Particle Characterization Analyzer

Technical Note

SZ-series instruments

TN165

Size Limit for Zeta Potential Measurement

UPPER SIZE LIMIT OF ZETA POTENTIAL MEASUREMENTS

Zeta potential is a measure of the charge on suspended particles. This property is typically more important for suspensions of small particles where there is high surface area and significant particle – particle interactions. While there is no theoretical upper particle size limit for zeta potential measurements, there are physical constraints in making useful measurements, which are addressed in this technical note.

Introduction

Zeta potential is a scientific term for electrokinetic potential in colloidal systems. It is the potential in the interfacial double layer at the location of the slipping plane versus a point in the bulk fluid away from the interface. In other words, zeta potential is the potential difference between the dispersion medium and the stationary layer of fluid attached to the dispersed particle – see Figure 1.

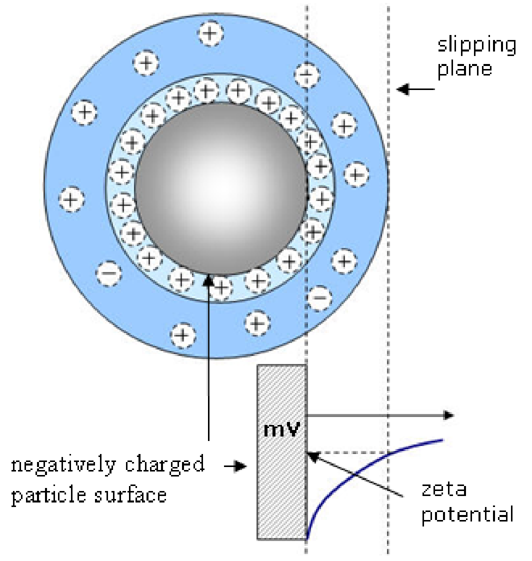


Figure 1: Zeta potential of a negatively charged particle

The term zeta potential is most often used in the field of colloid chemistry, which is by definition a two phase system where the dispersed phase is in the size range of 1 nm – 1 µm (1). When applying this definition there is not much interest in measuring the zeta potential of samples where the dispersed phase (particles) is larger than 1 micron. As particle size gets larger there is less available surface area and lower particle – particle interactions. Therefore the study or measurement of zeta potential becomes irrelevant. But there is occasionally an interest in the zeta potential of suspensions with particles greater then 1 µm, so it may be useful to test the upper particle size limit of an instrument used for these measurements.

There is no theoretic limit to the measurement as defined by the equations used to determine electrophoretic mobility, μ (equation 1) and from mobility to calculate zeta potential, ζ (equation 2).

$$\mu = \frac{\Delta\omega\lambda_0}{4\pi n E \sin(\frac{\theta}{2})\sin(\frac{\theta}{2}+\xi)}$$

Equation 1

$$\mu = \frac{2\zeta\varepsilon}{3\eta_o} f(\kappa r)$$

Equation 2

Although there is no theoretical particle size limit to defining zeta potential, there are practical and experimental limits worthy of consideration. It is worth asking the question "How important is zeta potential for suspensions of particles above 1 µm?" But even if there may be an interest in measuring these samples, there are experimental realities that hinder reproducible results.

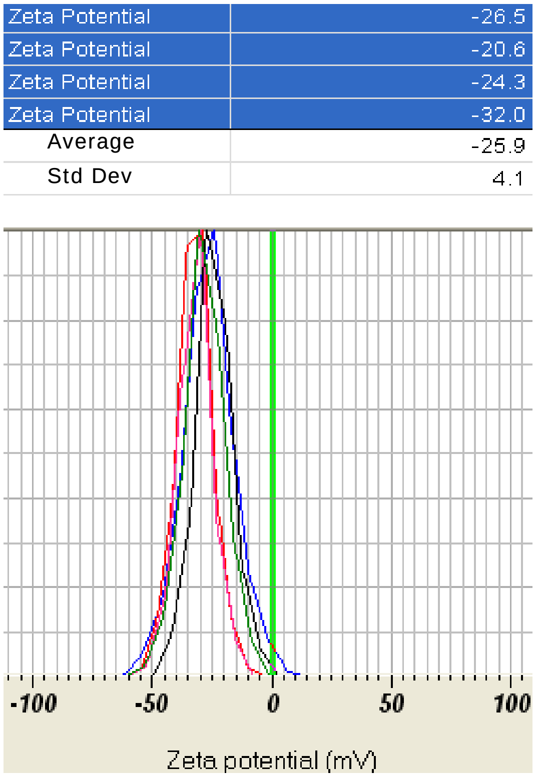
The equations used for the calculations assume all particle movement comes from a reaction to the applied electric field. Both Brownian motion (from very small particles) and settling (from large particles) can not be properly modeled or taken into account. Larger, heavier particles will settle due to gravitational force, and therefore introduce an error in the measurement. More significantly, these larger particles will settle in the measurement cell and not be analyzed. In the extreme case all particles will settle before a good measurement can be completed.

Experimental

Polystyrene latex particles with a size of 100 µm were measured on the SZ-100 nanoparticle analyzer, Figure 2. The sample was Thermo Scientific (formerly manufactured by Duke Scientific) catalog number 4310A, lot number 37593, mean diameter 100 µm ± 1.0 µm.

Figure 2: The SZ-100 Nanoparticle Size and Stability analyzer

The first set of measurements was made with the 100 µm particles suspended in 10 mM KCl solution. The particles were agitated in an attempt to keep them in suspension by alternatively pushing on the top rubber stoppers used to seal the zeta potential cell. Since the particles are large enough to be visible it was possible to judge the rate of settling by eye. Data from these experiments are shown in Table 1.



Zeta Potential	-26.5
Zeta Potential	-20.6
Zeta Potential	-24.3
Zeta Potential	-32.0
Average	-25.9
Std Dev	4.1

Table 1: 100 µm PSL in 10 mM KCL

The second set of measurements was made with the 100 µm particles suspended in a 10 weight percent sugar (sucrose) suspension in an attempt to reduce settling rate by increasing the viscosity, which was entered as a variable in the final calculation. Data from these experiments are shown in Table 2.

Measurement Type	Zeta Potential (Mean)(mV)
Zeta Potential	-32.0
Zeta Potential	-31.4
Zeta Potential	-31.2
Zeta Potential	-30.4
Zeta Potential	-30.2
Zeta Potential	-29.6
Zeta Potential	-28.6
Zeta Potential	-28.2

Average	-30.2
Std Dev	1.3

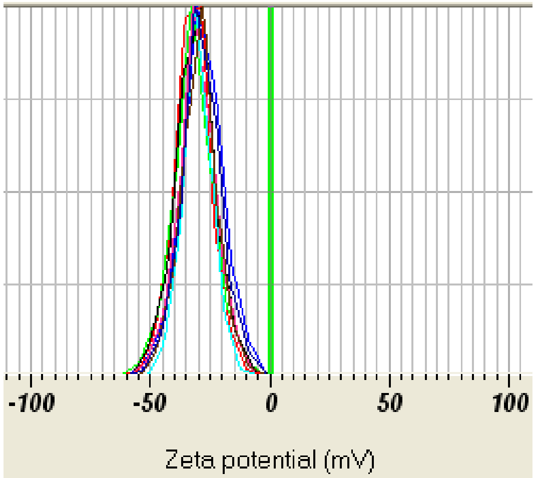


Table 2: 100 µm PSL in 10 wt% sucrose

Conclusions

While there is no theoretical limit to the upper particle size range of zeta potential measurements, in reality the analysis becomes more difficult in the presence of gravitational settling. Measuring 100 µm PSL particles in 10 mM KCL was extremely difficult and required manual manipulation in order to generate fairly repeatable results (standard deviation = 4.1, mean = -25.9 mV). Measuring the same sample at higher viscosity generated more repeatable results (standard deviation = 1.3, mean = -30.2 mV). The sugar solution slightly altered the surface chemistry, and therefore the zeta potential by several mV, but the results support the claim that the SZ-100 is capable of measuring zeta potential at a particle size of up to 100 µm. This does not imply it is suggested to frequently measure samples this large for zeta potential.

References

1. Hiemenz, Principles of Colloid and Surface Chemistry, Marcel Decker, 1977

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