Extending the Lifetime of Zeta Potential Electrodes

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ABSTRACT

Nanoparticle development and manufacturing require appropriate particle characterization techniques to determine if design or quality goals are being met. One important aspect of many nanoparticle systems is the zeta potential, a measure of surface charge. Particle charge is typically measured by a technique known as electrophoretic light scattering. In this measurement, light scattering is used to probe the motion of a particle due to an applied electric field. The effective application of electric field is a critical part of the zeta potential measurement. Therefore, the choice of electrode material has a profound effect on the measurement results. An Uzgiris type cell with graphite electrodes was tested for longevity, that is, the number of zeta potential measurements that could be performed with the cell before the measurement results degraded. It was shown that graphite can be used for over 800 measurements and therefore it lasts longer than other electrode systems.

Keywords: nanoparticle, zeta potential, surface charge, light scattering, particle size

1 INTRODUCTION

Nanoparticle development and manufacturing require appropriate particle characterization techniques to determine if design or quality goals are being met. One important aspect of many nanoparticle systems is the zeta potential, a measure of surface charge. The zeta potential is the charge on the particle at the shear plane and is typically expressed in millivolts. Since electrostatic interactions are long range interactions, they have strong effects on the physical behavior of nanoparticles [1]. For example, when all of the particles in a system have a strong charge of the same sign, then they will repel each other. This repulsion prevents particle-particle collisions that can lead to flocculation or aggregation. Therefore, particle charge is often used to ensure that nanoparticle remain “nano.”

Particle charge is typically measured by a technique known as electrophoretic light scattering. In this measurement, light scattering is used to probe the motion of a particle due to an applied electric field. The particle motion leads to a Doppler shift in the scattered light which is measured by optical mixing techniques to extract particle velocity. The quantity obtained from this measurement is the electrophoretic mobility, which is then converted into the zeta potential with a model. For aqueous systems, the Smoluchowski model has gained wide acceptance [2].

Figure 1: Zeta potential electrode assembly with solid graphite electrode material. Note that graphite electrodes extend down into the measurement area in order to avoid electro osmotic flow effects.

The effective application of electric field is a critical part of the zeta potential measurement. Therefore, the choice of electrode material has a profound effect on the measurement results. Noble metal plated electrodes are typically chosen. However, these electrodes are readily fouled and the thin metal coating tends to peal away. Therefore, the electrode assemblies must be routinely replaced. A longer lived electrode material improves measurement accuracy and lowers measurement costs.

2 METHODS

Zeta potential measurements were performed by electrophoretic light scattering with an SZ-100 nanoparticle analyzer. The zeta potential cell under test was of the Uzigiris type (to minimize electro-osmotic flow) with graphite electrodes. The initial sample was bovine serum

albumin (BSA) in DI water. This sample was measured 100 times. The cell was then quickly rinsed and a second aliquot of material injected for a second test. The second sample was a coffee creamer that forms a soft nanoparticle on dilution. Initially a sample was measured ten times to estimate repeatability under the experimental conditions (10 seconds duration, 25 C, 10 seconds between measurements, Smoluchowski model). A second sample was then measured 100 times during an overnight run. After these measurements were completed, a fresh sample was prepared and seven batches of 100 measurements were performed and the cell inspected periodically during the test. After 800 measurements, the experiment was terminated.

3 RESULTS AND CONCLUSIONS

Zeta potential as a function of analysis number for the BSA samples is shown in Figure 2. The results from the first aliquot are shown in red and the results from the second aliqout are shown in blue. In both cases, the obtained results did not show significant variation as the analyses proceeded. The same cell was then cleaned for the next, longer series of measurements.

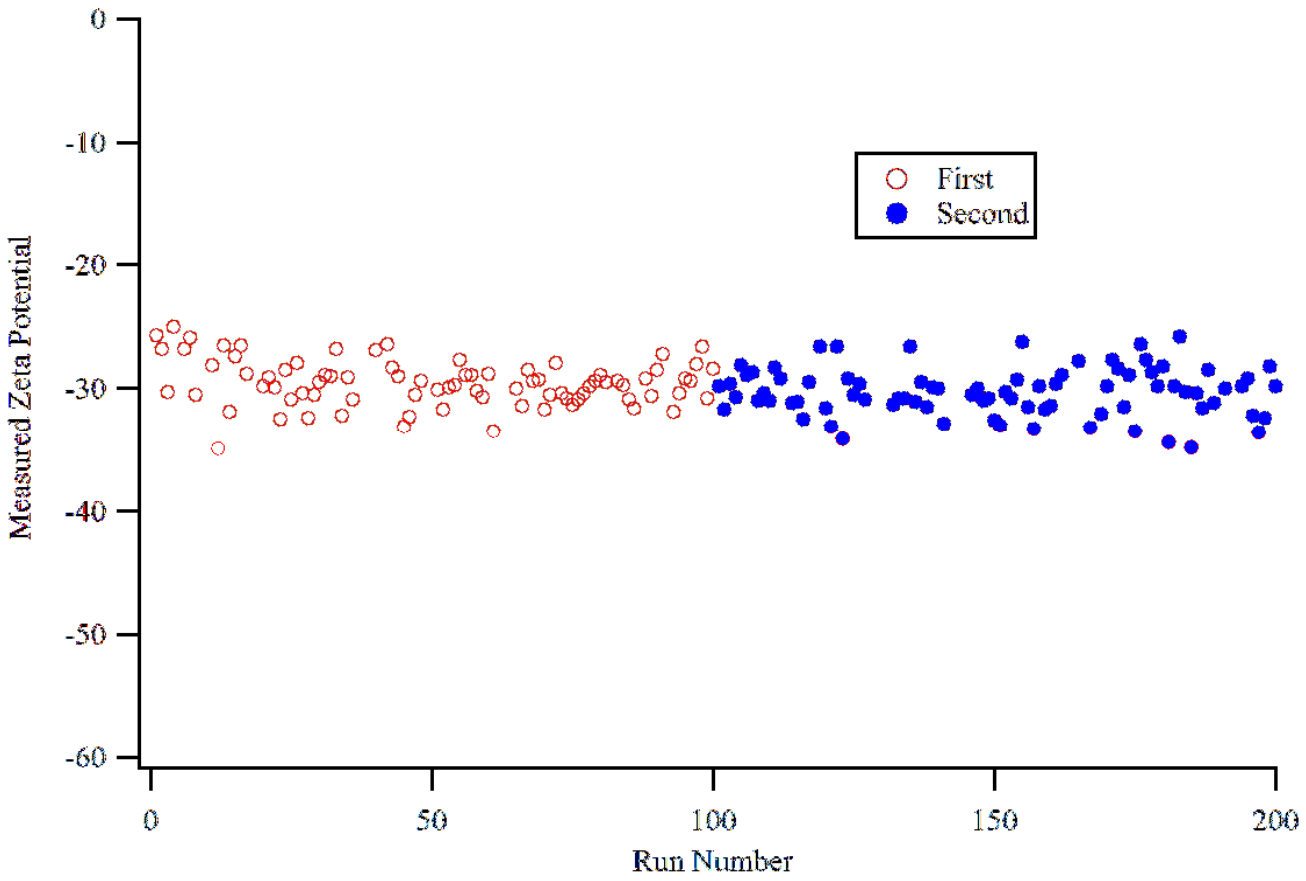

Figure 2: Zeta potential as a function of run number for two soft nanoparticle samples. Results from the first sample are in red with open circles and results from the second sample are in blue with closed circles. Cell electrode performance is effectively unchanged during this long series of measurements.

Figure 3 shows the results from the coffee creamer sample. The results from sample 1 are shown in red and the results from sample 2 are shown in blue. For sample 1, the average zeta potential was -89 mV and the standard deviation was 2.8 mV. When the sample was changed, there was a change in the measured zeta potential due to the new formulation. For sample 2, the average zeta potential was -100 mV and the standard deviation was 4.2 mV. In the subsequent runs, the zeta potential values changed slightly presumably due to aging of this soft nanoparticle sample. More importantly, the spread in obtained values (e.g., noise) did not change significantly. This difference is quite small. These data show that the graphite cells last longer than typical gold plated cells.

Cell longevity is important for zeta potential measurements since it reduces instrument lifecycle cost (or cost per analysis). A long lifetime cell is considerably less expensive for the user than disposable cells. Material choice is one factor that enables the manufacture of long lifetime zeta potential cells.

REFERENCES

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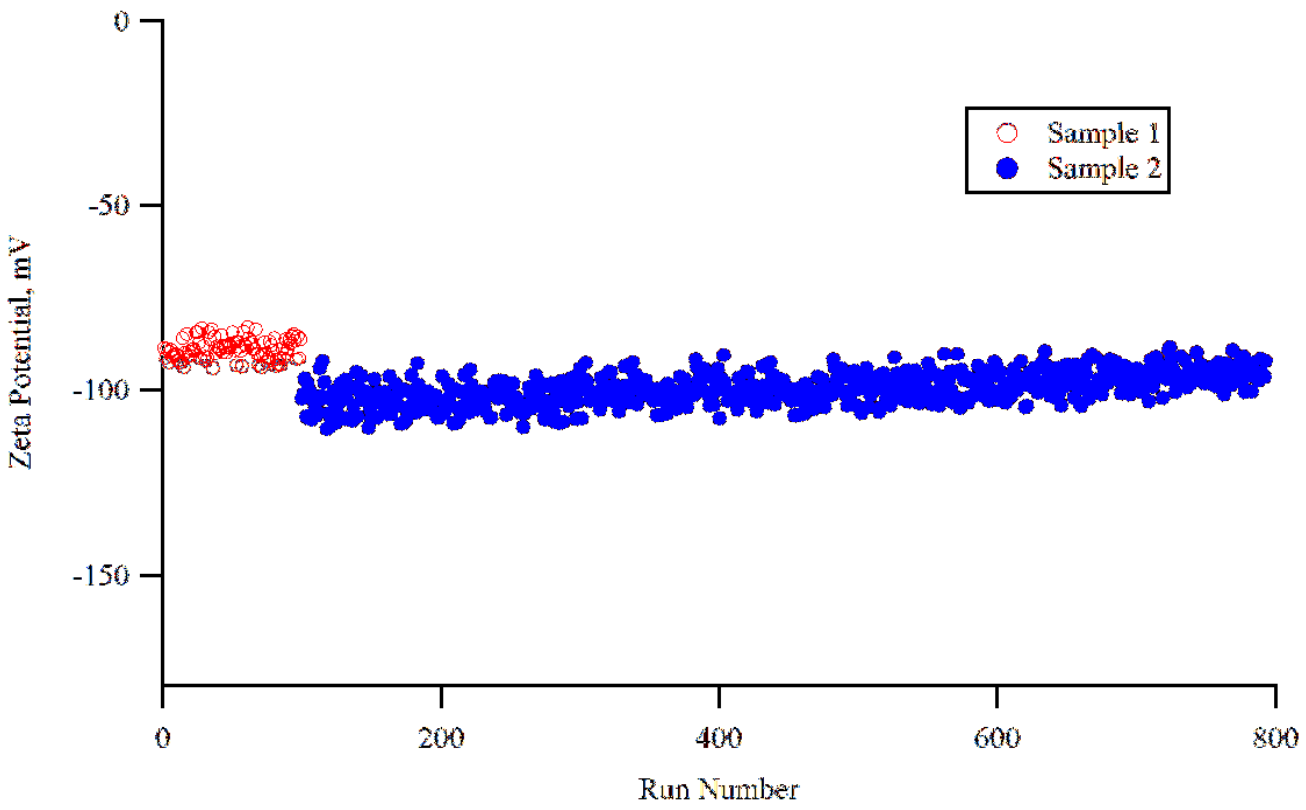

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