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Mechanical and Solubility Behavior of Chitosan Coated Hydroxyapatite Foams

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. ***Abstract-***In this study highly porous hydroxyapatite foam fabricated by powder metallurgy method for various sintering temperatures and coated with chitosan after sintering. The solubility of the samples were in Lactated Ringer's solutions for various day. From the results compression strength developed from ~1.2 MPa to ~12 MPa. The pH of the solution was changed from ~7 to 7.45 and 7.28 for uncoated and chitosan coated samples. Finally, the sintered samples at 1150 ºC for 2h showed the highest density and compressive strength.

Keywords – Hydroxyapatite, chitosan, foam, compression, solubility

I. Introduction

Today calcium-phosphates hydroxyapatite (HA) shows great interest in health sector. HA intensively used in the production of biomaterials as orthopedics and surgery, dentistry and bone tissue engineering [1]. HA high biocompatibility, slow decay, the chemical structure of the bone mineral most closely resemble. Thanks to the high bioactivity of HA, bone and HA bioceramic interface very strong bonds can occur. HA in natural bone, biologically more active than synthetic HA [2,3]. High-porous bioceramics, according to low porous bioceramics, showed better support for new bone formation [4, 5]. Hulbert et al. in the study for bone mineralization, bioceramics should be at least 100 µm in pore size [6]. The studies done Karageorgiou et al. for better biocompatibility, the bioceramic pore size should be at least 300 µm [7]. Application to porous bioceramic human bone, the pore structure takes on the role as a channel system [8]. Table 1. gives the HA bioceramic and porous bone mechanical properties. In our previous studies, highly porous bioceramics with maximum 6.5 MPa compressive strength has been achieved [9].

Table 1. Mechanical properties of HA and real bone

Mechanical properties	HA	Porous Bone
Elastic modulus (GPa)	4.0-117	0.05-0.5
Compressive strength (MPa)	147	0.1-16
Density (theory, g/cm^3)	3.16	1-2.5

In this study HA foam fabrication were purposed for various sintering temperatures. Fabricated foams were coated with chitosan and then characterized with compression test and solubility test.

II. Materials and Method

The HA powder were prepared with polyvinyl alcohol to enhance the plastic behavior during shaping. Fabricated powder was shaped in disc for various load. The samples were sintered at 950 ℃, 1050 ℃, 1150 ℃ for 1-3 hours. The microstructure was observed with scanning electron microscopy (SEM). After sintering, chitosan was used to coat the HA. Samples were kept in Lactated Ringer's solution for 17 days and pH values measured every 3 days.

III. Results and Discussion

In this study, all samples were sintered at 950 ℃, 1050 ℃,1150 ℃ for 1-3 hours. Table 2. shown the compressive strengths of all sintered samples. The best mechanical properties (4.98MPa) were observed for 1150 ℃ for 2h.

Table 2. The compressive results with temperature and time

	950 ℃	1050 ℃	1150 ℃
1 hour	1.27 MPa	1.49 MPa	3.36 MPa
2 hour	1.76 MPa	2 MPa	4.98 MPa
3 hour	2.44 MPa	2.285 MPa	4.08 MPa

Table 3 gives the for various shaping loads for 300 MPa, 450 MPa and 600 MPa pressure on compressive behavior of ceramics. As given, the samples have more damage with increasing load.

Table 3. The results of compression test after forming and sintering.

Shaping Load (MPa)	Compression test (MPa)
300	11.56
450	6.88
600	4.99

Fig. 1, a-f. gives the SEM results of HA foams for 950℃, 1050℃ and 1150℃ for 2 hours. Samples obtained at 950 ℃ degrees indicate the porous structure. When the sintering temperature increases in the bonding between the grains is improving and the density of the cell wall increased.

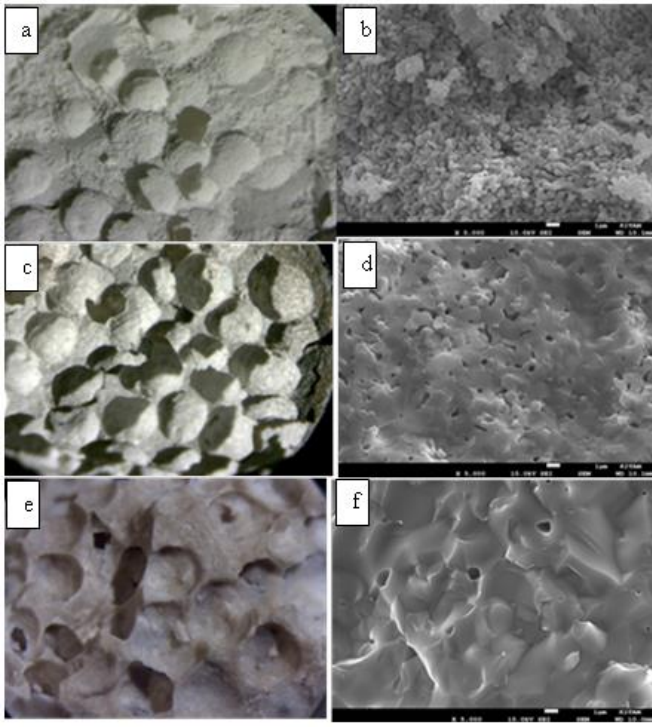

Fig 1. The SEM images of HA foams for various sintering temperatures: a-b) 950 ºC, c-d) 1050 ºC, e-f) 1150 ºC

The pH value of the uncoated and chitosan coated samples in Lactated Ringer's solution shown in Fig. 2. As clearly shown that pure HA foam pH changed from ~7 to 7.45 with increasing day. Chitosan coated sample pH changes to ~7.28. This results should be supported with atomic scale characterization as ICP-MS and animal tests.

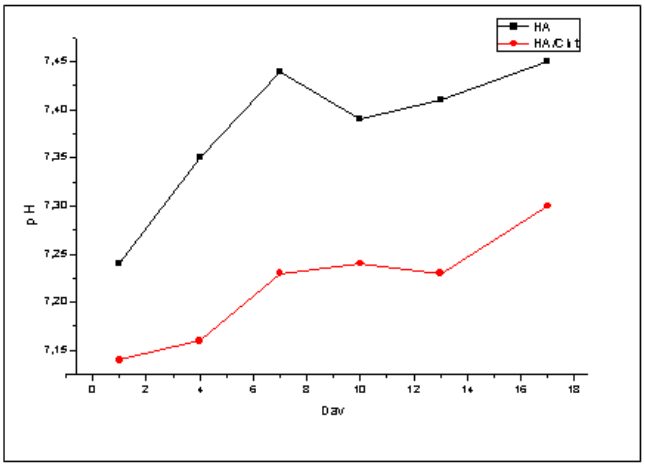

Fig 2. The dissolution behavior of pure and chitosan coated HA foams depending of the day

IV. CONCLUSION

In this study highly porous hydroxyapatite foam fabricated and coated with chitosan. The solubility of the samples were tested in Lactated Ringer's solutions. The compressive strength enhanced from ~1.2 MPa to ~12 MPa. The pH of the samples in solution was varied from ~7 to 7.45 and 7.28 for uncoated and chitosan coated foams.

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