ZETASIZER

THE ZETASIZER FAMILY OF DISPERSION TECHNOLOGY SYSTEMS

MALVERN
INSTRUMENTS

INTRODUCTION

Practical Problem Solving

Adding science to experience

In industries as diverse as ceramics manufacture and healthcare, gaining control over the stability of disperse systems is crucial in determining the performance of the final product. Even with today's extensive product development programs this is one area where an empirical "trial and error" approach persists and where a successful outcome may be highly dependent on the experience of the investigator.

Traditional approach

The phenomena of caking, creaming and flocculation are indications of poor dispersion stability. The traditional approach to control these effects is to define the parameters thought to be responsible – surfactant concentration, pH, temperature, exposure to light, reaction with the container – and prepare trial formulations. These are assessed over a period of time using the analyst's own experience to interpret results. Often large numbers of trial formulations are made up and held in a variety of storage conditions. Data from daily, weekly and monthly examination must be collated and compared before the optimum formulation can be determined – a lengthy and labour intensive procedure.

Malvern approach

Malvern Instruments' Dispersion Technology Systems now provide objective scientific measurements to help match experience to performance. By measuring fundamental parameters known to affect stability – such as zeta potential, particle size, pH and conductivity – the Zetasizer range offers a comprehensive, objective assessment of disperse systems. Investigators can identify, measure and vary the parameters that determine stability.

These measurements allow simple, direct comparison of proposed formulations. The data generated assists in the preparation of a reduced number of trial formulations, each of which will have a good chance of success. Formulation consequently can be optimized quickly and easily, reducing development time and cost, and contributing directly to improving the competitive advantage of both the product and the company.

APPLICATIONS

Using a systematic, more scientific approach often yields surprising results. Additives do not always produce the anticipated effect on **dispersion stability** and may prompt new approaches to formulation.

Avoid caking of suspensions

Efficient dosage, predictable shelf life and batch to batch consistency are essential for pharmaceutical emulsions and suspensions. Controlling zeta potential can minimize caking problems.

Enhance strength of ceramics

Achieving a uniform dispersion during ceramics manufacture is essential to ensure a dense, strong and consistent product. Controlling the dispersion forces involved may be a simple matter of adjusting the ionic concentration of the various species in the dispersion.

Maximize recovery in mineral processing

The efficiency of a **froth flotation** process is determined by the zeta potential of the minerals in the processed slurry. Understanding the effect of additives and control of any pre-processing is required to determine the optimum conditions for maximum mineral recovery.

Optimize paper manufacture

Zeta potential controls the interaction of pulp fibres, particles and additives in paper manufacture. Its manipulation enables improvements in process economy. It also helps produce consistent quality despite changes in source materials.

Prevent creaming

Mixing a fat emulsion, sugars, amino acids and minerals for parenteral nutrition can tend to cause flocculation of the emulsion. Formulation of intravenous lipid emulsions for specific patient regimes is improved by controlling the zeta potential of the mixture.

Minimize processing costs

In **water** processing, measurement of zeta potential in combination with parameters such as pH and conductivity enables treatment protocols to be adjusted to match exactly the treatment requirements of the source water.

Dispersant selection

Commercially important dispersions in non-polar liquids include photocopier toners and **inks**.

Selection of the correct dispersant in the right quantities is aided by the measurement of zeta potential.

Reduce formulation times

Many **cosmetics**, polishes, **foods** and agrochemicals are formulated as emulsions.

Zeta potential and particle size measurements quickly identify problems associated with product ageing, pH or temperature changes and interaction with packaging materials.

Agrochemicals often require dilution before application. Zeta potential can be used to ensure compatibility with local water sources.

Control flocculation

Conventional measurement of flocculation in **fermentation** processes depends on time-consuming manual techniques that can be unreliable.

Consideration of zeta potential provides a new approach.

ZETA POTENTIAL THEORY

Particles and interactions

Overall system stability depends on the interaction between individual particles

If mutual repulsion exists between particles in a system the dispersion will resist flocculation. However, in the long term there may be caking or creaming through natural sedimentation.

Where this mechanism does not exist, the attractive forces present in the dispersion will cause flocculation or coagulation to occur.

It follows that most stability problems should be approached by considering the balance between the repulsive and attractive forces.

In practice there are two ways to achieve this balance:

Polymers may be added which adsorb on to the surface of the particles within the system causing repulsion by steric effects. Alternatively, the ionic composition of the system can be adjusted, with the change in distribution of charged species determining the stability of the system.

Both methods have benefits depending on the application.

The use of polymers to generate stability through steric forces is often seen as a simple approach. However, polymers rarely act by steric forces alone and it can be difficult subsequently to flocculate the system. The addition of polymers to stabilize a system during the manufacturing process may cause problems if their removal is required at a later stage. Polymers can also be expensive, hence this is often not an ideal solution.

Measurement of zeta potential, which brings detailed insight into the dispersion mechanism, is the key to electrostatic dispersion control.

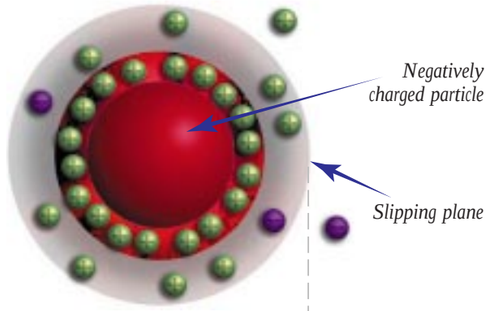
The simple act of adjusting the concentration of ions can bring an improvement in stability. The process is reversible – and potentially inexpensive.

Generally, a combination of electrostatic and steric effects is responsible for stability. Optimization of the electrostatic effects using Malvern's Zetasizer is often the most effective route to producing stable formulations.

The interaction of particles in polar liquids is not governed by the electrical potential at the surface of the particle, but by the effective potential of the particle and its associated ions.

To utilize electrostatic control, it is the zeta potential of a particle that must be measured rather than its surface charge.

What is zeta potential?



Particles dispersed in a liquid can acquire a surface charge in a variety of ways.

Charged particles will attract ions of opposite charge in the dispersant.

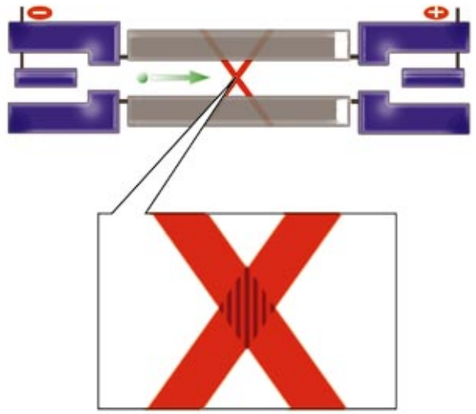
Ions close to the surface are strongly bound, those further away form a more diffuse region.

Within this region is a notional boundary known as the slipping plane within which the particle and ions act as a single entity.

The potential at the slipping plane is known as the zeta potential.

How is zeta potential measured?

Malvern Instruments' Zetasizer range employs microelectrophoresis to measure zeta potential.

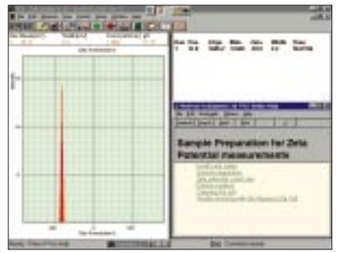


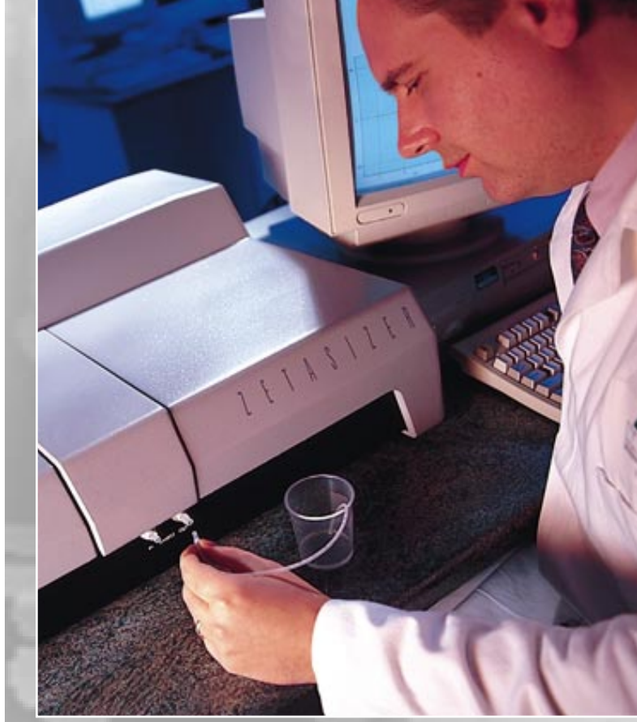
The sample under investigation is contained within an electrophoresis cell. A known field is applied and the sample illuminated by crossed focused laser beams.

Particles moving through the measurement volume scatter light. The intensity of the light fluctuates with a frequency proportional to the velocity of the particles.

The velocity is calculated from the measured frequency then expressed as a mobility by dividing by the applied field. This is converted to zeta potential using established theories.

A typical result





SIZE THEORY

Knowledge of particle size combined with zeta potential provides information for control in critical applications.

Malvern understands particle characterization. In many applications it is the combination of the measurement of size and zeta potential that ultimately gives control. The Zetasizer range includes systems that use Photon Correlation Spectroscopy (PCS) to measure particle size, zeta potential or both parameters in one optical unit.

Measurement of particle size

Particles dispersed in a fluid are in constant random motion, commonly referred to as Brownian motion. PCS measures the speed of this motion, calculates the diffusion coefficient, and relates this to size using the Stokes Einstein equation. Malvern's implementation of PCS technology not only gives reproducible and meaningful size results, it can also reveal additional information about surface structure, solvation efficiency, adsorbed polymer layer thickness or changes in particle shape.

INSTRUMENT & SELECTION GUIDE

The Zetasizer Range

Malvern Instruments has combined the latest advances in laser and optical design with Windows™ based software to give systems that offer great flexibility and ease of use.

An integrated range of accessories and options allows each Zetasizer to be tailored to meet the requirements of a diverse range of applications.

Most applications will be served by the Zetasizer 1000, 2000 and 3000 systems that feature fixed, pre-aligned optics requiring no user set-up or optimization. The multi-angle optics of the Zetasizer 4000 and 5000 allow these instruments to provide the most comprehensive characterization, enabling even traditionally difficult samples, such as polydisperse systems, to be accurately and reliably analyzed.

The Zetasizer range excels in its precise temperature control, regarded as the key to meaningful measurements. All instruments feature a stable 10mW He-Ne laser, single photon digital correlation for efficient data processing, built-in pH measurement and user friendly help files.

Zetasizer	Parameters measured		Size range	Size range for zeta potential	Accessory compatibility
	Size	Zeta			
90° optics					
1000	YES	NO	2nm – 3000nm	–	
2000	NO	YES	–	5nm – 30µm	
3000	YES	YES	2nm – 3000nm	5nm – 30µm	
Multi angle optics					
4000	YES	NO	2nm – 3000nm	–	
5000	YES	YES	2nm – 3000nm	50nm – 30µm	

Aqueous Dip Cell

Non-Aqueous Cell

Autotitrator

Autosampler

High power laser option

High-pressure zeta potential cell

ACCESSORIES

Aqueous Dip Cell

Highly adsorbent substances, su surfactants, polymers and prote pose a contamination risk unle measurement cells are meticulo cleaned. The disposable Aquec Dip Cell helps to eliminate car contamination and brings great convenience to the measureme process. The ability to analyze sample volumes as small as 0.7 makes it particularly important protein studies in pharmaceuti and biotechnology research.

Analysis of toxic substances is simpler and safer with disposa cells. The use of a low sample volume reduces both the haza the operator and the disposal

Non-Aqueous Cell

Developed to enable the characterization of particles in low conductivity media, the I Aqueous Dip Cell provides hi field strengths for zeta potenti measurement of materials such carbon black dispersions, important in the developmen photocopier toners.

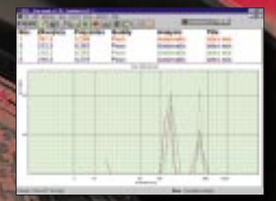
SOFTWARE

Software for QA and Research

Zetasizer software brings you the power to choose just how you want to operate the system and display the results. Start with the easy to use mode, then reveal greater capability as your analytical requirements and experience with the system develop.

A Wizard function guides users through the complete set up and measurement procedure, making Zetasizer systems ideal for inexperienced or occasional operators.

Three levels of access deliver a choice of simple operation with high security through to fully flexible operation with extensive data modelling.



A built-in Results Quality Factor (RQF) gives a single criterion as a quick and easy check on the reliability of each measurement.

Context sensitive help screens and indexed help notes provide comprehensive on-screen guidance.

INSTRUMENT & SELECTION GUIDE

The Zetasizer Range

Malvern Instruments has combined the latest advances in laser and optical design with Windows™ based software to give systems that offer great flexibility and ease of use.

An integrated range of accessories and options allows each Zetasizer to be tailored to meet the requirements of a diverse range of applications.

Most applications will be served by the Zetasizer 1000, 2000 and 3000 systems that feature fixed, pre-aligned optics requiring no user set-up or optimization. The multi-angle optics of the Zetasizer 4000 and 5000 allow these instruments to provide the most comprehensive characterization, enabling even traditionally difficult samples, such as polydisperse systems, to be accurately and reliably analyzed.

The Zetasizer range excels in its precise temperature control, regarded as the key to meaningful measurements. All instruments feature a stable 10mW He-Ne laser, single photon digital correlation for efficient data processing, built-in pH measurement and user friendly help files.

Zetasizer	Parameters measured		Size range	Size range for zeta potential	Accessory compatibility
	Size	Zeta			
90° optics					
1000	YES	NO	2nm – 3000nm	–	
2000	NO	YES	–	5nm – 30µm	
3000	YES	YES	2nm – 3000nm	5nm – 30µm	
Multi angle optics					
4000	YES	NO	2nm – 3000nm	–	
5000	YES	YES	2nm – 3000nm	50nm – 30µm	

Aqueous Dip Cell

Non-Aqueous Cell

Autotitrator

Autosampler

High power laser option

High-pressure zeta potential cell

ACCESSORIES

Aqueous Dip Cell

Highly adsorbent substances, such as surfactants, polymers and proteins, pose a contamination risk unless measurement cells are meticulously cleaned. The disposable Aqueous Dip Cell helps to eliminate carryover contamination and brings greater convenience to the measurement process. The ability to analyze sample volumes as small as 0.75ml makes it particularly important for protein studies in pharmaceutical and biotechnology research.

Analysis of toxic substances is simpler and safer with disposable cells. The use of a low sample volume reduces both the hazard to the operator and the disposal cost.

Non-Aqueous Cell

Developed to enable the characterization of particles in very low conductivity media, the Non-Aqueous Dip Cell provides high field strengths for zeta potential measurement of materials such as carbon black dispersions, important in the development of photocopier toners.

Flexible configurations — Options & Accessories

Sample Cells

A variety of cells is available for size and zeta potential measurement, from chemically resistant quartz and glass cells to disposable polystyrene cuvettes and flow cells for automation.

High-pressure cell

This cell is designed to measure the zeta potential of particulate materials dispersed in volatile non-conductive fluids under pressure. The sampling port and pressure specifications are designed specifically for the metered dose inhalers commonly used in the pharmaceutical industry.

Autosampler

The Autosampler provides full automation of size and zeta potential measurements, bringing high throughput and repeatability. Samples may be added while the unit is operating. High priority samples can be processed immediately.

Autotitrator

Zeta potential measured as a function of another parameter often yields more useful information than a single zeta potential measurement alone.

The Autotitrator provides automatic determination of zeta potential as a function of pH, conductivity or any specific ion for which an electrode is available, making zeta potential profiles rapid and routine.

Controlled via an addition to the standard software, the Autotitrator determines zeta potential at pre-defined points across a range, displaying each on screen as an evolving plot.

High power laser option

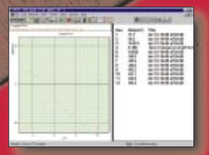
A high power laser can be added to extend the range of applications to sizes as low as 2nm. This will also allow the analysis of small samples and those with poor scattering characteristics, such as micelles and coloured samples.

Standards

NIST traceable size standards are available in a range of sizes to match the size range of the sample being measured. These can be used to validate system performance – for GLP conformance and your own peace of mind. Pre-prepared transfer standards for zeta potential measurement are available to verify correct system operation.

SOFTWARE

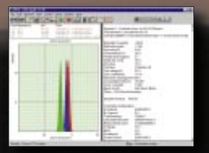
Many Zetasizer applications are in regulated industries. Malvern's implementation of ISO 13321 ensures compliance with GLP protocol requirements.



Customization is simple, enabling users to precisely define the results presentation format. Cut and paste tables allow the export of data to external spreadsheets or word processing applications.

Automation of most functions, including automatic data analysis, ensures rapid results with minimal user input required.

For complete integration within the laboratory, Zetasizer software runs under Windows 95™ and is fully compatible with versions 3.1 and 3.11.



User preferences or applications specific protocols can be stored so that sample and method details only need be set up once.

External systems – samplers, pumps, and alarms – can be controlled via the RS232 interface.

Setting standards of excellence – our commitment to you

The people at Malvern Instruments are innovators, not just in product design, but in every area of business. Malvern has invested to achieve ISO9001 with TickIt accreditation – we accept nothing short of excellence. As many of our systems are used in the toughest regulatory markets, product validation and development traceability are key commitments to our customers.

Malvern trained specialists are available in more than 50 countries to assist with applications development and to advise on and analyze 'difficult' samples. Our laboratory facilities in North and South America, Europe and Asia routinely run thousands of customer samples every year.

Our innovative approach to customer service is illustrated by the development of after-sales remote diagnostics. Malvern Instruments' service specialists can access and control systems via standard telephone lines in order to minimize down time and reduce cost.

In many industries particle size analysis has become a key QC parameter. The need to obtain data as close to the line as possible, and to react quickly to that data, is increasingly important. Malvern's in-process division applies its expertise to meet this challenge through the development and production of on-line particle characterization systems for in-process applications.

With laboratory systems and in-process products, Malvern Instruments meets your particle analysis needs from Lab to Line.

For a full description of all Malvern Instruments' products and services please contact your nearest office.

Malvern Instruments Limited
Enigma Business Park
Grovewood Road
Malvern
Worcestershire
UK
WR14 1XZ
Tel: +44 (0)1684 892456
Fax: +44 (0)1684 892789

Malvern Instruments SA
Parc Club de L'Université
30, Rue Jean Rostand
91893 Orsay Cedex
France
Tél: +33 (1) 69 35 18 00
Fax: +33 (1) 60 19 13 26

Malvern Instruments Inc.
10 Southville Road
Southborough
MA 01772
USA
Tel: +1 (508) 480-0200
Fax: +1 (508) 460-9692

Malvern Instruments GmbH
Rigipsstraße 19
71083 Herrenberg
Germany
Tel: +49 (0) 7032 97770
Fax: +49 (0) 7032 77854

Malvern Instruments (Asia Pacific)
4th Floor
Syed Kechik Foundation Building
Jalan Kapas
Bangsar 59100
Kuala Lumpur
Malaysia
Tel: +60 (0) 3 2836390
Fax: +60 (0) 3 2836139

Malvern Instruments Nordic AB
Box 15045, Vallongatan 1
750 15 UPPSALA
Sweden
Tel: +46 (0) 18 55 24 55
Fax: +46 (0) 18 55 11 14

www.malvern.co.uk

Designed & produced by C+Force Communications Limited, Hungerford, UK.

Ref: MRK276