SURFACE MODIFICATION OF cp-Ti AND Ti-6Al-4V BY WET BLASTING TECHNIQUE FOR BIOMEDICAL APPLICATION

Acharya RAKNGARM^a, Kousei OYAMA^b, Yoshiharu MUTOH^c

^aGraduate Student, Nagaoka University of Technology, Kamitomiokamachi 1603-1, Nagaoka,

^aUndergraduate Student, Nagaoka University of Technology, Kamitomiokamachi 1603-1, Nagaoka,

^cDept. of Mechanical Engineering, Nagaoka University of Technology

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ABSTRACT

The cp-Ti and Ti-6Al-4V substrates were blasted with HAp and HAp/Ti mixed powders at room temperature using a wet blasting machine. The surface of substrate was found to be coated with HAp and HAp/Ti composite which was clearly showed HAp peaks from both XRD and EDS analysis. Anyhow, CaTiO₃ was occurred at low volume ratio of HAp in HAp/Ti mixed powder. The HAp attached tightly to the substrate, at least at the microscope level. It was stable against ultrasonic vibration for at least 5 min. The reaction between HAp and its substrate might be strong mechanochemical bonding which could produce a strong coating for biomedical application.

INTRODUCTION

Blasting technique is commonly employed to clean surfaces and to achieve both microretentive topography and increased surface area. Interestingly, the blasted particle sticks to the plate in some cases[1-2]. Generally, the blasting impact not only affects the metal surface but additionally leads to the deformation and in some cases to the total disintegration of the grain itself [3]. If hydroxyapatite (HAp) powders and/or HAp/Ti mixed powders stick to the titanium substrate, it may be possibility to create a strong bonding between the coating layer and the substrates by the deformation of the substrates surface. So, the main goal of the present work was the development of a reproducible method which create HAp and/or HAp/Ti layer on cp-Ti and Ti-6Al-4V substrate for biomedical application.

EXPERIMENTAL PROCEDURES

Commercial pure titanium (cp-Ti) and Ti-6Al-4V plates were used as substrates in this study. The cp-Ti and Ti-6Al-4V with a size of 10 x 50 x 3 mm³ were cleaned ultrasonically in distilled water, acetone, and ethanol for 20min. After that, the substrates were ultrasonically cleaned again in distilled water for another 10 min and then dried in air. Hydroxyapatite (HAp) powders (Taihei Chemical) were sintered at 1,150 °C for an hour. Subsequently, HAp sintered clusters were milled in a ball milling to obtain HAp sintered powders. The round Ti powder (Sumitomo Titanium Corporation) was mixed with the sintered HAp powders. This mixed powders of HAp (25 µm)/Ti (45 µm) were used for wet blasting at chamber pressure of 0.20 MPa with blasting pressure of 0.25 MPa. The mixed powders of 100 ml were feed into 400 ml distilled water in the chamber of blasting machine. The stirrer was operated during the blasting processes.

RESULTS AND DISCUSSION

Table 1 shows the volume ratio of HAp/Ti mixed powders which were blasted on both cp-Ti and Ti-6Al-4V substrates. It can be seen that all of the blasting conditions were successfully blasted to the substrates. The EDS analysis of the cp-Ti and Ti-6Al-4V substrates before and after blasting processes are also shown in Table 1. The Ca/P molar values of the specimens after blasting were almost the same, which is close to those of human bone (1.67).

Table 1 The various blasting condition on cp-Ti and Ti-6Al-4V with its existing phase(s) after blasting process

HAp/Ti vol. percent	Ca/P ratio		Phase(s) existed	
	cp-Ti	Ti-6Al-4V	cp-Ti	Ti-6Al-4V
20% HAp:80% Ti	1.77	1.71	Calcium Titanate, HAp	HAp
40% HAp:60% Ti	1.73	1.69	HAp	HAp
80% HAp:20% Ti	1.70	1.76	HAp	HAp
pure HAp	1.76	1.81	HAp	HAp

For further identification of the surface, XRD analysis was carried out. The XRD results are also shown in Table 1. Phases corresponding to the titanium and HAp powder were found on cp-Ti

and Ti-6Al-4V substrates after blasting show. At 20% HAp volume ratio, CaTiO₃ was co-existed and clearly observed through XRD. Thus, there was some compositional or crystallographic change during blasting process, especially, at higher volume percent of titanium powder contents.

Fig 1 SEM micrographs of (a) cp-Ti, (b) Ti-6Al-4V before blasting and after blasting with pure HAp for (c) cp-Ti, (b) Ti-6Al-4V substrates.

It is commonly known that titanium surface is covered with TiO₂. This oxide layer is thin and extremely fast to form within a few second. If the tiny particle of HAp hit with Ti/TiO₂ particle, the released energy would cause the decomposition of HAp and Ca-ion would be released. On the other hand, TiO₂ is an amphoteric oxide, it could easily react with any substance in both acidic and/or basic region. When Ca-ion impacted with TiO₂ with enough activation energy, CaTiO₃ may occur. However, at volume ratios of HAp higher than 40%, there were no compositional or crystallographic changes during blasting process.

Figure 1 shows the SEM micrographs of the substrate surface before and after blasting. It is found that the HAp attached tightly to the substrate, at least at the SEM level. In additions, it was stable against ultrasonic vibration for at least 5 min. So, the reaction between HAp and substrate may cause strong mechanochemical bonding.

CONCLUSION

Wet blasting of HAp/Ti mixed powder on cp-Ti and Ti-6Al-4V substrates were success. There was no compositional or crystallographic change during blasting process at volume ratios of HAp higher than 40%. The minor phase of CaTiO₃ was observed only at 20% volume ratio of HAp. Anyhow, the HAp powders were remained on the substrate even after ultrasonic cleaning. The reaction between HAp and substrate may cause strong mechanochemical bonding.

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