Malvern Panalytical
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Water Treatment Solutions

Coagulant optimization in water treatment processes

Optimizing cost-efficient Water Treatment

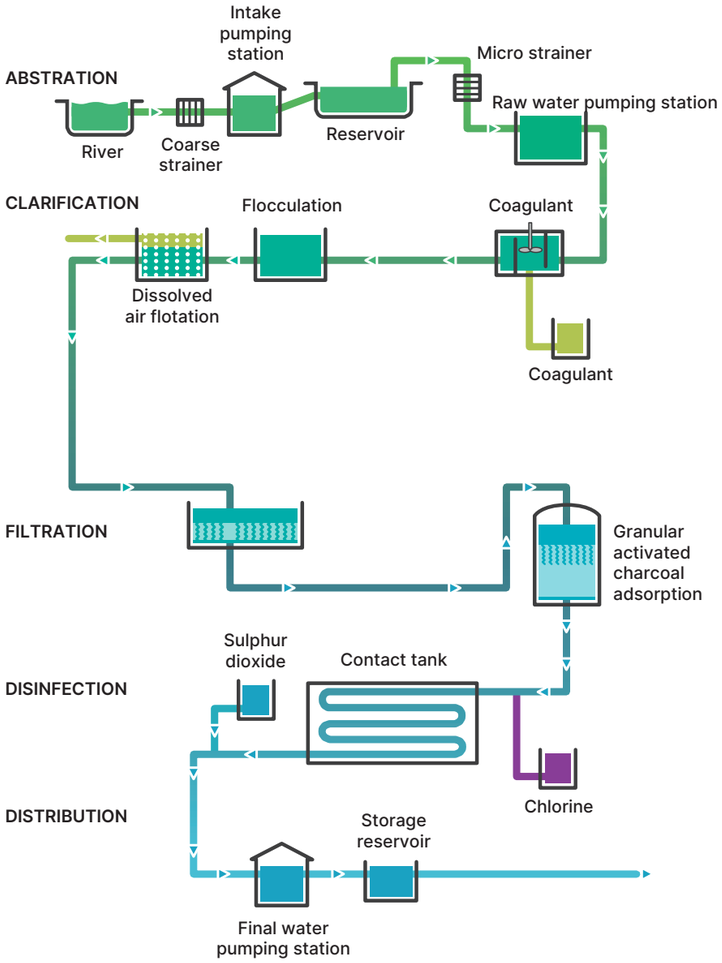
For the water treatment industry, quality is nonnegotiable. Consistently demonstrating that regulatory standards are met, while at the same time driving down treatment costs, provides the stimulus for continuous process improvement. Plant stability is the defining operational goal and a primary driver for the adoption of routine monitoring.

Complementary aims are to:

- Confidently meet quality targets even when raw water quality changes sharply and rapidly
- Reduce chemical consumption in the face of rising costs and reduced availability
- Routinely monitor and optimize chemical treatment
- Minimize sludge production and associated disposal costs
- Reduce filter cleaning and increase plant uptime from less coagulant usage
- Replace qualitative jar tests with a quantitative analysis using zeta potential measurements

The crucial first step of removing physical contaminants via clarification provides a foundation for the entire water treatment process. Coagulant overdosing during charge neutralization is common and is often considered as insurance against process fluctuations stemming from sub-optimal analysis and control. Taking a hit on chemical usage and sludge production is preferable to compromising water quality.

However, overdosing can re-stabilize suspended particles, decreasing filtration efficiency, as well as increasing treatment costs. The ideal is to maintain the process in a relatively narrow operating window, where just enough coagulant is added to form a large and stable floc. Reaching this level of performance requires sensitive, relevant, and timely monitoring.



"Potential coagulant cost savings of 22%, generating 10% less sludge production, and more stable treated water quality."[1]

Reference [1]: E. Sharp et al "Zeta Potential Measurements Render the Flow Test

Building on the legacy of the industry-leading Zetasizer Nano Series, the Zetasizer Advance family of light scattering instruments brings increased versatility and expertise to your laboratory. The extensive range of six Zetasizer Advance systems provides a perfect fit for every application and every workflow challenge

Zeta Potential – Why Use It?

There are different methods to optimize coagulants used in the water treatment industry. For example, in jar testing, the effect of polymer/coagulant addition overtime is observed on a small scale.

Another way is to use turbidity tests, where the transmitted light can be related to the amount of organic matter.

Zeta potential is a measure of the charge that particles and macromolecules have and is a well- established, proven parameter for assessing suspension stability and directly quantifies the likelihood of coagulation.

The magnitude of the zeta potential gives an indication of sample stability. If all the particles in suspension have a large negative or positive zeta potential, then they will tend to repel each other and there is no tendency for the particles to come together. However, if the particles have low zeta potential values, then they will interact and flocculate.

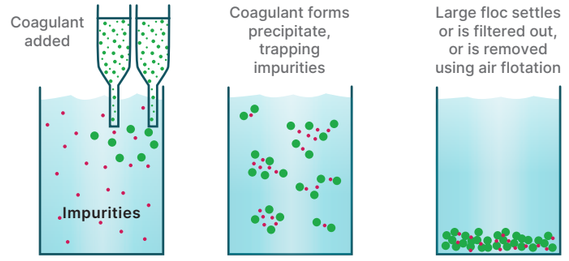
The **zeta potential** of raw water is typically negative, in the region of -25 mV to -15 mV. Adding coagulants neutralizes this negative charge, moving zeta potential towards zero and ultimately into the positive range.

Flocculation is typically seen at zeta potentials from -8 mV to +3 mV with particle re-stabilization occurring above +5 mV.

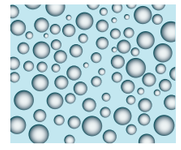
Controlling coagulant dosing by directly referencing zeta potential to a set point optimizes the charge neutralization process. A typical set point will be in the region of -5 mV to 0 mV.

Addition of coagulant and subsequent measurement of zeta potential allows the optimum concentration to be determined. In the plot shown, 30 ppm of aluminium sulphate is near to the sample's isoelectric point i.e. the point of zero zeta potential.

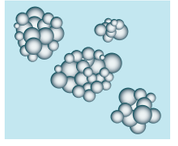
Zeta potential is distinctly different from current density measurements as reported by streaming current meters (SCMs). It provides a measurable quantity to identify maximum coagulation conditions and can be used to adjust coagulant dosage levels periodically to minimize cost of chemicals for water purification.

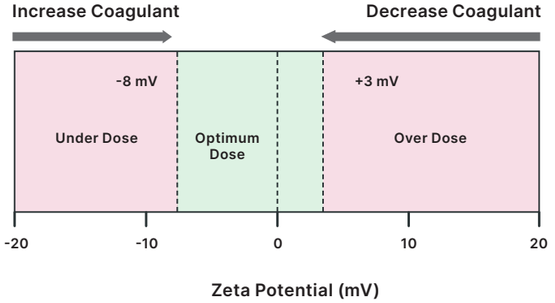


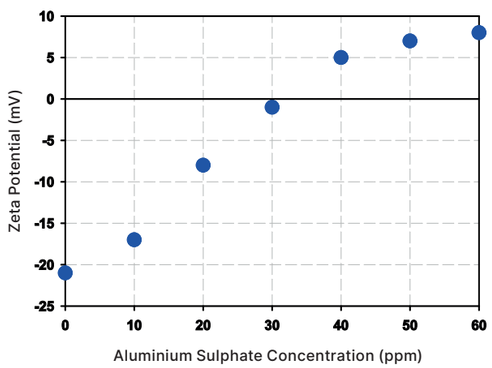
High Zeta Potential
Stable suspension



Low Zeta Potential
Unstable suspension







Why infer process performance ...

Traditional techniques used for monitoring particle charge in coagulation and sedimentation processes include the jar test and, in some cases, SCMs. These techniques have several limitations for efficient charge neutralization and clarification control.

Jar testing

Jar tests are a traditional method for optimizing coagulant dosing and give a direct view of the flocculation process.

Disadvantages include:

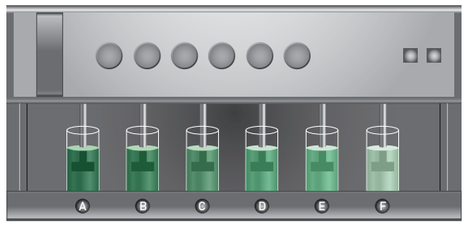
- A failure to exactly mimic conditions in the plant
- Time to perform analysis
- Requirement for operator interpretation

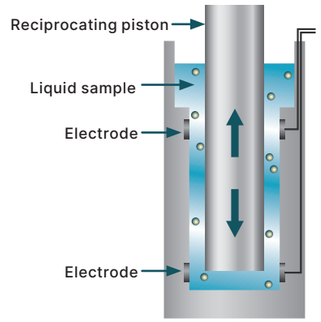
The time delay between sampling and results is a significant limitation for responsive plant control.

Streaming current meter

SCMs can be installed online for continuous monitoring but have a number of drawbacks including:

- A failure to exactly mimic conditions in the plant
- Poor sensitivity at low charge conditions observed during coagulation
- Difficulty indicating the required change in coagulant dose due to non-absolute reading
- Measurements are influenced by changes in water conductivity and deposits on the sensing surface.





Summary of Differences in Techniques

Streaming current	Electrophoretic Light Scattering
Measures a proportion of particles that adsorb onto cell walls	Measures all particles, organics and minerals directly
Calibration of output required	Absolute technique, no calibration required
The low concentration of particles in feed water leads to a very low signal, so insensitive to small changes	Can measure at very low concentrations
Signal depends on sample conductivity, which varies as the nature of the sample changes	Zeta potential is reported directly

When you can measure it directly

The Zetasizer Advance uses the technique of electrophoretic light scattering to measure the zeta potential of a sample. The zeta potential is determined by measuring the particle velocity induced when a voltage is applied across a capillary cell containing the sample.

Electrophoretic light scattering is an absolute technique eliminating the need for calibration. A NIST traceable standard is available for verification if required. The measurement is performed in a temperature - controlled celland is insensitive to factors not impacting particle charge.

The **Zetasizer Lab Red** is an ideal tool for your coagulant monitoring effort. In today's treatment plants you need to optimize coagulant dose at variable water conditions. With zeta potential, operators gain quantitative data to target the treatment process. Simply sample, fill the flow cell, insert and press go. Results of 3 separate zeta potential measurements are obtained in 2 minutes.

Although classified as a benchtop instrument, many of our users transport their Zetasizer from one water treatment plant to another to enable effective remote coagulation control.

Relevant Zetasizer Advance Specifications for this application are as follows:

Hardware

- Fully pre-aligned optics with no user adjustment required.
- **Simple to operate:** insert the sample cell and press Start.
- **Temperature adjustable range to any water temperature:** 0°C – 120°C.
- **Integrated condensation control:** Purge facility using dry air.
- **Detector:** Avalanche Photo Diode (Absolute sensitivity >20kcps Toluene count rate at side angle scattering).
- **Laser:** HeNe (gas) laser, 633 nm wavelength.

Zeta potential and Electrophoretic Mobility measurements

- **Zeta Potential Range:** ±500 mV, over size range 3.8 nm to 100 µm.
- **Wide range of water conditions:** up to sample conductivity of 260 mS/cm.
- Typical sample volume = 1mL with minimum sample volume of 20 µL (using barrier diffusion method).
- Use of disposable, folded-capillary cells with integrated electrodes to eliminate cross-contamination.
- Mixed Mode Measurement Phase Analysis Light Scattering (M3-PALS) offers superior performance
- through combining both the fast field and the slow field reversal measurement technique.

Software

- Ability to measure with manually defined parameters, or by defining a 'Method'.
- Over-plots of up to 20 zeta potential distributions.
- A report designer facility to customize reports for printing.
- Linking 'Methods' and 'Pause' available to automate data acquisition.
- Access to all measured data, zeta potential and conductivity available for easy export.

Zetasizer Advance and Zeta potential advantages and benefits in coagulation optimization

Zeta potential measurement technology can be used in the laboratory for the off-line study and optimization of flocculation/coagulation processes.

Advantages relative to traditional techniques include:

- Speed of measurement
- Ease of use
- Reproducibility - not subject to operator-to-operator variability

Zeta potential measurements have been demonstrated to give the following benefits:

- Improved process stability
- The ability to respond to changes in raw water and plant conditions
- A reduction in chemical coagulant costs – 15-20% reported by users

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About Malvern Panalytical

Malvern Panalytical is a global leader in the analytics of material and life sciences. We unleash the power of small things to make big things happen for our customers.

Our vision is to make the world cleaner, healthier, and more productive.

We partner with our customers to make their solutions possible through the power of precision measurements, our expertise, trusted data, and insights.

Our people are partners in discovery. We collaborate with our customers and with each other to discover new possibilities and achieve breakthroughs.

Our culture is a healthy, high-performance culture shaped by our values: Own it, Aim High and Be True.

We're committed to Net Zero in our own operations by 2030 and in our total value chain by 2040.

With over 2300 employees across the globe, we are part of Spectris plc, the world-leading precision measurement group.

Malvern Panalytical. We're big on small™

Service & Support

Malvern Panalytical provides the global training, service and support you need to continuously drive your analytical processes at the highest level. We help you increase the return on your investment, and ensure that as your analytical requirements grow, we're there to support you.

Our worldwide team of specialists adds value to your business processes by ensuring applications expertise, rapid response, and maximum instrument uptime.

- Proactive local and remote support
- Full and flexible range of service agreements
- Compliance and validation support
- Onsite or classroom-based training courses
- e-Learning training courses and web seminars
- Digital services, including MyStore and My Customer Support Portal
- Sample analysis, method development, and applications consultancy

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