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Biomedical potential of porous Ti6Al4V scaffolds prepared by selective laser melting (SLM)

Katarzyna Haraźna [1*], Julia Sadlik[2], Edyta Kosińska[2], Agnieszka Sobczak-Kupiec[1], Mansoureh Rezapourianghahfarokhi[3], Irina Hussainova[3], Agnieszka Maria Tomala[1]

[1] *Department of Materials Science, Faculty of Materials Engineering and Physics, Cracow University of Technology, 37 Jana Pawła II Av., 31-864 Krakow, Poland*

[2] *Department of Materials Science, Faculty of Materials Engineering and Physics, CUT Doctoral School, Cracow University of Technology, 37 Jana Pawła II Av., 31-864 Krakow, Poland*

[3] *Department of Mechanical and Industrial Engineering, Tallinn University of Technology, 19086 Tallinn, Estonia*

INTRODUCTION & AIM

Bone defects and fractures have emerged as a significant global health issue, primarily due to factors such as an aging population, osteoporosis, tumors, trauma, and orthopedic diseases. Consequently, more than four million surgical procedures utilizing bone grafts and replacement materials are performed annually, making bone the second most commonly transplanted tissue worldwide [1]. The global orthopedic implants market represents a vital and expanding sector within the medical industry, currently valued at approximately USD 48 billion in 2023, and is expected to growth to USD 78 billion by 2033 [2]. The use of artificial bone implants is significant, as they mitigate the risk of disease transmission associated with autologous and allograft bone transplants, positioning them as a vital solution for the repair of damaged bones [1].

Metals such as stainless steel, cobalt-chromium (Co-Cr) alloys, and titanium-based alloys are vital materials used in strong and reliable medical implants. Titanium alloys, particularly Ti-6Al-4V, are the preferred choice for bone replacement because of their excellent biocompatibility and outstanding corrosion resistance [3].

This paper will present the biomedical potential of materials produced using SLM technology with different porosities and pore shapes. The results will show the relationship between the structure of the material and the observations from indirect and direct cytotoxicity tests, as well as direct proliferation for mouse pre-osteoblast cells (MC3T3-E1).

METHOD

Cytotoxicity tests were performed in accordance with ISO 10993-5 using the indirect method, using extracts obtained from 24-hour incubation of materials in culture medium (α-MEM). ISO 10993-12 was used to obtain the extracts, according to which metal materials should be incubated at a ratio of 200 mg per 1 ml of medium. The tests were performed on a mouse pre-osteoblast cell line (MC3T3-E1). The application of the materials produced dictated the choice of cell line – applications in bone tissue engineering. The tests were carried out using two approaches: the first, based on the reduction of tetrazolium salt (XTT) – Fig. 1a, and the second, based on the capture of a dye, neutral red - Fig. 1b.

In the next step, direct proliferation tests were performed, in which a small number of cells were seeded onto the surface of the material to provide them with a surface for growth and proliferation. To achieve this, tests based on resazurin reduction were used.The absorbance results obtained were converted into cell numbers using a calibration curve prepared for MC3T3-E1 cells at known concentrations (Figure 2). Measurements in the proliferation tests were performed on days 1, 3 and 7. The cells after direct proliferation experiments and the morphology of materials were analyzed using scanning electron microscopy (SEM) coupled with energy-dispersive spectroscopy (EDS) (JEOL,

RESULTS

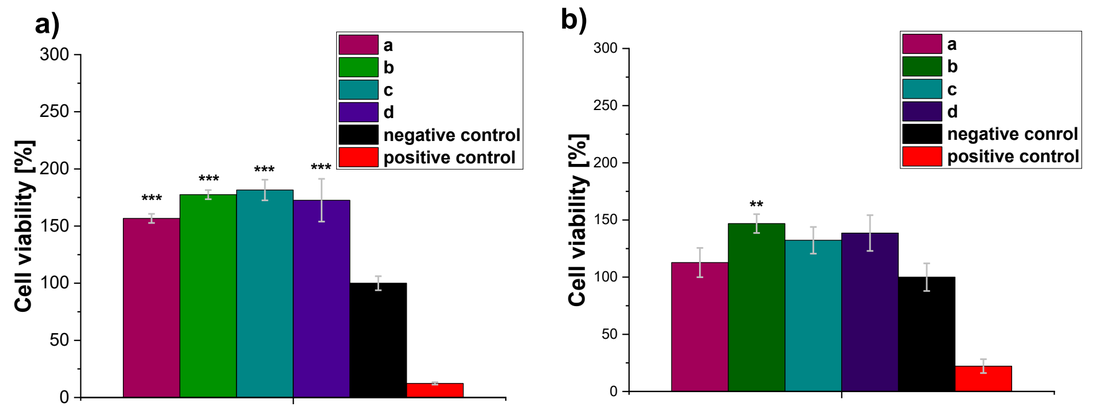

Figure 1. The Results of indirect cytotoxicity test based on **a)** XTT reduction, **b)** neutral red uptake. The results are statistically significant, where p**<0.01; p***<0.001.

Table 1. Sample abbreviations.

Abb.	Composition
A	Infill lattice
B	Iso Truss lattice
C	Gyroid lattice
D	Voronai lattice

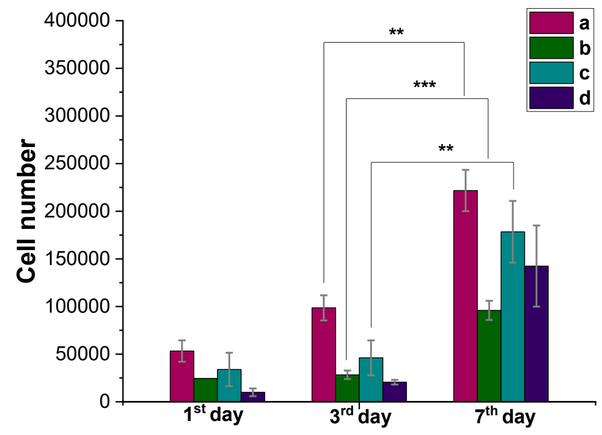

Figure 2. Results of direct proliferation test, which are statistically significant where p**<0.01 and p***<0.001.

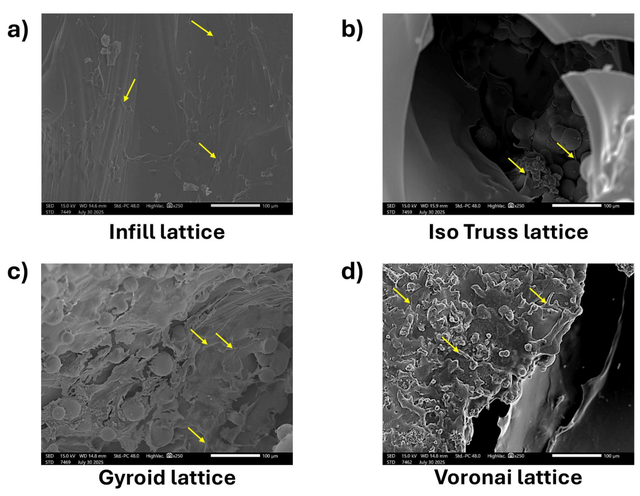

Figure 3. Morphology of cells on materials. The arrow indicates cells located on the surface of the materials. The images were obtained at 250x magnification.

REFERENCES

[1] Xu C., Qi. J., Zhang L., Liu Q., Ren L. (2023), Additive Manufacturing, 78, 103884.

[2] Orthopedic Implants Market Size, https://www.grandviewresearch.com/industry-analysis/orthopedic-implants-market

[3] Schöbel L., Ayerbe M.G., Polley C., Arruebarrena G., Seitz H., Boccaccini A.R. (2025) ACS Biomater. Sci. Eng. 11, 4057−4061.

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