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Performance of atmospheric plasma sprayed HA coatings under dry and wet fatigue conditions

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Hydroxyapatite (HA) is widely used as a coating on orthopaedic devices, as it provides a means of enhancing cell adhesion to the device surface. Atmospheric plasma spray (APS) is the most widely applied HA deposition technology today. There are concerns however regarding the high deposition temperatures used in the APS process, as this can cause changes in HA crystallinity. For example, HA coatings that exhibit a higher amorphous content tend to display higher dissolution rates. There are further concerns regarding the affect these higher dissolution rates may have on the integrity between the metal interface and the HA coating. The aim of this study is to evaluate the fatigue performance of APS HA coatings, carried out under both dry and wet fatigue conditions. Dry tests were performed in air, while the wet test samples were encapsulated by a solution called Simulated Body Fluid (SBF). This SBF solution enabled the *in vitro* simulation of the HA coating's response to a typical *in vivo* implant environment. Commercial APS HA coatings were obtained on Ti alloy rods. The coated rods were subjected to 10^7 cycles in a rotating cantilever fatigue tester, with a stress amplitude of 500 MPa at 4700 rpm. The tested substrates were ultrasonically cleaned in deionised water and oven dried at 50 °C prior to evaluation. SEM, EDX and XRD examination demonstrated that the coating properties of both the reference (as recieved) and dry samples were almost identical, however the cross sectional micrographs showed some signs of material loss for the dry samples. Conversely, wet fatigue tests resulted in complete failure of the HA coating after the 10^7 cycles. The SEM and XRD examination also demonstrated no evidence of HA present on the metal interface after these tests. In conclusion, HA coating delamination after SBF fatigue tests was attributed to material loss due to coating dissolution, occurring both at the interface and within the coating. The disparity in response for the two fatigue test conditions, indicates that the SBF tests are more severe. Literature indicates however that the use of SBF is more representative of the implanted device environment, and thus, this fatigue test methodology should help to provide a more accurate assessment of the long term performance of HA coatings in the body.

Keywords
Mechanical Fatigue, Biomimetic testing, Plasma Spray, Bio-medical Coatings