast curing time, off-gassing is a significant health concern since formaldehyde is considered toxic.

Although ultra-low emitting formaldehyde and less toxic binders do exist in, there are concerns about inferior performance as well as other environmental factors regarding additives, manufacturing processes, and biodegradability. Therefore, as environmental concerns grow, binders and technologies that prove to be fully renewable and biodegradable without reducing the material properties of the finished products are becoming highly desirable.

Invention: The invention describes a novel fiber board building material using randomly oriented cellulose nanofibrils (CNF) as the binder instead of conventional resin binders. The CNF slurry (comprised solely of CNF particles and water) impregnates, bonds, and reinforces the wood particle base material (e.g., wood shavings, wood meal, saw dust, etc.) using a process that is free from harmful chemicals or additives. The end product is a versatile, 100% bio-based composite that is entirely renewable and biodegradable while having impressive strength and stiffness properties suitable for many applications.

Advantages:

- All materials are 100% renewable, biodegradable, recyclable, and nontoxic
- Completely eliminates the need for a resin-based binder system, reducing health problems associated with formaldehyde exposure
- Can be fabricated utilizing existing production techniques and systems
- Up to 25% increase in material strength
- 20–1000% increase in fracture toughness

Possible Applications: The proposed invention is suitable for many applications. It can be used for the production of engineered wood products, including particle board, wallboard, oriented strand board (OSB), medium-density fiberboard (MDF), and high-density fiberboard (HDF).

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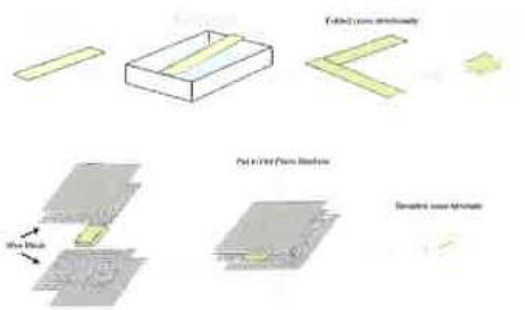
"Cellubound" Composite Products of Paper

Technology ID: 2015-11

Status: Patent Pending



Introduction: Laminated paper composites are typically constructed by saturating layers of kraft paper in an adhesive binder and curing at high heat and pressure to form the panels. The result is a durable, lightweight, and versatile panel made of renewable paper material. However, because the resins used for such products are traditionally urea-formaldehyde based due to their low cost and fast curing time, off-gassing is a significant health concern since formaldehyde is considered toxic.

Although ultra-low emitting formaldehyde and less toxic binders do exist in, there are concerns about inferior performance as well as other environmental factors regarding additives, manufacturing processes, and biodegradability. Therefore, as environmental concerns grow, binders and technologies that can prove to be fully renewable and biodegradable without reducing the material properties of the finished products are becoming highly desirable.

Invention: The invention describes a novel laminated paper composite material and method of manufacture using randomly oriented cellulose nanofibrils (CNF). In place of conventional resin binders, the CNF slurry (comprised solely of CNF particles and water) impregnates, bonds, and reinforces the paper sheets, which can be laid up in different stacking sequences (unidirectional, cross, angle) depending on the application and desired properties. The laminate is then cured using heat and pressure. The end product is a new bio-nanocomposite laminate system that is entirely renewable and biodegradable while having impressive strength and stiffness properties suitable for many applications.

Advantages:

- All materials are 100% renewable, biodegradable, recyclable, and nontoxic
- Completely eliminates the need for a resin-based binder system, reducing health problems associated with formaldehyde exposure
- Can be fabricated utilizing existing production techniques and systems
- Orthotropic or anisotropic properties possible for specific applications
- Excellent strength to weight ratio

Possible Applications: The proposed invention has many applications in several industries, including the automotive and aerospace (interior panels), marine (backer boards), consumer product (cutting boards, countertops), furniture/casework, architecture (decorative surfaces), and packaging industries.

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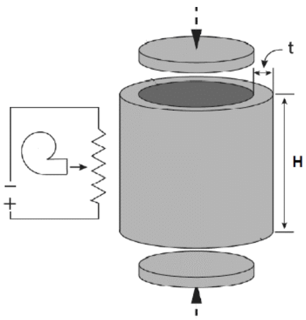
Controlled Porosity Structural Material with Nanocellulose Fibers

Technology ID: 2015-16

Status: Patent Pending



Introduction: Since its initial discovery in the early 1970s, nanocellulose has been studied extensively. With recent advancements in the field of nanotechnology, new and diverse potential market opportunities have arisen, resulting in significant global research to discover new applications and processing methods.

Nanocellulose is most commonly obtained from wood pulp or cellulose stock, by which fibrous cellulose is pre-treated and processed to separate the bulk fibers and eventually create nanoparticles of cellulose with high aspect ratios. The properties of the nanocellulose are controlled by the pre-processing treatment, the amount of water that remains in the polymer after synthesis, and the post-processing procedures. However, traditional dewatering processes typically rely on heat, air, and gravity, which tend to be inefficient and can often result in inconsistent and unreliable properties.

Invention: The invention describes a novel method of dewatering saturated nanocellulose after production. This method utilizes a porous dewatering material along with hydrostatic and evaporative processes to rapidly create nanocellulose products. Additional steps such as freeze drying or vacuum drying can also be used to further remove water. The processing parameters can be adjusted to fine tune the density, porosity, pore size distribution, biocompatibility, hydrophobicity, and dissolution kinetics.

Advantages:

- More reliable and precise control of porosity
- Improved processing efficiency
- Scalable for manufacturing large amounts of nanocellulose
- Can be used to create biocompatible and/or biodegradable compositions
- Additives can be incorporated to alter physical/chemical properties

Possible Applications: The proposed invention has many applications due to the unique properties of nanocellulose. Potential applications include paper and paper-based packaging, biomedical and biocompatible materials (structural nanocomposites), energy storage (batteries and capacitors), and food additives.

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Method to Reduce the Shrinkage of Semi-Crystalline Polyolefins During Fused Layer Modeling

Technology ID: 2017-04

Status: Patent Pending

Introduction: Polyolefins such as polypropylene (PP) and high-density polyethylene (HDPE) represent a nearly half of the consumed thermoplastics globally and have various applications spanning several industries. However, even as three-dimensional (3D) printing material and technology developments have surged over the years, PP has not been widely utilized for additive manufacturing processes such as fused layer modeling (FLM) 3D printing. This is mainly due to challenges stemming from material shrinkage, which results in dimensional instabilities. Although a commercial PP filament is available in today's market, inorganic fillers are used to enhance the stiffness of the polymer, and still, the physical properties are poor, making it unsuitable for many applications. Additionally, the inorganic fillers are not easily recyclable and non-renewable, making them incompatible with "green" manufacturing initiatives. Thus, polyolefin-based filaments with reduced shrinkage, improved physical properties, and that are more environmentally friendly could be revolutionary to the FLM printing market.

Invention: The invention describes PP filament formulations with reduced shrinkage for FLM processing. The formulations include a polymer blend made of PP and HDPE, an impact-modified PP copolymer, and a PP random copolymer. The polymers are made into filaments using an extruder, and cellulosic nanofibers can be added during melt compounding to further enhance the mechanical properties of the printed parts.

Advantages:

- Enables reliable printing of PP parts by reducing shrinkage
- Stronger, lower cost, lighter, and more renewable than the only existing PP filament on the market
- Can utilize recycled PP and PE, which represent the majority of consumed thermoplastics
- Increases the value of polyolefins and lowers the cost of the commercial filaments
- Cellulosic nanofibers can be added to further enhance the mechanical properties

Possible Applications: The proposed invention has many applications as a 3D printing plastic filament, including automotive components, aerospace components, packaging, consumer products, and medical components. It can also be used as an alternative to glass fiber reinforced plastics.

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