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CLAYS and CLAY MINERALS at a glance

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DETERMINATION OF SURFACE AREA BY SURFACTANT ADSORPTION IN AQUEOUS SUSPENSION—I. DODECYLAMINE HYDROCHLORIDE

G. William Kalb and R. Bruce Curry 47

Conductometric titrations of clay suspensions with surfactant solutions offer a rapid method of surface area determination of clay particles suspended in aqueous media. A cationic surfactant, dodecylamine hydrochloride, was used in this investigation. This surfactant was adsorbed by electrostatic bonding at cation exchange sites and by van der Waals forces. A monomolecular or bimolecular layer of the surfactant coats the particle and the completion of the layer is determined from a change in slope of the conductometric titration curve due to the formation of micelles. Good agreement between this method and BET determined values were obtained for kaolinite. The bentonite suspensions had a strong tendency to flocculate after the initial stage of adsorption causing the results to vary considerably. This method of surface area measurement of clay particles offers many advantages over the present techniques: (1) a dry particle is not required; (2) the equipment is inexpensive; (3) the method is rapid; (4) vacuum and high temperature are not required; and (5) the method measures the internal as well as external surface area.

A METHOD FOR REMOVING TITANIUM DIOXIDE IMPURITIES FROM KAOLIN

R. N. Maynard, N. Millman and J. Iannicelli 59

The removal of titanium minerals from kaolin can be accomplished by treatment with dispersing agents in an amount in excess of that required to produce maximum deflocculation of the kaolinite particles. In this reflocculated state the kaolinite particles attain a high degree of suspensional stability, and the titanium mineral particles, primarily anatase, are liberated and can be separated by sedimentation. Substantial removal of anatase impurities can be achieved by this method.

HYDRAULIC AND ELECTRICAL FLOWS IN CLAYS

Kandiah Arulanandan 63

The electrical conductivity of saturated kaolinite clay–water–electrolyte systems of different particle size distributions and of illite and montmorillonite clays were determined over the frequency range of 50–10^8 c/s. The conductivity increases as the frequency increases, and the experimental values show two distinct dispersions, one in the low frequency range and the other in the high frequency range. The frequency range over which the first dispersion occurs is experimentally shown to be dependent on particle size. The average particle size is uniquely related to the frequency at which half the dispersion occurs. The magnitude of conductivity variation, the high frequency conductivity, and the streaming potential values are related to the microscopic permeability coefficient. This microscopic permeability coefficient, evaluated from a knowledge of the above electrical properties, is shown to be uniquely related to the Darcy permeability coefficient at various consolidation states of the kaolinite clays. Similar unique relationships have been observed in illitic clays.

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INTERPARTICLE POTENTIAL ENERGIES IN Na-MONTMORILLONITE CLAY SUSPENSIONS

T. R. Taylor and P. W. Schmidt 77

The small angle X-ray scattering data obtained in an earlier investigation of a series of Na-montmorillonite clay samples containing varying concentrations of sodium metaphosphate have been used to calculate the potential energy $\phi(x)$ of the interaction between two isolated parallel clay platelets separated by a distance x. All $\phi(x)$ curves have the form expected for Na-montmorillonite. In each curve there is a potential well for a platelet separation approximately equal to the most probable separation distance determined in the earlier study. Because the depth of the potential well is of the order of 0·01 eV for all samples, the attractive forces are relatively weak. While the calculated $\phi(x)$ functions are not highly accurate, in future investigations precautions can be taken to increase the reliability of the computed potential energy functions. This preliminary study suggests that determination of $\phi(x)$ from small angle X-ray scattering data can be a useful method for quantitative study of interparticle forces in Na-montmorillonite clays.

RHEOLOGICAL MODEL STUDIES IN CLAY

R. W. Christensen and J. S. Kim 83

The process of deformation in clays is visualized as the combination of recoverable deformation resulting from bending and rotation of individual particles and irrecoverable deformation due to relative movement between adjacent particles at their points of contact. The relative movement between particles is treated as a rate process in which interparticle bonds are continually broken and reformed as the deformation proceeds. Accordingly, the rate of deformation is governed by the activation energy associated with the rupture of interparticle bonds. Thus, in terms of rheological model, the fundamental element consists of a spring, representing the recoverable deformation, in series with a rate process dashpot representing the irrecoverable deformation. Owing to the heterogeneous nature of the fabric of clay soils, i.e. varying particle size, shape, orientation, surface characteristics, etc., a wide range of activation energies, elastic stiffness, and other material properties is anticipated. This is accounted for by assuming a Gaussian distribution for the model properties. Thus, the complete rheological model postulated in this study consists of a combination of spring and dashpot elements covering the complete spectrum of model properties. The response of the rheological model is analyzed for creep and constant strain-rate loading. The analysis is accomplished numerically using a digital computer because no closed form solution exists for the non-linear systems of equations that result from this model. Experimental data for a number of triaxial tests on clays under various conditions of loading are presented for comparison with the model behavior.

SPECIFIC CO-ABSORPTION OF PURINES AND PYRIMIDINES BY MONTMORILLONITE (CLAY-ORGANIC STUDIES XV)

G. E. Lailach and G. W. Brindley 95

The co-absorptions of various purines and pyrimidines from aqueous solutions by Na- and Ca-montmorillonite are studied in the range of pH 1–6. The pyrimidines, thymine and uracil, which are not absorbed from solutions of these compounds alone, are appreciably absorbed from solutions containing also adenine or 2,6-diaminopurine, are weakly absorbed from solutions containing hypoxanthine, and are not absorbed from solutions containing purine, cytosine, and caffeine. The specific co-absorption is tentatively attributed to hydrogen-bond formation between the molecules in solution rather than to an overlapping of the molecular configurations (vertical stacking). The montmorillonite-organic associations have a basal spacing of about 12·5Å which permits only a single molecular layer between successive silicate layers.

COMPLEX VISCOSITY OF A KAOLIN CLAY

Arley G. Franklin and Raymond J. Krizek 101

The complex viscosity of a material is a two-component quantity, comprising real and imaginary parts. The real part of the complex viscosity is often very useful because in many materials it approaches the ordinary steady-flow viscosity at low frequencies. Because many materials with high viscosities are very slow in reaching a steady-flow condition, the determination of the steady-flow viscosity may be very difficult; however, an approximation can often be obtained from low-frequency values of the real part of the complex viscosity. In this study, the complex viscosity of a Georgia kaolin has been determined by measurements made on specimens subjected to oscillatory simple shear, over three decades of frequency. Other independent variables in the study are the water content of the clay and the shear strain amplitude. Data were obtained from experimental measurements in the form of values of the magnitude, or absolute value, of the complex viscosity, and the phase angle between the imposed oscillatory strain and the stress response. Empirical functional relationships are developed to relate these quantities to the independent variables, and these in turn are used to obtain the real and imaginary parts of the complex viscosity as functions of the independent variable. The results of this study

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indicate that the complex viscosity is not linear, but decreases approximately as a power function of the strain amplitude; the relation between the complex viscosity and the water content is approximately an inverse logarithmic one, and changes very rapidly at water contents near the liquid limit; and the phase angle increases with increasing strain amplitude approximately as a power function.

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