Particulate Systems

NanoPlus

Zeta Potential and Nano Particle Analyzer

A MICROMERITICS BRAND

The NanoPlus

Particle Size & Zeta Potential Analyzer

The NanoPlus is a unique instrument that utilizes photon correlation spectroscopy and electrophoretic light scattering techniques to determine particle size, zeta potential, and molecular weight. The instrument is compact and easy to use with an extended analysis range, intuitive software, and multiple sample cells to fit the user's application.

The instrument is available in three model configurations:

NanoPlus-1 : Nano Particle Sizing Instrument

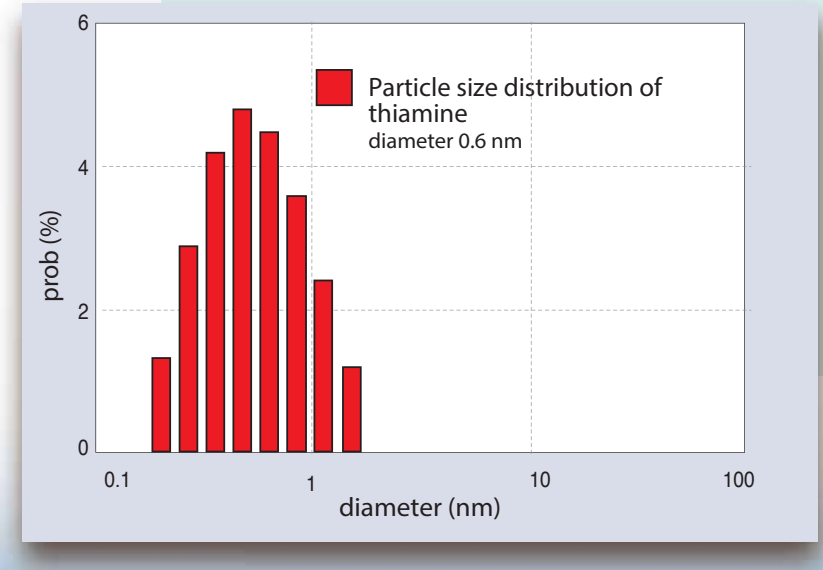
NanoPlus-2 : Zeta Potential Instrument

NanoPlus-3 : A Combination Nano Particle Sizing and Zeta Potential Instrument

The NanoPlus Series

Particle size:	0.1 nm - 12.30 μm
Zeta Potential:	-500 ~ +500 mV
Molecular Weight Range:	1.84×10^3 Da to 2×10^7 Da (using DLS)
Concentration range:	0.00001~ 40%

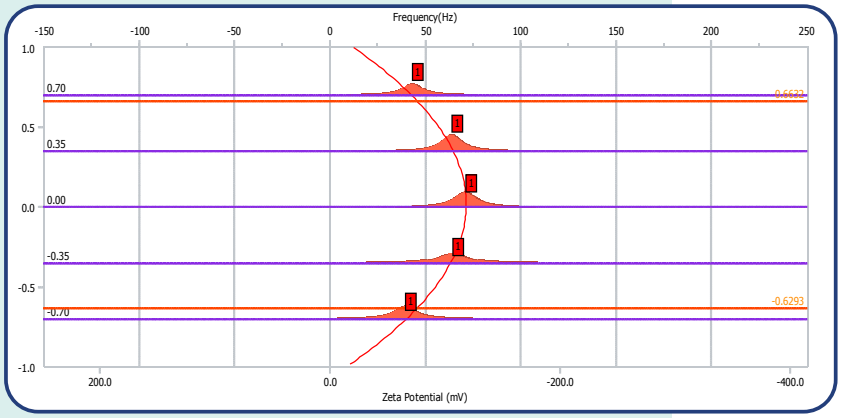
Particle Size



- Measures particle size of samples suspended in liquids in the range of 0.1 nm to 12.30 μm w/sample suspension concentrations from 0.00001% to 40%
- Well-established photon correlation spectroscopy technique conforms to ISO 13321 and ISO 22412
- Combination of linear and log-scale correlators covers diverse sample characteristics
- Variety of sample cells available

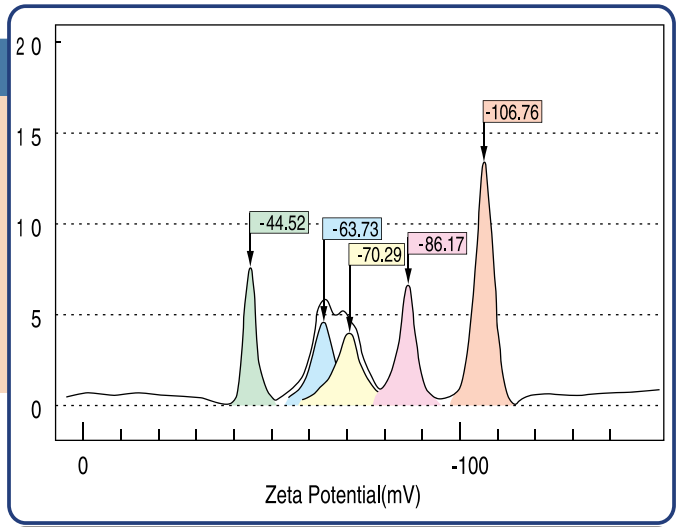
Zeta Potential

- Measures zeta potential of a sample suspension in the range of -500 mV to +500 mV with concentrations from 0.001% to 40%
- Reliable measurements based on electrophoretic light scattering technology conforms to ISO 13099-2
- Accurately characterizes both dilute and concentrated suspensions
- Capable of measuring the surface charge on solid surfaces, film, etc. based on probing particles
- Variety of sample cells available

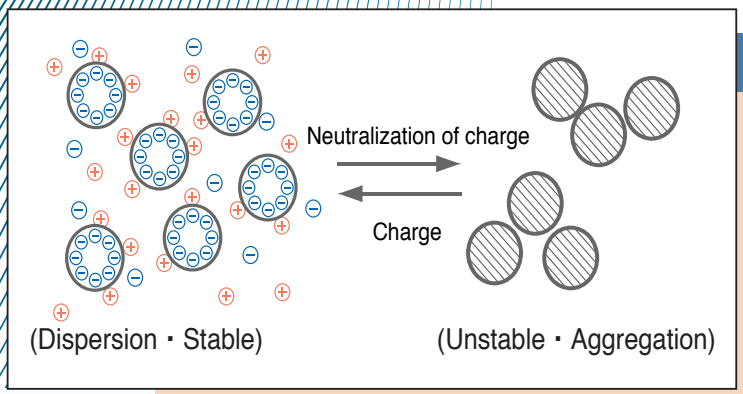


Electrophoretic Mobility Plot

The NanoPlus is capable of obtaining high resolution zeta potential analyses even with multi-component samples. In the example on the right, a mixture of five polystyrene latexes of different particle sizes were measured. Five spectrums corresponding to each latex component was detected. The zeta potential of these components were in the range of -45 mV to -107 mV.



Zeta Potential of Polystyrene Latex Mixture



Evaluation of Dispersion Stability by Zeta Potential/Particle Size

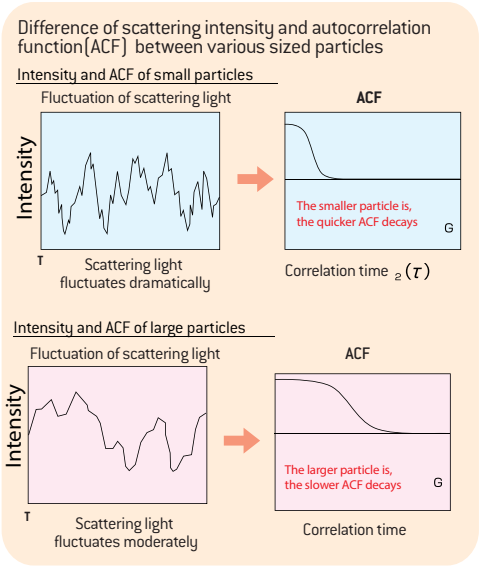
As the absolute value of zeta potential increases, colloidal systems give generally stable dispersions due to electrostatic repulsion between particles. However, as the zeta potential approaches zero, the stability of the dispersion reduces and aggregation becomes likely.

The NanoPlus

Particle Size & Zeta Potential Analyzer

Principle of Particle Sizing

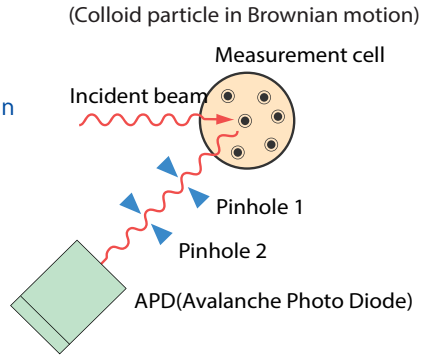
Particulates dispersed in a solution are normally subject to Brownian motion. The motion is slower with larger particles and faster with smaller particles. When laser light illuminates particles under the influence of Brownian motion, scattered light from the particles shows fluctuation corresponding to individual particles. The fluctuation is observed according to the pinhole type photon detection method so that particle size and particle size distributions are calculated.



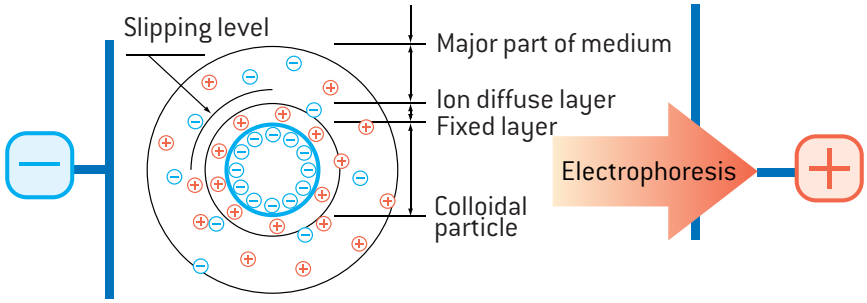
$$G_2(\tau) = 1 + \alpha(G_1(\tau))^2$$
$$G_1(\tau) = \exp(-Dq^2\tau)$$
$$d = kT/3\pi\eta D \quad \text{... Stokes-Einstein equation}$$

$G_1(\tau)$, $G_2(\tau)$: Secondary and primary auto-correlation function(ACF)

- D : Diffusion coefficent
- q : Scattering vector
- τ : Correlation time
- d : Hydrodynamic diameter
- k : Boltzmann's constant
- T : Absolute temperature
- η : Viscosity of medium



Principle of Zeta Potential Measurement



$$\Delta v = 2Vn\sin(\theta/2)/\lambda$$
$$U = V/E$$
$$\zeta = \eta U/\varepsilon \quad \text{... Smoluchowski equation}$$

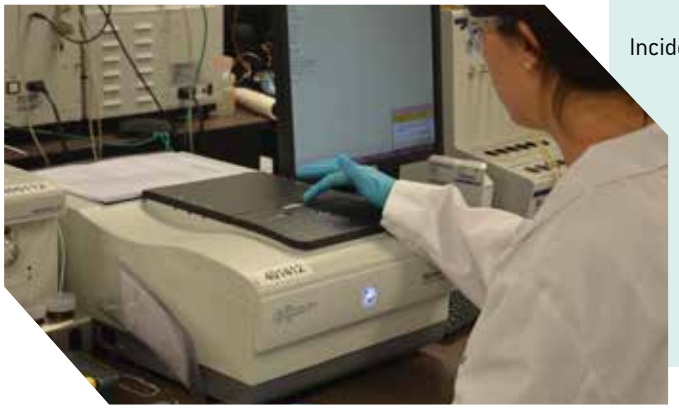
- Δv : Doppler shift
- V : Velocity of particle movement
- n : Refractive index
- η : Viscosity
- θ : Detect angle
- λ : Wavelength of incidence light
- U : Electrophoretic mobility
- E : Electric field
- ζ : Zeta potential
- ε : Permitivity

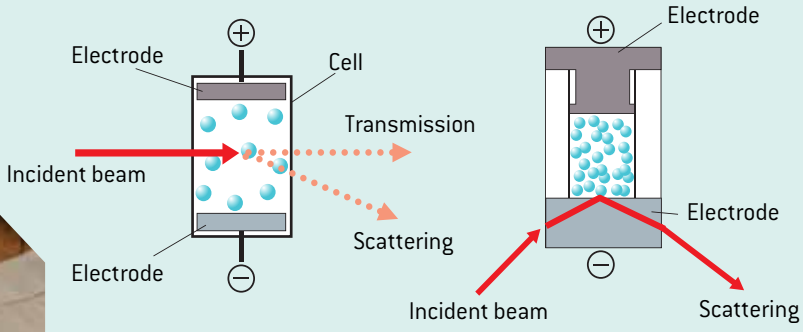
In most cases, colloidal particles possess a positive or negative electrostatic charge. As electrical fields are applied to the particle dispersion, the particles migrate in oppositely charged directions. As particles are irradiated in migration, scattering light causes Doppler shift depending on electrophoretic mobility. NanoPlus software calculates the amount of Doppler shift followed by electrophoretic mobility and zeta potential by combining a heterodyne system and photon correlation method to perform Fourier transform (FFT) of obtained correlation function.

Concept of FST Method

By conventional methods, scattered light from a concentrated suspension can not be measured correctly due to multiple scattering (A) or in very concentrated solutions due to its ability to transmit light. The FST method detects the scattered light from particles through a transparent electrode. The optical path length is minimized to reduce the effects of multiple scattering. Thus, the NanoPlus can perform a zeta potential measurement of a concentrated suspension with a high degree of accuracy (B).

FST – Electrophoretic mobility measurement of concentrated suspension using Forward Scattering through Transparent electrode





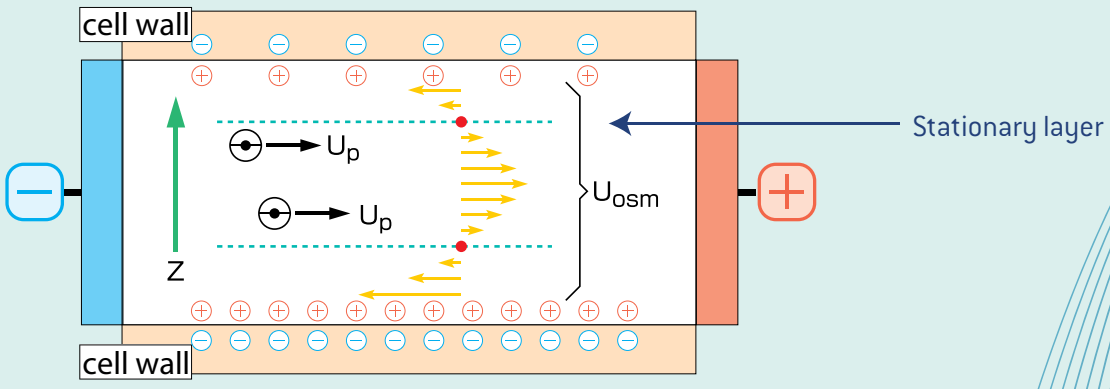
(A) Standard cell

(B) High concentration cell

*Patented technology

Determination of True Electrophoretic Mobility

When the measurement of electrophoresis is actually taken, an electroosmotic current is generated in the cell due to an electric charge on the cell wall. With a negatively charged cell wall, the electroosmotic flow phenomenon causes the positively charged ions and particles to gather together by the cell walls. The solution located by the cell walls migrates toward the negative electrode during electrophoresis. The solution located in the cell center moves in the opposite direction (toward the positive electrode) to compensate for the flow by the cell walls. Therefore, an electroosmotic flow is created during electrophoresis. The NanoPlus is designed to measure electrophoretic mobility at several points in the cell to obtain a position (i.e. stationary point) not influenced by electroosmotic flow. As a result, the instrument can calculate and accurately measure electrophoretic mobility, even if the electroosmotic profile of the system is asymmetrical due to adsorption or sedimentation of the sample on the cell walls.

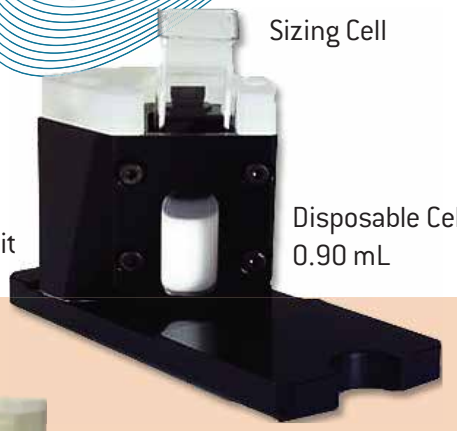


Particle Sizing			
Standard cell	Aqueous	Organic	Dilute
Micro volume disposable cell	Aqueous	Organic	Dilute
Disposable cell	Aqueous		
High concentration cell	Aqueous	Organic	Concentrated
Low conductivity cell			
Solid sample cell	Solid sample		
Zeta Potential (ZS/Z)			Dilute/Concentrated
Sizing cell	Aqueous	Organic	
Disposable cell	Aqueous		
Micro volume cell	Aqueous	Organic	
Flow cell	Aqueous		

Optional Sample Cells

The NanoPlus has an array of compatible sample cells for both nano particle size and zeta potential measurements. Each sample cell provides additional measurement capabilities of samples in liquid suspensions.

Sizing Cell



Sizing Cell Unit

Disposable Cell Available
0.90 mL

Particle Size

For use with the NanoPlus-1 and NanoPlus-3

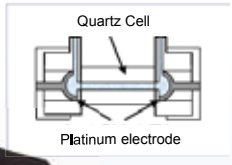
- Standard nano particle sizing cell (0.90 mL) – one included with NanoPlus-1 and NanoPlus-3
- Disposable nano particle sizing cell (0.90 mL)
- Micro volume nano particle sizing cell (20 µL)
- Flow cell assembly for nano particle sizing

Microvolume Cell
20 µL

Low Conductivity Cell

Micro Volume Disposable Cell
130 µL

Zeta Potential
High Concentration Cell
0.70 mL



Design utilizes a straight capillary to provide greater accuracy

Standard Zeta Potential Cell with Dome Electrode
0.70 mL

Zeta Potential

For use with the NanoPlus-2 and NanoPlus-3

- Standard sample flow cell assembly (0.70 mL) one included with NanoPlus-2 and NanoPlus-3
- Micro volume cell assembly (130 µL)
- Disposable cell for zeta potential measurement
- High concentration sample cell for zeta potential measurement
- Low conductivity sample cell for zeta potential measurement for use with organic dispersions
- Solid sample cell for zeta potential measurement

Solid Sample Cell

Evaluation of the Surface Charge of a Solid Sample by Zeta Potential

Novel method to measure the zeta potential of solid surfaces using probing particles.

- Surface charge of solid sample can be evaluated. Determination of electrostatic interactions between particles and flat surfaces
- Easy to use - Large sample size, min: 14 x 33 mm, max: 16 x 37 mm up to 5 mm thickness
- Solid surface modification analysis. Additive effect and particle adhesion. Zeta potential vs. pH/additive volume also available
- Wide sample application - Soft sample-like fibers can be measured

Applications:

- Fibers and textiles
- Thin films
- Shampoo and conditioner
- Membranes and filters
- Biomedical surfaces
- Semiconductor industry
- Polymer surfaces and coatings
- Optical glass polishing
- Protein adsorptive studies
- Paper and pulp industry
- Antimicrobial surfaces
- Packaging materials
- Recording media
- Printing and paint

Solid Sample Cell

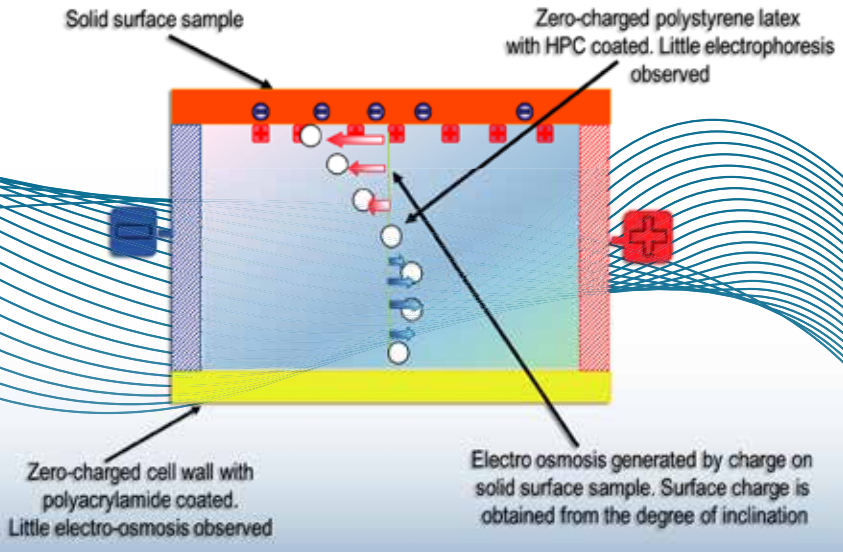
The zeta potential of solid flat surface samples is measured using a flat surface cell. The flat surface cell has quartz glass with an open side on which the sample, whose zeta potential is to be determined, is placed. The quartz crystal is filled with reference particles made up of polystyrene latex. The pH of a reference particle solution can be maintained at the desired pH by adding an acid or base. A voltage is applied across the platinum electrodes. In a closed electrophoresis cell, electroosmosis leading to a parabolic velocity profile is observed. However, in this case, the velocity profile is asymmetric because of a difference in the charges at upper and lower surfaces. This profile can be described by using the Mori and Okamoto equation:

$$U\,obs\,(y) = AUo(y/b)^2 + \Delta Uo(y/b) + (1-A)Uo + U\,p$$

$$A=\left[\frac{2}{3}-\frac{0.42}{K}\right]^{-1}$$

$$K=a/b$$

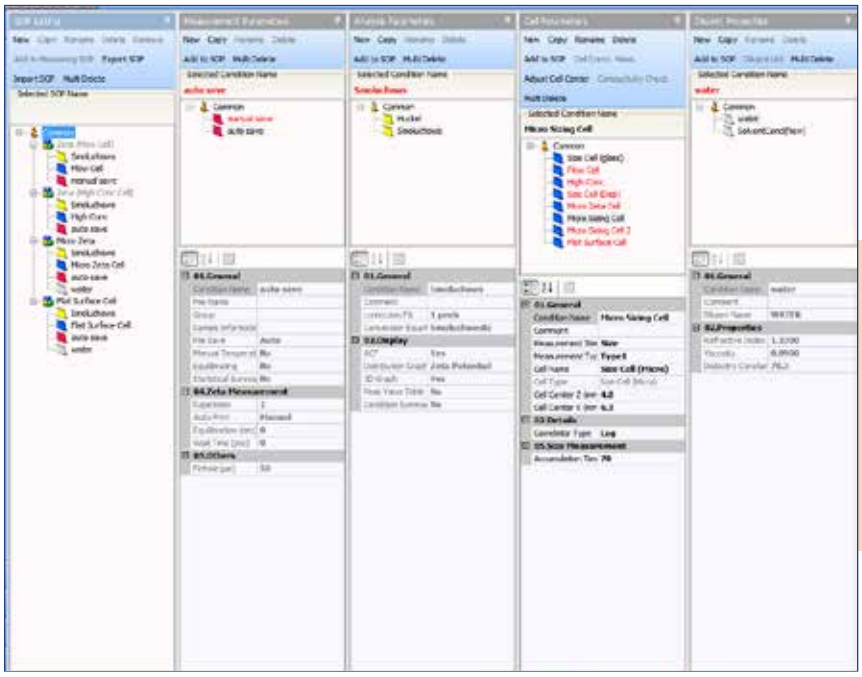
The true electrophoretic mobility values of the particles, as well as the upper and lower surfaces of the cell, are determined by measuring the apparent electrophoretic mobilities at different cell positions and fitting the results into the above equation. Electrophoretic mobility is converted to zeta potential by using the Smolochowski equation.



The NanoPlus

Intuitive Instrument Control, Data Acquisition, and Superior Analysis Results

The NanoPlus software provides intuitive and powerful instrument control, data acquisition, and data analysis. Our software is designed to enable the user to easily understand instrument control and method development to ensure that your lab productivity is always fully optimized.



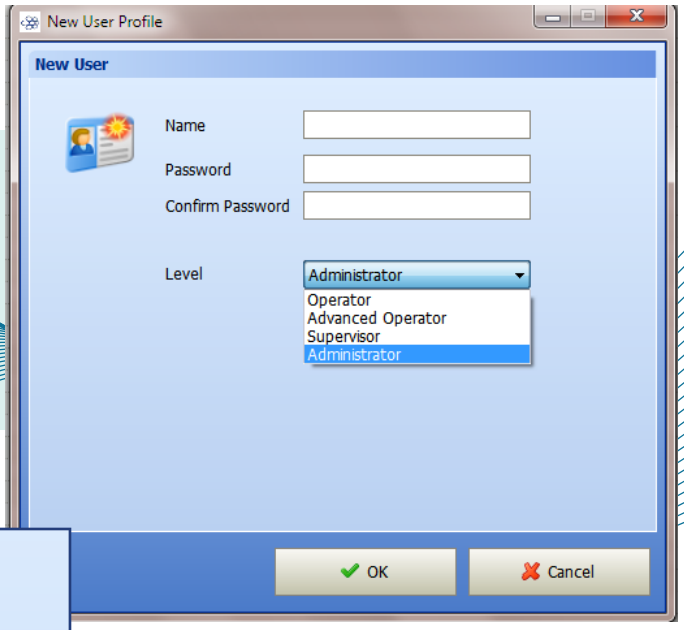
SOP Designer

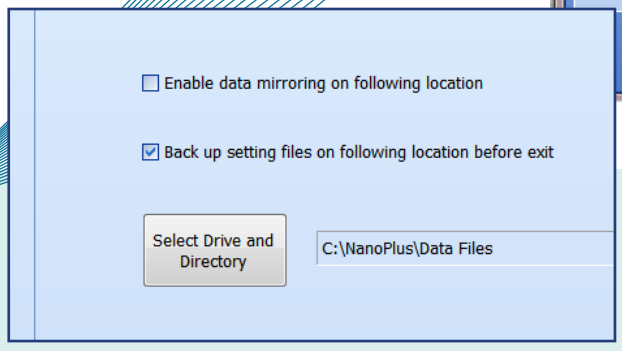
Intelligent and automatic creation of standard operating procedures

Ensure that you get the best results, regardless of the operator or instrument utilized in an analysis. Our intelligent SOP designer permits you to establish fixed SOPs that generate reproducible and repeatable results time after time. Simply input the color-coded conditions for measurement, analysis, cell, and diluent conditions. Name and save your SOP, load your sample, and start your run.

Configurable Security Levels

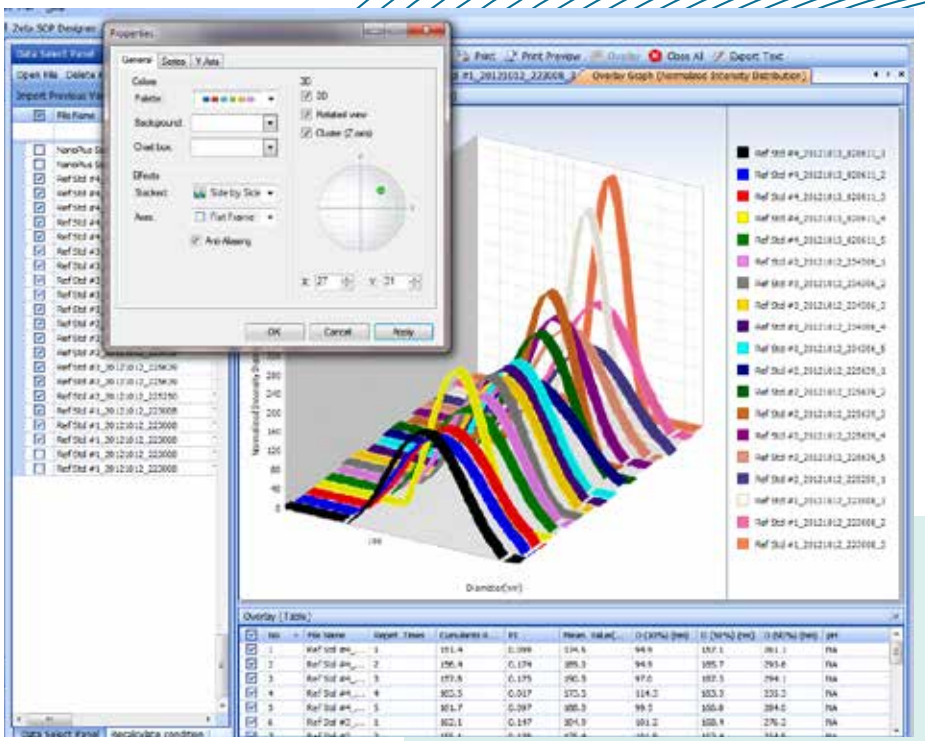
Easily and quickly set up four levels of security for accessing software, data collection, and report generation. Complies with 21 CFR Part 11 requirements.





Easy Data File Back-up

Data back-up is automated. Simply choose the directory, network drive, or wireless data storage device directly from the NanoPlus software. A copy of all data files and SOP parameter files will automatically be backed up at the selected location as soon as it is generated, giving the researcher peace of mind.

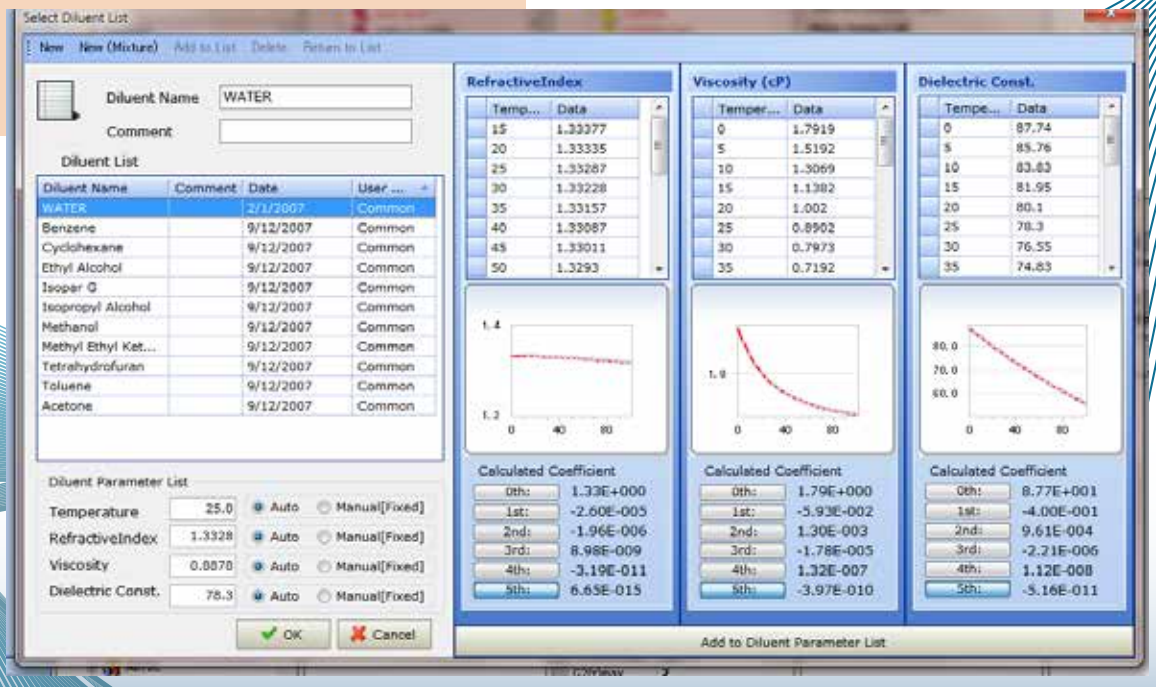


Customizable 3D Graph

Easily compare multiple data files using customizable 3D graphs. Use this function to track changes over time and compare lots, as well as monitor effects of pH changes, additive quantities, and temperature changes. This 3D visual representation of collected data is ideal for both R&D and quality control labs.

Pre-Loaded, Dispersion Liquid Properties

There is no need to research dispersion liquid properties such as refractive index, viscosity, and dielectric constants. Software comes pre-loaded with all common dispersion liquids and required properties for size and zeta potential analysis, including different temperature variations.

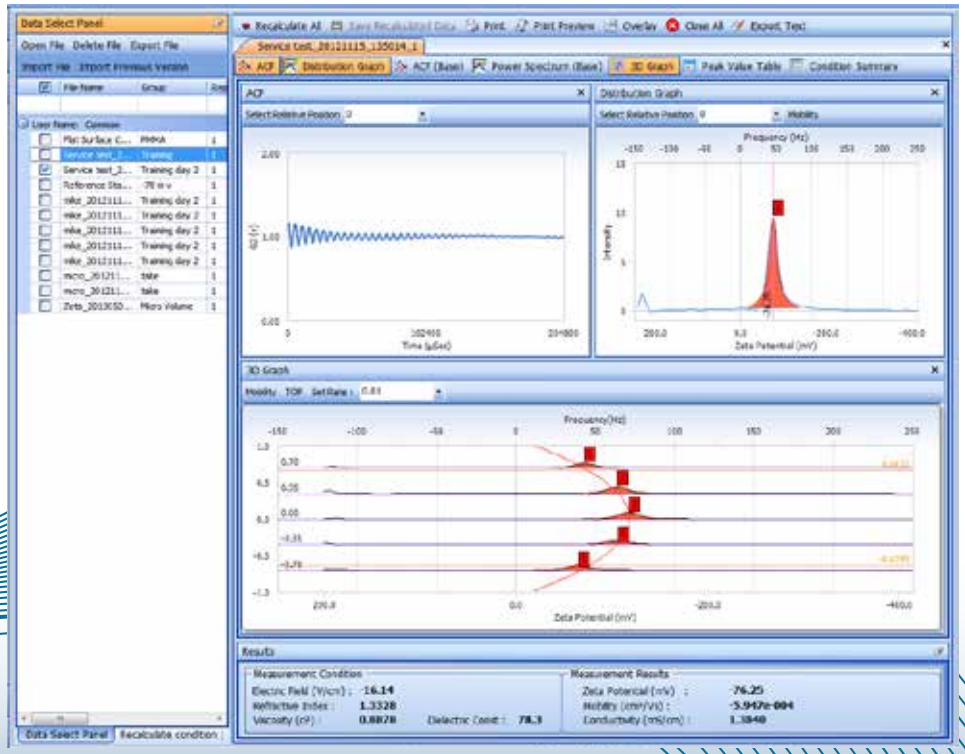


Real-Time Analysis Monitoring

Data is presented in real time during analysis. The screen can be customized to present as many graphs and tables as needed to fully characterize the material in real time.
Post analysis data files are easy to find, organize, and review.

Particle Size Analysis Results

Zeta Potential Analysis Results



The NanoPlus

Accessories

The NanoPlus AT is used to titrate sample suspensions in a pH range from 1 to 13. The instrument automatically controls the pH of these suspensions and conducts titrations during both zeta potential or nano particle size analysis measurements.

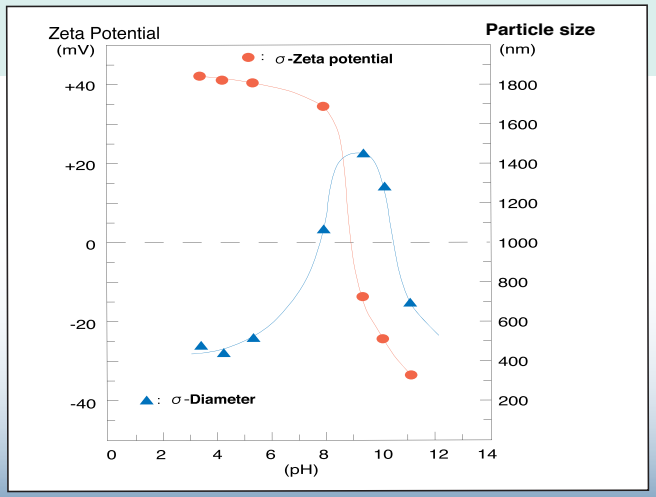
Features

- Automatic unattended operation
- Automatic determination of isoelectric point
- Software control of the titration and measurement provides automatic control through standard operating procedures
- Automatically generated reports and graphs – plot size and zeta potential vs. pH value and additive volume

Auto-Titrator

Function:	Automatically performs liquid titration for zeta potential and particle size measurements
Principle:	Automatic pH control of liquid suspension
Operation Temperature:	15 to 35 °C
Dimensions:	250(W) x 310(D) x 290(H) mm
Number of titrants:	Maximum of three
Titrant volume:	Standard glass vials: 50 mL Plastic vials: 50 mL
Sample volume:	Minimum: 30 mL; Maximum: less than 50 mL for standard vial
Titrant dispense volume:	Minimum: 0.1 µL
Circulation flow rate:	10 – 40 mL/min
Maximum number of pH settings:	100
pH probe:	1 – 13
pH range:	User defineable up to pH calibration
pH calibration:	Up to three points
Sample stirrer:	Magnetic
Applicable temperature range:	0 – 100 °C

As the pH value of a solution changes from acidic to alkaline, alumina particles show a significant change from plus to minus zeta potential values.



Specifications

	NanoPlus™ 1	NanoPlus™ 2	NanoPlus™ 3
Function	Particle Size Analyzer	Zeta Potential Analyzer	Particle Size & Zeta Potential
Principle	Photon Correlation Spectroscopy	Electrophoretic Light Scattering (ELS)	Combination of both measurements
Laser Source	Diode Laser	Diode Laser	Diode Laser
Detector	Avalanche Photodiode	Avalanche Photodiode	Avalanche Photodiode
Minimum Sample Volume	Glass Cell - 0.90 mL Micro Volume Cell - 20 µL	Flow Cell - 0.70 mL High Concentration - 0.60 mL Disposable - 130 µL	Accomodates all NanoPlus cells
Concentration	0.00001 to 40%	0.001 to 40%	0.00001 to 40% Particle Size 0.001 to 40% Zeta Potential
Measurement Range	0.1 nm to 12.30 µm	Zeta -500 to +500 mV	0.1 nm to 12.30 µm Particle Size -500 to +500 mV Zeta Potential
Laser Wavelength	660 nm	660 nm	660 nm
Laser Power	70 mW	30 mW	Dual Laser 30 mW + 70 mW
Correlator	Includes both, time-domain and time-of-arrival correlators. Maximum of 1,000,000 equivalent channels	Includes both, time-domain and time-of-arrival correlators. Maximum of 1,000,000 equivalent channels	Includes both, time-domain and time-of-arrival correlators. Maximum of 1,000,000 equivalent channels
Temperature Control	Peltier	Peltier	Peltier
Temperature Range	Operating range from 10 °C below room temperature to 90 °C	Operating range from 10 °C below room temperature to 90 °C	Operating range from 10 °C below room temperature to 90 °C
Temperature Accuracy	within+/-0.2 °C	within+/-0.2 °C	within+/-0.2 °C
Measurement Angles	160° & 15°	15° & 30°	160° + 15° Size 15° + 30° Zeta
Conductivity Range		Up to 200 mS/cm	Up to 200 mS/cm

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