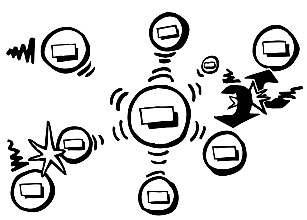
Everything you want to know about Zeta Potential…

Everything you want to know

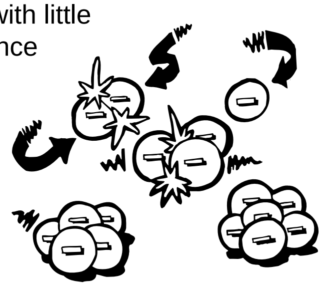
Who wants to know?

Maybe you do — especially if you need to control fine particles in liquids. Blood, water, wine, clays, cements, dyestuffs, pharmaceuticals, paints, paper, and ink are all examples of colloidal suspensions. Your goal may be to make a product more effective, easier to prepare, or easier to use. You may want to enhance its shelf life or separate the particles from the liquid. In almost every instance, your key to control is to modify the colloid's behavior.

What controls colloid behavior?



Particle-to-particle interaction is a crucial element in determining the characteristics of colloidal suspensions. One of the most important forces is electrokinetic repulsion. It is produced by the charge which is almost always found on the surfaces of particles in liquids. If their surface charge is relatively high, then adjacent colloids will repel each other and will tend to maintain their individuality. The force of gravity is insignificant on such small colloids and their rate of settling will be on the order of inches per hour or per day. As a result, highly charged colloids tend to remain discrete and in suspension.



On the other hand, a colloid with little or no charge has little resistance to the natural tendency for fine particles to gather together into aggregates. Small clumps will form and, in turn, aggregate into larger flocs which settle quickly or form an interconnected matrix. This changes the physical characteristics of the suspension.

You can control particle charge by modifying the environment around the colloids. This can be done by varying the pH or the ionic species in solution. Another, more direct technique is to add flocculants or dispersants to the suspension. These are surface active agents which adsorb directly to the colloid and change its surface characteristics, including charge.

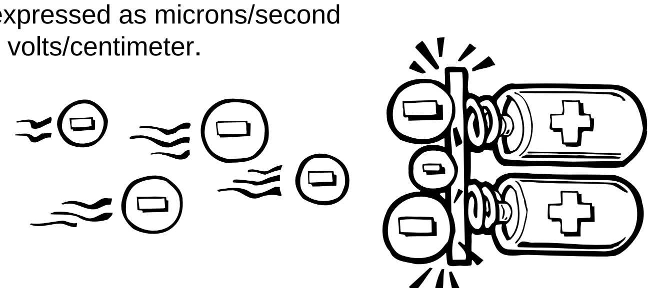
Why zeta potential?

Control the charge and you control the suspension. But direct measurement of surface charge is not easy, so we use zeta potential instead. Zeta potential (ZP) is a name that we give to the electrical voltage difference between the surface of each colloid and its suspending liquid. The potential is caused by the surface charge, so it's a fairly direct measure of your efforts to modify the suspension.

Zeta potential measurements can be used for routine process and quality control measurements or for in-depth research. They work for both aqueous and non-aqueous samples, and for dilute suspensions or concentrated slurries. So, whether you're looking at a system on a microscopic scale and attempting to analyze the electrostatic forces between particles or just interested in the system's bulk properties, zeta potential can help.

How is it measured?

Zeta potential is measured by tracking the motion of charged particles in a DC voltage field. This is a direct measurement called electrophoretic mobility (EM). EM is expressed as microns/second per volts/centimeter.

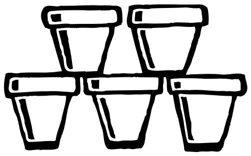


The first term (microns per second) is simply a velocity measurement, while the second (volts per centimeter) is an expression of the electric field strength. Electrophoretic mobility is, therefore, a relative measure of how fast a particle moves in an electric field.

Zeta potential can be calculated from the measured electrophoretic mobility using a theoretical relation between the two that is also dependent on the dielectric constant and the viscosity of the suspending liquid. It is better to express results in zeta potential units (millivolts), even though it is an approximation, because it is a more direct representation of colloidal stability and is easier to visualize.

Practical Applications

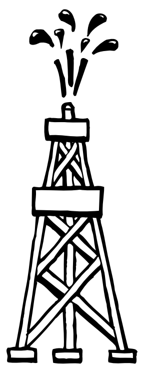
Ceramics & Clays



Slip casting is used in volume production of ceramic ware and varying the charge of the clay colloids can affect the properties of the ceramic objects. A suspension of clay is prepared and poured into porous molds, which draw off the water from the clay particles by capillary action. A filter cake of clay forms as the water is drawn off. The structure of the clay layer depends on the degree of dispersion of the clay suspension.

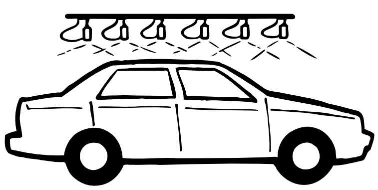
Besides ceramics, clays are an essential part of paper, adhesives, ointments, rubber, and synthetic plastics. In each of these systems, we have to deal with dispersions of clay in water or other fluids. Clay colloid chemistry helps us tailor their characteristics to fit the task.

Drilling Fluids



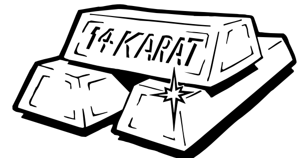
Clays are used as drilling fluids in water well and petroleum well production. They are often called drilling muds and are chemically conditioned to vary their properties during drilling. A highly charged suspension is often desirable for the initial drilling operation. This keeps the clay colloids discrete, allowing them to penetrate into the porous wall of the drilled hole and clog the pores, forming a thin, impermeable cake which prevents the loss of drilling fluid. Later, the clay charge may be reduced to form a flocculated suspension in order to keep it from clogging the lower, pumping zone of the well.

Electrocoating



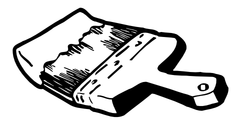
Electrocoating is a major advance in paint technology. It allows a highly effective prime coat to be applied to metal surfaces. Charged colloidal paint pigments are attached to the metal part by connecting a DC voltage to the surface. The colloids migrate to the region where they lose their charge and become firmly deposited onto the metal surface. Zeta potential measurements can help to establish the optimum additive dosage for each particular pigment.

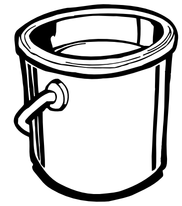
Minerals and Ores



Many raw mineral ores (such as those for copper, lead, zinc and tungsten) are separated by first grinding the ore, mixing it with a collector and then suspending it in water. Air is bubbled through the mixture and the collector causes the mineral particles to adhere to the bubbles so they can be recovered at the surface. The efficiency of this process depends upon the degree of adsorption between the collector and the mineral, which is controlled by the zeta potential of the mineral.

Paints





The pigments in paint must be well dispersed in order for the paint to perform successfully. If the pigments agglomerate, then the paint will seem to have larger pigment particles and may fail color quality. Gloss and texture are also affected by the degree of dispersion between the particles in the paint. Zeta potential measurements can be used in this application to control the composition of the paint and the dosage of additive required for an optimum dispersion.

Pharmaceuticals

Pharmaceuticals are often prepared by suspending colloid-size particles of the drug uniformly throughout a liquid vehicle. Successful suspensions are stable and enjoy a long shelf life. This is sometimes achieved by raising the zeta potential to produce a strong dispersion of discrete particles which settle very slowly. Unfortunately, the repulsive energy between adjacent particles causes them to pack together as tightly as possible without touching. This forms a dense cake at the bottom of the container which is difficult to re-suspend.

Another approach is to produce weakly flocculated suspensions by lowering the zeta potential to near zero. These preparations break up and disperse rapidly with gentle shaking. On standing, the suspension returns to its loosely flocculant structure, which prevents cake formation.

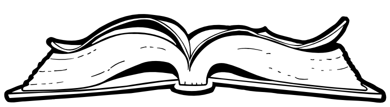
Soil Mechanics

Stability, aeration and drainage are important in both soils engineering and agriculture. Clays and silts can exert a beneficial or detrimental effect and are more important than sand and gravel in determining overall soil properties. The colloidal condition of these fine materials determines how they interact with the large aggregates. If the silts or clays have a low surface charge, then they will probably form a flocculant matrix of particles, giving structure to the soil and allowing water to drain easily.

Undesirable changes can take place if the charge on the fine particles increases. This can be caused by natural events such as rain water draining through the soil and leaching out flocculating salts. At first this can weaken the flocculant matrix of silts and clays that provides shear strength to the soil. In extreme cases, this can actually result in landslides.

Once the flocculant structure collapses, the now highly charged clay and silt particles will disperse. This frees them to be carried along with the draining water until they enter a narrow pore and clog it. A filter cake is formed which hampers aeration and drainage, and reduces soil permeability. Sometimes simple flocculating chemicals such as gypsum or lime can be used to reverse this and improve soil characteristics.

Papermaking



The retention of fines and fibers can be increased through zeta potential control. This reduces the amount of sludge produced by the wastewater treatment facility and reduces the load on the white water recycle systems. Zeta potential measurements help the papermaker to understand the effect of various paper ingredients as well as the physical characteristics of the paper particles themselves.

Biomedicine

The interface between an organism and its environment is the site of many important reactions. Zeta potential measurements help describe this interface and have been used in studies of bacteria, plant cells, blood cells, etc. These measurements are a good supplement to chemical analysis and can be carried out without altering the organism's original environment.

Surface charge characterizations are useful both in research and in practical clinical work. Areas that have been studied include: blood cells and circulatory problems; differentiation of normal and malignant tissue; detection of cystic fibrosis; and, effects of antibodies and viruses.

Water and Wastewater Treatment

In water and wastewater treatment, the suspended solids which are the most difficult to remove are the colloids. They can easily escape both sedimentation and filtration because of their small size. Examples of these solids include: spent protein and emulsions from domestic waters, bacterial cells, algae, industrial waste colloids, silts, clays, and organic matter from soil wash.

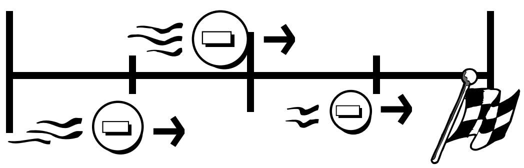
The key to effective colloid removal is reduction of the zeta potential. Once the charge is reduced or eliminated, no repulsive forces exist. Gentle agitation of the flocculation basin causes numerous colloid collisions, forming microflocs and then visible floc particles which can easily be settled or filtered. Coagulants such as alum, ferric chloride and cationic polymers all act through reduction of zeta potential.

Our Instrument

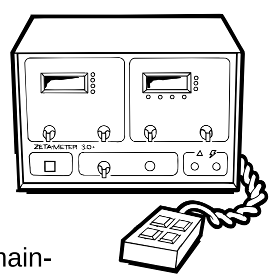
Practical Instrumentation

We pioneered the development of practical zeta potential instrumentation more than thirty years ago. Our Instruments have always been accurate, reliable, and simple to use, and our Zeta-Meter System 3.0 continues this tradition.

It measures zeta potential using the principle of microelectrophoresis. A microscope is used to observe colloidal particles inside a chamber called an electrophoresis cell. Electrodes placed in each end of the cell are connected to a power supply which creates an electric field, causing the charged colloids to move. Individual particles are tracked as they travel under a grid in the eyepiece of the microscope. Just press the “track” button when a colloid crosses the start and release it when the colloid reaches the finish line. Each traverse takes from about 3 to 5 seconds and the total running time is less than 5 minutes.



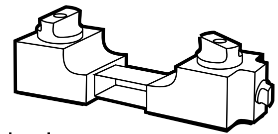
Zeta-Meter 3.0 Unit



Our Zeta-Meter 3.0 unit supplies the stable DC voltage required to track colloids and instantly calculates and displays the zeta potential or electrophoretic mobility each time you finish tracking one. It maintains a constant record of your measurements which can be reviewed at any time. Simply press the “status” button to see the number of colloids tracked, their average zeta potential or electrophoretic mobility and their standard deviation.

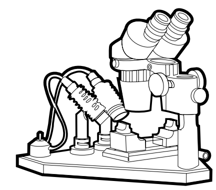
A printer can be connected to provide you with a permanent record of your measurements, or the Zeta-Meter 3.0 can be connected to your personal computer for a thorough analysis of your data. Our free software prepares the data for Lotus 1-2-3® and we supply templates which make graphing and data review a simple task.

Electrophoresis Cell



The electrophoresis cell holds your sample during testing. We manufacture two precision cells. Each has an optically polished cylindrical geometry. Our best and most durable cell is made of fused quartz and Teflon, while our less expensive model is fabricated from plexiglas.

Microscope Module

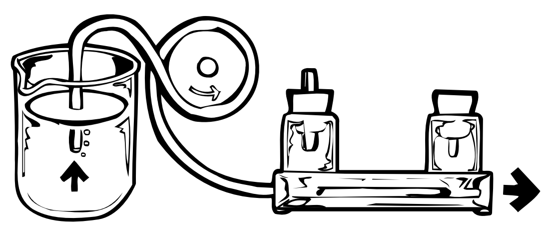


Our high quality stereoscopic microscopes provide comfortable viewing of the micron-sized colloids. Our viewing technique is known as darkfield illumination. A sharply focused light beam passes through the electrophoresis cell. Any colloids in its path will reflect the light upward into the microscope and appear like stars in a night sky.

Automatic Sample Transfer System

Our Automatic Sample Transfer (AST) system is convenient for multiple and repetitive measurements. It is especially helpful when you work with systems that have fast-settling colloids or a high specific conductance.

The AST system consists of a recirculating pump and an electric pinch valve. The pump recirculates your sample from a beaker until you are ready to track. A flip of a switch stops the pump and activates the valve, isolating the sample in the cell for tracking.



After a few colloids are tracked, the pump is turned on for a while to recirculate the sample then a few more colloids are tracked. This insures sample uniformity, temperature equilibrium and re-suspension of settled colloids.

Our Company

Affordable zeta potential

We are a small specialty company and have been developing and manufacturing Zeta-Meters for more than thirty years. Our instruments are reasonably priced and cost almost nothing to maintain. In addition, our careful quality control means excellent reliability.

Free advice

If your problem involves electrokinetics, then we probably know something about it. If we don't make what you need, then we can recommend a reliable company that does — even a competitor. All questions are welcome and all advice is free.

Try before you buy

You can rent a Zeta-Meter to be sure it's the one for you, and part of your rental cost can be applied to your purchase. We can also run a few tests on your own samples if it will help you make up your mind. Ask us for details.

You can count on us

If you buy an instrument from us, you're entitled to unlimited technical support via telephone (toll-free in the USA), e-mail or fax. Call us for help. We will do everything possible to solve your problems. If you think of something we can do better, just give us a call. We welcome your suggestions.

Two-year warranty

Everything you buy from us is covered by a 2-year limited warranty. Actually, very few of our units have any problems at all but it's nice to know that you are protected.

If you can't do without it…

If your Zeta-Meter ever needs servicing and you just can't do without it, don't worry — we'll send you one at no charge. Just pay the freight and insurance and it's yours for as long as we have your system here for repair. In fact, if your unit is under warranty we'll ship the other to you absolutely free. We can't ship you a substitute unit if you are outside the USA; instead, we'll send easy-to-install replacement parts by express mail or courier service.

Get our catalog

If you want a Zeta-Meter catalog, please call, fax, or e-mail. The catalog describes our instruments and accessories in depth, and assists you in selecting the appropriate configuration. If you have any questions regarding the proper components for your system, call us and let us help.

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