



Nanostructured Magnesium-coated Acid-etched Titanium Implant Surface for Enhancement of Both Osteoblast-like Cells and Fibroblast Cells Responses

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Introduction

- Adequate osseointegration is important for the prevention of the failure of dental implant treatment.
- Role of dental implant surface modification plays pivotal role in the enhancement of fixation between bone and implant surface.
- Magnesium (Mg) exhibits synergistic interactions with initial cellular processes of bone formation, thereby facilitating early osseointegration and promoting osteoblastic differentiation.
- Leveraging the simplicity, environmental friendliness, cost-effectiveness, and scalability of hydrothermal treatment, Mg precipitation onto nanostructured roughened titanium surfaces has been pursued to augment bioactivity.

Aim

The purpose of this study is to enhance the bioactivity of the nanostructured magnesium-coated surface of acid-etched titanium implants including the osteoblastic cells like behavior and fibroblast responses.

Materials and Methods

Mg ions were deposited onto microlevel roughened acid-etched titanium surfaces using four distinct concentrations of magnesium acetate solutions via the hydrothermal method, with treatment durations of 3 hours and 6 hours. Subsequently, the physical properties and biological responses of the magnesium-coated surface were examined to discern enhancements in its characteristics.

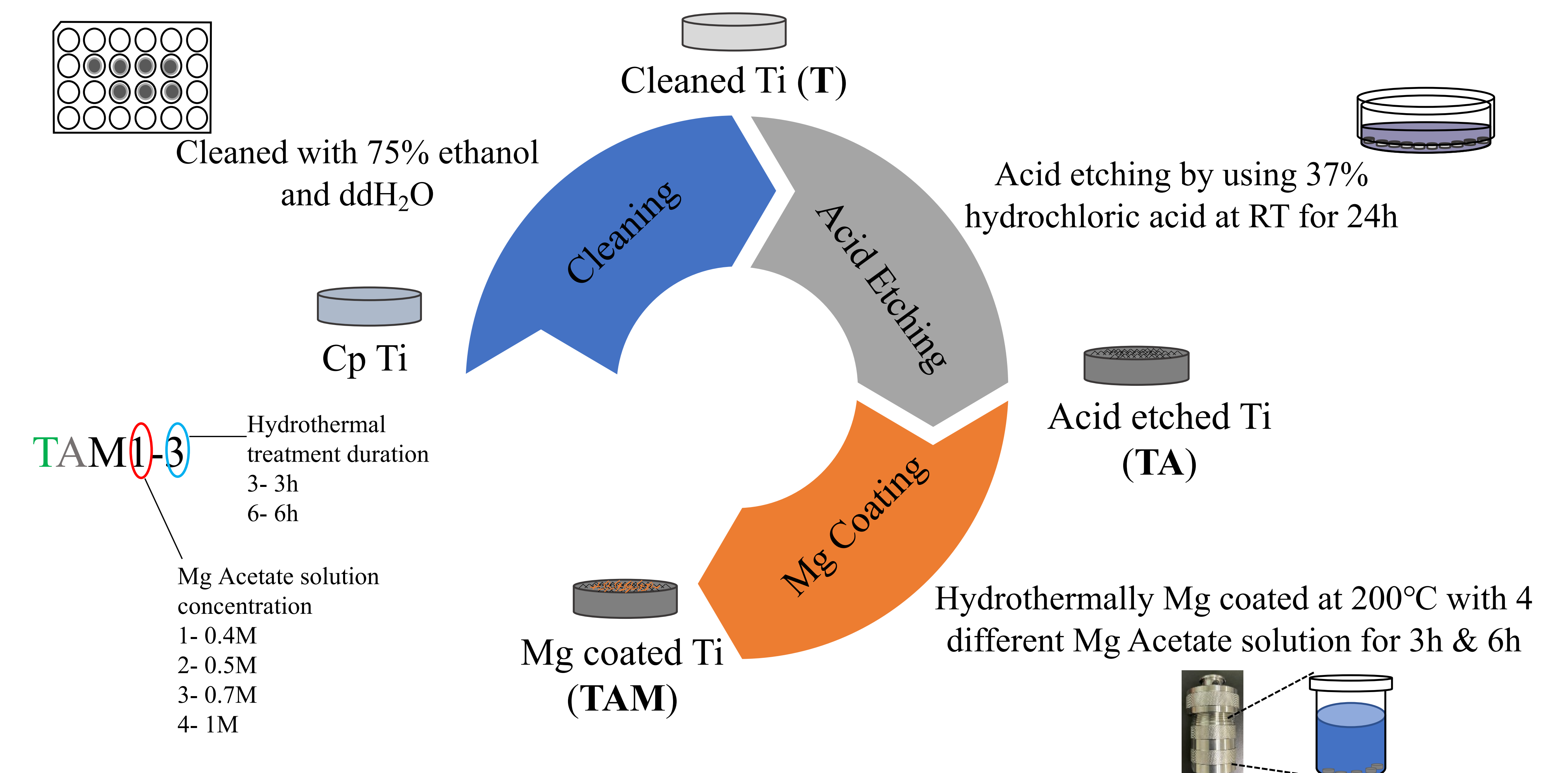


Figure 1. The process of generating Mg coated titanium implant surface.



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Materials and Methods

Physical properties analysis:

- Surface morphology analysis
- Elemental composition analysis
- Wettability test
- Surface crystallinity analysis
- Roughness analysis

Biological properties analysis (MG 63 cell line):

- Focal cell adhesion analysis

- Cell proliferative analysis
- Cell differentiation analysis (ALP)
- Cell mineralization analysis (ARS)
- Osteoblastic gene analysis (qPCR) (HGF-1 cell line):
- Cell attachment analysis
- Focal cell adhesion analysis
- Cell proliferative analysis

Results

- Porous structured titanium surface exhibited a layer of magnesium coating characterized by a muddy pattern interspersed with rod-shaped nanostructures (0.1~0.3 μm) which is shown in the Fig 2.
- In Fig 3 (B), the hydrophilicity properties of titanium surfaces were enhanced after magnesium coating.

Results

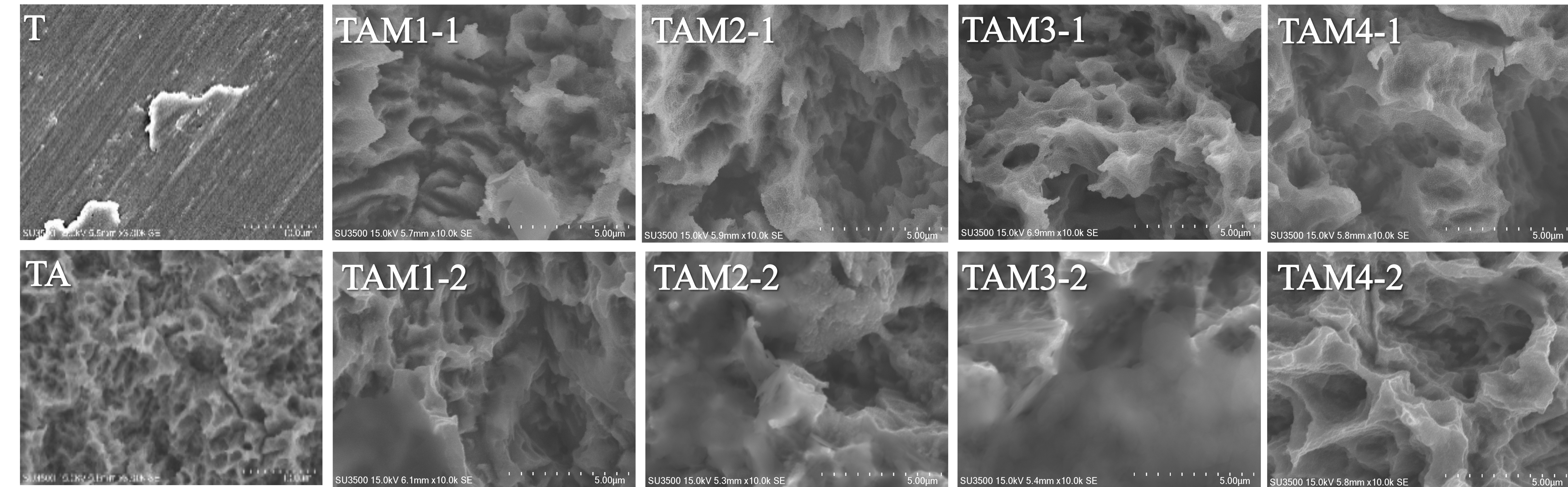


Figure 2. SEM image of control, acid treated (x5,000 magnification) and Mg coated samples (x10,000 magnification).

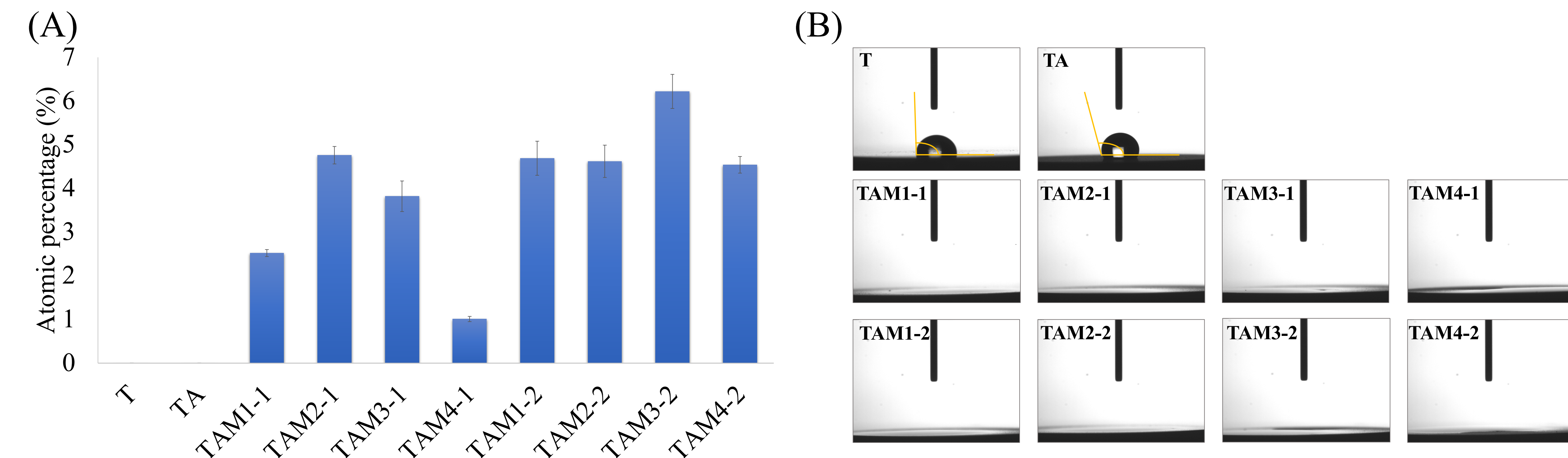


Figure 3. (A) Atomic Mg percentage after hydrothermal treatment. (B) real time images of wettability properties by using water contact angle measurement.



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Results

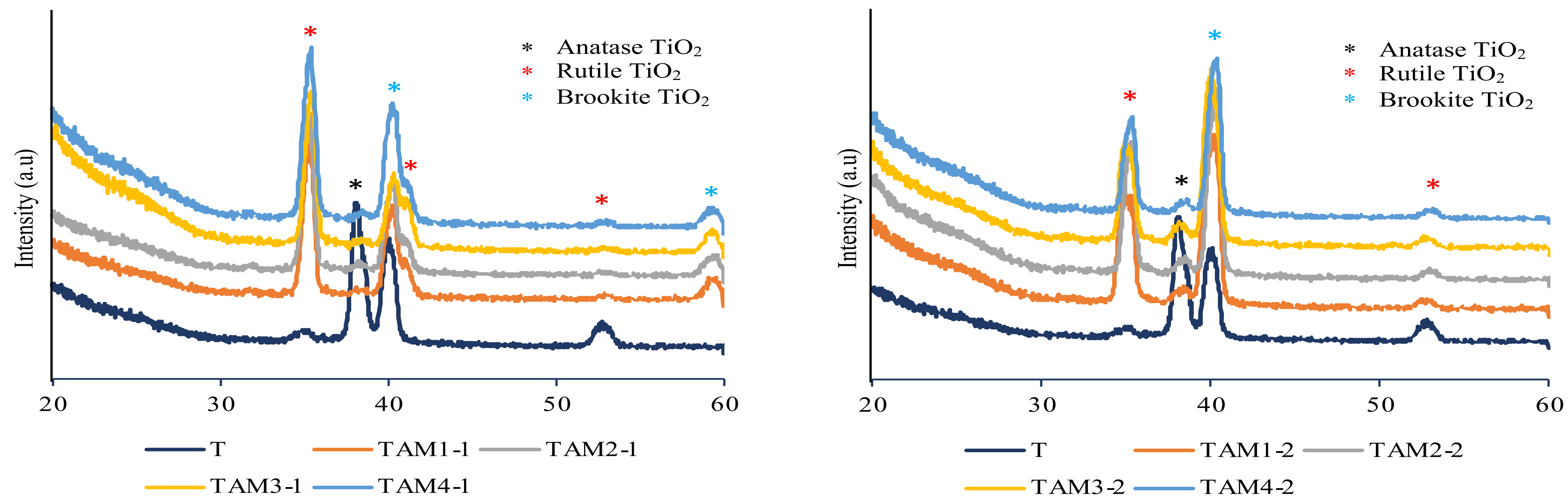


Figure 4. Surface crystallinity analysis of titainum and Mg coated samples.

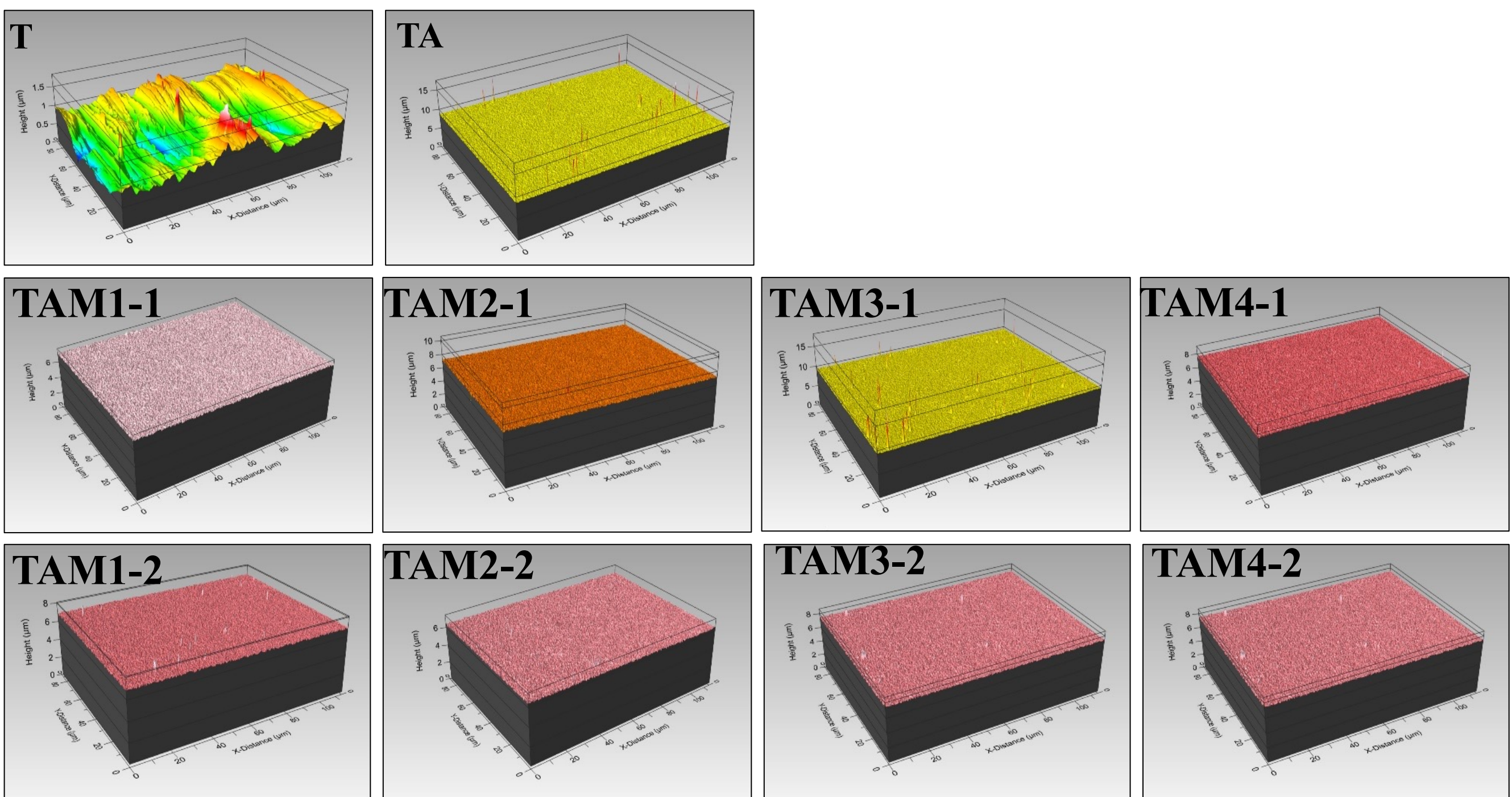


Figure 5. 3D images, and roughness value by using white light interferometry for surface roughness analysis.

Results

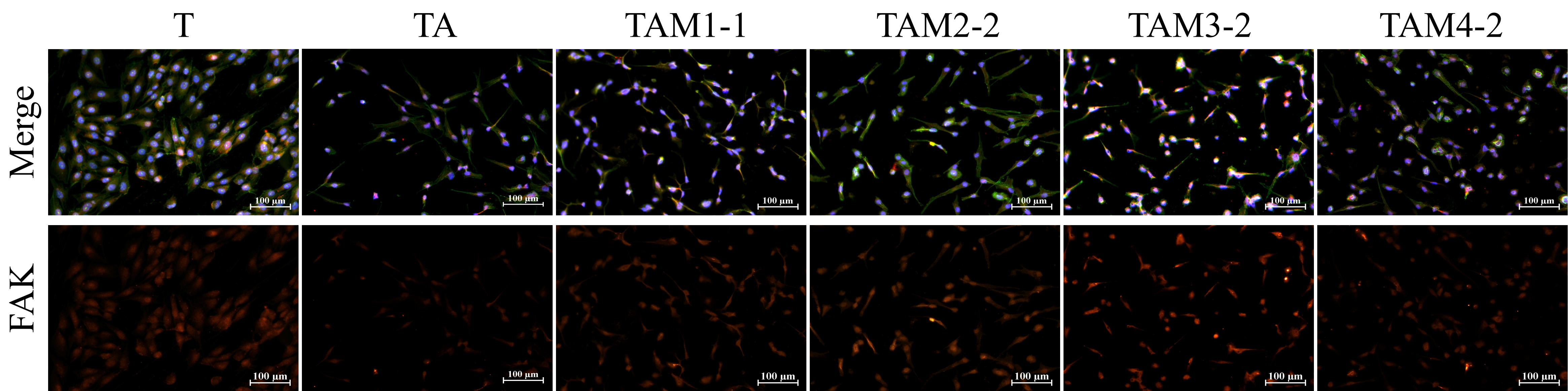


Figure 6. MG 63 Focal cell adhesion analysis by using the immunofluorescence staining (red: FAK, green: actin, blue: nuclei).

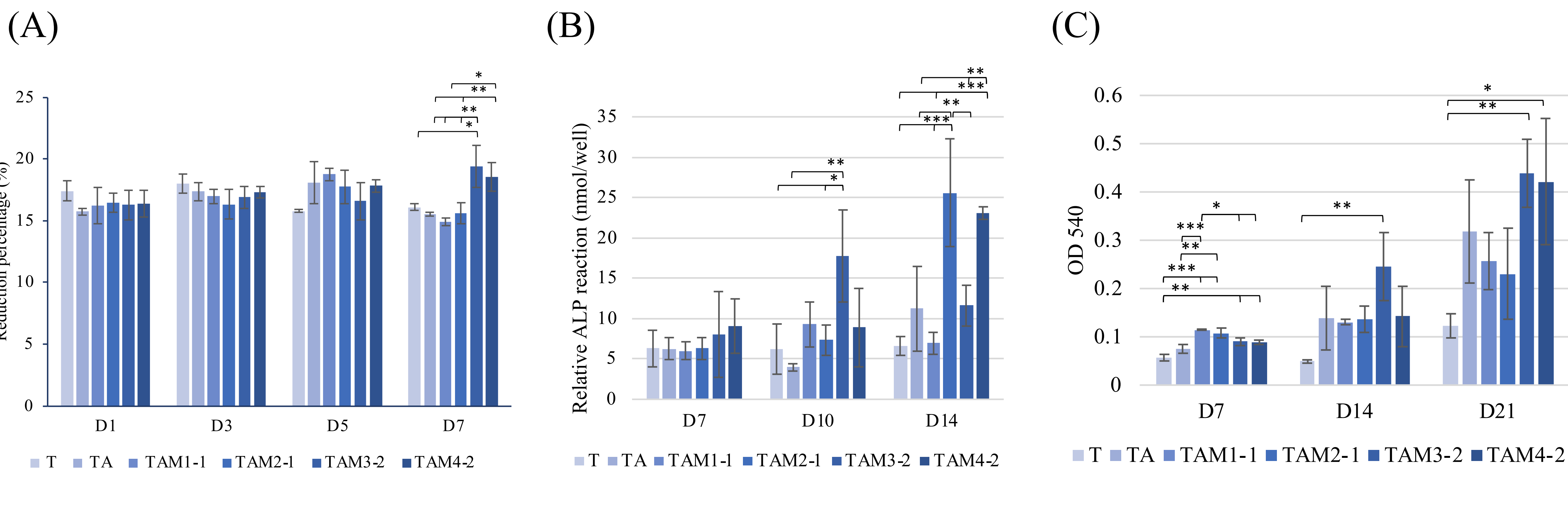


Figure 7. MG 63 cells line (A) cell proliferation analysis, (B) cell differentiation analysis, and (C) quantitative analysis of cell mineralization.



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Results

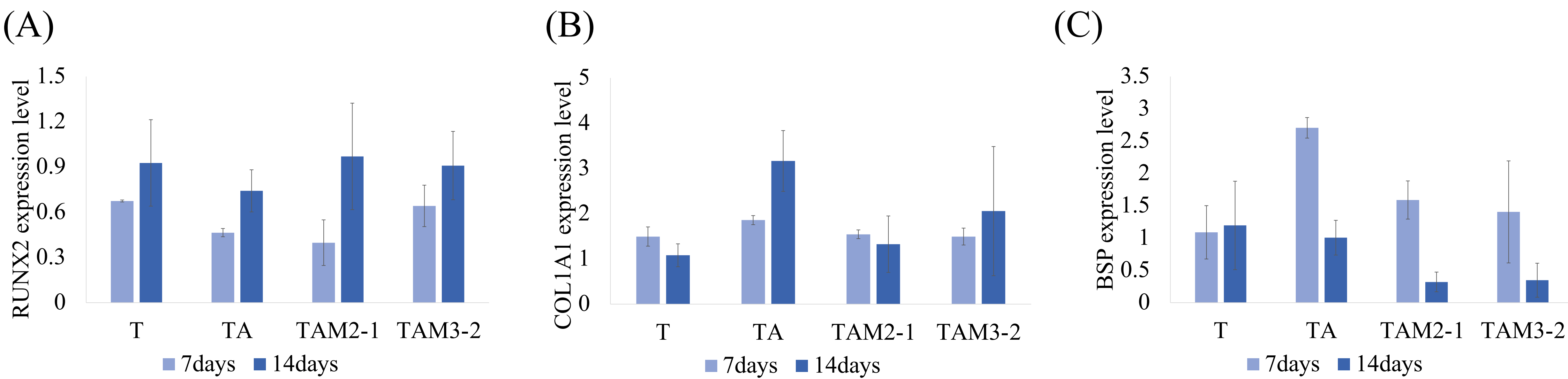


Figure 8. The relative expression level of (A) RUNX2, (B) COL1A1, and (C) BSP.

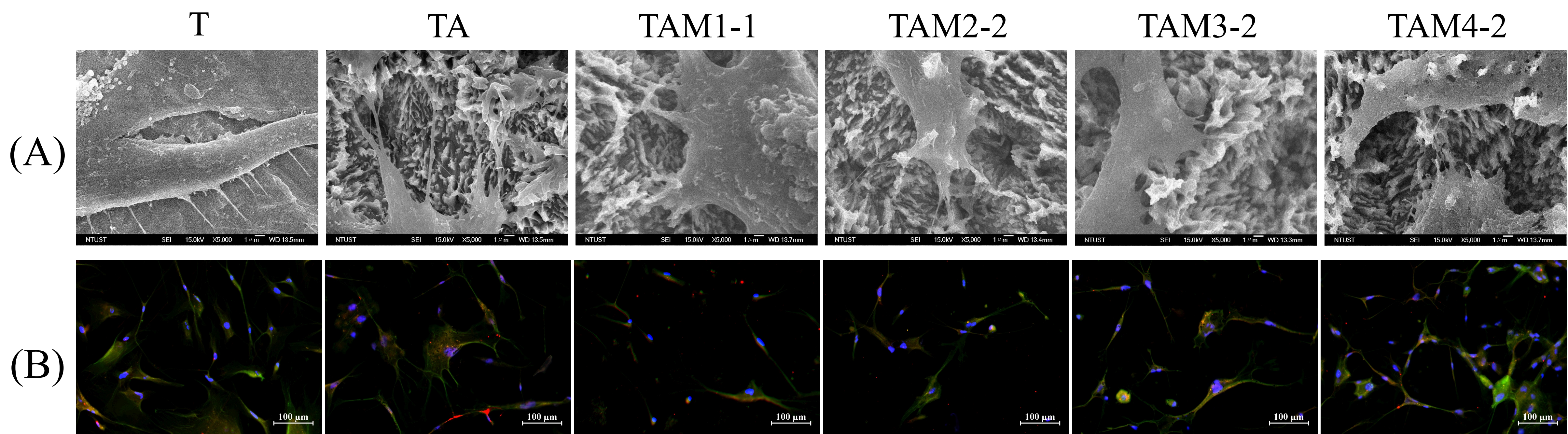


Figure 9. HGF-1 cell line (A) cell attachment analysis for 24hr, (B) focal cell adhesion analysis for 24hr by using the immunofluorescence staining (red: FAK, green: actin, blue: nuclei).

Results

- MG63 cell response is the greatest in the TAM2-1 and TAM3-2 groups.
- HGF-1 cell responses is the highest in TAM2-1 group in focal adhesion analysis for 24hr and cell proliferation analysis.

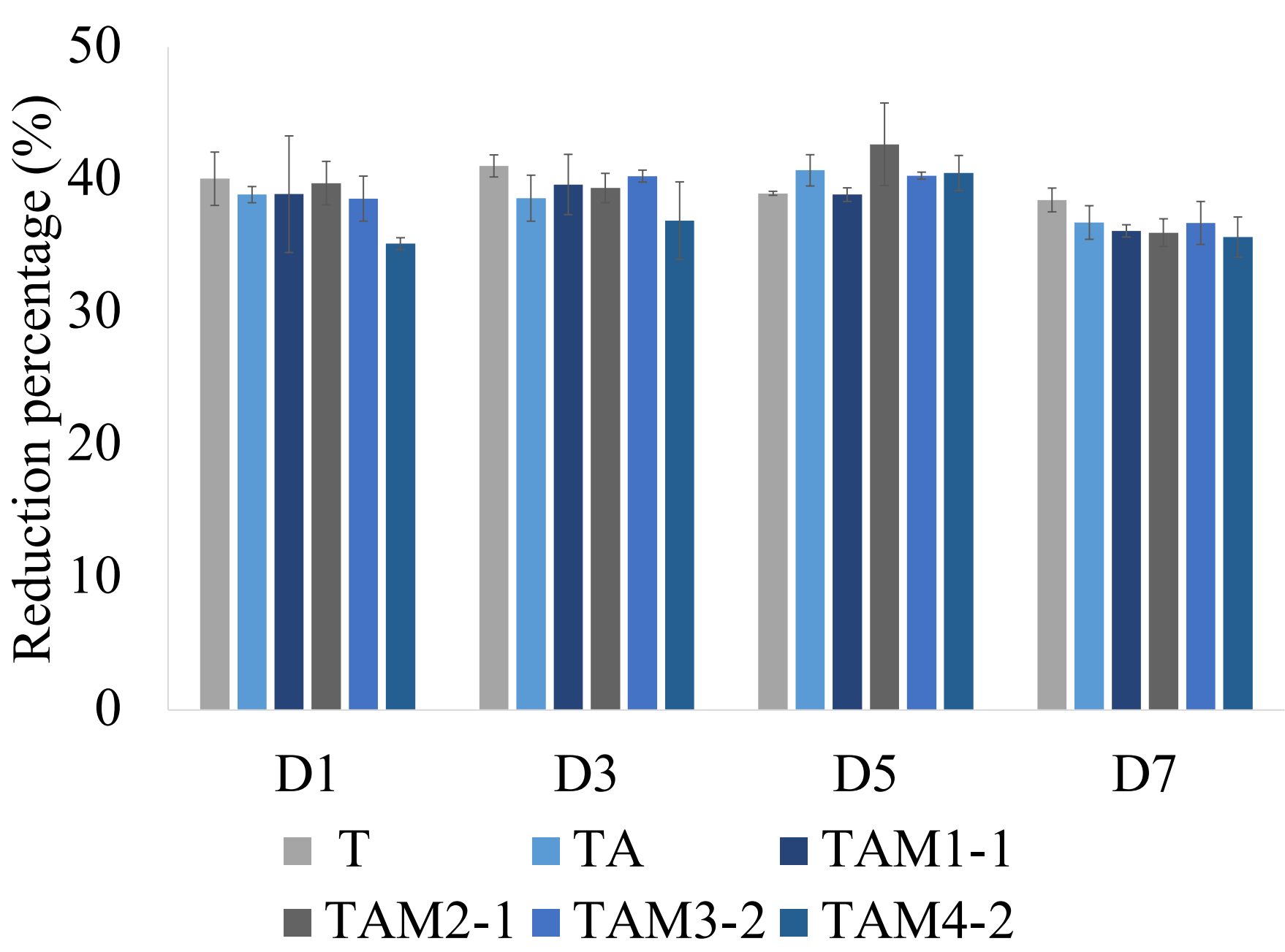


Figure 10. HGF-1 cell proliferation analysis

Conclusion

The modified nanostructured magnesium-coated titanium surface exhibited superior physical properties and enhanced bioactivities for the biomaterial's characteristics. Consequently, magnesium emerges as a promising candidate for use as a coating ion in dental implant materials.

Reference

Qiao, X., Yang, J., Shang, Y., Deng, S., Yao, S., Wang, Z., Guo, Y. and Peng, C., 2020. Magnesium-doped nanostructured titanium surface modulates macrophage-mediated inflammatory response for ameliorative osseointegration.