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Effect of substrate geometry on microstructure and biological response of air plasma-sprayed hydroxyapatite coatings

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This study investigates the influence of substrate geometry on the microstructural evolution, phase stability, and biological response of air plasma-sprayed hydroxyapatite (HAp) coatings on Ti-6Al-4V alloy substrates. Coatings were applied under atmospheric conditions onto three geometrically distinct substrates: flat disks, thick cylinders, and cylindrical rods, followed by immersion in simulated body fluid (SBF) to simulate physiological conditions.

X-ray diffraction and microscopy techniques were employed to evaluate phase composition, crystallinity, residual stresses, and surface morphology. All coatings exhibited characteristic plasma-sprayed features, including pancake splats, glassy regions, and cracks. Initial residual stresses were small and tensile, decreasing over 56 days of immersion. For instance, the average normal stress on flat disks dropped from 36.0 ± 3.0 MPa to 27 MPa. Similar trends were observed on the other geometries.

Immersion in SBF promoted ion dissolution, surface roughening, and precipitate formation, with growth occurring through a 3D network of channels. Energy-dispersive spectroscopy (EDS) confirmed increasing oxygen and decreasing phosphorus content across all samples after immersion. The Ca/P ratio declined in all geometries, most notably in thick cylinders (2.38 to 0.99).

XRD results confirmed HAp as the dominant phase, with minor tetra calcium phosphate, tricalcium phosphate and calcium oxide phases. HAp content increased within the first 7 days and slightly declined thereafter. For example, flat disks showed a rise from 70 wt% to 85 wt%, decreasing to 82 wt% by day 56. The findings underscore the significance of substrate geometry in tailoring coating performance for biomedical applications.

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