

INVESTIGATION ON QUALITY OF HYDROXYAPATITE ADHESION ON  
INVESTMENT CASTING MOULD

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*To my beloved father and mother*

*Amir*

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## ABSTRACT

Quality of Hydroxyapatite adhesion on investment casting mould was investigated in this project. Investment casting is a new method for HAp coating onto the metals. First stage of applying this method is making appropriate investment casting mould. Appropriate investment casting mould should have specific properties such as: sufficient strength, proper shape for obtaining sound casting, and the most important one, enough amount of HAp should adhered onto the inner layer of investment casting mould to defuse into the metal during casting for desirable coating. For this purpose appropriate methods used to stick sufficient amount of Hydroxyapatite onto inner layer of ceramic investment casting mould to prepare it for metal coating by casting. therefore 3 different HAp-water mixture viscosities: 5, 7.5 and 10 seconds, were applied to find out which of them was support enough amount of Hydroxyapatite after dewaxing and firing. Dewaxing in three different temperatures 100°, 200° and 300° C applied as well to investigate the effect of the dewaxing temperature on the quality of HAp adhesion on to the moulds. Finally after gathering the results of dewaxing; moulds that have the desirable properties were fired at 600° C to study the effect of firing process on the quality of hydroxyapatite adhesion on moulds. After all XRD, EDAX tests and 3D microscope supervision were done to find out the results. By considering these tests 5 seconds viscosity of HAp-water mixture and 300°C dewaxing temperature had the desirable properties for making sufficient investment casting moulds for metal coating.

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## CHAPTER 1

### INTRODUCTION

Hydroxylapatite, also called hydroxyapatite, is a mineral. It is a naturally occurring form of calcium apatite with the formula  $\text{Ca}_5(\text{PO}_4)_3(\text{OH})$ , but is usually written  $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$  to denote that the crystal unit cell comprises two molecules. Hydroxylapatite is the hydroxyl endmember of the complex apatite group. The OH<sup>-</sup> ion can be replaced by fluoride, chloride or carbonate. It crystallizes in the hexagonal crystal system. It has a specific gravity of 3.08 and is 5 on the Mohs hardness scale. Pure hydroxylapatite powder is white. Naturally occurring apatites can however also have brown, yellow or green colorations..

Hydroxylapatite can be found in teeth and bones, within the human body. Therefore, it can be used as a filler to replace amputated bone or as a coating to promote bone ingrowth into prosthetic implants. Although many other phases exist with similar or even identical chemical makeup, the body responds much differently to them.

Many modern implants, e.g hip replacements and dental implants, are coated with hydroxyapatite. It has been suggested that this may promote osseointegration and there is good evidence for this. Because of its poor mechanical strength most of



the time it is needed to use it as a coating of any other materials such as Titanium alloys, Cobalt alloys and medical grade Stainless steel.

There are various ways for coating HAp on to different materials each method of coating has its own advantage and disadvantages; The method of coating is depend on the usage of the implant, accuracy, amount of HAp that was needed to coat and the cost of the method as well. Some of these methods are summarized in table 2.1. in chapter 2.

One of the most new methods for coating HAp on to the metallic materials is coating by investment casting method, also called lost-wax casting, is one of the oldest known metal-forming techniques. From 5,000 years ago, when beeswax formed the pattern, to today's high-technology waxes, refractory materials and specialist alloys, the castings allow the production of components with accuracy, repeatability, versatility and integrity in a variety of metals and high-performance alloys. Lost foam casting is a modern form of investment casting that eliminates certain steps in the process. Investment casting consist of 3 main stage, at first making the wax and preparing ceramic shell on it, second dewaxing the moulds and finally fire the dewaxed moulds.

This method of coating firstly used to coat HAp on to Cobalt alloys [J.C. Escobedo, et. al. 2006]. This method of coating has its own advantages and disadvantages. This method is very cheap regarding to other coating methods and it is very simple as well. Also according to using simple methods control of the elements which are involved in the finale results is easier than other coating methods like plasma spraying or electro chemical methods for coating.

In this project finding the best dewaxing temperature for moulds aimed. And investigation to find out what is the best viscosity of HAp-water mixture for coating the inner layer of investment casting moulds was targeted as well.

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