Overview of Research on Medical Composite Material

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Abstract:
The paper presents an overview of the research, the basic system of biomedical composti materials. The author conducts a system of biomedical composites, classifies materials, synthesizes materials containing composites, and analyzes them in detail.

Keywords: *Medical Composite Material*

1. Introduction

Materials are an important area for industrial life and production. Each material has its advantages and disadvantages (for example, organic materials: light, durable, cheap, easy to process but not usable at high temperatures; inorganic materials: good strength, cheap, can be used in wide temperature range but less durable, heavy structure, difficult to process ...). The strong development of modern technology has led to a huge demand for materials and at the same time have many essential properties that traditional materials cannot stand alone. life meets both that urgent need and is the product of research works in the second half of the twentieth century in order to exploit and develop the law of association - a common law in nature. Today, composite materials have been gradually replacing traditional materials such as inorganic, organic, metal materials ... to make machine parts and structures including heavy load structures. as well as other civil products, including the medical field - a new field - that is biomedical composites.

Biomedical composites are a material that not only has good tolerability in the human body, but also has the ability to create a biochemical direct link between it and living body bone cells. Therefore, it is an ideal material for repairing and replacing human dental bone parts in orthopedic surgery.

2. Literature review

2.1. Concepts

Composite materials (composites) are composite materials from two (or more) materials of different nature. The constituent material has a characteristic superior to that of each component material when standing alone. [1]

The first composite material appeared thousands of years ago. 5000 BC ancient people added crushed stone or organic materials to clay to reduce shrinkage, shit when firing bricks or ceramics. In Egypt about 3000 BC, people made boat hulls with bituminous reeds soaked, if ignoring some of the concepts, that technique is like the modern boat-making technique from glass-reinforced plastic today. In Vietnam, a bamboo boat mixed with sawdust paint is an example of composite material. [2]

In 1851, Nelson Goodyear used zinc oxide as a filler for elonite. In 1920, Bakeland used filler flour in bakelite resin and John used cellulose as a filler for resins. [8]

Although being formed very early, but the construction of new composite materials really got attention about 60 years ago. In the 1930s Slayter was reinforced by Ellis and Foster for unsaturated polyester. Glass fiber reinforced polyester was used in aviation in 1938. [8] In 1944, thousands of parts were made of composite plastics for aircraft and warships for the second world war. In 1950, the quality of polymer composite materials was enhanced thanks to the advent of epoxy resins and cargo. fiber reinforcement series such as cabon, polyester, aramit (kelva), silicon ...

From 1970 to the present, components made from fiber-reinforced composites have been widely used in industry, building materials and high-tech industries. [5]

However, research to improve quality, improve mechanical properties, thermal properties, electricity, etc., expanding the field of application of this material has always been in place.

2.2. Classification:

To classify composite materials, people rely on their common characteristics:

- According to the nature of the base material: Polymer composites based on ceramics, ceramics, graphite, metals, mixed mixtures.
- According to the core geometry: granular composites (coarse, fine), fiber-reinforced composites (long, short).
- According to the material structure: composite plate, layer, 3-layer plate, block, honeycomb ...
- According to manufacturing methods: Casting, molding, injection molding, rolling ...
- According to the scope of application: High-grade composite, technical composite.

2.1. Classify by nature of base material.

* Metal background:

Metal has high strength, stiffness, and ductility, and can withstand higher temperatures than polymers in an oxygenated environment. Metal-based composites have a very high modulus (~ 110 GPa), which requires a high modulus reinforced yarn. Al, Mg, Ti, Cu have been studied and applied as the composite base, especially light metals, which are very popular in the aviation industry.

- Metal base has some advantages compared to polymer background:

+ The metal is generally flexible and quite durable, so it improves the physical and mechanical properties of polymers such as elastic modules.

+ Has higher conductivity, heat

+ No ignition, less affected by moist environment.

+ Has elasticity, so in some cases easy to process and assemble.

- The main disadvantage of metal substrate is its high specific gravity. Technology for manufacturing metal-based composites is much more complex than that of polymers and therefore the cost of products will be higher. This limits the selection and deployment of their applications in industry

* Polymer background:

Polymer-based composites account for about 90% of total composites. Polymers are very popular because of their low density, electrical insulation, good heat and easy processing. Polymers used as base have 2 types: Thermoset resins and thermoplastics [1].

Common thermoplastics: Polyethylene (PE), Polypropylene (PP), Polystylene, Polyamide ... [3]

The most common thermosetting resins are: Epoxy, unsaturated polyester, phenolic, polyurethane ... [3]

* Ceramic and glass base:

Typical organizations of ceramics are polyphase and polycrystalline. Two main phases make up the organization of a ceramic: The glass phase is distributed alternately between the crystal phase regions and binds them together. Ceramic is a material with high durability, maintaining its durability at high temperatures (~ 1600o C), high resistance to oxidation. However, with low tensile strength, poor impact resistance. [1]

Inorganic glass is a material obtained by rapidly quenching an inorganic compound from the molten state at high temperatures to a state of non-crystalline solids. The process is similar to thermoplastics so the machining methods of thermoplastics can be applied. The glass has high strength and high elasticity module (~ 69GPa), low thermal expansion. Due to its good flow properties, the increase in temperature and pressure can increase the fiber content but not reduce material strength. [1]

* Carbon / graphite base:

Grafit is very good heat-resistant material, hard, heat-resistant (> 2000oC), typically carbon-carbon composite. This material is used extensively in aviation, pharmaceutical chemistry, medical ... [1]

2.3. Classification by core geometry:

* Granular composites:

Is composed of the core particles of isotropic particles evenly distributed in the background. The core molecules are diverse: Natural minerals, oxides, carbides, nitrites.

- Fine-grained composites: usually have a base of metal or alloy, small-sized reinforcement (<0.1 cốtm) are usually durable materials, have high thermal stability such as carbide, nitrite. The core interaction occurs at the micro level with atomic and molecular sizes.

- Coarse grain composites: The base may be polymers, metals or ceramics. Reinforcing is usually included to improve compressive, tensile, bending, abrasion resistance, dimensional stability, heat resistance, etc. or create a new property as required. The core interaction does not occur at the atomic or molecular level. [1]

* Short fiber reinforced composite:

The fiber length is less than 5 cm. Short fiber reinforced composites are processed by conventional plastic processing methods such as molding, extrusion and injection molding. When extruding or injection molding into a mold, the fiber must be able to pass through the gap in the device body. Short fibers are often used as reinforcement for thermoplastics. Thermoset resins due to their high molecular weight when cured are not beneficial if short fibers are used. All fiber reinforced composites are of technical composites. [4]

* Fiber reinforced composites with medium length:

Fiber length is from 10 to 100 mm, often used for thermosetting resins with quite a large amount of fillers. The most commonly used machining method is the wet method. The fiber must be completely wetted to the composites to achieve the highest properties. This composites also belong to technical composites. [4]

* Fiber-reinforced coposit:

This yarn, also known as continuous fiber, is often used as a reinforcement for thermosetting plastics, making high quality composites. This composite can be made with inorganic, ceramic and metal substrates. [4]

Classification by application scope:

According to the scope of application, composite is divided into 2 groups. These two groups differ mainly in the type of yarn, the length of reinforced yarn and the type of resin used as the base.

The first group is called advanced composites, which are made from long-lasting and highly durable fibers. Plastic substrates are also good, heat resistant and chemically stable resins. High quality composites are often used in aviation and aerospace (such as rockets, aircraft parts), as well as high-end sports equipment (such as tennis rackets, golf players ...), medical materials. birth (repair, replacement of dental parts, body bones).

The second group is called engineering composites, which consist of short fiber reinforced composites with lower mechanical properties. Plastic substrates also have lower properties. Products made from technical composite include ship hulls, canoes, bathtubs, tanks ...

3. Materials with a major constituent of composite

The main composites are base and reinforcing materials. There are also hardening agents, fillers and some pigments (if needed) .The reinforced materials make the composite more resistant to the load. The base material plays the role of connecting the core material and transmitting force. mechanics to them, as well as to protect the environment. [3]

3.1. Essence

In the composite block, in terms of arrangement, the distribution is discontinuous. The essence can be very diverse depending on the properties of the composite to be manufactured. In fact the core can be metal (stainless steel, vofram, molybdenum ...), inorganic substances (boron, carbon, glass, ceramic ...) and organic matter (aromatic polyamides, epoxy resins ...). [first]

Shape, size, content and core distribution are factors that strongly affect the properties of composites.

Some forms of space distribution are: one-dimensional (linear), two-dimensional (face), three-dimensional (block).
For properties of each type, see section 2.2.

3.2. Background [1]

In background composites play the following major role:
- Linking all the core elements into a unified block.
- Creating the possibility to conduct composite material processing methods into design details.
- Covering and protecting the skeleton to avoid mechanical and chemical damage due to the effect of the external environment.

The background can be very different materials. Basically one can classify the base into four groups: polymers, metals, ceramics and mixtures. Characteristics of each type of substrate see section 2.1.

3.3. Interaction between background and core

The foundation and the core are combined into a uniform composite block through the connection at the phase boundary area. In principle, the foundation and the core in the composite block under normal working conditions do not occur the phenomenon of diffuse diffusion. However, depending on the manufacturing technology process, the system may undergo thermodynamically favorable high temperature and pressure states for the various interactions between the substrate and the substrate to occur. [1]
Types of interaction between the background and the core. [1]
According to characteristics, they classified the interaction base into three basic forms:
- The base and base do not dissolve with each other and do not form chemical compounds.
 For example: Al-B, SiC-Al composites ...
- Interacting base and base creates a solid solution with very small solubility and does not create chemical compounds.
For example: Composit: Nb-W, Ni- W ...
- Background and core interact with each other to create chemical compounds.
For example: Composit: Al-SiO_2, Ti-Al_2O_3, Ti-SiC ...

Depending on the type of interaction, the background and core will form a certain link. The strength of composites is strongly influenced by the strength of the core-substrate bonds.
 The types of cohesion between the core - the foundation. [1]
In composite materials, there are 6 basic types of bonding:
* Mechanical linkage (Figure 1.2a):
This connection is made by a pure mechanical coupling between the base and the core through surface roughness or friction.
* Wet link (picture 1.2b):
This connection is made possible by surface tension energy. For composites that create a mechanical connection, when making fabrication process, if the mixture is melted and wet with the substance, there will always be a process of diffuse dissolution between them even though it is very The surface tension on the foundation-reinforced boundary after the solidification phase is the decisive factor for the latter type of connection.
* Reaction link
Reaction bonds occur when on the baseline boundary, a reaction creates a chemical compound in the form of mfx. The properties of this new compound make a decisive influence on the bonding strength between core and substrate.
* Link response segment
The feature of this bond is that the overall reaction takes place in several stages, including one without speeding the link.
* Oxide bonding
Bonding in this composite is made by producing reaction products in the form of oxide films (Mox).
* Link mix

This bond is a mixture of the types of bonds that appear in the composite and the interaction between the substrate and the core depends strongly on the manufacturing or use.

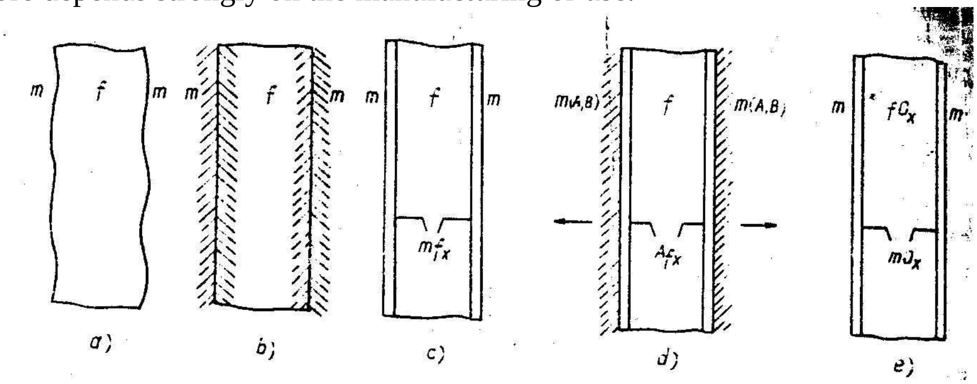

Figure 1. Types of link between base and core

4. STRUCTURE AND NATURE OF COMPOSIT.

4.1. Structure of composite materials.

In terms of structure, composite materials are divided into several types as follows: multi-layer composite, three-layer composite.

Multi-layer composites.

Material composed of uniform layers of yarn or fabric; The directions of fibers or fabrics in each layer are not necessarily the same.

The core material of each material layer is very different in nature: it can be fiber, glass cloth, carbon ... The choice of the core material of the material layers depends on the user so that it satisfies the highest properties. durable, hard ... when under load.

If we compare the arrangement types of reinforced materials, we see:

-The uniform layers give high mechanical properties in the direction of the yarn.

-The layer "mat" (tangled yarn) has poor tensile strength, so it should be arranged in the area of compression.

- Square layer composite materials are easily separated.

-When strengthening in all 3 directions, we will be material-isotropic. [3]

Composite material "three layers"

"Three-layer" composite materials include:

-Core (material or structure is light but with good compression)

-2 casing (with high compression resistance).

The selection of materials depends on the purpose of the user and the conditions of the person working (heat mode, environment, cost ..).

People often use the following materials:

+ Solid core: wood or cotton, sponge, plastic reinforced by glass wool vibi.

+ Hollow core or honeycomb made of: light alloy, plastic impregnated paper, polyamide paper ...

+ Shell is laminated material (glass, carbon ...) or light alloy plate.

5. A number of factors affecting the properties of fiber-reinforced composites:

The properties of composites depend on many factors: the nature of the core material and the substrate, the strength of the core-bonding link on the boundary, the fiber distribution and orientation, the size-shape of the reinforcement, the base ratio. -well (volume ratio and mass ratio) .. [1]

5.1. Foundation-core ratio. [3]

The relative ratio of reinforced materials and base materials is an important factor, which determines the mechanical properties of composite materials. This ratio can be expressed as a volume or volume ratio.

* Volumetric ratio (Vi):

We investigated a block of composites (vc) containing a block of fibers (vs) and a block of substrate (vn). The yarn's volume ratio will then be:

$$V_s = \frac{v_s}{v_c},$$

And the volume ratio of the substrate will be:

$$V_n = \frac{v_n}{v_c}$$. Với $V_n = 1 - V_s$, → $v_c = v_s + v_n$

**** Mass ratio (Mi):***

From the weight of the composite (mc), the fiber weight (ms) and the weight of the substrate (m¬n), the mass ratio is similar to the above.

Between mass and volume there is a relationship:

$m_c = v_c.\rho_c$; $m_s = v_s.\rho_s$; $m_n = v_n.\rho_n$; (where ρ_i is the density).

The total weight of composite materials is:

$m_c = m_s + m_n$ hay $v_c.\rho_c = v_s.\rho_s + v_n.\rho_n$

→ $\rho_c = V_s.\ \rho_s + V_n.\rho_n$ or $\rho_c = V_s.\rho_s + (1 - V_s).\rho_n$.

$v_c = v_s + v_n$

→ $$\frac{m_c}{\rho_c} = \frac{m_s}{\rho_s} + \frac{m_n}{\rho_n}.$$

→ From there we show the density through specific gravity:

→ $$\rho_c = \frac{1}{\frac{M_s}{\rho_s} + \frac{M_n}{\rho_n}}$$

$$M_s = \frac{m_s}{m_c} = \frac{\rho_s.v_s}{\rho_c.v_c} = \frac{\rho_s}{\rho_c}.V_s$$

$$M_n = \frac{\rho_n}{\rho_c}.V_n$$

→ $$V_s = \frac{\rho_c}{\rho_s}.M_s\ ;\ V_n = \frac{\rho_c}{\rho_n}.M_n$$

For a given fiber reinforced composite, if the foundation-fiber link is considered to be perfect, the properties of that material are directly influenced by such factors as the distribution, size, shape and content of the material. fiber reinforced.

5.2. The influence of fiber geometry on the properties of composites [1]

Fiber counts can be distributed and oriented according to different options depending on the requirements of the composite. To investigate, people distinguish the following two types of distribution:

- One-way distribution, in which all fibers are oriented in a parallel parallel uniformly.
- Multilateral distribution: In this way the fiber can be distributed in the form of a "mat" ie distributed tangled, completely random on one side, similar to felt felt.

d) Knitting and wrapping three perpendicular directions

The strength of unidirectional fiber reinforced composite is perpendicular to the core is very small. In the case of multi-dimensional distribution ("mat" or two-dimensional weaving), the tensile strength will be minimal in the direction perpendicular to the fiber distribution surface. If the yarn is wound in 3 perpendicular directions, the composite will have the greatest simultaneous strength in all 3 corresponding directions.

The geometrical factor of the yarn including its shape, length, and diameter has a great influence on the properties of the composite.

Below we will analyze the properties of unilateral fiber composites when changing the geometry of the fiber.

Continuous fiber (Endless fiber length). [1]

To conduct the analysis, it is assumed that the survey composite meets the following conditions:

-Infinitely long fiber, distributed and oriented in a parallel projection

-The composition and organization of the base material must be absolutely the most crowded.

-The foundation-bonding is done in a perfect way, ensuring the deformation of the reinforcement and the foundation occurs simultaneously, compatible until destruction, ie: $\varepsilon_{composit} = \varepsilon_{nền} = \varepsilon_{sợi}$.

When placing the load in a direction parallel to the axle, from the condition of perfect connection between the foundation and the core, we have:

$P_c = P_n + P_s$ (1)

Or $(\sigma_b)_c.F_c = \sigma_b.F_n + \sigma_b.F_s$ (2)

➔ $(\sigma_b)_c = V_s.(\sigma_b)_s + (1- V_s).(\sigma_b)_n$ (3)

Inside:

Fc, Fn, Fs: the corresponding total cross-sectional area of composites, substrates, and fibers.

σ_b: effective stress at the time of breaking of the fiber, with

$\sigma = \varepsilon.E.$

➔ $E_c = V_s.E_s + (1- V_s).\frac{d\sigma_n}{d\varepsilon_n}$ (4)

With $\frac{d\sigma_n}{d\varepsilon_n}$ is the inclination of the background tensile strain curve determined at the value σ_n.

When the value of σ_n is in the elastic region of the tensile curve, $\frac{d\sigma_n}{d\varepsilon_n}$ the value is equal to the elastic modulus of the E_n base.

➔ $E_c = V_s.E_s + V_n.E_n$ (5)

(1) & (5) ➔ $\frac{p_s}{p_n} = \frac{V_s.E_s}{V_n.E_n}$ (6)

For composites with better plasticity there is always a value V_s^{min} corresponding to $V_s < V_s^{min}$ destruction of the fibers does not lead to an immediate destruction of the composite material. In this case, too small content of the reinforcement was not enough to cause a durable chemical effect. If the load is applied to the composite model, the entire load will affect the background and deform the sample. The simultaneous deformation process of the fiber and substrate occurs until the elongation of the sample is equal to the destructive elongation of the fiber. At this time, if the force continues to work, all the meager thread will be destroyed (broken). However, the sample continued to deform and the eventual destruction only occurred when the sample distortion reached the destructive strain value of the ground.

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