Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, Vol. 4, No 1, Suppl. 1, Article ID 645, 1 Page

Infinite Science Publishing

Abstract

Comparative Analysis of Laser Powder Bed Fusion (L-PBF) manufactured Co-Cr-Mo and Co-Cr-Mo-Fe alloy for dental applications: Metallographic, Mechanical & Corrosion analyses

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This work seeks to lay the basis for developing and evaluating alloys safe for implanting, with the benefits of digital design techniques and economies of material consumption while using Laser Powder Bed Fusion for metal additive manufacturing (MAM). The primary choice of Co-Cr base alloys for dental applications is due to their excellent mechanical and tribological properties. However, the toxicity and the cost due to the higher concentration of Co is a major concern. In our work, we reduce the concentration of Co by the addition of Fe without sacrificing the mechanical and corrosion properties of the alloy.

The cobalt-chromium-molybdenum-iron (Co-Cr-Mo-Fe) samples were additively manufactured by the Laser Powder Bed Fusion method. The microstructure, mechanical and corrosion properties of printed Co-Cr-Mo-Fe alloy were investigated and compared with commercial cobalt-chromium-molybdenum (Co-Cr-Mo) alloy. An optical microscope, SEM, EDS and an XRD are used to determine the microstructure, elemental segregation profile and identify the crystal structure. In as printed condition, no preferential elemental segregation was observed owing to rapid heating/cooling rates encountered in the L-PBF manufacturing technique.

At the same time, upon the heating the as-printed specimens of Co-Cr-Mo-Fe alloy to 1000^{o}C at a rate of 5^{o}C/min tend to segregate Cr and Mo rich precipitates in Fe and Co rich matrix where the Cr_7C_3 and $Cr_{23}C_6$ carbides also tend to decorate the precipitates interface. The tensile strength, yield strength, and elongation are significantly improved by Fe addition in Co-Cr-Mo-Fe alloy as compared to conventional Co-Cr-Mo alloys. Vickers hardness analysis showed a 15 % improvement in the hardness value of Co-Cr-Mo-Fe alloy than Co-Cr-Mo alloy.

The results of this study indicate that Co-Cr-Fe alloy is a superior alternative to the traditional Co-Cr-Mo alloy for the additive manufacturing of fixed dental restorations. The corrosion behaviour of the alloy was investigated by performing both immersion studies and electrochemical tests using artificial saliva as the physiological media according to ISO-10271:2020 standard. Both the studies showed improved corrosion resistance in Co-Cr-Mo-Fe alloy as compared to Co-Cr-Mo alloy.

AUTHOR'S STATEMENT
Conflict of interest: Authors state no conflict of interest. Animal models: n.a. Ethical approval: n.a. Informed consent: Informed consent has been obtained from all individuals included in this study.

DOI: 10.18416/AMMM.2022.2209645