

## Application Note 08

### Zeta Potential – Streaming Potential

#### 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. Additionally, quantification of zeta potential is useful for the prediction of interactions in a multi-component system.

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*<sup>1</sup>. 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.

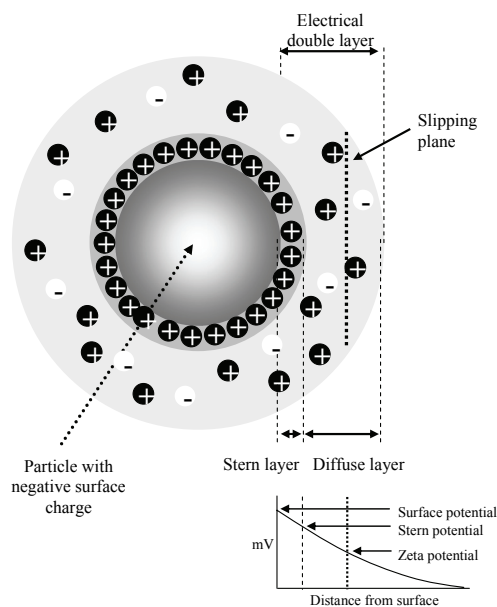


Figure 1: Schematic representation of the distribution of ions around a charged particle in solution

#### Streaming Potential

The techniques for measuring zeta potential discussed so far, electrophoresis and electroacoustics, are designed for stable suspensions of small (<10  $\mu\text{m}$ ) 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.

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 elsewhere<sup>2</sup>.

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.

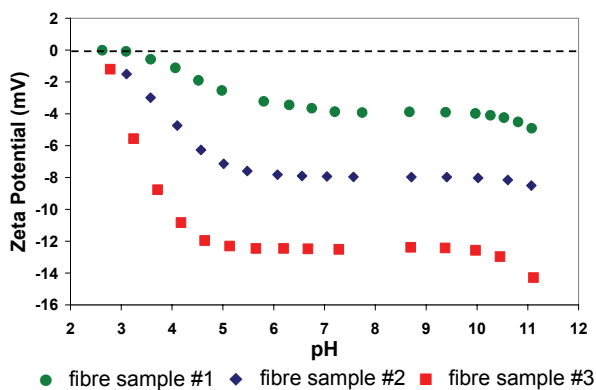


Figure 2: Zeta potential vs. pH for three different fibre samples.

## References

<sup>1</sup> R.J. Hunter, 'Zeta Potential in Colloids Science', Academic Press, NY, 1981

<sup>2</sup> M. Smoluchowski, 'Handbook of Electricity and Magnetism', Volume 2, Barth, Leipzig, 1921, 366

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