Electrokinetic phenomena accompanying treatment of soy milk production wastewater by agent based on electric arc furnace dust

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Electrokinetic phenomena accompanying treatment of soy milk production wastewater by agent based on electric arc furnace dust

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Annotation. The electrokinetic phenomena were studied on model systems represented by finely dispersed water emulsions imitating the wastewater of soy milk production. The study has shown the presence of a suspension effect and its dependence on various factors. The results have proven that the coagulating suspension on the basis of electric arc furnace (EAF) dust is an effective way to treat soy milk production wastewater. The interaction of system components is stipulated by opposite charges of the particles in coagulating suspension and emulsion.

1. Introduction

The technological processes of soy milk production result in wastewater that contains fats, proteins, carbohydrates, vitamins and other compounds comprising the raw materials, soy beans [1, 2]. Chemical oxygen demand (COD) of such water reaches 18,000 (40,000) mg O_2/l, while biological oxygen demand (BOD) goes up to 15,000 mg O_2/dm^3 [3, 4]. Such wastewaters are hard to treat and stale fast, which leads to the emission of wastewater decay products: hydrogen disulfide, ammonia, mercaptans, etc. Dumping untreated soy milk wastewater into water bodies disturbs the biotic balance, causes deterioration of habitat of hydrobionts, rotting and eutrophication.

When the untreated soy milk production wastewater gets into the city sewage system, this can undermine the operation of biological water treatment facilities and reduce the quality of purified water [5, 6]. Thus, such wastewater must be deeply treated.

To treat wastewaters of various nature and composition, a wide range of physicochemical methods are used today [7–14]. However, the soy milk production wastewaters are hard to treat since they are dispersed colloid systems with long-term relative thermodynamic stability. The stability of colloid dispersed systems is known [15, 16] to be conditioned by similar electrical charges on the surface of particles that causes their mutual repulsion, counteraction of the coalescence, weighting up and sedimentation of the particles.

To break the stability of such finely dispersed system, it is needed to change the surface charge to achieve the isoelectric state of the system. Hence, the information on electrokinetic phenomena manifesting during the purification of finely dispersed suspensions of organic and inorganic substances is of great importance for regulating the properties of such systems.

The authors have studied the electrokinetic phenomena in model soy milk production wastewater during their treatment chemically using modified dust of electric arc furnaces (EAFs) of the Oskolsky electrometallurgical works (Belgorod region). Annual volume of such waste amounts to approximately 30 thousand tons, so the recycling of this technogenic material is an essential issue.

EAF dust produced during steel melting contains the following oxides: FeO, Fe_2O_3, ZnO, $Ca(OH)_2$, SiO_2, MgO, while the iron content of iron compounds in conversion to Fe_2O_3 is up to 50%. The dust is highly dispersed; the particle diameter is from 0.01 to 50 μm [17]. After dust treatment by sulphuric acid (1N), the authors have obtained a coagulating suspension (CS) with ions of Fe^{2+} and Fe^{3+} [18]. The produced CS was used to treat model soy milk production wastewater. The investigation also considered the suspension effects and impact of various factors on the change in ξ-potential of particles in systems "CS–water" and "CS–model soy milk production wastewater".

2. Objects of Study and Methods

The investigation involved a coagulating suspension produced on the basis of EAF dust treated by concentrated H_2SO_4, and model soy milk production wastewater.

The pH factor of water solutions was measured by pH-meter (I-500 ionometric converter, Akvilon, Russia); ξ-potential was measured by Zetatrac analyzer (Microtrac, USA).

The clarification of emulsions was determined by the turbidity (NTU) using HI 98703 Portable Turbidimeter (Hanna Instruments, USA)

3. Results and Discussion

At the first stage, the suspension effect was investigated in the considered systems. This effect is conditioned by the difference in the composition of dispersed medium away from the particles in the diffusion layer. During the sedimentation, the concentration of the dispersed phase occurs: below, for the particle density more than that of the medium, mentioned above, for less dense particles. The particles are found at the distances comparable to the thickness of the ion atmosphere; so, in the precipitate, the major part of the dispersed medium consists of diffusion layers of ions. This leads to the difference in average composition of dispersed medium in different parts of the system. For instance, if the diffusion layer contains excess of H^+ or OH^- ions, then the dispersed medium in the precipitate mentioned above has different average pH values [16].

Fig. 1 depicts the CS volume impact on the change in suspension and filtrate pH in the model emulsion.

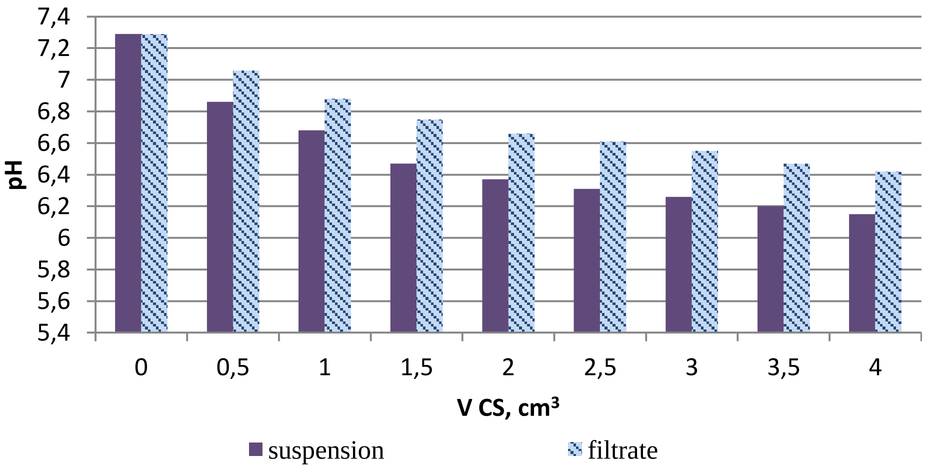

Figure 1. Impact of CS volume on suspension and filtrate pH change in the model emulsion with initial COD of 78 mg O/dm^3

Under the increased volume of added CS, the emulsion pH reduces, which indicates the change in ion composition of the dispersed medium. To obtain more comprehensive information, the change in suspension effect in the system under study was investigated.

The results of ΔpH dependence on the volume of added CS for emulsions of soy milk in water are presented in Fig. 2.

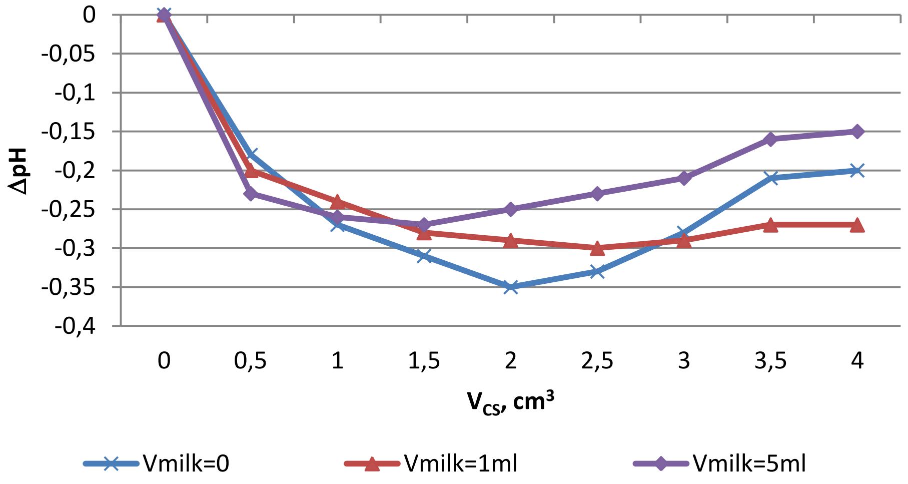

Figure 2. Dependence of ΔpH on the volume of added CS

According to Fig. 4, with the increase in the CS volume added to the emulsion, ΔpH first decreased to minimum at Vcs = 2–2.5 ml per 200 ml of emulsion, and then again gradually increases. This can be connected with the interaction of iron ions with OH^- ions in the solution which results in the shift of particle charge towards a neutral value, while the solution pertains excess of H^+ ions, which in its turn results in acidic pH.

Electrokinetic potential of soy milk emulsion is negative (Fig. 3), which explains the effective interaction of CS with model water.

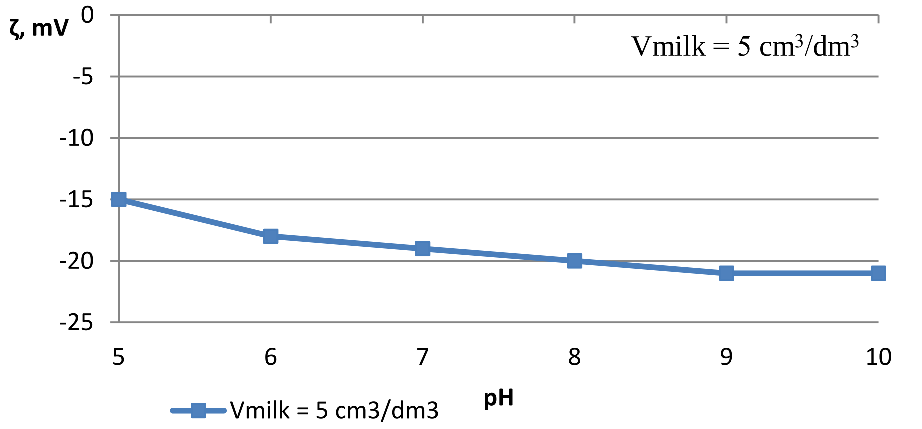

Figure 3. Effect of pH on ξ-potential

Ions of Fe^{2+} and Fe^{3+} and negatively charged soy milk emulsion droplets are mutually attracted to the system, which provokes the coagulation of emulsified components.

The diagram (Fig. 4) presents clarification of soy milk model emulsions using CS.

The photos (Fig. 5) demonstrate visual clarification of emulsions after interaction with the suspension.

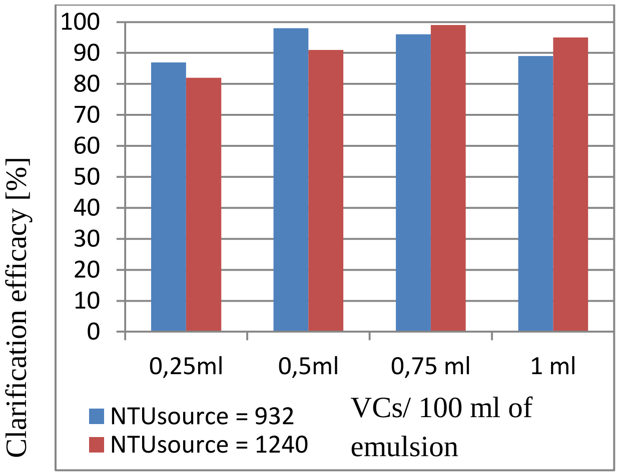

Figure 4. Clarification of soy milk model emulsions using CS

Figure 5. Visual clarification of emulsions after interaction with the suspension.

Thus, the modification of EAF dust by sulphuric acid allows obtaining the coagulation suspension that effectively clarifies soy milk emulsions and can be used for water treatment.

4. Conclusions
The coagulation suspension produced from EAF dust is an effective coagulant that can be used for treating soy milk production wastewater. The studies of electrokinetic potential of soy milk emulsion explains the effective interaction with CS since the system components have opposite electrostatic charges.

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