Universidad
Carlos III de Madrid
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MATERIALS SCIENCE AND ENGINEERING

TOPIC 8. COMPOSITE MATERIALS

1. Classification according to type of reinforcement and matrix
2. Type of constituents
3. Particle reinforced composite materials
4. Rule of mixtures
5. Fiber reinforced composite materials
    5.1 Types of fibers (glass, carbon, aramid, boron and ceramics)
6. Structural composite materials (laminates and sandwich structures)

DEFINITION AND TYPES

"Mix of two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure"

1. CLASSIFICATION

Reinforcement:

- Particles *(dispersion strengthened or large particles)*
- Fibers *(discontinuous - short or continuous - aligned)*
- Structural *(laminates and sandwich structures)*

Matrix:

- Metal matrix composites (MMC)
- Ceramic matrix composites (CMC)
- Polymer matrix composites (PMC)

When is a material considered to be a composite?

Microstructural level (< 0,01 cm) to macrostructural (> 0,01 cm)

Wood		**Concrete**
Hypoeutectoid steel	?	**Reinforce concrete**
Austenitic stainless steel		**Cement**
Cellophane		**Reinforced plastic**
Paper		

DEFINITION AND TYPES

Wood (lignin + celullose)

Concrete (gravel + cement)

Hypoeutectoid steel (ferrite + pearlite)

Reinforced concrete (gravel + cement + steel)

Austenitic stainless steel (grains =)

Cement

Cellophane (Multiple polymeric layers)

Reinforced plastic (it doesn't improve its properties)

Paper (only cellulose fibers)

- Composite material
- Limit of composite material
- Not a composite material

COMPOSITES IN NATURE

Sea shells

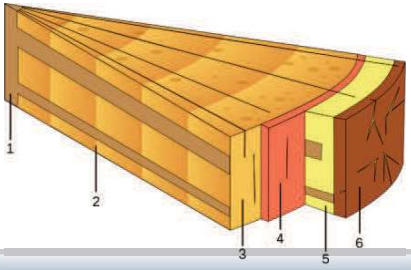
Abalone shell:
$CaCO_3$
+ 3% organic material
>3000* stronger than calcite

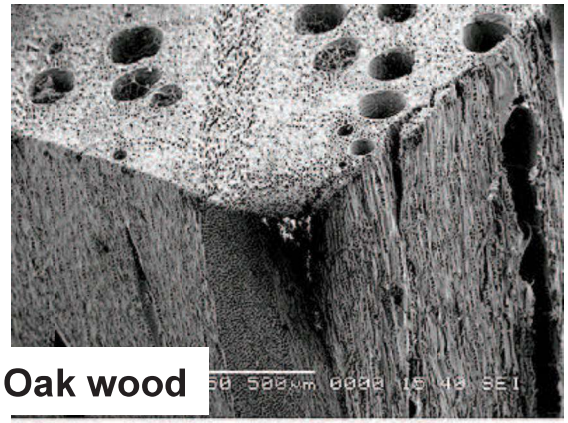
Wood

cellulose-filaments in a matrix of lignin and hemicellulose

growth rings form a layered composite

perpendicular to the growth rings are radially oriented ribbon-like structures : rays which provide a redial stiffening and reinforcement





Oak wood

pine wood

http://commons.wikimedia.org/wiki/File:Wood_structure_numbers.svg
http://commons.wikimedia.org/wiki/File:Hard_Soft_Wood.jpg

CLASSES ACCORDING TO REINFORCEMENT AND MATRIX

Different matrix, reinforcement and properties of CM		
Matrix	**Reinforcement material**	**Properties**
Metal	Metal fibers, ceramic, carbon, glass	Electric resistance to temp.↑ thermal stability
Ceramic	Particles and metallic fibers and ceramics	Chemical and thermal resistance to temp. ↑
Glass	Glass and ceramic particles	Mechanical strength and chemical resistance to temp.↑ thermal stability
Organic	Carbon, glass and organic fibers	Mechanical strength to high temp. chemical and electrical, and erosion resistance, flexibility and thermal stability

Properties to take into account for material design ⇒

- **For ceramic and metallic component: Physical (thermal, electrical, optical…) and mechanical (stiffness, toughness, stress-strain behaviour…)**
- **For plastic components: Physical and mechanical. Also the water absorption and transmission**

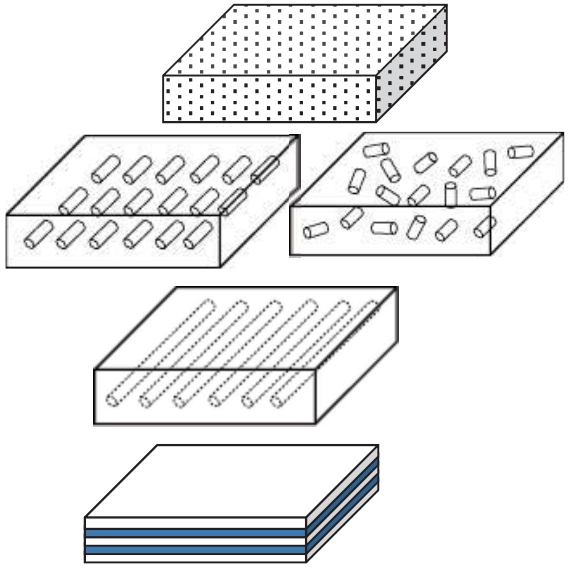
TYPE OF CONSTITUENTS

Structures, reinforcements, types and properties of composite materials

COMPOSITE MATERIALS

- Particle-reinforced
  - Large-particle
  - Dispersion strengthen
- Fiber-reinforced
  - Continuous (aligned)
  - Discontinuous (short)
    - aligned
    - Randomly oriented
- Structural
  - Laminates
  - Sandwich panels

Structure



Reinforcement	Composite material	Properties
Particles	Particle-reinforced	Isotropic
Short fibres	Random Aligned	Isotripic Anisotropic
Continious fibers	Aligned continous fibres	Anisotropic
Laminates or layers	laminates	Anistotropic

TYPE OF CONSTITUENTS

The composite material properties depend upon the properties of each of its phases, their relative proportions and their geometry

Schematic representation of several geometric and spatial characteristics of particles of the dispersed phase