ABSTRACT

A growth medium formed as an inoculum including a preselected fungus and a nutrient material capable of being digested by the fungus is placed in or on a tool formed of a material capable of being at least partially consumed by the fungus. The tool may define a cavity of predetermined shape for the growth medium or the tool may form a scaffolding on which the growth medium grows into the final product taking on the shape of the tool.
MYCOLOGICAL BIOMATERIAL

[0001] This application claims the benefit of Provisional patent application 61/686,443, filed Apr. 5, 2012 and is a Division of U.S. Patent application 13/857,403, filed Apr. 5, 2013.

[0002] This invention relates to mycological biomaterials. More particularly, this relates to mycological biomaterials grown in tools that are consumed or enveloped during the growth process.

BACKGROUND OF THE INVENTION

[0003] As is known from published U.S. patent applications, use can be made of a fungus to form composite materials by mixing an inoculum including a preselected fungus with discrete particles and a nutrient material capable of being digested by the fungus. It is also known that such a fungus can be grown as a mass of fungus tissue in a mold of low density chitosan material.

[0004] Generally, the methods employed for growing biomaterials of the above nature for a wide array of applications use an encapsulated tool to house the materials as they grow. This presents several disadvantages:

[0005] The plastic tool only serves to produce one shape, and is not easily customizable for different applications after a product has been produced.

[0006] The plastic tool is easily broken during general handling and the biomaterial extraction process. This short life span requires periodic replacements to be manufactured.

[0007] The plastic tools take up a considerable amount of space and therefore are cumbersome to store and transport between stages of a manufacturing process.

[0008] The plastic tools must be thoroughly cleaned before and after each use because the manufacturing processes rely on the growth of a biological organism.

[0009] Accordingly, it is an object of the invention to provide mycological biomaterials that are grown in a tool that is at least partially consumed in the process of growth.

[0010] It is another object of the invention to provide a tool to house mycological biomaterials as they grow while contributing to the growth process.

[0011] It is another object of the invention to provide a mycological biomaterial that may be grown in an economical manner.

[0012] Briefly, the invention provides a mycological biomaterial that is formed by forming a growth medium comprising an inoculum including a preselected fungus and a nutrient material capable of being digested by the fungus; and placing the growth medium in a tool formed of a material that is capable of being at least partially consumed by the fungus, wherein the tool defines a cavity of a predetermined shape for the growth medium and the tool serves as a scaffold for growth of the preselected fungus.

[0013] In accordance with the invention, the tool is made of at least one of: plant fibers, paper fibers, plant-derived non-woven materials, and plant-derived woven materials.

[0014] The process of growing the mycological biomaterial comprises the steps of forming a growth medium including discrete particles, an inoculum including a preselected fungus and a nutrient material capable of being digested by the fungus; placing the growth medium in a tool defining a cavity of predetermined shape for the growth medium; and growing the fungus on and through the growth medium in the tool to form a product corresponding to the predetermined shape provided by the tool.

[0015] In another embodiment, the growth medium is formed without discrete particles, i.e., the inoculum includes a preselected fungus and a nutrient material, such as grain spawn, capable of being digested by the fungus. In this embodiment, the growth medium is placed on a tool of predetermined shape formed of a material capable of being at least partially consumed by the fungus and defining a scaffold for the growth medium. The growth medium is allowed to grow on the tool to form a product corresponding to the predetermined shape of the tool with the fungus consuming at least some of the tool.

[0016] In this latter embodiment, the tool could be consumed entirely or in part by the fungus grown on the nutrient medium. In this context, the resultant product would be a thin walled material that is colonized with mycelium grown on a nutrient material (i.e., grain spawn). The consumable portion of the tool would serve as scaffolding and potentially nutrition depending on composition.

[0017] In accordance with the invention, the discrete particles may be of any suitable type including fibers that can be bound together with fungal mycelium to grant a specific form and function.

[0018] In one embodiment, the tool is made of a material that is formed of a material capable of being fully consumed by the fungus into the produced product. For example, the tool may be made of at least one of paper pulp, bamboo, papier-mâché, gelatin, starches, plant fibers, paper fibers, burlap, plant-derived nonwovens and wovens, and pre-grown mycelium sheets.

[0019] In another embodiment, the tool is made of a material that is partially consumed by the fungus into the produced product. For example, the tool may be made of at least one of synthetic fibers, glass fibers, carbon fibers, nylon fibers and plastic mesh materials.

[0020] In this latter embodiment, mycelium will tolerate and bind to a variety of materials and substances during growth. These most intuitively encompasses biological materials, such as plant fibers and particles liquid as paper and burlap. The mycelium will also populate negative spaces between and around synthetic fiber materials, thus effectively partially “consuming” the tool.

[0021] In still another embodiment, the tool may be made of an unconsumerable material, such as, polyethylene terephthalate (PETG) (a plastic) in the form of a tray.

[0022] Unconsumed tools, such as plastic trays that are partially open to the environment provide an opportunity for altering the growth environment of the biomaterial to achieve specific growth characteristics. Further, incubating the tools without lids in a controlled incubation environment would significantly reduce capital costs as there would not be a need for lids on the tools for regulating incubation conditions (RH, CO2).

[0023] The growth environment of mycological biomaterials such tools may use several possible options. These may be open-air incubation, filter-patch bags, controlled-environment incubators, controlled-environment rooms, and the like.

[0024] The tool used in the process may take several shapes. For example, the tool can be a woven or non-woven textile that is laid flat on the ground or other flat surface. In this case, a slurry of discrete particles and inoculum is poured on the textile tool. The textile would serve as a
carrier for the complete product once the mycelium has grown and bound to the material of the textile.

[0025] Typically, the tools used in the process provide both strength and form to the grown product as opposed to imparting only strength as in Example 9 of published U.S. Patent Application 2008/0145577. The consumed tools grant both strength and form and are external to the discrete particles, i.e. are on the face of the final product (enveloped, or bound, with mycelium).

[0026] These and other objects and advantages of the invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 illustrates a casting of mycological biomaterials in accordance with the invention;

FIG. 2 illustrates the casting of Fig. 1 during a step of spraying the casting with a starch or gelatin to form a coating thereon; and

FIG. 3 illustrates the casting of FIG. 1 after the spray on coating has formed a hardened shell in accordance with the invention.

The following sets forth several process examples in accordance with the invention:

EXAMPLE 1

Starch Shell Over Casted Substrate

1. A slurry of cellulose fibers, hemicellulose, water, and nutrients is created, sterilized, and subsequently vacuum-pressed on a buck of the desired form. This process molds the tool.

2. Once the tool is formed, hardened, and dry, it may be filled with a mixture of sterilized buckwheat hulls and 20% (v:v) liquid culture inoculum of Ganoderma tsugae.

3. The part is allowed to incubate in a controlled environment incubator at 90% relative humidity, 28°C, and 2000 ppm CO₂.

4. Once the part has been fully colonized and the tool is completely consumed, the produced product is dried to 0% moisture.

EXAMPLE 2

Consumable Paper Fiber Tool

1. A slurry of cellulose fibers, hemicellulose, water, and nutrients is created, sterilized, and subsequently vacuum-pressed on a buck of the desired form. This process molds the tool.

2. Once the tool is formed, hardened, and dry, it may be filled with a mixture of sterilized buckwheat hulls and 20% (v:v) liquid culture inoculum of Ganoderma tsugae.

3. The part is allowed to incubate in a controlled environment incubator at 90% relative humidity, 28°C, and 2000 ppm CO₂.

4. Once the part has been fully colonized and the tool is completely consumed, the produced product is dried to 0% moisture.

EXAMPLE 3

Molded Plastic Mesh

1. The tool is created by thermoforming a plastic mesh material over a buck of desired form. The mesh has large enough cavities to allow maximum airflow and small enough cavities to prevent substrate from spilling through.

2. The tool is filled with sterilized oat hulls and 20% v:v Ganoderma tsugae millet inoculum.

3. The part incubates in a controlled environment chamber at 99% relative humidity, 50% O₂ and 25°C.

4. Once the substrate is fully colonized and the mesh has been overgrown and is no longer visible, it may be dried to 0% moisture.

EXAMPLE 4

Plastic Trays Partially Open to the Environment

1. The plastic tray is created by thermoforming a plastic sheet over a buck of desired form.

2. The tool is filled with sterilized coconut coir and 20% v:v Ganoderma tsugae millet grain inoculum.
3. The part is incubated in a controlled-environment incubator at 30°C, 95% relative humidity, and 4000 ppm CO₂.

4. Once the part is fully colonized, it is dried to 0% moisture.

The invention thus provides a mycological biomaterial that is grown in a tool that is at least partially consumed in the process of growth. The invention also provides a tool to house mycological biomaterials as they grow while contributing to the growth process.

Still further, the invention provides a mycological biomaterial that can be grown in an economical manner.

What is claimed is:

1. A mycological biomaterial, wherein the mycological biomaterial is formed by:
   forming a growth medium comprising an inoculum including a preselected fungus and a nutrient material capable of being digested by the fungus; and
   placing the growth medium in a tool formed of a material that is capable of being at least partially consumed by the fungus, wherein the tool defines a cavity of a predetermined shape for the growth medium and the tool serves as a scaffold for growth of the preselected fungus.

2. The mycological biomaterial of claim 1, wherein the material that is capable of being at least partially consumed by the fungus comprises at least one of: plant fibers, paper fibers, plant-derived non-woven materials, and plant-derived woven materials.

3. The mycological biomaterial of claim 1, wherein the material that is capable of being at least partially consumed by the fungus comprises at least one of:
   synthetic fibers, glass fibers, carbon fibers, nylon fibers and plastic fibers.

4. The mycological biomaterial of claim 1, wherein the tool serves as a scaffold for fungal growth by allowing pre-selected fungus to bind to the tool.

5. The mycological biomaterial of claim 1, wherein the tool serves as a scaffold for fungal growth by defining a negative space that is populated during fungal growth.

6. The mycological biomaterial of claim 1, wherein the preselected fungus grows through and over the tool.

7. The mycological biomaterial of claim 6, wherein the tool is formed of a plastic mesh and the preselected fungus grows through and around the plastic mesh.

8. The mycological biomaterial of claim 7, wherein the plastic mesh has a plurality of cavities that are of sufficient diameter to retain the growth medium while allowing air flow.