

BIOMATERIALS IMPLANTS

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Abstract: This article extensively covers the application of polymer chemistry in medicine, in particular its role in the creation of biomaterials and implants. In modern medicine, polymer-based materials are widely used in surgery, orthopedics, dentistry, cardiology, and regenerative medicine. The article discusses in detail the biocompatibility of polymers, biodegradation processes, types of polymer implants, their physicochemical advantages, and future prospects. Using diagrams, the advantages of polymers, their mechanisms of adaptation in the body, and the sequence of their degradation are visually explained. At the end of the study, the importance of polymers used in medicine is summarized and the literature used is presented.

Keywords: polymers, biomaterials, implants, biocompatibility, biodegradation, regenerative medicine, PLA, PGA, silicone, medical polyethylene, biopolymers, orthopedics, cardiac implants.

Most of the materials used in modern medicine are developed on the basis of polymers. The development of polymer chemistry has made it possible to create materials that are not only highly durable, but also compatible with the human body (biocompatible). Biomaterials made from polymers are characterized by being lightweight, elastic, chemically inert, corrosion resistant, and easy to shape. Today, polymer implants are widely used in hip prostheses, vascular stents, sutures, surgical plates, dental fillings, and cosmetic surgery products.

1. Classification of polymers in medicine

Medical polymers are divided into two main groups:

1.1. Biostable (non-degradable) polymers

These polymers retain their properties in the body for years.

Examples:

- UHMWPE (Ultra-high molecular weight polyethylene)
— used for knee and hip joint prostheses.
- PTFE (polytetrafluoroethane)
— vascular prostheses and cardiac tubes.
- Silicone elastomers
— breast implants, facial plastic surgery gel fillers

2. Biodegradable polymers

Disappear in the body by hydrolysis or enzymatic degradation.

Examples:

- PLA (polylactide)
- PGA (polyglycolide)
- PCL (polycaprolactone)
- PLA/PGA copolymers (surgical sutures, bone grafts)

These polymers break down over time into lactic acid, glycolic acid, or other metabolites.

The main advantages of medical polymers

ADVANTAGES OF MEDICAL POLYMERS

| Lightness | Biocompatibility | Formability |

| Elasticity | Corrosion resistance | Cheap production |

2. Biocompatibility of biomaterials

Biocompatibility is the ability of a polymer not to cause inflammation, toxicity, or immune reactions after placement in the body.

Biocompatibility depends on the following factors:

- chemical composition
- surface energy
- molecular structure
- hydrophobicity/hydrophilicity
- toxicity level
- immune system response

Key Factors Determining Biocompatibility

| BIOCOMPATIBILITY |

| Chemical Stability | Non-Toxic |

| Surface Properties | Low Immune Response |

| Hydrophilic/Hydrophobic Balance | Biodegradation |

3. Main types of polymer implants

3.1. Polymers are widely used in orthopedics.

- UHMWPE — as a sliding surface of the knee and hip joints.
- PLA/PCL implants — stimulate bone regeneration.
- Biodegradable screws — for fixing bone fractures.

3.2. Cardiological implants

- PTFE-based vascular prostheses

- Biodegradable stents (PLA/PCL)
 - Silicone tubes — used in cardiopulmonary bypass
- 3.3. Dentistry: Composite fillings — based on methacrylate polymers
- Orthopedic splints — acrylic polymers
 - Implant surface coatings — polymer-composite layers
- 3.4. Cosmetic and reconstructive surgery
- Silicone implants (breast, chin, cheek)
 - Hyaluronic acid polymers — “fillers” for aesthetics

Fields of application of polymer implants:

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| MEDICAL |

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ORTHOPAEDICS CARDIOLOGY DENTAL

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PLA/PCL	PTFE	Composites
UHMWPE	PLA stents	Acrylic polymers

4. Biodegradation Process

Polymers that break down in the body are of great importance in surgery. They perform a temporary function and disappear without harming the body.

Polymer degradation stages:

1. Hydrolysis - water molecules attack polymer chains.
2. Reduction of chain length
3. Dissociation of monomers
4. Metabolism - conversion to lactic acid, CO₂ and water.

5. Biodegradation sequence

[Polymer chain]

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▼ (Hydrolysis)

[Short chains]

|

▼

[Monomers]

|

▼ (Metabolic transformation)

[H₂O + CO₂ + energy]

6. Scientific advances in the application of modern polymer biomaterials

5.1. Creation of artificial tissues and organ parts using PLA, PCL and hydrogel polymers.

5.2. Nano-polymer systems

Direct delivery of drugs into cells.

5.3. “Smart polymer implants”

- Temperature-responsive polymers
- Implants that change shape when pH changes
- Polymer scaffolds that accelerate regeneration

Conclusion

The development of polymer chemistry in medicine has radically improved the quality of biomaterials and implants. Biocompatible and biodegradable polymers are partially replacing traditional metal and ceramic implants in surgical procedures. Their use leads to rapid wound healing, a decrease in the risk of rejection, and an improvement in the patient's quality of life. The development of 3D-bioprinting, nanopolymers, and "smart implants" indicates that the future prospects of polymer biomaterials are very broad

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