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# Synthesis and colloidal-chemical properties of manganese dioxide hydrosols

## Abstract

**Relevance of the research topic**

The primary objective of chemical technology in the modern industrial field is to improve the process efficiency. The catalytic reactions that produce the majority of the products used by humans become critically important as a result of this demand. Membrane catalysts are effective in helping increase efficiency.

There are many reactions, the catalysts of which are catalysts with deposited colloidal particles. Examples of such reactions include oxidation, electron transfer reactions, hydrogenation, etc. Manganese (IV) oxide-based materials are widely used in water treatment processes as catalysts, ion exchangers and sorbents. Transition metal oxides are much cheaper, and their catalytic activity can be optimized by adapting their crystal structures, morphology, and surface properties during synthesis.

Colloidal systems consisting of metal oxides are distinguished by their size dependent properties. The catalytic and sorption selective properties of the obtained materials depend on the phase composition and parameters of the porous structure of polymorphic modifications of manganese oxide. Sol-gel technology with the ability to control the structure and composition of manganese oxide coatings by changing the conditions of ash and gel formation is the most promising for the production of membrane-catalytic materials based on manganese (IV) oxide. The development of the basics of sol-gel synthesis of such materials, as well as their bulk analogues, is impossible without knowledge of the basic colloidal-chemical properties of sols, such as electrical and optical properties, aggregative stability, coagulation, etc.

To obtain oxide materials with the necessary characteristics, such as: dispersion, pore size, specific surface area, the use of sol-gel technology is effective, since it allows the process to be carried out under optimal conditions in terms of controlling the properties of the final product, energy costs and process productivity. There are a number of literature data on the synthesis of manganese dioxide nanoparticles, but not much attention is paid to the synthesis of aggregatively stable sols.

**Purpose of the work:** development of methods for the synthesis of manganese dioxide sols suitable for obtaining catalytically active layers deposited on the surface of a ceramic carrier and to obtain a data set that is necessary for further development of application methods.

**Work tasks.** To achieve this goal, it was necessary to solve the following tasks:

1. To develop the main stages of synthesis of aggregatively stable manganese dioxide sols;

2. To obtain a set of data on the main colloidal-chemical properties of synthesized

sols;

3. Based on these data, theoretically evaluate and experimentally test the possibility of adagulation of sol particles on the surface of a macroporous carrier α-Al2O3;

4. Using synthesized sols to obtain samples of MnO2/α-Al2O3 catalysts and conduct catalytic tests.

**Scientific novelty of the work**

1. Methods of synthesis have been developed to obtain aqueous sols of $MnO_2$ nanoparticles (sols) that are aggregatively stable and ideal for the production of deposited catalysts.

2. It has been established that the various conditions for the synthesis of sols influence the qualitative and quantitative composition of the dispersed phase and the dispersion medium, and also the shape and size of the nanoparticles.

3. A set of data on the main colloidal-chemical properties of synthesized sols was obtained:

- the range of values of the dispersion medium's pH between which sols maintain their aggregate stability is 3.0 to 13.0 units;

– the sign and magnitude of the electrokinetic potential of the synthesized systems are determined, the influence of synthesis conditions on the magnitude of the electrokinetic potential and the threshold of rapid coagulation is established;

- based on the experimental data obtained, complex Hamaker constants are determined evaluation of the possibility of adagulation of particles on the surface of α-$Al_2O_3$, followed by experimental verification.

**Theoretical and practical significance of the work**

Methods have been developed for the synthesis of manganese dioxide sols, which makes it possible to obtain systems with reproducible properties. The main colloid-chemical properties necessary for the controlled production of supported catalysts have been determined. The pH ranges in which the sols are aggregatively stable were determined, and the values of the electrokinetic potential were obtained. It has been established that after the exposure of the sols, the pH range in which the sols retain their aggregative stability decreases. The thresholds for rapid coagulation of sols were determined upon the addition of various electrolytes, which turned out to be indifferent electrolytes. It was found that the amount of electrolyte introduced depends both on the pH value and on the concentration dispersed phase.

**The main provisions for the defense:**

1. Results from four methods were used for synthesizing manganese dioxide sols based on reactions between potassium permanganate and four different reagents.
2. Influence of synthesis conditions on some colloidal-chemical properties of sols, in particular, on the aggregative stability of sols and the electrokinetic potential of dispersed phase particles, optimal synthesis conditions are selected.
3. Influence of applied catalysts based on manganese dioxide on the oxidation of

the methylene blue dye in the presence of hydrogen peroxide.