Airo International Research Journal

Volume XIV, ISSN: 2320-3714
February, 2018
Impact Factor 0.75 to 3.19

ज्ञान-विज्ञान विमुक्तये
UGC Approval Number 63012

A Multidisciplinary Indexed International Research Journal

ISSN : 2320-3714
Volume : XIV
Journal : 63012
Impact Factor : 0.75 to 3.19

Airo
ADHYAYAN
INTERNATIONAL
RESEARCH
ORGANISATION

Airo International Research Journal

Volume XIV, ISSN: 2320-3714
February, 2018
Impact Factor 0.75 to 3.19

ज्ञान-विज्ञान विमुक्तये

UGC Approval Number 63012

REVIEWED STUDY ON TECHNIQUES FOR ORTHOPAEDIC COMPOSITES IN BIOMEDICAL INDUSTRY

Dr. Padman Kumar Patel

M.S. (Ortho), Orthopaedic Specialist, CM@HO office, Raigarh, Chhattisgarh

patel.drpadman@gmail.com

Dr. H.S. Varma

Prof. Orthopaedic

NSCB Medical College Jabalpur

Abstract

This paper glances through the biomaterials used in the biomedical industry for a bone plate application. It has found among all biomaterials, currently titanium and stainless steel alloys are the most common in manufacturing of bone plates. The metallic bone plates have certain problems like metal incompatibility, corrosion, magnetism effect, anode cathode reactions, including a decrease in bone mass, increase in bone porosity therefore composite materials for bone plates with higher strength and stiffness and more similarity to natural bone had started to develop. The main requirement for the choice of the biomaterial is its acceptability by the human body. The most common types of materials used as biomedical materials are Metals, Polymers, Ceramics, and Composite. This review touches on various aspects of biomaterials such as its biocompatibility, advantages and as well mechanical properties.
Keywords: Biomaterial, Orthopaedic bone plate, fracture fixation, composite, ceramics, Stiffness.

1. Introduction

Origins of biomaterials date back thousands of years, as archeologists have discovered that metal dental implants have been utilized as a part of 200 A.D. Be that as it may they have been produced significantly after World War II. Today, biomaterials are characterized as "artificial or natural materials utilized as a part of the manufacturing structures for supplanting the lost or infected organic structure to restore its form and function". Performance of biomaterials is controlled by two characteristics of bio functionality and biocompatibility. Bio functionality characterizes the ability of the gadget to perform the required function and alludes to mechanical properties of the biomaterial, though biocompatibility determines the compatibility of the material with the body. Orthopedic specialists have been utilizing metallic bone plates for the fixation of bone fractures. Recently, metallic prosthesis, which are for the most part made of stainless steel and titanium composites, cause a few issues like metal incompatibility, corrosion, magnetism effect, anode-cathode reactions,

Incorporating a diminishing in bone mass, increment in bone porosity (osteoporosis), and postponement in fracture recuperating (callus formation, ossification) (stress protecting effect/stress protection atrophy). Because of insufficient bone growth, refractors after the evacuation of the prostheses are likewise broadly reported.

Composite materials are made of two stages: Matrix and Reinforcement. The reinforcement fills the matrix stage and gives it more strength and stiffness. In orthopedic application this 2phase can imitate the natural bone and can be inserted inside the issue that remains to be worked out it from inside. Therapeutic composites have a lot of applications in medication and orthopedic. In this thesis work we consider their orthopedic application while the experimental part of the work surveys manufacturing methods of medicinal composite for orthopedic application as bone implants. Biomedical/orthopedic composites have a place with a gathering of materials called biomaterials (Biomaterial can substitute natural tissues in the body and perform their functions). In view of the exploration improved the situation this thesis, it was discovered that biomaterials had been utilized since ancient civilization time.

Some implantable biomaterial was found to be used at that time such as:

1. Joint replacement, bone plates, dental implants, and heart valves.
2. Artificial hearts- blood tubes.
3. Artificial eyes-noses by Egyptian

Some implantable biomaterials at that age were made of natural material like: wood, some tissue of living organs, zinc, gold, iron.

1.1 Market

According to a report in 1995 from London's institute of biomaterial, it is the market of 12 billion dollar for every year for biomaterial and this market is expanding in the scope of 7-12% every year. As to fact that biomaterial medicinal composites perform their function in the body and in contact with tissues, their properties and structures ought to be as near living tissues however much a could be expected.

For instance, in orthopedic composites the amount of stress that bones endure is almost 4 MPa, but for other tissues like tendons, this can be more amid every day work, up to 40-80 MPa. The normal amount of load on the hip joint is almost 3000N and can increment amid bouncing up to 10000N. And unmistakably this amount of stress isn't constant and can be changed in different sort of activities. Therefore, a wide range of sort of composite materials for bone implants have been made of different materials amid last decades. But manufacturing and preparing of material that could impersonate the bone functions and structures is still the instance of interest. Composites with high strength and stiffness, high biocompatibility and flexural strength are re-seen infrequently as a potential gathering of materials to have a perfect biomechanical behavior. Since last 30 years numerous investigates had been done to discover the action and interaction between implanted biomaterial and living organs. This made it evident that those materials to be inserted and implanted inside the body ought to be compatible. Some of composites were observed to be compatible inside the body and in contact with the encompassed tissues and some of them had a few disappointments, but different reaction in different bodies and conditions were watched too.

In manufacturing of orthopaedic composite some factors should be considered like biocompatibility of composite.

- **Biocompatibility**:

Is the ability of the composite material to interact and perform in contact with living host tissue? To reach this goal for orthopaedic composites, they should be structurally and physically (surface) compatible:

- **Surface compatibility:**

The surface of biocompatible material should have an optimum chemical, physical and biological compatibility with host tissue or organ. .

- **Structural compatibility:**

The optimum biomaterial ought to likewise exhibit a matching mechanical performance in contact with living tissue. And this incorporates the strength of the implant and in addition stack transmission; that implies the small mum interface mismatch.

For a perfect compatibility of implant-tissue, both structural and surface compatibility ought to be accomplished and in manufacturing and characterization of medicinal composite this fact must be considered. Composites are made to have best function of 2 constituent materials and represent the best me-concoction properties, for example, strength-fatigue resistance and stiffness and likewise the best biocompatibility which is significantly more important than mechanical properties.

2. PROBLEM DISCUSSION

For many years many, different material had been used as bone implants, each of them with some advantages and shortcomings.

2.1 Various types of implantable biomaterial in orthopaedic:

The materials that have been used until now as biomaterials in orthopaedic are:

- ceramic material
- Metals
- Polymeric biomaterial
- Composite material which can be

made of combination of previous material

- **Biocompatible ceramics**

This group includes Aluminatitania-zironica-bioglass or bioactive glass-carbone and hydroxyl appetite as well as ceramic and glasses and glass-ceramics.

It was used since 30 years ago and called bioceramics. It is found to be biocompatible because of the chemical similarity with human body environment. They are containing ions like: (Ca+2-K+, Mg2+, Na+). Some ceramics like Alumina, zirconia are used in total hip replacement.

2.2 The types of advanced composites in bone replacements:

There are many polymer composites that are made or are still under investigation.

1. HA/HDPE (high density bioethylene) the first bioactive composite

Advantages of polyethylene as matrix:

Is it very biocompatible and used in orthopedic and HDPE is a liner polymer.

2. Hydroxy apetite reinforced polysulfurHA/PSU

Is a new composite for bone replacement with almost 40%HA. PSU is polymer with high modulus and strength. It is applied in load bearing prosthesis. It has better mechanical proper-ties than HDPE and is resistant to oxidation and hydrolysis.

3. Bioglass reinforced high density polyethylene

To improve and increase bonding reaction between bone and implant, glasses are found to be better and more bioactive than HA. Composites are made with 30% bio-glass volume.

4. Calcium phosphate reinforced polyhydroxybutyrate and its copolymer

- are biodegradable composites TCP/ PHB. PHB is **β**-hydroxyacid and liner polyester.

5. Calcium phosphate reinforced chitin

Chitin is natural polymer and also biodegradable PcHA/ chitin.

6. Bioactive and biodegradable scaffolds:

Bioactive and biodegradable scaffolds have Chitin or poly (L-lactic acid) (PLLA)as the matrix polymer and HA, while containing 20%bioactive ceramic psHA/PLLA.

3. ADVANTAGES OF POLYMERIC COMPOSITE MATERIALS:

- By changing and altering the fraction of reinforcement/ matrix phase it is possible to de-sign and make the implants mechanically and physically suitable for different tissues.
- There is no corrosion like in metal implants.
- Metals and ceramics can show some failures in X-ray

radiography and are not totally radio transparent. But polymeric composites can be transparent by the help of some contrast material to the polymer.

- Polymeric composite materials have shown high compatibility with many new diagnosis methods like: MRI because they are not magnetic as well as computed tomography (CT).

- Reinforced composites have more fatigue resistance than un-reinforced composites, which is very important in knee joint replacement.

4. Fabrication process of orthopedic composites

4.1 Processing methods

There are different manufacturing methods for composite production, depending on used matrix and reinforcements, different application and shape, the desired composite has to be made.

1. Hand lay-up
2. Vacuum bag moulding or vacuum bagging
3. Vacuum injection moulding
4. Resin transfer moulding
5. Compression moulding

4.2 Manufacturing and Grouping of the samples:

The samples are named according to resin batch number.

- **Name of the resin batches:**

F1-UCB-00x

F: Refers to fiber reinforced

UCB: University college of Borås

00 xs: number of batch

- **Name of the samples:**

F1-UCB-00x-coy

Co: Refers to composite number **y**

Table 4.1 Effect of different processing technique

Method	Sample name	Properties	Fiber content
1	F1-UCB-008-co4	Sandwich 40 unidirectional fiber+ Hexel 1080 300g/m2	54.07%
2	F1-UCB-008-co2	One layer multidirectional woven	50.72%
3	F1-UCB-008-co11	Unidirectional 2layer of 2*16 bundle	58.69%
4	F1-UCB-008-co10	Sandwich of unidirectional fiber+prove4	74.63%

		bidirectional	

.

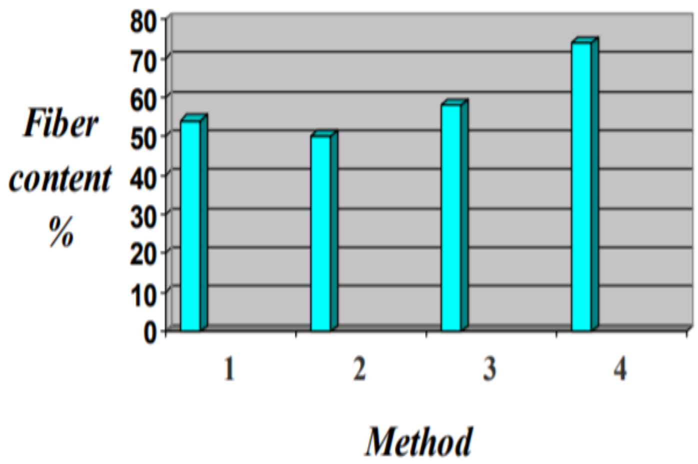

FIGURE 4.1 Comparison methods vs. fiber content

5. RESULTS

Amid the practical part of this thesis, a lot of composite examples in different conditions and preparing factor had been made. From every readied test in each step and from each gathering, some representative examples were selected and characterized by concoction and mechanical tests to accomplish the best properties of the composite examples. In light of limits to this thesis work, a few examinations couldn't be completed and should be worked on in future, for example, Tensile strength and Fatigue resistance to evaluate the mechanical strength and properties of the example. The results of what has been done during the experiment can be summarised as following:

- For curing the resin, the first 2 (F1-UCB-007-co1, F1-UCB-007-co2) samples after curing, the colour was not much changed from yellow to light yellow. But in the 3rd sample (F1-UCB-007-co3) it was polymerised better and a change in the colour after curing was ob-served.

- Better impregnation with woven structures than with unidirectional fibres and

  Unidirectional fibers, which was found to be difficult to wet by resin (less resin flow time and easier impregnation).

- The best processing technique has found to be vacuum injection moulding with higher fiber content and less void content which also results in better mechanical properties of the sample.

- Within the used reinforcing material, it was found out that Hexel bidirectional fiber have shown better arrangement with matrix phase and are easier to impregnate by resin with less air bubbles.

In higher temperature (60 - 65ºC) better impregnation and shorter resin flow time has been observed compared with room temperature.

- With using glass fibres and polymer based resin matrix material, more complex composites like Implantable medical devices are possible to impregnate and manufacture with low amount of Voids.
- The method can offer flexible but rigid light weight materials
- Better impregnation with woven structures than unidirectional fibers.
- Unidirectional fibers difficult to wet by resin.
- With high processing temperature and sandwich structures, manufacturing of thicker composites is possible with resin injection moulding.
- It is assumed that even more complex composites are possible to impregnate with a satisfactory low amount of voids

REFERENCES:

1) Ramakrishna S., Mayer J., 2001, 'Biomedical applications of polymer-composite materials: a review', *Composite Science and Technology*, Vol. 61, pp. 1189 - 1224

2) Min Wang, 2003, 'Developing bioactive composite materials for tissue replacement', *Bioma-terials*, Vol. 24, pp. 2133-2151

3) Liu Y., Wang. M, 2007, 'Developing a composite material for bone tissue repair', *Current Applied Physics*, Vol. 7, pp. 547 - 554

4) S.L.Evans, P.J.Gregson, 1997, 'Composite technology in load-bearing orthopaedic implants', *Biomaterials*, Vol. 19, pp. 1329 - 1342

5) Adams, Donald Frederick (2002) "Experimental c haracterization of advanced composite ma-terials", Third edition, University of Akron, USA

6) A. Brent Strong, (2006) "Plastics: Materials a nd Processing", Third Edition, Brigham Young University

7) http://www.kissolar.com/images/fiber%203mm%202.jpg *(2009)*, "kissolar Company" (con-sulted November 2008)

8) http://www.fiberglass-china.com/products/20057614541822.jpg (2004), "CHINA YANG-ZHOU GUOTAI FIBERGLASS Co.Ltd" (consulted November 2008)

9) http://www.rtpcompany.com/produ

cts/structural/glass.jpg (2009) "RTP Company Imagineering Plastics" (consulted November 2008)

10) http://www.engr.iupui.edu/~tgchu/ myweb/images/bioglass_scaf.jpg (2007), "Advanced Biomaterial Lab", (consulted November 2008)

11) *http://www.bikudo.com/photo_stock/48677.jpg (2009),* " Bikudo Global B2B Marketplace", (consulted November 2008)

12) http://www.dpdillon.com/cozy/tips techniques/howtolayup/images/Cozy_chapt6_Mar07_042 _small.jpg, 2008, " How to do a fiberglass layup by Daniel Dillon", (consulted November 2008)

13) [13] http://www.baaqmd.gov/pmt/handbook/hlayup.jpg (2001), " Polyester Resin Operations" (consulted November 2008)

14) http://www.substech.com/dokuwiki /lib/exe/fetch.php?w=&h=&cache=cache&media=compr

15) ession_molding.png (2009)," **S**ubs Tech (Substances & Technologies)", (consulted November 2008)

16) http://www.twi.co.ir/images/common/equipment/ksfcs002f3.jpg (2006), TWI Ltd: World Centre for Materials Joining Technology, (consulted November 2008)

17) R.G .Graig, J.M Powers, (2003), "Dental Materi als. Properties and Manipulation" Missouri, USA, 7th edition,

18) Brouwer W. ,D van Herpt and M. Labordus, 2001, 'Vacuum injection moulding for large structural applications', *Composites. Part A, Applied science and manufacturing*, Vol. 34, p. 551 - 558

19) http://composite.about.com/od/aboutcompositesplastics/l/aa000109.htm, 2009, "About.com: Composites /Plastics", (consulted November 2008)

20) http://compositeenvisions.com/images/vacuum%20bag%20film.jpg , 2009, "Composite En-visions", (consulted November 2008)

21) Gallova J., N., "Manual Density Determination by Pycnometer";