



BIOCOMPATIBILITY BEHAVIOR AND BIOMEDICAL APPLICATIONS OF TI-NI BASED SHAPE MEMORY ALLOYS: A BRIEF REVIEW

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Abstract:

Shape memory alloys provide new areas for the design of biomaterials in biomedical engineering and also for the design of artificial hard tissues and surgical instruments, since they have definite distinctiveness and remarkable characteristics. This study will explore the biocompatibility behavior of Ti-Ni based shape memory alloys and its medical applications with high possible for improving the present and future quality of bioengineering. In particular, the biocompatibility behavior, vivo and vitro corrosion analysis, histological studies of tissues, vitro and vivo cytotoxicity and applications of Ti-Ni based shape memory alloys in the fields of Cardiovascular, Gastroenterology and Urology, Orthopedics and bone-related purposes have been discussed in this paper.

Keywords: Shape memory alloys, biocompatibility, corrosion, tissue reconstruction, artificial organ, artificial muscle

1. Introduction:

Shape memory alloys (SMA) possess certain original properties, particularly their ability to return to their memorized shape by a change of temperature. Biomaterials science examines the physical, physiochemical and chemical properties of materials in addition to the host response to material in biological system. It has been defined as the study and understanding of the interactions between living as well as non-living materials, and biomaterial as a material that will interface with biological systems to treat or replace any tissue, organ or function from the living system[1]. Stainless steels, cobalt and chromium metals were the first materials effectively used inside living systems intended for fracture fixation, etc. In 1960's, Sir Ruben Charnley made the first effort to help link in concert a metal hip prosthesis and high-density polyethylene using metachrylate bone tissue. It was considered the start of modern orthopedics, where the development connected with better materials plays a new central position. In the late 1960's, the titanium was discovered for different medical treatments [2]. Distinct materials (polymers, ceramics, composites and also metals with improved properties) and also applications (orthopedics, vascular and center medical procedures, etc.) have been developed ever since then.

2. Biocompatibility behavior of Ti-Ni Shape Memory Alloys

The biocompatibility of materials can be the main consideration for devices planned for use into living systems. Biocompatibility can be summarized as the ability of the material to achieve with an appropriate biological system response in a very definite purpose. There are two principal components in which biocompatibility of a material can be determined: the host reactions induced with the material and the degradation of the material in the biological environment [3].

2.1 Cytotoxicity and blood compatibility of metallic biomaterials

There are lots of factors that may evaluate cyto-toxicity of metallic implants. These include patient features, such as cells perfusion, immunological elements, or implant features, such given that surface condition, chemical reactions inside surface, corrosion properties of the materials, and the toxicity on the individual metals seen in the metallic implants [4]. Histology is used to evaluate the toxic effects of metallic implants by investigating the tissue response towards implants.

After implantation, a coagulating along with vascularizing process takes place which may influence tissues morphology and blood composition of the living systems. The implant is under the influence of blood flow by way of blood clot containing leukocytes, erythrocytes, thrombocytes and aminoacids. Inflammatory cell reaction, primary polymorphonuclear granulocytes and monocytes are present to help expurgate the exact debris. If excessive foreign substance is intended regarding granulocytes, monocytes developed into macrophages in addition to a delay with removing the exact substance seemed to be observed, the digestive enzymes [5]. The implantation response in bone fragments differs inside a few techniques from which taking setup soft muscle. There is definitely an inflammatory as well as a reparative response which arise one within the other. The reparative response starts 2-3 days following implantation. This stem tissue of bone fragments grow in osteoblasts, which form a layer with the implant as well as

fibroblasts. Fibroblasts, osteoblasts along with capillaries penetrate to the blood clot, replacing that, and load space between implant along with bone [6].

2.3 Corrosion behavior

The corrosion behavior of the implant alloy is a significant parameter of its biocompatibility evaluation. As described above, the nature of the living system and the surface treatments use an obvious influence on corrosion. Almost all of the studies on the corrosion behavior of Ni-Ti are from scientific studies of dentistry as well as in vitro conditions. In fact, the experimental data of the corrosion behavior of Ni-Ti into the body is very inadequate.

The good corrosion resistance of Ni-Ti in sea water was initially reported by Buehler et al [??]. The attempts to measure the corrosion in a simulated physical environment and also comparisons with other implant metals were carried out. Speck et al. [7] discovered in Hank's solution, titanium resources, which consist of Ni-Ti, have much better corrosion resistance than Co-Cr-Mo or 316L stainless steels. The inclusion of cysteine amino acid to the solution caused a reduced breakdown possibility of Ti-Ni. Edie et al. [8] found that when it was compared with stainless steel orthodontic wire connections, the Ni-Ti wires have more corrosion resistance than stainless steel. Sarkar et al. (1983) reported that Ni-Ti alloys are more vulnerable to rust than titanium in 1% NaCl option. Pitting corrosion of the Ni-Ti surface area was also investigated and reported that pitting may be due to help selective dissolution associated with nickel through Ni-Ti. Ni-Ti was examined in artificial saliva and it was concluded that release rates associated with nickel from other metallic implants will not be significantly diverse [9]. Vivo corrosion is investigated by weight loss technique and the microstructures of the metallic implants can be recorded by SEM and deterioration of said implants can be observed through the surface study. Castleman et al. reported that no generalized and localized deterioration of Ni-Ti metallic implants was observed, during examination on magnifications of 50X, which was maximum for 17 months after implantation in dogs [8-9]. Neutron initial analysis of organs in the same examine showed no deposition of trace metals from Ni-Ti. Cragget al.[10] implanted forty four Ni-Ti stents in the bloodstream of 22 sheep, minimal corrosion was seen after half a year. Pitting has been the predominant form of corrosion. Corrosion solution analysis around the pit indicated that this pitting have been a titanium bearing substance, probably in form of oxide. The medical importance of Ti-Ni-Fe has not been determined.

3. Medical applications of shape memory alloys

Ti-Ni based shape memory alloys are extensively used in biological systems. In this section, biomedical applications of Ti-Ni based alloys are briefly described. Ti-Ni superelastic wires were primary introduced directly into orthodontic surgery. Nowadays, there are many commercial applications available worldwide. Presently, this progress in self resilient stents using gastroenterology, radiology as well as cardiovascular applications looks very effective. Through the applications of stents, major operative operations could possibly be avoided [11]. Stents have demonstrated that Ni-Ti using certain criteria has become material using huge opportunities.

3.1 Cardiovascular

The primary vascular Ni-Ti technique was Simon Nitinol Filtration System (SNF) employed to treat pulmonary embolism. The filtration system is inserted becoming a skinny wire through minute weary catheter useful for angiographic assessment. Upon attainment of the lumen from the inferior vena cava along with sensing body's temperature, it reverts in order to its pre-specified intricate filtration system shape along with hair straight into a position forever, trapping any additional thromboemboli from the pelvis or the low limbs [12]. Intracoronary along with peripheral vascular Ni-Ti stenting also is apparently increasing. The benefits consist of great radial expansion capabilities along with versatility. Regardless of the improvements, restenosis along with reocclusion remain a tremendous dilemma and also the optimal physical and exterior properties regarding arterial stent are yet to recently already been defined (some missing, please make correction). However, Endoluminal mend of infrarenal aortic aneurysms in the event that Dacron-covered Ni-Ti stent-grafts are achievable, safe and clinically effective. The attempts to improve properties that have a heparin-coated Dacron cover demonstrate a marked inflammatory retort [13].As described by some other authors [??], the desire to guage this biocompatibility regarding new vascular products is visible. Polyurethane stent shell was in addition regarding a great inflammatory tissue response. A transcatheter strategy for the occlusion regarding atrial septal defects continues to be recently reported.

3.2 Gastroenterology and Urology

There are also many applications in the fields of gastroenterology and urology. Self expanding stents as esophageal strictures and the palliation applications have also been studied by numerous authors [14]. Esophageal Ni-Ti stents are easy to embed, present efficient palliation about malignant esophageal obstructions, and these work a little chance of significant disorders. The drawback is initial stent expansion resulting tumor overgrowth which happened in nearly 30 percent of the particular patients. Covering the particular Ni-Ti primarily based stent a thin covering may provide probably to clear ingrowth and it uses the particular stent even comes to fistulas stents are efficient in attaining enduring palliation as one patient. Later on, FDA released a stent for this reason. The healing way of cancerous biliary strictures together metallic stents is of a low long-term patency rate. Using stents reestablishes bile flow from the occluded biliary sapling [14]. The usage of Ni-Ti prostatic stents has also improved while initially described by Lopatkinet.al. All for subvesical obstruction a result of prostatic carcinoma, the implantation of a material stent system gives a functional substitute for transurethral resection. Ni-Ti stents can also be used for the treatment method of cancerous prostatic hyperplasia [15].

3.3 Orthopedics and bone-related purposes

A number of the early in vitro systematic studies were completed by Baumgart et al. who analyzed the Ni-Ti distraction rod on the improvement of scoliosis [15]. Lu et al. [??] implanted Ni-Ti fishing rods in twenty six patients using scoliosis. Rectification had been reported to get good results and no complications were found. It would appear that the scoliosis correction scheme depending on Ni-Ti shape memory or may be superelastic alloy has intricate biomechanical problems due to compression and commotion.

According to Dai [??], some form of shape memory alloy was used in living systems in 1981. Another application of Ni-Ti hook is utilized to reestablish the particular dislocated acromio-clavicular combined [16].

Based on the early characterization and research, it was observed for being very valuable and useful inoperable tracheal or may be bronchial stenosis is due to intraluminal cancerous growth invasion [14]. The latest Ni-Ti dependent mesh-expanding prosthesis regarding laparoscopic hernioplasty substantially has abbreviated the actual service incident [17].

Outlook:

The materials implanted in the body require particular properties, biocompatibility and bioactivity and must have good corrosion resistance. The direction of studies of biocompatibility, bioactivity, cytotoxicity and corrosion resistance of SMA implants must follow from their specific functions. These characteristics define the applications of materials in a specific biological environment. This article showed their obvious potential in the medical field. As a result, numerous applications have been considered, but many more are envisioned. Considering their revolutionary characteristics, these alloys are the incentive for the most daring applications since the 1960s and have been used to smash some technical barriers and achieve scientific challenges. In this paper, the biocompatibility of Shape Memory Alloys has been studied in a precise and systematic way to authenticate the long term effects of the implants and also its biomedical applications in the fields of Cardiovascular, Gastroenterology, Urology and Orthopedics surgery.

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