HORIBA Scientific

# Application Note

## Zeta Potential Analysis of Clay

AN201

**Using the SZ-100 Nanoparticle Analyzer, the concentration of additive needed to reduce the zeta potential of wastewater suspended solids to zero can be reliably evaluated and so the efficiency of different additives can be readily compared such that the most economical option can be chosen. Particulate aggregation is typically achieved through the use of additives: coagulants (inorganic) and flocculants (polymeric). In this note, the effect of coagulant choice and concentration on the treatment of suspended clays is analyzed.**


**Figure 1: SZ-100 Nanoparticle Analyzer.**

### Introduction

Suspended solids are a common impurity in wastewater from industrial and mining operations. Safety and aesthetics dictate that all potable water be essentially free of suspended matter. In order to meet requirements for water clarity for reuse or discharge, the suspended solids are often allowed to settle to the bottom or float (cream) to the top of large tanks. The duration of these processes is a strong function of the particle size; larger particles settle/cream faster. Thus, if particles can be made to aggregate, the settling rate is increased making removal easier resulting in an overall more efficient and less expensive operation.

Particle aggregation can be an energetically favored process; as particles coagulate or flocculate, the total particle surface area is decreased resulting in a more stable system.

However, aggregation cannot occur if particle collisions are hindered because of electrostatic interactions. That is, if two particles have the same charge (positive or negative), they will repel each other.

Aggregation is enhanced through the mechanism of charge neutralization; additives are used to reduce the magnitude of the particle surface charge to zero, ideally at minimal cost. This minimal cost requirement implies that the optimal amount of additive needed be determined. One widely used class of such additives are termed coagulants; typically inorganic salts with polyvalent ions. Unfortunately, addition of too much coagulant (overdosing) causes charge reversal resulting in re-stabilization of the suspended solids with a resultant deterioration in subsequent processing.

The electrokinetic charge that exists at the surface of suspended particulate matter is related to a property known as zeta potential and so its measurement, using for example the HORIBA SZ-100 Nanoparticle Analyzer (Figure 1), can be used to monitor the effect of coagulant addition.

### Materials and Methods

An industrial clay suspension from a waste stream was used for this study, which was initially diluted in a 1 mM NaCl solution. This small amount of NaCl serves as a background electrolyte to keep the suspension ionic strength constant and suppress variations in results due to dissolved gases such as $CO_2$.

The coagulants chosen for this study were gypsum, $CaSO_4$ and an alum, $Al_2(SO_4)_3$. Industrial grade materials were used rather than pure reagents so the analysis would be more relevant to real-world conditions.

## Results and Discussion

The zeta potential value of the clay suspension as a function of added gypsum and added alum is plotted in Figure 2 below. As is common with this analysis, the additive amounts are plotted on a logarithmic scale.

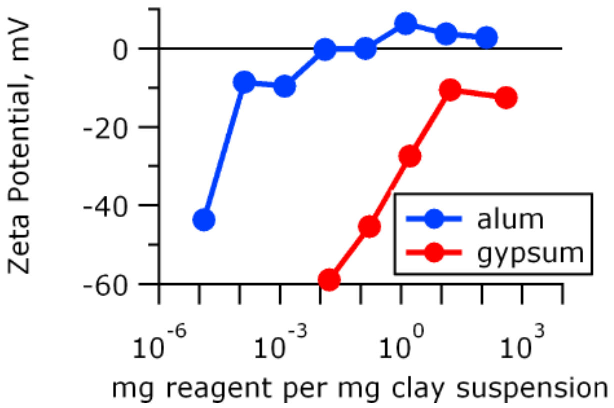


**Figure 2: Zeta potential of clay as a function of added alum and gypsum.**

It can be seen that the zeta potential of the clay decreases and approaches zero with increasing coagulant material concentration.

The plot clearly shows that alum is much more effective than gypsum for clarifying the waste stream since a smaller quantity of alum is required for a given quantity of clay. This is not unexpected as the trivalent aluminum ion ($Al^{3+}$) in alum is known to be more effective than the divalent calcium ion ($Ca^{2+}$) in gypsum.

The data here suggests that 1 part of alum should be added to each 100 parts clay suspension for optimum water treatment.

However, this data does not take into account the ratio in the cost of the gypsum to the alum and the effects of each on subsequent treatment and other processing requirements.

There is one final and important lesson from the data shown here. As additional alum is added, the zeta potential reaches zero, then it crosses zero and the net charge on the particle becomes positive. This results in a re-stabilized clay suspension now of opposite charge. Thus, the danger in adding too much coagulant is not merely the additional cost in reagents, but also that the treatment process will become ineffective.

## Conclusions

The results of these measurements show that a benchtop device, the SZ-100, can be used to characterize the effectiveness of different wastewater treatment strategies. Zeta potential considerations can provide a basis of optimizing operation of wastewater purification. Very quickly two or more candidate additives can be compared and evaluated. Thus, data from the SZ-100 can guide decision making to ensure that the least expensive treatment options are chosen while protecting the environment.