CELLULOSE-SILICA COMPOSITES OF HYDROPHILIC- HYDROPHOBIC NATURE

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ABSTRACT

It is known that the study of the properties of cellulose-silica composites has attracted great interest in recent years. Because of this, cellulose- silica composites have their own characteristics. That is why it is important to obtain composite materials based on it at present. In the thesis, cellulose-silica composites were synthesized, their structure, physico-chemical properties were studied. As a result of the conducted studies, various thermodynamic properties, including the average energy of mixing Agm, Gibbs energy AGi, capillary-pore indicators, and the limit of true adsorption were determined. Based on water vapor sorption properties of water-soluble cellulose-silica composites obtained in different proportions, their capillary-pore structures (capacity of monolayers, specific surface area, and total volume of pores and radius of pores) were calculated. The hydrodynamic properties of aqueous solutions of the samples under different conditions were studied.

Keywords: *Cellulose, silica, composite, IR-infrared spectroscopy, MTMS-methyltrimethoxysilane, SEM - scanning electron microscope, TGA - thermogravimetric analysis.*

Introduction. In recent years, due to its unique structure, attention has been paid to silica-based materials. By changing their properties (surface, porosity, structure, etc.), the areas of application can be expanded. In particular, aerogels with complex properties were obtained by controlling the hydrophilic-hydrophobicity of silica-based materials, which have unique mechanical properties, high surface area (>1000 m^2/g), very low density (0.03-0.20 g/cm^3) and is characterized by unique properties such as highly effective thermal insulation, high temperature resistance, non-flammability, good transparency, low refractive index and low electrical conductivity, sound absorption.

Substitution of one organoxy group in tetraorganoxysilane, which has a strong hydrophilic nature, with a hydrocarbon radical leads to a significant increase in the hydrophobicity of silica. The greater the amount of Si-O-Si, Si-C and C-H functional groups in silica, the higher their hydrophobicity. Therefore, it is advisable to use alternative precursors with a high percentage of hydrophobic groups to obtain hydrophobic materials.

Methodical part. Based on the above, methyltrimethoxysilane - (CH3-Si-(OCH3)3, MTMS) was used as a precursor for the synthesis of hydrophilic and hydrophobic silica samples by the sol-gel method.

The synthesis process was carried out in several stages. In the first step, MTMS was hydrolyzed in ethanol medium in the presence of 0.1 M NH4OH. In the second stage, the resulting mass was first dried at room conditions, then at a temperature of 60°C and calcined at a temperature of 500°C. It should be noted that the hydrophilic-hydrophobicity of silica was controlled by changing the time of the condensation process.

The hydrophilic-hydrophobicity of the synthesized silica was evaluated by measuring the exposure/contact angle formed by it with a water droplet. The exposure/contact angle was found using images taken with the iPhone 14 Pro camera. In this case, the 0/2 angle method was used to determine the limit angle.

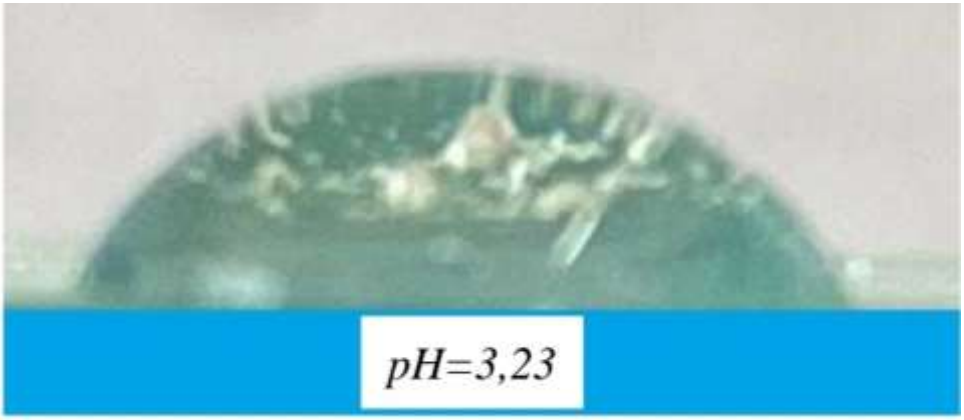

Figure 1. The layer obtained based on MTMS at pH=3,23 (1 M CH_3COOH)

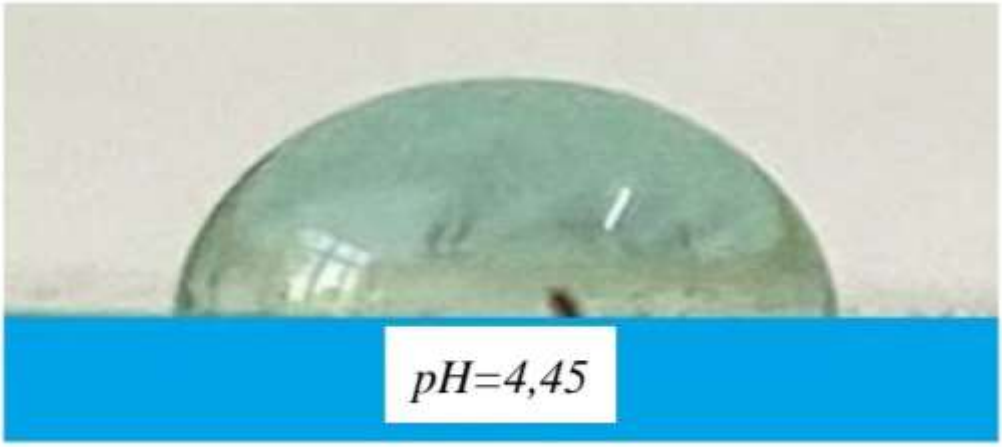

Figure 2. The layer obtained based on MTMS at pH=3,23 (0.025 M CH_3COOH)

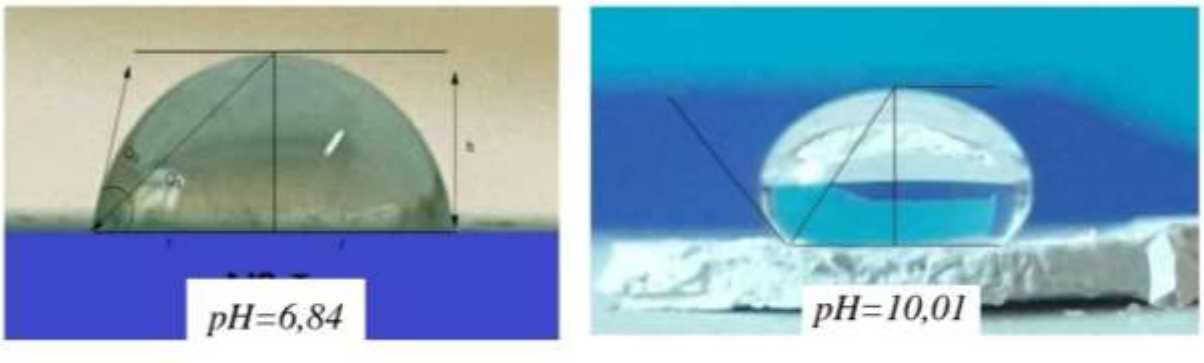

Figure 3. The layer obtained based on MTMS at pH=6.84

It was observed that carrying out the coating in different pH environments affects the angle of contact of the coating with water. It was observed that an increase in the pH value of the reaction mixture environment leads to an increase in the hydrophobicity of the layer to be removed.

It was found that as the layer based on methyltrimethoxysilane passes from an acidic to an alkaline environment, the hydrophilic properties of the unit increase, and the contact angle with water increases.

It can be seen that methyltrimethoxylan has a great effect on the hydrophobicity of the ceramic surface. The water droplets formed on the ceramics without MTMS coating were very wide and spread over the ceramic surface, the water contact angle on the ceramic surface was 37°, after the addition of MTMS, the water droplets became more rounded the ceramic surface showed more hydrophobic property. The higher the pH, the larger the water contact angle, and the contact angles of MTMS thin films calcined at 350°C were always greater than 500°C for all pH variations.

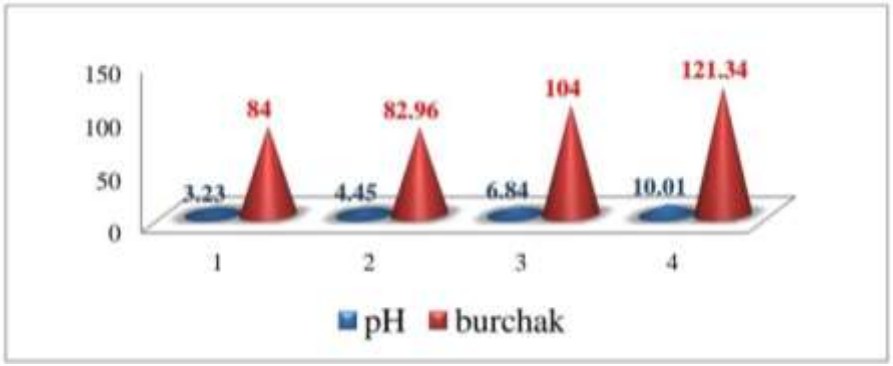

Figure 4. Dependence of the exposure/contact angle (th2) formed by silice sem with a water dropet on thr pH value of the solution medium

The relationship between exposure angle and pH is presented in Figure 4. Calcined at two different calcination temperatures. The higher the pH, the greater the contact angle with silica calcined at 350°C or 500°C.

Table 1.

The angle of contact with water of coatings formed in different environments

pH	H,mm	2r, mm	Θ_1	Θ_2
3.23	1.40	3.15	42.00	84.00
4.45	1.90	4.30	41.46	82.96
6.84	1.70	5.40	52.00	104.00
10.01	1.65	1.90	60.67	121.34

From the data presented in Table 1, it can be seen that the hydrophilicity of silica obtained after the hydrolysis process decreased, which is explained by the dominance of -CH3 groups over -OH groups. In this case, the system starts the condensation process or is in a state of branching. With increasing branching, the silica surface becomes rougher, which, in turn, leads to an increase in its hydrophobicity. In other words, the lower the smoothness of the surface and the higher its roughness, the higher the hydrophobicity of the surface of the material. As a result of the unevenness of the surface, the angle of wetting with water increases, due to which the surface rises and creates a barrier to water.

Summary. The effect of environmental pH on the sol-gel polymerization of methyltrimethoxysilane was studied. In this case, it was found that with the increase in the pH value of the environment, the hydrophilicity of the obtained silica decreases, and the hydrophobic properties increase. The silica synthesized at pH=10.01 showed superhydrophobicity (02-121.34°).

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