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Synthesis and characterization of alumina-fluorapatite coatings deposited by atmospheric plasma spraying

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Abstract: In this work, the effect of an alumina (Al_2O_3)-fluorapatite (Fap: $Ca_{10}(PO_4)_6F_2$) composite coating on 316 L stainless steel was investigated. Only a small amount of fluorapatite (6.68 % Fap corresponding to 0. 25% fluor) was introduced into alumina using a mixture of powders to increase the bioactivity of the coatings. The mixed powders were deposited onto 316 L SS substrates using atmospheric plasma spraying. The characteristics of the coatings were investigated with various methods including scanning electron microscopy (SEM), X-ray diffraction (XRD). The bioactivity of the Al_2O_3/Fap composite was evaluated by immersing the samples in simulated body fluid (SBF). Al_2O_3/Fap coating showed excellent behavior in vitro test revealing that the Fap is quite effective in improving biocompatibility.

Keywords: Fluorapatite; Alumina; Plasma Spraying; Simulated body fluid; Bioactivity.

1. Introduction:

Hydroxyaptite (Hap) and fluorapatite (Fap) constitute the inorganic basis of human hard tissues. Thermally sprayed Hap is widely used in orthopedic prostheses given its great potential in bone regeneration activity [1]. However, it has been reported that the high degradation rate of Hap coatings in biological environment remains a serious concern [2]. Previous research works have shown that the solubility of fluoro-hydroxyapatite (FHap) decreases with the increase in F^- concentration [3].

Thus, Fap has recently attracted some attention as an alternative to pure Hap coatings on metallic implants due to its chemical composition similar to the bone mineral [4], and therefore its excellent biocompatibility [5]. In fact, the human bone contains approximately 1wt% of Fluor [6] which is known as an effective element in inhibiting caries [7].

In this context, the present work is an attempt to investigate the potential interest of Fap-Al_2O_3composite coatings. A considerable amount of research already focused on alumina coatings given its chemical stability and its high mechanical strength. Alumina has for a long time provided excellent bioinertia [8]. It is also one of the most widely investigated reinforcement materials for Hap bioceramics [9]. Meanwhile, considering the interesting bioactivity of Fap, it is surprising that, up to now, there has been very limited works on the synthesis and characterization of Fap-Al_2O_3 composite coatings.

The aim of the present work was to investigate a 6.68 w% Fap-Al_2O_3 coating deposited on a 316 L SS substrate using atmospheric plasma spraying (APS). The micro-structural and biological properties of these Fap-alumina coatings are presented and discussed in order to determine their possible use as an implant material.

2. Materials and methods:

The Fap powder was synthesized using a wet-chemical method [10]. A calcium nitrate solution was slowly poured into a boiling solution containing di-ammonium hydrogeno-phosphate, and a 28% NH_4OH solution was added to the mixture in order to adjust the pH to 9. The precipitate was filtered and calcined at 500°C. The pure α-alumina (α-Al_2O_3) powder (Medicoat, 98.9 %) was used as base material. The powder mixtures were milled in ethanol. The mixtures were dried at 80 °C for 24 h.

Pure Al_2O_3 and Al_2O_3-Fap coatings were deposited on 316 L SS discs by APS using a Sulzer-Metco F4-MB (Switzerland) plasma gun mounted on an ABB-IRB2400 robot (Sweden). The plasma spray process parameters are listed in Table 1. The coating thickness was evaluated using a micrometer (250 µm).

Table.1. Plasma spray process parameters

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