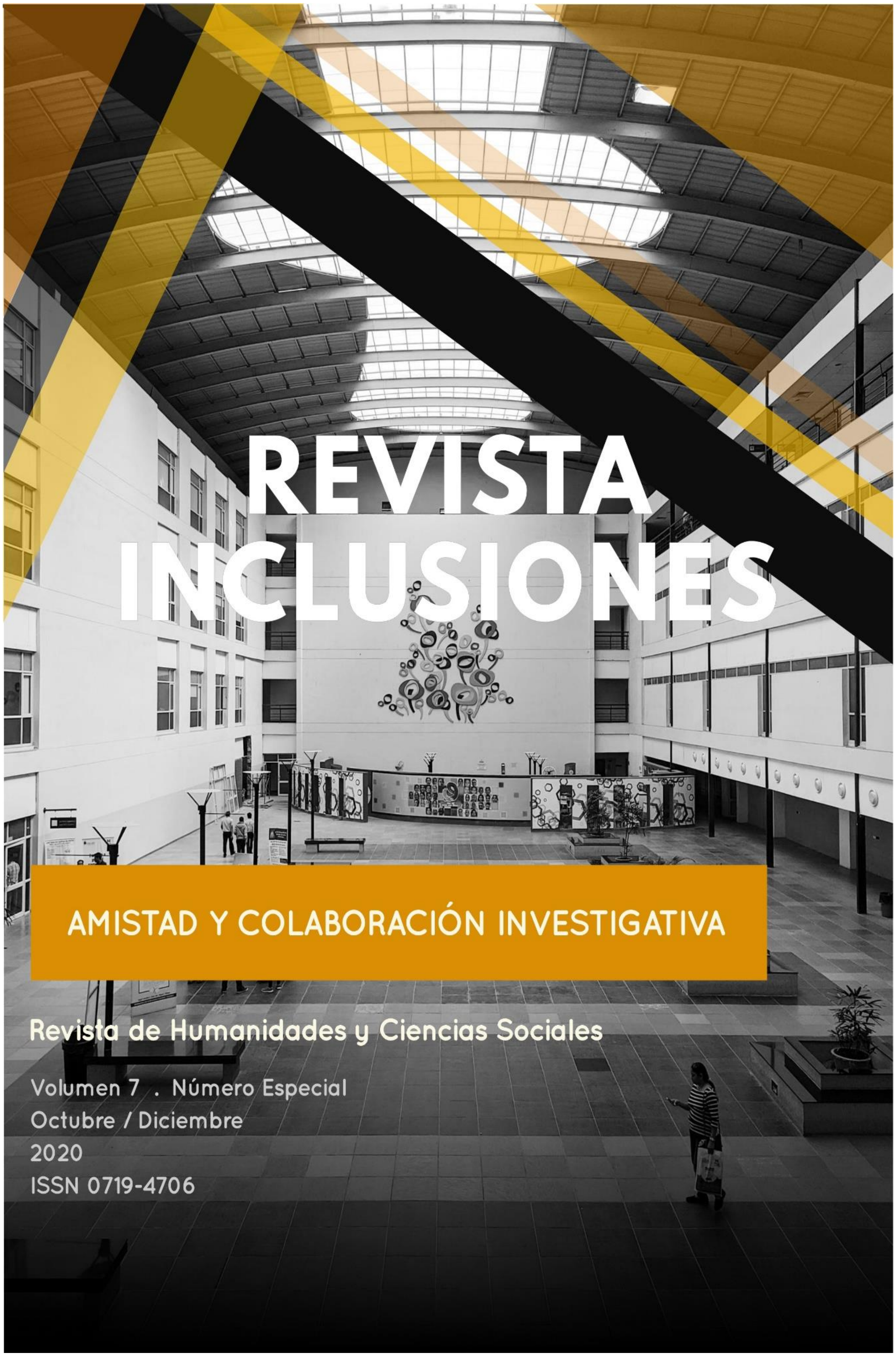

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# THE EFFECT OF SURFACE MECHANICAL ACTIVATION OF INORGANIC PIGMENTS ON THE STABILITY OF THEIR AQUEOUS DISPERSIONS IN THE PRESENCE OF ETHYL HYDROXYETHYL CELLULOSE

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## Abstract

The stability of aqueous dispersions of inorganic pigments $TiO_2$ and $Fe_2O_3$ in the presence of a non-toxic water-soluble polymer (ethylhydroxyethyl cellulose) with two methods of mechanically activating the surface of the pigments processing them in a disintegrator and in ultrasound field was studied. If there is no polymer stabilizer, intense exposure to aqueous dispersions of pigments leads to their rapid coagulation. If there is ethylhydroxyethyl cellulose, a small stabilizing effect is observed, which is significantly enhanced when processing dispersions in a disintegrator and in an ultrasonic field. Moreover, the stability of pigment dispersions depends not very much on the method of mechanically activating their surface, but on the duration of intense exposure.

**Keywords**

Pigments – Stability – Particles – Mechanical activation – Ultrasound

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## Introduction

In recent years, there is great scientific and practical interest of environmentally friendly aqueous dispersions of pigments widely used in the paint and varnish and printing industries[1]. An important problem for dispersed systems is the problem of their stability[2]. Surfactants are usually used to stabilize dispersions: with low molecular weight and polymeric ones[3].

A number of studies have shown that some water-soluble polymers (such as polyvinyl alcohol, polyvinylpyrrolidone, polyvinylcaprolactam, cellulose derivatives) can be used as stabilizers for aqueous disperse systems[4]. In this case, the polymers are reversibly and irreversibly adsorbed on the surface of solid particles, forming protective adsorption-solvate layers[5]. This method of stabilization of disperse systems is commonly called adsorption-chemical modification [6].

Recently, works that show that, to obtain highly dispersed stable systems, it is effective to use mechanochemical modification along with the adsorption-chemical modification of the surface of the solid phase (mechanochemical modification) have appeared[7]. In a number of studies, the method of mechanochemical modification (mechanical action during processing in various types of mills) was used to obtain dispersions of iron, chromium and lead oxides in organic solvents in the presence of polymers[8]. The authors conclude that an increase in the rate of adsorption of the polymer from the solvent on the surface of metal oxides during mechanical action due to structural changes in the surface layer of the solid phase[9].

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It was previously shown that treatment in an ultrasonic field of aqueous dispersions of titanium dioxide in the presence of water-soluble polymers leads to a significant increase in their stability[10]. It is assumed that during the process of mechanical activation in the presence of a polymer stabilizer, two processes simultaneously occur: disaggregation of pigment agglomerates and the formation of protective adsorption-solvate layers of the polymer on the "freshly formed", and therefore "active" surface of the solid phase [11]. The result is highly dispersed and stable systems[12].

However, these assumptions have not yet been experimentally confirmed, and the mechanism of mechanical activation processes remains unclear[13].

In this work, there was set the task to obtain highly dispersed stable aqueous pigment systems $TiO_2$ and $Fe_2O_3$ in the presence of polymer stabilizer ethylhydroxyethyl cellulose as a result of mechanical action on them in two ways: by processing them in an ultrasonic field and in a disintegrator[14].

## Experimental part

## Objects of study

Pigment $Fe_2O_3$ of Bayferrox company; pigment surface is treated with aluminum and silicon oxides[15].

Pigment $TiO_2$ RN-56 of Kronos company; pigment surface is treated with oxides of aluminum, silicon and zirconium to reduce photosensitivity[16].

A non-toxic water-soluble polymer, ethylhydroxyethyl cellulose, with a molecular weight of 60 000, was used as a stabilizer of aqueous pigment dispersions[17].

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## Research methods

The sedimentation behavior of the pigments was investigated as follows: weighed portion of the pigment was mixed with an aqueous dispersion medium[18]. The dispersion was placed in a glass cylinder with divisions and then, over time, the lowering of the interface between the solid phase and the pure dispersion medium was monitored[19]. ml from sedimentation time (min., logarithmic coordinates)[20]; The average particle size of the fillers and pigments was evaluated on the device Coulter – N – 4 – particl size analizer[21]; Mechanical activation by ultrasonic treatment was carried out on an ultrasonic generator UZDN-2 with a frequency of 22 kHz and intensity 30W/cm$^2$, processing time ranged from 2 to 30 minutes[22].

For mechanical activation, we also used a laboratory disintegrator manufactured by Disintegrator (Estonia) company; it has a passage type, containing five rows of discs with teeth that rotate towards each other at a speed of about 1000[23].

## Results and discussion

Before proceeding to a direct discussion of the results, it is important to emphasize that in the studies there were used pigments, the surface of which was treated with oxides of aluminum, silicon and zirconium[24]. This circumstance suggests the similarity of the properties of the studied pigment dispersions $TiO_2$ and $Fe_2O_3$ [25].

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The results of a study of the effect of mechanical activation (ultrasonic treatment and processing in disintegrator (DI treatment) of aqueous pigment dispersions $TiO_2$ in the presence of ethylhydroxyethyl cellulose on their sedimentation stability, as well as on the average particle sizes of the corresponding dispersions, show that in the absence of polymer the treatment of dispersions in the ultrasound field and DI leads to their rapid coagulation, and the particle sizes are on average 1.0 - 1.1 μm[26]. This is apparently due to the formation on the surface $TiO_2$ during mechanical activation of a freshly formed surface with uncompensated charges[27]. The system seeks to reduce surface energy, which leads to a sharp decrease in the stability of dispersions[28].

The presence of ethylhydroxyethyl cellulose in the system increases the stability of the dispersions, and the particle size decreases to 0.5 μm[29]. During mechanical activation (ultrasound or DI treatment) in the presence of ethylhydroxyethyl cellulose, the stability of dispersions increases significantly (approximately 100 times)[30]. The particle size is thereby reduced to the original particle size of the titanium dioxide used[31]. A similar effect can be observed by analyzing the sedimentation stability of pigment dispersions $Fe_2O_3$ in water and in a solution of ethylhydroxyethyl cellulose, and data on particle sizes confirm a significant decrease in particle sizes of dispersions after their ultrasonic and di-processing[32].

It should be noted that the stability of the systems obtained as a result of processing in an ultrasonic field is slightly higher than the stability of the same dispersions after their DI processing, but this difference is insignificant[33].

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Thus, common to the studied aqueous dispersions of inorganic pigments $TiO_2$ and $Fe_2O_3$ is the disaggregation of pigment particles during mechanical activation, and in the presence of a polymer stabilizer, protective adsorption-solvate layers are formed, which apparently serves as the reason for the high activity of mechanical activation methods to increase the stability of disperse systems[34].

However, it should be noted that polymers can degrade during mechanical activation[35]. This fact can significantly affect the effectiveness of the mechanochemical modification method[36].

In fact, in the study of sedimentation of pigment dispersions $Fe_2O_3$ in an aqueous solution of ethylhydroxyethyl cellulose for various durations of ultrasound treatment, it was found that the optimal processing time to obtain stable dispersions of this pigment is 2 minutes[37]. An increase in the time of ultrasonic exposure leads to a significant decrease in the stability of systems. It can be assumed that ethylhydroxyethyl cellulose, being an insufficiently flexible polymer, undergoes mechanical destruction, which weakens its stabilizing effect[38].

Experimental results showing particle distribution of aqueous pigment dispersions $Fe_2O_3$ in the presence of ethylhydroxyethyl cellulose, in size before and after ultrasonic treatment, it is shown that, under ultrasonic treatment of dispersions, the distribution curve narrows significantly, which indicates that the dispersion $Fe_2O_3$ with a more uniform structure is obtained[39].

## Conclusions

It was shown that ultrasonic treatment of aqueous dispersions of inorganic pigments leads to a significant narrowing of the particle size distribution curve, which indicates that dispersion with a more uniform structure is obtained. The spectral studies made it possible to conclude that the ethylhydroxyethyl cellulose is firmly sorbed on the surface of the pigments, and the intense effect leads to the activation of the adsorption of polymer molecules on the “freshly formed” surface of the pigments.

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