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STUDY OF THE VANADIUM XEROGEL STRUCTURE BY THE ELECTRON MICROSCOPY METHOD

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ABSTRACT

The paper presents the results of a study of vanadium xerogel synthesized by sol-gel method. It shows that in aging process of the gel formation of layered gel structure fibers chains of V–O occurs forming the relief nanoscale structure.

Key words: Sol-gel method, Gel, Vanadium pentaoxide, Template, Nanostructure materials.

INTRODUCTION

Xerogels of vanadium oxides $V_2O_5 \cdot nH_2O$ referred to intercalation compounds, where the ions or guest molecules disposed between oxide layers of the host material. They exhibit properties as the main vanadium-oxygen matrix and intercalates. A characteristic feature of these compounds-quasi-single structure with disordered turbo layers, where can be easily implemented not only cations but also organic molecules[1].

Layered structures are ideal precursors for nanotubular forms of metal oxides. The most effective precursors may be xerogels of the vanadium oxide[2]. A favorable condition for folding of the oxides planes occurs with the distance increase between them and the formation of uncompensated bonds.

It is known that the gel $V_2O_5 \bullet nH_2O$[3] relates to the class of acid (pH 2.3-2.4) with pH increase of the medium it reacts with ammonia-template by the hydrolytic mechanism.

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EXPERIMENTAL

This paper presents the results of structure studies of synthesized vanadium xerogel V_2O_5•nH_2O[4] by electron microscopy method. As the template ammonia was used. The addition of ammonia into the structure of the gels (xerogels) increases the interlayer distance during formation of tubes. Herewith interaction between the V-O layers decreases.

The gel sample was analyzed by the scanning probe microscope with a Tape Integra Prima prefix. Filming took place in an atomic force mode. Moreover, microscopic analysis of the gel was performed on low vacuum scanning electron microscope Jeol JSM-brand 6490 LV.

RESULTS AND DISCUSSION

From the obtained data (Fig. 2), it is seen that the synthesized vanadium xerogel has a layered structure. The structure of the gel formed by the fibers of the VO chains and water molecules. The twisting factor of V-O layers is the anisotropic distribution of vanadium ions with the different valence and size. The effective twisting of VO layers leads to the formation and stabilization of the nanotubes.

The fibers represent flat ribbons ranging in length from 100 to 600 nm and a width of about 25 nm. Their structure is similar to the structure of the orthorhombic vanadium pentoxide. The orthorhombic nexus constituting the ribbon is not located in the common plane but form a relief structure with an amplitude of 2, 8 Å[5,6]. The interlayer distance (d) depends on the content of water and under normal conditions is in the range from 150 to 200 nm.

On the surface of membranes was found partially ordered elongated, highly anisotropic particles, similar in size to the "ribbons" of vanadium oxide gel. Nanoribbons of V_2O_5 gel with an average diameter of 25-40 nm and a length of 600 nm. Dimensions of the diameters and lengths of the gel nanoribbons were determined by Nova program. Such ribbons are often agglomerates together by forming splices.

It is interesting to note that many one-dimensional nanocrystals of vanadium bronzes[2,7] is growing exactly along this direction, testifying the formation of these crystals by splitting layers of ribbon-like colloidal particles of hydrated vanadium oxide during crystallization of orthorhombic V_2O_5.

Studies by the IR spectroscopic methods of analysis[8] synthesized vanadium xerogel in comparison with published data on the presence and offset of the absorption bands of groups V=O and V–O, and suggests that a high degree of order in the membranes related to the fact that one of the water molecules is opposite short of double bond V = O- groups.

Consequently, the chain growth takes place predominantly in the plane OH-equivalent groups. Most VO-H consist of twisted (helical) vanadiumoxygen layers and have a morphology "whistle" (Fig. 3), the ends of which are open. Owing to the morphology of the "whistle" VO-H are characterized by significant structural flexibility that distinguishes them not only from carbon, but most other nanotubes.

Found that the removing of moisture from the gel, leads to the formation of porous layer structure of a vanadium complex.

Figure 2 shows a snapshot of the dried gel, which confirms the presence of stratified structural fibers.

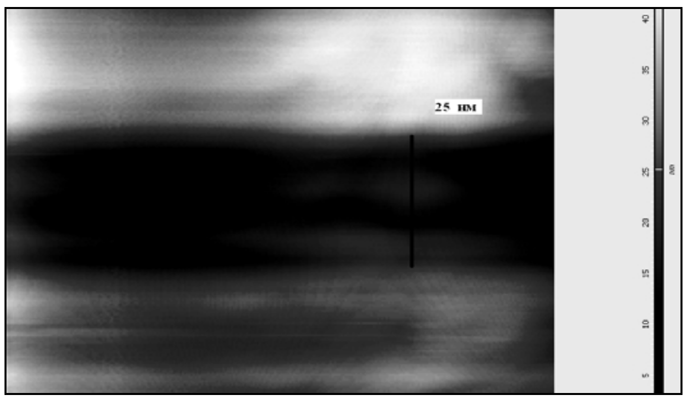
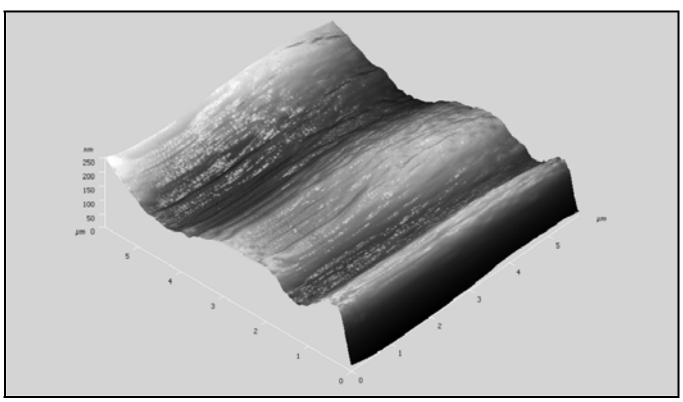


Fig. 1: Micrograph of a SWNT based on vanadium xerogel



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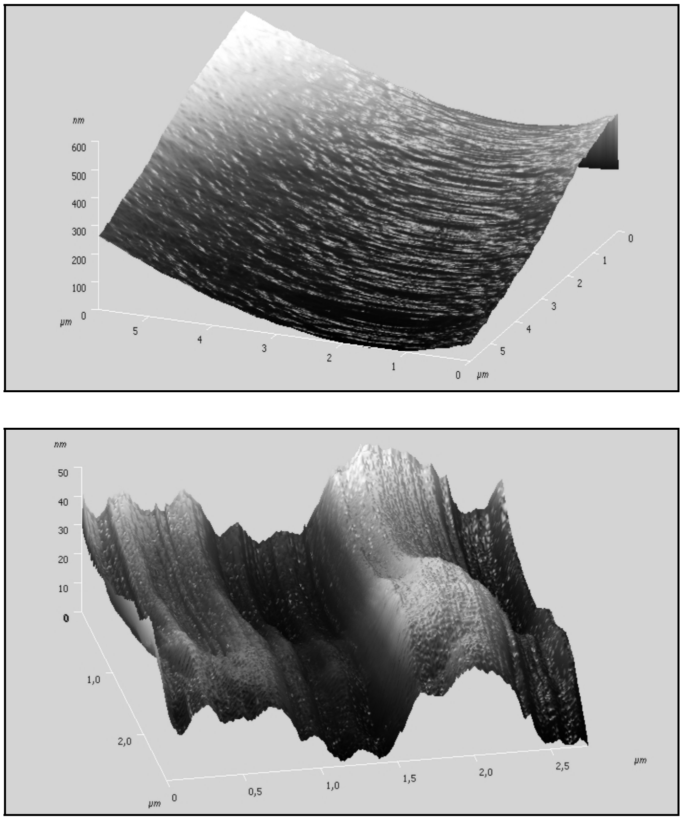

Fig. 2: Micrographs of the vanadium-containing gel surface, taken at different magnifications and angles

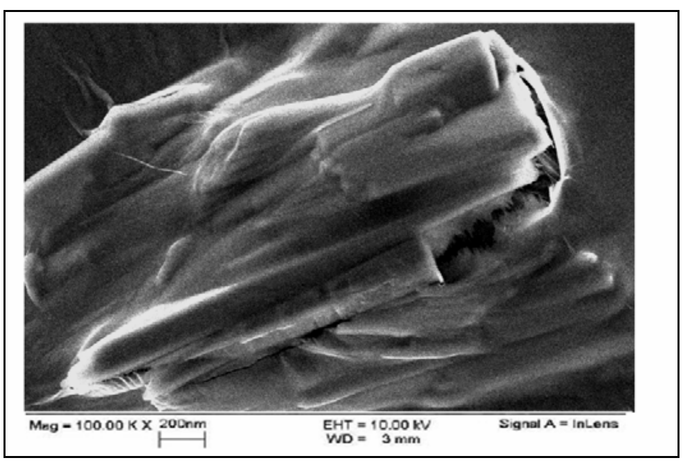

Fig. 3: Spatial strucrure of the dried up in the air gel of vanadium-contaning complex

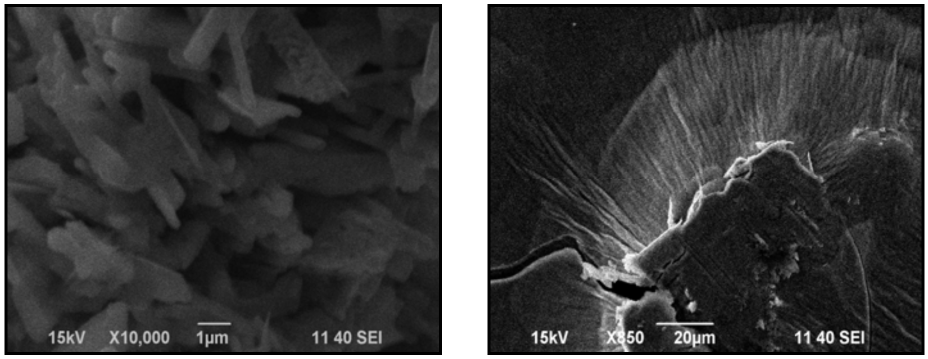

Fig. 4: Pictures of vanadium-containing gel at different magnifications

The obtained results of studies about formation mechanism of nanoscale tubular structure (in the form of nanotubes and nanoribbons) of vanadium oxide in good agreement with literature data.

CONCLUSION

Formation of the layered structure of vanadium complex opens up great possibilities of using synthesized substance in various nanotechnologies to obtain precision composite materials and alloys, highly efficient catalysts and sorbents, etc. Furthermore, xerogels of vanadium oxide (V) - reactive substances and can be used for efficient low-temperature synthesis of complex oxides of vanadium. Currently, they are considering as promising precursors for the synthesis of nanotubular and related nanostructures of simple and complex oxides of vanadium.

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