Hydroxyapatite coating on Ti by Electrophoretic Deposition

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Abstract: Commercial grade submicron sized Hydroxyapatite (HAp) particles were Electrophoretically deposited on Ti in ethanol medium. EPD is a non line of sight process capable of producing thick coating. Thickness of the green coating was adjusted by the key processing parameters like applied voltage and deposition time. Sintering was done at an elevated temperature to get a good bonding between Ti and Hap and to compact the coating. X-Ray diffraction is used to determine the surface composition and crystallinity. Coating thickness was determined to see the effect of deposition voltage and time. Cell culture is done on the coated samples to study the cell material interaction.

Introduction:
Metals are widely used in load bearing prosthesis primarily due to their ductility and good mechanical properties. Concerns with metal is that they are bioinert and takes a long time to form any kind of biological bonding with surrounding tissue. Another material which has been extensively studied for biomedical application is Hap. Hap is a constituent of natural bone and shows excellent bioactivity. But the application of Hap as a load bearing prosthesis is restricted due to their poor mechanical properties. Hap is brittle in nature and fails in catastrophic manner with initiation of small cracks.

Problems can be overcome by giving a bioactive Hap coating over strong metal to take advantage of both the materials.

Concerns are
- Interfacial bond strength of metal and ceramic
- Stability of the coating in long term application

Various coating process tried are plasma spray, dip coating, thermal deposition, sol-gel coating, electrophoretic deposition (EPD). Of these processes EPD came up with certain advantages like
- Homogeneous coating
- Great control over chemical composition and coating thickness
- Non line of sight process
- Ability to form highly crystalline coating phase

In EPD charged particles migrate towards the counter charged electrodes under the influence of applied electric field

Challenges in EPD are
- Good interfacial bond strength
- Ability to make total crack free interface

Objective: objective of this project is to understand the effect of key processing parameters on coating thickness and their physical, mechanical and biological properties.

Processing: Key processing parameters for EPD are applied voltage, coating time and sintering temperature.
- Applied voltage varied from 50V to 250 V
- Coating times were 15, 30, 45 and 60 Sec
- Sintering temperature was 950°C, 1000°C. Higher temperature was discarded due to loosing the chemical purity of the coating phase.

Process flow chart
- Suspension preparation
- Substrate preparation
- EPD coating
- Drying at 60°C for 2h
- Sintering for 60 min

Surface and interface morphology
- Surface and interface of the coating has been studied microscopically. Surface microstructure shows rough surface without any visible crack.

Cell material interaction
To get the biological activity of coating surface, human osteoblast cells are cultured on the surface of the samples. The cell culture medium was McCoy’s 5A medium. Fungizone was added to the culture media to prevent fungus attack. Coated samples were autoclaved at 121°C for 45 minutes. Cells were seeded from the culture plate and put on the surface of the samples. Samples with cells and culture media were incubated at 37°C in an atmosphere of 5%CO2 and 95% air. Culture media was changed after every 2 days. Cells were cultured for 5 and 11 days.

5 day cell culture study shows not may cells on the surface. But the cells are spreading and attaching to the surface. Also the surface is becoming smooth due to deposition of mineral phase.

11 Day cell culture results shows lot more cells on the surface. Cells are interacting with each other spreading and covering the surface.

Influence of applied voltage
Samples coated for 60Sec. After sintering samples are cross sectioned with epoxy mounting to determine the thickness of coating.

Coating thickness is significantly influenced by applied voltage.

Influence of coating time
Samples are coated at 100V. Same cross sectional process is used to determine the coating thickness.

Summary:
- Thickness of the coating is significantly influenced by applied voltage and coating time.
- Crack free surface and interface is achieved by controlling the processing parameter.
- Cell culture results show that after EPD coating surface is bioactive.

Future Work
- determine the interfacial bond strength
- tailor the composition to improve the bond strength

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References