

The effect of topological design on the degradation behavior of additively manufactured porous zinc alloy

Yixuan Shi^{1,2}, Yageng Li^{1,2}, Lu-ning Wang^{1,2}

¹ Beijing Advanced Innovation Center for Materials Genome Engineering, School of Materials Science and Engineering, University of Science and Technology Beijing, Beijing, 100083, China

² Institute of Materials Intelligent Technology, Liaoning Academy of Materials, Shenyang, 110004, China

Abstract The advent of additively manufactured biodegradable porous metals presents a transformative opportunity to meet the criteria of ideal bone substitutes. Precisely tailoring their degradation behavior constitutes a pivotal aspect of this endeavor. In this study, we investigated the effects of topological designs on the degradation profile of laser powder bed fusion (LPBF) Zn scaffolds under dynamic in vitro immersion tests. Specifically, four types of Zn-0.4Mn-0.2Mg scaffolds (beam-based: diamond, face center cubic; surface-based: gyroid, schwarz-P) were designed and fabricated. The degradation mechanism of the scaffolds was comprehensively evaluated using both experimental and simulation methods. The results illuminate the profound impact of structural design on the degradation properties of the Zn alloy scaffolds. The beam-based diamond and face center cubic scaffolds exhibited a degradation rate of 0.08–0.12 mm per year with a relatively uniform degradation mode under dynamic immersion. On the contrary, the surface-based gyroid and Schwarz-P scaffolds demonstrated a notably reduced degradation rate due to lower permeability. This restricted the diffusion of medium ions within the pores, culminating in the accumulation of degradation products and more severe localized degradation. This study underscores the potential of topological design as a compelling strategy for tailoring the degradation profile of additively manufactured biodegradable scaffolds, thereby advancing their suitability as bone substitutes.

Keywords: Additive manufacturing; Zn alloy; Degradation;