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Studies on Biocompatibility of shape memory alloys: A Review

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***Abstract:*-- Shape memory alloys (SMAs) are the systems which retain their original shapes. Due to the applied thermo mechanical load SMAs undergo Martensitic phase transformation and when they are heated above certain temperature they recover their permanent strains. SMAs have drawn critical consideration and enthusiasm for recent years in the field of medicinal and commercial improvement, because of their novel and predominant properties; this advancement has been upheld by fundamental and applied research Studies. Thus, this article presents an extensive review on the research progress achieved and carried out in the sector of " shape memory alloys of biocompatibility" including an historical overview, outline of recent advances and proposes recent research objective and methodology for created opportunities.**

Index Terms— Words: Shape memory alloys, Biocompatibility, Applications.

I. INTRODUCTION

The word biocompatibility implies to the group of a living system or tissue with a completed medicinal device or Component materials. In general, a biocompatible material or device is safe for the patient. A typical word reference definition is "the nature of being good with living tissue or a living framework by not being poisonous or harmful and not causing immunological rejection". In a regulatory sense, biocompatibility is testing to decide the potential difficulties because of direct contact with a material or restorative device. Systemic as well as local both reactions are evaluated. The parts of the body and also the nearby part that reaches the material or device are influenced by systemic response.

II. SURVEY OF LITERATURE

The SMA has multiple applications in implant ology due to its unique properties. Some applications are still in research stage such as hip prostheses, and rest are like synthetic bone plates, blood filters and dental implants are developed into products. In practice, all the materials which are used as human implants for a shorter or longer period of time must and should be tested for their “biocompatibility”. Hence, all the implantable materials should undergo three important tests before going for human implantation.

The 3 different types of biocompatibility tests are as follows;
1. In-vitro test
2. In-vivo test
3. Clinical test

[A]BIOCOMPATIBILITY: A REVIEW [1]

Dr.Dakshitha Joy Sinhaet.alhasmade a detailed review on the concept of biocompatibility materials with respect to dental issues. He has discussed that biocompatibility is on a very basic level imperative to guarantee the wellbeing of patients, Dental staff members (including research facility members) including professionals. The legitimate obligation of dental practitioners is frequently connected to issues regarding biocompatibility. Practitioners ought to see enough about biocompatibility testing strategies to basically judge advertising claims and make applicable inquiries of producers. At last, 100% safety is not given by any material, every dental practitioner must decide to use a material in their practice must balance benefits and risks both.

[B] CONSIDERATIONS FOR THE BIOCOMPATIBILITY EVALUATION OF MEDICAL DEVICES [2]

Raju G. Kammula et.al has studied about biocompatibility evaluation of the medical devices. Generally, assessing the biocompatibility of medicinal devices and biomaterials has been an intricate assignment. This intricacy emerges from the way that devices are made of a differing scope of materials and have different proposed utilizes, with body contact going from transient skin contact to contact with blood to changeless implantation. There are a few national and universal accord norms that address the toxicological assessment of medicinal devices. Recently, the Center for Devices and Radiological Health (CDRH)— has been thinking about the utilization of these agreement benchmarks to assist the biocompatibility survey of medicinal devices. This article examines the information required by FDA to assess restorative devices previously clearing or endorsing them for market, or supporting their examination in human

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subjects. It likewise depicts how FDA as of now utilizes perceived agreement measures to encourage the biocompatibility survey of restorative devices.

[C]A REVIEW OF THEBIOCOMPATIBILITY OF IMPLANTABLE DEVICES: CURRENT CHALLENGES TO OVERCOME FOREIGN BODY RESPONSE [3]

Yoshinori Onuket.al has made a review on the foreign body response of implantable devices. In recent years, an assortment of devices such as stents, manufactured organs, biosensors, catheters, heart valves etc., have been created for implantation into patients. Nonetheless, when such devices are inserted into the body, the body can respond to these in various diverse ways. These responses can bring about a sudden hazard for patients. In this way, it is vital to survey and advance the biocompatibility of implantable devices. To date, various procedures have been researched to conquer body responses incited by the implantation of devices. This survey centres on the remote body reaction and the methodologies that have been taken to conquer this. The organic reaction following device implantation and the techniques for biocompatibility assessment are condensed.

[D] IN VITRO BIOCOMPATIBILITY OF NI-FREE TI-BASED SHAPE MEMORY ALLOYS FOR BIOMEDICAL APPLICATIONS [4]

Hiroyasu Kanetaka et.al has studied about invitro biocompatibility of Nickel free Ti-based SMA.This examination was embraced to assess the invitro biocompatibility of recently created in the absence of NiTi-based shape memory composites (SMA) in contrast with that of business unadulterated titanium (cpTi). This examination thought about Ti-24mol%Nb-3mol%Al(Ti-Nb-Al) and Ti-7mol%Cr-3mol%Sn (Ti-Cr-Sn) to cpTi from a cell-similarity point of view. Taking all things together, 63 tests (21 tests for each gathering) were prepared, which were machined into 10-mm-measurement, 0.15-mm-thick, reflect cleaned plates. Their surface morphology was assessed utilizing scanning electron microscopy (SEM). The synthetic creation of the example surface was resolved utilizing an energy dispersive X-ray analyser (EDX). Test surface roughness was estimated utilizing a non-contact 3D profiler. After example surface perceptions, the cell multiplication and suitability of African green monkey kidney fibroblast cell line COS7 in coordinate contact with these new composites were assessed by DNA quantification, by live cell imaging utilizing CelLuminate Red fluorescent cell recolor as another strategy, and by cytoskeletonetal perceptions by immune fluorescent acting labelling. Cell multiplication was inspected following 1, 3, and 5 days of culture. The outcomes recommend that Ti-Nb-Al combination has biocompatibility as high as that of cpTi and could be more appropriate for biomedical applications.

[E]IN VITRO EVALUATION OF BIOCOMPATIBILITY OF TI–MO–SN–ZR SUPERELASTIC ALLOY [5]

Shoko Nunome et.al have studied about the invitro evaluation of biocompatibility of Ti-Mo-Sn-Zr.The point of this investigation was to assess the biocompatibility of a recently created,Ni free Ti-based SMA for medicinal utilization. The newly developed SMA made of Ti–Mo–Sn–Zr was prepared into a circle of 15.1mm in measurement. Pure titanium of a similar shape was set up as control. All the disc surfaces were cleaned utilizing emery papers, #120, #400, and #600. Scanning electron microscopy and a 3D optics profiler were utilized to assess the surface of the materials. In this study, the biocompatibility of the newly developed Ni-free Ti–Mo–Sn–Zr alloy was evaluated using cell growth assay with DNA measurement and FDA staining, colony formation assay, cellular metabolic activity assay with Alamar Blue, and the cell cycle analysis with a cytometer in the Chinese hamster lung fibroblast cell line (V79) and the mouse osteoblastic cell line (MC3T3-E1). The present outcomes recommend that the recently created Ti– Mo– Sn– Zr combination demonstrated the high biocompatibility comparable to pure titanium and can be utilized as productive biomaterial for medicinal utilization.

[F]DETERMINATION OF THE CHARACTERISTIC TRANSFORMATION TEMPERATURES OF THE BIOCOMPATIBLE SHAPE MEMORY ALLOYS [6]

DejanTanikić et al have studied about the transformation temperatures of biocompatible SMA.Shape memory compounds are particular materials which can change their shape and change to some remembered state, which is caused by changing in their temperature. These materials are regularly biocompatible which empowers their utilization in prescription. Martensitethermoelasticchange from martensite to austenite, and the other way around, is a key procedure which empowers shape changing of shape memory composites. Beginning and completing temperatures of the martensite change, and in addition beginning and completing temperatures of the austenite change relies upon the physical and the chemical characteristics of alloy. This work thinks about utilizing the manmade brainpower based framework for anticipating the trademark change temperatures of the shape memory combinations. Favourable mechanical and physical qualities of the shape memory composites, and in addition shape memory impact, are generally utilized as a part of all fields of science and strategy. Biocompatibility of those materials is one of the significant attributes which groups them in the need class of the materials which are utilized as a part of biomedicine.

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[G]EVALUATION OF BIOCOMPATIBILITY FOR TITANIUM-NICKEL SHAPE MEMORY ALLOY IN VIVO AND IN VITRO ENVIRONMENTS [7]

Masafumi Morita et.al evaluated the biocompatibility for Titanium-Nickel SMA in invivo and in vitro environments.This examination was led to assess the biocompatibility of titanium-nickel shape memory combination utilized as a therapeutic embeds material. The electrochemical corrosion test were conducted by authors and invivo and invitro natural tests for some metals and alloy and compounds clinically utilized beforehand to contrast the powers concerned and the biological reactions. The communication amongst tissue and the metal surface is influenced on the biocompatibility assessment. Particularly, the issue of metallic particle discharge with metal erosion in the body is critical. In this paper, electrochemical erosion test and some organic tests were conducted for Ti-Ni alloy and researched one of the biocompatibility. The accompanying outcomes were observed: (1) the potential changed from passive to the Transpassive state, demonstrating a pit erosion for the arrangement treated Ti-55Ni alloy was approximate. The maturing treatment was enhanced the consumption protection and the potential was ascended to approx. (2) In the L929 cell coordinate contact test for Ti-55Ni combination, there were no significant differences between cell multiplications contrasted and that of SUS316L and Ti6Al-4V. Since detached films are electrochemically steady, they are viewed as dormant to cells and have little effect on cell expansion, regardless of base metal write. (3) In the L929 cell introduction test for Ti-55Ni partner erosion items, we found that Ti-55Ni combination indicated preferable biocompatibility over Ti-6Al-4V. (4) The erosion extractions introduction test, LDH action and IL-1 and TNF-creation topped with 30massppm for Ti-6Al-4V. In any case, Ti-55Ni composite did not show such pinnacles. Along these lines, it is viewed as that Ti-55Ni combination has preferred biocompatibility over Ti6Al-4V. (5) In histological biocompatibility assessment for Ti-55Ni combination, it was found to have biocompatibility equivalent to or more prominent than that of SUS316L stainless steel.

[H]BIOCOMPATIBILITY EVALUATION OF Cu-Al-Ni SHAPE MEMORY ALLOYS [8]

Ana Todorović et.al has studied about the biocompatibility of Cu-Al-Ni SMA in vitro.Melt spinning was employed in the production of Cu-Al-Ni thin strips for testing. MTT outcomes showed that Cu-Al-Ni base compounds (alloy control) totally decreased metabolic movement of fringe blood mononuclear cells (PBC), while none of Cu-Al-Ni strips composes demonstrated a factually critical impact on the metabolic action of cells contrasted and control (cells developed just in the medium).

[I]POTENTIAL USE OF POROUS TITANIUM–NIOBIUM ALLOY IN ORTHOPEDIC IMPLANTS: PREPARATION AND EXPERIMENTAL STUDY OF ITS BIOCOMPATIBILITY IN VITRO [9]

JianXu et.al has studied about the biocompatibility invitroof Ti-Ni alloy which is porous in orthopaedic implants.The change of bone ingrowths into prosthesis and improvement of the mix of the range between the prosthesis and bone are essential for long haul steadiness of manufactured joints. They are the attention of research on uncommented simulated joints. Permeable materials can be of potential use to unravel these problems. All Titanium-25Niobiumalloys indicated great biocompatibility paying little heed to the level of porosity. The essential prerequisite of clinical orthopaedic inserts was achieved, lead to the combination of a decent prospect for applications in medical fields. The composite with a porosity of 70% had mechanical properties which were ideal and appropriate pore size and porosity, which permitted enough bone ingrowths.

[J]FABRICATION OF SMART SELF-EXPANDING BIOCOMPATIBLE STENTS IN BODY TEMPERATURE [10]

MehranAbbasiShirsava et.al have discussed about fabrication of smart self-expanding biocompatible stents in body temperature.Stent implantation has pulled in significant consideration since the dire need of coronary angioplasty as the most widely recognized reason for heart assaults. Shape memory alloys can have two shapes at various conditions. Since the brilliant materials are self-expandable, the nearness of the inflatable in stents takes out due its issues like outlining, material properties and measurement of inflatables. In this work, shape memory polymers which have bunches of favourable circumstances fit as a fiddle memory alloys, for example, high versatile twisting, great process ability, light weight, ease, low thickness, and capability of biocompatibility so they have turned into a legitimate possibility for embed materials. It has been discovered that mechanical properties of polymeric materials can be enhanced by presenting a uniform scattering of nanoparticles. The primary objective of this paper is to describe theprogressiveselfexpansion shape memory Polyurethane/Polycaprolactane-ZnOnano-composite blends.

[K]MEDICAL APPLICATIONS OF SHAPE MEMORY ALLOYS[11]

L.G. Machado et.al has studied about medical applications of SMA.Shape memory compounds (SMA) are materials that can come back to a previous shape when subjected to a

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proper thermomechanical method. Pseudoelastic and shape memory impacts are a portion of the practices exhibited by these alloys. The one of a kind properties concerning these alloys have urged numerous agents to search for uses of SMA in various fields of human information. Thisreview article describes thebehavior of SMA in a thermomechanical way and looks to their applications in medical field. Uses of SMA to the biomedical field have been fruitful as a result of their utilitarian characteristics, improving both the likelihood and the execution of less intrusive surgeries. In this way, one can state that keen materials, particularly SMA, are getting to be observable in the biomedical field.

III. RESEARCH OBJECTIVE

In the light of the above literature survey, it is found that limited work has been carried out on the biocompatibility of Cu-Al-Mn SMA. Hence, based on the research problem, the objectives set are as follows;

1. To prepare the ternary shape memory alloy Cu-Al-Mn in different composition.
2. To examine the biocompatibility effect of Cu-Al-Mn SMA.

[A]RESEARCH METHODOLOGY

This research work is proposed to conduct study on synthesis and evaluation of biocompatibility of ternary SMAinbio-medical applications.

1. Procurement of Cu-Al-Mn SMA raw materials
2. Casting of required sizes
3. Homogenization at 900°C for 6 hours
4. Rolled to sheet of 1mm thickness
5. Betatization at 900°C for 30 minutes
6. Quenching
7. SME test
8. Transformation temperature by DSC
9. SME by bend test
10. Biocompatibility test

IV. CONCLUSION

The present paper is a review of biocompatibility of shape memory alloys. Based on the literature review, research objectives were defined and also the future frame work for the synthesis and evaluation of biocompatibility of Cu-Al-Mn shape memory alloy for bio-medical applications. However, the review of the biocompatibility of shape memory alloy shows that there is a scope to Cu-Al-Mn shape memory alloy in the field of human implantation.

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