

7.1 Definition:

Bio-ceramics are ceramic materials specially developed for use as medical and dental implants. They are usually used to replace hard tissue in the body like bone and teeth.

7.2 Special ceramic for biological use and their characteristics:

The bio materials which are particularly use for bio ceramic purpose or replacement and reconstruction of segment of damaged bones, human body are :-

● Bio inert alumina, Zirconia and bio-active calcium phosphate.

(i) They are normally provide cellular prostheses or replacement part for the human body like skin, cartilage, bones etc.

(ii) Acellular replacement parts capable of inducing regeneration (Bone morphogenic protein)

(iii) Vehicle for delivering engineered cells.

Surfacing non biological devices, higher sensors, catheters, orthopedic devices can be prepared from ceramic materials.

Properties:

- ① They should be non reactive in nature.
- ② They should have the compatibility with the psychological environment.
- ③ They are composed of ions normally found in our body like calcium, K, Mg, Na and other ions showing limited toxicity to the body, tissues, Al, Titanium, Zirconium (Zr) etc.
- ④ The physiological media the ceramic suffer the loss of strength and decreasing ~~fatigue~~ ^{fatigue} properties and ~~ion~~.

Questions:

- ① Define bioceramics.
- ② What do you mean by hydroxyapatite?
- ③ What is the main goal of using ceramic inside the human body?
- ④ What are the ~~main~~ ^{most} common bio-ceramic materials?
- ⑤ What are the main characteristics of composed ion found in our body?

Main characteristics of bio ceramic:

Ceramic suffer a loss of strength in case of artificial joint where is one of the life emitting factor. For example - rate of wear in the lowest for Al_2O_3 , and femoral head. Al_2O_3 accept a blur curve combination of hip joint as compare to metal ultra high molecules polyethylene.

Most of the ceramic implant normally encounter by bone tissue. They are application like dental implant which can when used in bio-ceramic purpose this can be parsataneous device in one of the application of carbon as a hard valve the interaction mainly with the blood. Therefore, a number of application is still being experiment in orthopedic.

7.3 Bio materials, Bio glass and bio composites for medical application:

Bio materials:

Bio materials which are used for biological purpose mainly called bio materials. Bio materials play key role in a medical device

and implant used for diagnostic or therapeutic purpose. Among these a ceramic material do not occupy the leading role like polymer or vital hard tissue implant.

Use of ceramic essential for artificial joint like HIP (Hydroxy Implant Process), which are load bearing. The replacement or re-construction of segment of ~~the~~ disease or damage bone also cause for the use of bio ceramic.

Questions:-

- ① What are the alumina allopatular curve combination of HIP joint?
- ② How bio ceramic applied in dental implant?
- ③ What is bio-material?
- ④ How this biomaterial are essential for a artificial joint?
- ⑤ How the bio material have the more load bearing capacity?

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Page

This review covers the application of ceramics in the human body, outlining the specific requirements that call for the use of bioinert alumina, zirconia and the bioactive calcium phosphates. The effect of ceramic coatings on metallic implants, to promote bone ingrowth and bonding for effective load transfer, is presented.

The emerging area of tissue engineering that aims at creating conditions for promotion of natural tissues is expected to alter the future scenario of biomaterials including ceramics. In this ~~area~~ era of biological revolution, the design of functional materials based on molecular engineering may even do away with the use of current synthetic materials.

Background:

The living organisms have unique properties of programmed development, differentiation, growth and movement. The molecular self organisation characterizes the living state. They are also open system exchanging both energy and matter with surroundings. Biomaterials are the very stuff of life, providing structure, form and

function. Nature is adept in the synthesis of composite material like bone, horn, wood and shell which have interesting mechanical and physical properties. Natural composites have diverse microstructures, evolved over long periods of time, to perform complex multifunctional roles.

Questions :-

① What is effect of ceramic coating on metallic implant?

A:- The effect of ceramic coatings on metallic implants to promote bone ingrowth and bonding for effective load transfer is presented. The current application and potential of carbon coating, fibers and composites are outlined.

② Write the emerging area of biological revolution.

A:- The emerging area of tissue engineering that aims at creating conditions for promotion of natural tissues is expected to alter the future scenario of biomaterials including ceramics.

③ What is

③ What is the unique property of living organisms?

A: The living organisms have unique properties of programmed development, differentiation, growth and movement. They are also open system exchanging both energy and matter with surroundings.

④ Biomaterials are open or close system justify your answer.

A: Biomaterials are open system exchanging both energy and matter with surroundings. These are the very stuff of life, providing structure from function. Nature is adept in the synthesis of composite materials like bone, horn, wood and shell which have interesting mechanical and physical properties.

⑤ Write the physical property of biomaterials.

A: Physical properties of biomaterials are:

(i) They should match with human skin (colour)

(ii) This should load bearing.

(iii) They can replaced easily.

(iv) They should match with living organism like differentiation, growth & movement.

(v) They have diverse microstructure evolved over

long periods of time to perform complex multifunctional role.

Bio-glass

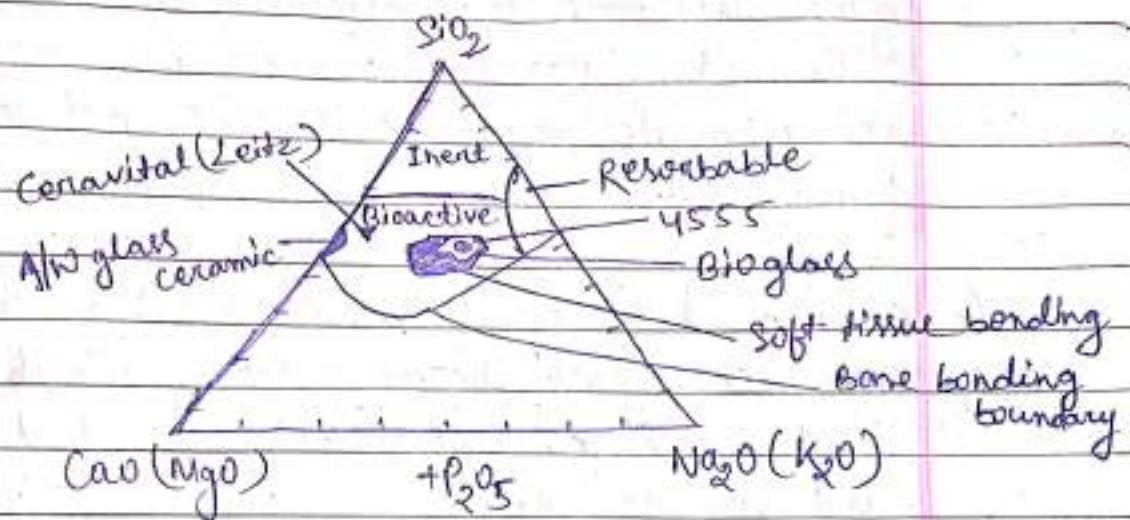
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Bio-glasses are also a part of bioceramics. In general, any bioglass is susceptible to both general corrosion and pitting attack in the body. The corrosion is brought about by the water penetrating the glassy network and replacing the alkali ion.

The alkali ion in solution produces OH^- ion, which destroys the Si-O-Si network and forms Si-OH bond. The latter can react with water. At pH less than 9, the alkali ion release is rapid and SiO_2 rich film is developed on the surface, which goes into solution. The release of SiO_2 is an important step for initiating bone mineralization. Thus a chemical bond can be formed between the glass and the bone.

The glass compositions are such that the dissolution is limited to the surface and at the same time, the kinetics of bond formation is reasonable. They can also form bonds with

Soft tissues. These materials are being tried as dental and middle ear implants. Though attractive scientifically, their applications are limited by their brittleness.



Compositional Ranges of bioactive glasses and glass ceramics.

Questions & Answers

① Define bioglass.

A: Bioglasses are the part of bio-ceramics. Bioglass is susceptible to both general corrosion and pitting attack in the body. It is composed of SiO_2 , Na_2O , CaO and P_2O_5 .

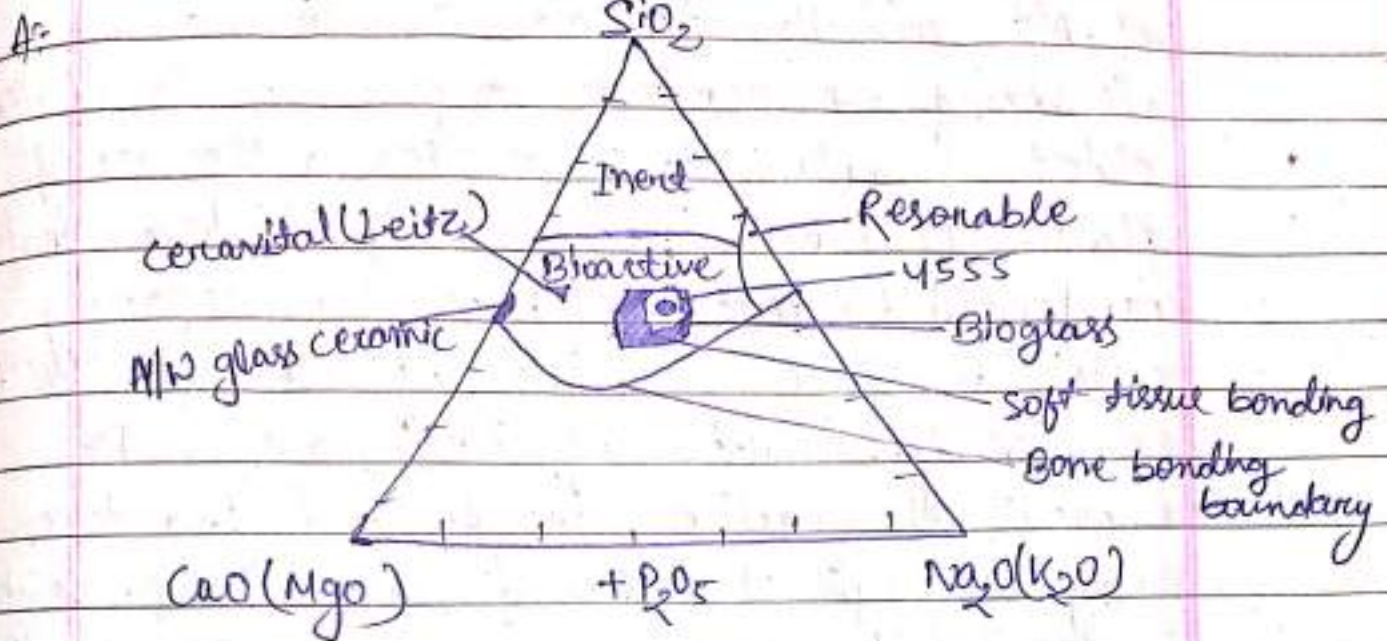
② How the alkali ion destroy Si-O-Si network?

A: Bioglasses are susceptible to general corrosion in the body. The corrosion is brought about by the water penetrating the glassy network and replacing the alkali ion. The alkali ion in solution produces OH^- ion and destroys the Si-O-Si network and forms Si-OH bond.

③ Compare between bioactive and bioinert glass.

A: Bioinert glass doesn't react with body but bioactive glass react with body and try to adjust.

Q Draw the triangular diagram of SiO_2 , CaO-MgO , and $\text{Na}_2\text{O}(\text{K}_2\text{O})$.



Q Write the application of bioglass.

- A:-
- Bioglasses are widely used in biomedical area.
 - Its primary application is the repair of bone injuries or defects.
 - These materials are being tried as dental and middle ear implants.

Bio Composite for medical application

Some of the limiting factors like inadequate strength of HA, the low fracture toughness of Al_2O_3 and HA etc, can be overcome by utilizing the ceramic composites. One of the oldest examples of composites is the use of plaster of paris (calcium sulphate hemihydrate) reinforced by textile fibres for preparing casts. There are a number of other possibilities such as the addition of ZnO to Al_2O_3 to increase the fracture strength and fracture toughness up to two times. Further improvement is feasible by adding SiC whiskers. Porous HA blocks can be infiltrated with biocompatible polymers or biodegradable polylactic acid to increase the bending strength. Maruno et al. have described a biocomposite coating (HA containing glass) on Ti dental implants that has better adhesion than the flame spread sprayed HA coatings. The composites based on the ceramic matrix are difficult to mfg with reproducible properties. Hence the applications in the biomedical field have not yet emerged.

Another alternative is to use the ceramic particles as fillers in the composites. In general,

These are added to polymers to:

- Increase abrasion resistance
- Decrease polymerization shrinkage
- Improve aesthetics (colour etc.)
- Induce bio-activity

Bio-degradable polymer - HA composites are being investigated as bone fillers. The role of the polylactic acid polymer is to prevent the movement of HA till the new bone is formed. The degradation rate of such resorbable polymers (co-polymer of polylactide and polyglycolide) can be varied from several weeks to a year by controlling the molecular weight, crystallinity etc. They alone or in combination with HA type of particles offer a viable alternative as bone graft materials. The same concept is also being used to develop new functional biodegradable bone cement for hip implants. An example of such cement is TCP (Tricalcium phosphate) dispersed in a gelatin-polyformaldehyde-salicylate matrix. It has a compressive strength of 7 MPa and a compressive modulus of 65 MPa. HA filler is also being tried as a bone compatible filler.

in the adhesive bone cement. Here, the role of HA is to facilitate direct bone bonding. This property of HA is also being utilized to develop HA filled glass ionomer cements that can chemically bond to the enamel and the dentin.

The use of composites is at present limited to the use of quartz or glass fillers in dental restorative materials. The use of calcium phosphate based ceramic particulates offers great potential in many applications requiring bonding with the bone. This is an area of active research and clinical applications are expected to emerge soon. The necessity to have the required biocompatibility in all the constituents of a composite invariably limits the use of such materials in biological environment. Hence, any composite which shows superior mechanical and physical properties and is also biodegradable (all the phases) would be the material of choice in future.

Questions

- ① What do you mean by biocomposite material?
- ② What are the advantages of ceramic composites for biological purpose?
- ③ What are the refractory material normally added to ceramic composite?
- ④ What do you mean by ~~be~~ resin bonded ceramic composite?
- ⑤ Write the use of ceramic composite for biological purpose?

Ceramic Implants

The bio ceramics can broadly be divided into bioinert (Al_2O_3 , ZrO_2 , carbon) and bioactive (hydroxyapatite, coral, sintered bovine bone, bioglass etc.). When a material such as Al_2O_3 is implanted into the bone, it is found that the new bone starts to grow at some distance and reaches the surface and there is no chemical bonding with the bone. In fact, a true bioinert material does not exist. Any foreign body induces tissue response, thereby forming a soft connective tissue capsule. "Bioinert" implies only a low grade tissue response. In case of bioactive materials, new

bone forms on the ceramic surface, implying chemical bonding.

Bio inert $\rightarrow$ which doesn't react with our body, which is inactive with the use.

Bio active $\rightarrow$ which is usually react with our body.

Questions:

- ① How can we divide ceramic implants?
A: Bio active & Bio inert.
- ② What do you mean by biological response?
- ③ Which material are used for bio inert?
- ④ How the Al_2O_3 like material is implanted in bones?
- ⑤ How we can classify new bone matrix?

Ceramic for artificial teeth

22/4/20

The artificial teeth are come from the chemical and biochemical stable substance that are strong. It is also known as artificial porcelain. These are classified into 4 categories:

- ① High temp firing (around 1300°C)
- ② Medium firing ($1100^{\circ}\text{C} - 1300^{\circ}\text{C}$)
- ③ Low firing ($850^{\circ}\text{C} - 1100^{\circ}\text{C}$)
- ④ Ultra low firing (below 850°C)

- In dental porcelain TiO_2 is maximum used.
- Kevline ($\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$) is around 3 to 5%.
- Quartz (SiO_2) → 12-25%.
- Feldspar ($\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$) - 70-80%.
- Metallic colourant - upto 1%.
- Glass upto 15%.

Oral cavity (Gateway of body)

It should be non toxic

It shouldn't give any allergic reaction.

Manufacturing:

→ For mfg. of dental porcelain all the compositions are combine together

Feldspar - 70%.

Kaoline - 15%.

Quartz - 15%

All are mixed together ~~though~~ through mixing machine.

→ After mixing some binders are added.
(Thermosetting resin)

→ Then the mixture is put inside the mould.

→ After removing from the mould sometimes drying is required.

Drying is done at a temp. of 110°C - 120°C .

→ Afterward It is fired.

High firing - 1200 to 1400°C

Low " - 1050 to 1200°C

Medium " - 800 to 1050°C

Dental porcelain is divided ~~in~~ into 3 types

① According to firing

② According to application

③ According to method of firing

60:40:10 [Feldspar, quartz and kaoline]

Questions:-

- ① Define artificial teeth?
- ② How we can classify artificial teeth?
- ③ What are the raw materials for artificial teeth?
- ④ What is dental composite resin?
- ⑤ What is the difference between bioceramic and dental porcelain?