

Review Article**Open Access****A Review on role of biomaterials in biomedical field**

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Abstract: Over the past few decades, we have seen impact advancement in the field of biomedical engineering and it ultimately leads to development in biomaterials. In the ancient world, Egyptians use the technology of biomedical engineering with the help of biomaterials. They have artificially corrected different sections of their body such as ears, eyes, teeth, and noses. Now, in the modern world we can clearly see advancement in biomaterials in the form of implants such as bone plates, bone cement, blood tubes, pacemakers, artificial heart, etc., are widely used to improve or correct dysfunction of degenerated or impaired tissues or organs in a patient. Thus, improving the life and quality of a patient. The basic need that we want in biomaterial is that materials should have high resistance to corrosion and wear; it should have good strength and shear, long life and least toxicity inside a patient. In this review, we have discussed biomaterial, their types along with their examples, advantages, disadvantages and their applications and what are the factors that we should keep in our mind before choosing any biomaterial.

Key words: Biomedical Engineering, Biomaterials, Implants

Introduction

In our Ancient Civilizations, we found uses of biomaterials in form of artificial ears, eyes, teeth, and noses that were found on Egyptian mummies. In early days, natural biomaterials such as wood, glue, rubber, and tissues from living ones and beside this, we also have manufactured materials such as iron, gold, silver, zinc, glass were also used as biomaterials. In Indian and as well Chinese civilization, use of biomaterials as waxes, glues, and tissues in reconstructing or defective parts of the body¹. Biomaterial is made as a structure or device or material that is used as an implantable material or repairing tissues as per need. Biomaterials can be classified as natural or synthetic as per their origin. Biomaterials can vary depending upon their physical, chemical, mechanical and specially their biological property².

A Standard Definition of Biomaterial by "The National Institutes of Health Consensus Development Conference" is Any substance (other than a drug) or combination of substances, that may be natural or synthetic in

origin, for any period of time which can be used, as a part or as a whole of a system which treats, augments, or replaces any tissue, organ, or function of the body³. Meanwhile, other definition of term "Biomaterials" can be any material whether from the natural or synthetic origin, that comprises whole or part of living structures or biomedical devices which performs, augments, or replace a natural function. In US alone every year 13 million medical devices are used^{5, 6}. In different parts of body, biomaterials can be used as artificial valves in the heart, stents in the blood vessels, replacement implants in the shoulders, knees, hips, elbows, ears and orthodontics structures⁷.

In Biomedical Application because of their outstanding properties, natural and synthetic polymers are common choices. Natural polymers offers good bioactivity and cytocompatibility such as collagen and fibronectin, silk fibroin, fibrin, chitosan etc whereas synthetic polymers offers good physicochemical properties i.e. microstructure,

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degradation rate, mechanical properties, porosity etc. due to which it is widely used in tissue engineering applications. Example of synthetic polyester that offers good structural tenability and good mechanical strength are⁸:

1. Polycaprolactone (PCL)
2. Poly Lactic-co-glycolic acid (PLGA)
3. Poly-Lactic Acid (PLA)
4. Polyvinyl Acetate (PVA)

Factors to be considered for the selection of a Biomaterial

Factors to be kept in mind while designing and selecting the parameters for biomaterial to avoid immune rejection with long term usage in body and have a successful, distant future of biomaterial inside or outside usage in the body^{9, 10}.

1. Biological Compatibility or Biocompatibility.
2. Adequate Mechanical Properties of Biomaterials.
3. High Corrosion Resistance.
4. High Wear Resistance.
5. Osseointegration
6. Toxicology

Biological Compatibility or Biocompatibility:

Biological Compatibility or Biocompatibility may be defined as "Ability or capacity of the material to be used in close connection with living tissue without causing damage or adverse effect to them^{11, 12}. Materials by which implants are made should be non toxic and does not show any inflammatory or allergic reactions, physical irritation, toxicity, mutagenic or carcinogenic action in human body^{13, 14, 15}.

Materials have must set of properties to be used safely in a biological organism are¹⁶:

1. Non-Carcinogenic
2. Non-Pyrogenic
3. Non-Toxic
4. Non-Allergenic
5. Blood compatible
6. Non-Inflammatory

Problems associated with Biocompatibility are¹⁷:

1. Adhesion of Blood Platelets to the surface of Biomaterials.

2. Blood clotting (Thrombosis)
3. Encapsulation of fibrous tissues from implanted soft tissue biomaterials.

Adequate Mechanical Properties of Biomaterials

It refers to biomaterials should be selected according to mechanical strength depending upon its site to be implanted and function to be performed¹⁸. Biomaterials and Bio implants shall have appropriate mechanical strength to withstand all forces and loads. Biomaterials should have following properties to withstand all forces and loads are¹⁹:

1. Biomaterials should have good tensile strength.
2. Biomaterials should have better yield strength.
3. Biomaterials possess' elastic modulus.
4. Biomaterials should be resistance to corrosion and fatigue.
5. Biomaterial's surface should be finish.
6. Biomaterials should have good hardness property.

High Corrosion Resistance

We should high corrosion resistance materials for bio implants otherwise low corrosion materials may leads to toxic, allergic and harmful reaction within the body of patients due to release of harmful and toxic metal ions such as Fe, Cr, Ni, Co, and Ti^{20,21}. Corrosion may reduce the life of bio implants and leads to revision of surgery and this may indirectly effect to human life²².

High Wear Resistance

Role of High Wear Resistance in biomaterial to keep its better functioning and fix the position of implant in the tissue and to protect it from loosening in the tissue. If there is a problem of Low Wear Resistance then it can lead to dislocation of implant from its position and causes serious health problems to patient such as inflammation, release of enzyme, infection, pain, osteolysis, and bone resorption²³. So, high wear resistance may protect from unwanted reactions in the tissue and improving the quality of implants and as well as life of patient²⁴.

Osseointegration

Magnitude of bone modulus plays an important role in bone surgery such as in total joint replacement. Depending upon bone and the measurement direction, the magnitude of bone modulus may vary from 4 to 30 GPa. If there is a larger difference or gap of Young's Modulus between bone and implant, it may develop stress conditions around bone-implant and result in weak bone. If this condition persists for long time then it may result in deterioration of implant and bone interface and result in loosening of implant from its position and lead to development of inflammation, pain, infection and bone resorption and result in failure of implant²⁵.

Toxicology

Biomaterials should be non-toxic, non-irritant and non-inflammatory. Biomaterial should be made up of materials that are approved by various regulatory agencies such as USFDA. Material should have toxic level indication on it²⁶.

Types of Biomaterials

Primary there are 4 types of biomaterials.

1. Metallic Biomaterials^{27, 28, 29, 30}

These are one of the most used materials in biomaterial category. It is mostly use for its load bearing property, excellent and prevailing mechanical properties in application of Fracture, Dental and Knee implant.

Examples of Metallic Biomaterials: Titanium and its alloy, Gold, Silver, Stainless steel, Cobalt-chromium molybdenum, etc.

Advantages:

- It has good strength.
- It has high ductility and malleability.
- It has toughness.
- It has excellent fatigue resistance.

Disadvantages:

- It may get easily corrode, if proper precaution not taken.
- It has high density.
- It has high modulus.
- Sometimes, preparation is difficult.

Application

Used in mainly knee implants, joint replacements, dental root implants, bone plates and pins, screws, wires, due to high load bearing property of metal.

2. Ceramic Biomaterials^{31, 32, 33, 34}

Traditionally these biomaterials were used as restorative materials in dentistry as crowns, cement and dentures. This material are mostly used for medical implants due to its good biocompatible property, compression with low electrical and thermal conductivities and high resistant to corrosion. Due to all this property, it has low toxicity level and show efficiency in forming new bone tissue. There are different biomedical applications of ceramic biomaterials based on bioactivity. Now, research focus on developing nanostructure ceramics biomaterials.

Examples of Ceramic Biomaterials: Calcium Phosphate, Hydroxyapatite, Alumina, Zirconia, etc.

Advantages:

- It has great strength and stiffness.
- It has low density.
- It is Biocompatible.
- It has good corrosion and wears resistance property.

Disadvantages:

- It is brittle in nature.
- It has low resistance to fatigue.
- It has anisotropic mechanical properties under different loading conditions.

Applications

- Due to its good corrosion and wear resistance, it is used widely in coating for load bearing.
- It is used in Dental and Orthopaedic implants.
- It is used in medical sensors.

3. Polymeric Biomaterials^{35, 36, 37, 38}

It is considered one of the best materials when we compare with other biomaterials because it can easily manufacture in various shape, ease of secondary processing stage is easy, available at

reasonable cost, it can readily available with desired mechanical and physical properties. Due to all this advantage over metal and ceramic biomaterial, polymeric biomaterials are widely accepted biomaterials.

Examples of Polymeric Biomaterials: Nylon, Polyester, Silicon.

Advantages:

- It is light in weight.
- It has good resistance property to corrosion.
- It is Biocompatible.
- It is easy to fabricate.

Disadvantages:

It has problem of low strength and may deform with time. Result in complete or partial deformation process.

Applications

It can be used in implant of Heart Valves, Artificial Heart, Hip Joint Socket, Contact Lens, Blood Vessels and etc.

4. Bio composites or Composites Biomaterials^{39, 40,41, 42, 43}

In Composites, it is a heterogeneous mixing of two or more than two biomaterials, which are different or same in their physical and as well as in their chemical. By, this method we developed a material which has specific physical, chemical and mechanical strength now. By, this method we can have better quality of material which is not shown by single material.

Examples: Polysaccharides, Proteins, Sugars, Lignins, Synthetic Polymers

Advantages:

It has resistance against corrosion and wear. It has high biocompatibility.

Disadvantages:

- It lacks homogeneity.
- Face difficulty in preparation.

Applications:

It can be used in joint replacements, bone plates, rods, screw, bone cement, dentistry, etc.

Conclusion

Before choosing any biomaterials, we should observe fundamental properties of biomaterials for specific application that has to be performed by implant. Ideal biomaterial is those which have high resistance property against corrosion. So, that it avoid release of non-compatible metallic ions from the implant to the patient life. After all we just want a better bio implant in all respect that have long life and least adverse effect that can help us to improve the quality of patient life. These requirements may be in future fulfil by Composite or Bio composite biomaterial because of the property it have such as high resistance to corrosion and wear, high strength and stiffness compared to other form of biomaterials. I hope, we can see more advancement in composite biomaterials in future.

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