Surface Zeta Potentials of Fibers, Membranes and Particles Determined through Streaming Potential

Standard electrophoretic Zeta potential measurement techniques for small particles and surfaces have been used extensively to characterize particle stabilities and surface Zeta potentials. Unfortunately, these techniques cannot characterize other sample shapes or larger particles. The streaming potential technique, however, can characterize these sample types. In a typical streaming potential measurement, an electrolyte solution is passed through a small capillary system formed by the surfaces of the specimens. The pressure to maintain the streaming flow is correlated to the streaming potential and current generated by the system. The Zeta potential, ζ, of a sample is then calculated according to the Fairbrother-Mastin equation for streaming potential or streaming current,

$$\text{Streaming Potential} \qquad \zeta = \frac{dU_{str}}{d\Delta P} * \frac{\eta}{\varepsilon \times \varepsilon_0} * \kappa$$

$$\text{Streaming Current} \qquad \zeta = \frac{dI_{str}}{d\Delta P} * \frac{\eta}{\varepsilon \times \varepsilon_0} * \frac{L}{A}$$

where $dU_{str}/d\Delta P$ is the slope of the streaming potential vs differential pressure plot, $dI_{str}/d\Delta P$ is the slope of the streaming current vs differential pressure plot, η is the electrolyte viscosity, ε_0 is the vacuum permittivity, ε is the dielectric constant of electrolyte, κ is the conductivity, L is the length of the channel and A is the cross-sectional area of the channel.

To illustrate how the streaming potential technique is used to determine surface Zeta potential, three samples were analyzed in this study: paintbrush fibers, a nitrocellulose membrane, and garnet particles.

Figure 1. From left to right: Paint brush fibers in the cylindrical cell, nitrocellulose membrane in the adjustable gap cell, and garnet particles in the cylindrical cell.

In order to measure the surface Zeta potential of each sample, they were first loaded into a sample holding cell designed to contain the corresponding specimen type. At least eight different

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sample holders are available for the SurPASS 3 Electrokinetic Analyzer (Anton-Paar, USA) to accommodate the widest variety of sample types including fibers, granules, hollow tubes, flat surfaces, contact lenses, and others. Loading the samples into the cells was done with minimal alteration to the sample surface. Once the samples were mounted in their holding cells (Figure 1), they were simply attached to the side of the instrument where the electrolyte solution (typically a low concentration KCl solution) was passed over the surface of the samples to measure the streaming potentials. Figure 2 shows the streaming potential as a function of the change in pressure for each of the samples.

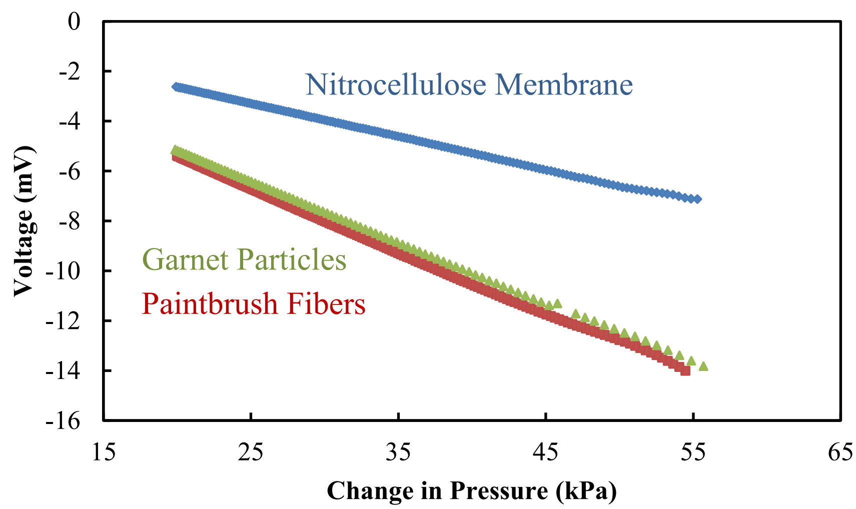

Figure 2. Streaming potential results for the paintbrush fibers, nitrocellulose membrane, and garnet particles.

The nearly identical slopes of the plots indicate that the paintbrush fibers and the garnet particles have a similar Zeta potential (Table 1). Additionally, the nitrocellulose membrane was found to have the lowest Zeta potential.

Due to its ease of use and wide range of sample handling capabilities, streaming potential has seen increasing applications in analyzing water treatment membranes, medical devices, semiconductor wafers, catheters, stents, and mineral flotation.

Table 1 Surface Zeta Potential Results of All Specimens

Sample	Zeta Potential (mV)
Paintbrush Fibers	-45.63
Nitrocellulose Membrane	-23.72
Garnet Particles	-44.20