Preparation and mechanical properties of Poly Lactic Acid, Alumina and Hydroxyapatite based composites (Bio-Composite) made by using Injection molding

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In order to perform new Bio-Composite material, we carried out the investigation on Poly Lactic Acid, Alumina and Hydroxyapatite based composites (Bio-Composite) and the composite made by using Injection molding. Samples of 50%, 30% and 25% of Hydroxyapatite are mixed with PLA in respectively proportion for reinforcement of the composites and also improve the strength of Composite material by adding Alumina in it. Fabrication of composite specimen can be made in sheet (Film) type. Finally, that had been examined under various mechanical test like tensile, compression, impact and Hardness test and also SEM test. The results of bio-composites has higher tensile strength of 10.66 MPa, compression strength of 2.22kN ,hardness value 83.66 and same impact value 2Joules as others samples of bio-composites. The SEM image has fine bonding and lesser cracks due to higher proportion of HA. The SEM images partially bonded due to lower proportion of HA.

Keywords: Hydroxyapatite, Biomaterial, destructive test, Film

INTRODUCTION

In recent times, there are several new developments done in medical field and many Biomaterials like Stainless Steel, Titanium, Cobalt and some alloys, etc., were used most commonly for implant applications and replacement of bone. In these traditional metallic materials are good mechanical strength and bio-compatible but, they are not biodegradable. So move on to hybrid composite materials (Polymers-ceramics) which are bio absorbable and biodegradable. And also more advantages over using traditional materials in implant applications. Polymers like PLA (Poly Lactic Acid), PLGA (Poly Lactic co glycolic Acid), are used in many medical applications. For example, fractured bone that has been fixated with the bio degradable materials .Finally, this polymers mixing together with ceramics, hybrid composites is obtained then; this bio-composite material can be characterized by their mechanical and physical properties with the help of several testing.

Siriporn Tanodekaew et al [1] investigated the natural bone tissue resembles a nano composite Structure in several senses that is, being a porous polymer ceramic material and a fiber-matrix material which provides appropriate physical and biological properties. To develop an ideal bone scaffold nano composites are the best choice as they can be engineered to possess the composition and structure. The aim of this study was to fabricate a polymer-ceramic bilayer nanocomposite scaffold based on electrospun polycaprolactone (PCL)/polyvinyl alcohol (PVA) bilayer NFs blended with hydroxyapatite nanoparticles (HAp). The structural, chemical, thermal and morphological investigation of nano composites was carried out. Annabi et al [2] investigated the present work focuses on the state- of-the-art of biodegradable ceramic-polymer composites with particular emphasis on influence of various types of ceramic fillers on properties of the composites.

Ratner et al [3] investigated that in this research, a series of experiments were conducted to study the mechanical and thermo-degradation properties of PLA and PLA composite films and to find a methodology that increases the degradation rate of PLA or PLA composites based on the data and results. Armentano M et al.[4] investigated that a series of polylactic acid/ hydroxyapatite/graphene oxide composite (PLA/HA/GO) were fabricated via solution blending and casting method using N,N-dimethyl-formamide (DMF) and CH_2Cl_2 as mutual solvents. P. Kurtycz et al. [5] investigated the PLA fibrous mats containing nanoalumina filler were fabricated by electrospinning method. The morphology of the mats was characterized by SEM, and TEM. In vitro biocompatibility of the electrospun fiber mats was also evaluated. Bernardo Zuccarelloa Et al. [6] investigates that although several works have recently been published in literature about bio-composites, about composites with polymeric matrix reinforced by natural fibers, only a few articles have been devoted to the implementation of high performance bio-composites for structural and semi-structural applications. Saeid Tajbakhsh Et Al.[7] investigated the fabrication of a suitable scaffold material is one of the major challenges for bone tissue engineering. Wan Jeffrey Basirun1 Et. al [8] the study of the synthetic process, physical and biological properties of hydroxyapatite (HA)–grapheme nanocomposites in a rapidly expanding new field of advanced bioceramics for orthopedic applications. Bioceramics are an important class of ceramics with different biocompatibility, from ceramic oxides to the other extreme bioresorbable materials.

Experimental Setup

Tensile tests are performed for several reasons. The results of tensile tests are used in selecting materials for engineering applications. Tensile properties frequently are included in material specifications to ensure quality. Tensile properties often are measured during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a material under forms of loading other than uniaxial tension.

The strength of a material often is the primary concern. The strength of interest may be measured in terms of either the stress necessary to cause appreciable plastic deformation or the maximum stress that the material can withstand. These measures of strength are used, with appropriate caution (in the form of safety factors), in engineering design. Also of interest is the material's ductility, which is a measure of how much it can be deformed before it fractures. Rarely is ductility incorporated directly in design rather, it is included in material specifications to ensure quality and toughness.

Low ductility in a tensile test often is accompanied by low resistance to fracture under other forms of loading. Elastic properties also may be of interest, but special techniques must be used to measure these properties during tensile testing, and more accurate measurements can be made by ultrasonic techniques. This chapter provides a brief overview of some of the more important topics associated with tensile testing shown in the fig.1 (a)(b).

1(a) Before tensile test specimen

1(b) After tensile test specimen

COMPRESSION TEST

The composite sheet (Films) is machined according to the ASTM D695 standards. The test is conducted in a universal testing machine (UTM). A compression test is any test in which a material experiences opposing forces that push inward upon the specimen from opposite sides or is otherwise compressed, “squashed”, crushed, or flattened. The test sample is generally placed in between two plates that distribute the applied load across the entire surface area of two opposite faces of the test sample and then the plates are pushed together by a universal test machine causing the sample to flatten. A compressed sample is usually shortened in the direction of the applied forces and expands in the direction perpendicular to the force. A compression test is essentially the opposite of the more common tension test. The aim of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring fundamental variables, such as, strain, stress, and deformation. By testing a material in compression the compressive strength, yield strength, ultimate strength, elastic limit, and the elastic modulus among other parameters may all be determined. With the understanding of these different parameters and the values associated with a specific material it may be determined whether or not the material is suited for specific applications or if it will fail under the specified stresses

IMPACT TEST

Impact Testing of metallic materials, using the Charpy Test method, determines the toughness or impact strength of the material in the presence of a flaw or notch and fast loading conditions. This destructive test involves fracturing notched impact test specimens at a series of temperatures with a swinging pendulum. The amount of energy absorbed by the material during fracture is measured. Charpy V notch or U notch test specimens are used. The test specimen is machined according to the standards ASTM D265. The Drop Weight Test determines the temperature at which the fracture mode of steel changes from ductile to brittle using a free-falling weight or striker.

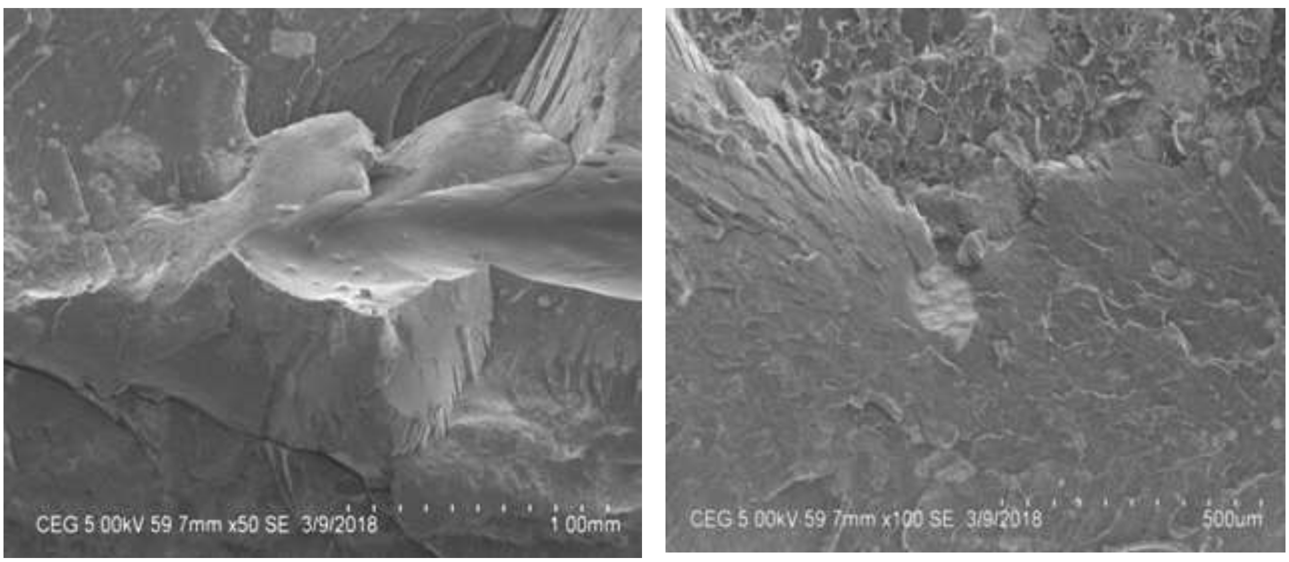
Iron and all other body-centered cubic metals undergo a transition from ductile behavior at higher temperatures to brittle behavior at lower temperatures. Impact Testing is required by many industries to evaluate the toughness of materials used in manufacturing products, including steel hull plate for ships, nuclear plant pressure vessels and forgings for electric power plant generator rotors, shown in the fig.2 (a)(b)

2(a) Before impact test specimen

2(b) After impact test specimen

SCANNING ELECTRON MICROSCOPE [SEM] IMAGING

When compared to all the samples of bio-composite testing results, sample 1 has lower compressive strength. So, the test specimens of sample1 were subjected to SEM test that images are show above fig3. The SEM images shown specimen finely bonded with proper proportion. So here is no present of fracture and cracks.



3. SEM images

CONCLUSION

In this process, for fabrication of bio-composite can be done by using the injection moulding process.PLA, Hydroxyapatite and Alumina are mixed proper proportion depending on the composition of samples. The fabricated samples are investigated under various mechanical testing as per the ASTM standards. The tensile tests were conducted in UTM ASTM D638.The bio-composites of samples has following tensile strength of 10.66MPa, 6.88MPa and 5.27MPa respectively. The compressive test were conducted in UTM ASTM D695.The bio- composites of samples has following compressive strength of 2.22KN,1.21kN and 1.76kN respectively. The hardness test was conducted in ASTM D2240.The bio-composites of samples has following average hardness value of 83.66,82 and 80 respectively. The impact test were conducted in charpy, impact test method ASTM D265.The bio-composites of all samples has same impact value 2 joules.

All the test results, it is concluded that sample1 bio-composite material which has 10.66MPa tensile. strength. So, it is suitable for using in medical applications of replacement of bones like tibla, femur, calcaneus and vertebra has following tensile strengths of 5.3MPa, 6.8MPa,10MPa and 2.4MPa respectively.

On comparing the results obtained from the mechanical tests, the following conclusions can be interpreted. The tensile test shows that bio-composite of Sample has higher tensile strength other than the two samples of bio-composite.and a compression test also revealed that the sample has higher compression strength due to addition of higher composition of Hydroxyapatitie and alumina in proper proportion which directly influencing for strength. Impact strength of all the samples have same amount of energy obtained and also sample has better hardness value other than two samples. The SEM images of test specimen were examined successfully due to observation of SEM images sample have fine bonding and without any cracks involved. The SEM images of samples specimen is partially bonded and also there is no cracks involved. The SEM images of sample 3 were carried out for study the nature of fracture.

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