

## **Mechanical properties of SEVA / hydroxyapatite composite with to HAP different particle sizes**

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### **Abstract**

Hydroxyapatite is a biocompatible ceramic and reinforcement for bone implantations. SEVA/HAP composite content HAP filler with difference particle sizes were designed. Mechanical tests like tensile modulus, UTS, strain at break and biodegradation were investigated. Results illustrated much increase tensile modulus of composites content HAP nano powders ratio to micro powders. Also UTS analysis of composites illustrated much increase UTS of composites content HAP nano powders ratio to micro powders and strain at break analysis of composites illustrated much decrease of strain at break composites content HAP nano powders ratio to micro powders. The composites degradation in PBS solution showed slowly degradation time of composites content HAP nano powders ratio to micro powders filler.

**Keywords:** *Biodegradation Material, Mechanical Properties, Particle Sizes, SEVA/HAP Composite*

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### **1. Introduction**

The ideal biomaterial for implantation should be the one that is biologically and mechanically compatible with bone [1]. The possibility of producing biodegradable load-bearing implants, based on bioabsorbable polymers or composites, that exhibit an appropriate initial strength and stiffness and controlled degradation rates (in the presence of human fluids) can overcome some problems traditionally associated with metallic implants applied in orthopaedics [2]. Some biodegradable polymers are already under clinical use, including polyglycolic acid (PGA) [2, 3], polylactic acid (PLA) [2, 3] and polyhydroxybutyrate (PHB) [2, 4].

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Over the past 30 years, synthetic hydroxyl apatite [5, 6] and glass/ceramics [7, 8] have been developed and used in the medical field [9]. It is well known that when these bioactive ceramics are implanted in the body, they spontaneously bond to living bone via an apatite layer deposited on their surface without forming the fibrous tissue around them [10-12]. Starch-based polymers are a potential alternative [13,14], especially when reinforced with bioactive bone-like ceramic fillers, such as hydroxyapatite (HA) [14], which are expected to confer a bone-bonding behaviour [15] and to improve the mechanical properties of these composites [14]. In spite of the promising results obtained so far, these composites exhibit a poor polymer /filler interface [14-21]. Starch with ethylene vinyl alcohol, named SEVA-C, can associate a degradable behaviour with interesting mechanical properties as well as a bioactive character when bioactive filler such as HA is incorporated [17, 21].

## **2. Materials and methods**

### **2.1. Materials**

SEVA-C (merk), Ca (NO<sub>3</sub>)<sub>2</sub>.4H<sub>2</sub>O [0.01 mol; Acros 99%], P<sub>2</sub>O<sub>5</sub> [0.03 mol; Acros 99%], HAP [size average 100 micrometer], ethyl alcohol, dioxide water.

### **2.2. Methods**

Commercially obtained Ca(NO<sub>3</sub>)<sub>2</sub>.4H<sub>2</sub>O [0.01 mol; Acros 99%] and P<sub>2</sub>O<sub>5</sub> [0.03 mol; Acros 99%], HAP were sed with the molar ratio of 10:3, which is desired Ca/P ratio obtained hydroxyapatite, and 10 ml of ethyl alcohol was used as the solvent. Solution after dissolving slowly transforms into a gel after a period of 1h. The gel is then dried in an oven at 120 °C in air for 15h following which the as-dried gel is subsequently heat-treated in stagnant air at 950 °C for 12h. HAP powders to particle sizes 100-150 nano meters by this sol-gel method obtained. SEVA/HAP composite content HAP with different particle sizes and amounts prepared by Twin-screw extruder.

### **2.3. Mechanical test**

The Tensile test of SEVA/HAP layer (Membrane strips with 5 mm in width) in dry state were performed with Instron Universal Mechanical Tensile Machine at room temperature using a crosshead speed of 1 mm/min and 40 mm grip distance. The results were the mean values of five independent measurements.

### **2.4. In vitro degradation study**

Layers (100 mg dry weight) with different weight rations were put into Falcon tubes containing 50 mg PBS (PH: 7.4; 37 °C). After 4 months incubation in PBS solution, the measured weights of samples were considered as original weights (100%).

### 3. Results and discussion

#### 3.1. Mechanical tests

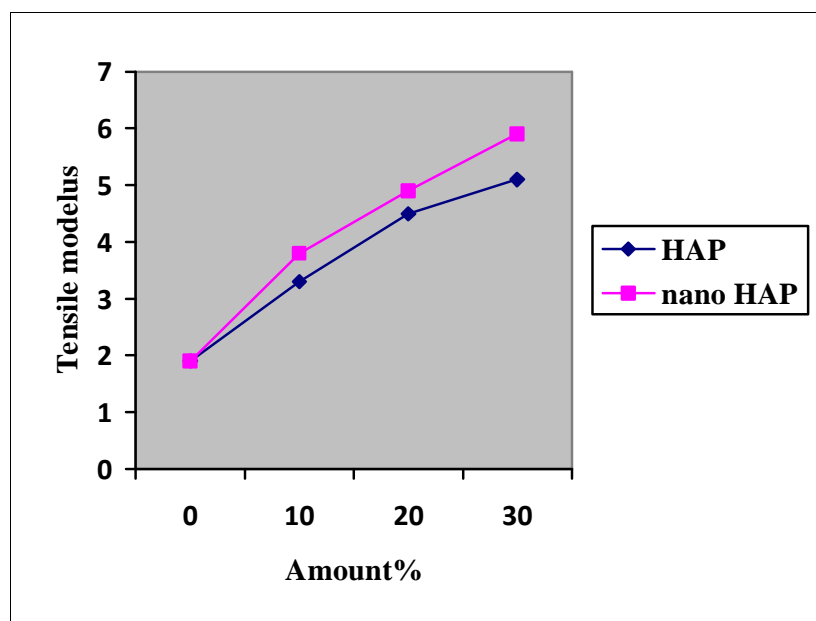
Tables 1 shows tensile modulus of composite content HAP micro & nano powders with different amounts. Figure 1 present tensile modulus of composite content HAP micro and nano powders. Tensile modulus of composite content HAP nano powders 1.9 to 5.9 Gpa and composite content HAP micro powders 1.9 to 5.1 Gpa obtained.

**Table 1a.** Tensile modulus of composite content HAP micro powders with different values

|                 |     |     |     |     |
|-----------------|-----|-----|-----|-----|
| <b>HAP %</b>    | 0   | 10  | 20  | 30  |
| <b>E0.8 Gpa</b> | 1.9 | 3.3 | 4.5 | 5.1 |

**Table 1b.** Tensile modulus of composite content HAP nano powders with different values

|                  |     |     |     |     |
|------------------|-----|-----|-----|-----|
| <b>NanoHAP %</b> | 0   | 10  | 20  | 30  |
| <b>E0.8 Gpa</b>  | 1.9 | 3.8 | 4.9 | 5.9 |



**Fig.1a.** Tensile modulus of composite content HAP micro and nano powders with different values

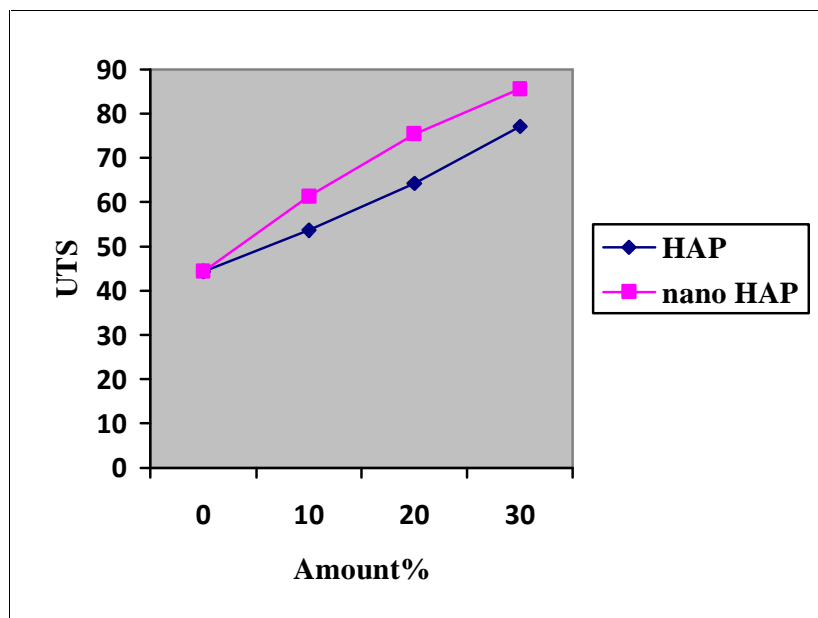
Tables 2 show UTS of composite content HAP micro & nano powders with different amounts. Figure 2 illustrate UTS of composite content HAP micro and nano powders. Therefore much increase UTS of composite content HAP nano powders 44.4 to 85.6 Mpa and 44.4 to 77.1 Mpa with micro powders obtained.

**Table 2a.**UTS of composite content HAP micro powders with different amounts

| HAP %    | 0    | 10   | 20   | 30   |
|----------|------|------|------|------|
| E0.8 Mpa | 44.4 | 53.6 | 64.3 | 77.1 |

**Table 2b.**UTS of composite content HAP nano powders with different amounts

| NanoHAP % | 0    | 10   | 20   | 30   |
|-----------|------|------|------|------|
| UTS Mpa   | 44.4 | 61.3 | 75.4 | 85.6 |



**Fig.2.** UTS of composite content HAP micro and nano powders with different amounts

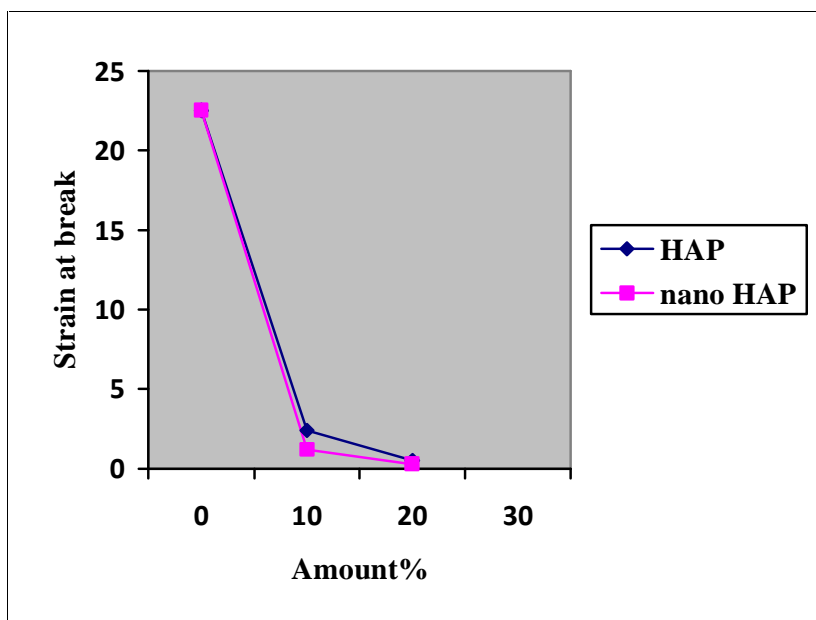
Tables 3 shows strain at break ( $\epsilon_r$ ) of composite content HAP micro & nano powders with two different amounts. Figures 3 illustrate strain at break ( $\epsilon_r$ ) of composite content HAP micro and nano powders. Therefore  $\epsilon_r$  of composite content HAP nano powders 22.5 to 0.3% and 22.5 to 0.5% .with HAP micro powders obtained.

**Table 3a** .Strain at break ( $\epsilon_r$ ) of composite content HAP micro powders with to difference value

| HAP %             | 0    | 10  | 20  | 30 |
|-------------------|------|-----|-----|----|
| Strain at break % | 22.5 | 2.4 | 0.5 | -  |

**Table 3b**. Strain at break ( $\epsilon_r$ ) of composite content HAP nano powders with two different values

| NanoHAP %         | 0    | 10  | 20  | 30 |
|-------------------|------|-----|-----|----|
| Strain at break % | 22.5 | 1.2 | 0.3 | -  |



**Fig.3a**. Strain at break ( $\epsilon_r$ ) of composite content HAP micro and nano powders with different amounts

### 3.2. *In vitro* degradation

Figure 4 shows degradation time of composites content HAP powders to different particle sizes after 4 months incubation in PBS solution (PH. 7.4, 37 deg.C). Curves illustrate much stability of composite content HAP nanopowders ratio to HAP micropowders.

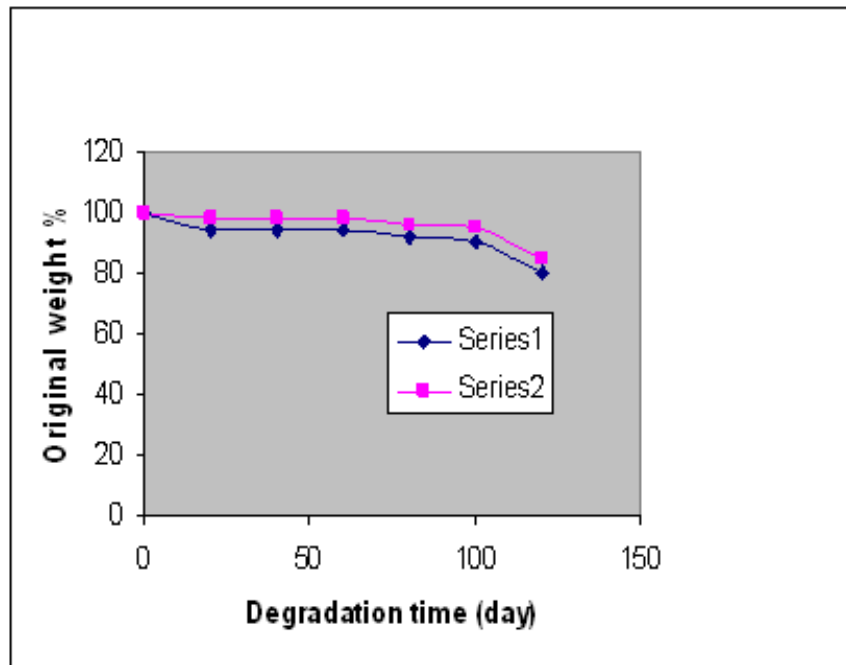


Fig.4. Weight loss profiles of composites (series1: HAP & series2: nano HAP). Figure illustrates decrease of degradation time of composite content HAP nanopowders ratio to micropowders.

### 4. Conclusion

In this study HAP nanopowder obtained by sol-gel method and HAP micro powders with different weight ratio mix to polymeric base (SEVA), then mechanical properties of SEVA/HAP composites content HAP nano & micro powders as filler investigated. Results of tensile modulus & UTS illustrated much increase strength of composite content HAP nanopowder ratio to HAP micropowder. Curves obtained from figure 4 illustrate much stability of composite content HAP nanopowders ratio to HAP micropowders and it's due to homogenizing distribution of HAP powders specially nanopowders in polymeric base that cause to their block for diffusion of PBS solution and instability composite.

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