Application Note 07

Zeta Potential - Electroacoustics

Introduction

All particles in suspension exhibit a zeta potential, or surface charge. Knowledge of a particle's zeta potential is critical for the optimisation of sample processing, and is a simple method of quality control. Zeta potential can also be used to predict the stability of a formulation.

The method of measuring a particle's zeta potential is dependent on the nature of both the particle and the suspension formulation. In general, the size and concentration of particles are the key parameters that determine which technique is applicable.

Theory

In solution, the presence of a net charge on a particle affects the distribution of ions surrounding that particle, resulting in an increase in the concentration of counter-ions (ions of opposite charge to the particle). The region over which this influence extends is called the *electrical double layer*[1]. Conventionally, this layer is thought of as existing as two separate regions; the inner region consists of strongly bound ions and is known as the *Stern layer*, while the outer layer comprises loosely associated ions and is called the *diffuse layer*. As the particle moves through solution, either due to gravity or an applied voltage, the ions (both counter- and co-) move with it. At some distance from the particle there exists a "boundary", beyond which the ions do not move with the particle. This is known as the surface of hydrodynamic shear, or the *slipping plane*, and exists somewhere within the diffuse layer. The potential that exists at the slipping plane is defined as the ***zeta potential*** (see figure 1).

The zeta potential is crucial in determining the stability of a colloidal suspension. When all the particles have a large negative or large positive they will repel each other, and so the suspension will be stable. If the zeta potential is low the tendency for flocculation is increased. Another important consideration when discussing zeta potentials is pH; in fact, quoting a zeta potential without an accompanying pH is almost meaningless. This is due to the fact that, for suspensions of most materials, a plot of zeta potential versus pH exhibits an ***isoelectric point***, a particular value of solution pH where the net charge on the particle is ***zero***. At this point the suspension is highly unstable, and flocculation is at its most likely.

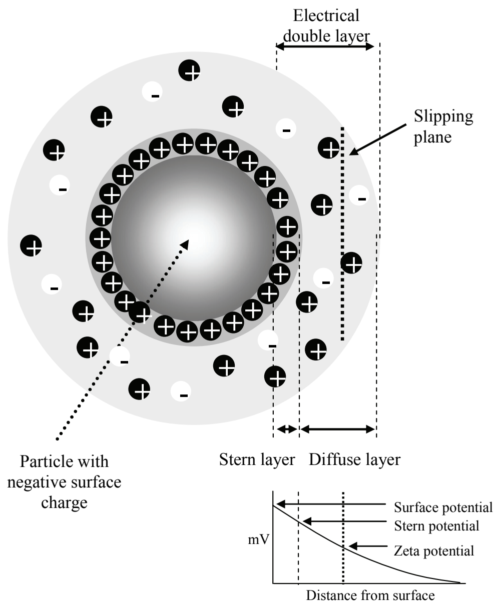

Figure 1: Schematic representation of the distribution of ions around a charged particle in solution

ElectroAcoustics

The electroacoustic technique characterises the ***dynamic mobility*** of particles in suspension. In this method, a high frequency (~106) electric field is applied to the samples, causing charged particles to oscillate, and to produce a sound wave of the same frequency. The oscillation (dynamic mobility) of the particles is described by its *magnitude* and *phase angle* (how far the particle motion lags behind the applied field). The sound wave is detected and analysed to determine the motion of the particles, *i.e.* to measure their dynamic mobility.

The theory used to produce zeta potential values via the electroacoustic technique is beyond the scope of this note. Readers interested in further details are directed elsewhere[2].

The ***Colloidal Dynamics ZetaProbe*** utilises the electroacoustic technique. The standout advantage of this instrument over ‘traditional’ electrophoretic machines is its ability to measure zeta potential in slurries of greater than 10 wt% solids concentration (up to 60 wt% depending on the sample).

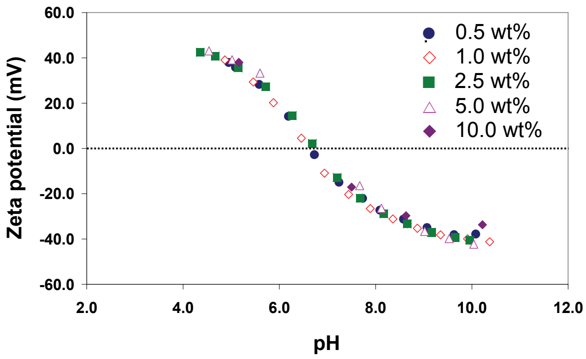

Figure 2: Zeta potential vs. pH for nanoparticles of TiO_2 in aqueous suspension of different concentration.

The ZetaProbe is able to measure zeta potential in concentrated solutions of particles in the size range 1 nm to 10 µm, depending on sample. It also offers the ability of automatic potentiometric and volumetric titrations.

References

[1] R.J. Hunter, ‘Zeta Potential in Colloids Science’, Academic Press, NY, 1981

[2] R.J. Hunter, ‘Recent developments in the electroacoustic characterizations of colloidal suspensions and emulsions’, Colloids and Surfaces, A: Physicochemical and Engineering Aspects, 1998, 141(1), 37 – 66

ParticlesCIC

Houldsworth Building ● Leeds ● LS2 9JT ● UK
Tel: +44 113 343 2378 ● Fax: +44 113 343 2377

www.particlescic.com