Application Note – Colloid Analysis

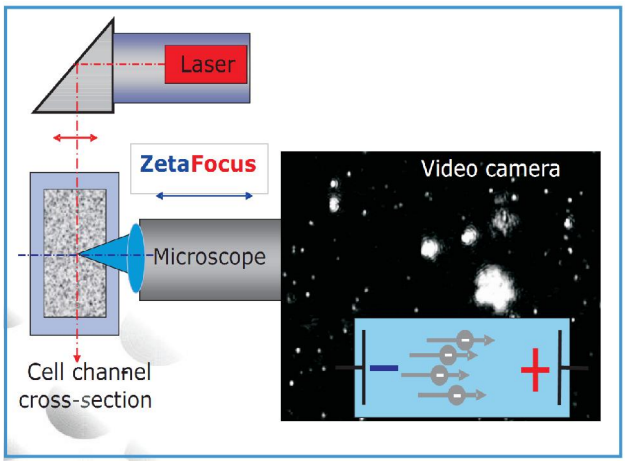
PARTICLEMETRIX

COMPETENCE IN PARTICLE CHARACTERIZATION

C14 - Electrophoresis & Electroosmosis

Electrophoresis zeta potential, Brownian particle size & electroosmosis: direct observation in the laser ZetaView® scattering video microscope by Nanoparticle Tracking

Unpack, set-up & measure ...



Layout of ZetaView®

Fig. 1: Electric field direction in direction of cell channel = perpendicular to the direction of the laser and the microscope. Brownian motion and electrophoresis are analyzed from each individual particle resulting in a **histogram of size and electrophoresis**. Profiles through the cell channel deliver mobility profiles giving useful information about the charge state of the walls. All this is done in an intuitive manner without alignment burden.

Electrophoresis: Zeta potential Distribution

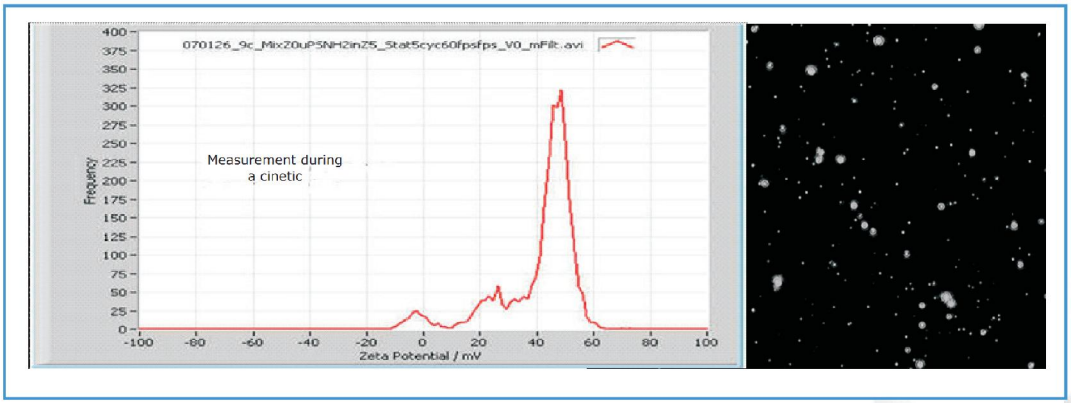


Fig. 2: In many cases, mixtures of differently charged material lead to mono-modal zeta potential distributions. The above distribution is taken during a kinetic undergoing after mixing of two samples by Particle Tracking. For the scientist, it might be interesting to find out why finally the cationic material "eats" the slightly anionic material. Interestingly to observe: in most cases, agglomerates carry the same charge density (=zeta potential) as the primary particles.

To be seen in the video at the right: 110 nm particles and agglomerates.

Zeta potential distribution showing quality differences of polyelectrolyte solutions

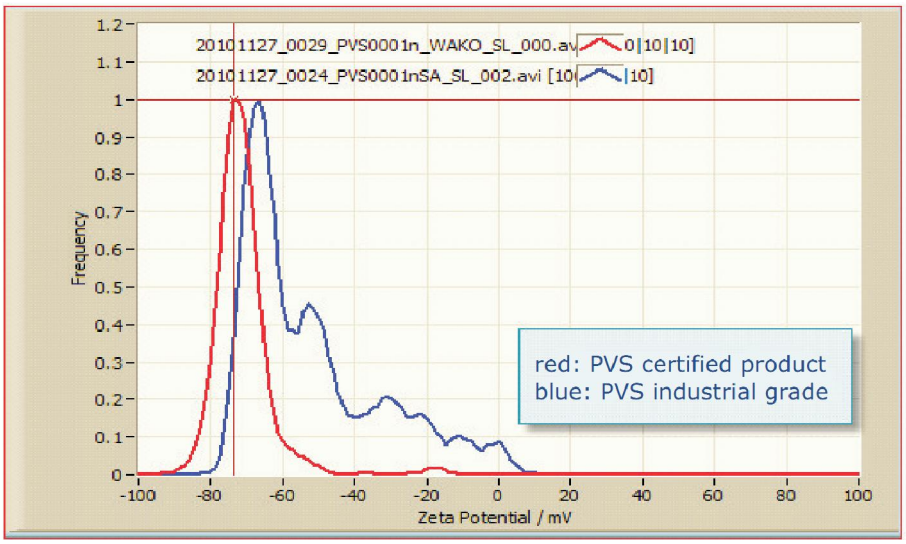


Fig. 3: Zeta potential - distribution of two 0.001n anionic polymer solutions. Both serve as calibration solutions for total charge determinations on dispersions and polyelectrolyte solutions, a typical experiment done with the StabiSizer® instrument. The red curve is from the certified, the blue one from an industrial grade product. The multi-modality of the „blue" material stays for hours. It would be interesting to find out the reason for it.

Bimodality at different pH settings

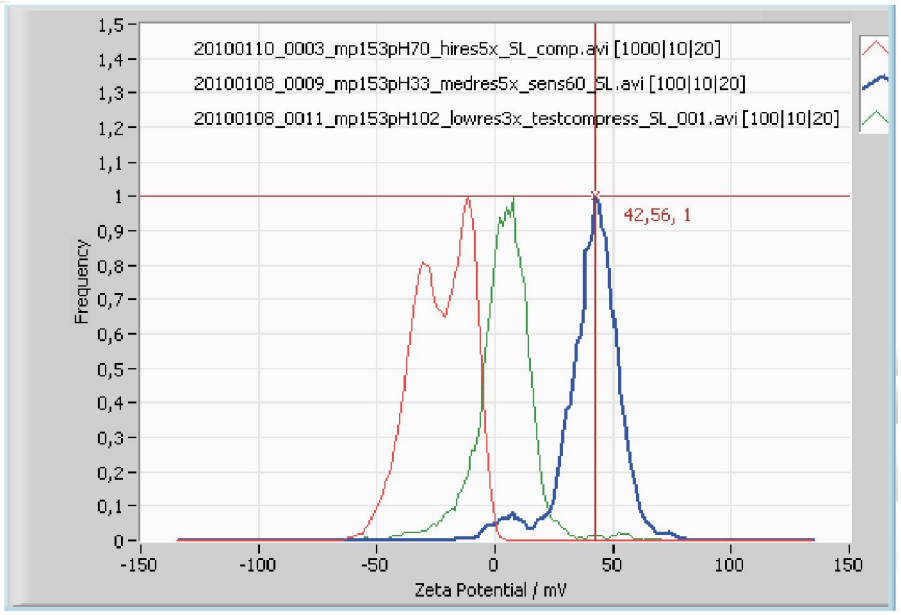


Fig. 4: This polystyrene latex sample of 153 nm size is very strongly dependent on pH. Blue: pH=3.3; red: pH=7.0; green: pH=10.2. Another characteristic feature of the sample is its bi-modality. The reason may be in the variety of constituents of the material.

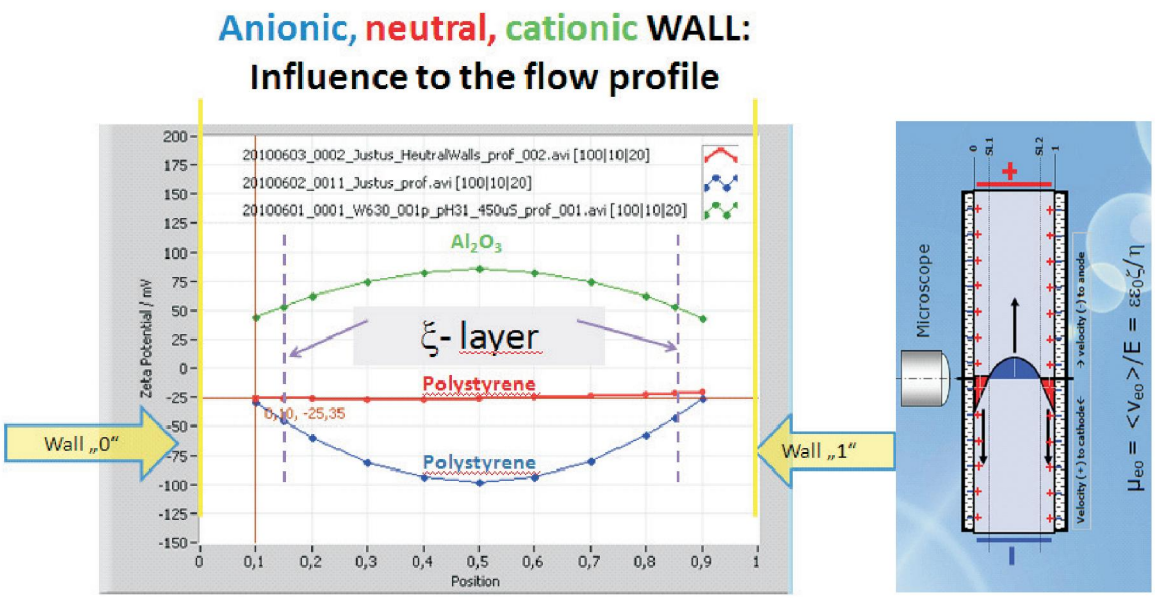


Fig. 5: Velocity profiles with applied electric field

Left: Simultaneous electrophoresis and electroosmosis. The electroosmosis movement is zero at the stationary layers, marked as dashed lines. Therefore the electrophoresis zeta potential (ZP) can be taken from there. The ZP readings are: -25 mV for the red, -40 mV for the blue and +50 mV for the green curve. The polarity of the wall charge is responsible for the direction of the parabolic profile. The curvature depends on the charge density = zeta potential (see explanation below). Blue curve: As expected for a clean quartz surface, the wall charge is negative. Red curve: wall is uncharged. The reason is coating of the walls by particles during a titration through the isoelectric point. Green curve: The cationic Al_2O_3 particles coat the wall and make it positive.

Right: In a closed cell – as in ZetaView® - these „stationary layers" are located near to the walls, where the electroosmosis motion reverses direction.

Excursion to electroosmosis
As the quartz wall is anionic, cations of the solutions try to compensate the wall charge. After applying an electric field, the mobile external part of this ion cloud moves towards the cathode, along the walls, pushing the whole liquid with it. The liquid moves back in the middle of the cell. As the liquid carries the particles, the electroosmosis is observed as a movement of the particles. At the layer, where the liquid reverses direction, the electroosmotic velocity is zero. At this point, only the electrophoresis velocity is apparent. Electroosmosis and electrophoresis movement vectors add to each other. The electrophoresis is a reaction of the particles to the electric field and is independent of the polarity and amount of the charge at the walls. The charge density of the walls (= zeta potential) is responsible for the profile velocity, the polarity of the wall charge is responsible for the direction of the velocity profile. All this can be nicely studied in ZetaView®, if of interest.

IMPORTANT REMARK #1
Although it is not the main objective to measure electroosmosis with ZetaView®, it is extremely useful as a quality tool. It helps to judge whether walls become coated or bubbly. All above described effects are automatically controlled by the auto-alignment and Zeta Focus method. The software separates the contributions from electrophoresis and electroosmosis.

Analysis report of a profile measurement

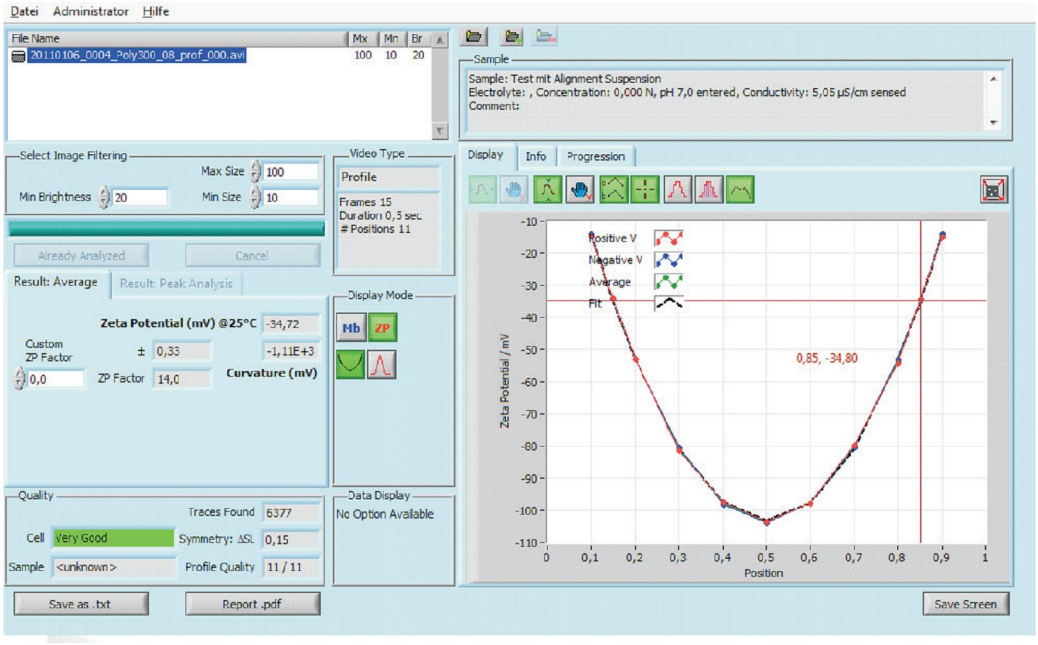


Fig. 6: The zeta potential result and quality parameters are given on the left side of the graph. The electrophoresis is calculated on the basis of the Smoluchowski formula.

By pushing the corresponding button  , the result can also be obtained as a zeta potential distribution (Fig. 7). A complete data export to Excel is possible via the "Save as.txt" button.

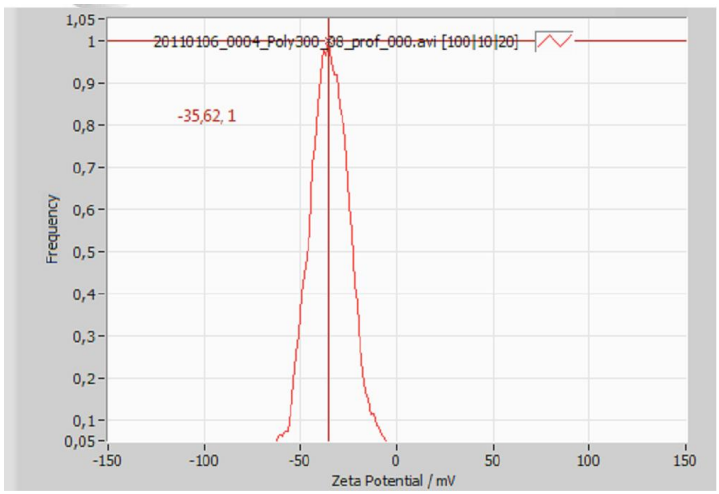


Fig. 7: By selecting the corresponding Button  , either the profile or the distribution is displayed.

IMPORTANT REMARK #2

The lowest detectable concentration is 10^6 Particles / cm^3.

Conclusion: "seeing is believing - ZetaView®"