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APPLICATION NOTE

Zeta Potential Measurement of Powdered Coffee Creamer Using the BeNano 90 Zeta

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Introduction

Zeta potential is a scientific term for electrokinetic potential in colloidal dispersions. One of the factors to affect the zeta potential values is the chemical composition at the particle surface, and the solution environment in which the particles are dispersed.

There is a close relationship between the zeta potential and the intermolecular forces between the particles, which determines the stability of a suspension system: a system with higher negative or positive zeta potential tends to be more stable, while a suspension system with lower zeta potential approaching 0 mv is less stable. When the pH value of the suspension system changes, the zeta potential may also differ. In general, the suspension system tends to be more positive charged in an acidic environment, and more negative charged in a basic environment.

In this application note, the relation between the zeta potential and pH is investigated by measuring the zeta potentials of a commercially available powdered coffee creamer in different pH environments. This creamer is a mixture of polysaccharides, proteins, and stabilizers.

Theory and Instrumentation

The technology utilized to measure the zeta potential is called electrophoretic light scattering (ELS). In an ELS experiment, a laser beam irradiates the sample, where the scattered lighted is detected at a forward angle of 12°. The diluted sample solution or suspension is subjected to an electric field applied to both ends of the sample cell, resulting in the electrophoretic movement of the charged particles in the sample. As a consequence, the scattered light intensity experiences a frequency shift compared to the incident light due to the Doppler effect. The scattered light signals with a frequency shift are converted to phase shift due to PALS analysis. By the phase plot, the velocity of electrophoretic movement per unit electric field, which is denoted as the electrophoretic mobility μ, is obtained. Through Henry's equation, one can relate the electrophoretic mobility μ and its zeta potential ζ as follow:

$$\mu = \frac{2\epsilon_r \epsilon_0 \zeta}{3\eta} f(\mathrm{K}\alpha)$$

where ε0 is the solvent dielectric constant in vacuum, εr is the relative dielectric constant, η is the solvent viscosity, f(Kα) is the Henry function, K is the reciprocal Debye length, α is the particle radius, and Kα refers to the ratio between the thickness of the double layer and the particle radius.

BeNano 90 Zeta (Bettersize Instruments Ltd.) is used for the size and zeta potential measurement in this application note. A laser beam with a wavelength of 633nm and a power of 10mW illuminates the sample. Avalanche photodiode detectors (APD) are set up to collect scattered light signals at 12° for zeta potential measurement and at 90°for size measurement, respectively. With using the phase analysis light scattering (PALS) technique, the BeNano 90 Zeta is efficient at detecting the zeta potential information of samples with low electrophoretic mobility.

Volume of HCl added [μL]	Volume of NaOH added [μL]	pH
0	0	8.3
60	0	3.2
30	0	3.7
20	0	4.1
10	0	4.8
5	0	5.6
0	20	9.8
0	100	11

Table 1. Volumes of HCl or NaOH added and the corresponding pH values in each sample

Experiment

10mg of powdered coffee creamer was dispersed in 100mL of distilled water and was dispersed using a magnetic stirrer for 15 minutes to obtain the stock solution. The pH value of the stock solution was measured to be 8.3. The stock solution was then equally divided into smaller portions in different sample cells, each with a volume of 3mL. The pH values of the solutions were changed by adding different amounts of 0.025M HCl or 0.025M NaOH solution into each of the stock solutions. The volumes of HCl or NaOH solution added and the corresponding pH values are shown in Table 1.

A built-in temperature control unit in the BeNano 90 Zeta maintains the temperature of the samples at 25°C ± 0.1°C. The zeta potential measurements were performed using the folded capillary cell. Each sample was measured at least three times to ensure the repeatability of the results.

Results and Discussion

The zeta potentials of the powdered coffee creamer suspensions were measured under different pH environments and the results are shown in Figure 1 below.

As can be seen from Figure 1, the zeta potential of powdered coffee creamer solution shows positive value in low pH ranges, indicating that the particles' surface carried positive charges in this pH range. As the pH value increased, the zeta potential value decreased, gradually approaching 0 mV when the pH was 5. After the isoelectric point (IEP) was reached, the pH of the system kept increasing as more NaOH was added, and the particles in the system started carrying negative charges. In the higher pH region, the absolute values of zeta potential gradually increased as the pH value increased.

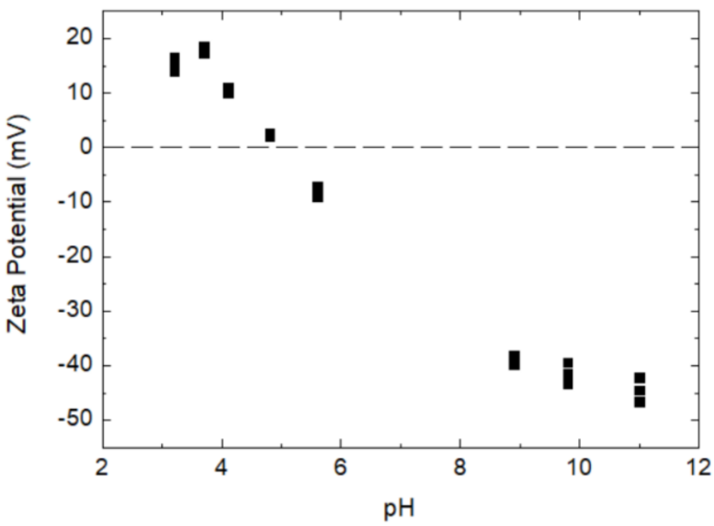

Figure 1. Scatter plot of powdered coffee creamer solution's pH vs zeta potential

Conclusion

The BeNano 90 Zeta employs PALS technique which can accurately detect signals even with low electrophoretic mobility efficiently. The zeta potential results obtained by the BeNano 90 Zeta show good accuracy and repeatability even at low zeta potential specifically in the ±10 mV range.

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