



## Determining the optimum dispersant dose

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### Abstract

In this note we show how the AcoustoSizer and ZetaProbe can be used for determining how much dispersant to add to a colloid.

### Introduction

Dispersing agents, as the name implies, are chemical compounds which, when added to a colloidal suspension, tend to make the particles more disperse. They are of two types: ionic and non-ionic. It is the ionic type that we are interested in here. The agents are sometimes simple inorganic ions, like the poly-(metaphosphate) ion, and sometimes organic polymers, with electrically charged groups along the chain. In both cases the dispersing agent adsorbs strongly onto the particle surface and gives it a high (usually negative) electric charge. It is this charge that causes the particles to repel one another when they approach, and that assists in the dispersion process.

The dispersing agents alter the zeta potential, so by using electroacoustic measurements it is possible to follow the changes in zeta caused by additions of dispersant. Such measurements are commonly used for determining the optimum dispersant dosage. If too little dispersant is used there will still be some flocs left, and if too much is used there is a risk that the particles will coagulate due to the increased electrolyte levels caused by the dispersant addition. Furthermore, overdosing can be expensive in large-scale operations.

### The Traditional Methods

The idea of using zeta to monitor dispersant addition is not new, but in the past it was necessary to add the agent in small doses and, when equilibrium was thought to be established, a small sub-sample was removed for zeta potential determination.

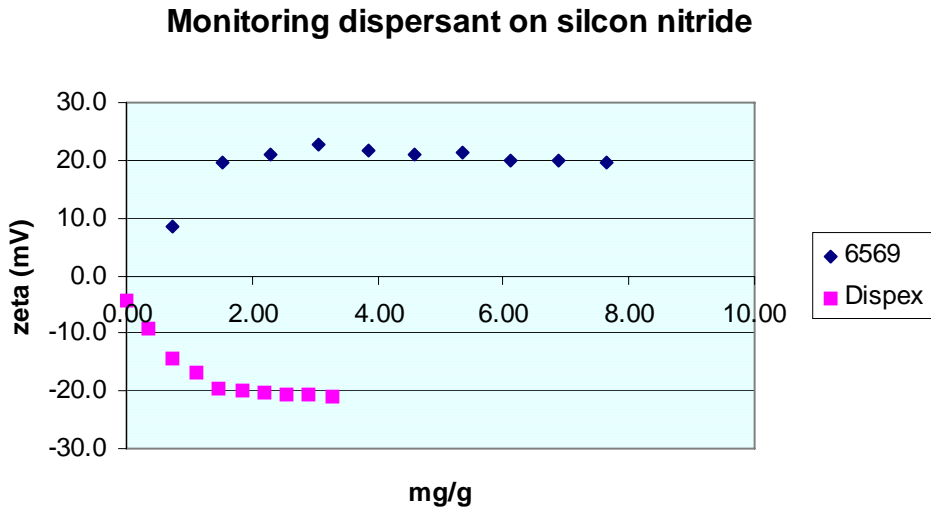
Most instruments for measuring zeta potential required that the sample have a very low particle concentration, so one was forced to dilute the sample many times. However it often happens that in the dilution process, the zeta potential of the system is drastically altered. Various procedures have been developed to try to overcome this problem but in some cases (e.g. some emulsion systems) the problems are insuperable.

In the ZetaProbe and AcoustoSizerII such dilution is unnecessary, for these instruments can measure in suspension of arbitrary concentration.

Other methods for determining the optimum dispersant dose involve measurements of rheology, adsorption isotherms and sedimentation. The electroacoustic method is faster and more convenient than any of these methods.

## Using the AcoustoSizer and ZetaProbe

These instruments are ideal for monitoring the effects of adding a dispersing agent to a colloidal suspension. In figure 1 we show AcoustoSizer zeta measurements of the adsorption of a cationic polyelectrolyte (6569) and an anionic polyelectrolyte (Dispex N40) [1]. Both these dispersants are manufactured by Ciba Chemicals, Bradford UK.

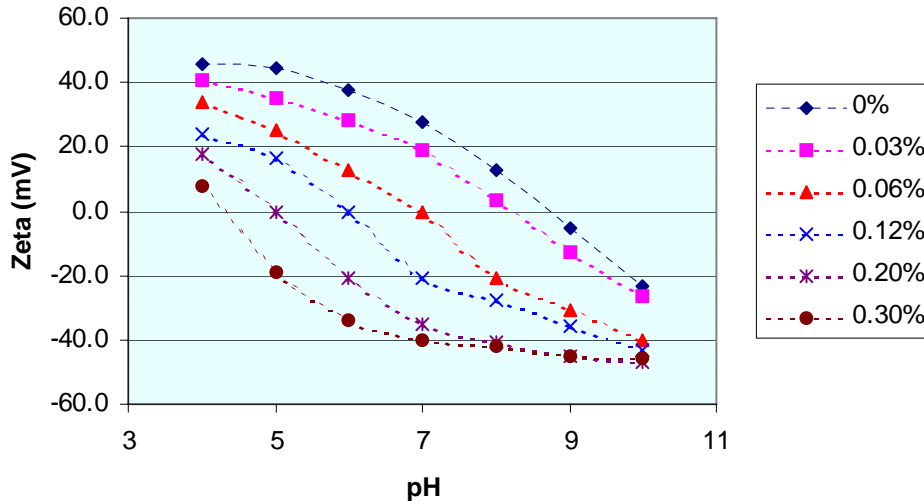


**Figure 1** The change in zeta with addition of a cationic and anionic dispersant. The dispersant level is in mg per gm of solid

In both cases the zeta potential increases in magnitude with dispersant dose and then levels off. The point at which this occurs is taken to be the optimum dose. Further addition of dispersant will not have any effect on stability since it is not going on to the particle surfaces. In the above figure the optimum doses are 3 mg/ g for the cationic polyelectrolyte and 1.8 mg/ g for the anionic dispersant [1].

The optimum doses determined by electroacoustics, rheology, adsorption isotherms and sedimentation height have been found to be in very good agreement [2-3].

For a given type of particle, the optimum dispersant dose depends on a number of factors, including the pH of the suspension. This is illustrated by the data in figures 2 and 3, which are based on measurements in reference [4].



**Figure 2** The zeta potential vs pH for alumina at various dispersant levels

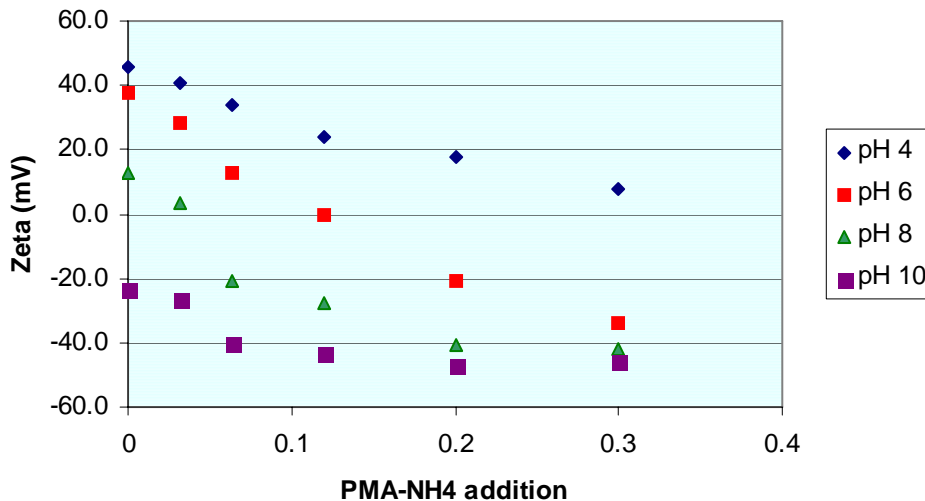
The results were compiled by first titrating an alumina suspension with acid from an initial pH of 10 in the absence of dispersant. That gives 0% curve in the diagram. At high pH values the alumina is negatively charged, it goes through a zero value at a pH about 9 and then becomes positive at lower pH, ending up at about 46 mV at pH 4.

A small amount of poly(acrylate) (PAA) was then added and, after equilibration, the system was titrated with base. Then after a further addition of PAA it was titrated with acid, and so on until the whole picture was built up. The entire operation took a few hours whereas, using the conventional procedures it might have taken weeks to compile such a detailed picture of the behaviour.

From this figure it can be seen how the PAA shifts the isoelectric point to lower pH values as it adsorbs on to the particle surface.

To provide a clearer picture of the effect of pH on optimum dispersant level, this data has been replotted as a function of dispersant addition in figure 3.

From this figure it can be seen that more dispersant is required at lower pH values. This is because at pH the underlying charge on the alumina surface becomes more positive as the pH drops, and so it attracts the PAA molecules more strongly. As the PAA adsorbs, negative charge is added to the surface and this reduces the attraction for more PAA. The process continues until the repulsive force between the PAA and the surface is strong enough to prevent further adsorption. This clearly requires a negative surface, with a zeta potential of around  $-40$  mV.



**Figure 3** At lower pH values, more dispersant is required

These measurements were carried out at particle concentration of 30 wt%. Clearly if one was to carry out such measurements by the light scattering techniques it would be necessary to work carry out massive dilutions. Such a dilution carries the risk that it will alter some parameter that affects the partition between the dispersant in solution and on the particle surface. Clearly, to get the true optimum dispersant dose it is much better to measure at the working particle concentration. The ZetaProbe and AcoustoSizer are the ideal instruments for this task.

## References

1. Greenwood, R. (2003) "Review of the measurement of zeta potentials in concentrated aqueous suspensions using electroacoustics" *Advances In Colloid And Interface Science* **106** 55-81

2. Greenwood, R. Bergstrom, L. (1997) "Electroacoustic and rheological properties of aqueous Ce-ZrO<sub>2</sub> (Ce-TZP) suspensions" *Journal of the European Ceramic Society* **17** (2) 537-548.
3. Burke, M. , Greenwood R., Kendall K. (1998) "Experimental methods for measuring the optimum amount of dispersant for seven Sumitomo aluminas" *Journal of Materials Science* **33** 5149-5156.
4. Beattie, J.K., Djedjev, A. (2000) "Rapid electroacoustic method for monitoring dispersion: zeta potential titration of alumina with ammonium poly(methacrylate)". *Journal of the American Ceramics Society* **83**(10) 2360-64.