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STRUCTURE OF NON CRYSTALLINE MATERIALS

STRUCTURE AND PROPERTIES OF ORGANICALLY MODIFIED SILICA NANOSTRUCTURAL MATERIALS

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Development of nanotechnology and biotechnology leads to design new hybrid materials with innovative structure and properties. Nanocomposites, which combine silica component and biopolymer are important, because of their long - term stability, durability and biocompatibility. The wide range of functionalities made them useful and applicable in different fields.

The aims of the present study were sol-gel synthesis, structural characterization and application of organically modified silica nanostructural materials. Inorganic SiO_2 precursor and biopolymer - modified with poly(lactic acid) chitosan were used as initial components. The structure of obtained hybrids was characterized by XRD, BET, FTIR, SEM and AFM analysis. Influence of nature and quantity of organic component on their properties was followed and discussed.

Introduction

Hybrid materials are extensively studied, because of the incorporation organic compounds in inorganic network, combining their properties. Sol-gel method allows to synthesized materials with high homogeneity and purity at a molecule level. Sol-gel process involves hydrolysis of silica precursor and condensation of Si–OH groups into SiO_4 tetrahedra. These building units are bridges by oxygen and lead to formation of Si-O-Si network. Silica materials obtained via sol-gel route exhibit good thermal and mechanical properties and long-term stability at different pH. Thermodynamic stability of Si-O bond enables interactions with many biomolecules and allows them to function normally in the presence of silicates.

Many researcher groups work on synthesis of biomaterials (biosensors and biocatalysts) and their interaction effect with different biomolecules – enzymes, proteins, living cells and others. Most of them combine inorganic matrix on the base of silica precursors with organic polymers, with potential application in different fields: biotechnology, medicine, optics, pharmacy and etc.

The addition of organic constituent improves the plasticity of the silicate matrix. Furthermore, using sol-gel synthesis we can easily insert functional groups from polymer into the silicate matrix and that will afford entrapment of biomolecules.

Chitosan is the second most abundant natural polysaccharide, composed of glucosamine and *N*-acetyl-glucosamine units. It has three reactive groups – primary amino or amide group and secondary hydroxyl groups. Chitosan is insoluble in water and organic solvents, but soluble in acid water solution (pH <6.5). In low pH conditions amino groups are protonated and become positively charged, which makes CS a cationic polyelectrolyte. Most of the bacteria's and enzymes are negative charged and can easy form bounds with amino groups of CS.

Si/CS hybrid materials can be used as biomaterials in medicine, pharmacy, as materials for enzyme immobilization, for adsorption of toxic metals and dyes in waste water etc.Materials based on silica and modified chitosan lead to formation of hybrids with good protective properties and high sorption activities.

Results and Discussion

From XRD patterns is visible amorphous halo at 23 2θ. This halo showed the amorphous character of the obtained hybrid materials.

Characteristic bounds of silica network, as well as modified chitosan are visible from FTIR spectra. Increasing quantity of the biopolymer lead to increasing intensity of chitosan peaks.

Modified chitosan plays an important role for surface area and porosity of hybrid materials. From BET analysis (fig.4) can be concluded, that with increasing amount of organic component surface area and pore size decrease. Hybrid material with highest values is sample 6, where SiO_2 – modified chitosan wt ratio is 60:40.

SEM micrographs showed smooth surface and evenly distribution of nanoparticles. With increasing quantity of biopolymer their size decrease. This tendency proved influence of chemical structure and properties of used polysaccharide on final structures.

Surface roughness play an important role for potential application of obtained hybrids. AFM histograms (Fig.5) showed the evenly distribution of nanoparticles in entire hybrid matrix. Variation of z-direction between 18,6 nm and 660,3 nm due to modification of silica materials with poly(lactic acid) chitosan.

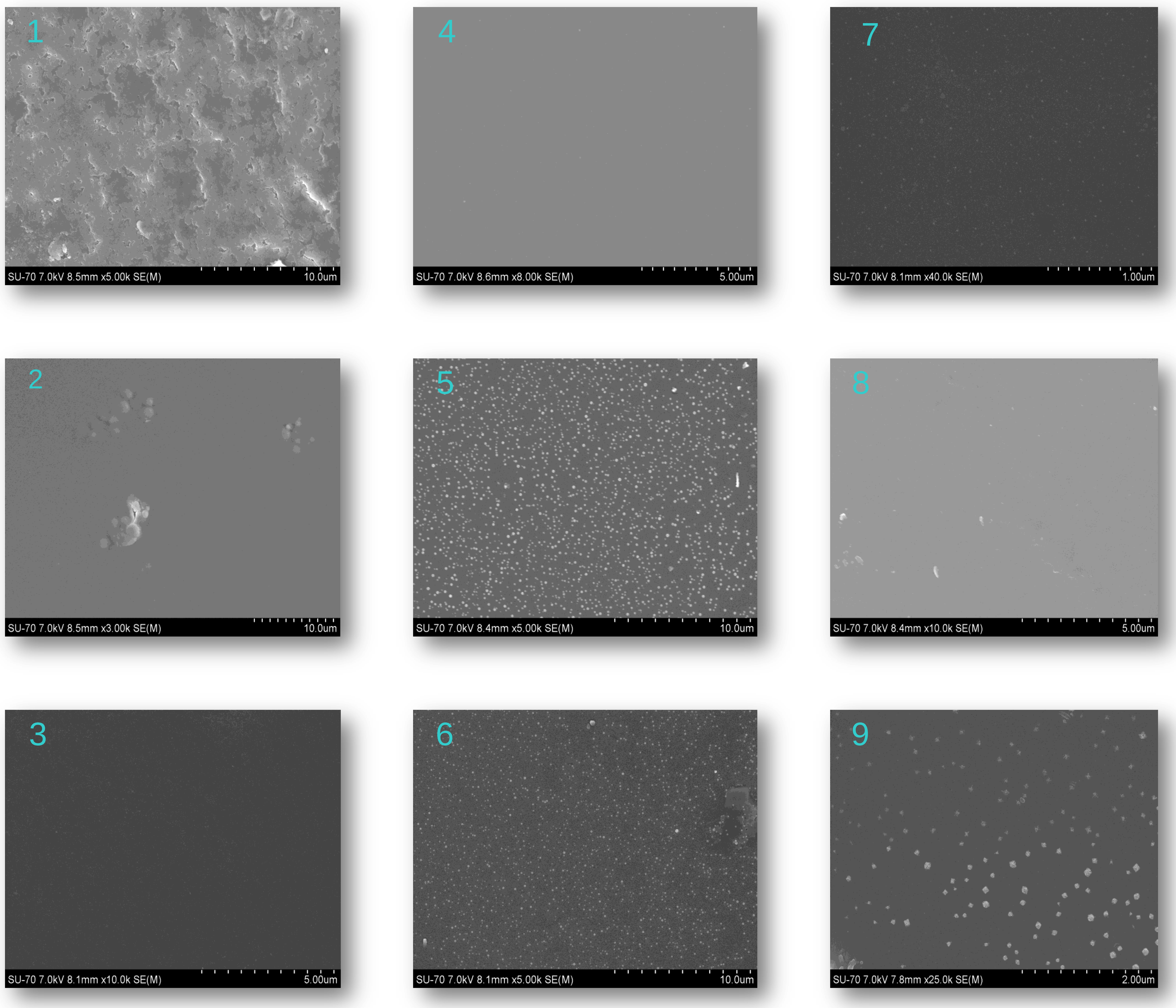


Fig. 1 SEM micrographs of synthesized hybrid materials

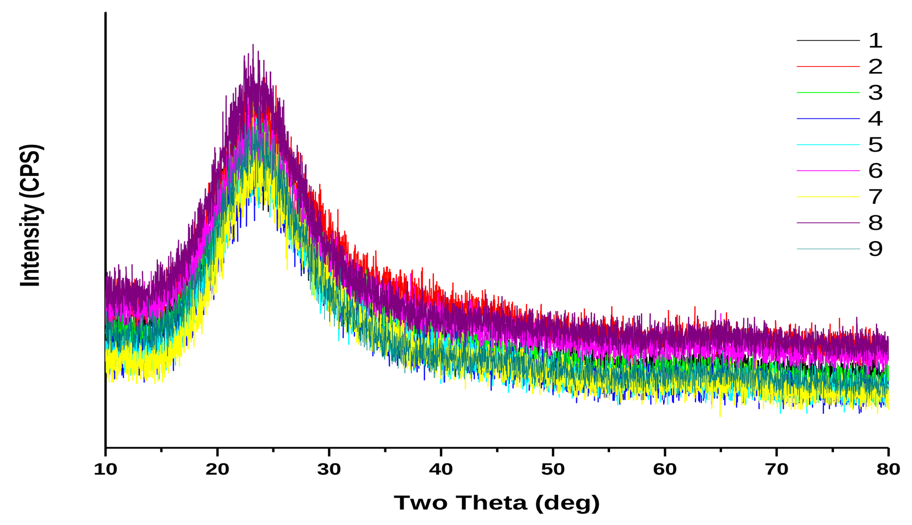


Fig. 2 XRD patterns of obtained hybrids

Fig. 3 FTIR spectra of obtained hybrids

Potential application

Obtained modified silica-chitosan materials will be use as carriers of fungal cells. These cells produce enzyme xylanase, which is useful in food industry.

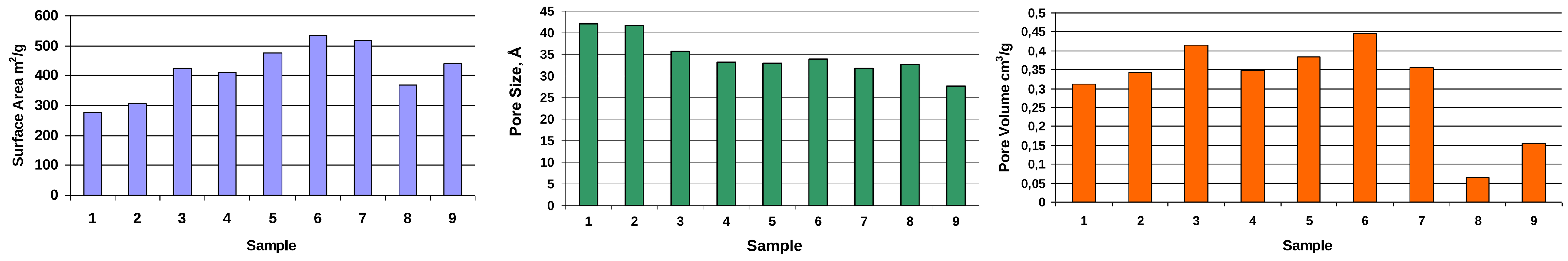
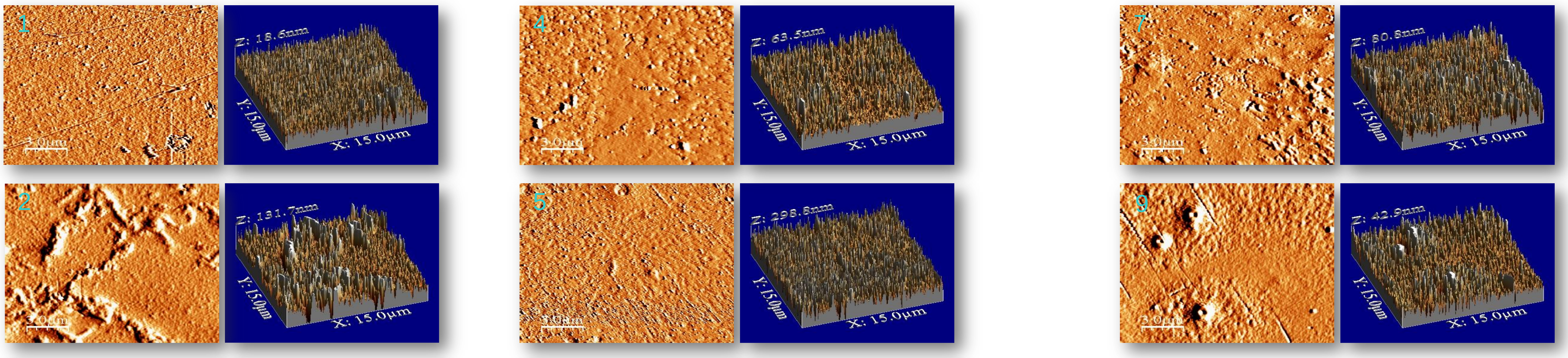


Fig. 4 Correlation between surface area, pore size and volume of synthesized materials



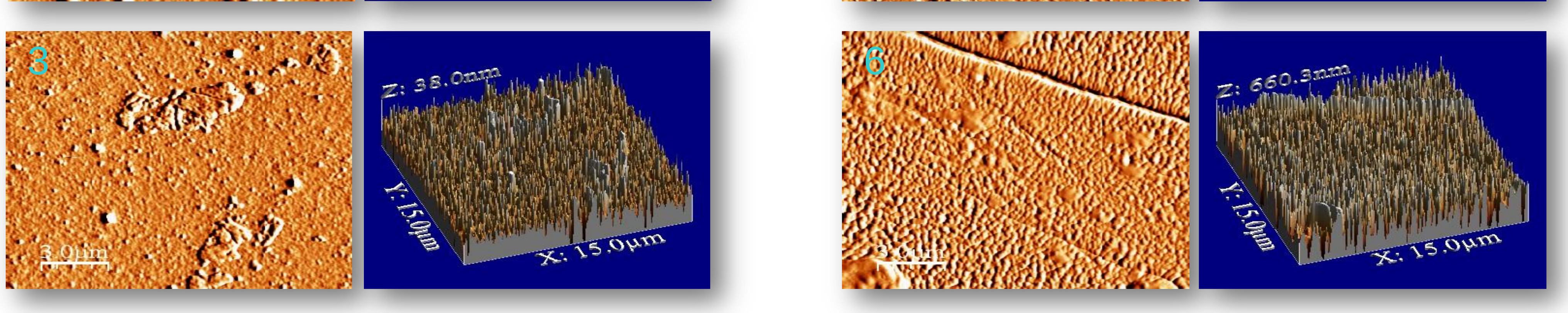


Fig. 5 AFM topography (2D, 3D) of obtained hybrid materials

Acknowledgments

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