

Zeta Potential – Electroacoustics

Introduction

All particles in suspension exhibit a zeta potential, or surface charge. The measurement and knowledge of which is critical for optimising processing, predicting formulation stability and interactions, and also as a simple method of quality control.

Methods of measuring a particle's zeta potential are 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 it, resulting in an increase in the concentration of counter-ions. 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 (figure 1):

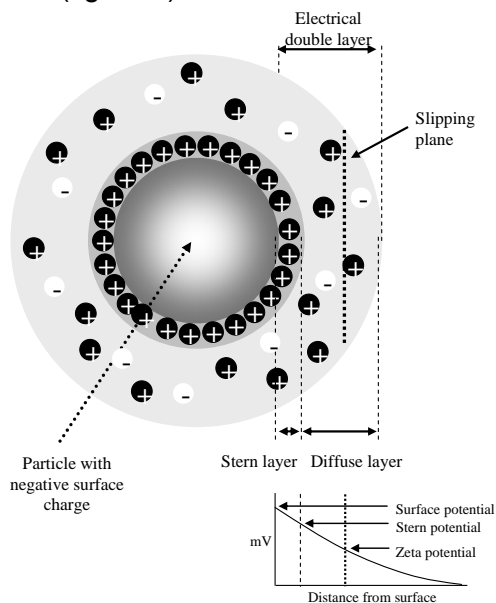


Figure 1: Schematic representation of the distribution of ions around a charged particle in solution.

- An inner region of strongly bound ions known as the *Stern layer*
- An outer layer of loosely associated ions called the *diffuse layer*.

As the particle moves through solution, due to gravity or an applied voltage, the ions move with it. At some distance from the particle there exists a “boundary”, beyond which 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. **It is the potential that exists at the slipping plane that is defined as the zeta potential**

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 particles is **zero**. At this point the suspension is highly unstable, and flocculation is at its most likely (figure 2)

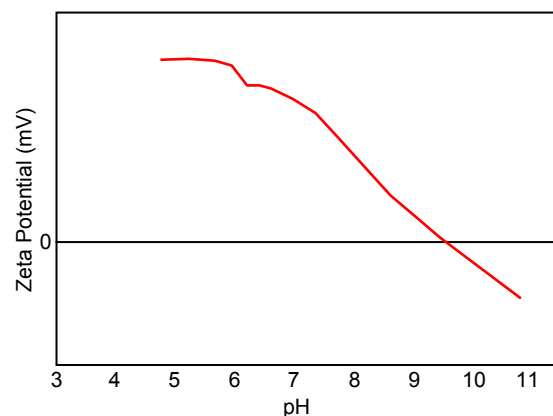


Figure 2: Zeta potential vs. pH for alumina slurry

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.

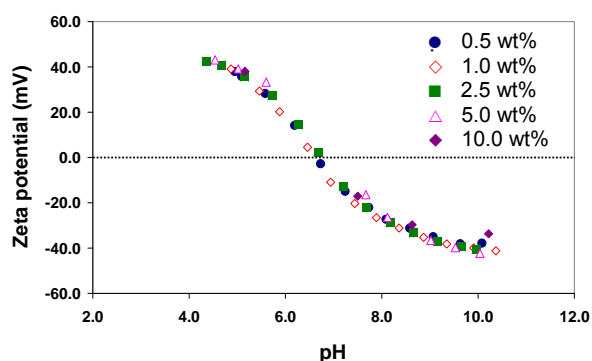


Figure 2: Zeta potential vs. pH for nanoparticles of TiO₂ in aqueous suspension of different concentration.

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 elsewhere².

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).

The ZetaProbe is able to measure zeta potential in concentrated solutions of particles in the size range 1nm to 10µm, 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

Escubed Ltd

Leeds Innovation Centre
103 Clarendon Road
Leeds LS2 9DF UK
tel +44 (0)870 126 3200
fax +44 (0)870 126 3201
www.escubed.co.uk