

Zeta Potential – Streaming Potential

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):

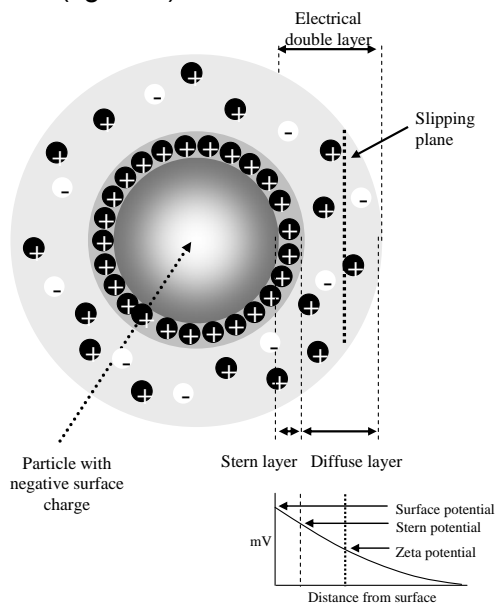


Figure 1: Schematic representation of the distribution of ions around a charged particle in solution.

- 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)

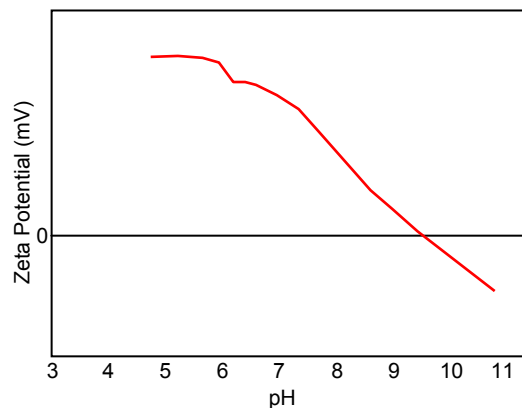


Figure 2: Zeta potential vs. pH for alumina slurry

Streaming Potential

The techniques for measuring zeta potential discussed so far, electrophoresis and electroacoustics, are designed for stable suspensions of small (<10 μ m) particles. Clearly, one may also wish to measure the surface charge of larger particles, which do not form stable suspensions, or indeed flat substrates. This is the realm of streaming potential devices.

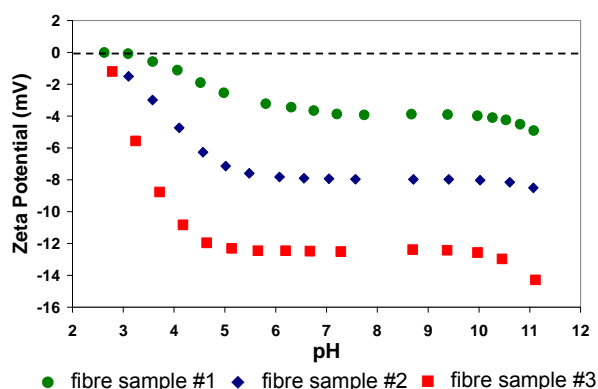


Figure 2: Zeta potential vs. pH for three different fibre samples.

As described previously, every solid object in solution has a surface charge, and so a distribution of ions near the surface occurs. Passing a liquid over the surface disrupts this distribution and creates a potential difference, the

streaming potential. In this technique, fluid is passed over the solid sample at different pressures, and the streaming potential measured. This is then converted to zeta potential. Again, the full details of this theory can be found elsewhere².

The **AntonPar Electro Kinetic Analyzer (EKA)** is a streaming potential device. It is applicable to solid substrates, such as silica, mica or polymer membranes. The EKA also has a cylindrical cell, in which a plug of almost any material may be inserted, for example fibres or large particles. Autotitration allows rapid sample characterisation, giving data such as that shown in figure 2.

References

- ¹ R.J. Hunter, 'Zeta Potential in Colloids Science', Academic Press, NY, 1981
- ² M. Smoluchowski, 'Handbook of Electricity and Magnetism', Volume 2, Barth, Leipzig, 1921, 366

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