EFRE 2020

BIOMIMETIC SYNTHESIS OF SILICON-SUBSTITUTED HA ON A TITANIUM SUBSTRATE

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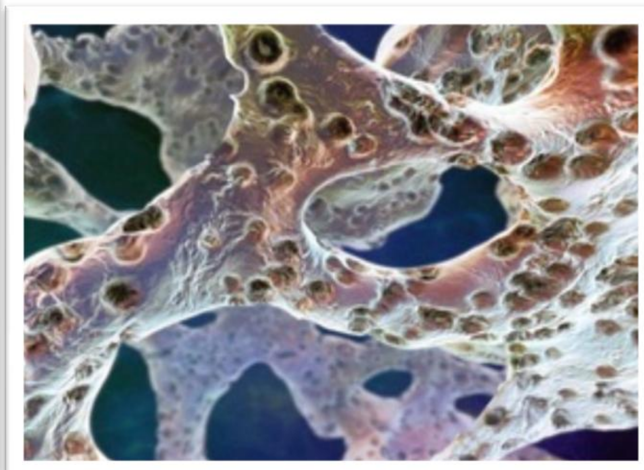
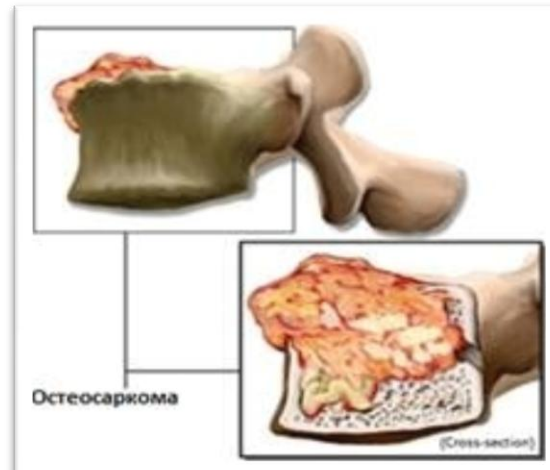
Research relevance





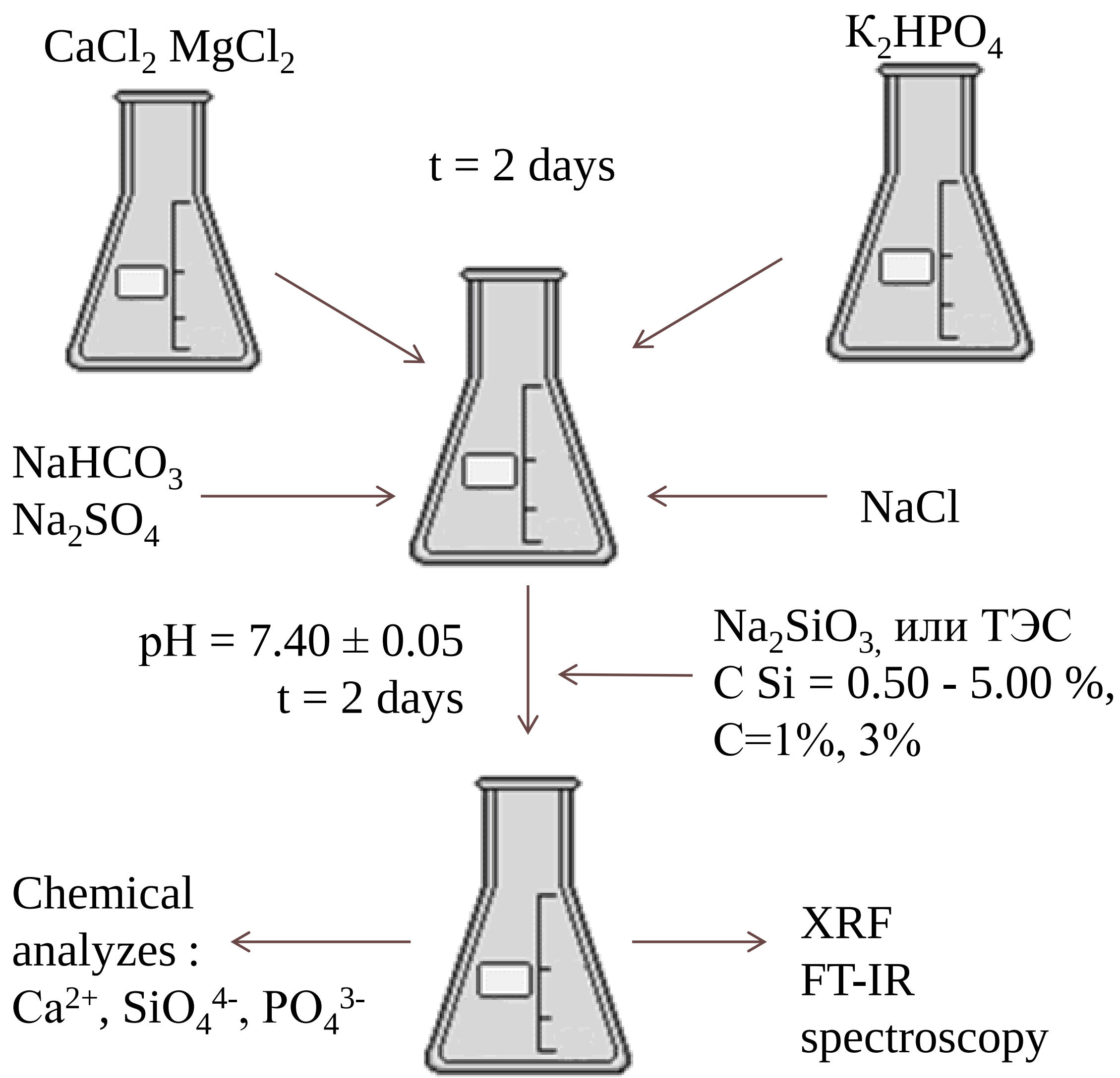
Biological Calcium Apatite $(Ca, Mg, Na)_{10}(PO_4, HPO_4, CO_3)_6(OH, F, Cl)_2$

Synthetic silicon-substituted hydroxylapatite $Ca_{10}(PO_4)_{6-x}(SiO_4)_x(OH)_{2-x}$

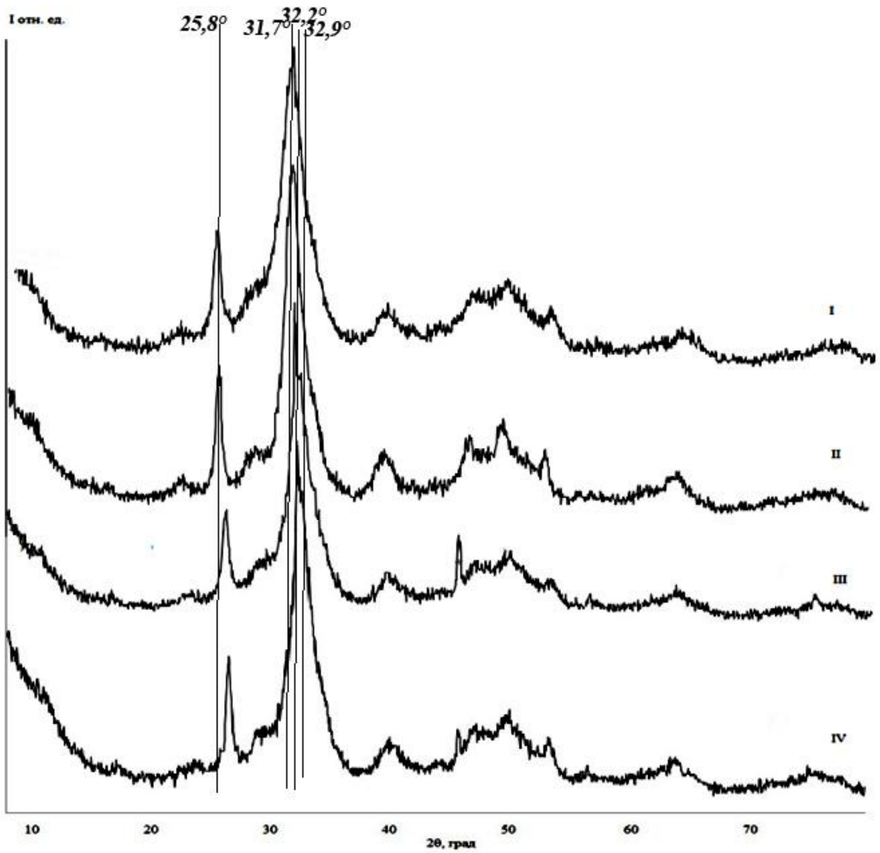
Method for the synthesis of modified hydroxylapatite from a model solution of extracellular fluid

Inorganic composition of the model solution of extracellular fluid«Simulated Body Fluid»

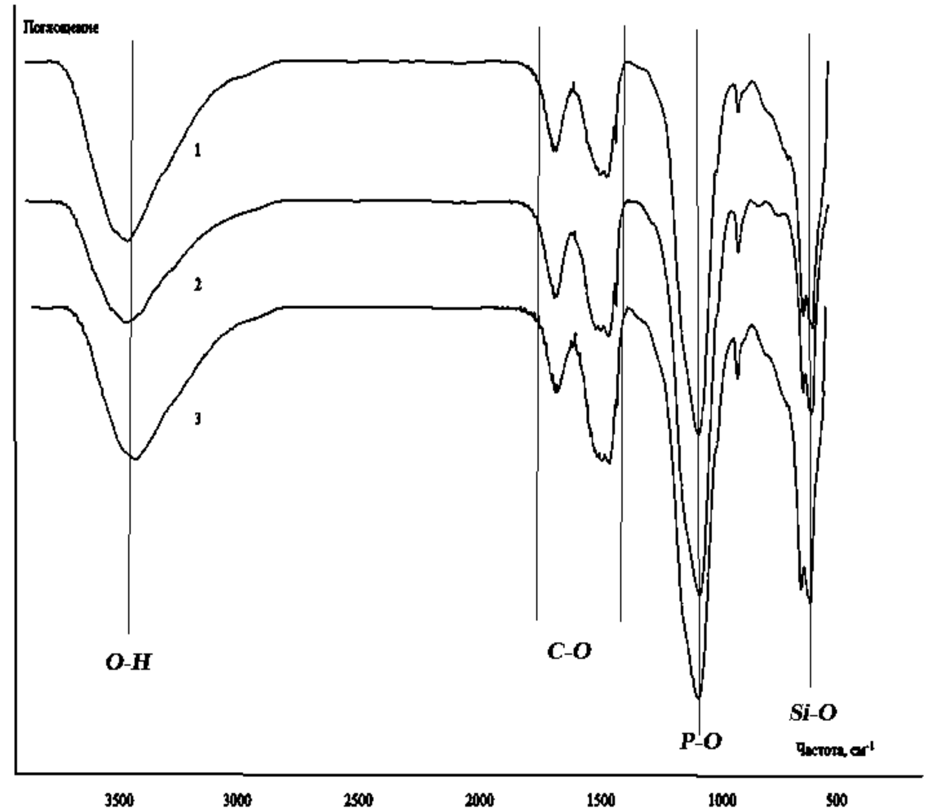
Composition	C, mmol/L
Ca^{2+}	2.5
Na^{+}	142
K+	5
Mg^{2+}	1.5
Cl^{-}	105
HPO_4^{2-}	1
HCO_3^{2-}	27
SO_4^{2-}	0.5



XRD and IR spectroscopy results for Si-HA samples



Diffraction patterns of hydroxylapatite samples modified Na_2SiO_3: *I* – C Si 0,5%; *II* - C Si 2,5%.; ТЭС: *III* – C Si 0,5%; *IV* - C Si 2,5%.



IR spectra of hydroxylapatite samples modified : *1* - Na_2SiO_3C Si 0,5%; *2* и *3* – ТЭС C Si 0,5 and 2,5%.

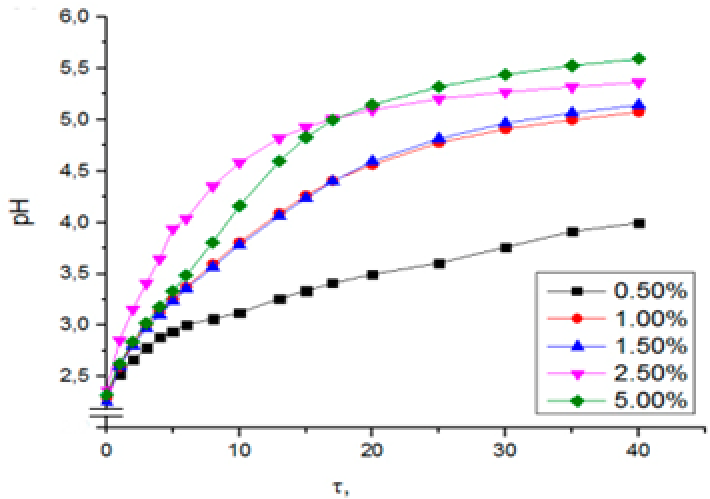
Crystal lattice parameters and phase composition Si-HA

Sample	C Si, %	Lattice constant, Å	
		a	*c*
HA	-	9.414	6.865
Na_2SiO_3	0.50	9.466±0.007	6.885±0.007
Na_2SiO_3	5.00	9.413±0.005	6.877±0.005
ТЭС	0.50	9.490±0.001	7.320±0.001
ТЭС	5.00	9.546±0.007	6.975±0.008

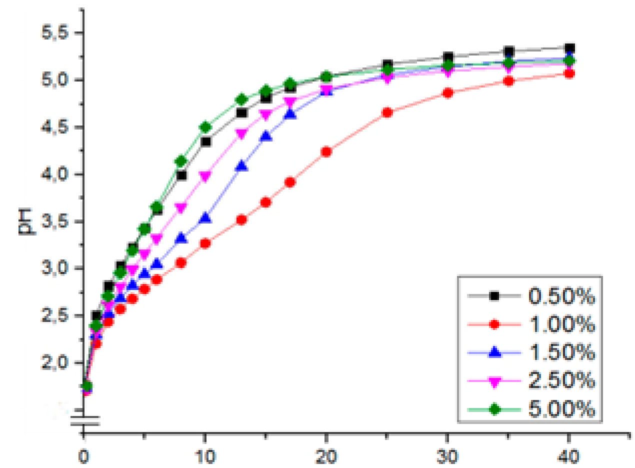
C Si, %	C Si, %		Ca/P		Solid phase composition
	Na_2SiO_3	ТЭС	Na_2SiO_3	ТЭС	Calcium excess hydroxyapatite
0.50	0.0076	0.0024	2.48	2.34	
2.50	0.11	0.11	2.31	2.23	
5.00	0.69	0.67	2.30	2.28	

Study of solubility in hydrochloric acid with varying temperature

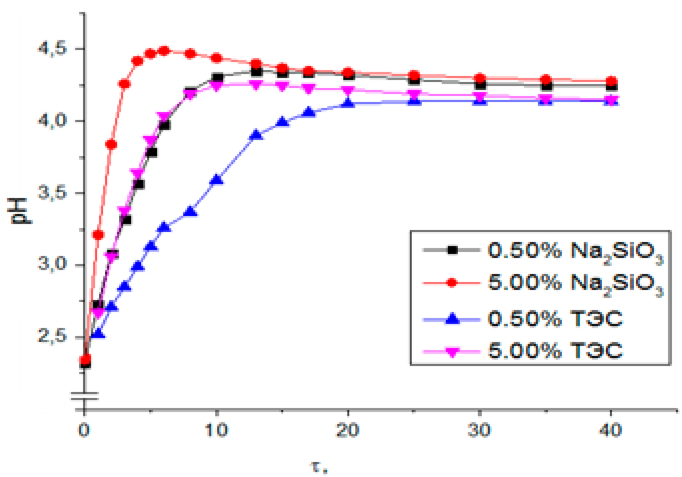
t=20ºC Na_2SiO_3



t=20º ТЭС



t=80ºC

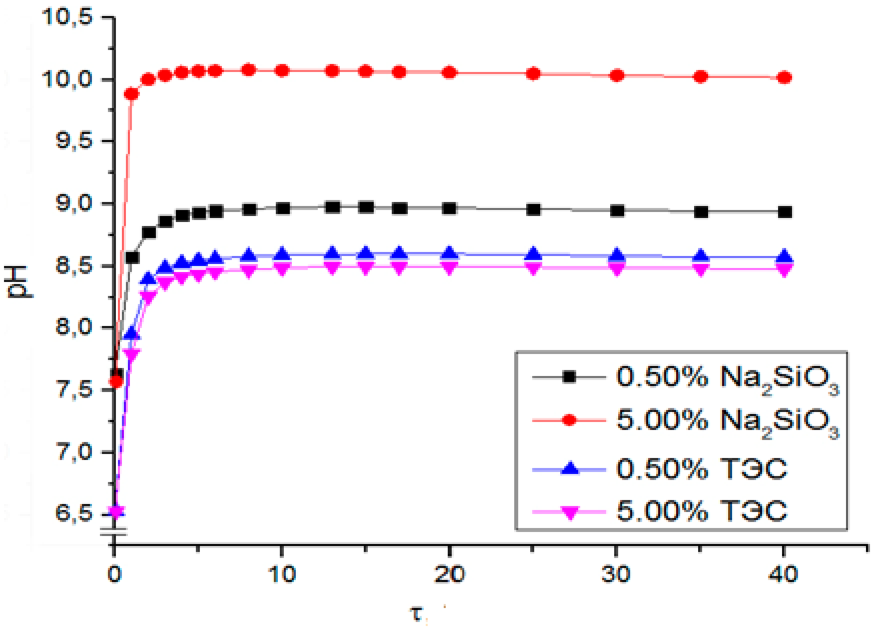


Kinetic parameters of the dissolution process

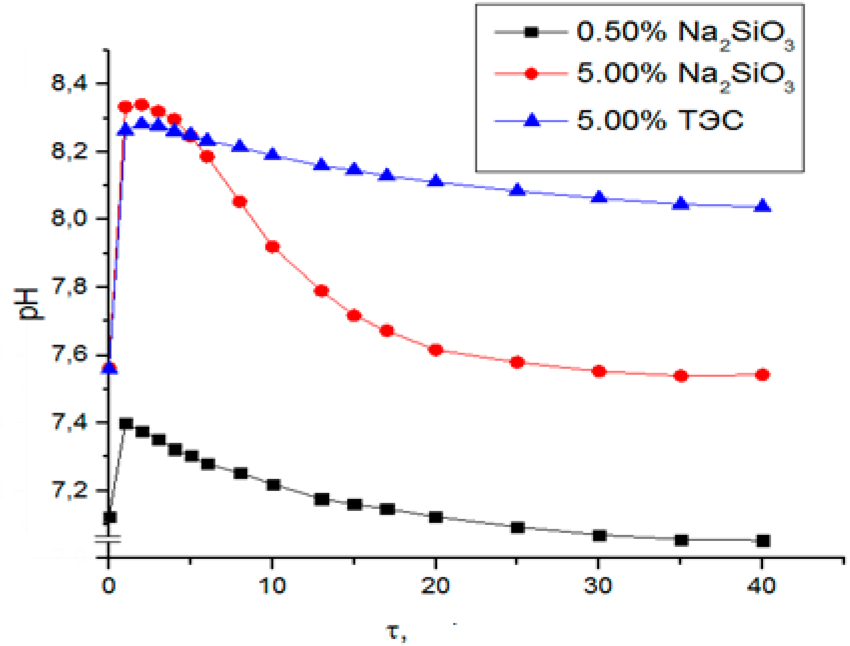
№	C Si, %	E_a , Dg/mol	n
1	0.50	435.81	2.36
2	5.00	461.58	2.41

Study of solubility in isotonic solution at different temperatures

t=20ºC



t=80ºC



$$Ca_{10}(PO_4)_{6-x}(SiO_4)_x(OH)_{2-x} + (n-1)H_2O \leftrightarrow 10Ca^{2+}$$

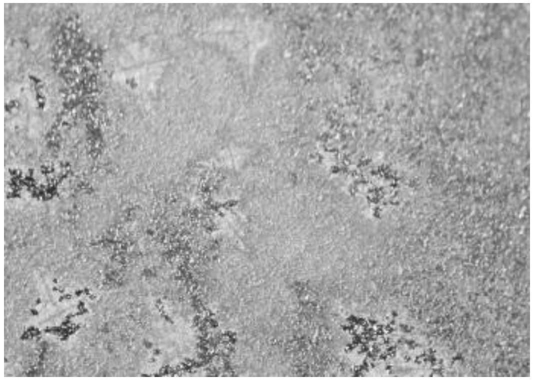
$$+ 6[x_1PO_4^{3-} + x_2HPO_4^{2-} + x_3H_2PO_4^{-} + x_4H_3PO_4] + nOH^- + xSiO_4^{4-}$$

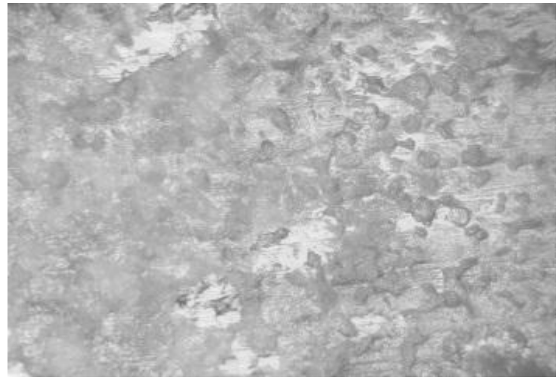
$$\equiv Si\text{-}OH + HPO_4^{2-}(\text{раств}) \leftrightarrow \equiv Si\text{-}O\text{-}PO_3^{2-} + H_2O$$

Calculation of the filling area of the titanium Si-HA

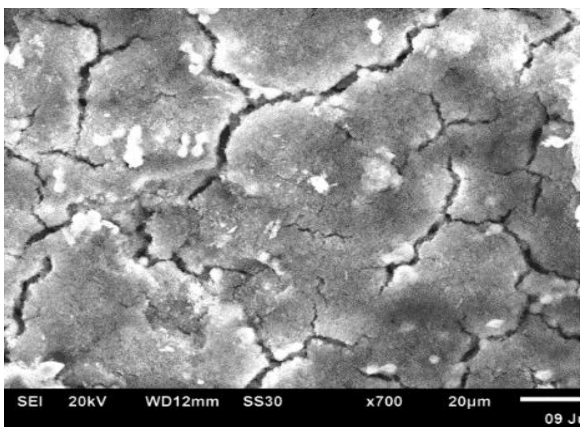
Treatment,Ti	$S_{cover,}$%				
	3 days	3+6 days	6 days	3+3 days	3+3+6 days
Etched	72	-	75	79	85
Not processed	60	-	67	70	78
Perforated and etched.	30	73	-	-	-
Perforated	25	79	-	-	-
Mip	-	-	60	-	-
Laser n=1	20	30	-	-	-
Laser n=2	23	35	-	-	-
Laser n=3	25	40	-	-	-
Laser n=5	27	44	-	-	-
Perforated Laser n=1	19	26	-	-	-

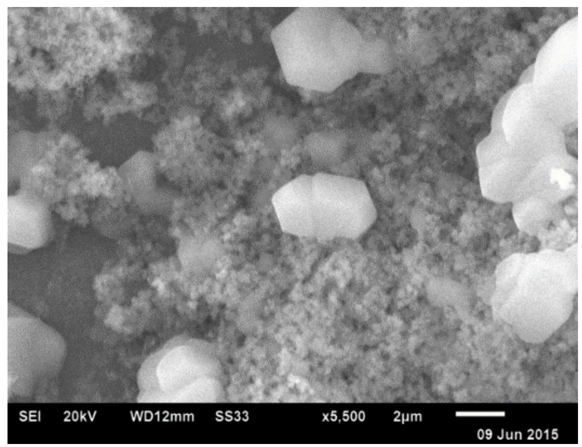
Surface morphology of Si-HA crystals on a titanium substrate

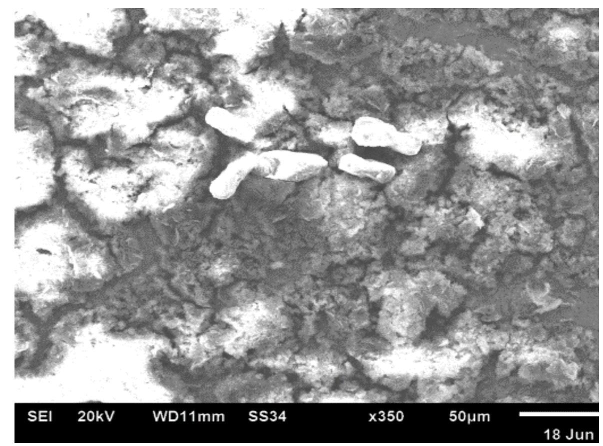




Surface morphology of hydroxyapatite crystals grown on the surface of VT1-0 titanium alloy after MIP irradiation with j = 50 A / cm^2



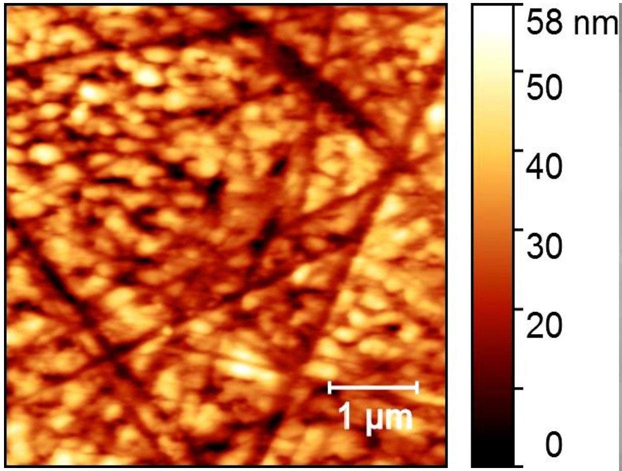




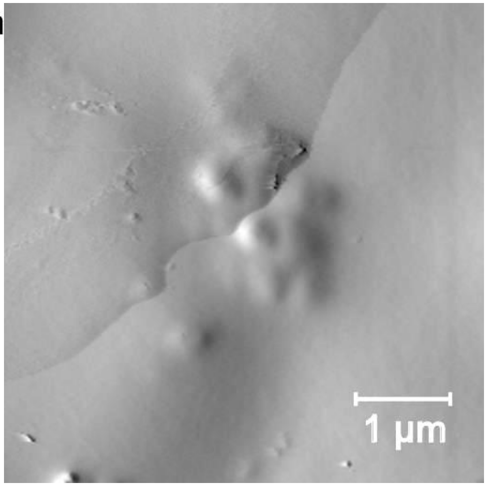
Surface morphology of HA-gelatin crystals grown on the ground surface of VT1-0 titanium alloy

Surface morphology of hydroxyapatite crystals grown on a ground surface of a titanium alloy VT1-0, after MIP irradiation

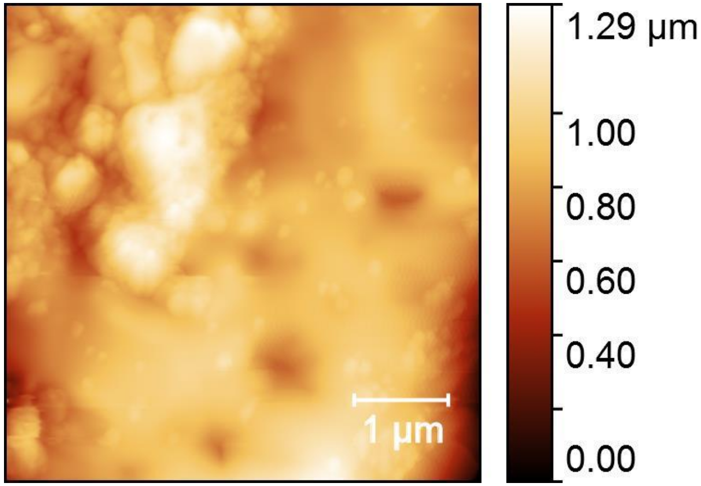
Surface morphology of Si-HA in a gelatinous matrix crystals on a titanium substrate according to AFM data



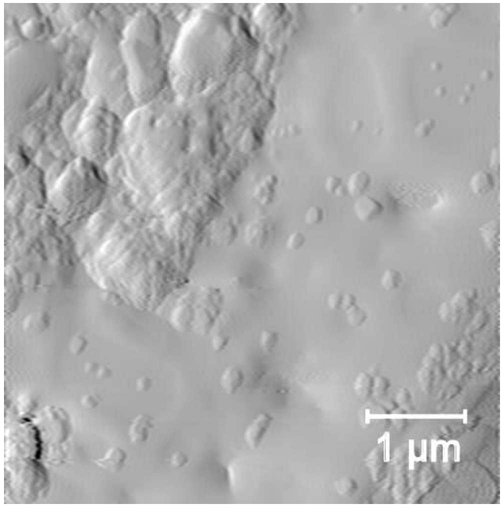
a



b



c



d

Surface morphology of hydroxylapatite crystals grown on the surface of VT1-0 titanium alloy obtained by AFM measurements: before MIP irradiation
a - high-altitude contrast;
b - amplitude contrast;
after irradiation with MIP in - high-altitude contrast;
d - amplitude contrast.

CONCLUSIONS

1. The process of crystallization of calcium phosphates from a model solution of human extracellular fluid has been studied. An original method of biomimetic synthesis of Si-HA from a solution close in ion-electrolyte composition to the human extracellular fluid has been proposed and patented. It was found that all synthesized samples are single-phase and represent hydroxylapatite. The nature of the reagent and the variation in the concentration of the modifier do not affect the phase composition of the sediments.
2. The bioactivity of silicon-containing samples was studied, and it was found that in hydrochloric acid the bioactivity of the samples is higher than in isotonic solution. The bioactivity of the samples decreases in the series HCl, Tris-HCl buffer, NaCl. It was found that the activation energy increases with an increase in the

CONCLUSIONS

3. It is shown that the thermal stability of the samples increases with an increase in the concentration of silicate ions in the sediment. It was found that at 600 ° C the formation of a two-phase system hydraxylapatite-tricalcium phosphate is observed. GAS samples (3 wt.% Gelatin) have low thermal stability and their destruction occurs at 400 ° C.
4. In the course of studying the surface and morphological characteristics of the obtained Si-HA coatings on VT1-0 titanium, it was found: an increase in the concentration of silicate ions in the composition of the deposit leads to a decrease in the wettability of the titanium sample surface and low values of the cohesion energy; the deposition of Si-HA on the surface of titanium substrates occurs better on etched samples.

Thanks for your attention