# Biomaterials

## *First Course*

### *Third Stage*

By

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## Lecture No. (4)

## Types of Bio-polymeric Materials

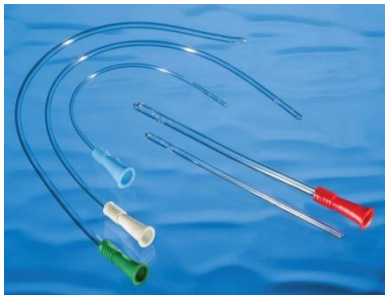
**Polymers used as Biomaterials:**

Although hundreds of polymers are easily synthesized and could be used as biomaterials only ten to twenty polymers are mainly used in fabrication of medical device and materials implants in human body from disposable (one time) to long-term.

**1- Polyvinylchloride (PVC)**

The PVC sheets are used in blood and solution storage bags. PVC tubing is commonly used in intravenous (IV), dialysis devices, catheters, and cannulae (i.e. mostly for external use).

**Cannulas**



**Catheters Tubes**

**2- Polyethylene (PE)**

The Polyethylene (PE) it is essentially:

1- Stable and suitable for long-time implantation under many circumstances.
2- Relatively inexpensive.
3- Has good general mechanical properties.

So that it has become a versatile biomedical polymer with applications ranging such as: catheters and joint-replacement. There are many types of PE include:

HDPE: is used in pharmaceutical bottles.

LDPE: is used for flexible container applications, disposable for packaging.

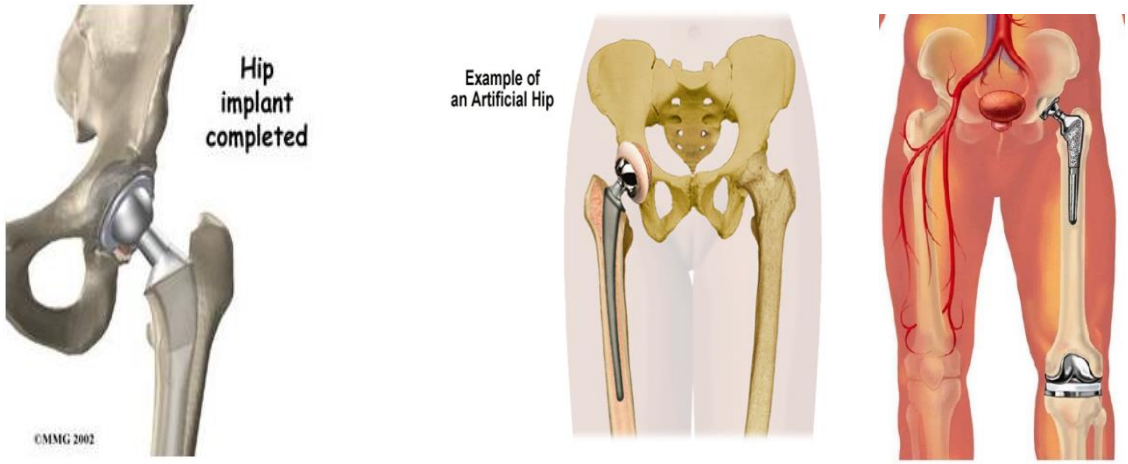
LLDPE: is employed in bags due to its excellent puncture resistance.

UHMWPE: has been used for fabrication of orthopedic implant, especially for load bearing applications such as total joint implants, hip joints and the surfaces knee joints. The properties of UHMWPE are:

a- Superior wear properties.

b- Tough.

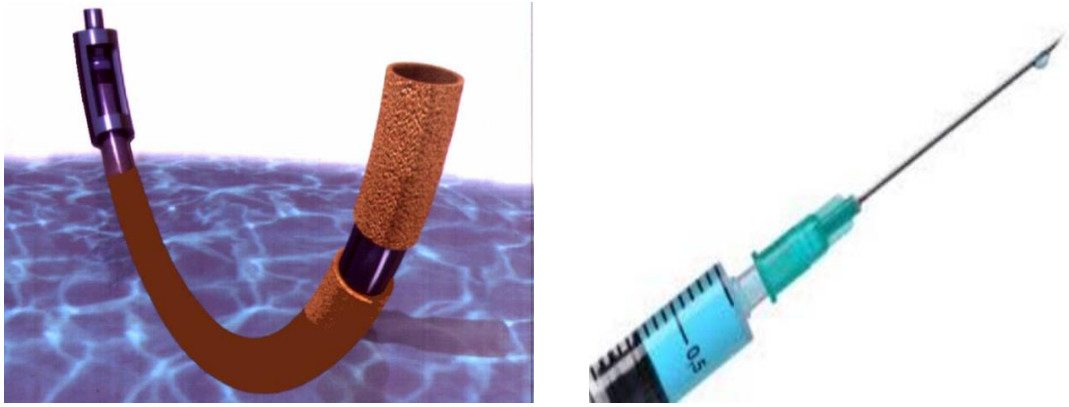
c- Ductile.




**Hip and Knee Joint Replacement**.

## 3- Polypropylene (PP)

Polypropylene (PP) is used to make disposable syringes, packaging for devices and drugs, suture, artificial vascular grafts, etc.



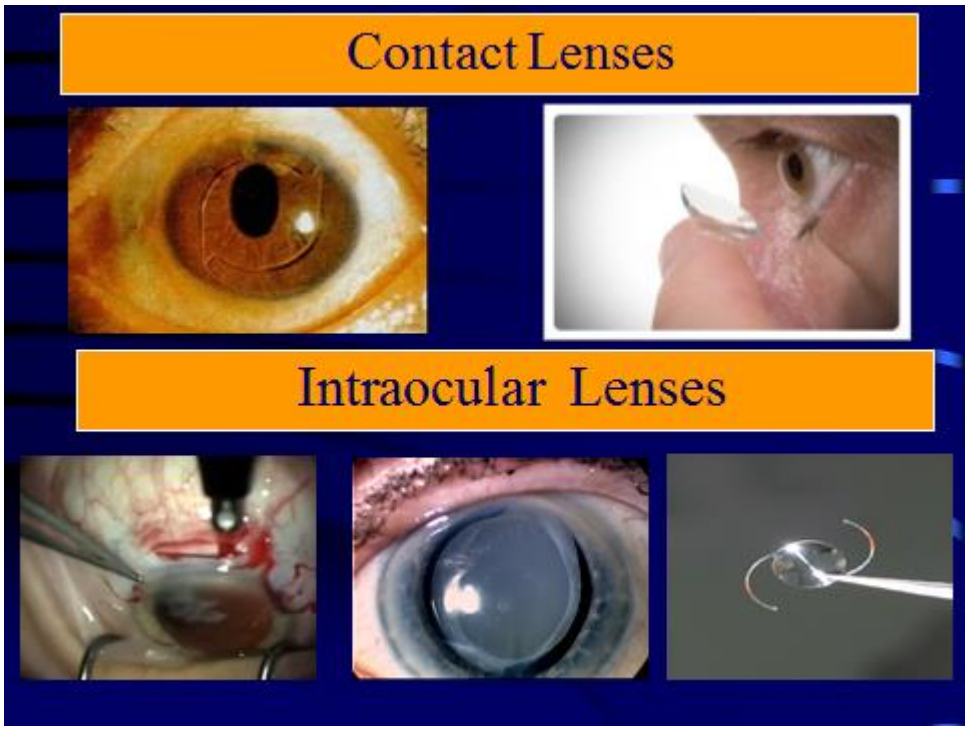
**Artificial Heart Vascular Grafts and Syringe Needle.**

## 4- Poly Methyl Methacrylate (PMMA)

PMMA is a hard and brittle thermoplastic polymer that appears to be unsuitable for most clinical applications, but it does have several important characteristics, that appears to be suitable for some clinical applications. The polymer is consisted from by mixing polymethylmethacrylate powder and

methylmethacrylate monomer liquid, which forms a dough stage that can be placed in the location, where it then sets.

PMMA is used broadly in medical applications such as a blood pump and blood tank, and membranes blood dialyzer. It is also found in contact lenses and implantable ocular lenses due to excellent optical properties, dentures, maxillofacial, and prostheses due to good physical and coloring properties, and bone cement for joint prostheses fixation.




**Disadvantage of PMMA:**

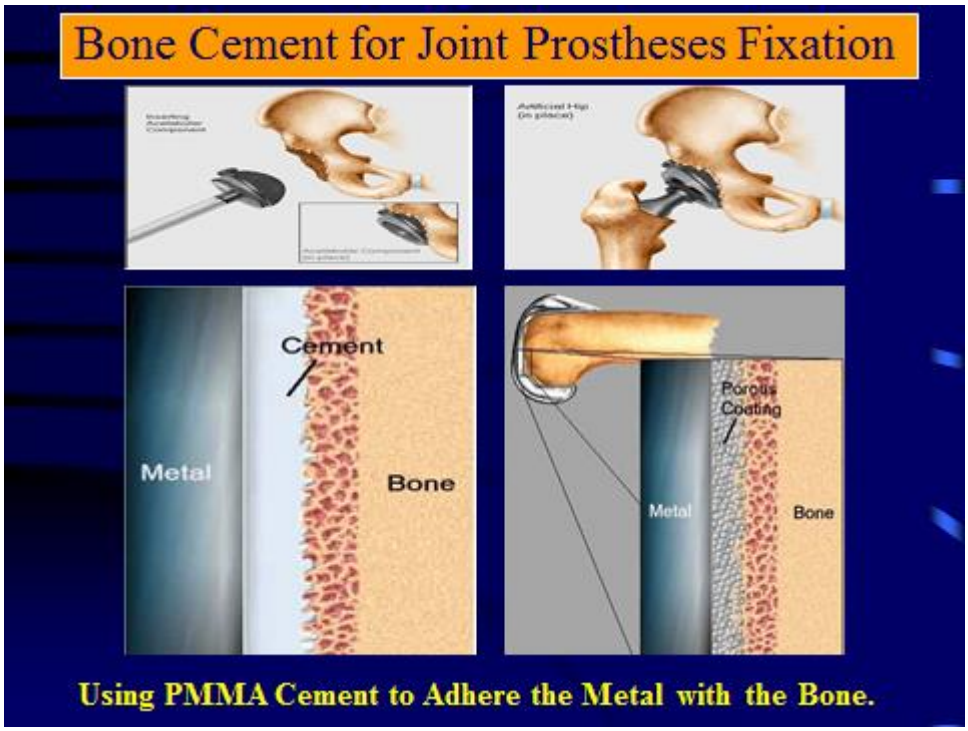
A- The exotherm of polymerization.

B- The toxicity of the volatile methylmethacrylate.

C- The poor fracture toughness.

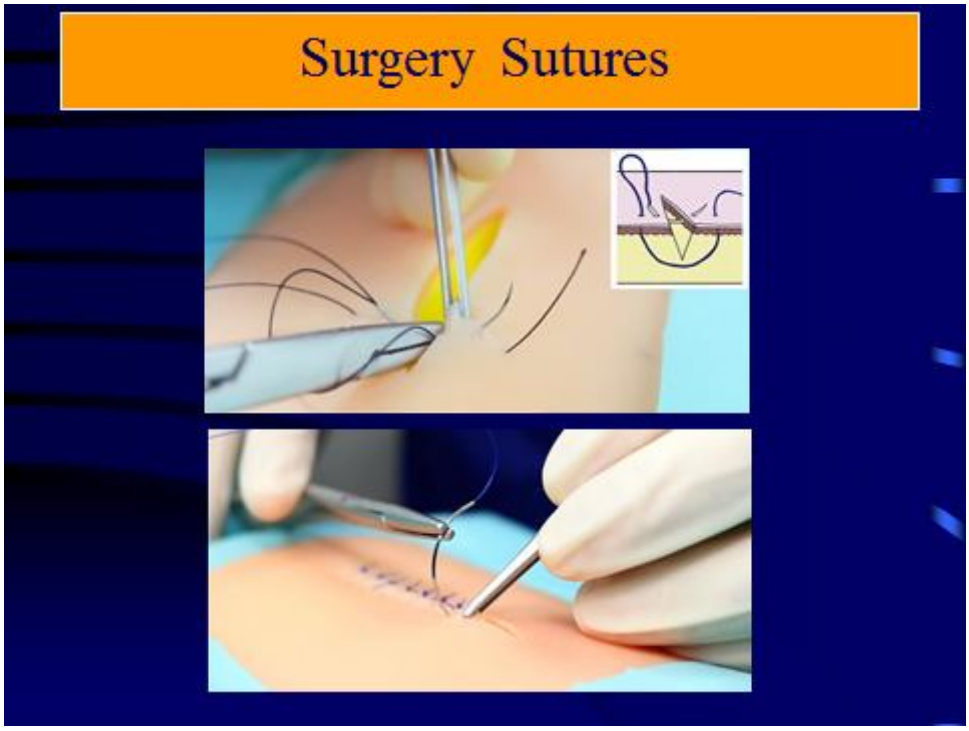
D- The hard and brittle polymer.

***Bone cement***: Mixture of polymethylmethacrylate powder and methylmethacrylate monomer liquid to be used as a grouting material for the fixation of orthopedic joint implants.



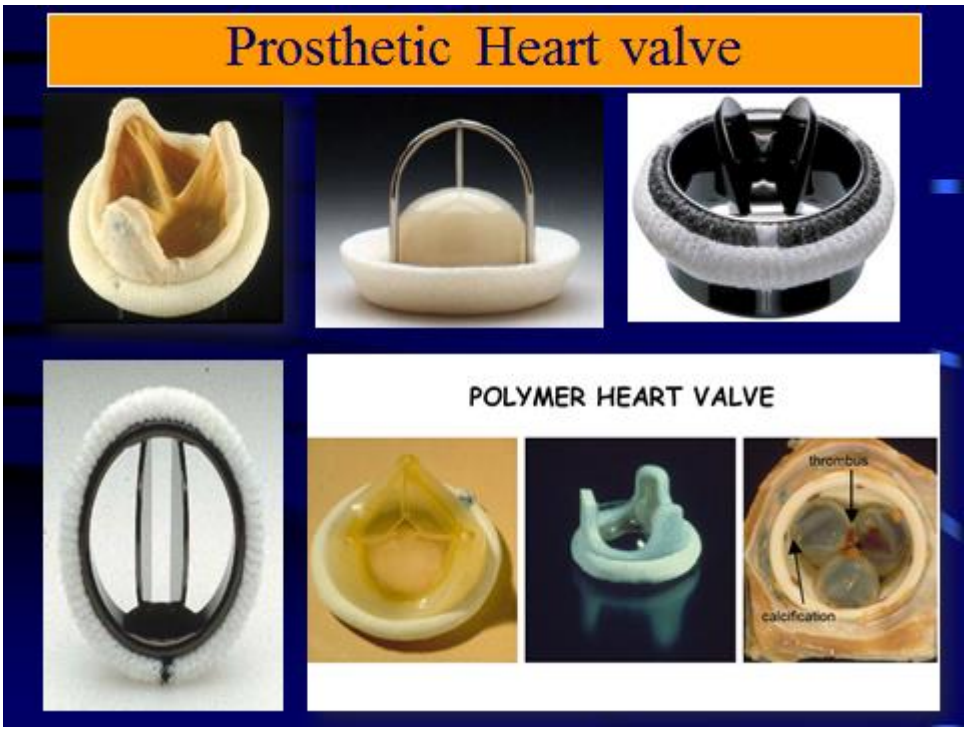

**5- <u>Polyesters</u>**

The polyester used for artificial vascular graft, sutures as a soft matrix and coating.



**6- Polyurethanes**

Polyurethanes are widely used for a number of biomedical applications including: coat implants, coat arteries, cardiovascular prostheses, catheters and pacemakers (as insulator), artificial heart valves, maxillofacial and ligament reconstruction. Because of their good mechanical properties and blood biocompatibility.




**7- Polycarbonates**

The polycarbonates have found their applications in the heart/lung assist devices, food packaging**.**

**8- Polyethylene terephthalate.**

Polyethylene terephthalate is one type of polymer is used in the artificial heart valves and large arteries, because tissue will grow through a polymer mesh. which called Dacron.

**9- Polytetrafluoroethylene (PTFE)**

Polytetrafluoroethylene (PTFE) is a fluorocarbon–based polymer. Commercially, the material is best known as Teflon. It is made by free- radical polymerization of tetrafluoroethylene and has a carbon backbone chain, where each carbon has two fluorine atoms attached to it.

**Properties of PTFE**

1- Hydrophobic (Water hating)

2- Biologically inert*

3- Non-biodegradable.

4- Has low friction characteristics.

5- Excellent "Slipperiness".

6- Relatively lower wear resistance.

7- Highly crystalline (94%)

8- Very high density (2.2 $kg.m^{-3}$)

9- Low modulus of elasticity (0.5MPa)

10- Low tensile strength (14MPa)

*** The chemical inertness (stability) of PTFE is related to the strength of the fluorine-carbon bond. This is why nothing sticks to this polymer.**

**PTFE has many medical uses, including:**

1- Arterial grafts (artificial vascular graft).

2- Catheters.

3- Sutures.

4- Uses in reconstructive and cosmetic facial surgery.

**Disadvantages of PTFE**

PTFE has relatively low wear resistance. Under compression or in solutions where friction or abrasion can occur, it can produce wear particles. These can result in a chronic inflammatory reaction, an undesirable outcome.

**10- Silicon Rubber**

These polymers are characterized by alternating silicon and oxygen atoms in their backbone silicone elastomers are used extensively in the biomedical industry, they have good blood biocompatibility.

**Applications of Silicones in Medical Fields:**

1. Cardiovascular applications including catheters.
2. Orthopedics include: Prostheses to replace finger joints, Carpal and foot bones.
3. Jaw augmentation.
4. Nasal supports.
5. Maxillofacial.
6. Aesthetic implant.
7. Spine.

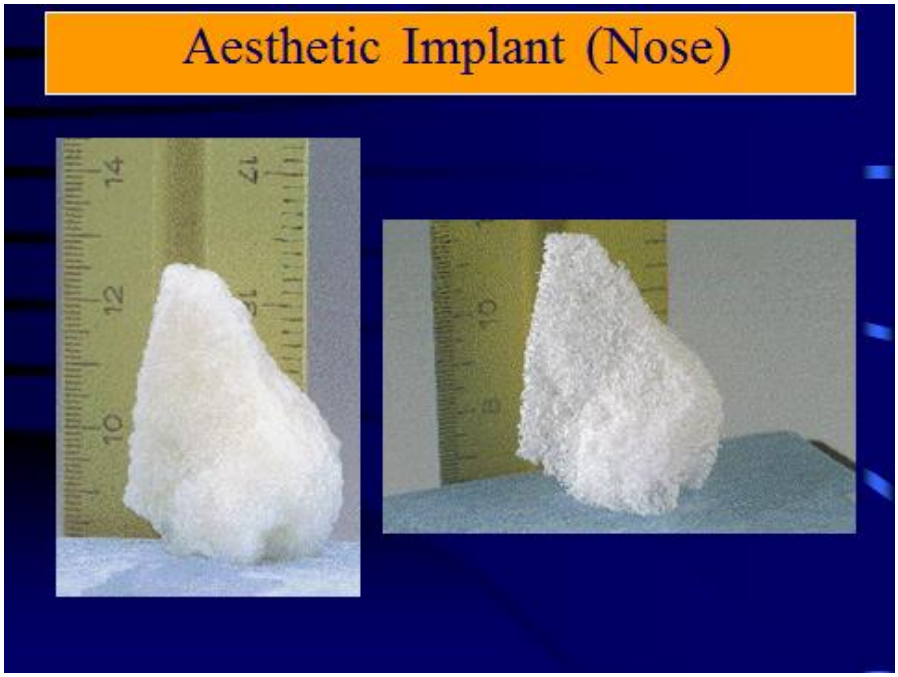


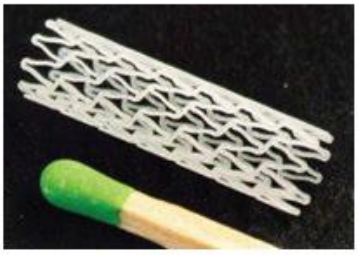
**Table (1): Show the Bio-polymer Materials are used in Important Biomedical Applications.**

| Application | Properties and design requirements | Polymers used |
|---|---|---|
| Dental | • stability and corrosion resistance.<br>• strength and fatigue resistance.<br>• good adhesion/integration with tissue.<br>• low allergencity. | PMMA<br>Polyamides |
| Ophthalmic | gel or film forming ability<br>oxygen permeability | Polyacrylamide<br>Polyhydroxy ethyl methacrylate |
| Orthopedic | strength and fatigue resistance<br>good integration with bones and muscles | PE,<br>PMMA |
| Cardiovascular | • fatigue resistance<br>• sterilizability | Silicones, Teflon, Poly(urethanes) |
| Drug delivery | • compatibility with drug, biodegradability | Silicones |
| Sutures | • good tensile strength, strength retention<br>• flexibility | PP, Nylon |

Acetabular cup of hip joint

Spinal cage for spine fusion

Vascular Implants & Stents



Cartilage