



University of Al-Mustaqbal
College of Science
Department of Medical
Physics



Biomaterials

Stage : fourth

LEC (5)

Polymeric Biomaterials

BY

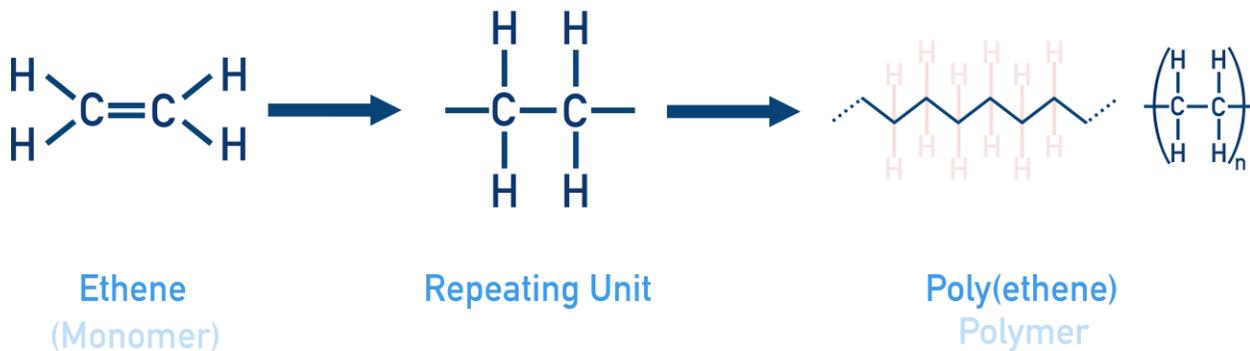
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1. Introduction

Polymeric biomaterials are widely used in modern medical applications due to their versatile physical and chemical properties. A **polymeric biomaterial** is defined as a polymeric material designed to interact with biological systems for medical purposes without causing harmful effects.

Polymers are **macromolecules** composed of repeating structural units called **monomers** linked by covalent bonds to form long molecular chains. Compared with metals and ceramics, polymers offer greater flexibility, lower density, and easier processing. These characteristics make them suitable for a wide range of medical devices and applications in medical physics.

For biomedical use, polymers must exhibit several essential properties including **biocompatibility, chemical stability, suitable mechanical properties, and the ability to be sterilized.**



2. Properties of Polymers Used in Medical Applications

Polymers used in biomedical applications must possess several important characteristics.

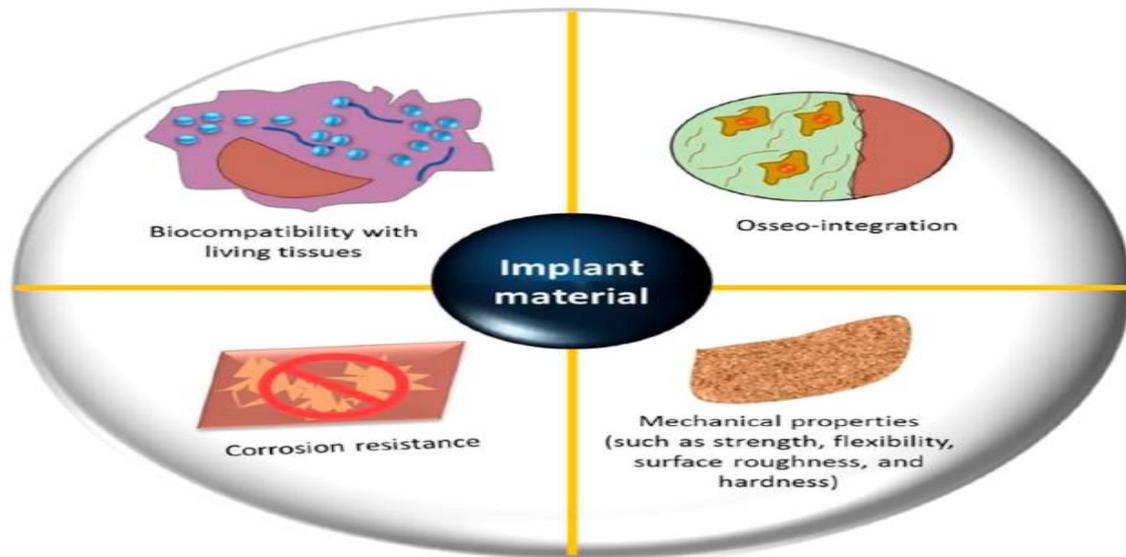
First: biocompatibility, meaning the material should not produce toxic effects, inflammation, or immune reactions when in contact with tissues or body fluids.

Second: appropriate mechanical properties, such as flexibility, strength, and resistance to fracture, especially for devices exposed to mechanical stresses.

Third: chemical stability, ensuring that the material resists degradation or chemical reactions in the biological environment.

Fourth: ease of processing, since polymers can be manufactured through various techniques such as molding, extrusion, or 3D printing.

Finally, the material must tolerate **sterilization methods**, including heat, radiation, or chemical sterilization, without losing its properties.



3. Classification of Polymeric Biomaterials

Polymeric biomaterials are generally classified into two main categories.

3.1 Non-biodegradable polymers remain stable in the body for long periods without significant degradation. These materials are commonly used in long-term medical devices. Examples include polyethylene (PE), polyurethane (PU), silicone, and polyvinyl chloride (PVC).

3.2 Biodegradable polymers, on the other hand, gradually degrade inside the body into non-toxic products that can be absorbed or excreted. These polymers are typically used in temporary medical applications such as sutures or drug delivery systems.

In many medical physics applications, particularly in radiation measurements and medical devices, **non-biodegradable polymers are preferred because of their stability.**

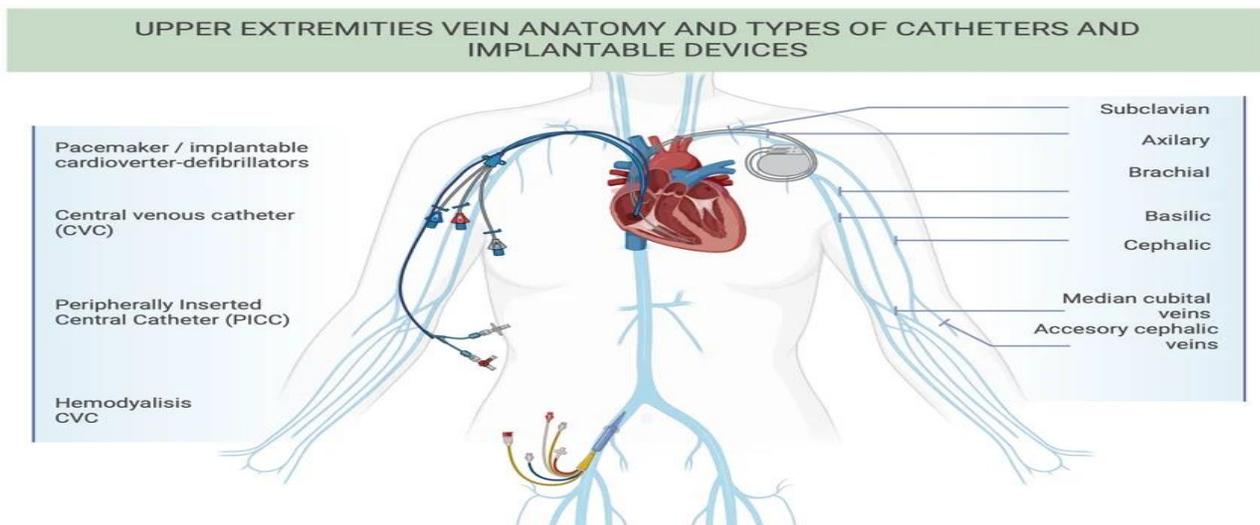
4. Applications of Polymers in Catheters

A catheter is a flexible medical tube inserted into the body for diagnostic or therapeutic purposes. Catheters are commonly used to deliver medications, drain fluids, or perform measurements within blood vessels or organs.

Catheters are often made from polymers because they provide the necessary flexibility and durability.

- **Polyurethane** is widely used due to its high mechanical strength and flexibility, making it suitable for vascular and cardiac catheters.
- **Silicone** is an important material for long-term catheters because of its high biocompatibility and resistance to biological reactions.
- **Polyvinyl chloride (PVC)** is commonly used for short-term catheters and medical tubing, as its flexibility can be adjusted using plasticizers.

Materials used in catheter manufacturing must have high flexibility, resistance to bending, minimal interaction with blood, and good compatibility with sterilization processes.



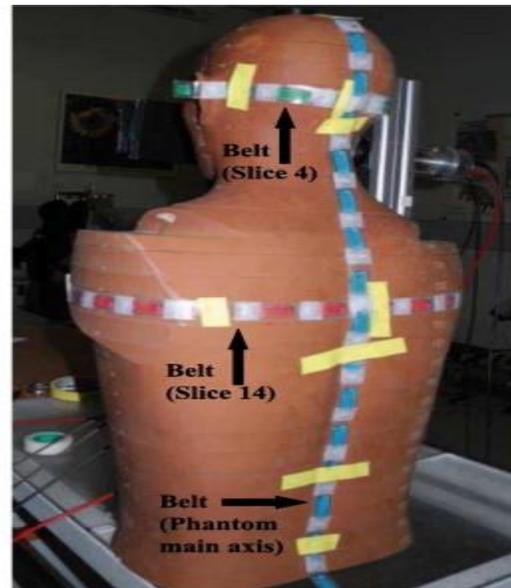
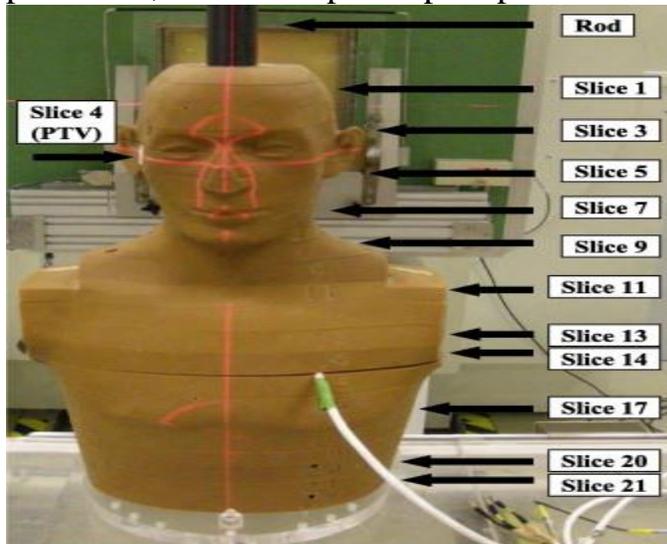
5. Polymers in Radiation Phantoms

A phantom is an artificial model designed to simulate human tissues for use in medical imaging and radiation therapy research. Phantoms play a crucial role in calibrating radiation therapy equipment and analyzing radiation dose distributions.

Polymers are commonly used in the construction of phantoms because their physical properties can be tailored to mimic those of human tissues, including density and radiation attenuation characteristics.

- **Polymethyl methacrylate (PMMA)**, also known as acrylic, is one of the most widely used materials. It is favored in X-ray and radiotherapy phantoms due to its stability, durability, and water-like density.
- **Polystyrene** is another polymer frequently employed in radiation experiments and dose measurement studies.
- **Epoxy resins** are often used to create complex three-dimensional anthropomorphic phantoms that replicate the anatomical shape of the human body.

Phantoms are generally classified into three categories: water phantoms, solid phantoms, and anthropomorphic phantoms.



6. Polymers in Radiation Dosimetry

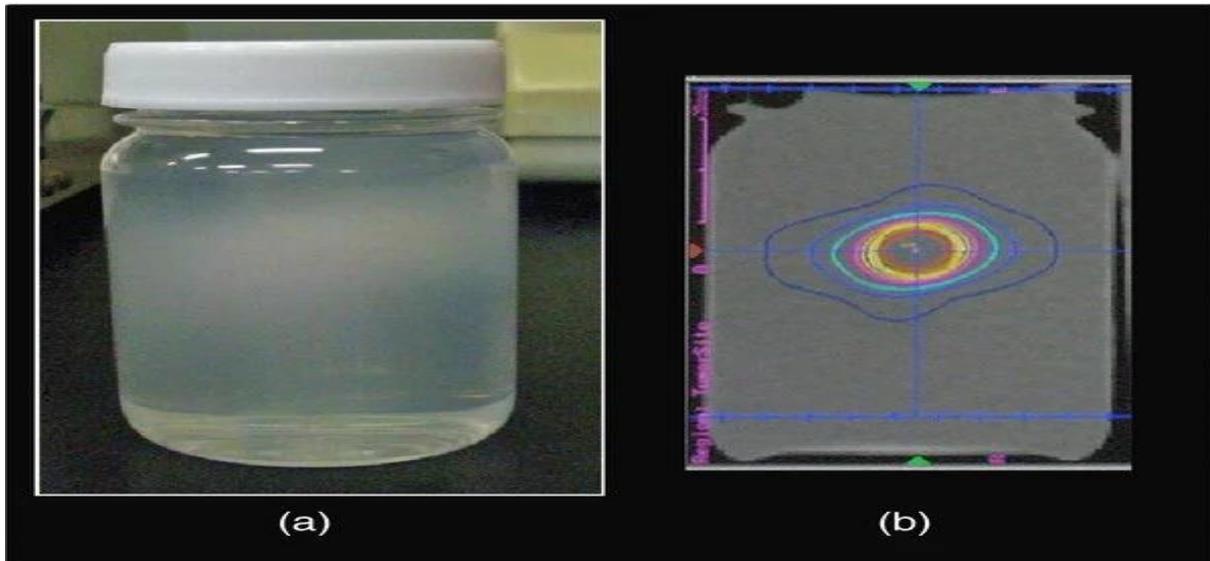
Radiation dosimetry involves measuring the amount of radiation absorbed by materials or biological tissues. It is a critical process in radiation therapy, radiation protection, and the calibration of medical and industrial equipment.

Polymers are key components in modern dosimetry systems because their chemical or physical properties can change upon exposure to radiation.

- **Polymer gel dosimeters** are an important example; they can measure three-dimensional radiation dose distributions, making them particularly valuable in advanced radiotherapy techniques.

- **Plastic scintillators** are another type of polymer used in dosimetry. They emit light when exposed to radiation, and the intensity of the emitted light can be measured to determine the radiation dose.
- **Radiochromic polymer materials** change color upon exposure to radiation, providing a straightforward and accurate method for assessing the absorbed dose.

Polymers thus offer versatile and precise tools for a wide range of radiation measurement applications.



7. Advantages of Polymers in Medical Physics

Polymers offer several advantages in medical and radiation applications. They are lightweight, inexpensive, and easy to manufacture. Their physical and chemical properties can also be tailored for specific medical uses.

Additionally, polymers can be fabricated in transparent forms or complex shapes, which makes them ideal for medical devices and anatomical models used in research and training.

CERAMICS VS METALS VS POLYMERS – ENGINEERING MATERIALS COMPARISON		
CERAMICS	METALS	POLYMERS
 High Heat Resistance	 High Heat Resistance	 Low-to-Medium Heat Resistance
 Brittle, Hard Behavior	 Ductile, Strong Behavior	 Viscoelastic Behavior
 Excellent Chemical Resistance	 Varies Chemical Resistance	 Good Chemical Resistance (Specific)
 Electrical Insulator	 Good Electrical Conductor	 Electrical Insulator (Typically)
 Low Flexibility	 High Flexibility	 High Flexibility

8. Limitations and Challenges

Despite their advantages, polymeric biomaterials have some limitations. Certain polymers may degrade over time or when exposed to high radiation doses. Their mechanical or physical properties may also change due to temperature variations or absorption of biological fluids.

Therefore, careful selection of polymeric materials is necessary depending on the specific medical or radiation application.

