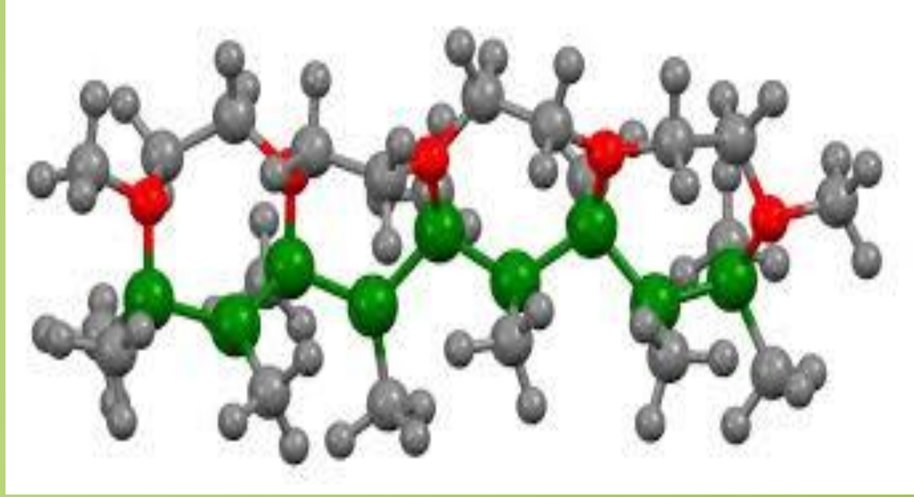
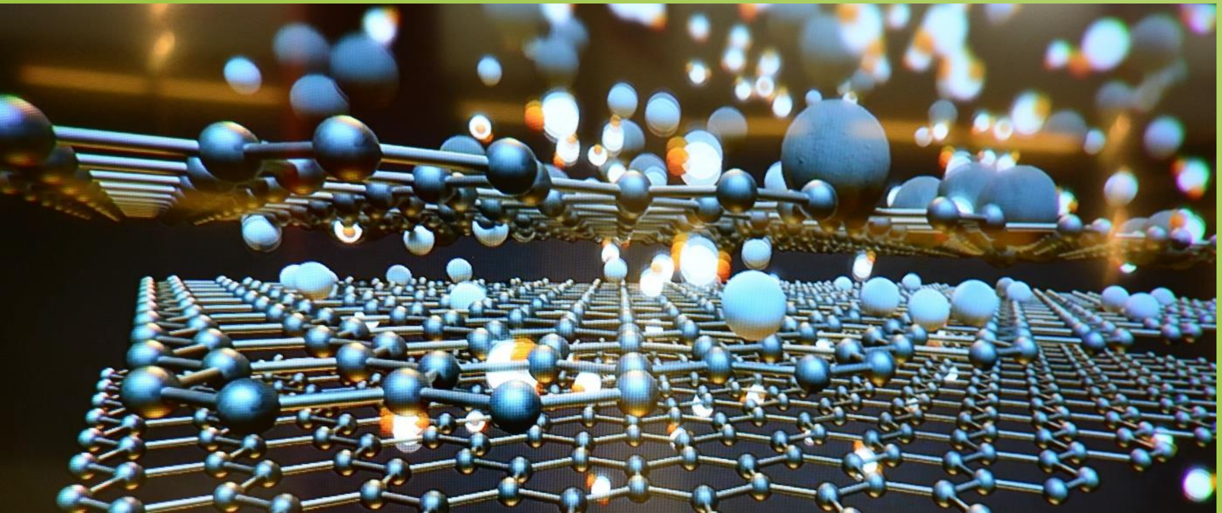


POLYMER COMPOSITES

Prepared by: *Melis ISIK*



1. Polymer Composites and General Concepts
2. Structure and Components of Polymer Composites
3. Classification of Polymer Composites
4. Shaping of the Polymer Composites
5. Usage Areas of Composites In Daily Life

WHAT ARE POLYMER COMPOSITES ?

- The polymer composites have another name called Polymer Matrix Composites (PMC).

- A polymer matrix composite (PMC) is a composite material composed of a variety of short or continuous fibers bound together by an organic polymer matrix. PMCs are designed to transfer loads between fibers of a matrix.

- **Another Definition :**

A *composite material* is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components.

PROPERTIES OF POLYMER COMPOSITES

- Lightweight,
- High stiffness,
- High strength along the direction of their reinforcements,
- Good abrasion resistance,
- Good corrosion resistance.

Structure and Components of Polymer Composites

STRUCTURE:

A polymer composite is a multi-phase material in which reinforcing fillers are integrated with a polymer matrix, resulting in synergistic mechanical properties that cannot be achieved from either component alone.

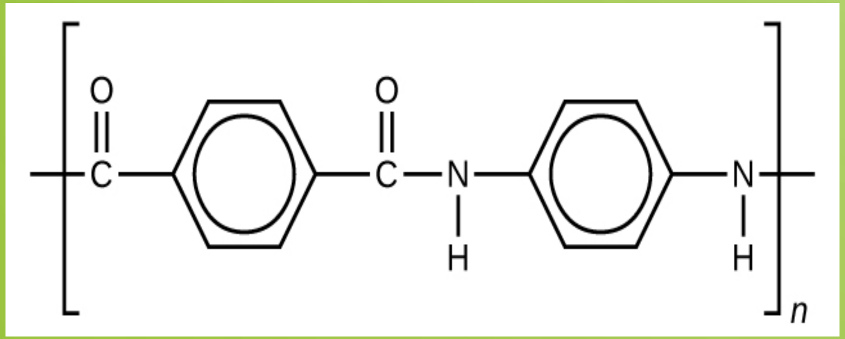
COMPONENTS OF POLYMER COMPOSITES

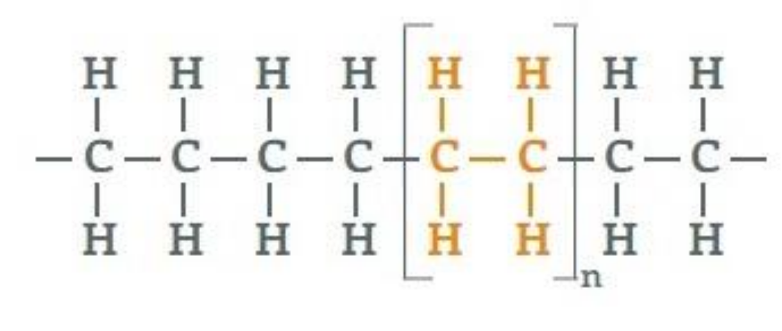
Modern composites are usually made of two components :

- Fiber
- Matrix

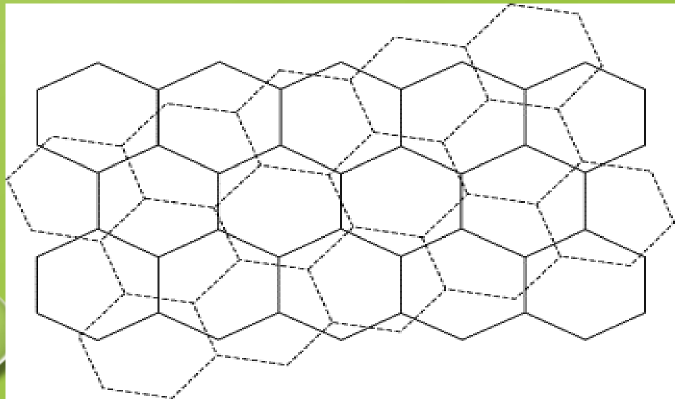
FIBER

The fiber is most often glass, but sometimes Kevlar, carbon fiber, or polyethylene.



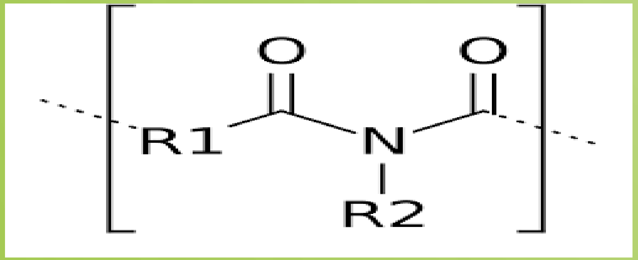


Molecular Structure of Polyethylene



MATRIX

The matrix is usually a thermoset like an epoxy resin, polydicyclopentadiene, or a polyimide. The properties of the matrix determines the resistance of the PMC to processes that includes impact damage, water absorption, chemical attack, and high-temperature creep.



- The fiber is embedded in the matrix in order to make the matrix stronger. Fiber-reinforced composites have two things going for them. They are strong and light. They're often stronger than steel, but weigh much less. This means that composites can be used to make automobiles lighter, and thus much more fuel efficient. This means they pollute less, too.

Drawbacks of Polymer Matrix

1. Environmental degradation.

2. Moisture absorption from environment causes swelling in the polymer as well as a decrease of Tg.

3. The moisture absorption increases at moderately high temperatures. These hydrothermal effects can lead to internal stresses in the presence of fibres in polymer composites.

4. A thermal mismatch between polymer and fibre may cause cracking or debonding at the interface.

The performance of polymer composites is generally determined by:

1. The properties of the fiber,
2. The properties of the polymer matrix,
3. The ratio of the fiber to the polymer matrix in the composite (fiber volume fraction), and
4. The geometry and orientation of the fiber in the composite.

- The performance is usually referred to as the mechanical properties of the polymer composites. It is considered to be the most important of the physical and chemical properties of the polymer composites.

Mechanical properties of composites are strongly influenced by the:

- size
- type
- concentration
- dispersion of reinforcing agent (filler)
- interfacial tension between the matrix and filler

CLASSIFICATION OF POLYMER COMPOSITES

There are 2 types of classifications about polymer composites

1. Classification according to their source

- Fibre-Composites
- Natural-Fibre Composites
- Bio-Composites

1. Classification according to polymer matrix

- Thermoplastic
- Thermoset
- Rubber

Classification According To Their Source:

A) <u>Fibre-Composites (fiber-reinforced composite):</u>

- FRC is high-performance fiber composite achieved and made possible by cross-linking cellulosic fiber molecules with resins in the FRC material matrix through a proprietary molecular re-engineering process, yielding a product of exceptional structural properties.
- Through this feat of molecular re-engineering selected physical and structural properties of wood are successfully cloned and vested in the FRC product, in addition to other critical attributes to yield performance properties superior to contemporary wood.
- This material, unlike other composites, can be recycled up to 20 times, allowing scrap FRC to be reused again and again.

B) <u>Natural-Fibre Composites (NFC):</u>

- Natural fibre composites (NFCs) are composite materials, in which at least the reinforcing fibres are derived from renewable and carbon dioxide neutral resources such as wood or plants. Natural fibre composites could be <u>100% biodegradable</u>. Biological and <u>environmental durability</u> is often cited as a key advantage of natural fibre composites over traditional materials.

C) Bio-Composites:

A biocomposite is a composite material formed by a matrix (resin) and a reinforcement of natural fibers. These kind of materials often mimic the structure of the living materials involved in the process keeping the strengthening properties of the matrix that was used, but always providing biocompatibility. The matrix phase is formed by polymers derived from renewable and nonrenewable resources. Biocomposites are divided into **non-wood fibers and wood fibers**, all of which present cellulose and lignin. In addition, biofibers are the principal components of biocomposites, which are derived from biological origins, for example fibers from crops (cotton, flax or hemp), recycled wood, waste paper, crop processing byproducts or regenerated cellulose fiber (viscose/rayon).

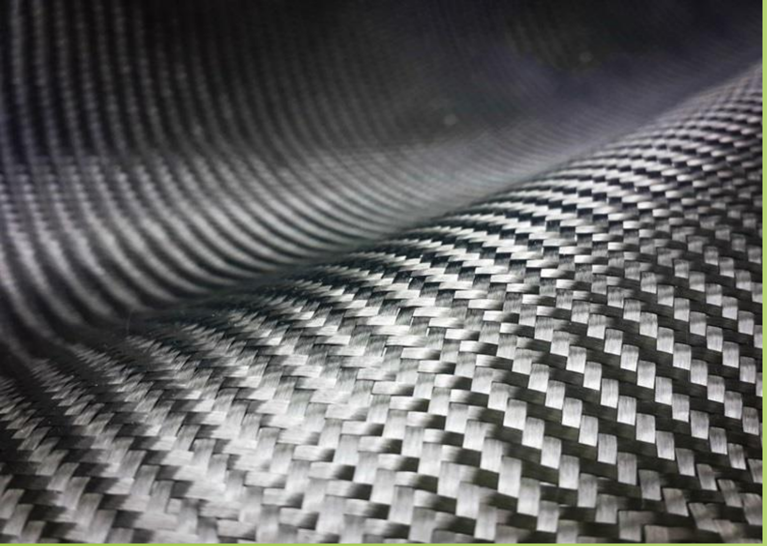
Classification According To Polymer Matrix:

A) <u>Thermoplastic-Composites (TMC):</u>

- Thermoplastic composites (TMCs) evolved from structural polymer composites. These materials do not experience chemical instability because they utilize a thermoplastic matrix. When heated, TMCs soften and can be remolded without degradation. When they cool, they solidify into the finished shape. This heating-cooling cycle can be repeated multiple times, giving the product an almost indefinite shelf life.

- Thermoplastic composites could also be shaped using techniques derived from wood and metalworking. They have increased recycling and damage tolerances due to the tough nature of the matrix material.

- Thermoplastic composites could be categorized into either **<u>Glass Mat Thermoplastics (GMT)</u>** or **<u>Advanced Thermoplastic Composites (ATC).</u>**



B) **Thermoste-Composites:**

- Thermoset composites, which are commonly based on glass, carbon or aramid fibers, are usually incorporated with resins such as polyesters, vinyl esters, epoxies, bismaleimides, cyanate esters, polyimides or phenolics.
- The recycling options for thermoset composites are limited

C) **Rubber-Composites:**

- Reinforced rubber products combine a rubber matrix and a reinforcing material, so high strength to flexibility ratios can be achieved. The reinforcing material, usually a kind of fibre, provides the strength and stiffness. The rubber matrix, with low strength and stiffness, provides air-fluid tightness and supports the reinforcing materials to maintain their relative positions. These positions are of great importance because they influence the resulting mechanical properties.

Shaping of The Polymer Composites

Basic necessities for any process…

Reinforcement Shaping

- to define **initial** architecture of reinforcement.

Part Shape Definition

- compressing reinforcement, or maybe prepreg, to **final** shape of the part.
- usually done within a **mould, or die.**

Matrix Infusion

- to fully immerse the reinforcing fibres in the polymer matrix.
- should expel all air, or voids, from part.

Matrix Solidification

- to provide for the necessary cure of a thermoset, or solidification of a thermoplastic.

Composite fabrication processes

A. <u>Spray lay-up:</u>

Chopped fibre (glass) and resin + catalyst (i.e. polyester) mixed in a hand-held gun and sprayed directly into the mould or on to the structure. Gives a random 2-D fibre array.

B. Wet lay-up, Hand lay-up:

Resins impregnated by hand (using rollers or brushes) into fibres (generally in the form of woven cloth). Only suitable for low-viscosity resins (may be warmed). Left to cure at room temperature. Roller used to spread resin and remove bubbles Gelcoat (resin only) on mould surface used to obtain good surface finish

C. Vacuum bagging:

- An extension of (b), but quality improved by applying hydrostatic (air) pressure through a flexible membrane before and during curing. Mould may be heated if the process is used to make finished goods; less easily done in the field for on-site repairs.
- The material may be supplied in the form of ***pre-preg*** (cloth plus uncured matrix resin in sheet or tape form)

D. Filament Winding:

Generally used for hollow (circular or oval sectioned) components, though large curved sheets can also be made by carving these up after winding. Fibre tows are passed through a resin bath before being wound onto a mandrel in a variety of orientations.

E. Pultrusion:

Fibres pulled through a resin bath and then through a die. If the composite is being produced in final form, the die is heated to cure the resin. Pultruded product may be small bundles or tapes of multiple fibres for subsequent processing, sheets (laminae, which are used for lay-up processes) or any extruded sections (e.g. rods, I-beams).

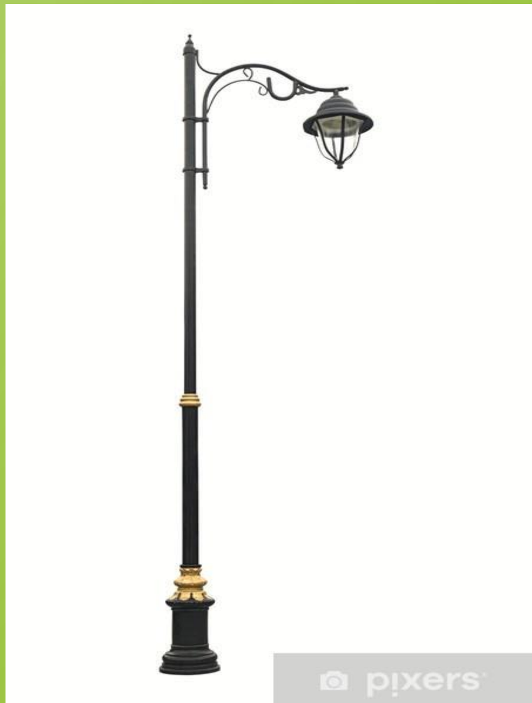
F. <u>Resin Transfer Moulding (RTM):</u>

Fibre cloth stacked up as a preform in a closed cavity mould, resin injected (if under vacuum, process known as Vacuum Assisted RTM), component cured in mould.

Usage Areas of Composites In Daily Life

Construction of:

- Buildings
- Bridges
- Housing
- Lampposts
- Smokestacks
- Highway culverts



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