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Abstract

Full Text

PHYSICAL CHEMISTRY

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STRUCTURAL-MECHANICAL CRITERIA IN EVALUATING THE COAGULATING ACTION OF ELECTROLYTES ON AQUEOUS DISPERSIONS OF MONTMORILLONITE

A large number of works have been devoted to the question of studying the coagulating action of electrolytes on aqueous dispersions of clays. However, all research in this area has been directed chiefly toward elucidating electrokinetic phenomena and, to a lesser extent, the features of coagulation structure formation and the role of deformation and relaxation processes in it. There are almost no works concerned with a complete structural-mechanical analysis of clay suspensions treated with electrolytes. For this purpose we applied the methods of physicochemical mechanics of disperse systems (*1*).

The object of the investigations was bentonite clay from the Gorb deposit (Ukrainian SSR). Data from X-ray structural analysis and electron microscopy showed that it is represented by the mineral montmorillonite with an admixture of kaolinite having an imperfect structure, resembling a halloysite structure but without the tubular morphology of the crystals. The indicated clay has the following principal physicochemical properties: total exchange capacity 40.5 mg-eq/100 g, amount of monomolecularly bound water 11.7%; calcium ions predominate in the exchange complex. As investigations have shown (*2*), suspensions of Gorb montmorillonite are characterized by high aggregate stability and, in contrast to other montmorillonite clays, are considerably less sensitive to the coagulating action of electrolytes. Fifteen-percent suspensions belong to the fifth structural-mechanical type, but develop appreciable elastic conditionally instantaneous deformations, ε_0', (25%) at comparable values of elastic ε_2' and plastic $\dot{\varepsilon}_1'\tau$ deformations (Fig. 1). Their structural-mechanical characteristics—the elasticity λ, plasticity P_{k1}/η_1, and period of true relaxation θ_1—satisfy the criterion values (*3*) (Fig. 2).

Fig. 1. Structural-mechanical classification of clay suspensions. O—V—

Fig. 2. Dependence of elasticity, plasticity, and the period of true relaxation of a 15% montmorillonite suspension on the amount of sodium chloride and calcium chloride. The hatched region is the region of the required values of elasticity, plasticity, and the period of true relaxation

Figure 2: Fig. 2. Dependence of elasticity, plasticity, and the period of true relaxation of a 15% montmorillonite suspension on the amount of sodium chloride and calcium chloride. The hatched region is the region of the required values of elasticity, plasticity, and the period of true relaxation

structural-mechanical types. 1—15% suspension of montmorillonite without treatment; 2—15% suspension of montmorillonite with addition of 5% NaCl; 3—the same with addition of 10% NaCl; 4—the same with addition of 0.25% $CaCl_2$; 5—with addition of 0.5% $CaCl_2$.

When 5% sodium chloride is introduced into the suspension, a marked decrease (by a factor of two) in the elastic conditionally instantaneous deformations is observed; the magnitude of these depends entirely on the number of direct contacts (*3*), which is connected with the greater development of hydration shells and aggregation of particles of the disperse phase (Fig. 1).

Such a change in the interaction of particles leads to an increase in elasticity, associated with the magnitude of the hydration shells, a decrease in plasticity and in the period of true relaxation, whose values depend on the forces of molecular interaction and on the number of particles per unit volume. In this case···

the suspension, by the values of elasticity, does not meet the criteria and is characterized by a decrease in aggregate stability (Fig. 2). With an increase in the amount of sodium chloride (up to 10%), a drop in elasticity and a further decrease in elastic conditionally instantaneous deformations, plasticity, and the period of true relaxation are observed, which indicates a deeper process of the coagulating action of the electrolyte. In this case the system loses aggregate stability to an even greater extent.

Fig. 2. Dependence of elasticity, plasticity, and the period of true relaxation of a 15% montmorillonite suspension on the amount of sodium chloride and calcium chloride. The hatched region is the region of the required values of elasticity, plasticity, and the period of true relaxation.

As the structural-mechanical analysis shows, calcium chloride, at significantly smaller additions (0.25–0.5%), leads to very intense aggregation of clay particles, as indicated by the character of the change in the deformation process (Fig. 1) and in the structural-mechanical characteristics (Fig. 2). Suspensions treated with calcium chloride do not meet the criteria with respect to the values of the period of true relaxation and possess the greatest aggregate lability.

Thus, structural-mechanical analysis made it possible to elucidate the character of coagulation structure formation in mineralized suspensions of montmorillonite clay and to establish structural deficiencies, which is of great importance for clarifying the mechanism of the coagulating action of electrolytes and for obtaining highly stable clay systems.

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