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New Ti6Al4V titanium–ceramic composites with hydroxyapatite for orthopedic applications

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INTRODUCTION & AIM

Currently, phenomena such as civilizational development, the fast pace of life, and increased pollution are leading to the development of civilizational diseases. Research conducted over the years indicates that despite significant advances in medicine, problems related to the circulatory, skeletal, and immune systems are not decreasing. In addition, an aging population contributes to the development of many skeletal diseases. For this reason, it is necessary to work on increasingly advanced implants.

This paper focuses on the production of titanium–ceramic composite materials using powder metallurgy, followed by the selection of appropriate sintering conditions. The addition of hydroxyapatite to the metallic material introduces properties such as bioactivity, which improves the osseointegration of damaged bone tissue. In turn, the Ti6Al4V titanium alloy, as one of the widely used materials in implantology, is characterized by excellent mechanical properties and good biocompatibility.

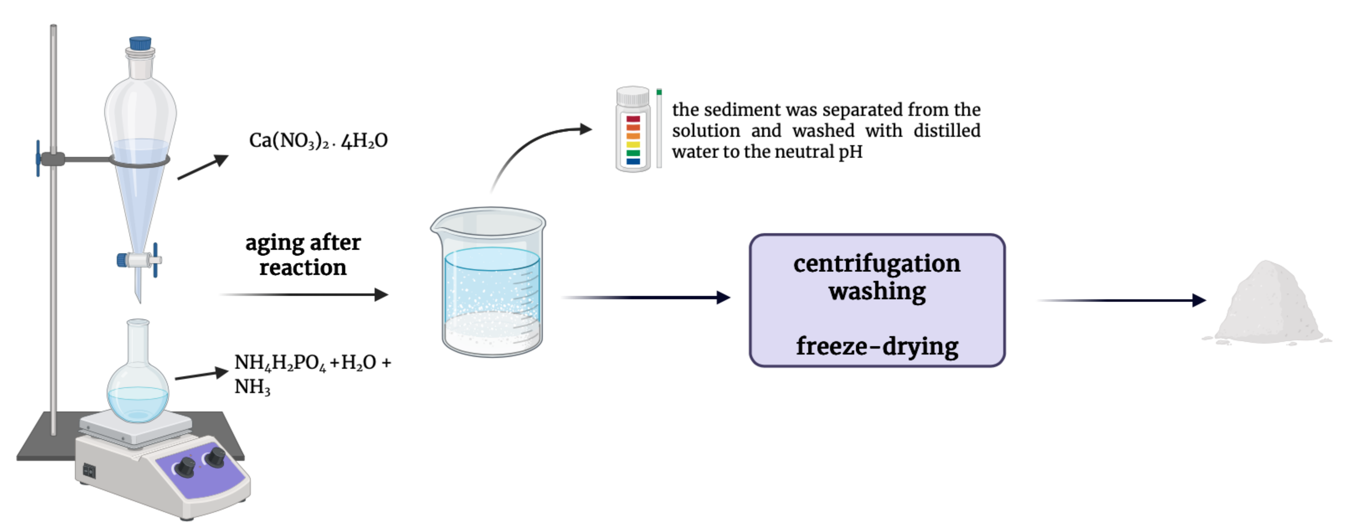
The obtained materials were then subjected to structural and phase analysis. In order to assess their behavior under conditions resembling the physiological environment, tests were carried out in incubation fluids. Microstructural analysis of the composite surfaces was performed using scanning electron microscopy (SEM-EDS) to determine the amount of calcium and phosphorus, indicating the formation of apatite layers.

The studies indicate that the modification of titanium alloy with bioactive ceramics affects its physicochemical properties, particularly in terms of biocompatibility and integration with bone tissue. The introduction of this type of modification may contribute to the development of more advanced medical implants that effectively support the bone regeneration process.

METHODS

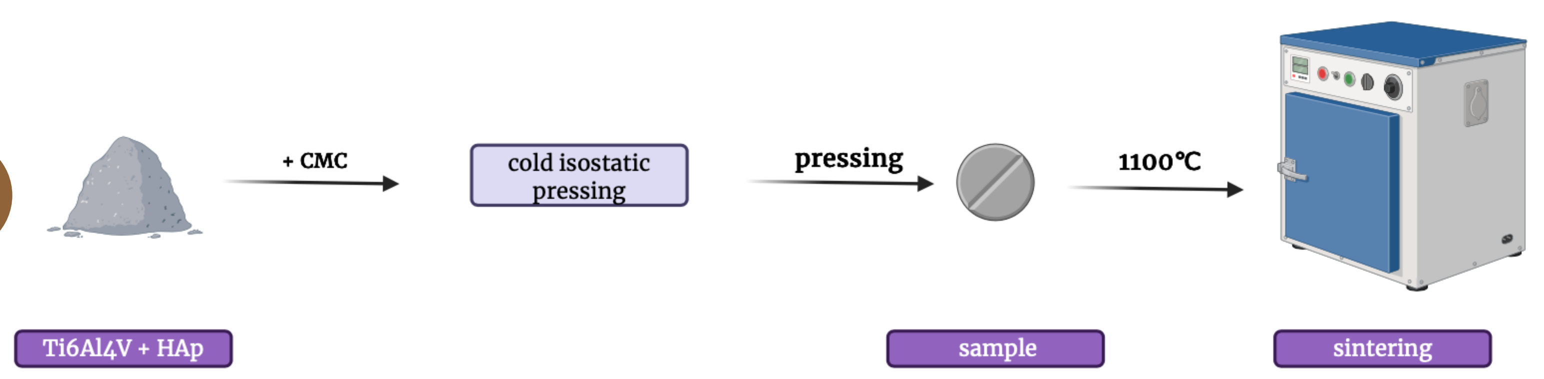
Hydroxyapatite synthesis

1



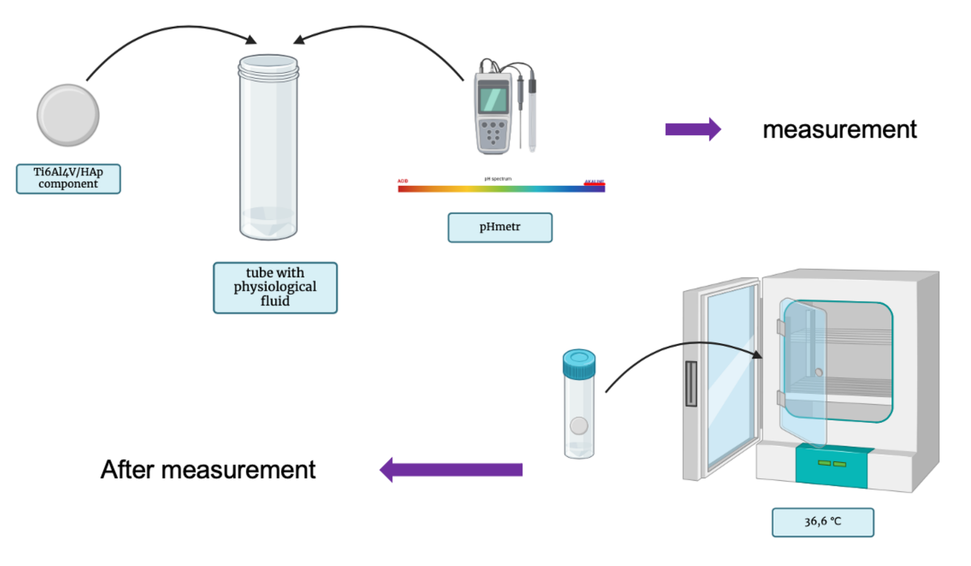
Composite manufacturing

2



Incubation proces in SBF

3

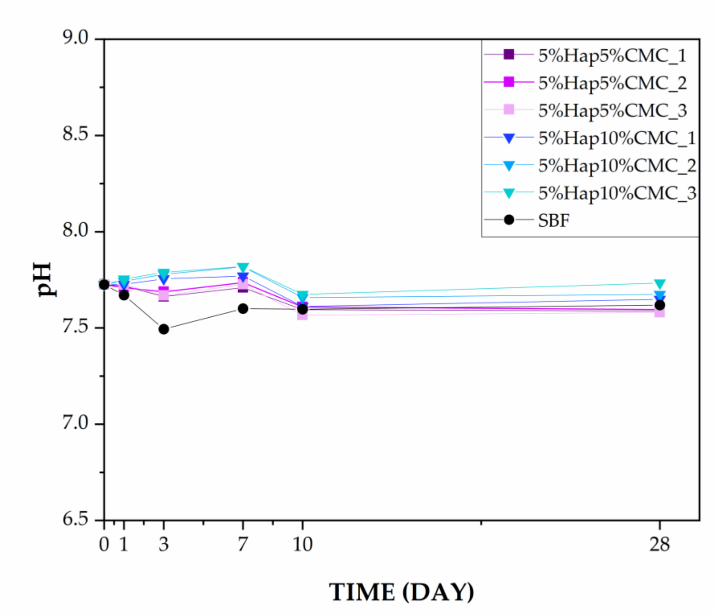


RESULTS & DISCUSSION

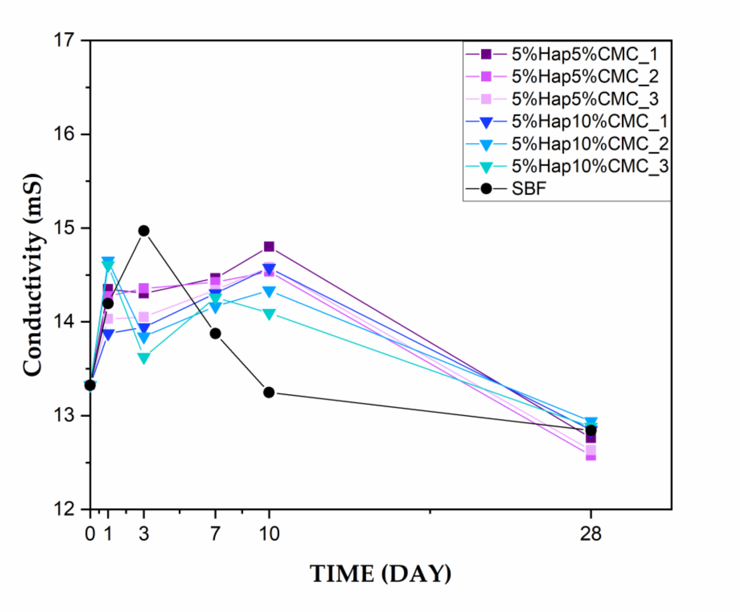
Incubation process in SBF

Potentiometric & conductometric tests

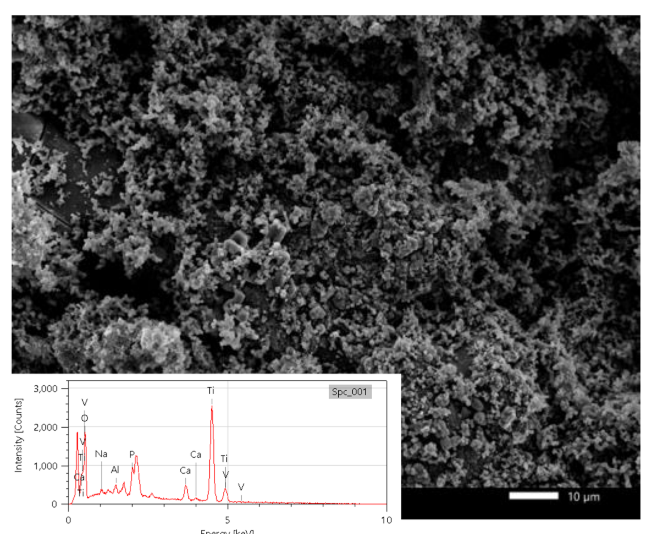
5%HAp5%CMC

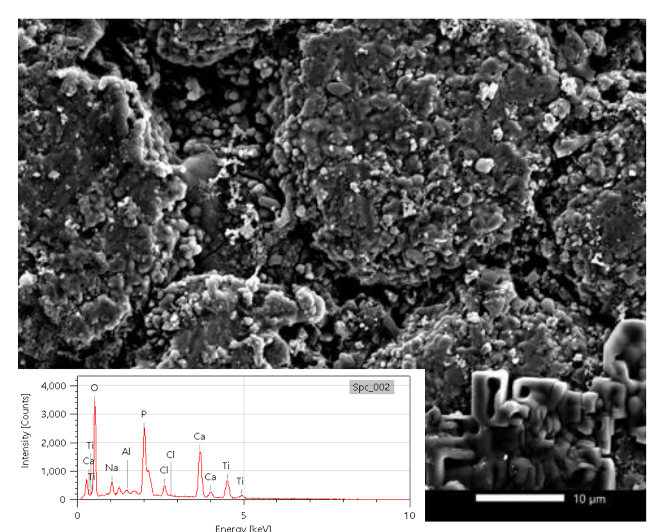


5%HAp10%CMC

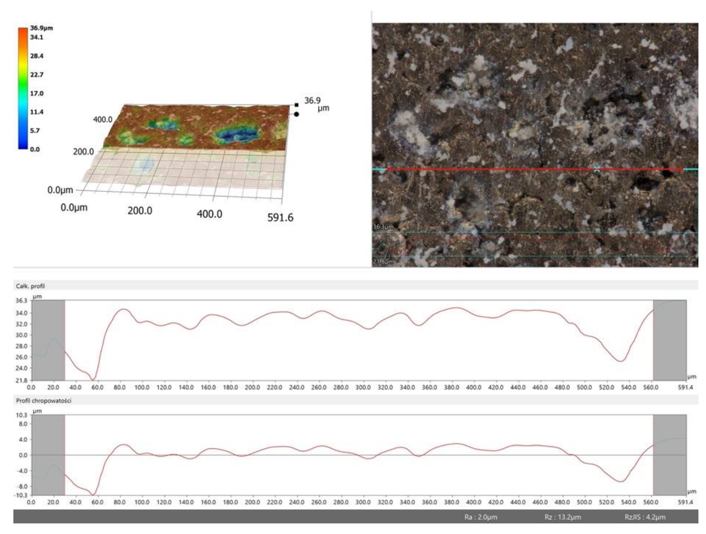


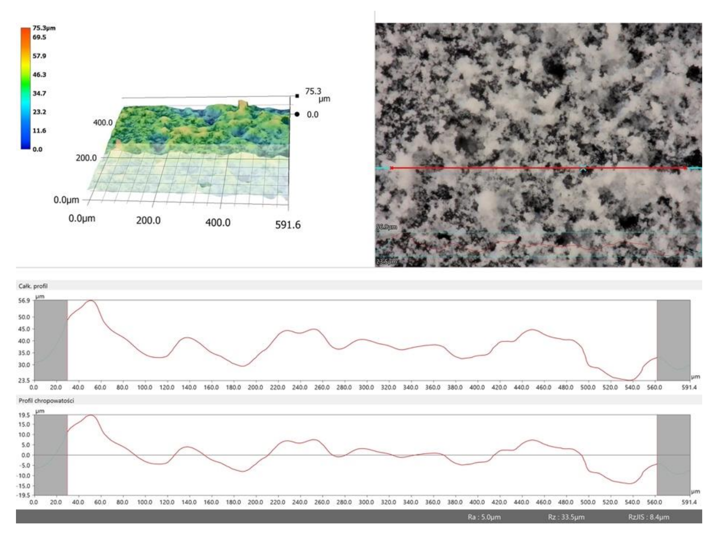
SEM-EDS





ROUGHNESS





Ti6Al4V+5%Hap5%CMC		Ti6Al4V+5%HAp10%CMC	
Parameter	Result [μm]	Parameter	Result [μm]
S_a (μm)	4.5	S_a (μm)	4.8
S_q (μm)	6.4	S_q (μm)	6.5
S_{sk} (μm)	-2.1	S_{sk} (μm)	-0.5
S_{ku} (μm)	7.0	S_{ku} (μm)	4.6
Area (μm²)	255017.5	Area (μm²)	252030.7

CONCLUSION

- ✓ The tested materials show **chemical stability** in a Simulated Body Fluid (SBF).
- ✓ **No significant pH changes** were observed, indicating no disruption of the acid-base balance.
- ✓ **Conductivity results** suggest similar ion exchange behaviour for all samples, particularly during the initial incubation period. The observed conductivity variations may be related to **apatite layer formation** on the material surface.
- ✓ After 28 days of incubation in SBF, **optical microscopy revealed secondary biomimetic apatite deposits** on both samples.
- ✓ The phenomenon was **most pronounced for Ti6Al4V+5%HAp+10%CMC**, confirming enhanced bioactivity of this composite material.

ACKNOWLEDGMENTS

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