Mechanical Properties and Morphological Studies on Pu-Ha Biocomposite

Khalid Mohammed Dahham[1], Mohamed Ansari M. Nainar[2]

[1, 2]Department of Mechanical Engineering, College of Engineering, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia

Abstract: ***This work demonstrates mechanical properties and morphological of polymer Polyurethane and bio composite hydroxyapatite (PU/HA),*** **it was used four types of experiment, the mechanical properties (tensile test, flexural test, impact test and the SEM). The samples were with the different filler loading (2, 4, 6, 8, 10 wt %) and with** ***dimensions 15 x 13 x 3 mm were used. These are used in many biomedical and applications because if their bioactivity and because their mechanical properties can be adjusted to suit. Hydroxyapatite, with biocompatibility and bioactivity, has already been used in clinics for filling of bone defects due to its similar chemical composition and structure to the mineral phase of human bone, and it can form bone bonding with living tissue. Polyurethane is one of the most versatile polymers for many different applications because of its good biocompatibility and favorable mechanical properties. Polyurethanes are used extensively in the medical field as intravascular devices, ureteral stents, for meniscal reconstruction, cartilage and bone repair. These polymers have excellent mechanical properties; high elongation capacity, good abrasion resistance, high flexibility and hardness, and good biocompatibility. These polymers coating can improve the biocompatibility of by blocking the diffusion of poisonous elements from the metal into the body. For that ,the purpose from this article it will be the focus of improvement of the properties of PU-HA by using experiment , study and develop better to mechanical properties , by using several testing ways.***

Keywords: Hydroxyapatite; Polyurethane, Mechanical properties, Morphological.

1. Introduction

Hydroxyapatite is a bioactive ceramics which, thanks to chemical composition and crystal structure similar to that of the human bone, can facilitate an integration of prostheses into osseous tissue. This ceramics has been used in medicine to restore bone tissue and to decrease the negative consequence of surgical operation since many years, because of its limited mechanical strength [1].

In fact, human bone tissue is a kind of composite composed of about 65 wt% nanohydroxyapatite (HAp) crystals and collagen matrix [2]. An ideal material for bone repairing must be biocompatible and bioactive, which is able to initiate osteogenesis. Moreover, its mechanical strength and composition should be similar to those of bone. In recent years, composite materials with high content of HAp nanoparticles have been studied, such as polyamide/HAp (PA/HAp) [2].

Polyurethanes are used extensively in the medical field as intravascular devices, uretral stents, for meniscal reconstruction, cartilage and bone repair, and as vehicles for sustained delivery of biologically active agents. Polyurethanes have excellent mechanical properties, high elongation capacity, good abrasion resistance, high flexibility and hardness, and good biocompatibility. Recent studies have pointed out the importance of porosity of the artificial material, more specifically, pore size distribution and structure, in promoting biocompatibility and biodegradability [5].

Hydroxyapatite (HAp, Ca10(PO4)6(OH)2) is among of the few materials that are classified as bioactive, meaning that it will support bone in growth and osseointegration when used in orthopaedic, dental and maxillofacial applications.

Coatings of hydroxyapatite are often applied to metallic implants, especially stainless steels and titanium alloys to improve the surface properties. Hydroxyapatite may be employed in forms such as powders, porous blocks and hybrid composites to fill bone defects or voids. These may arise when large sections of bone have had to be removed or when bone augmentations are required (e.g. dental applications) [6].

2. Polyurethane

PU is a versatile class of polymers; it is also one of the most interesting classes of synthetic elastomers that used in a broad range of applications due to its excellent physical properties and relatively good biocompatibility.

Much attention has been given to the synthesis, morphology, and chemical and mechanical properties of this family of materials. Polyether-type polyols possess good physical strength, abrasion resistance, water resistance, fatigue life, and biocompatible characteristics. Research on PU has focused on its potential application as a facial prosthesis in dentistry based on its inherent environmental stability, high tear resistance, and low modulus without the use of plasticizer, as well as its good ultimate strength and elongation. This material can accept intrinsic coloring and is amenable to maxillofacial processing techniques. Polyether-based impression materials have been used in restorative dentistry to record intra-oral structure for the fabrication of definitive restorations [12].

2.1 Applications of Polyurethane (PU)

Polyurethane is one of the most versatile polymers for many different applications because of its good biocompatibility and favorable mechanical properties. Polyurethanes are used extensively in the medical field as intravascular devices, ureteral stents, for meniscal reconstruction, cartilage and

bone repair, and as vehicles for sustained delivery of biologically active agents. Polyurethanes have excellent mechanical properties, high elongation capacity, good abrasion resistance, high flexibility and hardness, and good biocompatibility. Recent studies have pointed out the importance of porosity of the artificial material, more specifically, pore size distribution and structure, in promoting biocompatibility and biodegradability [2]. Polyurethane-enhancing the quality of our lives whether shoe soles, mattresses, steering wheels or insulation-our world today is unthinkable without polyurethane. In the world of sports or leisure activities, in the home or in the car, polyurethanes have a positive impact on our daily lives. They are needed everywhere, [18]. Polyurethane possesses the following characteristics,
[3].

- Strong crystallization tendency, low thermo-plasticity.
- Easy to solve.
- Excellent bonding strength for various materials.
- Very strong initial bonding strength.
- Very strong heat resistance.

3. Hydroxyapatite

The main crystalline component of the mineral phase of the bone is calcium-deficient carbonate–HA. The similarity of synthetic HA to bone minerals makes it the most clinically used biomaterial. HA has a hexagonal symmetry and unit cell lattice parameters a = 0.95 nm and c = 0.68 nm. Taking into account the lattice parameters and its symmetry, its unit cell is considered to be arranged along the c-axis, which would justify a preferred orientation that gives rise to an oriented growth along the c-axis and a needle-like morphology.

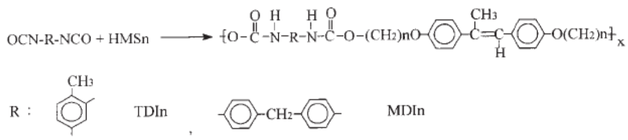
HA belongs to the calcium phosphate class characteristically resorbable in the body. Tetracalcium phosphate (Ca4P2O9), amorphous calcium phosphate, α-tricalcium phosphate (Ca3 (PO4)2), β-tricalcium phosphate (Ca3 (PO4)2), and HA (Ca10 (PO4)6(OH) 2) are members of calcium phosphates in the order of decreasing solubility in body fluids. Unlike other calcium phosphates, HA does not break down under physiological conditions. In fact, HA is thermodynamically stable at physiological pH and actively takes part in bone bonding, forming strong chemical bonds with the surrounding bone. For bone mimetic implants, synthetic HA is produced by various methods.

3.1 Applications of Hydroxyapatite (HAP)

Applications of hydroxyapatite include surface coating of orthopedic and dental metal implants where HA both promote sseointegration process and reduce metal ion release by acting as a physical barrier; bioceramic preparation for replacements of bone fragments, repair of periodontal bony defects; and use as drug carrier for controlled drug release with promising potential to heal bone fractions and suppress inflammation process, [9].. Hydroxyapatite may be employed in forms such as powders, porous blocks or beads to fill bone defects or voids. These may arise when large sections of bone have had to be removed (e.g. bone cancers) or when bone augmentations are required (e.g. maxillofacial reconstructions or dental applications). The bone filler will provide a scaffold and encourage the rapid filling of the void by naturally forming bone and provides an alternative to bone grafts. It will also become part of the bone structure and will reduce healing times compared to the situation, if no bone filler was used, [22]. Hydroxyapatite has been used clinically in different applications. It has been utilized as a dense, sintered ceramic for middle ear implants, alveolar ridge reconstruction and augmentation, in porous form as granules for filling body defects in dental and orthopaedic surgery and as a coating on metal implants, [23]. Hydroxyapatite, with biocompatibility and bioactivity, has already been used in clinics for filling of bone defects due to its similar chemical composition and structure to the mineral phase of human bone, and it can form bone bonding with living tissue through osteoconduction mechanism. Hydroxyapatite is not only a main constituent of bones and teeth, but a material applied as adsorbents since it has an excellent affinity to biomaterials such as proteins, [24].

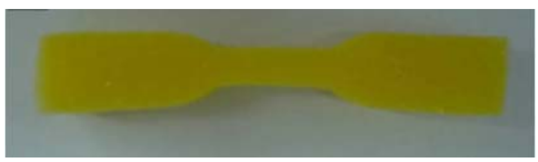
4. Materials and methods

Polyurethane was used in this experiment two part (A) and part (B) , and has been treated under the conditions of room temperature(20-25 C)[4].and, Hydroxyapatite (HAp) with the structural formula of $Ca_{10}(PO_4)_6(OH)_2$, inorganic [5]. The main crystalline component of the mineral phase of the bone is calcium-deficient carbonate–HA. The similarity of synthetic HA to bone minerals makes it the most clinically used biomaterial. HA has a hexagonal symmetry and unit cell lattice parameters a = 0.95 nm and c = 0.68 nm. Taking into account the lattice parameters and its symmetry, its unit cell is considered to be arranged along the c-axis, which would justify a preferred orientation that gives rise to an oriented growth along the c-axis and a needle-like morphology.



Preparation of Polyurethane

Five type cell specimens (150 × 13 × 3 mm) were used for the tensile strength test using an Instron universal testing machine (Model No. 8801 UK, Instron) at ambient temperature according to ASTM D 638 procedure 27C. The rate a crosshead movement was 10 mm/min. The samples were prepared by casting method cut from cast sheet of 3 mm thickness as shown in Figure(1). It was got of the tensile stress, tensile modulus and tensile strain of the PU and PU/HA composite samples data were measured with screen software.



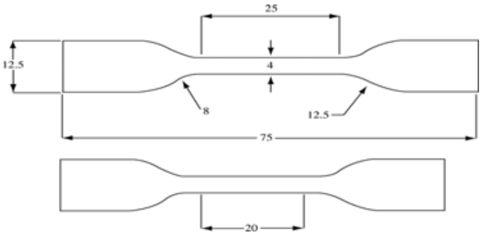


Figure 1: Diagram showing samples experiment

5. Conclusion

In this work mechanical properties and morphological of polymer polyurethane and bio composite hydroxyapatite (PU/HA) ,on this experiment the mechanical properties have improved when compared to polyurethane without any filler loading(control).In this experiment it was used four types of experiment, the mechanical properties (tensile test, flexural test , impact test and the SEM). The samples were with the different filler loading (2, 4, 6, 8, 10 wt %) and with dimensions 15 x 13 x 3 mm were used. For that ,the purpose from this article it will be the focus of improvement of the properties of PU-HA by using experiment , study and develop better to mechanical properties , by using several testing ways.

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