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METHOD AND MEANS FOR MEASURING ELECTROKINETIC POTENTIAL

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The present invention is concerned with improved means for determining the difference in electrical potential that exists across a colloidal solids-liquid interface. In the case of colloidal or nearly colloidal size material, this electrical potential is commonly called electrokinetic or zeta (ζ) potential. More specifically, the present invention deals with an improved device for determining such electrokinetic potential characteristics of colloids in a highly reproducible manner characterized by simplicity of measurements as well as the lack of interference and complications such as those caused by gravity sedimentation which occurs in other conventional zeta potential measuring devices.

It has long been observed that colloidal or near colloidal particles migrate under the influence of an electric field at varying rates depending on the nature of the medium in which the particles are suspended, electrical charge on the colloidal particles, etc. The zeta-potential is a fundamental property of a colloidal material. It helps to explain behavior of a colloidal system. One of the main problems encountered in industrial products consisting of colloidal or near colloidal materials is the dispersion of the materials in the suspending medium. Thus it has been found that maximum dispersion is obtained when the zeta potential is at a maximum while conversely maximum aggregation of the particles (flocculation) occurs at zero potential. Thus, it is quite valuable to be able to measure accurately the zeta potential of colloidal systems since the results of the measurements can readily be employed to obtain more efficient operation.

For example, in shipping clay in the form of a slurry in tank cars, it is necessary to have the clay as well dispersed as possible (maximum zeta-potential) so that the slurry may be shipped at very high solids and still be free-flowing. Thus the use of zeta potentials to determine the optimum amount of dispersant required for a given clay suspension has obvious practical benefits. Conversely when one desires to filter a colloidal dispersion, maintaining conditions so as to minimize the zeta potential will optimize the degree of filtration obtainable. Numerous other applications wherein the measurement of zeta potential have important advantages associated therewith are well known in the art. Typically, the measurement of zeta potential is important in dispersing paints so that the pigment particles are as well dispersed as possible so as to thus obtain a paint with minimum viscosity and highest hiding power. Similarly, the flow behavior of colloidal dispersions of latex or adhesive paper coatings, etc. are directly related to the zeta potential measurements.

It thus becomes apparent that the measurement of the zeta potential represents an important tool to the colloid chemist or to those people dealing with colloidal or near colloidal dispersions. Heretofore attempts to supply a simple but accurate measuring device for determining zeta potential have proven to be unfruitful. While devices are available to measure this property of colloidal solutions, their operation is either relatively intricate or the results relatively inaccurate. Thus, for example, it has been suggested to impress a known potential across a porous cake of the colloidal material. From the measured water flow rate or pressure developed the zeta potential can be determined. However, this method requires precise manipulative techniques and it can only apply to fairly coarse particles at high solids concentrations. Investigators using this method claim an accuracy of about 5%. It has further been suggested to impress a field of known potential gradient across a dilute suspension of particles in a specially designed cell and to view the particles under microscope and thus determine their migration rates which in turn is related to the zeta potential. However, this method suffers from the severe limitation that it requires extreme dilutions of colloid and the effect of concentrations of colloid on zeta potentials cannot be determined. Accuracies of no greater than 1% have been claimed in the literature.

It has further been suggested to place a colloidal suspension in a U-tube, and then cover the top surface of the suspension with a solution of the same composition as the liquid in which the colloid is suspended. A potential is applied across two arms of the U-tube and the migration of the colloidal particles in response to the potential elevates the level of the colloid in one arm of the tube and depresses the level of the colloid in the other arm. From the rate of change of the levels in the arms of the tube, the zeta potential is calculated. However, this method generally gives an accuracy of anly 5% or so and is limited to colloidal materials that do not settle appreciably under the force of gravity since the basic movement of the colloid and liquid is of a vertical nature. Similarly, a method employing two breakers connected by an inverted U-tube has been suggested with the change in relative concentrations of the two reservoirs after a potential has been applied being then related to the zeta potential. However, this procedure again relies on relatively vertical movement of the colloidal particles and liquid and cannot be employed to determine the zeta potential of colloidal suspensions that settle appreciably under the influence of gravity. In any event some error is automatically introduced by the essentially vertical movement characteristic of this procedure.

Both of these methods require careful handling and manipulative techniques. For instance, in the moving boundary method, extreme care must be taken to prevent mixing of the two layers of material when filling the tube. During the passage of electric current the temperature must be regulated extremely closely to prevent the mixing of the two layers due to thermal currents. Any mixing of the two layers causes the boundary to become indistinct and renders the measurement inexact. If a colloidal material is nearly transparent relative to the suspending fluid, special optical and photographic techniques such as the Schlieren system are required to render the boundary visible. The present technique makes unnecessary the use of elaborate temperature controls and further there is no problem of boundary observation. An additional further important advantage of the present invention is that the measurement of the zeta potential in a wide range of colloid concentrations may be made.

In accordance with the present invention, means are taught for determining the zeta potential or similar electrical characteristics of colloidal or nearly colloidal dispersions in a manner characterized by its highly reproducible nature as well as ease of performance. More specifically, in accordance with the present invention there is employed an assembly comprising a cell at one end portion. The cell defines a relatively enclosed volume having one end portion in open fluid communication with the opposite end of the assembly. Both end portions of the assembly, namely the end of the cell as well as the opposite end of the assembly are fitted with electrodes, the electrodes being in turn connected to an outside voltage source. In use the cell is filled with a suspension of the colloid to be measured and the entire assembly immersed in a container containing additional