Biomaterials

Third Stage

By

Prof. Dr. Qahtan Adnan Hamad

Lecture No. (3)

Bio-polymeric Materials

Introduction of Biopolymer

A variety of polymers both natural and synthetic are used as biomaterials are similar to other common materials that used in this field. They range from synthetic polymers such as polyethylene, poly methyl methacrylate and polystyrene, while the natural polymers such as starch, cellulose, c ollagen and gelatins.

Medicine Polymers

The medicine polymers engineering is the application of engineering science and technology to the solution of problems in medicine and biology. Biopolymers can be defined as materials, which are used in contact and interact with tissue, blood, cells and any other living substance.

Bio polymeric materials are chosen for different applications depending on their properties and are widely used in clinical applications such as dentistry, ophthalmology, orthopedics, cardiology, drug delivery, sutures, plastic and reconstructive surgery, extracorporeal devices, encapsulates and tissue engineering.

Therefore, the polymers materials have assumed an important role in medical applications. In most of these applications, polymers have little or no competition from other types of materials.

Choose of the Right Polymer for Biomedical Use

The choice of a specific polymer determined by consideration of the following:

1- A proper specification of the desired function for the polymer.

2- An accurate characterization of the environment in which it must function, and the effects that environment will have on the properties of the polymers.

3- A delineation of the length of time the material must function.

4- A clear understanding of what is meant by safe for human use.

Important Applications of Polymer in Biomedical Field

1. Tissue engineering.
2. Implantation of medical devices (cardiac pacemakers) and artificial organs.
3. Prostheses.
4. Dentistry.
5. Reconstructive surgery.
6. Kidney dialyses.
7. Bone repair.
8. Sutures.
9. Encapsulates.
10. Contact lenses.
11. Drug delivery and targeting into sites of inflammation or tumors.
12. Plastic tubing for intra-venous infusion.
13. Bags for the transport of blood plasma.
14. Catheter and vascular grafts.

Advantages of Biopolymers

1- Not expensive.

2- Flexibility.

3- Easy to fabricate.

4- Easy to manufactured into products with the desired shape.

5- Easy to make complicated items.

6- Resistance to corrosion and biochemical attack.

7- Low density (low weight).

8- May be biodegradable.

9- Good biocompatibility.

10- Low coefficient of fraction.

<u>Disadvantages of Biopolymers</u>

1- Low mechanical strength**.**
2- Thermo-sensitive.
3- Absorb water & proteins etc.
4- Wear & breakdown.
5- Biodegradation
6- Sensitive and difficult to sterilization techniques because of their permeability and porous structures.
7- Bacterial colonization because of their organic structure.

The main advantages of the **polymeric** biomaterials compared to **metal** or **ceramic** materials are ease of manufacturability to produce various shapes (sheet, fibers, ...etc.), processability, reasonable cost, and availability with desired mechanical and physical properties and lack of toxicity.

In orthopedic applications (screws…)

a. Metal alloys present greatest load bearing.
b. Polymers present lower load bearing.

In vascular applications (stents…)

a. Magnesium alloys degrade too fast in biological environment and they dissolve in the body.
b. Polymers degrade slower than magnesium alloys.

<u>General Classification of Biopolymer Materials</u>

In general, the biopolymer materials may be:

1- **Thermoplastic biopolymer:** materials that can be shaped more than once. (used as replacements for blood vessels.).
2- **Thermosetting biopolymer:** materials that can only be shaped once (used in dental devices and orthopedics such as hip replacements.).
3- **Elastomer biopolymer:** material that is elastic, if moderately deformed, they will return to its original shape (used as catheters).

Biodegradable Polymers

Biodegradable polymers are designed as temporary structures having the desired geometry and the physical, chemical, and mechanical properties required for implantation.

Recently, several biodegradable polymers such as **polylactide** (PLA), **polyglycolide** (PGA), **poly(lactide-co-glycolide)** (PLGA), **poly(carbonate)** are extensively used in a wide range of medical applications due to their good biocompatibility, controllable biodegradability, and relatively good process ability.

There are many important properties must be considered in the design of biodegradable biomaterials. These materials must

1) Not cause inflammatory response.
2) Possess a degradation time coinciding with their function.
3) Have appropriate mechanical properties for their use.
4) Produce nontoxic degradation products.
5) Include appropriate permeability and process ability for designed application.

These properties are greatly affected by a number of features of degradable polymeric biomaterials including: **material chemistry**, **molecular weight**, **water adsorption**, **degradation**, and **erosion mechanism**. Biodegradable polymeric biomaterials have been experimented with as:

(1) Vascular grafts.

(2) Vascular stents.

(3) Nerve growth.

(4) Defected bone.

(5) Ligament/tendon prostheses.

Mechanisms causing degradation

A- Physical Mechanisms

1. Sorption/swelling.
2. Softening.
3. Dissolution.
4. Cracking due to stresses and fatigue.

B- Chemical Mechanisms

- Hydrolysis, Oxidation and Enzymatic.

Natural Polymers

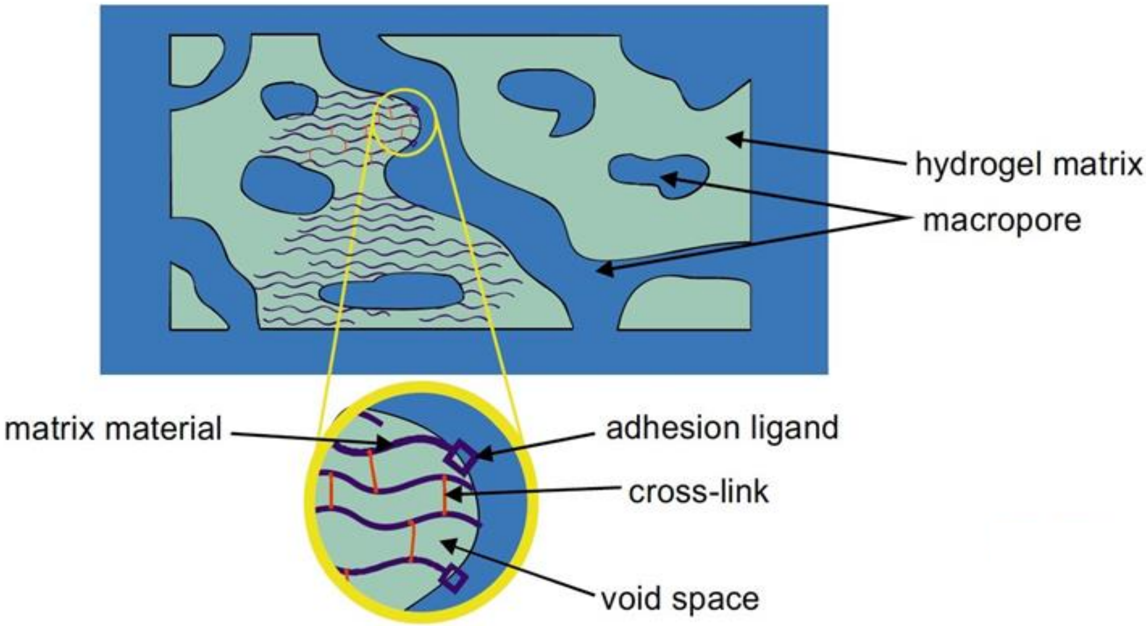
Natural polymers, is polymers derived from living creatures, which are of great interest in the biomaterials field such as proteins, alginate, collagen, gelatin, and chitosan. In the tissue-engineering, for example, scientists and engineers look for scaffold on which one may successfully grow cells to replace damaged tissue. Typically, it is desirable properties for these scaffolds to be:

(1) Biodegradable.
(2) Non-toxic/ non-inflammatory.
(3) Mechanically similar to the tissue to be replaced.
(4) Highly porous.
(5) Encouraging of cell attachments and growth.
(6) Easy and cheap to manufacture.
(7) Capable of attachment with other molecules (increase scaffold interaction with normal tissue).

Normal polymers often easily fulfill these points, as they are naturally engineered to work well within the living body from which they come.

Hydrogels Polymers

The hydrogel polymer can be defined as a crosslinked polymeric network using in drugs delivery applications which has the capacity to hold water within its porous structure, the amount of water present in a hydrogel may vary from 10%-20% to thousands of times of the weight of the zerogel and hence become swollen. **A zerogel** may be defined as a polymeric network devoid of water.



The water holding capacity of a Zerogel is dependent on:

1- Type of functional group of polymers: the water holding capacity of the hydrogels arise mainly due to the presence of hydrophilic groups in polymer chains, such as amino, carboxyl and hydroxyl groups, in the polymer chains.

2- The number of the hydrophilic groups: the higher the number of the hydrophilic groups, lead to higher in the water holding capacity.

3- Cross linking density: the cross linking decrease water holding capacity because of ionic interaction and hydrogen bonding. When increase in the crosslinking density there is a decrease in the swelling due to the decrease in the hydrophilic groups in polymers.